Light availability controls in the benthic nearshore ecosystem of the Elwha River

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Speaker
Hannah Glover, Andrea S. Ogston, Emily F. Eidam, Ian M. Miller, Stephen P. Rubin, and Helen D. Berry
Controls on Light Availability in the Benthic Nearshore Ecosystem of the Elwha River, WA

Hannah Glover

Andrea S. Ogston, Emily Eidam, Ian Miller, Steve Rubin, & Helen Berry
Elwha River Dam Removal Project

Built in early 1900s
30 Mt of sediment in reservoirs
Dam removal in 2011 to 2014
2011-2017 sediment flux and deposition

Approximately 15 Mt of sediment have eroded so far (half of reservoir) in Fresh Water Bay.

Data from Curran, et al., 2014

John Felis (USGS)
Nearshore ecosystem impacts: macroalgae

• Extensive macroalgae mortality during dam removal (Rubin, et al, 2017)

• Hypotheses for cause of mortality:
  • Changes to substrate
  • Direct scouring
  • Reduced light availability

How does a sediment pulse event and subsequent sediment transport impact benthic light availability?
Lambert-Beers Law and sediment transport

\[ E(z) = E_0 \exp(-K_d z) \]

\[ K_d = \frac{-1}{z} \ln\left( \frac{E}{E_0} \right) \]

\[ K_d = K^*_{w} + K^*_s[S] + K^*_\text{chla}[\text{chl-a}] + K^*_\text{CDOM}[\text{CDOM}] + \ldots \]

Figure adapted from E. Eidam
Monitoring light availability in 2016 – 2017
Elwha River Hydrograph 2016 - 2017
Raw benthic light availability data

Take values between 10:00 – 15:00

\[ K_d = \frac{-1}{Z} \ln \left( \frac{E}{E_o} \right) \]
Mean $K_d$ for all deployments

$K_d$ decreases away from the river

Wide range of values observed over the 7 deployments:
- Tides
- River discharge
- Waves
$K_d$ from river discharge and wave climate

$K_d$ increases with discharge

$K_d$ increases with wave height

$0.78 (0.11)$

$0.54 (0.06)$

$0.30 (0.04)$

$0.56 (0.07)$

$0.18 (0.03)$
$K_d$ from river discharge and wave climate

- $K_d$ increases with discharge
- $K_d$ increases with wave height

Hindcast to dam removal
\( K_d \) from sediment load during dam removal

<table>
<thead>
<tr>
<th>Light requirement (mol/m²/day)*</th>
<th>Maximum ( K_d ) (m⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gametophyte: 0.4</td>
<td>0.54</td>
</tr>
<tr>
<td>Adult: 1</td>
<td>0.45</td>
</tr>
<tr>
<td>Adult: 2</td>
<td>0.38</td>
</tr>
</tbody>
</table>

*Schiel and Foster, (2015), *The Biology and Ecology of Giant Kelp Forests*

- \( K_d \sim 0.5 \) at station F
- Wave height: 0.2 – 0.45 m
- Discharge: 200 – 4000 t
Summary and future work

• Sediment discharge has decreased since dam removal
• Benthic light availability has returned to a healthy range for macroalgae.
• Light availability is impacted by:
  • Sediment flux from the river
  • Distance from river mouth
  • Waves
  • Tides
• Data will be used to calibrate a model being developed by Andrew Stevens (USGS)
• PLUGS: Andrea Ogston (Session 3.3), Steve Rubin (Session 3.1)