6.2 Ocean Indicators
Relative to Protected Species

NOAA FISHERIES

NWFSC

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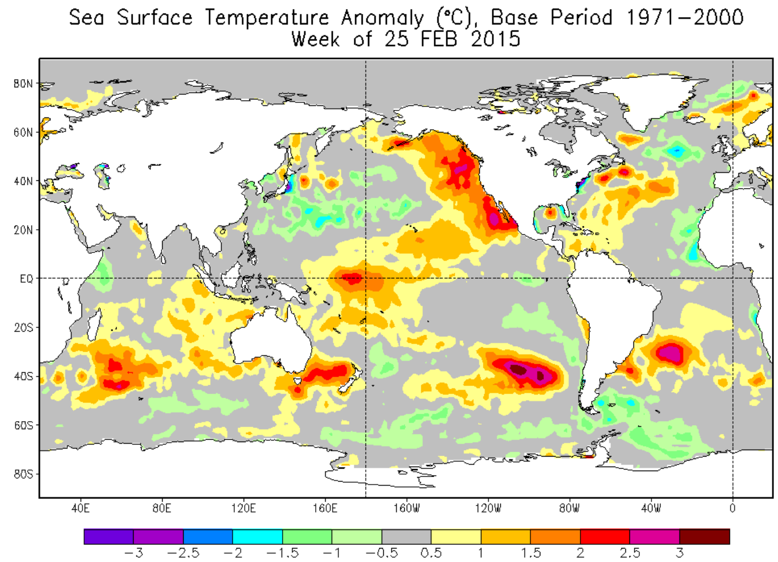
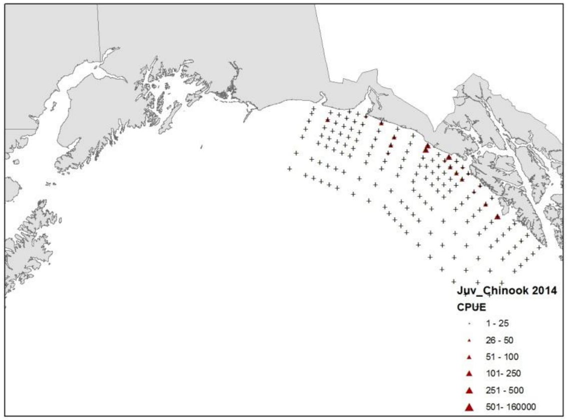
May 5th, 2015

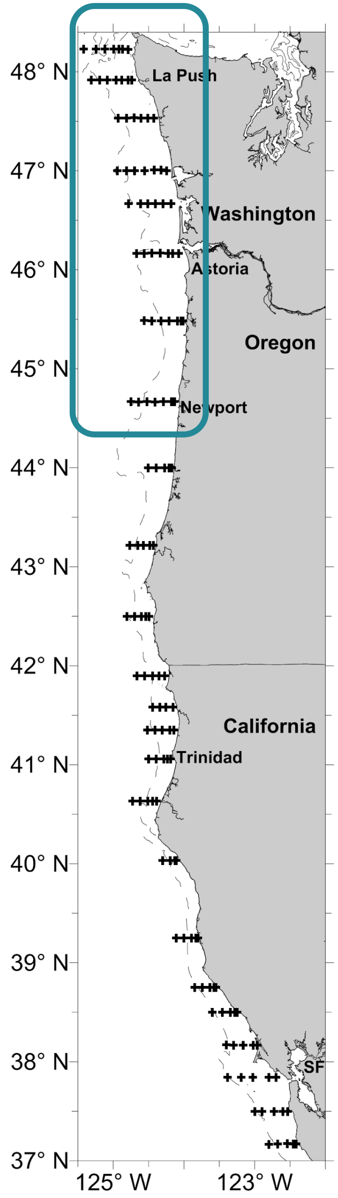


Outline

- Indicators (of ocean conditions)
- Forecasting
- Spatial distribution and future directions
- Data Gaps

Observations





Juvenile salmon sampling:

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

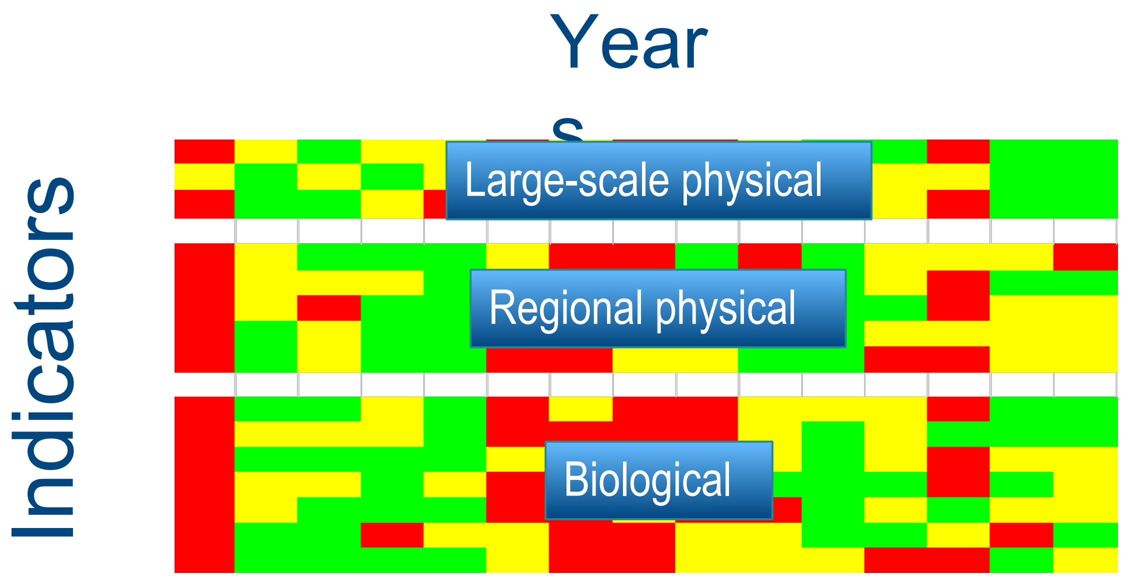
- Measure physical and biological conditions
- Focus on distribution & abundance of juvenile salmonids along with metrics of growth & condition

Indicators
(of ocean conditions relative to salmon)

- **Basin Scale:**
  - PDO, NPGO, ONI
- **Local-Regional Scale SST:**
  - SST offshore and SST mid-shelf in summer; SST in winter
- **Coastal upwelling:**
  - spring transition; length of upwelling season, upwelling in spring; deep T and S in mid-shelf waters
- **Copepods:**
  - species richness, northern copepod biomass, copepod community structure index, date of biological spring transition
- **Ichthyoplankton:**
  - density in Jan-Mar of the larvae of species of fish that salmon eat
- **Salmon:**
  - catches of spring Chinook in June and coho in September

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

General Characterization of Ocean Conditions



Good **Fair** **Poor**

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

Stoplight Chart

Ecosystem Indicators		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
PDO (December-March)		16	6	3	12	7	17	11	15	13	9	5	1	14	4	2	8	10
PDO (May-September)		10	4	6	5	11	15	14	16	12	13	2	9	7	3	1	8	17
ONI Jan-June		17	2	1	5	13	14	12	15	7	11	3	9	16	4	5	7	9
46050 SST (May-Sept)		15	8	3	4	1	7	17	14	5	16	2	9	6	10	11	12	13
NH 05 Upper 20 m T winter prior (Nov-Mar)	*	17	11	8	10	6	14	15	12	13	5	1	9	16	4	3	7	2
NH 05 Upper 20 m T (May-Sept)	*	13	10	12	4	1	3	17	15	7	8	2	5	11	9	6	14	16
NH 05 Deep Temperature (May-Sept)	*	17	6	8	4	1	9	12	14	10	5	2	7	13	11	3	16	15
NH 05 Deep Salinity (May-Sept)	*	17	3	7	4	5	13	14	8	6	1	2	11	15	10	9	12	16
Copepod Richness Anomaly	*	17	2	1	7	6	13	12	16	14	11	9	10	15	4	5	3	8
N. Copepod Biomass Anomaly	*	16	13	9	10	3	15	12	17	14	11	6	8	7	1	2	4	5
S. Copepod Biomass Anomaly	*	17	2	5	4	3	13	14	16	12	10	1	7	15	9	8	6	11
Biological Transition	*	17	11	6	7	8	12	10	16	15	3	1	2	14	4	9	5	13
Winter Ichthyoplankton	*	17	8	2	4	6	15	14	10	13	12	1	9	3	11	7	5	16
Chinook Juv Catches (June)	*	16	4	5	14	10	12	15	17	11	8	1	6	7	13	3	2	9
Coho Juv Catches (June)	*	16	7	11	5	6	2	13	17	14	3	4	8	9	12	15	1	10
Mean of Ranks		15.9	6.5	5.8	6.6	5.8	11.6	13.5	14.5	11.1	8.4	2.8	7.3	11.2	7.3	5.9	7.3	11.3
RANK of the Mean Rank		17	5	2	6	2	14	15	16	11	10	1	8	12	7	4	8	13
Principle Component Scores (PC1)		6.70	-1.93	-2.55	-1.71	-1.96	1.81	2.94	4.41	1.02	-0.66	-4.70	-1.30	1.45	-1.47	-2.11	-1.35	1.42
Principle Component Scores (PC2)		-0.72	0.09	0.24	-1.10	-1.81	-1.36	2.17	-0.97	-1.20	0.38	-1.26	0.49	-1.11	1.08	0.57	1.90	2.62
Ecosystem Indicators not included in the mean of ranks or statistical analyses																		
Physical Spring Trans (UI Based)		3	6	16	13	4	10	12	17	10	1	5	2	7	9	14	8	15
Physical Spring Trans (Hydrographic)		16	3	12	7	5	11	13	17	6	8	1	8	15	3	10	2	14
Upwelling Anomaly (Apr-May)		7	1	14	3	6	11	10	17	7	2	4	5	12	14	12	9	16
Length of Upwelling Season (UI Based)		6	2	15	9	1	10	8	17	5	3	7	3	12	14	12	11	16
NH 05 SST (May-Sept)	*	10	6	5	4	1	3	16	14	8	12	2	15	9	7	11	13	16
Copepod Community Structure	*	17	5	4	8	1	13	14	16	15	10	2	6	12	9	7	3	11
Coho Juv Catches (Sept)	*	11	2	1	4	3	6	12	14	8	9	7	15	13	5	10	NA	NA

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

* Collected during NWFSC cruises

Stoplight Chart

DFO - WCVI

Environmental Variables	***1998***	***1999***	***2005***	***2008***	***2009***	***2010***	***2011***	***2012***	***2013***	***2014***
PDO (May-Sep)	10	4	16	2	9	7	3	1	8	17
NPGO (May-Sep)	14	5	17	2	11	6	7	4	12	15
ENSO (May-Sep)	8	2	11	6	17	1	5	14	4	15
Mean SST - WCVI (Amphitrite) - Mar-Jun	16	1	17	6	9	13	10	2	7	14
WCVI Coho Summer Growth	16	2	17	8	14	7	15	6	13	1
Mean Rank	12.8	2.8	15.6	4.8	12.0	6.8	8.0	5.4	8.8	12.4
Rank of Mean Ranks	16	1	17	2	13	6	7	3	10	14

AFSC

Pink salmon parent brood year				Chronological ecosystem variables										Pink salmon harvest	
Brood year (BY)	SEAK pink harvest (M)	Pink regional proportionality (% Northern harvest. Green = 40-60%, Yellow = >20<40%, or >60<80%, Red = <20% >80%)	SEAK pink escapement index	**Ocean entry year (BY lagged 1 yr later)**	Auke Creek fry outmigration (1,000s) Lat 58°N	Upper 1-20 m avg. Icy Strait temp. "ISTI" May-Aug	Juvenile peak pink (CAL) CPUE June or July	Juvenile peak pink (TTD) CPUE June or July	Peak seaward migration month	Proportion of pink in trawl hauls in June-July-Aug	Adult coho predation impact Coho total #s/J-pink CPUE	North Pacific Index (June, July, Aug)	**Ranking of the avearge annual scores of the six significant variables**	**SEAK pink harvest (M) (BY lagged 2 yrs later)**	**SEAK pink harvest (M) (response variable)**
Data source	*ADFG₁*	*ADFG*	*ADFG₁*		*NOAA₁*	*NOAA₁*	*NOAA₂*	*NOAA₂*	*NOAA₁*	*NOAA₂*	*NOAA₂ ADFG₃*	*CGD*	↓		*ADFG₁*
1996	64.6	17%	18.1	1997	31.1	9.5	2.5	2.2	July	18%	1.5	15.6	11	1998	42.4
1997	28.9	47%	14.8	1998	60.8	9.7	5.6	5.3	June	46%	0.8	18.1	1	1999	77.8
1998	42.4	44%	14.3	1999	53.5	9.0	1.6	1.4	July	9%	3.9	15.8	16	2000	20.2
1999	77.8	50%	27.3	2000	132.1	9.0	3.7	3.3	July	28%	1.0	16.9	4	2001	67.0
2000	20.2	39%	10.8	2001	61.5	9.5	2.9	2.6	July	30%	2.0	16.8	8	2002	45.3
2001	67.0	22%	18.6	2002	150.1	8.6	2.8	2.5	July	26%	2.5	15.6	10	2003	52.5
2002	45.3	49%	16.6	2003	95.1	9.8	3.1	2.7	July	20%	1.8	16.1	9	2004	45.3
2003	52.5	44%	20.0	2004	169.6	9.7	3.9	3.4	June	32%	1.4	15.1	5	2005	59.1
2004	45.3	54%	15.7	2005	87.9	10.2	2.0	1.7	Aug	35%	3.3	15.5	15	2006	11.6
2005	59.1	51%	19.9	2006	65.9	8.9	2.6	2.3	June	23%	1.9	17.0	7	2007	44.8
2006	11.6	72%	10.2	2007	81.9	9.3	1.2	1.0	Aug	17%	3.7	15.7	18	2008	15.9
2007	44.8	29%	17.6	2008	117.6	8.2	2.5	2.2	Aug	24%	2.1	16.1	12	2009	38.0
2008	15.9	14%	9.5	2009	34.8	9.5	2.1	2.7	Aug	26%	1.7	15.1	13	2010	24.0
2009	38.0	31%	12.7	2010	121.6	9.6	3.7	5.0	June	60%	0.9	17.6	2	2011	58.9
2010	24.0	43%	11.2	2011	30.9	8.9	1.3	1.6	Aug	27%	4.1	15.7	17	2012	21.3
2011	58.9	81%	14.3	2012	61.8	8.7	3.2	4.3	July	49%	1.1	16.7	3	2013	94.7
2012	21.3	13%	11.0	2013	51.2	9.2	1.9	2.6	July	13%	2.8	16.0	14	2014	37.2
2013	94.7	44%	25.2	2014	47.4	9.4	3.4	4.6	July	57%	2.1	15.8	6	2015	??.?

Forecasting:

Forecasting: 1st Generation Model

Indicators

Year

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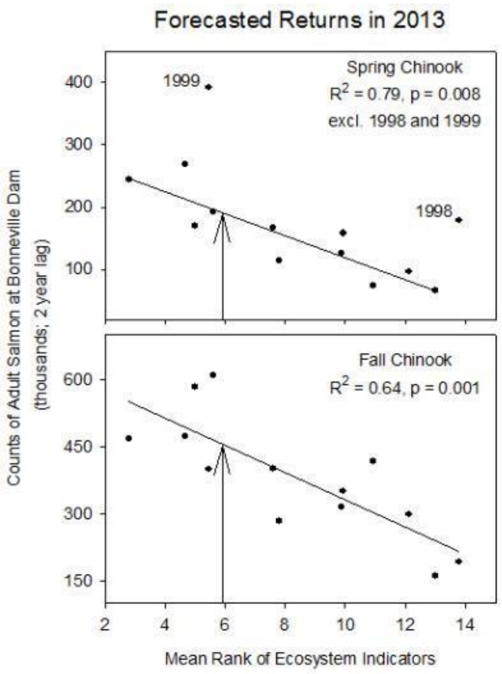
Good Fair Poor



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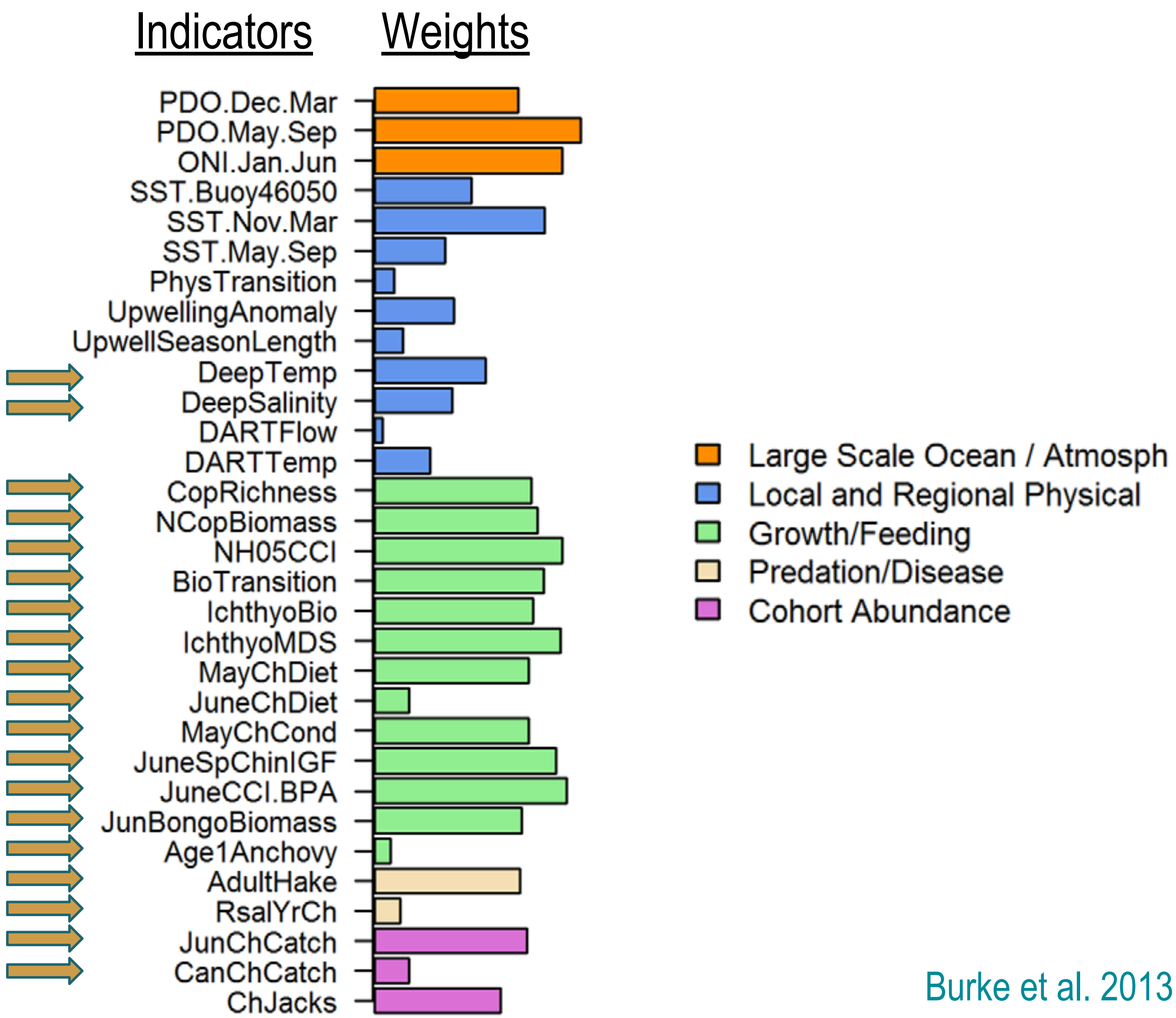
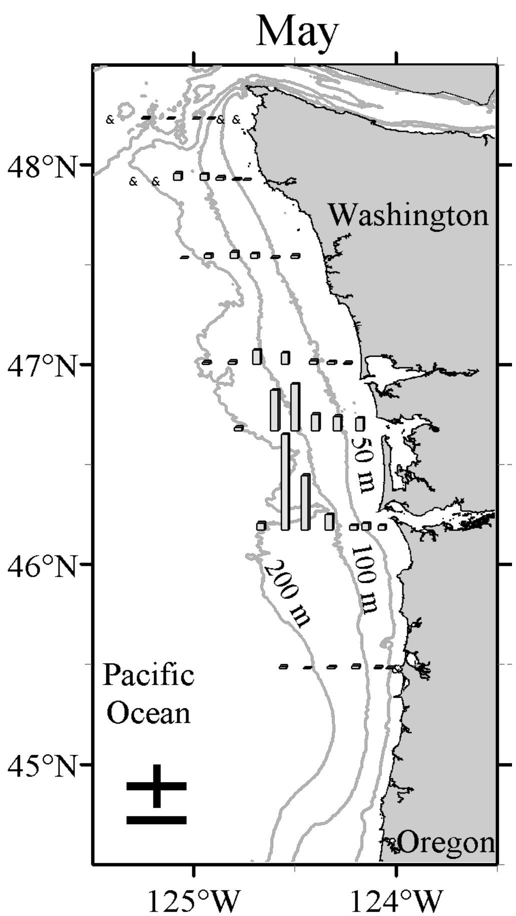
Forecasting: 2nd Generation Model

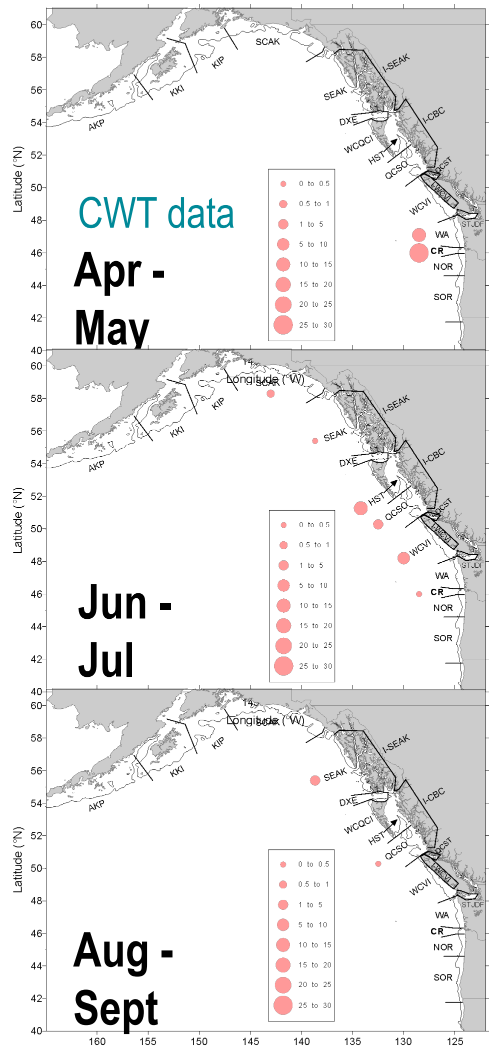


Burke et al. 2013 *PLoS ONE*

Spatial Distribution

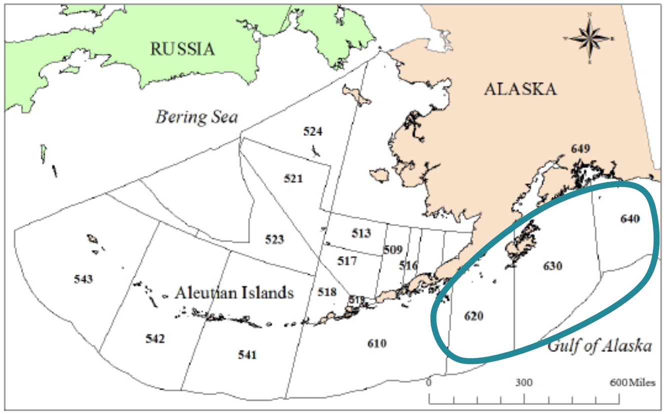
Snake River yearling Chinook salmon





Adapted from Fisher et al. 2014, TAFS

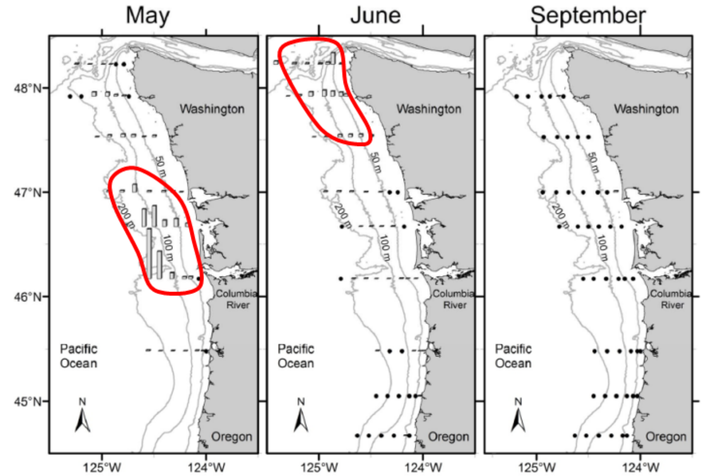
- 60-80% of juvenile Chinook salmon caught in AFSC surveys were from Oregon, Washington, and Columbia River
- 40% of Chinook from walleye pollock bycatch was from U.S. West Coast



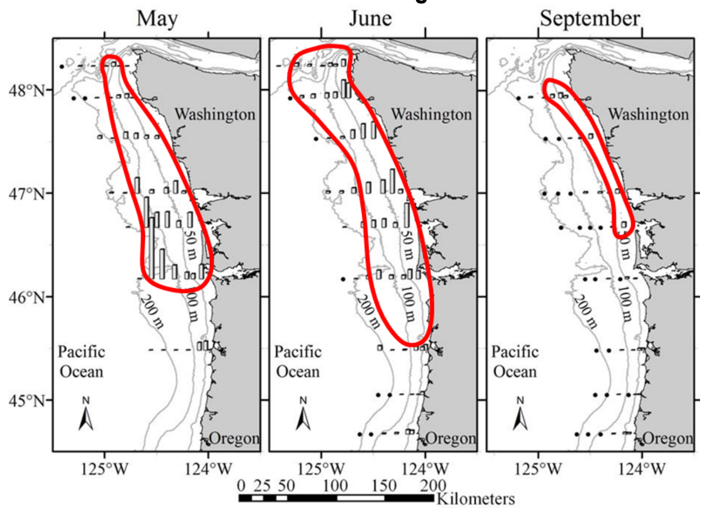
Guyon et al. 2015. NOAA Tech Memo NMFS-AFSC-291

Spatial distribution is stock-specific

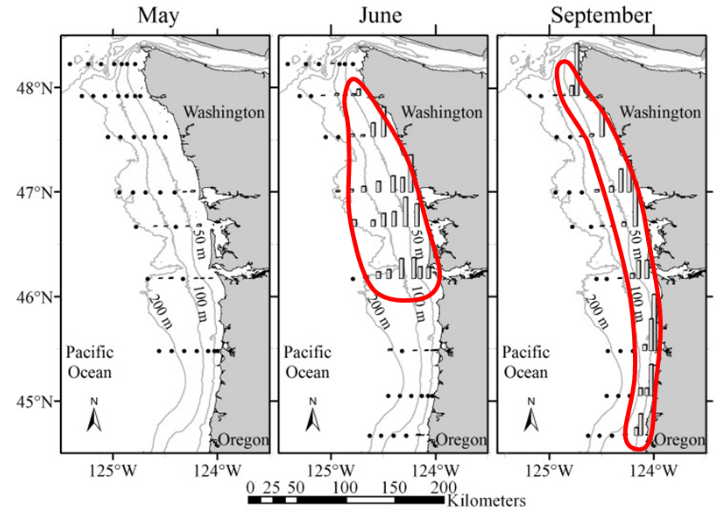
Snake River Yearling Spring Chinook



Snake River Yearling Fall Chinook

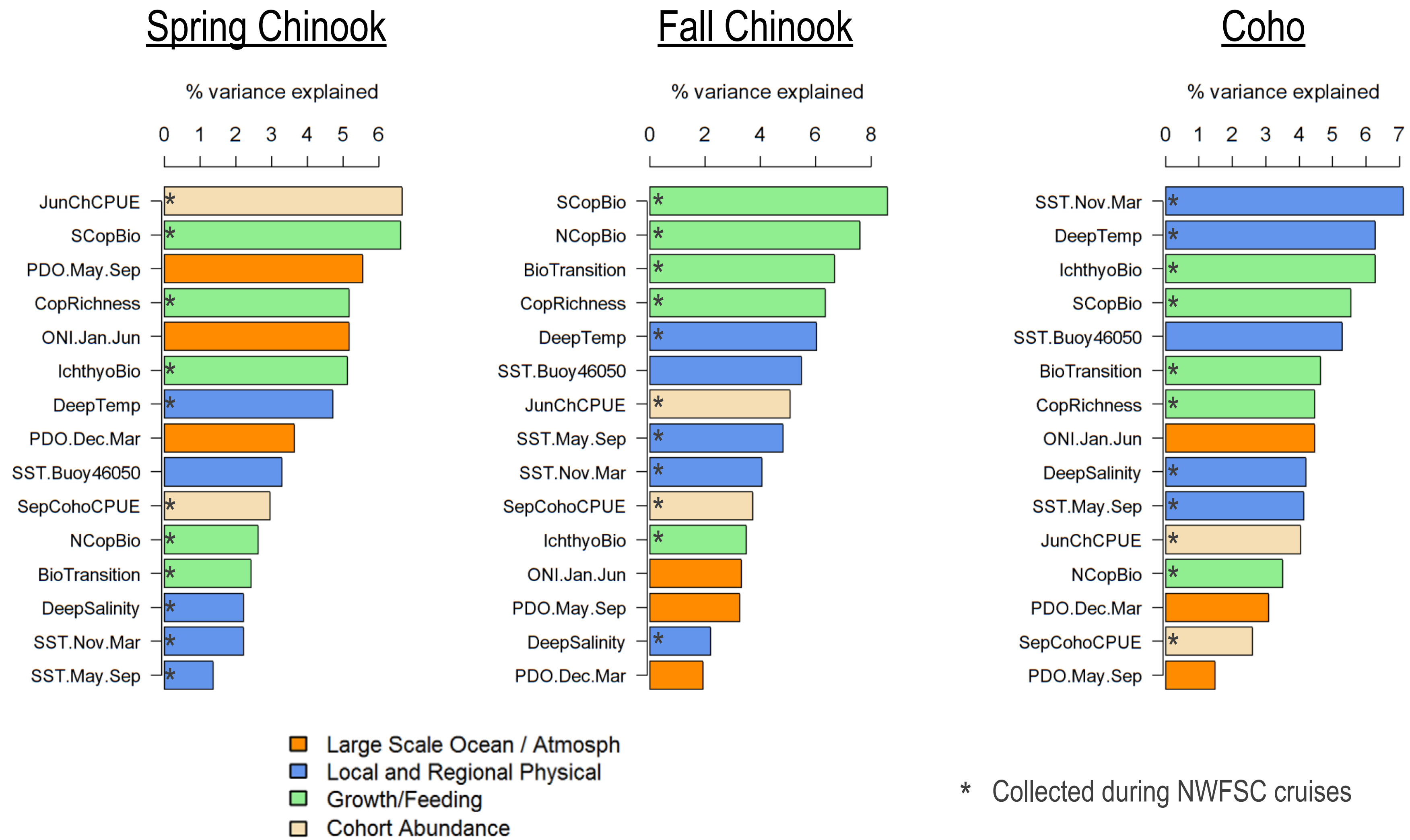


Snake River Subyearling Fall Chinook



Teel et al. 2015. Marine and Coastal Fisheries, In press.

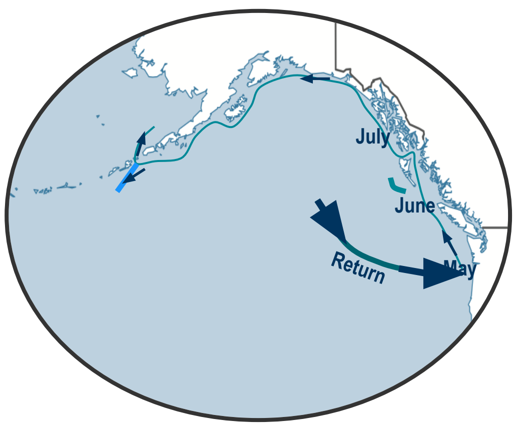
Variable importance differs among runs/species



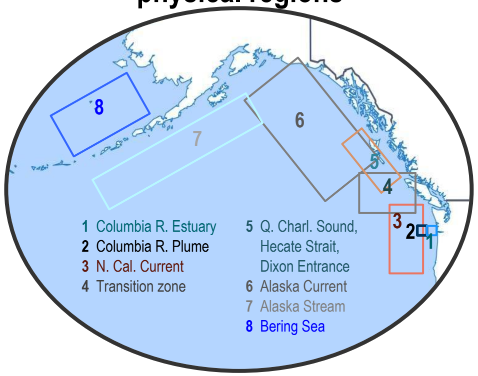
Forecasting: 3rd Generation Model

- Better tools
  - Multivariate Autoregressive State Space Models
  - Spatial Factor Analysis
- Better spatial/temporal matchup

Snake R. Chinook salmon

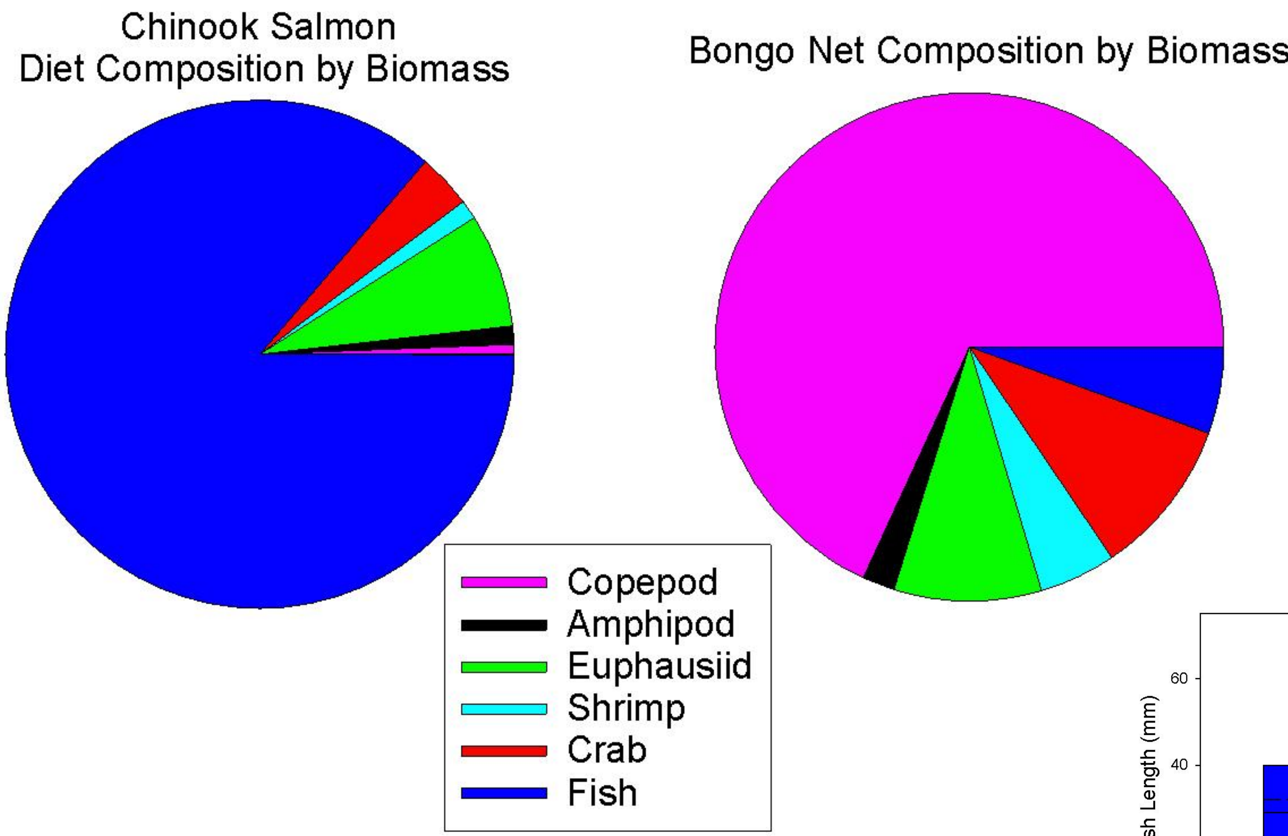


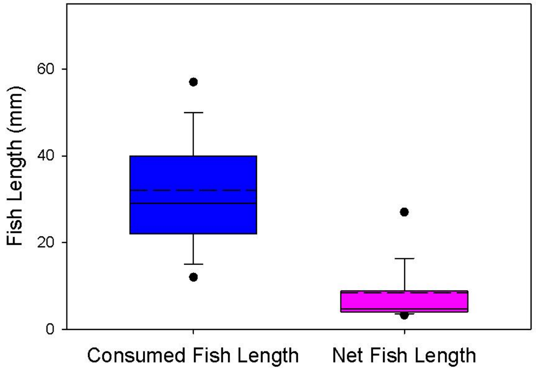
Oceanographic physical regions



Data Gaps:

Data Gaps: We don’t sample their prey





Data Gaps: We don't sample their predators

Back-of-the-envelope estimates suggest >5 million smolts/year

Sooty Shearwaters and Common Murres; photograph: Jen Zamon