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Early marine survival of steelhead smolts in Puget Sound

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Survival of steelhead in Puget Sound and Hood Canal

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Manchester Research Station
and
Salish Sea Marine Survival Project
Steelhead Workgroup
Threatened steelhead


Puget Sound

Washington Coast

South North

South North
Marine survival trends

- Marine survival rates have declined dramatically over the last 25-30 years.
- Puget Sound populations have not rebounded in recent years as have coastal and Columbia populations.
- Marine migration through Puget Sound seems to be a major limiting factor.
Acoustic telemetry

7mm and 9 mm transmitters
@ 69kHz, 136 db
Puget Sound Telemetry Project

Hood Canal Rivers: 2006-2010
- 362 tagged smolts
- NOAA Fisheries

Green River: 2006-2009
- 337 tagged smolts
- Fred Goetz, Tom Quinn/UW

Puyallup River: 2006, 2008-2009
- 206 tagged smolts
- Puyallup Tribe

Nisqually River: 2006-2009
- 187 smolts tagged
- Nisqually Tribe

Skagit River: 2006-2009
- 250 smolts tagged
- Seattle City Light
### Migration Segments

<table>
<thead>
<tr>
<th>Hood Canal</th>
<th>Puget Sound</th>
<th>Skagit</th>
</tr>
</thead>
<tbody>
<tr>
<td>River Mouth - HCB</td>
<td>River Mouth - CPS</td>
<td>River Mouth - DP</td>
</tr>
<tr>
<td>HCB - ADM</td>
<td>CPS - ADM</td>
<td></td>
</tr>
<tr>
<td>ADM - JDF</td>
<td>ADM - JDF</td>
<td>DP - JDF</td>
</tr>
</tbody>
</table>
Mark-Recapture Model: Cormack-Jolly-Seber

### Population Counts

<table>
<thead>
<tr>
<th>Population</th>
<th>N(_{2006})</th>
<th>N(_{2007})</th>
<th>N(_{2008})</th>
<th>N(_{2009})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hood canal</td>
<td>106</td>
<td>170</td>
<td>109</td>
<td>78</td>
</tr>
<tr>
<td>Green</td>
<td>100</td>
<td>89</td>
<td>98</td>
<td>50</td>
</tr>
<tr>
<td>Nisqually</td>
<td>55</td>
<td>49</td>
<td>14</td>
<td>69</td>
</tr>
<tr>
<td>Puyallup</td>
<td>50</td>
<td>0</td>
<td>90</td>
<td>66</td>
</tr>
<tr>
<td>Skagit</td>
<td>23</td>
<td>47</td>
<td>100</td>
<td>80</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>334</strong></td>
<td><strong>355</strong></td>
<td><strong>411</strong></td>
<td><strong>293</strong></td>
</tr>
</tbody>
</table>

\(N=1393\)

### Variables included in the survival analysis

**Factors:** Population, Region (HC, SS, Skagit, Puyallup), Rear type, Migration Segment, Year, Tag Type

**Covariates:** Distance, Body Length

Model with lowest AICc = ~Segment:population+year+reartype
Marine survival is low in Hood Canal and Puget Sound

Combined early marine survival estimate = 17% (hatchery = 12% , wild = 20%)
Travel Times

Puget Sound

Hood Canal

Travel time (days)

- Nisqually
- Puyallup
- Green
- Skagit

- Skok
- Dewatto
- BBC
Potential factors affecting marine survival (why do so many steelhead die so quickly)

- **Freshwater influences**
  - Reduced diversity (‘Portfolio effect’: e.g., Schindler et al. 2012. *Nature*)
  - Hatcheries (genetic or ecological)
  - Water quality (toxic contaminants)
  - Disease-causing pathogens (nanophytyetus)

- Changes in the Puget Sound ecosystem that have influenced predator-prey dynamics
  - Avian predators: cormorants, Caspian terns, common mergansers, and loons
  - Mammalian predators: harbor seals, harbor porpoise
Predator-prey interactions (harbor seals)

Harbor seal counts

Jeffries et al. 2003 J. Wildlife Manage.
Predator-prey interactions (harbor porpoise)

1993-1998

1999-2004

2005-2011

(J. Evenson, WDFW, 2013, unpublished data)
Herring Biomass


Figure 5. Estimated herring spawning biomass, 1973-2011.
Pacific Cod Abundance

Data source: Palsson et al. via NMFS 2000 Status Review
Summary

• Early marine survival rates of Hood Canal and Puget Sound steelhead populations are low considering short observed travel times

• Travel times within the Puget Sound environment are very short, giving little time for long term sources of mortality to take effect

• Puget Sound has undergone a major ecosystem shift timed with the decline in steelhead abundance and SAR.

• Future studies: tag more steelhead smolts and harbor seals
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Temperature in Puget Sound (Strait of Juan de Fuca)

Early Marine Mortality in Puget Sound makes up a substantial amount of overall marine mortality.

Slope of the line = instantaneous mortality rate

Red line = estimates from previous telemetry work in Hood Canal

Blue Line = 2x Hood Canal estimates, providing for underestimation of early mortality rate

Assumed 3% Smolt to Adult return rate (SAR)
Where within Puget Sound is survival occurring?

![Puget Sound map with survival rates over distance from Juan de Fuca Strait]

- Big Beef
- Green
- Nisqually
- Puyallup
- Skagit
- Skokomish

Survival (%) vs. Distance from Juan de Fuca Strait (km)