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# Reading the Signals: Ocean Ecosystem Indicators, Recent Trends, and Why They Matter

*Upper Columbia River Salmon Recovery Board Summit  
January 21<sup>st</sup>, 2026*



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NOAA Fisheries, NWFSC  
Brian.Burke@noaa.gov

**Team:** Brian Beckman, Anna Bolm, Elizabeth Daly, Jennifer Fisher, David Huff, Mary Hunsicker, Kym Jacobson, Jessica Miller, Cheryl Morgan, Catherine Nickels, Joe Smith, Kelcee Smith, Laurie Weitkamp, Amy Wallace, Brian Wells, Jen Zamon, Sam Zeman

Also supported by:



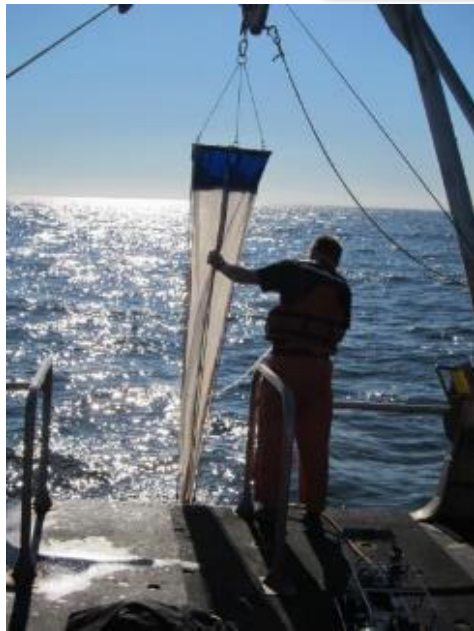
# Outline

- Who we are and what we do
- The Ocean Ecosystem
- Why this matters to you



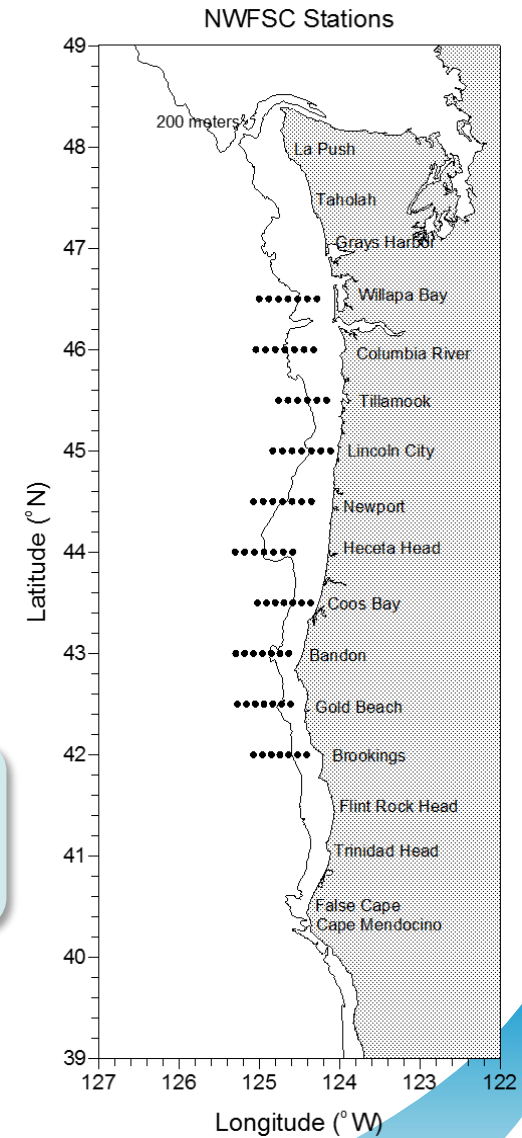
# Newport Hydrographic Line and Northern California Current Survey

**Newport Line:** Sampled biweekly for 30 years



**Pre-recruit:** May-June (2011, 2013-present)

**NCC Survey:** Seasonal (2-4 times per year)



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# Juvenile Salmon and Ocean Ecosystem Survey (JSOES)



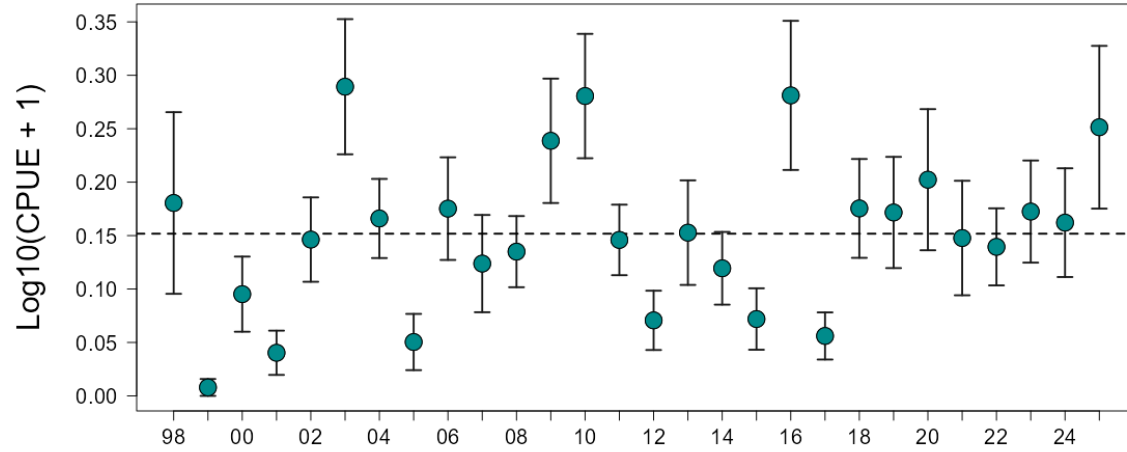
- May (2006 – 2012, 2015 - present)
- June (1998 – present)
- September (1998 – 2012)



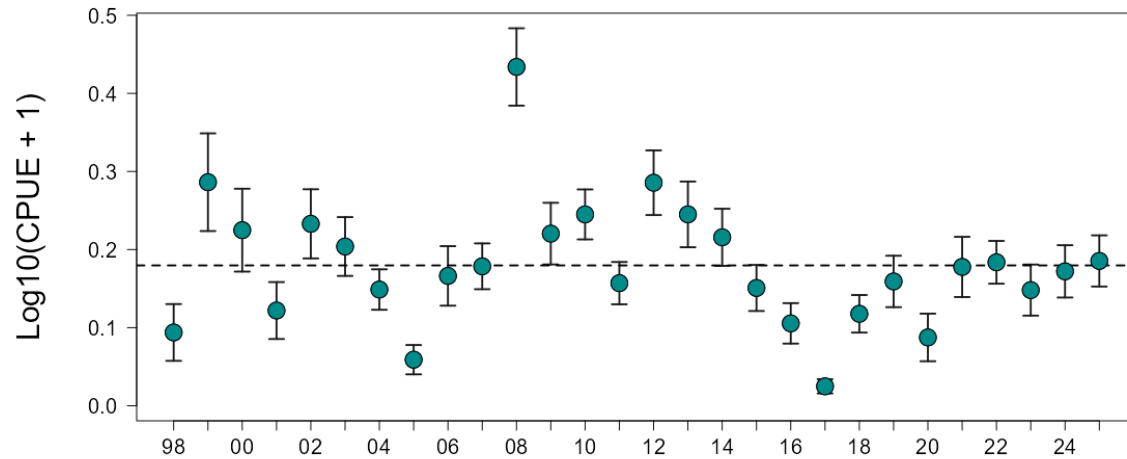
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# JSOES Catches - June, 1998-2025

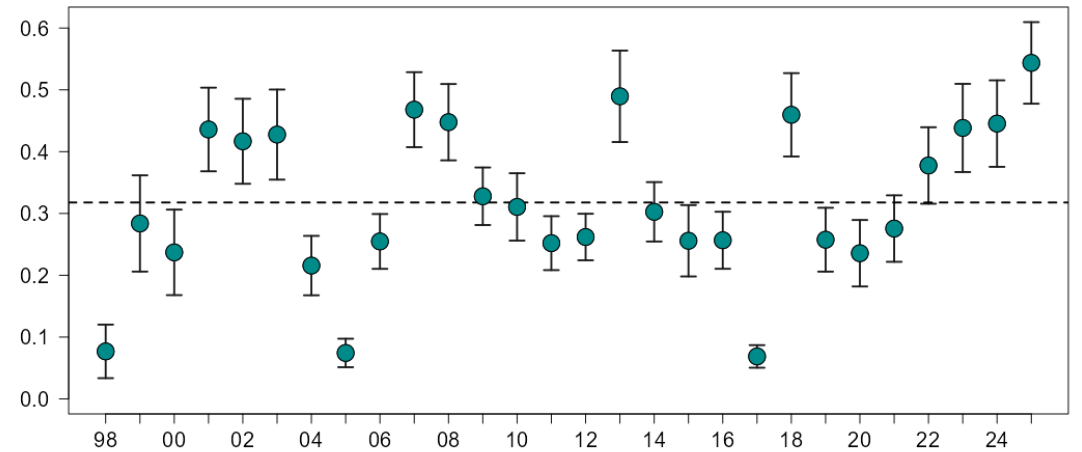
## Subyearling Chinook salmon



## Yearling Chinook salmon



## Coho salmon



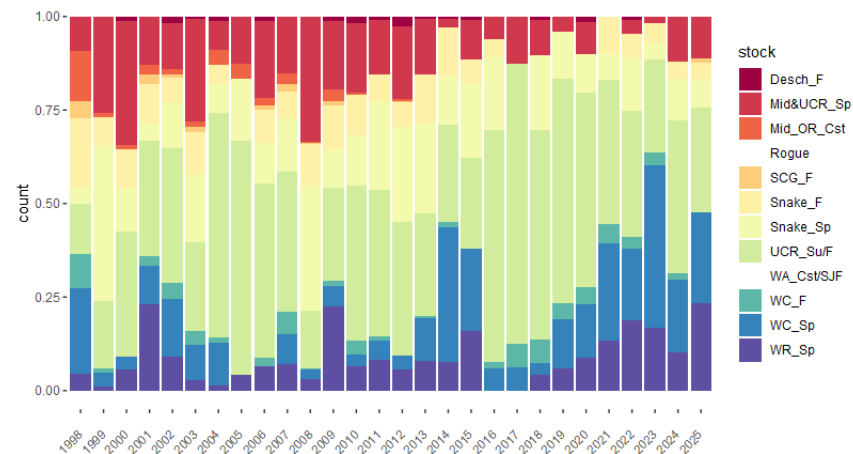
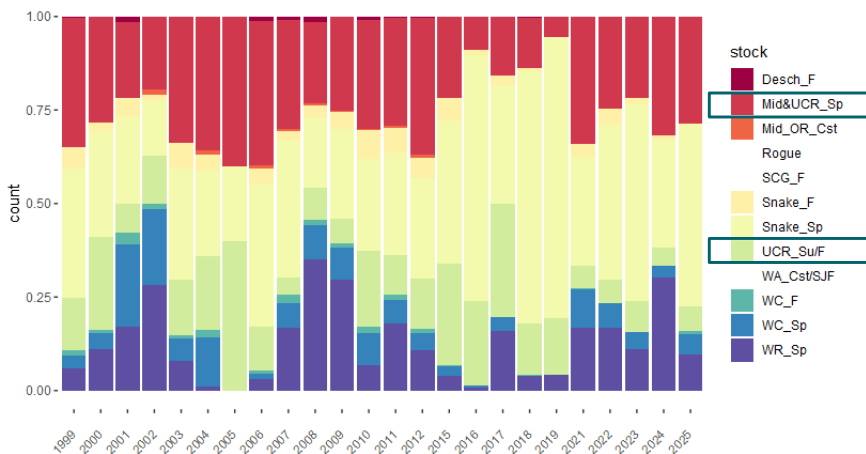
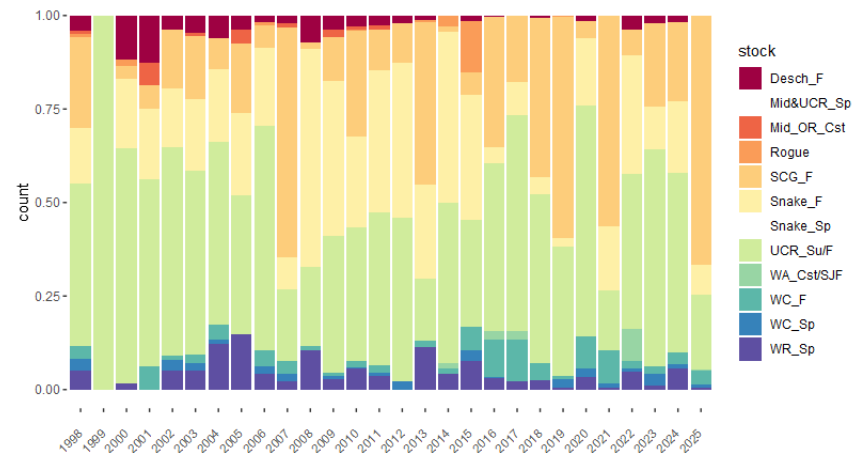
# Upper Columbia River Contributions to our Catch

May

June

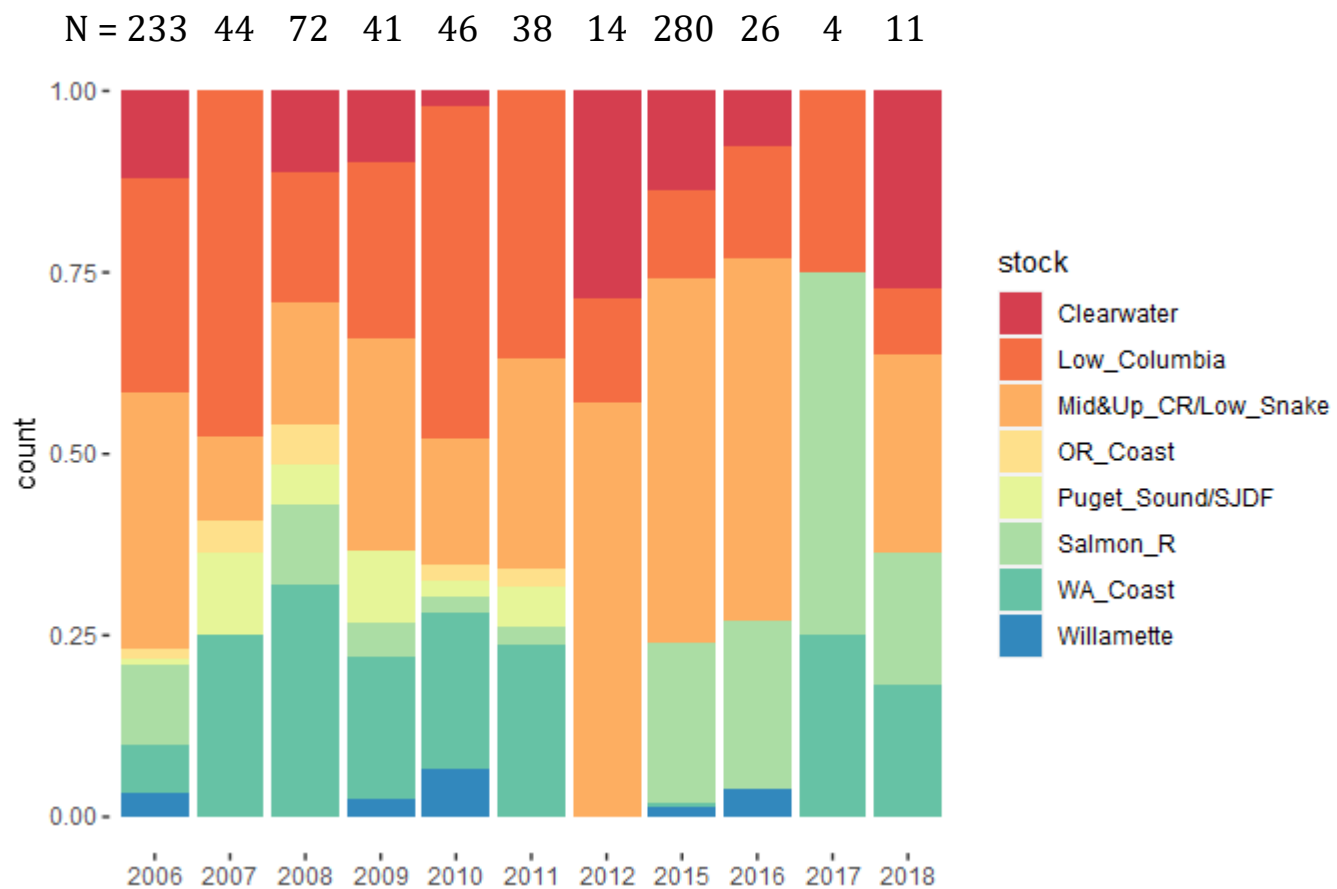
Subyearling  
Chinook

We catch very few  
Subyearling Chinook in May



Yearling  
Chinook

# Columbia River Steelhead

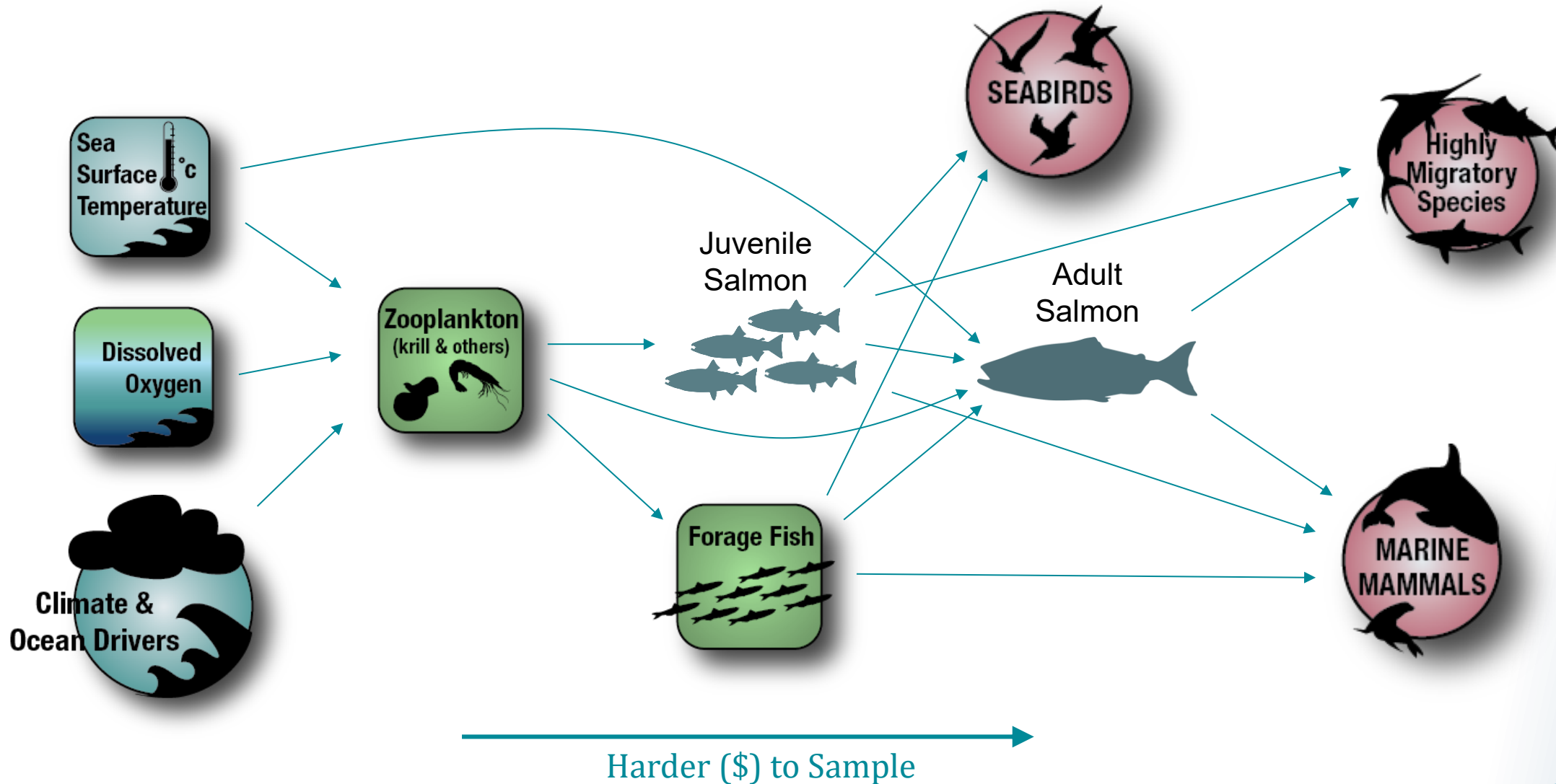


# Outline

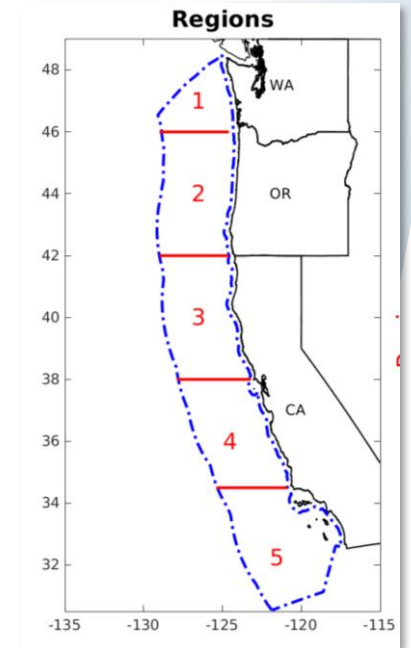
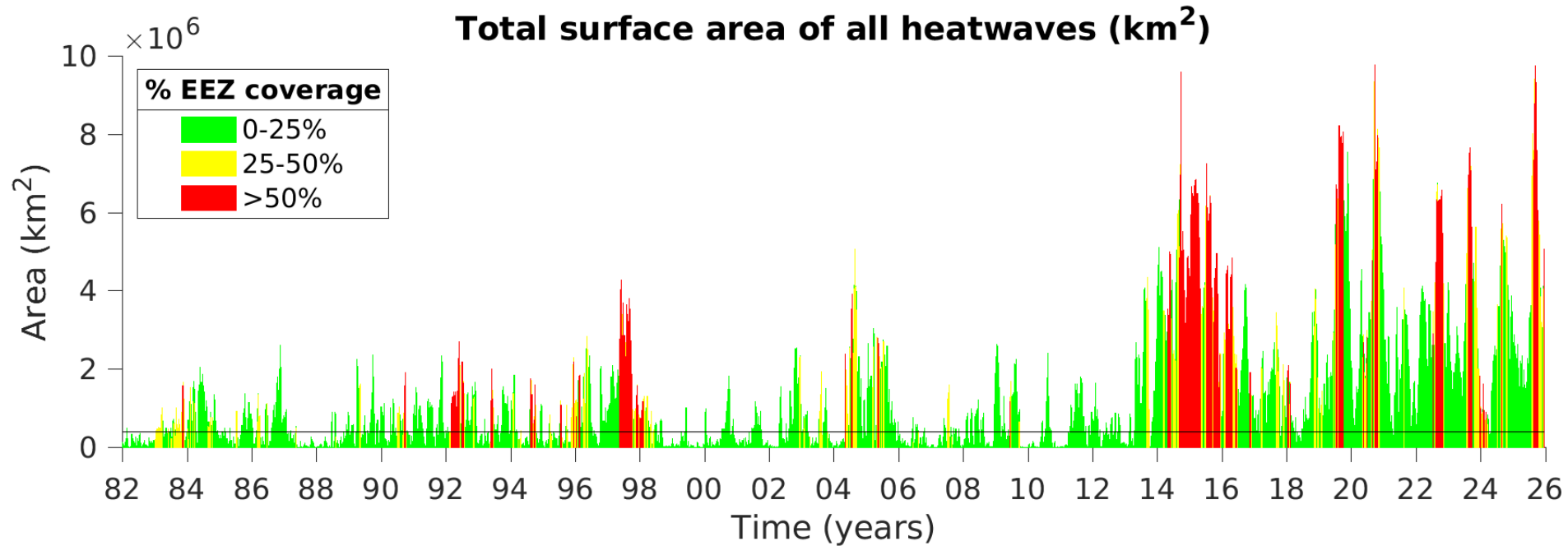
- Who we are and what we do
- **The Ocean Ecosystem**
- Why this matters to you



# Oversimplified Ocean Dynamics



# How should we think about Marine Heatwaves?

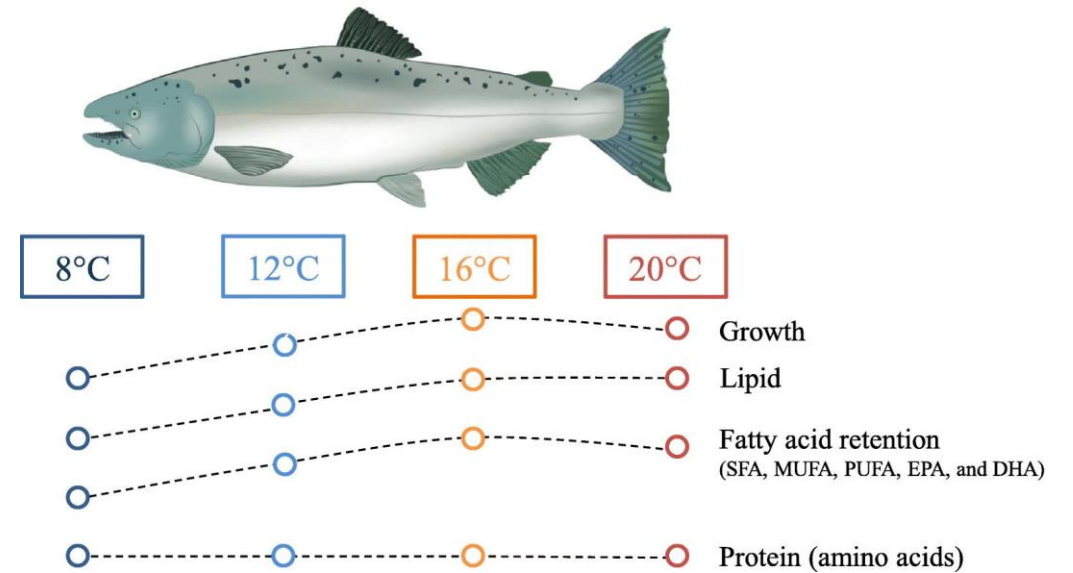
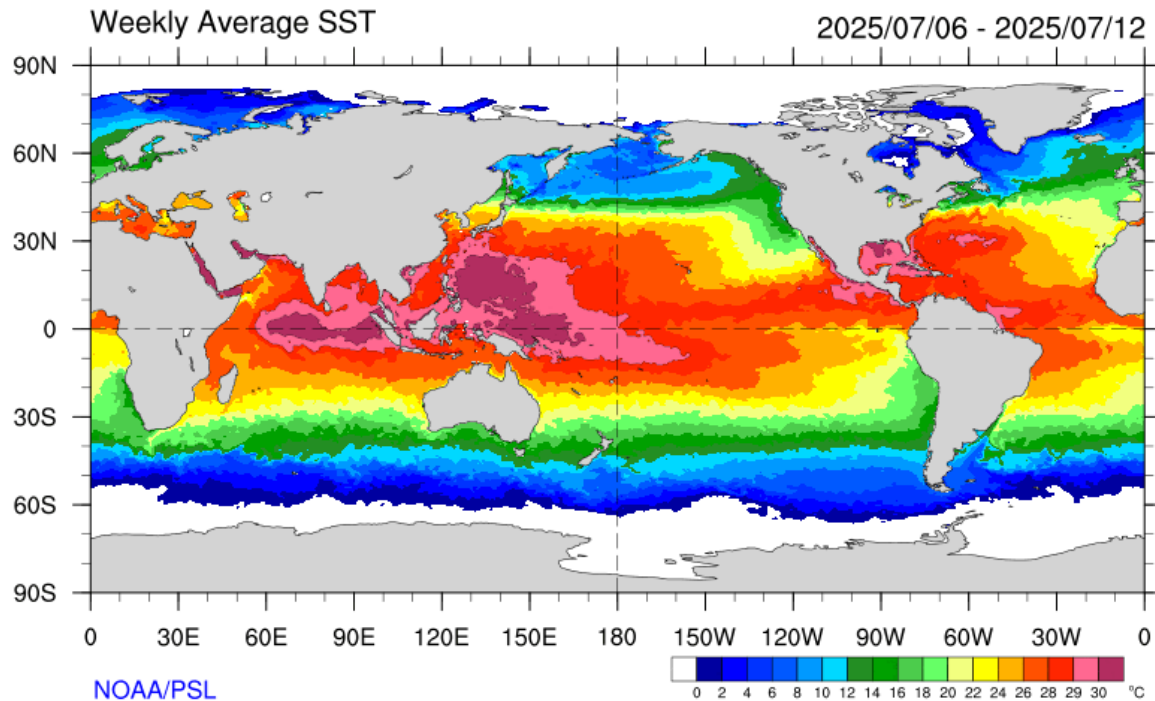


California Current Ecosystem Status Report NOAA  
<https://www.integratedecosystemassessment.noaa.gov/regions/california-current/california-current-marine-heatwave-tracker-blobtracker>



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# Direct impacts of temperature changes are probably minor



Bruno et al. 2023. <https://doi.org/10.1016/j.cbpa.2023.111412>

# Ocean Indicators: Correlations with broader Ecosystem Impacts

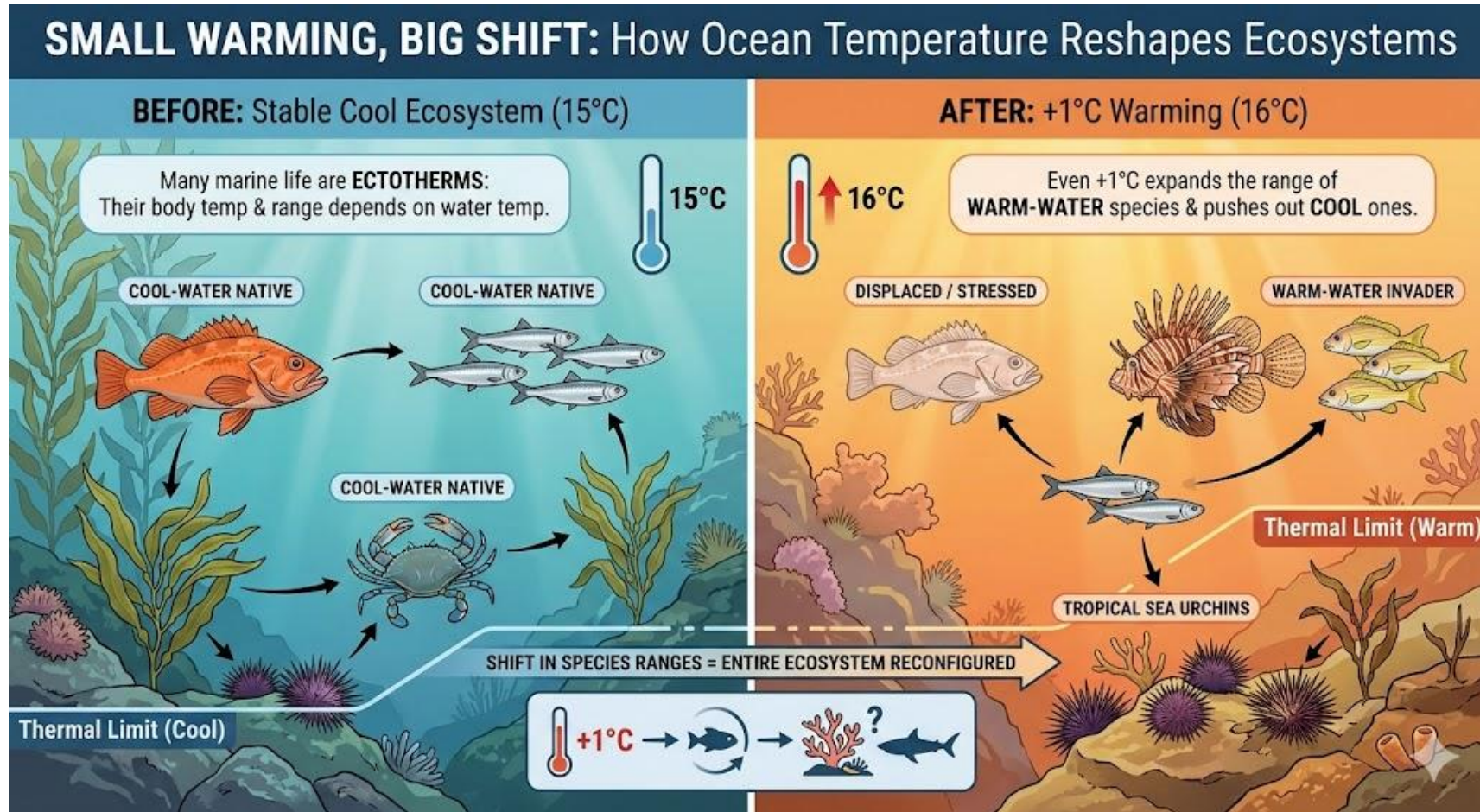
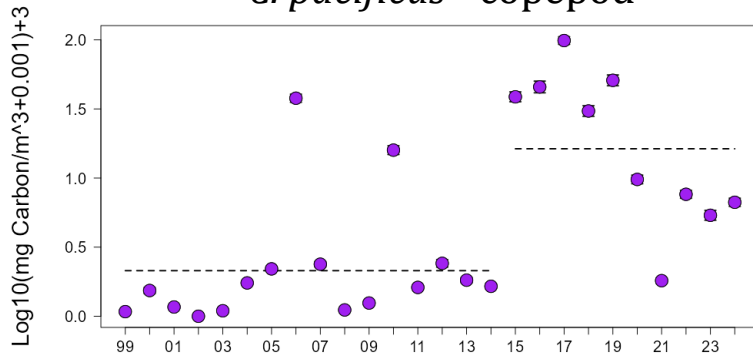


Image created by Gemini

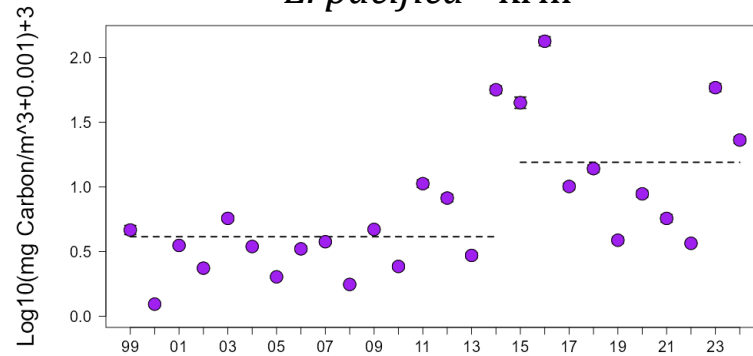
# Multiple Plankton Species Increased Since 2014

## (from copepods to larval fish)

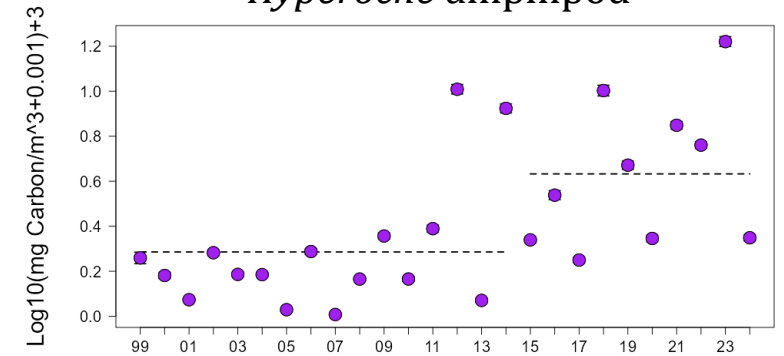
*C. pacificus* - copepod



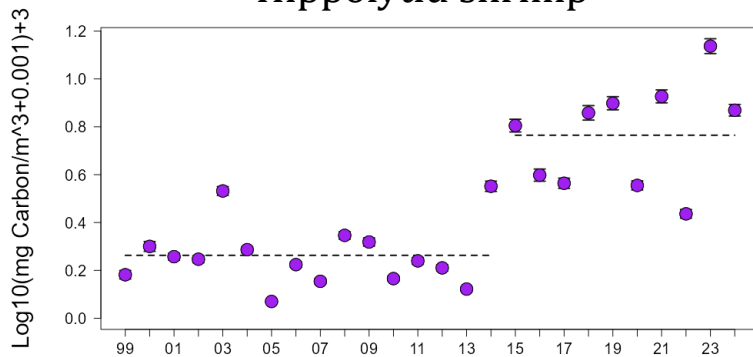
*E. pacifica* - krill



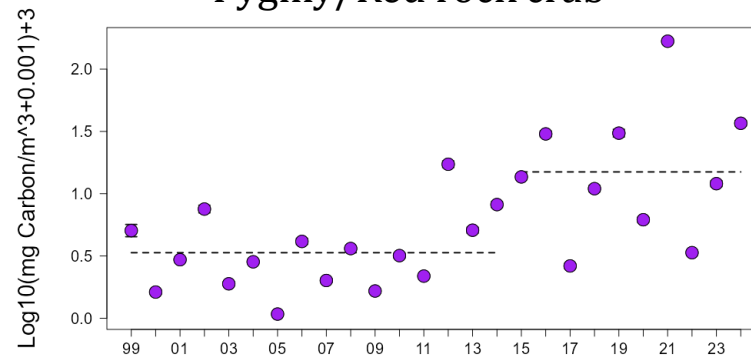
*Hyperoche* amphipod



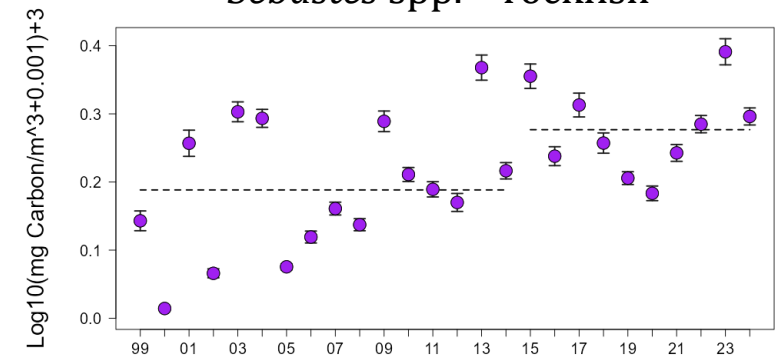
Hippolytid shrimp



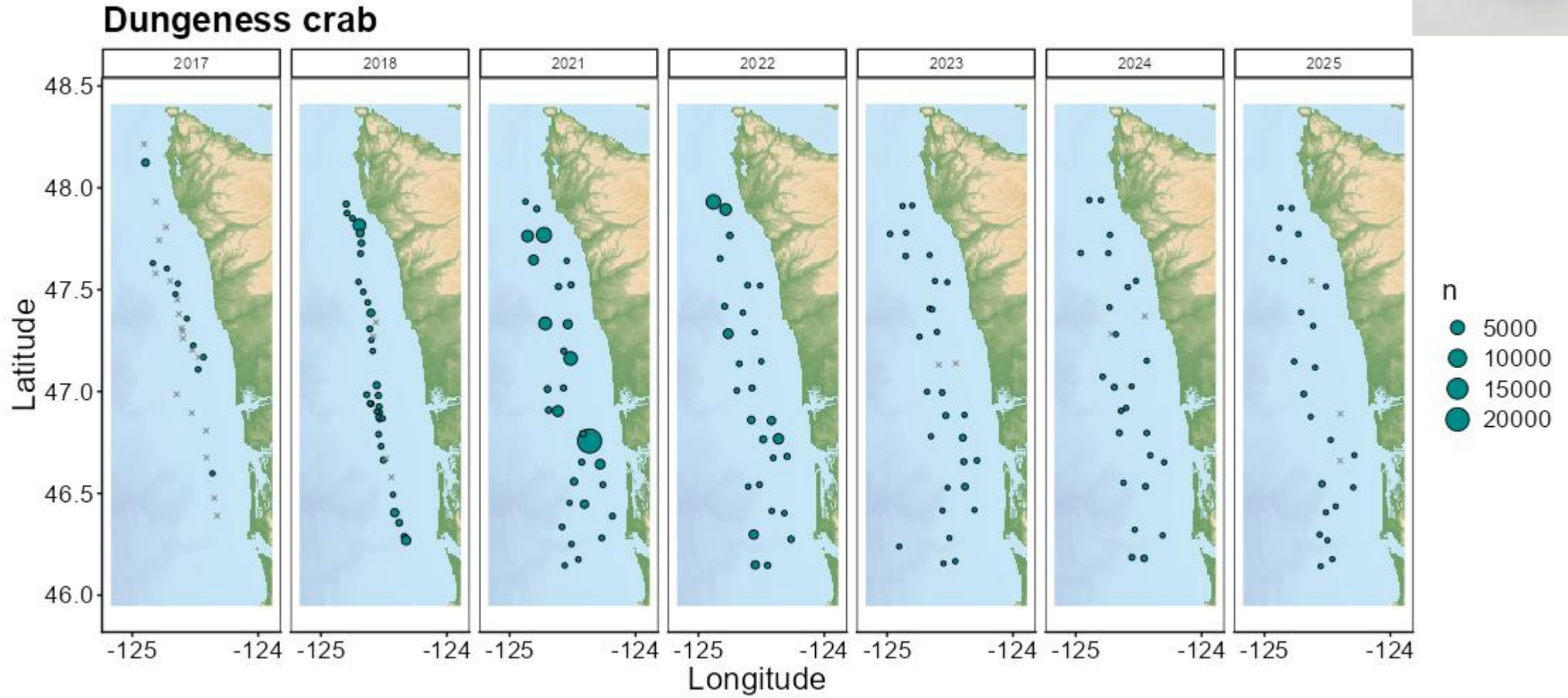
Pygmy/Red rock crab



*Sebastes* spp. - rockfish



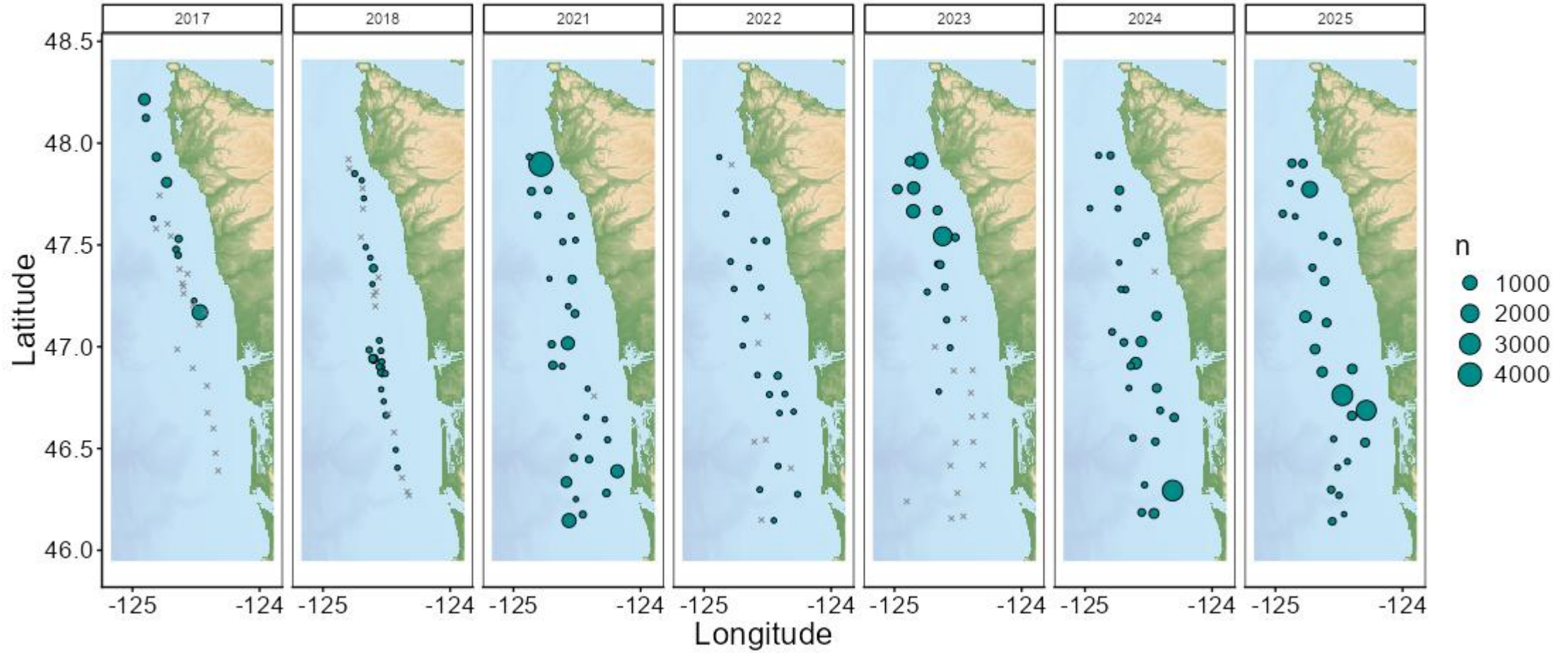
# May Prey – Dungeness Crab Megalopae



# May Prey – Juvenile Pacific sardine



## Pacific sardine



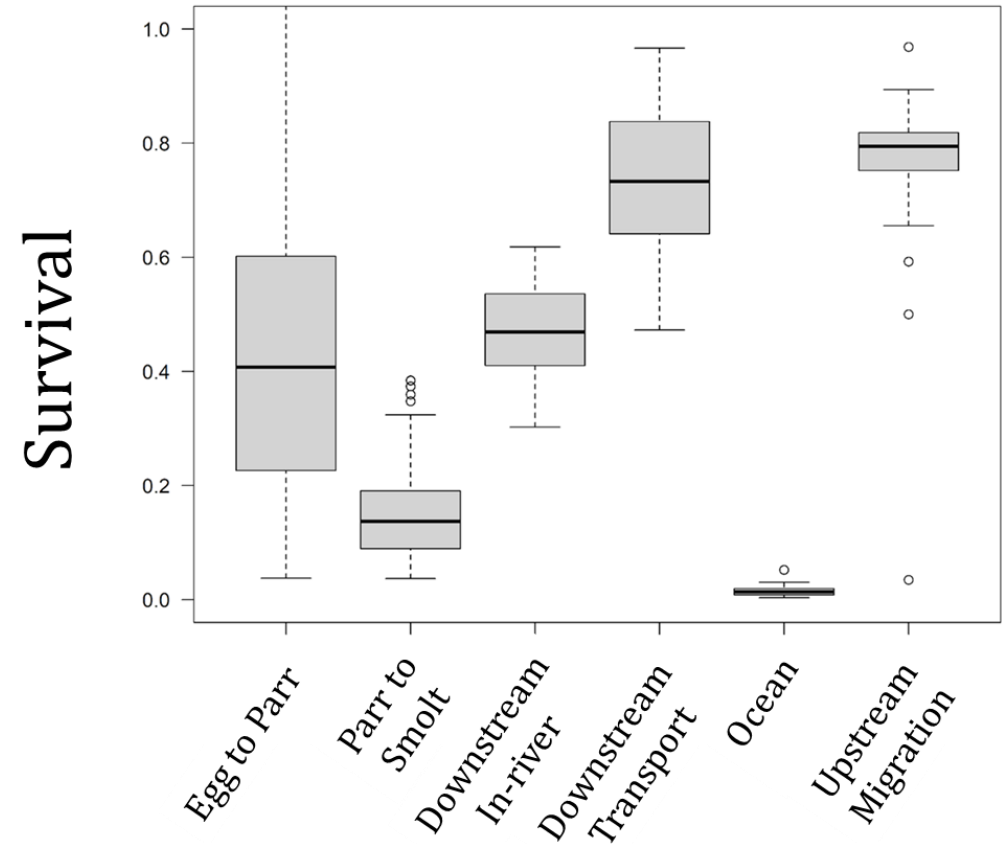
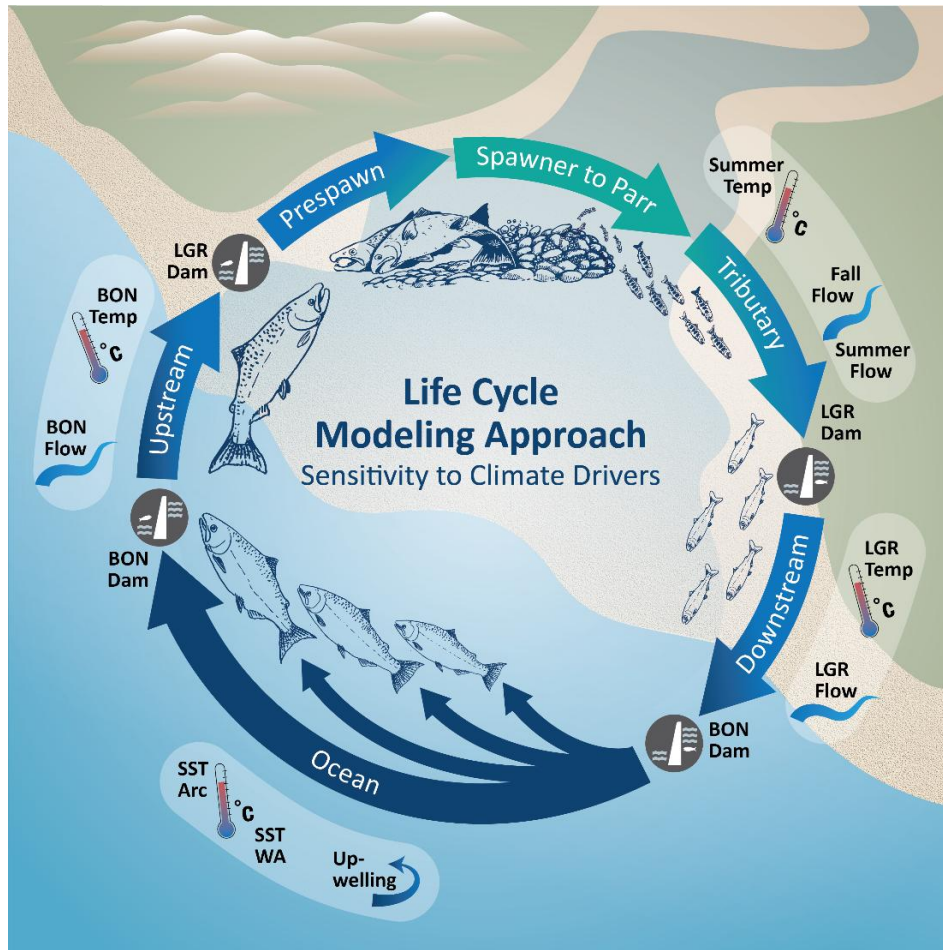
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# Life Cycle Models, Survival, and the Ocean



Crozier et al. 2021. Communications Biology  
<https://doi.org/10.1038/s42003-021-01734-w>

# NOAA's 'Stoplight Chart'

<https://www.fisheries.noaa.gov/west-coast/science-data/ocean-ecosystem-indicators-pacific-salmon-marine-survival-northern>

## Basin Scale

ECOSYSTEM INDICATORS		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
CLIMATE & ATMOSPHERIC	PDO (Sum Dec-March)	Red	Yellow	Green	Red	Yellow	Red	Yellow	Red	Yellow	Green	Green	Red	Green	Green	Yellow	Yellow	Red	Red	Red	Red	Yellow	Yellow	Green	Green	Green	Yellow	Green	Green
	PDO (Sum May-Sept)	Yellow	Green	Yellow	Yellow	Green	Green	Red	Red	Yellow	Green	Green	Green	Yellow	Green	Green	Red	Red	Red	Red	Red	Yellow	Yellow	Green	Green	Green	Yellow	Green	Green
	ONI (Average Jan-June)	Red	Green	Green	Green	Yellow	Red	Yellow	Red	Yellow	Green	Green	Yellow	Red	Green	Green	Yellow	Yellow	Red	Red	Red	Yellow	Red	Red	Green	Green	Yellow	Red	Yellow

## Local Physical Conditions

LOCAL PHYSICAL	SST NDBC buoys (°C; May-Sept)	Red	Green	Yellow	Green	Green	Yellow	Red	Yellow	Green	Green	Yellow	Green	Green	Yellow	Green	Red	Red	Red	Red	Red	Yellow	Yellow	Green	Red	Yellow	Green	Green	
	Upper 20 m T (°C; Nov-Mar)	Red	Red	Yellow	Green	Yellow	Yellow	Red	Red	Yellow	Green	Green	Green	Yellow	Green	Green	Red	Red	Red	Red	Red	Yellow	Yellow	Green	Green	Yellow	Red	Yellow	Green
	Upper 20 m T (°C; May-Sept)	Red	Yellow	Yellow	Green	Green	Green	Red	Red	Yellow	Green	Green	Green	Yellow	Green	Green	Red	Red	Red	Red	Red	Yellow	Yellow	Green	Green	Red	Yellow	Green	Green
	Deep Temp (°C; May-Sept)	Red	Green	Green	Green	Yellow	Yellow	Red	Red	Yellow	Green	Green	Green	Yellow	Green	Green	Yellow	Yellow	Red	Red	Red	Red	Yellow	Yellow	Green	Red	Yellow	Green	Green
	Deep Salinity (May-Sept)	Red	Green	Yellow	Green	Green	Red	Red	Yellow	Green	Green	Green	Yellow	Green	Green	Yellow	Yellow	Red	Red	Red	Red	Yellow	Yellow	Green	Green	Red	Yellow	Green	Green

## Local Biological Conditions

LOCAL BIOLOGICAL	Copepod richness (May-Sept anom)	Red	Green	Green	Yellow	Yellow	Red	Red	Red	Red	Yellow	Yellow	Yellow	Red	Green	Green	Green	Yellow	Red	Red	Red	Yellow	Yellow	Green	Green	Green	Yellow	Green	Green
	N copepod biomass (May-Sept anom)	Red	Red	Yellow	Yellow	Green	Yellow	Yellow	Red	Red	Yellow	Yellow	Yellow	Yellow	Green	Green	Green	Yellow	Red	Red	Red	Red	Yellow	Yellow	Green	Green	Yellow	Green	Green
	S copepod biomass (May-Sept anom)	Red	Green	Green	Green	Green	Red	Red	Red	Red	Yellow	Yellow	Yellow	Yellow	Green	Green	Green	Yellow	Red	Red	Red	Red	Yellow	Yellow	Green	Green	Yellow	Green	Green
	Biological transition	Red	Yellow	Yellow	Green	Green	Yellow	Yellow	Yellow	Yellow	Green	Green	Green	Yellow	Green	Green	Yellow	Yellow	Red	Red	Red	Red	Yellow	Yellow	Green	Green	Yellow	Green	Green
	Coastal Ichthyoplankton Prey Biomass (Jan-Mar)	Red	Green	Yellow	Yellow	Green	Red	Red	Red	Red	Yellow	Yellow	Yellow	Yellow	Green	Green	Green	Yellow	Red	Red	Red	Red	Yellow	Yellow	Green	Green	Yellow	Green	Green
	Ichthyoplankton Community Composition (Jan-Mar)	Yellow	Green	Green	Green	Green	Red	Red	Red	Red	Yellow	Yellow	Yellow	Yellow	Green	Green	Green	Yellow	Red	Red	Red	Red	Yellow	Yellow	Green	Green	Yellow	Green	Green
	Chinook salmon juvenile catch	Red	Green	Green	Red	Green	Yellow	Red	Red	Red	Yellow	Yellow	Yellow	Yellow	Green	Green	Green	Yellow	Red	Red	Red	Red	Yellow	Yellow	Green	Green	Yellow	Green	Green
	Coho salmon juvenile catch	Red	Yellow	Red	Green	Yellow	Green	Red	Red	Red	Yellow	Yellow	Yellow	Yellow	Red	Yellow	Yellow	Yellow	Red	Red	Red	Red	Yellow	Yellow	Green	Green	Yellow	Green	Green

## Summary

MEANS & RANKS	Mean of ranks	24.1	8.8	10.1	10.2	8.4	17.7	21.4	22.4	14.3	12.6	4.1	11.3	16.3	9.6	7.8	10.6	16.7	23.3	23.0	21.6	15.9	19.9	15.4	7.4	12.6	12.4	16.2	11.4
	Rank of the mean rank	Red	Green	Green	Green	Green	Red	Red	Red	Yellow	Green	Green	Yellow	Yellow	Green	Green	Yellow	Yellow	Red	Red	Red	Yellow	Yellow	Green	Green	Yellow	Green	Yellow	Green

## Additional Indicators

NOT INCLUDED IN THE MEAN OF RANKS OR STATISTICAL ANALYSES	Physical Spring Trans (UI based)	Green	Green	Red	Red	Green	Yellow	Yellow	Red	Yellow	Green	Green	Green	Yellow	Yellow	Red	Yellow	Red	Red	Red	Yellow	Yellow	Yellow	Yellow	Green	Red	Yellow	Green	Green	
	Physical Spring Trans - Hydrographic	Red	Green	Yellow	Green	Green	Yellow	Yellow	Red	Red	Yellow	Yellow	Yellow	Yellow	Green	Green	Green	Yellow	Red	Red	Red	Red	Yellow	Yellow	Green	Green	Yellow	Green	Green	
	Upwelling Anomaly (sum April-May)	Yellow	Green	Red	Green	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Red	Red	Red	Red	Red	Red	Red	Yellow	Yellow	Yellow	Yellow	Green	Red	Yellow	Green	Green
	Length of Upwelling Season (UI based)	Green	Green	Green	Green	Green	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
	Copepod Community Index (May-Sept)	Red	Green	Green	Green	Green	Red	Red	Red	Red	Yellow	Yellow	Yellow	Yellow	Green	Green	Green	Yellow	Yellow	Red	Red	Red	Red	Yellow	Yellow	Green	Green	Yellow	Green	Green

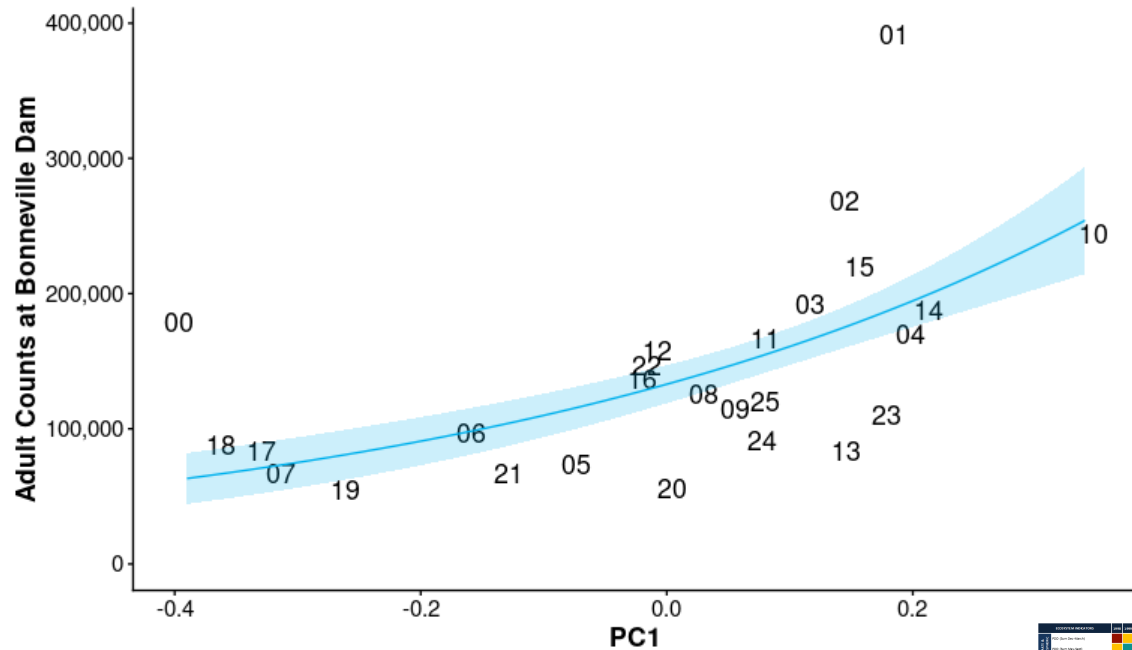


# Ocean conditions are correlated with salmon returns

## Spring Chinook

Output from a Generalized Linear Model

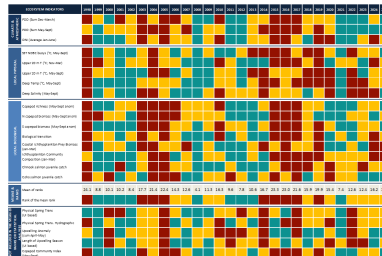
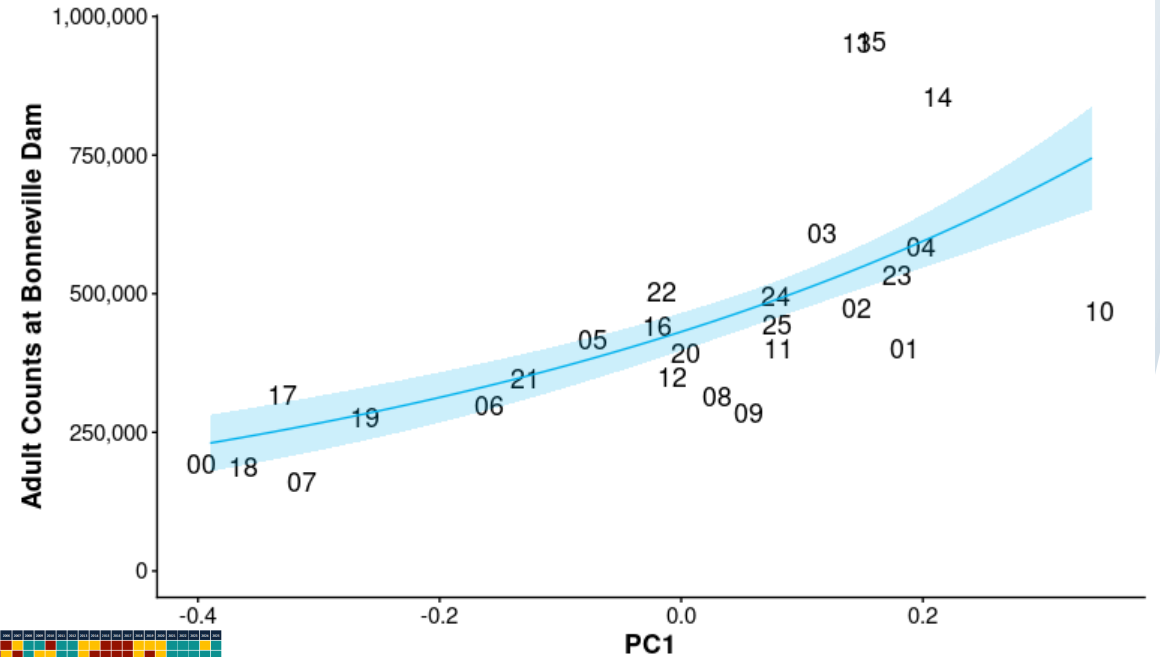
$$R^2 = 0.34$$



## Fall Chinook

Output from a Generalized Linear Model

$$R^2 = 0.44$$



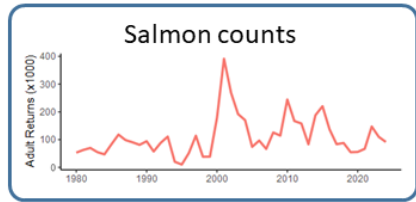
Count data obtained from:  
[https://www.cbr.washington.edu/dart/query/adult\\_annual\\_sum](https://www.cbr.washington.edu/dart/query/adult_annual_sum)



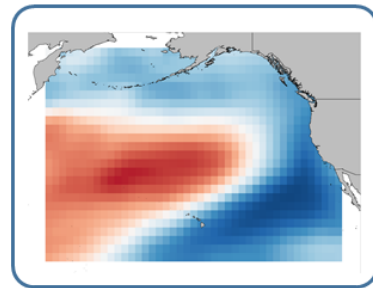
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# Stock-specific Index based on Sea Surface Temperature

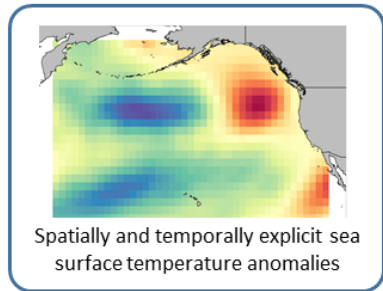
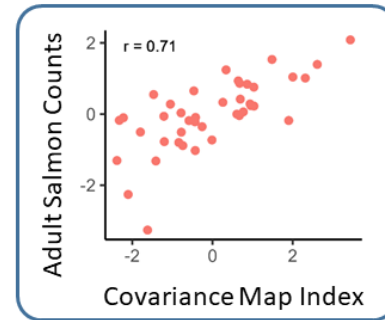
Improving salmon marine survival models with covariance map indices (CMI) of sea surface temperature and height



The Covariance Map shows the spatial patterns of how salmon counts co-vary with sea surface temperature

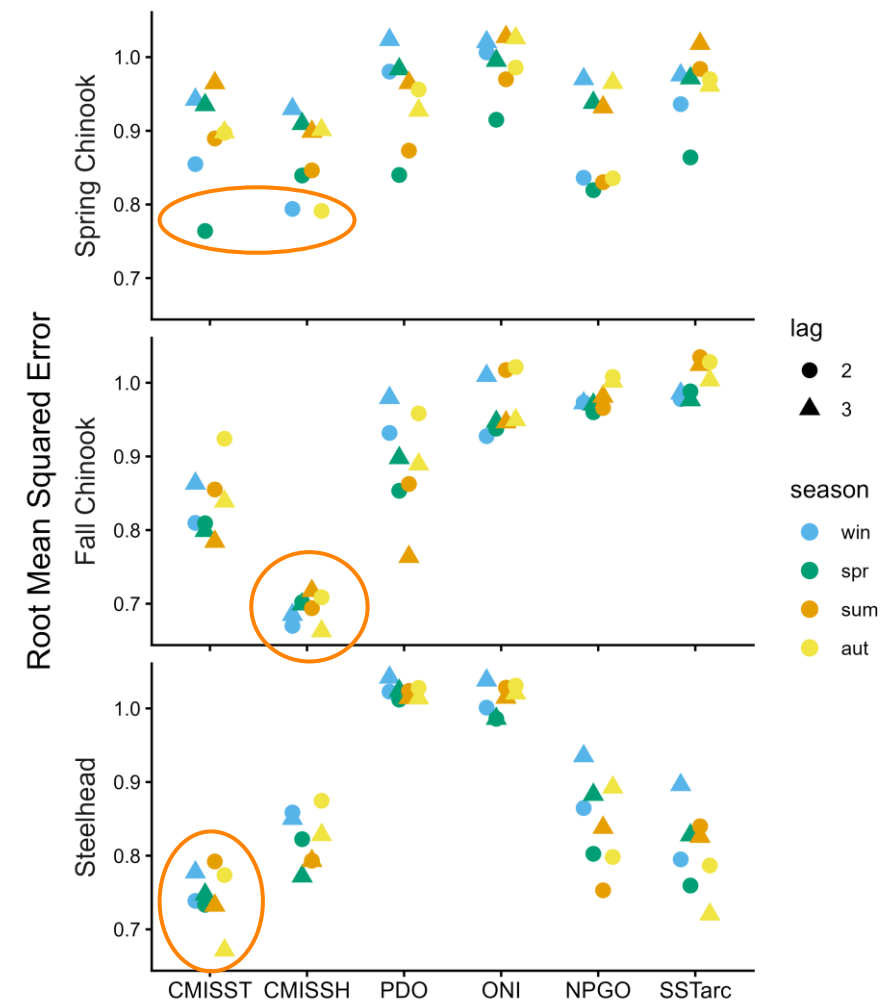


Annual sea surface temperature values regressed onto the covariance map; regression coefficients become the CMI values



Burke et al. 2025

**Conclusion:** We can use publicly-available data to generate stock-specific indices that can enhance predictive accuracy for salmon returns compared to traditional broad-scale indicators, offering practical benefits for fisheries management.



Publication: <https://doi.org/10.1016/j.ecoinf.2025.103575>

Shiny App: <https://connect.fisheries.noaa.gov/CMISST/>

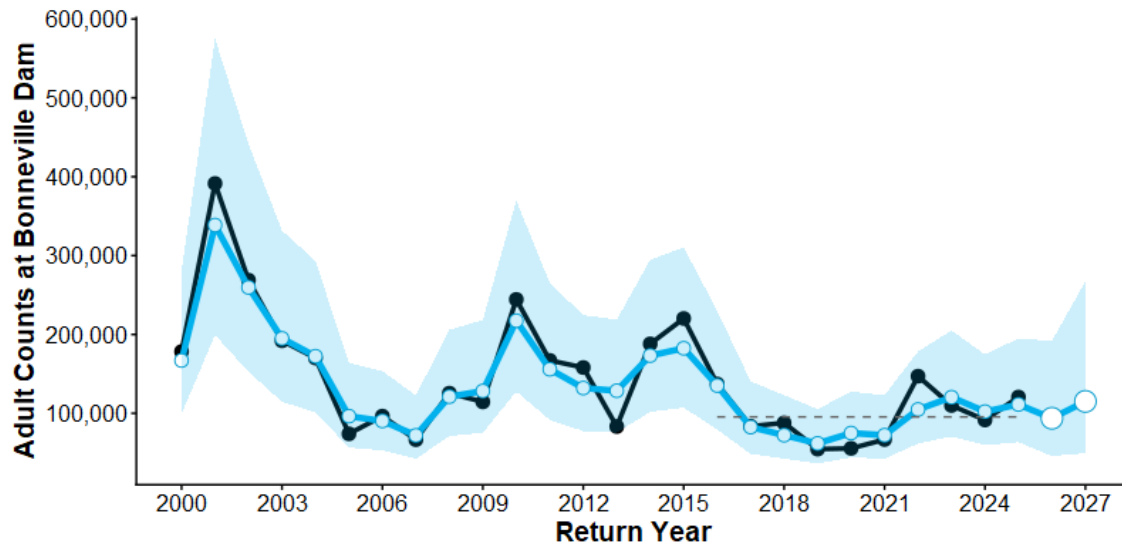
# Spring Chinook at Bonneville Dam

## Stoplight - based

Output from a Dynamic Linear Model

Forecast for 2026 = 94K

Forecast for 2027 = 115K

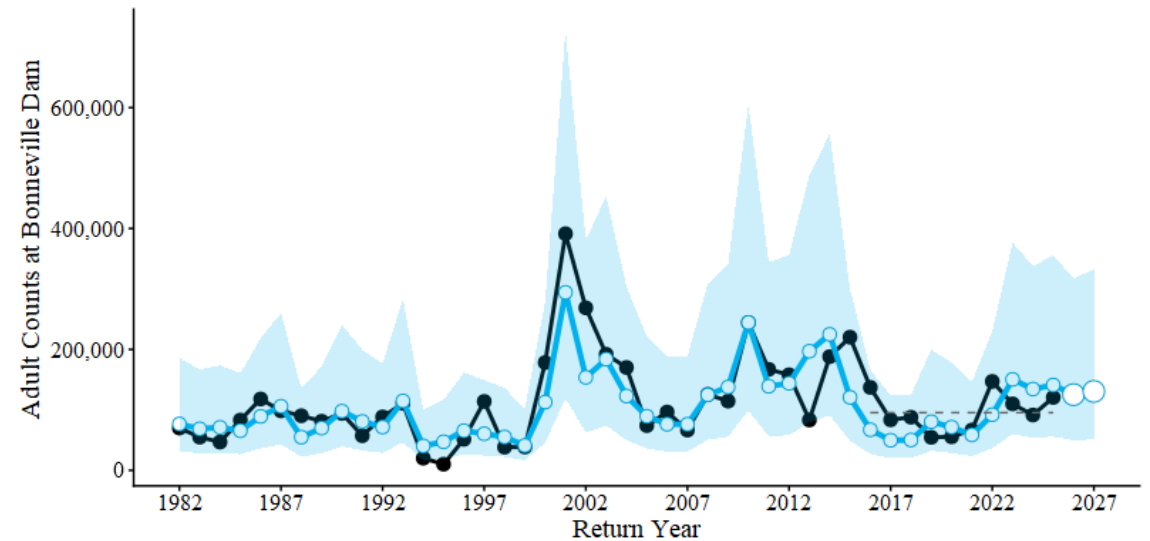


## CMISST

Output from a Dynamic Linear Model

Forecast for 2026 = 125K

Forecast for 2027 = 131K



Count data obtained from: [https://www.cbr.washington.edu/dart/query/adult\\_annual\\_sum](https://www.cbr.washington.edu/dart/query/adult_annual_sum)

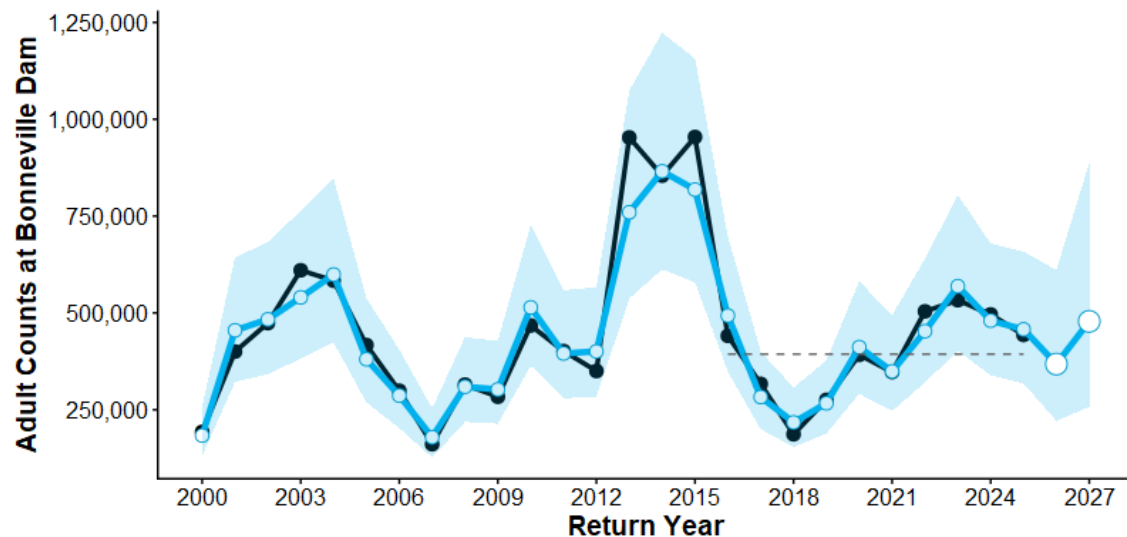
# Fall Chinook at Bonneville Dam

## Stoplight - based

Output from a Dynamic Linear Model

Forecast for 2026 = 368K

Forecast for 2027 = 478K



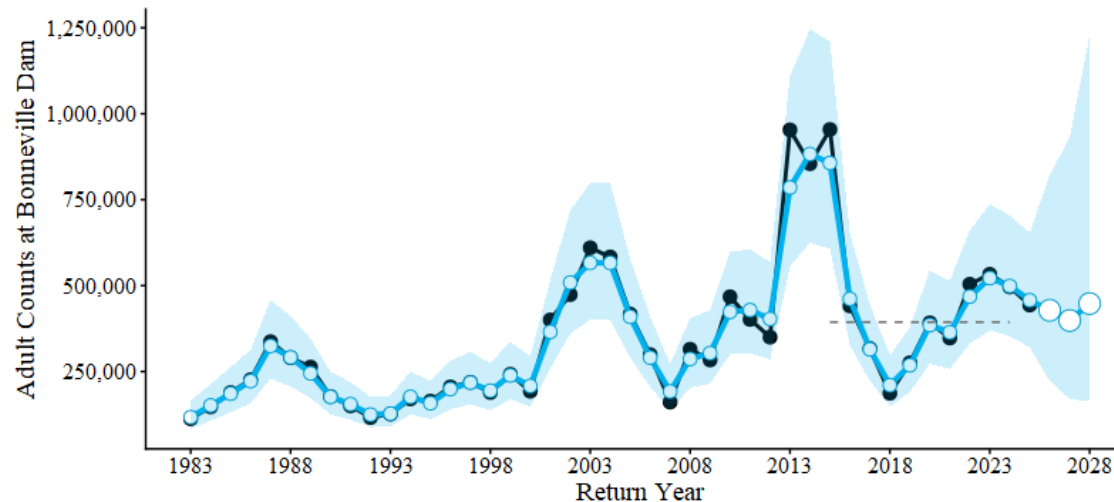
## CMISST

Output from a Dynamic Linear Model

Forecast for 2026 = 428K

Forecast for 2027 = 398K

Forecast for 2028 = 448K



Count data obtained from: [https://www.cbr.washington.edu/dart/query/adult\\_annual\\_sum](https://www.cbr.washington.edu/dart/query/adult_annual_sum)



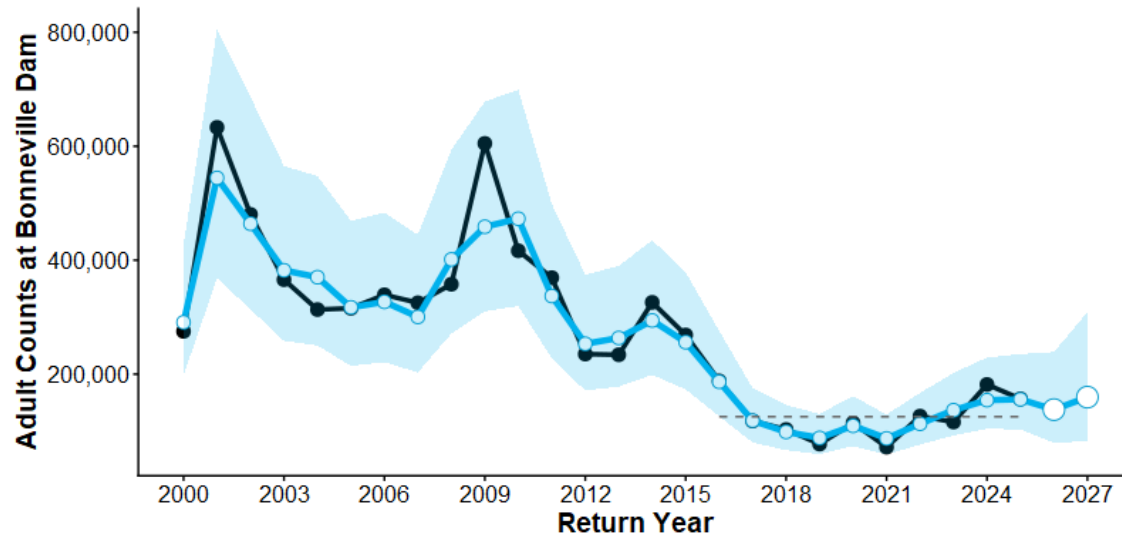
# Steelhead at Bonneville Dam

## Stoplight - based

Output from a Dynamic Linear Model

Forecast for 2026 = 138K

Forecast for 2027 = 160K



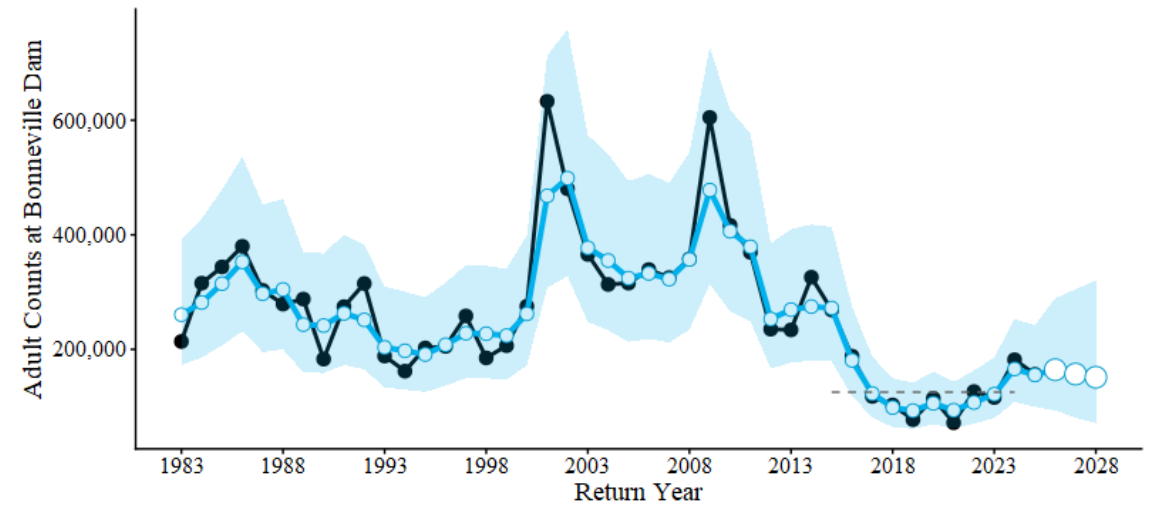
## CMISST

Output from a Dynamic Linear Model

Forecast for 2026 = 164K

Forecast for 2027 = 157K

Forecast for 2028 = 151K

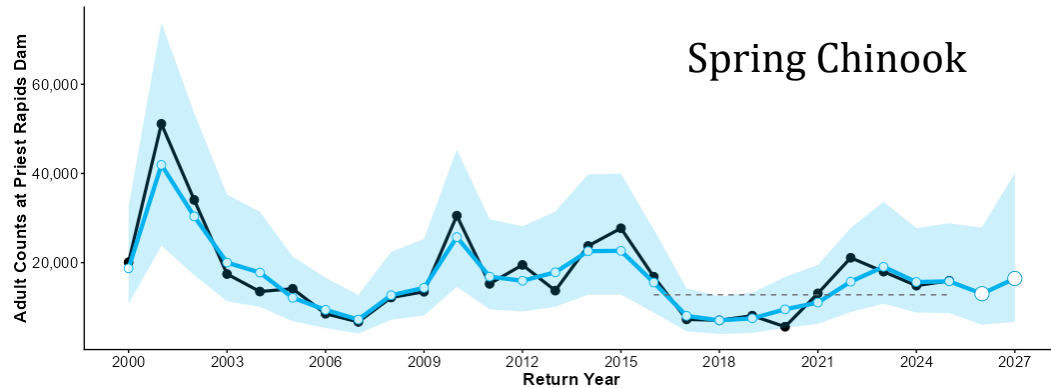


Count data obtained from: [https://www.cbr.washington.edu/dart/query/adult\\_annual\\_sum](https://www.cbr.washington.edu/dart/query/adult_annual_sum)



# Expectations for Priest Rapids Dam Counts

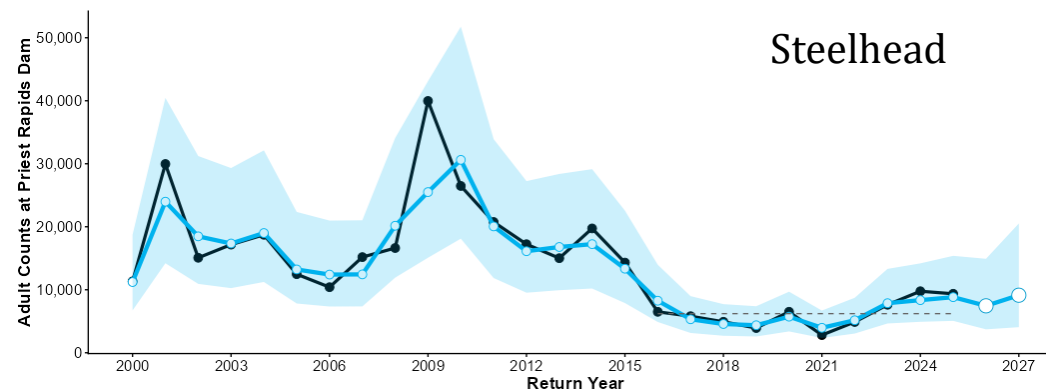
Output from a Dynamic Linear Model  
 Forecast for 2026 = 13K  
 Forecast for 2027 = 16K



Output from a Dynamic Linear Model  
 Forecast for 2026 = 21K  
 Forecast for 2027 = 23K

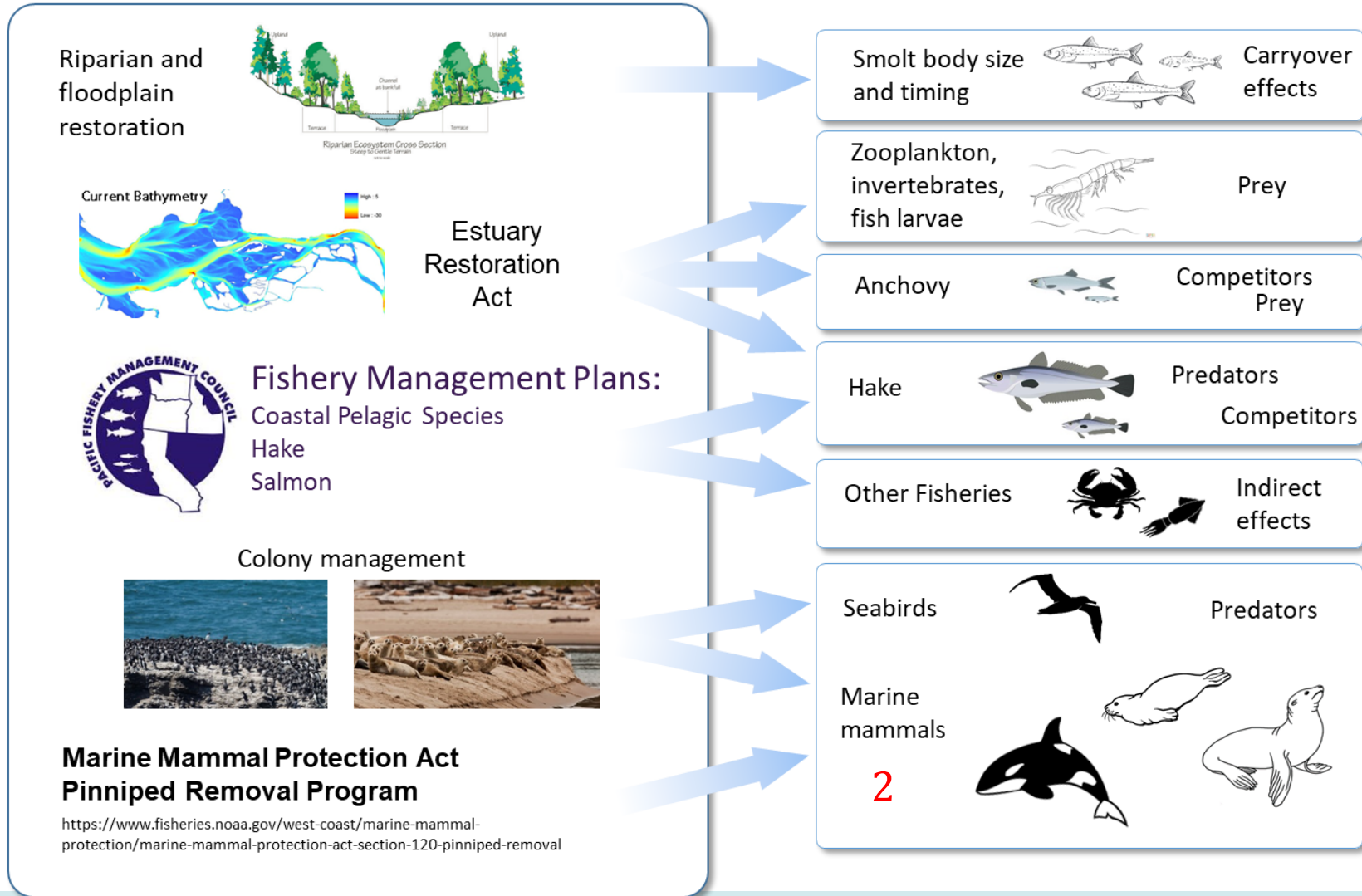


Output from a Dynamic Linear Model  
 Forecast for 2026 = 7K  
 Forecast for 2027 = 9K



Count data obtained from: [https://www.cbr.washington.edu/dart/query/adult\\_annual\\_sum](https://www.cbr.washington.edu/dart/query/adult_annual_sum)

# We Have Management Options for Ocean Survival



# 1. Where does Size Variability come from?

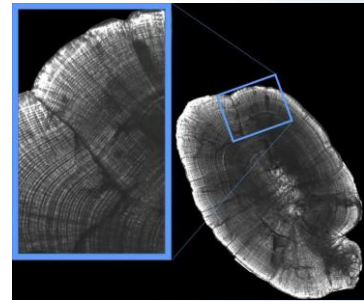
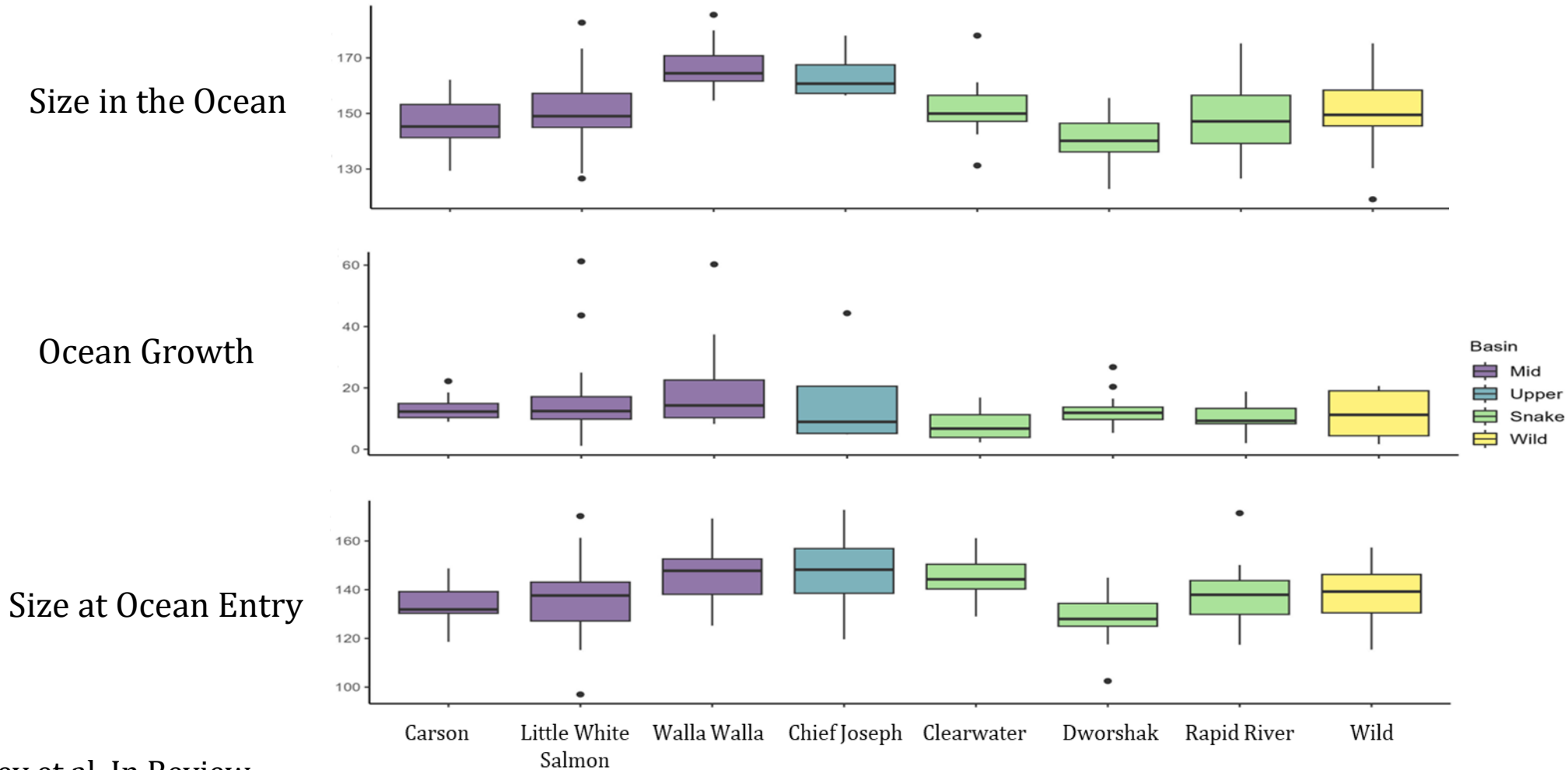


Photo by Elianna Rosenthal

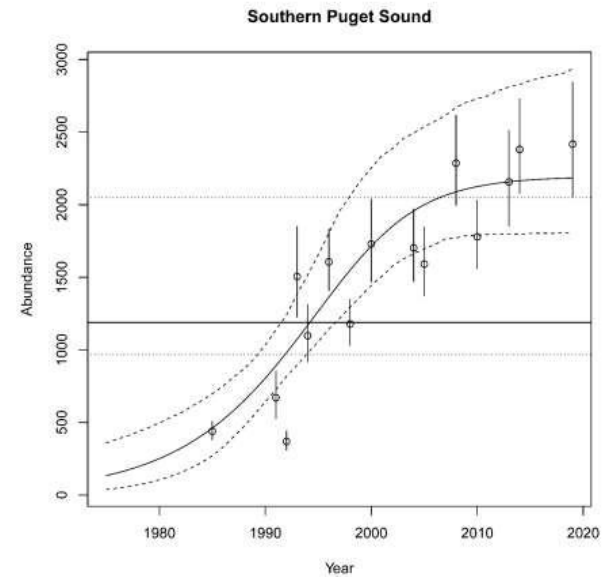
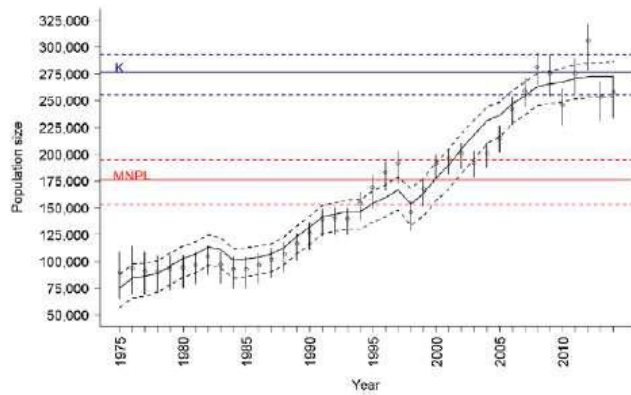
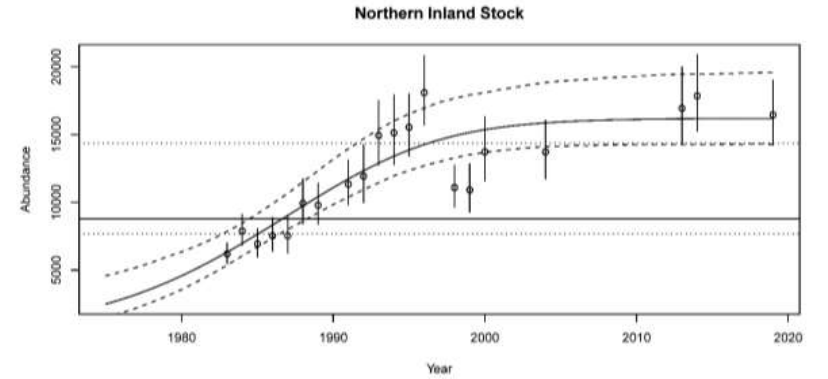
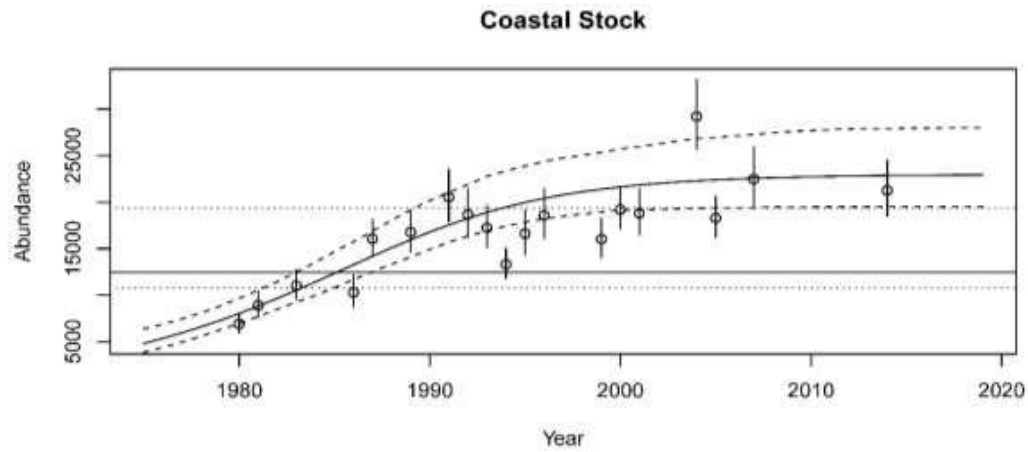


Forney et al. In Review



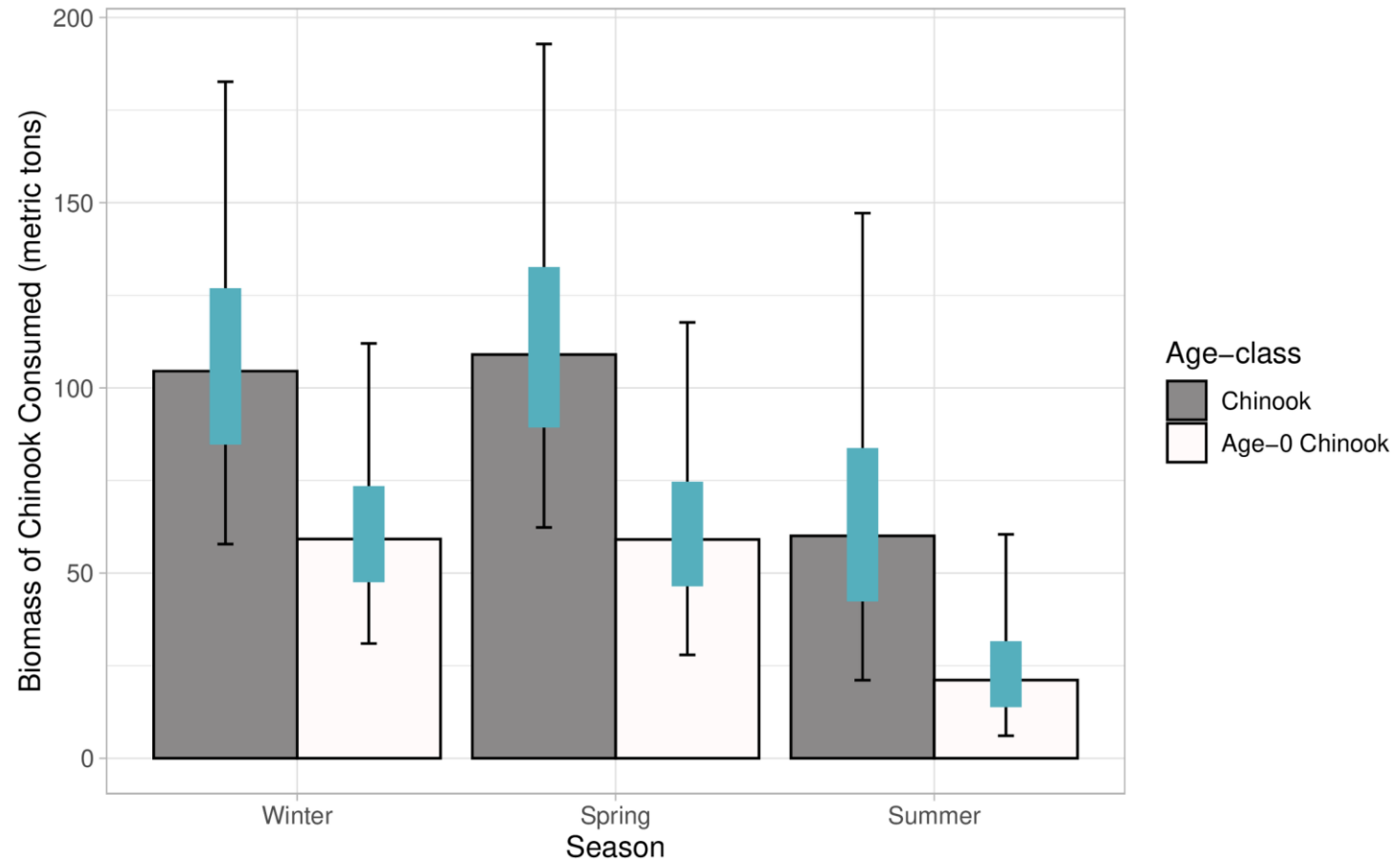
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# 2. Washington pinnipeds are more abundant than they ever were



<https://wdfw.wa.gov/sites/default/files/publications/02579/wdfw02579.pdf>

# Stellar Sea Lions eat more juveniles than we thought



Lewis et al. 2025. <https://doi.org/10.1371/journal.pone.0334612>



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# Take Home Messages

1. The ocean is not homogenous – where and when salmon migrate will determine their ocean experience, growth, and survival
2. 2022 through 2025 were about average – adult returns this year and next year should be too (generally speaking)
3. We *can* influence marine survival; even freshwater management can affect marine survival

# Thanks for your interest



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