IX. NEXT STEPS

In 2011 and 2012, National Wildlife Federation (NWF), in partnership with the University of Washington Climate Impacts Group (CIG), will convene six expert focus groups to confirm, augment, and disseminate the findings of this report. Leveraging NWF's existing efforts in outreach and stakeholder engagement and CIG's expertise conducting similar focus groups, NWF will utilize a participatory, integrative approach to engage experts in focus group discussions of climate change effects and adaptation strategies in marine and coastal ecosystems in the NPLCC geography.

Similar to the review process used to produce this final draft report, information gathered during focus group meetings will be incorporated into this report and reviewed by focus group participants as well as others. Focus groups will address climate change at both the local- and landscape-level, incorporating expert knowledge on the major effects resulting from climate change in marine and coastal ecosystems, the implications for biological communities across taxa and trophic levels, and adaptive approaches to address impacts into this report to produce the first picture of landscape-wide climate change effects in these ecosystems. Further, focus groups will confirm and revise the adaptation options described in the draft reports to produce a menu of policy and management options that respond to climate change in these ecosystems, and are therefore useful and relevant to management needs across the NPLCC landscape. The final product will be the first compilation of landscape-wide climate change impacts and adaptation approaches for the NPLCC region's marine and coastal ecosystems.

X. APPENDICES

Appendix 1. Key Terms and Definitions

A

Absolute sea level: a measurement of sea level incorporating steric and eustatic effects

Adaptive capacity: the ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

Aerosol: highly dispersed solid or liquid particles suspended in a gas

Anoxia: a water column devoid of oxygen

Aragonite: a calcium carbonate (limestone) mineral, used by shell- or skeleton-forming, calcifying organisms such as corals (warm- and coldwater corals), some macroalgae, pteropods (marine snails) and non-pteropod molluscs such as bivalves (e.g., clams, oysters), cephalopods (e.g., squids, octopuses).Aragonite is more sensitive to ocean acidification than calcite, also used by many marine organisms.[1754]

Avulse: when a river changes its course from one channel to another as a result of a flood.[1755]

B

Benthic community: the community of organisms living on or near the bottom of a water body such as a river, a lake, or an ocean.[1756]

C

Calcite: a calcium carbonate (limestone) mineral, used by shell- or skeleton-forming, calcifying organisms such as foraminifera, some macroalgae, lobsters, crabs, sea urchins and starfish. Calcite is less sensitive to ocean acidification than aragonite, also used by many marine organisms.[1757]

California Current System: a ~621-mile-wide (1000 km), sluggish current spanning the North American Pacific Coast from ~20°N (near Guadalajara Mexico) to 50°N (northern Vancouver Island);[1758] the dominant current in the NPLCC region south of 50°N; the large marine ecosystem in the NPLCC region south of 50°N

Climate: Climate in a narrow sense is usually defined as the 'average weather', or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to

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[1754] Parry et al. (Eds.) *Climate Change 2007: Impacts, Adaptation, Vulnerability: Appendix I: Glossary*. (2007, p. 871)
[1755] Nicholls et al. (2007, p. 326)

[1756] Parry et al. (Eds.) (2007, p. 870)
[1757] Parry et al. (Eds.) (2007, p. 871)
[1758] Hickey and Banas. (2008, p. 93)

thousands or millions of years. Climate in a wider sense is the state, including a statistical description, of the climate system. The classical period of time is 30 years, as defined by the World Meteorological Organization (WMO).[1759]

Climate change: Climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs from that in the United Nations Framework Convention on Climate Change (UNFCCC), which defines 'climate change' as: 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods'.[1760]

Climate change adaptation: a dynamic management strategy that involves identifying, preparing for, and responding to expected climate change in order to promote ecological resilience, maintain ecological function, and provide the necessary elements to support biodiversity and sustainable ecosystem services.[1761]

Climate shift: a rapid change in relatively stable physical ocean properties that affects biota and ecosystems

Climate threshold: The point at which external forcing of the climate system, such as the increasing atmospheric concentration of greenhouse gases, triggers a significant climatic or environmental event which is considered unalterable, or recoverable only on very long time-scales, such as widespread bleaching of corals or a collapse of oceanic circulation systems.[1762] *See also Threshold.*

Climate variability: Climate variability refers to variations in the mean state and other statistics (such as standard deviations, statistics of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability).[1763]

Coastal squeeze: the squeeze of coastal ecosystems (e.g., salt marshes, mangroves and mud and sand flats) between rising sea levels and naturally or artificially fixed shorelines, including hard engineering defenses[1764]

D

[1759] Parry et al. (Eds.) (2007, p. 871)
[1760] Parry et al. (Eds.) (2007, p. 871)
[1761] Glick et al. (2009, p. 8).
[1762] Parry et al. (Eds.) (2007, p. 872)
[1763] Parry et al. (Eds.) (2007, p. 872)
[1764] Parry et al. (Eds.) (2007, p. 872)

Delta: landforms naturally shaped by a combination of river, wave and tide processes;[1765] River-dominated deltas receiving river sediment input show prominent levees and channels that meander or avulse, leaving abandoned channels on the coastal plains. Wave-dominated deltas are characterized by shore-parallel sand ridges, often coalescing into beach-ridge plains. Tide domination is indicated by exponentially tapering channels, with funnel-shaped mouths. Delta plains contain a diverse range of landforms but, at any time, only part of a delta is active, and this is usually river-dominated, whereas the abandoned delta plain receives little river flow and is progressively dominated by marine processes.[1766]

E

Ecosystem: The interactive system formed from all living organisms and their abiotic (physical and chemical) environment within a given area. Ecosystems cover a hierarchy of spatial scales and can comprise the entire globe, biomes at the continental scale or small, well-circumscribed systems such as a small pond.[1767]

El Niño: the warm phase of ENSO; characterized by stronger than average sea surface temperatures in the central and eastern equatorial Pacific Ocean, reduced strength of the easterly trade winds in the Tropical Pacific, and an eastward shift in the region of intense tropical rainfall

El Niño-Southern Oscillation: the major source of inter-annual climate variability in the Pacific Northwest (PNW), abbreviated ENSO. ENSO variations are more commonly known as **El Niño** (the warm phase of ENSO) or **La Niña** (the cool phase of ENSO)

Estuary: partially enclosed body of water formed where freshwater from rivers and streams flows into the ocean, mixing with the salty sea water; Primary estuarine problems include habitat alterations, degradation, and loss; diverted freshwater flows; marine sediment contamination; and exotic species introductions.[1768] West Coast estuaries (defined as the coasts of BC, WA, OR, and CA) are geologically young and composed of a variety of geomorphological types.[1769]

Eustatic sea level rise: changes in global ocean volume due to melting of ice caps, continental ice sheets and mountain glaciers, and thermal expansion due to rising water temperatures

Expendable bathythermograph (XBT): a probe which is dropped from a ship and measures the temperature as it falls through the water. Two very small wires transmit the

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[1765] Nicholls et al. (2007, p. 326).
[1766] Nicholls et al. (2007, p. 326).
[1767] Parry et al. (Eds.) (2007, p. 874)
[1768] PSNP (2003); PSNERP (2010); LCREP (2010); Snover et al. (2005, p. 28)
[1769] Emmett et al. (2000, p. 765)

temperature data to the ship where it is recorded for later analysis. The probe is designed to fall at a known rate, so that the depth of the probe can be inferred from the time since it was launched. By plotting temperature as a function of depth, scientists can get a picture of the temperature profile of the water up to 4921 feet (1500 m) depth.[1770]

Exposure (to climate change): the nature and degree to which a system is exposed to significant climatic variations

Extinction (of species): the state of a species that no longer exists anywhere on Earth (includes wild and captive species)

Extirpation (of species): native species that no longer exist in the wild in any part of their original distribution area, although they may exist elsewhere

F

Flux: the amount of a substance flowing through an area over a certain period of time

G

Gyre: a spiral oceanic surface current moving in a clockwise direction

H

Habitat: the locality or natural home in which a particular plant, animal, or group of closely associated organisms lives.[1771]

Hydrologic cycle: the existence and movement of water on, in, and above the Earth; composed of sixteen components: water storage in oceans, evaporation, sublimination, evapotranspiration, water in the atmosphere, condensation, precipitation, water storage in ice and snow, snowmelt runoff to streams, surface runoff, streamflow, freshwater storage, infiltration, groundwater storage, groundwater discharge, springs; the processes and pathways involved in the circulation of water from land and water bodies to the atmosphere and back again (Brooks, et al. 2003, 21)

Hydrology: the science encompassing the behavior of water as it occurs in the atmosphere, on the surface of the ground, and underground

Hypoxia: a water column largely deficient of dissolved oxygen; generally, a water column with less than 2.0 milligrams of oxygen per liter of water dissolved within it

I

[1770] NOAA. *Upper Ocean Thermal Center: The Expendable Bathythermograph (XBT) (website).* (2011)

[1771] Parry et al. (Eds.) (2007, p. 876)

(climate change) Impacts: the effects of climate change on natural and human systems.[1772]

J

Joule: a measure of energy, work, or quantity of heat

K

L

La Niña: the cool phase of ENSO; characterized by the opposite – cooler than average sea surface temperatures, stronger than normal easterly trade winds, and a westward shift in the region of intense tropical rainfall.

M

N

Nearshore: the estuarine/delta, marine shoreline and areas of shallow water from the top of the coastal bank or bluffs to the water at a depth of about 10 meters relative to Mean Lower Low Water. This is the average depth limit of light penetration. This zone incorporates geological and ecological processes, such as sediment movement, freshwater inputs, and subtidal light penetration, which are key to determining the distribution and condition of aquatic habitats. The nearshore extends landward into the tidally influenced freshwater heads of estuaries and coastal streams and includes deltas, beaches, mudflats, kelp and eelgrass beds, salt marshes, and gravel spits.[1773]

O

Ocean acidification: process in which carbon dioxide is absorbed by seawater, and chemical reactions occur that reduce seawater pH, carbonate ion concentration, and saturation states of the biologically important calcium carbonate minerals (calcite and aragonite); the term used to describe the process responsible for the observed decline in average ocean pH since the Industrial Revolution (ca. 1800).

Oxygen minimum zone (OMZ): the depth of seawater at which oxygen saturation is at its lowest

P

Pacific Decadal Oscillation (PDO): long-lived El Niño-like pattern of Pacific climate variability

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[1772] Parry et al. (Eds.) (2007, p. 876)

[1773] PSNP (2003); PSNERP (2010)

Pacific Northwest: a region in the northwestern continental United States, largely comprised of the states of Oregon, Washington, Idaho, western Montana, and southern British Columbia

pH: activity of hydrogen ions (which is closely related to concentration), expressed as $\log_{10}$ (moles H^+ $liter^{-1}$)[1774]; a measure of the acidity or alkalinity (i.e. basicity) of a substance, ranging on a scale of 0 to 14, where 7 is "neutral" (neither acidic nor basic). The scale is logarithmic (i.e. a substance with pH 5 is ten times more acidic than a substance with pH 6).

Phenology: the study of natural phenomena that recur periodically (e.g. development stages, migration) and their relation to climate and seasonal changes.[1775]

Phytoplankton: the plant forms of plankton; the dominant plants in the sea, and the basis of the entire marine food web. These single-celled organisms are the principal agents of photosynthetic carbon fixation in the ocean.[1776]

Plankton: microscopic aquatic organisms that drift or swim weakly.[1777] The plant form is phytoplankton and the animal form is zooplankton.

Precipitation: the general term for rainfall, snowfall and other forms of frozen or liquid water falling from clouds

Puget Sound: a large estuary complex in the Pacific Northwest

Q

R

Radiative forcing: measure of the influence a factor has in altering the balance of incoming and outgoing energy in the Earth-atmosphere system; an index of the importance of the factor as a potential climate change mechanism

Realignment adaptation: a type of adaptation typically used in already significantly disturbed systems in which the system (e.g., an organism, population, community, or ecosystem) is changed to be healthy under expected future conditions rather than returned to historical conditions

Recruitment: the number of fish entering each size or age class[1778]

Relative sea level: a local increase in the level of the ocean relative to the land, which might be due to ocean rise and/or land level subsidence. In areas subject to rapid land-level uplift,

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[1774] Dodds & Whiles. (2010)
[1775] Parry et al. (Eds.) (2007, p. 879)
[1776] Parry et al. (Eds.) (2007, p. 879)
[1777] Parry et al. (Eds.) (2007, p. 879)
[1778] Dodds & Whiles. (2010)

relative sea level can fall;[1779] a measurement of sea level that includes local and regional ocean (e.g. altered wave heights due to upwelling or storms), land (e.g. uplift and subsidence), hydrologic (e.g. coastal runoff) and atmospheric (e.g. winds) dynamics in addition to eustatic and steric effects

Relocation: a type of adaptation in which a system (e.g., an organism, population, community, or ecosystem) is moved to a new location, either by natural processes or through human assistance (latter also known as assisted migration)

Resilience: the amount of change or disturbance that can be absorbed by a system (e.g., an organism, population, community, or ecosystem) before the system is redefined by a different set of processes and structures; the ability of a system to recover from change or disturbance without a major phase shift

Resistance: the ability of a system (e.g. an organism, population, community, or ecosystem) to withstand a change or disturbance without significant loss of structure or function

Response adaptation: a type of adaptation that facilitates the transition of ecosystems from current, natural states to new conditions brought about by a changing climate

S

Saltmarsh: highly productive habitats found near river mouths where fresh and saltwater mix. Salt marshes support a mix of plant and animal species, including sedges, rushes, shrimp, crabs, salmon, terns and herons. The plants filter suspended sediments and nutrients, regulate dissolved oxygen in the water column, stabilize bottom sediments, and reduce flooding by retaining stormwater during high-flow periods. Salt marsh growth and distribution are affected by sea level, salinity, temperature, freshwater inputs, tidal flooding, and the physical characteristics of the landscape.[1780]

Saltwater intrusion / encroachment: displacement of fresh surface water or groundwater by the advance of salt water due to its greater density; usually occurs in coastal and estuarine areas due to reducing land-based influence (e.g. from reduced runoff & associated groundwater recharge; from excessive water withdrawals from aquifers) or increasing marine influence (e.g., relative SLR).[1781]

Saturation horizon: a natural depth boundary in seawater above which calcium carbonate forms, and below which it does not

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[1779] Parry et al. (Eds.) (2007, p. 881)

[1780] PSNP (2003); PSNERP (2010); LCREP (2010); Emmett et al. (2000, p. 765); Snover et al. (2005, p. 28)

[1781] Parry et al. (Eds.) (2007, p. 880)

Saturation state of seawater: a measure of the thermodynamic potential for a mineral to form or dissolve

Sea level rise: an increase in the mean level of the ocean. *See also eustatic sea level rise, steric sea level rise, absolute sea level, and relative sea level*

Sensitivity (to climate change): the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli.

Species diversity: generally measured as the number of species in an area and their evenness (relative abundance) [1782]

Species richness: the number of species in an area[1783]

Steric sea level rise: global and regional changes in ocean volume due to thermal expansion and salinity effects on water density (warmer, fresher water occupies more volume than colder, saltier water)

Stratification: density differences in water that can maintain stable layers[1784]

T

Thermal expansion: in connection with sea level rise, this refers to the increase in volume (and decrease in density) that results from warming water. A warming of the ocean leads to an expansion of the ocean volume and hence an increase in sea level.[1785]

U

Upwelling: process occurring when alongshore winds blow toward the equator along the western margin of continents, pushing surface waters offshore and replacing them with deeper, (100-200m), colder, saltier, nutrient and carbon dioxide-rich but oxygen-poor ocean waters moving up the continental shelf toward shore

V

Threshold: The level of magnitude of a system process at which sudden or rapid change occurs. A point or level at which new properties emerge in an ecological, economic or other system, invalidating predictions based on mathematical relationships that apply at lower levels.[1786] *See also climate threshold.*

Vulnerability (to climate change): the extent to which a species, habitat, or ecosystem is susceptible to harm from climate change impacts. It is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.

[1782] Dodds & Whiles. (2010)
[1783] Dodds & Whiles. (2010)
[1784] Dodds & Whiles. (2010)
[1785] Parry et al. (Eds.) (2007, p. 882)
[1786] Parry et al. (Eds.) (2007, p. 882)

Vulnerability Assessment: structured approaches to identify species and ecological systems likely to be most sensitive to climatic changes and assist managers in setting priorities for natural resource adaptation efforts and funding.

WXYZ

Water column: a conceptual column of water from surface to bottom sediments

Water cycle *See hydrologic cycle*

Watt: a measure of power (the rate at which work is performed or energy is converted) or radiant flux (the rate of flow of electromagnetic waves); one Watt (W) is equivalent to one Joule per second (J/s)

Wetland: lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water.[1787]; areas inundated or saturated by surface or groundwater at a frequency and duration sufficient to support a prevalence of vegetation adapted for life in saturated soil conditions[1788]

[1787] U.S. FWS. *660 FW 2, Wetlands Classification System (website).* (1993)
[1788] Dodds & Whiles. (2010)

Appendix 2. SRES Scenarios and Climate Modeling

The explanation of SRES scenarios is excerpted from the IPCC's AR4 Synthesis Report (p. 44). Figure 28 was accessed online at http://sedac.ciesin.columbia.edu/ddc/sres/, December 2, 2010.

SRES scenarios

SRES refers to the scenarios described in the IPCC Special Report on Emissions Scenarios (SRES, 2000). The SRES scenarios are grouped into four scenario families (A1, A2, B1 and B2) that explore alternative development pathways, covering a wide range of demographic, economic and technological driving forces and resulting GHG emissions. The SRES scenarios do not include additional climate policies above current ones. The emissions projections are widely used in the assessments of future climate change, and their underlying assumptions with respect to socio-economic, demographic and technological change serve as inputs to many recent climate change vulnerability and impact assessments. {WGI 10.1; WGII 2.4; WGIII TS.1, SPM}

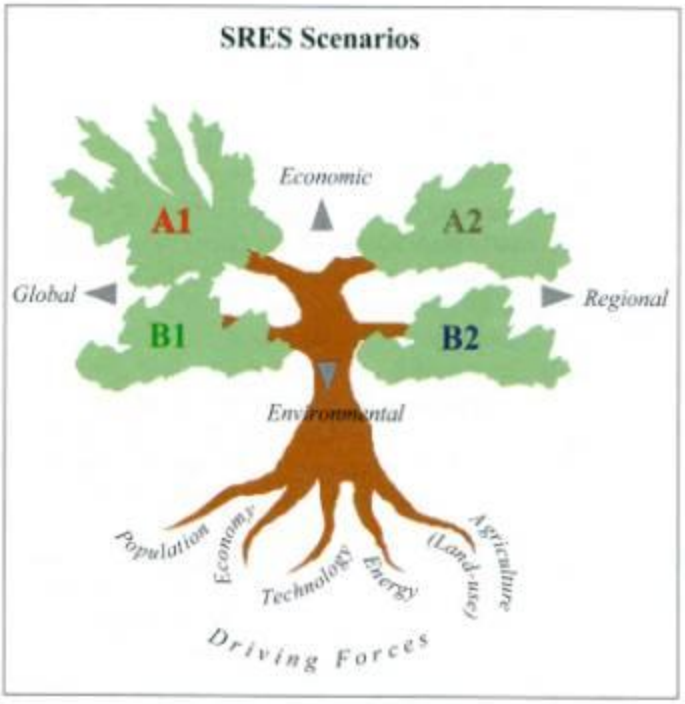

Figure 28. SRES Scenarios.

The A1 storyline assumes a world of very rapid economic growth, a global population that peaks in mid-century and rapid introduction of new and more efficient technologies. A1 is divided into three groups that describe alternative directions of technological change: fossil intensive (A1FI), non-fossil energy resources (A1T) and a balance across all sources (A1B). B1 describes a convergent world, with the same global population as A1, but with more rapid changes in economic structures toward a service and information economy. B2 describes a world with intermediate population and economic growth, emphasising local solutions to economic, social, and environmental sustainability. A2 describes a very heterogeneous world with high population growth, slow economic development and slow technological change. No likelihood has been attached to any of the SRES scenarios. {WGIII TS.1, SPM}

Climate modeling

Global Models

Envisioning global climate in a future with much higher greenhouse gases requires the use of physically based numerical models of the ocean, atmosphere, land, and ice, often called global climate models

(GCMs) or climate system models.[1789] A common set of simulations using 21 GCMs was coordinated through the Intergovernmental Panel on Climate Change (IPCC).[1790] These models typically resolve the atmosphere with between 6,000 and 15,000 grid squares horizontally, and with between 12 and 56 atmospheric layers.[1791]

Simulations of 21st century climate require projections of future greenhouse gases and sulfate aerosols (which reflect sunlight and also promote cloud formation, thereby offsetting greenhouse gases locally), of which more than 40 were produced and six "marker" scenarios selected (B1, B2, A1, A1B, A1F1, A2) under the auspices of the IPCC.[1792] Three of these scenarios were commonly chosen for forcing the GCMs: B1, A1B, and A2.[1793] A2 produces the highest climate forcing by the end of the century, but before mid-century, none of the scenarios is consistently the highest.[1794] Though B1 is the lowest of the IPCC illustrative scenarios, it still produces changes in climate that many scientists call "dangerous" — a threshold that a growing number of political leaders have stated their intention to avoid.[1795] At the high end, scenario A1FI results in even higher climate forcing by 2100 than A2 or A1B.[1796] Mid-2000s global emissions of CO_2 exceeded even the A1FI scenario.[1797]

Downscaled Climate Models

Note: While the information described here pertains to Washington State, it is often applicable for sub-global (e.g., regional, local) modeling elsewhere.

Global climate models do not account for the atmospheric processes that determine the unique spatially heterogeneous climatic features of Washington.[1798] Statistical downscaling is based on fine-scale data derived using assumptions about how temperature and precipitation vary over complex terrain in order to interpolate the sparse station network (about 50-km spacing) to a 0.0625° grid.[1799] Information simulated by the coarse-resolution global models (with output on a 100-to-300 km grid) is then used to project the future climate.[1800] This approach represents the mean climate and local regimes quite well but does not take into account how the terrain influences individual weather systems.[1801]

Salathé, Jr. et al.'s (2010) results show that, with increased spatial resolution relative to global models, regional climate models can represent the local forcing from the complex terrain to produce more realistic spatial and temporal variability of temperature, precipitation, and snowpack in the State of

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[1789] *Mote and Salathé, Jr. (2010, p. 29)
[1790] *Mote and Salathé, Jr. (2010, p. 29-30)
[1791] *Mote and Salathé, Jr. (2010, p. 30)
[1792] *Mote and Salathé, Jr. (2010, p. 30)
[1793] *Mote and Salathé, Jr. (2010, p. 30)
[1794] *Mote and Salathé, Jr. (2010, p. 30)
[1795] *Mote and Salathé, Jr. (2010, p. 31). The authors cite Schellnhuber et al. (2006) for information on changes in climate that many scientists call dangerous.
[1796] *Mote and Salathé, Jr. (2010, p. 31).
[1797] *Mote and Salathé, Jr. (2010, p. 31). The authors cite Raupach et al. (2007) for information on mid-2000s emissions and state "…we must emphasize that the scenarios used here may not span the range of possibilities" (p. 31).
[1798] *Salathé, Jr. et al. *Regional climate model projections for the State of Washington*. (2010, p. 52)
[1799] *Salathé, Jr. et al. (2010, p. 52)
[1800] *Salathé, Jr. et al. (2010, p. 52)
[1801] *Salathé, Jr. et al. (2010, p. 52)

Washington.[1802] With the ability to resolve topographic effects, more robust changes in mountain snowpack and extreme precipitation emerge.[1803] These changes are consistent between the two regional simulations despite differences in seasonal precipitation and temperature changes in the global and regional model results.[1804] It is clear that changes in the seasonal climate and the frequency of extreme events may be locally much more intense than can be inferred from statistical methods.[1805] The implication is that, while a valuable tool for regional climate impacts assessment, multi-model ensembles of global climate projections and statistical methods may under represent the local severity of climate change.[1806]

[1802] *Salathé, Jr. et al. “Regional climate model projections for the State of Washington.” In: *Washington Climate Change Impact Assessment.* (2009, p. 65)
[1803] *Salathé, Jr. et al. (2009, p. 65)
[1804] *Salathé, Jr. et al. (2009, p. 65)
[1805] *Salathé, Jr. et al. (2009, p. 65)
[1806] *Salathé, Jr. et al. (2009, p. 65)

Appendix 3. Major Climate Patterns in the NPLCC: ENSO and PDO

This explanation is excerpted from a webpage written by Nathan J. Mantua (Ph.D.) of the University of Washington's Joint Institute for the Study of the Atmosphere and Oceans and Climate Impacts Group. The webpage is not copied in its entirety; sections that explain climate variability and its impacts on climate in the NPLCC region are emphasized. The full-text can be accessed at http://www.atmos.washington.edu/~mantua/REPORTS/PDO/PDO_cs.htm (accessed December 9, 2010).

Introduction

In addition to El Niño, there are other heavily researched climate patterns that exert important influences on regional climates around the world. For instance, many studies highlight the relative importance of the Pacific Decadal Oscillation and Arctic Oscillation/North Atlantic Oscillation in North American climate. Each of these major patterns--El Niño/Southern Oscillation, Pacific Decadal Oscillation, and Arctic Oscillation/North Atlantic Oscillation--has characteristic signatures in seasonally changing patterns of wind, air temperature, and precipitation; each pattern also has a typical life time for any given "event".

A PDO definition

The Pacific Decadal Oscillation, or PDO, is often described as a long-lived El Niño-like pattern of Pacific climate variability (Zhang et al. 1997). As seen with the better-known El Niño/Southern Oscillation (ENSO), extremes in the PDO pattern are marked by widespread variations in Pacific Basin and North American climate. In parallel with the ENSO phenomenon, the extreme phases of the PDO have been classified as being either *warm* or *cool*, as defined by ocean temperature anomalies in the northeast and tropical Pacific Ocean.

Two main characteristics distinguish the PDO from ENSO. First, typical PDO "events" have shown remarkable persistence relative to that attributed to ENSO events - in this century, major PDO eras have persisted for 20 to 30 years (Mantua et al. 1997, Minobe 1997). Second, the climatic fingerprints of the PDO are most visible in the North Pacific/North American sector, while secondary signatures exist in the tropics - the opposite is true for ENSO. Several independent studies find evidence for just two full PDO cycles in the past century (e.g. Mantua et al. 1997, Minobe 1997): cool PDO regimes prevailed from 1890-1924 and again from 1947-1976, while warm PDO regimes dominated from 1925-1946 and from 1977 through (at least) the mid-1990's. Recent changes in Pacific climate suggest a possible reversal to cool PDO conditions in 1998, an issue that is discussed in more detail at the end of this article.

The North American climate anomalies associated with PDO warm and cool extremes are broadly similar to those connected with El Niño and La Niña (Latif and Barnett 1995, Latif and Barnett 1996, Zhang et al. 1997, Mantua et al. 1997). Warm phases of the PDO are correlated with North American temperature and precipitation anomalies similar to those correlated with El Niño (Figure 4): above average winter and spring time temperatures in northwestern North America, below average temperatures in the southeastern US, above average winter and spring rainfall in the southern US and northern Mexico, and below average precipitation in the interior Pacific Northwest and Great Lakes regions. Cool phases of the PDO are simply correlated with the reverse climate anomaly patterns over North America (not shown), broadly similar to typical La Niña climate patterns. The PDO-related temperature and precipitation patterns are also strongly expressed in regional snow pack and stream flow anomalies, especially in western North America (see Cayan 1995, Mantua et al. 1997, Bitz and Battisti 1999, Nigam et al. 1999). A summary of major PDO climate anomalies are listed in Table 1.

Table 1: Summary of North American climate anomalies associated with extreme phases of the PDO.

Climate Anomalies	**Warm Phase PDO**	**Cool Phase PDO**
Ocean surface temperatures in the northeastern and tropical Pacific	Above average	Below average
October-March northwestern North American air temperatures	Above average	Below average
October-March Southeastern US air temperatures	Below average	Above average
October-March southern US/Northern Mexico precipitation	Above average	Below average
October-March Northwestern North America and Great Lakes precipitation	Below average	Above average
Northwestern North American spring time snow pack	Below average	Above average
Winter and spring time flood risk in the Pacific Northwest	Below average	Above average

An ENSO definition

This definition is excerpted from the Climate Impacts Group website El Niño/Southern Oscillation, available at http://cses.washington.edu/cig/pnwc/aboutenso.shtml (accessed 1.18.2011)

The El Niño/Southern Oscillation (ENSO) is the major source of inter-annual climate variability in the Pacific Northwest (PNW). ENSO variations are more commonly known as **El Niño** (the warm phase of ENSO) or **La Niña** (the cool phase of ENSO).

An El Niño is characterized by stronger than average sea surface temperatures in the central and eastern equatorial Pacific Ocean, reduced strength of the easterly trade winds in the Tropical Pacific, and an eastward shift in the region of intense tropical rainfall. A La Niña is characterized by the opposite – cooler than average sea surface temperatures, stronger than normal easterly trade winds, and a westward shift in the region of intense tropical rainfall. Average years, i.e., years where there is no statistically significant deviation from average conditions at the equator, are called ENSO-neutral. Each ENSO phase typically lasts 6 to 18 months.

Although ENSO is centered in the tropics, the changes associated with El Niño and La Niña events affect climate around the world. ENSO events tend to form between April and June and typically reach full strength in December (hence the name El Niño, which is Spanish for “Little Boy” or “Christ Child”; La

Niña means "Little Girl"). The ENSO influence on PNW climate is strongest from October to March; by summer, Northern Hemisphere wind patterns are such that they effectively trap ENSO-related disturbances in the tropics.

The CIG has demonstrated numerous linkages between changes in ENSO and variations in PNW climate and natural resources. El Niño winters, for example, tend to be warmer and drier than average with below normal snowpack and streamflow. La Niña winters tend to be cooler and wetter than average with above normal snowpack and streamflow. These linkages and the availability of ENSO forecasts a few months to one year in advance of the event's maturation provide resource managers opportunity to consider how a particular ENSO forecast may affect resource management choices.

Interactions between ENSO and PDO

This definition is excerpted from the Climate Impacts Group website Impacts of Natural Climate Variability on Pacific Northwest Climate, available at http://cses.washington.edu/cig/pnwc/clvariability.shtml (accessed 1.18.2011).

The potential for temperature and precipitation extremes increases when ENSO and PDO are in the same phases and thereby reinforce each other. This additive effect is also seen in the region's streamflow and snowpack. There is no evidence at this time to suggest that either PDO or ENSO dominates with respect to temperature and precipitation when the two climate patterns are in opposite phases (i.e., an El Niño during a cool phase PDO or a La Niña during a warm phase PDO). The opposite effects on temperature and precipitation can cancel each other out, but not in all cases and not always in the same direction. Similar effects are seen on regional streamflow.

Implications for climate predictions

This explanation is excerpted from a webpage written by Nathan J. Mantua (Ph.D.) of the University of Washington's Joint Institute for the Study of the Atmosphere and Oceans and CIG. The full-text can be accessed at http://www.atmos.washington.edu/~mantua/REPORTS/PDO/PDO_cs.htm (accessed 1.18.2011).

Recent studies suggest that ENSO teleconnections with North American climate are strongly dependent on the phase of the PDO, such that the "canonical" El Niño and La Niña patterns are only valid during years in which ENSO and PDO extremes are "in phase" (i.e. with warm PDO+El Niño, and cool PDO+La Niña, but not with other combinations) (Gershunov and Barnett 1999, Gershunov et al. 1999, McCabe and Dettinger 1999). Other studies have identified PDO connections with summer rainfall and drought in the US (Nigam et al. 1999), and the relative risks for winter and spring flood events in the Pacific Northwest (Hamlet and Lettenmeier, in press).

Appendix 4. Sea level Affecting Marshes Model (SLAMM): Limitations, Improvements, & Alternatives

Reviewers commented the report would benefit from a discussion of the SLAMM model, including limitations and alternatives. SLAMM simulates dominant processes involved in wetland conversions and shoreline modifications during long-term sea level rise (SLR). Within later versions of SLAMM (5.0, 6.0, 6.0.1 Beta), five primary processes can affect wetland fate under different scenarios of SLR: inundation, erosion, overwash, saturation, and salinity.

Development of the Model: SLAMM was first developed in the mid-1980s and is now managed by Warren Pinnacle Consulting, Inc. The most recent version was released January 2010 (version 6.0.1 Beta).

Model Limitations: Like all models, SLAMM makes certain simplifying assumptions and excludes certain processes and factors. Jonathan Clough of Warren Pinnacle Consulting, Inc. lists six primary limitations:

- No mass balance of solids (i.e., accretion rates are not affected by freshwater flow rates or nutrients; no consolidation of inundated tidal flats, beaches).
- It is not a detailed bathymetrical model (i.e., the tidal effects of estuary geometry are not predicted and must be entered as a model input; geometry effects on salinity are quite simple).
- There is no model of sea grasses or marine flora.
- The overwash model is subject to additional uncertainty (frequency of storms and magnitude of effects is uncertain; may be turned off or parameters refined).
- No concept of “marsh health” (e.g., transitional marsh produced when dry lands regularly inundated)
- Accretion rates are based on empirical relationships (not a mechanistic model; does not account for peat collapse)

Regarding SLAMM5 limitations, Kirwan and Guntenspergen (2009) cite a lack of feedback among variables that may be altered by changes in sea level and the use of declining accretion rates in the model. The latter may exacerbate projections of coastal vegetated habitat loss (e.g., convert to open water), particularly where habitat conversion may be more likely. Mcleod et al. (2004) note changes in wave regime from erosion or sub-surface vegetative properties are not modeled. Further, SLAMM lacks a socioeconomic component for estimating the costs of SLR, which may limit its usefulness in informing adaptation policies.

Recent Model Improvements: Based on feedback from scientists working in the field and the experience of modelers, SLAMM 6 was upgraded from previous versions. Key updates include:

- An accretion feedback component, wherein feedbacks based on wetland elevation, distance to channel, and salinity may be specified.
- A salinity model with the ability to specify multiple time-variable freshwater flows and habitat switching as a function of salinity. Estimates of salinity at Mean Lower-Low Water, Mean Higher-High Water, and Mean Tide Level are mapped.

- Using an integrated elevation analysis, SLAMM will summarize site-specific categorized elevation ranges for wetlands. Ranges will be derived from Light-imaging Detection and Ranging (LiDAR) data or other high-resolution data sets.
- Flexible elevation ranges for land categories, useful for situations in which site-specific data indicate that wetlands range beyond SLAMM defaults.
- An improved user interface and improved memory management, including backwards compatibility with SLAMM5 and new maps of elevations, salinity, and variable accretion rates.

Alternatives to SLAMM: The USGS's *Coastal Vulnerability Index* is a relative ranking of the likelihood that physical change will occur along the shoreline as sea level changes. *The Kirwan marsh model* couples sediment transport processes with vegetation biomass productivity. The more straight-forward *"bathtub" models* assess which coastal areas are likely to be inundated under various SLR scenarios based on coastal elevation. *Ecological landscape spatial simulation models* (e.g., BTELSS) incorporate environmental and biotic feedbacks to calculate the rate of marsh elevation change as a function of depth and sediment supply. They are often used to examine marsh platform evolution over hundreds of years. Finally, several multidisciplinary support tools have been developed that can provide information on potential physical, ecological, and socioeconomic impacts, e.g. *the Dynamic Interactive Vulnerability Assessment Tool*, which also assesses the costs and benefits of adaptation, and *SimCLIM*, which allows users to examine sectoral impacts, conduct sensitivity analyses, test adaptation measures under present and future conditions, and in some custom applications, to estimate monetary costs and benefits of adaptation.

Sources: Clough, Park, & Fuller. *SLAMM 6 beta Technical Documentation (draft; pdf).* (2010, p. 5); Glick, Clough and Nunley (2010); Glick, Clough and Nunley (2007); Kirwan and Guntenspergen. *Accelerated sea level rise - A response to Craft et al*. (2009); Mcleod et al. *Sea level rise impact models and environmental conservation: A review of models and their applications*. (2010); Warren Pinnacle Consulting, Inc. *SLAMM Overview (presentation).* (2010a); Warren Pinnacle Consulting, Inc. *SLAMM: Sea level Affecting Marshes Model: SLAMM Version and Development History (website).* (2010b).

Appendix 5. Resources for Adaptation Principles and Responses to Climate Change

1. **Recommendations for a National Wetlands and Climate Change Initiative.** Association of Wetland Managers, Inc. January 20, 2009. Available online at http://www.aswm.org/calendar/wetlands2008/recommendations_2008_112008.pdf (accessed January 14, 2011).

   Summary: The report discusses the role U.S. agencies, Congress, states and local governments could play in implementing a national wetlands and climate change initiative (pp. 4-6). It also includes chapters on specific measures needed to better protect and adapt coastal and estuarine lands (pp. 7-10) and freshwater wetlands (pp.10-12). It concludes with a chapter on priority management-oriented and basic research needs (pp. 13-15)

2. **A New Era for Conservation: Review of Climate Change Adaptation Literature.** Glick, Patty; Staudt, Amanda; Stein, Bruce. March 12, 2009. Report produced by the National Wildlife Federation. Available online at http://www.nwf.org/News-and-Magazines/Media-Center/Faces-of-NWF/~/media/PDFs/Global%20Warming/Reports/NWFClimateChangeAdaptationLiteratureReview.ashx (accessed January 25, 2011).

   Summary: The report reviews the common barriers to climate change adaptation (including solutions; pp. 9-13), describes five overarching principles of climate change adaptation (pp. 12-17) and provides a six-stage framework to use as a guideline for developing adaptation strategies (pp. 18-23). It also includes sector-specific adaptation strategies for forests (pp. 23-29), grasslands and shrublands (pp. 30-35), rivers, streams, and floodplains (pp. 36-43), and coasts and estuaries (pp. 44-52).

3. **Biodiversity management in the face of climate change: A review of 22 years of recommendations.** Heller, Nicole E. and Zavaleta, Erika S. 2009. *Biological Conservation.* 142: 14-32. Available online at http://people.umass.edu/gce/Heller%20and%20Zavaleta,%202009.pdf (accessed January 13, 2011).

   Summary: See Table 1 (pp. 18-22) for a list of recommendations for climate change adaptation strategies for biodiversity management.

4. **Climate change adaptation strategies for resource management and conservation planning.** Lawler, Joshua J. 2009. *Annals of the New York Academy of Sciences (The Year in Ecology and Conservation Biology).* 1162: 79-98. Available online at http://training.fws.gov/branchsites/lkm/climate_change/june_09/cc-adaptreview.pdf (accessed January 13, 2011).

   Summary: Lawler provides an overview of general strategies for addressing climate change including removing other threats and reducing additional stressors, expanding reserve networks, increasing connectivity, restoring habitat and system dynamics, adaptive management, and translocation. Specific recommendations for addressing climate change in freshwater, marine, and terrestrial systems are also provided.

5. **A review of climate-change adaptation strategies for wildlife management and biodiversity conservation.** Mawdsley, Jonathan R.; O'Malley, Robin; and Ojima, Dennis S. 2009. Available online at http://www.uwpcc.washington.edu/documents/PCC/mawdsley-etal-2009.pdf (accessed January 13, 2011). *Conservation Biology.* 23(5): 1080-1089.

    Summary: Mawdsley and colleagues describe sixteen adaptation strategies, organized by strategies related to land and water protection and management (seven strategies), direct species management (four strategies), monitoring and planning (four strategies), and reviewing and modifying existing laws, regulations, and policies regarding wildlife and natural resource management (one strategy).

6. **Preparing for climate change: a guidebook for local, regional, and state governments.** Snover, Amy K.; Whitely Binder, Lara; Lopez, Jim; and Colleagues. 2007. In association with and published by ICLEI – Local Governments for Sustainability, Oakland, CA. Available online at http://cses.washington.edu/cig/fpt/guidebook.shtml (accessed January 13, 2011).

    Summary: The guidebook provides a suggested checklist for governments on how to prepare for climate change. It includes five milestones: initiate your climate resiliency effort, conduct a climate resiliency study, set preparedness goals and develop your preparedness plan, implement your preparedness plan, and measure your progress and update your plan.

7. **Climate Savvy: Adapting conservation and resource management to a changing world.** Hansen, Lara J. and Hoffman, Jennifer R. 2011. Island Press: Washington, DC. Available online for preview and purchase at http://islandpress.org/bookstore/detailsee40.html (accessed July 13, 2011).

    Summary: Hansen and Hoffman assess the vulnerabilities of existing conservation and resource management tools to climate change, then describe how these tools can be adapted to address climate change impacts. The book begins with a general overview of climate change and its effects, and key facets of building a plan to address climate change impacts. The tools include protected areas, species-based protection, connectivity, regulating harvests, reduction of pollutants, control of invasive species, pests, and disease, restoration, and a broader rethinking of governance, policy, and regulation.

8. **U.S. natural resources and climate change: concepts and approaches for management adaptation.** West, Jordan M.; Julius, Susan H.; Kareiva, Peter; and Colleagues. 2009. *Environmental Management.* 44: 1001-1021. Available online at http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2791483/pdf/267_2009_Article_9345.pdf (accessed January 13, 2011).

    Summary: West and colleagues provide several concepts and approaches for assessing impacts to support adaptation, management strategies for resilience to climate change, responding to barriers and opportunities for implementation, and advancing the nation's capability to adapt. Twelve tables provide examples of specific approaches that are in use or have been proposed (e.g. Table 5, pp. 1009, provides examples of adaptation actions that focus on restoration as a means of supporting resilience).

Appendix 6. List of Reviewers and Interviewees

Reviewers

Alaska

Laura Baker, The Nature Conservancy
Mandy Lindeberg, National Oceanic and Atmospheric Administration
Scott W. Johnson, National Oceanic and Atmospheric Administration

British Columbia

Dave Secord, Tides Canada Foundation
Tory Stevens, BC Ministry of Environment
Trevor Murdock, Pacific Climate Impacts Consortium

Washington

Carey Smith, US Fish and Wildlife Service
Curtis Tanner, Washington Department of Fish and Wildlife
Hugh Shipman, Washington State Department of Ecology
Jean Takekawa, US Fish and Wildlife Service
Lara Whitely Binder, Climate Impacts Group
Mark Scheuerell, National Marine Fisheries Service
Nathan Mantua, Climate Impacts Group
Paul McElhany, National Marine Fisheries Service
Richard Feely, National Oceanic and Atmospheric Administration
Shallin Busch, National Marine Fisheries Service
Spencer Reeder, Cascadia Consulting Group

Oregon

Bruce Taylor, Pacific Coast Joint Venture
Kathie Dello, Oregon Climate Change Research Institute
Kathy Lynn, University of Oregon
Rowan Baker, US Fish and Wildlife Service
Sara O'Brien, Defenders of Wildlife
Tim Mayer, US Fish and Wildlife Service
William Pearcy, Oregon State University

California

Laura Rogers-Bennett, California Department of Fish and Game
Paula Golightly, US Fish and Wildlife Service
Susan Schlosser, California Sea Grant Extension Program

Native Alaskans, First Nations, Tribal

Other

Doug Inkley, National Wildlife Federation
Patty Glick, National Wildlife Federation

Interviewees (*continued on following page*)

Alaska

Andrew Schroth, US Geological Survey
Bill Hanson, US Fish and Wildlife Service
Doug DeMaster, Alaska Fisheries Science Center
Doug Vincent-Lang, Alaska Department of Fish and Game
Eran Hood, University of Alaska - Southeast
Evie Witten, The Nature Conservancy
Gordie Reeves, US Forest Service
John Crusius, US Geological Survey
Laura Baker, The Nature Conservancy
Lilian Petershoare, US Forest Service
Mandy Lindeberg, National Oceanic and Atmospheric Administration
Mark Shasby, Alaska Climate Science Center
Michael F. Sigler, Alaska Fisheries Science Center
Mike Goldstein, Alaska Coastal Rainforest Center
Ray Paddock, Central Council Tlingit and Haida Indian Tribes of Alaska
Reid Johnson, Central Council Tlingit and Haida Indian Tribes of Alaska
Richard T. Edwards, US Forest Service
Rick Fritsch, National Oceanic and Atmospheric Administration
Roman Motyka, University of Alaska – Southeast
Sarah Fleisher Trainor, University of Alaska – Fairbanks
Scott W. Johnson,National Oceanic and Atmospheric Administration
Shannon Atkinson, University of Alaska – Fairbanks
Tom Ainsworth, National Oceanic and Atmospheric Administration

British Columbia

Darcy Dobell, World Wildlife Fund
Dave Secord, Tides Canada Foundation
Hans Schreier, University of British Columbia
James Casey, World Wildlife Fund
Jenny Fraser, BC Ministry of Environment
Robyn Hooper, Pacific Institute for Climate Solutions
Stewart Cohen, Environment Canada
Tory Stevens, BC Ministry of Environment

Oregon

Ben Clemens, Oregon State University
Carl Schreck, Oregon State University
Chris Hathaway, Lower Columbia River Estuary Partnership
Kathie Dello, Oregon Climate Change Research Institute
Kathy Lynn, University of Oregon
Keith Hatch, Bureau of Indian Affairs
Laurele Fulkerson, Wild Salmon Center
Mark Trenholm, North American Salmon Stronghold Partnership
Rowan Baker, US Fish and Wildlife Service
Roy Lowe, US Fish and Wildlife Service
Sara O'Brien, Defenders of Wildlife
Steve Caico, US Fish and Wildlife Service
Tim Mayer, US Fish and Wildlife Service
William Pearcy, Oregon State University

California

Aldaron Laird, Trinity Associates
Armand Gonzales, California Department of Fish and Game
Jeff Black, Humboldt State University
Eric T. Nelson, US Fish and Wildlife Service
Frank Shaughnessy, Humboldt State University
Iris Stewart-Frey, Santa Clara University
Laura Rogers-Bennett, California Department of Fish and Game
Lisa Ballance, University of California San Diego
Paula Golightly, US Fish and Wildlife Service
Peter Moyle, University of California - Davis
Susan Schlosser, California Sea Grant Extension Program

Native Alaskans, First Nations, Tribal

Abby Hook, Tulalip Tribe
Charles P. O'Hara, Swinomish Indian Tribal Community
Christopher Ellings, Nisqually Indian Tribe
Claire Wood, Confederated Tribes of Siletz Indians
Ed Knight, Swinomish Indian Tribal Community
Mike Kennedy, Confederated Tribes of Siletz Indians
Preston Hardison, Tulalip Tribe
Scott Andrews, Swinomish Indian Tribal Community
Stephen Kullmann, Wiyot Tribe
Tim Nelson, Wiyot Tribe

Trevor Murdock, Pacific Climate Impacts Consortium

Washington

Alan Parker, The Evergreen State College
Bruce Jones, Northwest Indian Fisheries Commission
Carey Smith, US Fish and Wildlife Service
Charlie Stenvall, US Fish and Wildlife Service
Curtis Tanner, Washington Department of Fish and Wildlife
Elizabeth Gray, The Nature Conservancy
Eric Grossman, US Geological Survey
Greg Hood, Skagit River System Cooperative
Hugh Shipman, Washington State Department of Ecology
Jean Takekawa, US Fish and Wildlife Service
Jennie Hoffman, EcoAdapt
Jesse Barham, US Fish and Wildlife Service
Jim Weber, Northwest Indian Fisheries Commission
Jon Hoekstra, The Nature Conservancy
Kate Skaggs, Washington State Department of Ecology
Kelley Turner, US Geological Survey
Lara Whitely Binder, Climate Impacts Group
Lisa Crozier, National Oceanic and Atmospheric Administration
Mark Scheuerell, National Marine Fisheries Service
Mary Mahaffy, US Fish and Wildlife Service
Mike Grayum, Northwest Indian Fisheries Commission
Nathan Mantua, Climate Impacts Group
Patty Glick, National Wildlife Federation
Paul McElhany, National Marine Fisheries Service
Rachel M. Gregg, EcoAdapt
Richard Cook, Bureau of Indian Affairs
Richard Feely, National Oceanic and Atmospheric Administration
Shallin Busch, National Marine Fisheries Service
Spencer Reeder, Cascadia Consulting Group
Timothy J. Beechie, National Marine Fisheries Service
Tom Dwyer, Ducks Unlimited

Other

Garrit Voggesser, National Wildlife Federation
Myra Wilensky, National Wildlife Federation
Steve Torbit, National Wildlife Federation

XI. BIBLIOGRAPHY

Abeysirigunawardena, Dilumie S., and Ian J. Walker. "Sea level responses to climatic variability and change in northern British Columbia." *Atmosphere-Ocean* 46, no. 3 (2008): 277-296.

Ackerly, D. D., et al. "The geography of climate change: implications for conservation biogeography (Supplemental Information)." *Diversity and Distributions,* 2010: 16, http://onlinelibrary.wiley.com/store/10.1111/j.1472-4642.2010.00654.x/asset/supinfo/DDI_654_sm_Data_S1andFig_S1-S8.pdf?v=1&s=93f8310b31bb81d495bae87579a8d7f4d710ca3e (accessed 6.8.2011).

ACRC, Alaska Climate Research Center. *Temperature Change in Alaska.* 2009 йил 9-March. http://climate.gi.alaska.edu/ClimTrends/Change/TempChange.html (accessed 2011 йил 7-January).

Adams, Peter N., and Douglas L. Inman. *Climate change hotspots and potential hotspots of coastal erosion along the southern California coast: Final Paper (CEC-500-2009-022-F).* California Climate Change Center, 2009, 73.

ADB, Asian Development Bank. *Climate Proofing: A risk-based approach to adaptation.* Asian Development Bank, 2005, 219.

Agency, California Natural Resources. "2009 California Climate Adaptation Strategy: A Report to the Governor of the State of California in Response to Executive Order S-13-2008." 2009.

AK-CCAP, Alaska Center for Climate Assessment and Policy. *Climate Change Impacts on Water Availability in Alaska (presentation).* 2009 йил 15-September. http://ine.uaf.edu/accap//documents/2009_09_Water_Availability_OBrien.pdf (accessed 2011 йил 6-January).

AK-DEC, Alaska Department of Environmental Conservation. "Final Report Submitted by the Adaptation Advisory Group to the Alaska Climate Change Sub-Cabinet." *Climate Change in Alaska: Adaptation Advisory Group of the Governor's Sub-Cabinet on Climate Change.* 2010. http://www.climatechange.alaska.gov/aag/aag.htm (accessed January 13, 2011).

Arora, V. K., et al. "Carbon emission limits required to satisfy future representative concentration pathways of greenhouse gases." *Geophysical Reseach Letters* 38, no. L05805 (2011).

Bakun, A. "Global climate change and intensification of coastal ocean upwelling." *Science* 247 (1990): 198-201.

Bakun, A., and S. J. Weeks. "Greenhouse gas buildup, sardines, submarine eruptions and the possibility of abrupt degradation of intense marine upwelling ecosystems." *Ecology Letters* 7 (2004): 1015-1023.

Baron, Jill S., et al. "Options for national parks and reserves for adapting to climate change." *Environmental Management* 44 (2009): 1033-1042.

Bauman, Yoram, Bob Doppelt, Sarah Mazze, and Edward C. Wolf. "Impacts of climate change on Washington's economy: a preliminary assessment of risks and opportunities (pdf)." Edited by Edward C. Wolf. November 2006. http://www.ecy.wa.gov/pubs/0701010.pdf (accessed January 18, 2011).

BBC. *The key effects of climate change.* March 10, 2009. http://news.bbc.co.uk/2/hi/science/nature/7933589.stm (accessed June 8, 2011).

BC, Biodiversity. *Taking Nature's Pulse: Table of Contents, Exec. Summary, and Introduction.* April 3, 2009. http://www.biodiversitybc.org/EN/main/downloads/tnp-introduction.html#sabout (accessed January 14, 2011).

BC, British Columbia. "Climate Action Plan." 2008. http://www.livesmartbc.ca/attachments/climateaction_plan_web.pdf (accessed January 13, 2011).

Berkes, Fikret, Johan Colding, and Carl Folke. "Rediscovery of traditional ecological knowledge as adaptive management." *Ecological Applications* 10, no. 5 (October 2000): 1251-1262.

Bindoff, N. L., et al. *FAQ 5.1 - AR4 WG1 Chapter 5: Observations: Oceanic Climate Change and Sea Level.* Edited by S. Solomon, et al. Cambridge, United Kingdon and New York, NY, USA Cambridge University Press. 2007. http://www.ipcc.ch/publications_and_data/ar4/wg1/en/contents.html (accessed March 28, 2011).

Boe, Jon, et al. "West Coast Governor's Agreement on Ocean Health Spartina Eradication Action Coordination Team Work Plan (pdf)." May 2010. http://westcoastoceans.gov/Docs/Spartina_Final_Work_Plan.pdf (accessed April 13, 2011).

Boeing, Wiebke J., and Janet T. Duffy-Anderson. "Ichthyoplankton dynamics, and biodiversity in the Gulf of Alaska: reponses to environmental change." *Ecological Indicators* 8 (2008): 292-302.

Bornhold, Brian D. *Projected sea level changes for British Columbia in the 21st century.* Library and Archives Canada Cataloguing in Publication, 2008.

Brandenberger, J. M., et al. *Reconstructing trends in hypoxia using multiple paleoecological indicators recorded in sediment cores from Puget Sound, WA.* National Oceanic and Atmospheric Administration, Pacific Northwest National Laboratory, Report No. PNWD-4013, 2008, 158.

Brooks, Kenneth N., Peter F. Ffolliott, Hans M. Gregerson, and Leonard F. DeBano. "Hydrologica Processes and Land Use." In *Hydrology and the Management of Watersheds*, by Kenneth N. Brooks, Peter F. Ffolliott, Hans M. Gregerson and Leonard F. DeBano, 21-22. Ames, Iowa: Blackwell Publishing, 2003.

Brown, A. C., and A. McLachlan. "Sandy shore ecosystems and the threats facing them: some predictions for the year 2025." *Environmental Conservation* 29, no. 1 (2002): 62-77.

Burgette, Reed J., Ray J. Weldon II, and David A. Schmidt. "Interseismic uplift rates for western Oregon and along-strike variation in locking on the Cascadia subduction zone." *Journal of Geophysical Research* 114 (2009): 1-24 (B01408).

Burgiel, S. W., and A. A. Muir. *Invasive species, climate change and ecosystem-based adaptation: Addressing multiple drivers of global change.* Washington DC, US, and Nairobi, Kenya: Global Invasive Species Programme (GISP), 2010, 56.

Butz, Ramona J., and Hugh Safford. "A summary of current trends and probable future trends in climate and climate-driven processes for the Six Rivers National Forest and surrounding lands (pdf)." December 15, 2010. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5251124.pdf (accessed March 7, 2011).

Byrne, Robert H., Sabine Mecking, Richard A. Feely, and Xuewu Liu. "Direct observations of basin-wide acidification of the North Pacific Ocean." *Geophysical Research Letters* 37, no. L02601 (2010): 1-5.

Canada, Parks. *Kluane National Park and Preserve of Canada Management Plan.* Parks Canada, 2010.

—. *The Climate is Changing Our National Parks: Impacts on Pacific Parks.* April 15, 2009. http://www.pc.gc.ca/docs/v-g/ie-ei/cc/repercussions-impacts6.aspx (accessed August 4, 2011).

CA-NRA, California Natural Resources Agency. *2009 California Climate Adaptation Strategy: a report to the Governor of the State of California in response to Executive Order S-13-2008.* State government publication, California Natural Resources Agency, 2009, 200.

Capalbo, Susan, James Julian, Thomas Maness, and Erin Kelly. "Toward assessing the economic impacts of climate change on Oregon." *The Oregon Climate Assessment Report.* Edited by K. D. Dello and P. W. Mote. Corvallis, OR: College of Oceanic and Atmospheric Sciences, Oregon State University, 2010.

Cayan, Daniel R., Edwin P. Maurer, Michael D. Dettinger, Mary Tyree, and Katharine Hayhoe. "Climate change scenarios for the California region." *Climatic Change* 87, no. Suppl 1 (2008): S21-S42.

Cazenave, A., et al. "Sea level budget over 2003-2008: a reevaluation from GRACE space gravimetry, satellite altimetry and Argo." *Global and Planetary Change* 65 (2009): 83-88.

Chan, F., et al. "Emergence of anoxia in the California Current large marine ecosystem." *Science* 319 (2008): 920.

Chang, Heejun, and Julia Jones. "Climate change and freshwater resources in Oregon." *Oregon Climate Assessment Report (OCAR).* Edited by K. D. Dello and P. W. Mote. Corvallis, OR: Oregon Climate Change Research Institute, College of Oceanic and Atmospheric Sciences, Oregon State University, 2010. 69-150.

Chavez, Francisco P., John Ryan, Salvador E. Lluch-Cota, and Miguel Niquen C. "From anchovies to sardines and back: multidecadal change in the Pacific Ocean." *Science* 299, no. 10 January (2003): 217-221.

Chen, J. L., C. R. Wilson, and B. D. Tapley. "Satellite gravity measurements confirm accelerated melting of Greenland Ice Sheet." *Science* 313, no. 5795 (September 2006): 1958-1960.

Cheung, William W. L., et al. "Large-scale redistribution of maximum fisheries catch potential in the global ocean under climate change." *Global Change Biology* 16 (2010): 24-35.

CIG, Climate Impacts Group. *Climate Change.* March 2008. http://cses.washington.edu/cig/pnwc/cc.shtml (accessed January 14, 2011).

—. *Climate Change Scenarios: Future Northwest Climate.* August 1, 2008. http://cses.washington.edu/cig/fpt/ccscenarios.shtml (accessed January 14, 2011).

—. *Climate Change: Future Climate Change in the Pacific Northwest.* March 2008. http://cses.washington.edu/cig/pnwc/cc.shtml (accessed January 14, 2011).

—. *Pacific Northwest Climate Maps.* 2011. http://cses.washington.edu/cig/maps/index.shtml (accessed March 16, 2011).

CIG, Climate Impacts Group. *Preparing for climate change: A guidebook for local, regional, and state governments.* Joint Institute for the Study of the Atmosphere and Ocean, University of Washington; King County, Washington, 2007, 186.

—. *The Washington Climate Change Impacts Assessment.* 2009. http://cses.washington.edu/cig/res/ia/waccia.shtml (accessed January 14, 2011).

Clough, Jonathan S., Richard A. Park, and Roger Fuller. "SLAMM 6 beta Technical Documentation (draft; pdf)." May 2010. http://warrenpinnacle.com/prof/SLAMM6/SLAMM6_Technical_Documentation.pdf (accessed August 16, 2011).

Collins, Mat, et al. "The impact of global warming on the tropical Pacific Ocean and El Nino." *Nature Geoscience* 3 (June 2010): 391-397.

Community, Swinomish Indian Tribal. "Swinomish Climate Change Initiative: Climate Adaptation Action Plan (pdf)." *Swinomish Climate Change Initiative.* October 2010. http://www.swinomish-nsn.gov/climate_change/Docs/SITC_CC_AdaptationActionPlan_complete.pdf (accessed March 8, 2011).

Connolly, T. P., B. M. Hickey, S. L. Geier, and W. P. Cochlan. "Processes influencing seasonal hypoxia in the northern California Current System." *Journal of Geophysical Research* 115, no. C03021 (2010): 36 pgs.

Cooley, Sarah R., Hauke L. Kite-Powell, and Scott C. Doney. "Ocean acidification's potential to alter global marine ecosystem services." *Oceanography* 22, no. 4 (2009): 172-181.

Crozier, L. G., et al. "Potential responses to climate change in organisms with complex life histories: evolution and plasticity in Pacific salmon." *Evolutionary Applications* 1, no. 2 (2008): 252-270.

Crusius, John, Andrew W. Schroth, Santiago Gasso, Christopher M. Moy, Robert C. Levy, and Myrna Gatica. "Glacial flour dust storms in the Gulf of Alaska: Hydrologic and meteorological controls and their importance as a source of bioavailable iron." *Geophysical Research Letters* 38, no. L06602 (2011): 1-5.

Davidson, Timothy M., Valance E. F. Brenneis, Catherine de Rivera, Robyn Draheim, and Graham E. Gillespie. "Northern range expansion and coastal occurrences of the New Zealand mud snail Potamopyrgus antipodarum (Gray, 1843) in the northeast Pacific." *Aquatic Invasions* 3, no. 3 (2008): 349-353.

Dawe, Jordan T., and LuAnne Thompson. "PDO-related heat and temperature changes in a model of the North Pacific." *Journal of Climate* 20, no. May 15 (2007): 2092-2108.

Defeo, Omar, et al. "Threats to sandy beach ecosystems: a review." *Estuarine, Coastal and Shelf Science* 81 (2009): 1-12.

Diffenbaugh, Noah S., Mark A. Snyder, and Lisa C. Sloan. "Could CO2-induced land-cover feedbacks alter near-shore upwelling regimes?" *Proceedings of the National Academy of Sciences* 101, no. 1 (2004): 27-32.

Domingues, Catia M., et al. "Improved estimates of upper-ocean warming and multi-decadal sea level rise." *Nature* 453, no. 19 June (2008): 1090-1093.

DU, Ducks Unlimited, Inc. *SLAMM Analysis of Grays Harbor, Washington.* Unpublished technical report, Vancouver, WA: Ducks Unlimited, 2010a, 197.

DU, Ducks Unlimited, Inc. *SLAMM Analysis of the Lower Columbia River, Washington and Oregon.* Unpublished technical report, Vancouver, WA: Ducks Unlimited, 2010b, 63.

DU, Ducks Unlimited, Inc. *SLAMM Analysis of Willapa Bay, Washington.* Unpublished technical report, Vancouver, WA: Ducks Unlimited, 2010c, 207.

DU, Ducks Unlimited, Inc. *Update of Puget Sound SLAMM Analysis.* Unpublished technical report, Vancouver, WA: Ducks Unlimited, 2010d, 29.

DU-Canada, Ducks Unlimited Canada. "British Columbia Spartina Eradication Program: 2009 Progress Report (pdf)." 2009. http://www.spartina.org/referencemtrl/BC_Spartina_Progress_Report_09.pdf (accessed April 13, 2011).

Ehler, Charles, and Fanny Douvere. "Marine Spatial Planning: a step-by-step approach toward ecosystem-based management." Paris: UNESCO, 2009.

Ekau, W., H. Auel, H.-O. Portner, and D. Gilbert. "Impacts of hypoxia on the structure and processes in pelagic communities (zooplankton, macro-invertebrates and fish)." *Biogeosciences* 7 (2010): 1669-1699.

Elston, R A, H Hasegawa, K L Humphrey, I K Polyak, and C C Hase. "Re-emergence of Vibrio tubiashii in bivalve shellfish aquaculture: severity, environmental drivers, geograhic extent and management." *Diseases of Aquatic Organisms* 82, no. 2 (Nov 2008): 119-34.

Emmett, Robert, et al. "Geographic signatures of North American West Coast Estuaries." *Estuaries* 23, no. 6 (2000): 765-792.

Environment, B.C. Ministry of. *Environmental Trends in British Columbia: 2007.* Victoria B.C.: State of Environment Reporting, 2007.

—. "In-depth report: Climate Change." *Environmental Trends in British Columbia: 2007.* 2007. http://www.env.gov.bc.ca/soe/et07/04_climate_change/technical_paper/climate_change.pdf (accessed November 23, 2010).

—. "In-depth report: Ecosystems." *Environmental Trends in British Columbia: 2007.* 2007. http://www.env.gov.bc.ca/soe/et07/06_ecosystems/technical_paper/ecosystems.pdf (accessed November 23, 2010).

—. "In-depth report: Species Conservation." *Environmental Trends in British Columbia: 2007.* 2007. http://www.env.gov.bc.ca/soe/et07/07_species_conserv/technical_paper/species_conservation.pdf (accessed November 23, 2010).

Environment, BC Ministry of. "Alive and Inseparable: British Columbia's Coastal Environment: 2006." BC Ministry of Environment, 2006. 335.

EPA, Environmental Protection Agency. *Inventory of U.S. Greenhouse Gas Emissions Emissions and Sinks: 1990-2006: Introduction (pdf).* 2006. http://www.epa.gov/climatechange/emissions/downloads/ghg_gwp.pdf (accessed 2010 йил 28-December).

EPA, United States Environmental Protection Agency. *Lessons Learned from the Climate Ready Estuaries Program.* U.S. Environmental Protection Agency, Climate Ready Estuaries Program, June 2011.

—. "Synthesis of Adaptation Options for Coastal Areas." Washington, D.C.: U.S. Environmental Protection Agency, Climate Ready Estuaries Program, January 2009. 32.

EPA, US Environmental Protection Agency. *Effects of Climate Change on Aquatic Invasive Species and Implications for Management and Research [EPA/600/R-08/014]*. National Center for Environmental Assessment, Office of Research and Development, Washington, DC: U.S. Environmental Protection Agency, 2008, 337.

ESR, Earth and Space Research. *Outreach and Education: Oceanographic Glossary.* January 21, 2004. http://www.esr.org/outreach/glossary.html#m (accessed April 8, 2011).

Fabry, Victoria J., James B. McClintock, Jeremy T. Mathis, and Jacqueline M. Grebmeier. "Ocean acidification at high latitudes: the Bellwether." *Oceanography* 22, no. 4 (2009): 160-171.

Feely, Richard A., Christopher L. Sabine, J. Martin Hernandez-Ayon, Debby Ianson, and Burke Hales. "Evidence for upwelling of corrosive "acidified" water onto the continental shelf." *Science* 320, no. 13 June (2008): 1490-1492.

Feely, Richard A., et al. "The combined effects of ocean acidification, mixing, and respiration on pH and carbonate saturation in an urbanized estuary." *Estuarine, Coastal and Shelf Science* 88 (2010): 442-449.

Feely, Richard A., Scott C. Doney, and Sarah R. Cooley. "Ocean acidification: present conditions and future changes in a high CO2 world,." *Oceanography* 22, no. 4 (2009): 36-47.

Field, C. B., et al. "North America." *Climate Change 2007: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Edited by M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden and C. E. Hanson. Cambridge: Cambridge University Press, 2007. 617-652.

Field, John C., Ken Baltz, A. Jason Phillips, and William A. Walker. "Range expansion and trophic interactions of the jumbo squid, Dosidicus gigas, in the California Current." *California Cooperative Oceanic Fisheries Investigations (CalCOFI)* 48 (2007): 131-146.

Fierstein, D. "Scientists and decision makers discuss the fate of the ocean." *Monterey Bay Aquarium Research Insitute.* 2007. http://www.mbari.org/news/news_releases/2008/oceansummit/oss-advisory.html (accessed December 6, 2010).

Forster, P., et al. *Changes in Atmospheric Constituents and in Radiative Forcing.* Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Intergovernmental Panel on Climate Change, 2007.

FWS, U.S. Fish and Wildlife Service. *Marbled Murrelet (Brachyramphus marmoratus): 5-Year Review (Final).* Lacey: U.S. Fish and Wildife Service, Washington Fish and Wildlife Office, June 12, 2009, 108.

Galatowitsch, Susan, Lee Frelich, and Laura Phillips-Mao. "Regional climate change adaptation strategies for biodiversity conservation in a midcontinental region of North America." *Biological Conservation* 142 (2009): 2012-2022.

Galbraith, H., et al. *Global climate change and sea level rise: potential losses of intertidal habitat for shorebirds. Forest Service General Technical Report PSW-GTR-191.* United States Department of Agriculture, 2005, 1119-1122.

GCRP, United States Global Change Research Program. "Global Climate Change Impacts in the United States (pdf)." Edited by Thomas R. Karl, Jerry M. Melillo and Thomas C. Peterson. Cambridge University Press (publisher). 2009. http://downloads.globalchange.gov/usimpacts/pdfs/climate-impacts-report.pdf (accessed January 6, 2011).

Glick, P., B. A. Stein, and N. A. Edelson, . *Scanning the Conservation Horizon: A Guide to Climate Change Vulnerability Assessment.* Washington, D.C.: National Wildlife Federation, 2011b.

Glick, P., J. Hoffman, M. Koslow, A. Kane, and D. Inkley. *Restoring the Great Lakes' Coastal Future: Technical Guidance for the Design and Implementation of Climate-Smart Restoration Projects.* Ann Arbor, MI: National Wildlife Federation, 2011a.

Glick, Patty, Amanda Staudt, and Bruce Stein. "A New Era for Conservation: Review of Climate Change Adaptation Literature." National Wildlife Federation, March 12, 2009. 69. Available online at http://www.nwf.org/News-and-Magazines/Media-Center/Faces-of-NWF/~/media/PDFs/Global%20Warming/Reports/NWFClimateChangeAdaptationLiteratureReview.ashx (accessed 12.14.2010).

Glick, Patty, Jonathan Clough, and Brad Nunley. *Assessing the Vulnerability of Alaska's Coastal Habitats to Accelerating Sea level Rise Using the SLAMM Model: A Case Study for Cook Inlet.* National Wildlife Federation, 2010, 30.

Glick, Patty, Jonathan Clough, and Brad Nunley. *Sea level Rise and Coastal Habitats in the Pacific Northwest: An Analysis for Puget Sound, Southwestern Washington, and Northwestern Oregon.* National Wildlife Federation, 2007, 106.

Karl, Thomas R., Jerry M. Melillo, and Thomas C. Peterson, . "Global Climate Change Impacts in the United States (pdf)." Cambridge University Press (publisher). 2009. http://downloads.globalchange.gov/usimpacts/pdfs/climate-impacts-report.pdf (accessed January 6, 2011).

Grafton, R. Quentin. "Adaptation to climate change in marine capture fisheries." *Marine Policy* 34 (2010): 606-615.

Grantham, B. A., et al. "Upwelling-driven nearshore hypoxia signals ecosystem and oceanographic changes in the northeast Pacific." *Nature* 429 (2004): 749-754.

Gregg, Rachel M., et al. *The State of Marine and Coastal Adaptation in North America: A Synthesis of Emerging Ideas (Final Report).* Bainbridge Island, WA: EcoAdapt, 2011, 145.

Grinsted, A., J. C. Moore, and S. Jevrejeva. "Reconstructing sea level from paleo and projected temperatures 200 to 2100AD." *Climate Dynamics* 34, no. 4 (2009): 461-472.

Groisman, Pavel Ya, Richard W. Knight, Thomas R. Karl, David R. Easterling, Bomin Sun, and Jay Lawrimore. "Contemporary changes in the hydrological cycle over the contiguous United States: Trends dervied from in situ observations." *Journal of Hydrometeorology* 5 (February 2004): 64-85.

Group, Climate Impacts. *The Washington Climate Change Impacts Assessment (WACCIA).* Seattle: University of Washington Climate Impacts Group, 2009.

Guinotte, J. M., and V. J. Fabry. "Ocean acidification and its potential effects on marine ecosystems." *Annals of New York Academy of Sciences* 320 (2008): 320-342.

Guinotte, John M., James Orr, Stephen Cairns, Andre Freiwald, Lance Morgan, and Robert George. "Will human-induced changes in seawater chemistry alter the distribution of deep-sea scleractinian corals?" *Frontiers in Ecology and the Environment* 4, no. 3 (2006): 141-146.

Hamlet, Alan F., and Dennis P. Lettenmaier. "Effects of 20th century warming and climate variability on flood risk in the western U.S." *Water Resources Research* 43 (2007): 17.

Hamlet, Alan F., Philip W. Mote, Martyn P. Clark, and Dennis P. Lettenmaier. "Twentieth-century trends in runoff, evapotranspiration, and soil moisture in the western United States." *Journal of Climate* 20, no. 8 (2007): 1468-1486.

Hansen, James, et al. "Earth's energy imbalance: confirmation and implications." *Science* 308, no. 3 June (2005): 1431-1435.

Hare, Steven R., Nathan J. Mantua, and Robert C. Francis. "Inverse production regimes: Alaska and West Coast Pacific Salmon." *Fisheries* 24, no. 1 (1999): 6-14.

Harris, P. M., A. D. Neff, S. W. Johnson, and J. F. Thedinga. *Eelgrass habitat and faunal assemblages in the City and Borough of Juneau, Alaska.* Technical Memorandum NMFS-AFSC-182, NOAA National Marine Fisheries Service Alaska Fisheries Science Center, 2008, 59.

Hasegawa, Hiroaki, Erin J. Lind, Markus A. Boin, and Claudia C. Hase. "The extracellular metalloprotease of Vibrio tubiashii is a major virulence factor for Pacific oyster (Crassostrea gigas) larvae." *Applied and Environmental Microbiology* 74, no. 13 (July 2008): 4101-4110.

Haufler, J. B., C. A. Mehl, and S. Yeats. *Climate change: anticipated effects on ecosystem services and potential actions by the Alaska Region, U.S. Forest Service.* Seeley Lake, Montana, USA: Ecosystem Management Research Institute, 2010.

Hauri, Claudine, et al. "Ocean acidification in the California Current System." *Oceanography* 22, no. 4 (2009): 60-71.

Heller, Nicole E., and Erika S. Zavaleta. "Biodiversity management in the face of climate change: a review of 22 years of recommendations." *Biological Conservation* 142 (2009): 14-32.

Helly, John J., and Lisa A. Levin. "Global distribution of naturally occurring marine hypoxia on continental margins." *Deep-Sea Research I* 51 (2004): 1159-1168.

Hermann, Albert J., et al. "Quantifying cross-shelf and vertical nutrient flux in the Coastal Gulf of Alaska with a spatially nested, coupled biophysical model." *Deep-Sea Research II* 56 (2009): 2474-2486.

Hickey, Barbara M., and Neil S. Banas. "Oceanography of the U.S. Pacific Northwest Coastal Ocean and Estuaries with Application to Coastal Ecology." *Estuaries* 26, no. 4B (August 2003): 1010-1031.

Hickey, Barbara M., and Neil S. Banas. "Why is the northern end of the California Current System so productive?" *Oceanography* 21, no. 4 (2008): 90-107.

Hinch, S. G., and E. G. Martins. *A review of potential climate change effects on survival of Fraser River sockeye salmon and an analysis of interannual trends in en route loss and pre-spawn mortality.* Cohen Commission Tech. Rept. 9, Vancouver, B.C.: Cohen Commission, 2011, 134.

Hoegh-Guldberg, Ove, and John F. Bruno. "The impact of climate change on the world's marine ecosystems." *Science* 328 (2010): 1523-1528.

Hoffman, Jennifer. "Designing reserves to sustain temperate marine ecosystems in the face of global climate change." *Buying Time: A user's manual for building resistance and resilience to climate change in natural systems.* Edited by L. J. Hansen, J. L. Biringer and J. R. Hoffman. World Wildlife Fund, August 2003. 246.

Hood, Eran, and Duran Scott. "Riverine organic matter and nutrients in southeast Alaska affected by glacial coverage." *Nature Geoscience* 1 (2008): 583-587.

Hood, Eran, et al. "Glaciers as a source of ancient and labile organic matter to the marine environment." *Nature* 462, no. 24 (December 2009): 1044-1048.

Howat, Ian M., Slawek Tulaczyk, Philip Rhodes, Kevin Israel, and Mark Snyder. "A precipitation-dominated, mid-latitude glacier system: Mount Shasta, California." *Climate Dynamics* 28 (2007): 85-98.

Huppert, Daniel D., Amber Moore, and Karen Dyson. "Impacts of climate change on the coasts of Washington State." *Washington Climate Change Impacts Assessment: Evaluating Washington's Future in a Changing Climate.* Edited by J. S. Littell, M McGuire Elsner, L. C. Whitely Binder and A. K. Snover. Seattle, WA: Climate Impacts Group, University of Washington, 2009. Chapter 8.

ICCWG, Intertribal Climate Change Working Group. "A Tribal White Paper on Climate Change Adaptation and Mitigation." August 13, 2009. 13.

Inc., WorldWinds. *About MM5.* 2011. http://www.worldwindsinc.com/aboutmm5.htm (accessed July 29, 2011).

"Integrated Climate Change Response Plan: Draft Topic Advisory Group Work Plan." November 3, 2009.

IPCC, Intergovernmental Panel on Climate Change. *2.3 Chemically and Radiatively Important Gases - AR4 WGI Chapter 2: Changes in Atmospheric Constituents and Radiative Forcing.* 2007. http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-3.html#2-3-1 (accessed 2010 йил 28-December).

—. *Climate Change 2007: Impacts, Adaptation, Vulnerability: Introduction.* 2007. http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-intro.pdf (accessed June 6, 2011).

IPCC, Intergovernmental Panel on Climate Change. *Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.)].* Geneva: IPCC, 2007.

IPCC, Intergovernmental Panel on Climate Change. "Climate Change 2007: Synthesis Report: Summary for Policymakers." 2007.

—. *FAQ 10.1 Are exteme events, like heat waves, droughts or floods, expected to change as the Earth's climate changes?* 2010. http://www.ipcc.ch/publications_and_data/ar4/wg1/en/faq-10-1.html (accessed December 15, 2010).

—. *IPCC Fourth Assessment Report: Climate Change 2007: Foreward.* 2007. http://www.ipcc.ch/publications_and_data/ar4/syr/en/frontmattersforeword.html (accessed January 14, 2011).

—. *IPCC Special Report on Emissions Scenarios: Chapter 5.1 Introduction.* 2010. http://www.grida.no/publications/other/ipcc_sr/?src=/climate/ipcc/emission/index.htm (accessed March 16, 2011).

—. *SRES Final Data (version 1.1) Breakdown.* July 2000. http://sres.ciesin.org/final_data.html (accessed March 16, 2011).

—. “Summary for Policymakers.” *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Edited by S. Solomon, et al. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press, 2007.

—. "Summary for Policymakers." *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Edited by M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden and C. E. Hanson. Cambridge: Cambridge University Press, 2007. 7-22.

—. *The SRES Emissions Scenarios.* 2010. http://sedac.ciesin.columbia.edu/ddc/sres/ (accessed 2011 йил 5-January).

—. *Working Group 1 Home.* 2011. https://www.ipcc-wg1.unibe.ch/ (accessed January 14, 2011).

IPCC-WGII, Intergovernmental Panel on Climate Change Working Group II. "Summary for Policymakers." *Climate Change 2001: Impacts, Adaptation, and Vulnerability.* 2001. 18.

Irvine, James R., and Masa-aki Fukuwaka. "Pacific salmon abundance trends and climate change." *ICES Journal of Marine Science* 68, no. 6 (2011): 1122-1130.

ISAB, Independent Scientific Advisory Board. "Climate change impacts on Columbia River Basin Fish and Wildlife (pdf)." May 11, 2007. http://www.nwcouncil.org/library/isab/ISAB%202007-2%20Climate%20Change.pdf (accessed March 15, 2011).

ITEP, Institute for Tribal Environmental Professionals. "Climate Change and the Coquille Indian Tribe: Planning for the effects of climate change and reducing greenhouse gas emissions (pdf)." *Tribes and Climate Change: Tribal Profiles: Pacific Northwest.* February 11, 2011. http://tribalclimate.uoregon.edu/files/2010/11/tribes_Coquille_web2.pdf (accessed April 7, 2011).

Janetos, A., et al. "Biodiversity." *The effects of climate change on agriculture, land resources, water resources, and biodiversity in the United States.* Washington DC: A report by the U.S. Climate Change Science Program and the Subcomittee on Global Change Research., 2008. 362.

Keefer, Matthew L., Mary L. Moser, Charles T. Boggs, William R. Daigle, and Christopher A. Peery. "Variability in migration timing of adult Pacific lamprety (Lampetra tridentata) in the Columbia River, U.S.A." *Environ Biol Fish* 85 (2009): 253-264.

Kelly, Brendan P., Thomas Ainsworth, Jr., Douglas A. Boyce, Eran Hood, Peggy Murphy, and Jim Powell. "Climate Change: Predicted impacts on Juneau. Report to: Mayor Bruce Botelho and the City and Borough of Juneau Assembly (pdf)." April 2007. http://www.juneau.org/clerk/boards/Climate_Change/CBJ%20_Climate_Report_Final.pdf (accessed March 1, 2011).

Killam, Daniel, A. Bui, W. C. Patzert, J. K. Willis, S. LaDochy, and P. Ramirez. “California rainfall is becoming greater, with heavier storms.” *22nd Conference on Climate Variability and Change.* American Meteorological Society, 2010. 4.

Kirwan, Matthew L., and Glenn R. Guntenspergen. "Accelerated sea level rise - A response to Craft et al." *Frontiers in Ecology and the Environment* 7, no. 3 (2009): 126-127.

Kling, David, and James N. Sanchirico. *An Adaptation Portfolio for the United States Coastal and Marine Environment.* Resources for the Future, 2009, 73.

Kopp, Robert E., Frederik J. Simons, Jerry X. Mitrovica, Adam C. Maloof, and Michael Oppenheimer. "Probablistic assessment of sea level during the last interglacial stage." *Nature* 462, no. 17 December (2009): 863-867.

Kroeker, Kristy J., Rebecca L. Kordas, Ryan N. Crim, and Gerald G. Singh. "Meta-analysis reveals negative yet variable effects on ocean acidification on marine organisms." *Ecology Letters* 13 (2010): 1419-1434.

Krueger, K. L., Jr., K. B. Pierce, T. Quinn, and D. E. Penttila. "Anticipated effects of sea level rise in Puget Sound on two beach-spawning fishes." Edited by H. Shipman, M. N. Dethier, G. Gelfenbaum, K. L. Fresh and R. S. Dinicola. *Puget Sound Shorelines and the Impacts of Armoring - Proceedings of a State of the Science Workshop, May 2009.* U.S. Geological Survey Scientific Investigations Report 2010-5254, 2010. 171-178.

Lawler, Joshua J. "Climate change adaptation strategies for resource management and conservation planning." *Annals of the New York Academy of Sciences (The Year in Ecology and Conservation Biology)* 1162 (2009): 79-98.

Legislature, Alaska State. "Final Commission Report: Alaska Climate Impact Assessment Commission." March 17, 2008. 125.

Levin, L. A., et al. "Effects of natural and human-induced hypoxia on coastal benthos." *Biogeosciences Discussions* 6 (2009): 3563-3654.

Levitus, S., J. I. Antonov, T. P. Boyer, R. A. Locarnini, H. E. Garcia, and A. V. Mishonov. "Global ocean heat content 1955-2008 in light of recently revealed instrumentation problems." *Geophysical Research Letters* 36, no. L07608 (2009).

Littell, J. S., M. McGuire Elsner, L. C. Whitely Binder, and A. K. Snover, . "The Washington Climate Change Impacts Assessment: Evaluating Washington's Future in a Changing Climate - Executive Summary." *The Washington Climate Change Impacts Assessment: Evaluating Washington's Future in a Changing Climate.* Seattle, Washington: Climate Impacts Group, University of Washington, 2009.

Litzow, Michael A. "Climate regime shifts and community reorganization in the Gulf of Alaska: how do recent shifts compare with 1976/1977." *ICES Journal of Marine Science* 63 (2006): 1386-1396.

Loehle, Craig. "Cooling of the global ocean since 2003." *Energy and Environment* 20, no. 1&2 (2009): 99-102.

Logerwell, E. A., N. Mantua, P. W. Lawson, R. C. Francis, and V. N. Agostini. "Tracking environmental processes in the coastal zone for understanding and predicting Oregon coho (Oncorhynchus kisutch) marine survival." *Fisheries Oceanography* 12, no. 6 (2003): 554-568.

Lueker, T. J. "Coastal upwelling fluxes of O_2, N_20, and CO_2 assessed from continuous atmospheric observations at Trinidad, CA." *Biogeosciences* 1 (2004): 101-111.

Lyman, John M., et al. "Robust warming of the global upper ocean." *Nature* 465, no. 20 May (2010): 334-337.

Mach, Megan E., Sandy Wyllie-Echeverria, and Jennifer Rhode Ward. "Distribution and potential effects of a non-native seagrass in Washington State: Zostera japonica workshop (pdf)." 2010. http://www.wsg.washington.edu/mas/pdfs/Machetal2010ZJWkshopRep.pdf (accessed April 13, 2011).

—. "Distribution and potential effects of a non-native seagrass in Washington State: Zostera japonica workshop." 2010. http://www.dnr.wa.gov/Publications/aqr_zostera_study.pdf (accessed August 16, 2011).

Madsen, Travis, and Emily Figdor. "When it rains, it pours: Global warming and the rising frequency of extreme participation in the United States (pdf)." December 2007. http://cdn.publicinterestnetwork.org/assets/oywshWAwZy-EXPsabQKd4A/When-It-Rains-It-Pours----US---WEB.pdf (accessed June 8, 2011).

Mantua, Nathan J., and Stephen R. Hare. "The Pacific Decadal Oscillation." *Journal of Oceanography* 58, no. 1 (2002): 35-44.

Mantua, Nathan, Ingrid Tohver, and Alan Hamlet. "Climate change impacts on streamflow extremes and summertime stream temperature and their possible consequences for freshwater salmon habitat in Washington State." *Climatic Change* 102 (2010): 187-223.

Martin, Jim, and Patty Glick. *A great wave rising: solutions for Columbia and Snake River salmon in the age of global warming.* Light in the River, 2008, 28.

Mawdsley, Jonathan R., Robin O. O'Malley, and Dennis S. Ojima. "A review of climate-change adaptation strategies for wildlife management and biodiversity conservation." *Conservation Biology* 23, no. 5 (2009): 1080-1089.

MBARI, Monterey Bay Aquarium Research Institute. *Upwelling.* 2010. http://www.mbari.org/chemsensor/n/upwelling.html (accessed December 15, 2010).

Mcleod, Elizabeth, Benjamin Poulter, Jochen Hinkel, Enrique Reyes, and Rodney Salm. "Sea level rise impact models and environmental conservation: A review of models and their applications." *Ocean & Coastal Management* 53 (2010): 507-517.

Meehl, G. A., et al. "Global Climate Projections." *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Edited by S. Solomon, et al. Cambridge, United Kingdom and New York, NY, USA.: Cambridge University Press, 2007.

Meehl, Gerald A., et al. "How much more global warming and sea level rise?" *Science* 307, no. 18 March (2005): 1769-1772.

Menge, Bruce A., Francis Chan, Karina J. Nielsen, Emanuele di Lorenzo, and Jane Lubchenco. "Climatic variation alters supply-side ecology: impact of climate patterns on phytoplankton and mussel recruitment." *Ecological Monographs* 79, no. 3 (2009): 379-395.

Merenlender, A. M., L. Huntsinger, G. Guthey, and S. K. Fairfax. "Land trusts and conservation easements: Who is conserving what for whom?" *Conservation Biology* 18, no. 1 (February 2004): 65-75.

Merryfield, W. J., B. Pal, and M. G. G. Foreman. "Projected future changes in surface marine winds off the west coast of Canada." *Journal of Geophysical Research Letters* 114 (2009): 10.

MoE, British Columbia Ministry of Environment. *Climate Change Adaptation Strategy.* 2011. http://www.env.gov.bc.ca/cas/adaptation/strategy.html (accessed January 13, 2011).

Morrison, John, Michael C. Quick, and Michael G.G. Foreman. "Climate change in the Fraser River watershed: flow and temperature projections." *Journal of Hydrology* 263 (2002): 230-244.

Moser, Susan, Guido Franco, Sarah Pittiglio, Wendy Chou, and Dan Cayan. “The future is now: An update on climate change science impacts and response options for California (pdf).” *2008 Climate Change Impacts Assessment: Second Biennial Science Report to the California Climate Action Team.* 2009 йил May. http://www.energy.ca.gov/2008publications/CEC-500-2008-071/CEC-500-2008-071.PDF (accessed January йил 2011-6).

Mote, Philip W. “Trends in temperature and precipitation in the Pacific Northwest during the Twentieth Century.” *Northwest Science* 77, no. 4 (2003): 271-282.

Mote, Philip W., and Eric P. Salathe Jr. "Future climate in the Pacific Northwest." *Climatic Change* 102, no. 1-2 (2010): 29-50.

Mote, Philip W., and Nathan J. Mantua. "Coastal upwelling in a warmer future." *Geophysical Research Letters* 29, no. 23 (2002): 2138.

Mote, Philip W., Daniel Gavin, and Adriana Huyer. "Climate change in Oregon's land and marine environments." *Oregon Climate Assessment Report.* Edited by K. D. Dello and P. W. Mote. Corvallis, OR: College of Oceanic and Atmospheric Sciences, Oregon State University, 2010.

Mote, Philip W., et al. "Preparing for climatic change: the water, salmon and forests of the Pacific Northwest." *Climatic Change* 61 (2003): 45-88.

Mote, Philip, Alexander Petersen, Spencer Reeder, Hugh Shipman, and Lara Whitely-Binder. *Sea level rise in the coastal waters of Washington State.* Seattle & Olympia: University of Washington Climate Impacts Group & Washington State Department of Ecology, 2008.

Mumford, T. F. *Kelp and eelgrass in Puget Sound. Puget Sound Nearshore Partnership Report No. 2007-05.* Technical Report 2007-5, Seattle, Washington: Seattle District, U.S. Army Corps of Engineers, 2007, 37.

NABCI, United States Committee North American Bird Conservation Initiative. *The State of the Birds 2010 Report on Climate Change, United States of America.* Washington, DC: U.S. Department of Interior, 2010, 32.

Najjar, Raymond G., et al. "The potential impacts of climate change on the mid-Atlantic coastal region." *Climate Research* 14 (2000): 219-233.

NAS, National Academy of Sciences. *Ecological impacts of climate change (pdf).* 2009. http://dels-old.nas.edu/dels/rpt_briefs/ecological_impacts.pdf (accessed December 14, 2010).

NASA, National Aeronautics and Space Administration. *Moody Pacific Unleashes Another Climate Mystery.* April 15, 2004. http://www.nasa.gov/vision/earth/environment/PDO.html (accessed January 17, 2011).

National Aeronautics and Space Administration, NASA. *GLOBAL Land-Ocean Temperature Index in 0.01 degrees Celsius (base period: 1951-1980).* 2010. http://data.giss.nasa.gov/gistemp/tabledata/GLB.Ts+dSST.txt (accessed December 10, 2010).

National Oceanic and Atmospheric Administration, NOAA. *Linear mean sea level (MSL) trends and 95% confidence intervals in mm/yr.* 2007. http://tidesandcurrents.noaa.gov/sltrends/msltrendstable.htm (accessed November 24, 2010).

—. *Tides and Currents: Sea Level Trends.* 2010. http://tidesandcurrents.noaa.gov/sltrends/sltrends.html (accessed November 24, 2010).

Neal, Edward G., Eran Hood, and Kathy Smikrud. "Contribution of glacier runoff to freshwater discharge into the Gulf of Alaska." *Geophysical Reserach Letters* 37, no. L06404 (2010): 1-5.

Nicholls, R. J., et al. "Coastal systems and low-lying areas." *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Edited by M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden and C. E. Hanson. Cambridge, UK: Cambridge University Press, 2007. 315-356.

Nicholls, Robert J., and Anny Cazenave. "Sea level rise and its impact on coastal zones." *Science* 328 (June 2010): 1517-1520.

NIST, National Institute of Standards and Technology. *International System of Units (SI): SI base units.* http://physics.nist.gov/cuu/Units/units.html (accessed January 17, 2011).

NOAA, National Oceanic and Atmospheric Administration. 2010. http://www.csc.noaa.gov/mbwg/htm/outreach/Shoreline31.pdf (accessed December 10, 2010).

NOAA, National Oceanic and Atmospheric Administration. *Adapting to Climate Change: A Planning Guide for State Coastal Managers,.* Available at http://coastalmanagement.noaa.gov/climate/adaptation.html: NOAA Office of Ocean and Coastal Resource Management, 2010.

—. *California Current: LME #3.* 2009. http://www.lme.noaa.gov/index.php?option=com_content&view=article&id=49:lme3&catid=41:briefs&Itemid=72 (accessed August 9, 2011).

—. *Gulf of Alaska: LME #2.* 2009. http://www.lme.noaa.gov/index.php?option=com_content&view=article&id=48:lme2&catid=41:briefs&Itemid=72 (accessed August 9, 2011).

—. *Living Shoreline Planning and Implementation,.* 2011. http://www.habitat.noaa.gov/restoration/techniques/lsimplementation.html (accessed April 14, 2011).

—. *Salmon Life Cycle (image).* http://www.swr.noaa.gov/recovery/life_cycle.gif (accessed December 14, 2010).

—. *State of the Climate Global Analysis 2010.* January 14, 2011. http://lwf.ncdc.noaa.gov/sotc/global/2010/13 (accessed March 16, 2011).

—. *Trends in Atmospheric Carbon Dioxide: Global.* 2011. http://www.esrl.noaa.gov/gmd/ccgg/trends/global.html (accessed March 16, 2011).

—. *Upper Ocean Thermal Center: The Expendable Bathythermograph (XBT).* 2011. http://www.aoml.noaa.gov/goos/uot/xbt-what-is.php (accessed August 10, 2011).

OCCRI, Oregon Climate Change Research Institute. "Oregon Climate Assessment Report." Edited by K. D. Dello and P. W. Mote. Corvallis, OR: College of Oceanic and Atmospheric Sciences, Oregon State University, 2010.

OCMP, Oregon Coastal Management Program. *Climate Ready Communities: A Strategy for Adapting to Impacts of Climate Change on the Oregon Coast (pdf).* Oregon Department of Land Conservation and Development OR-DLCD. 2009. http://www.oregon.gov/ENERGY/GBLWRM/docs/climate_ready_communities.pdf?ga=t (accessed December 15, 2010).

OR, State of Oregon. "The Oregon Climate Change Adaptation Framework." 2010. http://www.oregon.gov/LCD/docs/ClimateChange/Framework_Final.pdf?ga=t (accessed January 13, 2010).

Orr, J. C., et al. "Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying organisms." *Nature* 437 (2005): 681-686.

Osgood, K. E., ed. *Climate Impacts on U.S. Living Marine Resources: National Marine Fisheries Service Concerns, Activities and Needs.* U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-F/SPO-89, 2008. 118.

Otto-Bliesner, Bette L., Shawn J. Marshall, Jonathan T. Overpeck, Gifford H. Miller, Aixue Hu, and CAPE Last Interglacial Project members. "Simulating Arctic climate warmth and icefield retreat in the last interglaciation." *Science* 311 (March 2006): 1751-1753.

Overland, J. E., and M. Wang. "Future climate of the North Pacific Ocean." *Eos* 88, no. 16 (2007): 178,182.

Overpeck, Jonathan T., Bette L. Otto-Bliesner, Gifford H. Miller, Daniel R. Muhs, Richard B. Alley, and Jeffrey T. Kiehl. "Paleoclimatic evidence for future ice-sheet instability and rapid sea level rise." *Science* 311 (March 2006): 1747-1750.

Palacios, Daniel M., Steven J. Bograd, Roy Mendelssohn, and Franklin B. Schwing. "Long-term and seasonal trends in stratification in the California Current, 1950-1993." *Journal of Geophysical Research* 109 (2004): C10016: 1-12.

Palacios, Sherry L., and Richard C. Zimmerman. "Response of eelgrass Zostera marina to CO2 enrichment: possible impacts of climate change and potential for remediation of coastal habitats." *Marine Ecology Progress Series* 344 (2007): 1-13.

Papiez, Chelsie. "Climate Change Implications for the Quileute and Hoh Tribes (pdf)." *The Evergreen State College: Environmental Studies/Natural Resources Case Subject.* October 29, 2009. http://www.evergreen.edu/tribal/docs/Papiez%20Climate%20Change_Case%20Study%20Nov%208%202009.pdf (accessed April 7, 2011).

Parry, M. L., O. F. Canziani, J. P. Palutikof, P. J. van der Linden, and C. E. Hanson, . "Appendix I. Glossary." *Climate Change 2007: Impacts, Adaptation, Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge: Cambridge University Press, 2007. 976.

PAWG, Preparation and Adaptation Working Group. *Leading the way - preparing for the impacts of climate change in Washington: Recommendations of the Preparation and Adaptation Working Groups.* Olympia, WA: Washington State Department of Ecology, 2008, 84.

Peterson, Garry D., Graeme S. Cumming, and Stephen R. Carpenter. "Scenario planning: a tool for conservation in an uncertain world." *Conservation Biology* 17, no. 2 (April 2003): 358-366.

Peterson, William, and Franklin Schwing. "California Current Ecosystem." *Climate Impacts on U.S. Living Marine Resources: National Marine Fisheries Service Concerns, Activities and Needs.* Edited by K. E. Osgood. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-F/SPO-89, 2008. 118.

Peterson, William T., Rian C. Hooff, Cheryl A. Morgan, Karen L. Hunter, Edmundo Casillas, and John W. Ferguson. "Ocean conditions and salmon survival in the northern California Current." 2006, 52.

Pew Center on Global Climate Change. *The Greenhouse Effect.* 2011. http://www.pewclimate.org/global-warming-basics/facts_and_figures/greenhouse.cfm (accessed March 16, 2011).

Pew Center on Global Climate Change and Pew Center on the States (Pew Center). "Climate Change 101: Understanding and Responding to Global Climate Change: Adaptation." 2009. http://www.pewclimate.org/docUploads/Climate101-Complete-Jan09.pdf (accessed August 15, 2011).

Philip Williams & Associates, Ltd. "California Coastal Erosion Response to Sea Level Rise - Analysis and Mapping (pdf)." March 11, 2009. http://www.pwa-ltd.com/about/news-CoastalErosion/PWA_OPC_Methods_final.pdf (accessed June 10, 2011).

Pierce, David W. "Future changes in biological activity in the North Pacific due to anthropogenic forcing of the physical environment." *Climatic Change* 62 (2004): 389-418.

Pike, Robin G., et al. "Climate Change Effects on Watershed Processes in British Columbia." *Compendium of forest hydrology and geomorphology in British Columbia.* no. www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh66.htm. Edited by R. G. Pike, T. E. Redding, R. D. Moore, R. D. Winker and K. D. Bladon. B.C. Min. For. Range, For. Sci. Prog., Victoria, B.C. and FORREX Forum for Research and Extension in Natural Resources, Kamloops, B.C. Land Manag. Handb. 66, 2010.

PISCO, Parternship for Interdisciplinary Studies of Coastal Oceans. "Hypoxia off the Pacific Northwest Coast." Corvallis: PISCO, Oregon State University, 2009. 2.

PRBO, Conservation Science. "Projected effects of climate change in California: Ecoregional summaries emphasizing consequences for wildlife. Version 1.0 (pdf)." 2011. http://data.prbo.org/apps/bssc/uploads/Ecoregional021011.pdf (accessed March 1, 2011).

PSNERP, Puget Sound Nearshore Ecosystem Restoration Project. *About the Nearshore Project.* 2010. http://www.pugetsoundnearshore.org/what.htm (accessed December 22, 2010).

PSNP, Puget Sound Nearshore Project. *Guidance for Protection and Restoration of Nearshore Ecosystems of Puget Sound (pdf).* August 2003. http://www.pugetsoundnearshore.org/whatwedo/Guidance.pdf (accessed December 11, 2010).

PSWQAT, Puget Sound Water Quality Action Team. "Sound Facts: Eelgrass (pdf)." *Puget Sound Partnership Resource Center: Publications.* October 2001. http://www.psparchives.com/publications/our_work/misc/Fact_sheets/eelgrass.pdf (accessed April 13, 2011).

Rahmstorf, Stefan. "A semi-empirical approach to projecting future sea level rise." *Science* 315, no. 19 January (2007): 368-370.

Rahmstorf, Stefan. "The current climate." *Nature*, 2003: 699.

Raupach, Michael R., et al. "Global and regional drivers of accelerating CO_2 emissions." *Proceedings of the National Academy of Science* 104, no. 24 (June 2007): 10288-10293.

RCS, Ramsar Convention Secretariat. "Coastal management: Wetland issues in Integrated Coastal Zone Management (pdf),." 2007. http://www.ramsar.org/pdf/lib/lib_handbooks2006_e10.pdf (accessed April 14, 2011).

Reed, Thomas E., Pete Warzybok, Alistair J. Wilson, Russell W. Bradley, Sarah Wanless, and William J. Sydeman. "Timing is everything: flexible phenology and shifting selection in a colonial seabird." *Journal of Animal Ecology* 78 (2009): 376-387.

"Research Spotlights." *Eos* 92, no. 18 (May 2011): 17-19.

Ries, Justin B., Anne L. Cohen, and Daniel C. McCorkle. "Marine calcifiers exhibit mixed responses to CO2-induced ocean acidification." *Geology* 37, no. 12 (2009): 1131-1134.

Rignot, Eric, and Pannir Kanagaratnam. "Changes in the velocity structure of the Greenland Ice Sheet." *Science* 311, no. 5763 (February 2006): 986-990.

Rogers-Bennett, Laura, Richard F. Dondanville, James D. Moore, and L. Ignacio Vilchis. "Response of red abalone production to warm water, starvation, and disease stressors: implications of ocean warming." *Journal of Shellfish Research* 29, no. 3 (2010): 599-611.

Rost, Bjorn, Ingrid Zondervan, and Dieter Wolf-Gladrow. "Sensitivity of phytoplankton to future changes in ocean carbonate chemistry: current knowledge, contradictions and research directions." *Marine Ecology Progress Series* 373 (2008): 227-237.

Ruggiero, Peter, Cheryl A. Brown, Paul D. Komar, Jonathan C. Allan, Deborah A. Reusser, and II, Henry Lee. "Impacts of climate change on Oregon's coasts and estuaries." *Oregon Climate Assessment Report.* Edited by K. D. Dello and P. W. Mote. Corvallis, OR: College of Oceanic and Atmospheric Sciences, Oregon State University, 2010. 209-267.

Ruggiero, Peter, Paul D. Komar, and Jonathan C. Allan. "Increasing wave heights and extreme value projections: the wave climate of the U.S. Pacific Northwest." *Coastal Engineering*, 2010: 14, doi: 10.1016/j.coastaleng.2009.12.005.

Rykaczewski, Ryan R., and John P. Dunne. "Enhanced nutrient supply to the California Current Ecosystem with global warming and increased stratification in an earth system model." *Geophysical Research Letters* 37 (2010): 5.

Sabine, Christopher L., et al. "The oceanic sink for anthropogenic CO2." *Science* 305, no. 16 July (2004): 367-371.

Salathe Jr, Eric P, L Ruby Leung, Yun Qian, and Yongxin Zhang. "Regional climate model projections for the State of Washington." *Climatic Change* 102, no. 1-2 (2010): 51-75.

Sanford, Eric. "Community responses to climate change: links between temperature and keystone predation in a rocky intertidal system." Chap. 4 in *Wildlife Responses to Climate Change: North American Case Studies*, edited by Stephen H. Schneider and Terry L. Root, 165-200. Washington, DC: Island Press, 2002.

Sarkar, Nandita, T. C. Royer, and C. E. Grosch. "Hydrographic and mixed layer depth variability on the shelf in the northern Gulf of Alaska, 1974-1998." *Continental Shelf Research* 25 (2005): 2147-2162.

Sarmiento, J. L., et al. "Response of ocean ecosystems to climate warming." *Global Biogeochemical Cycles* 18 (2004): 23.

Sigler, M. F., et al. *Forecast fish, shellfish and coral population responses to ocean acidification in the north Pacific Ocean and Bering Sea: An ocean acidification research plan for the Alaska Fisheries Science Center.* AFSC Processed Rep. 2008-07, 17109 Point Lena Loop Road, Juneau AK 99801: Alaska Fisheries Science Center, NOAA, National Marine Fisheries Service, 2008, 35.

Sigler, Michael, J. Napp, and A. Hollowed. "Alaska Ecosystem Complex." *Climate Impacts on U.S. Living Marine Resources: National Marine Fisheries Service Concerns, Activities and Needs.* Edited by K. E. Osgood. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-F/SPO-89, 2008. 118.

Snover, A. K., P. W. Mote, L. Whitely Binder, A. F. Hamlet, and N. J. Mantua. "Uncertain Future: Climate Change and its Effects on Puget Sound. A report for the Puget Sound Action Team by the Climate Impacts Group (Center for Science in the Earth System, Joint Insititute for the Study of the Atmosphere and Oceans)." Seattle: University of Washington, 2005.

Snyder, Mark A., Lisa C. Sloan, Noah S. Diffenbaugh, and Jason L. Bell. "Future climate change and upwelling in the California Current." *Geophysical Research Letters* 30, no. 15 (2003): 1-4.

Somero, G. N. "The physiology of climate change: how potentials for acclimatization and genetic adaptation will determine ‘winners’ and ‘losers’." *The Journal of Experimental Biology* 213 (2010): 912-920.

Sorte, Cascade J. B., Susan L. Williams, and Robyn A. Zerebecki. "Ocean warming increases threat of invasive species in a marine fouling community." *Ecology* 97, no. 8 (2010): 2198-2204.

Spear, Larry B., and David G. Ainley. "Migration routes of sooty shearwaters in the Pacific Ocean." *The Condor* 101 (1999): 205-218.

Stafford, J. M., G. Wendler, and J. Curtis. “Temperature and precipitation of Alaska: 50 year trend analysis.” *Theoretical and Applied Climatology* 67 (2000): 33-44.

Steinacher, M., et al. "Projected 21st century decrease in marine productivity: a multi-model analysis." *Biogeosciences* 7 (2010): 979-1005.

Stewart, Iris T. "Changes in snowpack and snowmelt runoff for key mountain regions." *Hydrological Processes* 23 (2009): 78-94.

Stewart, Iris T., Daniel R. Cayan, and Michael D. Dettinger. "Changes toward earlier streamflow timing across western North America." *Journal of Climate* 18 (2005): 1136-1155.

TAG, WA Department of Ecology Topic Advisory Groups. "Integrated Climate Change Response Plan: Draft Topic Advisory Group Work Plan." November 3, 2009.

Tallis, Heather M. "Japanese Eelgrass." In *Invasive Species in the Pacific Northwest,* by P. Dee Boersma and Amy N. Van Buren, 26-27. Seattle, WA: University of Washington Press, 2006.

The H. John Heinz III Center for Science, Economics and the Environment. "Strategies for Managing the Effects of Climate Change on Wildlife and Ecosystems (pdf)." 2008. http://www.heinzcenter.org/publications/PDF/Strategies_for_managing_effects_of_climate_change_on_wildlife_Nov_4_2008.pdf (accessed April 7, 2011).

The Wildlife Society. *Global climate change and wildlife in North America: Technical review 04-2.* Technical Review, Bethesda: The Wildlife Society, 2004, 34.

Thom, Ronald M., et al. "Factors influencing spatial and annual variability in eelgrass (Zostera marine L.) meadows in Willapa Bay, Washington and Coos Bay, Oregon, Estuaries." *Estuaries* 28, no. 4B (2003): 1117-1129.

Thomas, R., et al. "Accelereated sea level rise from West Antarctica." *Science* 306, no. 8 October (2004): 255-258.

Tohver, Ingrid, and Alan F. Hamlet. "Impacts of 21st century climate change on hydrologic extremes in the Pacific Northwest region of North America." 2010. http://www.hydro.washington.edu/2860/products/sites/r7climate/study_report/CBCCSP_chap7_extremes_final.pdf (accessed August 15, 2011).

Tokay, Ali. *Chapter 13: Mid-latitude cyclones.* 2009. http://userpages.umbc.edu/~tokay/chapter13new.html (accessed January 18, 2011).

Trenberth, K.E., et al. “Observations: Surface and Atmospheric Climate Change.” *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental panel on Climate Change.* Edited by S. Solomon, et al. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press, 2007.

Trenberth, Kevin E., Aiguo Dai, Roy M. Rasmussen, and David B. Parsons. "The changing character of precipitation." *Bulletin of the American Meteorological Society* September (2003): 1205-1217.

Tribe, Jamestown S'Klallam. "Newsletter (Vol 32, Issue 2) (pdf)." February 2011. http://www.jamestowntribe.org/announce/newsletter/tribal_newsletter_2011_02.pdf (accessed April 7, 2011).

Tribes, Tulalip. "Climate Change Impacts on Tribal Resources (pdf)." 2006. http://www.tulalip.nsn.us/pdf.docs/FINAL%20CC%20FLYER.pdf (accessed April 7, 2011).

—. *The Tulalip Spartina Control Project: 1998 Annual Report.* July 16, 2002. http://www.tulalip.nsn.us/htmldocs/spartinacontrolproject.htm (accessed April 13, 2011).

UK Royal Society. "Ocean acidification due to increasing atmospheric carbon dioxide." The Royal Society, June 2005. 68.

UCAR, Univeristy Corporation for Atmospheric Research. *The Community Earth System Model: NCAR's latest step in the quest to model Earth's climate.* October 4, 2010. http://www2.ucar.edu/staffnotes/news/2746/community-earth-system-model (accessed December 10, 2010).

UCAR, University Corporation for Atmospheric Research. *Community Earth System Model: About CESM 1.0.* 2010. http://www.cesm.ucar.edu/models/cesm1.0/ (accessed December 10, 2010).

—. *Community Earth Systems Model.* 2010. http://www.cesm.ucar.edu/models/ (accessed December 10, 2010).

USAID, United States Agency for International Development. *Adapting to coastal climate change: A guidebook for development planners.* USAID, 2009, 148.

USEPA, United States Environmental Protection Agency. *Adaptation Planning for the National Estuary Program.* U.S. Environmental Protection Agency, 2009, 19.

—. *Environmental Justice Grant Recipients in the Pacific Southwest: Yurok Tribe Project.* March 24, 2011. http://www.epa.gov/region9/ej/ej-grants-projects.html (accessed April 7, 2011).

USEPA, United States Environmental Protection Agency. *National Estuary Program Coastal Condition Report. Chapter 6: West Coast National Estuary Program Coastal Condition, Puget Sound Action Team.* USEPA, 2007, 323-332.

USFWS, U.S. Fish and Wildlife Service. “Landscape Conservation Cooperatives: Better Conservation through Partnerships in the Pacific Region.” Fact Sheet, 2010, 4.

USFWS, U.S. Fish and Wildlife Service. “North Pacific Landscape Conservation Cooperative.” August 2010, 2.

—. *North Pacific Landscape Conservation Cooperative High Resolution Map (pdf).* 2010. http://www.fws.gov/pacific/climatechange/pdf/NPLCCMap.pdf (accessed December 15, 2010).

USFWS, U.S. Fish and Wildlife Service. *Pacific Lamprey (Lampara tridentata) Draft Assessment and Template for Conservation Measures.* Portland, OR: U.S. Fish and Wildlife Service, 2010, 276.

—. "Rising to the urgent challenge: strategic plan for responding to accelerating climate change (pdf)." *Conservation in a Changing Climate: Climate Change Strategy.* September 2010. http://www.fws.gov/home/climatechange/pdf/CCStrategicPlan.pdf (accessed March 8, 2011).

US-GCRP, US Global Change Research Program. "Global Climate Change Impacts in the United States." *U.S. Global Change Research Program.* Edited by T. R. Karl, J. M. Melillo and T. C. Peterson. June 16, 2009. http://downloads.globalchange.gov/usimpacts/pdfs/climate-impacts-report.pdf (accessed November 29, 2010).

Vaquer-Sunyer, Raquel, and Carlos M. Duarte. "Thresholds of hypoxia for marine biodiversity." *Proceedings of the National Academy of Sciences* 105, no. 40 (2008): 15452-15457.

Vermeer, Martin, and Stefan Rahmstorf. "Global sea level linked to global temperature." *Proceedings of the National Academy of Sciences* 106, no. 51 (December 2009): 21527-21532.

Vincent, Lucie A., and Eva Mekis. "Changes in daily and extreme temperature and precipitation indices for Canada over the twentieth century." *Atmosphere-Ocean* 44, no. 2 (2006): 177-193.

WA-DNR, WA Department of Natural Resources. "Eelgrass Stressor-Response Report: 2005-2007 Report." December 2007. http://www.dnr.wa.gov/Publications/aqr_nrsh_05_07_biennial_report.pdf (accessed August 16, 2011).

WA-ECY, Washington State Department of Ecology. *Offshore Fault.* 2011. http://www.ecy.wa.gov/programs/sea/coast/waves/fault.html (accessed January 17, 2011).

Wall, Dennis. "Indigenous Perspectives on Climate Change (pdf)." *Tribes and Climate Change: Tribal Profiles: Traditional Knowledge.* 2009. http://www4.nau.edu/tribalclimatechange/tribes/docs/tribes_IndigenousPers.pdf (accessed April 7, 2011).

Wang, Muyin, James E. Overland, and Nicholas A. Bond. "Climate projections for selected large marine ecosystems." *Journal of Marine Systems* 79 (2010): 258-266.

Ward, David H., Austin Reed, James S. Sedinger, Jeffrey M. Black, Dirk V. Derksen, and Paul M. Castelli. "North American Brant: effects of changes in habitat and climate on population dynamics." *Global Change Biology* 11 (2005): 869-880.

Warren Pinnacle Consulting, Inc. "SLAMM Overview Powerpoint." *SLAMM: Sea Level Affecting Marshes Model.* December 23, 2010a. http://warrenpinnacle.com/prof/SLAMM/index.html (accessed April 2, 2011).

—. *SLAMM: Sea Level Affecting Marshes Model: SLAMM Version and Development History.* October 20, 2010b. http://warrenpinnacle.com/prof/SLAMM/SLAMM_Versions.html (accessed April 2, 2011).

Washington State Department of Ecology. *Preparing for impacts: adapting to climate change.* 2011. http://www.ecy.wa.gov/climatechange/adaptation.htm (accessed January 13, 2011).

—. *Topic Advisory Groups.* 2011. http://www.ecy.wa.gov/climatechange/2010TAG.htm (accessed January 13, 2011).

WCGA. *West Coast Governors' Agreement on Ocean Health: Action Teams.* February 15, 2011a. http://westcoastoceans.gov/teams/ (accessed April 14, 2011).

WCGA, West Coast Governors' Agreement on Ocean Health. "West Coast Governors' Agreement on Ocean Health: Climate Change Action Coordination Team Work Plan (pdf),." *West Coast Governors' Agreement on Ocean Health: Action Teams.* May 2010. http://westcoastoceans.gov/Docs/Climate_Final_Work_Plan.pdf (accessed April 14, 2011).

—. *West Coast Governors' Agreement on Ocean Health: Home,.* February 15, 2011b. http://westcoastoceans.gov/ (accessed April 14, 2011).

Wells, Brian K., Churchill B. Grimes, John G. Sneva, Scott McPherson, and James B. Waldvogel. "Relationships between oceanic conditions and growth of Chinook salmon (Oncorhynchus tshawytscha) from California, Washington, and Alaska, USA." *Fisheries Oceanography* 17, no. 2 (2008): 101-125.

West, Jordan M., et al. "U.S. natural resources and climate change: concepts and approaches for management adaptation." *Environmental Management* 44 (2009): 1001-1021.

West Coast EBM Network. "Community-based management of coastal ecosystems: Highlights and lessons of success from the West Coast Ecosystem-Based Management Network (pdf),." May 2010. http://www.westcoastebm.org/WestCoastEBMNetwork_EBMGuide_June2010.pdf (accessed April 14, 2011).

WGII, IPCC Working Group II. "Coastal systems and low-lying areas." *Climate Change 2007: Impacts, Adaptation, and Vulnerability.* Vol. Chapter 6. 2007. 42.

—. "North America." *Climate Change 2007: Impacts, Adaptation, and Vulnerability.* Vol. Chapter 14. Intergovernmental Panel on Climate Change, 2007. 36.

Whitely Binder, Lara C., et al. "Preparing for climate change in Washington State." *Climatic Change* 102 (2010): 351-376.

Whitney, Frank A., Howard J. Freeland, and Mary Robert. "Persistently declining oxygen levels in the interior waters of the eastern subarctic Pacific." *Progress in Oceanography* 75 (2007): 179-199.

Wolf, Shaye G., Mark A. Snyder, William J. Sydeman, Daniel F. Doak, and Donald A. Croll. "Predicting population consequences of ocean climate change for an ecosystem sentinel, the seabird Cassin's auklet." *Global Change Biology* 16 (2010): 1923-1935.

Wootton, J. Timothy, Catherine A. Pfister, and James D. Forester. "Dynamic patterns and ecological impacts of declining ocean pH in a high-resolution multi-year dataset." *Proceedings of the National Academy of Science* 105, no. 48 (2008): 18848-18853.

Wright, Nikki. *Eelgrass conservation for the B.C. coast: a discussion paper.* SeaChange, 2002, 16.

Yukon Government. *Executive Council Office: General Facts: Land.* July 29, 2011. http://www.eco.gov.yk.ca/stats/1467.html (accessed August 4, 2011).

Yukon Government. *Government of Yukon Climate Change Strategy.* Whitehorse: Yukon Department of Environment, Policy and Planning Branch, July 2006, 20.

Yukon Government. *Yukon Government Climate Change Action Plan.* Whitehorse: Environment Yukon, Environmental Programs Branch, February 2009, 48.