

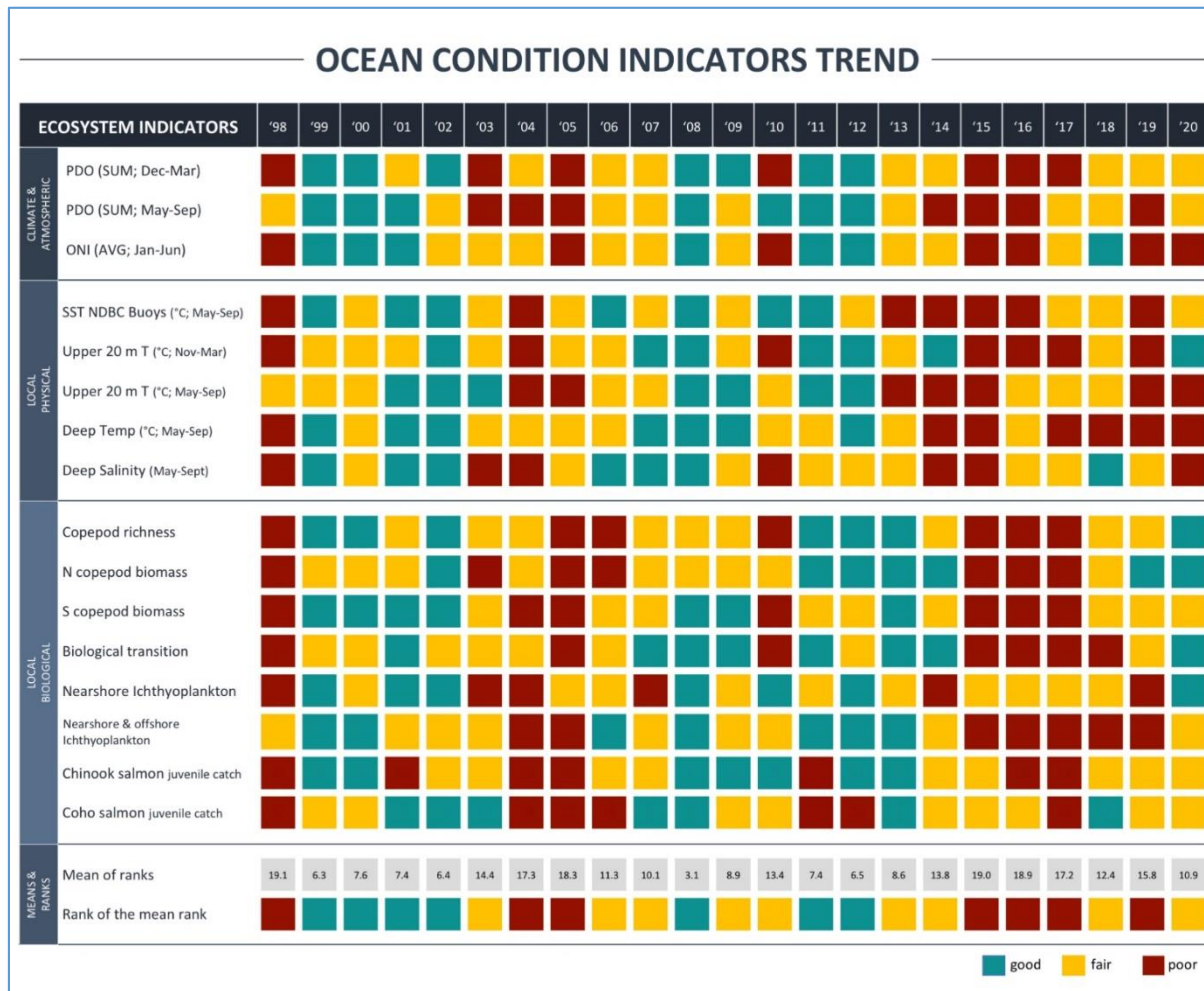


Selecting and Using *Indicators* for Columbia River Salmon

Brian Burke, Jennifer Fisher, Sam Zeman,
Kym Jacobson, & Cheryl Morgan



NOAA's Stoplight Chart

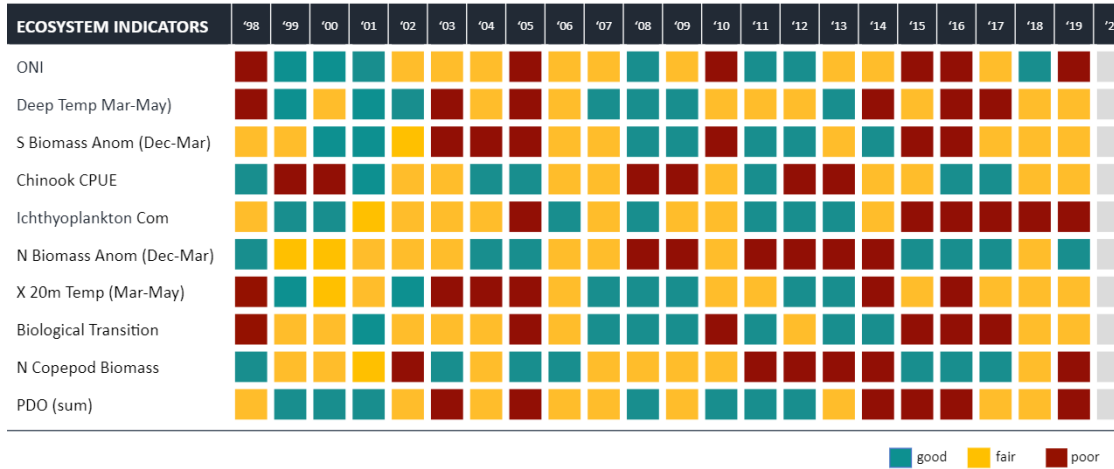


- Are these the best set of indicators for a given application?
- What level of cross-correlation exists in the table, and what effect does that have any conclusions drawn from the table? E.g., from PCA.

Ideally,

- Variables are all informative, in a predictive sense
- Correlation among variables is minimized, so summary metrics, such as the first Principal Component, represents *all* variables

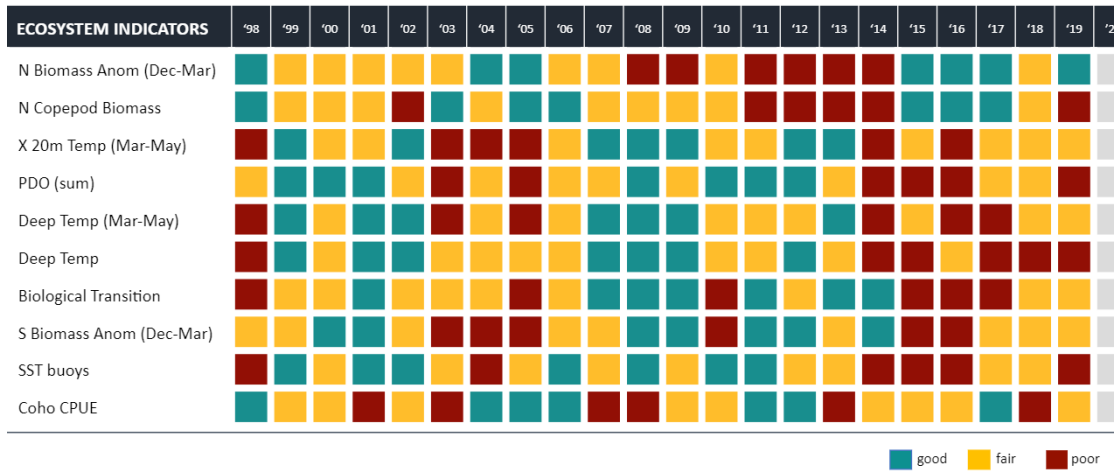
Spring Chinook



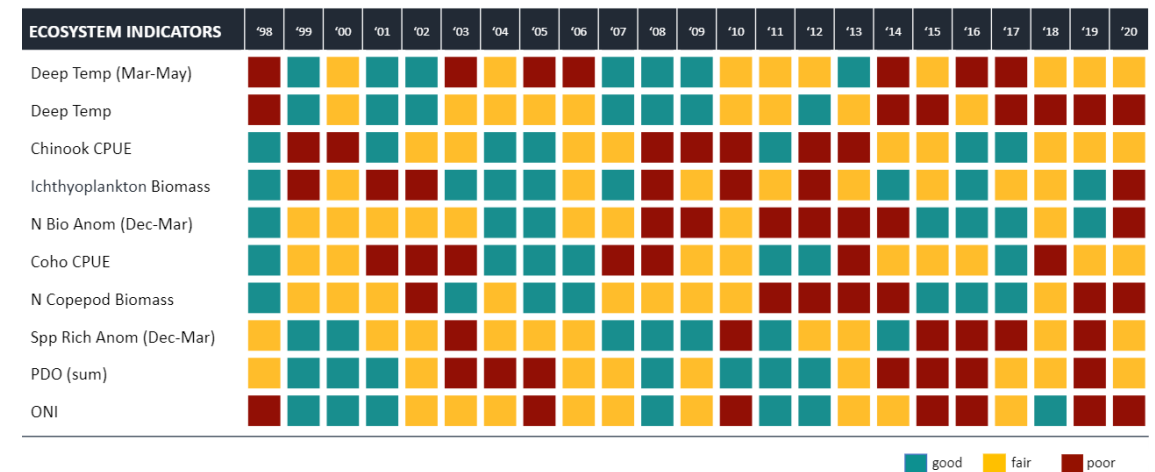
Stock-Specific Stoplight Charts

Optimized for Predictive Ability

Fall Chinook

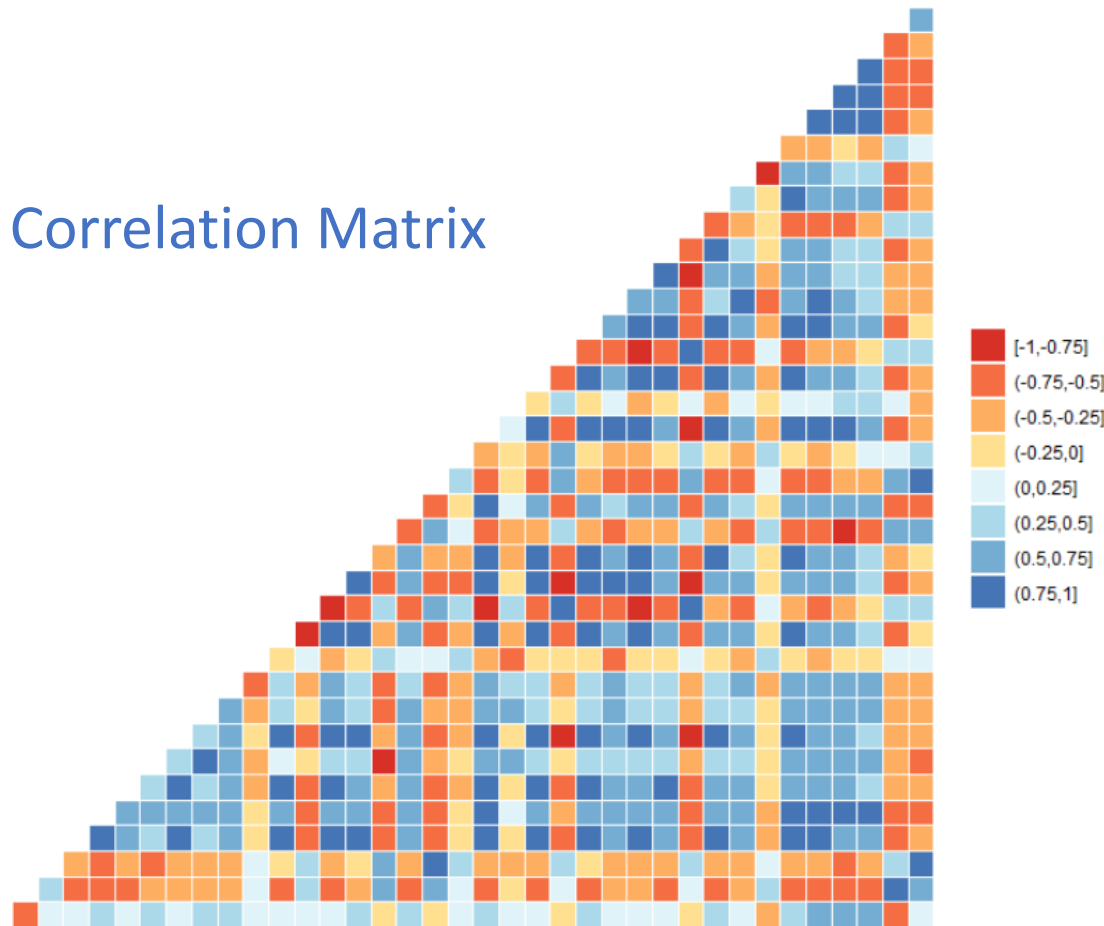


Coho



We have too many potential *indicators*!

Correlation Matrix



Southern Copepods Deep Temperature Flow

Spring Transition SST Upwelling Strength

PDO Biological Transition

Ichthyoplankton Composition Chinook CPUE

Northern Copepods

NPGO Ichthyoplankton Biomass

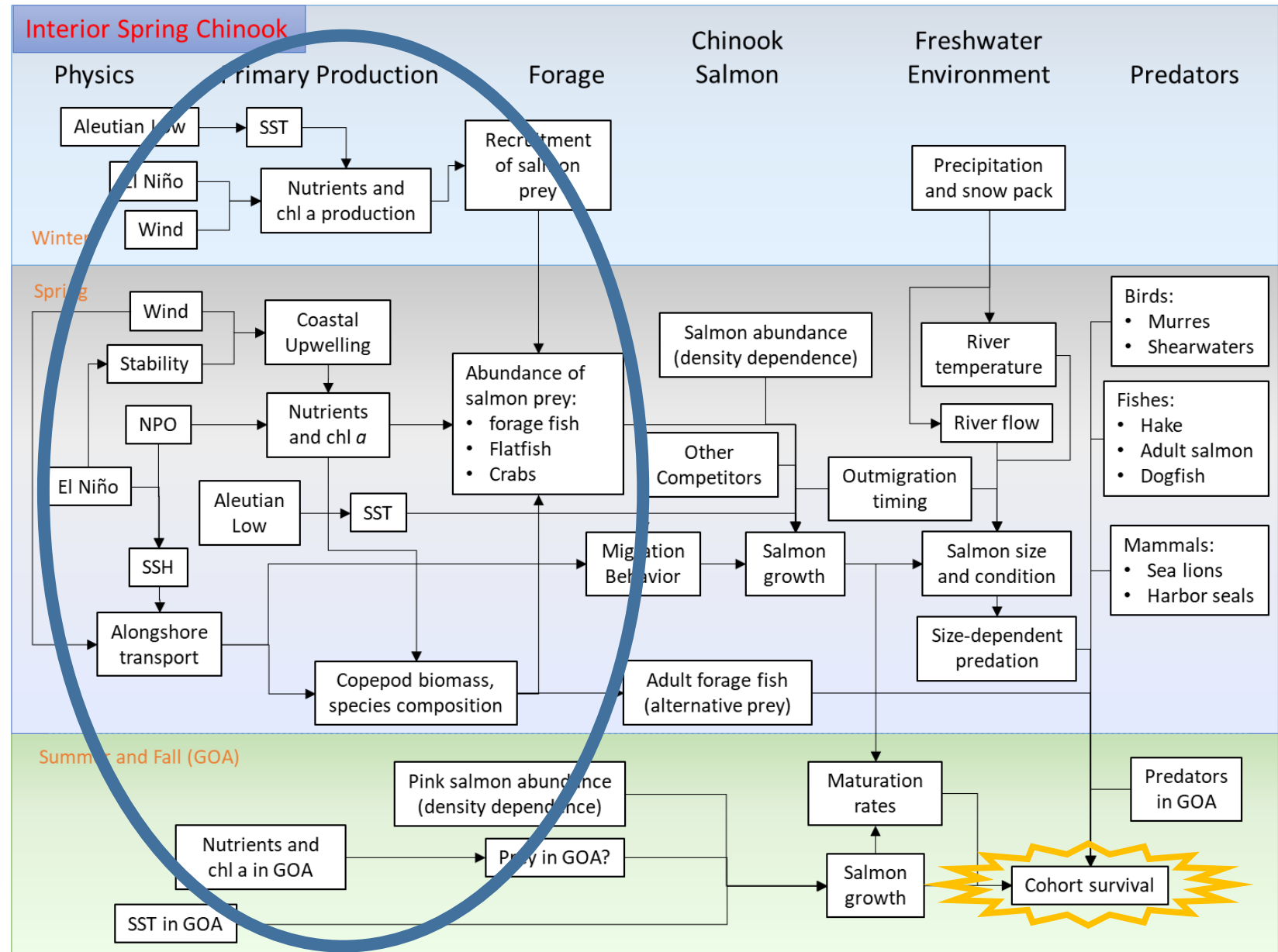
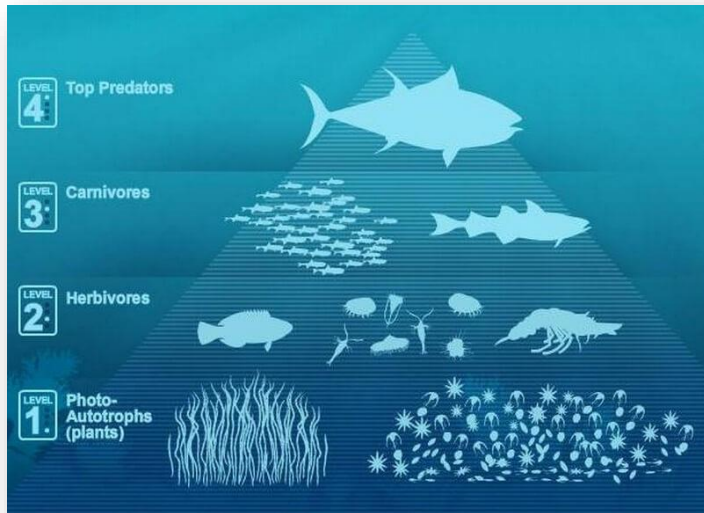
Dissolved Oxygen Bird Abundance

Seal Abundance ONI

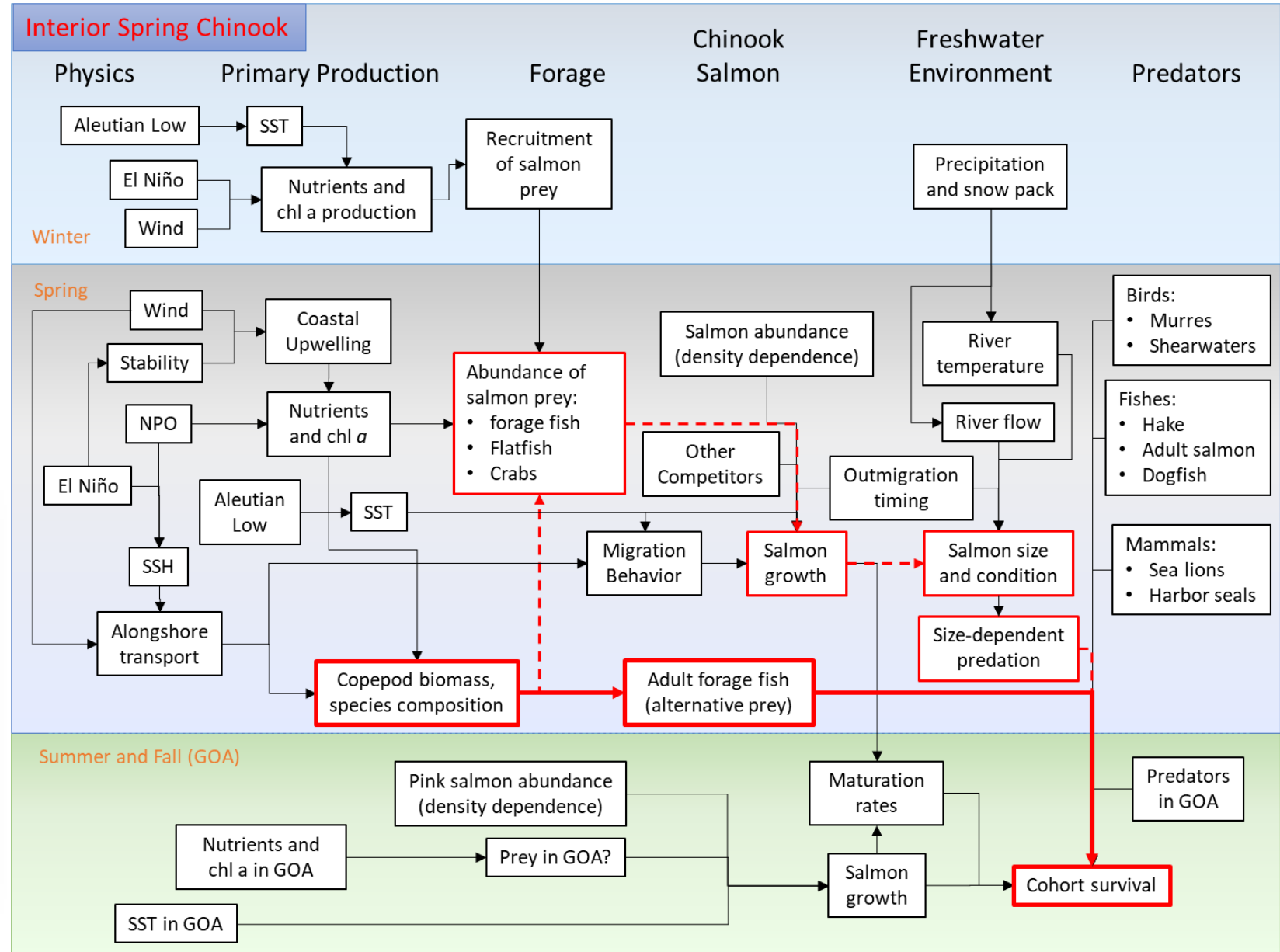
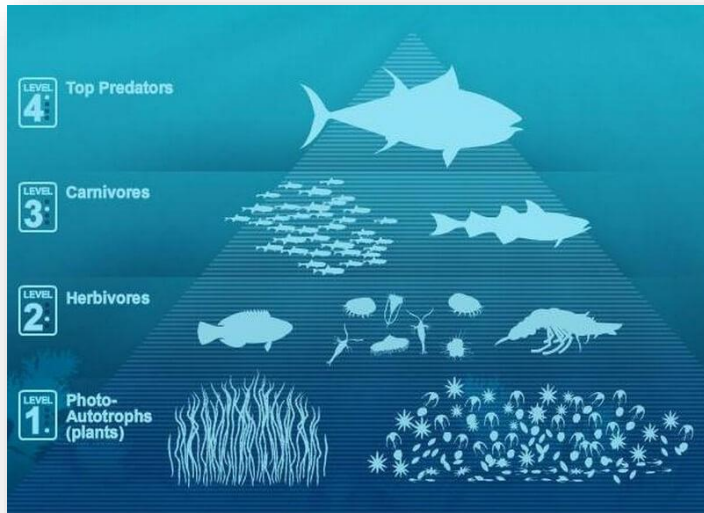
NPI Winter Temperature Salinity

 Copepod Species Richness

Mechanistic indicators are best, but are not often available



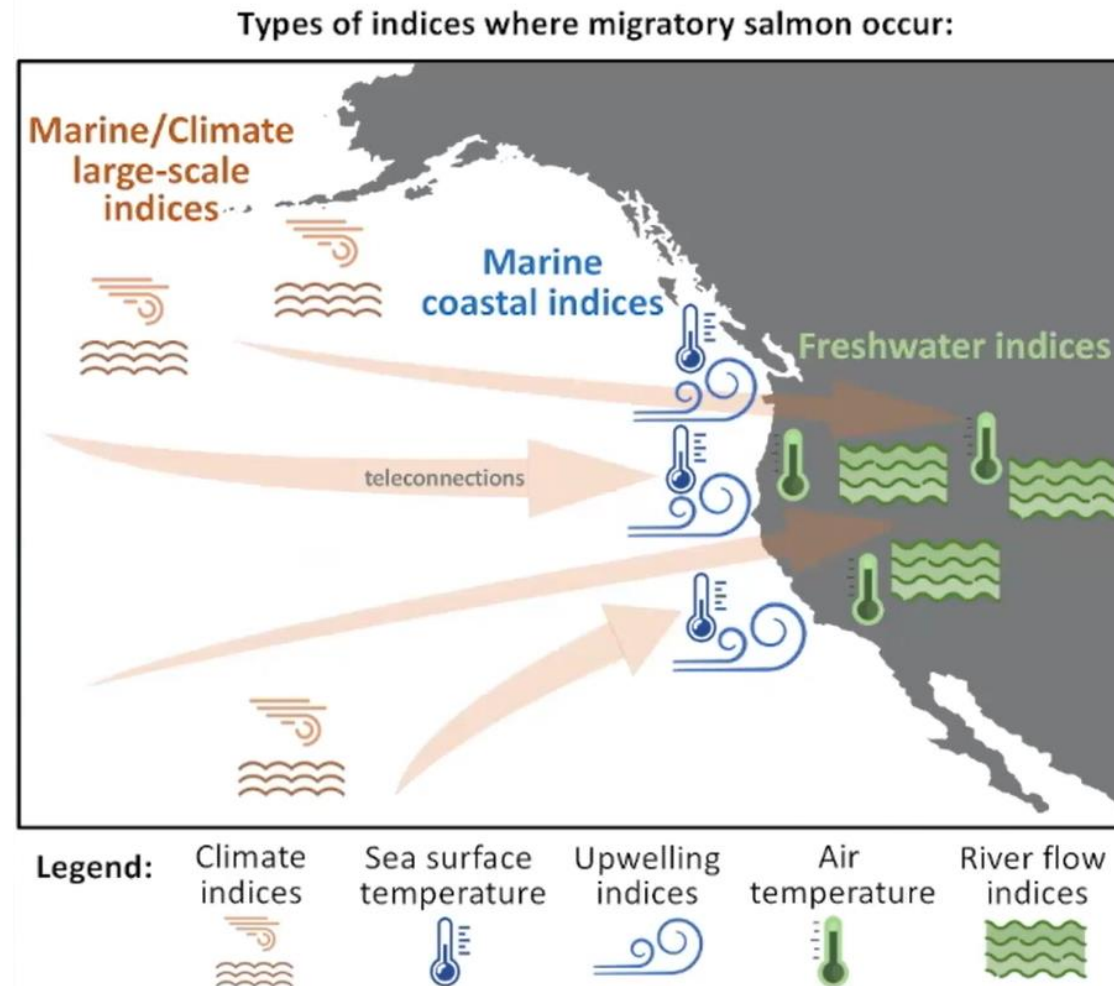
Mechanistic indicators are best, but are not often available



Some issues to be aware of...

1. Cross-correlations

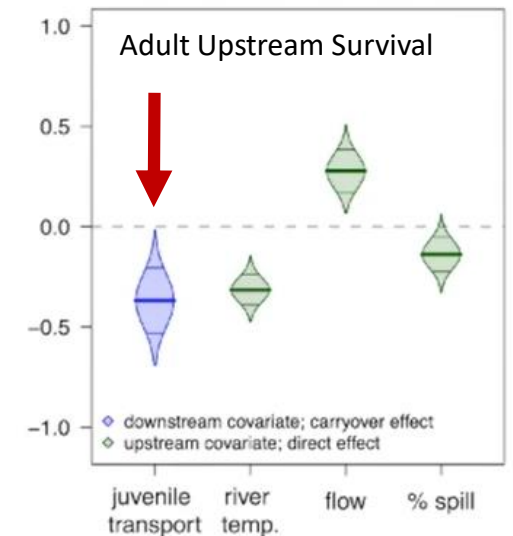
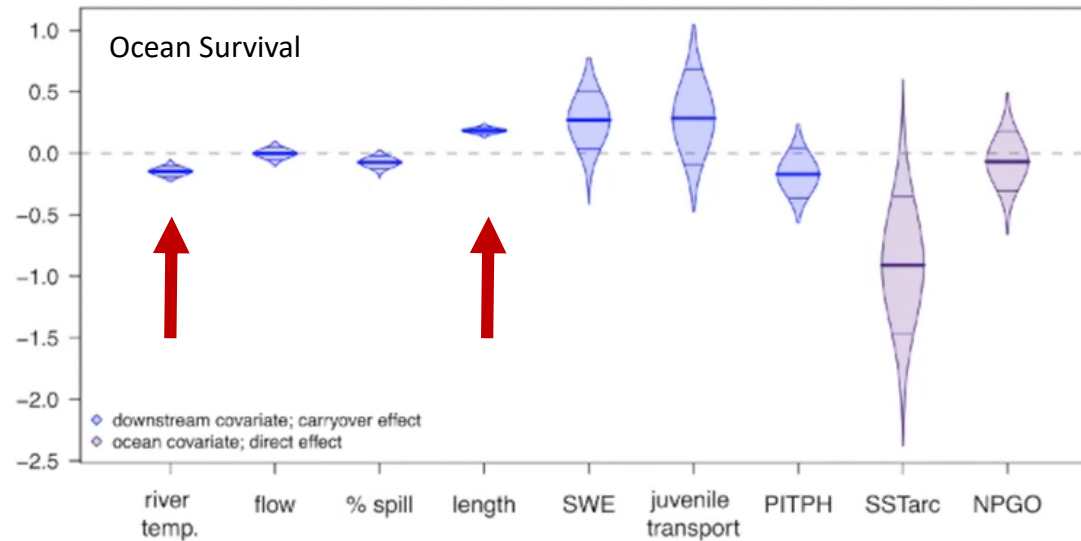
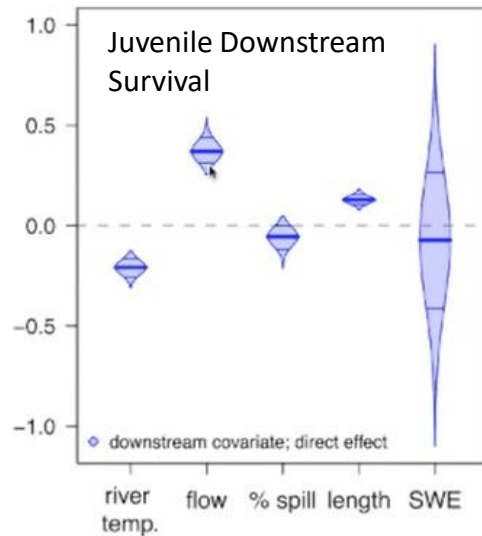
Drivers of environmental variability can be common across habitats



Some issues to be aware of...

2. Carryover Effects

We need to think about both *direct* and *indirect* relationships between indicators and responses



Some issues to be aware of...

3. Non-stationarity

Correlations will not remain static!

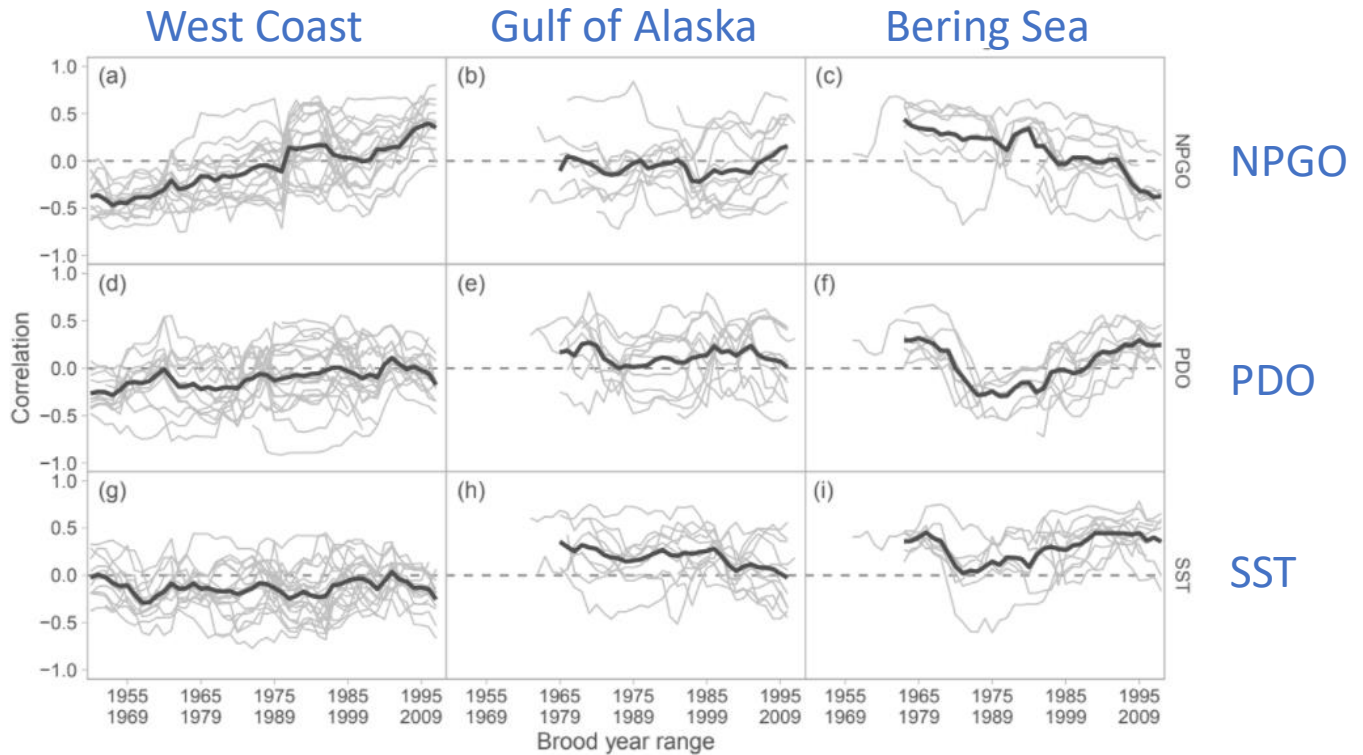
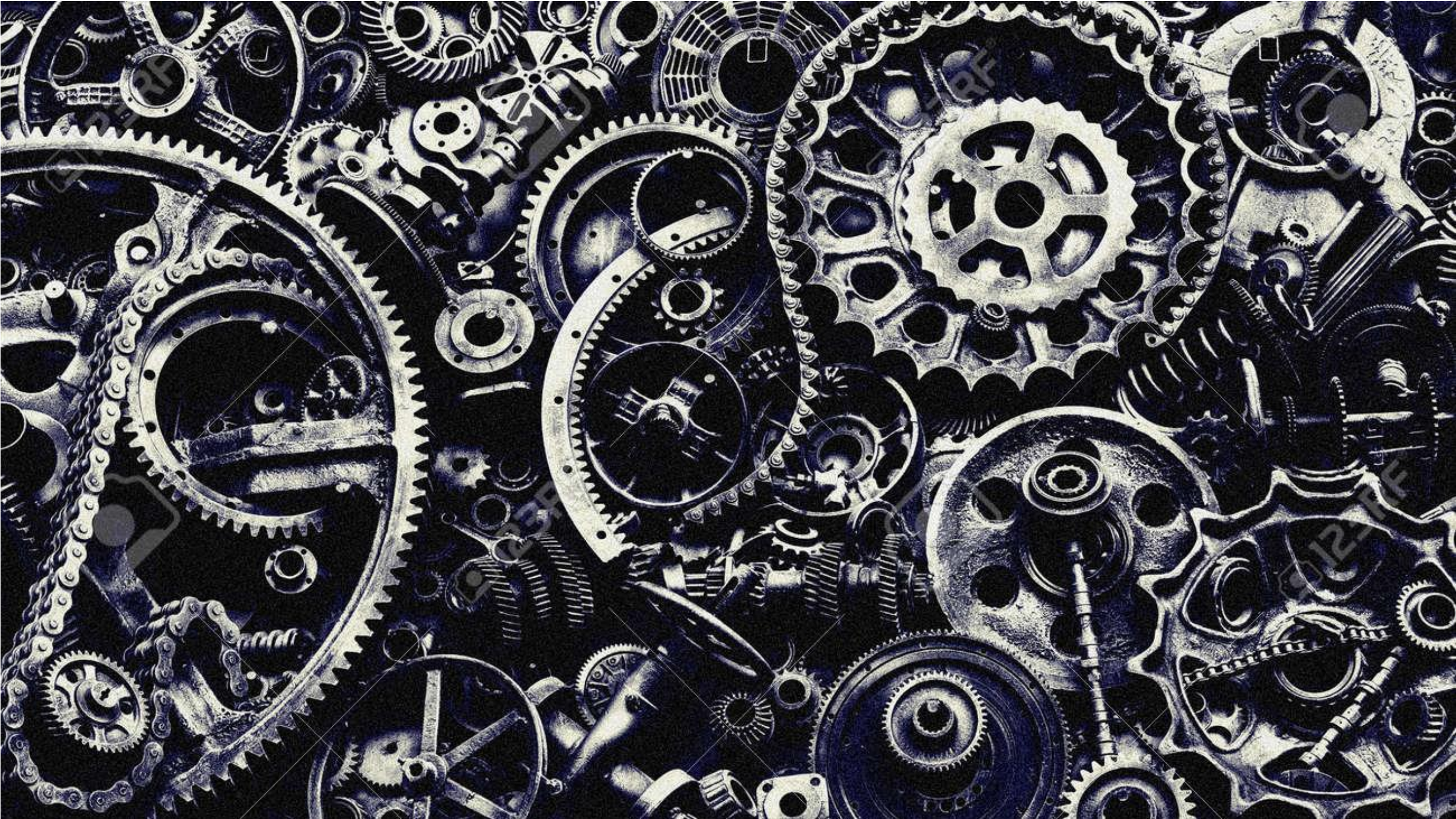
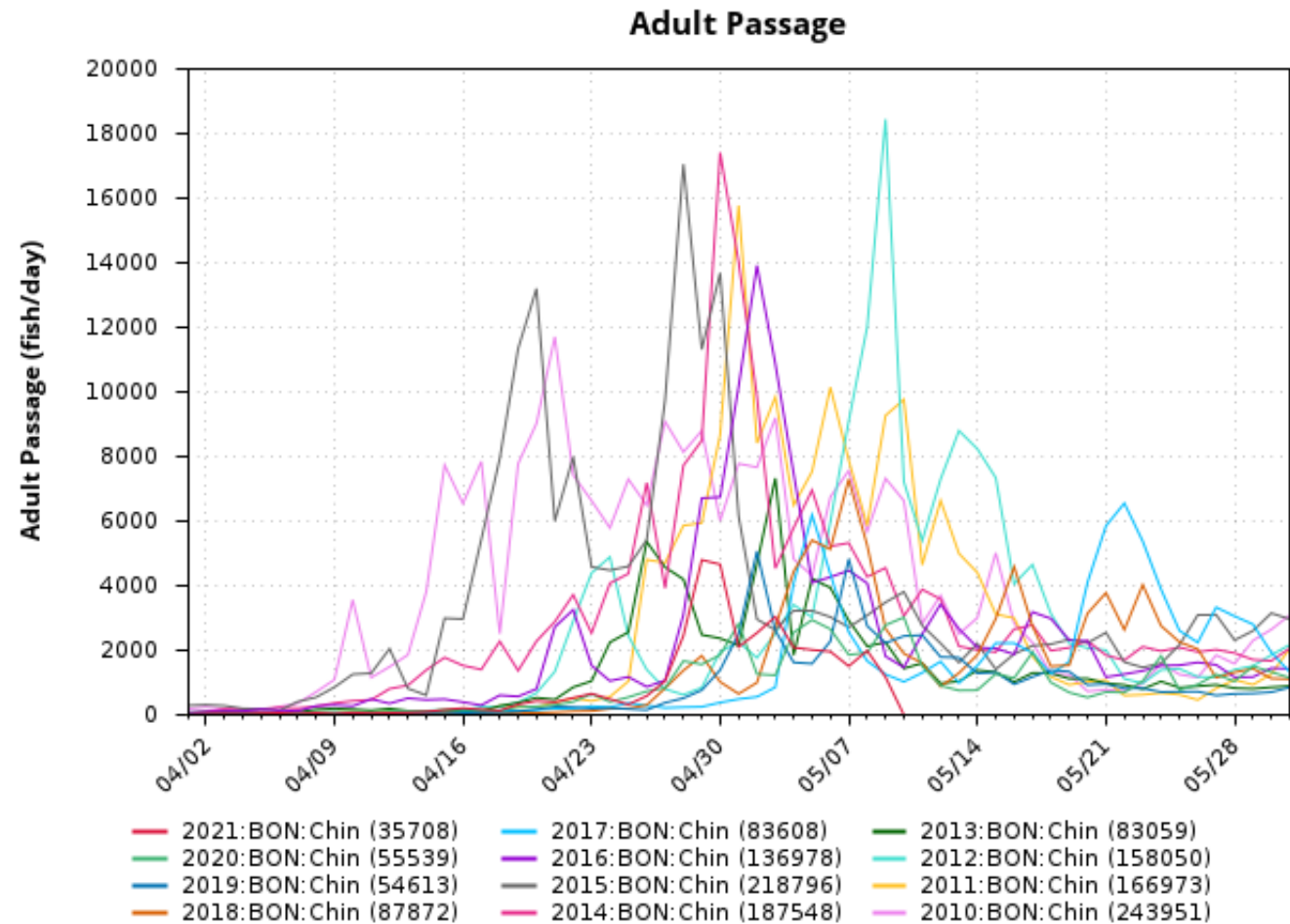


Figure 2: Sliding window correlation time series. Light grey lines show the stock-specific sliding window correlation series and the thick black lines show the average correlation across stocks for each brood year. Average is only shown for years that have correlations for more than 3 stocks. Horizontal axis provides the brood year ranges covered by the sliding window.



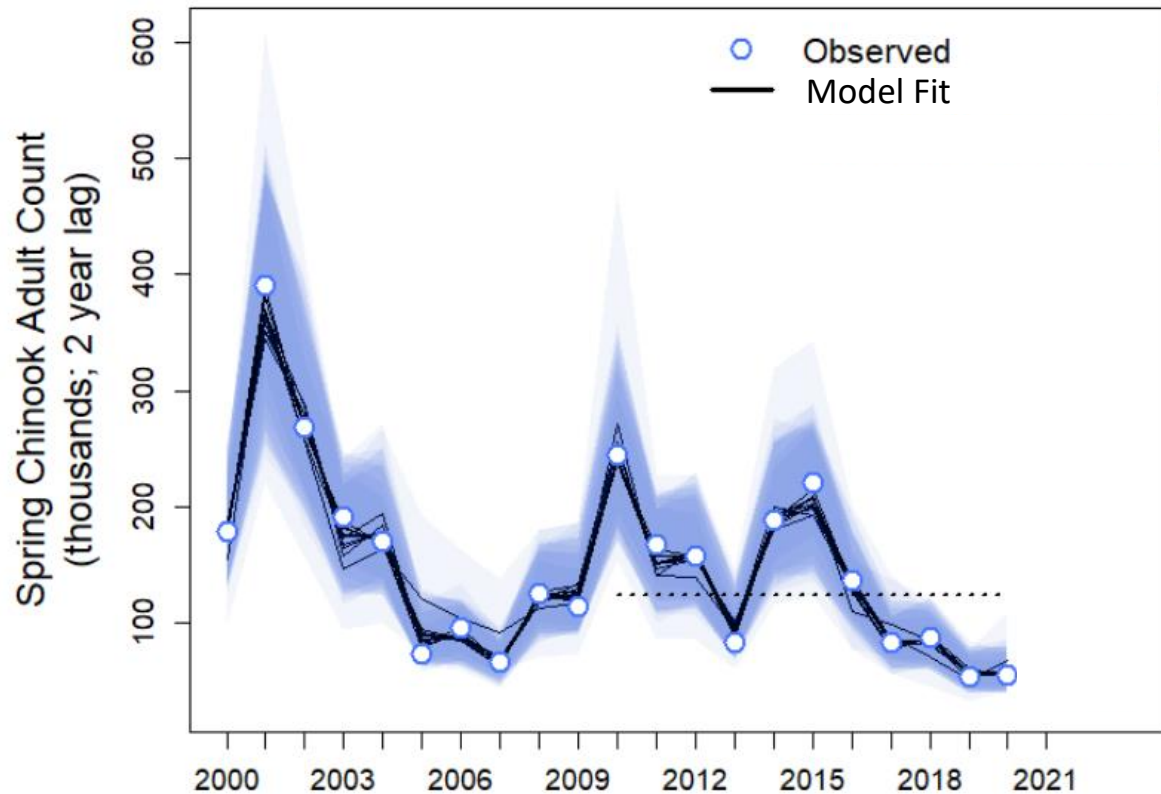
Example Application: Spring Chinook at Bonneville Dam



A very important distinction

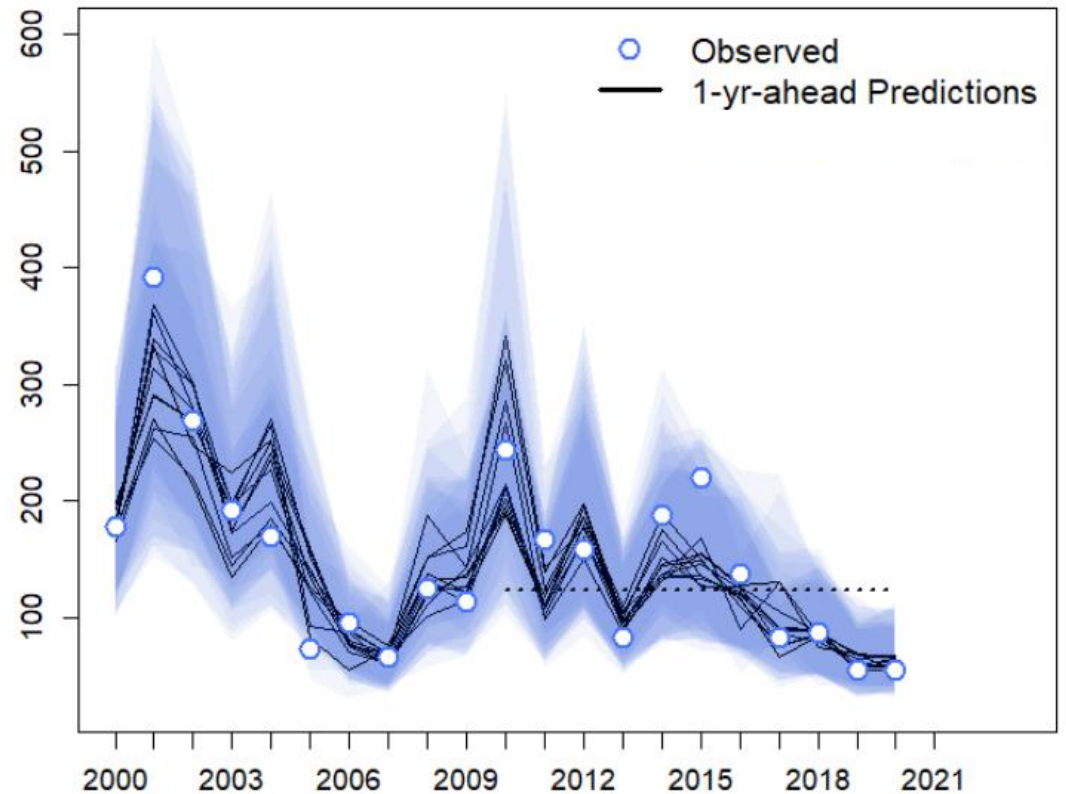
Model Fit

Top models based on AICc

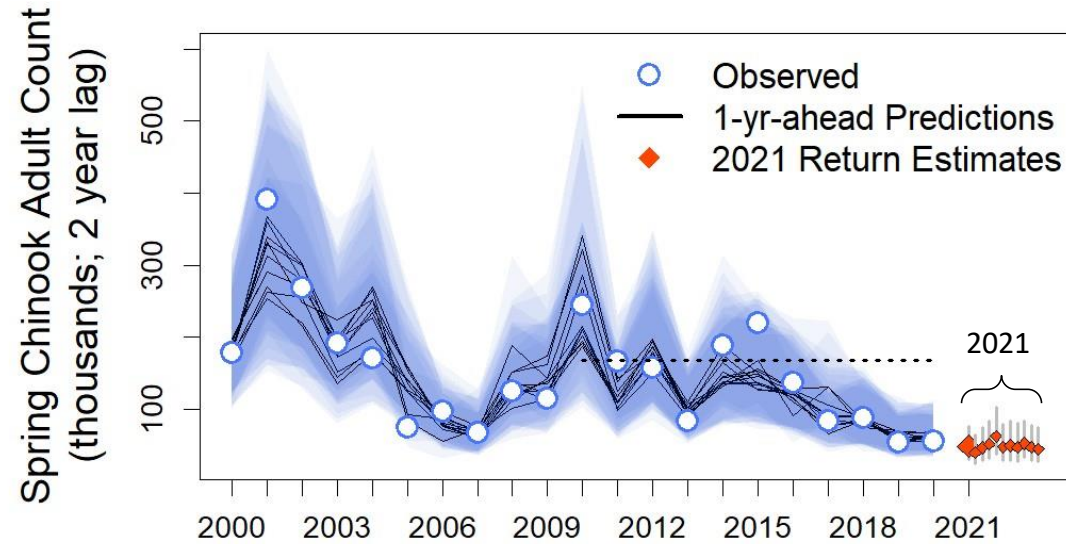


1-Step Ahead Predictions

Top models based on MAE



One-Step Ahead Predictions and 2021 Estimate



Estimates for 2021 returns

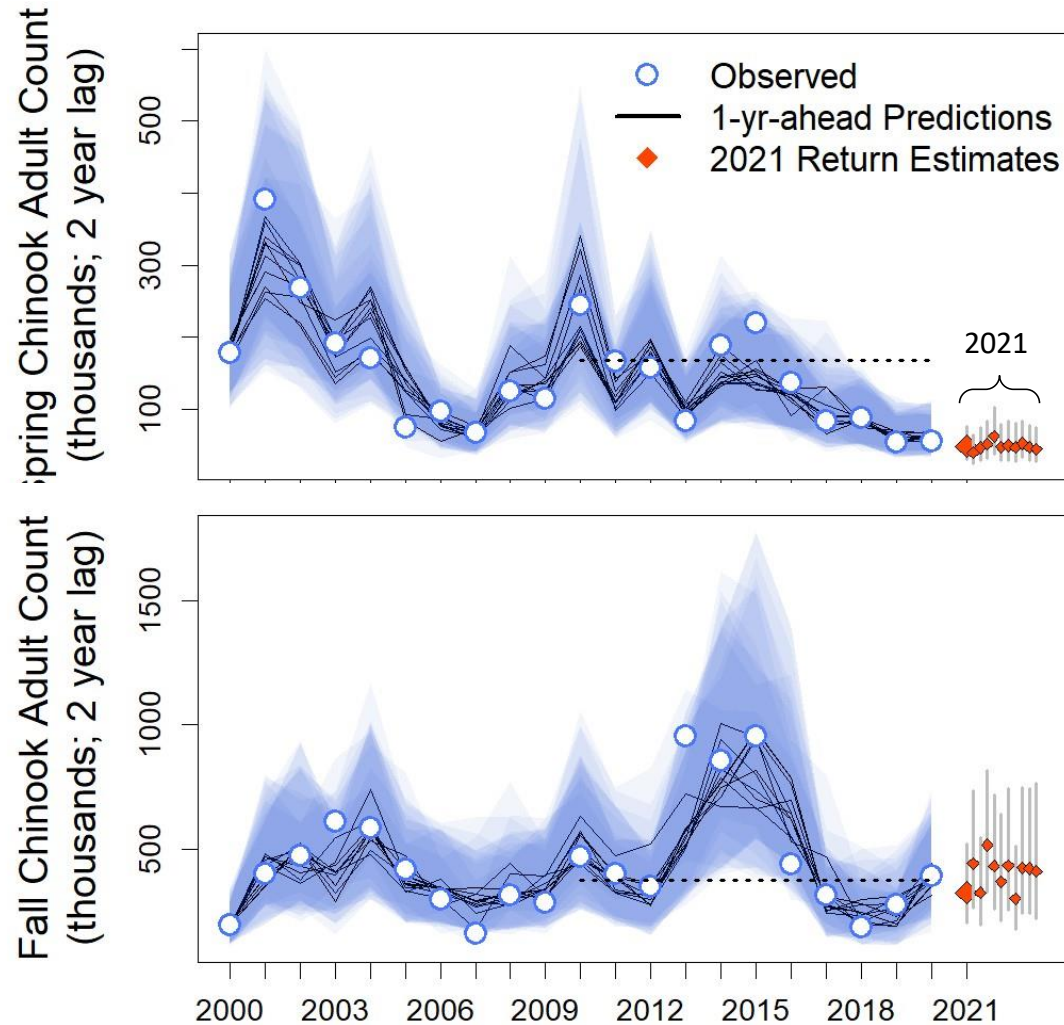
Spring Chinook: 48K Adults (30K - 76K)

ECOSYSTEM INDICATORS	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13	'14	'15	'16	'17	'18	'19	'20
ONI	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good
Deep Temp Mar-May	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good
S Biomass Anom (Dec-Mar)	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good
Chinook CPUE	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good
Ichthyoplankton Com	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good
N Biomass Anom (Dec-Mar)	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good
X 20m Temp (Mar-May)	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good
Biological Transition	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good
N Copepod Biomass	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good
PDO (sum)	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good	good

good fair poor

$$\text{Adult Returns} = f(\text{jack returns}) + f(\text{ocean indicator}) + \text{linear trend}$$

One-Step Ahead Predictions and 2021 Estimate

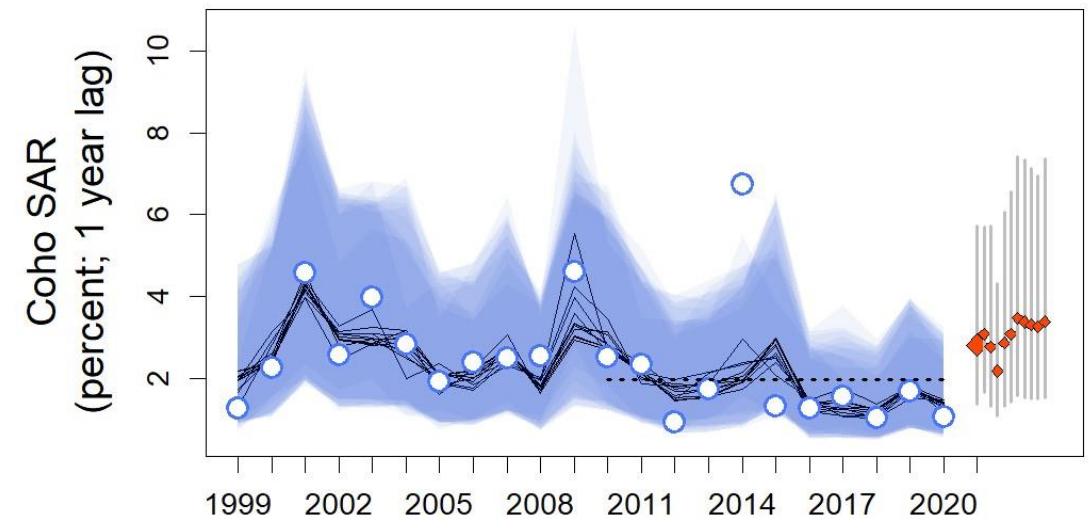


Estimates for 2021 returns

Spring Chinook: 48K Adults (30K - 76K)

Fall Chinook: 325K Adults (203K – 520)

OPIH coho SAR: 2.6% Survival (1.3 - 5.4)

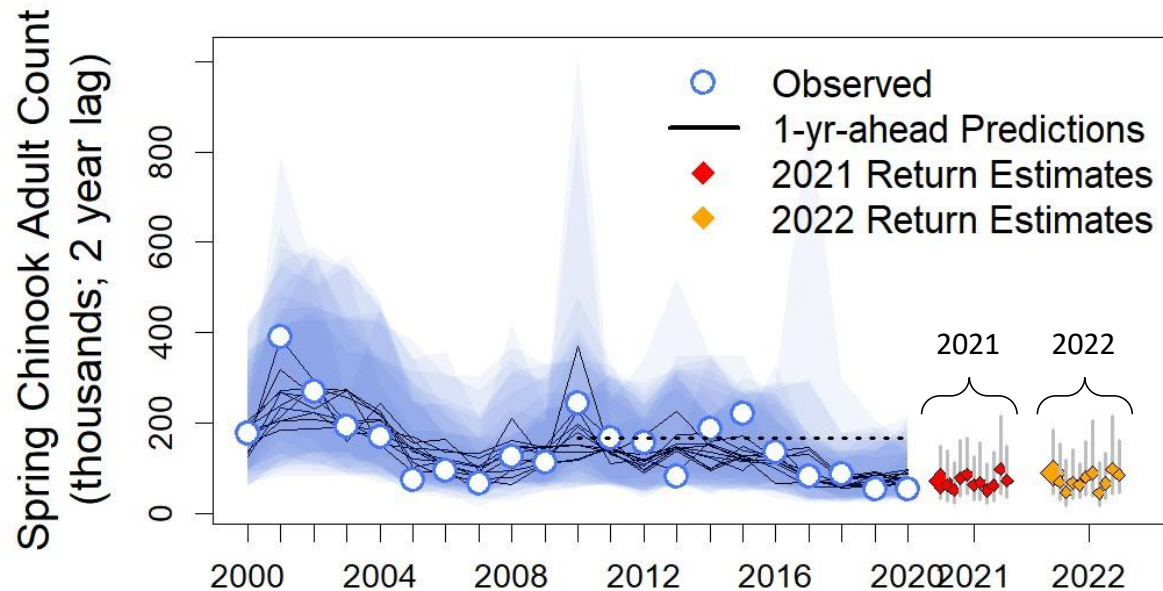


$$\text{Adult Returns} = f(\text{jack returns}) + f(\text{ocean indicator}) + \text{linear trend}$$

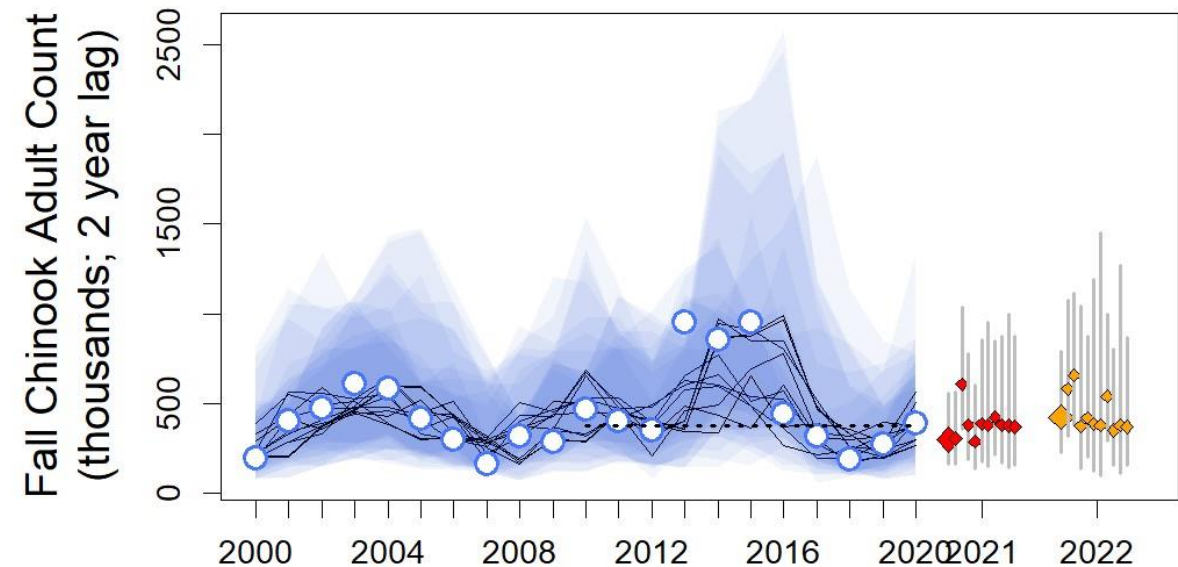
One-Step Ahead Predictions and 2021, 2022 Estimates

(no jacks included)

Spring Chinook

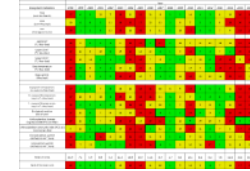


Fall Chinook

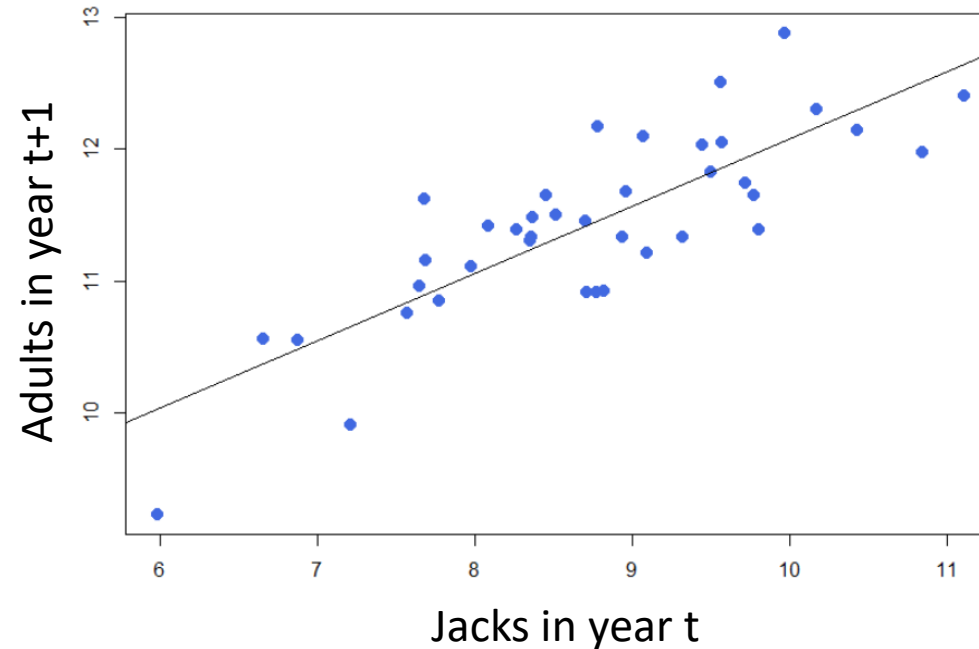


$$\text{Adult Returns} = f(\text{jack returns}) + f(\text{ocean indicator}) + \text{linear trend}$$

Tip: Embrace New Quantitative Tools



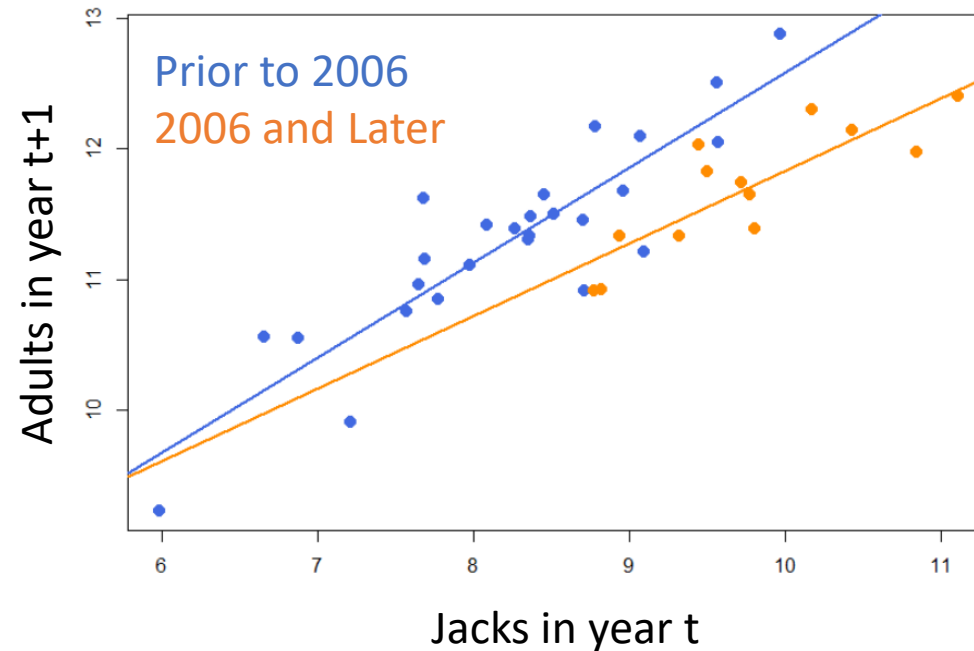
$$Adults = f(Jacks + Ocean)$$



Tip: Embrace New Quantitative Tools



$$Adults = f(Jacks + Ocean)$$



*We now use Dynamic Linear Models, or DMLs, to model Chinook returns

Conclusions and suggestions

- Be (stock) specific
- Mechanistic indicators are best, if you can find them
- Consider both indicator performance and information redundancy
- Embrace quantitative tools and technologies