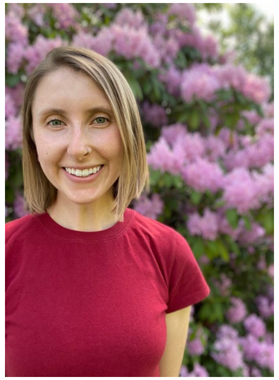
Assessing Sources and Bioaccumulation of Mercury in Two Contrasting Arctic Ecosystems Using Stable Mercury Isotopes



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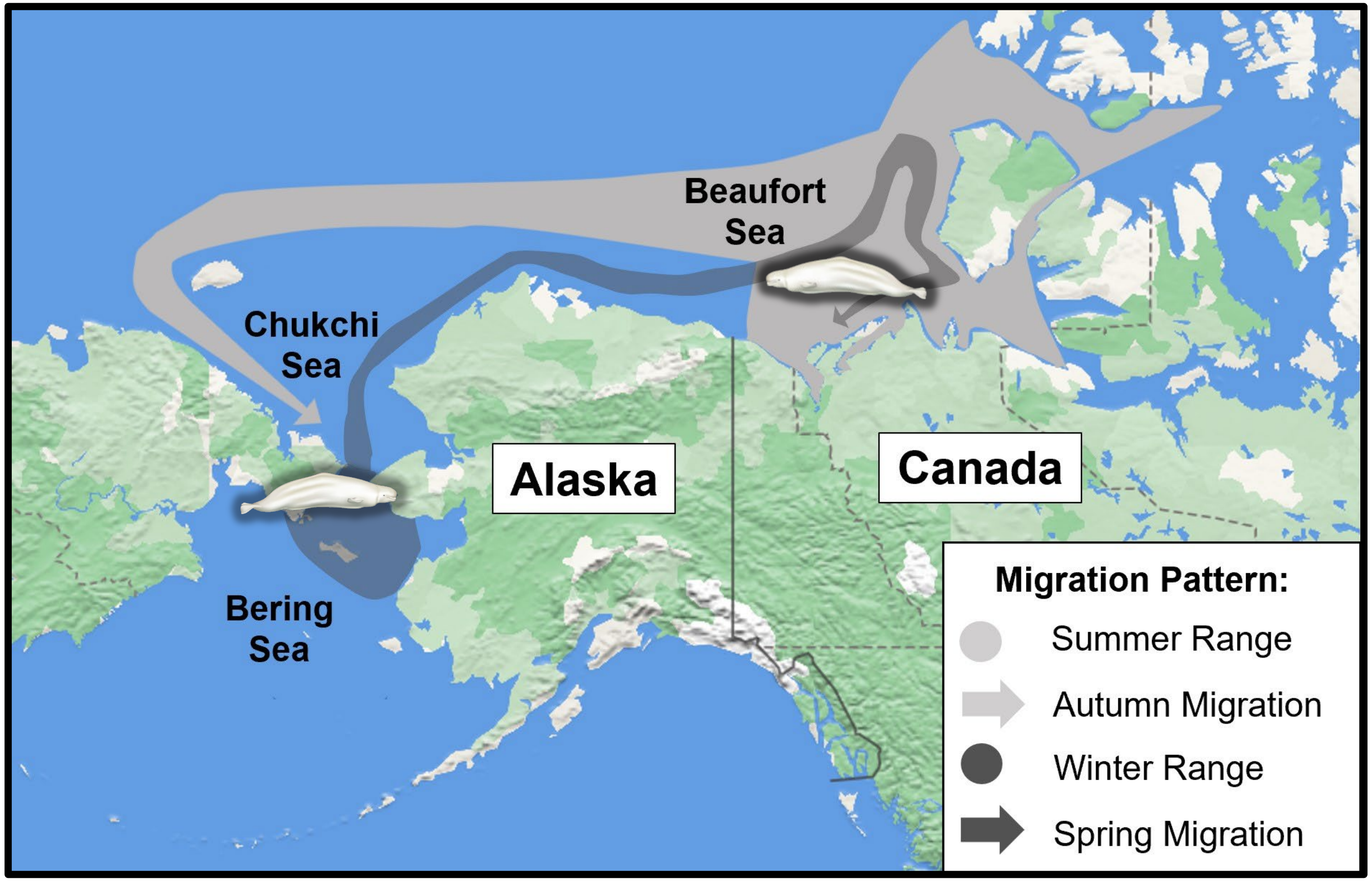
University of Delaware · Pohang University of Science and Technology · Harvard · NOAA Fisheries · Fisheries and Oceans Canada

Introduction

Stefan Hendricks / Alfred-Wegener-Institut

- Long-range transport to arctic via atmosphere and ocean currents.
- Rapid changes in the Arctic, such as sea ice decline and temperature increase, are affecting arctic food webs in many ways.
- The **foraging behavior** and **mercury burden** of some sentinel species are changing, although the mechanism is unclear.

Introduction – East Beaufort Sea beluga



Winter in Bering Sea
January - March

Spring Migration
When cracks form in ice

Summer in Beaufort Sea
Late May/Early June – Nov.

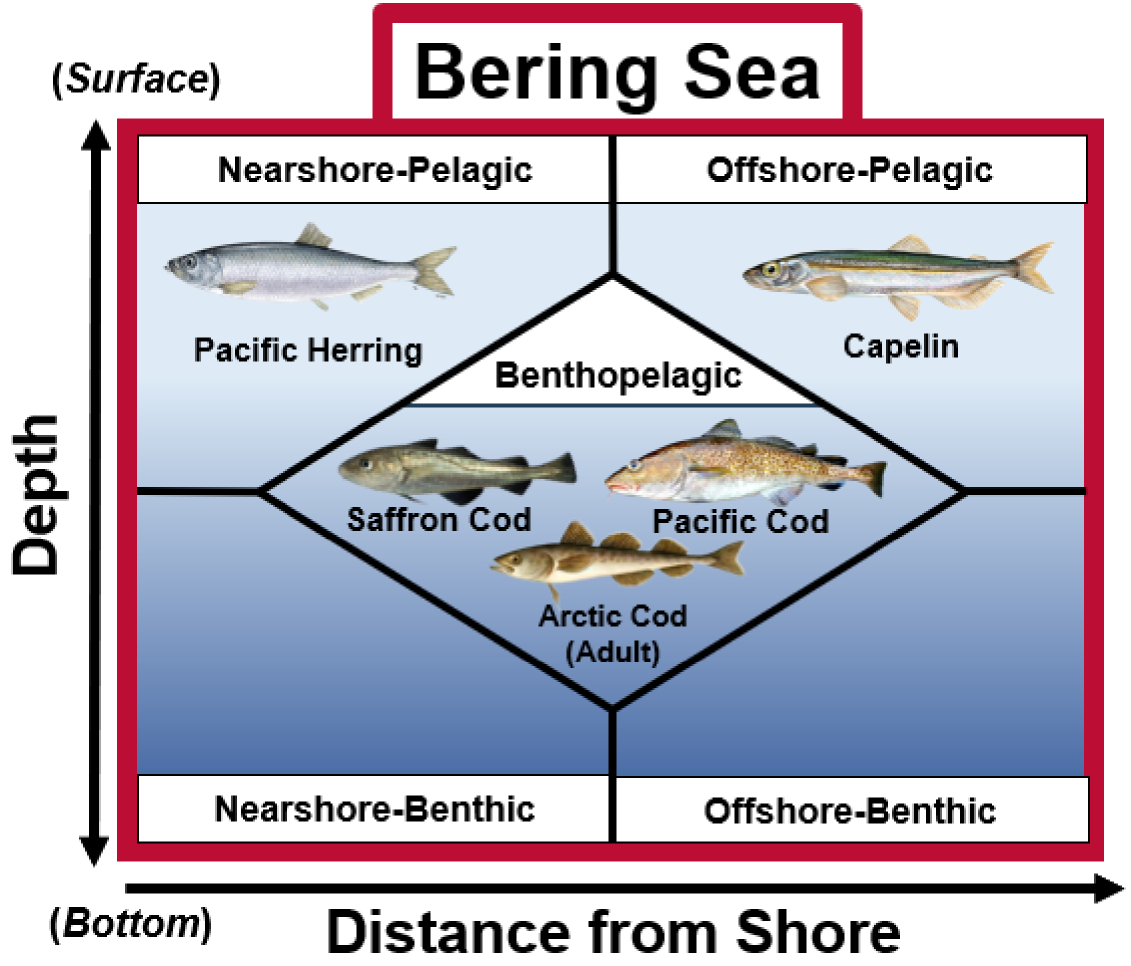
Fall Migration
~ November

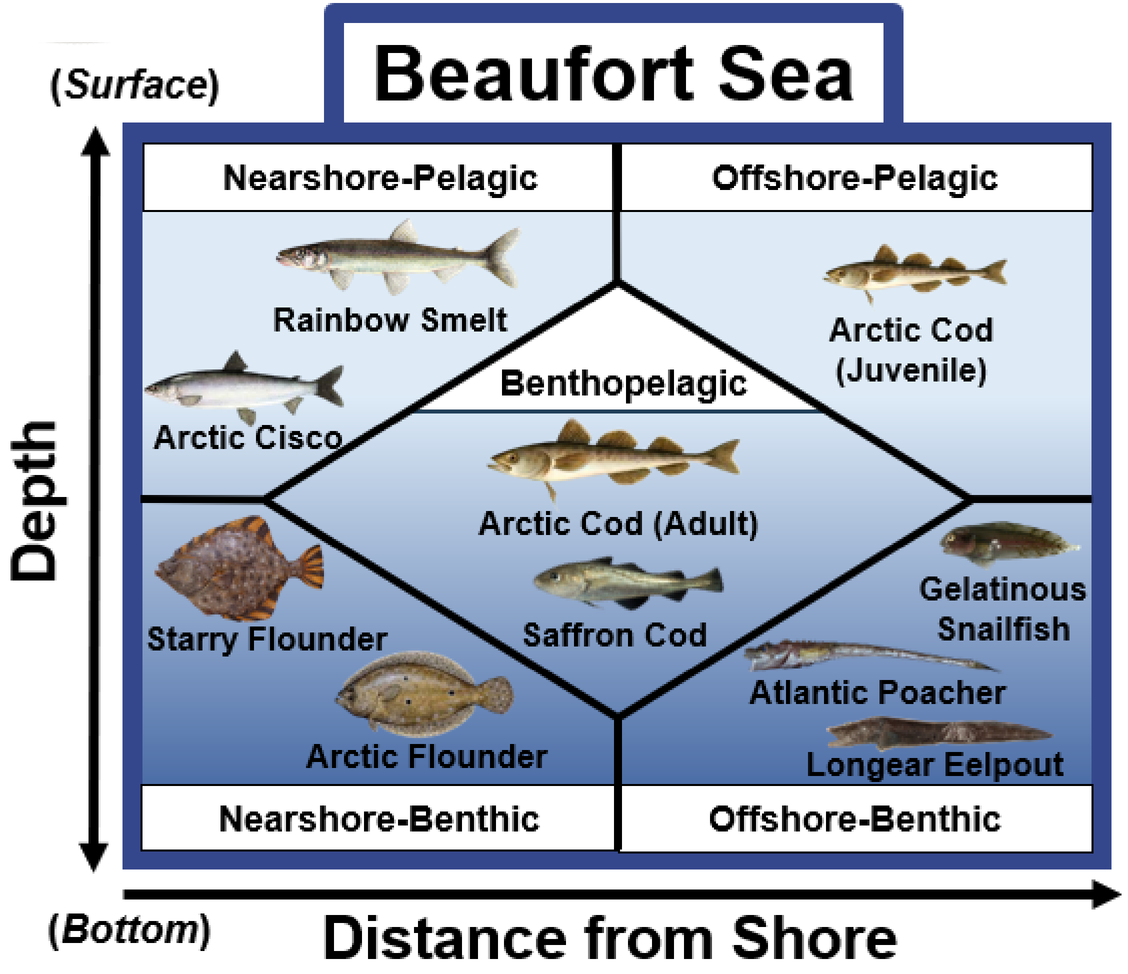
Research Objectives

Objective: To better understand environmental sources and bioaccumulation mechanisms of Hg in two distinct arctic ecosystems supporting EBS belugas

Hypothesis: Stable isotopes are effective habitat tracers (surface vs. benthic, and Bering vs. Beaufort Sea)

Methods:

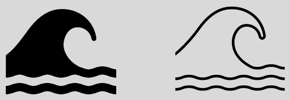

Bering Sea
(Surface)
Depth
(Bottom)
Distance from Shore
Nearshore-Pelagic
Offshore-Pelagic
Pacific Herring
Capelin
Benthopelagic
Saffron Cod
Pacific Cod
Arctic Cod
(Adult)
Nearshore-Benthic
Offshore-Benthic


Beaufort Sea
(Surface)
Depth
(Bottom)
Distance from Shore
Nearshore-Pelagic
Offshore-Pelagic
Rainbow Smelt
Arctic Cod
(Juvenile)
Arctic Cisco
Benthopelagic
Arctic Cod (Adult)
Gelatinous
Snailfish
Starry Flounder
Saffron Cod
Atlantic Poacher
Arctic Flounder
Longear Eelpout
Nearshore-Benthic
Offshore-Benthic

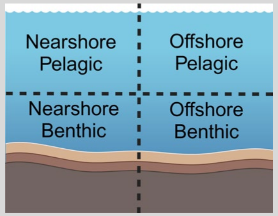
Methods

MeHg

Where is MeHg come from?



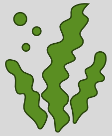
Bering v. Beaufort Sea Fishes?



Specific Habitat?

$\delta^{13}C$

Where do organisms get their plant source?



Nearshore v. Offshore
Pelagic v. Benthic

$\delta^{15}N$

Where do organisms feed in the food chain?

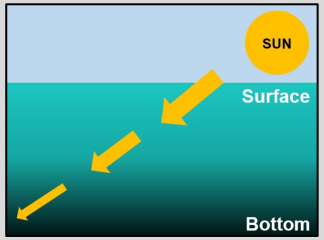
$\delta^{202}Hg$

What sea do organisms feed in?

Bering v. Beaufort

$\Delta^{199}Hg$

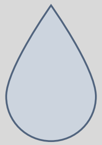
Where do organisms feed in the water column?

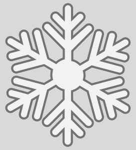


Pelagic v. Benthic

$\Delta^{200}Hg$

What is the atmospheric Hg source?



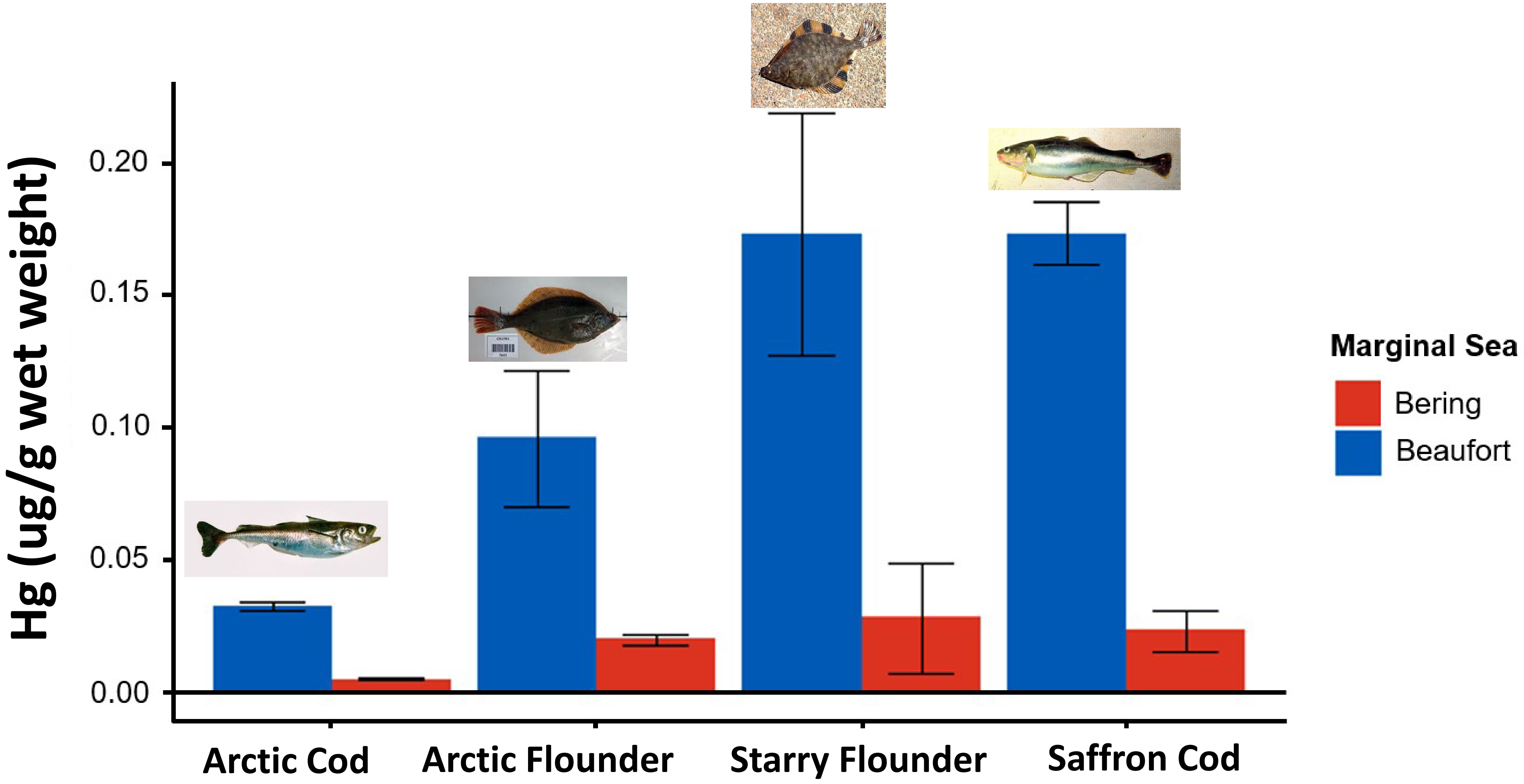


Rain

Snow

Results

Beaufort Sea fishes have more than 6X higher Hg concentration than Bering Sea

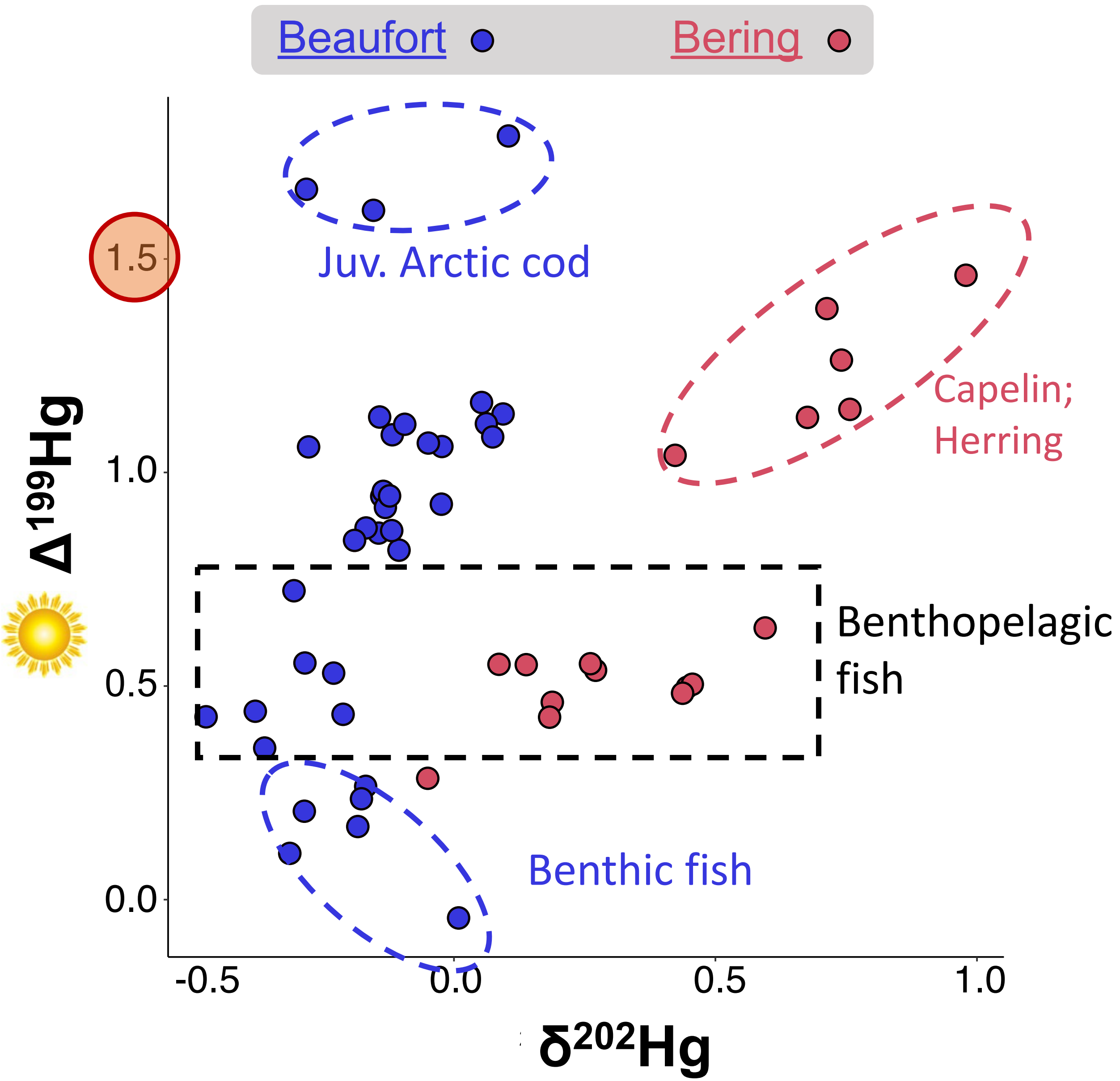


Hg isotope signatures differ between Bering vs. Beaufort fish

- Bering & Beaufort sea fishes have different $\delta^{202}Hg$ values

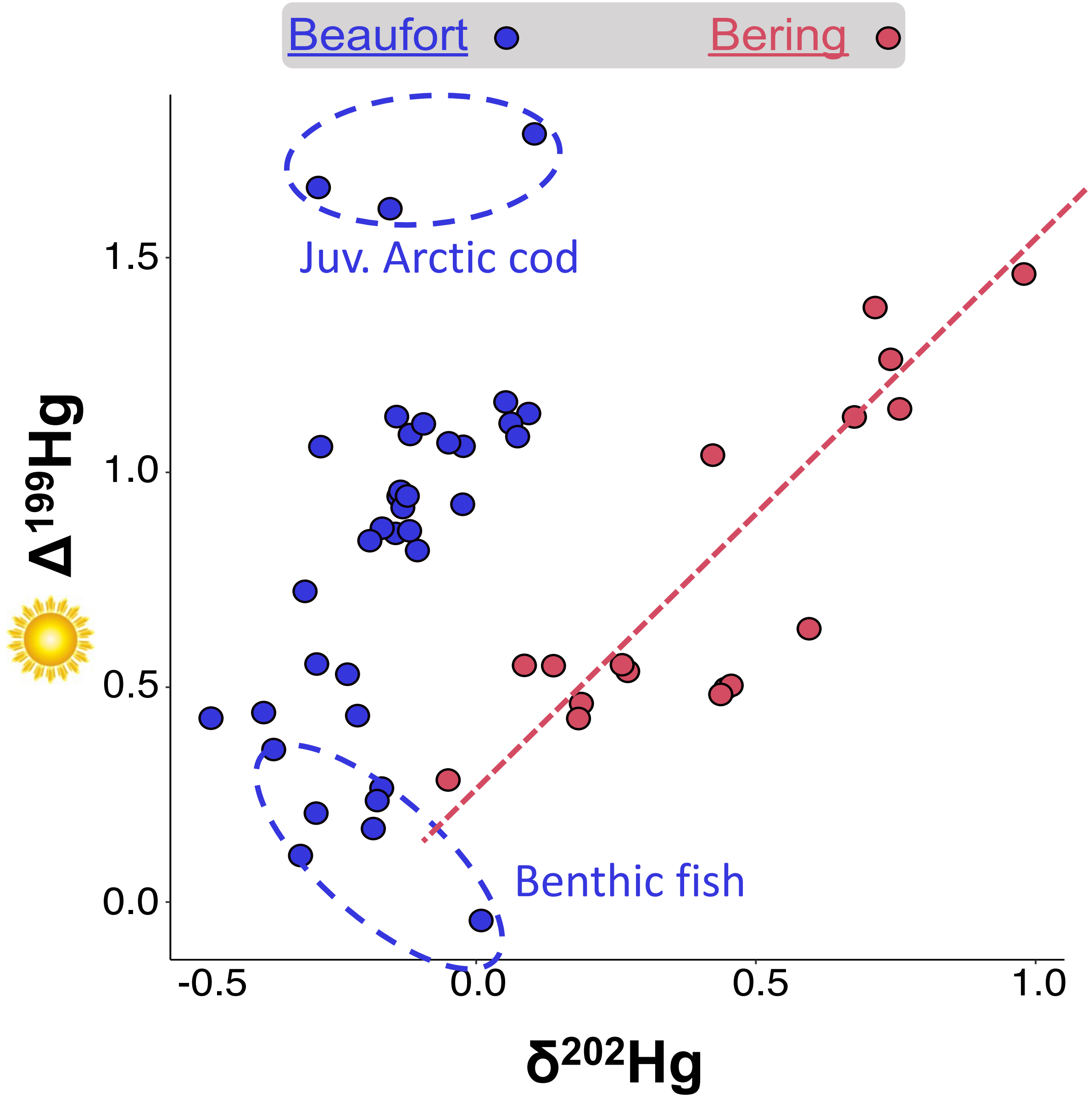
- Pelagic species have higher $\Delta^{199}Hg$ values than benthic ones

- The highest $\Delta^{199}Hg$ values in fish from both seas are much lower than other marine systems (low solar irradiation; sea ice cover).

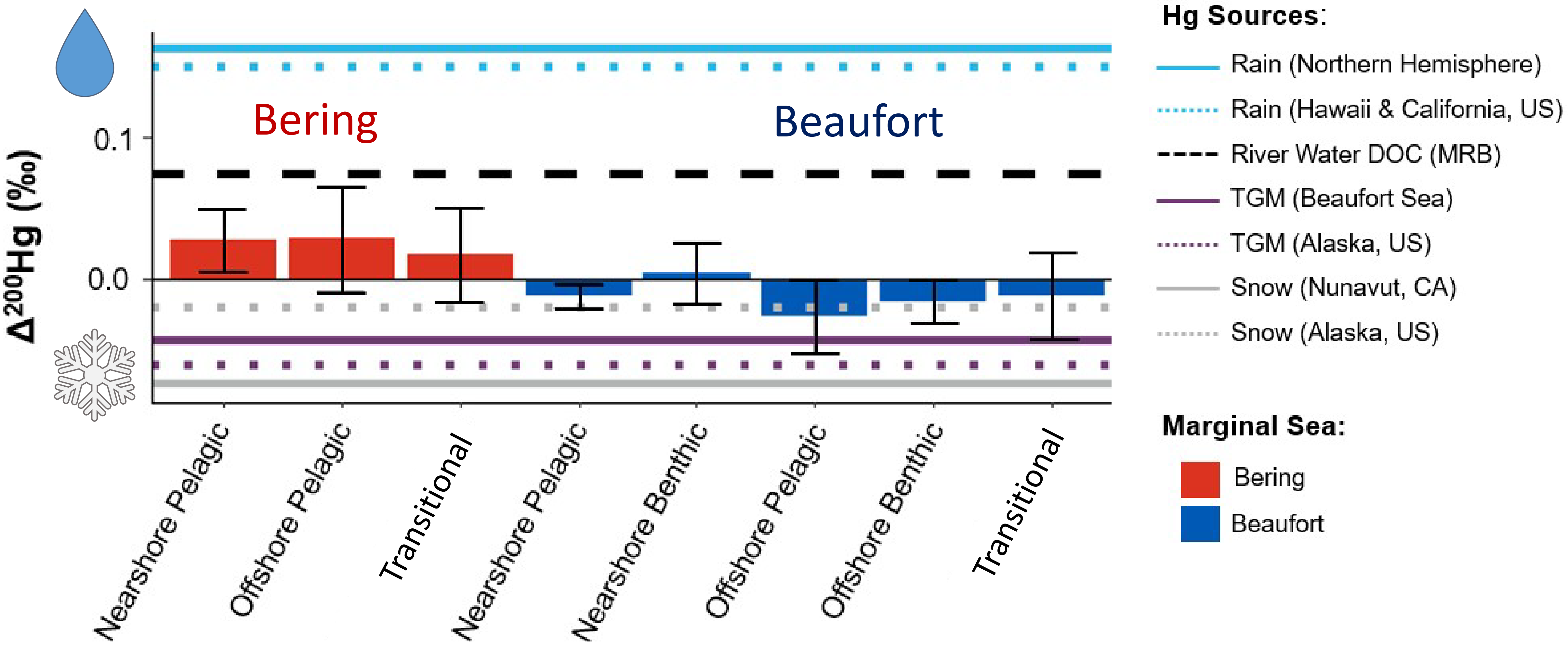


Puzzling Hg isotope signatures in Beaufort Sea fish

- Bering Sea fishes has a strong indication of photodegradation of MeHg
- Beaufort Sea offshore system seems to be decoupled between pelagic and benthic species.
    - Sea ice Hg source
    - Total Gaseous Hg source
    - Sediment Hg source
    - Fish MeHg%



Δ^{200}Hg values indicate different Hg influencers in Beaufort vs. Bering



Summary

- Hg stable isotopes effectively differentiate the fish samples between Bering vs. Beaufort Sea and between pelagic vs. benthic habitats.

- Beaufort biota have higher Hg burden than that of Bering Sea.

- Beaufort offshore ecosystem may have complex Hg sources, including influence of dry deposition of Hg.

Discussion and Collaboration 😀

Thank you!
Questions?

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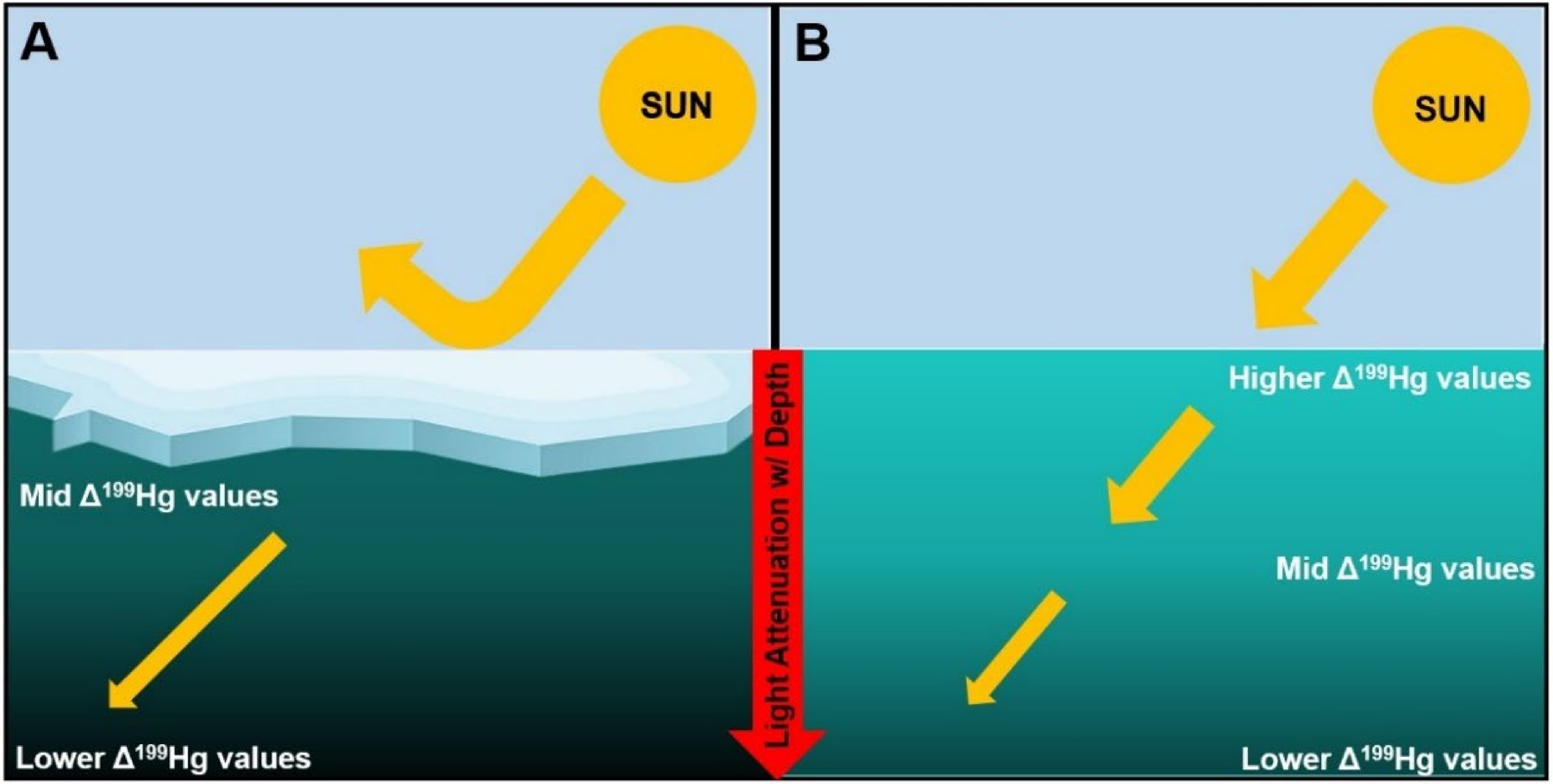
School of Marine Science and Policy
University of Delaware

<u>MeHg Photodegradation</u>: MeHg $\xrightarrow{(sunlight)}$ iHg



Potential factors can explain MeHg levels in fishes between Beaufort and Northern Bering Seas

1. Ecosystem productivity →Biomass Dilution
   - Northern Bering is about three times more productive than Beaufort.
2. Fluxes of inorganic Hg and MeHg
   - Hg and MeHg budget is poorly understood in Bering Sea, so we cannot directly compare with Beaufort.
3. Methylation and demethylation rates
   - Similar for Bering vs. Canadian Arctic Archipelago.

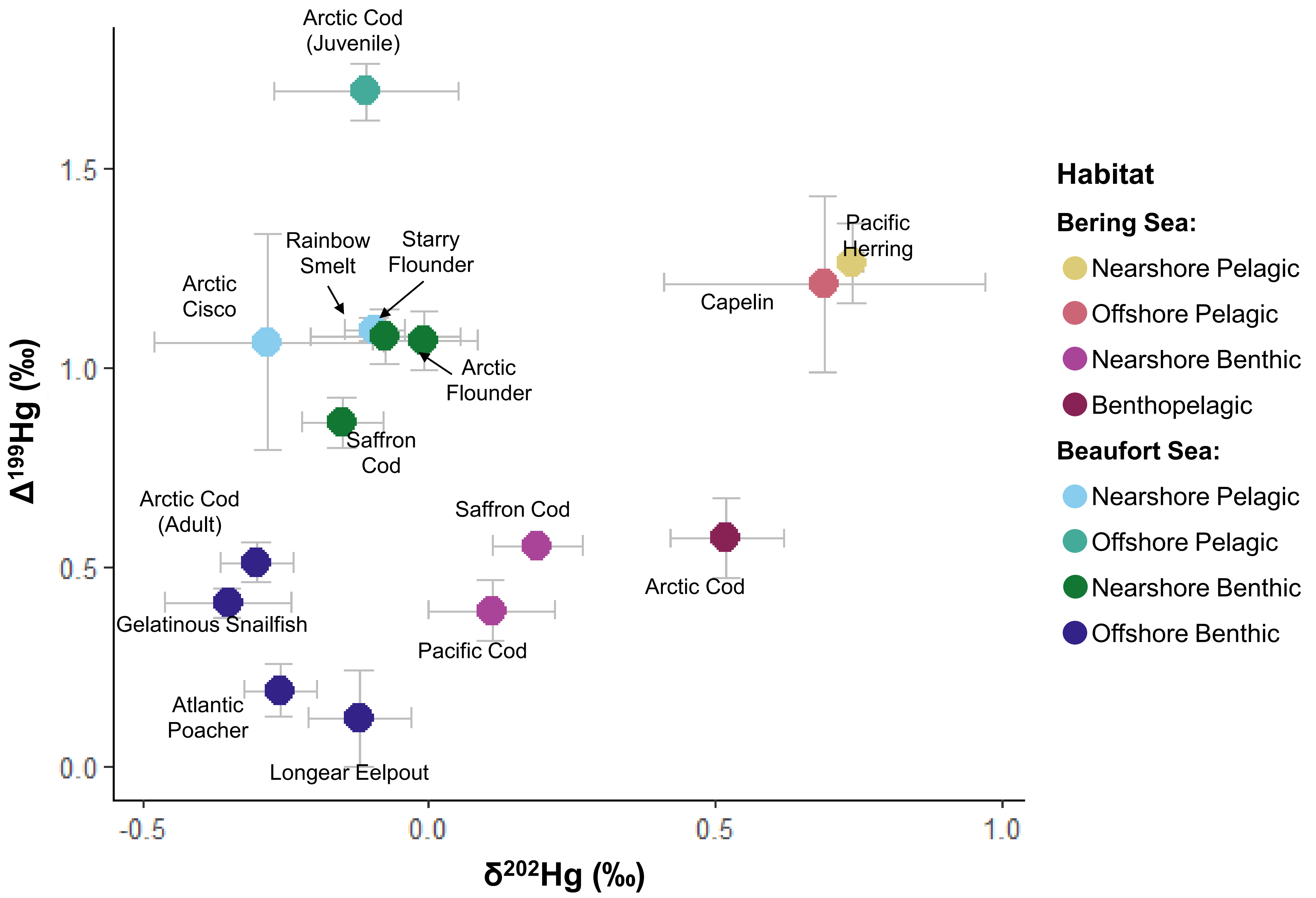

Arctic Cod
(Juvenile)
Rainbow
Smelt
Starry
Flounder
Arctic
Cisco
Pacific
Herring
Capelin
Arctic
Flounder
Saffron
Cod
Arctic Cod
(Adult)
Saffron Cod
Arctic Cod
Gelatinous Snailfish
Pacific Cod
Atlantic
Poacher
Longear Eelpout
1.5
1.0
0.5
0.0
-0.5
0.0
0.5
1.0
Δ199Hg (‰)
δ202Hg (‰)
Habitat
Bering Sea:
Nearshore Pelagic
Offshore Pelagic
Nearshore Benthic
Benthopelagic
Beaufort Sea:
Nearshore Pelagic
Offshore Pelagic
Nearshore Benthic
Offshore Benthic

Table 2: Summary of mean MeHg concentrations of fishes collected in the Bering and Beaufort Sea. Average MeHg concentrations are calculated using data from Table S3.

Organism	Depth Range (m)	MeHg ± SE (µg/g ww)	n	Depth References
Bering Sea				
Pacific Herring	19 – 130	0.010 ± 0.001	35	[48]
Capelin	15 - 100	0.004 ± 0.001	11	[49]
Saffron Cod	0 - 60	0.020 ± 0.001	20	[50–52]
Pacific Cod	19 - 281	0.022 ± 0.005	4	[48]
Arctic Cod	0 - 150	0.005 ± 0.000	19	[50,51]
Beaufort Sea				
Rainbow Smelt	0 - 150	0.042 ± 0.007	6	[53]
Arctic Cisco	0 - 2	0.033 ± 0.007	8	[54]
Arctic Flounder	0 - 60	0.096 ± 0.026	5	[55]
Starry Flounder	0 - 54*	0.173 ± 0.046	5	[56]
Arctic Cod (Juvenile)	0 - 60	0.012 ± 0.001	3	[57,58]
Atlantic Poacher	349 - 351	0.055 ± 0.004	10	[58]
Gelatinous Snailfish	0 - 520	0.026 ± 0.002	10	[59]
Longear Eelpout	346 - 500	0.092 ± 0.015	10	[60]
Saffron Cod	43 – 68*	0.173 ± 0.012	9	[56]
Arctic Cod (Adult)	200 - 500	0.033 ± 0.002	10	[57,60]
EBS Beluga	0 - 1336	1.049 ± 0.080	18	[3]

C13

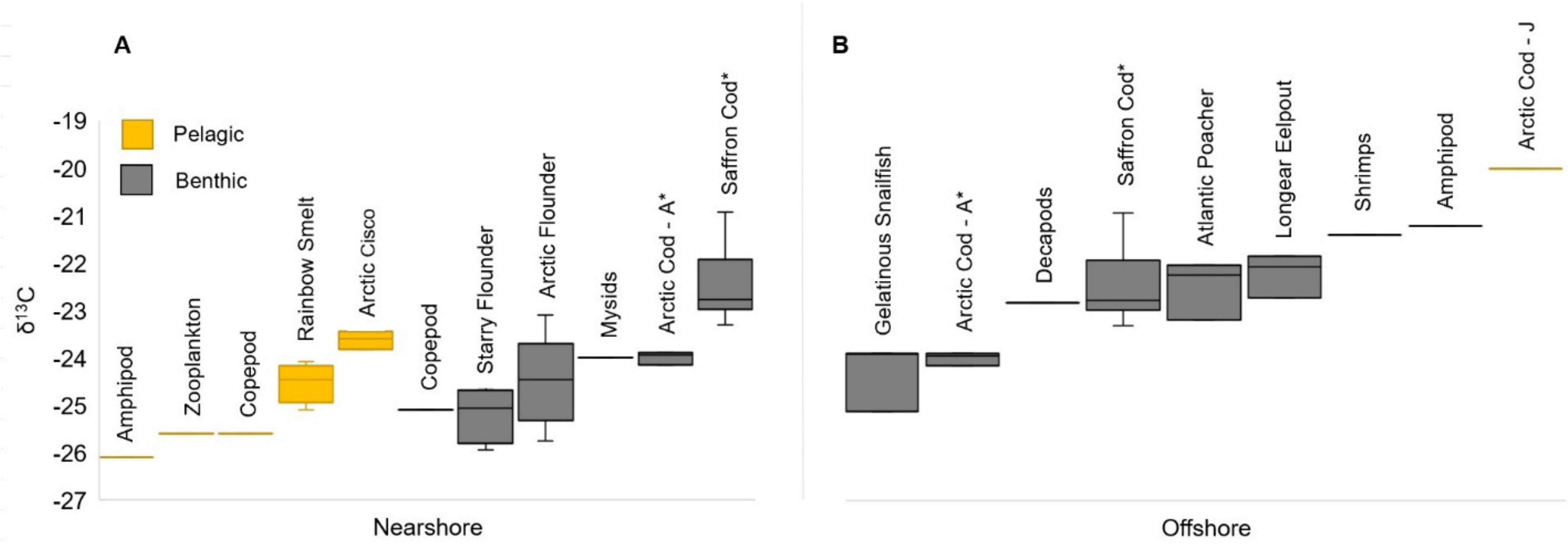


Figure 3. Box and whisker plot of $\delta^{13}C$ data for each species in the (A) nearshore and (B) offshore Beaufort Sea food chains. Error bars or whiskers represent the range of the data beyond the quartiles. Asterisk denotes species whose data was used in multiple food chains as published research shows they inhabit both inshore and offshore environments.