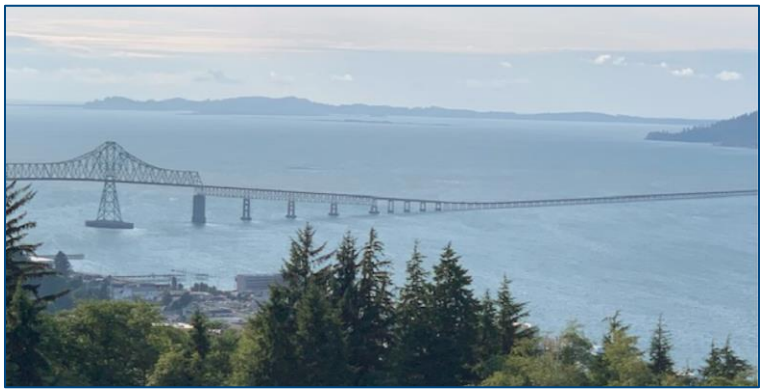


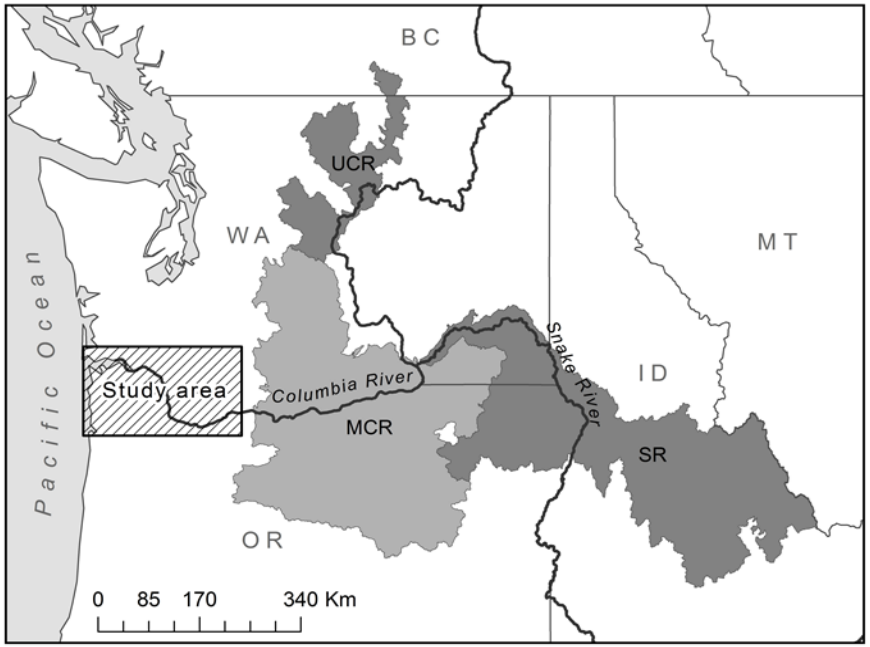
NOAA FISHERIES

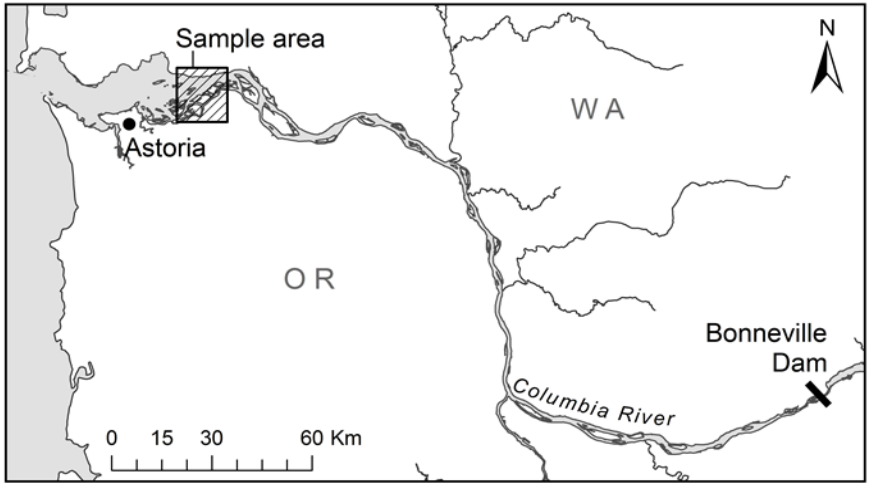
# Estimating pinniped predation on Columbia River salmon while staying one step ahead of a natural born fisher

A. Michelle Wargo Rub, B. P. Sandford, N. A. Som, M. J. Henderson, D. M. Van Doornik, D. J. Teel, M. J. Tennis, O. P. Langness, B. K. van der Leeuw, Matthew Nesbit, Samuel Rambo, Jesse Lamb, Louis Tullos, Kinsey Frick, April Cameron, and D. D. Huff

NOAA Fisheries Northwest Fisheries Science Center (NWFSC)

The primary goal of this study is to provide estimates of survival and run timing through the estuary and lower CR for spring/summer Chinook salmon returning to the Middle & Upper Columbia & Snake Rivers




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


Photo credit: Washington Department of Fish and Wildlife

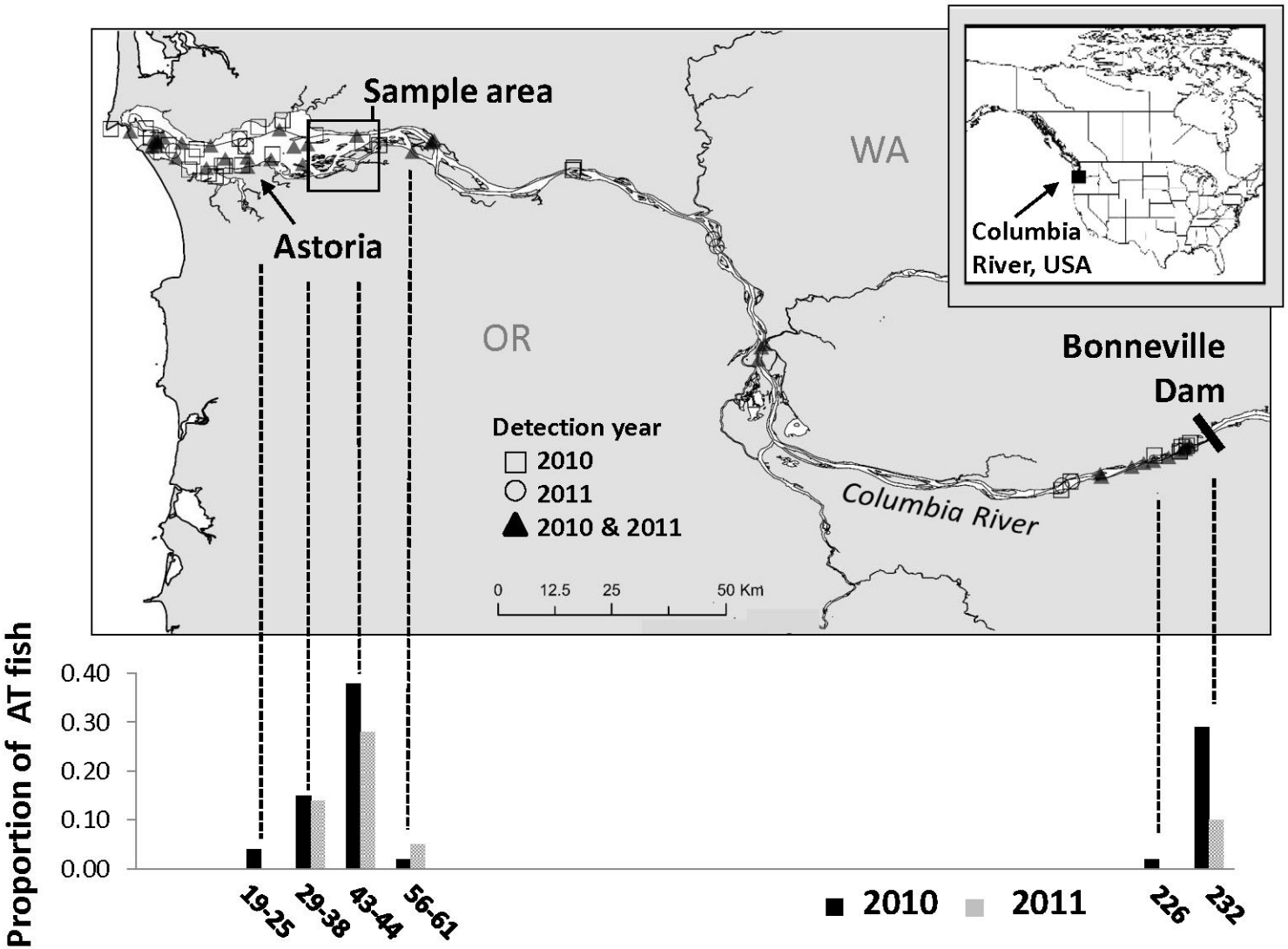
March 2015; 6k harbor seals (top) &
2k sea lions (bottom)


Photo credit: Washington Department of Fish and Wildlife

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

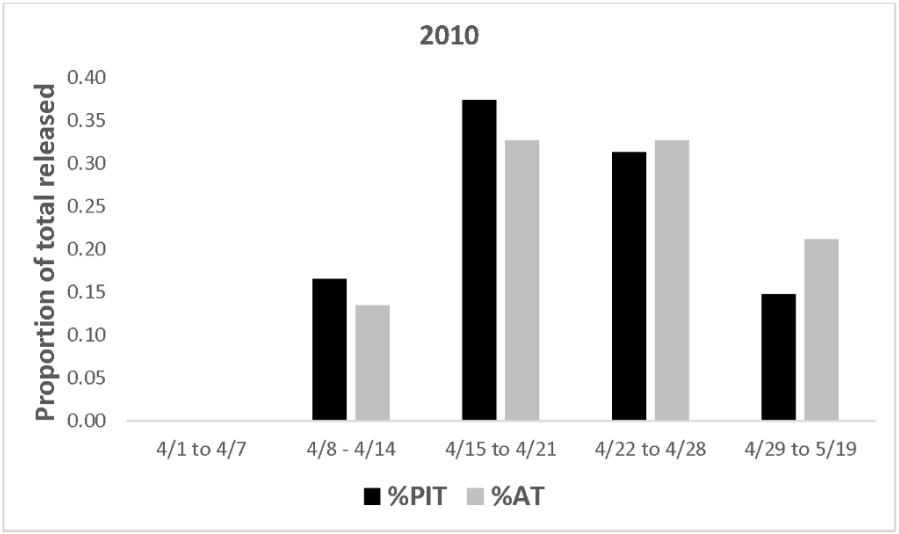
| Year | Adult Chinook salmon (N) | Range of sampling dates | Baseline Survival (95% CI) | Baseline Mortality | % Harvest | Run Size |
|---|---|---|---|---|---|---|
| 2010 | 172 | 4/14-5/11 | .74 (.68-.80) | 0.26 | 12 | 315,345 |
| 2011 | 381 | 4/1-5/16 | .73 (.69-.77) | 0.27 | 7 | 221,158 |
| 2012 | 372 | 3/23-5/31 | .69 (.64-.75) | 0.31 | 7 | 203,090 |
| 2013 | 73 | 4/19-6/14 | .60 (.47-.74) | 0.4 | 8 | 123,136 |
| 2014* | 297 | 3/20-5/13 | .46 (.38-.53) | 0.54 | 7 | 242,635 |
| 2015 | 205 | 3/19-5/8 | .52 (.42-.61) | 0.48 | 8 | 288,994 |
| 2016 | 70 | 3/28-5/23 | .70 (.58-.82) | 0.3 | 8 | 187,816 |
| 2017 | 89 | 3/21-5/22 | .62 (.50-.74) | 0.38 | 7 | 115,821 |
| 2018* | 75 | 3/28-5/23 | .52 (.35-.69) | 0.48 | 7 | 115,081 |

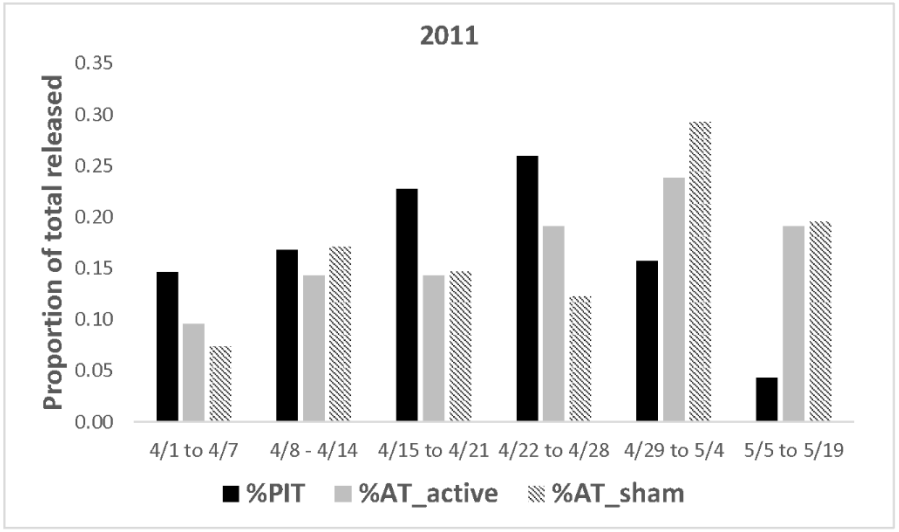
**Wargo Rub, A. M.,** Som, N. A., Henderson, M. J., Sandford, B. P., Van Doornik, D. M., Teel, D. J., Tennis, M., Langness, O. P., van der Leeuw, B. K., and Huff, D. D. 2018. Changes in adult Chinook salmon (Oncorhynchus tshawytscha) survival within the lower Columbia River amid increasing pinniped abundance.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


Sample area
Astoria
WA
OR
Columbia River, USA
Bonneville Dam
Columbia River
Detection year
2010
2011
2010 & 2011
0 12.5 25 50 Km
Proportion of AT fish
0.40
0.30
0.20
0.10
0.00
19-25
29-38
43-44
56-61
2010
2011
226
232
Upriver progress of AT Fish by rkm

# Acoustic/PIT tag comparison study 2010 & 2011:

| | Number of fish tagged | |
|---|---|---|
| | 2010 | 2011 |
| PIT only | 115 | 185 |
| AT active | 52 | 42 |
| AT inactive | NA | 41 |

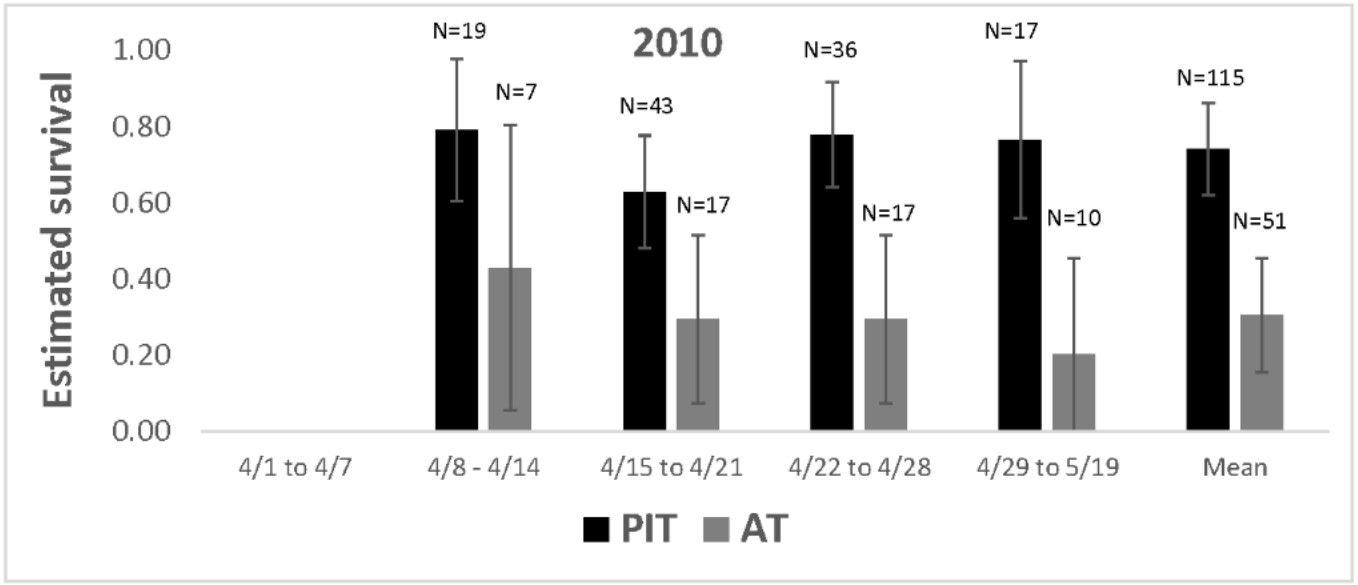



*All included fish were genetically identified as originating from stocks upriver from Bonneville Dam with a certainty of at least 0.95

| | Survival | |
|---|---|---|
| | **2010** | **2011** |
| **PIT only** | .74 (95% CI=.62-.96) | .73 (95% CI=.60-.86) |
| **AT active** | .30 (95% CI=.15-.45) | .10 (95% CI=0.00-.24) |
| **AT inactive/sham** | NA | .75 (95% CI=.54-.97) |

PIT-AT active = .44 during 2010 ($p=0.004$)
PIT-AT active = .63 during 2011 ($p \leq 0.001$)


2010
Estimated survival
1.00
0.80
0.60
0.40
0.20
0.00
N=19
N=7
N=43
N=17
N=36
N=17
N=17
N=10
N=115
N=51
4/1 to 4/7
4/8 - 4/14
4/15 to 4/21
4/22 to 4/28
4/29 to 5/19
Mean
PIT
AT

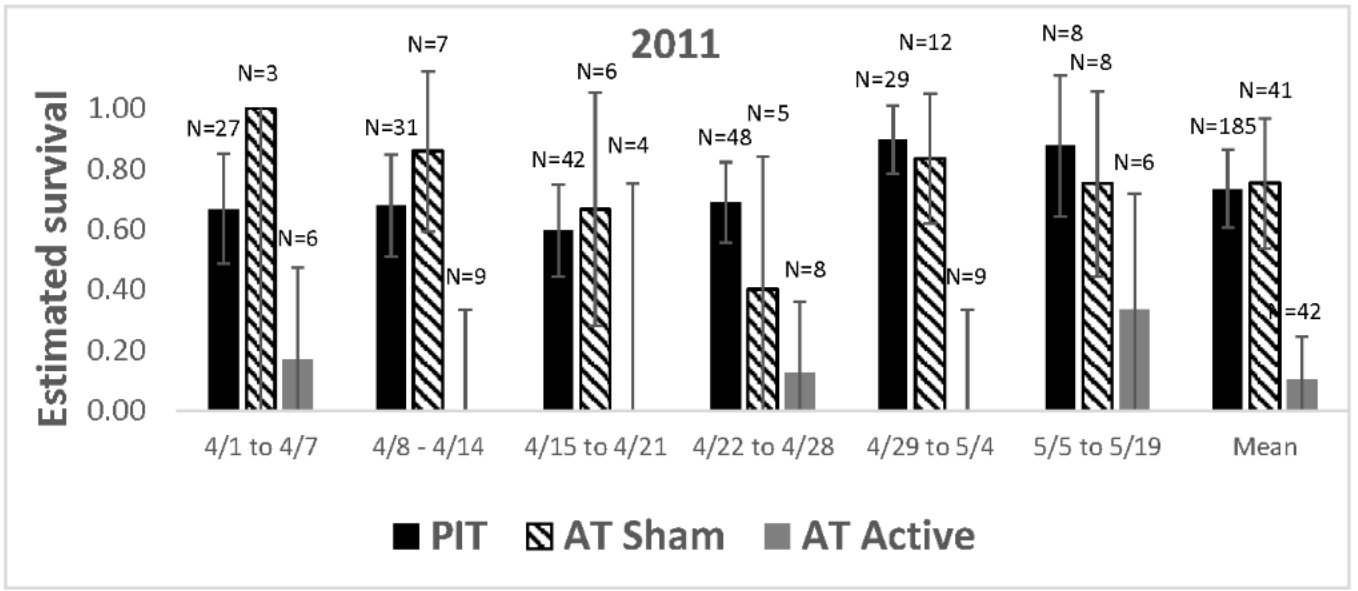
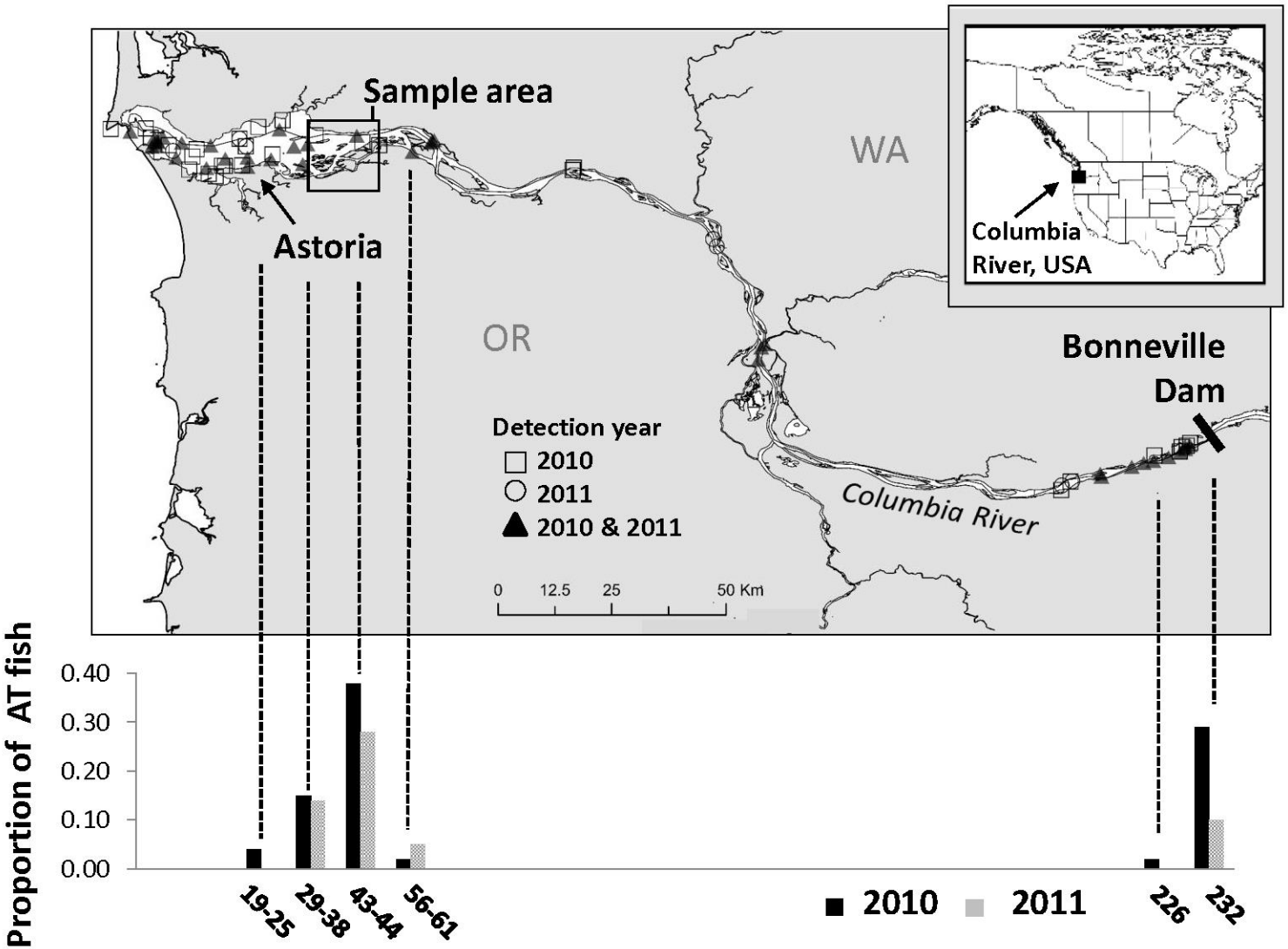

2011
Estimated survival
1.00
0.80
0.60
0.40
0.20
0.00
N=27
N=3
N=6
N=31
N=7
N=9
N=42
N=6
N=4
N=48
N=5
N=8
N=29
N=12
N=9
N=8
N=8
N=6
N=185
N=41
N=42
4/1 to 4/7
4/8 - 4/14
4/15 to 4/21
4/22 to 4/28
4/29 to 5/4
5/5 to 5/19
Mean
PIT
AT Sham
AT Active

**Table 2.** Number of days between release and first detection at marine mammal body temperature (36-38°C) for acoustic-tagged fish during 2011. Also shown are locations where detected tags were presumed to be carried by fish (8-10°C) vs. marine mammals.

| Adult salmon | Time from release to detection in marine mammal (d) | Location of detection in fish (rkm) | Location of detection in marine mammal (rkm) |
|---|---|---|---|
| **Upriver fish** | | | |
| **1** | 2.7 | 43.6, 37.8 | 43.6 |
| **2** | 42 | no detection | 43.6 |
| **3** | 1.3 | 43.6 | 43.6 |
| **4** | 2.2 | 43.6, 37.8, 33.0 | 28.9 |
| **Lower river fish and fish with probabilities of upriver origin < 0.95** | | | |
| **5** | 0.4 | 43.6 | 28.9 |
| **6** | 0.4 | no detection | 37.8 |
| **7** | 0.6 | no detection | 43.6 |
| **8** | 1.1 | 37.8, 33.0 | 37.8 |
| **9** | 8.2 | 33.0, 32.2, 28.9, 24.9, 18.5, 13.7 | 28.9 |
| **10** | 1.9 | 43.6, 37.8, 33.0 | 33 |
| **11** | 2.2 | 34.4, 28.9 | 20.1 |
| **12** | 2.6 | no detection | 37.8 |
| **13** | 2.7 | 43.6 | 43.6 |


Sample area
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0.00
19-25
29-38
43-44
56-61
2010
2011
226
232
Upriver progress of AT Fish by rkm

+

69 kHz @
158 dB re 1µ Pa

=

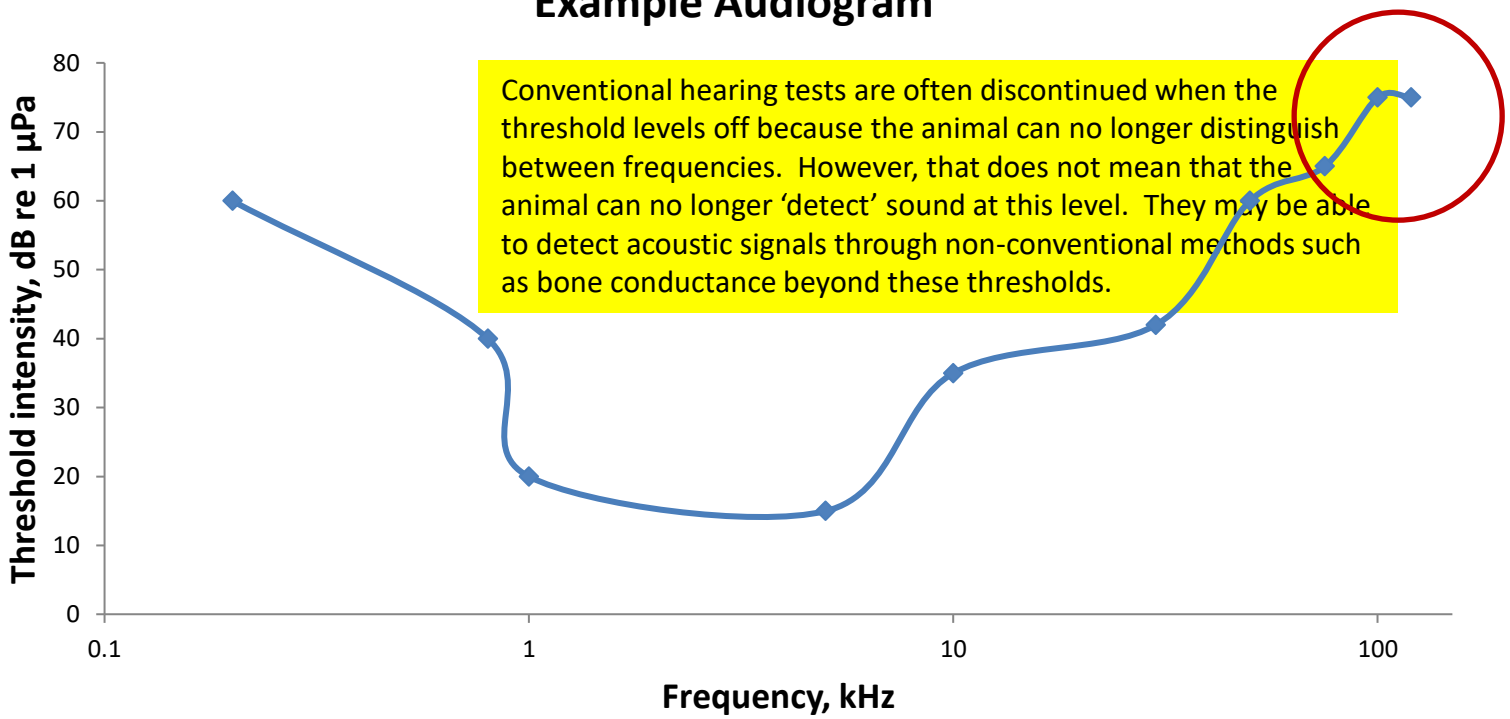
?

**Published High-Frequency hearing limits:**

100 kHz  for Harbor Seals

34kHz for California Sea Lions

## Example Audiogram




There are at least three problems with applying hearing thresholds from the published literature to our applications:

1.) studies were conducted on only a few animals
2.) tests were conducted to determine the upper threshold at which animals were able to distinguish between different frequencies, not necessarily the upper hearing limit
3.) tag intensities are well above those which have been tested during conventional hearing tests (e.g. 150 dB re 1µPa compared to 60 dB re 1µPa)

**Collaborative research conducted between researchers at the NWFSC, the SWFSC, and the Institute of Marine Sciences, Long Marine Laboratory, UCSC**


24yr old male harbor seal Sprouts


4yr old female CSL Ronin

## Both Animals were exposed to a 69 kHz pure tone

**Harbor seal detected this tone at 106 dB (this was slightly lower (i.e. more sensitive than expected), but within the range of published data)**

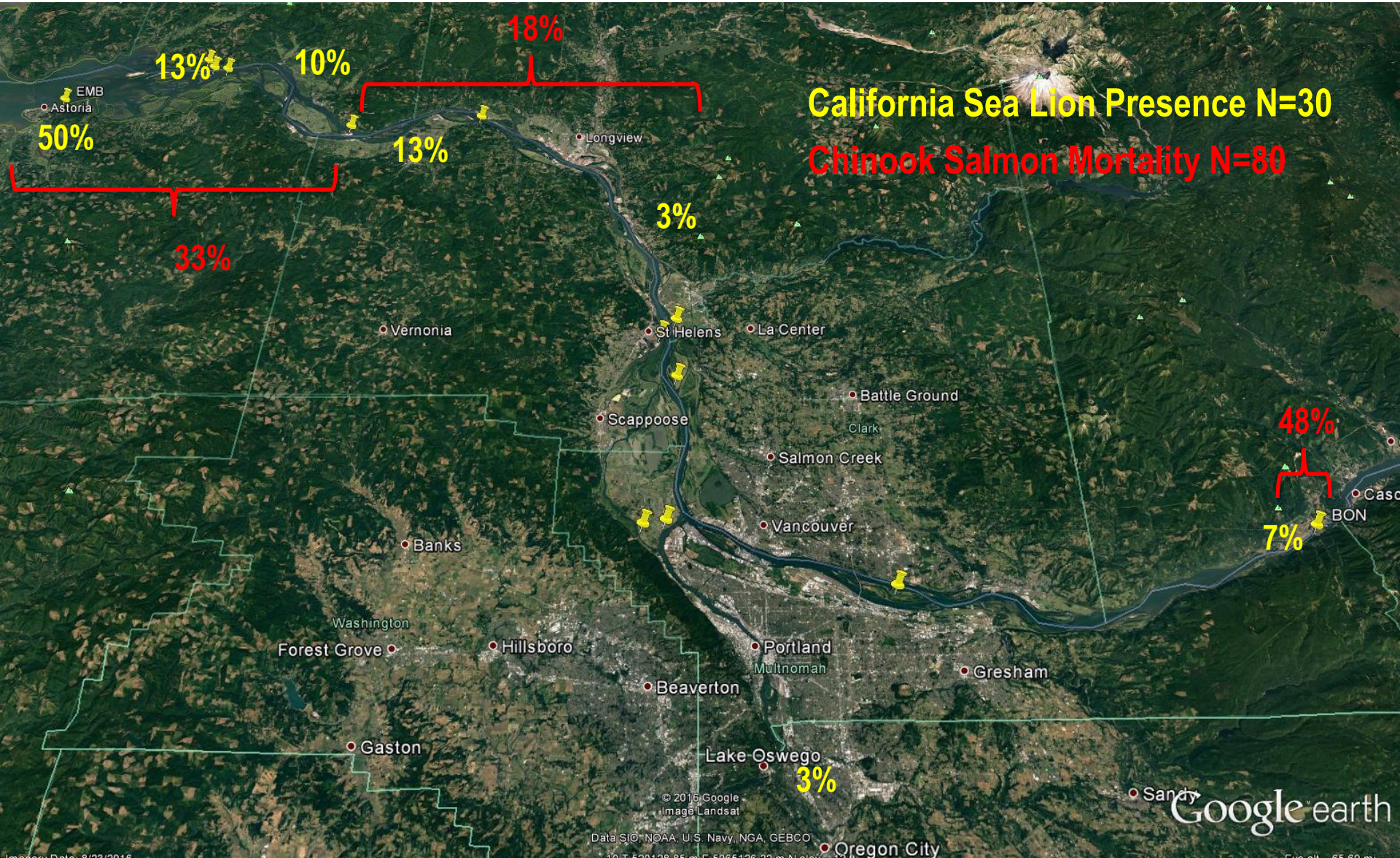
***Based on this information, the detection range of a Vemco 69 kHz high OP transmitter would be ~900 m in FW**

**CSL detected this tone at 112dB (this was 33 dB lower than expected compared to published data)**

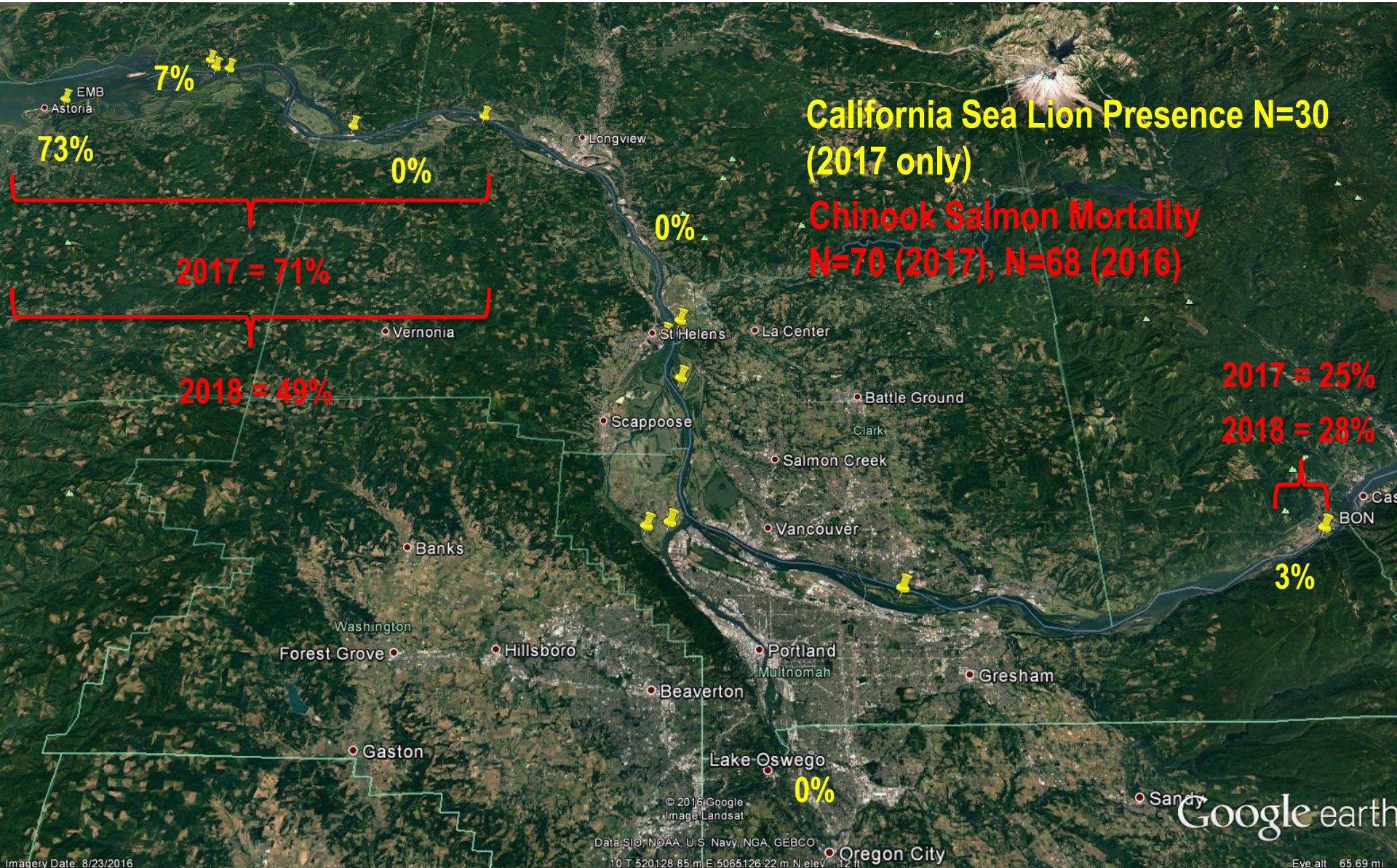
***Based on this information, the detection range of a Vemco 69 kHz high OP transmitter would be ~350m in FW**

Cunningham et al. 2014 & Wargo Rub, A. M., and Sandford. B. P. 2020 (michelle.rub@noaa.gov)

# Radio Telemetry Results 2016



# Radio Telemetry Results 2017



# Acknowledgements:

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