Total mercury and methylmercury levels in hair, blood, and urine of individuals following controlled intake of tuna fish

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Introduction

Fish – an important source of nutrients but also the main source of human exposure to Hg

→ large, predatory fish can contain high amounts of MeHg (biomagnification through the food chain)

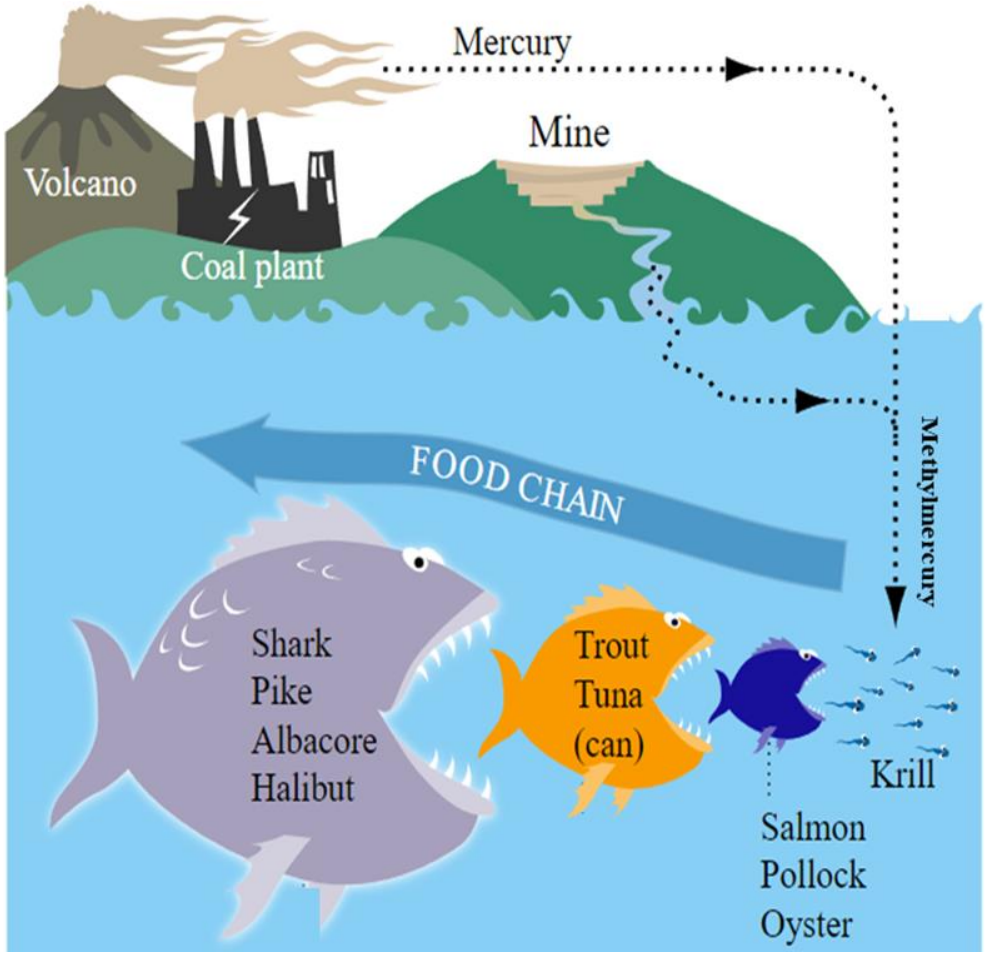
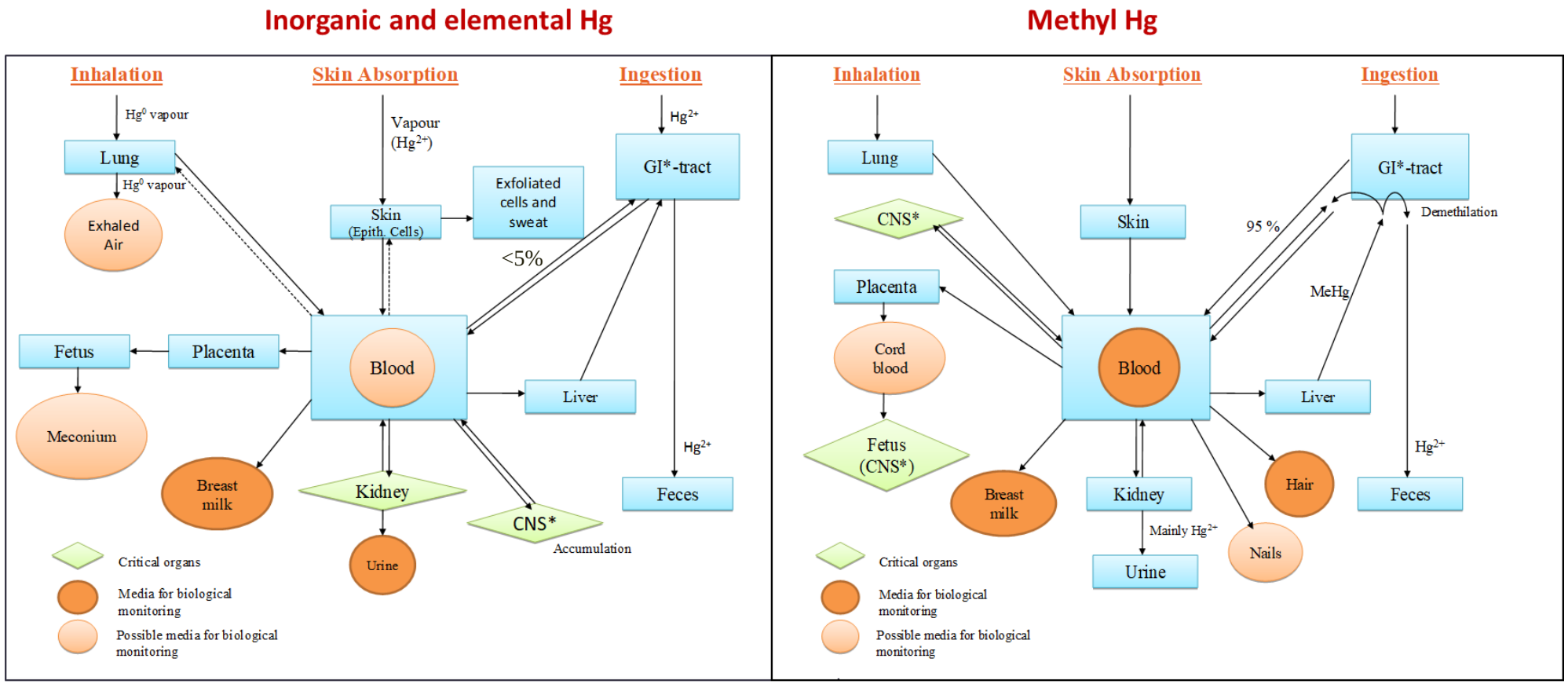


*Image adapted based on Bretwood Higman, Ground Truth Trekking

- Different mercury **species have different toxicokinetic properties**

→ MeHg is readily absorbed in the GI tract, IHg absorbed very little



*GI: gastrointestinal; CNS: Central Nervous System

Elinder CG, Gerhardsson L, Oberdorster. 1988. Biological monitoring of toxic metals-Overview. p 1-71. In Biological Monitoring of Toxic Metals, Ed. T.W. Clarkson, L. Friberg, G.F. Nordberg and P.R. Sager, eds. New York. Plenum press.

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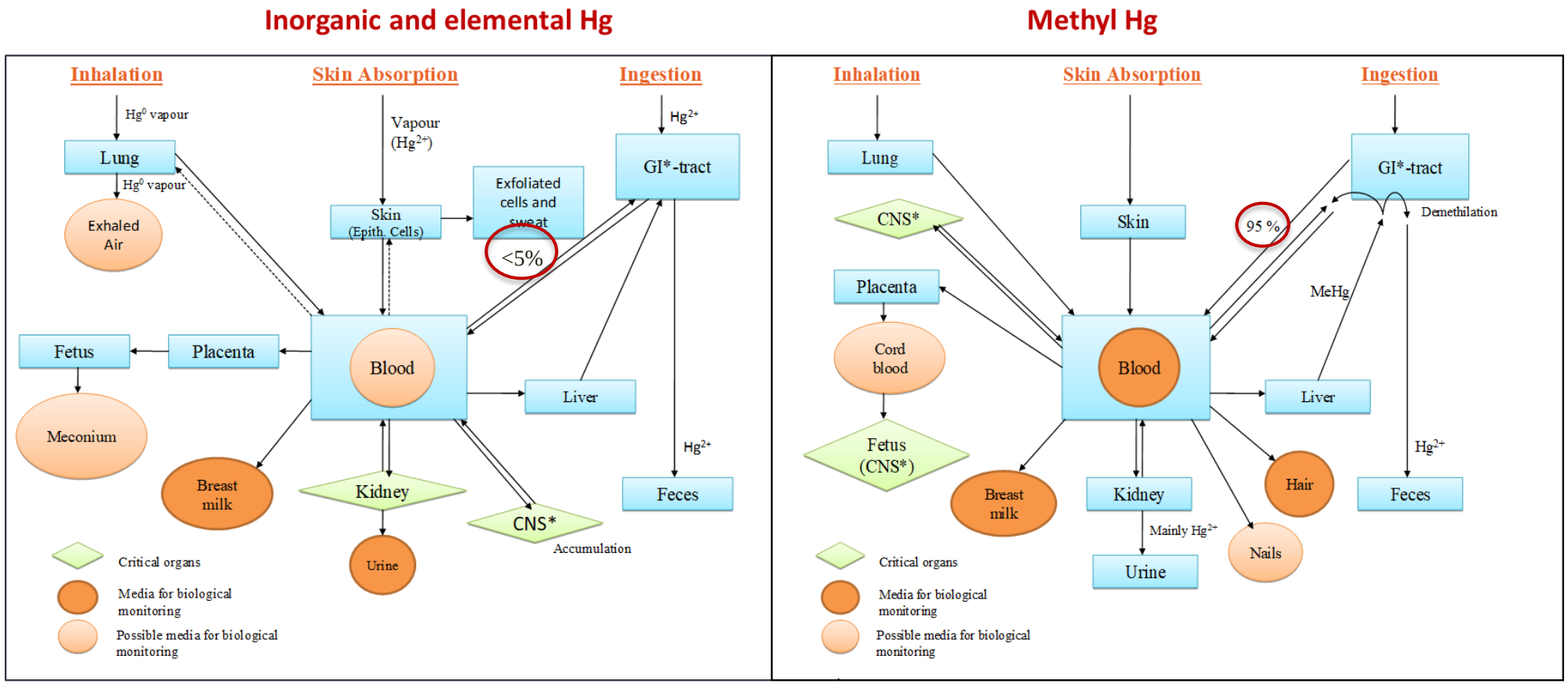

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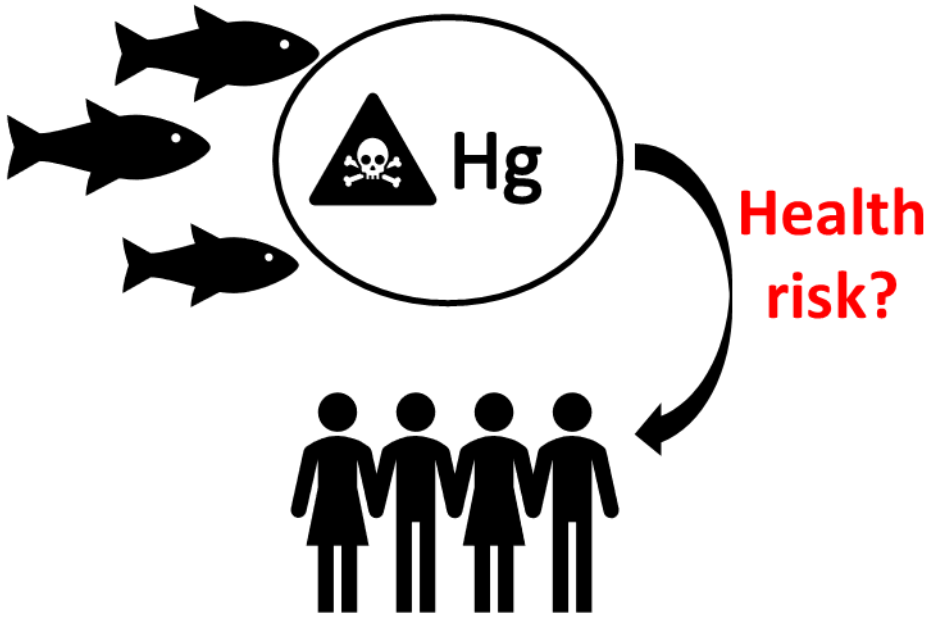
- Common assumptions in health risk assessment:

  → all Hg in fish is MeHg
  → ingested MeHg from fish is 95-100% bioavailable

- based on **outdated** studies with significant **limitations**
  (e.g. unrealistic exposure routes, not using MeHg bound to fish tissue from natural contamination)

- studies on Hg kinetics – outdated, often limited data
- many uncertainties, worst-case scenario approach



This can lead to an overestimation of exposure and risk!

Our aim: reduce the uncertainties in the exposure and HRA and validate pharmacokinetic models (detailed kinetic data from controlled exposure) → better prediction of individual internal dose, better risk assessment

The tuna experiment

→ creation of a **realistic** and **controlled** exposure scenario and subsequent measurements of **THg and MeHg** in **multiple** biological samples

→ **16 volunteers** (10 in experimental group + 6 in control group)

cut into 300 g steaks
(50 steaks)

THg concentrations differed between the 4 different original steaks (378-1157 ng/g fresh weight)

- samples for THg and MeHg measurements and multielemental analysis taken from each steak
- each volunteer in the experimental group was given 5 steaks to consume over 5 consecutive days

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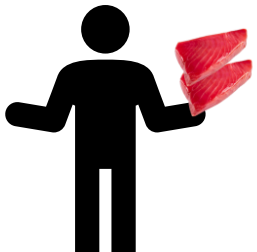

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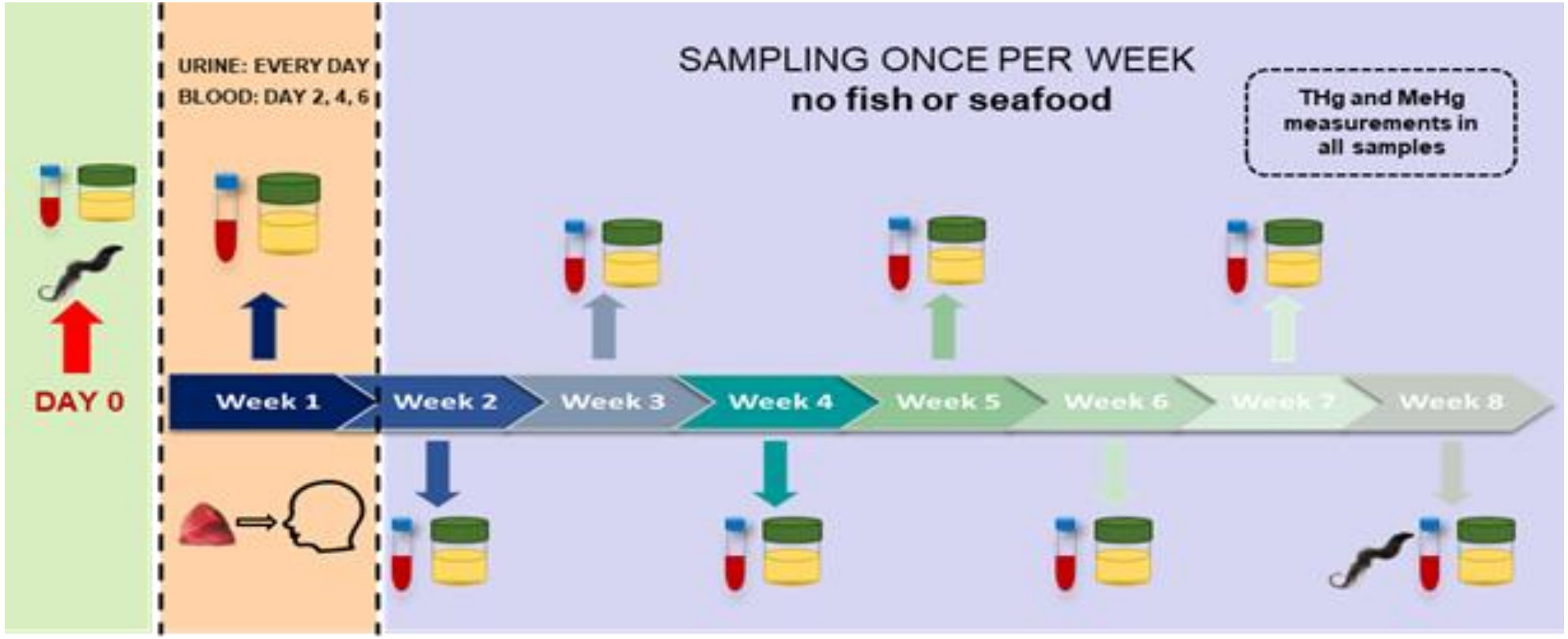
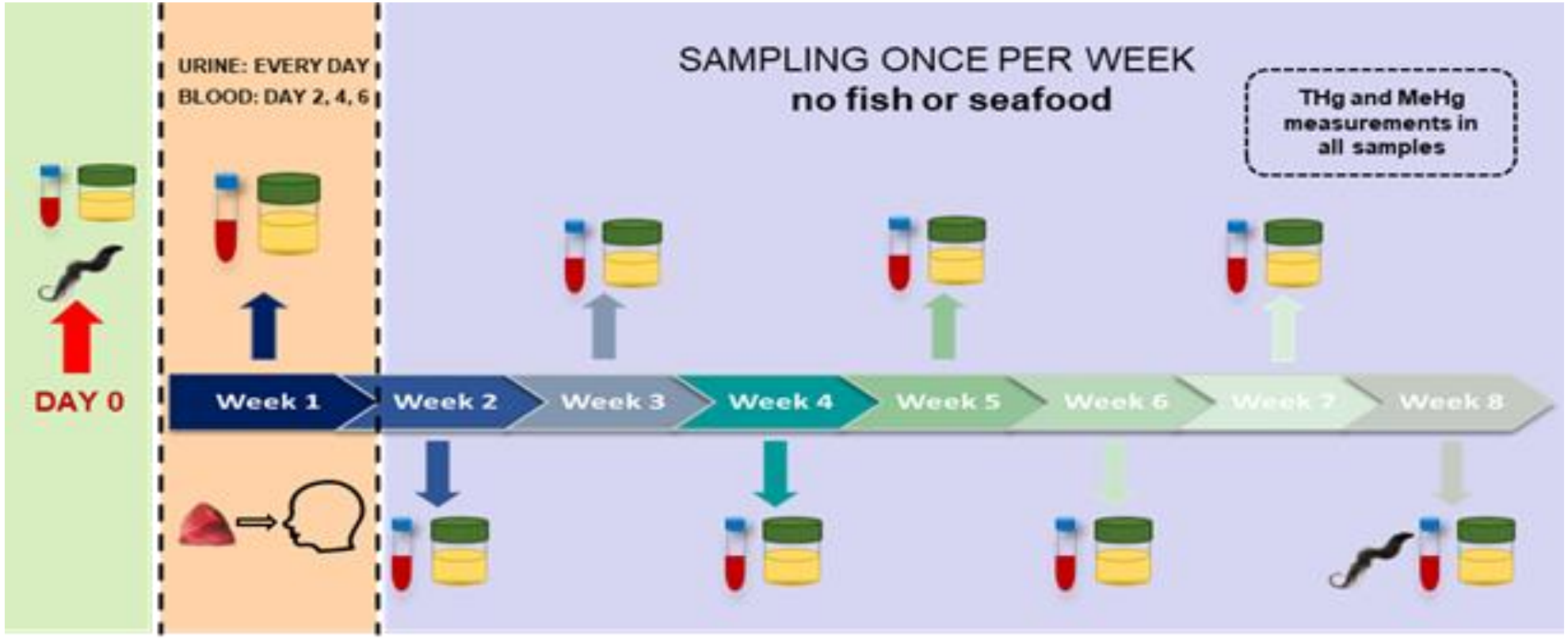
The sampling regimen



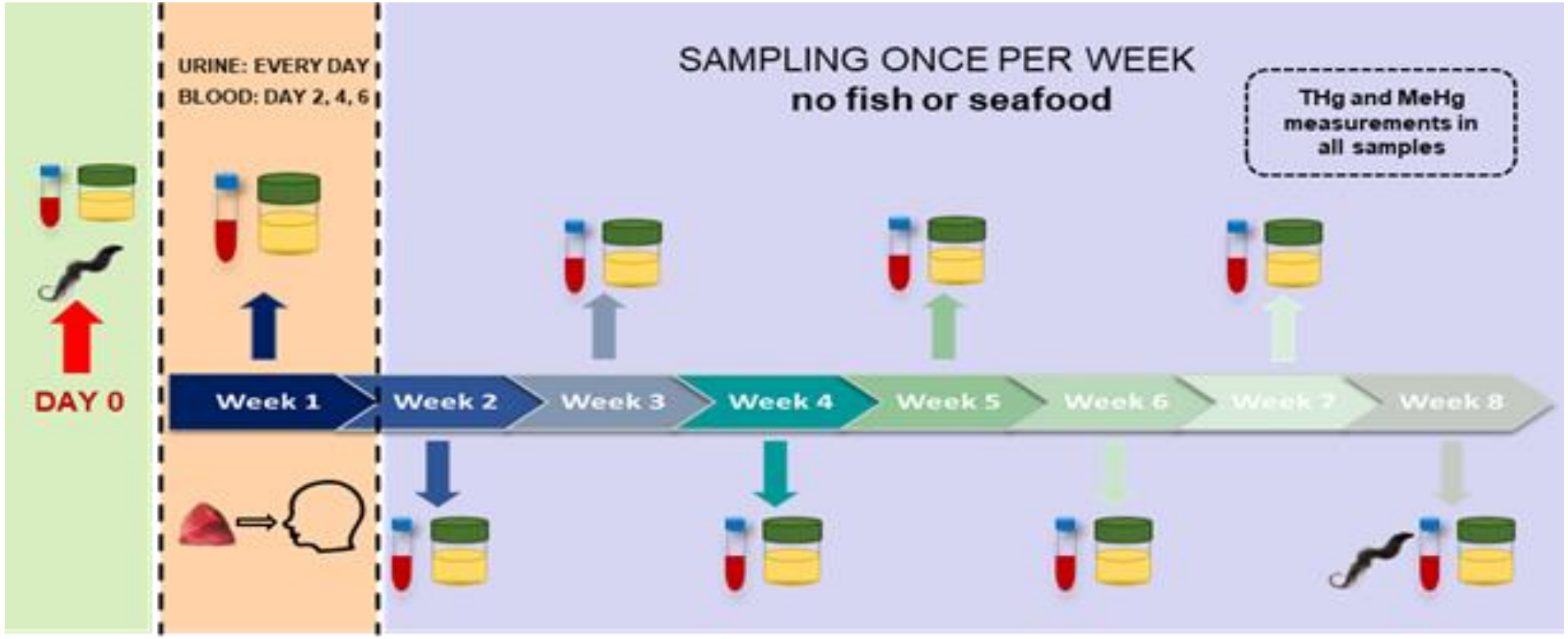
The sampling regimen

13.01.2023



The sampling regimen

Dietary diary – how tuna was prepared, foods and drinks consumed with it



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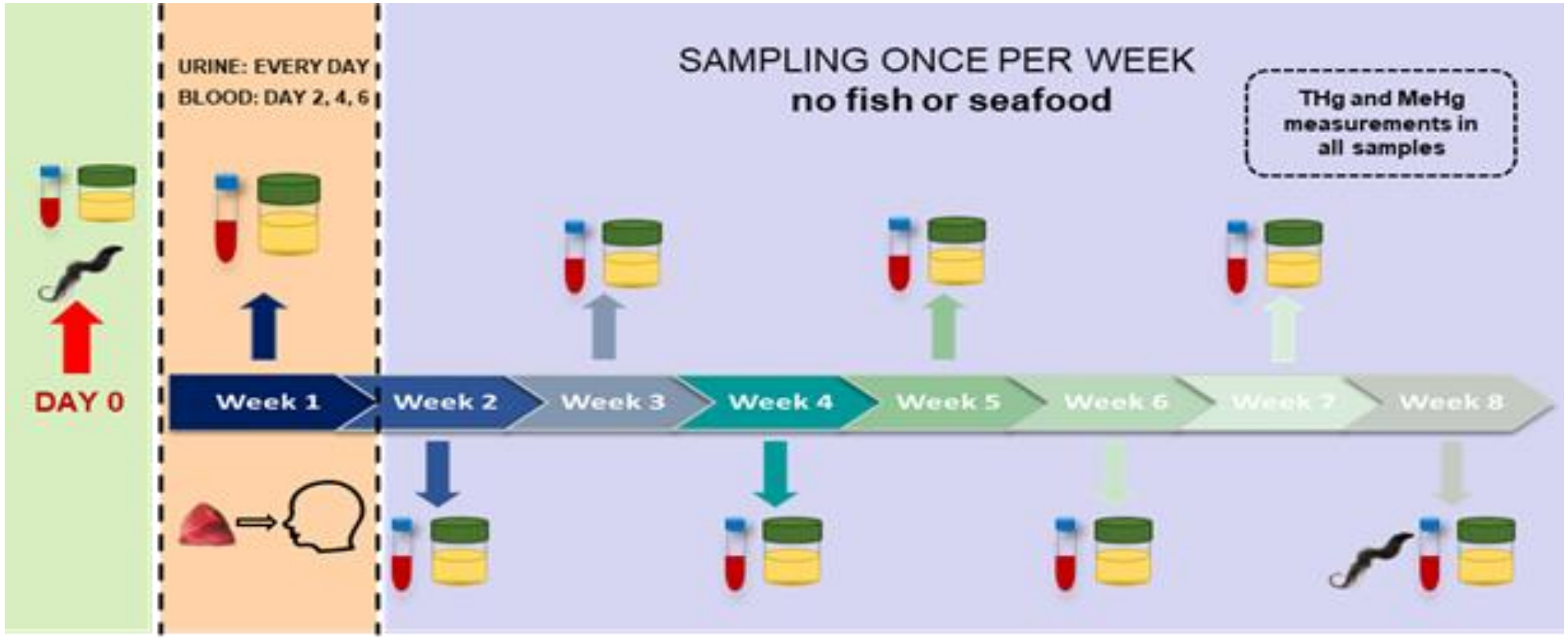

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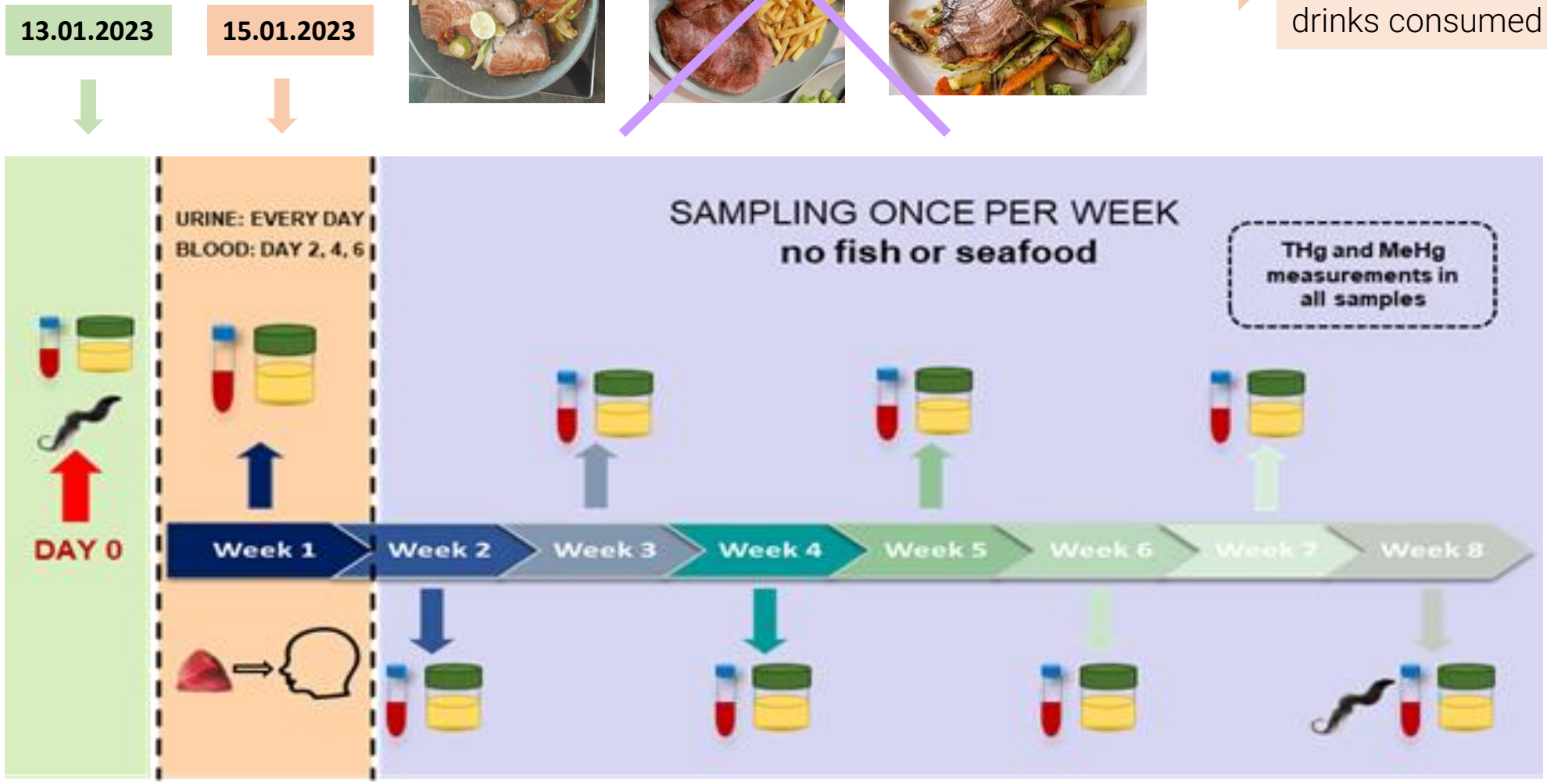
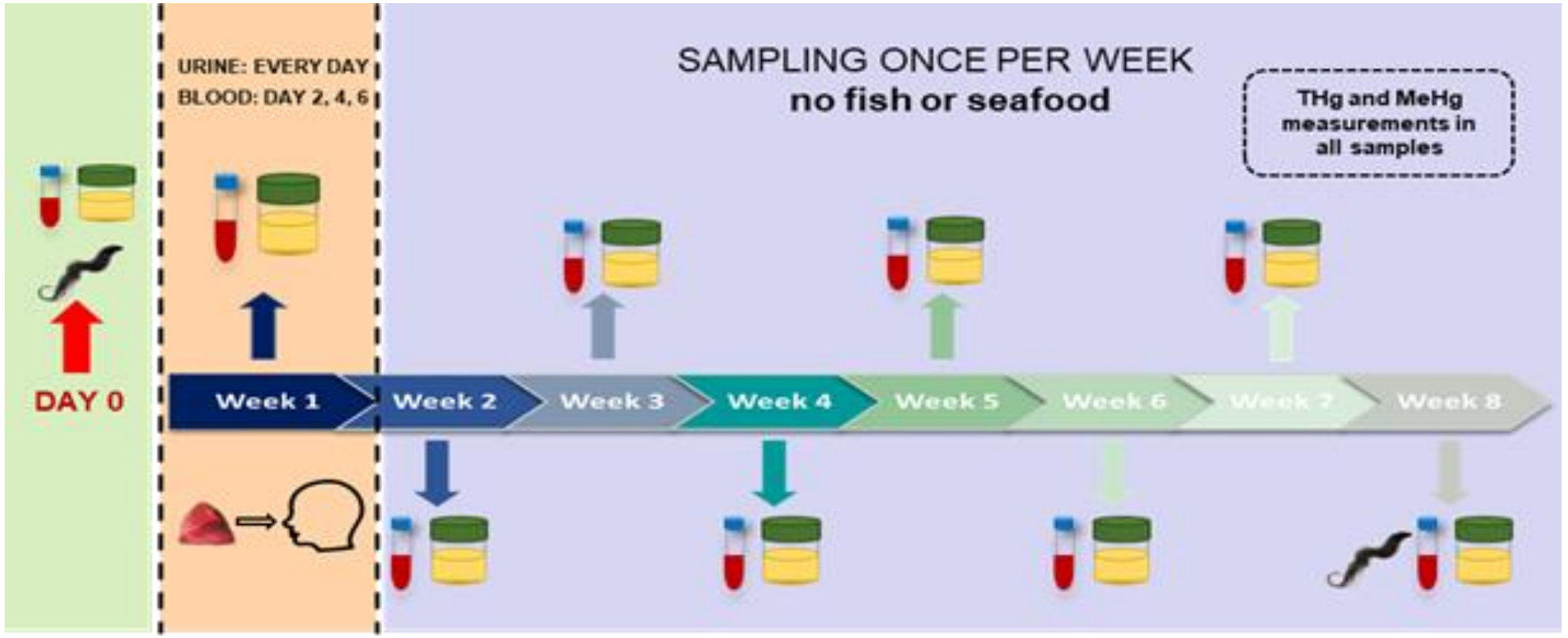


The experiment was continued until week 12, with **13 total sampling dates** (last on the 14th of April)

The sampling regimen

Different cooking methods – reduction of bioaccessibility of Hg from fish

Dietary diary – how tuna was prepared, foods and drinks consumed with it



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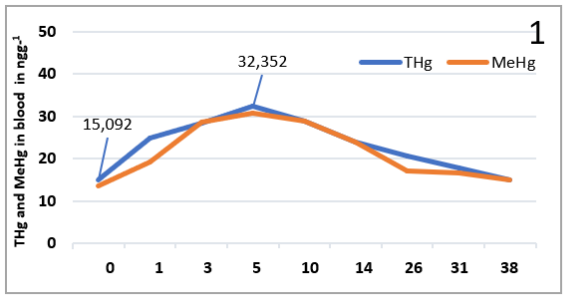
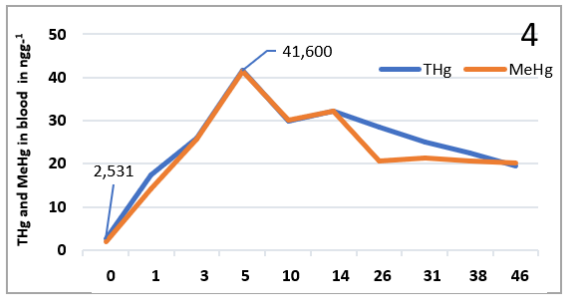
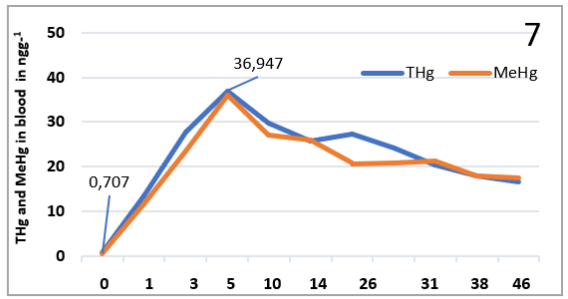
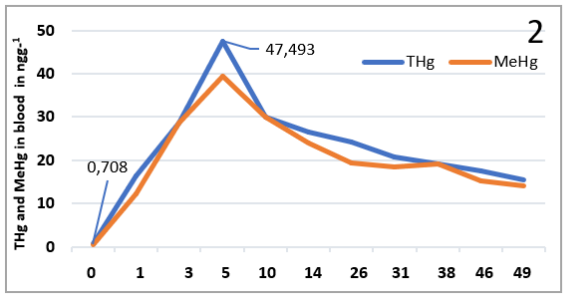
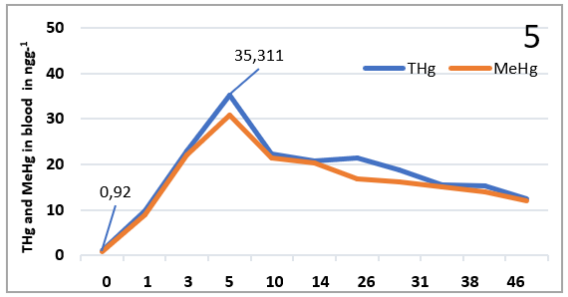
Total and methylmercury levels in blood over time – experimental group

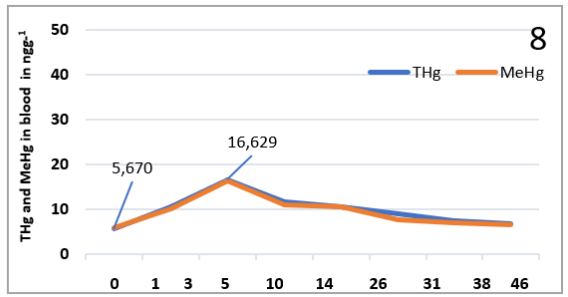


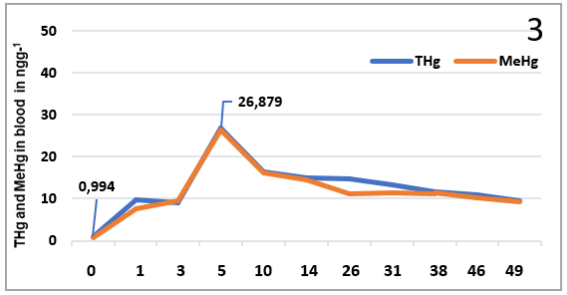


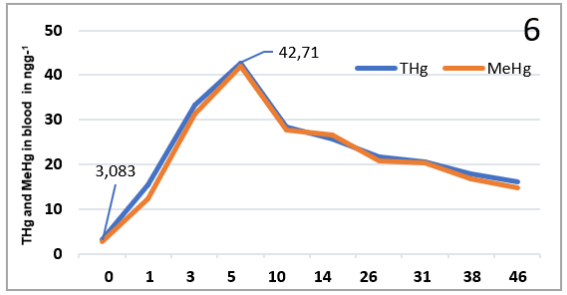


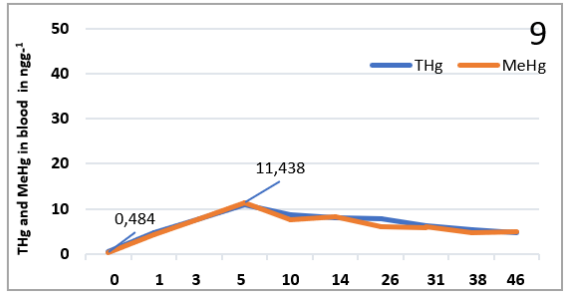


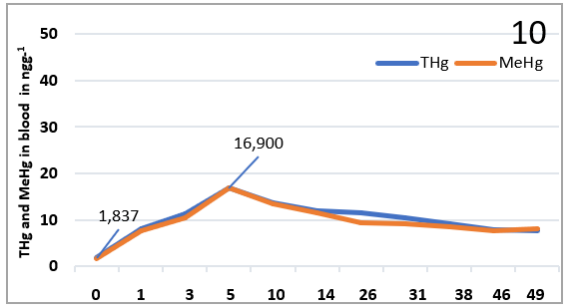


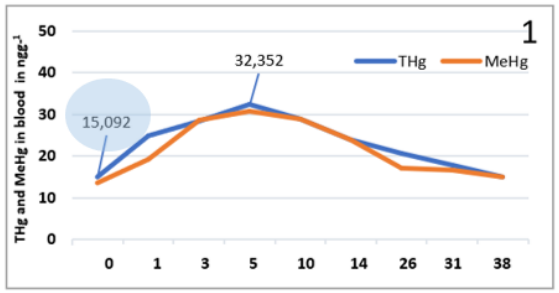


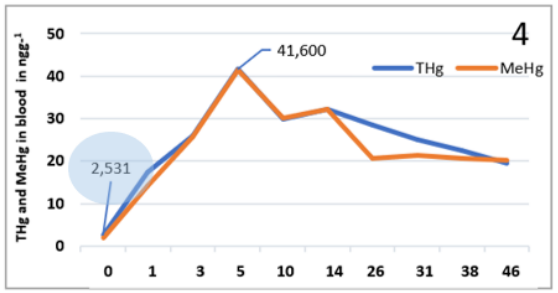


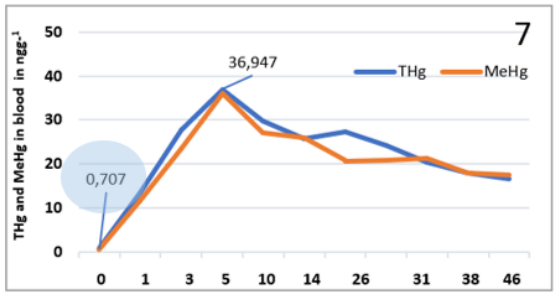


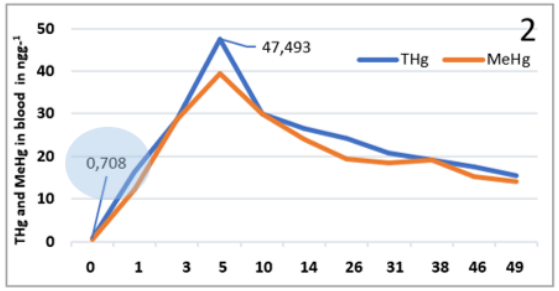


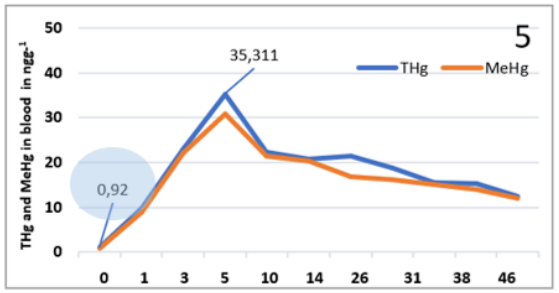


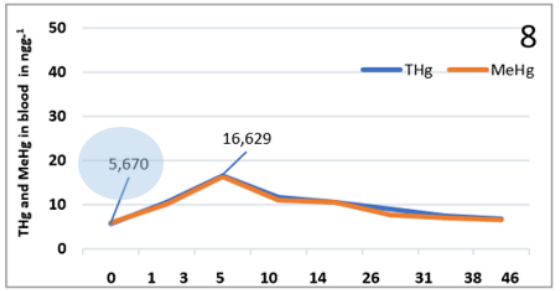

1
THg and MeHg in blood in ngg-1
THg
MeHg
15,092
32,352
0 1 3 5 10 14 26 31 38

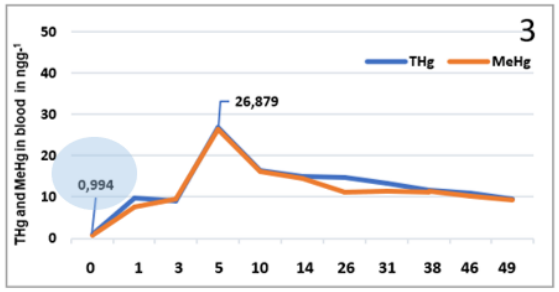

4
THg and MeHg in blood in ngg-1
THg
MeHg
2,531
41,600
0 1 3 5 10 14 26 31 38 46

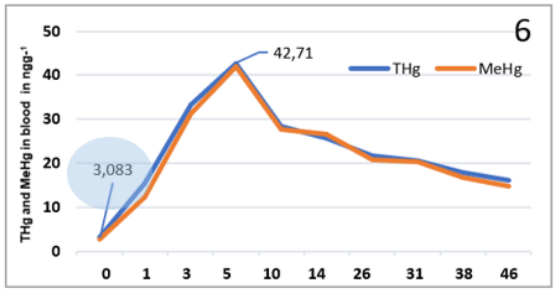

7
THg and MeHg in blood in ngg-1
THg
MeHg
0,707
36,947
0 1 3 5 10 14 26 31 38 46

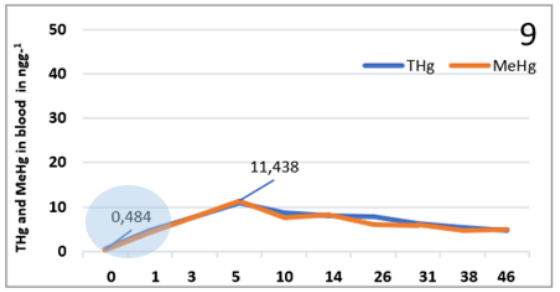

2
THg and MeHg in blood in ngg-1
THg
MeHg
0,708
47,493
0 1 3 5 10 14 26 31 38 46 49

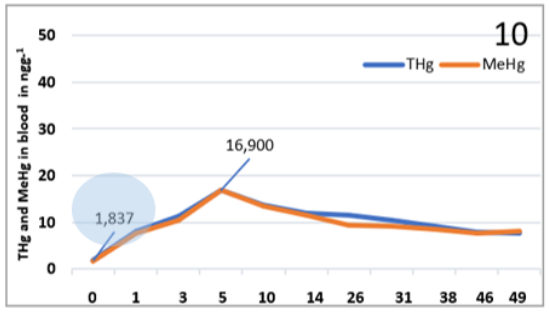

5
THg and MeHg in blood in ngg-1
THg
MeHg
0,92
35,311
0 1 3 5 10 14 26 31 38 46

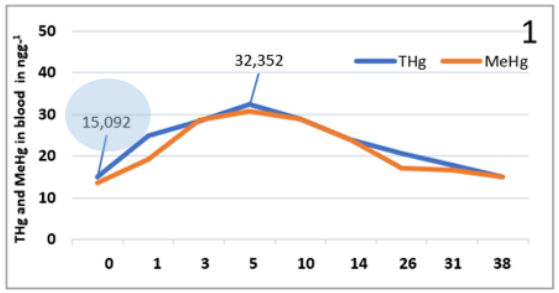

8
THg and MeHg in blood in ngg-1
THg
MeHg
5,670
16,629
0 1 3 5 10 14 26 31 38 46

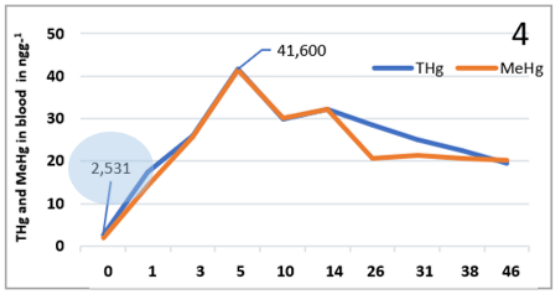

3
THg and MeHg in blood in ngg-1
THg
MeHg
0,994
26,879
0 1 3 5 10 14 26 31 38 46 49

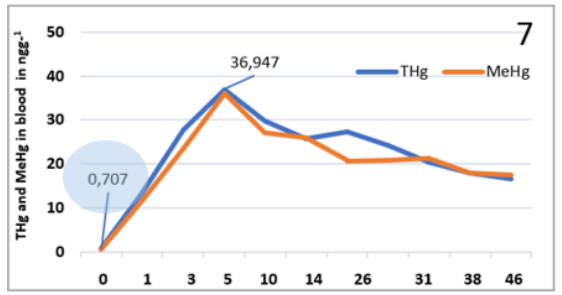

6
THg and MeHg in blood in ngg-1
THg
MeHg
3,083
42,71
0 1 3 5 10 14 26 31 38 46

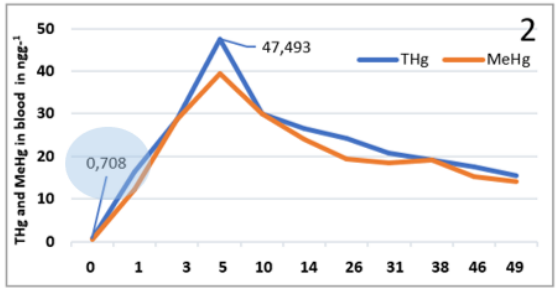

9
THg and MeHg in blood in ngg-1
THg
MeHg
0,484
11,438
0 1 3 5 10 14 26 31 38 46

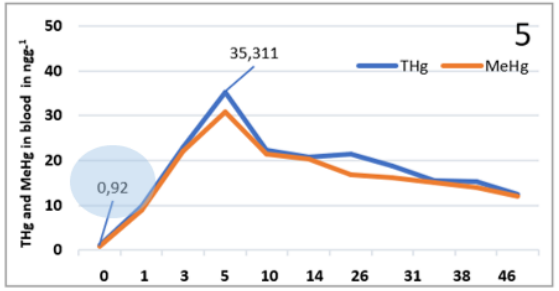

10
THg and MeHg in blood in ngg-1
THg
MeHg
1,837
16,900
0 1 3 5 10 14 26 31 38 46 49

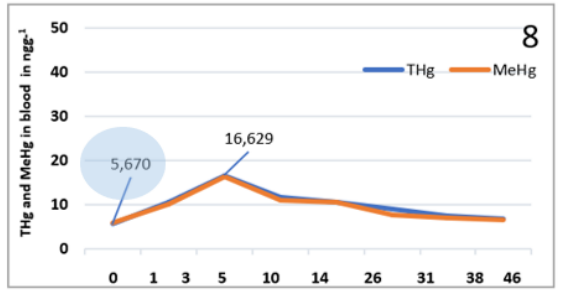


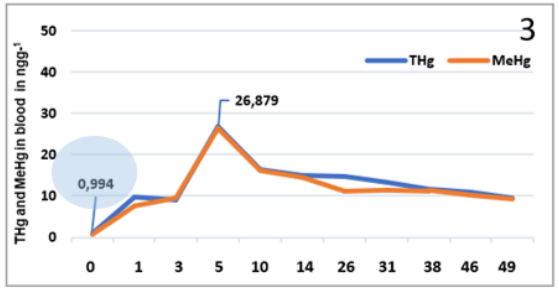


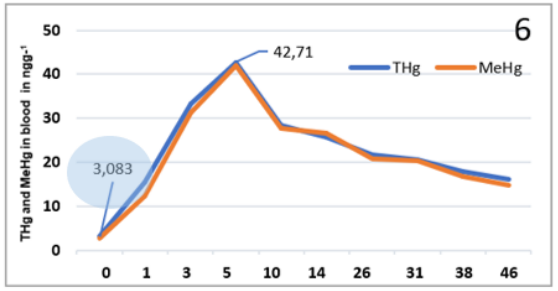


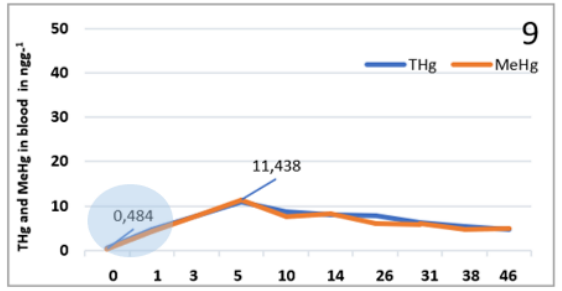


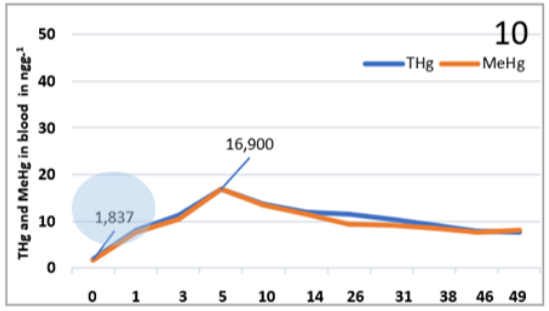




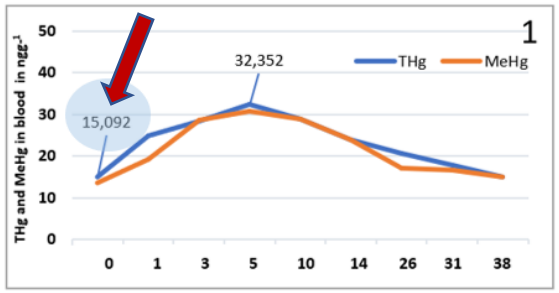


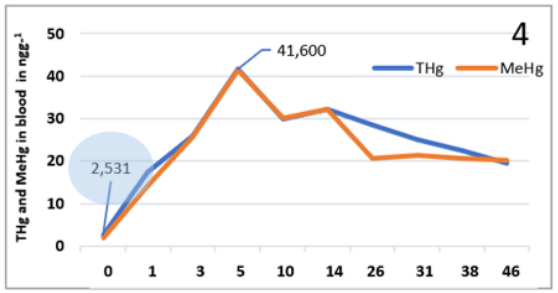


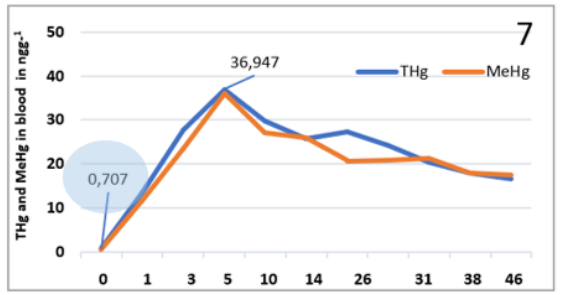


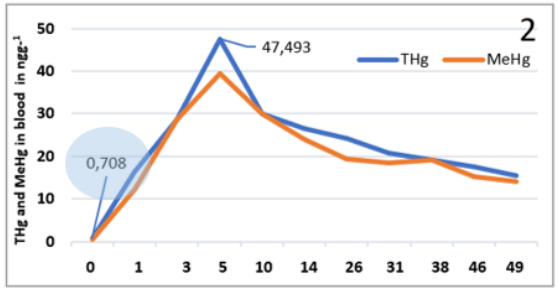


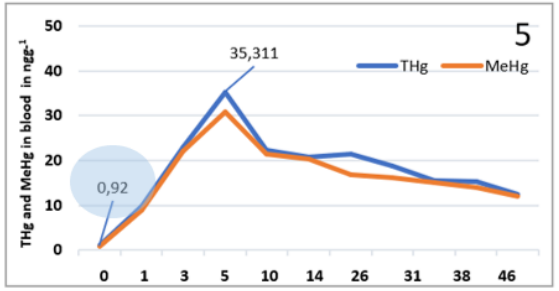
- different previous fish consumption habits → different starting concentrations of MeHg and THg in blood

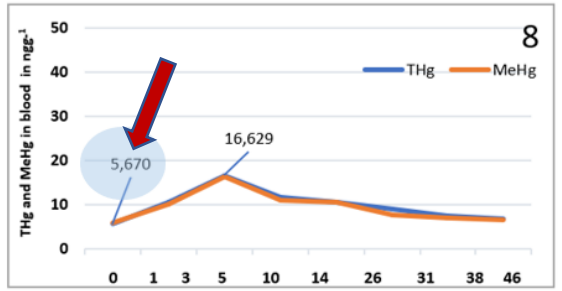


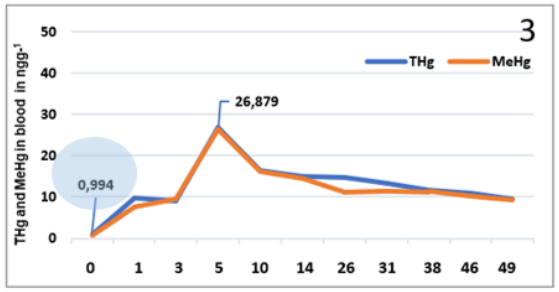


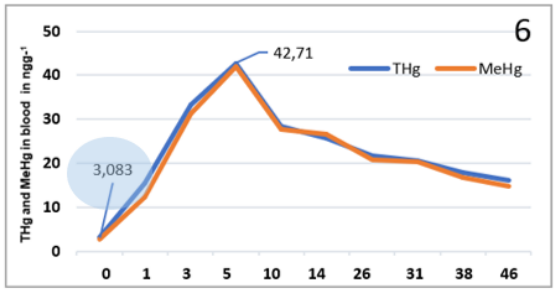


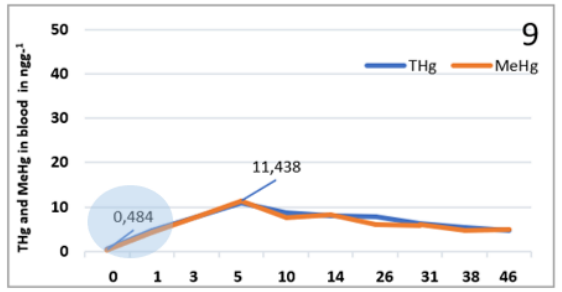


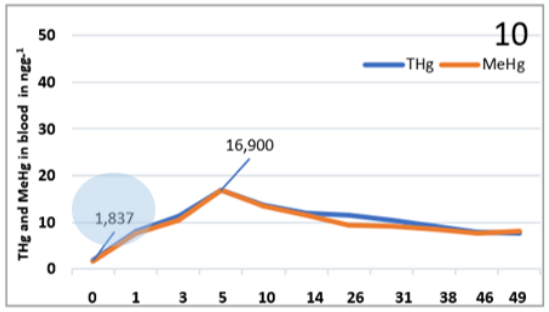




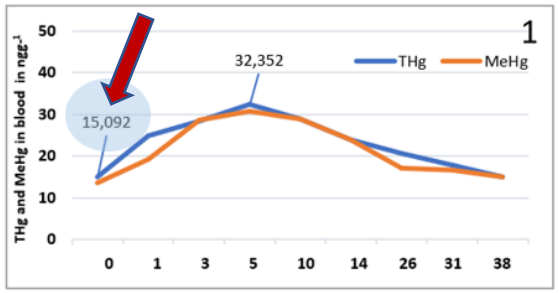


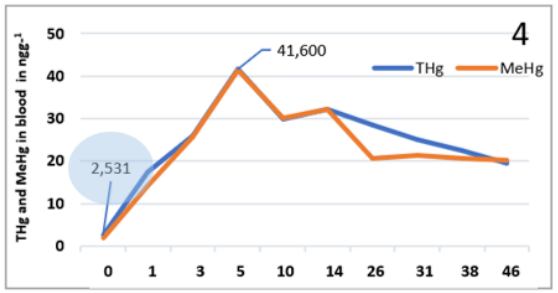


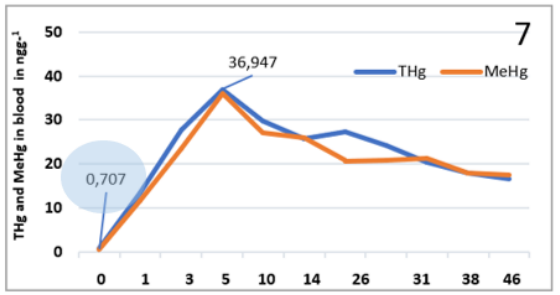


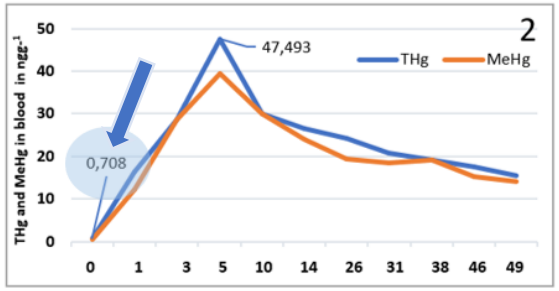


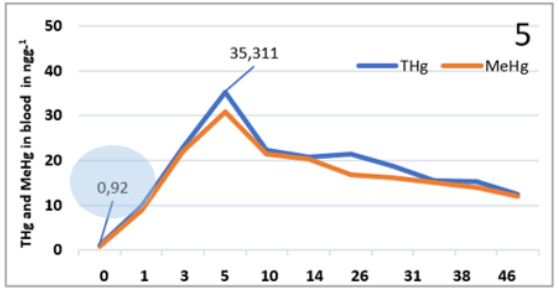
- different previous fish consumption habits → different starting concentrations of MeHg and THg in blood

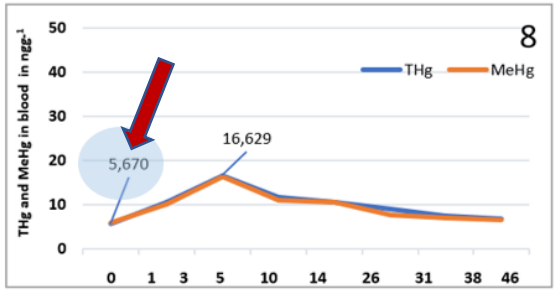


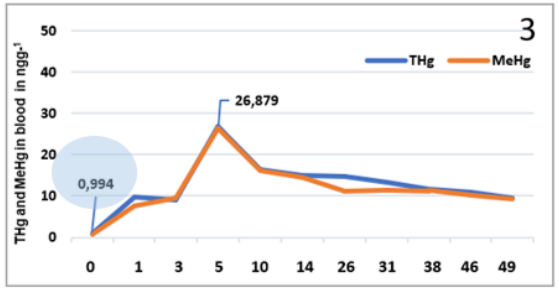


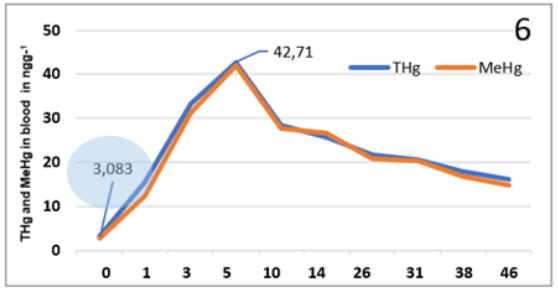


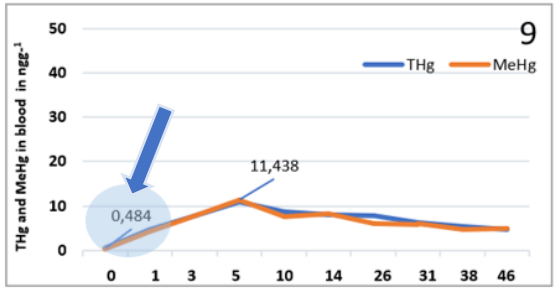


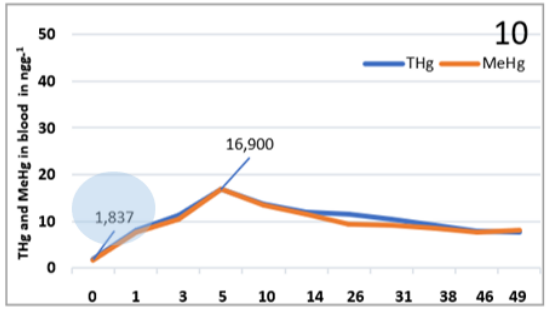




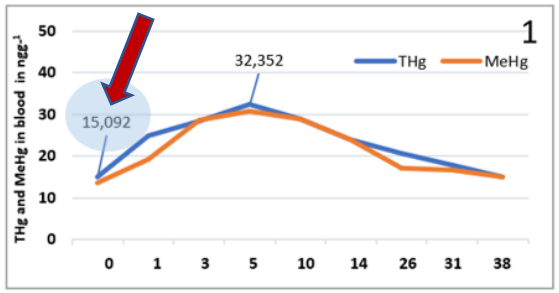


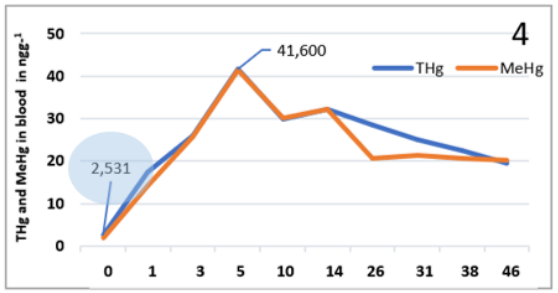


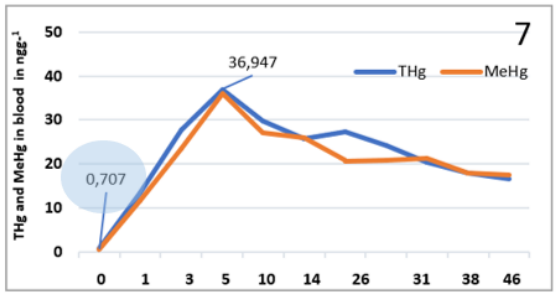


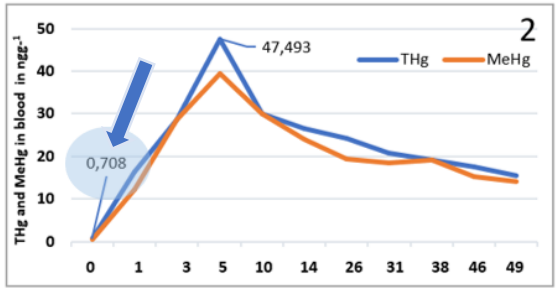


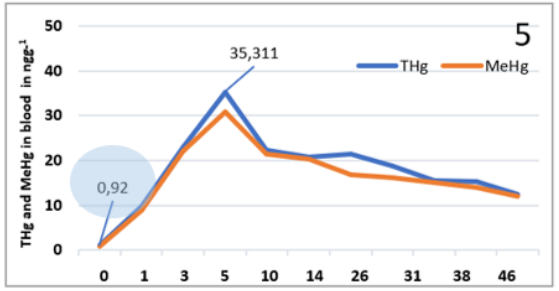
- different previous fish consumption habits → different starting concentrations of MeHg and THg in blood

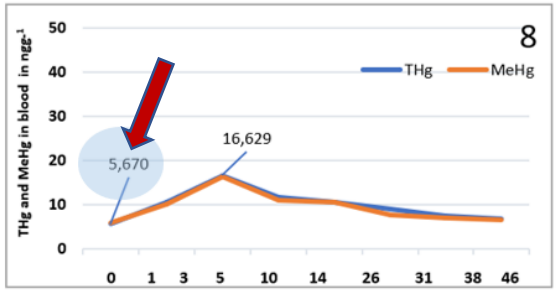


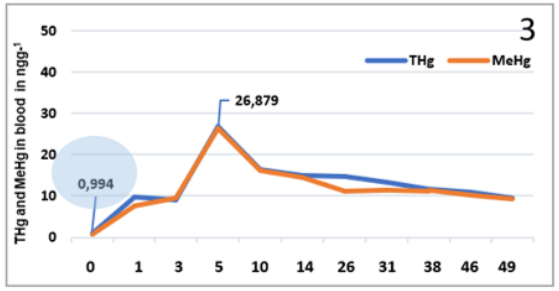


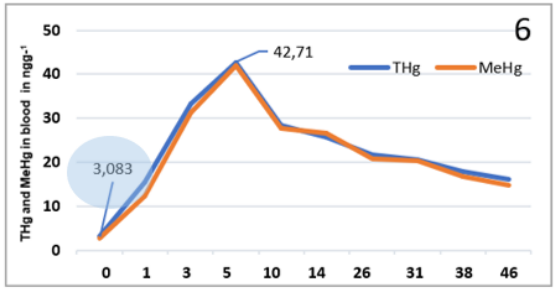


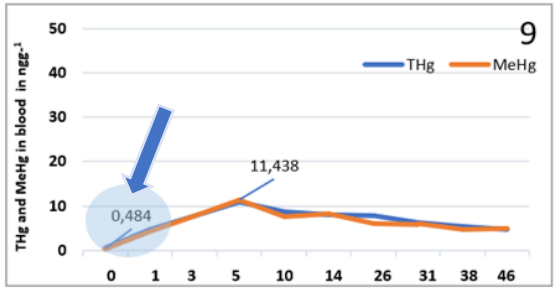


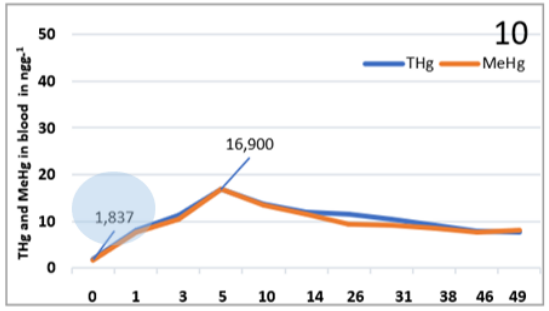




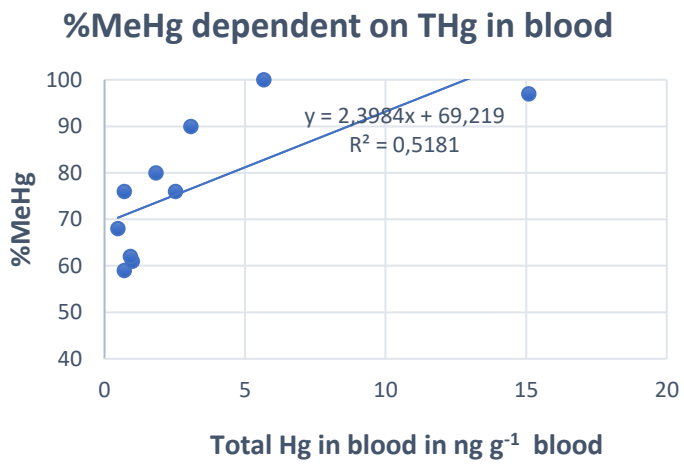


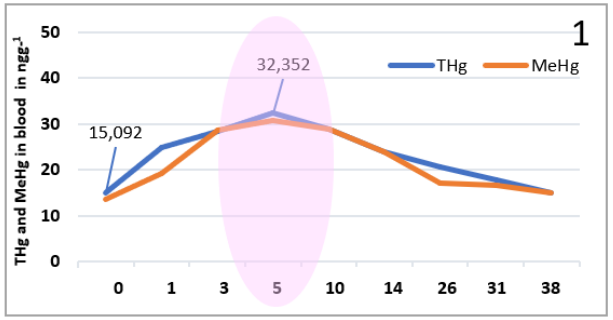


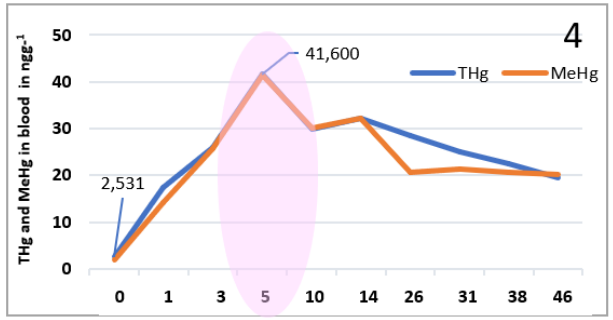


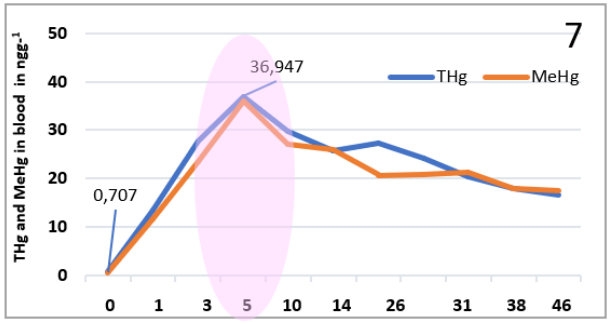


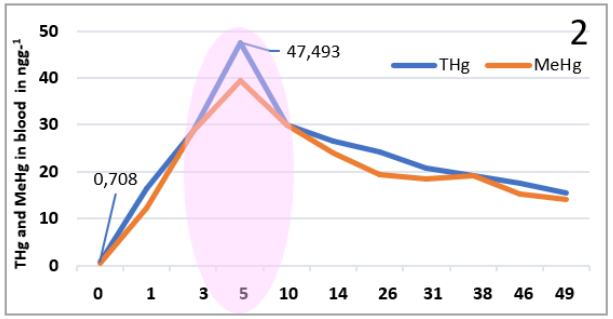
- different previous fish consumption habits → different starting concentrations of MeHg and THg in blood
- lower THg concentrations – higher % of inorganic mercury

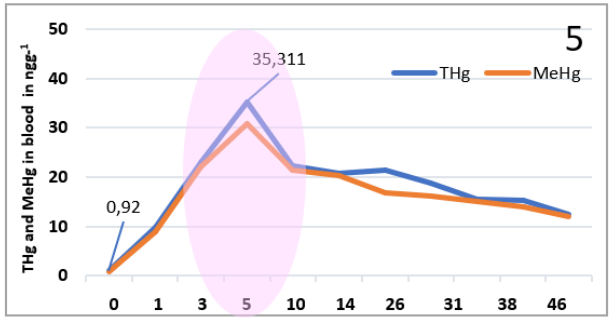


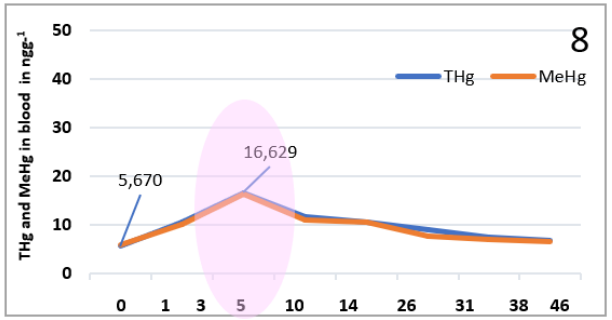


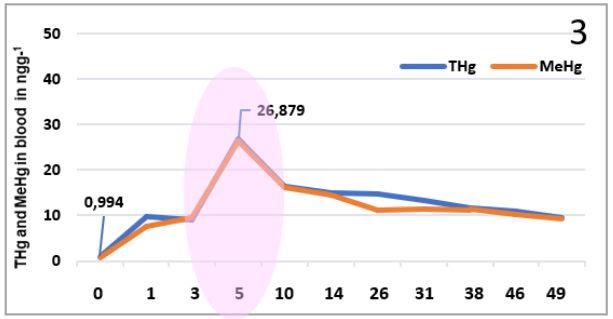


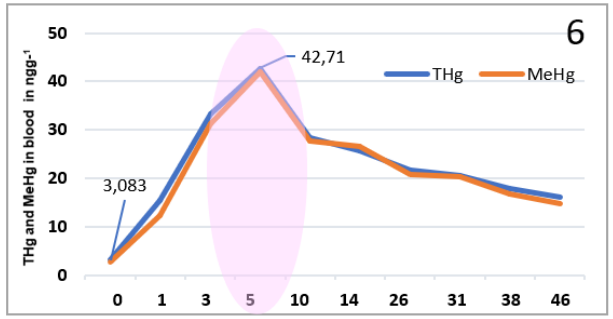


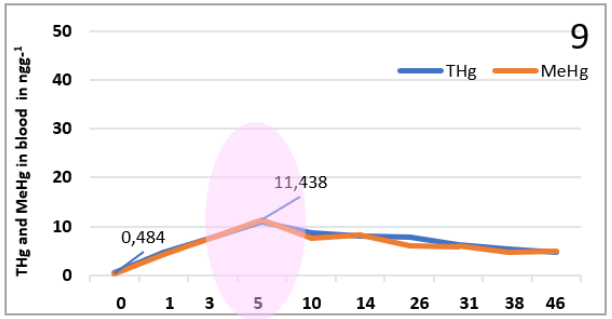


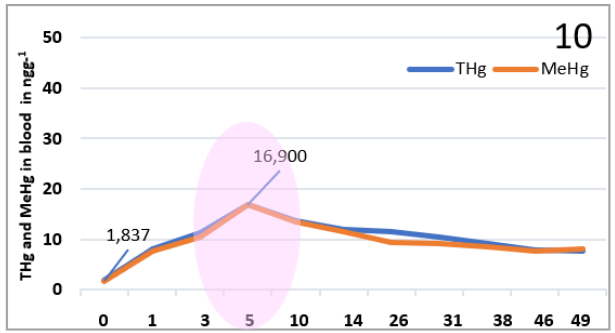






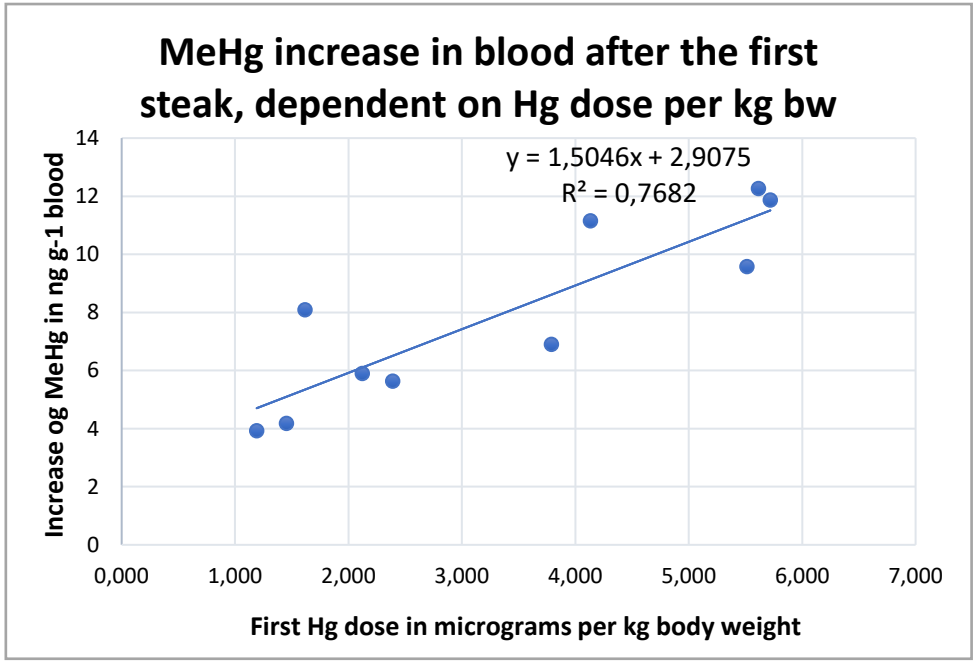


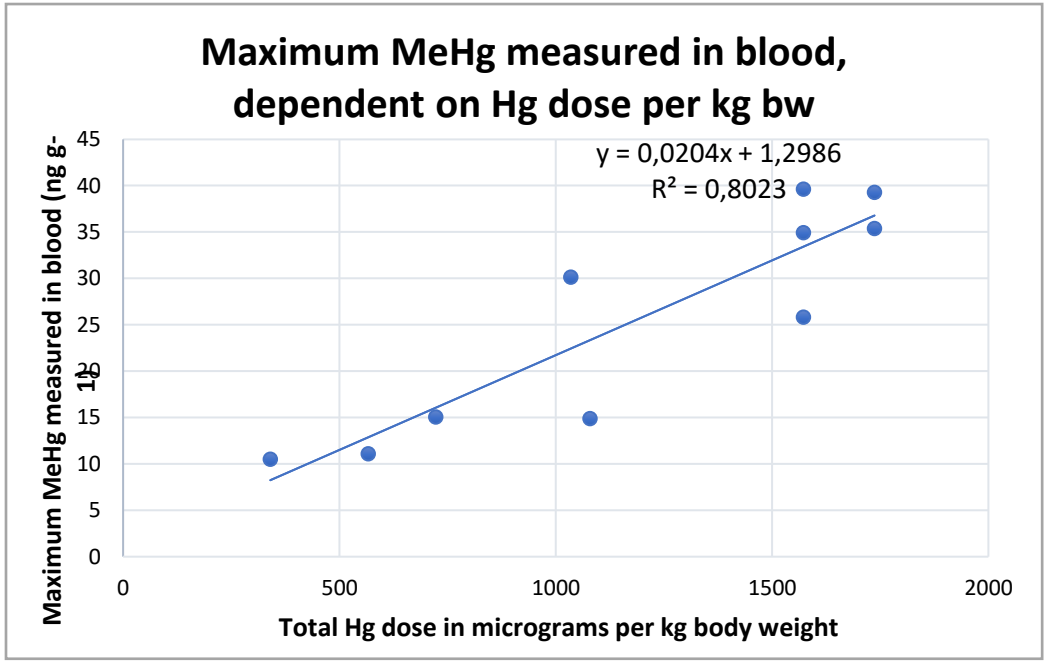




- all participants reached **maximum THg and MeHg** concentrations at the **day 5 of the experimet**
- practically **all Hg was MeHg**
- **maximum concentrations varied significantly among the participants**

- The increase in THg and MeHg levels in blood strongly depends on the Hg concentration in tuna and dose per kilogram body weight

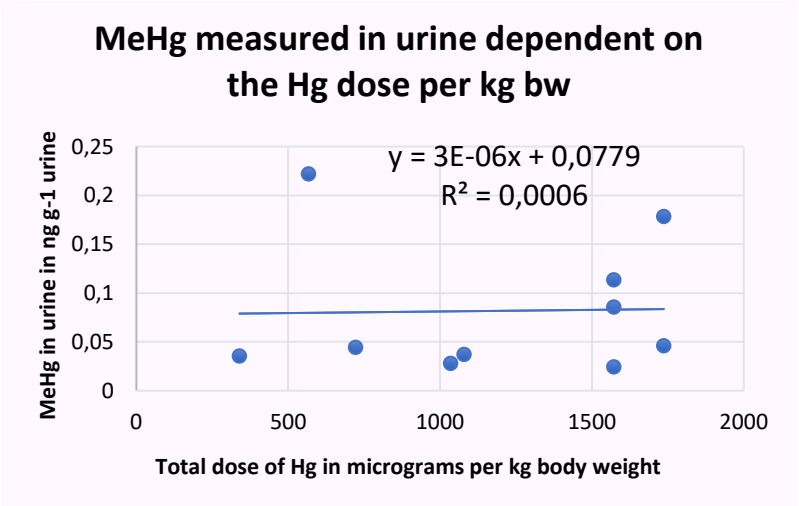




Total and methylmercury levels in urine over time – experimental group

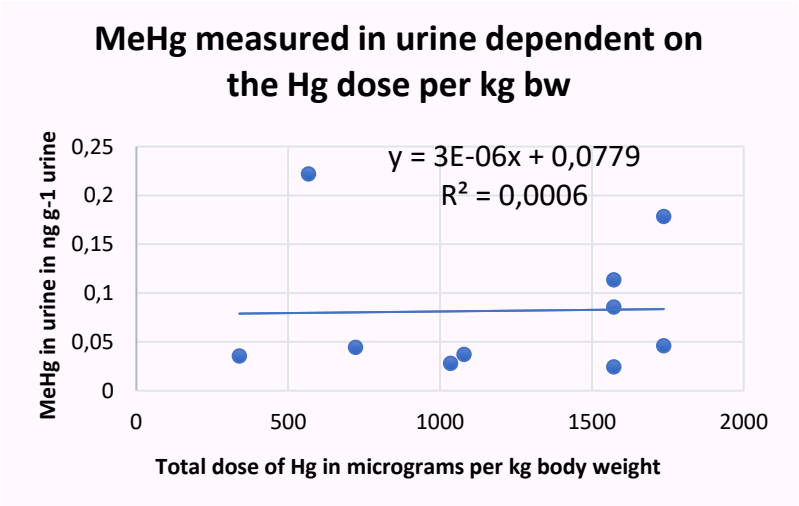
Total and methylmercury levels in urine over time – experimental group

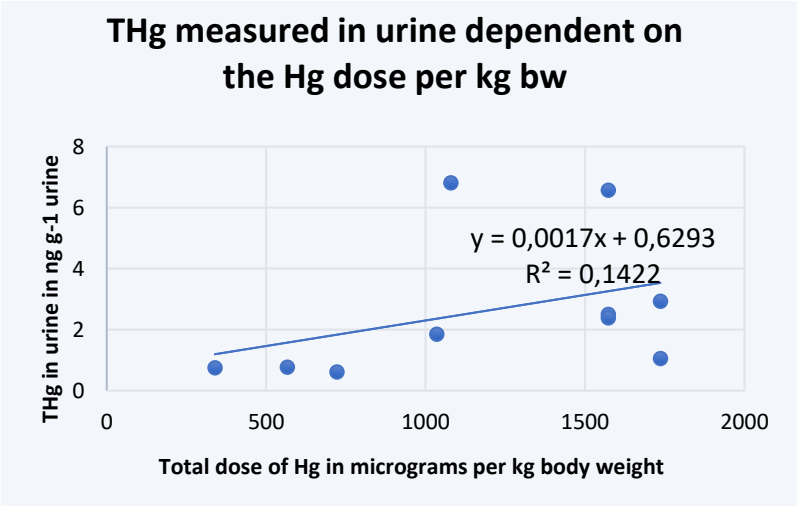
- MeHg measured in urine independent of the administered dose of Hg

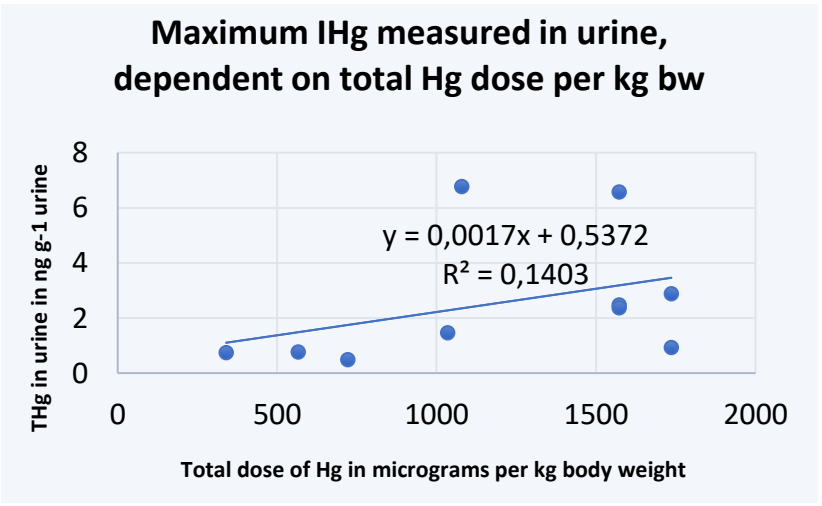


Total and methylmercury levels in urine over time – experimental group

- MeHg measured in urine independent of the administered dose of Hg
- THg and IHg are very weakly dependent on the administered dose of Hg







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- **the highest MeHg in urine was measured at the end of the first week** (right after tuna consumption)
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  - MeHg represented up to 13% of the total mercury
- the highest THg measured in urine was one month after the tuna consumption

There are large individual differences in mercury levels in urine

→ Genetic factors? Is demethylation more efficient in people who often eat fish?

Conclusions

- Presented results are only preliminary – there is still a lot to do!

→ more measurements:

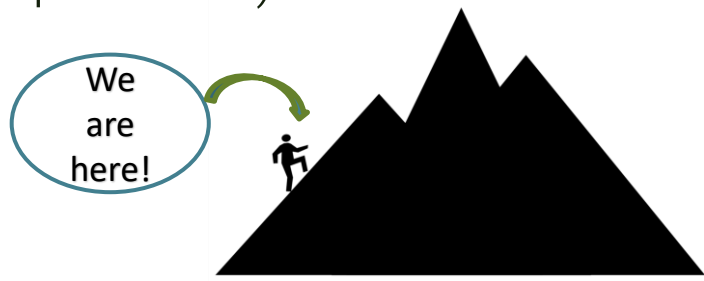
  - MeHg speciation in tuna
  - hair THg and MeHg, multielemental analysis
  - THg and MeHg in plasma, erythrocytes
  - Se speciation in in blood and plasma
  - Hg isotopic measurements

→ genotyping for single nucleotide polymorphisms previously found associated with Hg kinetics (e.g. APOE, GSH-related genes)

→ analyses of the results (multielemental + speciation)

→comprehensive approach

→improvement of kinetic models



Thank you for your attention!

This work was implemented as part of the ARRS program P1-0143 funded by the Slovenian Research Agency and implemented in the framework of the fellowship provided by Salonit Anhovo. We thank the volunteers for their participation.