Northwest **Power** and
Conservation Council

July 6, 2016

MEMORANDUM

TO: **Fish and Wildlife Committee members**

FROM: **Kendall Farley**

SUBJECT: **Use of Passive Integrated Transponder (PIT) Tag Data to Model Wind River Steelhead Life Cycle Survival**

BACKGROUND:

Presenters: Dan Rawding, Columbia River Science/Policy Coordinator for the Washington Department of Fish and Wildlife and Thomas Buehrens Research Scientist for the Washington Department of Fish and Wildlife.

Summary: The development and refinement of the Passive Integrated Transponder (PIT) tag technology including adult and juvenile PIT tag detection systems at Columbia River dams has allowed for: 1) estimates of juvenile survival through mainstem reaches in the Snake and Columbia rivers, 2) estimates of adult conversion (survival) between these reaches, and 3) smolt to adult return rates. Typically these are calculated in separate analyses, and are often not provided at the population scale for wild steelhead because too few individuals are tagged to obtain a reliable estimate. We present a novel approach to simultaneously estimate survival of Wind River steelhead for eight life stages from the parr (juvenile) to repeat spawner (adult) stages over nine cohorts using a multi-level Cormack-Jolly-Seber (CJS) model based on tagging and detection of PIT tags in the Wind and lower Columbia rivers. In addition, we

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demonstrate how the survival estimates from our model can be used to identify limiting life stages to focus on additional research or restoration actions. We conclude with some recommendation for continued improvements of life cycle models.

Relevance: The Adaptive Management section in the Council's 2014 Fish and Wildlife Plan Council (2014-12) supports continued research and life cycle modeling to inform decision makers of the biological benefits that may be achieved by implementing different measures across the life cycle of anadromous fishes (p. 106). The Plan's monitoring principles support the development of statistical life cycle models (p. 101) and recommend summarizing information by life cycles stages (p. 105). The results of this first Columbia River steelhead life cycle model, based on Passive Integrated Transponder (PIT) tagging and detection, are an important contribution to our understanding on population life stage specific survival rates for summer steelhead. Results and recommendation from this life cycle modeling effort are also relevant to the Council's Critical Uncertainties Report (ISAB/ISRB 2016-1) and address many themes including: tributary habitat, hydro-system flow and operations, predation, estuary, plume, & ocean, and monitoring & evaluation methods).

Wind River Steelhead Life Cycle Modeling

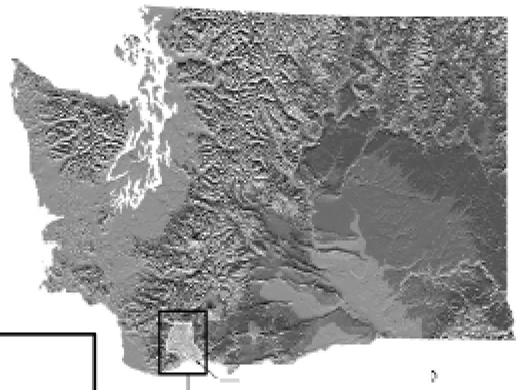
Dan Rawding,
Thomas Buehrens, and
Charlie Cochran

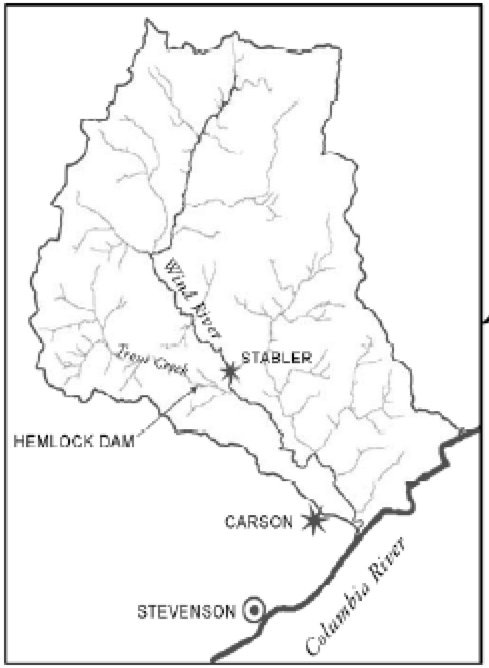
Washington Department of
FISH and WILDLIFE

Outline

- Project History
- Life Cycle Model
- Results & Limiting Factors
- Summary

Wind River Watershed





- Located ~10 miles upstream of BON Dam; 52 miles east of Portland, OR
- 223 sq. miles of drainage area
- Four waterfalls @ RM 2 that limit passage to summer steelhead & daring kayakers

Wind River Watershed Project

- Project started in the early 1990's in response to low adult steelhead abundance with smolt trapping & restoration
- BPA funding in 1998 with cost share from partners
  - Habitat restoration by Underwood Conservation District (UCD) & United States Forest Service (USFS)
  - United States Geological Survey (USGS) - parr life history & evaluate of instream restoration
  - WDFW monitoring juvenile outmigrants and returning adults. BPA funding allows installation and operation of year round adult trap in a fish ladder. seasonal operation of smolt traps, and PIT tagging.

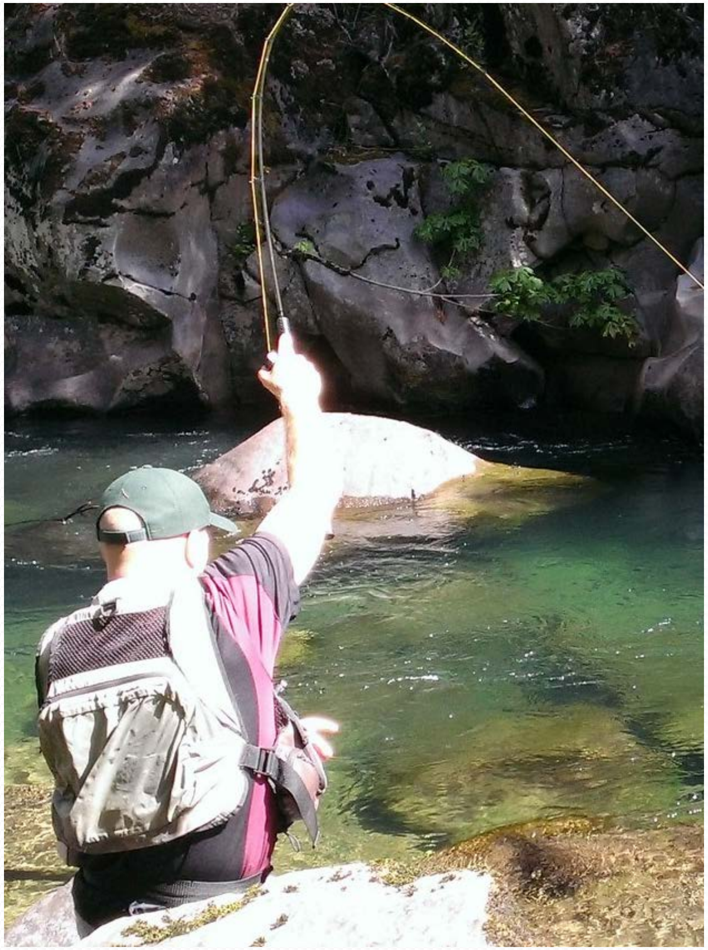
WDFW Monitoring Program

- Operate traps to estimate wild steelhead adult and juvenile abundance
  - Fish In/Out monitoring meets NOAA recovery plan of one population per MPG
  - Meets NPCC guidance as reference wild steelhead population for the Columbia Basin:
    - limited Hydro-influence 12 miles above BON
    - WDFW gene bank/stronghold with good habitat
  - Key indicators for the project are:
    - Natural Origin Spawner Abundance, Smolt Abundance, Smolt to Adult Returns , and Recruits per Spawner
- All indicators are provided to the Coordinated Assessment (CA) project and available through StreamNet

Hemlock Dam Removal Evaluation

- In 2009 USFS, BPA and partners removed Hemlock Dam on Trout Creek at a cost of ~ $2M
  - After USFS stopped its tree nursery operations in the 1990's the dam was obsolete, a liability, degraded water quality and fish habitat, and did facility not meet fish passage standards
- Watershed scale baseline monitoring of adults and smolts, allows WDFW to evaluate steelhead response to dam removal
- Expected steelhead response in 2 to 3 generations (10 to 15 years)

Recreational Benefits



- Wind River was closed to steelhead fishing for a decade but now reopened
  - Used relationship between smolts and spawners to estimate the number of spawners needed to seed habitat.
  - PIT tags & trap data allow in-season wild steelhead run size to be estimated
  - C&R fishery opens in September only if run size is greater than spawners need to seed habitat
- WDFW is funding study to estimate C&R mortality on summer steelhead based on PIT tagging and detections

PIT Tag Technology

- With the 2000 installation of adult PIT tag detectors at BON there was an opportunity to use PIT tags for life cycle modeling
- Switched from marking juvenile steelhead with a tattoo to using PIT tags after modifying FY 2002 BPA contract
- 2000-4000 juvenile and adult steelhead per year with annual cost of $4-8,000
- With proper tagging technique PIT tagging impacts low and approximately 2%, 10%, and 30% of parr, smolts, and adults are PIT tagged annually

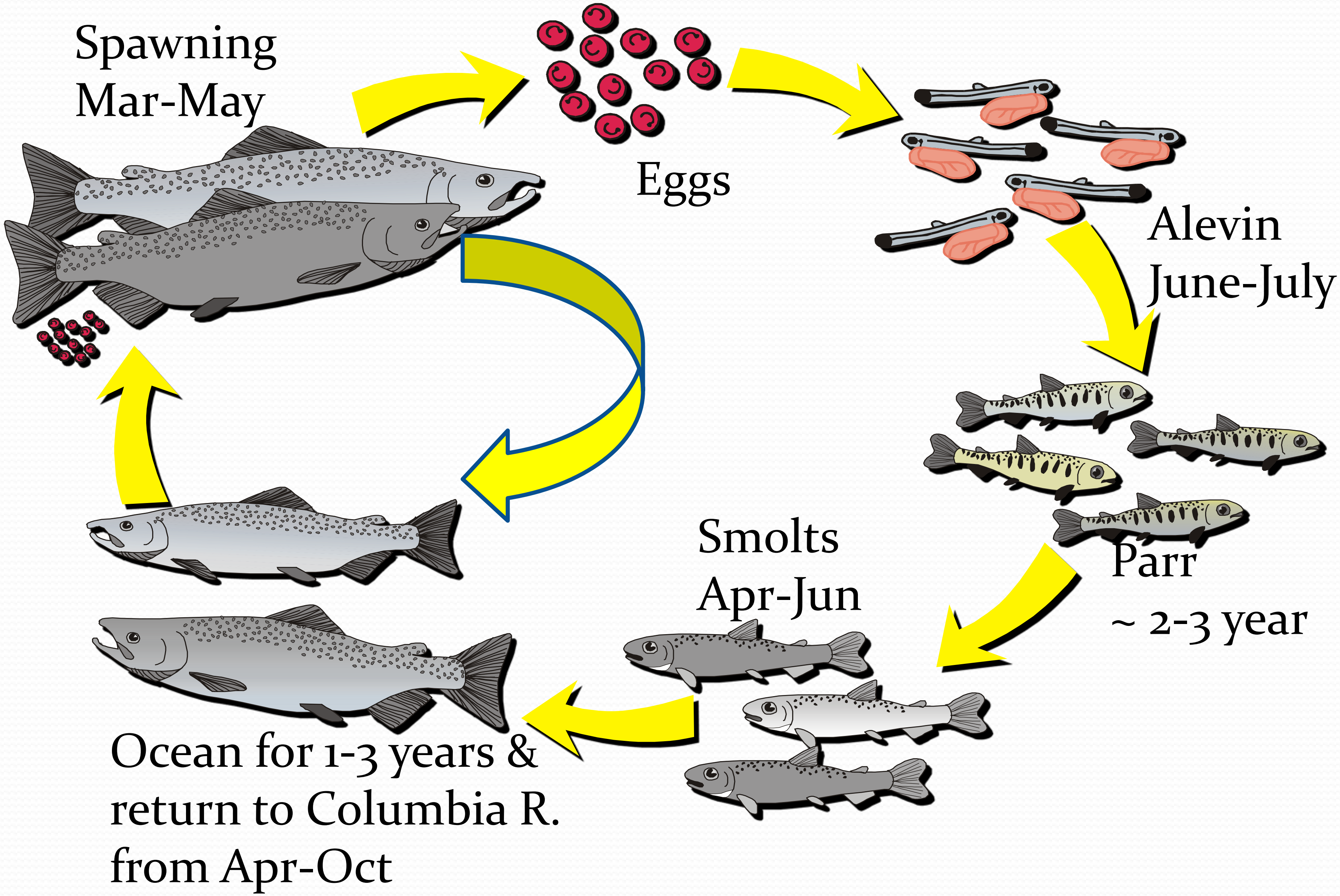
Life Cycle Models (LCM)

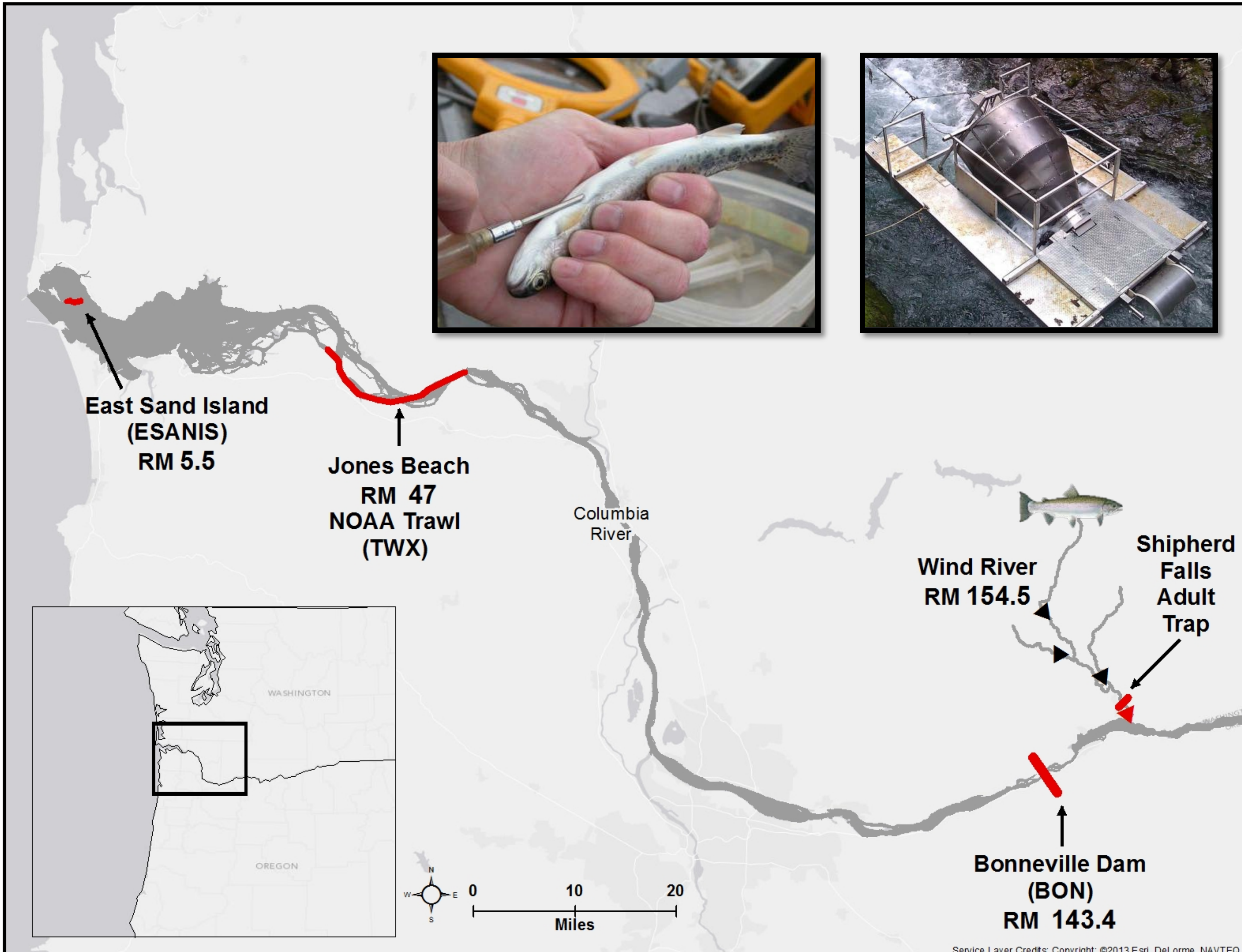
- LCM tie together different data to aid in the identification of necessary, salient, and sufficient features in the life cycle of a salmon (Hilborn & Mangel 1997)
- No clear definition of a Life Cycle Model
  - Two stage model that estimates survival in freshwater and marine environment
  - Multistage model that estimates the habitat capacity and productivity (density dependent survival) by each habitat reach through out the life cycle (e.g. Ecosystem Diagnosis & Treatment –EDT model)
  - Everything in between

Wind River Life Cycle Model Framework

- ROSTER (River-Ocean Survival and Transportation Effects Routine) model to track survival of smolts from LWG to the ocean and back using PIT tags(Buchanan and Skalski 2007)
- We modified their framework to include:
  - Multi-level modeling approach to better estimate the probability of capture & survival with small release groups
  - Used PIT tag recoveries from the NOAA trawl & bird colonies to estimate survival from BON to Columbia River Estuary
  - Extended the model to estimate parr to smolt survival
  - Extended model to estimate survival from first spawning to second spawning (Repeat Spawners), which is needed for steelhead

Steelhead Life Cycle





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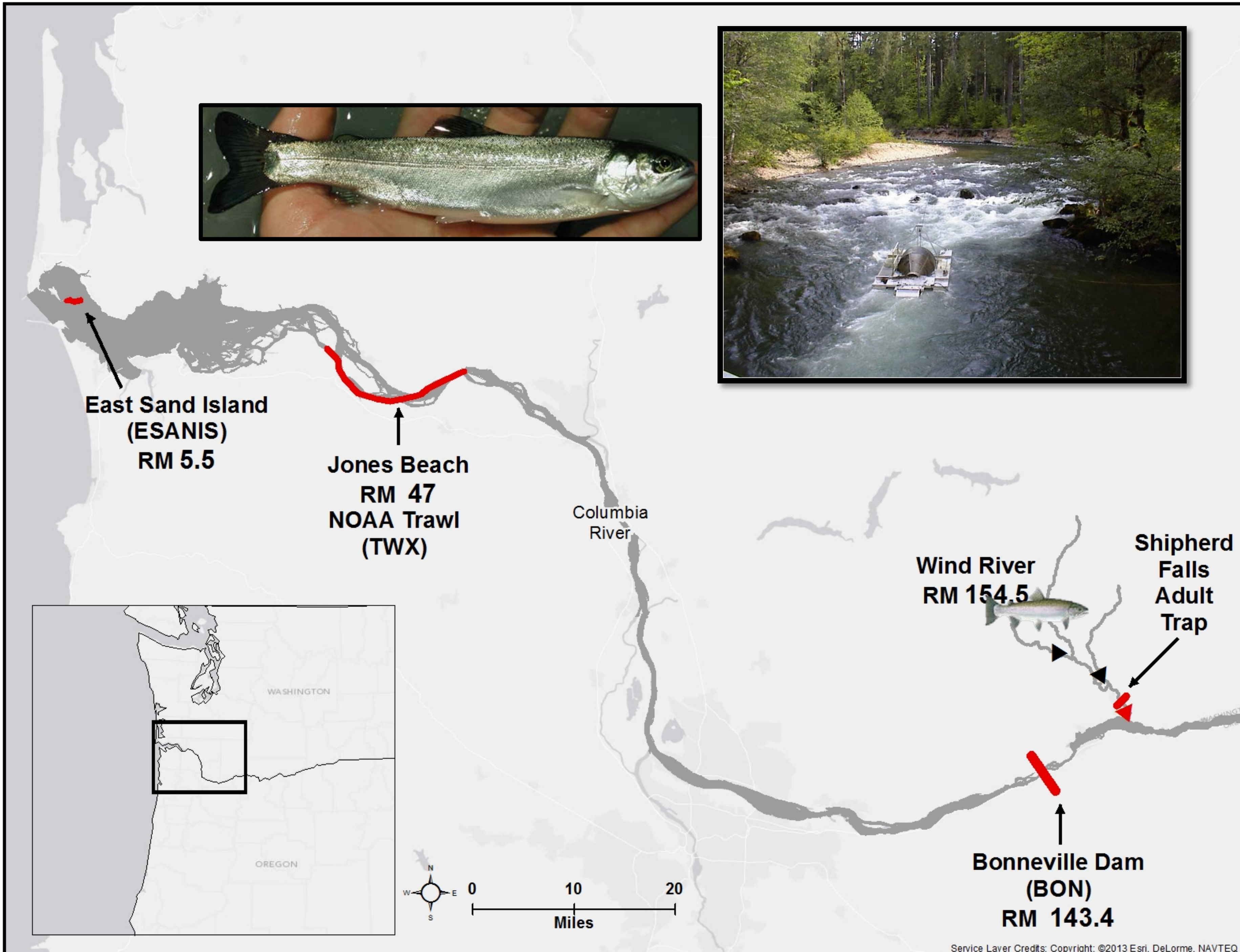
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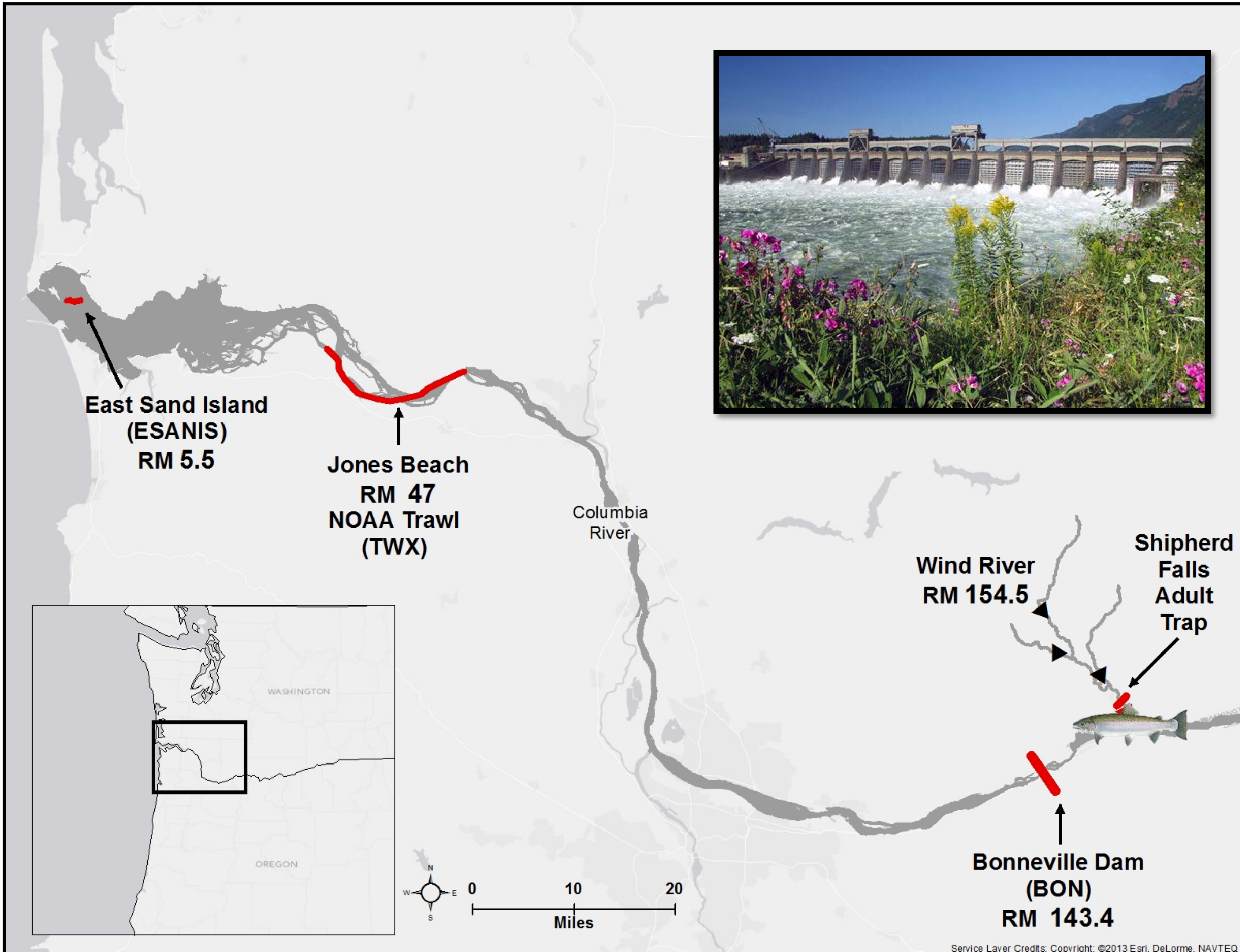
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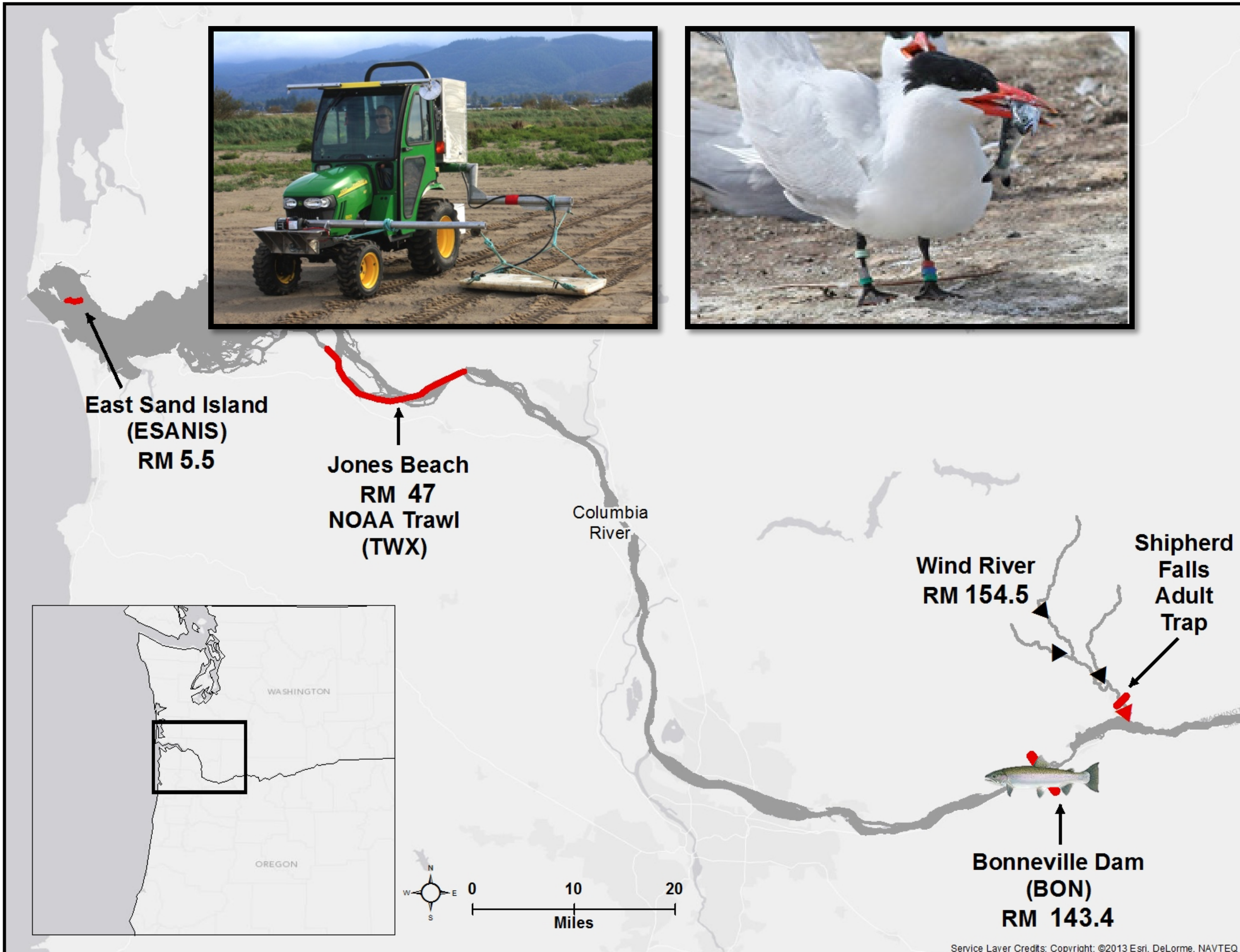

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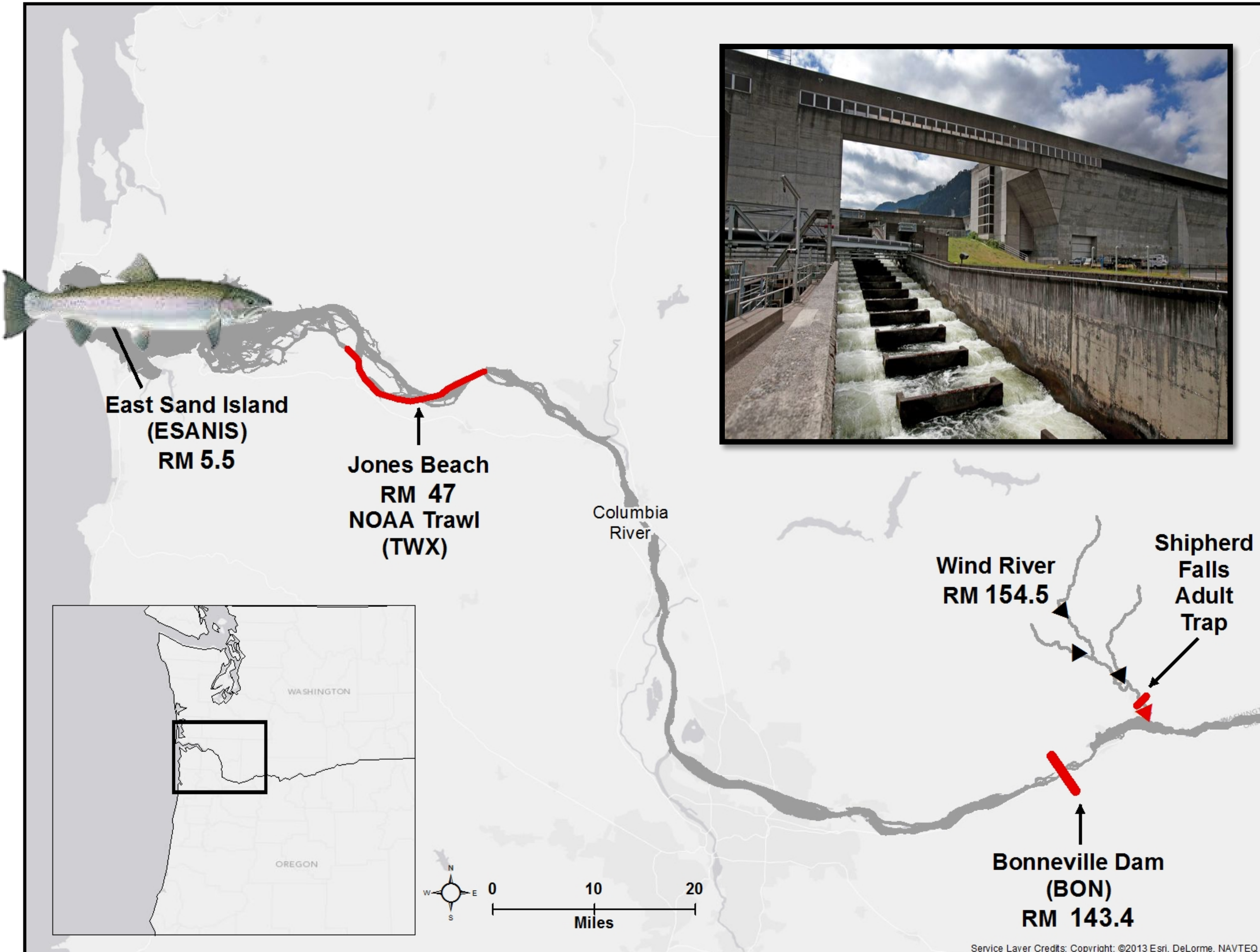
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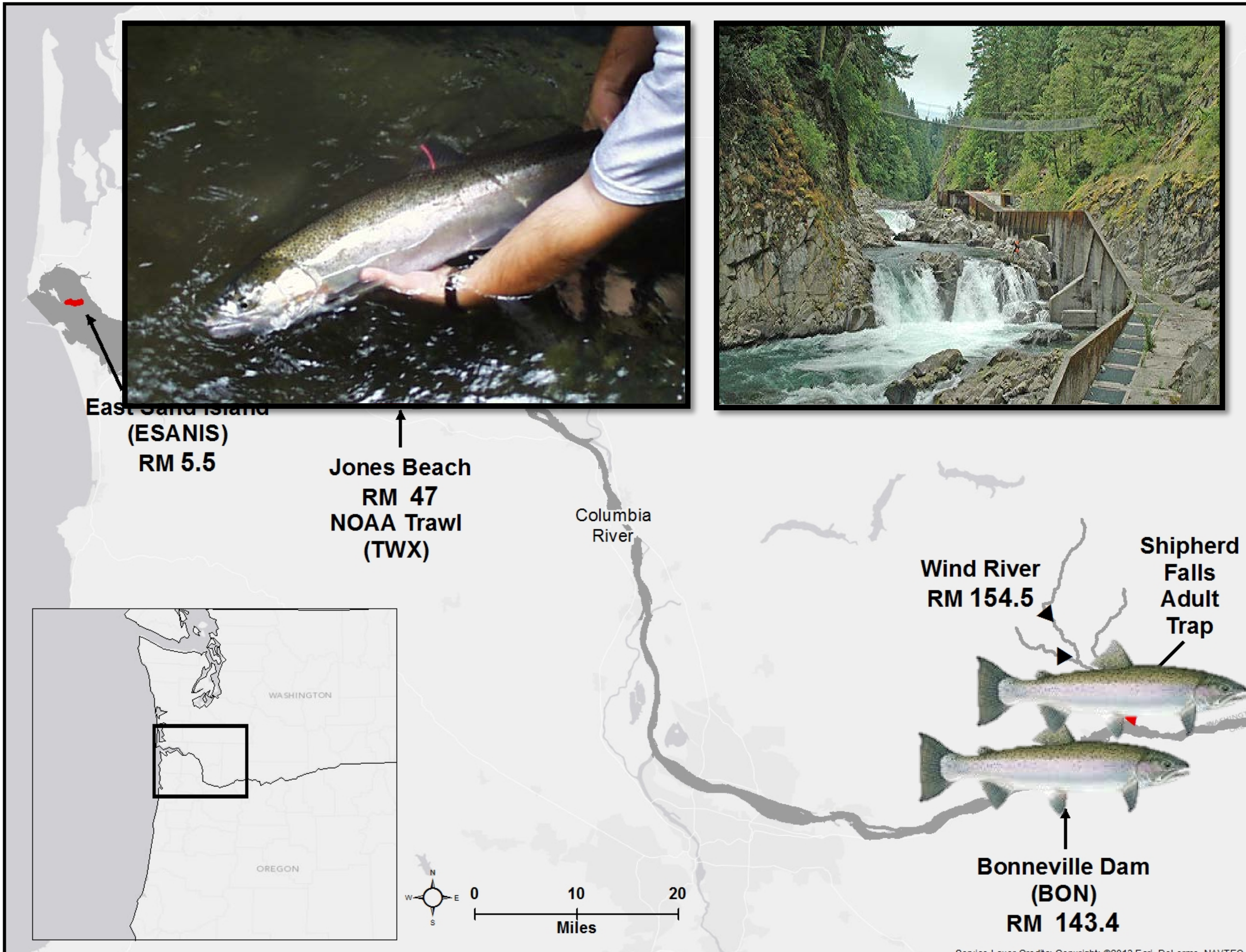

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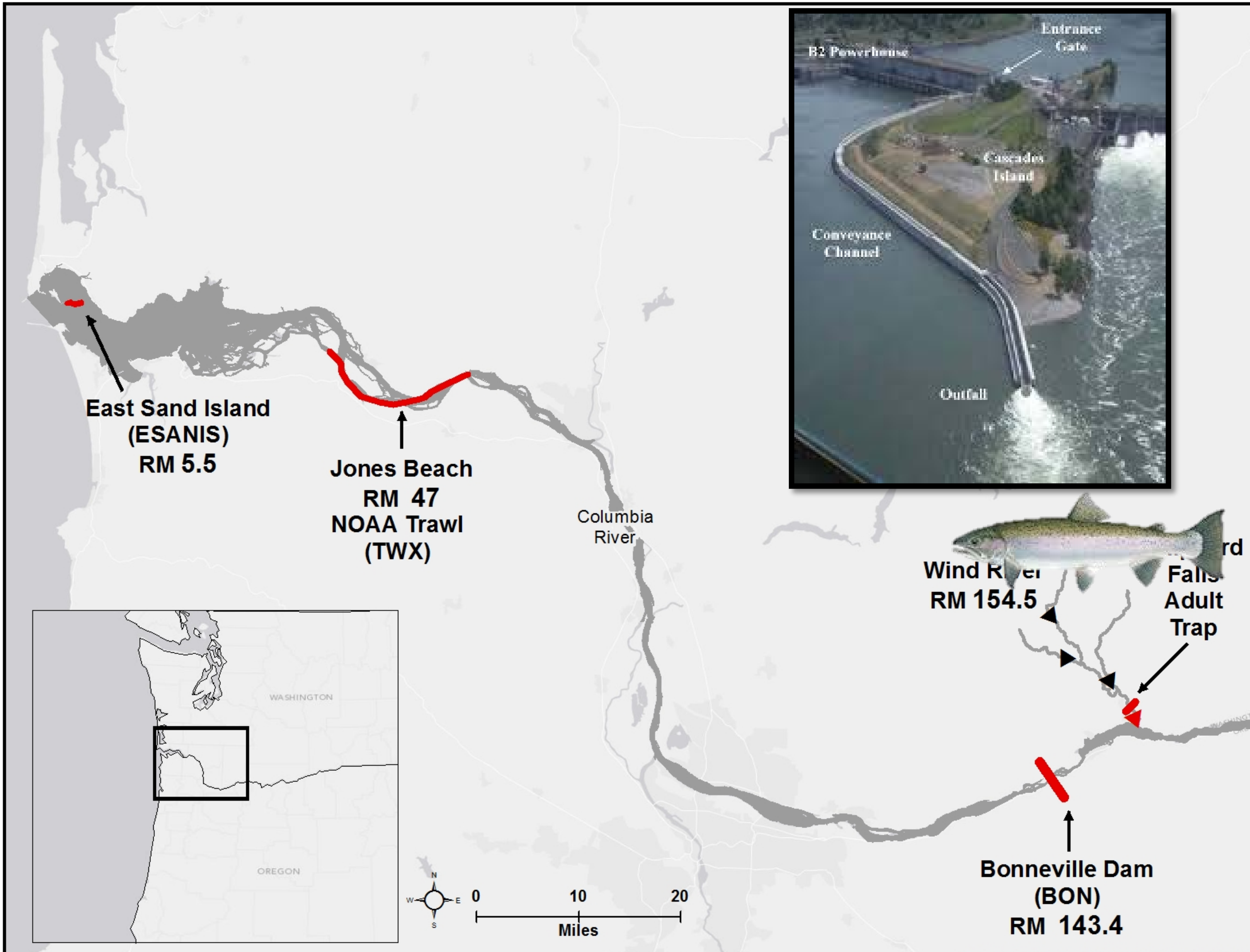

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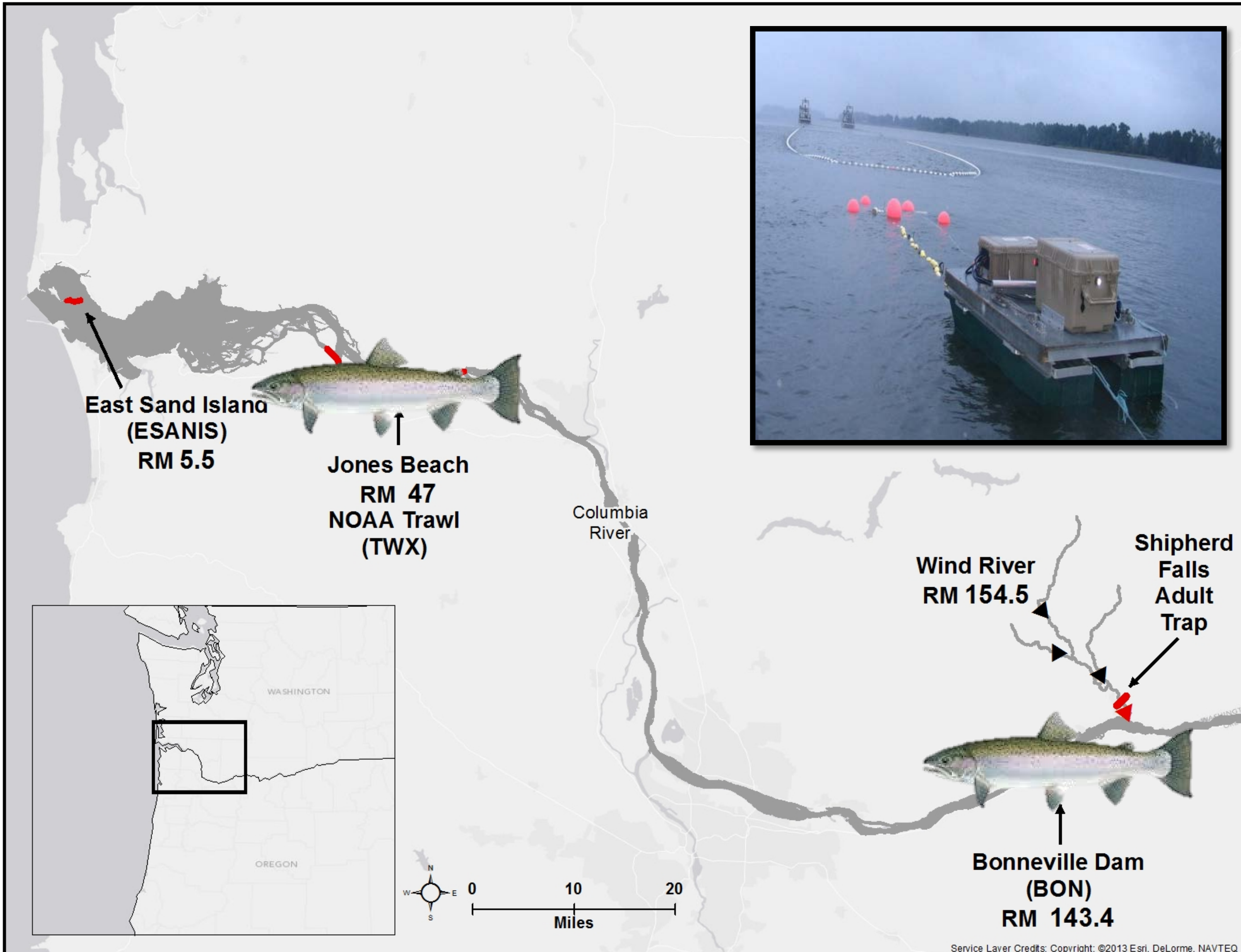

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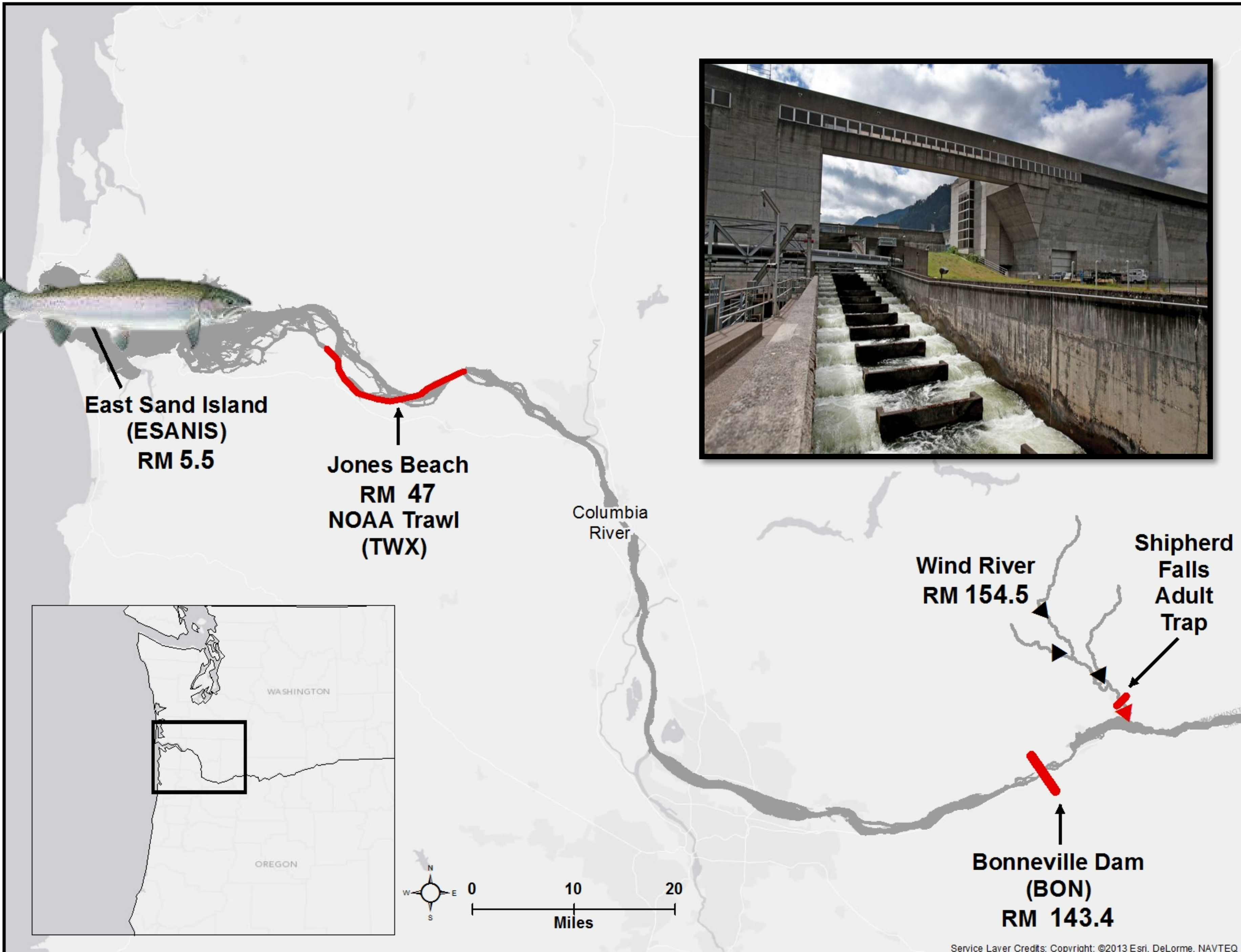
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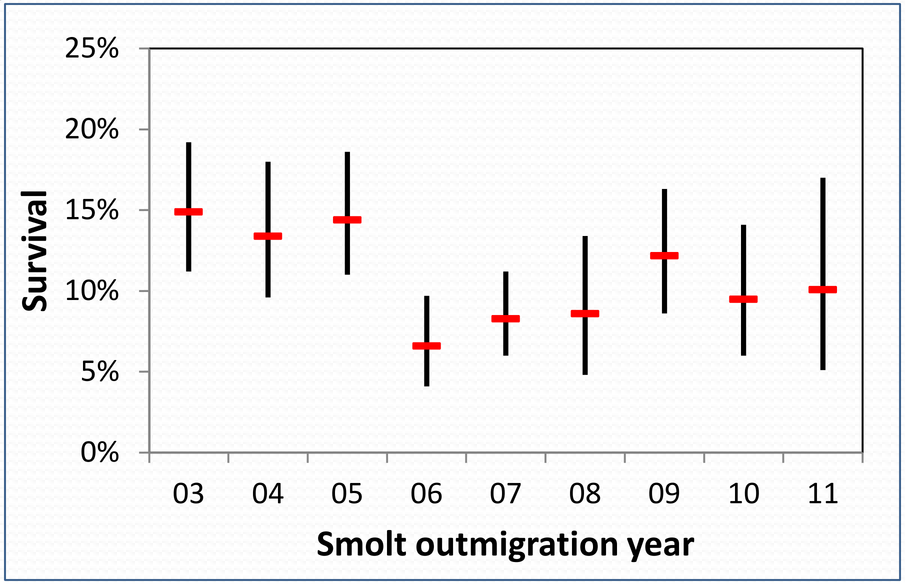
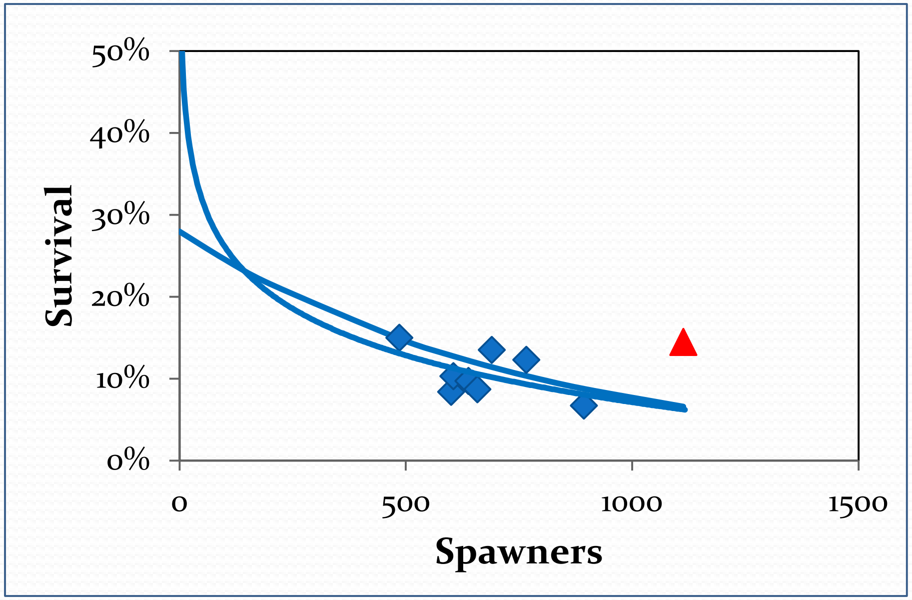
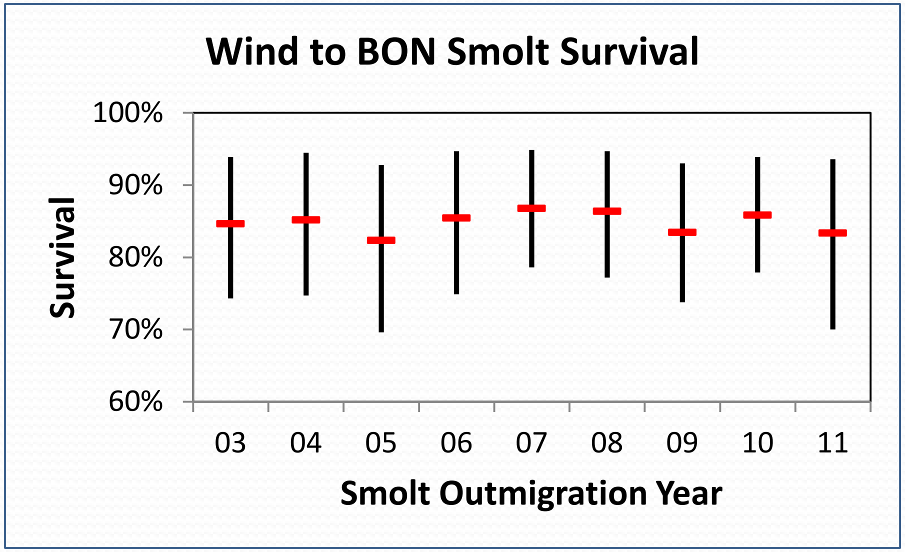
Parr to Smolt Survival

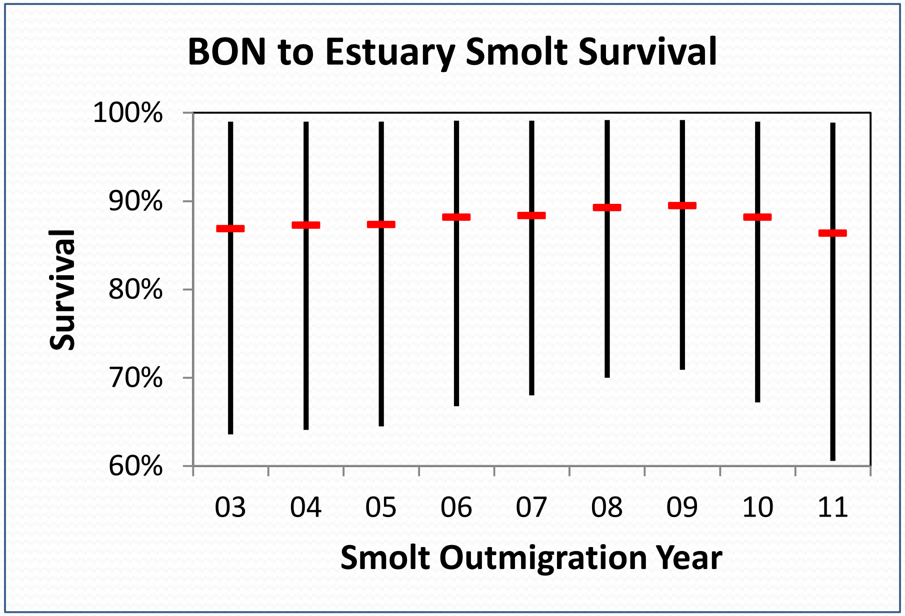




- Survival estimates may be slightly biased low since some "steelhead" parr may be rainbow trout, which do not emigrate
- Some of the variation is due to density dependence (e.g. lower survival at high density)
- Waiting for returns from higher and lower escapement to better define spawner and parr to smolt survival relationship

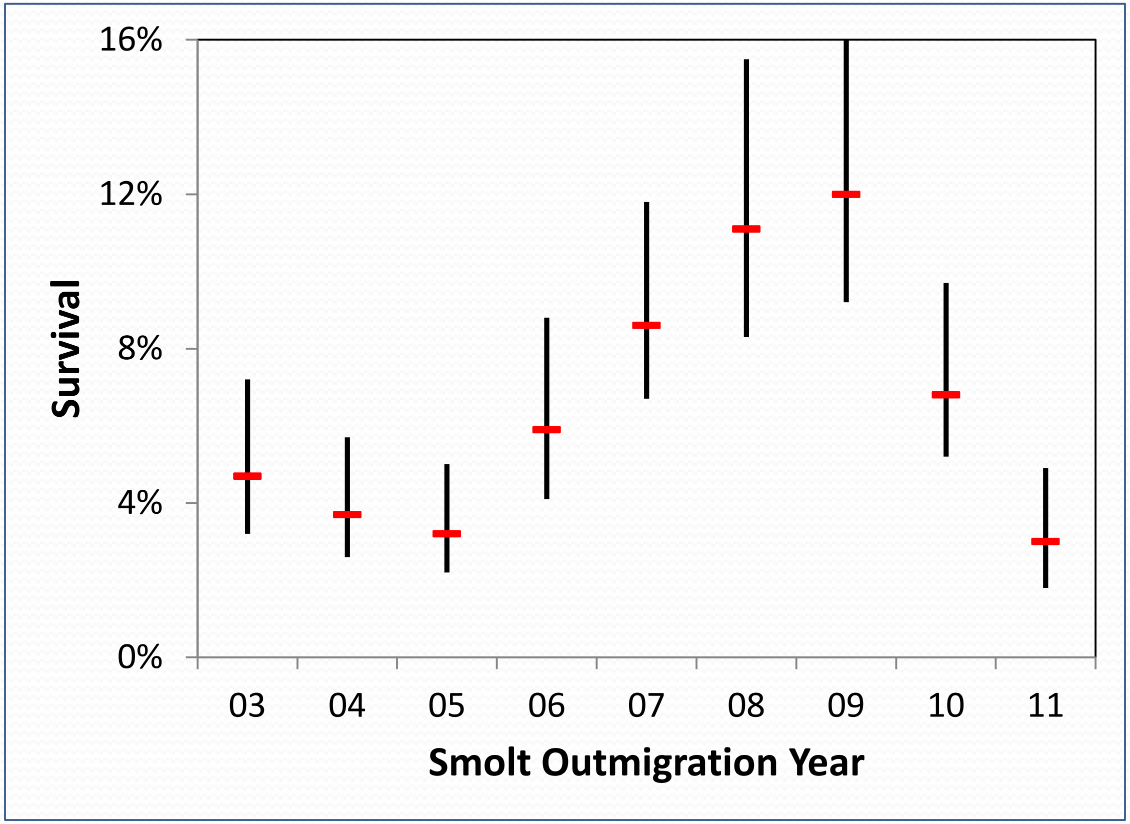
Columbia River Smolt Survival



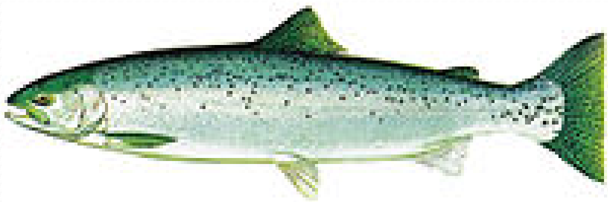


- Survival in the mainstem Columbia is high (~85%) due to short travel time
- The survivals estimates include mortality from BON passage (4%), predation by birds ~ 10%, and other sources.
- Survivals are less precise due to a low capture rate of PIT tags in the NOAA estuary trawl and bird colonies

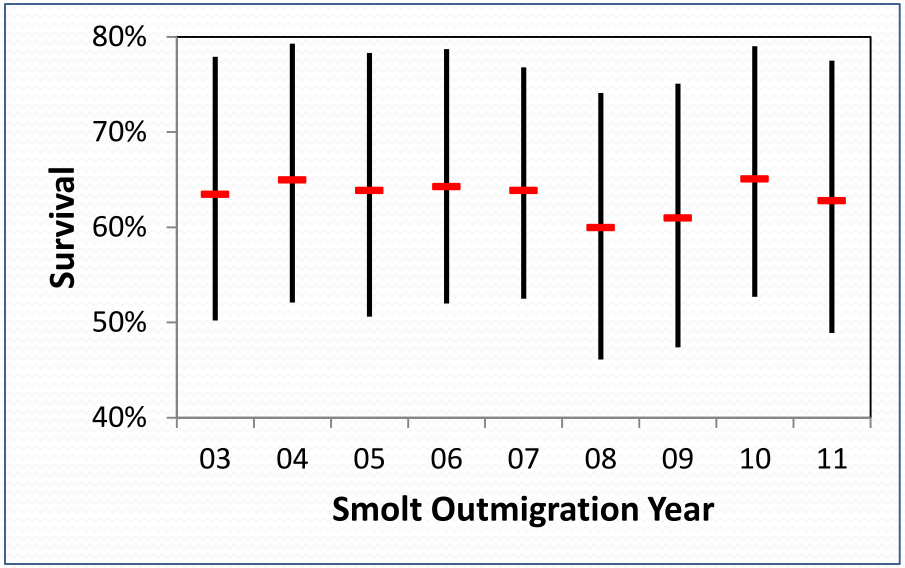
Smolt to Adult Survival from the Estuary to BON



- This life stage explained most of the variation in our life cycle model
- This result may or may not apply to other steelhead populations

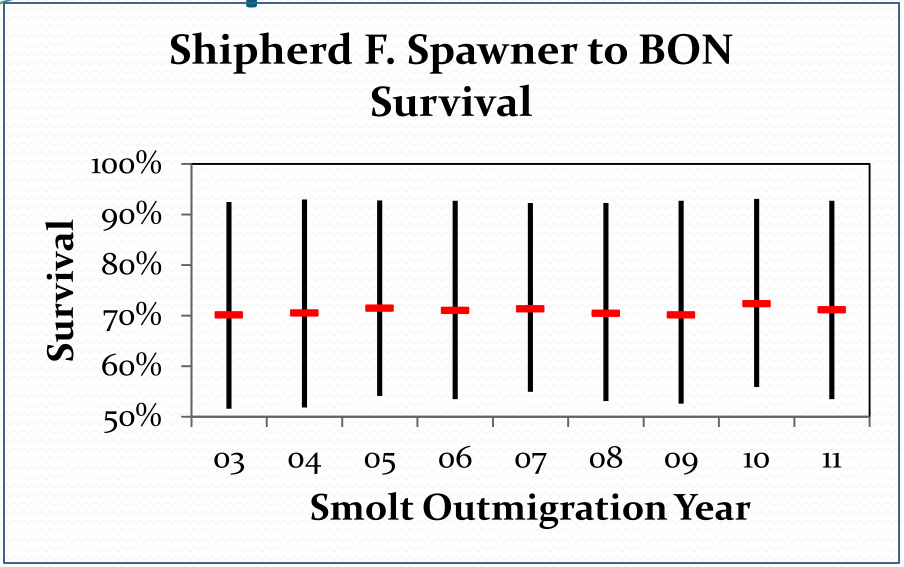


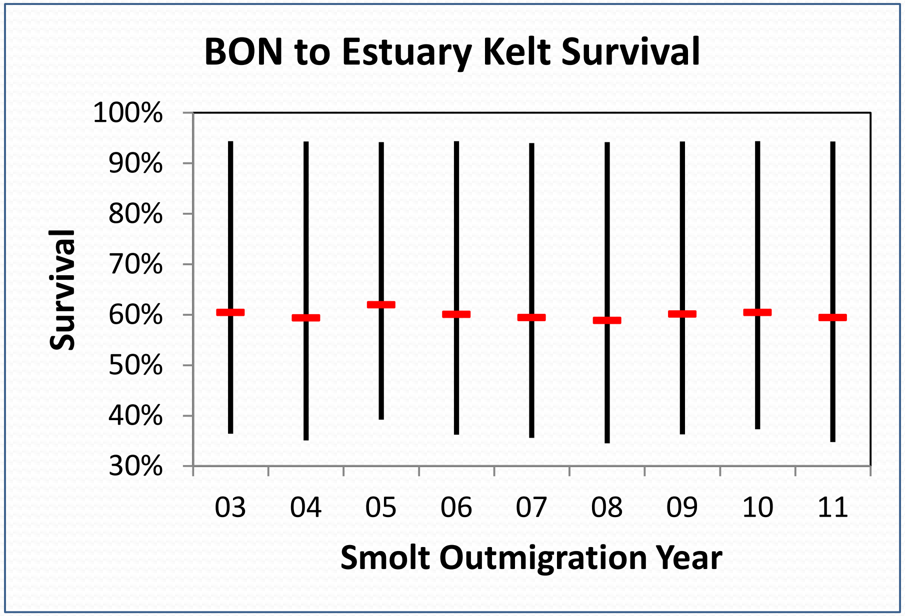
Adult Survival from BON to Shipherd Falls Ladder (RM 2 Wind River)



- On average less than 65% of the adult steelhead survive the 14 miles from BON to Wind. ODFW reports similar survivals for 15mile Cr in BON pool.
- Salmon conversion to LWG and to Upper Columbia Dams is often higher than 65% and they migrate many hundreds of miles
- The most limiting life stage in achieving the recovery plan abundance goal of 1000 adults
- Population specific harvest rates are unknown in treaty and recreational wild release fisheries
- BON pool can be in excess of 22 degrees, which exceeds the 1 & 7-day average maximum of 22 & 17 degrees

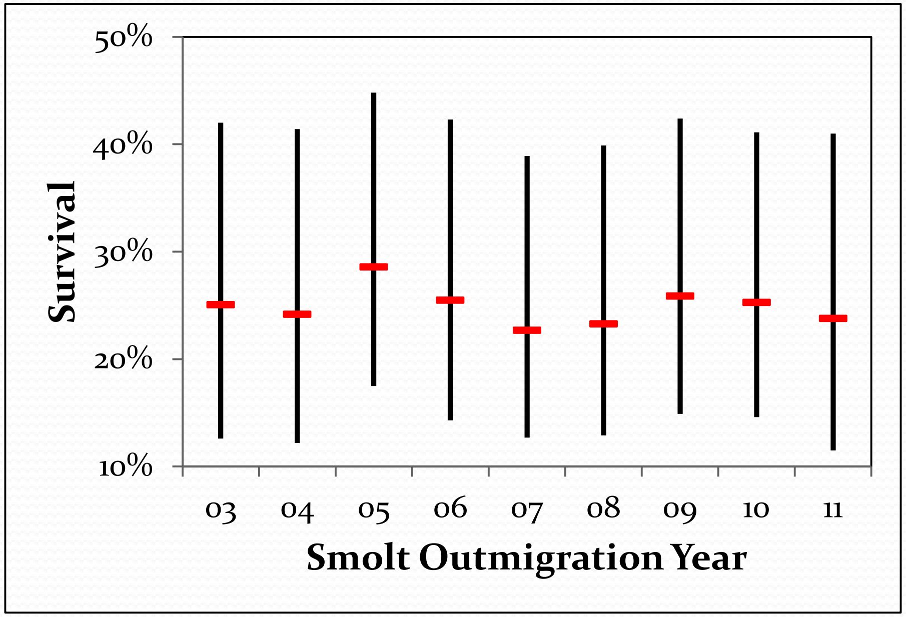
Spawner and Kelt Survivals





- Steelhead kelt life stage is from the completion of spawning to entry back into the ocean
- Most kelts use the BON Corner Collector to emigrate downstream
- Difficult to compare these survival estimates because this is the first time they have been made
- Most imprecise estimates in our LCM because few kelts captured in NOAA trawl.
- Increase adult tagging rate to improve precision in the recent years.

Estuary Kelt to Repeat Spawner Survival to BON



- Kelts return to the ocean to feed and return the same year to spawn (consecutive spawners) or remain in the ocean for an additional year (skip spawners)
- These high repeat spawner rates are also observed in some coastal steelhead populations (west of the Cascades) but in general repeat spawner rates are less for interior populations (east of the Cascades)
- Repeat spawners are important because they increase life time productivity and diversity

Columbia R. Kelt Survival Rates

Kelt to Adult Return (KAR)	Kelt Tag Location	Repeat Recovery Location	Reference
1%	LWG	BON	Keefer et al. 2008
6%	MCN	BON	Keefer et al. 2008
6%	JDA	BON	Keefer et al. 2008
15%	BON	BON	This presentation

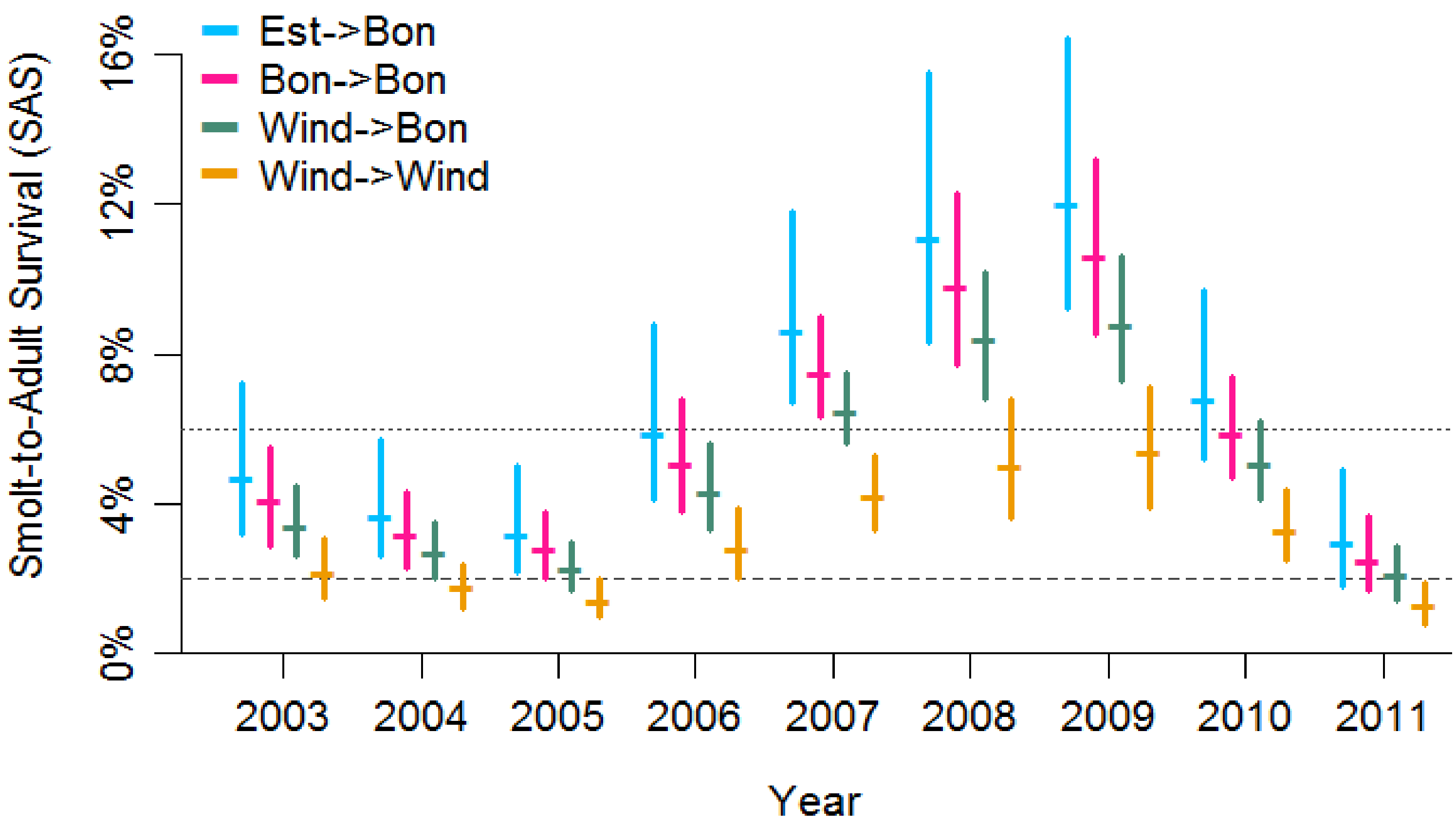
- Travel Time of Kelts from Radio Tracking Studies
  - 43-54 km/day-Skeena
  - 100 km/day - Frazier
  - 99-111 km/day –Columbia @Hanford Reach
  - 13-16 km/day – Snake (Impounded)
  - 39 km/day – Upper Columbia (Impounded)

Kelt Survival Summary

BON Corner Collector

- Odds of a Wind River kelt surviving to a repeat spawner are 2.5 to 15 times higher than those reported by Keefer et al. 2008.
  - Kelts mortality due to difficulty in locating safe passage routes at dams, delayed travel time, and reduced spring freshet due to water storage.
  - Delayed travel time of kelts leads to later ocean entry, which may not be synchronized with ocean food supply and environmental conditions that lead to high ocean survival.
  - Downstream passage issues for adult steelhead is not limited to kelts by also a problem for adult “overshoots”.
  - Kelt reconditioning and barging may considered to increase kelt survivals.

Different SAS for Wind River Steelhead



- SAS1 = Estuary to BON for use in range wide comparison(blue)
- SAS2 = BON to BON for comparison between Col. R. pops (pink)
- SAS3 = Wind to BON reflects juv. mort. from Wind - BON (green)
- SAS4 = Wind to Wind reflects 35% mort. of adults>BON (orange)

Wind Summary

- Good monitoring programs and infrastructure often lead to research opportunities (e.g. evaluation of Hemlock dam removal, hooking mortality study) in a cost-effective manner. Not always a clear line between monitoring and research.
- Given Wind steelhead designation as a stronghold population, robust juvenile & adult monitoring, location just above BON, and use as cold water refuge makes this an ideal reference population and river for the F&W program
- High adults loss (35%) between BON and Wind is concerning and may be addressed by:
  - 1) funding PIT tag detection at near the mouth based on 2016 NOAA Sockeye Report recommendation or
  - 2)use sort by PIT tag code at BON to radio tag steelhead destined for Wind River.
- Improving to a full life cycle (e.g. add spawners and track by spawning year not smolt year).

LCM Summary

- Life cycle models are a natural way to organize our thinking about salmon and steelhead and this presentation demonstrated a way to look for bottlenecks or limiting life stage survivals.
- 2008 FCRPS BiOp used steelhead life cycle models to evaluate hydropower effects, mitigation actions, and ocean/climate scenarios on the long-term viability
- The FCRPS Adaptive Management Implementation Plan (AMIP) & Recovery Plans identified the need for improved empirical LCM for modeling & evaluation
- Empirical (data-driven) LCM models are relatively new and it takes careful design, infrastructure, and a long-term commitment.

WDFW Life Cycle Models

- Estimating reach scale overwinter survival of spring Chinook and steelhead in Wenatchee & Tucannon rivers (ongoing)
- Develop predictive fish/habitat relationships to evaluate habitat restoration on Tucannon with funding from PCSRF grant (2016):
  - Evaluate fish density and survival at restored and unrestored sites
  - Working with CHaMP so fish and habitat sampling are aligned
  - Need to optimize study design for competing objectives
- Challenging to obtain funding for LCM

Making LCM More Available

- Organize the F&W program not as a series of individual projects but as integrated approach across common themes to better leverage individual project contributions across entire program (LCM work group)
- Complicated code/queries to summarize raw data because steelhead migrating year round with lots of potentially confounding upstream and downstream movement
- Code may need adapted for other populations because of different migration locations and patterns but beyond scope of Wind River contract
- Broad scale application of LCM will require additional database and statistical support, and partnerships

Questions?