I. INTRODUCTION

This report compiles existing knowledge on known and potential climate change effects on marine and coastal ecosystems within the geographic extent of the North Pacific Landscape Conservation Cooperative (NPLCC). The report also includes a menu of policy and management responses, culled from published science and grey literature, to adapt to climate change in marine and coastal environments. The North Pacific Landscape Conservation Cooperative is one of twenty-one Landscape Conservation Cooperatives (LCCs) planned for the United States, Canada, and Mexico.[1] LCCs are member-directed conservation partnerships among State and Federal agencies, Tribes, nongovernmental organizations, universities, existing partnership efforts, and other conservation entities.[2] Other key partners of the NPLCC will be the three regional Climate Science Centers (CSCs) within the geographic area of the NPLCC – Alaska, Northwest, and Southwest CSCs.[3] The CSCs will deliver basic climate change impact science for their region, prioritizing fundamental science, data and decision-support activities based principally on the needs of the LCCs.[4] LCCs will link the science with conservation delivery.[5] Thus, LCCs are management-science partnerships that inform resource management actions and provide needed tools.[6] They provide a forum for identifying common science questions and needs for the defined landscapes, across organization lines.[7] More specifically, LCCs generate applied science to inform conservation actions related to climate change, habitat fragmentation, and other landscape-level stressors and resource issues.[8] For further information, please see http://www.fws.gov/science/shc/lcc.html (accessed March 14, 2011).

Description of NPLCC

The NPLCC region comprises approximately 204,000 square miles (530,000 square kilometers, km^2) in six western U.S. states and Canadian provinces (see Figure 3 on page 4).[9] Public lands make up approximately 78 percent, or 159,000 square miles (412,000 km^2) of the NPLCC, with 82,000 square miles (212,000 km^2) of Federal lands in the U.S. portion of the NPLCC and 77,000 square miles (200,000 km^2) of Crown lands in the Canadian portion of the NPLCC.[10] The total amount of coastline is

[1] *US Fish and Wildlife Service. *Landscape Conservation Cooperatives: Better Conservation through Partnerships in the Pacific Region.* (2010, p. 1)
[2] *USFWS. *North Pacific Landscape Conservation Cooperative*. (August 2010, p. 1)
[3] USFWS. *North Pacific Landscape Conservation Cooperative (pdf, website).* (December 2010, p. 2). A total of eight CSCs are being established to support the 21 LCCs. They consist mainly of university-based consortiums.
[4] *U.S. Department of the Interior. *Interior's plan for a coordinated, science-based response to climate change impacts on our land, water, and wildlife resources (pdf, website).* (n.d., p. 2)
[5] *U.S. Department of the Interior. *Interior's plan for a coordinated, science-based response to climate change impacts on our land, water, and wildlife resources (pdf, website).* (n.d., p. 5)
[6] *USFWS. *North Pacific Landscape Conservation Cooperative*. (August 2010, p. 1)
[7] *USFWS. *North Pacific Landscape Conservation Cooperative*. (August 2010, p. 1)
[8] *USFWS. *North Pacific Landscape Conservation Cooperative*. (August 2010, p. 1)
[9] USFWS. *North Pacific Landscape Conservation Cooperative High Resolution Map.* (2010). Within the Yukon Territory (YT; 186,272 mi^2, 482,443 km^2), the only land within the NPLCC region is that covered by the Kluane National Park and Preserve (8,487 miles^2, 21, 980 km^2; ~4.6% of total area in YT), located in the southwest corner of the Territory. While information on climate change adaptation planning in Kluane National Park and Preserve was limited, information for the Government of Yukon was available. Please see Chapter VIII, Section 8 for further information.
[10] USFWS. *North Pacific Landscape Conservation Cooperative High Resolution Map.* (2010)

approximately 38,200 miles (~ 61,500 km)[11] and extends from Kenai Peninsula in southcentral Alaska to Bodega Bay in northern California. The inland extent of the NPLCC is delineated according to the Pacific Flyway, ecoregions, and the crests of several mountain ranges and, from the coast, stretches inland up to 150 miles (~240 km); therefore only the lower extent of many of the larger river watersheds are included within the area. This area encompasses a variety of water forms including bays, estuaries, inlets, and lagoons. Land types include deltas, coastal dunes and beaches, rocky shores, salt marshes, and mudflats. A wide variety of fish, wildlife, and other organisms populate this region.

Organization of Report

Key findings begin in Chapter II, which describes observed trends and future projections, both globally and within the NPLCC geography, for greenhouse gas concentrations, temperature, and precipitation. Chapter III describes the primary effects of changes in greenhouse gas concentrations, temperature, and precipitation on ocean acidification, sea surface temperature, hydrology, ocean currents, storms, sea level, coastal upwelling, and hypoxia and anoxia in the NPLCC region. The report then describes how the changes presented in Chapter II and the effects presented in Chapter III impact marine and coastal ecosystem processes (Chapter IV), the geomorphology of coastal nearshore systems (Chapter V), species behavior and community-level responses (Chapter VI), and specific fish, wildlife, plants, plankton, and shellfish (Chapter VII) in the NPLCC region. In Chapter VIII, the report provides a menu of policy and management responses to address the impacts of climate change on species and habitats in the marine and coastal environment described in Chapters IV-VII. These responses are based on the general tenets of climate change adaptation for natural systems and are culled from published scientific literature, grey literature, and interviews with experts throughout the NPLCC region. Chapter IX briefly describes future work in the NPLCC region. Six appendices provide key terms and definitions, an explanation of climate modeling and emissions scenarios, an explanation of long-term climate variability, a discussion of the Sea level Affecting Marshes Model (SLAMM), resources for adaptation principles and responses to climate change, and a list of reviewers and interviewees.

Definitions for Marine and Coastal Environments

In this report, we use definitions for marine and coastal areas based on oceanography and law (Figure 1 and Figure 2).[12] **Nearshore** areas extend from the farthest reach inland of tidally-influenced water to the depth of light penetration in the ocean (usually about 10 meters).[13] **Coastal waters** are described often as extending to the edge of the continental shelf. The **open ocean** is described often as the area beyond the edge of the continental shelf.

[11] USFWS. *North Pacific Landscape Conservation Cooperative High Resolution Map.* (2010)
[12] NOAA. *Federal Geographic Data Committee's (FCDG) Marine Boundary Working Group Shoreline Boundaries Diagram*. (2010). The mean higher high water (MHHW) is the average of the higher high water height of each tidal day. The mean lower low water (MLLW) is the average of the lower low water height of each tidal day. The mean high water (MHW) is the average of all high water heights.
[13] Puget Sound Nearshore Project (website). (2003); Puget Sound Nearshore Ecosystem Restoration Partnership (website).(2010).

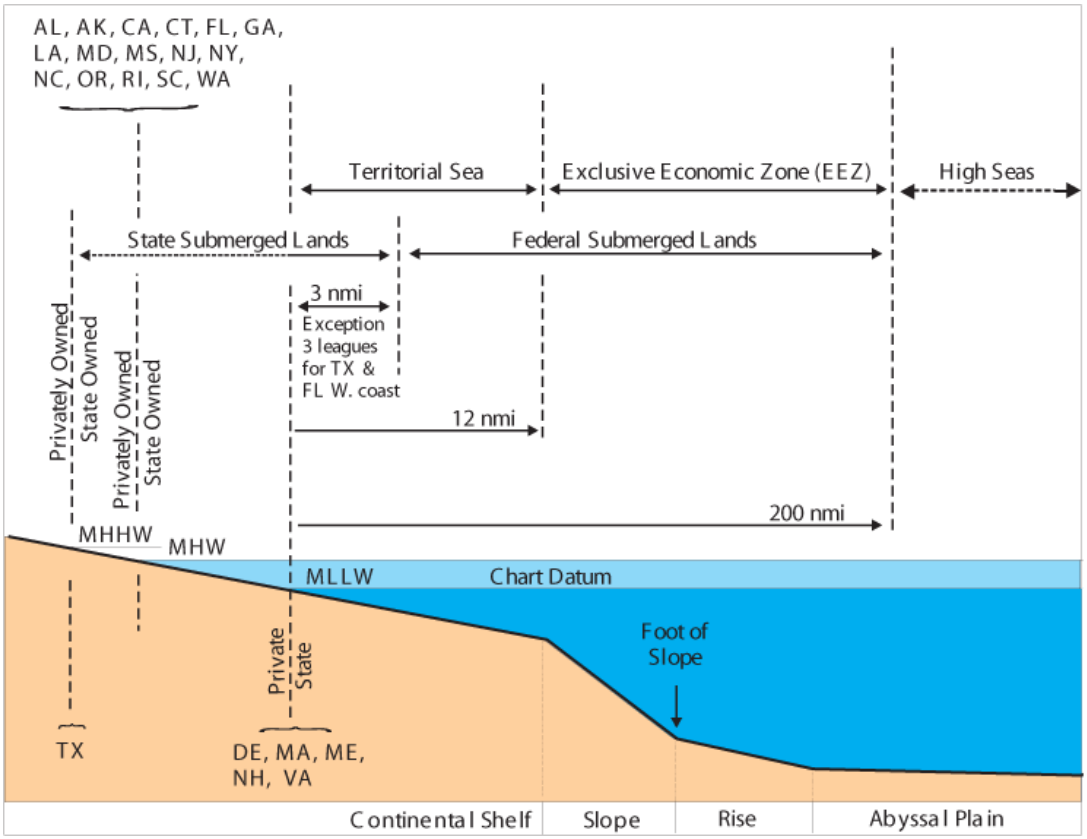

Figure 1. This diagram illustrates shoreline boundaries as defined by different states as well as seaward boundaries (state and federal submerged lands, contiguous zone, territorial seas, exclusive economic zone, etc.).
Source: NOAA. Federal Geographic Data Committee's (FCDG) Marine Boundary Working Group Shoreline Boundaries Diagram. (2010).

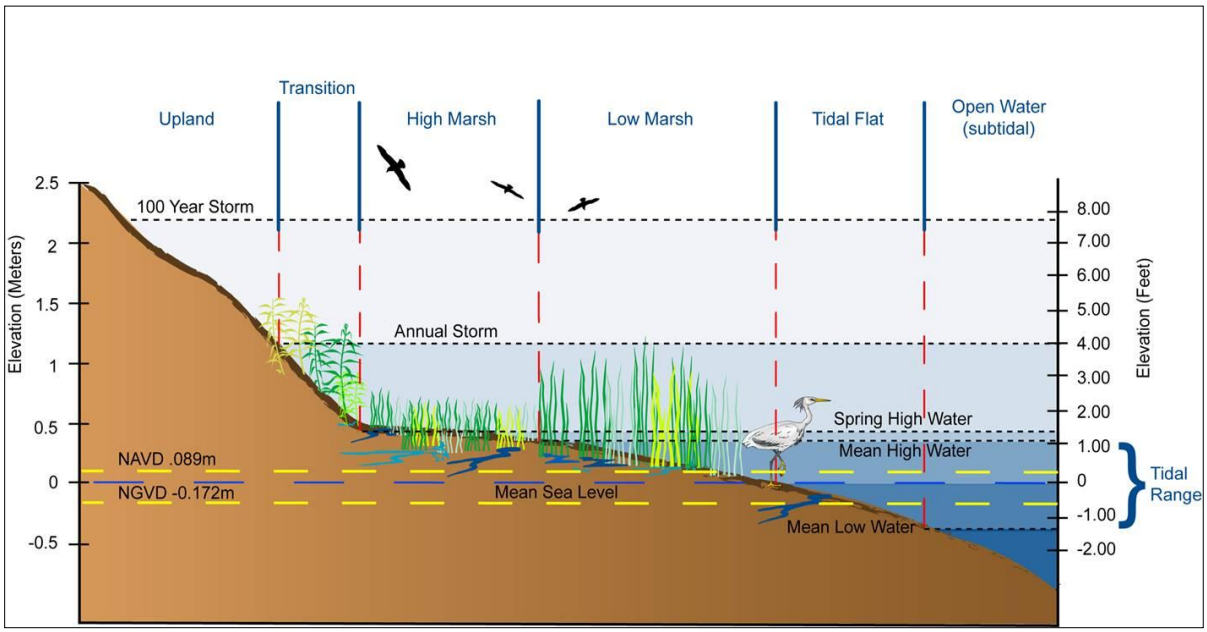

Figure 2. General marine habitat types and associated tidal influence.
Source: http://maps.risingsea.net/wetland_loss/tides_wetlands_elevation.jpg (accessed 2.11.2011)

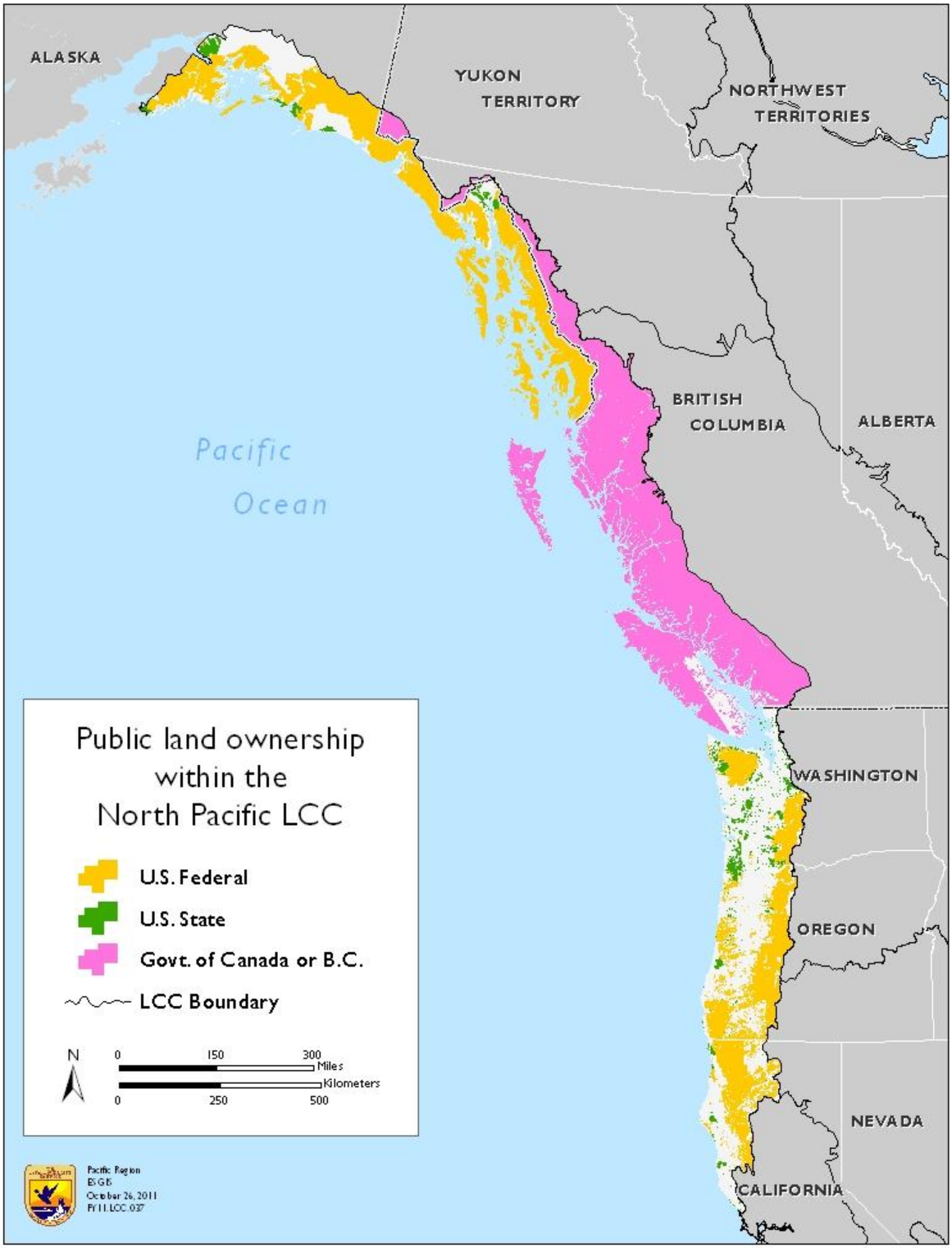

Figure 3. Public land ownership within the North Pacific Landscape Conservation Cooperative (NPLCC). *Source: U.S. Fish and Wildlife Service (2011). This is a preliminary land ownership map, including only federal, state, and provincial lands. At a later date, the map will be updated to include Native Alaskan, First Nations, and Tribal lands. Lands owned by other entities (e.g. NGOs, private property) may be included as well.*