

# Salmon Ocean Ecology: Distribution, Growth, and Survival Trends

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*Washington Coastal Marine Advisory Council  
September 20<sup>th</sup>, 2018*

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Brian Burke  
NOAA Fisheries, NWFSC

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Supported by:

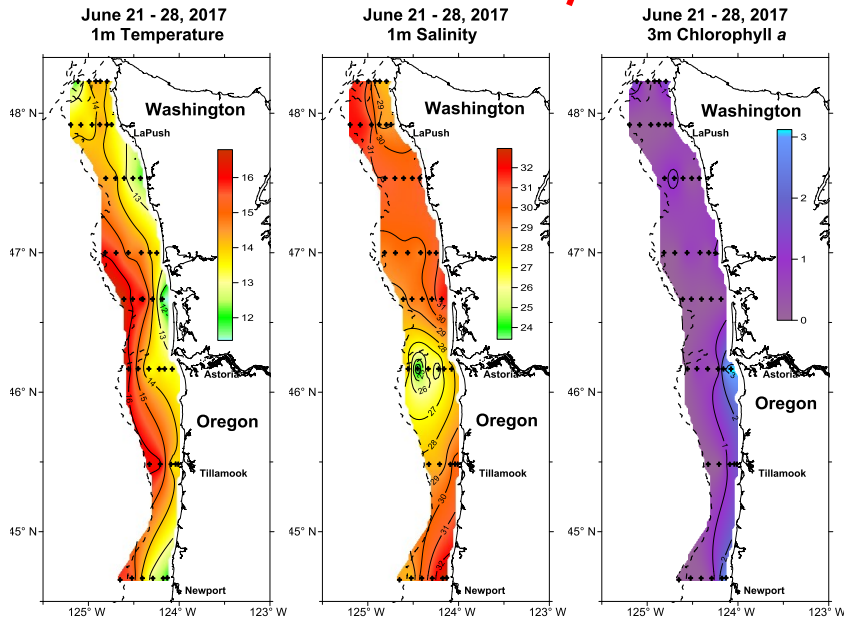




# Outline

- Summary of research projects
- Recent ocean conditions
- Salmon distribution and trophic interactions
- Addressing survival (3 examples)

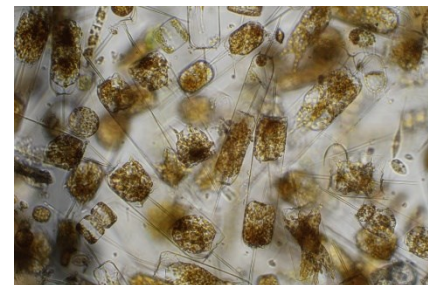
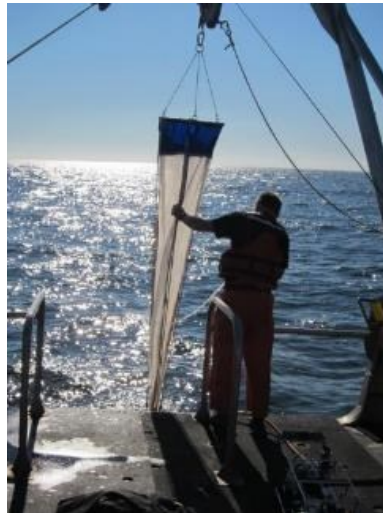
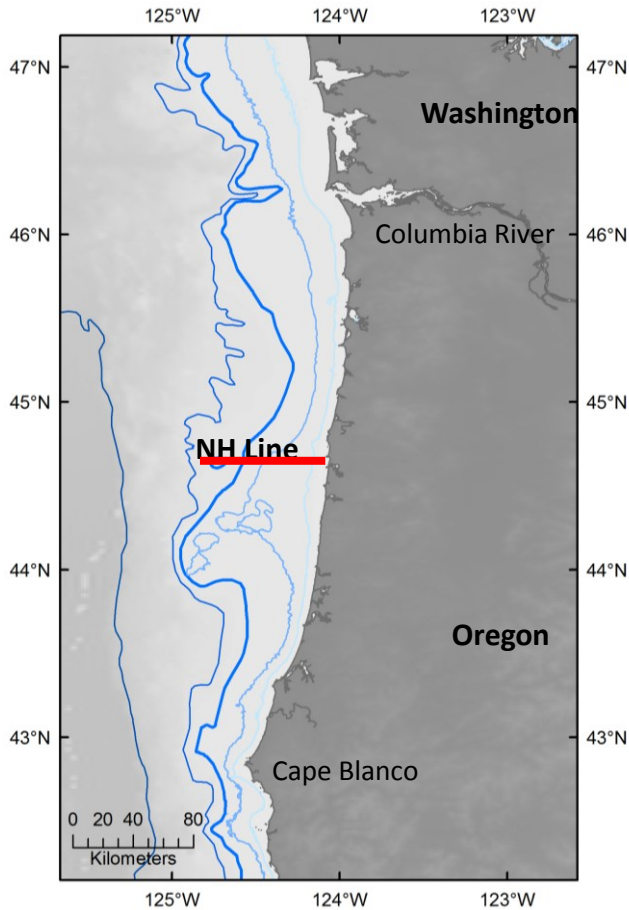
# Understanding complex ecosystems requires Research and Monitoring





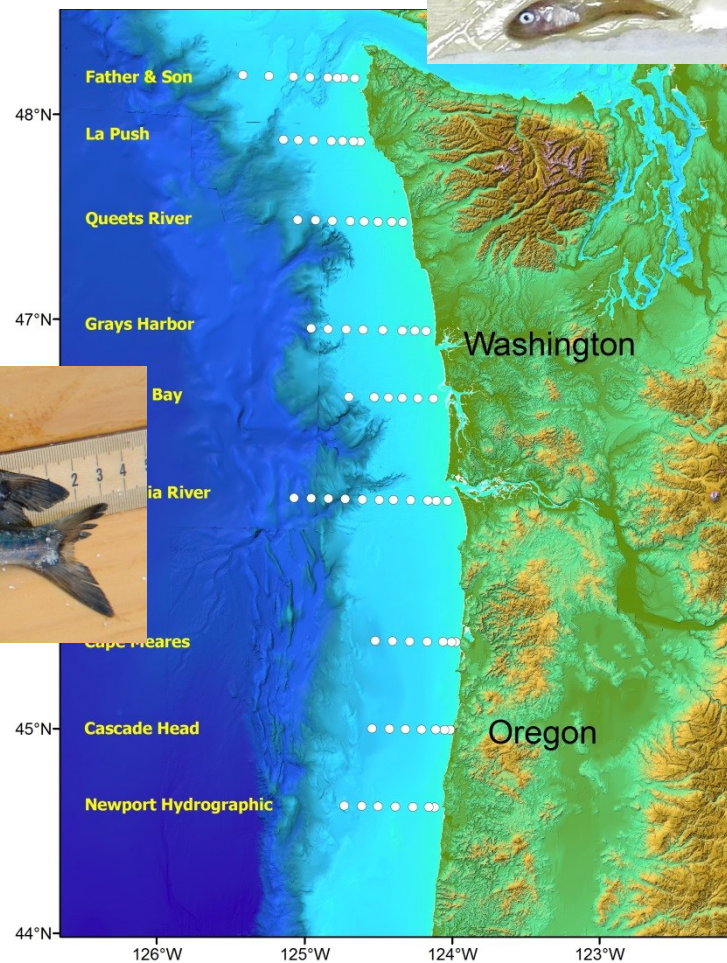
# Newport Hydrographic Line

- Sampled biweekly for 20+ years (1996 – present)
  - 7 stations
  - 1 – 25 nm, seasonally out to 200 nm
- CTD, nutrients, chl-*a*, phytoplankton and HABs, zooplankton, ichthyoplankton





# Juvenile Salmon and Ocean Ecosystem Survey (JSOES)

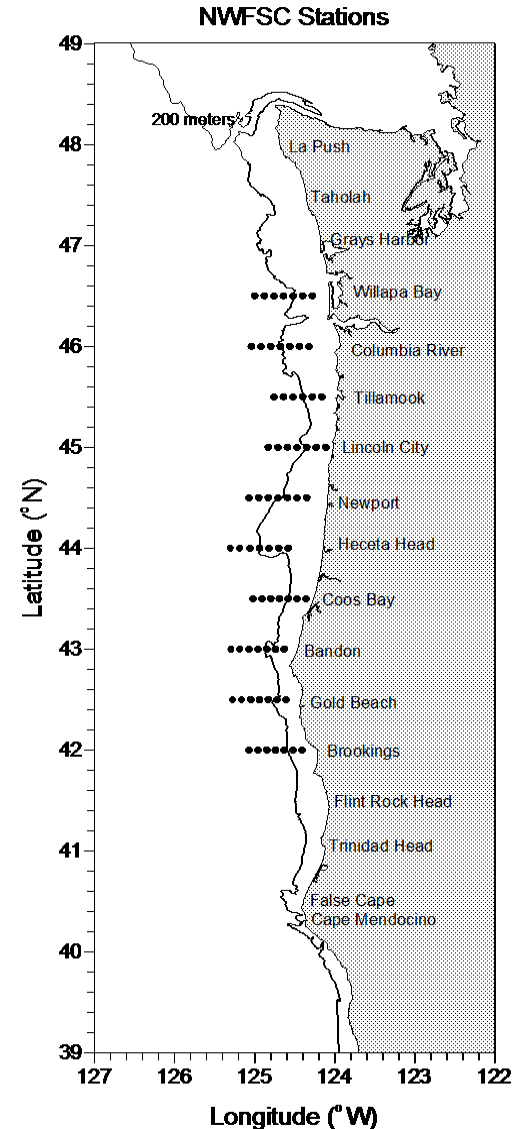




# Pre-recruit survey and ecosystem assessment project

**Objective:** Examine abundance and distribution patterns of age-0 fish including rockfish, hake, and flatfishes in relation to ocean conditions

**Sampling:** May-June (2011, 2013-2018); night trawls at 30 m depth, plankton, CTD, acoustic, seabird and mammal surveys





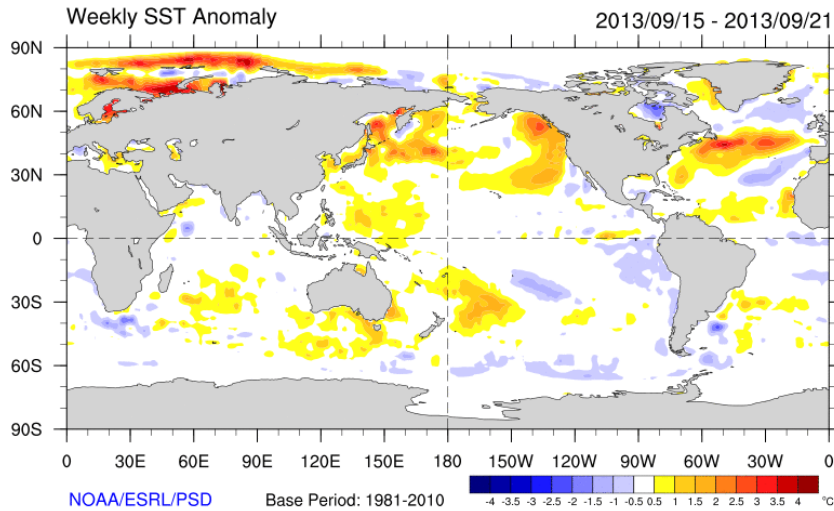
The image shows three rectangular trays filled with salmon fillets. The trays are colored blue, yellow, and green from left to right. The salmon is cut into uniform pieces and is piled in the trays. The background is slightly blurred, showing what appears to be a kitchen or food preparation area.

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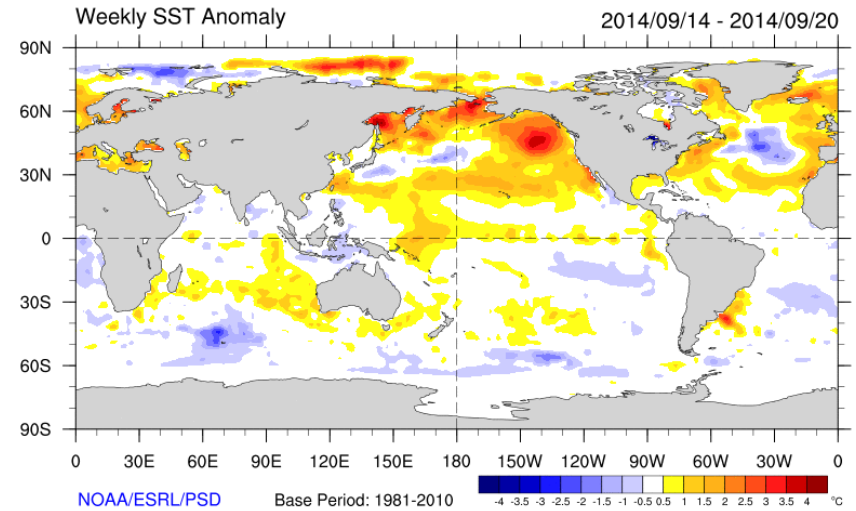
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# Pacific Basin-Scale Dynamics

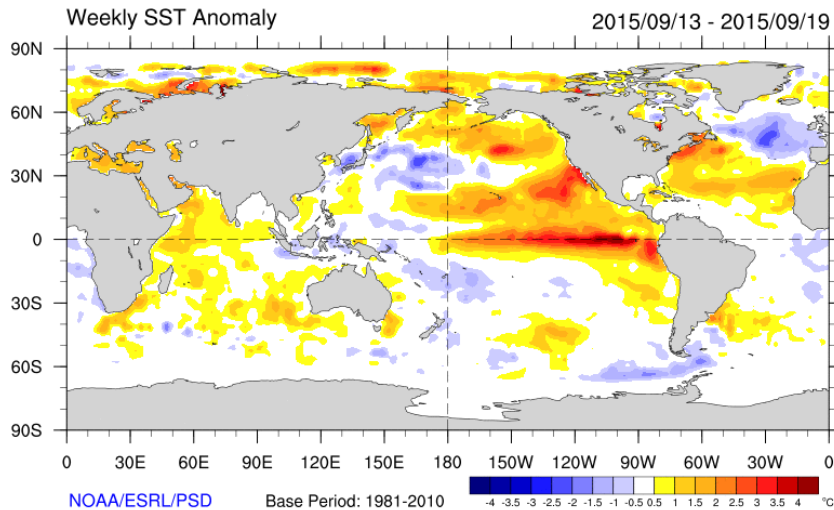
September 2013



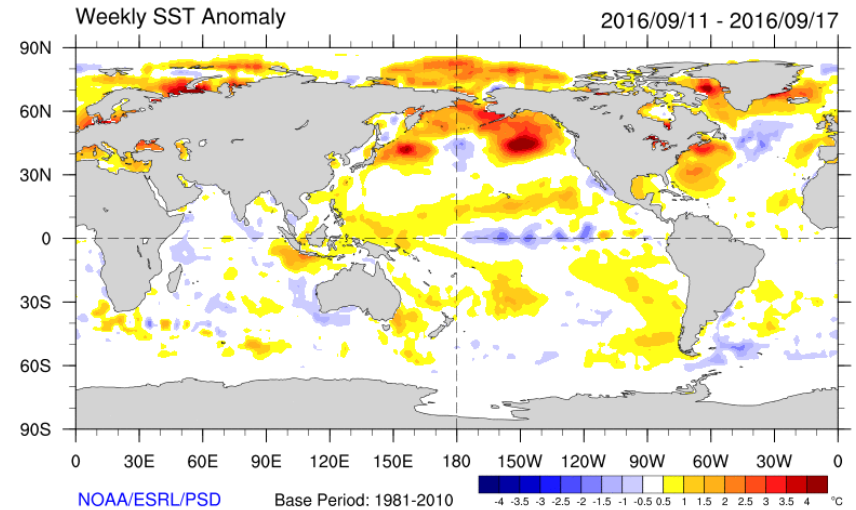
September 2014



September 2015



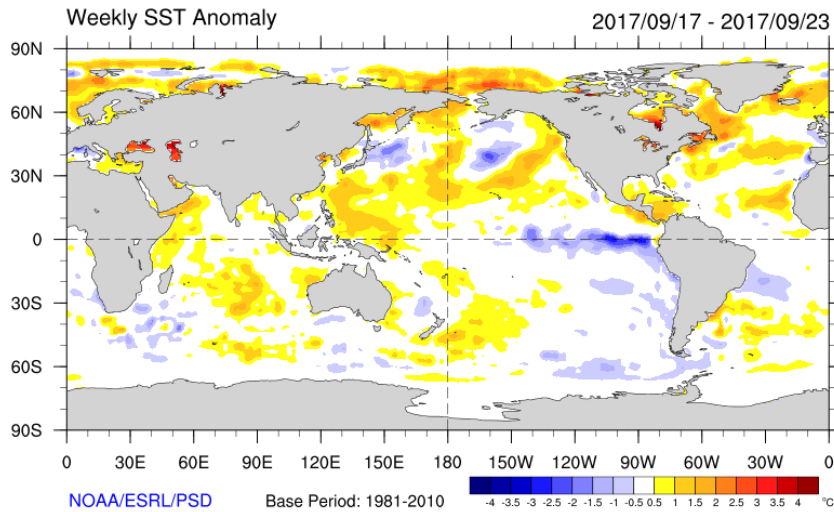
September 2016



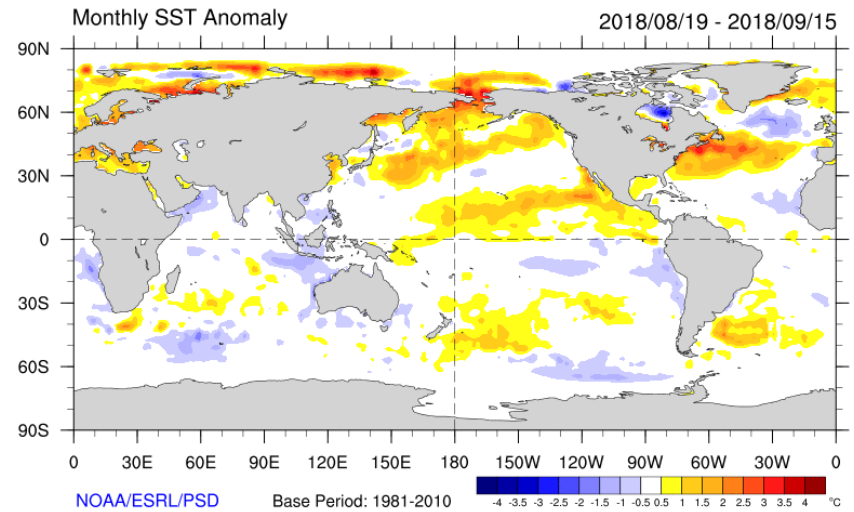


# Pacific Basin-Scale Dynamics

September 2017



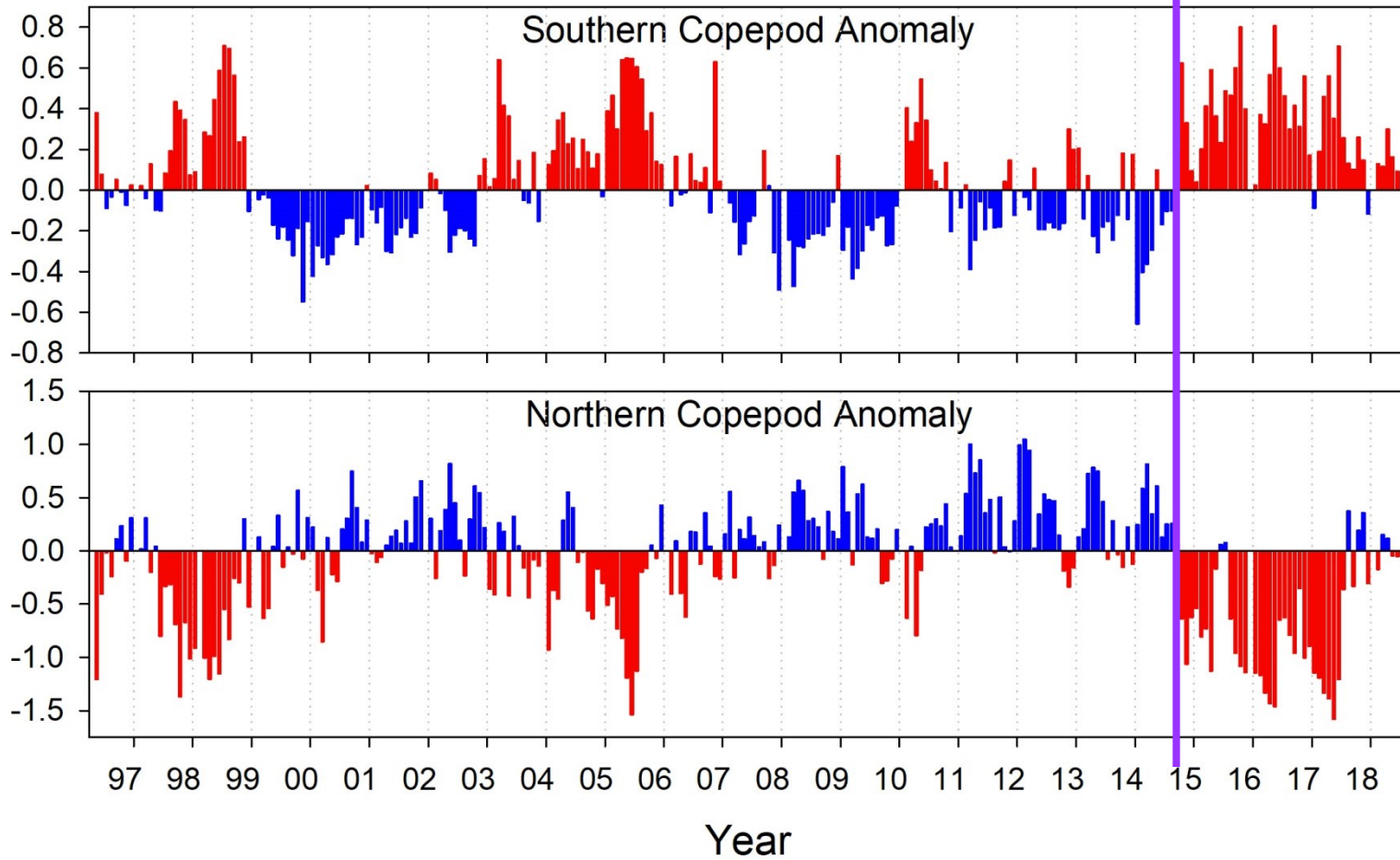
September 2018





# Zooplankton

The blob  
came onshore







# Euphausiid Catch in Trawls



2011

2013

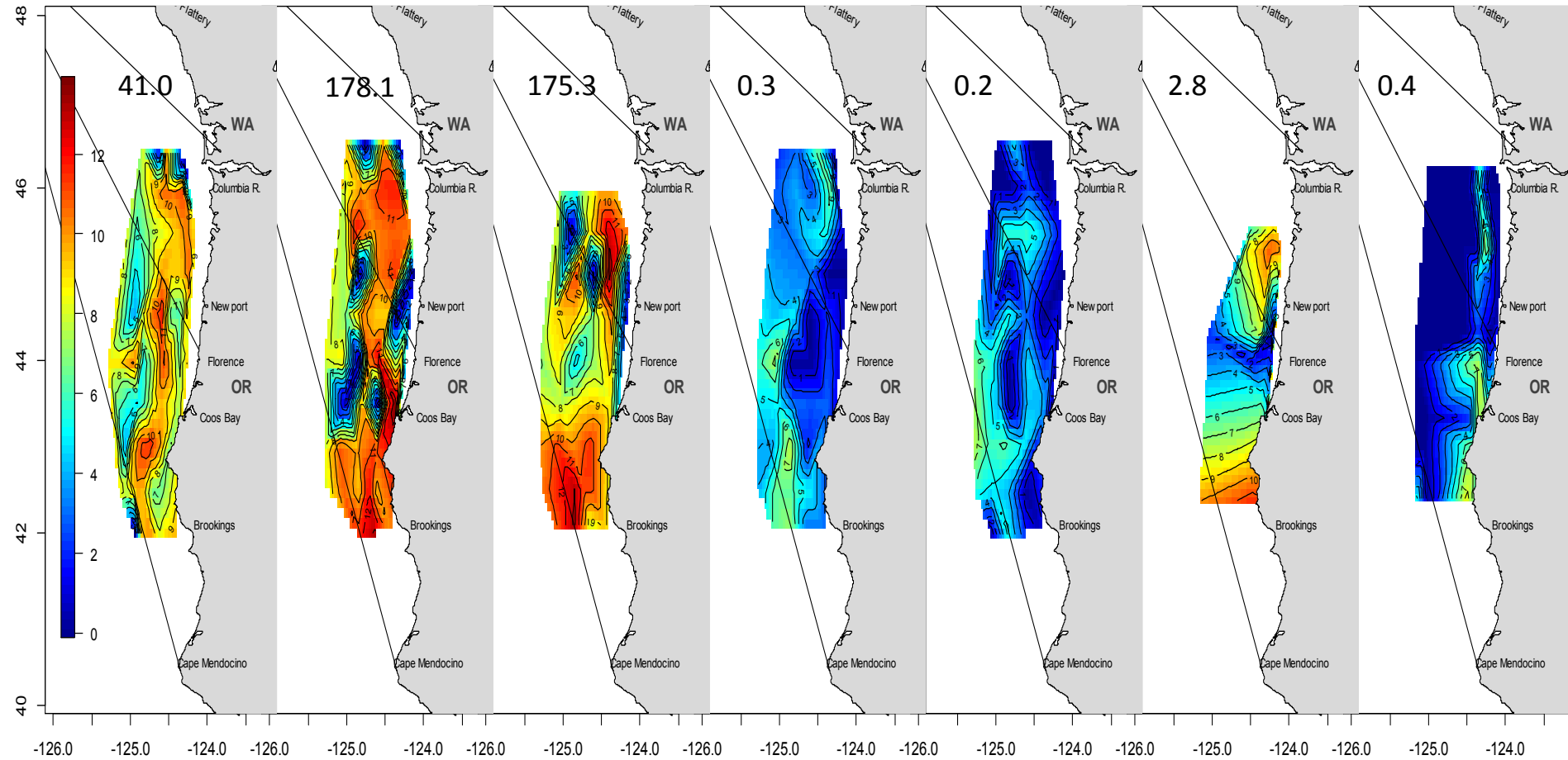
2014

2015

2016

2017

2018



Scale bar = log (abundance)

Number = Geometric mean abundance  $\times 10^{-4}$

Brodeur et al. (MS)

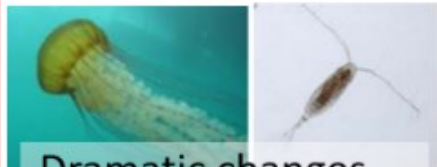
# Systemic Biological Response to the Blob

## 2015

Tropicals  
In Oregon



Species  
range  
extensions  
from CA to  
AK



Dramatic changes  
to food webs

Domoic acid closes  
crab and clam  
fisheries AK-CA



Young  
Chinook &  
coho in ocean  
very skinny

## 2016

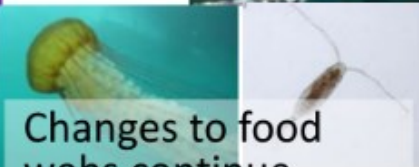


Red pelagic  
crabs in  
Oregon!

Anchovies  
invade the  
Salish Sea



Changes to food  
webs continue



Crab and clam  
fishery closures

## 2017



High Pacific  
lamprey counts at  
Bonneville Dam

Pyrosomes  
explode  
AK-CA



Swordfish off  
Vancouver  
Island

Extremely low  
Pacific cod  
abundance in  
Gulf of Alaska



Crab and clam  
fishery closures

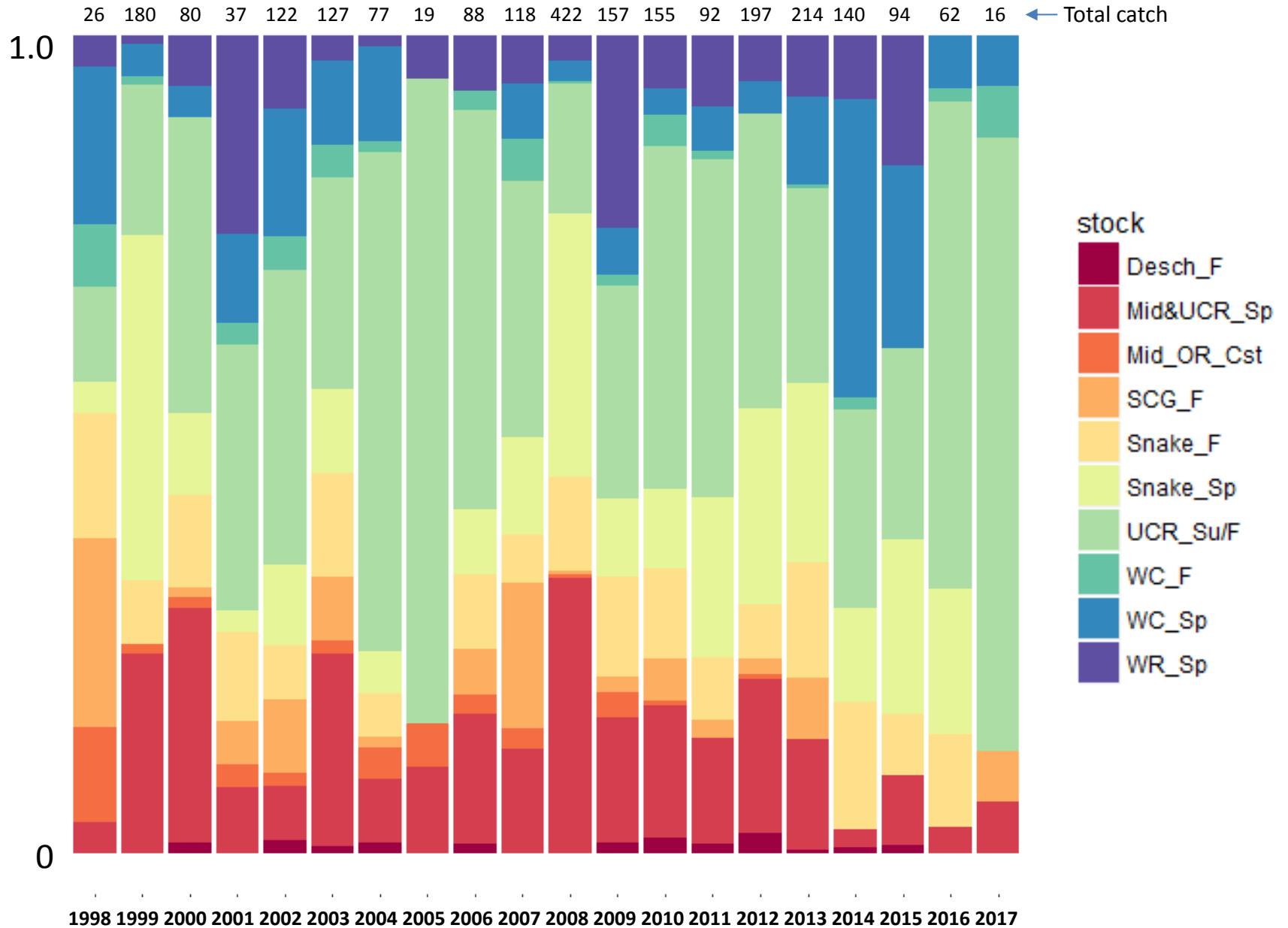


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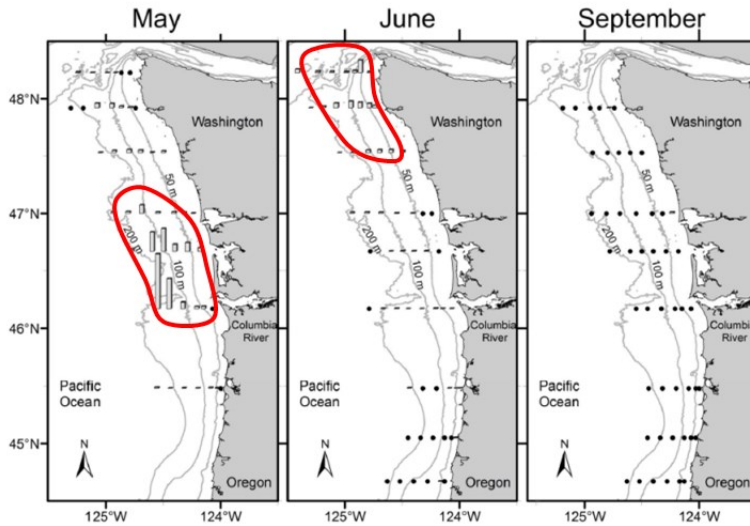
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# Yearling Chinook Stock Composition in June

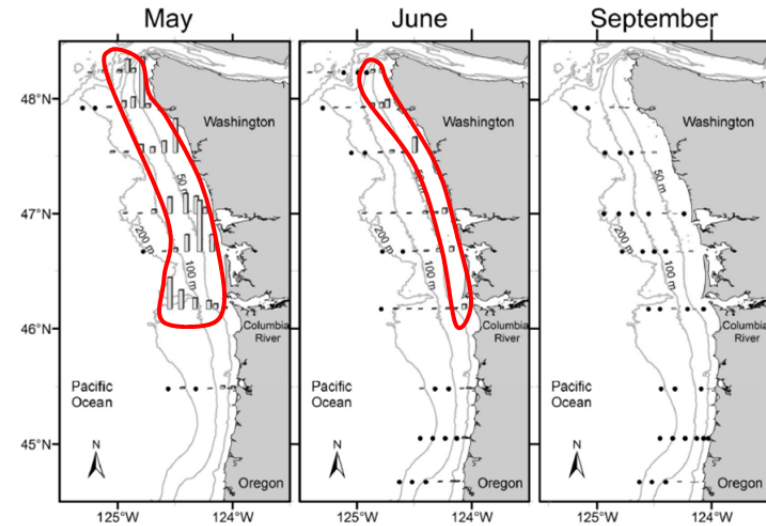


# Spatial distribution is stock-specific

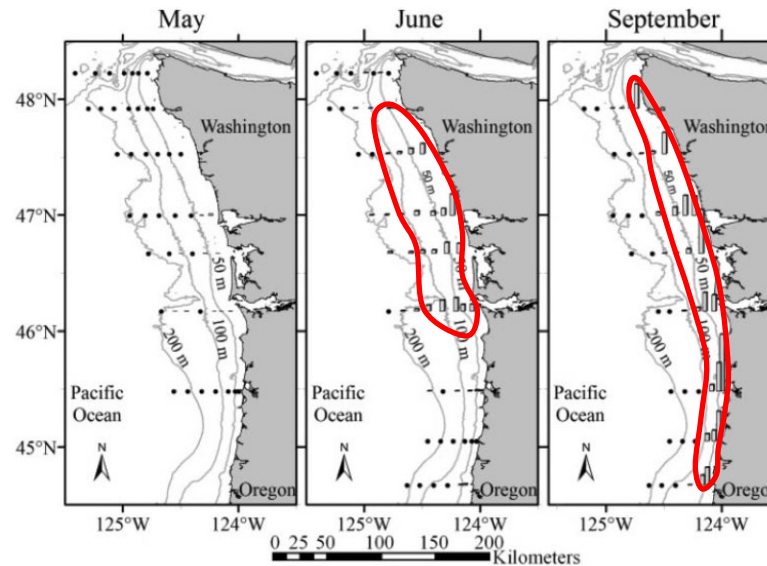
**Snake River Yearling Spring Chinook**



**Willamette River Yearling Spring Chinook**



**Upper Columbia River Summer/fall Subyearling Chinook**





# Subadult and Adult Distributions are Less Clear

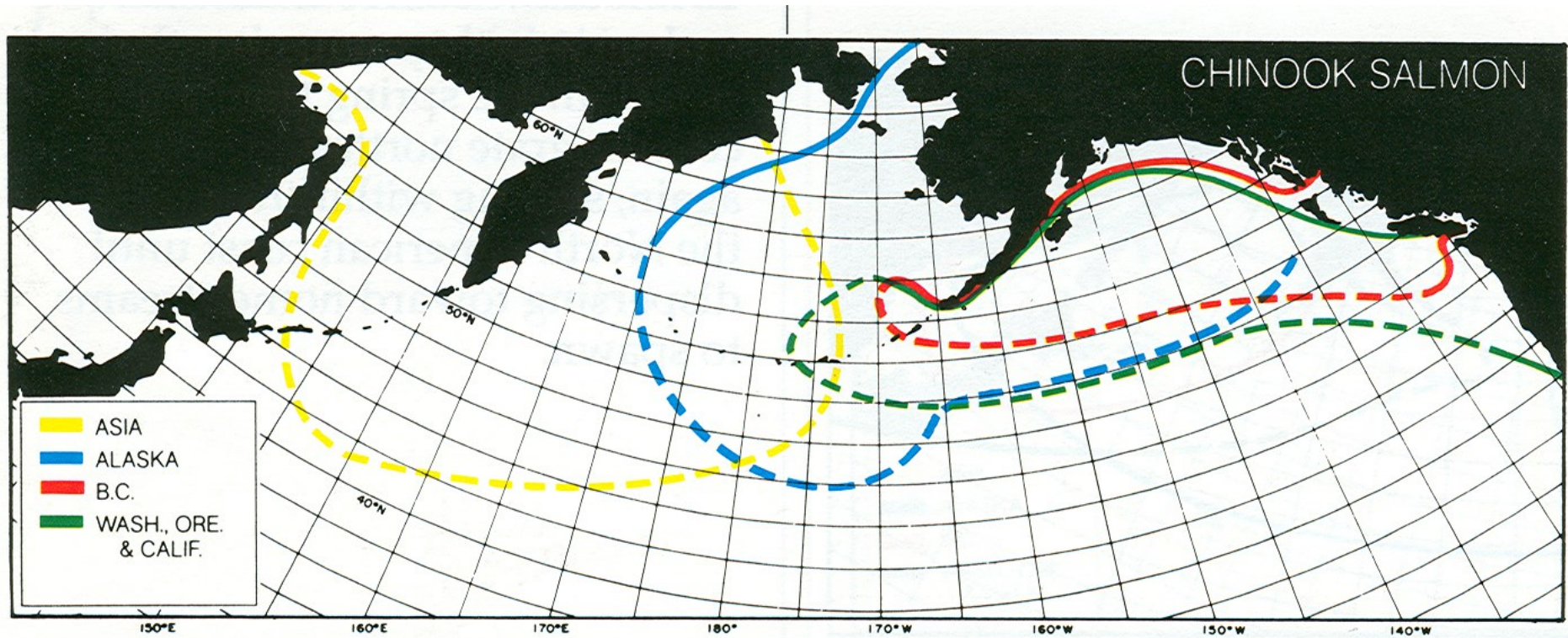
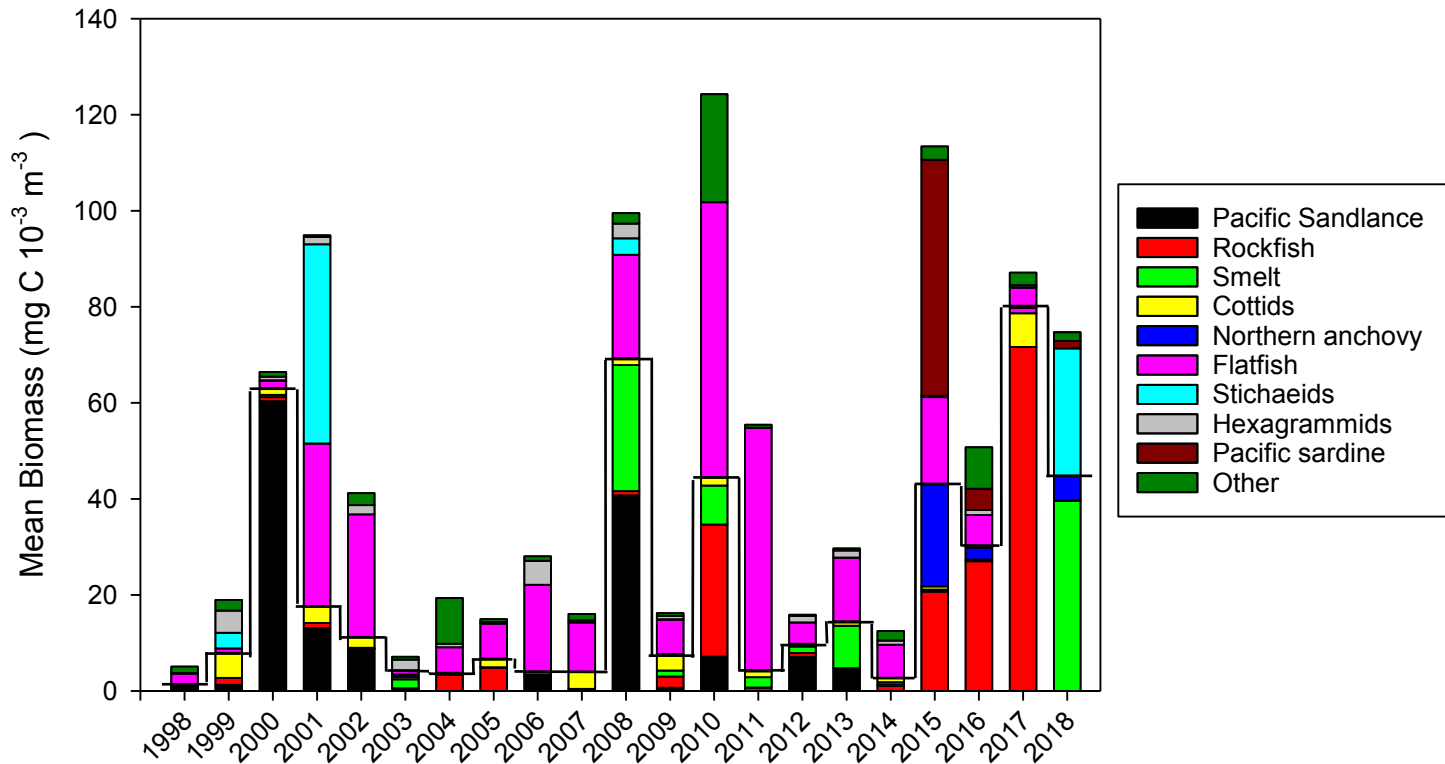
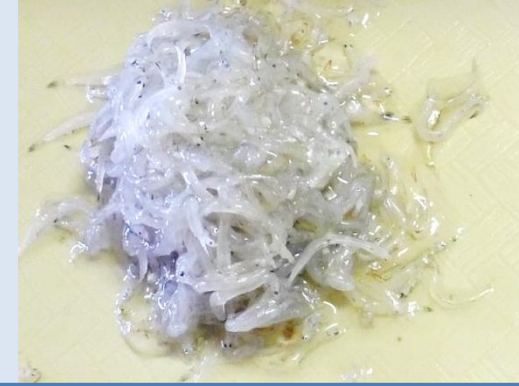


Image by DFO Canada



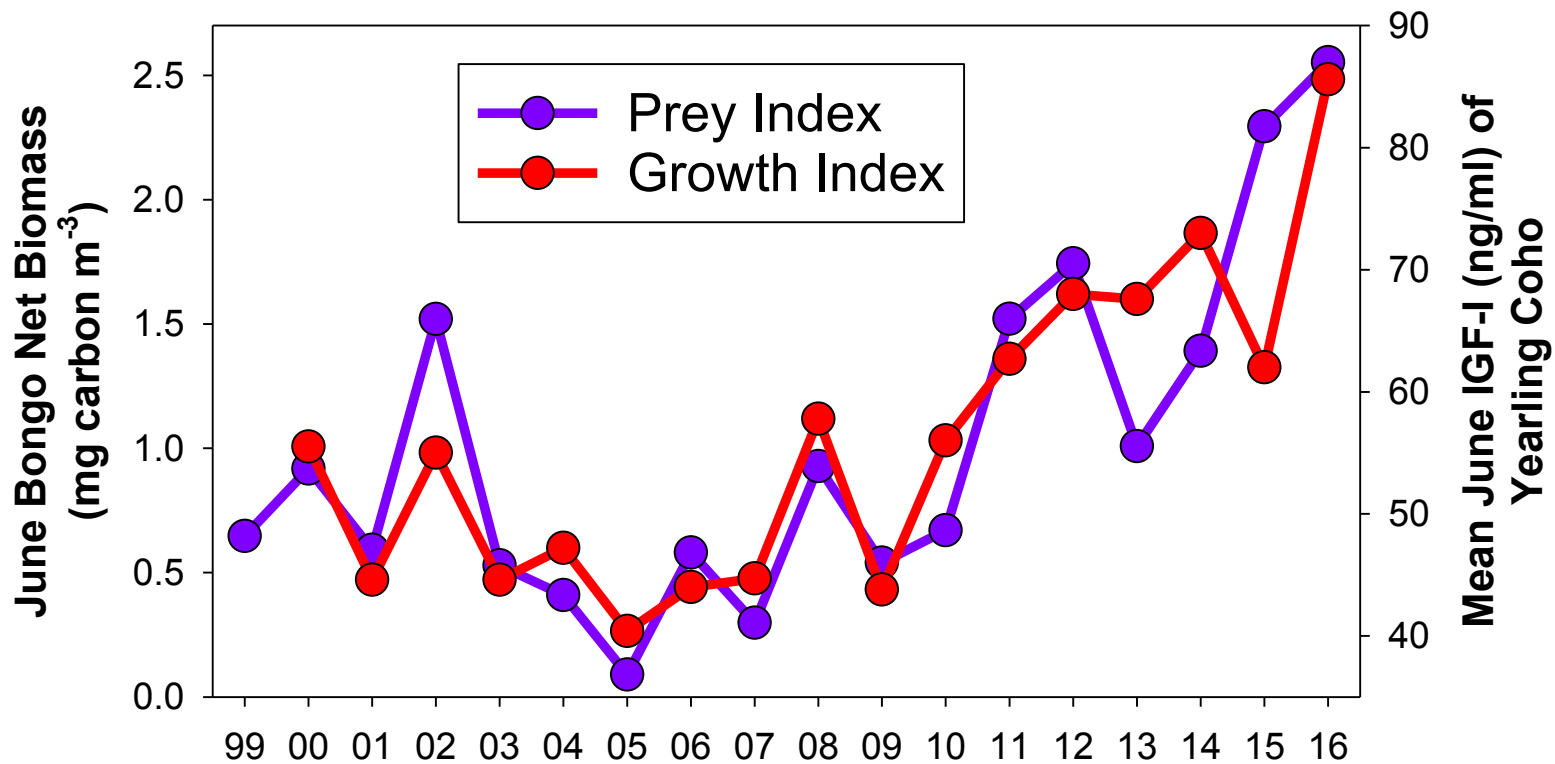
# Potential Prey Resources



Annual mean biomass of larval fish taxa collected during winter (January-March in 1998-2018) along the Newport Hydrographic Line

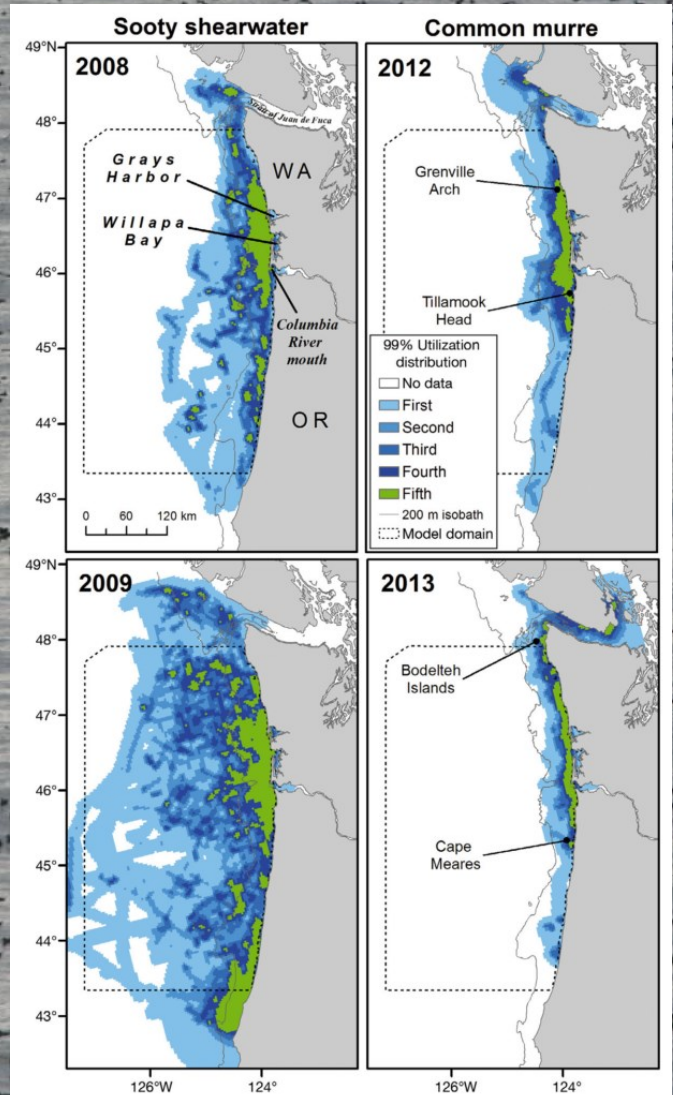


# Prey abundance and estimated growth have been high



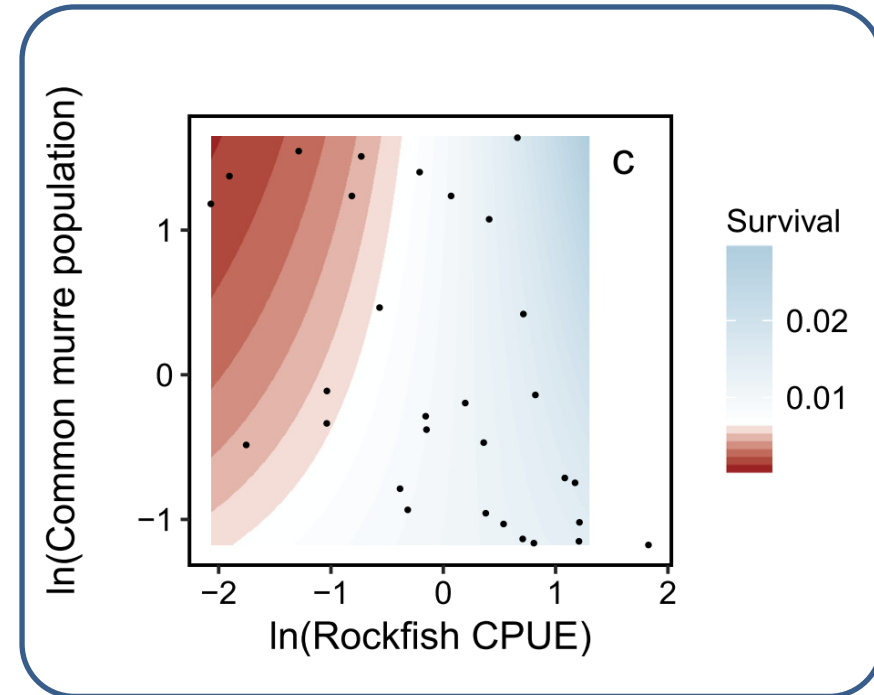
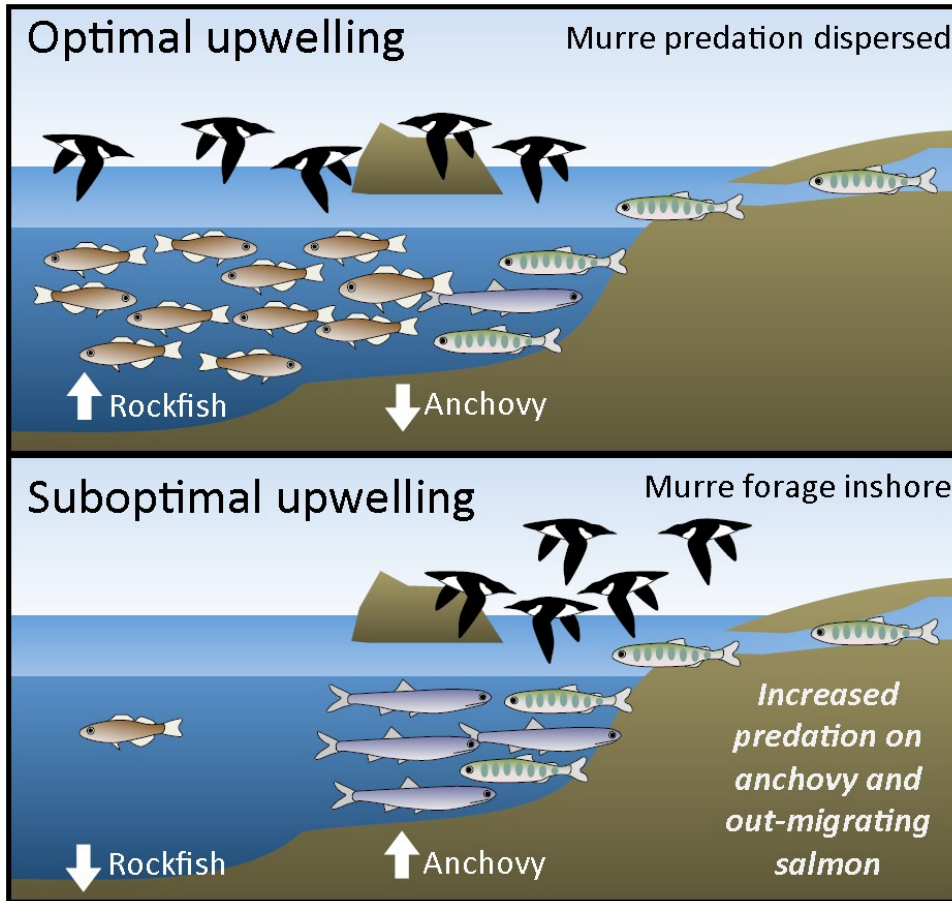


# Predation impacts remain a data gap



Phillips et al. 2018

# Predation impact depends on alternative prey





The image shows three rectangular trays filled with salmon fillets. The trays are colored blue, yellow, and green from left to right. The salmon is cut into uniform pieces and is piled in the trays. The background is slightly blurred, showing what appears to be a wooden surface.

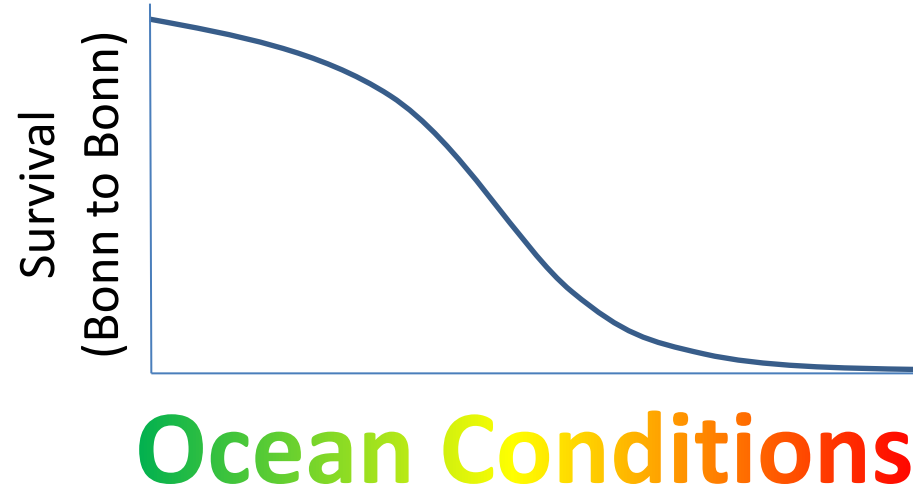
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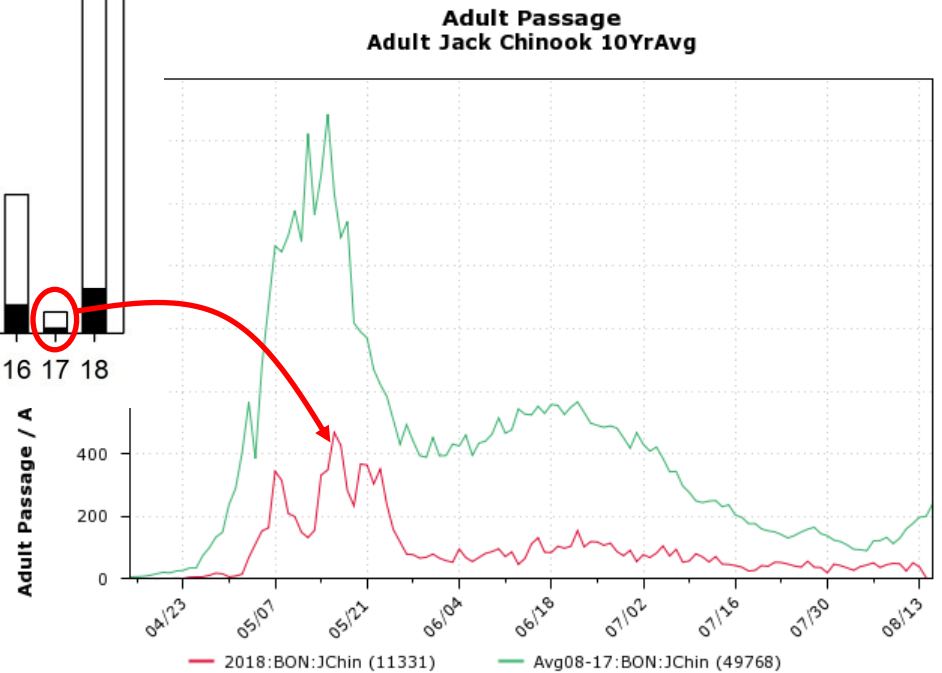
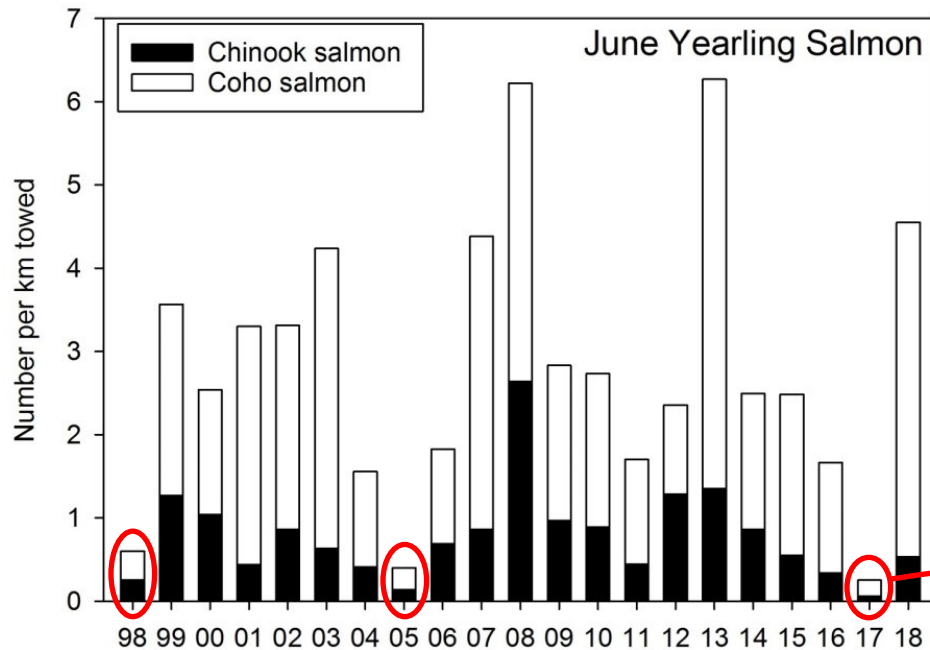
# Early Warning: Stoplight Chart

Ecosystem Indicators	Year																			
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
PDO (Sum Dec-March)	17	6	3	12	7	19	11	15	13	9	5	1	14	4	2	8	10	20	18	16
PDO (Sum May-Sept)	10	4	6	5	11	16	15	17	12	13	2	9	7	3	1	8	18	20	19	14
ONI (Average Jan-June)	19	1	1	6	13	15	14	16	8	11	3	10	17	4	5	7	9	18	20	12
46050 SST (°C; May-Sept)	16	9	3	4	1	8	20	15	5	17	2	10	7	11	12	13	14	19	18	6
Upper 20 m T (°C; Nov-Mar)	19	11	8	10	6	14	15	12	13	5	1	9	16	4	3	7	2	20	18	17
Upper 20 m T (°C; May-Sept)	16	12	14	4	1	3	20	18	7	8	2	5	13	10	6	17	19	9	15	11
Deep temperature (°C; May-Sept)	20	6	8	4	1	10	12	16	11	5	2	7	14	9	3	15	19	18	13	17
Deep salinity (May-Sept)	19	3	9	4	5	16	17	10	7	1	2	14	18	13	12	11	20	15	8	6
Copepod richness anom. (no. species; May-Sept)	18	2	1	7	6	13	12	17	15	10	8	9	16	4	5	3	11	19	20	14
N. copepod biomass anom. (mg C m <sup>-3</sup> ; May-Sept)	18	13	9	10	3	15	12	19	14	11	6	8	7	1	2	4	5	16	20	17
S. copepod biomass anom. (mg C m <sup>-3</sup> ; May-Sept)	20	2	5	4	3	13	14	19	12	10	1	7	15	9	8	6	11	17	18	16
Biological transition (day of year)	17	8	5	7	9	14	13	18	12	2	1	3	15	6	10	4	11	20	20	16
Ichthyoplankton biomass (log(mg C 1000 m <sup>-3</sup> ); Jan-Mar)	20	11	3	7	9	18	17	13	16	15	2	12	4	14	10	8	19	5	6	1
Ichthyoplankton community index (PCO axis 1 scores; Jan-Mar)	9	13	1	6	4	10	18	16	3	12	2	14	15	11	5	7	8	17	20	19
Chinook salmon juvenile catches (no. km <sup>-2</sup> ; June)	18	4	5	15	8	12	16	19	11	9	1	6	7	14	3	2	10	13	17	20
Coho salmon juvenile catches (no. km <sup>-2</sup> ; June)	18	7	12	5	6	2	15	19	16	4	3	9	10	14	17	1	11	8	13	20
Mean of ranks	17.1	7.0	5.8	6.9	5.8	12.4	15.1	16.2	10.9	8.9	2.7	8.3	12.2	8.2	6.5	7.6	12.3	15.9	16.4	13.9
Rank of the mean rank	20	6	2	5	2	14	16	18	11	10	1	9	12	8	4	7	13	17	19	15



<https://www.nwfsc.noaa.gov/oceanconditions>

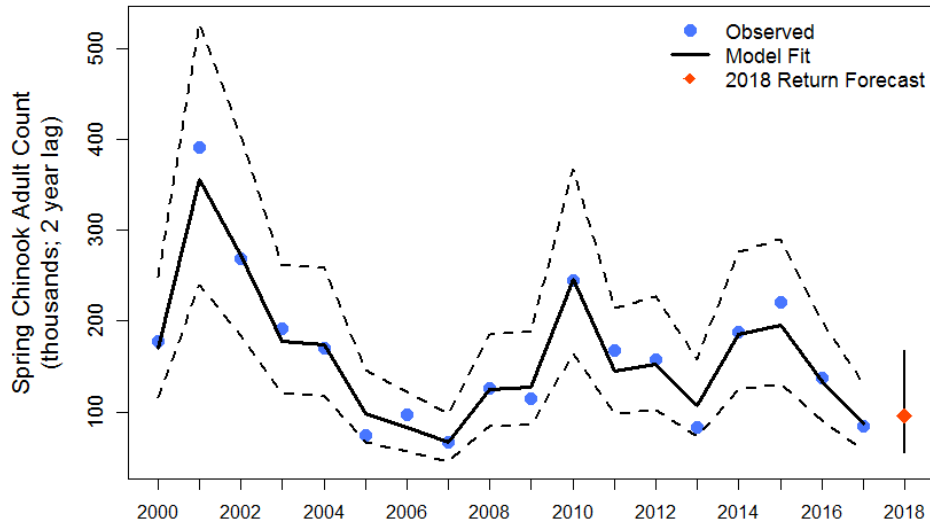
# Early Warning: Extremely Low Salmon Abundance in 2017



# Chinook at Bonneville Dam

## Dynamic Linear Models

Sibling Regression and the first Principal Component of the stoplight chart

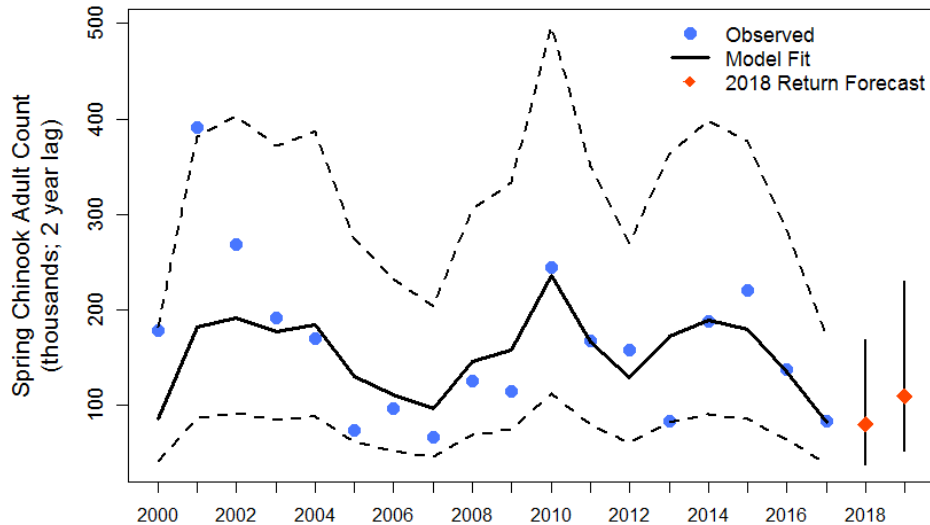


## Spring Chinook

March 15 – May 31

Outlook for 2018: **96K (55-168)**

(Observed for 2018: 88K)

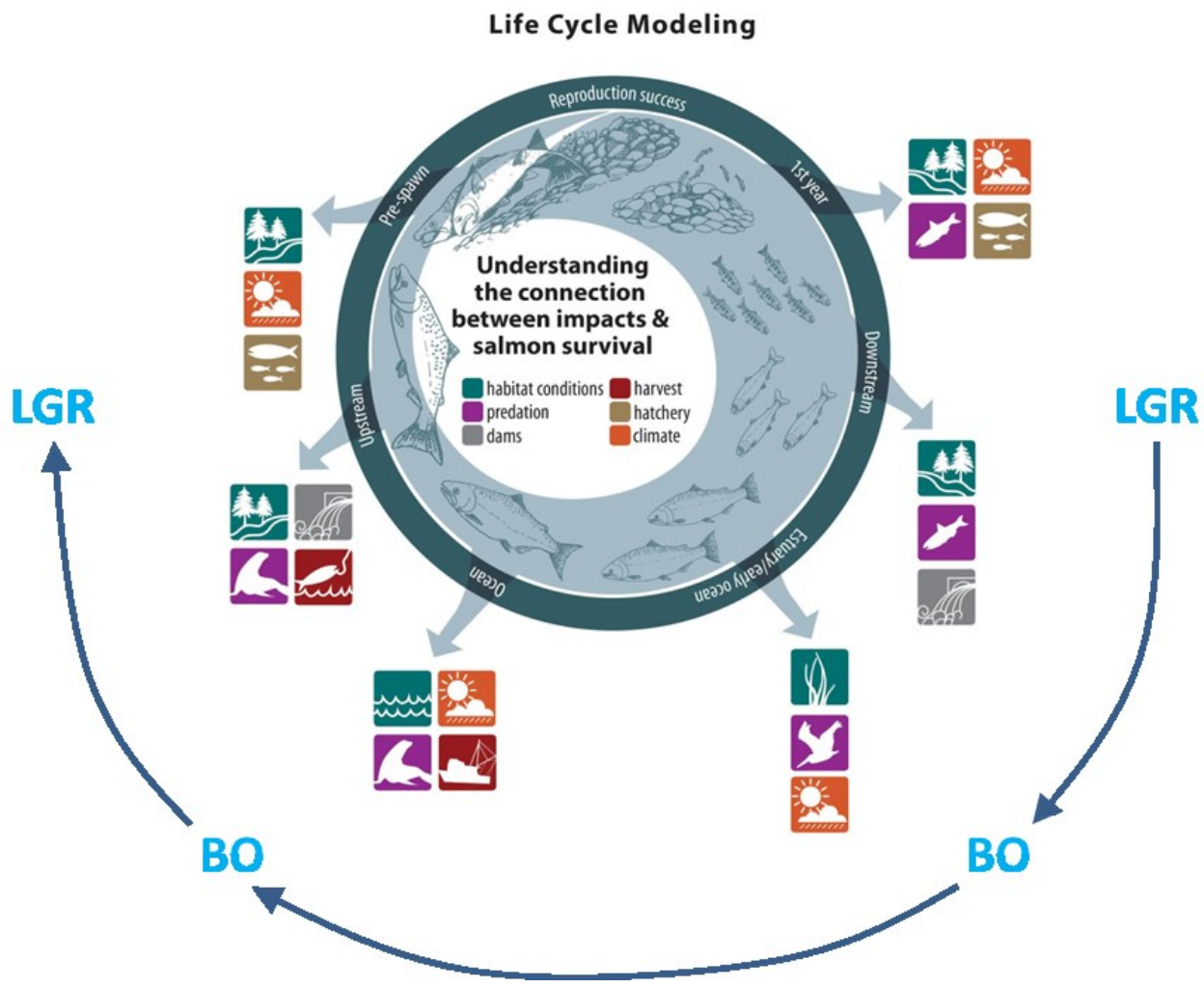


Outlook for 2019: **109K (52 – 230)**

(no jack data used)



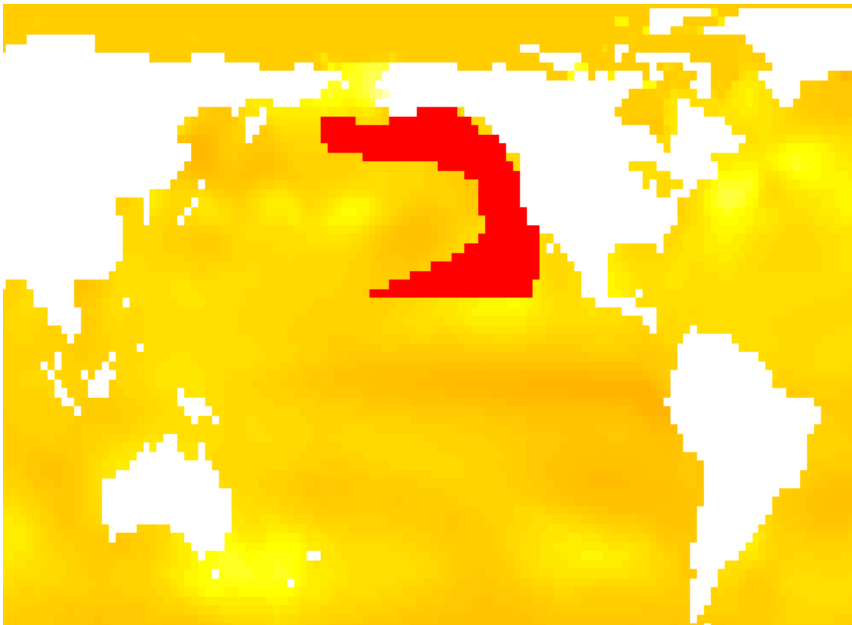
# Life Cycle Modeling



# Best Set of Covariates\*

## Large-scale **winter** SST

Recreated using ERSST v5 data

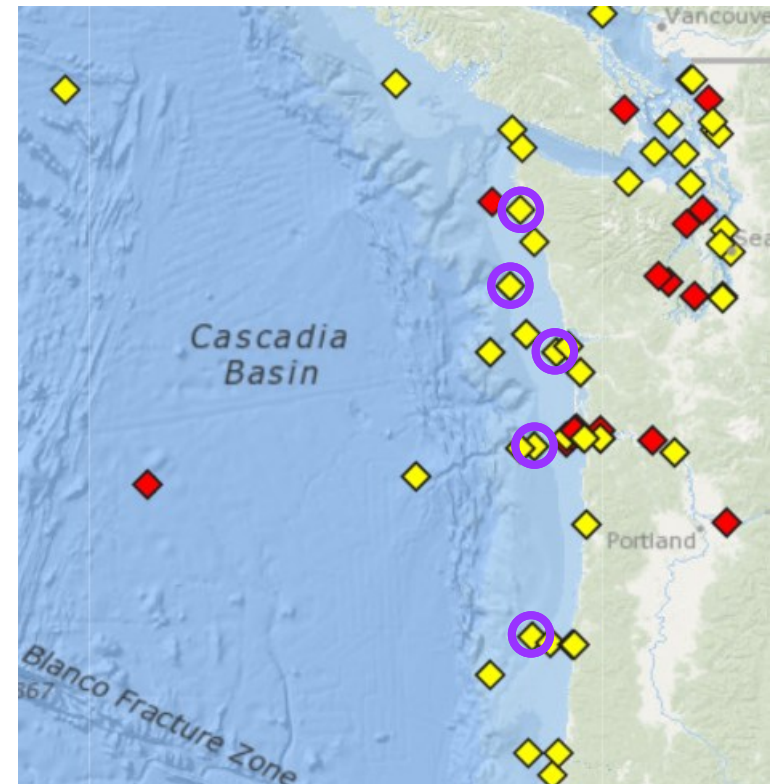


Johnstone and Mantua. 2014

<https://www.ncdc.noaa.gov/data-access/marineocean-data/extended-reconstructed-sea-surface-temperature-ersst-v5>

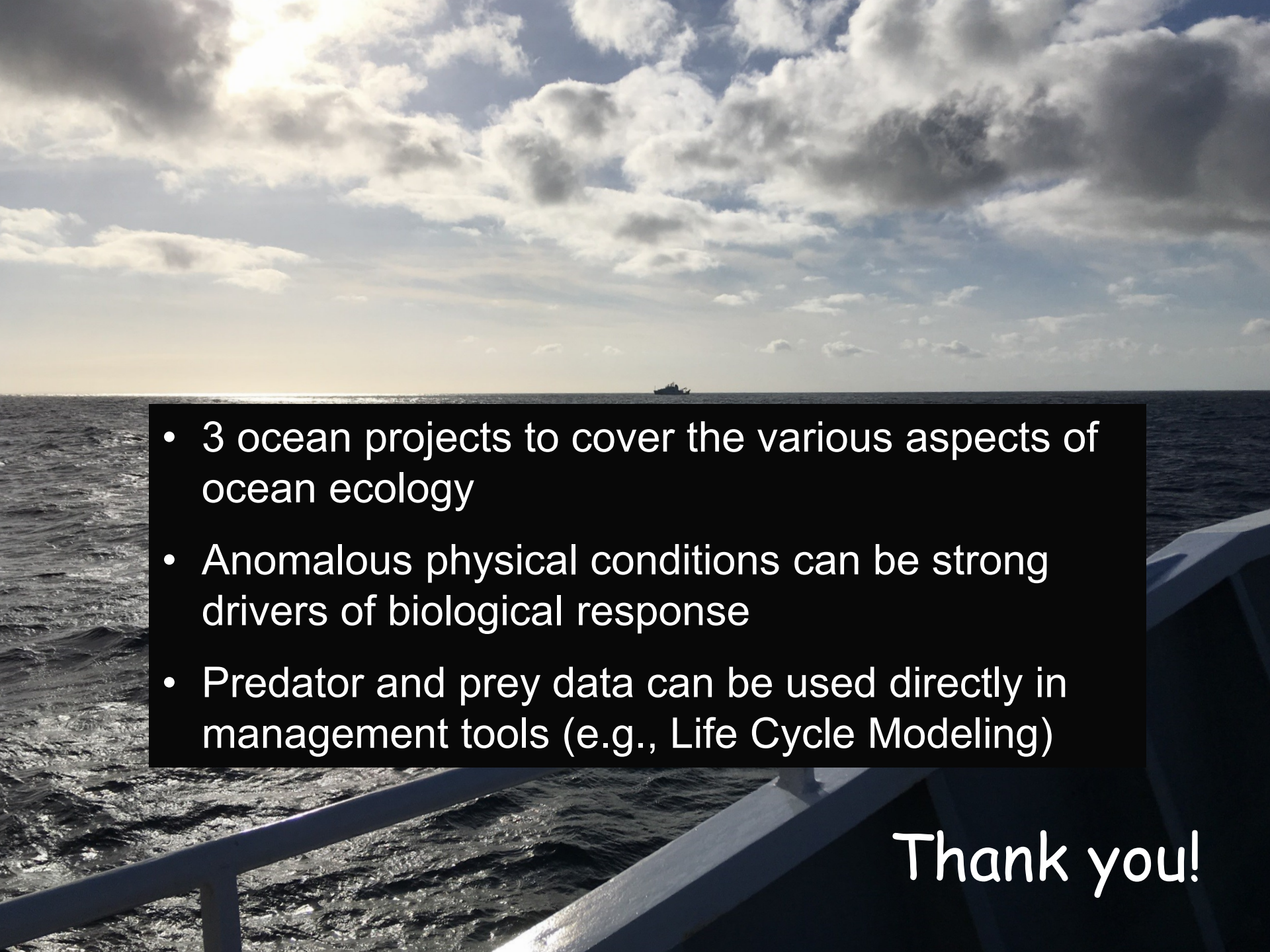
## Local **summer** SST

From Buoys



<http://www.ndbc.noaa.gov/>

\* These should be thought of as *indices* of the (unmeasured) ecological processes

- 
- 3 ocean projects to cover the various aspects of ocean ecology
  - Anomalous physical conditions can be strong drivers of biological response
  - Predator and prey data can be used directly in management tools (e.g., Life Cycle Modeling)

Thank you!