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

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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

Ruggerone and Irvine 2018
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)

Ruggerone and Irvine 2018
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

Ruggerone and Irvine 2018
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?

Batten et al. 2018
Do Pink Salmon Cause a Trophic Cascade?

Plankton response to Pink Salmon

Large copepods decline when pinks abundant

Diatoms increase when few zooplankton and many pink salmon

Batten et al. 2018
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

Batten et al. 2018
Do Pink Salmon Cause a Trophic Cascade?
Tufted Puffins, Aleutian Islands

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

Late breeding in odd years when pink salmon abundant
Early breeding in even years when few pink salmon
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)

Hatching success lower in odd years when pink salmon abundant

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

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?

46 sockeye S-R time series
BY = 1950—2007
Max years = 58
Min years = 23

NCEAS-SASAP-Salmon Ocean Climate Group
Pink Salmon Effect on Sockeye Mediated by Climate

Bayesian hierarchical models

\[
\log(R_{li,t}/S_{li,t}) = \alpha_i + \beta_i S_{li,t} + \gamma_i SST_{li,t} + \kappa_i Compl_{li,t} + \chi_i (SST_{li,t} Compl_{li,t}) + \epsilon_{li,t}
\]
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

NCEAS-SASAP-Salmon Ocean Climate Group: preliminary findings
Do Pink Salmon Impact SEAK Coho Salmon?

See supporting analyses
Shaul and Geiger 2014

Fewer females in odd years
Coho Marine Survival

R^2 = 0.673
Adjusted R^2 = 0.658
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

Ruggerone et al. 2016
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)
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?

Taku Chinook data courtesy of Jeff Williams (ADF&G)

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.


Questions?

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

Y. Berra 1998