

A light gray map of the Pacific Ocean region, showing the coastlines of North America, South America, and the islands of the Pacific. The map is oriented with North at the top.

Pacific salmon responses to a warming and more crowded ocean

Pacific Salmon Commission Seminar Series
October 26, 2022

Brendan Connors

Institute of Ocean Sciences, Fisheries and Oceans Canada

Acknowledgements

Collaborators

- Milo Adkison (UAF/ADF&G)
- Rob Campbell (PWSSC)
- Kristen Gorman (UAF)
- Jim Irvine (DFO)
- Trond Kristensen (Farallon Institute)
- Mike Litzow (NOAA)
- Mike Malick (NOAA)
- Peter Rand (PWSSC)
- Greg Ruggerone (NRC)

Funding



Fisheries and Oceans
Canada

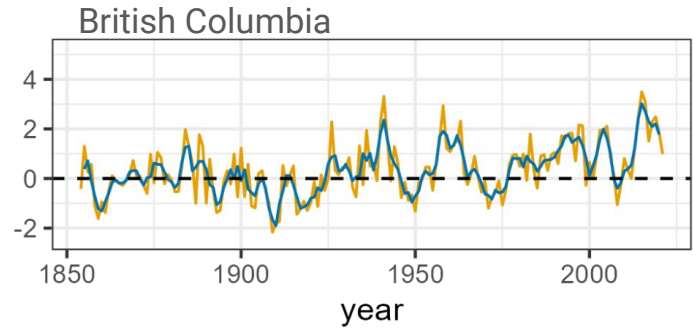
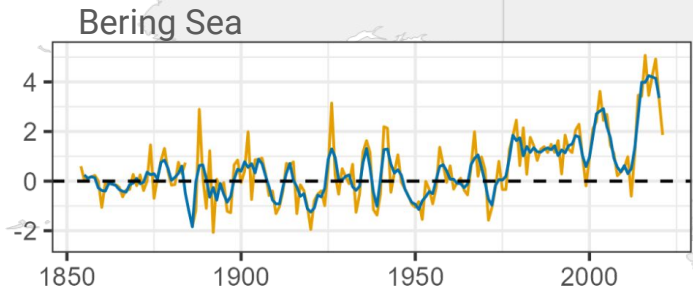
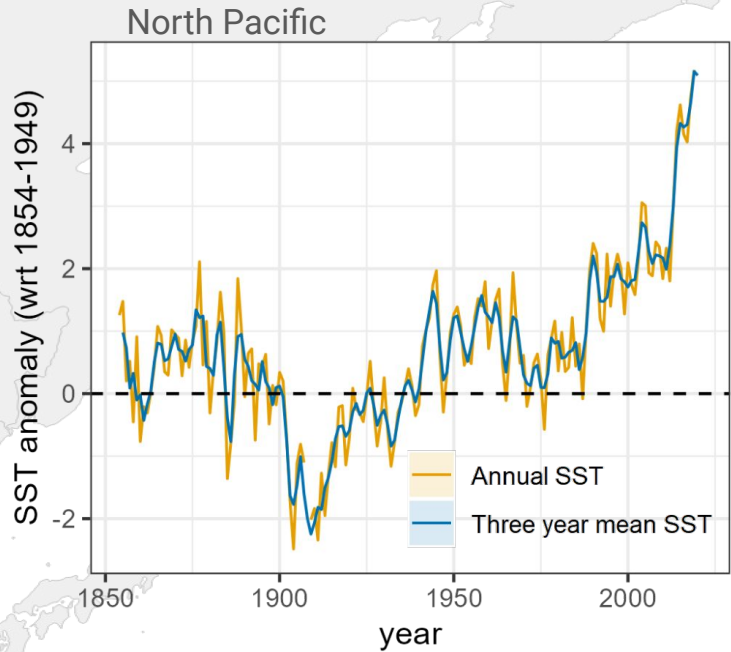
Pêches et Océans
Canada



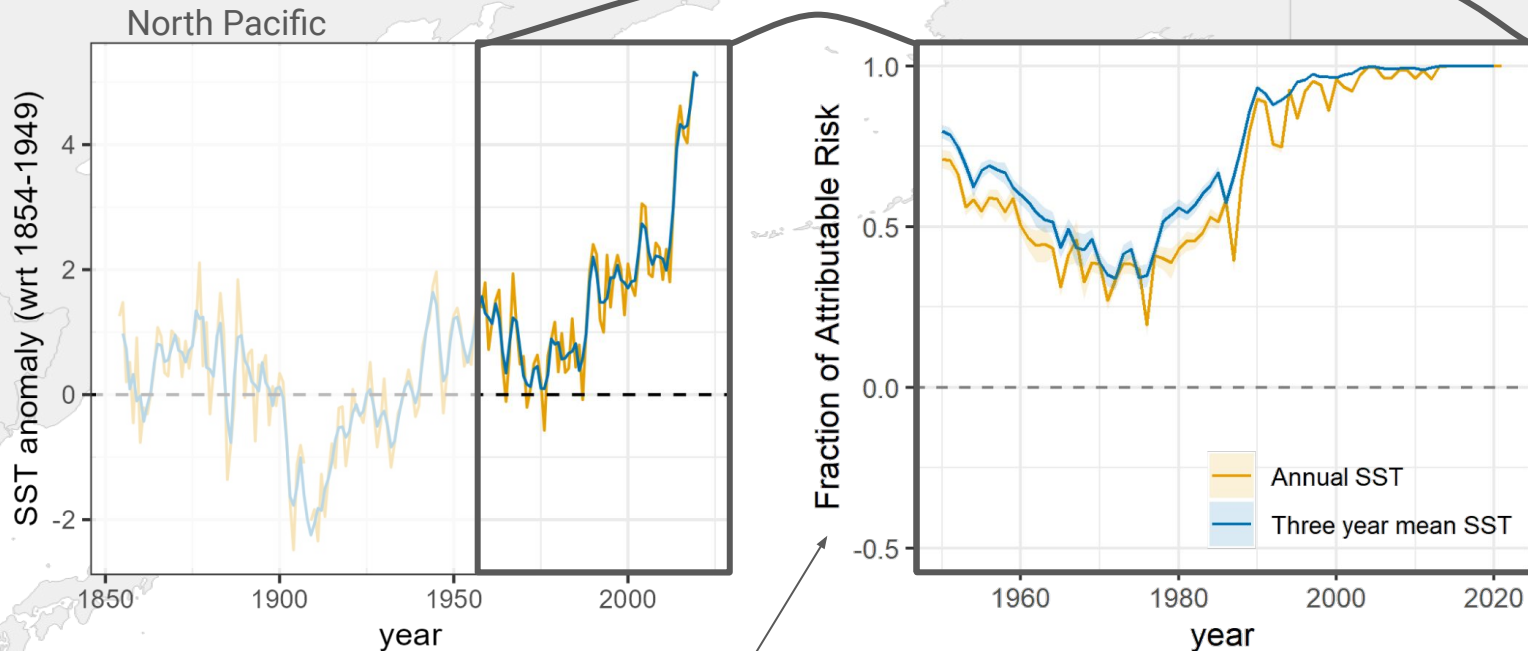
National Center for Ecological Analysis and Synthesis

SASAP State of Alaska's
Salmon and People

The North Pacific is getting warmer

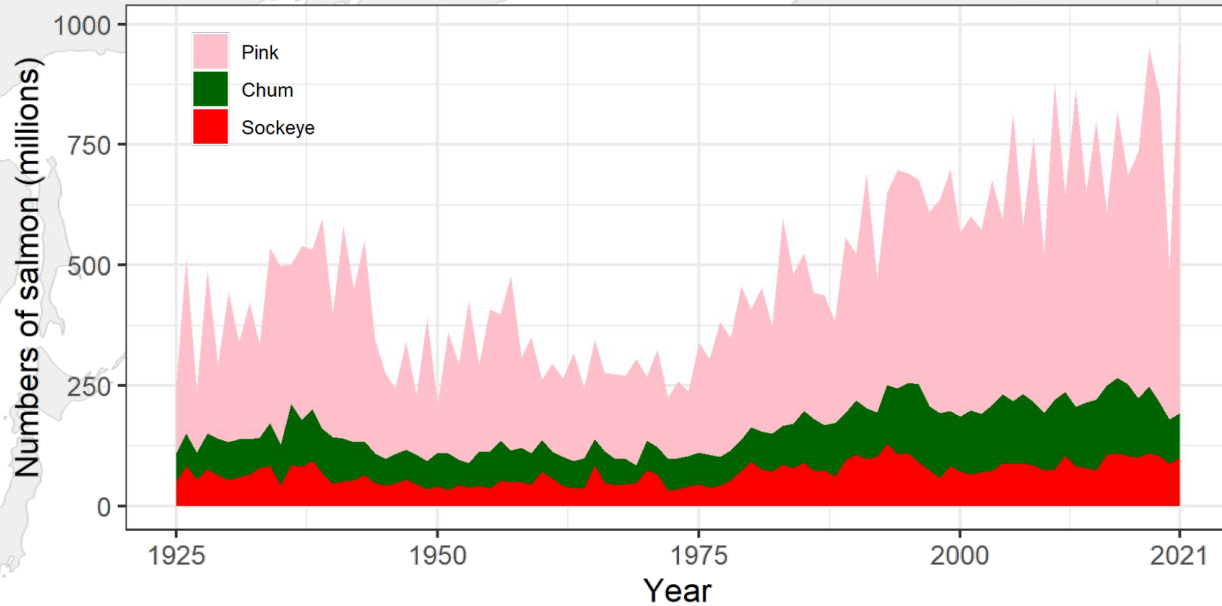


The North Pacific is getting warmer, in large part due to Climate Change



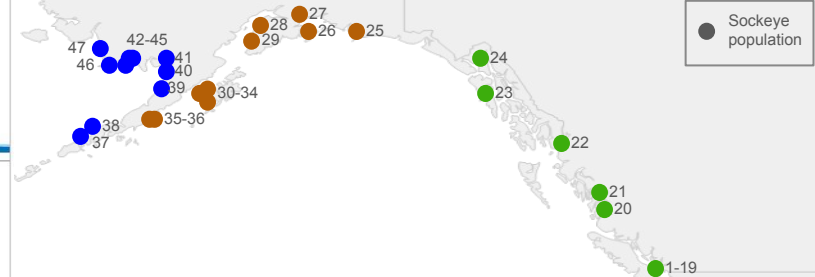
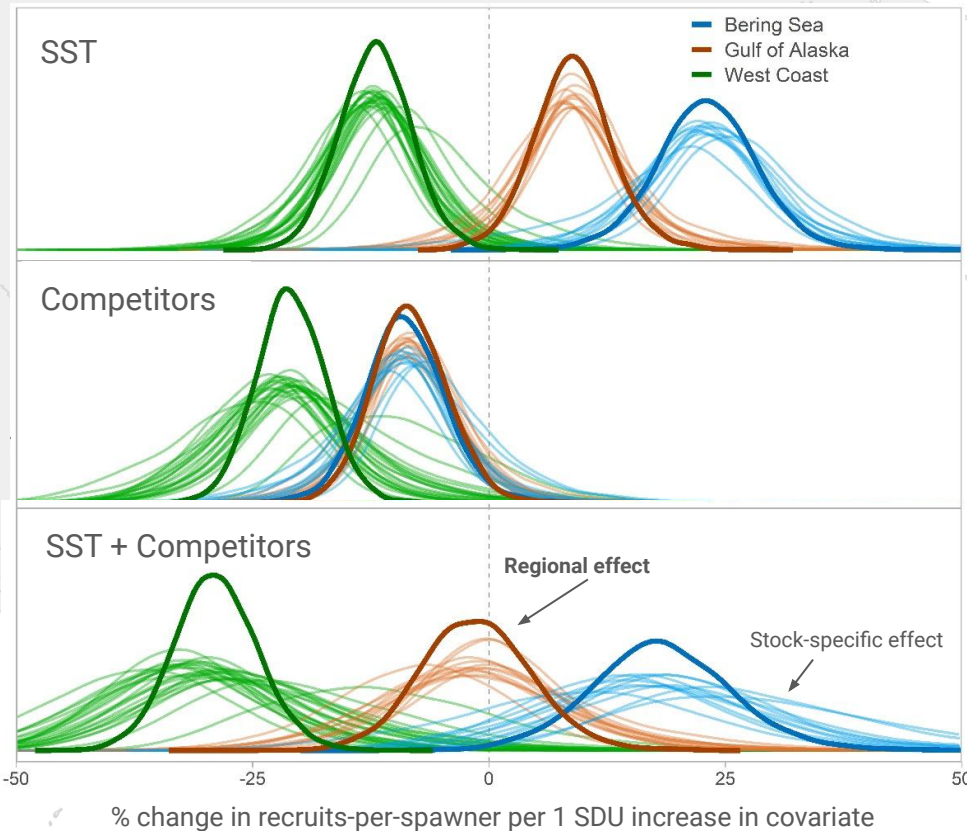
$$\text{FAR} = 1 - (\text{preindustrial probability} / \text{current probability})$$

On average, there are more salmon in the North Pacific now than at any other time in past century



Approximately 20% of production is hatchery origin, in recent years

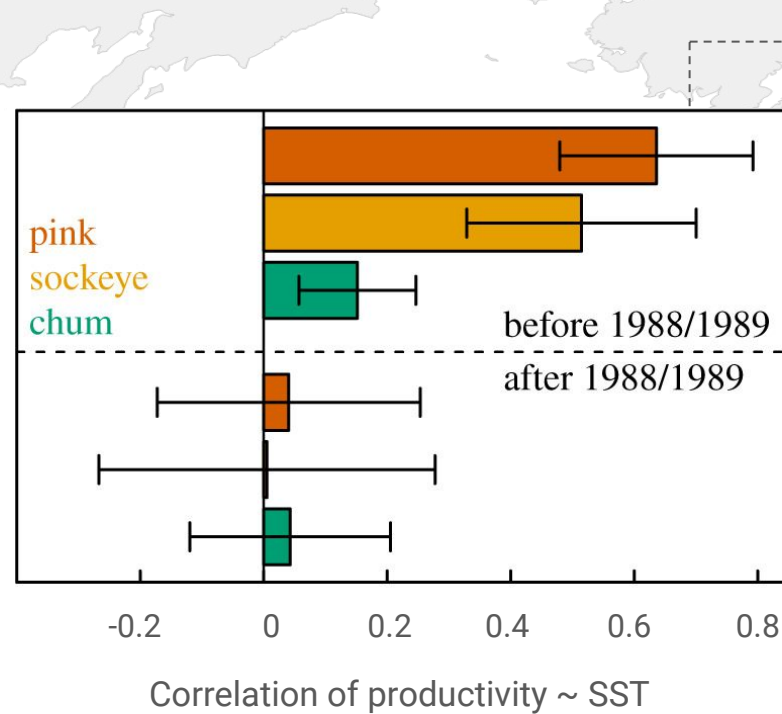
Responses to warming and competition vary in space...



SST = at marine entry

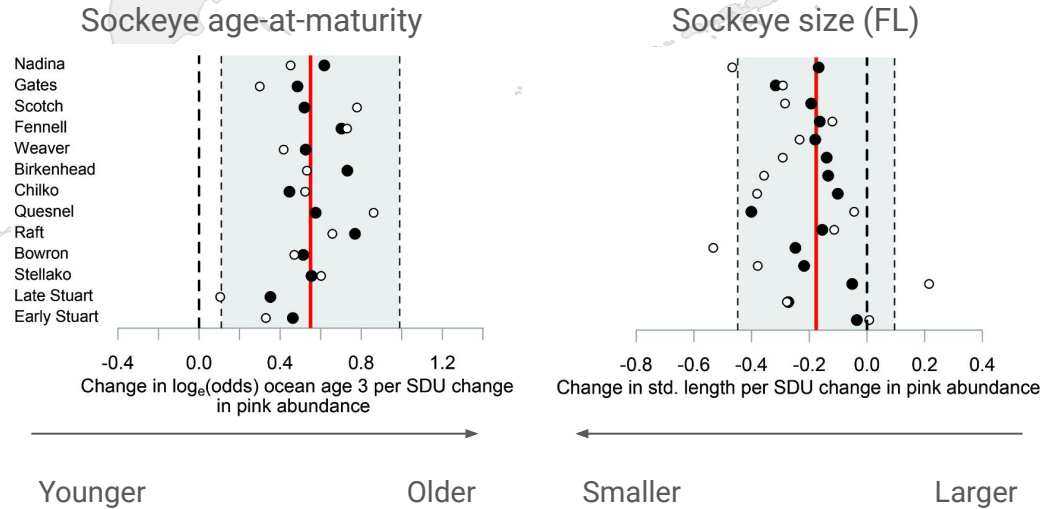
Competitors = North Pacific pink salmon abundance in second sockeye year at sea

Responses to warming vary over time

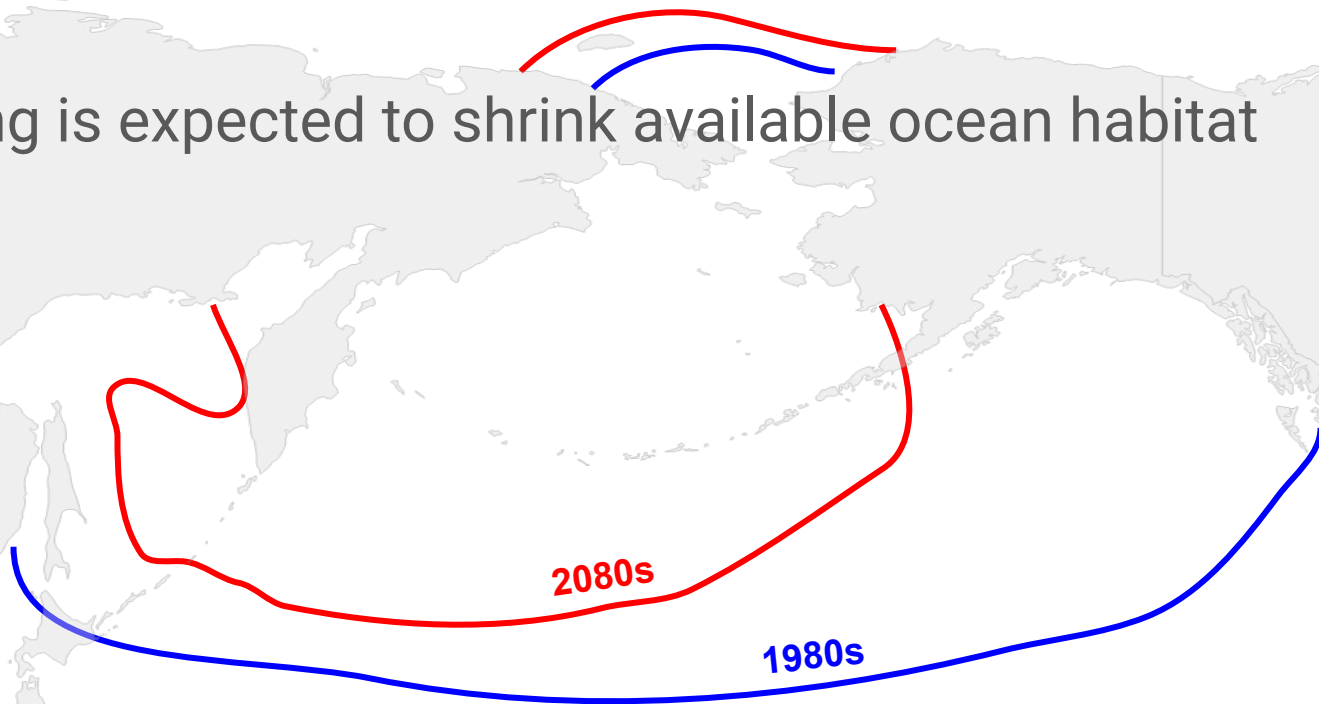


Gulf of Alaska

Competition is associated with older maturation and reduced size



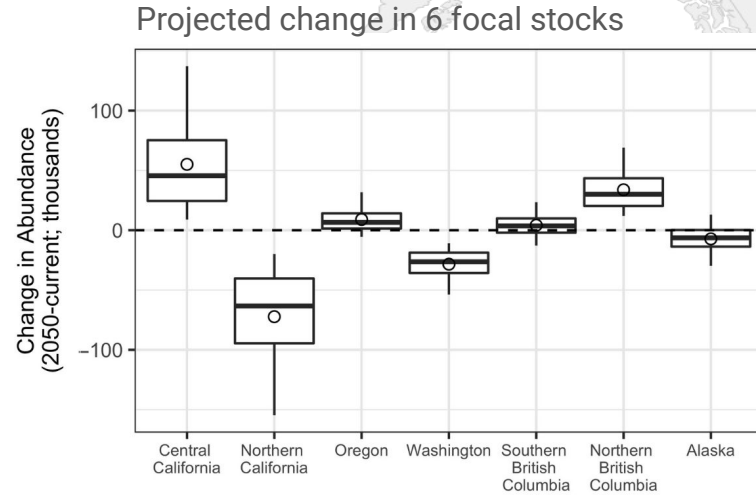
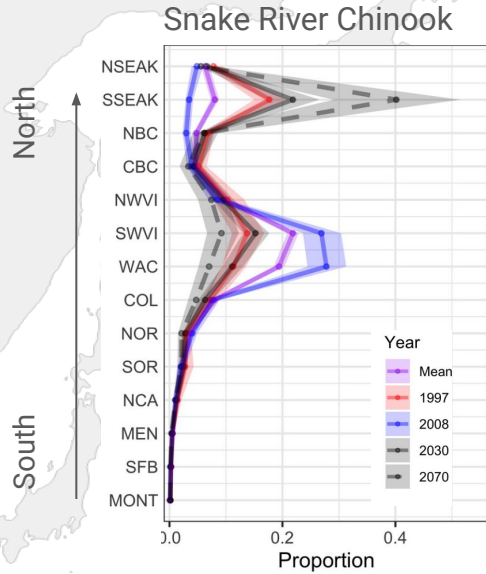
Warming is expected to shrink available ocean habitat



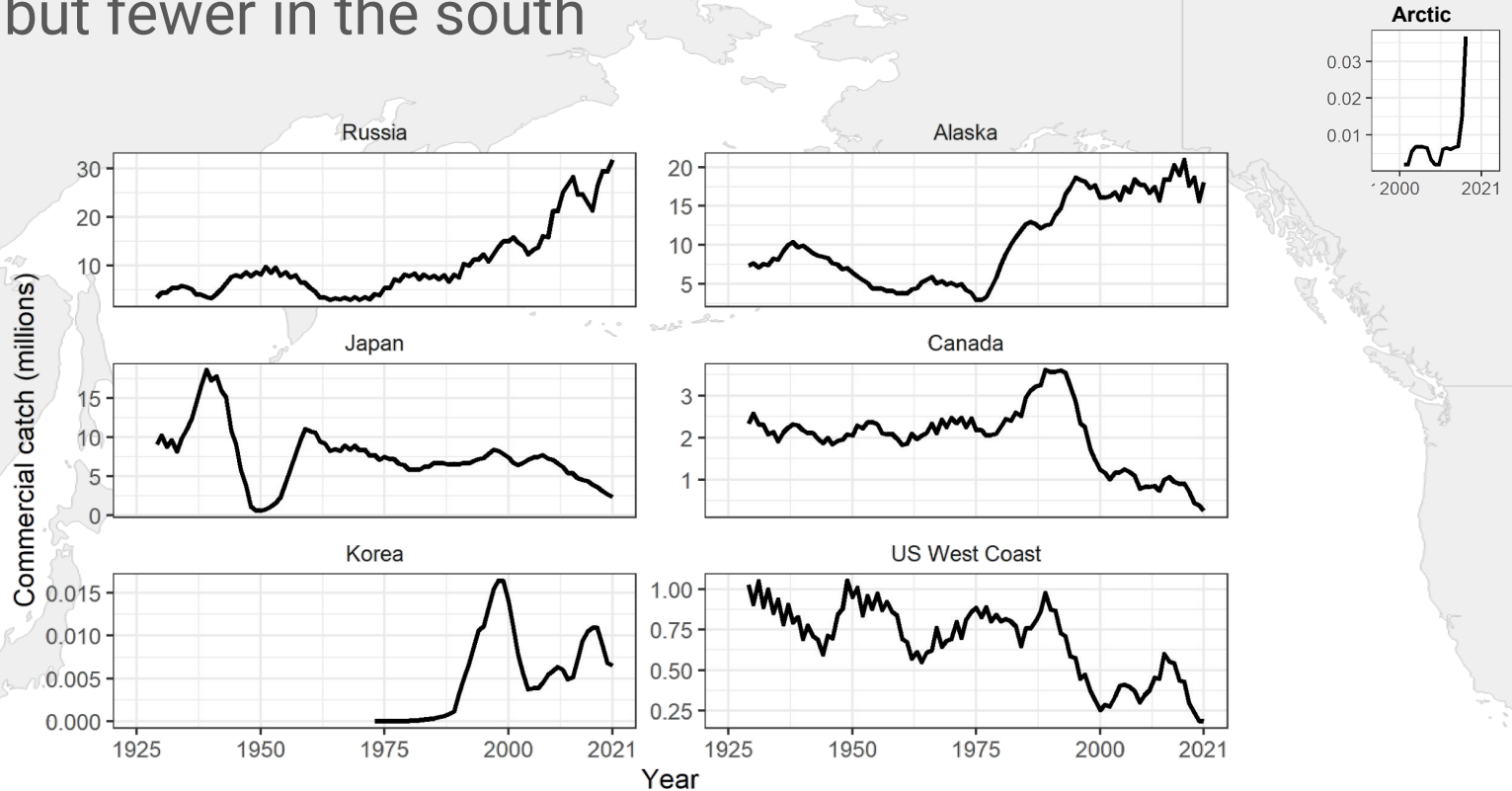
Projected change in summer (thermal) habitat from 1980s to 2080s under high emissions scenario

Sockeye	Chum	Pink	Coho	Chinook	Steelhead
-52%	-31%	-32%	-33%	-88%	-43%

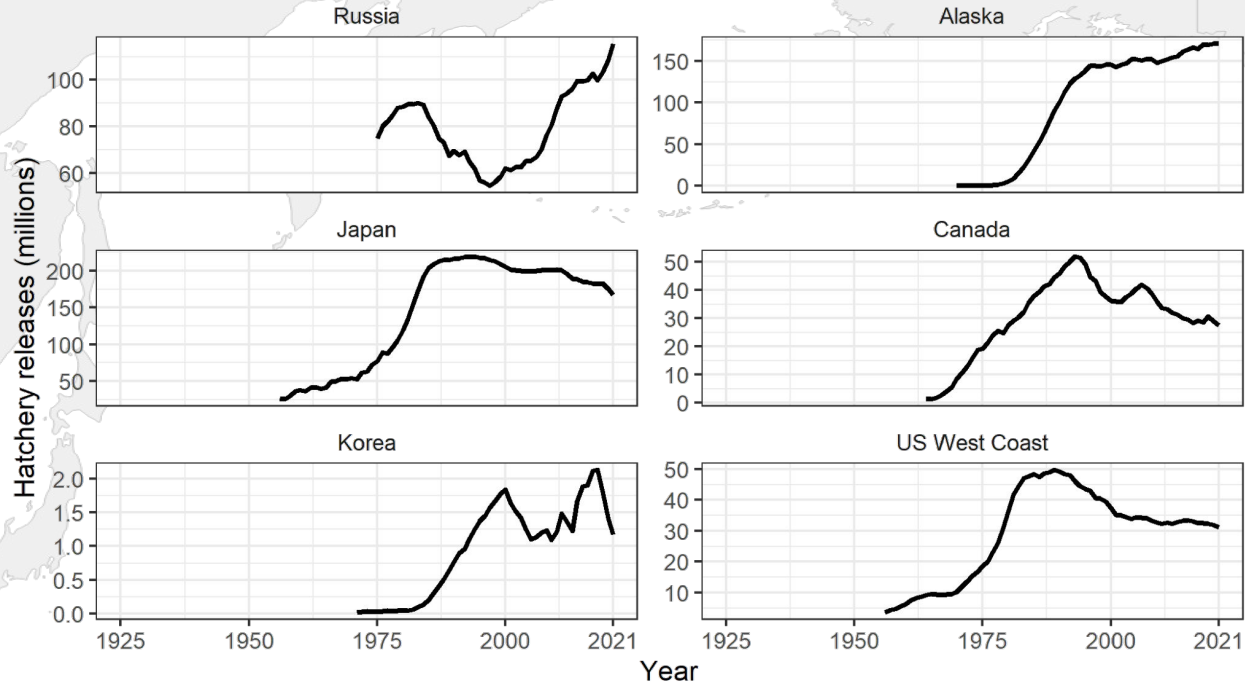
Warming is expected to shift distributions at sea



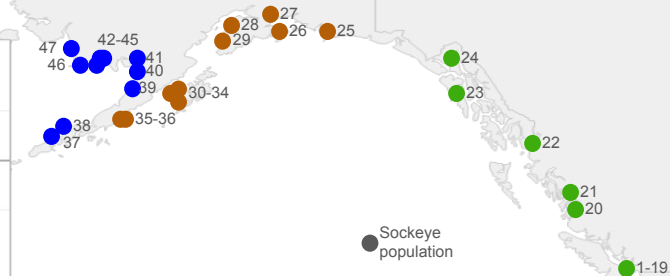
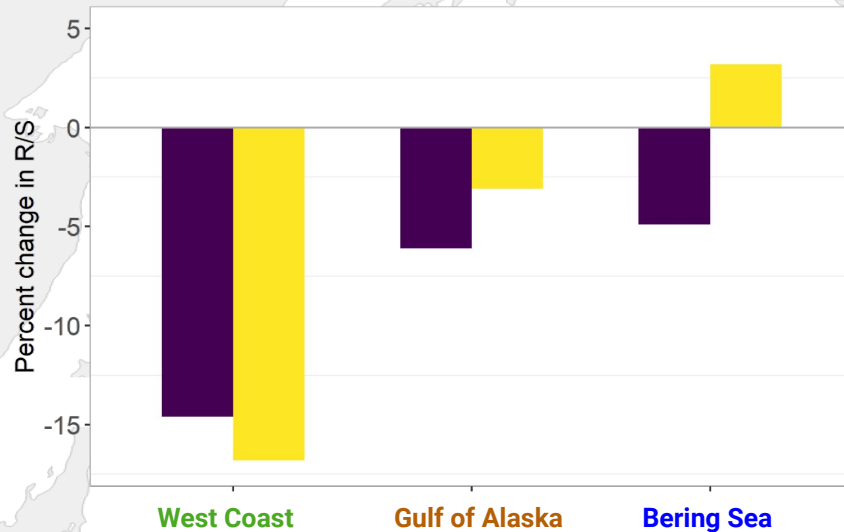
Warming contributes to more (new) fishing opportunities in the north, but fewer in the south



Warming favours hatchery marine survival in north...

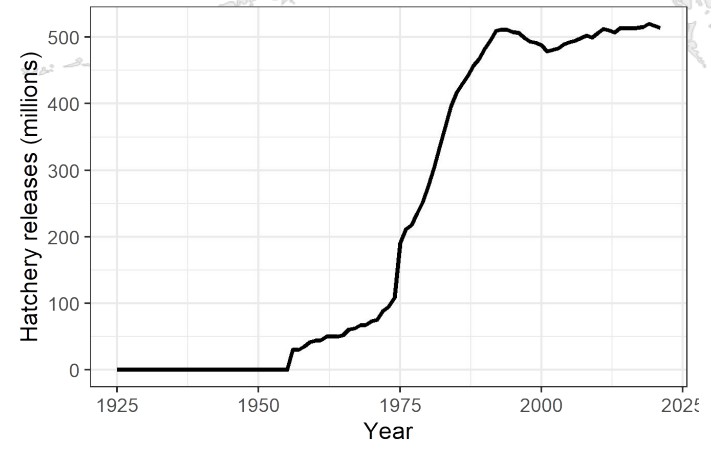
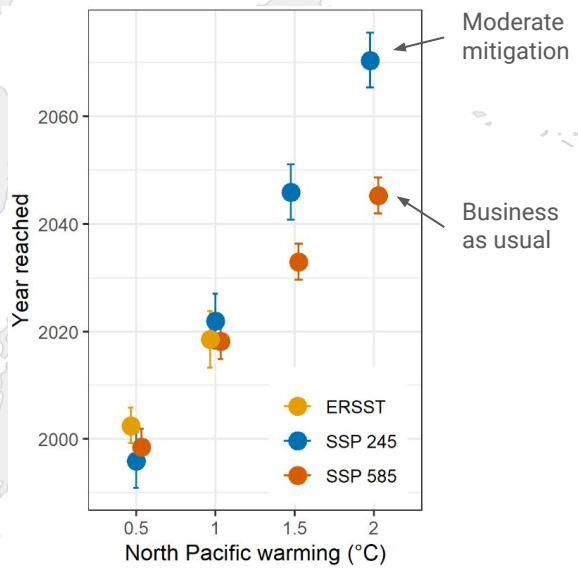


... but increasing hatchery production may exacerbate conservation risks and curtail fisheries in the south



■ Hatchery
■ Hatchery + SST

What happens to salmon in a warming and more crowded ocean is not entirely outside our control





Take home messages

- The North Pacific is getting warmer and more crowded with salmon
- Salmon responses to warming vary latitudinally and over time
- Increasing abundance of salmon at sea is associated with change in survival, growth, and age at maturation
- Warming may shrink available ocean habitat, and shift distribution of salmon at sea
- Hatchery production likely benefits from warming in north, but may exacerbate conservation risks in south
- What happens to salmon in ocean is not entirely outside human control (e.g., GHG mitigation, hatchery production)

Literature cited

Abdul-Aziz et al. 2011. Potential climate change impacts on thermal habitats of Pacific salmon (*Oncorhynchus spp.*) in the North Pacific Ocean and adjacent seas. *Canadian Journal of Fisheries and Aquatic Sciences* 68: 1660-1680.

Connors et al. 2020. Climate and competition influence sockeye salmon population dynamics across the Northeast Pacific Ocean. *Canadian Journal of Fisheries and Aquatic Sciences* 77: 943-949.

Dunmall et al. 2018. Community-based Monitoring Demonstrates Increasing Occurrences and Abundances of Pacific Salmon in the Canadian Arctic from 2000 to 2017. *NPAFC Tech Rep* 11: 87-90.

Litzow et al. Attribution time series track the growing human influence on North Pacific sea surface temperature. Unpublished

Litzow et al. 2018 Non-stationary climate–salmon relationships in the Gulf of Alaska. *Proceedings of the Royal Society B* 285: 20181855.

North Pacific Anadromous Fish Commission (NPAFC). 2022a. NPAFC Pacific salmonid catch statistics (updated June 2022). North Pacific Anadromous Fish Commission, Vancouver. <https://npafc.org>.

North Pacific Anadromous Fish Commission (NPAFC). 2022b. NPAFC Pacific salmonid hatchery release statistics (updated June 2022). North Pacific Anadromous Fish Commission, Vancouver. <https://npafc.org>.

Shelton et al. 2021. Redistribution of salmon populations in the northeast Pacific ocean in response to climate. *Fish and Fisheries* 22: 503-517.

Ruggerone and Connors., 2015. Productivity and life history of sockeye salmon in relation to competition with pink and sockeye salmon in the North Pacific Ocean. *Canadian Journal of Fisheries and Aquatic Sciences* 72: 818-833.

Ruggerone and Irvine. 2018. Numbers and biomass of natural-and hatchery-origin pink salmon, chum salmon, and sockeye salmon in the north Pacific Ocean, 1925–2015. *Marine and Coastal Fisheries* 10: 152-168.