IYS 2022 High Seas Survey: motivation, methods and initial results
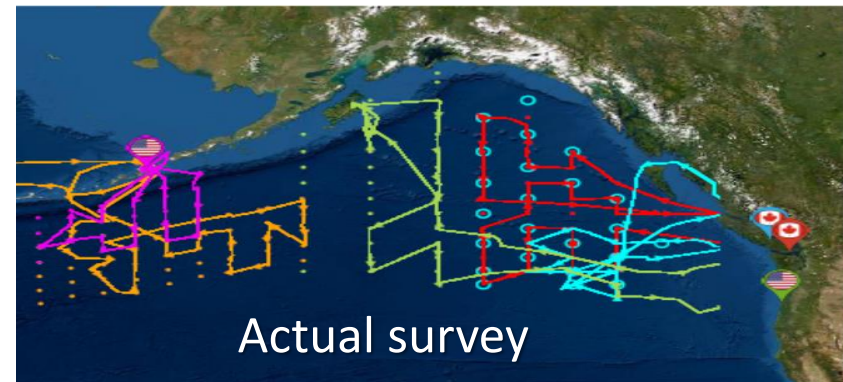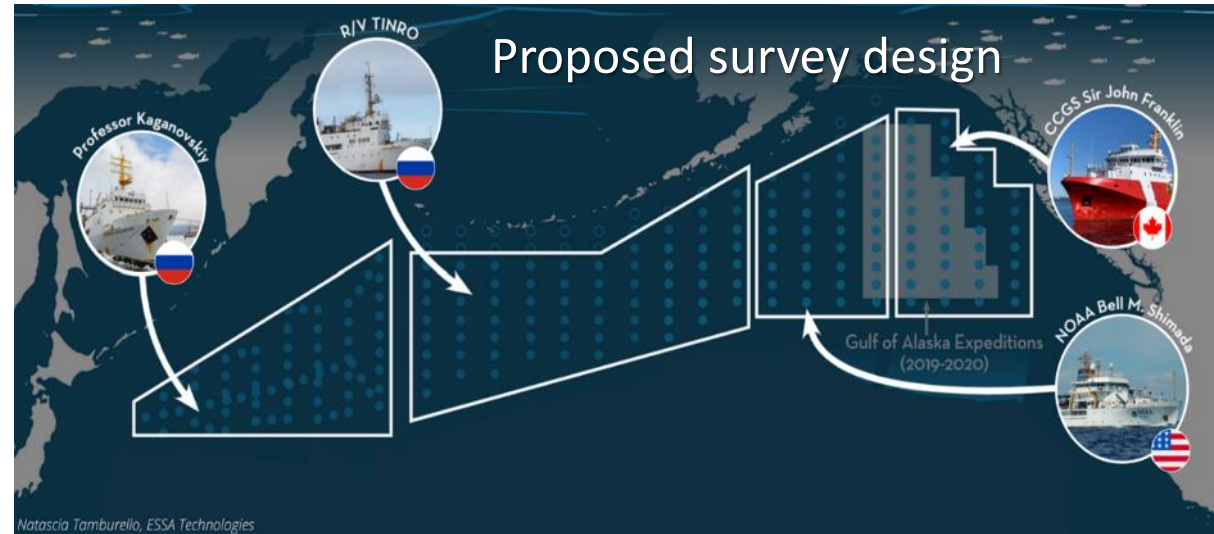
Dick Beamish, Scientist Emeritus

Chrys Neville, Fisheries and Oceans Canada

Brian Riddell, Pacific Salmon Foundation

Laurie Weitkamp, NOAA Fisheries/NWFSC

What was the vision for the 2022 IYS Pan Pacific Survey?

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

Why high seas salmon research?

1 – Work as international teams to improve understanding of the winter ocean ecology of Pacific salmon.

2 – Can winter surveys improve forecasts of Pacific salmon returns to British Columbia?

3 – NEW – Understand why the British Columbia commercial salmon fishery has collapsed and what to do about it.

Collapse of British Columbia Commercial Salmon Fishery
% of total all country catch caught by Canada

2021 =0.2%
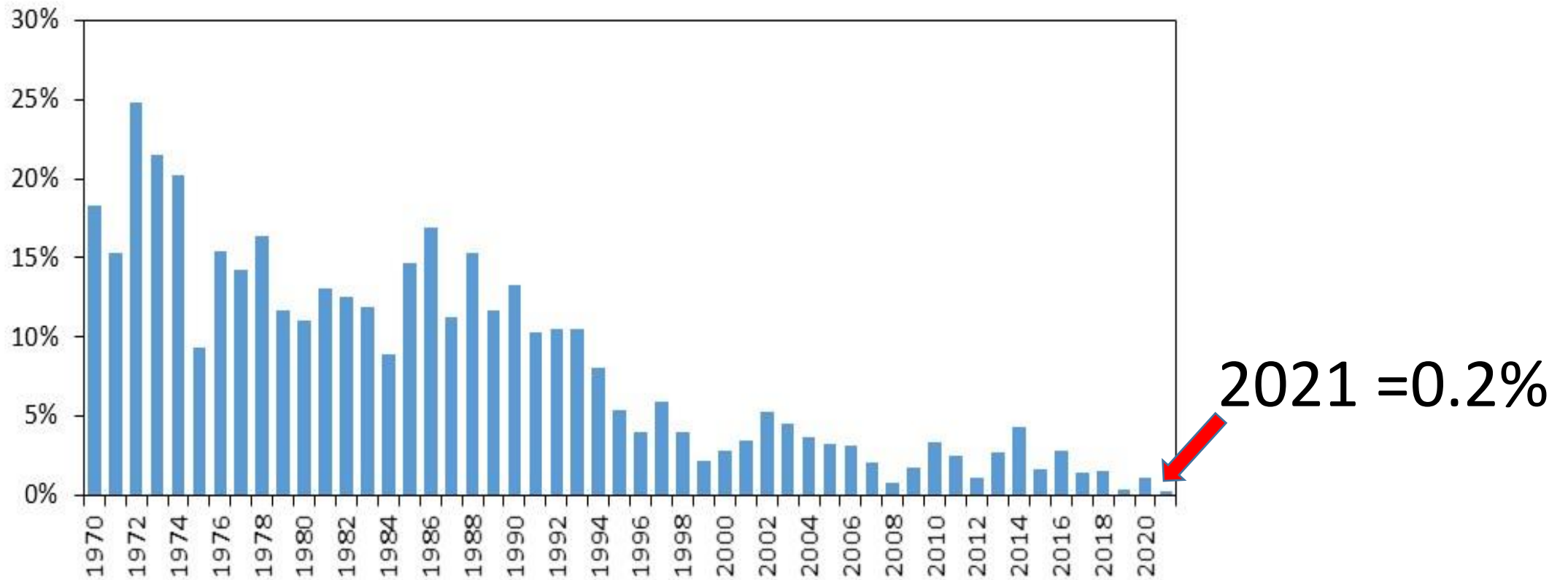
Why the 3rd expedition (IYS) and Gillnets?

- IYS multi-vessel research was a continuation of 2019 and 2020 trawl sampling to address limitations of single vessels and limited spatial coverage.

- Addition of Gillnet and Longline vessel addressed 3 uncertainties:
    1. Past catches were substantially less than expected (but how to assess that?)
    2. Catches varied between day/night and species seem to indicate heterogeneous distributions.
    3. What is an appropriate 'Catchability' to apply to the trawl samples when estimating abundance? An alternative sampling gear could be compared directly with trawl samples.

Gillnets and longlines were established sampling methods from past research in the North Pacific Ocean; applied Japanese research gillnets manufactured in Japan (longlines built by crew members). Gillnets tracked by satellite buoys.

An issue was by-catch of commercial gillnets in past practices, but NPAFC limits gillnet use to 3 nets (2.5 Km each, with variable mesh) for research. Each net consists of 3 tans (50m panel) each of variable mesh sizes (48, 55, 63, 72, 82, 93, 106, 121, 138, and 157 mm) combined with 9 panels of 'commercial' gillnets (115 mm mesh size) at each end of net.
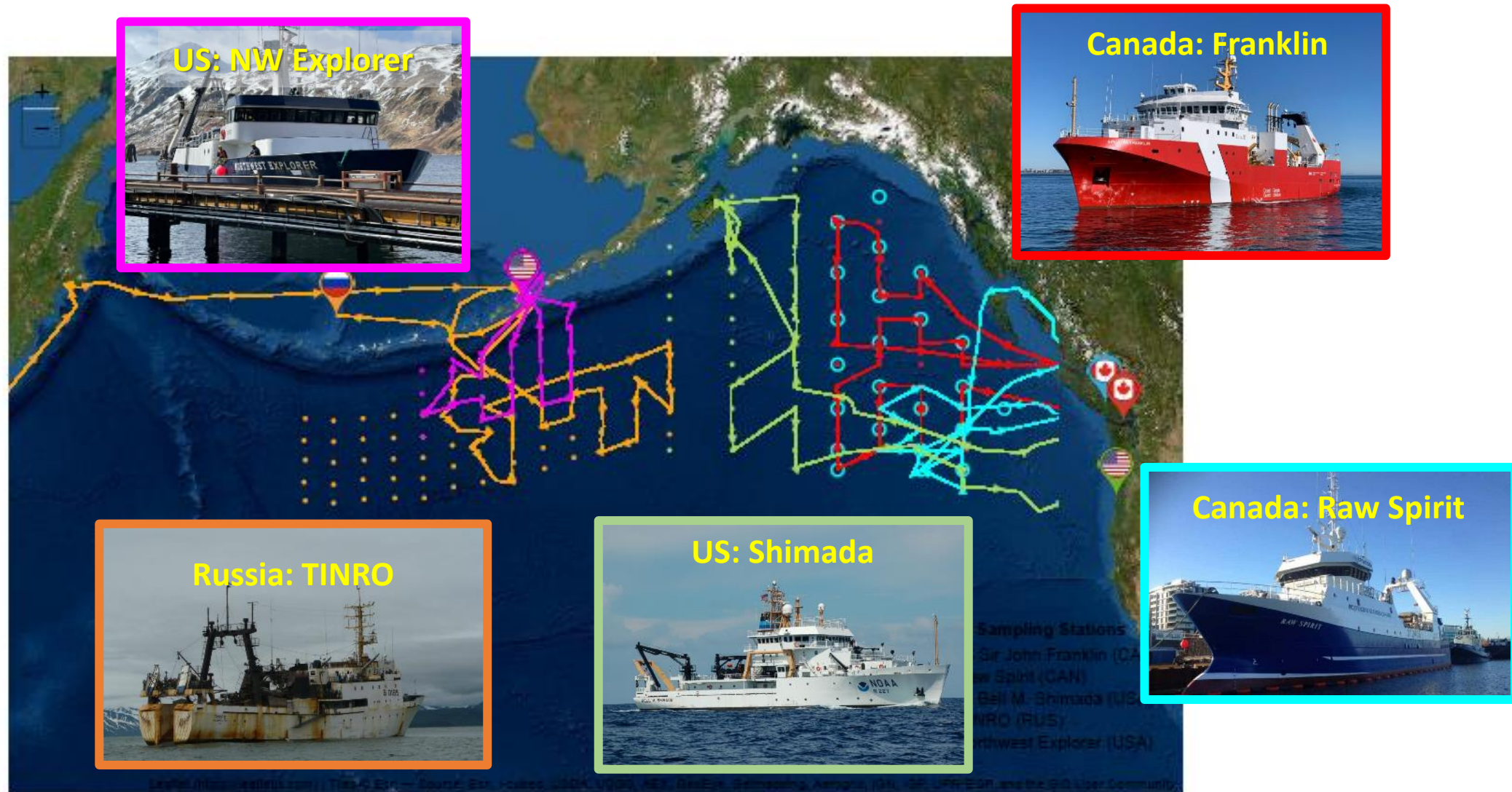
Gillnets were modified by adding much stronger float lines (11mm Spectra) to account for stresses of pulling the lines during rougher seas.

Methods

Loading trawls on NOAA Ship Shimada, January 18, 2022

Five ships sampled 131 stations across 2.5 million km²
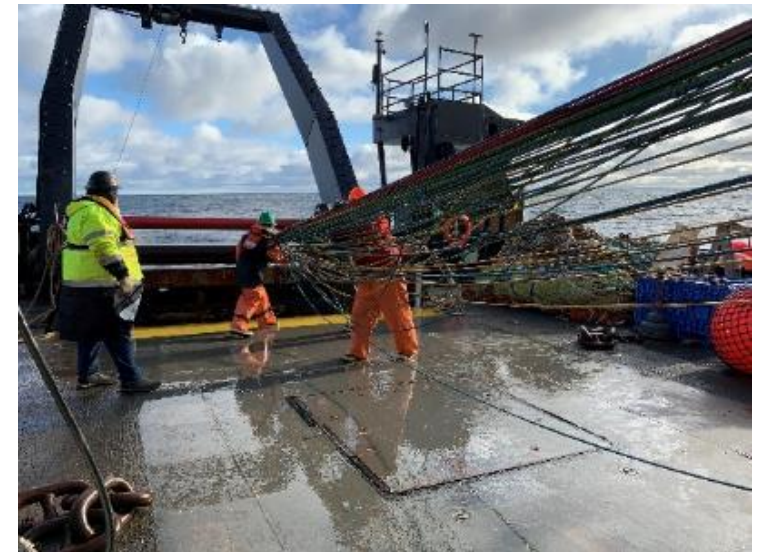
Common methods across ships

Physical
oceanography

Biological
oceanography

Fishing
(surface trawl or gillnet)

CTD casts to 300-2000m
Multi-depth samples for O_2,
nutrients, Chl a, flow cytometry,
POM, HPLC,
environmental DNA

Standardized vertical bongo
nets (all ships), also Tucker
trawls (Shimada, Franklin),
Juday net (TINRO)

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

Measurements & samples collected from *salmon*

- Length, weight
- Scales (age, growth)
- Otoliths (age, hatchery thermal marks)
- CWTs (origins, age)
- External marks (possible predation attacks)
- Stomach contents (food habits)
- Fin clips (Genetic Stock Identification)
- Gill tissue (pathogens, up/down regulation of genes)
- Blood (Insulin-like Growth Factor hormone)
- Muscle (bioenergetics, fatty acids, stable isotopes, thiamine)
- Liver (bioenergetics, fatty acids, stable isotopes, thiamine)
- Gonads (bioenergetics, maturation)
- Eye lenses (elemental analyses)
- Opercula & vertebrae (life-time hormone levels, parasites)

Measurements and samples collected from non-salmonids
(myctophids, squid, jellyfish, other fishes)

- Species identification, counts, lengths, total/individual weight

- Tissues for
  - Diets
  - Bioenergetics
  - Stable isotopes, fatty acids
  - Microplastics
  - Voucher specimens
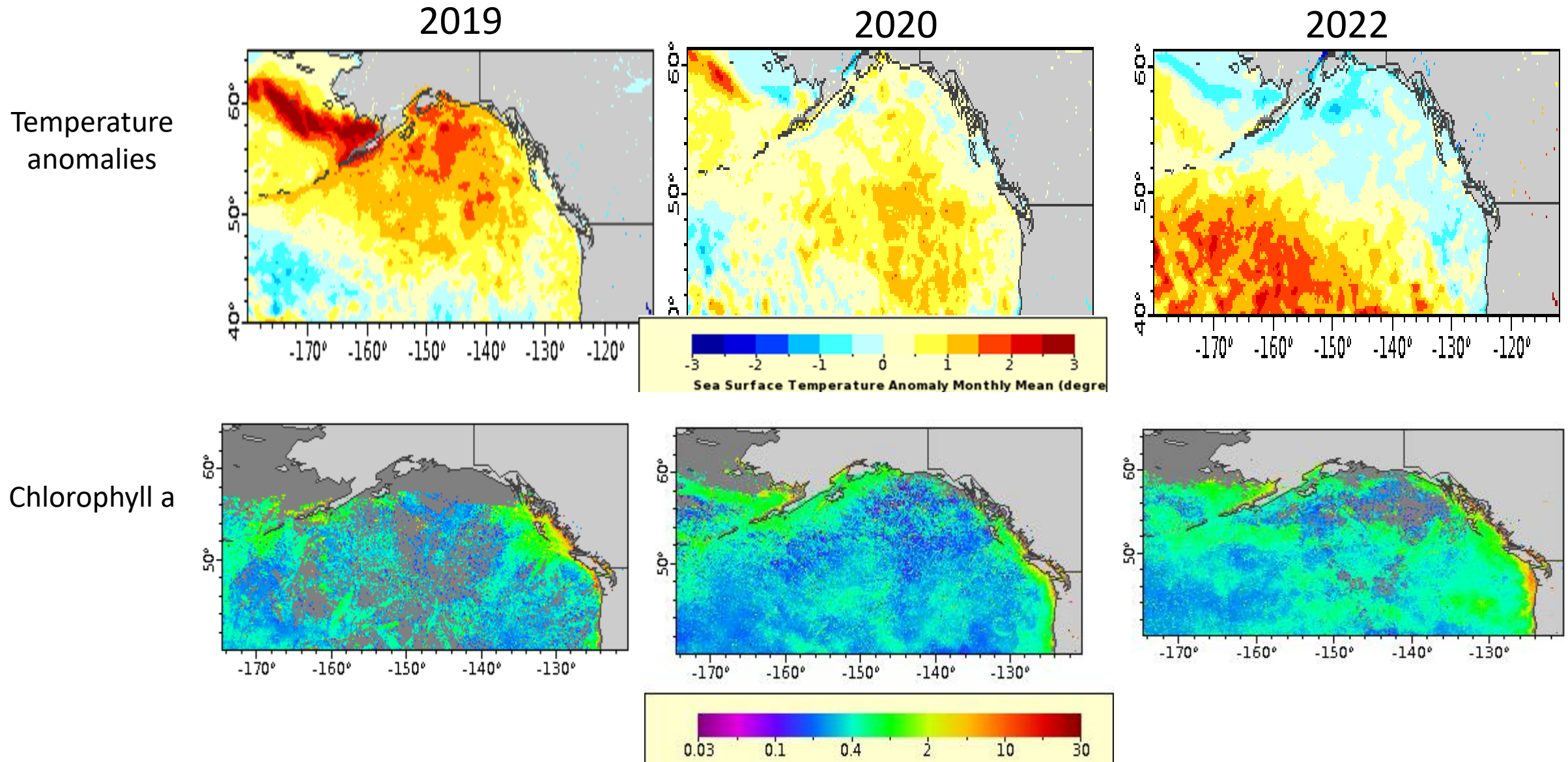
- Salmon sharks
  - Tagged with archival and satellite tags & released
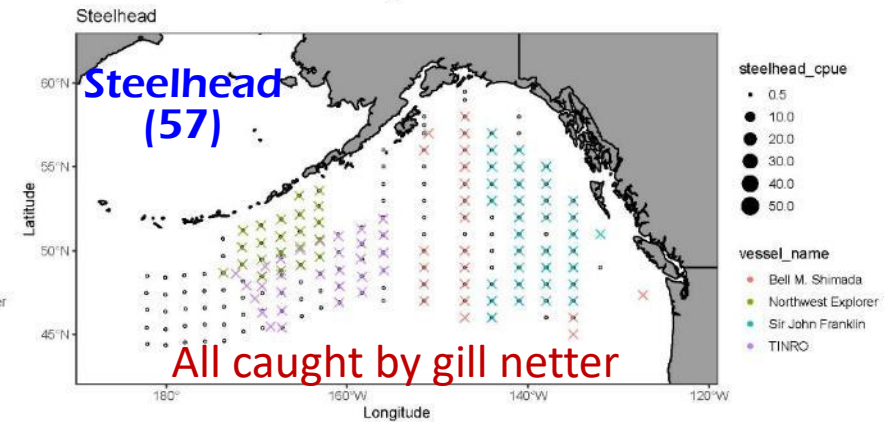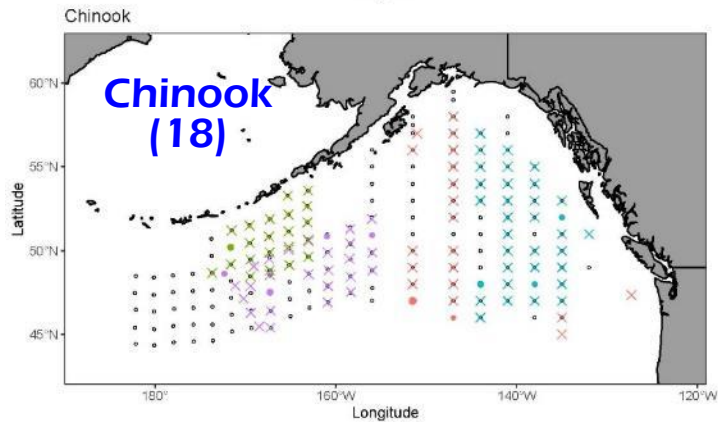

Gonatid squid

Processing the catch on the Shimada

Temperatures and Chl a across the survey area
(monthly means for February 2022)

Sea Surface Temperature Monthly Mean (degree C)

Chlorophyll a (mg m^-3)
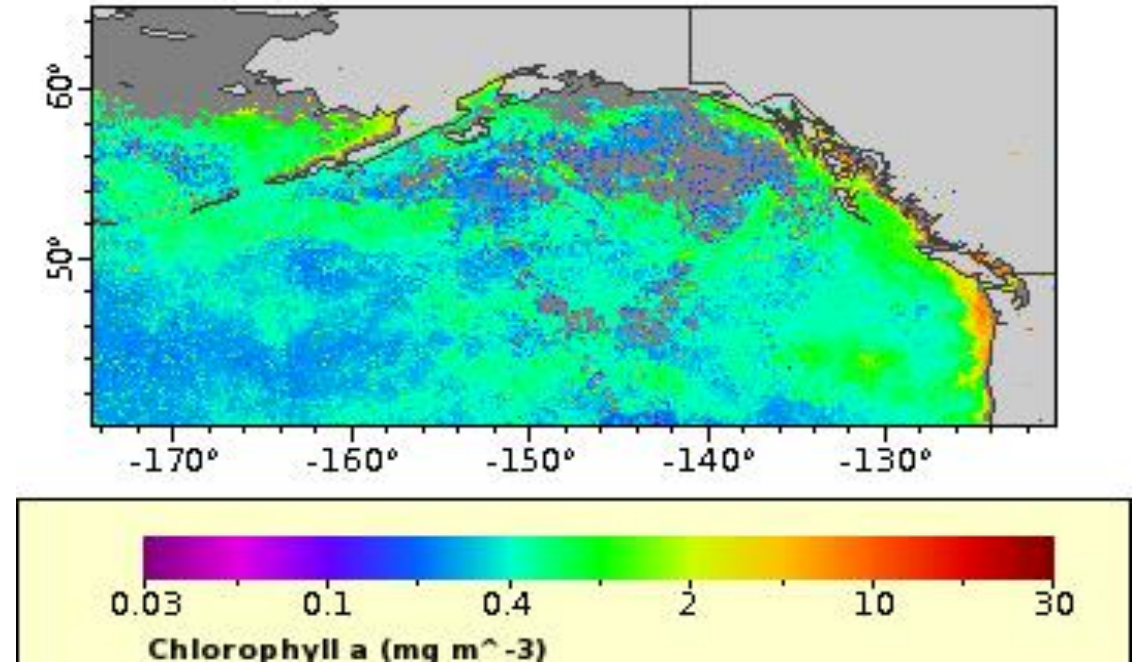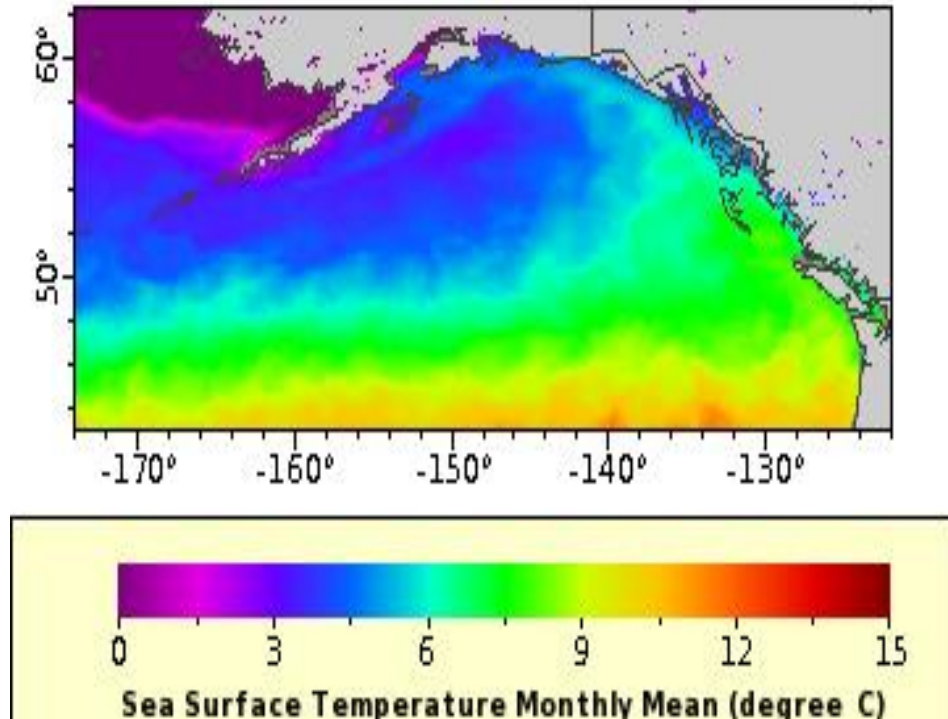
Comparisons to 2019 and 2020

2019

2020

2022

Temperature anomalies
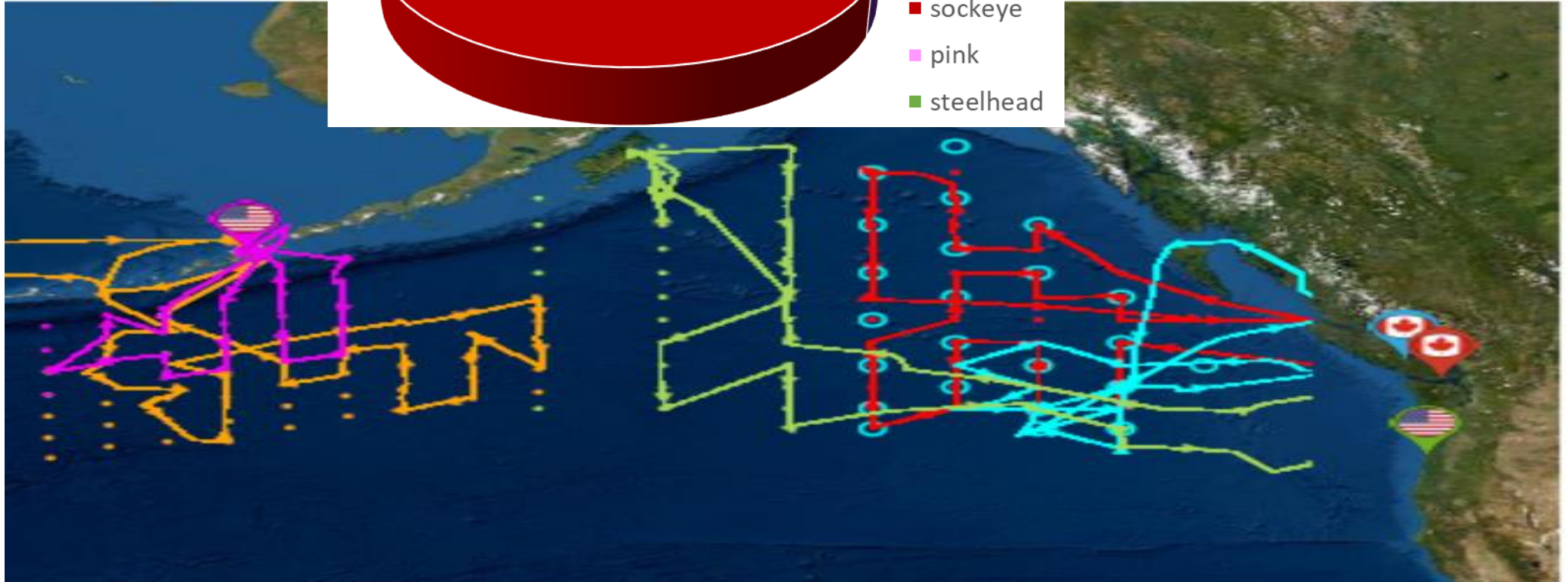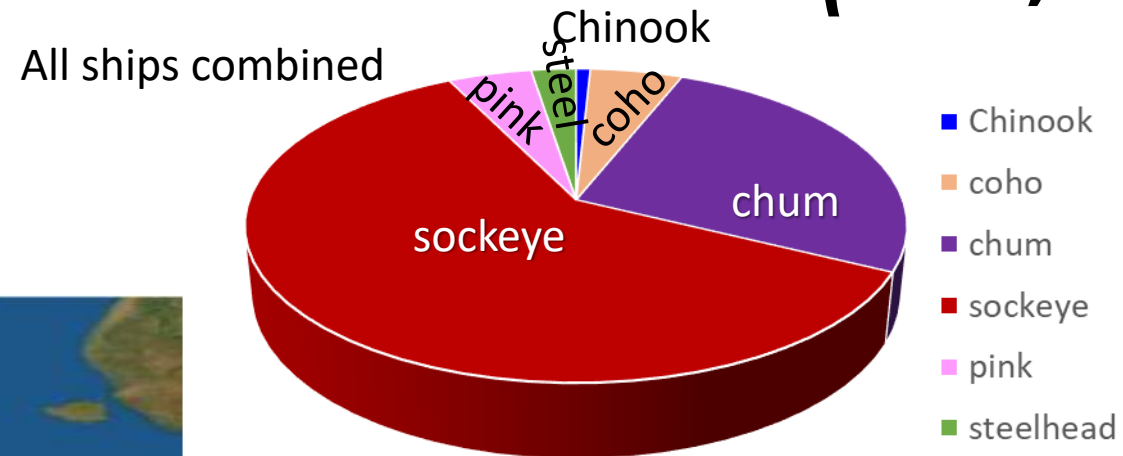

Sea Surface Temperature Anomaly Monthly Mean (degre
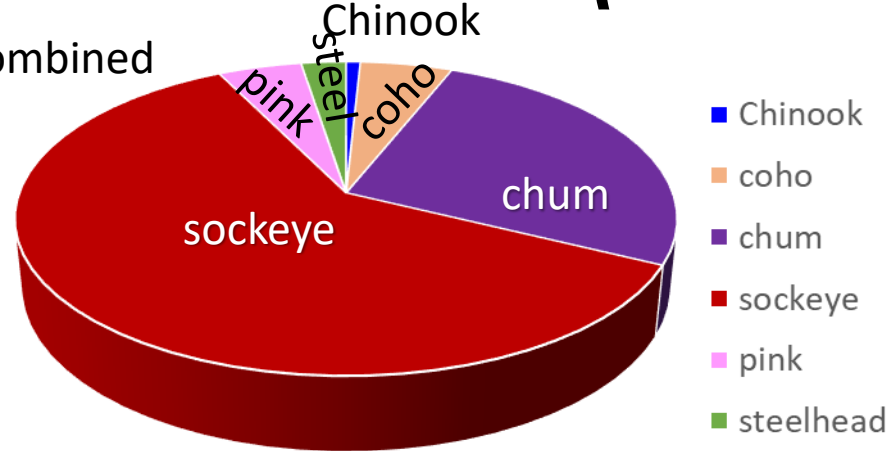
Chlorophyll a

2022 salmon catches by species and ship (trawl only)
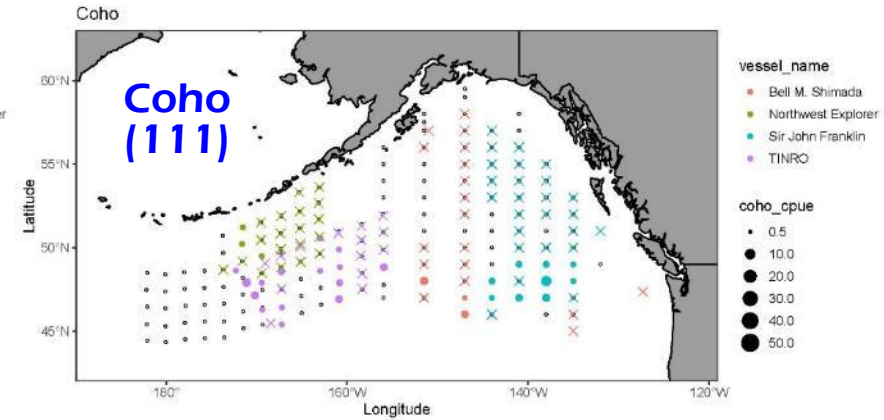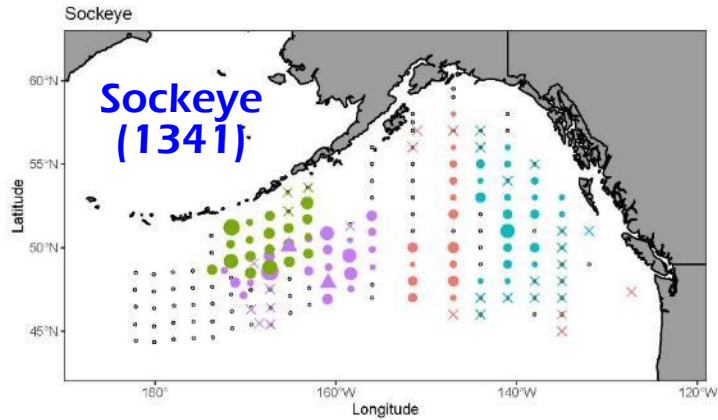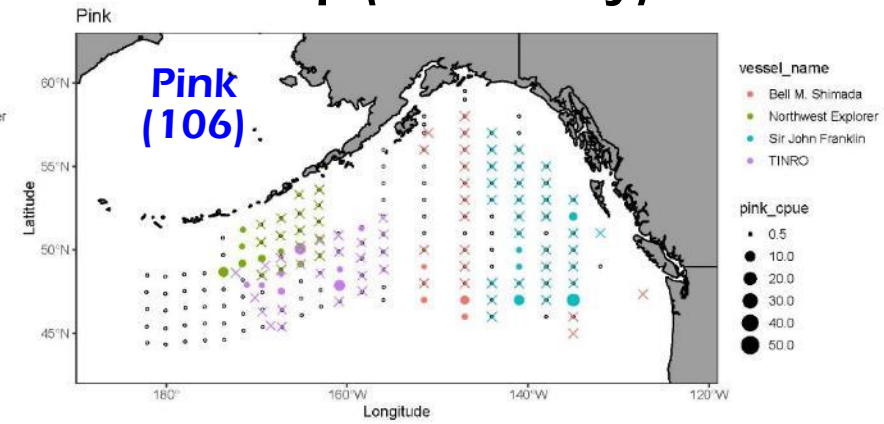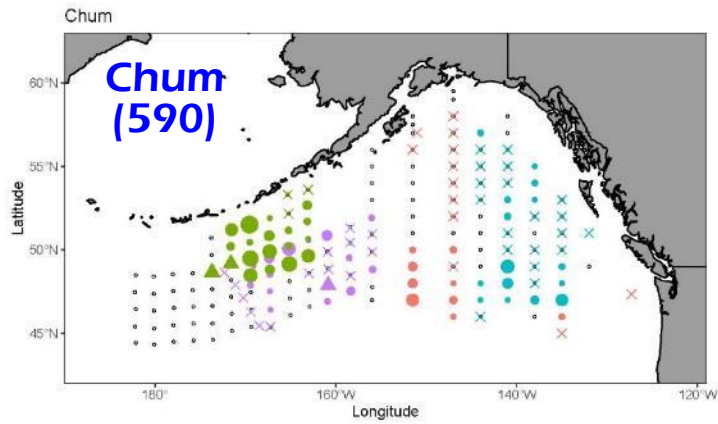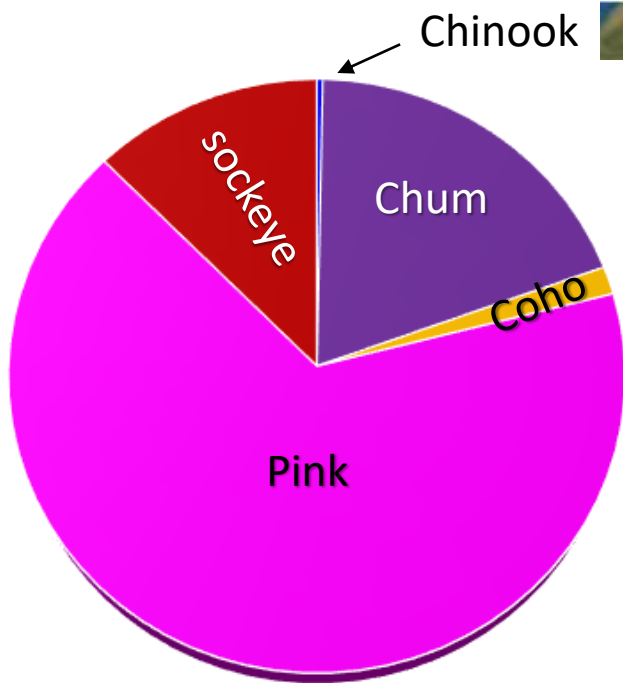
Catch of *salmon* (n=2,323)

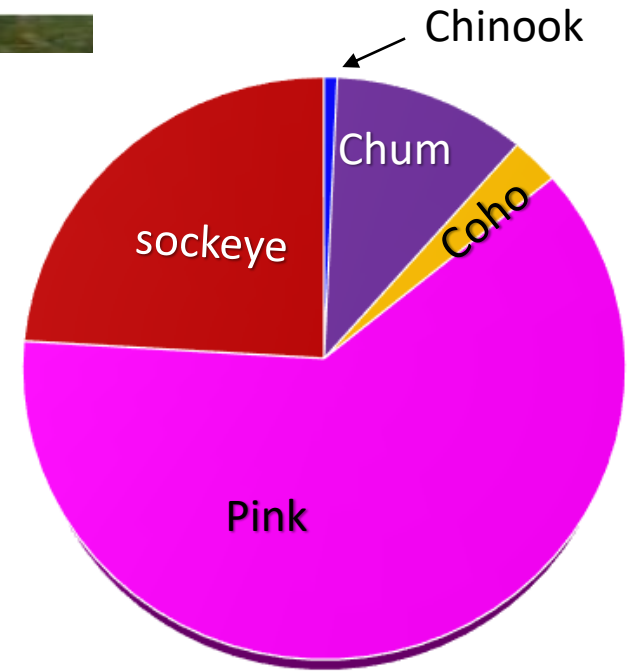# Catch of *salmon* (n=2,323)

All ships combined

Whole Pacific catch
2000-2021
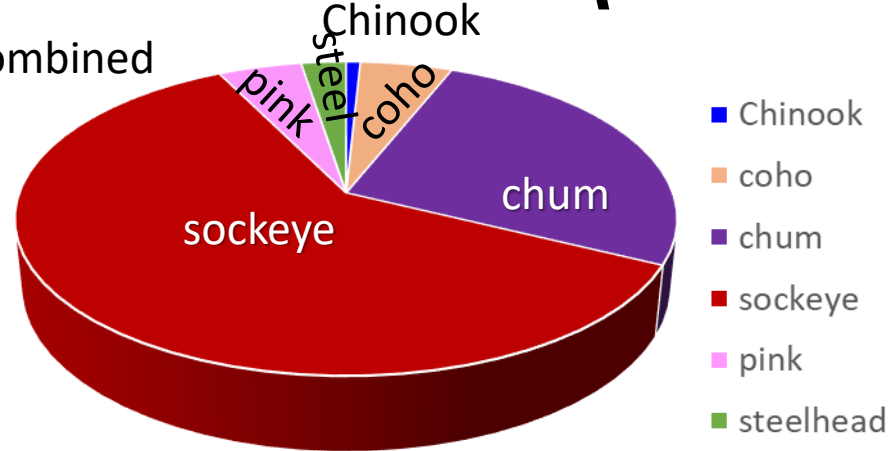
US & Canada catch
2000-2021

Catch of salmon (n=2,323)

All ships combined
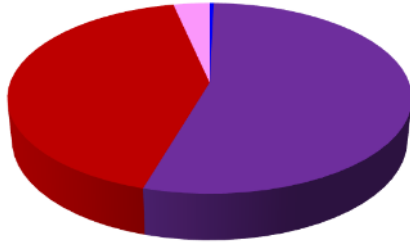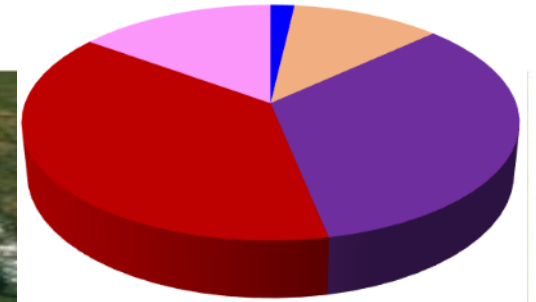
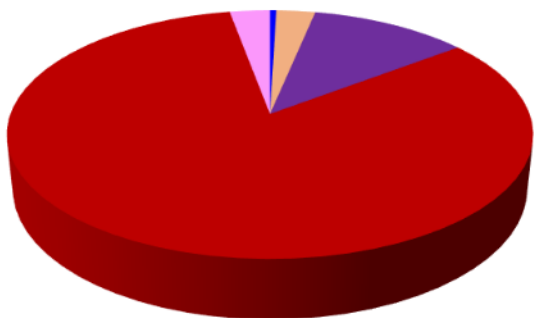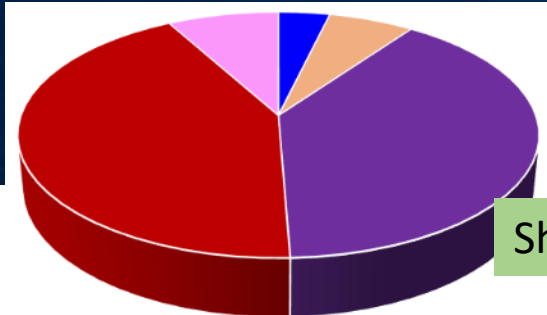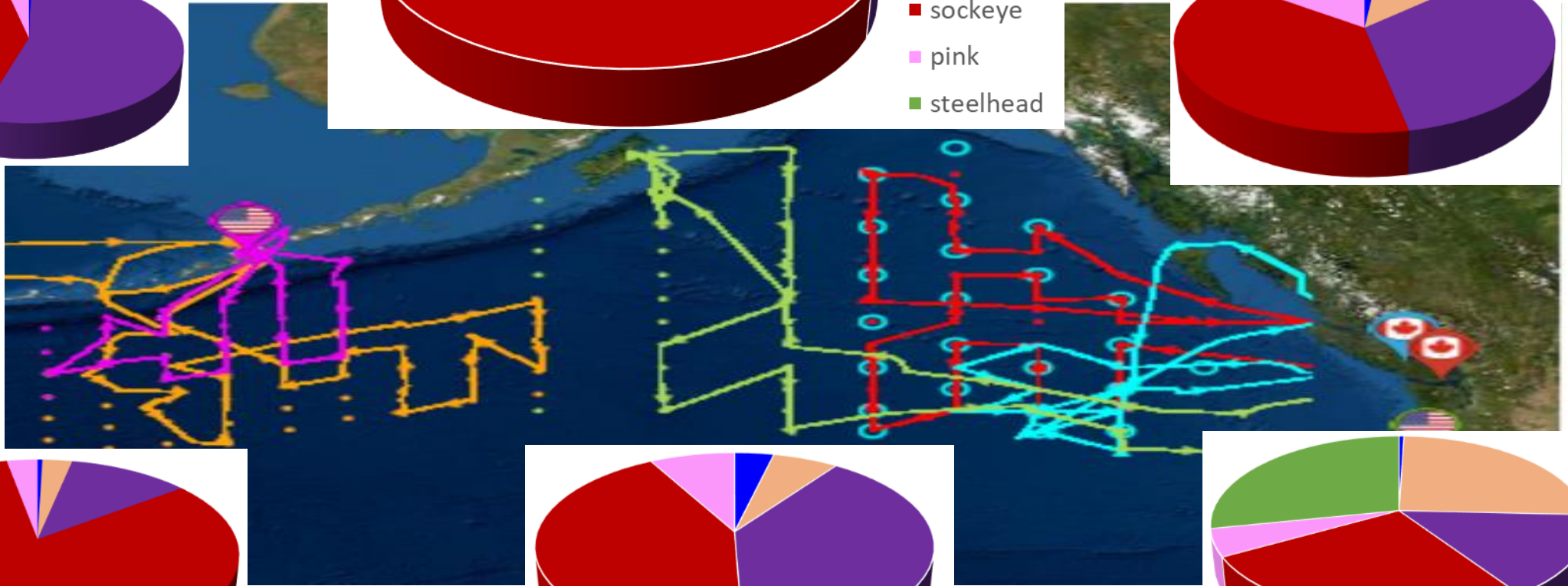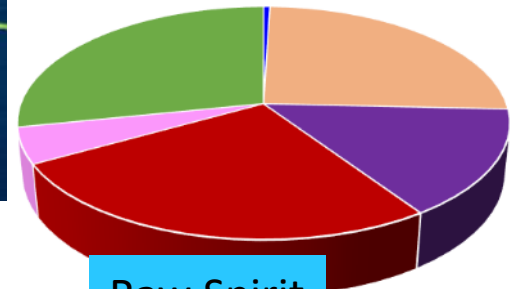# 2022 catches versus 2019 and 2020

2019 (423)
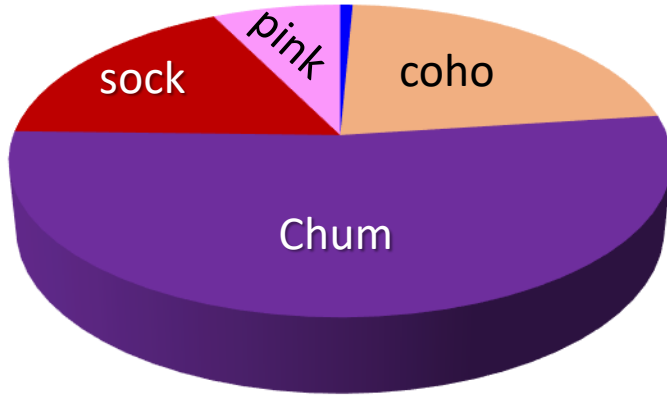
2020 (566)
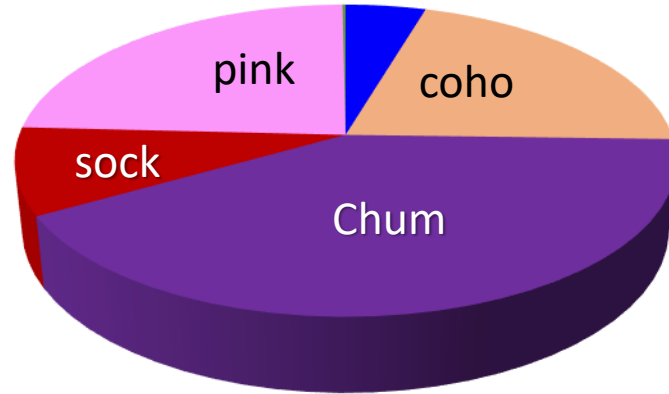
2022 (2,323)

Legend:
- Chinook
- coho
- chum
- sockeye
- pink
- steelhead
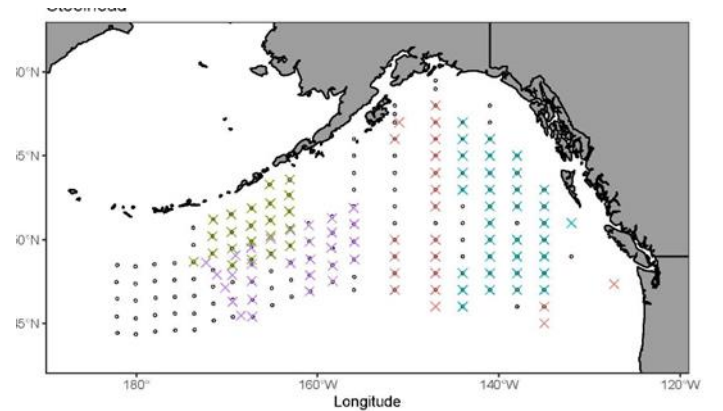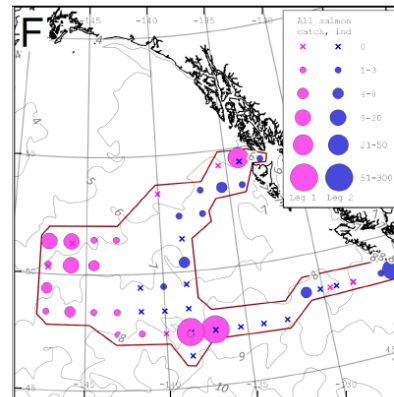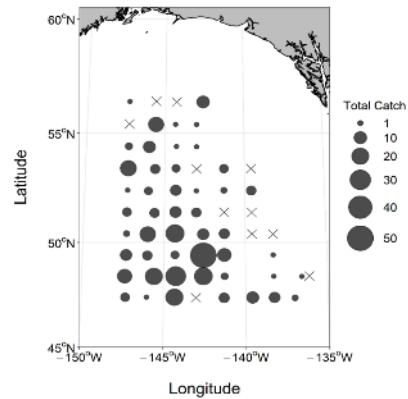
Gulf of Alaska catches by year

2019 (423)
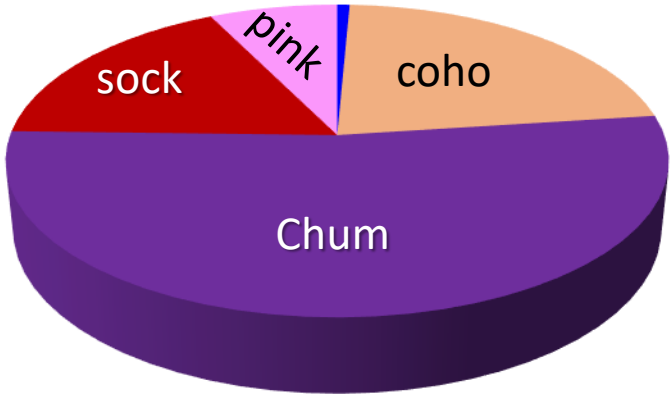
2020 (566)
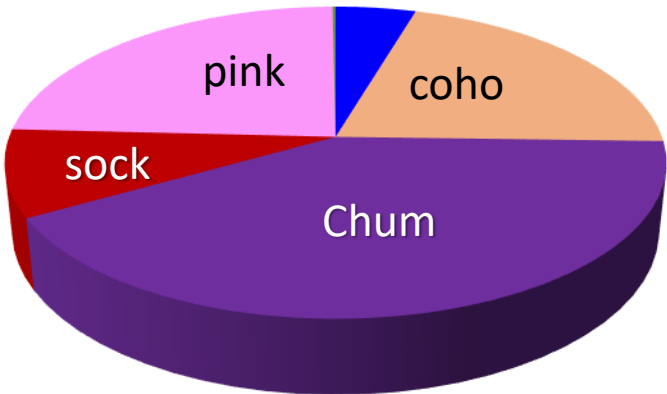
2022
Franklin &
Shimada (383)
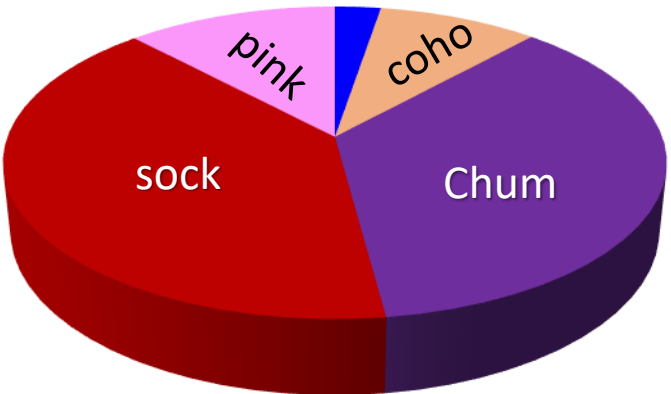
- Chinook
- coho
- chum
- sockeye
- pink
- steelhead
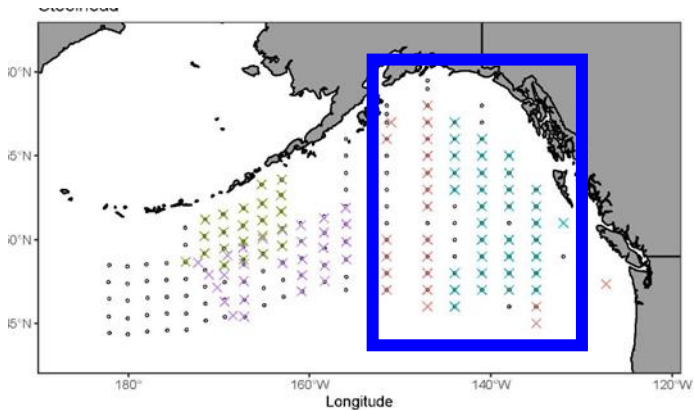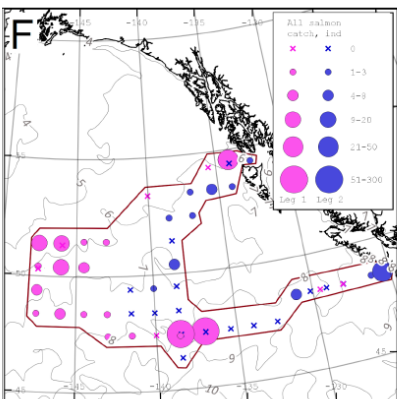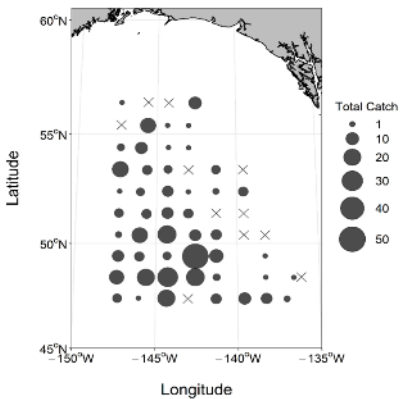
Salmon catches by temperature
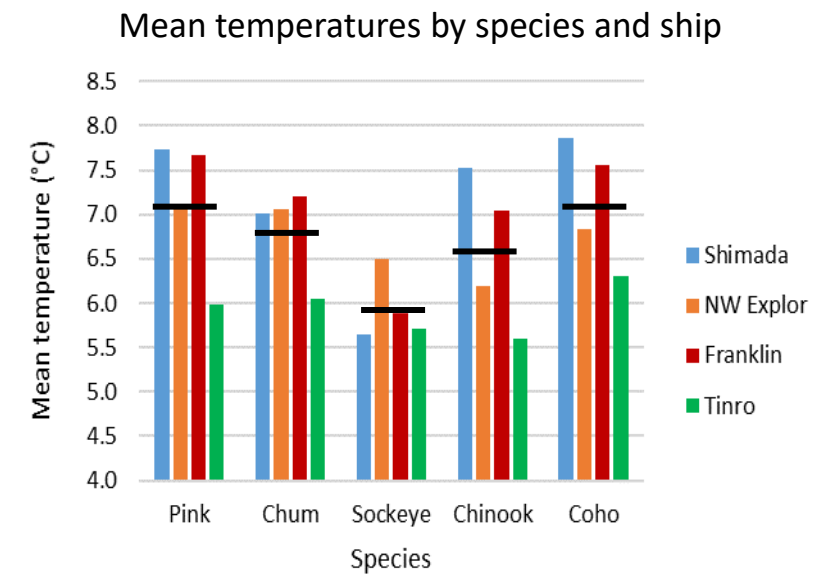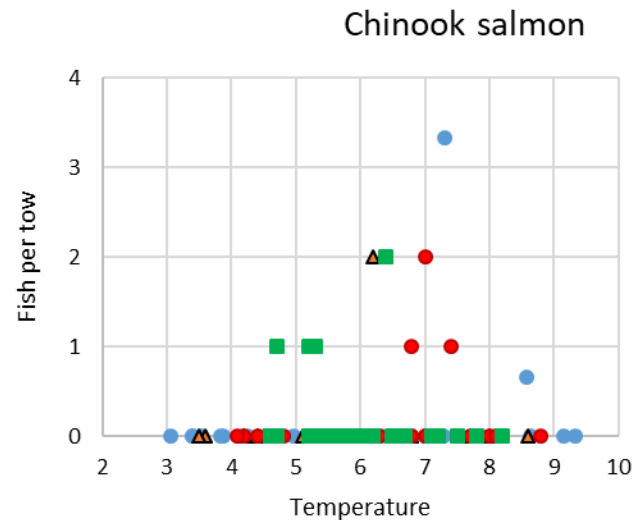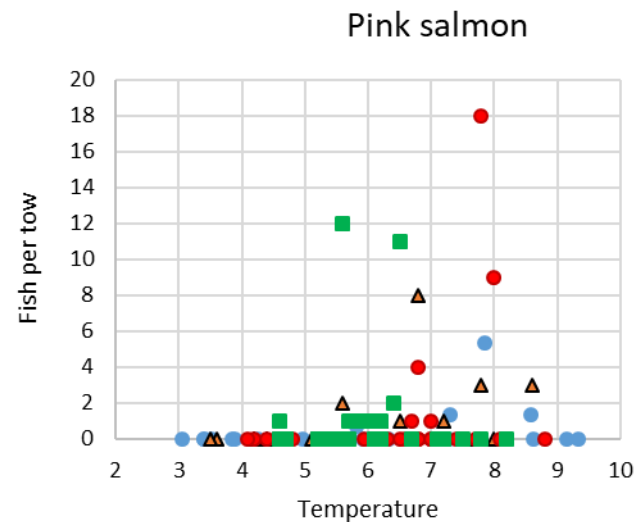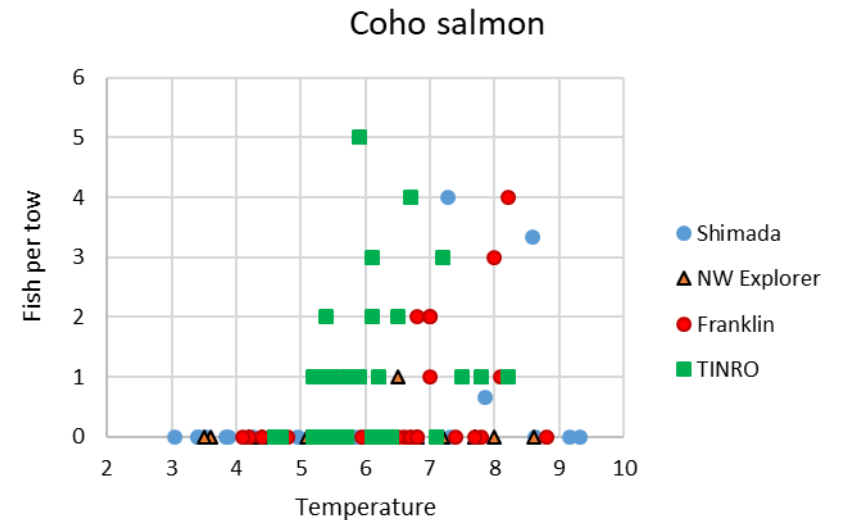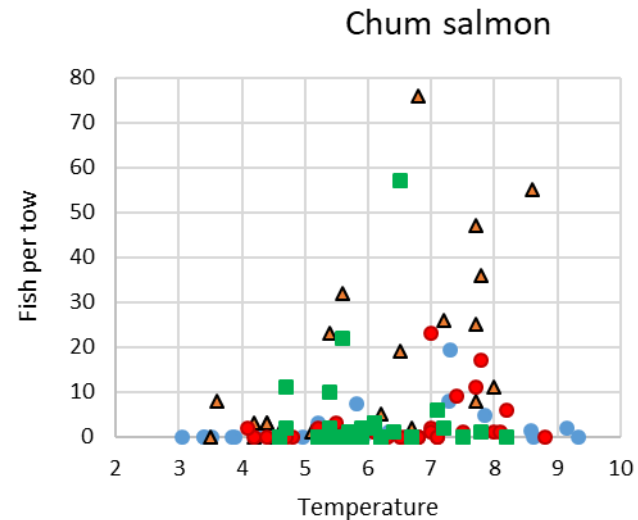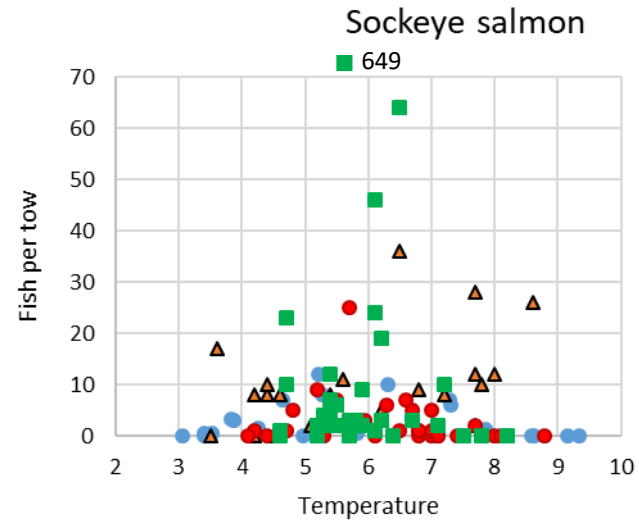
Sockeye and pink salmon generally don't co-occur

Pink and sockeye salmon by haul
(all surface trawls)
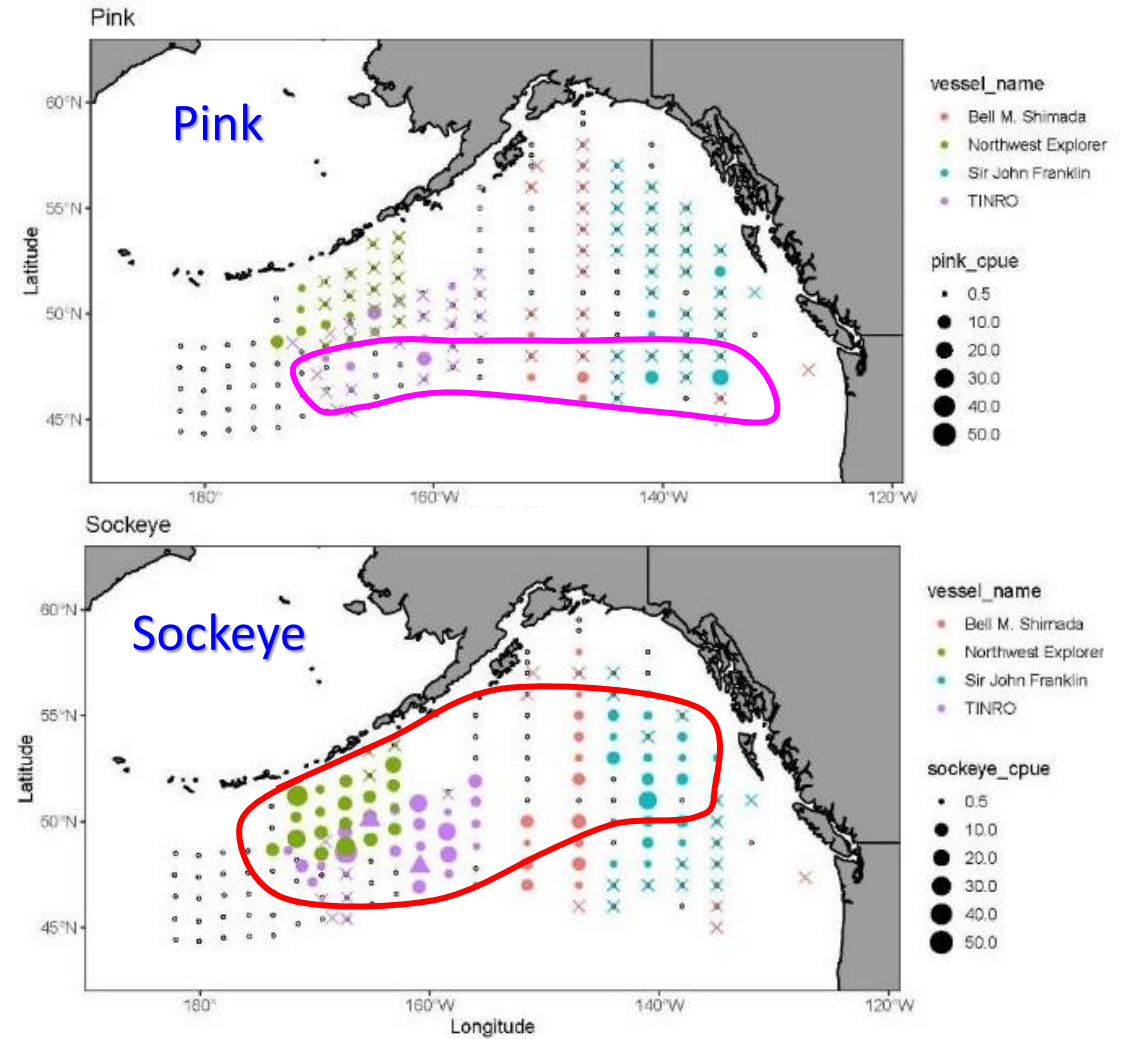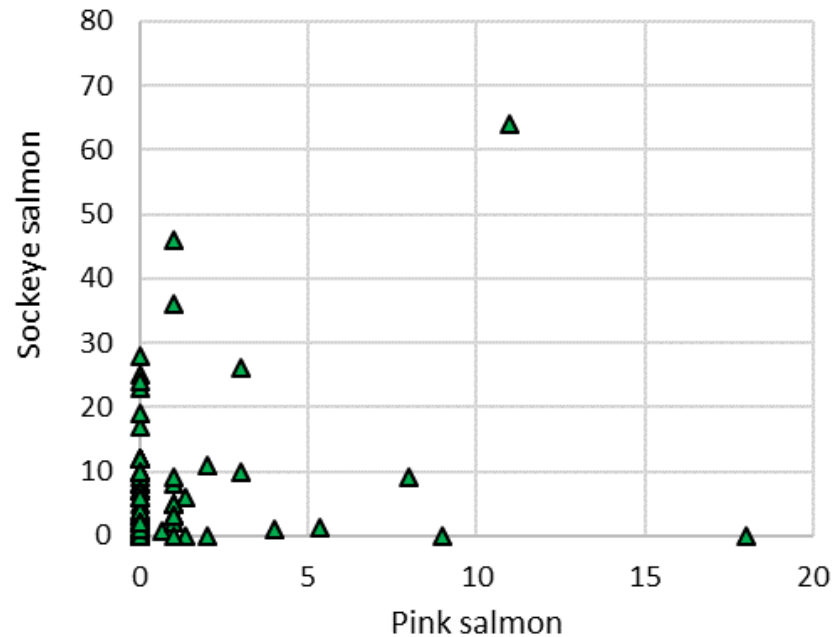
Coho schooling in 2020 GOA survey

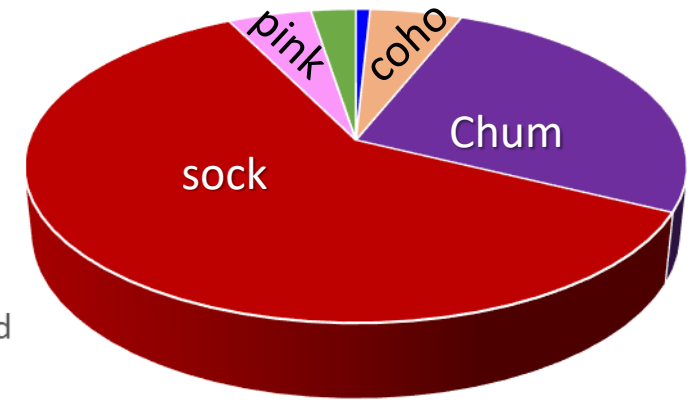| Origin	Area	Number -52	Percent
Southern US		18	34.6%
	Columbia R	6	
	Coastal Washington	10	
	Juan de Fuca	2	
British Columbia		27	51.9%
	East Coast Vancouver Island/JF	6	
	Central BC	3	
	Northern BC	15	
	Other BC	2	
SE Alaska	(three stocks)	6	11.5%
Russia	(Apuka R)	1	1.9%

Mixed stock schools - set 4 and 5   N=98, 2020

- Coho salmon caught in mixed stock schools March 15-16, 2020.
- No Coho salmon caught when resampled April 2-3, 2020.

Coho salmon mixed stock schools – February 2010 trawl survey Strait of Georgia

Origin	Number- 110
BC southern mainland	7
East coast Vancouver Island	10
Lower Fraser River	47
Mid Fraser River	7
Thompson River	6
Other SOG/Fraser	7
Puget Sound	23
Not classified	3

- Trawl survey February – 1 set caught ~ 6000 coho salmon.

- Very few coho salmon (< 20) were caught in recreational fishery in the Strait of Georgia March, April and May 2010 indicating that the school observed in February had likely left the Strait of Georgia

- The interpretation is that a large school of coho salmon entered the Strait of Georgia in the winter probably looking for food and then left.

Chum salmon – GOA 2022

- Chum salmon caught within one panel of gillnet

- Preliminary stock ID indicates from northern BC, SEAK and central Alaska stocks.

Implications

*Salmon school to minimize metabolic costs of feeding in the winter

*Political implications (shared issue across nations)

Chum

British Columbia chum salmon ages show relatively few ocean age 3, 4 and 5 fish in 2020 and 2022*

	Ocean Age 1	Ocean Age 2	Ocean Age >3
2019	15	14	7
2020	27	2	9
2022	8	1	2

*Gillnet catches only

Steelhead
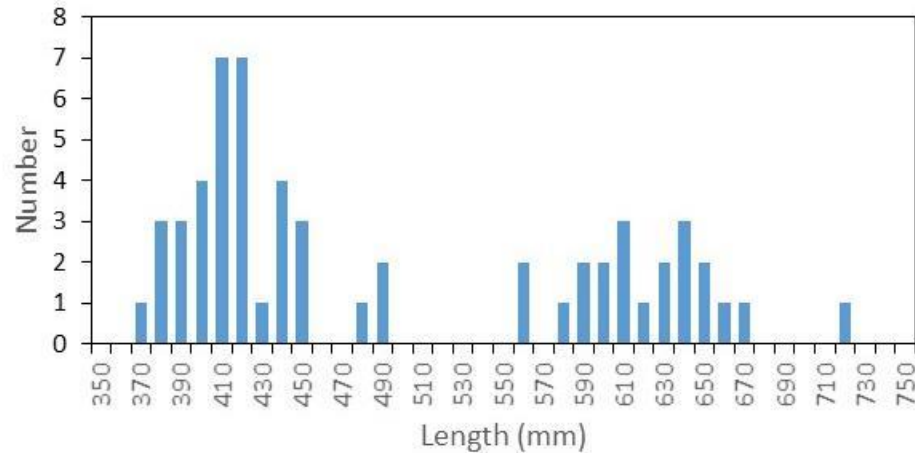
- Steelhead length frequency and age frequency (7 of 57 ad clipped)
- Steelhead in the open ocean are virtually unstudied, yet they are confined to the surface and very susceptible to temperature and other surface ocean changes.

Freshwater winters		Ocean winters	
2 winters	17	1 winter	12
3 winters	14	2 winter	8
4 winters	1	>2 winters	1

Sockeye salmon catch 2019-2020

2019 N=73 sockeye
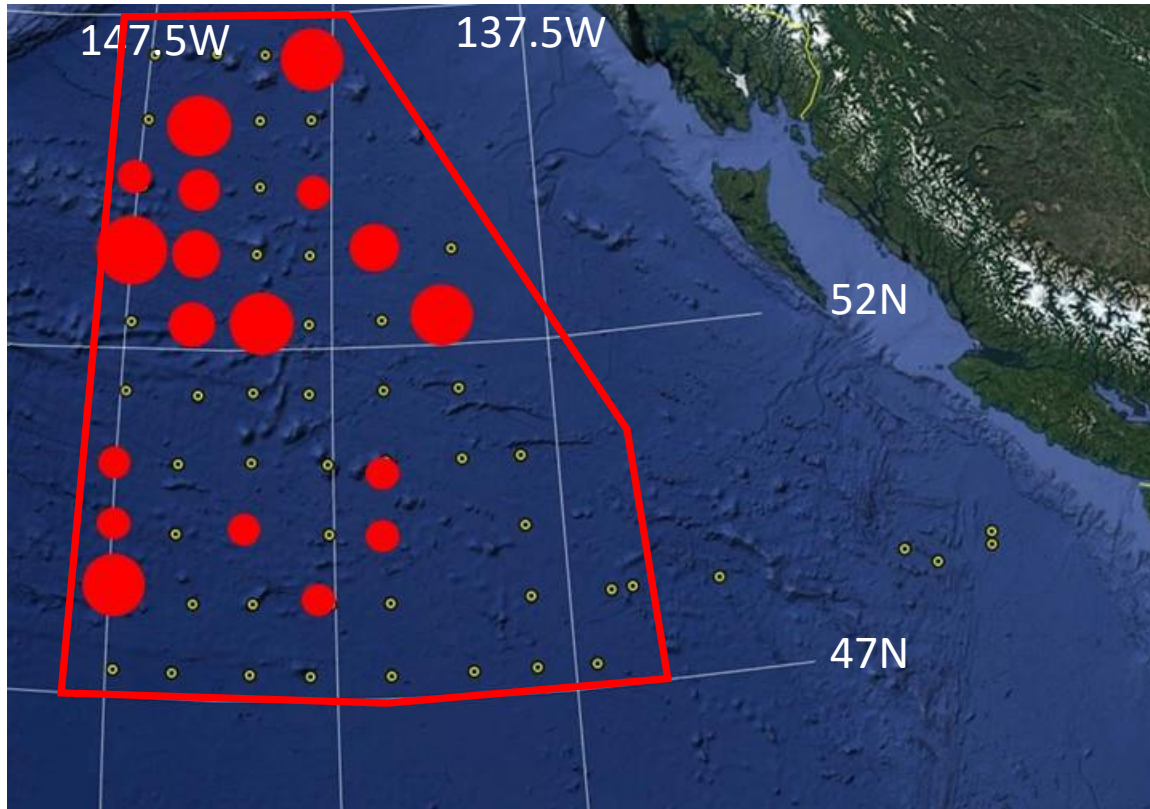
2020 N=51 sockeye
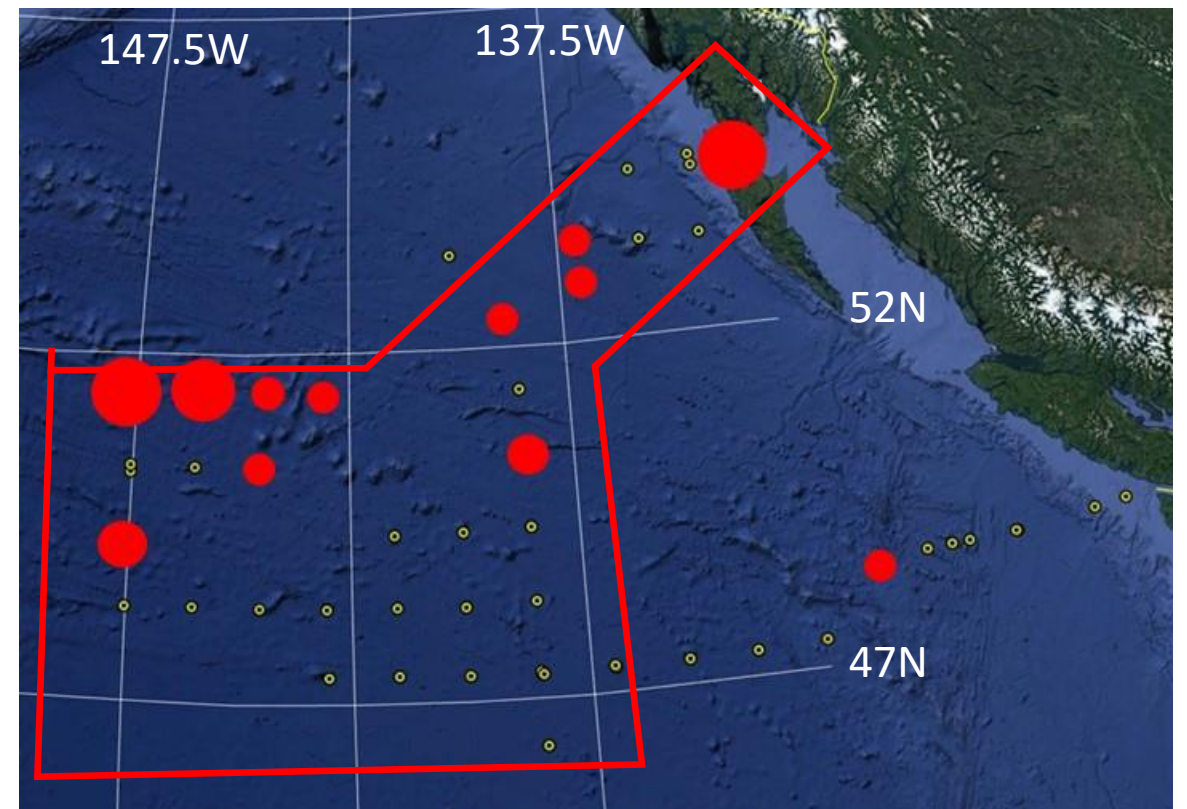
Gulf of Alaska expeditions

2019 N=73 sockeye
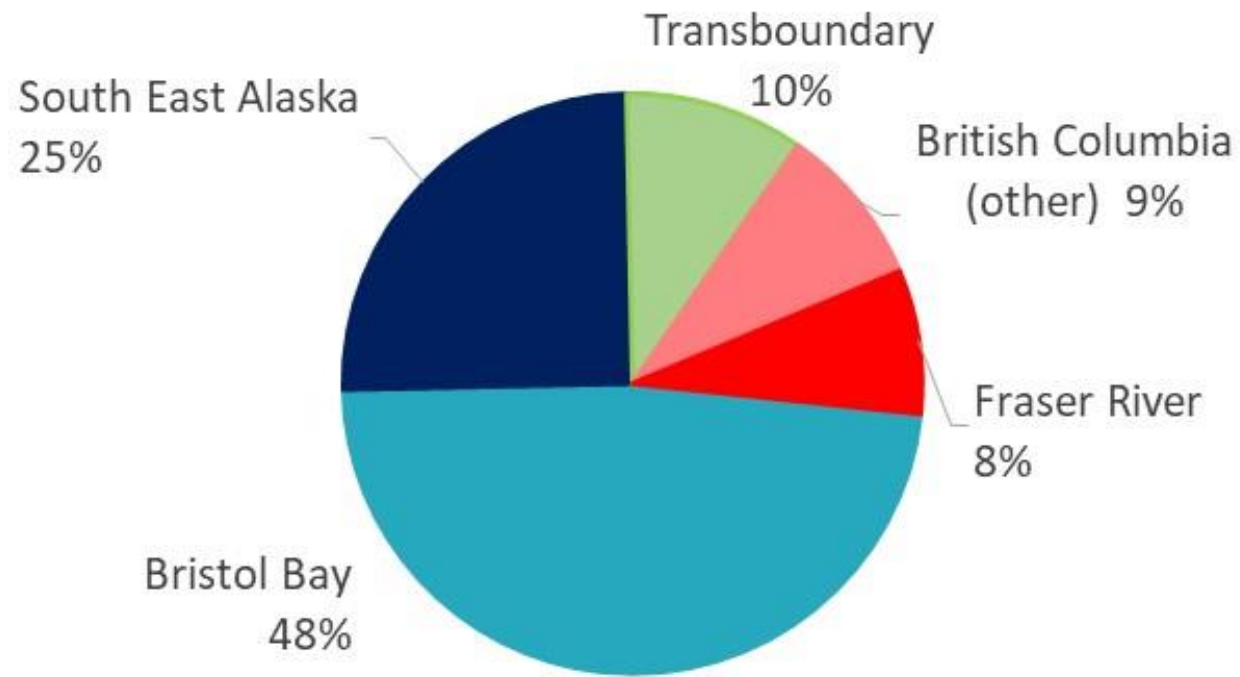
2020 N=51 sockeye
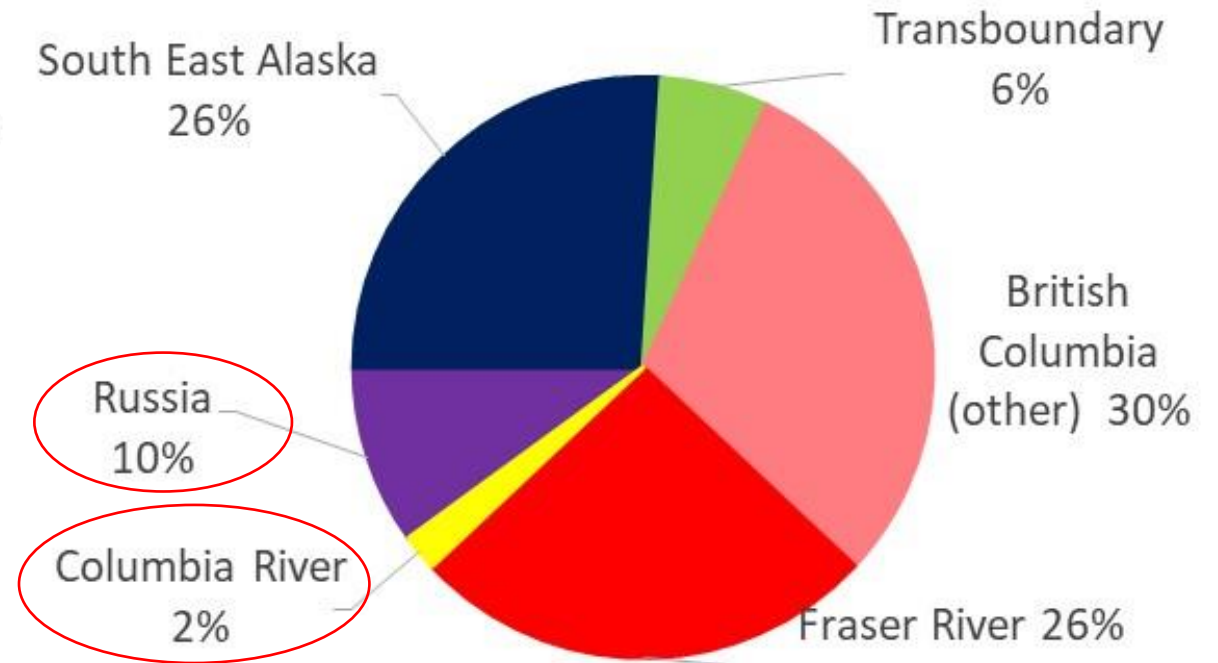
Canadian sockeye – Total catch 2019 and 2020 expeditions

~4,000 km

176.2E

52N

47N

167.5E   177.5E   167.5W   157.5W   147.5W   137.5W
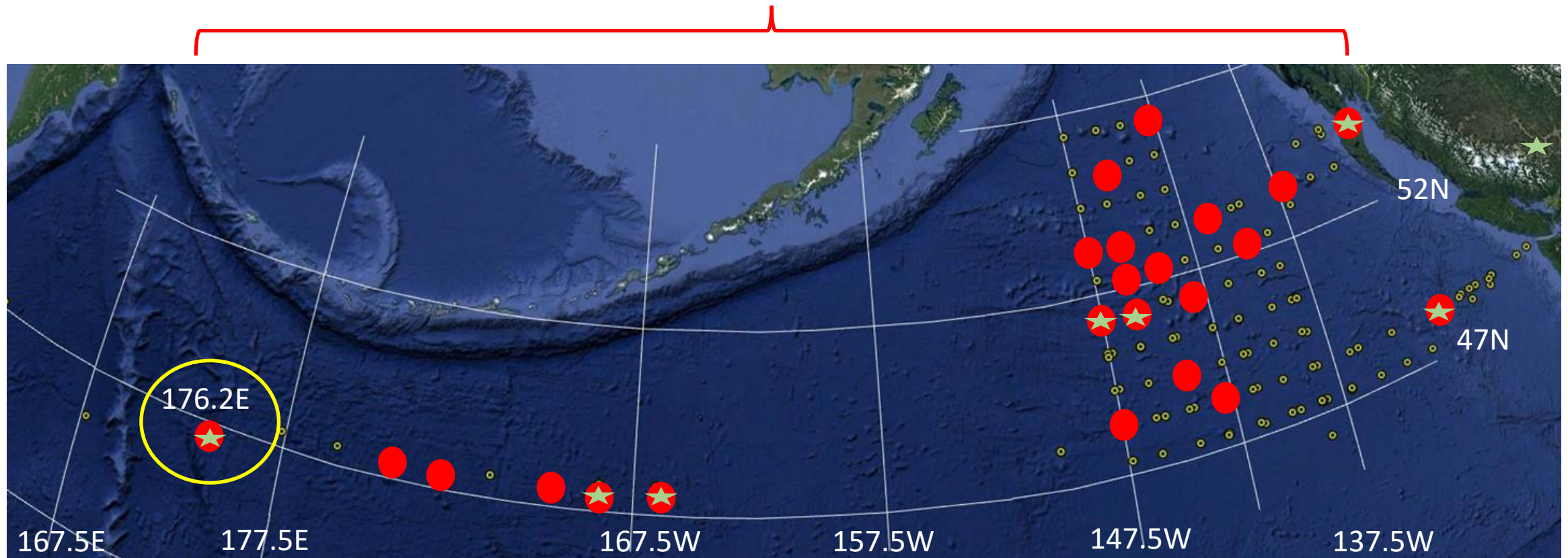
★ Chilko Lake sockeye

2022 – Preliminary results from Raw Spirit

Alaska, 60%

Southern US, 4%

Fraser, 28%

Other BC, 8%
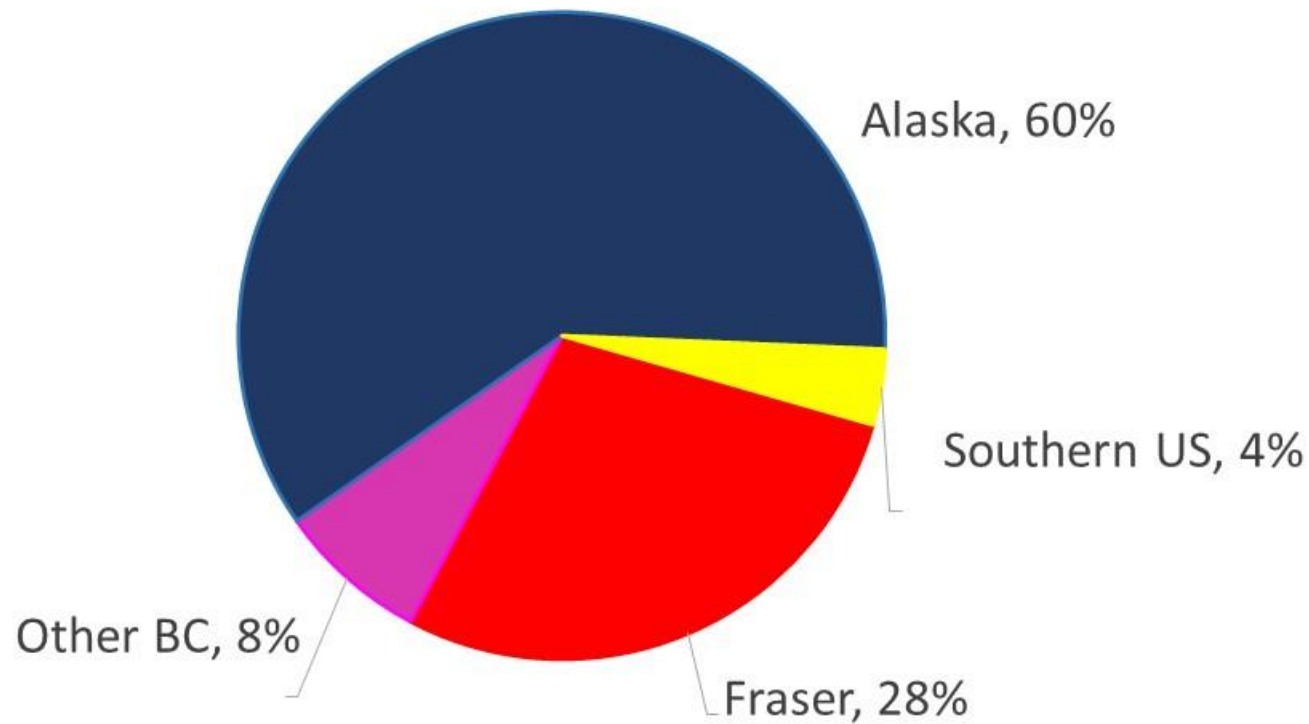
- As in 2019 and 2020 a mixture of stocks
- 36% from BC and 28% from Fraser River
- Caught primarily in most northerly sets

2022 – Fraser River sockeye

- 2022 is an Adams River year
  - Historically dominated by late-run sockeye

- The 2022 pre-season forecast
  - 38% late-run and 45% summer-run.

- Raw Spirit
  - 15 Fraser River sockeye caught but only 14% late-run sockeye

- Combined eastern Pacific*
  - Raw Spirit and Sir John Franklin Fraser River sockeye
  - Only 15% late run sockeye!
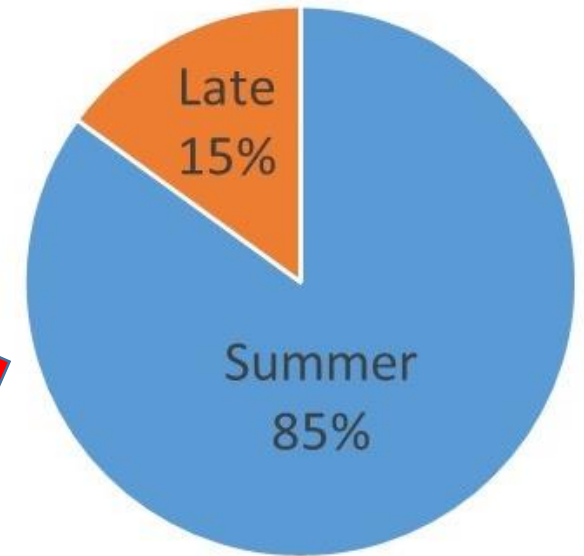
Is this an indication of poor survival of late-run stocks OR are they rearing outside of our study area??

*DNA from other vessels not yet processed.

Predation on salmon on the high seas
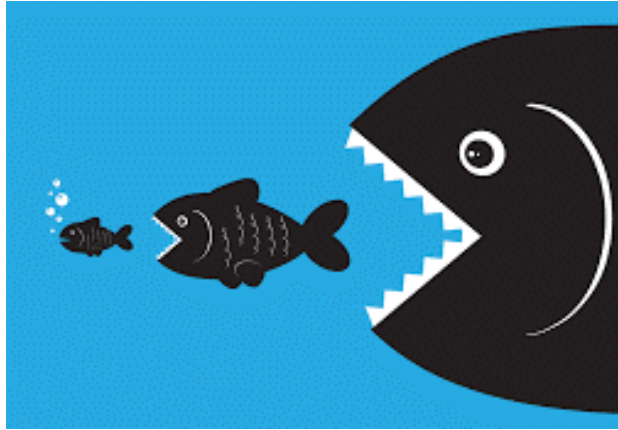
Likely high seas salmon predators
(Bugaev and Shevlyakov 2007, Naydenko and Temnykh 2016)

Long snouted Lancetfish, *Alepisaurus ferox*

Daggertooth, *Anotopherus pharao*

Spiny dogfish, *Squalus acanthias*

Salmon shark, *Lamina ditropis*

Dolphins and porpoises

Toothed whales

Pinnipeds

Likely high seas salmon predators
(Bugaev and Shevlyakov 2007, Naydenko and Temnykh 2016)

Long snouted Lancetfish, *Alepisaurus ferox*

Daggertooth, *Anot...*

Spiny dogfish, *Squalus acanthias*

Salmon shark, *Lamina ditropis*

Dolphins and porpoises

Toothed whales

Pinnipeds

Few potential predators caught or observed

Environmental DNA Reveals few Potential Salmon Predators

Salmon shark

Spiny dogfish

Lingcod

Daggertooth

Long snouted lancetfish
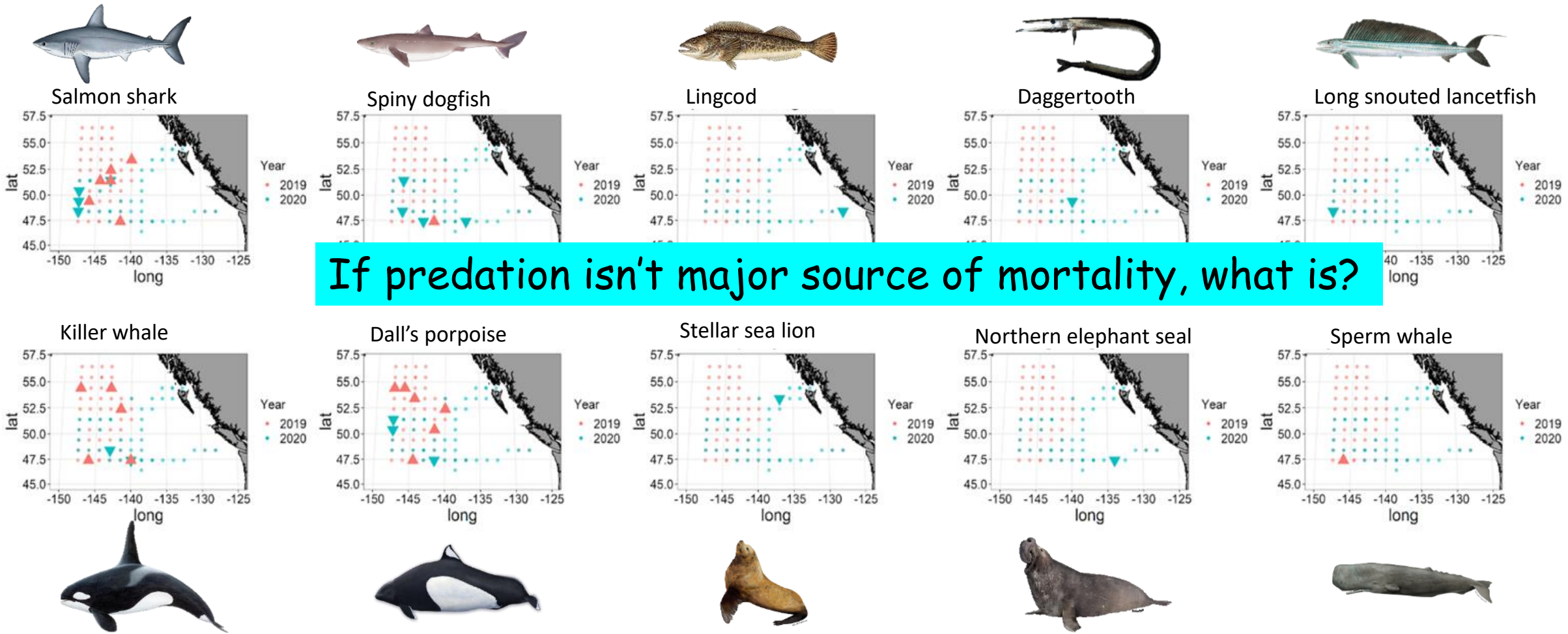
If predation isn't major source of mortality, what is?

Killer whale

Dall's porpoise

Stellar sea lion

Northern elephant seal

Sperm whale

Source: Christoph Deeg (UBC/DFO)

Importance of continuing surveys

1) Projected climate impacts tell us very little in the short-medium terms (5 – 20 yr), management of fish/fisheries requires an informative and timely sampling program to inform decisions and support communities.

2) We know very little about the ecosystem interactions of species in the open ocean or the spatial/temporal scale of effects.

3) Sustained international collaboration is necessary to address issues across the North Pacific / Bering Sea region. *It's a big area out there!*

A sustained effort will stimulate innovation and technology, provide training opportunities, and inform communities adapting to climate variation and trends.

A role for the PSC and Endowments?

PSC manages the effects of environmental variation and trends ... but also has an unique opportunity to support future initiatives (e.g., UNDOS (BECI)).

The PSC management entities focus on salmon conservation and fisheries, but also manage essential habitats in freshwater, estuaries, and coastal waters; and maintain core annual assessment programs that vary by species/areas. Involvement in broader collaborations and high seas studies will better inform current and future decisions.

Targeted research projects can build collaborations and knowledge; e.g.,

i. Comprehensive stock identification/PBT baselines for use on high seas

ii. Timely access to environmental indices

iii. A network of partners will leverage resources and insights.

iv. Test hypotheses on mechanisms regulating salmon in ocean (coastal ⟷ high seas)

What's next?

- Lots of data and 1,000s of samples to process
- IYS synthesis conference in early October in Vancouver BC
- Many reports and papers to come
- Future Pan Pacific cruises as part of UN Decade of Ocean Sciences proposal (Basin scale events to coastal impacts; BECI.info)
  - Science planning and fund raising underway
- Why stop now?

Final benefit: built a collaborative multinational science community around high seas salmon work