October 4, 2016

MEMORANDUM

TO: **Council members**

FROM: **Patty O'Toole and Lynn Palensky**

SUBJECT: **Update on unusual ocean conditions and stellar sea lion presence and predation**

BACKGROUND:

Presenter: Patty O'Toole and Lynn Palensky – Council Staff; and Brian Burke Northwest Fisheries Science Center, Seattle, and Robert Anderson, NOAA Fisheries, Portland

Summary: At the October Council meeting, we will be hearing from NOAA Fisheries about recent unusual ocean conditions and also about unusual behavior of Steller sea lions, particularly in respect to the unusually high numbers observed at Bonneville dam in recent weeks. The Council has heard much about the anomalous river conditions in 2015. Ocean conditions in recent years have been unusual as well, with warmer than normal water temperatures observed. These conditions may be affecting marine mammal populations and their feeding behavior.

Relevance: This topic is related to one of the seven emerging program priority areas in the Investment Strategy of the 2014 Fish and Wildlife Program – "preserving program effectiveness by supporting expanded management of predators". Our continued understanding of in-river sea lion populations is important as we consider management for fish and pinniped interactions. Stellar sea lions continue to be present in the past weeks in the lower river around Bonneville Dam, which is unusual for this time of

year. While outside of the normal pinniped monitoring schedule, the Army Corps of Engineers staff at Bonneville Dam has reported over 30 individual Steller sea lions observed in one day at the dam in the past week. This topic is also related to emerging priority #2, “Implement adaptive management…and taking into account the effects of climate change.”

As part of this discussion, it is important to understand what is happening in the ocean and estuary that may be affecting the river conditions and food web interactions. For example, the warmer than normal ocean temperatures have correlated with many unusual species observations and events, such as the wide-spread bloom of a naturally occurring toxic algae. In fact, in 2015, researchers found some of the highest concentrations of domoic acid (produced by the algae) ever observed off the west coast. The presence of this toxin was observed throughout the food web, from shellfish to sea lions. In another example, humpback whales have been observed during August and September this year in the Columbia River estuary, as far upstream as the east side of the Astoria-Megler Bridge. Experts suggest that ocean conditions could be driving many sea animals toward shore looking for food.

Workplan: The work is being tracked in the Division’s annual work plan as a high-priority task, and in the Council’s Annual Work Plan for 2016.

Background: The Council’s 2014 Fish and Wildlife Program, predator management, plume and nearshore ocean strategies.

More Info: July 2016 packet memo to Committee on Report on Sea Lion predation.

Recent Oceanographic and Biological Observations

Northwest Power & Conservation Council
Fish and Wildlife Committee Meeting
October 11th, 2016

Brian Burke
NOAA Fisheries, NWFSC

Supported by:

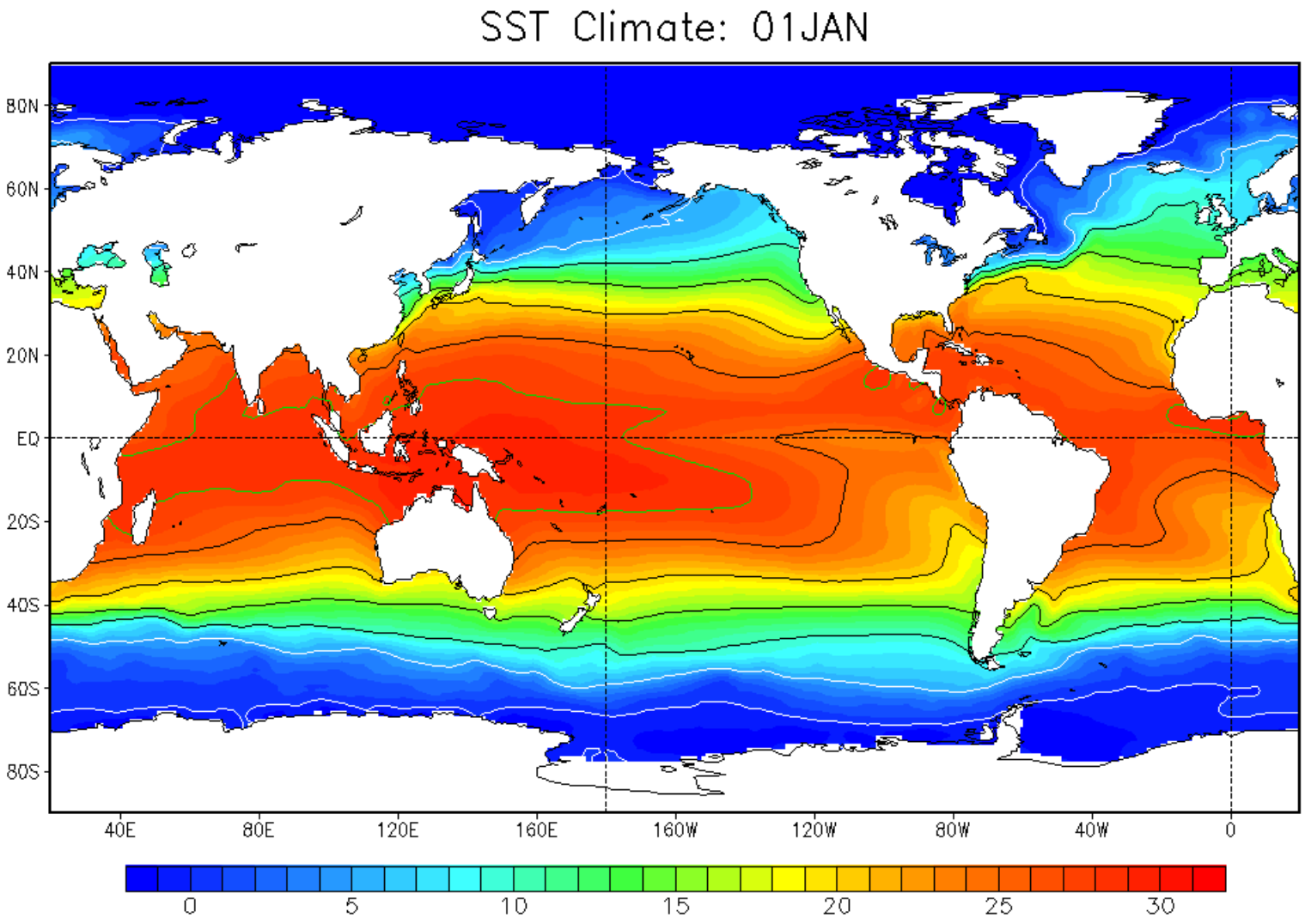
- Large-scale Oceanographic Patterns

  (The blob and El Niño)

- Field Sampling / Data Collection

- Unusual Ecology

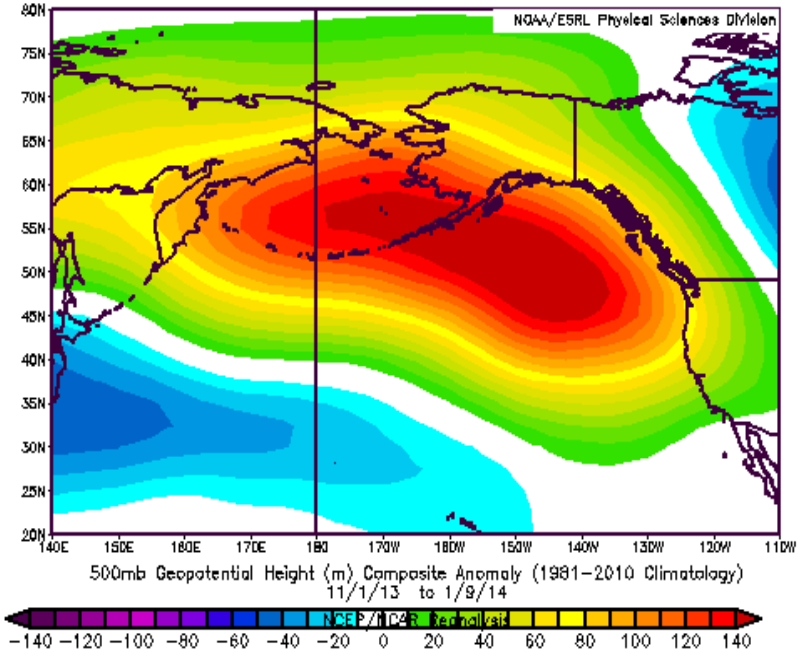
Annual SST Pattern



Formation of the warm blob:

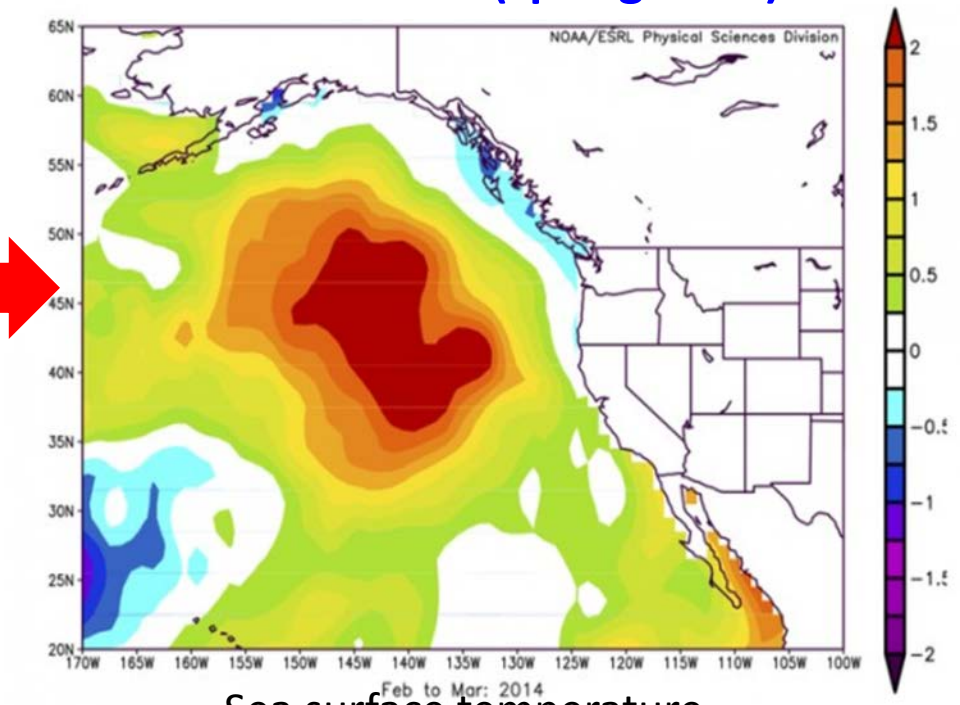
Unusually high pressure over the North Pacific in winter 2013/2014 blocked storms that normally redistribute ocean heat to atmosphere and deep water

Ridiculously resilient ridge (RRR):



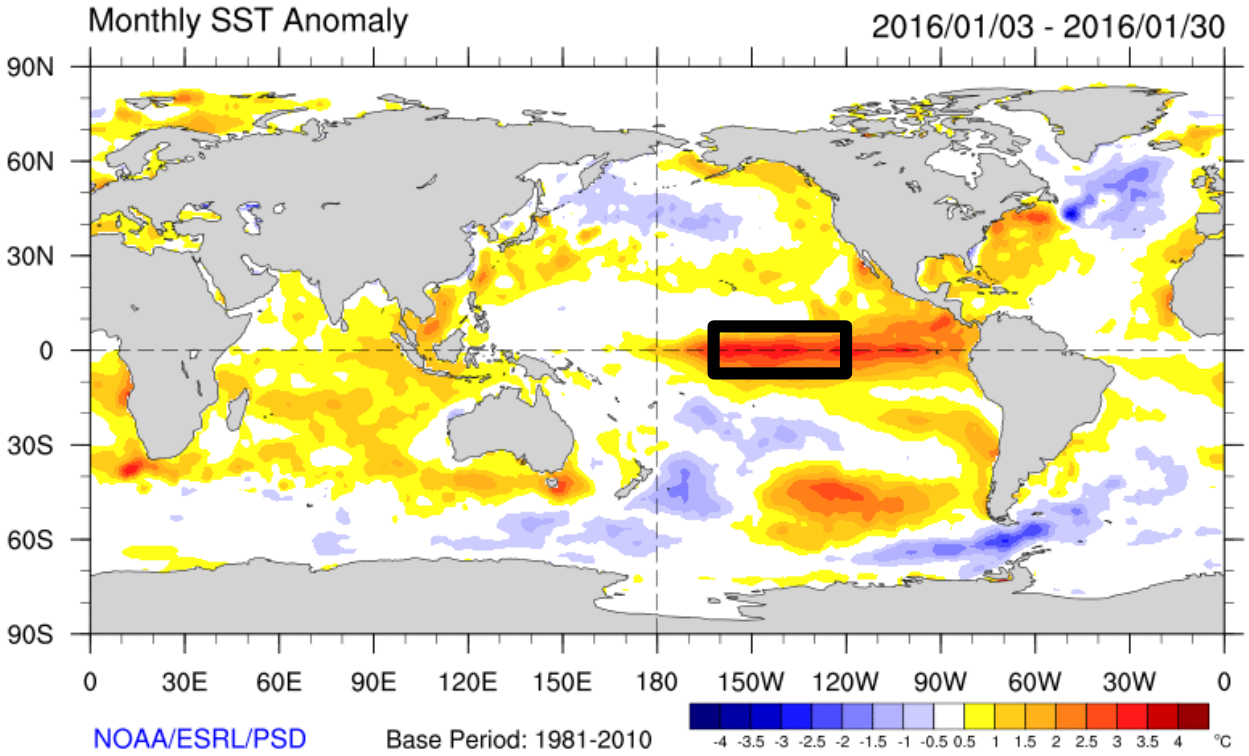
Atmospheric pressure anomalies

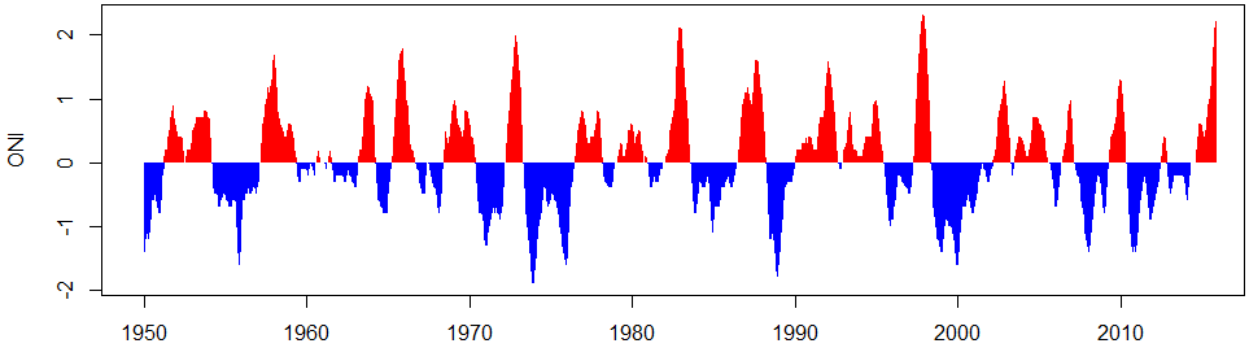
The warm blob (spring 2014)



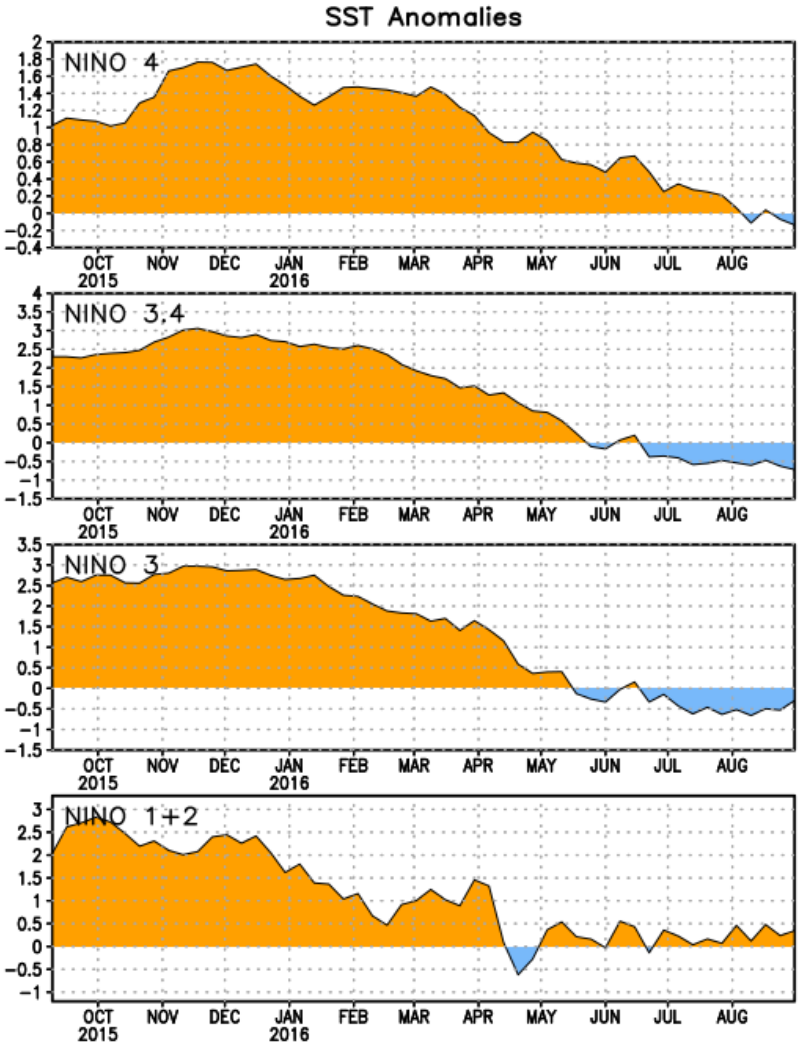
Sea surface temperature (SST) anomalies

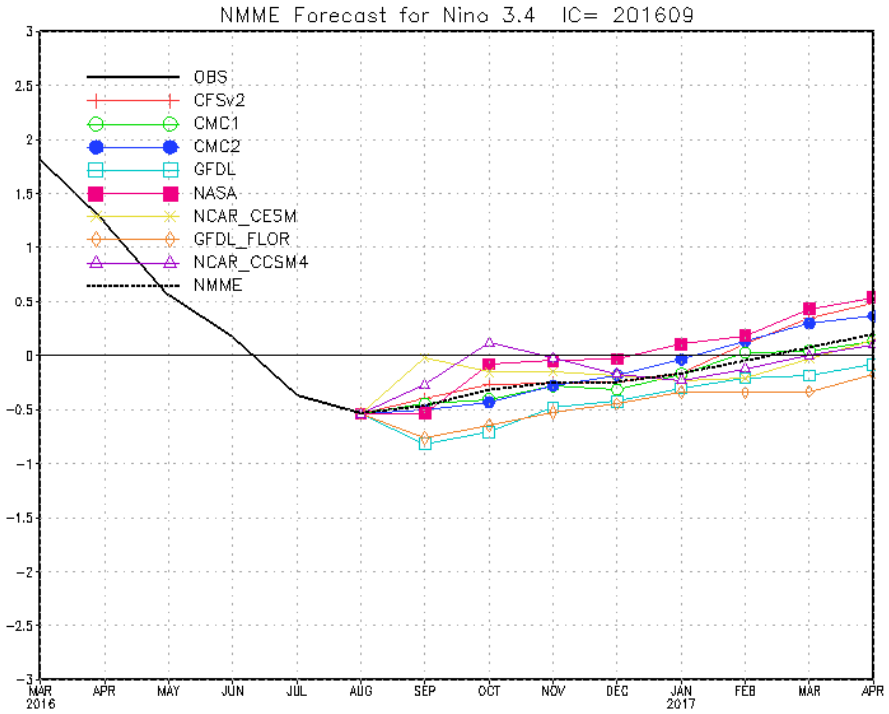
El Niño

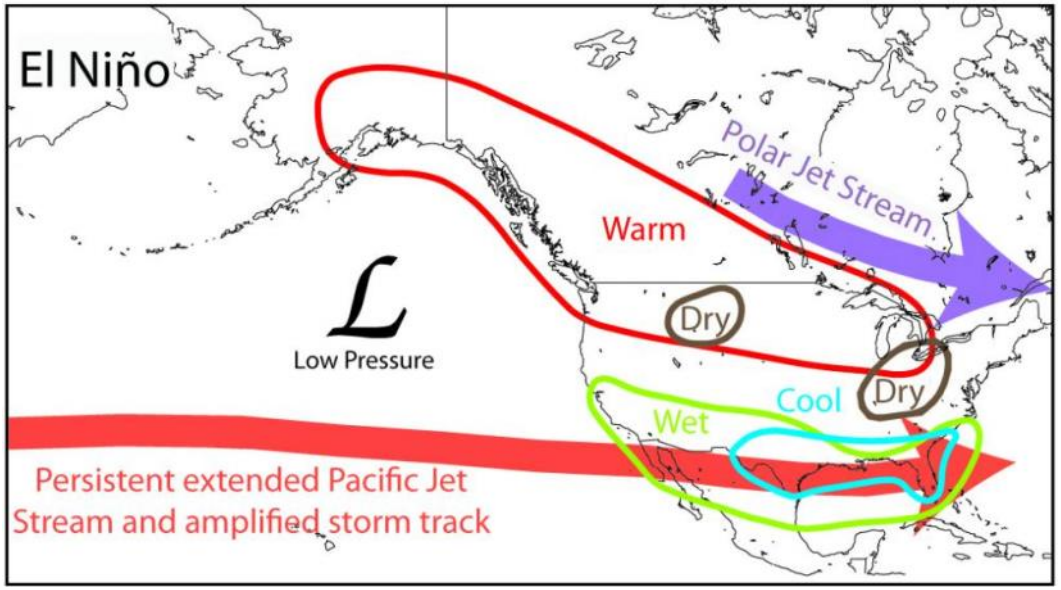

Monthly SST Anomaly
2016/01/03 - 2016/01/30
90N
60N
30N
0
30S
60S
90S
0
30E
60E
90E
120E
150E
180
150W
120W
90W
60W
30W
0
NOAA/ESRL/PSD
Base Period: 1981-2010
-4 -3.5 -3 -2.5 -2 -1.5 -1 -0.5 0.5 1 1.5 2 2.5 3 3.5 4 °C

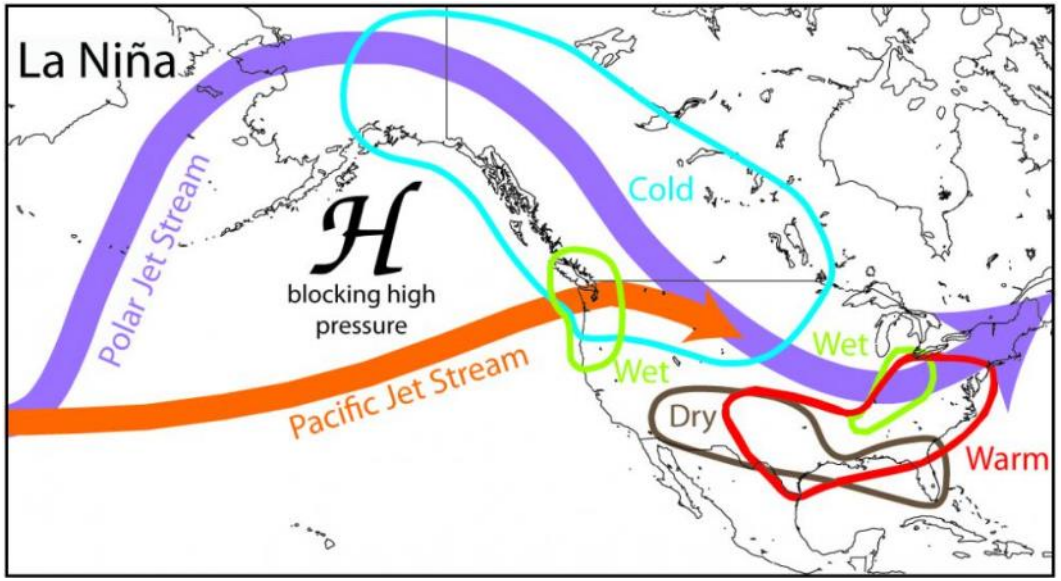

ONI
2
1
0
-1
-2
1950
1960
1970
1980
1990
2000
2010

El Niño, come and gone

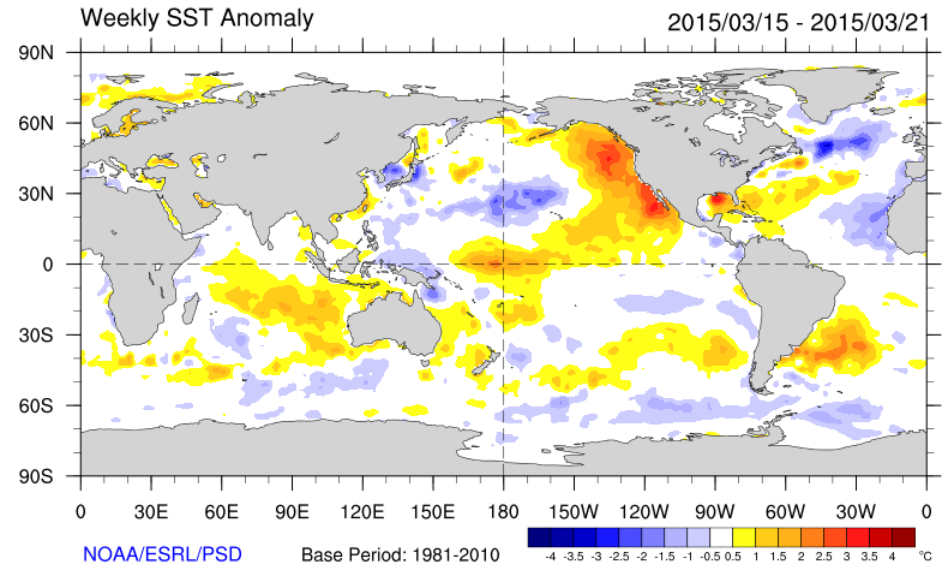




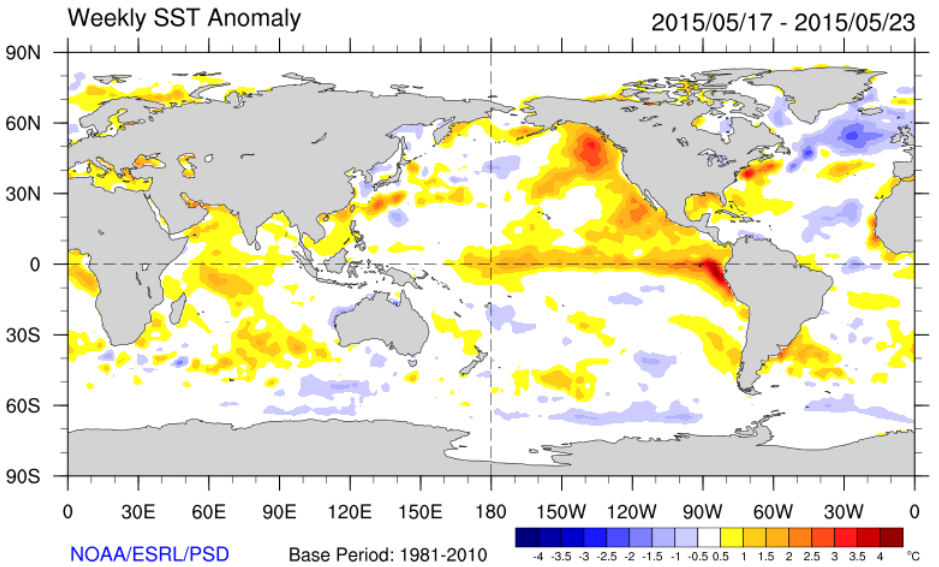

El Niño
Polar Jet Stream
Warm
L
Low Pressure
Dry
Dry
Cool
Wet
Persistent extended Pacific Jet
Stream and amplified storm track


La Niña
Polar Jet Stream
H
blocking high
pressure
Cold
Wet
Wet
Pacific Jet Stream
Dry
Warm

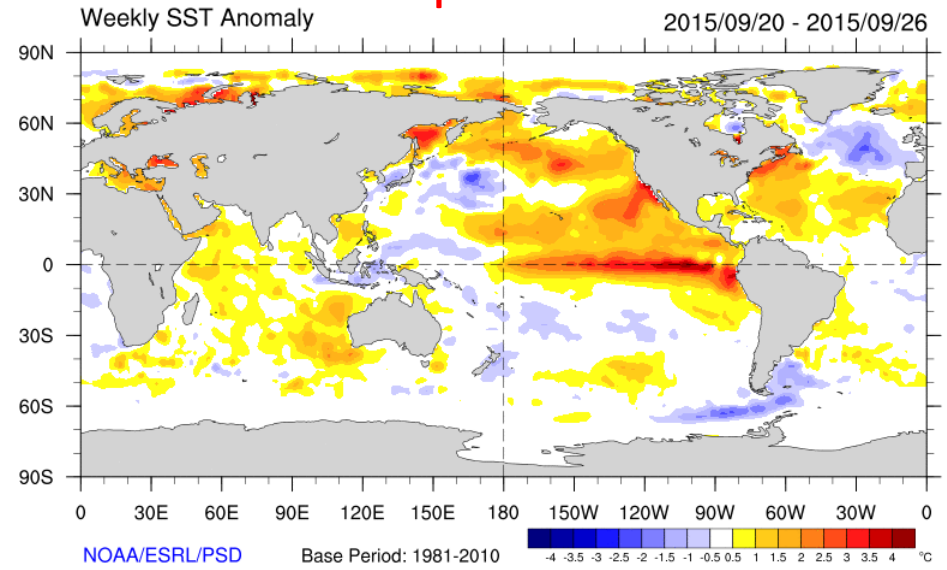
March 2015



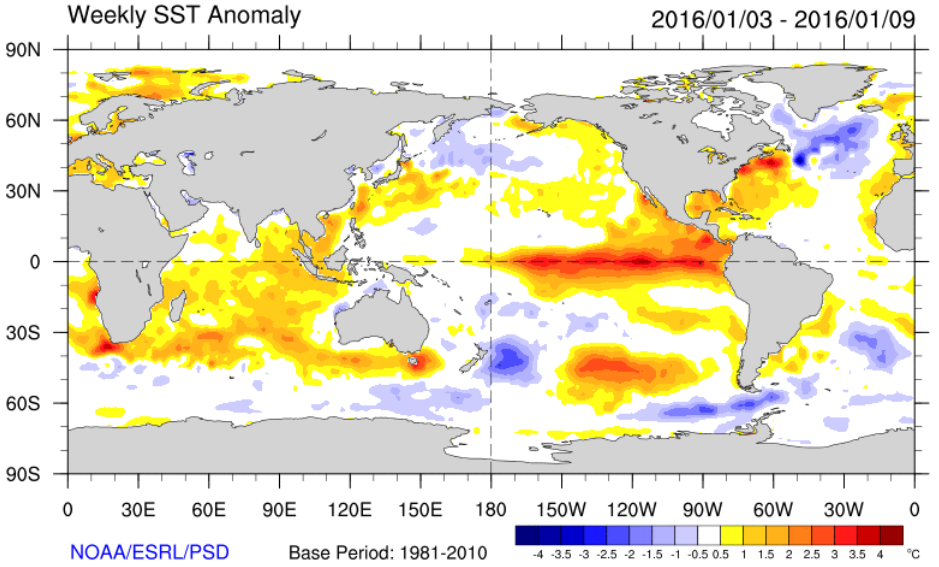
May 2015



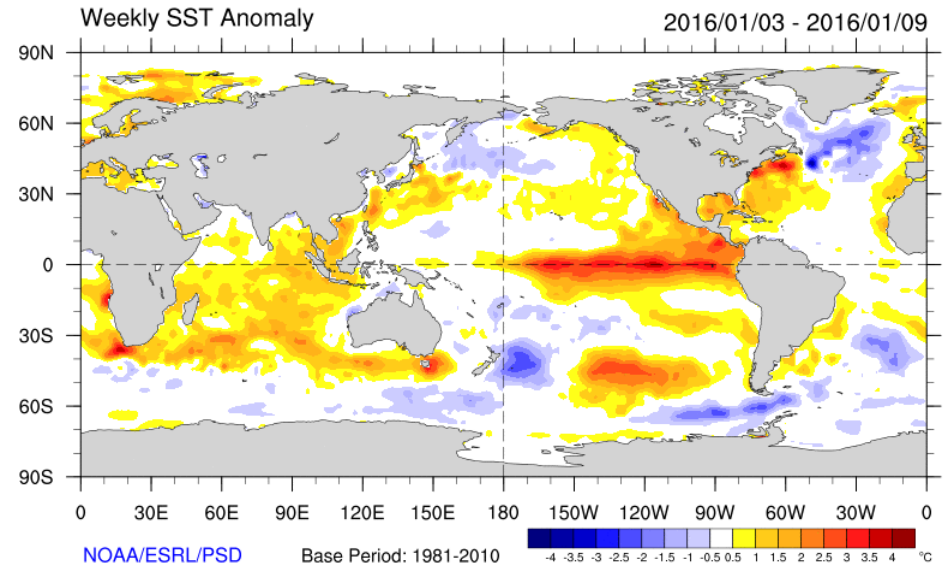
Sept. 2015



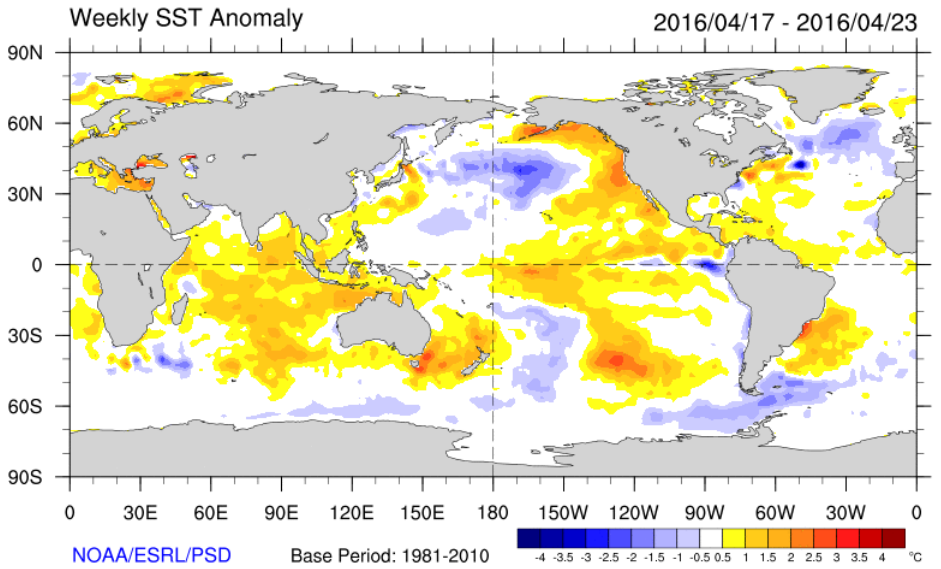
Jan. 2016



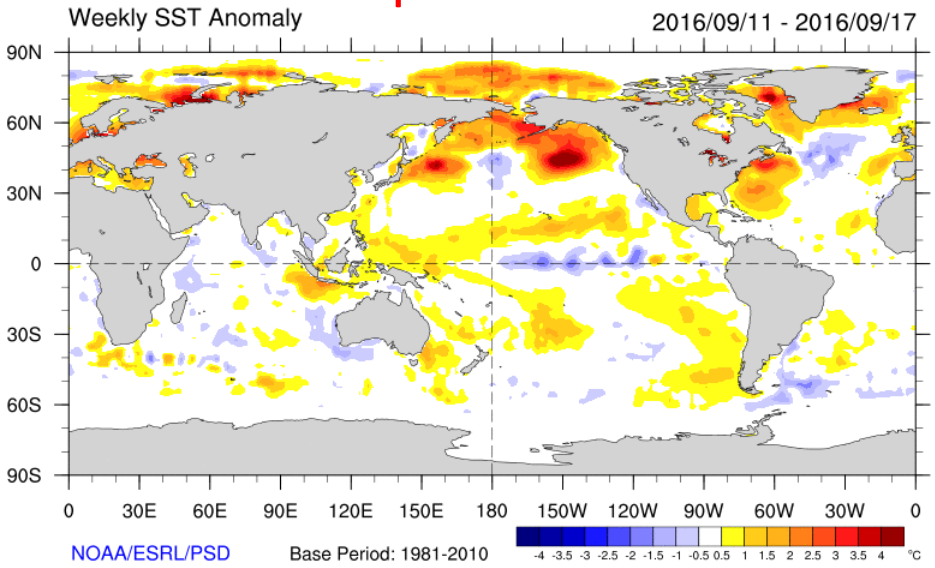
Jan. 2016



May 2016



Sept. 2016



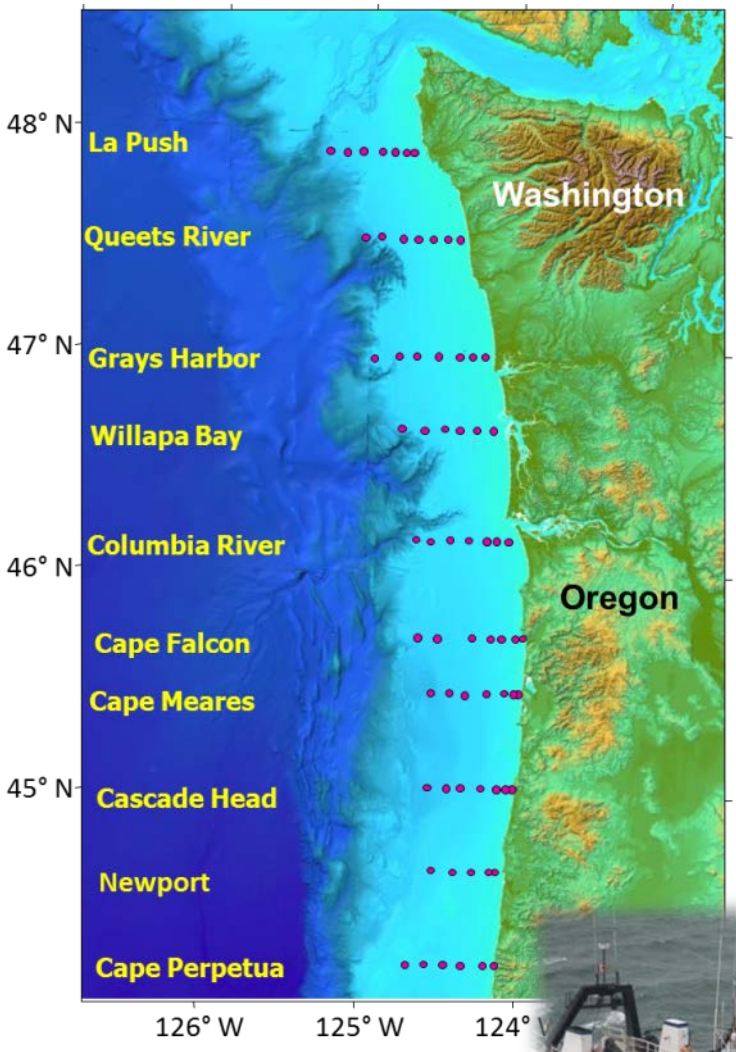
- Large-scale Oceanographic Patterns

  (The blob and El Niño)

- Field Sampling / Data Collection

- Unusual Ecology

Field Sampling



Juvenile salmon sampling:

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

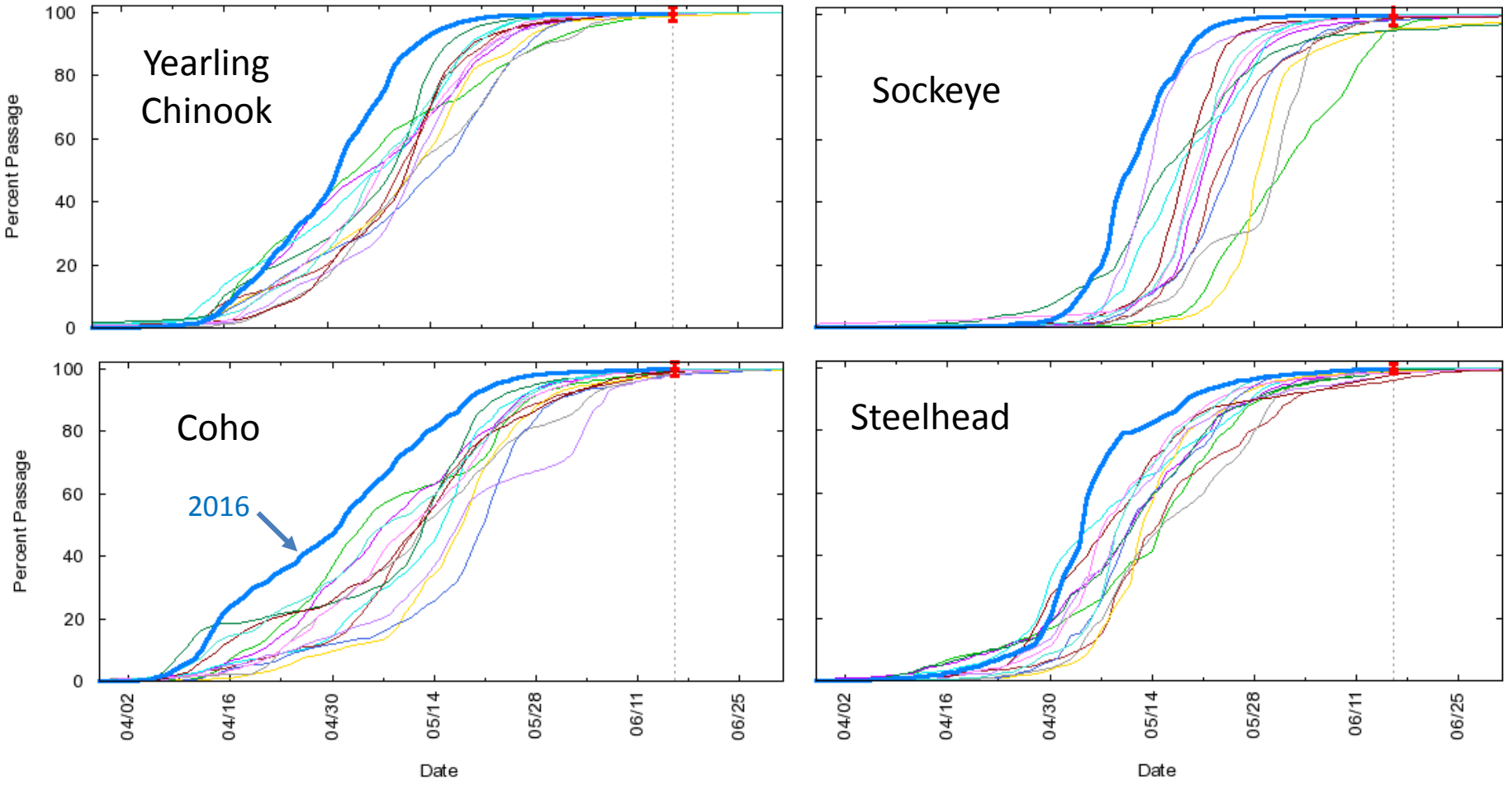
Newport Line

- Biweekly (1996-present)

Micronekton Survey, 30 m

- June (2011, 2013 - 2016)

Early out-migration in 2016



Qualitative Indicator Summary

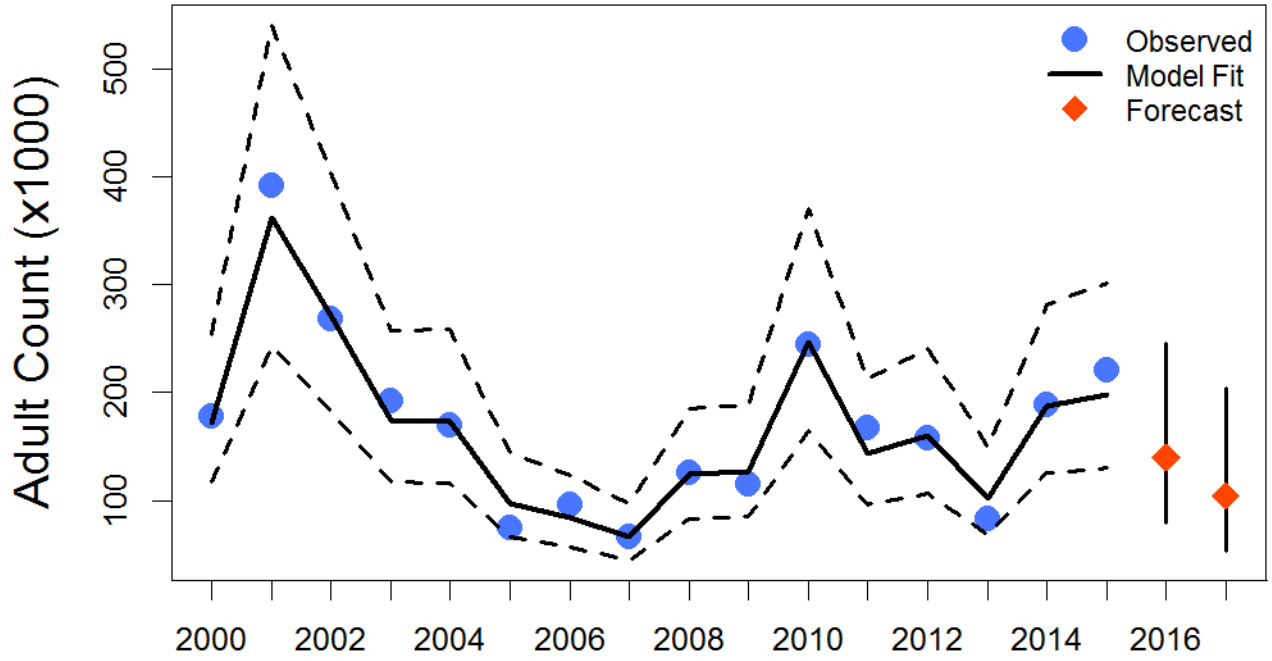
Good – Fair – Poor

	Year																	
Ecosystem Indicators	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*
PDO (Sum Dec-March)	16	6	3	12	7	17	11	15	13	9	5	1	14	4	2	8	10	18
PDO (Sum May-Sept)	10	4	6	5	11	15	14	16	12	13	2	9	7	3	1	8	17	18
ONI (Average Jan-June)	18	1	1	6	12	14	13	15	8	11	3	10	16	4	5	7	9	17
46050 SST (°C; May-Sept)	15	8	3	4	1	7	18	14	5	16	2	9	6	10	11	12	13	17
Upper 20 m T (°C; Nov-Mar)	17	11	8	10	6	14	15	12	13	5	1	9	16	4	3	7	2	18
Upper 20 m T (°C; May-Sept)	14	11	13	4	1	3	18	16	7	8	2	5	12	10	6	15	17	9
Deep temperature (°C; May-Sept)	18	6	8	4	1	9	12	14	10	5	2	7	13	11	3	17	16	15
Deep salinity (May-Sept)	18	3	7	4	5	14	15	8	6	1	2	11	16	10	9	13	17	12
Copepod richness anom. (no. species; May-Sept)	17	3	1	7	6	13	12	16	14	11	8	10	15	4	5	2	9	18
N. copepod biomass anom. (mg C m^{-3}; May-Sept)	17	13	9	10	3	15	12	18	14	11	6	8	7	1	2	4	5	16
S. copepod biomass anom. (mg C m^{-3}; May-Sept)	18	2	5	4	3	13	14	17	12	10	1	7	15	9	8	6	11	16
Biological transition (day of year)	17	11	6	7	8	12	10	16	15	3	1	2	14	4	9	5	13	18
Ichthyoplankton biomass (mg C 1000 m^{-3}; Jan-Mar)	18	9	2	5	7	16	15	11	14	13	1	10	3	12	8	6	17	4
Chinook salmon juvenile catches (no. km^{-2}; June)	17	4	5	15	10	12	16	18	11	8	1	6	7	14	3	2	9	13
Coho salmon juvenile catches (no. km^{-2}; June)	17	7	12	5	6	2	14	18	15	3	4	9	10	13	16	1	11	8

http://www.nwfsc.noaa.gov/oceanconditions

Spring Chinook at Bonneville Dam

March 15 – May 31



Outlook for 2016: 142K

Observed in 2016: 137K

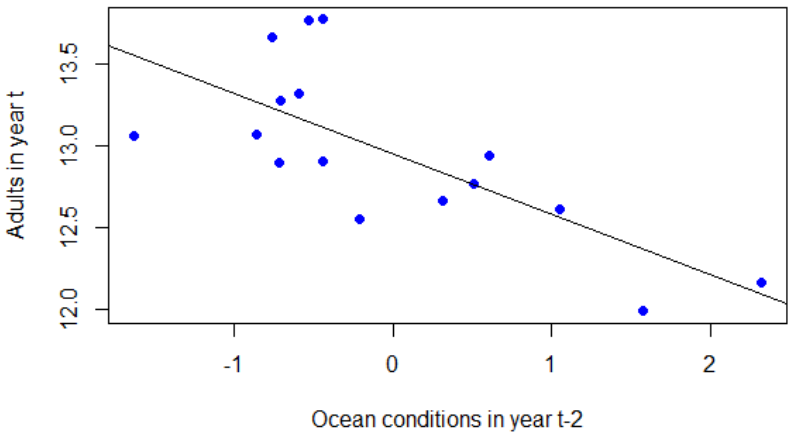
Dynamic Linear Models

With jack counts and the first Principal Component of the stoplight chart variables

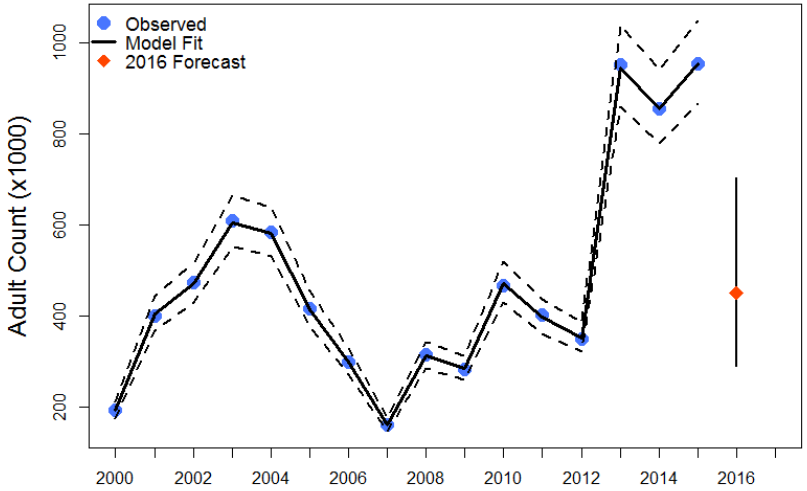
Data from Columbia Basin Research, DART

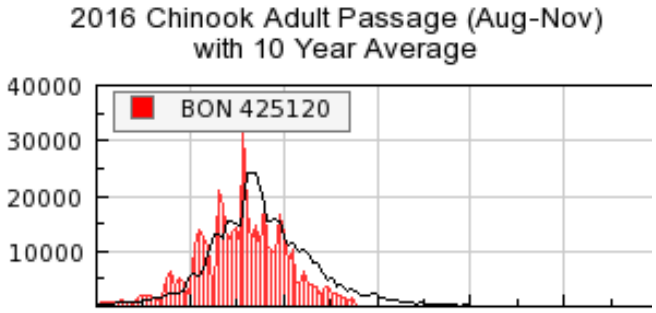
Fall Chinook at Bonneville Dam

Simple linear regression
2016 returns ~ 500K



Fancier, time-series model (DLM)
2016 returns ~ 450K

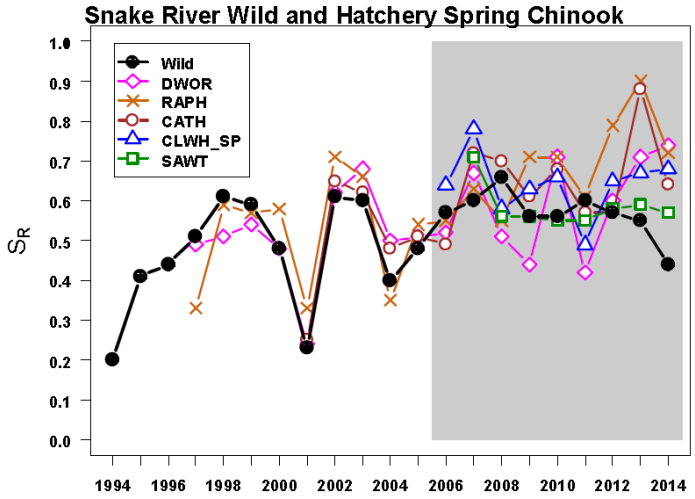




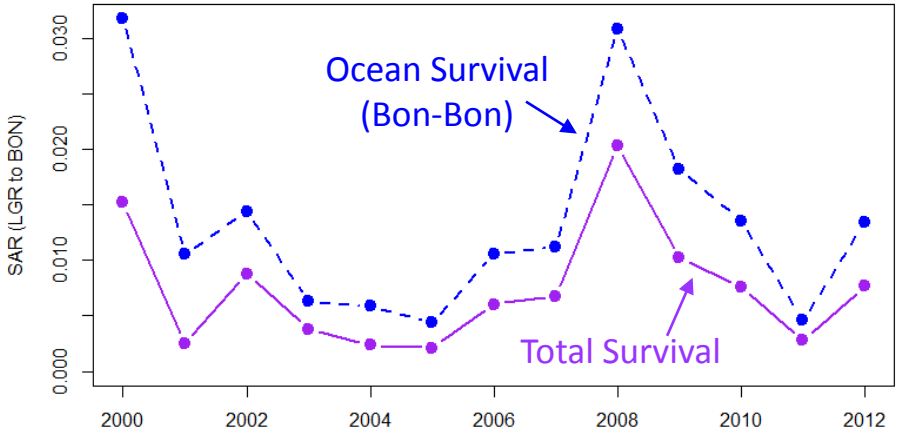
http://www.cbr.washington.edu/dart/quick_look/adult

Where is the source of variability?

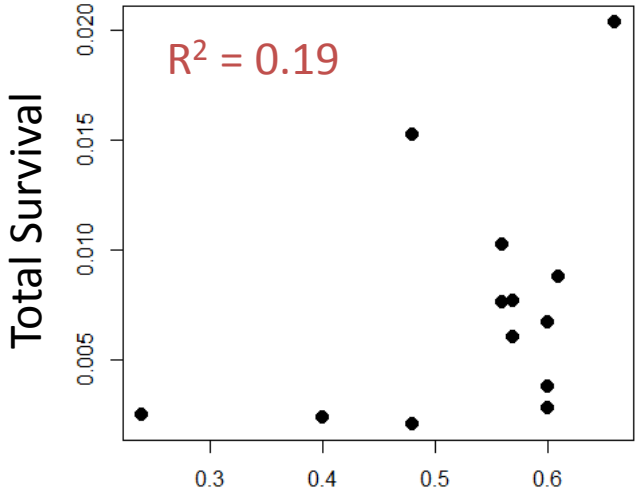
Wild and hatchery Chinook

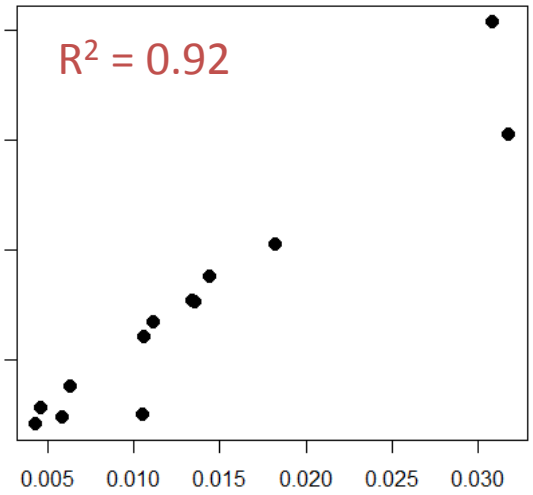


Obtained from CSS – 2015 Annual Report

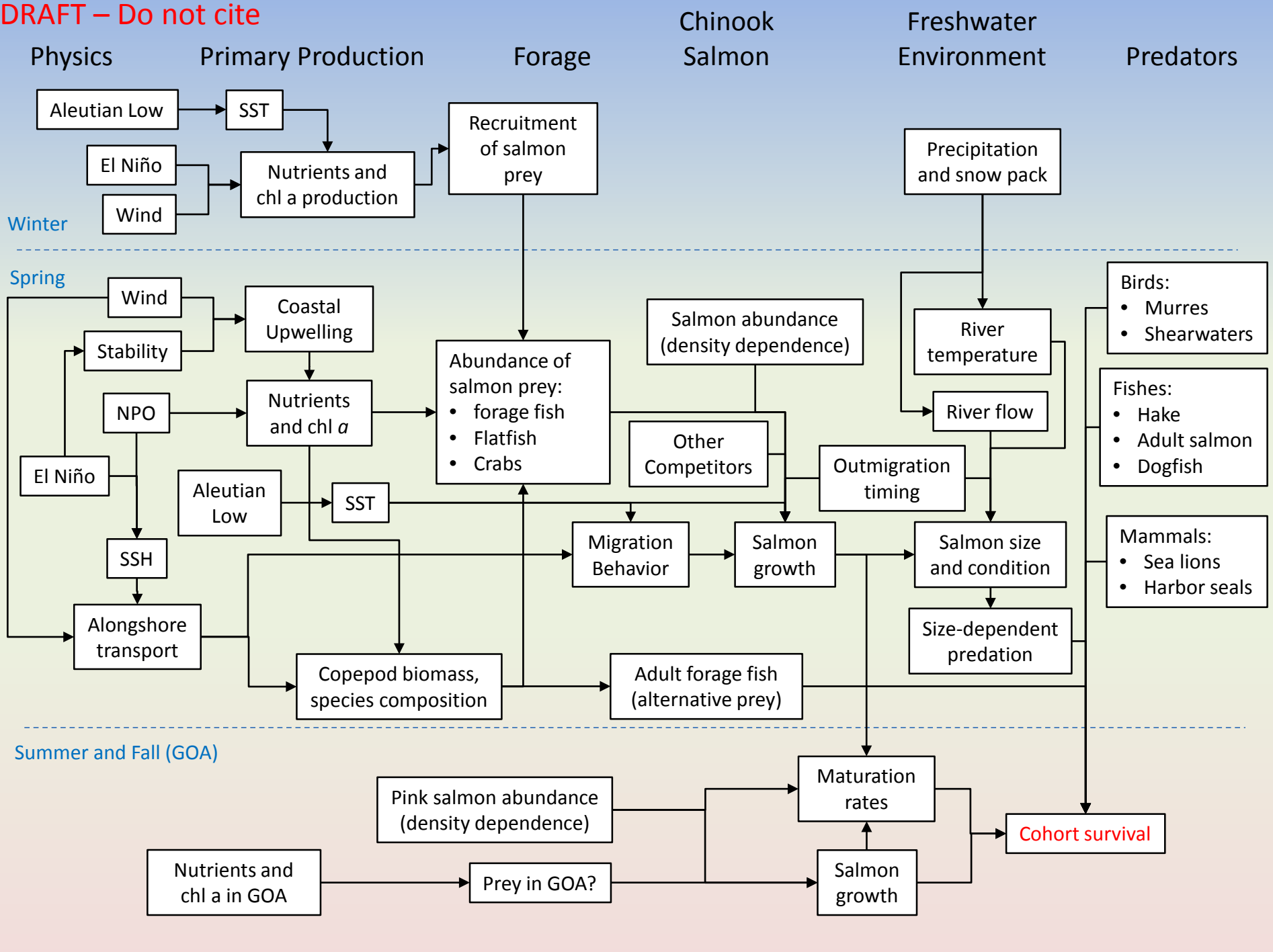


Raw data from PTAGIS, survival estimated by B. Burke





DRAFT – Do not cite



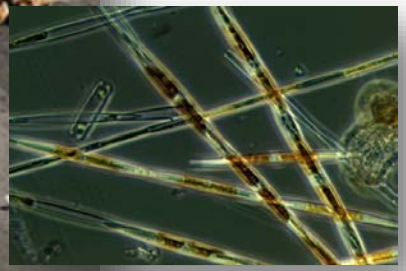
- Large-scale Oceanographic Patterns

  (The blob and El Niño)

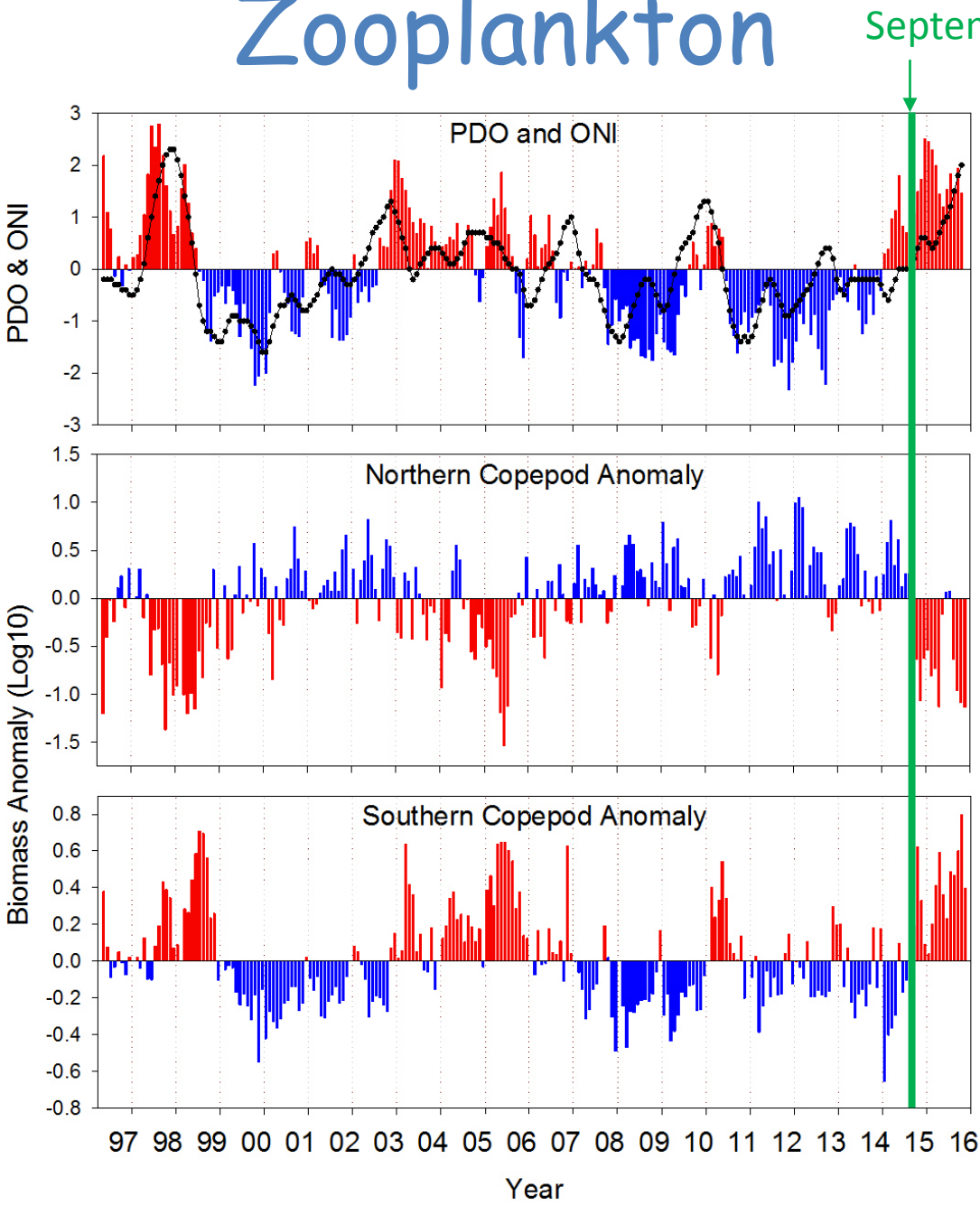
- Field Sampling / Data Collection

- Unusual Ecology

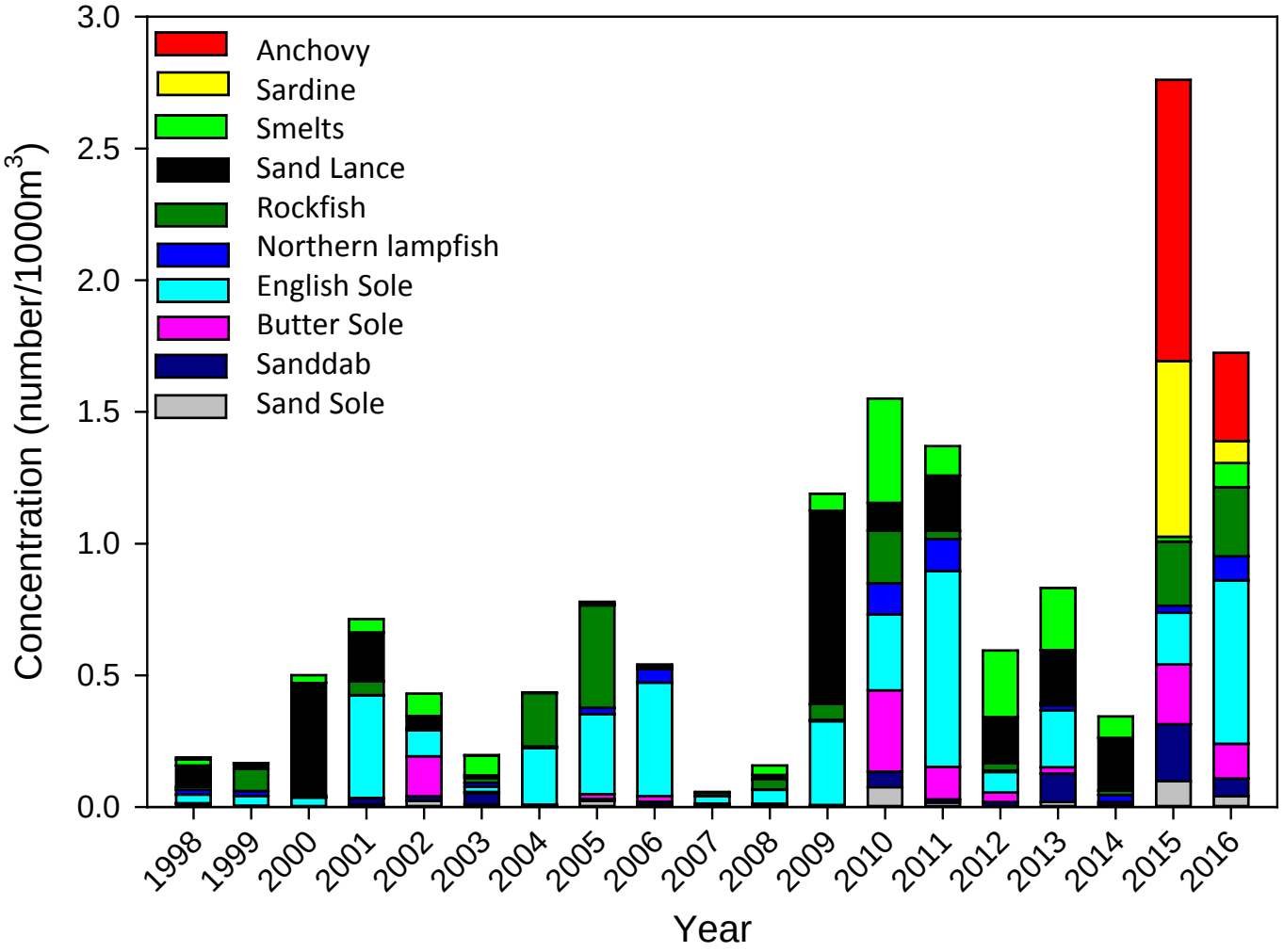
Unusual Ecology



Zooplankton



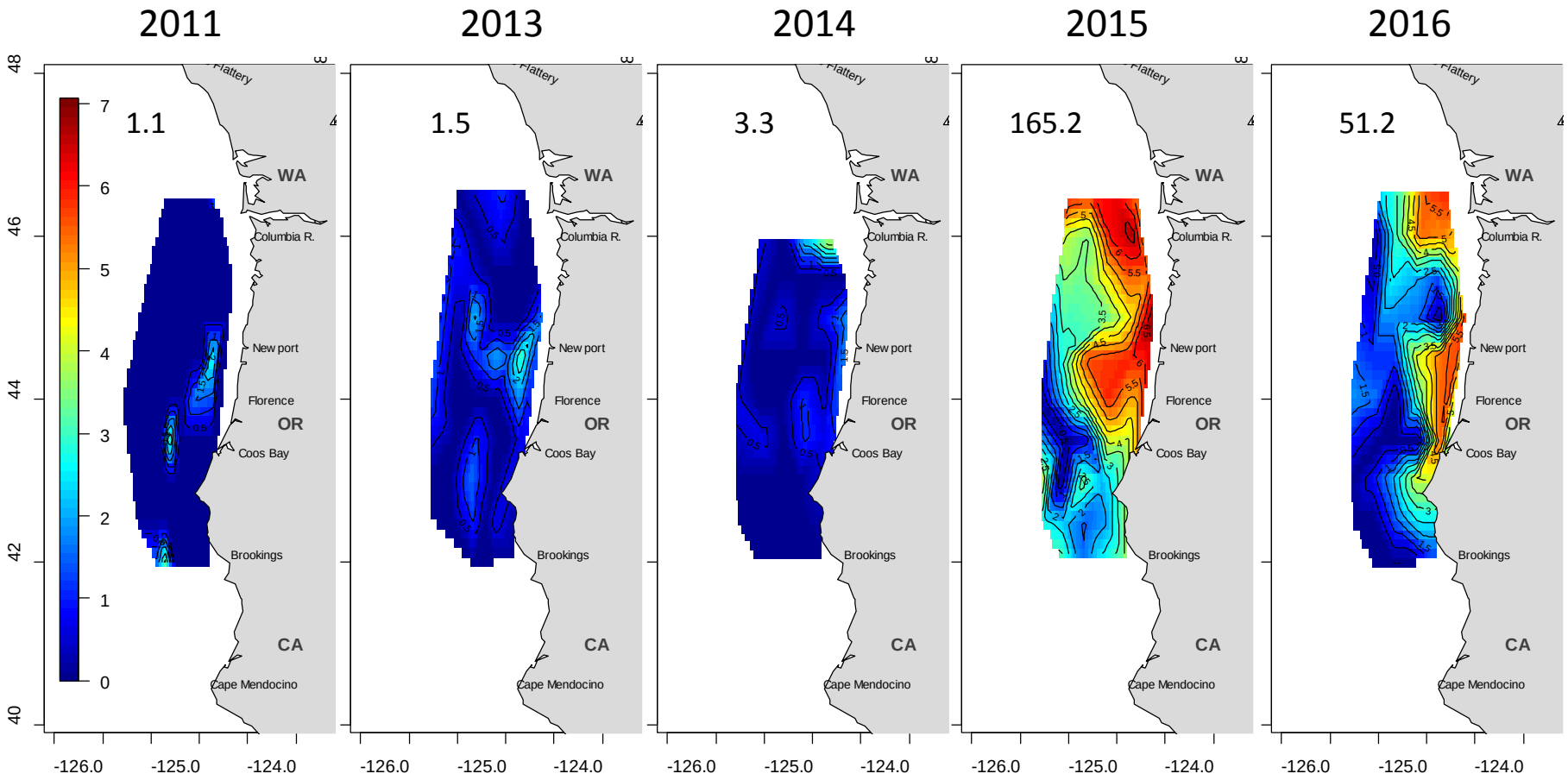
Winter (Jan. – March) Ichthyoplankton from Newport Line Samples



- Earliest (by three months) and most widespread spawning of anchovies and sardines in NCC
- Also found Pacific hake and jack mackerel eggs and larvae off Newport
- Both years had a diversity of larvae represented in the winter samples

Auth et al. (In prep.)

Water Jellies (*Aequorea victoria*)

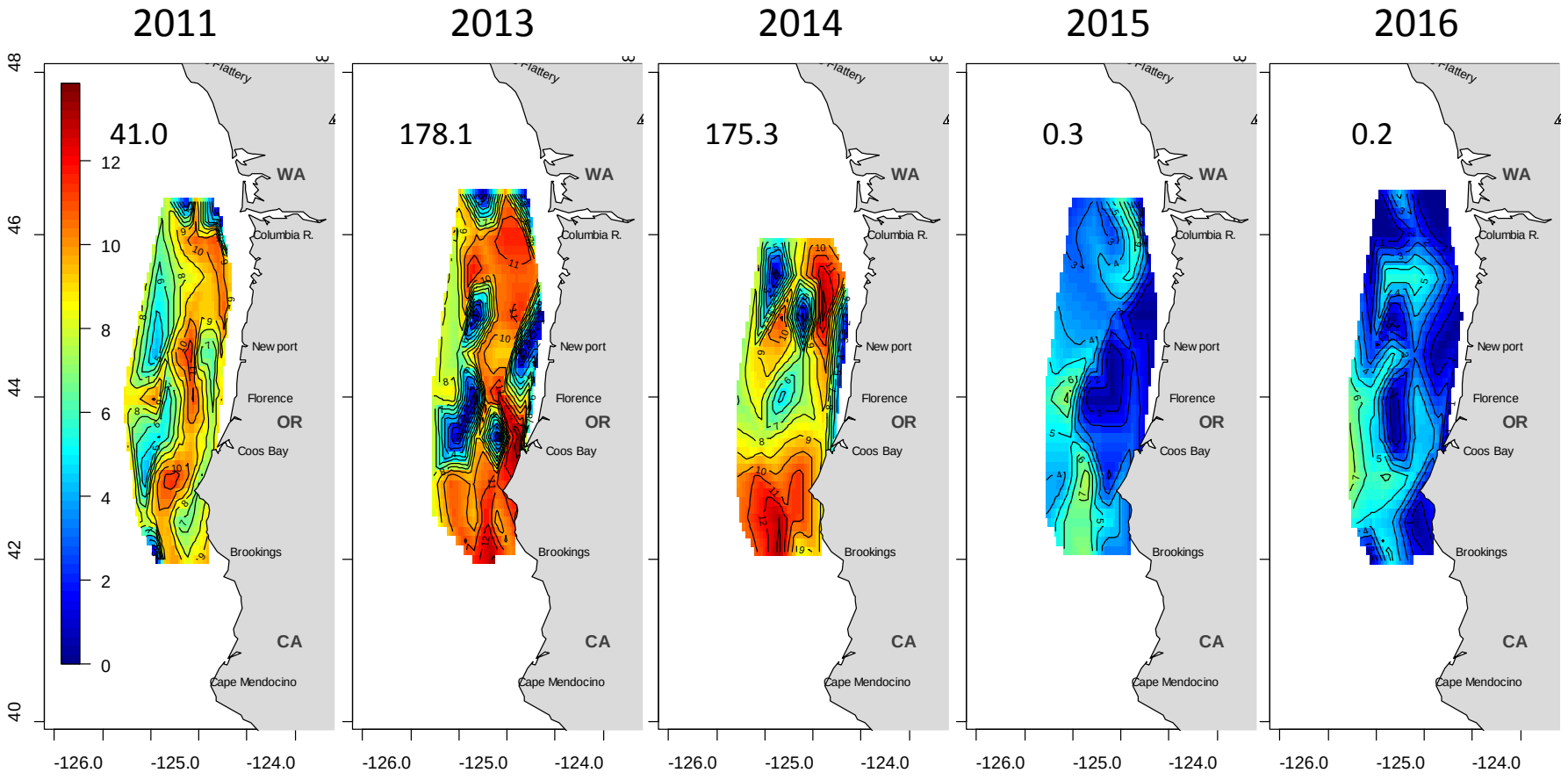


Scale bar = log (abundance)

Number = Geometric mean abundance

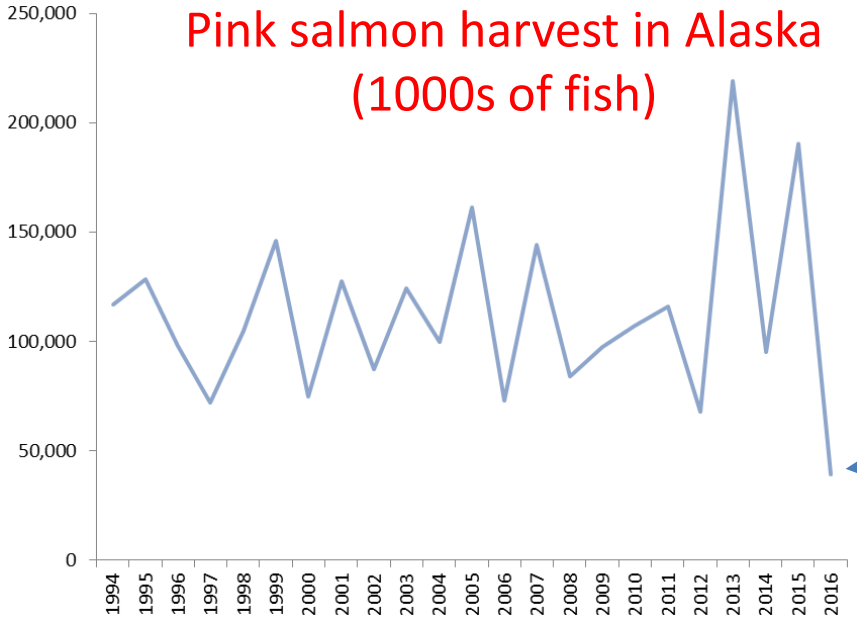
Data from Ric Brodeur, NOAA Fisheries

Total Krill
Euphausiidae



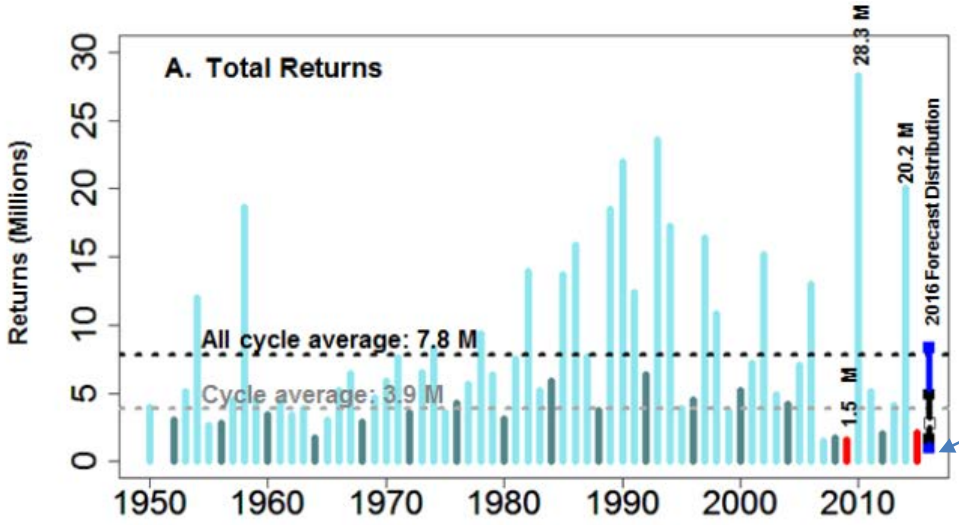
Data from Ric Brodeur, NOAA Fisheries

Pink salmon harvest in Alaska (1000s of fish)



http://www.adfg.alaska.gov/index.cfm?adfg=commercialbyfisherysalmon.salmoncatch

Fraser River Sockeye



Fisheries and Oceans Canada

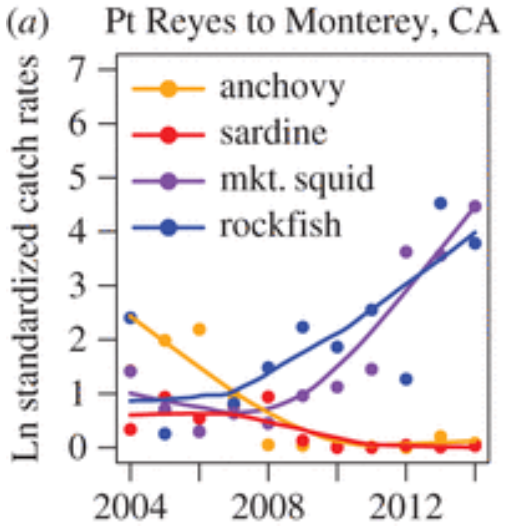


Figure 2a from McClatchie et al. 2016. Royal Society Open Science

Overall, the taxa most responsible for regime diet composition differences were changes in the amount of juvenile rockfishes eaten…

-Daly et al. 2015. PLoS One 10:e0144066

Science, Service, Stewardship

Ocean Conditions and Pinnipeds

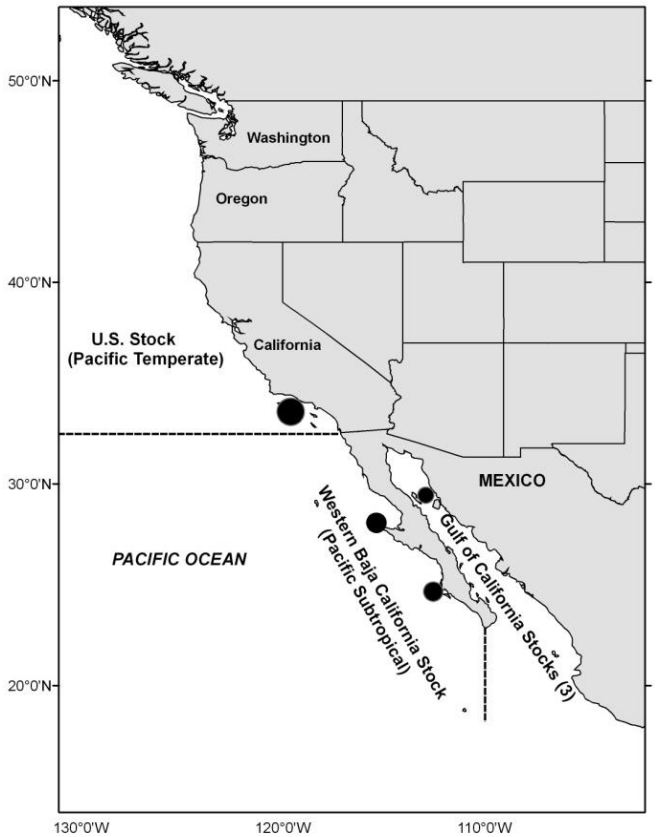
Northwest Power and Conservation Council
Fish and Wildlife Committee

October 11, 2016

Robert Anderson
National Marine Fisheries Service

NOAA FISHERIES SERVICE

California Sea Lions



Distribution – (U.S.) Channel Islands to Alaska – only males migrate.

Status - Five stocks (4 in Mexico).

U.S. Stock – 296,750 (NMFS: MMSAR 2014).

Growth Rate: 5% per year (except El Nino years).

Last 4 years significant pup mortality rates - population likely significantly less than the 2014 population estimate.

However, males, 8 years and older, are likely at their peak abundance.

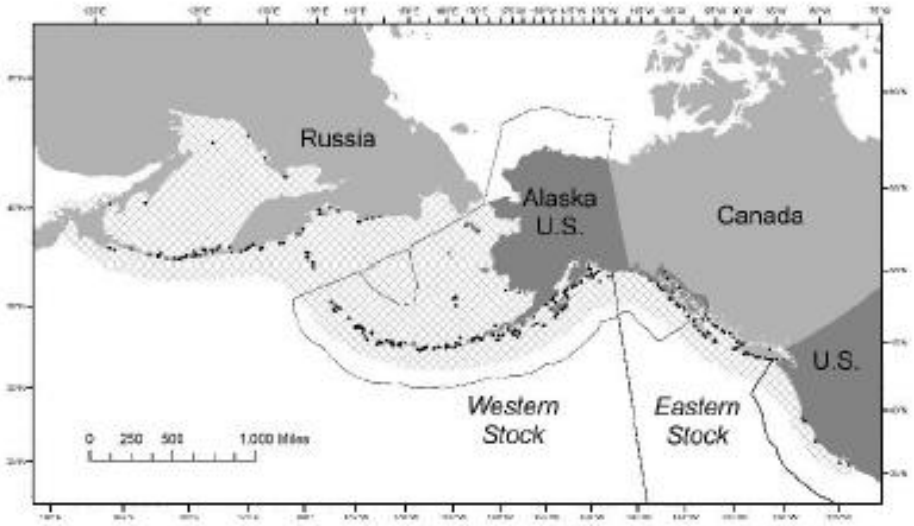
Pacific Northwest

Seasonal migrants (fall, winter, spring).

Nearly all sub-adult and adult males.

California sea lions breed in July and August

Steller Sea Lions



Distribution - California to Alaska (Eastern DPS).

Status - U.S. stocks (2): Western, Eastern (East of 144 degrees West)

Eastern Stock: 63,000-78,000 sea lions (NMFS: MMSAR 2013)

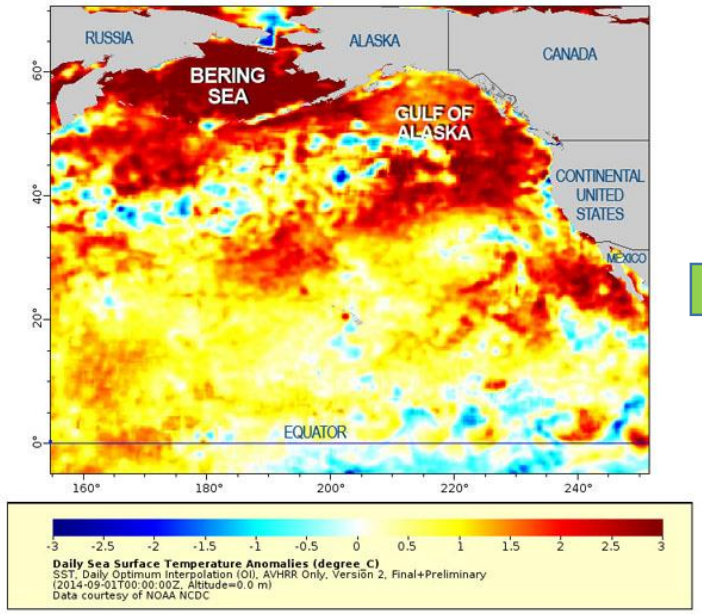
Growth Rate: 3%-5% per year.

Listed as a threatened species in 1990.

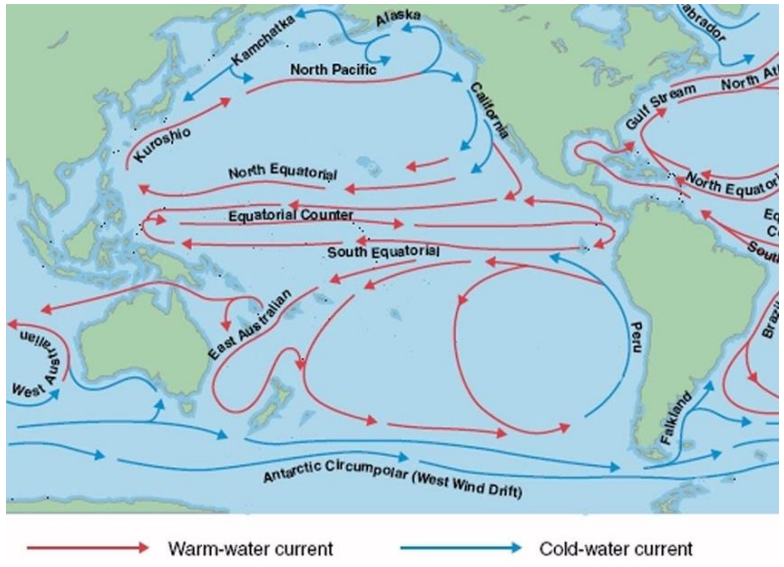
Steller sea lions were delisted in 2013.

Steller sea lions are colonial breeders — breeding occurs in May

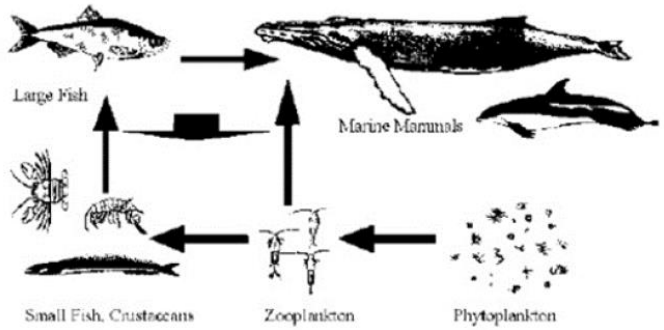
Ocean Conditions, Food Productivity, and Effects on Pinnipeds



Affects



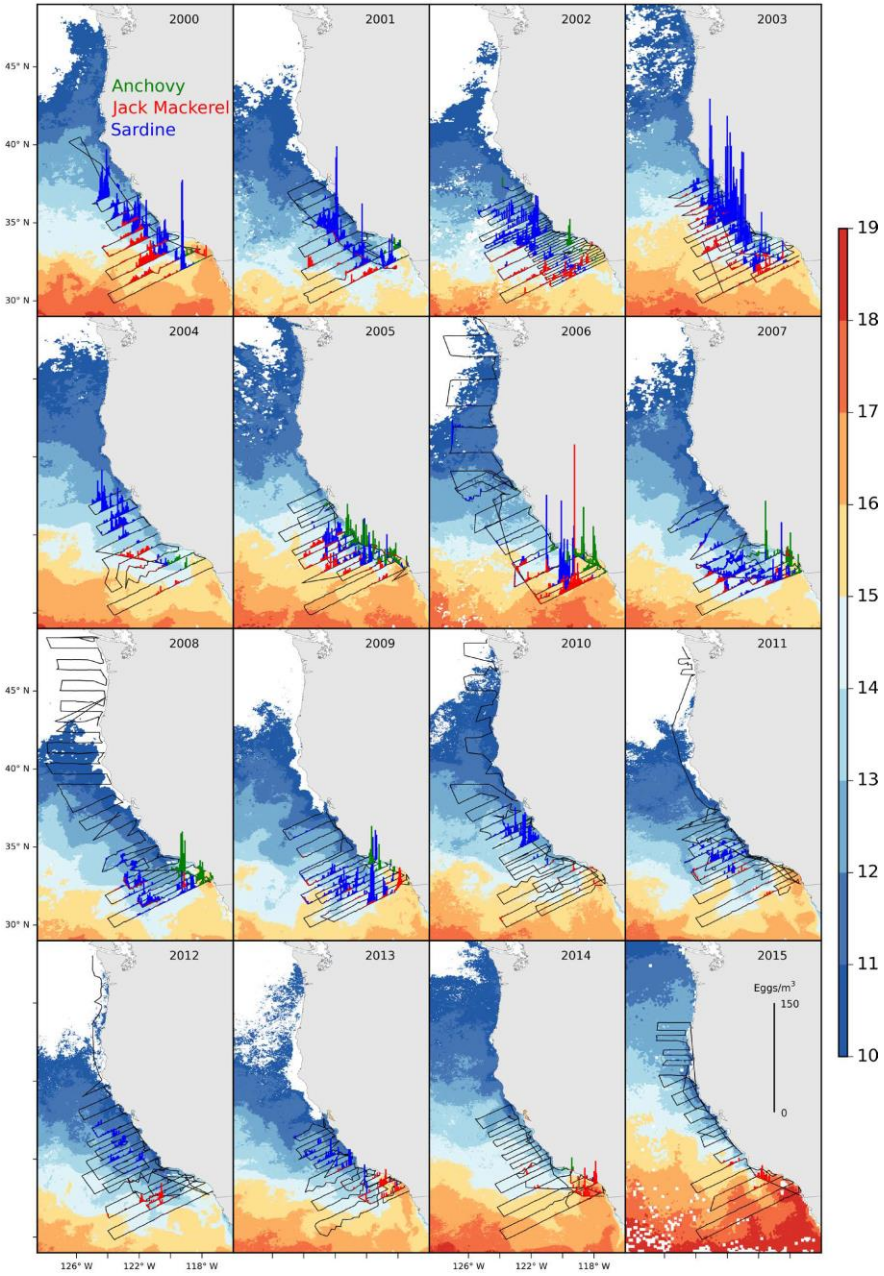
Affects



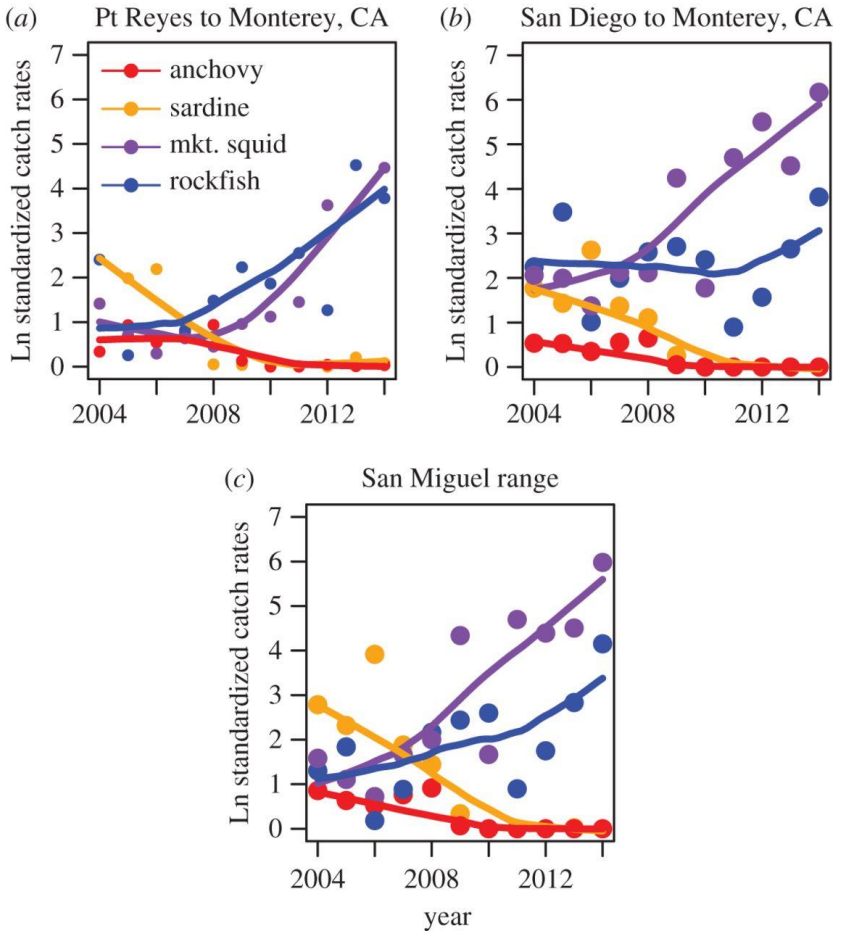
Affects

Thermoregulation

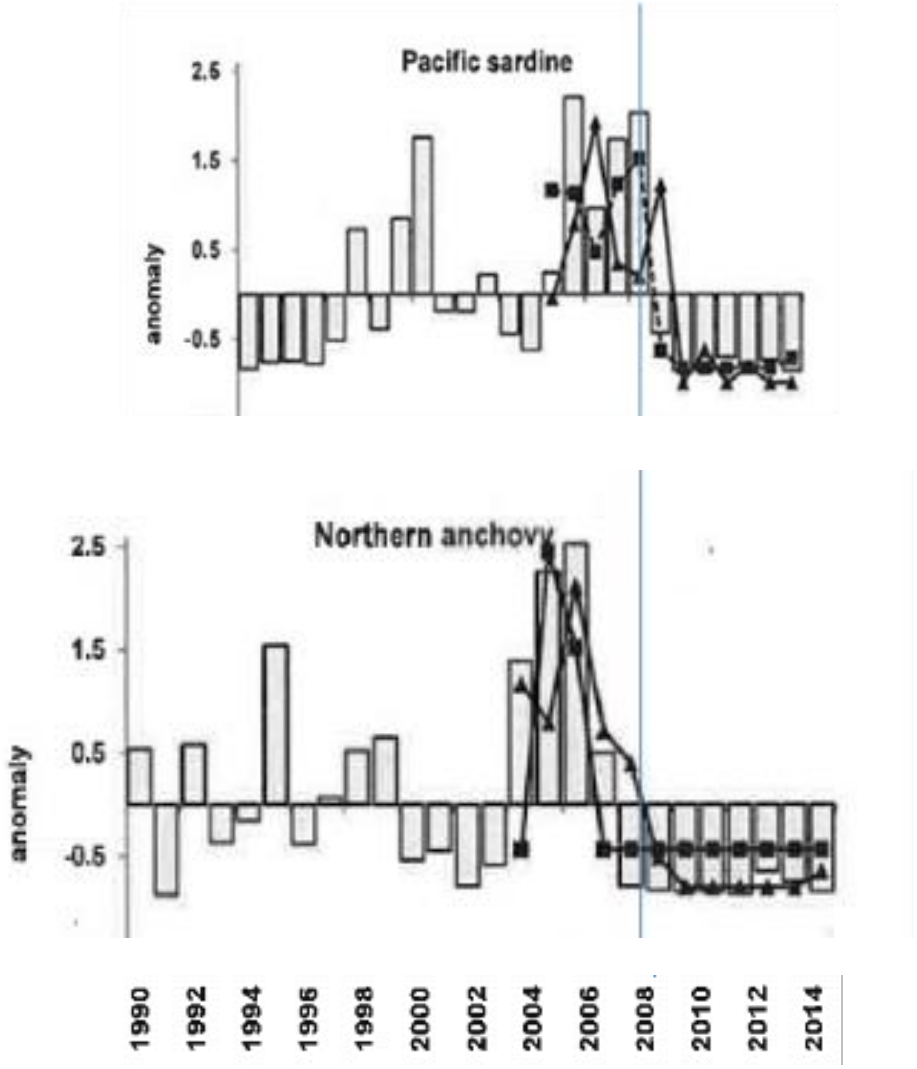
- Mammals are homeothermic endotherms with a high (36 to 38°C) and stable body temperature.
- Water conducts heat away from the body 25 times faster than air.



April Fish Egg Density and SST 2000-2015 (Leising et al. 2015)



Time series from 2004 to 2014 of relative abundance
of forage fish from the fishery-independent Rockfish Recruitment Ecosystem Assessment Survey
conducted in summer off southern and central California (McClatchie et al. 2016)



Leising et al. 2015

Prey Species Trends, 1990-2014, in the California Current

2008 Shift from sardine/anchovy to rockfish/market squid

Taxa	cal g−1	total fat g−1
Pacific sardine	2.17	0.124
Northern anchovy	1.31	0.048
Rockfish	0.94	0.016
Market squid	0.92	0.014

McClatchie et al. 2016

California sea lions

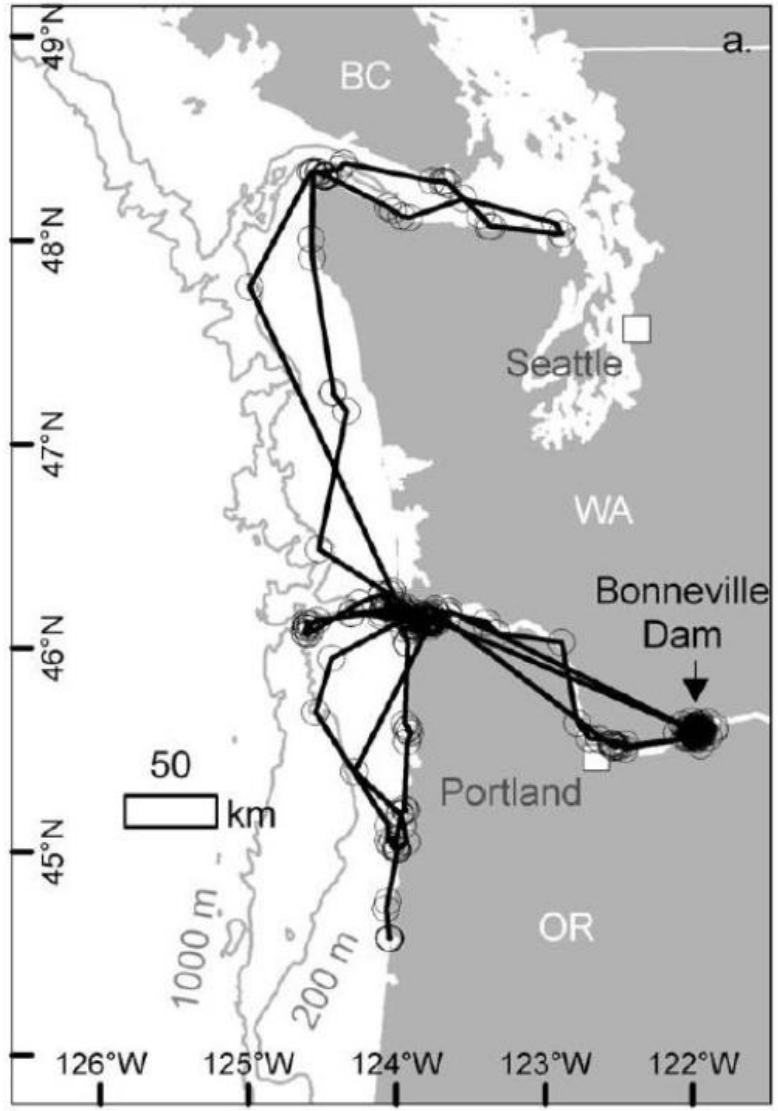
Ocean Diet: feed mainly in upwelling areas on a variety of prey such as squid, anchovies, mackerel, rockfish, and sardines.

River Diet: (males, subadult 4-8 years; adult 8+ years) salmon, smelt, sturgeon.

Steller sea lions

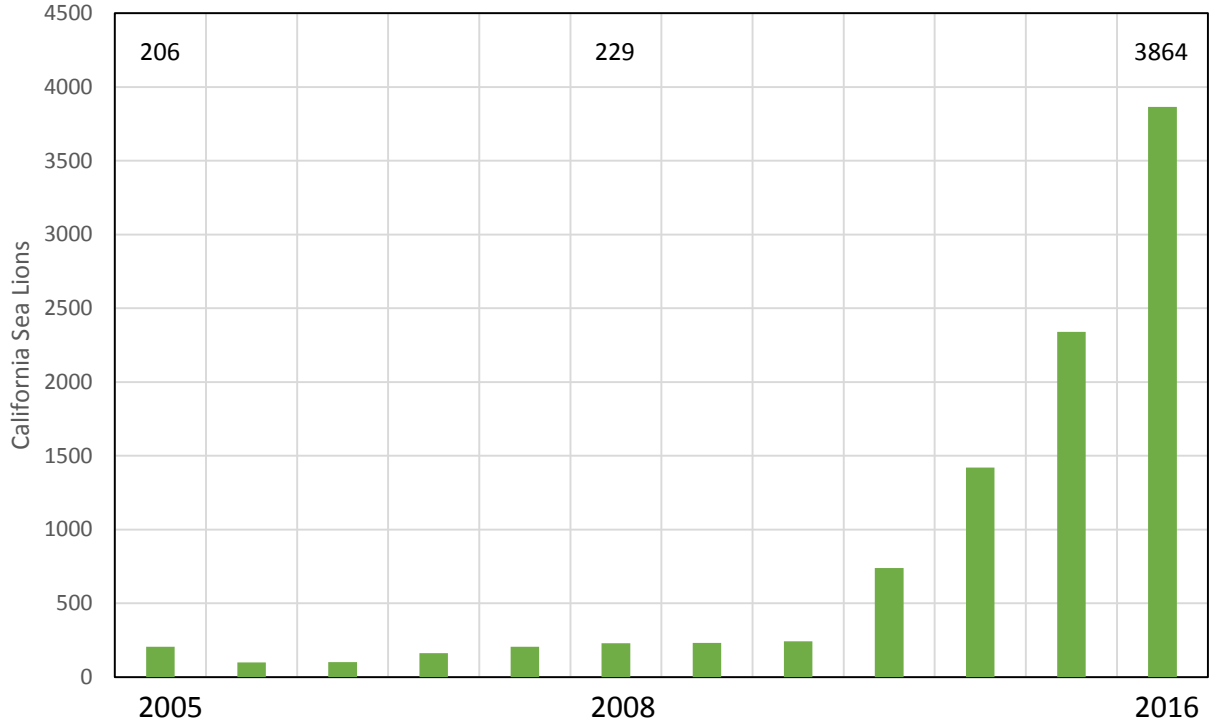
Ocean Diet: feed on a variety of fishes: capelin, cod, herring, mackerel, pollock, rockfish, salmon, sand lance, etc., bivalves, squid, octopus, and gastropods.

River Diet: (males, subadult 6-9 years; adult 9+ years) salmon, smelt, sturgeon.

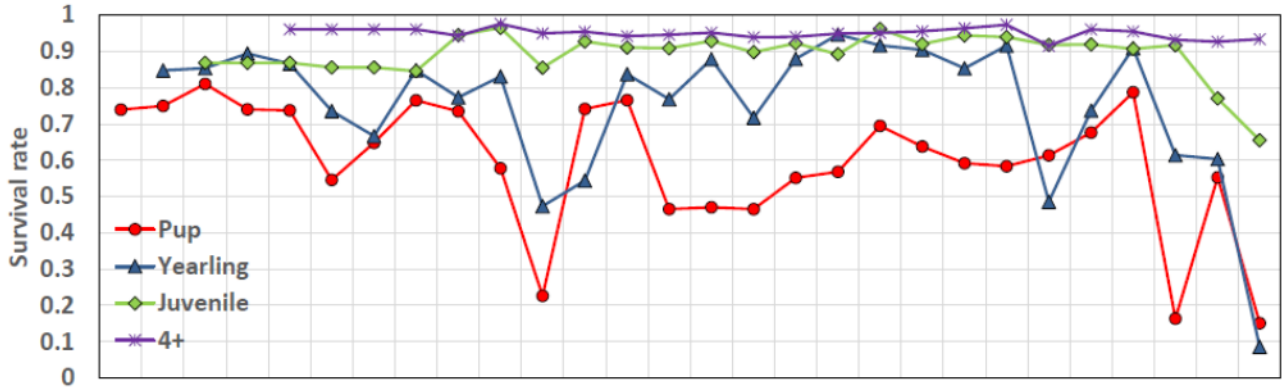


Movement for C265, a “river”-type California sea lion, Tracked from 1 February to 25 May 2007 (Wright et al. 2010)

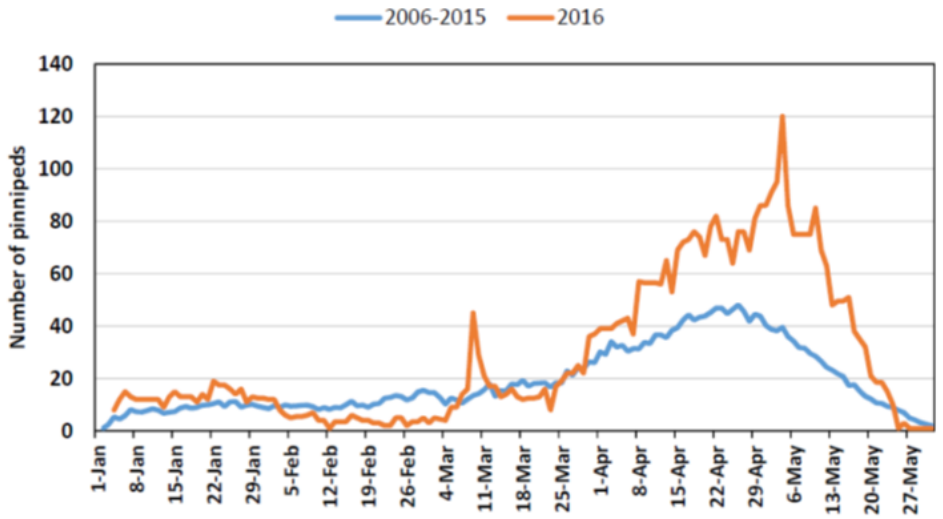
Peak Spring Counts of California Sea Lions in Astoria's East Mooring Basin 2005-2016



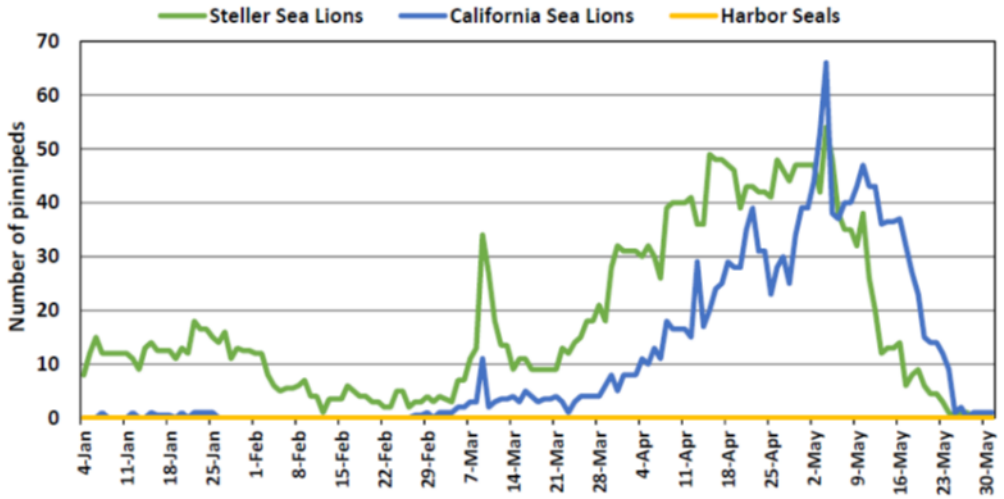
California sea lion survival estimates 1987-2014 (Melin 2016)



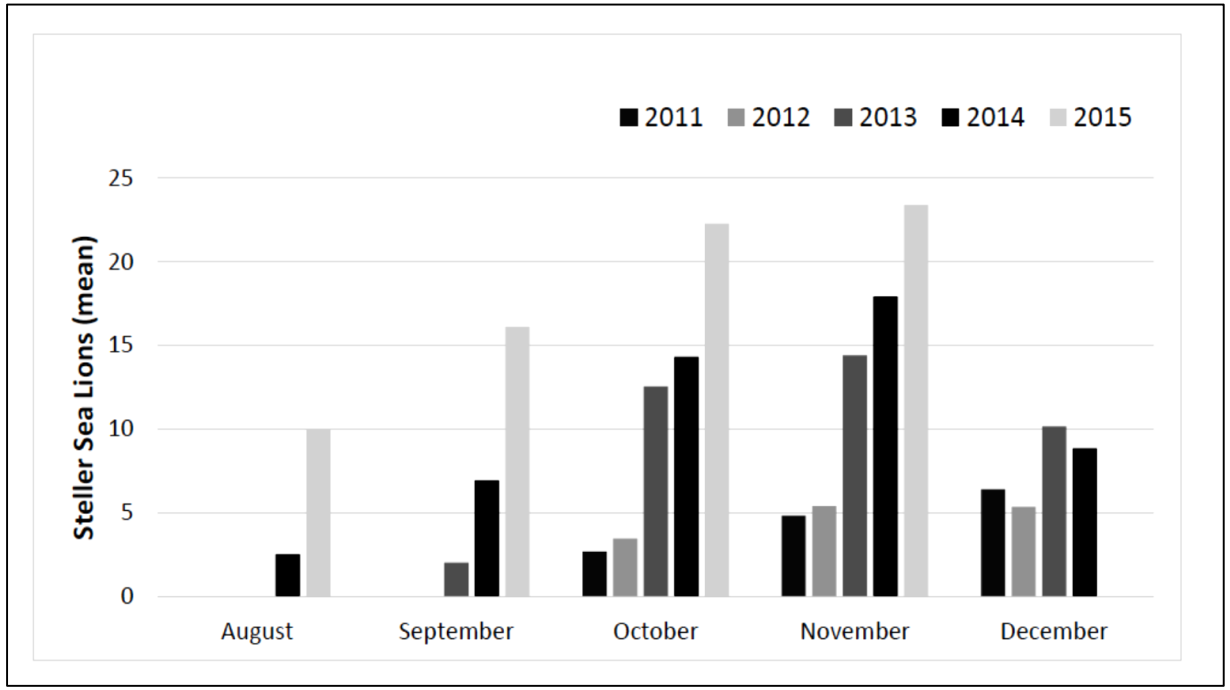
NOAA FISHERIES



California and Steller sea lions combined maximum daily count January 1 through May 31 at Bonneville Dam (Corps 2016)



Maximum daily count of pinnipeds by species through May 31, 2016 at Bonneville Dam (Corps 2016)



Monthly mean Steller sea lion abundance from August through December, 2011-2015. Data was not collected in 2011 and 2012 for August and September.

QUESTIONS?

Northern Anchovy (*Engraulis mordax*)

Pacific Sardine (*Sardinops sagax*)