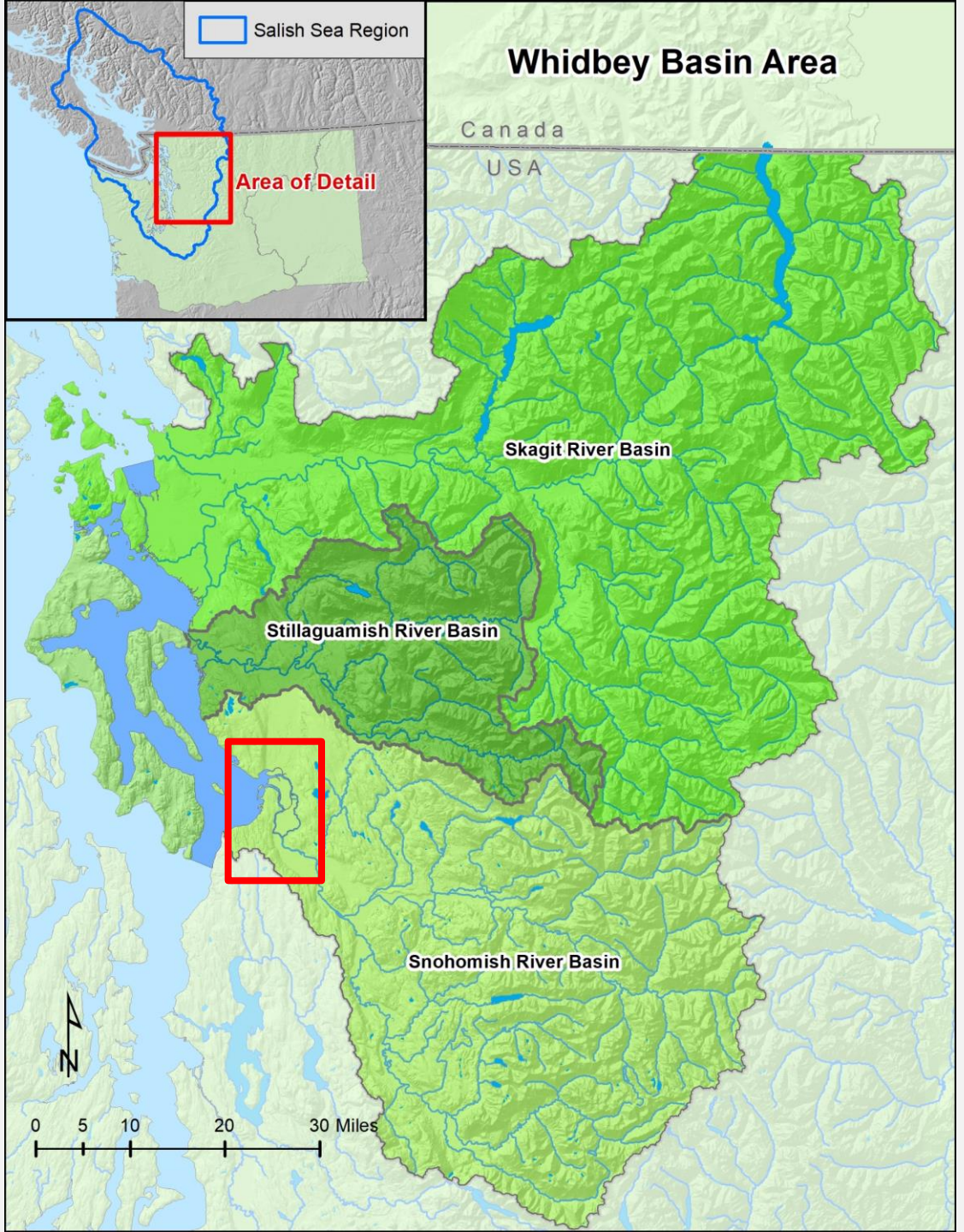
RESTORATION MONITORING IN THE SNOHOMISH RIVER DELTA

Promoting Effective Estuary Restoration Workshop – Monitoring Guidance, Data Tools, & Collaborative Platforms - May 6, 2025

Todd Zackey
Field Projects Manager
Tulalip Tribes Natural & Cultural Resources Department


Pacific Ocean
Salish Sea Region
Vancouver Island
Straight of Georgia
Canada
USA
Straight of Juan de Fuca
Whidbey Basin
Puget Sound
Pacific Ocean
Washington State
N
0 5 10 20 30 Miles


Salish Sea Region
Area of Detail
Whidbey Basin Area
Canada
USA
Skagit River Basin
Stillaguamish River Basin
Snohomish River Basin
N
0 5 10 20 30 Miles

Historic Estuary Extent = 15,642 acres

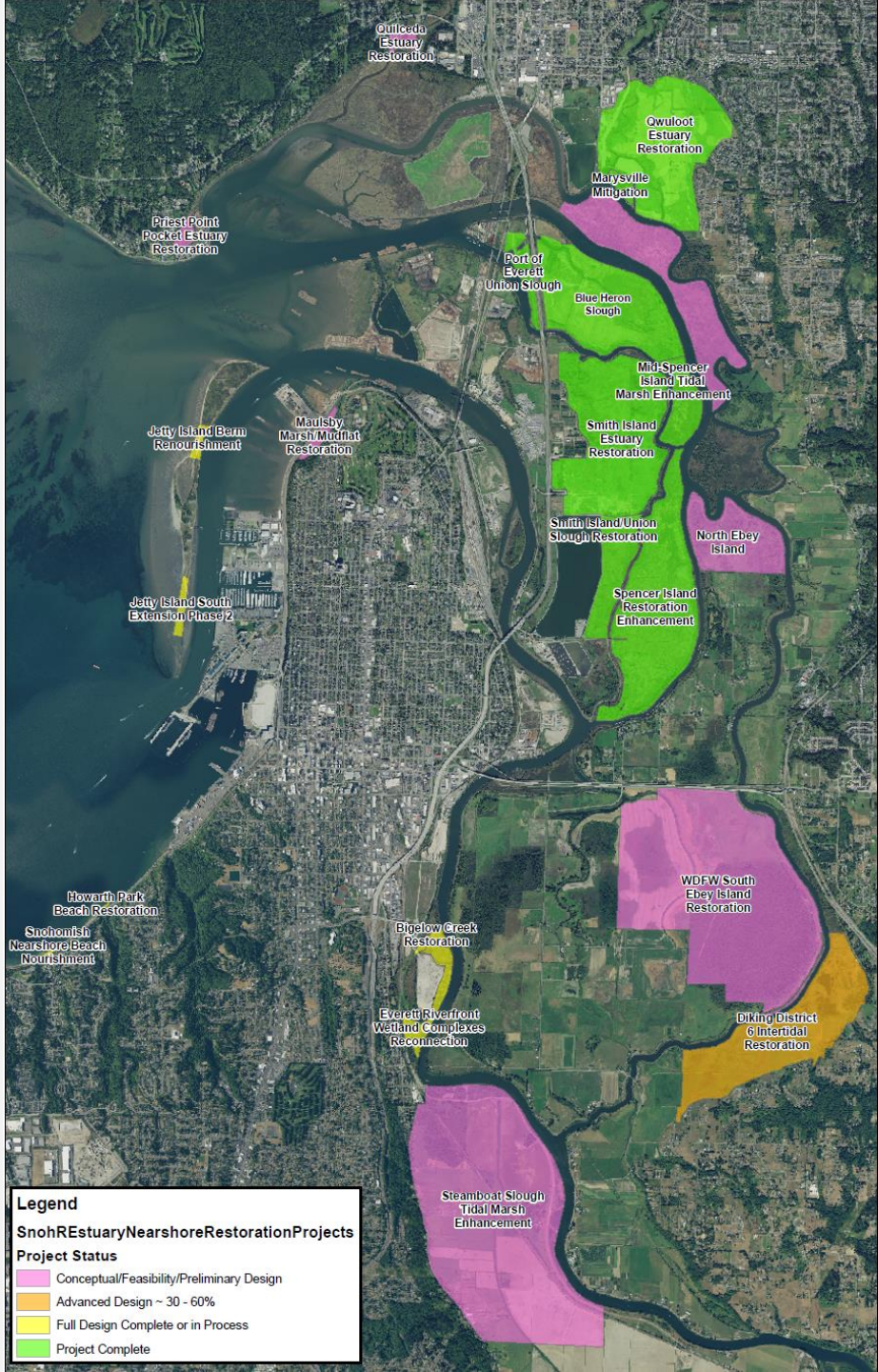
Remaining Estuary (pre-restoration) = 1,663 acres

Restoration work completed = 1,475 acres

Restoration projects in advance design = 376 acres

Restoration projects in conceptual design/feasibility stage = 2,647 acres

(Brophy et al 2019)



Snohomish River Estuary Monitoring Plan

Monitoring Plan for the Qwuloolt Restoration Project

DRAFT

Revised 3/26/11

Casimir Rice, Phil Roni, Jason Hall, Josh Chamberlin, Gregory Hood, Glenn Guntenspergen, Lyndal Johnson, Hiroo Imaki, Maria Calvi, Anna Portinga, Caren Crandell, and Lucinda Tear

Snohomish River Estuary Monitoring Plan

REVISED June 10, 2019

Aerial image of Quilceda Marsh in the lower Snohomish River estuary. Available: https://fortress.wa.gov/ecy/shorephotoviewer/

Jason Hall [1], Joshua Chamberlin [2], Todd Zackey [3], Holly Zox [4], Michelle Totman [3], and Casimir Rice [5].

[1] Cramer Fish Sciences, Watershed Sciences Lab (Email: Jason.Hall@fishsciences.net) [2] National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center, Watershed Program (Joshua.Chamberlin@noaa.gov); [3] Tulalip Tribes Natural and Cultural Resources Department (Email: tzackey@tulaliptribes-nsn.gov); and [4] One Horse Enterprises (Email: cj_haz@hotmail.com); [5] Posthumous recognition of contributions while working at National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center, Watershed Program.

https://salishsearestoration.org/wiki/Snohomish_Delta_Ecosystem_Monitoring_and_Evaluation

Restoration Goals:

"Restore historical tidal circulation processes and functions to the Qwuloolt Estuary, and move the biological integrity and function of the site towards comparable natural habitats of the region."

(1) Topography:
Allow maximum tidal inundation.
Maintain and develop elevation, soil conditions, and hydrologic connectivity favorable to native biota historically present.

(2) Hydrology:
Maximum tidal inundation.
Temperature, salinity, and dissolved oxygen favorable to native biota historically present.

(3) Biota:
Character of the biota onsite returns over time to a condition similar to that historically present.

(4) Society:
No major adverse effects to property and infrastructure.
Positive contribution to natural and cultural heritage of the community in terms of conservation, education, and recreation.
Positive contribution to restoration science and practice

Focus Areas	Monitoring Element	Monitoring Component	Project Scale	System Scale
Topography	Sediment & Elevation	Marker horizons (MHs)	**Core**	Supp.
		RSETs with MHs	**Core**	Supp.
		UAV and LiDAR	**Core**	Supp.
		RTK/veg grid transects	**Core**	Supp.
		Sediment pins	Supp.	Supp.
		Soils	Supp.	Supp.
	Bathymetry	Multi/single-beam sonar	Supp.	Supp.
Hydrology	Temp & Salinity	Continuous water sensors	**Core**	**Core**
		Point measurements	**Core**	**Core**
		Water column profiles	Supp.	Supp.
	Inundation	Continuous water sensors	**Core**	**Core**
	Water quality	DO, pH, nutrients, contaminants	Supp.	Supp.
	Flow	River discharge	**Core**	**Core**
		Point measurements	Supp.	Supp.
		Channel cross-sections	Supp.	Supp.
Biota	Fish	Beach seining	**Core**	**Core**
		Smolt trapping	**Core**	**Core**
		Fyke trapping	**Core**	Supp.
		Otolith microstructure	Supp.	Supp.
		Tissue contaminants	Supp.	Supp.
		Genetic mark-recapture DNA	Supp.	Supp.
	Vegetation	RTK/veg grid transects	**Core**	Supp.
		Intensive quadrats	**Core**	Supp.
		UAV and Aerial Imagery	Supp.	Supp.
	Birds	Marsh bird point counts	Supp.	Supp.
	Invertebrates	Benthic coring	Supp.	Supp.
		Nueston sampling	Supp.	Supp.
		Fallout trapping	Supp.	Supp.
		Salmon diets	Supp.	Supp.
	Beaver	Dam, slide, and den surveys	Supp.	Supp.
Qualitative	Visual record	Photo points and observations	**Core**	Supp.
		Timelapse photography and video	**Core**	Supp.
		UAV and Aerial Imagery	**Core**	Supp.

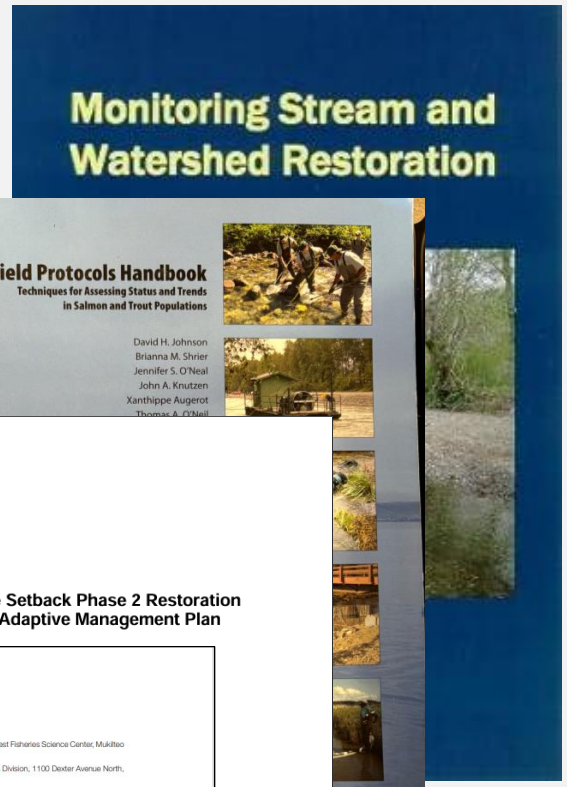
Core and supplemental monitoring elements for project and system scale monitoring

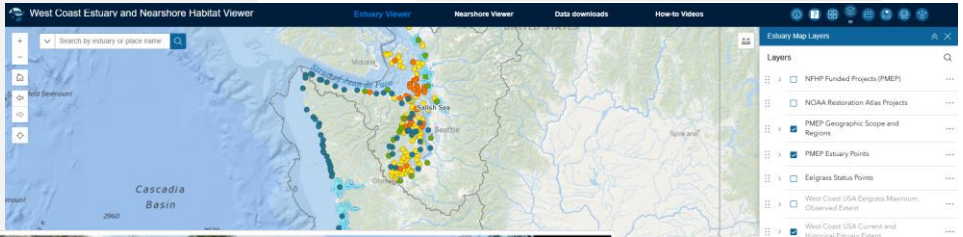
Monitoring Methods Sources

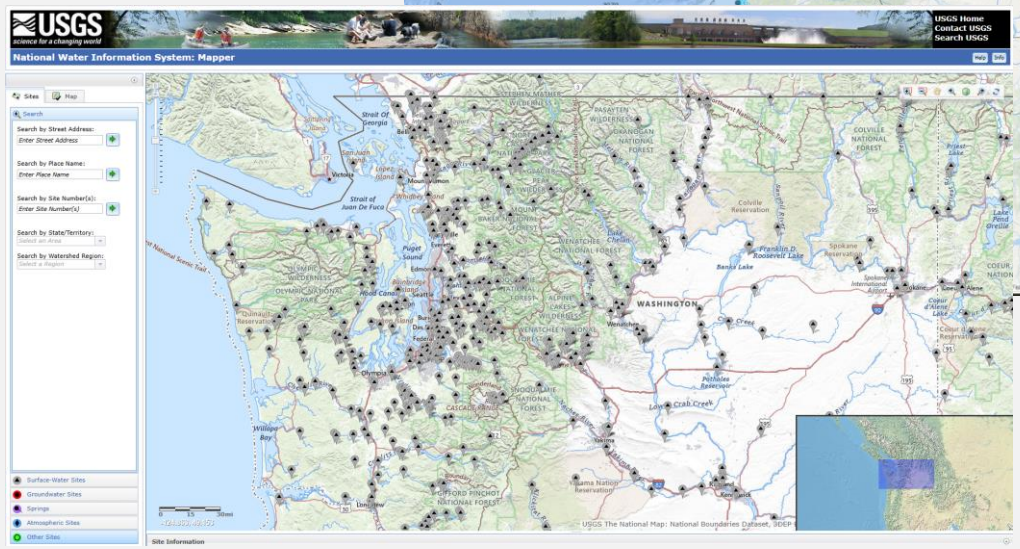
- Books & Scientific Journals
- Reports, white papers, grey literature
- Webpages
- Webtools

Content Creators:

- Universities Research Institutes
- Governments
- Tribes
- NGOs
- Consultants
- Others







Historic and Change Analysis Data

PMEP

Home About Projects Library Data Committee Portal News

Data Products

Home › Data Products

Applications

Estuary and Nearshore Habitat Viewer

This map viewer highlights spatial data products developed by PMEP to characterize habitats and synthesize information in support of habitat conservation and restoration goal setting. Most of the data presented in this viewer are available for download below.

West Coast Estuaries Explorer

This application is useful for quickly comparing estuaries to each other along the coastlines of Washington, Oregon, and California. Using dynamic filters and an interactive map you can find estuaries that meet specific criteria; or estuaries that provide habitat for focal species of interest to you.

West Coast USA Current and Historical Estuary Extent

This layer represents the current and historical tidal wetlands, or estuary extent, for the West Coast of the contiguous United States.

PMEP Estuary Points

This layer represents estuaries, as points, in the Pacific Marine and Estuarine Fish Habitat Partnership's (PMEP) spatial data system.

West Coast USA Estuarine Biotic Habitat

These data represent the Biotic Component (BC) of the Coastal and Marine Ecological Classification Standard (CMECS) for estuaries of the West Coast of the contiguous United States.

West Coast USA Eelgrass (Zostera sp.) Habitat

This package of map layers represents the presence and maximum observed extent of eelgrass (Zostera sp.) habitat on the West Coast of the United States (Washington, Oregon, and California), based on the best available existing spatial data showing the current and historic extent of eelgrass in the region.

https://www.pacificfishhabitat.org/

Puget Sound River History Project

Home | People | Research | Data | Atlas

Historical GIS data for Puget Sound available for download from this site

19th century Coast Survey topographic sheets (T-sheets)

19th century public land survey plat maps

1930s-era aerial photography

Additional GIS data

Puget Sound Lidar Consortium
Gemorphological Research Group (regional raster & vector data)

Additional non-GIS source data

19th century land survey field notes (links to BLMsite)

web server note: *Our 12-year-old java zoom/pan scripts have stopped working in 2016. Please accept our weak substitutes.*

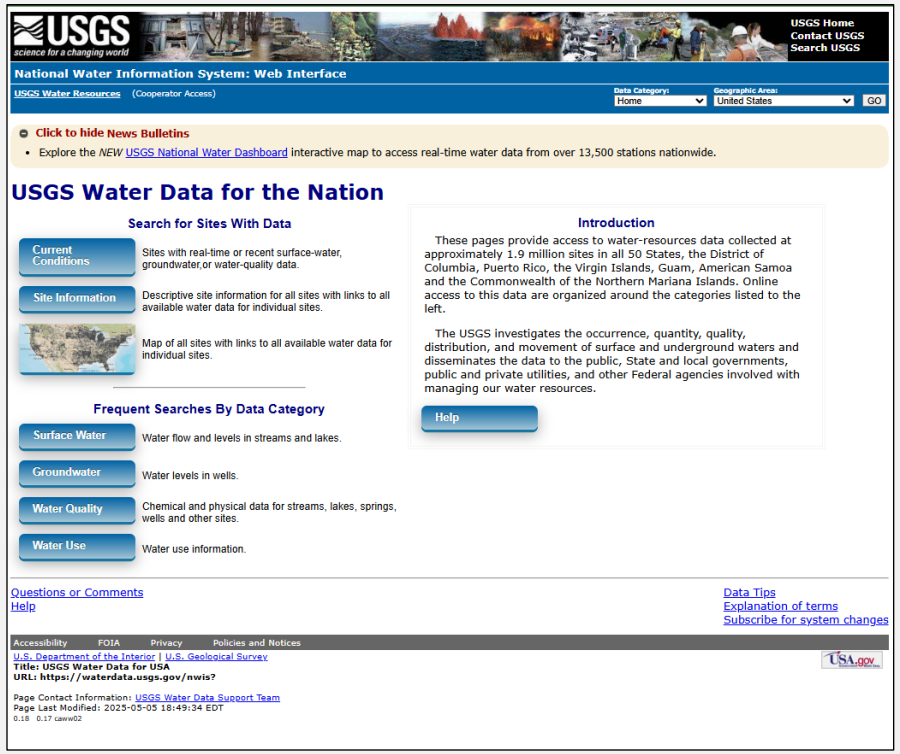
Home | People | Research | Data | Publications | Atlas

https://riverhistory.ess.washington.edu/data.php

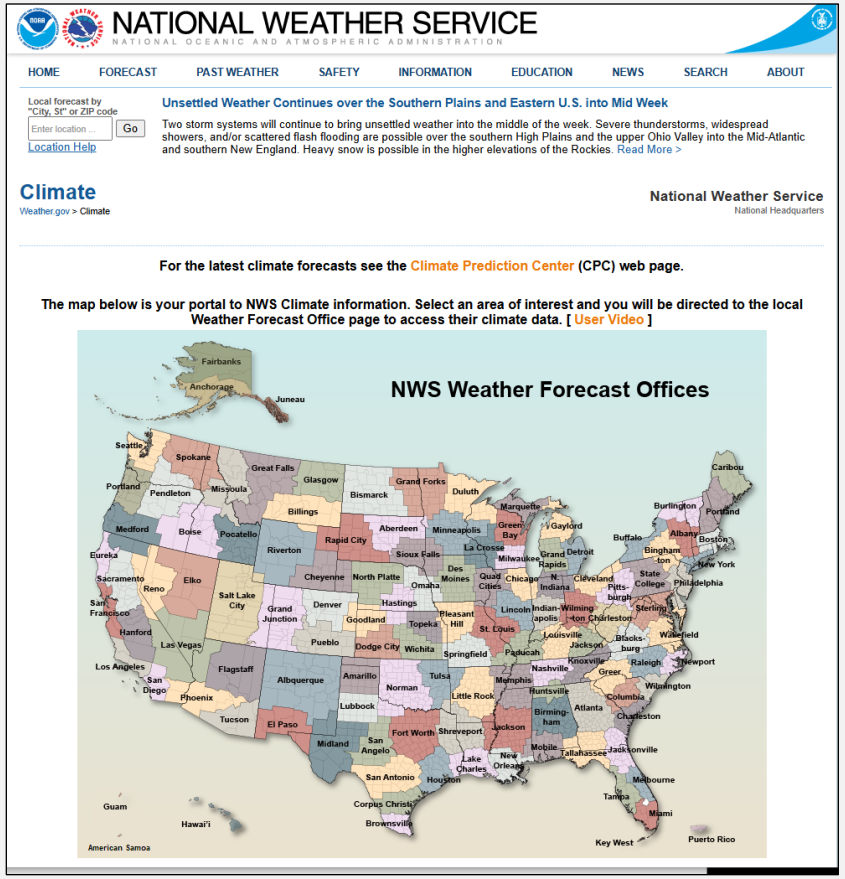
Hydrology and Water Chemistry

Hydrologic monitoring network needs additional info to correct and analyze data

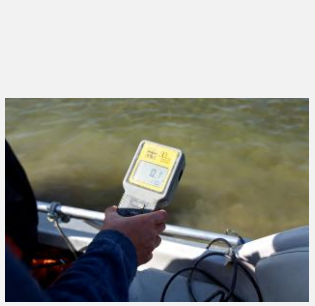
- Base flow data from USGS Streamflow data
- Atmospheric Pressure from local NWS station for depth logger correction

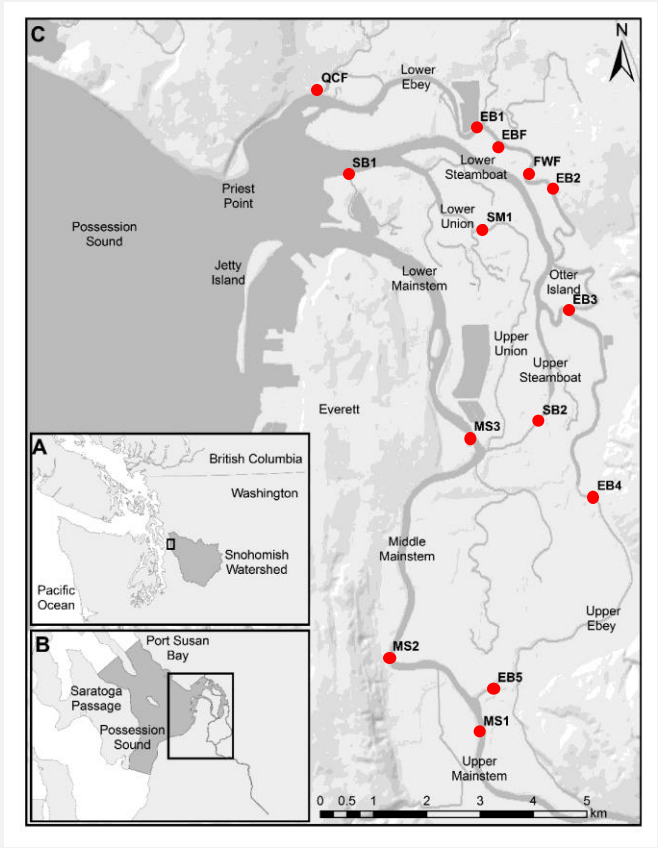


https://waterdata.usgs.gov/nwis



https://www.weather.gov/wrh/climate





Elevation - LiDAR

Puget Sound Lidar Consortium

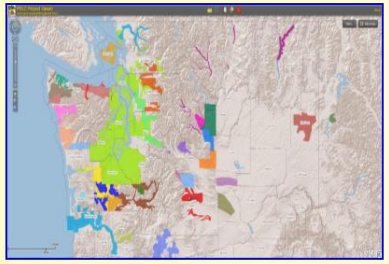
Home | About Lidar | About the PSLC | Data | Uses of Lidar data | Links | Contact us

PSLC Data by Project

PSLC datasets consist of Bare Earth and Top surface Elevation Rasters, Bare earth point data and All-returns point data. The raster data is available in USGS quarter quads and most are also available as mosaic File Geodatabases.

PSLC projects shapefile - Nov 2017

Back to Download Data Menu

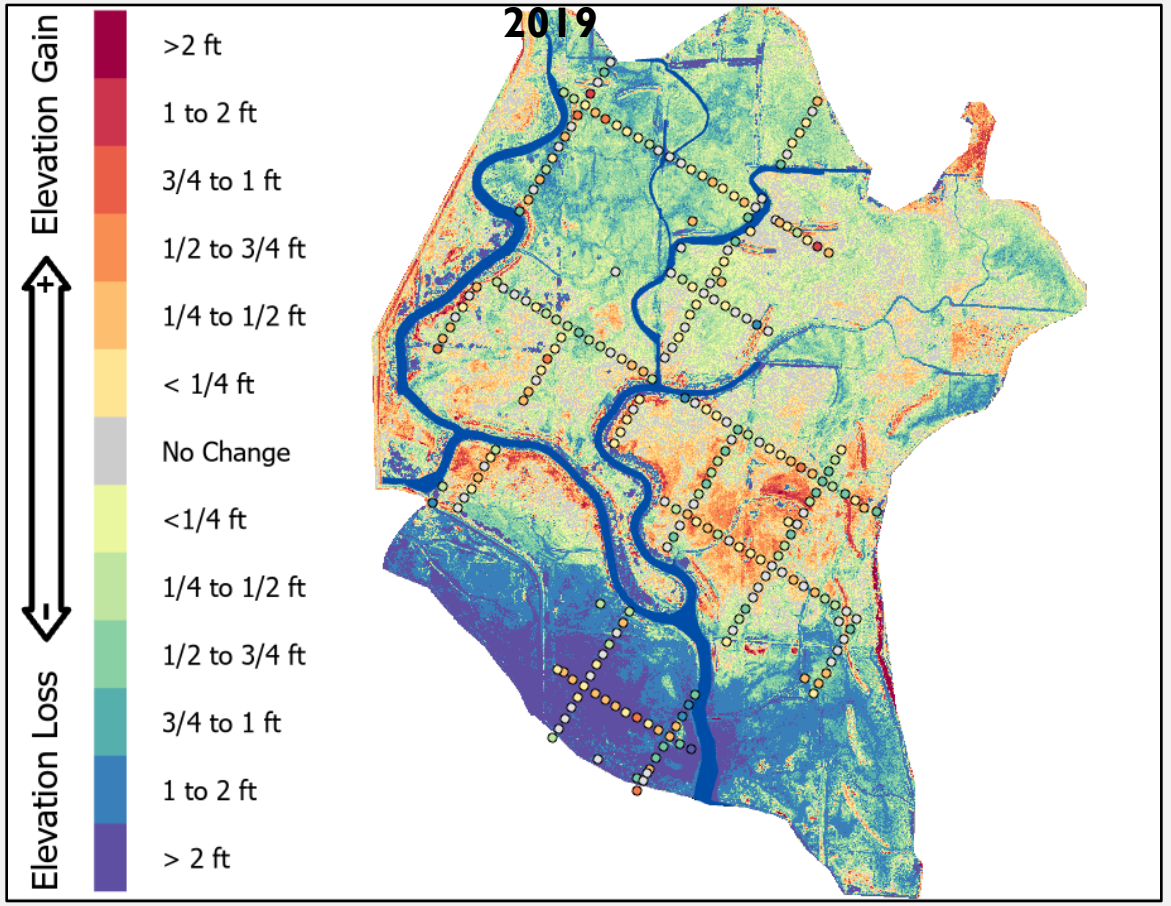


PSLC Project Viewer

Projects	Acquisition Year	General Geography	Map
Puget Sound Lowlands	2000 to 2005	Partial coverage of King, Pierce, Snohomish, Jefferson and Mason Counties. Full Coverage of Kitsap, Island and Thurston counties.	MAP
Clallam County	2001-2002	Partial Coverage from the north eastern county to past Joyce. And also an area in the vicinity from Forks to La Push.	MAP
Lewis County	2003	Small section of the Snoqualmie National Forest, northwest of Packwood.	MAP
Yakima County	2003	Partial coverage of the county along the Ahtanum Creek.	MAP
Portland, Oregon	2004	Partial coverage of the following cities: Lake Oswego, Gladstone, West Linn, Oregon City.	MAP
Lewis County	2005	Partial coverage of central Lewis County.	MAP
Lower Columbia River	2005	Lower Columbia River from Bonneville Dam to the Pacific Ocean.	MAP
Olympic Peninsula	2005	Coverage in the vicinity of Sekiu. Coveing parts of the following: Hoko River, Clallam River and Reed Creek.	MAP
Yakima County	2005	Area covering part of Cowiche Creek, Toppenish Creek and Yakima River.	MAP
Lewis County	2006	Partial coverage of Western Lewis County.	MAP
Eastern Washington and Oregon River Corridors	2007	John Day, Lower and Upper Okanogan, Methow and Wenatchee rivers. Lake Roosevelt.	MAP
Sumpter, Oregon	2007	Partial coverage of City of Sumpter and the Powder River.	MAP
San Juan County and Lummi Island	2009	Partial coverage of San Juan County. Lummi Island, Point Roberts.	MAP
Umpqua River, Oregon	2009	Partial coverage of the river. Northwest of Sutherlin.	MAP
Nooksack River	2009	Coverage from Strandell to south of Acme.	MAP
Snohomish River Estuary	2009	From the mouth of the River to South of the City of Snohomish.	MAP

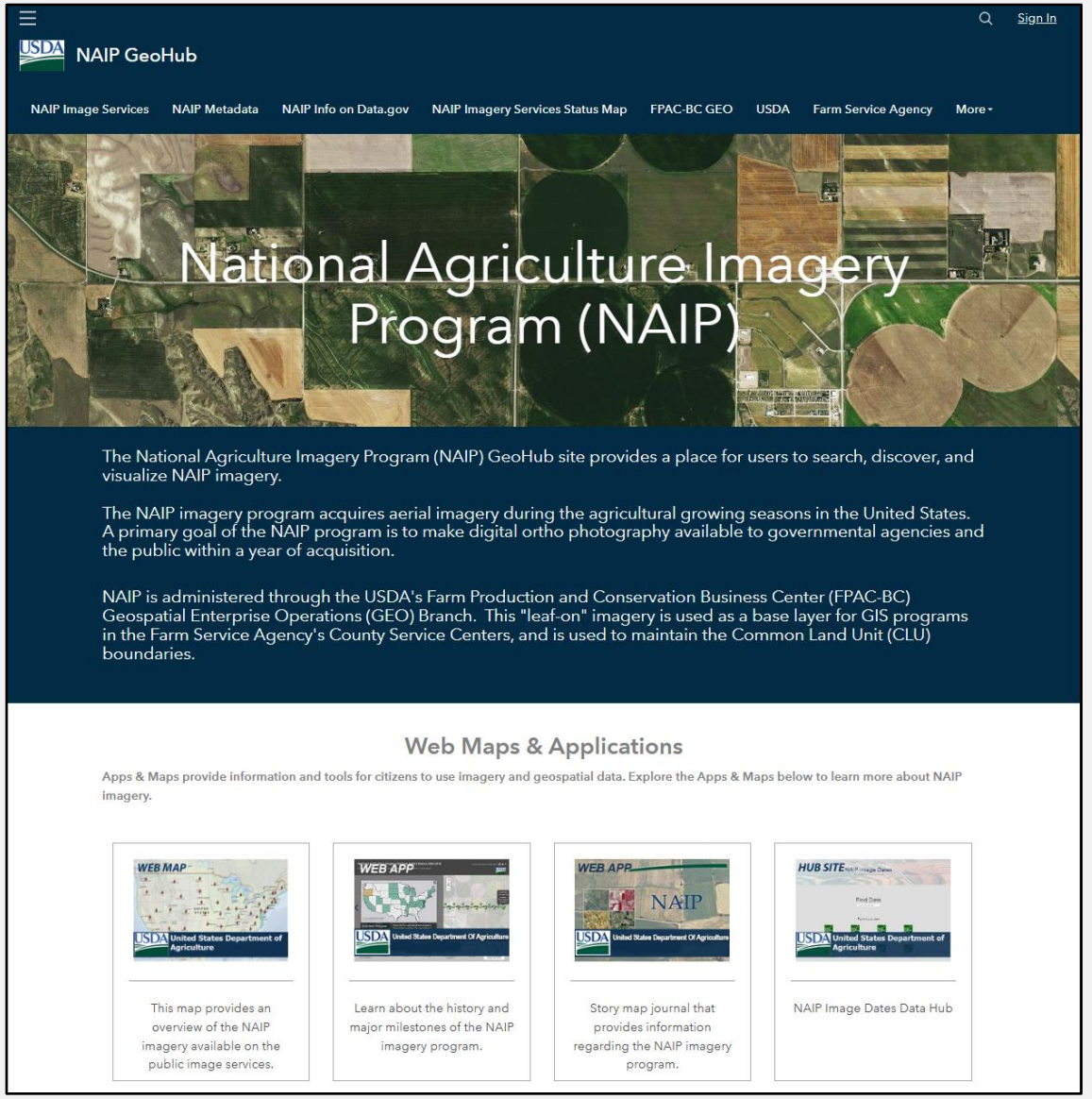
https://pugetsoundlidar.ess.washington.edu/index.html

Remotely Sensed and RTK Elevation Change Assessments in Qwuloolt 2016 - 2019



Aerial & Satellite Imagery – *National Agricultural Inventory Program/ Earth Resources Observation & Science Center*

https://www.usgs.gov/centers/eros/data

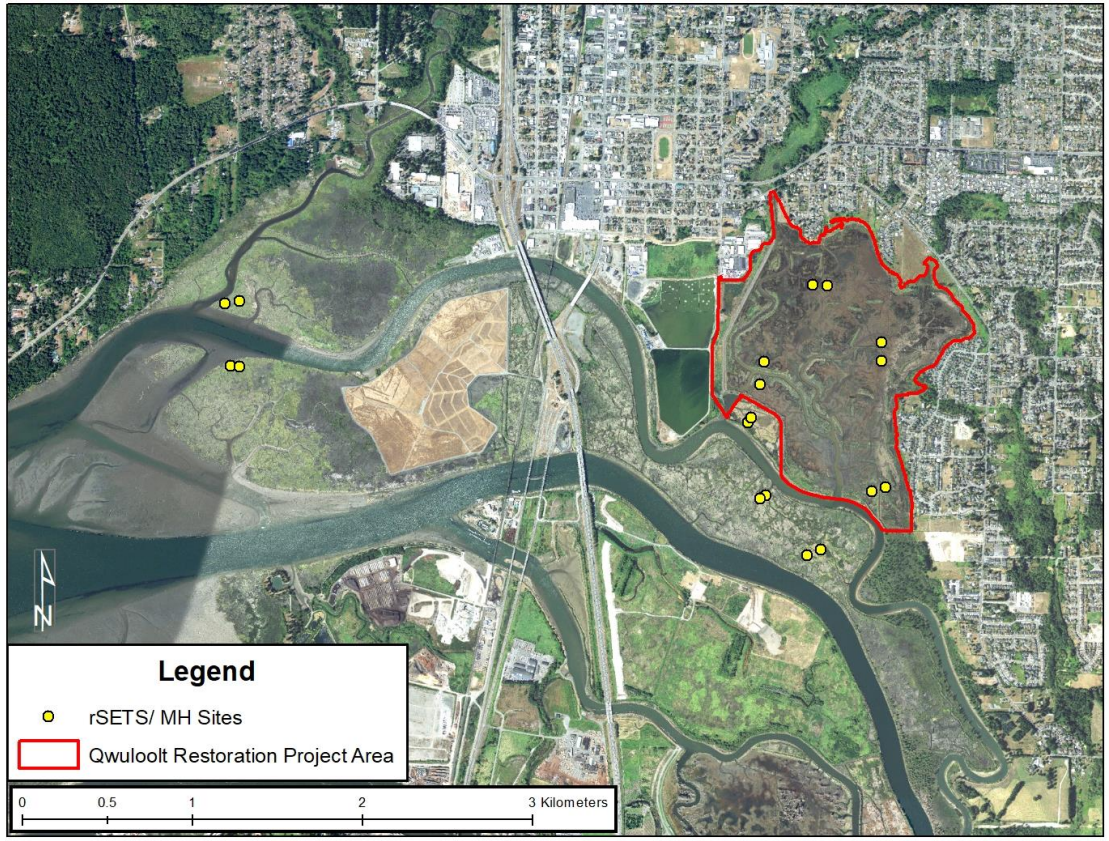


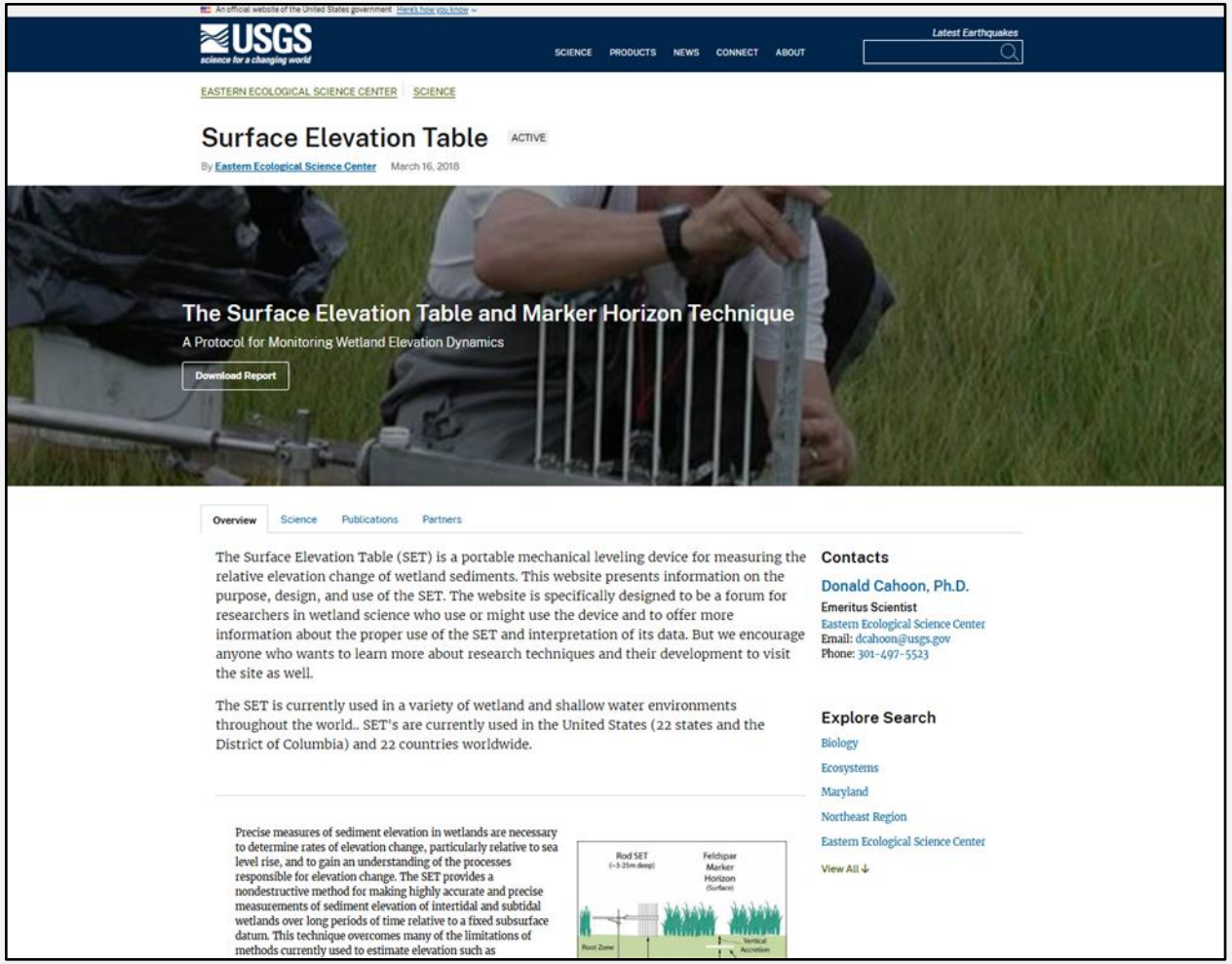
https://naip-usdaonline.hub.arcgis.com/

Sediment Accretion/Erosion

We utilize Sediment Elevation Tables (SETs) and horizon markers to track elevation changes in restoration and reference sites

Utilize USGS methods available on their website





https://www.usgs.gov/centers/eesc/science/surface-elevation-table

Vulnerability to Sea-Level Rise Varies Among Estuaries and Habitat Types: Lessons Learned from a Network of Surface Elevation Tables in Puget Sound

Melanie J. Davis1 · Katrina L. Poppe · John M. Rybczyk · Eric E. Grossman · Isa Woo · Joshua W. Chamberlin · Michelle Totman · W. Todd Zackey · Frank Leonetti · Suzanne Shull · Susan E.W. De La Cruz

Avian Monitoring

- Initially partnered with local Audubon Society
- Tulalip Wildlife Program did surveys
- A monitoring frame work was developed by local scientists

Standardized North American Marsh Bird Monitoring Protocol

COURTNEY J. CONWAY[1]

U.S. Geological Survey, Arizona Cooperative Fish and Wildlife Research Unit, 325 Biological Sciences East, School of Natural Resources and the Environment, University of Arizona, Tucson, Arizona, 85721,USA

[1]Present address: U.S. Geological Survey, Idaho Cooperative Fish and Wildlife Research Unit, P.O. Box 441141, CNR Room 103E 6th & Line Streets, University of Idaho, Moscow, ID 838444, USA

E-mail: cconway@usgs.gov

Abstract.—Little is known about the population status of many marsh-dependent birds in North America but recent efforts have focused on collecting more reliable information and estimates of population trends. As part of that effort, a standardized survey protocol was developed in 1999 that provided guidance for conducting marsh bird surveys throughout North America such that data would be consistent among locations. The original survey protocol has been revised to provide greater clarification on many issues as the number of individuals using the protocol has grown. The Standardized North American Marsh Bird Monitoring Protocol instructs surveyors to conduct an initial 5-minute passive point-count survey followed by a series of 1-minute segments during which marsh bird calls are broadcast into the marsh following a standardized approach. Surveyors are instructed to record each individual bird from the suite of 26 focal species that are present in their local area on separate lines of a datasheet and estimate the distance to each bird. Also, surveyors are required to record whether each individual bird was detected within each 1-minute subsegment of the survey. These data allow analysts to use several different approaches for estimating detection probability. The Standardized North American Marsh Bird Monitoring Protocol provides detailed instructions that explain the field methods used to monitor marsh birds in North America. *Received 26 January 2011, accepted 2 April 2011.*

Key words.—bitterns, call-broadcast surveys, detection probability, marsh birds, rails, tape playback.

Waterbirds 34(3): 319-346, 2011

https://pubs.usgs.gov/publication/70034495

Takes you to a link where you can download the paper

SALISH SEA ESTUARIES AVIAN MONITORING FRAMEWORK

FINAL REPORT

Prepared by: Amanda Summers (Stillaguamish Tribe), Trina Bayard (Audubon Washington), Catie Porro (Ecostudies Institute), Nicole Michel (Audubon Washington), Gary Slater (Ecostudies Institute), and Kyle Spragen (Washington Department of Fish and Wildlife.

30 June 2023

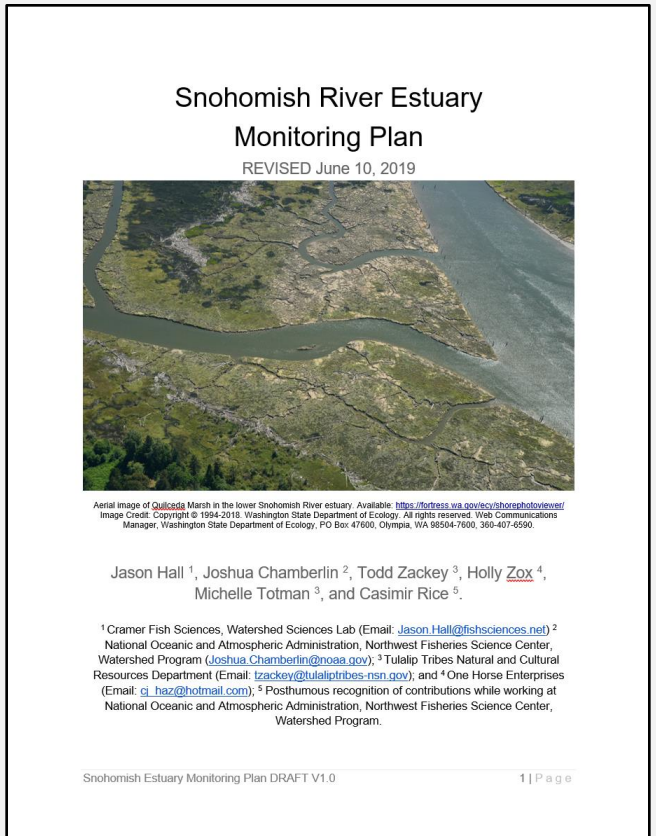
https://ecoinst.org/

Fish Sampling

- The study design for fish sampling was developed by staff at NOAA Northwest Fisheries Science Center

- Utilized standard sampling methods which can be found in the, *Salmonid Field Protocols Handbook*

- Methods can also be found in the, *Snohomish River Estuary Monitoring Plan Report* – available on the Salish Sea Restoration Platform



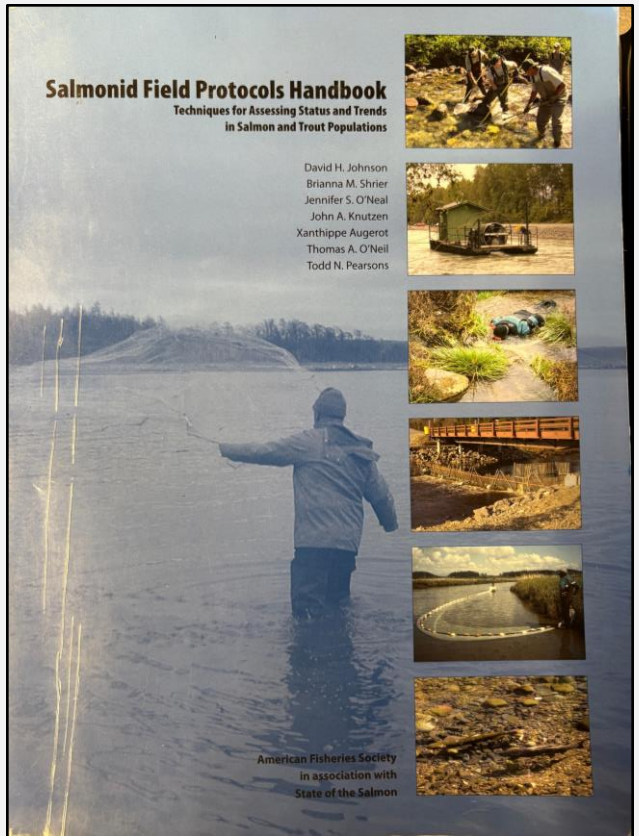
Snohomish River Estuary
Monitoring Plan

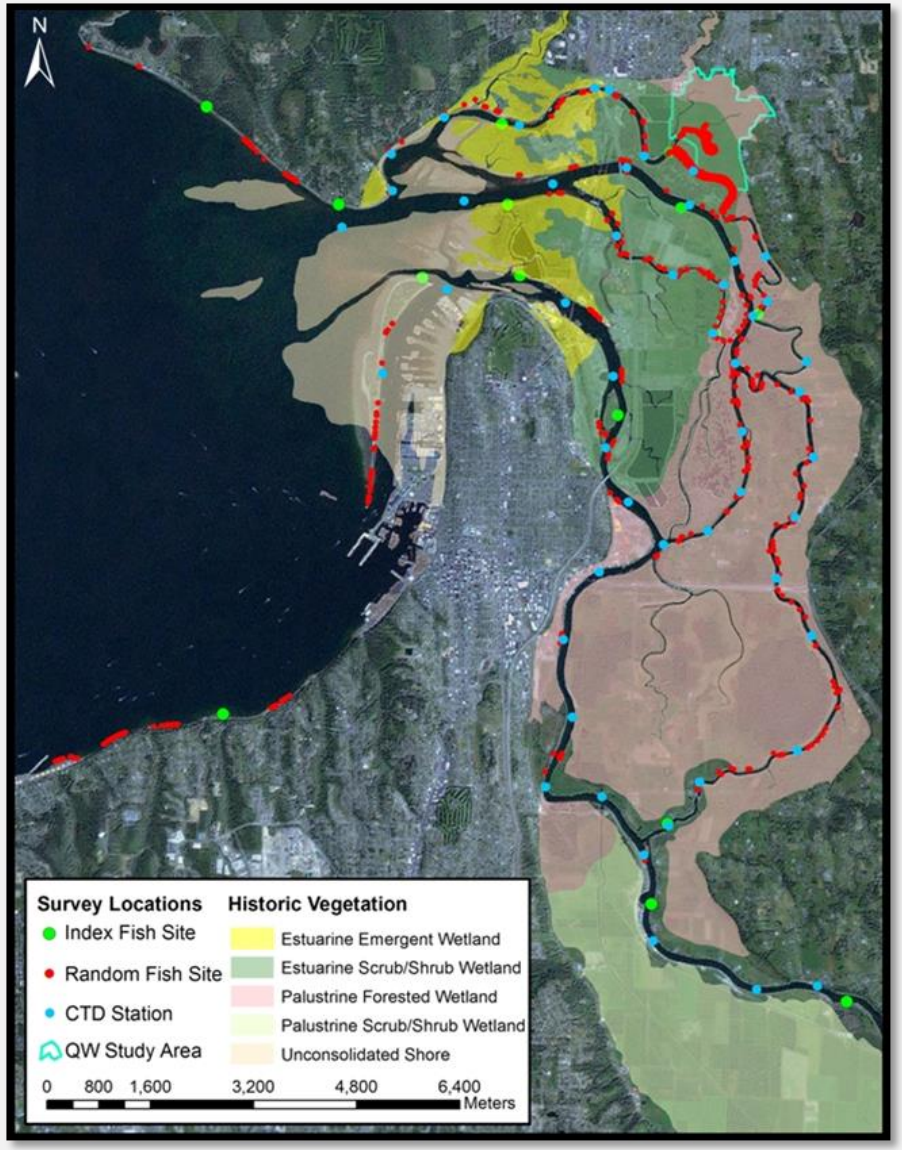
REVISED June 10, 2019

Aerial image of Quilceda Marsh in the lower Snohomish River estuary. Available: https://fortress.wa.gov/ecy/shorephotoviewer/
Image Credit: Copyright © 1994-2018, Washington State Department of Ecology. All rights reserved. Web Communications Manager, Washington State Department of Ecology, PO Box 47600, Olympia, WA 98504-7600, 360-407-6590.

Jason Hall [1], Joshua Chamberlin [2], Todd Zackey [3], Holly Zox [4], Michelle Totman [3], and Casimir Rice [5].

[1] Cramer Fish Sciences, Watershed Sciences Lab (Email: Jason.Hall@fishsciences.net) [2] National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center, Watershed Program (Joshua.Chamberlin@noaa.gov); [3] Tulalip Tribes Natural and Cultural Resources Department (Email: tzackey@tulaliptribes-nsn.gov); and [4] One Horse Enterprises (Email: cj_haz@hotmail.com); [5] Posthumous recognition of contributions while working at National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center, Watershed Program.





Invertebrates

Stationary sampling posts

Reliant on flow rate ~>0.01m/s to collect invertebrates

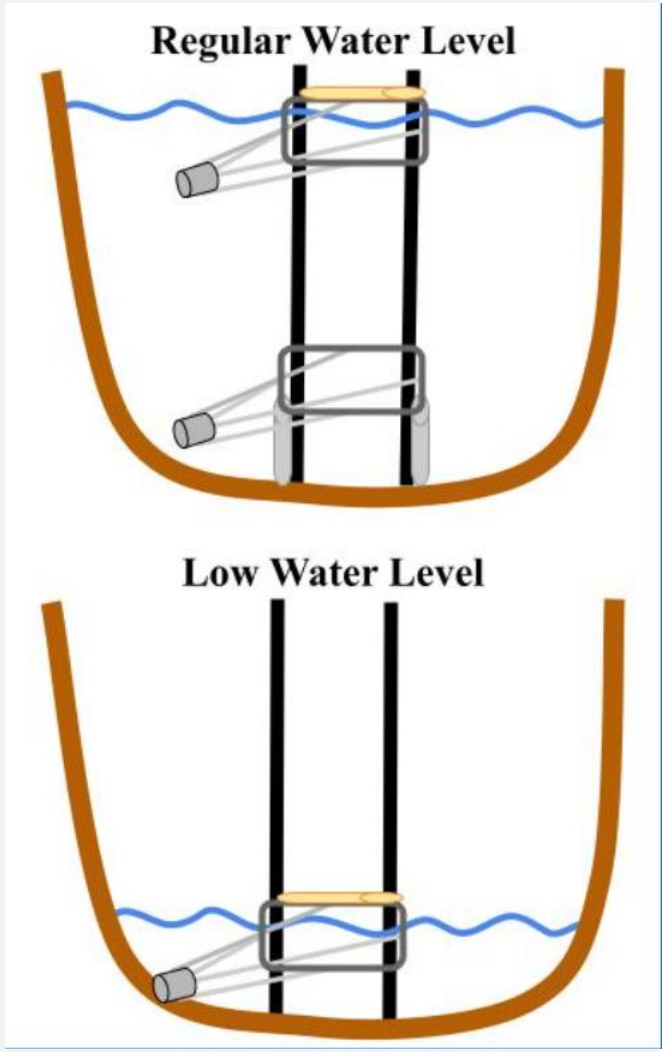
Laboratory Work

Identification down to the order level for all organisms

Organisms were filtered into three size fractionations (0.5mm, 1.0mm and 5.6mm)

Ash-Free Dry Weight

After Identification, the 1.0mm and 5.6mm organisms were recombined for AFDW



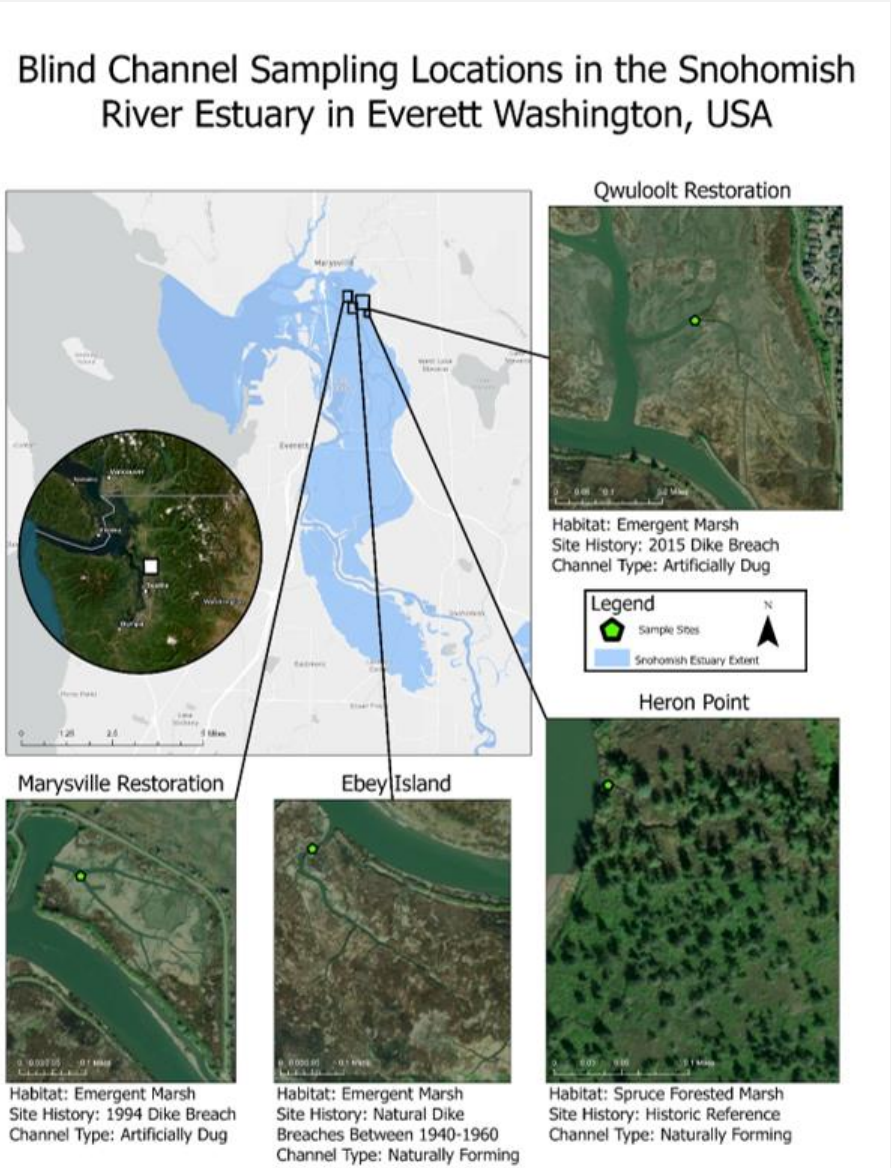
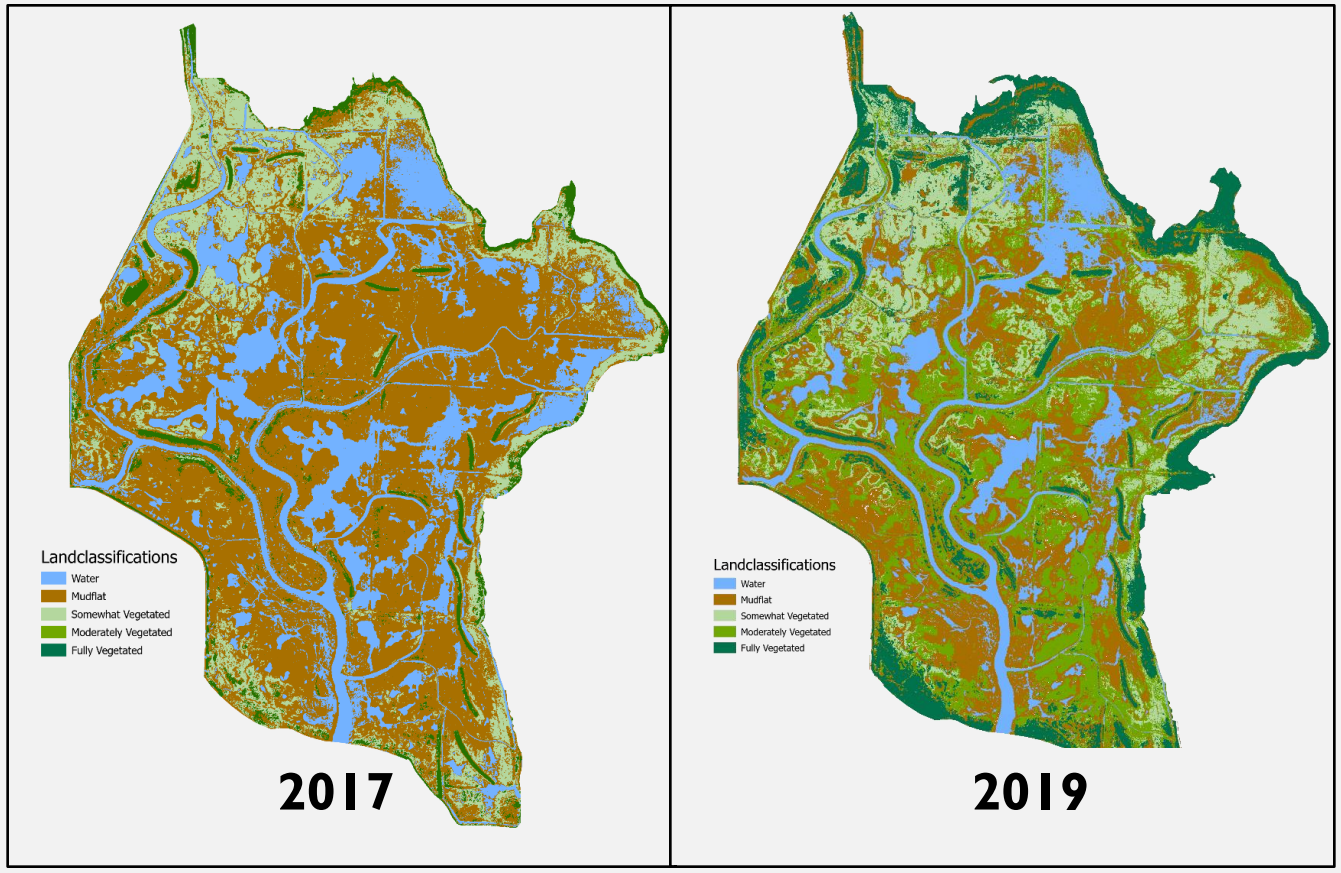


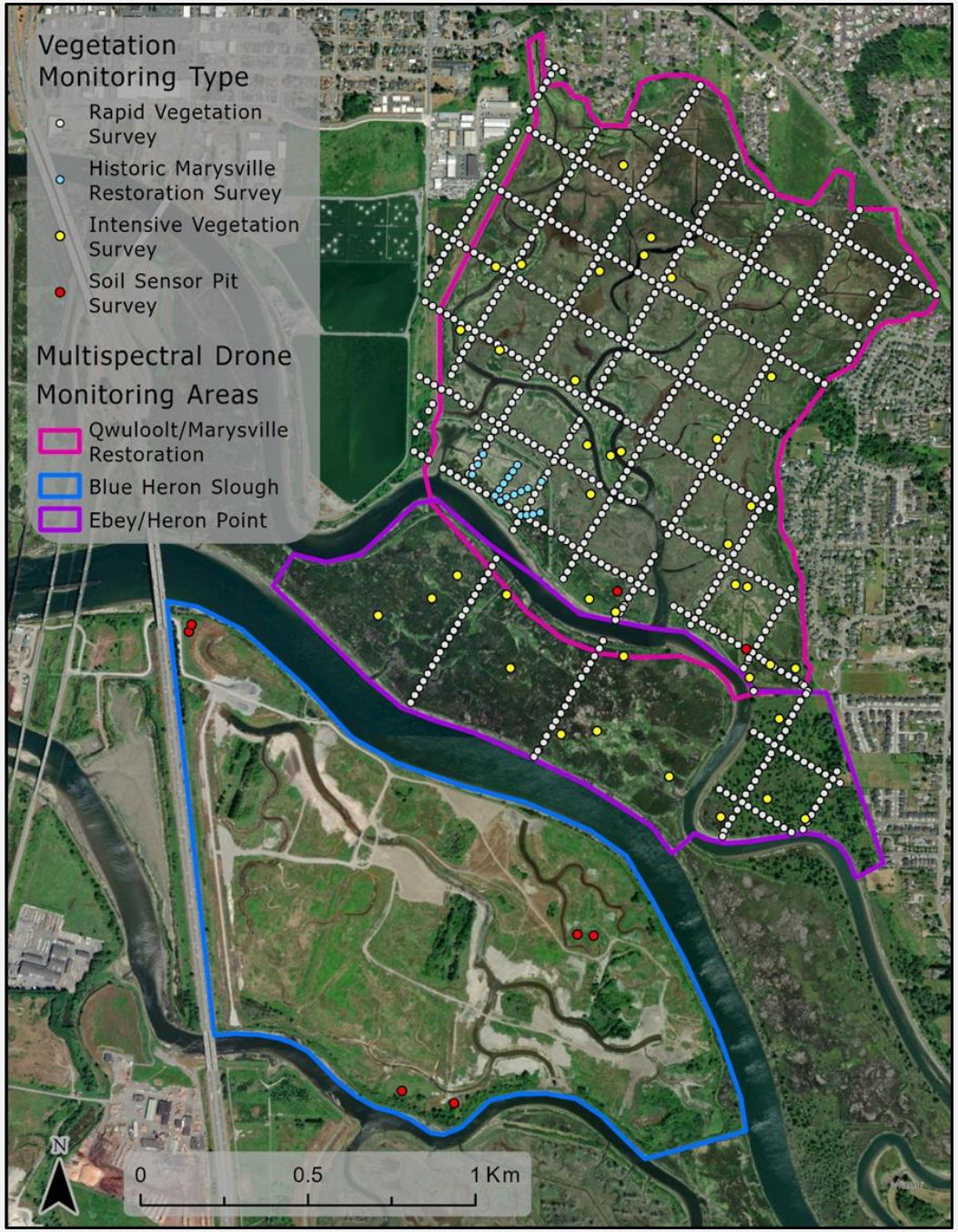
Figure 1. Invertebrate sampling locations within blind channels in the lower Snohomish Estuary. Estuary extent is from the Pacific Marine and Estuarine Fish Habitat Partnership (PMEP 2019). Map created in ARCGIS Pro 3.2.0.

Vegetation Monitoring

Initially worked with experts from University of Washington and USACE for vegetation monitoring plan.

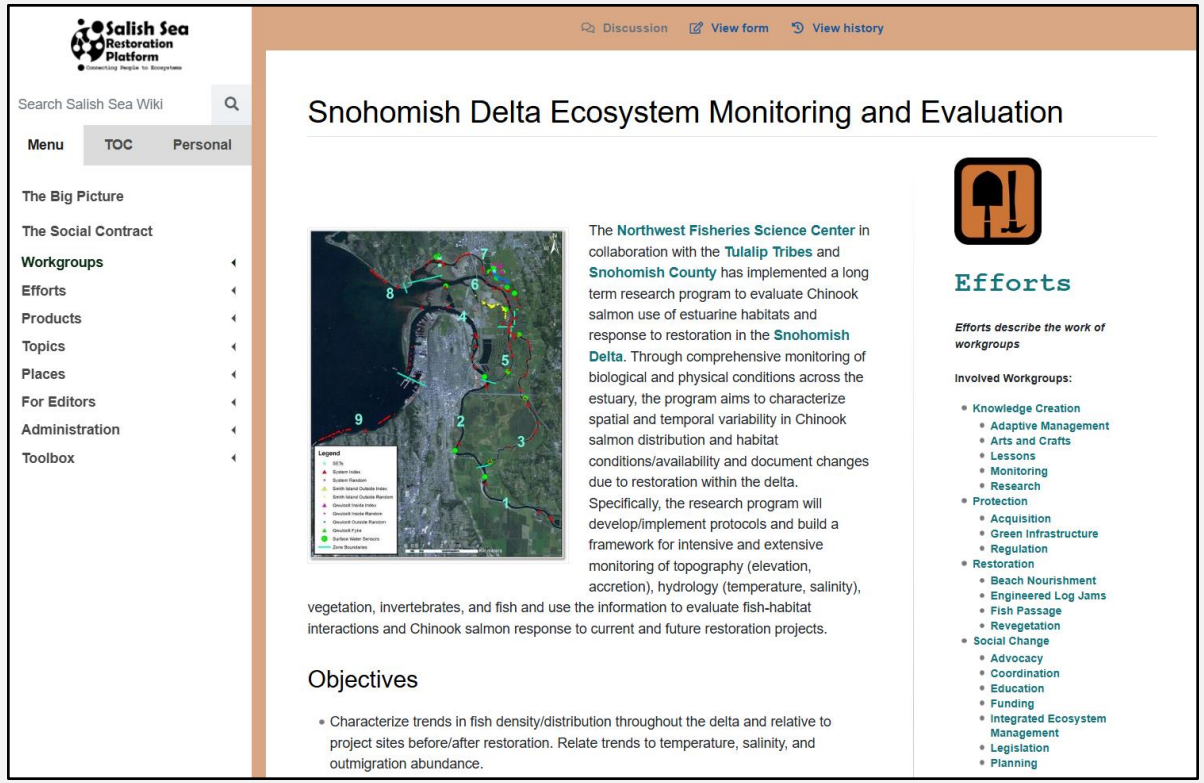
Ultimately we designed our own plan utilizing a variety of methods





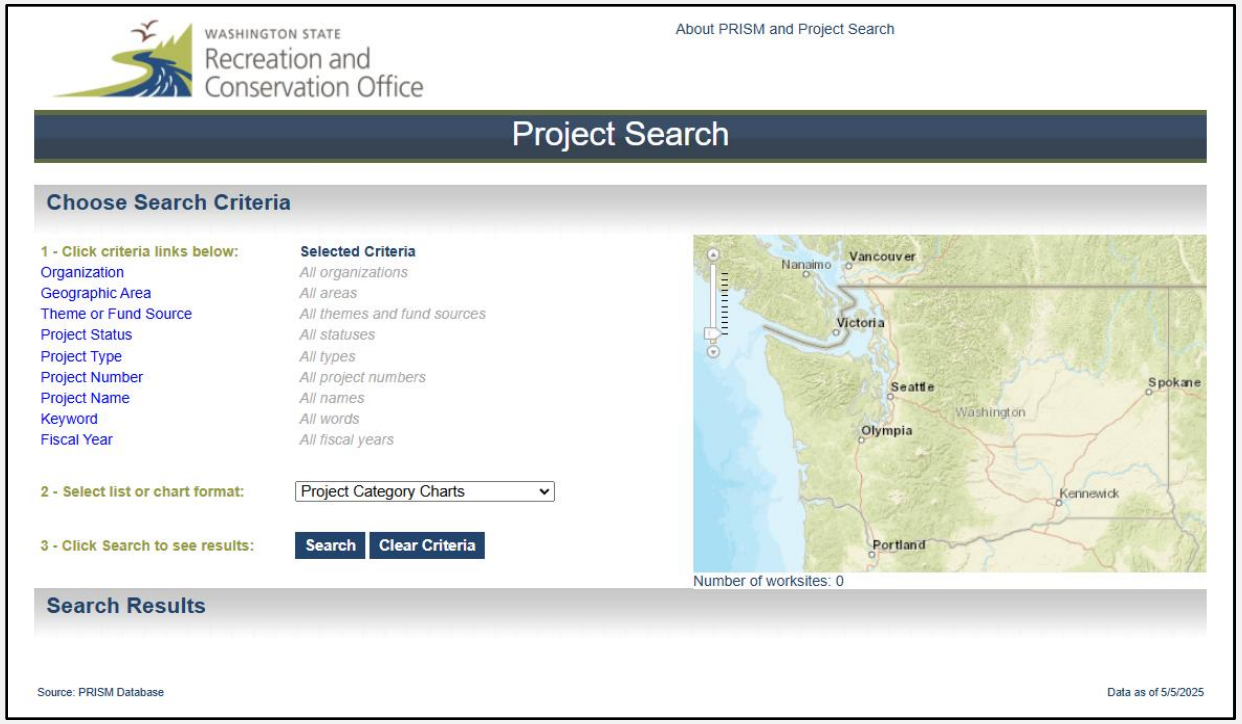
Specific Restoration Site Information

Salish Sea Restoration Platform



https://salishsearestoration.org/

PRISM Project Search



https://secure.rco.wa.gov/prism/search/projectsearch.aspx

Other Sources for Methods Documents

State and Federal Environmental Agencies

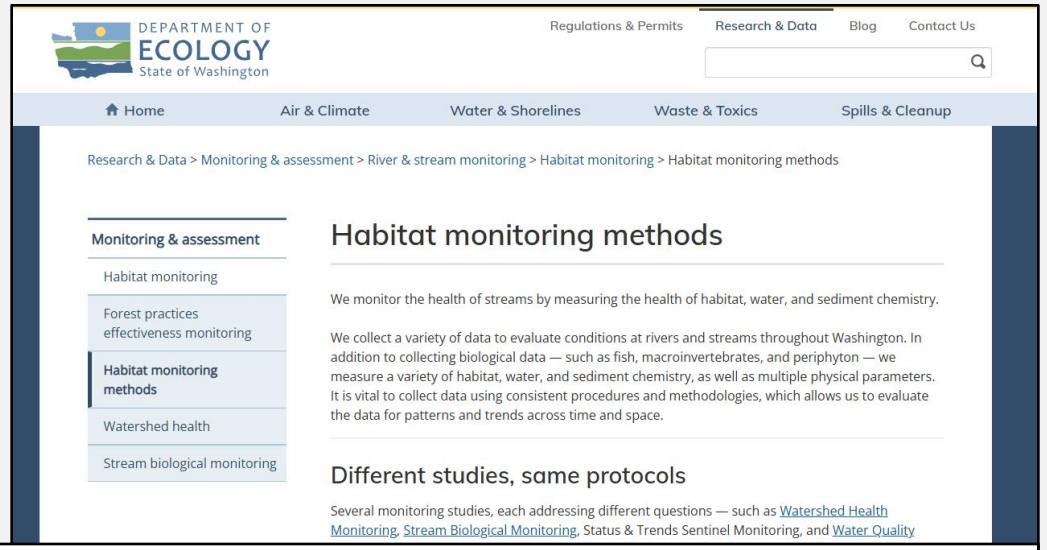
Quality Assurance Project Plans (QAPPs)

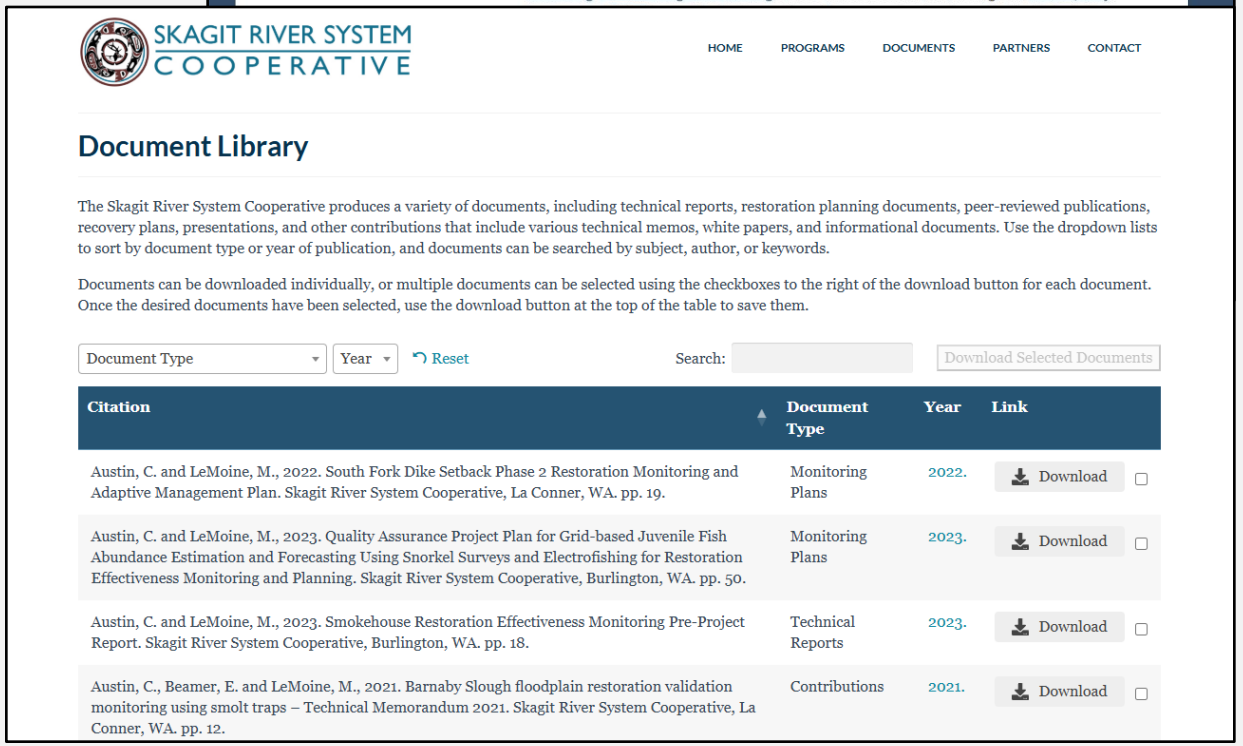
- Washington Dept of Ecology
  - https://ecology.wa.gov/research-data/monitoring-assessment/river-stream-monitoring/habitat-monitoring

Research Centers and NGOs

Tribal Environmental and Natural Resources Depts

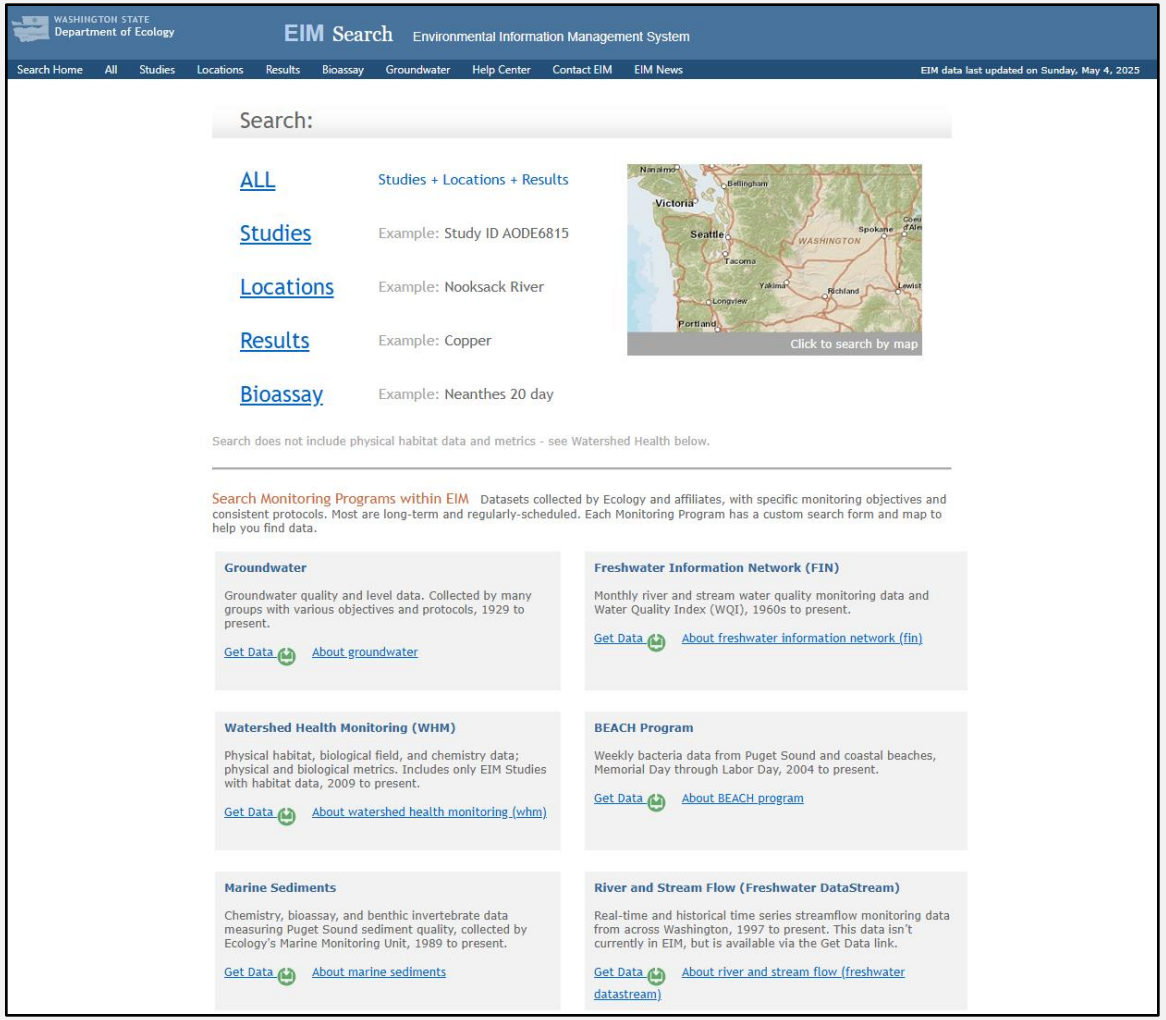
- Skagit River System Cooperative
  - https://skagitcoop.org/document-library/
- Tulalip Tribes
  - https://nr.tulaliptribes.com/Topics/HabitatMonitoringAndResearch





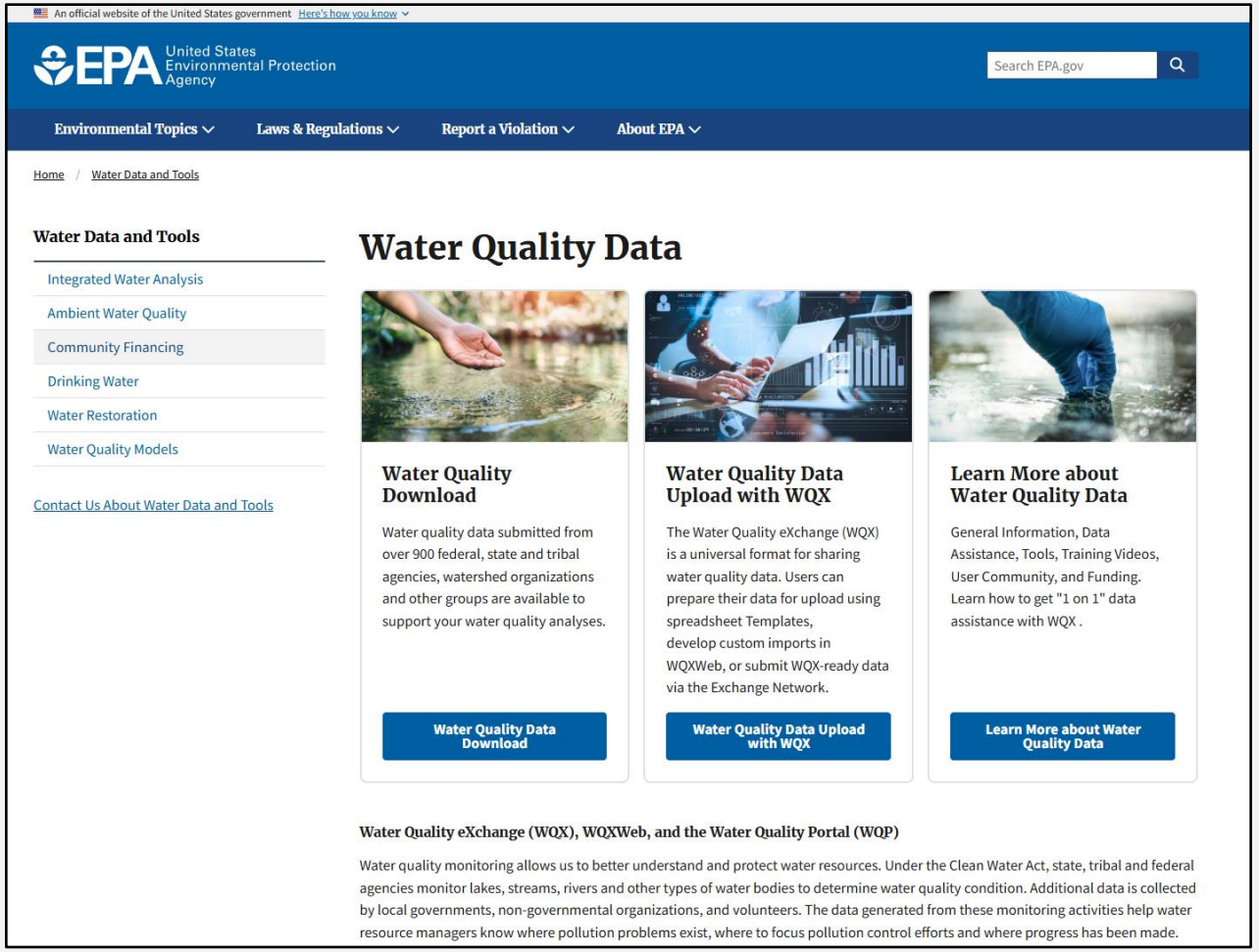
Other Sources for Environmental Data

Washington Dept of Ecology EIM



https://apps.ecology.wa.gov/eim/search/default.aspx

EPA - STORET



https://www.epa.gov/waterdata/water-quality-data

List of webpage links referenced

National Weather Service – climate observation data - *https://www.weather.gov/wrh/climate*

USGS Streamflow Site - *https://waterdata.usgs.gov/nwis*

Puget Sound LiDAR Consortium - https://pugetsoundlidar.ess.washington.edu/index.html

USGS Earth Resources Observation & Science Center - https://www.usgs.gov/centers/eros/data

USGS Sediment Elevation Table Methods - https://www.usgs.gov/centers/eesc/science/surface-elevation-table

Nation Agricultural Inventory Program - https://naip-usdaonline.hub.arcgis.com/

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