May 1st, 1:30 PM - 3:00 PM

Early marine survival of steelhead smolts in Puget Sound

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Speaker
Megan Moore, Barry Berejikian, Fred Goetz, Thomas Quinn, Sayre Hodgson, Ed Connor, and Andrew Berger

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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


0% 10% 20% 30% 40% 50% 60% 70% 80%

Nisqually  Puyallup  Green  Skagit  Quinault  Queets  Hoh  Quillayute

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
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>
</table>
Mark-Recapture Model: Cormack-Jolly-Seber

<table>
<thead>
<tr>
<th>Population</th>
<th>N_{2006}</th>
<th>N_{2007}</th>
<th>N_{2008}</th>
<th>N_{2009}</th>
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<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>
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<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)
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

<table>
<thead>
<tr>
<th>Region</th>
<th>Travel Time (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RM-NAR</td>
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<tr>
<td>RM-CPS/DP</td>
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<td>RM-ADM</td>
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<td>RM-JDF</td>
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</tr>
</tbody>
</table>

Legend:
- Blue: Nisqually
- Green: Puyallup
- Orange: Green
- Red: Skagit
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 (nanophyjetus)

- 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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Jeff Laake (NOAA SWFSC)

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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?