水星

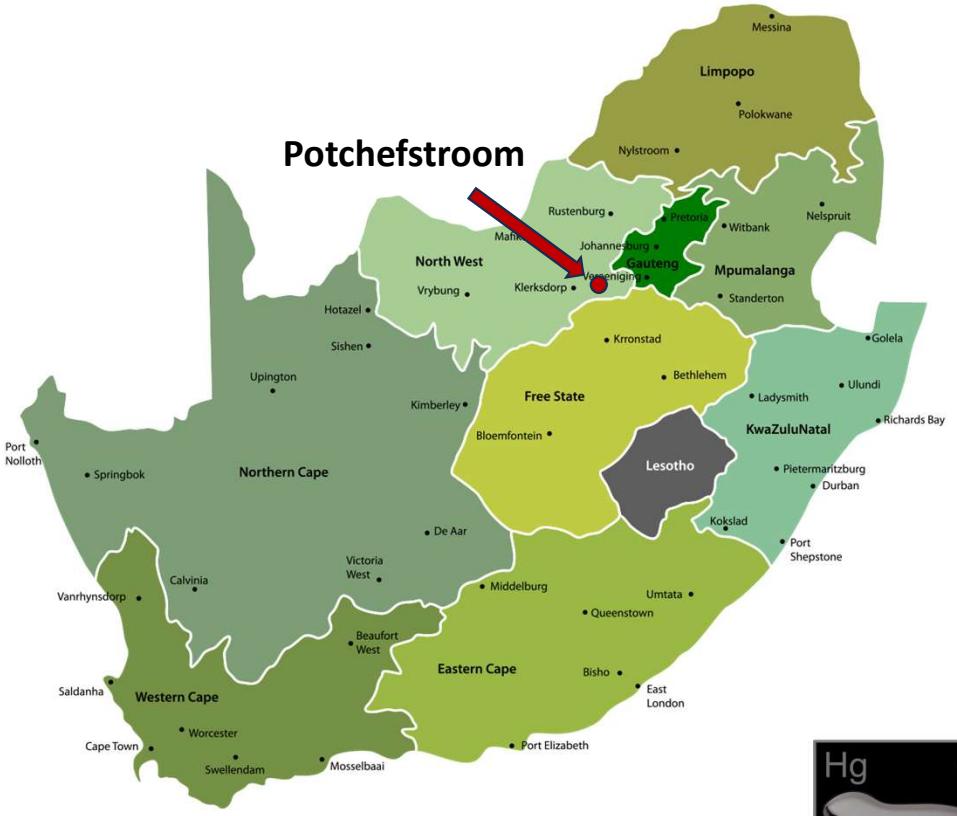
汞

# Mercury


ปรอท

kwik

# Background Information


# Background Information

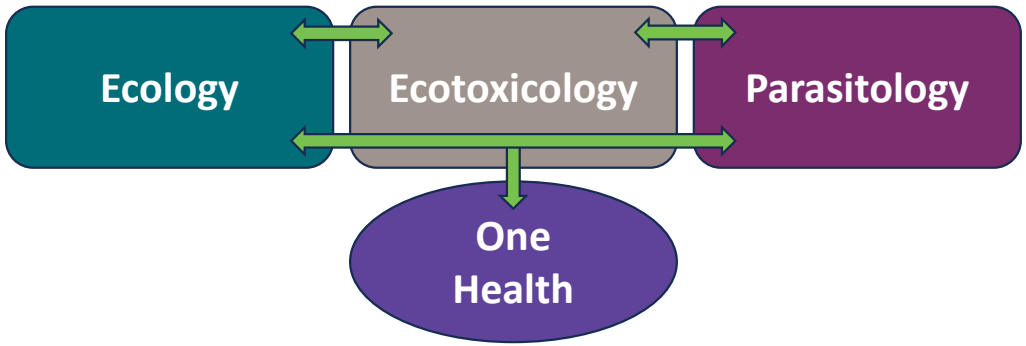
## North-West University (NWU):

- Undergrad Zoology and Microbiology (2011-13)
- Masters in Environmental Science (2015-16)
- PhD in Environmental Science (2017-20)
- Postdoc focusing on mercury (2020-present)

- Lecturer at Hokkaido University (2024-present)

## Water Research Group (WRG):

- Trained Ecotoxicologist
- Aquatic Scientist




SCAN ME

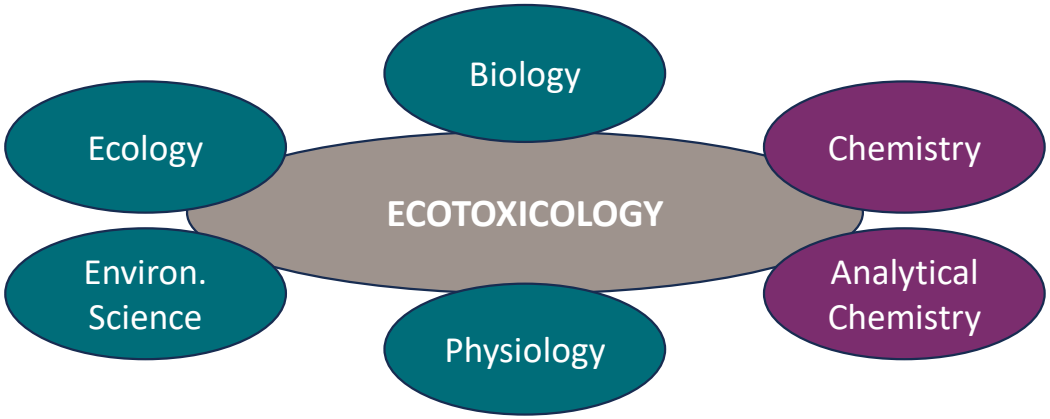
SCAN ME

# Did you know?

- Mercury is a very rare element in the Earth's crust?
- It is the only metal that is liquid at room temperature?
- It is really heavy and dense?
- It is highly toxic even in low concentrations?
- Mercury is used in fluorescent lamps?
- It is highly volatile and produce vapor?
- It does not react with most acids?
- It forms amalgams with all other metals, except iron
- It is a global and persistent pollutant

# Ecotoxicology

- **Ecotoxicology is the study of harmful effects of toxic pollutants in ecosystems**
- **It started in 1969 by René Truhaut**
- **A multidisciplinary approach**




# Mercury contamination in South Africa's aquatic ecosystems: Any cause for concern?


**J.H. Erasmus**

W. Malherbe, N.J. Smit, V. Wepener

Water Research Group,
Unit for Environmental Sciences and Management, North-West University, Potchefstroom 2520,
South Africa



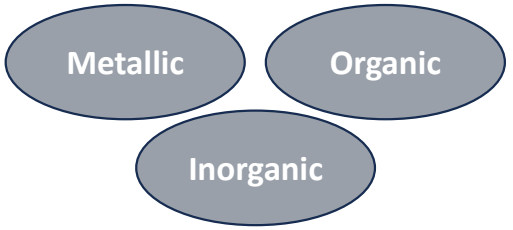
**Introduction to Ecotoxicology and One Health, Joint Summer Camp**
**31 July 2024 | Hokkaido University**

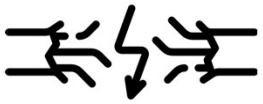
# Introduction - Mercury

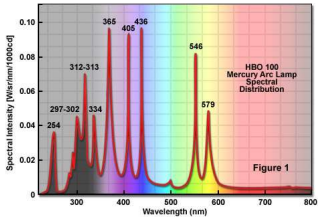
Water Research Group

## Characteristics of mercury:

- Liquid at room temperature
- Different forms in environment
- Good electrical and thermal conductor
- Ability to dissolve gold and silver
- Enters humans and biota
- Have detrimental effects







# Introduction - Uses

Water Research Group

## Miracle to worst nightmare

- Ancient Egyptians (2500 BC)
- Barometer (1643), thermometer (1720)
- Industrial revolution (1850s)




Electrical and electronics


Extraction of metals


Chlor-alkali process

Medical and dental


# Introduction - Uses

Water Research Group

## Miracle to worst nigh

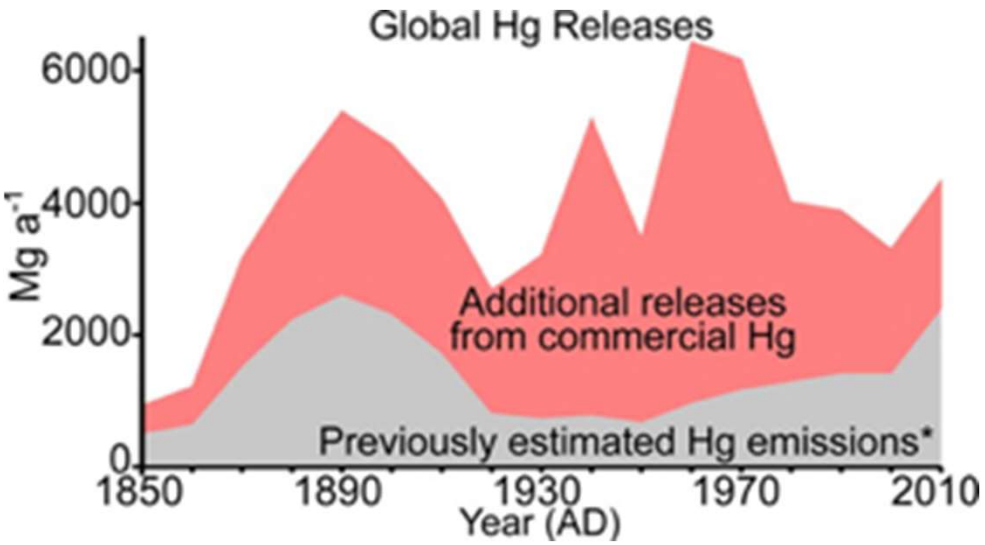
- Ancient Egyptians (25
- Barometer (1643), the
- Industrial revolution (

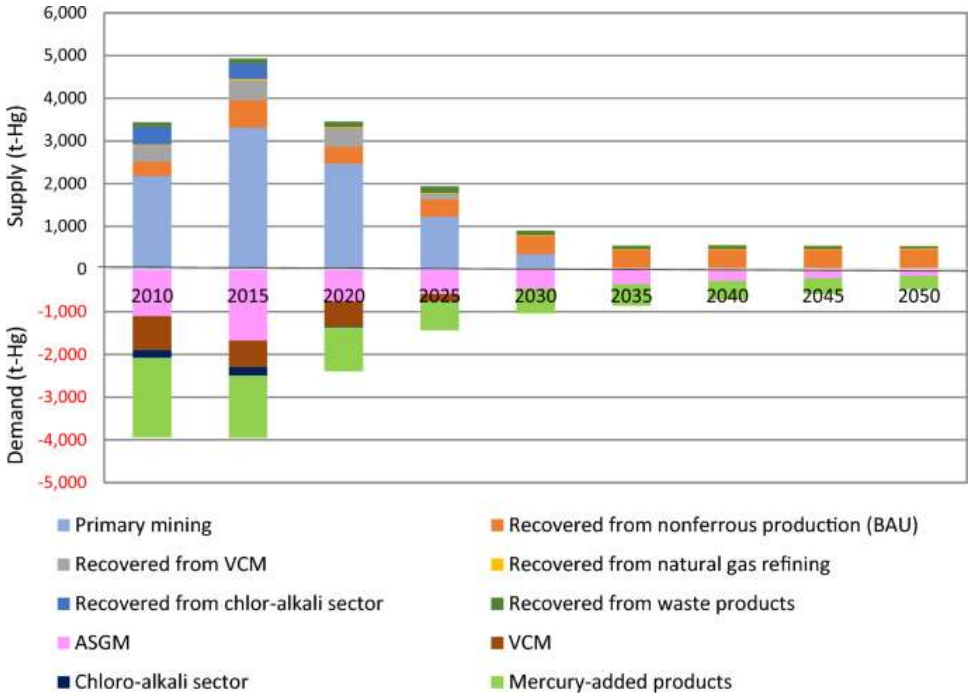
Electrical and electron



Medical and dental


# Introduction - Demand and Supply



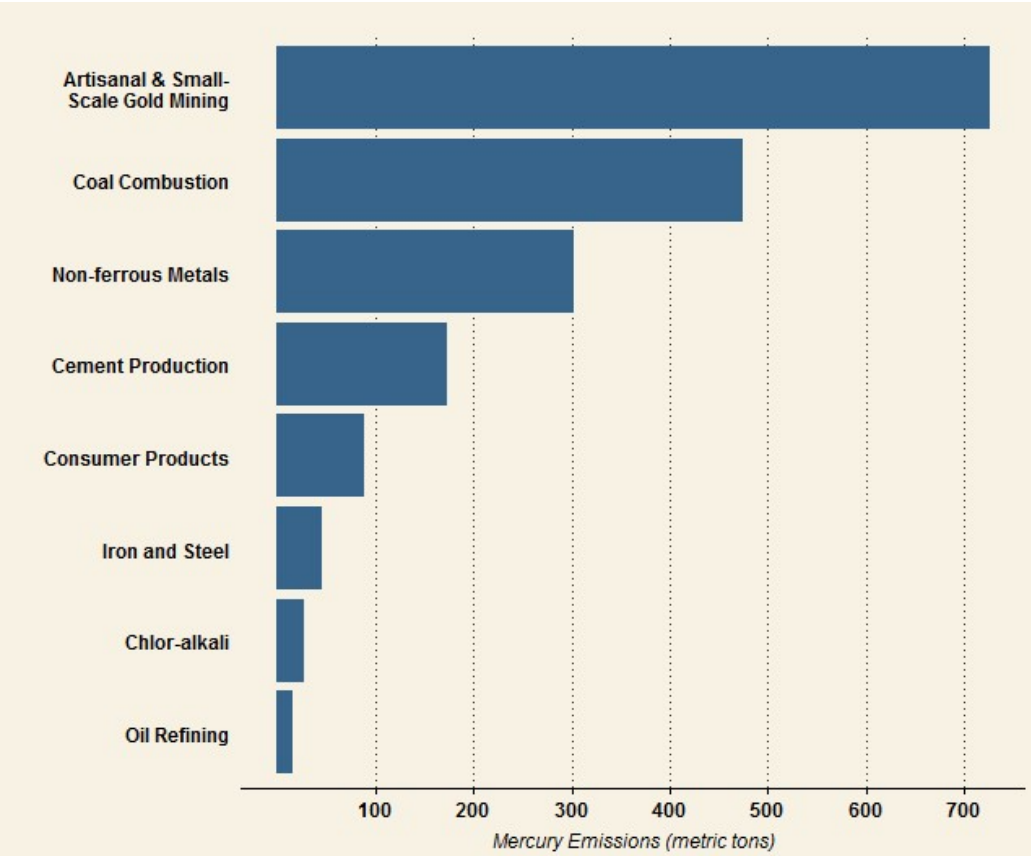



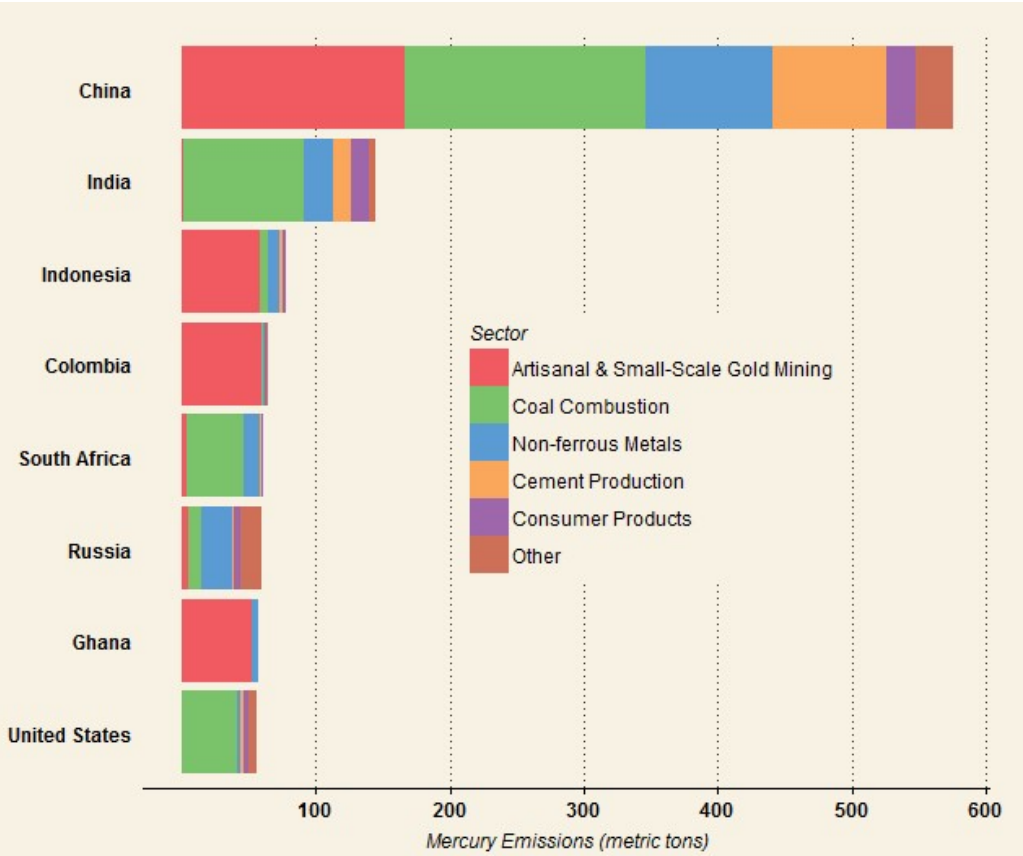

Horowitz *et al*. 2014. Historical mercury releases from commercial products: global environmental implications. *Environ. Sci. Technol.*, 48:10242-10250

Sodeno 2023. Projected global mercury supply, demand, and excess to 2050 based on impacts of the Minamata Convention. *J. Mater. Cycles Waste Manag.*, 25:3608-3624

# Introduction - Emissions to Environment

Water Research Group



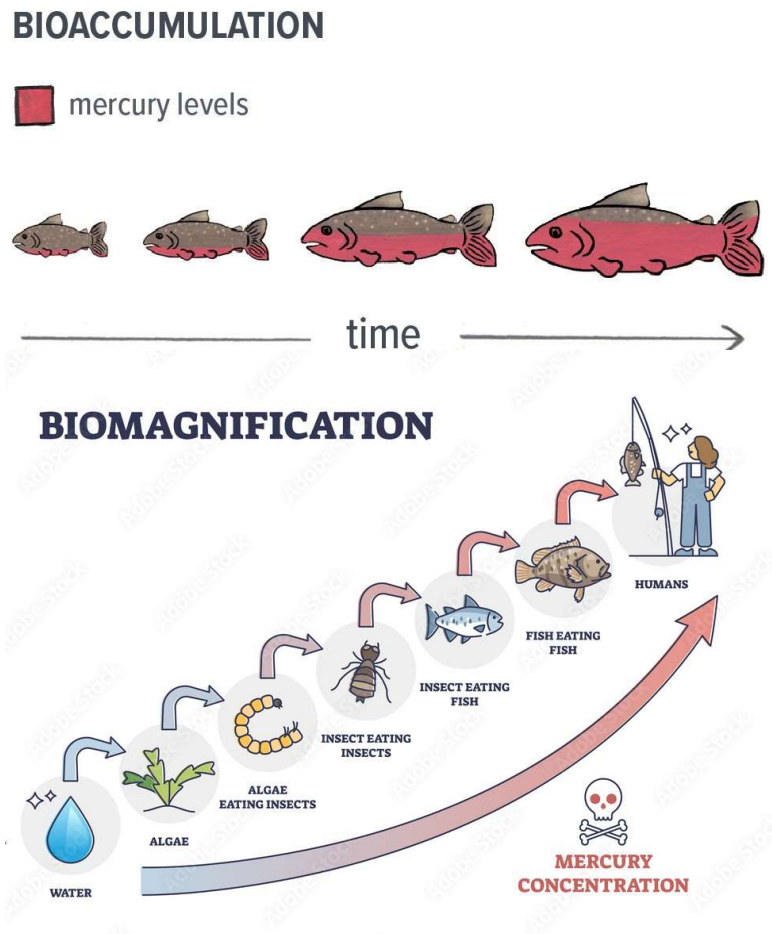

Zhang *et al*. 2021. Global health effects of future atmospheric mercury emissions. *Nature communications*, 12:3035

# Introduction - What we know

Water Research Group

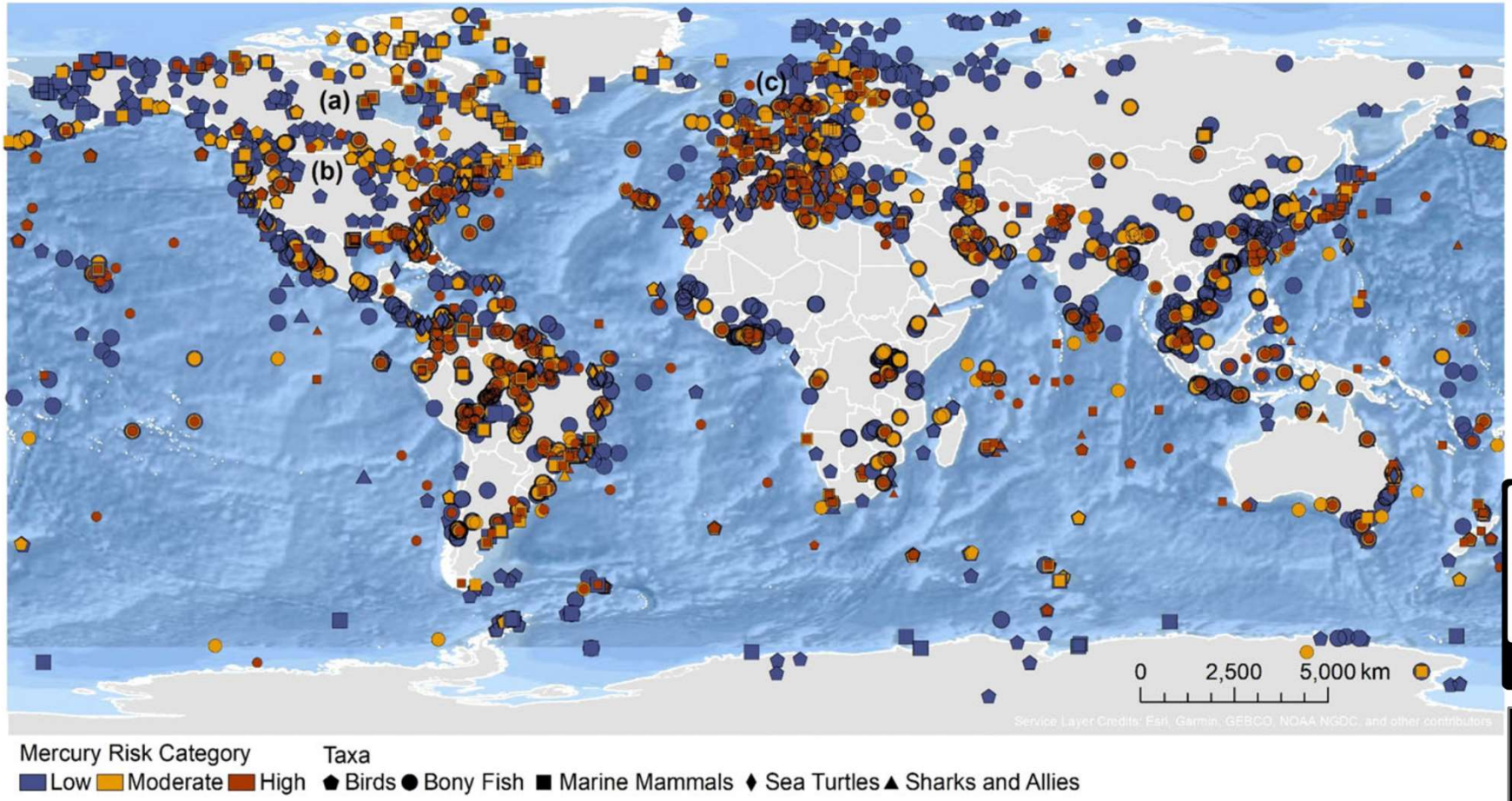
**Mercury in ecosystems:**

- **Legacy pollutant**
- **Bioaccumulate**
- **Biomagnify**




# Introduction - International monitoring

Water Research Group

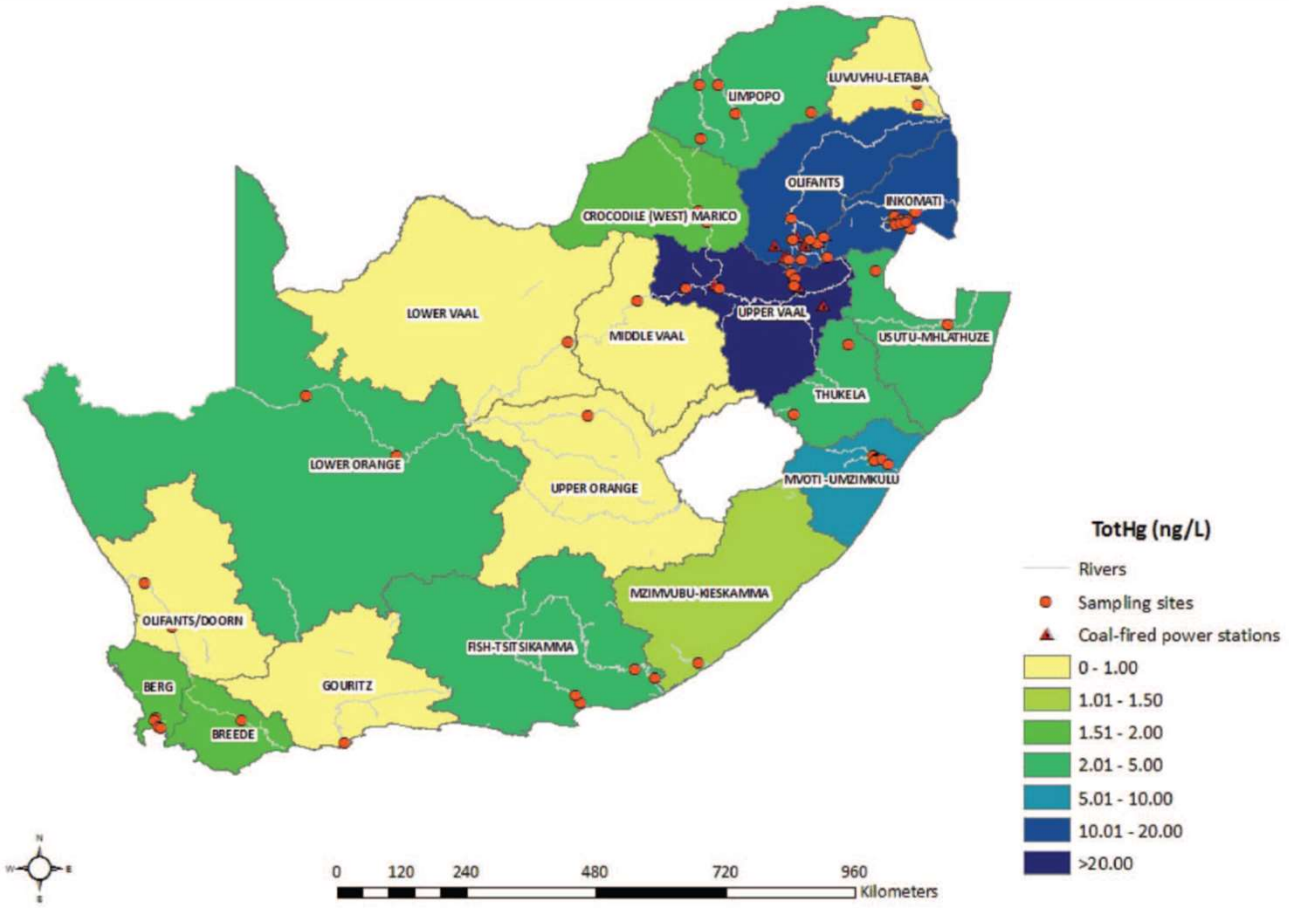



SCAN ME


Evers *et al*. 2024. Global mercury concentrations in biota: their use as a basis for global biomonitoring framework. *Ecotoxicology*.

# Introduction - SA perspective

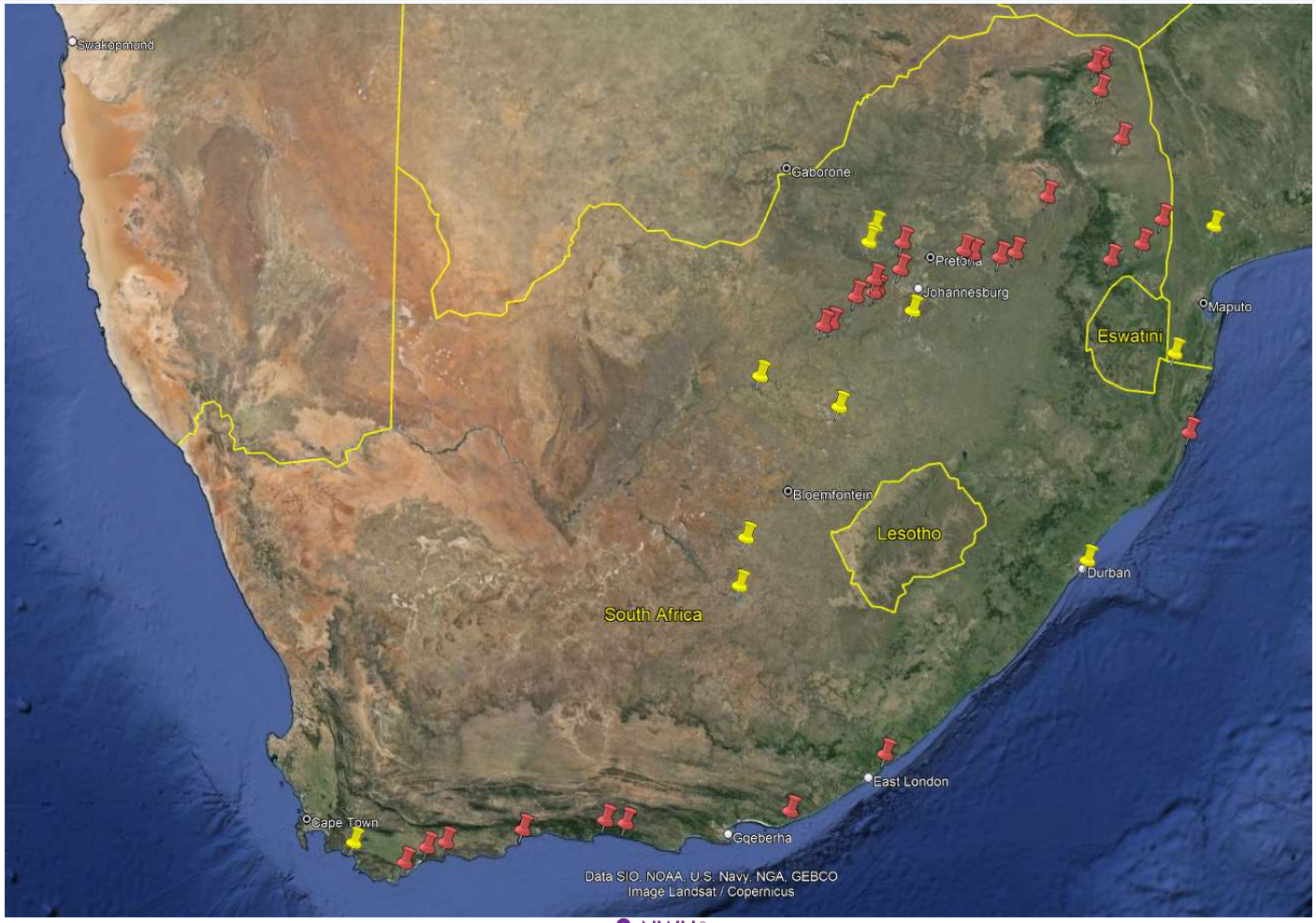
Water Research Group




Walters *et al*. 2011. A review of mercury pollution in South Africa: Current status. *J. Environ. Sci. Health*, 46:1129-1137

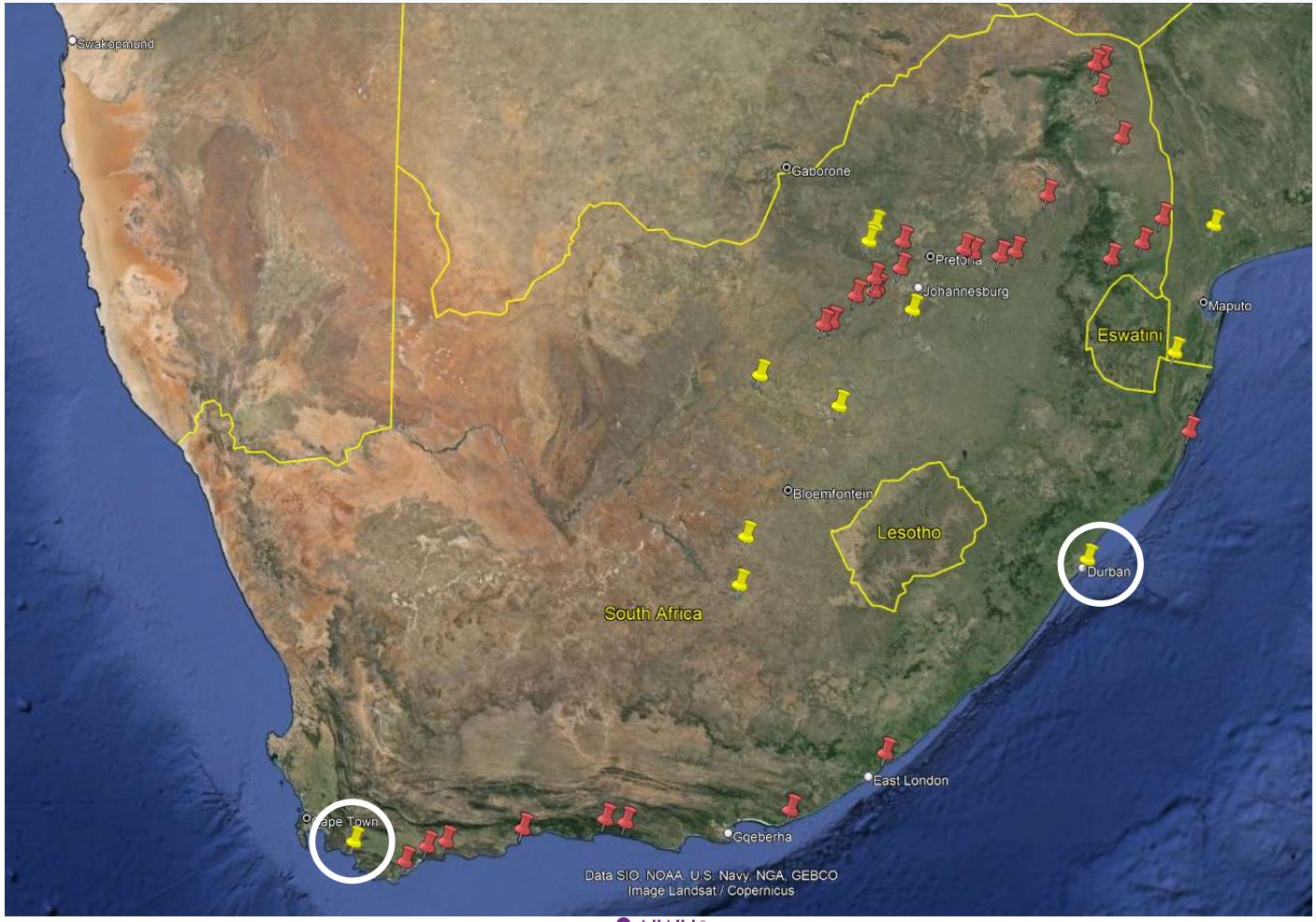
# Mercury Project - 2022–present

Water Research Group




# Case Study 1 - Elasmobranchs

Water Research Group



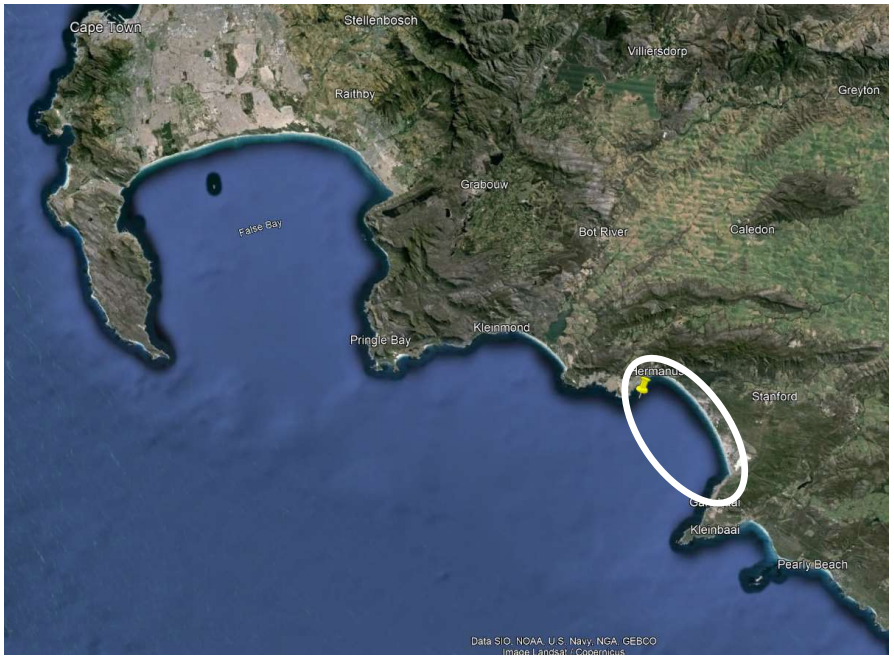

# Case Study 1 - Elasmobranchs

Water Research Group

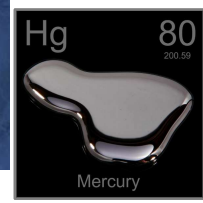
- **Total of 22 elasmobranch species (n = 86)**
  - South coast: 6  2 
  - East coast: 10  4 

KWAZULU-NATAL SHARKS BOARD Maritime Centre of Excellence

SOUTH AFRICAN SHARK CONSERVANCY SASC



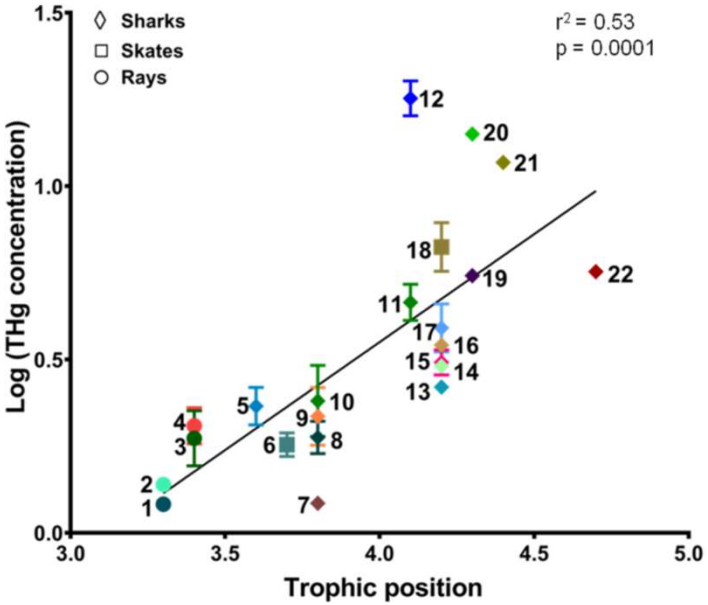




# Case Study 1 - Elasmobranchs

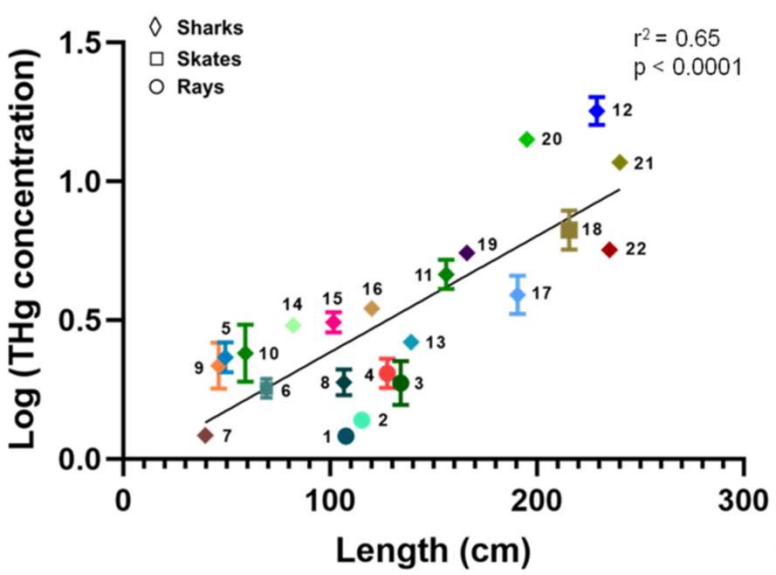
Water Research Group

a)




| Code | Common name |
|---|---|
| 1 | Shortfin devil ray |
| 2 | Longhorned mobula |
| 3 | Oman cownose ray |
| 4 | Bull ray |
| 5 | Leopard catshark |
| 6 | Spotted skate |
| 7 | Dark shyshark |
| 8 | Smooth-hound shark |
| 9 | Puffadder shyshark |
| 10 | Brown shyshark |
| 11 | Tiger shark |
| 12 | Scalloped hammerhead |
| 13 | Blacktip shark |
| 14 | African angelshark |
| 15 | Dusky shark |
| 16 | Smooth hammerhead |
| 17 | Spinner shark |
| 18 | White skate |
| 19 | Pigeye shark |
| 20 | Bull shark |
| 21 | Sand tiger shark |
| 22 | Broadnose sevengill shark |

b)

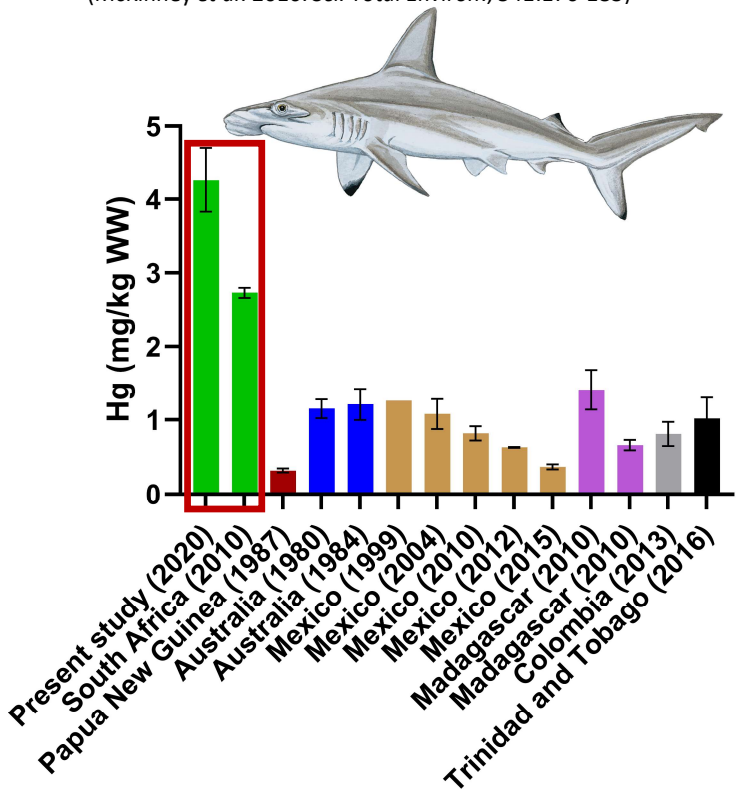


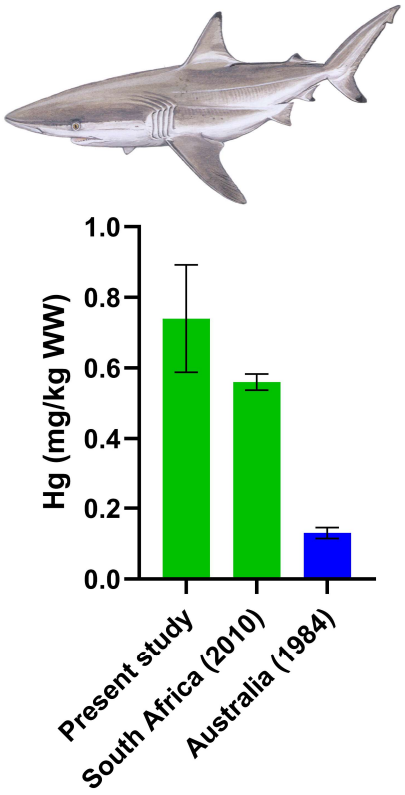

| Code | Common name |
|---|---|
| 1 | Shortfin devil ray |
| 2 | Longhorned mobula |
| 3 | Oman cownose ray |
| 4 | Bull ray |
| 5 | Leopard catshark |
| 6 | Spotted skate |
| 7 | Dark shyshark |
| 8 | Smooth-hound shark |
| 9 | Puffadder shyshark |
| 10 | Brown shyshark |
| 11 | Tiger shark |
| 12 | Scalloped hammerhead |
| 13 | Blacktip shark |
| 14 | African angelshark |
| 15 | Dusky shark |
| 16 | Smooth hammerhead |
| 17 | Spinner shark |
| 18 | White skate |
| 19 | Pigeye shark |
| 20 | Bull shark |
| 21 | Sand tiger shark |
| 22 | Broadnose sevengill shark |

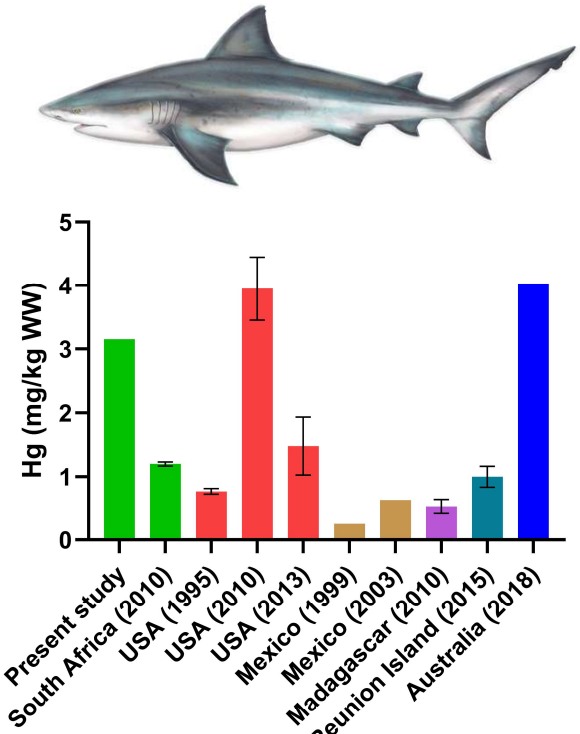
# Case Study 1 - Elasmobranchs

- **Most species have increased [Hg] compared to 2005-2010 study**

(McKinney *et al*. 2016. *Sci. Total Environ*., 541:176-183)



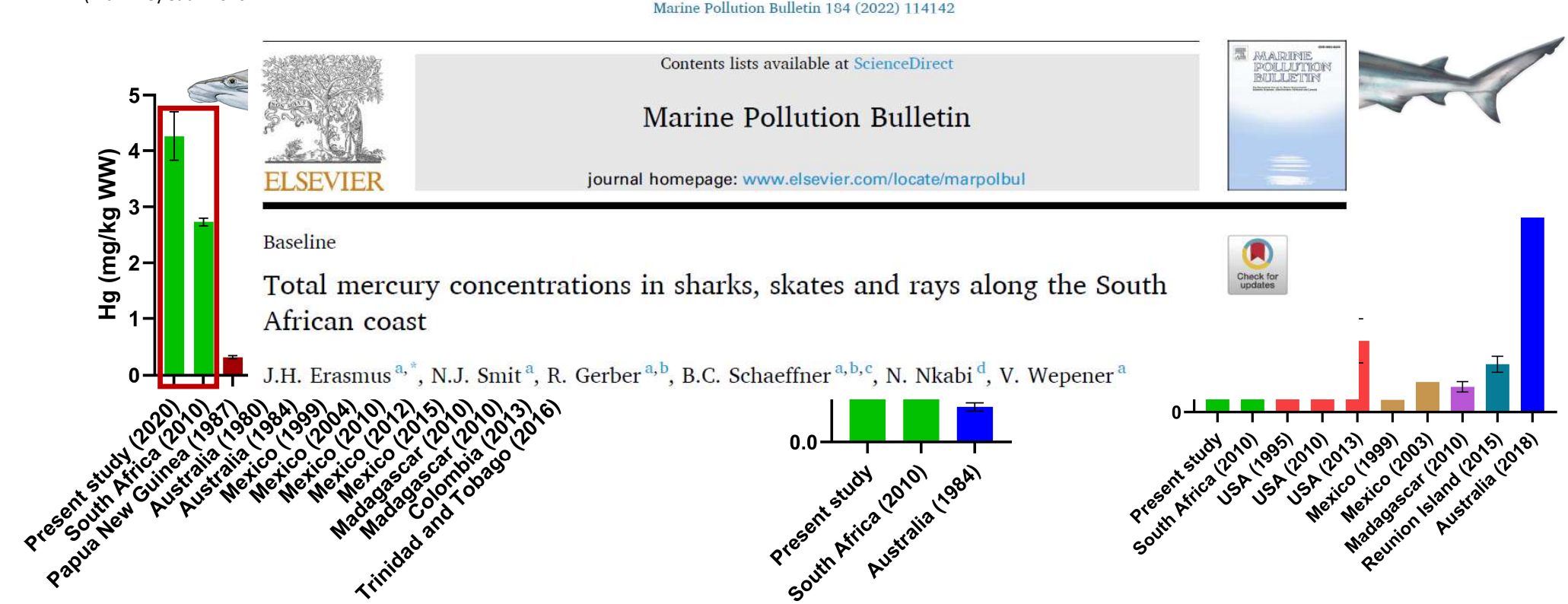



# Case Study 1 - Elasmobranchs

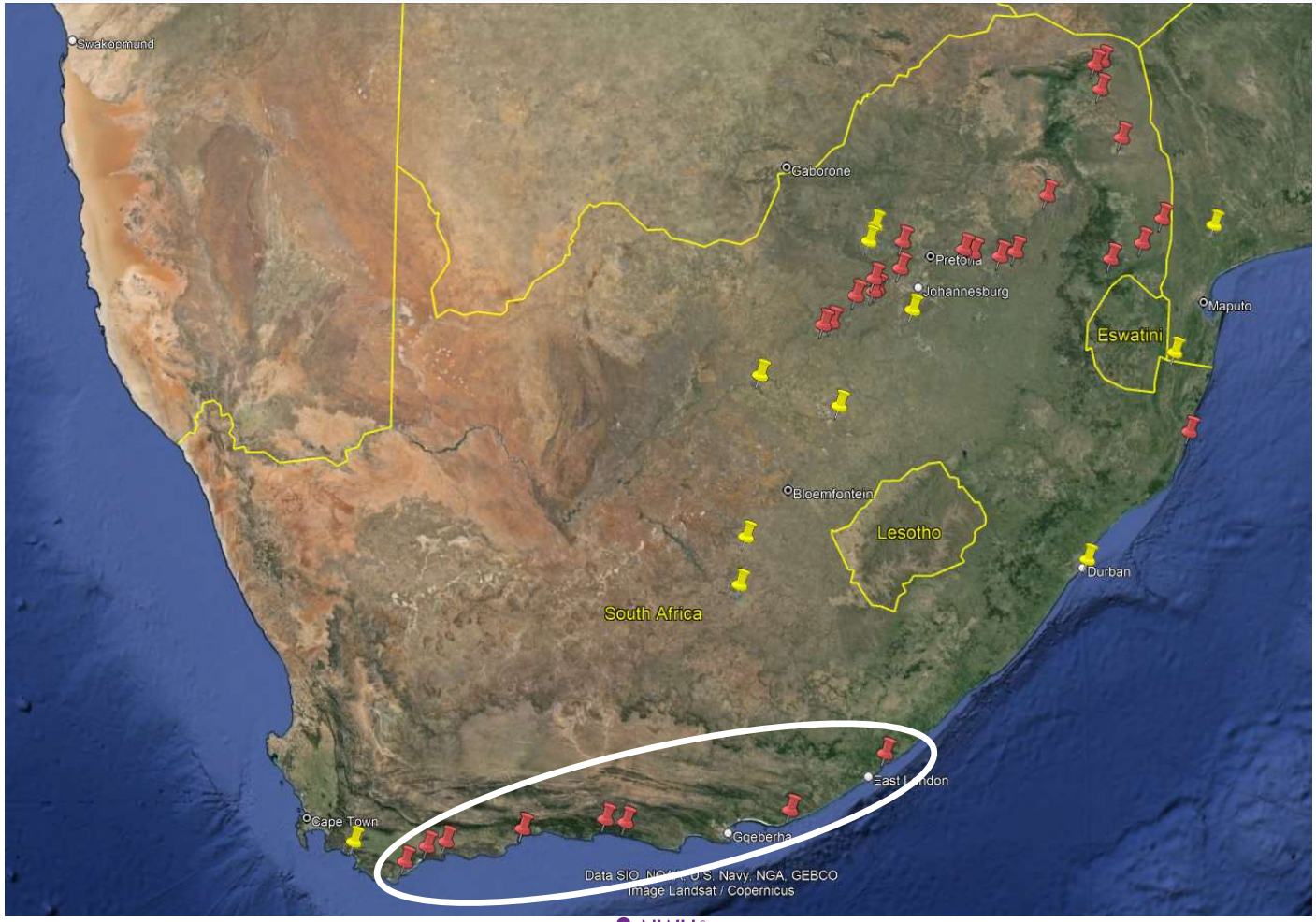
- **Most species have increased [Hg] compared to 2005-2010 study**

(McKinney *et al*. 2016 Sci. Total Environ. 541:176-183)



# Case Study 2 - Cape white seabream

Water Research Group

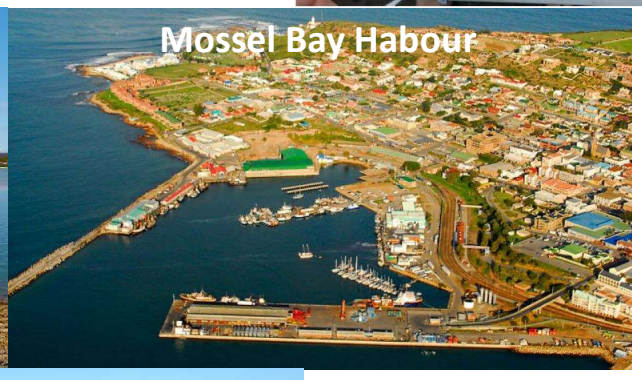



# Case Study 2 - Cape white seabream

Water Research Group

- Cape white seabream (*Diplodus capensis*)
- n = 40 from impacted and non-impacted sites







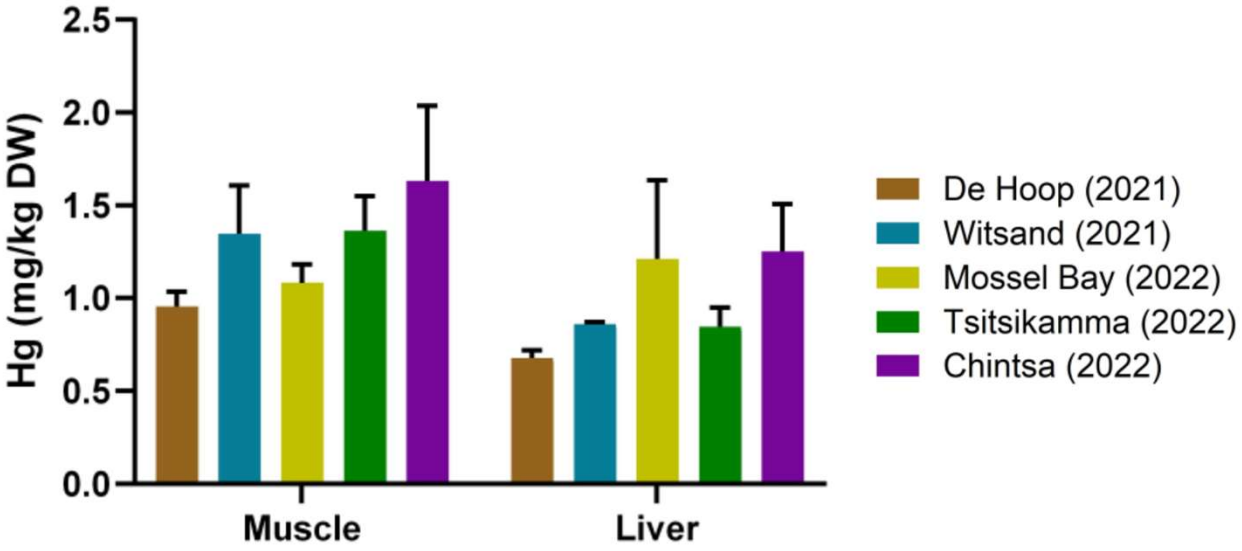

# Case Study 2 - Cape white seabream

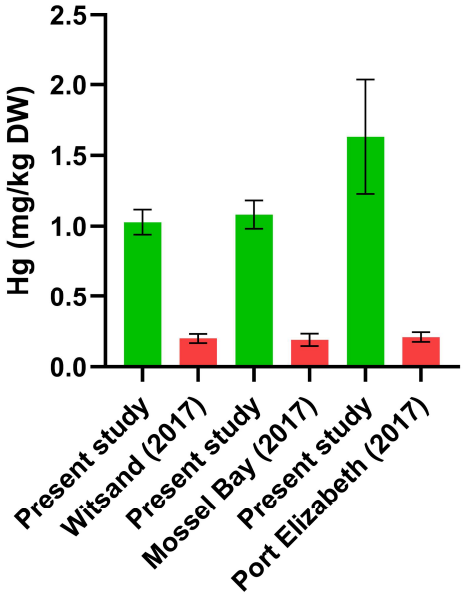
Water Research Group

- **Higher [Hg] compared to previous study in 2014**

(Bosch *et al*. 2016. *J. Sci. Food Agric*., 96:32-48)

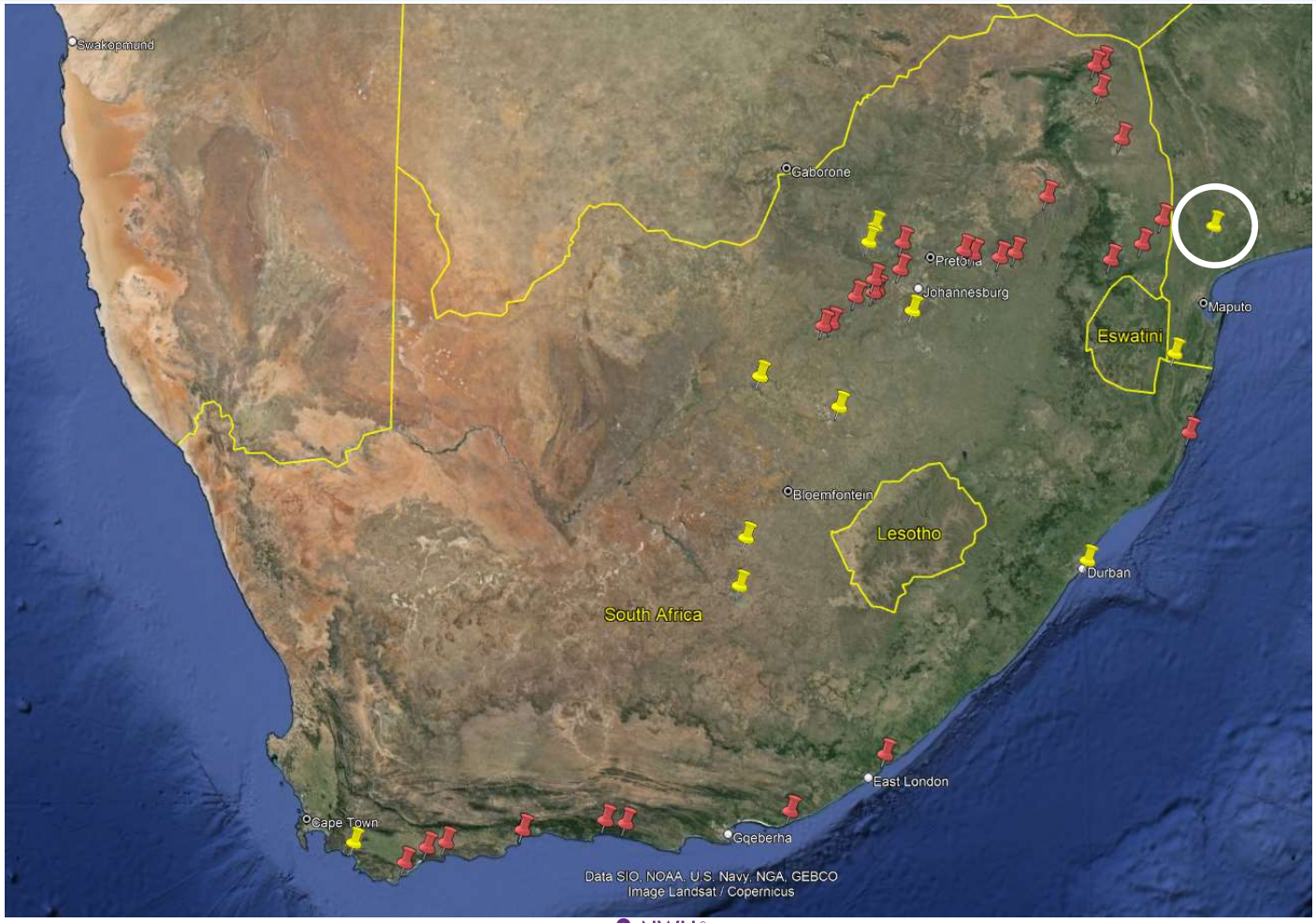
- **Human health risks associated with consumption**




# Case Study 3 - Freshwater eels

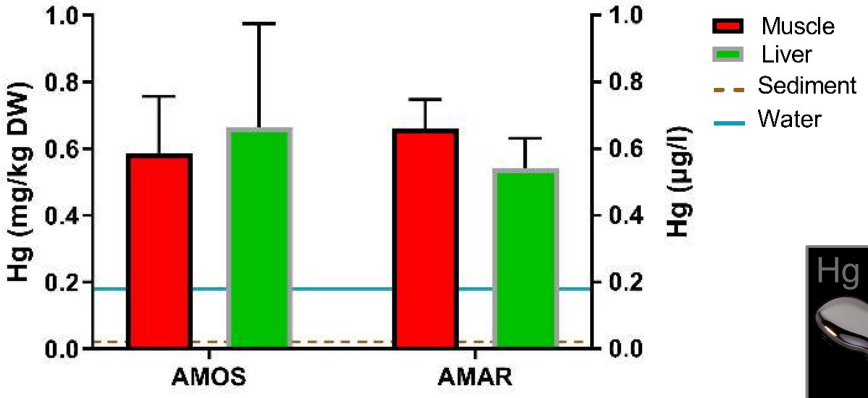
Water Research Group




# Case Study 3 - Freshwater eels

Water Research Group

- **Two eel species (n = 19)**
- **Higher [Hg] compared to *A. marmorata* from Ba River, Vietnam** (Le *et al*. 2012. *Coast. Mar. Sci*., 35:136-141)
- **Human health risks – locally and international**




# Case Study 3 - Freshwater eels

Water Research Group

- **Two eel species (n = 19)**
- **Higher [**

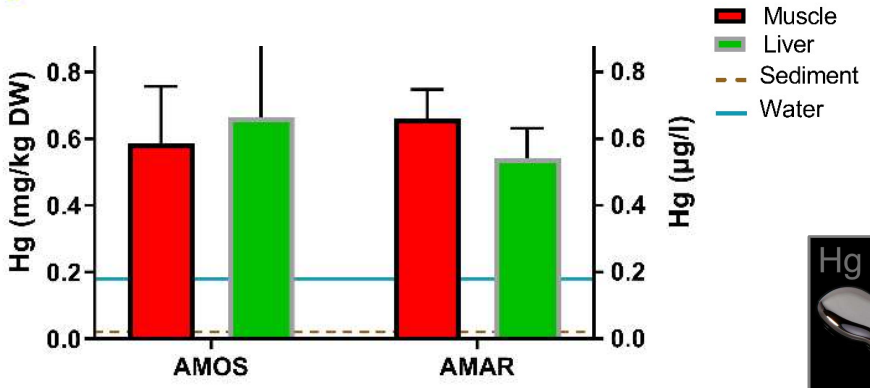
  **Vietnan**
- **Human**

Bulletin of Environmental Contamination and Toxicology (2023) 111:34
https://doi.org/10.1007/s00128-023-03795-5

Check for updates

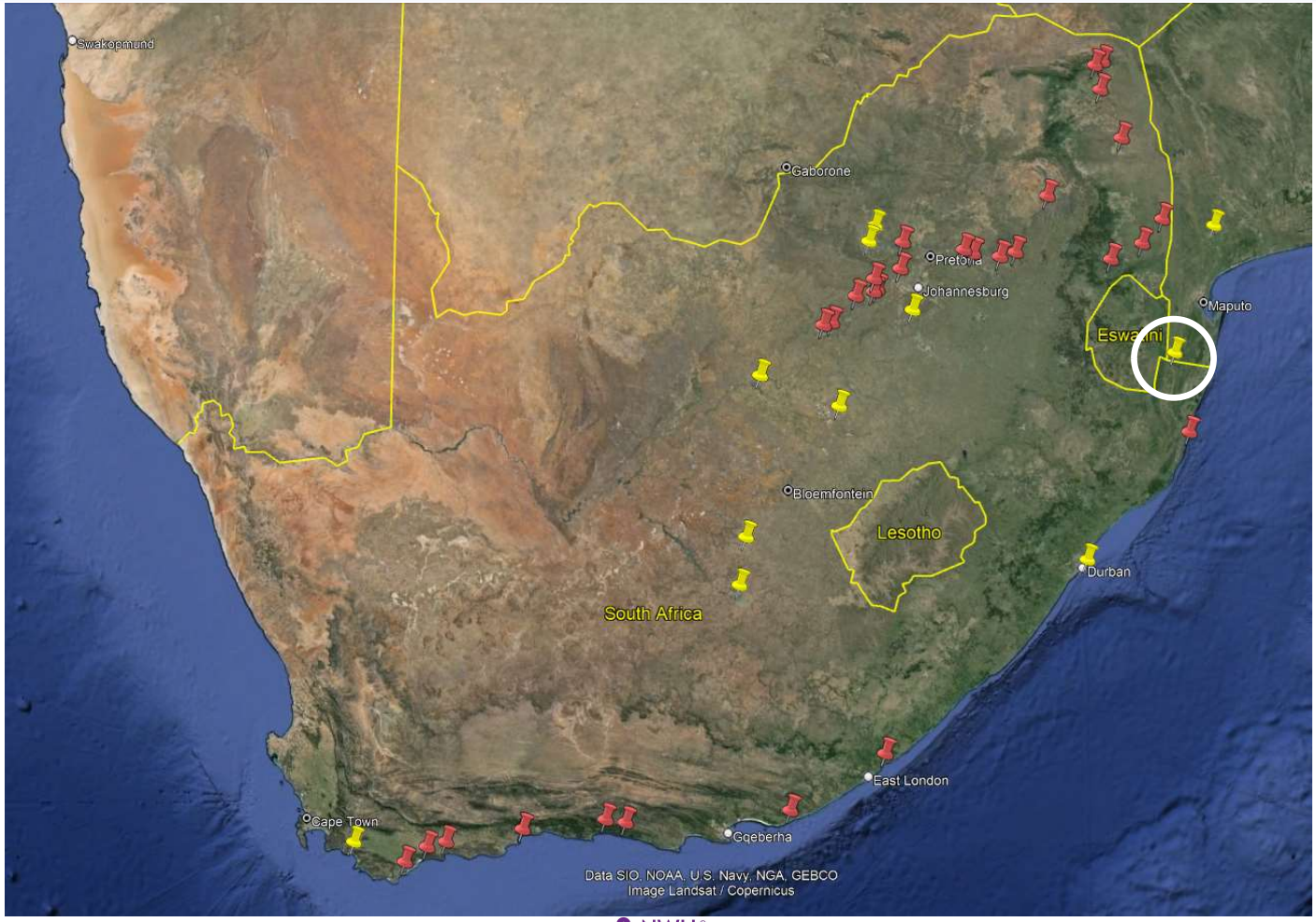
## Element Concentrations in Muscle and Liver Tissue of Two Eel Species from the Incomati River, Mozambique

Johannes H. Erasmus[1] · Shaun Herselman[1] · Victor Wepener[1]




# Case Study 4 - Floodplain systems

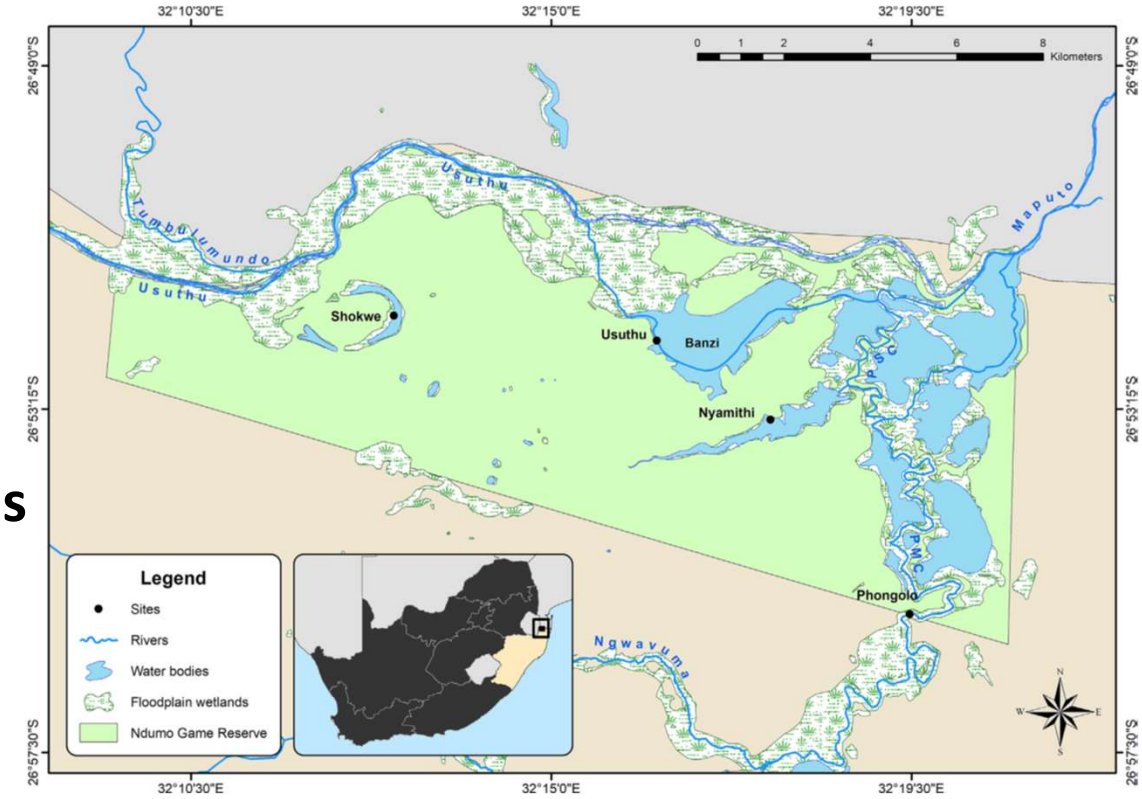
Water Research Group




# Case Study 4 - Floodplain systems

Water Research Group

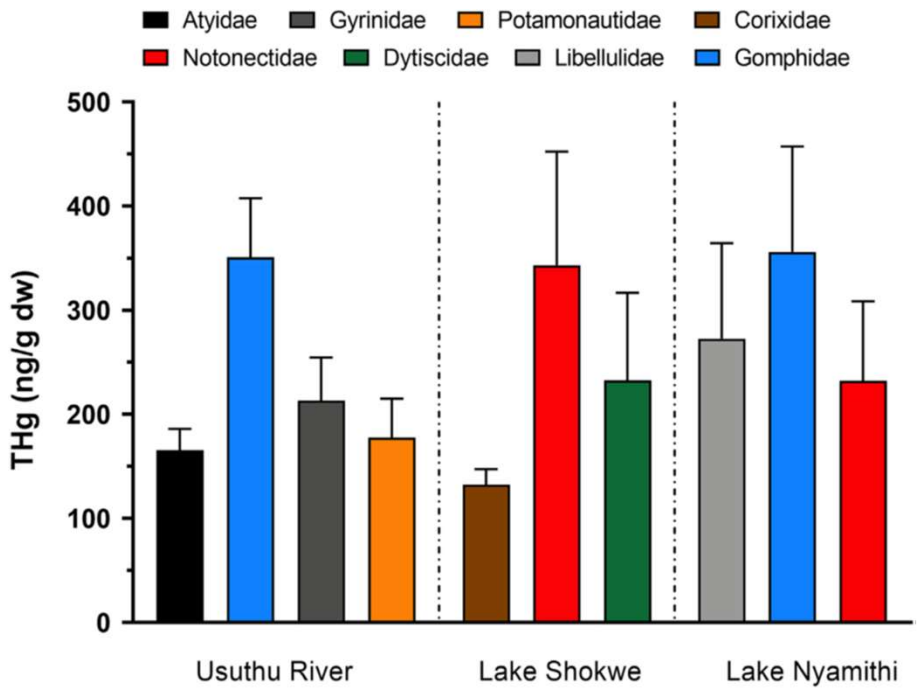
- Largest floodplain system in SA
- Located in a nature reserve
- Receives water from various anthropogenic land-use activities




# Case Study 4 - Floodplain systems

Water Research Group

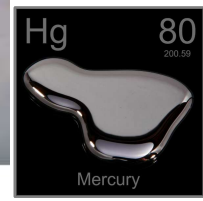
- **Invertebrate families**
- **Comparable concentrations to river in Italy near chlor-alkali plant** (Marziali *et al*. 2021. *Toxics*, 9:197)







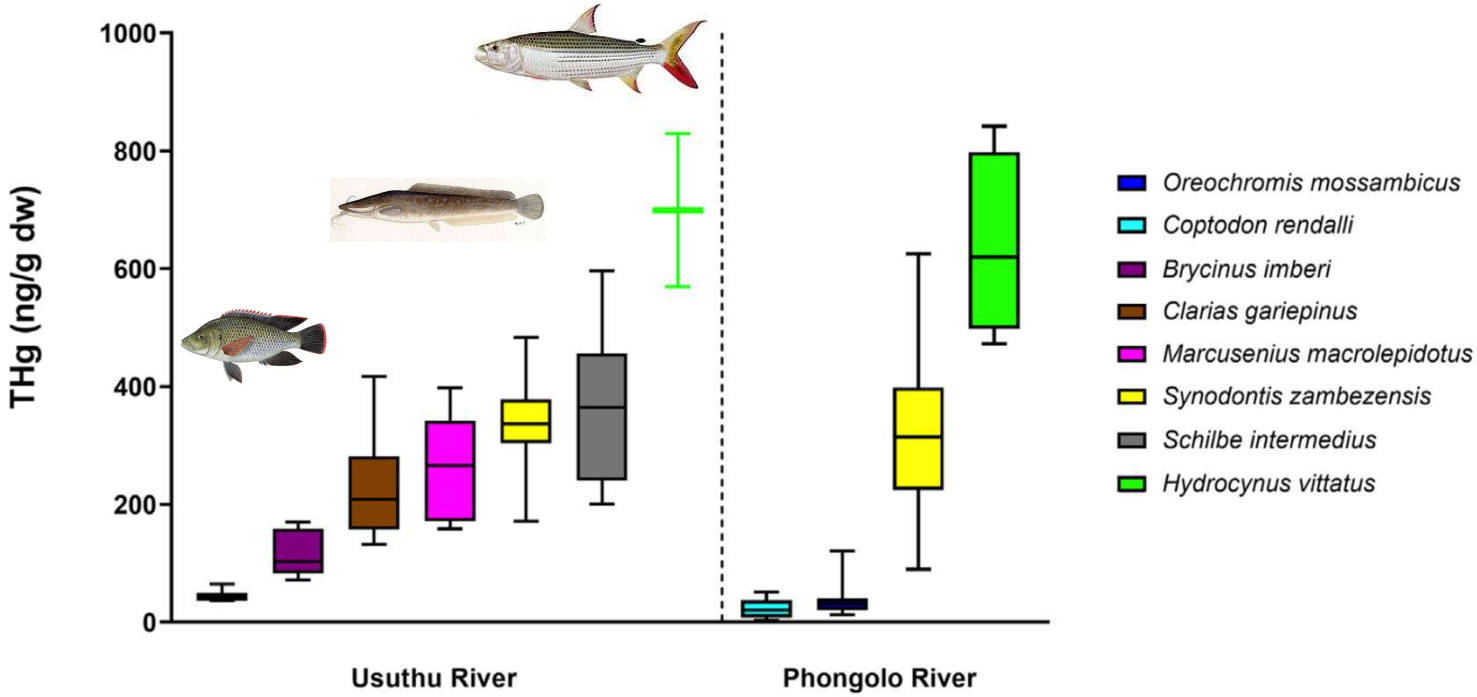


# Case Study 4 - Floodplain systems

Water Research Group

- **Fish species**
- **Exceeding European biota environmental quality standards**



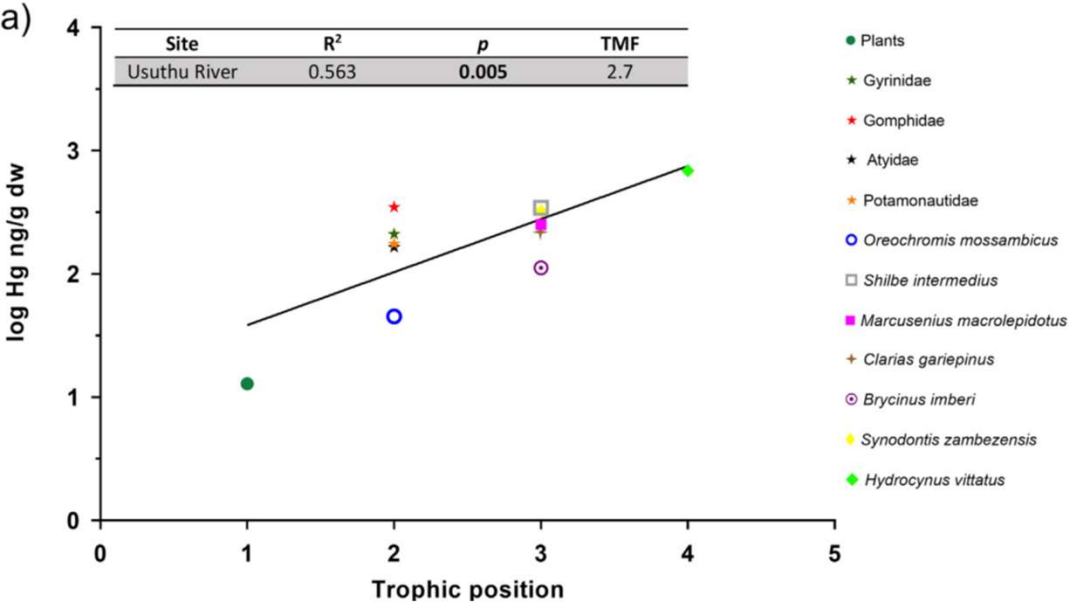

# Case Study 4 - Floodplain systems

Water Research Group

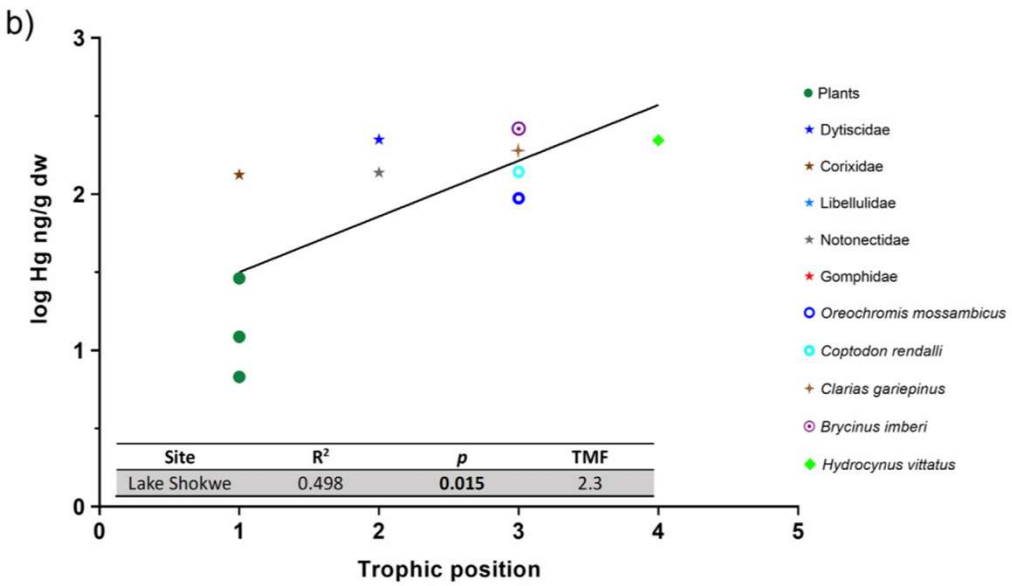
- **Biomagnification**

a)

| Site | $R^2$ | *p* | TMF |
|---|---|---|---|
| Usuthu River | 0.563 | **0.005** | 2.7 |




b)

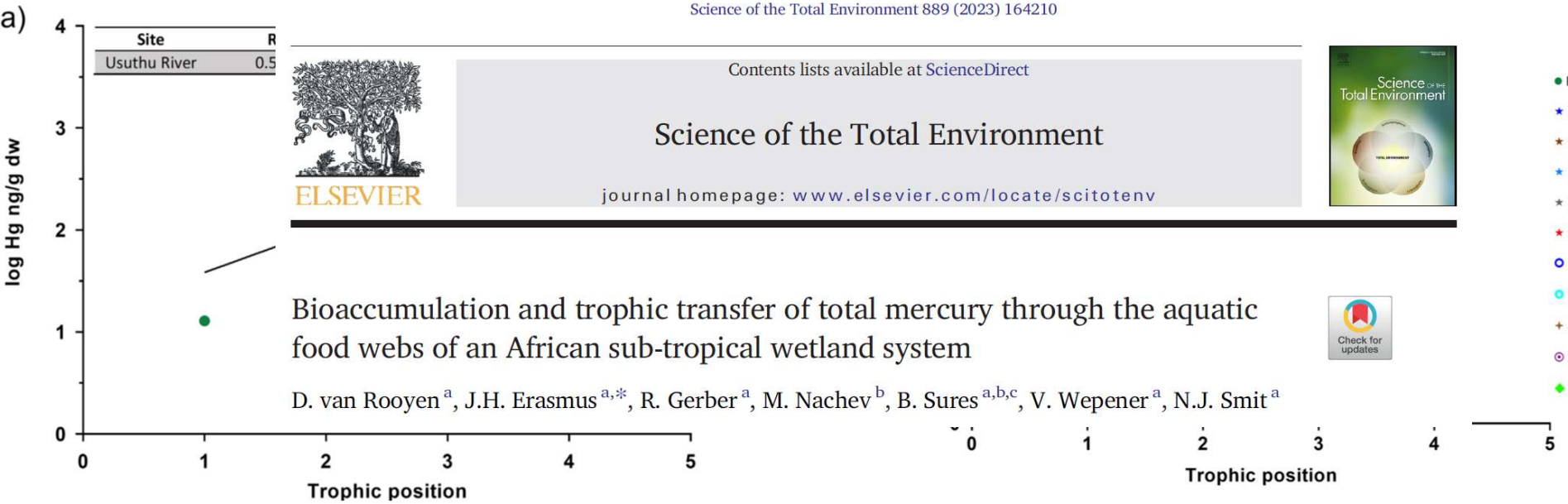



| Site | $R^2$ | *p* | TMF |
|---|---|---|---|
| Lake Shokwe | 0.498 | **0.015** | 2.3 |

# Case Study 4 - Floodplain systems

Water Research Group

- **Biomagnification**




Science of the Total Environment 889 (2023) 164210

Contents lists available at ScienceDirect

Science of the Total Environment

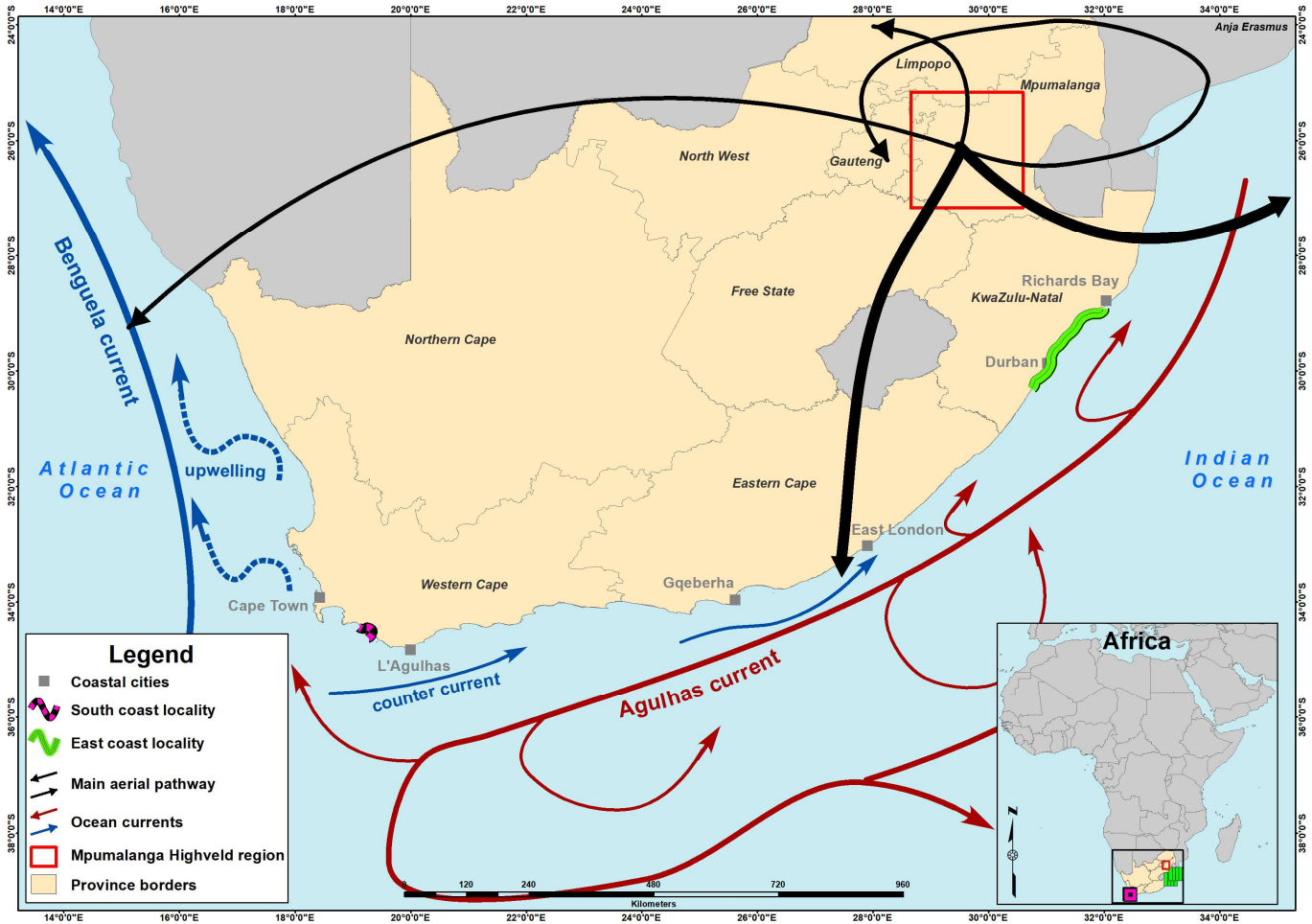
journal homepage: www.elsevier.com/locate/scitotenv

## Bioaccumulation and trophic transfer of total mercury through the aquatic food webs of an African sub-tropical wetland system

D. van Rooyen [a], J.H. Erasmus [a,*], R. Gerber [a], M. Nachev [b], B. Sures [a,b,c], V. Wepener [a], N.J. Smit [a]

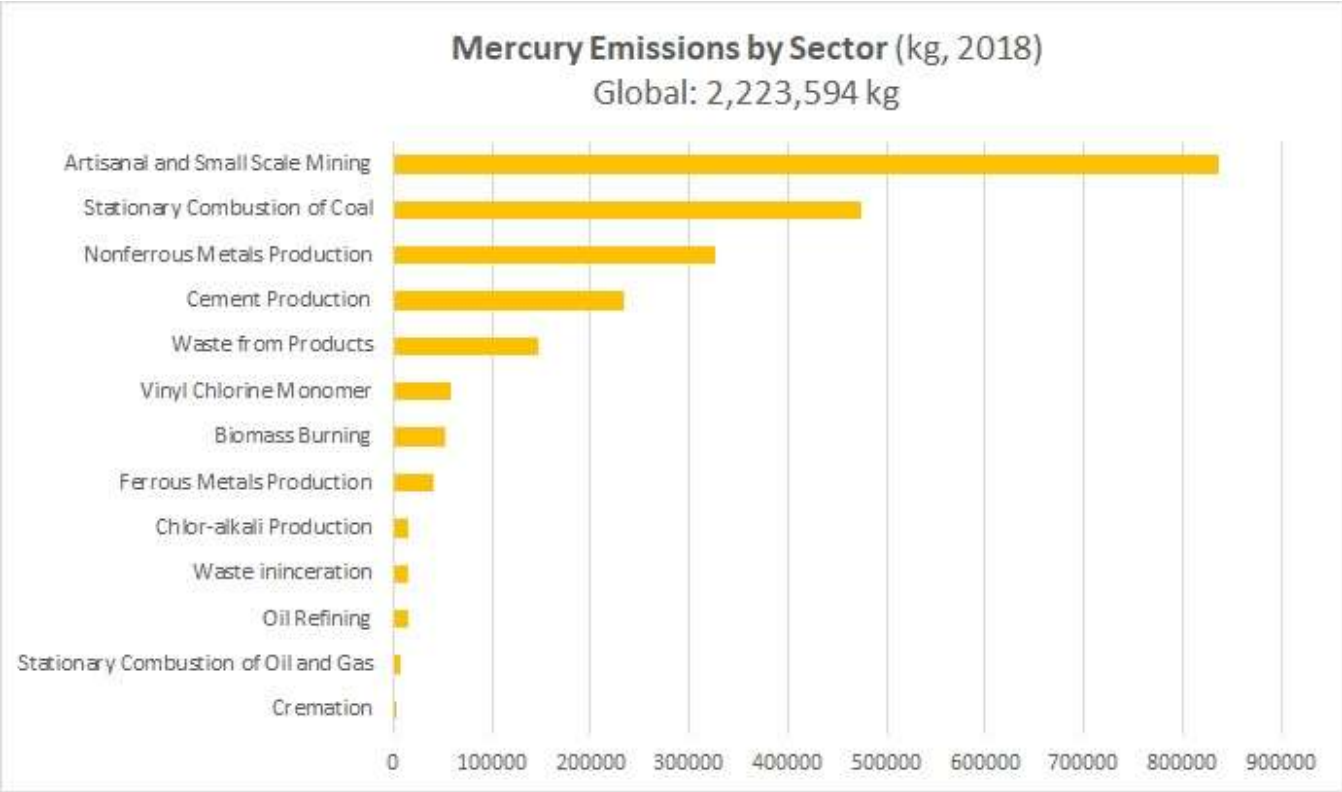
# Why unexpected results?

Water Research Group




# Conclusions

Water Research Group




United Nations Environment Programme, 2019. Technical background report to the global mercury assessment

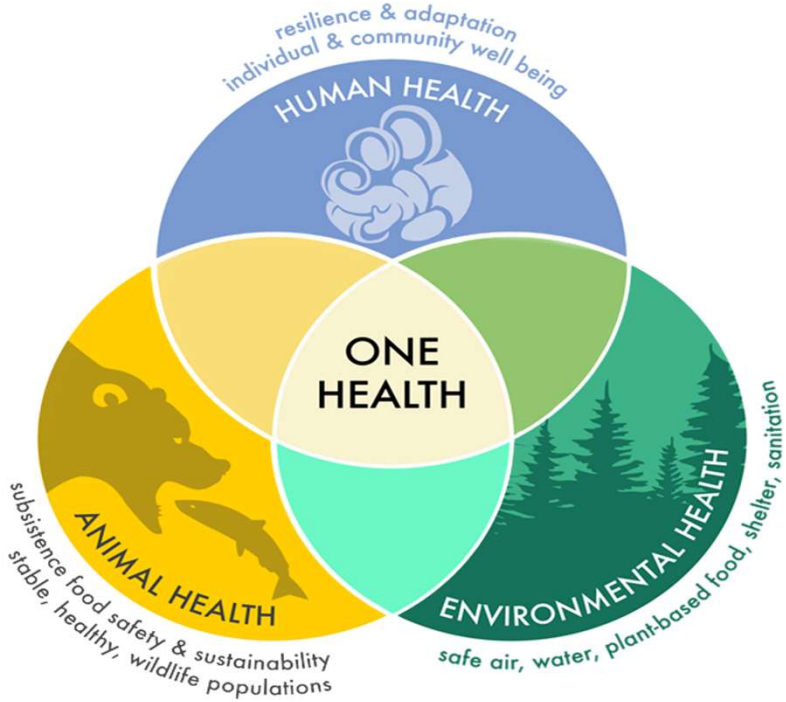
# Conclusions

Water Research Group

- Elevated [Hg] even found in relatively “pristine areas”
- Hg contamination due to several sources
- [Hg] in different biota pose human health risks
- Continuous monitoring is needed even in “pristine sites”
- The implications not only relevant to this study but a global concern

# One Health Approach

Water Research Group




# Interdisciplinary approach

Water Research Group

Environmental Scientists / Ecotoxicologist

Environmental / Chemical Engineers

Social Scientists / Communication

Environmental Law

“Healthy” Environment and humans

# THANK YOU