AN INTEGRATED APPROACH FOR THE REMEDIATION OF A CATCHMENT IMPACTED BY FORMER MERCURY MINING

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EU - Hg strategy

January 2005, the Commission sent to the Council and to the European Parliament a communication on a **Community strategy on mercury** (doc. 5999/05), adopted on 24.June, 2005.

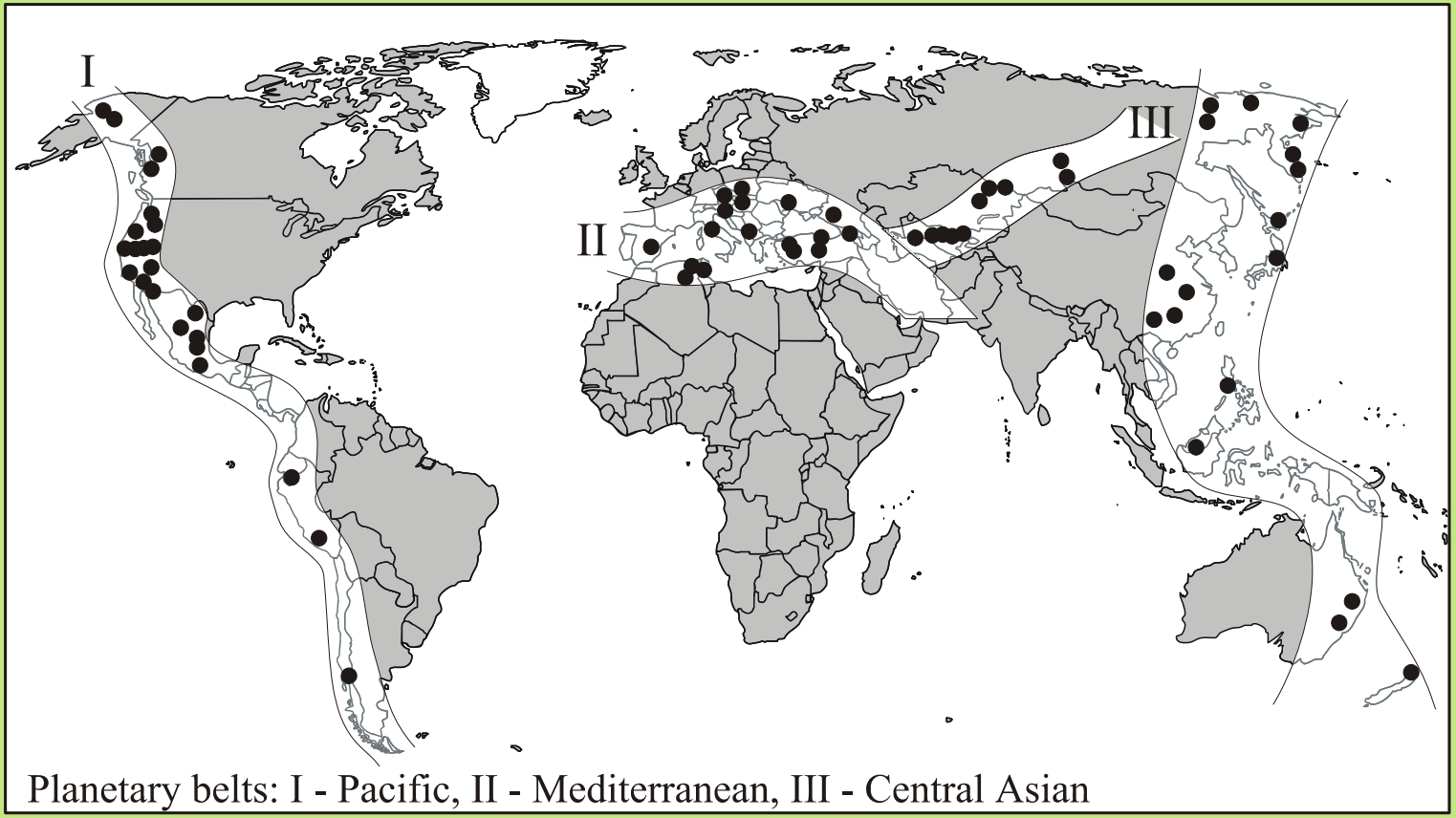
- Reducing mercury emissions
- Cutting supply and demand
- Looking for long-term solutions for mercury surpluses and reservoirs
- Protecting against mercury exposure
- Improving understanding of the mercury problem
- Supporting and promoting international action on mercury.

EU Hg strategy

International action

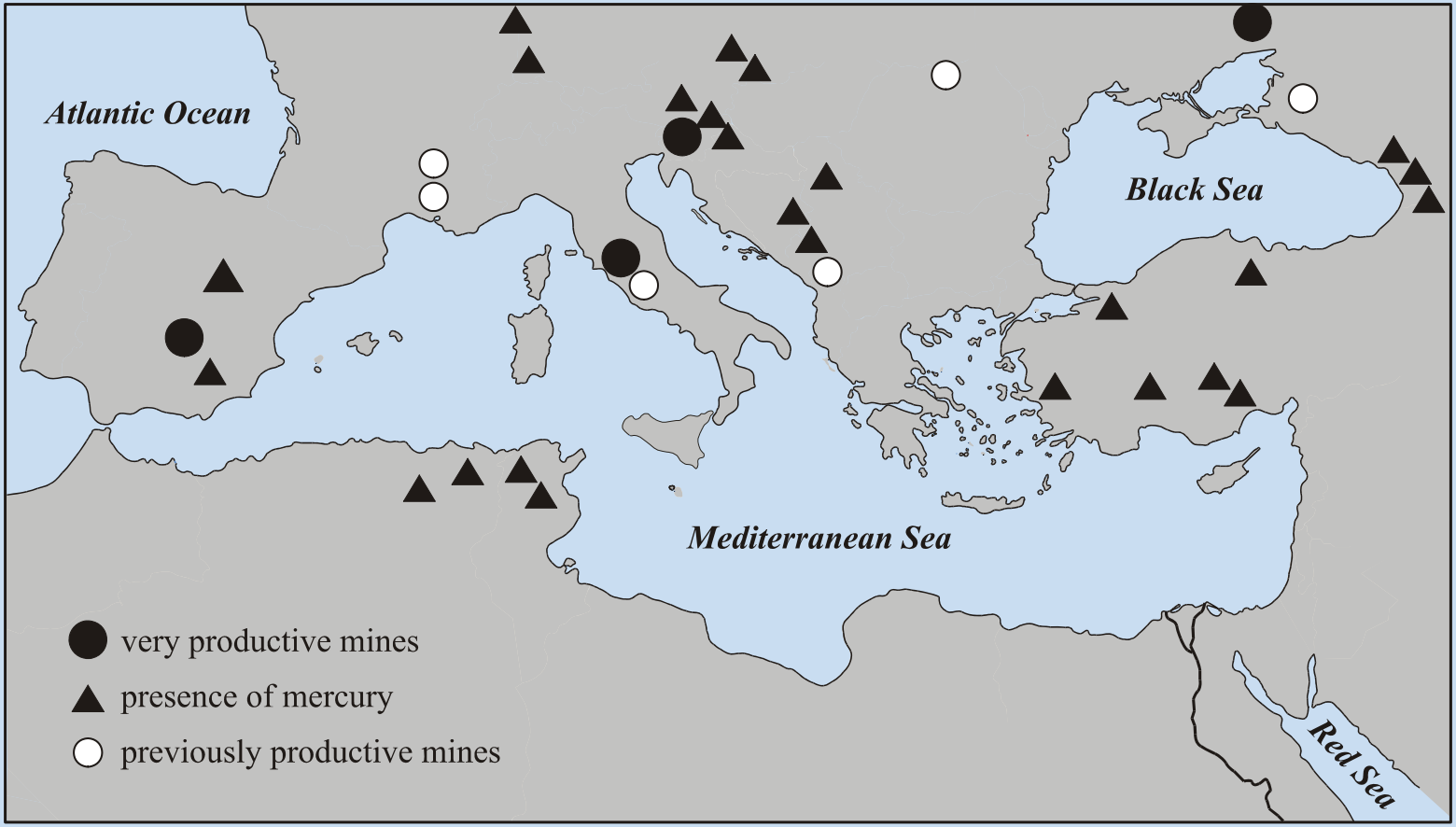
- International initiative on production and supply
- Bilateral support
- UNEP Mercury Programme
- UNDP/GEF/UNIDO Global Mercury Programme
- UNECE Convention on Long-Range Transboundary Air Pollution
- EU Hg conference, Brussels, 26 – 27. October 2006

Why Mediterranean?



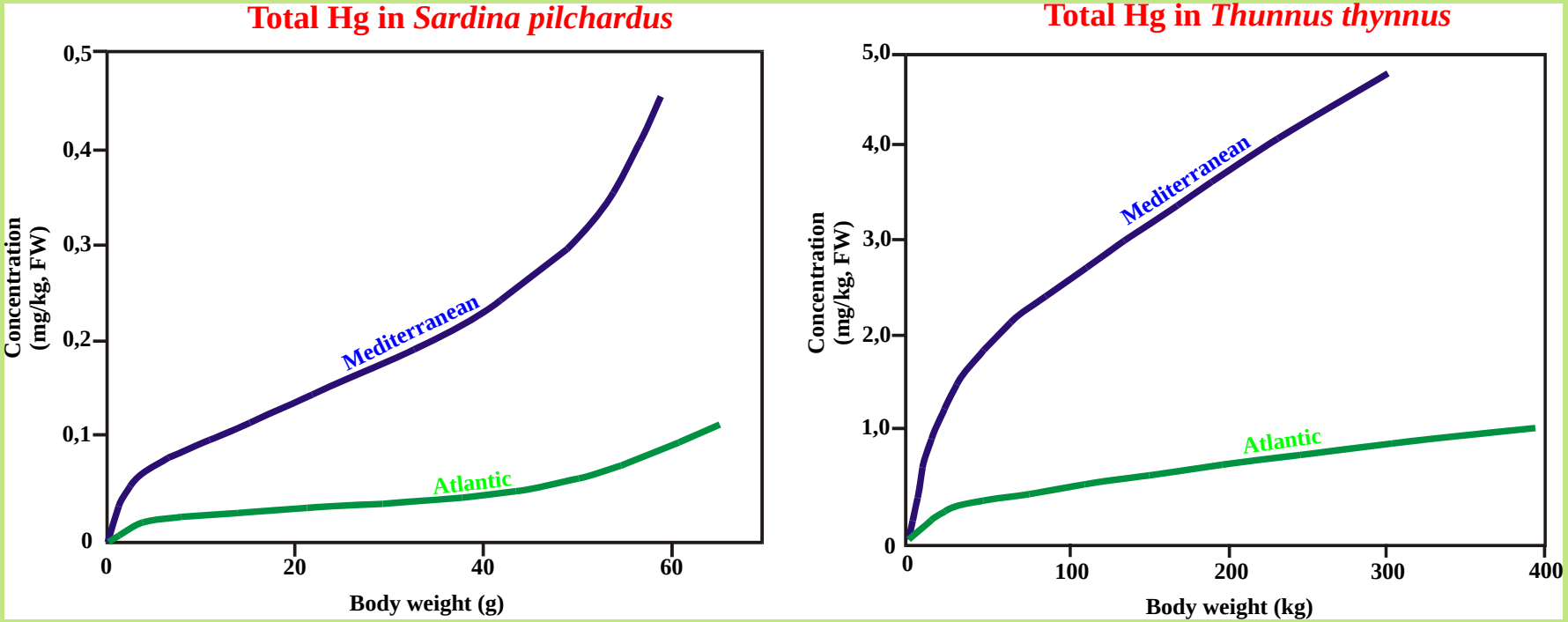
Planetary belts: I - Pacific, II - Mediterranean, III - Central Asian

LOCATIONS OF MERCURY MINES IN THE MEDITERRANEAN



Location of active and inactive mercury mines in the Mediterranean
(courtesyof meeting Amiata Minining Company)

MERCURY IN THE MEDITERRANEAN FISH



Bernhard et al., 1990

Study area: interaction between the catchment and coastal environments

Past:

- 500 years of Hg mining (1490-1990)
- **127.000 tons** of Hg extracted
- **>37.000 tons** lost into the environment
- **>12.000 tons** entered the river system

Today:

- About **2500 kg/y** enters the river system
- About **1500 kg/y** transported to the Gulf of Trieste

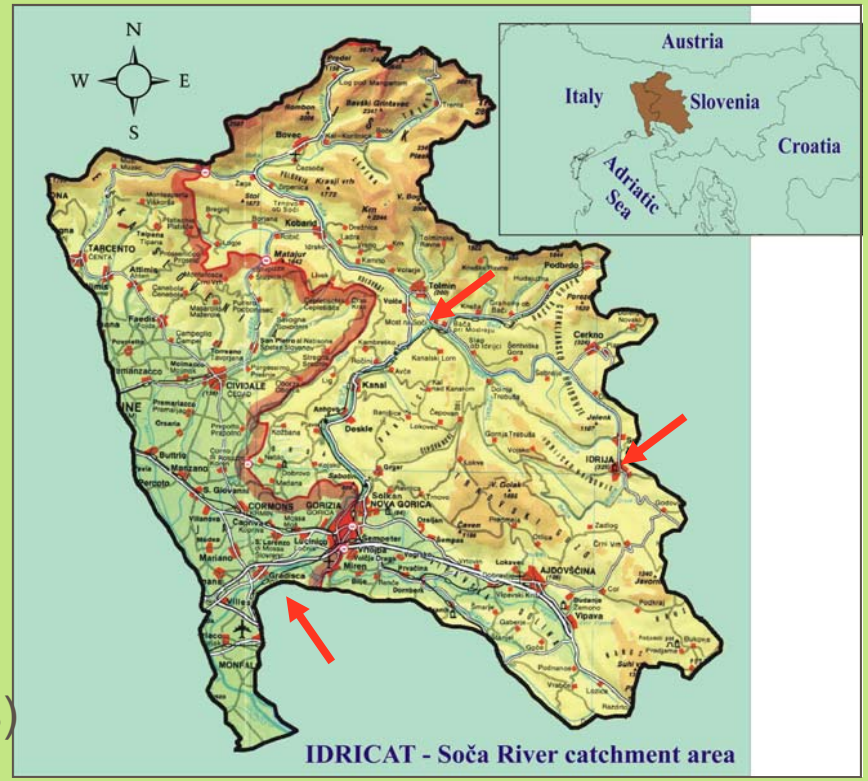
Catchment area: 3300 km^2

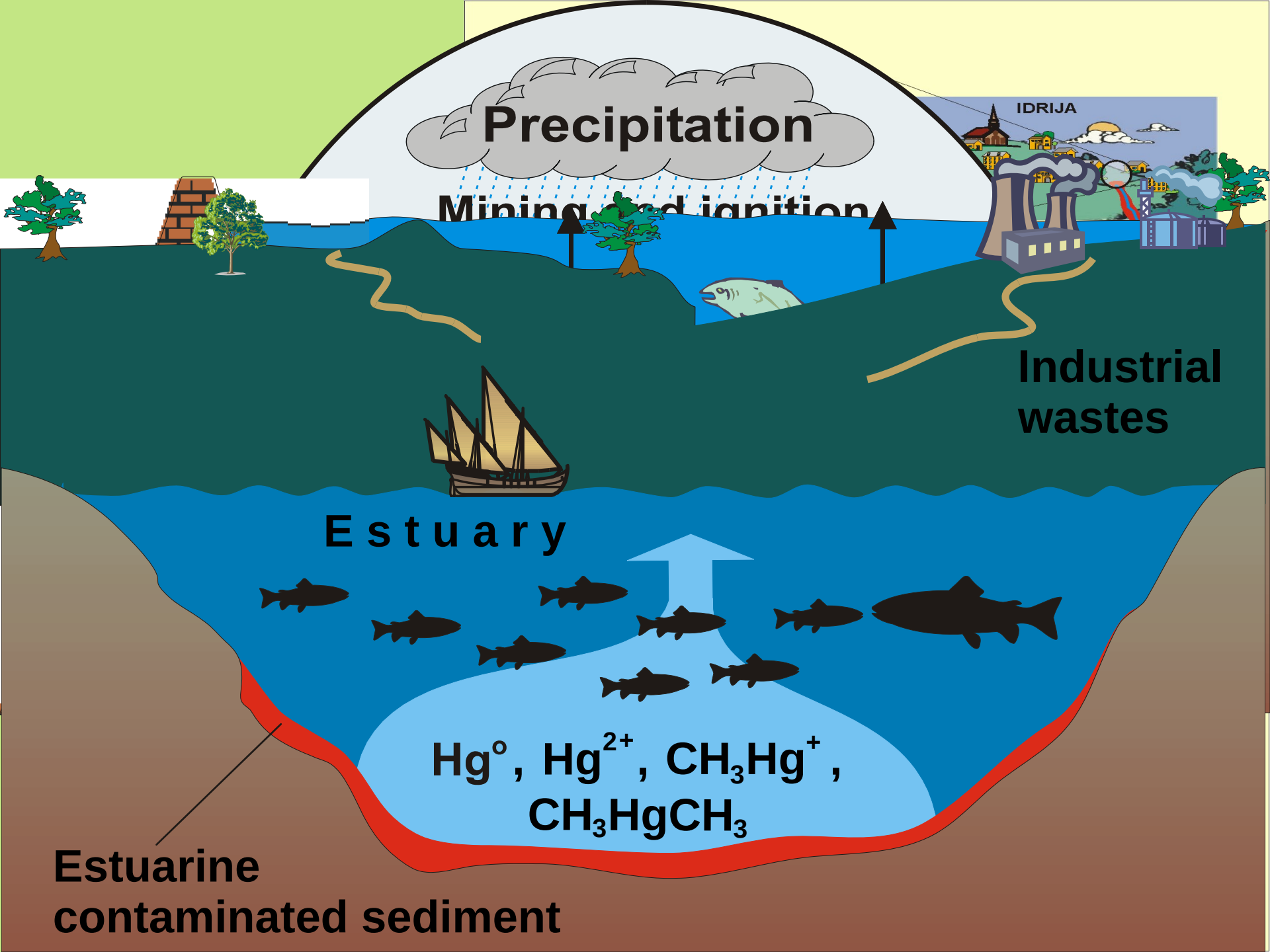
Soča at the mouth: 170 m^3/s

(extreme 3000– 4000 m^3/s)

Precipitation: 1500 mm/y

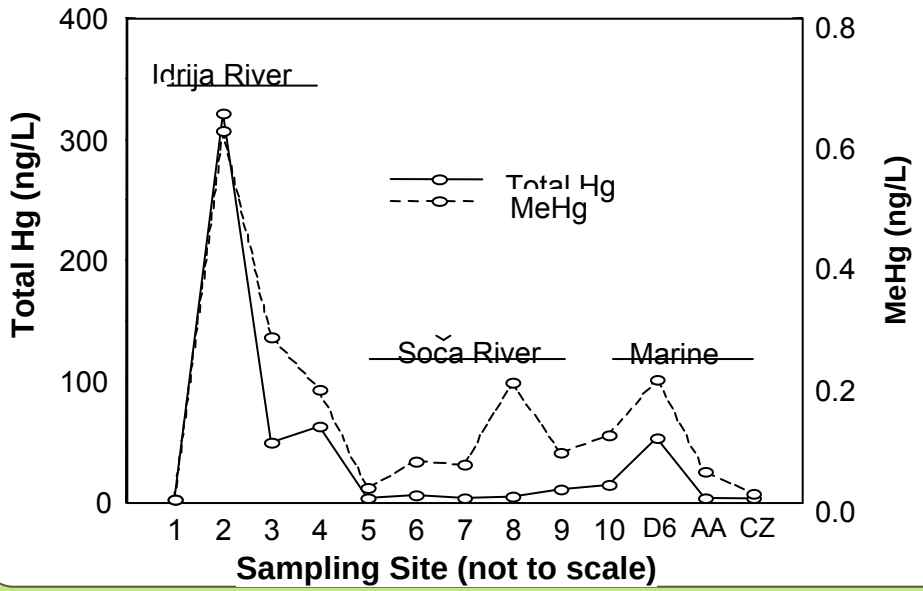
0.3 Mio inhabitants

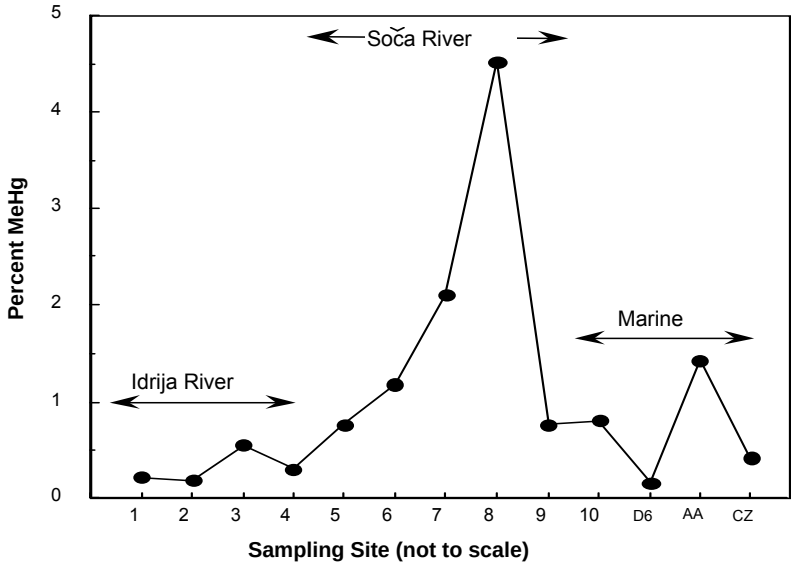



Precipitation
IDRIJA
Industrial wastes
Estuary
Hg°, Hg^{2+}, CH_3Hg^{+}, CH_3HgCH_3
Estuarine contaminated sediment


I: ASSESMENT OF THE
CURRENT SITUATION

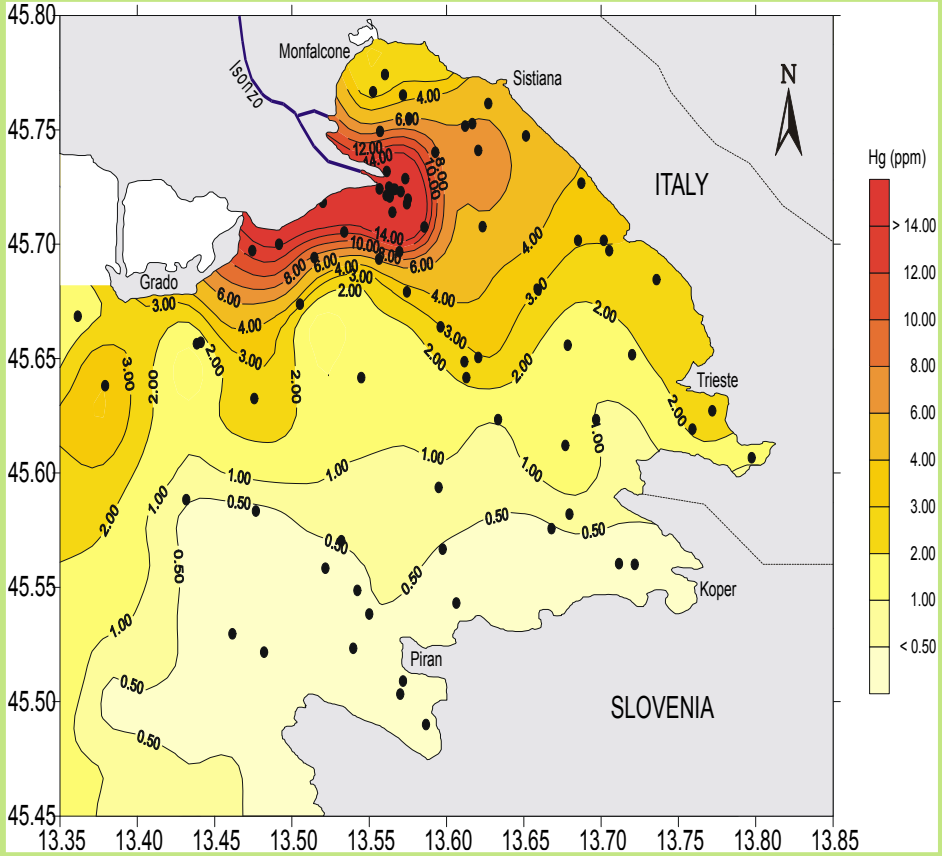
Mercury in river water



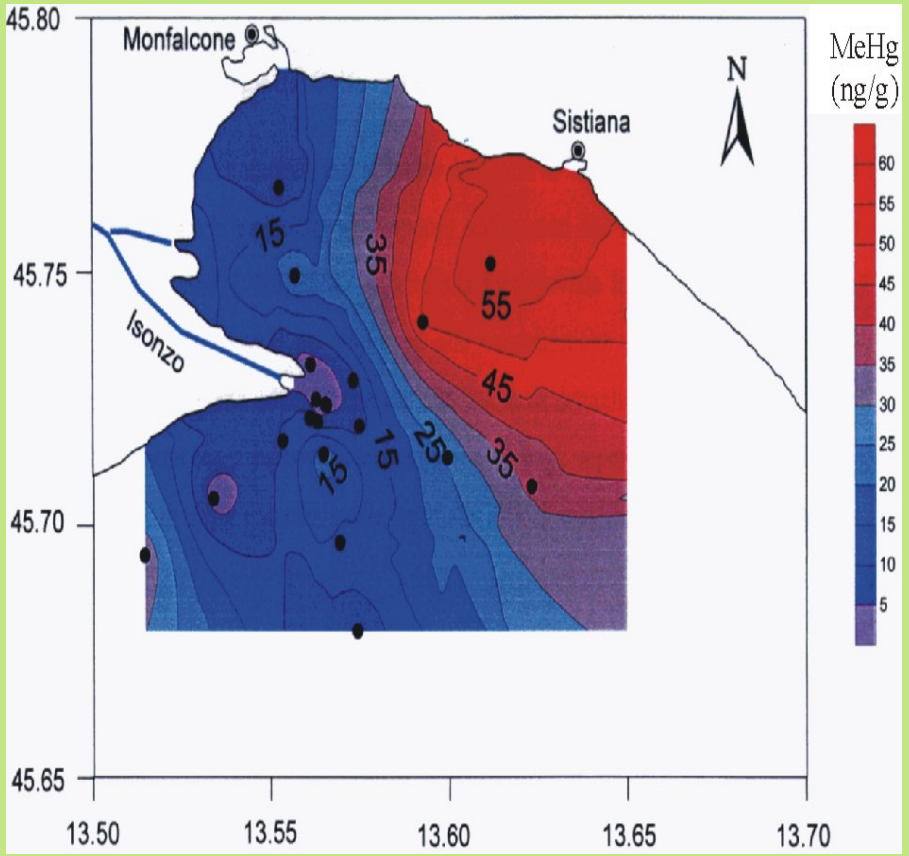


Mercury in marine sediments

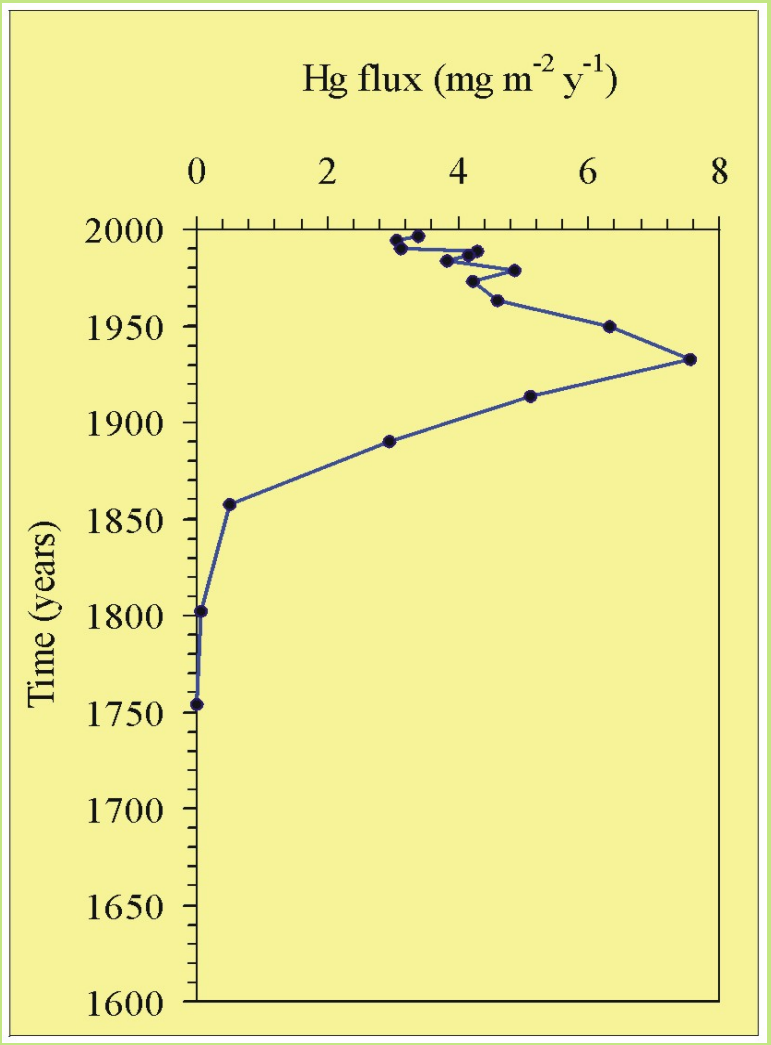
Total Hg



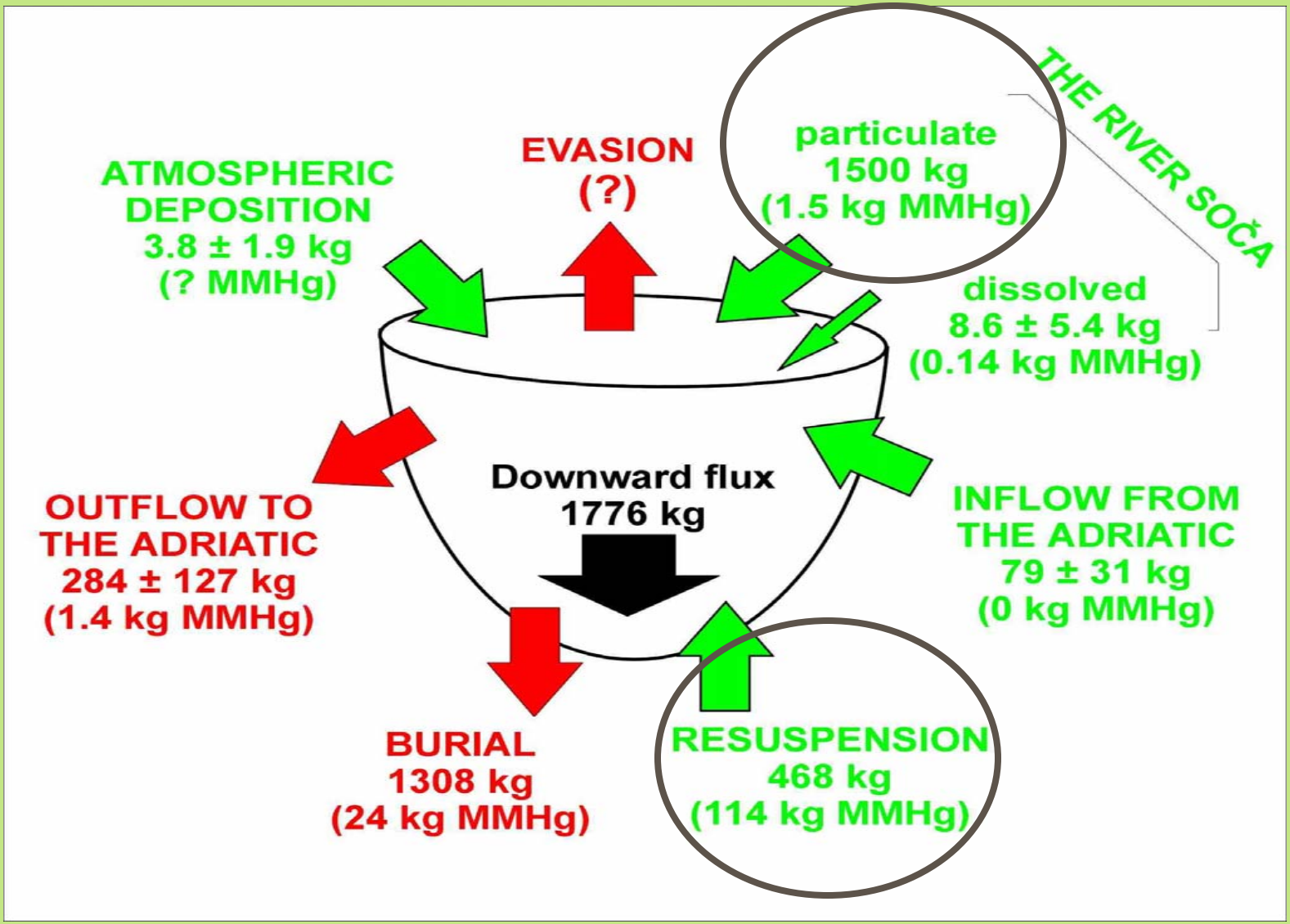
MeHg



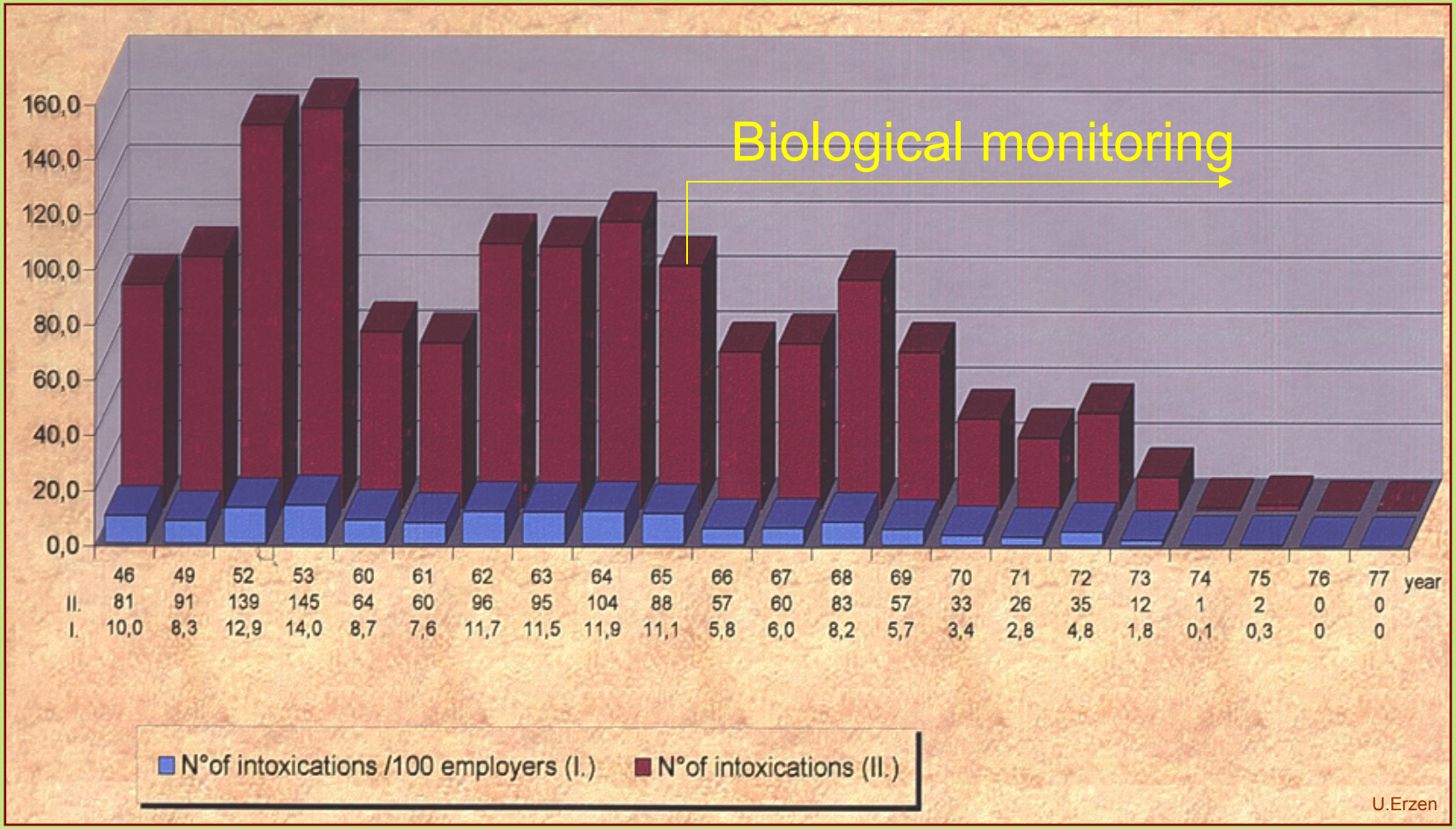
Mercury flux into the Gulf of Trieste



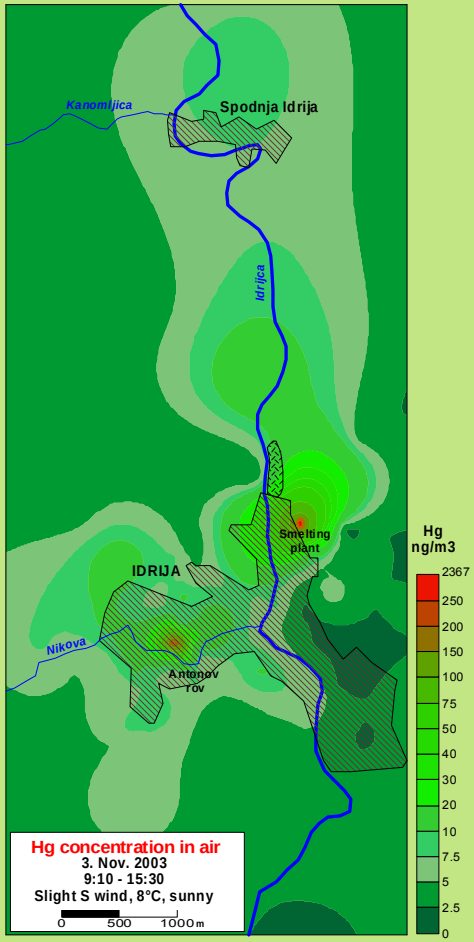
Mass balance of Hg in the Gulf of Trieste

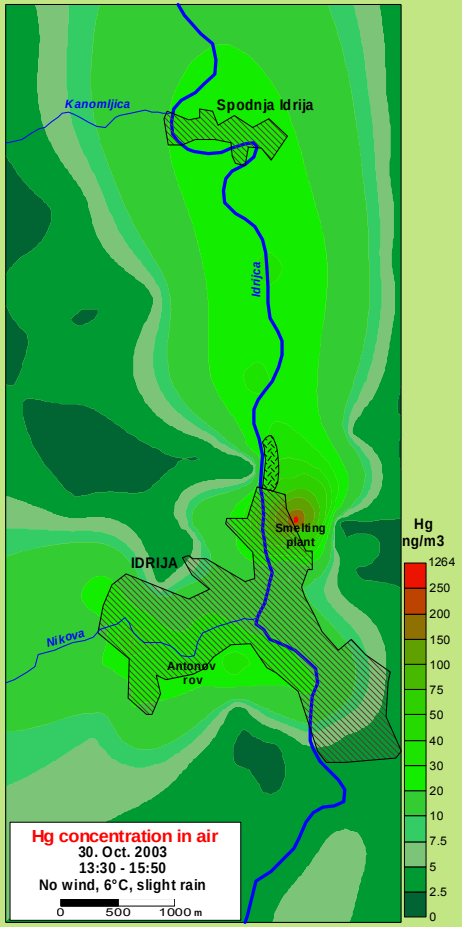


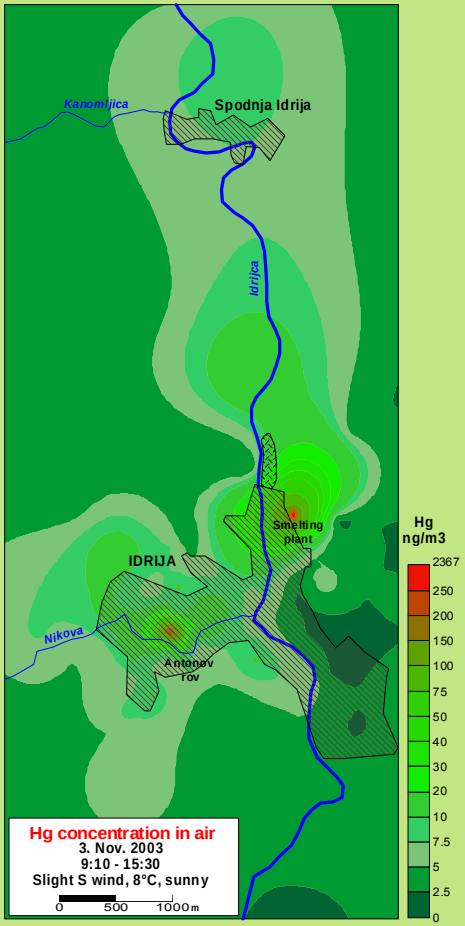
Occupational mercury intoxications in Idrija Mercury Mine from 1946 to 1977



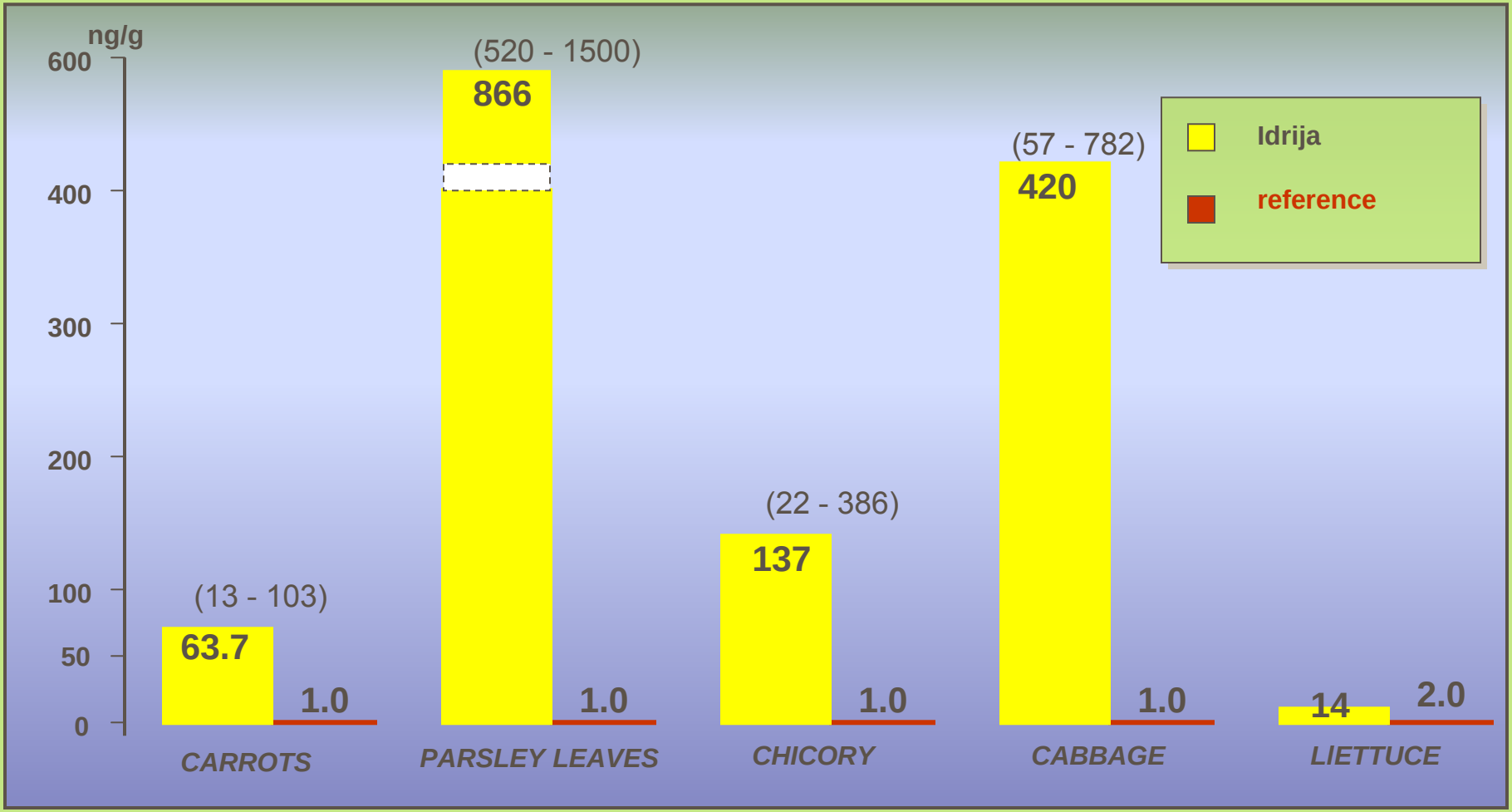
Idrija: Mercury in air



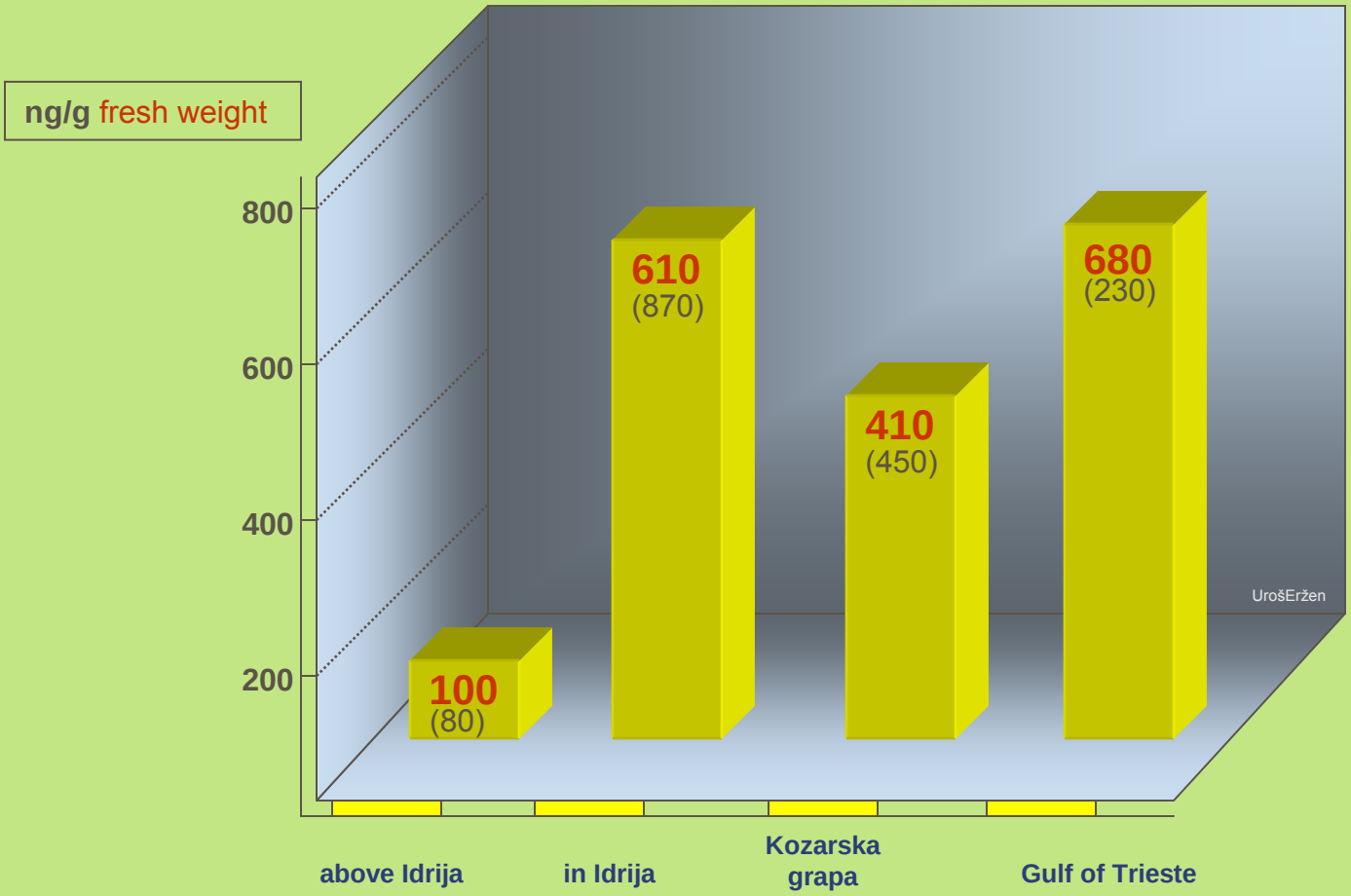




T-Hg concentration (mean, range) in selected vegetables



Mean (SD) T-Hg concentrations in river fish of the Idrijca river (Salmo sp.) and in marine fish (Conger conger) of the Gulf of Trieste



Contaminated food and fish is the main source of exposure

Estimated daily intakes of Hg in humans expressed in $\mu gHg/day/kg_{bw}$

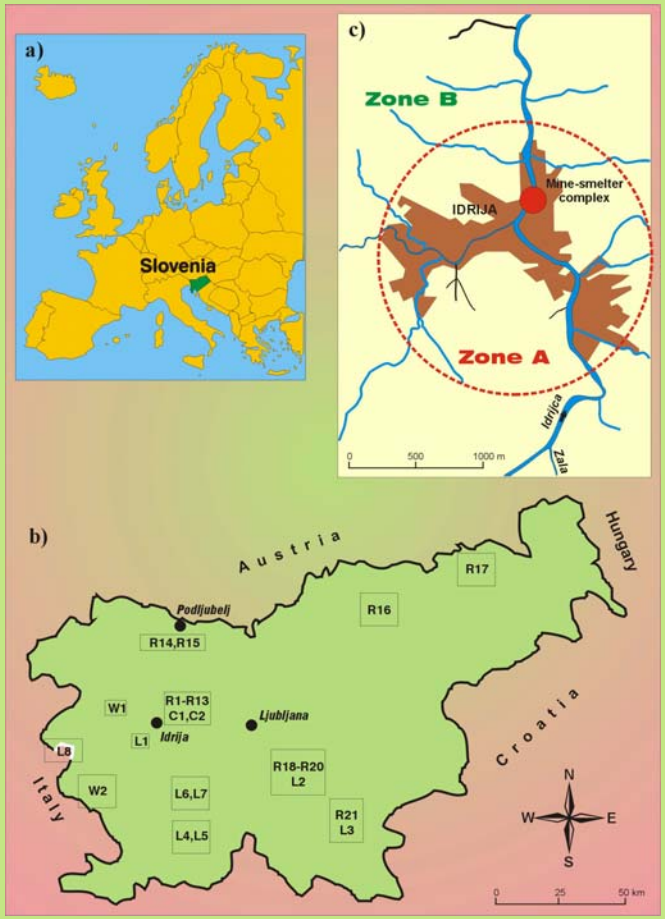
60 kg body weight

	Idrija		Coastal area	
	T-Hg	MeHg	T-Hg	MeHg
Air	0.05- 0.10	-	0.001 - .005	-
Fish (50/100g/day)	0.20 - 3.33	0.09 - 1.60	0.18 - 1.35	0.17 - 1.33
Other food	0.66	0.132	0.05	0.01

US EPA recommended RfD: 0.1 $\mu gHg/day/kg_{bw}$

WHO/JECFA recommended RfD: 0.23 $\mu gHg/day/kgbw$

Mercury mine Idrija, Slovenia
Inhaled vs. ingested Hg in roe deer

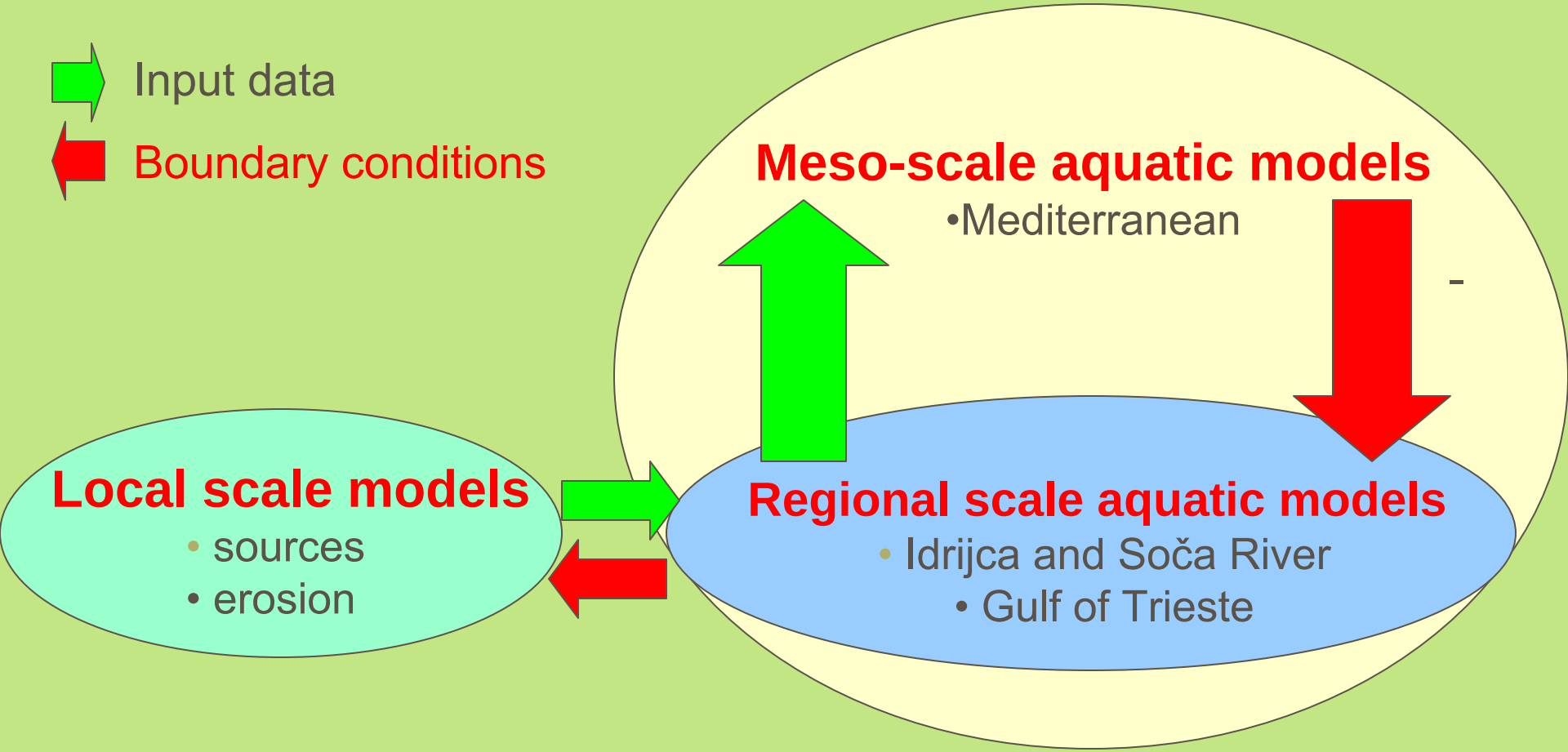


Location	Hg intake into roe deer		
	Inhalation	Ingestion	Inhalation: ingestion
	Hg (µg/kg/day)	Hg (µg/kg/day)	Ratio (%)
Idrija – Zone A	0.10	109	0.09
Zone B	0.30	435	0.07
Near smelter	4.0	2520	0.16
Podljubelj	0.07	36.5	0.19
Controls	0.007	4.2	0.17

Gnamus and Horvat, 2001


II. Modelling tools

Interaction between the models



Models

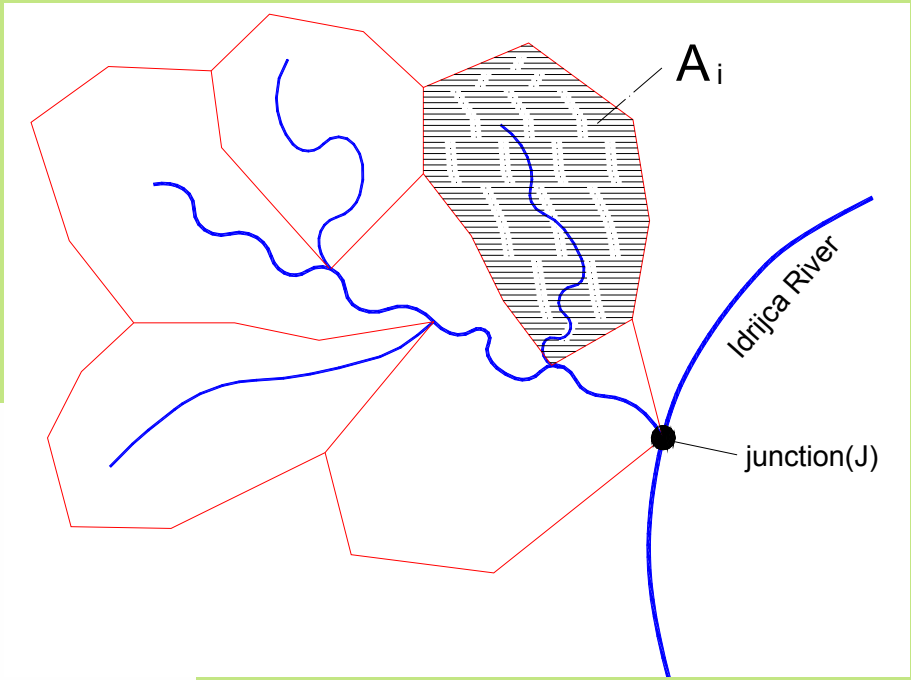
- **Erosion model**
  (Idrija region): Hg release 2.500 kg/year
- **River model**
  (Idrijca and Soča): transport and transformations
- **Marine model**
  (Gulf of Trieste): Hg input 1500 kg/year

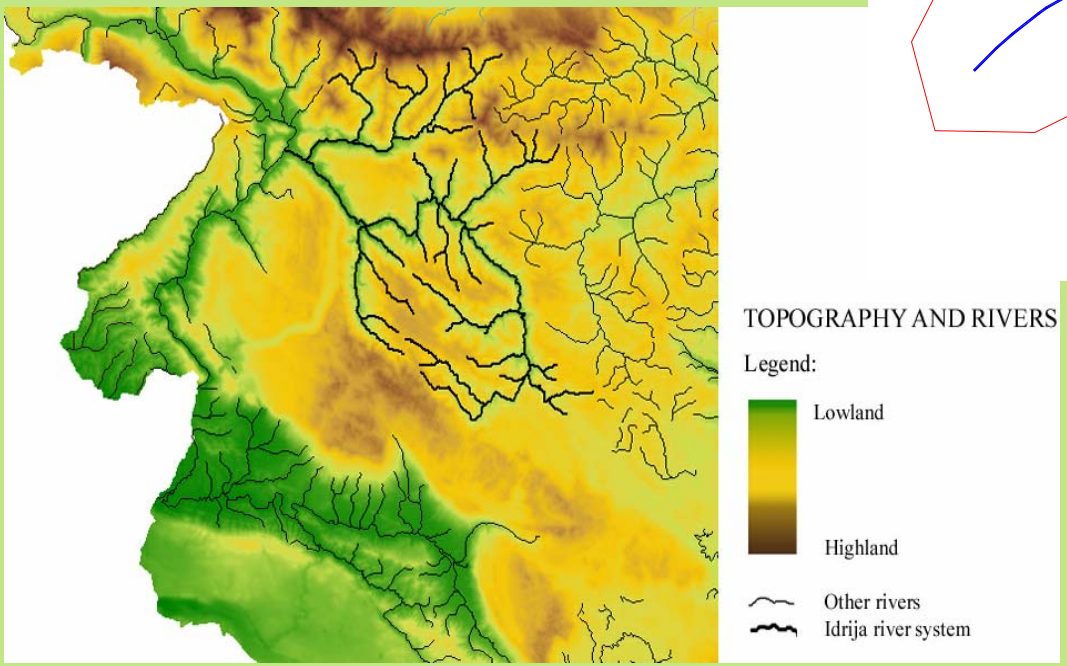
EROSION MODEL and Hg release

GIS-layer based model

Data – layers: topography, geology, pedology, land cover, land use, slope, precipitation, runoff.

Measurements: Hg

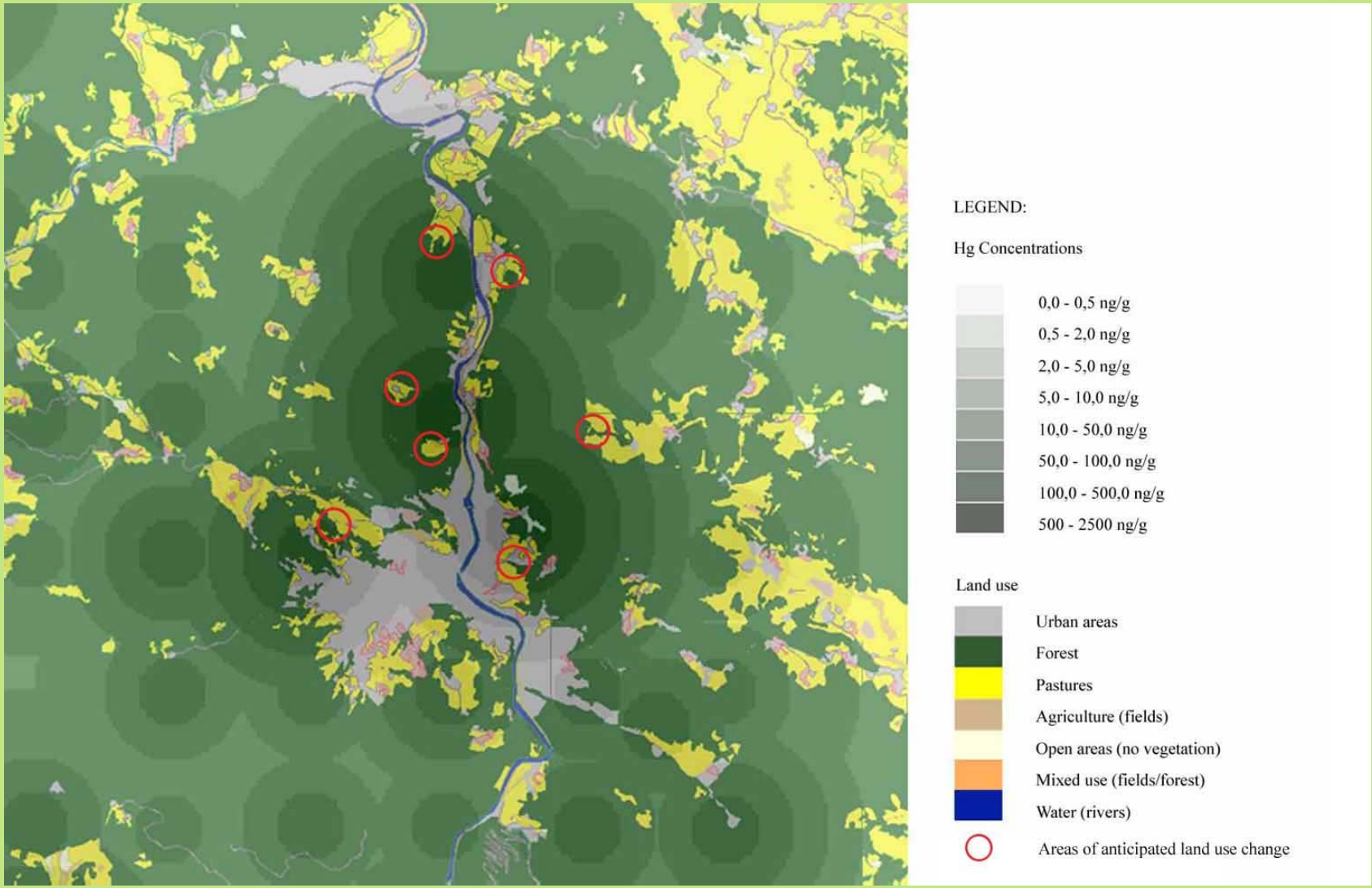




Results:

- input data for the river model
- possible remediation measures

Modelling results for PT scenario



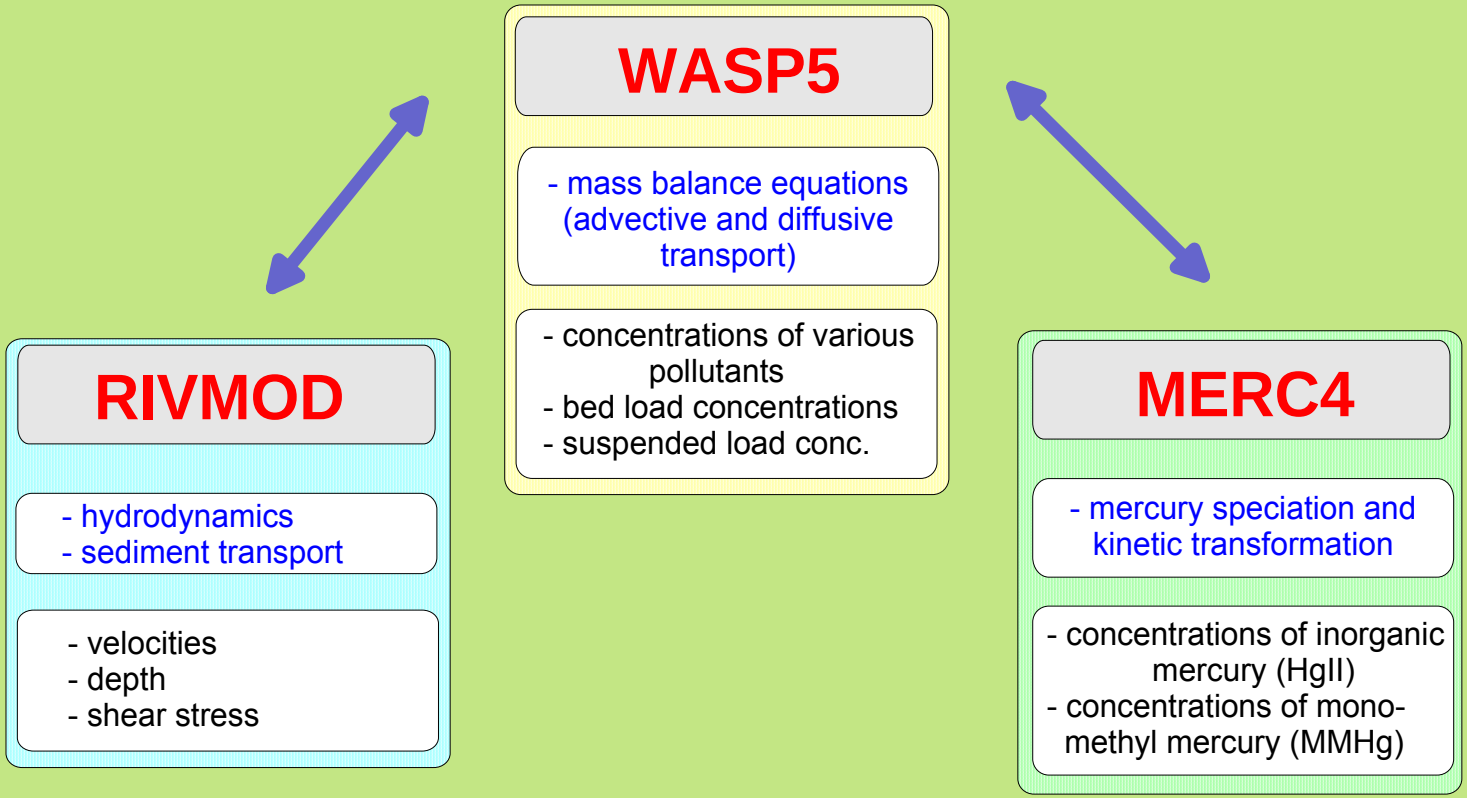
Results and findings from EROSION MODEL

- ***Present situation*:**
  - annual Hg release to Idrijca River: 2500 kg
- ***PT scenario:***
  - change in land use and elimination of hot spots:
  - decrease of annual Hg release to 1445 kg

Possible reduction: 42 %

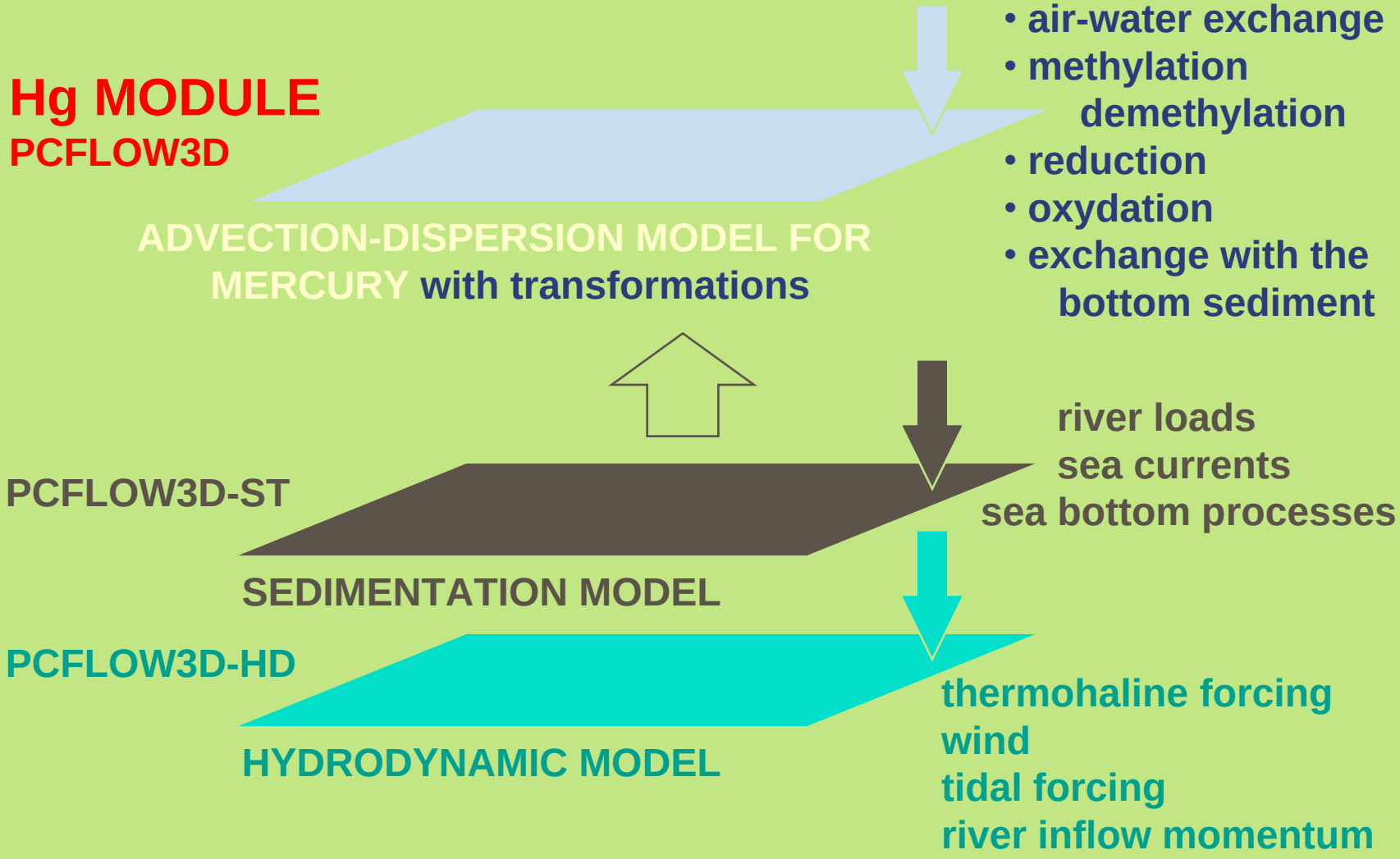
Cost: 28 mil. €

1-D model MeRiMod structure

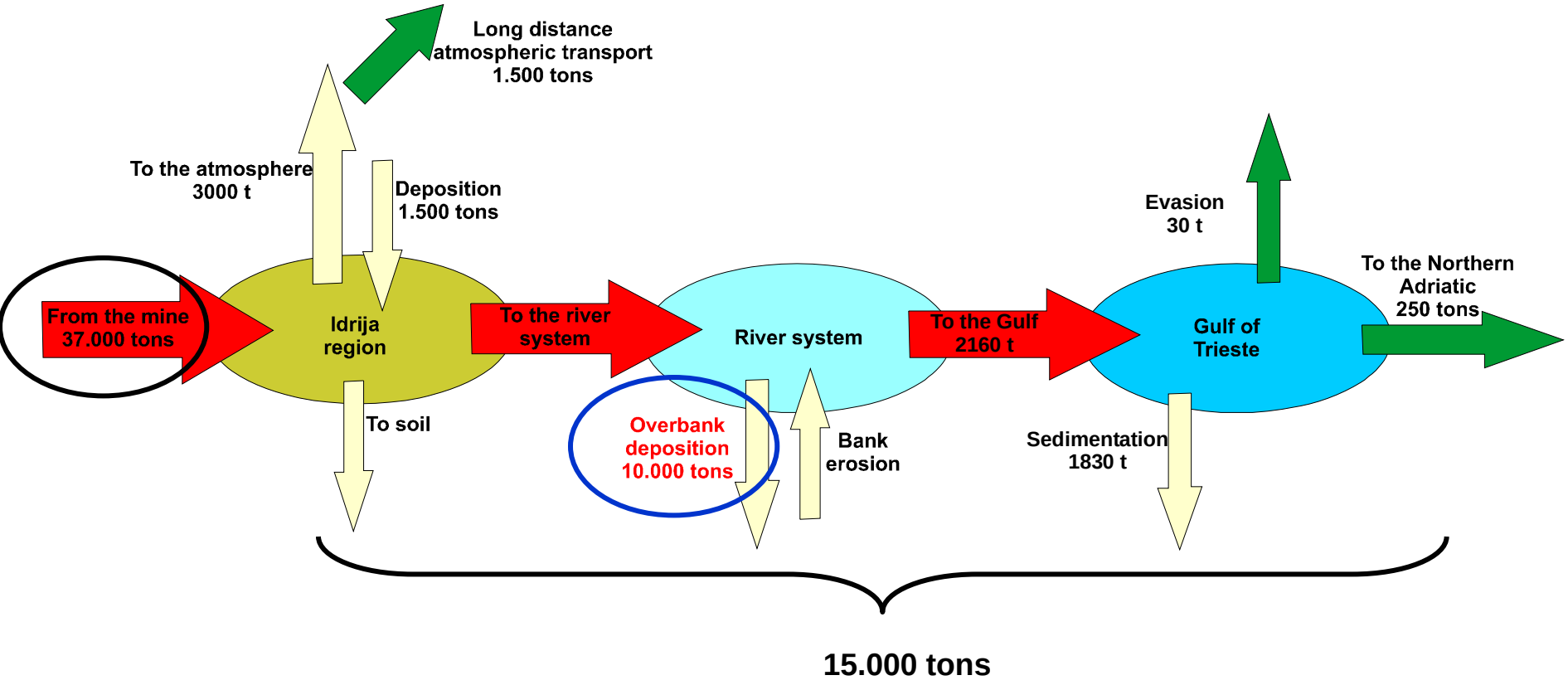


- already used for the Carson River (NV, USA)
- adapted for Idrijca and Soča Rivers (parameters – measurements)
- real time unsteady-state simulations

CONCEPT OF THE 3D WATER MODELING SYSTEM (MARINE ENVIRONMENT)



Historical Mass Balance of the Idrijca and Soča River Catchment




III. WHAT WE CAN DO

It is generally accepted that the formation and bioaccumulation of **MeHg is the most critical point of environmental quality in mercury contaminated sites.**

The reduction of MeHg in seafood can therefore be defined as the priority objective with regard to the mercury contamination problem in the wider Idrija area and in the Gulf of Trieste.

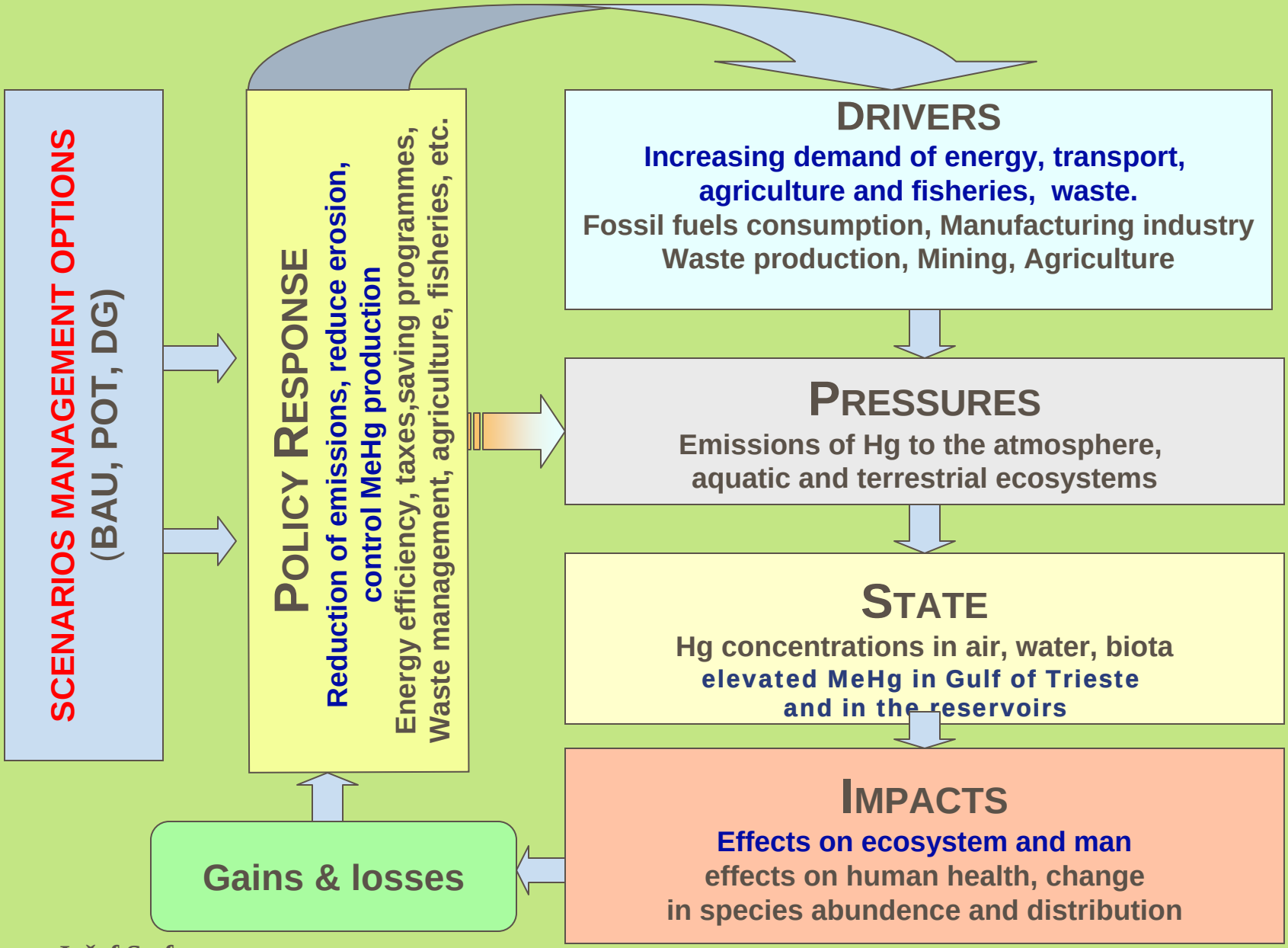
POSSIBLE MEASURES to reduce toxic effect of MeHg in the area

- Reducing Hg transport within the river system:
  - diminish erosion near Idrija (forestation, elimination of hot spots)
  - dredging of sediments along both rivers
  - construction of new reservoirs (?) – *or elimination (?)*

- Reducing methylation (conditions):
  - to improve water quality in the river sytem and the Gulf – WW treatment, reducing mariculture, *aeration (?)*
  - dredging of bottom sediment to reduce the source of MMHg - technically possible, very expensive, *where to put Hg contaminated sediment (?)*

- Administrative measures – prohibition of fishing, mariculture…

A conceptual *Drivers-Pressure-State-Impact-Response* model (DPSIR)



Definition of IDRICAT scenarios




Business as usual - no additional measures to physical closing of the mine envisaged, "leave it as it is"

Policy targets – collection of measures aimed at reducing introduction of Hg into the catchment: elimination of the hot spots, reduction of erosion potential, construction of WWTPs

Deep Green – reducing potentials formation of MeHg and exposure of population to Hg

CURRENT STATUS – SCENARIOS:

Business as Usual – not acceptable, not further explored in any specific detail, except for modelling fluxes

Policy Targets – preferred, explored in detail in terms of mass balance modelling and institutional assessment (questionaire based survey) – efficiency needs to be determined based on monitoring

Deep Green – considered on the level of the mass balance modelling only; still under development/verification, results not yet available

EU Mercury Strategy – Hg contaminated/polluted sites (I)

- **Reducing emissions:**
  - Polluted sites as important source category
  - Inventory of Hg polluted sites
  - Comparability of data on emissions (standardized protocols)
- **Reducing supply:**
  - Hg mining: historical, economic and societal significance and reponsability for environmental degradation
- **Protecting against exposure:**
  - mixed exposure to inorganic and organic Hg
- **Improved understanding:**
  - Integrated tools for the remediation of Hg polluted sites (including modeling)
  - Integrated measurement tools (chemical, physical and biological) – early warning systems

EU Mercury Strategy – Hg contaminated/polluted sites (II)

- **Societal and economic implications of emission reduction measures**
  - **Benefits:** environmental and health & economic and societal
  - **Selection of alternatives:** Strategic environmental assessment (SEA)
    - Reduction of global pool of Hg in longer time perspective
    - Increase of quality of life (social&security, employment, education, etc..)
    - Economy (generator of further local/regional developoment, transition from production to service, transition to higher education jobs, etc..)

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