Regional Patterns in Spring/Summer Chinook Salmon and Steelhead Juvenile Survival Relative to Smolt-to-Adult Return Rates

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Key Questions:

What are the spatial and temporal patterns in survival?

What factors are associated with the patterns in survival?

Can management efforts help achieve regional survival goals?

NPCC Goal: Smolt-to-Adult survival rates averaging 4%

Minimize Smolt-to-Adult survival rates < 1%

What are the spatial and temporal patterns in survival?

Species?

Wild spring/summer (yearling) Chinook salmon
Wild steelhead

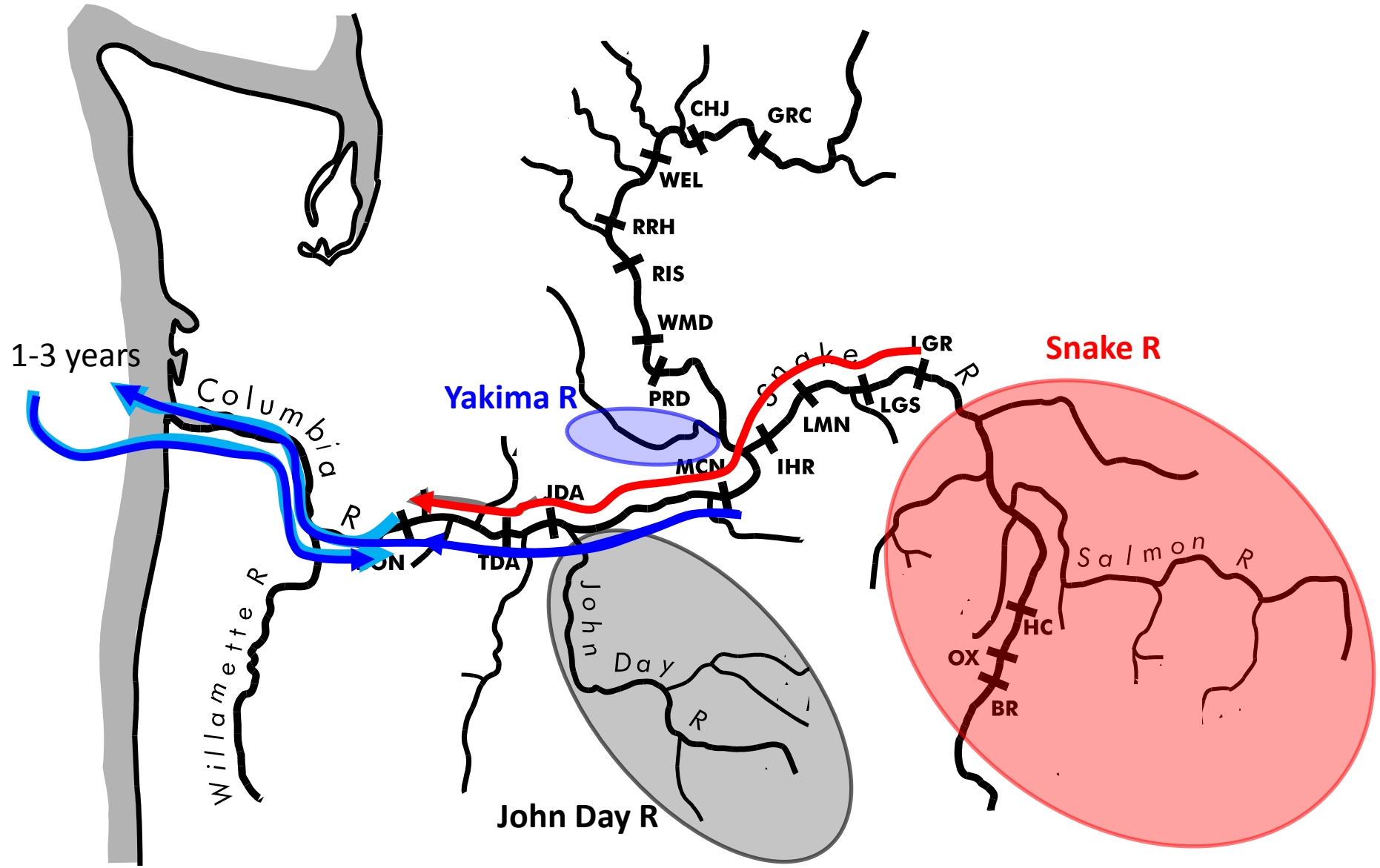
Timeframe?

Juvenile outmigration years 2000-2012

Tools?

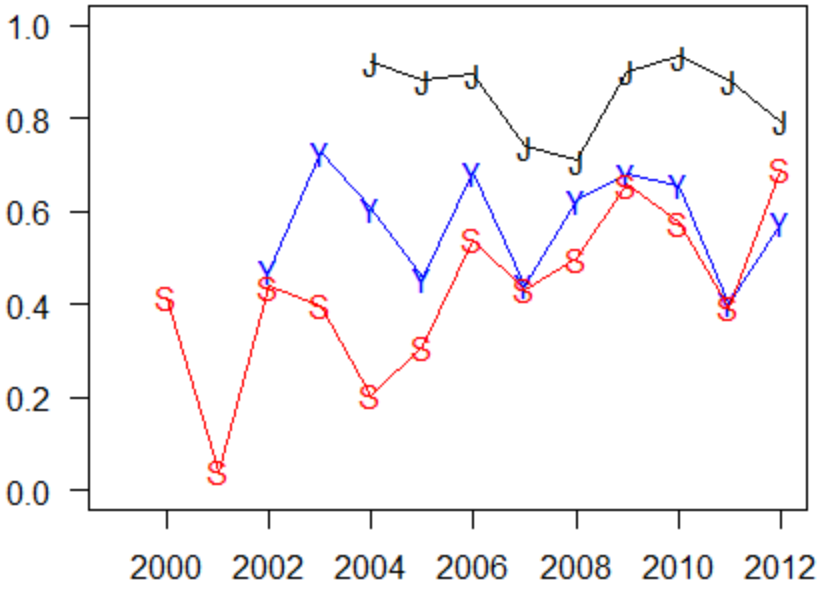
Mark-recapture methods using PIT tags
330K steelhead, 1.1 million Chinook salmon tags

Study Area


1-3 years
Columbia R
Willamette R
Yakima R
CHJ
GRC
WEL
RRH
RIS
WMD
PRD
MCN
IHR
JDA
TDA
LMN
LGS
LGR
Snake R
John Day R
Salmon R
HC
OX
BR

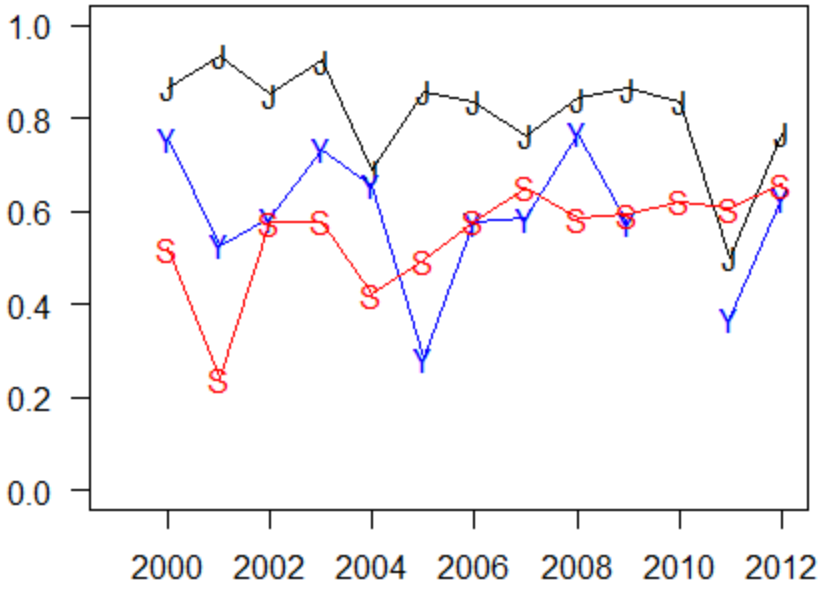
Freshwater survival

steelhead



Mean: 85% >> 57% > 48%

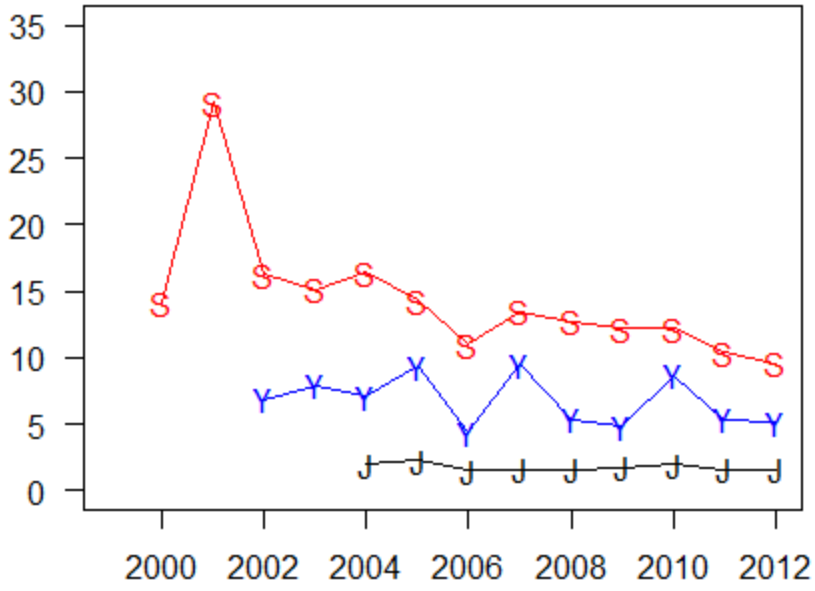
Chinook salmon



Mean: 81% >> 60% > 54%

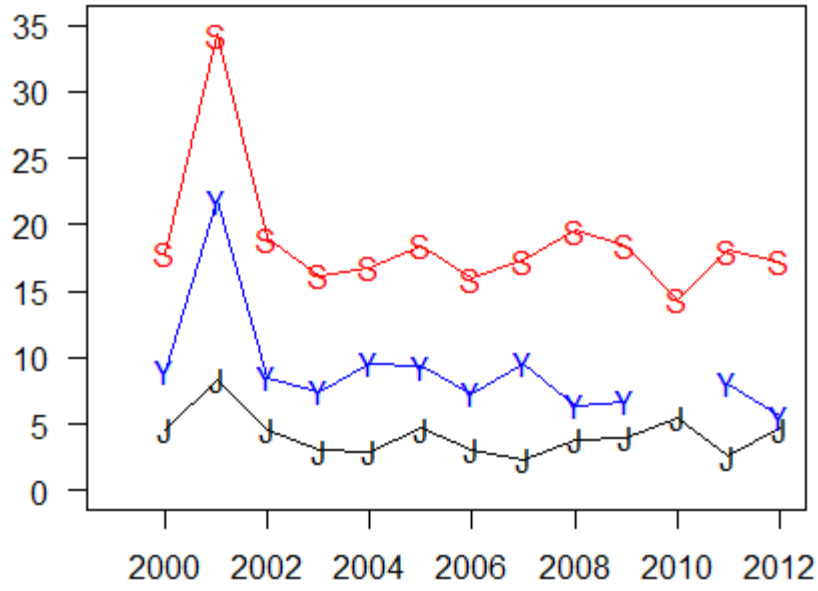
Fish Travel Time

steelhead



Mean: 1.8 << 6.6 << 12.5

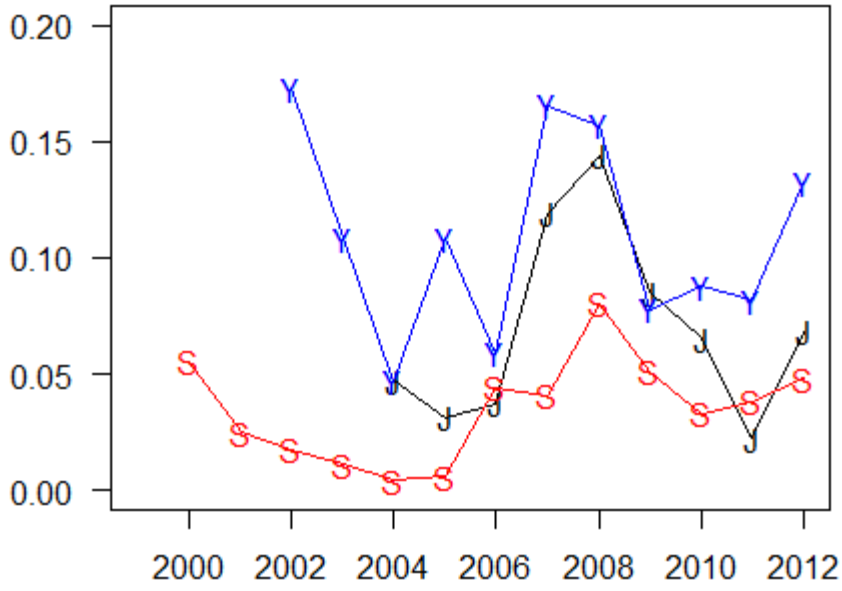
Chinook salmon



Mean: 4.1 << 9.9 << 19.1

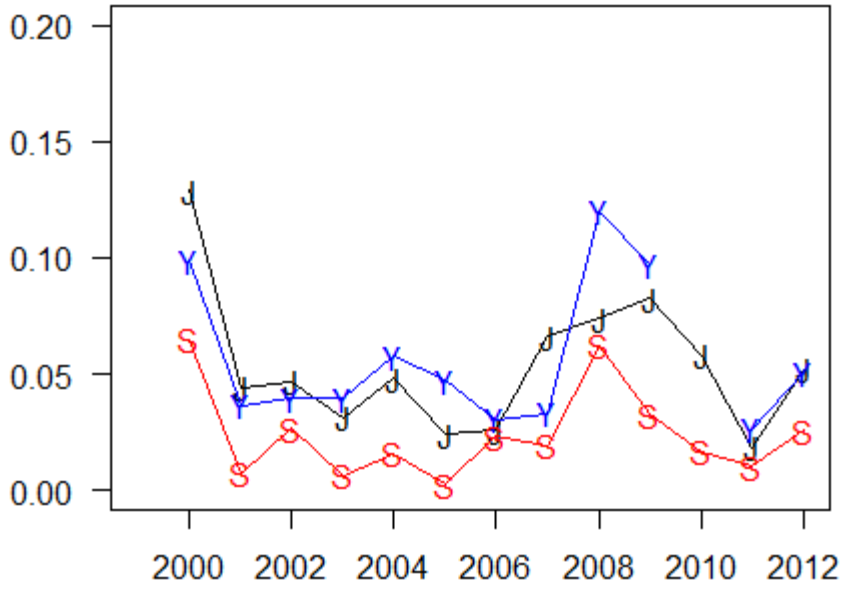
Ocean survival

steelhead



Mean: 10.2% > 7.0% >> 3.8%

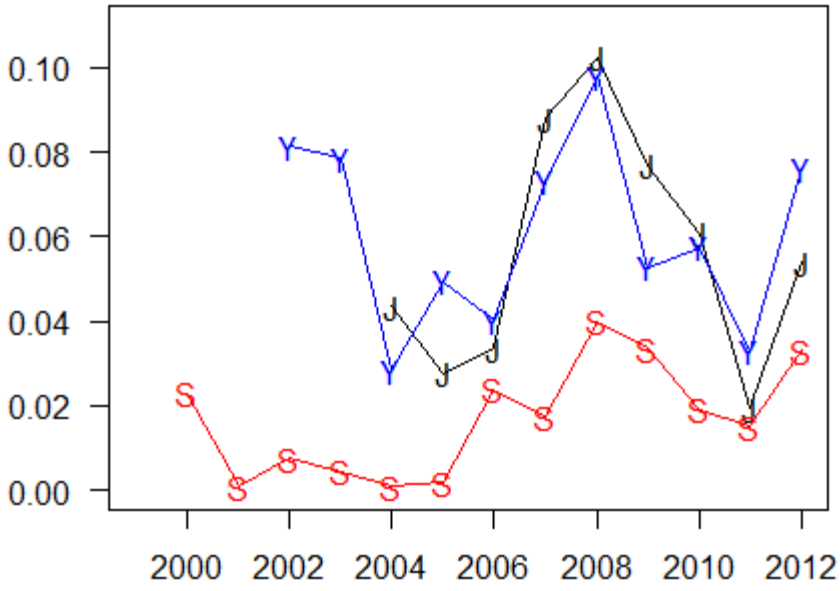
Chinook salmon



Mean: 6.0% ≈ 5.4% >> 2.5%

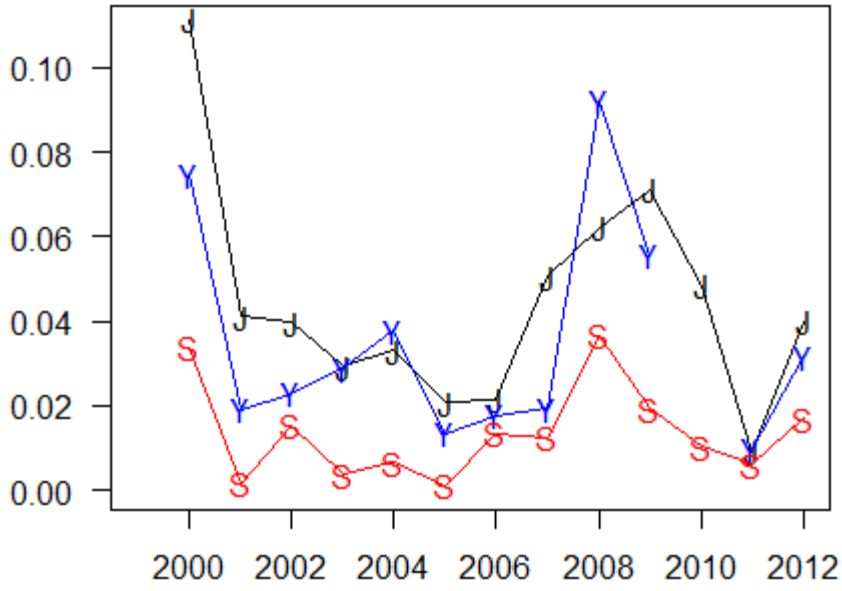
Smolt-to-Adult survival

steelhead



Mean: 5.6% ≈ 5.6% >> 2.1%

Chinook salmon

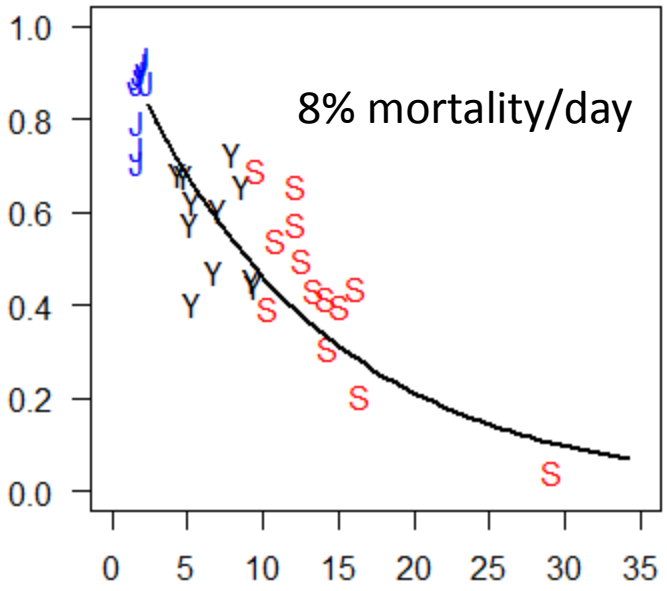


Mean: 4.4% ≈ 3.7% >> 1.4%

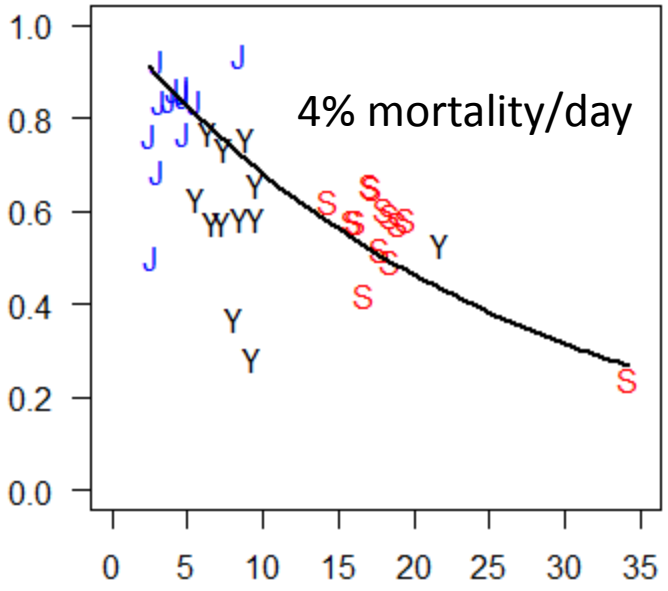
Instantaneous mortality rates

Freshwater Survival

steelhead

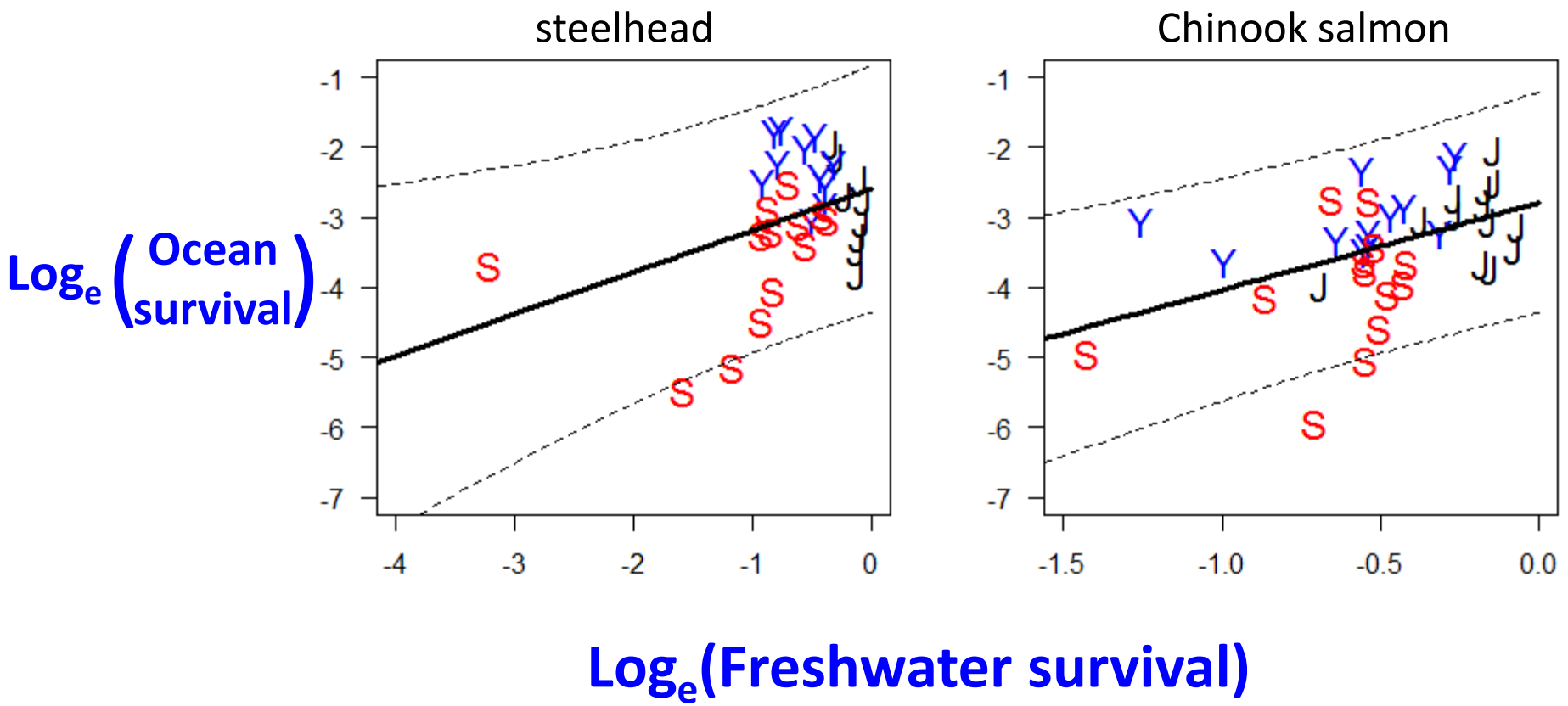


Chinook salmon

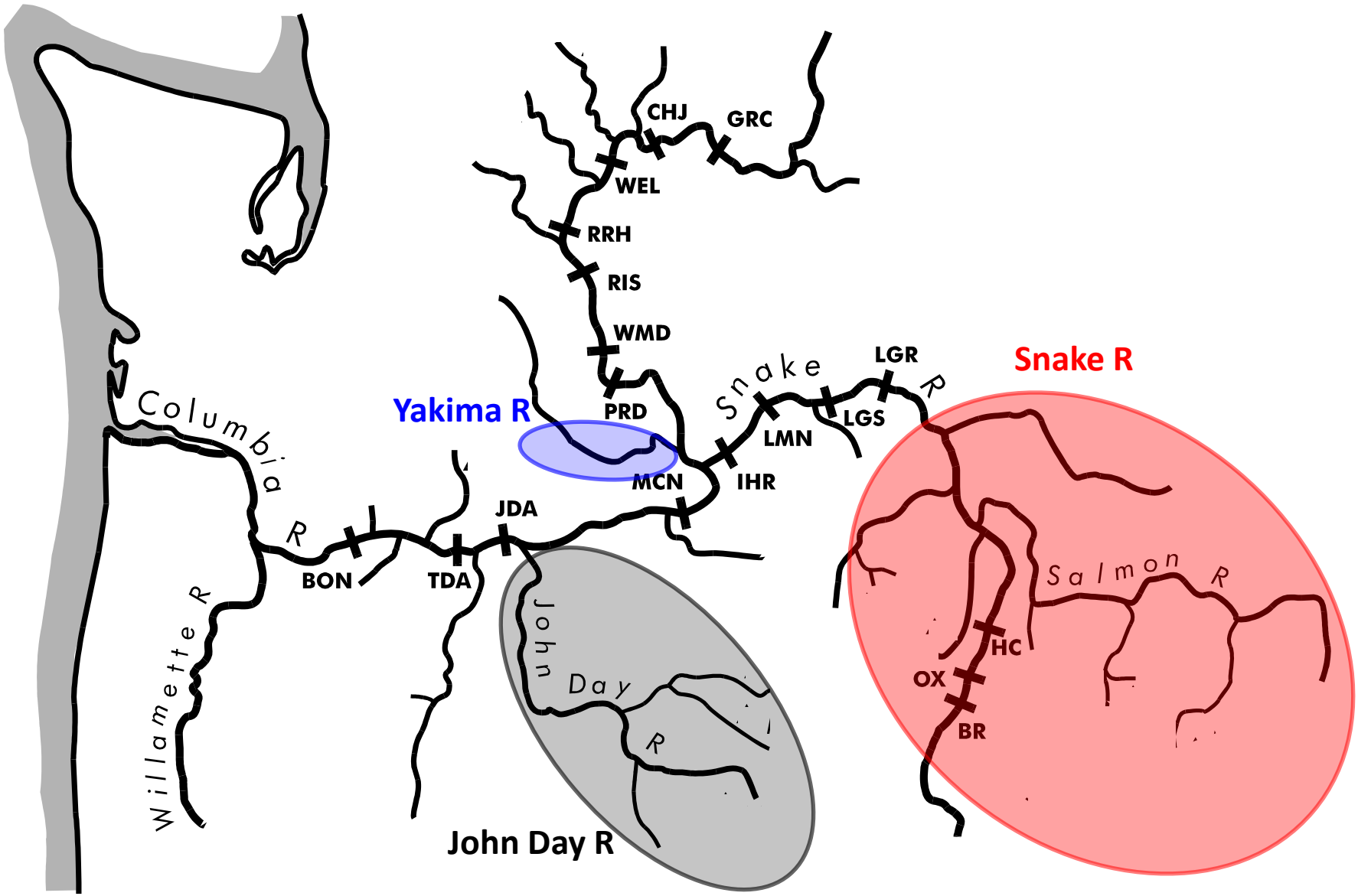


Fish Travel Time

Correlations between freshwater and ocean survival



Study Area


CHJ
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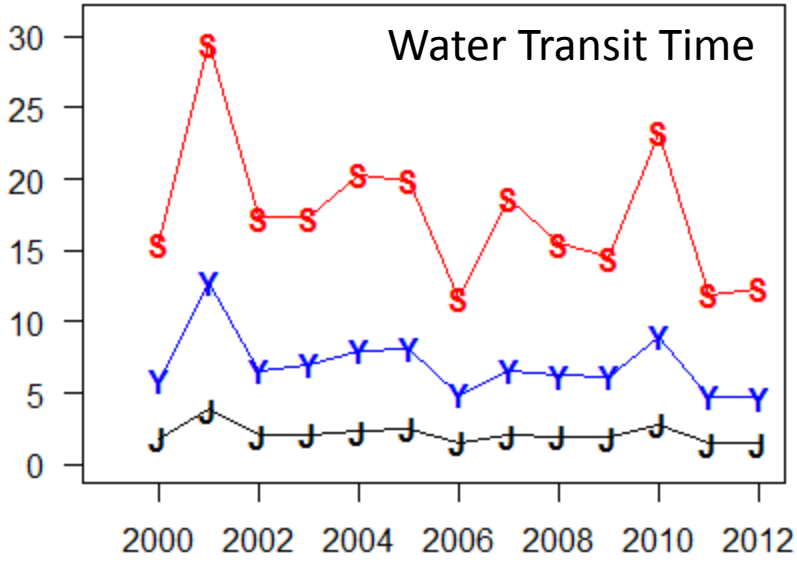
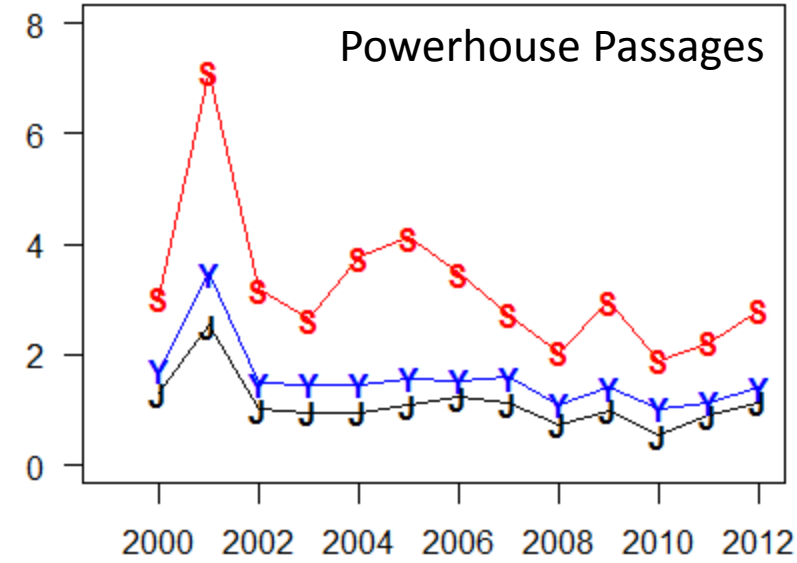
Snake R
Yakima R
Columbia R
JDA
TDA
BON
Willamette R
John Day R
Snake R
Salmon R
HC
OX
BR
John Day R

Variable environmental conditions

Variable environmental conditions

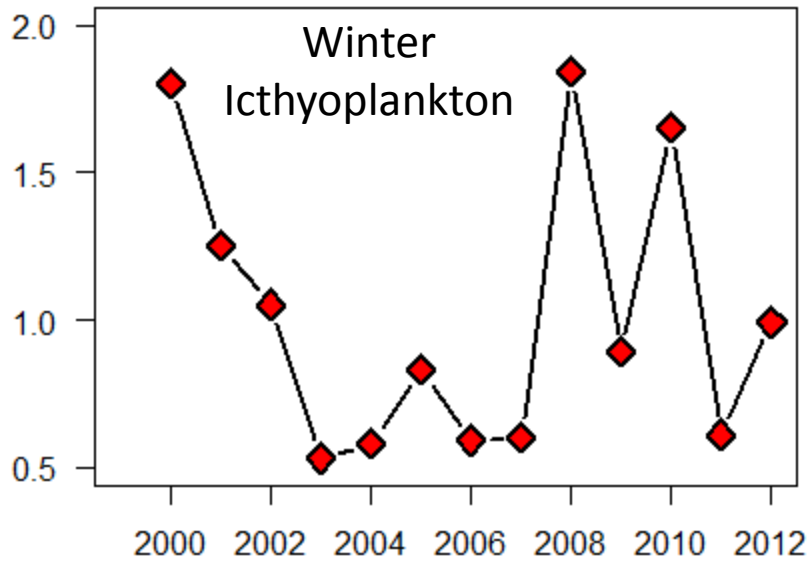
Freshwater

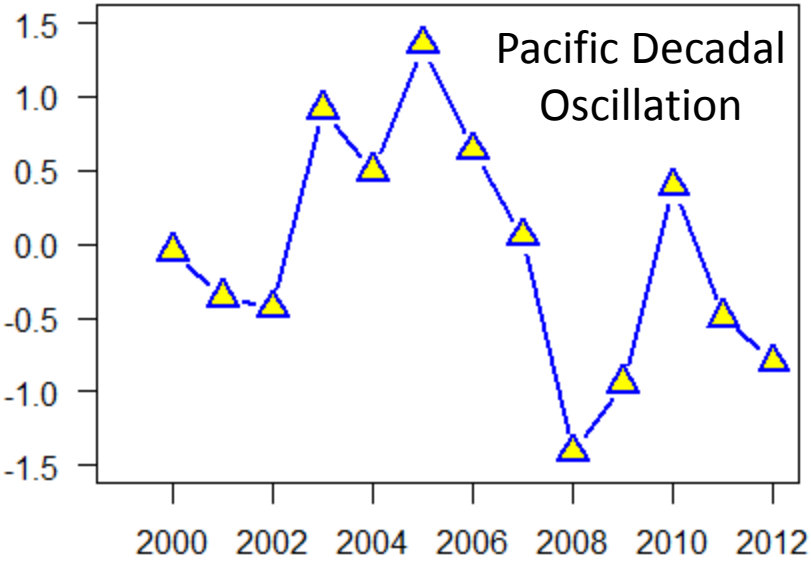




Variable environmental conditions

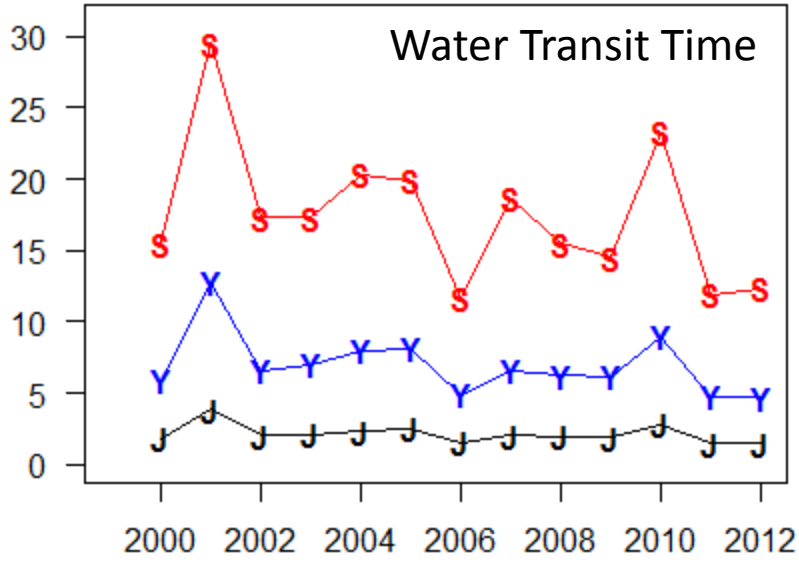
Marine

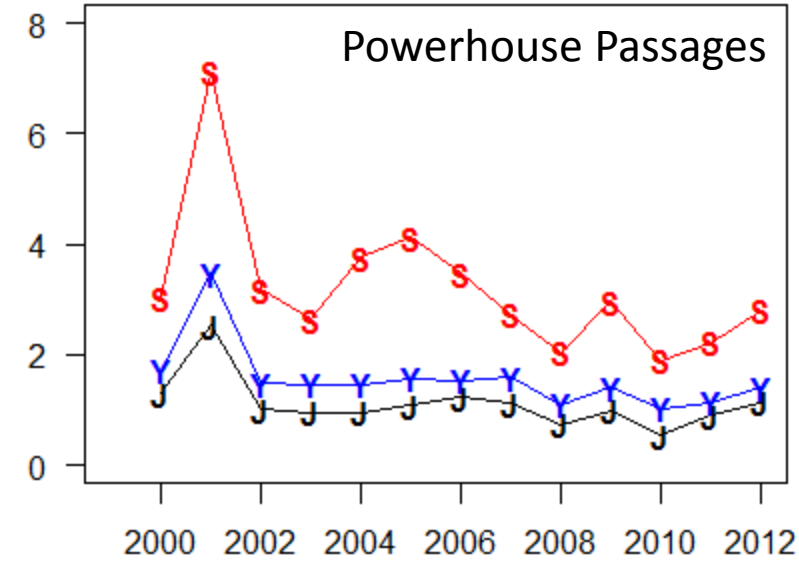




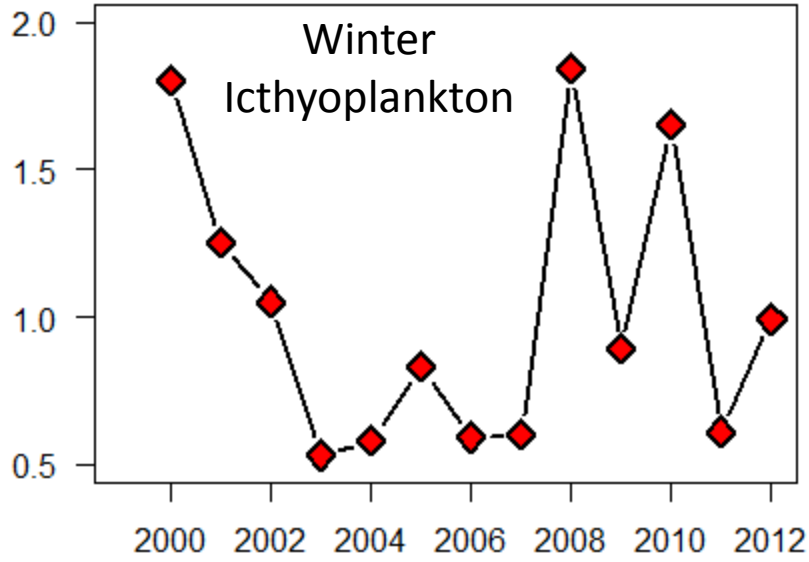
Variable environmental conditions

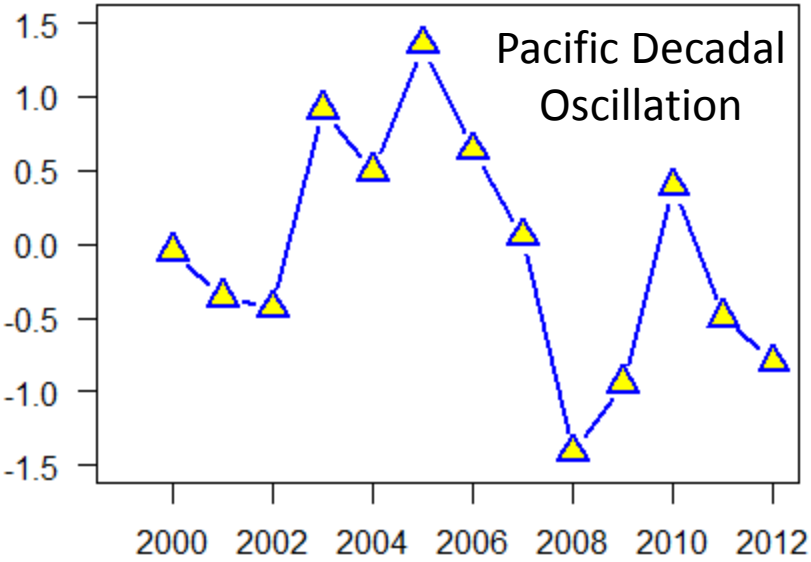
Freshwater



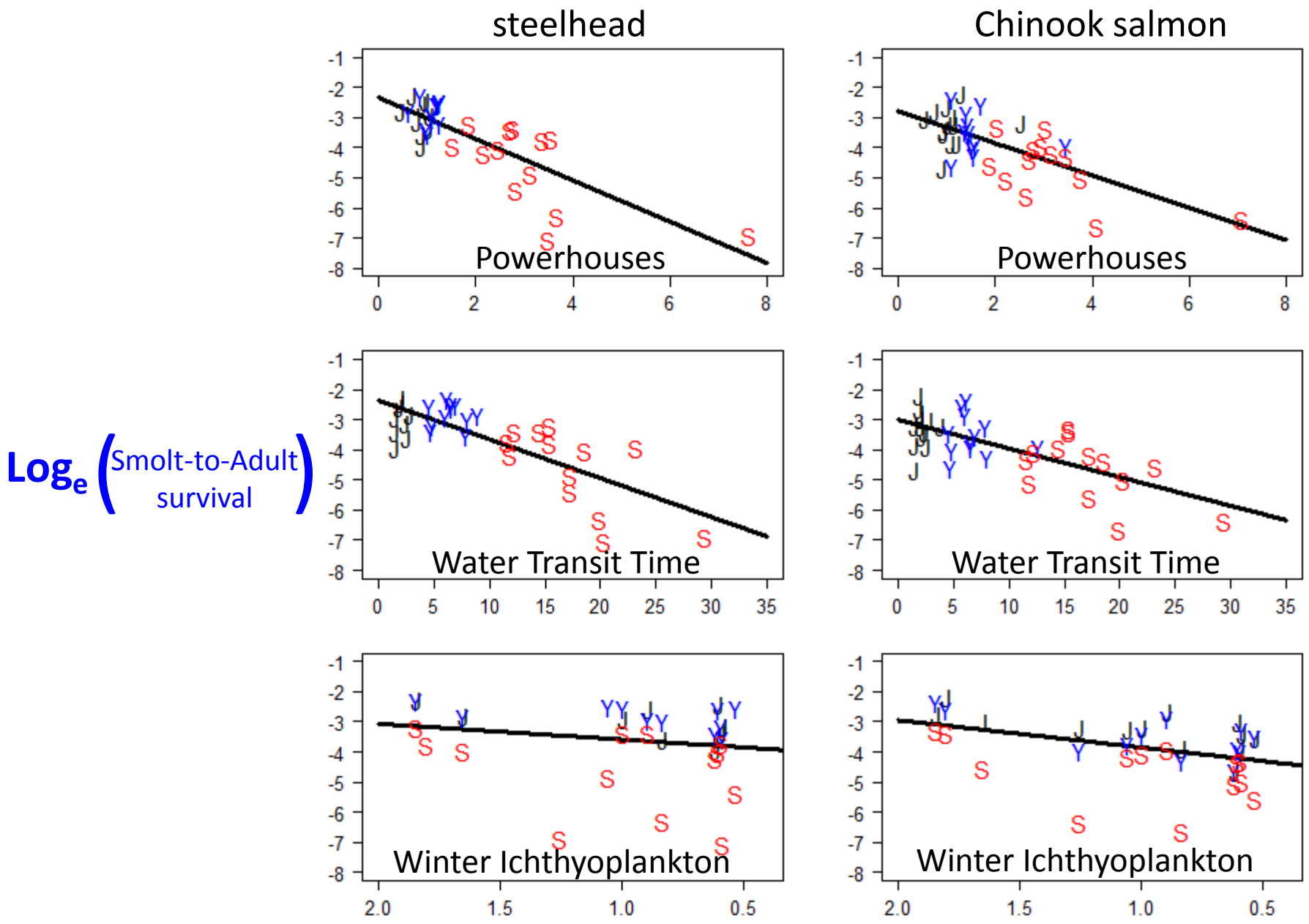


Marine





Variable environmental conditions



What factors are associated with the patterns in survival?

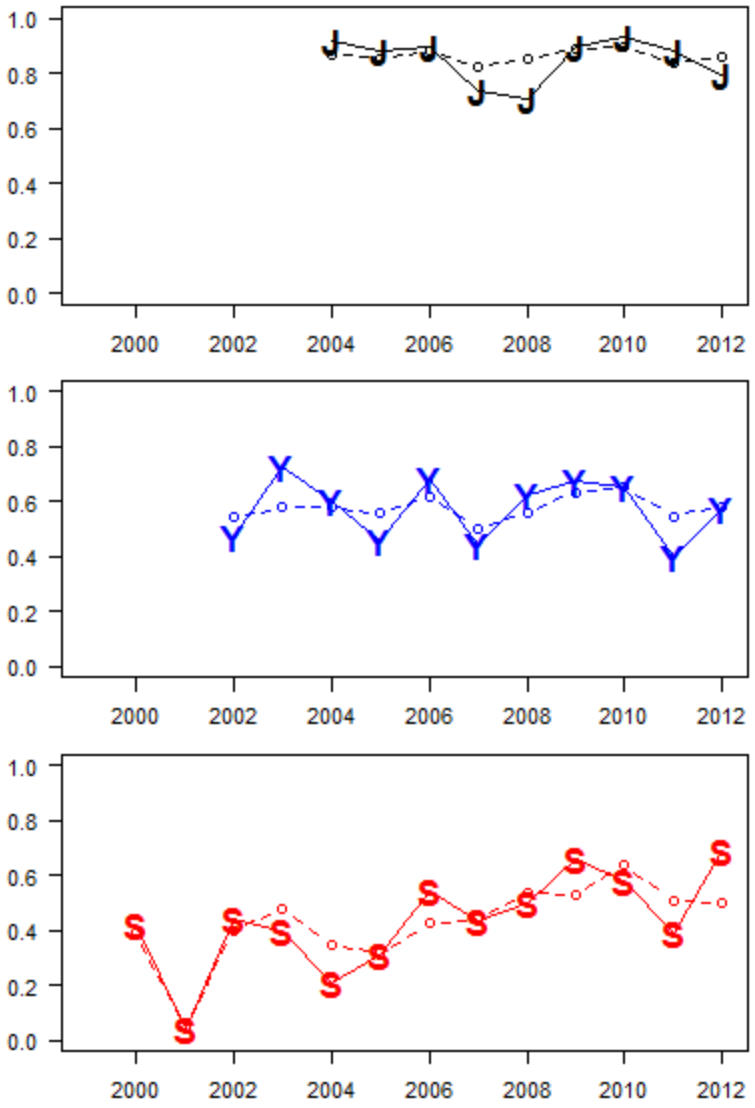
Multiple regression with multi-model inference

Migration year as random effect

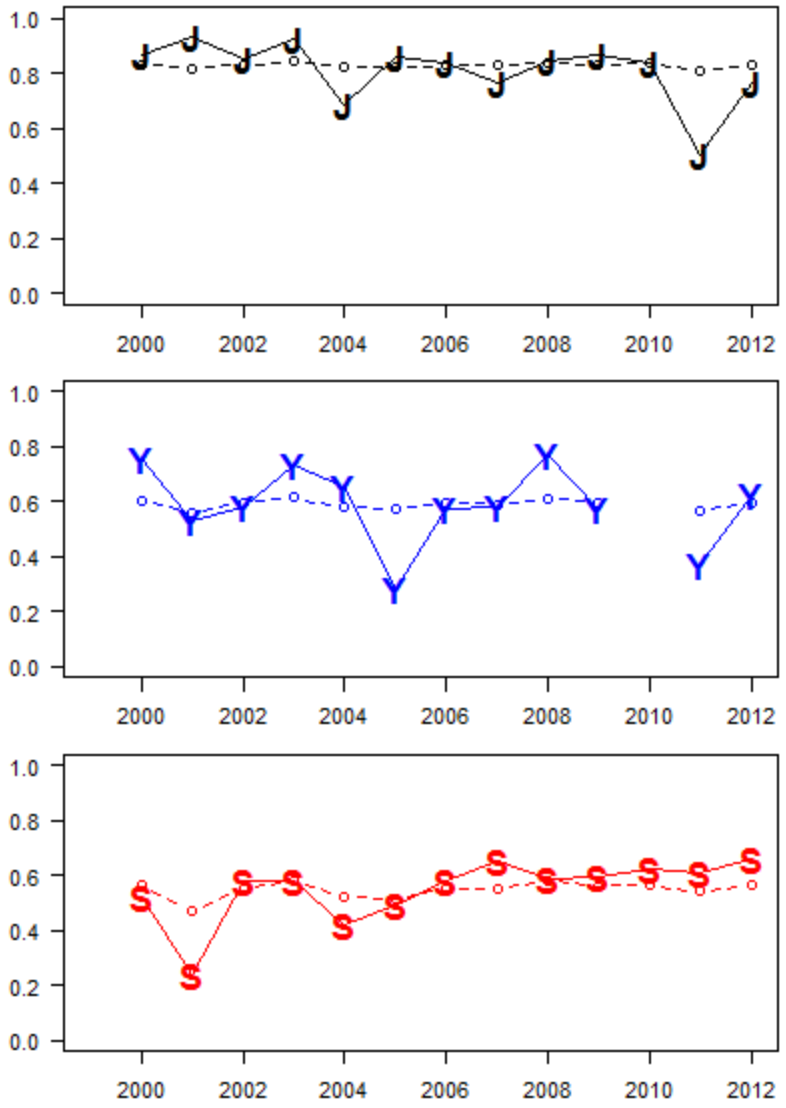
Variables	Freshwater survival	Ocean survival	Smolt-to-Adult survival
Water Transit Time	✓	✓	✓
Powerhouse passages	✓	✓	✓
Average dissolved gas	✓	✓	✓
Stock	✓	✓	✓
Winter Ichthyoplankton		✓	✓
Pacific Decadal Oscillation		✓	✓

Fitted freshwater survival

steelhead $R^2 = 0.85$

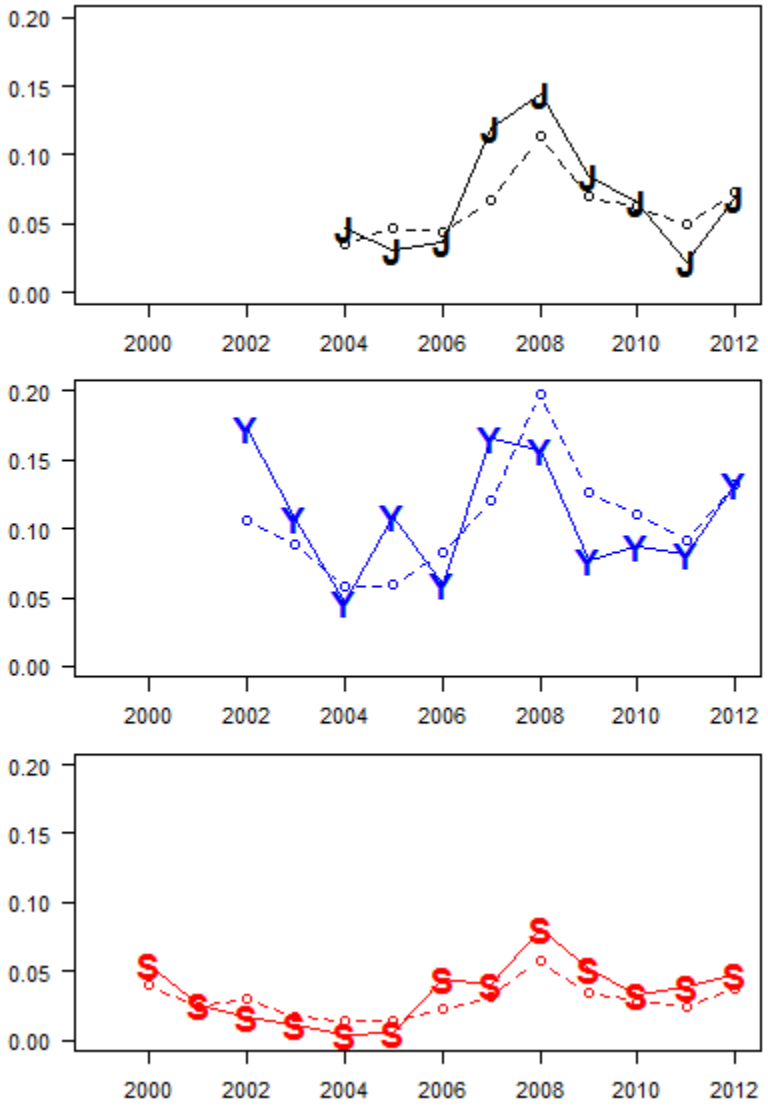


Chinook salmon $R^2 = 0.60$

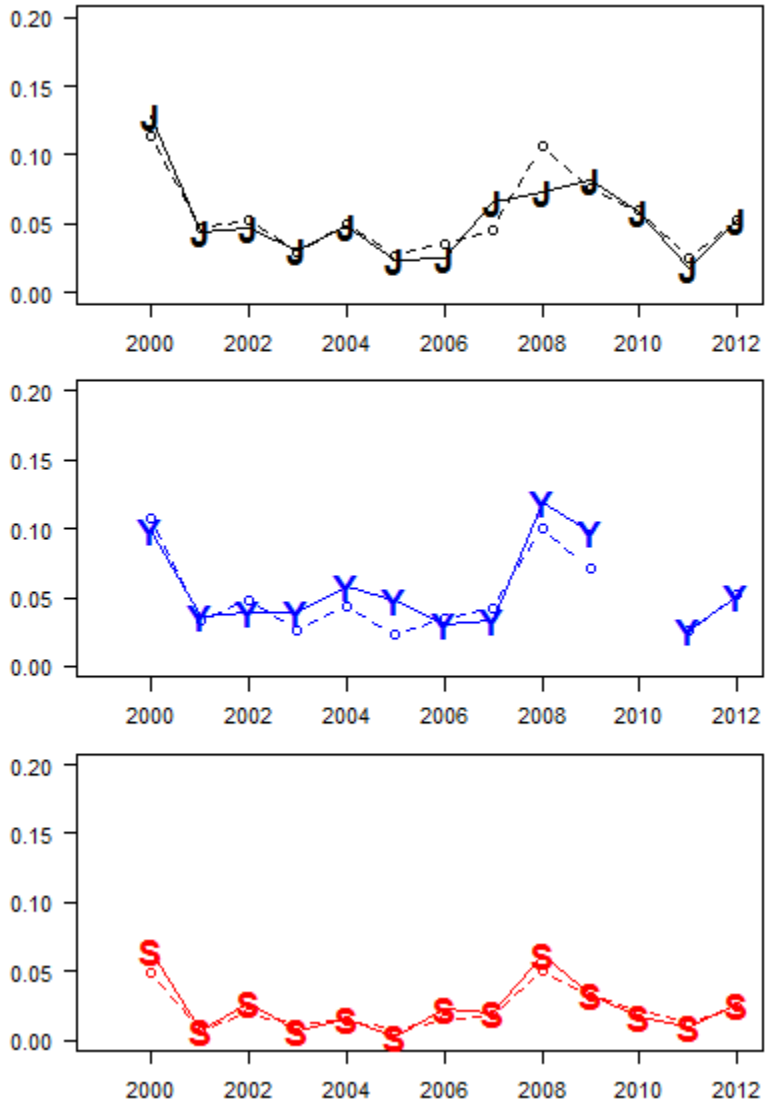


Fitted ocean survival

steelhead $R^2 = 0.70$

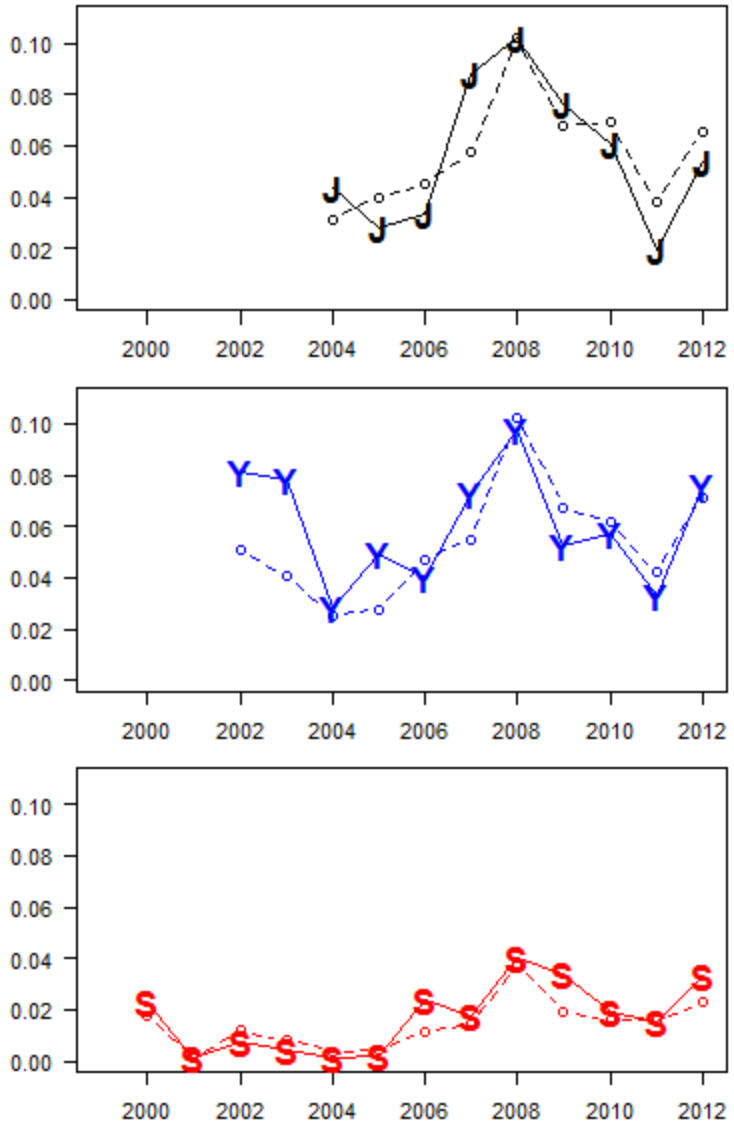


Chinook salmon $R^2 = 0.87$

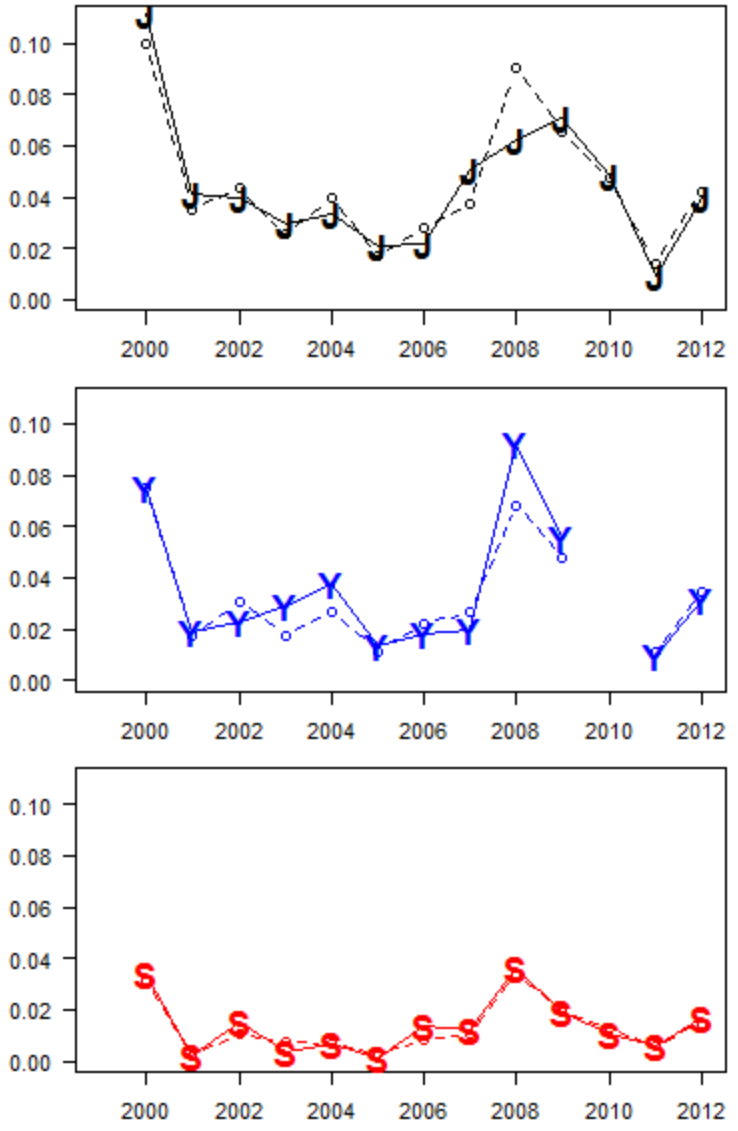


Fitted Smolt-to-Adult survival

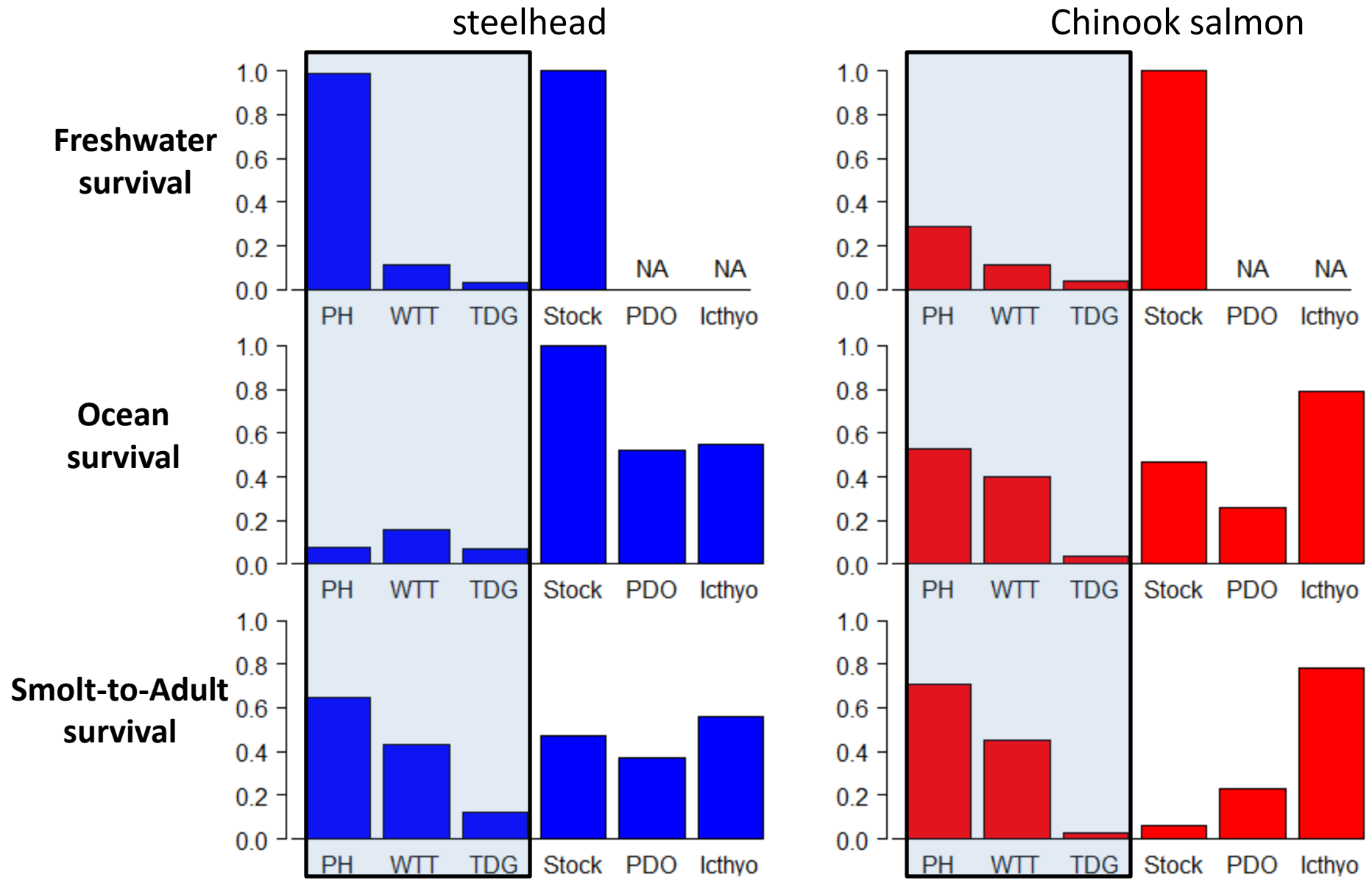
steelhead $R^2 = 0.79$



Chinook salmon $R^2 = 0.90$



Relative Variable Importance



Can management efforts help achieve regional survival goals?

Use model-averaged coefficients to forecast Smolt-to-Adult survival rates

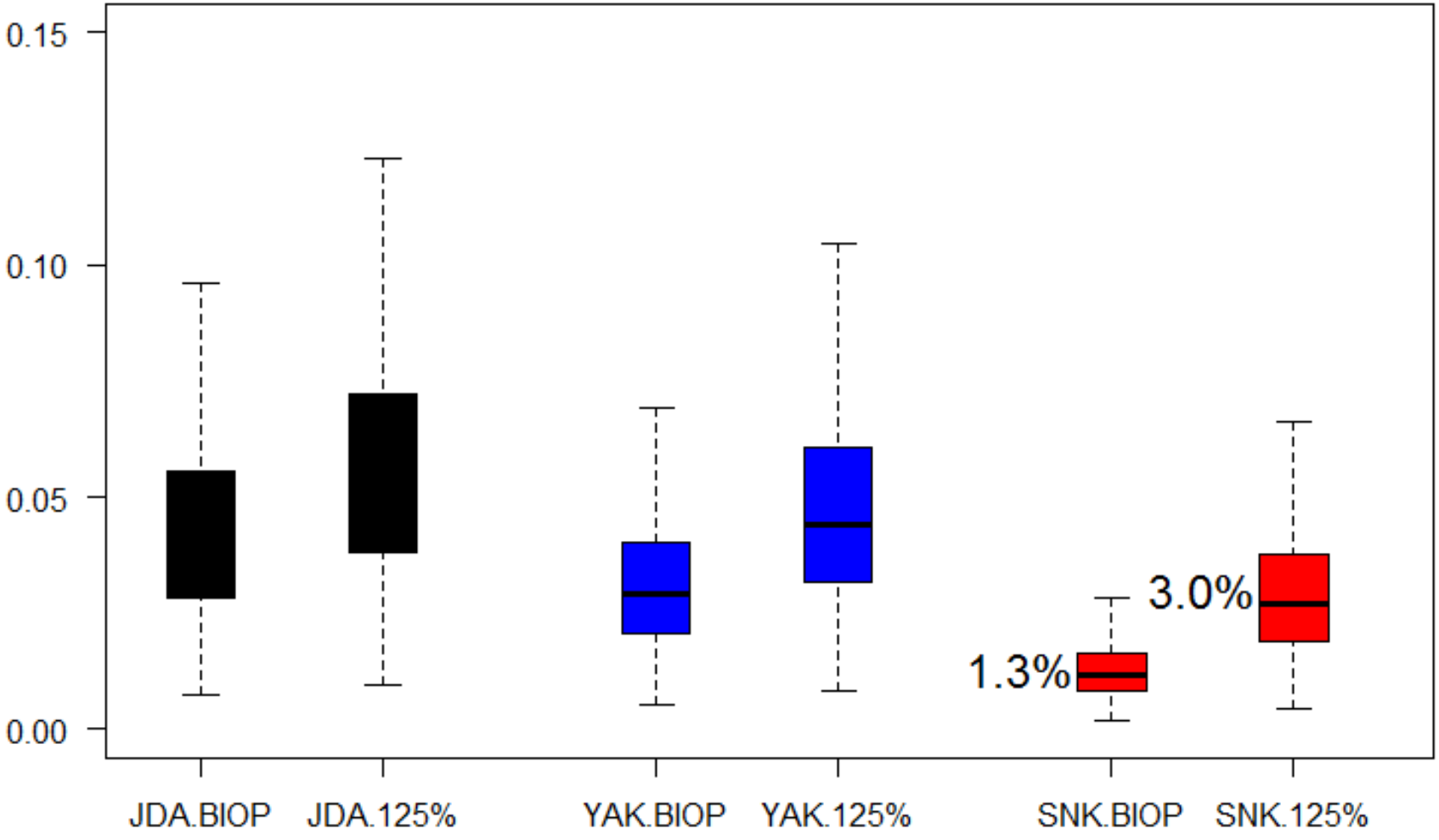
Considered two management scenarios:

- Current Biological Opinion spill levels
- Spill to 125% dissolved gas limits

Account for variable freshwater and ocean conditions:

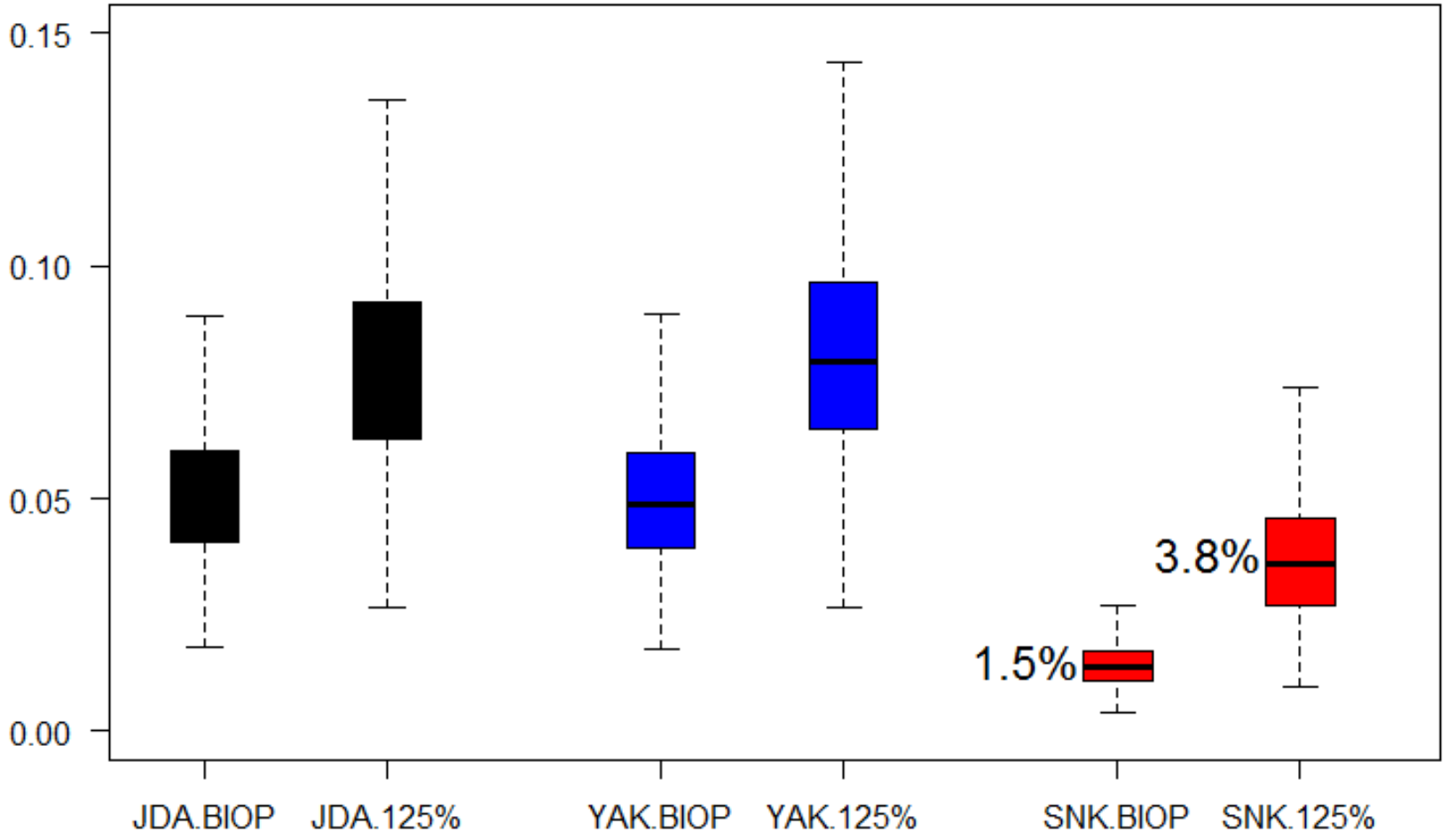
- High, average, low flow years
- Winter Ichthyoplankton, Pacific Decadal Oscillation

Predicted Smolt-to-Adult survival rates: Chinook salmon



Prob. (< 1% SAR): 38% 5%

Predicted Smolt-to-Adult survival rates: steelhead



Prob. (< 1% SAR): 26% 0%

Conclusions

Models captured high degree of spatial and temporal patterns in variation

Freshwater: Powerhouses + Water Transit Time

Ocean: Powerhouses + Water Transit Time + Ichthyoplankton + PDO

Smolt-to-Adult: Powerhouses + Water Transit Time + Ichthyoplankton + PDO

Snake: 230% - 250% improvement in Smolt-to-Adult survival with increased spill

Yakima: 50% - 60% improvement

John Day: 30% - 50% improvement

Adaptive Management Experiment:

Ongoing tagging efforts provides framework for monitoring