From the Mountains to the Sea: Spatial Prioritization for Adaptation using the Yale Mapping Framework

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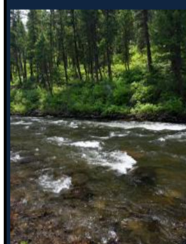
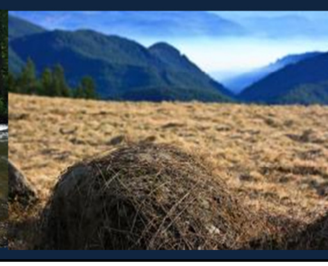
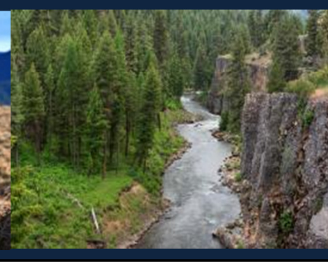
Photos courtesy of Jonny Armstrong

Questions

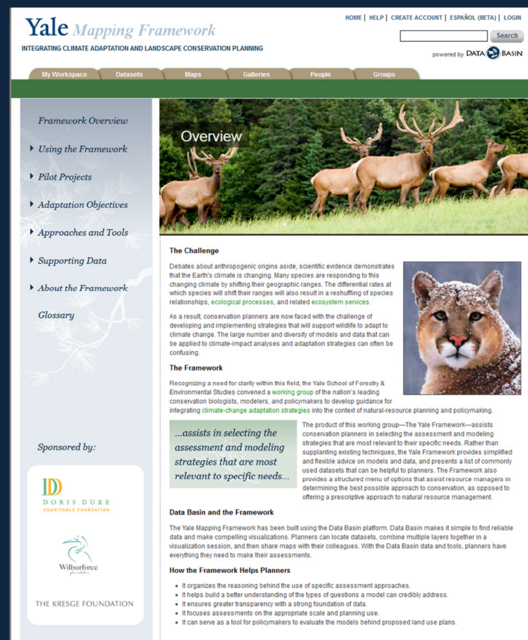
- Where might there be more or less change in aquatic habitats (and why)?
- How could natural resource management planning benefit?
- How possible is it to consider freshwater systems through watersheds to the coast?


The Yale Framework

…assists in selecting the assessment and modeling strategies that are most relevant to specific needs…

DataBasin.org/Yale

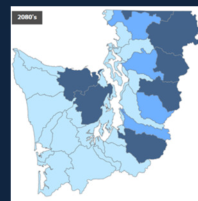


A Watershed Approach: Objectives

1. Identify which watersheds are expected to remain relatively stable under changing climate conditions
2. Identify which coastal habitats are vulnerable to sea level rise impacts

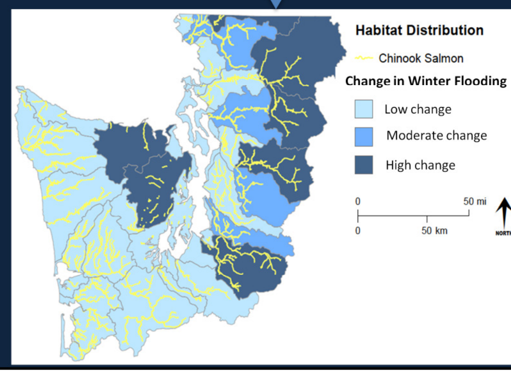
General methodology

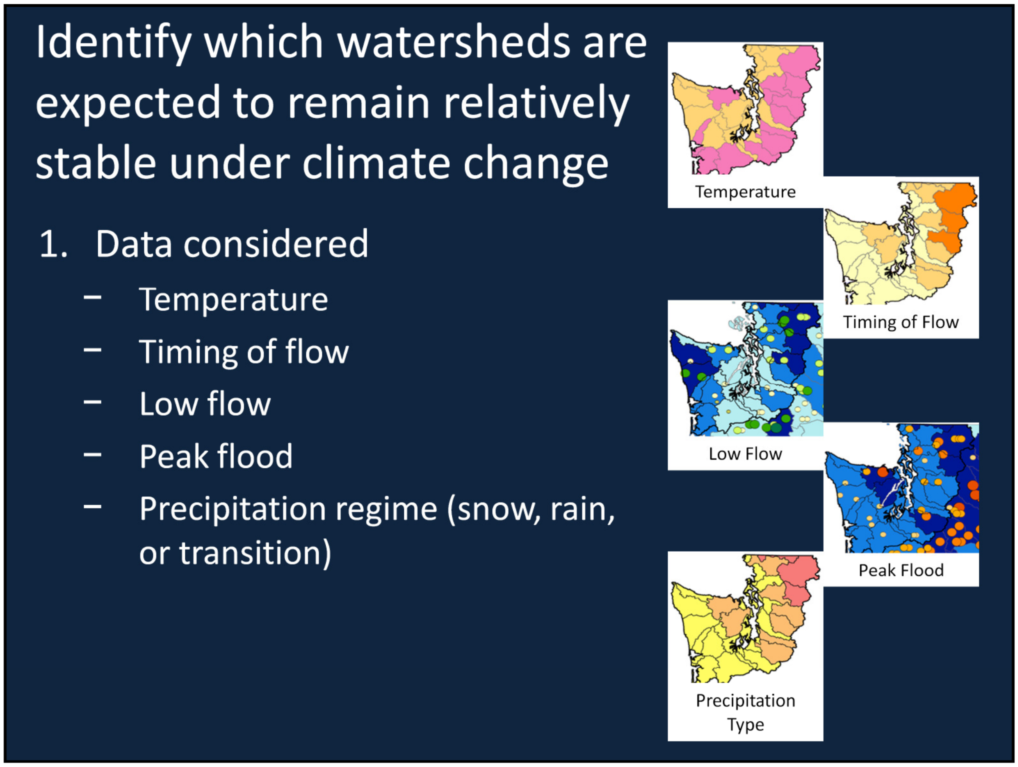
How:
Comparative mapping of existing spatial datasets (e.g., focal species distributions and biodiversity hotspots) and climate change model projections



Predicted change in winter flooding

Chinook distribution



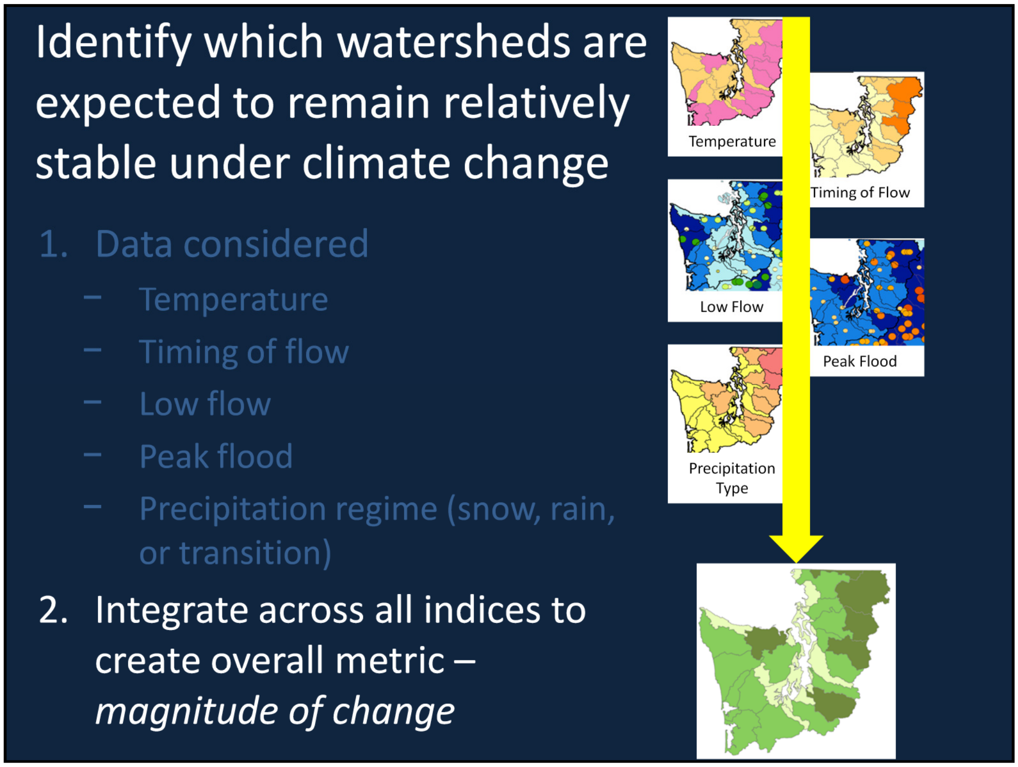


1. Wanted to choose biologically relevant data – met with scientists from state and federal agencies and the University of Washington who helped us narrow it down to these five metrics.
2. 10 GCMs were run using the A1B emissions scenario for 2040 and 2080. The climate scenarios were then downscaled to create higher resolution climate projections of temperature and precipitation. The downscaled A1B scenarios were used to drive the VIC hydrologic model that uses climate and other information to develop projections of future hydrologic conditions and stream flow.

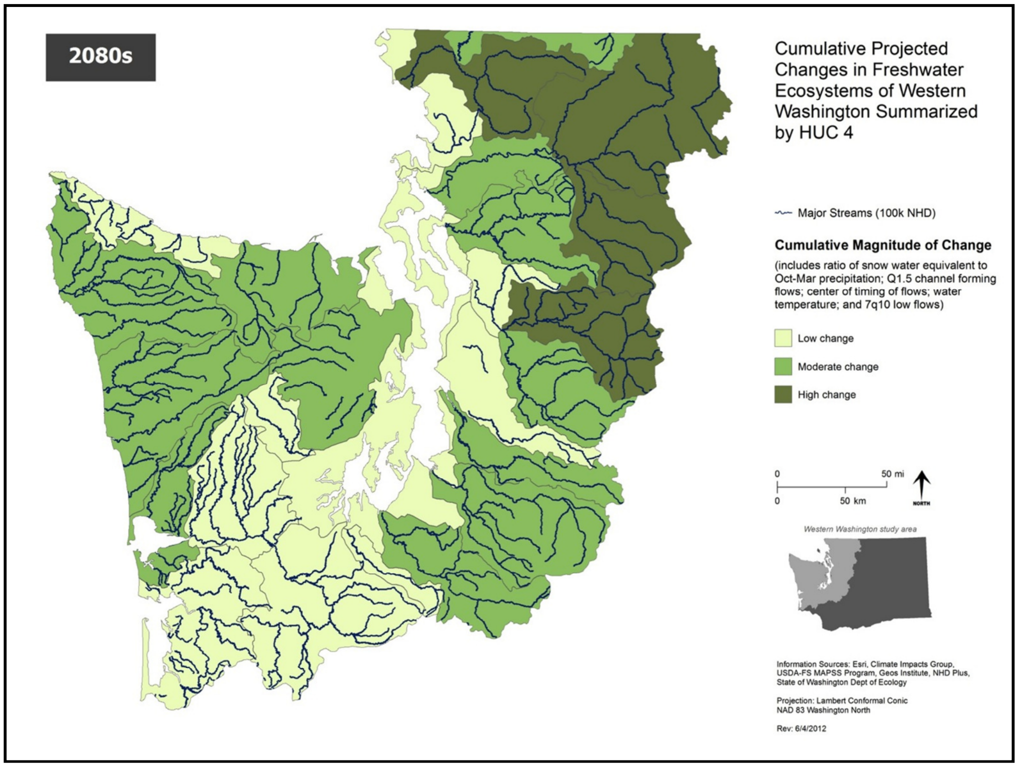
Following the methods described by Hamlet et al. (2010), a selection of 10 GCMs was chosen based on a ranking of model fidelity to the observed Pacific Northwest climate.

Low-resolution global simulations must be "downscaled" to obtain the final, high resolution projections needed for impacts studies. The projections described in the present report make use of the "Hybrid-Delta Method" statistical downscaling approach (Hamlet et al., 2010) down to 1/16th degree. As the name implies, the latter is a hybrid approach in which monthly projected changes in the *probability distribution of temperature and* precipitation, as simulated by the GCMs, are applied to the gridded daily historical record. The result is a dataset that includes the time series properties (e.g., storm timing and spacing) of the historical record, but a mean and distribution that are scaled according to GCM projections.

The downscaled projections in temperature and precipitation are used to drive the Variable Infiltration Capacity (VIC) macroscale hydrologic model (Liang *et al. 1996;* Liang *et al. 1998; Nijssen et al. 1997). VIC is a physically-based model, unique in its* representation of the soil column and infiltration process. The model also includes a sophisticated parameterization for snow that operates on both sub-daily and sub grid scales, and represents multiple vegetation types and soil layers, allowing for variable infiltration and evaporation. VIC is used here to assess the implications of temperature and precipitation changes on hydrologic variables such as snowpack, low flows, peak flood, and changes in the timing of flows.



How do we condense this into one or two metrics that people/managers can digest? So here's a preliminary figure where we integrated across all variables to produce a single metric looking at magnitude of change.



The climate change component allows us to get at Yale Framework objective #5 – Protect climate refugia – because we mapped locations projected to maintain stable climates. Adding the locations of dams within the study area also allows us to get at Objective #2 – Project future patterns of biodiversity – because we can get at the actual vulnerability of the watersheds (at least to flooding). We are also able to get at vulnerability a bit more when we add current land cover so we can see what land use is like surrounding these major aquatic areas.

Higher magnitude of change watersheds are those likely to

GOAL: Establish new Wild and Scenic Rivers designations that provide habitat security for aquatic organisms

↓

ASSESS CLIMATE IMPACTS: Areas that appear to be good habitat for aquatic species today may shift due to warmer stream temperatures and hydrologic changes

↓

CURRENT OR PLANNED ACTIVITY? Yes, currently pursuing efforts to pass WSR designation in Hood Canal, Dungeness-Elwha, and Lower Chehalis watersheds

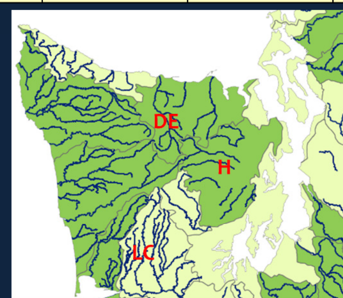
↓

ACTIVITY ALLEVIATE POTENTIAL CLIMATE IMPACTS? No, WSR designation does not alleviate potential climate impacts to freshwater habitats

How might you improve Wild and Scenic River Designation?

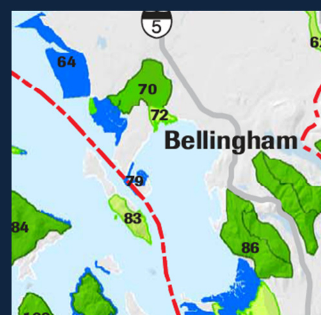
Watershed (HUC 4)	Mean % Change in Stream Temperature	Mean % Change in Low Flow	Mean % Change in Channel Flow	Mean Change in Timing (days)	Change in Watershed Type	Relative Score
Hood Canal	+9.1% to +18%	-2% to -9%	+26% to +50%	-15 to -25 days	Transition-> Rain	2
Dungeness-Elwha	+9.1% to +18%	-10% to -19%	+26% to +50%	-15 to -25 days	Transition-> Rain	2
Lower Chehalis	0% to +9%	-20% to -35%	+7% to +15%	0 to -15 days	Stays rain dominant	1

Dependent on your management goal…



Identify which coastal habitats are vulnerable to sea level rise impacts

1. Data considered
   - SLAMM modeling
   - TNC Ecoregional Assessments for Puget Sound



Predicting climate change effects – coastal habitats

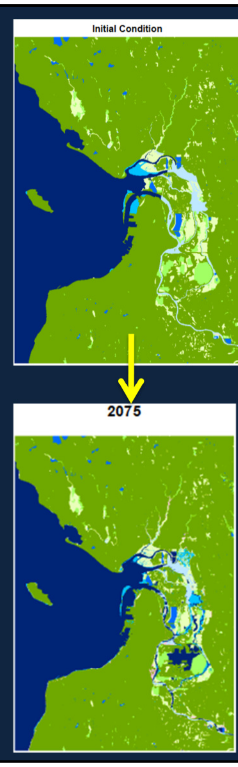
1-meter sea level rise by 2100

Sea Level Affecting Marshes Model (SLAMM 5.0)

NOAA tidal data, wetland information, LiDAR data, USGS DEMs

Project changes in habitat associated with sea level rise

Considers inundation, erosion, overwash, saturation, and salinity



Habitat type	Loss/Gain by 2075
Dry land	-2.4%
Swamp	-17%
Marsh	+5%
Freshwater tidal	-42%
Open freshwater	-11%
Low tidal	+108%
Open saltwater	+6.8%

The model used for this analysis is called Sea Level Affecting Marshes Model, Version 5.0 (SLAMM 5.0), which was designed to simulate the dominant processes involved in wetland conversion and shoreline modification under long-term sea-level rise. The model integrates information about projected global sea-level rise with area-specific NOAA tidal data, detailed wetland information from the FWS National Wetlands Inventory, regional Light-imaging Detection and Ranging (LiDAR) data,

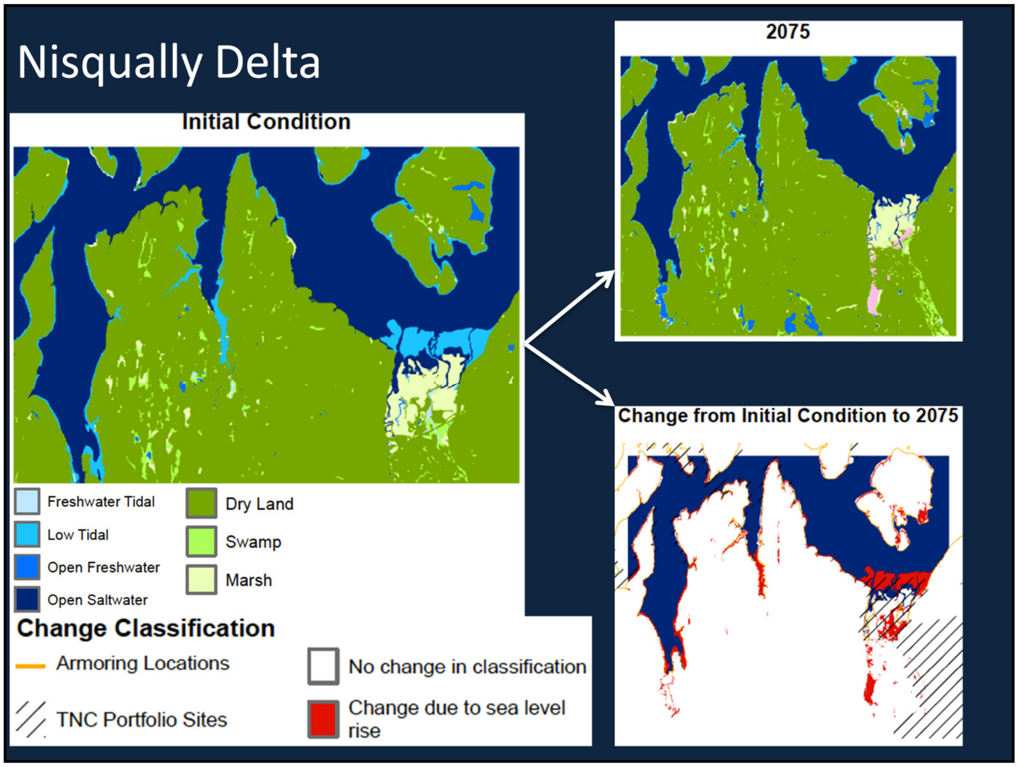
and U.S. Geological Survey (USGS) Digital Elevation Maps to project habitat changes associated with sea-level rise. Table 5 lists the coastal habitats included in the model.

This model provides greater detail than by just looking at static coastal topography alone. For example, it can assess the extent to which sea water inundation contributes to the conversion of one habitat type to another based on elevation, habitat type, slope, sedimentation and accretion and erosion rates, and the extent to which the affected area is protected by existing sea walls. It can also assess how much erosion may occur due to changes in wave action.

In addition, SLAMM 5.0 accounts for relative sea-level change for each study site. Relative sea level rise is calculated as the sum of the historic eustatic (global average) trend, the site specific rate of change of coastal elevation due to subsidence and isostatic adjustment, and the accelerated rise, depending on the future scenario chosen. Sea-level rise is also offset by sedimentation and accretion, again using site specific average values.

The SLAMM 5.0 model incorporates a simplifying assumption that all currently-developed areas will remain protected by seawalls and other coastal armoring, so it does not project inundation of existing urban areas. This does not mean, however, that low-lying urban areas, such as parts of Olympia and Tacoma, are not also vulnerable to sea-level rise, only that the potential impacts are not captured here. For example, a 1993 study conducted for the City of Olympia, portions of which have been built on fill just a few feet above sea level, projected significant tidal flooding and inundation in the downtown area under a scenario of 4-foot relative sea-level rise by 2100 (Craig, 1993). While it is beyond the scope of this study to address impacts on the region's vulnerable developed areas, the potential for sea-level rise to cause significant and costly damage to property and infrastructure should not be ignored.

In our initial model runs, we also assumed that agricultural areas and other dry land currently protected by dikes will remain protected. Because some of these dikes are being removed to assist in habitat restoration, however, we thought it would be useful to see how sea level rise might affect the region's coastal areas if the dikes were not there. So we conducted some simulations with no dikes protecting agricultural areas. Not surprisingly, there is a considerably greater loss of dry land at all of the modeled sites if the dikes are removed, although in several areas there is also greater expansion of some habitat types, such as saltmarsh and tidal flats.

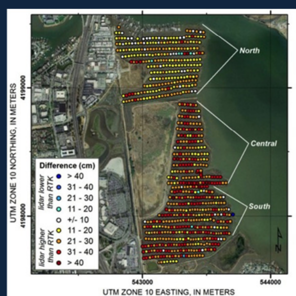


Nisqually Delta
Initial Condition
2075
Change from Initial Condition to 2075
Freshwater Tidal
Low Tidal
Open Freshwater
Open Saltwater
Dry Land
Swamp
Marsh
Change Classification
Armoring Locations
TNC Portfolio Sites
No change in classification
Change due to sea level rise

Other Regional Approaches

SF Bay Tidal Marshes: Joining Top-Down Climate Models with Parcel Based Management

(John Takekawa et al. USGS)



Webpage: www.werc.usgs.gov/SFBaySLR

About the Project
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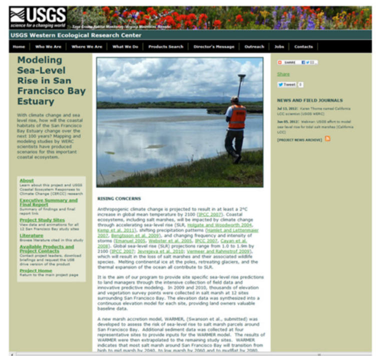
Literature
Products and Contacts

www.werc.usgs.gov/SFBaySLR



Baseline Conditions → Sediment/Hydro Dynamics → SLR Response Model → Wildlife Risk Assessment

Predicting Climate Change Threats to Estuaries in the Pacific Northwest (Debborah Reusser et al.)

Estuary function: SST, SLR/Elevation, Salinity Dynamics, Hydrology, Accretion/Erosion

Vulnerability of coastal and estuarine species

nccwsc.usgs.gov/webinar/116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Predicting Climate Change Threats to Key Estuarine Habitats and Ecosystem Services in the Pacific Northwest

Print Version

Project Information

Principal Investigator(s):
Deborah A Reusser

Co-Investigator(s):
Rebecca A Loiselle
Meredith Payne (*Oregon State University*)

Project Status: In Progress
Tags: climate change, estuaries, Pacific Northwest, sea level rise, fish

Summary

Global climate change and sea-level rise will have profound effects on estuarine fish, shellfish and wildlife populations and their habitats. Our ability to manage sustainable fish, shellfish and other wildlife populations in the future will be seriously compromised unless we have a basic understanding of the coming changes and use this to develop mitigation and adaptation measures. The overall objective of this multi-agency research is to develop the baseline climatic and biological data, models, and tools to predict the cumulative impact of climate change on habitats and ecosystem services in a series of coastal estuaries of the Pacific Northwest. In collaboration with other federal, state, and NGO partners, USGS scientists will develop predictions of climate-related alterations of the distribution and abundance of oysters and seagrass, both of which provide critical habitats that serve as nurseries for estuarine fishes and crabs. In addition, the project will look at climate impacts to tidal marsh, including effects on wetland restoration and juvenile salmon habitat. The research will provide insights into future changes that impact wildlife and economically important species, and will help land managers understand the ramifications of the changes that are coming and what those changes may mean for both the wildlife and the ecosystem services provided by these estuaries. Partner and collaborator organizations included in this research are the Oregon Climate Change Research Institute, U. S. EPA, U. S. Fish and Wildlife, U. S. Dept. of Agriculture, U. S. Forest Service, The Nature Conservancy, Oregon State University and the Oregon Institute of Marine Biology.

Products & Data

On the Web

Workshop Support Page

- ecoadapt.org/workshops/detail/11

Yale Framework & Watershed Project Products

- DataBasin.org/Yale

John Takekawa et al. SF Bay Work

- www.werc.usgs.gov/sfbayslr

Deborah Reusser et al. PNW Estuaries

- nccwsc.usgs.gov/webinar/116

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