



SALISH SEA

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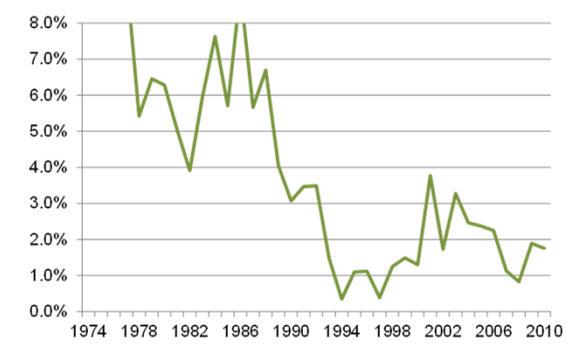
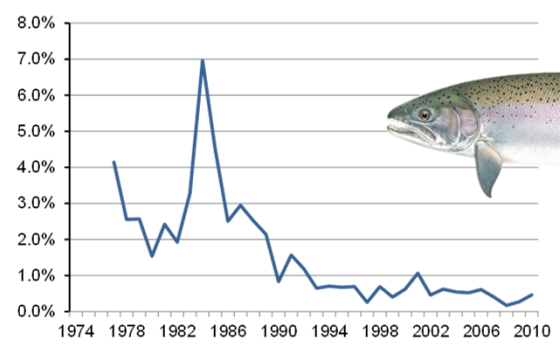
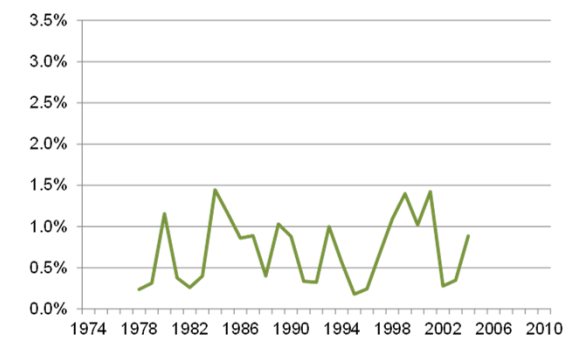
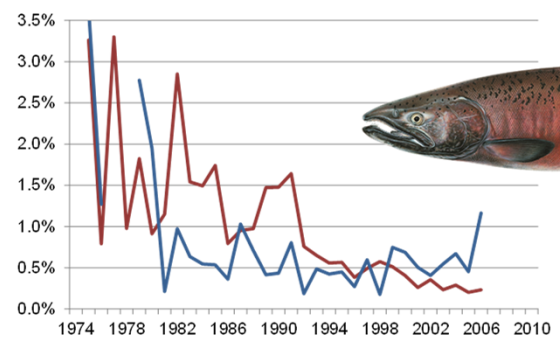
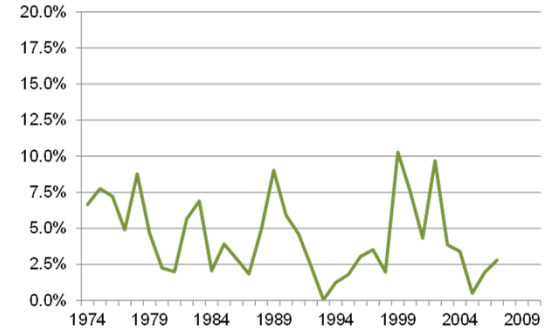
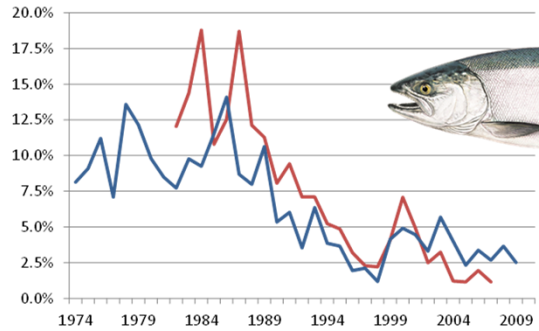
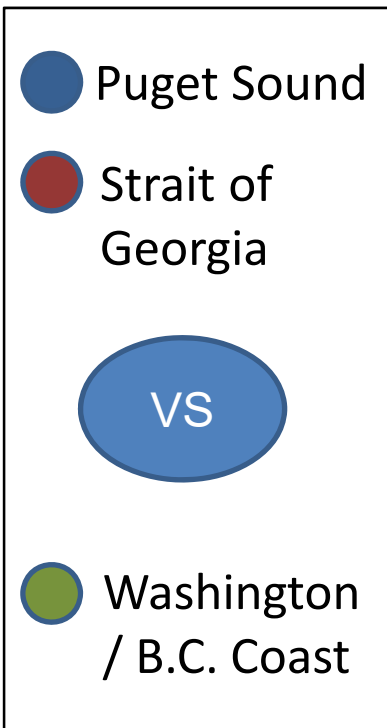
Declining patterns of Pacific Northwest steelhead trout spawner abundance and marine survival

Neala Kendall, Gary Marston, and Matt Klungle

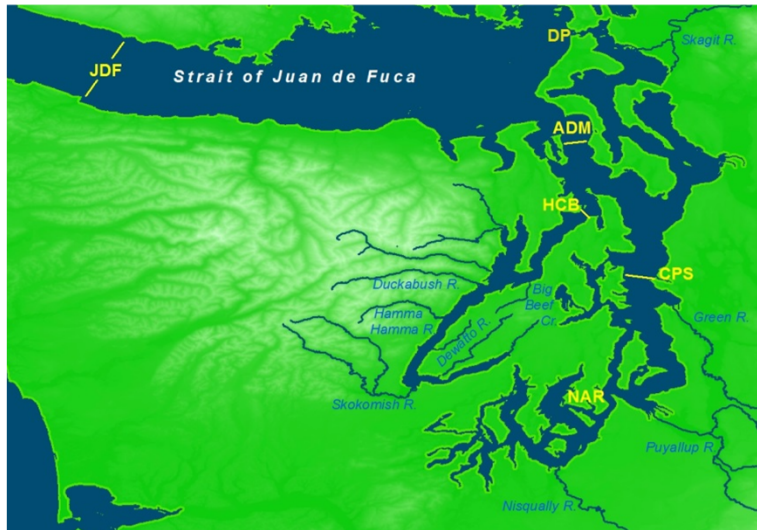
Washington Department of Fish and Wildlife

Presented by: Erik Neatherlin, WDFW

Decline in Salish Sea Marine Survival



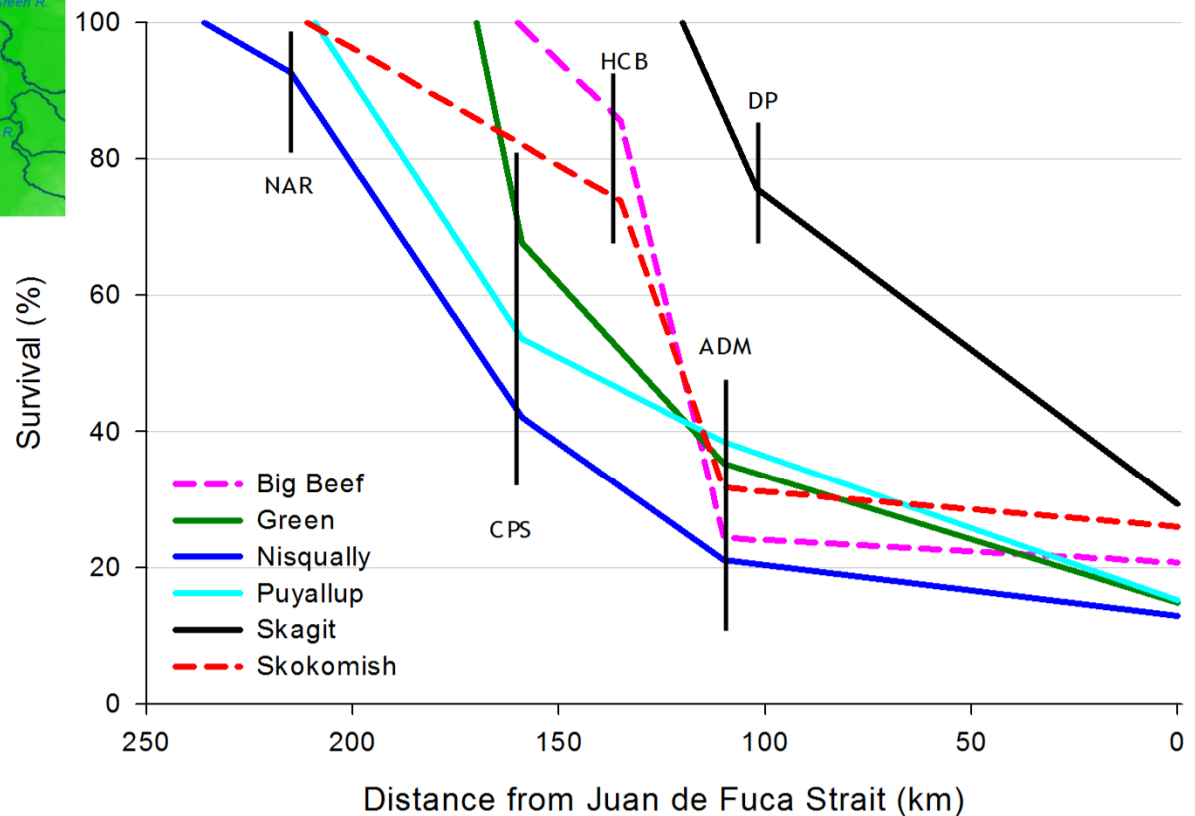
Steelhead mortality in Puget Sound



NAR = Tacoma Narrows
 CPS = Central Puget Sound
 ADM = Admiralty Inlet
 HCB = Hood Canal Bridge
 DP = Deception Pass

~80% mortality in Puget Sound within 2-3 weeks

Mortality of wild acoustic tagged populations: 2006- 2009



Puget Sound Steelhead Abundance and Marine Survival

- Are Puget Sound abundance & marine survival trends different than those in other regions?
- How has survival changed over time?
- What environmental and fish characteristics are most related to marine survival trends?



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Constraints/challenges



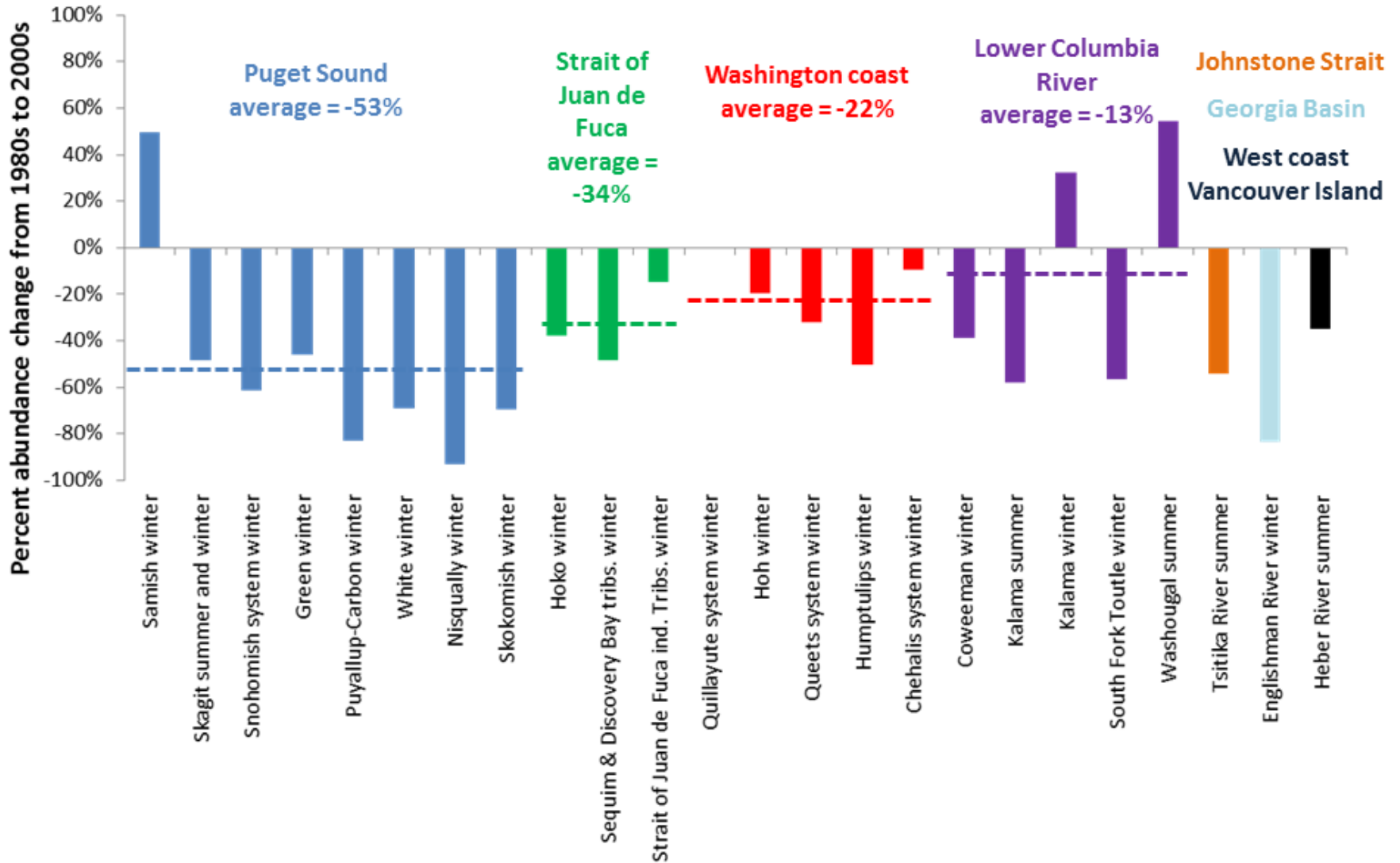
- Steelhead smolts are strong swimmers so harder to trap
 - Adults return when waters are high (spring spawners) so more difficult to monitor spawning
 - Steelhead are not coded wire tagged (CWT)
- Less data over shorter time periods available for wild populations

Steelhead spawner abundance data



Photo: Morgan Bond

Abundances changes 1980s vs. 2000s

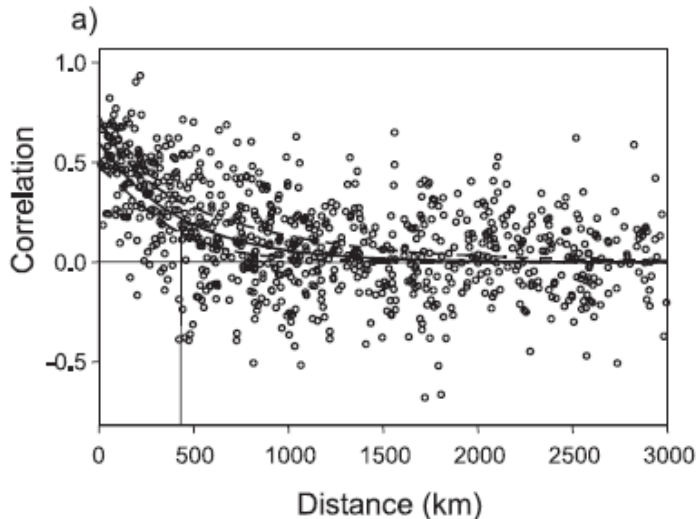


Steelhead marine survival trends



Photos by Morgan Bond

Marine survival correlation by distance

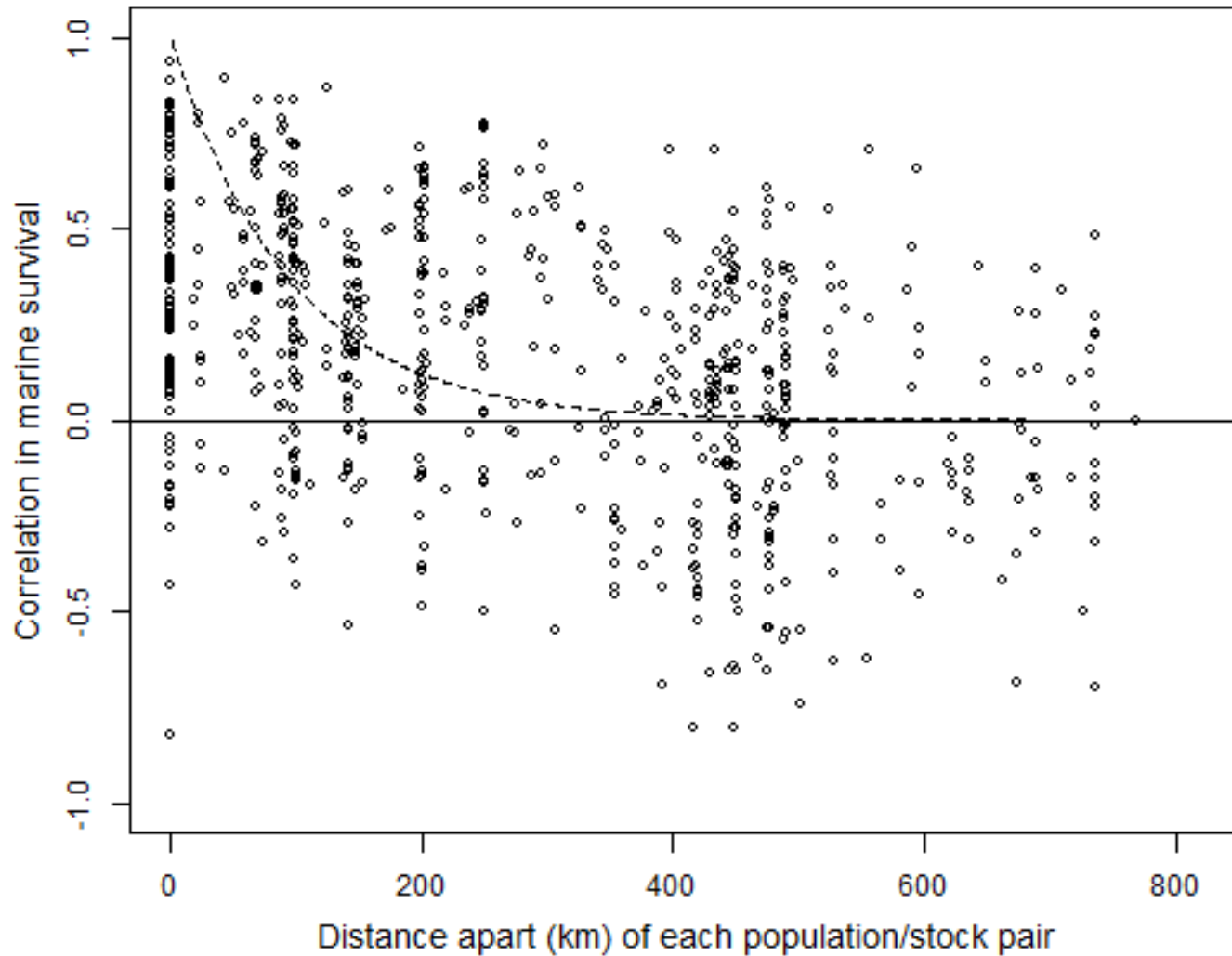


Pyper et al. 2001 CJFAS—pink salmon

**What about for
steelhead??**

- For pink, chum, sockeye, Chinook, and coho salmon:
 - Mostly positive correlations across North Pacific Ocean—demonstrating general regional coherence
 - Closer populations are more tightly correlated—demonstrating local coherence

Steelhead positive marine survival correlation by distance



Steelhead marine survival trends



Photos by Morgan Bond

Hatchery & wild marine survival: smolt-to-adult return rates (SAR)

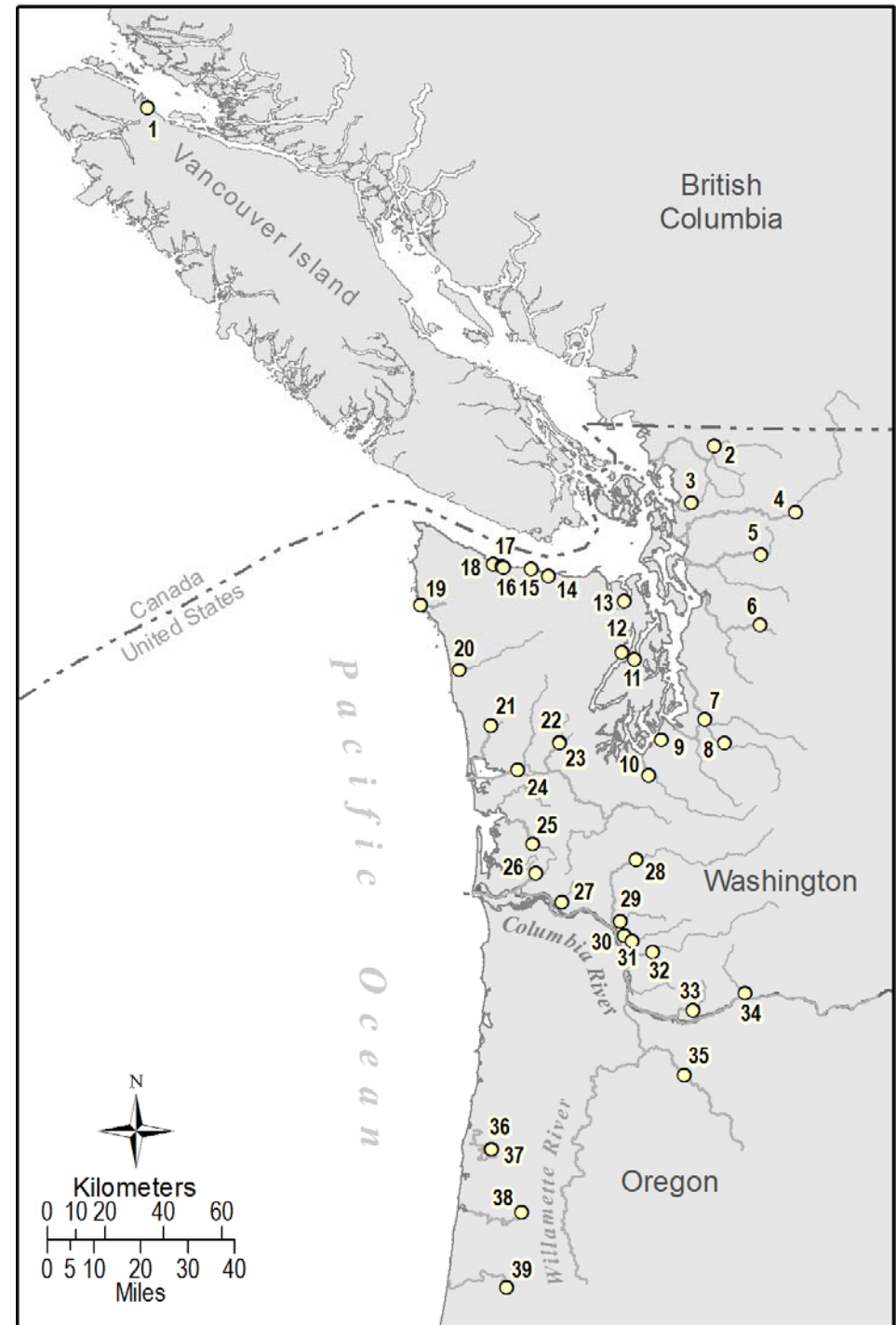
- Percent of smolts leaving freshwater that survival to return as adults

Smolt survival = $\frac{\# \text{ spawners/hatchery returns} + \# \text{ catch}}{\# \text{ smolts}}$



48 steelhead stocks/pops:

- **Puget Sound:**
10 hatchery stocks,
2 wild populations
- **Strait of Juan de Fuca:**
1 hatchery stocks,
5 wild populations
- **Coast:**
11 hatchery stocks,
2 wild populations
- **Lower Columbia:**
12 hatchery stocks,
4 wild populations
- **Johnstone Strait:**
1 wild population



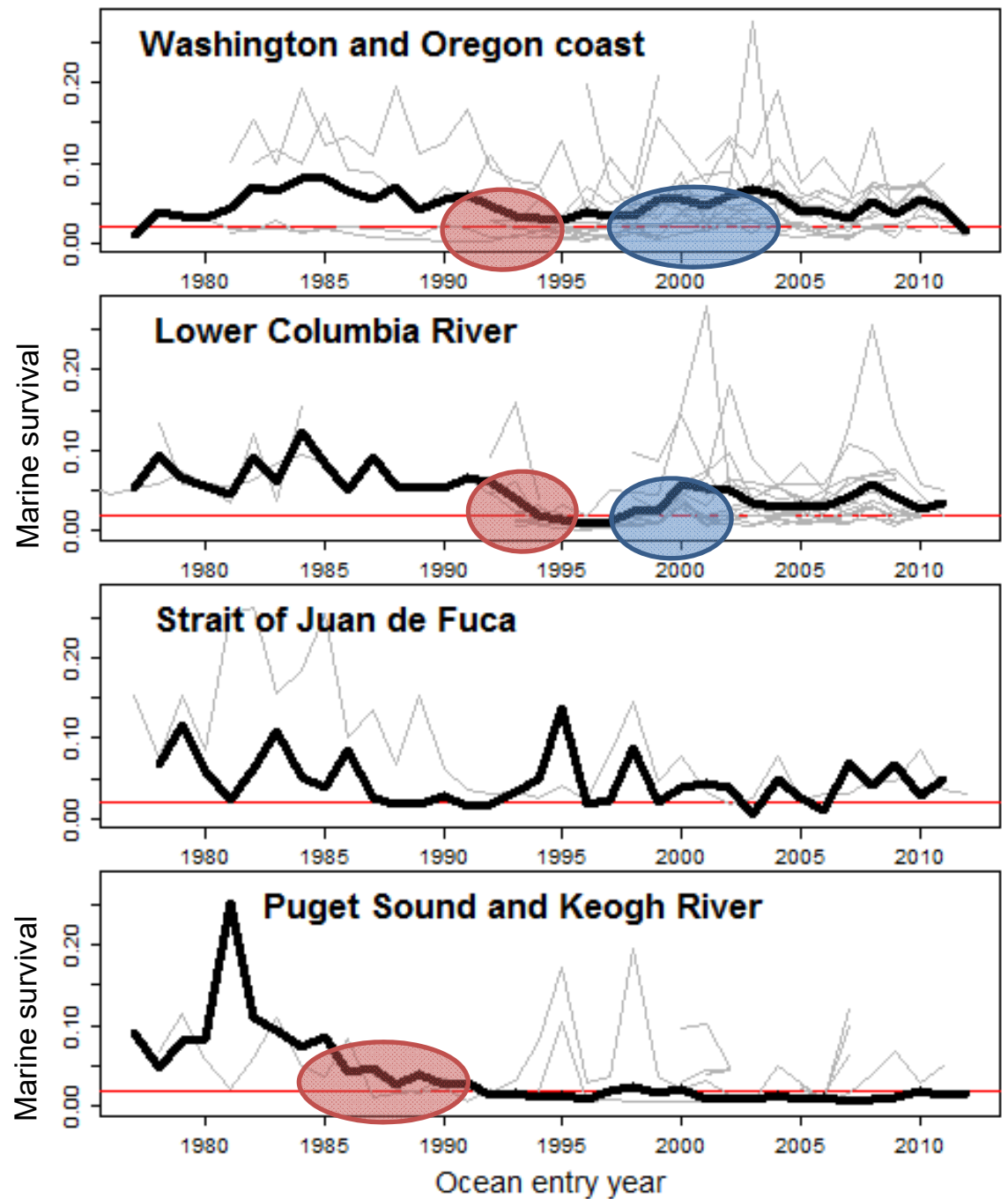
Map by Dale Gombert, WDFW

Determining Steelhead Groupings

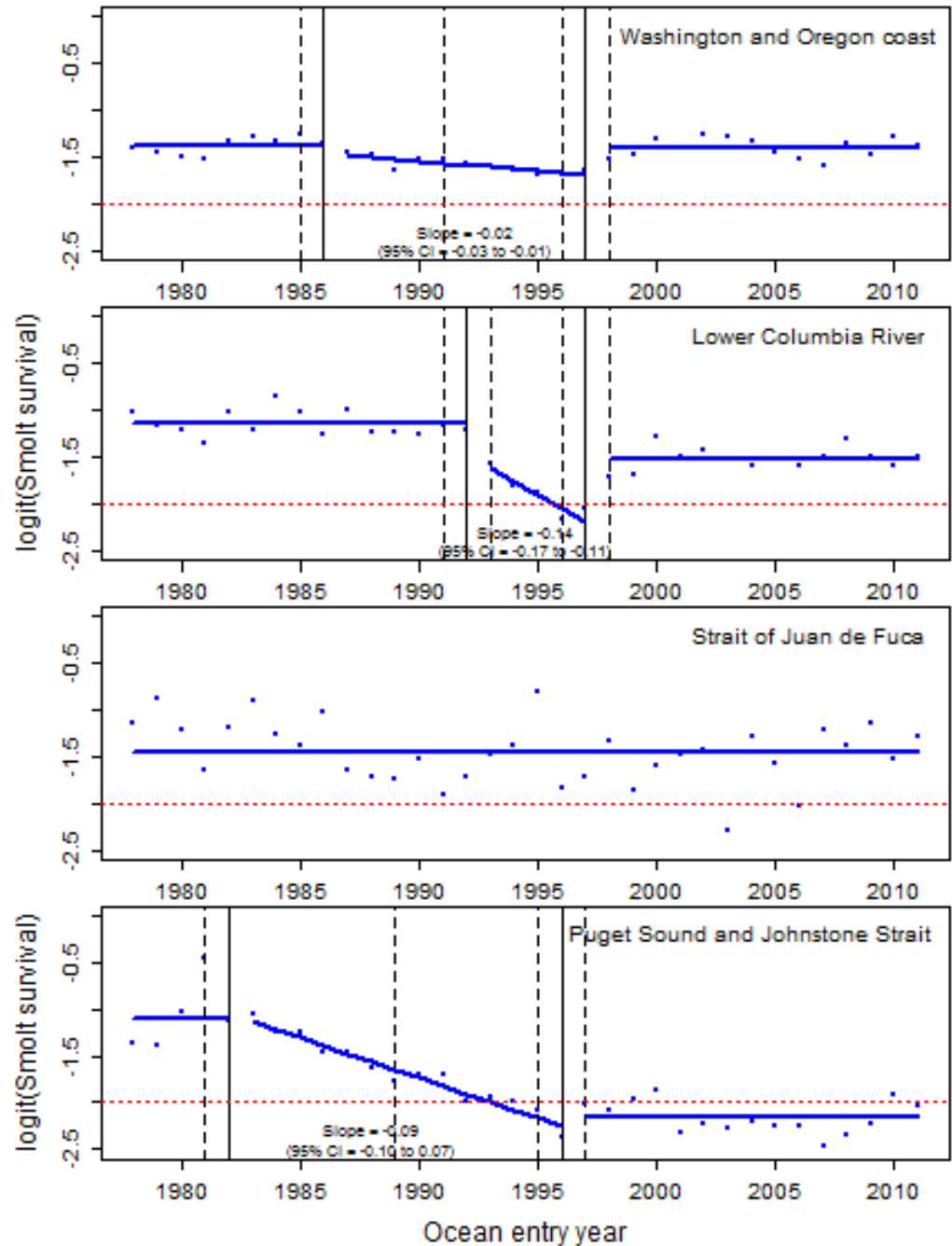
Multivariate Auto-Regressive State-Space (MARSS)

- Fit models to time-series data using maximum likelihood, includes both *process* and *observation* error
- Does not require all data series to cover the same time period
- Provides statistical support for various population/stock groupings → best-supported models determined by AIC_c

Regional groupings and steelhead marine survival trends



Steelhead marine survival time series— breakpoints

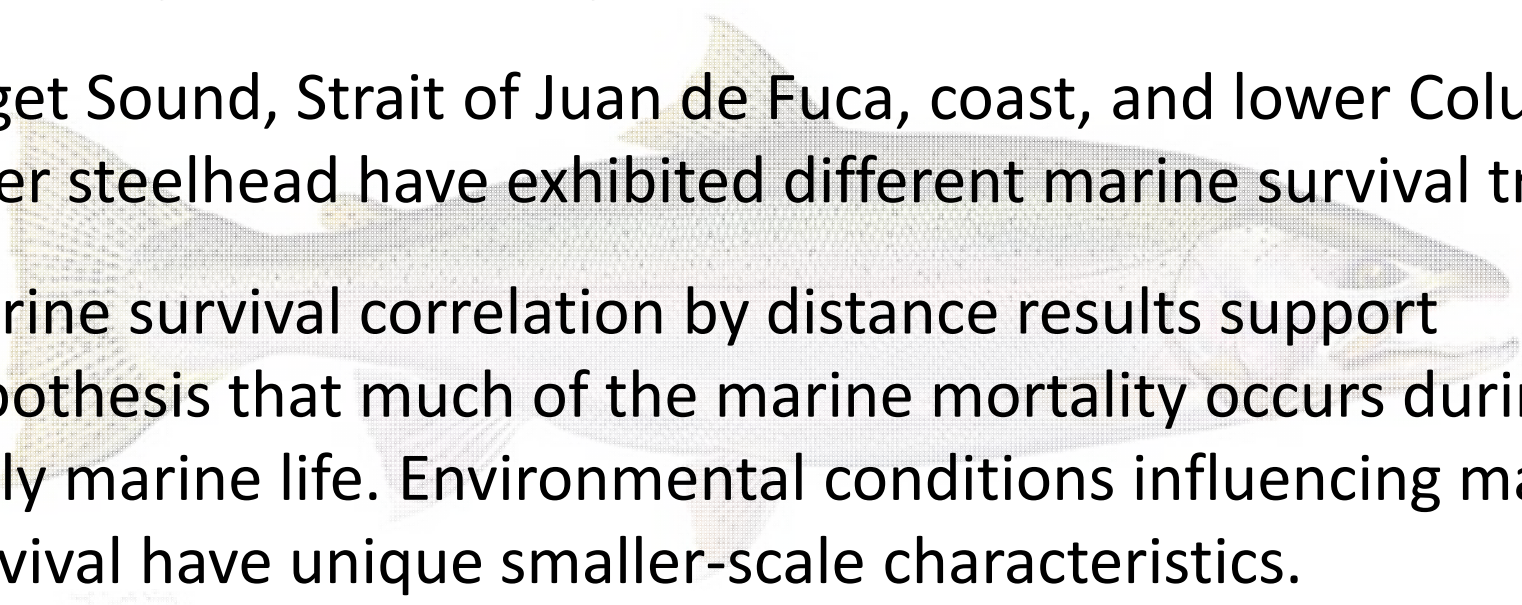


Environmental indicators

- Ocean: climate forcing and large-scale factors
- Region specific: nearshore and Strait of Juan de Fuca
- Local/basin– more immediate marine entry

	Ocean	Region specific	Local/basin
LOWER COL	NPGO SOI PDO NOI	Sea surface temp (coastal shelf) Coastal upwell index (45N) + Spring transition Copepod community index Winter ichthyoplankton Chlorophyll a level	River flow
WA COAST		Race Rocks temp Race Rocks salinity Neah Bay sea level Pacific coast sea surface temp - Sea surface salinity (SJDF) Coastal upwelling index (48N) +	River flow Temperature, salinity Dissolved oxygen Chlorophyll a levels Density, pH Light transmissivity Adult herring abund. + Hatchery coho abundance - Seal abundance + and marine bird abundance of other marine fishes
PUGET SOUND			
Kendall et al. (WDFW)			

Steelhead marine survival summary

- Puget Sound steelhead marine survival has declined over time, especially low since early 1990s
 - Puget Sound, Strait of Juan de Fuca, coast, and lower Columbia River steelhead have exhibited different marine survival trends
 - Marine survival correlation by distance results support hypothesis that much of the marine mortality occurs during early marine life. Environmental conditions influencing marine survival have unique smaller-scale characteristics.
 - Breakpoint analysis suggested that we can focus on specific time periods of decline and correlate with environmental conditions and trends
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Next steps



- Further summarize environmental indicator data to relate to steelhead marine survival trends
- Carry out the modeling work to relate indicators to marine survival trends

Acknowledgements

- Many WDFW, tribal, and other biologists who have provided wild and hatchery smolt and adult data to estimate SARs
- Mark Scheuerell, Thomas Buehrens, Joe Anderson, Mara Zimmerman, and others for helpful conversations and insights
- Puget Sound steelhead early marine survival working group, including Michael Schmidt (Long Live the Kings)



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Thank you



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