Rapid Temporal Decline of Mercury in Greenland Halibut

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AMAP (2022)

Support, Network, & People

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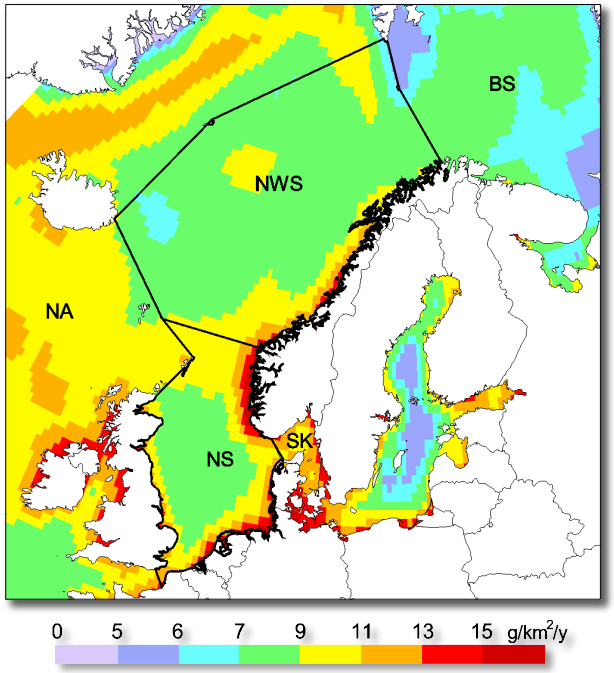
Presentation Outline

- Background – Hg in Norway
- Hg in Greenland Halibut
- Bayesian Model
- MCM Relevance & Synthesis

Lab Accreditation: NS-EN ISO / IEC 17025 (2017-Present)

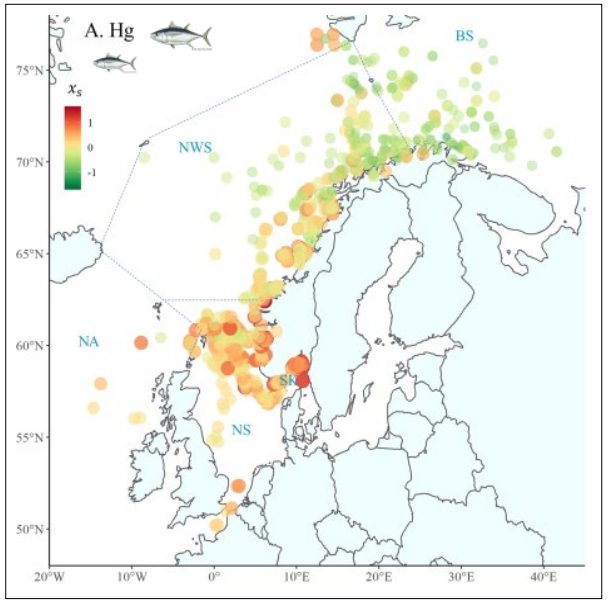
Mercury in Norway - NEAO Hg Model
Atmospheric Chemistry-Trophic Transfer-Human Exposure

2015 Mercury Deposition to NEAO (NMA 2022)



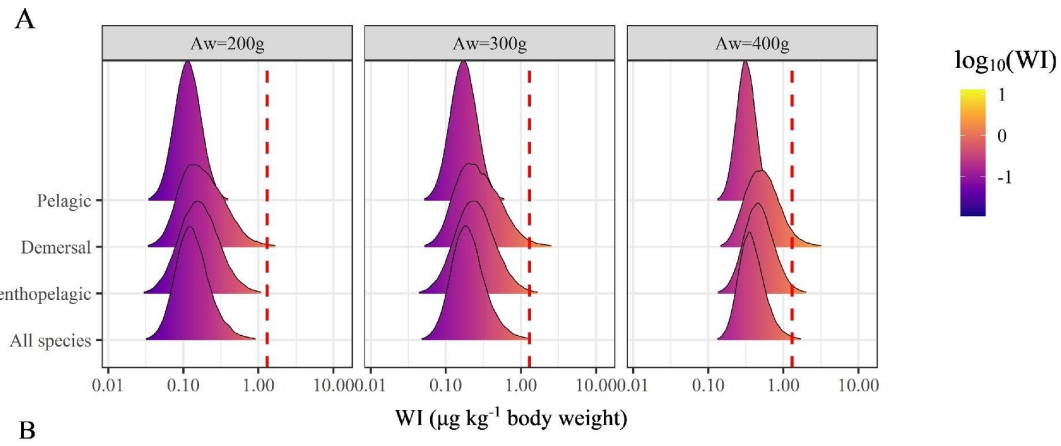
Multi-model simulations
AMAP Ensemble Model
Hg Assessment

Length-Adjusted Mercury Concentrations in Marine Fish (*n*=25,631, 2006-2019)



Fish measurements
(Ho* & Bank* *et al.*, 2021)
*co-first authors

Methylmercury Human Exposure 2006-2019 Monte Carlo Simulation



Human Cooperation:
Oleg Travnikov / AMAP

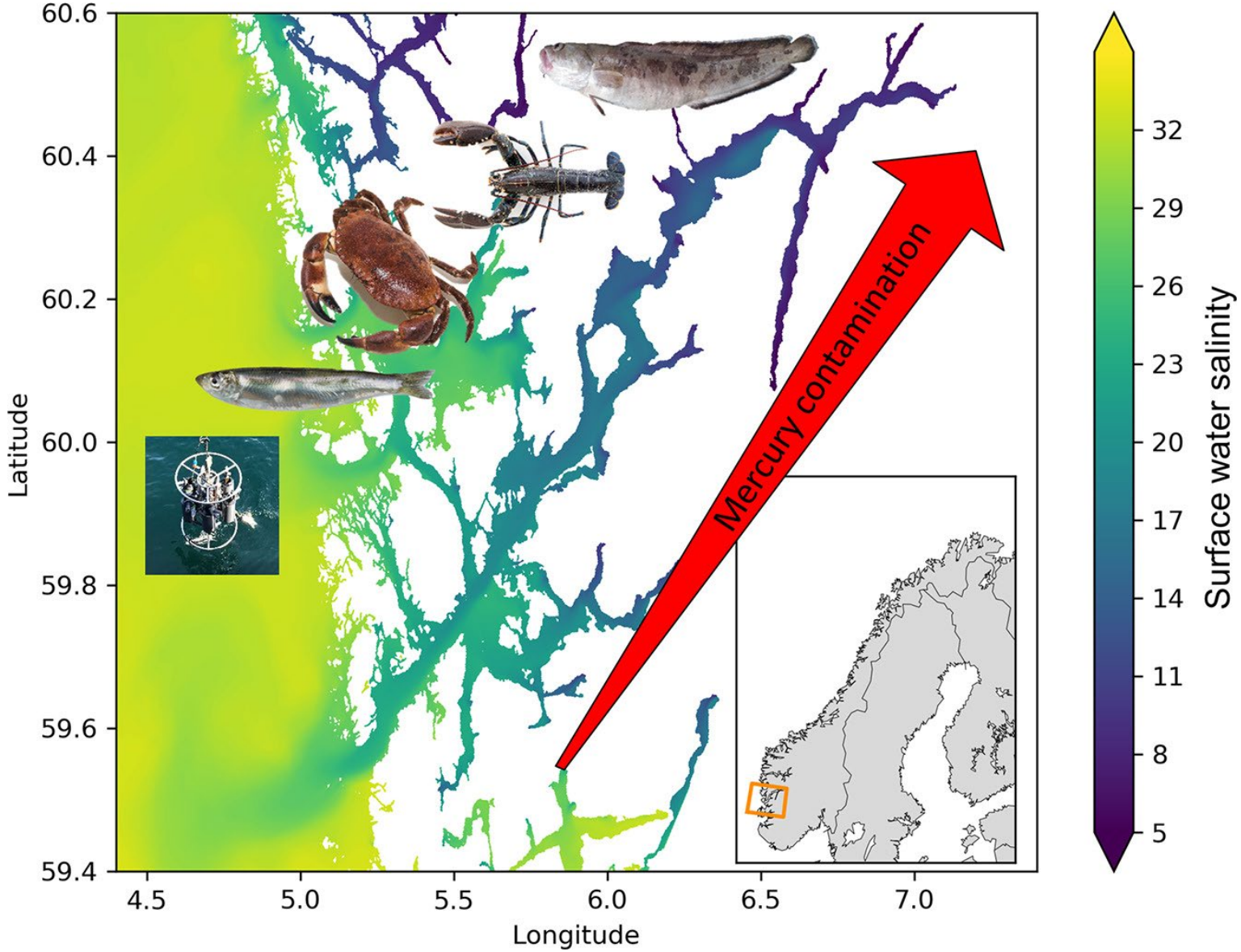
Logic Note: Fish Hg is spatially correlated with atmospheric Hg deposition.

Bank et al. 2025
(In Prep, STOTEN)

Mercury in Norwegian Fjords: Sensitive Ecosystems

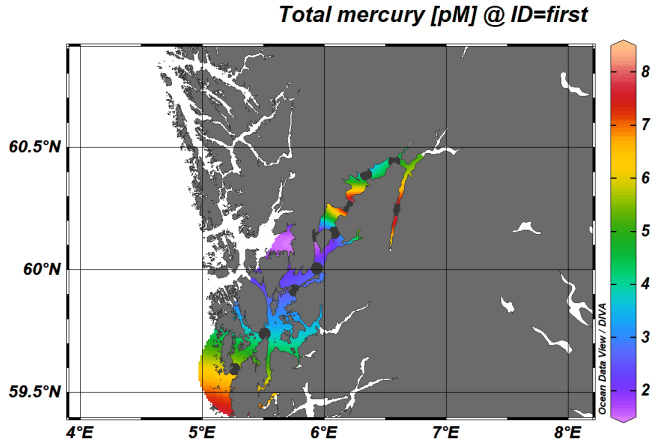
- **<u>Fjord</u> – a long, narrow, deep inlet of the sea between high cliffs**

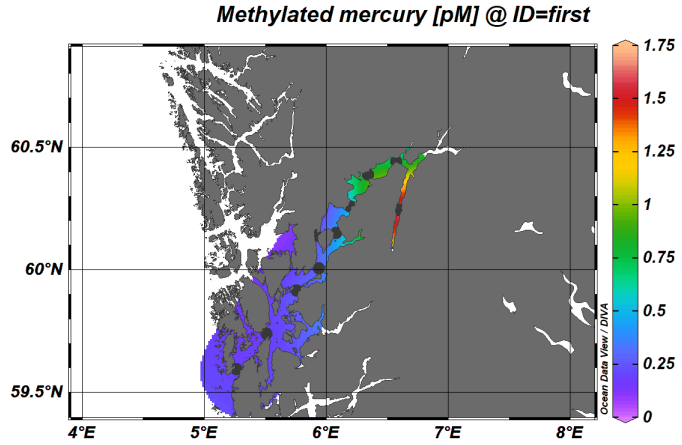
Mercury Trophic Transfer and Speciation in Hardangerfjord

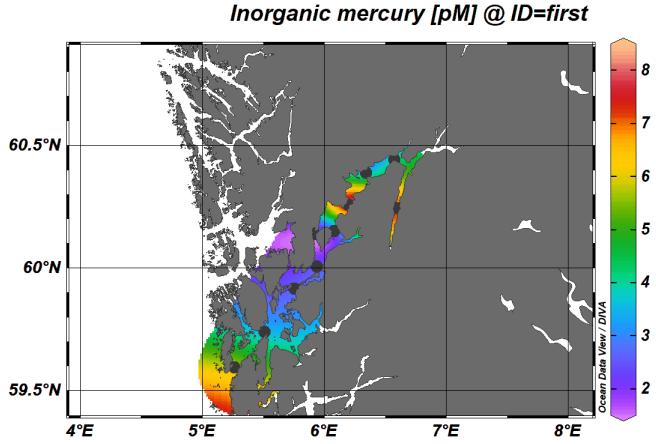


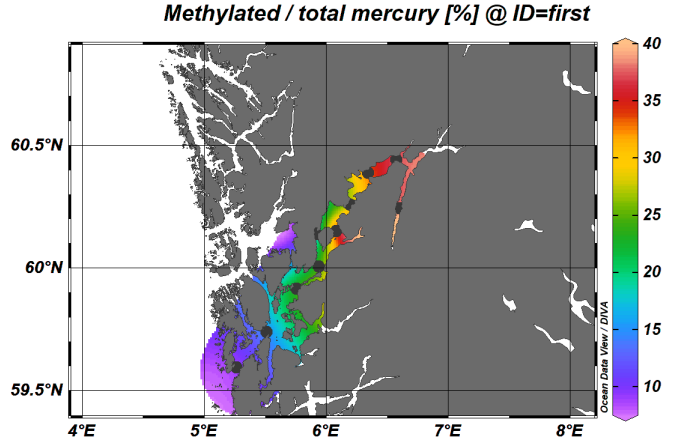
Azad et al., 2019 STOTEN

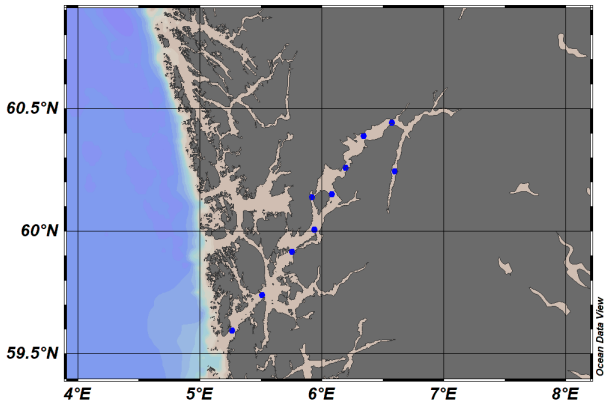
Mercury Speciation in Fjord Ecosystems: Spatial Trends of Maximum Observed Values











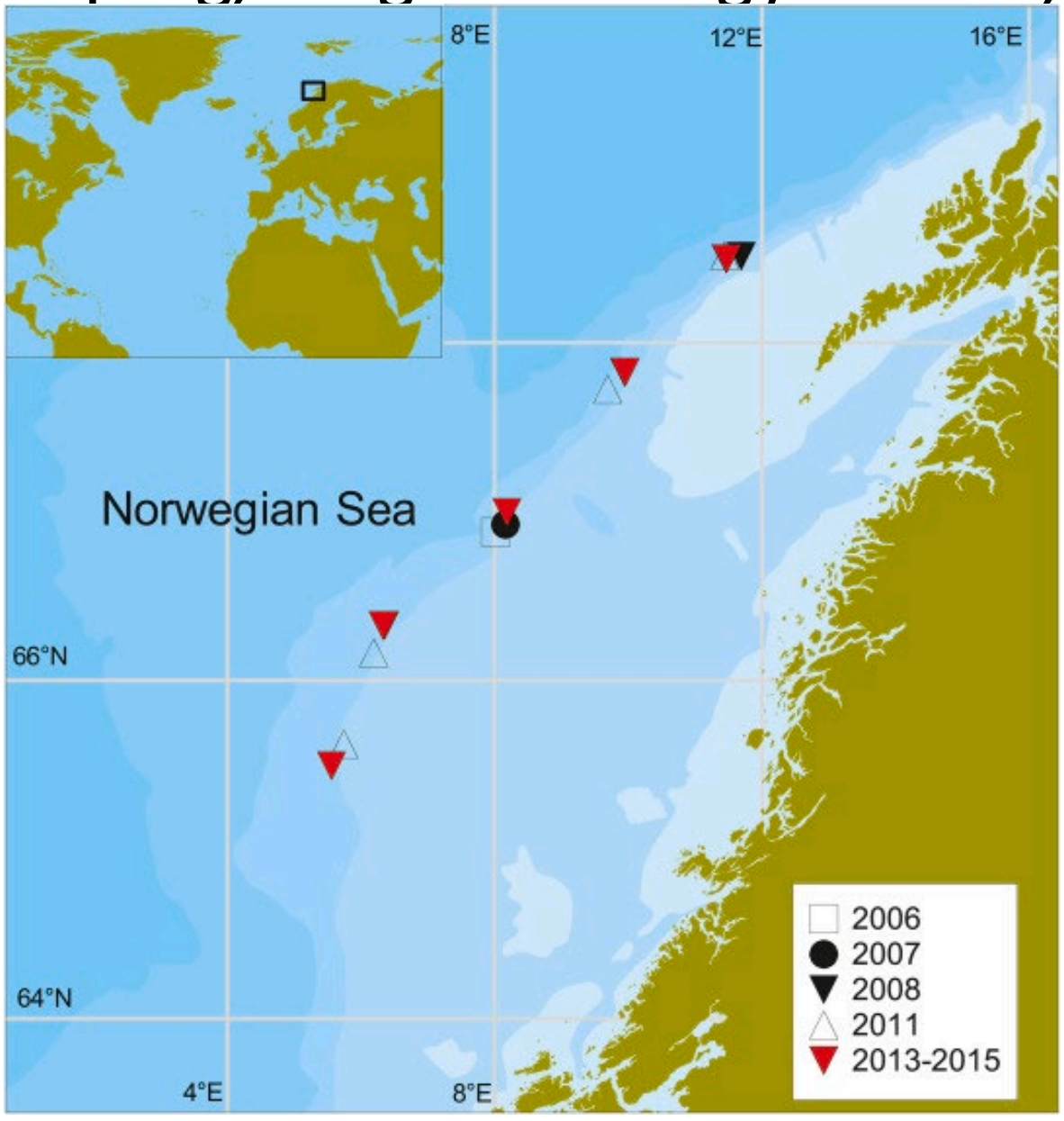
Maximum value for each station

Greenland Halibut (*Reinhardtius hippoglossoides*) Life History

- Diet - Shrimp, Caeplin, Squid, Cod, Redfish (Pelagic or Semi-Pelagic Feeders)
- Habitat – deep water (200-2200m) w/ vertical migration (Benthopelagic)
- Max. Weight – 45 kg & Max. Total Length – 120 cm
- IUCN Conservation Status – Near Threatened
- Circumpolar Distribution

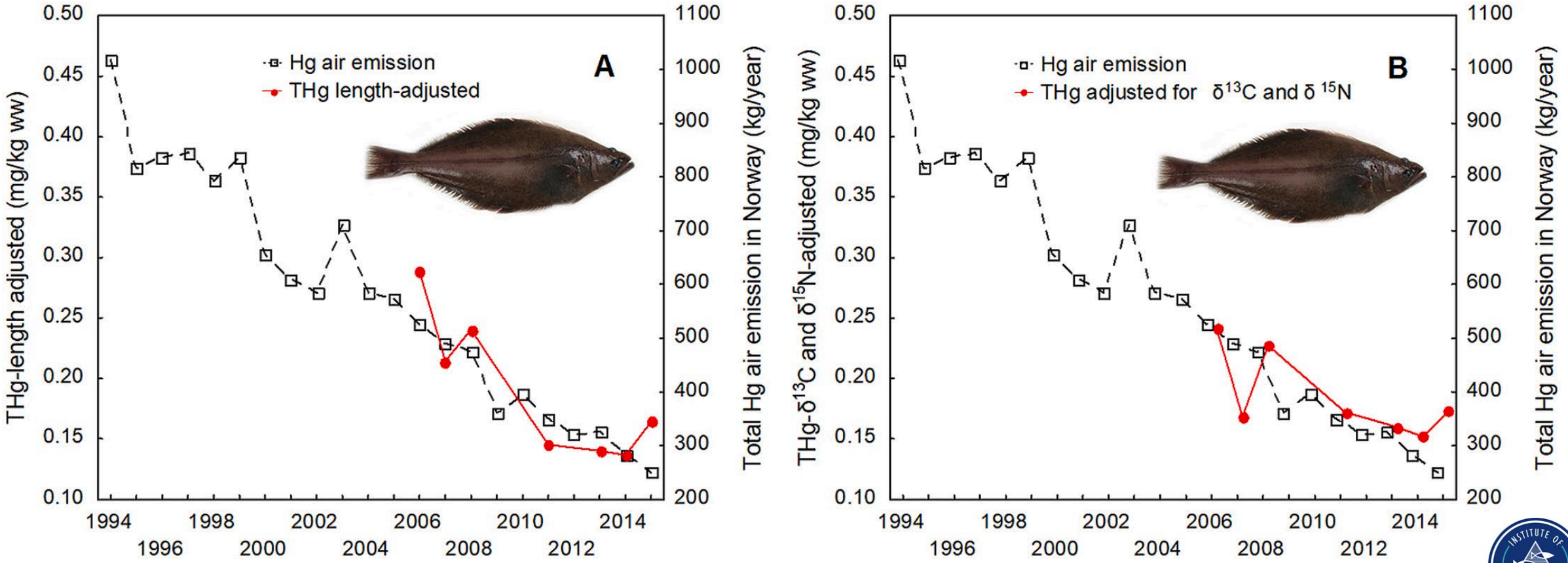
Bank et al. 2021, *Environmental Pollution*

Greenland Halibut Hg Temporal Assessment (2006-2015 Sampling, Longline Fishing / Gillnets, n=625)



Greenland Halibut Fillets: THg, and C and N Isotopic Niches
35-50% Decline in THg (≥77% as Methyl Hg)

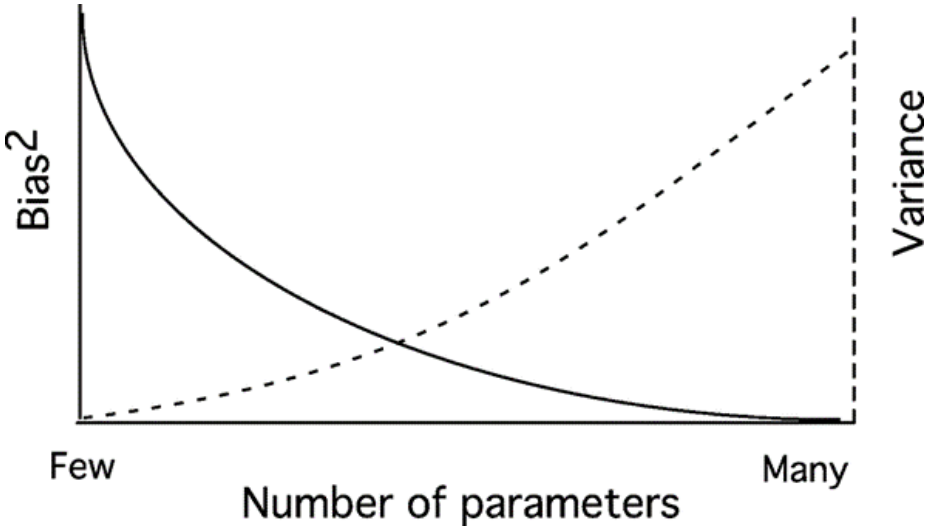
Bank et al. 2021, *Environmental Pollution*



***C isotope data are lipid corrected**

Degrees of Belief and the Bayesian Mindset……
***Akaike Information Criterion (AIC)* Modeling**

1. **Collinearity** - Sensitive to Correlated Variables
2. Variable Reduction Helps (**Parsimony Based**)
3. Sensitive to **Missing Values (Sex, C and N)**



$$AIC = n \log(\hat{\sigma}^2) + 2K,$$

where $\hat{\sigma}^2 = \frac{\text{Residual Sum of Squares}}{n}$

$$w_i = \frac{\exp\left(-\frac{1}{2}\Delta_i\right)}{\sum_{r=1}^{R}\exp\left(-\frac{1}{2}\Delta_r\right)}$$

Poly-Parameter Temporal Model of Greenland Halibut THg:

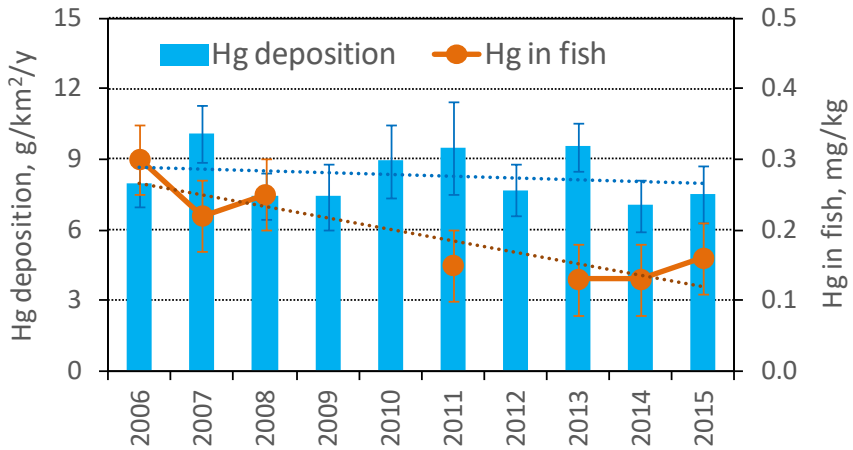
An Information Theoretic Approach

Model	K	*n*	RSS	AIC	Δ_i	w_i
Length	3	512	42.58	-1267.27	208.89	0.00
$\delta^{13}C$	3	512	30.27	-1441.95	34.21	0.00
$\delta^{15}N$	3	512	43.77	-1253.16	223.0	0.00
Fat Content	3	512	46.80	-1218.93	257.22	0.00
Year	3	512	38.16	-1323.38	152.78	0.00
Sex	3	512	46.69	-1220.15	256.01	0.00
Year + Length	4	512	36.56	-1343.29	132.87	0.00
Year + Fat Content	4	512	37.19	-1334.63	141.53	0.00
Year + $\delta^{13}C$	4	512	28.94	-1463.06	13.10	0.00
Year + $\delta^{15}N$	4	512	37.39	-1331.88	144.28	0.00
Year + Sex	4	512	38.16	-1321.40	154.76	0.00
$\delta^{13}C$ + $\delta^{15}N$	4	512	28.80	-1465.51	10.65	0.00
Year + $\delta^{13}C$ + $\delta^{15}N$	**5**	**512**	**28.10**	**-1476.16**	**0.00**	**0.82**
Year + Length + $\delta^{13}C$	5	512	28.72	-1464.94	11.22	0.00
Year + Length + $\delta^{15}N$	5	512	35.48	-1356.67	119.49	0.00
Length + $\delta^{13}C$ + $\delta^{15}N$	5	512	28.27	-1472.96	3.20	0.17
Global*	6	512	28.52	-1466.43	9.73	0.01

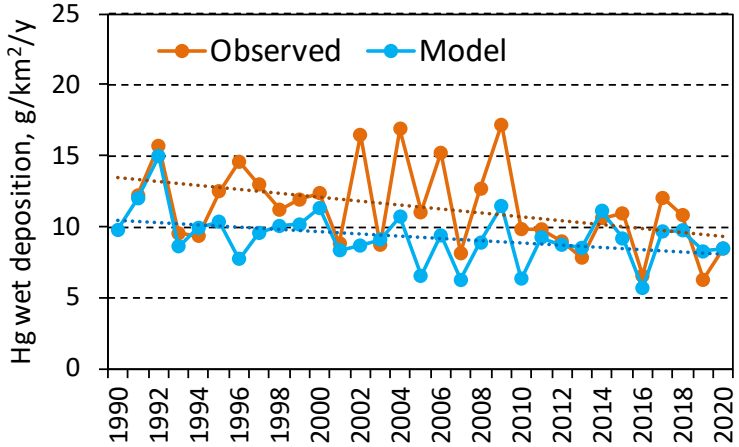
*The global model includes all significant variables ($\delta^{13}C$, $\delta^{15}N$, length, and year).

Long-Term Trends of Hg Pollution in Norway

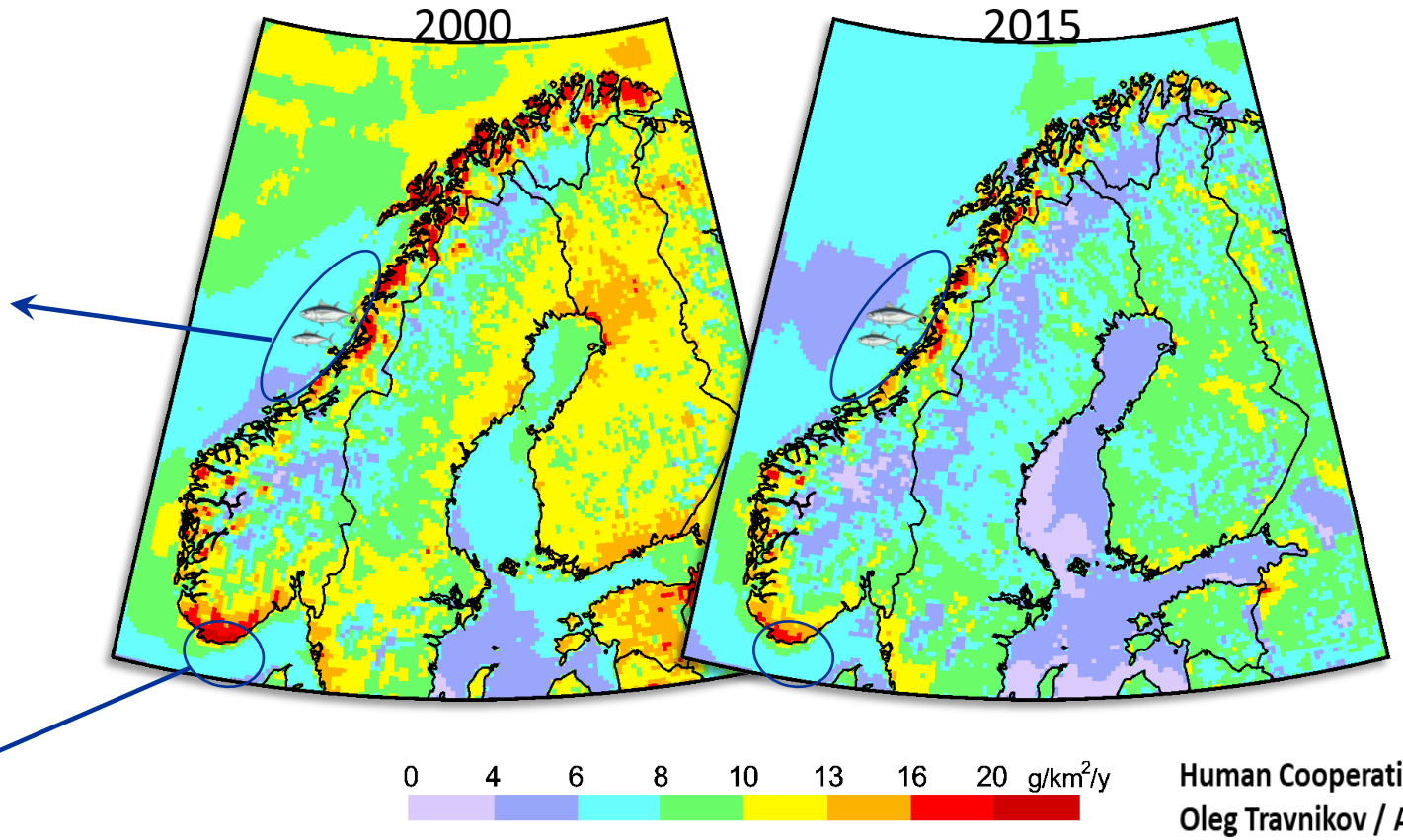
Hg Deposition vs. Greenland Halibut Mercury



Hg wet deposition (Birkenes/Lista)



Hg Atmospheric Deposition (GLEMOS)



Human Cooperation:
Oleg Travnikov / AMAP

Logic Note:

- Reduction of Hg in Greenland Halibut is stronger than decrease of Hg deposition. Process is likely highly nuanced and species-specific.

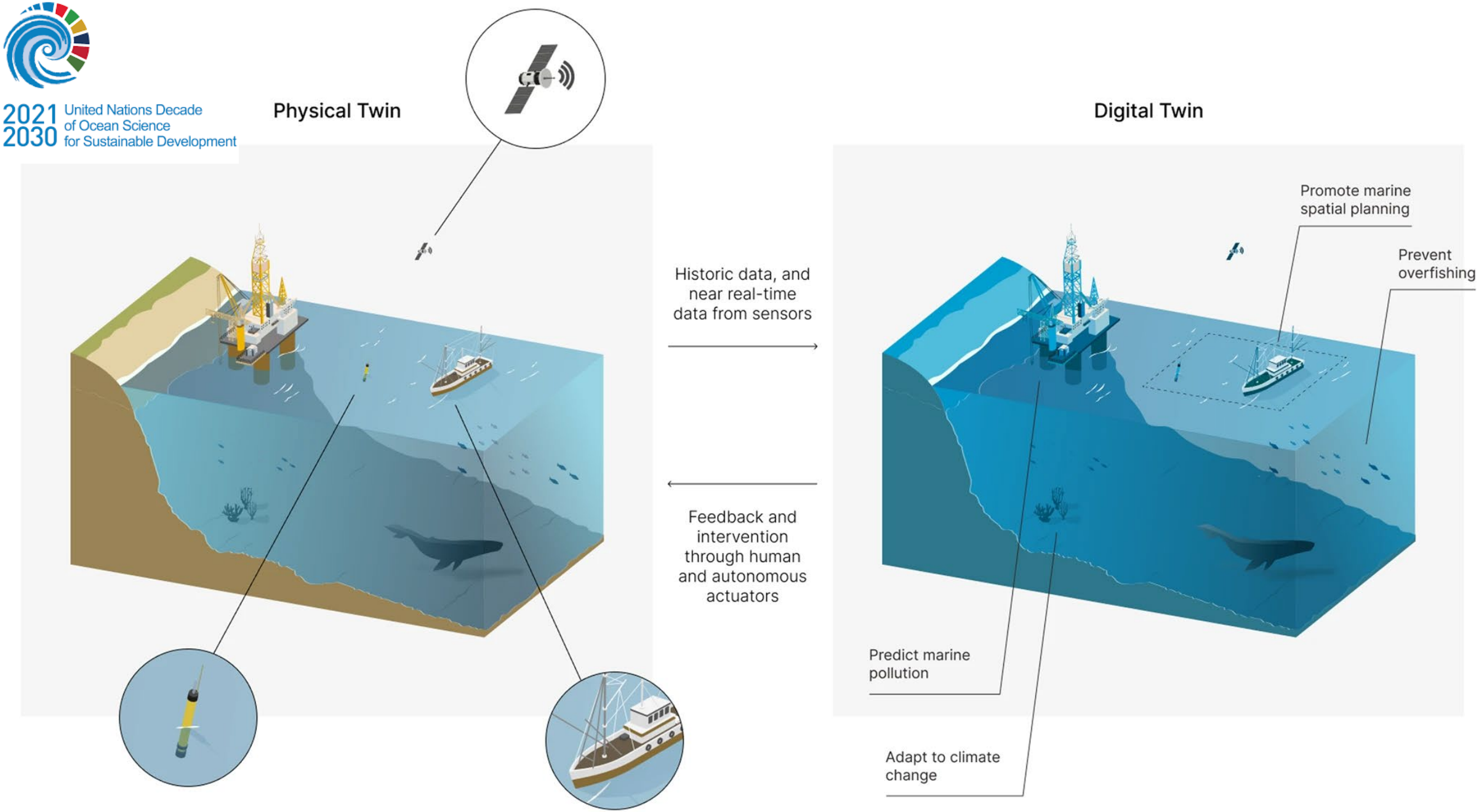
Synthesis

35-50% Decline in THg at decadal scale (2006-2015)

'Best Model' Hg (Log_{10}) **decreased with time (Year/air Hg emissions)**, and was higher in fish utilizing more **marine pelagic prey species (C), that were higher on the food web (N)** and in **individuals with greater length (cm)**

Good ecoindicator for deep water marine fish in support fo the UN Minamata Conveniton on Mercury

2021 2030 United Nations Decade of Ocean Science for Sustainable Development



Tzachor et al. 2023 To appreciate these prospects, we acknowledge potential applications of DTs across four thematic areas: (a) reducing and preventing overfishing, (b) modeling and predicting marine pollution, (c) adapting to climate change, and (d) marine spatial planning (see Fig. 1).

Capacity Building in Africa & Asia

- Largest Ocean Science Capacity Building Program in the World (Africa to the Bay of Bengal Region of Asia)
- Project is designated as ‘Aid’ (UN-FAO, NORAD & IMR)
- Collaboration with 60 Countries & Celebrating 50 Years of service this year!
- Scientists from Africa & Asia learn about ***chemical pollution***, fisheries, ecosystem dynamics, and oceanography, etc.
- Contact **Michael.Bank@hi.no** for more information.

Nansen Programme