Reconstructing a century of coastal productivity and predator trophic position in WA with archival bone

AFS WA/BC Annual Meeting

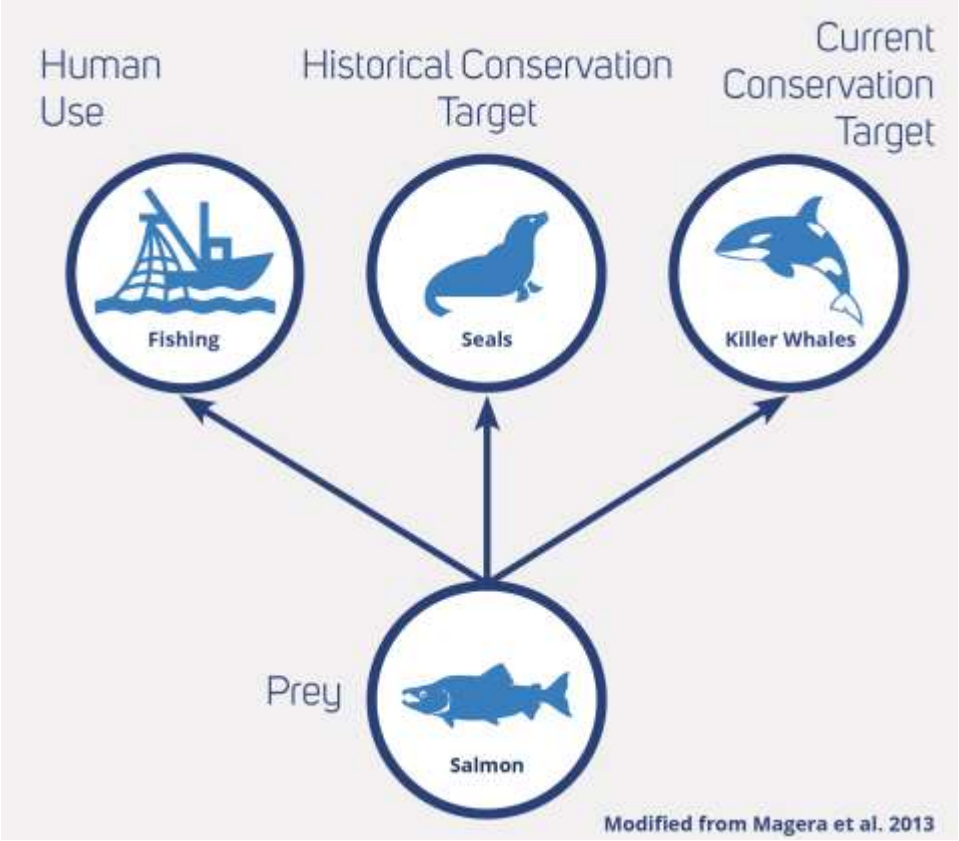
Megan Feddern
Gordon Holtgrieve, Eric Ward

Competing Interests

1. Recovering predator populations that increase competition with humans for the same prey

2. New tradeoffs that emerge when protected predators consume protected prey, and

3. Multiple predator populations that compete for the same limited prey.



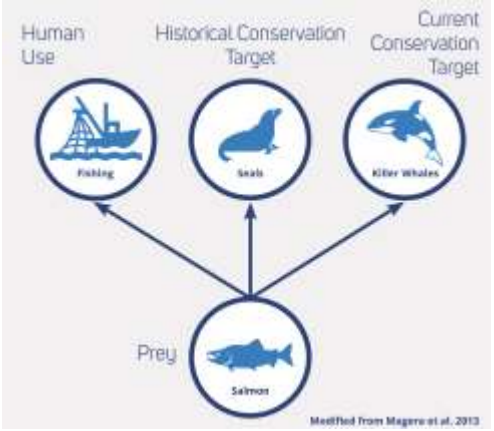
Single Species Management

What was the status of the resource historically?

What is the status of the resource now?

Recovery Plan

What is the desired future status of the resource?

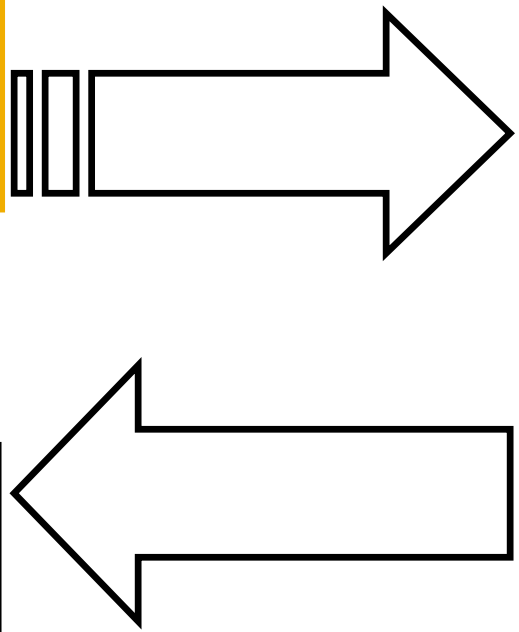


Multi Species Management

What was the status of *predators/competitors* historically?

What is the status of the *predators/competitors* now?

How can we manage for *predators/competitors* in the future?



Objectives

- Identify variability in harbor seal trophic position: spatio-temporal (sex and size)
- Identify historic (1928-2013) relationships between **harbor seal trophic position** and the ecosystem
- Reconstruct historic environmental isotope **baseline $\delta^{15}N$** and its relation to productivity

Objectives

- Identify spatio-temporal, sex, and size variability in harbor seal trophic position
  - *Trophic position will vary through time*
- Identify historic (1928-2013) relationships between **harbor seal trophic position** and the ecosystem
  - *Trophic position will change through time and reflect in response to prey availability and environmental condition*
- Reconstruct historic environmental isotope **baseline $\delta^{15}N$**
  - *$\delta^{15}N$ will change through time in response to human population and environmental productivity*

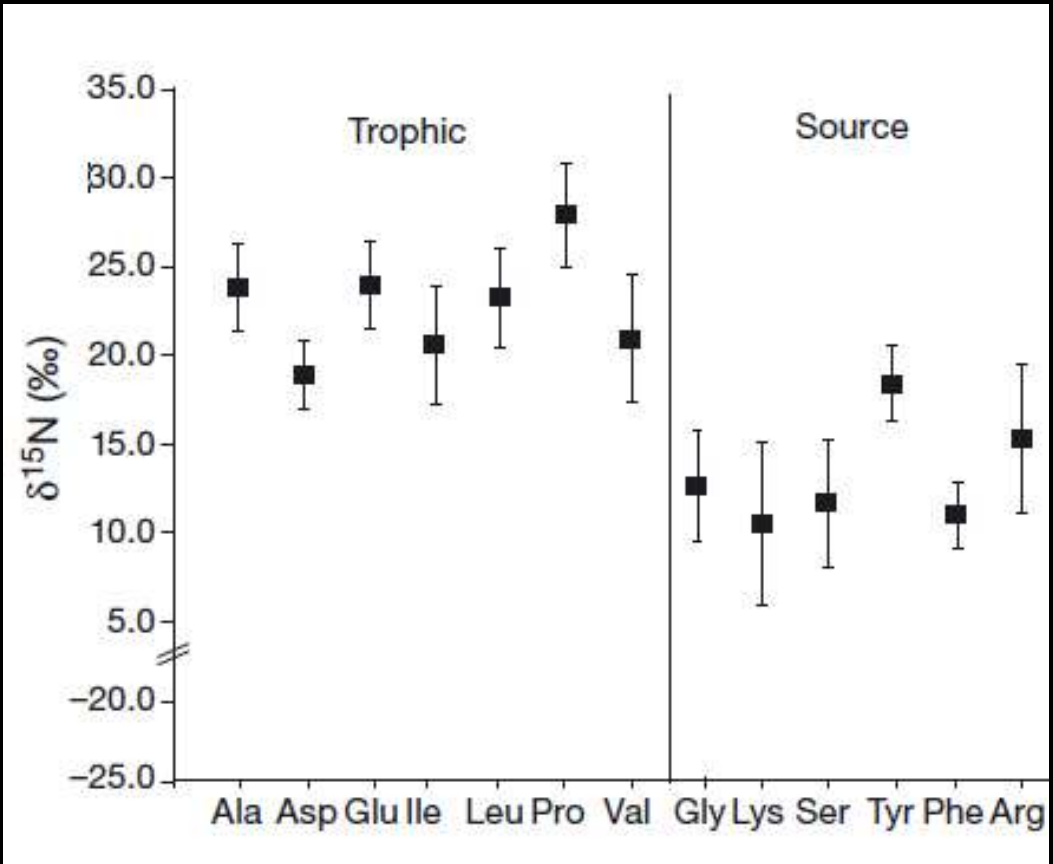
Analysis

- Compound specific stable isotope analysis of amino acids (n = 145)
  - Skulls from Burke and Slater Museums in WA
  - National Marine Mammal Laboratory
  - Smithsonian Institute in DC
  - Royal Museum in BC
- Bulk Stable Isotope
  - C & N

$$TP = [(\delta^{15}N_{Glu\text{-}Phe,\ seal} - TEF_{Glu\text{-}Phe,seal} + 3.4) / TEF_{Glu\text{-}Phe,plankton}] + 1$$

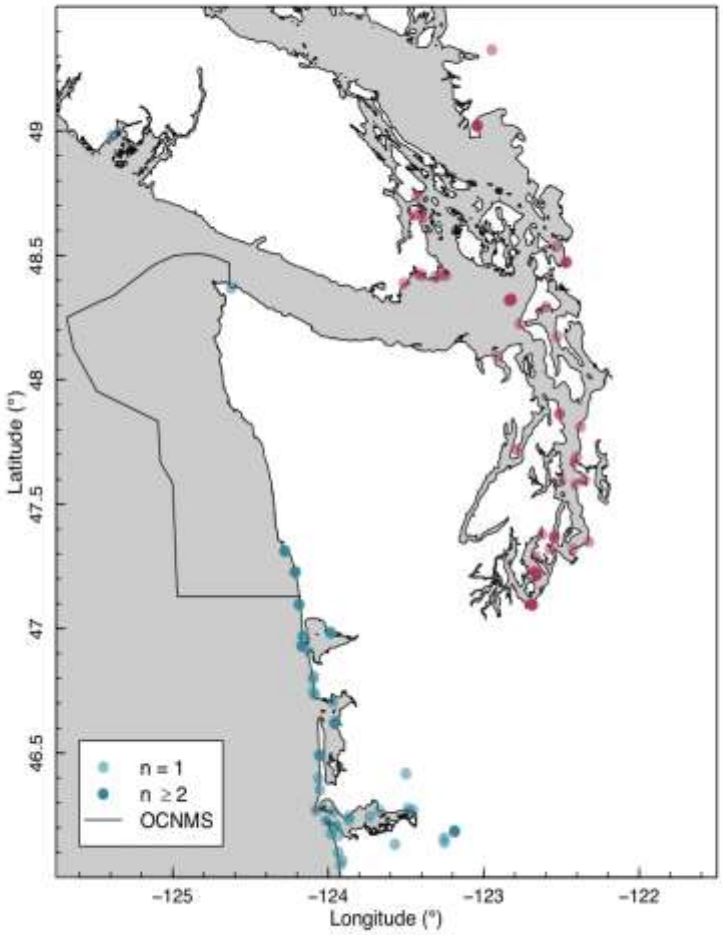
4.3

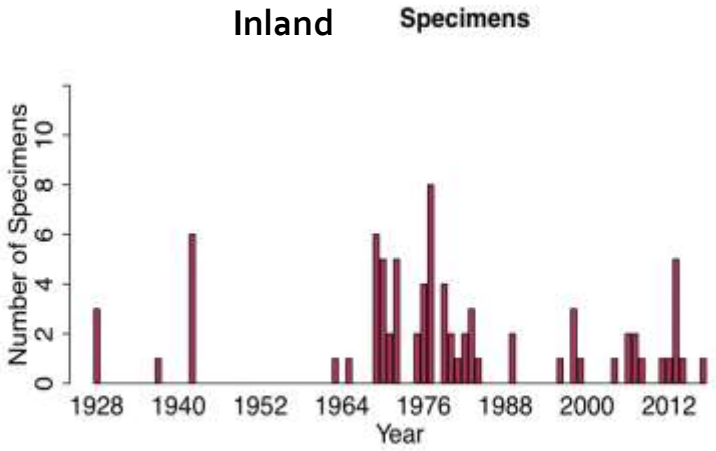
7.6

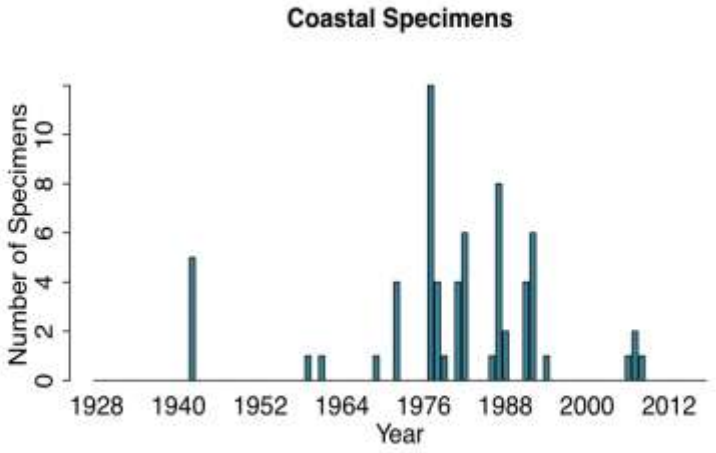


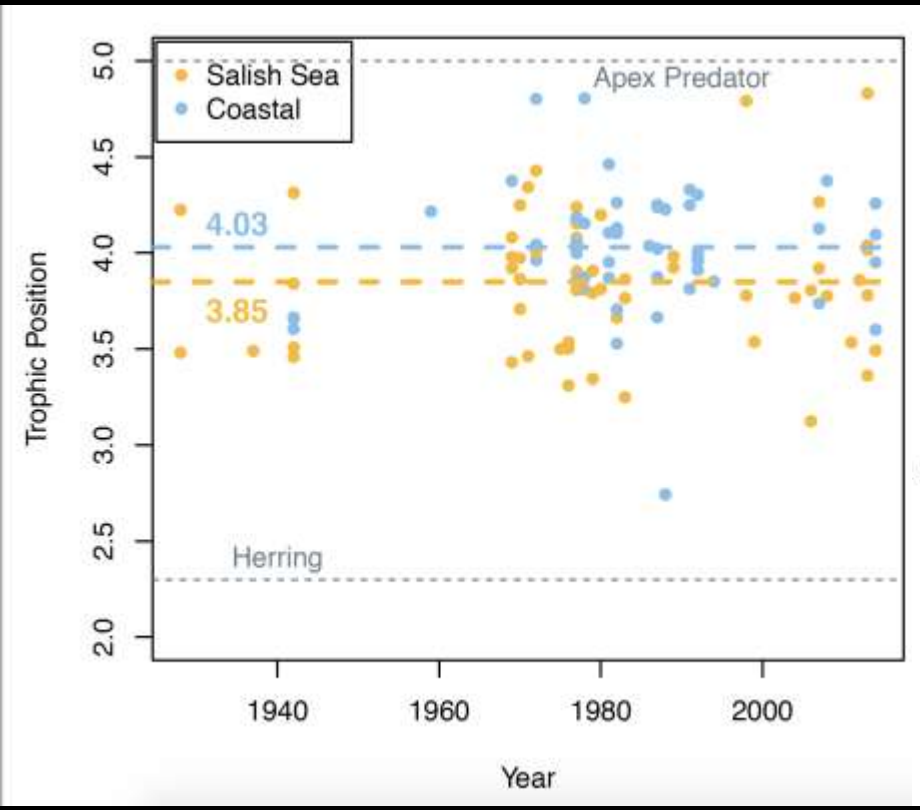
Germain et al. 2013

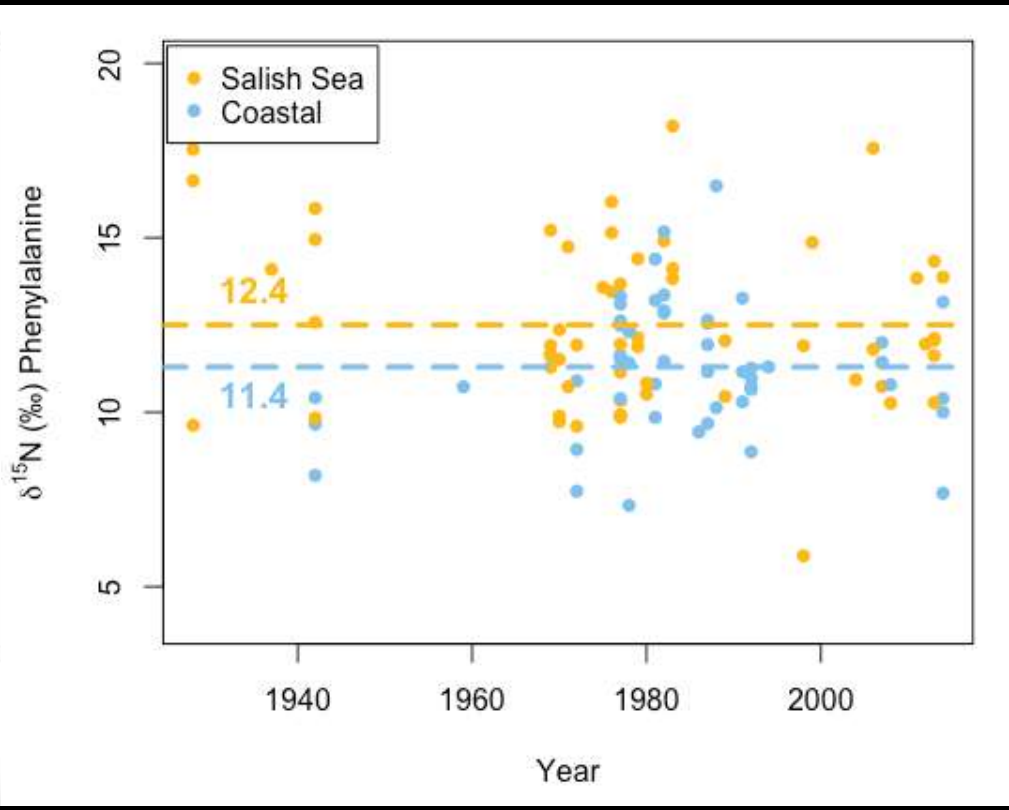
N = 145


Latitude (°)
49
48.5
48
47.5
47
46.5
−125
−124
−123
−122
Longitude (°)
n = 1
n ≥ 2
OCNMS


Inland
Specimens
Number of Specimens
0
2
4
6
8
10
1928
1940
1952
1964
1976
1988
2000
2012
Year


Coastal Specimens
Number of Specimens
0
2
4
6
8
10
1928
1940
1952
1964
1976
1988
2000
2012
Year


Salish Sea
Coastal
Apex Predator
4.03
3.85
Herring
Trophic Position
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1940
1960
1980
2000
Year


Salish Sea
Coastal
12.4
11.4
δ15N (‰) Phenylalanine
20
15
10
5
1940
1960
1980
2000
Year

Comparative Datasets

PREY SOURCES

- WA Chinook Salmon Escapement
  - WA Rivers, Fraser River, 1980-2014
  - Summarized by Chasco et al. 2017
- Hatchery Chinook Releases
  - WA, 1971-2015
  - Summarized by Chasco et al. 2017
- Eulachon
  - Total Landings
  - 2010 WDFW Report
- Hake
  - WDFW, 2017 Status Report
  - Total Biomass 1966-2017
- Herring
  - WDFW, 2012 Stock Assessment Report
  - Spawning Biomass by Stock
- Harbor Seal Population
  - WDFW, 1999
  - 1978-1999

ENVIRONMENTAL

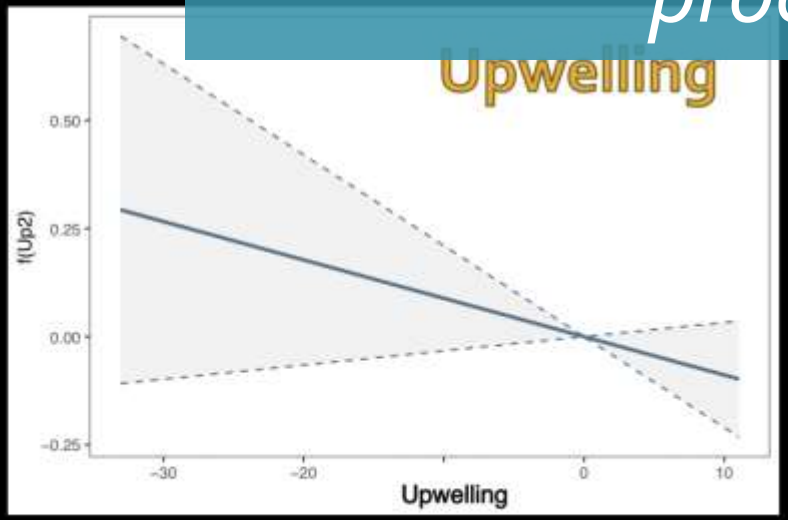
- PDO
  - JSIAO
  - 1900-2017
- Upwelling
  - Stiletz Bay, La Push
  - Pacific Fisheries Environmental Laboratory
  - Components of Ekman transport, Coast Angle
  - 1967-2018, Annual average of monthly index
- Human Population (King County)
  - WA State Office of Financial Management Forecasting Division
  - 1960-2010

ANALYSIS

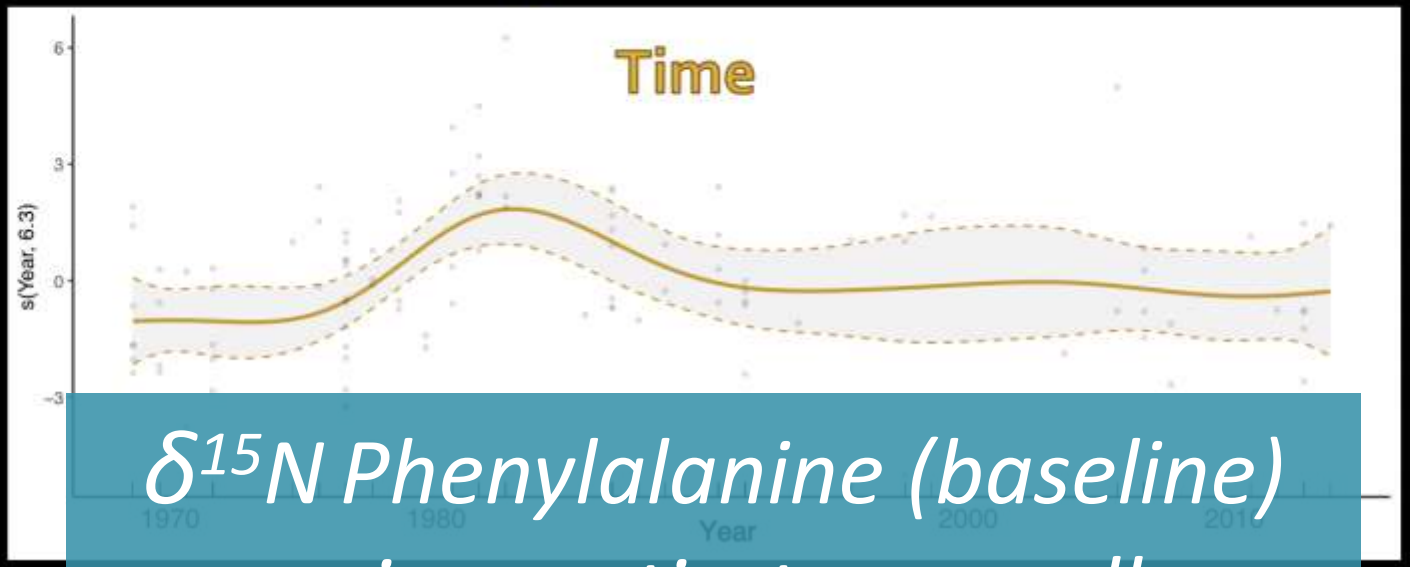
- Generalized Additive Model
- Dynamic Factor Analysis
  - Gaussian Process Model

Reconstructing historic harbor seal trophic position

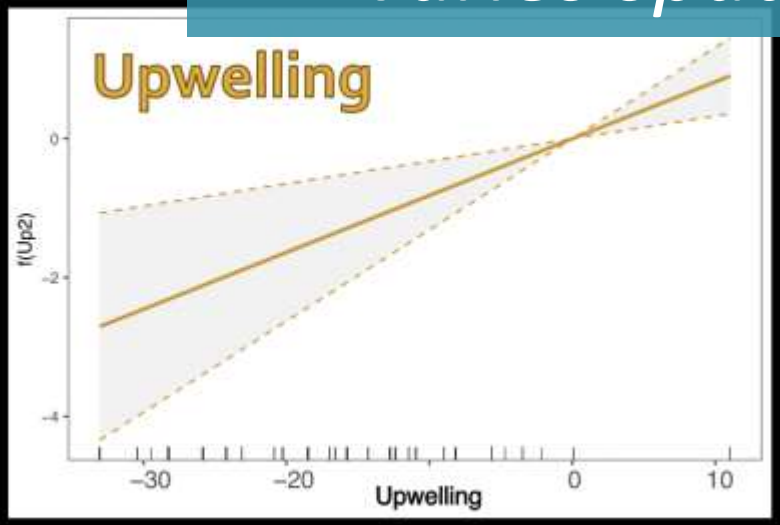
Harbor seal trophic position is determined by bottom up processes



Reconstruct historic environmental isotope baseline $\delta^{15}N$



$\delta^{15}N$ Phenylalanine (baseline) varies spatio-temporally

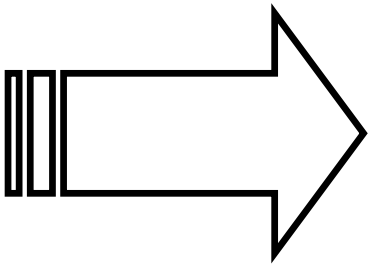


Objectives

- Identify spatio-temporal, sex, and size variability in harbor seal trophic position
  - *Trophic position varies based on location and time*
- Identify historic (1928-2013) relationships between **harbor seal trophic position** and the ecosystem
  - *Trophic position will change through time and reflect in response ~~to prey availability and~~ environmental condition*
- Reconstruct historic environmental isotope **baseline $\delta^{15}N$**
  - *$\delta^{15}N$ phenylalanine will change through time in response to ~~human population and~~ environmental productivity*

Conclusions: Management

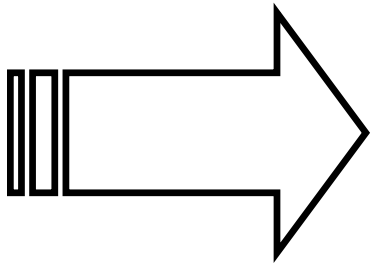
What was the status of *predators/competitors* historically?



- Harbor seal trophic position is driven by productivity
- Harbor seals feed lower in the food web with increased upwelling
- Trophic position varies spatially and temporally

Conclusions: Methodological

What was the status of *predators/competitors* historically?



- Museum specimens are useful data source for retrospective analyses
- Collagen amino acids can provide estimates of historic primary productivity

Acknowledgments

Burke Museum

Smithsonian Institution

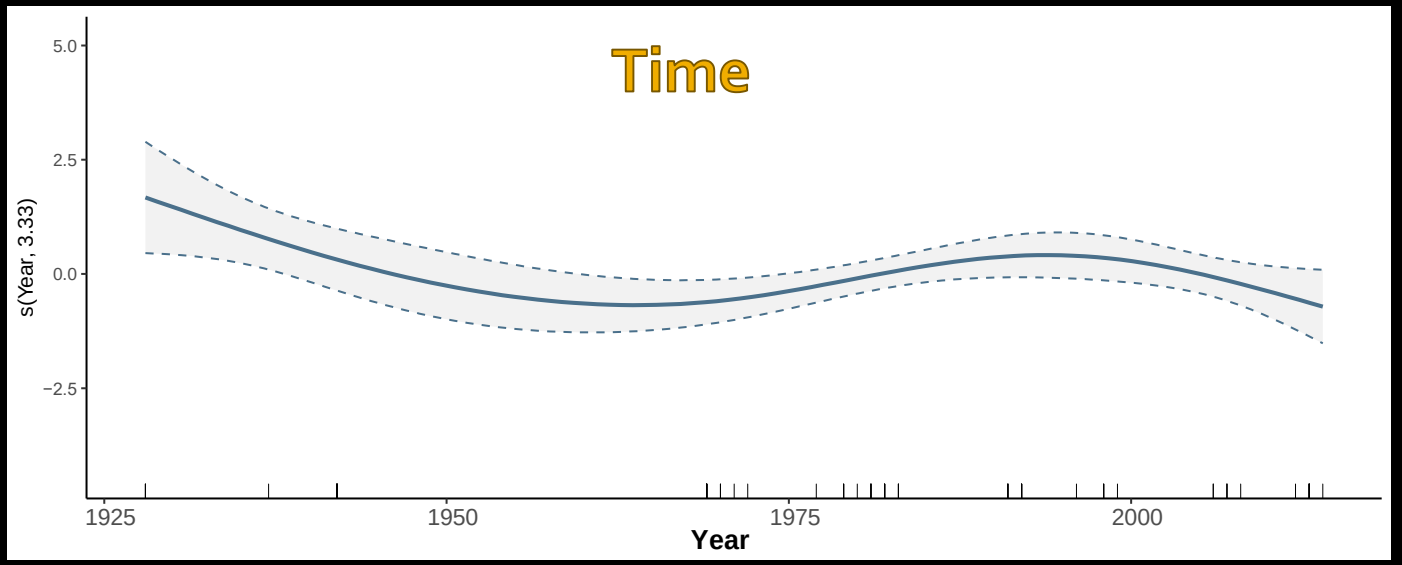
Sea Grant Washington

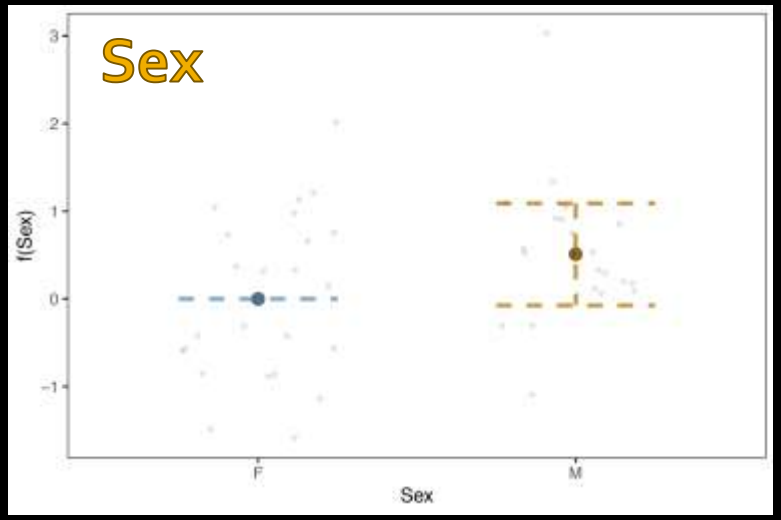
Royal BC Museum

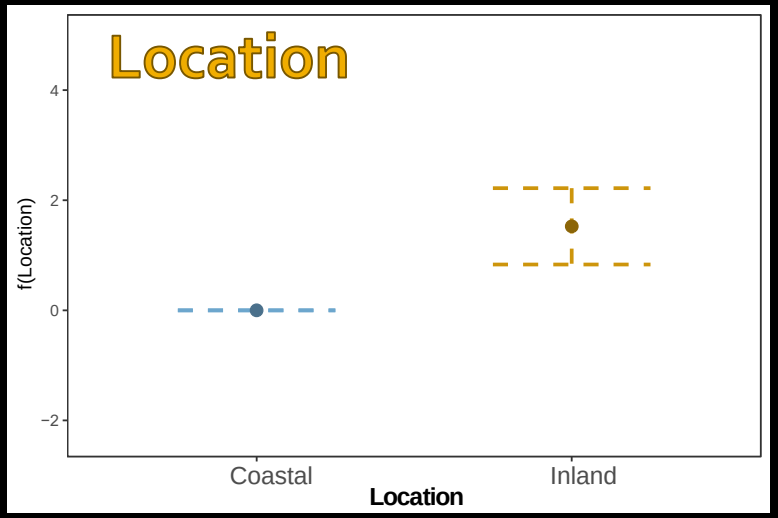
National Oceanic and Atmospheric Administration — NOAA — U.S. Department of Commerce

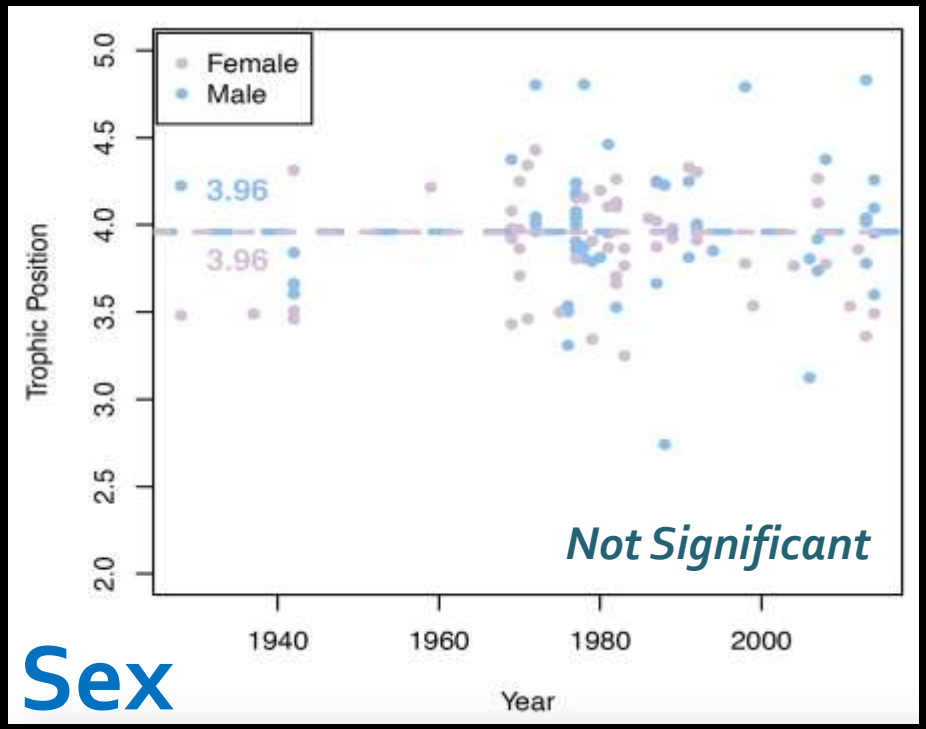
Slater Museum of Natural History, University of Puget Sound

Reconstruct historic harbor seal $\delta^{13}C$

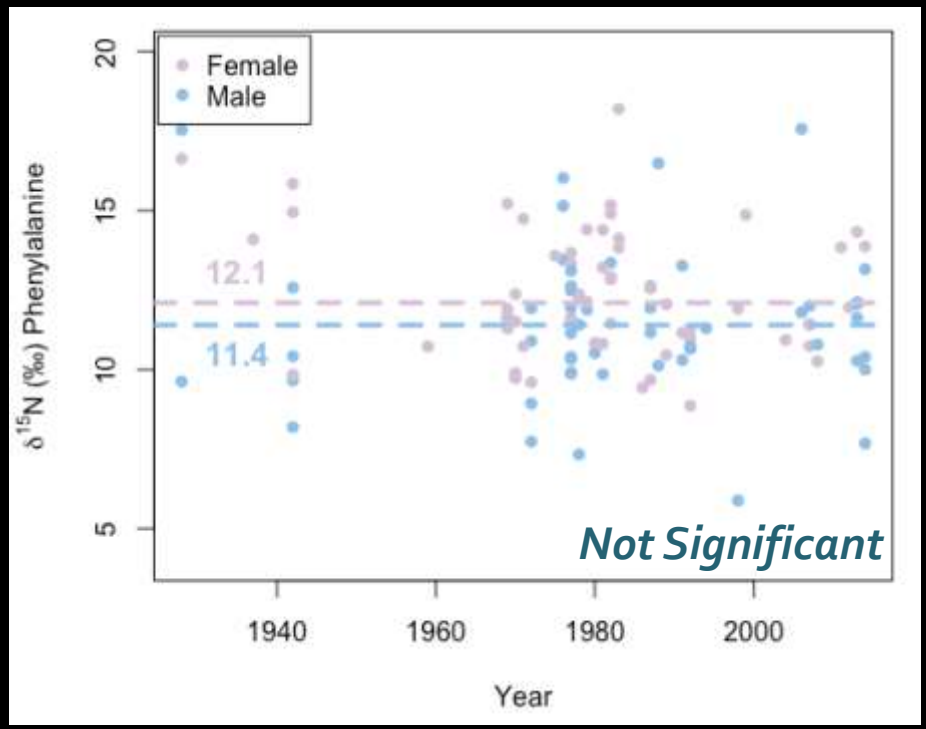


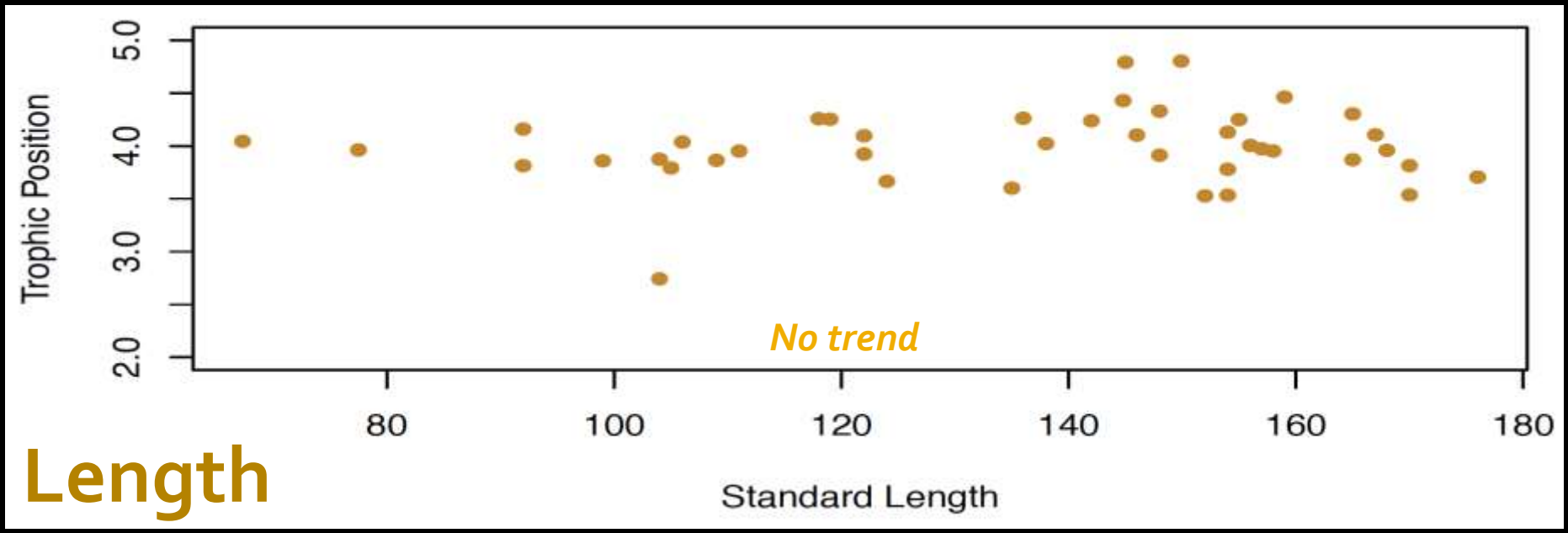





Female
Male
3.96
3.96
Trophic Position
Year
Not Significant

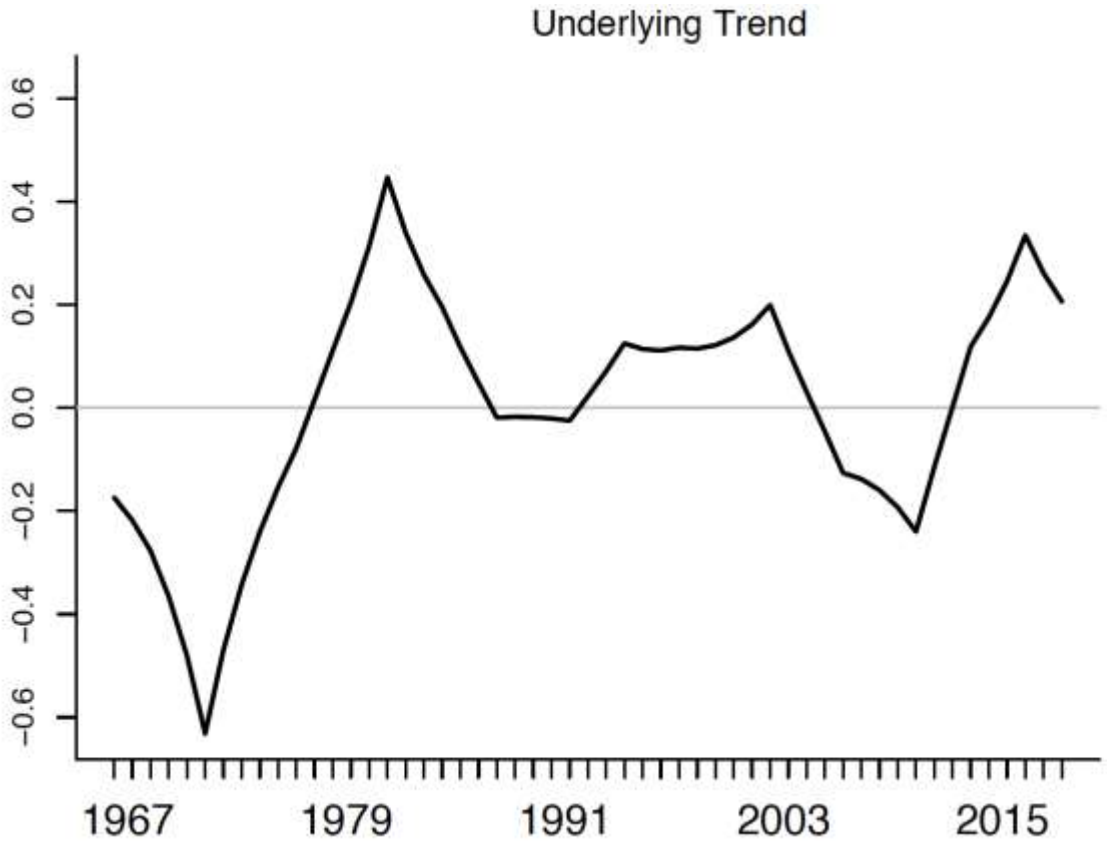
Sex

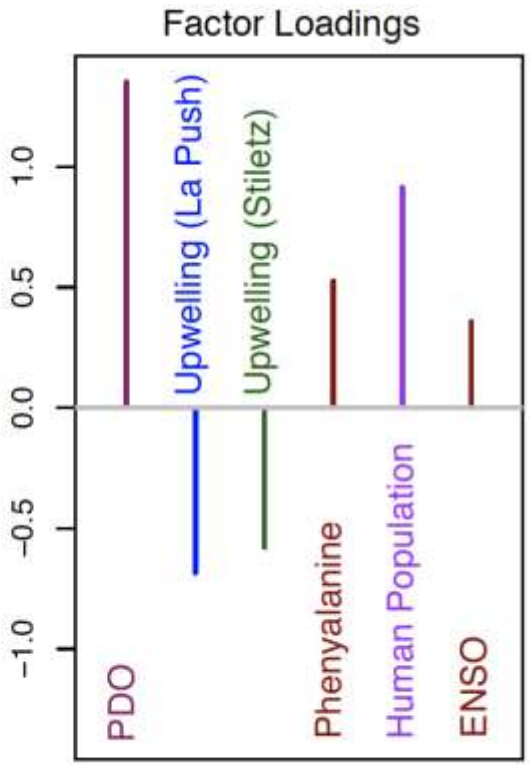

Female
Male
12.1
11.4
δ15N (‰) Phenylalanine
Year
Not Significant


Trophic Position
No trend
Standard Length

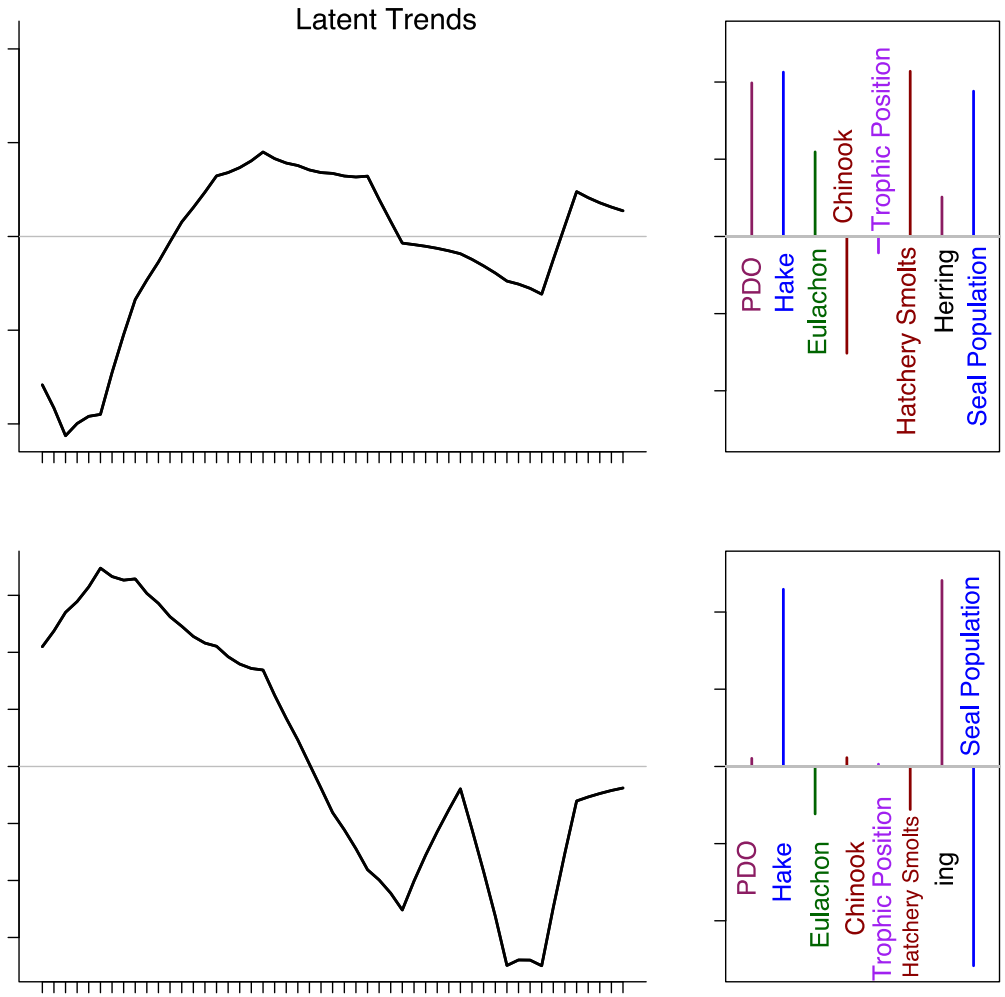
Length

Underlying trends with ecological variables: $\delta^{15}N$

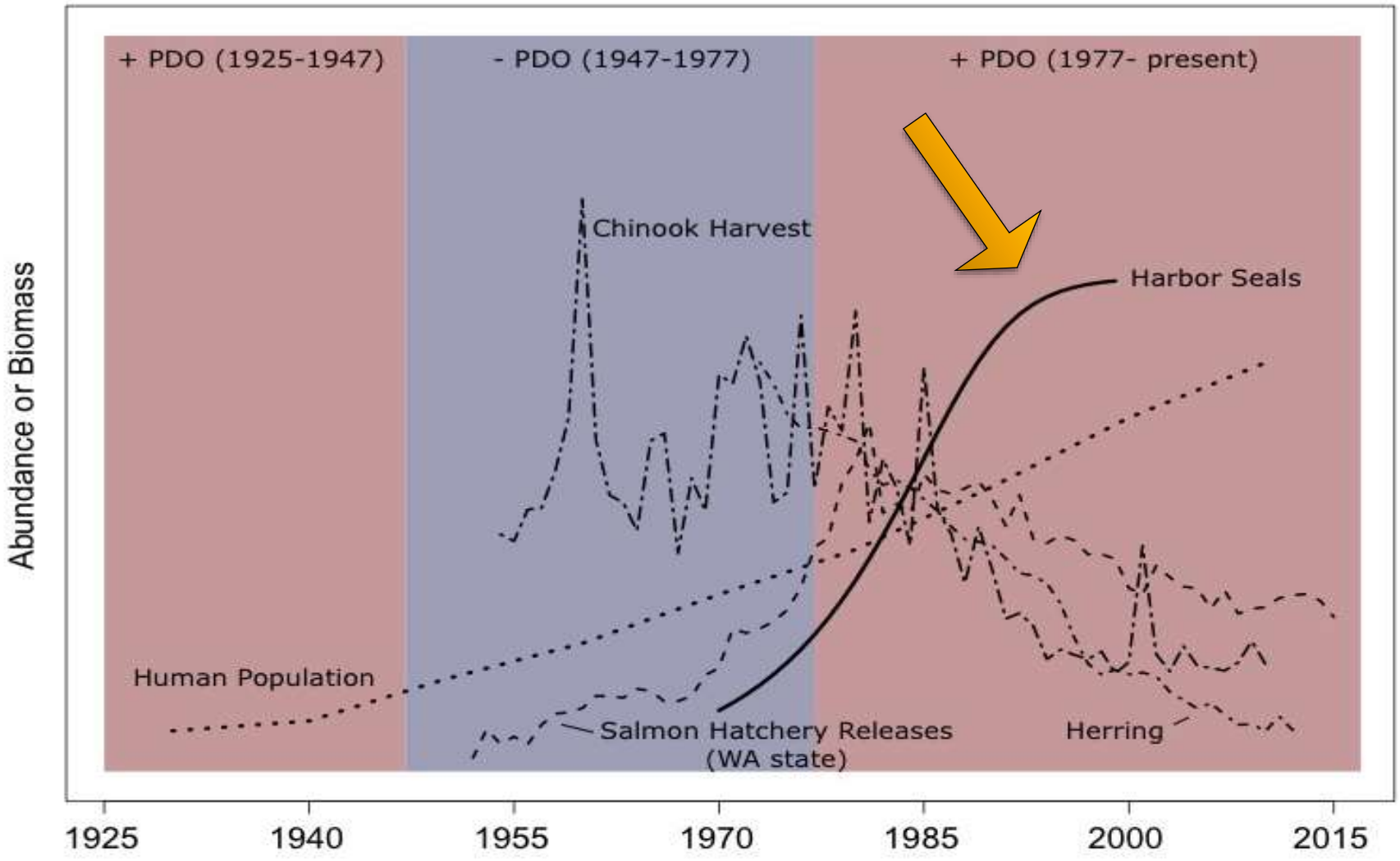


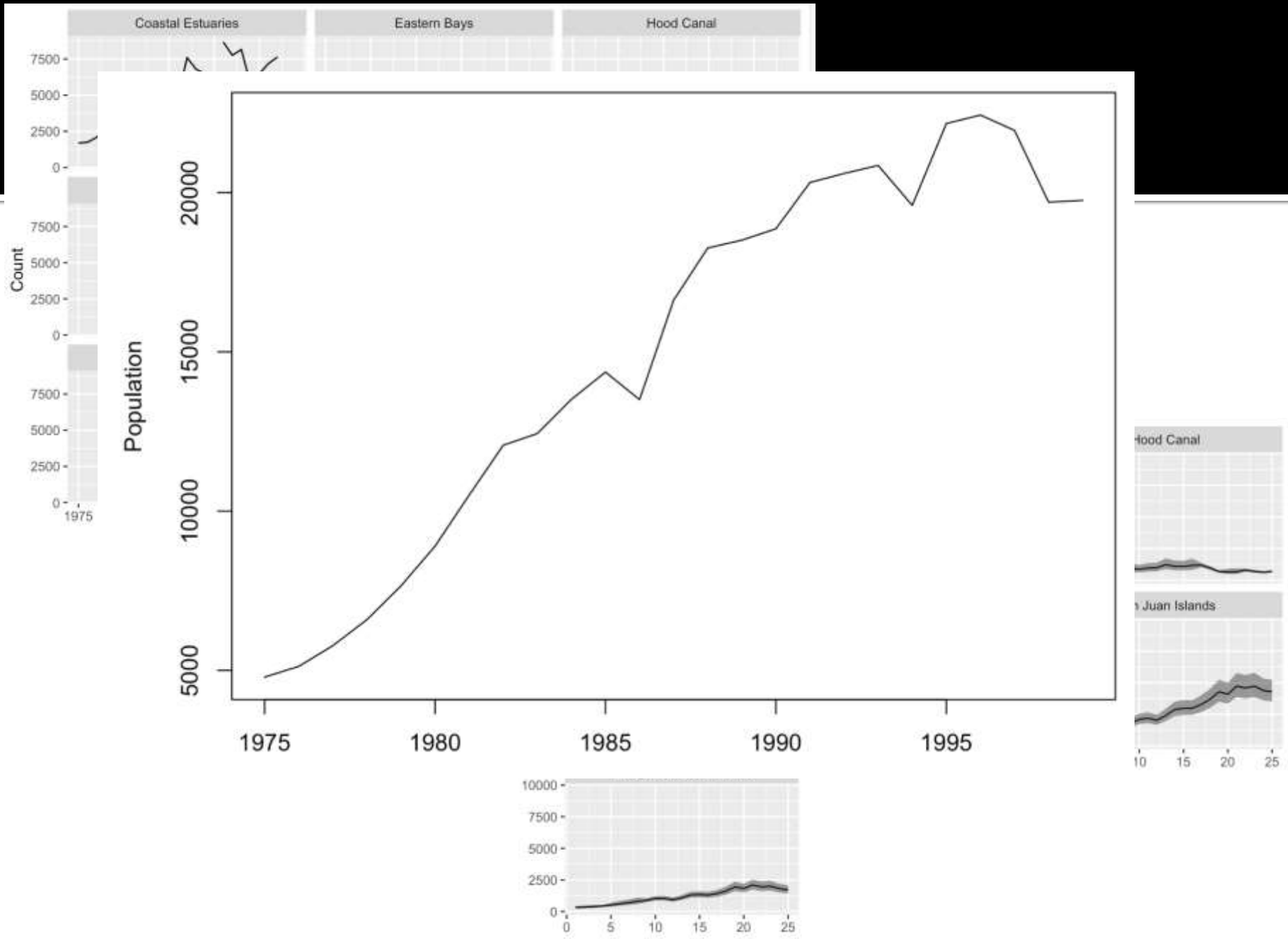


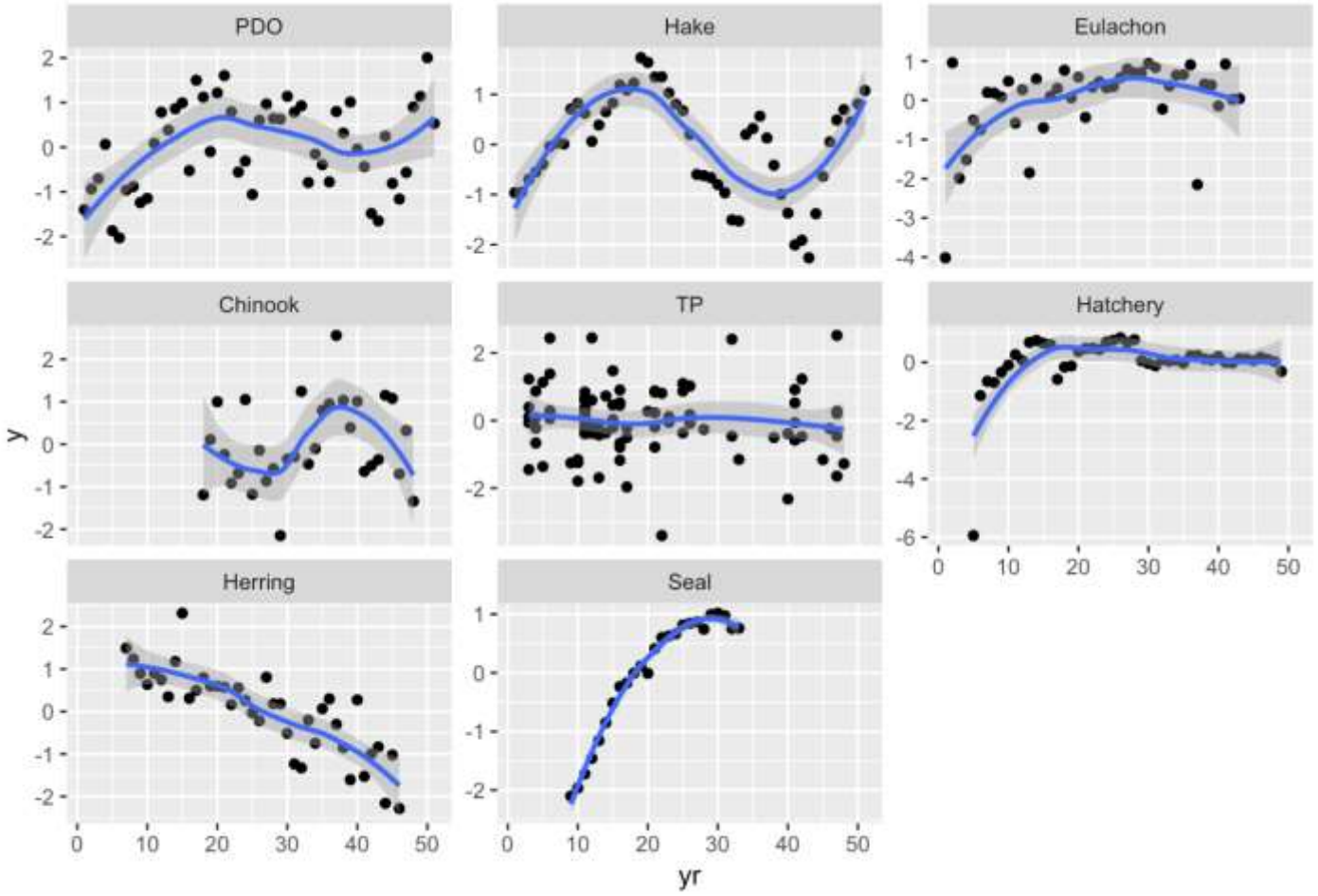
Underlying trends with ecological variables: Trophic Position



Pinniped Recovery in Washington

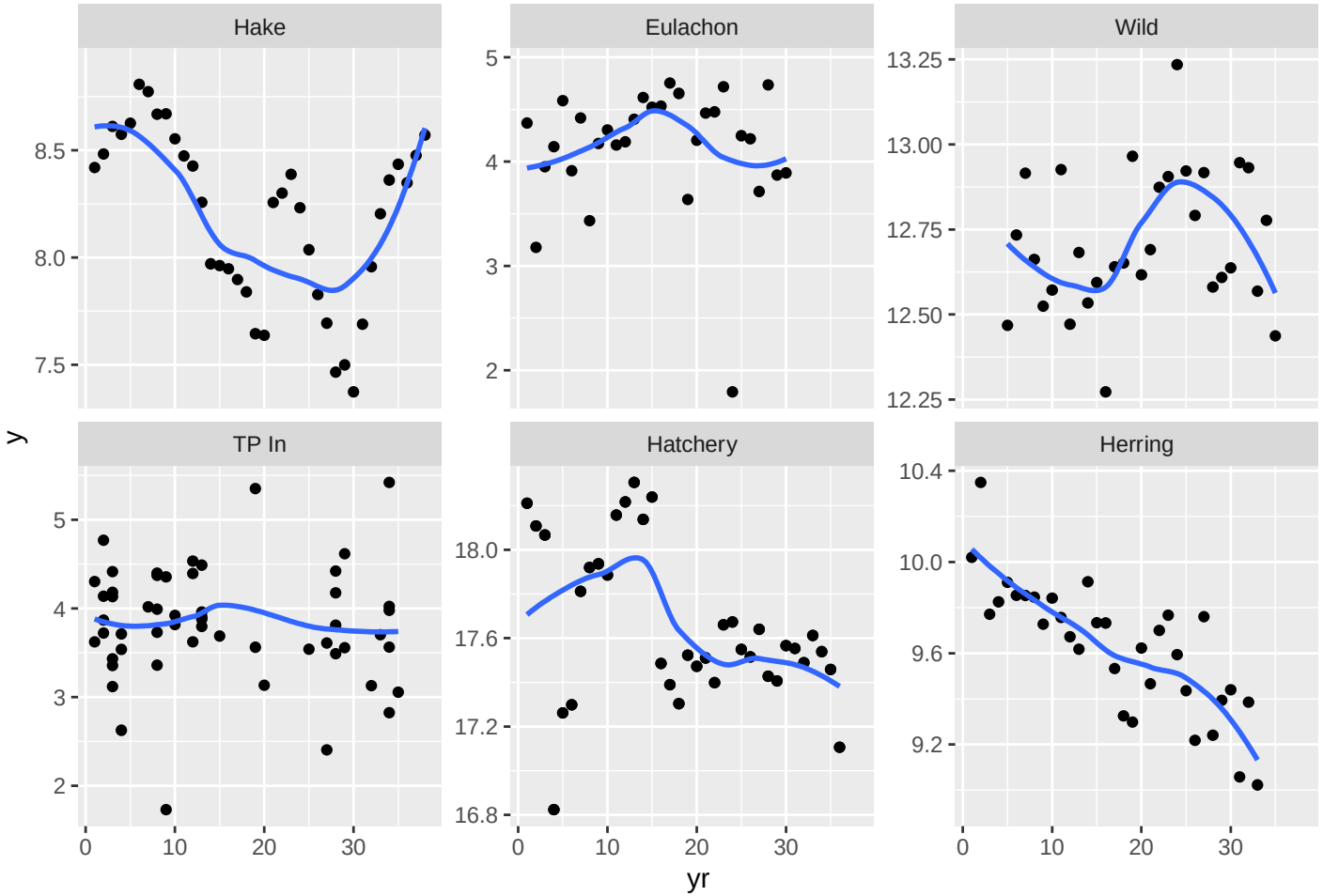


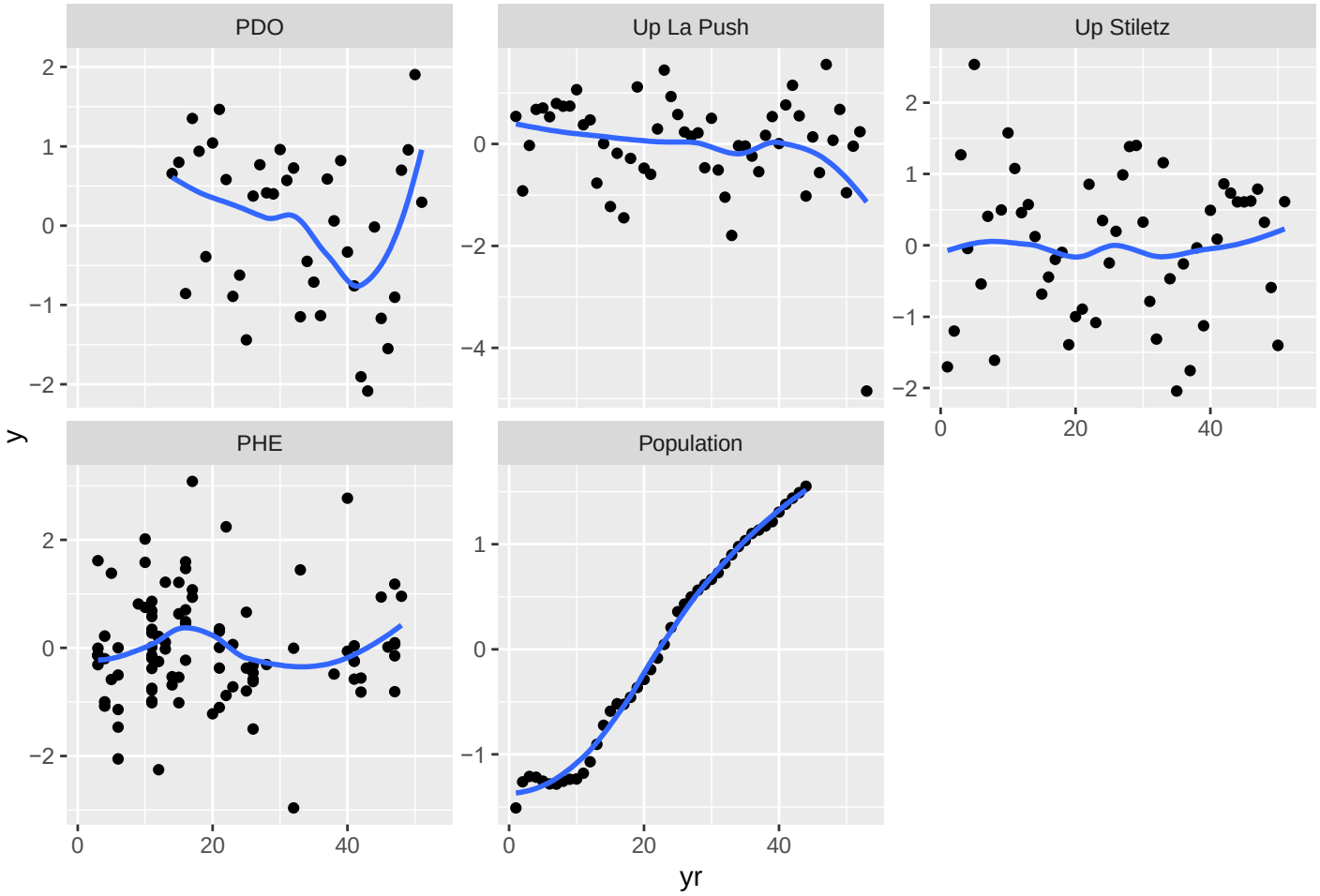

Coastal Estuaries
Eastern Bays
Hood Canal
Count
7500
5000
2500
0
1975
Population
20000
15000
10000
5000
1975
1980
1985
1990
1995
Hood Canal
Juan Islands
10
15
20
25
10000
7500
5000
2500
0
0
5
10
15
20
25


PDO
Hake
Eulachon
Chinook
TP
Hatchery
Herring
Seal
y
yr

Gaussian Dynamic Factor Analysis

Model	LOOIC	SE
TP, 2 locations, 1 Trend	679.1	36.2
TP, 2 locations, 2 Trends	651.3	40.2
TP, 2 locations, 3 Trends	648.9	41.1
TP, 1 location,1 Trend	677.5	34.8
TP., 2 Trend	647.8	38.0
TP., 3 Trend	***642.8***	***39.0***
TP., 1 Trend, Env	681.1	32.5
$\delta^{15}N_{Phe}$, 2 locations, 1 Trend	537.8	31.1
$\delta^{15}N_{Phe}$, 2 locations, 2 Trends	537.2	32.0
$\delta^{15}N_{Phe}$, 2 locations, 3 Trends	537.6	32.5
$\delta^{15}N_{Phe}$, 1 location, 1 Trend	539.8	31.7
$\delta^{15}N_{Phe}$, 1 location, 2 Trends	539.3	32.6
$\delta^{15}N_{Phe}$, 1 location, 3 Trends	***536.4***	***33.2***


Hake
Eulachon
Wild
TP In
Hatchery
Herring
y
yr
8.5
8.0
7.5
5
4
3
2
13.25
13.00
12.75
12.50
12.25
5
4
3
2
18.0
17.6
17.2
16.8
10.4
10.0
9.6
9.2
0
10
20
30


PDO
Up La Push
Up Stiletz
PHE
Population
y
yr
2
1
0
−1
−2
−4
0
20
40