Fecundity trends of Chinook salmon in the Pacific Northwest

Michael J. Malick

James Losee, Gary Marston, Mickey Agha, Barry Berejikian, Brian Beckman, and Matthew Cooper

Western Division AFS, Boise, ID
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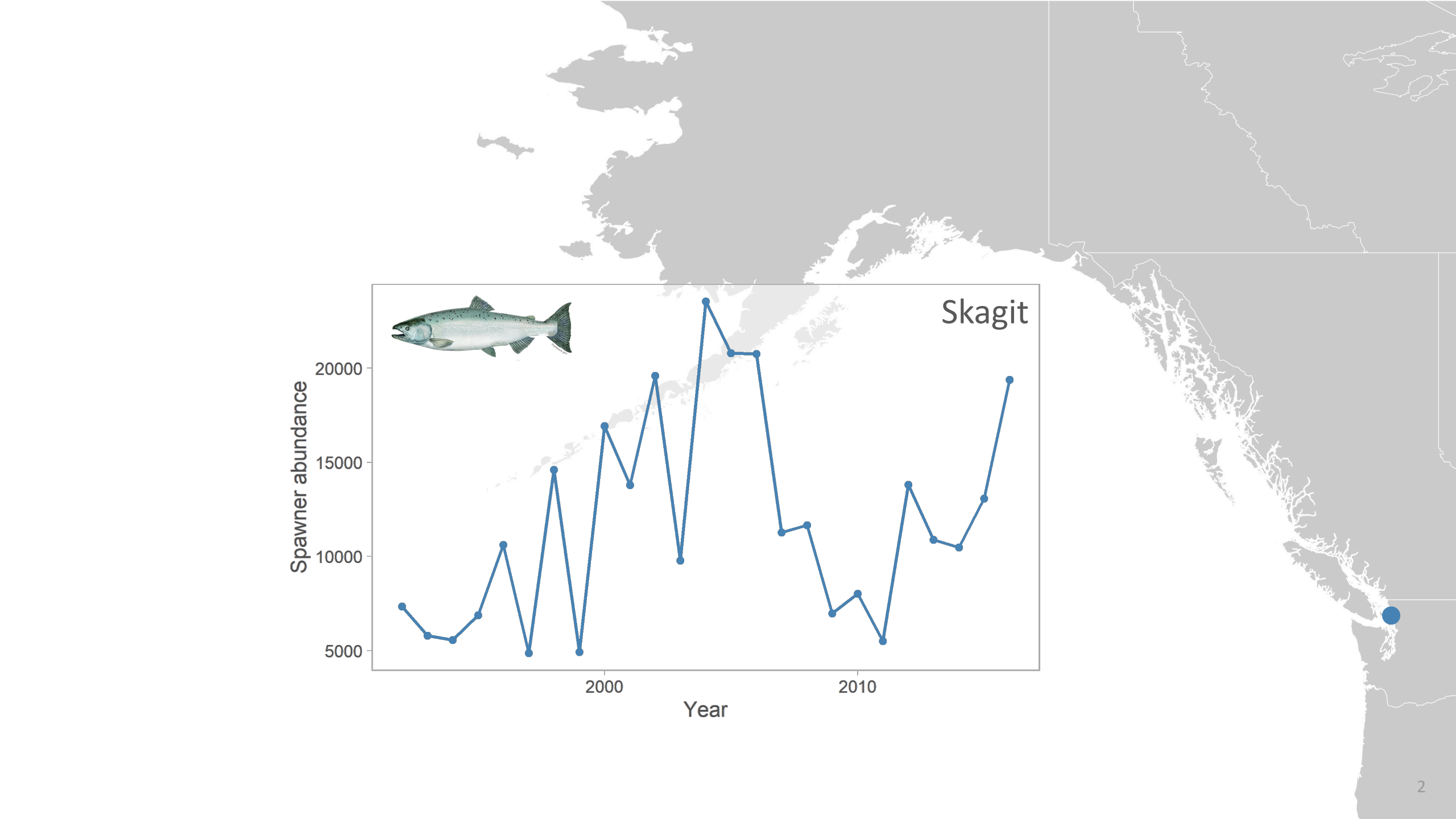
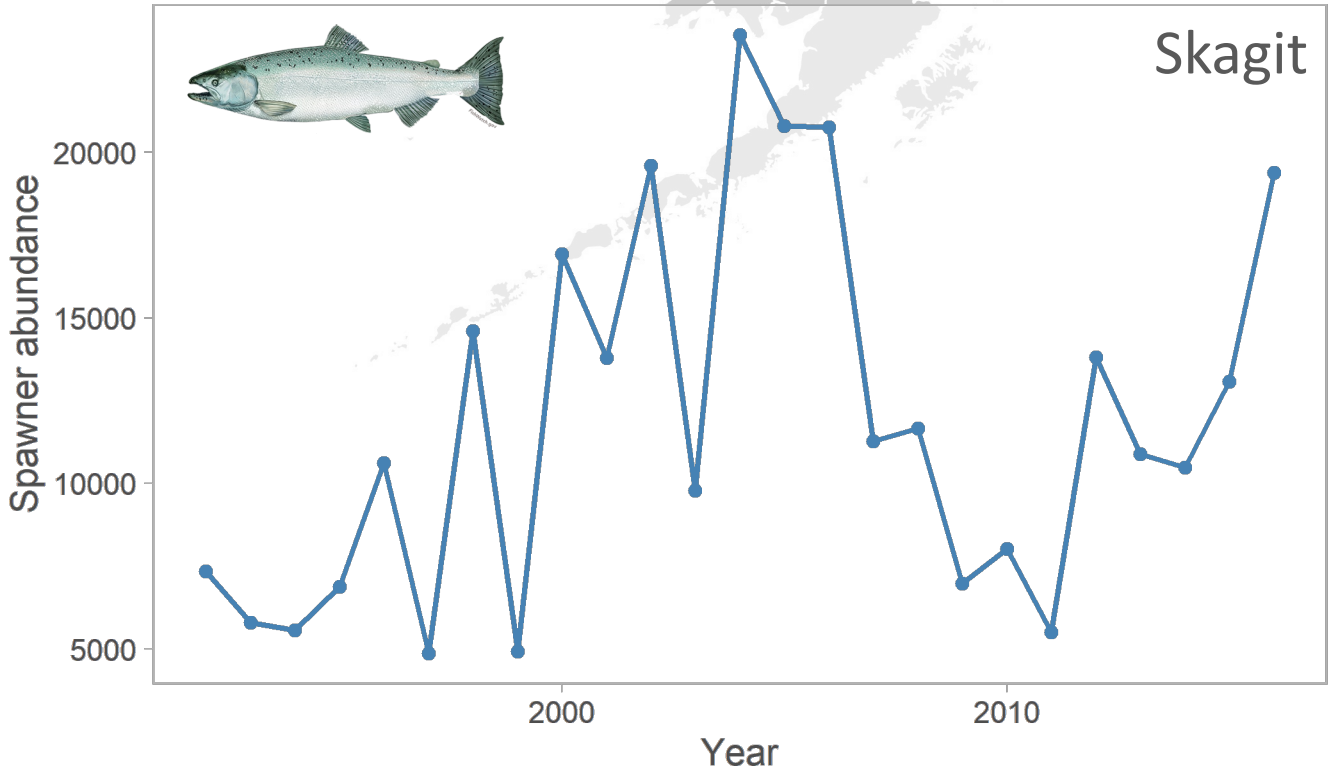
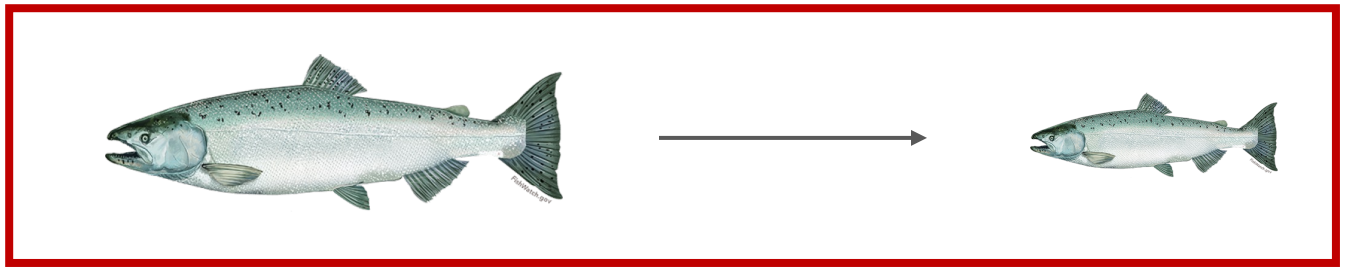
NOAA FISHERIES
National Oceanic and Atmospheric Administration


Skagit
Spawner abundance
20000
15000
10000
5000
2000
2010
Year

N = # eggs x egg-to-adult survival





ORIGINAL ARTICLE

WILEY FISH and FISHERIES

Demographic changes in Chinook salmon across the Northeast Pacific Ocean

Jan Ohlberger[1] | Eric J Ward[2] | Daniel E Schindler[1] | Bert Lewis[3]

Recent declines in salmon body size impact ecosystems and fisheries

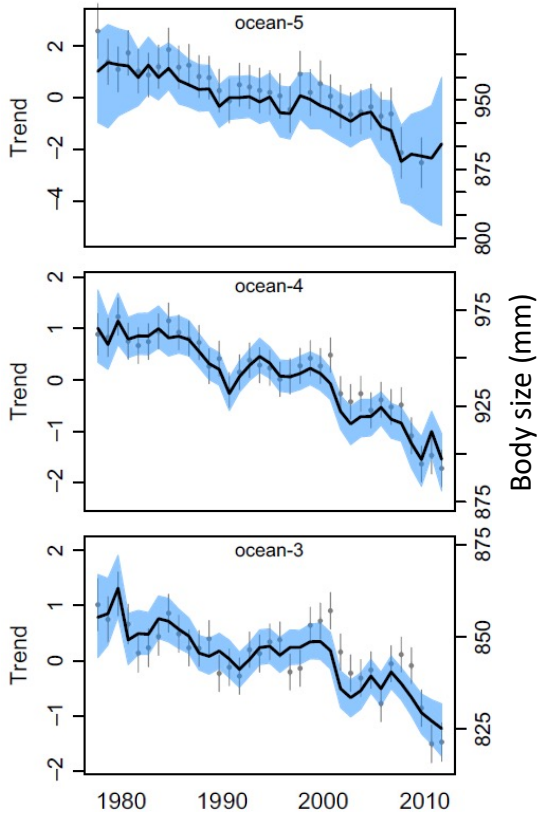
K. B. Oke[1,2✉], C. J. Cunningham[2,3], P. A. H. Westley[4✉], M. L. Baskett[5], S. M. Carlson[6], J. Clark[7], A. P. Hendry[8], V. A. Karatayev[5], N. W. Kendall[9], J. Kibele[7], H. K. Kindsvater[10], K. M. Kobayashi[1], B. Lewis[11], S. Munch[1,12], J. D. Reynolds[13], G. K. Vick[14] & E. P. Palkovacs[1✉]

ORIGINAL ARTICLE

FISH and FISHERIES WILEY

Changing salmon: An analysis of body mass, abundance, survival, and productivity trends across 45 years in Puget Sound

James P. Losee | Neala W. Kendall | Aaron Dufault



Ohlberger et al. (2018)

Research questions

Has fecundity of hatchery Chinook salmon in Washington State changed over the past three decades?

If so, to what extent are fecundity trends shaped by changes in body size?

Fecundity

Stocks = 43

Years = 1995—2019

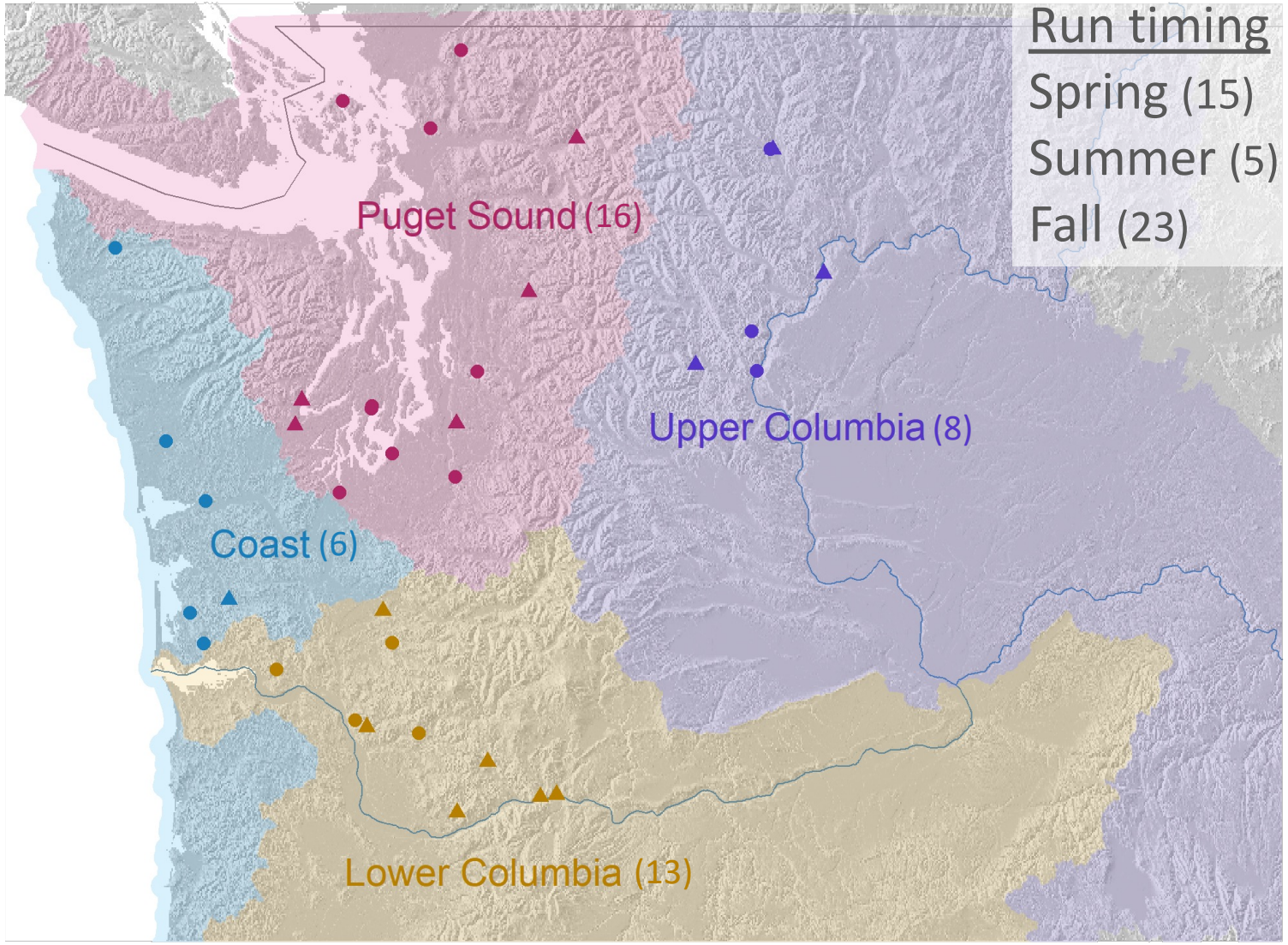
$\overline{N}$ = 23 years

Body size

Stocks = 18

Years = 1995—2019

$\overline{N}$ = 25 years



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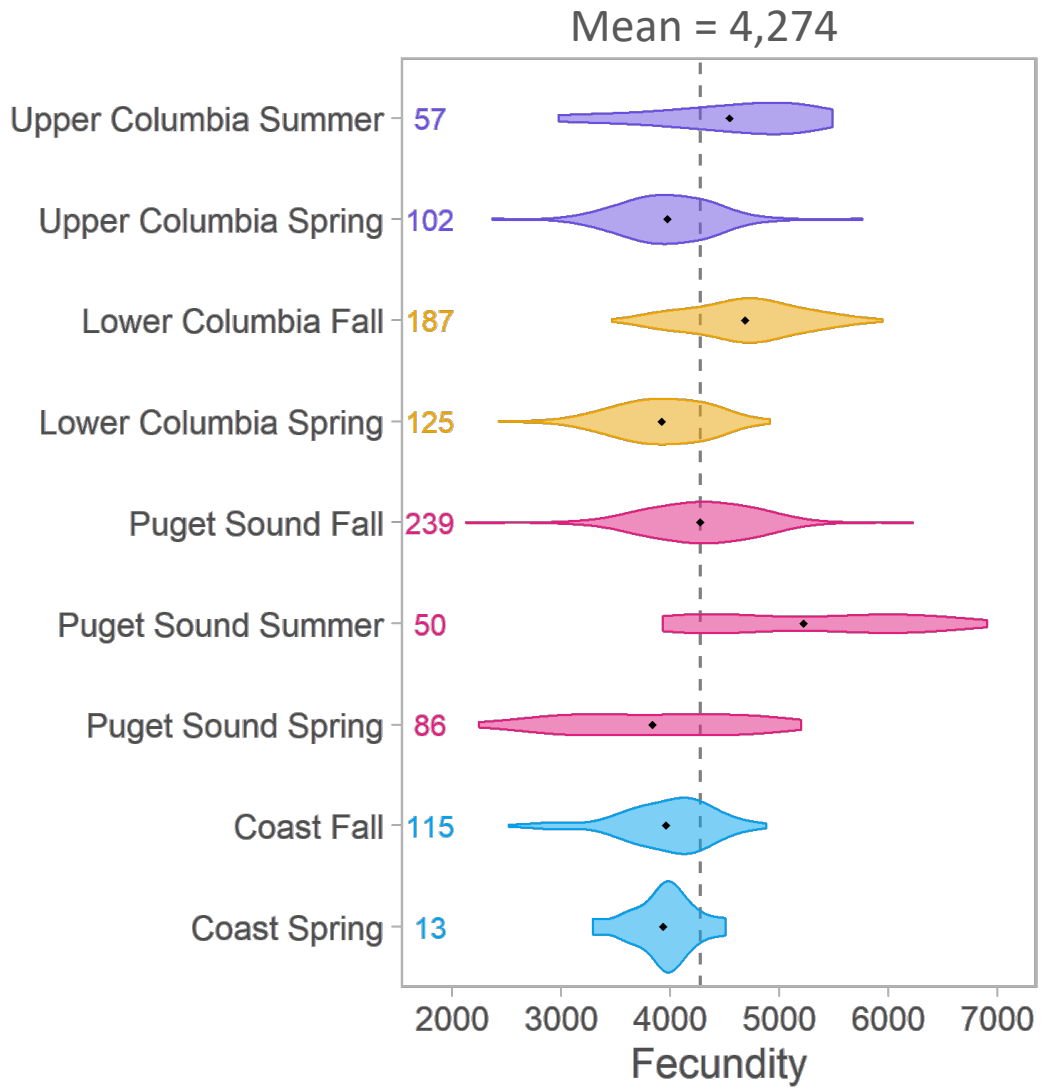


Modeling methods

1. Estimate stock-specific fecundity trends
2. Estimate common fecundity & size trends
3. Estimate size effects on fecundity

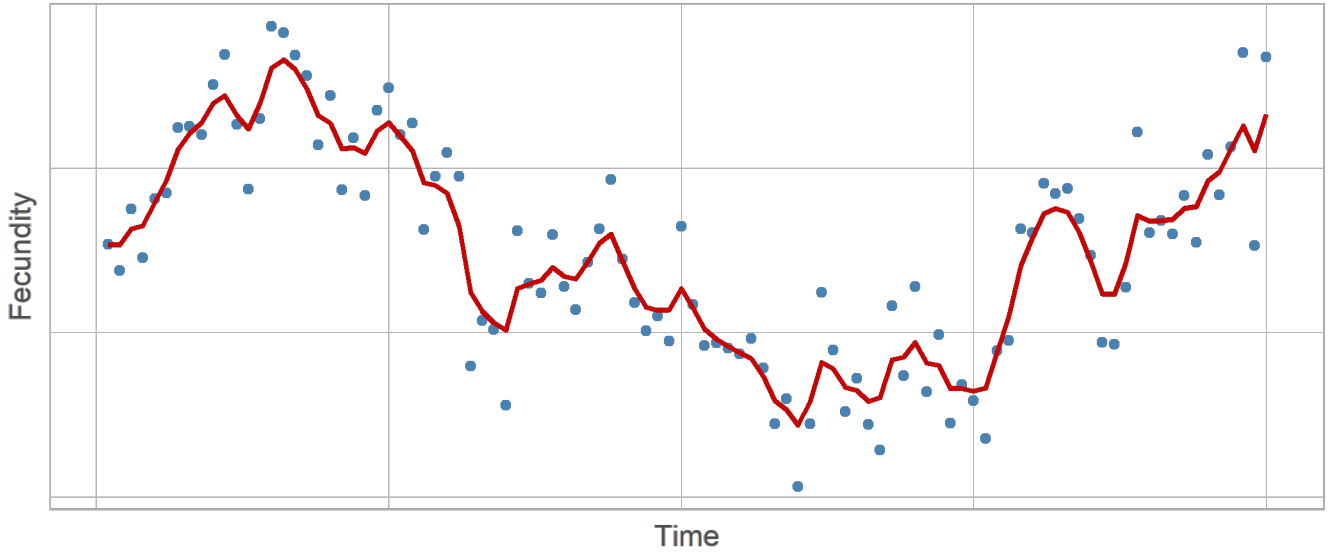
1. Estimating stock-specific fecundity trends

Fecundity

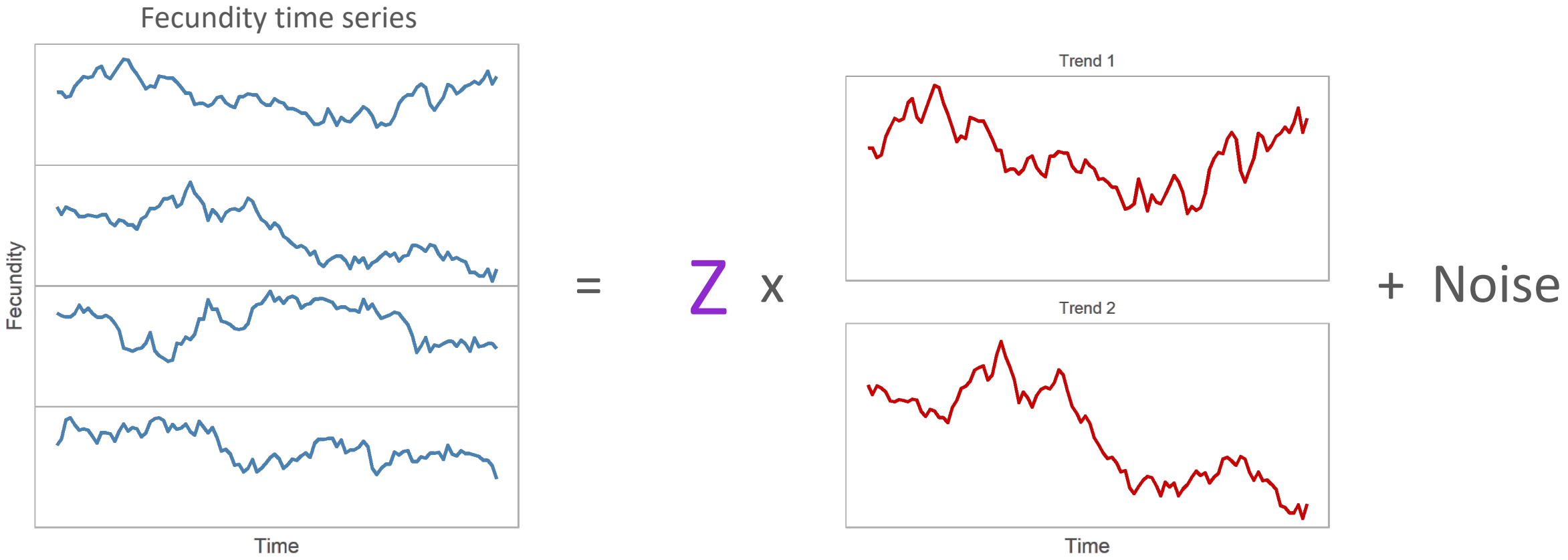
$$y_t = x_t + v_t \qquad v_t \sim N(0, \sigma_v^2)$$ Observation equation

$$x_t = x_{t-1} + w_t \qquad w_t \sim N(0, \sigma_w^2)$$ State equation

Latent trend



2. Estimating common fecundity & size trends

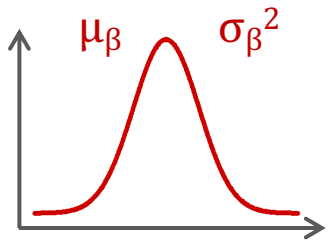


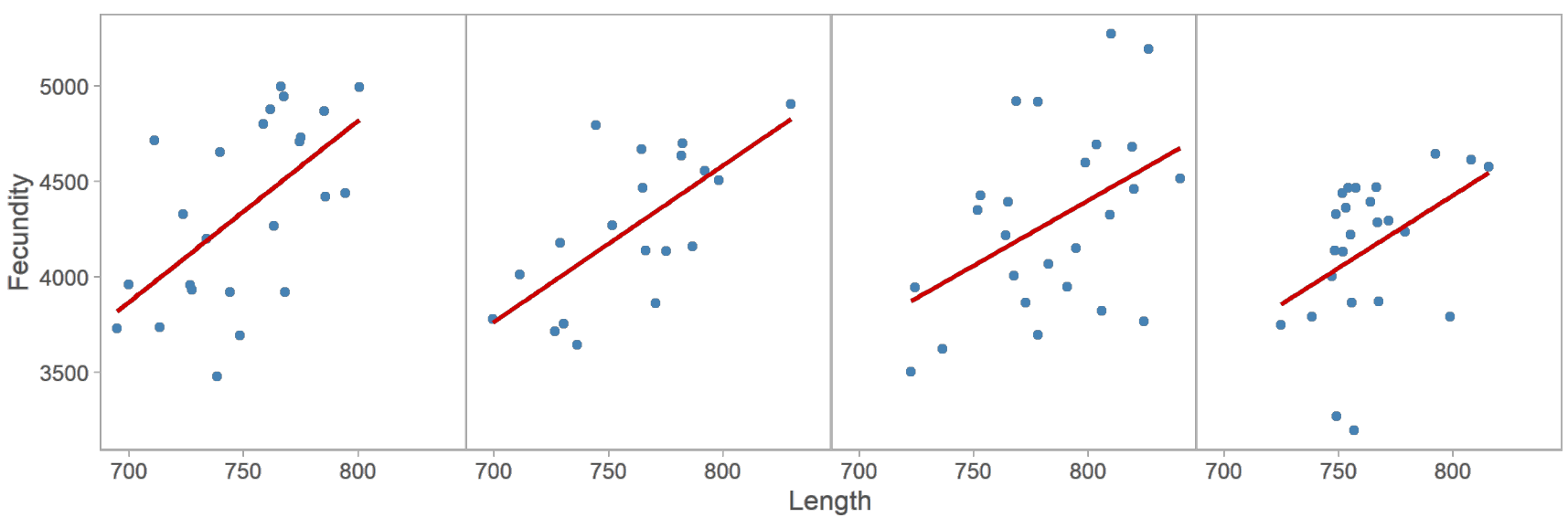
Dynamic Factor Analysis (DFA)

3. Estimating size effects on fecundity

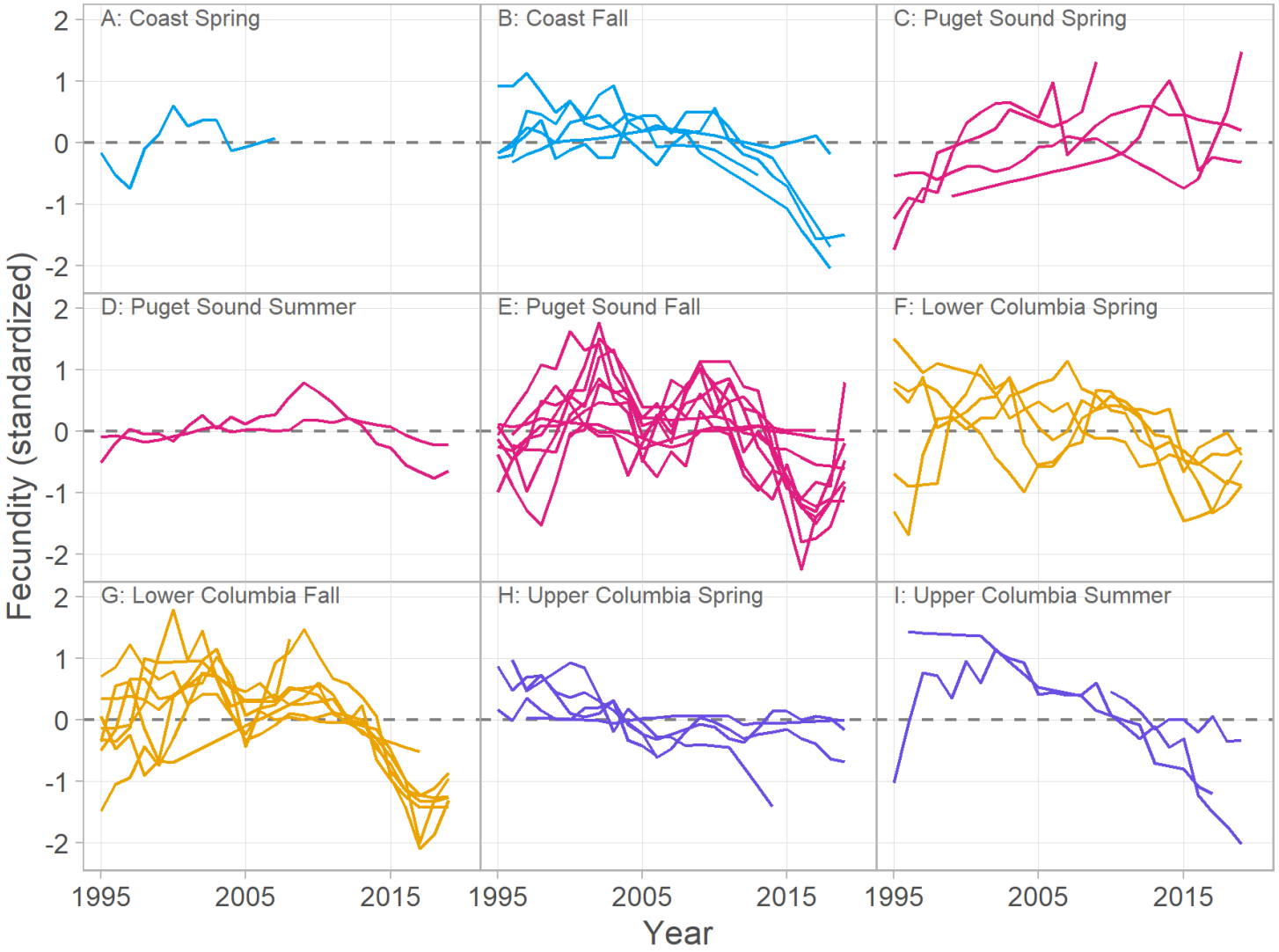
Fecundity Length

$$y_{i,t} = \alpha_i + \beta_i L_{i,t} + e_t \qquad e_t \sim N(0, \sigma^2)$$

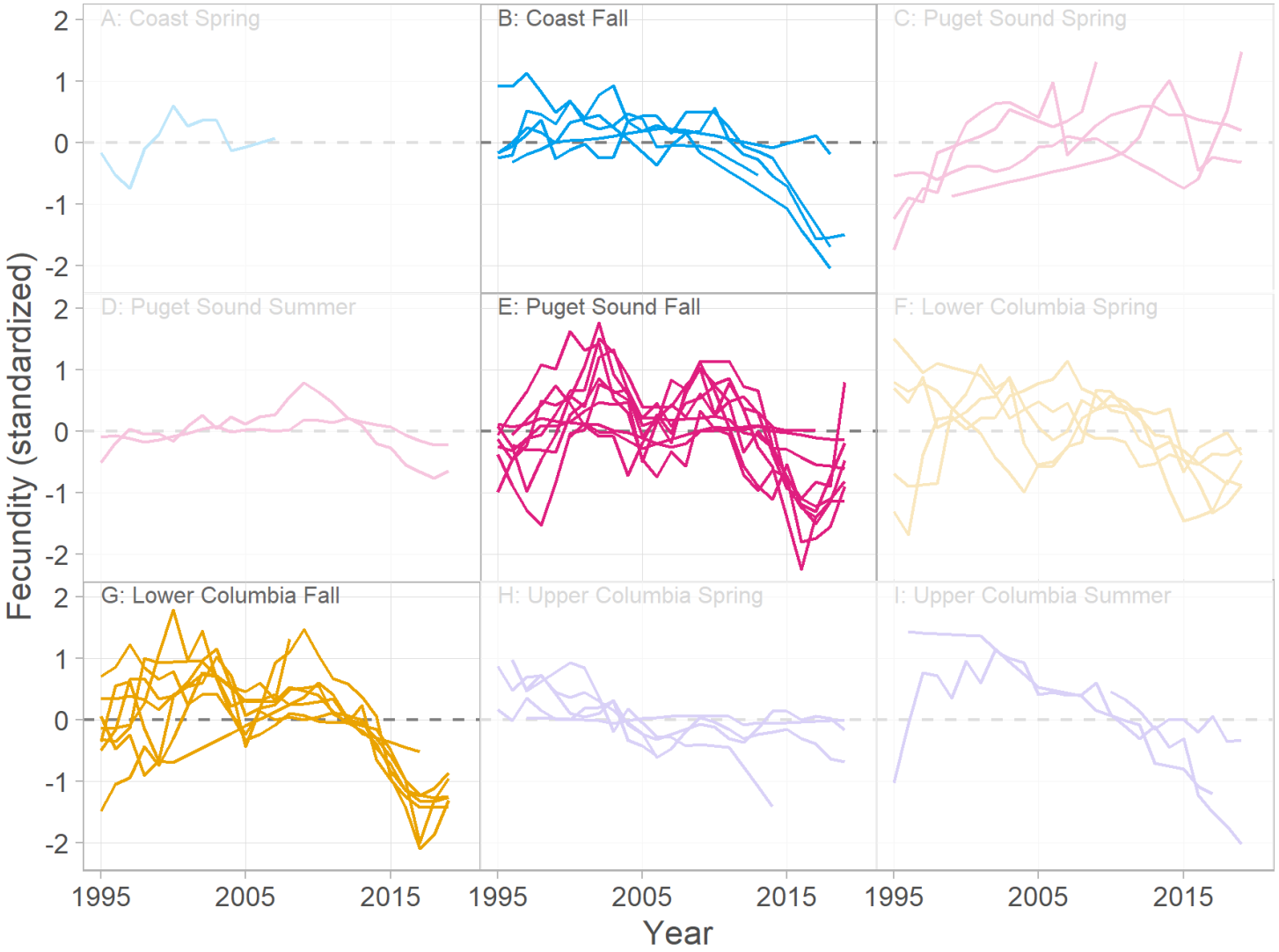




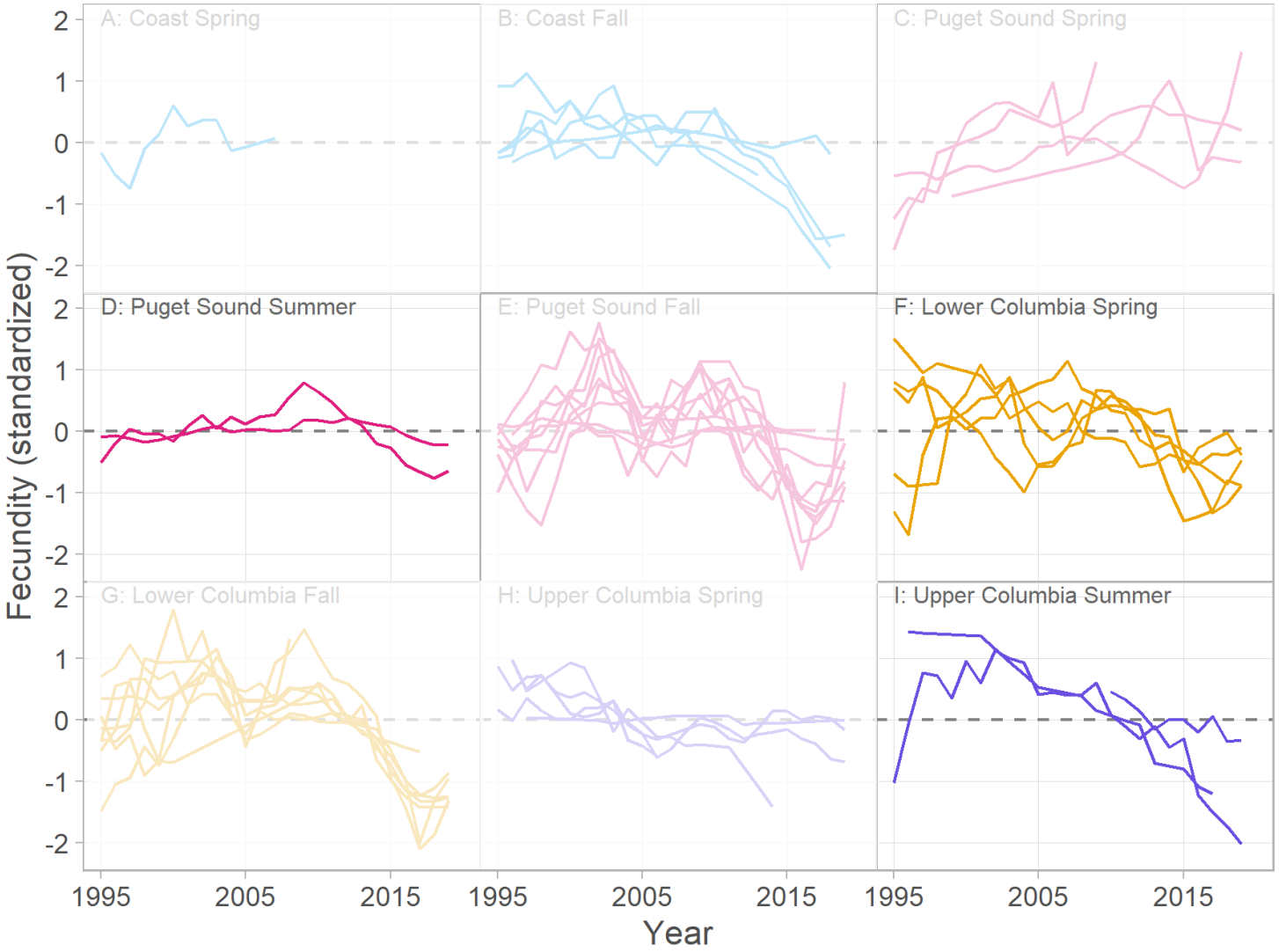
Fecundity trends: stock-specific



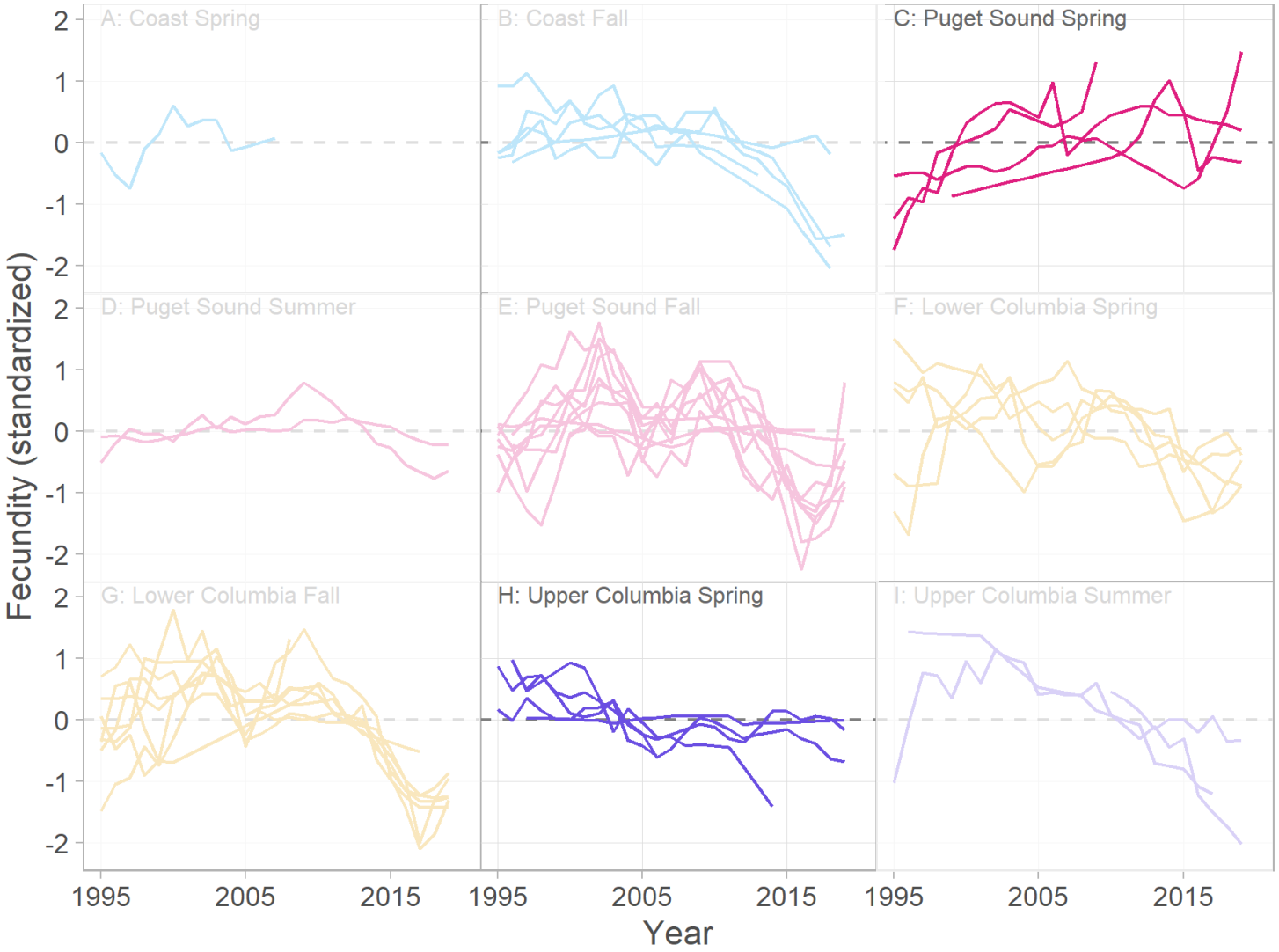
Fecundity trends: stock-specific



Fecundity trends: stock-specific

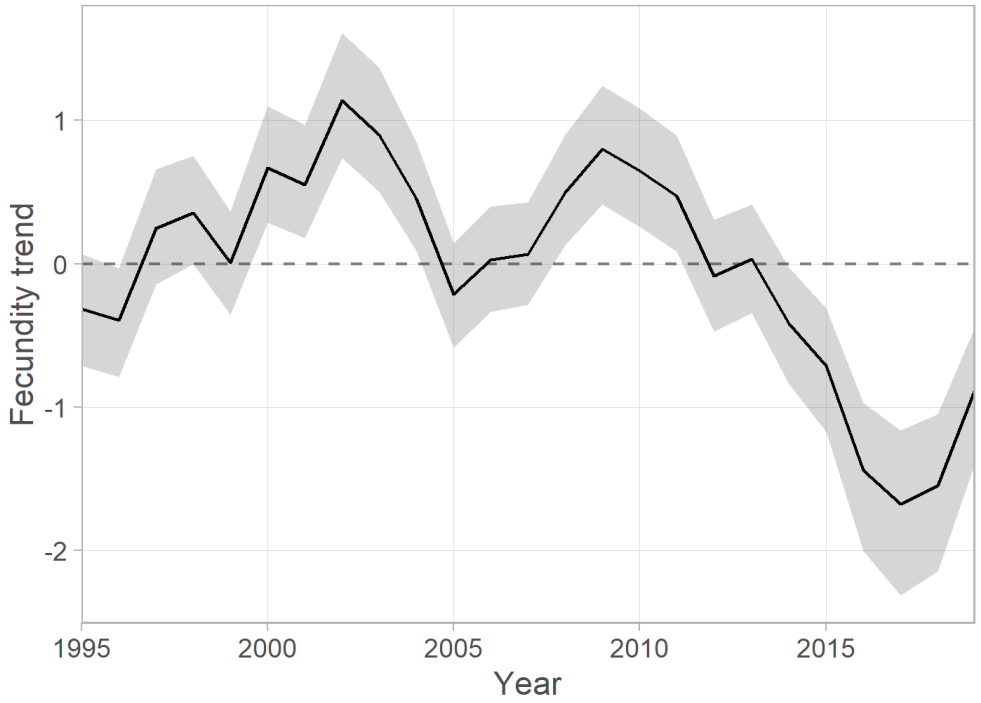


Fecundity trends: stock-specific

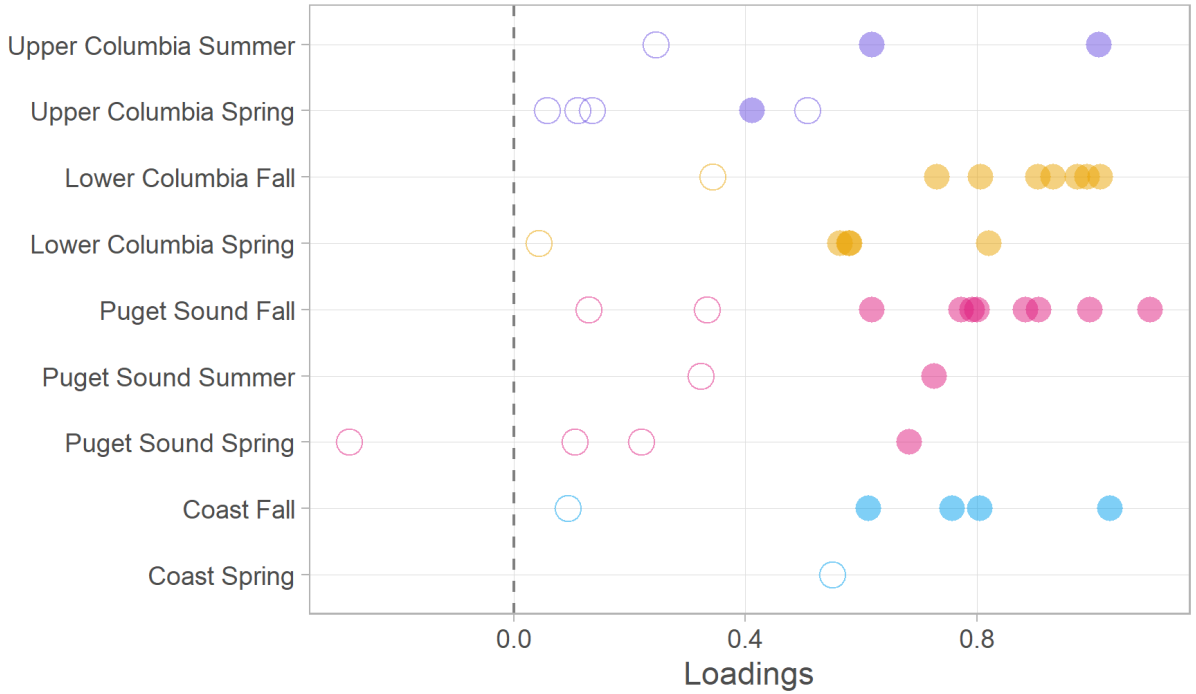


Fecundity trends: common

Common trend



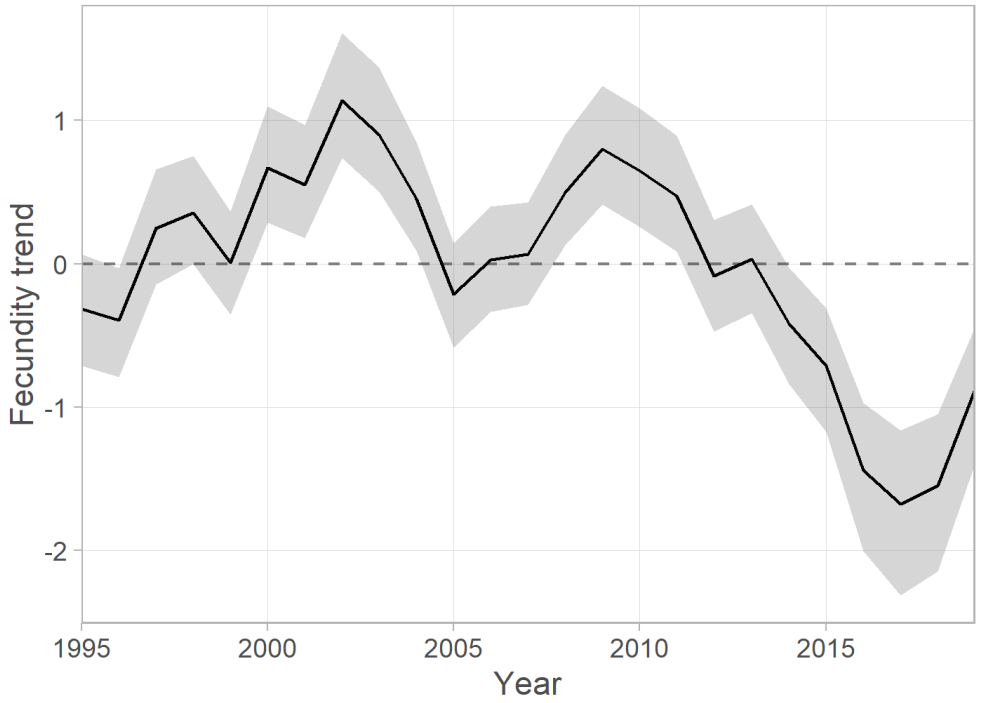
Loadings



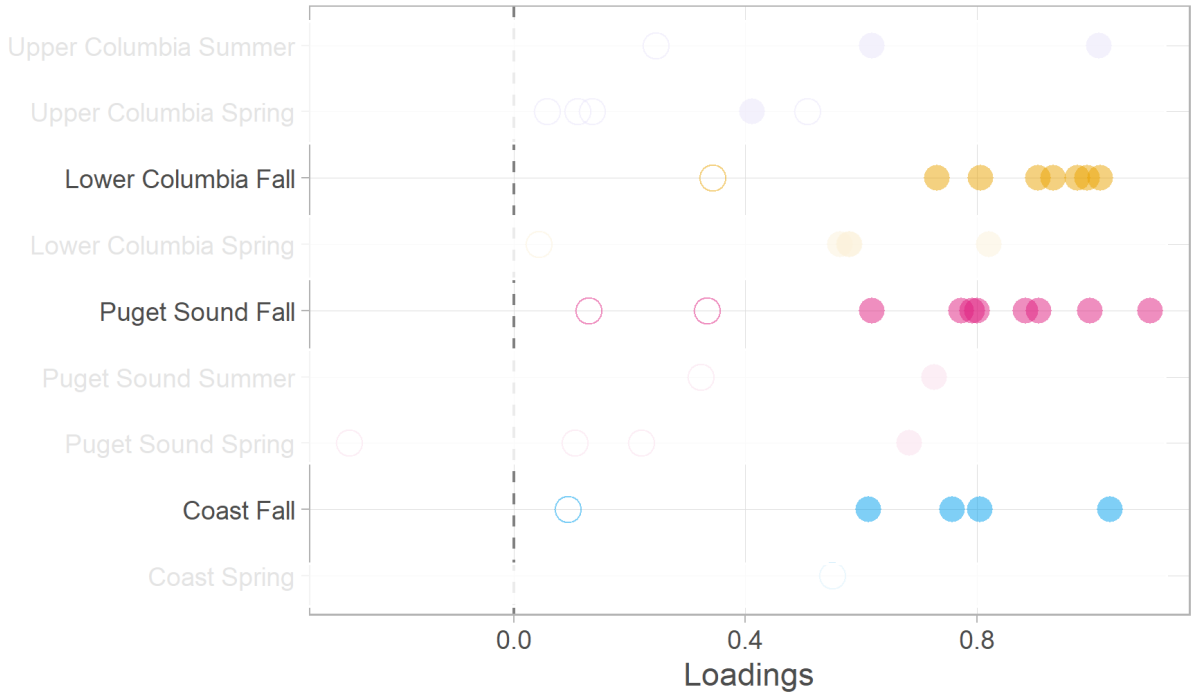
65% of stocks have a significant loading

Fecundity trends: common

Common trend

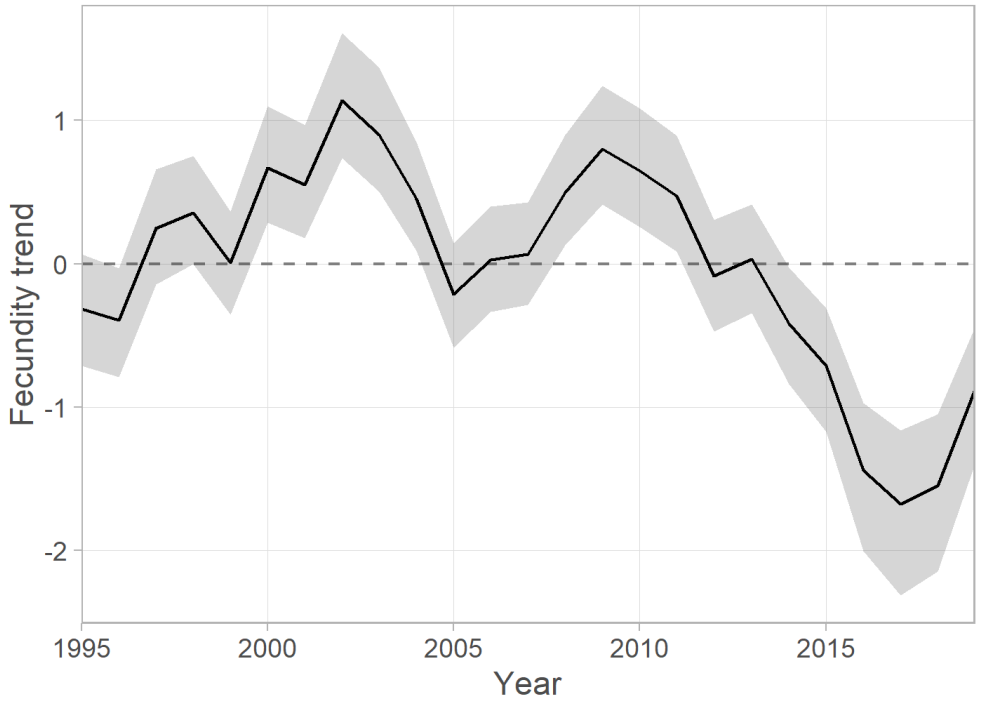


Loadings



Fecundity trends: common

Common trend



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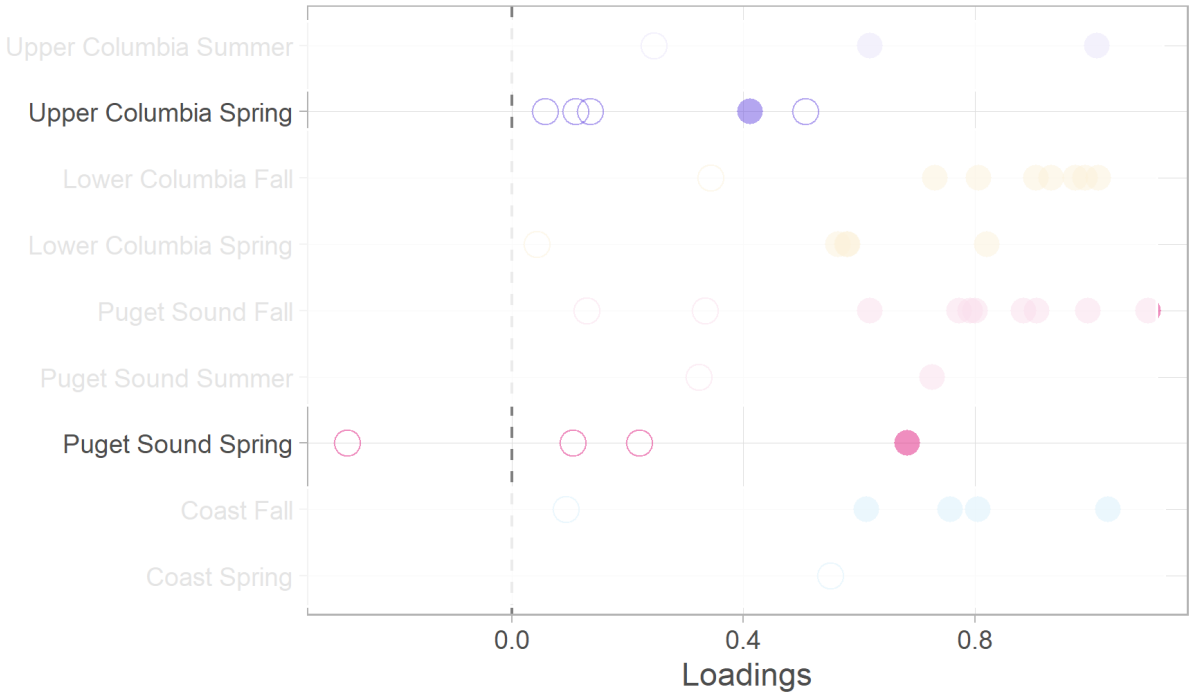
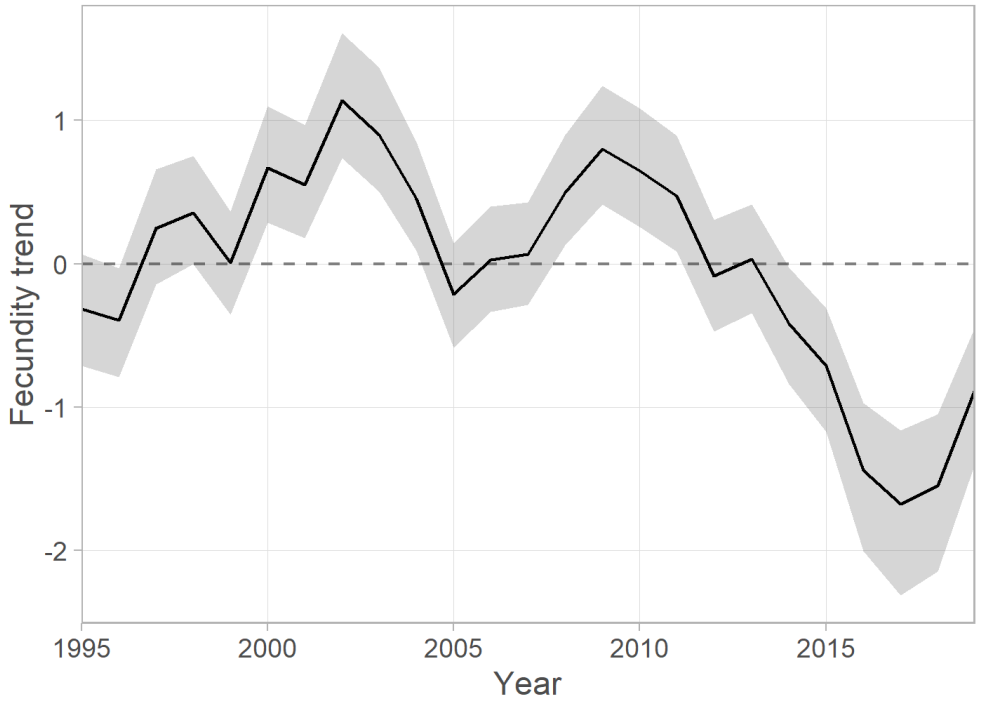


Fecundity trends: common

Common trend



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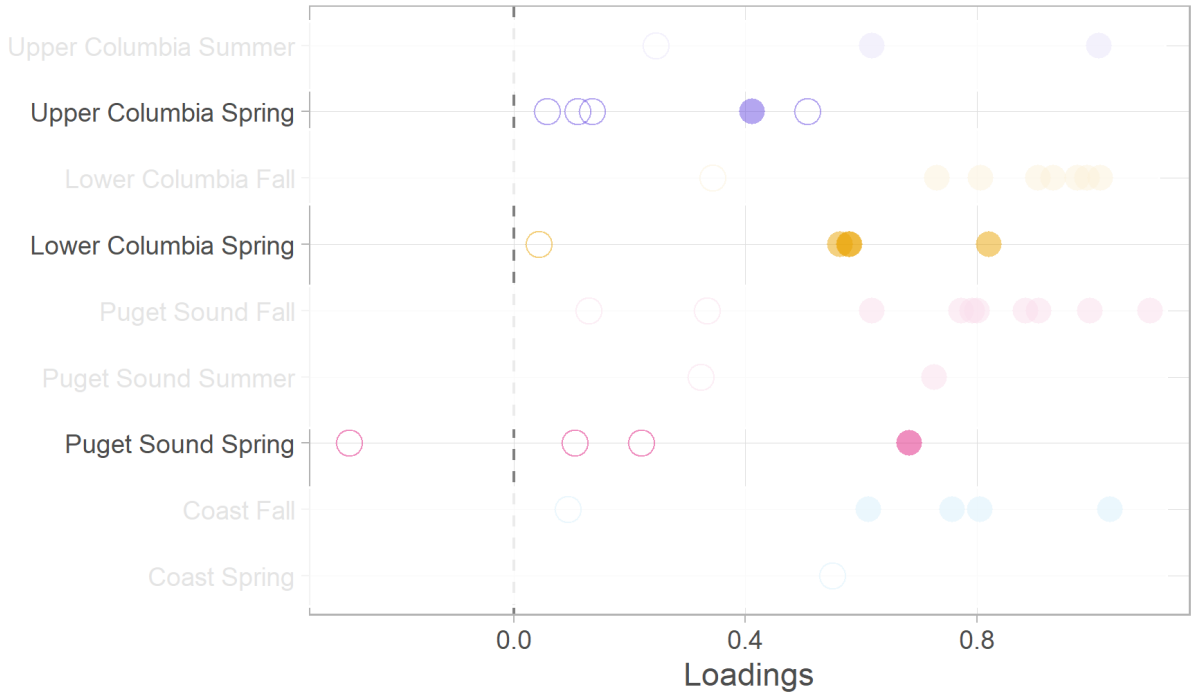
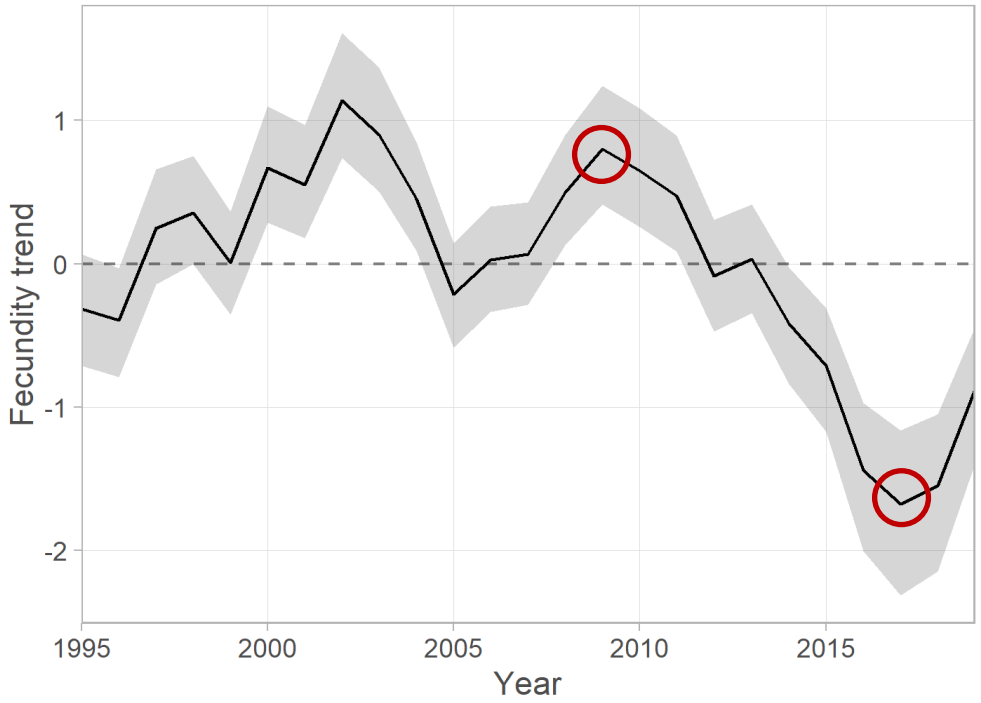
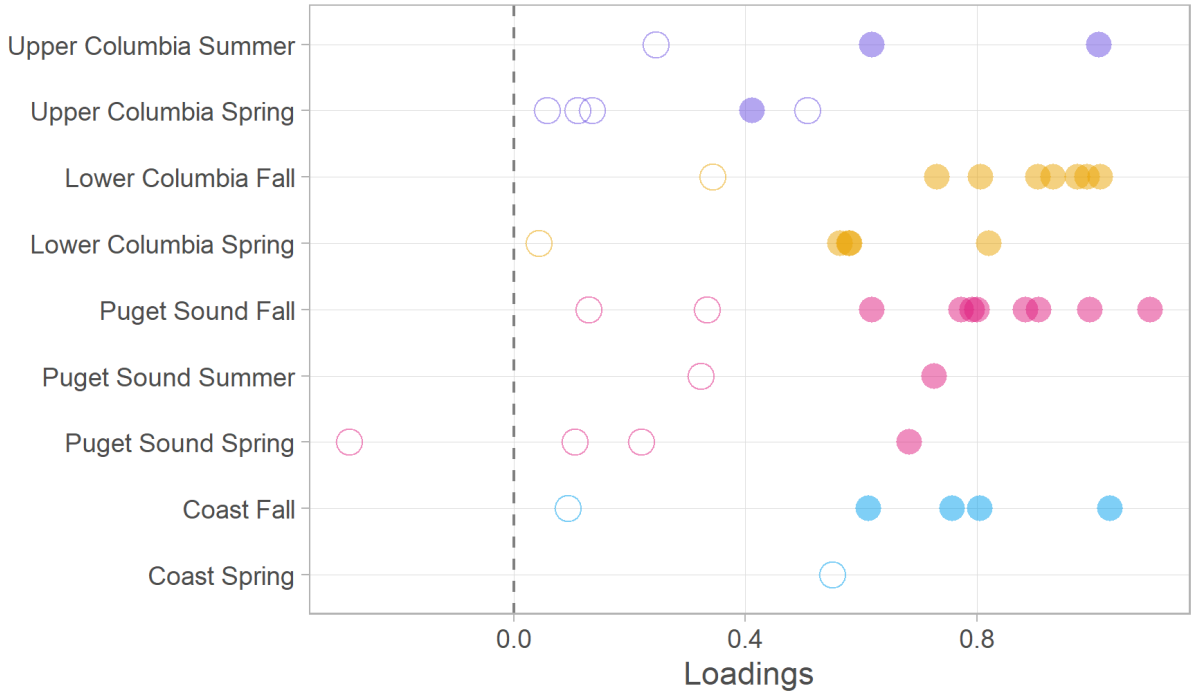


Fecundity trends: common

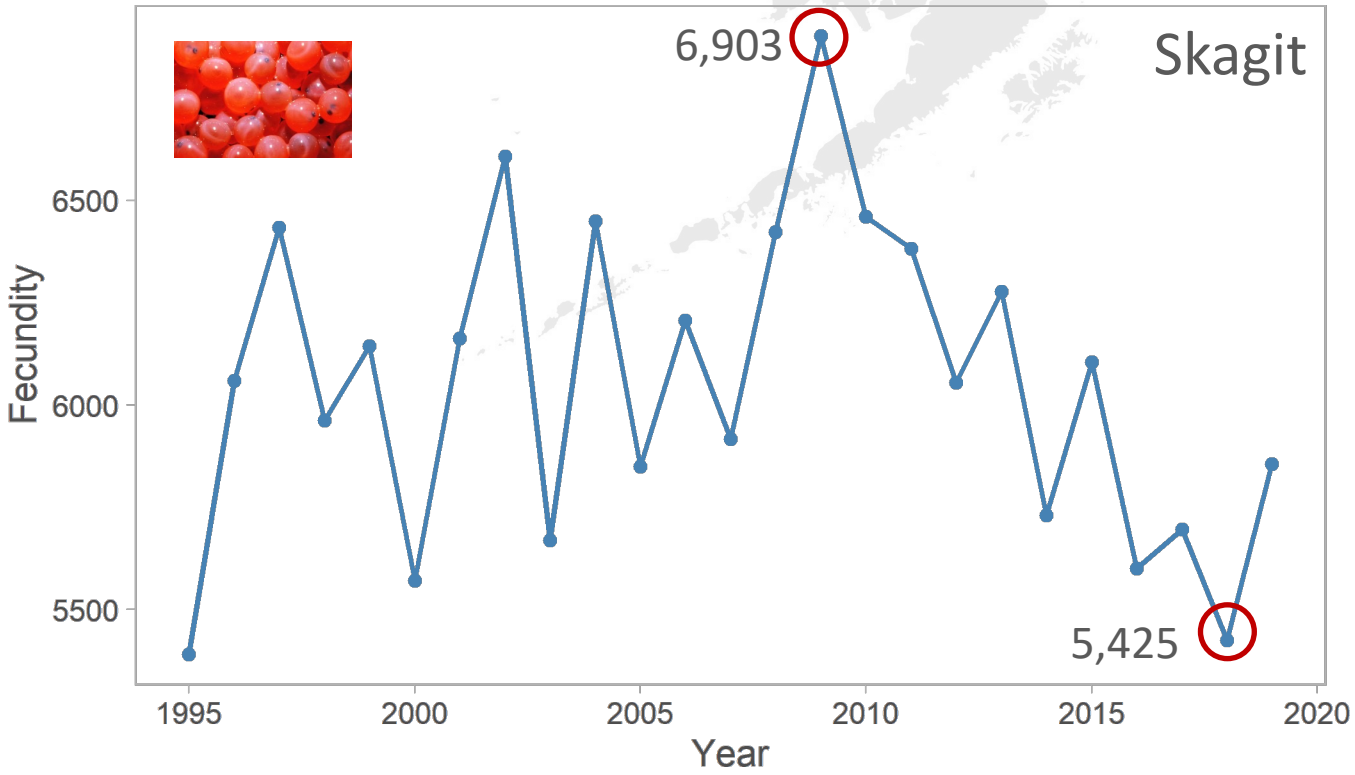
864 average egg decline for 2009—2017





21% decline = 1,477 eggs / female

~9 million eggs total



Research questions

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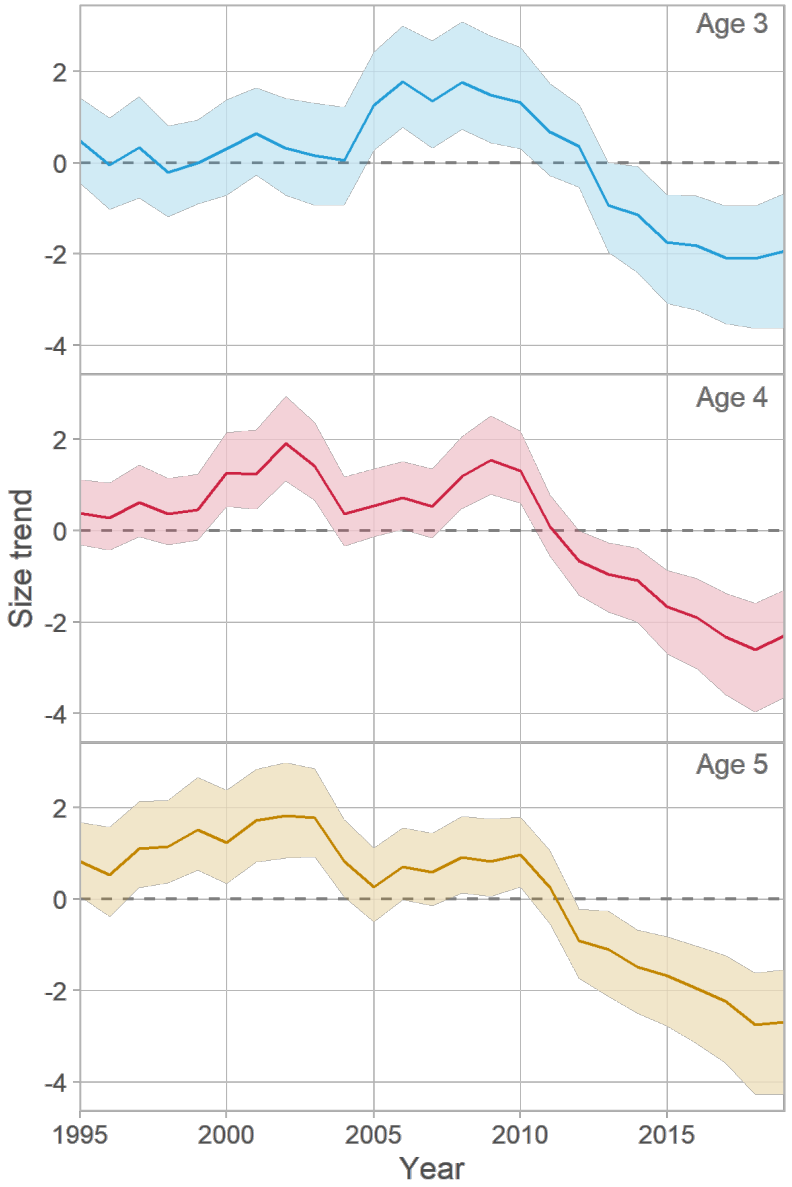
If so, to what extent are fecundity trends shaped by changes in body size?

Size trends: common



2009—2017 average

31 mm decline

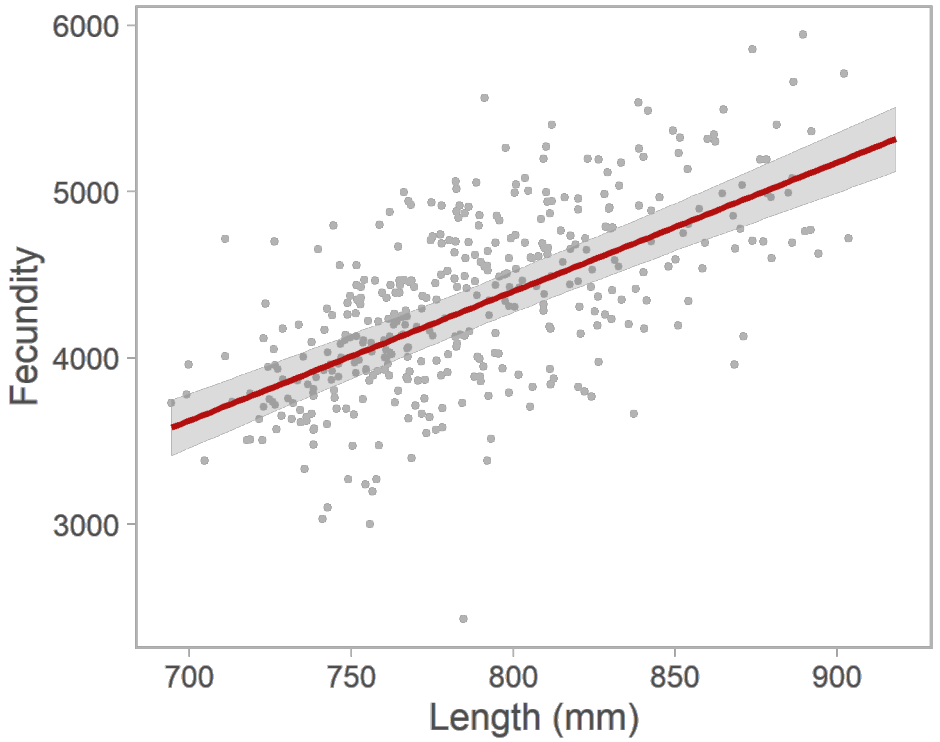
45 mm decline

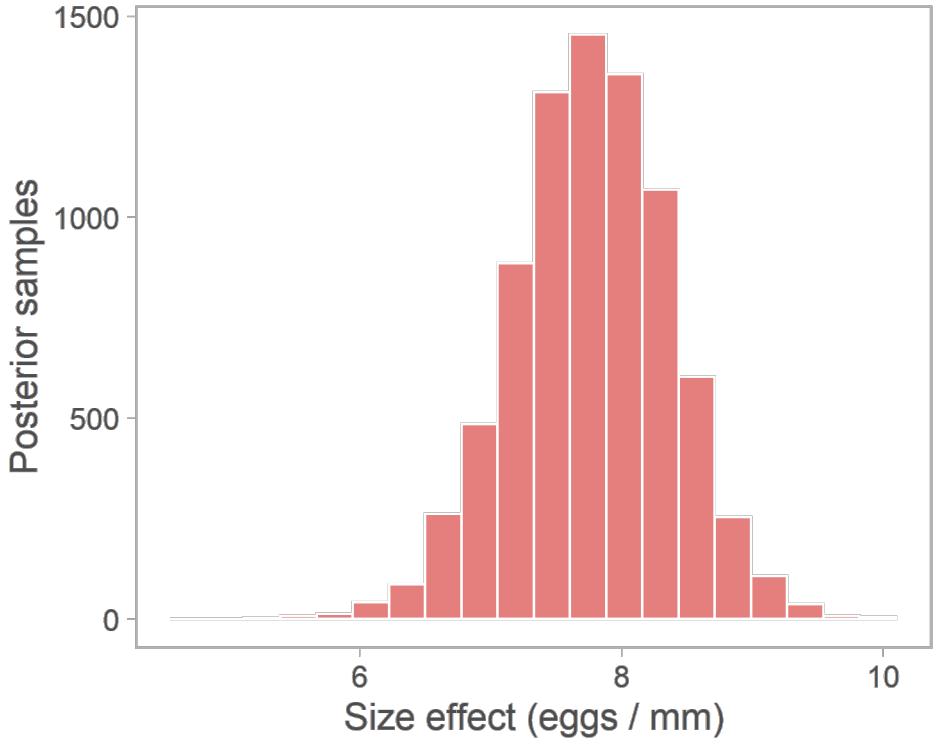
34 mm decline

Size effects on fecundity

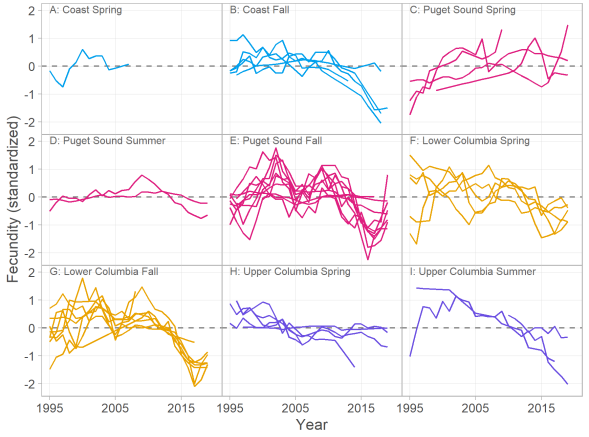
$R^2 = 0.62$

Slope = 7.8 eggs / mm

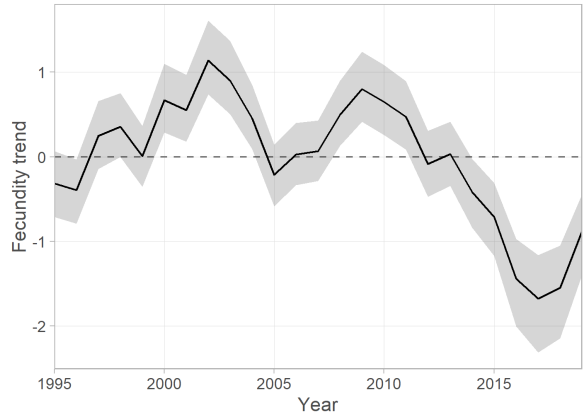




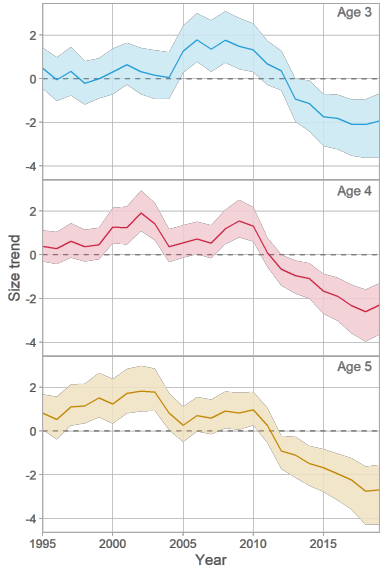
1. Widespread declines in fecundity



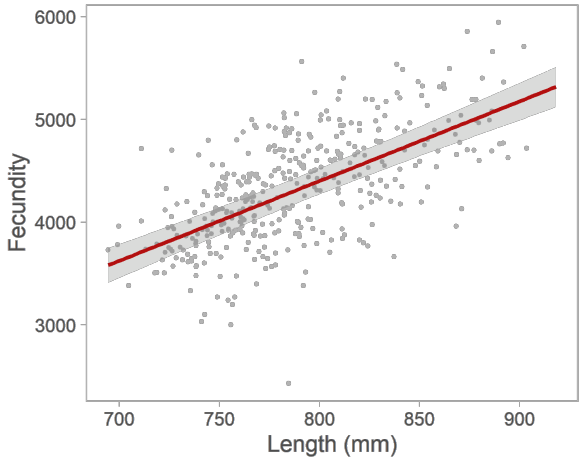
2. Single common trend



3. Size declines over the same period



4. Fecundity strongly related to size



Fecundity of Chinook salmon has declined, largely due to changes in body size

<u>Declines in fecundity have implications:</u>

1. Fewer eggs spawned may reduce population productivity and the ability to recover depressed populations

2. Egg takes for hatchery operations could be constrained, increasing the potential for inter-hatchery egg transfers

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