

Highlights from the 2022 Pan-Pacific Winter High Seas Expedition



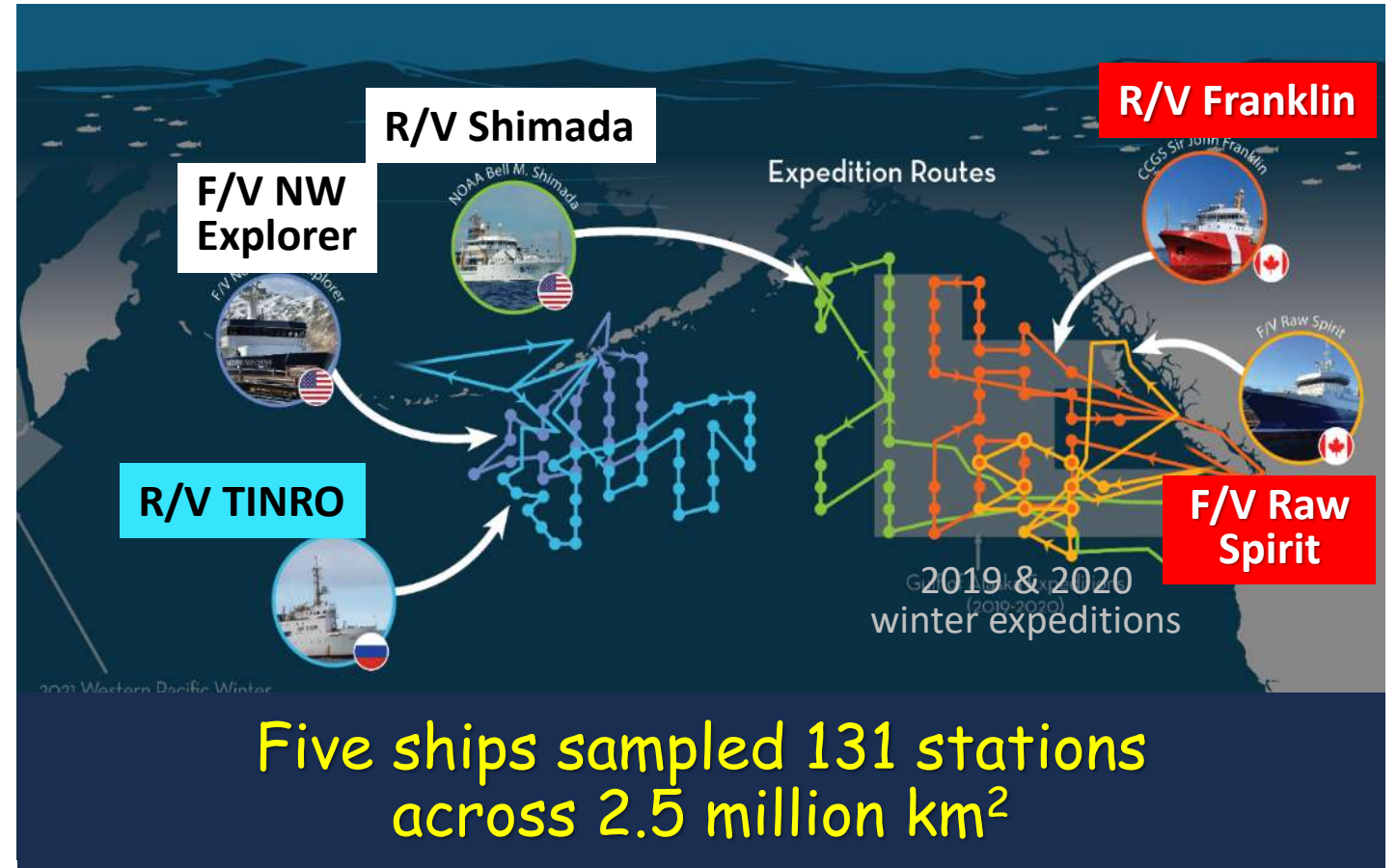
Laurie Weitkamp and Ed Farley: U.S. NOAA Fisheries
Evgeny Pakhomov: University of British Columbia
Jackie King and Cam Freshwater: Fisheries & Oceans Canada
Aleksey Somov: Russian Res Inst Fisheries & Oceanography-Pacific
Mark Saunders, Caroline Graham, Aidan Schubert: IYS/NPAFC
Vladimir Radchenko: North Pacific Anadromous Fish Commission
Dick Beamish: Independent
Brian Riddell: Pacific Salmon Foundation



Fisheries and Oceans Canada
Pêches et Océans Canada

What was the 2022 International Year of the Salmon (IYS) Pan Pacific Winter Expedition?

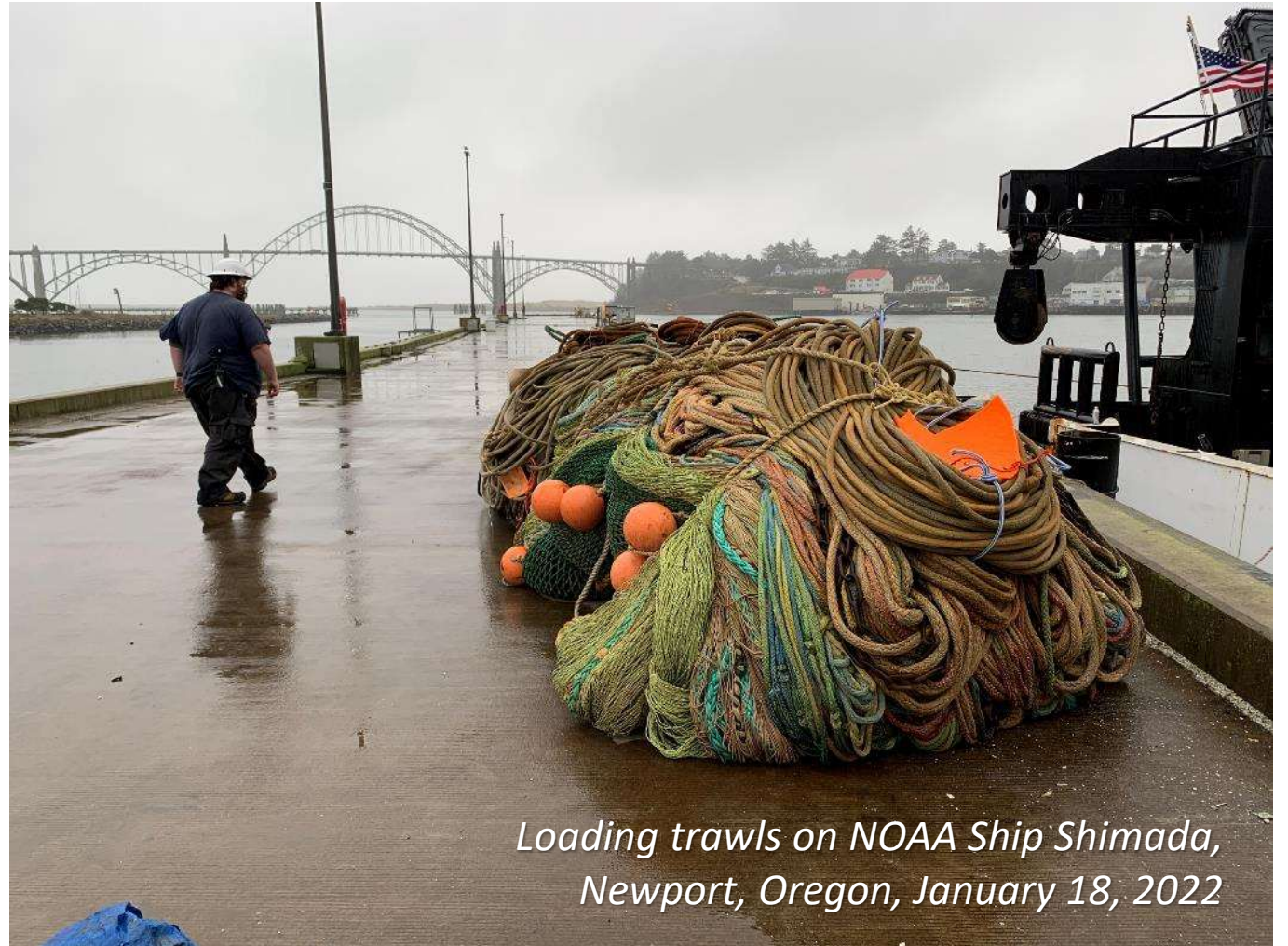
A well-publicized international, multi-ship survey of Pacific salmon high seas ecosystems across the North Pacific Ocean conducted in late winter 2022.



<https://yearofthesalmon.org/high-seas-expeditions/>

Today's talk

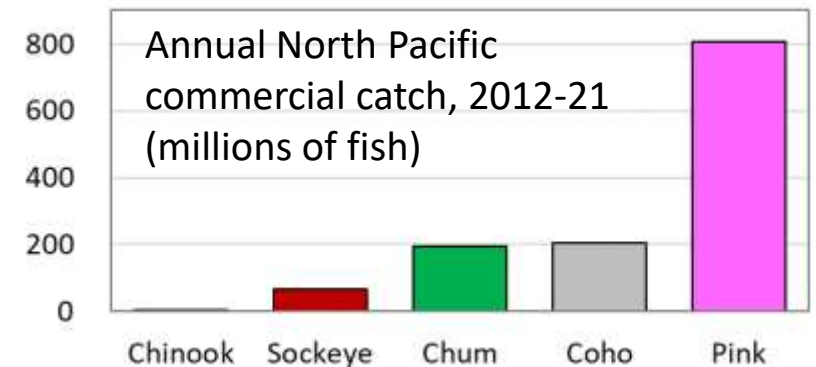
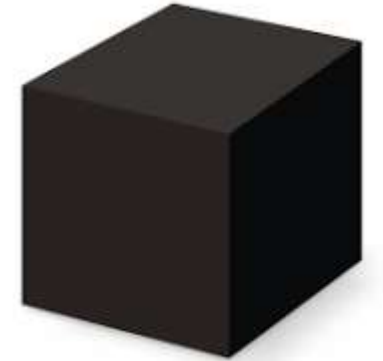
- Why the survey?
- Methods
- Initial results
- Looking forward



*Loading trawls on NOAA Ship Shimada,
Newport, Oregon, January 18, 2022*

High seas in winter is least understood part of the salmon life cycle

- Poor understanding of:
 - Stock-specific distributions (and why distributed as they are)
 - Prey field and food habits
 - Competitors (salmon and non-salmon)
 - Predators
 - East-west variation in salmon ecosystems
- Proposed as time when super-abundant pinks interact with other salmon
 - Responsible for strong even-odd signal in other salmon
- Expect high mortality due to low prey availability
 - Especially small fish with low energy reserves entering winter
- Ultimate cause of mortality is predation
 - Or something else (starvation, disease, or)?



Management questions

- Have changes to salmon winter ecology contributed to long term declines in some salmon populations?
- Is changing winter ecology responsible for unexpectedly high or low recent returns of salmon?
- Can winter surveys improve forecasts of Pacific salmon returns?
- Which stocks may be impacted by illegal, unregulated and unreported (IUU) fishing?



Spoiler alert! Northwest salmon use the high seas!

The 2022 Pan Pacific survey and winter surveys to Gulf of Alaska (2019, 2020) have caught:

- **Coho**: Washington, Oregon, Columbia River
- **Sockeye**: Columbia River
- **Chum**: Washington
- **Chinook**: Columbia River
- **Steelhead**: Columbia River (analysis not complete)

NW salmon are minor players compared to salmon from other areas, but still out there!



History of winter high seas surveys starting in 1960s

North Pacific Anadromous Fish Commission
 Bulletin No. 6: 113-138, 2016

Pacific Salmon

What is the same? What is different?

Katherine W. Myers¹, James R. Irvine², Elizabeth A. Logerwell³, Shigehiko Urawa⁴,
 Svetlana V. Naydenko⁵, Alexander V. Zavolokin^{5,6}, and Nancy D. Davis⁷

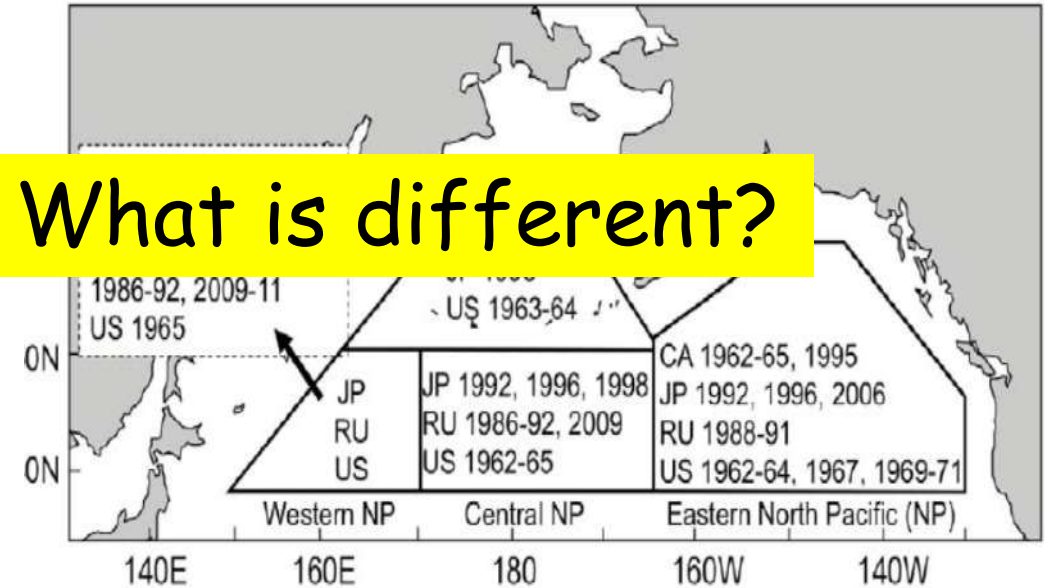
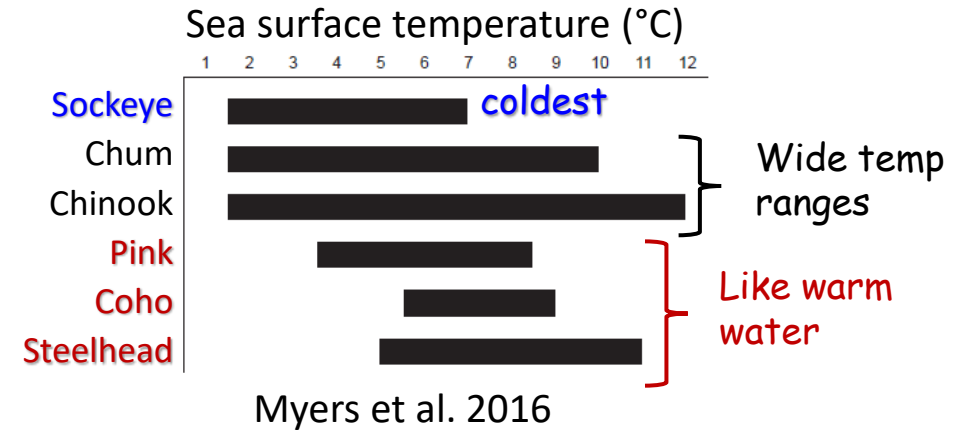


Fig. 3. The regional locations of high seas salmon winter research by Canada (CA), Japan (JP), Russia (RU), and the United States (US) in the Bering Sea and North Pacific Ocean, 1958-2015.

What did we expect to find?

1. Patterns from historic winter surveys:

- Species temperature/distributional differences
- General diet patterns
 - Fish: Chinook, coho, Steelhead
 - Zooplankton: Sockeye, pinks
 - Gelatinous: Chum



2. Hypotheses testing

- Are smallest fish the skinniest?
- Are pinks abundant?
- Are predators widespread? Lots of wounded salmon (=near misses)?



Scars on high seas salmon



Common methods across ships

Physical oceanography



CTD casts to 300-2000m
Multi-depth samples for O₂,
nutrients, Chl a, flow cytometry,
POM, HPLC,
environmental DNA

Biological oceanography



Vertical bongo nets,
Tucker trawls,
Juday net (R/V *TINRO*)

Fishing (surface trawl or gillnet)



Surface trawls or Japanese-
style research gill net (F/V
Raw Spirit)

Bongo Tows

Slide from Jackie King, CDFO



Tucker Trawls



Surface Trawls



Measurements & samples collected from trawls catches

Basic biology

- Length, weight
- Scales (age, growth)*
- Otoliths (age, hatchery thermal marks)*
- CWTs (origins, age)*
- External marks (possible predation attacks)
- Gonads (maturation)*

Food web linkages/bioenergetics

- Stomach contents (food habits)
- Muscle, liver, gonads (bioenergetics, fatty acids, stable isotopes, thiamine)

*Salmon only

“Newish” technologies*

Fin clips (Genetic Stock Identification)

Gill tissue (pathogens, up/down regulation of genes)

Blood (Insulin-like Growth Factor hormone)

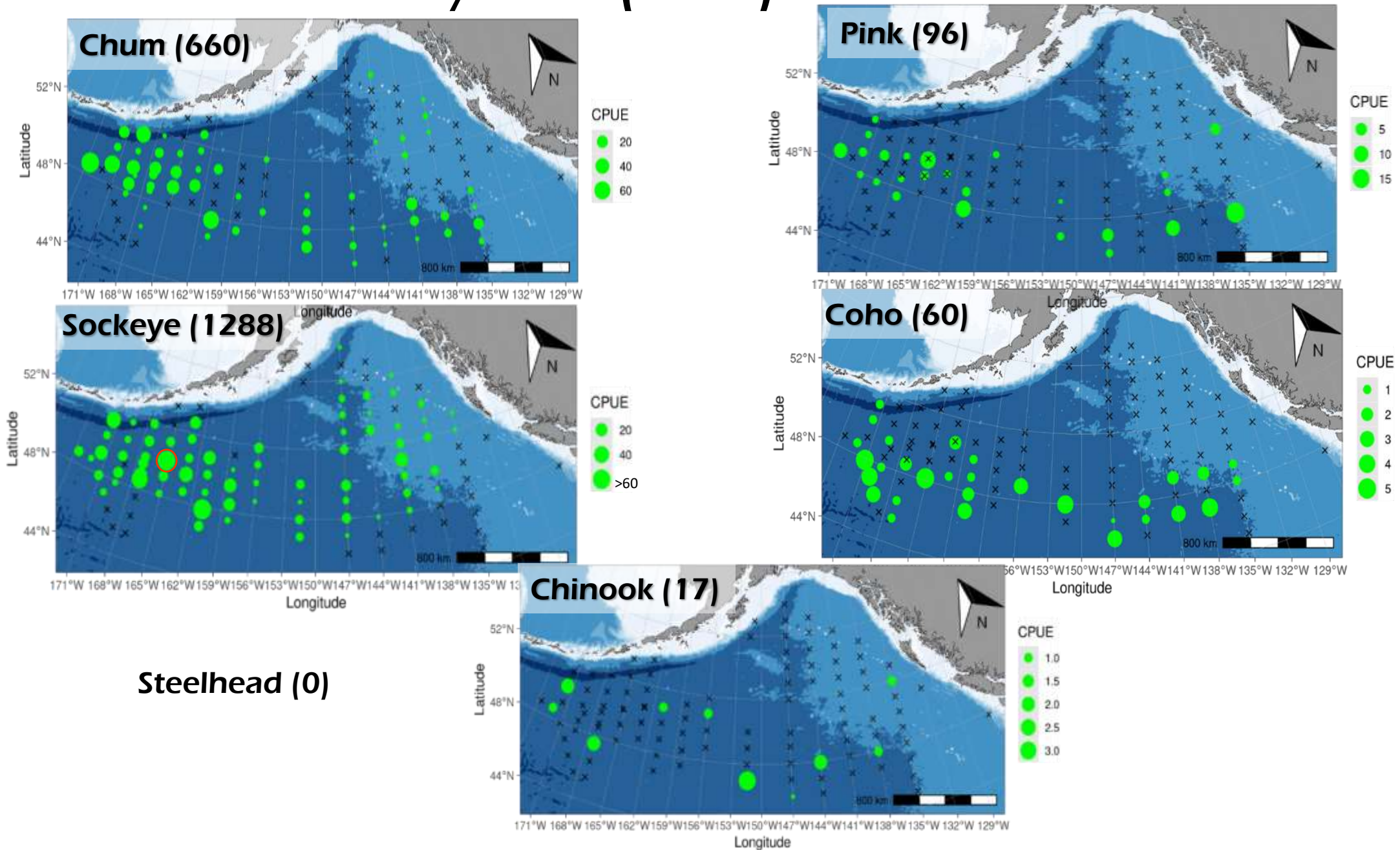
Stomachs (microplastics; also from myctophids & squid)



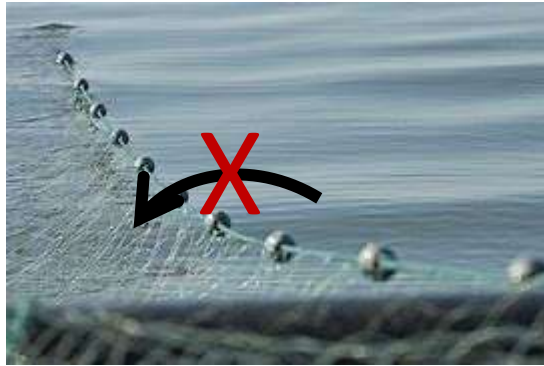
Processing the catch on the *Shimada*



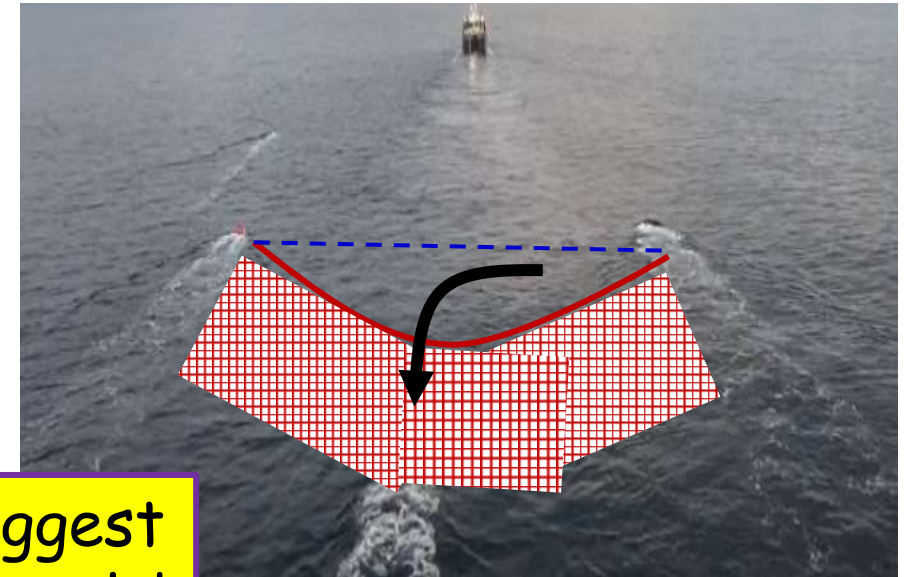
Salmon counts/hour (total) in trawls



All steelhead (N=57) were caught by the gill netter (F/V *Raw Spirit*), none by the trawls



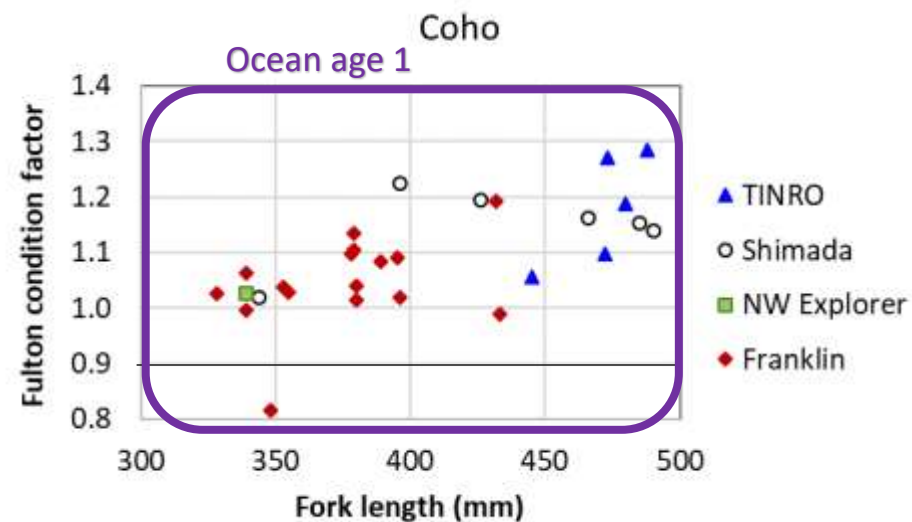
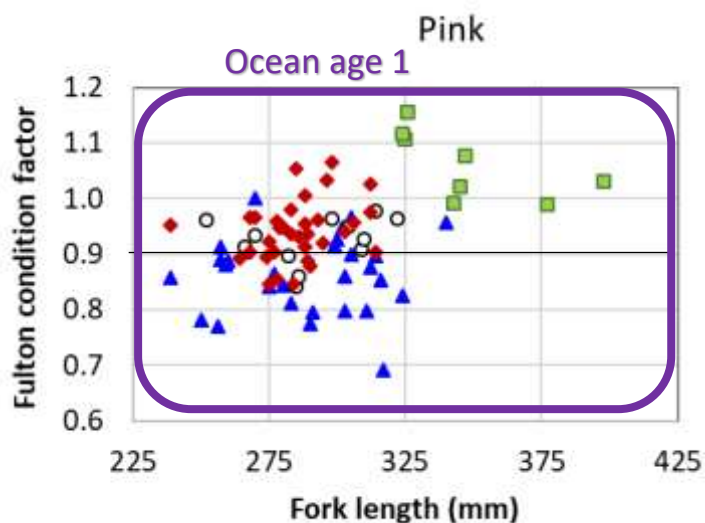
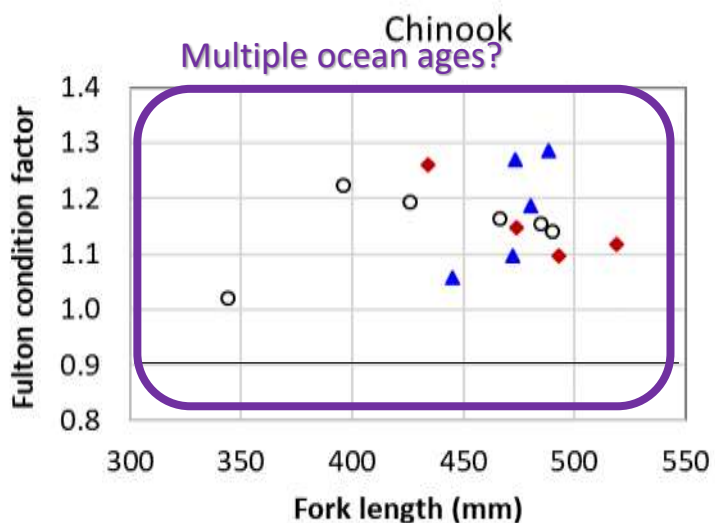
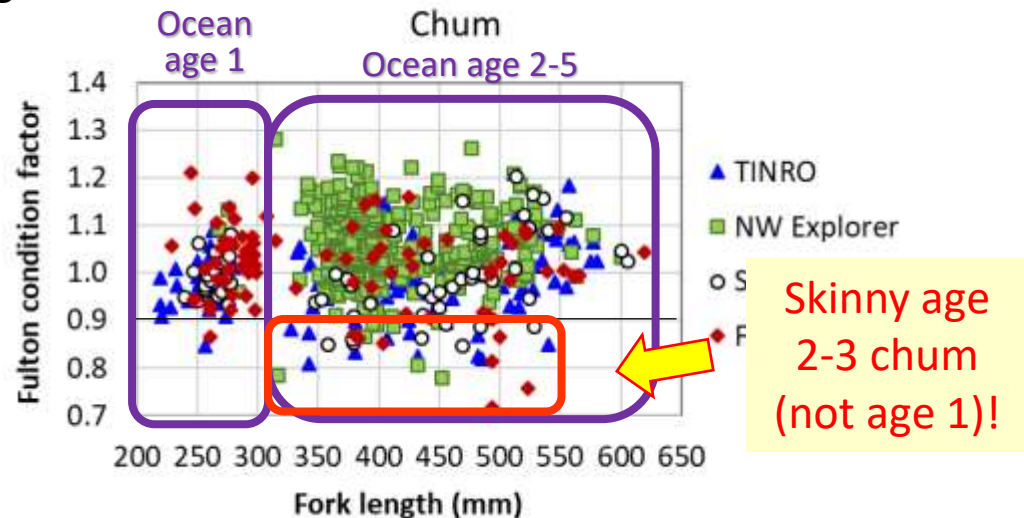
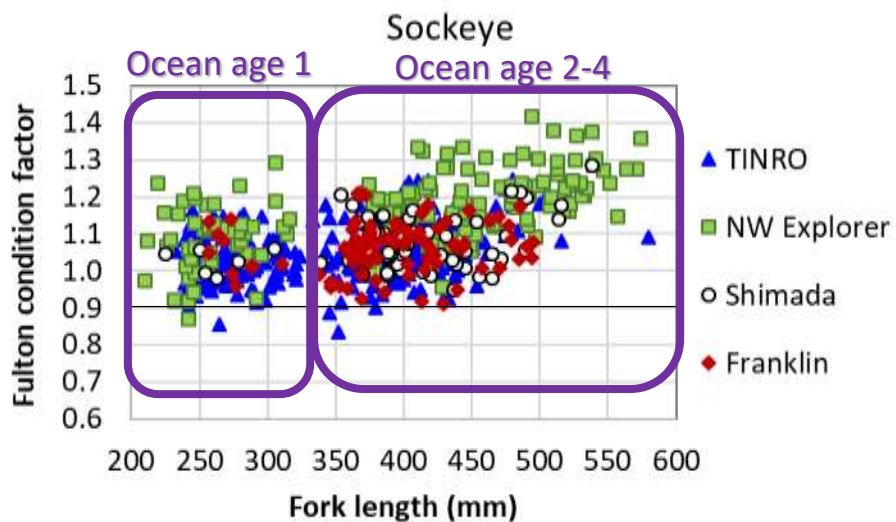
Extremely surface-oriented steelhead go over sagging trawl headropes but not gillnet corklines!



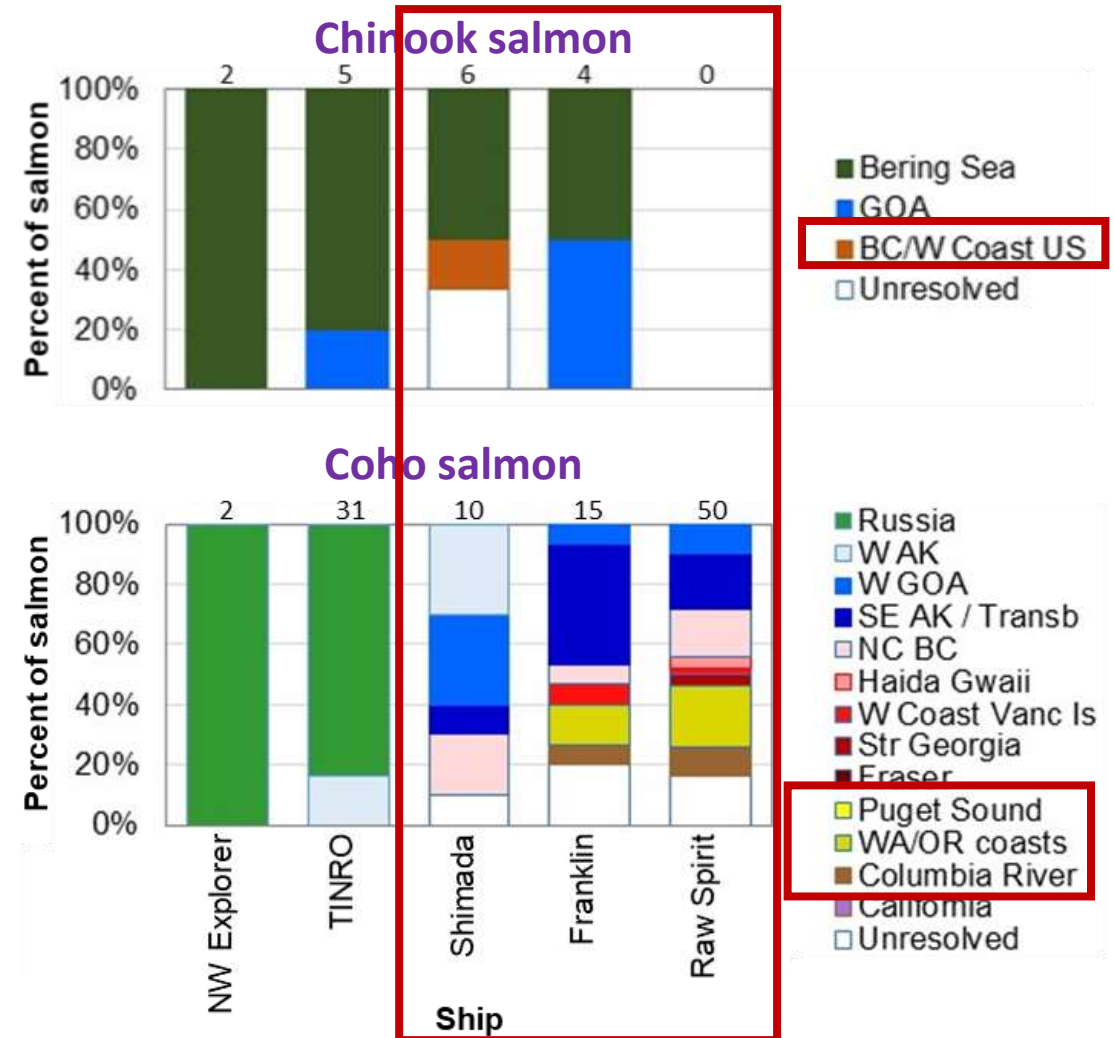
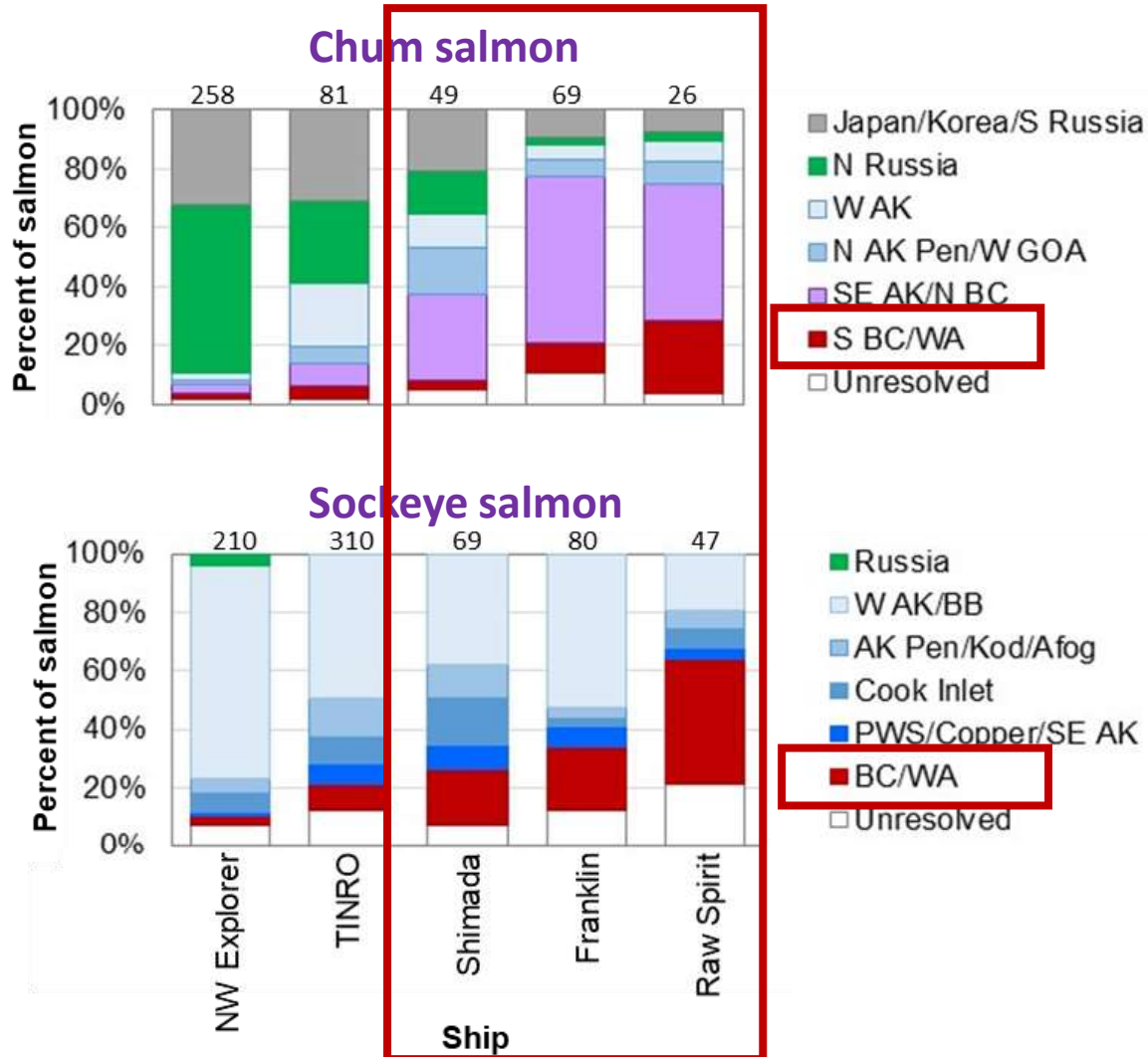
Preliminary eDNA results suggest we missed steelhead with trawls!

Salmon length vs Fulton's condition factor (CF)

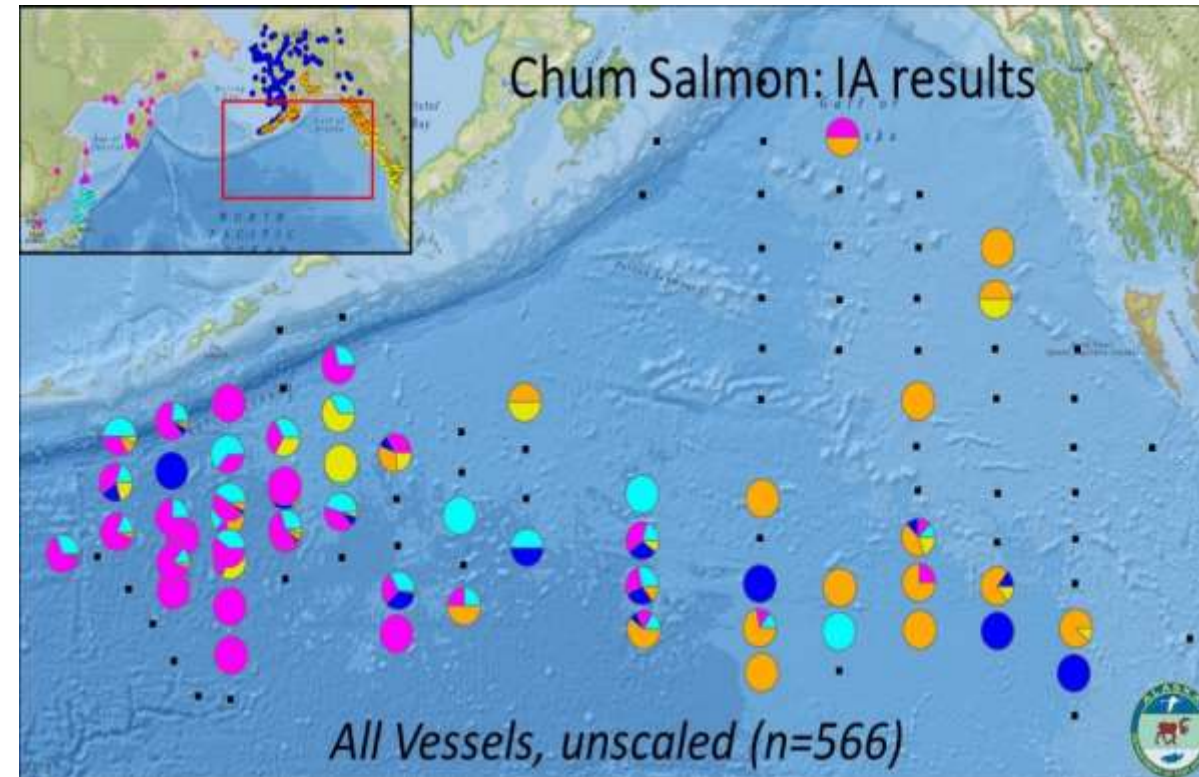
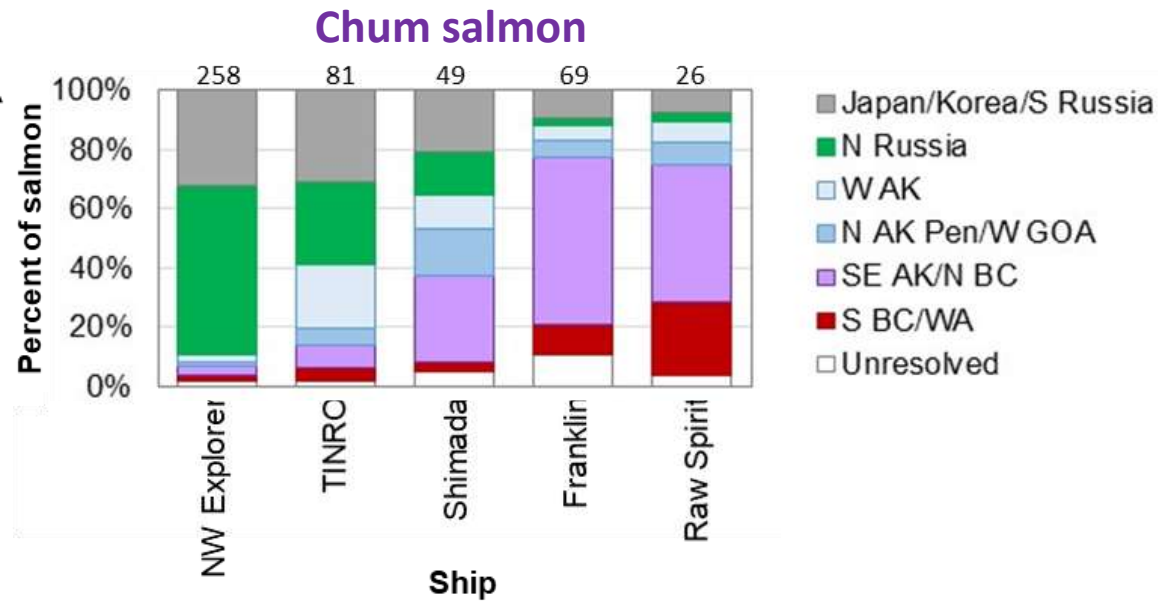
$CF = \text{weight}/\text{length}^3$



Origins of salmon (from genetics)



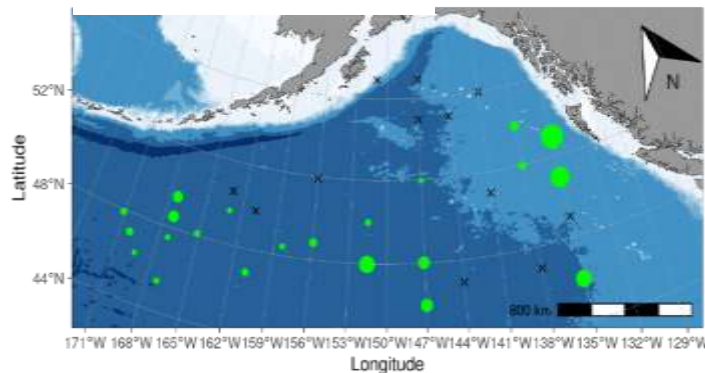
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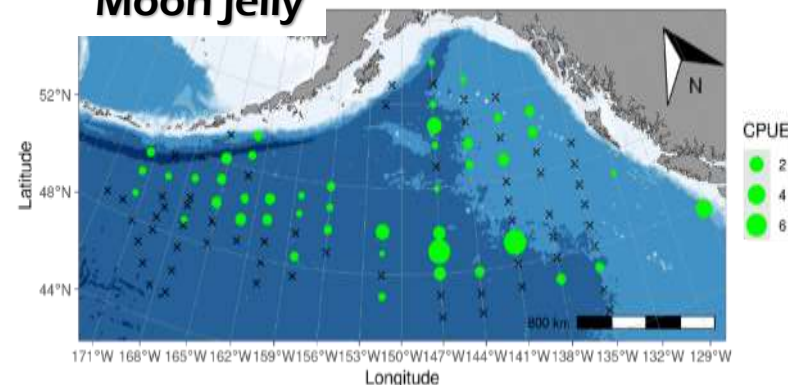
Other frequently caught species: squid, myctophids and jellyfish (kg/hour)

Prey, competitors

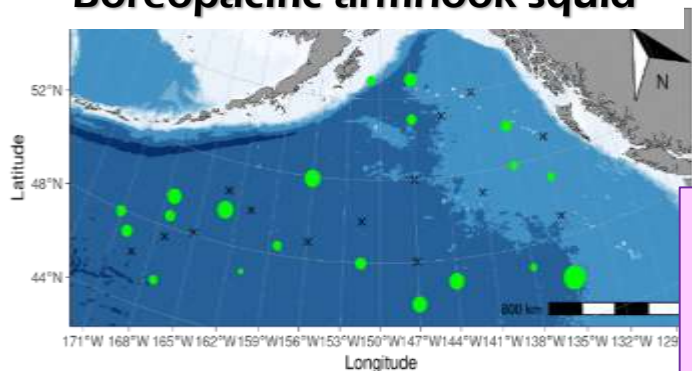
Blue lanternfish



Moon jelly



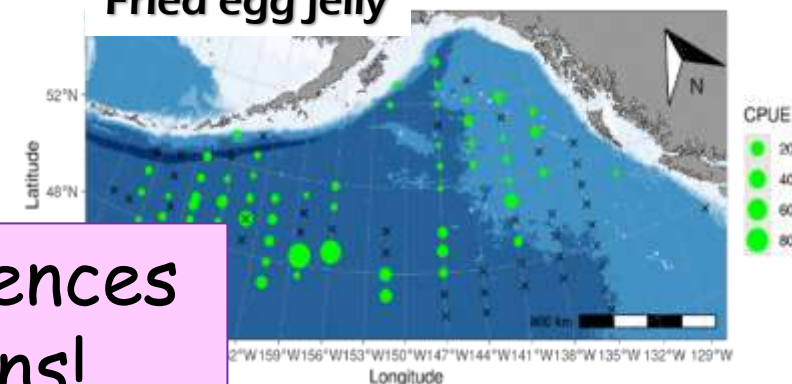
Boreopacific armhook squid



Northern lampfish

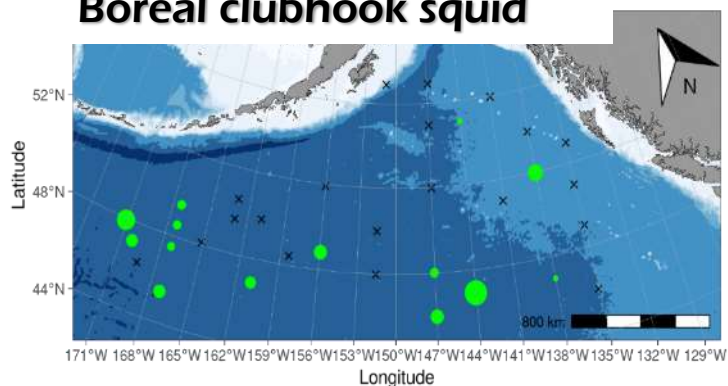


Fried egg jelly

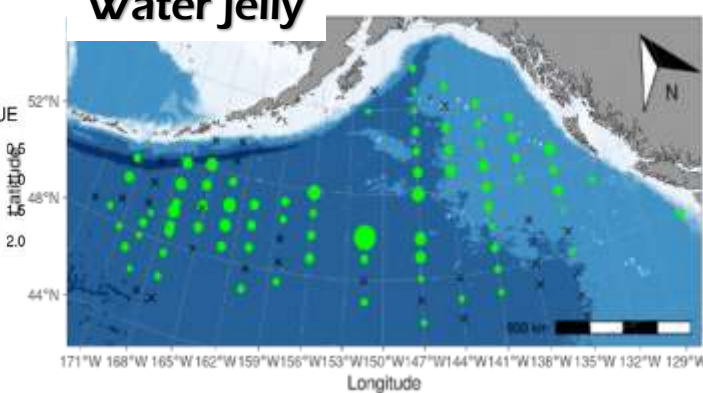


No big east-west differences in species distributions!

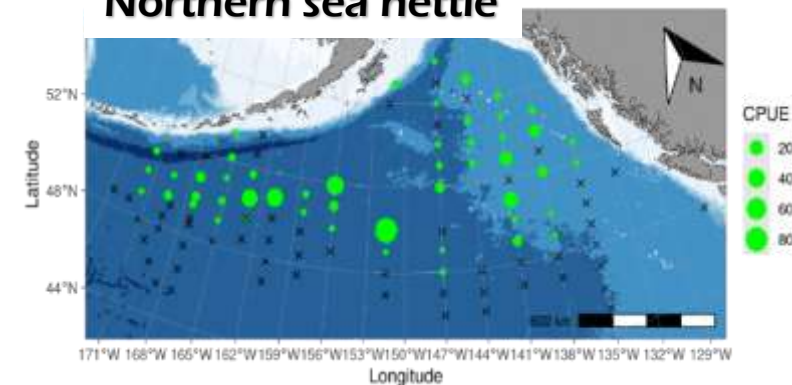
Boreal clubhook squid



Water jelly



Northern sea nettle



Likely high seas salmon predators

(Bugaev and Shevlyakov 2007, Naydenko and Temnykh 2016)



Few potential predators caught by nets or eDNA or observed



If predation isn't the source of mortality, what is?



Looking forward

- Many samples to run, data to analyze
- Synthesize many data sets (multiple layers)
- Why stop high seas expeditions now?
 - Dick Beamish organizing a First Nations/Tribal-staffed cruise April 2024
 - Basin Event to Coastal Impacts (Beci.info), joint NPAFC/PICES “ocean intelligence system” of monitoring, research, analytical approaches for high seas and coastal systems.

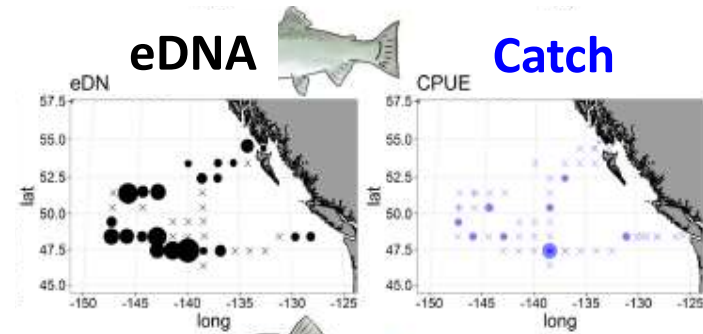


Questions?

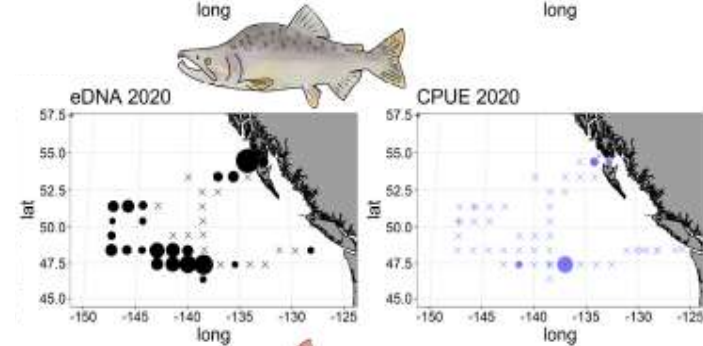
Approaching Kodiak at the end of Leg 1
on the NOAA Ship *Shimada*, Feb 16, 2022

Comparing eDNA to salmon catches, 2020 winter expedition

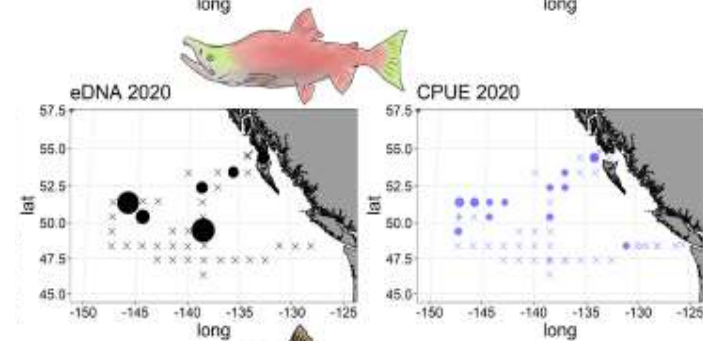
Coho



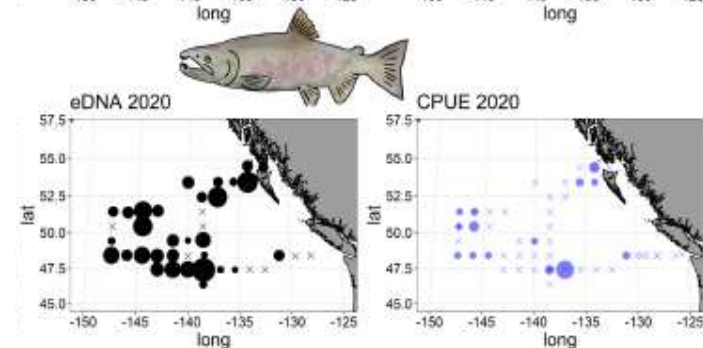
Pink



Sockeye



Chum



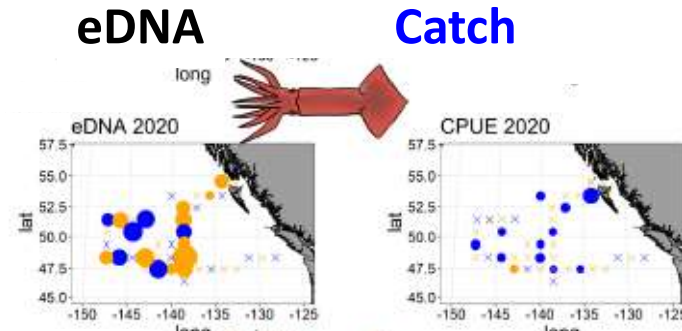
Deeg et al. 2023
Environmental DNA

eDNA detects vertically-migrating taxa regardless of time of sampling, 2020 Gulf of Alaska expedition

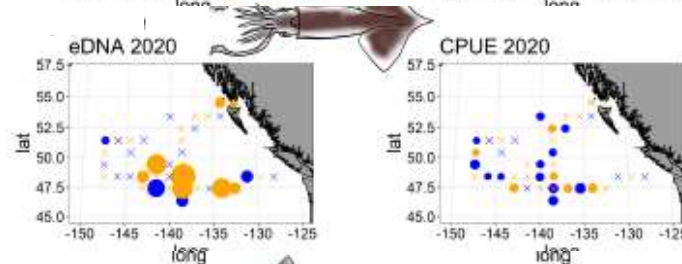


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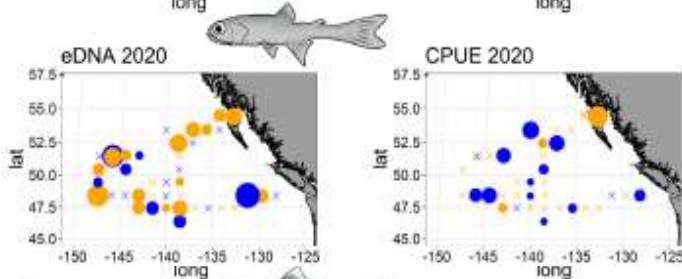
Boreo-pacific armhook squid



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