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**Restoration of the Nisqually River Delta and increased rearing opportunities for salmonids**

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Speaker
Kelley Turner, Christopher Ellings, John Takekawa, Isa Woo, Eric Grossman, Aaron David, Jennifer Cutler, and Sayre Hodgson

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Restoration of the Nisqually River Delta and increased rearing opportunities for salmonids

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1. Nisqually Indian Tribe Natural Resources Department
2. USGS Western Ecological Research Center
3. USGS Coastal and Marine Geology, Pacific Coastal and Marine Science Center
4. Nisqually National Wildlife Refuge
5. University of Washington
6. Current address: Hamer Environmental, L.P.
Development
Salmon Recovery and Conservation Drives Delta Restoration

Nisqually Estuary Restoration
Status as of June 2011

Nisqually NWR
- Historic Sloughs Reconnected
- Log Jam Constructed
- Dikes and Levees Removed
- New Dike Constructed
- New Estuary Trail Completed
- New Estuary Boardwalk Completed
- Twin Barns Loop Trail
- Freshwater Wetlands Enhanced
- Surge Plain Restored

Nisqually Indian Tribe
- Dikes Removed
- Dike Removal Planned
- Surge Plain Restored

Image Source: USGS, July 2010
Cartography by: J. Cutter, Nisqually Indian Tribe
Chinook Response to Estuary Restoration

Chinook estuary rearing is a critical component of Chinook life history

**Opportunity:** Chinook are able to access estuarine habitats

**Capacity:** Estuarine habitats support Chinook rearing functions

**Realized Function:** Chinook take advantage of estuarine capacity

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**Opportunity Performance Metrics:**
- Delta connectivity
- Full tidal inundation
- Channel development
- Chinook presence

**Capacity Performance Metrics:**
- Water quality
- Sedimentation
- Elevation
- Vegetation composition and structure
- Invertebrate composition and abundance

**Realized Function Performance Metrics:**
- Chinook estuary feeding ecology
- Chinook estuary residence time
- Chinook estuary growth
- Chinook life history diversity

Based on Simenstad and Cordell (2000)
Opportunity: Tidal Channels

Tidal channels are the functional interstates of estuaries

Pre-restoration 2005

Post-restoration 2011
Opportunity: Delta Connectivity
Put physical metrics in terms of juvenile Chinook

- Constrained inundation model to peak outmigration season (March - August)
- Elevation data
- Only included tidal depths supporting juvenile Chinook (≥ 0.4 m; Hering et al. 2010)

Salmon River estuary, OR (from Hering et al. 2010)
Opportunity: Delta Connectivity

Measurements

For each tidal datum:
- Number of pathways
- Complexity
- Length of time

Verified results with Chinook presence
Opportunity: Delta Connectivity

Pre-restoration Mean Lower Low Water

One reference site accessible:
• McAllister
  • One pathway
  • Complexity using tortuosity ratio:
    • straight line/traveled path
      • 2.5 km/ 10 km = 0.25
One reference site accessible:
• McAllister
  • One pathway
  • Complexity using tortuosity ratio:
    • straight line/traveled path
    • $2.5 \text{ km/} 10 \text{ km} = 0.25$
Opportunity: Delta Connectivity

Pre-restoration Mean Tide Level

Three reference sites accessible:

- **McAllister**
  - One pathway
  - Complexity = 0.35

- **Control**
  - One pathway
  - Complexity = 0.48

- **Animal**
  - One pathway
  - Complexity = 0.70
Opportunity: Delta Connectivity

Post-restoration Mean Tide Level

Three reference sites accessible:

- McAllister
  - One pathway
  - Complexity = 0.33

- Control
  - One pathway
  - Complexity = 0.48

- Animal
  - One pathway
  - Complexity = 0.70
Opportunity: Delta Connectivity

Pre-restoration Mean Higher High Water

Three reference sites accessible:
- **McAllister**
  - One pathway
  - Complexity = 0.35

- **Control**
  - One pathway
  - Complexity = 0.49

- **Animal**
  - One pathway
  - Complexity = 0.78

![Map of Delta Connectivity with reference sites and water levels](image-url)
Opportunity: Delta Connectivity
Post-restoration Mean Higher High Water

Three reference sites accessible:
- **McAllister**
  - One pathway
  - Complexity = 0.31
    - Path 1 = 0.36
- **Phase 2**
  - Path 2 = 0.74
    - One pathway
  - 0.76
- **Control**
  - One pathway
  - Complexity = 0.22

Three restored sites accessible:
- **Phase 1**
  - One pathway
  - Complexity = 0.31
- **Phase 2**
  - One pathway
  - Complexity = 0.22
- **Madrone**
  - Two pathways
  - Complexity = 0.49
    - Path 1 = 0.32
    - Path 2 = 0.84
- **Animal**
  - Two pathways
  - Complexity
    - Path 1 = 0.78
    - Path 2 = 0.89

= Reference
= Restored
Opportunity: Delta Connectivity
Fish Presence: Methods

**Fyke Trap Surveys**
- Tidal channels
  - 3 Restored
  - 2 Reference
- Set on high tide, removed low tide
- Post-restoration

**Beach Seine Surveys**
- 30 sites
- Mid to high tide
- Pre and post-restoration
Annual proportion of months when juvenile Chinook were detected in both a tidal slough (fyke trap) and Nisqually estuary (beach seine).
Opportunity: Delta Connectivity
Fish Presence: Results

Restored channels:

- Least complex path:
  - Madrone - Phase 1 – Phase 2

- Highest number of paths:
  - Madrone

- Path accessible longest:
  - Madrone and Phase 2
Opportunity: Delta Connectivity
Summary

1. Restoration has led to increased tidal channel development and connectivity.

2. Juvenile Chinook are accessing all restored tidal channels.

3. Presence of juvenile Chinook was higher in those channels with greater connectivity.

4. Studies of delta connectivity for salmonids should consider species specific limitations (e.g. water depth, phenology).

5. Estuary restoration should not only plan for the number of restored tidal channels, but their connectivity to rivers and valuable habitats throughout the estuary.
About the Project

After a century of diking off tidal flow, the Brown Farm Dike was removed to inundate 308 ha of the Nisqually National Wildlife Refuge (Refuge) in October 2009. Along with 57 ha wetlands restored by the Nisqually Indian Tribe, the Nisqually Delta represents the largest tidal marsh restoration project in the Pacific Northwest to assist in recovery of Puget Sound salmon and wildlife populations. Over the past decade, the Refuge and close partners, including the Tribe and Ducks Unlimited, have restored more than 35 km of the historic tidal slough systems and re-connected historic floodplains to Puget Sound, increasing potential salt marsh habitat in the southern reach of Puget Sound by 50%. More »

Restoration News

Restoration of the Nisqually Estuary: Tracking the Changes. The Flyway, Spring 2010. September 24, 2010. The restoration of the tides to 762 acres of the Nisqually Estuary in the fall of 2009 initiated many changes at the Refuge. As a mixture of fresh and saltwater habitats, the Nisqually Estuary provides critical habitats for a large variety of fish, wildlife and plants.

Recent Updates
- Reflections on the Water: Conversations About the Salish Sea
- Rivers and Tides: Restoring the Nisqually Estuary Video
Project Partners and Collaborators

Funding includes: EPA, ESRP, FWS (SSP and CCS), NFWF, and USGS YIF and SISNAR Internships

- Nisqually National Wildlife Refuge
- Nisqually Indian Tribe
- USGS Western Ecological Research Center
- USGS Pacific Coastal and Marine Geology
- USGS Western Fisheries Research Center
- USGS Washington Water Science Center
- Nisqually River Foundation
- Ducks Unlimited
- Nisqually Reach Nature Center
- Avian Design
- USGS Patuxent Wildlife Research Center
- Washington Department of Fish and Wildlife