Columbia Basin Partnership Workshop #1

The Estuary, Ocean and Salmon

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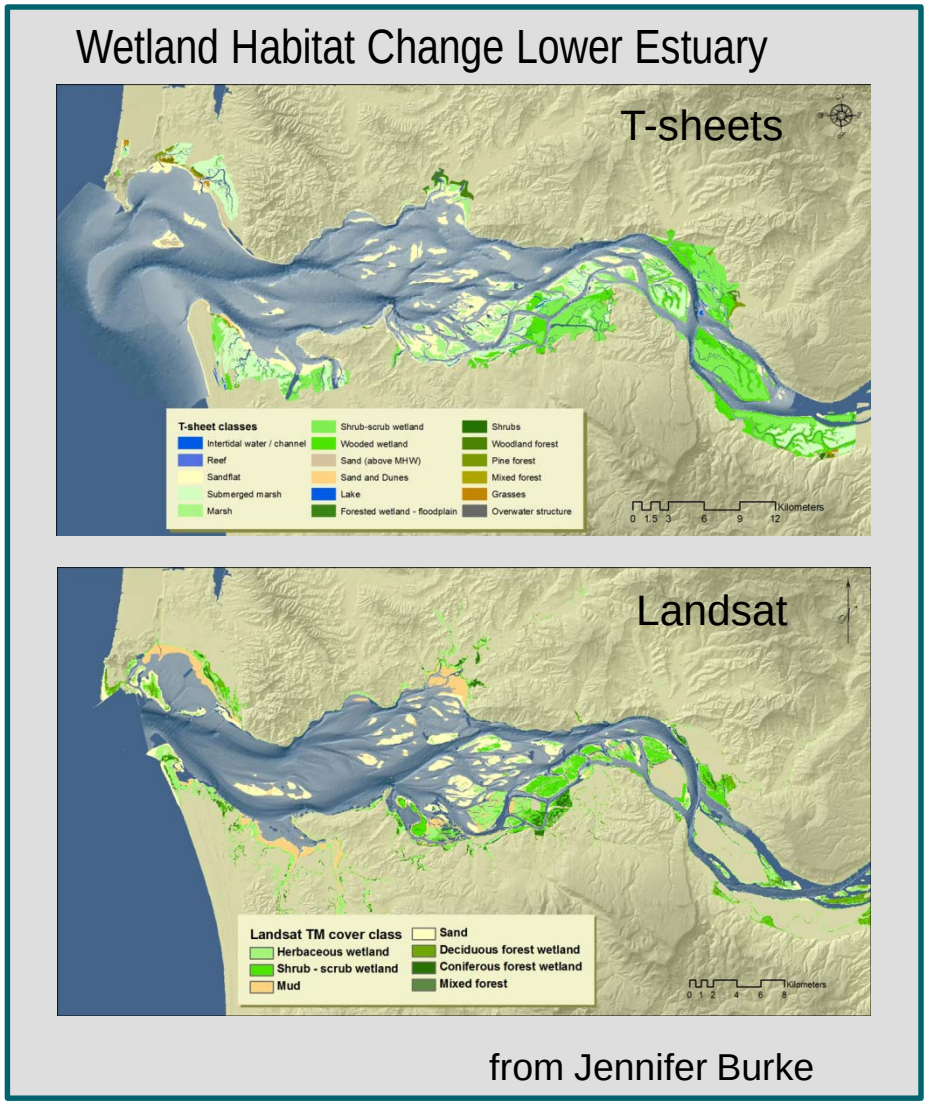
Salmon and The Columbia River Estuary

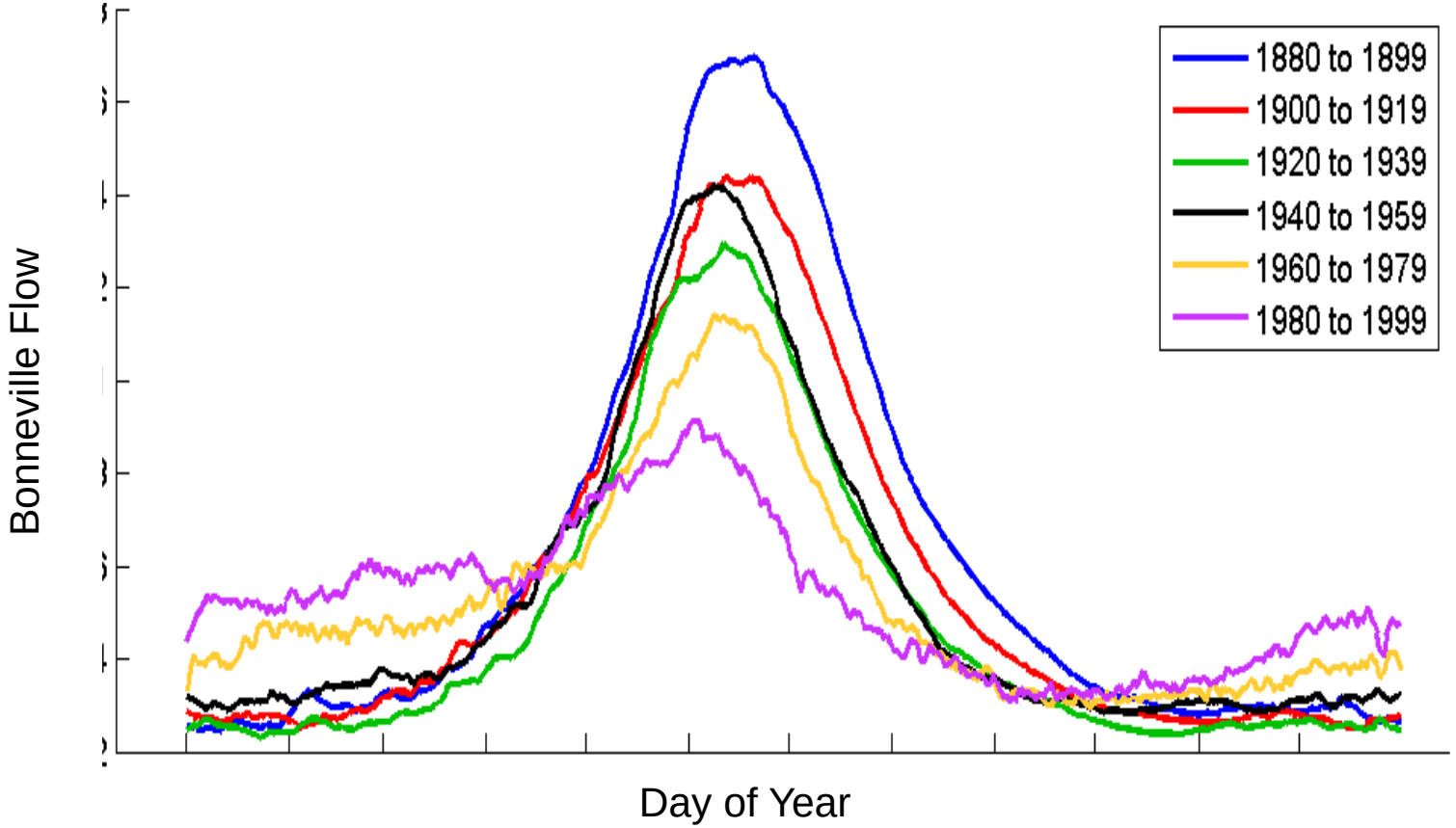
Dramatic Changes in Amount and Distribution of Estuary Habitat has Occurred

Historical floodplain habitat (mouth to Bonneville) ~1468 km^2
68% to 70% of tidal wetlands (mouth to Bonneville Dam) lost to diking, filling, and flow changes

(After Keith Marcoe and Steve Pilson. 2011. *Habitat change in the Lower Columbia River and Estuary, 1870 – 2010.* Lower Columbia Estuary Partnership, Portland, Oregon)



Bonneville Flow

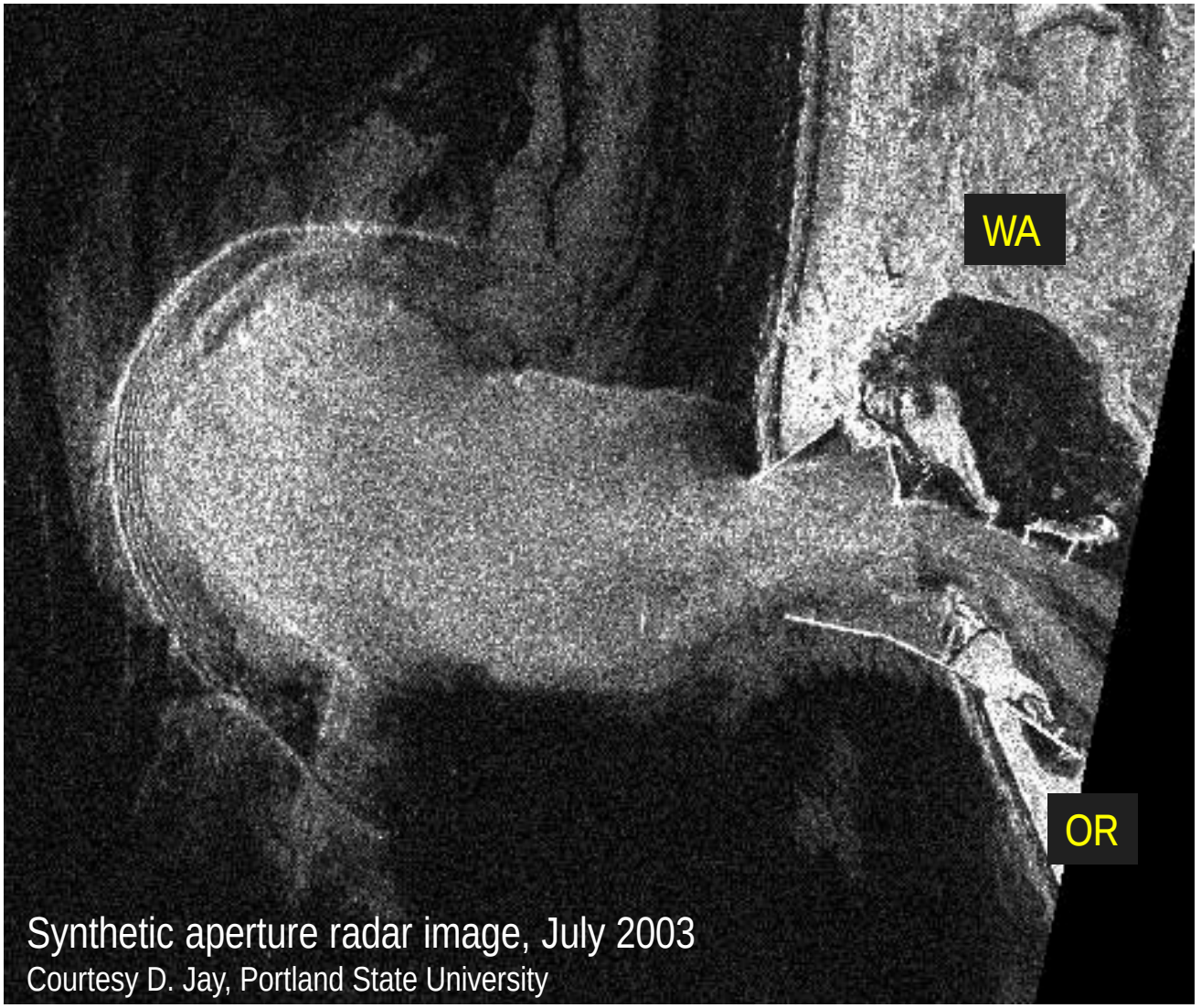


The Plume

Freshwater from the Columbia River mixing with the ocean

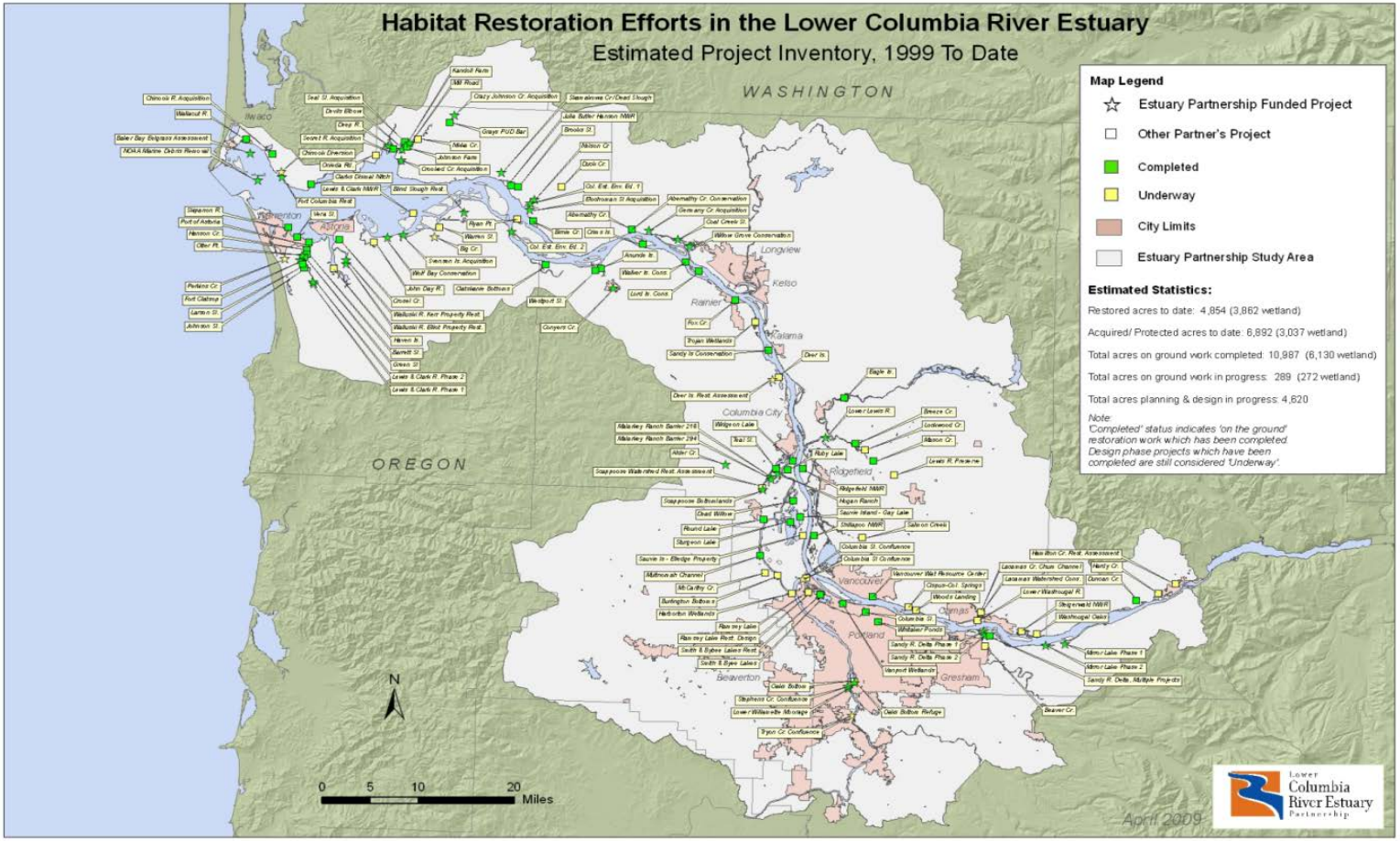
About **44% of variability in plume volume is explained by Bonneville river discharge. Coastal winds explains ~30% of the variability in plume volume.**

Dynamic nature of Plume

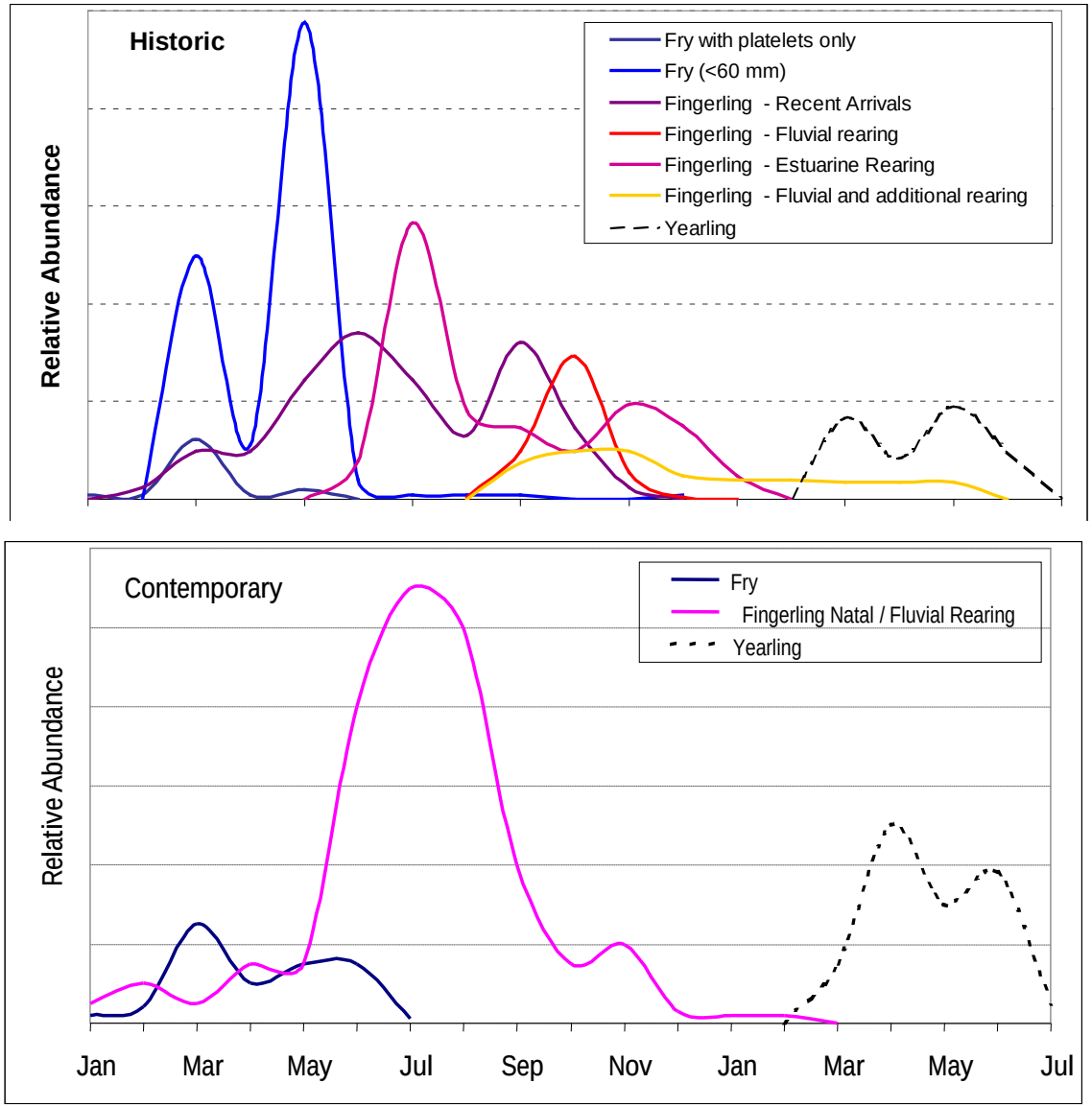


Synthetic aperture radar image, July 2003
Courtesy D. Jay, Portland State University

Major Investments in Wetland Restoration in the Columbia River Have Occurred



Changes in How Salmon Use the Estuary



Estimated proportions of juvenile salmon life histories from historical and contemporary surveys

From Burke, 2005. Data from Rich (1920) & Dawley et al. (1985)

Use of the Columbia River Estuary by Juvenile Salmon

- **Use of the Estuary (Habitat and Timing) Varies with Species, Stock/Population (Spring vs Fall), and Life History Type (Yearling vs. Sub-yearling).**

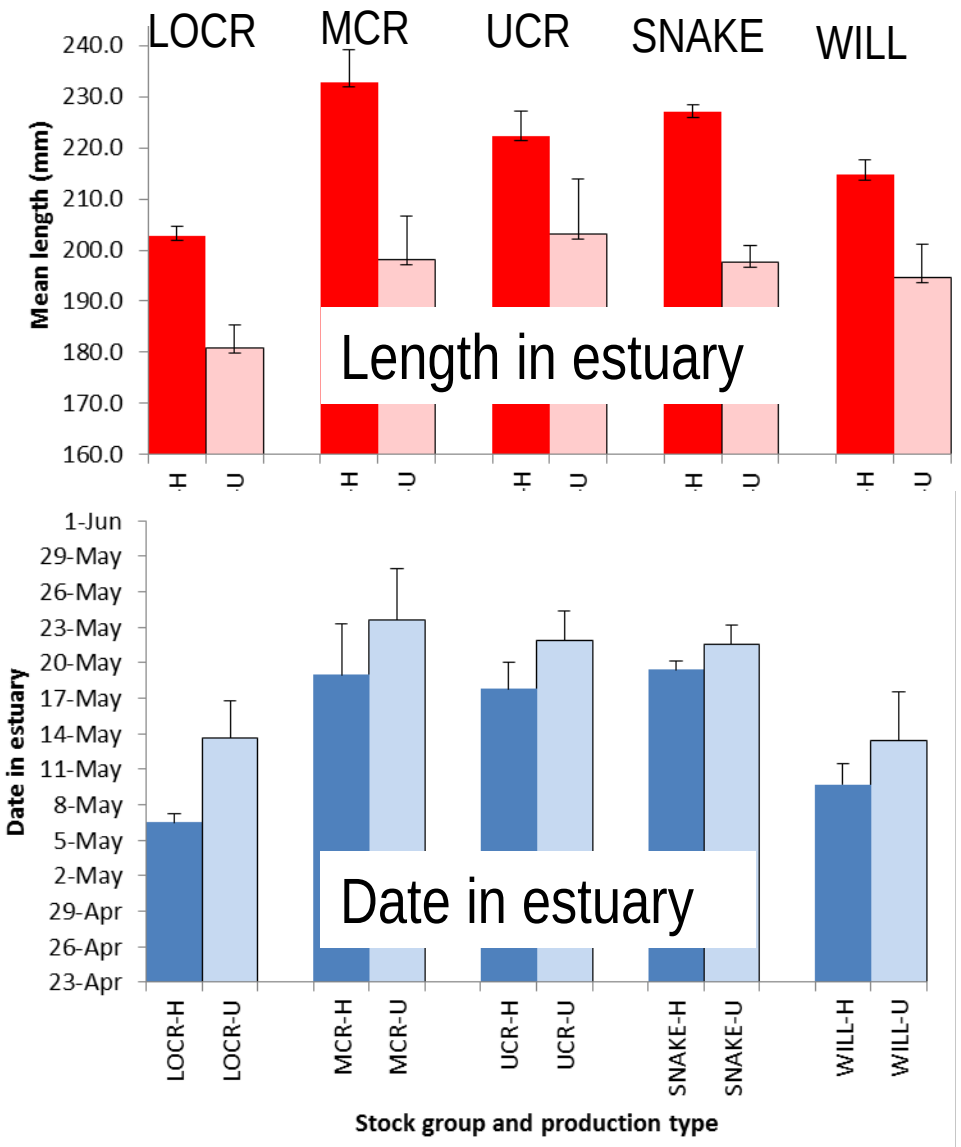
- **Where you have been and what you are help determine where you are going.**

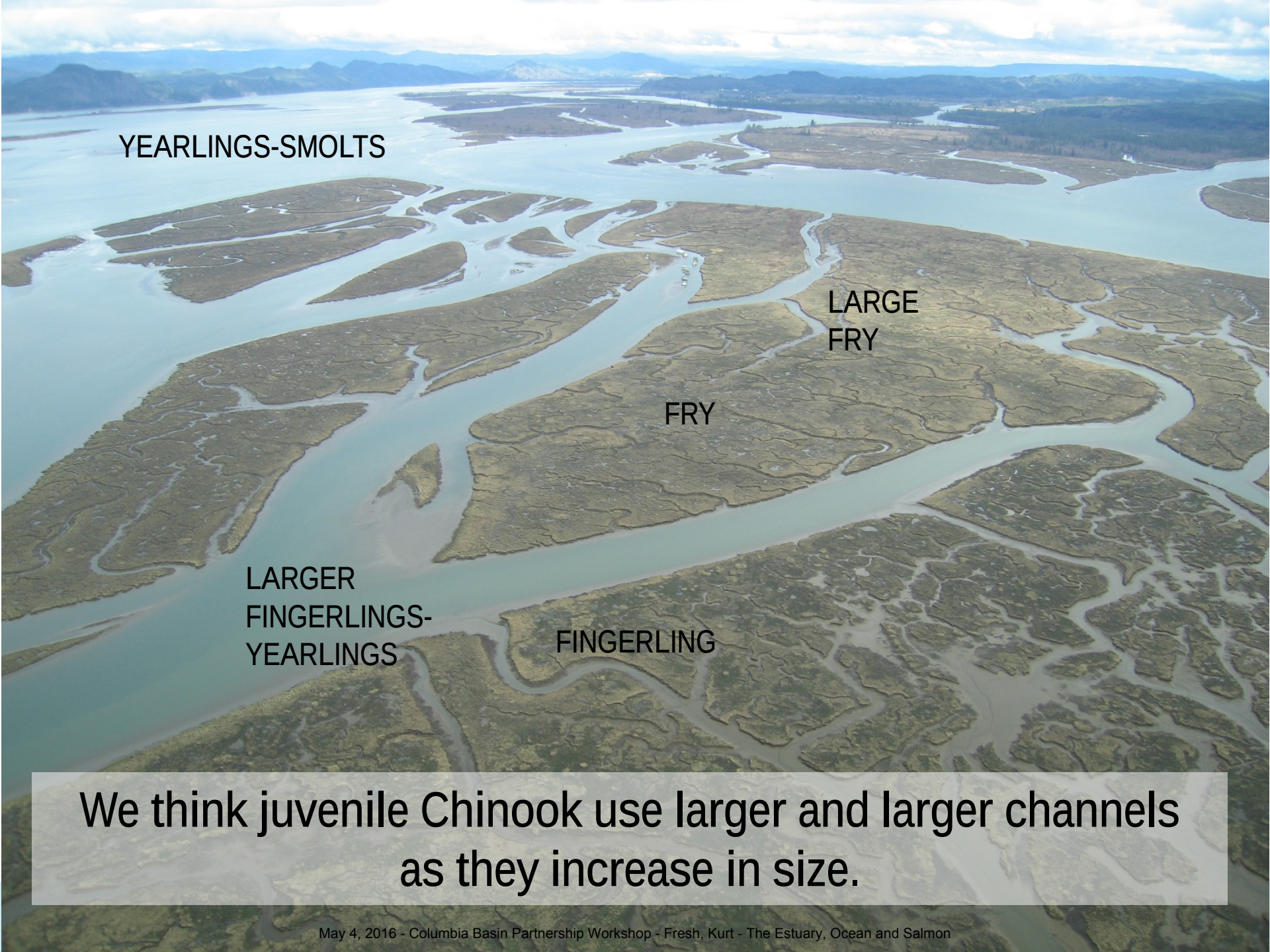
Steelhead Timing and Size in Estuary

Based on genetics, CWTs, PIT tags

- Stock-specific and hatchery (H) and unclipped (U) differences
- Despite huge size differences, H-U timing very similar

Dark bars: Hatchery
Light bars: Unclipped (=H+W)





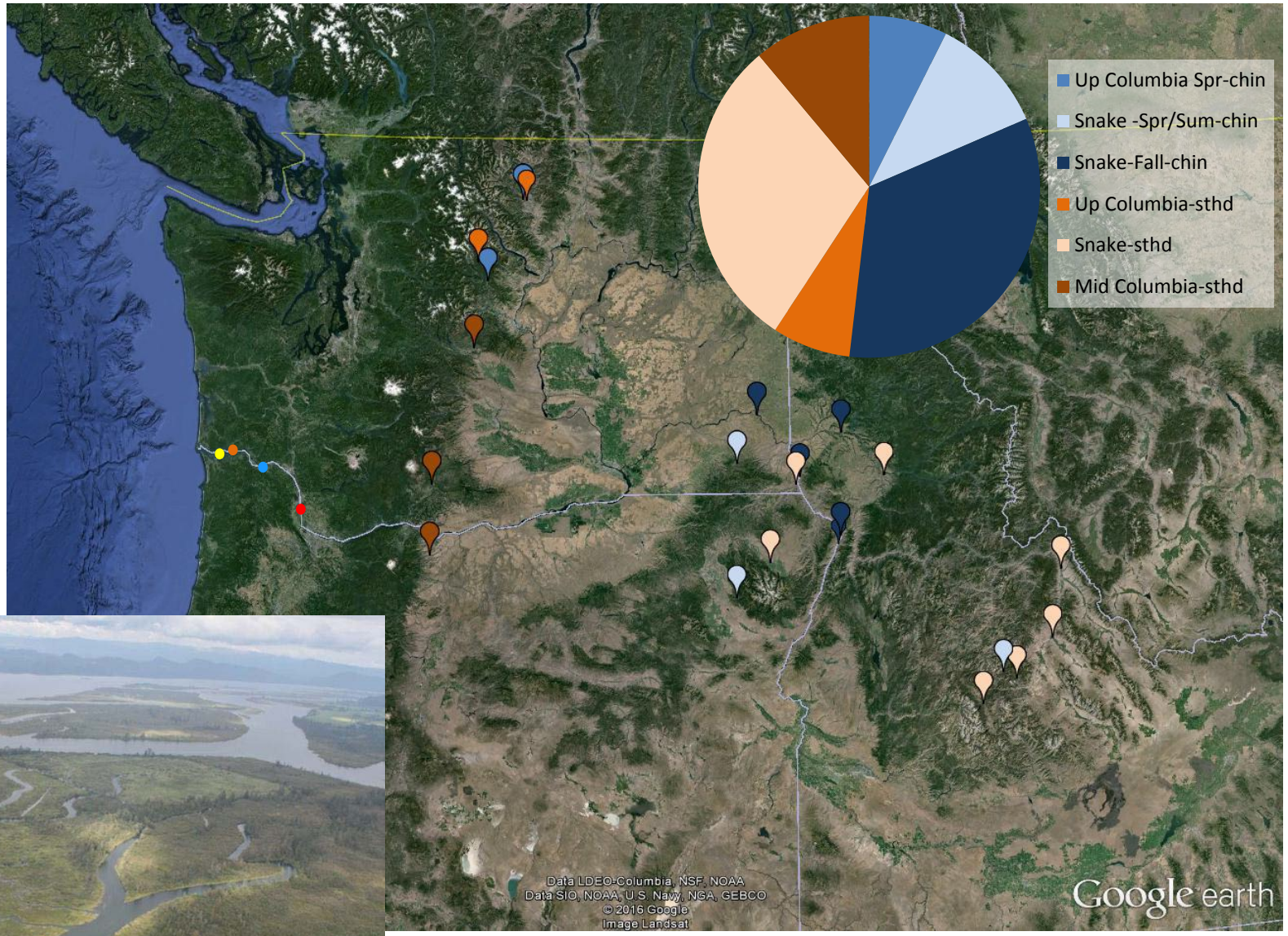
We think juvenile Chinook use larger and larger channels as they increase in size.

Sources of Fish Detected in Estuary Wetlands

Site	N
Russian =	13
Woody =	7
Wallace =	2
Sauvie =	5
Total =	27

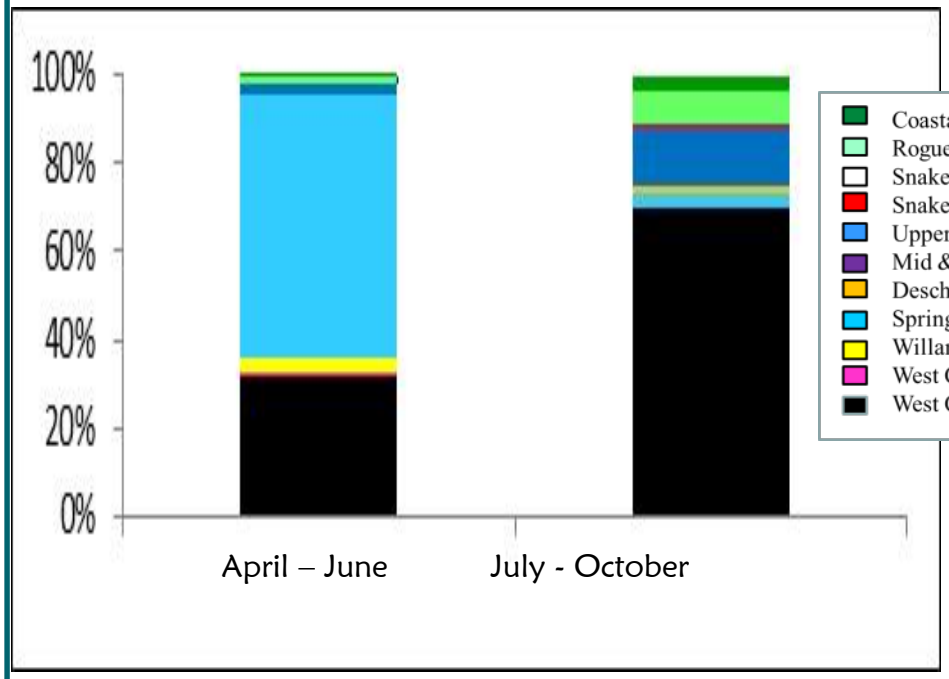
Juveniles = 25

Adult steelhead = 2

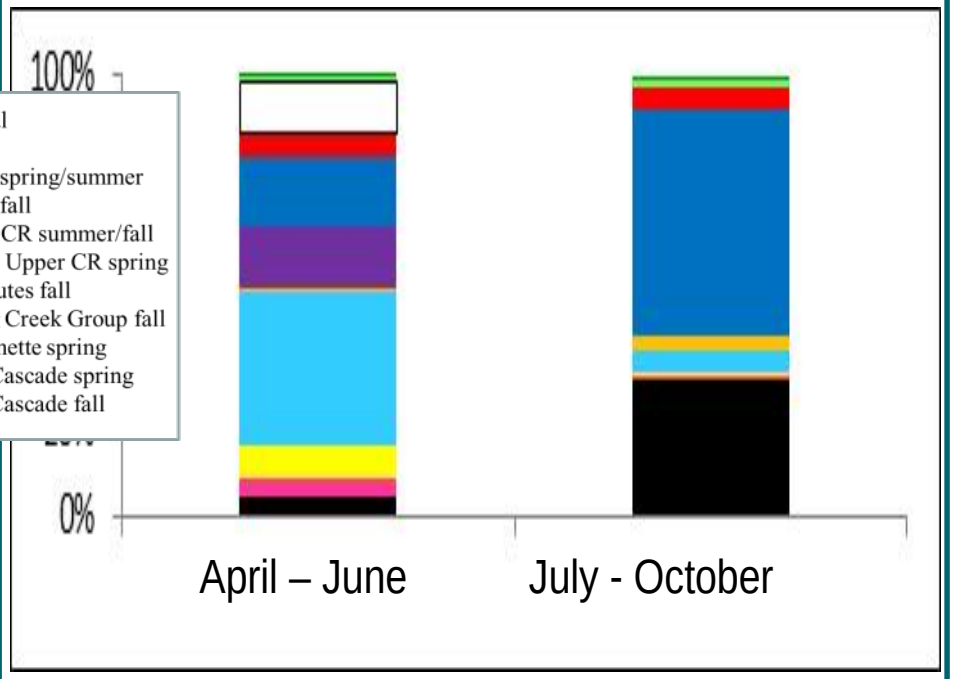


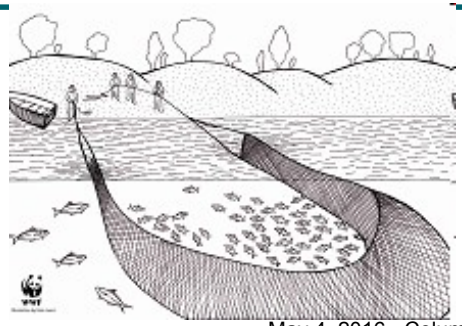
Genetic Stock Compositions of Chinook Salmon Outmigrants 2010-2011

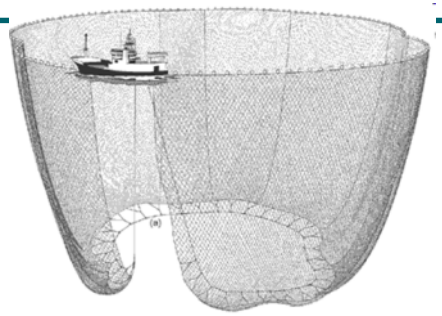
Shallow Water Beach Seine



Deep Water Purse Seine

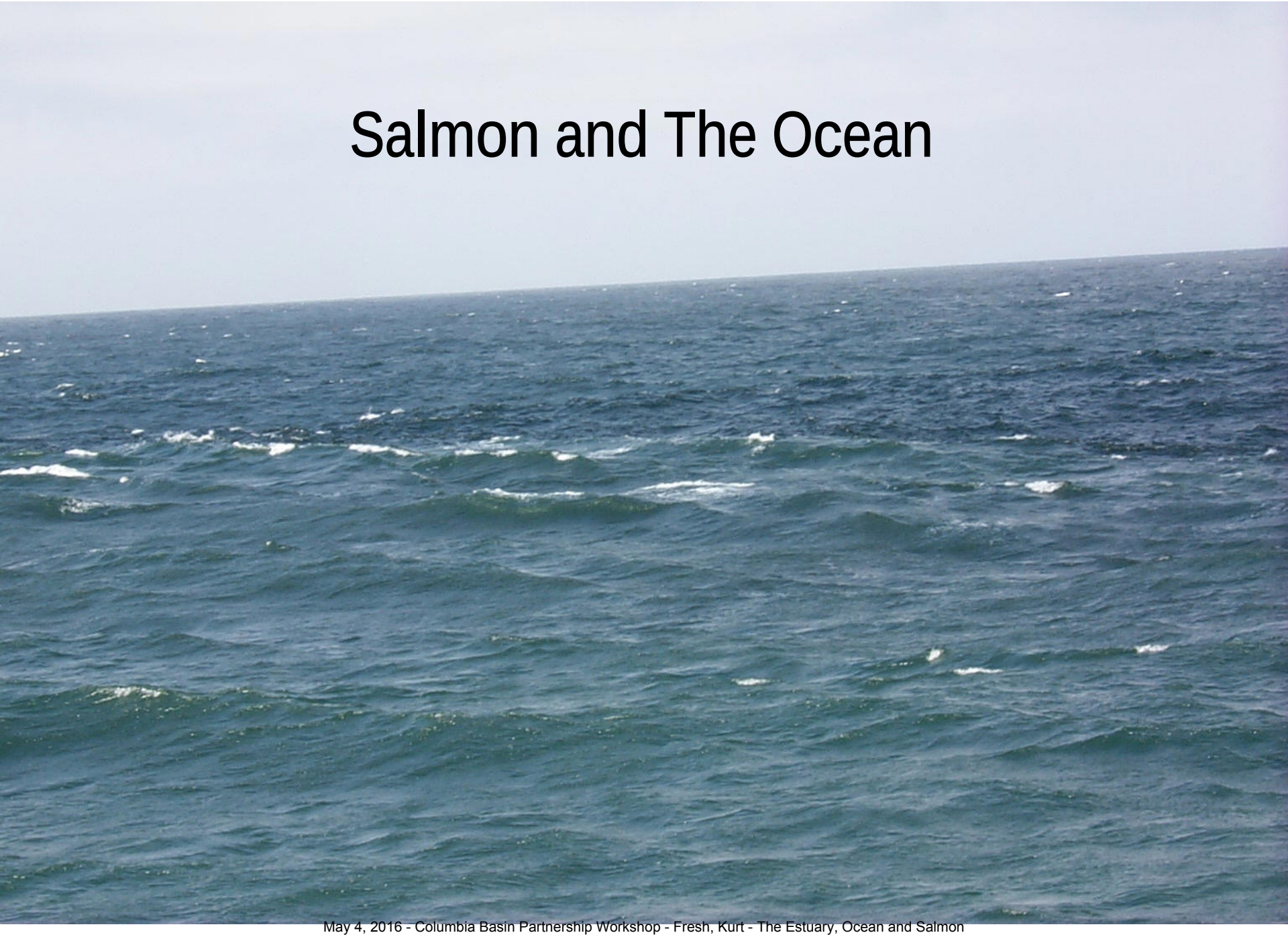






Graphics: D Teel

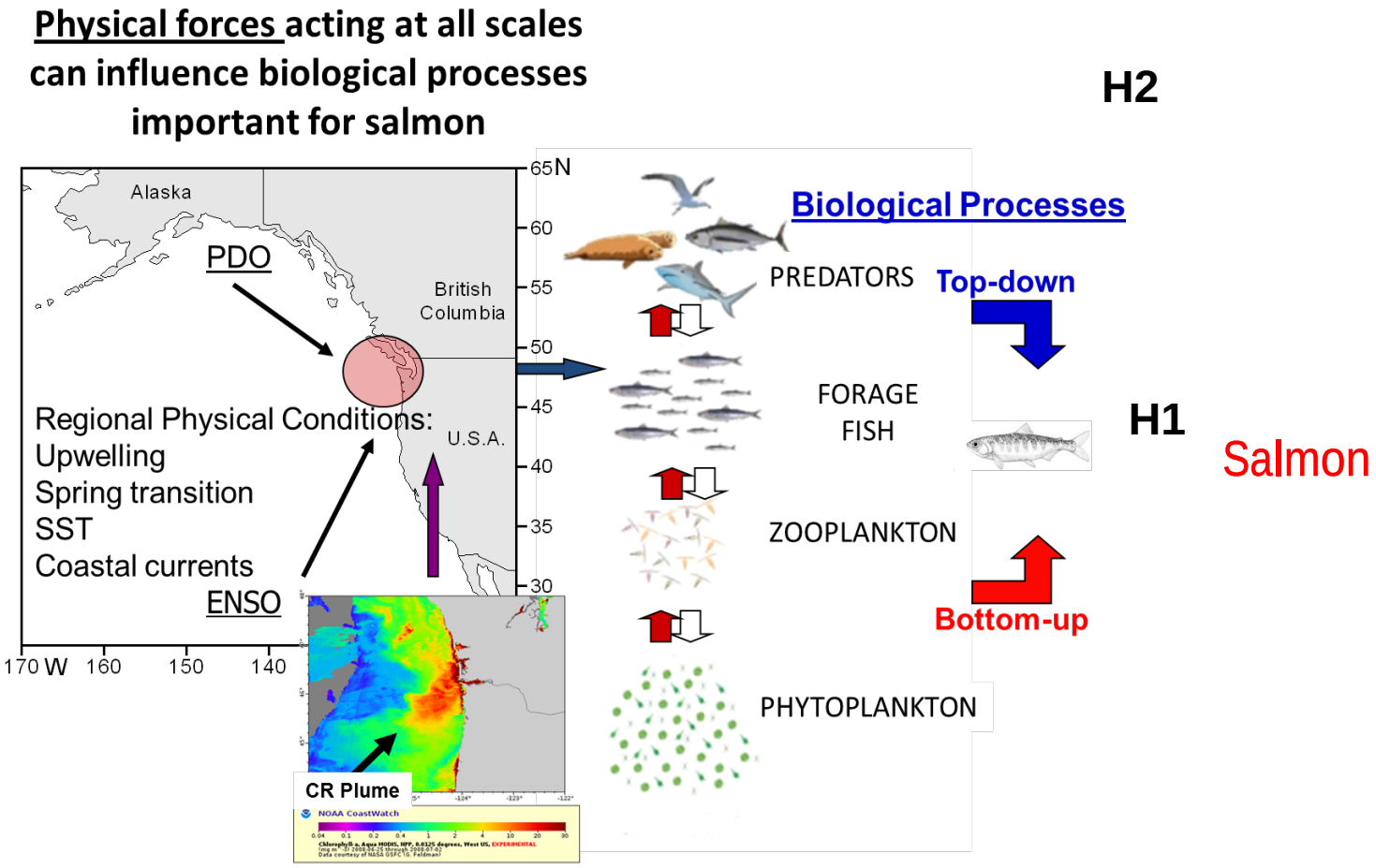
Salmon and The Ocean



North Pacific Ocean

Salmon Habitat in the Ocean

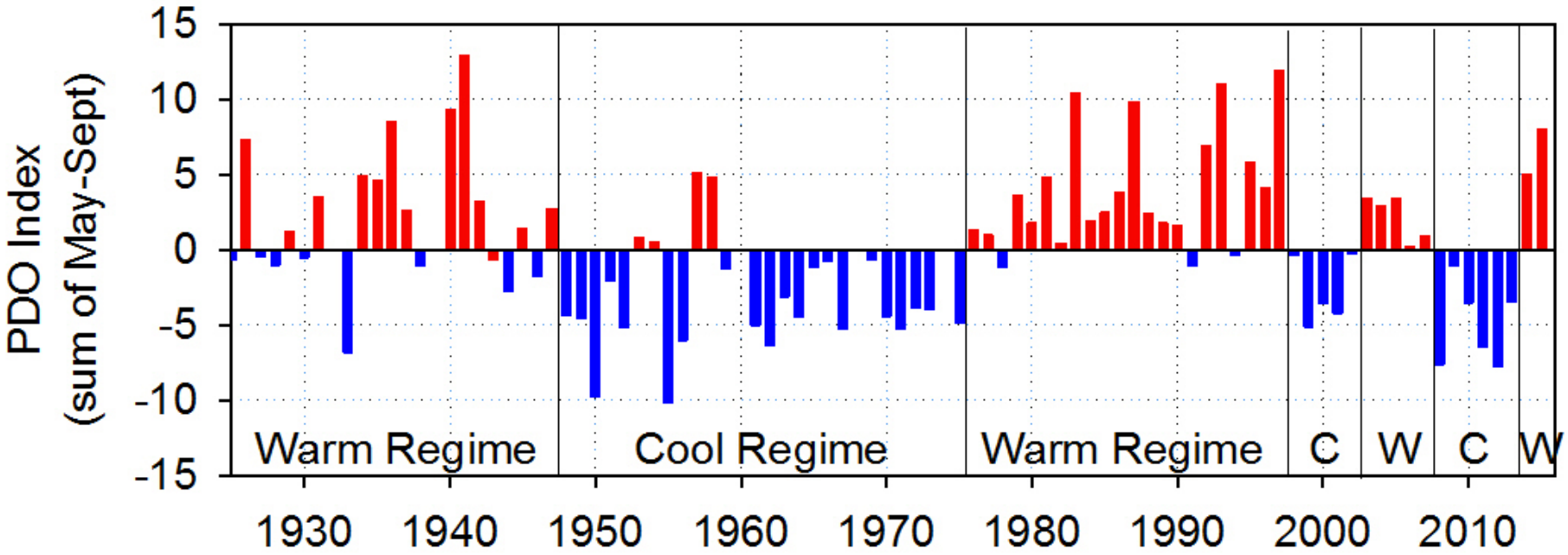
Ocean Habitat is Formed by Ecosystem Processes Acting at Multiple Scales.



PDO- Pacific Decadal Oscillation
Pacific Ocean Scale

- A very large-scale climate pattern that is reflected by changes in ocean temperatures and other oceanographic attributes.
- Driven by basin scale wind shifts.
- Cool phase. Colder temperatures. Flow of water from the North. Better food web conditions. Higher salmon survival.
- Warm phase. Warmer temperatures. Flow of water from South. Poorer food web conditions. Lower salmon survival.

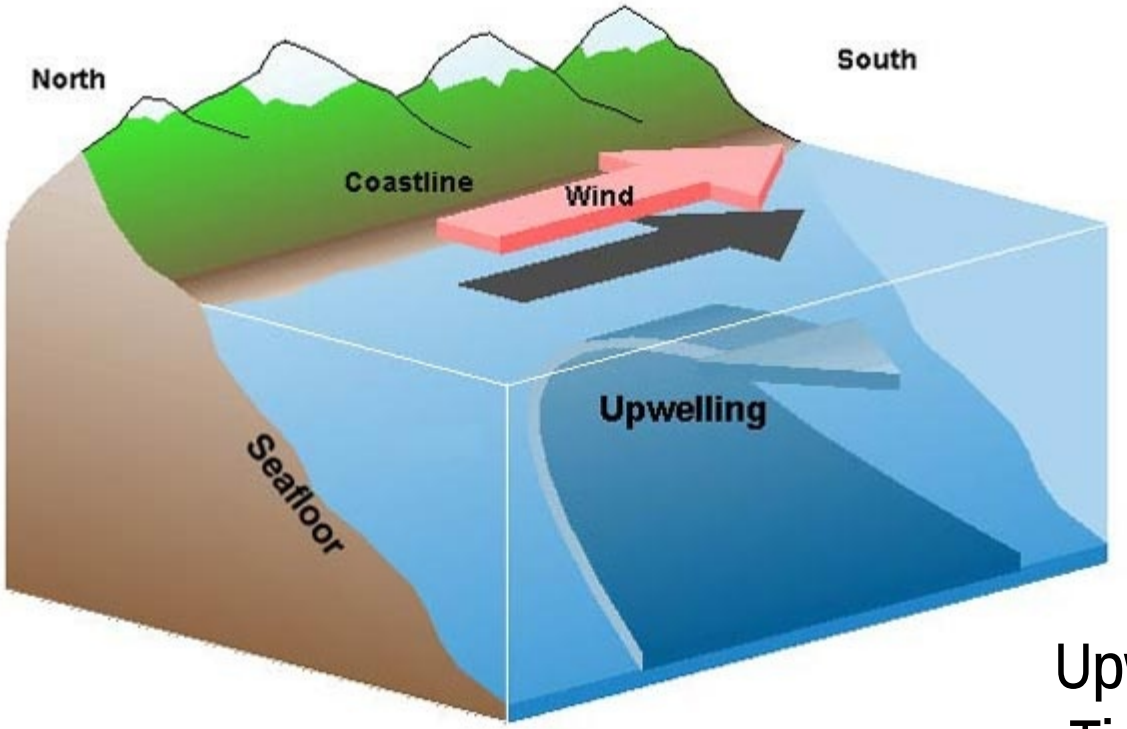
Pacific Decadal Oscillation Index



ENSO
Pacific Scale

- El Niño–Southern Oscillation (ENSO) is an irregularly periodical climate pattern over the tropical eastern Pacific Ocean. There are global affects of this climate pattern.
  - El Nino= Warming of Northern California Current. Not good for salmon in this area.
  - La Nina= Cooling of Northern California Current. Better for salmon.

Upwelling
Local/Regional Scale

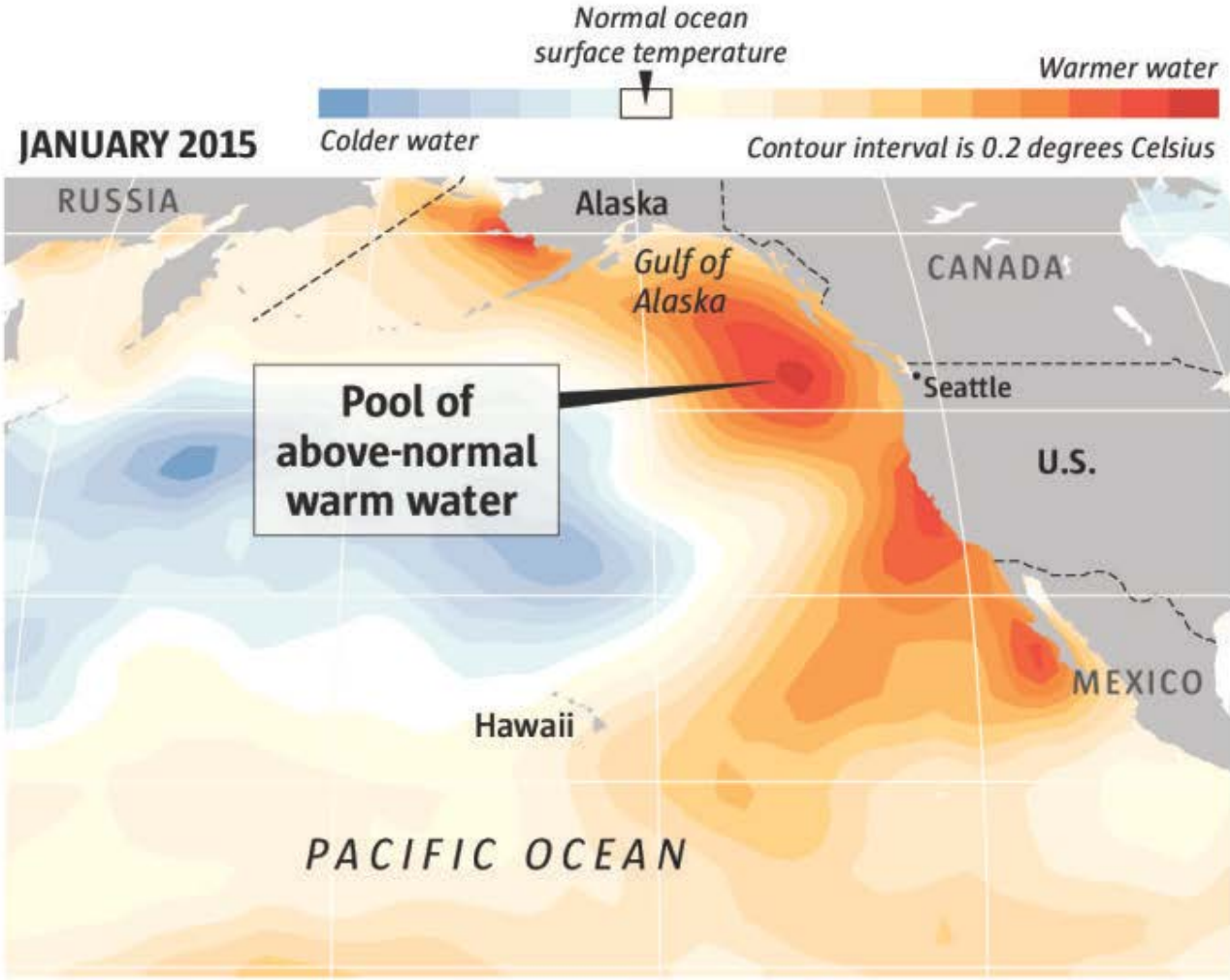


Upwelling Brings Nutrients and Cool Water Into Coastal Areas. Good for Juvenile Salmon.

Upwelling has:
- Timing
- Duration
- Strength

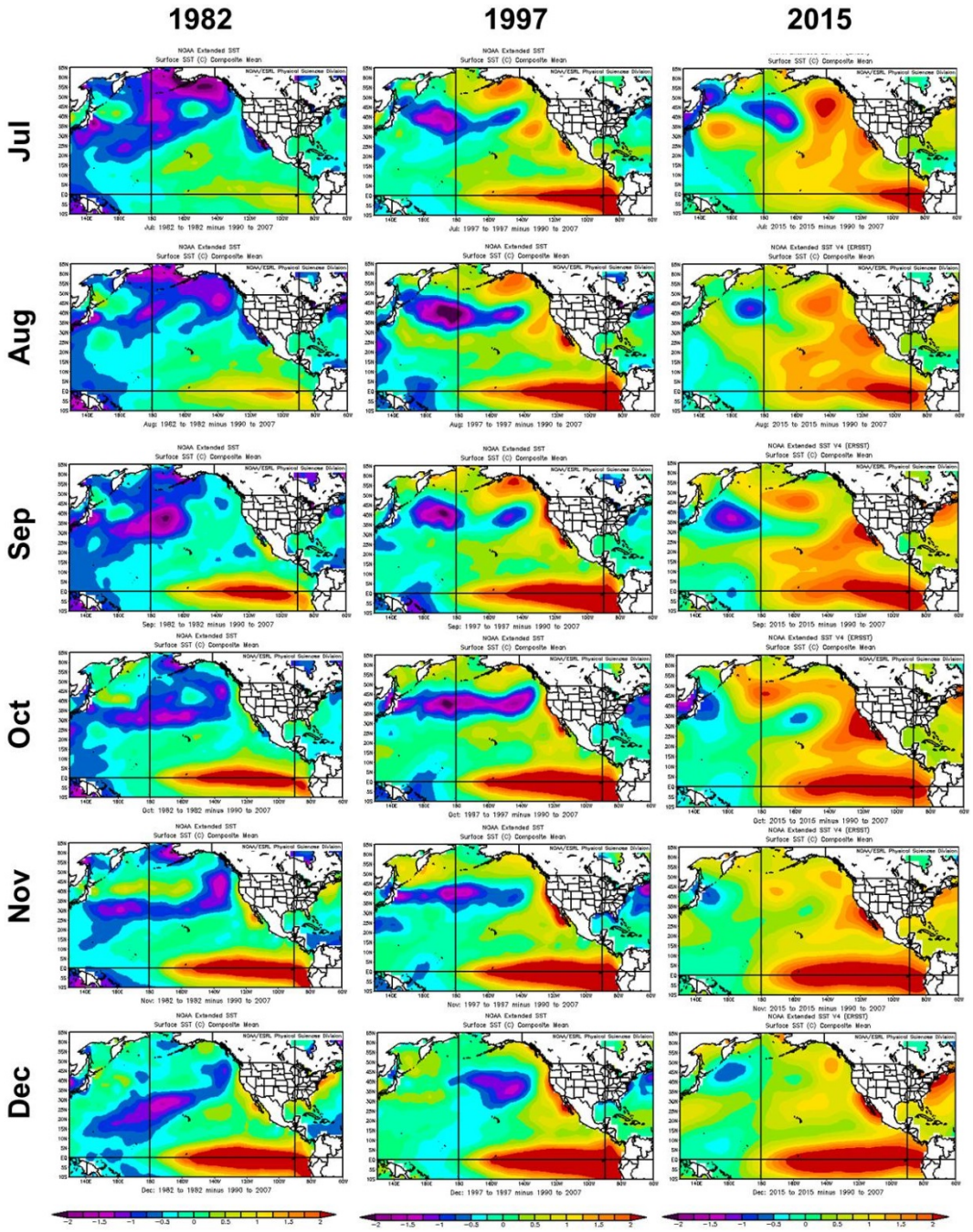
The blob off our coast

Scientists say a vast pool of warm water off our coast is affecting marine life and local weather, and is part of a bigger pattern that includes California's drought and East Coast blizzards.



Source: Department of Atmospheric Sciences, University of Washington

MARK NOWLIN / THE SEATTLE TIMES



Sea Surface Temperature for 1982, 1997, 2015

North Pacific Ocean

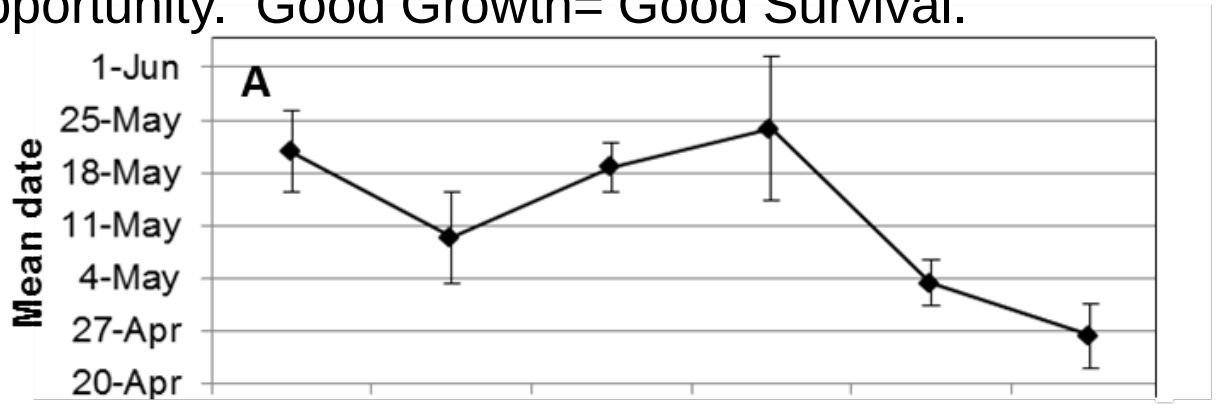
Use of the Ocean (Habitat and Timing) varies with Species, Stock/Population (Spring vs Fall), and Life History Type (yearling vs. sub-yearling).

Where you go depends on where you have been and what you are.

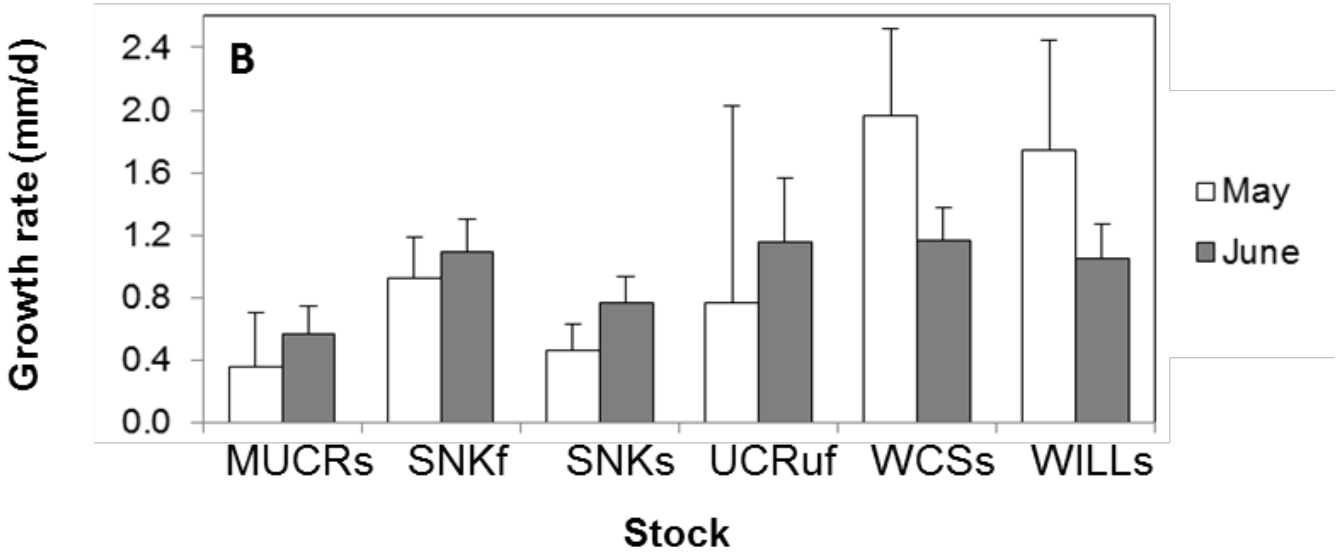
Ocean Entry Timing

Yearling Chinook Ocean Entry Timing Influences Ocean Growth Opportunity. Good Growth= Good Survival.

Mean date of ocean entry



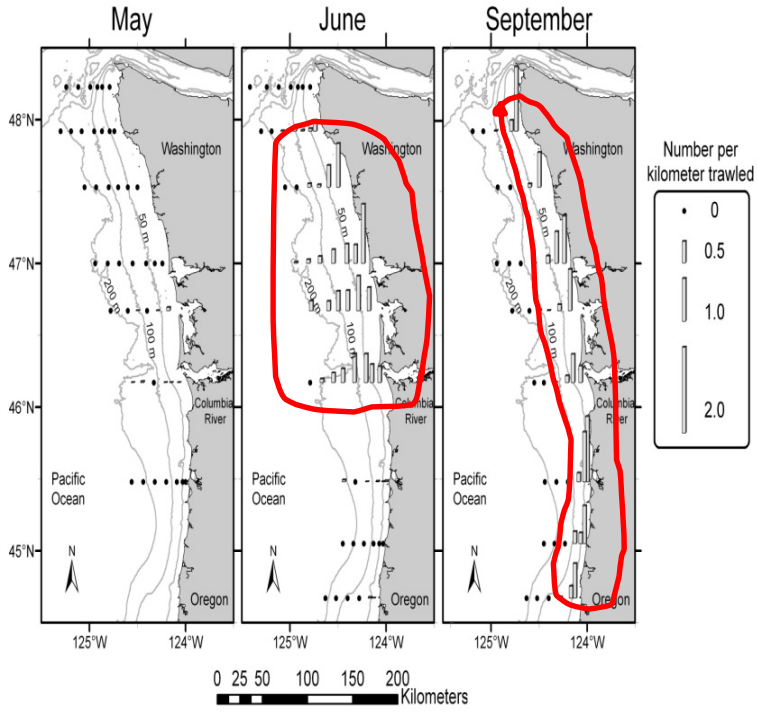
Ocean growth rate for fish collected during May & June ocean surveys



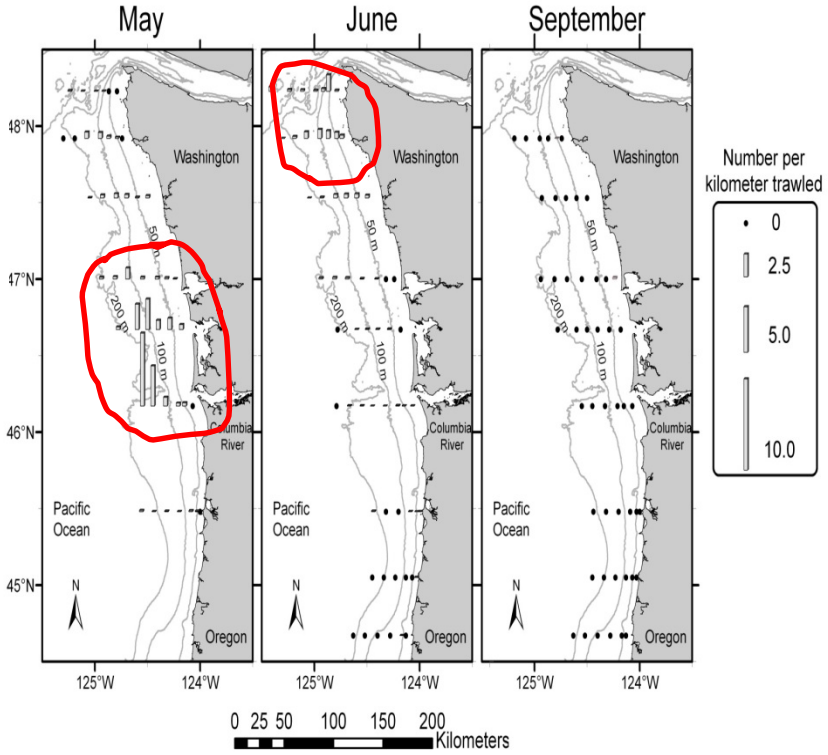
Variability in Ocean Entry timing between Hatchery, Wild; species; within a year vs. between years.

NCC Distribution Is Stock Specific

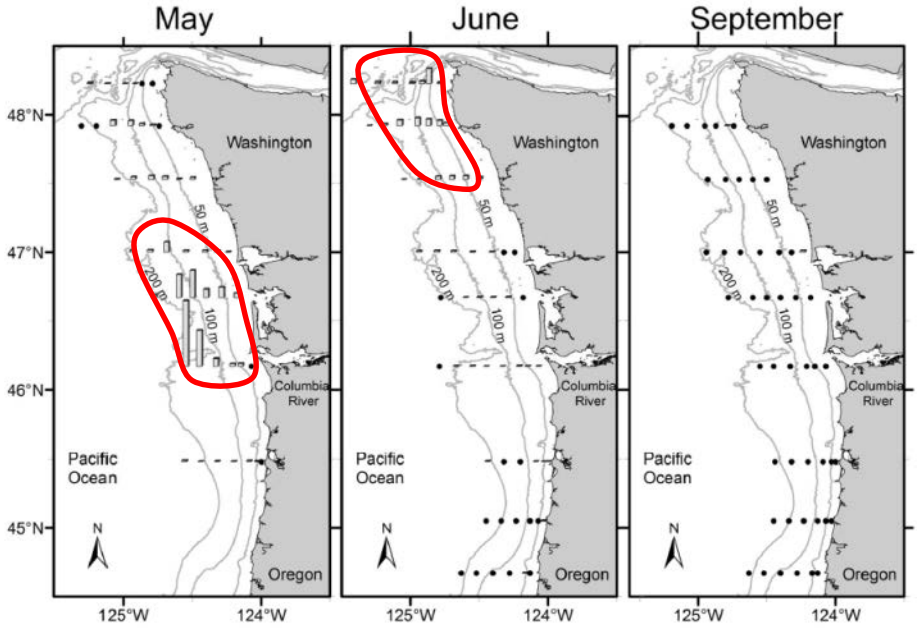
Snake River Sub-yearling Fall Chinook



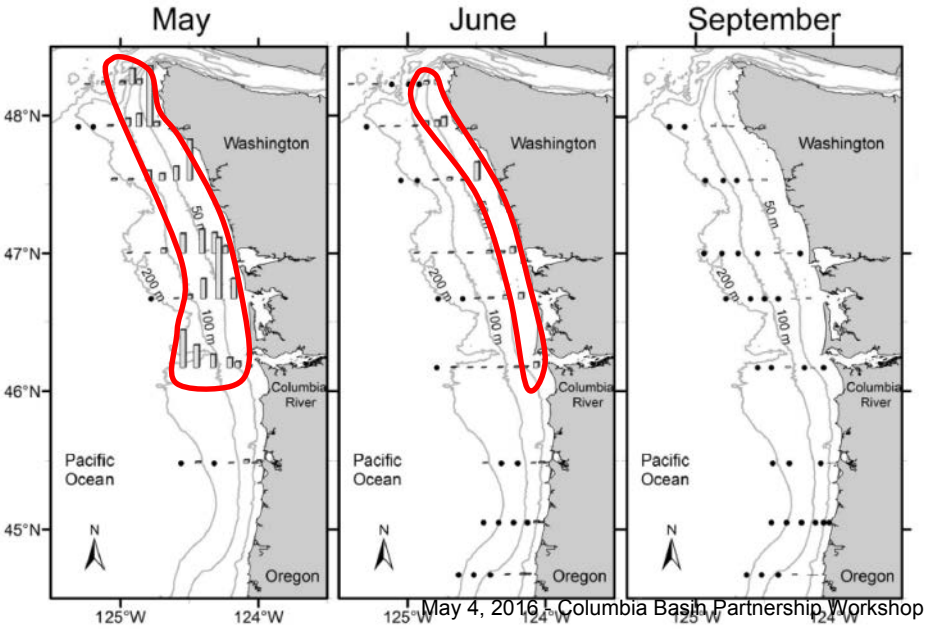
Snake River Yearling Spring Chinook



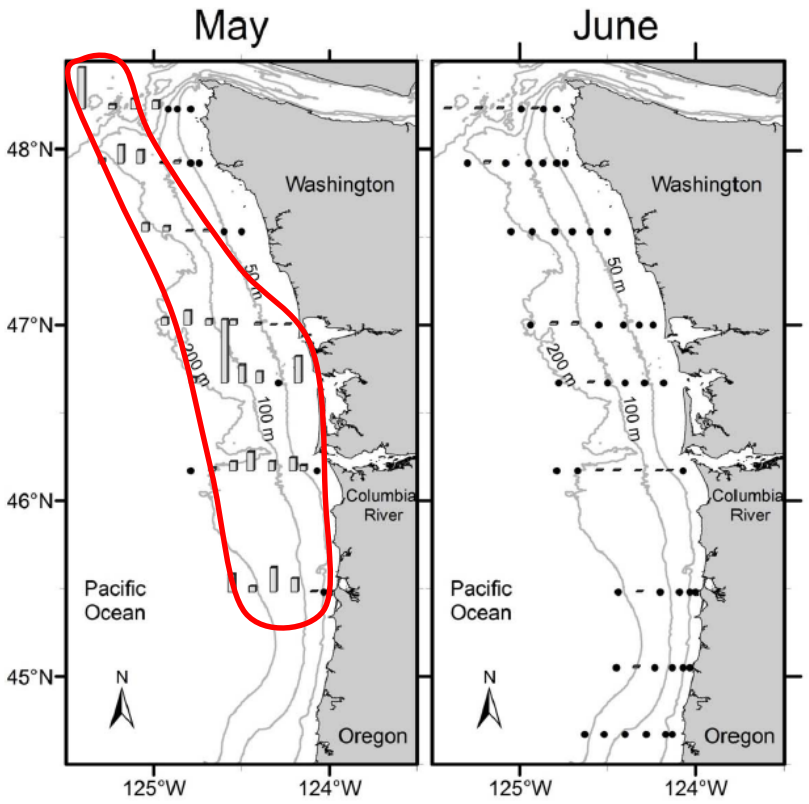
Snake River Yearling Spring Chinook



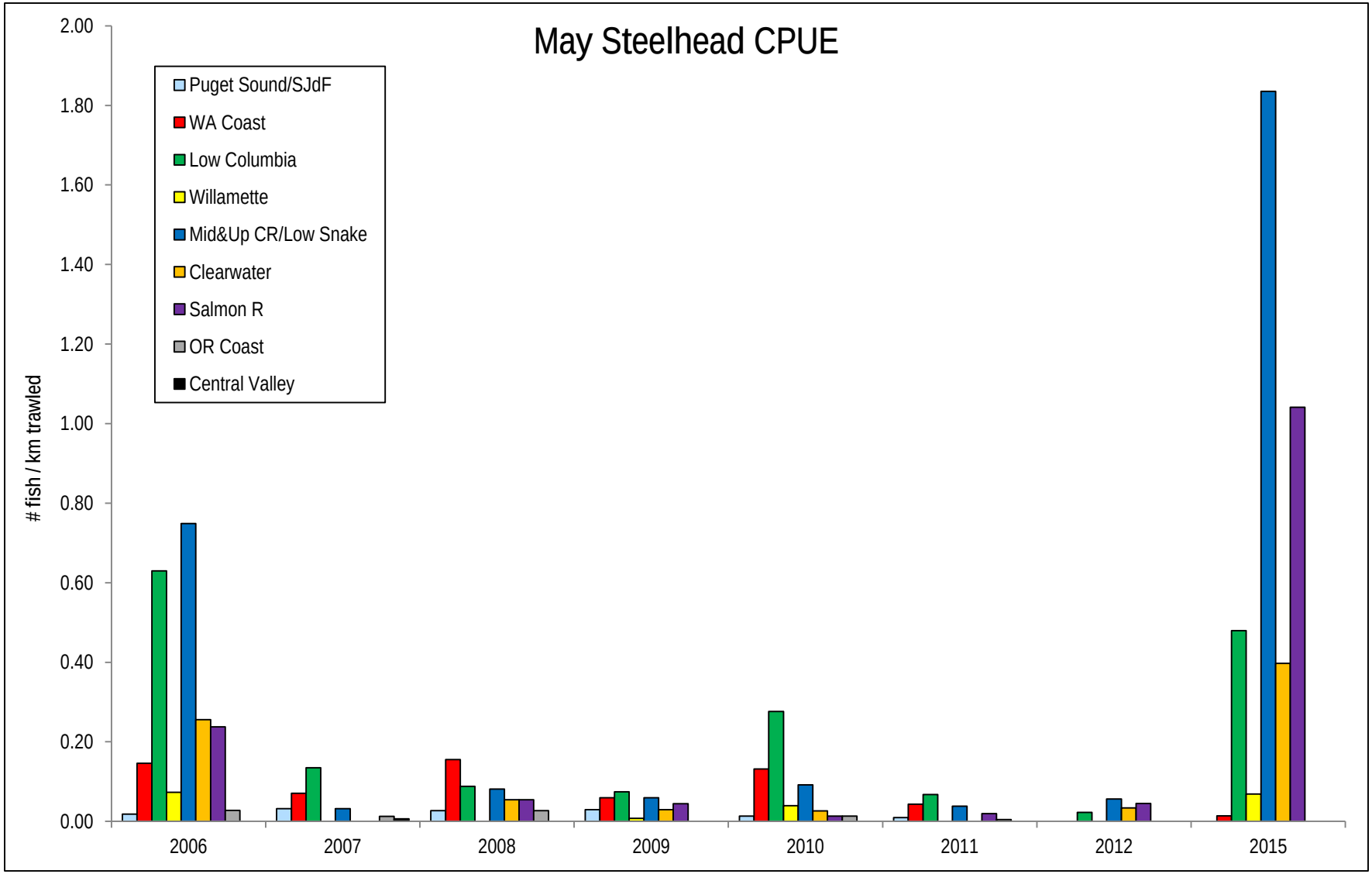
Willamette River Yearling Spring Chinook



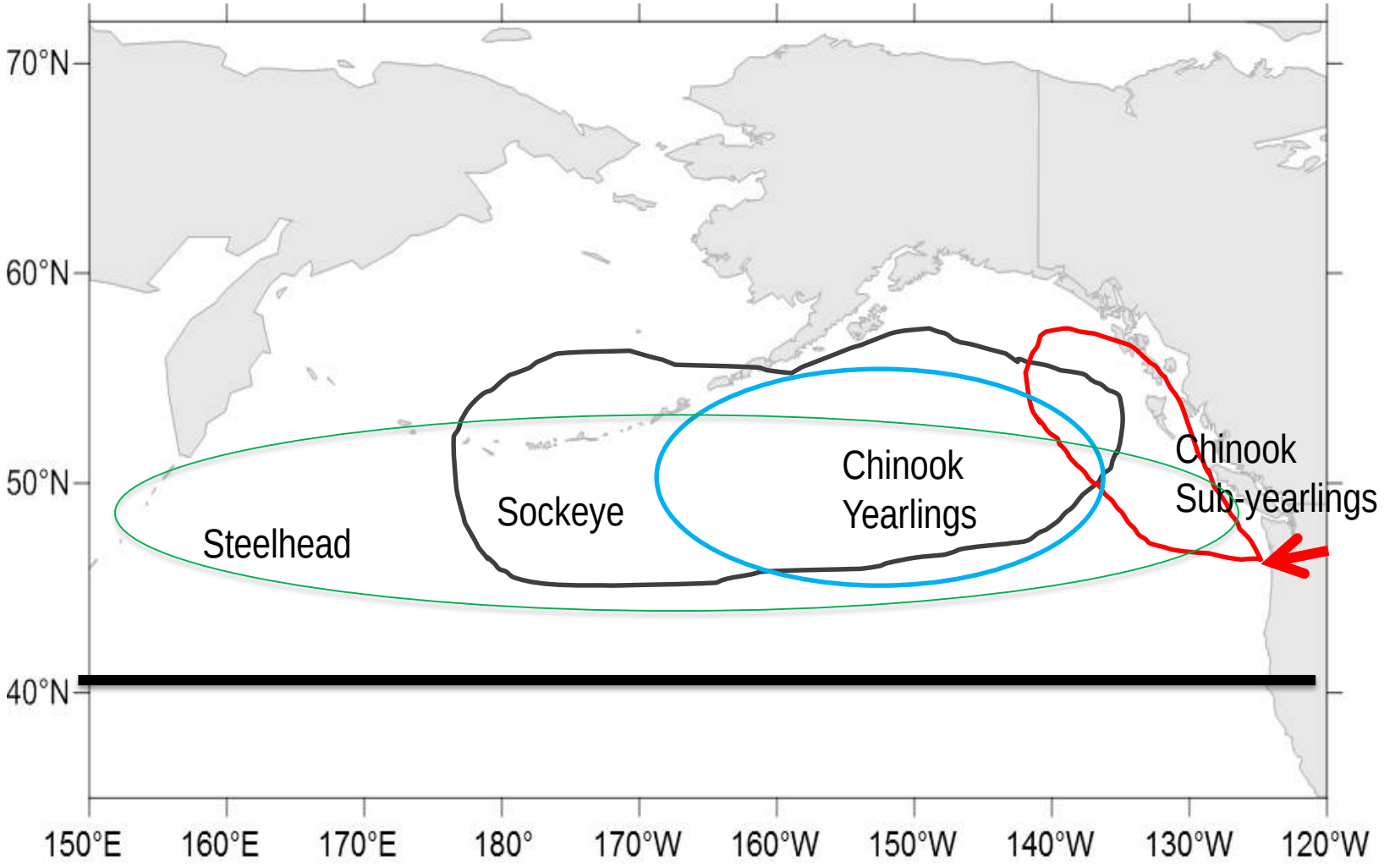
Steelhead



Origin of Steelhead in May NCC Ocean Cruises



NORTH PACIFIC OCEAN



Growth and Survival

Ocean life is important. 95% of salmon can die during ocean life.

Growth (size) appears to be a major factor affecting survival of some salmon stocks

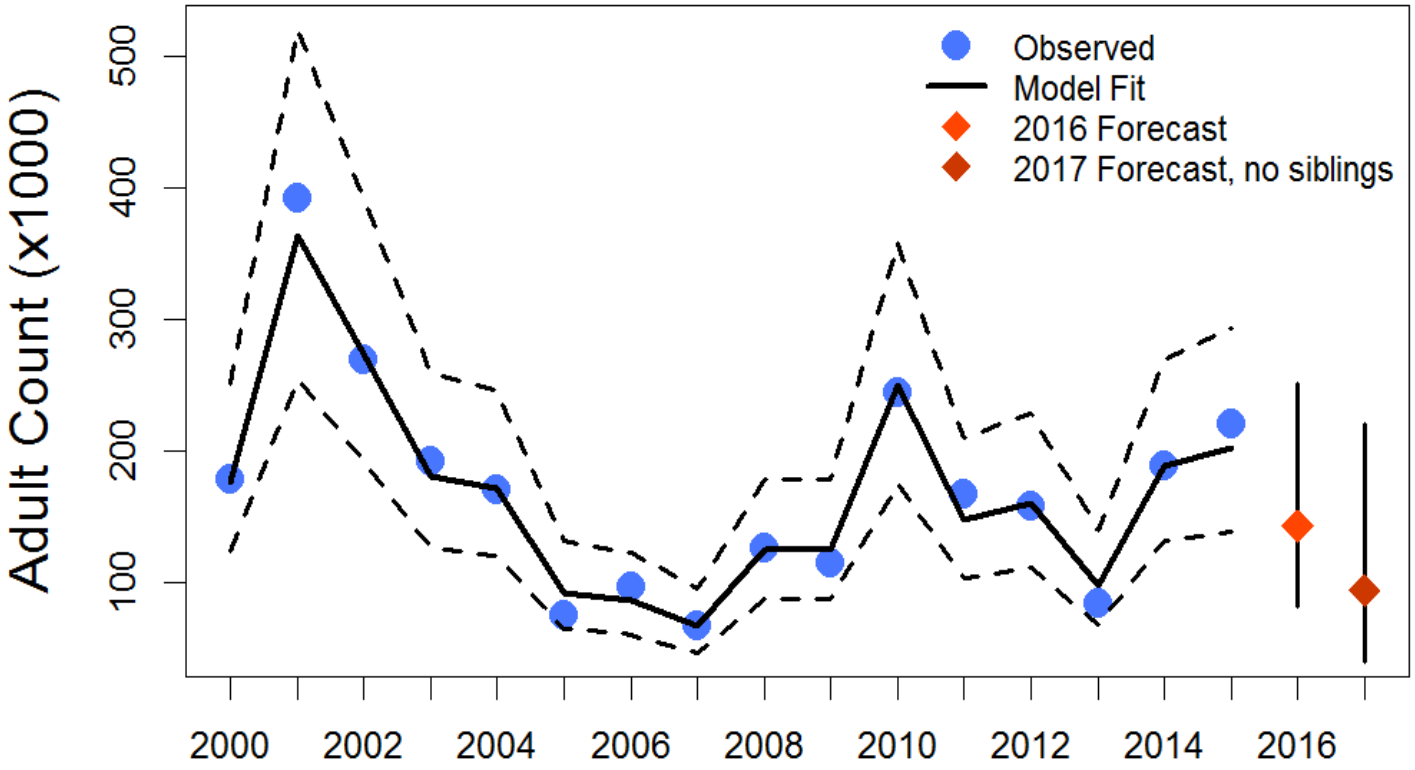
-- Relationship varies between populations within a species.
    -- Spring Chinook: Early marine life-first months of first ocean year
    -- Steelhead: Summer/fall of first ocean year
-- Growth is driven by food quality and quantity which is driven by changes in ocean conditions.
    -- Bad ocean years: Growth closely linked to poor survival for fall Chinook.

Stoplight Chart- Using our Understanding of Ocean Effects on Salmon.

	1998	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*
PDO-Wi	16	6	3	12	7	17	11	15	13	9	5	1	14	4	2	8	10	18
PDO-su	10	4	6	5	11	15	14	16	12	13	2	9	7	3	1	8	17	18
ONI	18	1	1	6	12	14	13	15	8	11	3	10	16	4	5	7	9	17
46050	15	8	3	4	1	7	18	14	5	16	2	9	6	10	11	12	13	17
Upper 20-Wi	17	11	8	10	6	14	15	12	13	5	1	9	16	4	3	7	2	18
Upper 20-Su	14	11	13	4	1	3	18	16	7	8	2	5	12	10	6	15	17	9
Deep T	18	6	8	4	1	9	12	14	10	5	2	7	13	11	3	17	16	15
Deep S	18	3	7	4	5	14	15	8	6	1	2	11	16	10	9	13	17	12
Richness	17	3	1	7	6	13	12	16	14	11	8	10	15	4	5	2	9	18
N-Cope	17	13	9	10	3	15	12	18	14	11	6	8	7	1	2	4	5	16
S-Cope	18	2	5	4	3	13	14	17	12	10	1	7	15	9	8	6	11	16
Biol Trans	17	11	6	7	8	12	10	16	15	3	1	2	14	4	9	5	13	18
Ichthyo	18	9	2	5	7	16	15	11	14	13	1	10	3	12	8	6	17	4
Rank	18	5	3	6	2	13	15	17	11	10	1	7	12	7	4	7	13	16

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Phys Trans UI)	3	6	17	14	4	11	13	18	11	1	5	2	7	10	15	8	16	9
Phys Trans (H)	17	3	13	8	5	12	14	18	6	9	1	9	16	3	11	2	15	7
UI	8	2	15	4	7	12	11	18	8	3	5	6	13	15	13	10	17	1
LUSI	6	2	16	10	1	11	8	18	5	3	7	3	13	15	13	12	17	9
SST NH05	8	6	5	4	1	3	18	15	9	16	2	17	10	7	13	12	14	11
CCI	18	5	4	8	1	13	14	16	15	10	2	6	12	9	7	3	11	17

N. Calif Current Ecosystem Indicators Can Predict Salmon Returns - Spring Chinook Salmon



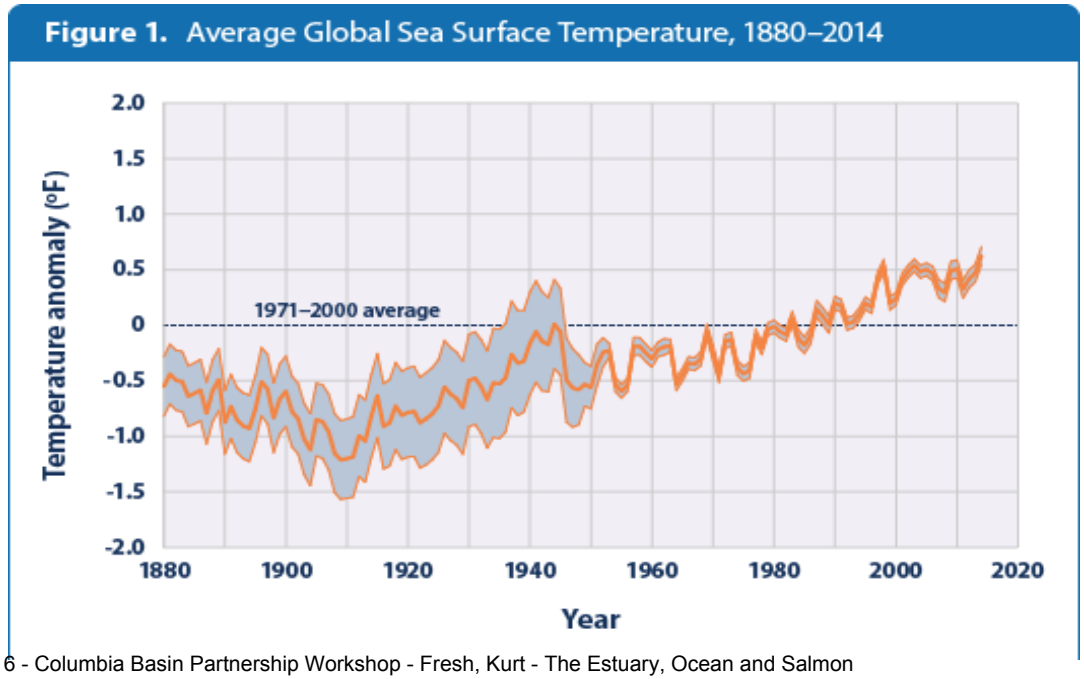
Adult Count at Bonneville Dam

Challenges For the Future

- Knowledge gaps.
  - What happens to salmon after their first year in the ocean.
  - Time of ocean entry.
  - Density dependent effects in estuary and ocean.
  - Predation effects.
- Ecosystem changes
  - Climate change
  - Continued change to quantity, quality, distribution of habitat.

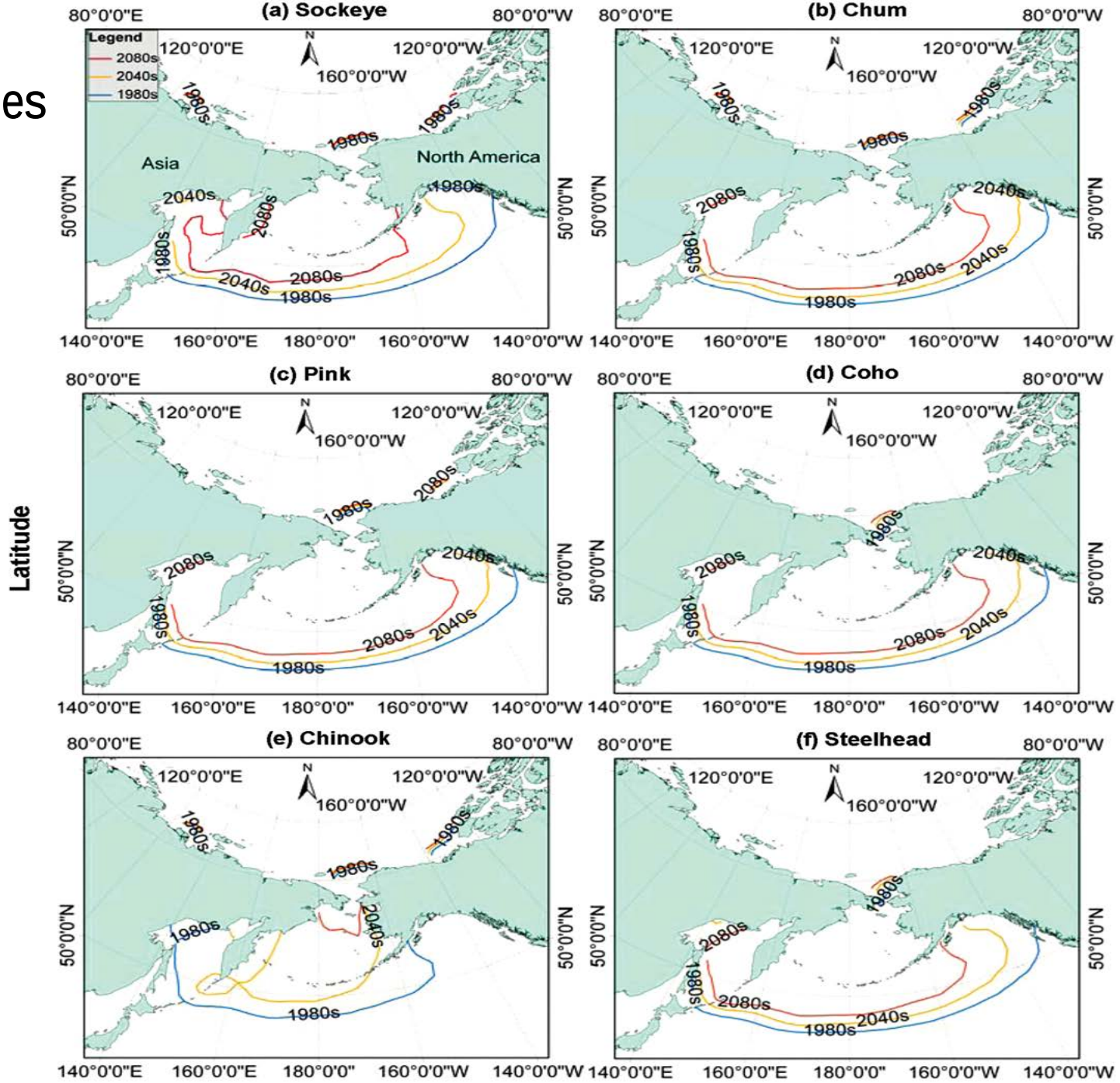
Climate Change and The Ocean

- Acidification. Declines in abundance of pelagic mollusks (the pteropod *Limacina*) are also being seen correlated with low pH.
- Upwelling. In the northern California Current, it is starting later and the length of the upwelling season is shorter.
- PDO. Increased variability PDO (since 1998, changes in sign every 5 years rather than every 20-30 years as seen in the past).
- Temperature. The ocean is warming and has been for a while. SALMON NEED COLD WATER!



Possible Changes In Ocean Distribution Resulting from Temperature Changes

Chinook and Sockeye Most Vulnerable



Abdul-Aziz et al. 2011. CJFAS. Volume 68.

QUESTIONS???

Photo, off North Head Lighthouse, looking west