SALISH SEA
MARINE SURVIVAL PROJECT
An update on Puget Sound steelhead research
Up to 10x Decline in Salish Sea Marine Survival

Puget Sound
Strait of Georgia
VS
Washington / B.C. Coast
Why are juvenile Chinook, coho & steelhead dying in the Salish Sea marine environment?
Hypotheses

A. Processes that drive prey availability have changed, and salmon aren't able to compensate.

B. More predators are making situation worse, eating juvenile steelhead, salmon and forage fish.

C. Multiple factors may compound the problem:
   - Disease
   - Contaminants
   - Hatchery management
   - Habitat loss
   - Cumulative effects

Ultimately, must weigh the contribution of:
- Local, human influence (water quality, predation management, hatchery management)
- Regional or global impacts (climate change, ocean acidification, natural cycles)
Research Across the Salish Sea

Over 80 Studies!
Puget Sound Steelhead

- Initiated in 2014
- 16 entities collaborating
- ~$1.6 M appropriated by Washington State
- $790k pending, State supplemental budget
- Substantial match from collaborators
- 15 studies to date
- Significant progress
Steelhead: where are we now?

**Predation IS proximate/direct cause of mortality**

Steelhead dying at high rate in PS

**Predation IS NOT proximate/direct cause of mortality**

**Ultimate or Contributing Cause**

Poor fish condition and/or altered behavior
freshwater (F) or marine (M) derived

1. Disease (F/M) – Central & South P. Sound
2. Outmigrant timing (F)
3. Poor water quality/toxics (F/M) – Nisqually
4. Genetic fitness (F)
5. Foraging/Starvation (M) [foraging induced predation maybe. Starvation not likely]
6. Outmigrant size/growth (F/M) [not likely]
7. HABs (M) [not likely]
8. Habitat modifications (M) [not likely unless associated w/ buffer prey]
Tracking Nisqually juvenile wild steelhead
Over 85% die in Puget Sound, before reaching the ocean.
Steelhead **PCB levels** generally low: 1.4 – 2.2x **lower** than Chinook at same locations.

16.7% Central and 25% South Puget Sound samples exceeded PCB adverse effects threshold.

Steelhead **PBDE levels** high in Nisqually, and **1.1 to 3 times higher** than Chinook at same locations.

+ 25% Central and South Puget Sound, and **33% Nisqually River samples** = increased disease susceptibility

▲ **33% Nisqually estuary samples** = altered thyroid production

O’Neil et al (WDFW)
Flame retardants high in Nisqually

Concentration of flame retardant in steelhead (ng/g lipid)

- Altered thyroid production
- More susceptible to disease

Skagit / Whidbey Basin
Green / Central Puget Sound
Nisqually / South Sound

O’Neill – Washington Department of Fish and Wildlife
Fish Health - Disease

Nanophyetus (parasite)

Key:
- 0: medium, high, very high
- Parasite load
- Infection prevalence

Findings:
- No Nanophyetus in Skagit, Snohomish, Tahuya, Whidbey Basin
- Prevalence and parasite loads increase from trap to estuary in Green.
- Prevalence and parasite loads in Nisqually extremely high.

Chen (NWIFC) and Hershberger (USGS)
Disease in Nisqually and Green

Number of *Nanophyetus s.* parasites in each steelhead kidney

- Reduced swim performance
- Increase in direct mortality

*Chen, O’Neill & Hershberger – NWIFC, WDFW, USGS, WDFW*
Formalin treatment for Nanophyetus parasite

Hershberger et al unpublished 2016
Open Water: Passage through Puget Sound

<table>
<thead>
<tr>
<th>Metacercaria / post. kidney</th>
<th>2016 Released Fish</th>
<th>2014 Nisqually River</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>232 (n=81)</td>
<td>2,546 (n=30)</td>
</tr>
<tr>
<td>Range</td>
<td>30 - 865</td>
<td>10 - 9,844</td>
</tr>
</tbody>
</table>

Hershberger - USGS
Genome-wide Association Study

- Omy05 genotypes may reduce probability of survival or result in a higher *Nanophysetus* count. Greater signal in Green vs Nisqually River.
- Omy05 may be associated with residency vs anadromy.
- Other loci appear associated with Nano counts and survival, but they are difficult to discern.
Steelhead and Seals

Inland Washington stock

Count

0 1600 1200 800 400
2014 -2016 Nisqually steelhead survival estimates

Moore, Berejikian – NOAA
2014 Results

- Stationary steelhead tags repeatedly detected by harbor seals at haulouts
- Tag detection patterns consistent with harbor seal movements
- Higher proportions of stationary tags and total seal-detected tags in Central Puget Sound where mortality was greatest
2016 Results

- No stationary steelhead tags detected by harbor seals at haulouts
- Tag detection patterns consistent with harbor seal movements in the Nisqually Estuary have increased
2016 Seal Scat Analysis Results

Freq. of Occurrence vs. DNA: May & June

- FO May+June (n = 163)
- DNA May+June (n = 149)

- All Skates*
- All Other*
- All Rockfishes*
- Steelhead
- Cutthroat trout
- Coho salmon
- Chum salmon
- Chinook salmon
- Adult Salmon and Trout
- Juvenile salmonid
- All Salmon & Trout*
- All Cephalopods*
- All Flatfishes*
- All Cottids*
- All Surfperches*
- All Clupeids*
- All Gadids*

Percent

Thomas, Pearson, Jeffries – Smith Root, WDFW
1997 vs 2016 Seal Scat Analysis

Spring 1997 vs. Spring 2016

- *All Surperch*
- Juvenile salmonid
- Adult salmonid
- *All Salmonids*
- *All other*
- *All Gadids*
- *All Flatfish*
- *All Cottids*
- Northern anchovy
- Herring species
- *All Clupeids*
- *All Cephalopods*

Percent

2016 (n = 239)
1997 (n = 123)

Pearson, Jeffries – WDFW
Are Anchovies Buffering Predation?

Marine survival rate of steelhead through Puget Sound relative to years of low ☺ vs. high ☺ anchovy abundance

Moore, Duguid – NOAA, U. of Victoria
Do Pulses of Hatchery Fish Attract or Buffer?

Change in distribution of Chinook hatchery releases by year

High steelhead marine survival

Low steelhead marine survival

Julian Day

factor (Year)

Sobocinski, Kendall, Marston - NOAA, WDFW

Release Abundance (millions)  4  8  12  16
Ecosystem Indicators Analysis

Hatchery release abundance and timing and harbor seal abundance had the strongest explanatory power.
**Fish Condition**

1. Nanophyetus parasite at very high loads for Green and Nisqually River steelhead
2. Flame retardants high loads in Nisqually River
3. Omy05 (residency gene?) and other loci may be contributing

**Predation**

1. Seals are eating steelhead
2. Lower mortality in years with increased buffer prey (e.g. anchovies)
3. Questions regarding potential influence of Chinook/coho hatchery releases on predator behavior
Next Steps

Obtain final funds from the Washington State legislature.
Supplemental budget appropriation ($793k to WDFW)

Complete the final research

- Isolate source of flame retardants in Nisqually River.
- Confirm severity of nanophyetus and identify "hot spots" of parasite and host snail in rivers.
- Continue to assess seal and steelhead interactions.
- Assess potential influence of hatchery Chinook releases.

Incorporate results into Steelhead Recovery Plan and other management plans. Begin testing solutions.
Example Actions*

*Dependent on study results

- Eliminate Nano parasite in hatcheries and manage host snail in rivers
- Remove sources of flame retardants
- Alter hatchery releases to discourage predation
- Address infrastructure that exacerbates predation (false haul-outs, locks, bridge, net pens, lighting)
- Address conflicts between marine mammal protection act and ESA
- Support forage fish recovery
Summary
Primary tributaries to the Sammamish River where steelhead might spawn include Swamp, North, Little Bear, Big Bear, Cottage Lake, and Issaquah Creeks. Available data suggests that steelhead generally do not spawn or rear in these streams. Very small numbers of adult steelhead (less than 5) may stray into these streams and spawn successfully in some years, but the Sammamish River tributaries do not currently support a viable steelhead population. Surveys are not conducted for adult steelhead spawners, but surveys for juvenile steelhead indicate that small numbers of juveniles are present in some streams in some years.

Adult Spawning Data
Adult spawning surveys for steelhead are not conducted in tributaries to the Sammamish River. Adult steelhead may stray into various Sammamish River tributaries in some years, but adults are not thought to spawn in these streams in large numbers. Sexually mature adfluvial rainbow trout from Lake Washington are known to migrate up the Sammamish River in the winter/spring. These adfluvial rainbows presumably spawn in Sammamish River tributaries and may produce juvenile rainbow trout.

Juvenile Use Data
There are two types of monitoring efforts that would detect juvenile steelhead in the Sammamish River tributaries: 1) Smolt trap data from the Big Bear Creek smolt trap, and 2) Electro-fishing data from King County monitoring efforts.

1) Smolt trap data from the Big Bear Creek smolt trap
A smolt trap located near the mouth of Big Bear Creek is operated from mid-January through mid-June each year by WDFW. The primary goal of the trap is to estimate annual Chinook production, but all species are caught and enumerated. Steelhead smolts are not encountered at the trap in most years. In years when smolts are encountered, the number of individuals encountered is very small (Table 1).

Table 1. Smolt Trap Data from Big Bear Creek. Steelhead smolts encountered at the Big Bear Creek smolt trap from 2006 to 2016.

<table>
<thead>
<tr>
<th>Smolt Trap Year, or Year of Out-Migration</th>
<th>Steelhead Smolts Sampled</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>1</td>
<td>no length</td>
</tr>
<tr>
<td>2008</td>
<td>1</td>
<td>no length</td>
</tr>
<tr>
<td>2009</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td>2</td>
<td>192mm and 258mm in length</td>
</tr>
</tbody>
</table>
2) Electro-fishing data from King County small streams monitoring

King County conducted annual electrofishing surveys for 5 consecutive years (2009-2013) at a number of different sites in the Issaquah Creek basin and in tributaries to the Sammamish River (Figure 1). Fifteen sites in the Sammamish River tributaries were monitored (Table 2) and thirteen sites in the Issaquah Creek basin were monitored (Table 3). Few rainbow trout were observed in any of these surveys. In the 15 sites located in the Sammamish River tributaries, 1,390 juvenile coho and 6,643 cutthroat trout were captured during the 5-year sampling period while only 9 rainbow trout (1 in North Creek and 8 in Bear Creek) were observed (Table 2). In the 13 sites located in the Issaquah Creek basin, 2,736 juvenile coho and 4,281 cutthroat trout were captured during the 5-year sampling period while only 3 rainbow trout were observed (Table 3).

Table 2. Salmonid species sampled during annual electro-fishing surveys conducted annually from 2009-2013 (5 sampling years) in Sammamish River tributaries.

<table>
<thead>
<tr>
<th>Basin</th>
<th>Creek</th>
<th>Site #</th>
<th>Coho</th>
<th>Cutthroat</th>
<th>Rainbow</th>
<th>Unid trout</th>
</tr>
</thead>
<tbody>
<tr>
<td>Big Bear</td>
<td>Bear Creek</td>
<td>1</td>
<td>7</td>
<td>63</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Bear Creek</td>
<td>2</td>
<td>123</td>
<td>127</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Bear Creek</td>
<td>3</td>
<td>19</td>
<td>61</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Bear Creek</td>
<td>4</td>
<td>17</td>
<td>116</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Evans Creek</td>
<td>1</td>
<td>4</td>
<td>333</td>
<td>0</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Cottage Lake Creek</td>
<td>1</td>
<td>53</td>
<td>224</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Mackey Creek</td>
<td>1</td>
<td>0</td>
<td>616</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>Little Bear</td>
<td>Little Bear Creek</td>
<td>1</td>
<td>18</td>
<td>431</td>
<td>0</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Little Bear Creek</td>
<td>2</td>
<td>40</td>
<td>589</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>North</td>
<td>North Creek</td>
<td>1</td>
<td>373</td>
<td>537</td>
<td>0</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>North Creek</td>
<td>2</td>
<td>1</td>
<td>143</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>North Creek</td>
<td>3</td>
<td>510</td>
<td>670</td>
<td>0</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>Sitka Creek</td>
<td>1</td>
<td>55</td>
<td>564</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>Swamp</td>
<td>Scribe Lake Creek</td>
<td>1</td>
<td>120</td>
<td>617</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Swamp Creek</td>
<td>1</td>
<td>50</td>
<td>1552</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Totals</td>
<td></td>
<td></td>
<td>1,390</td>
<td>6,643</td>
<td>9</td>
<td>160</td>
</tr>
</tbody>
</table>

Table 3. Salmonid species sampled during annual electro-fishing surveys conducted annually from 2009-2013 (5 sampling years) in the Issaquah Creek basin.

<table>
<thead>
<tr>
<th>Basin</th>
<th>Creek</th>
<th>Site #</th>
<th>Coho</th>
<th>Cutthroat</th>
<th>Rainbow</th>
<th>Unid trout</th>
</tr>
</thead>
<tbody>
<tr>
<td>Issaquah</td>
<td>Issaquah Creek</td>
<td>1</td>
<td>228</td>
<td>82</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Issaquah Creek</td>
<td>2</td>
<td>95</td>
<td>302</td>
<td>0</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Issaquah Creek</td>
<td>3</td>
<td>64</td>
<td>177</td>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Issaquah Creek</td>
<td>4</td>
<td>103</td>
<td>76</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Issaquah Creek</td>
<td>5</td>
<td>235</td>
<td>480</td>
<td>0</td>
<td>47</td>
</tr>
<tr>
<td></td>
<td>Issaquah Creek</td>
<td>6</td>
<td>57</td>
<td>26</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>East Fork Issaquah</td>
<td>1</td>
<td>283</td>
<td>564</td>
<td>0</td>
<td>126</td>
</tr>
<tr>
<td></td>
<td>East Fork Issaquah</td>
<td>2</td>
<td>962</td>
<td>645</td>
<td>0</td>
<td>109</td>
</tr>
<tr>
<td></td>
<td>East Fork Issaquah</td>
<td>3</td>
<td>491</td>
<td>459</td>
<td>0</td>
<td>127</td>
</tr>
<tr>
<td></td>
<td>East Fork Tributary</td>
<td>1</td>
<td>0</td>
<td>490</td>
<td>0</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>Holder Creek</td>
<td>1</td>
<td>0</td>
<td>137</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Carey Creek</td>
<td>1</td>
<td>127</td>
<td>309</td>
<td>0</td>
<td>108</td>
</tr>
<tr>
<td></td>
<td>Carey Creek</td>
<td>2</td>
<td>91</td>
<td>534</td>
<td>0</td>
<td>47</td>
</tr>
<tr>
<td>Totals</td>
<td></td>
<td></td>
<td>2,736</td>
<td>4,281</td>
<td>3</td>
<td>663</td>
</tr>
</tbody>
</table>
Water Resource Inventory Area (WRIA) 8 Sampling Sites

- WRIA 8 Sites
- WRIA Boundary
- County Boundary
- Major Highway
- Major Waterbody
- Incorporated Area

Figure 1. Map of King County electro-fishing sampling locations.
Northern Cascades MPG

Two Summer Populations at High Viability: No
Five Winter Populations at High Viability: No
Achieve Minimum Criteria of 2.2: No (1.83)
Table 1. Factors to consider in the designation of Northern Cascades populations as Primary, Contributing, or Stabilizing.
Draft: January 17, 2018

<table>
<thead>
<tr>
<th>Population or Watershed</th>
<th>Run Type</th>
<th>NOAA Intrinsic Potential (IP) (^{1/})</th>
<th>Average Spawners (2007-2016)</th>
<th>NOAA Viability Assessment P(Viable) (^{2/})</th>
<th>Past Segregated Hatchery Gene Flow (^{3/})</th>
<th>% Public Land</th>
<th>Hydrology (^{4/})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drayton Harbor</td>
<td>Winter</td>
<td>4,852</td>
<td>Not Available</td>
<td>Moderate</td>
<td>-</td>
<td>&lt; 1%</td>
<td>100% Lowland</td>
</tr>
<tr>
<td>Nooksack</td>
<td>Winter</td>
<td>44,091</td>
<td>1,680</td>
<td>Moderate</td>
<td>1% (W), 0% (S)</td>
<td>40%</td>
<td>31% Lowland, 22% Highland, 17% Snow</td>
</tr>
<tr>
<td>S.F. Nooksack</td>
<td>Summer</td>
<td>2,273</td>
<td>Not Available</td>
<td>Moderate</td>
<td>0% (W), 0% (S)</td>
<td>59%</td>
<td>41% Snow, 30% Highland, 23% Rain &amp; Snow</td>
</tr>
<tr>
<td>Samish/Bellingham</td>
<td>Winter</td>
<td>6,386</td>
<td>854</td>
<td>Moderate</td>
<td>5% (W), 0% (S)</td>
<td>19%</td>
<td>50% Lowland, 41% Rain</td>
</tr>
<tr>
<td>Skagit</td>
<td>Summer/Winter</td>
<td>129,551</td>
<td></td>
<td>Moderate</td>
<td>4% (W), 1% (S)</td>
<td>61%</td>
<td>47% Highland, 18% Snow, 13% Rain &amp; Snow</td>
</tr>
<tr>
<td>Nookachamps</td>
<td>Winter</td>
<td>2,462</td>
<td>6,163</td>
<td>Moderate</td>
<td>2% (W), 0% (S)</td>
<td>31%</td>
<td>45% Lowland, 40% Rain</td>
</tr>
<tr>
<td>Baker (^{5/})</td>
<td>Summer/Winter</td>
<td>10,056</td>
<td></td>
<td>Moderate</td>
<td>-</td>
<td>90%</td>
<td>46% Highland, 22% Snow, 19% Rain</td>
</tr>
<tr>
<td>Sauk</td>
<td>Summer/Winter</td>
<td>46,460</td>
<td></td>
<td>Low-Moderate</td>
<td>3% (W), 0% (S)</td>
<td>94%</td>
<td>54% Highland, 21% Snow</td>
</tr>
<tr>
<td>Stillaguamish</td>
<td>Winter</td>
<td>38,236</td>
<td>1,746</td>
<td>Low</td>
<td>1% (W), 17% (S)</td>
<td>59%</td>
<td>35% Rain, 33% Lowland, 14% Rain &amp; Snow</td>
</tr>
<tr>
<td>Deer</td>
<td>Summer</td>
<td>3,144</td>
<td>Not Available</td>
<td>Moderate</td>
<td>0% (W), 0% (S)</td>
<td>70%</td>
<td>44% Snow, 28% Rain &amp; Snow</td>
</tr>
<tr>
<td>Canyon</td>
<td>Summer</td>
<td>243</td>
<td>Not Available</td>
<td>Moderate-High</td>
<td>0% (W), 0% (S)</td>
<td>62%</td>
<td>44% Snow, 36% Rain &amp; Snow</td>
</tr>
</tbody>
</table>
Table 1. Factors to consider in the designation of Northern Cascades populations as Primary, Contributing, or Stabilizing (cont.)

<table>
<thead>
<tr>
<th>Population or Watershed</th>
<th>Run Type</th>
<th>NOAA Intrinsic Potential (IP) (^1)</th>
<th>Average Spawners (2007-2016)</th>
<th>NOAA Viability Assessment P(Viable) (^2)</th>
<th>Past Segregated Hatchery Gene Flow (^3)</th>
<th>% Public Land</th>
<th>Hydrology (^4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snohomish/Skykomish</td>
<td>Winter</td>
<td>42,779</td>
<td>1,029</td>
<td>Moderate</td>
<td>0% (W) 5% (S)</td>
<td>79%</td>
<td>45% Lowland 21% Rain 13% Rain &amp; Snow</td>
</tr>
<tr>
<td>Pilchuck</td>
<td>Winter</td>
<td>10,386</td>
<td>720</td>
<td>Low</td>
<td>2% (W) 2% (S)</td>
<td>35%</td>
<td>56% Lowland 35% Rain</td>
</tr>
<tr>
<td>N.F. Skykomish</td>
<td>Summer</td>
<td>1,325</td>
<td>39 (^6)</td>
<td>Moderate</td>
<td>1% (W) 95% (S)</td>
<td>100%</td>
<td>61% Highland 27% Snow</td>
</tr>
<tr>
<td>Snoqualmie</td>
<td>Winter</td>
<td>33,479</td>
<td>812</td>
<td>Moderate</td>
<td>4% (W) 3% (S)</td>
<td>56%</td>
<td>28% Rain 24% Lowland 18% Highland</td>
</tr>
<tr>
<td>Tolt</td>
<td>Summer</td>
<td>641</td>
<td>82</td>
<td>Moderate</td>
<td>0% (W) 68% (S)</td>
<td>42%</td>
<td>31% Snow 31% Rain &amp; Snow 26% Rain</td>
</tr>
</tbody>
</table>

\(^1\) Source: Viability Criteria for Steelhead within the Puget Sound Distinct Population Segment, Table B-1, Puget Sound Technical Recovery Team 2013.

\(^2\) Source: Viability Criteria for Steelhead within the Puget Sound Distinct Population Segment, Fig. 57, Puget Sound Technical Recovery Team 2013.

\(^3\) Estimates of PEHC are for historical segregated programs and do not generally reflect program changes implemented with approved Hatchery Genetic Management Plans.


\(^5\) Regarding this historical population, the TRT states “Many of the TRT members and reviewers considered the Baker River DIP to have been extirpated, although resident O. mykiss in the Baker River Basin may retain some of the historical genetic legacy of this population.” Identifying Historical Populations of Steelhead Within the Puget Sound Distinct Population Segment, page 74, Puget Sound Technical Recovery Team 2013.

\(^6\) Infrequent and incomplete surveys likely result in an underestimate of spawners.
Figure E-2. Map of Drayton Harbor Tributaries Winter-Run population spatial structure, including migration barriers and spawning potential.

Figure E-5. Map of Nooksack River Winter-Run population spatial structure, including migration barriers and spawning potential.

Figure E-8. Map of South Fork Nooksack River Summer-Run population spatial structure, including migration barriers and spawning potential.

Figure E-11. Map of Samish River and Bellingham Bay Tributaries Winter-Run population spatial structure, including migration barriers and spawning potential.

Figure E-14. Map of Skagit River Summer-Run and Winter-Run population spatial structure, including migration barriers and spawning potential.

Figure E-17. Map of Nookachamps Creek Winter-Run population spatial structure, including migration barriers and spawning potential

Figure E-20. Map of Baker River Summer-Run and Winter-Run population spatial structure, including migration barriers and spawning potential.

Figure E-23. Map of Sauk River Summer-Run and Winter-Run population spatial structure, including migration barriers and spawning potential.

Figure E-26. Map of Stillaguamish River Winter-Run population spatial structure, including migration barriers and spawning potential.

Figure E-31. Map of Deer Creek Summer-Run population spatial structure, including migration barriers and spawning potential.

Figure E-34. Map of Canyon Creek Summer-Run population spatial structure, including migration barriers and spawning potential.

Figure E-37. Map of Snohomish/Skykomish Rivers Winter-Run population spatial structure, including migration barriers and spawning potential.

Figure E-40. Map of Pilchuck River Winter-Run population spatial structure, including migration barriers and spawning potential.

Figure E-43. Map of North Fork Skykomish River Summer-Run population spatial structure, including migration barriers and spawning potential.

Figure E-46. Map of Snoqualmie River Winter-Run population spatial structure, including migration barriers and spawning potential.

Figure E-49. Map of Tolt River Summer-Run population spatial structure, including migration barriers and spawning potential.

# Puget Sound DPS
## Nooksack/Samish MU
### Nooksack River System Winter-run Steelhead

**Nooksack River Winter-run Steelhead**

**Whatcom County**

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<th>Year (n)</th>
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<th>Sport Harvest (Jan-Mar)</th>
<th>Tribal Harvest (Mar-May)</th>
<th>Escapeement</th>
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<th>Smolt Release</th>
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**Comments**

- **Hatchery**

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- **Return**

  - 2016: 1079
  - 2017: 1372
  - 2018: 1372
  - 2019: 1578
  - 2020: 238
  - 2021: 606
  - 2022: 606
  - 2023: 606
  - 2024: 606
  - 2025: 606

- **Sport Harvest (Jan-Mar)**

  - 2016: 1079
  - 2017: 1372
  - 2018: 1372
  - 2019: 1578
  - 2020: 238
  - 2021: 606
  - 2022: 606
  - 2023: 606
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  - 2025: 606

- **Tribal Harvest (Mar-May)**

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  - 2017: 1372
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  - 2020: 238
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- **Escapeement**

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- **Total Runsize**

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- **Smolt Release**

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**System Estimate & Tribal Harvest from 2016/17 Nooksack River SEPA.**

**Other Hatchery releases:** Steelhead releases into the Nooksack River System began in 1933. Data quality vary erratically.

**NDF wild river entry: E. Dec – E. Jul.**


---

**Nooksack System Components:** Nooksack River, Nooksack River and Mill Fork, Nooksack River and North Fork, Nooksack River South Fork, Nooksack River below North Fork, Nooksack River Mill Fork, and Nooksack River North Fork.
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Note: Sport harvest data from WDFW. Summer run data from WDFW. Winter run data from DFO.
### Steelhead Historical Database

**Stillaguamish/Snohomish MU**  
Stillaguamish River System Winter-run Steelhead  
**WRIA 05.0001**  
Includes: Marrain, North Fork, and South Fork of the Stillaguamish, Pilchuck and Canyon Creeks

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Other Hatchery Releases: Steelhead released into the Stillaguamish System began in 1933. Data quality very erratic.

*Total number of steelhead trapped (from WDFW Final Hatchery Escapement Report) only. Therefore, total hatchery number components such as fish that spawn or die below the hatchery, fish that are recaptured or released to the stream and become trapped again, or fin that caused the trap undetected have not been accounted for.*

---

**DMPS\StillaguamishSystem_WSH June 28-2017 b22.xlsx1/17/2018**
## Puget Sound DPS

### Stillaguamish/Snohomish MU

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<td>14,900</td>
</tr>
<tr>
<td>October</td>
<td>100</td>
<td>5,200</td>
<td>3,000</td>
<td>8,200</td>
<td>1,000</td>
<td>9,200</td>
<td>2,300</td>
<td>4,600</td>
<td>6,900</td>
<td>10,000</td>
<td>4,900</td>
<td>14,900</td>
</tr>
<tr>
<td>November</td>
<td>100</td>
<td>4,800</td>
<td>2,600</td>
<td>7,400</td>
<td>1,000</td>
<td>8,400</td>
<td>2,100</td>
<td>4,200</td>
<td>6,300</td>
<td>10,000</td>
<td>4,900</td>
<td>14,900</td>
</tr>
<tr>
<td>December</td>
<td>100</td>
<td>4,400</td>
<td>2,200</td>
<td>6,600</td>
<td>1,000</td>
<td>7,600</td>
<td>1,900</td>
<td>3,800</td>
<td>5,700</td>
<td>10,000</td>
<td>4,900</td>
<td>14,900</td>
</tr>
</tbody>
</table>

**Note:** The numbers in the table represent actual counts or estimated values for the specified months and years. The values are used to determine the population dynamics and trends within the Puget Sound DPS for the Stillaguamish/Snohomish MU.
Guidance for Selection of Wild Steelhead Gene Banks
Revised January 17, 2018 with Focus on Northern Cascades MPG

Statewide Steelhead Management Plan
The Statewide Steelhead Management Plan (SSMP) includes the following strategy to conserve and recover wild steelhead:

“Establish a network of wild stock gene banks across the state where wild stocks are largely protected from the effects of hatchery programs. At least one wild stock gene bank will be established for each major population group in each steelhead DPS. Each gene bank will have the following characteristics and management:

a. Each stock selected for inclusion in the gene bank must be sufficiently abundant and productive to be self-sustaining in the future.

b. No releases of hatchery-origin steelhead will occur in streams where spawning of the stock occurs, or in streams used exclusively by that stock for rearing.

c. Fisheries can be conducted if wild steelhead management objectives are met as well as any necessary federal ESA determinations.”

Puget Sound Hatchery Action Advisory Committee
The Washington Department of Fish and Wildlife (Department) created the Puget Sound Hatchery Action Advisory Committee (PSHAAC) in 2011 to help guide the prioritization of hatchery reform actions needed to reduce the risks posed by the state’s hatchery operations in the Puget Sound region. The group was provided with information regarding the status of natural populations of salmon and steelhead as well as the performance and economic benefits of hatchery program throughout the Puget Sound. Based on these data, the PSHAAC suggested watersheds in which steelhead would not be released from state-operated hatcheries (Table 1).

Table 1. PSHAAC recommendations for WSGBs (HEAT 2013).

<table>
<thead>
<tr>
<th>Major Population Group</th>
<th>Population or Watershed</th>
<th>Run Type</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern Cascades</td>
<td>South Fork Nooksack</td>
<td>Summer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Samish</td>
<td>Winter</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sauk</td>
<td>Summer &amp; Winter</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Skagit</td>
<td>Summer &amp; Winter</td>
<td></td>
</tr>
<tr>
<td></td>
<td>High ranking candidate by most members but not a consensus selection.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Central &amp; South Puget Sound</td>
<td>White</td>
<td>Winter</td>
<td>Recommended when supplementation program has ended.</td>
</tr>
<tr>
<td></td>
<td>Puyallup/Carbon</td>
<td>Winter</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nisqually</td>
<td>Winter</td>
<td></td>
</tr>
</tbody>
</table>
Table 1. PSHAAC recommendations for WSGBs (HEAT 2013) (continued).

<table>
<thead>
<tr>
<th>Major Population Group</th>
<th>Population or Watershed</th>
<th>Run Type</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hood Canal &amp; Strait of Juan de Fuca</td>
<td>Skokomish</td>
<td>Winter</td>
<td>Recommended when supplementation program has ended.</td>
</tr>
<tr>
<td>East Hood Canal</td>
<td>Winter</td>
<td>Recommended when supplementation program has ended.</td>
<td></td>
</tr>
<tr>
<td>West Hood Canal</td>
<td>Winter</td>
<td>Recommended when supplementation program has ended.</td>
<td></td>
</tr>
<tr>
<td>Sequim/Discovery Bay</td>
<td>Winter</td>
<td>Recommended when supplementation program has ended.</td>
<td></td>
</tr>
<tr>
<td>Elwha</td>
<td>Winter</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

WSGB Selection Guidance
The Department built upon the general WSGB strategy identified in the SSMP to develop additional guidance to inform the selection of WSGBs. Four population or watershed attributes were defined: 1) Abundant and Productive; 2) Self-Sustaining in the Future; 3) Wild Stock; and 4) Population Diversity.

The Department assessed each attribute and categorized the population as either a “Preferred”, “Adequate”, or “Poor” match with an ideal WSGB (Table 2).

Abundant and Productive. This attribute was assessed using analyses of extinction risk, the long-term change in the number of spawners, and the short-term change in the number of spawners (Appendix Table 1). The extinction risk of each population was predicted using the time trend of spawners and a population-specific quasi-extinction threshold. The quasi-extinction threshold is a number below which extinction is likely due to genetic or demographic risks. Additional information can be found in Cram and Kendall (2015).

Self-Sustaining in the Future. The Department assessed the likelihood that a population would be self-sustaining in the future by analyzing existing habitat ownership (Appendix Table 1). We assumed that federal, tribal, state, or local government ownership was likely to provide habitat protection suitable to ensure the maintenance of steelhead populations in the future. We recognize that other types of land ownership can protect and restore steelhead habitat, and used this information where available.

Wild Stock. The Department assessed the extent that the genetic characteristics of a population may have been affected by gene flow from a hatchery program (Appendix Table 1). Gene flow is the rate at which genes from a hatchery population are incorporated into a wild population. Hatchery-wild gene flow occurs when hatchery fish spawn successfully with wild fish on the spawning grounds. The greater the number of hatchery-wild hybrids produced, the
greater the gene flow. The proportion effective hatchery contribution (PEHC) is a method to estimate gene flow using genetic analysis of tissue samples. Additional information can be found in Warheit (2014) and Hoffmann (2014).

Population Diversity. The Department compiled information on the run-timing type (Summer or Winter) of each population and the hydrographic type of the associated watershed (Appendix Table 1). The hydrographic type is one attribute that can be used to assess the diversity of watersheds. The Puget Sound Technical Recovery Team (2013) classified the percentage of the watershed associated with each population that was in the following categories: Highland, Lowland, Rain Dominated, Rain/Snow Dominated, and Snow Dominated. Appendix Table 1 identifies the two most prevalent hydrographic types.

The Department recognizes that in some cases the current status of steelhead populations may require the selection of populations that do not meet the criteria for “Preferred” or “Adequate”.

Table 2. Attributes and guidance for identification of WSGBs.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Preferred</th>
<th>Adequate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abundant &amp; Productive</td>
<td>Probability of extinction 10% or less in 20 years.</td>
<td>Probability of extinction 20% or less in 20 years.</td>
</tr>
<tr>
<td></td>
<td>Spawner numbers declined less than 60% since 1980.</td>
<td>Insignificant decline in spawners during last 12 years.</td>
</tr>
<tr>
<td>Self-Sustaining in the Future</td>
<td>Habitat Protection. More than 70% of watershed with existing habitat protection measures (e.g., national park, national forest, state forest, Habitat Conservation Plan).</td>
<td>Habitat Protection. More than 50% of watershed with existing habitat protection measures (e.g., national park, national forest, state forest, Habitat Conservation Plan).</td>
</tr>
<tr>
<td>Wild Stock</td>
<td>Proportion Effective Hatchery Contribution (PEHC) or gene flow less than 2%.</td>
<td>PEHC or gene flow less than 5%.</td>
</tr>
<tr>
<td>Population Diversity</td>
<td>Each major population group has representation of winter and summer run timing, if applicable, and a variety of hydrographic types.</td>
<td>Each major population group has representation of winter and summer run timing, if applicable.</td>
</tr>
</tbody>
</table>

WSGB Assessment
The Department assessed the attributes of all populations recommended by the PSHAAC and two additional populations (Deer and Snoqualmie). Results from the assessment are presented in Table 3.

Selection of Wild Steelhead Gene Banks
The Department will select the WSGBs after review of the public comments, assessment of the fishery and economic implications, and discussion with the tribal co-managers.
Table 3. Summary of candidate populations relative to selection guidance.

<table>
<thead>
<tr>
<th>Population</th>
<th>Run Type</th>
<th>Abundant &amp; Productive</th>
<th>Self-Sustaining in the Future</th>
<th>Wild Stock</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Fork Nooksack</td>
<td>Summer</td>
<td>No Data</td>
<td>Adequate</td>
<td>Preferred</td>
</tr>
<tr>
<td>Samish</td>
<td>Winter</td>
<td>Preferred</td>
<td>Poor</td>
<td>Poor</td>
</tr>
<tr>
<td>Sauk</td>
<td>Summer &amp; Winter</td>
<td>Preferred</td>
<td>Preferred</td>
<td>Adequate</td>
</tr>
<tr>
<td>Skagit</td>
<td>Summer &amp; Winter</td>
<td>Preferred</td>
<td>Adequate</td>
<td>Preferred</td>
</tr>
<tr>
<td>Deer Creek</td>
<td>Summer</td>
<td>No Data</td>
<td>Preferred</td>
<td>Preferred</td>
</tr>
<tr>
<td>Pilchuck</td>
<td>Winter</td>
<td>Preferred</td>
<td>Poor</td>
<td>Adequate</td>
</tr>
<tr>
<td>NF Skykomish</td>
<td>Summer</td>
<td>No Data</td>
<td>Preferred</td>
<td>Poor</td>
</tr>
<tr>
<td>Snoqualmie</td>
<td>Winter</td>
<td>Preferred</td>
<td>Adequate</td>
<td>Poor</td>
</tr>
<tr>
<td>Tolt</td>
<td>Summer</td>
<td>Poor</td>
<td>Poor</td>
<td>Poor</td>
</tr>
</tbody>
</table>
References


<table>
<thead>
<tr>
<th>Major Population Group: Northern Cascades</th>
<th>South Fork Nooksack</th>
<th>Samish</th>
<th>Sauk</th>
<th>Skagit</th>
<th>Deer Creek</th>
<th>Pilchuck</th>
<th>NF Skykomish</th>
<th>Snoqualmie</th>
<th>Tolt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population Recommended</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Run Type</td>
<td>Summer</td>
<td>Winter</td>
<td>Summer &amp; Winter</td>
<td>Summer &amp; Winter</td>
<td>Summer</td>
<td>Summer</td>
<td>Summer</td>
<td>Summer</td>
<td>Summer</td>
</tr>
<tr>
<td>Extinction Risk</td>
<td>4%</td>
<td>4%</td>
<td>0%</td>
<td>-38%</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Hydrology Longterm Abundance Trend</td>
<td>41% Rain</td>
<td>23% Rain &amp; Snow</td>
<td>41% Rain</td>
<td>54% Highland</td>
<td>21% Snow</td>
<td>47% Highland</td>
<td>44% Snow &amp; Snow</td>
<td>28% Rain &amp; Snow</td>
<td>35% Rain</td>
</tr>
<tr>
<td>Past Hatchery Genic Flow</td>
<td>0% (W)</td>
<td>6% (W)</td>
<td>4% (W)</td>
<td>2% (W)</td>
<td>0% (W)</td>
<td>1% (S)</td>
<td>2% (W)</td>
<td>1% (W)</td>
<td>1% (W)</td>
</tr>
<tr>
<td>% Public Land</td>
<td>59%</td>
<td>19%</td>
<td>94%</td>
<td>61%</td>
<td>70%</td>
<td>56%</td>
<td>42%</td>
<td>69%</td>
<td>69%</td>
</tr>
</tbody>
</table>

1/ High ranking candidate by most members but not a consensus selection.


3/ Estimates of steelhead spawners are available only for the entire Skagit River watershed – not individual populations. Statistics for the Extinction Risk, Longterm Abundance Trend, and Short Term Decline are reported for the aggregate of the Skagit, Sauk, and Nooksack populations.
AHA/ ISIT Model

- Data intensive model developed by Lars Mobrand, that uses habitat, hatchery and harvest data to predict harvest and impact on natural origin populations.
- The AHA Model was used to estimate the impact of hatchery programs (pHOS and PNI) on natural populations.
- Model primary needs:
  - Goals for transitioning between harvest phases
  - Requires smolt capacity and productivity and SAR% data for the natural population.
  - Harvest rates
  - Hatchery SAR% and Stray Rate
  - Hatchery Fitness Loss
  - Release data, broodstock data (pNOB and pHOB), Spawning Ground data (NOS and HOS).
- Has a built in life cycle model that incorporates the Pacific Ocean Decadal Oscillation (PDO).
Upper Skagit General Model: Natural Origin Parameters

- Primary Population
  - PNI Threshold > 0.67
  - pHOS < 30%

- Natural Origin Parameter Overview
  - Smolt productivity = 110 smolts per female
  - Capacity = 112,105 smolts
  - SAR% = 4%

- Harvest Phases
  - Phase 1: 4% Wild and 22% Hatchery: ≤ 2,004 NORs
  - Phase 2: 10% Wild and 55% Hatchery: 2005 - 3,006 NORs
  - Phase 3: 20% Wild and 60% Hatchery: 3,007 - 4,008 NORs
  - Phase 4: 25% Wild and 62.5% Hatchery: ≥ 4,009 NORs
    - Thresholds based on proportion of overall population in the Skagit DIP
Hatchery Parameters

- Program Size: Maximum program size is 200,000 smolts
- In-basin stray rate
- Assumed that 70% of fish return to the hatchery
- Fitness Effect = 20% Fitness loss
- Hatchery SAR = 0.5%
- For PDO cycles: 1954 (Good Conditions) 1989 (Poor Conditions)
Model Scenarios

- Used model to assess impacts under different scenarios.
  - General model
  - Reduced fitness = 60% Fitness loss
    - Fitness loss so small that this was negligible.
  - Reduced homing to the hatchery
    - 75% stray rate after fisheries.
  - What natural and hatchery SAR% to hit 30% pHOS
  - No Hatchery Entire Skagit Model
Model Outputs

- The model predicts the following between 2017 and 2041:
  - Number of Natural Origin Spawners
  - Percent Hatchery origin spawners (pHOS)
  - Proportion of Natural Influence (PNI)
  - Natural Origin (NOR) Catch
  - Hatchery Origin (HOR) Catch
  - Population Fitness at 2041
- Provides the average and 95% Confidence Intervals.
- Results vary based on PDO cycle.
- Used the average of 25 model iterations.
Model Sensitivity

- The model is most sensitive to SAR%.
- Fitness had little impact on the outputs.
  - Due to using 100% NOB and low hatchery SAR% and robust natural population.
- Stray rate had a slight impact on the model outputs.
### Modeled Outcomes versus Biological Targets for each Phase

*Average, minimum and maximum values from 2017 to 2041*

<table>
<thead>
<tr>
<th></th>
<th>Harvest Phase 1 (4% NOR; 22% HOR)</th>
<th>Harvest Phase 2 (10% NOR; 55% HOR)</th>
<th>Harvest Phase 3 (20% NOR; 60% HOR)</th>
<th>Harvest Phase 4 (25% NOR; 62.5% HOR)</th>
<th>Actual Status In 2016</th>
<th>Projected Status In 2017</th>
<th>Average</th>
<th>Range*</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOS</td>
<td>&gt; 2,004</td>
<td>&gt; 2,005</td>
<td>&gt; 3,007</td>
<td>&gt; 4,008</td>
<td>3.920</td>
<td>4.503</td>
<td>4.282</td>
<td>2.677 - 7.055</td>
<td>3.936 - 4.629</td>
</tr>
<tr>
<td>pHOS</td>
<td>&lt; 30%</td>
<td>&lt; 30%</td>
<td>&lt; 30%</td>
<td>&lt; 30%</td>
<td>5.6%</td>
<td>1.1%</td>
<td>3.0%</td>
<td>0.2% - 7.8%</td>
<td>2.3% - 3.7%</td>
</tr>
<tr>
<td>PNI</td>
<td>&lt; 0.67</td>
<td>&lt; 0.67</td>
<td>&lt; 0.67</td>
<td>&lt; 0.67</td>
<td>0.93</td>
<td>0.99</td>
<td>0.97</td>
<td>0.927 - 0.998</td>
<td>0.965 - 0.978</td>
</tr>
<tr>
<td>NOR Harvest</td>
<td>&gt; 0</td>
<td>&gt; 0</td>
<td>&gt; 0</td>
<td>&gt; 0</td>
<td>0</td>
<td>1.118</td>
<td>1.398</td>
<td>0.392 - 2.352</td>
<td>1.277 - 1.518</td>
</tr>
<tr>
<td>HOR Harvest</td>
<td>&gt; 0</td>
<td>&gt; 0</td>
<td>&gt; 0</td>
<td>&gt; 0</td>
<td>0</td>
<td>0.64</td>
<td>0.851</td>
<td>0.64 - 1.597</td>
<td>0.695 - 1.006</td>
</tr>
<tr>
<td>Fitness</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0</td>
<td>1.00</td>
<td>1.000</td>
<td>0.999 - 1</td>
<td>NA</td>
</tr>
</tbody>
</table>

**NORs and Program Phase**

- **NORs**
- **Phase**

**Biological Indicators**

- **pHOS**
- **Fitness**
- **pNDS**
### Upper Skagit Steelhead Base Model Results

<table>
<thead>
<tr>
<th>Condition</th>
<th>Population Fitness</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good Ocean Conditions</td>
<td>NOS: 4,183 (95% CI: 3,815 - 4,551)</td>
<td>Primarily in the top harvest phase (25% NOR and 62.5% HOR)</td>
</tr>
<tr>
<td></td>
<td>PHOS: 2.9% (95% CI: 2.2 - 3.6)</td>
<td>PNI: 0.97 (95% CI: 0.9 - 1.0)</td>
</tr>
<tr>
<td></td>
<td>NOR Harvest: 1,349 (95% CI: 1,222 - 1,476)</td>
<td>HOR Harvest: 831 (95% CI: 790 - 1,082)</td>
</tr>
</tbody>
</table>
Upper Skagit Steelhead Base Model Results

**Biological Indicators**

- **pHOS**
- **Fitness**
- **pNOB**
Upper Skagit Steelhead Base Model Results

- Poor Ocean Conditions

- Natural Origin Fitness in 2041 (99.9%)
  - NOS – 2,817 (95% CI: 2,422– 3,211)
    - Primarily in the middle two harvest phases
    - (10% to 20% NOR and 55% to 60% HOR)
  - pHOS – 3.4% (95% CI: 2.6% - 4.2%)
  - PNI – 0.97 (95% CI: 0.96 – 0.98)
  - NOR Harvest – 559 (95% CI: 436 – 683)
  - HOR Harvest – 503 (95% CI: 370 - 635)
Upper Skagit Steelhead Base Model Results

**Biological Indicators**

- **pHOS**
- **Fitness**
- **pNOB**

Years: 2005 to 2041
Upper Skagit Steelhead Base Model Results

Total Catch by Origin

Year

2005  2012  2019  2026  2033  2040

Harvest

0  500  1,000  1,500  2,000  2,500  3,000

NORs  Int. HORs
Increased Straying – Only 25% return to hatchery after fisheries

- **Good Ocean Conditions**
  - PHOS – 7.0% (95% CI: 5.4% - 8.7%)
  - PNI – 0.940 (95% CI: 0.92 - 0.95)

- **Poor Ocean Conditions**
  - PHOS – 8.0% (95% CI: 6.2% - 9.8%)
  - PNI – 0.93 (95% CI: 0.91 - 0.94)
What SAR% to hit 30% pHOS

- Poor Ocean Conditions
- Natural SAR = 2.5%
- Hatchery SAR = 2.0%

Results
- Fitness in 2041 = 96.5%
- NOS – 1,825 (95 CI: 1,545 - 2,105)
- pHOS – 25.0% (95% CI: 20.0 % - 30.0%)
- PNI – 0.80 (95% CI: 0.766 - 0.835)
- NOR Harvest – 153 (95% CI: 196 - 380)
- HOR Harvest – 1,276 (95% CI: 818 – 1,733)
No Hatchery Scenario

- Used a model parameterized for the entire Skagit Basin (Skagit, Sauk, Nookachamps)
- Natural Origin Parameter Overview
  - Smolt productivity = 110 smolts per female
  - Capacity = 168,841 smolts
  - SAR% = 4%
- Harvest Phases
  - Phase 1: 4% Wild: ≤ 4000 NORs
  - Phase 2: 10% Wild: 4001-6000 NORs
  - Phase 3: 20% Wild: 6001-8000 NORs
  - Phase 4: 25% Wild: ≥ 8001 NORs
No Hatchery Model Results

- Preliminary Results (Based on entire Skagit watershed)
  - Good Ocean Conditions
    - Primarily in the top two harvest phases (20% to 25%)
    - Average harvest 1,868 (95% CI: 1,689 – 2,047)
  - Poor Ocean Conditions
    - Primarily in the middle two harvest phases (10% to 20%)
    - Average harvest 610 (95% CI: 454 – 766)
No Hatchery Model Results – Good Ocean Conditions
No Hatchery Model Results - Good Ocean Conditions

NOR Catch by Fishery (Good Ocean Conditions)

Terminal Catch

Year

2041
2039
2037
2035
2033
2031
2029
2027
2025
2023
2021
2019
2017
2015
2013
2011
2009
2007
2005

NOR Catch

4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
No Hatchery Model Results — Good Ocean Conditions
No Hatchery Model Results – Good Ocean Conditions

NOR Catch by Fishery (Poor Ocean Conditions)

- Year
  - 2005
  - 2007
  - 2009
  - 2011
  - 2013
  - 2015
  - 2017
  - 2019
  - 2021
  - 2023
  - 2025
  - 2027
  - 2029
  - 2031
  - 2033
  - 2035
  - 2037
  - 2039
  - 2041

- NOR Catch
  - 200
  - 400
  - 600
  - 800
  - 1,000
  - 1,200
  - 1,400
  - 1,600
  - 1,800

- Terminal Catch
Ecological Impacts – Hatchery Residuals

- Literature values suggest 0 - 17% residual rate for hatchery steelhead (Hausch and Melynchuck 2012).
  - Average 5.6%
- Data from Duckabush River suggests a 7.5% residual rate.
  - Two year old smolts
  - Likely included cutthroat hybrids
  - Out-planted
  - Most concentrated near release sites
- At 7.5% and a 200,000 release would anticipate ~15,000 residuals
  - Would be expected to hold near the hatchery
  - Expected that volitional release will reduce residual rate