Alaska Hatchery Interactions Research: Overview of results and products

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to the

Alaska Board of Fisheries
Cordova, Alaska
December 10, 2024

Precautionary Approach

Alaska Constitution: Article 8

Fish, forests, wildlife, grasslands, and all other replenishable resources belonging to the State shall be utilized, developed, and maintained on the sustained yield principle, subject to preferences among beneficial uses.

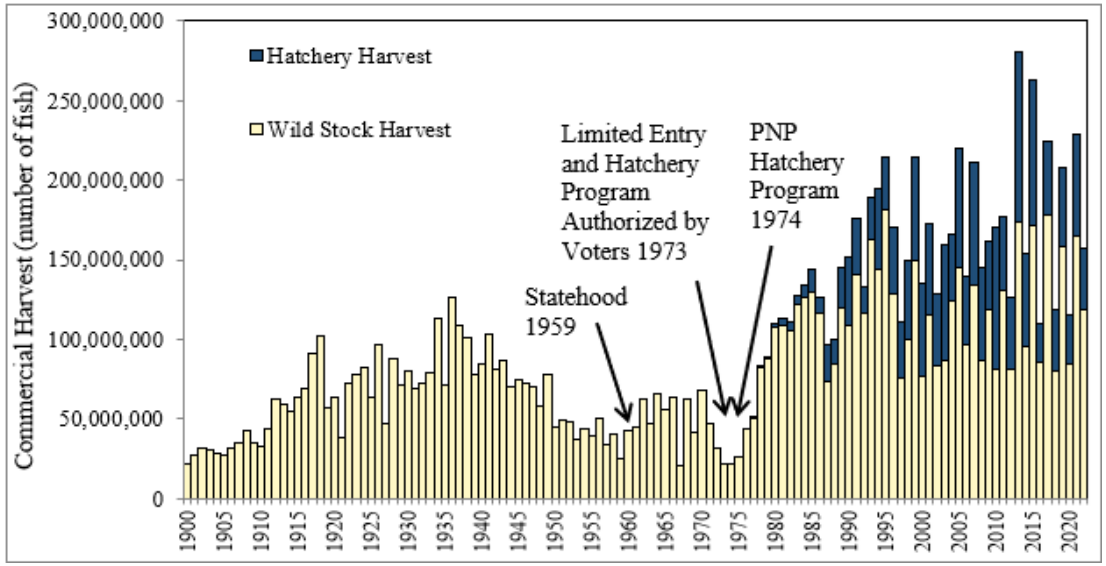
ADF&G Mission

To protect, maintain, and improve the fish, game, and aquatic plant resources of the state, and manage their use and development in the best interest of the economy and the well-being of the people of the state, consistent with the sustained yield principle.

Precautionary Approach
Salmon Hatcheries

Alaska's Salmon Fishery Enhancement Program

- Recovery and support of Alaska's salmon fisheries and fishing economy
- Provide an economic engine to support and grow coastal communities
- Policies and statutes to protect wild fish were developed early



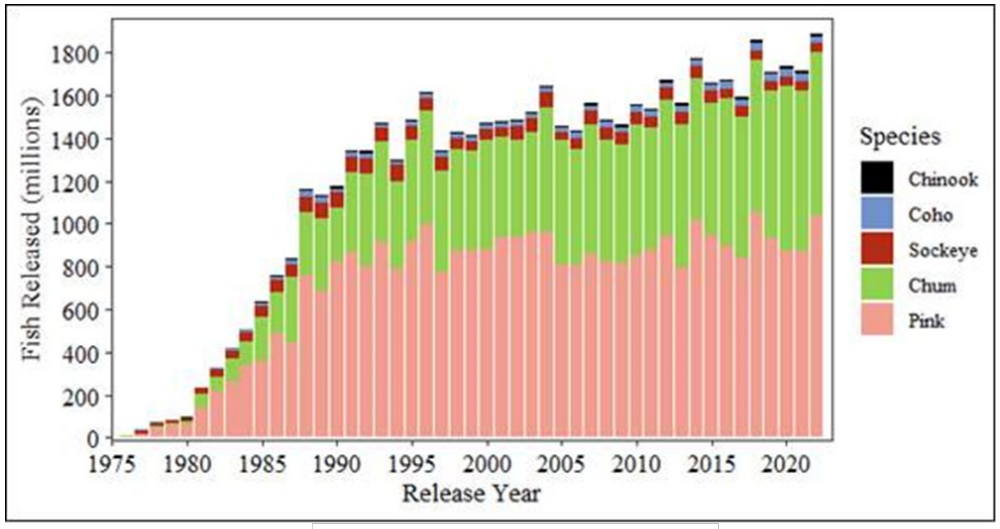
Alaska commercial harvest of wild and hatchery salmon, 1900-2022

Wilson (2023)

Presentation to Board of Fish October 2018 -
https://www.adfg.alaska.gov/static/regulations/regprocess/fisheriesboard/pdfs/2018-2019/ws/rcs/rc039_ADF&G_Hatchery_Reports_Alaskas_Precautionary_Approach.pdf

Precautionary Approach
Salmon Hatcheries

Large-scale releases of pink and chum salmon and observations of hatchery fish in spawning streams raised important management-related questions.



Alaska hatchery releases, 1975-2022

For example:

1. Do hatchery salmon interbreed with wild salmon?
2. If they do, is the fitness and productivity of wild stocks diminished?
3. Are escapements of wild stocks biased by hatchery salmon leading to excessive harvest of wild fish?
4. Do density interactions diminish productivity of wild salmon?

Alaska Hatchery Research Program
Overview of PWS results and products

Three fundamental and scientifically answerable questions

1) What is the genetic stock structure of pink and chum in PWS and SEAK?

2) What is the extent and annual variability of straying?

3) What is the impact on fitness (productivity) of natural pink and chum stocks?

Alaska Hatchery Research Program
Overview of PWS results and products

1) What is the genetic stock structure of pink and chum in PWS?

<u>Why is this important</u>?

- Measure of genetic diversity and capacity for resilience
- Provides insight into changes associated with hatchery production
- Track future changes

Overview of PWS results and products

Pink Population Structure

Genetic differences:

1. Among recent collections of wild fish
   - Population structure exists, though overall variation is small
   - Main patterns of variation: Early / Late run, East / West streams

2. Between recent & historical samples from hatcheries
   - Hatchery broodstocks have not changed measurably over time

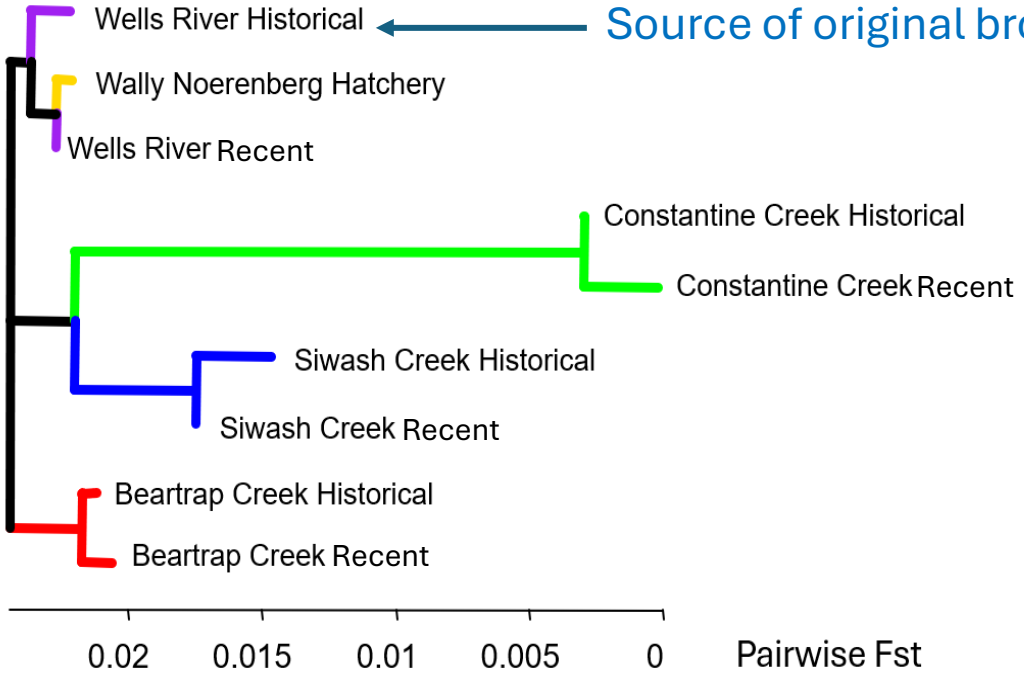
3. Between recent & historical, hatchery vs. wild
   - Some evidence that wild populations more similar to hatcheries
   - Overall population variation is small so these changes are small

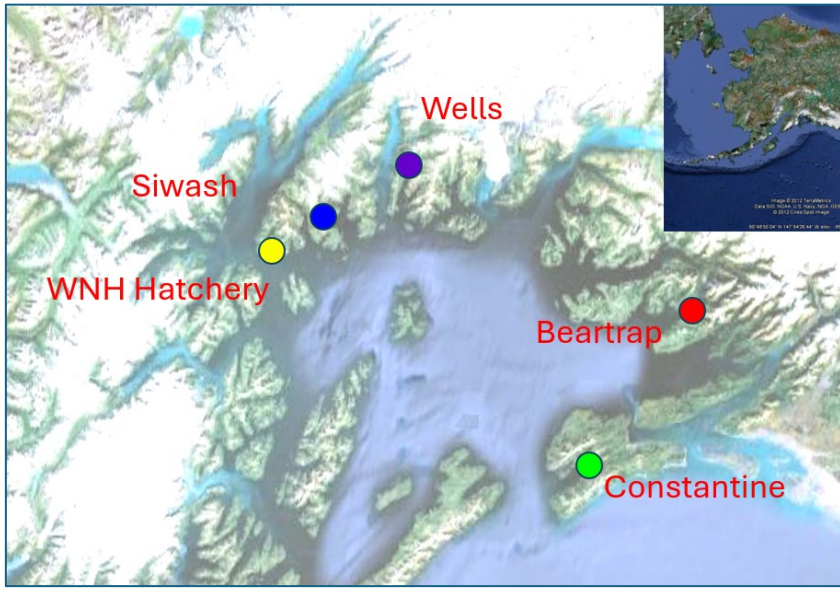
Overview of PWS results and products

Chum Population Structure

Population structure after 30 years of hatcheries

- Populations remain similar over time
- Some indication of introgression of hatchery strays





Jasper, J.R. et al. 2013. Source-sink estimates of genetic introgression show influence of hatchery strays on wild chum salmon populations in Prince William Sound, Alaska. PloS one, 8(12)

Overview of PWS results and products

Population Structure

Take-Home: Genetic Structure

- **Chum salmon**
  - Population structure of wild chum not visibly eroded after 30 years
  - Structure driven by run timing and geography
  - Introgression exists; rates vary among locations driven by distance from the hatchery and life history
- **Pink salmon**
  - Even and odd-year are genetically distinct
  - Genetic variation among wild populations small but measurable

    Odd year: geographic separation – East/West

    Even year: run timing separation – Early/Late
  - Population structure similar after 30 years
  - Hatchery broodstocks have not changed genetically over time

Alaska Hatchery Research Program
Straying

2) What is the extent and annual variability of straying?

Why is this important?

- Hatchery fish must be present for there to be genetic risk
- Evaluating risk requires information about amount of straying and patterns in space and time

Alaska Hatchery Research Program
Straying

Hatchery Proportions in Escapement

Individual Stream Escapements, 2013-2015

Species	2013	2014	2015
Pink	0.0% – 86.8%	0.0% – 91.5%	0.0% – 80.7%
Chum	0.1% – 96.5%	0.0% – 80.3%	0.3% – 89.7%

Hatchery-origin fish found in most streams with greater presence closer to hatcheries

Soundwide Escapement, 2013-2015

Species	2013	2014	2015
Pink	4.5%	14.7%	10.5%
Chum	2.8%	3.3%	9.2%

Knudsen et al. 2021. Hatchery fish straying, run sizes, escapement, and harvest rates of adult Pink Salmon and Chum Salmon returning to Prince William Sound, Alaska in 2013-2015. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 13:58–85

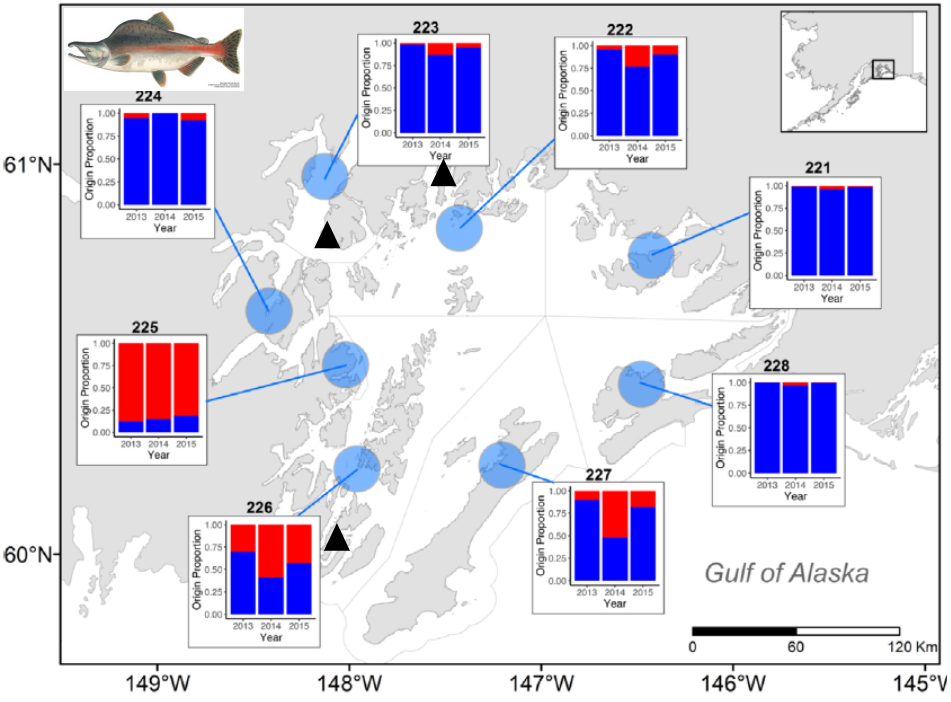
Alaska Hatchery Research Program

Straying

Geographic Pattern of Stray Proportions in Escapement

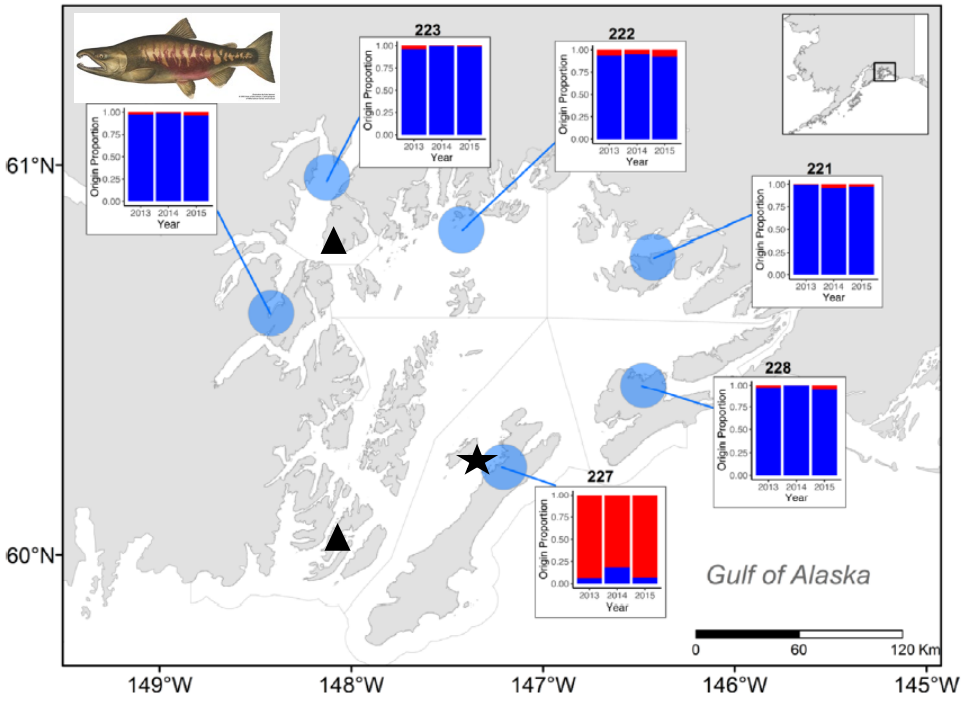
By District, 2013-2015

Pink



Range: 0.1% - 89.9%

Chum



Range: 0.0% - 84.6%

Hatchery Origin
Natural Origin
▲ **Hatchery**
★ **Remote Release**

Alaska Hatchery Research Program

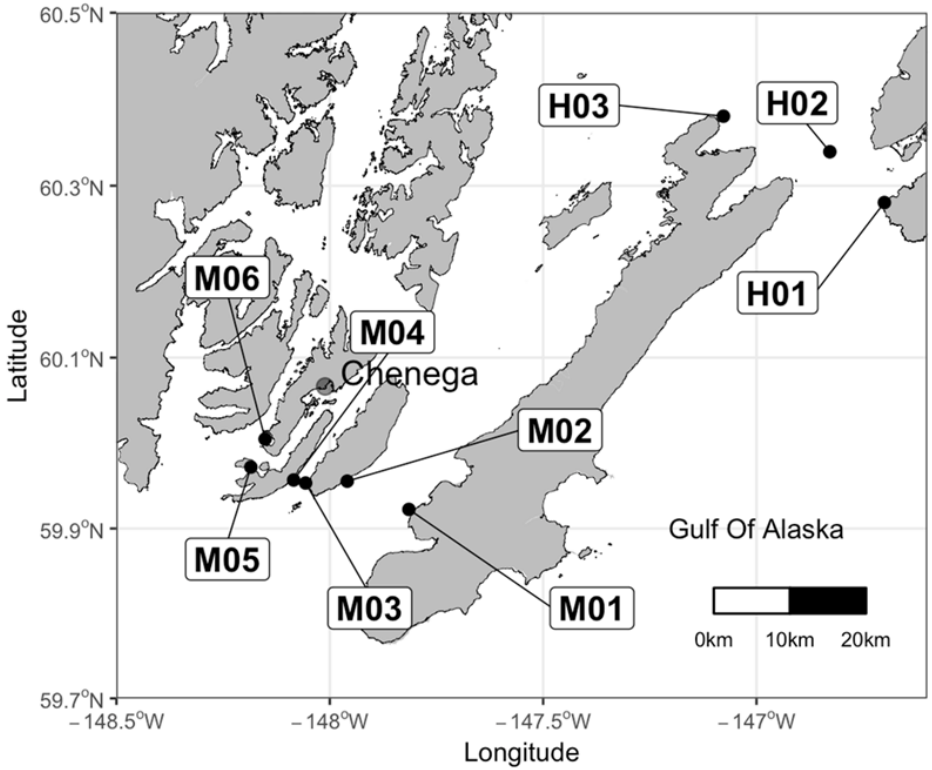
PWS Run Reconstructions 2013-2015

Why is this important?

Run reconstruction provides independent measures of important values.

- Total size of hatchery and wild runs
- Independent estimates of wild escapement
- Number of hatchery strays
- Harvest rates of hatchery and wild runs
- Hatchery donor stray rate

Test Fishery Locations



Knudsen et al. 2021. Hatchery fish straying, run sizes, escapement, and harvest rates of adult Pink Salmon and Chum Salmon returning to Prince William Sound, Alaska in 2013-2015. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 13:58–85

Alaska Hatchery Research Program

PWS Run Reconstructions 2013-2015

Proportions hatchery fish entering PWS

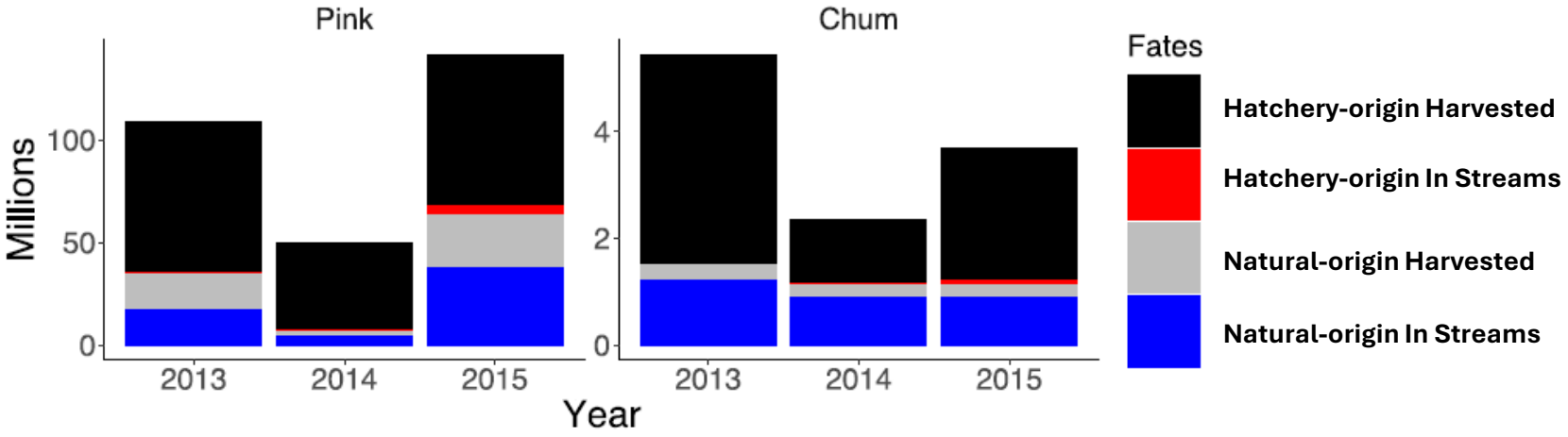
- Pink salmon: 55% - 86%
- Chum salmon: 51% - 73%

Species Common Name	Year	Hatchery Proportion	SE
Pink Salmon	2013	0.679	.016
	2014	0.864	.03
	2015	0.549	.004
Chum Salmon	2013	0.725	.019
	2014	0.511	.029
	2015	0.688	.015

Alaska Hatchery Research Program

PWS Run Reconstructions 2013-2015

Where did the salmon end up?



Harvest Rate

	Pink		Chum	
Year	Wild	Hatchery	Wild	Hatchery
2013	0.50	0.99	0.17	0.99
2014	0.27	0.98	0.20	0.97
2015	0.40	0.94	0.19	0.96

Most of the hatchery run is harvested while Most wild fish escape to spawn

Alaska Hatchery Research Program

PWS Run Reconstructions 2013-2015

Soundwide Stray Rates, Pink Salmon

	2013	2014	2015
Straying out of Hatcheries (Donor)	1.0%	1.6%	5.2%
Straying into Streams (Recipient)	4.5%	14.7%	10.5%

Soundwide Stray Rates, Chum Salmon

	2013	2014	2015
Straying out of Hatcheries (Donor)	1.0%	2.5%	3.5%
Straying into Streams (Recipient)	3.0%	3.0%	9.0%

- **Less than 5% of the hatchery run strays into escapement (Donor)**
- **But those same strays can be up to 15% of the escapement (Recipient)**

Overview of PWS results and products

Straying

Take-Home: Straying & Reconstruction

Pink & Chum

- Hatchery strays are found in most PWS spawning streams
- Highest stray proportions are near hatcheries and along migratory pathways
- Estimated hatchery stray proportions of total PWS escapement

  2013-2015 Pink: 5 – 15% Chum: 3 – 9%
- Fewer than 5% of the hatchery run strays into total PWS escapement
- Those strays can be up to 15% of the total PWS escapement
- Higher harvest rates on hatchery (>0.94) than wild (<0.50) portions of the run

Overview of PWS results and products

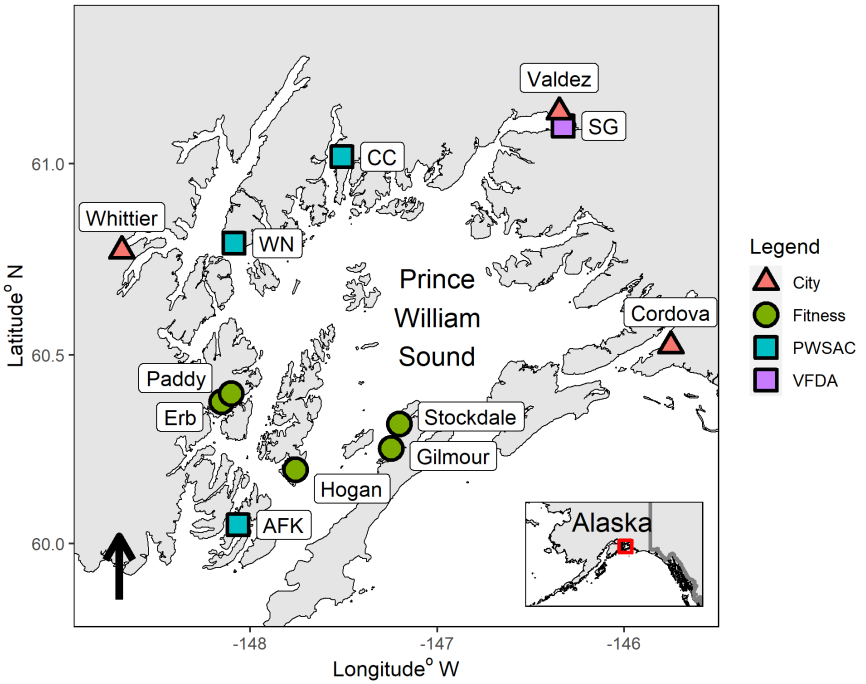
Fitness

3) What is the impact on fitness (productivity) of wild pink and chum stocks?

Why is this important?

- Wild stocks of salmon have priority
- Wild stock productivity and sustainability are main concern (Fitness)
- Long-term effects of hatchery/wild interactions will likely be inherited
- Genetic effects may include:
  - Loss of diversity among populations
  - Introduction of poorly adapted traits

    For example: run timing, size, and development rates

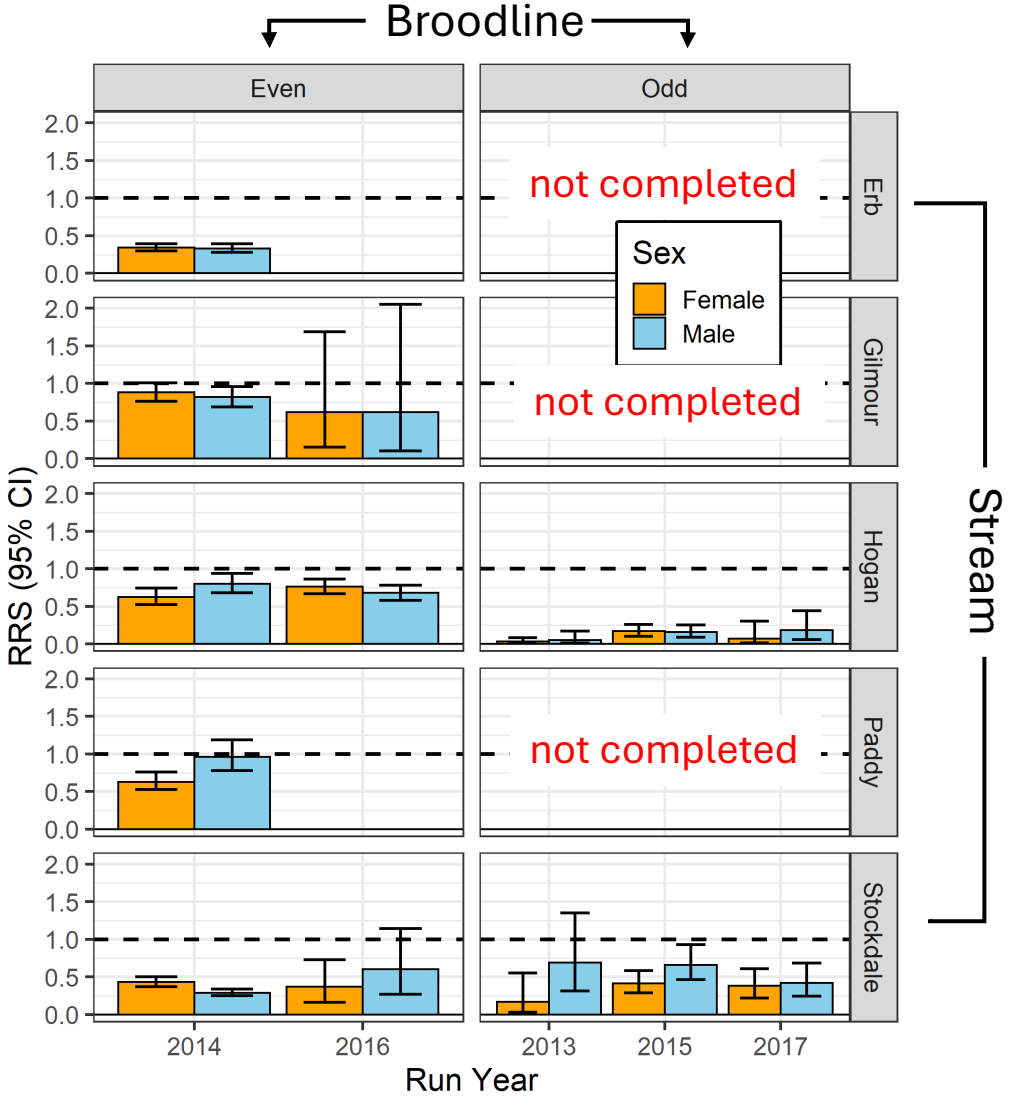


Streams in AHRP fitness study

Overview of PWS results and products

Fitness – Pink only

Reproductive success of Hatchery compared to Wild



Initial analysis and demonstration of method

- Hatchery-origin spawners consistently have lower reproductive success (RRS) in streams
- Variation among streams, broodlines, and sexes

1.0 = equal success (dashed line)
< 1.0 hatchery-origin lower success

Overview of PWS results and products

Fitness – Pink only

Additional Questions

- Are observed reductions in relative reproductive success in hatchery-origin spawners an artifact of the study design?

  The study design enables investigation of additional causes like timing, spawning location, sex, etc.

- Are results consistent in other streams and years?

  Yes, in initial analysis data, hatchery-origin RRS consistently < 1, but lots of variation.

- Do hatchery/natural hybrids consistently produce fewer offspring than two natural-origin pink salmon?

  Yes, on average.

- Are reductions in fitness persistent across generations (grand-offspring and beyond)?

  We do not know yet.

Overview of PWS results and products

Fitness – Pink only

Take-Home: Fitness – Initial Results

- Hatchery-origin pink salmon spawn in PWS streams
- Hatchery-origin pinks have lower reproductive success in streams
- Relative fitness varies across even/odd, streams, years, sexes
- Body size, sample date, sample location also matter
- Hatchery-origin pinks are consistently less productive (~50%) when spawning in streams

Projected times for completion

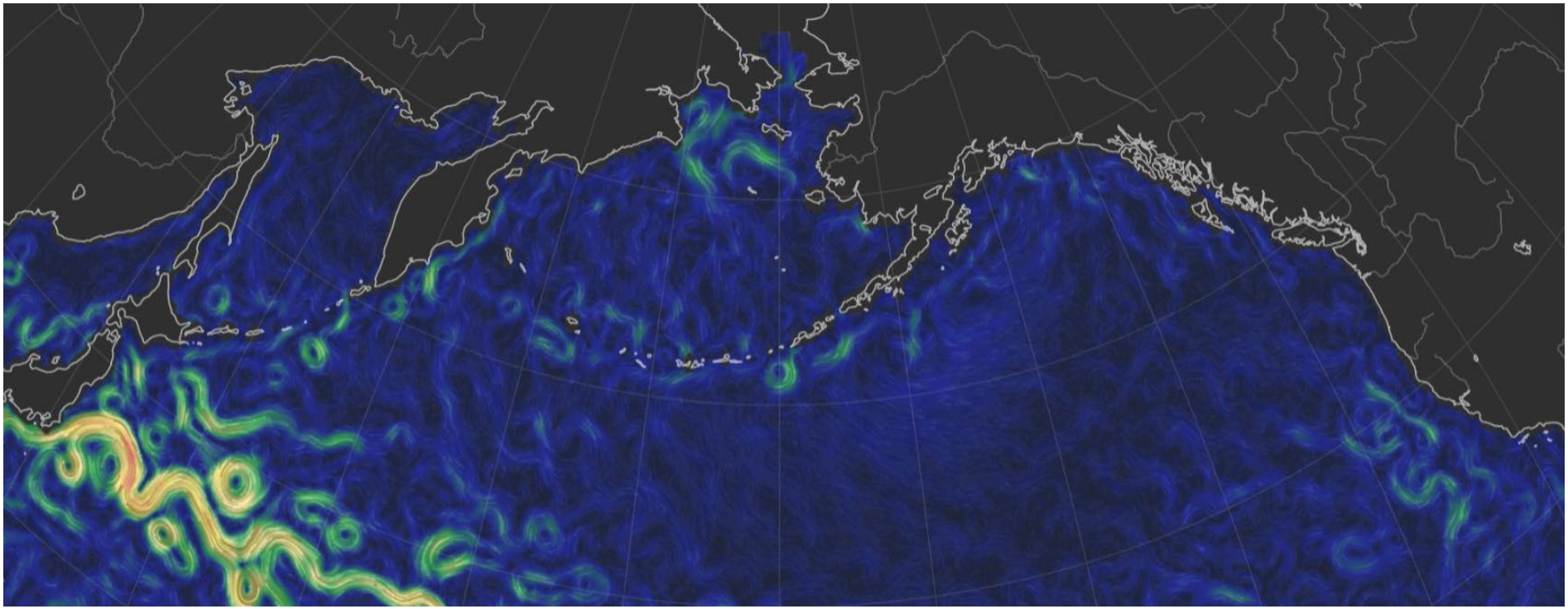
Pink salmon – Spring/Summer 2025

Chum salmon – Fall/Winter 2025

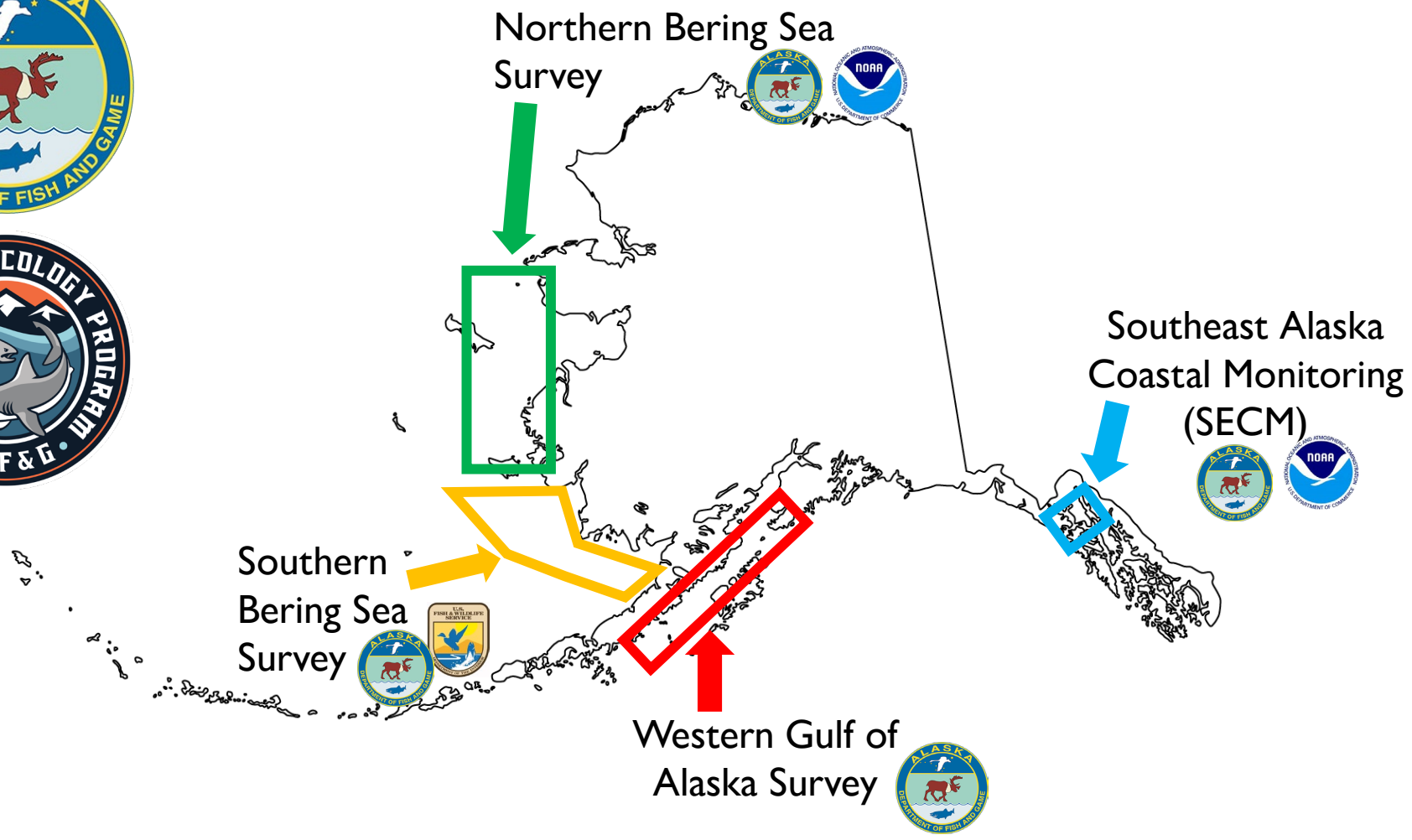
Alaska Hatchery Research Program
Presentations and Publications

- 2019
  - Genetic structure: https://www.adfg.alaska.gov/static/regulations/regprocess/fisheriesboard/pdfs/2018-2019/hc/or4.pdf
- 2020
  - Genetic structure: https://www.adfg.alaska.gov/static/regulations/regprocess/fisheriesboard/pdfs/2019-2020/hc/tab4.pdf
  - Straying: https://www.adfg.alaska.gov/static/regulations/regprocess/fisheriesboard/pdfs/2019-2020/hc/tab5.pdf
  - Fitness: https://www.adfg.alaska.gov/static/regulations/regprocess/fisheriesboard/pdfs/2019-2020/hc/tab6.pdf
- 2022
  - Genetic structure: https://www.adfg.alaska.gov/static/regulations/regprocess/fisheriesboard/pdfs/2021-2022/hc/6_GilkBaumer%20AHRP%20Study%20Question%201%20Population%20Structure.pdf
  - Straying: https://www.adfg.alaska.gov/static/regulations/regprocess/fisheriesboard/pdfs/2021-2022/hc/7_Templin%20AHRP%20Study%20Question%202%20Straying%20and%20Run%20Reconstruction.pdf
  - Fitness: https://www.adfg.alaska.gov/static/regulations/regprocess/fisheriesboard/pdfs/2021-2022/hc/8_Shedd%20AHRP%20Study%20Question%203%20Relative%20Reproductive%20Success%20Update.pdf
- General Information
  - AHRP Website: https://www.adfg.alaska.gov/index.cfm?adfg=fishingHatcheriesResearch.current_research
  - Informational Meetings: https://www.adfg.alaska.gov/index.cfm?adfg=fishingHatcheriesResearch.meetings#infomeetings
- Peer-reviewed Publications
  - Knudsen, E. et al. 2021. Hatchery-Origin Stray Rates and Total Run Characteristics for Pink Salmon and Chum Salmon Returning to Prince William Sound, Alaska, in 2013–2015. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 13:41–68
  - Josephson, R et al. 2021. Proportions of hatchery fish in escapements of summer-run Chum Salmon in Southeast Alaska, 2013–2015. North American Journal of Fisheries Management 41:724-738
  - Kyle R. Shedd, et al. 2022. Reduced relative fitness in hatchery-origin Pink Salmon in two streams in Prince William Sound, Alaska. Evolutionary Applications 15:429-446.

ADF&G Efforts to Address Data Gaps



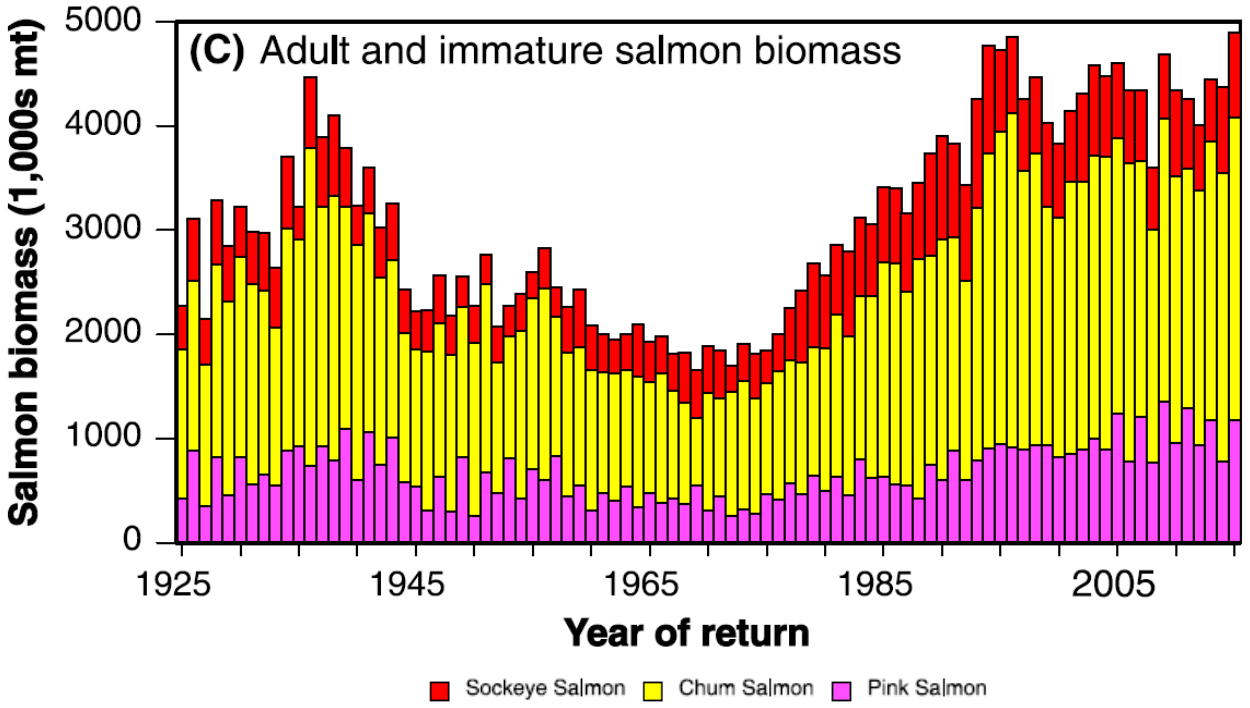
Salmon Ocean Ecology Program



Diet and prey analyses in partnership with UAF

Improved Abundance Accounting for Salmon

North Pacific Anadromous Fish Commission (NPAFC)



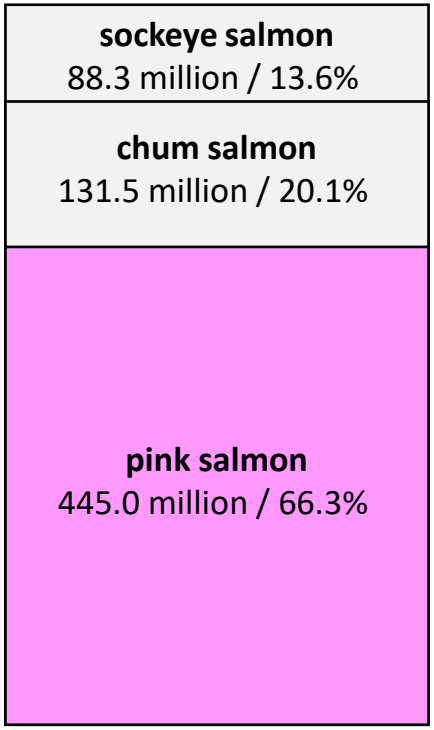
NPAFC's Working Group on Stock Assessment

- Assembles information on abundance, catches, hatchery releases, and escapements across North Pacific.
- This is the source for estimating abundance and biomass in the North Pacific
  For example: Ruggerone & Irvine 2018

Understanding Alaska Hatcheries & Competition
Pink Salmon

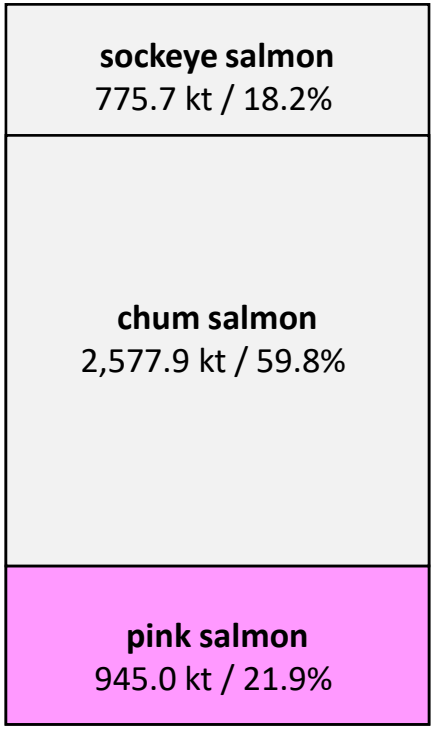
Average Annual Proportion 1990 - 2015

Adult-only Abundance (#s)

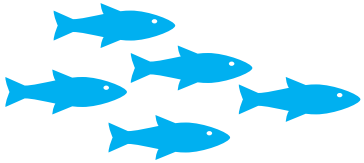


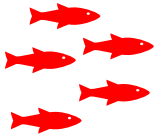
e.g., Local competition for redd space

Adult & Immature Biomass (kt)

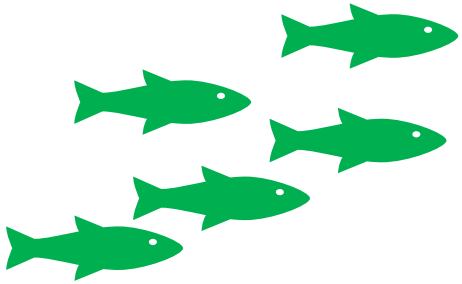


e.g., High seas competition for food





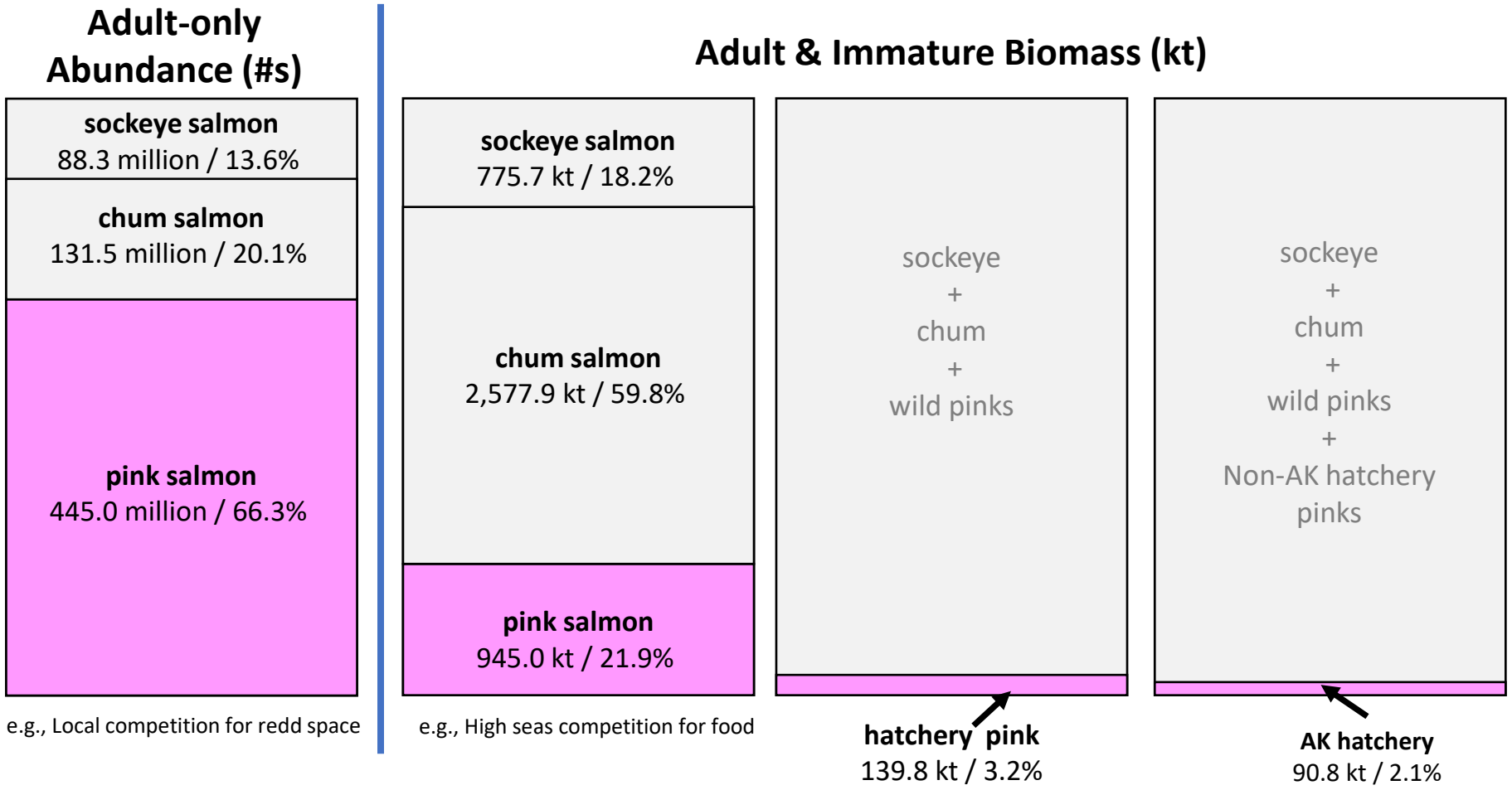
In food web studies, productivity is measured in either units of energy (e.g., calories) or in **biomass**, because **biomass** represents stored energy



1990-2015 from Ruggerone & Irvine (2018) supplementary data

Understanding Alaska Hatcheries & Competition
Pink Salmon

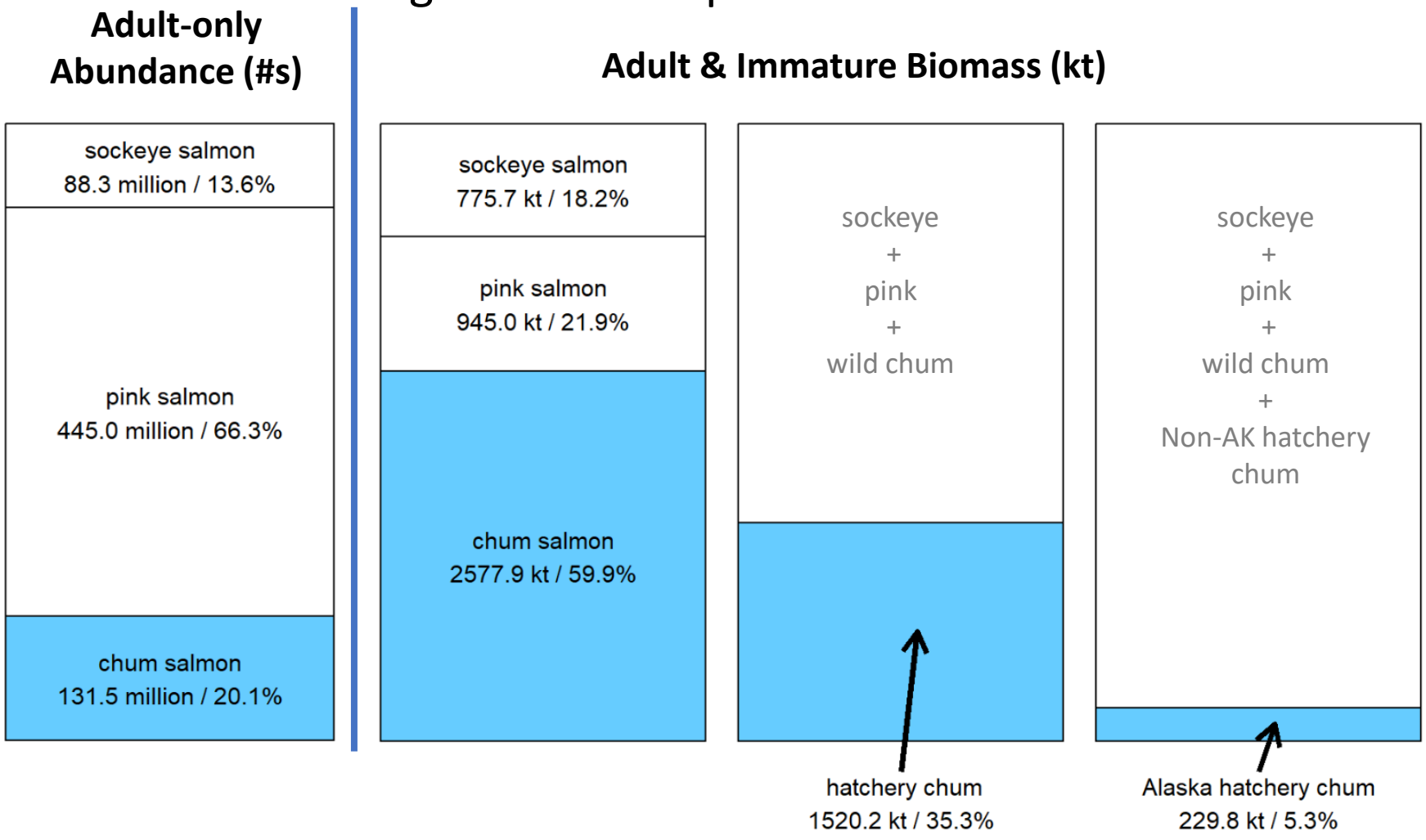
Average Annual Proportion 1990 - 2015



Changes to AK hatchery production will likely not affect North Pacific-wide marine competition but may play a larger role nearshore with local stocks.

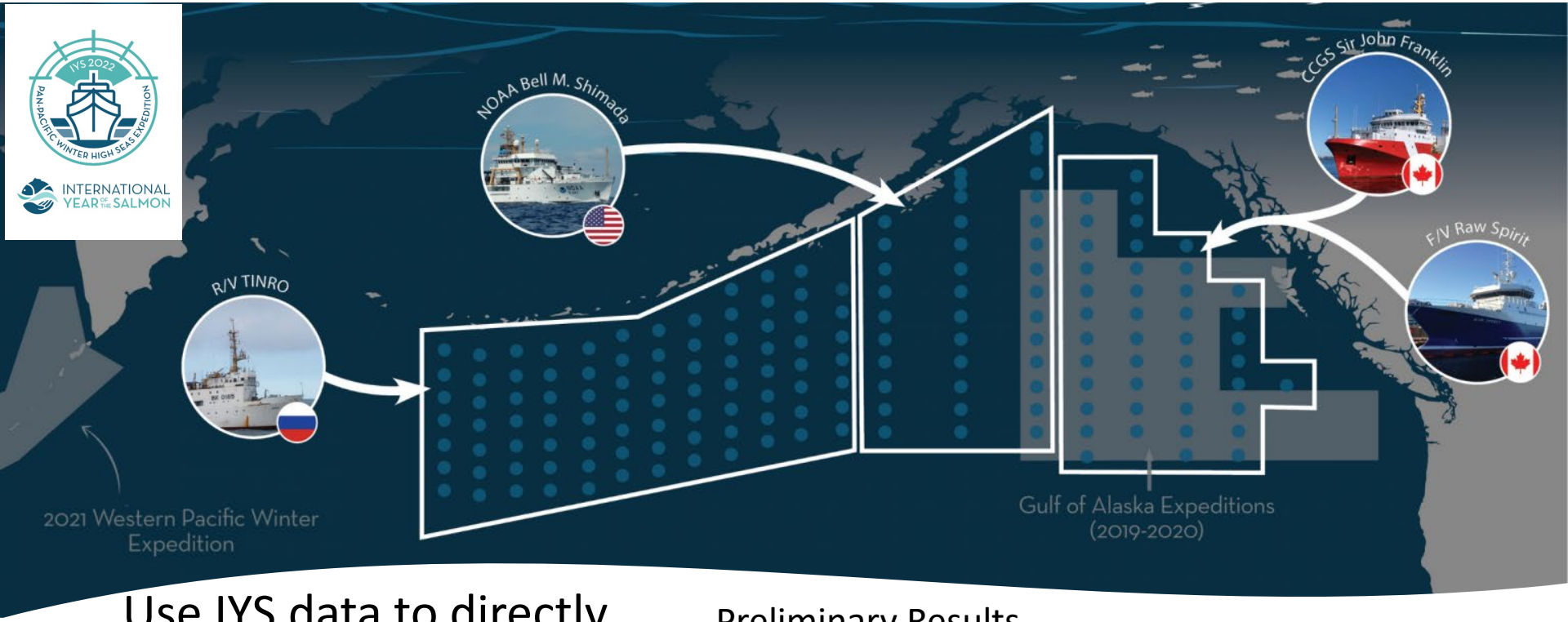
Understanding Alaska Hatcheries & Competition
Chum Salmon

Average Annual Proportion 1990 - 2015



Changes to AK hatchery production will likely not affect North Pacific-wide marine competition but may play a larger role nearshore with local stocks.

International Year of the Salmon
North Pacific survey in winter of 2022

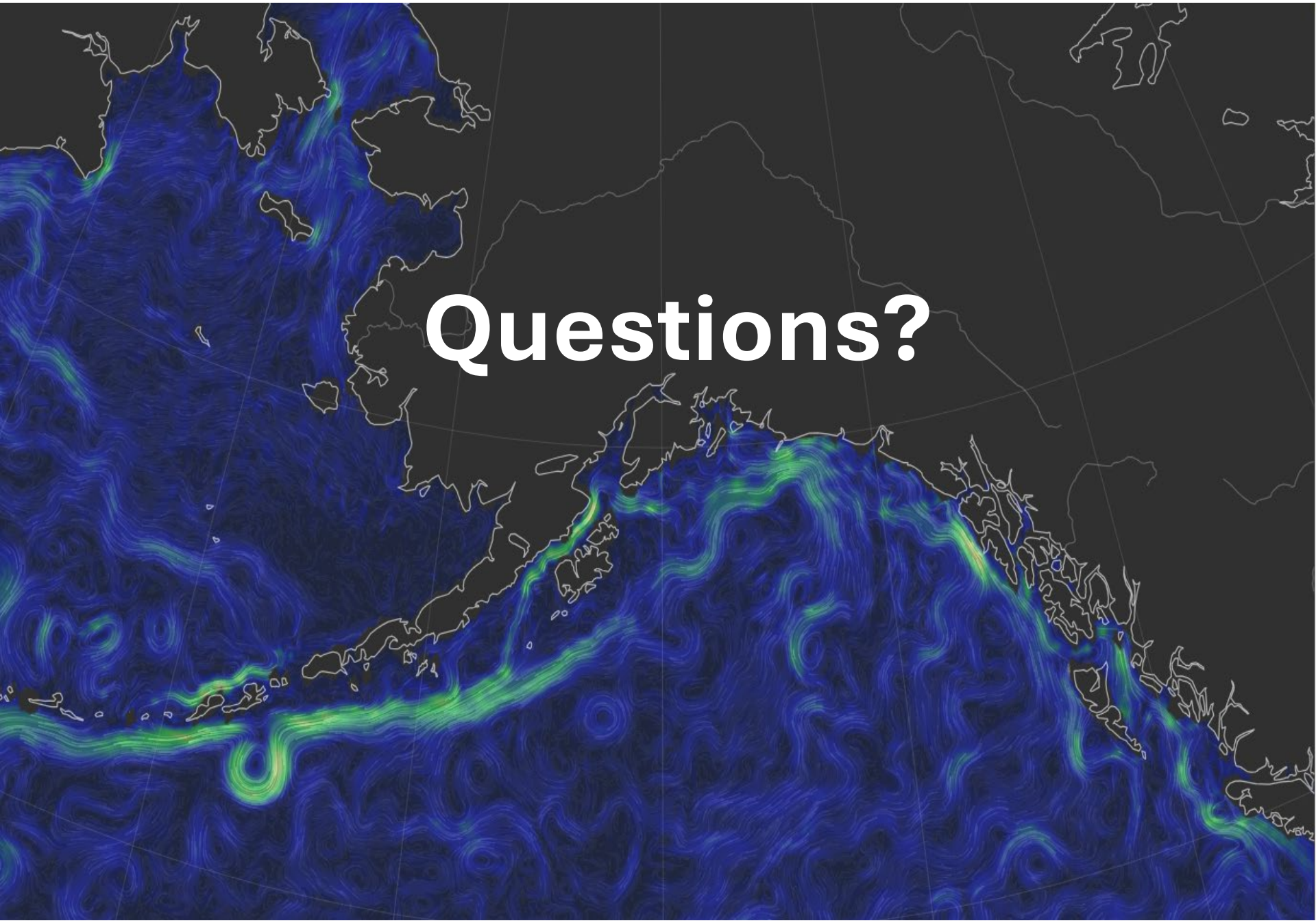


Use IYS data to directly measure spatial overlap and trophic competition between AYK chum and other species/stocks

Preliminary Results

- Chum salmon originating across the North Pacific are eating the same food as AYK chum salmon.
- Food is limited in winter, forcing chum to rely on fat reserves.
- No evidence that limited food was severe enough in 2022 to lead to starvation.

Miller, T. W., et al. Linking Juvenile Chum Salmon (*Oncorhynchus keta*) Nutritional Condition and Trophic Status to Genetic-Based Stock Assignments. North Pacific Anadromous Fish Commission. *In press*.


Questions?