# Evaluating Spring Chinook Salmon Releases Above Detroit Dam And Below Big Cliff Dam, On The North Santiam River, Using Genetic Parentage Analysis

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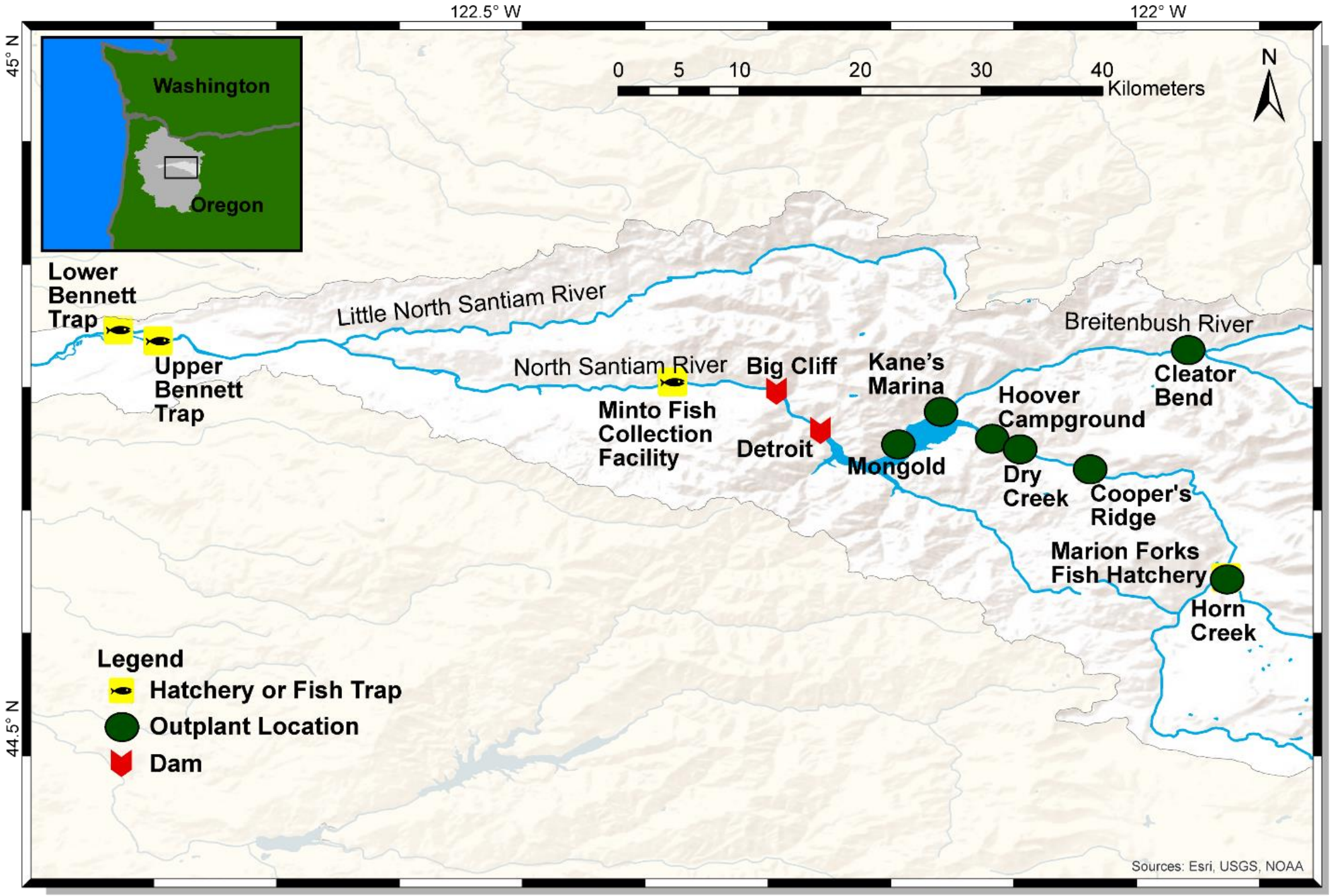
OSU Oregon State University

State Fisheries Genomics Lab

OREGON Fish & Wildlife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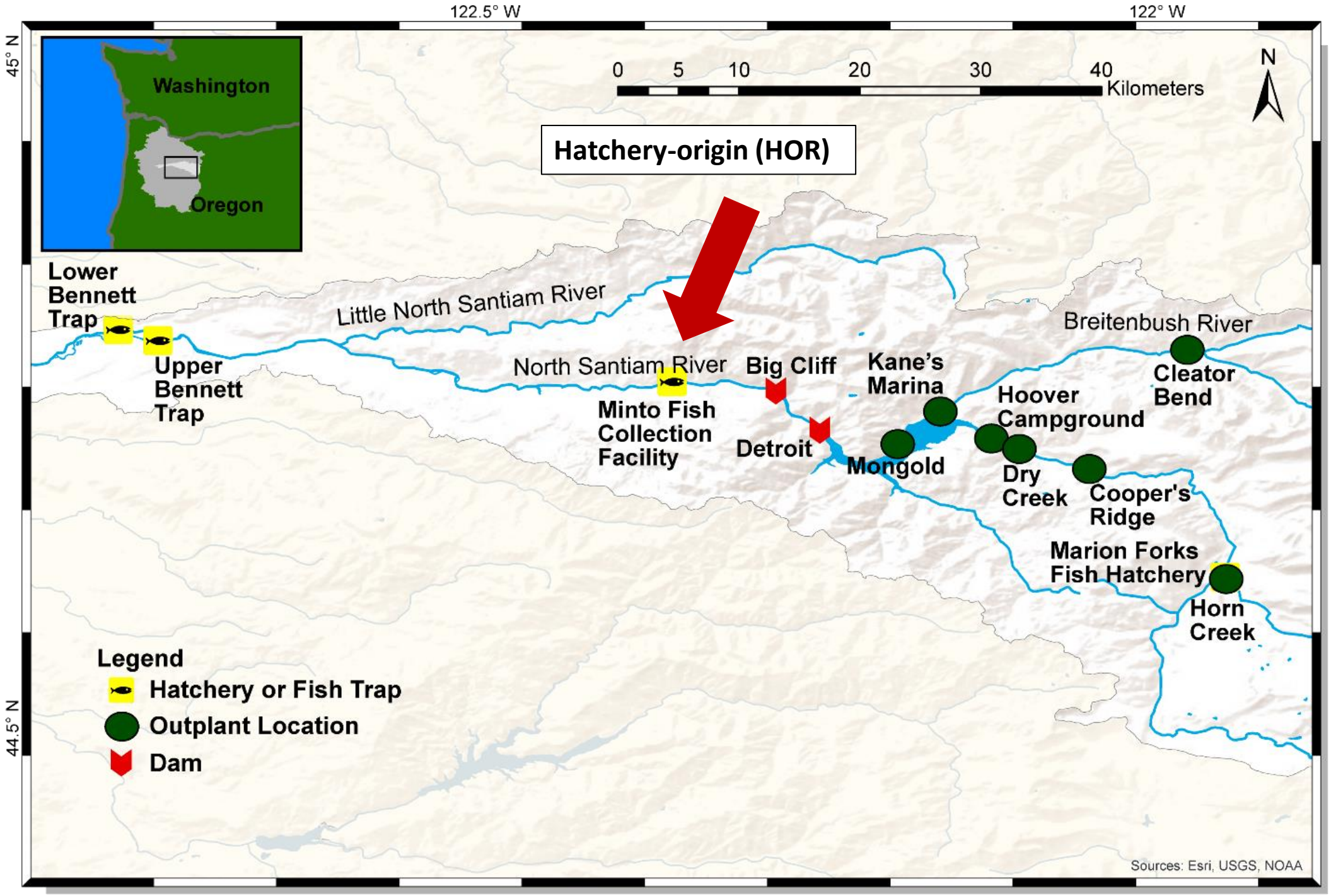
North Santiam River
Minto Fish Collection Facility
Big Cliff
Detroit
Kane's Marina
Mongold
Hoover Campground
Dry Creek
Cooper's Ridge
Breitenbush River
Cleator Bend
Marion Forks Fish Hatchery
Horn Creek
Legend
Hatchery or Fish Trap
Outplant Location
Dam
Sources: Esri, USGS, NOAA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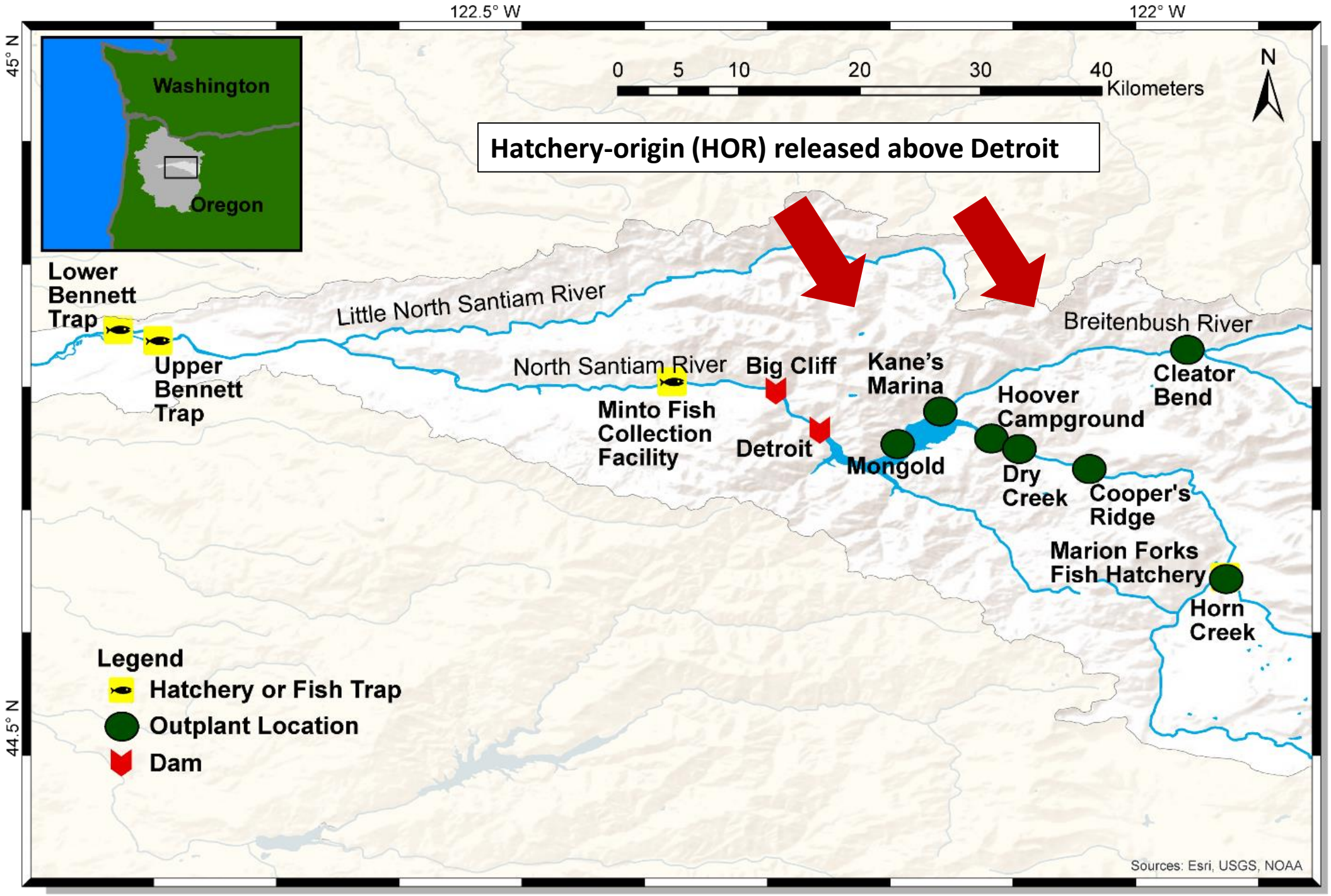
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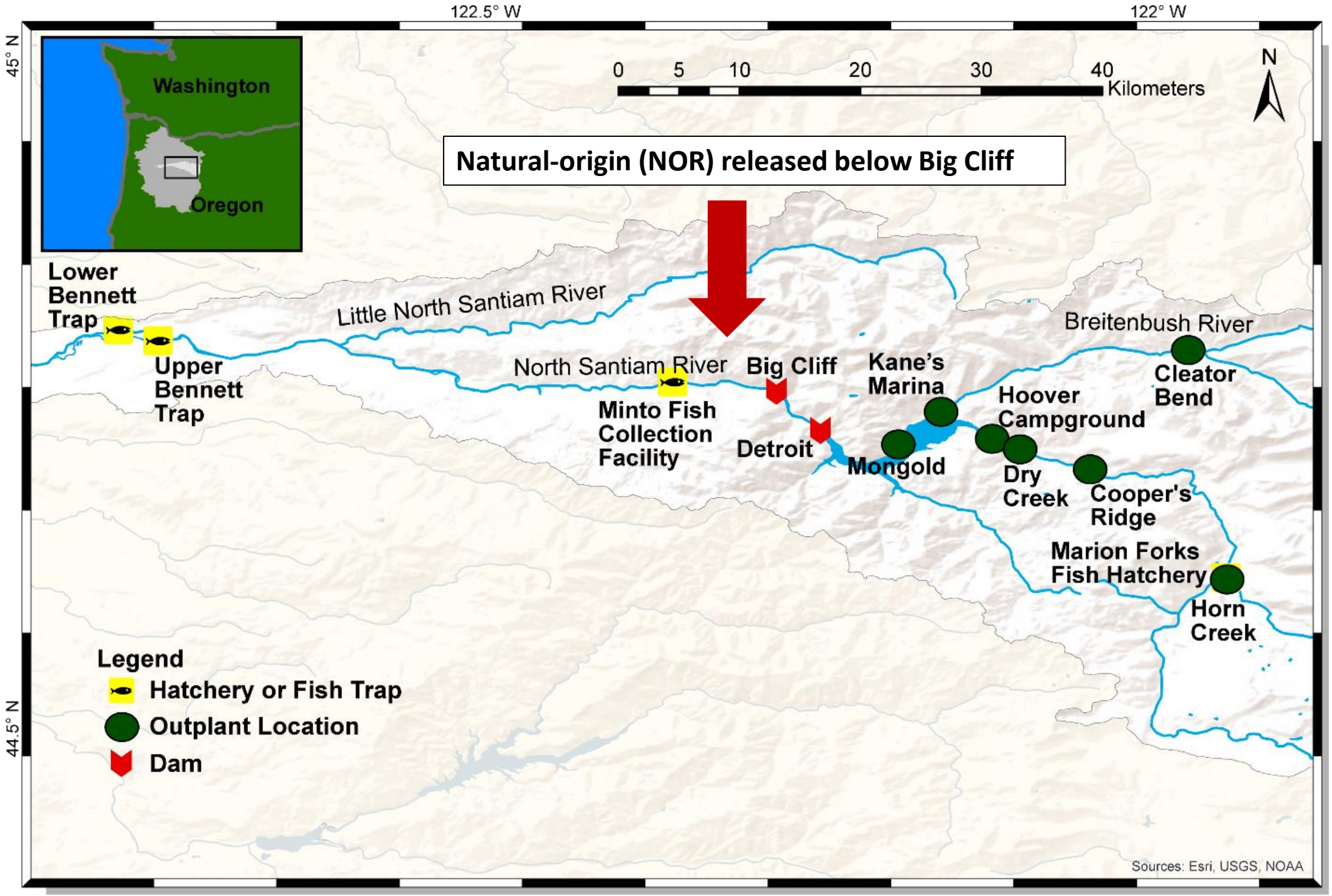
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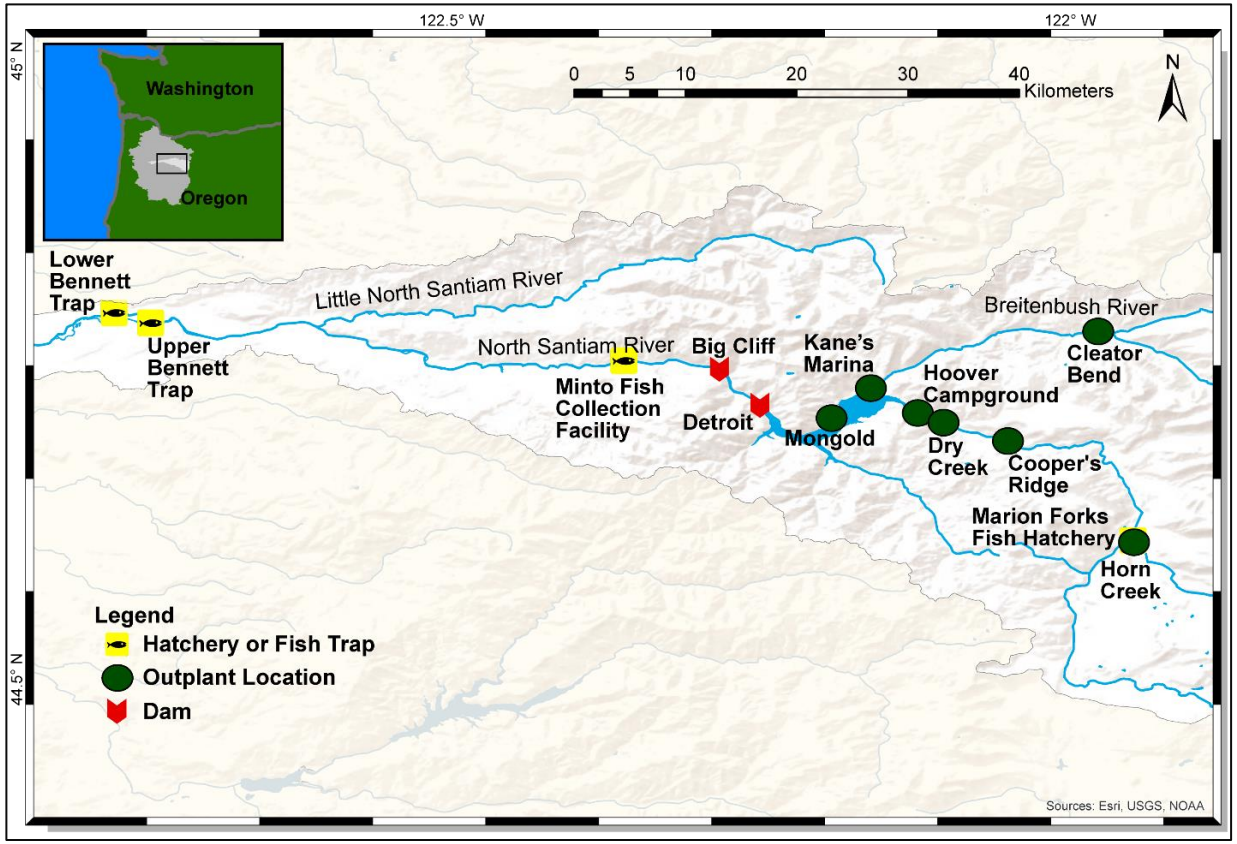
# Evaluate contribution of the outplanting program to adult salmon recruitment

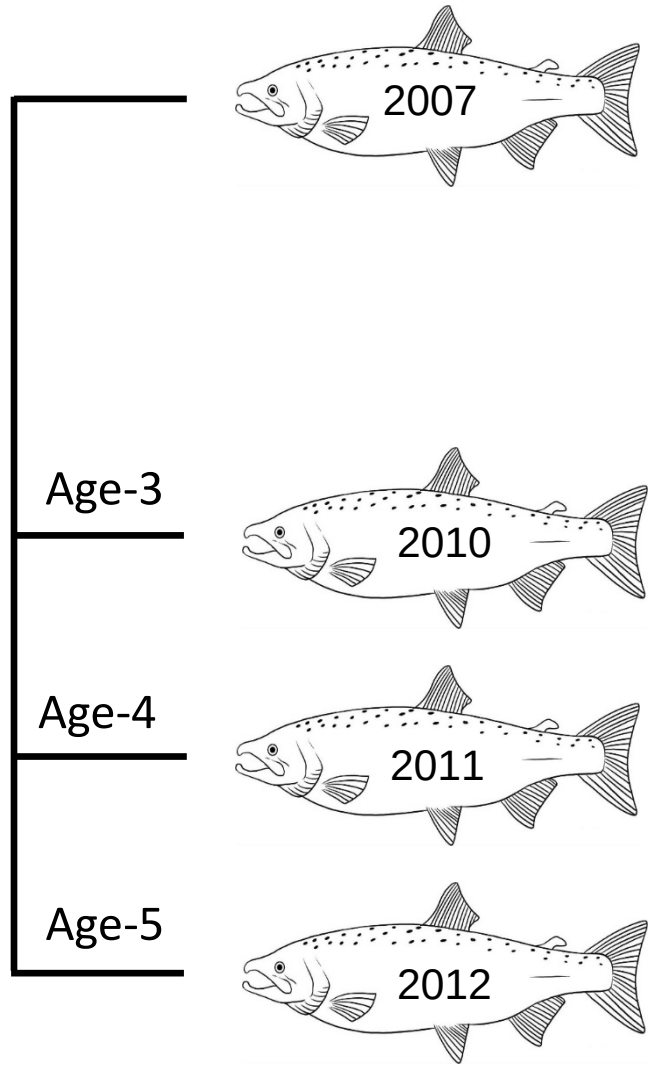
Tissue samples have been collected from:

- Primarily HOR salmon released above Detroit Dam since 2007
- NOR carcasses below Big Cliff Dam since 2011
- NOR salmon at the new Minto Fish Collection Facility (MFCF) since 2013



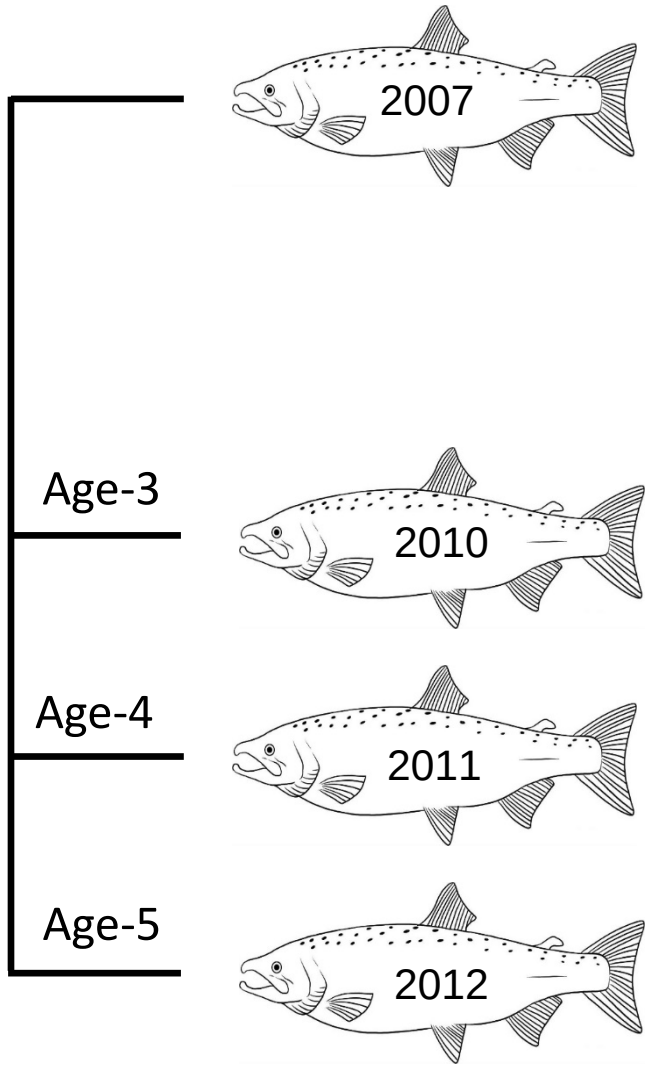

- MFCF under construction 2011-2012; salmon collected at Upper Bennett

# Identify parent-offspring relationships



# Identify parent-offspring relationships

- O'Malley et al. (2015) assigned 2010 – 2014 adult returns to salmon released in 2007 – 2011
- O'Malley et al. (2017) assigned 2015 adult returns to salmon released in 2010 – 2012
- Incomplete sampling limited our evaluation of the outplanting program above Detroit Dam in 2007 – 2010



# Extend to evaluate 2011 – 2015 parental cohorts

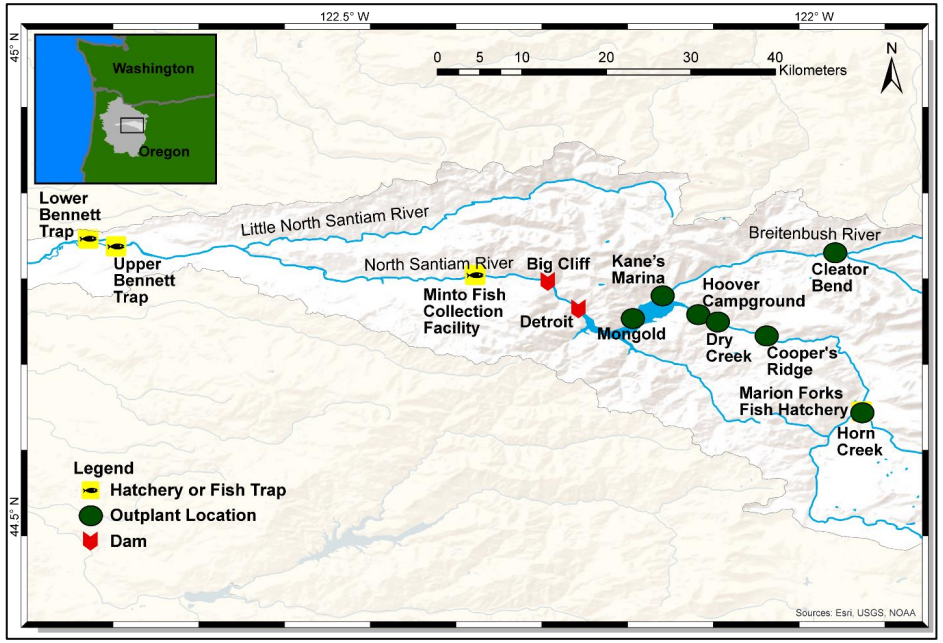
- Assign the 2016 – 2020 NOR adult returns to salmon released
    - Above Detroit Dam or
    - Below Big Cliff Dam in 2011 – 2017

Genetic dataset = 12,357 salmon

O'Malley *et al.* (2023)

# Extend to evaluate 2011 – 2015 parental cohorts

- Assign the 2016 – 2020 NOR adult returns to salmon released
  - Above Detroit Dam or
  - Below Big Cliff Dam in 2011 – 2017
- In 2015, ~500 NOR salmon released above Detroit
  - Special measure given extremely low, warm water year




O'Malley *et al.* (2023)

# Objectives and Results

I. Assignment rates of NOR adult returns
(Objectives 1 – 2)

II. Productivity of primarily HOR salmon released above Detroit Dam
(Objectives 3 – 5)

III. Productivity of NOR salmon released below Big Cliff Dam
(Objectives 6 – 7)

# Assignments of NOR adult salmon returns

1. Determine the number of NOR adult salmon (2016 – 2020) that assign as offspring of salmon released above Detroit Dam or below Big Cliff Dam (2011 – 2017)

2. Estimate the age structure of returning adult salmon (2016 – 2020)

# Objective 1 Results:
# NOR adult returns assigned to previously released salmon

| Return year | # Adult returns | # Assigned |
|---|---|---|
| 2016 | 539 | |
| 2017 | 519 | |
| 2018 | 251 | |
| 2019 | 819 | |
| 2020 | 1593 | |

# Objective 1 Results:
# NOR adult returns assigned to previously released salmon

| Return year | # Adult returns | # Assigned |
|---|---|---|
| 2016 | 539 | 191 (35%) |
| 2017 | 519 | 343 (66%) |
| 2018 | 251 | 180 (72%) |
| 2019 | 819 | 665 (81%) |
| 2020 | 1593 | 1449 (91%) |

Assignment rate increased from 35% (2016) to 91% (2020)

# Objective 1 Results:
# NOR adult returns assigned to previously released salmon

All parents (2013 – 2015) handled at the new MFCF

| Return year | # Adult returns | # Assigned |
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| 2016 | 539 | 191 (35%) |
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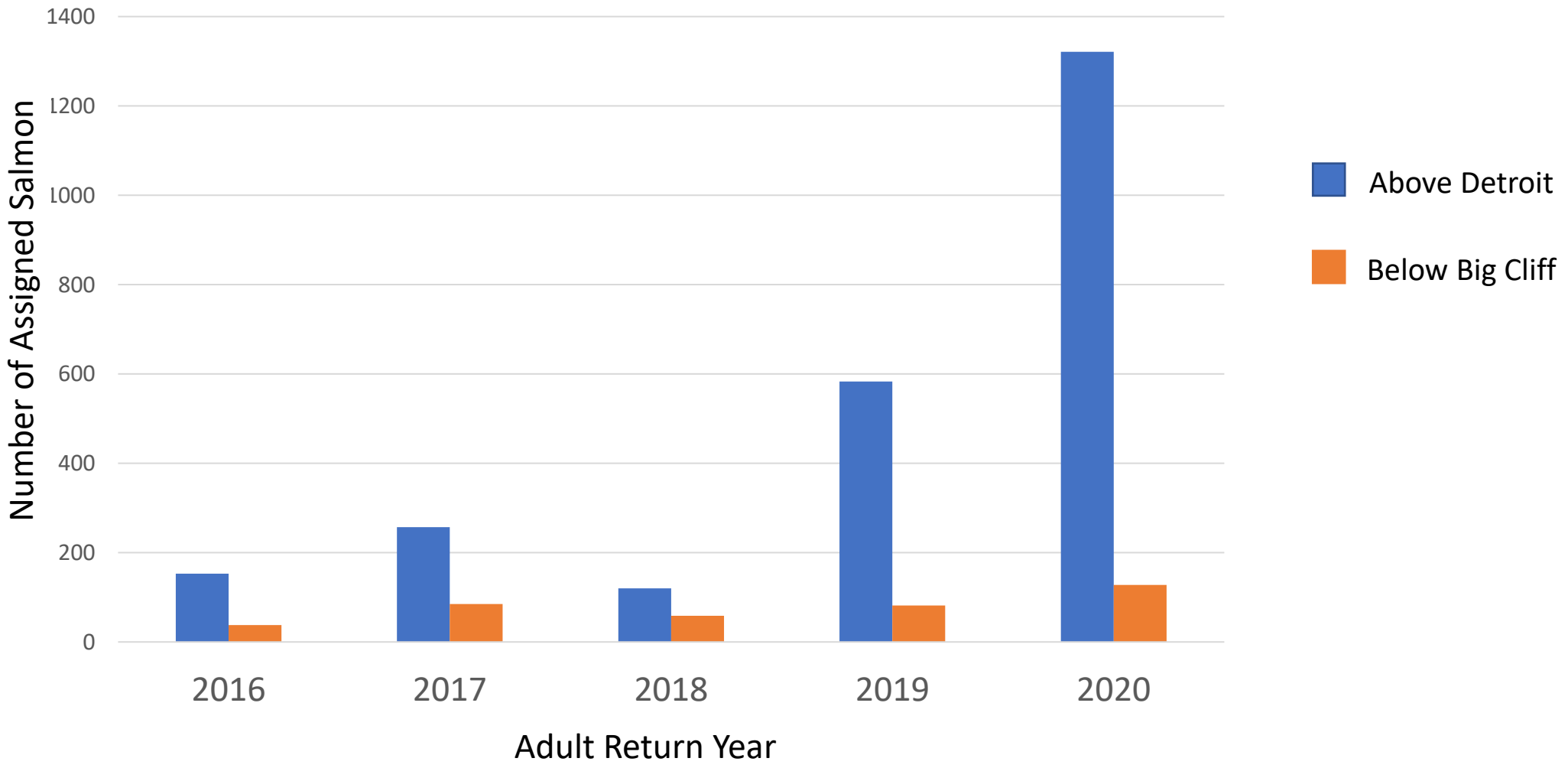
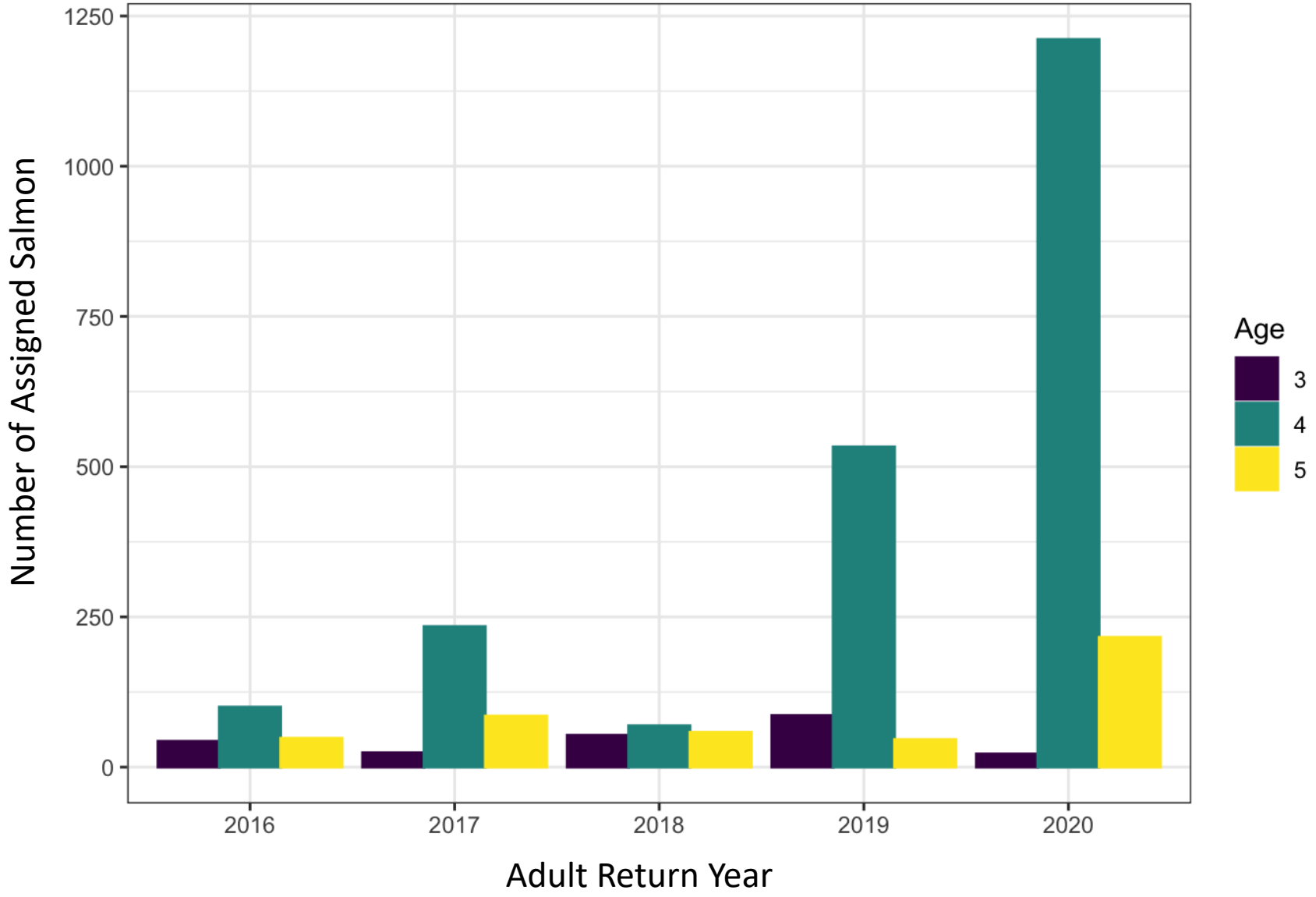
# Objective 1 Results:
# Assignments to salmon above Detroit or below Big Cliff



# Objective 2 Results:
# Age structure of NOR adult salmon returns

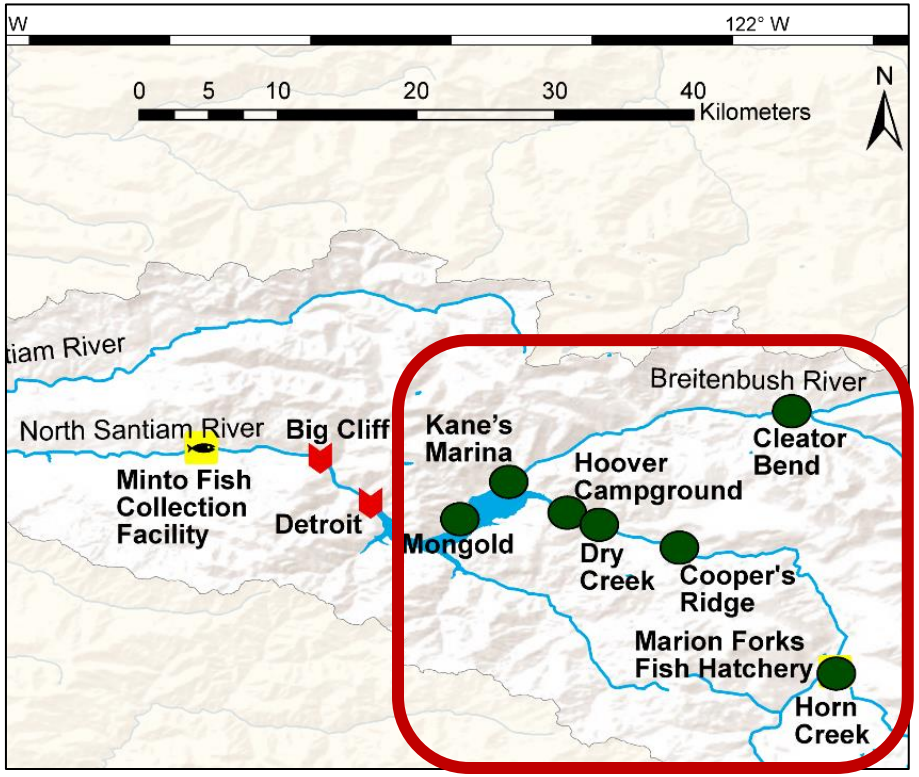


# Productivity of primarily HOR salmon released above Detroit Dam in 2011 – 2015

3. Estimate the Total Lifetime Fitness (TLF)

4. Evaluate potential predictors of TLF

5. Estimate Cohort Replacement Rate (CRR)



# Objective 3 Results:
# Total Lifetime Fitness (TLF) of salmon released above Detroit Dam

TLF = age-3, age-4, age-5 adult offspring

| Release year | Origin | Produced ≥1 Adult Offspring | Sex ratio (M:F) |
|---|---|---|---|
| 2011 | HOR | 34% | 1.07 : 1.00 |
| 2012 | HOR | 40% | 1.00 : 1.30 |
| 2013 | HOR | 22% | 1.35 : 1.00 |
| 2014 | HOR | 12% | 1.95 : 1.00 |
| 2015 | HOR and NOR | 32% | 1.22 : 1.00 |

# Objective 3 Results:
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- Productivity decreased as male-biased sex ratios increased

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- Mean female TLF > male TLF
  - Except 2012; sex ratio female-biased

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- In 2015, mean TLF of NOR > HOR

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# Objective 4 Results:
# Predictors of TLF of salmon released above Detroit Dam

**Generalized Linear Mixed Model**
**5 release years (2011 – 2015)**

**Response Variable**
Total Lifetime Fitness (TLF):

n = 3,847 individuals

**Fixed Effects**

- Sex
- Release day
- Release location
- Release group density
- Release group sex ratio
- Total # of fish released annually
- Annual sex ratio
- Sex*release group density
- Sex*release group sex ratio
- Sex*annual sex ratio

**Random Effects**

- Year
- Release group

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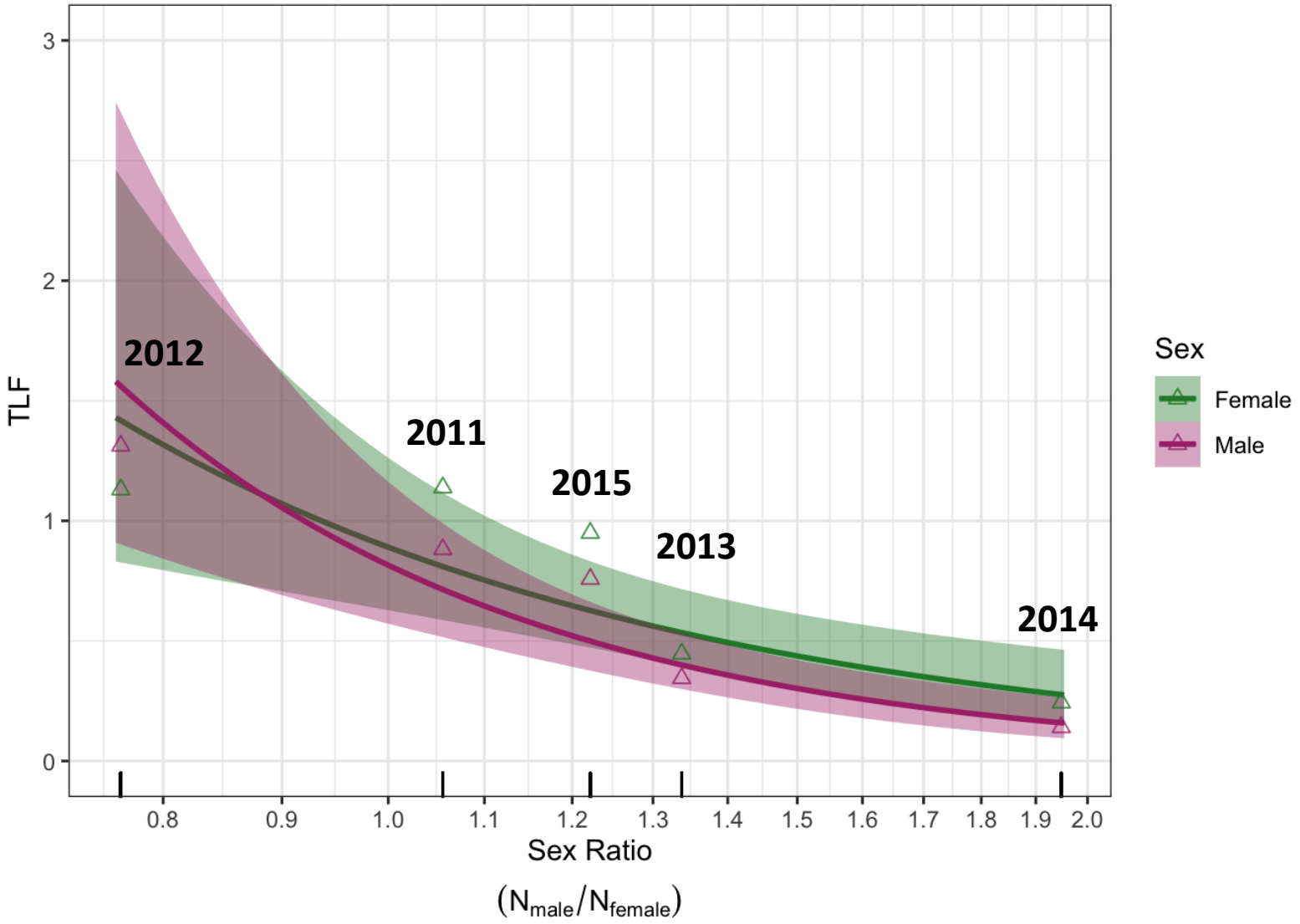
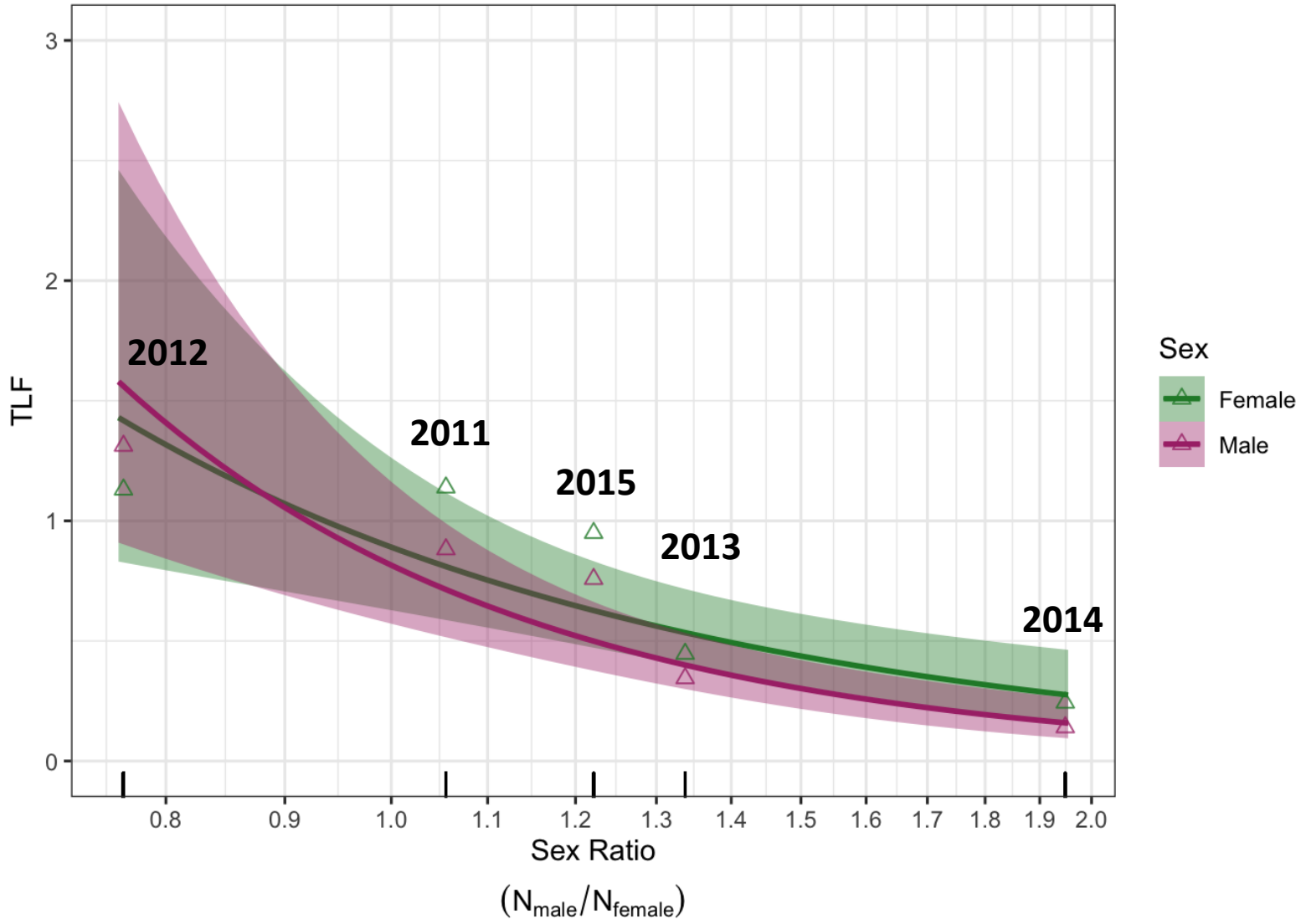


# Objective 4 Results:
# Predictors of TLF of salmon released above Detroit Dam

- TLF differences between sexes, males have lower fitness
- Sex ratio more male-biased, TLF decreases
- Effect of sex ratio dependent on sex



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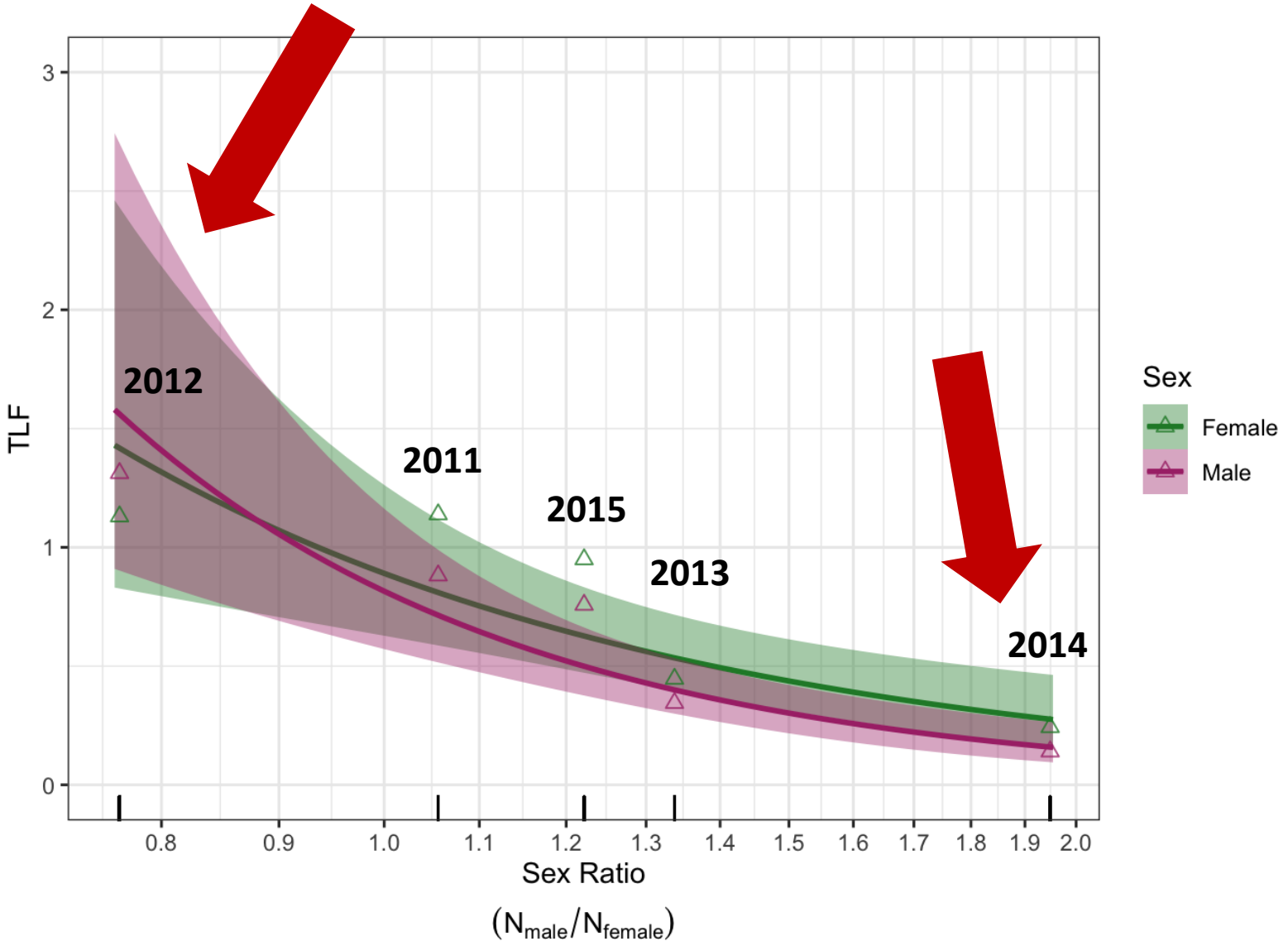
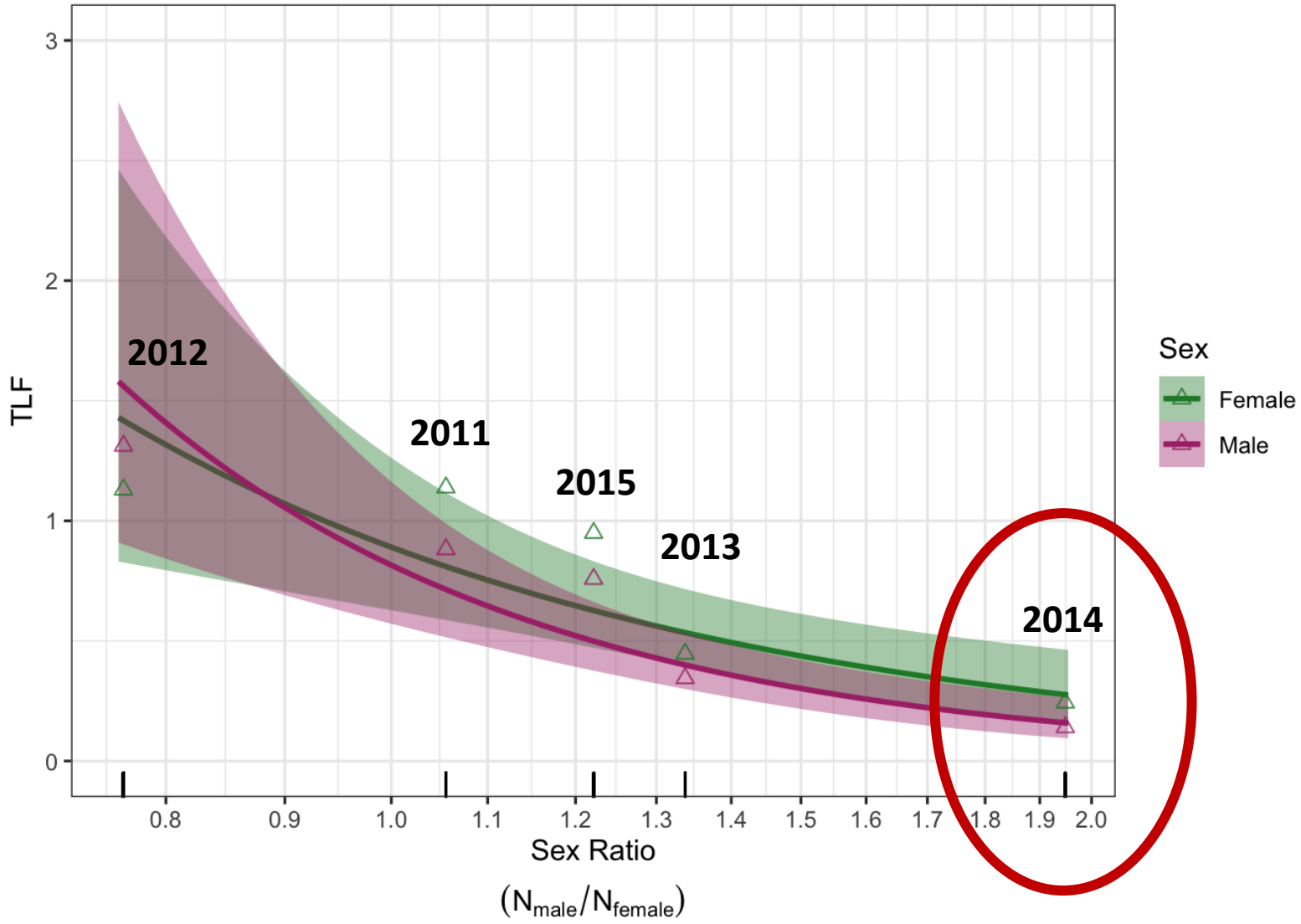


# Objective 4 Results:
# Predictors of TLF of salmon released above Detroit Dam

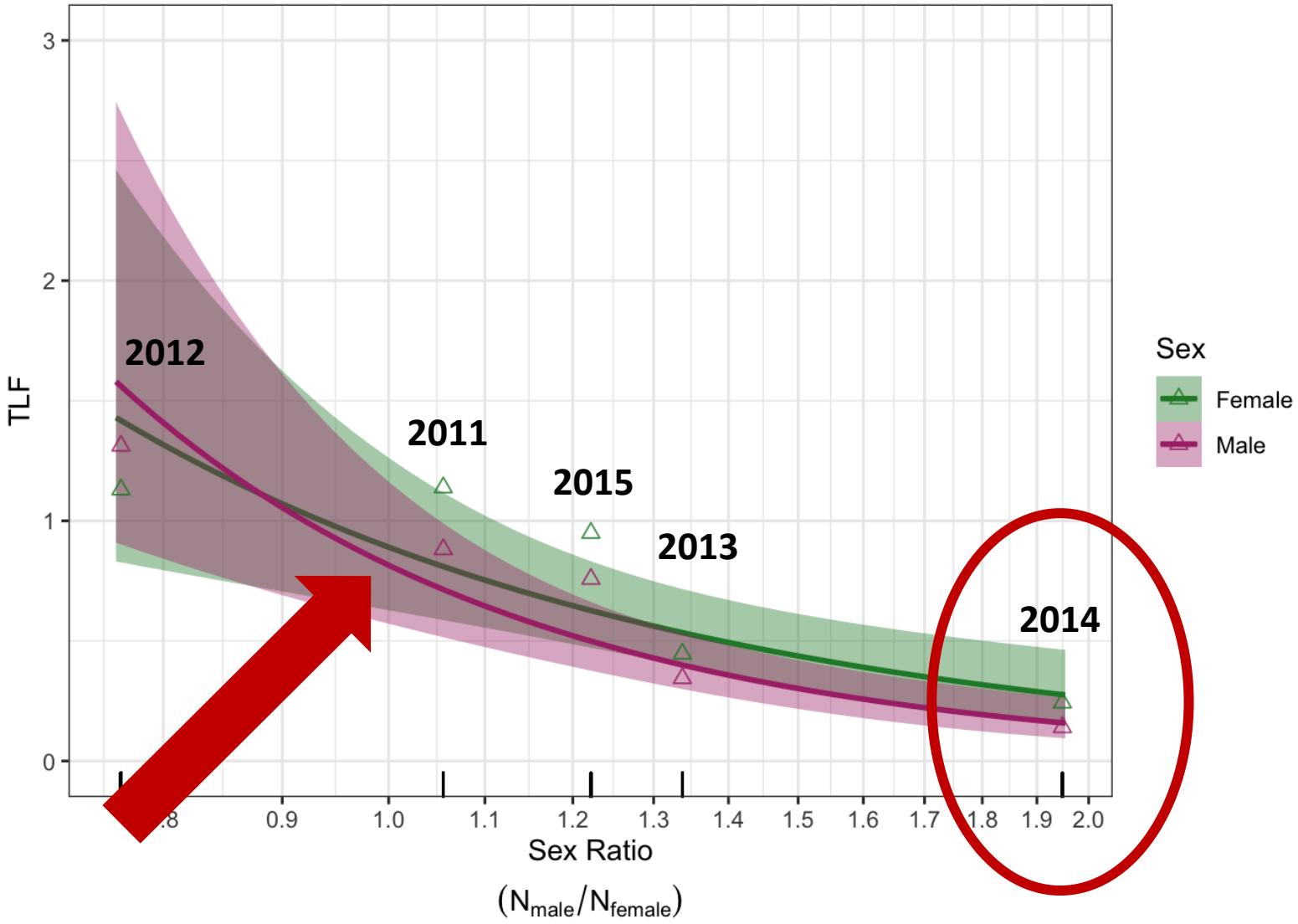
- In 2014, ~2x more males than females



# Objective 4 Results:
# Predictors of TLF of salmon released above Detroit Dam

- ~2x more males than females in 2014

- Balanced sex ratio predicted to increase female TLF 3.2-fold and male TLF 5.1-fold



# Objective 5:
# Cohort Replacement Rate (CRR) of salmon released above Detroit Dam

CRR = number of future spawners produced by a spawner[1]

$$\text{CRR 2011} = \frac{\text{Total \# of adult offspring (2014 – 2016) assigned to salmon released in 2011}}{\text{Total \# of salmon released in 2011}}$$

CRR ≥ 1 indicates replacement has been met

[1]Botsford and Brittnacher (1998)

# Objective 5 Results:
# CRR of salmon released above Detroit Dam

| Release year | N | Sex ratio (M:F) | CRR |
|---|---|---|---|
| 2011 | 149 | 1.07 : 1.00 | 0.63 |
| 2012 | 258 | 1.00 : 1.30 | 0.67 |
| 2013 | 1125 | 1.35 : 1.00 | 0.22 |
| 2014 | 861 | 1.95 : 1.00 | 0.10 |
| 2015 | 1473 | 1.22 : 1.00 | 0.49 |

# Objective 5 Results:
# CRR of salmon released above Detroit Dam

| Release year | N | Sex ratio (M:F) | CRR |
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| 2011 | 149 | 1.07 : 1.00 | 0.63 |
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- CRR never approaches replacement

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# CRR of salmon released above Detroit Dam

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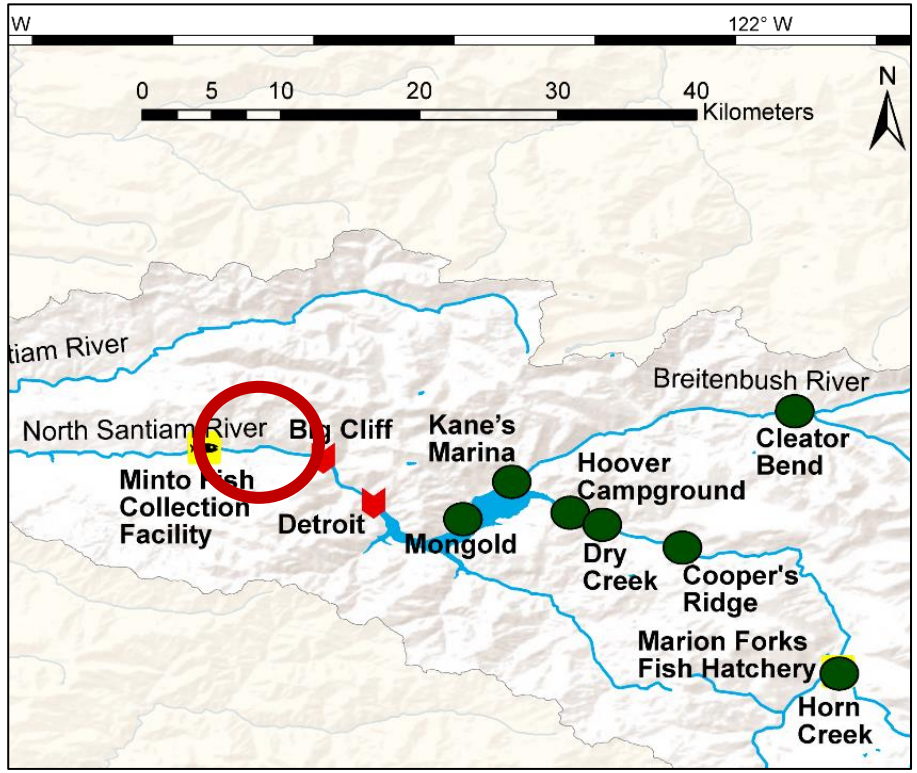
- CRR never approaches replacement
- Effect of sex ratio is apparent with lowest CRRs in 2013 and 2014

# Productivity of NOR salmon released below Big Cliff Dam in 2013 – 2015

6. Estimate the Total Lifetime Fitness (TLF)

7. Estimate Cohort Replacement Rate (CRR)



# Objective 6 Results:
# Total Lifetime Fitness (TLF) of NOR salmon released below Big Cliff

| Release year | Produced ≥1 Adult Offspring | N | Sex ratio (M:F) |
|---|---|---|---|
| 2013 | 18% | 554 | 2.36 : 1.00 |
| 2014 | 8% | 754 | 1.56 : 1.00 |
| 2015 | 33% | 148 | 1.11 : 1.00 |

Low, warm water year

# Objective 6 Results:
# Total Lifetime Fitness (TLF) of NOR salmon released below Big Cliff

| Release year | Produced ≥1 Adult Offspring | N | Sex ratio (M:F) |
|---|---|---|---|
| 2013 | 18% | 554 | 2.36 : 1.00 |
| 2014 | 8% | 754 | 1.56 : 1.00 |
| 2015 | 33% | 148 | 1.11 : 1.00 |

- Only 148 salmon released
- Sex ratio close to 1
- 33% of released salmon produced adult offspring
- Mean TLF (males and females) greatest

# Objective 7 Results:
# Cohort Replacement Rate (CRR) of salmon released below Big Cliff

| Release year | N | Sex ratio (M:F) | CRR |
|---|---|---|---|
| 2013 | 554 | 2.36 : 1.00 | 0.12 |
| 2014 | 754 | 1.56 : 1.00 | 0.05 |
| 2015 | 148 | 1.11 : 1.00 | 0.44 |

# Summary

## I. NOR Adult Returns

- Assignment rates increased from 35% (2016) to 91% (2020)

## II. Productivity above Detroit Dam

- Across the five release years, ~30% of salmon, on average, produced ≥1 adult offspring

- Mean TLF was higher for females than males, except in 2012 when sex ratio was female-biased

# Summary Cont'd

## II. Productivity above Detroit Dam

- Only significant predictors of TLF were sex, annual sex ratio, and their interaction
- Modeling result suggests that fitness could be substantially improved if male-biased sex ratios were avoided
- CRR was highest in 2012 (0.67) when sex ratio was female-biased and lowest in 2014 (0.10) when sex ratio was male-biased
- Only one year of female-biased sex ratio (2012); conservative approach and recommend balancing sex ratio

# Summary Cont’d

## III. Productivity below Big Cliff Dam

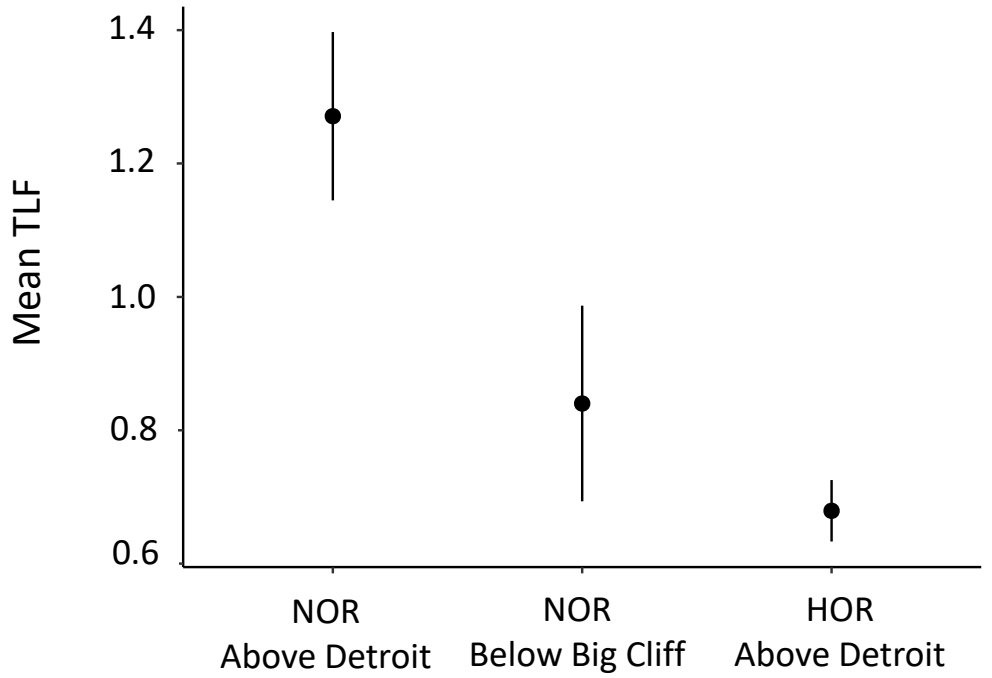
- ~20% of salmon, on average, produced ≥1 adult offspring
- Strongly male-biased sex ratios impact TLF in similar direction and magnitude as for salmon released above Detroit Dam
- CRR highest in 2015 (0.44) during the low, warm water year when only 148 salmon were released and sex ratio was close to one
- Recommend balancing sex ratios and further evaluating release number

# Additional Key Findings: NOR *vs.* HOR

- Releasing ~500 NOR salmon above Detroit Dam in 2015 increased productivity in the system for that year

- Mean TLF of NOR salmon above Detroit 1.51-fold > TLF of NOR below Big Cliff and 1.87-fold > TLF of HOR above Detroit

- Only one year of data (2015) available to compare NOR above and below dam to HOR above dam



# Additional Key Findings:
# 2016 Release

- An exceptionally large number of salmon (n = 1,174) returning in 2019 and 2020 assigned to 2016 parents
    - Preliminary fitness estimates are high

# Proposed Next Steps

- Estimate TLF and CRR of salmon above Detroit and below Big Cliff in 2016 and 2017
    - Assign 2021 (age-4, age-5) and 2022 (age-5) adult returns

**Above Detroit**

- Did TLF and CRR *increase*?
    - Evaluate impact of female-biased sex ratios in both years

**Below Big Cliff**

- Did TLF and CRR *decrease*?
    - Evaluate impact of male-biased sex ratios and large releases

# Acknowledgments


- Funding: U.S. Army Corps of Engineers
- Sample collection: ODFW