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Early marine survival of steelhead smolts in Puget Sound

Megan Moore  
*United States. National Marine Fisheries Service*, megan.moore@noaa.gov

Barry Berejikian  
*United States. National Marine Fisheries Service*

Fred Goetz  
*United States. Army Corps of Engineers*

Thomas Quinn  
*University of Washington*

Sayre Hodgson  
*Nisqually Indian Tribe*

*See next page for additional authors*

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Speaker
Megan Moore, Barry Berejikian, Fred Goetz, Thomas Quinn, Sayre Hodgson, Ed Connor, and Andrew Berger
Survival of steelhead in Puget Sound and Hood Canal

Megan Moore, NOAA Fisheries
Barry Berejikian, NOAA Fisheries
Manchester Research Station
and
Salish Sea Marine Survival Project
Steelhead Workgroup
Threatened steelhead


Puget Sound

South North

Washington Coast

South North

Nisqually Puyallup Green Skagit Quinault Queets Hoh Quillayute
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
Telemetry array

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>
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</tr>
<tr>
<td>ADM - JDF</td>
<td>ADM - JDF</td>
<td>DP - JDF</td>
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</tbody>
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Mark-Recapture Model: Cormack-Jolly-Seber

Variables included in the survival analysis

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

Covariates: Distance, Body Length

Model with lowest AICc = ~Segment:population+year+reartype

<table>
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<tr>
<th>Population</th>
<th>N&lt;sub&gt;2006&lt;/sub&gt;</th>
<th>N&lt;sub&gt;2007&lt;/sub&gt;</th>
<th>N&lt;sub&gt;2008&lt;/sub&gt;</th>
<th>N&lt;sub&gt;2009&lt;/sub&gt;</th>
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<tbody>
<tr>
<td>Hood canal</td>
<td>106</td>
<td>170</td>
<td>109</td>
<td>78</td>
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<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>
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<tr>
<td>TOTAL</td>
<td>334</td>
<td>355</td>
<td>411</td>
<td>293</td>
</tr>
</tbody>
</table>

N=1393
Marine survival is low in Hood Canal and Puget Sound

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

- 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
Acknowledgements

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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?