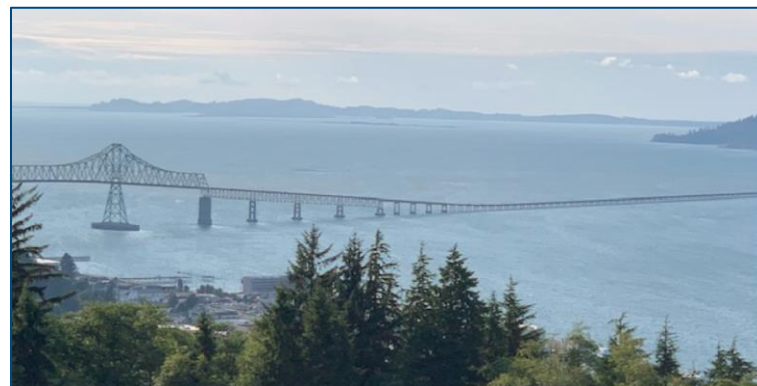


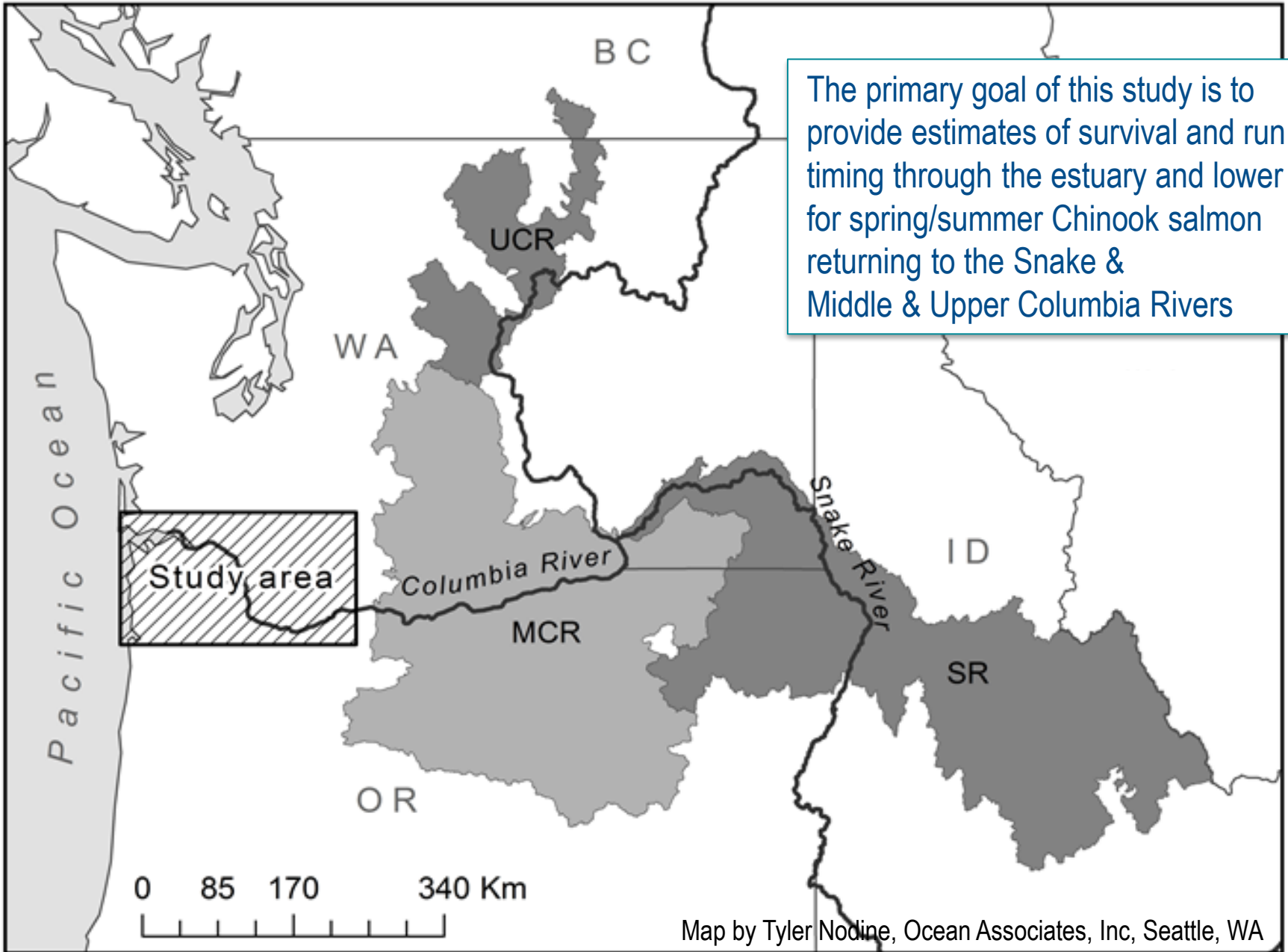
**NOAA**  
**FISHERIES**



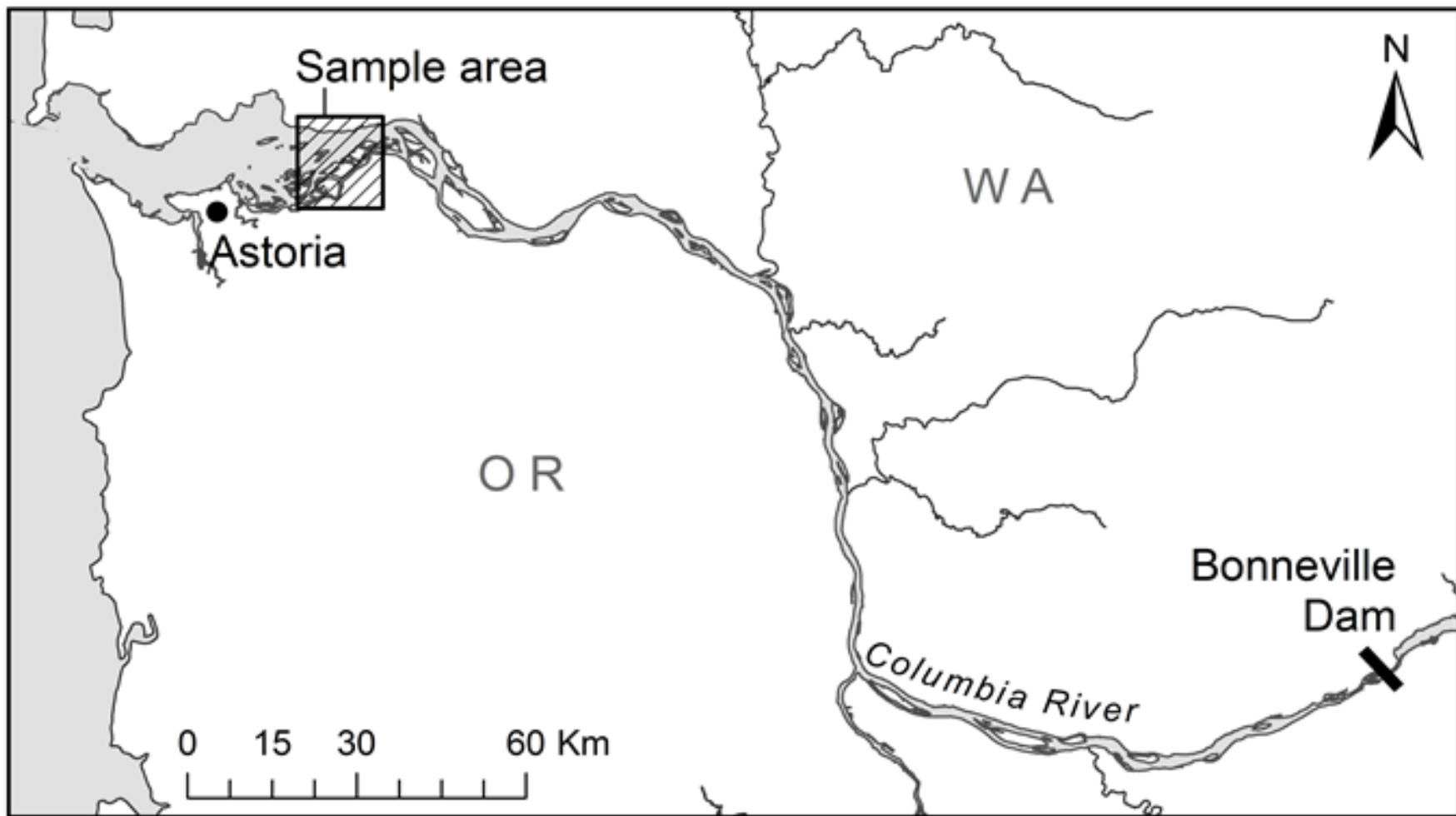
# Survival of adult spring/summer Chinook salmon (*Oncorhynchus tshawytscha*) through the estuary and lower Columbia River amid a rapidly changing predator population

A. Michelle Wargo Rub, Ben Sandford, Don Van Doornik, David Teel, Matthew Nesbit,  
Samuel Rambo, Jesse Lamb, Louis Tullos, Kinsey Frick, April Cameron,  
Nicholas Som, Mark Henderson, and David Huff

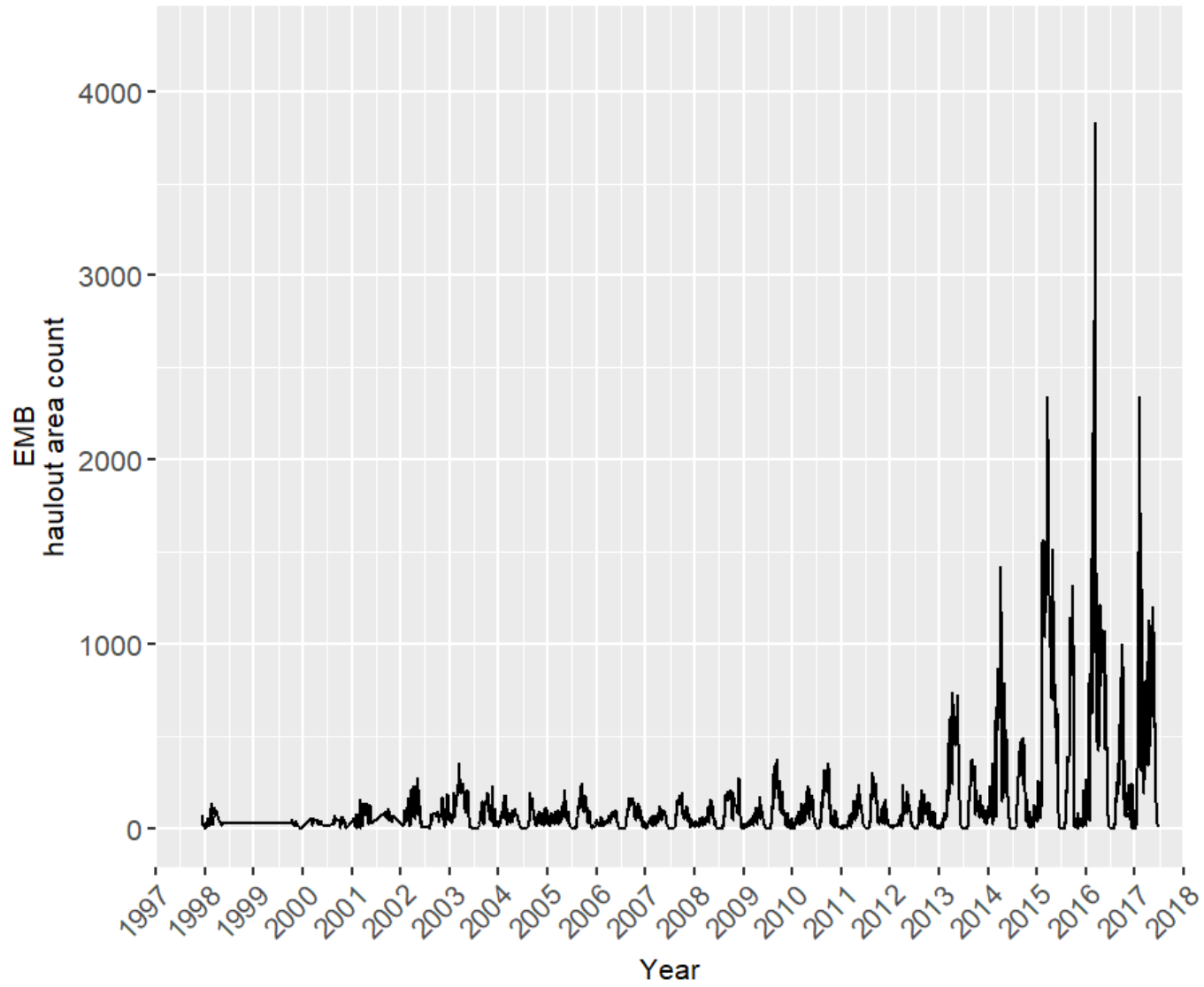
NOAA Fisheries Northwest Fisheries Science Center (NWFSC)



Map by Tyler Nodine, Ocean Associates, Inc, Seattle, WA

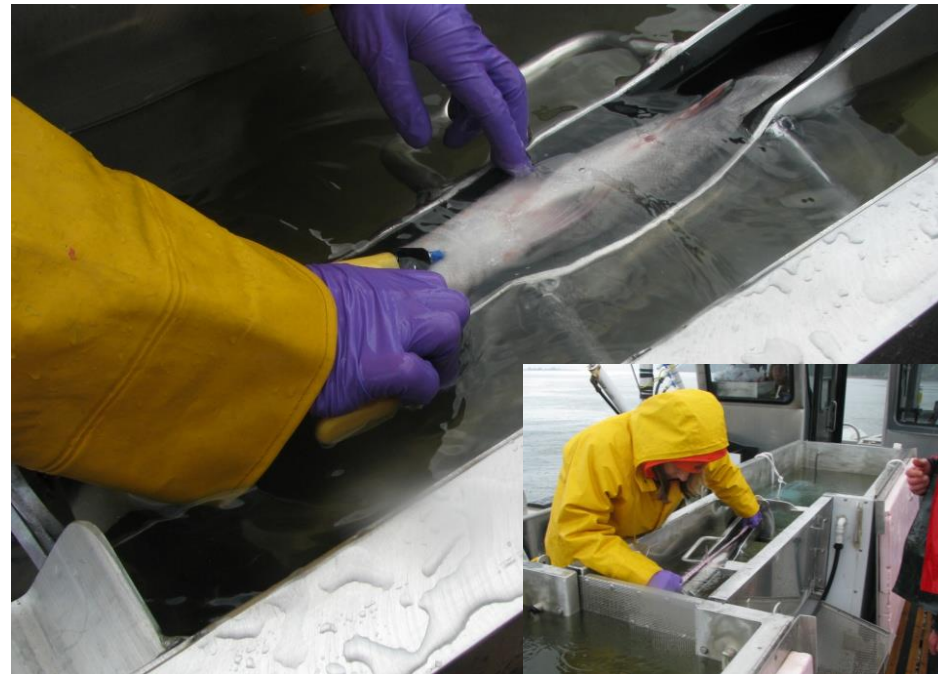


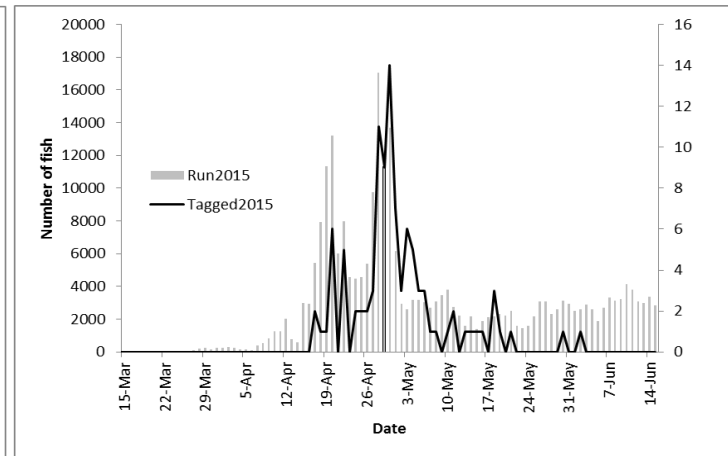
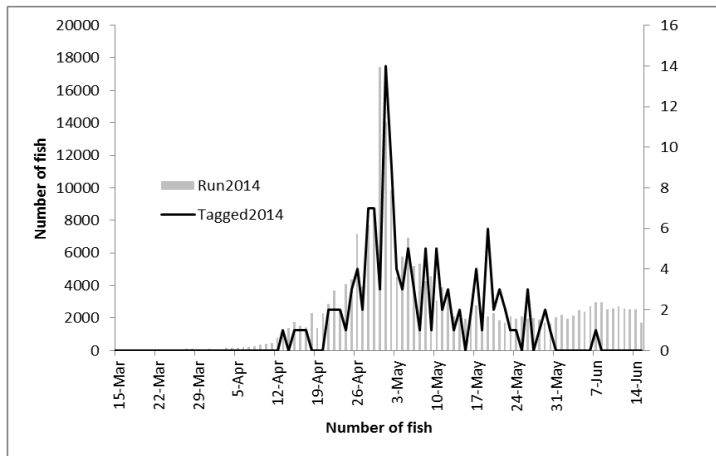
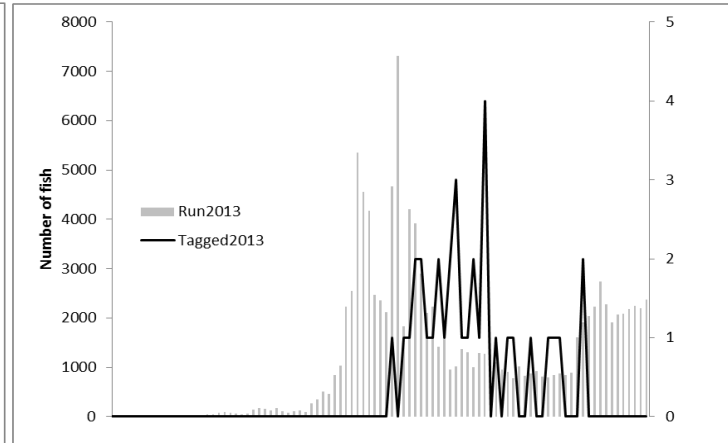
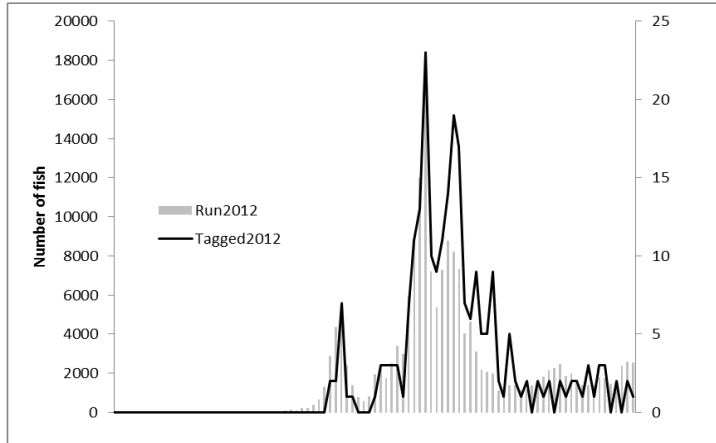
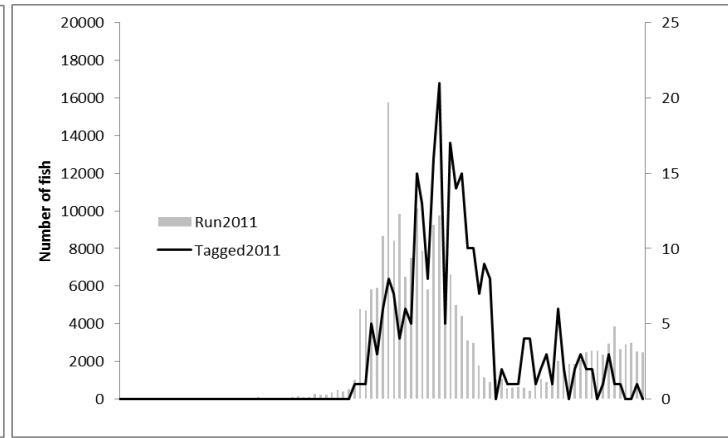
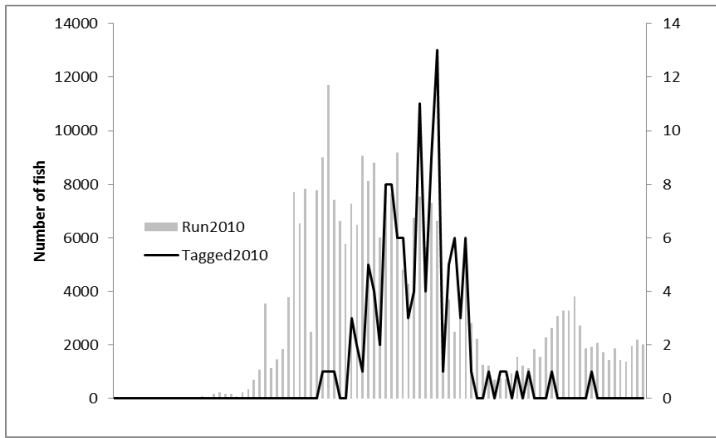
Map by Tyler Nodine, Ocean Associates, Inc, Seattle, WA



# Commercial tangle-net crew hauling in a Chinook salmon

Fish are captured by CR commercial fishermen, tagged by NOAA Fisheries research biologists, and released. Greater than 3200 adult salmon have been PIT- tagged for this study since 2010.





## Weighted Mean Survival for Interior CR adults (FL ≥ 56 cm)

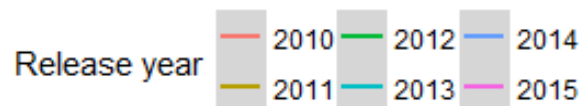
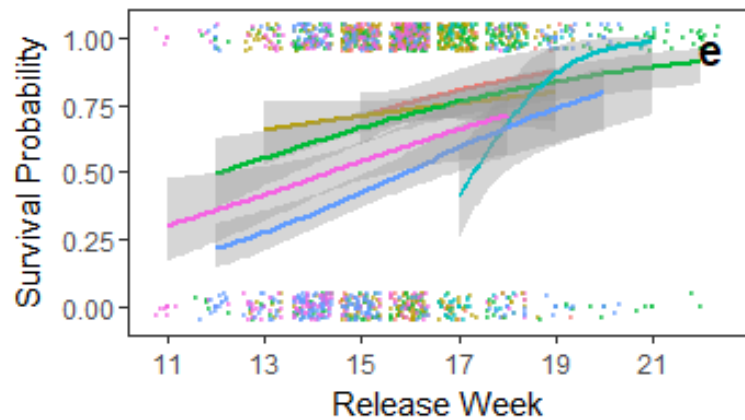
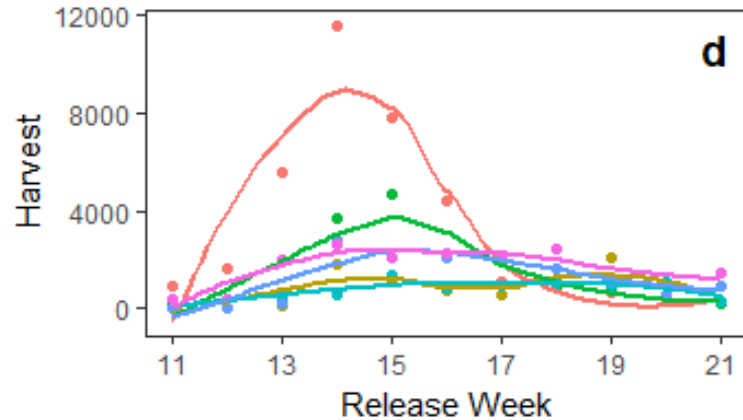
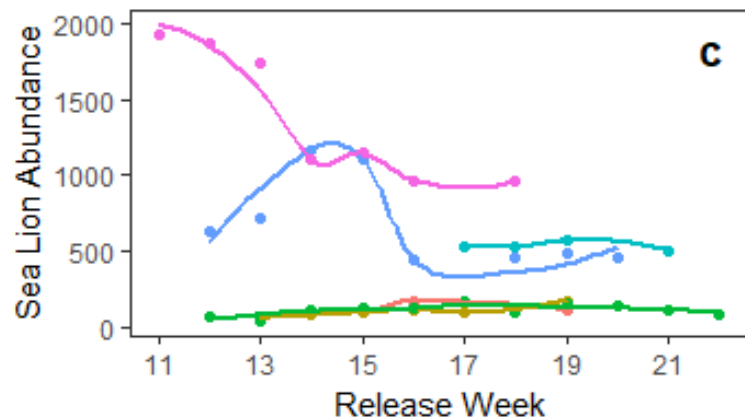
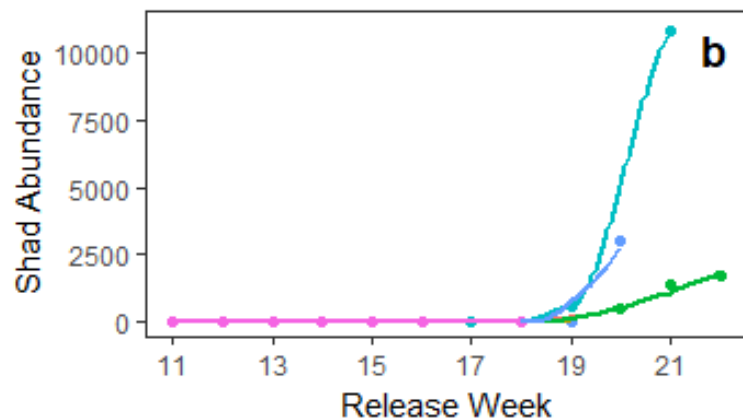
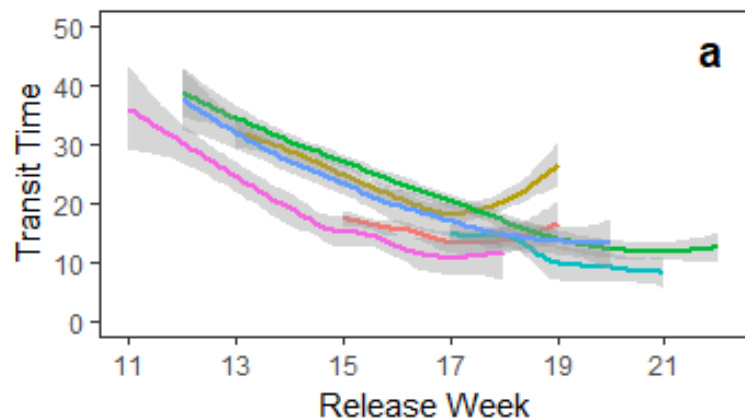
Year	Adult Chinook salmon (N)	Range of sampling dates	Baseline Survival (95% CI)	Baseline Mortality	Run Size (% Harvest)
2010	172	4/14-5/11	.74 (.68-.80)	0.26	315,345 (12)
2011	381	4/1-5/16	.73 (.69-.77)	0.27	221,158 (7)
2012	372	3/23-5/31	.69 (.64-.75)	0.31	203,090 (7)
2013	73	4/19-6/14	.60 (.47-.74)	0.40	123,136 (8)
2014*	297	3/20-5/13	.46 (.38-.53)	0.54	242,635(7)
2015	205	3/19-5/8	.52 (.42-.61)	0.48	288,994 (8)
2016	70	3/28-5/23	.70 (.58-.82)	0.30	187,816 (8)
2017	89	3/21-5/22	.62 (.50-.74)	0.38	115,821 (7)
2018*	75	3/28-5/23	.52 (.35-.69)	0.48	115,081 (7)



# Additional sources of mortality

- Straying
- Disease
- Capture and handling





# Linear Mixed Effects Modelling

## Random effect:

- Week of tagging nested within year with autoregressive component

## Fixed effects:

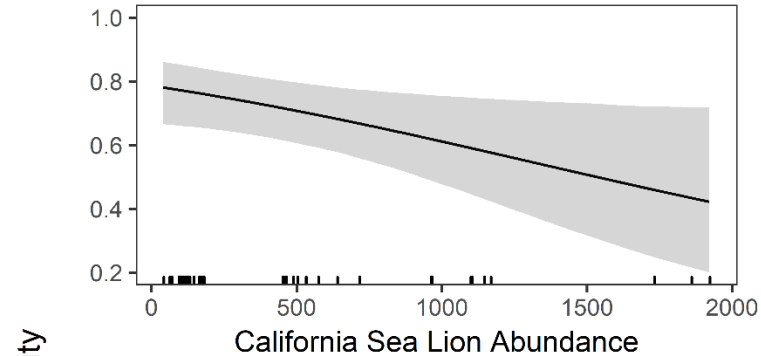
- Clip status
- Exposure to California Sea Lions based on EMB abundance during the week fish were tagged
- Abundance of Shad in the estuary during the week fish were tagged

**Note:** Annual Eulachon abundance is highly correlated ( $=.83$ ) with annual CSL abundance

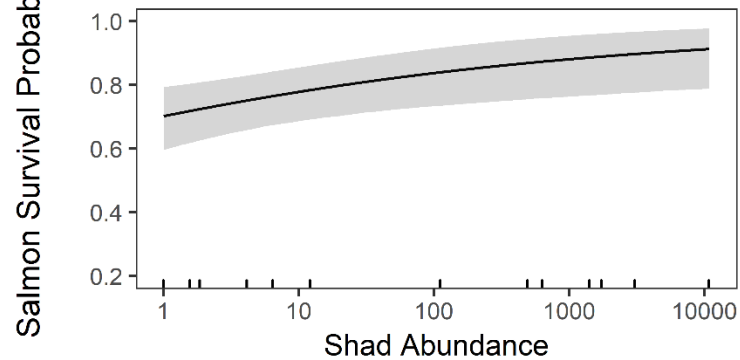
\*The area under the ROC was .70 indicating the model is 'good' with respect to being able to predict survival

**Wargo Rub, A. M.,** Som, N. A., Henderson, M. J., Sandford, B. P., Van Doornik, D. M., Teel, D. J., Tennis, M., Langness, O. P., van der Leeuw, B. K., and Huff, D. D. 2018. Changes in adult Chinook salmon (*Oncorhynchus tshawytscha*) survival within the lower Columbia River amid increasing pinniped abundance. *Canadian Journal of Fisheries and Aquatic Sciences*; 76(10):1862-1873. doi: 10.1139/cjfas-2018-0290

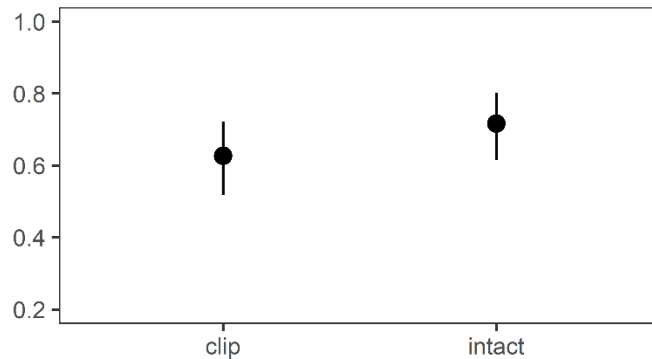
# Model response curves:



Odds ratio:  
0.66 (.13-.51), Unit Eq=467



Odds ratio:  
1.32 (0.08-.61), Unit Eq=~720



Odds ratio:  
0.66 (.13-.51), Unit Eq=NA

# Upriver spring/summer Chinook salmon mortalities

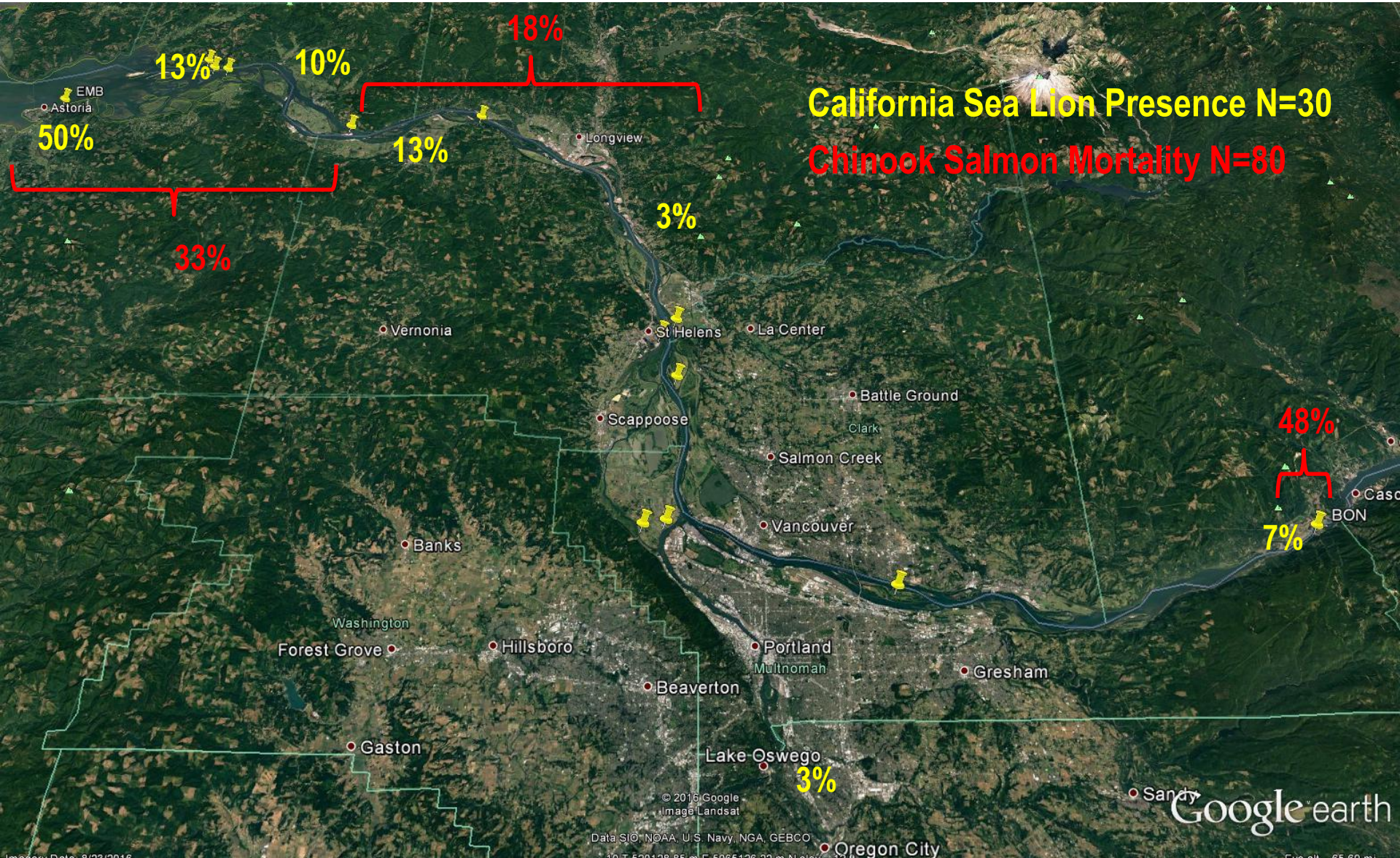
Year	Mean	Std Dev	2.5%	50%	97.5%	Natural mortality
2010	77.56	21.72	43.36	74.71	127.43	0.20
2011	59.48	16.71	33.18	57.27	97.83	0.22
2012	51.75	14.39	29.08	49.86	84.80	0.20
2013	35.21	9.11	20.60	34.11	56.14	0.22
2014	98.47	26.05	57.30	95.16	158.53	0.29
2015	224.45	107.98	85.65	201.25	495.21	0.44

Annual estimated number of fish lost to natural mortality from the Columbia River Estuary to Bonneville Dam. Credible intervals were estimated based on 100000 random draws from the model parameter posteriors. Natural mortality was the mean number of natural mortalities divided by the estimated total number of fish in the estuary in each year.

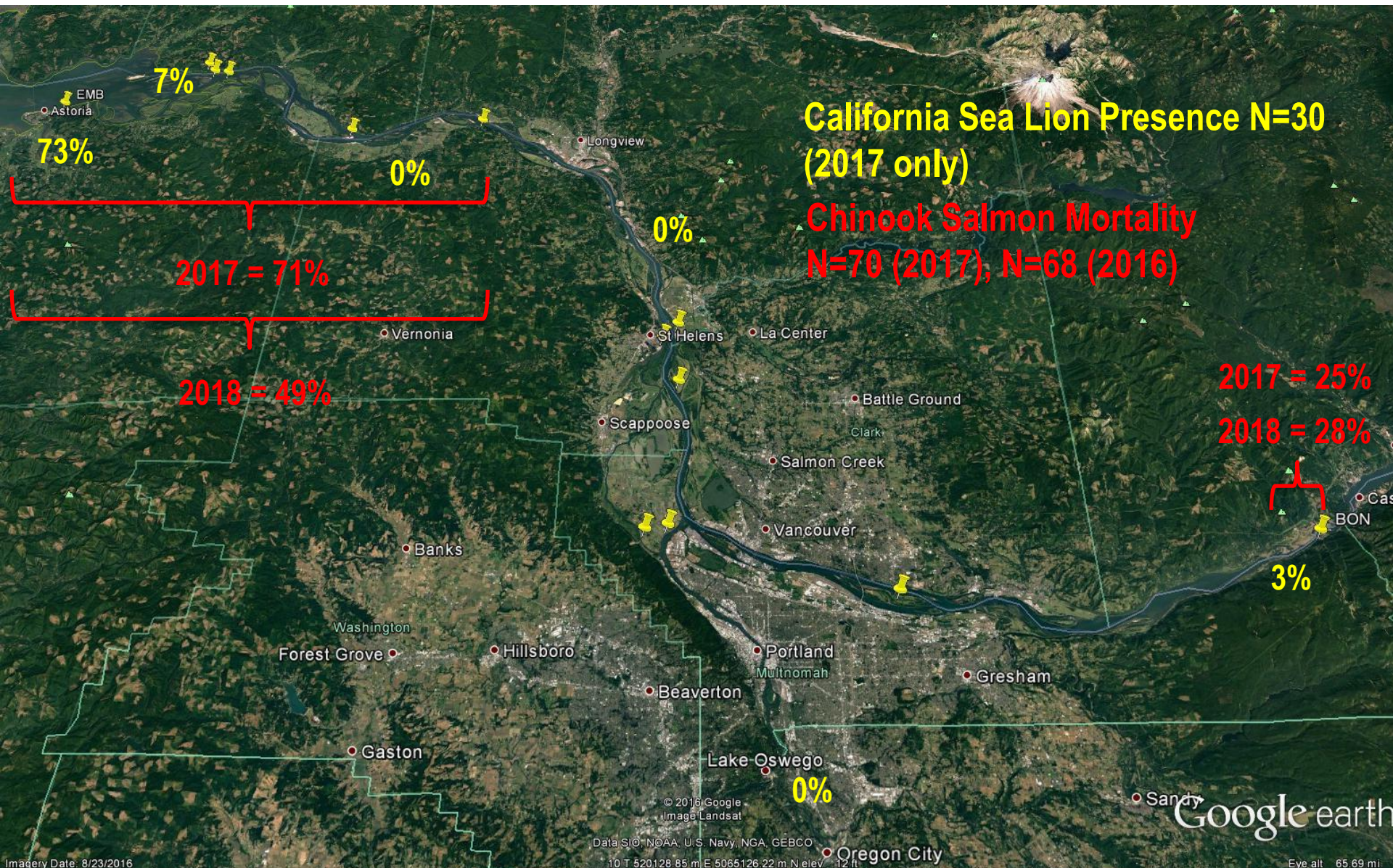
# Collaborative effort with ODFW & WDFW to track pinnipeds and fish

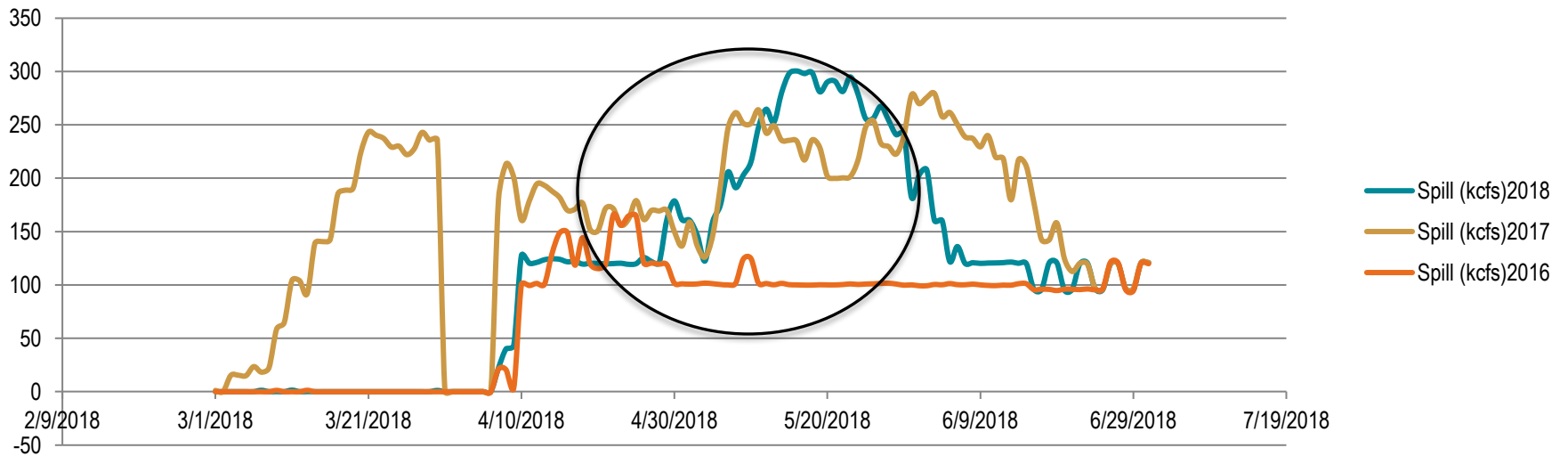
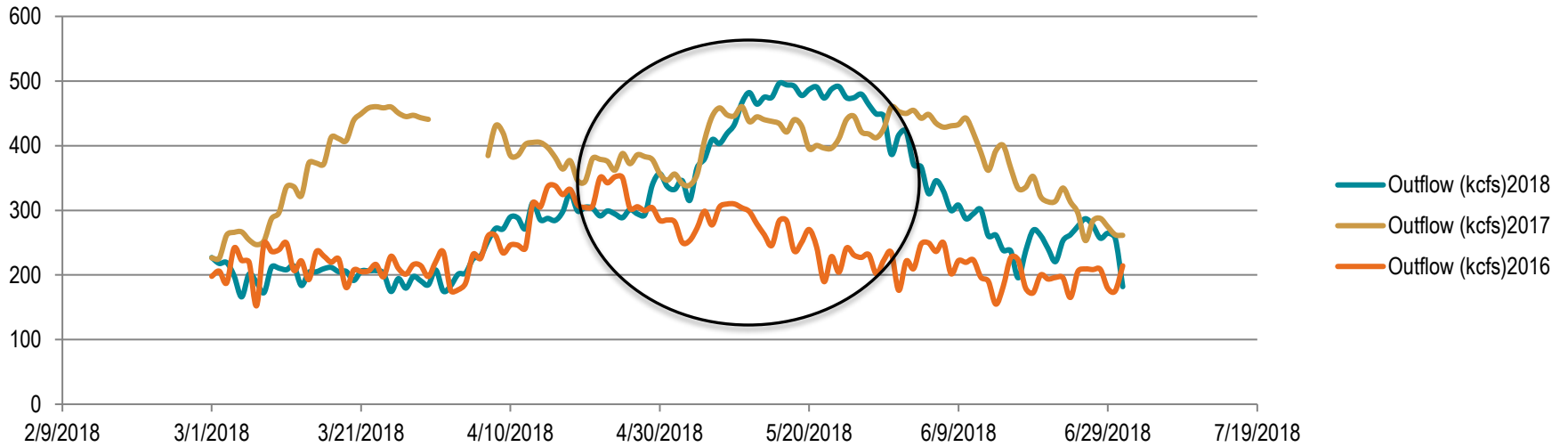


# Radio Telemetry Results 2016



# Radio Telemetry Results 2017





Bonn outflow and spill from mid March through mid June; we start seeing fish arrive at Bonneville in late April through mid June





4.3 mile



2017=100%  
2018=100%

2016= 76%  
2017= 83%  
2018= 80%

.7-1.7 mile



BON-L

BON-U

Evergreen Hwy

30

© 2017 Google

Google earth

# Chinook salmon mortality estimates Bonneville Dam Tailrace

Year	USACE observed mortality (adult and jack salmon)*		NOAA estimated mortality (adults)		difference multiplier
	Number of fish	% of run	Number of fish	% of run (early/late)	
2016	9222	5.9	43,498	24 (36/18)	4.7x
2017	4951	4.5	15,322	17 (36/7)	3.1x
2018	2813	2.7	19,177	20 (50/7)	6.8x

\*Tidwell, K.S., B.A. Carrothers, K. N. Bayley, L.N. Magill, and B. K. van der Leeuw 2018/19. EVALUATION OF PINNIPED PREDATION ON ADULT SALMONIDS AND OTHER FISH IN THE BONNEVILLE DAM TAILRACE, 2018. U.S. Army Corps of Engineers, Portland District Fisheries Field Unit. Cascade Locks, OR.

## Recap

- We have identified significant mortality that is unexplained by harvest and handling for upriver spring/summer Chinook salmon
- This mortality appeared to peak during 2015 at approximately 200k fish.
- Pinniped predation is likely the primary source of mortality but not all animals are equal with respect to the impact they are having on returning fish
- Additional covariates potentially influencing survival include the clip status, river flow, and the abundance and timing of alternative prey species such as eulachon and shad

## Acknowledgements:

**Susan Hinton, George McCabe, Paul Bentley, and Bob Emmett of NOAA Fisheries Pt. Adams Research Station, Jim Simonson and crew of NOAA Fisheries Pasco Research Station, Laurie Weitkamp of NOAA Fisheries NWFSC, Newport Research Station, David Kuligowski of NOAA Fisheries NWFSC, Manchester Research Station, John Hess, Doug Hatch & Ryan Brandstetter of CRITFC, Jason Romine and Mike Parsley of USGS, Chris Kern and Geoffrey Whisler, Matt Tennis, Bryan Wright, Robin Brown of ODFW, Steve Jeffries of WDFW, Matt Campbell of IDF&G, Brian, Frank, & Stephanie Tarabochia, and Dan Marvin of Astoria, OR, Sean Hayes of NOAA Fisheries SWFSC, Kane Cunningham & Colleen Reichmuth of the Institute of Marine Sciences, Long Marine Laboratory, UCSC, NOAA Near Term Priority (2010 & 2011) and NOAA Fisheries Cooperative Research (2012, 2013, & 2014), Albert Little, Wyatt Wullger, Ben Rudolph, & Cody May of Ocean Associates, Dave Caton & Lila Charlton of PSMFC**