Pacific salmon ecosystems on the high seas: Initial findings from the Winter 2019 Gulf of Alaska Expedition

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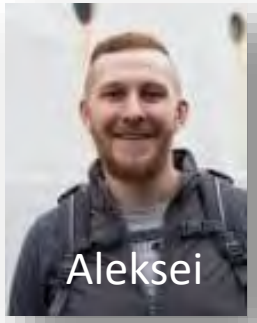
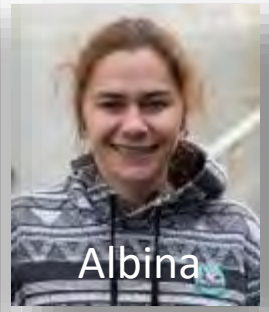
Photo by Egor Glyzin, 3rd mate

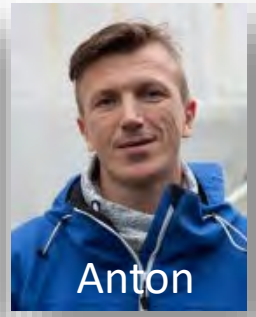
A team effort: the science team

Not shown: 31 crewmembers and officers

The Fish Team

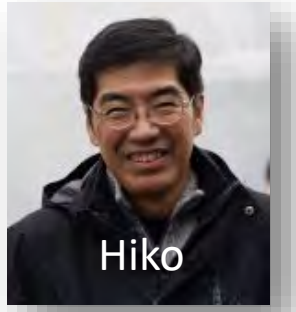


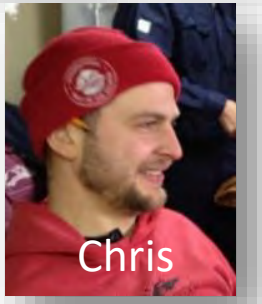




Russia

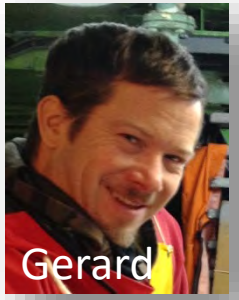
Japan

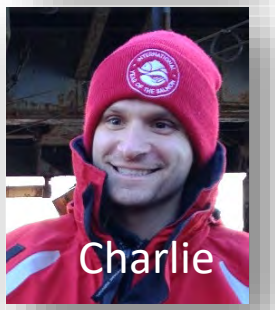


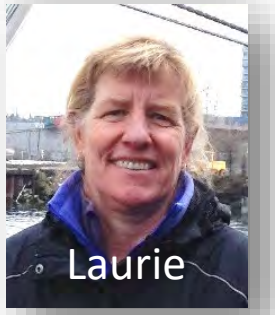


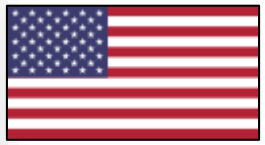
Canada

NPAFC









U.S.A.

Today's talk

- Previous winter research
- Fishing Methods
- Salmon results
  - Distributions
  - Species distributions vs environmental variation
  - Latitudinal trends
- New questions
- Conclusions

(Other talks on catches, diets, other nekton, etc)

Previous salmon research in Gulf of Alaska in winter

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

Pacific Salmon and Steelhead: Life in a Changing Winter Ocean

Katherine W. Myers[1], James R. Irvine[2], Elizabeth A. Logerwell[3], Shigehiko Urawa[4], Svetlana V. Naydenko[5], Alexander V. Zavolokin[5, 6], and Nancy D. Davis[7]

"In general, we learned that the "why" of ocean distribution of salmon is complex and variable, depending on spatio-temporal scale and synergies among heredity, environment, population dynamics, and phenotypic plasticity."

Previous salmon research in Gulf of Alaska in winter

Factors influencing winter distribution of salmon (Myers et al. 2016)

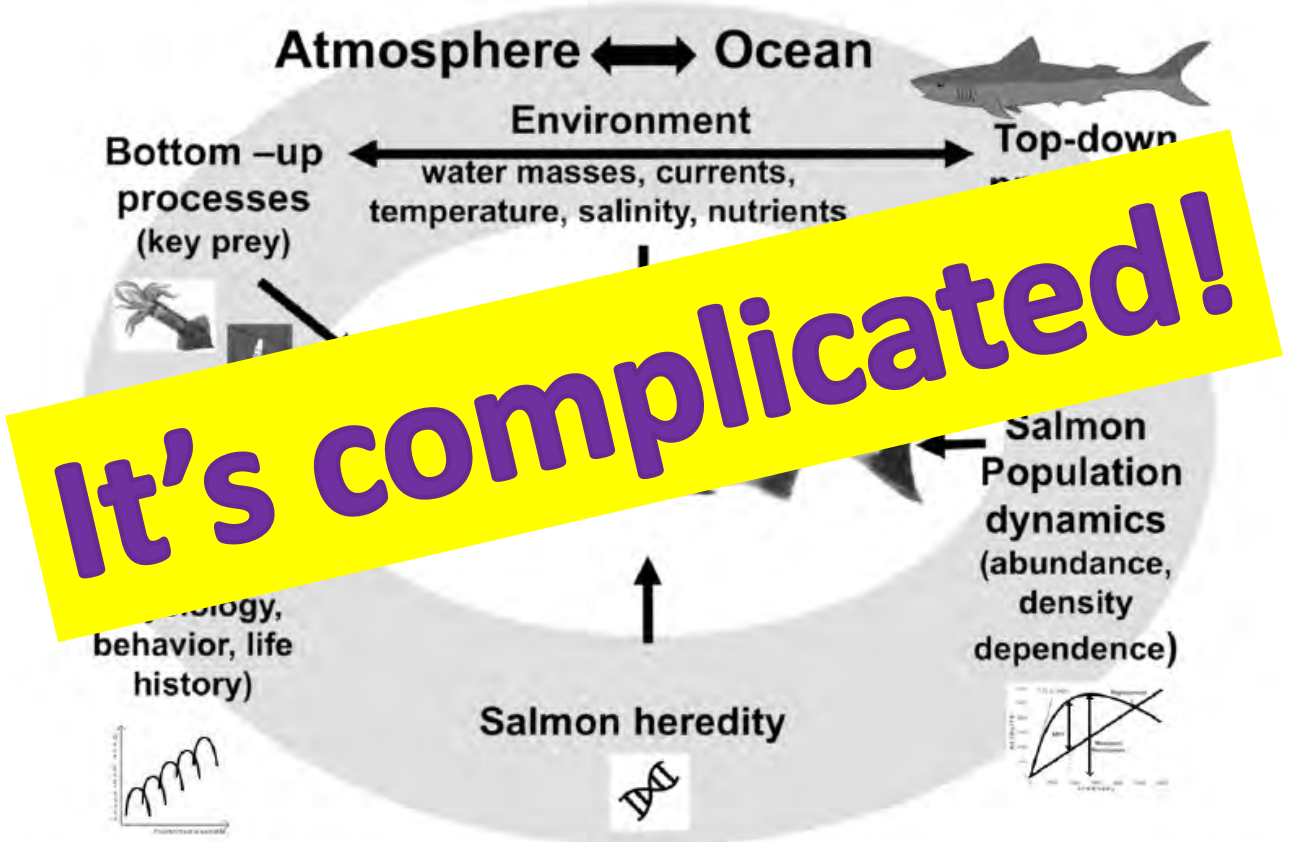


Fig. 12. A schematic illustration of potential factors influencing the winter distribution of high seas salmon and steelhead in the North Pacific Ocean.

Previous salmon research in Gulf of Alaska in winter

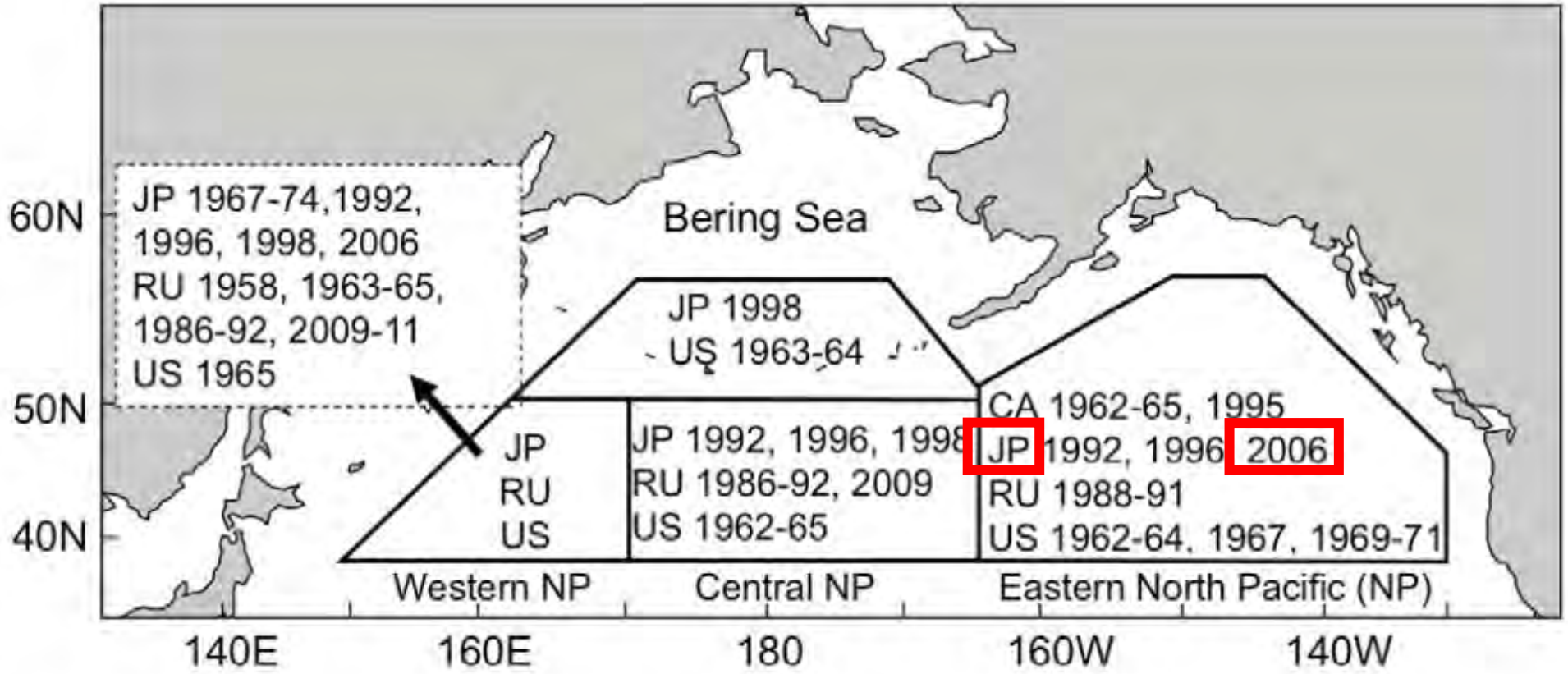
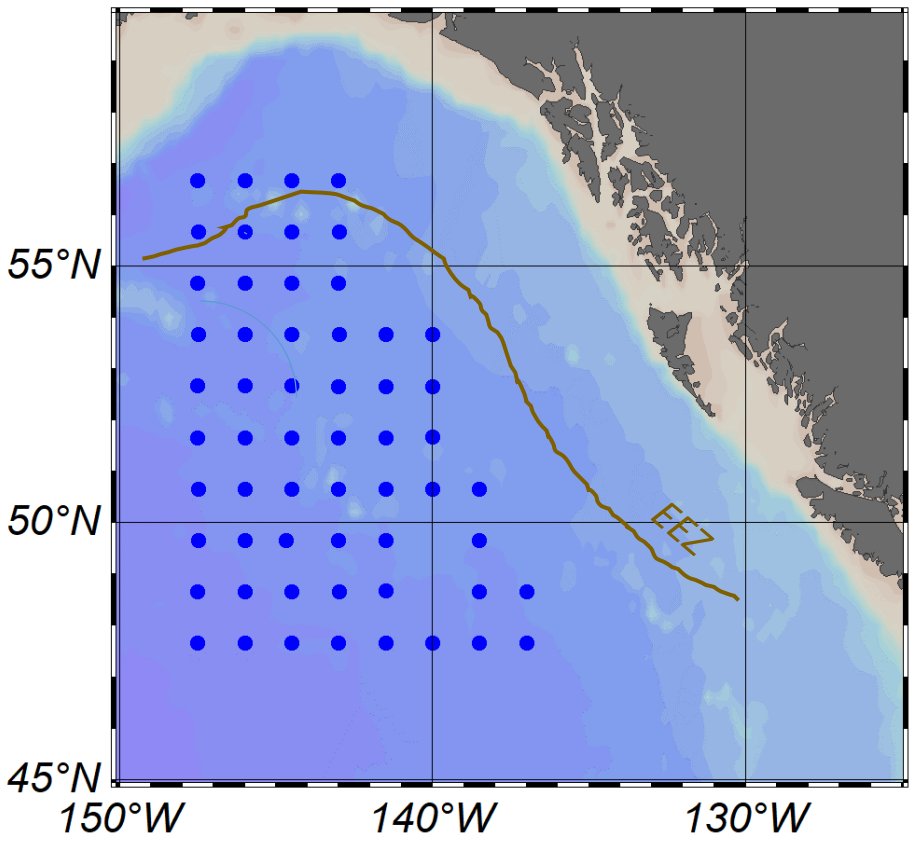
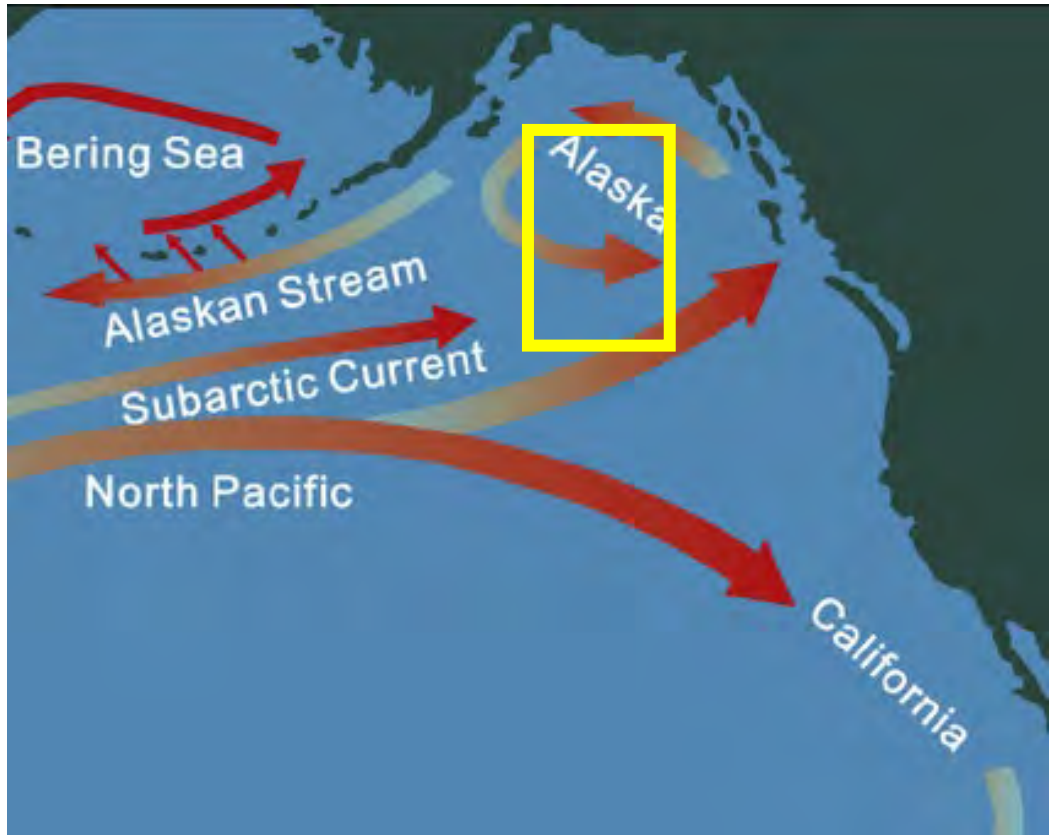


Fig. 3. The regional locations of high seas salmon winter research by Canada (CA), Japan (JP), Russia (RU), and the United States (US) in the Bering Sea and North Pacific Ocean, 1958–2015.

Study area

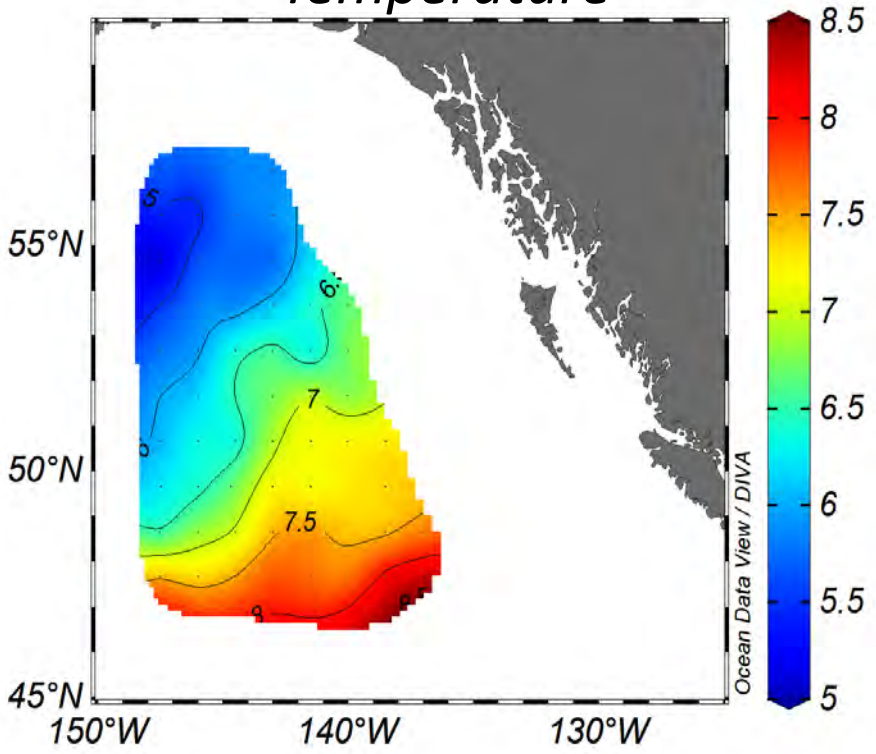

55°N
50°N
45°N
150°W
140°W
130°W
EEZ


Bering Sea
Alaska
Alaskan Stream
Subarctic Current
North Pacific
California

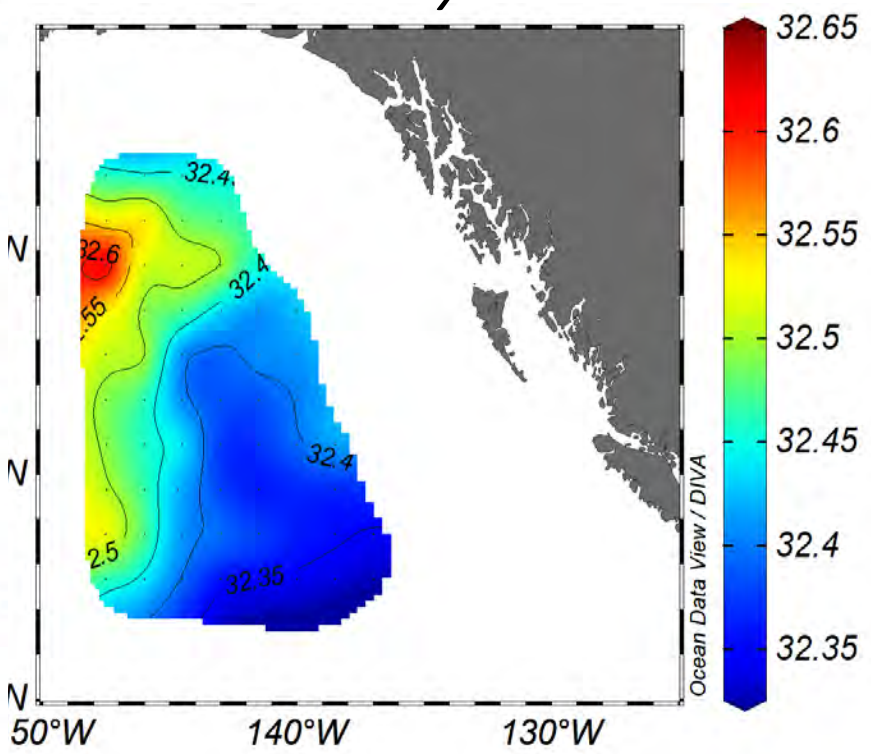
Surface temperature and salinity

Anna Vazhova, Arkadii Ivanov, Gennady Kantakov, Igor Shurpa -Russia
Hae Kun Jung – South Korea

Temperature



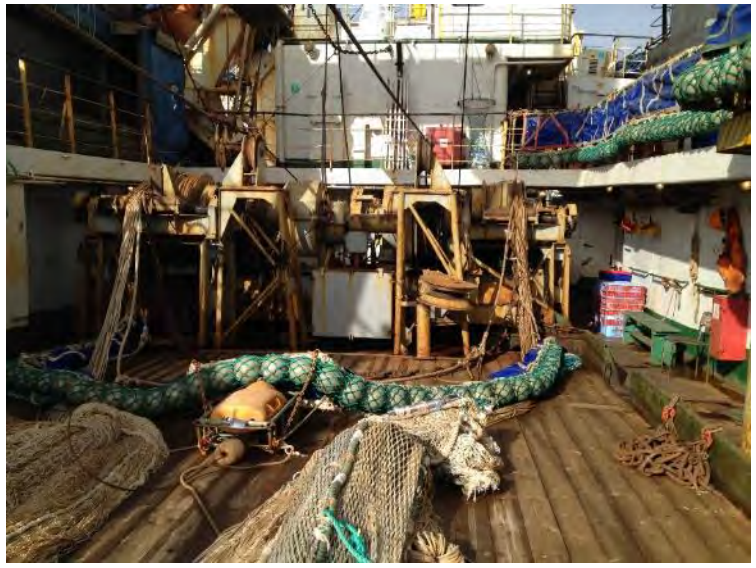
Salinity



- Mixed layer depth at ~100 m throughout study area
- Chemical signatures indicate warm and cool water chemically distinct

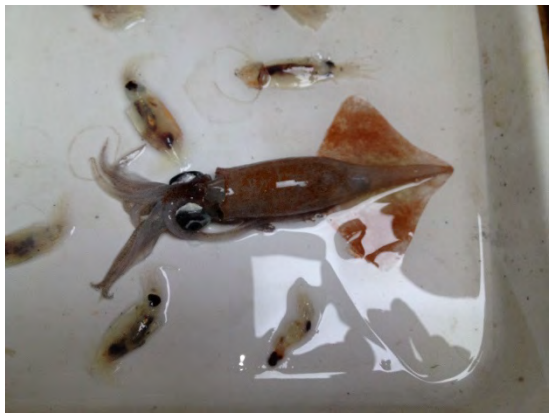
Fishing Methods

Rope trawl (40m x 30m) towed for 1 hour near surface



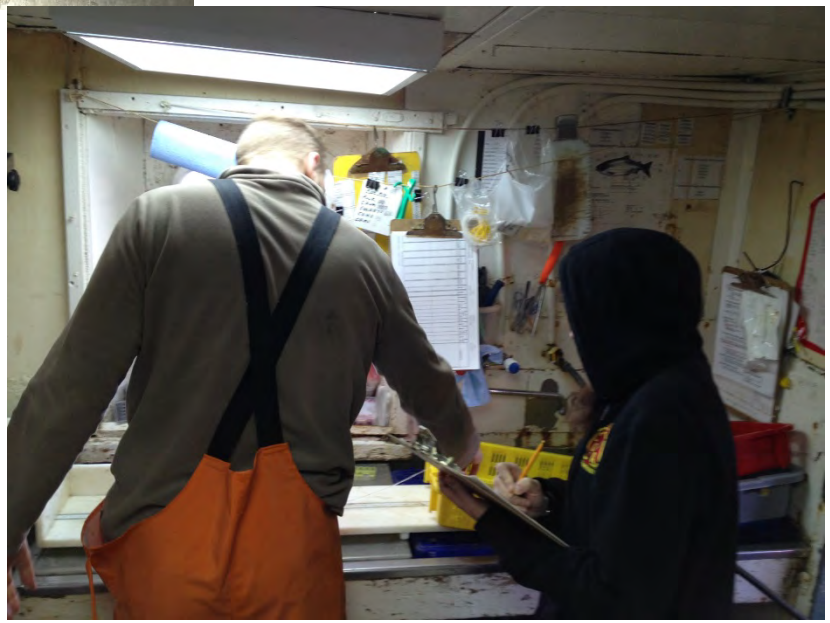
Fishing Methods: Fish processing

- **Everything** identified, counted, measured



Fishing Methods: Fish processing

- **All salmon** had stomachs, fin clips, otoliths, scales, and muscle collected



Fishing Methods: Fish processing

- **Fish health salmon** (*n*=10/set) also had blood, spleen, heart, kidney, liver, pyloric caeca, brain tissues collected

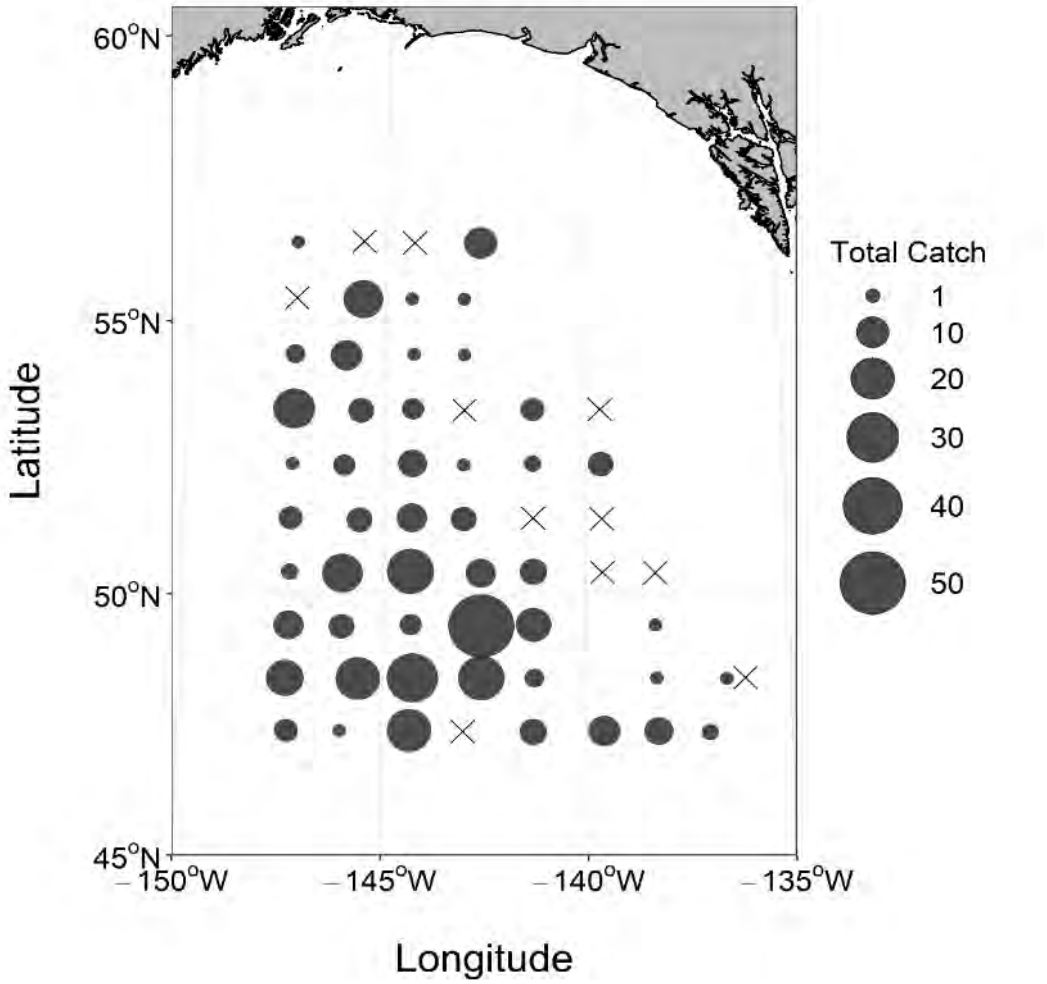
Initial results

- Salmon distribution by species
  - Comparison to previous surveys
- Possible patterns between salmon and the environment
- Trends by latitude

Each salmon was assigned a unique number on a Floy tag

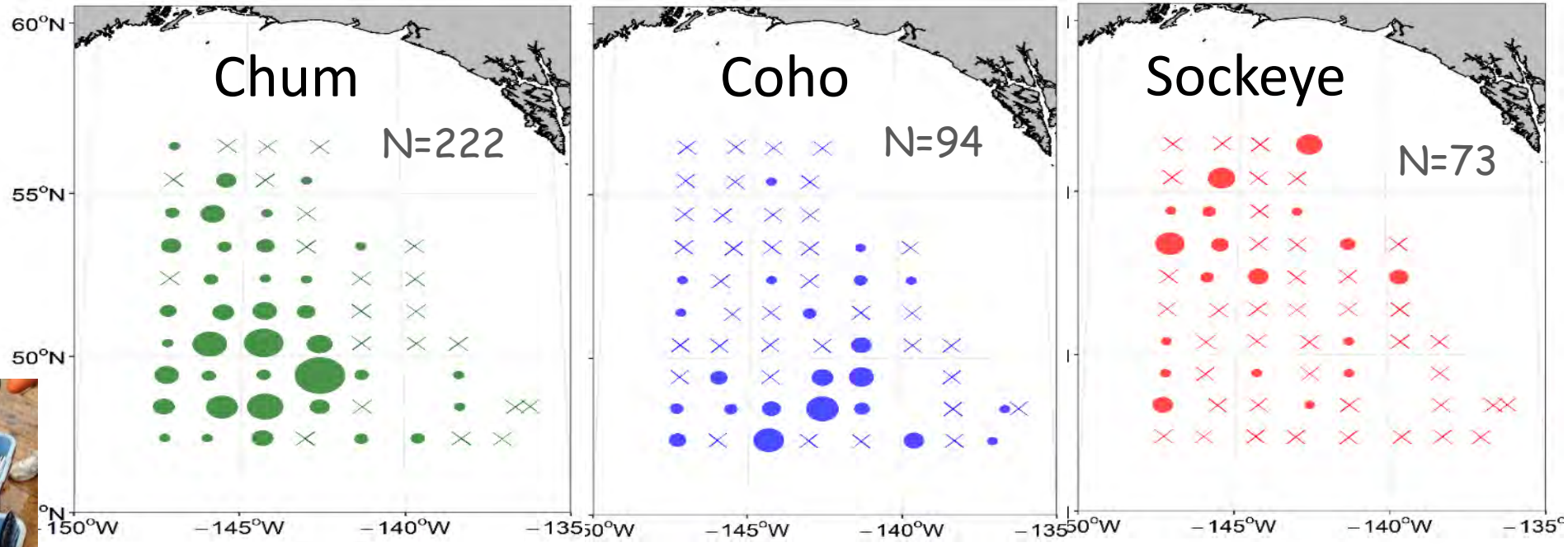
Total salmon catch (all species)

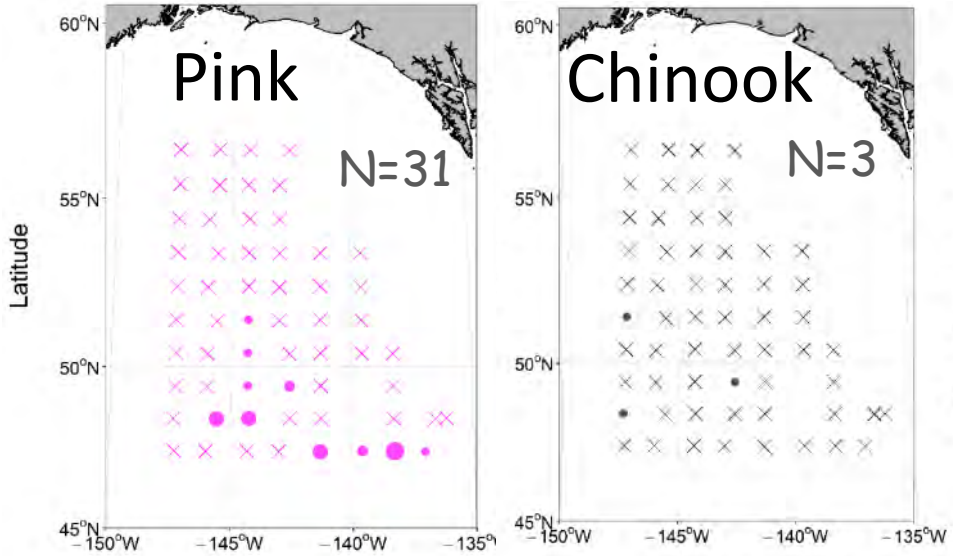
FISH TEAM: Chrys Neville – Canada; Charlie Waters, Laurie Weitkamp, Gerard Foley – US; Hiko Urawa – Japan; Aleksei Somov, Albina Kanseparova, - Russia; Vladimir Radchenko - NPAFC

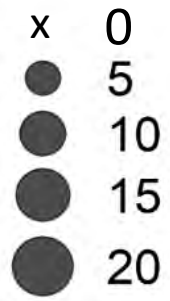


- Salmon caught in 85% of sets

Fish team cont.

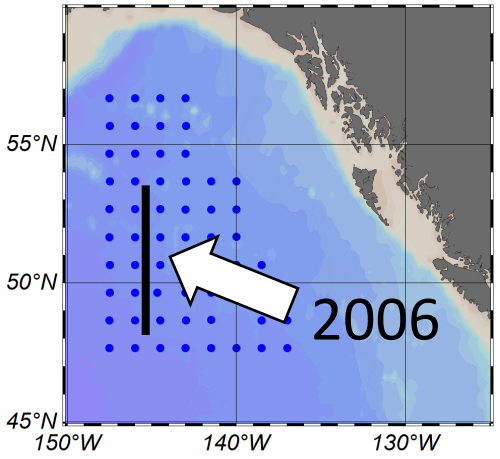




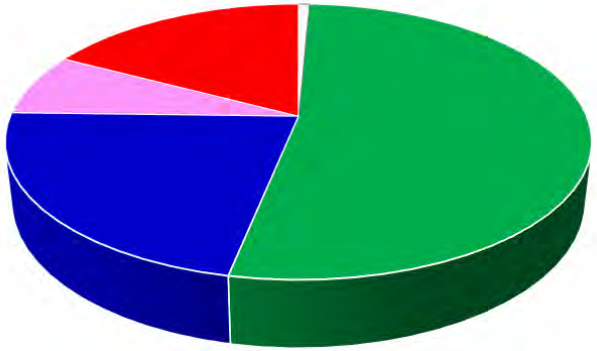


- Clear north-south and east-west differences between species

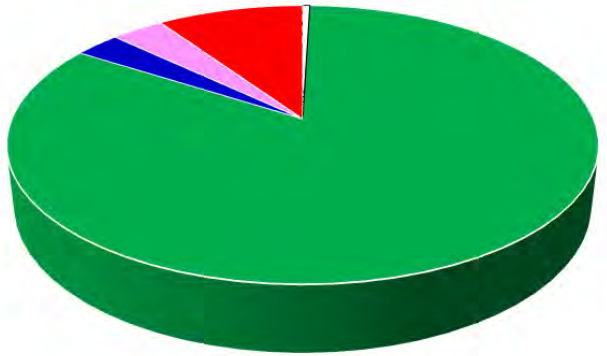
Comparison to previous surveys



This study (Winter 2019)



Fukuwaka et al. 2006 (Winter 2006)



Initial species distributions vs. environmental variation

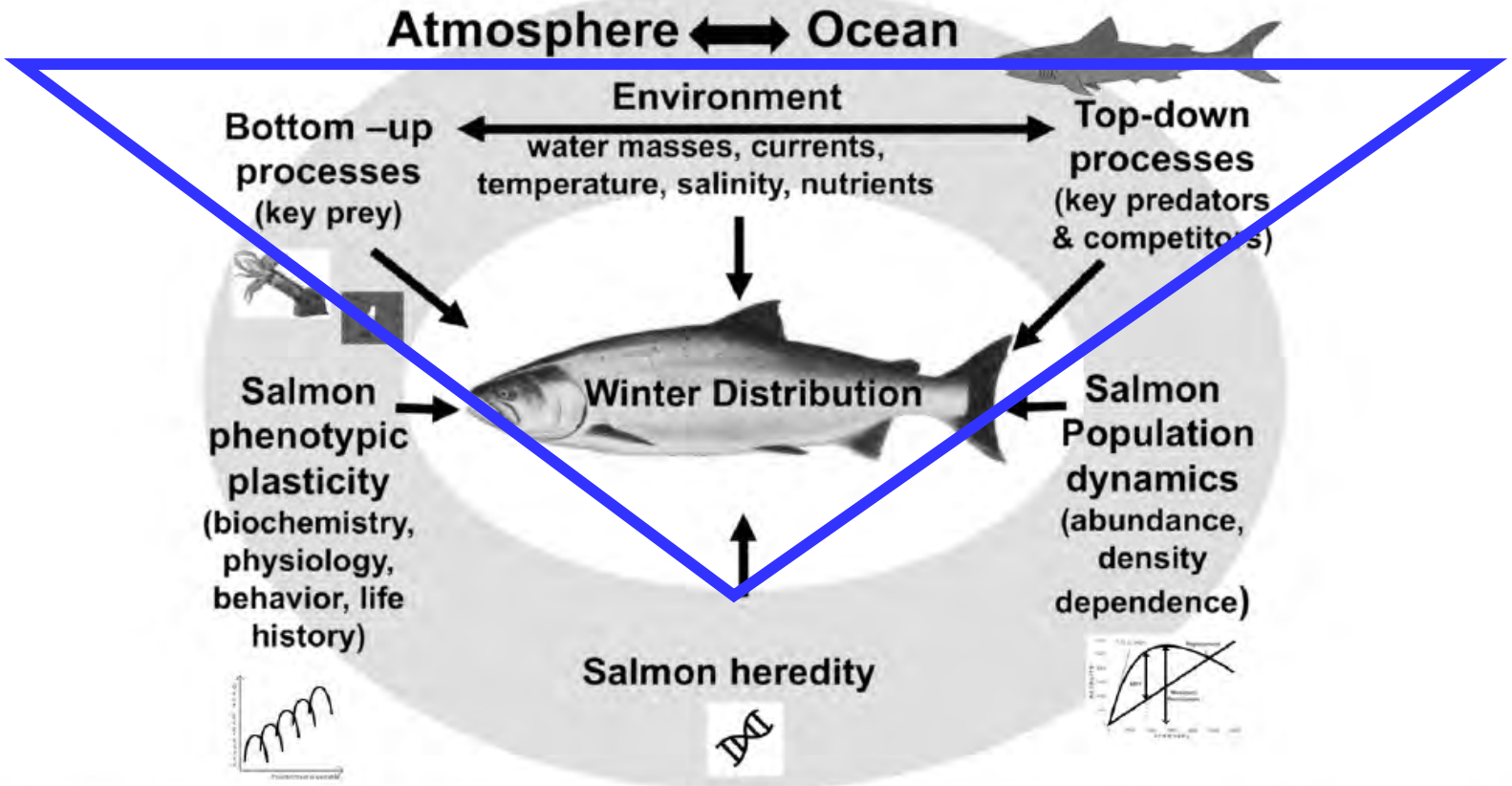
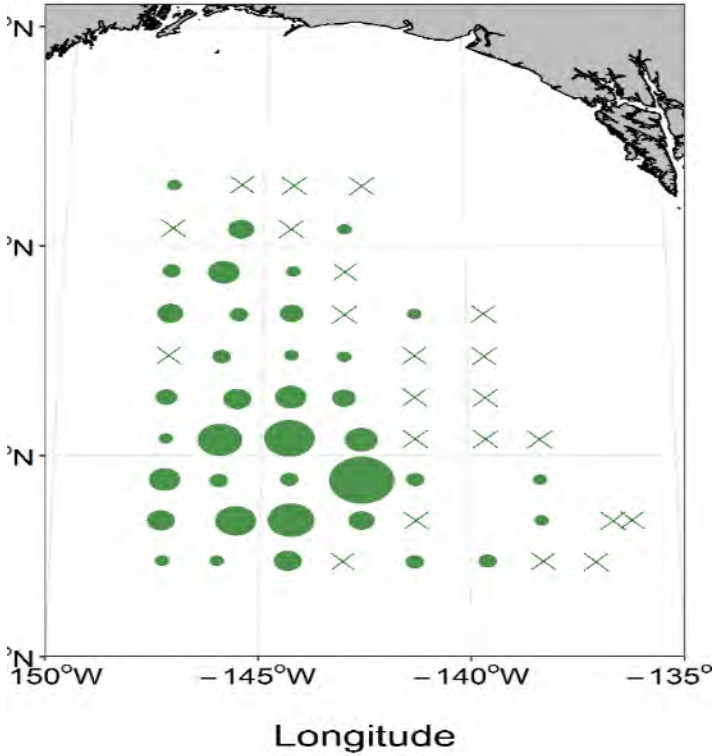
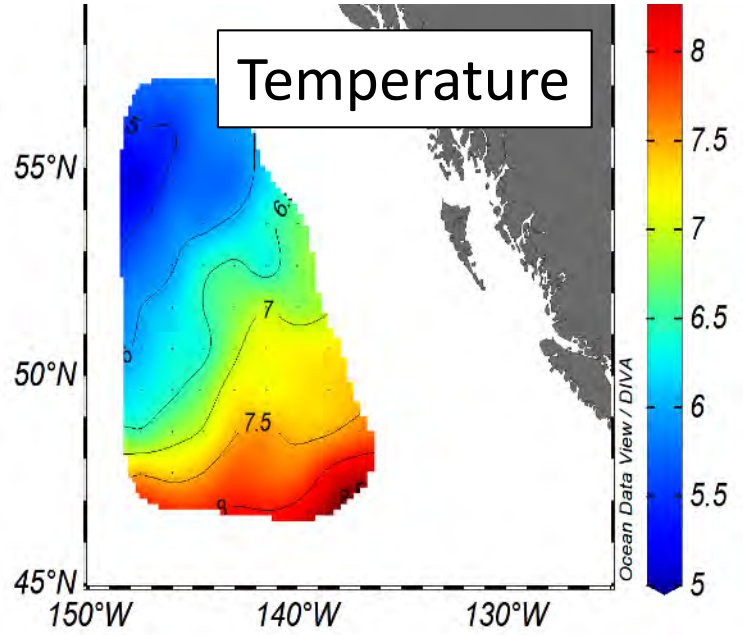


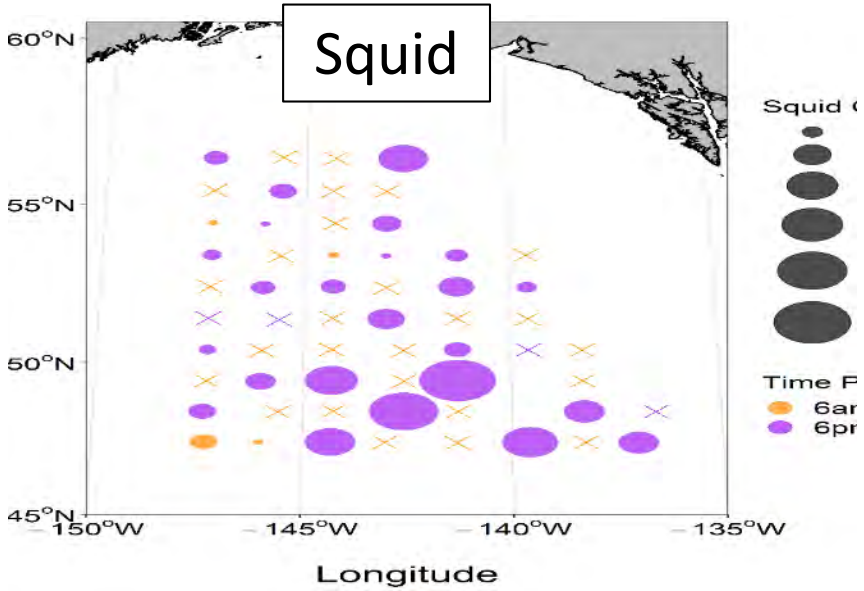
Fig. 12. A schematic illustration of potential factors influencing the winter distribution of high seas salmon and steelhead in the North Pacific Ocean.

Chum salmon

Skinny chum







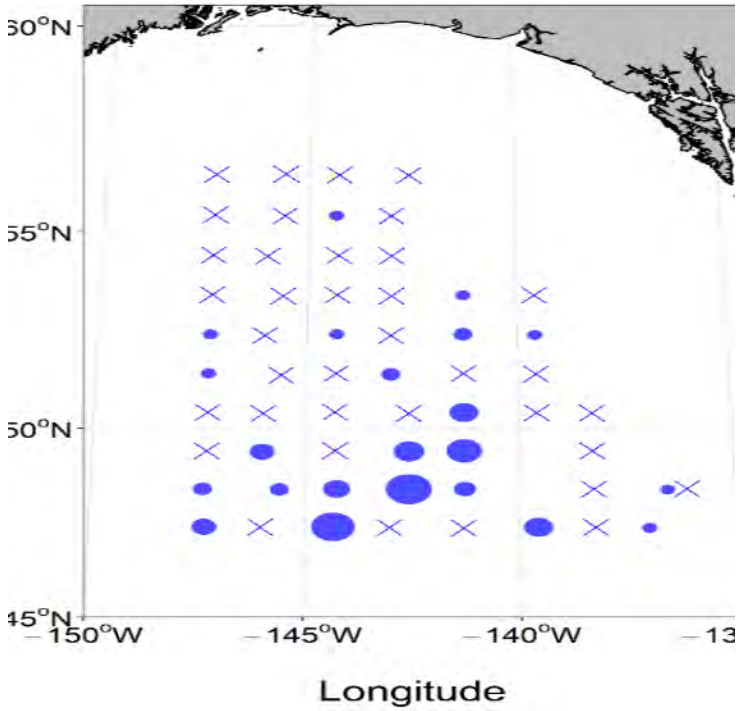
-Widely distributed, but highest in south (=wide temp range).

- Lowest condition and many empty stomachs

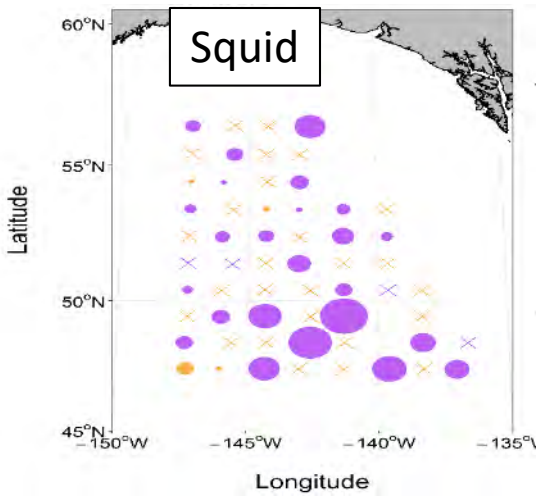
- Possible overlap with squid, but not eating squid

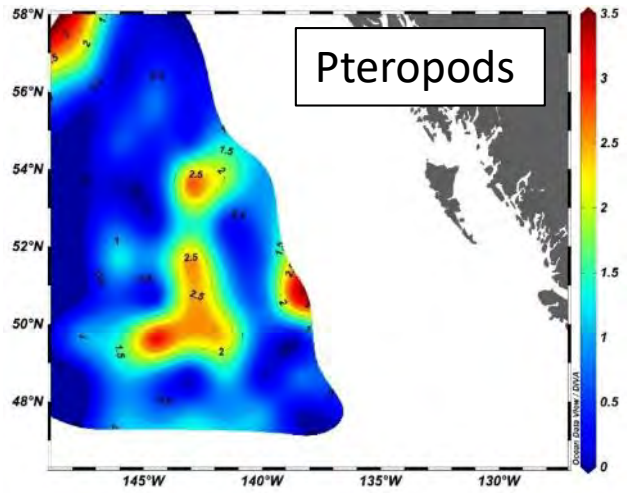
Coho salmon

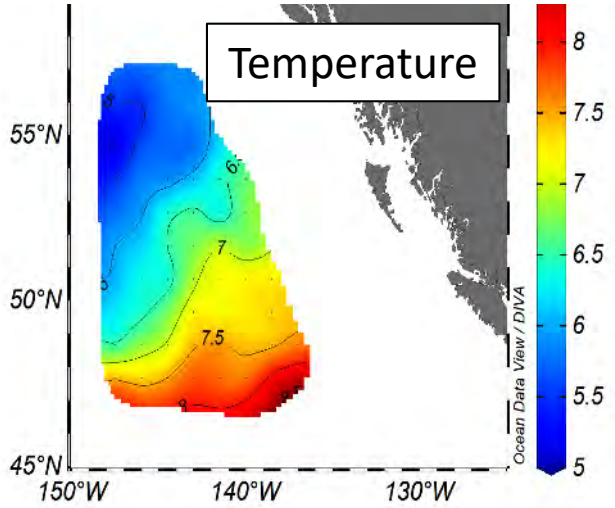
Squid in coho stomach



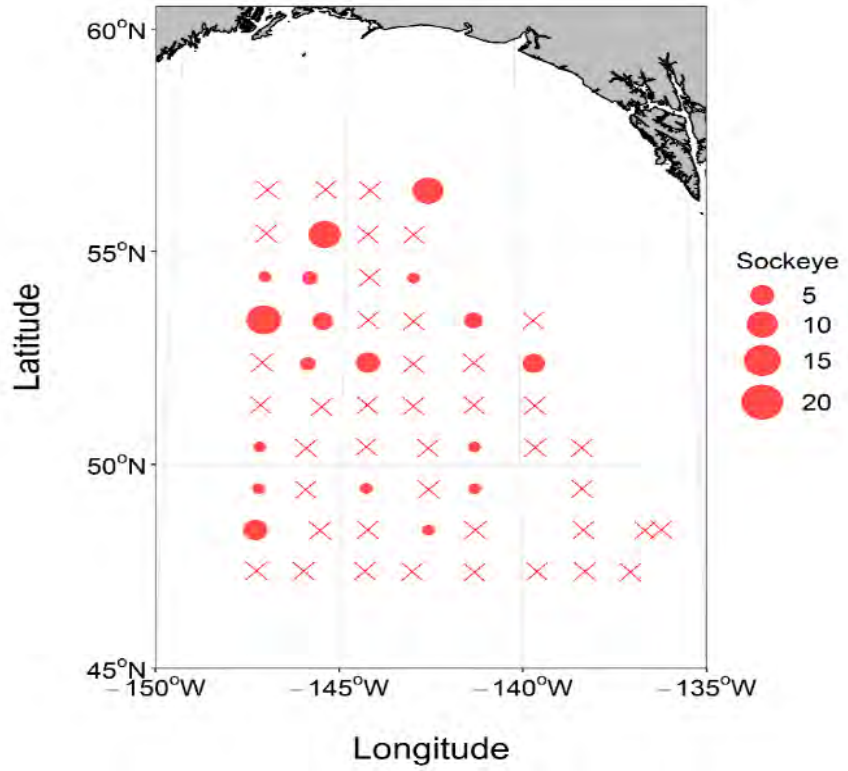
- Most in warmer waters of survey area.
- Distribution overlap with pteropods, which were important prey.
- Also overlap with squid, which were minor prey.

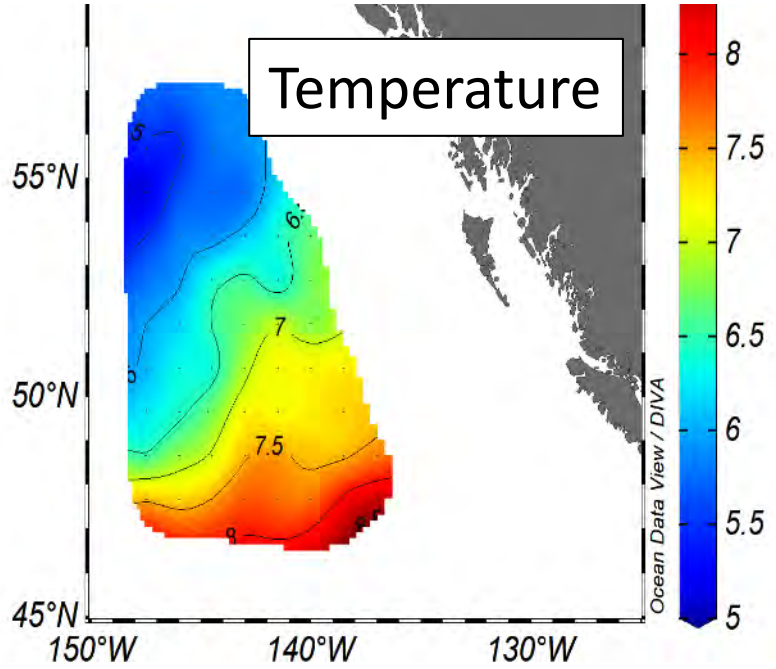


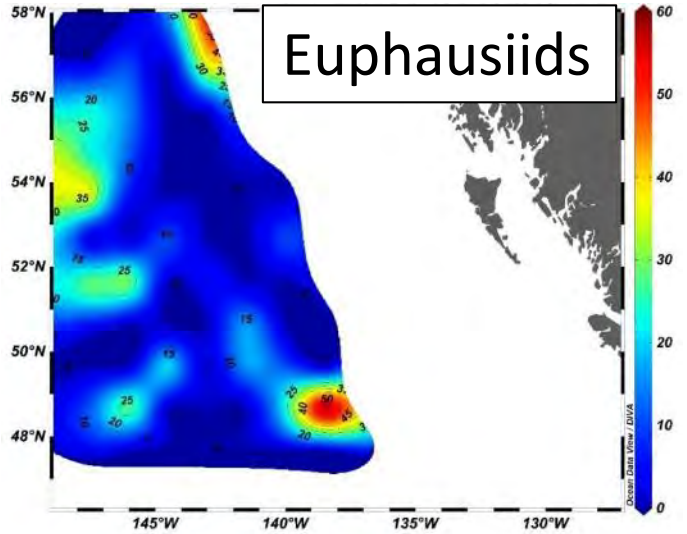




Sockeye salmon







-Distribution primarily in cooler waters in north.

- Distribution overlapped euphausiid concentrations, which were dominant prey in north.

Trends by latitude of catch

- Are there common patterns across salmon species?
  - Size, condition, stomach fullness
- What does it tell us about the influence of “past” (=size, condition) versus “present” (stomach fullness) conditions?

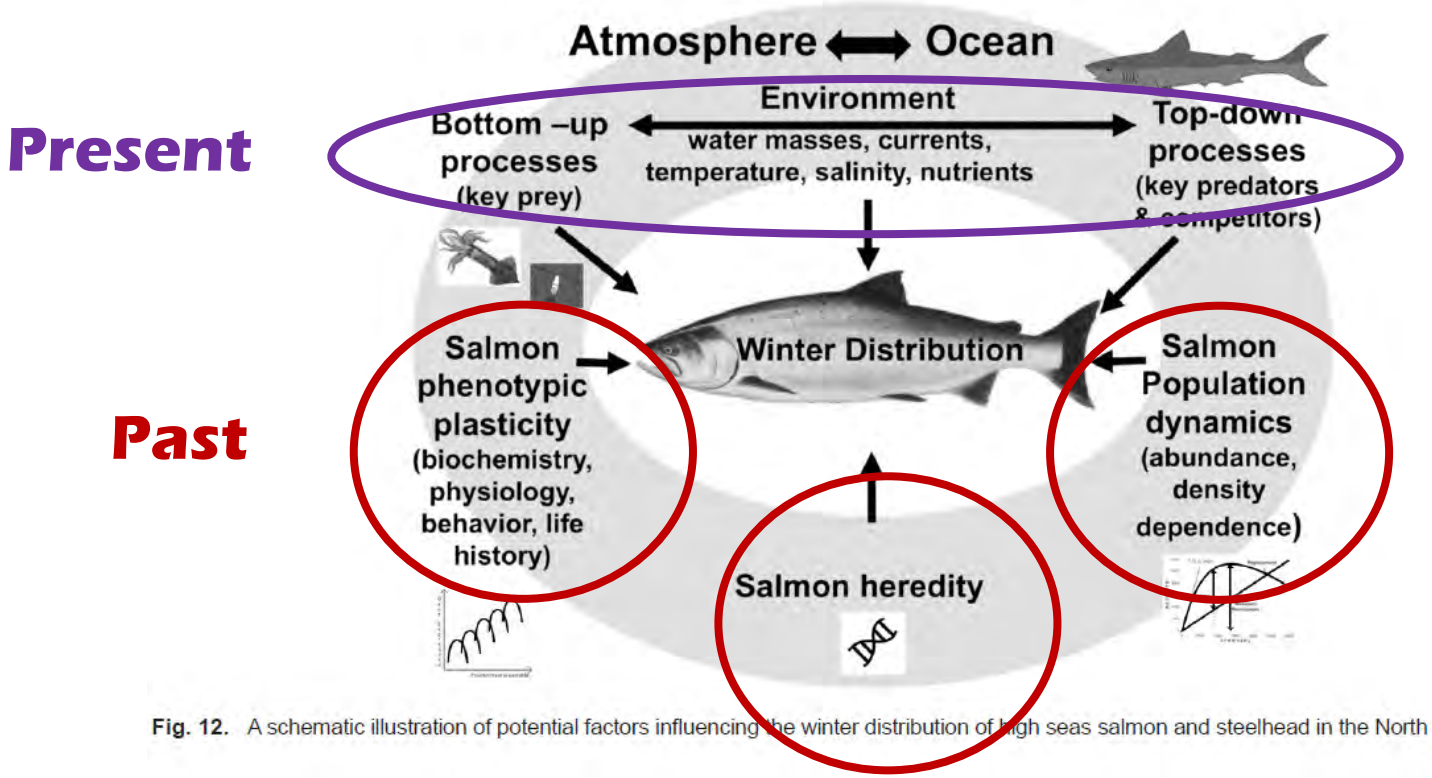
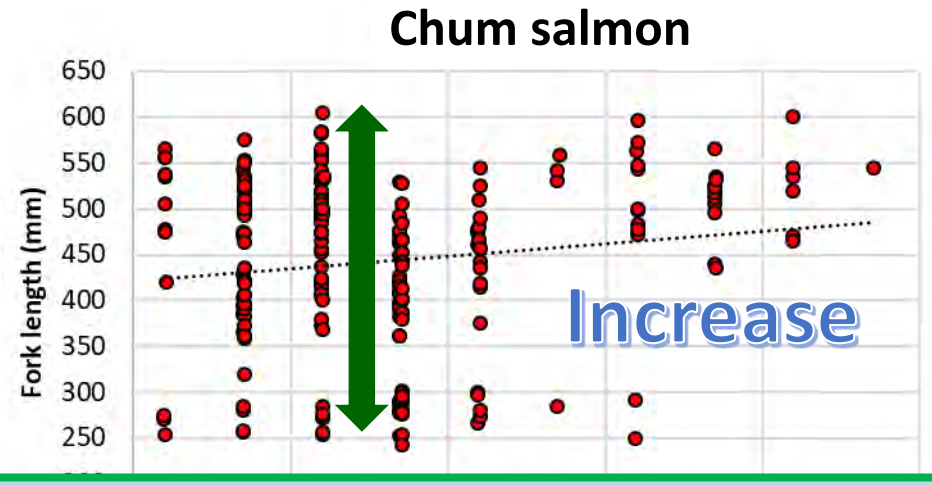
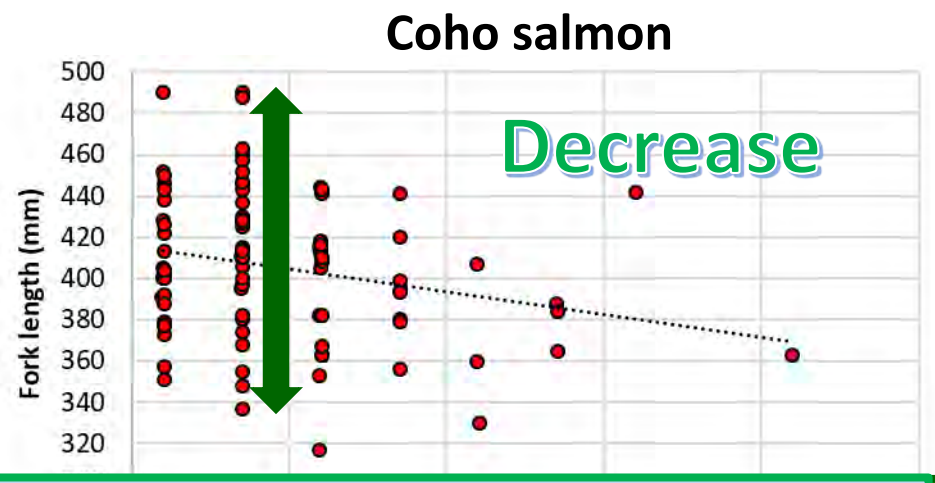


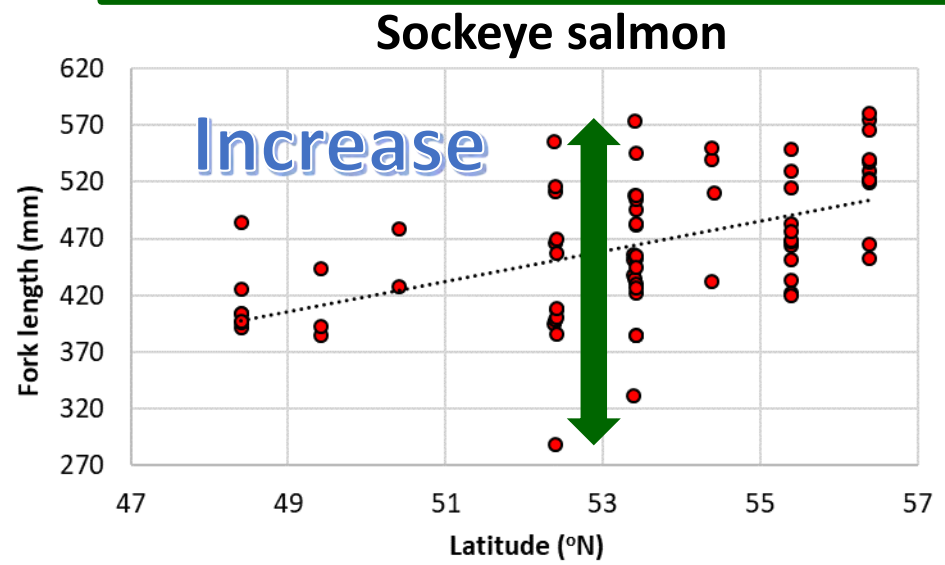
Fig. 12. A schematic illustration of potential factors influencing the winter distribution of high seas salmon and steelhead in the North Pacific Ocean.

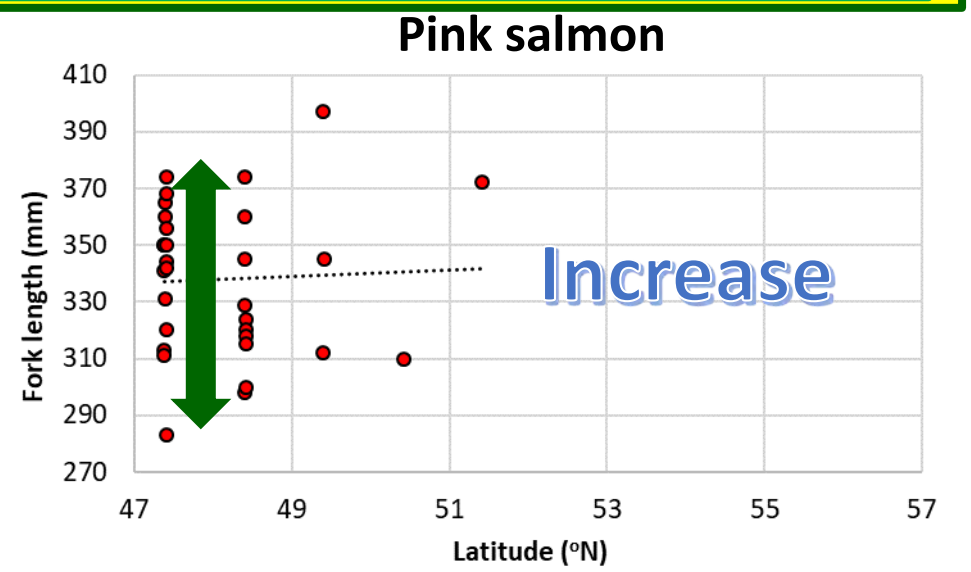
Salmon size by latitude



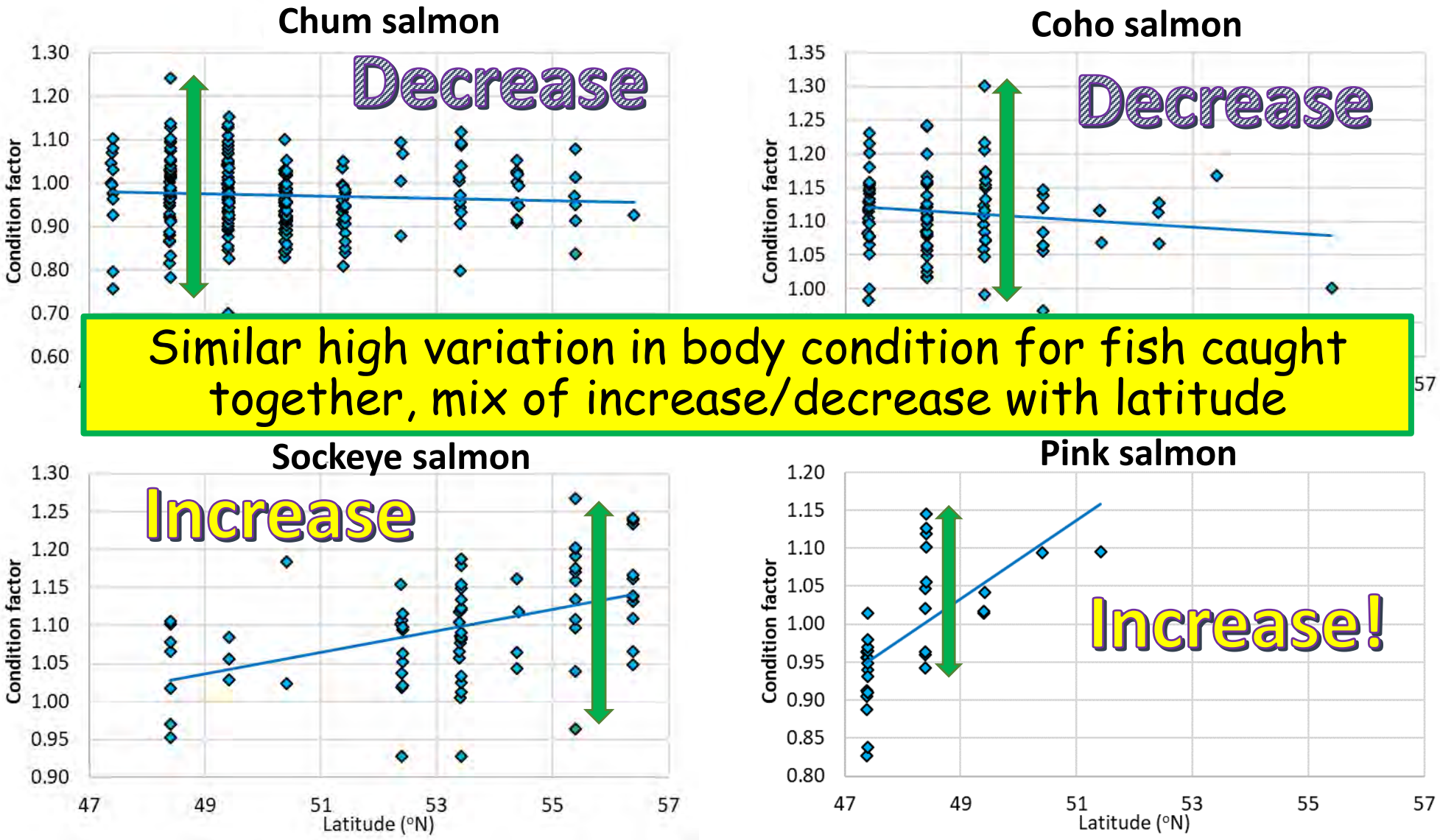


Generally fish bigger in north than south

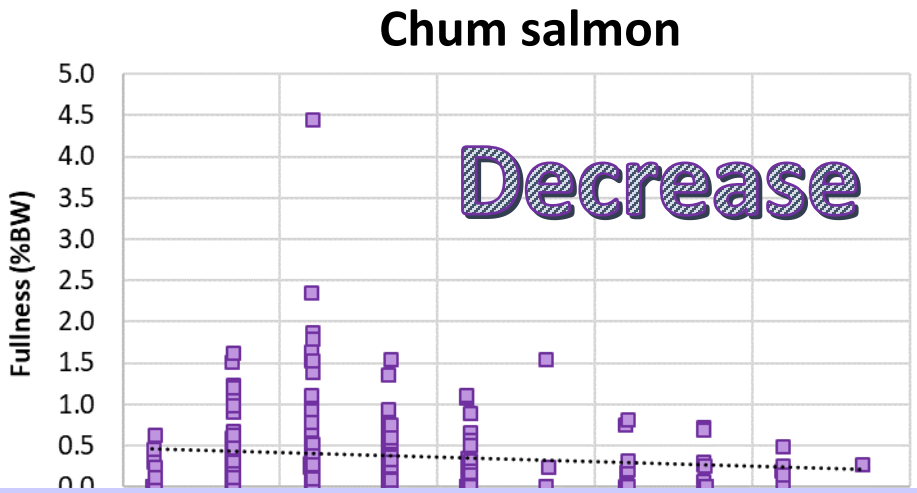


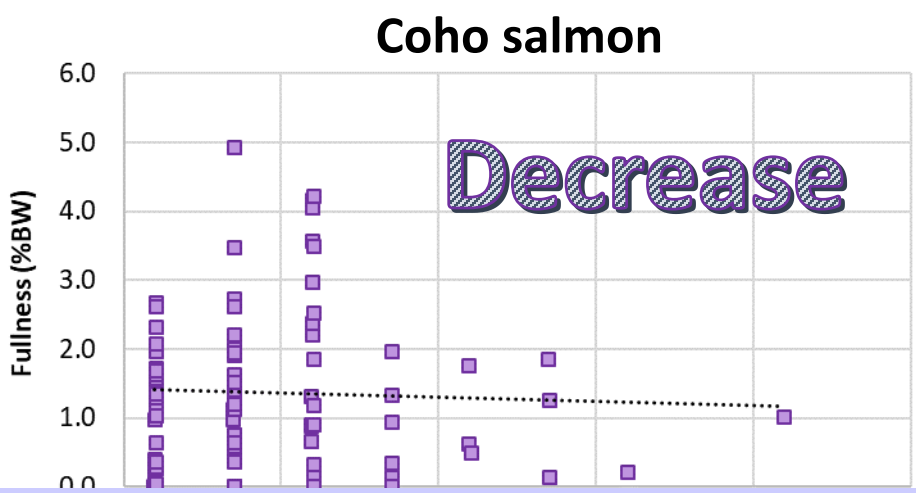


Salmon condition factor by latitude

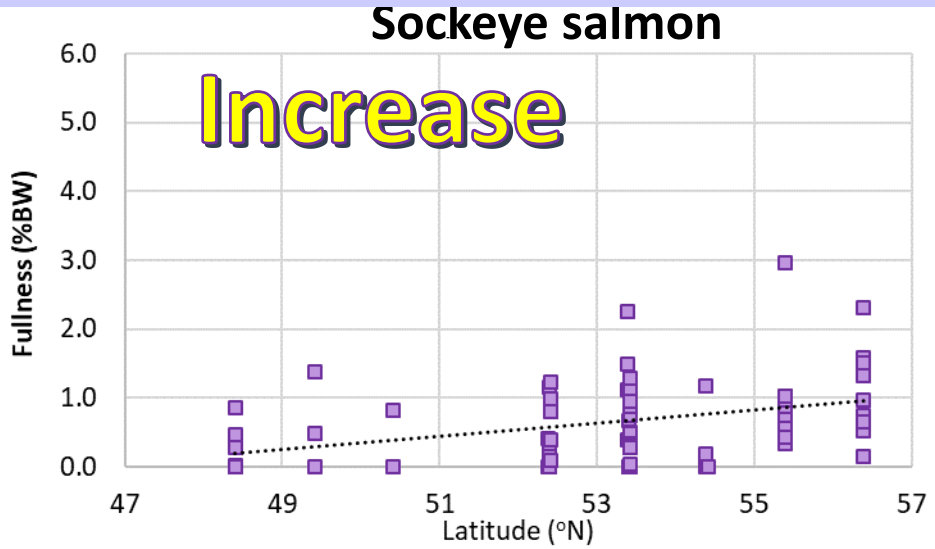


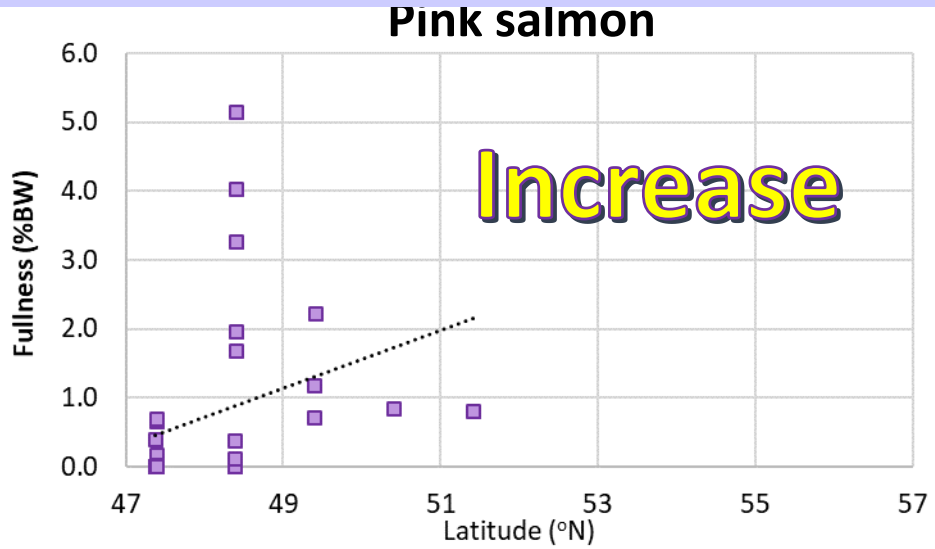
Salmon stomach fullness by latitude



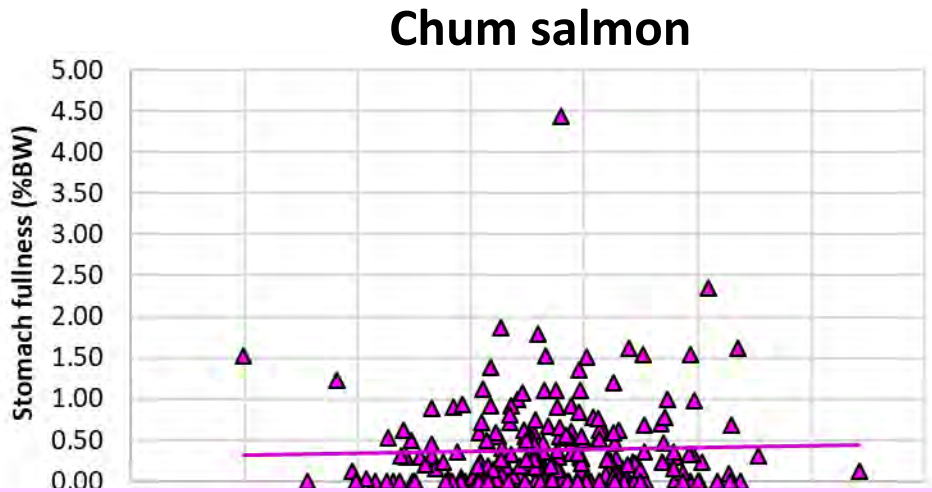


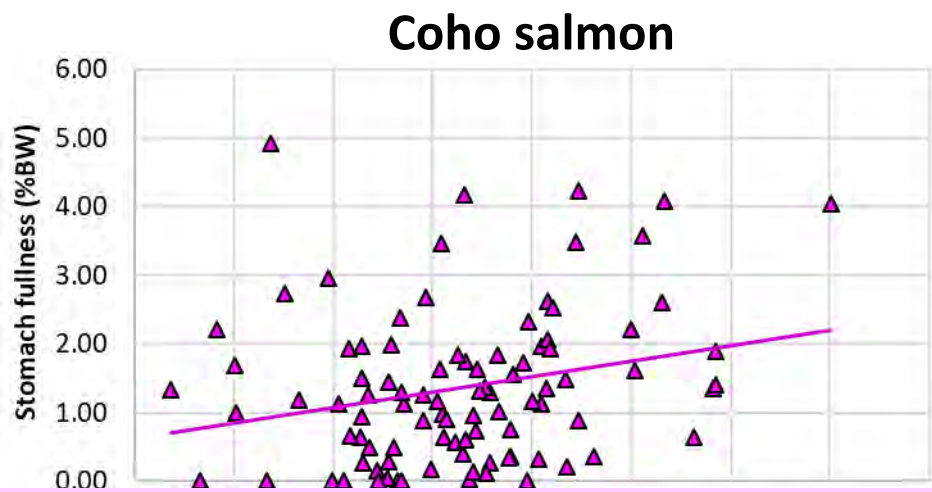
Similar pattern of increase/decrease by latitude as condition



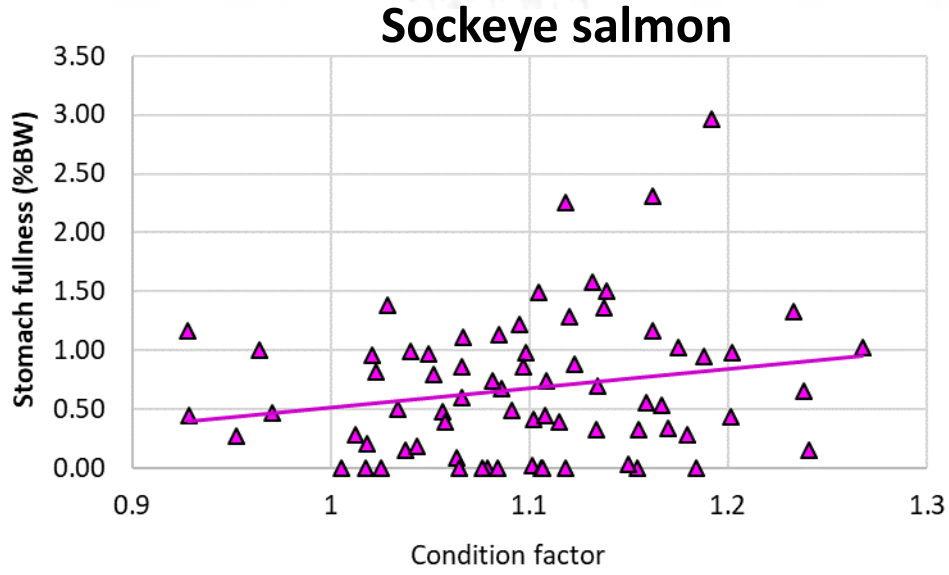


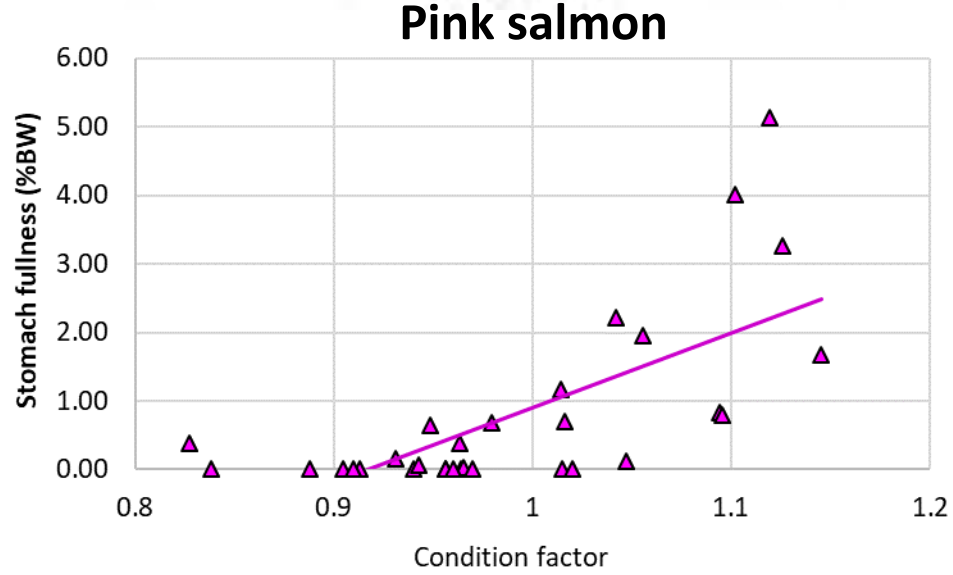
Condition vs stomach fullness

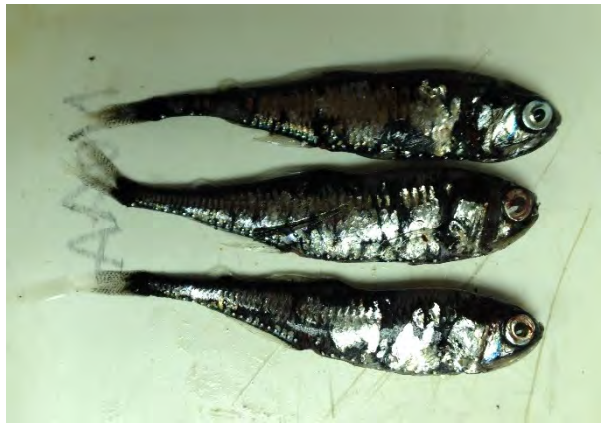




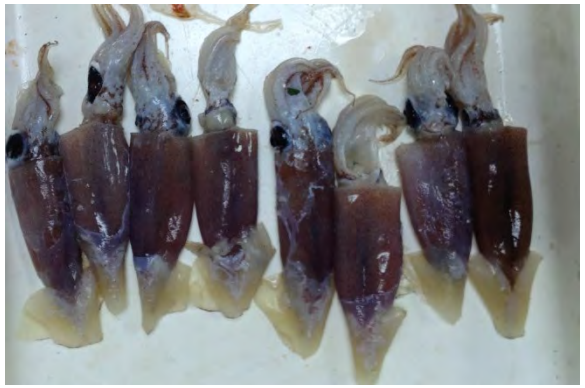
Condition and stomach fullness positively related for all species







Other nekton in upcoming talks



New salmon questions

Where are all the **pink** salmon?

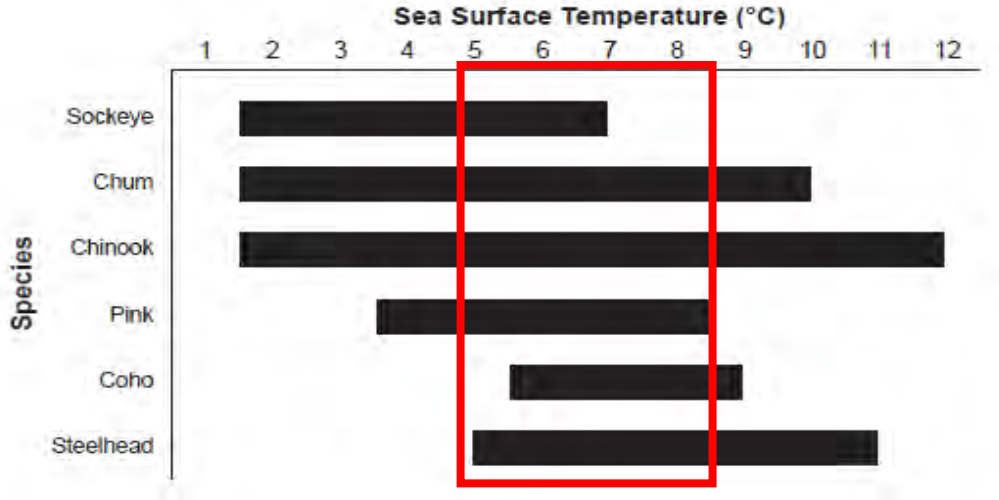
- Most abundant salmon species in N Pacific
- 2019 was a reasonable return year

Coho can be a "coastal" species (Urawa et al. 2016) and were minor species in previous winter surveys

➔ 2nd most abundant species in our survey.

- Bumper crop to come?
- Change in distributions?
- Why?

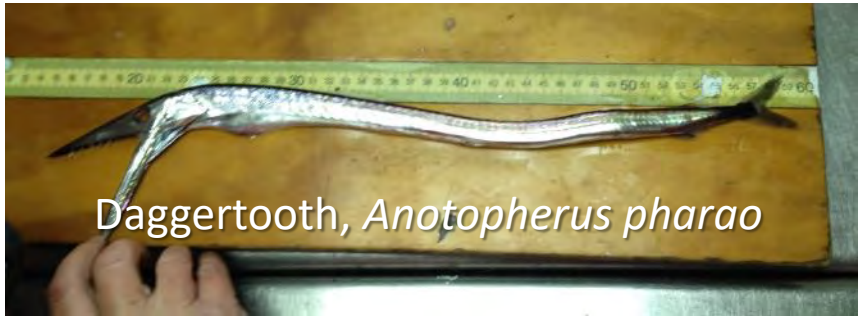
Salmon winter temperature preferences (Myers et al. 2016) cover our entire study area, yet we observed fine-scale temperature selectivity. Didn't they read the paper?!



Myers et al. 2016. NPAFC Bull 6.

Where are the predators?

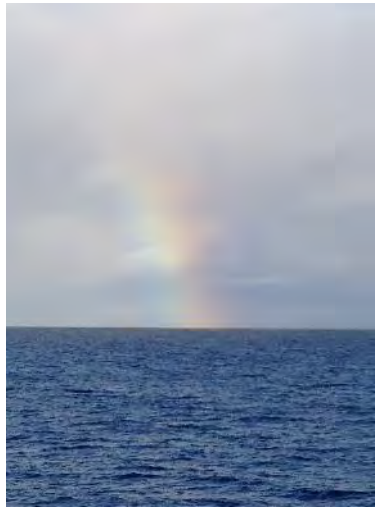
- We caught two spiny dogfish and several daggertooth
- No other sharks caught
- Few predators caught during previous winter surveys (Myers et al. 2016, Naydnko et al. 2016).
- eDNA: Will be able to determine if we missed big predators

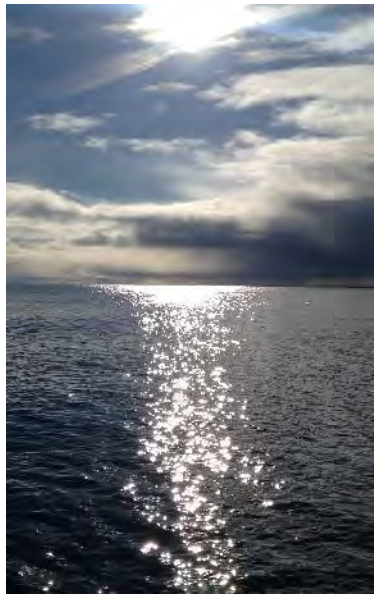

Daggertooth, *Anotopherus pharao*


Salmon shark, *Lamina ditropis*


White shark, *Carcharodon carcharias*


Spiny dogfish, *Squalus acanthias*



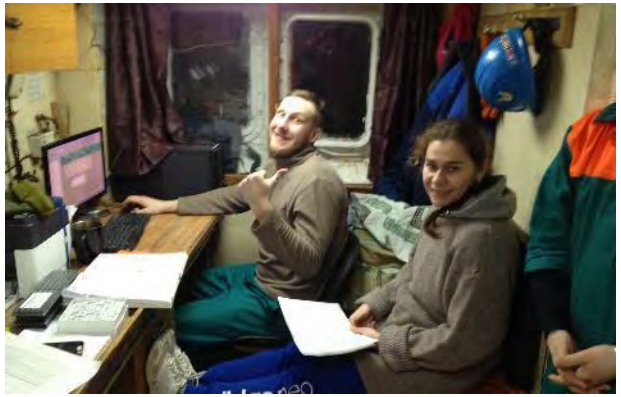


Initial conclusions

- Salmon differed substantially in their distributions, size, condition, and stomach fullness, even in same haul
  - Few consistent patterns across species, except …
  - condition was positively related to stomach fullness
  - Influence of past vs present conditions
- Some species distributions showed potential links to environmental conditions
  - Sockeye and cool water, euphausiids
  - Pink and Coho warmer water
- Stock-specific differences may explain some of the variation in distributions, size, and condition (Urawa & Neville talks)

Fantastic teamwork!



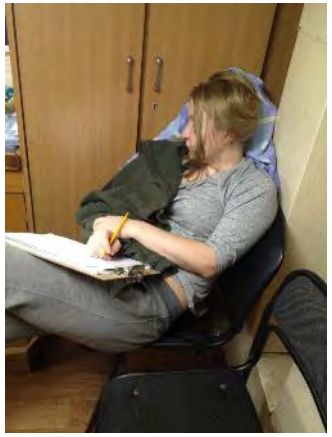
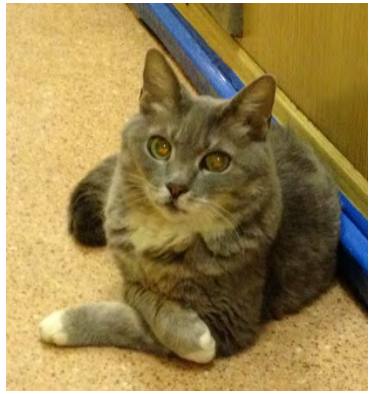




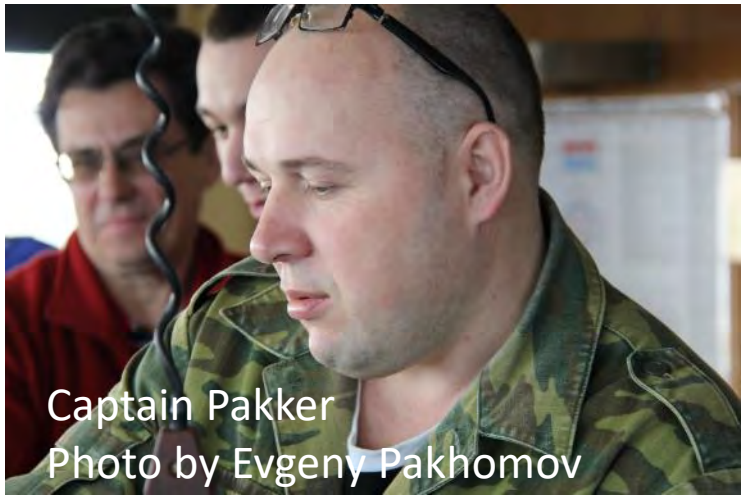


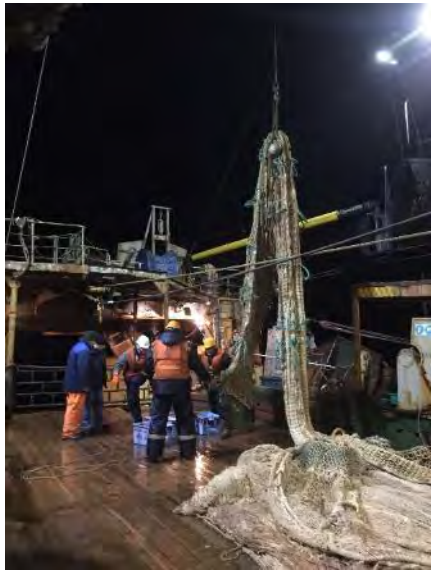




Deepest gratitude to the sponsors! And to the Prof. Kaganovsky crew, officers, mechanics and Captain Alexander Pakker !!!






Questions?