



Western Washington University
Western CEDAR

Salish Sea Ecosystem Conference

2014 Salish Sea Ecosystem Conference
(Seattle, Wash.)

Apr 30th, 3:30 PM - 5:00 PM

Biocomplexity in Pacific herring (*Clupea pallasii*) of Puget Sound, USA

Margaret Siple
University of Washington, mcsiple@gmail.com

Tessa B. Francis
University of Washington Tacoma. Puget Sound Institute

Daniel E. Schindler
University of Washington

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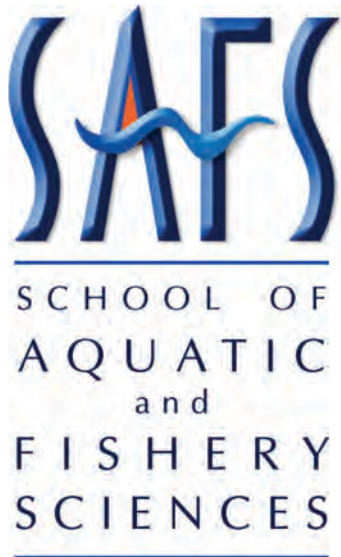
Siple, Margaret; Francis, Tessa B.; and Schindler, Daniel E., "Biocomplexity in Pacific herring (*Clupea pallasii*) of Puget Sound, USA" (2014). *Salish Sea Ecosystem Conference*. 13.
<https://cedar.wwu.edu/ssec/2014ssec/Day1/13>

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Biocomplexity in Pacific herring of the Salish Sea

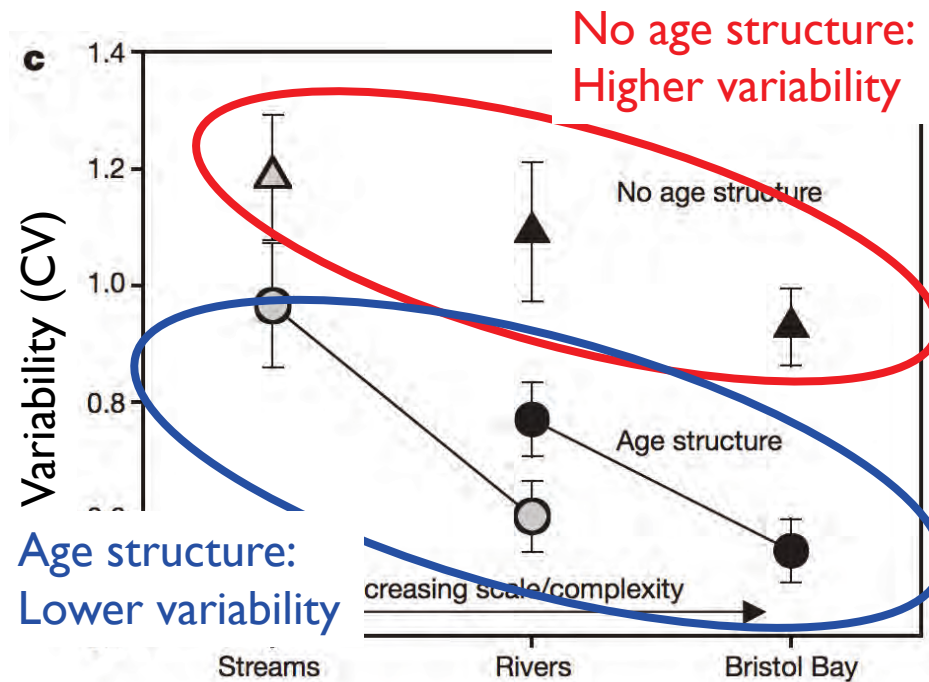
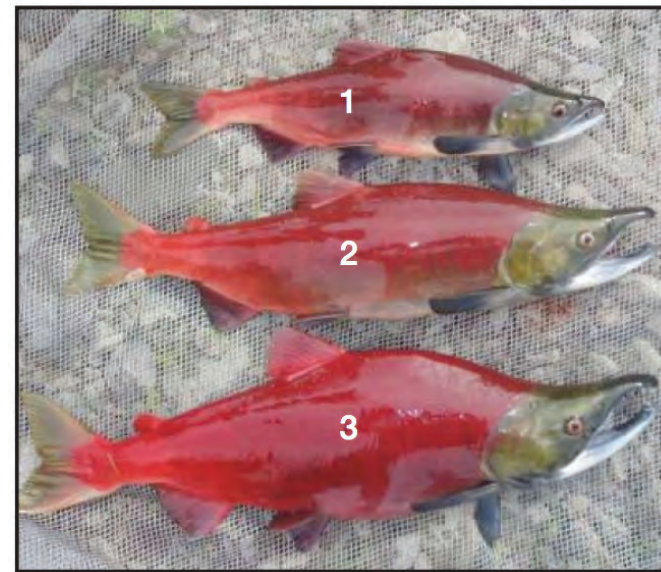
Megsie Siple, Tessa Francis
& Daniel Schindler



Photos: Dan @ Flickr, Eiko Jones, raincoast.org

Biocomplexity

“Phenomena that arise from dynamic interactions that take place within biological systems and between these systems and the physical environment.” ~ NSF



Portfolio effects

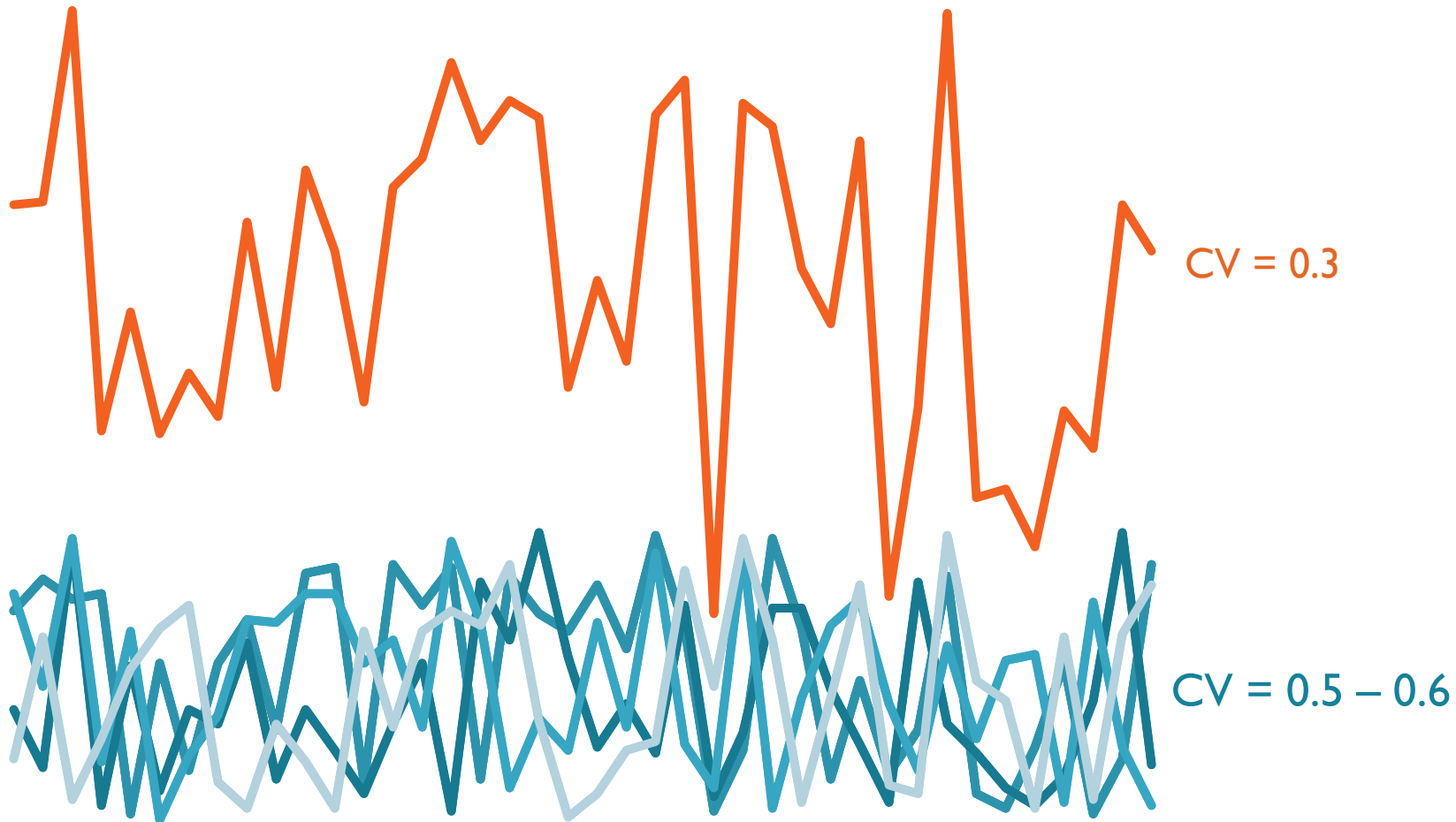






Photo: Rick Rae

Pacific herring in British Columbia

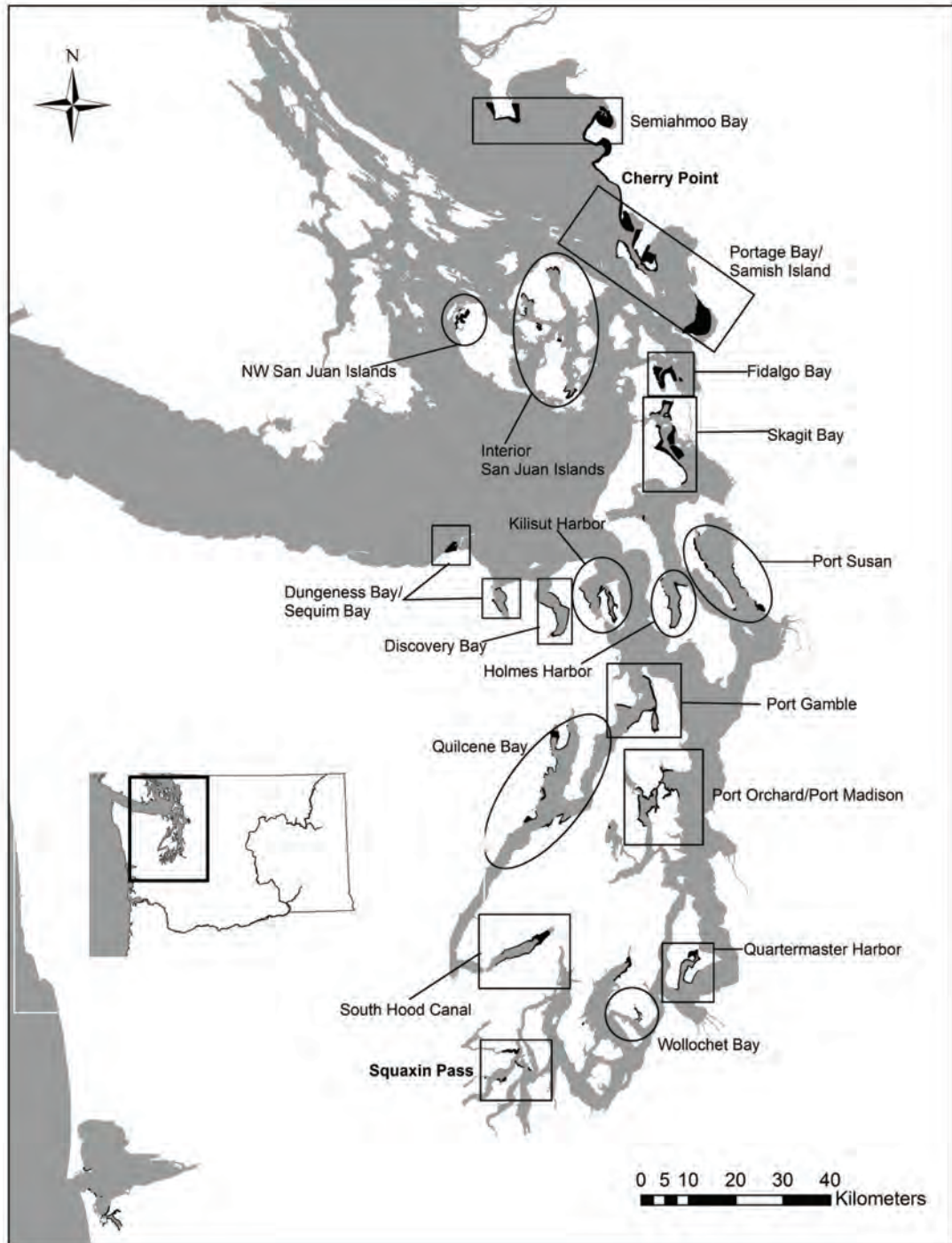
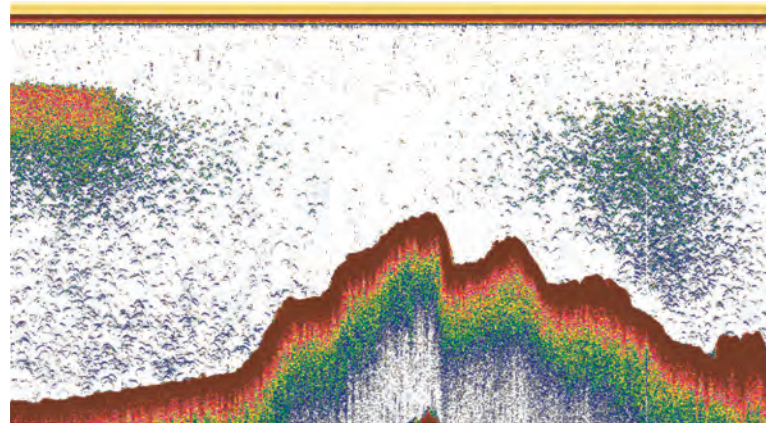
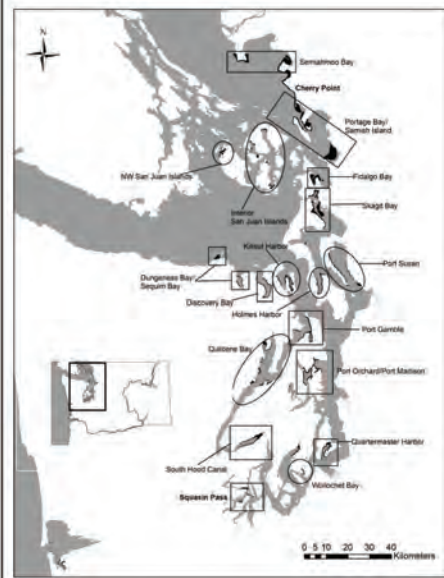
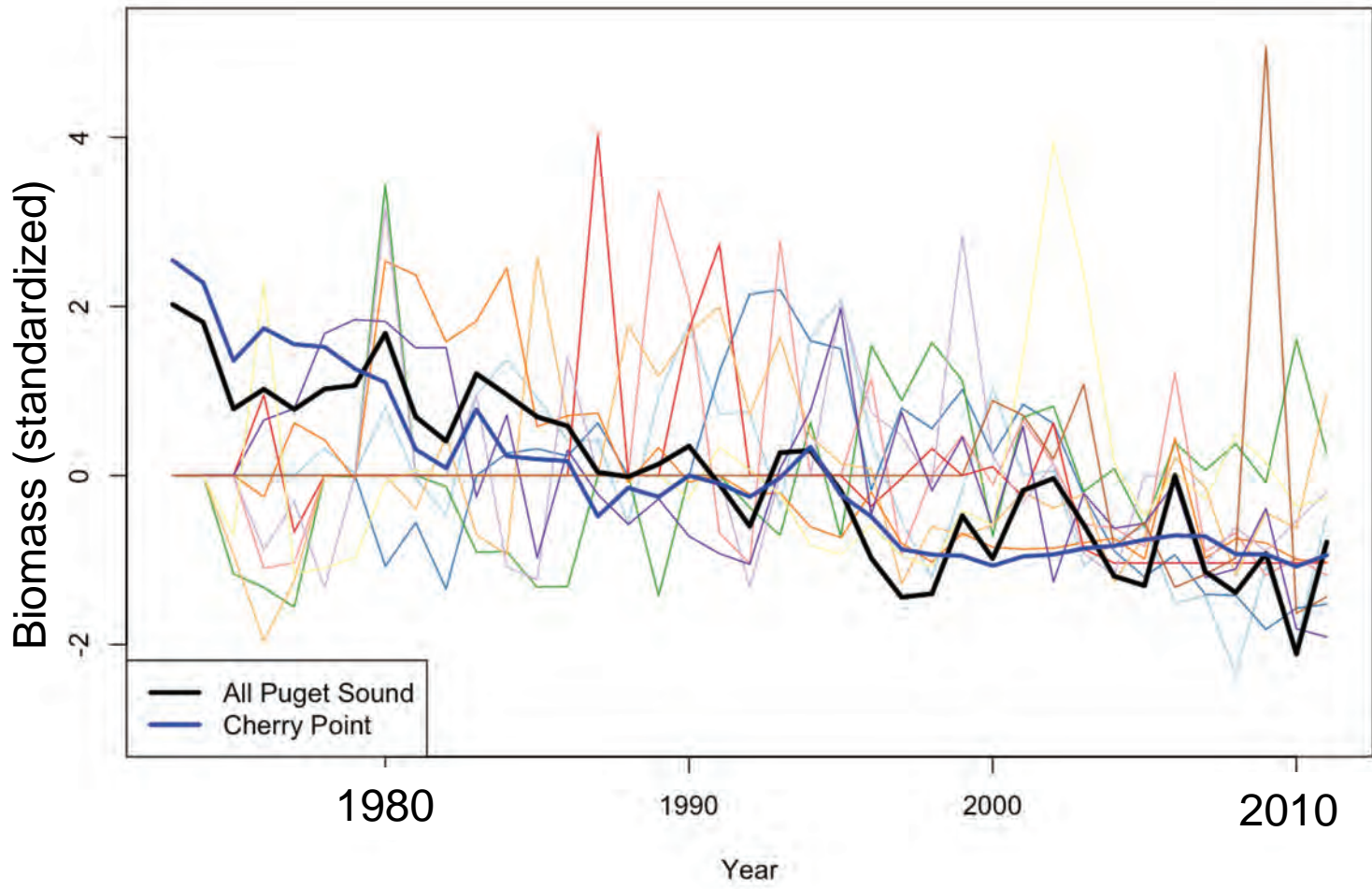


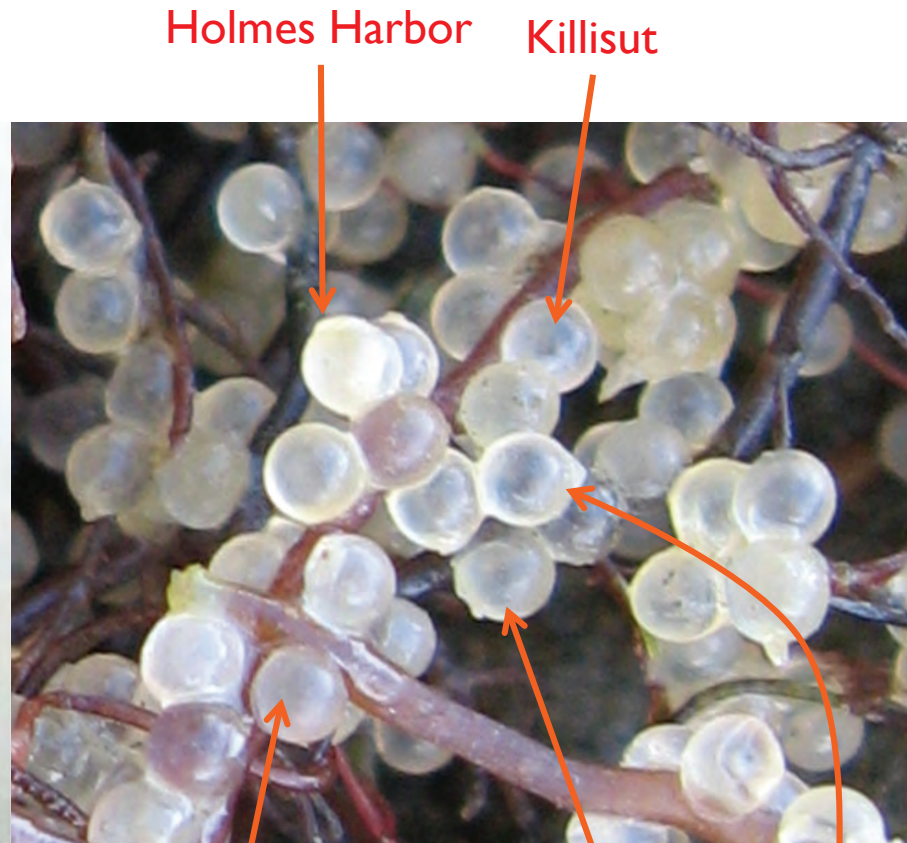
Photo: DFO



n = 21



Graph: Tessa Francis



Holmes Harbor

Killisut

Cherry Point

Port Gamble

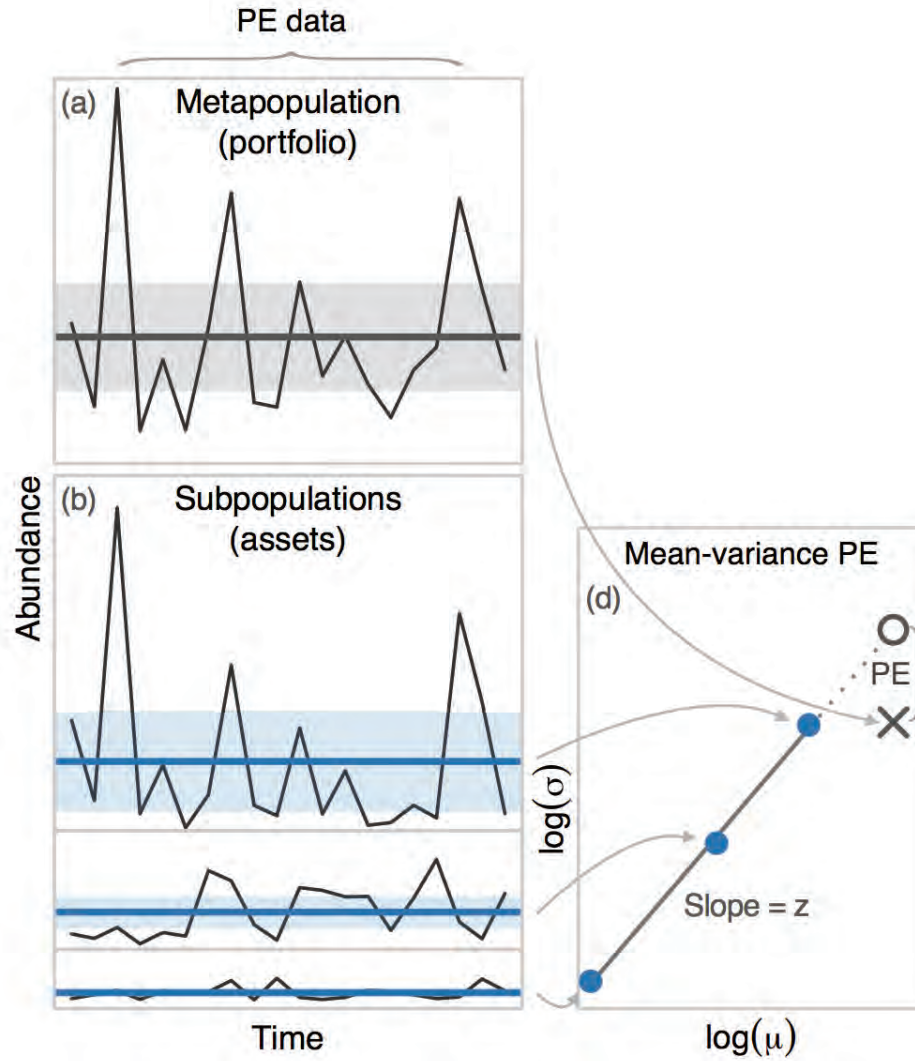
NW San Juan Islands

Modeling goals

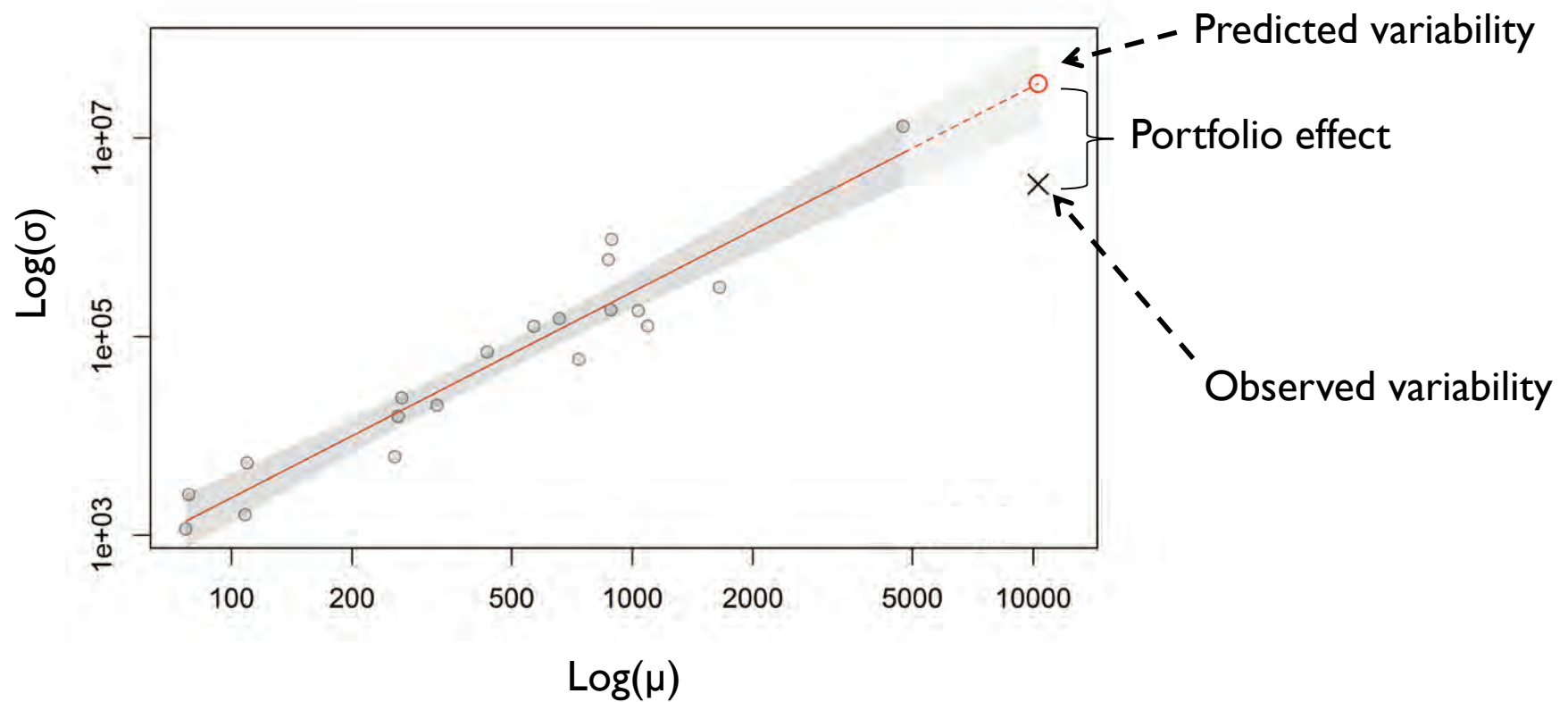
1. Portfolio
2. Underlying trends



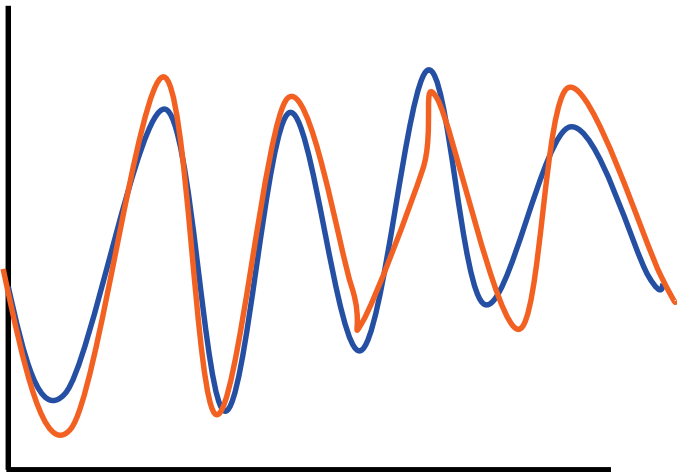
Portfolio effects



Portfolio effects in herring biomass

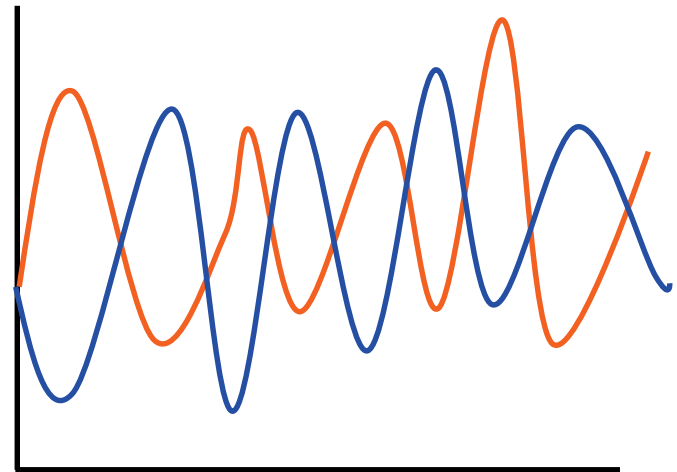


Synchrony



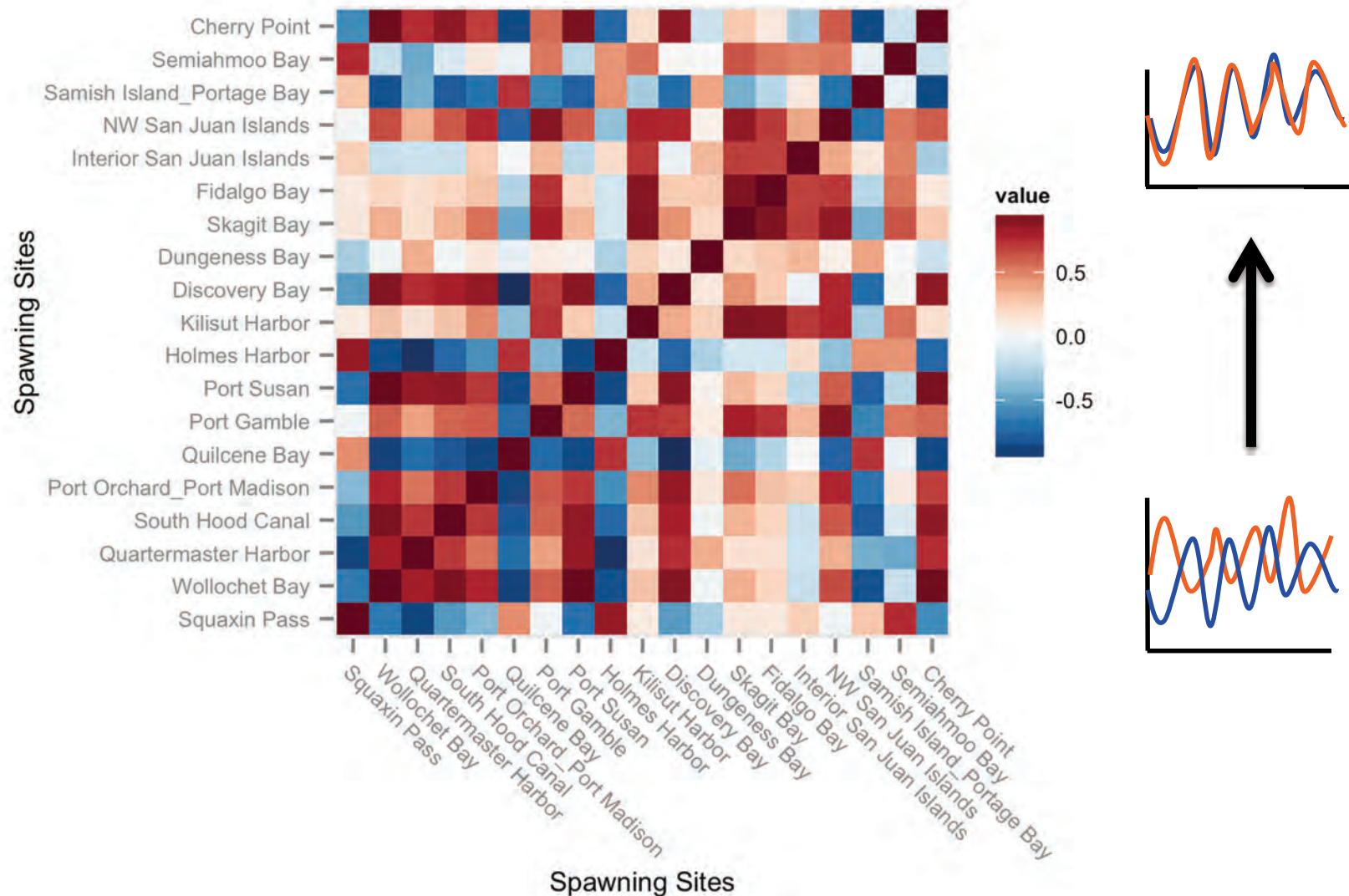
Shared drivers

Asynchrony



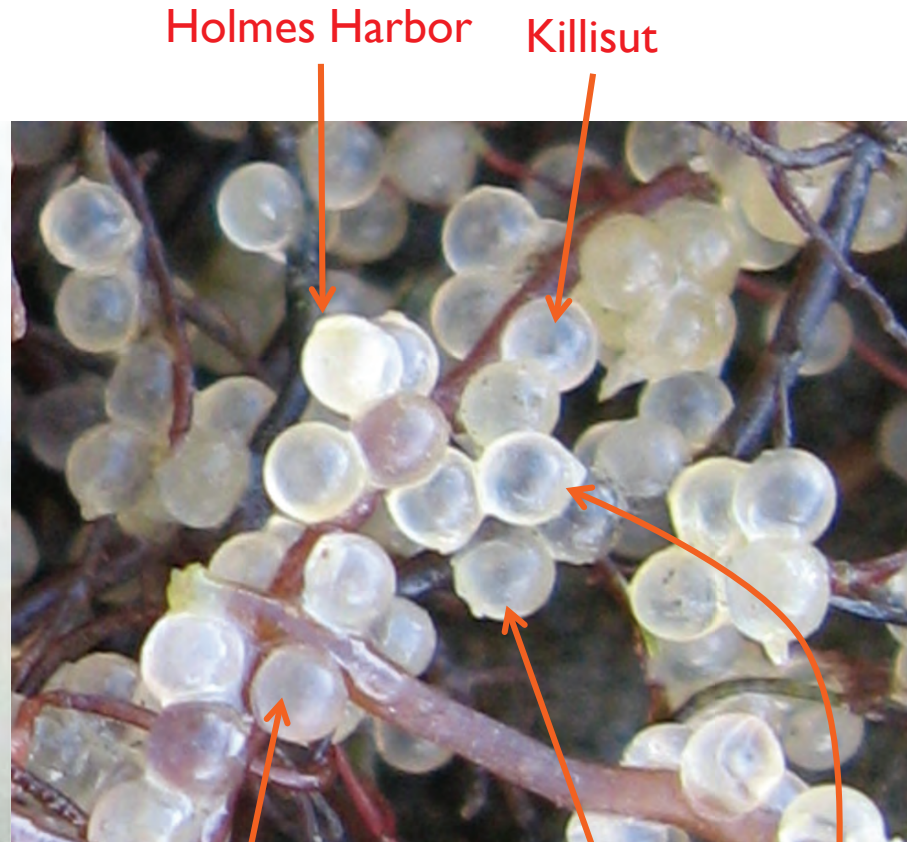
Habitat diversity or
response diversity

Synchrony: Is a good year for one stock a good year for the others?



What causes the biocomplexity?

How many eggs in the basket?



Cherry Point

Port Gamble

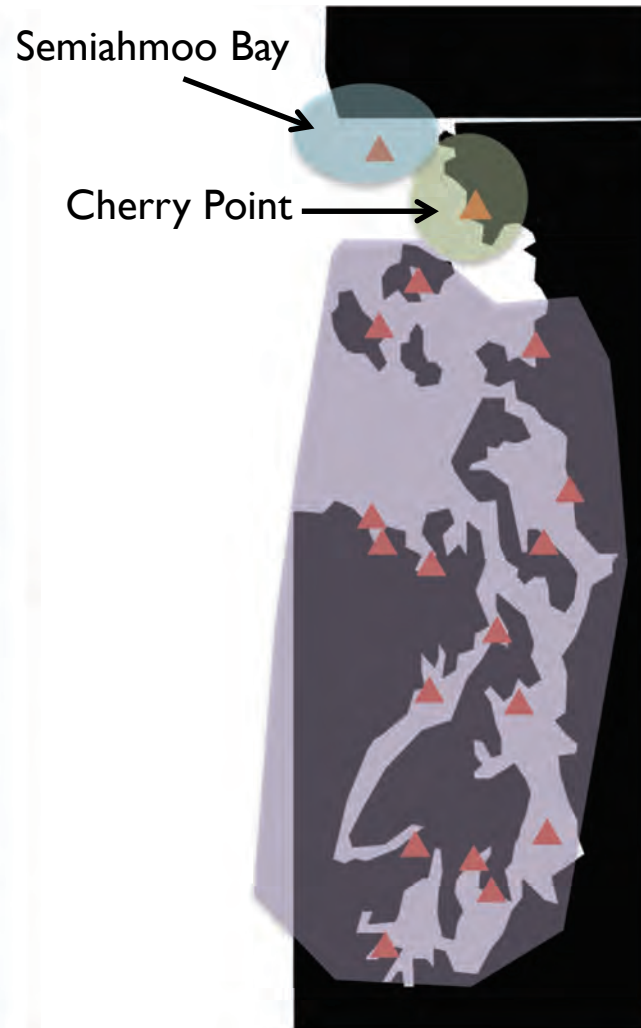
NW San Juan Islands



Genetics
(Small et al. 2005)



Contaminants
(West et al. 2008)



Geographic separation
(Penttila 2007)



Panmictic



All separate



Modeling approach

Process

$$\begin{bmatrix} X_{CP,t} \\ X_{SP,t} \\ X_{others,t} \end{bmatrix} = \begin{bmatrix} X_{CP,t-1} \\ X_{SP,t-1} \\ X_{others,t-1} \end{bmatrix} + \begin{bmatrix} u_{CP} \\ u_{SP} \\ u_{others} \end{bmatrix} + \begin{bmatrix} w_{CP} \\ w_{SP} \\ w_{others} \end{bmatrix}; \mathbf{w} \sim \text{MVN}(0, \mathbf{Q})$$

Observations

$$\begin{bmatrix} Y_{CP,t} \\ Y_{SP,t} \\ Y_{POPM,t} \\ Y_{DUNG,t} \\ Y_{INTSJ} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & 0 & 1 \\ 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} X_{CP,t} \\ X_{SP,t} \\ X_{others,t} \end{bmatrix} + \begin{bmatrix} A_{CP,t} \\ A_{SP,t} \\ A_{POPM,t} \\ A_{DUNG,t} \\ A_{INTSJ} \end{bmatrix} + \begin{bmatrix} v_{1,t} \\ v_{2,t} \\ v_{3,t} \\ v_{4,t} \\ v_{5,t} \end{bmatrix}; \mathbf{v} \sim \text{MVN}(0, \mathbf{R})$$

Panmictic



All separate



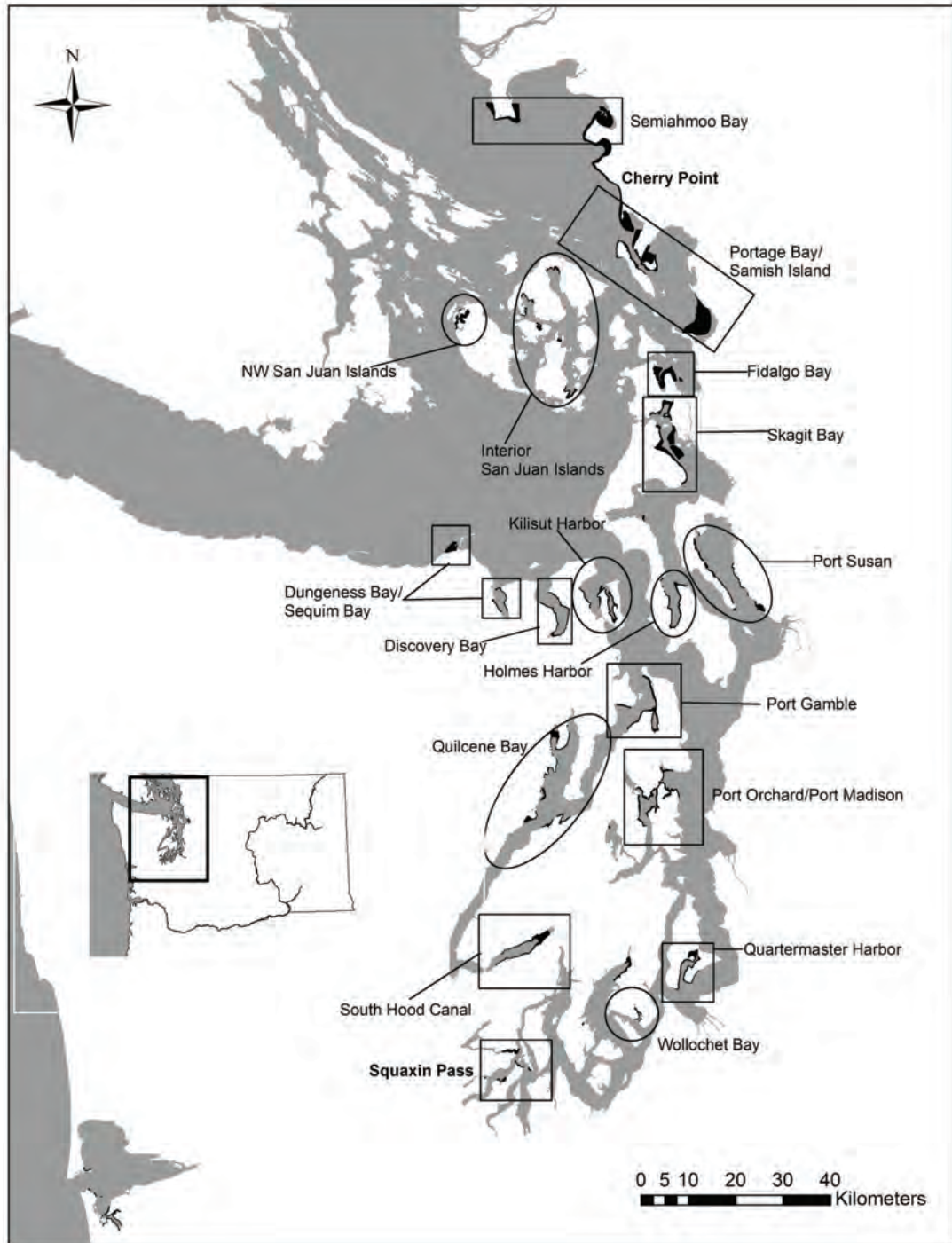
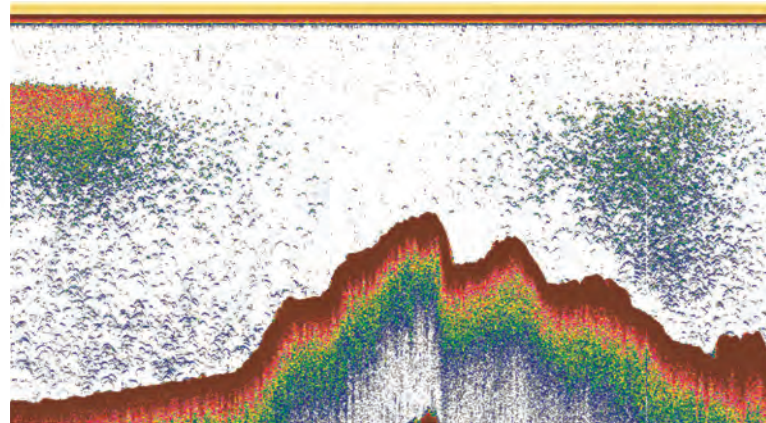
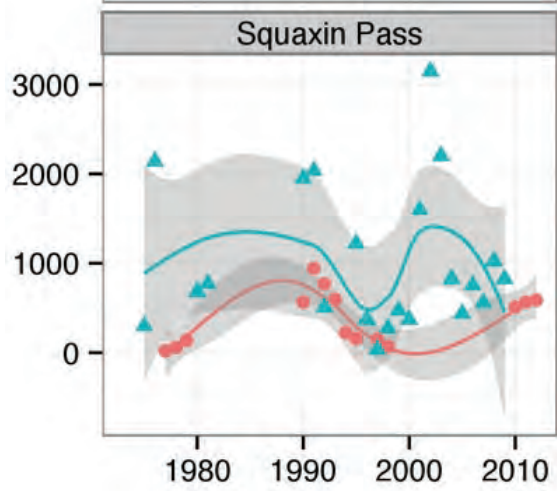
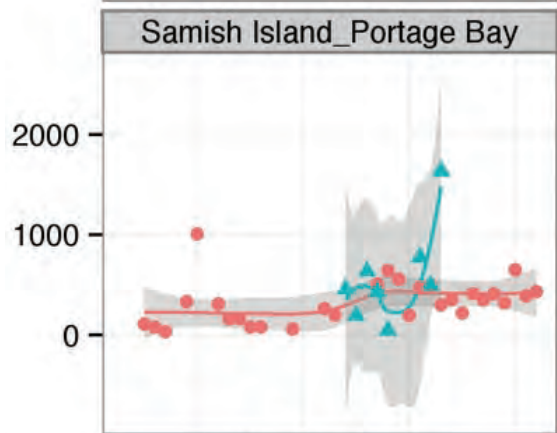
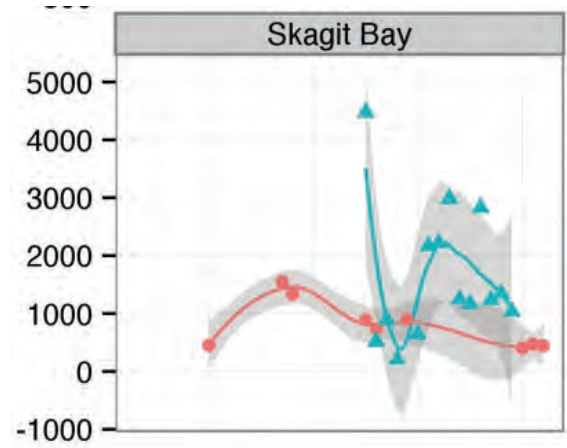
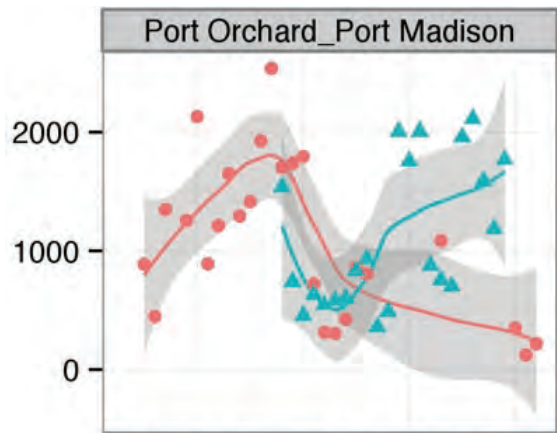


Photo: DFO

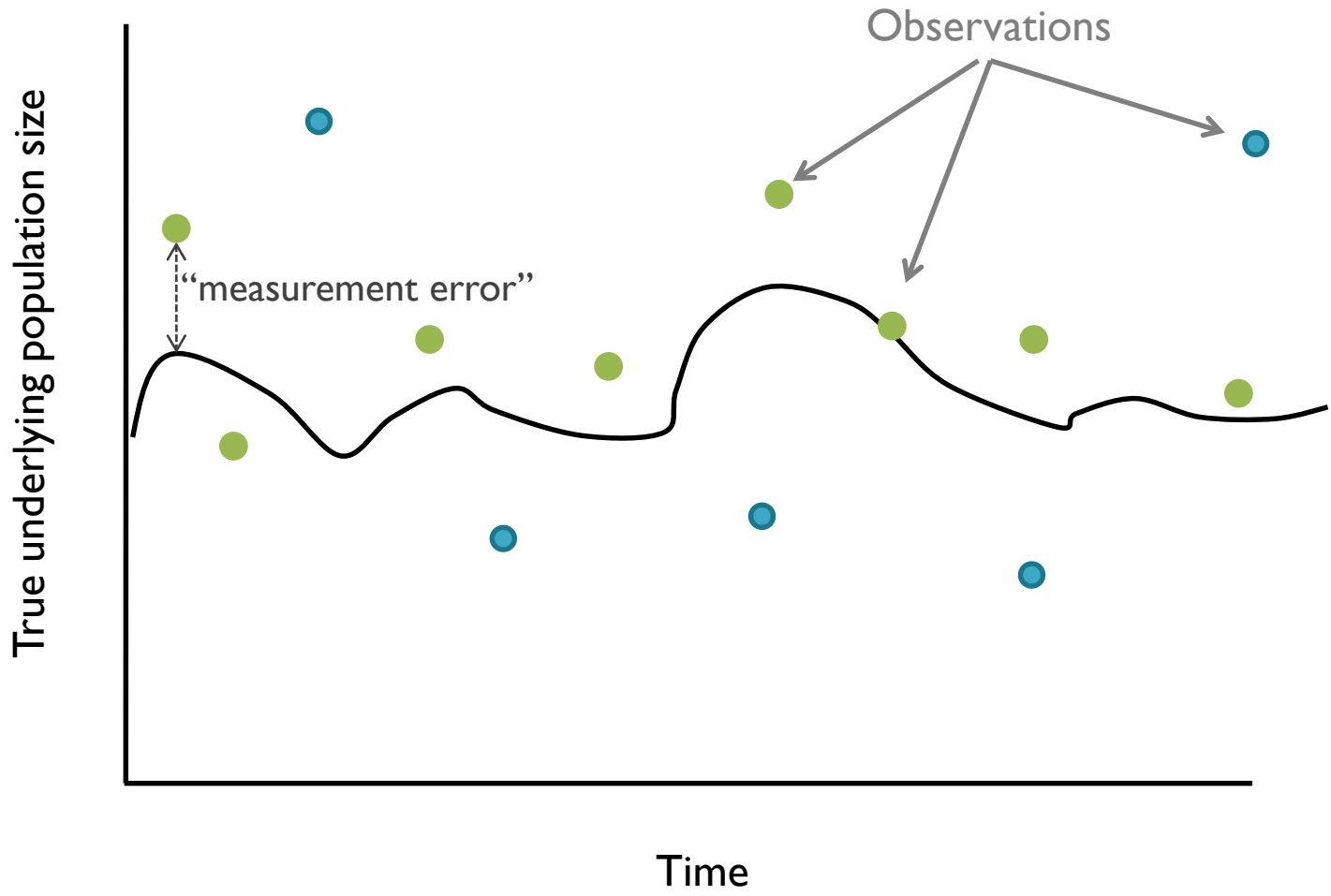


n = 21

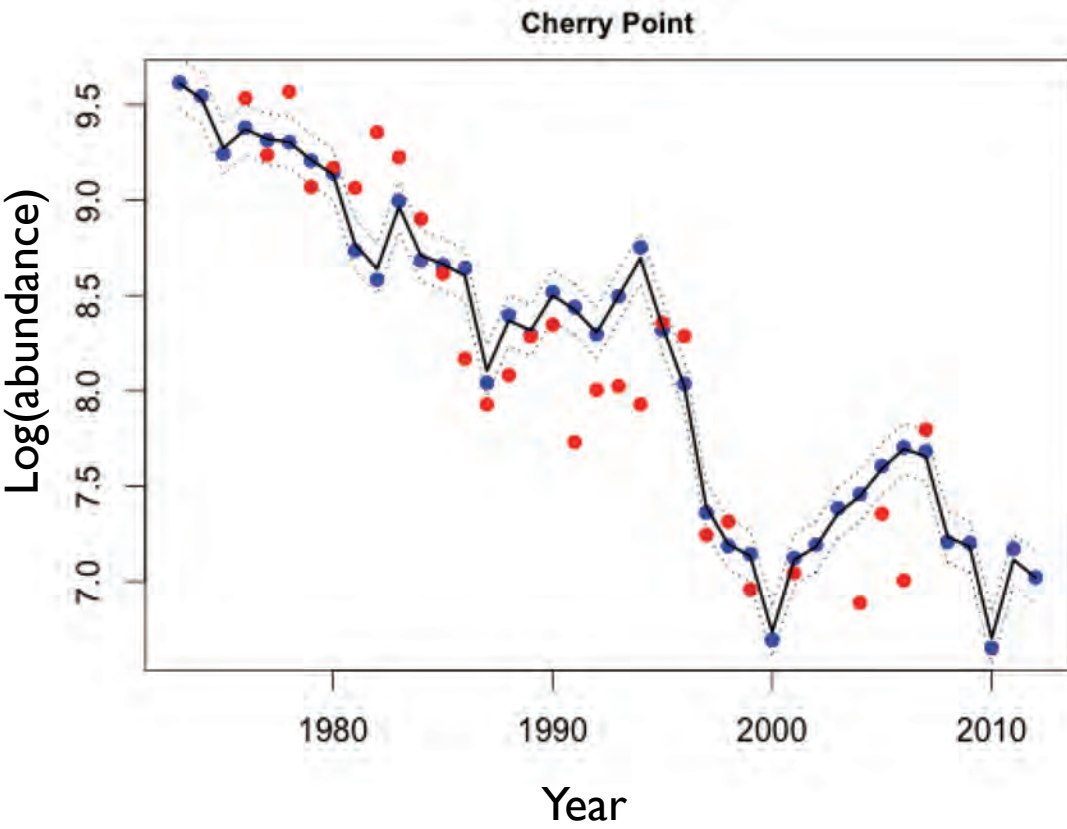
Do survey results both tell the same
story?



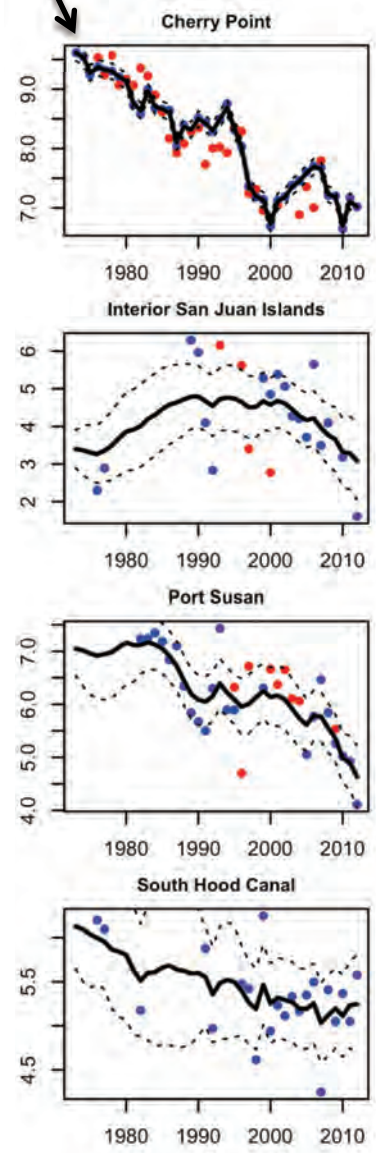
- Egg deposition
- Acoustics and trawls



Points= survey data

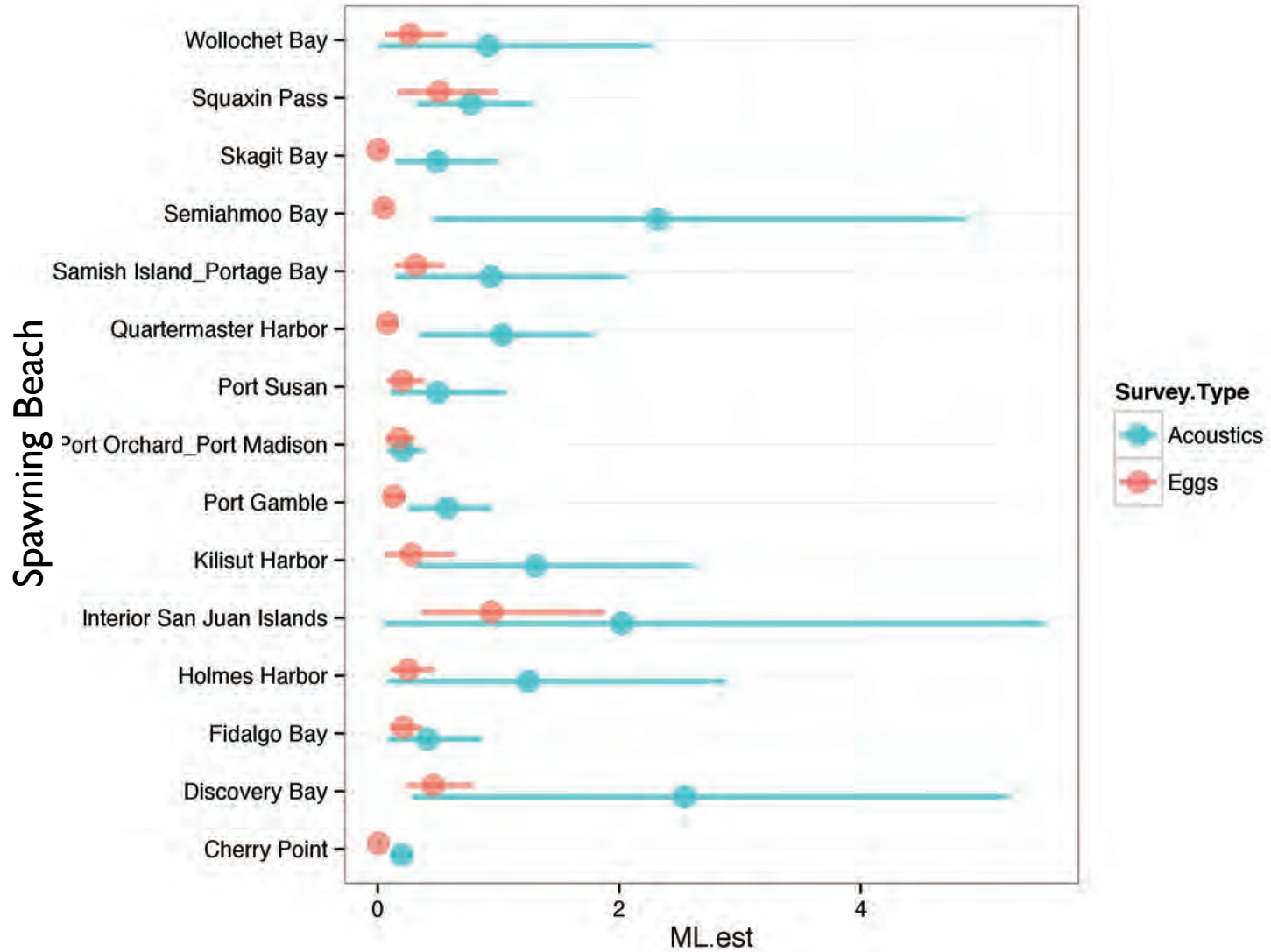


- Eggs
- Acoustics



Black lines = estimated abundance

Measurement error varies by beach



More accurate

Less accurate



Summary

1. Puget Sound herring are stabilized by many subpopulations
2. Local dynamics drive abundance
3. Survey methods differ in their error rates

Committee

Tessa Francis
Daniel Schindler
Tim Essington
Trevor Branch
Dave Beauchamp

**Data and Herring
Wisdom**

Kurt Stick
Dayv Lowry
Adam Lindquist

MARSS people

Eli Holmes
Mark Scheuerell
Eric Ward

Funding

NSF GRFP
SAFS
ARCS
UW College of the
Environment

**PSI Forage Fish
Study Panel**

