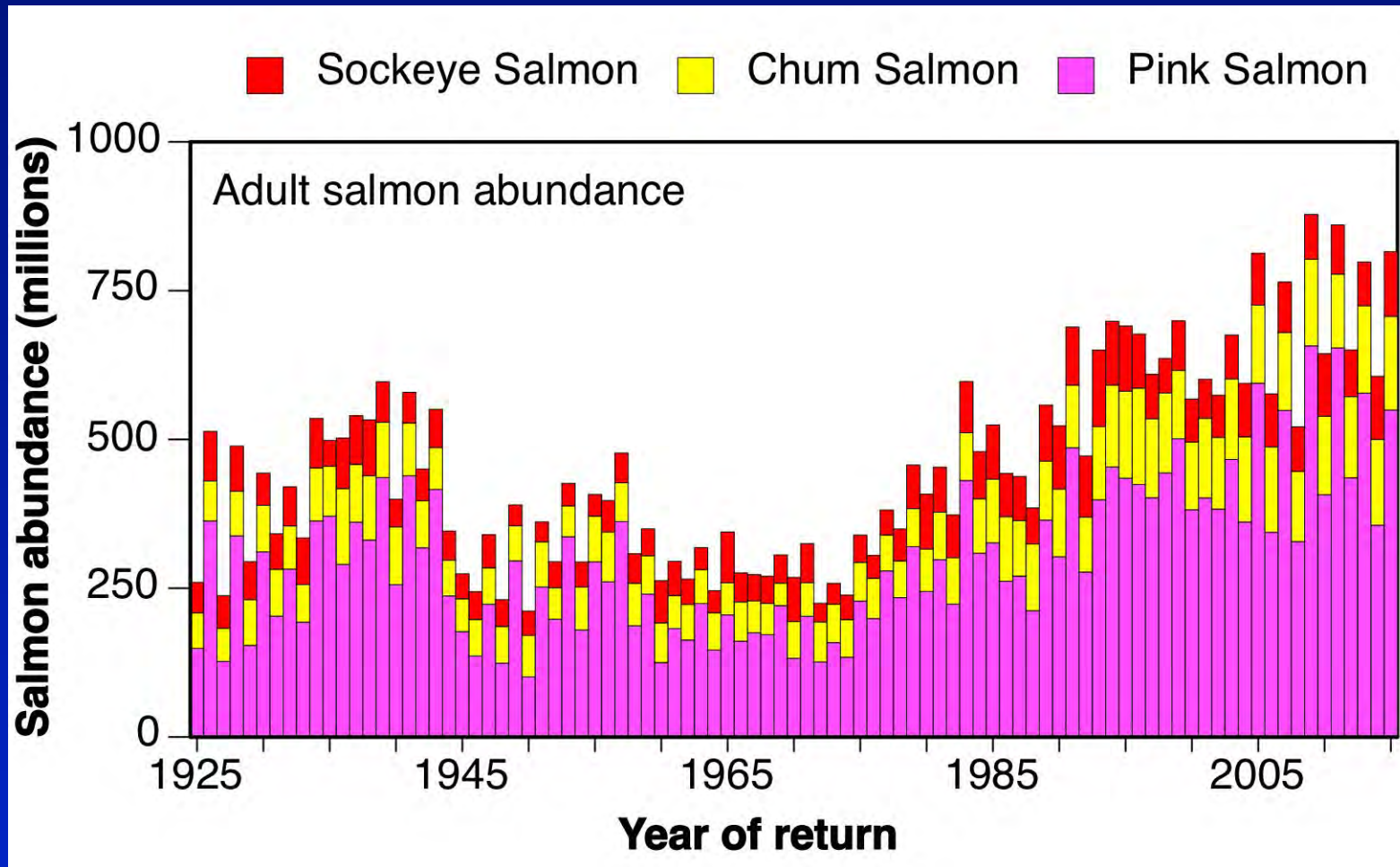


Do pink salmon affect the structure of the North Pacific ecosystem and contribute to declining Chinook salmon populations in Alaska?

Greg Ruggerone (NRC), Sonia Batten (SAHFOS), Brendan Connors (DFO), Jim Irvine (DFO), Michael Malick (OSU), Pete Rand (PWSSC), Leon Shaul (ADFG), Alan Springer (UAF)



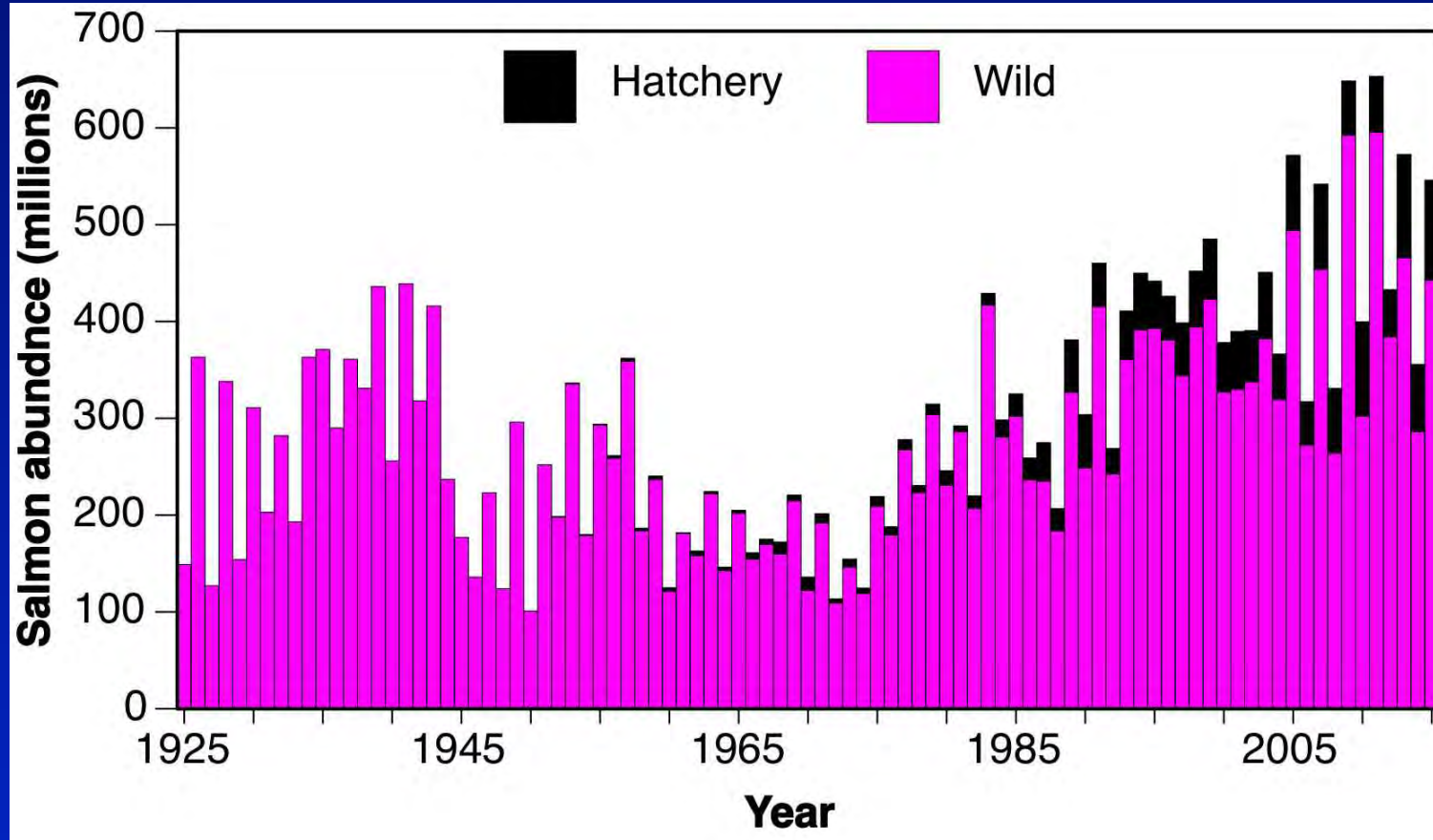
Pink Salmon Dominate Pacific Salmon Numbers



- 500 million pinks/yr, 2005-2015
- Pinks nearly 70% of all salmon

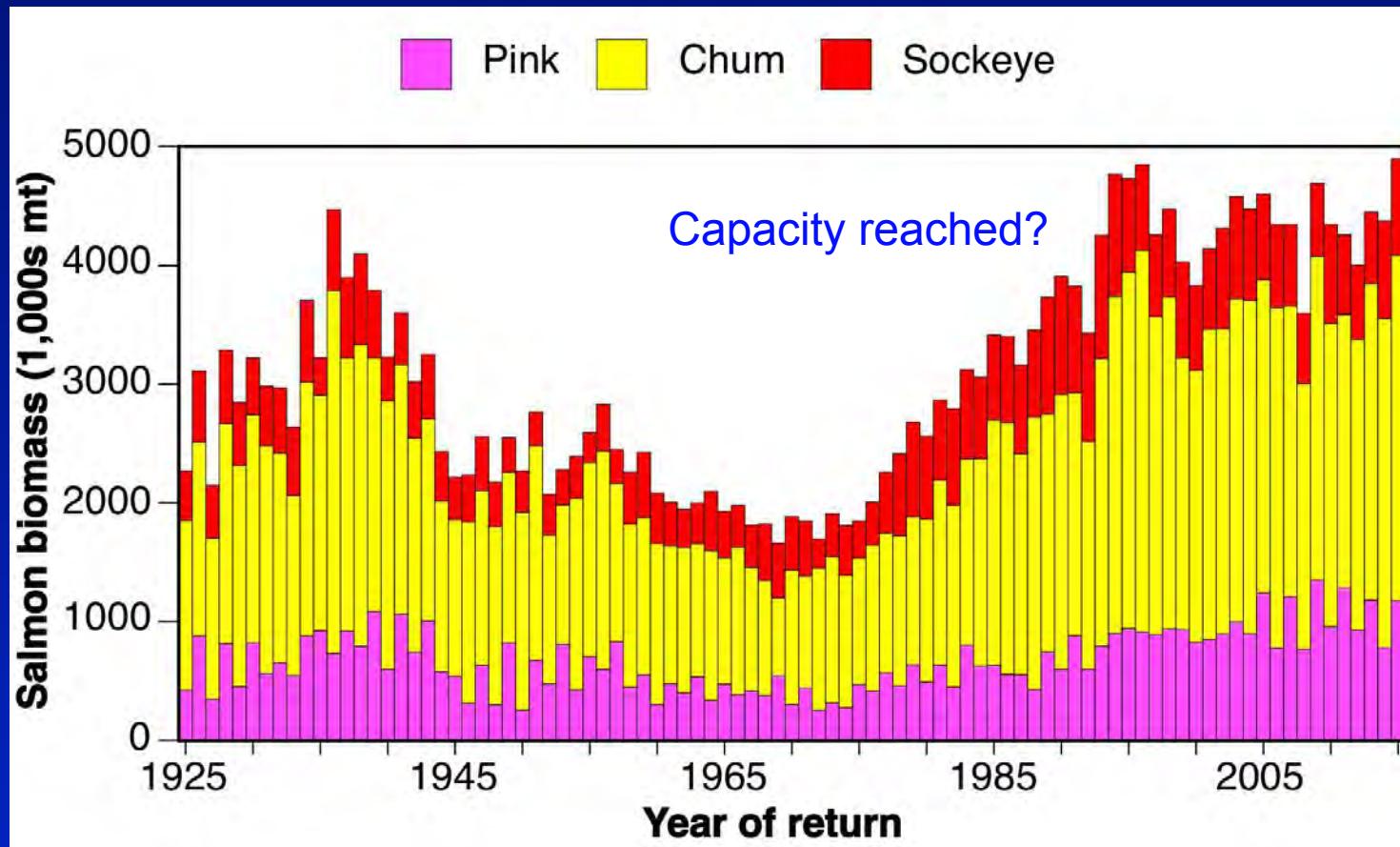
Chinook, coho, steelhead
<5% of total catch biomass

Pink Salmon Dominate Pacific Salmon Numbers



- 650 million pink salmon in peak odd- yrs
- Hatchery pinks = 15% of total pink salmon
- Alaska: up to 48% commercial catch = hatchery fish (mostly pinks)

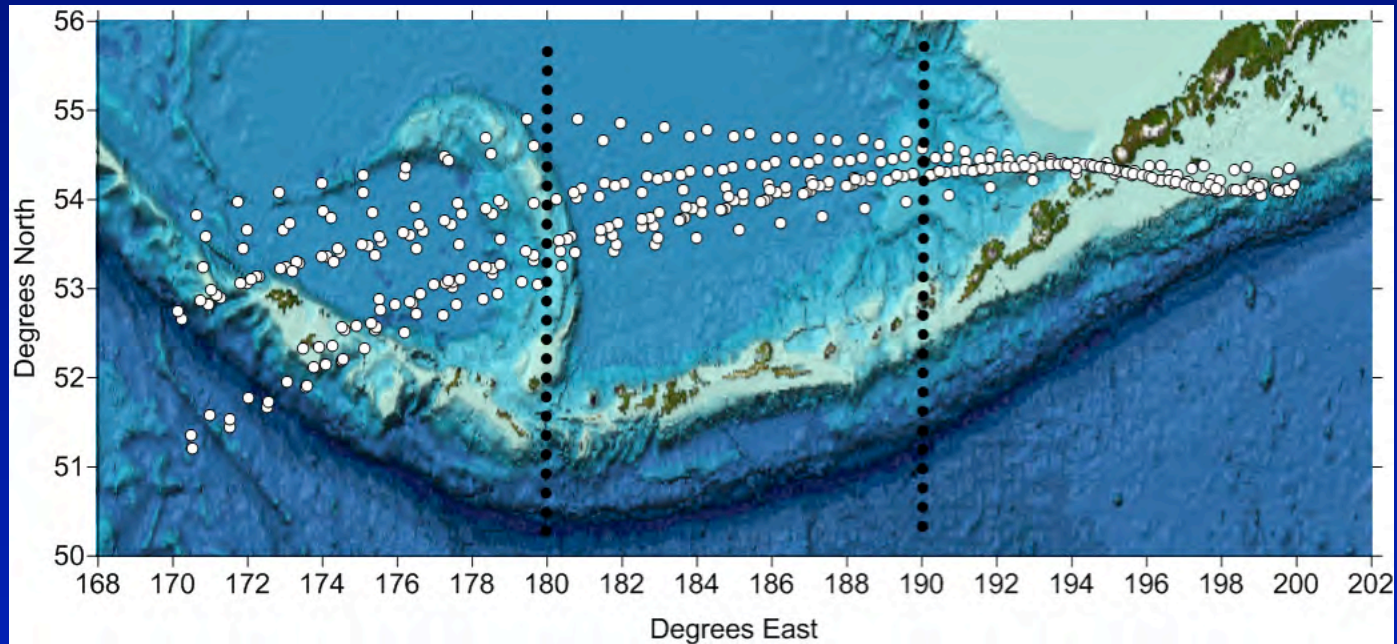
Chum Salmon Dominate Adult & Immature Biomass



- ~40% of adult and immature salmon biomass is hatchery origin, largely due to chum (Japan, Russia, SEAK, PWS)
- Chum diet largely different from other salmon

Do Pink Salmon Cause a Trophic Cascade?

Continuous plankton recorder, June-Aug., 2000-2014



Batten et al. 2018

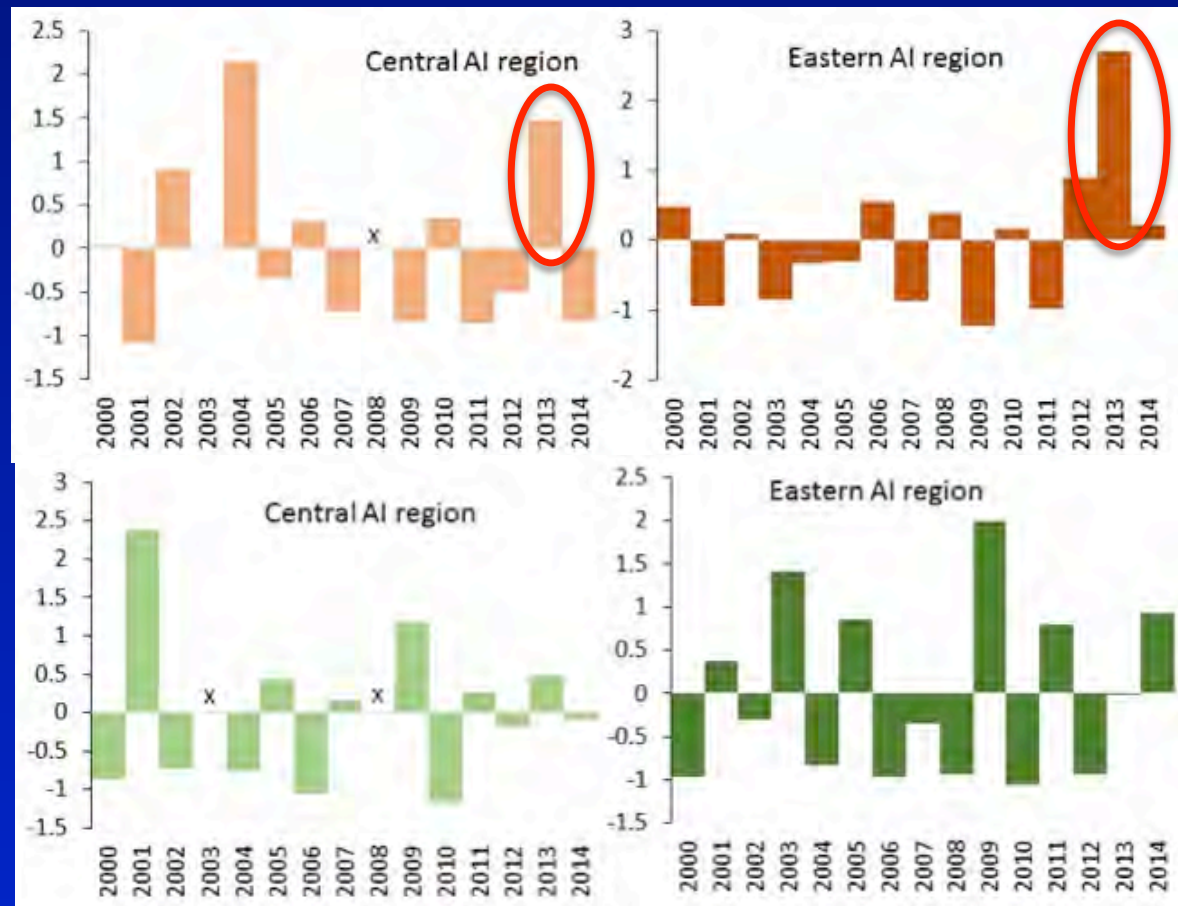
Do Pink Salmon Cause a Trophic Cascade?

Plankton Counts: June-Aug 2000-2014

Large copepods decline in odd years when pinks ~40x more abundant



Diatoms increase in odd years when more pinks and fewer zooplankton



Climate cannot explain odd/even patterns
2013: Zooplankton boomed unexpectedly. Why?

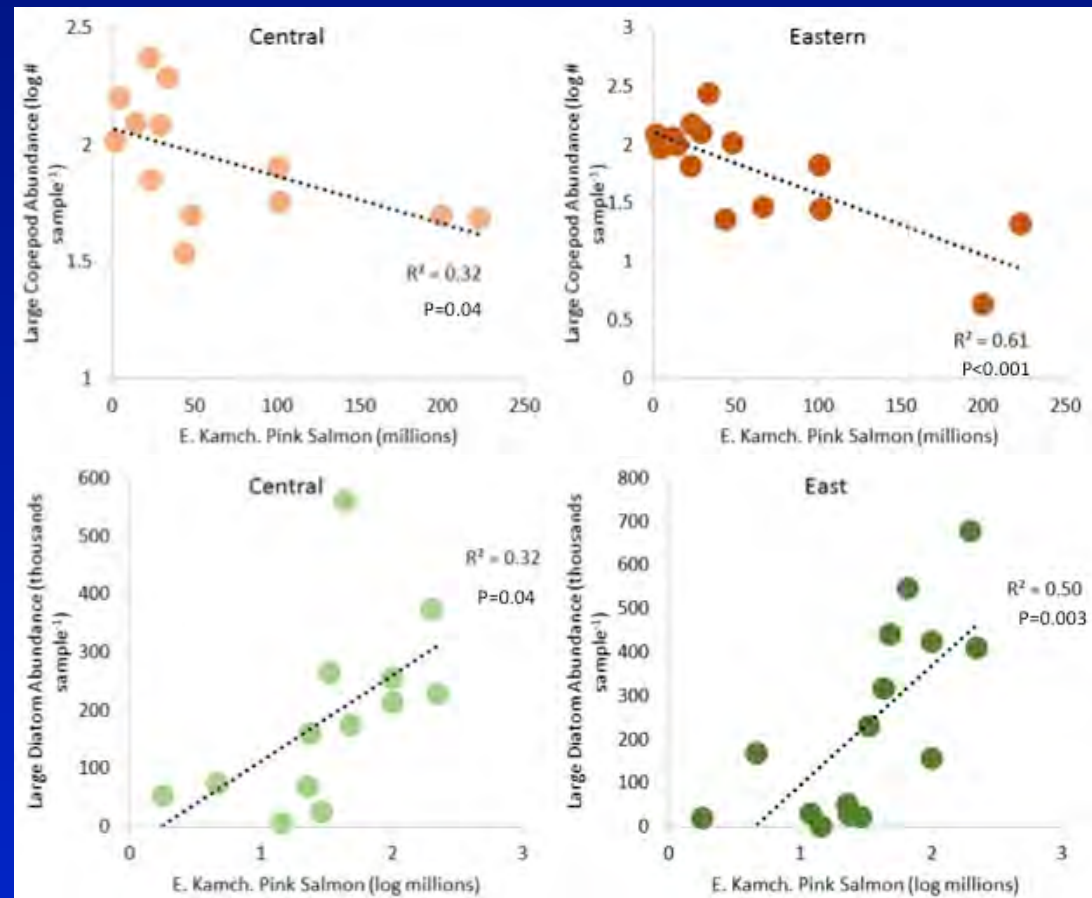
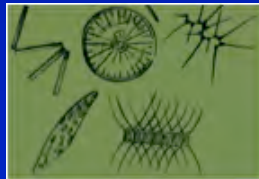
Do Pink Salmon Cause a Trophic Cascade?

Plankton response to Pink Salmon

Large copepods decline when pinks are abundant



Diatoms increase when few zooplankton and many pink salmon

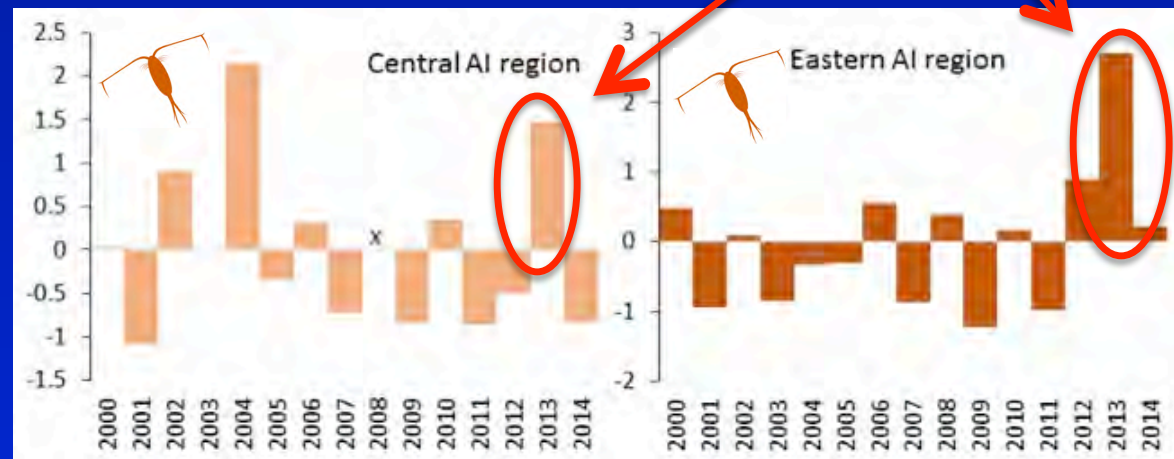
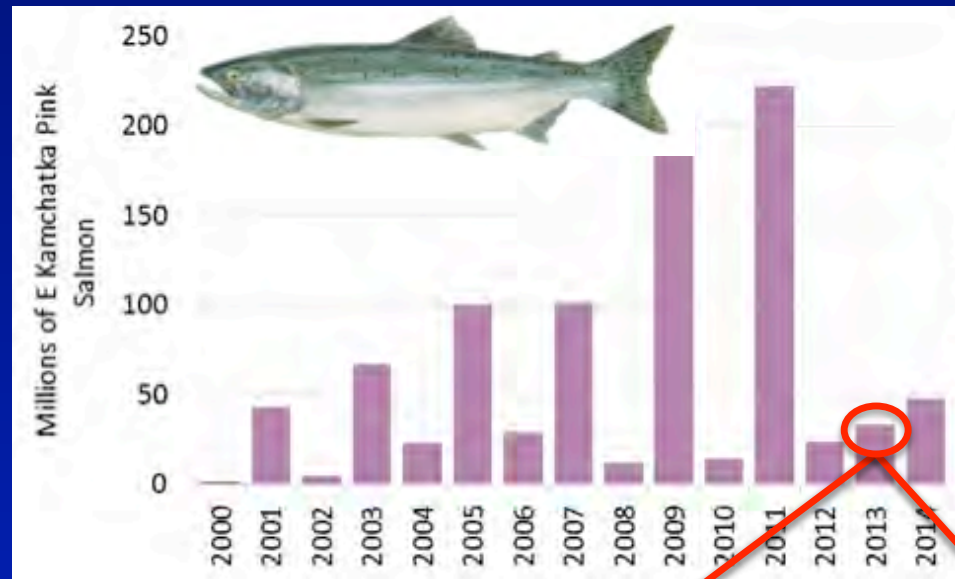


Do Pink Salmon Cause a Trophic Cascade?

2013:

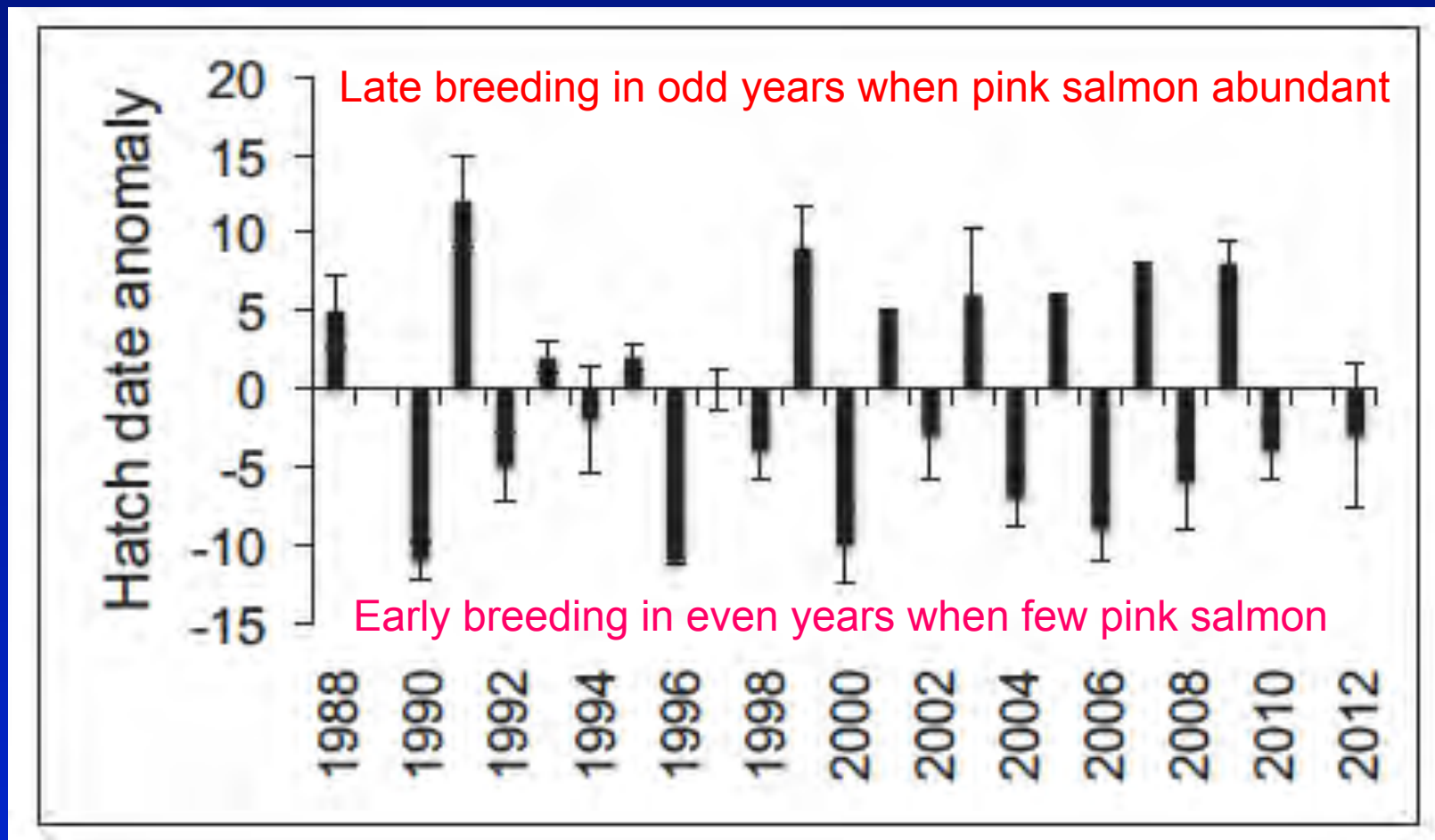
Eastern Kamchatka pink salmon unexpectedly crashed, and zooplankton rebounded sharply

- Patterns not apparent in Western Bering Sea
 - Higher zooplankton counts
 - Pinks not biennial



Do Pink Salmon Cause a Trophic Cascade?

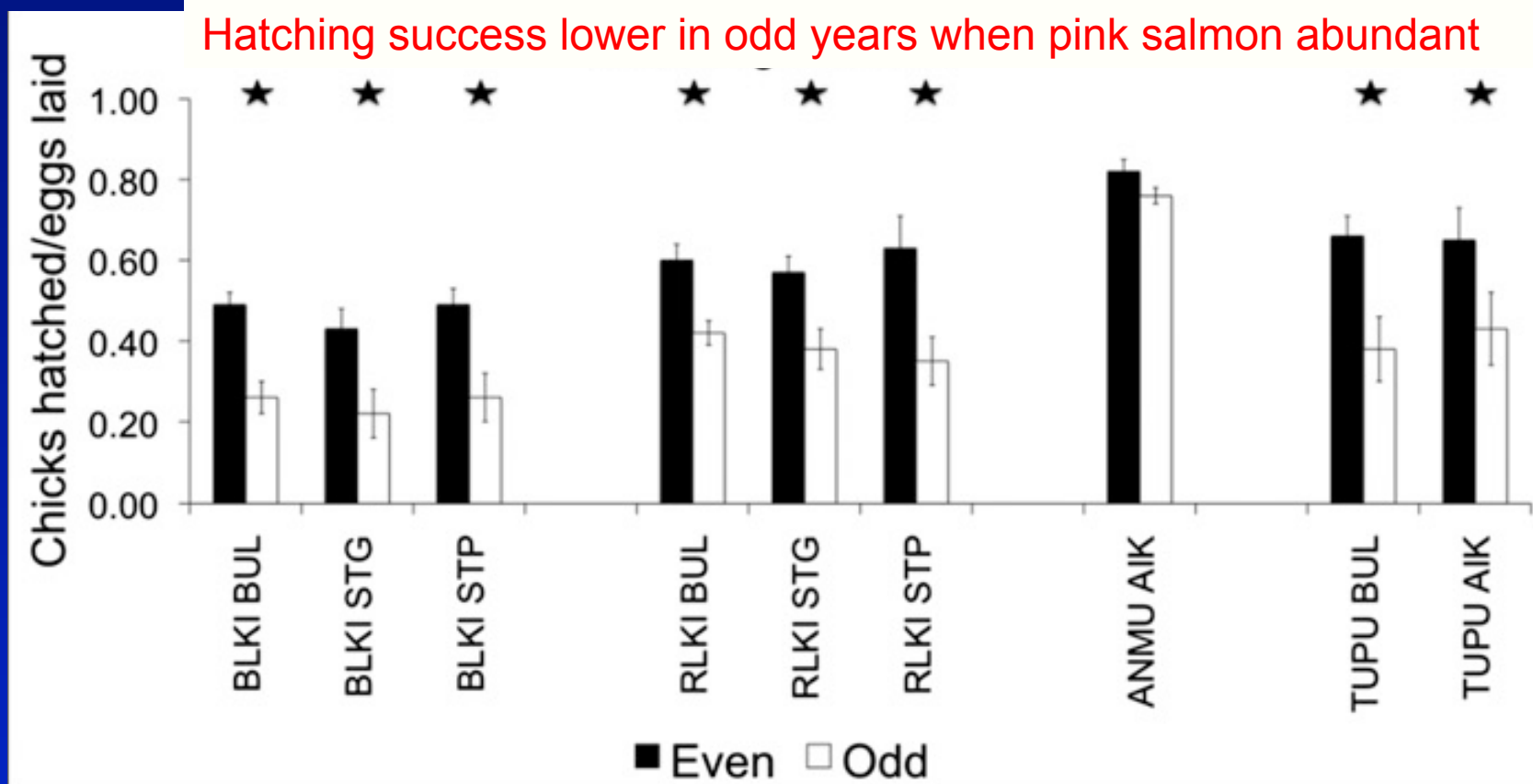
Tufted Puffins, Aleutian Islands



Springer and van Vliet (2014); no data in 1989, 2011

Do Pink Salmon Cause a Trophic Cascade?

Seabird Hatching Success Declines When Pink Salmon Abundant



- Negatively correlated with E Kamchatka pink salmon abundance
- Black-legged kittiwake (BLKI), Red-legged kittiwake (RLKI), Ancient murrelet (ANMU), Tufted puffin (TUPU)
- Buldir I (BUL), St George I (STG), St Paul Island (STP)

Springer and van Vliet (2014)

Pink Salmon Competition with Sockeye Salmon

Competition between Asian pink salmon (*Oncorhynchus gorbuscha*) and Alaskan sockeye salmon (*O. nerka*) in the North Pacific Ocean

Evidence for competitive dominance of Pink salmon (*Oncorhynchus gorbuscha*) over other Salmonids in the North Pacific Ocean



ARTICLE

Productivity and life history of sockeye salmon in relation to competition with pink and sockeye salmon in the North Pacific Ocean

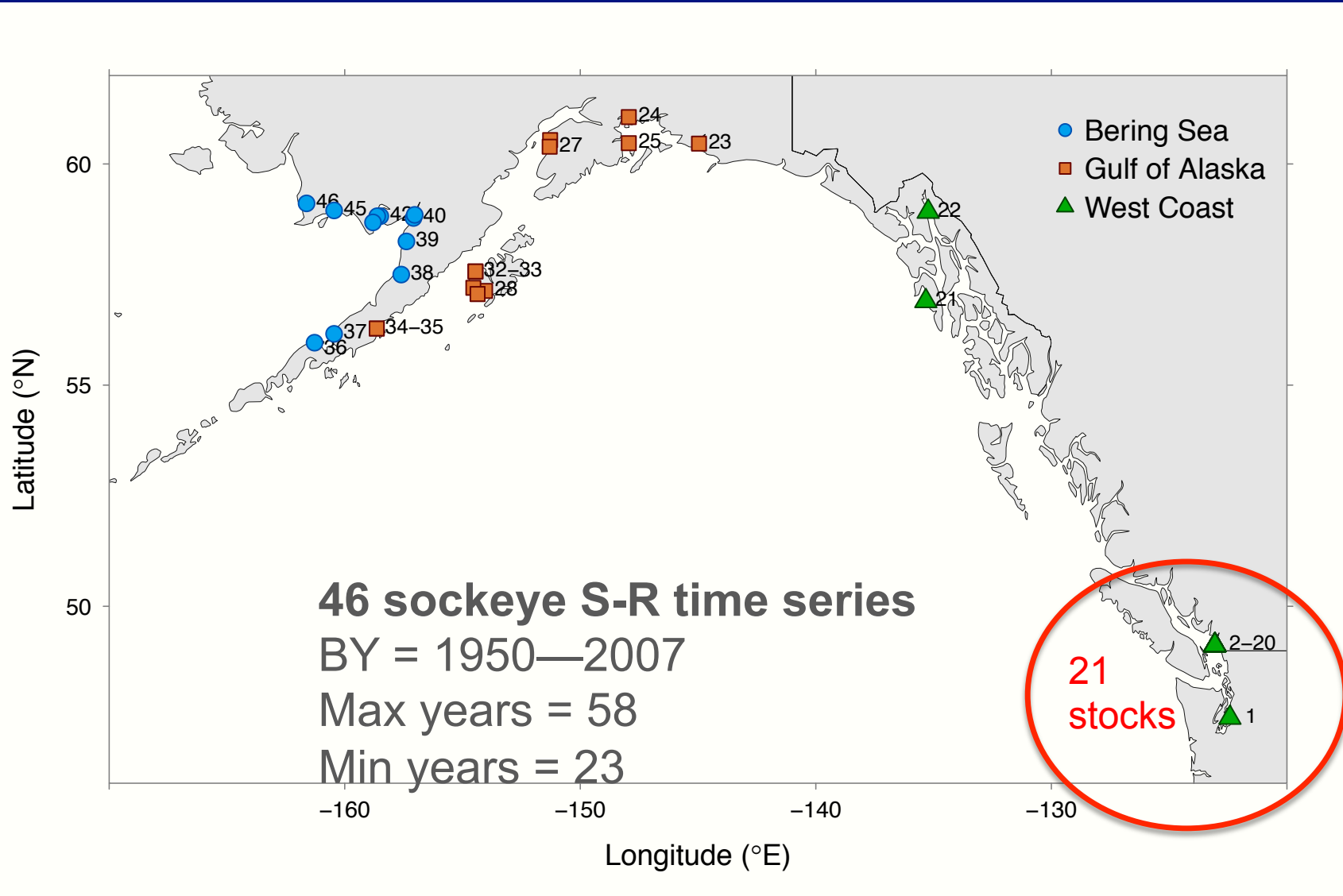
Influence of the marine abundance of pink (*Oncorhynchus gorbuscha*) and sockeye salmon (*O. nerka*) on growth of Ozernaya River sockeye

Pink and Sockeye Salmon Interactions at Sea and Their Influence on Forecast Error of Bristol Bay Sockeye Salmon

Evidence for Bottom-Up Effects on Pink and Chum Salmon Abundance and the Consequences for Other Salmon Species

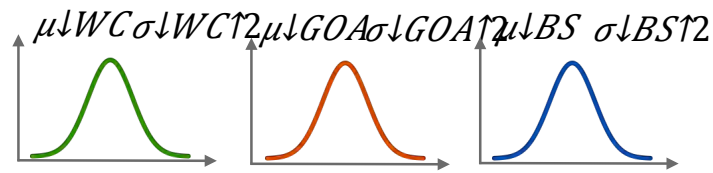
Seasonal marine growth of Bristol Bay sockeye salmon (*Oncorhynchus nerka*) in relation to competition with Asian pink salmon (*O. gorbuscha*) and the 1977 ocean regime shift

Is Pink Salmon Effect on Sockeye Mediated by Climate?

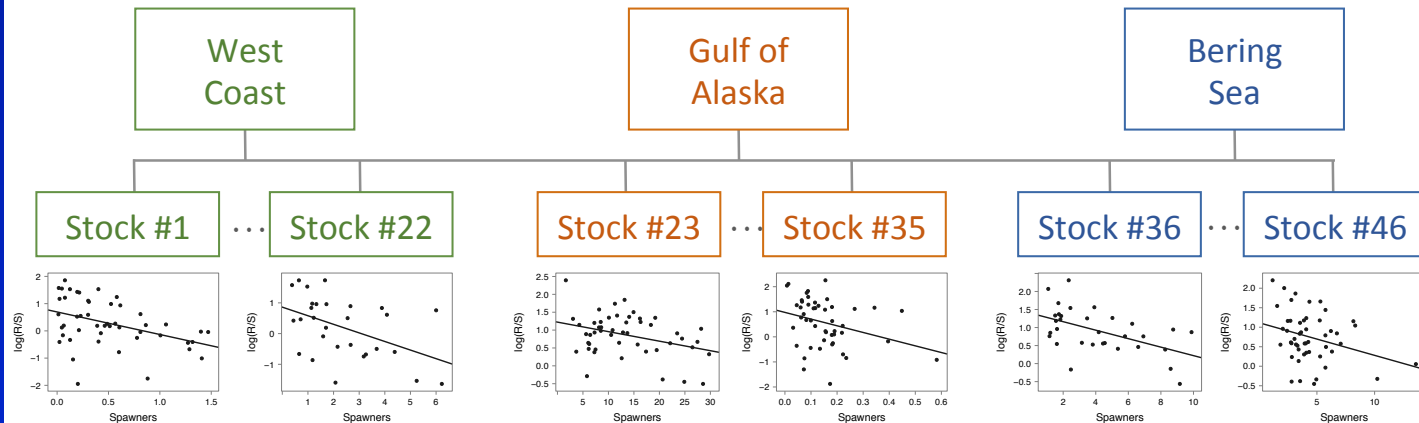


Pink Salmon Effect on Sockeye Mediated by Climate

Bayesian hierarchical models



$$\log(R_{li,t} / S_{li,t}) = \alpha_{li} + \beta_{li} S_{li,t} + \gamma_{li} SST_{li,t} + \kappa_{li} Comp_{li,t} + \chi_{li} (SST_{li,t} Comp_{li,t}) +$$



Pink Salmon Effect on Sockeye Mediated by Climate

West Coast:

- Moderate negative SST effect
- Strong adverse effect of pink salmon
- Small negative interaction (sockeye more vulnerable to pinks when high SST)

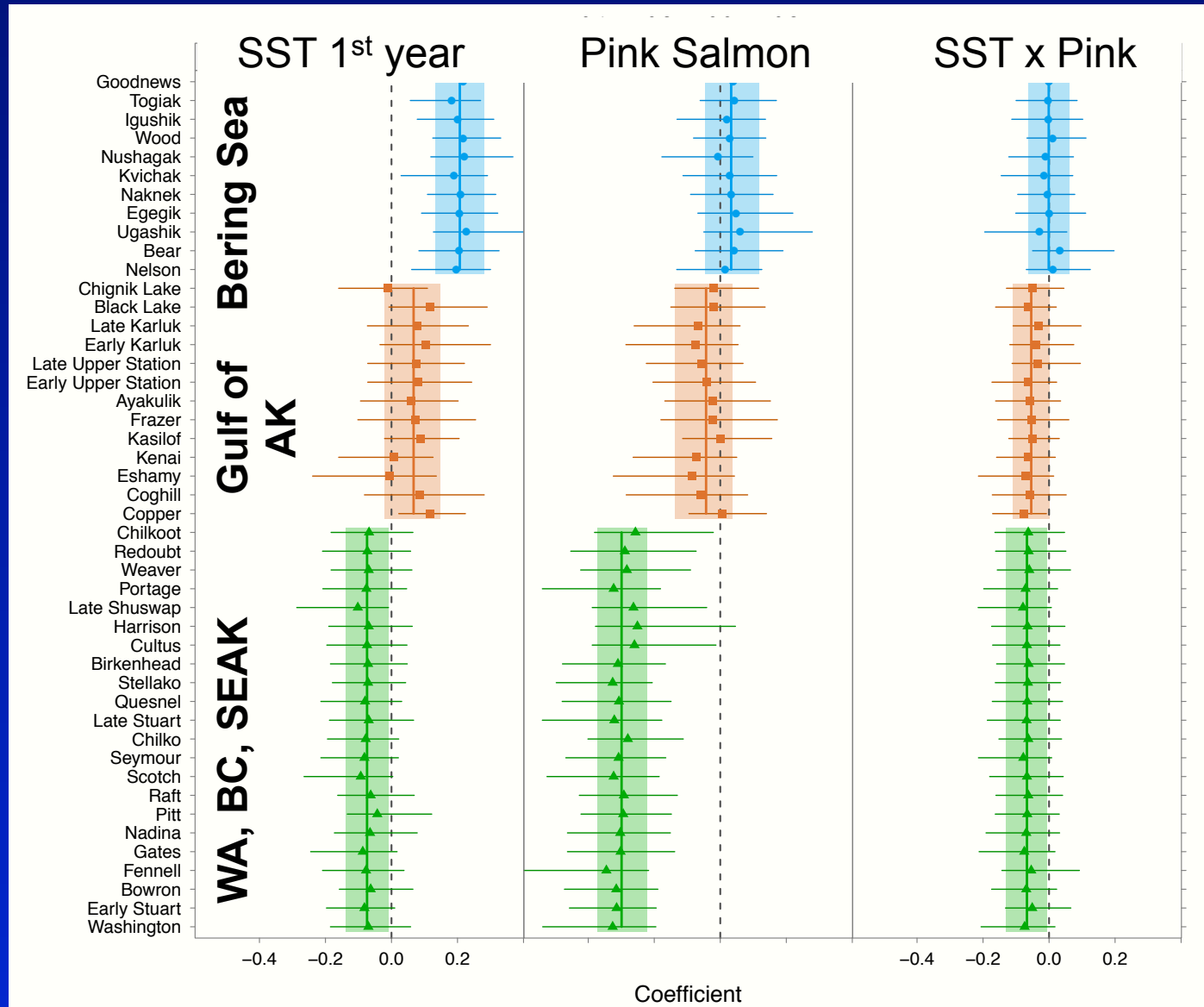
Bering Sea:

- Strong + SST effect
- No pink effect detected

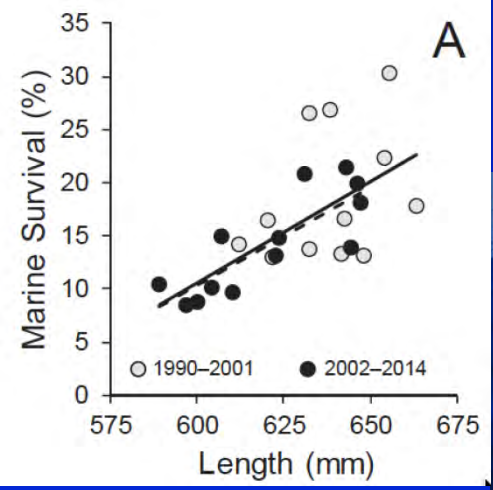
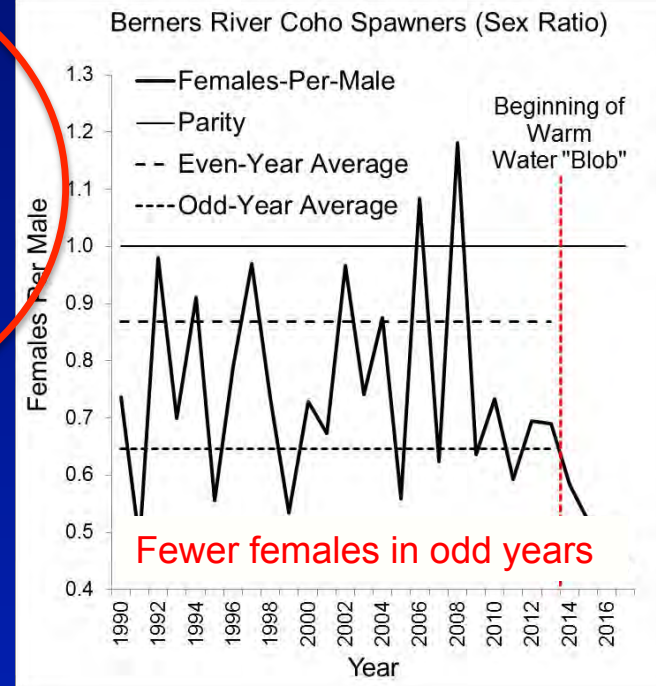
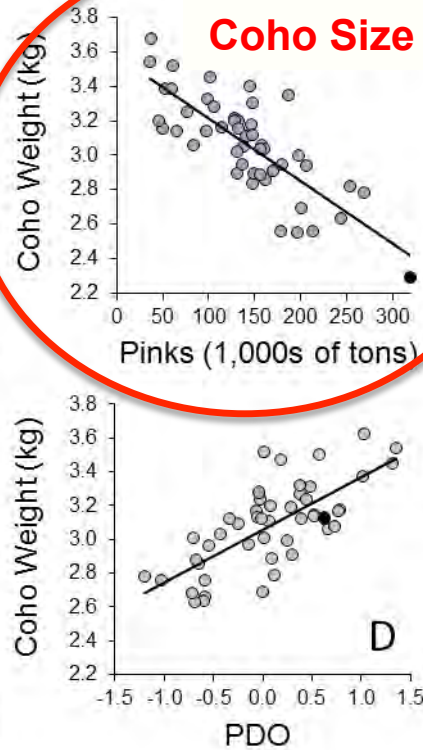
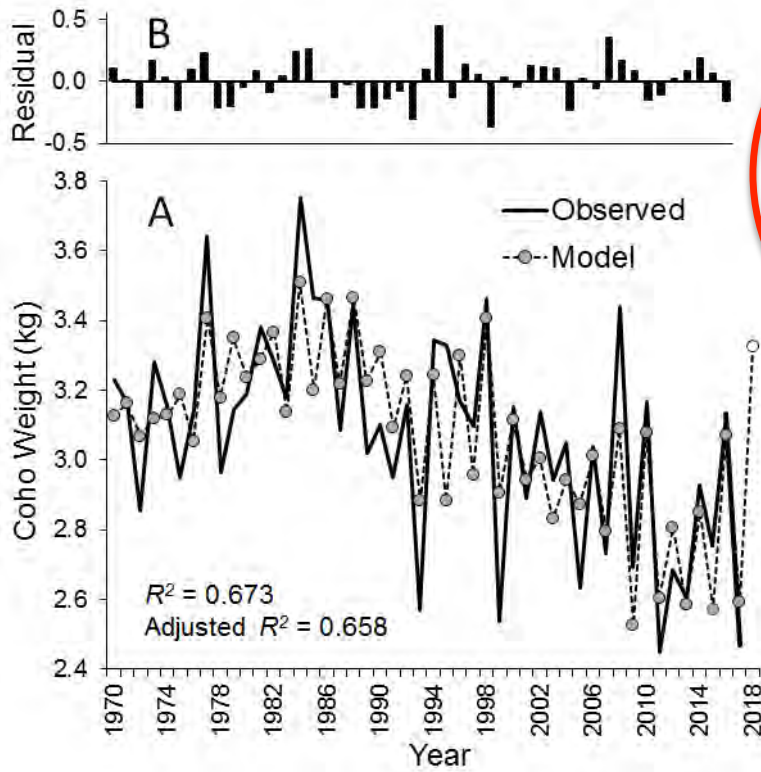
Gulf of AK

- Moderate + SST effect
- No pink effect detected

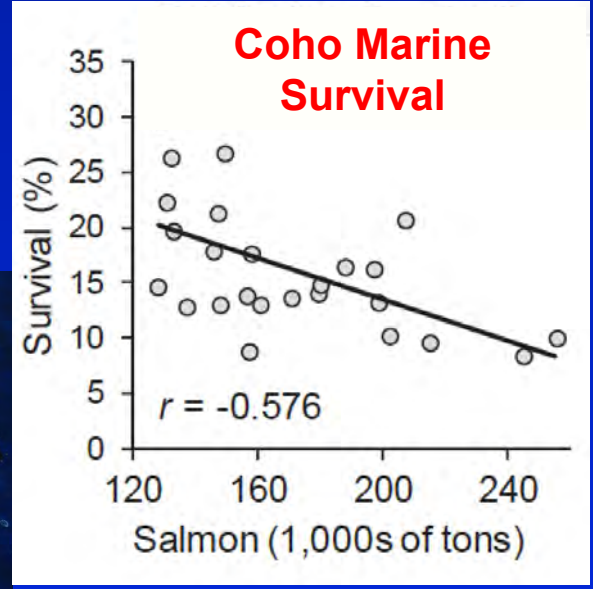
Good early ocean conditions in North benefit both pinks and sockeye & mask pink effect; age diversity masks pink effect



Do Pink Salmon Impact SEAK Coho Salmon?

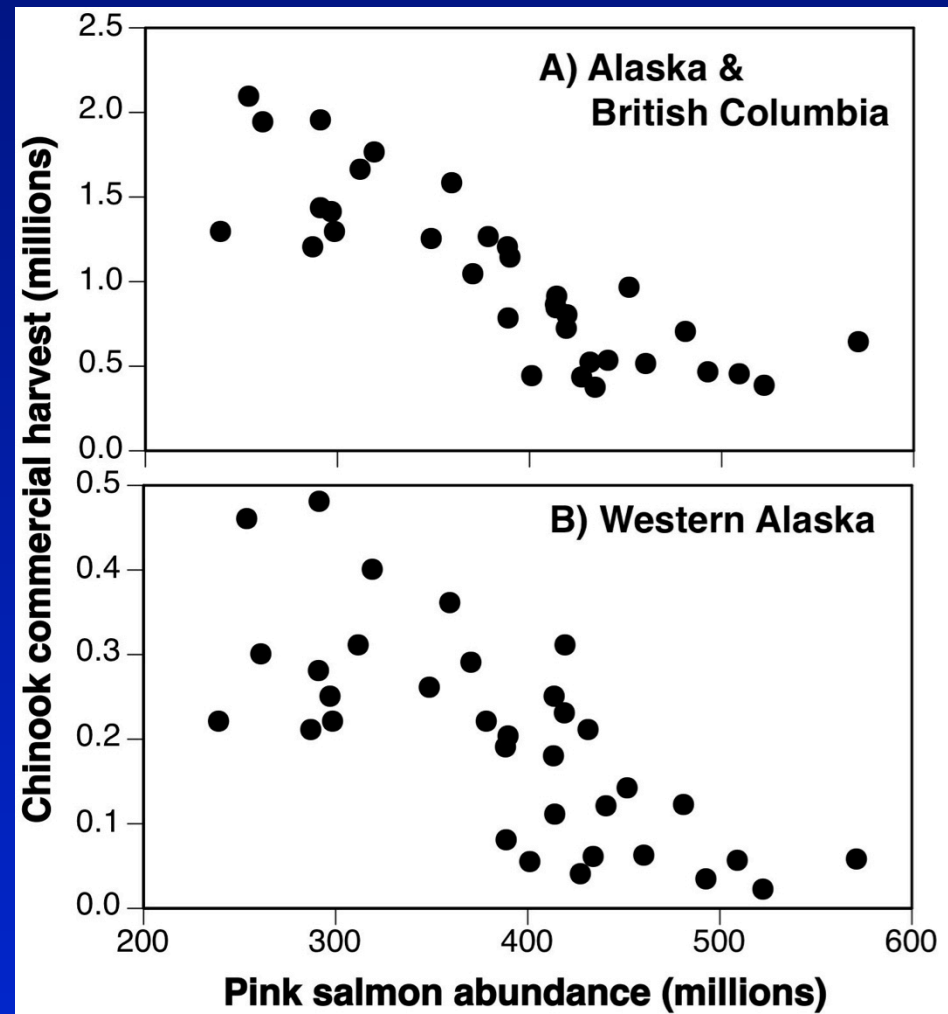


See supporting analyses
Shaul and Geiger 2014

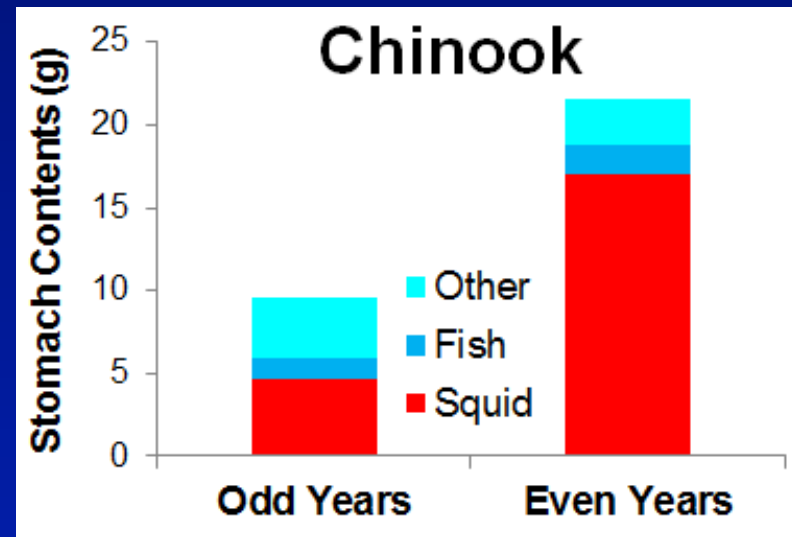
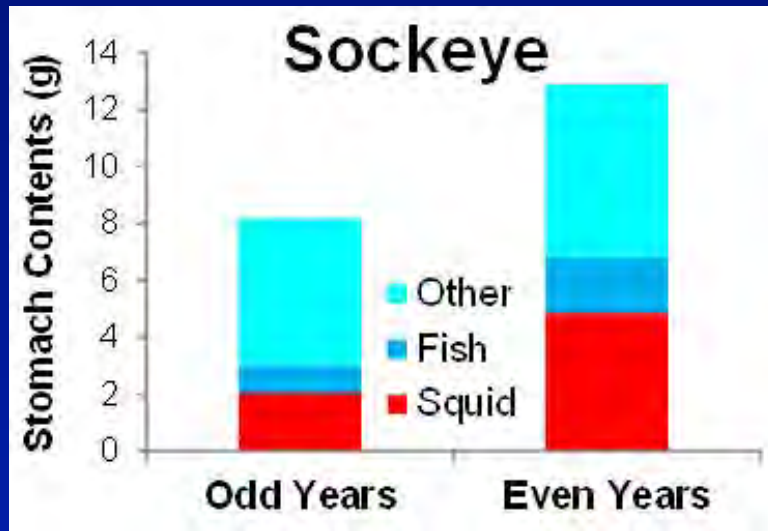


Are Pink Salmon Reducing Chinook Survival?

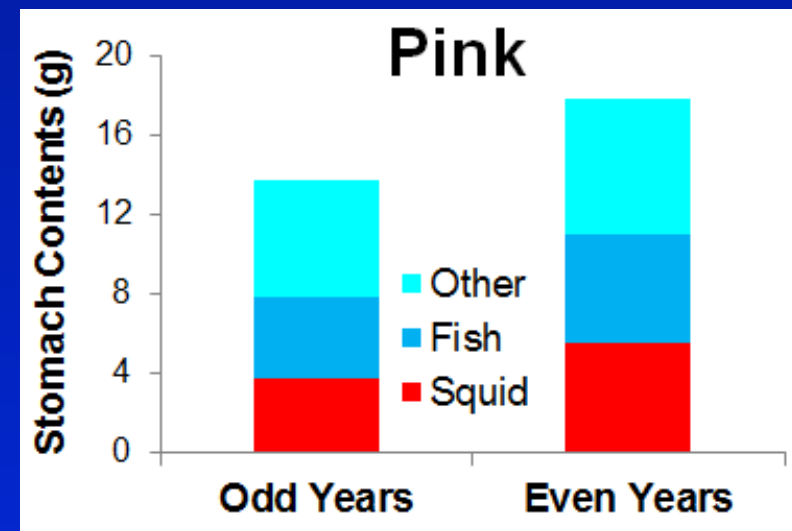
- Chinook abundance depressed throughout Alaska.
- Several new Stocks of Concern listings in SEAK.
- Long-term decline in size at age & age at maturation (Lewis et al. 2015)
- Pink abundance averaged over 3 yrs of overlap with Chinook



Are Pink Salmon Reducing Chinook Growth & Survival?



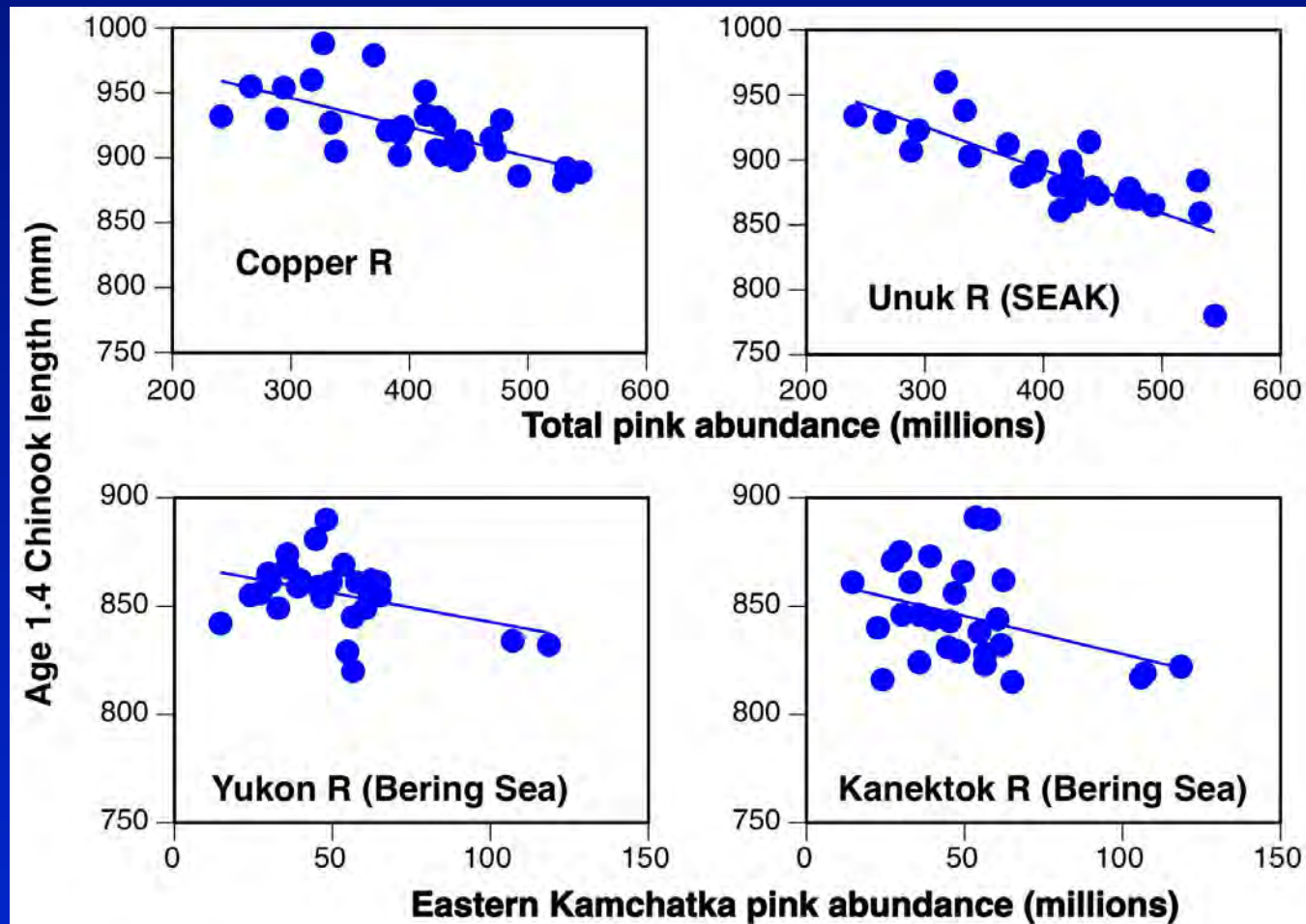
- Chinook feed at higher trophic level, but diet overlap (squid, fish)
- **Bering Sea:** In odd-yrs, 56% decline in Chinook stomach fullness; 68% reduction in squid & fish, 1991-2000 (Davis 2003)



Davis 2003

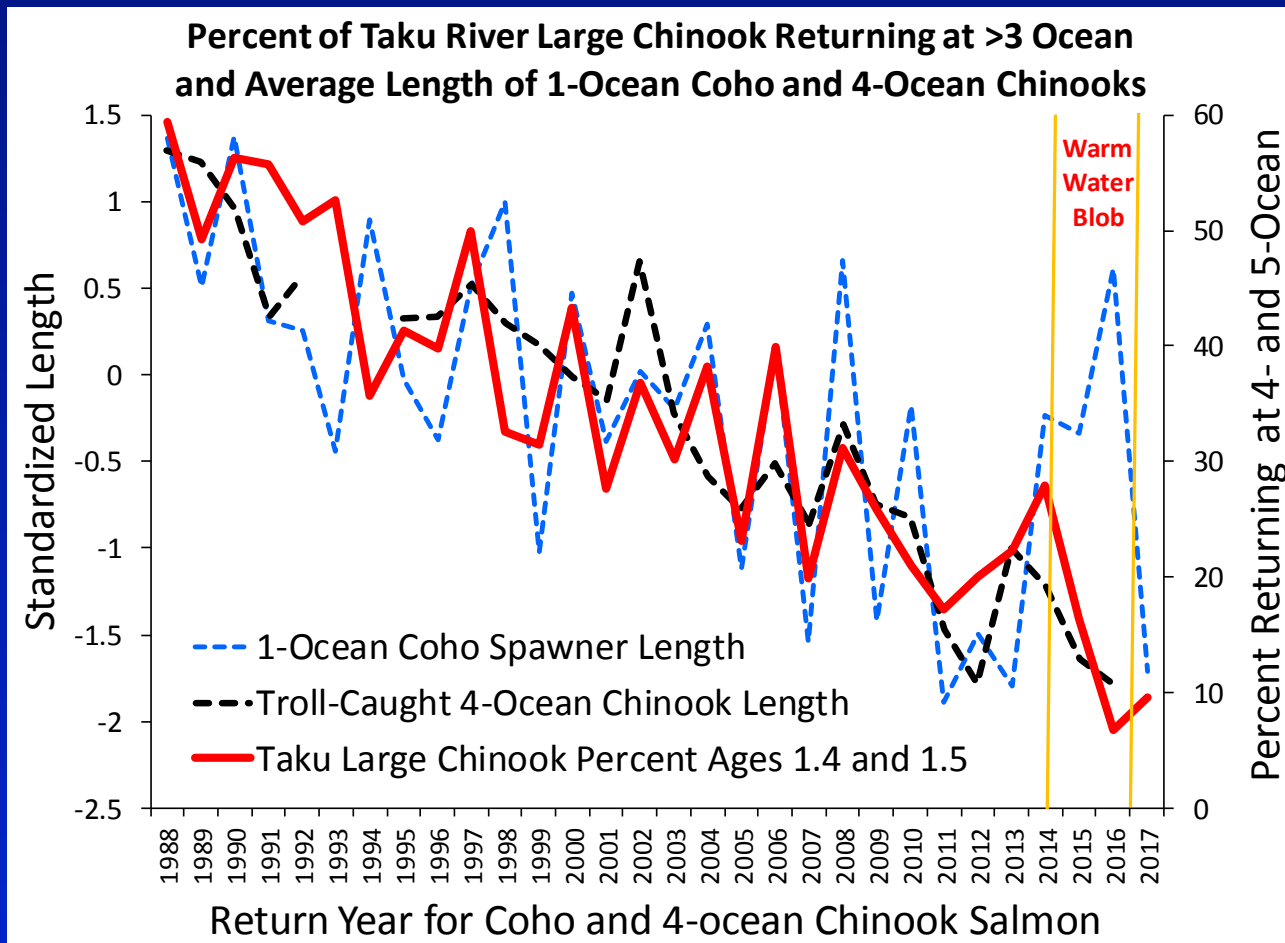
Do Pink Salmon Impact Chinook Salmon?

Chinook Length on pink salmon abundance



Chinook length data source: Lewis et al. 2015

Are Chinook Finding Enough to Eat? Is Late Ocean Mortality Increasing?



15 of 28 (54%) large tagged Chinook died via large predators (mostly salmon sharks). 71% of large salmon succumbed to natural mortality

Andy Seitz, UoA

Hypothesis for Decline of Chinook Salmon

- The North Pacific Ocean is supporting more pink, chum, and sockeye than ever before.
- High abundances of these species, especially pink salmon, cause a trophic cascade that reduces prey availability for higher trophic species such as Chinook and coho salmon in offshore areas.
- This trophic cascade leads to reduced growth of both Chinook and coho salmon in offshore areas.
- Reduced growth at later life stages affects overall survival, especially females, and this contributes to the observed younger age-at-maturation in Chinook salmon and low female/male ratio of Chinook & coho.

Shaul, L.D., and H.J. Geiger. 2016. Effects of climate and competition for off shore prey on growth, survival, and reproductive potential of coho salmon in Southeast Alaska. North Pacific Anadromous Fish Commission Bulletin 6:329–347.

Ruggerone, G.T., B.M. Connors, B.A. Agler, L.I. Wilson, and D.C. Gwinn. 2016. Growth, age at maturation, and survival of Yukon, Kuskokwim, and Nushagak Chinook salmon. Final report to Arctic-Yukon-Kuskokwim Sustainable Salmon Initiative, Anchorage, Alaska.

Questions?

"Nobody goes there anymore. It's too crowded."

Y. Berra 1998

