Impacts of Climate Change on River Basin Hydrology and Collaborative Adaptation Planning Efforts for the Nooksack River

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Nooksack Indian Tribe Climate Change Project

Co-Investigators:
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• Jezra Beaulieu, Water Resources Specialist, Nooksack Indian Tribe
• Robert Mitchell, Professor of Geology, Western Washington University
• Christina Bandaragoda, Senior Research Scientist, University of Washington
• Treva Coe, Habitat Program Manager, Nooksack Indian Tribe
• Mauri Pelto, Glaciologist, Nichols College, MA
• Ryan Murphy, Climate Scientist, Point–No Point Council
Sources of Funding:

- EPA – PPG, NEP
- BIA
- NWIFC
- NPLCC and ATNI
- WA Dept. Ecology - NEP
Nooksack Indian Tribe

- 2000 members
- 2.2-acre res.
- 4000 ac trust
- 780,000-ac U and A

Salish Sea

Bellingham

13 miles

Nooksack Tribe
Attributes of Overall Climate Project:

Baseline Monitoring:
- Baseline Temperature.
  - Seasonal temperature sensors.
  - Year-round temperature sensors.
- Discharge, year-round and seasonal.
- Turbidity, suspended sediment.
- Water oxygen isotope monitoring.
- Glacier ablation monitoring.
- Water quality monitoring.
- Lapse rate studies.
- Salmon Habitat Restoration Effectiveness monitoring.
Attributes of Overall Climate Project:

Modeling:
- Climate Change stream temperature modeling.
- Glacier ablation modeling.
- Modeling of Hydrologic change.
- Sediment dynamics modeling.
Attributes of Overall Climate Change Project:

Holistically address:
Where are the Glaciers:
Where are the Glaciers:

- 148 glaciers and glacierets
- 15.76 square miles
- North Fork: 12.02 square miles
- Middle Fork: 3.32 square miles
- South Fork: 0.42 square miles
Glacier Field Studies:

- Snow and ice ablation
- Streamflow
- Stream and air temperature
- Turbidity and suspended sediment
- Weather station: precip, solar, RH, temperature
- Oxygen isotope analysis
Mazama Glacier
Sholes Glacier
Sholes Glacier: ablation rates

ELEVATION

ABL7: 6172 ft
ABL6: 5936 ft
ABL5: 5822 ft
ABL4: 5489 ft
Recently exposed unconsolidated earth material ready for transport.
RESULTS:
Sholes Glacier: **Ablation Rates**

**ELEVATION**

ABL7: 6172 ft  
ABL6: 5936 ft  
ABL5: 5822 ft  
ABL4: 5489 ft

Melt is a significant component of summer flow and modulated stream temperatures

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<td>1.8</td>
<td>1.8</td>
<td>3.3</td>
<td>2.5</td>
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</table>
Modeling for Climate Trends:

- Funded by Nooksack Indian Tribe
- Collaboration between UW and WWU
- UW provided to WWU:
  - Training on Climate forcing and downscaling
  - Source code for glacier ablation module for use with the DHSVM model
- WWU:
  - Calibrated and verified DHSVM
  - Simulating river basin hydrology using several GCMs and RCPs
  - Ryan Murphy conducted the modeling for his MS thesis
GLACIER MODELING:
Hydrologic Modeling

2075 Streamflow

2075 SWE

Murphy and Mitchell, unpublished
**South Fork**

Rainfall to Transitional - Bimodal

- SFLowerIntensive

Hydrograph narrows

- 500 cfs

Rainfall - Uni-modal

- 700 cfs

**Monthly Median RCP4.5**

**Monthly Median RCP8.5**
South Fork – Recurrence Intervals

Aug Exc Prob RCP4.5

Aug Exc Prob RCP8.5
Other Results

• Streamflow response to glacier melt very important in late summer – currently about 15%.

• In the North Fork Nooksack River by 2075:
  • 153% increase in January
  • -75% decrease in July
  • Due to becoming mostly rainfall dominated

• Historic glacier retreat 40 percent 1958-2007
• Since 1895, Mazama Glacier has retreated 7,200 ft
• Since 1993, 2,240 ft
• Rainbow Glacier, approximately 10,000 ft
Other Results

• Larger portion of the watershed will be rain dominated, with less area of transition and snowmelt dominated.

• April 1 SWE:
  • Historic: 0.7m
  • 2075: 0.2m

• Glacier retreat will be significant with smaller glaciers disappearing and residual glaciers receding to higher elevations with significantly less mass, 88 percent less, 90% recession by 2100.

• Increased ice melt will partially compensate for decreased streamflow due to reduced snowpack and earlier snow melt.
Other Results

- Glacier melt contribution will increase to 2050, then decrease.

- Increase in contribution in first half ~ 150-185%.

- Glacier melt contribution:
  - Historic: 16%
    - BUT, in 2015, we found glacier melt contribution to be 60-90% of total late summer flow
  - 2025: 51%
  - 2075: 38%
Other Results

Climate change impacts on fish:

• Higher peak flows
• Lower low flows
• Increase stream temperatures
• Increased sediment
• Required minimum instream flows will be *met more infrequently*
• Agricultural demand will be *met more infrequently*
• Impact all life stages of salmon throughout the year.
Results

- Vulnerability Assessment
- Adaptation Planning
- Fish
SOUTH FORK NOOKSACK RIVER
CLIMATE CHANGE IMPACT
ASSESSMENT, VULNERABILITY
ASSESSMENT AND ADAPTATION
PLANNING PROJECT

Collaboration between:

- EPA-ORD,
- EPA Region 10,
- Nooksack Indian Tribe,
- WA Dept of Ecology,
- Tetra Tech, Inc.
Not Just Technical, But Also a Story of:

- Converging and integrating project pathways
- Voluntary collaboration
- Co-production of climate change analysis
- Actionable science
Converging and Integrating Project Pathways

- In 2011, Nooksack Indian Tribe provided comment on SFNR temperature TMDL:
  - Climate change
  - Upland watershed processes
  - Realistic natural conditions
  - Focus on impacts to fish – the designated or beneficial use
    - Not just the CWA numeric criteria

- Independently, EPA-ORD initiated a climate change pilot research project in 2012 to:
  - Demonstrate how climate change can be included in a temperature TMDL
  - Address climate change, ESA fish recovery, and CWA compliance in one research demonstration pilot project

  “Circumstance meets opportunity” to yield the:

  “EPA Region 10 Climate Change and TMDL Pilot Project”
Guiding Principles

• This project was structured as a stakeholder-centric process. That means EPA supported and facilitated stakeholder (Federal, Tribal, State, Local & NGO) actions to plan and implement Climate Change Adaptation.

• The EPA Region 10 Climate Change TMDL Pilot is all about demonstrating how cutting-edge science can be applied in a real-word problem-solving context (actionable science) with the participation (co-production) of scientists, environmental practitioners and stakeholders.
Climate Change Risk Assessment

Consists of a Quantitative and Qualitative Assessment

Quantitative Assessment (Led by EPA-ORD and Tetra Tech, Inc.):
- Comparison of QUAL2Kw modeled stream flow and temperatures, including riparian shading, with and without climate change for the 2020s, 2040s and 2080s.
- Responsive to the CWA TMDL Numeric Cold-Water Temperature WQS.

Qualitative Assessment (Led by the Nooksack Indian Tribe):
- Comprehensive analysis of freshwater habitat for ESA salmon restoration in the SFNR under climate change.
- Will result in a prioritized list of climate change adaption strategies that supports salmon restoration in the SFNR under climate change.

Together, the Assessments represent robust and comprehensive actions to protect the CWA beneficial uses (salmon habitat) and ESA recovery goals under climate change.
ESA Salmon Recovery and Climate Change Process Linkages

Climate Change Process
- Problem Understanding
- Identify Climate Trends
- Assess Vulnerability / Risk
- Identify Adaptation Options
- Implementation and Monitoring

ESA Salmon Recovery (WRIA 1 Process)
- Salmon Recovery Plan (SRP)
- SRP 10 year update
- 3-Year Implementation Plan
- SRFB/PSAR Prioritization Matrices (annual)

Stakeholder Involvement & Public Participation

ESA Monitoring and Adaptive Management Framework/Plan
Qualitative Assessment: Evaluating the Impacts of Climate Change on Endangered Species Act Recovery Actions for the South Fork Nooksack River, WA

Key Messages (In Press):

• Identify and prioritize ESA climate change adaptation strategies or recovery actions for the SFNR that explicitly include climate change as a risk.

• Methodology based on Scientific Literature: *Restoring Salmon Habitat for a Changing Climate* (Beechie et al. 2013).

• Utilized Interdisciplinary Teams (Federal, Tribal, State, Local, WRIA 1) to develop research pilot demonstration and complete the assessment.
QUALITATIVE ASSESSMENT

Evaluate Climate Impacts

Evaluate Species Impacts

Evaluate Actions

Recommendations
Qualitative Assessment: Timing of Climate Change Effects of Stream Flow and Temperature on Spring Chinook by Life History Periodicities


CLIMATE RISK

- Increased Winter Peak Flows
- Loss of Spring Snowmelt Reducing Discharge
- Increased Summer Temperatures
- Decreased Summer Low Flows and Increased Temperatures
- Respective Life Stage Periodicities
  Includes increases in turbidity and sediment
Qualitative Assessment: Summary of Major Categories of Restoration Action Types

**Ability To Ameliorate Climate Change Effects**

<table>
<thead>
<tr>
<th>Climate Risk</th>
<th>Restoration Tool</th>
<th>Expected climate change effect</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Longitudinal connectivity</td>
<td>Floodplain connectivity</td>
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<tr>
<td>Increased temperature</td>
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<td>Y</td>
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<tr>
<td>Decreased low flow</td>
<td>Y</td>
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<tr>
<td>Increased peak flow</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>Reduced diversity</td>
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</tr>
</tbody>
</table>

QUALITATIVE ASSESSMENT

- Evaluate Climate Impacts
- Evaluate Species Impacts
- Evaluate Actions
- Recommendations
ACTIONS TO PROMOTE RESILIENCE TO CLIMATE CHANGE:

- RECONNECT RIVER TO FLOODPLAIN
- RESTORE AND PROTECT RIPARIAN AREAS
- CONTINUE INSTREAM REHABILITATION/RESTORATION

MORE, BIGGER, FASTER

- RESTORE FLOW REGIMES
- PROMOTE LONGITUDINAL CONNECTIVITY
- REDUCE SEDIMENT DELIVERY
• ACKNOWLEDGE AND ADDRESS THE ROLE OF UPPER WATERSHED PROCESSES IN MAINSTEM RIVER WATER QUALITY AND FISH HABITAT IMPAIRMENT

• DEVELOP A WATERSHED CONSERVATION PLAN THAT INCLUDES TOOLS THAT PROMOTE WATERSHED RESILIENCE IN THE FACE OF CLIMATE CHANGE

• DESIGN AND IMPLEMENT WATERSHED RESTORATION TOOLS THAT SUPPORT AND SUPPLEMENT TRADITIONAL INSTREAM TOOLS

• VOLUNTARY ACTIONS THROUGHOUT THE WATERSHED
  • Forestry
  • Transportation
  • Agriculture
  • Development
Next Steps for “Climate-Ready” ESA Salmonid Recovery in the Puget Sound

Develop a SFNR Watershed Conservation Plan that focuses on resilience to climate change
- Form a “SFNR Watershed Council”
- Public Outreach and Stakeholder Engagement in the Development of the Plan
- Act on Recommendations of the Qualitative Assessment and TMDL

Inform the Update of the ESA WRIA 1 Salmonid Recovery Plan
- Puget Sound Partnership (PSP) Salmon Recovery Council
- NOAA Fisheries
- WRIA 1 Salmon Recovery Team

Scale-up and Refine the Qualitative Assessment Methodology to other Adjacent Watersheds
- Middle Fork, North Fork and Lower Mainstem of the Nooksack River Basin
- Stillaguamish River Watershed, which similarly impaired

Scale-up and Replicate the Qualitative Assessment Methodology for ESU-Wide Implementation
- Connect and Coordinate with Other Puget Sound Entities: PSP, PSP-Salmon Recovery Council, Lead Watershed Entities (WRIAs, Watershed Councils), EPA National Estuaries Program (NEP), NOAA Fisheries
Planning Team

WRIA 1 Update

Expanded Planning Team

Public Meeting

“Watershed Council”

Draft Plan

Final Plan

SOUTH FORK NOOKSACK COMMUNITY ENGAGEMENT

Interest Group Meetings

Add agencies and key players

Gather input and ideas

Expanded planning team plus interest groups

Synthesize science and community needs

Gather input and ideas

SOUTH FORK NOOKSACK COMMUNITY ENGAGEMENT

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Draft Plan

Final Plan
THANK YOU!
THANKS!

EPA website:
https://cfpub.epa.gov/si/si_public_record_Report.cfm?dirEntryId=288533