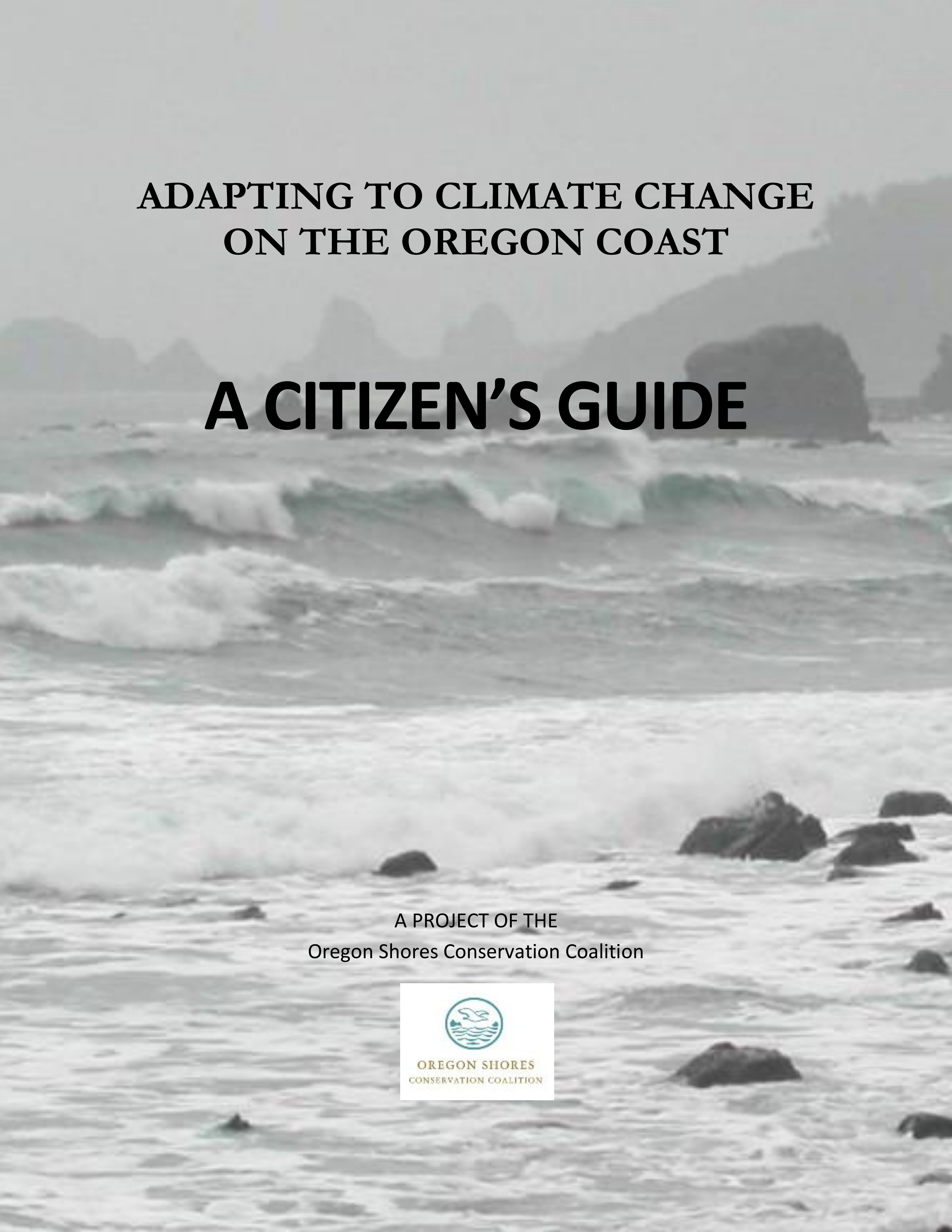

ADAPTING TO CLIMATE CHANGE ON THE OREGON COAST

A CITIZEN'S GUIDE

A PROJECT OF THE
Oregon Shores Conservation Coalition

A Citizen's Guide to Climate Change on the Oregon Coast

March 2015

OREGON SHORES
CONSERVATION COALITION

LINKS TO ADDITIONAL INFORMATION:

This ***Citizen's Guide*** is intended to serve as an introduction to the vast amount of information available on topics related to climate change effects on the Oregon coast, as well as a sourcebook for citizens interested in helping their communities to begin the long process of adapting to these effects. In publishing the ***Guide***, the Oregon Shores Conservation Coalition anticipates that most readers will access and read it online with Internet access or in an electronic format, such as a PDF, which will enable easy access to additional information.

The ***Guide*** has two parts:
Part One, A Primer, presents an overview of the topics pertaining to adapting to climate change on the Oregon coast. The Primer contains numerous embedded hyperlinks to enable readers to click directly to external websites or online PDF documents for additional information.

Part Two, Scientific and Policy Considerations, is a set of papers written by Oregon experts in science, law, and policy. These papers, commissioned by Oregon Shores for this project in 2012, also contain references to further information.

Although readers of a paper version of the ***Guide*** will be unable to directly link to external documents, a list of those external web-based sources at the end of Part One will enable the reader to enter those Internet addresses directly via a keyboard at their convenience.

NOTE:

Need a printed paper copy of the ***Guide***? Download all or part of it.
If interested in distributing a number of print version more widely, please contact Oregon Shores, P.O. Box 33, Seal Rock, OR 97376; (503) 754-9303; phillip@oregonshores.org.

Adapting to Climate Change on the Oregon Coast

A Citizen's Guide

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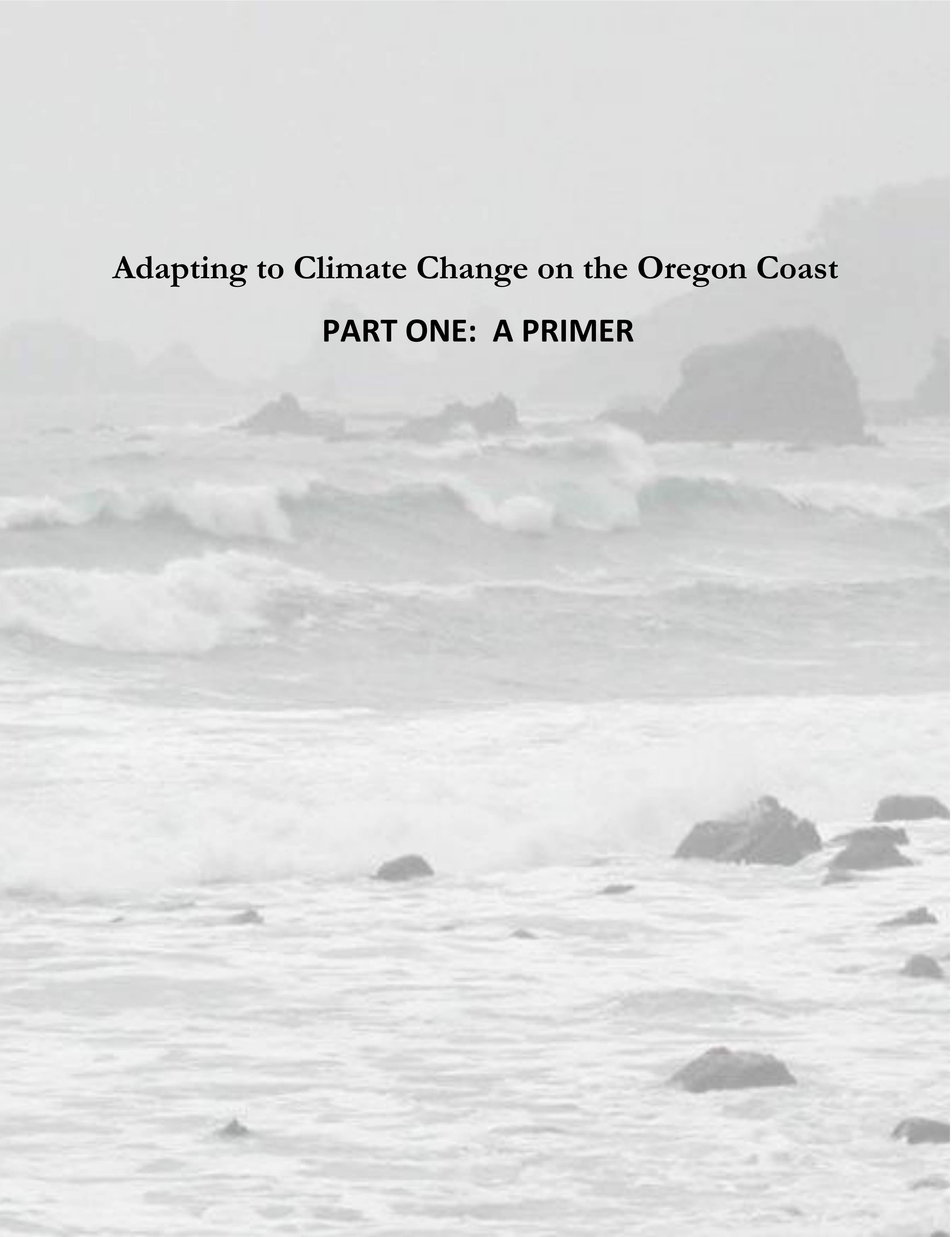
Overview:

Oregon's beautiful, dynamic coast and coastal communities are vulnerable to the effects of Earth's rapidly changing climate. In fact, Oregon's coast and communities are already feeling the effects of such climate change, perhaps most notably through serious negative impact on the shellfish industry from ocean acidification. While neither the rate of change nor severity of future effects can be known precisely, scientists are already measuring how the climate affects many of the natural physical and ecological settings and geologic processes on the Oregon coast and are discovering trends that offer clues to likely future impacts.

The effects of climate change are important matters. Coastal communities have considerable private and public development and infrastructure built over the years on a presumption of a somewhat stable set of conditions. Unfortunately, those conditions will change significantly during the coming decades. Responding to these likely changes is a complex task partly because not all coastal locations will be affected equally. Impacts will depend on the particular geography and development in an area and the specific ways that sea level rise, flooding, erosion, acidification and other effects will impact that specific location. It is essential that the citizens of each community work together and with relevant government agencies and non-governmental organizations to assess their specific vulnerabilities, plan how to best to adapt to climate-driven change, and increase the community's overall resilience.

Oregon has the legal, policy, and planning tools to help coastal communities address climate change. Scientists are learning how the climate affects the coastal environment and are providing crucial information to aid citizens and communities in planning for on-coming climate effects. Local governments such as Tillamook County have begun to address ocean erosion hazards at the community scale, which will help point the way for other communities to address effects from climate change. Projects to remove dikes and levees to restore estuarine habitats offer important lessons of how restoration can help respond to and perhaps mitigate effects of climate change, enhancing natural, low-cost flood control and improving overall ecosystem functioning and productivity. And Oregon has been a leader in using new digital information technologies to enable local governments, watershed councils, and citizens to find and use mapped information to assess vulnerability and develop appropriate, effective solutions.

The Oregon Shores Conservation Coalition, supported by the Spirit Mountain Community Fund, the Meyer Memorial Trust, and the Lamb-Baldwin Foundation offers this ***Citizen's Guide*** to coastal climate change to help citizens understand the key issues, so that they can effectively participate in planning for these oncoming changes on the Oregon coast.



Adapting to Climate Change on the Oregon Coast

PART ONE: A PRIMER

Climate, Change and the Oregon Coast

Oregon's coast is a region in flux even as it seems to stay the same. Ocean tides, driven by the sun and moon, regularly ebb and flow in estuaries and on the ocean shore about every six hours; highest tides occur in winter and early spring while lowest low tides come in summer. Winter storms may last only a day or two but they flood estuaries, move vast quantities of sand along the ocean shore, and erode coastal bluffs. Comparison of old photographs with present conditions shows that beach conditions have changed and that bluffs behind ocean beaches have eroded over time. Scientific study of tide gauge data reveals the gradual geologic uplift of the coastal landscape, while an ongoing series of infrequent but large earthquakes causes periodic lowering of some sections of coastline. Mud, sand, and other debris buried beneath estuarine marshlands give evidence of these catastrophic earthquakes and overwhelming tsunamis that reconfigure the entire coastline overnight. An excellent overview, written for the layman, of how the ocean and atmosphere affect the coast of the Pacific Northwest is The Pacific Northwest Coast: Living With the Shores in Oregon and Washington by Paul Komar, a now-retired professor of oceanography at Oregon State University.

The coastal climate and related weather patterns have always been variable within typical patterns: summers are typically dry with strong northwest winds while fall and winter are often wet and blustery with storms from the southwest. El Nińo and its opposite, La Nińa—climate conditions generated by swings in atmospheric conditions in the western Pacific Ocean—affect atmospheric and ocean currents across the entire Pacific Ocean Basin and dramatically alter ocean temperature patterns and the direction of storm tracks across the Pacific Northwest. Still other climatic and oceanic cycles come and go over longer periods, such as the Pacific Decadal Oscillation that affects the ocean survival of salmon as well as the path and intensity of storms emerging from the Gulf of Alaska. The Climate Impacts Group at the University of Washington provides excellent summaries of these and other climate phenomena in the Pacific Northwest.

From Astoria to Brookings, Oregon's coastal communities occupy a topographically rugged landscape challenged by the weather and climate. Highway 101, other highways, and railroads link coastal communities to each other and to the rest of Oregon. Ports, cities, and other development built over the past 150 years occupy lands that were once low-lying wetlands or estuarine tideflats. In the late 1800s and early 1900s protective dikes, drainage structures and tidegates converted coastal wetlands into pasture for agriculture and related uses. After World War II, increasing population, growing wealth, and leisure time drove construction of homes and other development along the ocean shore which sometimes changed the shore itself through "armoring" of the inland edge of the beach with seawalls, boulder piles and other structures. All of this development, as development everywhere, presumed a stable environment with property lines and infrastructure reliably in place within an essentially unchanging landscape. Now, however, the on-going processes of coastline change plus the added on-coming effects of climate are likely to put a substantial amount of this development at risk.

Oregon's land use and other laws enacted in the early 1970s have largely succeeded in protecting much of the coastal environment from degradation and have helped direct new development away from hazardous and environmentally important areas. However, the most likely effects of climate change are so significant that a substantial portion of existing coastal development, even that considered to be safe by current standards, will in the future be vulnerable by sea level rise and other effects. Oregon's comprehensive land use laws and programs provide a strong framework for addressing the likely effects of climate change, but must be applied in order to work. These laws and programs may need to be thoughtfully amended in order to meet these unprecedented circumstances.

Climate Science and Predicting Climate Change

A substantial body of scientific literature and other information is available on the Internet that explains the forces at work in the Earth's atmosphere that are triggering changes in the climate. These websites provide basic information at the international, national, regional, and state levels:

- The Intergovernmental Panel on Climate Change (IPCC) is the leading international collaborative body that assesses the effects of climate change on the Earth and publishes benchmark scientific reports for all others to use.
- The US Global Change Research Program has a vast amount of information on climate change and climate adaptation and resilience nationwide, including the latest (March 2014) National Climate Assessment.
- The Climate Program Office of the National Oceanic and Atmospheric Administration focuses on coastal and ocean climate applications.
- The Oregon Climate Change Research Institute at Oregon State University (OSU) provides data, information, and syntheses for Oregon and represents Oregon's interests in regional investigations and reporting on climate issues.
- The Oregon Climate Service, also at OSU, is the state repository for climate and weather information, much of which is available via its website. Oregon Sea Grant has produced an excellent short video on the science of predicting climate change.

How the Oregon Coast is Likely to be Affected

While many sources of information exist concerning potential or likely effects of climate change on the Oregon coast, four publications/websites may be of particular interest for understanding the anticipated effects of climate change on the Oregon coast at varying levels of specificity. These reports are available on-line and include links to further information and sources:

- Northwest Climate Assessment Report, published in 2013 through the Oregon Climate Change Research Institute, assesses the impacts of climate change on the Pacific Northwest. Chapter 4 in particular focuses on the implications of climate change for ecosystems and communities in the Oregon and Washington coastal region.
- Climate Ready Communities, published in 2009 by the Oregon Coastal Management Program, is an overview of the multiple effects of climate change on the Oregon coast and how they will likely affect Oregon's coastal environment and communities. This report also contains a framework of recommended steps for communities and local governments to begin to address these potential effects.
- Impacts of Climate Change on Oregon's Coast and Estuaries, which is Chapter 6 of the Oregon Climate Change Assessment by the Oregon Climate Change Research Institute, is an extensive report on how and why the changing climate will affect the Oregon coast.
- Climate Change for Oregon's South Coast, a website of the Partnership for Coastal Watersheds, contains technical references and specific discussions of effects on coastal habitat in the region (e.g. sea level rise effects on marshlands at the Bandon Marsh on the Coquille River estuary).

Part Two of this ***Citizen's Guide*** contains a set of scientific/technical papers that provide detailed information and science-based explanation of current geophysical processes and potential effects of climate along the Oregon coast. Many of these papers are referenced in this Primer

Effect #1: Rising Sea Level

Perhaps the most profound long-term consequence of Earth's changing climate for the Oregon coast will be rapidly rising sea level. This rapid rise is driven by thermal expansion of a warming ocean and by freshwater added by melting glaciers and polar ice. The likely effects of rapidly rising sea level over the coming decades will fundamentally alter Oregon's ocean shore and coastal environment in many ways.

In 2010 the states of California, Oregon, and Washington, through the West Coast Governors Alliance on Ocean Health, commissioned a regional review by the National Academy of Sciences of sea level rise along the West Coast. Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future, published in 2012 by the National Academy of Sciences, is a thorough examination of potential effects on the West Coast. Among its findings are:

- *Vertical land motions caused by plate tectonics and the ongoing response of the Earth to the disappearance of North American ice sheets will have a significant impact on sea level rise along the Washington, Oregon, and California coasts.*
- *For the Washington, Oregon, and California coasts north of Cape Mendocino, sea level is projected to change between minus 4 cm (minus2 in), sea level fall and plus23 cm (9 in) by 2030, -3 cm (-1 in) and +48 cm (19 in) by 2050, and 10-143 cm (4-56 in) by 2100. These values are lower than projections further north.*
- *Uncertainties grow as the projection period lengthens. Confidence in the projections is high for 2030 and perhaps 2050. By 2100, we are confident only that the value will fall within the uncertainty bounds.*
- *Most coastal damage will be caused by the confluence of large waves, storm surges, and high astronomical tides during a strong El Niño.*
- *Some models predict a northward shift in North Pacific storm tracks, and some observational studies report that the largest waves are getting higher and winds are getting stronger. Observational records are not long enough to confirm whether these are long-term trends.*
- *Even if storminess does not increase in the future, sea level rise will magnify the adverse impact of existing levels of storm surges and high waves on the coast.*
- *Storms and sea level rise are causing coastal cliffs, beaches, and dunes to retreat at rates from a few cm/yr to several m/yr. Cliffs could retreat more than 30 m (about 100 feet) by 2100.*
- *Wetlands are likely to keep pace with sea level until 2050. Their survival until 2100 depends on maintaining elevation through high sedimentation, room to move inland, or uplift.*

Impacts of higher sea level:

Physical Impacts*:* A number of credible scientific projections are in rough agreement that the Oregon coast is likely to experience a rise in sea level of between three and six feet by the end of the century. However, the net rise of sea level relative to the land will not be the same everywhere on the Oregon coast. As shown in a graph in the attached technical paper *Sea Level Rise and Ocean Acidification* by Allen Solomon, variations in large-scale geologic forces affect relative sea level along the Oregon coast: the southern Oregon coast from northern California to the vicinity of Bandon is being uplifted faster than sea level is rising and is thus a rising shoreline; the shoreline from about Coos Bay northward to about Neahkahnie Mountain is subsiding relative to sea level; and the northern Oregon shoreline from Neahkahnie Mountain to the Columbia River is rising relative to sea level. Local geology and geography will determine how and where sea level rise affects the coast. But even with these variables, the net effect on the Oregon coast will be profound.

A higher sea level will fundamentally alter the geologic equilibrium—the uneasy truce—that exists between the ocean and the land. The ocean shore will move inland through erosion and will penetrate current coastal shorelands by inundation of low-lying areas behind beaches, around estuaries, and along tidally-influenced coastal streams. A higher tidal base elevation will amplify the effect of high tides, ocean storm surges, and river flooding (see *Waves and Water Levels* by Peter Ruggiero) and over time will permanently submerge some lands and subject others to tidal ebb and flow with periodic saltwater inundation. A recent paper in the Journal of Coastal Research summarizes research into determining how geologic forces (tectonics) and atmospheric forces (climate) affect the variability of sea level along the coast of the Pacific Northwest. Further, the Oregon Sea Grant has produced a short video on the shoreline effects of climate change.

A higher sea level will be felt far inland. Lowlands along the Columbia River at least to Bonneville Dam, 146 miles upstream, and to Willamette Falls at Oregon City, 129 miles upstream will be vulnerable to significantly higher tidal elevations and river flooding. Along coastal rivers, the head of tide will move upstream in response to higher tidal levels. Even small creeks and their valleys, such as Sixes River and Euchre Creek in Curry County, Beaver Creek and Yachats River in Lincoln County, and Siltcoos Creek in Lane County will be affected as tidal waters push into those drainages. Some freshwater wetlands that are currently exposed to brackish waters and tidal influence only during each winter's "King Tides" (a term for the highest tide series of the year) will be exposed to the influence of tidal waters on a daily basis. Pastures and open meadows currently protected behind dikes or levees will be vulnerable many miles inland depending on the location, height and condition of dikes and levees.

Three papers in Part Two provide more detailed information and analysis of factors that control the effect of sea level rise on ocean beaches and tidal wetlands and explain how estuaries will respond: 1) *Impacts of Predicted Global Sea Level Rise on Oregon Tidelands* by Curt Peterson, 2) *Impacts of Predicted Global Sea Rise on Oregon Beaches* by Curt Peterson, and 3) *Oregon's Estuaries and Climate Change* by Corrina Chase.

Ecological Impacts: Various estuarine and wetland habitats and associated assemblages of plants and animals are distributed primarily based on minute differences in elevation that affect submergence or air exposure above or below tidal range and by changes in salinity as the ocean's salt water mixes with freshwater of coastal streams. Rising sea level will affect these two basic physical conditions and will, in turn, affect the distribution and composition of habitats in estuarine and shoreline areas within reach of fresh and tidal waters. Effects on these environments and ecosystems will vary, depending on the exact setting of each estuary, stream, tidal marsh and freshwater wetland. Some habitat assemblages may be able to migrate inland with the rising sea level while others will undoubtedly be lost and replaced with new habitats and species that are adapted to the new environmental conditions. The speed of sea level rise will affect habitat change and the ability of habitats and species to adapt or migrate. Eventually, even though the types of habitats and their associated plants and animals may be similar to those of today, their locations and distribution will likely be quite different.

Social and Economic*:* In the near-term, coastal communities in the path of rising sea level will face flooding and eventual inundation of infrastructure and development located at or near the level of present highest tides. Much of this development is already vulnerable to flooding or erosion, and all of it is highly vulnerable to tsunamis. Most communities on the Oregon coast have some urban development built along a riverfront or estuary on filled former tidelands or wetlands that were subject to tidal reach. In these areas, public infrastructure such as streets, sewers, and water lines as well as private buildings, facilities, and operations will suffer damage and loss. Coos Bay, Seaside, and other cities with significant development on filled lands currently at or near high tide levels will experience increased flooding by routine stormwater runoff and tidal intrusion through the storm sewer system.

Other communities, such as Gearhart, Rockaway, and Lincoln City that are built wholly or in part on the ocean shore, will feel the most immediate impacts through repeated episodes of higher ocean storm surge and waves that damage or destroy community infrastructure and push the ocean further inland. Oceanfront development in such low-lying areas as Alsea Spit (Bayshore), Siletz Spit (Salishan), the mouth of the Rogue River (Rogue Shores) and many other areas will be assaulted by the ocean unless residents spend large amounts of money for the construction of massive protective structures that will likely, in the end, prove futile.

Rural lands and development in coastal valleys will be affected, too. Lands diked and drained for agriculture over the last 140 years in the Tillamook, Youngs, Coquille, Nehalem, Coos and other river valleys will be wholly reliant on the integrity and function of dikes, levees, tidegates, and other such structures to protect against tidal flooding. Aerial photos taken during winter high "King Tides" show that coastal agricultural lands and related development are highly dependent on these protective structures. The Estuary Map Viewer on the Oregon Coastal Atlas includes map overlays of information showing the location, extent, and type of all dikes and levees on the Oregon coast. These lands will be at increasing risk for seasonal or permanent inundation unless these structures are maintained and strengthened or reconfigured, at significant cost, to withstand higher tidal and flood elevations. Even then it would be increasingly difficult to drain freshwater runoff that accumulates behind these levees from rainstorms in surrounding hills; pumps may be required. In addition to all these monetary outlays, there would be costs associated with foregoing or replacing the natural flood control that is provided by having seasonal wetlands connected to rivers and streams rather than cut off by dikes; rivers channelized by dikes are prone to creating greater flooding problems upstream or downstream of areas that would otherwise naturally slow the rise, fall, and movement of floodwaters.

Increasing tidal elevations will jeopardize vulnerable portions of key transportation facilities such as Oregon Coast Highway 101, state highways and county roads built at or near current sea level, some railroad segments, and several airports, some of which are already vulnerable to river, estuarine, or ocean flooding (not to mention tsunamis). Wave attack at the toe of ocean bluffs and cliffs will trigger landslides and slippage under roads or railroads and public utilities that are located high above the direct reach of the waves. Although Oregon's coastal roads and bridges are routinely damaged by winter storms, higher sea level will bring a higher level of vulnerability and damage. Photos taken along the Oregon coast during winter "King Tides" show that even now, some of these facilities are affected by high water and are at increasing risk from even higher tidal elevations.

Effect #2: More Intense Storms and Increased Wave Height

Oregonians, especially those living on the coast, are familiar with the power of winter storms and their effects on the coastal environment. Things, however, are likely to get worse. Scientific study has shown that the maximum "significant wave height" generated by winter storms has been increasing for more than 30 years. Winter storm wave heights are now routinely measured in the 15 – 17 meter (50 – 55 feet) range and extreme wave heights may reach 25 meters (82 feet) off the Pacific Northwest. The paper by Peter Ruggerio, previously cited, explains storms and ocean wave height. In addition, data show that both the frequency and intensity of storms have increased in recent years. Projections suggest that future winter storms may be similar to strong El Niño-influenced storms in 1996-1997 that raised sea level by about 1.5 feet and accelerated coastal erosion and related damage to property and infrastructure.

These changes in the characteristics of storms will be amplified by an increase in mean sea level. Storm surge, which is effectively a higher level of sea surface driven by sustained storm winds and lower barometric pressure, will ride on top of an increase in base sea level. As it is, winter storms often ride on the extreme high tides of winter to increase erosion of the ocean shore and push water levels even higher in estuaries and the lower reaches of coastal rivers; these severe storm events will be exacerbated by climate change. A good overview of the forces affecting beach erosion in Oregon may be found in the State of the Beach Report on Beachipedia, an information website hosted by the Surfrider Foundation about the health of ocean beaches nationwide.

Storms across the Pacific Northwest are a result of massive low pressure systems that develop in Gulf of Alaska that then move eastward with the jet stream to make landfall between southern Alaska and Mexico. Oregon is typically in the path of many of these weather systems. However, these storm tracks often vary due to other atmospheric phenomena such as the El Niño/La Niña phenomena (ENSO, for El Nino/Southern Oscillation). These periodic conditions affect the direction of storm tracks over the Pacific Northwest which in turn influence how ocean beaches and bluffs are impacted by storm waves and how sand is moved as a result of beach and bluff erosion.

Effects on Oregon's beaches are likely to be dramatic as erosion is increased and sand is removed from beaches and redistributed. Curt Peterson's paper in Part Two, *Impacts of Predicted Global Sea Level Rise on Oregon Beaches,* describes these and other effects.

Effect #3: Altered Precipitation Patterns

Climate change models predict significant changes in patterns of precipitation throughout the Pacific Northwest. While over the course of a year the total amount of precipitation may remain about the same as today, those amounts are projected to come primarily in the form of rain rather than snow at mid- to high elevations and in shorter but more intense rainfall events. The Climate Impacts Group at the University of Washington has an excellent website with an explanation of current weather patterns in the Pacific Northwest and scenarios of projected impacts of climate change on those patterns.

The effects of more precipitation falling as rain rather than snow are likely to be felt more in streams that drain the Cascade Mountains and beyond such as the Columbia River and coastal rivers such as the Umpqua and Rogue, with headwaters in these mountains. Low or absent snow pack in these mountains will affect stream levels in summer that are needed for fish such as salmon, for agriculture irrigation, and for municipal water supplies. Streams originating in the Coast Range and Klamath mountains will likely be affected by heavier rainfall events leading to more flooding during winter, followed by longer, drier periods during spring, summer, and fall, challenging some communities with unfamiliar shortages of fresh water. Warm water temperatures that are now common in late summer and early fall on coastal streams are likely to begin earlier in the summer and extend later into the fall. These changes will pose significant challenges for Coho salmon survival in coastal streams.

Effect #4: Changing Ocean Conditions:

Earth's oceans and surrounding atmosphere are inextricably linked. The rising concentration of carbon dioxide and increasing temperatures in the enveloping atmosphere directly affect the condition of the ocean, its circulation, and its water. The Oregon Department of Fish and Wildlife (ODFW) has published a technical summary of the effects of climate change on the nearshore ocean environment off Oregon as part of a process to update the Oregon Nearshore Strategy. Oregon Sea Grant has produced a short video about the broader effects of climate change on the ocean and coast.

Three particular changes in ocean conditions are of special interest and are described below. Links to more specific information are embedded in these summaries.

Acidification

"Acidification" of ocean water off Oregon is a principal concern. Because the ocean absorbs carbon dioxide from the atmosphere, the chemical composition of the ocean is becoming more acidic. Changes in the acidity (pH) of ocean waters on the Oregon coast were first noticed by oyster growers at Whiskey Creek on Netarts Bay. A brief summary of the causes and effects of ocean acidification on the Pacific Northwest has been published by the West

Coast Ocean Acidification and Hypoxia Panel. Oregon State University has also published an overview of the twin topics of acidification and hypoxia (low oxygen conditions that can result in massive mortality of crabs and other animal populations on the ocean floor).

Acidification is of concern because marine food webs are based on biologic productivity of tiny shell-forming marine organisms—zooplankton—many of which depend on the carbonate concentration of seawater. The larval and juvenile stages of many marine organisms build their shells from calcium carbonate that is normally available in ocean water. Changes in the carbonate chemistry of the ocean make development of the calcium-based shells or exoskeletons of these creatures difficult or impossible which, in turn, could reduce the ability of other marine populations which feed on them to survive or adapt to other changes in the marine environment. These adverse effects have implications for the health of the entire marine ecosystem as we know it, and on the commercial and cultural uses of ocean resources. The ODFW technical summary cited above contains a discussion of ocean acidification in the nearshore marine environment. Oregon Sea Grant has produced three video interviews with Richard Feely, a scientist and expert on ocean acidification at NOAA's Pacific Marine Environmental Laboratory in Seattle, who explains how ocean acidification occurs and what its effects are.

Hypoxia

Water masses with low dissolved oxygen (hypoxia) have caused dramatic die-offs of marine creatures along the Oregon coast in recent years. The presence of these water masses appears to be related to changes in ocean upwelling which, in turn, are related to changes in ocean circulation patterns and atmospheric conditions that are being driven by a changing climate. The ODFW technical summary contains a discussion of hypoxia in the nearshore marine environment. A short video produced by Oregon State University explains the hypoxia phenomenon.

Warmer Ocean Water

Warming ocean water temperatures will result in a number of effects that will change the way the ocean behaves. Warmer surface temperatures will increase "stratification" of ocean water and hamper mixing between deeper, colder, more dense nutrient-rich waters and warmer, less-dense, sunlit surface areas. The distribution and abundance of marine organisms that are suited to particular temperature ranges will change in response to warming; coldwater species will be replaced with species favoring warmer water. Predatory species such as salmon are also adapted to a specific range of ocean temperatures; warmer waters will affect both the range of salmon and the distribution of the smaller fish they eat. Upwelling, which drives the rich productivity of marine life over the continental margin, will likely be affected in timing and intensity. On a larger scale, major ocean circulation patterns will likely be affected.

Responding to Climate Change

Responding to the likely effects of climate change seems a daunting challenge. Yet many communities, organizations, and governments nationwide and globally have begun to assess these on-coming effects and prepare plans to adapt to the changes and to increase community resiliency. A quick Internet search will yield many guidebooks and articles. Three will get you started:

1) Adapting to Climate Change: A Planning Guide for State Coastal Managers, published by the NOAA Office for Coastal Resources Management, not only provides useful information but also links to many other information resources.

2) Climate Ready Communities, published in 2009 by the Oregon Coastal Management Program, explains potential impacts and lays out a proposed "action framework" to assist coastal local governments and residents begin the process of planning for adaptation to climate change.

3) Green Works for Climate Resilience, published by the National Wildlife Federation in 2014, is an excellent guide for communities, especially those on the coast, for dealing with the likely effects of climate change.

In addition, the Climate Adaptation Knowledge Exchange (CAKE) provides an excellent on-line source of information to help communities address adaptation to climate change.

Two papers in Part Two provide more information and examples to aid citizens and local governments in adaptation planning: *Planning For Climate Change: Tools for Coastal Communities and Local Governments* by Courtney Johnson and *Climate Change Adaptation Efforts: A Review* by Paris Edwards. .

Tools for Adaptation Planning

A variety of planning tools is available to assist in moving forward on coastal adaptation work. These are discussed below under the headings of Legal and Policy Tools, Technical and Information Tools, and Action Examples and Case Studies.

Legal and Policy Tools

Local Land Use Plans and Implementing Ordinances

Oregon land use law (ORS 197) delegates to cities and counties responsibility to plan for and regulate development. Local land use plans and ordinances are critical legal and policy tools for addressing the likely effects of climate change in specific locations and for planning to increase community resilience. Local government plans must respond to state laws and policies, federal laws and policies, and the needs and desires of the public. Within Oregon's coastal counties and cities, no aspect of climate change planning is more important than addressing high-probability impacts on coastal shorelands. *Coastal Shorelands and Climate Change*, a technical paper by Steve Schell in Part Two, examines legal and policy considerations of planning for the coastal shoreland area. Key issues include:

- ***Amending Land Use Regulations***
  Some local governments, such as Lincoln City and Tillamook County, have already prepared and adopted amendments to local their plans and ordinances that are directed at impacts of climate change in those communities. Other cities and counties are considering how best to proceed. Costs and availability of needed information are often the primary constraints for local governments to undertake planning to address climate change. The Oregon Coastal Management Program (OCMP) in the Department of Land Conservation and Development (DLCD) has completed several projects aimed at reducing these costs by providing data, information, and technical assistance needed to support amendments to local comprehensive land use plans and ordinances.

- ***Transfer of Development Rights***
  One policy tool that may prove useful to local governments is Transfer of Development Rights (TDR), which is "a device by which the development potential of a site is severed from its title and made available for transfer to another location." It is especially useful for protecting certain natural resource areas from development and assisting landowners in relocating proposed development to safer, more suitable sites. The DLCD, under 2009 and 2011 state law, has already begun to explore the use of TDRs as a planning tool. The paper in Part Two by land use attorney Carrie Richter, *Oregon Coast Climate Change Adaptation – Transfer of Development Rights*, offers a detailed discussion of how this tool might be applied to the Oregon coast to protect areas for habitat restoration or migration, to direct development away from likely destruction along the ocean shore, and to help ensure that the design of existing communities will foster resilience to climate change impacts.

- ***Takings Issues***
  Climate change presents unprecedented challenges for local governments in amending comprehensive land use plans and ordinances to address climate change. Local governments and property owners will need to address the fact that some effects of climate change, such as sea level rise, will significantly affect some properties more than others, and will impact some properties that may have been considered safe under prior assumptions of hazard risk. Questions are likely to arise as to the legal options available to local governments to authorize relocation of threatened uses or to approve certain protective structures but not others. A paper in Part Two, *Constitutional Limitations on State and Local Government*

Regulation of Land Use by Ed Sullivan, a noted Oregon land use attorney, discusses the issue of "takings" of private property due to government regulation.

State Laws and Policies

The State of Oregon has important policy and legal tools to help ensure that adaptation planning for climate change is integrated and coordinated among the many affected state and federal agencies and across jurisdictional boundaries.

- ***State Climate Change Policies***
  The December 2010 Oregon Climate Change Adaptation Framework, developed by an interagency team convened by Governor Ted Kulongoski, provides a strategic framework for "continued development of strategies and plans to address future climate conditions." The Framework identifies eleven expected climate-related risks in three tiers: *Highly Likely, Likely,* and *More Likely Than Not*. It also identifies short- and long-term actions that are needed to address those risks and lists basic the capacities needed to do so. The Adaptation Framework is supported by a companion document, the Oregon Climate Assessment Report, prepared by the Oregon Climate Change Research Institute, which provides a detailed scientific assessment of climate change in Oregon.

- ***State Land Use Laws***
  Oregon's statewide land use planning program creates the basic planning and legal framework for addressing the land use effects of climate change on Oregon's coastal communities. Under state law (ORS 197), each city and each county has an adopted land use plan and implementing ordinances that meet the requirements of the statewide planning goals. As time goes on and communities develop strategies to address the effects of sea level rise and other elements of climate change, local governments will need to amend their local comprehensive land use plans, zoning and development ordinances, and perhaps other ancillary plans such as Capital Improvement, Transportation System, and Public Facilities plans as part of the business of local government.

  > NOTE: Oregon's statewide planning program and coastal management program are complex. The Oregon Coastal Management Program has created an on-line training curriculum geared for citizens and local officials about Oregon's land use program, with an emphasis on understanding the statewide coastal planning goals and the coastal management program. This self-guided, self-paced curriculum contains nine chapters and provides an excellent, easily accessible overview for those unfamiliar with Oregon's planning program.

  - ***Statewide Planning Goals***
    While the comprehensive land use plans and ordinances of all jurisdictions statewide must comply with 14 basic statewide goals, coastal cities and counties also must comply with three additional goals that set land use policy for major coastal features: Goal 16,

Estuarine Resources; Goal 17, Coastal Shorelands; and Goal 18, Beaches and Dunes. The requirements of these goals are complex and inter-connected. The DLCD works with state agencies to assist local governments in interpreting and applying the requirements of these goals to specific planning or development situations.

Of critical importance in considering the impacts of sea level rise and increased storm intensity are the requirements in Goal 18 that, except in certain specific instances, prohibit structures built after January 1, 1977, from being eligible for a standard state permit for a shorefront protective structure. Although local governments issue permits for construction of structures on private property along the shore, permits for shoreline protective structures are issued by the Oregon Parks and Recreation Department (OPRD). However, OPRD regulations allow for "emergency permits" that may be issued to protect a structure from imminent destruction during a storm or other event. This Goal 18 policy, along with state laws protecting the public beaches (below) is the primary state policy that will be affected by climate change. In Part Two, *Coastal Shorelands and Climate Change* by Steve Schell discusses how climate change may affect the application of policies and requirements of Goals 17 and 18 to coastal shorelands.

- ***Ocean Shore Laws***

  Enacted in 1967, the Beach Bill is one of Oregon's benchmark statutes that protects the public's right to use the beach. This law was enacted to resolve the question of whether a property owner had the right to exclude the public from the privately owned "dry sand" beaches. The 1967 law granted to the public free and uninterrupted access to the ocean beach and directed that the beach be administered as a State Recreation Area (see The *Oregon Beach Bill* by Steven Bender, in Part Two.

  Under this law, the Oregon Parks and Recreation Department (OPRD) has the responsibility and authority to manage uses of the "Ocean Shore" defined in law as "land lying between extreme low tide of the Pacific Ocean and the line of vegetation as established and described by state law." Part of this Ocean Shore, the strip between ordinary high tide and extreme low tide, is under concurrent jurisdiction of the State Land Board and OPRD.

  OPRD regulates all shoreline protective structure (SPS), whether riprap (large rocks), gabions (small rocks contained inside a wire framework), or seawall (usually concrete or heavy treated wood timbers). The Oregon Coastal Atlas shows examples of protective structures. OPRD must approve these structures guided by requirements of Statewide Planning Goal 18 which specifies that, with limited exceptions, development built after January 1, 1977 is not eligible for SPS installations (aside from those allowed through "emergency permits"). However, many stretches of the central and north coast were developed prior to 1977 and are heavily armored by a variety of SPSs. Parcels within these developed areas that were undeveloped in 1977 have become valuable for home sites because they are usually eligible for an SPS under Goal 18's exceptions. Thus, armoring of some stretches of the coast is nearly complete. In other stretches, without development prior to 1977, there is little armoring. The accompanying article in Part Two, *Permits for Structures on Oregon's Beaches* by Bill Kabeiseman, discusses the policy and legal framework for protective structures in detail.

In the long run, armoring the ocean shore will prove futile against sea level rise and erosion. In the meantime, significant practical and policy questions arise in light of the effects of rising sea level on the ocean shore. One is the current practice of issuing "Emergency Permits" for armoring otherwise ineligible properties during storm events. These permits are meant to be temporary to enable property owners to find other solutions to erosion or flooding hazards but could become a means of circumventing requirements on a permanent basis as sea levels rise and properties are routinely threatened.

Despite temporary advantages that may be gained by some property owners from building seawalls or similar structures, there are significant public costs and consequences of shoreline armoring, one of which is threats to the very existence of nearby beaches along with public access to the shoreline. Higher tides and more intense storms will trigger increased erosion of the beach, which, over time, means that the beach in front of armored properties will disappear, first at high tide and then, increasingly, throughout the tide cycle. In addition, not only will these structures and properties become vulnerable to continuous attack and eventual destruction by ocean waves, but in the interim the public's beach will have disappeared. Conversely, beaches with unarmored dunes or bluffs will be able to migrate landward as sea level rises which will pose threats to properties once thought invulnerable inland of the beach.

The article in Part Two by Janet Neuman, *Accretion, Reliction, and Avulsion – Oregon Common Law*, discusses the important policy implications of the likely landward advance of mean high tide (the upper boundary of public ownership) due to sea level rise. Carrie Richter's paper in Part Two, *Oregon Coastal Climate Change Adaptation - Transfer of Development Rights*, focuses on a possible technique to support a strategy of retreat from the advancing ocean's edge, providing landowners with an attractive alternative to coastline armoring.

- ***Inventory and Database of Shorefront Protective Structures***

  Both OPRD and DLCD in 2013 began a project supported by NOAA's Coastal Service Center to complete a GIS (Geographic Information System) database of each known shorefront protective structure and each specific property that may be eligible for a protective structure under Goal 18 exceptions. These databases and related mapped depictions of the structures will eventually be viewable on-line through the Oregon Coastal Atlas. One of the principal purposes of the project, which is due for completion by August 2015, is to provide a basis for assessing the need to amend or add to state policies for shoreline armoring in light of on-coming impacts of climate change.

- ***Submerged and Submersible Lands***

  As the tidal waters in the ocean and estuaries advance on the land due to sea level rise, so too will the public's ownership of these newly submerged and submersible lands. Upon statehood, the State of Oregon became the trustee, on behalf of the public, of submerged lands of the state, which are "lands lying below the line of ordinary low water...within the boundaries of the state..." and for submersible lands, which are "lands lying between the line of ordinary high water and the line of ordinary low water of all navigable waters and all islands, shore lands...within the boundaries of this state...whether tidal or non-tidal." "Ordinary high and low water" means "annual mean high or mean low water of the preceding year." The State Land Board (comprised of the Governor, Secretary of State, and State Treasurer), with administrative support from the Department of State Lands, has exclusive jurisdiction over all tidal submerged lands owned by the state that have not been sold or otherwise conveyed out of public ownership.

Federal Laws and Agencies

Federal laws and agencies will play important roles in Oregon to address the effects of climate change on the coast. Four of these agencies or laws are important to note:

- ***National Oceanic and Atmospheric Administration***

  The National Coastal Zone Management Program authorized by the (national Coastal Zone Management Act of 1972 (CZMA) provides the authority for Oregon to review federal agency permits and authorizations to ensure they are consistent with federally-approved enforceable coastal management policies which, in Oregon, include certain local comprehensive plan and ordinance policies. This authority could prove to be helpful in ensuring that federal agency programs and actions support efforts by Oregon and local governments to address climate change. In addition, the National Oceanic and Atmospheric Administration (NOAA) Office for Coastal Management provides Oregon with financial and technical resources that are essential to efforts to assess and plan for climate change.

  U.S. Army Corps of Engineers (USACE)

  The USACE administers a number of laws and programs critical to coastal development and response to climate change. In particular, the Rivers and Harbors Appropriations Act of 1899 governs the procedures by which the Corps maintains navigation channels in estuaries, builds and maintains jetties, levees and dikes and other related navigational structures, and approves any fill or removal in navigable waters. The Clean Water Act of 1972 expanded the USACE authority to regulate any fill or removal affecting public waters including wetlands (under Section 404). The Corps of Engineers will be an essential partner in determining the future repair, construction, or removal of dikes, levees, tidegates, and other structures and restoration of the estuarine lands behind them that may be affected by rising tidal elevations

- ***U.S. Fish and Wildlife Service***

  The U.S. Fish and Wildlife (USFWS), through its Oregon Coast Refuge Office, will be an important partner in addressing the effects of climate change, particularly in and adjacent to estuaries and coastal streams. Over the past 20 years the USFWS has established several significant National Wildlife Refuges in or near estuaries along the Oregon coast and has begun to restore estuarine areas in some, such as Siletz Bay, Nestucca Bay, and Bandon Marsh on the Coquille River, by removing dikes and levees to allow tidal inundation. These refuges and restoration efforts will be important laboratories for understanding how best to respond to rising sea level in the estuarine environment in order to provide needed wetlands and aquatic habitat.

- ***Endangered Species Act of 1972***

  The Endangered Species Act (ESA) will drive the consideration by all governmental entities of the health of coastal salmonid populations and other listed species in decisions relating to planning for the effects of climate change. Exactly how the ESA will be employed is unknown, but it has been the primary legal tool that has led to the extensive efforts by citizens, coastal watershed councils, local governments, state agencies, and federal agencies to work together to protect and restore coastal watershed habitats for salmon. Given the serious adverse effects of climate change expected in virtually every component of habitat needed by salmon during various life-history stages, the ESA will likely be a crucial legal instrument affecting adaptation planning.

- ***Federal Emergency Management Agency***

  The Federal Emergency Management Agency (FEMA) conducts several programs on the Oregon coast that are relevant to planning for the effects of climate change. One is the National Flood Insurance Program (NFIP) through which FEMA has worked closely with several agencies in Oregon and other federal agencies such as the U.S. Geological Survey to update RiskMaps of potential flood hazard areas and flood hazard risk based on new, more accurate topographic data, primarily from LiDAR (highly accurate aerial laser-based mapping) for the coast. FEMA and the NFIP are the basis for a governor to declare a natural disaster as the result of major storm damage and for the state to then receive disaster relief funds needed by local governments and property owners. A major component of FEMA's work has been to update maps of potential ocean flooding caused by major storms and including areas that will be vulnerable to tsunami inundation. These maps will be very useful to coastal local governments in assessing vulnerability and risk from severe storms expected as a result of climate change. The Oregon Department of Geology and Mineral Industries (DOGAMI) and the DLCD are the primary state agencies working with FEMA.

Federal *Emergency Management Agency (FEMA) Activities on the Oregon Coast*, a paper by Janet Neumann in Part Two, provides more information about four issues and programs: general FEMA disaster assistance; FEMA flood mapping; FEMA's flood zoning and flood insurance program; and FEMA's limits on repeat claims and its program for acquiring at-risk properties.

Technical and Information Tools

Adaptation planning and actions on the Oregon coast will depend on accurate information about the setting and characteristics of specific locations as well as other information about potential effects and examples of how other communities have addressed this issue.

The Oregon Coastal Atlas

The Oregon Coastal Atlas is an online data repository hosted by the Oregon Coastal Management Program that makes available a wide variety of traditional and digital data about the Oregon coast. The purpose of the Atlas is to "facilitate decision-making relating to the Oregon Coastal Zone." Some data tools are unique products of the Atlas, other tools link to data tools on other websites. Data Tools are organized into three categories: for Planners, Researchers, and the Public. Three of the Data Tools will be of direct interest to citizens and local governments needing to address climate change:

- **Estuary Data Viewer**
  This online viewer allows a user to display a large number of mapped data sets pertaining to Oregon's estuaries (e.g. zoning, transportation facilities, habitats, topography, levees and dikes, etc). The Data Viewer was designed to enable local planners and citizens working in and around estuaries to find, view, overlay, evaluate, and manipulate these mapped data from the large spatial database of the Coastal Atlas. Data were derived from recent LiDAR digital images of the Oregon coast (see also LiDAR Viewer, below) and combined with other existing digital map information to accurately locate all dikes, levees, and other water control structures in Oregon estuaries. The Estuary Data Viewer will be especially useful for tasks related to assessing impacts of sea level rise on Oregon estuaries under statewide planning Goals 16 and 17 and local estuary management plans.

- **Coastal Access Inventory**

This database of all public access sites in the Oregon Coastal Zone is searchable by county or by the type of access facilities available. The inventory was performed by the Oregon Coastal Management Program between 2006 and 2009 as an update to previous inventories. All known public access sites on ocean, estuary, river, and lake shores in Oregon are included.

- **Marine Map**
  Marine Map was constructed to support ocean planning under Statewide Planning Goal 19 (the "Territorial Sea" goal that relates to nearshore and intertidal ocean waters under the state's jurisdiction). Marine Map contains a large number of data sets about the marine environment along the Oregon coast, displayed on the Google Earth platform. Among the many data sets are the locations of critical marine mammal and seabird habitats, shoreline types, and current protected and recreation areas.

ShoreZone Image Library

The Oregon ShoreZone Image Library, with related habitat classification data, is the result of a joint project of a number of state agencies to fly along the Oregon coast during spring low tides and acquire thousands of low-elevation, oblique aerial photographs of Oregon's ocean and estuarine shoreline and related shorelands (see flight report). The site opens with searchable maps of all flight lines and photo locations organized by county. Once a photo is opened, a user can move the viewer forward or backward one image at a time along the flight line using clickable arrows. So a user can virtually fly over the Oregon coast at low tide to see features not visible from ground level. This tool, along with Google Earth aerial imagery and the LiDAR imagery (below), will be very useful in understanding the extent and potential effects of climate change at particular coastal locations.

Oregon LiDAR Image Viewer

The Oregon LiDAR Image Viewer is a easy-to-use website maintained by the Oregon Department of Geology and Mineral Industries. With it, a viewer can find, view, and print detailed surface topographic imagery of the surface of the ground along the Oregon coast and other parts of Oregon. LiDAR has become a fundamental and invaluable tool for assessing the potential extent and effects of sea level rise, ocean and riverine flooding, and tsunami inundation. LiDAR stands for Light Imaging Detection and Ranging. Data that make up a LiDAR image are obtained from a laser signal sent from an aircraft that reflects from the ground surface and is then processed in a computer to determine the differences in surface height. Combined and processed in a computer, these data provide detailed images of the topography of an area surveyed by the aircraft, even minute topographic changes virtually indiscernible in the field.

Climate Adaptation Knowledge Exchange

The Climate Adaptation Knowledge Exchange (CAKE) is an information service of EcoAdapt, a non-governmental organization based in Washington state that is devoted to addressing climate change through adaptation at the community level. CAKE "includes case studies of on-the-ground adaptation efforts, a library of resources to support your work, a community forum with an expert advice column, a directory of individuals and organizations rich with adaptation knowledge, and a tools section full of useful online resources for adaptation planning and implementation."

King Tide Photo Project

The Oregon King Tide Project is part of a global effort to photograph the highest tides (so-called "King Tides") to convey visual examples of what coastal locations will look like in a future with higher sea levels. Citizens are urged to participate in photographing high tide at locations of their choosing during the highest tides of December, January and February. Oregon Shores' CoastWatch program and the Oregon Coastal Management Program are the principal partners in this project for Oregon.

Strategic Planning and Action Examples

Coastal citizens, local communities, and governmental agencies and organizations have begun to take a number of actions to address climate change. Some are creating plans that will enable coordinated action among cooperating communities, non-governmental organizations, and state and federal agencies. Other actions focus on the needs and opportunities of a particular location.

Strategic Planning/Action Frameworks

- ***Regional Framework for Climate Adaptation: Clatsop and Tillamook Counties***

  (URL not yet available) Completed in February 2015, creation of this regional framework was led by the OCMP and Oregon Sea Grant and involved local governments in Clatsop and Tillamook counties, numerous state and federal agencies, several universities and institutes, and many non-governmental organizations. It is based on the eleven climate risks identified in Oregon's state-level Climate Change Adaptation Framework and 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." The project identified priority climate risks, management objectives for climate adaptation, and actions to reduce the consequences of climate risks for four *management regimes*: Infrastructure, Public health and safety, Natural systems, and Working lands. The framework is supported by extensive information in an Appendix document (URL not yet available) and is an excellent example of the kind of coordinated strategic planning that will be required for communities to take effective action to adapt to climate change.

- ***Coquille Estuary Climate Change Vulnerability Assessment***

This science-based assessment was conducted in 2012 and 2013 focusing on the vulnerability of the estuary and its ecosystems to the effects of climate change. The project was co-led by staff from EcoAdapt, The Nature Conservancy, the Coastal Programs of the U.S. Fish and Wildlife Service, and the Oregon Coastal Management Program. It attempted to determine the vulnerability of the habitats, species, areas, and resources of the Coquille River estuary to the effects of climate change. A core feature of the project was obtaining expert information from local stakeholders and local experts about key sensitivities and adaptive capacity of local ecosystem components. The project website provides links to the final report and many supporting information products that contain detailed scientific information about the estuary and its likely vulnerability. This project may provide a model for similar assessments in other estuarine systems of the Oregon coast.

Community Planning

- ***Tillamook County/Neskowin Coastal Hazards Adaptation Plan***

The Tillamook County/Neskowin Coastal Hazards Adaptation Plan and related county development ordinance provisions adopted in 2014 are the result of a multi-year process sponsored by the county to assist the Neskowin community and relevant government agencies to address the increasing threat of ocean erosion and destruction of property along the Neskowin ocean shoreline. Residents were concerned that severe winter storms in 1999 coupled with likely effects of higher sea level due to climate change were a direct threat to the community. They asked Tillamook County officials to assist in developing a plan to address these potential impacts. Oregon Sea Grant, a partner in the process, has an excellent overview of this community effort. Residents and staff from the Oregon Coastal Management Program, Oregon Sea Grant, the Oregon Department of Geology and Mineral Industries, the Oregon Parks and Recreation Department, and scientists from Oregon State University participated.

- ***Tillamook County Coastal Futures Project***

The Tillamook County Coastal Futures Project, led by scientists at Oregon State University and Oregon Sea Grant, is co-sponsored by the Pacific Northwest Climate Impacts Research Consortium (CIRC). Participants include citizens from affected coastal communities in Tillamook County, county officials, city officials, several state agencies, scientists, and others. Participants are assessing a wide variety of information needed to assess vulnerability and develop adaptive capacity. The website provides extensive information on the progress of the project, the participants, and recent publications and products that may be of interest to other communities anticipating similar projects. Of note are links on the website to several presentations by DLCD and OPRD staff.

Habitat Restoration

- ***Ni-les'tun Tidal Marsh Restoration, Bandon Marsh National Wildlife Refuge***

The Ni-les'tun Tidal Marsh Restoration, at the Bandon Marsh National Wildlife Refuge, was completed in October, 2011. After years of planning, this restoration project by the US fish and Wildlife Service returned 418 acres to tidal flooding from the Coquille River by removing dikes that had kept the water from covering this dairy pasture. The project was intended to provide critical lower river/estuarine habitat for young salmon and for shorebirds and waterfowl that migrate through the area. This is the kind of restoration project that may help estuaries respond in a more natural way to the effects of increased tidal elevations due to rising sea levels.

Links to information sources cited in the text:

Climate, Change and the Oregon Coast

The Pacific Northwest Coast: https://www.dukeupress.edu/The-Pacific-Northwest-Coast/index-viewby=title&sort=.html

Climate Impacts Group: http://cses.washington.edu/cig/pnwc/aboutenso.shtml

Climate Change on the Oregon Coast

Climate Science and Predicting Climate Change

International Panel on Climate Change: http://www.ipcc.ch/

U.S. Global Change Research Program: http://www.globalchange.gov

U.S. Climate Change Program Office: http://cpo.noaa.gov/ClimatePrograms/ClimateandSocietalInteractions/COCAProgram.aspx

Oregon Climate Change Research Institute: http://occri.net/

Oregon Climate Service: http://ocs.oregonstate.edu/

Oregon Sea Grant Program video: http://seagrant.oregonstate.edu/video/oregon-climate-2

How the Oregon Coast is Likely to be Affected

Pacific Northwest Climate Change Assessment: http://occri.net/wp-content/uploads/2013/11/ClimateChangeInTheNorthwest.pdf

Climate Ready Communities: http://www.oregon.gov/LCD/docs/Publications/climate_ready_communities.pdf

Climate Change for Oregon's South Coast: http://www.partnershipforcoastalwatersheds.org/climate-change-an-overview-for-oregons-south-coast/

Impacts of Climate Change on Oregon's Coast and Estuaries (Chapter 6 of Oregon Climate Assessment Report): http://occri.net/wp-content/uploads/2011/04/chapter6ocar.pdf

Effect #1 Rising Sea Level

National Academy of Sciences report: http://dels.nas.edu/Report/Level-Rise-Coasts/13389

Journal of Coastal Research: http://www.bioone.org/doi/full/10.2112/JCOASTRES-D-10-00116.1

Oregon Sea Grant Program video: http://seagrant.oregonstate.edu/video/oregon-climate-3

Climate Change and Salmon in the Oregon Coast: http://www.fs.fed.us/pnw/lwm/aem/projects/climate_change_and_salmon.html#key_findings2

Oregon Estuary Map Viewer: http://www.coastalatlas.net/estuarymaps/

Oregon King Tide Photo Project: https://www.flickr.com/photos/90112147@N04/with/13246991654

Effect #2 More Intense Storms and Increased Wave Height

State of the Beach Report:
http://www.beachapedia.org/State_of_the_Beach/State_Reports/OR/Beach_Erosion

El Nino/Southern Oscillation: http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/enso.shtml

Effect #3 Altered Precipitation Patterns

Climate Impacts Group, University of Washington: http://cses.washington.edu/cig/pnwc/pnwc.shtml

Climate Impacts Group, University of Washington:
http://cses.washington.edu/cig/fpt/ccscenarios.shtml

Effect #4 Changing Ocean Conditions

Oregon Department of Fish and Wildlife Technical Summary PDF:
http://dfw.state.or.us/conservationstrategy/docs/climate_change/Climate_Change_Supplemental_pdf_9_25_12.pdf

Oregon Department of Fish and Wildlife Nearshore Strategy:
http://www.dfw.state.or.us/mrp/nearshore/document.asp

Oregon Sea Grant Program video: http://seagrant.oregonstate.edu/video/oregon-climate-4

Oregon Sea Grant Program: http://seagrant.oregonstate.edu/confluence/2-1/whiskey-creek-1

West Coast Ocean Acidification Hypoxia PDF: http://westcoastoah.org/wp-content/uploads/2014/06/OA18PNWFacts14V51.pdf

Oregon Sea Grant Program: http://oregonstate.edu/terra/2011/02/tipping-point/

Oregon Department of Fish and Wildlife Technical Summary PDF:
http://dfw.state.or.us/conservationstrategy/docs/climate_change/Climate_Change_Supplemental_pdf_9_25_12.pdf

Oregon Sea Grant Program videos: http://seagrant.oregonstate.edu/video/acidification-1

Partnership for the Interdisciplinary Studies of the Coastal Ocean (PISCO) PDF:
http://tinyurl.com/pk2j37a

Nature: Hypoxia: http://www.nature.com/news/2010/100811/full/466812a.html

Oregon Department of Fish and Wildlife Technical Summary PDF:
http://dfw.state.or.us/conservationstrategy/docs/climate_change/Climate_Change_Supplemental_pdf_9_25_12.pdf

Oregon State University video: http://www.youtube.com/watch?v=yh5Ev8VEbZ0

Northwest Fisheries Science Center: http://www.nwfsc.noaa.gov/news/features/food_chain/index.cfm

Effects on Salmon PDF: http://tinyurl.com/qxlse7m

Responding to Climate Change

Adapting to Climate Change PDF:
http://coastalmanagement.noaa.gov/climate/docs/adaptationguide.pdf

Climate Ready Communities PDF:
http://www.oregon.gov/lcd/docs/publications/climate_ready_communities.pdf

Green Works PDF: http://www.nwf.org/~/media/PDFs/Global-Warming/Climate-Smart-Conservation/2014/green-works-final-for-web.pdf

Climate Adaptation Knowledge Exchange: http://www.cakex.org/

Adaptation Planning

Transfer of Development Rights: http://www.kzoo.edu/convene/Rules/tdr.htm

Legal and Policy Tools

State Climate Change Adaptation Framework: http://tinyurl.com/ob6z75f

Oregon Climate Assessment Report: http://tinyurl.com/od5hqr6

Statewide Planning Goals : http://www.oregon.gov/LCD/Pages/goals.aspx

Oregon Land Use Planning Training video: http://www.oregon.gov/LCD/Pages/goals.aspx

Oregon Parks and Recreation Dept : http://www.oregon.gov/OPRD/RULES/Pages/oceanshores.aspx

National Coastal Zone Management Program: http://coast.noaa.gov/czm/about/

National Coastal Zone Management Act: http://en.wikipedia.org/wiki/Coastal_Zone_Management_Act

US Army Corps of Engineers Coastal Programs:
http://www.marbef.org/wiki/US_Army_Corps_of_Engineers%E2%80%99_Coastal_Programs

1899 Rivers and Harbors Act: http://en.wikipedia.org/wiki/Rivers_and_Harbors_Act

Clean Water Act: http://www.marbef.org/wiki/Clean_Water_Act

National Wildlife Refuges: http://www.fws.gov/refuges/

Oregon coast National Wildlife Refuges: http://www.fws.gov/oregoncoast

Bandon Marsh NWR Restoration:
http://www.fws.gov/oregoncoast/bandonmarsh/restoration/index.cfm

Endangered Species Act: http://www.fws.gov/endangered/laws-policies

Federal Emergency Management Administration: http://www.fema.gov/

Oregon RiskMap: http://www.oregonriskmap.com/index.php/state-status/41-curent-mapping

Technical and Information Tools

Oregon Coastal Atlas: http://www.coastalatlas.net/

Estuary Data Viewer : http://www.coastalatlas.net/index.php/tools/planners/63-estuary-data-viewer

Oregon Coast LiDAR: http://coast.noaa.gov/digitalcoast/stories/oregon-dikes?redirect=301ocm

Coastal Access Inventory: http://www.coastalatlas.net/index.php/tools/public/55-coastal-access

Oregon Marine Map: http://oregon.marinemap.org/

Oregon Shore Zone Image Library: http://oregonshorezone.info

Oregon ShoreZone flight report: http://oregonshorezone.info/OregonProtocol_Final_July2014.pdf

DOGAMI LiDAR Viewer: http://www.oregongeology.org/dogamilidarviewer/

CAKE: http://www.cakex.org/

EcoAdapt: http://www.ecoadapt.org/

King Tide Photo Project: https://www.flickr.com/groups/oregonkingtides

Strategic Planning and Action Examples

Clatsop-Tillamook Regional Framework for Adaptation to Climate Change (URL not yet available)

Appendices for Clatsop-Tillamook Framework (URL not yet available)

Coquille Estuary Climate Change Vulnerability Assessment: http://ecoadapt.org/data/documents/Coquille_Estuary_Climate_Change_Vulnerability_Assessment_FINAL_1April14.pdf

Coquille Estuary Climate Change Vulnerability Project: http://ecoadapt.org/programs/awareness-to-action/Lower-Coquille-Vulnerability-Project

EcoAdapt: http://www.ecoadapt.org/

Neskowin Community Plan: http://tinyurl.com/npmwjys

Oregon Sea Grant Program: http://oregonstate.edu/terra/2012/01/surfs-up/

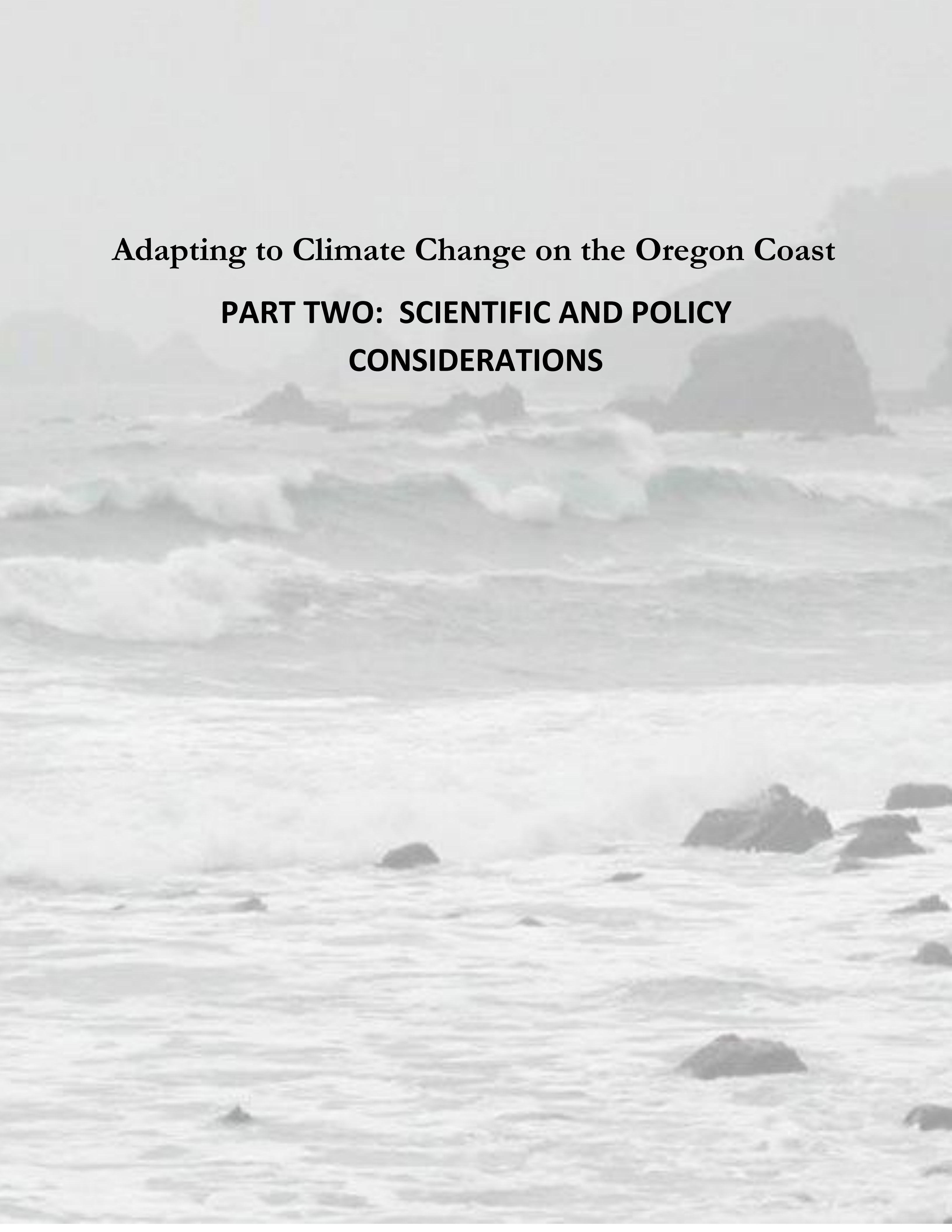
Tillamook County Futures Project: http://envision.bioe.orst.edu/StudyAreas/Tillamook/

Ni-les 'tun (Bandon Marsh NWR) Restoration: http://www.oregonlive.com/environment/index.ssf/2010/06/the_once_and_future_marsh_in_b.html

Ni-les 'tun (Bandon Marsh NMR Restoration): http://www.fws.gov/oregoncoast/bandonmarsh/restoration/index.cfm

Adapting to Climate Change on the Oregon Coast

PART TWO: SCIENTIFIC AND POLICY CONSIDERATIONS



Question: How will climate change affect our ocean along Oregon's coast?

Sea Level Rise and Ocean Acidification

Allen M. Solomon*

The Issue. The fundamental issue for the Oregon coast is that global sea level is rising and is expected to continue doing so in the future along with increasing greenhouse gas emissions. Greenhouse gasses, led in total volume by carbon dioxide (CO_2), warm the lower atmosphere. Some of the excess heat the greenhouse gasses produce is absorbed by the oceans. Warmer ocean water fills more space than cool water. As a result, sea level has been rising, and doing so at increasing rates. In addition to simple ocean warming, the polar and Greenland ice caps and mountain glaciers around the world have been melting and adding their stored water to oceans. Some of the CO_2 is also absorbed by oceans, increasing the acidity of the water. As sea level rises, beaches, estuaries and coastal infrastructure are increasingly threatened. As seawater acidity increases, organisms that grow their shells and skeletons by accreting calcium from ocean water—corals, some of the microscopic algae at the base of the food chain, oysters, clams, and so on—have increasing difficulty developing those shells.

> *Sea level on the Oregon coast may rise an average 3 to 6 feet (1-2 m) by the end of this century.*

Importance to the Oregon Coast. Coastal life and resources of Oregon rely on the sea level and chemistry of the ocean remaining at their historic values. Coastal ecosystems and organisms depend on this status quo, as does the built environment of homes, parks, docks, roads, dikes, municipal facilities, aquaculture, and the like. Sea level rise threatens to damage or destroy many of these ecosystems and structures, while disrupting breeding by nearshore and estuarine aquatic organisms. In addition, increased sea level facilitates intrusion by salt water into fresher water of estuaries and into groundwater that supplies drinking water. The changing acidity of ocean waters can threaten not only commercial crab, clam, and oyster harvesting, but also the basic food chains of ocean life. Increasing ocean acidity impacts calcareous algae (e.g., coccolithophorids) at the base of a food chain that includes these planktonic algae (among others), that are consumed by zooplankton, consumed in turn by other invertebrates, then to be consumed by small fish, and these by larger fish.

Description of the science. Sea levels have been historically measured at buoys throughout the world, and more recently have been measured very accurately by satellite sensors. The most recent report by the Intergovernmental Panel on Climate Change (IPCC) summarized the rate of sea level rise by 2003 at 2-3 millimeters (mm) per decade (IPCC, 2007), with 2 mm the average from 1961-2003 and the 3 mm representing the average from the more recent decade in these data, 1993-2003. Projections for future increases provided by the U.S. Global Change Research

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Program are considerably greater than the earlier IPCC estimates, suggesting a sea level rise of three to six feet by the end of this century (Karl et al., 2009; page 150) or perhaps the next.

Sea level rise at regional scales will differ from these global averages. First, sea levels vary from place to place. For example, between 1993 and 2007 some areas underwent three times the global average sea level rise, as measured by satellite altimetry (Cazenave and Llovel, 2010). In addition, sea levels vary from one season to the next; winter sea levels off the Oregon coast average about 25 centimeters (cm) higher than summer sea levels (Ruggerio et al., 2010). Sea levels also vary with multi-annual climate cycles such as the El Niño-Southern Oscillation (ENSO). Allan and Komar (2002) demonstrate that for strong El Niño years, mean monthly water levels were about 50 cm higher in winter than in previous summers. Coupled with the fact that large storms are most common in winter, the El Niño sea level increases can be more destructive to beaches and infrastructure than the averages would suggest.

Multi-decadal climate cycles have similar effects, though for different reasons. The Pacific Decadal Oscillation (PDO) is a multi-year climate cycle. In its warm phase, which has dominated for the past three decades, it generated strong north winds in summer along the coasts of Oregon and California, increasing upwelling of cold dense water. As a result, regional sea levels have been lower than global levels. The apparent present shift of the PDO to its cool phase with reduced north winds is now permitting sea levels in Oregon to increase as downwelling dominates, drawing in warm and less dense surface waters. This pattern is expected to continue for at least the next few decades (Bromirski et al., 2011).

Another source of regional variability in sea level rise is tectonic, as the entire Oregon coast is rising, some places more rapidly than others. Thus, the relative sea level rise depends on the absolute rise in the ocean surface and on the amount of rise or fall of coastal surfaces. Here in Oregon, South Coast surfaces have been rising at about the same rate that ocean levels have risen, while Middle and North Coast surfaces have risen more slowly, and have not kept up with the sea level rise (Figure 1).

In addition to sea level rise, the ocean is increasingly becoming more acidic. Ocean acidity has increased by 30% since the beginning of the industrial revolution. The IPCC (2007) estimates that acidity will increase 150% over pre-industrial values by the end of this century, if current GHG emission trends continue. Like sea level, acidity also varies spatially. The cold upwelling along the California and Oregon coasts induced by the warm phase PDO during the past three decades has also resulted in higher ocean acidity (lower pH) there, than in the ocean as a whole (Feeley et al., 2008).

An excellent recent source of detailed ocean acidification and sea level information is available on-line (Ruggiero et al., 2010). Much of the material in the paragraphs above was based on this review.

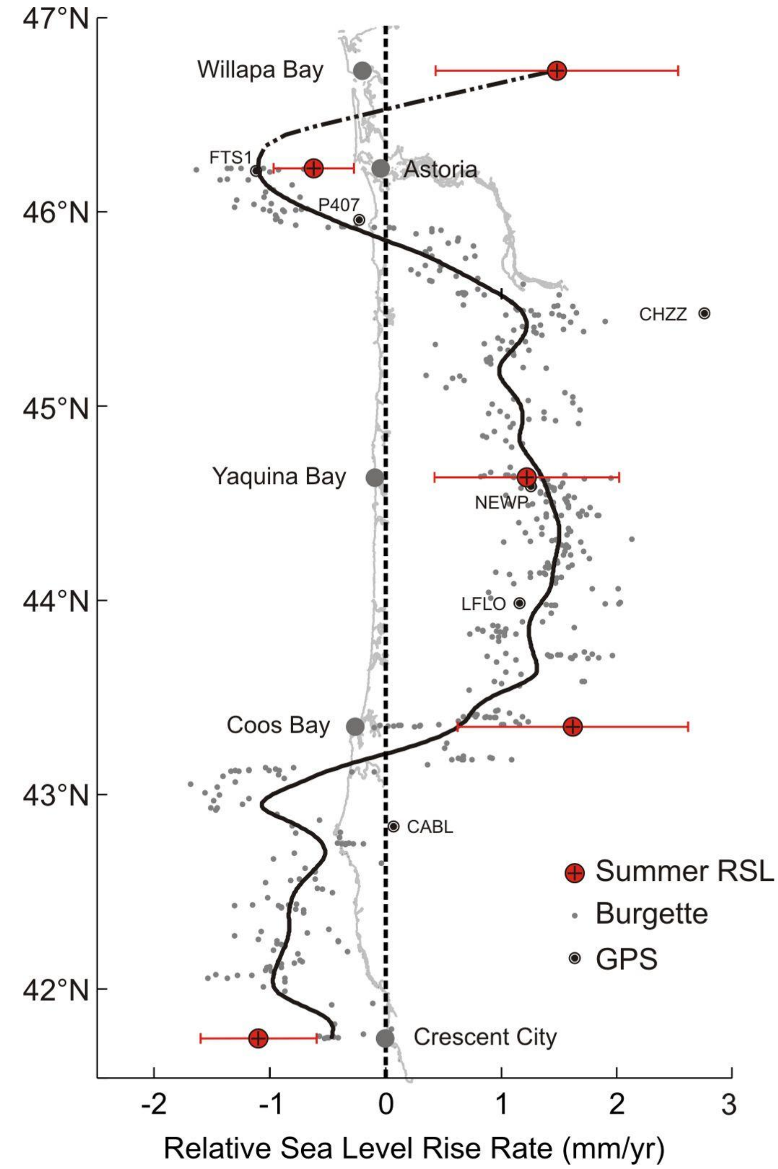

Figure 1. Movement of land relative to movement of sea level in mm per year shown as solid black line. Grey dots (labeled "Burgette") are changes in land elevation measured between 1930 and 1980 surveys (Burgette et al., 2009). Measures of summer relative sea level (RSL) and 95% confidence intervals are shown as red dots and bars, respectively. Note that from about Bandon south (43^{o}N), rising sea level is being exceeded by rising land surfaces while from Coos Bay north (except Astoria), sea level is rising more rapidly than land surfaces. Figure is from Komar et al., (2011).

Effects on the Oregon Coast. The rise in sea level will have several direct effects on the Oregon coast. Much concern has been directed at potential increases in beach, dune, and cliff erosion and the impact on vulnerable coastal infrastructure. A three to six foot increase in sea levels in a century is likely to also endanger many coastal roads, rail lines, jetties, recreational facilities, and coastal city facilities such as stormwater systems, water supply systems, and wastewater treatment plants. As illustrated in Figure 1, these impacts are likely to be of particular importance from Florence north almost to Astoria, an area where considerable beach erosion is already evident.

Increasing ocean acidity is likely to have critical impacts on natural populations of corals and on harvests of planted clams and oysters as well as on fisheries, especially near the end of the century as calcareous phytoplankton decline. Already, the higher acidity of northwest coastal waters has caused an oyster hatchery failure at the Whiskey Creek hatchery at Netarts Bay. High acidity and low concentrations of the carbonate mineral aragonite (required for oyster shell growth) in upwelled coastal waters during 2009 caused the year's oyster spat production to fall below economically viable levels (Barton et al., 2012). Meanwhile, increasing ocean acidity also reduced larval oyster survival by 60% in 2008 and 80% in 2009 at the Taylor Hatchery on Dabob Bay in Puget Sound, near Quilcene, Washington. In response, that hatchery has moved part of its operation to Kona, Hawaii, where waters are less acid.

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Question: How will climate change affect Oregon coastal wave heights and water levels?

Climate Controls on Northeast Pacific Wave Heights and Total Water Levels

Peter Ruggiero*

The Earth's changing climate has effects on multiple atmospheric and oceanic processes that influence coastal hazards in Oregon. Given these effects, we must update the methods we use to predict and quantify vulnerability to coastal flooding and erosion, in order to better protect coastal populations, infrastructure, and ecosystems. Most recent attention has been directed toward potential acceleration in the global average rise in sea levels (e.g., Church and White, 2006; Bindoff, 2007). This problem has received considerable scientific, public, and political attention, and research has focused not only on predicting the magnitude and time scales associated with sea level rise (e.g., Rhamstorf, 2007), but also on studies quantifying the merits of various mitigation and adaptation strategies (e.g., Nichols and Tol, 2006). A second important phenomenon that has been linked to global climate change (Graham and Diaz, 2001), but has received considerably less attention, is that of increasing extra-tropical storm intensities and the heights of the waves they generate.

The Oregon coast is well known for the severity of its winter storms and the heights of the waves they generate (Ruggiero et al., 2010a). During storms, the deep-water significant wave heights are regularly greater than 10 meters (about one storm of this size per year), the "significant wave height" being defined as the average of the highest one-third of the measured wave heights within (typically) a 20-minute period. Since this figure is an average, there are larger individual waves generated by the storm, with the maximum height being approximately 1.7 times greater than the significant wave height. Therefore, for a storm with a 10-meter significant wave height, waves having heights up to about 17 meters can be expected. The most extreme storm in recent years in terms of the heights of the waves measured by offshore buoys occurred in early March, 1999, when the significant wave heights reached 14 to 15 meters (Allan and Komar, 2002). The highest individual waves during that storm likely had heights of about 25 meters, the height of a 10-story building.

The first buoys designed to measure waves off of Oregon's coast were deployed by the National Oceanic and Atmospheric Administration (NOAA) in the mid-1970s, providing hourly measurements of wave heights and periods. Of concern is the fact that the heights of these waves have been increasing over the decades (Allan and Komar, 2000, 2006, Komar et al., 2009, Ruggiero et al., 2010b), as a result of increasing storm intensities. The analyses by Allan and Komar (2000, 2006) were based on averages of the winter significant wave heights, "winter" being taken as the months of October through March, the dominant season of strong storms that are important to erosion and flood hazards along the coast. Those analyses documented that since the 1970s, when the buoys became operational, the greatest rate of increasing wave heights had occurred off the shores of Washington and Oregon, with lower rates of increase off the northern and central California coasts. Meanwhile, waves off southern California were

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found to have experienced little net change. Analyses by climatologists of North Pacific extra-tropical storms have concluded that their intensities (as measured by wind velocities and atmospheric pressures) have increased since the late 1940s (Graham and Diaz, 2001). This implies that the trends of increasing wave heights likely began in the mid-20th century, earlier than could be documented with the direct measurements of the waves by buoys. Graham and Diaz (2001) suggested that the intensification of North Pacific winter storms has resulted from increasing upper-level winds; a finding that had been observed earlier by Ward and Hoskins (1996). They further hypothesized that this increasing trend in upper-level winds might be the result of global warming, specifically the increased sea surface temperatures in the western tropical Pacific.

Additional research on trends in mid-latitude extra-tropical storms in the Eastern North Pacific has confirmed an increase in intensity but has documented a decrease in frequency, possibly since the storm tracks have shifted polewards during the latter half of the 20th century (McCabe et al., 2001). However, Geng and Sugi (2003) found that the decrease in annual numbers of storms is typically due to fewer storms of weak-to-medium strength, while stronger storms have actually increased in frequency. These documented changes in storm tracks are thought to be primarily due to changes in baroclinicity, which in turn is linked to changes in atmospheric temperature distributions due to increased greenhouse gas emissions. In other words, in the mid-latitudes of the Northern Hemisphere a decrease in the meridional temperature gradient (i.e., north-south; the poles are warming faster than lower latitudes) has led to a decrease in mid-latitude storm frequency. Yin (2005) used the output of 15 coupled general circulation models to relate the poleward shift of the storm track to changes in baroclinicity in the 21st century. Though these studies were conclusive that the storm track shifts poleward in the Northern Hemisphere with warmer temperatures, uncertainties regarding natural variability and model limitations remain. Recently, Favre and Gershunov (2006) analyzed wintertime cyclones (low pressure 'storms') and anticyclones (high pressure 'calms') over the Northeast Pacific for the period 1950 to 2001. They observed that while the strength of anticyclones had gradually diminished and their frequency had become more variable, extratropical cyclones had intensified (consistent with the earlier work of Graham and Diaz, 2001). However, the exact cause of these changes and the degree of intensity was not explained.

Unfortunately, a detailed understanding of the impact of future climate controls on Northeast Pacific wave heights is presently lacking. However, of particular significance to Oregon's coastal hazards is that the more extreme waves generated by the strongest storms are increasing at appreciably higher rates than are the winter averages (Allan and Komar, 2006; Ruggiero et al., 2010b). This is shown in Figure 1, with a series of data plots and regression lines illustrating the annual average measured significant wave heights, the winter averages, the average of the five largest measured significant wave heights that occurred each winter, and the annual maximum significant wave height representing the most severe storm each year. All four analyses displayed in Figure 1 reveal increasing significant wave heights over the decades. While the averages of all significant wave heights measured during the winter have been increasing at a rate of 0.023 m/year, the maximum significant wave heights of the strongest storms have been increasing at the substantially higher rate of 0.093 m/year. As shown in the topmost regression line, this maximum significant wave height has increased from about nine meters in the latter 1970s to about 12 meters in 2005, the 30-year span of measurements from the NOAA buoys.

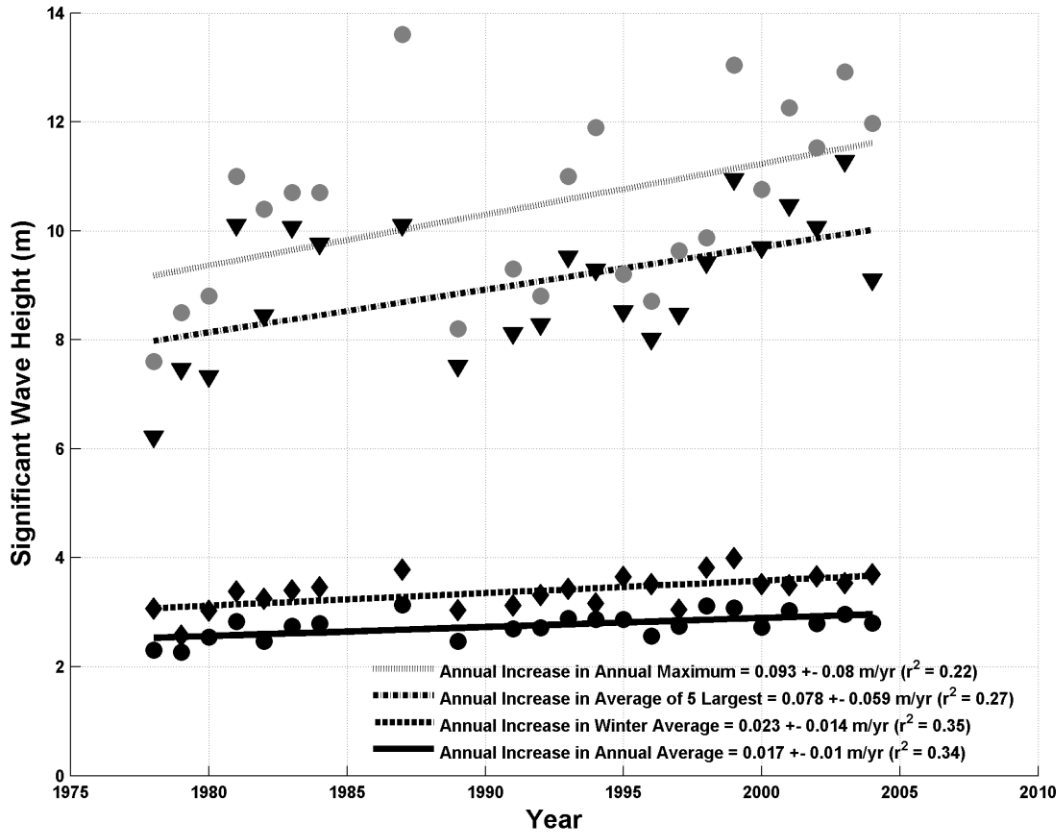

Figure 1: *Decadal increases in annual average and winter average significant wave heights, average of the five largest significant wave heights per winter, and annual maximum significant wave height measured by NDBC buoy #46005. The regression slopes and the uncertainty of the regression slopes are given along with the r^2 values. The coefficient for the increase in wave height over time in each of the regressions is statistically significant at the 95% confidence level. (after Ruggiero et al., 2010b).*

Ruggiero et al. (2010b) pointed out that since the wave height climates are governed by the log-normal probability distribution, a modest increase in the annual mean can have a significant impact on the frequency and magnitude of extreme events. Therefore, measurements of significant wave heights off the Pacific Northwest coast represent a clear example of a phenomenon that was suggested by Wigley (1988) in general terms; a gradual change in the mean climate of an environmental variable can result in significant increases in the frequency of extreme events.

The analyses in Figure 1 of the decadal trends in the average significant wave heights provide documentation of the increasing storm-generated waves measured by buoys off the coast of the Pacific Northwest. To a degree they can provide guidance as to the magnitudes of increases in the extreme-value projections, the 25- through 100-year events that are needed in coastal-hazard assessments and by ocean engineers in their designs of coastal structures. However, formal statistical analysis procedures have been developed that can be applied to time-varying changes in data populations, with many directed toward the environmental consequences of global warming (e.g., temperatures, rainfall, and river discharges). Such statistical procedures represent a significant advance over classical extreme-value theory, and have been applied in analyses of the decadal changes in the wave climate of the Pacific Northwest, with projections of its extremes (Ruggiero et al., 2010b). Figure 2 presents the results of such an application to the NOAA buoy data, with the measurements analyzed being the five highest significant wave heights measured each year (not their averages as analyzed in Figure 1 to determine the trends in the annual averages). This analysis represents an application of the *r* largest-order statistical model to extreme-value analyses, with time being modeled as a covariate via the location parameter of the generalized extreme value (GEV) distribution (Ruggiero et al., 2010b). The three lines included are for the 25-, 50- and 100-year projections, each increasing at a rate of approximately 0.07 m/year, a result that is in good agreement with the linear regression for the highest measured significant wave heights (Figure 1), but by having analyzed the extreme values using the more advanced procedures, the statistical significance and confidence in the results has considerably improved.

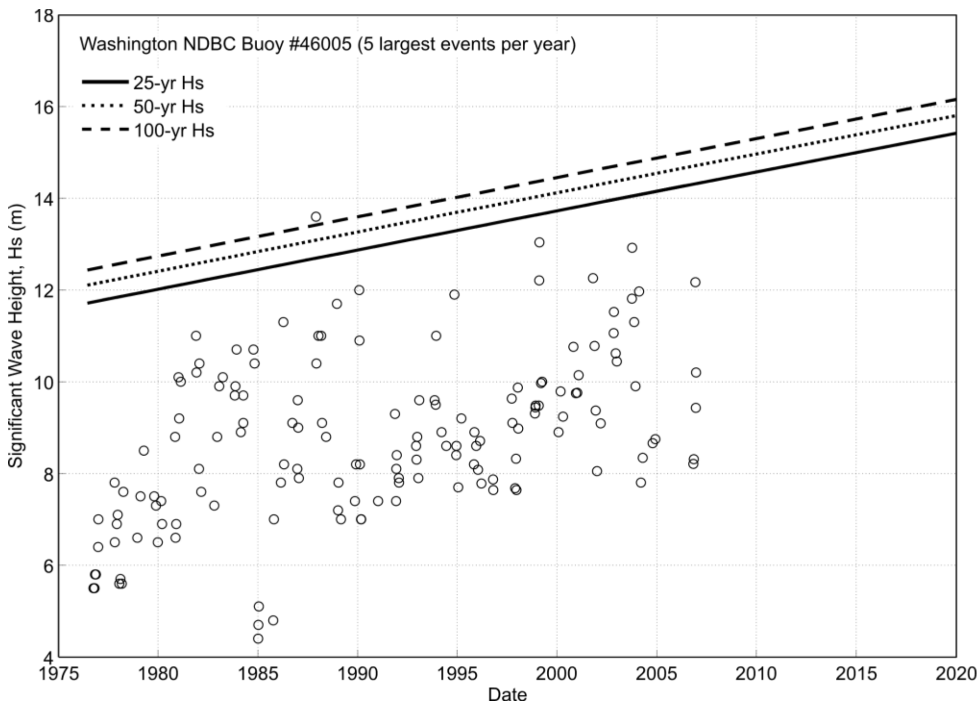

Figure 2: *Statistical analyses of the increasing extreme-value projections for wave height, having approximately a 0.7 m/year rate of increase, based on the five highest significant wave heights measured each year by the Pacific Northwest buoy.*

The relative contributions of sea level rise and increasing extra-tropical storminess to the frequency with which waves attack coastal properties can be assessed with simple total water level models. Ruggiero (2008) showed that for the coast of the Pacific Northwest over the period of wave-buoy observations (~30 years), wave height (and period) increases have had a more significant role in the increased frequency of coastal flooding and erosion than has the rise in sea level during that time period. Where tectonic-induced vertical land motions are significant, the impact of increasing wave heights has been two to three orders of magnitude more important than relative sea level change. While it is uncertain whether wave height increases will continue into the future at their present rates, it is clear that this process will remain more important than or at least as important as sea level rise, and must be taken into account in terms of the increasing exposure to coastal hazards. Under future climate change scenarios, rising storm wave heights may increase the probability of coastal erosion/flooding as much as three times as quickly as sea level rise alone, while the combination of these climate effects on the total water level could cause as much as a ten-fold increase in the frequency of erosion and flooding.

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Question: Will Oregon's beaches be lost as sea level rise occurs?

Impacts of Predicted Global Sea Level Rise on Oregon Beaches

Curt Peterson*

Future global sea level rise of 1-2 meters (3-6 feet), predicted to occur during the next century or two (Pfeffer et al., 2008; Vermeer and Rahmstorf, 2009), will impact Oregon beaches through beach sand erosion and sea cliff retreat. Some of the most susceptible beaches in Oregon are showing evidence of the initial impacts of renewed beach erosion after several thousand years of relative stability (Hart and Peterson, 2007). Some of the beach sand loss might be attributed to changes in storm wave direction (Peterson et al., 1990), height, and/or frequency (Ruggiero et al., 2010), but the long-term sand loss to the continental shelf and other submerging sand sinks will eventually impact all of Oregon's sandy coastlines.

The onset of net sand loss is apparent at many Oregon beaches where "mystery tree stumps" are being exposed by episodic erosion, after having been buried by beach sand for several thousand years. From north to south, some of these beaches are those at Arch Cape, Cape Lookout, Neskowin, Beverly Beach, Seal Rock, and Nesika Beach (Hart and Peterson, 2002). The most recent exposures of the mysterious stumps were documented following strong El Niños in 1983 and 1998 (Hart and Peterson, 2007). Stumps from some beach platforms located north of Yachats, Newport, Neskowin, Cape Lookout, and Arch Cape are now exposed during winter storm periods on an annual basis.

The exposure of the surf zone stumps and the wave-cut beach platforms in which they are rooted demonstrates very shallow depths of beach sand along much of the Oregon coast. Many of the wide beaches that are apparent during summer low tide conditions actually represent very thin layers of sand (1-2 m in thickness) above gravel or sedimentary rocks (Peterson et al., 1991; Peterson et al., 1994). The wide summer beaches shown in many scenic photographs of Cannon Beach, Agate Beach, Port Orford, and Gold Beach, among others, will not exist when the remaining thin layer of beach sand is permanently lost from the beach face within the next century.

Historically, the Oregon beaches were thought to be in dynamic seasonal equilibrium, as summarized by Fox and Davis (1978). This theory proposed that offshore and northward transport of beach sand during winter months was balanced by onshore and southward transport of sand during summer months. However, longer-term records of sand supply to many Oregon beaches do not support the equilibrium theories. For example, net littoral drift is indicated by dune sand accumulations at the northern ends of littoral cells in northern Oregon and at the southern ends of littoral cells in southern Oregon (Peterson et al., 2009). The episodic export of sand from one littoral cell to another might account for long-term loss of sand from some of these cells including Lincoln City, Neskowin, and Arch Cape in northern Oregon and Gold Beach and Brookings in southern Oregon.

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Observations from some littoral cells in central Oregon focus on areas that do not experience any net alongshore littoral drift, yet show long-term loss of beach sand. In addition to the mystery stumps that are being exposed along some of these beaches, such as Newport and Bandon, large sand dune ramps that backed up against the sea cliffs in those beaches have been largely eroded away (Hart and Peterson, 2007). The broader list of eroded prehistoric sand ramps includes exposed sea cliffs at Oceanside, Cape Lookout, Cape Kiwanda, Lincoln Beach, Nye Beach, Yaquina Point, Seal Rock, Waldport, Tilicum, Silver Surf, Yachats, Washburne, Heceta Head, Whiskey Run, Bandon, Blacklock Point, Nesika, Otter Rock, and Crook Point (Hart and Peterson, 2007).

The wide-scale planting of European dune grass has caused historic foredune accretion in some Oregon beaches (Reckendorf et al., 1998). However, the artificially produced foredune accretion presents a false impression of long-term beach stability. The foredunes have not continued to accrete seaward at either Coos Bay or Florence since their development several decades ago. In some localities, including Port Orford, Ona Beach, and Neskowin, the artificially accreted foredunes are undergoing modern erosion.

With the important exception of the Clatsop Plains, and a few other beaches located near large rivers, most of the Oregon's beach sand originated from onshore transport of continental shelf sand (Clemens and Komar, 1988). That onshore transport of sand peaked during the middle Holocene transgression five to eight thousand years ago (Peterson et al., 2007). During the last several thousand years of minimal sea level rise of 1.0 meter per thousand years (Darienzo et al., 1994), the ocean waves pushed ashore the remaining shelf sand that was within their reach of water depth, known as "wave base." There are no significant sources of new sand other than eroding sea cliffs that are now available to supply the beaches of the central Oregon coast. The predicted increase of sea level rise (1-2 meters) from ongoing global warming (Vermeer and Rahmstorf, 2009) will effectively raise the depth of wave base and thus allow eroding beach sand to backfill the deepening inner continental shelf (Bruun, 1962). This reversal of net across-shore sand supply from early transgressive onshore transport to post high-stand offshore transport has already been reported from some of the world's most susceptible shorelines, such as in the Netherlands. The submergence of estuarine tidal flats in some of Oregon's bays will provide a smaller sink for eroding beach sand. Longshore transport of beach sand will temporarily benefit downdrift beaches at the expense of updrift beaches in some littoral cells (Peterson et al., 2009). However, the lack of new sand supply, under a regional condition of rapidly rising sea level (1-2 meters in the next century or two), will ultimately impact all of the Oregon beaches.

There are different methods of predicting the shoreline retreat that will occur from global sea level rise along the Oregon coast. Probably the simplest methods are based on lateral shifts of equilibrium across-shore profiles, i.e., assumptions that the current shape, slope, and annual sand replenishment cycle of a beach (its "equilibrium profile") will be maintained and this whole system will simply move inland as the sea level rises. The "Bruun rule" equates beach shoreline retreat distance to a landward shift of the equilibrium profile, based on the rise of relative sea level (Bruun, 1988). Calculated ratios of retreat distance to sea level rise range from 100:1 or 200:1 for sand-bottomed beaches in the northern Oregon coast (Peterson et al., 2000). A sea level rise of 1-2 meters could therefore be expected to yield 100-200 meters (~300-600 feet) of beach retreat. Such retreat distances in Oregon are confirmed by evidence from coseismic subsidence events following the last Cascadia great earthquake in 1700 C.E. In some locales, during the earthquake the land surface at the coast dropped 1 to 2 meters, causing catastrophic beach erosion in southern Washington and northernmost Oregon (Meyers et al., 1996).

Most of Oregon's beaches are narrower than the calculated retreat distances. Most Oregon beaches lack sufficient sand buffers to accommodate 100 meters of beach retreat without exposing sea cliffs and associated wave-cut platforms (flat areas of rock at the base of cliffs, along the upper border of the beach) to wave attack. Steeply sloped wave-cut platforms provide cliffs with more protection against sea level rise than do gently sloped ("low gradient") wave-cut platforms. An equilibrium profile method can be used to estimate the retreat of wave-cut platforms and sea cliffs that are cut into weak Pleistocene strata, layers of cliff that are common along the coast. A 1.5 meter rise in sea level is estimated to result in 30 to 60 meters (90-180 feet) of landward shifts of representative sea cliffs cut into weakly cemented sand or mudstone strata, based on wave cut platform gradients of 3.0 and 1.5, respectively. Such low gradient platform slopes have been measured in Cannon Beach, Lincoln City, Otter Rock, Newport, Yachats, Whisky Run, and Garrison Beach, among other locations (Peterson et al., 1994).

These geometric methods do not provide rates of shoreline retreat (how quickly the shoreline will move landward), but only the long-term response to a prolonged change of sea level (how much the shoreline will eventually retreat given a certain amount of sea level rise). Nevertheless, the estimates provided above demonstrate the potential for widespread loss of existing sandy beaches (> 80%) and destabilization of sea cliffs (> 50%) along the Oregon coastline in response to predicted sea level rise of 1-2 meters during the next century, or two.

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Question: What effects on Oregon's bays and coastal rivers and their surrounding wetlands can be anticipated from climate change and what planning responses should there be?

Oregon's Estuaries and Climate Change

Corrina Chase*

Estuaries, where rivers meet the ocean, are complex and ecologically valuable habitats. The nature of estuaries is governed first by physical factors such as geology, tides, and the size of the river flowing into them. Biological factors, such as dominant plants or invasive species, are also important. Human factors such as shoreline development and increased erosion or altered water flow regimes due to logging and other activities in watersheds are producing significant changes. Predicted climate changes will influence all these parameters and produce major effects in estuaries on the Oregon coast. Although these effects are difficult to predict precisely, they are likely to have negative consequences for salmon and other wildlife populations, as well as causing flooding of low elevation housing and other elements of the built environment, among other concerns.

> ***Estuary***
> *A partly enclosed coastal body of water with one or more rivers or streams flowing into it, and with a free connection to the open sea.*
> (Pritchard, 1967)

Unique Factors for Oregon Estuaries. In order to discuss how climate changes will affect estuaries, it is important to understand the factors that make estuaries in Oregon unlike, for example, estuaries in Bangladesh, and why individual estuaries in Oregon are different from each other. Factors and processes that determine the characteristics of the estuary may change with climate (such as river flow and sea level) or may influence how the estuaries will respond to changes in climate (such as watershed size).

> ***Key estuary drivers***
> - *Geomorphology*
> - *River influence*
> - *Ocean saltwater and tides*
> - *Biological (dominant native and invasive species)*
> - *Development and restoration*
>
> *(Brophy, 2011)*

Coastal geomorphology is the understanding of how the land is formed and with what types of materials. In Oregon, the subduction of the Juan de Fuca Plate beneath the North American Plate has produced the volcanic Cascade Mountains where the melted oceanic plate rises upwards as magma, and the coastal range, where the North America plate responds to the pressure eastwards with an upward ridge like a rumple in a carpet that has been pushed from one side.

The Coast Range narrowly parallels the Oregon coast and creates small, steep watersheds with a limited coastal plain. Upstream from estuaries, rivers narrow rapidly into steeper gradients in the hills of the coastal range. This is important because there is little room for estuaries to migrate inland in the circumstance of sea level rise (Brophy, 2011).

**Tryon Creek Watershed Council staff member and Oregon Shores board member*

Tectonic movement is causing the shoreline to slowly rise. In general, there is a very slow uplift in elevation, approximately 1 millimeter (mm) per year or less in Lincoln County and up to 4.5 mm/yr both to the south near Port Orford and to the north by Astoria (Burgette et al., 2009). The upper bounds of this rate are within the upper range of estimated increasing sea level rate, meaning that near Astoria and Port Orford, relative sea level height may not increase because the shoreline is rising as fast or faster than the sea is rising. In Lincoln County, however, this is not the case and sea levels are expected to increase relative to the land. Another key consideration is that a major subduction zone earthquake is predicted to lower elevations along the coast by up to a meter, resulting in a sudden increase in relative sea level (Hawkes et al., 2011). The scientific community estimates up to a 37% chance that this type of earthquake, similar to the 2011 earthquake in Japan, will occur in the next 50 years (Rojas-Burke, 2010).

Oregon Tides and Estuary Drivers. The ocean's influence is a defining feature of estuaries. In Oregon the tidal range is large, with extreme tides at 4 meters above average low water level. These high tides can be amplified by storms or river flow. Where narrowing estuarine river valleys act as a funnel and focus tidal height, this can be even more dramatic. To visualize what normal tidal fluctuations might look like in the future, one can look at the high tides during "King Tides" or the highest tides created by gravitational pull of the aligned sun and moon (Price, 2011). Amplifying these tidal events by storm surges and/or heavy river flows will result in more frequent and larger flooding events.

Water level and salt influence are key factors for estuary vegetation and geomorphology. An elevation of less than a foot can make the difference between a mudflat dominated by pickleweed versus a high marsh dominated by tufted hair grass. Change of a meter or more through climate-induced sea level rise, in addition to lowered land elevation due to a subduction earthquake, could turn a high marsh into subtidal habitat and change upriver floodplains into the new estuary.

Freshwater. Freshwater is the other side of the estuary equation. The size, sediment load, upstream characteristics, and changing flow levels of rivers all influence their estuaries. In general, there is high river flow during the winter months due to rain, and decreased river influence during the drier summer. The seasonally high flows combined with rapid narrowing of the river valley upstream result in the middle to upper estuary being heavily influenced by river flow (Brophy, 2011). Rivers deposit sediments in the estuaries as the water slows, spreads out, and mixes with saltwater. This deposition creates the broad floodplain in estuaries and drives the evolution of its wetlands. Rivers bring organic matter ranging from organic sediments to large trees into the estuary, especially during winter storms.

River flow patterns are predicted to change on the Oregon coast due to climate change, with increased winter precipitation and lower levels during the summer (Mote, 2010). The balance between the freshwater from rivers and saltwater from the ocean determines salinity levels. These fluctuate daily with tide and yearly with seasons. A change in the pattern will result in different plant communities, soil chemistry, and habitat (Adamus et al., 2005). A salmon smolt may experience a much sharper gradation from fresh to salt water as it migrates downstream with extreme flooding or drought conditions.

Biological Factors. Biological factors are important to the structure and function of estuaries as well. Native plant communities such as Sitka spruce swamps, tufted hair grass meadows, and eelgrass beds affect the fundamental properties of the habitat such as water temperature, soil structure, and chemistry.

Invasive plants and animals can affect these parameters. For example, a new parasite is causing population decline in mudshrimp, which are very important for their influence on the structure and chemistry of mudflats (Griffen, 2009). Invasive species invading local ecosystems appear to gain a competitive advantage from climate change and are likely to become more dominant in the future (Stachowicz et al., 2002).

Populations of species that are present in estuaries will be affected in other ways by climate change, resulting in changing community dynamics. Some animals are especially important to conserve for their roles within the ecosystem. Beavers construct dams and tunnels, especially near the upper influence of the tide. Their activities are important components of the ecosystem; for example, they provide important habitat for salmon. Beaver activity helps lessen the impact of climate change in river systems by providing cool water refuges, reducing peak flooding, and increasing summertime stream flow. Their activity encourages small floodplains to develop, which may help estuaries move upstream.

Human Factors. In the 1900s most estuaries in Oregon were diked and ditched as part of conversion to agricultural use. Agricultural, industrial, and urban development from the 1950s through the 1970s led to filling and infrastructure development in areas formerly part of the intertidal ecosystem. Estuaries have also been dredged for ship canals or affected by upstream dams or water withdrawal, changing flows and sediment transport (Adamus et al., 2005). Many houses and communities are built on filled estuarine marsh and mudflat areas and in floodplains that are within reach of estuary flooding. Highway 101 and other transportation routes added significant dikes.

Diking of estuaries and other wetlands may decrease the frequency of flooding, but causes land subsidence (sinking) by preventing the natural deposit of sediments in the flood plain, resulting in lower elevations. Diking also dramatically increases the height of flooding in the remaining floodplain areas because the river is not allowed to spread out over a large area during high water events. The increased risk of flooding due to sea level rise, the upstream movement of head of tide, and heavier winter river flows will result in more destructive flooding of communities.

How will estuaries be affected?

- *Increased flooding and landward migration of estuaries*
- *Continued impacts from development, invasive species, and other external factors*
- *Can sediment accretion, restoration projects, and upstream conservation help?*

(Brophy, 2011)

Despite a general reduction in the size, functioning, and dynamic movement of estuarine areas due to diking and development, restoration projects have helped bring back some estuarine habitat.

Sea Level Rise and Estuaries. With sea level rise, there is a significant overall loss of estuary area. Since the Government Land Office land surveys in 1890, 70 to 80 percent of tidal marshes and over 90 percent of tidal swamps have already been lost in Oregon (Adamus et al., 2005). How the balance of development and restoration will change with climate change and other future factors is an open question. It is almost certain that the Oregon coast will experience even more intensive population growth and development pressure in the future. Fortunately, how this trend manifests itself is at least partially within our power to direct.

Our best understanding is that there will be significant changes in Oregon's estuaries due to climate change. Increased winter river flows combined with sea level rise should result in increased flooding and landward migration of estuaries. These effects will likely be compounded by increasing development pressure and with the event of a subduction earthquake which will lower land elevations in portions of the coast. Small watersheds with specialized biological communities and no room to move upstream are most at risk.

Adaptation. We do have the ability to shape these changes, and there are other factors that can give cause for hope. Rivers deposit sediments in estuaries that can build elevations of marsh surfaces. If this happens at a rate that can keep up with sea level rise, plant and biological communities can more easily adjust. The restoration and conservation community is strong on the Oregon coast, and many projects are already restoring previously developed or diked estuary habitat. Restoration that increases estuary size gives more area for flooding to occur, reducing the overall flood height. Projects protecting upstream habitats and making landward migration of estuary habitat possible are also important tools.

Intact habitat and the processes that allow natural adjustment and resilience are the most important natural features to conserve and restore. For instance, ensuring natural sediment deposition by removing dikes to allow flooding and sheet flow across the estuary and protecting upstream sediment transport will help marsh surfaces maintain their elevation. Protecting and restoring beaver populations, guarding against invasive species, and protecting key species such as salmon will increase the resiliency of the estuary.

If the ecosystem is stressed by other factors, it has less ability to adjust to the impacts of climate change. This holds true for humans as well. Planning, changes in land-use, economic diversification, and community strengthening will help people be less drastically affected. Each estuary is unique and will respond in different ways. A conceptual model of key processes, ecological and human priorities, potential climate induced changes, and other human impacts should be used for planning on the watershed level. The bottlenecks that restrict adaptation and resilience should be identified and addressed. Threats and adaptation needs must be widely communicated to the community. While there will be very serious changes in Oregon's estuaries, there are some clear steps that can be taken to help our communities and ecosystems adapt.

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Question: How will climate change and sea level rise affect Oregon's tidelands?

Impacts of Predicted Global Sea Level Rise on Oregon Tidelands

Curt Peterson*

Future global sea level rise of 1–2 meters (3–6 feet), predicted to occur during the next century or two (Pleffer et al., 2008; Vermeer and Rahmstorf, 2009), will impact Oregon tidelands through increased flooding and salinity intrusion. Estuary tidelands in Oregon range from freshwater spruce bogs growing 2 meters (6 feet) above mean (average) sea level to freshwater-brackish marsh (1–2 meters above mean sea level) to brackish-marine marsh (0–1 meters above mean sea level) to mud and sand tidal flats below mean sea level. These tidelands, also known as tidal wetlands, provide unique conditions for biological productivity and habitat in Oregon estuaries.

During the last several decades much work in Oregon has gone into the restoration and protection of these valuable coastal wetlands (PNCERS: Oregon Sea Grant, 2003). Additional submergence of the tidal wetlands by 1–2 meters (3–6 feet) of sea level rise will kill the lowest spruce bogs, bury the salt marshes under mud, and erode some tidal channel banks (Peterson et al., 2000). The higher sea levels will also increase winter flooding in upper estuarine reaches, impacting dikes, tide gates, roads, and combined sewer outfalls (Barnett, 1997).

The long-term ecological impacts of global sea level rise will occur in estuaries where human-built dikes have cut off the enclosed floodplains from tidal influence (Borde et al., 2003). The extensive dikes in the Columbia River estuary, Tillamook Bay, and Coos Bay will prohibit the creation of new spruce bogs or tidal marshes ("re-colonization") under the conditions of predicted global sea level rise. Shallow tidal creeks used by juvenile salmonids (PNCERS, 2003) will be lost, as well as the nutrient organic matter that is produced in tidal marshes (Ruesnick et al., 2003).

The recent geologic record of coastal wetland response to rapid submergence in Oregon and Washington is well established. These abrupt burials of tidal marshes by bay mud and sand have occurred repeatedly from episodic lowering of coastal land elevations by 1–2 meters (3–6 feet) during great Cascadia earthquakes (Atwater et al., 1995). These "coseismic subsidence" events, reoccurring every few hundred years (Atwater et al., 2004), provide direct analogs to the expected impacts from predicted global sea level rise in Oregon tidelands. Earthquake-caused lowering of the shoreline in the Nehalem, Tillamook, Netarts, Siletz, and Yaquina Bays killed 80-90 % of the pre-existing tidal marshes (Darienzo et al., 1994; Barnett, 1997).

Tectonic rebound and uplift of 0.5–1.5 meters eventually permitted the tidal mashes to recolonize the barren mudflats within a century or two (Darienzo, 1991; Darienzo and Peterson, 1990). Unlike these prehistoric earthquake cycles, the predicted global sea level rise is not expected to reverse in the

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foreseeable future. In the worst-case scenario a global sea level rise of 1–2 meters could be augmented by earthquake-generated coseismic subsidence, resulting in an additional 0.5 to 1.5 meters of relative sea level rise in Oregon following the next Cascadia megathrust rupture (Peterson et al., 2000), yielding a combined submergence or relative sea level rise of 1.5–3.5 meters.

In addition to the submergence of tidelands the predicted global sea level rise will also impact estuaries, small coastal creeks, and shallow beach sand aquifers by salinity intrusion. Salinity intrusion following global sea level rise is of concern around the world, but the potential impacts in Oregon have not been widely reported.

Salinity wedges (layers of salt water extending inland from the coast underneath the freshwater that flows near the surface of rivers) occur in all of the Oregon estuaries, reaching maximum landward distances of 22-49 kilometers (km) in the Columbia River estuary (www.ldeo.columbia.edu, 2011), 21-31 km in the Nehalem, Yaquina, Alsea, Siuslaw, Umpqua and Coos Bays (Percy et al., 1974), and 3 km in the Sixes River (Boggs and Jones, 1976). The landward extents of salinity wedges are controlled by many factors including tidal basin bathymetry, tidal prism (volume of tidal exchange), and seasonal fluvial discharge. However, increased distances of salinity intrusion can be most simply estimated from current salinity gradients and predicted global sea level rise. The salinity gradients are measured from mean depth at the bay mouth to mean depth at the maximum intrusion distance. Using the present salinity gradients for the central Oregon estuaries (Nehalem to Coos Bay) and a predicted global sea level rise of 1.5 meters, the salinity intrusions could extend an additional 5 to 7 km in landward distance. Marine, brackish, and freshwater tidal habitats could be substantially displaced in all of the Oregon estuaries, until net sedimentation reduces the salinity wedge depths and shortens saltwater intrusion distances.

Saltwater wedges also occur in subsurface aquifers that are hosted in sand barriers and beach plains. Measurements of current salinity gradients in barrier beach plains of the Columbia River littoral cell (Peterson et al., 2007) range about 0.03-0.003 (Peterson et al., 2002). Assuming a maximum global sea level rise of 2.0 meters and a minimum salinity gradient of 0.003, the salinity intrusion in low gradient coastal sand barriers could extend an additional 0.6 km inland. Though of limited distance, the saltwater intrusions into shallow sand aquifers could impact water quality in ponds, wetlands, and shallow water wells that are located in narrow sand spits and beach plains of the Oregon coast.

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Question: What particular areas or populations are more vulnerable to environmental impacts due to social and demographic factors than others on the Oregon coast?

Social Vulnerability and Climate Change

Carrie Richter*

In *"Community Variations in Social Vulnerability to Cascadia*-*Related Tsunamis in the U.S. Pacific Northwest,"* Nathan J. Wood, Christopher G. Burton and Susan L. Cutter (2010) argue that the impacts of future tsunamis on individuals and communities in Oregon will vary widely due to socioeconomic and demographic differences. The science of social vulnerability gauges how "physical, social, economic, and political components influence the degree to which an individual, community, or system will be threatened by a particular event, as well as their ability to mitigate those threats and recover if the event was to occur" (p. 370). Given that one of the most significant tsunami threats in the United States is likely to occur within the Cascadia subduction zone, along the Oregon coast, understanding community vulnerability is essential for planners and emergency managers in order to identify those groups that are more susceptible to loss and to develop risk-reduction strategies directed toward local community needs. It stands to reason that these same vulnerability factors should be considered when planning for other climate change impacts such as sea level rise.

Social and demographic factors relevant to determining vulnerability include gender, age, employment, housing, socio-economic status, education, race, and ethnicity. For example, a 2007 survey indicated that 45 percent of the residents in the City of Bandon are over 65 years of age and these older residents may have difficulty evacuating within the 30-minute window predicted between an earthquake and tsunami inundation. Vulnerability can also be evaluated at the community level. An entire neighborhood might be considered to be particularly vulnerable if it contains, for example, a high concentration of single-parent, low-income, poorly educated families living near each other. Where vulnerabilities overlap, the effects are often amplified. Mapping areas with the greatest number of vulnerability factors and overlaying those maps with those areas subject to tsunami inundation provides some interesting results.

The article concludes that in general, the Oregon tsunami-hazard zone contains primarily low to middle income households. The percentage of families earning $100,000 or more in this zone is approximately half the national average whereas the percentage of individuals living in poverty here approximates the national average. The number of individuals within the tsunami inundation zone who lack a high school diploma is slightly less than the national average. Low-income households and the less educated are impacted to a greater degree by disasters as they are not as likely to have structurally maintained their homes, making these structures more prone to damage, and they often have insufficient reserves to repair or replace their homes.

**Attorney with Garvey Schubert Barer*

Households within tsunami inundation zones at the Oregon coast are likely to be smaller and to contain fewer children than the national average, while the percentage of individuals 65 years in age or older is more than double the national average. Seniors are more likely to have mobility or health issues, making relocation more difficult; they are more likely to be reluctant to evacuate, and are more apt to lack social and economic resources to recover. A relatively high percentage of individuals over age 65 reside in mobile homes and are recipients of Social Security benefits. Coastal communities include a very low percentage of individuals maintaining full employment. All of these factors work to increase the social vulnerability of certain areas.

Wood et al. (2010) concluded that although gender, race, and ethnicity can contribute to social vulnerability, they do not play a big role in Oregon. Gender-related variables are not significant predictors of vulnerability to environmental hazards. The number of individuals in Oregon classifying themselves of American Indian or Alaska Native descent is higher than the national average, and the Grand Ronde, Siletz, Coquille and Coos, Lower Umpqua and Siuslaw tribes, with their reservations and tribal governments, are significant components of the coastal fabric. However, age and socioeconomic status appear to be the primary predictors of vulnerability to environmental hazards rather than gender, race, or ethnicity. It is interesting to note when it comes to gender differences, women tend to have a heightened perception of risk, are more likely to have a disaster preparedness plan, and are more likely to respond to warnings than men. Women in general are also more likely to be single parents, have lower incomes, and have less autonomy than men, though this pattern is not found in Oregon.

Notwithstanding these general trends, vulnerability scores varied widely by city and even by block within cities. Of those individuals considered to have high social vulnerability, "76% come from only four incorporated cities (Seaside, Lincoln City, Waldport, and Warrenton) and the unincorporated portions of two counties (Tillamook and Coos)" (Wood et al., 2010, p. 381). This suggests that there is no discernible geographic trend for where these populations are likely to locate – they reside in areas from the northernmost to the southernmost corners of the state. The article finds no specific correlation between the numbers of residents considered to be highly vulnerable with the total number of residents within the tsunami hazard zone in a given area. "For example, Seaside has the highest number of residents with high levels of social vulnerability (422), but this group only represents 9% of the in-hazard population" (Wood et al., 2010, p. 381). The authors caution against overlooking these special needs populations that are large in numbers but represent a small fraction of those who may be impacted. On the other extreme, communities like Astoria, Nehalem, Wheeler, Toledo and Bandon have low numbers of individuals with high social vulnerability overall "but these few individuals represent a large percentage of the in-hazard population. In these communities, emergency responders will be assisting small, but disproportionately highly vulnerable, populations (Wood et al, 2010, p. 382). All of these impacts will be aggravated by the scale of the vulnerability and the extent and severity of the natural hazard.

Planning for and responding to climate change effects, as for the inevitability of tsunamis, must include identifying socially vulnerable communities in a geospatial way and understanding how those vulnerabilities place people at risk. In realizing that efficient and effective disaster planning cannot occur on a one-size-fits-all basis, individual counties and cities must identify strategies focused not only on the type of hazard but also upon the socio-economic status of the specific population that is threatened.

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Question: *Can preparation for tsunamis also facilitate planning for climate change impacts on the Oregon Coast?*

Tsunami Law in Oregon

Alex Wheatley*

Background: Oregon is located in a tsunami hazard area. Tsunamis are large sea waves that are triggered by sudden movements on the sea floor such as underwater earthquakes, landslides, or volcanic activity. The wave generated by the movement can travel across the ocean very quickly and may only be a few inches high while still in the deep ocean. Then, as it approaches land and finds bottom in shallower water, the wave height can rise significantly. Tsunamis have been known to reach more than 100 feet in vertical height, though most do not exceed 10 feet in height. The largest tsunami ever recorded was caused by a giant landslide in Lituya Bay, Alaska, which caused a tsunami wave measuring over 1,700 feet in height in the narrow inlet (Leonard et at., 2010)

In March of 2011 a subduction earthquake measuring 9.0 on the Richter scale occurred near of the coast of Japan, causing a tsunami approximately 35 feet high. Tens of thousands of people were killed by this event and over 125,000 buildings were damaged or destroyed. The tsunami is estimated to have caused from $14.5 to $34.6 billion in insured losses alone, aside from uninsured losses. The tsunami also caused damage to the Fukushima Daiichi nuclear reactor by, among other things, knocking out the plant's auxiliary generators which were necessary to pump cooling water into the reactor core to keep the radioactive fuel from melting. The loss of electrical power at the plant caused the cooling water levels to fall too low, leading to a partial meltdown and the release of large amounts of long-enduring radioactive contamination.

The Oregon Situation. The northern Oregon coast is in a subduction earthquake zone with characteristics very similar to those on the northern coast of Japan. As shown by the recent tsunami in Japan as well as the geological record in the Pacific Northwest, subduction earthquakes can cause major tsunamis. Because of its location, the Oregon coast will one day be hit by a tsunami; it is not a matter of if, but when.

Oregon's Senate Bill 379 was enacted in 1995 and is codified as ORS 455.446 and 455.447. This law is based on a recognition of the risk that tsunamis pose to the coastal areas of Oregon, and spurs efforts to plan ahead in order to reduce the negative impacts of the occurrence of a known environmental risk. The law requires the Oregon Department of Geology and Mineral Industries (DOGAMI) to analyze the topography of the coast and designate tsunami inundation zones. It then restricts or prohibits the building of certain essential facilities, hazardous facilities, major structures, and special occupancy structures in the tsunami inundation zones.

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Such restrictions will reduce the negative impact of a tsunami. The law is intended to help ensure that essential facilities such as hospitals remain operational in a time of disaster and that people who cannot evacuate, such as those immobilized in a hospital, are not trapped in harm's way. It also requires that hazardous facilities such as nuclear reactors, chemical plants, and warehouses that could be damaged by a tsunami are located out of harm's way, so that the hazardous materials they house will not be released. Finally, it also discourages large investments in structures, especially with public funds, in areas where the structure might be damaged or destroyed by a tsunami and would have to be rebuilt or repaired.

This law provides an example of legislation that takes into account a known natural risk and attempts to plan for that eventuality in a way that will reduce its negative effects. In a similar fashion, such legislation could be implemented to plan for the very likely effects of climate change. Many of the anticipated impacts of climate change are considered very likely. These include sea level rise, increased storm intensity in the Northern Pacific region, increased frequency and height of spring flooding along rivers fed by snowpack, increased summer drought, and increased wildfire risk. For the same reasons that building is restricted in a tsunami zone, development in other high-risk areas could be restricted to ensure that large investments, especially critical public infrastructure investments or hazardous facilities, are not lost to these anticipated calamities.

The disaster in Japan underscores the need for legislation like Oregon's law restricting building in high risk areas. Some of the impacts from climate change – like those created by a tsunami – are certain to occur at some point in time. The only question is whether we will prepare for those impacts now or deal with them later.

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Question: How will Oregon's Beach Bill accommodate sea level rise?

The Oregon Beach Bill

Steven W. Bender*

Enacted in 1967 with the aim to preserve public rights to Oregon beaches, the Beach Bill (found at Or. Rev. Stat. § 390.605 et seq.) often is falsely credited with establishing the public's right to recreate on Oregon shores. As discussed below, the credit belongs primarily to the Oregon Supreme Court and past generations of Oregonians.

Oregon beaches can be divided into at least three zones moving eastward—the wet sand, dry sand, and uplands regions. First, the wet sand area refers to the land lying seaward of the high tide line, extending to the low tide line. Originally designated by the Oregon legislature in 1913 as a public highway, a 1947 legislative amendment changed the purpose of the public's use of Oregon's 362-mile-long wet sand area to public recreation, and the Beach Bill continued its usage as a state recreation area (Or. Rev. Stat. § 390.615).

The dry sand area refers to the region between the mean high tide and the visible line of vegetation. The Beach Bill provides that where public use of this dry sand area has been sufficient to create public easements, these rights shall be vested in the State of Oregon as public recreation areas. Fearful of constitutional compensation claims for the taking of private property, the Beach Bill was thus dependent on the courts to establish public rights in the significant portion of the Oregon coastline that is held in private ownership.

In 1969, the Oregon Supreme Court decided the case of *State ex. rel. Thornton v. Hay*, 254 Or. 584, 462 P.2d 671 (1969). Rejecting the efforts of the owners of a Cannon Beach motel to fence off the dry sand portion of the beach for the private use of its patrons, the Oregon Supreme Court issued a landmark decision to activate the Beach Bill. Invoking the English doctrine of custom, akin to an easement, the court conferred the public recreational rights that the authors of the Beach Bill had contemplated and that were subsequently administered under the Beach Bill. The court relied on longstanding beach usage by native peoples and then European settlers, noting that from the time of the earliest settlement "the public has used the dry-sand area for picnics, gathering wood, building warming fires, and generally as a headquarters from which to supervise children or to range out over the foreshore as the tides advance and recede."

Although the *Thornton v. Hay* dispute involved only the Surfsand Motel in Cannon Beach, the Oregon Supreme Court expressed a policy for uniform treatment of the Oregon beaches, border-to-border, and this 1969 decision is regarded as having established the public's right to continue to recreate on the entirety of the Oregon coastline. A 1989 court decision did impose some limits on the public's right—restricting usage to just those beaches, whether of sand, gravel, or

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boulders, that have a similar lengthy history of public use. Thus, the court concluded in the absence of such a showing of longevity that the public had no right to use the beach surrounding Little Whale Cove south of Depoe Bay, a freshwater pool adjacent to the ocean that occasionally mixes with ocean water during storms or extreme high tides [*McDonald v. Halvorson*, 308 Or. 340, 780 P.2d 714 (1989)].

The third beach zone, the uplands, refers to the property immediately landward of the line of vegetation. This zone includes privately owned hotels and restaurants, condominium projects, and single-family dwellings. Private owners of the uplands enjoy rights of direct access from their property to the dry sand area and they may exclude the general public from crossing the upland portion of their land; members of the general public must use public right-of-ways to access the beach. Although the uplands are not subject to the public's recreational easement rights, the movement of the vegetation line over time raises the possibility of the uplands becoming part of the dry sand region and thus falling under those public access rights. Oregon's Beach Bill acknowledges the fluidity of the vegetation line that defines the boundary between the dry sands' upper limit and the uplands, authorizing the Oregon Parks and Recreation Department to recommend periodic adjustment of the recognized vegetation line to the legislature (Or. Rev. Stat. § 390.755).

With global warming comes the possibility of movement of the three beach zones, including:

- the prospect of gradual inroads of the dry sand area onto what are now upland areas;
- the complete loss of the dry sand zone (and possibly wet sand beaches as well) where the existing vegetation line is reinforced by sea walls to protect upland hotels and other development; and
- the possibility of massive landward relocation of the line of vegetation during major storm events.

Public ownership of remaining wet sand areas will shift with their movement. But the effect of movement of the line of vegetation and thus the dry sand area is uncertain under Oregon law. Whether the public's recreational rights will encompass the dry sand area as it moves inland depends on whether Oregon courts will embrace the concept of a "rolling" easement as England did for customary rights on its shoreline. The Texas Supreme Court in 2010 refused to recognize rolling public easements when 2005's Hurricane Rita moved the line of vegetation landward to such an extent that houses were now seaward of the line. Although Oregon based its Beach Bill on the Texas Open Beaches Act, the Oregon courts are in no way bound by this decision.

The scenario that poses the biggest risk to public recreation in Oregon is where a sea wall or riprap armors an uplands structure and rising water displaces the existing dry sand beach, which cannot move inland through natural processes because of the artificial armoring of the upland area. Neither the doctrine of customary use nor any allowance of rolling easements would appear to address the scenario where man-made development combined with sea level rise or beach erosion completely eliminates a dry sand beach that has customarily been used by the public.

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Question: Does Oregon follow the common law, which says that if land is gradually lost to the ocean, then the line of ownership moves inland accordingly?

Accretion, Reliction, and Avulsion – Oregon Common Law

Janet Neuman[*]

Issue. The "Oregon coast" is not a fixed line, but rather a dynamic line. The precise location of the boundary between water and land can change gradually — through years of incremental erosion or deposition — or the boundary can change suddenly and dramatically, as when a winter storm washes away a beach or breaches a spit overnight. This dynamism is nothing new, but the familiar historical patterns are expected to alter with climate change. Specifically, scientists expect an increase in the frequency and intensity of sudden, dramatic changes due to larger and more frequent storms and greater storm surges. Additionally, gradual sea level rise will also affect the patterns and speed of incremental change. This paper addresses how common law has traditionally treated waterfront boundary changes, both incremental and sudden.

Importance of This Issue on the Oregon Coast. As all Oregonians know, the beaches on the Oregon Coast are open to the public. There are several reasons for this unique level of public access, most notably the 1967 Oregon Beach Bill adopted by the state legislature and the 1969 decision of the Oregon Supreme Court holding that the ancient doctrine of "custom" guarantees public access to the dry sand area of the entire Oregon coastline.[i] It is important, however, to distinguish public *access* from public *ownership*. Even though the public has the right to use the entire dry sand area of the Oregon coast up to the vegetation line, public ownership extends only to the mean high tide line, which is generally below the vegetation line.

The increased dynamism of the Oregon coastline due to climate change will have important consequences for both public access and public ownership along the coast. Coastal residents and policy makers need to understand the doctrines and rules of decision provided by existing law for handling waterfront boundary changes and consider whether these principles will still be workable in an even more dynamic regime of coastline change.

Description of Relevant Science and Law. As a scientific fact, waterway boundaries move naturally and gradually over time. The classic example is a meandering stream, with lots of bends and loops. On the outside of a bend, where the flow velocity is greater, the stream gradually erodes the bank, while on the inside of a bend, where the velocity is slower, the stream deposits sediment (also called "accretion"). Waterway boundaries may also change through

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[i] *State ex. rel. Thornton v. Hay*, 254 Or. 584, 462 P.2d 671 (1969). See paper # 8 for additional discussion of the Beach Bill and the *Thornton* case.

“reliction”; this term describes the process whereby a parcel of land gradually increases in size due to a receding shoreline, rather than due to deposition of sediment.

Suppose that Landowner A owns the land on the outside of the bend, and Landowner B owns the land on the inside of the bend, with the center of the river representing the legal boundary line between their two properties.[ii] The common law of boundary determinations pragmatically incorporates the natural hydrologic processes by providing that the property line will move gradually along with the river. In other words, Landowner A's parcel will lose ground over time to erosion, while Landowner B's property will gradually increase because of the deposition or accretion. The common law treats reliction the same as accretion, allowing a parcel to increase in size with the addition of the land exposed due to reliction.

The rules change, however, when the stream movement is sudden and dramatic (or "avulsive") rather than slow and gradual. An avulsive change can be either natural or artificial; the important thing is that it happens fairly quickly. For instance, again using the example of a meandering stream, a flood may cause the stream to bypass a meander and scour a new channel across the neck of the bend. Artificial dredging or filling can also change a channel location. In these instances, the property boundary lines stay where they were before the change. In the above example, Landowner B's property is now bisected by the new stream channel, while the boundary between A and B remains at the location of the bypassed meander.

Although oceans are different than rivers, the same basic common law principles apply. Where gradual erosion eats away at the ocean shoreline, that shoreline parcel becomes smaller, both physically and legally. Where sediment is deposited on the shoreline or the sea level drops, the shoreline parcel grows, both physically and legally. When the changes are avulsive rather than gradual, the boundaries stay where they were before the avulsive event.

Effects/ How the Issue Will Play Out on the Oregon Coast. How will the common law principles of water boundary determinations operate on a changing Oregon coastline? Two types of changes are expected due to climate change. First, sea level is expected to rise gradually over coming decades. The common law can accommodate those natural, gradual changes just as it always has: public ownership will rise along with the sea level to follow the changing level of mean high tide, while privately-owned shoreline properties will gradually shrink in size. Depending on the size of those properties to begin with — and more important, their elevation in relation to the increase in sea level — the shrinkage could be significant in some locations. The effect on public access could also be significant wherever rising sea levels submerge substantial portions of the existing dry sand beaches.

Climate change is also expected to increase the frequency and intensity of avulsive events along the coastline, such as more severe winter storms that cause significant erosion. In fact, recent increases have already been observed, with some dramatic consequences for existing beaches.[iii] The common law response to these sudden changes is to fix property lines at their pre-change

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[ii] When a stream is legally classified as "non-navigable", the private owners' property will usually extend to the middle of the stream, but if a river is considered legally "navigable", the private riparian property boundary generally stops at ordinary high water and the river itself is owned by the state in trust for the public.

[iii] *See* Jonathan C. Allan, Ron Geitgey, and Roger Hart, Dynamic Revetments for Coastal Erosion in Oregon 3 (2005) (describing some "significant examples of coastal retreat" from storm events in the 1990s).

locations. This could mean that former shoreline owners would end up with "land" that is now under water, while the public ownership line (the former location of mean high tide) would be some distance off shore, and the previous dry sand beach may have disappeared entirely.[iv] (The previous vegetation line that demarcates the area of public access may also be drastically altered by such avulsive events.) The fact that private owners still hold title to their property does not necessarily guarantee that they will be allowed to restore it to pre-submergence condition—either because of legal restrictions or economic limitations.

As coastal communities and shoreline property owners begin to experience these changes—whether gradual or sudden—it is likely that pressure will grow to "armor" the coastline to protect property against the elements, whether by filling, building or lengthening jetties, or hardening the coastline. However, these activities are in themselves avulsive actions with both legal and physical consequences. Moreover, Oregon rules do not allow most properties along the coast to be armored, particularly those developed after 1976, as described in the paper in this volume on permits for structures on Oregon's beaches. Even when such actions are allowed to "hold the line" legally, they cannot stop the sea from rising or storms from brewing, and as to physical consequences, changes at one location will affect other parts of the coast, no matter how unintentionally.

In summary, the common law doctrines of waterfront boundary determinations provide fairly clear rules for handling the dynamism of the Oregon coastline, both past and future. In that sense, these rules will help the Oregon coast adapt to climate change. However, strict application of the rules may not always produce the most desirable result for coastal communities or the state as a whole.

[iv] This is exactly what happened to residents of Bayocean Spit near Tillamook many years ago, though as a result of avulsive events unrelated to climate change. Storms breached the spit (following upon severe erosion caused in part by jetty construction that interfered with delivery of sand to the spit) and left several property owners with tax lots completely covered with water. *See* Thomas Terich and Paul Komar, Development and Erosion History of Bayocean Spit, Tillamook, Oregon (1973).

ADDITIONAL RESOURCES:

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Eugene A. Hoerauf, Willamette River: River Lands and River Boundaries (OSU Water Resources Research Institute, 1970) (discussing common law rules on rivers)

Bureau of Land Management, *Basic Law of Water Boundaries*, Cadastral Casebook, Chapter D, *available at* http://www.blm.gov/cadastral/casebook/basicwater.pdf

Ashley S. Miller, *Nature and Property: A Riparian Law Perspective*, 34 ENVIRONMENTAL LAW REPORTER 10704 (2004), pages 10708-10710 (discussing common law rules pertaining to accretion)

Stop the Beach Renourishment, Inc. v. Florida, 560 U.S. __, 130 S.Ct. 2592, 177 L.Ed.2d 184 (2010) and *Nebraska v. Iowa,* 143 U.S. 359 (1892) (discussing common law rules)

Bonnett v. Division of State Lands, 51 Or. App. 143, 949 P.2d 735 (1997) (the state was the owner of new land formed by accretion next to an individual's oceanfront lot, because the accretion started on state-owned tidelands and grew toward shore rather than accreting directly onto plaintiff's shoreland).

Stop the Beach Renourishment, Inc. v. Florida, 560 U.S. 2606, 130 S.Ct. 2592, 177 L.Ed.2d 184 (2010) and *Nebraska v. Iowa* (both discussing common law rules)

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Question: If sea level rise and storm surges lead to an increase in shoreline erosion, may beachfront owners build hardened protection structures onto the dry or wet sand areas to preserve their property?

Permits for Structures in Oregon's Beaches

Bill Kabeiseman*

Ocean shore alteration permits trace their origin to Oregon's unique beach ownership pattern, which involves a public easement along the beach. Although the origin of the easement has a lengthy history, the 1967 Legislature initiated the modern era by adopting ORS Chapter 390, better known as the Beach Bill. In that bill, the legislature proclaimed the state's sovereignty over what is now called the "ocean shore," more commonly understood as the dry sand area of the beach. The court's declaration of ownership of the ocean shore was upheld by the Oregon Supreme Court in *State ex rel Thornton v. Hay*, 254 Or 584, 462 P2d 671 (1969):

> "This case deals solely with the dry-sand area along the Pacific shore, and this land has been used by the public as public recreational land according to an unbroken custom running back in time as long as the land has been inhabited . . . The custom of the people of Oregon to use the dry-sand area of the beaches for public recreational purposes meets every [legal requirement]." 254 Or 598.

The Oregon Parks and Recreation Department's (OPRD) permitting scheme is based on the idea that the public has a sovereign right to use the ocean shore and that the state merely holds that right in trust for the public. Although an individual may own the underlying fee title to the dry sand area, it is subject to an overriding easement allowing public travel and recreation.

The basic premise of the permitting scheme is that an applicant does not have a "right" to build a structure on the beach, even if the applicant owns the underlying fee title. Essentially, the state is acting as the holder of easement rights and gets to decide whether it will allow the public's use of the beach to be sacrificed on behalf of the upland owner's rights.

The legislature has made clear that, in some cases, the public is willing to give up its rights to the ocean shore, but only in certain circumstances. In particular, ORS 390.610 sets out the state's policies in the ocean shore area:

> "To protect and preserve such public rights or easements as a permanent part of Oregon's recreational heritage . . . It is in the public interest to do whatever is necessary to preserve and protect scenic and recreational use of Oregon's ocean shore."

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The Land Conservation and Development Commission (LCDC) has acknowledged the requirement to protect the public beaches in the Statewide Planning Goals. In particular, Goal 17, addressing Coastal Shorelands, states a preference for "non-structural solutions" over structural solutions, such as engineered riprap, to resolve problems such as erosion:

> "Land use management practices and non-structural solutions to problems or erosion and flooding shall be preferred to structural solutions." Goal 17, Implementation Requirement 5.

Similarly, Goal 18, addressing Beaches and Dunes, includes Implementation Requirement 5, which allows for beachfront protective structures such as the engineered riprap only for development that existed prior to 1977. As the Land Use Board of Appeals (LUBA) recognized:

> "Implementation Requirement 5 is an acknowledgment that…beachfront protective structures are man-made structures that cause problems – they cause problems for adjacent property owners, they cause problems for non-adjacent owners and they cause problems for the state, which owns and manages in trust for the public the ocean shore and all lands westward of the ocean shore. Because [the Land Conservation and Development Commission] knew that such structures can cause problems and also recognized that some development had already occurred in reliance on the ability to build such structures, it adopted Implementation Requirement 5….The State would not interfere with the right of property owners who owned developed property to protect that property, because they may have developed with the expectation that their structures could be protected. However, new development will only occur with the knowledge that beachfront protective structures will not be allowed. New development will not be allowed to cause problems for others." *Regan v. Lincoln County*, 49 Or LUBA 386, 391 n 12 (2005.)

OPRD has taken the policies adopted by the legislature and LCDC and folded those policies into its administrative rules for the issuance of permits. The rules adopted by OPRD can be found in OAR Division 736-020; most important, those rules set out the six criteria to be used in determining whether an ocean shore alteration permit should be granted:

> "(1) Project Need -- There shall be adequate justification for the project to occur on and alter the ocean shore area.
>
> "(2) Protection of Public Rights -- Public ownership of or use easement rights on the ocean shore shall be adequately protected.
>
> "(3) Public Laws -- The applicant shall comply with federal, state, and local laws and regulations affecting the project.
>
> "(4) Alterations and Project Modifications -- There are no reasonable alternatives to the proposed activity or project modifications that would better protect the public rights, reduce or eliminate the detrimental affects on the ocean shore, or avoid long-term cost to the public.

> “(5) Public Costs -- There are no reasonable special measures which might reduce or eliminate significant public costs. Prior to submission of the application, the applicant shall consider alternatives such as nonstructural solutions, provision for ultimate removal responsibility for structures when no longer needed, reclamation of excavation pits, mitigation of project damages to public interests, or a time limit on project life to allow for changes in public interest.
>
> “(6) Compliance with LCDC Goals -- The proposed project shall be evaluated against the applicable criteria included within Statewide Land Conservation and Development Goals ##5 (“: Natural Resources, Scenic and Historic Areas, and Open Spaces); #17 (“: Coastal Shorelands”); #18 (“: Beaches and Dunes”); and #19 (“: Ocean Resources”), and other appropriate statewide planning goals. In accordance with the Statewide Land Conservation and Development Commission Goal #18, permit applications for beachfront protective structures on the ocean shore shall be considered only where development existed on January 1, 1977. The project shall be consistent with local comprehensive plans where such plans have been approved by LCDC. When the application is for a pipeline, cable line or conduit under ORS 390.715, the project shall be consistent with Statewide Planning Goal #19, Ocean Resources, and applicable requirements of the Oregon Territorial Sea Plan.”

The standards are stated in mandatory terms and nowhere in the terms of the standards is there any indication that the standards can be looked at as a “balancing” test. All of the criteria must be met in order to issue a permit.

State law also allows OPRD to issue emergency permits when “property or property boundaries are in imminent peril of being destroyed or damaged by action of the Pacific Ocean or the waters of any bay or river of this state.” OPRD’s rules make clear that emergency permits may only be obtained for property that is otherwise eligible for a permit, but the permit need not go through a review process prior to being written and, in fact, may be issued orally. An emergency permit is initially issued as a temporary permit, but the permit holder can seek to make it permanent by going through the typical permit process with the emergency measure in place.

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Question: How will climate change impacts affect the regulation of "coastal shorelands" in Oregon?

Coastal Shorelands and Climate Change

Steve Schell[*]

We love to walk and play along Oregon's beaches. Access to, and along, those ocean shore areas is very important to many Oregonians. But rising sea levels, coupled with storms and high tides, are causing beachfront owners along the coast to "harden" their beachfront lots in many areas, and applications to do more hardening are regularly heard by the public's watchdog, the Oregon Parks and Recreation Department (OPRD). Such hardening could easily result in loss of the "beach" in Cannon Beach, or in Rockaway, Neskowin and other areas threatened by erosion. Oregon has at least three sets of requirements to prevent or slow the loss of the dry sands portions of its beaches: (1) our beach law; (2) the Land Conservation and Development Commission (LCDC) Statewide Land Use Planning Goal 17 on Coastal Shorelands; and (3) the LCDC Goal 18 on Beaches and Dunes.

The Beach Law (created by Oregon's landmark Beach Bill) regulates activities in and on the ocean shore. "Ocean Shore" is defined as the land between extreme low tide and a vegetation line, which is defined as being the most inland of either a surveyed line expressly set out in Oregon law, <u>or</u> as "the line of established upland shore vegetation."[i] Thus, the line is intended to move if erosion pushes the actual vegetated area inland from the "statutory vegetation line" found in the state statute. Further, OPRD is required to re-examine the line periodically and provide the information needed to preserve both private and public rights and interest in the ocean shore.[ii]

Under LCDC's Goal 18 all beaches must be identified. The goal is to conserve, protect and, where appropriate, restore the benefits of coastal beach and dune areas. This will cause beaches to move. If sea level rise, coupled with high tides and storms, threatens or destroys those beaches, it follows that restoration is required.

In Oregon, *coastal shorelands*, under LCDC Goal 17, must be inventoried and will be shown on the local planning and zoning maps. The planning area is generally the upland areas between the nearest major highway, usually Highway 101, and the area defined as beach or *ocean shore* in the Beaches and Dunes Goal (Goal 18). Oregon's land use system establishes the statewide goals and requires cities and counties to implement those goals within their jurisdictions. At a minimum, the areas defined as coastal shorelands must include: "areas subject to ocean flooding and lands within 100 feet of the ocean shore or within 50 feet of an estuary or a coastal lake." Goal 17 requires agencies as well as cities and counties, in their planning, zoning and permitting, to address the critical relationships between coastal shorelands and the resources of coastal

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waters, as well as the geologic and hydrologic hazards associated with coastal shorelands, on the basis of six factors prioritized from high to low as follows:

"1. Promote uses which maintain the integrity of estuaries and coastal waters;

2. Provide for water-dependent uses;

3. Provide for water-related uses;

4. Provide for nondependent, nonrelated uses which retain flexibility of future use and do not prematurely or inalterably commit shorelands to more intensive uses;

5. Provide for development, including nondependent, nonrelated uses, in urban areas compatible with existing or committed uses; and

6. Permit nondependent, nonrelated uses which cause a permanent or long-term change in the features of coastal shorelands only upon a demonstration of public need."

Implementation requirements of the shorelands goal specify: (1) protection and maintenance of special shoreland values and forest uses; (2) areas for mitigation required as a result of estuarine filling and dredging; (3) dredged fill disposal sites; (4) maintenance of riparian vegetation; (5) a preference for non-structural over structural solutions (e.g., buffer areas over riprap, or swales over pipes); and (6) retention of access to and along coastal waters.

There is a rule issued by LCDC under Goal 17 that requires the designation of areas next to estuaries as "water dependent coastal shorelands areas," and these areas must be equal to or greater than past and present uses of that type. It is possible to take an exception to the Goal 17 requirements but the requirements for doing so are difficult to meet.[iii]

Access Across and Along the Shorelands. Oregon Shores Conservation Coalition opposed and litigated the vacation of a part of County Road 804 through the City of Yachats in Lincoln County, which would have given up existing public access to a coastal trail. The Oregon Court of Appeals agreed with Oregon Shores and overturned the vacation of this route, citing the Goal 17 implementation requirement, which requires that "existing public ownerships, rights of way, and similar public easements in coastal shorelands which provide <u>access to or along coastal waters</u> shall be retained or replaced if sold, exchanged or transferred." At least where any vacated access is along the ocean shore, the retained access across an affected site must also be within coastal shorelands. Furthermore, the "affected site"[iv] must also be defined as being part of "the relevant Coastal Shorelands." Thus, in considering adaptation to climate change impacts affecting the shoreline, there must be consideration of how to retain access to and along coastal waters and the defined area of "Coastal Shorelands" must include that access.

Water Dependent Uses and Incidental Uses. In a Coos County case (also brought by Oregon Shores) involving the Sitka Dock site bordering the Coos Bay estuary, Oregon's Land Use Board of Appeals (LUBA) said that any shoreland so designated shall be "suitable for water dependent uses." This means at a minimum that the shoreland areas possess or are capable of being developed with structures or facilities that provide water-dependent uses with access to the adjacent coastal water body. Goal 17 permits non-water-dependent uses within water-dependent shorelands that are "in conjunction with and incidental and subordinate to a water-dependent use." Examples of incidental uses include a restaurant on the second floor of an existing seafood processing plant or a retail sales room as part of that plant. Incidental "means that the size of the non-water-dependent use is small in relation to the water-dependent operation."[v] Thus, as waters rise, the quantity of upland areas designated as shorelands must remain, and the lands need to be designated for "water-dependent uses," such as docks.

FEMA Maps on Ocean Flooding. Mapping of shorelands can be significant. If a city (such as Gold Beach) adopts a map produced by FEMA (the Federal Emergency Management Agency—see article #16, below) which shows the area of ocean flooding as its shorelands, then it cannot use another line to define its shorelands, such as the "conditionally stable foredunes."[vi] The emphasis on the FEMA line of ocean flooding is a very important consideration in dealing with adaptation to sea level rise and coastal flooding along the Oregon Coast. Failure to make changes to the line as conditions change results in a failure to implement the goals and also weakens the reliability of the FEMA mapping system.

Site Assessment and Geologic Hazards. If undelineated geological hazards are to be included in shorelands under a local ordinance then any determination of the location of the shorelands must require a geological study. Thus, a city erred where it allowed "coastal shorelands" to be defined as the top of a bluff, in the absence of a study making an assessment of the geologic stability of the area between the original boundary and the boundary as proposed.[vii] What this means is that as storm surges and sea level rise cause erosion and landslides into the beach area or ocean waters, the shoreland boundaries must be changed.

Shorelands Boundary to Include Both Areas of Ocean Flooding and Geological Instability. Recently, Curry County granted a resort destination approval, which Oregon Shores challenged. LUBA upheld Oregon Shores' position that Curry County must set the coastal shorelands boundaries to include both the areas subject to ocean flooding and the adjacent areas of geologic instability.[viii] If sea level rise and storm surge cause more frequent flooding and instability, local plans must change to address these issues. It would follow that in its periodic review processes, LCDC must take account of any such rapid changes.

Saltwater Intrusion. One of the Goal 17 implementation requirements specifies protection and maintenance of special shoreland values. In the above-mentioned destination resort case, Curry County had adopted a policy to "take measures to protect groundwater from drawdown which would lead to loss of stabilizing vegetation, loss of water quality, or intrusion of salt water into water supplies." In its findings approving the resort, Curry County did not address this policy. LUBA remanded the case, placing the onus on the county to address this policy.[ix] Drawdown may not be the only cause of saltwater intrusion – more frequent ocean flooding may have a similar effect. Hence, the current implementation requirement may be too limited in the context of coastal climate change adaptation.

Climate Change Impacts. First, coastal shorelands must include all areas subject to "ocean flooding." As severe storms and sea level rise change the areas subject to ocean flooding, the area recognized as coastal shorelands must also change. Cooperation from FEMA and the

Oregon Department of Geology and Mineral Industries (DOGAMI) is needed to assure that this happens. Second, with rapidly changing coastlines, the coastal shorelands line must move so that areas of geological instability are accounted for. Third, the possibility of saltwater intrusion is significant in low-lying areas and must be re-examined on a regular basis.

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Question: How could the "transfer of development rights" planning tool be employed on the Oregon coast?

Oregon Coastal Climate Change Adaptation--Transfer of Development Rights

Carrie Richter*

In its 2007 Fourth Assessment Report, the Intergovernmental Panel on Climate Change (IPCC) predicted that sea levels will rise up to 1.6 feet by the end of the century if climate-changing greenhouse gas emissions are not reduced, and this is now considered to be an underestimate based on more recent work by the U.S. Global Change Research Program (Karl et al. 2009). In Oregon, the Oregon Department of Energy has concluded that "a rise in sea level could threaten beaches, sandy bluffs and coastal wetlands. Coastal towns could experience more flooding, causing increased damage to roads, buildings, bridges and water and sewer systems."

In addressing this range of potential impacts, coastal communities and their elected governments may look for long-range options that might: a) prevent new development in areas that will become increasingly vulnerable; b) help property owners remove existing development affected by flooding and erosion; c) encourage the preservation or restoration of natural areas to give marshes and other ecosystem types a place to move in response to sea level rise; and d) promote the retention of forests to maintain watershed quality and provide other valuable ecosystem services. These types of measures can be vital in preserving the long-term resilience of coastal communities, but establishing them can be extremely challenging in the current planning environment while taking into account existing property rights. One tool that can potentially facilitate these types of adaptive planning measures is the "transfer of development rights."

A transfer of development rights (TDR) program could work to protect natural habitats such as forestlands or wetlands and serve as a means of adapting existing development to respond to the effects of climate change. A TDR program, for instance, could provide a pathway for pulling development away from cliffs, dunes and estuary shorelines that will become increasingly at risk as sea level rises and higher storm surges reach new areas. Transfer of development can be accomplished in one of two ways: the property owner may maintain title subject to a conservation easement, while gaining development rights to another property inland; or, alternatively, there may be a direct land ownership swap. Local governments create these systems by identifying areas to be protected (sending areas) and areas suitable for development (receiving areas). In order to build (or build at greater densities than would previously have been allowed) in the receiving areas, a developer must acquire development right credits from the landowners in the sending areas. The number of sending area credits required and the amount of the density incentive available is set by the local or regional government.

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Generally, in Oregon, local governments may rely on one of three authorizations to create a TDR program: (1) the pilot program adopted by 2009 Senate Bill 763; (2) as part of an established system for the purchase and sale of severable development interests pursuant to ORS 195.310 (Measure 49); or (3) city charter authority. In 2009, the Oregon Legislature created a pilot program, run by the Department of Land Conservation and Development (DLCD), authorizing qualifying local governments to develop and adopt transfer development rights programs to preserve forest and agricultural land directing development away from resource areas designated as sending areas and into urban areas or receiving areas (SB 763). In order to qualify for participation, an eligible pilot project is one that will benefit the forest or agricultural economy of the state and minimize adverse impacts to public utilities, services or natural resources. The pilot program allows for the transfer of multiple development rights but it limits the transfer to a single credit if the receiving area is located outside of an urban growth boundary. Areas within an urban growth boundary are preferred receiving areas. Although Lane County expressed some interest in participating in the pilot, it did not qualify and as of the date of this drafting, applications have been sparse and no pilot programs have been established.

Hoping to enhance participation, in 2011 the legislature adopted House Bill 2132, which modifies provisions of the pilot program to authorize additional unincorporated communities as receiving areas for transferred rights and allows higher transfer ratios in certain circumstances than the 2009 legislation. Rights may now be transferred to urban unincorporated communities and rural communities at a ratio of 2 to 1 provided that public facilities are sufficient. The new legislation removes the requirement for public access to the sending area, a major concern to forest land owners that may have deterred participation. The revised law also requires density in the transfer receiving areas to be at least five units per acre (rather than ten) or 125% of the allowed density, whichever is greater. Again, although DLCD has been in discussion with coastal communities and large forest landholders about participating in this system, it is too soon to tell if these amendments will be sufficient to kick-start the program.

One of the most important components for an effective TDR program is the creation of specialized master planned receiving areas that provide incentives developers actually want. Many TDR programs fail because there is not enough demand or the cost of credits is too expensive to preserve any meaningful amount of land. There must be development pressure of some type within receiving areas to fuel the market for the purchase and sale of TDRs. Local government efforts to downzone property in order to increase the demand for credits can negatively affect receiving area interest, and such efforts typically fail. Making these areas attractive for development will require adequate infrastructure to support additional growth and comprehensive or master planning that is consistently applied. It is also important to be realistic about providing market incentives through transfer ratios that make sense. The objective is to allocate enough TDRs so that the amount paid for TDRs equals or exceeds the reduction in land value caused by the sending site easement. For example, if one unit per 25 acres is worth $20,000 but developers within a density receiving area would be willing to pay $100,000 for each bonus dwelling, the result is a five to one ratio transfer ratio.

The most successful TDR programs are those that transfer development density from rural areas to urban areas where the demand and infrastructure already exist. For example, pursuant to a TDR Pilot Program, Deschutes County worked with the City of La Pine to create a TDR program transferring development so as to protect forestlands. However, given the lack of urban-scale densities in most central coastal communities, consideration should be given to creating an inter-jurisdictional system where the sending areas may be under one city or county jurisdiction and the receiving area could be a larger incorporated city. Revisions adopted as part of HB 2132 authorize local governments to share the prospective additional tax revenues derived from new development in the receiving area, and this may encourage greater creativity amongst the various jurisdictions.

Another option, one that was proposed as part of the 2011 Legislative session, would be to allow greater rural development in unincorporated communities where demand already exists. Some jurisdictions have seen success by master planning entirely new town areas, although the cost of providing infrastructure to serve these areas is often prohibitive. Another option might be to identify low density receiving areas that may only allow slightly more development than resource protective zoning would allow.

Given the similar development objectives for coastal residents, it may make sense to create a regional TDR program providing comparable alternatives through the region to achieve similar results for all similarly situated coastal communities. For example, the New Jersey Pinelands program requires that the 60 jurisdictions conform their codes to implement the regional TDR program, with a regional commission reviewing and certifying all zoning and master plans for consistency with the regional plan.

Finally, a key component to a successful TDR program is the commitment of the public and participating local governments to preservation of important habitat areas and fair, rational policies to assist property owners in pulling back current or proposed development from shoreline hazard areas. This commitment could manifest itself through a local or state funded purchase program or a TDR bank, where the government uses public funds to buy TDRs and hold them for sale to developers. This can work to stabilize TDR prices. Successful TDR programs rely on the commitment of all affected parties to their continual existence. They are implemented over decades. A continual effort at outreach and education will be required in order to keep developers aware and to maintain public support.

In the special circumstances of the Oregon coast, this could involve building public awareness of the ways in which climate-driven effects, such as sea level rise, increased storm surges, and intensified erosion could transform the landscape and thus affect the built environment and natural areas. Coastal cities and counties that don’t want to see beaches and bluffs lost to continuous walks of riprap or marshes disappearing because they are trapped between a rising sea and rigid seawalls may be able to foster broad public support for taking measures to avoid these outcomes, once they are understood. With this kind of community support for long-term planning for climate change, a TDR program can be a feasible and useful tool for adaptation.

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Question: What is the Oregon Global Warming Commission doing about adaptation on the Oregon Coast?

The Global Warming Commission

Alex Wheatley[*]

The Oregon Global Warming Commission was created in 2007 with the passage of House Bill 3543. It is tasked with recommending ways to coordinate state and local efforts to reduce greenhouse gas emissions in Oregon that are consistent with Oregon's reduction goals. ORS 468A.205 states that those goals are: (1) arresting the growth of Oregon's greenhouse gas emissions by 2010; (2) achieving greenhouse gas levels that are 10% below 1990 levels by 2020; and (3) achieving greenhouse gas levels that are at least 75% below 1990 levels by 2050. According to the Global Warming Commission, Oregon is on track to meet the first goal with the policies and actions that are already in place to reduce greenhouse gas emissions. The commission warns, however, that Oregon will not meet the 2050 goal and likely will not meet the 2020 goal without further action.

Along with suggesting ways to reduce greenhouse gas emissions, the commission is also tasked with recommending efforts to help Oregon prepare for the effects of global warming. The truth of the matter is that regardless of how much we reduce our emissions and how quickly we do so, some of the effects of climate change will be felt. Indeed, we are experiencing these effects already. It is therefore necessary that we as a society think about the long-term risks that climate change will pose, and inform our investment decisions with this information. As explained in the Global Warming Commission's 2008 report[i], *"A Framework for Addressing Rapid Climate Change"*:

> "Planning now for a different and uncertain future can benefit the present in many ways. Thinking strategically now about future risks posed by climate change can reduce those risks and also produce future benefits, for example, by increasing energy and water efficiency now and reducing the need for additional supplies in the future; or building infrastructure such as storm treatment facilities that can handle extreme storm events now, rather than paying for the cost of repair and cleanup in the future."

The Global Warming Commission may recommend statutory and administrative changes, argue for different policy measures, and make recommendations to be carried out by state and local governments, businesses, nonprofit organizations, or residents. It must consider economic, environmental, health, and social costs and the risks and benefits of alternative strategies including least-cost options, and must solicit public comments relating to its recommendations. The commission must also examine greenhouse gas cap and trade systems, including a statewide

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[i] The Governor's Climate Change Integration Group. (2008). *Final report to the Governor: A framework for addressing rapid climate change.* Retrieved March 21, 2012 from oregon.gov/ENERGY/GBLWRM/docs/CCIGReport08Web.pdf

and multi-state carbon cap and trade system and market-based mechanisms as a means of achieving the climate reduction goals. The commission must examine possible funding mechanisms to obtain low cost greenhouse gas emission reductions and energy efficiency enhancements as well. The commission must conduct public outreach, and evaluate the ongoing development of scientific understanding of climate change, measures adopted to address climate change, and the progress toward meeting emission reduction goals. Finally, the commission may recommend the formation of citizen advisory groups and must give the legislature progress reports every other year concerning its work.

While the formation of the Global Warming Commission represents a significant step in the right direction, whether it will prove effective remains to be seen. The establishment of the commission was only a first step. The commission is tasked with studying the problem and suggesting ways to deal with that problem. Implementation of those suggestions is still required.

In 2009, the City of Portland and Multnomah County adopted a Climate Action Plan that outlines actions meant to achieve an 80% reduction in greenhouse gas emissions by 2050. Also in 2009, a series of climate bills were signed into law expanding carbon emission reporting requirements and supporting energy efficiency projects. These are significant implementation actions, but the Global Warming Commission reports no major achievements since 2009 on its website. Much more remains to be done, particularly with regard to planning how Oregon will respond to the most likely consequences of global climate change, such as sea level rise and increased summer drought conditions – which are now unavoidable even if further increases in greenhouse gas emissions are avoided..

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Question: Land and other resources owned for the benefit of all people can't be transferred away by a government entity currently in power. Does this doctrine have any application in Oregon when dealing with Coastal Climate Change Adaptation issues?

The Public Trust Doctrine in Oregon

Alex Wheatley[*]

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The public trust doctrine generally states that every sovereign government holds certain resources in trust for the people's use. Traditionally, it protected the rights of citizens to use natural resources like tidelands and rivers to exercise important common rights like fishing and navigation. Under the doctrine, the government has the obligation to protect those resources from obstruction or other harm that would impair the people's right to use those resources. More recently, some scholars have advocated for expansion of the doctrine in light of our increased understanding of what resources are valuable (Wood and O'Toole 2009).[1]

> ***Public Trust Doctrine***
> *……. every sovereign government holds certain resources in trust for the people's use.*

The principle is the same as with other types of trusts like charitable trusts. The trust property – natural resources when talking about the public trust doctrine or money, or other property when talking about a charitable trust – is held and managed by someone who does not own it. The trustee holds and manages the property in the charitable trust, and the government holds the responsibility of managing the public trust property – the environmental resources. In both cases, the trust property does not belong to the trustee. The trustee has only the responsibility of ensuring that those entitled to the benefit of the trust get that benefit. Thus, in the example of the charitable trust, the trustee's responsibility is to see that the charity gets the benefit of the trust property, and in the example of the public trust, the government trustee's responsibility is to see that the public – both current and future generations – gets the benefit of the natural resource trust property.

This doctrine is underpinned by the principle that natural resources have value and that the right to benefit from the use of those resources, and from the services derived from those resources, is common to all people. Furthermore, the doctrine is applied to those resources for which private ownership is either impractical, such as with fish in the sea, because they cannot be owned before they are caught, or undesirable, such as with navigable rivers, because private ownership and the power of exclusion that comes with it would be bad economically. In order to manage

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[1] Mary Wood & Susan O'Toole, "How to Sue for Climate Change: The Public Trust Doctrine," in *Outlook*, Oregon State Bar Environmental and Natural Resources Section (Winter 2009) (advancing the idea that the doctrine could be used to protect the rights of the people to use the atmosphere and impose an obligation of the state to take action to stop carbon emissions).

the resource without private ownership, the state must take responsibility. Because of the value of these resources and the risk that the actions of a few could diminish that value for the many, government is tasked with seeing that those resources are protected and preserved for the public at large and for future generations.

Though the origins of the doctrine are ancient, what constitutes a 'vital' resource has evolved over time. Justinian law from Roman times held that seashore land could not be privately owned because it was public property open to all.[xi] British law also recognized a public right to have navigable waters kept free of obstruction and codified public ownership of submerged and submersible lands.[xii] In *Illinois Central Railroad v. Illinois*,[xiii] the United States Supreme Court held that the public trust doctrine prevented the Illinois legislature from selling the public right to land under navigable water. In that case, the Illinois legislature granted a large portion of the underwater land in the Chicago Harbor to the Illinois Central Railroad. A later elected legislature sought to revoke that grant. The Supreme Court held that the public never lost its right to object to actions that would harm the right or ability to navigate those waters, so the state could revoke its grant. The right to prevent the obstruction of the navigable water of the Chicago Harbor belongs to the public, and the court held that the Illinois state government could take back the land it had granted in order to ensure that that right was protected.

In Oregon, elements of the public trust doctrine can be found in statute and case law. First, in the areas of ground and surface water, Oregon law provides that "all water within the state from all sources of water supply belong to the public."[xiv] The Water Rights Act goes even further and declares that "in-stream water rights" are "held in trust by the Water Resources Department for the benefit of the people of the State of Oregon."[xv] In *State ex rel. Thornton v. Hay*,[xvi] the Oregon Supreme Court held that owners of beachfront property could not prohibit or obstruct the public's access to the dry sand portions of the beach. The court based this decision on a theory of customary use – because the public had used that area of the beach for so long, it acquired a right to continue to do so. This theory is similar to the public trust doctrine, and, in fact, Justice Arno Denecke, who concurred in the decision, said that he would have decided that the beachfront property owners could not keep the public off of the dry sand beach because of the "extreme desirability to the public of the right to the use of the dry sands."[xvii] The use of this resource was vital to the public. Therefore, for the good of the public as a whole and to ensure that the resource would continue for future generations, the state is charged with preventing individuals from obstructing or otherwise harming the right.

The most definitive statement regarding Oregon's public trust law came in the case *Morse v. Oregon Division of State Lands*.[xviii] There, the court considered whether the public trust doctrine would prevent the filling of approximately 32 acres of Coos Bay to expand a public airport. The court held that the filling of that portion of Coos Bay did not materially interfere with the public's use of the waterway. The Oregon Attorney General's office has opined that, given the *Morse* decision and others like it, "the public trust doctrine prevents the state from alienating or otherwise encumbering the public's rights to use state-owned waterways so as to materially affect or impede those public rights."[xix]

More recently, the doctrine has been successfully invoked to protect recreational and aesthetic values[xx] and has been suggested as a way to force government to address climate change issues.[xxi] "Atmospheric health is essential to all facets of civilization and human survival. As such, it falls within the core of the purpose of the public trust doctrine to protect human assets crucial to human survival and welfare."[xxii] As science progresses and we realize that other natural resources are vital to human existence, the public trust doctrine should evolve to encompass that trust property as well.

The public trust doctrine could offer a tool for addressing climate change in Oregon. Whether the argument is that the atmosphere itself, or the right to have and use the atmosphere, is public trust property—or that actions that contribute to the diminishment of other public trust rights, like access to the dry sand beaches, are contrary to the public trust—the doctrine offers a basis on which to argue that the government must take action. As trustee, the state would have an affirmative duty to protect those resources for future beneficiaries. The problems posed by this possible solution are that: it may only address the problem on a piecemeal basis; the litigation costs could be too high; and the courts may not have the resources to oversee and implement the orders they might issue under the doctrine.

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Question: How do constitutional limits on private property 'takings' affect what can be done to plan for adaptation to climate change?

Constitutional Limitations on State and Local Government Regulation of Land Use

Ed Sullivan[*]

Although news stories and discussions may make it may appear that the constitutional limitations on the regulation of property are many and rigorous, those limitations are, in fact, few in number and the cases in which they act as a brake on regulation are rare indeed. Those limitations can be found in two places — the federal and the various state constitutions. Often, but not always, similar constitutional provisions may be interpreted similarly; however, state constitutional provisions may have different wording, history, and interpretations of the same words (such as "free speech" or "takings") in the federal constitution. State constitutional provisions should be applied first in the event that both federal and state provisions are at issue. (change footnotes to lower case Roman)

The constitutional provision most often applied as a limitation on the land use regulatory power is the "takings clause," which appears in the Oregon Constitution,[2] as well as in the Fifth Amendment to the Federal Constitution.[3] These amendments have been construed similarly. In analyzing those clauses the critical question is, "Just what qualifies as an 'unconstitutional taking'?" Two governmental actions almost always result in a requirement to pay "just compensation" — the physical invasion of land[4] and the denial of all viable economic use of land.[5] In almost every other case, a court will have to apply a three-factor test that weighs: (1) the economic impact on the property owner; (2) the extent of interference with investment-

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REFERENCES:

[2]In relevant portion, this provision states: "Private property shall not be taken for public use, nor the particular services of any man be demanded, without just compensation."

[3] " …nor shall private property be taken for public use, without just compensation." United States Constitution, Amendment V.

[4]*Loretto v. Teleprompter Manhattan CATV Corp.*, 458 US 419 (1982).

[5] *Lucas v. South Carolina Coastal Council*, 505 US 1003 (1992).). *Lucas* was a case in which a developer proved that his his two oceanfront, non-contiguous lots had been rendered valueless by regulation. A state coastal commission had adopted regulations to protect the lives and properties of others. It is likely that the fact that other property owners had already placed homes on their similarly situated lots and there was no variance or other remedy available were major factors in the takings determinations.

backed expectations; [6]and (3) the character of the governmental action.[7] Simply stated, in order to prove a taking, a plaintiff must demonstrate how badly she is financially hurt by the regulation, that the regulation was not of the type a reasonably prudent investor could have anticipated, and that the regulation was more like a physical invasion than a mere economic regulation. As a balancing test, none of the factors are dispositive of the result, but all will be considered. A taking can also occur when a public agency attaches a condition to a land use approval and this condition requires the owner to convey some of his or her private real property to the state, but this conveyance of land to the state is either unrelated to the impacts of the private land use that was proposed by the owner or is not "roughly proportional" to the impacts created by the owner's proposed use of their land. For example, an applicant for a single family house cannot be required to convey to the state private land adjacent to a beach so that people can walk across that beachfront unless there is some relationship between the impacts of the new home and that conveyance of private land to state ownership, beyond the public's desire to use that property without compensating the owner.[8] Nor may that owner be required to convey an amount of land to accommodate a new freeway, simply because he or she wants to build a house, because the single family house is not related to and does not justify conveyance of that amount of land for a freeway.[9]

Another constitutional issue often raised is one of fair treatment. Under the Oregon Constitution, there must be equality of privileges and immunities;[10] however, that provision has been interpreted to mean that there may not be any positive privileges granted to one person by the state that are not given to others.[11] The Federal Constitution speaks in terms of "equal protection" as part of the post-Civil War amendments to end slavery and its effects.[12] Although

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[6] In *Stop the Beach Renourishment, Inc. v. Florida Department of Environmental Protection*, 130 S. Ct. 2592 (2010), the United States Supreme Court found no taking due to a law that allowed the state ownership over certain reclaimed lands, but left open the possibility that such a claim could be made after a sudden change in law.

[7] The three factors are found in *Penn Central Transportation Co. v. New York City*, 438 U.S. 104, 124 (1978).

[8] *Nollan v. California Coastal Commission,* 483 U.S. 825 (1987). This case involved an attempt to secure an easement across a property where a single family house was proposed, with the easement intended to connect two state parks by taking public ownership of a strip of coastal land between the parks. The Coastal Commission said its objective was to assure that citizens had visual access to the ocean, i.e. that the line of sight from public areas to the ocean would be preserved. The United States Supreme Court found that the request for the easement in this particular case was unconnected with the ability to see the ocean from public areas, since the proposed house could be conditioned to minimize blocking those views -- inferring that the Coastal Commission was using its land use approval powers to extort the easement that it would otherwise be required to pay for, to allow pedestrian connections between the two state parks.

[9] *Dolan v. City of Tigard,* 512 U.S. 374 (1994),

[10] Or. Cons., Art. I, sec. 20 states:

> No law shall be passed granting to any citizen or class of citizens privileges, or immunities, which, upon the same terms, shall not equally belong to all citizens.

[11] *Hewitt v. SAIF,* 294 OR 33, 653 P2d 970 (1982).

[12] In relevant part, the Fourteenth Amendment provides:

> "nor shall any State * * * deny to any person within its jurisdiction the equal protection of the laws."

this clause was central to the end of segregation in the United States,[13] most equal protection cases are determined by whether there was a "rational basis" for a legislative distinction.[14] In the absence of a specifically protected constitutional right[15] or a "suspect classification" such as race or national origin,[16] the rational basis test will apply.

The last significant constitutional limitation on regulation comes under the "due process" clause of the 14th Amendment to the Federal Constitution.[17] There is no similar provision of the Oregon Constitution. For due process to apply, a life, liberty or a property "right" must be at issue. The clause has its origin in the Magna Carta and in common law.[18] For about a hundred years, the clause had a substantive element, which allowed courts to determine whether a law was, in the eyes of the judge, "arbitrary or capricious" or had "no relationship with the public health, safety, morals or general welfare."[19] Since about 1938, the United States Supreme Court has abandoned substantive due process.[20] Nevertheless, it has an attraction in the popular imagination. Within these constraints voters and legislatures may act as they judge appropriate.

[13] *Brown v. Board of Education*, 347 U.S. 483 (1954).

[14] "*We deal with economic and social legislation, where legislatures have historically drawn lines which we respect against the charge of violation of the Equal Protection Clause if the law be 'reasonable, not arbitrary' * * * and bears 'a rational relationship to a [permissible] state objective.'" * * * Village of Belle Terre v. Boraas, 416 U.S. 1 (1974).*

[15] *See e.g., R.A.V. v. City of St. Paul* 505 U.S. 377 (1992), which involved a failed attempt to criminalize "hate speech."

[16] *See, e.g., Loving v. Virginia*, 388 US 1 (1967), in which the US Supreme Court overturned Virginia's anti-miscegenation law.

[17] " * * *nor shall any State deprive any person of life, liberty, or property, without due process of law * * *"

[18] Sullivan, *The Missing Link: Fairness, British Natural Justice and American Planning and Administrative Law*, 11 Urban Lawyer 75 (1979).

[19] In *Lawton v. Steele*, 152 US 133, 137 (1894), the Supreme Court explained substantive due process thus:

> "To justify the state in thus interposing its authority in behalf of the public, it must appear first that the interests of the public generally, as distinguished from those of a particular class, require such interference, and second that the means are reasonably necessary for the accomplishment of the purpose, and not unduly oppressive upon individuals. * * *"

[20] *U.S. v. Carolene Products*, 304 U.S. 144, 154, n. 4 (1938).

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Question: If increased storm surges and a higher sea level combine to destroy coastal properties, is government money available to help owners rebuild?

Federal Emergency Management Agency Activities on the Oregon Coast

Janet Neuman[*]

Issue. Most citizens are familiar with the activities of the Federal Emergency Management Agency (FEMA, now within the Department of Homeland Security) even if they have not had any direct personal experience with the agency. FEMA responds to disasters of all kinds — such as floods, earthquakes, tornados, hurricanes, and wildfires — with a variety of emergency aid. The aid ranges from immediate assistance with public safety, food, water, and shelter to longer-term economic aid for rebuilding or relocating. There are several prerequisites that Oregon coastal communities, land use planners, and property owners need to be aware of in order to be eligible for FEMA aid when disaster strikes. This paper briefly addresses four FEMA issues and programs: general FEMA disaster assistance; FEMA flood mapping; FEMA's flood zoning and flood insurance program; and FEMA's limits on repeat claims and its program for acquiring at-risk properties. These topics focus primarily on aid for flood disasters, but some of the provisions discussed also apply to other disasters possible on the coast, such as storms, and the paper will note those as well.

Importance of the issue on the Oregon Coast. FEMA has assisted with past disaster events along the Oregon Coast, including the 1962 Columbus Day Storm, the 1996 floods, and the 2011 tsunami generated by the earthquake in Japan. Climate change will likely bring more flooding and large storm events to the Oregon Coast, resulting in additional requests for FEMA aid. Coastal communities and residents must stay in compliance with national rules in order to be eligible for help from FEMA in the event a disaster does occur in their area. Interested readers should also refer to the Vernonia case study in this compilation for additional details about how FEMA programs actually work in practice.

FEMA Disaster Assistance. The federal government, under FEMA's coordination, provides a wide variety of aid to states, local governments, households, and individuals in the wake of a declared emergency or major disaster. These events are defined below.[1] The President is authorized to declare an emergency or disaster based on a request from the governor of a state. Federal agencies can then provide assistance to the state in the form of personnel, supplies, equipment, advice, funds, and distribution of food and medicine. The federal government may

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[1] An "emergency" exists when the President has determined that "Federal assistance is needed to supplement State and local efforts and capabilities to save lives and to protect property and public health and safety, or to lessen or avert the threat of a catastrophe in any part of the United States." 42 U.S.C. § 5122(1). A major disaster exists when the President has determined that the disaster "is of such severity and magnitude that effective response is beyond the capabilities of the State and the affected local governments and . . . Federal assistance is necessary." 42 U.S.C. § 5170. Major disasters include, among other things, storms, high water, wind-driven water, tidal waves, tsunamis, and floods. 42 U.S.C. § 5122(2).

also provide housing and financial assistance directly to households and individuals, depending on the level of disaster declaration.

The federal disaster relief programs also include grants and other financial assistance for states to use in planning for emergencies and disasters ahead of time. To the extent they have not already done so, Oregon's coastal communities should investigate these programs to enhance their emergency preparedness before disaster strikes. Coastal citizens should also pay attention to state funding for flood planning, because when the state provides insufficient matching funds, it will not receive as much federal funding.

FEMA Flood Mapping and Flood Insurance. FEMA maintains maps of areas around the country at high risk of flooding. The maps, called Flood Insurance Rate Maps (FIRMs), identify Special Flood Hazard Areas (SFHAs) based on historical, meteorological, hydrologic, and hydraulic data, as well as open-space conditions, flood-control works, and development. An SFHA is an area that is subject to a "100-year flood," also called a "base flood." FEMA uses elevation levels to predict how high the water will be during a base flood at various locations. Despite its name and common misconceptions, a 100-year flood is not a flood that occurs every 100 years. The term is instead a statistical concept describing a flood that is so large that it has just a one percent chance of being matched or exceeded in any given year. However, a 100-year flood has a 26 percent chance of occurring during a 30-year period, the duration of many home mortgages. Furthermore, flood maps do not always accurately predict the parameters of a base flood. Since the 100-year flood is a statistical concept and the mapping is based on computer models, the maps are not infallible. It is important for communities to mobilize to collect actual data whenever flooding does occur in order to ground-truth the maps and provide information for possible map revisions.

Current FEMA maps for the Oregon coast may be obtained from FEMA's online Map Service Center (See Resources listed below). In fact, the FEMA website allows a property owner to simply enter an address to find out if a particular parcel is in an SFHA. Federal law requires property owners to buy flood insurance if their property is in an SFHA and they are subject to a federally-supported mortgage. Property owners can also buy flood insurance at a lower rate if their property lies outside an SFHA. Even if only part of the property is in the SFHA, owners may be required to buy insurance by their lender. If property is owned outright (with no outstanding mortgage), the owners are not obligated to purchase flood insurance. Nonetheless, even if property owners are not required by federal law or by their mortgage holders to buy flood insurance, having such insurance is a prerequisite to receiving FEMA aid. Thus, property owners who receive such aid will be required to buy insurance or they risk becoming ineligible for further assistance. Furthermore, not all floods result in federally declared disasters qualifying for FEMA aid, and insurance proceeds may be the only assistance available in those circumstances.

Property within designated SFHAs may have a lower value than equivalent property outside of an SFHA due to the identified risk of flooding and the requirement to purchase flood insurance; thus, a property owner may disagree with FEMA's mapping of flood hazard areas. Before a map is finalized, a property owner may appeal the proposed delineations, but in order to contest FEMA's decision, the property owner will be required to provide elevation information collected by a certified surveyor or engineer. Depending on the property, a survey may cost thousands of dollars. Thus, property owners must weigh the immediate costs of the flood insurance requirements and the effect on their property value against the cost of appealing and their possible long-term losses if the property does flood. If FEMA agrees with the submitted information, the map may be amended.

FEMA Zoning and the National Flood Insurance Program. As noted, when property is in a Special Flood Hazard Area, the property owner will be required to buy flood insurance in order to qualify for federally supported mortgages. Communities that include areas mapped as SFHAs can adopt flood-hazard regulations (including zoning and other limitations on development) to qualify for the National Flood Insurance Program ("NFIP"). The NFIP is a federal insurance program that offers lower rates than private insurers. The insurance is still offered through private insurance agents, but the rates are set and subsidized by the federal government, determined by factors including the date and type of construction and a building's level of risk. Currently, the NFIP has an upper limit of $250,000 for insurance on any given property. However, these subsidized rates have been criticized because they do not reflect true actuarial loss rates and because the NFIP is not self-sufficient financially. There have been recent proposals to change the law to eliminate the subsidies; thus, flood insurance may become more costly in the future. Furthermore, recent changes in the NFIP are eliminating the insurance subsidies for second homes at a rate of 25% a year beginning on July 1 of 2012; this change will likely affect many coastal property owners.

Communities eligible for the NFIP include Indian Tribes and political subdivisions of a state with zoning and building code jurisdiction over lands included in any SFHA. Participating communities are required to demonstrate to FEMA that they have sufficient regulations in place to minimize development in flood-prone areas and to mitigate damage from flooding. In fact, because of the possible errors in flood mapping, communities may want to be even more protective in their own zoning ordinances than FEMA might require.

FEMA's Limits on Repeat Claims and its Program for Acquiring At-Risk Properties. Historically, about one percent of the claimants for FEMA disaster aid have received more than 30 percent of the agency's payments, largely because this group of property owners suffers repetitive flood losses. Furthermore, one out of every ten home owners who have suffered repetitive losses has filed claims that cumulatively exceed the value of the house. Property owners who suffer repetitive losses from disasters thus take a disproportionate share of FEMA aid. As a result, FEMA has designed programs to mitigate repeat hazards and decrease claims for repetitive losses.

The Flood Insurance Reform Act of 2004 amended the NFIP and imposed limits on repeat claims for disaster aid as well. FEMA will not pay more than $25,000 to fix a damaged property from a single disaster, subject to an annual cost of living adjustment. The dollar limit is applied per property, not per owner, so a property owner may legitimately file separate claims for separate properties, but each claim is subject to the dollar cap. It is important to note that FEMA disaster aid is separate from flood insurance proceeds.

FEMA defines "repetitive loss properties" as properties that have incurred two or more flood losses greater than $1,000 within any 10-year period. A subset of these properties is designated as "severe repetitive loss properties" (SRL) based on their high potential for recurring substantial damages. Although FEMA does not place an outright limit on the number of claims a property owner may file, FEMA does provide incentives to property owners to sell these severely flood-prone properties and move.

The SRL program allows a community to designate areas as severe repetitive loss properties when the properties:

(a) are residential;

(b) are covered by an NFIP flood insurance policy;
(c) have received at least four NFIP claim payments over $5,000 each, or have received at least two separate claim payments where the cumulative amount of the building portion of such claims exceeds the market value of the building; and
(d) for (c) above, where at least two of the referenced claims occurred within any 10-year period, and were more than 10 days apart.

If a community designates property as SRL property, then a property owner has three options: 1) buy additional flood insurance; 2) modify the property to reduce losses; or 3) sell the property. If a property owner chooses to modify the property, acceptable mitigation activities include: relocation of at-risk structures; conversion of the property to open space; and elevation of existing structures to at least the base flood elevation.

If a property owner is willing to sell, federal funds are available to Indian tribal governments and states (who in turn make the funds available to local communities) to help them buy the property. These funds are known as Hazard Mitigation Assistance ("HMA") funds. FEMA funds about 75 percent of the cost of the acquisition projects (in some cases up to 90%) and states or Tribes are responsible for the remainder as a cost share. For "preventive" acquisitions, the purchase price is the current market value of the property, determined according to federal guidelines. If the acquisition follows a recent disaster, the market value of the property right before the disaster is used to determine the purchase price. Funding is subject to the availability of appropriations and the approval of mitigation plans. For instance, the pre-hazard mitigation acquisition program has not received any appropriations for 2013.

Property owners do not directly apply to FEMA for relief. Instead, their community sponsors an application on their behalf. However, money is limited and not all mitigation needs can be met. Therefore, states prioritize acquisition projects with input from local communities, and all projects are subject to further FEMA review and approval. Once a buyout project is approved, the community conducts the purchase and title transfer and covers the transaction costs, such as appraiser fees. The property owner remains responsible for any mortgages, liens, or similar obligations, just as in any other real estate transaction. Owners are also responsible for their own relocation costs.

Once the property is acquired, the community removes or destroys buildings and clears the land. Property purchased with HMA funds must then be kept as open space. The land may be used for a public park, wildlife refuge, or other compatible use, but it can never be sold, subdivided, or developed. Property acquisition is thus the most permanent form of hazard mitigation, removing people and property from harm and breaking the cycle of destruction and repair. Acquisition provides property owners a fair market price while helping them get to safer ground. Of course, fair market values do not necessarily compensate property owners for the personal value of their property, including sentimental value and other intangibles. Nor can the purchases compensate for the loss of history and disruption of community caused by large-scale buyouts. But the program reduces repetitive spending of taxpayer money on foreseeable and preventable losses.

The property acquisition program is voluntary, and no property owner is forced to sell his or her property. However, property owners who remain in SRL-designated areas may be required to pay more for flood insurance, elevate their homes, or install flood-proofing if they are subject to a mortgage or want to be eligible for FEMA aid.

In spite of FEMA's efforts to mitigate flood damage and acquire at-risk property, the roster of repetitive loss properties keeps growing, with SRL properties outnumbering mitigated properties by a ratio of 10 to 1. This trajectory is likely to continue with additional climate-change-induced flooding, putting pressure on already limited funds.

Effects on the Oregon Coast. FEMA reports 27 major disasters in Oregon between 1955 and 2011 — including floods, severe storms, mudslides, landslides, and debris flows — and one declaration in 1994 due to El Niño effects on the salmon industry.[2] The majority of these involved at least one coastal county, and the events giving rise to the disaster declarations are of the type expected to increase with climate change. It is thus critical for coastal communities and residents to be aware of any prerequisites in federal, state, or local law that will enable them to receive FEMA disaster assistance. However, it is even more important for coastal communities to be pro-active in order to take full advantage of federal funding assistance for advance disaster planning, particularly given the uncertainties associated with predicting specific climate change impacts.

FEMA Flood Maps Are Available for the Entire Oregon Coastline. The Resources section below lists documents and online materials from FEMA, the Department of Land Conservation and Development, and Oregon State University for accessing these maps. According to FEMA, all of the Oregon communities with identified flood hazards already participate in the National Flood Insurance Program. However, that does not necessarily mean that all property owners are in compliance with the program. Coastal residents should thus determine for themselves if they are in flood-prone areas and if they must — or should — purchase flood insurance. Citizens should also work with their local governments to review existing floodplain zoning and other regulations to be sure they adequately anticipate expected changes in historic flooding patterns. Furthermore, coastal communities and their residents should be vigilant in making sure that FEMA keeps flood maps up to date as flood risks change along the coast. Communities may also want to be proactive in seeking federal assistance to mitigate for flood risks before flooding occurs. Property modifications and acquisitions should be fully explored to reduce future damage. Coastal communities should also fine-tune their land use regulations and disaster planning to be prepared for an increase in events other than flooding, such as storms, severe erosion, wind-driven water, mudslides, landslides, and debris flows.

[2] There have also been emergencies declared for drought and wildfire. Oregon's FEMA history can be viewed at: http://www.fema.gov/news/disasters_state.fema?id=41

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Question: Does the federal government provide any tools for coastal climate change adaptation through its Coastal Zone Management Act?

The Coastal Zone Management Act

Janet Neuman*

Issue. One of the regulatory schemes governing land use along the Oregon coast is the federal Coastal Zone Management Act (CZMA), adopted by Congress in 1972 "to preserve, protect, develop, and where possible, to restore or enhance, the resources of the Nation's coastal zone for this and succeeding generations." Although state participation in the CZMA program is voluntary, participating states receive federal funds for their coastal programs and are authorized to review federal activities within the coastal zone for consistency with the state plan. Oregon participates in the CZMA program, with the Department of Land Conservation and Development (DLCD) as the lead agency. This participation gives the state, local governments, and citizens additional authority over and funding for coastal zone activities, but also imposes a number of specific regulatory requirements to which the state must adhere.

Importance of this Issue on the Oregon Coast. Oregon's coastline stretches 362 miles from Washington to California. For purposes of the CZMA, the coastal management zone also extends three miles offshore and inland to the crest of the Coast Range, except at three locations: (1) along the Columbia River, the zone extends inland to the downstream end of Puget Island; (2) on the Umpqua River, it extends inland to Scottsburg; and (3) on the Rogue River, inland to Agness. Within this zone, a comprehensive state management program approved by the U.S. Secretary of Commerce governs development and preservation of coastal lands and resources.

Description of Relevant Law and Science. Oregon's first coastal zone management program was approved in 1977. In 1987, the management plan was updated in a document called the "Green Book," which is the approved version of the plan today (see Resources, below). The state DLCD is the lead agency under the CZMA. The primary state authorities for Oregon's management program are the state's land use planning laws, including the state authority in Oregon Revised Statutes Chapter 197 and the city and county authority in Chapter 197, 215, 221, and 227. In addition to the land use laws, several other state statutes governing particular resources are also incorporated into the coastal management program, such as the Beach Bill, the removal-fill laws, energy facility siting requirements, and many other specific authorities.

As part of its CZMA program, Oregon was also required to prepare a Coastal Nonpoint Pollution Control Program for the approval of both the Secretary of Commerce and the Administrator of the Environmental Protection Agency. The purpose of the nonpoint program is to restore and protect coastal waters from pollution. The coastal program is an appendix to the state's overall

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nonpoint pollution control program, available on the Department of Environmental Quality's website.

Oregon's adoption of its statewide land use planning laws in 1973 positioned the state very well to participate in the CZMA program. In fact, Oregon was only the second state to have a federally approved plan. Four of the statewide planning goals directly address coastal resources: Goal 16 ("Estuarine Resources"); Goal 17 ("Coastal Shorelands"); Goal 18 ("Beaches and Dunes"); and Goal 19 ("Ocean Resources"). The Coastal Zone Management Act and its implementing regulations contain a number of specific requirements that must be included in a state management program in order to win approval and be eligible for federal funding. Listing just a few of them illustrates how closely they track the state's own land use requirements:

- an inventory and designation of areas of particular concern within the coastal zone;
- a procedure to designate areas for preservation;
- broad guidelines on priorities of uses in particular areas, including specifically those uses of lowest priority;
- a definition of permissible land and water uses within the coastal zone which have a direct and significant impact on the coastal waters and the means by which the state proposes to exert control over those uses;
- a definition of the term "beach" and a planning process for the protection of, and access to, public beaches and other public coastal areas of environmental, recreational, historical, esthetic, ecological, or cultural value;
- a planning process for assessing the effects of, and studying and evaluating ways to control, or lessen the impact of, shoreline erosion, and to restore areas adversely affected by such erosion; and
- a description of the organizational structure proposed to implement the management program, including the responsibilities and interrelationships of local, area-wide, state, regional, and interstate agencies in the management process and a mechanism to ensure that all agencies follow the program.

The federal regulations also contain several requirements for inclusion in the state's plan that are directly related to the impacts of climate change on the Oregon coast:

- information on the impacts of global warming and resultant sea level rise on natural resources such as beaches, dunes, estuaries, and wetlands, on salinization of drinking water supplies, and on properties, infrastructure and public works;

- areas where, if development were permitted, it might be subject to significant hazard due to storms, slides, floods, erosion, settlement, salt water intrusion, or sea level rise; and

- areas needed to protect, maintain or replenish coastal lands or resources including coastal flood plains, aquifers and their recharge areas, estuaries, sand dunes, coral and other reefs, beaches, offshore sand deposits and mangrove stands.

The overall framework and mandates of the CZMA thus enable Oregon's coastal communities and citizens to use the coastal management program, processes, and funding to help them adapt to coastal climate change impacts.

Effects on the Oregon Coast. The local land use plans adopted by cities and counties within Oregon's coastal zone are the "bread and butter" of the coastal management program, just as these plans provide the basic framework for prioritizing land uses and reviewing development activities in the rest of the state. The coastal-area plans incorporate the special requirements of the CZMA; thus, once they have been reviewed and approved by DLCD, they provide the necessary standards for reviewing proposed projects and developments to satisfy both state and federal law.

Some components included in the coastal land use plans that would not necessarily be found in plans adopted in other parts of the state include a requirement that the state consider national interests in its planning process, such as in energy facility siting and in the protection of national resources. The climate change requirements mentioned above are also unique to the coastal land use plans. It is important that the coastal communities fully implement these planning mandates in order to prepare for sea level rise, shoreline changes, and other expected hazards associated with climate change.

Oregon has been receiving federal CZMA funds for more than 30 years. Currently, the state receives about $2 million in federal funds annually; these funds are matched with state funds on a one-to-one basis. Much of this funding is in turn made available directly to local governments to help with their planning efforts — especially those that are above and beyond what would otherwise be required by the state land use laws. For instance, in 2011, DLCD issued a round of grant awards designed specifically to help local governments assess and plan for risks and hazards associated with climate change. The DLCD website contains information about annual grant opportunities.

In addition to the eligibility for federal funds, another advantage of having an approved coastal management program under the CZMA is the authority given to the state to review federal activities within the coastal zone for consistency with the state's program and plans. Indeed, the state's authority extends beyond just review and comment; these federally permitted activities are required to be certified as compliant with Oregon's program. The list of federal activities subject to certification is included in the Green Book, cited below. Certification works as follows: the applicant for a listed federal approval prepares a certification explaining how the project is consistent with the state's program and requirements and submits it to DLCD. Applicable federal regulations and locally adopted plans specify the information that must be included in a certification submission. DLCD then has up to six months to either concur with or object to the certification. A project cannot go forward without the state's concurrence (though failure to respond within six months is deemed a concurrence). Federal regulations also give DLCD the authority — with NOAA's approval — to add to the list of activities requiring certification; the state can also request permission to review individual projects that are not included in the list of types of approvals requiring certification.

Oregon's coastal management program provides both the capacity and capability to help local communities face climate change. Both the state and local governments should continue to aggressively seek funding and other technical assistance to help plan for the coming changes and uncertainties. The state should also use the overarching management program to coordinate the efforts of the local communities to assure that individual jurisdictions' efforts to plan for, adapt to, and protect themselves from climate change do not hinder similar efforts for neighboring communities.

RESOURCES:

Statutes

16 U.S.C. §§ 1451-1466,

http://frwebgate.access.gpo.gov/cgi- bin/usc.cgi?ACTION=BROWSE&TITLE=16USCC33&PDFS=YES.

Regulations

15 C.F.R. §§ 923-930, http://ecfr.gpoaccess.gov.

Online Resources

Green Book, Oregon Coastal Management Program, http://www.oregon.gov/LCD/OCMP/docs/Green_Book.pdf.

Oregon's Coastal Zone, Oregon Coastal Management Program http://www.oregon.gov/LCD/OCMP/CstZone_Intro.shtml.

Publications, Oregon Coastal Management Program, http://www.oregon.gov/LCD/OCMP/Publications.shtml.

FAQ on Federal Consistency Review, Oregon Coastal Management Program, http://www.oregon.gov/LCD/OCMP/FedCon_FAQ.shtml.

Federal Coastal Zone Management Act, Oregon State University Library website, http://oregonexplorer.info/landuse/CoastalLandUse/CoastalZoneManagementAct.

Oregon's Coastal Management Program Grant Guidelines, http://www.oregon.gov/LCD/OCMP/index.shtml

Nonpoint Pollution Control Program, Oregon Department of Environmental Quality, http://www.deq.state.or.us/wq/nonpoint/plan.htm.

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Question: In responding to the need for climate change adaptation, what are the initial steps that local governments can take towards developing a plan?

Planning For Climate Change: Tools for Coastal Communities and Local Governments

Courtney Johnson*

In order to prepare for the possible effects of climate change on the Oregon coast, decision-makers and community residents will need to look far ahead to anticipate such long-term impacts and create a framework for adaptation to climate change over coming decades. Planning should focus on creating resilient communities on the Oregon coast that will be able to adjust to and withstand the impacts of a changing climate.

Advance planning is critically important given two opposing forces likely to result from climate change. On the one hand, increased storm frequency and intensity along with sea level rise and decreased summertime precipitation will put coastal properties, natural areas, and water sources at risk. On the other hand, Oregon's coastal climate is likely to remain mild, with longer, warmer summers and temperate winters. As a result, our coastal communities may attract "climate refugees" and experience greater in-migration and associated pressures on land use and water resources. At the convergence of these two forces, Oregon's coastal communities will likely see property disappearing as beaches migrate inland and storm surges increase, while human population growth increases the need for land and resources. As a result, it is critical that local cities and counties begin immediately to account for climate change impacts in land use planning and infrastructure development decision-making.

Oregon already has a statewide report from the Governor's Climate Changes Integration Group, which included the key recommendation that Oregon transform its planning processes to deal with climate change.[i] Specifically, the report urges that at all levels of government, decision-makers must: 1) consider climate change as a key element in our current planning process; 2) modify planning processes so that we conduct them on a holistic basis that considers multiple interconnected systems; and 3) develop dynamic planning processes designed to handle changing rather than stable conditions.

Based on the statewide report, the Department of Land Conservation and Development (DLCD, through the Oregon Coastal Management Program) developed a coastal adaptation strategy with two objectives: 1) to enable coastal local governments to prepare adaptation plans by 2015 to account for the effects of climate change on property, infrastructure, habitats, and resources; and

Attorney and counsel to Oregon Shores Conservation Coalition through the Coastal Law Project, a partnership with Crag Law Center, a non-profit law center that supports community efforts to protect and sustain the Pacific Northwest's natural legacy.

2) to ensure that public infrastructure and investment decisions made by the State of Oregon are coordinated with local government climate change adaptation plans.[ii]

While climate change is a global trend, localities will experience its impacts in differing degrees and ways. Local governments are in a strong position to tailor climate change preparedness strategies to the specific circumstances and climate change impacts in each area. In order to achieve climate change preparedness, communities should develop strategies and an adaptation plan to address risks and issues specific to the area. The specific adaptation plans will vary from place to place, but developing a systematic approach to adaptive planning will help communities prepare a meaningful and appropriate strategy for adapting to climate change.

(Note: The following constitutes general advice for local government jurisdictions initiating an adaptive planning process, developed by The Climate Impacts Group.[iii] Oregon Shores' Coastal Climate Change Adaptation Project is an attempt to address many of these needs through the leadership of a non-governmental organization, developing broad grassroots support for an adaptive planning proposal before bringing it to local government for consideration.)

A good starting place for planning is to assess the risks and likely impacts to the community. This involves collecting and reviewing important climate information to answer the questions:

1) How could climate change affect my region? and

2) Could those impacts pose a risk to my community?

Some impacts likely to affect coastal communities include:[iv]

Infrastructure	• Need for new or upgraded flood and erosion control structures • More frequent landslides, road washouts, and flooding • Increased demands on stormwater management systems with potential for more combined stormwater and sewer overflows • Reduced effectiveness of sea walls with sea level rise • Impacts on business infrastructure in coastal areas
Coastal Resources	• Increased erosion or damage to coastal infrastructure, dunes, beaches, and other natural features due to sea level rise and storm surge • Loss of coastal wetlands and other coastal habitats due to sea level rise and erosion, and/or the necessity of allowing wetlands and related habitat areas to move inland onto adjacent land as they naturally would as a result of sea level rise • Increased costs for maintenance and expansion of coastal erosion control (natural controls, or if appropriate, man-made controls) • Saltwater intrusion into coastal aquifers due to sea level rise • Increased risk of pollution from coastal hazardous waste sites • Loss of cultural and historical sites on coastline to sea level rise and related impacts
Hydrology and	• Lower summer streamflows • Increased risk of summer drought

Water Resources	• Increased risk of winter flooding • Increased competition for fresh water • Warmer temperatures in lakes and rivers • Changes in water quality

Local governments should adopt an ordinance or resolution to form a team and take steps to prepare for climate change, including drafting a preparedness plan with regular updates. One possible tactic for keeping planning efforts on track and helping to develop the political will in the community to support these efforts is to identify a climate change "champion." This could be a well-respected figure in the community who can lead the charge to make tough decisions about changing from the status quo. The locality should develop an outreach plan to communicate the objectives and purpose of climate change preparedness planning, balancing the need for change with optimism that adaptation is possible.

Local governments may find it helpful to put together a climate preparedness team. The team might include members associated with public health, planning and zoning, water and wastewater systems, transportation infrastructure, community organizations, business advisors, science advisors, and tribes.

The planning team should identify planning topics relevant to climate change and the current and expected stresses to the built, natural, and human systems in each area, then conduct a climate change vulnerability assessment.[v] The vulnerability assessment will help determine the sensitivity of each system. Ask: will the systems associated with this planning topic be significantly affected by projected changes in climate? This may include considering questions like: 1) How exposed is the system to the impacts of climate change? 2) Is the system subject to existing stress? 3) Will climate change cause the demand for a resource to exceed its supply? 4) Does the system have limiting factors that may be affected by climate change? 5) For plant and animal species, is a species of concern in your system currently located near the edge or lowest elevation point of its range? 6) What is the "impact threshold" associated with the system? For example, a seawall designed for certain size storm – what sea level rise would cause overtopping during this type of storm?

The vulnerability assessment should also evaluate the adaptive capacity of built, natural, and human systems. For example, communities may want to consider the following questions:

1) Are the local systems associated with each planning topic already able to accommodate climate changes?

2) Are there barriers to a local system's ability to accommodate changes in climate?

3) Are the systems already stressed in ways that will limit their ability to accommodate changes in climate?

4) Is the rate of projected climate change likely to be faster than the adaptability of the systems?

5) Are there efforts already under way to address impacts of climate change related to these systems?

The combined results of the sensitivity and adaptability analyses can be used to assess the vulnerability of community systems to climate change impacts. With this in hand, a community can assess its climate change risks. Consider the consequence (how costly, how much impact?) together with the probability (how likely is it that this impact will occur?). Based on vulnerability and risk, the community can establish a list of priority planning areas. Communities can then start setting preparedness goals and developing adaptation plans, putting priority areas first.

The type of adaptation measure taken to prepare for climate change may include retaining the status quo, preventing the loss by proactive measures, spreading the loss across the population, changing the activity through land use planning or wetland restoration, changing the location of infrastructure and structures, or enhancing the adaptive capacity of the system. The environmental costs and benefits of each option should be carefully analyzed with regard to location and timing. For example, maintaining the status quo may seem like the easiest option but may in fact result in the highest cost to government and residents. On the other hand, investing now in measures to prepare for, and adapt to, the impacts of climate change may significantly reduce the cost and extent of damage.

Oregon's coastal cities and counties should consider adopting an ordinance that directs local planning authorities to evaluate climate impacts, including, but not limited to, those pertaining to sea level rise, storm intensity, beach erosion, etc., when reviewing land use applications and infrastructure development. King County, Washington, has adopted a policy to "consider projected impacts of climate change, including more severe winter flooding, when updating disaster preparedness, levee investment, and land use plans, as well as development regulations."[vi] Homer, Alaska, adopted a Climate Adaptation Plan in 2007 recognizing that adaptation will be essential for the future health of the community. Taking this step now would help ensure that Oregon's coastal communities are moving towards local implementation of the strategies and frameworks that have been adopted at the statewide and regional level.

Finally, local governments should review and measure progress made towards adaptation and update their plans as necessary to account for changes in information, risk analysis, or impacts as more information becomes available. The Coastal Climate Change Adaptation Project seeks to develop a model for a citizen-based process through which communities can build strong support for adaptive climate change planning and collaborate with their local governments in addressing its many challenges.

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Question: How are federal, state, and local governments and non-governmental organizations currently working to promote climate change adaptation efforts?

Climate Change Adaptation Efforts: A Review

Paris Edwards*

Planning for the anticipated impacts of climate change is occurring all over the world. In the United States more than 20 states have created or are in the process of creating adaptation plans. The number of communities taking on the task is steadily growing. The movement to adapt signifies a recognition of two facts: 1) global climate change is happening, regardless of arguments about the extent to which human activities are the primary cause; and 2) climate change is causing changes in natural systems and conditions that are already impacting, or will soon impact, built environments and the natural resources upon which humans depend. The following is a broad survey of current adaptation efforts.

While the initial policy response to climate change has tended to take the form of "Action Plans" that primarily focused on mitigation through emissions reductions, efforts targeted at adaptation are gaining popularity. *Mitigation* refers to attempts to limit or prevent climate change, generally through reduced greenhouse gas emissions--a different effort that is complementary with *adaptation* to changing climate conditions. According to the Georgetown Climate Center (2011), 26 states have made some adaptation planning effort and have identified climate change as the driver. According to the Pew Center for Global Climate Change, of the 20 states with completed or recommended adaptation plans, over half are coastal (Cruce, 2009).

In general, state plans initiate statewide risk assessments that identify areas where the risk of significant climate impacts is critical. These plans offer a political "green light" for leadership to implement climate-aware policy. In the case of Oregon's efforts, in 2007 the legislature (through House Bill 3543) created the Global Warming Commission to advise the Governor and legislature, and also created the Oregon Climate Change Research Institute (based at Oregon State University).

Many states are making concerted efforts toward better oversight and data collection to illuminate the adaptation process. However, because actual impacts are specific to local conditions such as geology, topography, coastal proximity, etc., states have recognized that adaptation actions must take place at the community level and focus on local risks.

Typically, communities are on their own to govern and fund adaptation related actions, identify place-based planning priorities, and create policy. A majority of available community-level

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plans have been assisted by ICLEI-Local Governments for Sustainability, originally organized through the United Nations as the International Council for Local Environmental Initiatives. The recent community-based efforts have, in part, emerged from a joint initiative with the National Oceanic and Atmospheric Administration (NOAA). The ICLEI model for community-based adaptation provides a formal five-step plan that includes planning assistance and funding for communities (CRC, 2012). For example, ICLEI collaborated with King County, Washington to create a free guidebook for community adaptation.

With or without assistance from non-governmental organizations (NGOs), most local planning efforts are initiated and lead by local government. Grassroots efforts by local citizenry are rare to non-existent. A current exception is Oregon Shores' Coastal Climate Change Adaptation Project, which involves "core teams" of citizen leaders who identify community risk factors and priorities. These groups are moving forward by drafting ordinances for the city of Newport and Lincoln County that address adaptive planning for shoreline, estuarine, and adjacent shoreland areas. While NGOs like Oregon Shores and ICLEI play key roles in community adaption, it is clear that updated information from research institutions and funding from the Federal Government will be critical for long-term success.

Federal Efforts. The federal government has made some initial executive efforts to promote awareness and collaboration among government agencies. The Obama administration created the Interagency Climate Change Adaptation Taskforce in 2009. In October of 2009, the President directed the taskforce to develop a report with recommendations for ways the federal government can strengthen policies and programs to prepare the nation for the impacts of climate change. The taskforce is a collaborative effort among representatives from more than 20 federal agencies, among them the Council on Environmental Quality (CEQ), the Office of Science and Technology Policy (OSTP), and NOAA (NAP, 2011).

The taskforce followed up with two annual progress reports and an Action Plan on managing freshwater resources. The progress reports make recommendations such as "make adaptation a standard part of Agency planning," but the recommendations for accomplishing these goals offer only vaguely worded directives to "move forward with flexibility." On the more concrete end of the spectrum are suggestions to build partnerships among local, state, and tribal decision-makers. Like most recommendations, this lacks the mandates necessary to transform it from a paper statement to action. Perhaps itis the case that much of the advice from the taskforce, with or without recommendations that could potentially be acted upon, can do little until directed at specific issues.

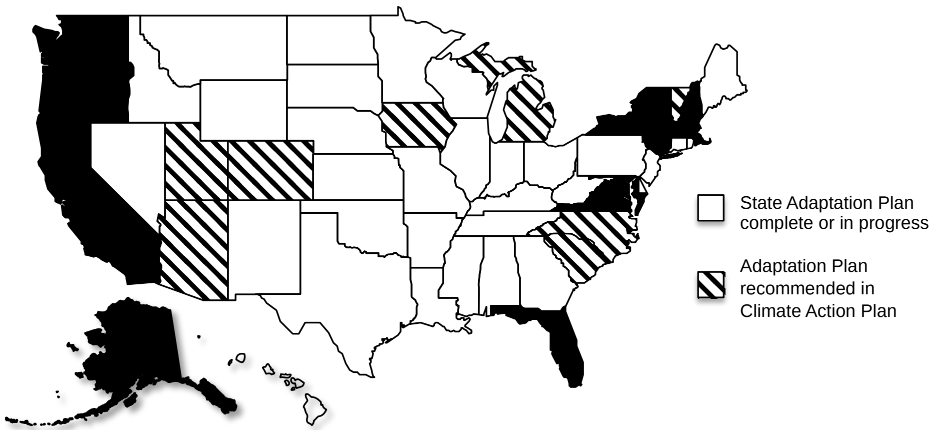
As an example of addressing specific issues, the Action Plan on water resource management lists the U.S. Army Corps of Engineers' incorporation of sea level change in project planning, the Environmental Protection Agency's development of a tool to assess water utility vulnerability to climate change, and the Bureau of Reclamation's "new science" to assess impacts on western water basins as concrete progress on adaptation. These programs exemplify targeted agency efforts. Additional adaptation plans from key federal agencies are forthcoming and expected by June, 2012 as mandated by the taskforce. "These plans are intended to help agencies integrate adaptation into their ongoing planning to ensure that resources are invested wisely and that Federal operations, policies and programs remain effective in a changing climate" (NAP, 2011).

What can be said about the federal response to climate change is that many branches are beginning to take account of relevant information and bureaucracies are making efforts to institutionalize adaptive planning. Key agencies with the influence to lead and fund projects are positioning themselves to incorporate adaptive efforts and, in some cases, have already begun providing planning tools such as those in the following table.

Agency	Climate Change Assessment Tool
Environmental Protection Agency (EPA)	Modifying methods for risk assessment for water utilities to consider climate change impacts, including the Climate Resilience Evaluation and Awareness Tool (CREAT)
National Oceanic & Atmospheric Administration (NOAA)]	Expanding pilot projects for regional early warning information systems for drought, including the National Integrated Drought Information System (NIDIS), and the Vulnerability Assessment Techniques and Applications (VATA) for coastal communities that includes training on vulnerability assessment of fish and wildlife and other natural resources
US Army Corps of Engineers (USACE)	Dam Safety Action Classification tool

At a glance many government actions seem beyond the scope of local concerns on Oregon's coast, but there are clear benefits that could be derived from an informed government that prioritizes climate change adaptation on a national political scale. It should be a priority of local organizers to communicate to agency leadership how these unfolding policies can and should translate to local projects with adequate funding in their communities.

State Efforts. Fewer than half of the 50 states have created formal "Climate Action Plans" or "Adaptation Action Plans" to guide policy. These states are displayed in the map below, adapted from Cruce, 2009.



After the release of the first IPCC report in 2007, many states responded with plans for emissions reductions, improved transportation infrastructure, waste reduction, energy efficiency and alternatives, and other climate change mitigation efforts. Recognition of the need to address climate change adaptation in addition to mitigation sparked a new focus in policy recommendations in these same states beginning in 2009. At least 20 states have implemented independent adaptation plans, and many have added adaptation strategies to their existing climate change policies. Initial steps in state efforts include assessments of the status quo and assessments of potential future risk. These data provide baseline information for long-term monitoring and dynamic risk assessment.

Many states are starting to address climate change mitigation with efforts such as greenhouse gas and solid waste reduction goals and assessments, programmatic efficiency plans for energy alternatives, and transportation improvements. When states also focus on climate change adaptation, economic risk is commonly chosen as one key metric for assessing climate change impacts; economic risk analysis has catalyzed the initial stages of broad policy recommendations to address climate change at the state level. Analysis of risks to economic drivers such as agriculture, natural resources, and industry, along with analysis of potential adaptation strategies, may form the starting point of adaptation planning efforts.

The Oregon Climate Change Adaptation Framework was designed as an initial "scoping exercise" to determine the risks and pinpoint critical areas in need of prioritized action. The assessment looks at potential impacts on forests, the ocean, and the built environment, systematically identifying how changes in temperature, hydrology, and disease could impact systems (DLCD, 2010).

States are also making progress with policy guidelines that help drive adaptation goals and focus resources. Several states have mandated independent research bodies to improve information through ongoing study of the risks and impacts on a state and regional scale. The Oregon Climate Change Research Institute (OCCRI), housed at Oregon State University in Corvallis, is one example. Regional collaborations such as the Pacific Northwest's Climate Impacts Group, a consortium of research groups at universities in Washington, Oregon, and Idaho, have come together to share resources and responsibility for planning and management of the critical Columbia River basin.

Like national bureaucracies, state agencies are slow to incorporate efforts to institutionalize climate-aware practices. Under current economic conditions, states have to stretch scarce funds over a wide array of priorities. Funding mechanisms are not included in state climate change plans, leaving communities to identify local needs and, in most cases, find funding. Adaptation progress at the state level hovers in the realm of high-minded political recommendations and agency reform. The question remains whether and how state efforts will translate to substantial change and how bureaucracies that are traditionally slow to change will adopt the "flexibility" considered integral to effective action. Further questions remain about how these changes will trickle down to communities that are in need of expertise and funds to identify and address their climate impact concerns.

City & County Efforts. Cities and counties across the country are beginning to take matters into their own hands with the help of a few very influential organizations and collaborations. In almost every case local efforts have been aided by organizations positioned to provide staff, planning formulas, and funding. A large portion of these resources have come from NOAA, a federal agency, supporting the argument that coupling national funds with local expertise can be a powerful formula for progress. These partnerships have shown clear advantages through the work of ICLEI, NOAA, and the National Sea Grant College Program (a NOAA program) in cities and counties across the country.

ICLEI has established itself as a leader in community-based climate change mitigation and adaptation, with over 300 cities and counties in its emissions-reducing climate protection program and a growing number of participants in its Climate Resilient Communities (CRC) program. Eight pilot cities were chosen for newly developed online tools, technical support, and other resources from the CRC effort. The diverse set of cities and counties include: Cambridge, MA; Miami-Dade, FL; Fort Collins, CO; Homer, AK; Keene, NH, and others. A network building tool is in (web) construction to facilitate communication among communities involved in adaptation efforts. Participation requires paid online membership, which may be a barrier to participation; however, this effort reflects the importance of improved communication among communities about "wins and losses" along the path of long-term planning.

In 2007, ICLEI began a partnership with NOAA to carry out the Climate Safe Cities initiative, an effort to help local governments improve resiliency to risks of crisis and disaster from climate variability. NOAA continues to provide research that ICLEI uses to create "operational tools" aimed at supporting government decision-making to reduce vulnerability to climate change. The Adaptation Database and Planning Tool (ADAPT) is an example of this collaboration. ADAPT guides local governments through the process of "assessing vulnerabilities, setting resiliency goals, and developing plans that integrate into existing hazard and comprehensive planning efforts" (ADAPT, 2010). The ICLEI-NOAA collaboration also extends to NOAA's Regional Integrated Sciences and Assessments (RISA) program that is geared at linking local government decision-making to university-housed research where funds are directed at modeling, tool development, and climate prediction generation. The Oregon Climate Change Research Institute, for example, provides data for the RISA program (RISA, 2011).

Sea Grant is administered by NOAA through 30 colleges and universities nationwide, including Oregon State University. The goal of the program is "to conserve and practically manage coasts, the Great Lakes and marine areas." In 2009, Sea Grant defined its role in understanding and preparing for climate change along America's coastlines and set goals to invest in research, investigate local needs at the community level, and educate and train coastal managers.

Sea Grant Oregon worked with the coastal town of Port Orford on a year-and-a-half-long pilot project to consider how the community might adapt to climate change. Sea Grant worked with an unofficial small group of interested citizens and planners, facilitating their learning process through "concept-mapping" exercises and survey evaluations at the beginning and end of the process. The working group discussed potential impacts of climate change in a formal presentation to the Port Orford Planning Commission, leading to a unanimous agreement to consider climate change when reviewing city ordinances and land development proposals (Sea Grant, 2011).

The roles played by Sea Grant, ICLEI and NOAA represent the current powerhouse for community-based climate change planning and adaptation. Many of the city- and county-level planning projects are still in their pilot phases or beginning to generate feedback through updates and reports; however, all of the current programs could benefit from increased transparency and follow-up. The benefits of these programs will be better understood over time, but much can be learned from the initial planning and collaboration efforts set up by these organizations.

The Oregon Shores Coastal Climate Change Adaptation Project's (CCCAP) grassroots approach to climate change adaptation appears to be unique, although it is possible that a few parallel efforts could exist elsewhere without national visibility. Regardless, small-scale organizations can and should learn from the aforementioned formalized adaptation efforts. The potential benefits of a grassroots approach are flexibility, specificity, and citizen-driven outcomes, while possible drawbacks are a lack of resources, the difficulty of maintaining consistent long-term participation by volunteers, and lack of specific kinds of needed expertise. To address the lack of precedent and potential drawbacks of citizen-driven planning, the CCCAP project is evaluated and updated regularly to respond to needed change where possible. The project is in its pilot year in Lincoln County, Oregon. A central aim of the project is to introduce successful planning approaches to all of Oregon's coastal communities.

Key elements in the climate change adaptation effort are to ensure that plans are created locally, that climate change researchers strive to provide high-resolution localized information, and that all present research and planning data be made easily accessible to the public. The ongoing training programs from NOAA, ICLEI, and Sea Grant are excellent efforts, but other advocacy organizations and interest groups should continue working to ensure that the kind of knowledge passed on through these training sessions spreads to the general public. Public knowledge, perception, and engagement are integral to making changes at the local level that are necessary for community resiliency.

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