



# The threat to the marine environment resulting from the presence of World War II shipwrecks, on the example of the s/s Stuttgart.

**Justyna Rogowska, Lidia Wolska**

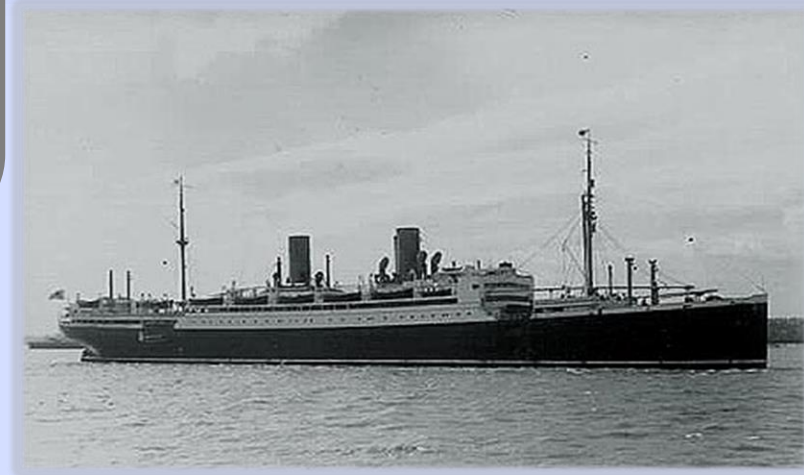
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Medical University of Gdansk  
23A Dębowa Str, 80-204 Gdańsk, Poland

**1923** – building of s/s Stuttgart as a passenger ship

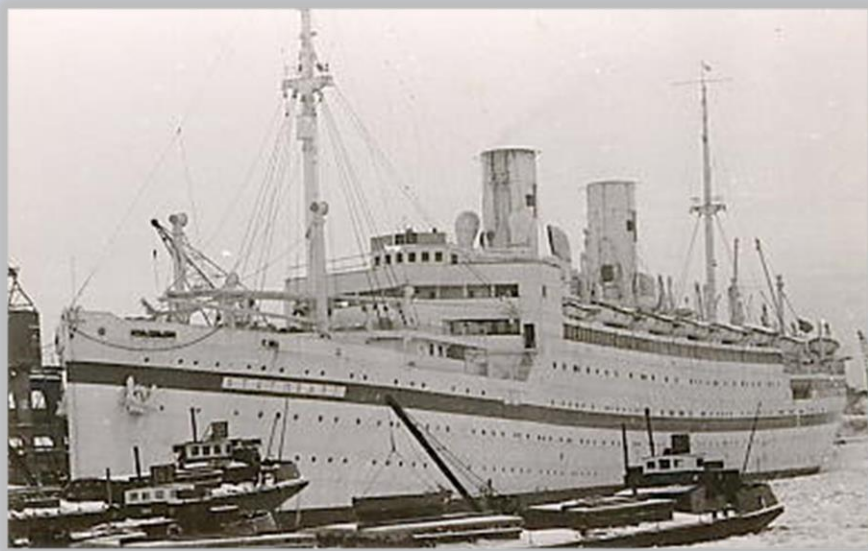
**1939** – rebuilding - *Lazaretschiff C* hospital ship

**1943** – damage and burning of the ship, the sinking on the waterway to Gdynia

## S/s Stuttgart



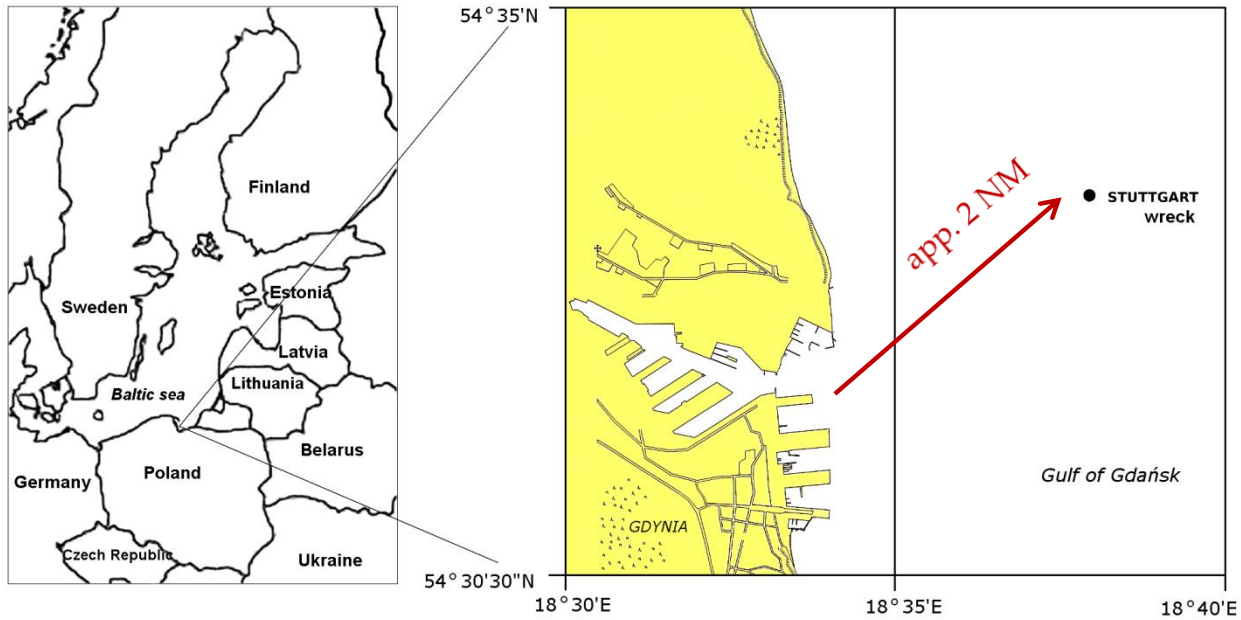
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[www.wlb-stuttgart.de/seekrieg/4310-bilder/stuttgart.jpg](http://www.wlb-stuttgart.de/seekrieg/4310-bilder/stuttgart.jpg)

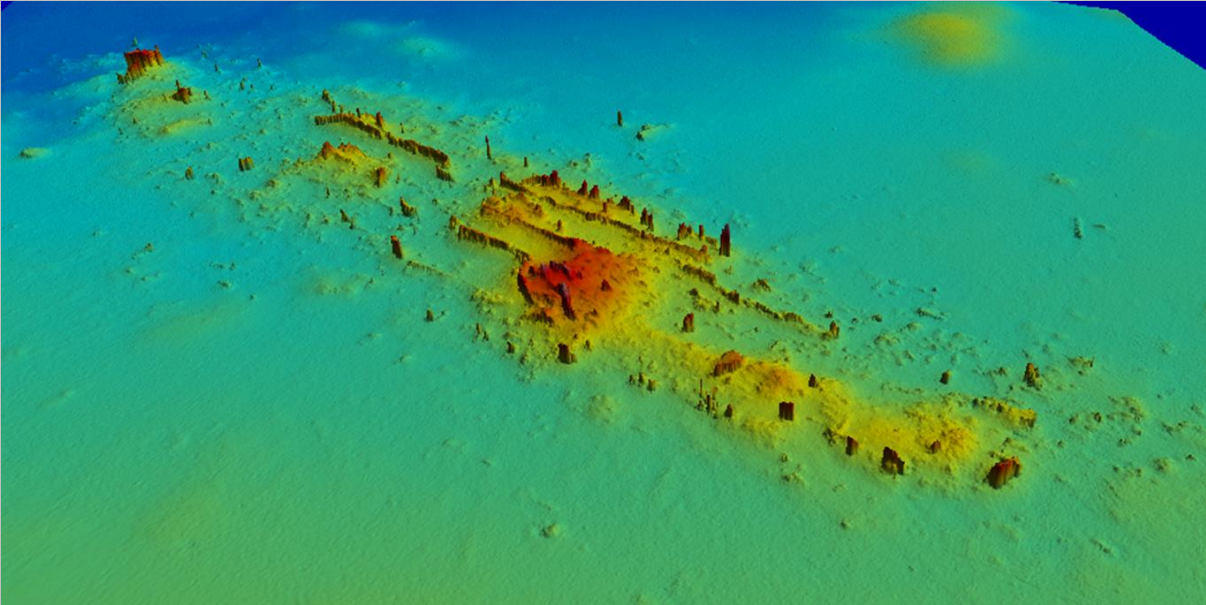
**1956** – removal of the parts of the wreck using pyrotechnic methods

**1992** – review of the position coordinates of the wreck



# S/s Stuttgart

Rogowska J., Wolska L., Namieśnik J., Impacts of pollution derived from ship wrecks on the marine environment on the basis of s/s "Stuttgart" (Polish coast, Europe), *Science of the Total Environment* 408, 5775–5783, 2010.



**Project:** Elaborating methodology aimed at determination of shipwrecks influence on the environment on the basis of s/s „Stuttgart”,

Ministry of Science and Higher Education, 2009-2012

Principal Investigator: Prof. Jacek Namieśnik

Contractor: Prof. Lidia Wolska

**Main contractor: Justyna Rogowska**

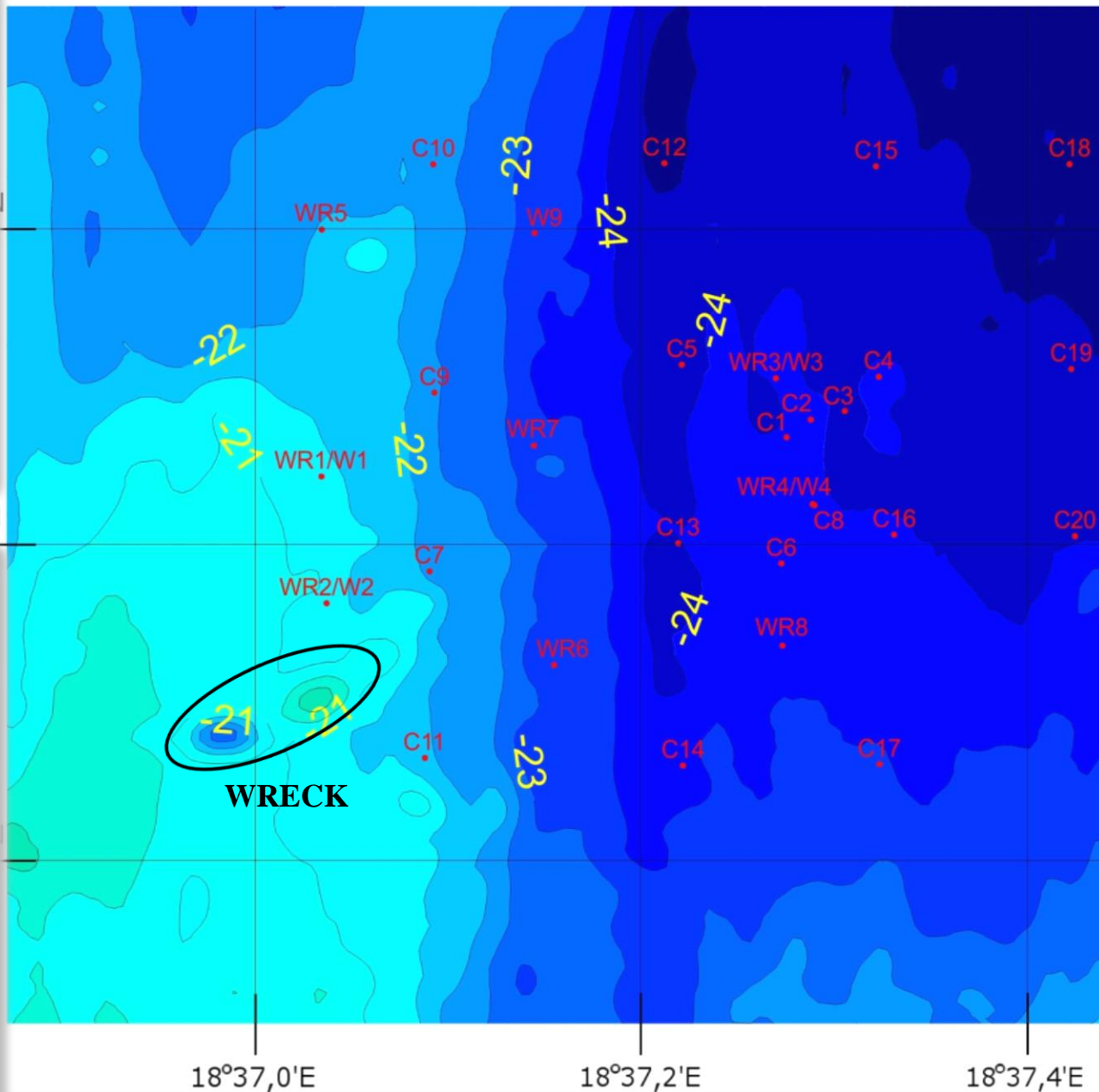


One of the objective of this study was to determine the environmental impact of the wreck of the ship s/s Stuttgart based on the results of chemical analyzes and ecotoxicological assessment





54°33,6'N



9 cores – WR1-WR9

20 surface sediments – C1-C20

# Research methodology

## Chemical analysis

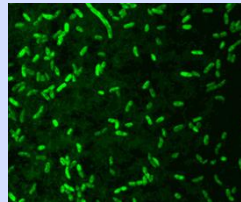
### Metals i.a.

Cr, Zn, Cd, Cu, Ni, Pb, Hg

$\Sigma$ PCBs: congeners 28, 52, 101, 118, 138, 153 i 180

**16 PAHs:** Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(a)pyrene, Indeno (1,2,3-cd) pyrene, Dibenzo(a,h)anthracene, Benzo(g,h,i)perylene

## Ecotoxicological assessment



Acute toxicity – *Microtox* test with *Vibrio fischeri*



Chronic toxicity – *Ostracodtoxit F<sup>TM</sup>* with *Heterocypris incongruens*



Toxicity – *Phytotoxkit* test with *Synapis alba*

# Chemical analysis

*Regulation of the Minister of Environment of 16 April 2002 on the types and concentrations of substances that cause the dredged materials is contaminated \**

(Journal of Laws of 2002 No. 55, item. 498)

*\*now – repealed: Regulation of the Minister of Environment of 11 May 2015 on the recovery of waste outside installations (Journal of Laws of 2015, item. 796) code: 17 05 06*

determination of all known and unknown pollutants is not possible

impact on living organisms

cost of analyzes

substances interaction

**ADDITIVITY**  
(2+2=4)

**ANTAGONISM**  
(2+3=3)

**POTENTIATION**  
(0+2=4)

**SYNERGISM**  
(0+2=8)

# RESULTS



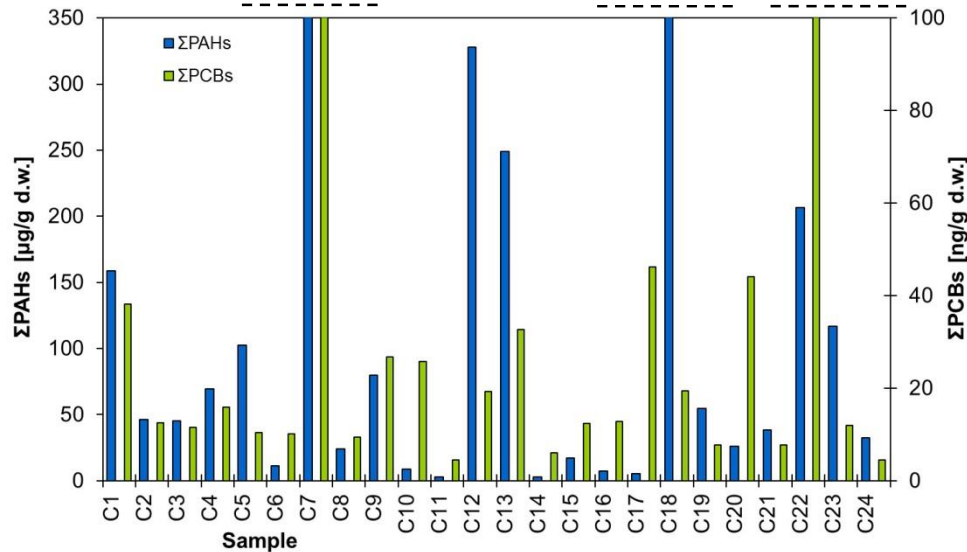


# Surface sediments - PAHs, PCBs

$\Sigma$ PAHs  $751 \times 10^2$

$\Sigma$ PCBs 354

$\Sigma$ PAHs  $83,7 \times 10^2$   $\Sigma$ PCBs 151

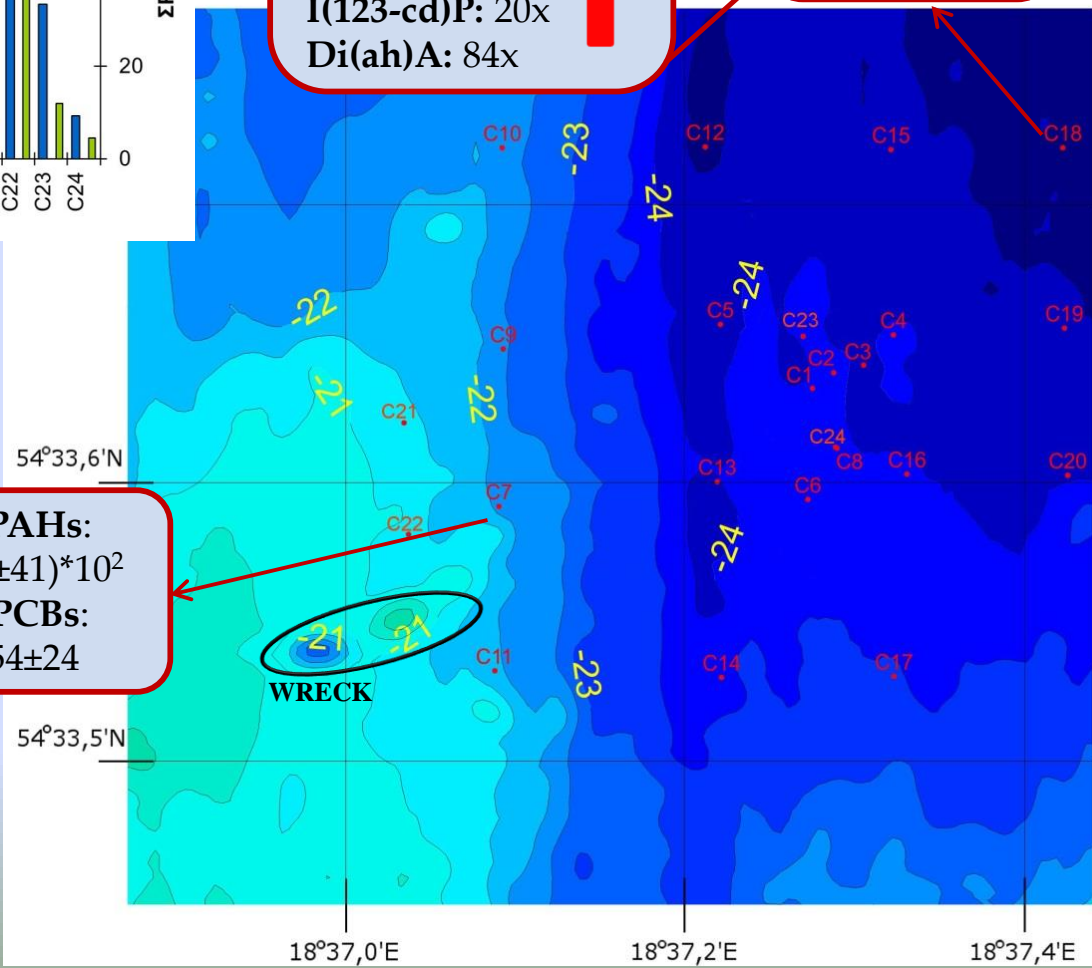


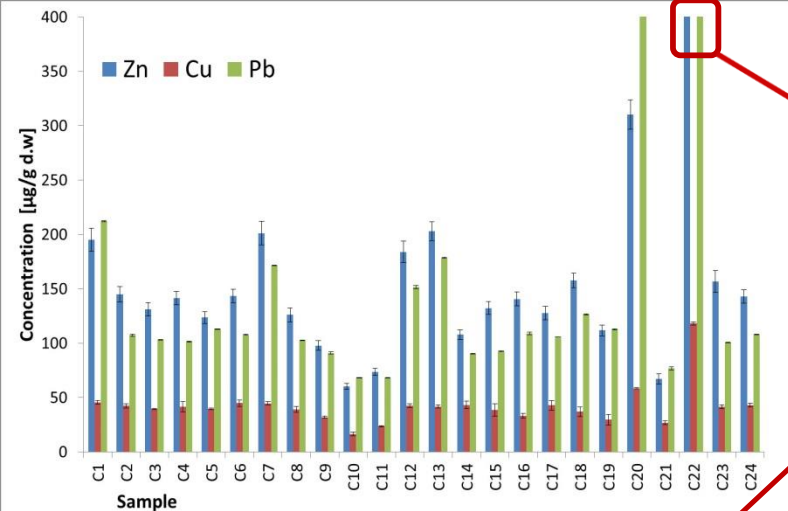
**B(a)A:** 241x  
**B(b)F:** 181x  
**B(k)F:** 92x  
**B(a)P:** 235x  
**B(ghi)P:** 103x  
**I(123-cd)P:** 20x  
**Di(ah)A:** 84x

$\Sigma$ PAHs :  $(83.7 \pm 4.6) \times 10^2$

**B(a)A:** 3800x  
**B(b)F:** 2270x  
**B(k)F:** 1150x  
**B(a)P:** 2070x  
**B(ghi)P:** 607x  
**I(123-cd)P:** 759x  
**Di(ah)A:** 449x  
 **$\Sigma$ PCBs:** 1x

$\Sigma$  PAHs:  
 $(751 \pm 41) \times 10^2$   
 $\Sigma$  PCBs:  
 $354 \pm 24$





## Surface sediments - metals

Zn:  $995 \pm 56$

Pb:  $2020.83 \pm 0.49$

Cd:  $4.46 \pm 0.05$

Hg:  $4.79 \pm 0.80$

Cu:  $118.2 \pm 1.4$

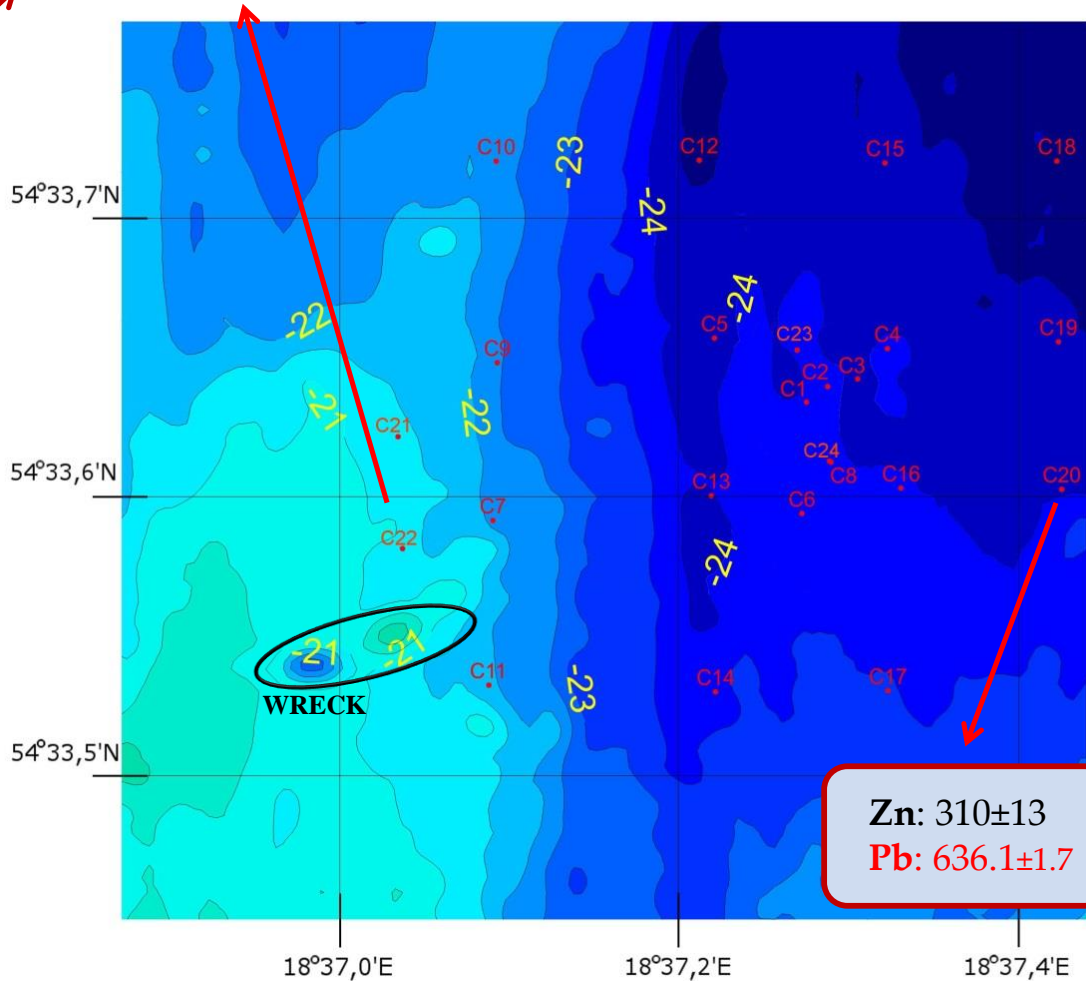
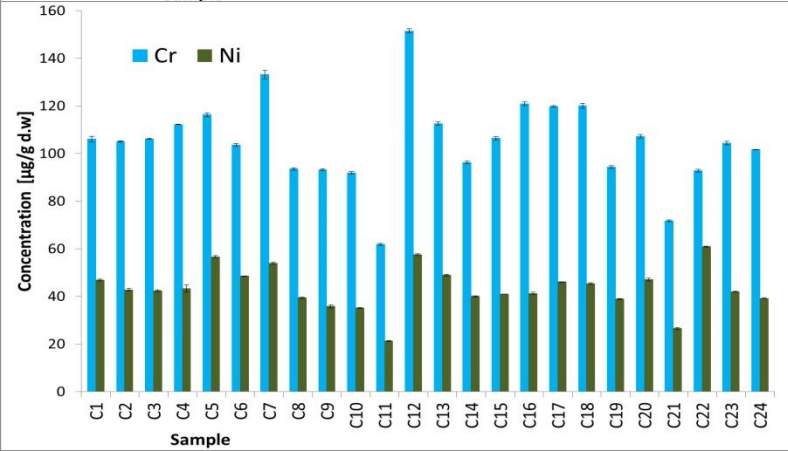
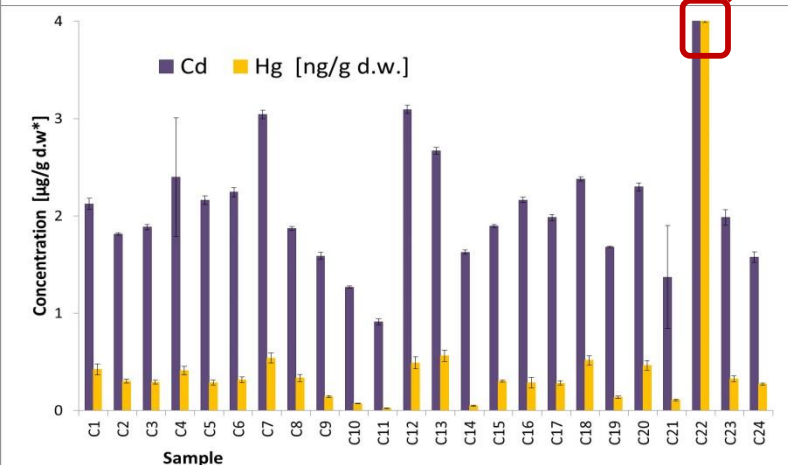
Zn: 1000

Pb: 200

Cd: 7.5

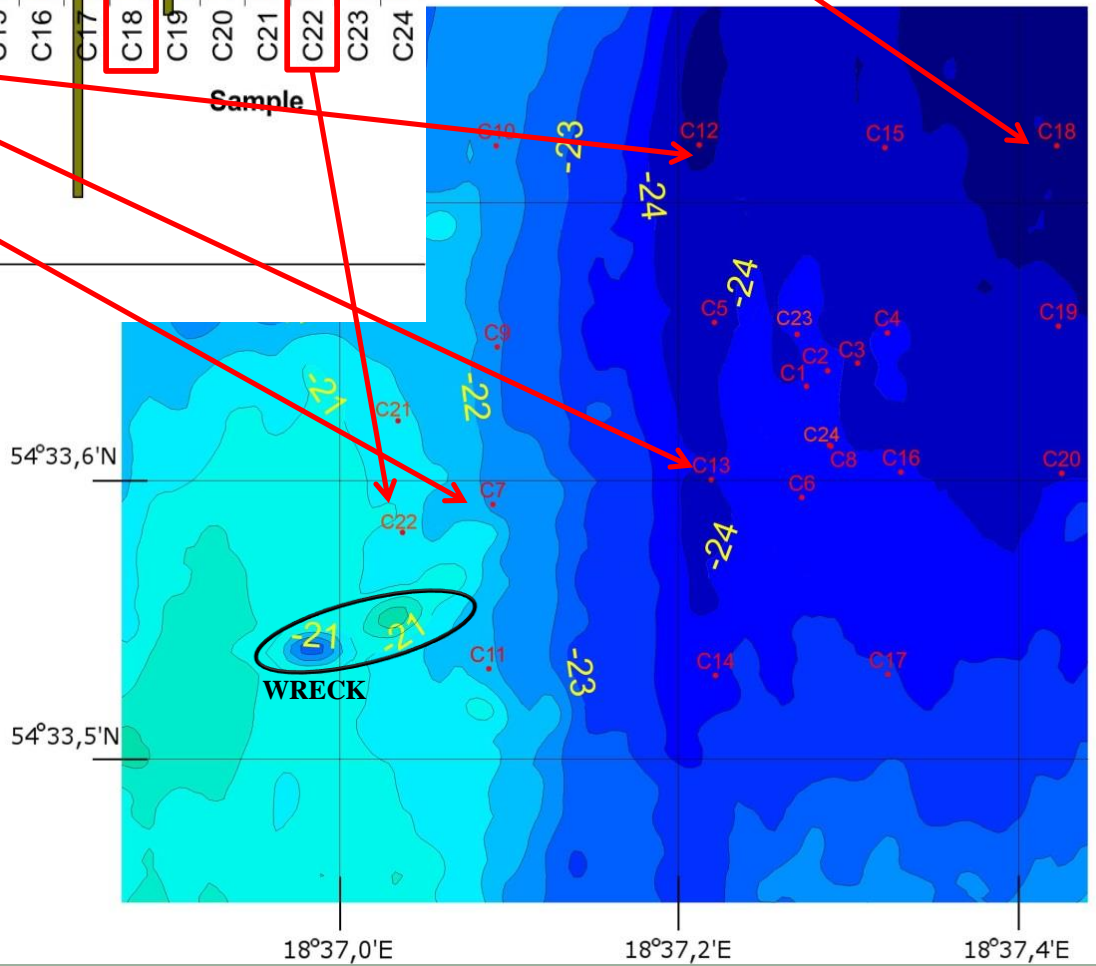
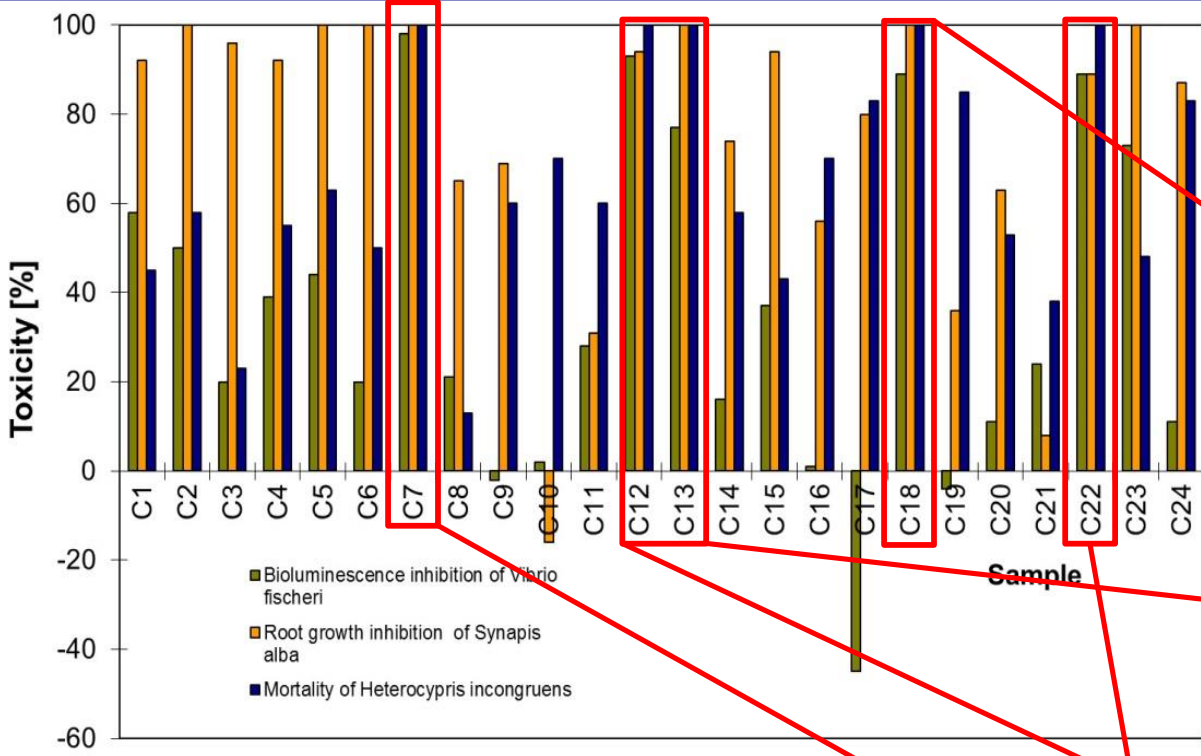
Hg: 1.0

Cu: 150



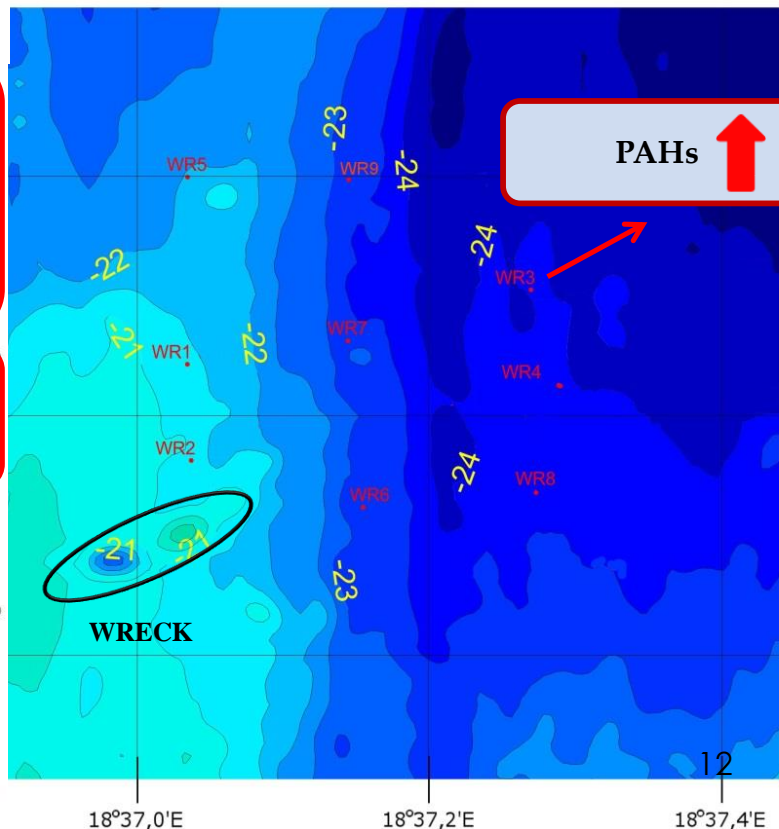
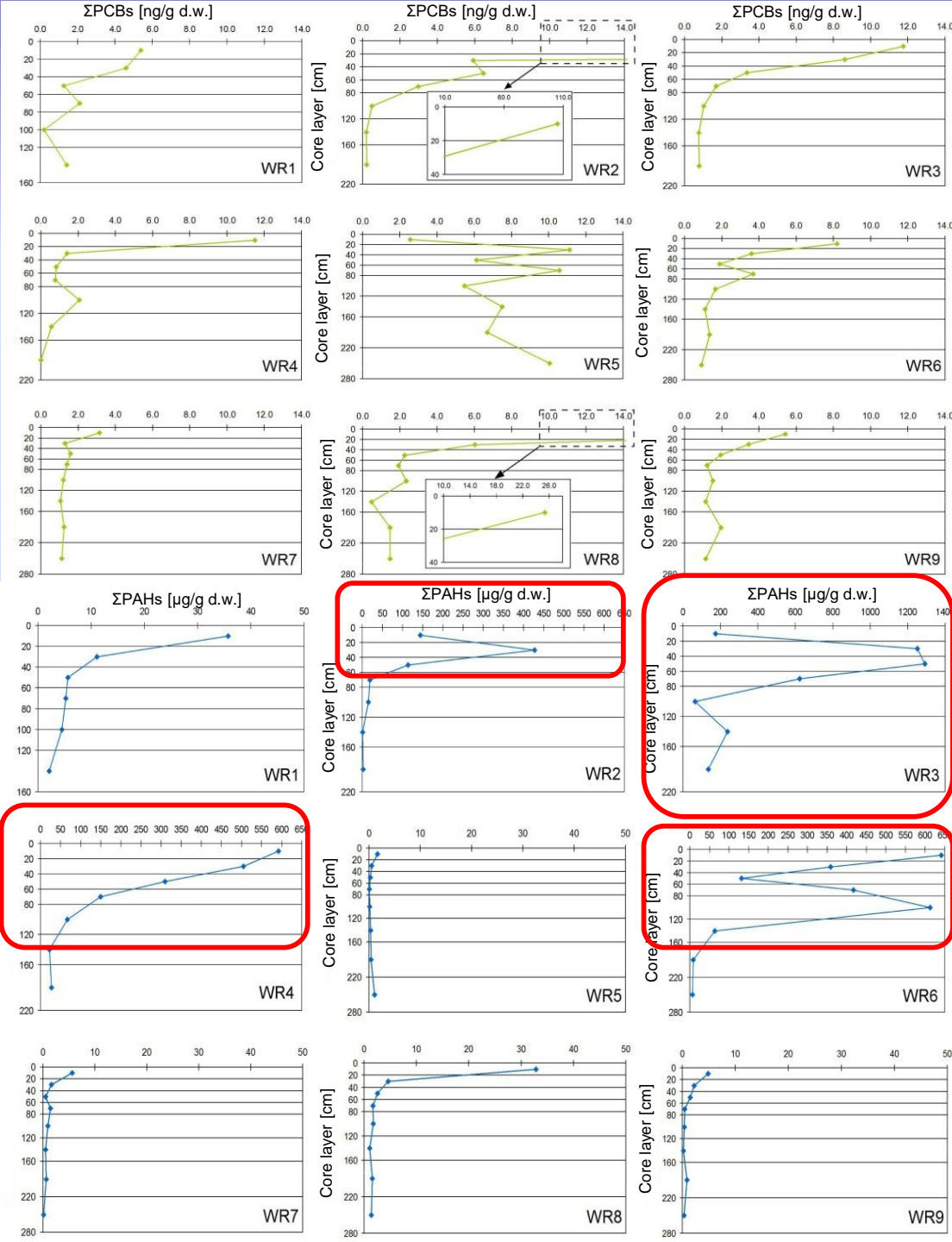
Zn:  $310 \pm 13$

Pb:  $636.1 \pm 1.7$



Surface sediments - toxicity

# Core sediments - PAHs, PCBs





# Core sediments - metals

Layer 0-20 cm

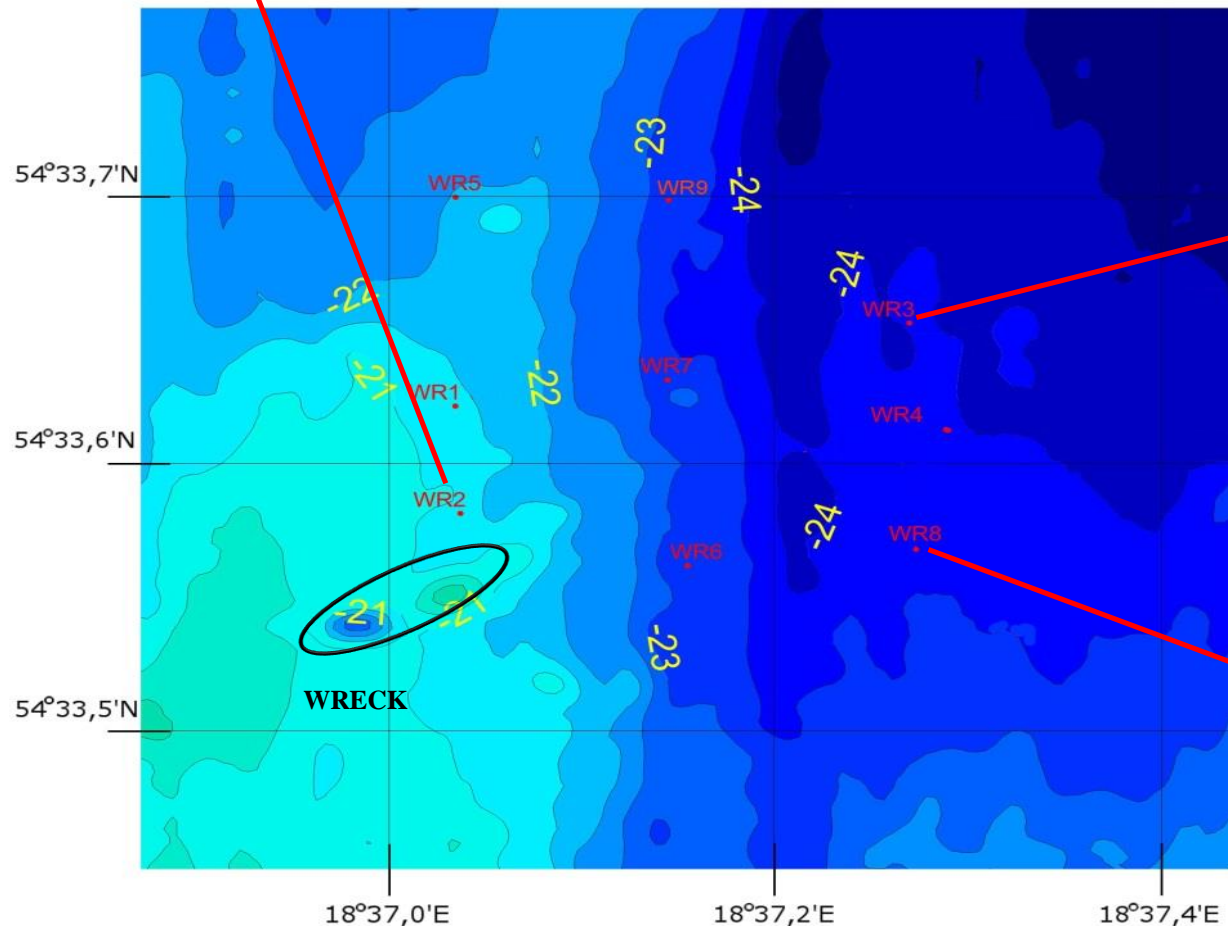
Zn:  $807 \pm 45$

**Pb:  $1812.2 \pm 1.3$**

Cd:  $5.49 \pm 0.79$

Cu:  $134.8 \pm 4.0$

[ $\mu\text{g/g d.w.}$ ]



Layer 0-20 cm

Zn:  $139.4 \pm 6.3$

**Pb:  $115.1 \pm 1.1$**

[ $\mu\text{g/g d.w.}$ ]

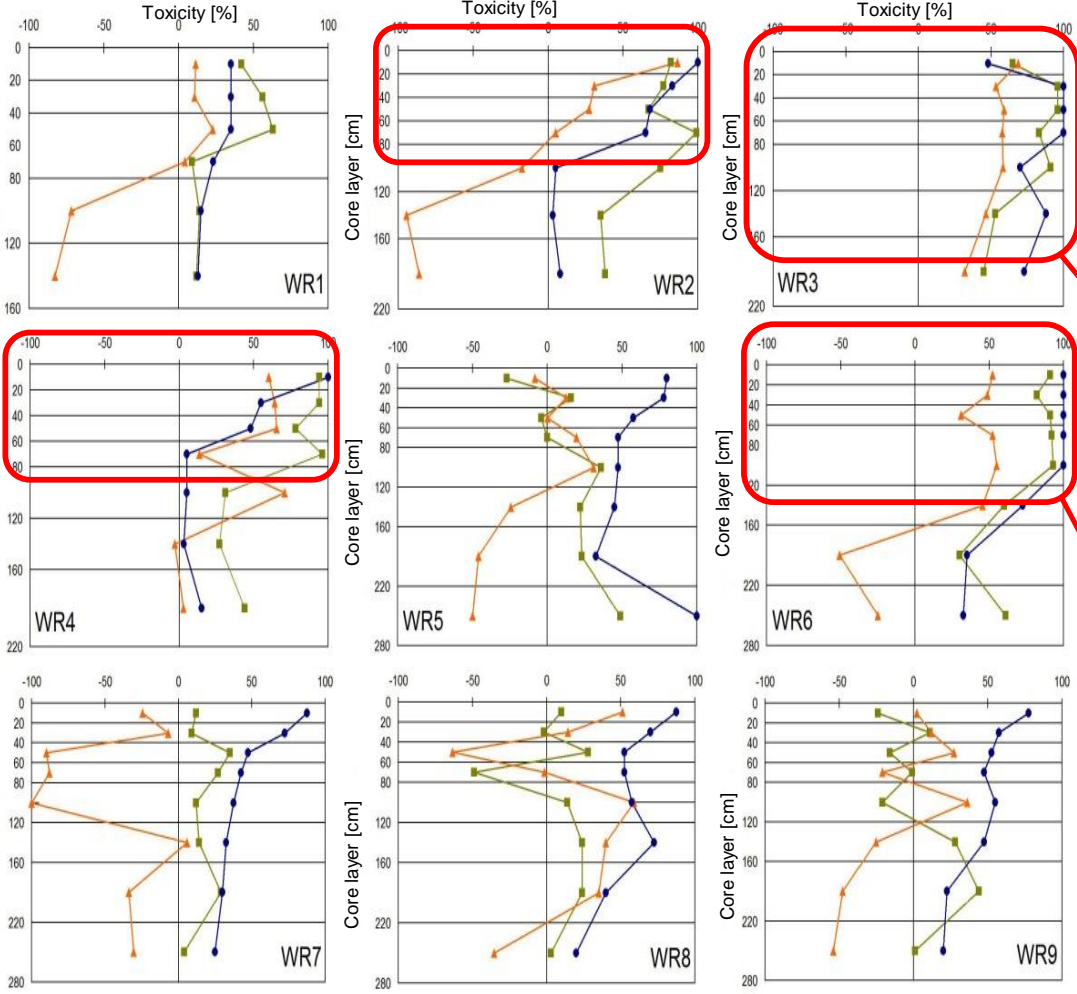
Layer 0-20 cm

**Pb:  $586.0 \pm 4.4$**

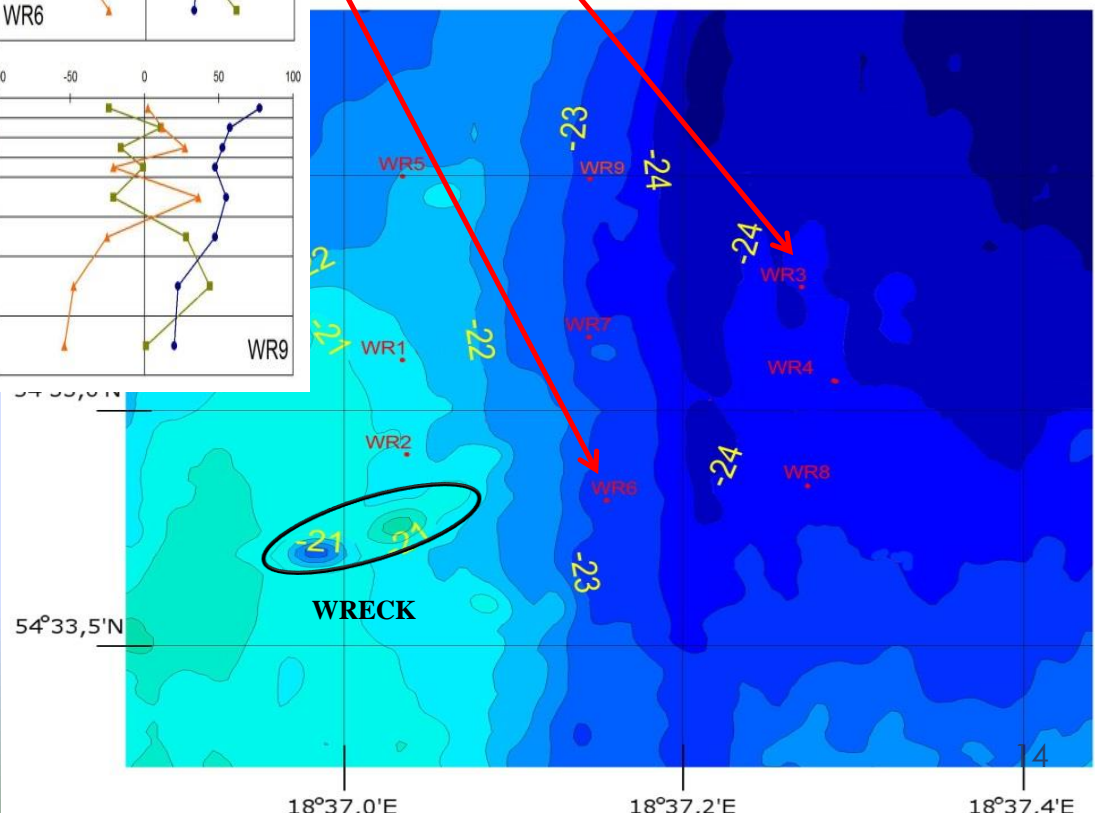
Cd:  $4.77 \pm 0.78$

[ $\mu\text{g/g d.w.}$ ]

# Core sediments - PAHs, PCBs



- Bioluminescence inhibition of *Vibrio fischeri*
- ▲ Root growth inhibition of *Synapis alba*
- Mortality of *Heterocypris inconguens*

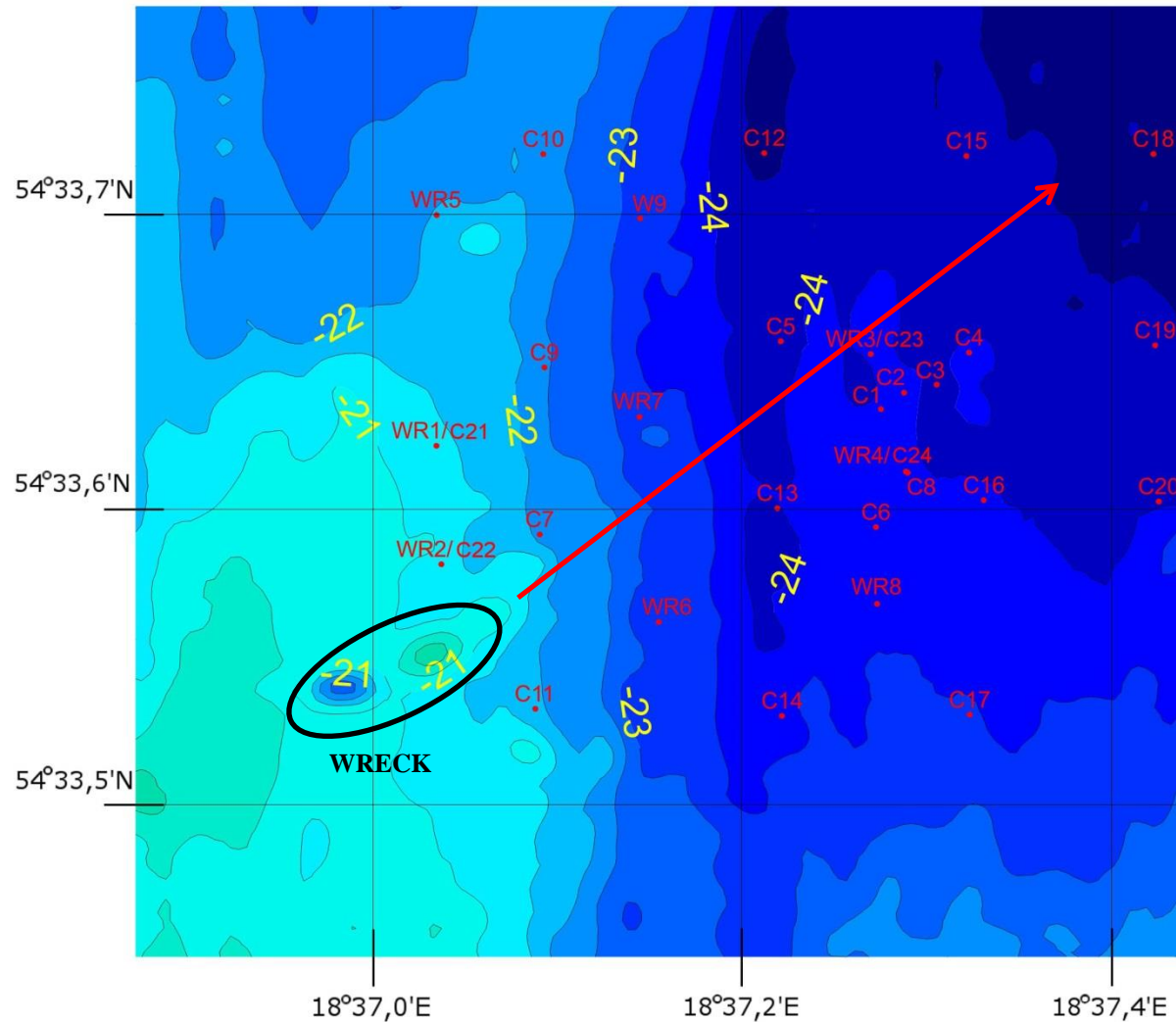




- S/s Stuttgart is a source of contamination, especially PAHs and metals
- The maximum permissible concentrations have been exceeded in some of the samples

## Remarks

- Vertical and horizontal transport of contamination
- Biotests are effective tools for the evaluation of the condition of the environment
- Biotests support assessment of contaminants impact on the living organisms
- They could be successfully used in such studies for the assessment of the dredged materials



**Task:** Assessment of the environmental condition around the shipwreck s/s Stuttgart in the view of ecotoxicological tests

Maritime Institute in Gdańsk, 2016

Head of the task: Prof. Lidia Wolska

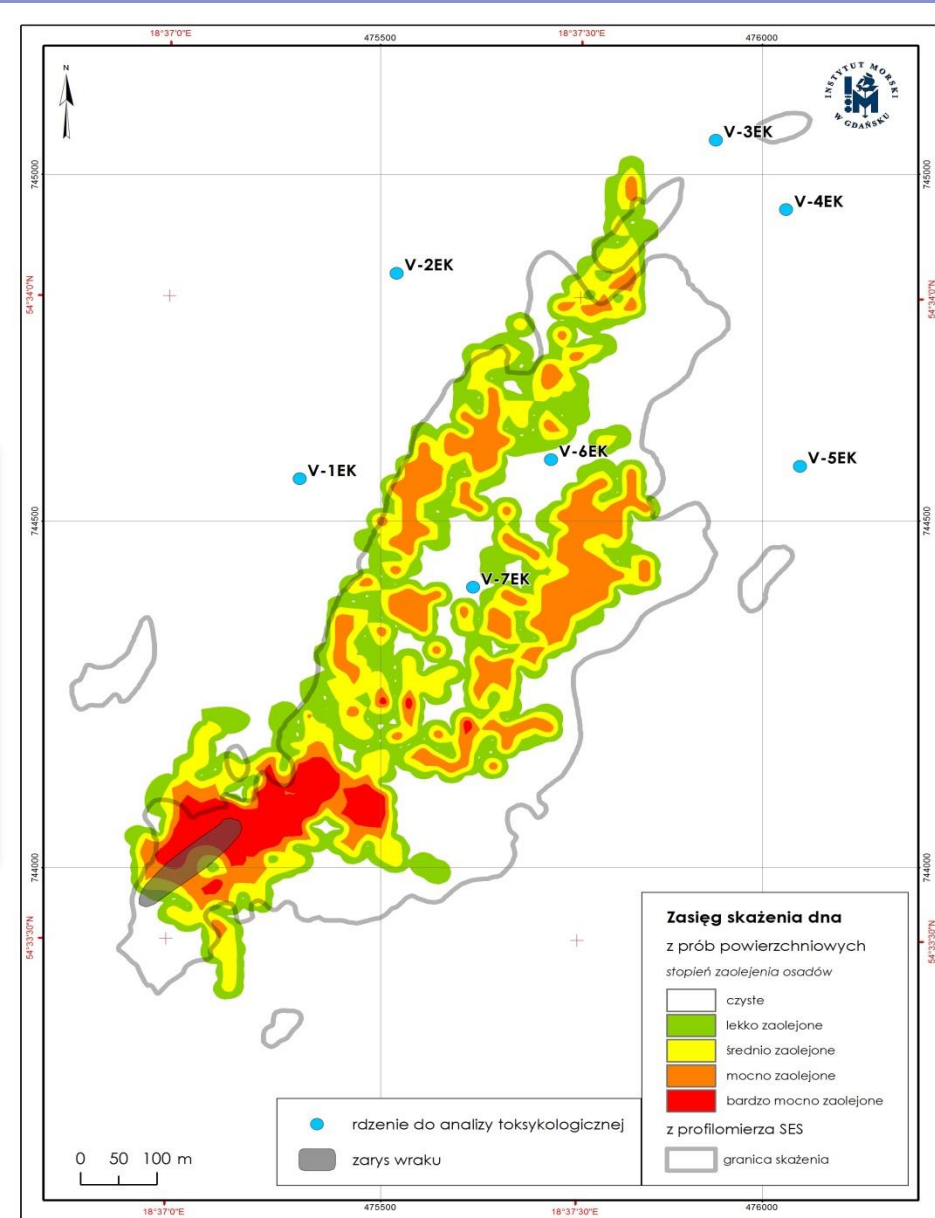
Contractor: **Justyna Rogowska**



The objective of this study was an ecotoxicological assessment of core samples taken in the area of the shipwreck s/s Stuttgart deposition site.



- *Vibrio fischeri* bacteria (test Microtox);
- *Heterocypris incongruens* crustacea (test Ostracodtoxit F<sup>TM</sup>);
- *Sorghum sacharatum* plant (test Phytotoxkit)

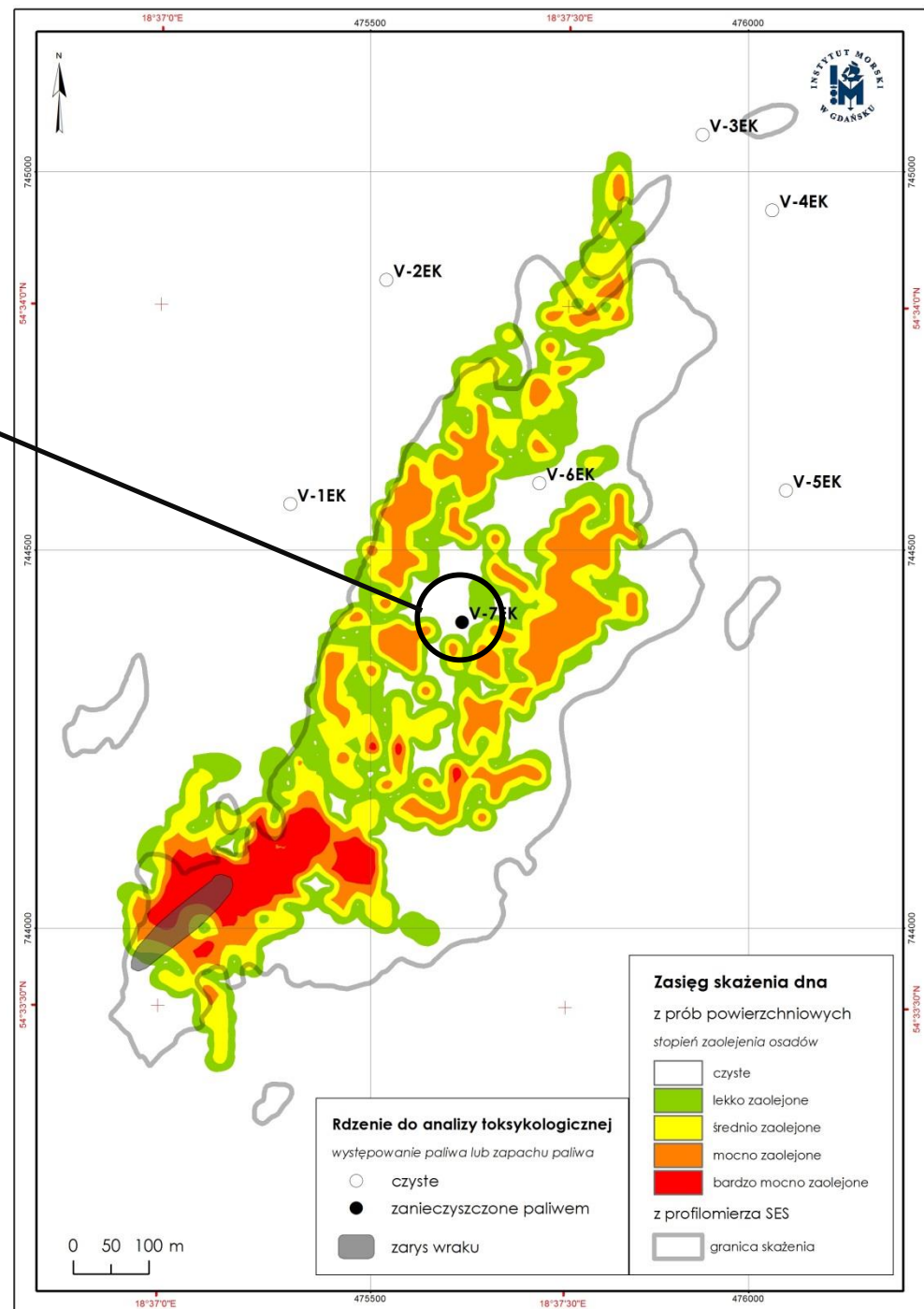


**7 cores – V-1EK – V-7EK**

Leyer 0-20 cm  
Vf – 89%  
HI – 100%



High toxicity





## What is next?

- identification of contaminants in sediments in the area of the s/s Stuttgart wreck deposition site
- incorporation of ecotoxicological studies to assess the quality of sediments around wrecks



What to do with the remains of the wreck and pollution?

# Literature

1. Rogowska J., Wolska L., Namieśnik J., Impacts of pollution derived from ship wrecks on the marine environment on the basis of s/s "Stuttgart" (Polish coast, Europe), *Science of the Total Environment* 408, 5775–5783, 2010.
2. [www.wlb-stuttgart.de/seekrieg/4310-bilder/stuttgart.jpg](http://www.wlb-stuttgart.de/seekrieg/4310-bilder/stuttgart.jpg).
3. [www.simplonpc.co.uk/NDL3.html#anchor228081](http://www.simplonpc.co.uk/NDL3.html#anchor228081).

## Acknowledgements

1. Project: Elaborating methodology aimed at determination of shipwrecks influence on the environment on the basis of s/s „Stuttgart”, Ministry of Science and Higher Education, 30.09.2009 - 29.09.2012, No. NN523422137, Principal Investigator: Prof. Jacek Namieśnik (Gdańsk University of Technology).
2. Project: Research and analysis of threats to the marine environment, which is the wreck of the Stuttgart ship together with the analysis of existing threat utilization technologies and the possibility of their use, Ministry of Environment, 2016, Executing Institution: Maritime Institute in Gdańsk.
3. Błażej Kudłak Ph.D., D.Sc., Eng.; Agnieszka Sagajdakow Ph.D., Eng.; Wojciech Ratajczyk Ph.D., for technical support in toxicity studies.
4. Dr Eng. Benedykt Hac (Maitime Institute in Gdańsk) for sharing the image from page 3.
5. Photos on pages 5, 18, 19: Prof. Leszek Łęczyński.

## More information about s/s Stuttgart

1. Rogowska J., Kudłak B., Tsakovski S., Gałuszka A., Nowak - Bajger G., Simeonov V., Konieczka P., Wolska L., Namieśnik J., Surface sediments pollution due to shipwreck s/s "Stuttgart" - a multidisciplinary approach, *Stochastic Environmental Research and Risk Assessment* 29, 1797-1807, 2015
2. Rogowska J., Kudłak B., Tsakovski S., Wolska L., Simeonov V., Namiesnik J., Novel approach to ecotoxicological risk assessment to sediments cores around the ship wreck by the use of selforganizing maps, *Ecotoxicology and Environmental Safety* 104, 239–246, 2014
3. Kudłak B., Rogowska J., Wolska L., Namieśnik J., Kałas M., Łęczyński L., Toxicity assessment of sediments associated with the wreck of s/s *Stuttgart* in the Gulf of Gdańsk (Poland), *Journal of Environmental Monitoring* 14, 1231-1236, 2012.
4. Rogowska J., Wolska L., Namieśnik J., Impacts of pollution derived from ship wrecks on the marine environment on the basis of s/s "Stuttgart" (Polish coast, Europe), *Science of the Total Environment* 408, 5775–5783, 2010.
5. Rogowska J., Namieśnik J., Wraki jako źródło zanieczyszczenia środowiska morskiego, *Inżynieria Morska i Geotechnika*, 1, 3-7, 2009.





Fot. Gdańska Organizacja Turystyczna <https://visitgdansk.com/>

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