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Health Hazard of Mercury-contaminated Fish from the Indonesian Marine Fish Ecosystem

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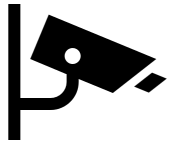
Key Point of this research

Mercury 

Biomonitoring 

Marine Life Sustainability 

Human Health 

Mercury reduction and elimination in Indonesia

Global -> Minamata Convention

As of 2024, 148 countries, including Indonesia, are parties to the Convention.

Indonesia ratified the Minamata Convention on mercury in 2017

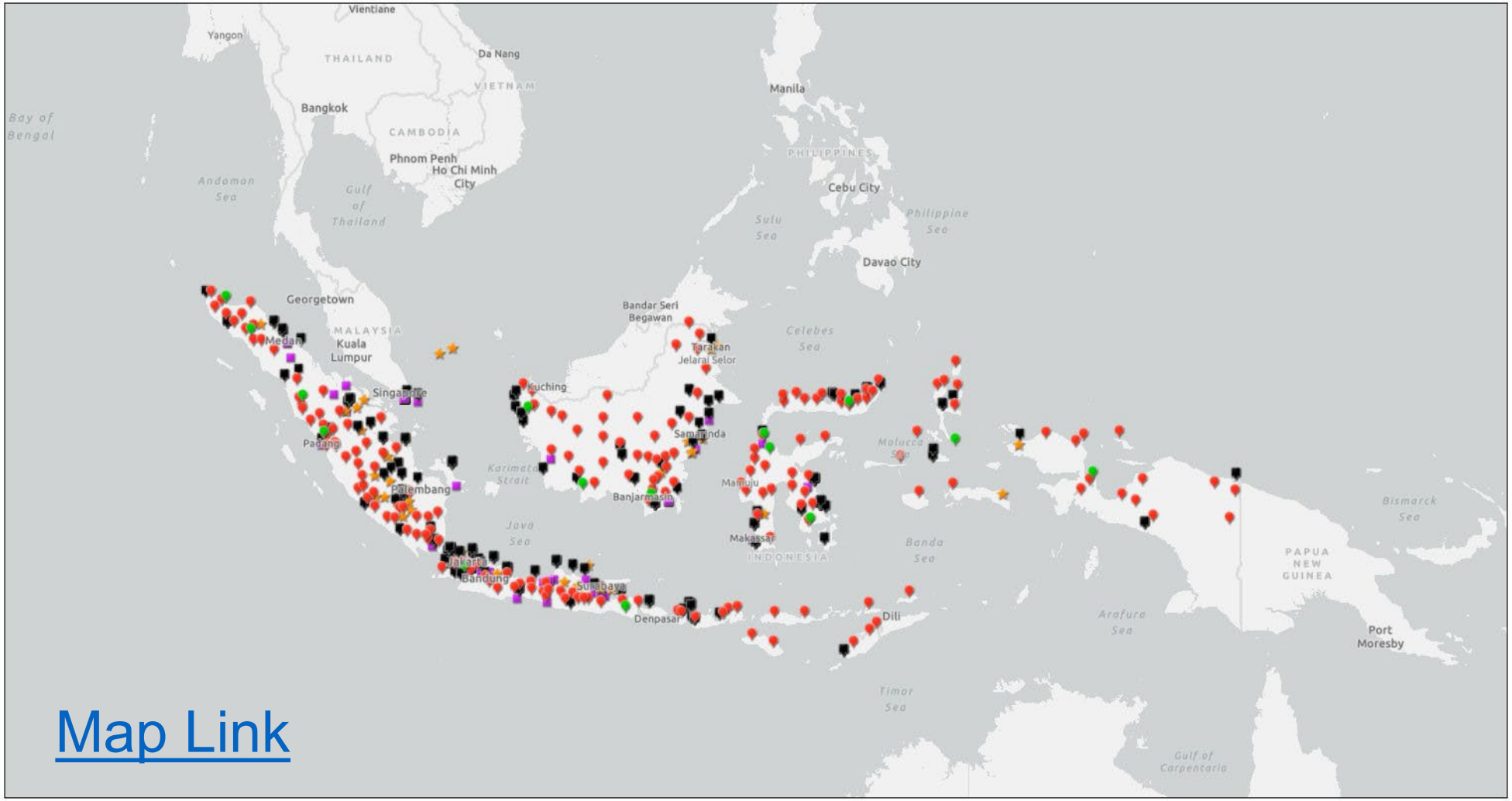
Political commitment:

- Law No. 11/2017
- Presidential Regulation 21/2019 NAP to reduce and eliminate mercury
- MoEF regulation No. P81/2019 to implement

Research Objective

- Assessment of Mercury Levels on Marine Fish
- Impact Analysis
- Health Risk Evaluation
- Recommendations to policy makers for mitigation

Integrated Map of Potential Mercury Sources in Indonesia



Sampling locations

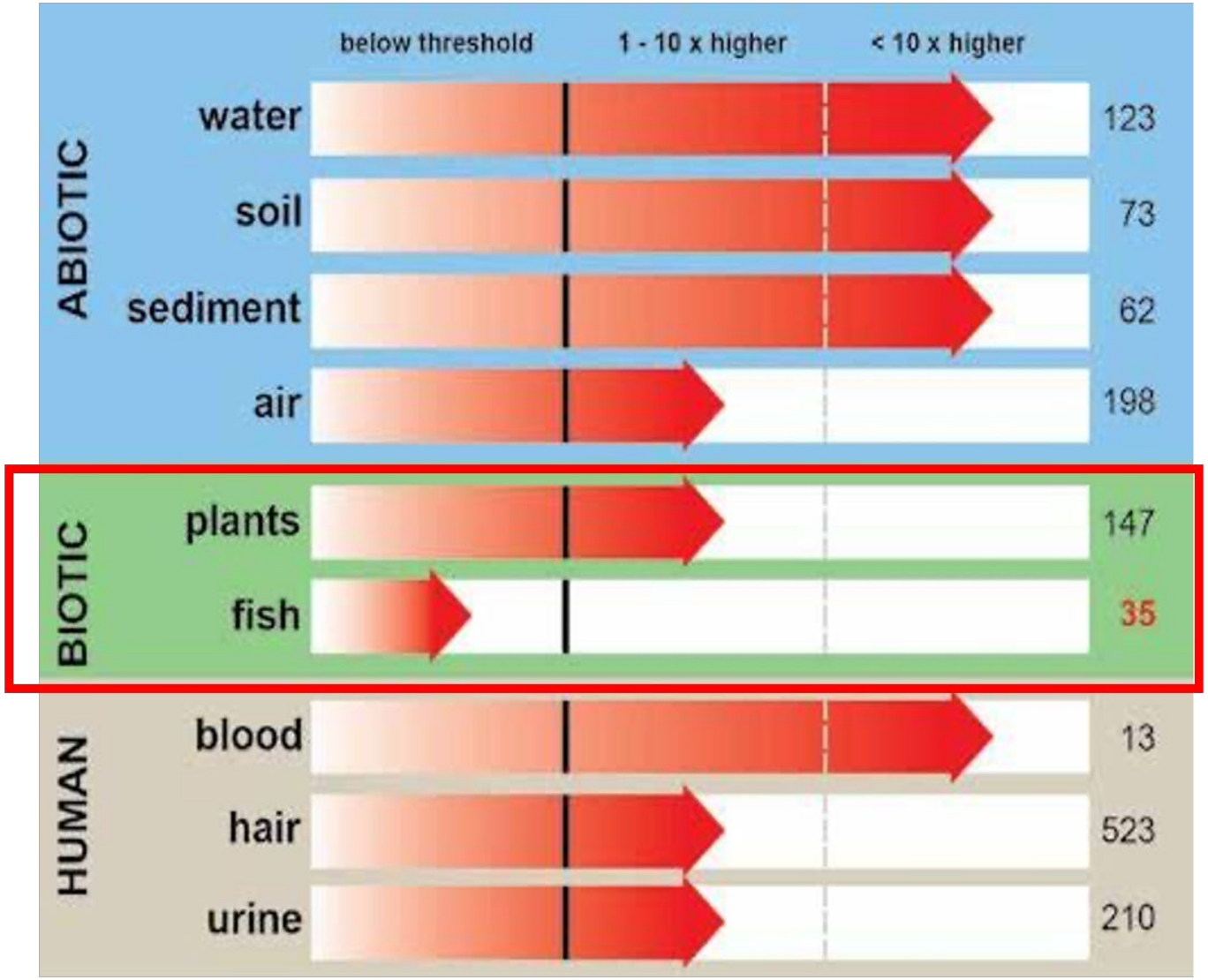
Sample size = 87

8 out of 38 provinces of Indonesia (2023)

Fish auctions

Mercury pollution in Indonesia: previous studies

All three major compartments are well above mercury safety thresholds



Methodology:
Marine Fish Sampling and Hg Analysis

- Marine fish samples: barracuda, tuna fish, snapper, etc. Also, some fish that mainly consumed by the local people (**n=248**)

Fish Muscle Tissues

ICP-MS -> THg Analysis

Impact Analysis
- Correlation
- EWI
- THQ

Health Risk Analysis -> MSCQ Analysis

Research Objective

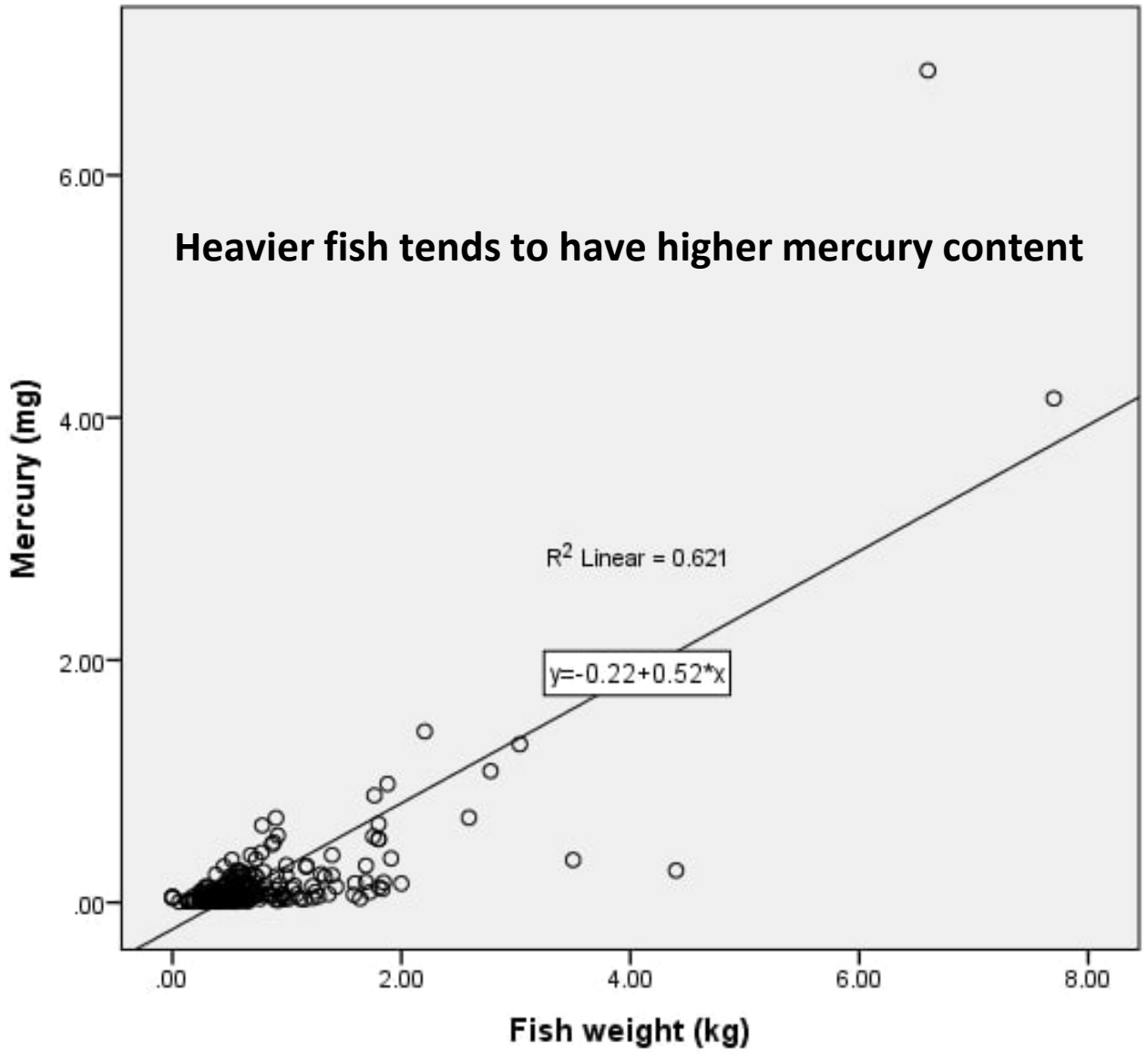
Assessment of Mercury Levels on Marine Fish

Results: fish weight vs THg content

The results of this monitoring indicate the presence of Hg contamination in fish, especially in muscle tissue.

The Hg content in several species showed varying values, and the Hg content was positively correlated with fish weight (R^2=0.62, p<0.05)

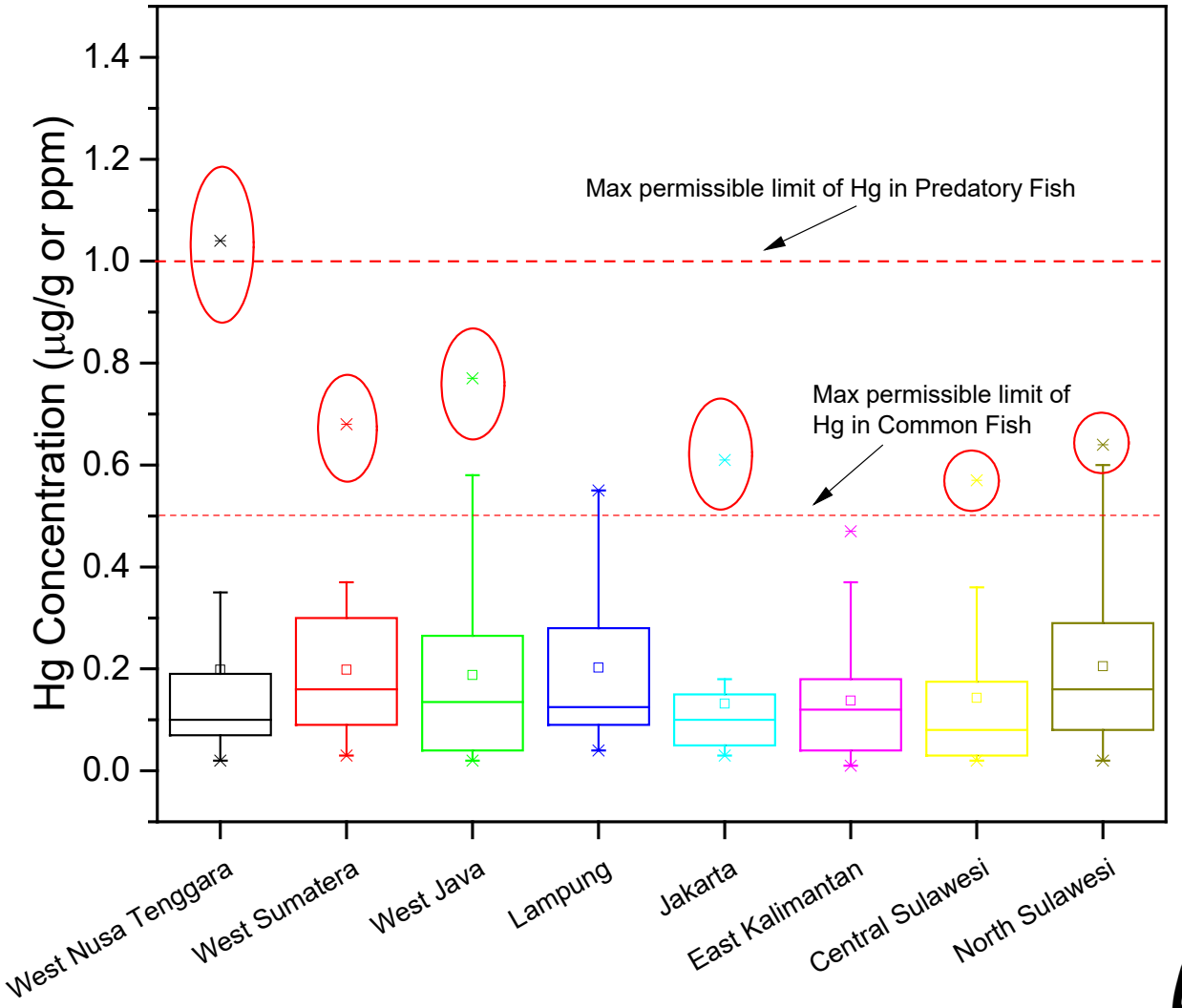
Indicating bioaccumulation of mercury occur in the marine fish samples

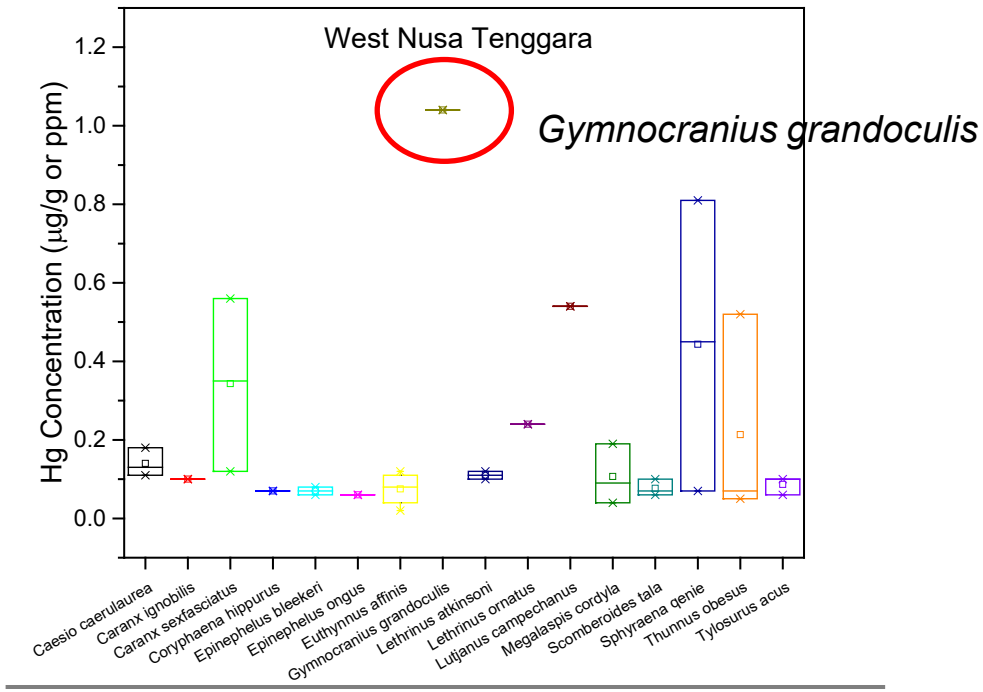


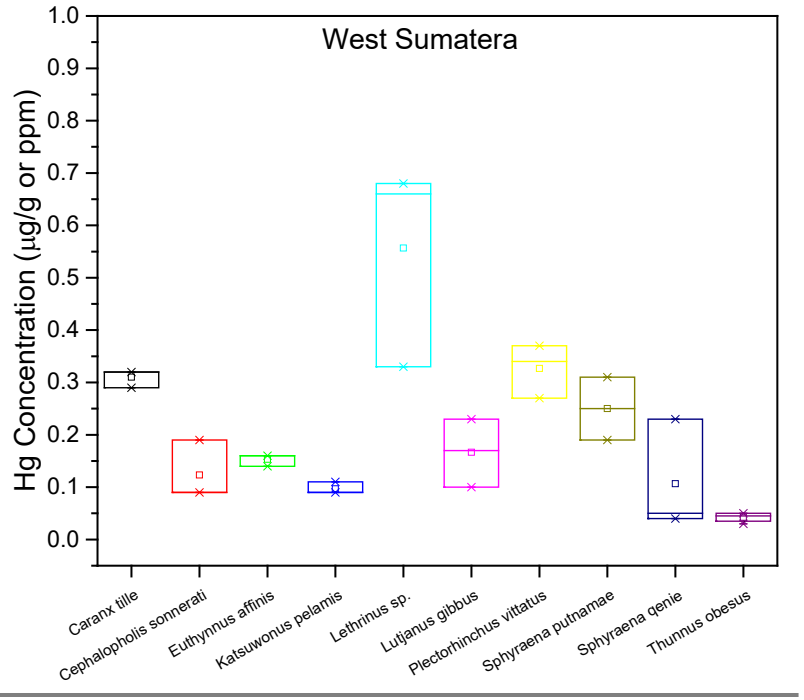
Hg in marine fish exceeding the safe level

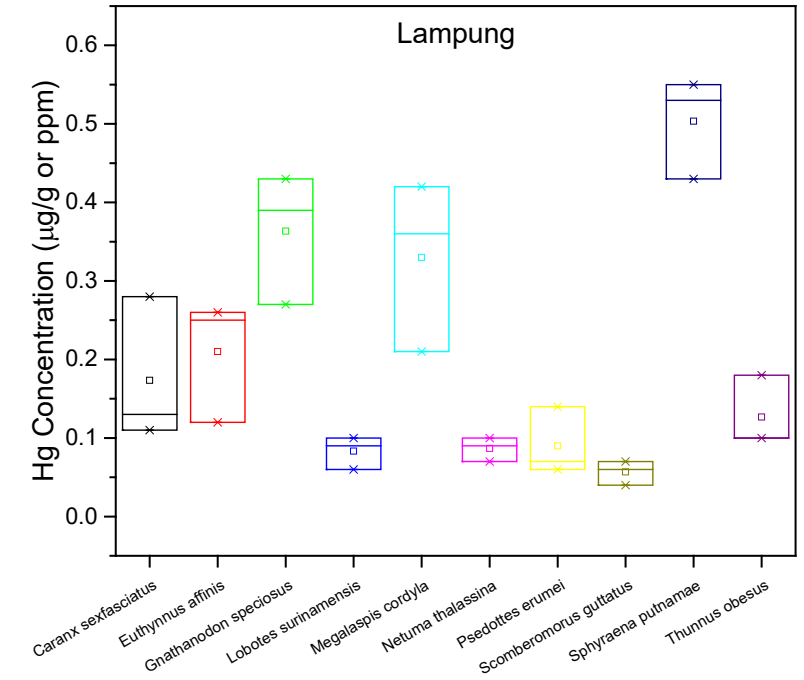
There are some fish that has reached or exceeded the permissible limit (permissible limit 0.5 mg/kg (WHO 1990):

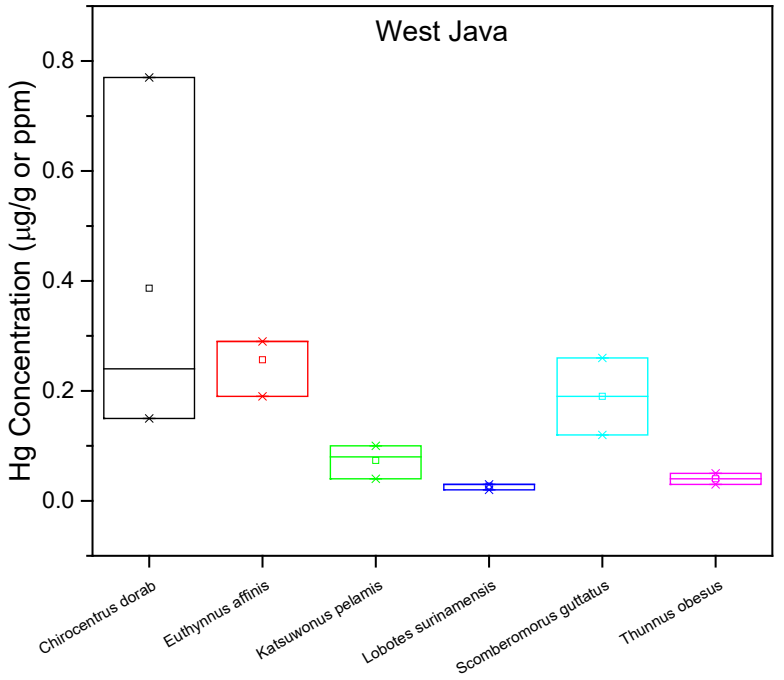
- Lethrinus sp. or **snapper** (**West Sumatra**)
- Sphyraena putnamae or **barracuda** (**Lampung**)
- Megalaspis cordyla or ***tengkek*** **fish** (**Jakarta**),
- Caranx sexfasciatus or ***pompano*** **fish** (**North Sulawesi**),
- Gymnocranius grandoculis or **white snapper** and Lutjanus campechanus or **red snapper** (**West Nusa Tenggara**)

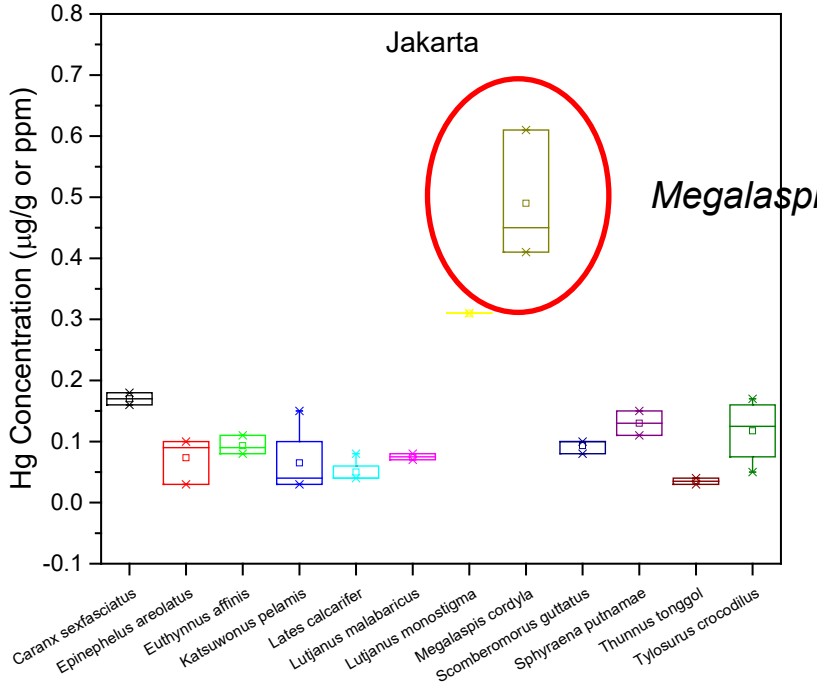



West Nusa Tenggara
Gymnocranius grandoculis
Hg Concentration (µg/g or ppm)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Caesio caerulaurea
Caranx ignobilis
Caranx sexfasciatus
Coryphaena hippurus
Epinephelus bleekeri
Epinephelus ongus
Euthynnus affinis
Gymnocranius grandoculis
Lethrinus atkinsoni
Lethrinus ornatus
Lutjanus campechanus
Megalaspis cordyla
Scomberoides tala
Sphyraena genie
Thunnus obesus
Tylosurus acus

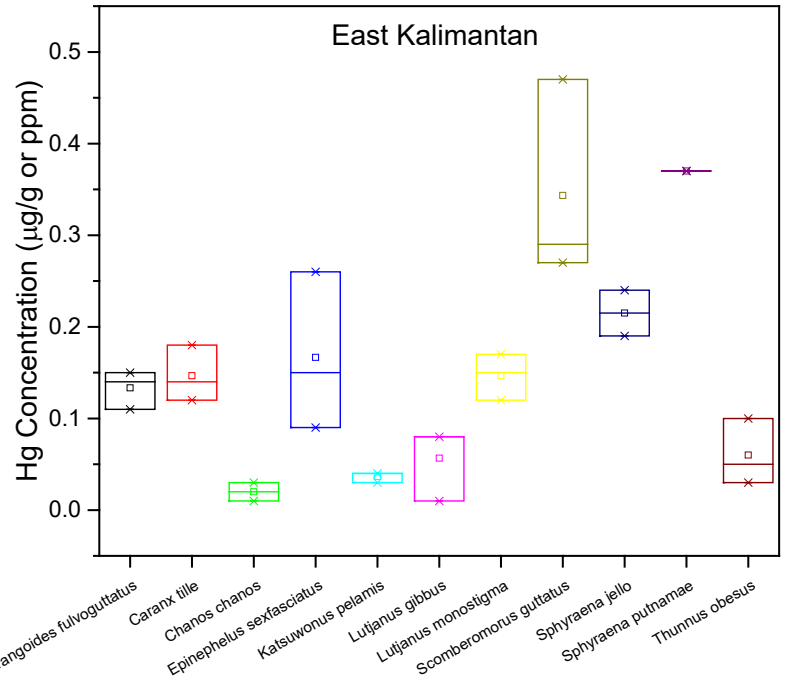

West Sumatera
Hg Concentration (µg/g or ppm)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Caranx tille
Cephalopholis sonnerati
Euthynnus affinis
Katsuwonus pelamis
Lethrinus sp.
Lutjanus gibbus
Plectorhinchus vittatus
Sphyraena putnamae
Sphyraena qenie
Thunnus obesus

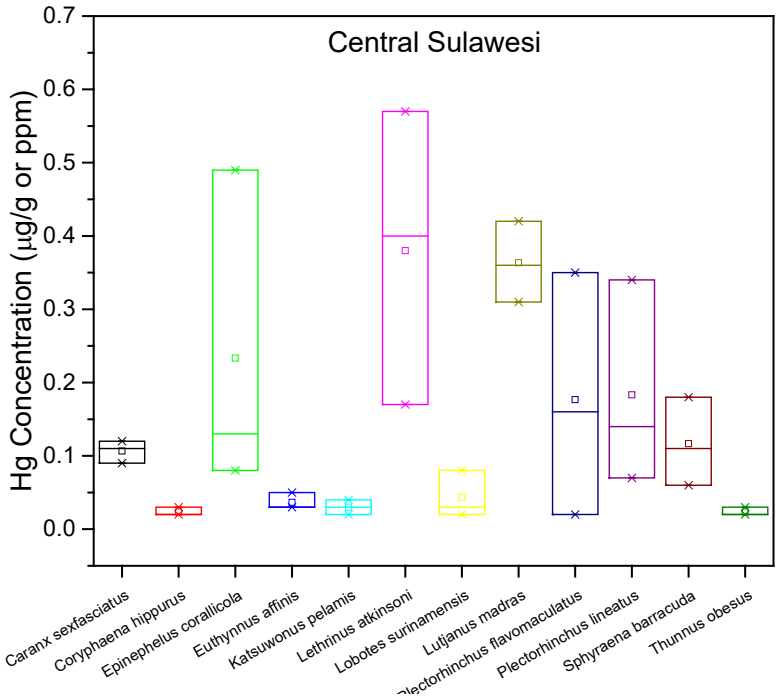

Lampung
Hg Concentration (µg/g or ppm)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Caranx sexfasciatus
Euthynnus affinis
Gnathanodon speciosus
Lobotes surinamensis
Megalaspis cordyla
Netuma thalassina
Psedottes erumei
Scomberomorus guttatus
Sphyraena putnamae
Thunnus obesus

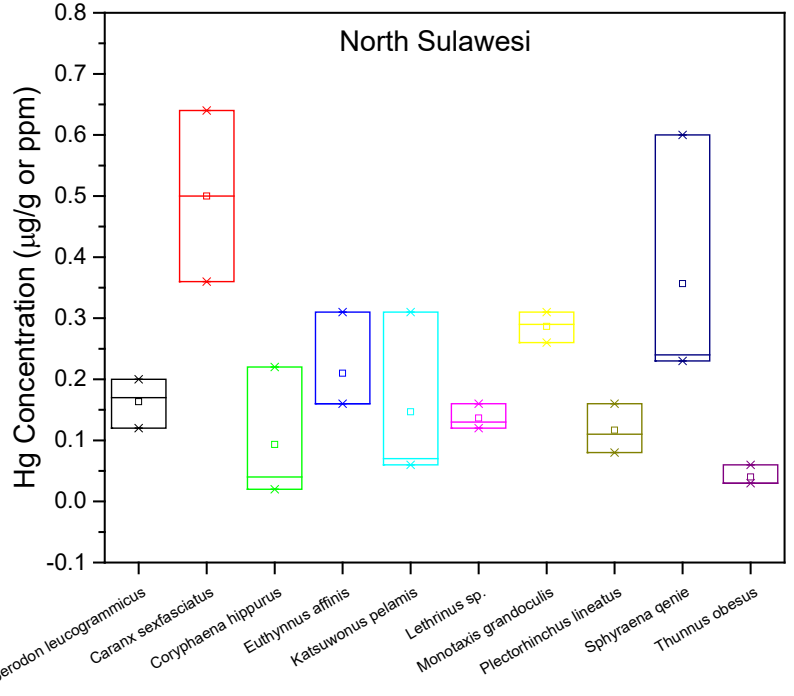

West Java
Hg Concentration (µg/g or ppm)
0.8
0.6
0.4
0.2
0.0
Chirocentrus dorab
Euthynnus affinis
Katsuwonus pelamis
Lobotes surinamensis
Scomberomorus guttatus
Thunnus obesus



Megalaspis Cordyla







Research Objective

Impact Analysis

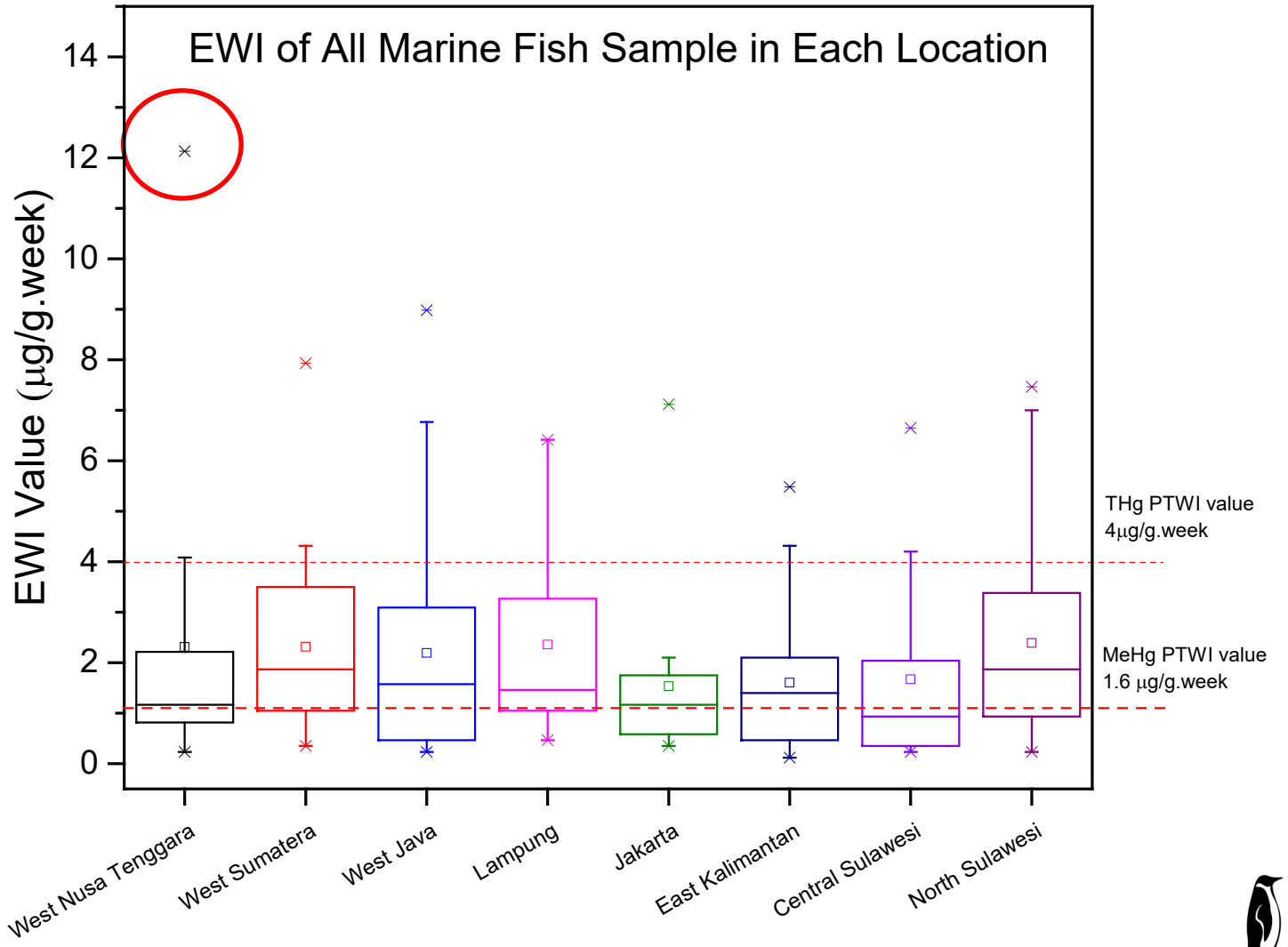
Estimated Weekly Intakes (EWI) Analysis

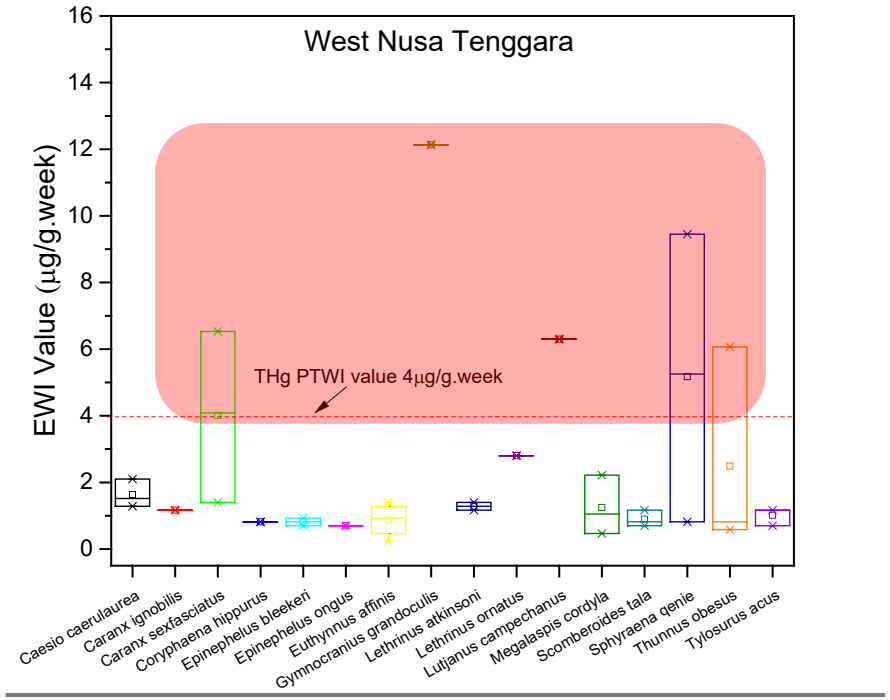
$$EWI = \frac{Hg\ concentration\ in\ fish\ \left(\frac{\mu g}{g}\right) x\ Weekly\ fish\ intake\ (g/week)}{person\ weight\ (kg)}$$

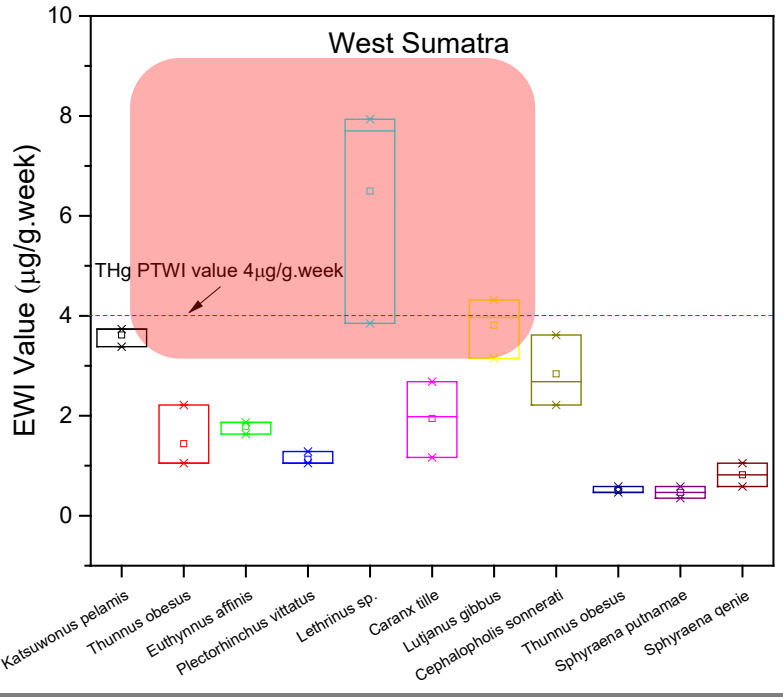
EWI helps to assess whether the intake of a contaminant exceeds safe levels established by health authorities.

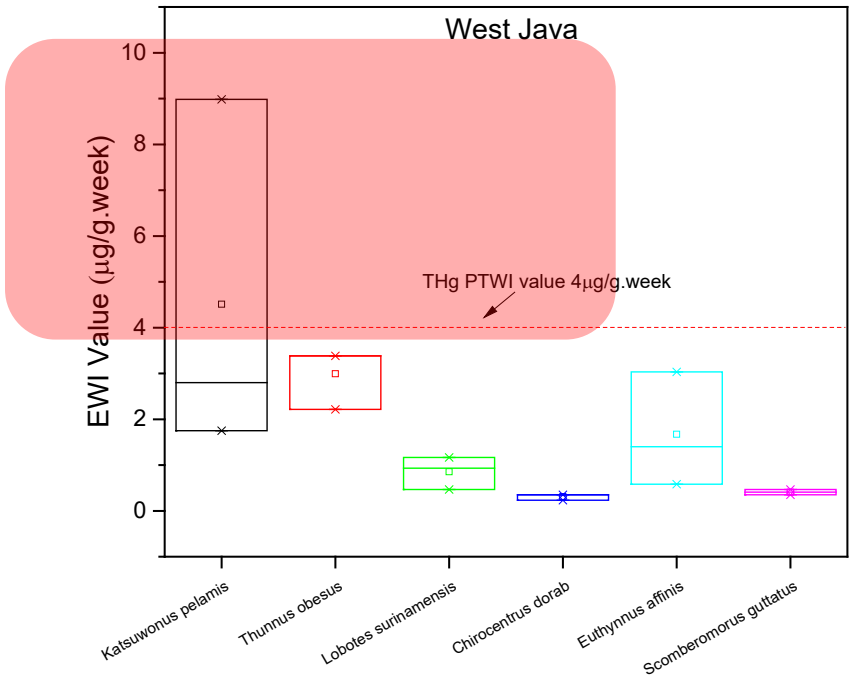
The highest **EWI value**, up to 3.0 times the PTWI (Provisional Total Weekly Intakes) value (THg 4.0 µg/kg.week) *Gymnocranius grandoculis* fish species is known locally as White Snapper in West Nusa Tenggara.

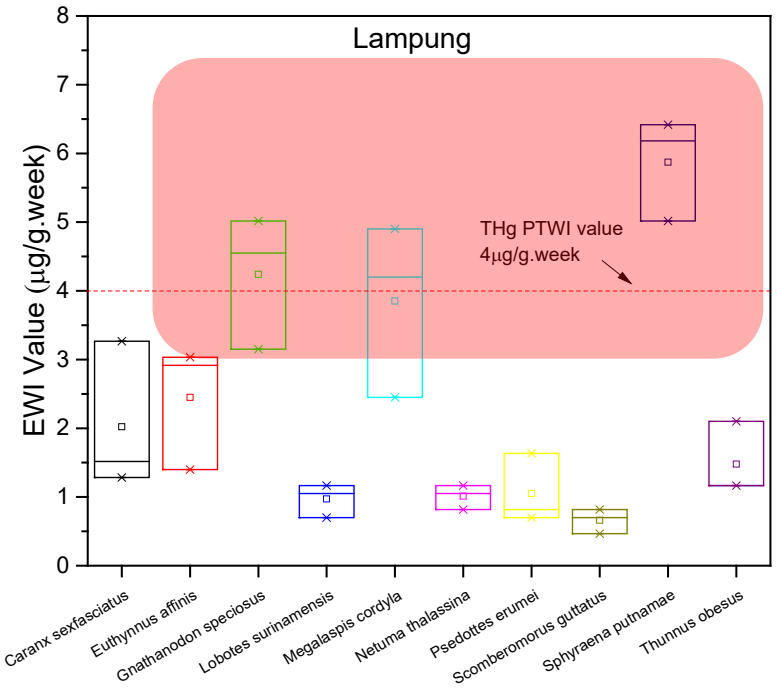
15 out of 87 fish species has EWI>PTWI

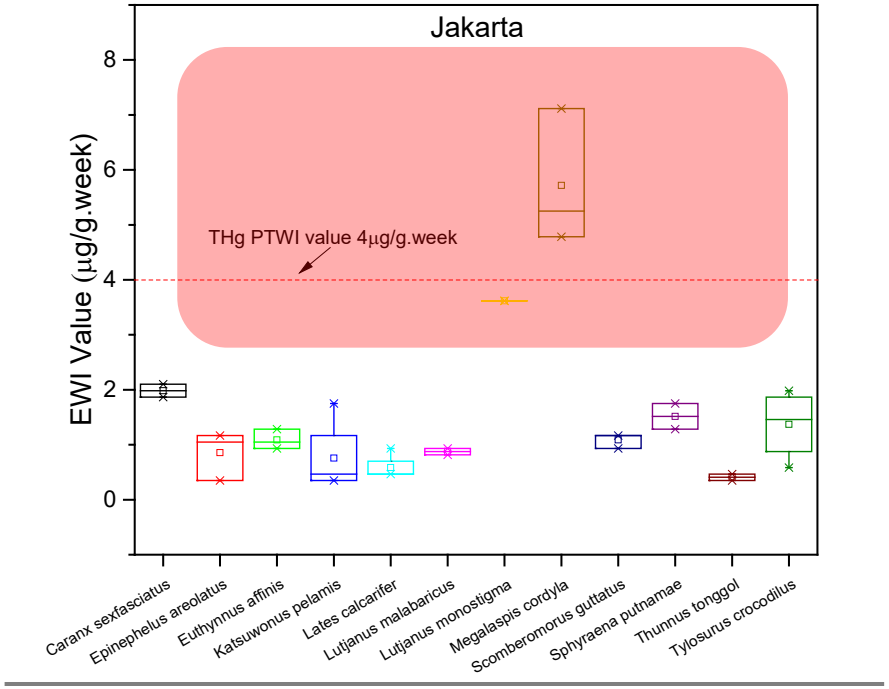


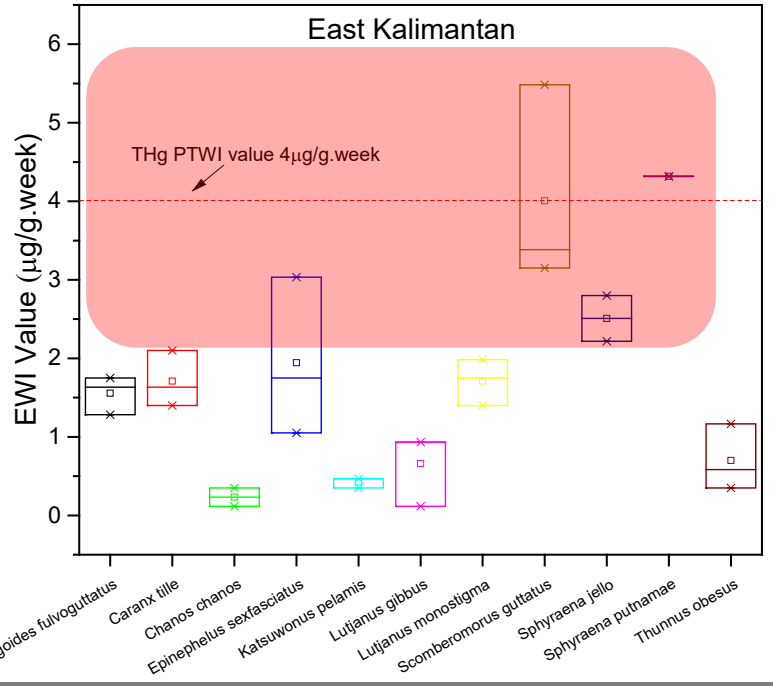

West Nusa Tenggara
EWI Value (µg/g.week)
THg PTWI value 4µg/g.week
Caesio caerulaurea
Caranx ignobilis
Caranx sexfasciatus
Coryphaena hippurus
Epinephelus bleekeri
Epinephelus ongus
Euthynnus affinis
Gymnocranius grandoculis
Lethrinus atkinsoni
Lethrinus ornatus
Lutjanus campechanus
Megalaspis cordyla
Scomberoides tala
Sphyraena qenie
Thunnus obesus
Tylosurus acus

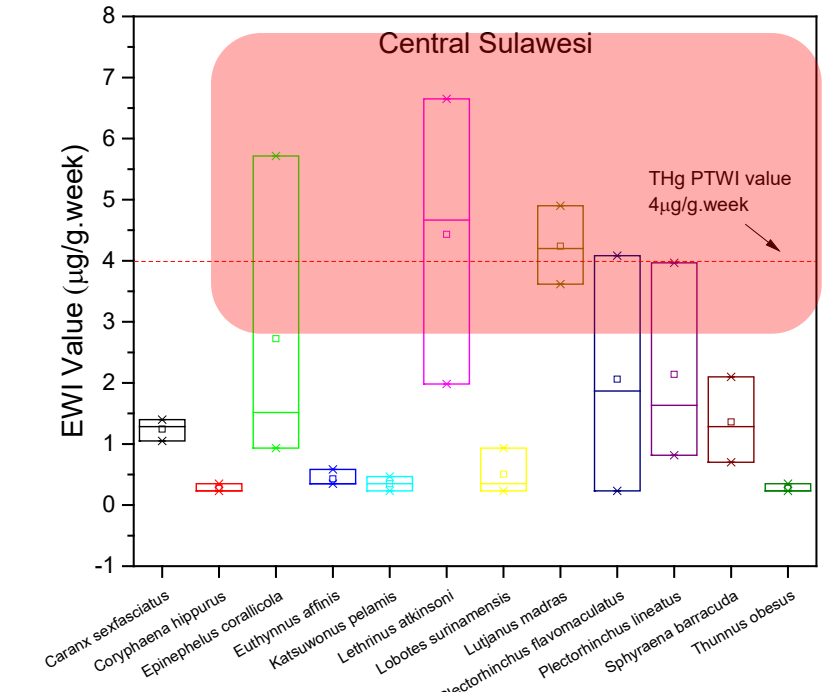

West Sumatra
EWI Value (µg/g.week)
THg PTWI value 4µg/g.week
Katsuwonus pelamis
Thunnus obesus
Euthynnus affinis
Plectorhinchus vittatus
Lethrinus sp.
Caranx tille
Lutjanus gibbus
Cephalopholis sonnerati
Thunnus obesus
Sphyraena putnamae
Sphyraena qenie

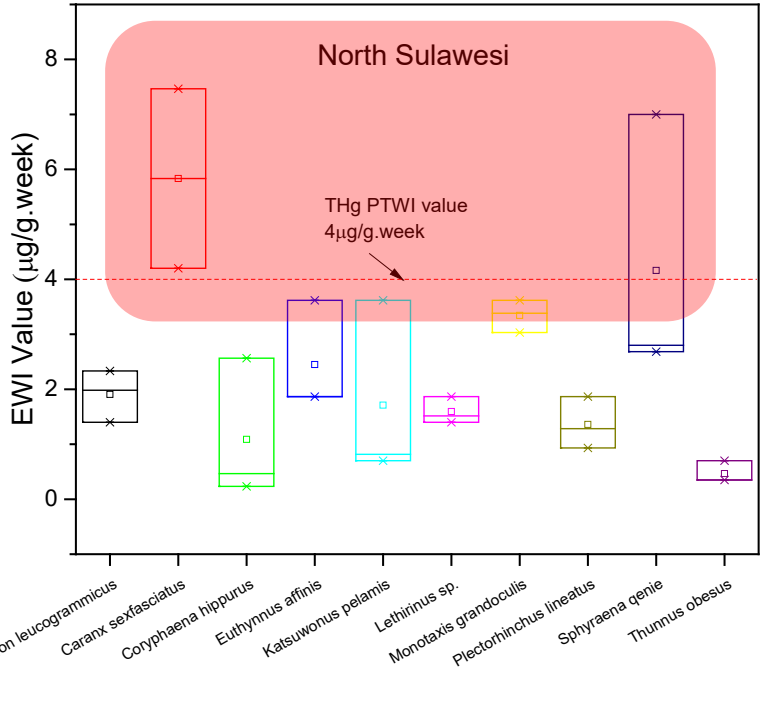

West Java
EWI Value (µg/g.week)
THg PTWI value 4µg/g.week
Katsuwonus pelamis
Thunnus obesus
Lobotes surinamensis
Chirocentrus dorab
Euthynnus affinis
Scomberomorus guttatus


Lampung
EWI Value (µg/g.week)
THg PTWI value
4µg/g.week
Caranx sexfasciatus
Euthynnus affinis
Gnathanodon speciosus
Lobotes surinamensis
Megalaspis cordyla
Netuma thalassina
Pseudotes erumei
Scomberomorus guttatus
Sphyraena putnamae
Thunnus obesus


Jakarta
EWI Value (µg/g.week)
THg PTWI value 4µg/g.week
Caranx sexfasciatus
Epinephelus areolatus
Euthynnus affinis
Katsuwonus pelamis
Lates calcarifer
Lutjanus malabaricus
Lutjanus monostigma
Megalaspis cordyla
Scomberomorus guttatus
Sphyraena putnamae
Thunnus tonggol
Tylosurus crocodilus


East Kalimantan
EWI Value (µg/g.week)
THg PTWI value 4µg/g.week
Carangoides fulvoguttatus
Caranx tille
Chanos chanos
Epinephelus sexfasciatus
Katsuwonus pelamis
Lutjanus gibbus
Lutjanus monostigma
Scomberomorus guttatus
Sphyraena jello
Sphyraena putnamae
Thunnus obesus


Central Sulawesi
EWI Value (µg/g.week)
THg PTWI value 4µg/g.week
Caranx sexfasciatus
Coryphaena hippurus
Epinephelus coralicola
Euthynnus affinis
Katsuwonus pelamis
Lethrinus atkinsoni
Lobotes surinamensis
Lutjanus madras
Plectorhinchus flavomaculatus
Plectorhinchus lineatus
Sphyraena barracuda
Thunnus obesus


North Sulawesi
EWI Value (µg/g.week)
THg PTWI value 4µg/g.week
Anyperodon leucogrammicus
Caranx sexfasciatus
Coryphaena hippurus
Euthynnus affinis
Katsuwonus pelamis
Lethrinus sp.
Monotaxis grandoculis
Plectorhinchus lineatus
Sphyraena qenie
Thunnus obesus

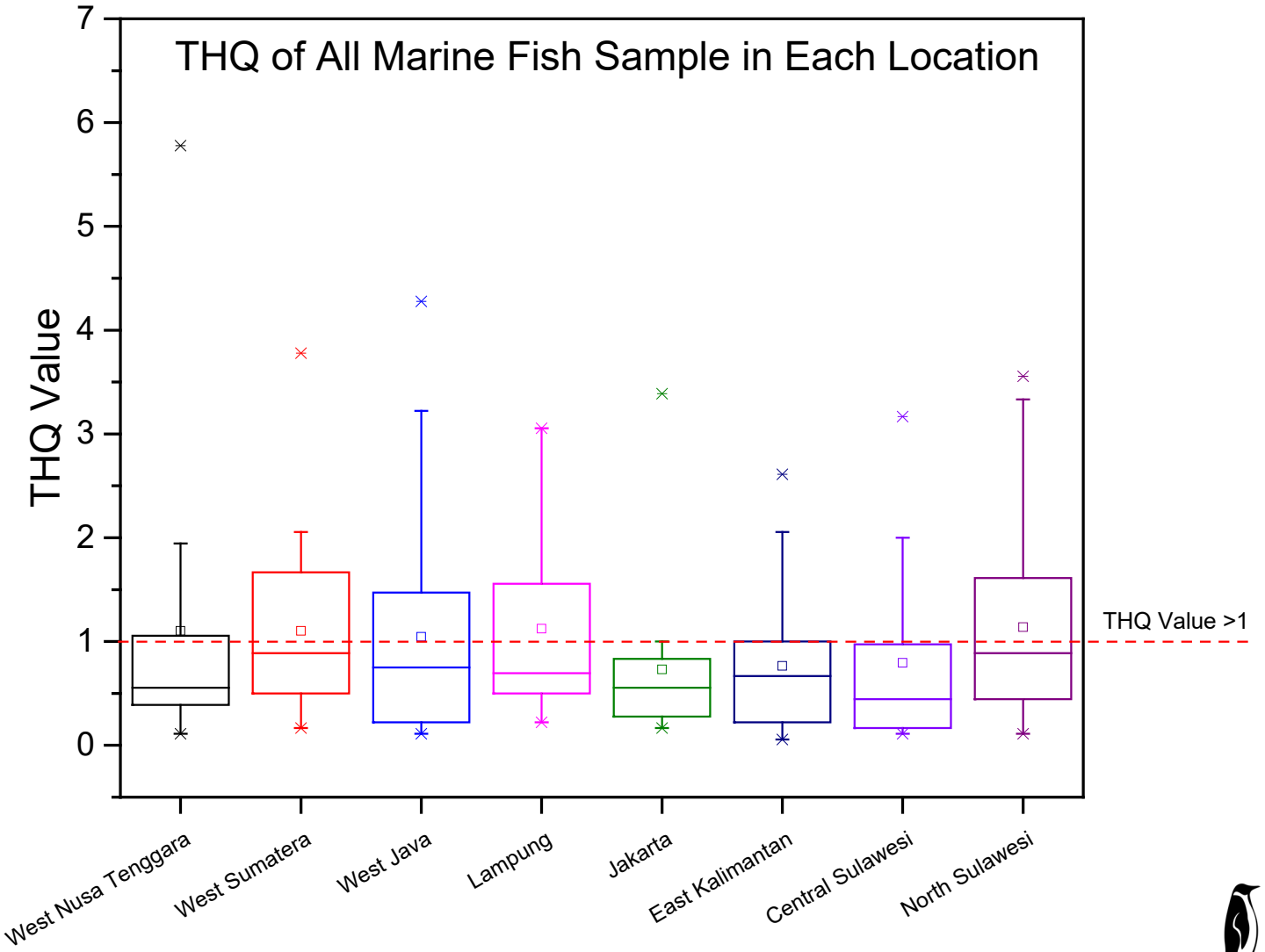
Total Hazard Quotient (THQ) Value

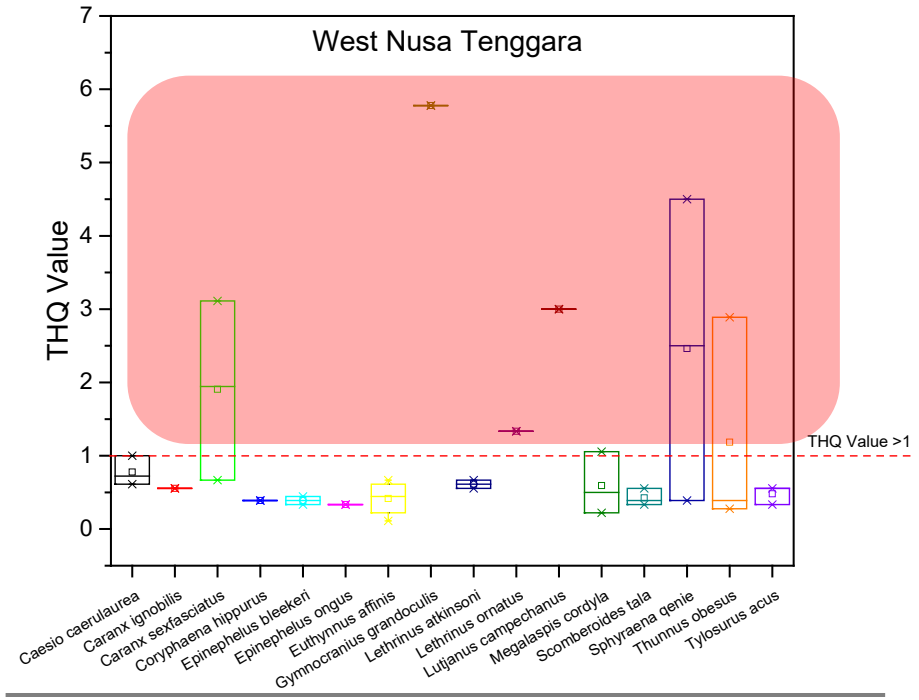
$$THQ = \frac{EF\ x\ ED\ x\ IR\ x\ C}{RD\ x\ BW\ x\ AT} x\ 10^{-3}$$

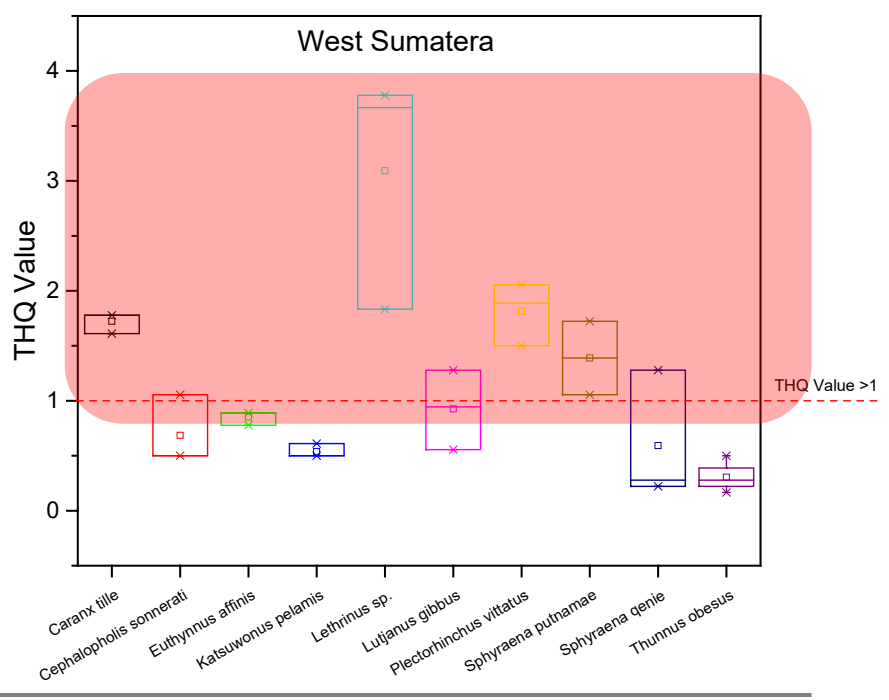
THQ is a **risk assessment** metric that quantifies the **non-carcinogenic health risk** posed by exposure to a hazardous substance over a specified period.

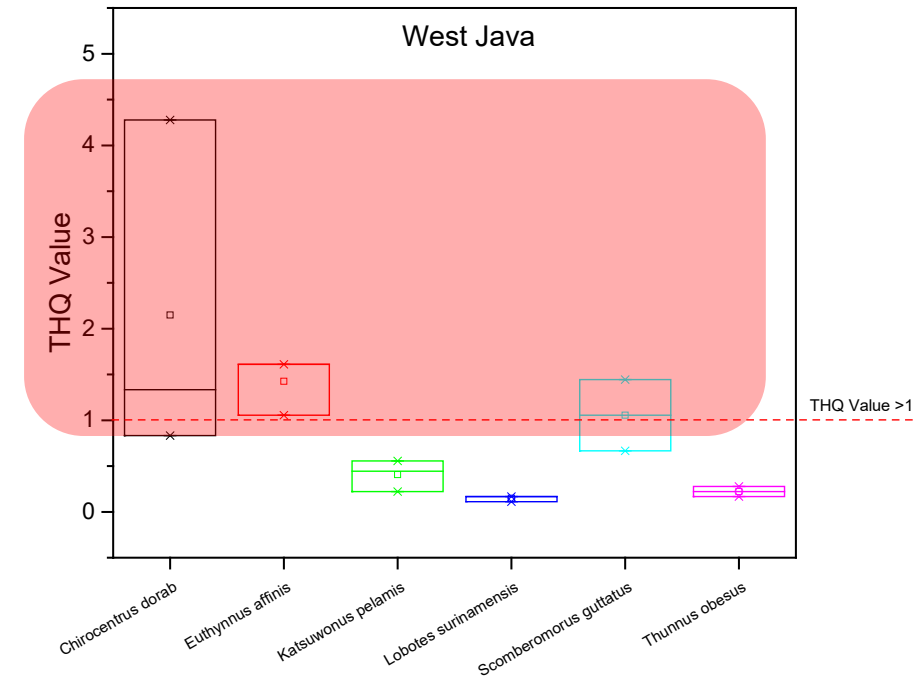
If THQ > 1, there is a potential health risk from the contaminant; if THQ < 1, the risk is considered negligible

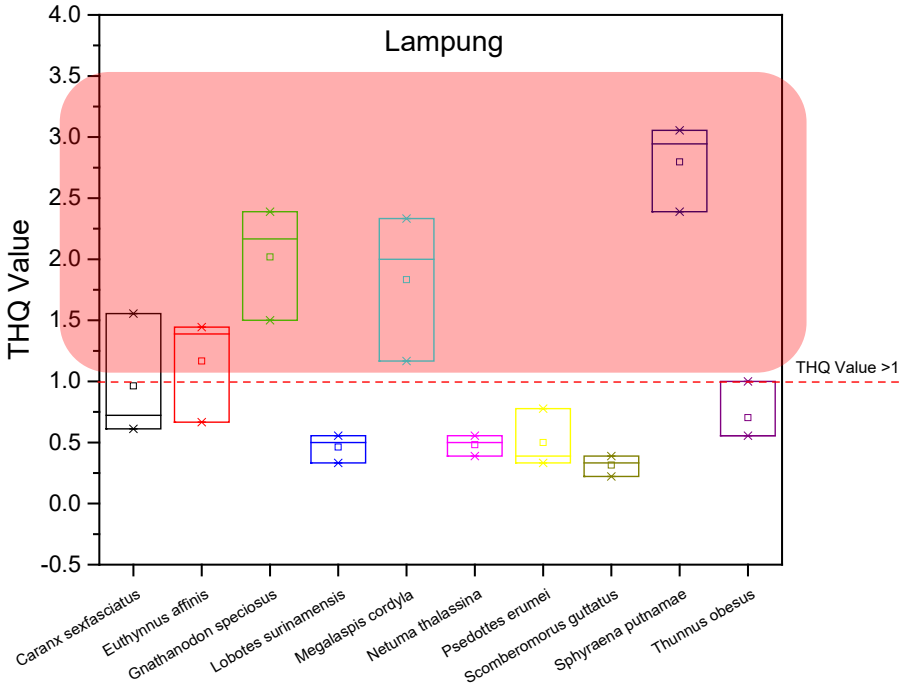
30 out of 87 fish species have THQ>1

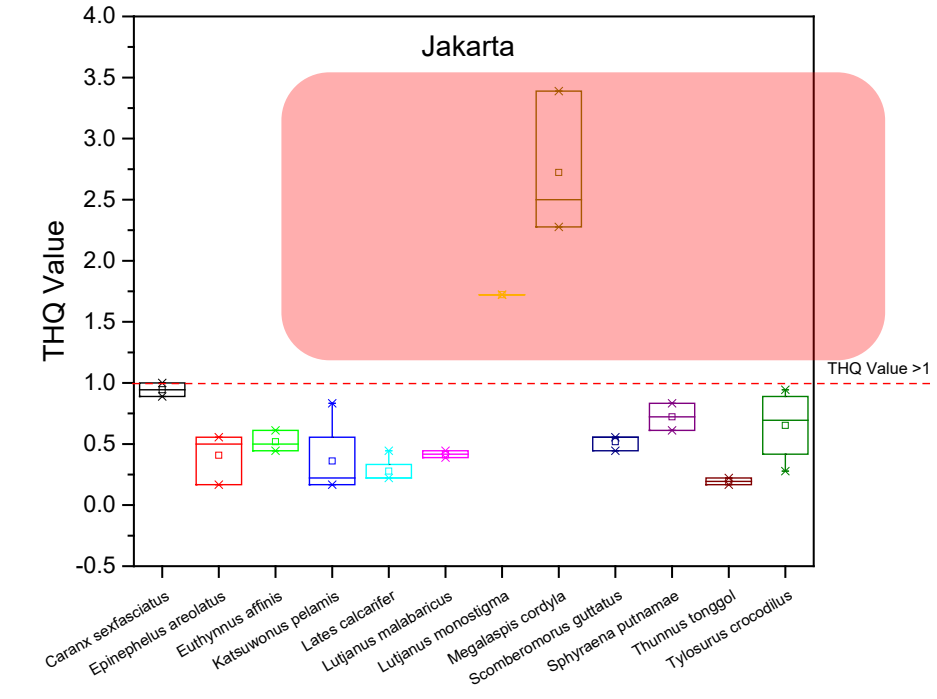


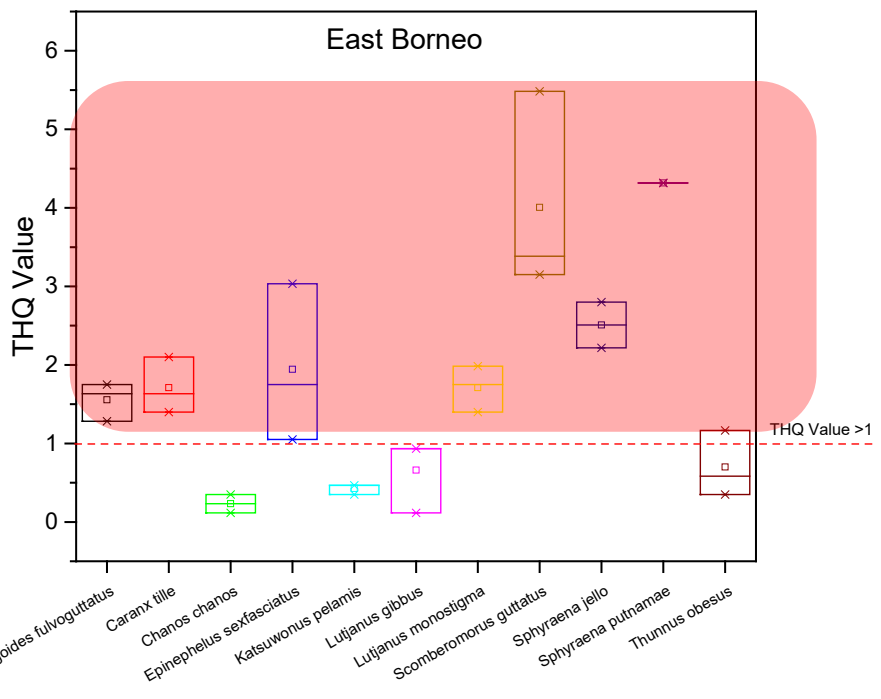

West Nusa Tenggara
THQ Value
THQ Value >1
Caesio caerulaurea
Caranx ignobilis
Caranx sexfasciatus
Coryphaena hippurus
Epinephelus bleekeri
Epinephelus ongus
Euthynnus affinis
Gymnocranius grandoculis
Lethrinus atkinsoni
Lethrinus ornatus
Lutjanus campechanus
Megalaspis cordyla
Scomberoides tala
Sphyraena qenie
Thunnus obesus
Tylosurus acus

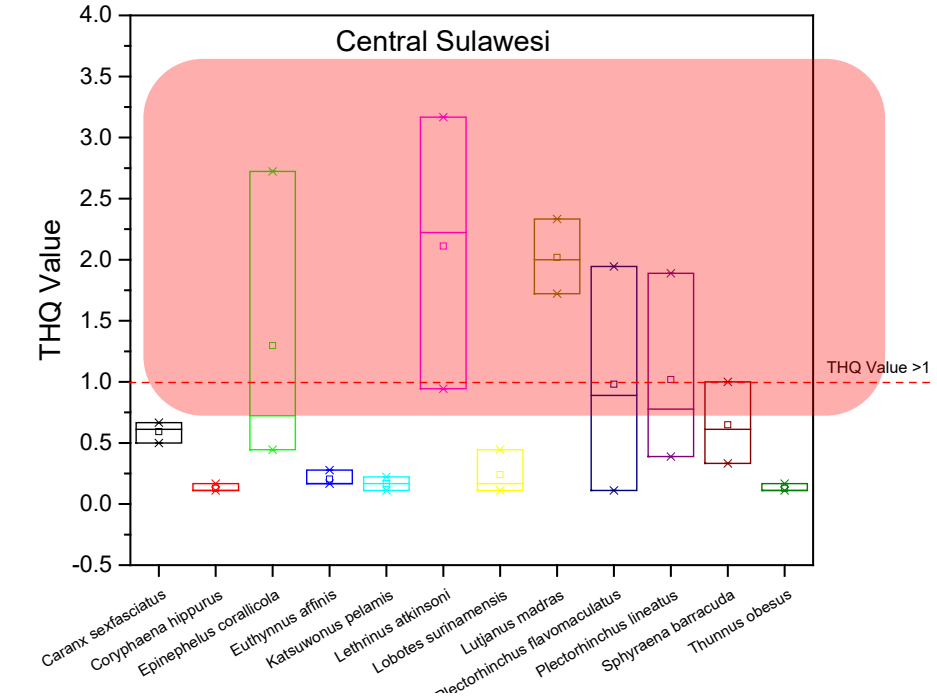

West Sumatera
THQ Value
THQ Value >1
Caranx tille
Cephalopholis sonnerati
Euthynnus affinis
Katsuwonus pelamis
Lethrinus sp.
Lutjanus gibbus
Plectorhinchus vittatus
Sphyraena putnamae
Sphyraena qenie
Thunnus obesus

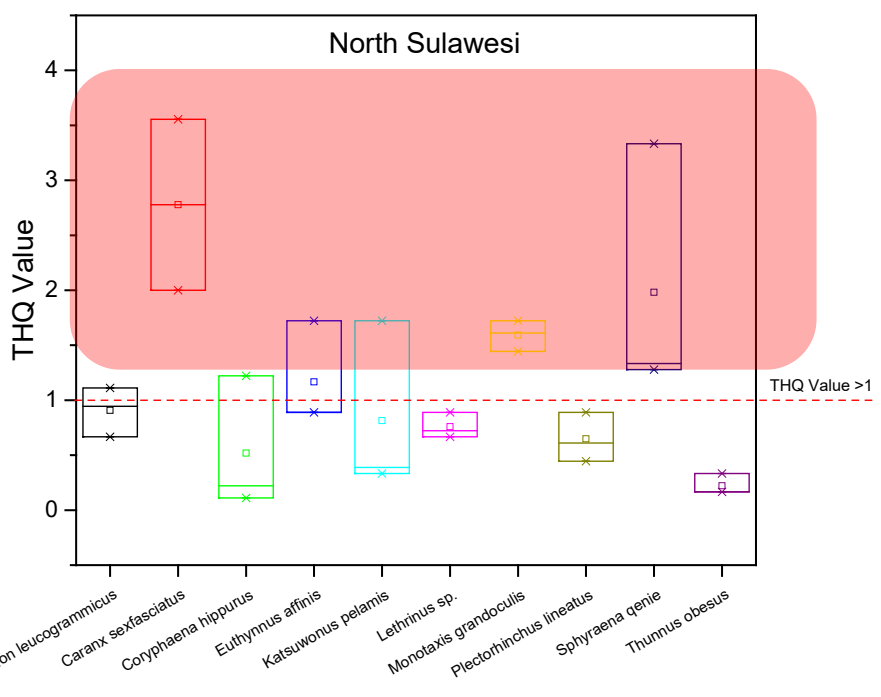

West Java
THQ Value
THQ Value >1
Chirocentrus dorab
Euthynnus affinis
Katsuwonus pelamis
Lobotes surinamensis
Scomberomorus guttatus
Thunnus obesus


Lampung
THQ Value
THQ Value >1
Caranx sexfasciatus
Euthynnus affinis
Gnathanodon speciosus
Lobotes surinamensis
Megalaspis cordyla
Netuma thalassina
Psedottes erumei
Scomberomorus guttatus
Sphyraena putnamae
Thunnus obesus


Jakarta
THQ Value
THQ Value >1
Caranx sexfasciatus
Epinephelus areolatus
Euthynnus affinis
Katsuwonus pelamis
Lates calcarifer
Lutjanus malabaricus
Lutjanus monostigma
Megalaspis cordyla
Scomberomorus guttatus
Sphyraena putnamae
Thunnus tonggol
Tylosurus crocodilus


East Borneo
THQ Value
THQ Value >1
Carangoides fulvoguttatus
Caranx tille
Chanos chanos
Epinephelus sexfasciatus
Katsuwonus pelamis
Lutjanus gibbus
Lutjanus monostigma
Scomberomorus guttatus
Sphyraena jello
Sphyraena putnamae
Thunnus obesus


Central Sulawesi
THQ Value
THQ Value >1
Caranx sexfasciatus
Coryphaena hippurus
Epinephelus corallicola
Euthynnus affinis
Katsuwonus pelamis
Lethrinus atkinsoni
Lobotes surinamensis
Lutjanus madras
Plectorhinchus flavomaculatus
Plectorhinchus lineatus
Sphyraena barracuda
Thunnus obesus

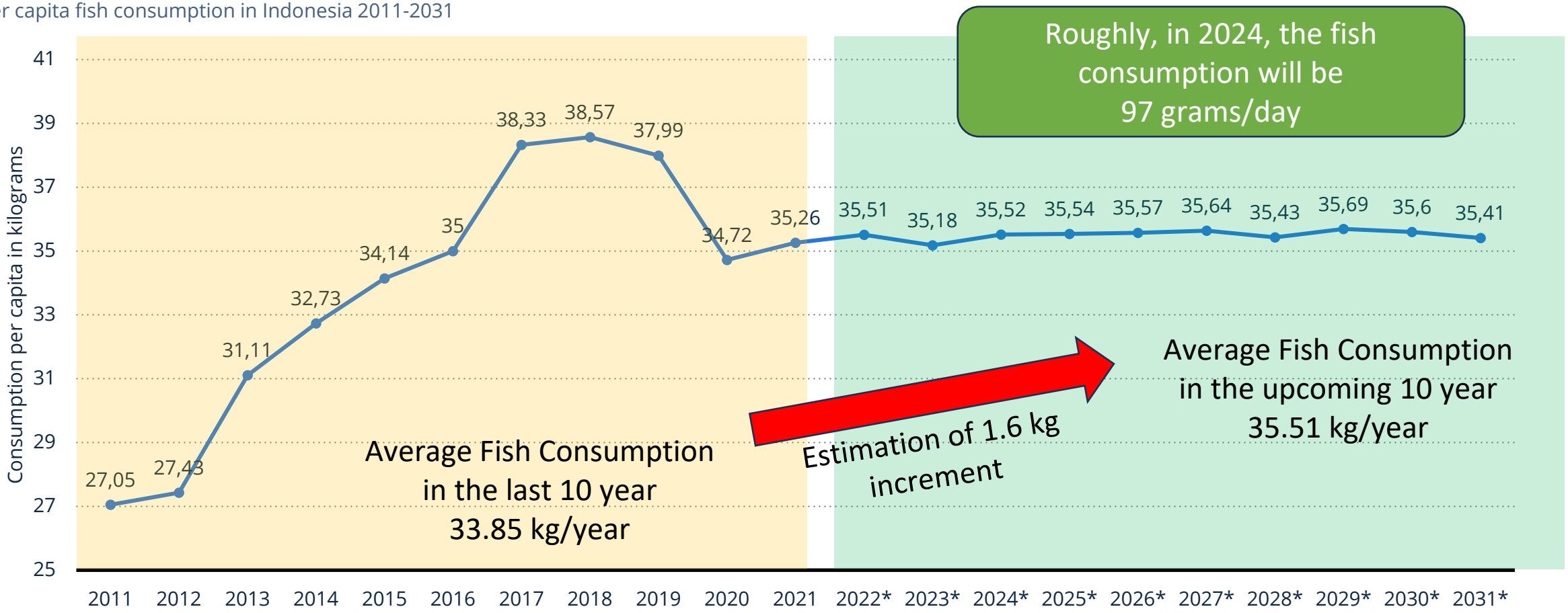

North Sulawesi
THQ Value
THQ Value >1
Anyperodon leucogrammicus
Caranx sexfasciatus
Coryphaena hippurus
Euthynnus affinis
Katsuwonus pelamis
Lethrinus sp.
Monotaxis grandoculis
Plectorhinchus lineatus
Sphyraena qenie
Thunnus obesus

Research Objective

Health Risk Evaluation

Fish consumption per capita in Indonesia from 2011 to 2021, with estimates until 2031 (in kilograms)

Per capita fish consumption in Indonesia 2011-2031



Description: As of 2021, each individual in Indonesia consumed approximately 35.26 kilograms of fish. The fish consumption per capita in Indonesia was forecast to slightly increase by around 0.15 kilograms per capita in 2031. In general, the consumption per capita is estimated to be subject to fluctuation over the following years. On the other hand, consumption per capita of other commodities in Indonesia, such as wheat and corn, was also estimated to have a relatively stable growth over the next years. Read more
Note(s): Indonesia; 2011 to 2021; *Forecast. Figures have been rounded. The source does not provide a publication date. Release date was date accessed. Read more
Source(s): OECD

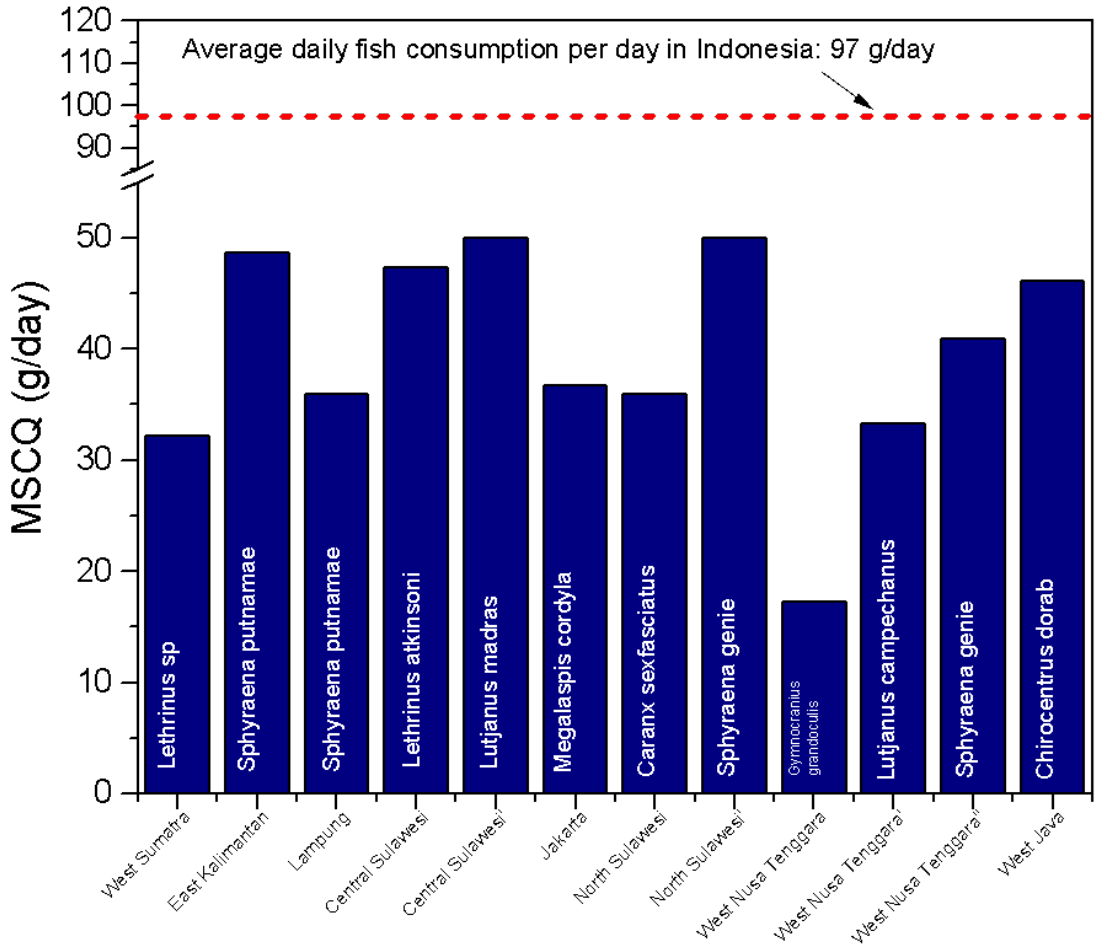
Maximum Safe Consuming Quantity (MSCQ)

$$\mathrm{MSCQ} = \frac{\mathrm{BWxRD}}{\mathrm{C_{CE}}} \mathrm{x1.0x10^3}$$

MSCQ indicates the **maximum amount of a contaminated food item that can be safely consumed** without exceeding the reference dose of the contaminant.

This index shows that the **higher the Hg content** in a fish species, the **lower the consumption limit** of the fish.

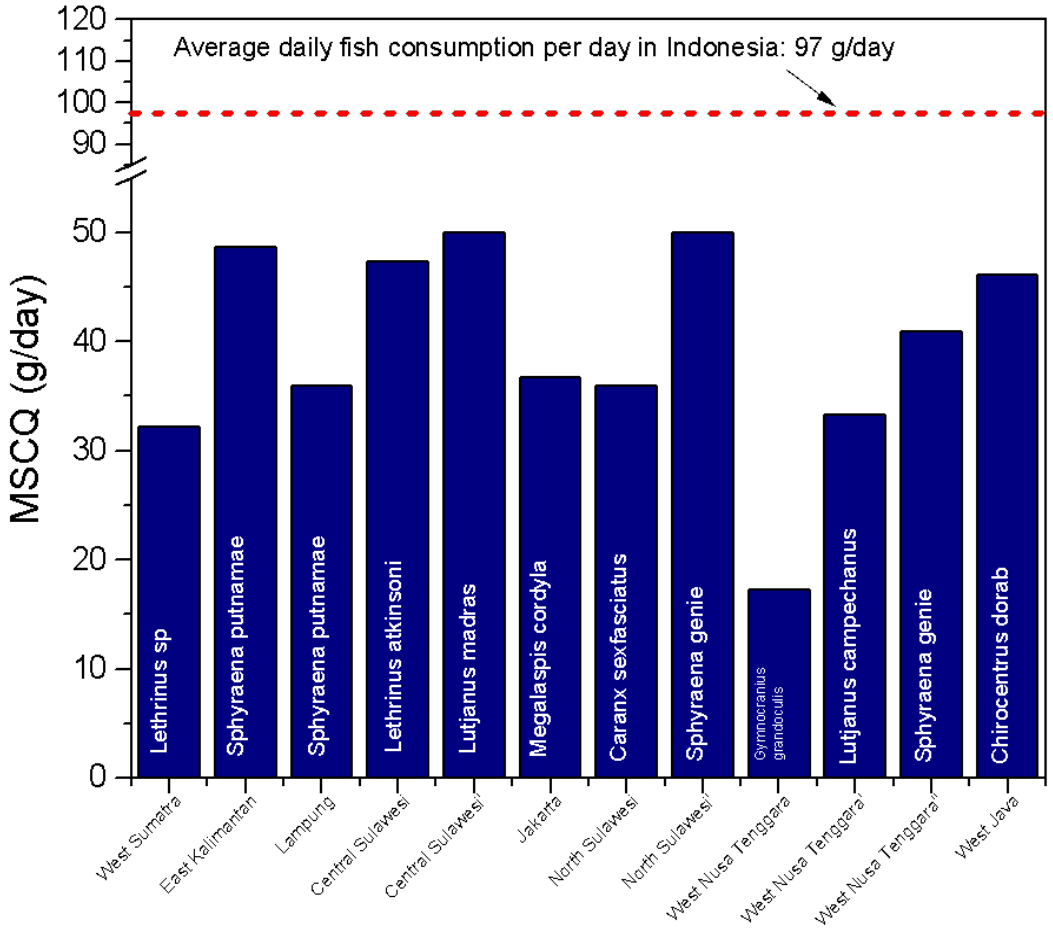
If the average daily consumption in Indonesia is 97 g/day, then several fish in the graph that have an **MSCQ value below 50 g/day are fish that tend to have a high potential for transferring mercury** to people who eat the fish.



12 fish species from 8 provinces in Indonesia

MSCQ Analysis (cont)

MSCQ levels of fish ≤50 g/day

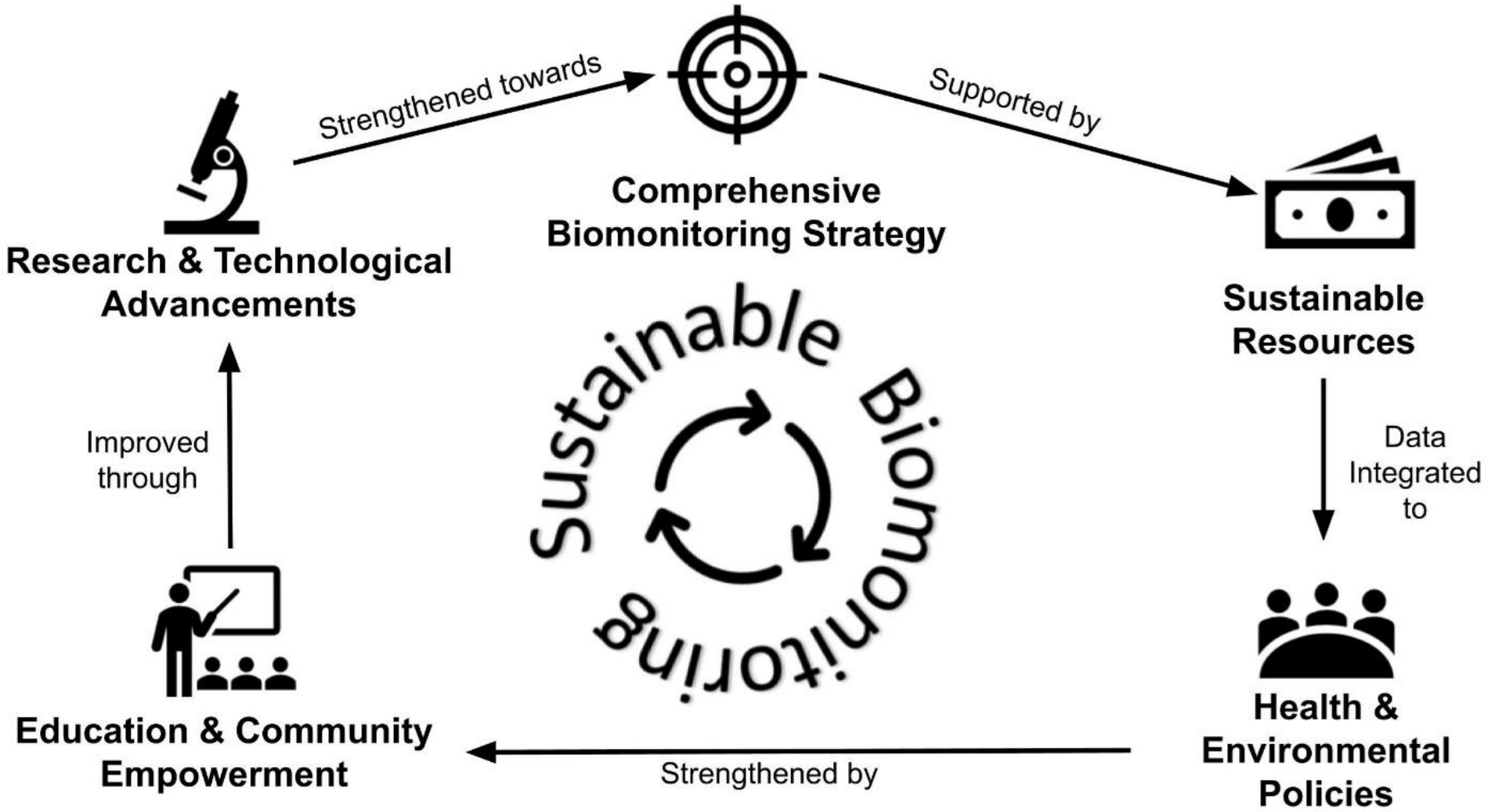


No.	Latin Name	Local Name	English Name	Province	MSCQ (g/day)
1	Lethrinus sp	Kakap	Ray-finned fishes	West Sumatra	32.1
2	Sphyraena putnamae	Barakuda	Sawtooth Baracuda	East Kalimantan	48.6
3	Sphyraena putnamae	Barakuda	Sawtooth Baracuda	Lampung	36.0
4	Lethrinus atkinsoni	Kakap Putih	yellow-tailed emperor	Central Sulawesi	47.4
5	Lutjanus madras	Katombo	Indian Snapper	Central Sulawesi	50.0
6	Megalaspis cordyla	Tengkek	Torpedo Scad	Jakarta	36.7
7	Caranx sexfasciatus	Kuwe	Bigeye Trevally	North Sulawesi	36.0
8	Sphyraena qenie	Barakuda	Blackfin barracuda	North Sulawesi	50.0
9	Gymnocranius grandoculis	Kakap Putih	blue-lined large-eye bream	West Nusa Tenggara	17.3
10	Lutjanus campechanus	Kakap Merah	Northern red snapper	West Nusa Tenggara	33.3
11	Sphyraena qenie	Barakuda	Blackfin barracuda	West Nusa Tenggara	40.9
12	Chirocentrus dorab	Balida	Dorab wolf-herring	West Java	46.2

Research Objective

Recommendations to policy makers for mitigation

Proposed design for biomonitoring plan



Future Recommendation

Regular monitoring is a must to identify the potential for mercury early on

Acknowledgment

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DEPARTMENT OF STATE
UNITED STATES OF AMERICA

Thank you for your attention

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Our team