Predicting ecosystem response to the removal of the Elwha River Dams, Washington State, U.S.A.

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The Elwha River – a brief history

Olympic Peninsula
Washington State

- approx. 13.7 million m³ behind dams
- dams to be removed 2008
Questions

• How will ecosystem processes and condition change with the removal of the Elwha River dams?
  – Primary & secondary productivity
  – Fish community response

• How do channel & floodplain dynamics affect primary & secondary productivity and fish community response?
Impacts of the dams
Blockage to upstream migration

- 146 km of mainstem and tributary habitat
- Floodplain channels
Impacts of the dams
Reduced habitat quality

Reduced river movement

River Kilometer 5.6

- Municipal Water Well
- Rip-Rap
- Dike
- Dike/Pilings
- WDFW Spawning Channel
Impacts of the dams
Loss, reduced, and altered salmonid populations

- Over 90% decline in salmonid abundance
- Likely extirpation of upstream stocks
- Shift in species composition

![Graph showing total number of salmonids before and after the dams.](chart)

- Pre-dam: Steelhead, Coho, Chinook, Sockeye, Chum, Pink
- Post-dam: Reduced numbers for all species
### Loss, reduced & altered salmonid populations

<table>
<thead>
<tr>
<th>Species</th>
<th>Proportion of population that is hatchery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summer/fall chinook</td>
<td>?</td>
</tr>
<tr>
<td>Coho</td>
<td>76%</td>
</tr>
<tr>
<td>Chum</td>
<td>0%</td>
</tr>
<tr>
<td>Pink</td>
<td>0%</td>
</tr>
<tr>
<td>Winter steelhead</td>
<td>83%</td>
</tr>
<tr>
<td>Summer steelhead</td>
<td>77%</td>
</tr>
<tr>
<td>Sea-run cutthroat</td>
<td>0%</td>
</tr>
<tr>
<td>Char</td>
<td>0%</td>
</tr>
<tr>
<td>Kokanee</td>
<td>?</td>
</tr>
</tbody>
</table>
Key points from existing information

• Remnant salmonid populations persist below the dams at dramatically reduced levels

• Habitat quantity and quality has been reduced

• The Elwha has a functioning forested floodplain that is currently utilized by all species at all life stages

• Salmonids will rebuild at a watershed-scale
  – interaction between the mainstem and functioning floodplain

• Uncertainty
  – hatcheries
Study design

- Two main changes:
  - Loss of downstream transport of sediment and wood
  - Loss of upstream migration of salmon

<table>
<thead>
<tr>
<th>Reach</th>
<th>Sediment</th>
<th>Fish</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quinault</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Upper Elwha</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Middle Elwha</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Lower Elwha</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Elwha response to dam removal

• Channel & floodplain dynamics
  – Increase in sediment & wood supply
    • Channel widening & aggradation
    • Increase in channel migration rate
  – Decrease in riparian stand age
  – Change in floodplain channel characteristics

• Salmon recolonization
  – Upstream movement of anadromous fish
Bounded alluvial valleys

Canyon reach
Alluvial valley
Primary productivity
Longitudinal patterns

organic matter density (AFDM)

• Initial reduction due to sediment

• Long-term increase due to marine derived nutrients?

p < 0.001
1-way ANOVA
log transformed
Tukey’s HSD
5 to 10 sites/reach
5 samples/site

mg/cm²
Secondary productivity
Channel & floodplain dynamics

Stand age – surrogate for channel dynamics

- Decreased stand age
- Increase in channel dynamics
- Sediment increase
- Detrital input
Fish community response
Do salmonids succeed in colonizing new habitats?

• Yes
• Straying
• Newly created or reopened habitats
• Establish self-sustaining populations in years to decades
• Success
  – Specific life history adaptations
  – Geomorphic and ecological conditions

Fraser River DFO, unpublished data
Fish community response
Recolonization

- Chinook & coho
- Lamprey
- Pink & chum
- Sockeye, Steelhead/rainbow, char, & cutthroat
Fish community response

Straying away from sediment source

- High sediment load in a short time period
  - Deleterious effects on salmon

- Straying away from Elwha

- Mt. St. Helens
  - Stray rates increased from 16% to 45%
Fish community response

Buffering effects -
Dams & floodplains

Canyon reach

Alluvial valley

Strait of Juan de Fuca

Port Angeles  Lower Elwha Reservation

41 281 60 km

OLYMPIC NATIONAL PARK

Coho salmon

Steelhead

Chinook salmon
Fish response
Channel & floodplain dynamics

- sculpin
- stickleback
- coho
- trout
- chinook

Surface water
Ground water

0%
25%
50%
75%
100%
Salmonid recolonization and response

- Distance from source population
- Habitat type & quality
- Interaction with resident fish
- Natural barriers

- Current population size
- Hatchery influence
- Sediment impacts
Distance from source population

- Most affected by distance
  - Chinook, coho, chum, pinks, sockeye
    - No resident component

- Least affected by distance
  - Steelhead, char, cutthroat
    - Resident component
Habitat type and quality

• Most affected by habitat type & quality
  – Chinook – mainstem
  – Coho – floodplains and tributaries
  – Chum and pinks – lower river sediment effects

• Least affected by habitat type & quality
  – Steelhead, char, cutthroat – generalists
Interaction with resident fish

• Most affected by interaction with resident fish
  – Positive – contribution to spawning population
    • Steelhead, char, cutthroat, sockeye (kokanee?)
  – Negative – competition for food and space
    • Chinook, coho

• Least affected by interaction with resident fish
  – Chum, pinks
Natural barriers

• Most affected by natural barriers
  – Pinks, chum, sockeye

• Least affected by natural barriers
  – Steelhead, Chinook, coho, char
Predicted response by species

Chinook, coho – habitat type & quality and distance

Chum, pink – natural barriers

Steelhead, char, & cutthroat – positive interaction with resident fish

Sockeye – Lake Sutherland

% habitat colonized

Lower Middle Upper
Elwha River hypotheses summary

• Channel widening, aggradation, increased migration & shift in floodplain characteristics

• Primary & secondary productivity
  • Initial decrease – sediment
  • Long term increase – marine derived nutrients & detrital input

• Salmonids will establish self-sustaining populations in the middle & upper Elwha
  • Lower river, other watersheds & resident populations

• Sediment impacts
  • Stray rates
  • Floodplain channels
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