Forecasting Natural Coho Salmon Run Size for the Lower Columbia River Tributaries, Washington State

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Presentation to the Ocean and Plume Science and Management Forum
Northwest Power Conservation Council
October 26, 2017

Outline

- Background
- Washington State wild coho forecasts
- Lower Columbia River natural coho forecasts

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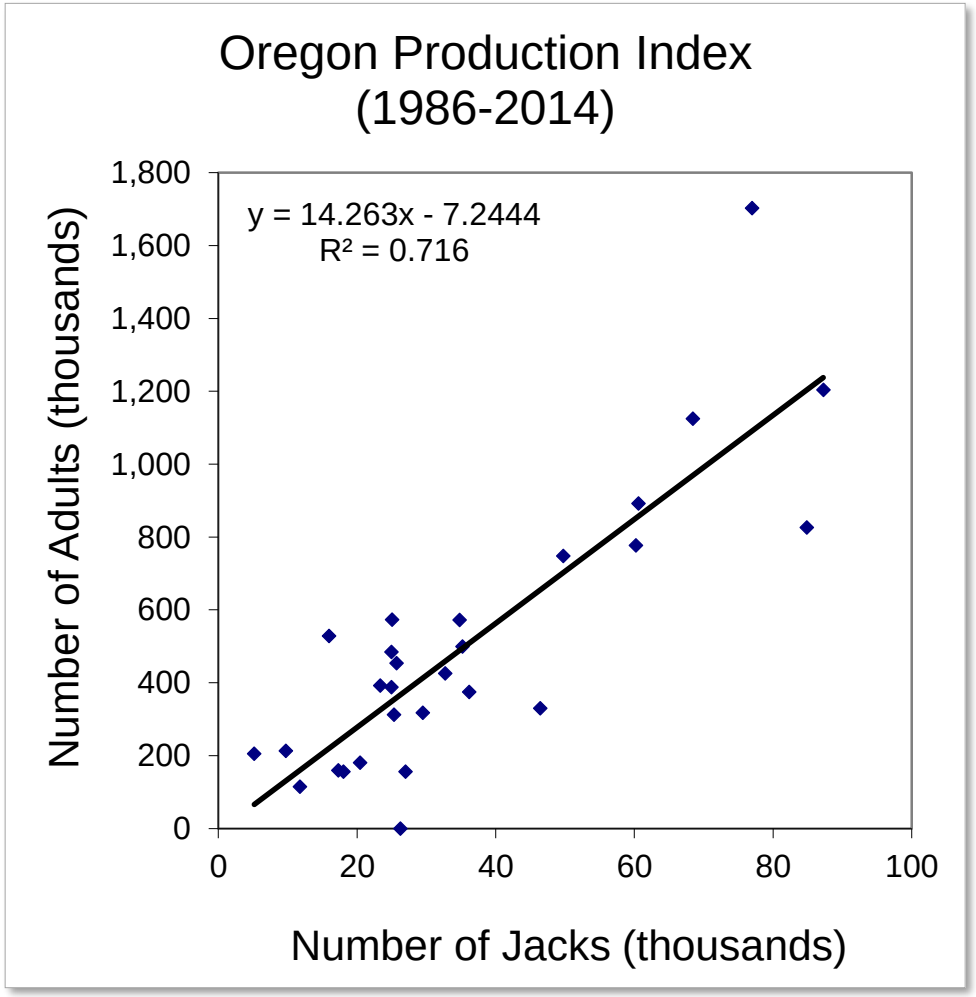
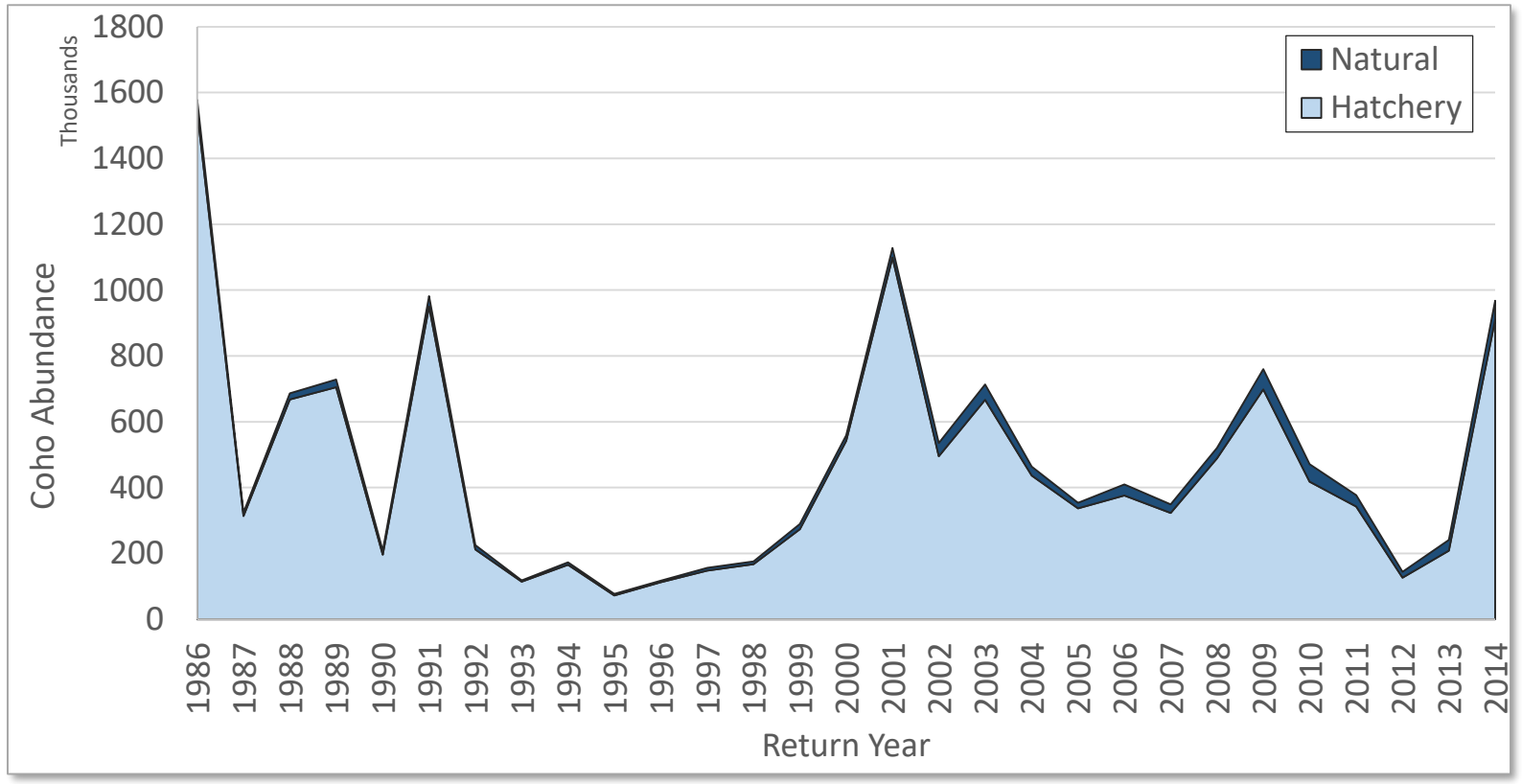
Columbia River Coho Salmon Forecasts
Oregon Production Index

- OPI based on CA, OR, WA populations, but primarily Col River hatchery coho
- Prepared annually by OPI Technical Team
- Predict adult run size (age-3) based on jack returns (age-2)



Columbia River Coho Salmon Returns

Natural versus hatchery coho



~20 hatchery: 1 natural

Data source: OPITT Table 5

Jack Predictions of Coho Salmon Survival

- Example: Bingham Creek, Washington
- Jack:adult ratio variable in wild populations!
- Jacks are not consistent predictors of wild coho adult returns

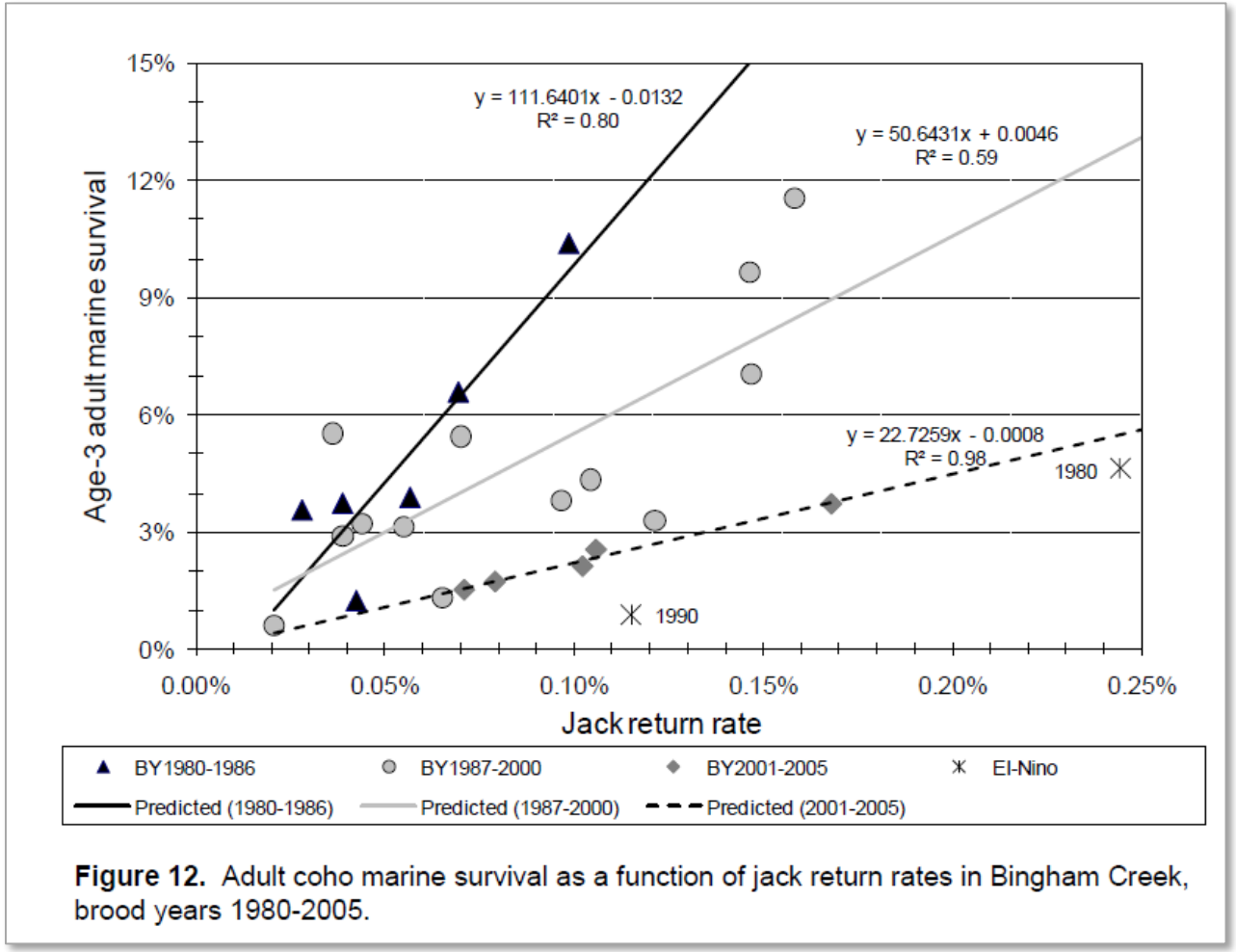


Figure 12. Adult coho marine survival as a function of jack return rates in Bingham Creek, brood years 1980-2005.

Zimmerman. 2009 Wild coho forecasts for Puget Sound, Washington Coast, and Lower Columbia.

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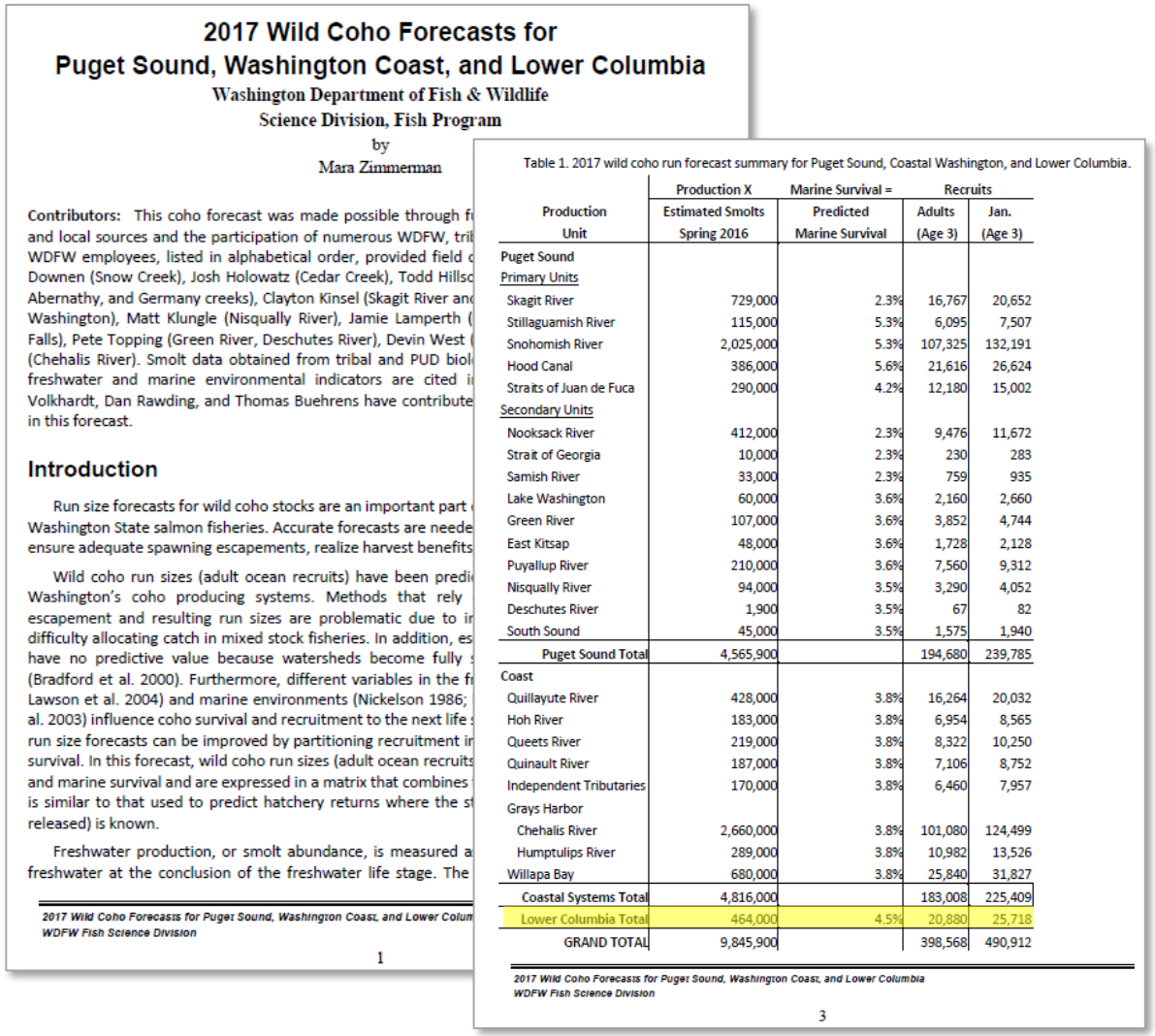
Wild Coho Forecasts for Washington State



2017 Wild Coho Forecasts for
Puget Sound, Washington Coast, and Lower Columbia

Washington Department of Fish & Wildlife
Science Division, Fish Program

by
Mara Zimmerman

Contributors: This coho forecast was made possible through f
and local sources and the participation of numerous WDFW, tril
WDFW employees, listed in alphabetical order, provided field d
Downen (Snow Creek), Josh Holowatz (Cedar Creek), Todd Hillso
Abernathy, and Germany creeks), Clayton Kinsel (Skagit River an
Washington), Matt Klungle (Nisqually River), Jamie Lamperth (
Falls), Pete Topping (Green River, Deschutes River), Devin West (
(Chehalis River). Smolt data obtained from tribal and PUD biol
freshwater and marine environmental indicators are cited i
Volkhardt, Dan Rawding, and Thomas Buehrens have contribute
in this forecast.

Introduction

Run size forecasts for wild coho stocks are an important part
Washington State salmon fisheries. Accurate forecasts are neede
ensure adequate spawning escapements, realize harvest benefits

Wild coho run sizes (adult ocean recruits) have been predi
Washington's coho producing systems. Methods that rely
escapement and resulting run sizes are problematic due to ir
difficulty allocating catch in mixed stock fisheries. In addition, es
have no predictive value because watersheds become fully s
(Bradford et al. 2000). Furthermore, different variables in the fr
Lawson et al. 2004) and marine environments (Nickelson 1986;
al. 2003) influence coho survival and recruitment to the next life s
run size forecasts can be improved by partitioning recruitment ir
survival. In this forecast, wild coho run sizes (adult ocean recruits
and marine survival and are expressed in a matrix that combines
is similar to that used to predict hatchery returns where the st
released) is known.

Freshwater production, or smolt abundance, is measured a
freshwater at the conclusion of the freshwater life stage. The

2017 Wild Coho Forecasts for Puget Sound, Washington Coast, and Lower Colum
WDFW Fish Science Division

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Table 1. 2017 wild coho run forecast summary for Puget Sound, Coastal Washington, and Lower Columbia.

	Production X	Marine Survival =	Recruits	
Production Unit	Estimated Smolts Spring 2016	Predicted Marine Survival	Adults (Age 3)	Jan. (Age 3)
Puget Sound				
Primary Units				
Skagit River	729,000	2.3%	16,767	20,652
Stillaguamish River	115,000	5.3%	6,095	7,507
Snohomish River	2,025,000	5.3%	107,325	132,191
Hood Canal	386,000	5.6%	21,616	26,624
Straits of Juan de Fuca	290,000	4.2%	12,180	15,002
Secondary Units				
Nooksack River	412,000	2.3%	9,476	11,672
Strait of Georgia	10,000	2.3%	230	283
Samish River	33,000	2.3%	759	935
Lake Washington	60,000	3.6%	2,160	2,660
Green River	107,000	3.6%	3,852	4,744
East Kitsap	48,000	3.6%	1,728	2,128
Puyallup River	210,000	3.6%	7,560	9,312
Nisqually River	94,000	3.5%	3,290	4,052
Deschutes River	1,900	3.5%	67	82
South Sound	45,000	3.5%	1,575	1,940
Puget Sound Total	4,565,900		194,680	239,785
Coast				
Quillayute River	428,000	3.8%	16,264	20,032
Hoh River	183,000	3.8%	6,954	8,565
Queets River	219,000	3.8%	8,322	10,250
Quinault River	187,000	3.8%	7,106	8,752
Independent Tributaries	170,000	3.8%	6,460	7,957
Grays Harbor				
Chehalis River	2,660,000	3.8%	101,080	124,499
Humptulips River	289,000	3.8%	10,982	13,526
Willapa Bay	680,000	3.8%	25,840	31,827
Coastal Systems Total	4,816,000		183,008	225,409
Lower Columbia Total	464,000	4.5%	20,880	25,718
GRAND TOTAL	9,845,900		398,568	490,912

2017 Wild Coho Forecasts for Puget Sound, Washington Coast, and Lower Columbia
WDFW Fish Science Division

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- WDFW Science Division
- Annual advisory document
- Co-managers use in fishery planning process
- Management unit scale

Wild Coho Forecasts for Washington State

- Forecasts run size as ocean age-3 abundance
- Includes spawners and harvest (tributaries, river, ocean)

*OA3 Abundance = Smolt * Marine Survival*

Outline

- Background
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- Lower Columbia River natural coho forecasts

Lower Columbia River Coho ESU

- 17 populations in Washington
- 5 populations in Oregon
- WA forecasts roll these populations up for the purpose of harvest management

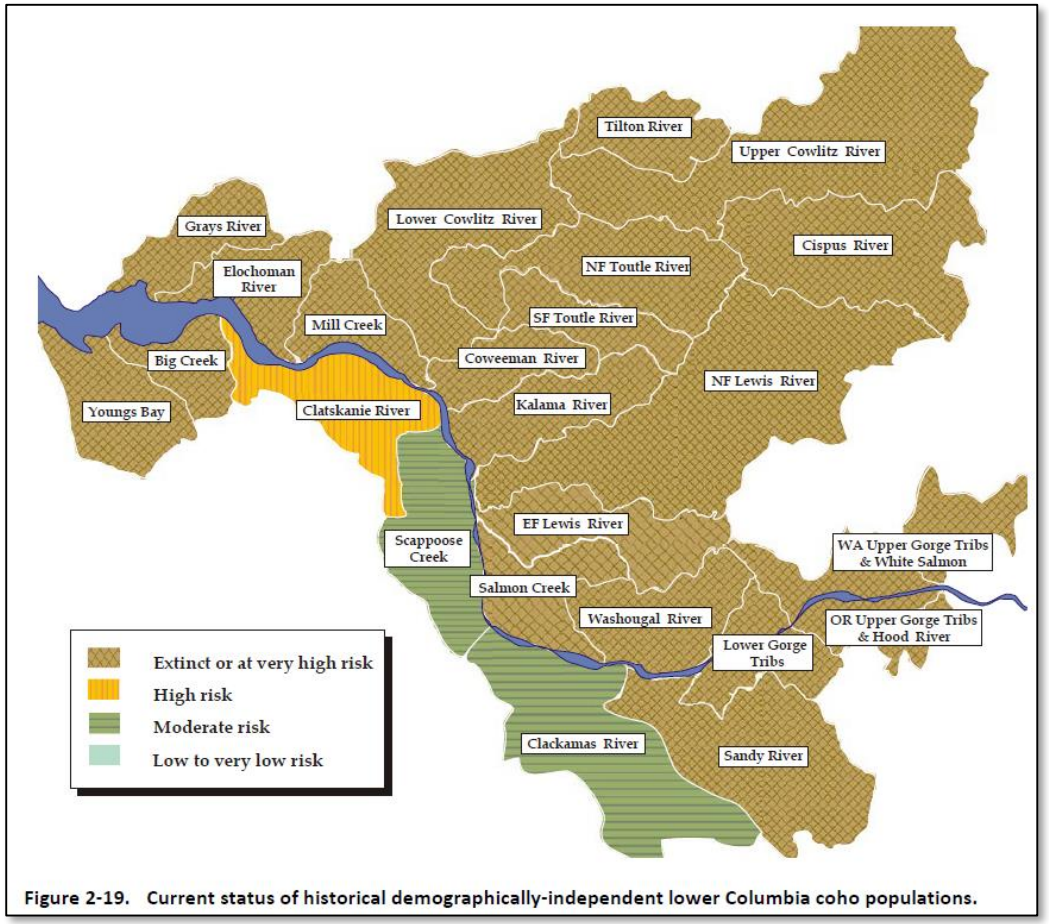


Figure 2-19. Current status of historical demographically-independent lower Columbia coho populations.

From: WA Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan

Lower Columbia River Natural Coho – Smolts

*OA3 Abundance = **Smolt** * Marine Survival*

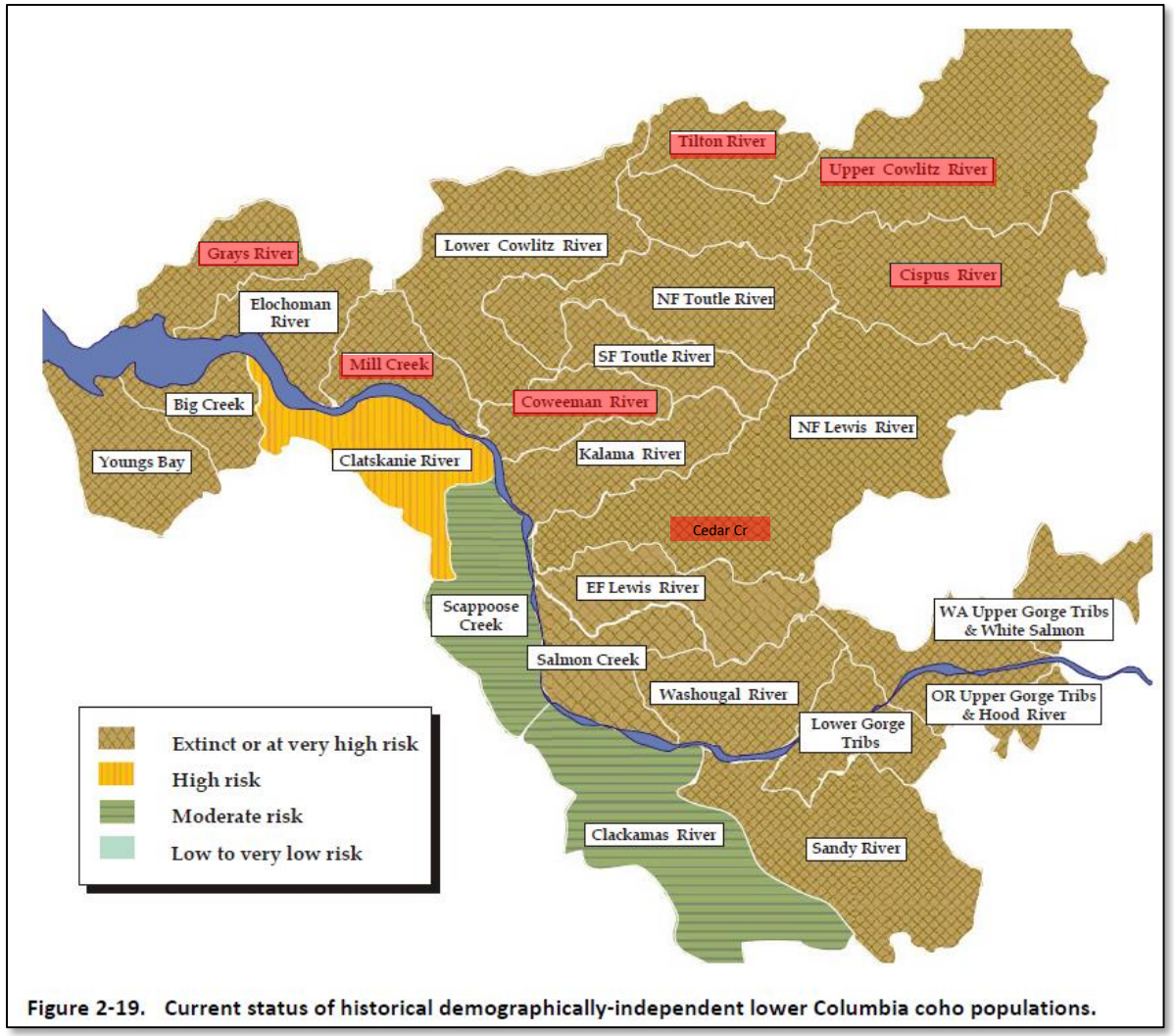


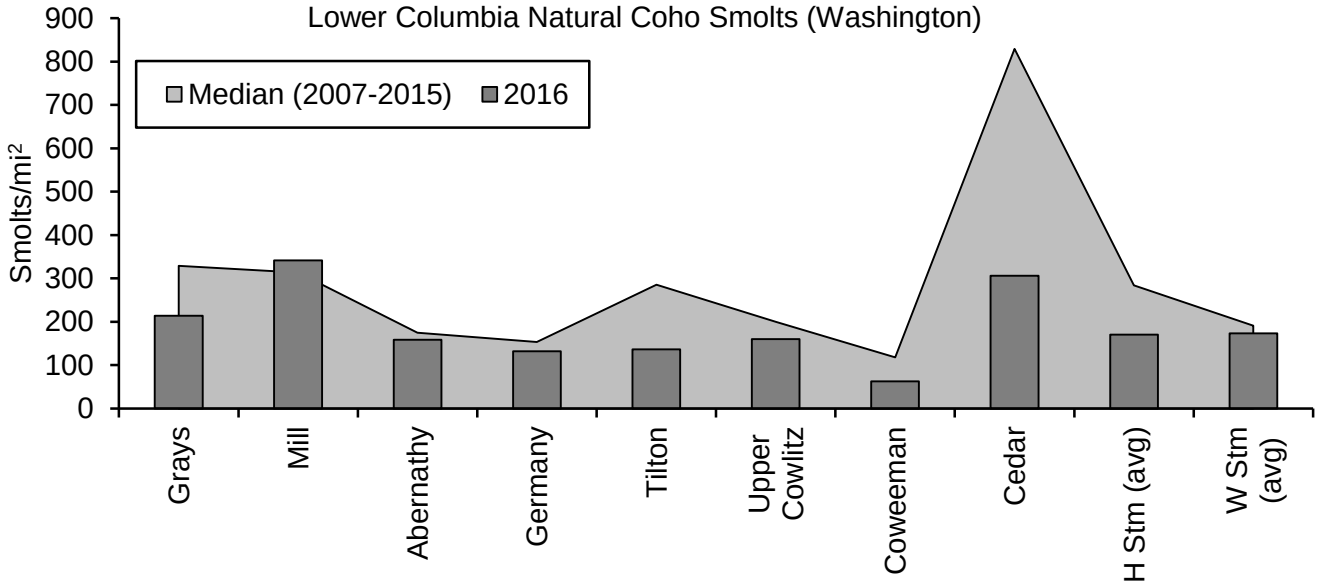
Figure 2-19. Current status of historical demographically-independent lower Columbia coho populations.

- 6 smolt traps
- 2 downstream collectors (Tilton, Cowlitz)

Lower Columbia River Natural Coho – Smolts

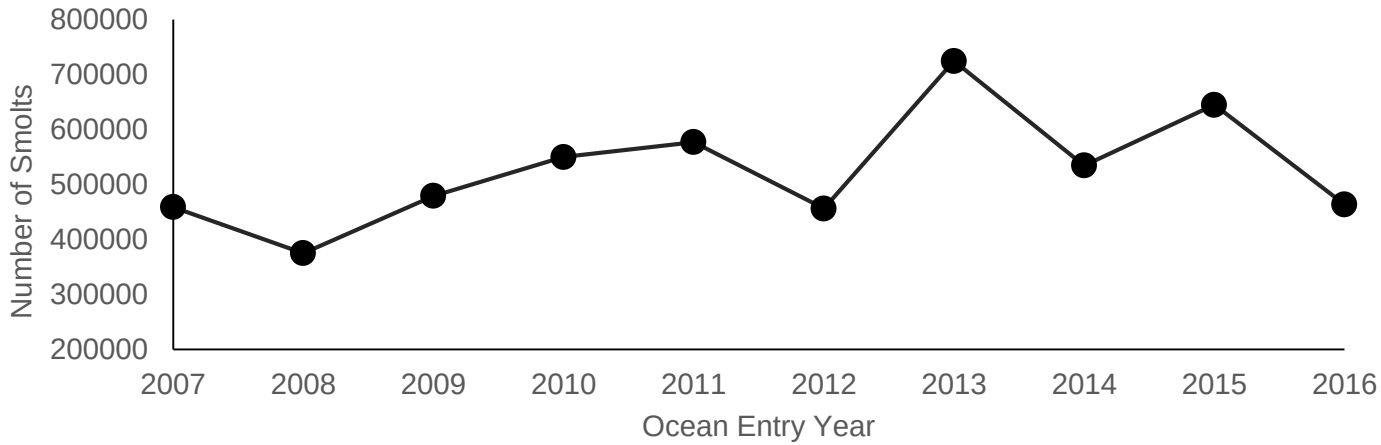
*OA3 Abundance = **Smolt** * Marine Survival*

- Smolt densities calculated in monitored watersheds
- Densities extrapolated to non-monitored watersheds



Total natural smolts

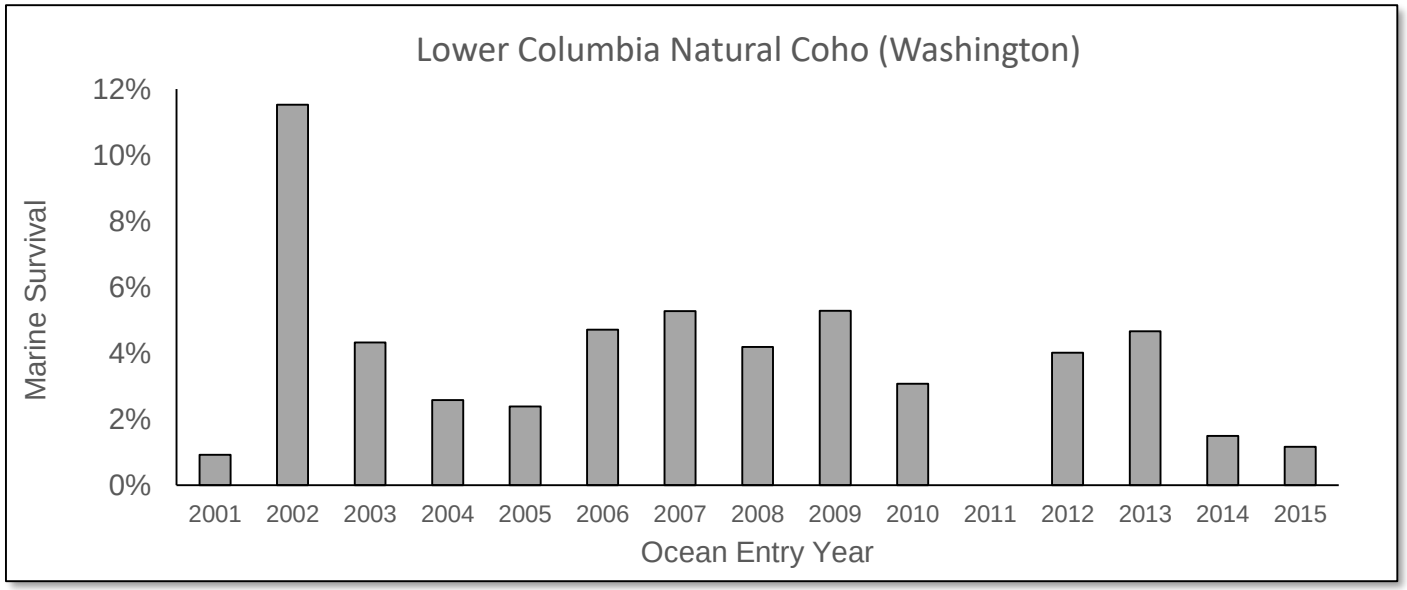
375,000 – 724,000



Lower Columbia River Natural Coho – Marine Survival

*OA3 Abundance = Smolt * **Marine Survival***

- Estimation via coded-wire tags (Tilton/Upper Cowlitz), exploitation rate model (LCN population)



Marine Survival

1% - 11%

Lower Columbia River Natural Coho – Marine Survival

Ocean Ecosystem Indicators from NWFSC

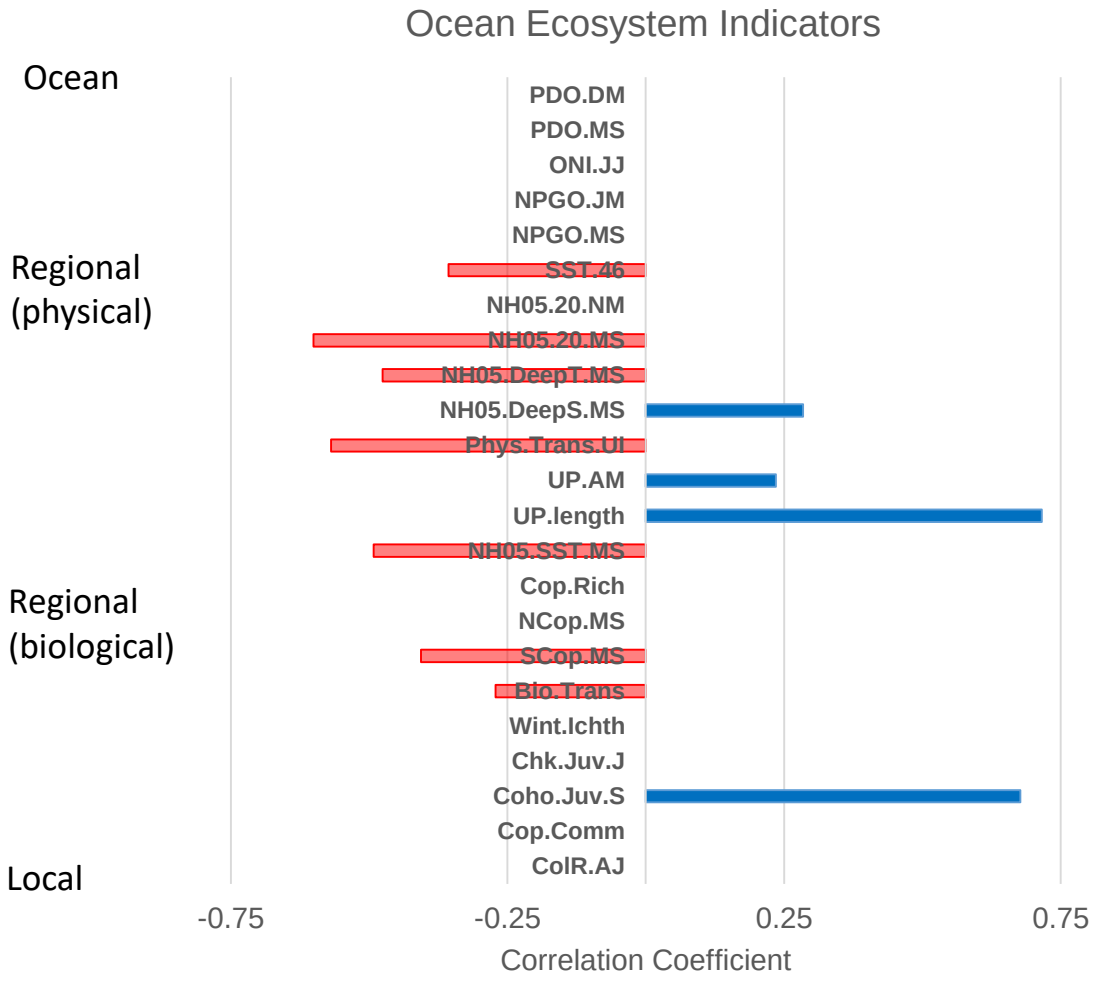
	Year																	
Ecosystem Indicators	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*
PDO (Sum Dec-March)	16	6	3	12	7	18	11	15	13	9	5	1	14	4	2	8	10	19	17
PDO (Sum May-Sept)	10	4	6	5	11	15	14	16	12	13	2	9	7	3	1	8	17	19	18
ONI (Average Jan-June)	18	1	1	6	12	14	13	15	8	11	3	10	16	4	5	7	9	17	19
46050 SST (°C; May-Sept)	15	8	3	4	1	7	19	14	5	16	2	9	6	10	11	12	13	18	17
Upper 20 m T (°C; Nov-Mar)	18	11	8	10	6	14	15	12	13	5	1	9	16	4	3	7	2	19	17
Upper 20 m T (°C; May-Sept)	15	11	13	4	1	3	19	17	7	8	2	5	12	10	6	16	18	9	14
Deep temperature (°C; May-Sept)	19	6	8	4	1	10	12	16	11	5	2	7	14	9	3	15	18	17	13
Deep salinity (May-Sept)	18	3	8	4	5	15	16	9	6	1	2	13	17	12	11	10	19	14	7
Copepod richness anom. (no. species; May-Sept)	17	2	1	7	6	13	12	16	14	10	8	9	15	4	5	3	11	18	19
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	19
S. copepod biomass anom. (mg C m^{-3}; May-Sept)	19	2	5	4	3	13	14	18	12	10	1	7	15	9	8	6	11	16	17
Biological transition (day of year)	17	11	6	7	8	12	10	16	15	3	1	2	14	4	9	5	13	19	19
Ichthyoplankton biomass (log (mg C 1000 m^{-3}); Jan-Mar)	19	10	2	6	8	17	16	12	15	14	1	11	3	13	9	7	18	4	5
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	19
Chinook salmon juvenile catches (no. km^{-1}; June)	18	4	5	16	10	13	17	19	12	8	1	6	7	15	3	2	9	14	11
Coho salmon juvenile catches (no. km^{-1}; June)	18	7	12	5	6	2	15	19	16	3	4	9	10	14	17	1	11	8	13
Mean of ranks	16.4	7.0	5.7	6.9	5.8	11.9	14.6	15.5	11.0	8.7	2.7	8.1	11.8	7.9	6.3	7.4	12.0	15.3	15.3
Rank of the mean rank	19	6	2	5	3	13	15	18	11	10	1	9	12	8	4	7	14	16	16
Ecosystem Indicators not included in the mean of ranks or statistical analyses																			
Physical Spring Trans. UI based (day of year)	3	7	18	15	4	12	14	19	12	1	6	2	8	11	16	9	17	10	5
Physical Spring Trans. Hydrographic (day of year)	18	3	13	8	5	12	14	19	6	9	1	9	17	3	11	2	15	7	16
Upwelling Anomaly (April-May)	9	3	16	5	8	13	12	19	9	4	6	7	14	16	14	11	18	1	2
Length of Upwelling Season UI based (days)	6	2	17	11	1	12	9	19	5	3	8	3	14	16	14	13	18	10	7
SST NH-5 (°C; May-Sept)	8	6	5	4	1	3	19	15	9	17	2	18	10	7	13	12	14	11	16
Copepod Community Index (MDS axis 1 scores)	18	5	4	8	1	13	14	16	15	10	2	6	12	9	7	3	11	17	19
Coho Juv Catches (no. fish km^{-1}; Sept)	11	2	1	4	3	6	12	14	8	9	7	15	13	5	10	NA	NA	NA	NA

https://www.nwfsc.noaa.gov/research/divisions/fe/estuarine/oeip/index.cfm

- Successful predictions of marine survival in wild coho populations on the WA coast (Bingham Creek)
- Are they useful for Lower Columbia natural coho?

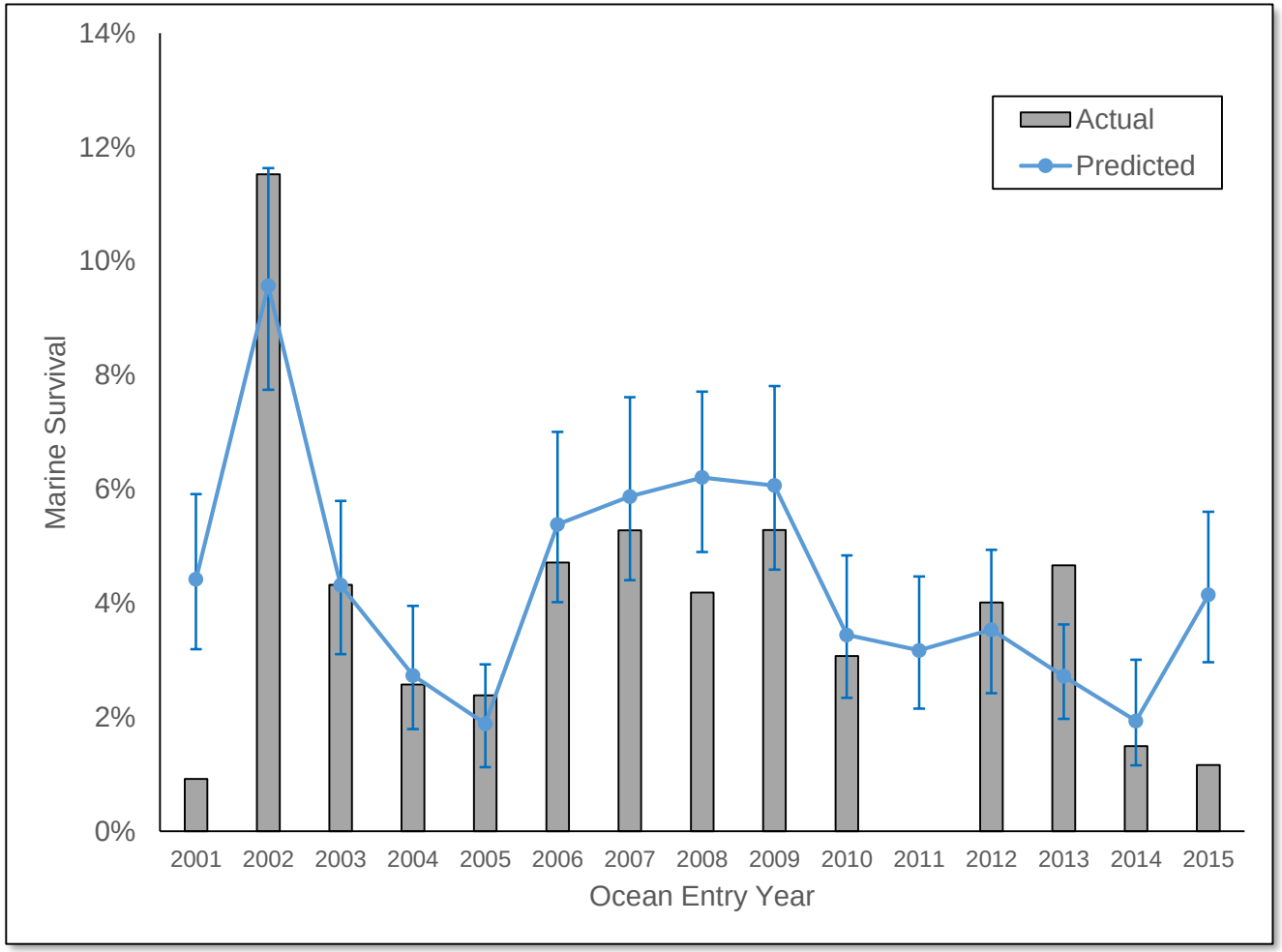
Lower Columbia River Natural Coho – Marine Survival

- Ocean, regional, local scales
- Examine individual regressions
- 11 of 23 individual variables correlated with marine survival



Lower Columbia River Natural Coho – Marine Survival

- Multiple regression model
- Upwelling length, sea surface temperature (NH05)
- Explain 84% of variation (2001-2015 OEY)
- Consistent with ecosystem predictors identified by
  - OR coastal natural coho (Logerwell et al. 2003)
  - WA hatchery coho (Ryding and Skalski 1999)



Lower Columbia River Natural Coho Forecasts

- Forecasts of natural coho (distinct from hatchery forecasts) important for Columbia River fishery management
- Forecast based on smolt estimates, marine survival predictions
- Ocean ecosystem indicators developed by NWFSC
  - Informative in this analysis
  - Physical and biological indicators
  - Critical to understand connections between physical/biological conditions in the ocean and salmon survival