Apr 5th, 1:45 PM - 2:00 PM

Comparing marine survival among Chinook and coho salmon and steelhead trout in the Salish Sea

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Salish Sea Marine Survival Project Ecosystem Indicators Development: Can We Exploit Common Trends?

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NEALA KENDALL, ERIC WARD

SALISH SEA
MARINE SURVIVAL PROJECT
www.marinesurvivalproject.com

Photo Credit: Tavish Campbell

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ORIGINAL ARTICLE

WILEY FISHERIES OCEANOGRAPHY

Salish Sea Chinook salmon exhibit weaker coherence in early marine survival trends than coastal populations

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Abstract

Identifying factors that influence anadromous Pa
population dynamics is complicated by their dive
graphic range. Over the last several decades, Chino

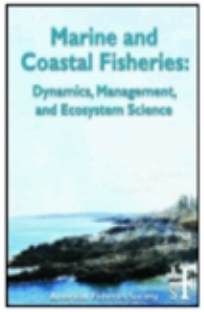
NRC Research Press

ARTICLE

Declining patterns of Pacific Northwest steelhead trout (*Oncorhynchus mykiss*) adult abundance and smolt survival in the ocean

Neala W. Kendall, Gary W. Marston, and Matthew M. Klungle

Abstract: Examination of population abundance and survival trends over space and time can guide management and conservation actions with information about the spatial and temporal scale of factors affecting them. Here, we analyzed steelhead trout (anadromous *Oncorhynchus mykiss*) adult abundance time series from 35 coastal British Columbia and Washington populations along with smolt-to-adult return (smolt survival) time series from 48 populations from Washington, Oregon, and the Keogh River



Marine and Coastal Fisheries
Dynamics, Management, and Ecosyster

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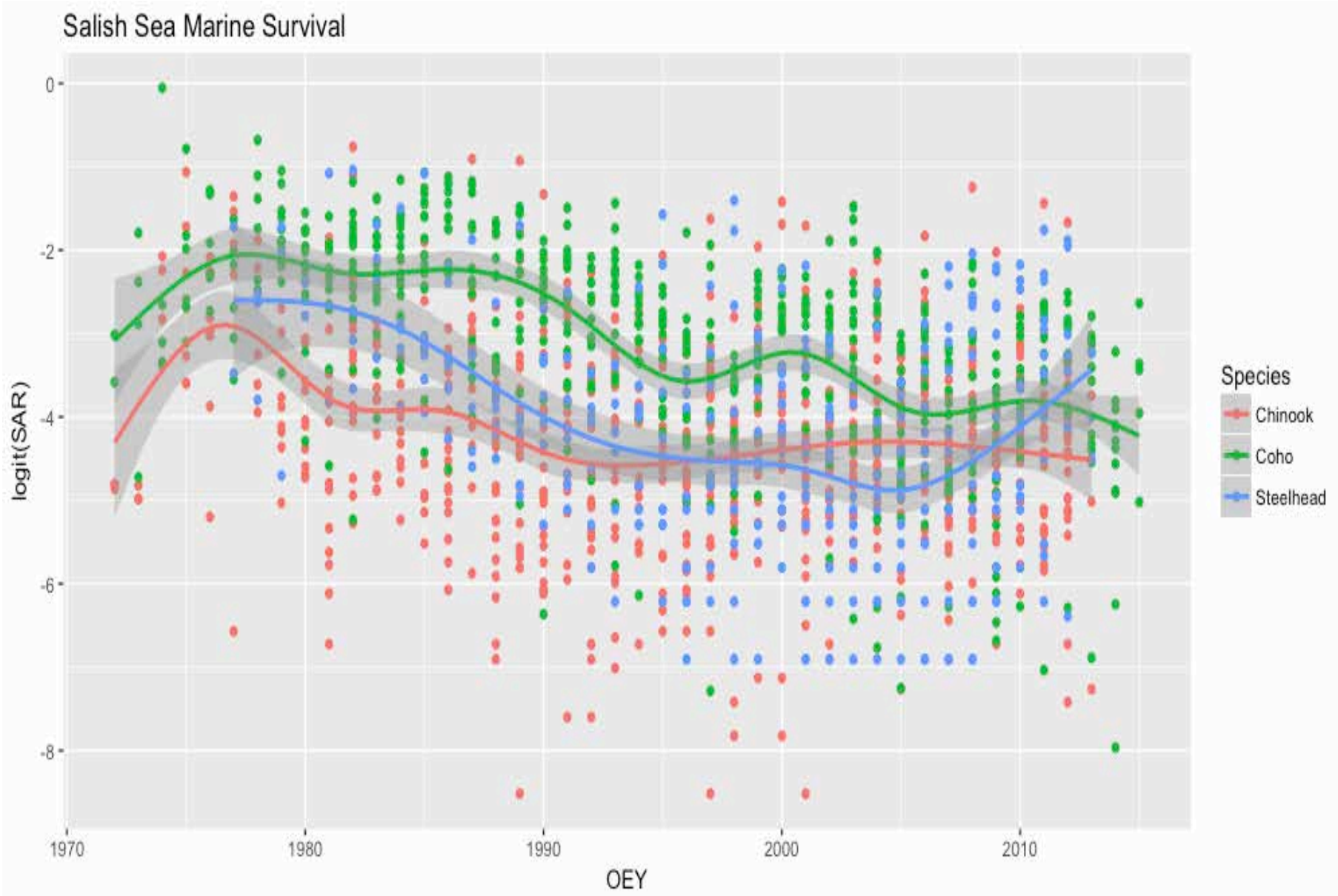
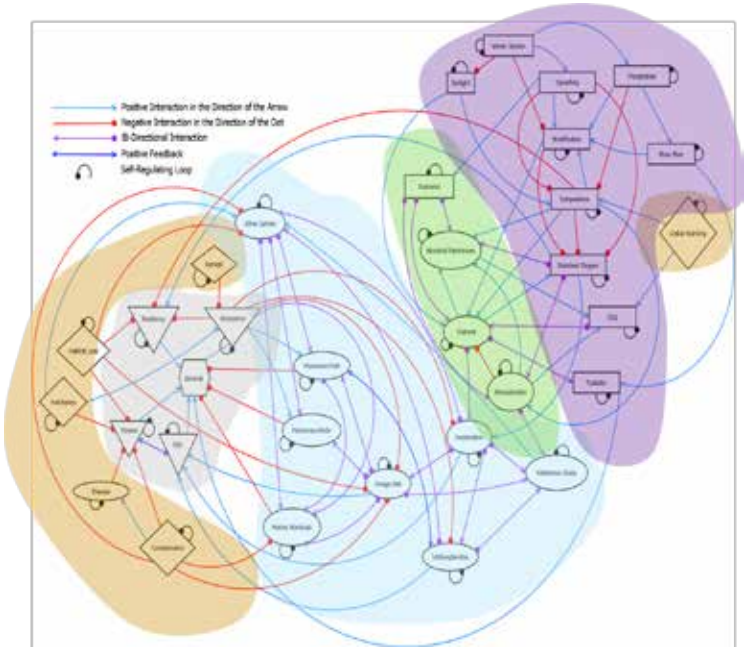
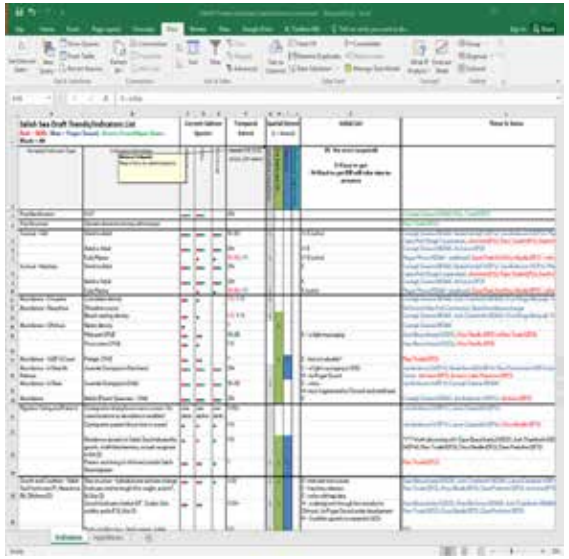
Spatial and Temporal Patterns in Smolt Survival of Wild and Hatchery Coho Salmon in the Salish Sea

Mara S. Zimmerman, James R. Irvine, Meghan O'Neill, Joseph H. Anderson, Correigh M. Greene, Joshua Weinheimer, Marc Trudel & Kit Rawson

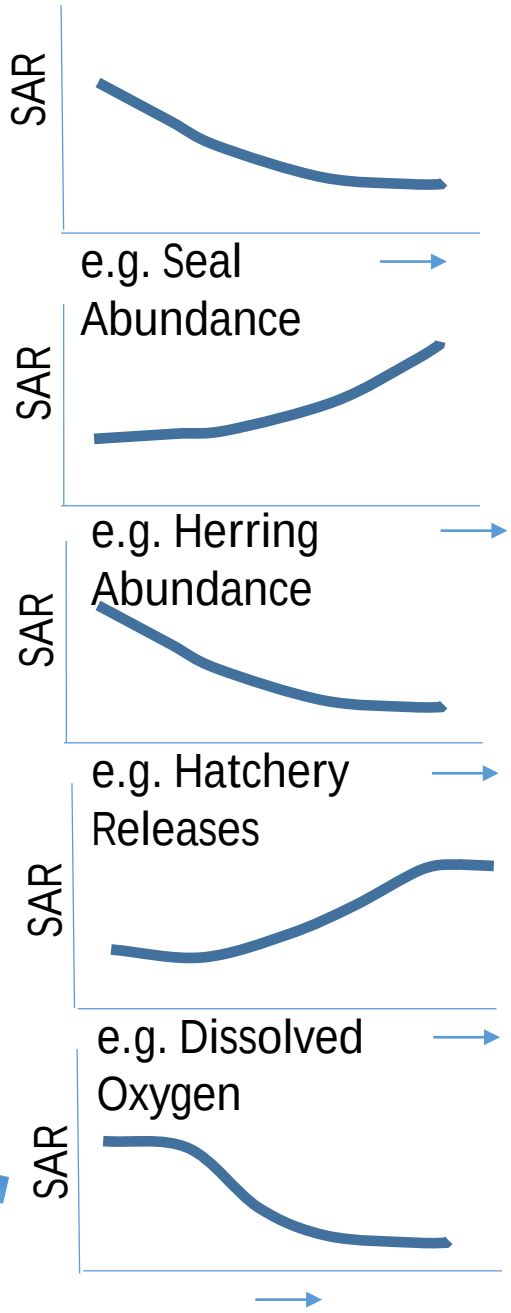

Salish Sea Marine Survival
0
-2
-4
-6
-8
logit(SAR)
1970
1980
1990
2000
2010
OEY
Species
Chinook
Coho
Steelhead



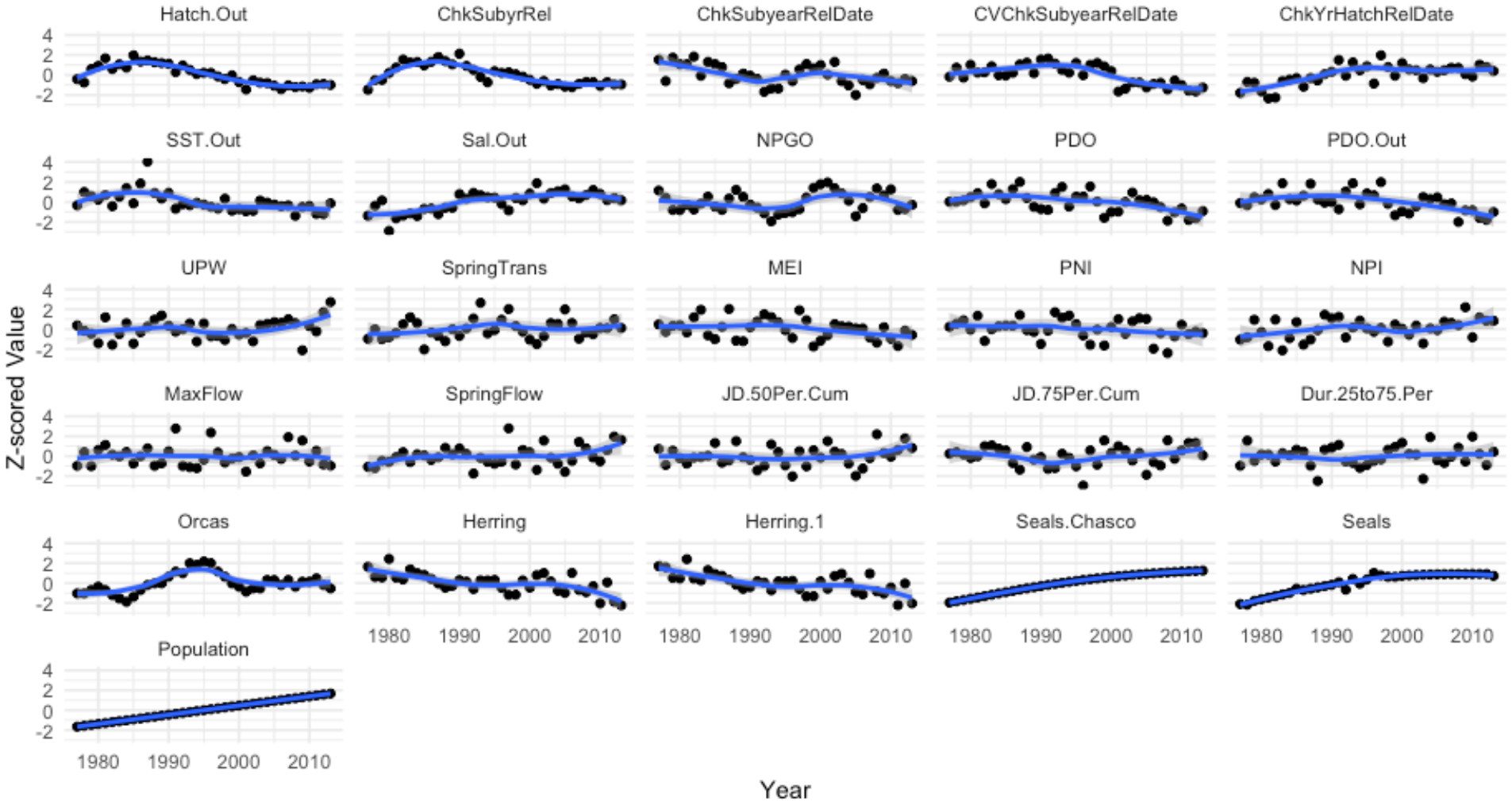


Sobocinski et al. 2017, Env. Conservation

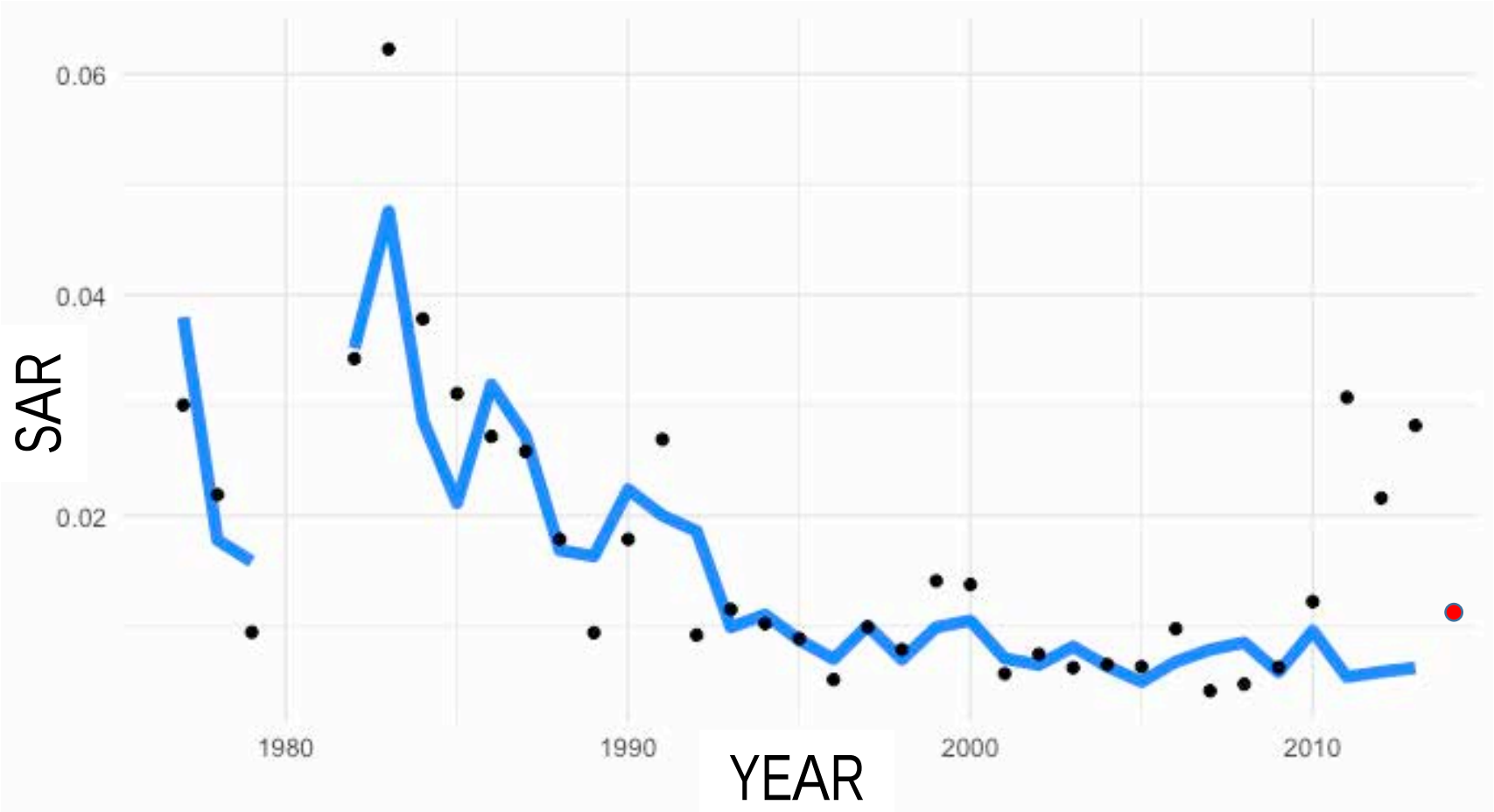
$$Y=\beta_0+\beta_1X_1+\beta_2X_2+\ldots\beta_nX_n+\varepsilon$$



Data and Time Series



Steelhead Statistical Model

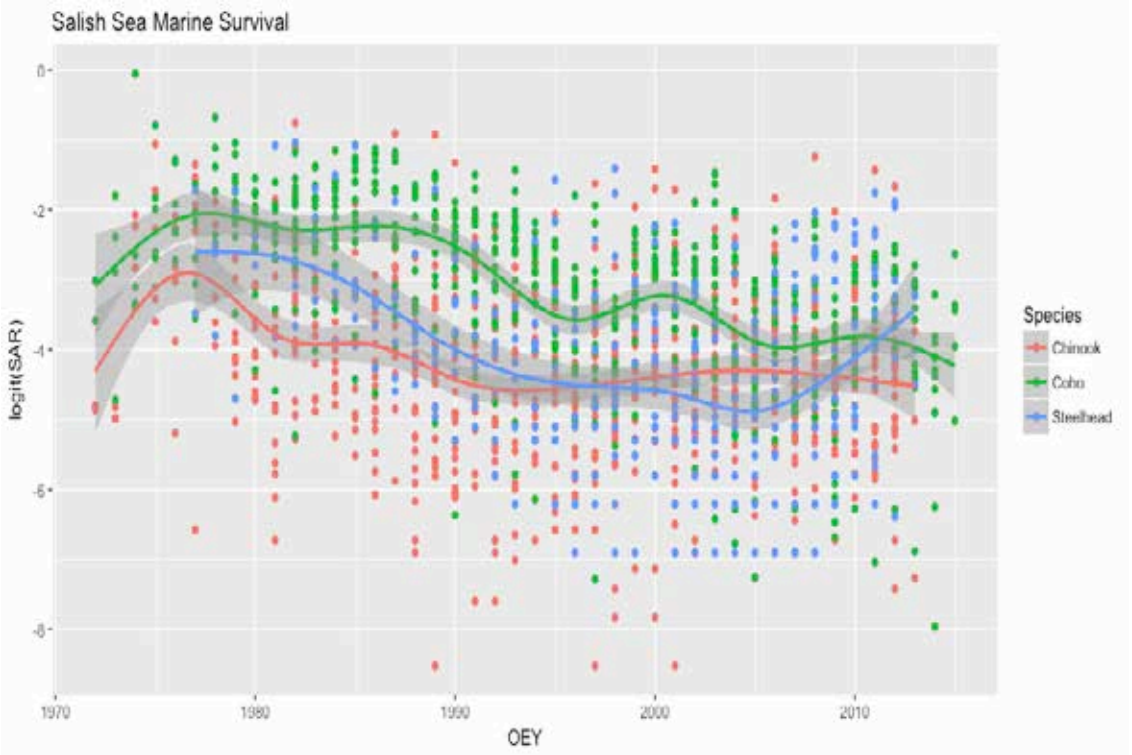


SAR (Runsize/Smolts) ~
Year + Subyear. CHK Hatch. Rel. + CV of Release Date + SST in Puget Sound + PDO + NPI + Seal Abundance

Challenges

- Correlated variables can explain variance, but may not be the most important factors to consider
- Indirect effects are not captured well
- Potentially important data streams don't exist (e.g. forage fish, zooplankton, fish predators)
- Model is light on "ecosystem" indicators—may not be the best model for forecasting

Looking forward to Chinook and coho indicators…



Are there common trends among species or within regions that may help focus indicator development?

Trends Analysis

- **Q1: Is there a common trend among all 3 species?**
  If so, what are the inflexion points?
- **Q2: Are there coherent trends among species within regions?**
  For subbasins with all 3 species, do we see a common trend?
- **Q3: Are there characteristics of hatchery released fish that explain common trends?**

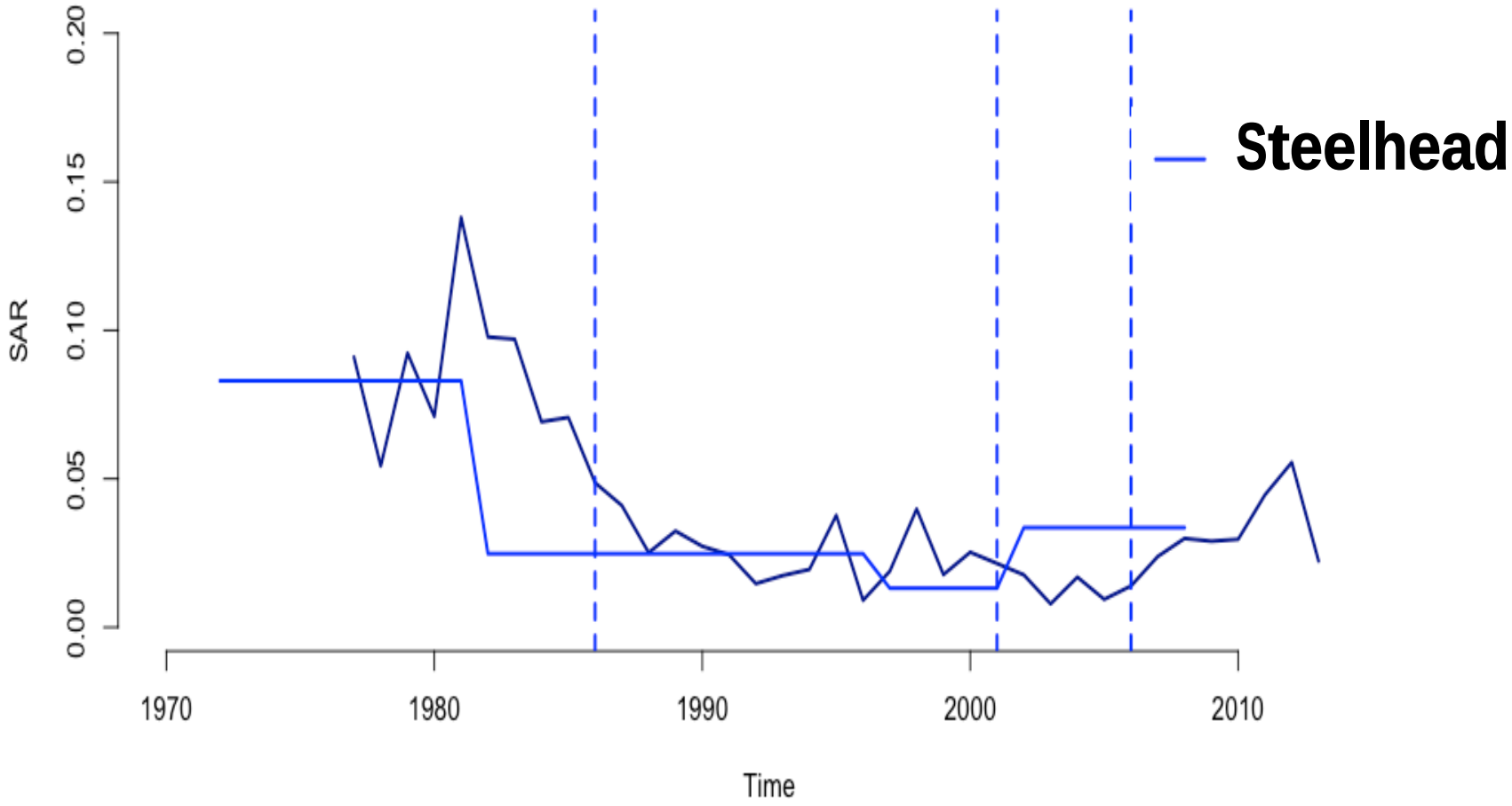
Use two techniques:

Breakpoint analysis and MARSS modeling

Q1. Common Trends Among Species

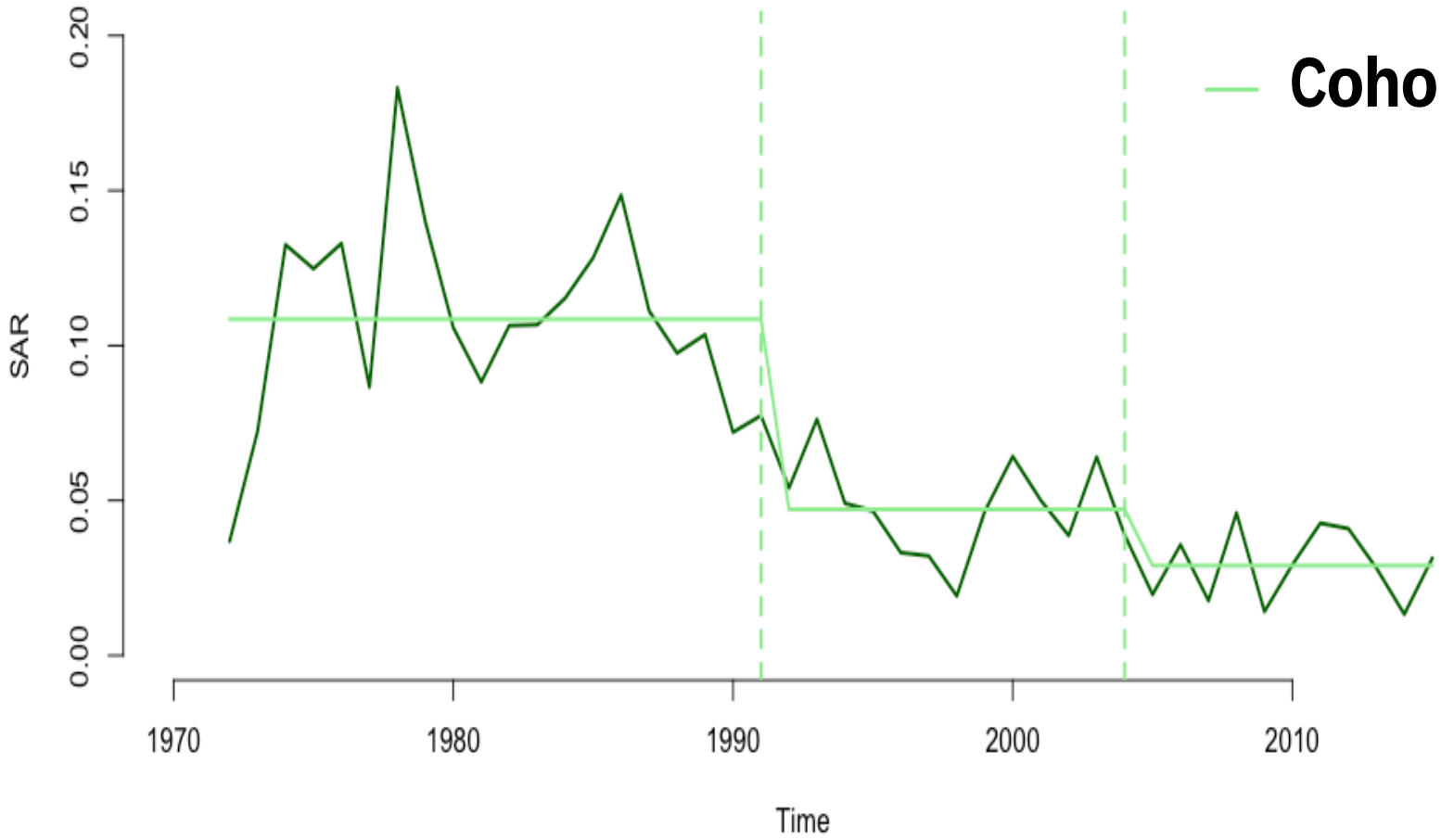
Break Points: Is there a common time period where we see the trends change?

Q1. Common Trends Among Species



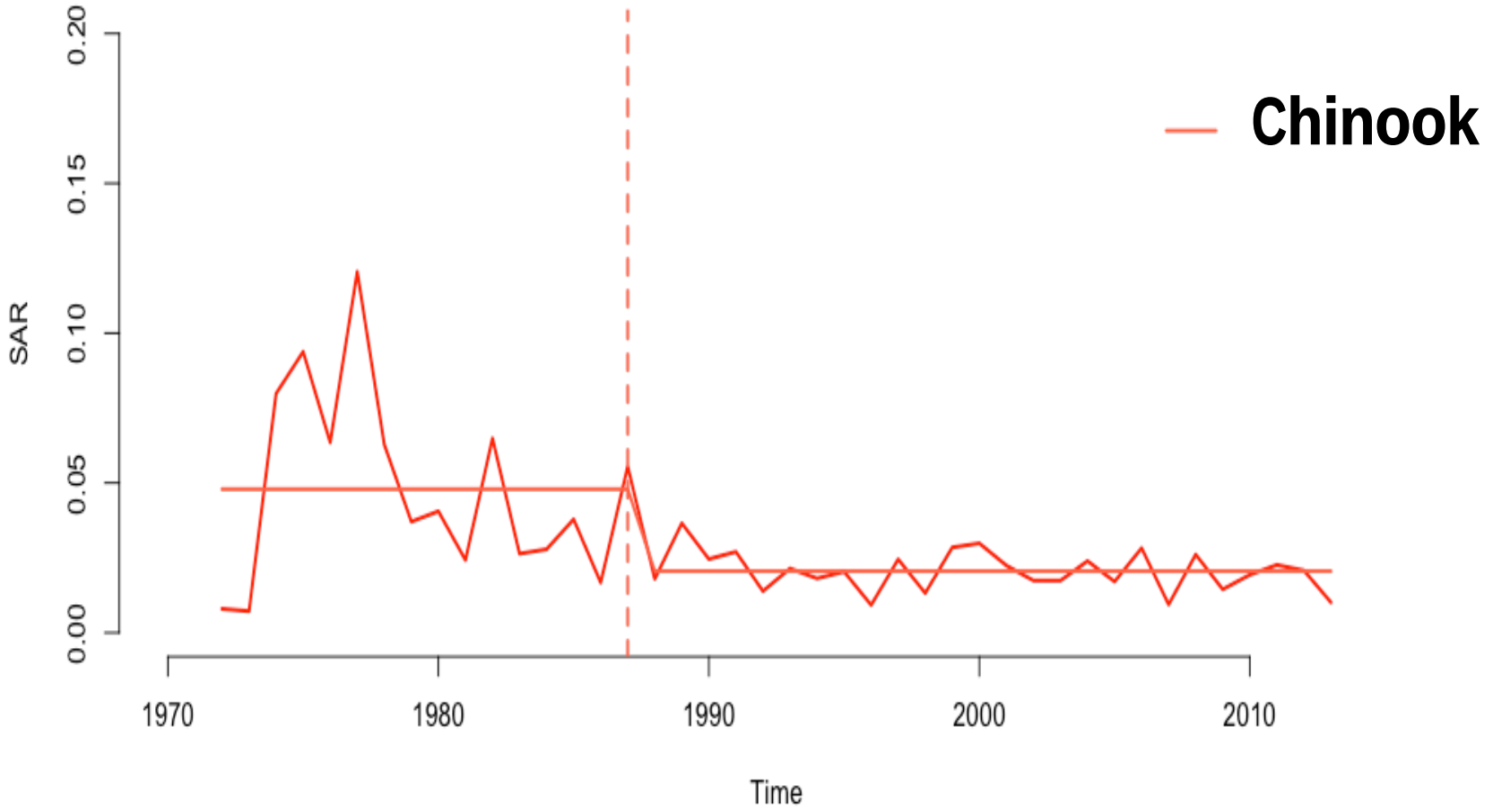
3 breakpoints: 1986, 2001, 2006

Q1. Common Trends Among Species



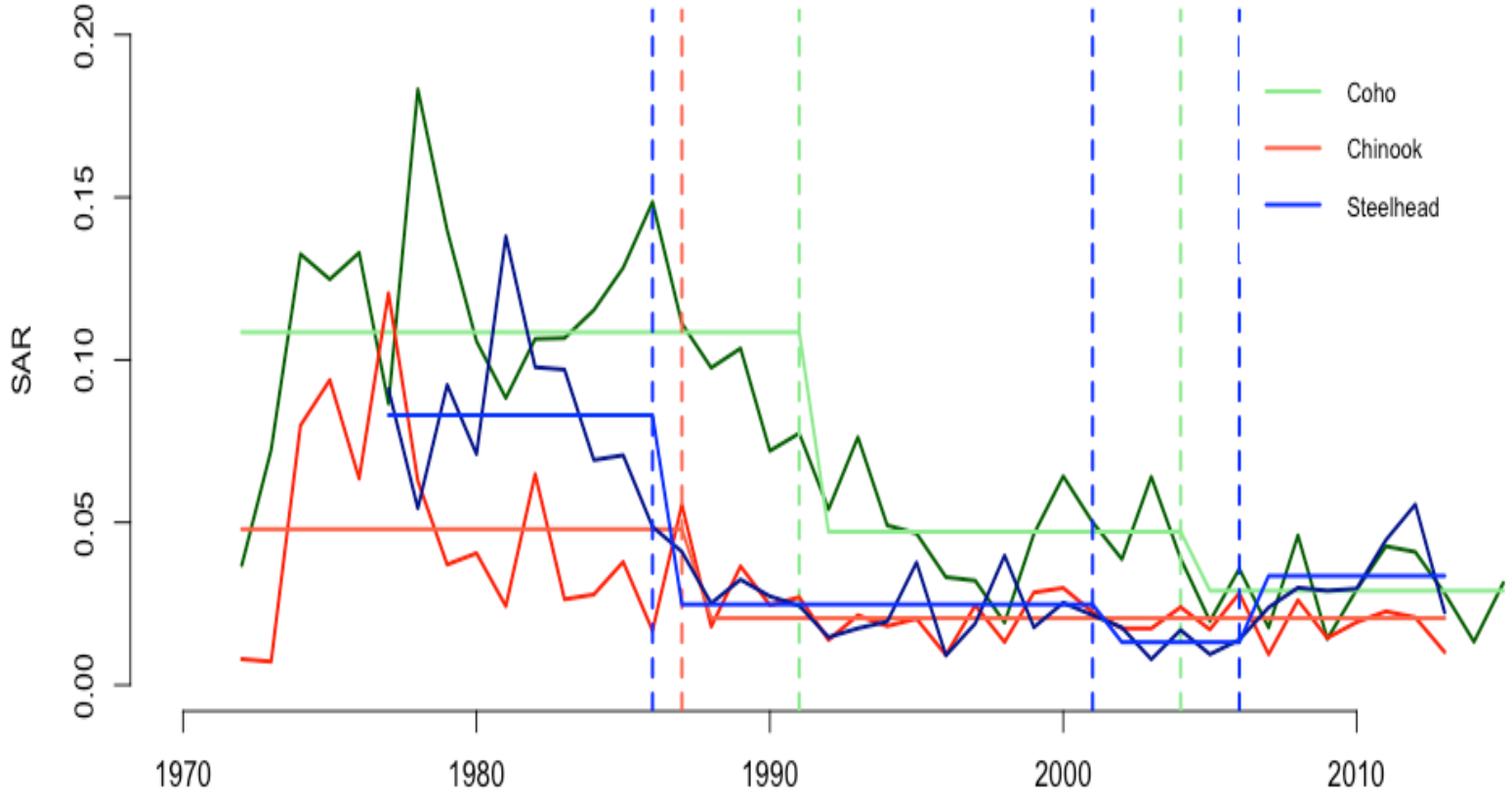
2 breakpoints: 1991, 2004

Q1. Common Trends Among Species



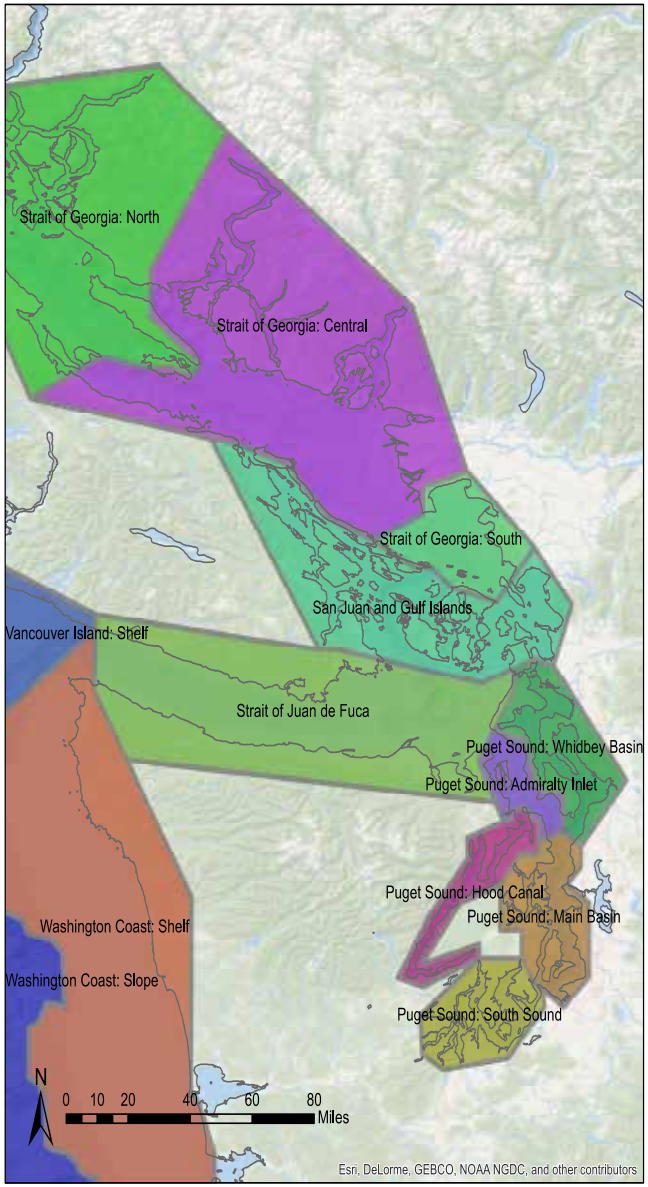
1 breakpoint: 1987

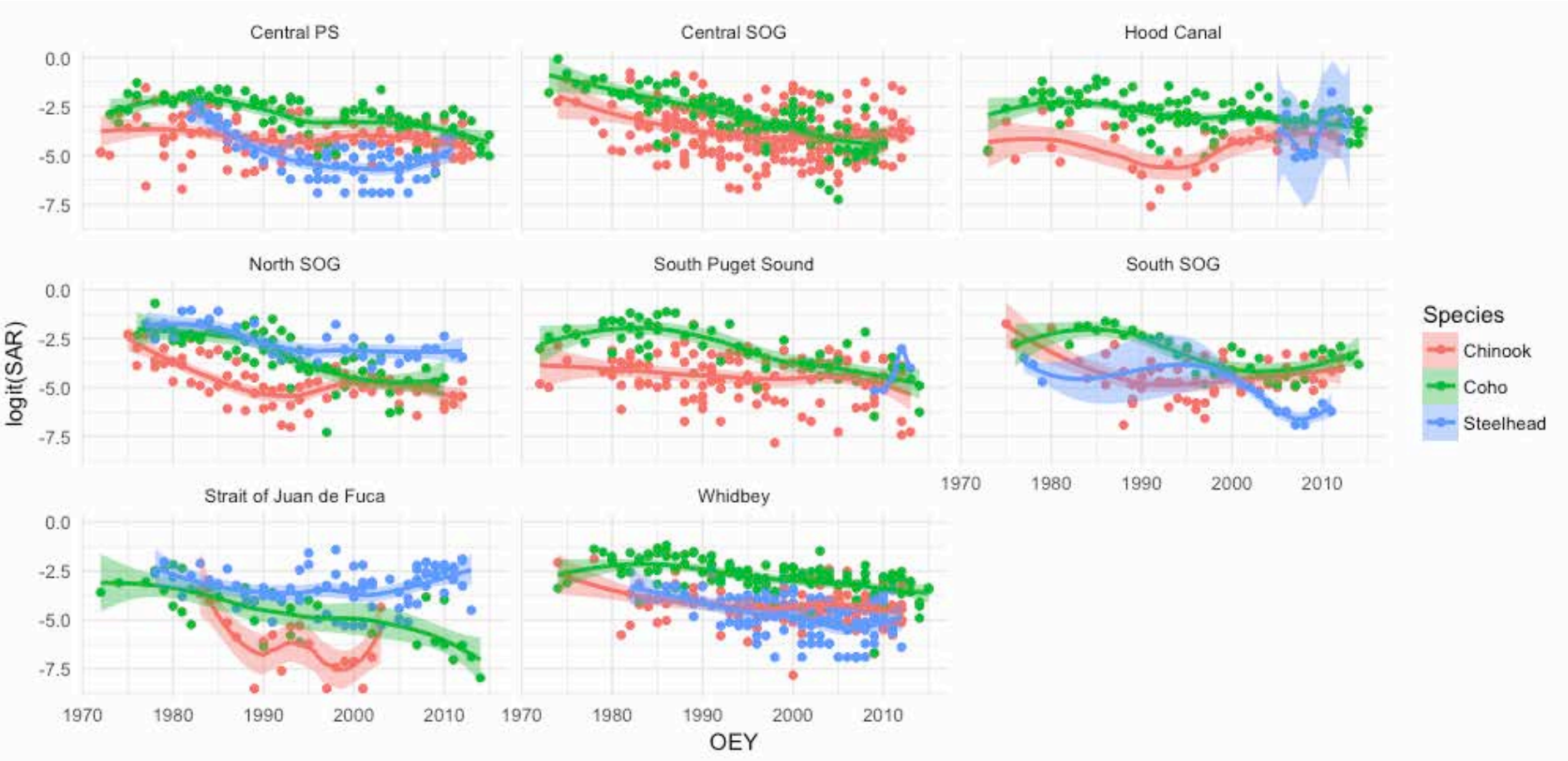
Q1. Common Trends Among Species?



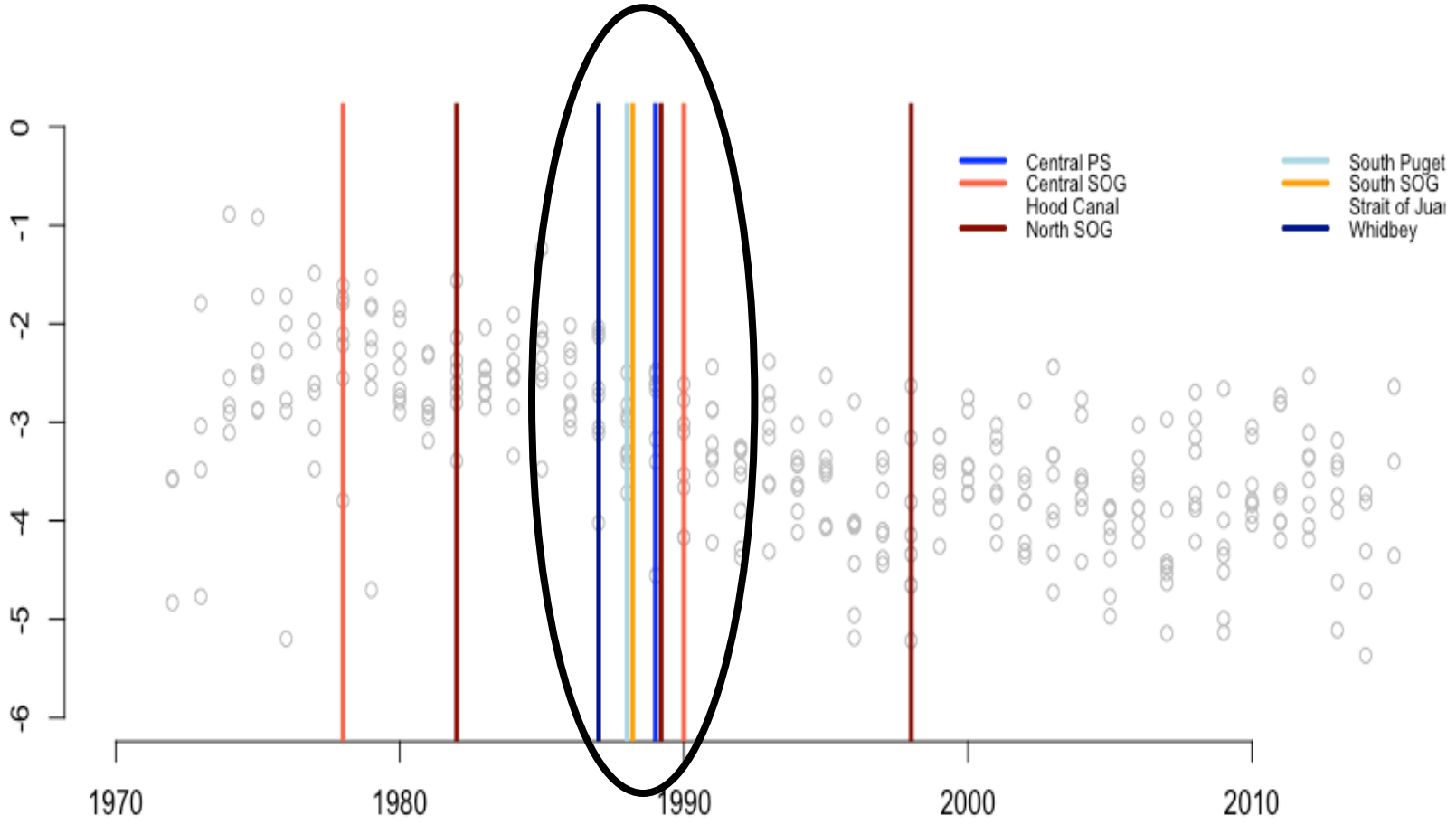
A1. Not exactly, but the late-1980s were a turning point

Q2. Common Trends In Regions?




Central PS
Central SOG
Hood Canal
North SOG
South Puget Sound
South SOG
Strait of Juan de Fuca
Whidbey
0.0
-2.5
-5.0
-7.5
1970
1980
1990
2000
2010
logit(SAR)
OEY
Species
Chinook
Coho
Steelhead

Q2. Common Trends Among Regions?



A2. The late1980s were a turning point in all subbasins

Ecosystem Context Matters

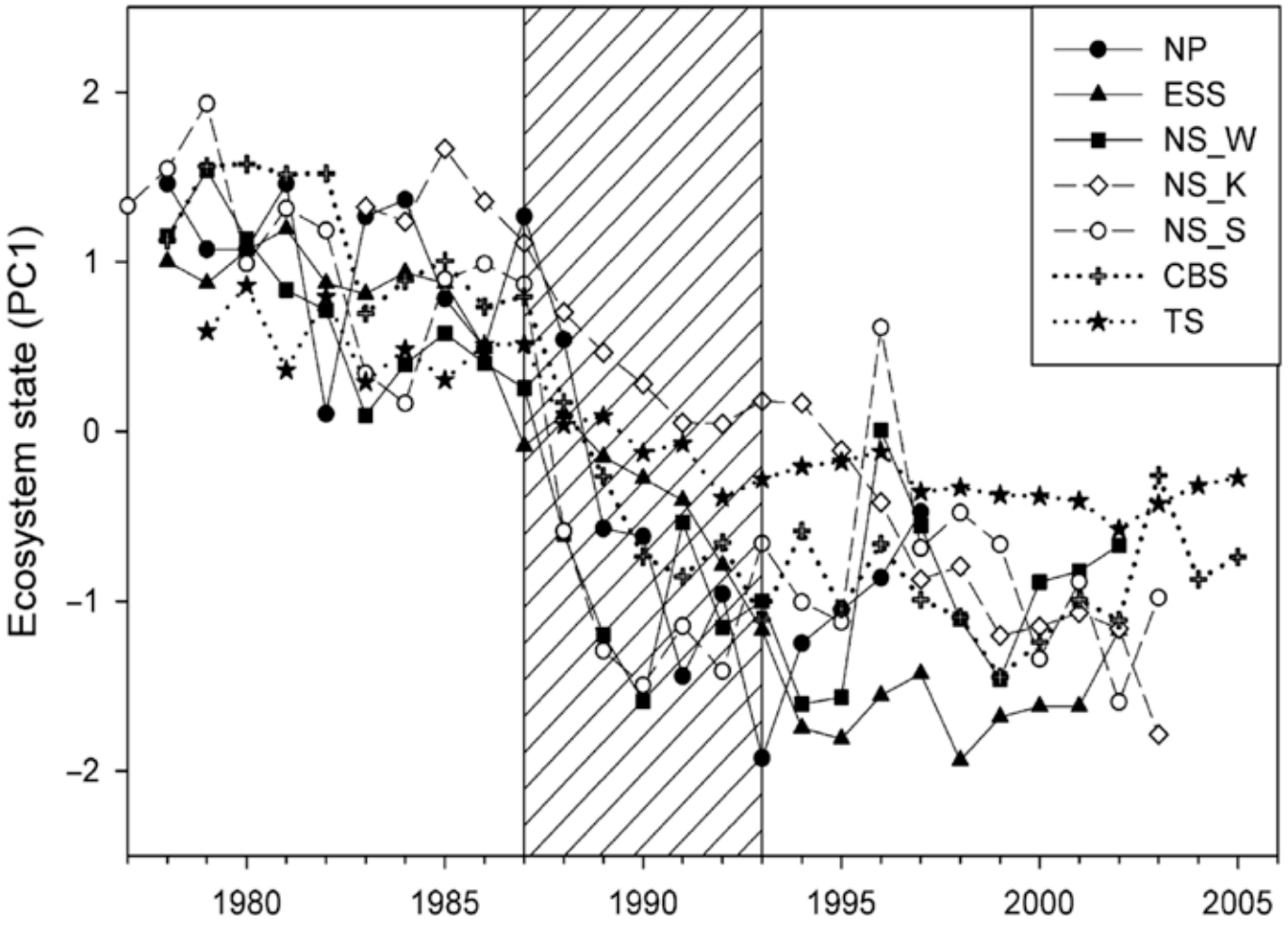


Figure. 9 from Möllmann and Diekmann 2012, *Advances in Ecological Research*

Summary

- Trends in time series are different among the three species; late 1980s time of decline
- Change was observed across all subbasins—argues for a deeper look at variables that are widespread?
- In steelhead model, environmental factors did not provide much explanatory power, but seal abundance and hatchery releases did—are these trends widespread enough in the Salish Sea to explain the timing of the decline?

Next Steps

- Look at trends among species within basins
- Get the MARSS models working
  - Objectives: Estimate common trend(s), use species and subbasins as covariates to determine trends

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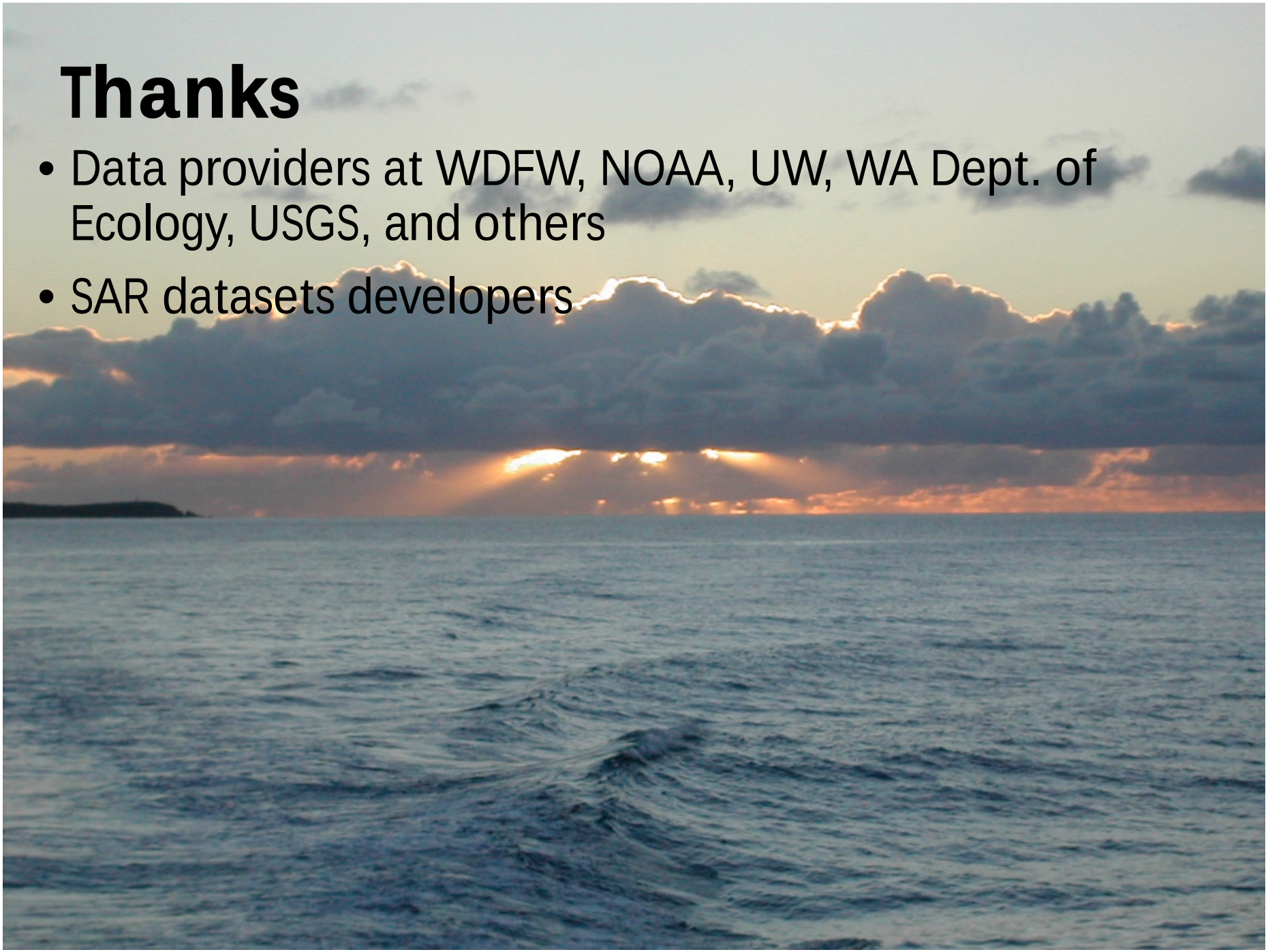
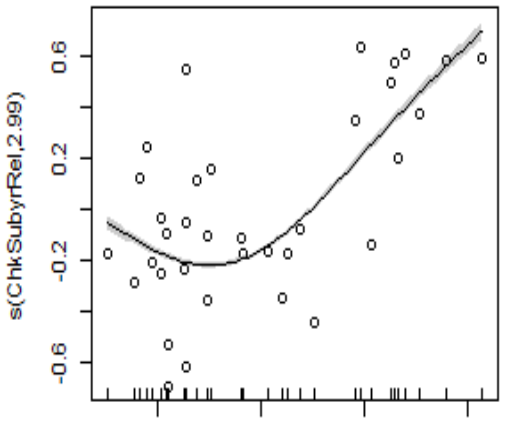
- Shift to coho and Chinook indicators development—draft up new hypotheses (open to suggestions) and re-aggregate data as appropriate



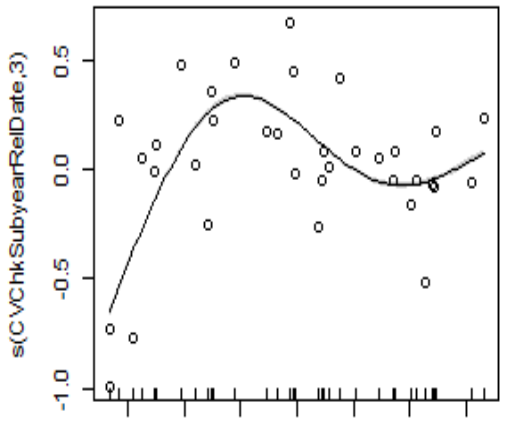
Thanks

- Data providers at WDFW, NOAA, UW, WA Dept. of Ecology, USGS, and others
- SAR datasets developers

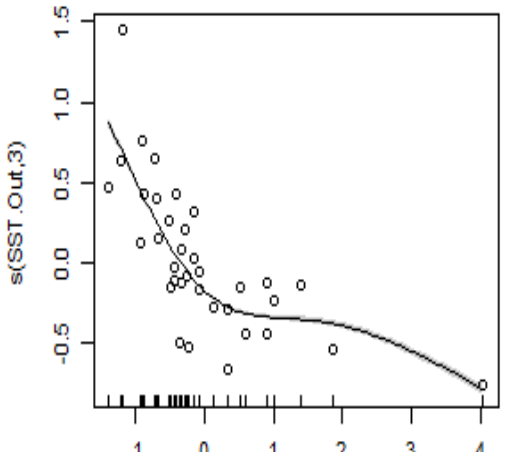
GAM Smooth Plots



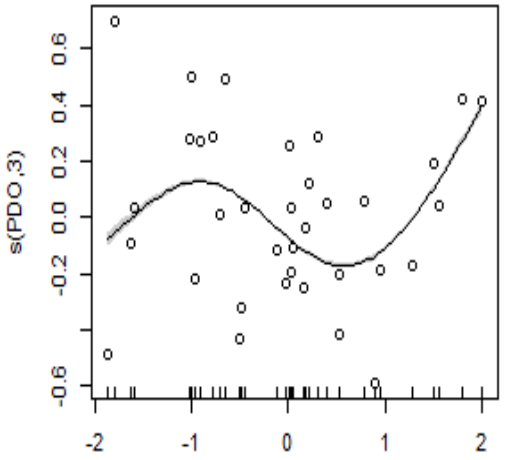
CHK Hatchery Release Abundance



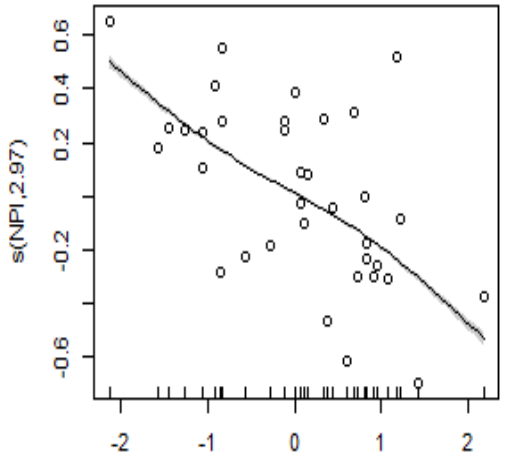
CV of Date of Hatch. Release



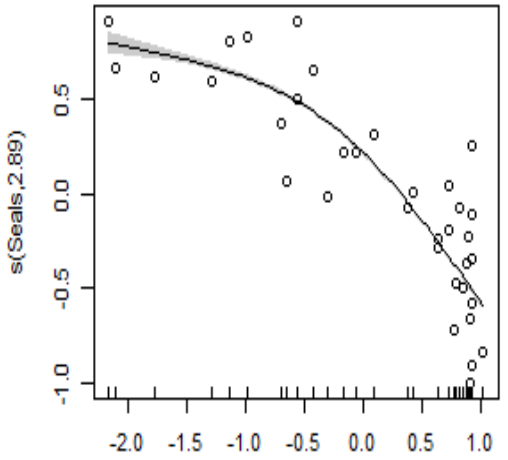
SST (Mar.-Jul. in PS)



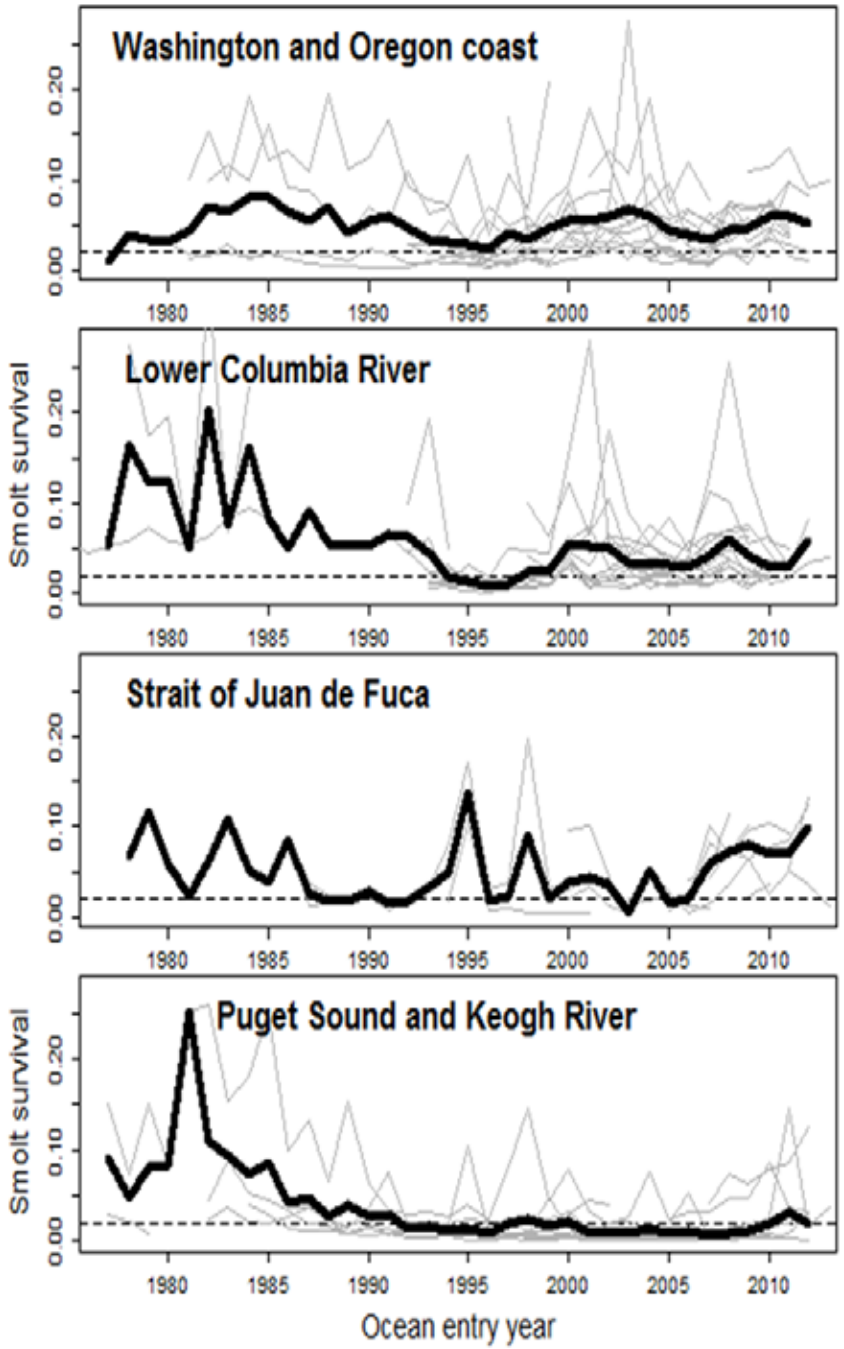
PDO

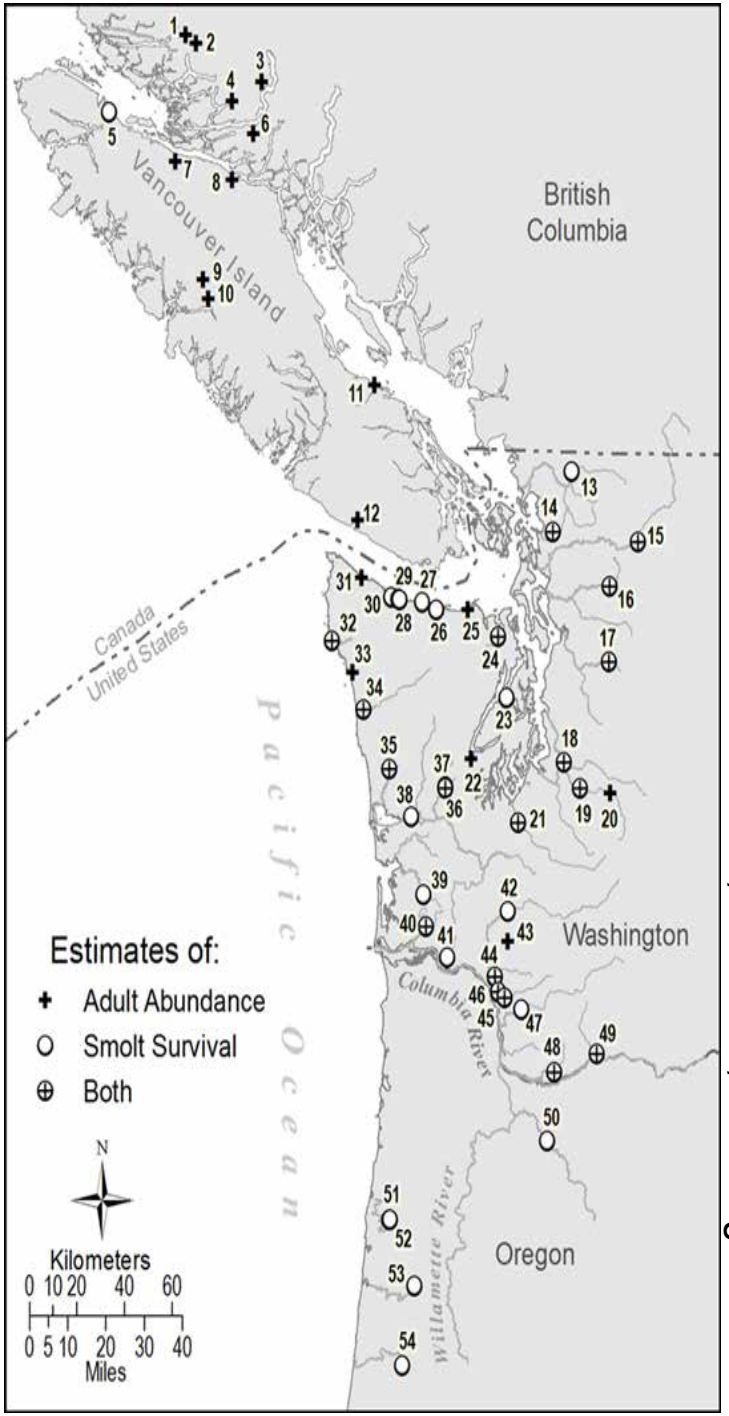


North Pacific Index



Seal Abundance





Kendall, Marston, & Klungle 2017

Evaluate Collinearity Among Potential Indicators