NOAA Fisheries' Ocean Indicators and Salmon Ocean Ecology

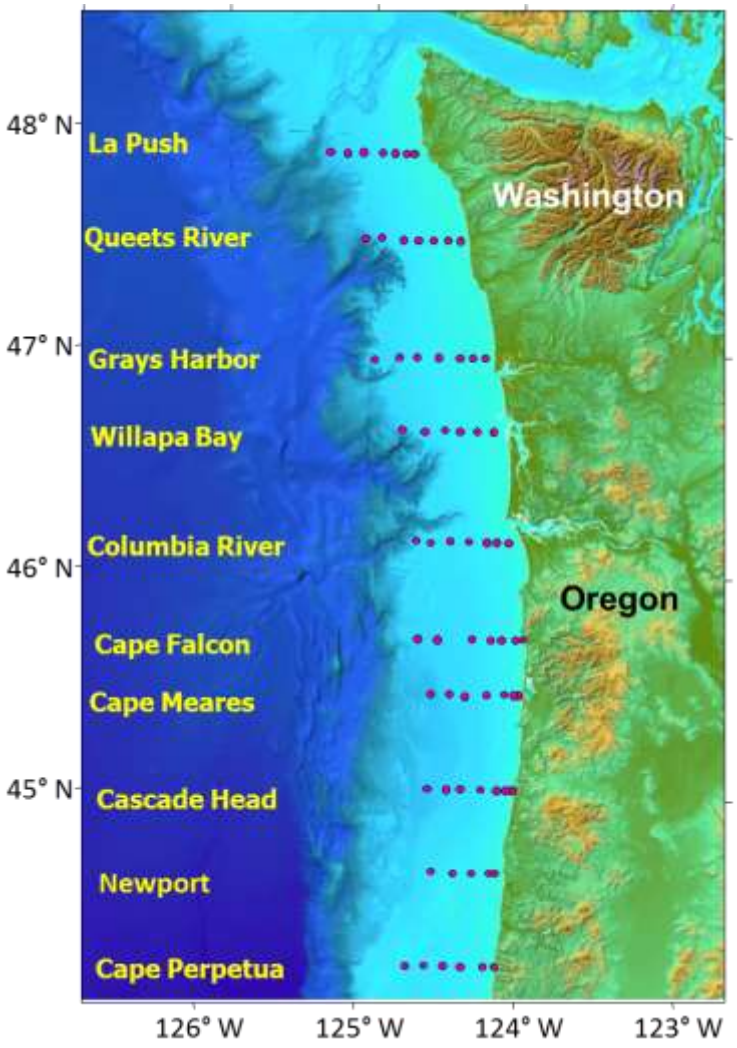
Brian J. Burke, Bill Peterson, Cheryl Morgan, Jay Peterson, Jennifer Fisher, Jennifer Gosselin, and Kurt Fresh

Columbia River Estuary Workshop, May 29th, 2014

Supported by:

- Ocean Indicators
- Adult return forecasts

  (and why the PDO can't solve all of our problems)
- Stock-specific approach and other future directions



Observations

Juvenile salmon sampling:

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

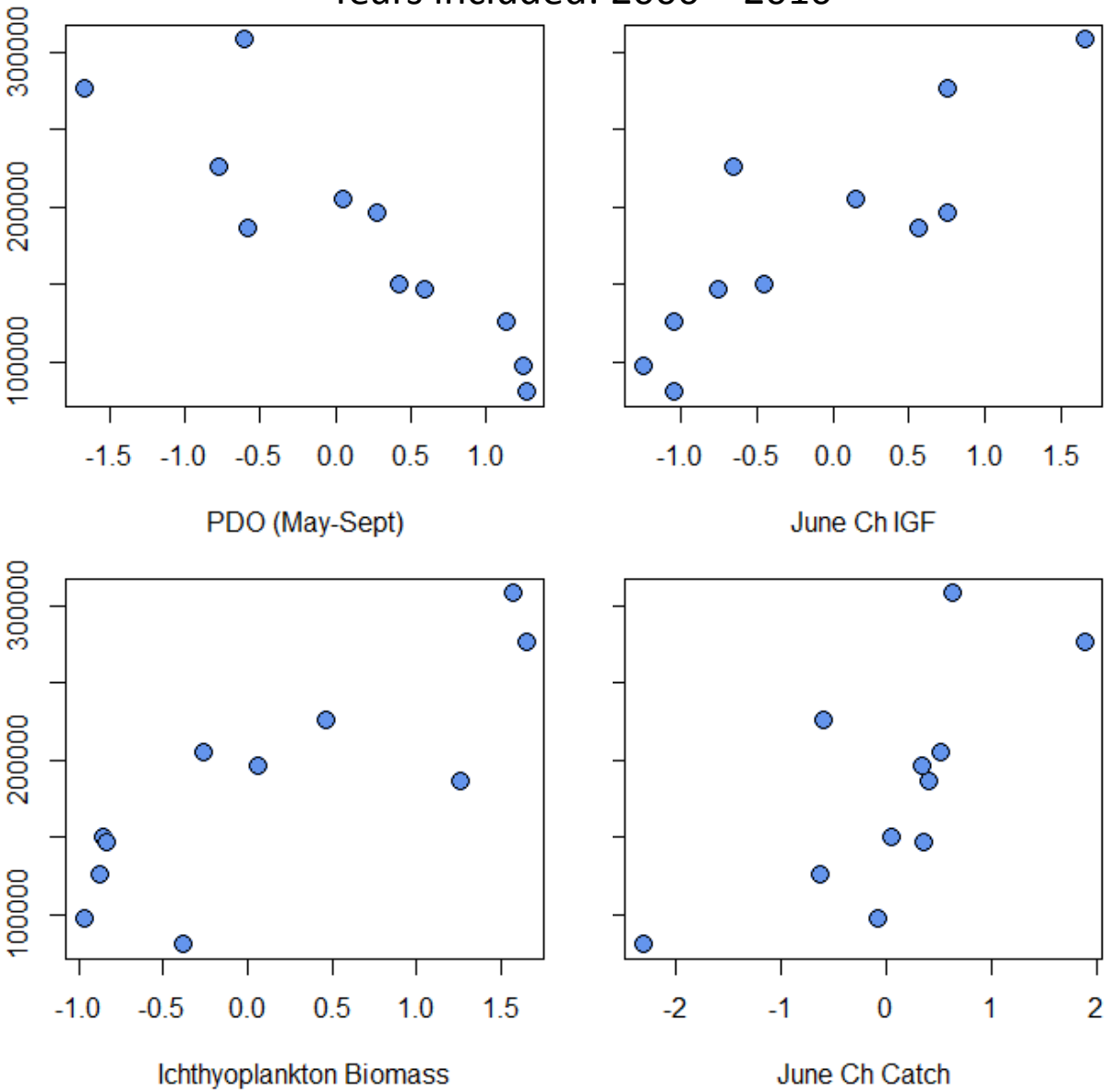
Measure physical and biological conditions

Focus on distribution & abundance of juvenile salmonids along with metrics of growth & condition

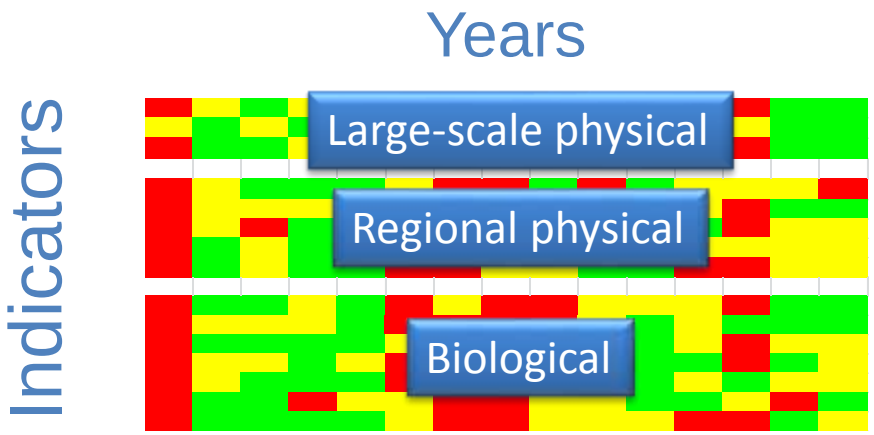
We get a lot of good correlations

Years included: 2000 – 2010

Adult Spring Chinook Salmon at Bonneville Dam (y+2)



General Characterization of Ocean Conditions



Good – Fair – Poor

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

Ocean Conditions through 2013

Ecosystem Indicators		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
PDO (December-March)		15	6	3	11	7	16	10	14	12	9	5	1	13	4	2	8
PDO (May-September)		10	4	6	5	11	15	14	16	12	13	2	9	7	3	1	8
ONI Jan-June		16	2	1	5	12	13	11	14	7	10	3	9	15	4	5	7
46050 SST (May-Sept)		14	8	3	4	1	7	16	13	5	15	2	9	6	10	11	12
NH 05 Upper 20 m T winter prior (Nov-Mar)	*	16	10	7	9	5	13	14	11	12	4	1	8	15	3	2	6
NH 05 Upper 20 m T (May-Sept)	*	13	10	12	4	1	3	16	15	7	8	2	5	11	9	6	14
NH 05 Deep Temperature	*	16	6	8	4	1	9	12	14	10	5	2	7	13	11	3	15
NH 05 Deep Salinity	*	16	3	7	4	5	13	14	8	6	1	2	11	15	10	9	12
Copepod Richness Anomaly	*	16	3	1	7	6	12	11	15	13	10	8	9	14	4	5	2
N. Copepod Biomass Anomaly	*	15	12	7	8	5	14	13	16	9	11	4	10	6	1	2	3
S. Copepod Biomass Anomaly	*	16	3	5	4	2	11	13	15	12	10	1	8	14	9	7	6
Biological Transition	*	16	11	7	3	8	12	10	15	14	4	1	2	13	5	9	6
Winter Ichthyoplankton	*	16	8	2	4	6	15	14	10	13	12	1	9	3	11	7	5
Chinook Juv Catches (June)	*	15	4	5	13	9	11	14	16	10	8	1	6	7	12	3	2
Coho Juv Catches (Sept)	*	11	2	1	4	3	6	12	14	8	9	7	15	13	5	10	NA

Ecosystem Indicators	*units*	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
PDO (Sum Dec-March)		5.07	-1.75	-4.17	1.86	-1.73	7.45	1.85	2.44	1.94	-0.17	-3.06	-5.41	2.17	-3.65	-5.07	-1.67
PDO (Sum May-September)		-0.37	-5.13	-3.58	-4.22	-0.26	3.42	2.96	3.48	0.28	0.91	-7.63	-1.11	-3.53	-6.45	-7.79	-3.47
ONI Jan-June (Average)		1.08	-1.10	-1.13	-0.42	0.23	0.33	0.20	0.37	-0.38	0.02	-1.05	-0.27	0.70	-0.77	-0.42	-0.38
46050 SST (May-Sept)	deg C	13.66	13.00	12.54	12.56	12.30	12.92	14.59	13.56	12.77	13.87	12.39	13.02	12.92	13.06	13.26	13.37
NH 05 Upper 20 m T winter prior (Nov-Mar)	deg C	12.27	10.31	10.12	10.22	10.08	10.70	10.85	10.60	10.61	10.04	9.33	10.19	11.01	10.02	9.62	10.09
NH 05 Upper 20 m T (May-Sept)	deg C	10.38	10.13	10.19	9.77	8.98	9.62	11.39	10.73	9.97	9.99	9.30	9.90	10.14	10.05	9.95	10.63
NH 05 Deep Temperature	deg C	8.61	7.63	7.74	7.56	7.45	7.81	7.89	7.97	7.83	7.58	7.48	7.73	7.89	7.86	7.56	8.30
NH 05 Deep Salinity		33.54	33.86	33.78	33.86	33.85	33.68	33.66	33.77	33.85	33.88	33.87	33.72	33.61	33.74	33.75	33.70
Copepod Richness Anomaly (May-Sept)	no. of species	4.37	-2.83	-3.61	-1.28	-1.35	1.67	1.24	4.14	2.47	-0.88	-1.01	-0.89	2.87	-2.38	-1.53	-3.16
N. Copepod Biomass Anomaly (May-Sept)	log mg C m^{-3}	-0.58	0.09	0.19	0.15	0.28	-0.08	0.05	-0.77	0.14	0.14	0.31	0.14	0.25	0.42	0.40	0.35
S. Copepod Biomass Anomaly (May-Sept)	log mg C m^{-3}	0.62	-0.30	-0.28	-0.29	-0.30	0.09	0.22	0.55	0.10	-0.10	-0.31	-0.22	0.24	-0.15	-0.23	-0.26
Biological Transition	day of year	263	134	97	79	108	156	132	238	180	81	64	65	169	82	125	91
Winter Ichthyoplankton	log mg C 1000 m^{-3}	0.12	0.90	1.80	1.25	1.05	0.53	0.58	0.83	0.59	0.60	1.84	0.89	1.65	0.61	0.99	1.16
Chinook Juv Catches (June)	fish per km	0.26	1.27	1.04	0.44	0.85	0.63	0.42	0.13	0.69	0.86	2.56	0.97	0.89	0.46	1.32	1.38
Coho Juv Catches (Sept)	fish per km	0.11	1.12	1.27	0.47	0.98	0.29	0.07	0.03	0.16	0.15	0.27	0.01	0.03	0.30	0.13	NA

* Collected during NWFSC cruises

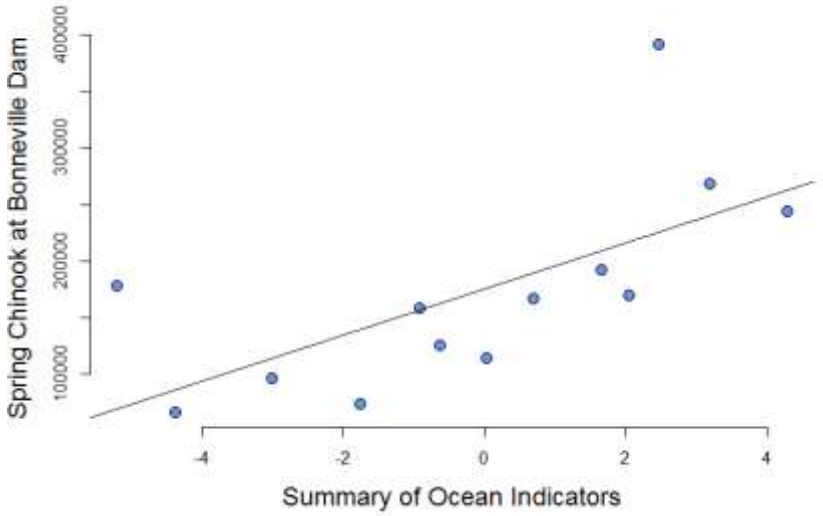
http://www.nwfsc.noaa.gov/oceanconditions

- Ocean Indicators
- Adult return forecasts

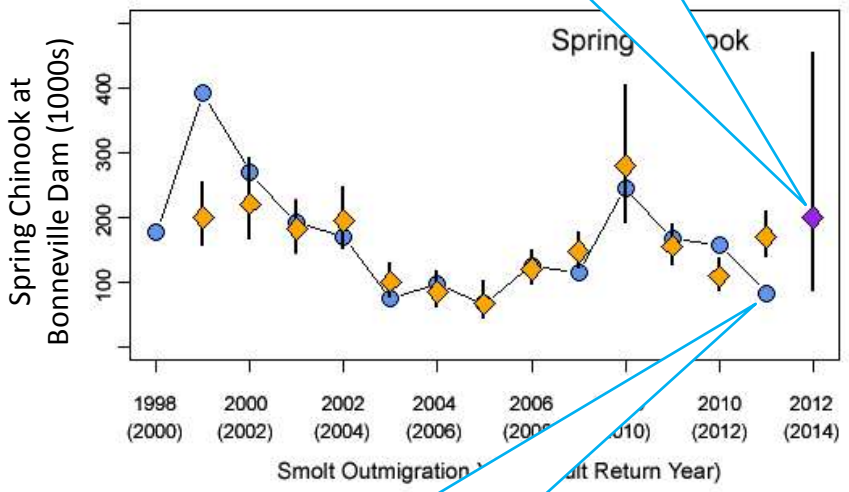
  (and why the PDO can't solve all of our problems)
- Stock-specific approach and other future directions

We use multivariate summaries of the ocean indicators in models of salmon returns

Years included: 1998 – 2010

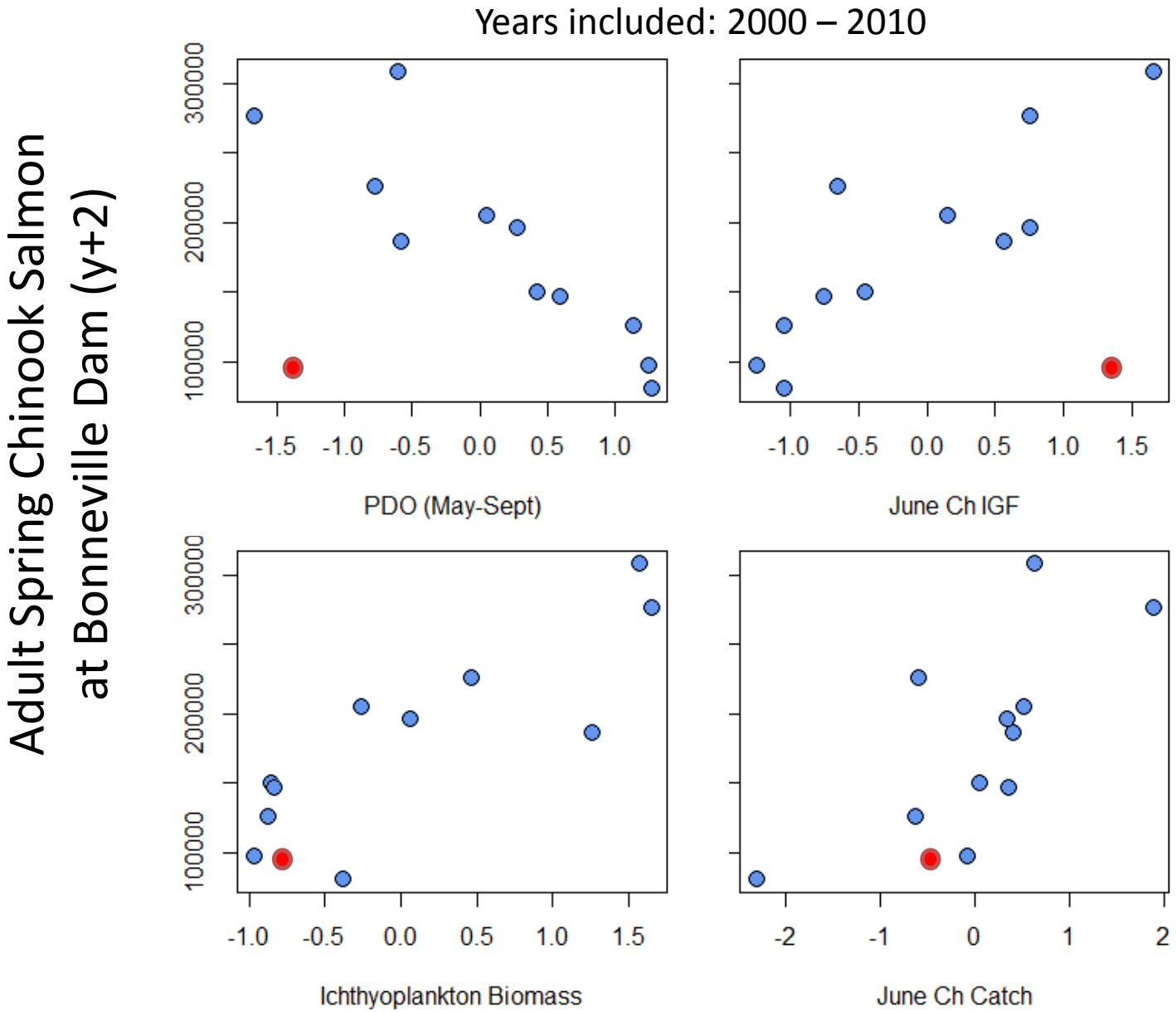


Preseason outlook: 200K
As of May 27th, 181K spring Chinook to Bonneville Dam



We overestimated 2013 returns

We learn best when models fail

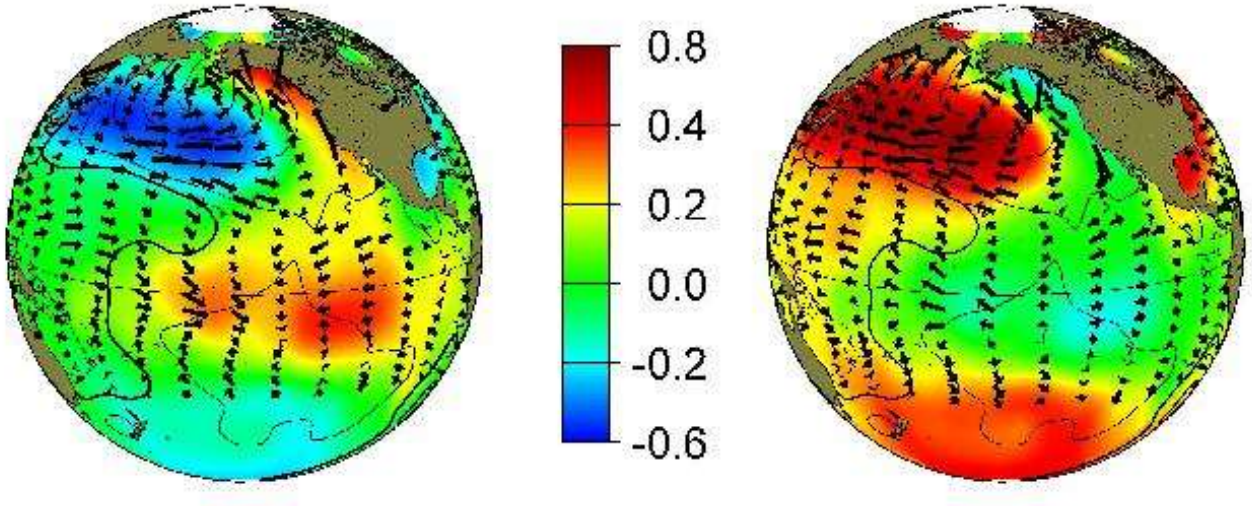


The PDO is not a measure of temperature

(It's a measure of a spatial pattern in temperature)

Warm year

Cold year



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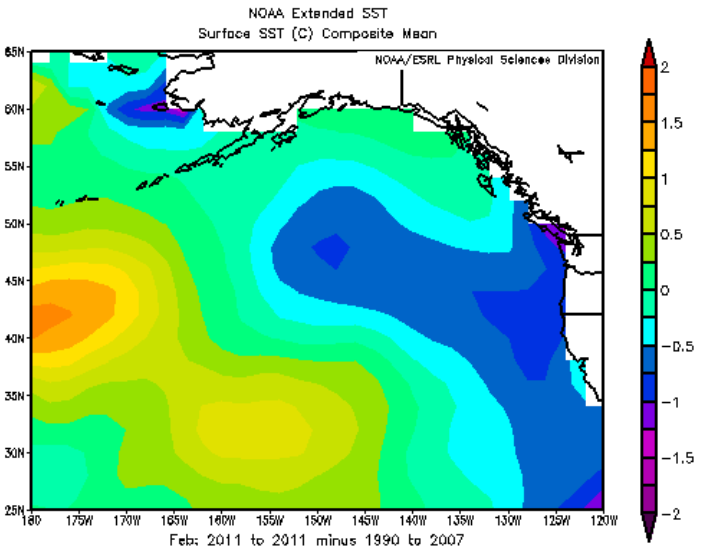
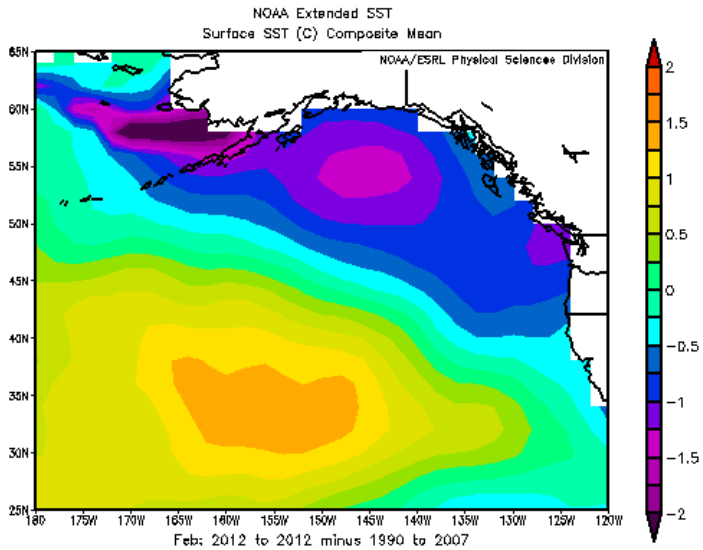
(It's a measure of a spatial pattern in temperature)

February 2011
PDO = -0.83



February 2012
PDO = -0.85

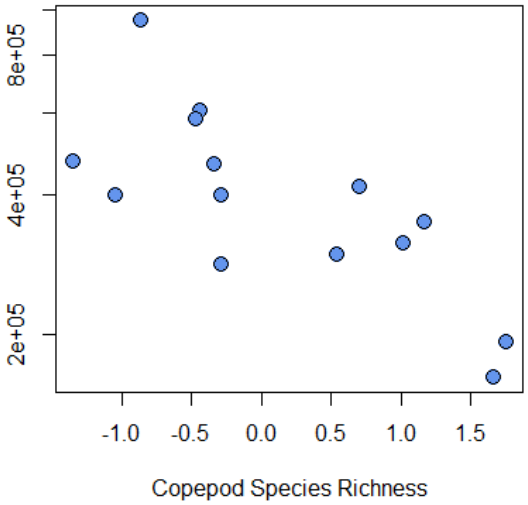


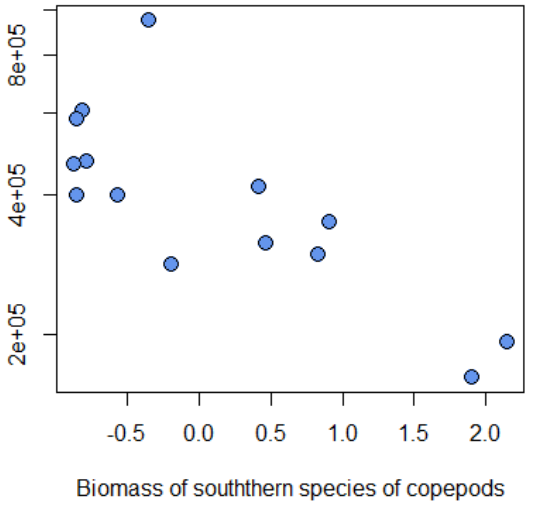
In **<u>2011</u>**, the status of a suite of ecosystem indicators cumulatively suggested that **<u>anomalous conditions had occurred in the Gulf of Alaska that year</u>**. The first indications were noted in **<u>upper trophic organisms that experienced reproductive failures and potential nutrient deficiencies</u>**. Evidence suggested that upper trophic organisms were influenced by bottom-up forcing that negatively influenced productivity at the lower trophic level.

Zador, S. and H. Renner. Red flags or red herrings revisited: Using ecosystem indicators to track ecosystem status in the Gulf of Alaska. 2014 PICES FUTURE Open Science Meeting, April 13-18, 2014, Kohala Coast, Big Island, HI, U.S.A.

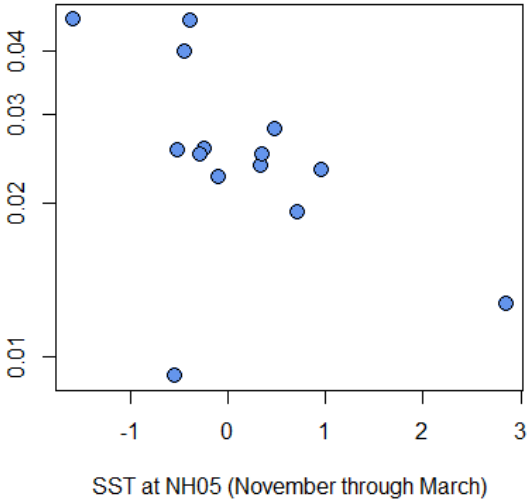
But we have other information (at multiple scales)

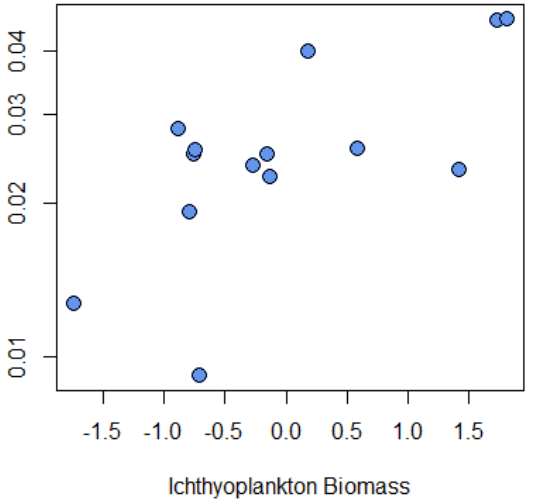
Fall Chinook salmon returns to Bonneville Dam





Coho SAR





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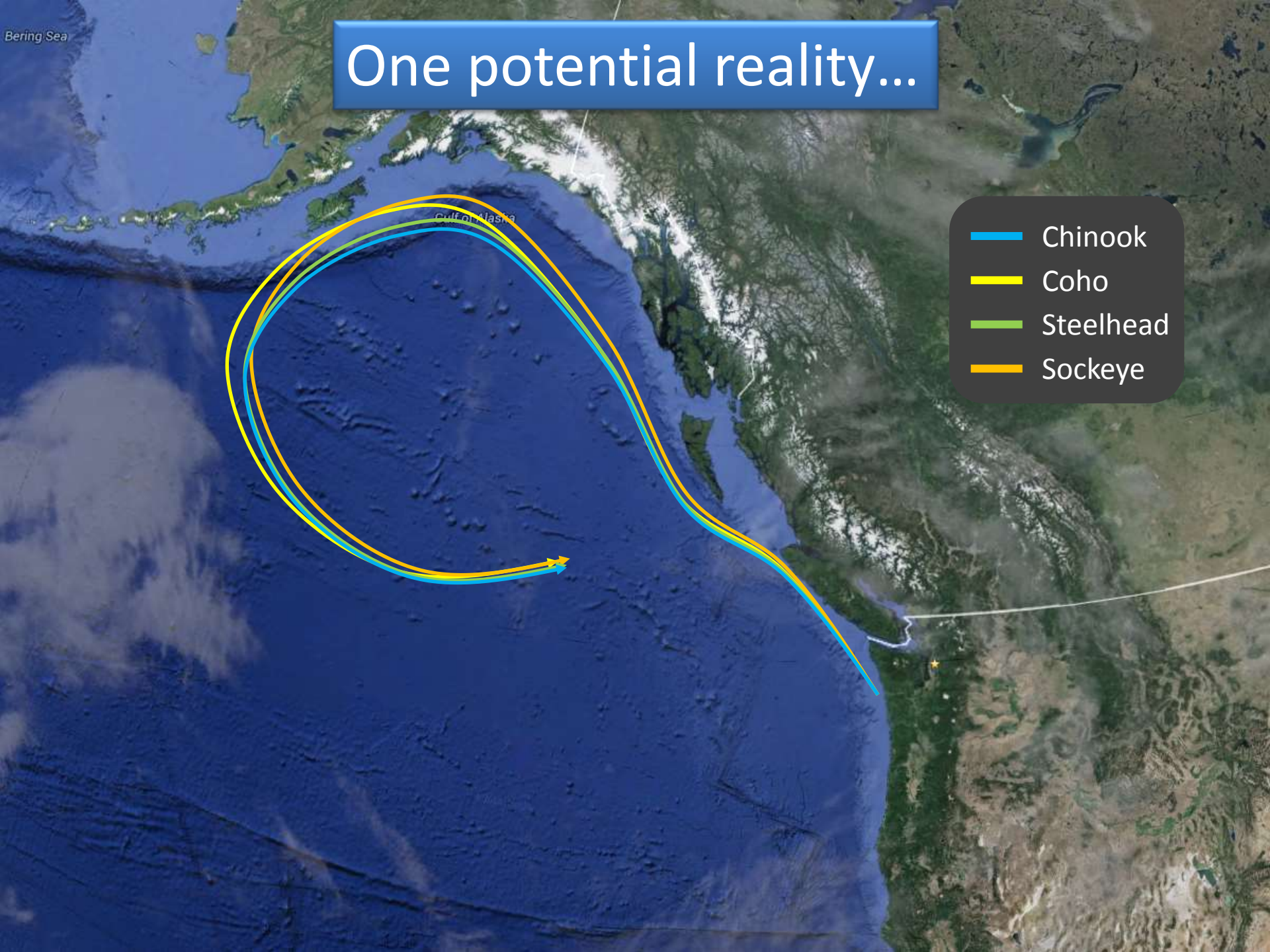
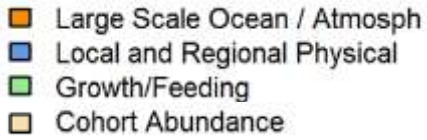
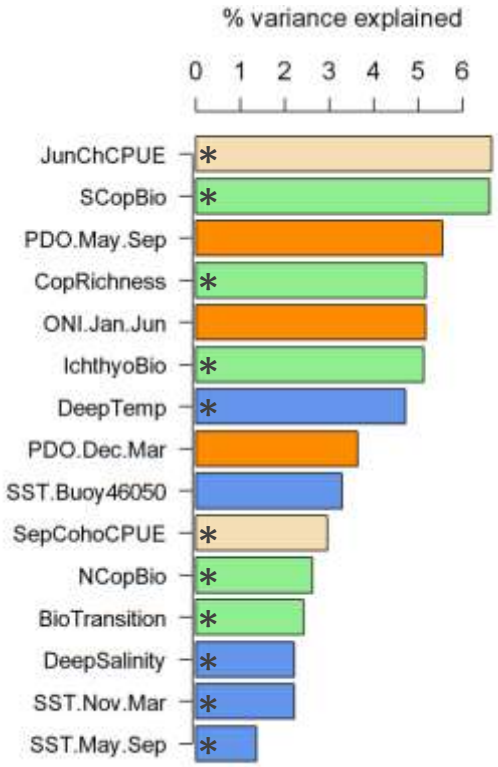

One potential reality…
Bering Sea
Gulf of Alaska
Chinook
Coho
Steelhead
Sockeye

A more accurate reality…

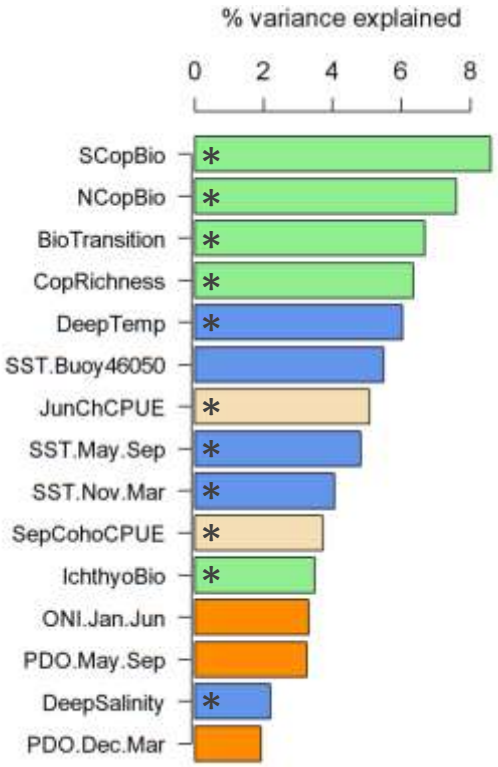
Variable importance differs among runs/species



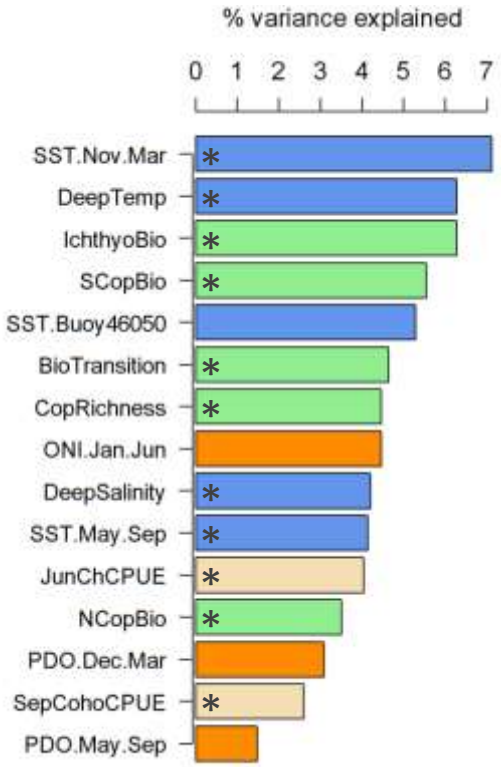
Spring Chinook



Fall Chinook



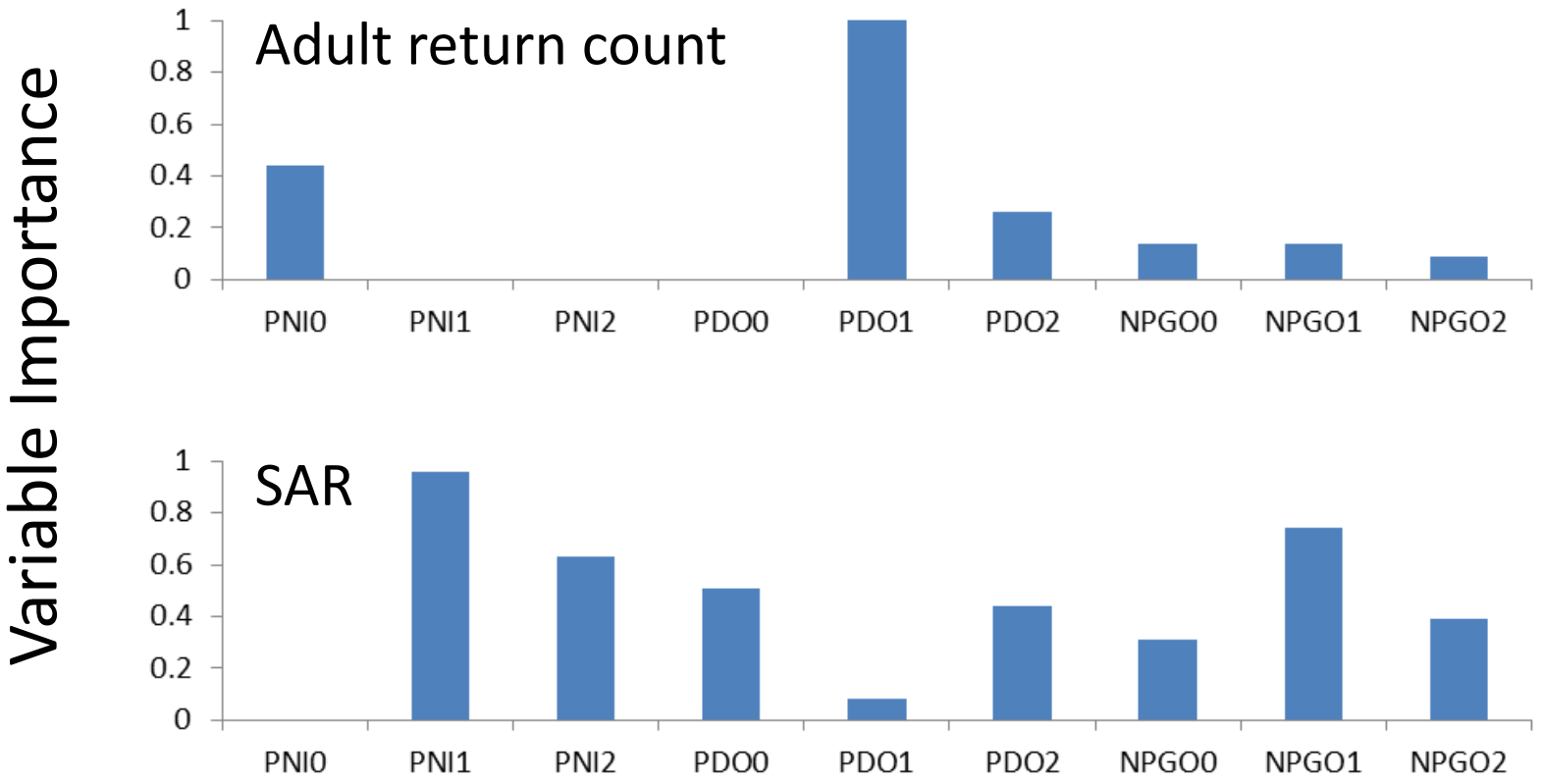
Coho



* Collected during NWFSC cruises

Quality of fish data is important

Coho salmon from WA to CA: data include brood years 1993-2012, analysis by Jennifer Gosselin, NOAA Fisheries



Spring Chinook salmon life cycle model