Appendix E

Resources relevant to developing climate change adaptation strategies in Tillamook County, Oregon.

1. Allan, J. C., P. Ruggiero, G. Garcia, F. E. O'Brien, L. L. Stimely, and J. T. Roberts. 2015. Coastal Flood Hazard Study, Tillamook County, Oregon. Oregon Department of Geology and Mineral Industries (DOGAMI) Special Paper 47.

This report contains information and maps on coastal geology, beach and bluff morphology, tides and storm surge, wave climate (input into SWAN model), wave runoff and overtopping, coastal erosion from storms, and flood mapping for estuaries and beaches. It contains extensive maps and photos of the coastline, with information on flood hazards. Climate change, and specifically sea level rise, were not considered. Maps showing historical and contemporary shoreline positions show changes over time and the narrowing of beaches.

2. Dalton, M. M., K. D. Dello, L. Hawkins, P. W. Mote, and D. E. Rupp. 2017. The Third Oregon Climate Change Assessment Report. Oregon Climate Change Research Institute, Corvallis, OR.

3. Ewald, M. and L. Brophy. 2012. Tidal Wetland Prioritization for Tillamook Bay Estuary. Prepared for Tillamook Estuaries Partnership. Green Point Consulting, Corvallis, Oregon.

This study identified and characterized current and former tidal wetlands in the Tillamook Bay Estuary and prioritized them for conservation and restoration purposes. It included extensive mapping and site characterization, including LiDAR data, National Wetland Inventory, historic vegetation data, and other datasets. Many variables are relevant to developing spatially-specific climate change adaptation variables, such as spatial display of the height above highest measured tide, land ownership, and prioritization score for restoration.

4. FEMA. 2016. Multi-hazard Risk Report for Tillamook County Including the Cities of Bay City, Garibaldi, Manzanita, Nahalem, Rockaway Beach, Tillamook, Wheeler, and Unincorporated Communities of Neskowin, Oceanside, Netarts, and Pacific City.

This report provides an overview of natural hazard risk assessment performed by DOGAMI and the communities of Tillamook County. They completed a quantitative risk assessment and identified mitigation opportunities. The results of this study could be used to look for areas of co-benefits between natural systems restoration projects that TEP prioritizes for adaptation strategies, and hazard mitigation strategies that reduce risks to local communities. However, much of the report focuses on risks to infrastructure (buildings, specifically) and climate change impacts were not incorporated. Hazards included earthquakes, tsunamis, 100-year flood events, landslides, coastal erosion, and wildfire exposure.

5. Hixon, M. A., S. V. Gregory, and W. D. Robinson. 2010. Chapter 7. Oregon's Fish and Wildlife in a Changing Climate *in Oregon's Climate Assessment Report*. K. D. Dello and P. W. Mote (eds). Oregon Cimate Change Research Institute, Corvallis, OR.

This report provides numerous adaptation strategy recommendations for specific species as well as ecosystems and habitats.

6. Hormann, L. 2012. ODOT Climate Change Adaptation Strategy Report. Oregon Department of Transportation.

The ODOT report is for the entire state of Oregon, and covers highways, bridges, culverts, and critical infrastructure. It includes an assessment of climate change impacts, as well as potential adaptation actions. These actions are important for two reasons – first, because they could complement or be coordinated with any adaptations strategies developed for this project, and second because some adaptation actions taken in the transportation sector could actually exacerbate existing stressors or become new stressors for natural systems. This would need to be addressed in the development of adaptation strategies for TEP.

7. Institute for Applied Ecology. 2017. Maps of tidal wetland migration zones for 4.7m sea level rise.

The maps show areas currently within tidal wetland classification that (1) would remain in tidal wetlands, or (2) would convert to mudflat or open water. They also show migration zones based on five prioritization factors. Maps were created for:

a. Nahalem River Estuary
b. Nestucca Bay Estuary
c. Netarts Bay Estuary
d. SandLake Estuary
e. Tillamook Bay Estuary

8. National Marine Fisheries Service. 2016. Recovery Plan for Oregon Coast Coho Salmon Evolutionarily Significant Unit. National Marine Fisheries Service West Coast Unit. Portland, Oregon.

This report will need to be consulted for adaptation strategies that affect Oregon Coast coho salmon. It includes a section on climate change and changing ocean conditions. It describes how climate change affects coho in each of the three main habitat types for growth and survival. Most of the projected changes in conditions are expected to result in "poorer and more variable habitat conditions for Oregon Coast coho salmon in freshwater, estuarine, and marine environments."

Table 3-5. Summary of effects of physical climate changes on Oregon Coast coho salmon by habitat type. Strength and direction of effects are rated from strongly positive (+ +) through neutral (0) to strongly negative (– –). (Table 14 in Stout et al. 2012, modified from Wainwright and Weitkamp 2013.)

Physical change	Certainty of change	Processes affecting salmon	Effect on salmon	Certainty of effect
Terrestrial				
Warmer, drier summers	Moderate	Increased number and intensity of fires, increased tree stress and disease affect large woody debris, sediment supplies, riparian zone structure	0 to – –	Low
Reduced snowpack	High	Increased growth of higher elevation forests affect large woody debris, sediment, riparian zone structure	+ to 0	Low
Freshwater				
Reduced summer flow	High	Less accessible summer rearing habitat	–	Moderate
Earlier peak flow	High*	Potential migration timing mismatch	0 to – (Umpqua: 0 to –)	Moderate
Increased floods	Moderate*	Redd disruption, juvenile displacement, upstream migration	0 to – (Umpqua: – to –)	Moderate
Higher summer stream temps	Moderate	Thermal stress, restricted habitat availability, increased susceptibility to disease and parasites	– to – –	Moderate
Estuarine				
Higher sea level	Moderate	Reduced availability of wetland habitats	– to – –	High
Higher water temperature	Moderate	Thermal stress, increased susceptibility to disease and parasites	– to – –	Moderate
Combined effects		Changing estuarine ecosystem composition and structure	+ to – –	Low
Ocean				
Higher ocean temperature	High	Thermal stress, shifts in migration, range shifts, susceptibility to disease and parasites	– to – –	Moderate
Intensified upwelling	Moderate	Increased nutrients (food supply), coastal cooling, ecosystem shifts; increased offshore transport	+ + to 0	Low
Delayed spring transition	Low	Food timing mismatch with outmigrants, ecosystem shifts	0 to –	Low
Intensified stratification	Moderate	Reduced upwelling and mixing lead to reduced coastal production and reduced food supply	0 to – –	Low
Increased acidity	High	Disruption of food supply, ecosystem shifts	– to – –	Moderate
Combined effects		Changing composition and structure of ecosystem, changing food supply and predation	+ to – –	Low

*Effects are strongest and most certain in higher elevation snow-fed basins.

9. National Marine Fisheries Service. 2016. 2016 5-year Review: Summary and Evaluation of Oregon Coast Coho Salmon. National Marine Fisheries Service West Coast Unit. Portland, Oregon.

While the report repeats much of what was written in the report above, specific to climate change impacts, it provides a list of adaptation strategies intended to help recover the Oregon coast coho salmon. Many of those strategies align with TEP's

priority actions. The strategies recommended in the NMFS report included:

- Revise local regulatory mechanisms to increase protection and restoration of watershed processes that promote winter and summer rearing habitats including Oregon's Agricultural Water Quality Management Act, Oregon Forest Practices Act, FEMA National Floodplain Insurance Program, and state beaver statutes and administrative rules.
- Develop and approve scientifically credible, thorough Strategic Action Plans consistent with ESU- level common framework.
- Implement the Strategic Action Plans to protect and restore ecosystem processes and functions and coho salmon habitats. Activities should include restoring habitat capacity for rearing juvenile coho salmon by increasing large wood loading, beaver habitat, and wetland/off-channel connectivity, and by increasing native riparian vegetation to provide bank stability and shade stream reaches during warm summer months.
- Collaborate with governmental and non-governmental organizations and others to identify, and implement, actions that will protect and restore watershed processes, provide stream complexity for juvenile rearing, increase shading to reduce stream temperatures, connect side channels, wetland and off-channel habitats, and reduce fine sediment levels.
- Coordinate with state agencies to improve water quality, especially water temperatures, to increase carrying capacity and provide high quality spawning, and juvenile summer rearing habitat.
- Collaborate with Soil and Water Conservation Districts, Oregon Department of Agriculture, and others to increase effectiveness of current agricultural water quality area rules and plans in order to meet water quality goals in the Tillamook population area.
- Provide and support public outreach, education, and volunteer actions to protect and restore ecosystem process and functions and improve juvenile coho salmon rearing habitats.
- Improve wood recruitment to support long-term increases in habitat complexity by improving timber harvest activities and agricultural practices.
- Increase habitat complexity by increasing large wood, boulders, or other instream structure and conducting riparian planting projects.
- Improve floodplain connectivity by increasing beaver abundance and reducing or limiting development of channel confining structures, including roads and infrastructure.
- Continuing low harvest rates that began in 1993.
- Controlling predation from introduced warm water fishes, such as smallmouth bass and largemouth bass, considered a primary limiting factor in the Lakes stratum by the both the ONCC TRT and BRT.
- Systematically reviewing and quantitatively analyzing the amount of habitat addressed versus the priority watershed reaches targeted for protection and restoration activities in the Proposed OC Coho Salmon Recovery Plan (NMFS 2015b) in order to track progress against plan objectives.
- Documenting and analyzing the effectiveness of existing land-use regulatory mechanisms and land-use management plans.
- Continuing to minimize adverse impacts of hatcheries on the OC coho salmon ESU.

10. Oregon Conservation Strategy. 2016. Oregon Department of Fish and Wildlife, Salem, Oregon. http://www.oregonconservationstrategy.org

The Oregon Conservation Strategy recommends numerous strategies for conserving Oregon's fish, wildlife, and plants. Regional, local, and species

specific strategies are described in the Oregon Conservation Strategy.

11. Oregon Dept. of Transportation. 2014. Climate Change Vulnerability Assessment and Adaptation Options Study.

This pilot study covered Tillamook and Clatsop Counties and identified vulnerable highway corridors and evaluates a range of site-specific adaptation strategies that address landslides, coastal erosion, and storm surge hazards. They provide information on where the most vulnerable highways and corridors are, with a map of vulnerability ratings.

12. Oregon Department of Land Conservation and Development. 2011. Adapting to Coastal Erosion Hazards in Tillamook County: Framework Plan. Final Draft.

This plan was prepared for Tillamook County with funding from the Oregon Department of Land Conservation and Development. The report focuses on coastal lands, including dunes and bluffs, and the hazards of coastal erosion and ocean flooding. It is a policy framework that identifies risks, policies for adaptation, and specifies measures for reducing vulnerabilities. It is intended to have a framework plan (this one) and tiered sub-plans that cover specific coastal communities, starting with Neskowin. It provides an overview of local and state policies and programs related to natural hazards, including the responsible agencies for each. Some of the impacts identified in this plan include:

Narrowing beaches

Shifting sand spits

Crumbling bluffs and cliffs

Landslides

Flooding (riverine and ocean, with focus on ocean flooding)

13. State of Oregon. 2010. The Oregon Climate Change Adapation Framework. Salem, OR.

The report includes 119 priority actions that link directly to specific identified risks. These should be consulted when developing the Adaptation Strategies for TEP.

14. Tillamook County. 2013. The Neskowin Coastal Erosion Adaptation Plan. Tillamook County, Dept. of Community Development, Tillamook, Oregon

This report is part of larger County planning efforts. It includes maps of the coastline, as well as specific information on land ownership, existing riprap, and areas at risk from coastal hazards. It includes a list of recommended actions that should be consulted during the development of adaptation strategies, as some of the recommendations could affect conservation of natural resources, and could act as indicators of how communities are responding to increasing coastal hazards.

15. Weber, J. 2015. Regional Framework for Climate Adaptation. Clatsop and Tillamook Counties. Oregon Sea Grant.

The regional framework is designed to help communities, land managers, and people in Clatsop and Tillamook Counties identify and revise policies, standards, criteria, and management practices that may underestimate risks to people, property, resources, and infrastructure from future climate conditions. Priority climate risks were identified, as well as management objectives for adaptation to address the anticipated effects in the following sectors: Infrastructure, public health and safety, natural systems, and working lands.