Ocean conditions and run size forecasts for natural coho salmon in Washington tributaries of the Lower Columbia River

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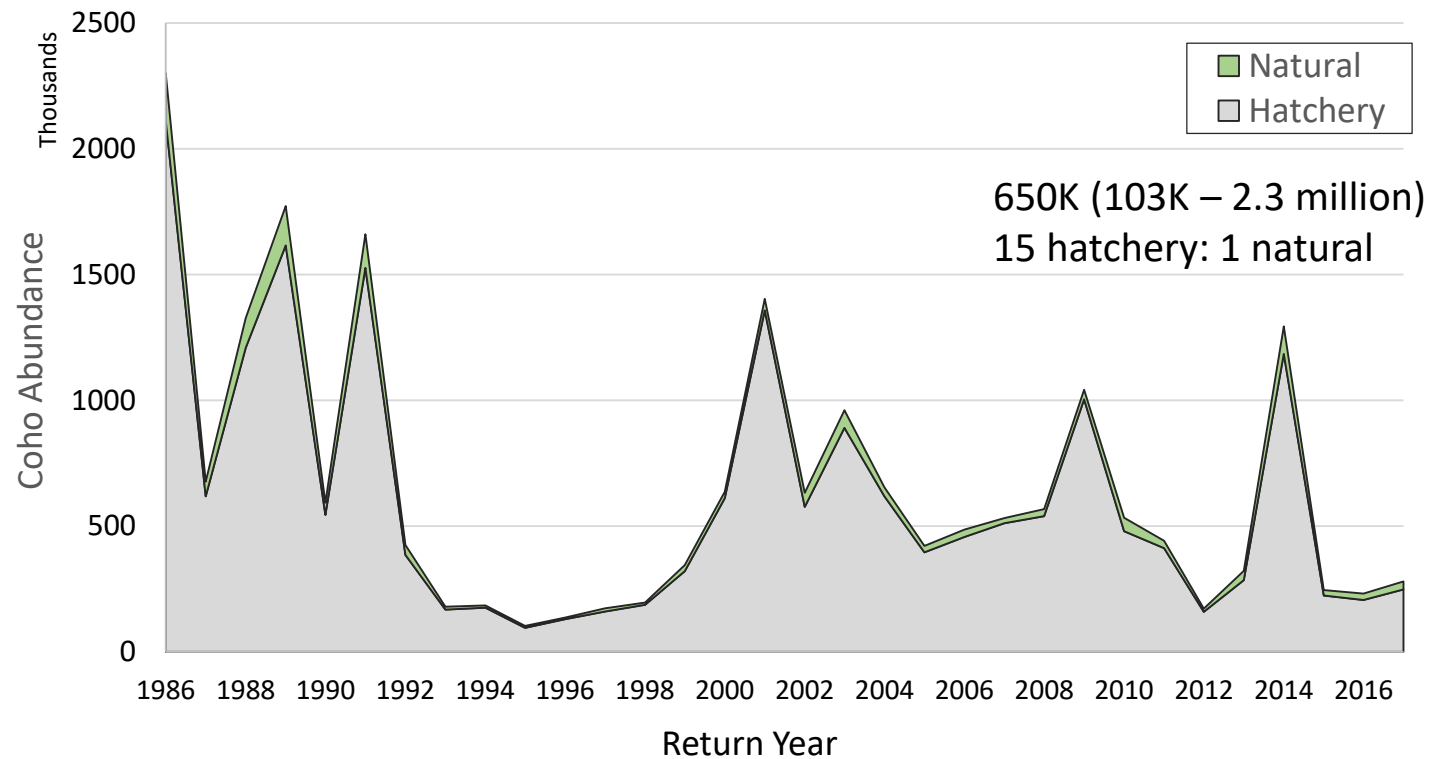
2018 Columbia River Estuary Conference

April 10, 2018

Outline

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

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Columbia River Coho Salmon Returns

650K (103K – 2.3 million)
15 hatchery: 1 natural

Legend: Natural (green), Hatchery (gray)

Y-axis: Coho Abundance (Thousands), 0 to 2500
X-axis: Return Year, 1986 to 2016
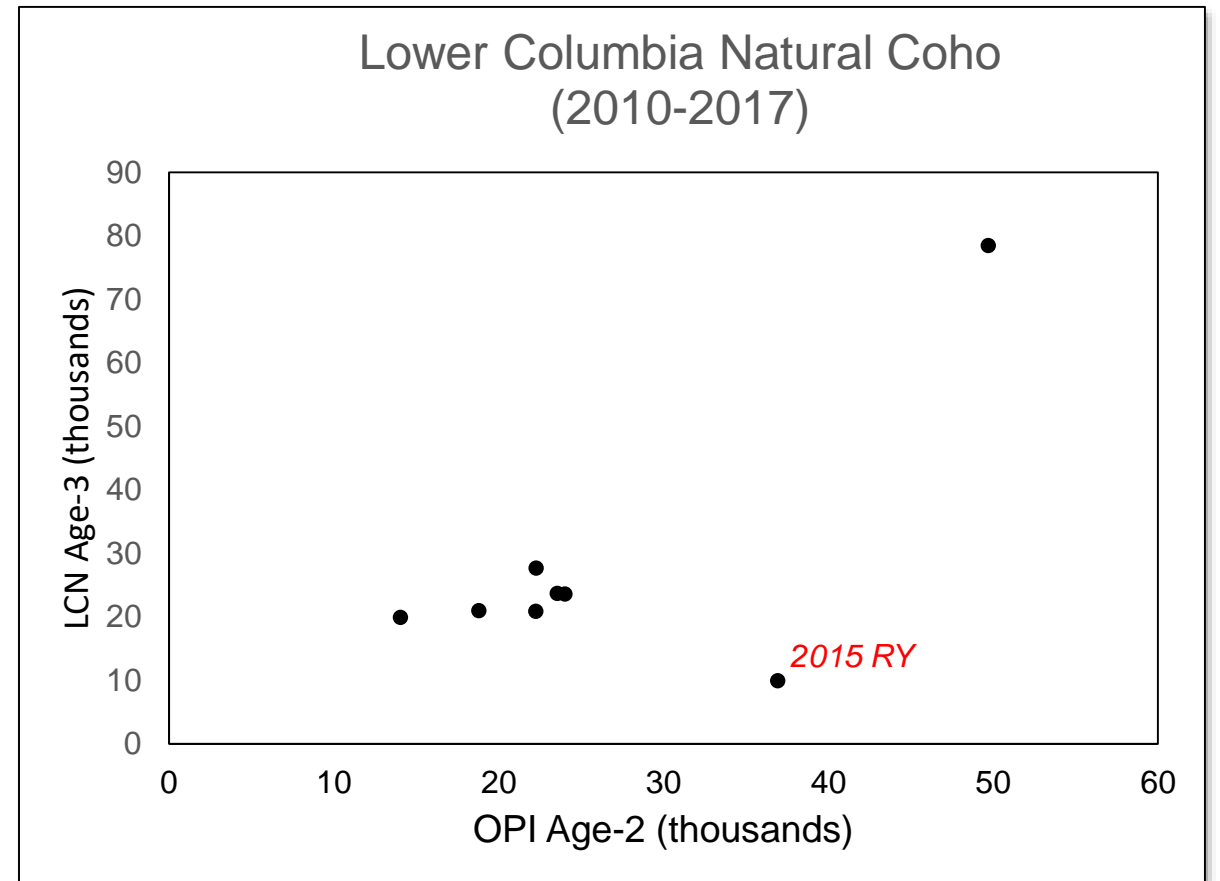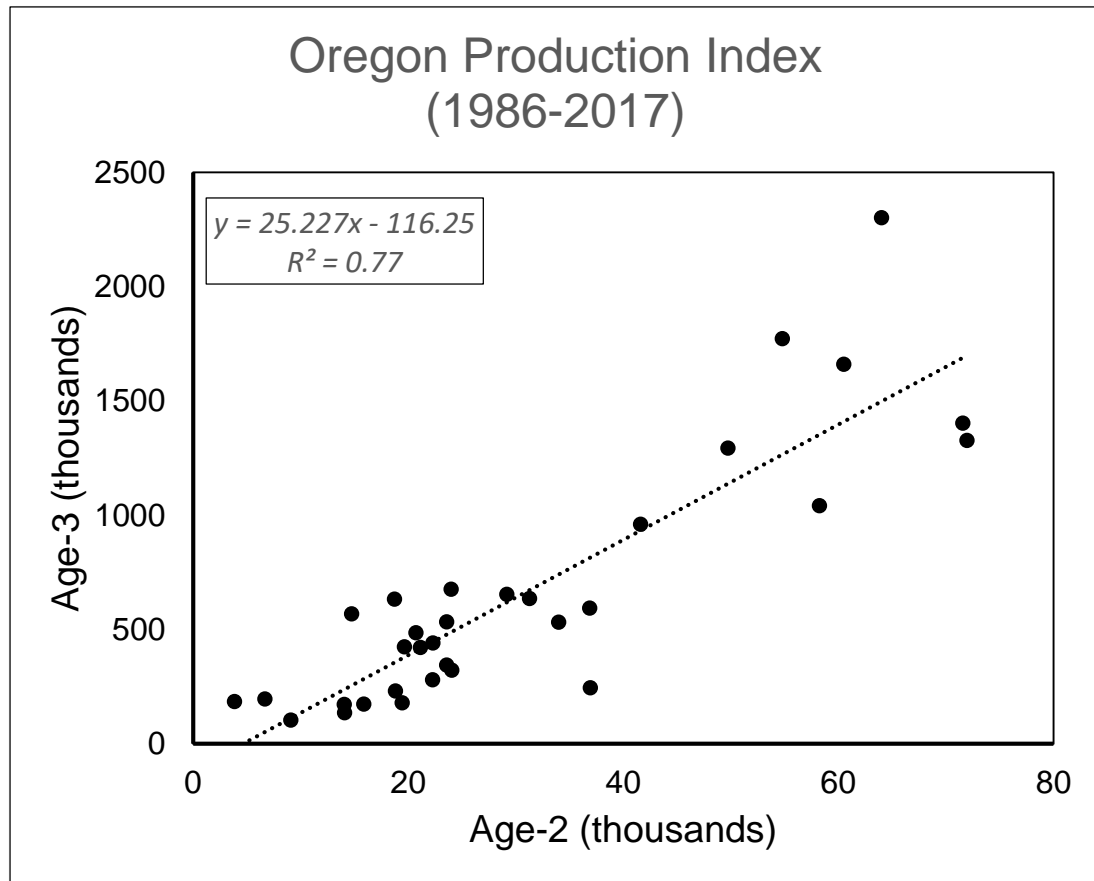
Data source: OPITT Table 5

Coho Salmon Management

- 2000s – robust monitoring program for natural spawner escapement (OR, WA)
- 2005 – *threatened* under Endangered Species Act
- 2014 - PFMC adopts harvest matrix for natural coho

Columbia River Coho Salmon Forecasts

- Sibling regression model - adult (age-3) predicted from jack (age-2) returns

Oregon Production Index (1986-2017)

$y = 25.227x - 116.25$
$R^2 = 0.77$

Age-3 (thousands) vs Age-2 (thousands)

Lower Columbia Natural Coho (2010-2017)

LCN Age-3 (thousands) vs OPI Age-2 (thousands)

2015 RY

Sibling Regression & Wild Coho Salmon

- Example: Bingham Creek, Washington

- Age-2 vs. age-3
  - Variable
  - Change over time

- Time varying maturation rates in wild populations
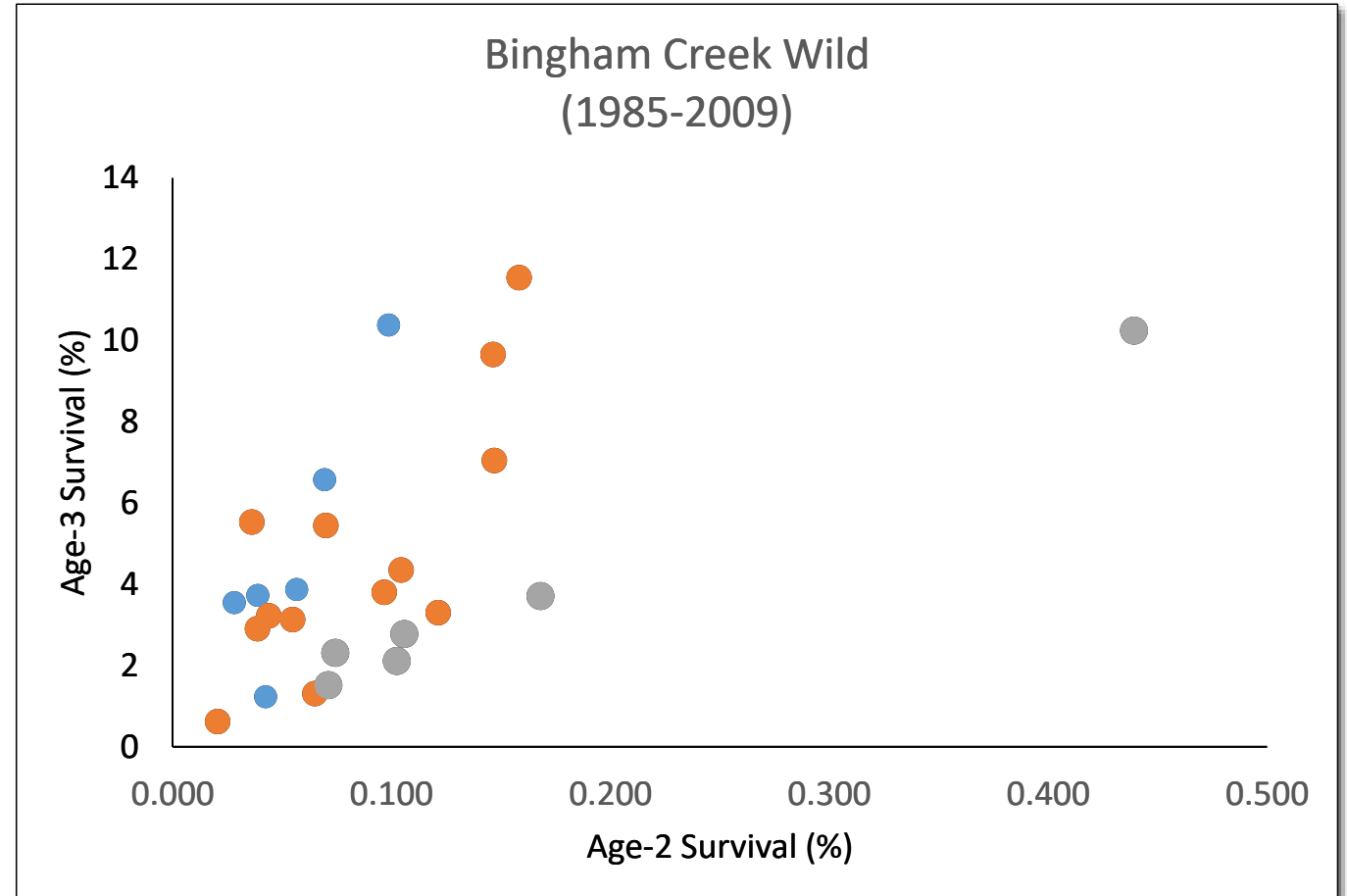
Bingham Creek Wild
(1985-2009)

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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, trib[...]
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 in[...]
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 predic[...]
Washington's coho producing systems. Methods that rely [...]
escapement and resulting run sizes are problematic due to in[...]
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 in[...]
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 [...]

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

Production Unit	Production X — Estimated Smolts Spring 2016	Marine Survival = Predicted Marine Survival	Recruits — Adults (Age 3)	Recruits — 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

- WDFW Science Division
- Annual advisory document
- Co-managers use in fishery planning process
- Scale = management unit

Wild Coho Forecasts for Washington State

- Run size is ocean age-3 (OA3) abundance
- Includes spawners and harvest (tributaries, river, ocean)

$$OA3\ Abundance = Smolt * Marine\ Survival$$
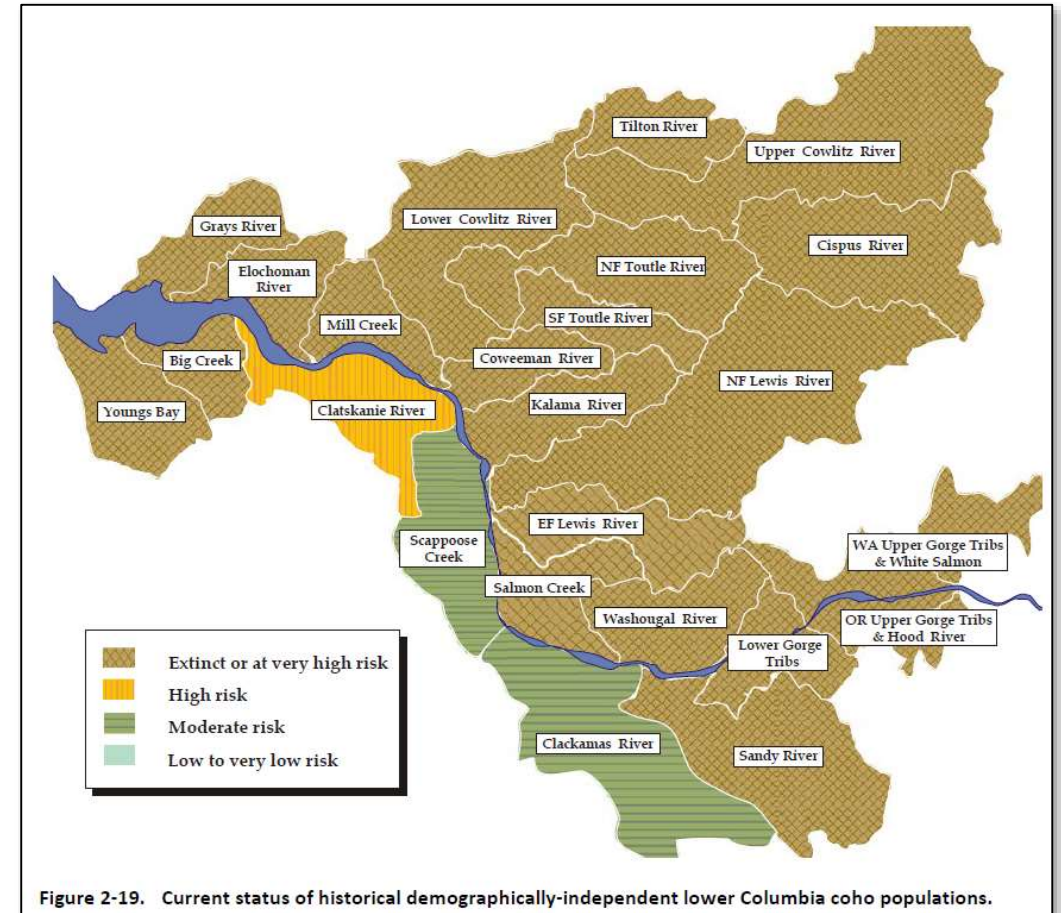
Estimated   Predicted

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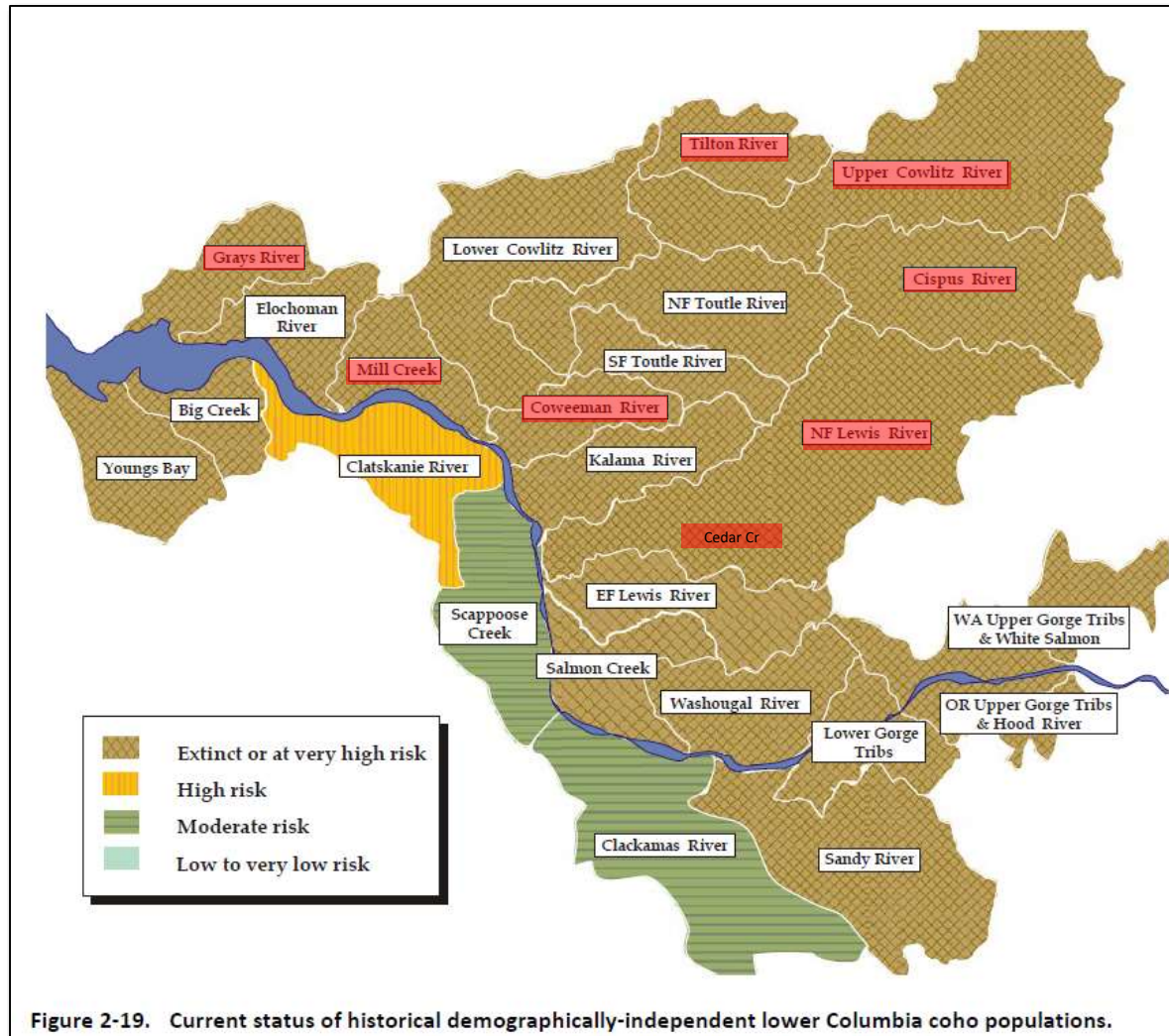
Lower Columbia River Coho ESU

- 17 populations in Washington

- 5 populations in Oregon

- Populations rolled up for purpose of forecasting

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
- 3 trap & haul operations (Cowlitz, Tilton, NF Lewis)

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 Natural Coho Smolts (Washington)
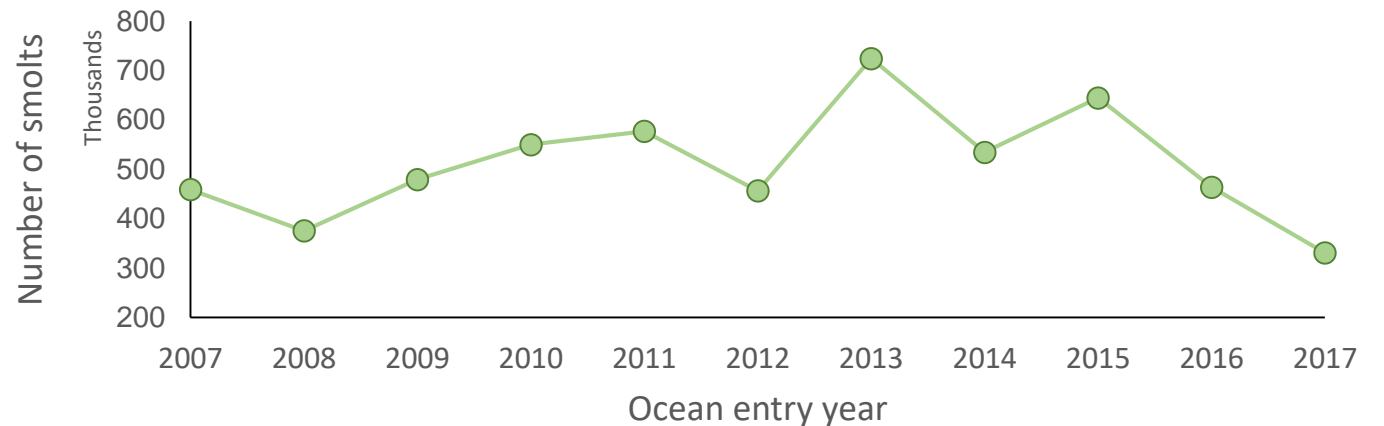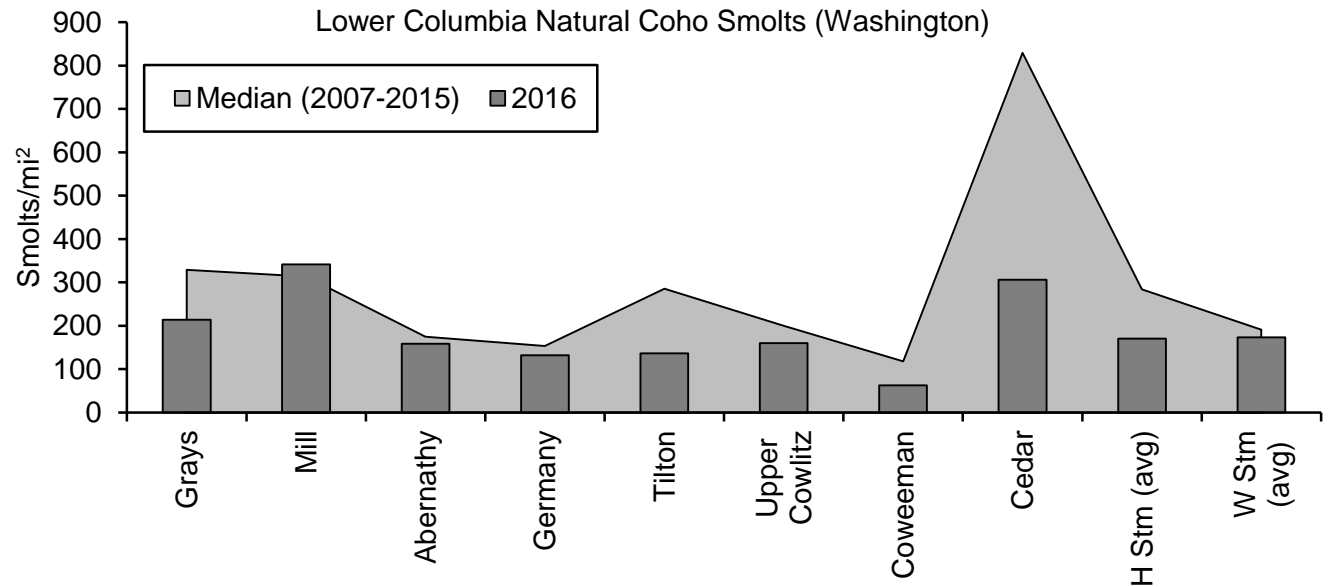
Lower Columbia River Natural Coho – Marine Survival
*OA3 Abundance = Smolt * Marine Survival*

- Cowlitz R indicator stock

- Smolt-to-spawner (coded-wire tag)

- Exploitation rate (model)

*Marine Survival
1% - 11%*

Lower Columbia River Coho Salmon
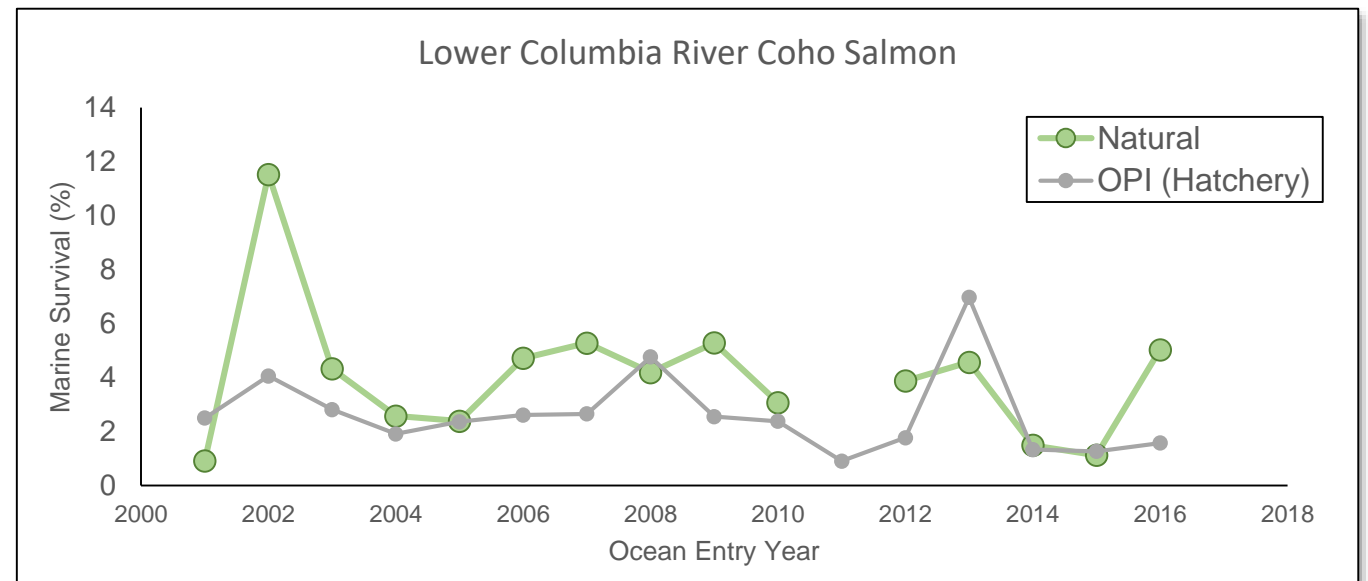
Lower Columbia River Natural Coho – Marine Survival
Ocean Ecosystem Indicators from NWFSC

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

- 9 of 24 variables correlated with marine survival

Ocean Ecosystem Predictors

Ocean
- PDO.DM
- PDO.MS
- ONI.JJ
- NPGO.JM
- NPGO.MS

Regional (physical)
- SST.46
- NH05.20.NM
- NH05.20.MS
- NH05.DeepT.MS
- NH05.DeepS.MS
- Phys.Trans.UI
- UP.AM
- UP.length
- NH05.SST.MS

Regional (biological)
- Cop.Rich
- NCop.MS
- SCop.MS
- Bio.Trans
- Wint.Ichth
- Chk.Juv.J
- Coho.Juv.S
- Cop.Comm

Local
- OPI.jacks
- CUR.AJ

-0.75 -0.55 -0.35 -0.15 0.05 0.25 0.45 0.65
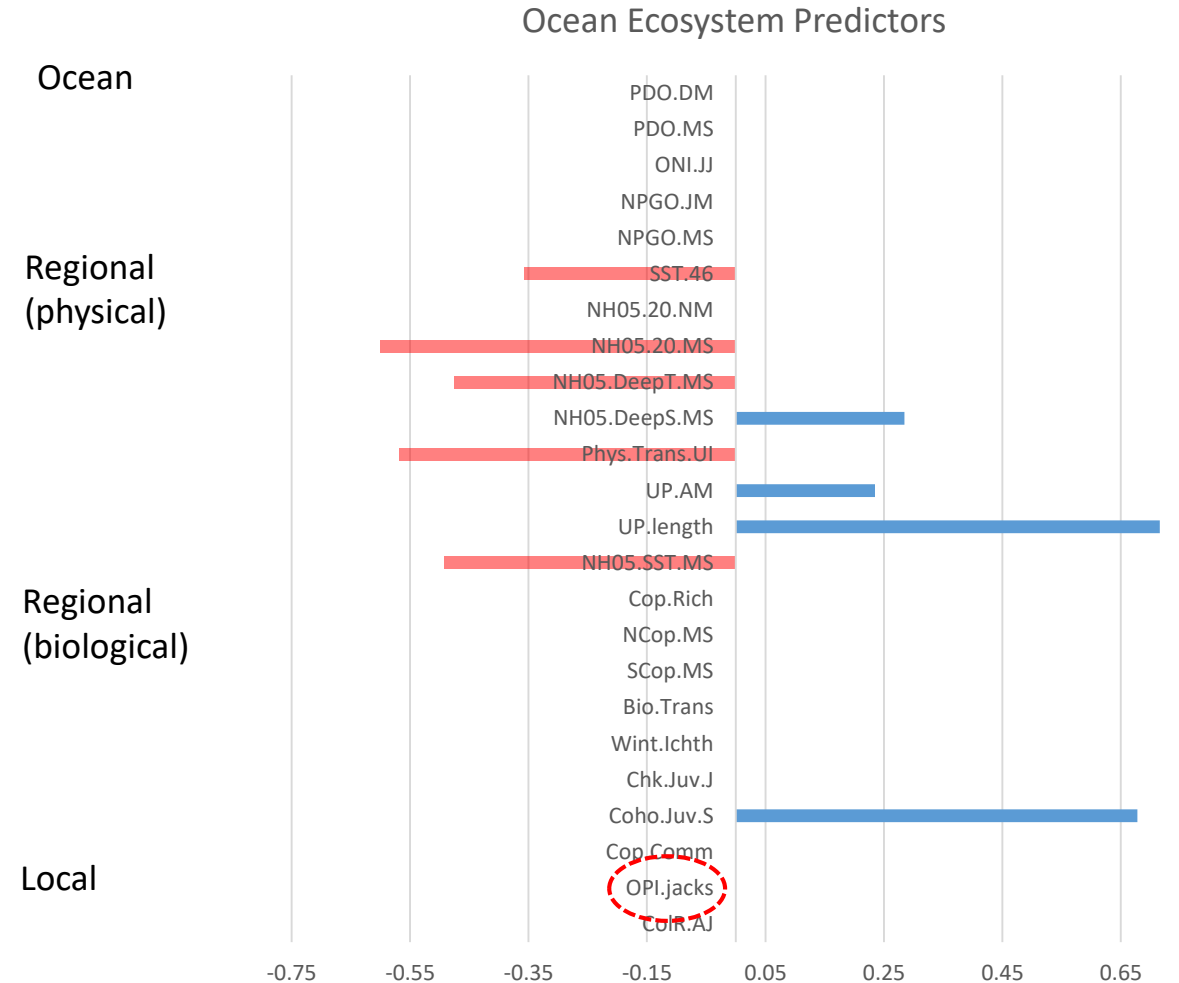
Lower Columbia River Natural Coho – Marine Survival

- ## Multiple regression model
  - ### Upwelling length
  - ### Sea surface temperature (NH05)

- ## Leave-one-out validation
  - ### MPE = -3.5%
  - ### MAPE = 21.2%

- ## Caveats
  - ### Short time series
  - ### 2001, 2015 OEY

Cowlitz River (Lower Columbia)
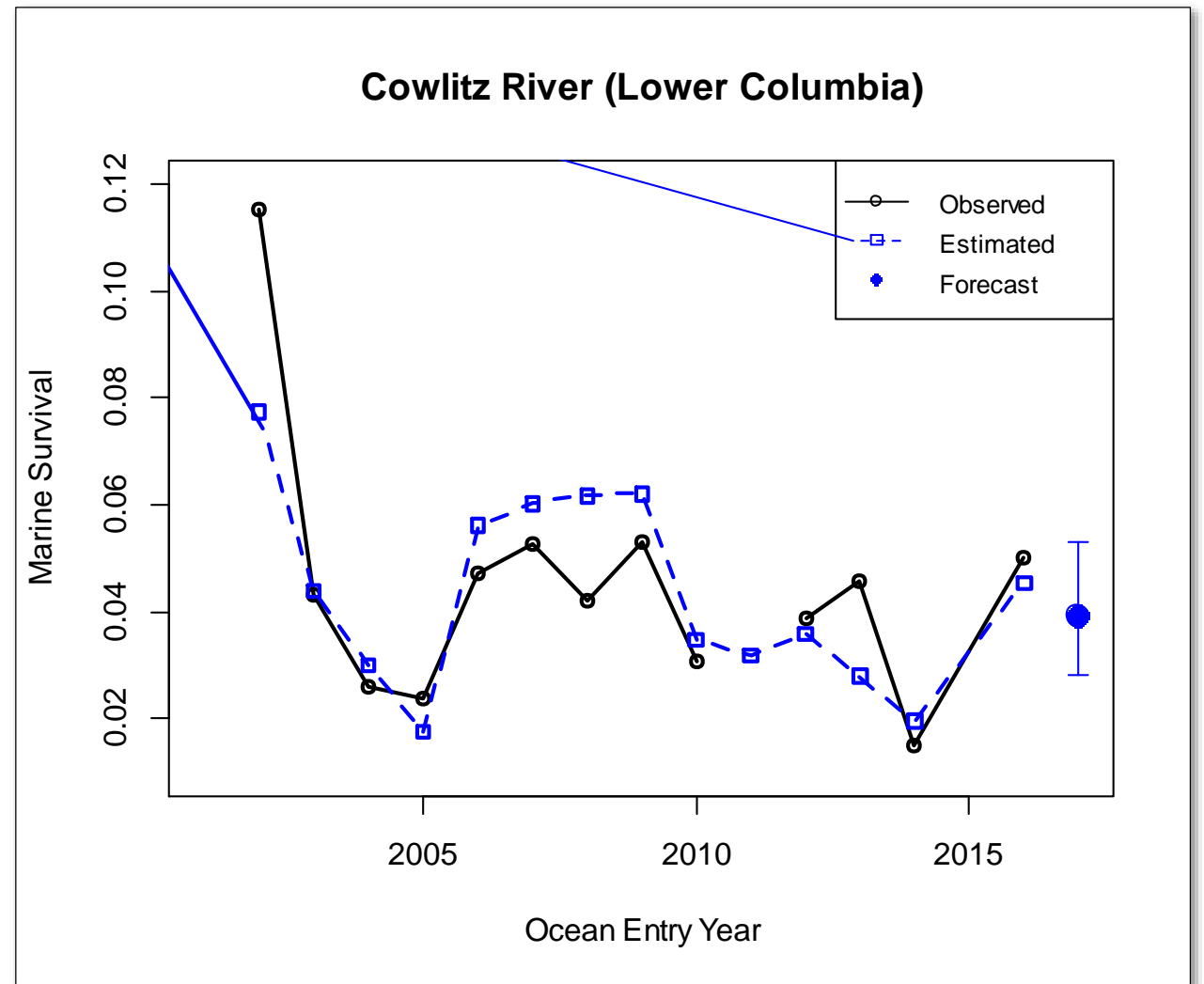
Lower Columbia River Natural Coho Forecasts

- Forecasts of natural coho (distinct from hatchery forecasts) important for Columbia River fishery management

- Sibling regression approach has uncertainties for natural populations

- Forecast approach incorporates smolt estimates, marine survival predictions

- Ecosystem indicators of marine survival
  - Caveat: short time series
  - Physical indicators more informative than biological indicators
  - OR coastal natural coho (Logerwell et al. 2003)
  - Col R hatchery coho (Ryding and Skalski 1999)