



IIT Hyderabad

Updates from India

13th Asia-Pacific Mercury Monitoring Network (APMMN) meeting

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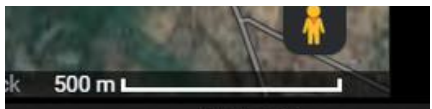
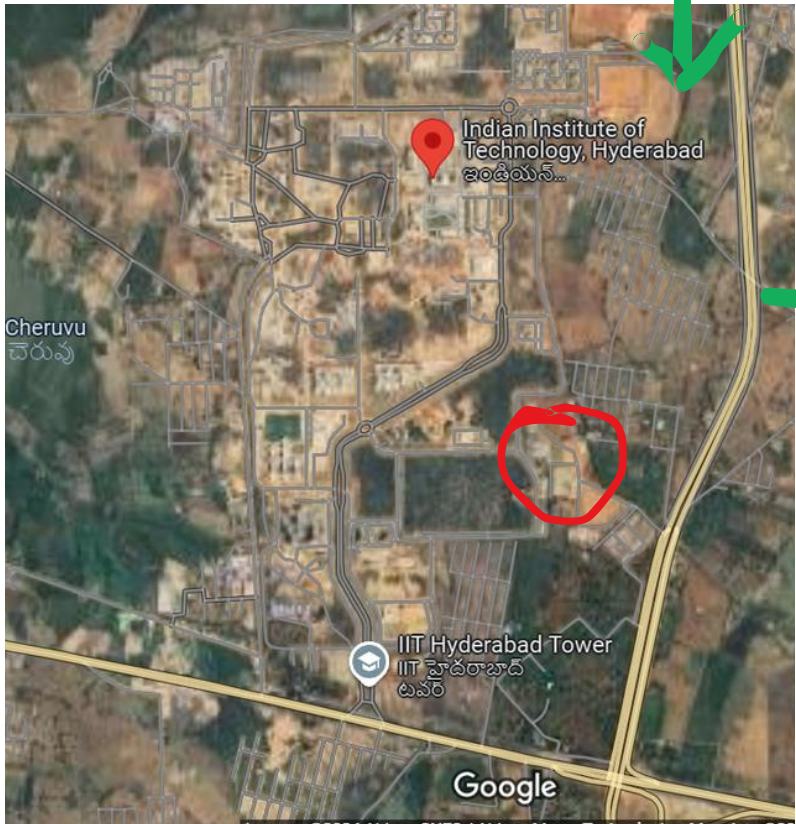
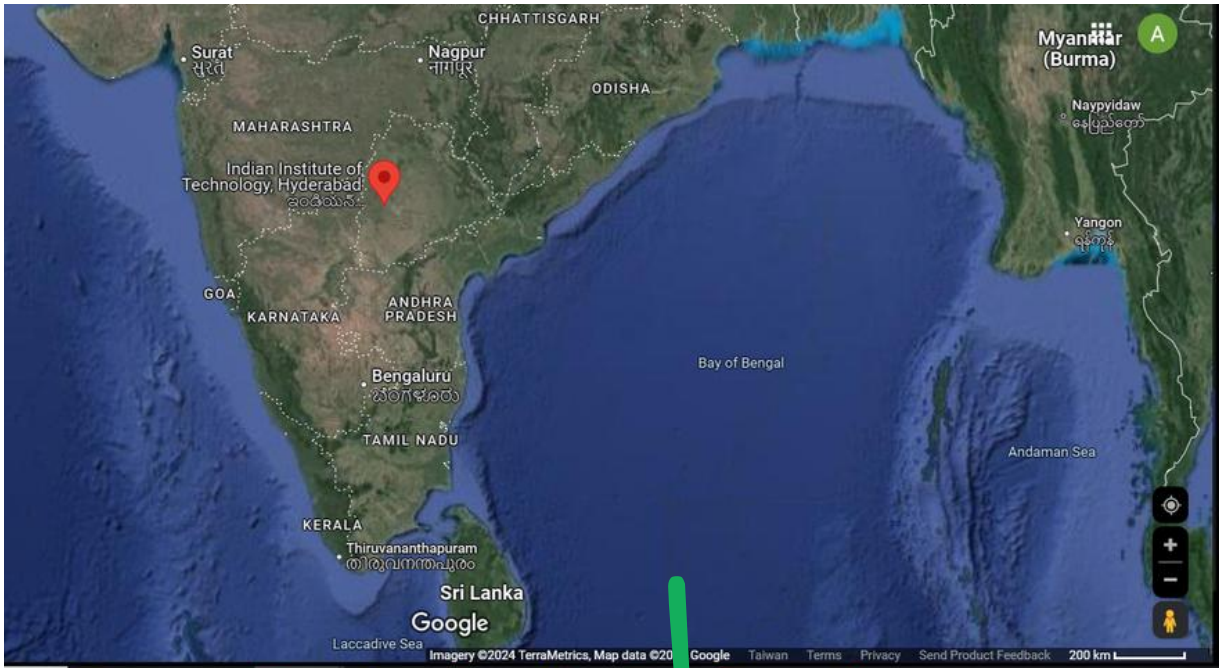
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4 September 2024

Site Location

IIT Hyderabad



APMMN
Sampler



Continuous Air Quality Monitoring
(central pollution control board, cpcb)
PM2.5, PM10, NOx, NH3, SO2, O3,
WS, WD, SR, AT

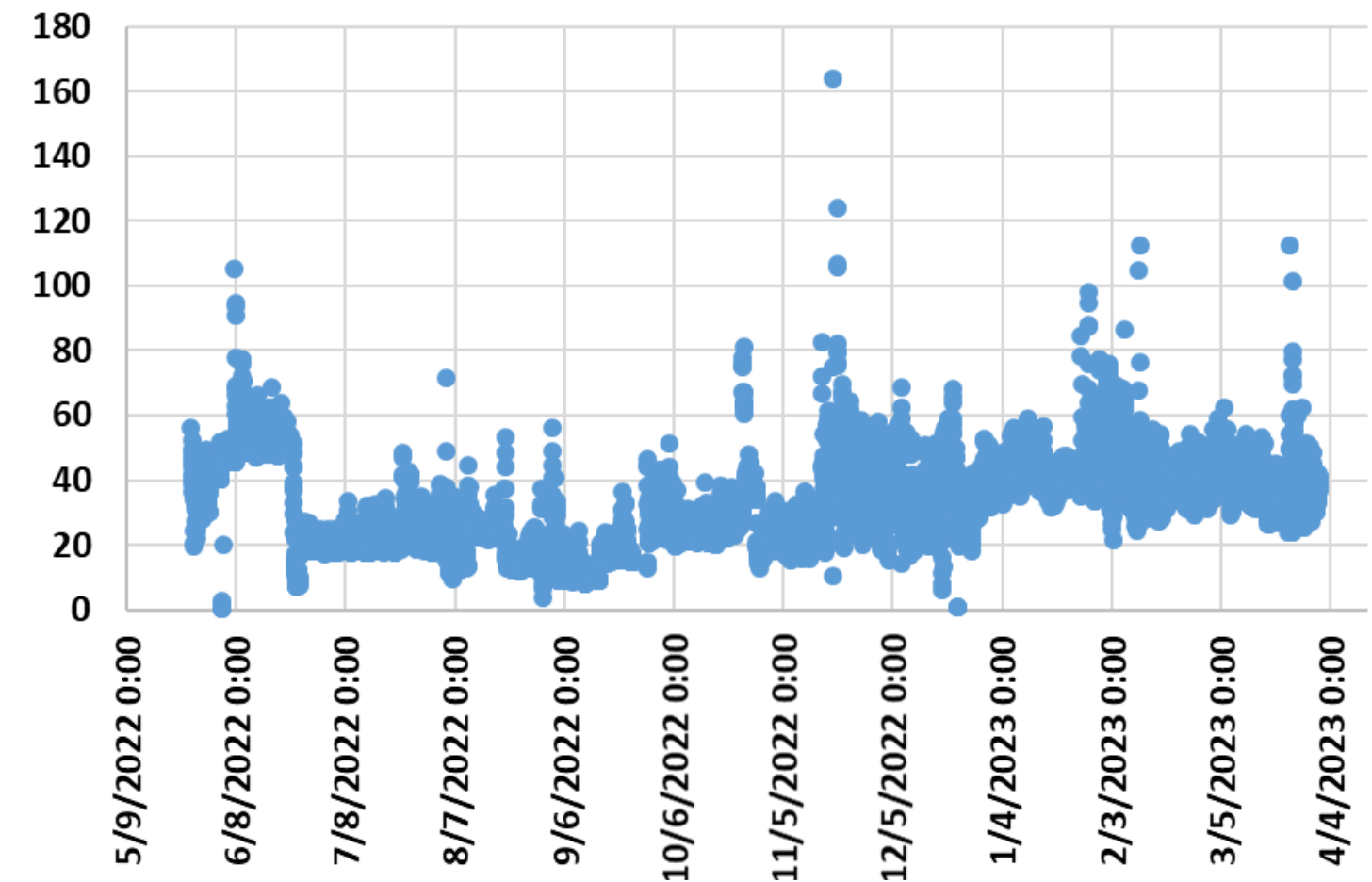
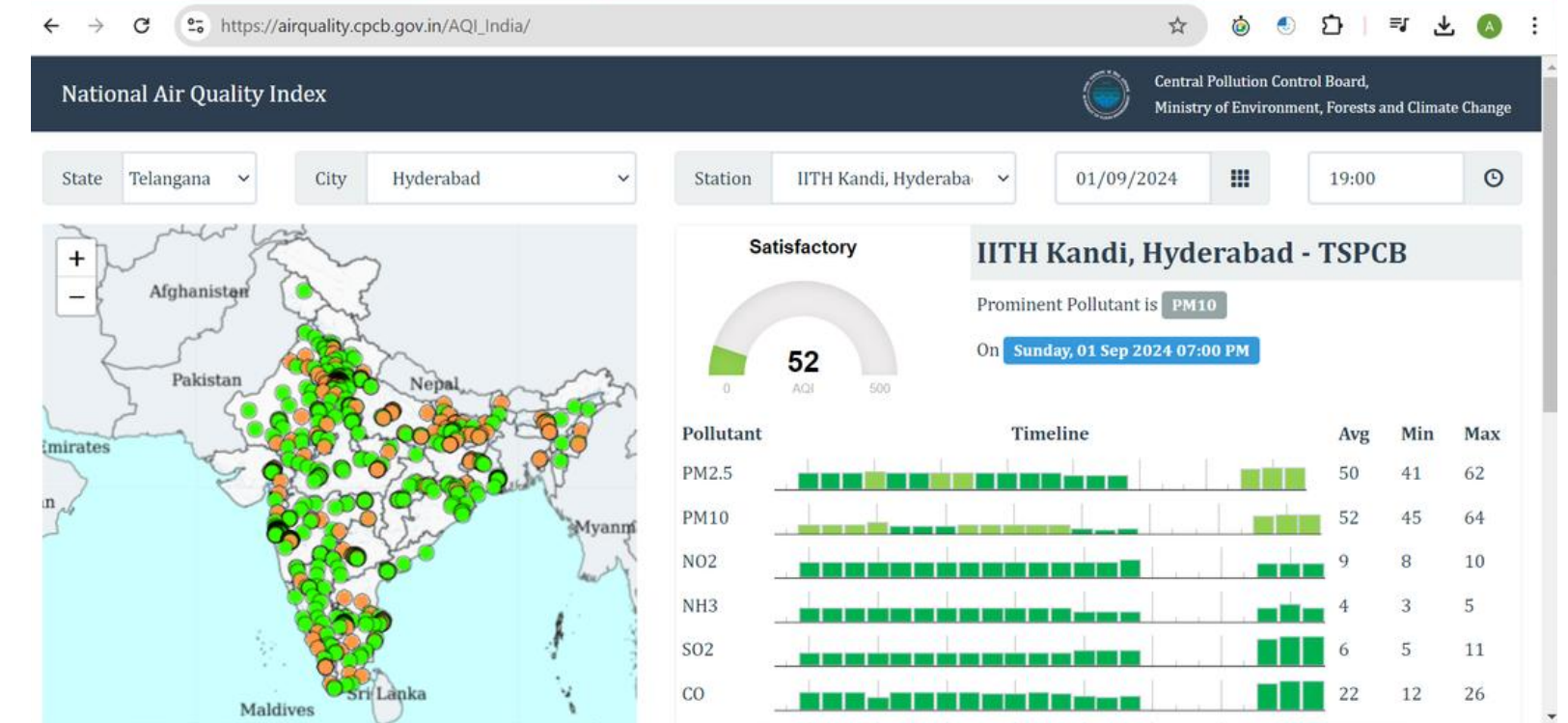
Mercury samples

- 07-16 July 2023 to 26 Jul-02 Aug 2024: 50 samples
- Shipped to NCU

Air quality data from cpcb

Plan

- Once Hg deposition data is obtained, study the variation w.r.t. other air quality parameters
- Trial with passive samplers
- Continuous GEM monitoring



<https://data.gov.in/catalog/historical-daily-ambient-air-quality-data>

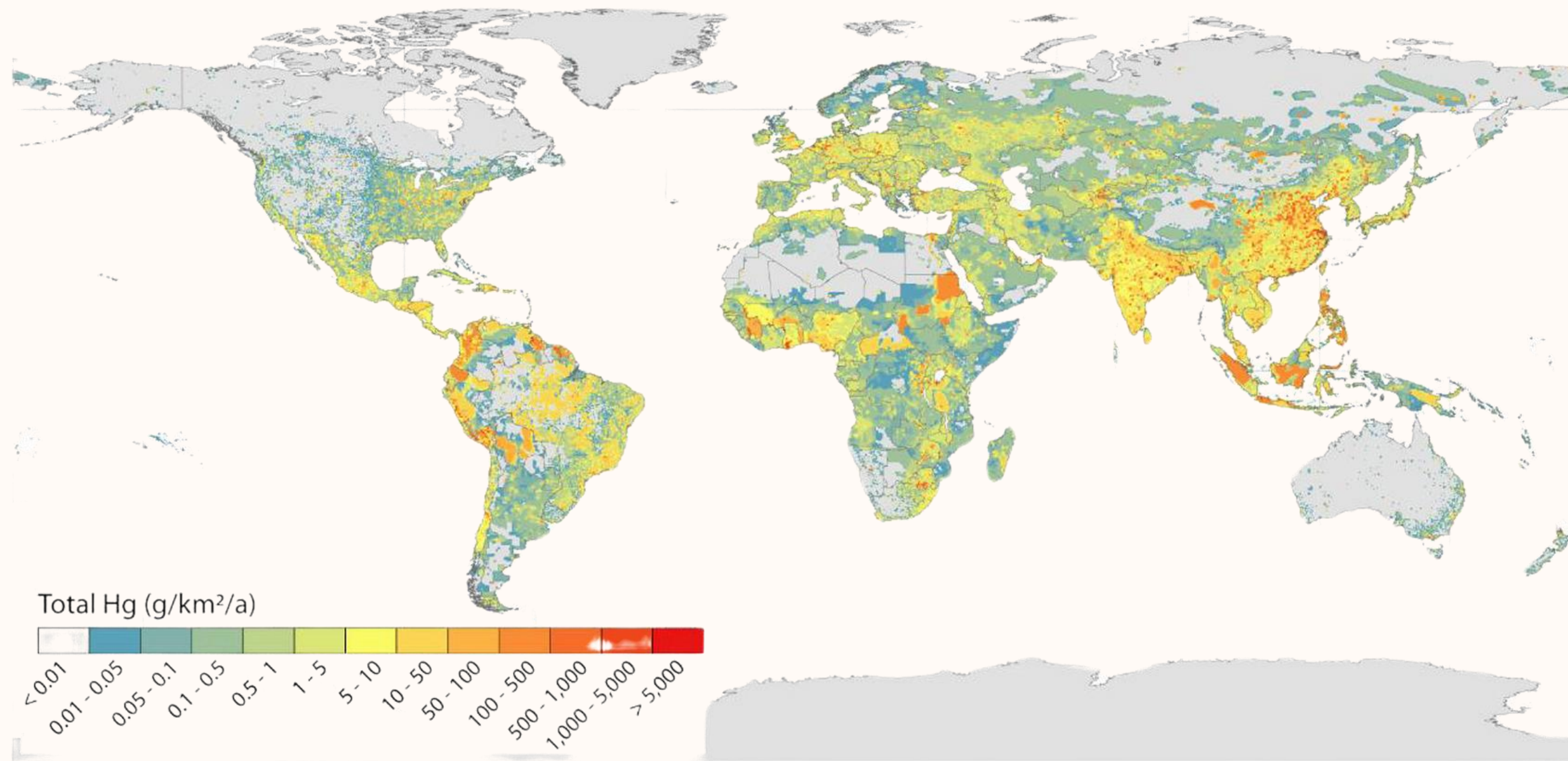
Rest of the presentation: an overview of some other mercury works carried out in my group

04.09.2024

Biomonitoring

India and Mercury

- India is second largest emitter to atmosphere

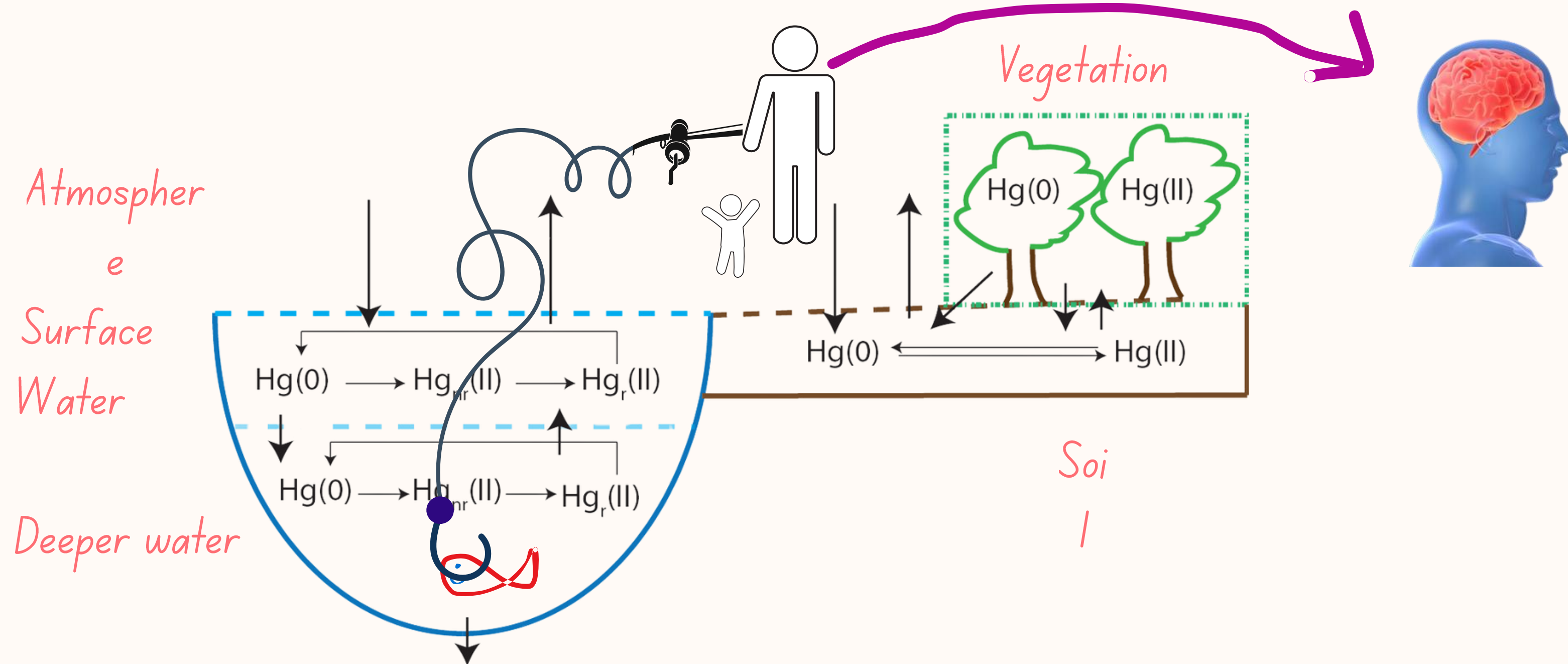


Global mercury emissions to the atmosphere in 2015
(Steenhuisen & Wilson, 2019)

Environmental Mercury Cycle & human exposure

Globally fish is a major nutrition source

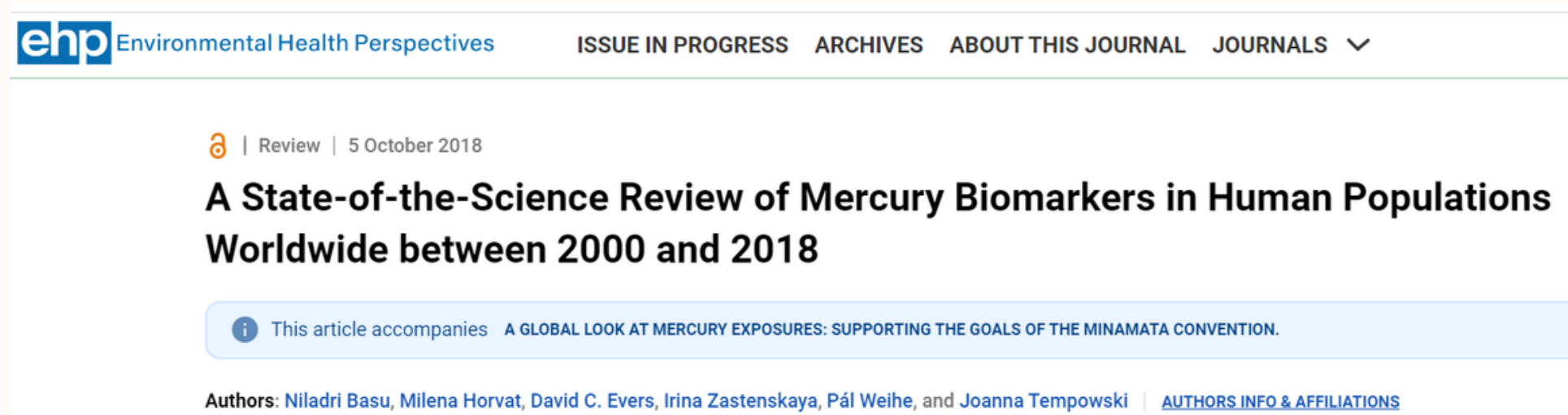
Concurrently people are exposed to mercury (& other contaminants)



Epidemiological studies and reference dose

Reference dose (RfD) for methylmercury... is a daily intake that is likely to be without appreciable risk of deleterious effects during a lifetime.

- Seychelles¹, New Zealand² and Faroe Islands³ data
- Hair Hg level corresponding to USEPA Ref dose $\sim 1 \mu\text{g/g}$ ⁴
(Revised: $0.58 \mu\text{g/g}$ ⁵)



Results:

We collected 424,956 mercury biomarker measurements from 335,991 individuals represented in 312 articles from 75 countries. General background populations with insignificant exposures have blood, hair, and urine mercury levels that generally fall under $5 \mu\text{g/L}$, $2 \mu\text{g/g}$, and $3 \mu\text{g/L}$, respectively. We identified four populations of concern: a) Arctic populations who consume fish and marine mammals; b) tropical riverine communities (especially Amazonian) who consume fish and in some cases may be exposed to mining; c) coastal and/or small-island communities who substantially depend on seafood; and d) individuals who either work or reside among artisanal and small-scale gold mining sites.

manager's decision tree: Step 2 - Determine mercury levels in composite hair samples). This should be targeted at young children and women of child-bearing age consuming one or more meals containing high mercury fish per week, as well as likely high fish consumers. Exposure can be assessed by analysis of total mercury concentrations in hair, which is a non-invasive, relatively inexpensive and accurate procedure for determining methylmercury in fish-eating groups. When financial resources are limited, composite samples consisting of hair of several individuals from each of the above three groups could be initially used instead of individual samples. Average mercury concentrations in composite hair samples from each group should be compared with reference values, such as $2 \mu\text{g/g}$ (WHO/IPCS, 1990) or national references values. Chapter 3 provides guidance in the collection and analysis of hair samples.

Study 1

[nature](#) > [journal of exposure science & environmental epidemiology](#) > [articles](#) > article

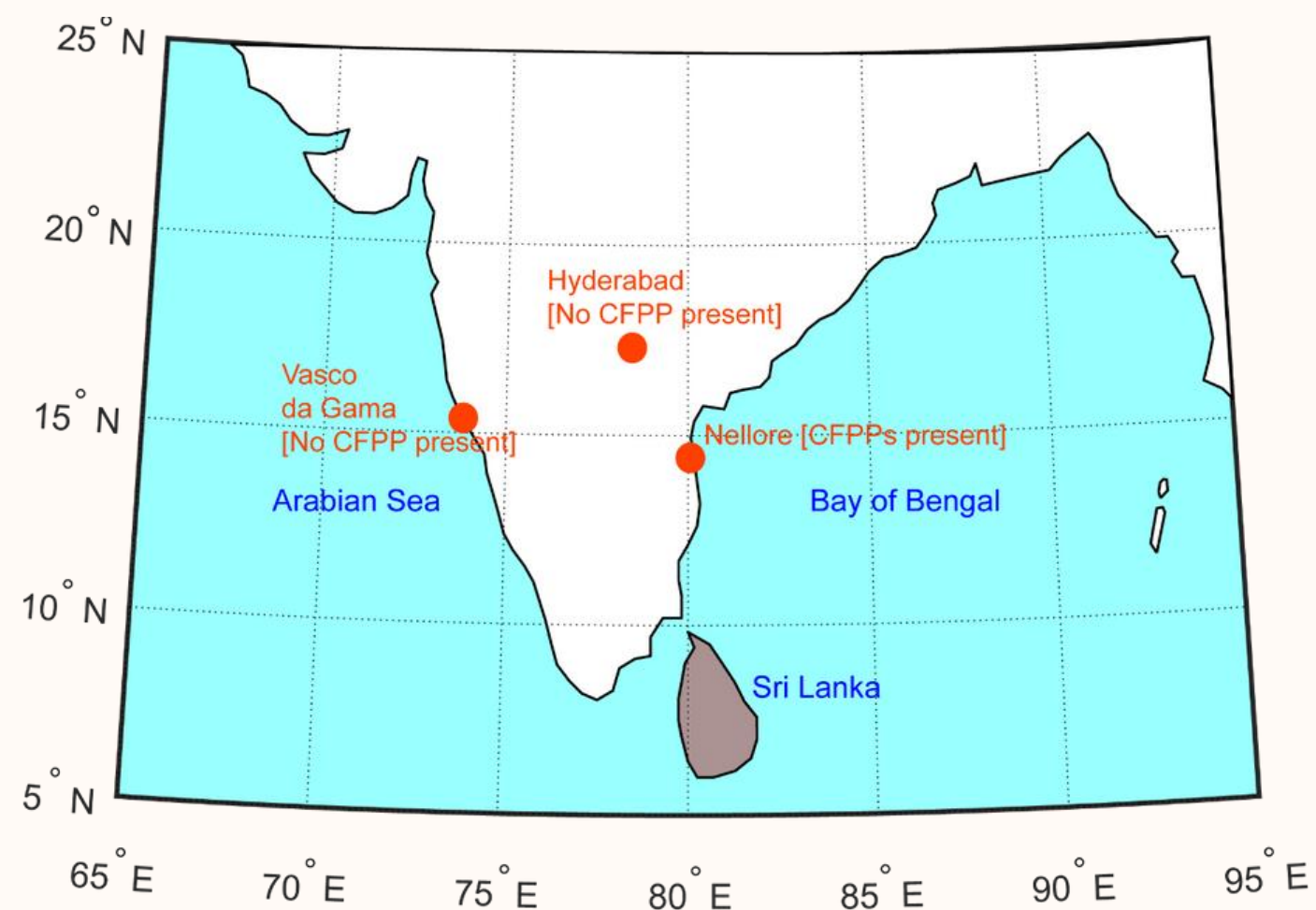
Article | Published: 10 January 2019

Mercury levels in human hair in South India: baseline, artisanal goldsmiths and coal-fired power plants

[K. L. Subhavana](#), [Asif Qureshi](#)  & [Arpita Roy](#)

[Journal of Exposure Science & Environmental Epidemiology](#) **29**, 697–705 (2019) | [Cite this article](#)

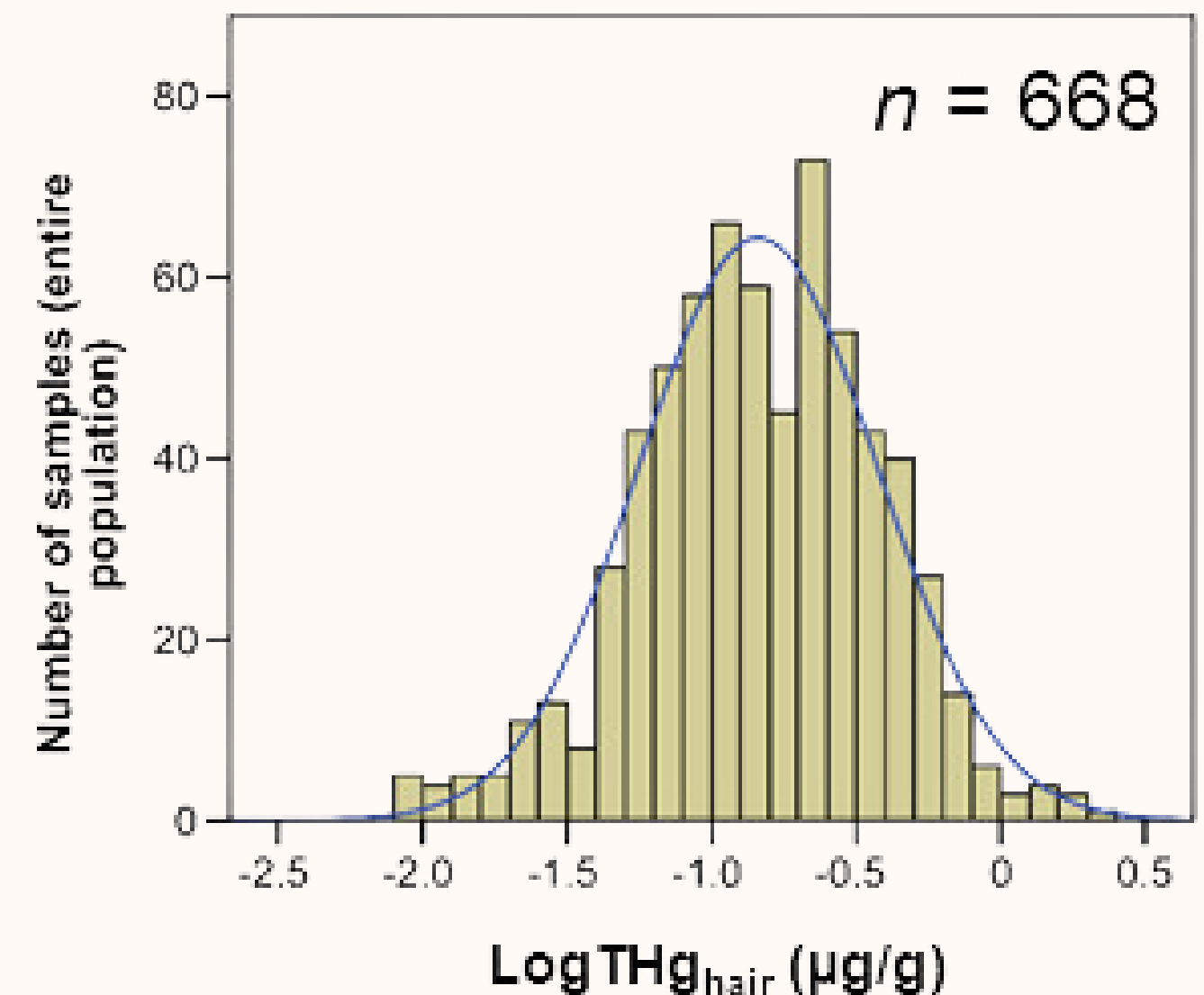
- Measure Hg in human biomarker in South India
 - Coastal vs Interior
 - Close vs away from sources



- Hair strands
- THg_hair – Direct mercury Analyzer (DMA – 80)
 - Detection limit (3 s.d.: 0.012 g)
 - Samples below LOD – none
 - Recovery from reference material – $88 \pm 6\%$

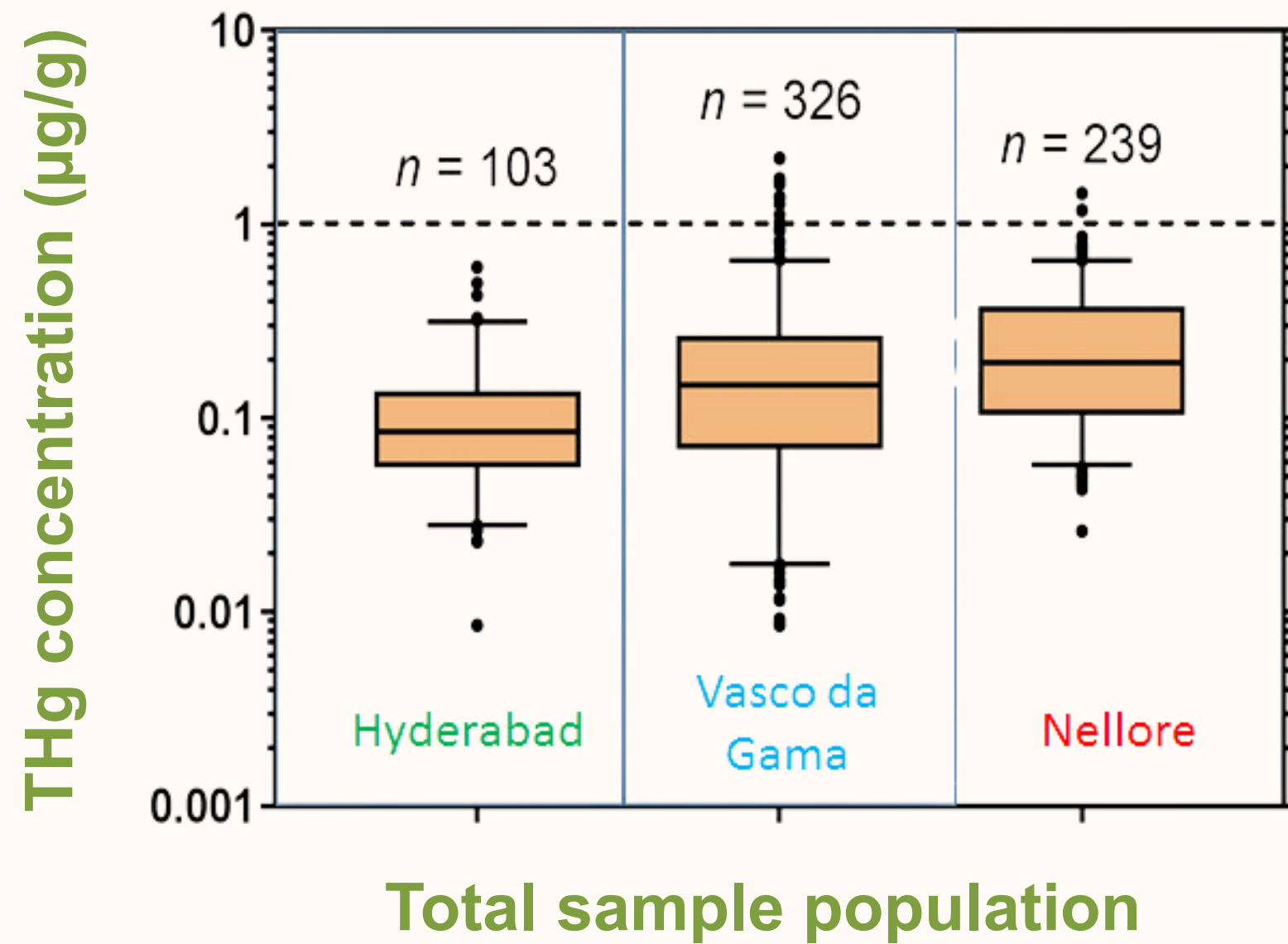
RESULTS:

THg distribution in sampled population



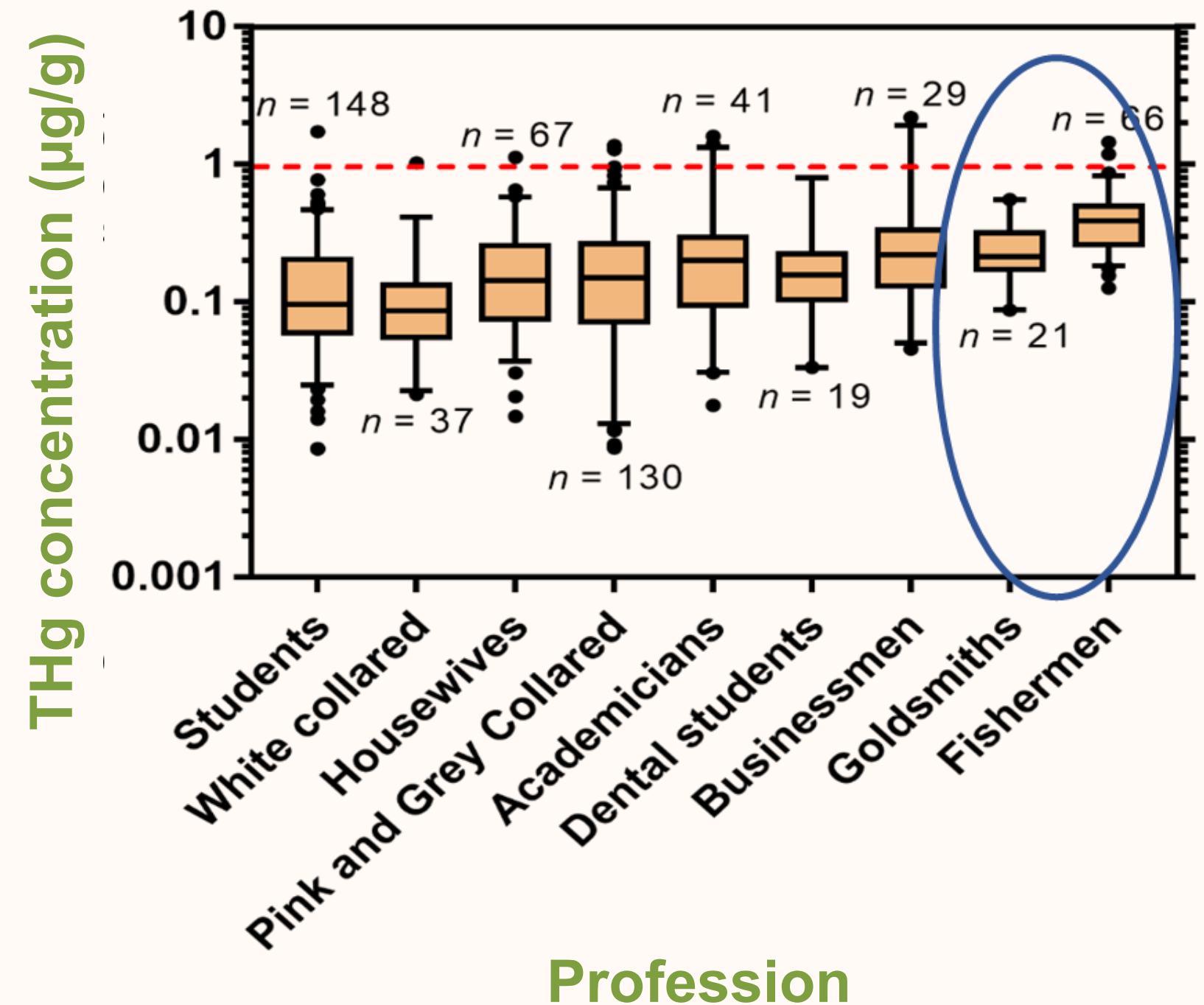
- Nellore ($n = 239$)
 - 4 coal fired power plants
 - High sea food consumption
 - Goldsmiths.
- Vasco da Gama ($n = 326$)
 - High sea food consumption.
- Hyderabad ($n = 103$)
 - Both vegetarian and non-vegetarian (mix of fish, chicken, mutton).

Results



- Significant predictor variables: Age, fish consumption frequency

- Main identified exposure groups: Fishermen and Goldsmiths



Pink and grey collared job: individuals in the service industry such as waiters, clerks, typists, florists, fruit sellers, cleaners in hospitals, auto rickshaw drivers and self-employed senior citizens.

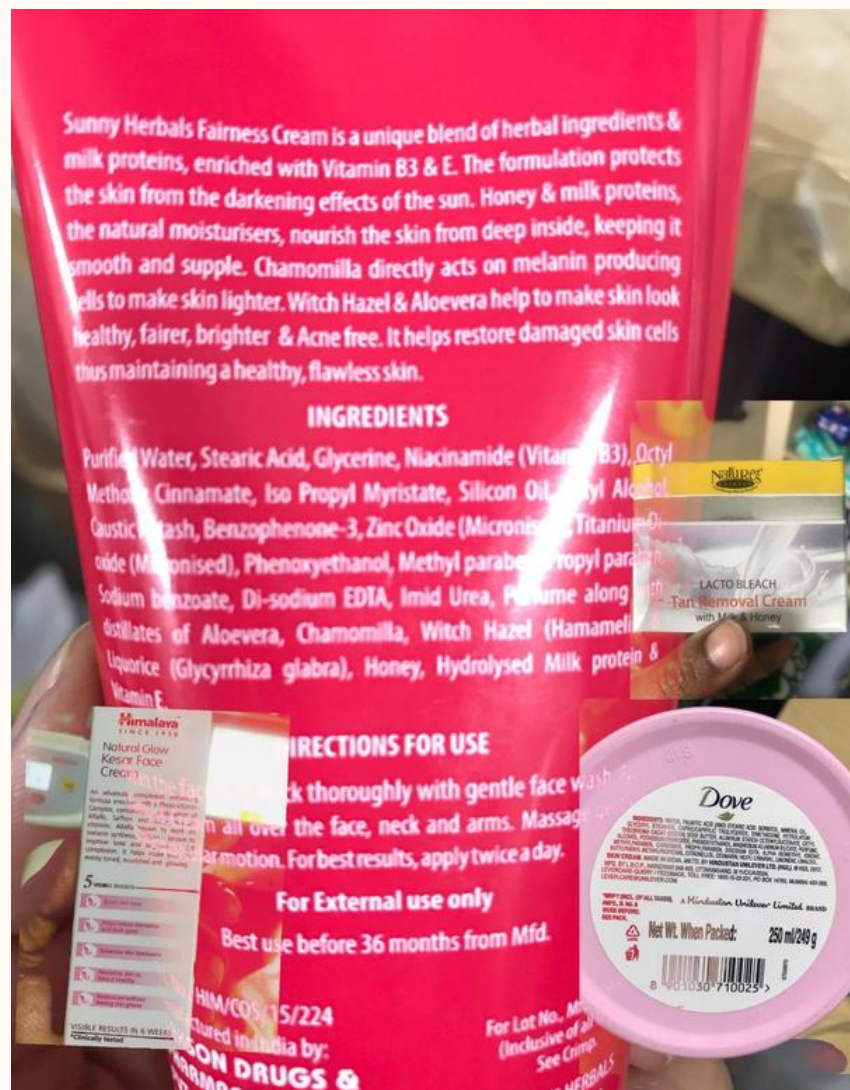
White-collared job holders: offices workers such as administrative and IT professionals.

Dermal exposure to mercury
from personal care products.

(fairness cream, body lotion ,
blemish balm, moisturizing
lotion, bleach)

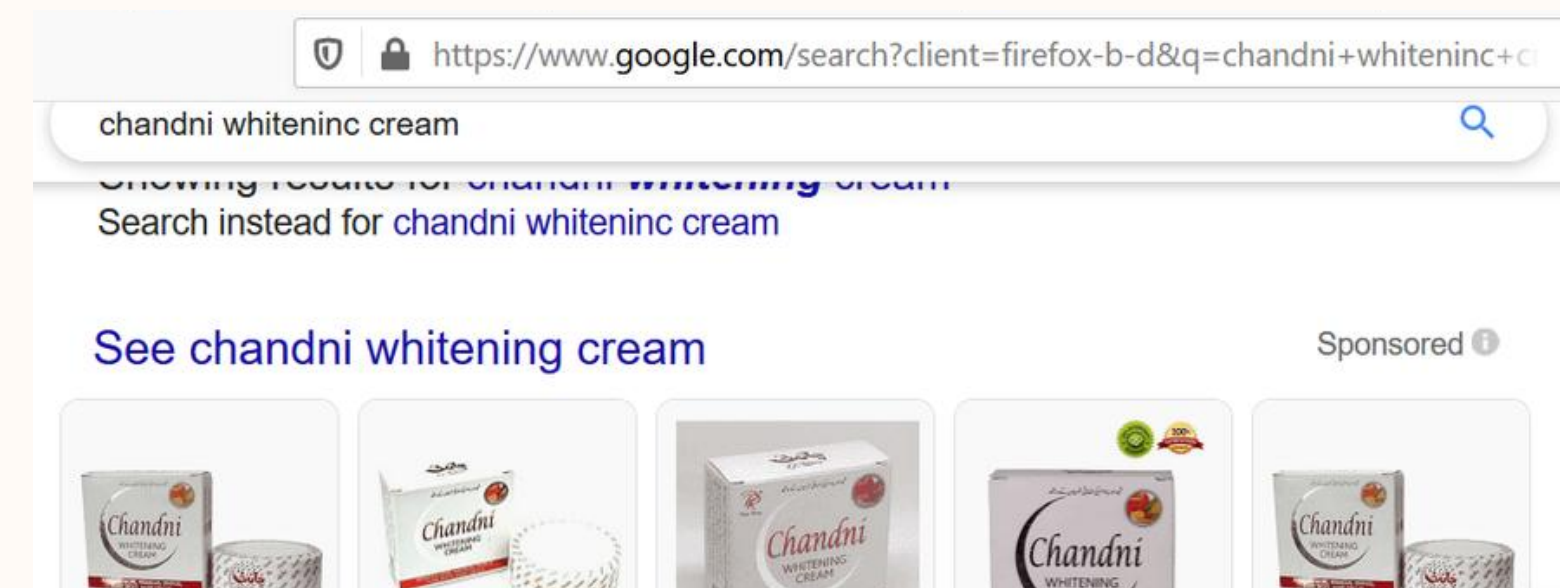
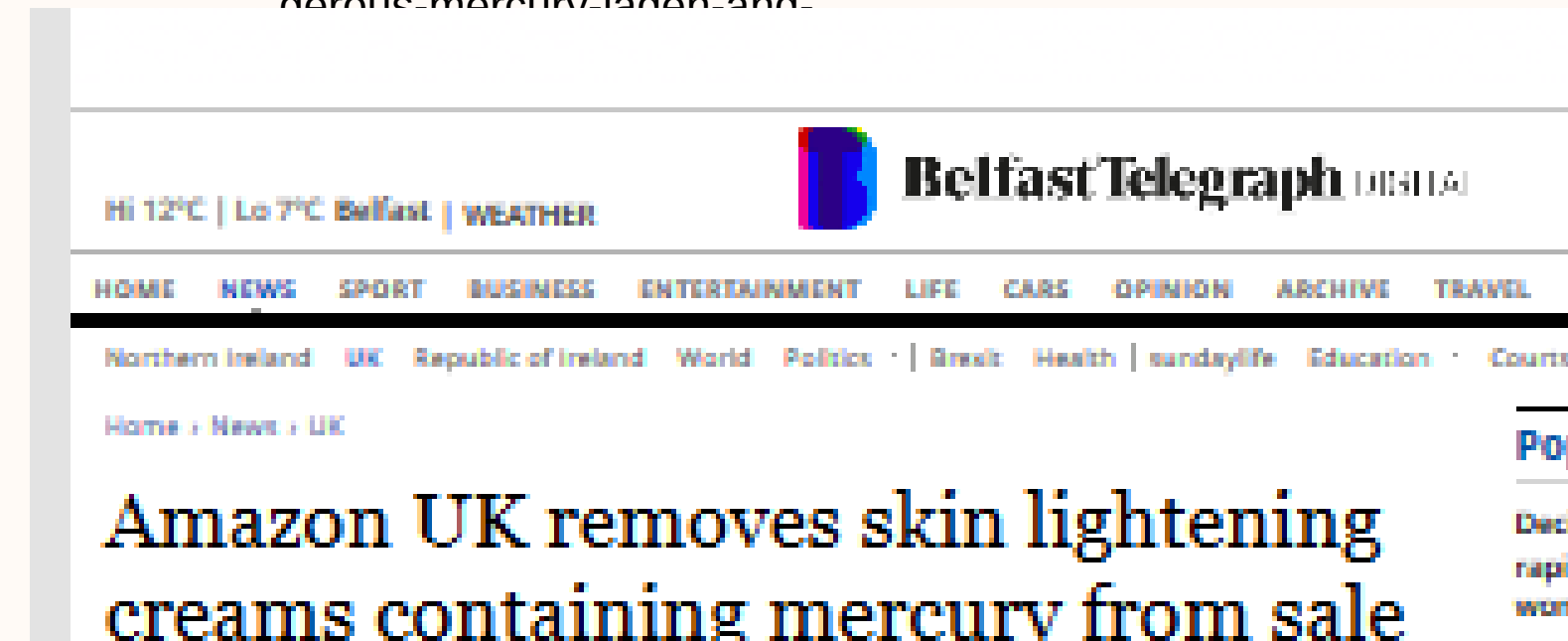
Hg present in cosmetic products

- Hg is used in 'Fairness cream' to block the melanin synthesis to increase the whiteness of the skin.
- Mercury presents in cream in organic or inorganic forms
 - Inorganic mercury= Mercuric iodine or mercury iodide (HgI_2) or poison, mercury oxide (HgO), mercurous chloride (Hg_2Cl_2), mercuric chloride (HgCl_2), calomel, ammoniated mercury (ClH_2HgN)
 - Organic mercury = Ethyl mercury ($\text{C}_2\text{H}_5\text{Hg}$), Phenylmercuric salts ($\text{C}_{11}\text{H}_{12}\text{HgO}_2$) in 'eye makeup'.



Product name	Countries where purchased	Concentration range (ppm mercury)
Aneesa Gold Beauty Cream	Djibouti, India, Nigeria, Philippines	17,086 – 54,653
Chandni Whitening Cream	Bangladesh, Djibouti, EU, India, Kenya, South Africa, USA	0 – 102,233

<https://www.zeromercury.org/wp-content/uploads/2019/11/Dangerous-mercury-laden-and->



Objectives

Assessing 'Hg' concentrations in creams

Methods and Materials

- **Assessing personal care products**

- i) Bought from both physical shops and online retail
- ii) 17 body lotions
- iii) 5 moisturizing lotions
- iv) 5 blemish balms
- v) 25 skin-whitening creams

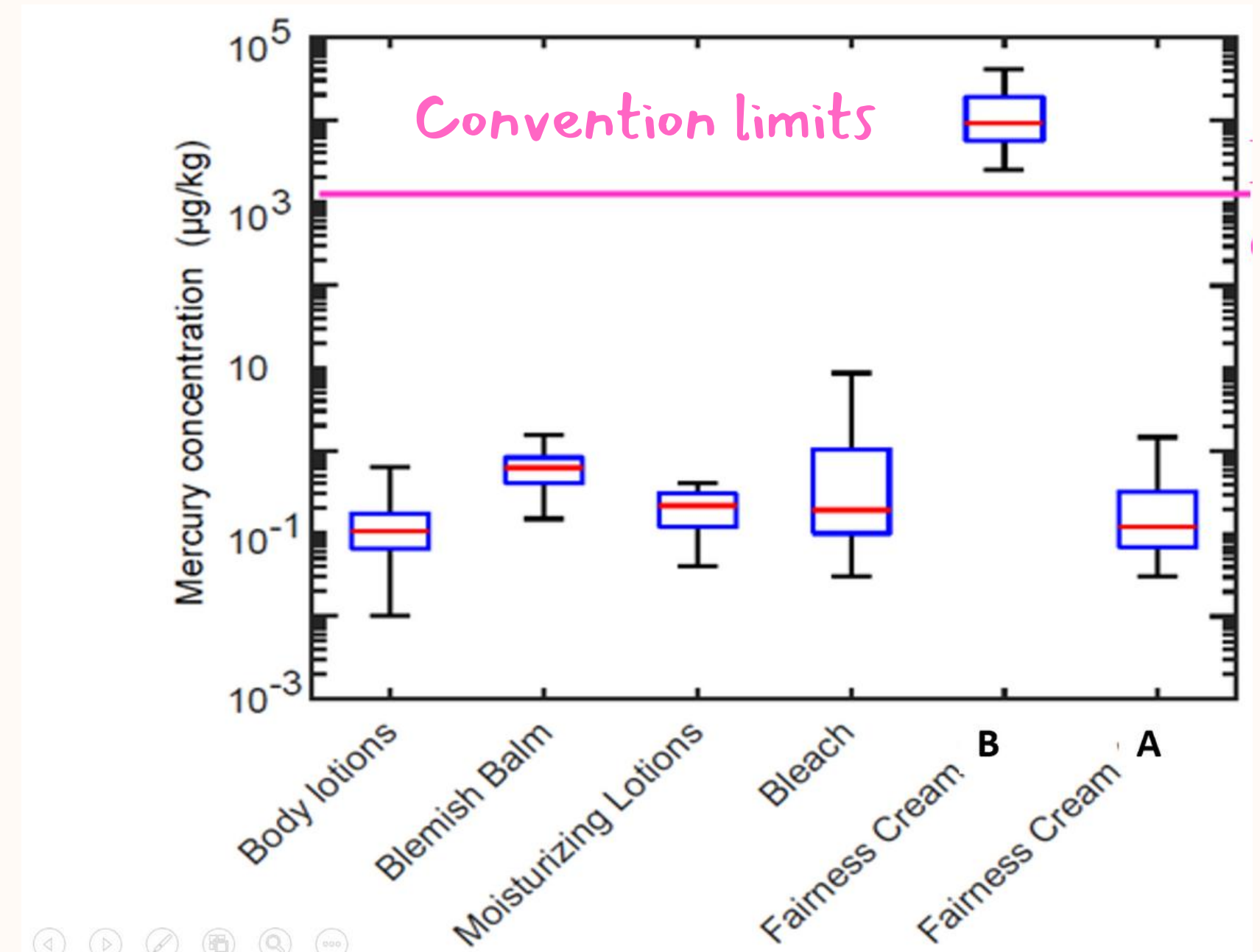
- **Creams analysed in the lab (DMA)**

- i) QA/QC: blanks, spiked samples
- ii) Limit of detection: 0.01 ng. Sample mercury more than several times this.
- iii) Spiked recoveries: $102 \pm 8\%$ ($n = 31$)

- **Human Health risk assessment :**

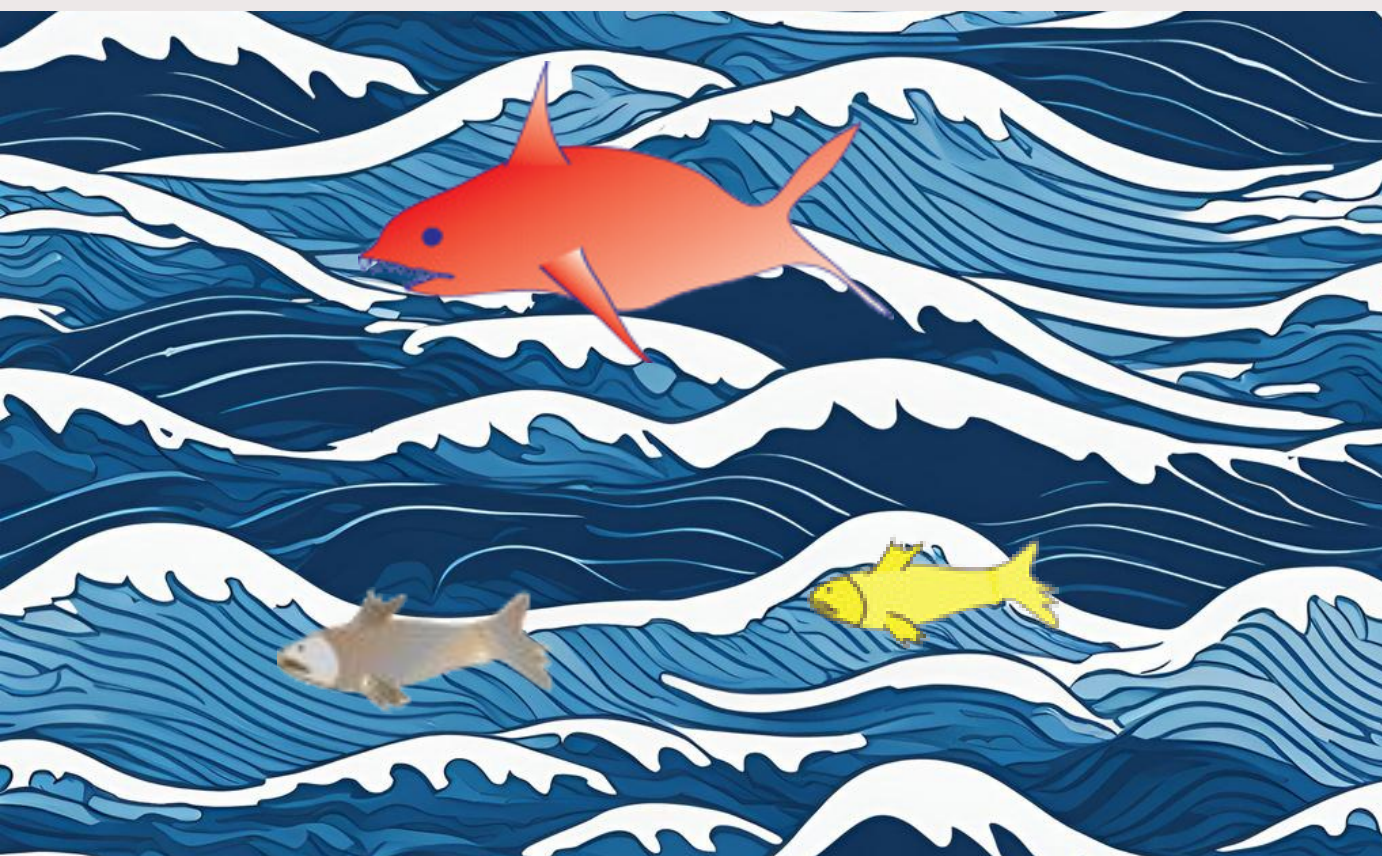
- i) Daily absorbed dose (DAD) through dermal exposure. (Non-Carcinogenic)
- ii) Hazard Quotient

Results



**IF YOU DON'T SEE IT DOESN'T MEAN IT IS NOT
WORKING:**
SAMPLE SIZE AND THE EFFECTIVENESS EVALUATION OF THE
MINAMATA CONVENTION

Asif Qureshi, Elsie Sunderland
IIT Hyderabad, Harvard University



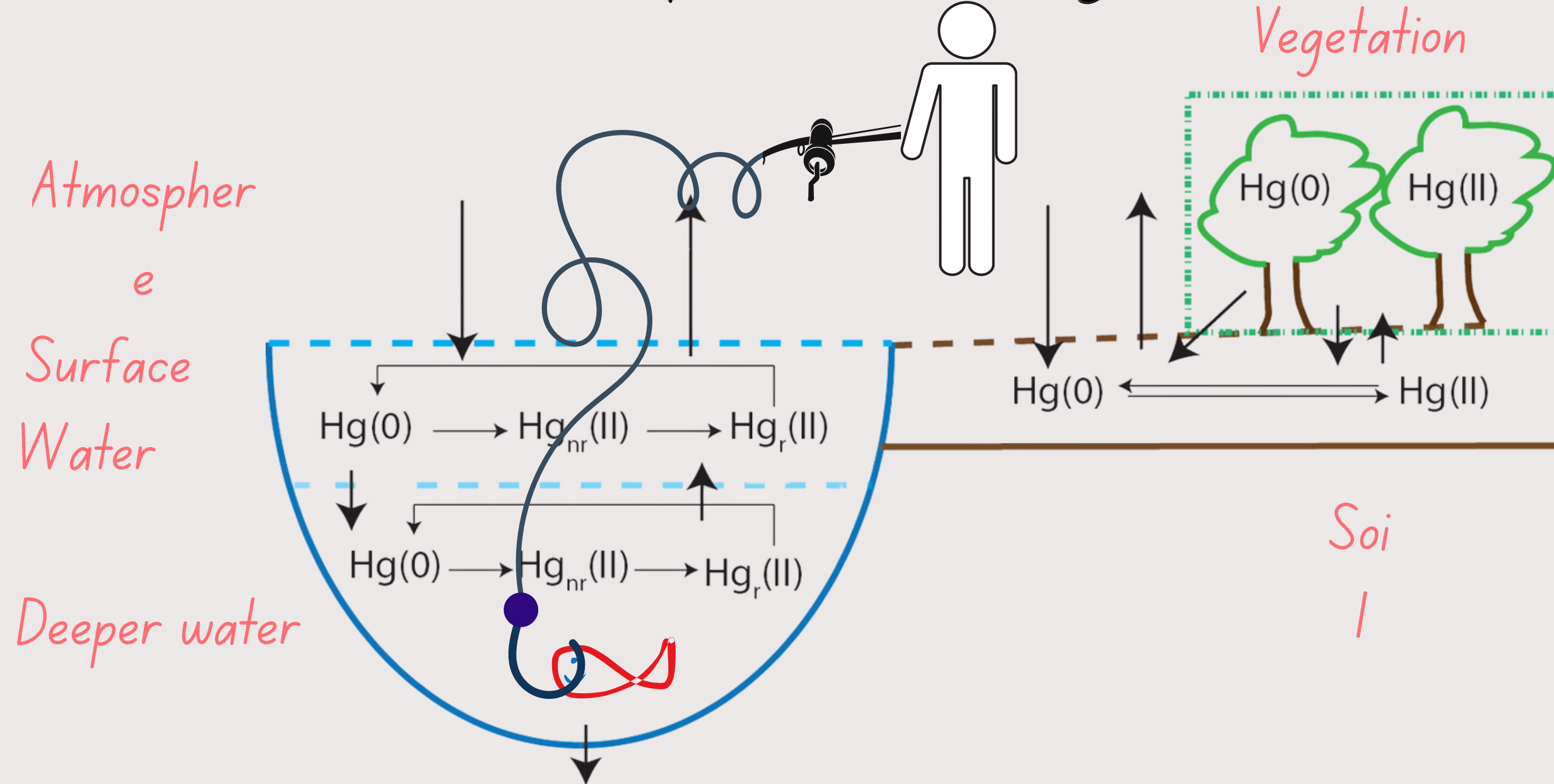
(in preparation)



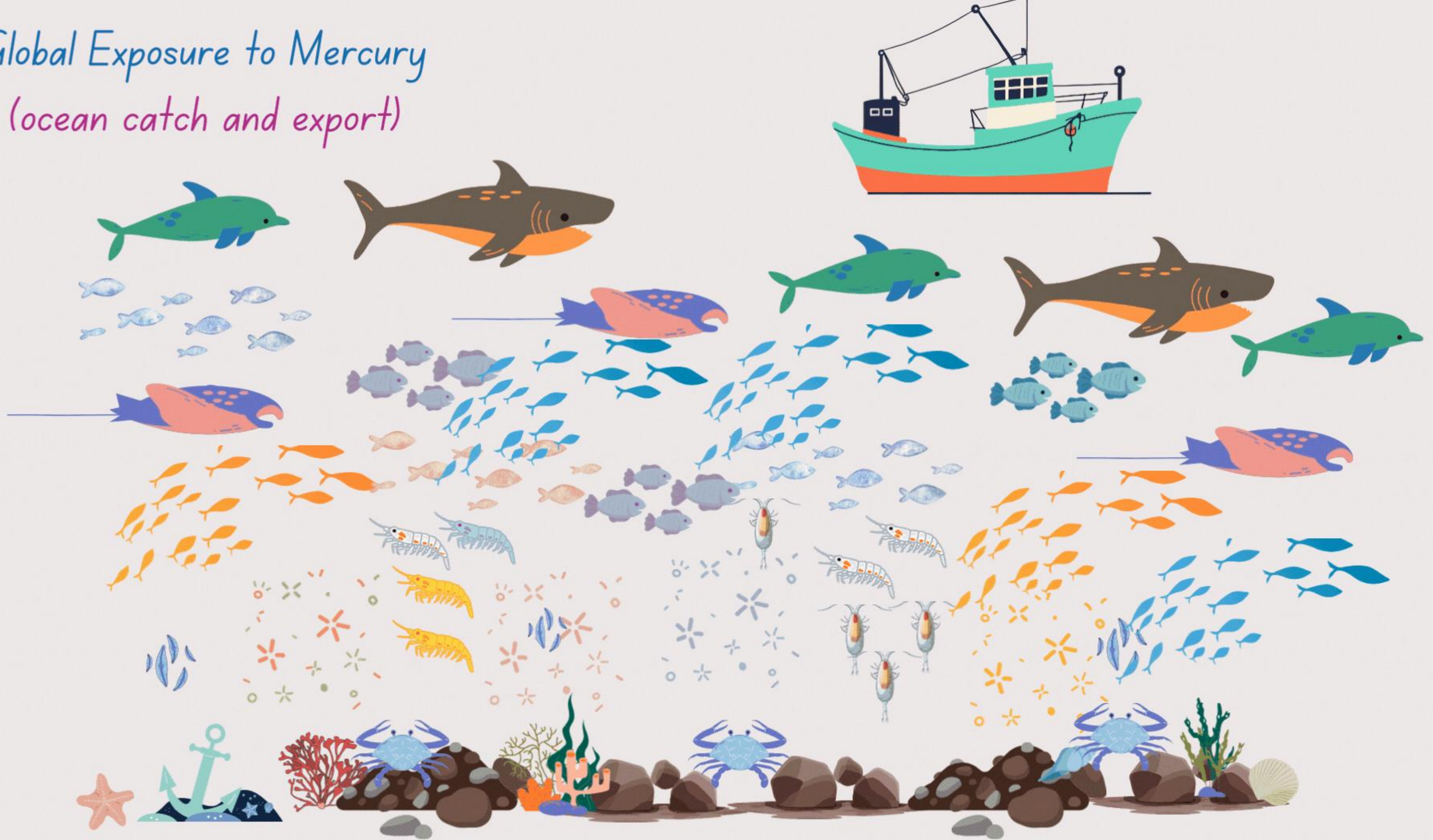
Globally fish is a major nutrition source

Concurrently people are exposed to mercury (& other contaminants)

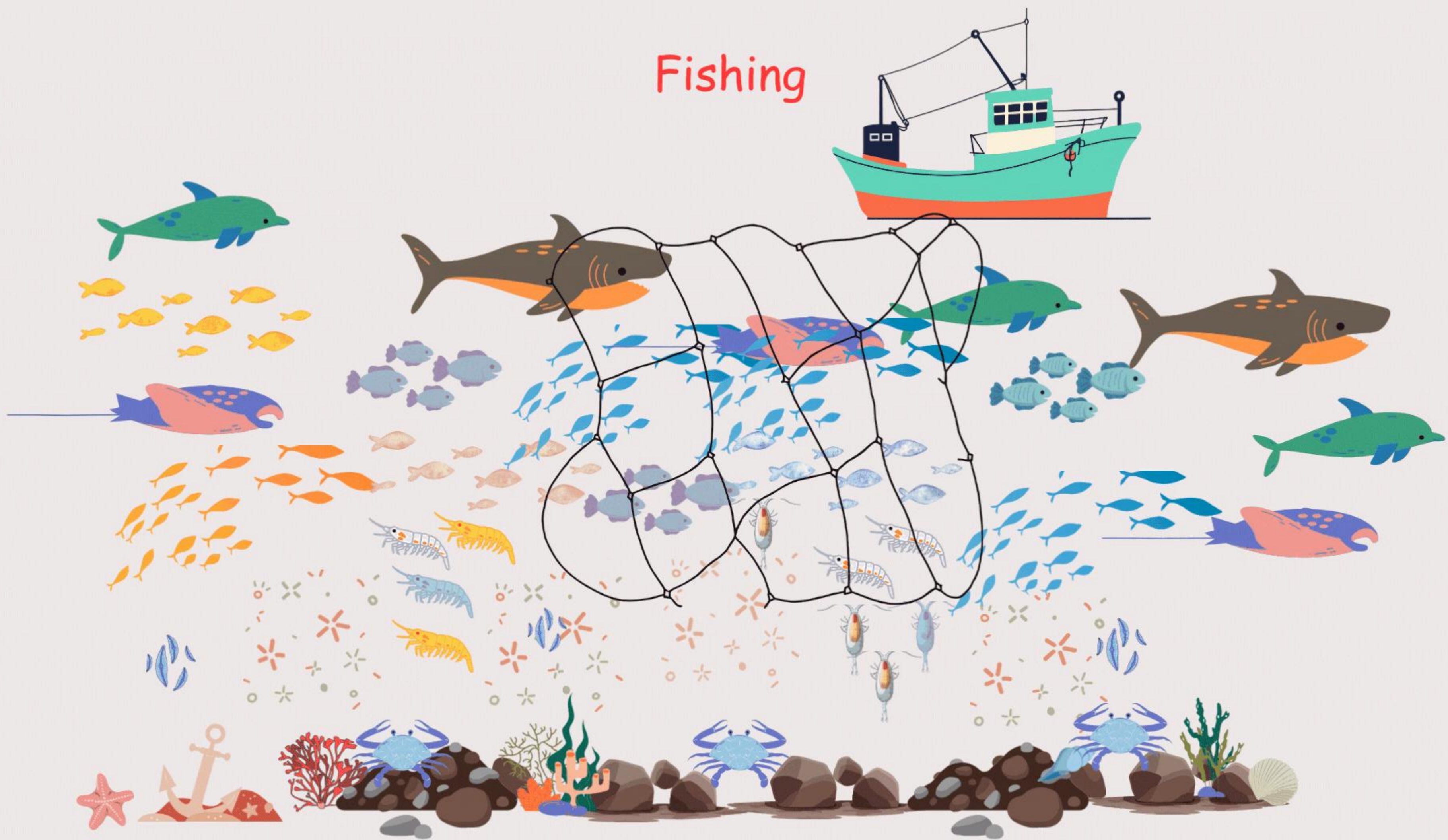
Local Exposure to Hg



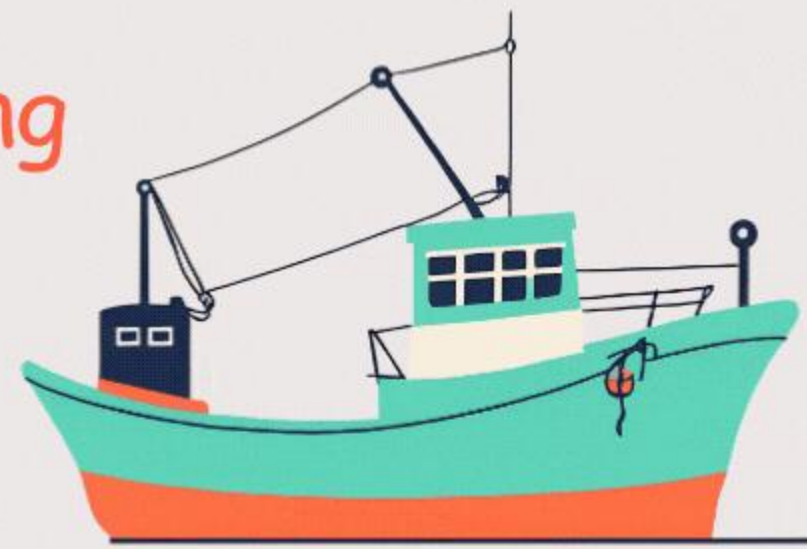
Global Exposure to Mercury (ocean catch and export)



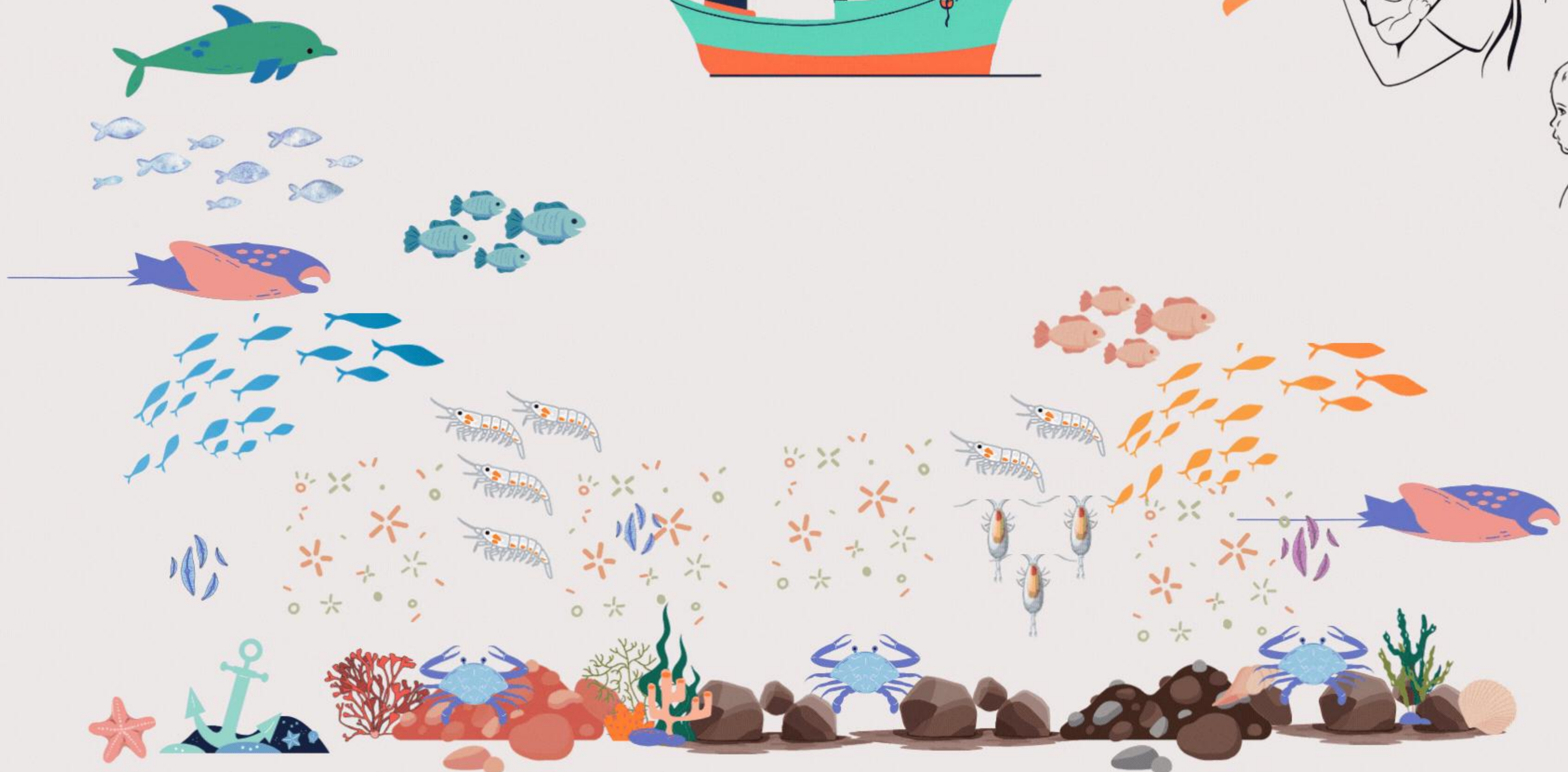
Fishing



Fishing



Exposure



Minamata Convention on Mercury

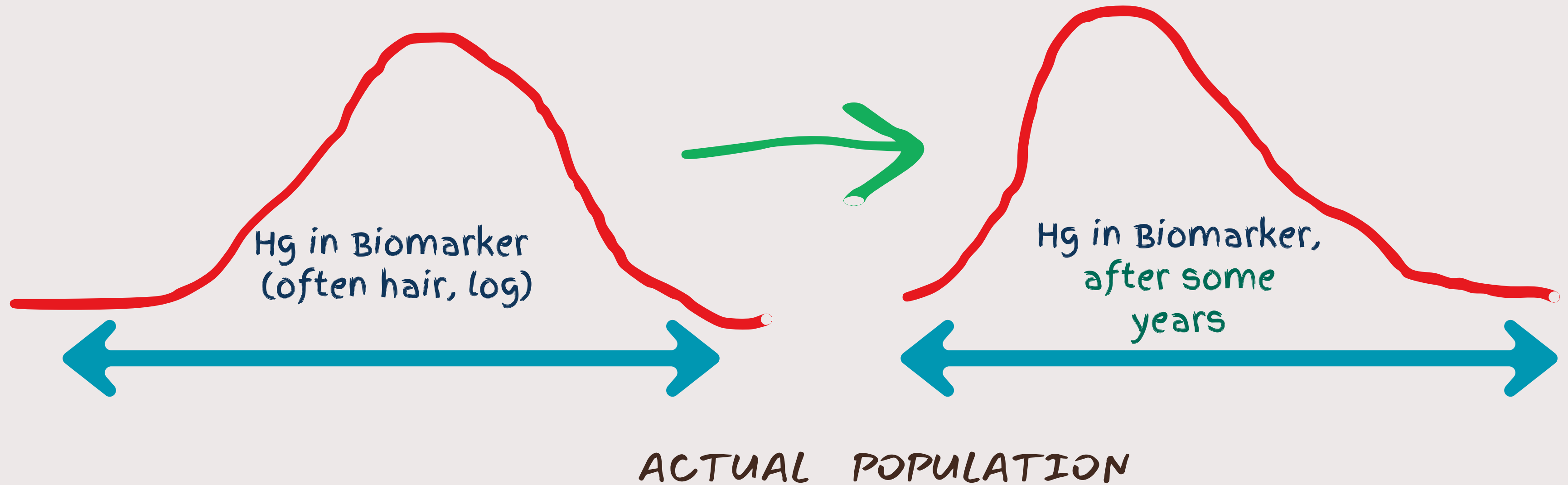
Primary goal: to
reduce human
exposure to mercury

Important to assess
how effective are
policy measures in
reducing the exposure

One of the approaches

- To monitor, and assess changes in, mercury in human biomarker over time
- Anything decreased or not

Assess changes in Hg exposure over time



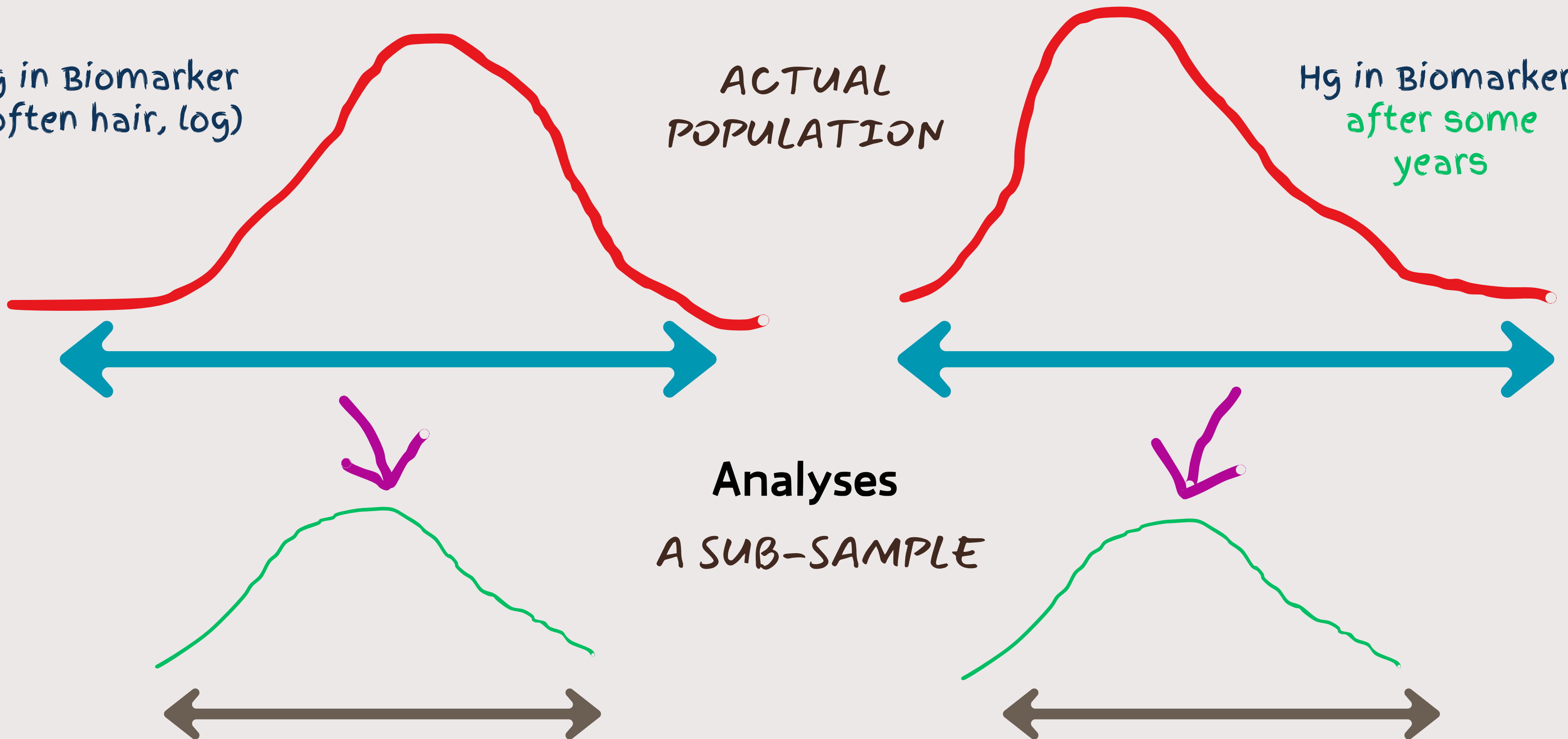
Hg in Biomarker
(often hair, log)

ACTUAL
POPULATION

Hg in Biomarker,
after some
years

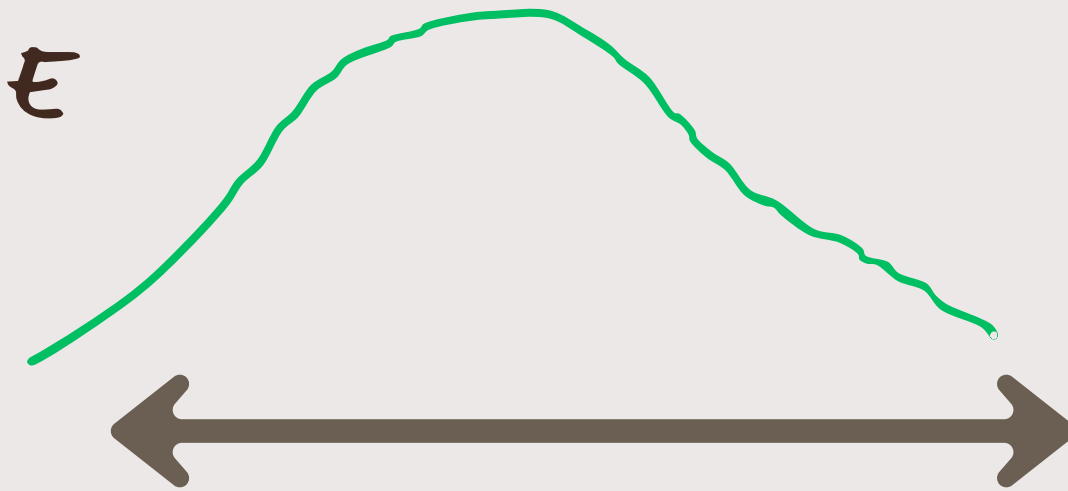
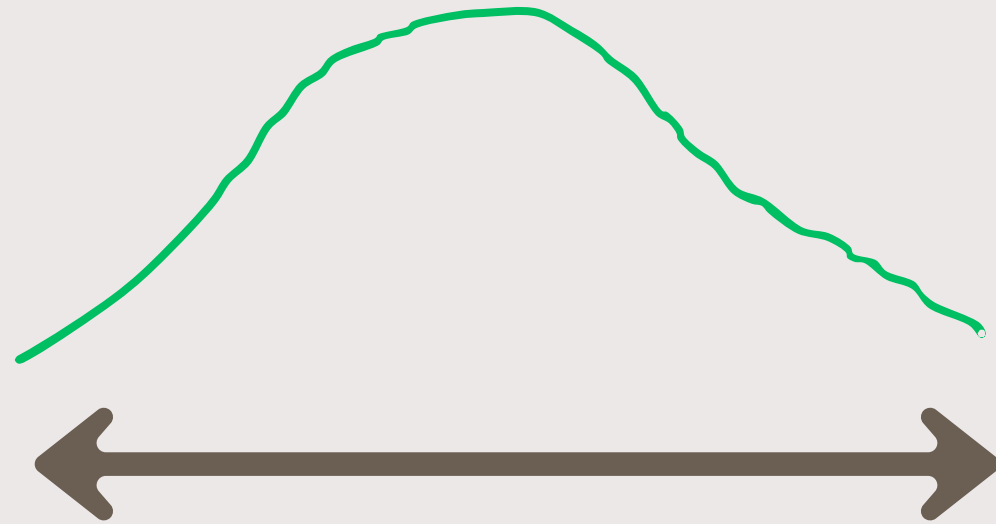
Analyses

A SUB-SAMPLE



Analyses

A SUB-SAMPLE



Key considerations

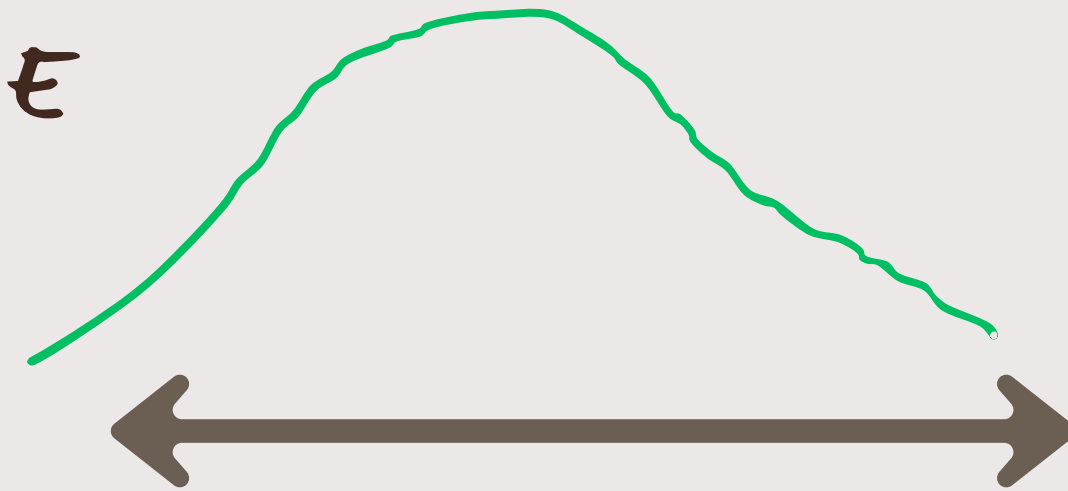
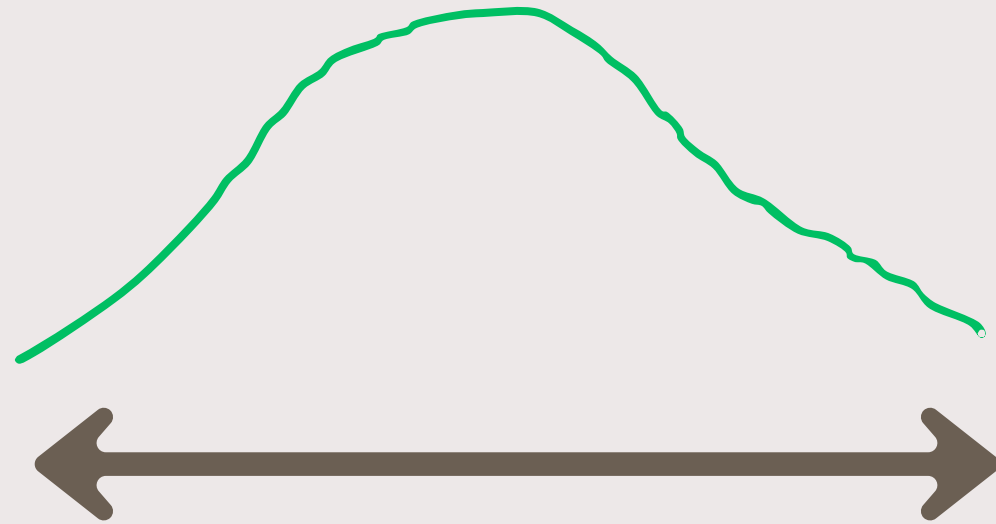
If there is a change, we should be able to detect it..

OR

If we are not detecting, is it because there is no change, or because there are sampling limitations?

Analyses

A SUB-SAMPLE



Key considerations

If there is a change, we should be able to detect it..

OR

If we are not detecting, is it because there is no change, or because there are sampling limitations?

THE GAME
OF....

SAMPLE SIZE !

(RE-) INTRODUCING STATISTICAL POWER

= (1- probability of failing to reject null hypothesis, when in fact it was false)

= "probability of making correct decisions" "detect an effect when one exists"

<https://www.ncbi.nlm.nih.gov/books/NBK557530/>

Non-consideration could lead to:

- poor reproducibility
- inability to assess impacts (= **lead to regulatory disappointment and inaction**)

f[sample size, effect size (mean, st.dev.), significance]

- Typically, one goes for a power of 80%, and significance level of 5%
- And determine the sample size that can detect a certain target trend

While all of us want to sample as many people as possible, it is not always possible...

- E.g., a global analyses by Basu et al (2018) had to constrain their a priori sample size cutoff by regions

"Because we anticipated fewer studies in low- and middle income countries, we reduced the minimum sample size so as to be able to report at least some data."

Basu et al. (2018) EHP

General population (LMIC): 100

General population (HIC): 200

Vulnerable population (HIC): 100

Vulnerable population (LMIC): 50

Sample-size in cross-sectional studies ranged from 50 to 1910

Background populations

South-east Asia: 1 sub-population with 80 individuals

Africa: 2 sub-populations with 162 individuals

Americas: 14 with 7622 (== ave = 544)

East Med.: 4 with 1072 (== ave = 268)

West Pacific: 30 with 36,259 (== ave = 1208)

ASGM: 30 sub-populations with 7800 individuals (== ave = 211)

If there is an intervention: WHEN ABOVE IS OK, WHEN NOT OK?

Key considerations

If there is a change, we should be able to detect it..

OR

If we are not detecting, is it because there is no change, or because there are sampling limitations?

MOTIVATION

For typical sample sizes in cross-sectional studies (tens to thousands)

- How well placed are we in reliably detecting trends, when they do exist?
- And not miss them..

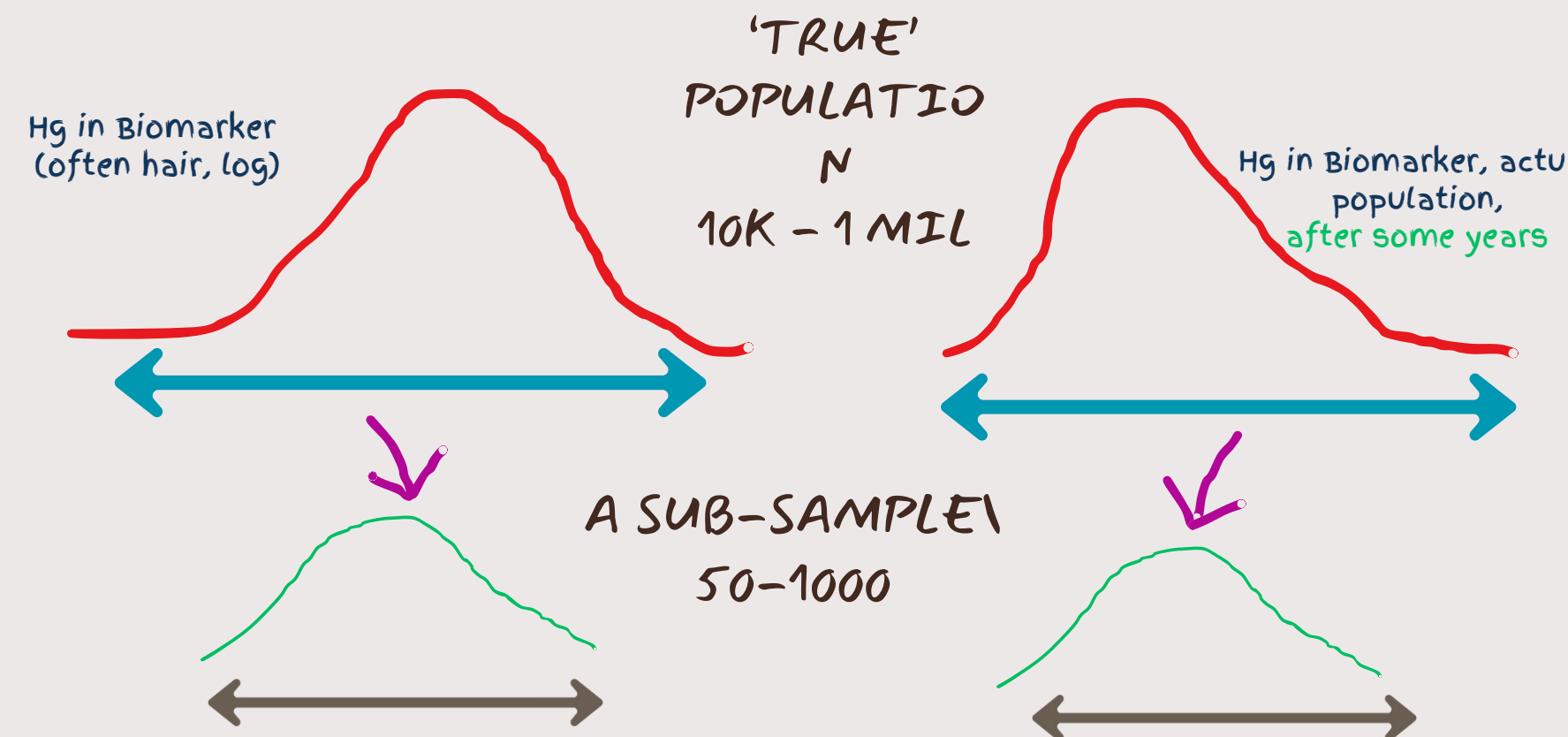
OBJECTIVES

To assess

- A sampling strategy for evaluating trends of mercury concentrations in populations using human hair as the biomarker

METHODS

- Three initial mercury doses: 0.01, 0.05, 0.1 g/kg.bw-d
- Using the USEPA one-box model for mercury toxicokinetics
 - Generate a distribution of mercury concentrations of
 - Three 'true' populations: 10 000, 100 000, 1 000 000
 - Decrease dose by 1%, 5%, 10%, 20%, 30% (Could be emissions reductions)
 - Take before and after sub-samples (as in a biomonitoring program)
 - 50, 100, 500, 1000 samples



1. Test reproducibility (1 mil pop)

- Draw sub-samples 10000 times
- Conduct a t-test
- How many times null hypothesis is rejected

2. Determine sample sizes

- a. To achieve $\alpha = 0.05$ and power = 80% at steady state

3. 'MC scenario'

- Decisions to reduce emissions by 30% over 20 years
- Hair biomarker measured every 4 years
- Calculate sample size

4. Effect of changes in dietary habits

RESULTS (1)

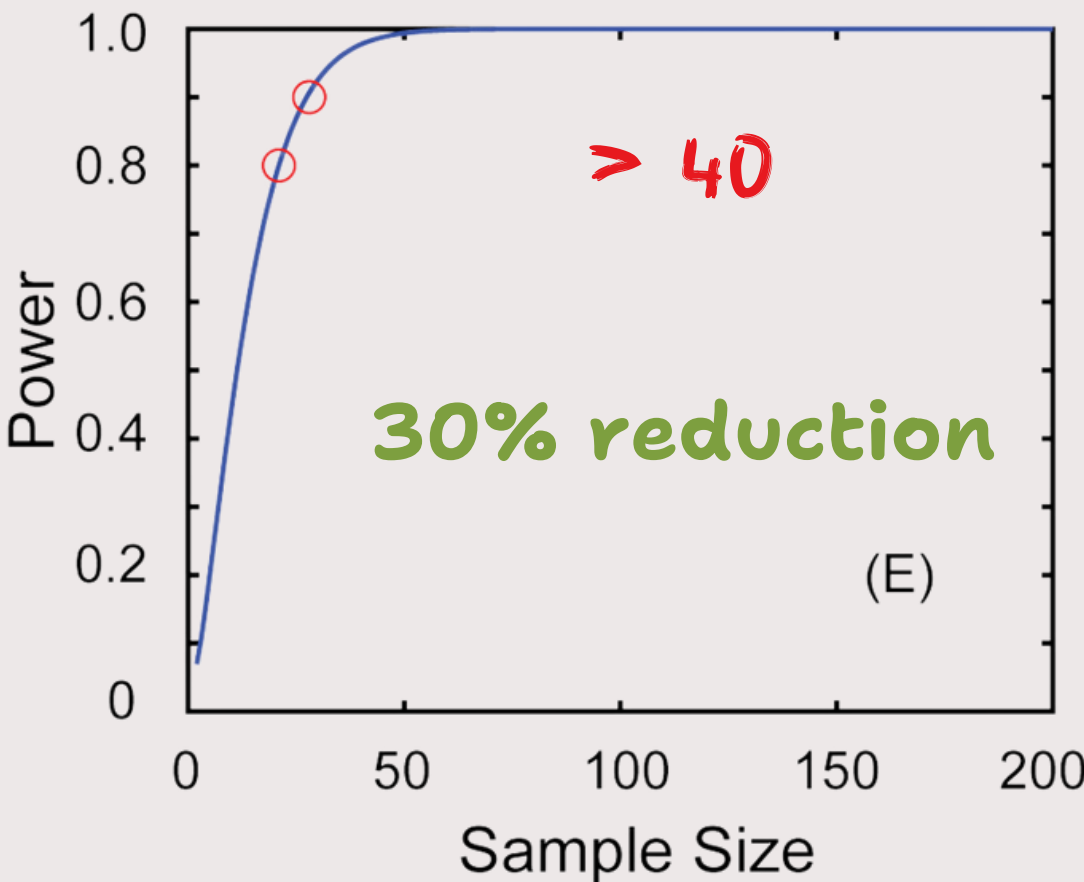
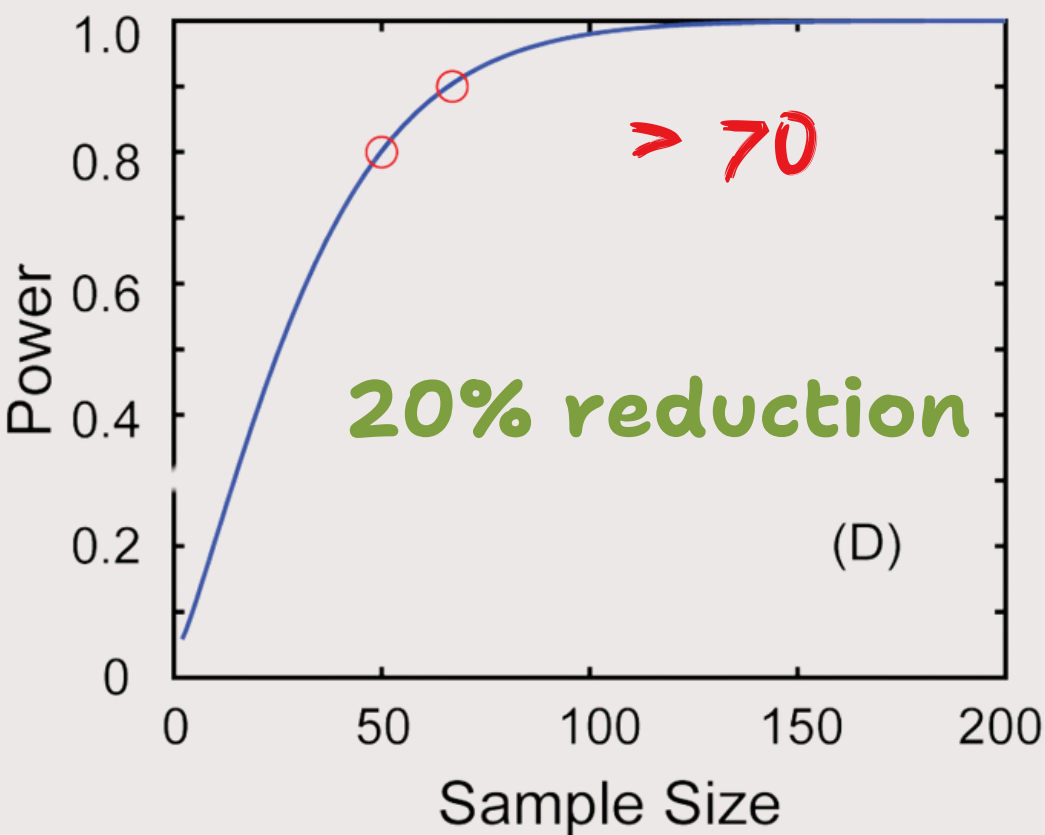
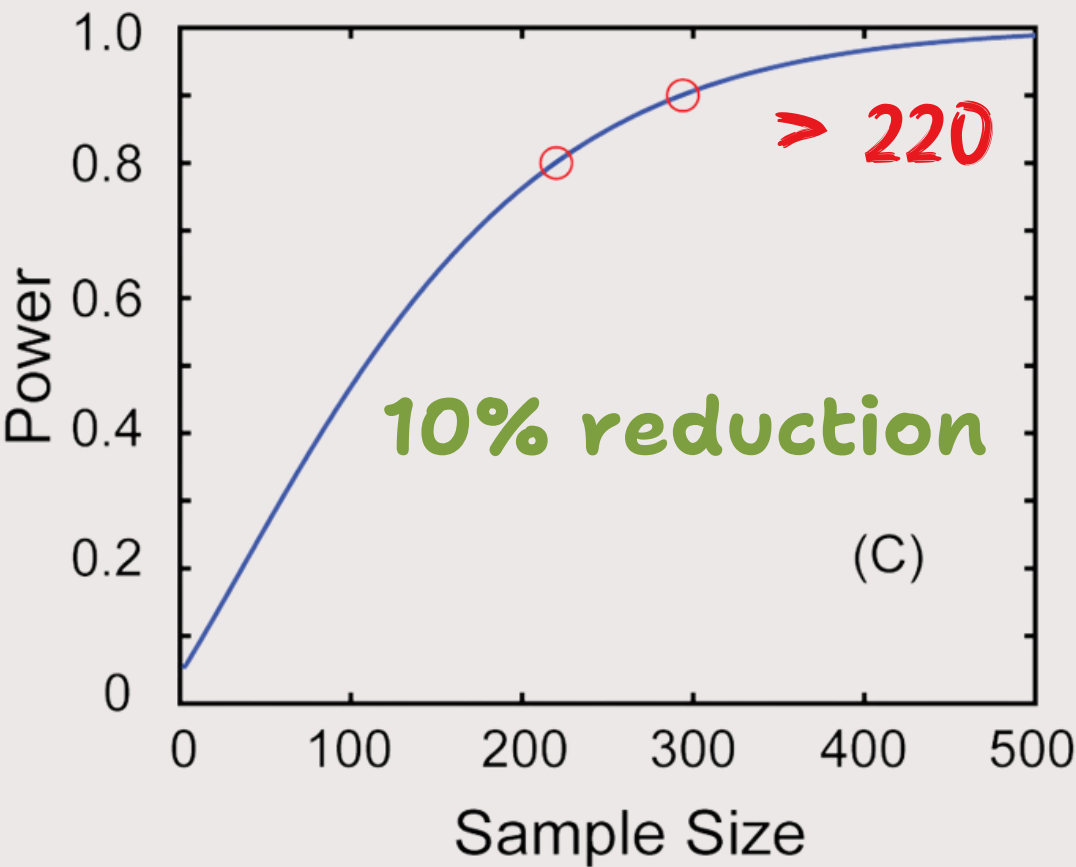
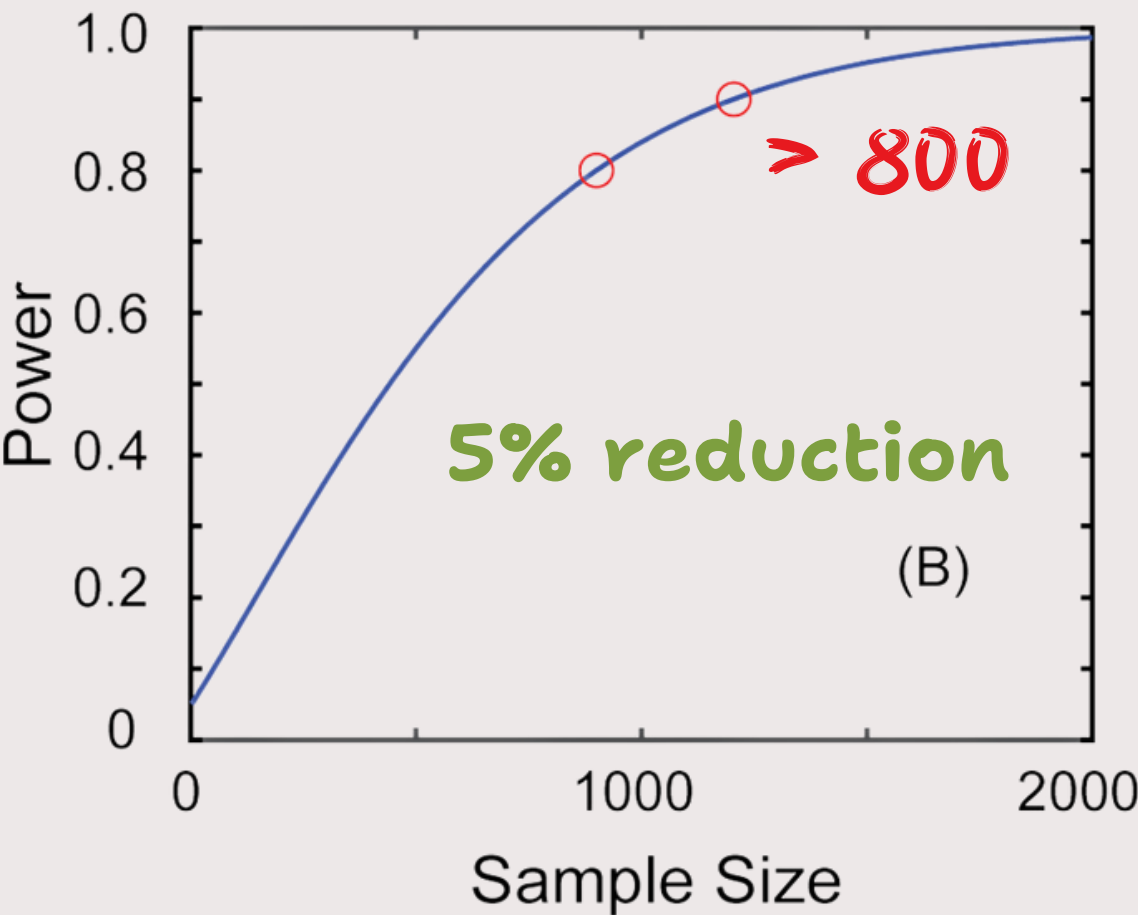
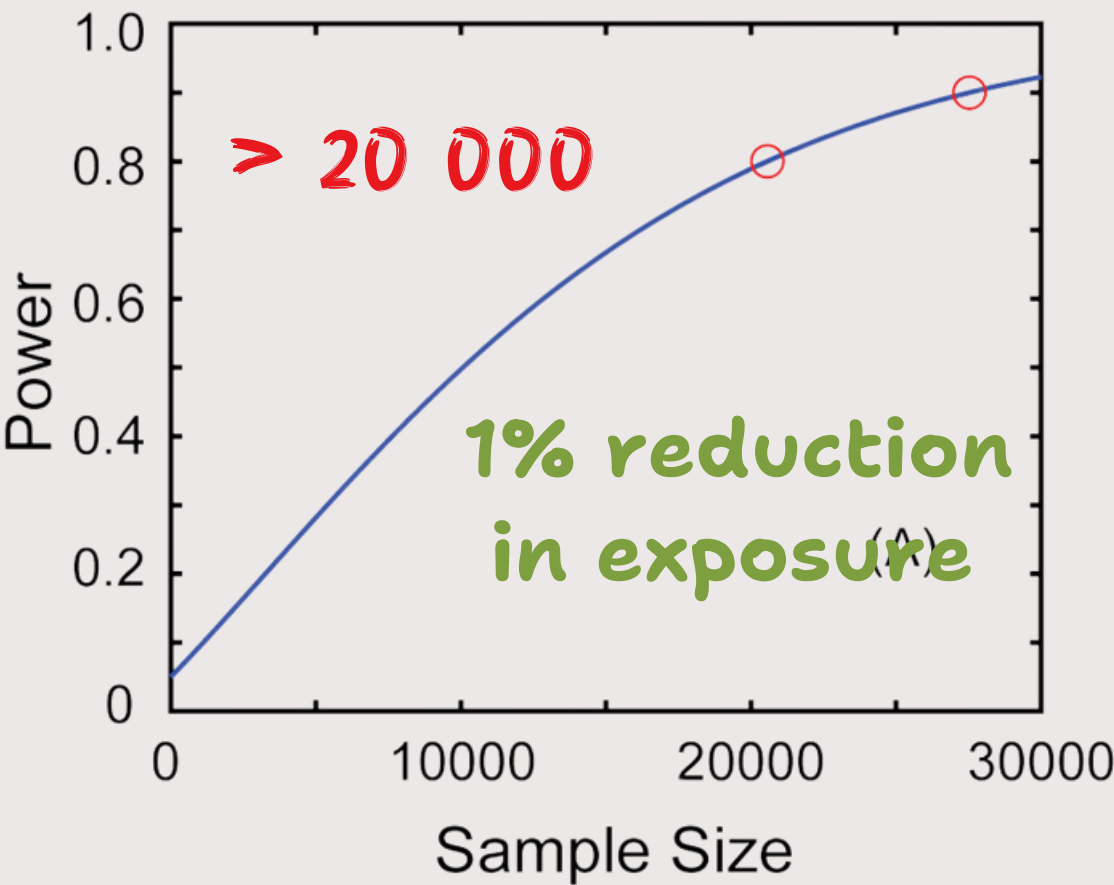
Probability of not rejecting the null hypothesis (that human exposure to mercury has not reduced) when it was false
BOLD is < 80% power

- 1. Test reproducibility (1 mil pop)
 - Draw sub-samples 10000 times; 50, 100, 500, 1000;
Conduct a t-test

Observations' Sample Size / Reduction in Exposure	50	100	500	1000
1 %	0.95	0.95	0.93	0.93
5 %	0.93	0.89	0.69	0.45
10 %	0.84	0.73	0.15	0.01
20 %	0.48	0.19	0	0
30 %	0.12	0.01	0	0

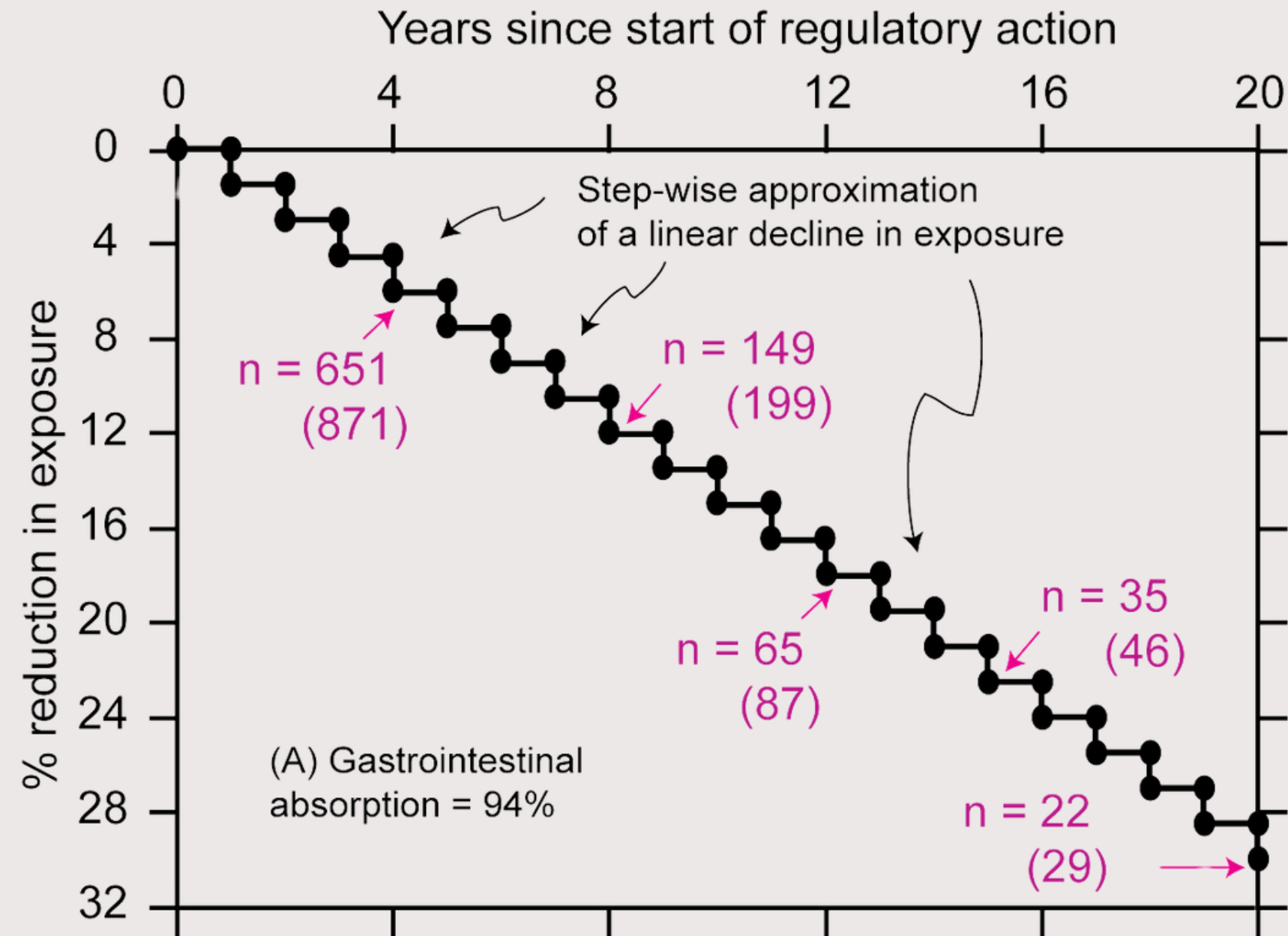
Even with 1000 sample size, studies will be divergent 45% of the times if reduction is < 5%

RESULTS (2)



Sample sizes to achieve 80% power (1 mil population)

RESULTS (3)



- 700 samples required to reliably detect change after 4 years
- 150 after 8 years
- So, if $n < 700$, non-observance of change should not deter continued reduction of emissions after the first 4-yearly evaluation

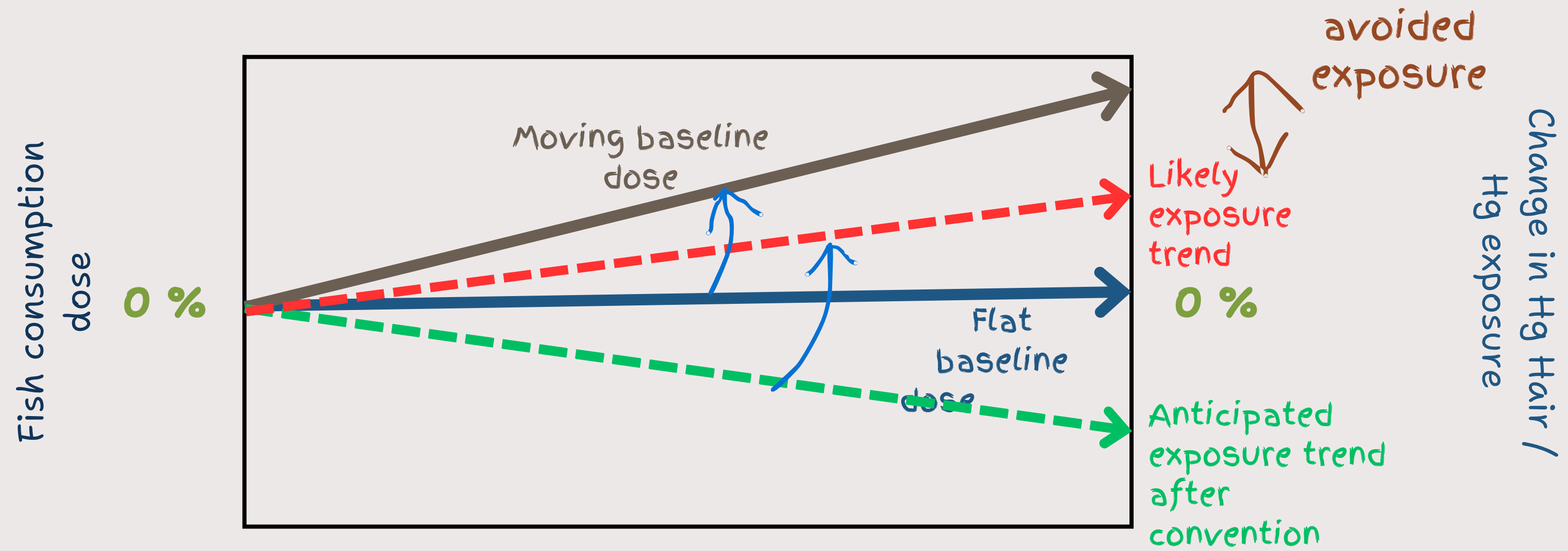
(4) Comment on changing diet

As an example

- All Adult mean seafood intake: 158 +/- 6 g/week
 - Nutritionists say seafood intake should increase

- If increases by 10%, it is unlikely we will see any reduction in hair Hg anytime soon
- Even though the convention is working effectively

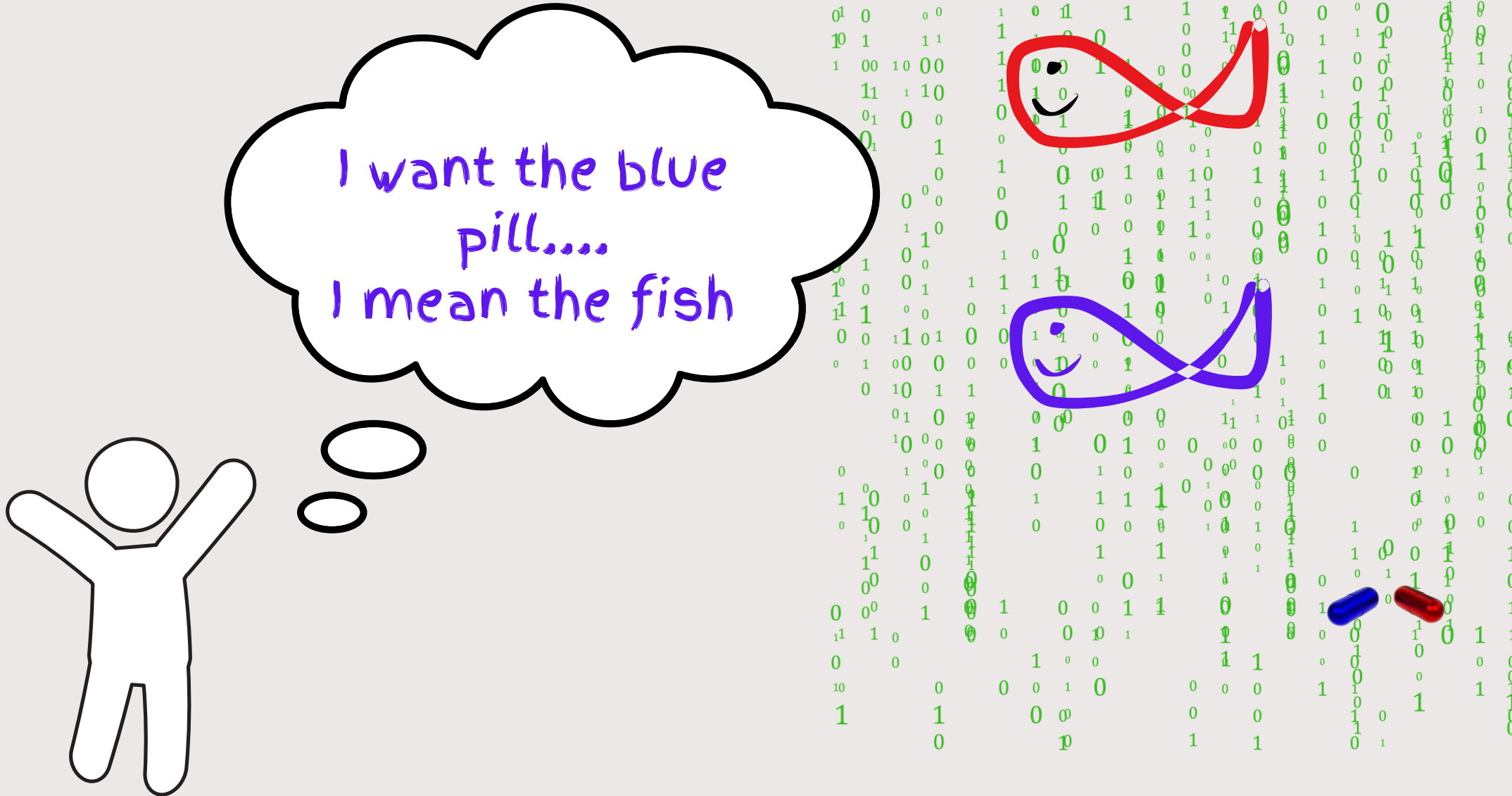
Jahns (2014) <https://doi.org/10.3390%2FnU6126060>



(4) COMMENT

What about feeding preference changes?

Fish	Mean Hg (ppm)
Mackerel	0.05
Cod	0.111
Salmon	0.022
Pollock	0.031
Sardine	0.013
Herring	0.078
Shrimp	0.009



What is feeding preference changes?

- Marginally switching diet from mackerel to cod could lead to increased Hg exposure by 10-20%
- Again, is unlikely we will see any reduction in hair Hg anytime soon
- Even though the convention is working effectively

SUMMARY

- For studies of sizes 50-500
 - difficult to reliably detect the effectiveness
 - if the magnitude of change is lower than 5% or so
- Effectiveness is easier to detect with smaller sample size in highly impacted populations
 - direct interventions → > 20% reductions
- For gradual decrease in emissions, effectiveness may anyways not be visible
- Observations will be complicated if the population changes diet

This should not discourage parties from taking more action

Without action, we would be actually increasing exposure (even if we don't detect it for the first few years)!

Thank you

Acknowledgements:

Taiwan EPA

NCU

Guey-Rong And Da-Wei

NADP & USEPA



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