California Ocean Science Trust

Literature Review for the West Coast Regional Needs Assessment

Prepared for the National Oceanic Atmospheric Administration Coastal Services Center

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1. Introduction

This report is an overview of the priority issues for the U.S. West Coast coastal resources management community based on existing literature, surveys, and needs assessments. A broad range of documents from Washington, Oregon, and California as well as national documents were reviewed (Table 1). The report is categorized into four thematic areas: 1) resiliency and adaptation to coastal changes resulting from climate change; 2) regional coastal and ocean planning; 3) implementing coastal management and habitat conservation at the ecosystem level; and 4) data and information access and usability (Table 1). California, Oregon, and Washington have more than 1,500 miles of coastline with vast rural areas, moderate sized coastal communities, and major metropolitan centers. Coastal population growth and development has historically been concentrated in urban areas but the increase in urbanization and other development will increase pressures on coastal resources within and around these population centers as a result. In 2004, the Costal States Organization (CSO) conducted and sponsored a national survey of state coastal resource managers to better understand their research and technology needs. The results for this survey were presented by region and the responses for the Pacific Region are in Table 2. The Pacific Region ranked land use and habitat as the top priority issues for this report. The Pacific region's state coastal programs continue to acknowledge these areas as priority issues by ranking cumulative and secondary impacts, wetlands, and coastal hazards as their primary concerns in their 2006 assessment and strategy reports (Table 3). This report attempts to summarize these findings and provide a useful guide to the priorities from a diverse compilation of documents.

2. Tables and General Information

Table 1: Issues of the West Coast Region

	Resiliency and Adaptation to Climate Change				Coastal and Ocean Planning						Habitat				Data			Crosscutting Issues	
Selected Literature	Communities	Ecosystems	Hazards	Coastal Processes	Regional, State Ocean Planning	Land Use Planning (Zoning)	Engineering/ Erosion/ Sediment Management	Ocean Energy	Aquaculture	Infrastructure	Watershed	Water Quality	Conservation/Restoration	Mapping	Access	Usability	Transparency	Ocean Observing	Ecosystem-Based Management
West Coast Gov Agreement	X				X		X	X				X	X	X	X			X	X
CSO Adaptation to Climate Change	X			X			X			X				X		X			
WA Ocean Action Plan	X		X		X		X			X				X				X	X
WA Dept of Ecology Strategic Plan		X									X	X							
WA Sea Grant	X	X	X											X					
WA - Puget Sound Conserv./Recov. Plan		X		X							X		X		X	X			
OR Conserv. Strategy													X						
OR Nearshore Strat						X								X					
OR - Coos Bay Strategic Plan					X	X	X					X	X	X					
OR Sea Grant	X		X						X					X	X				
SCC Infrastructure Plan										X	X			X					
CA OPC Strategic Plan		X					X					X	X	X	X				X
Protecting Our Ocean CA's Action Strategy							X		X	X	X	X			X			X	X
CA - Elkhorn Slough Conservation Plan												X	X						
CA Hazard Mitigation	X		X				X												

Table 2: Coastal States Organization National Survey Results: West Coast Managers' Priority Issues and Needs
(Coastal States Organization 2004a)

Management Issue Ranked Very Important or Important		Top-Ranked Research Need		Top-ranked Information Need		Top-ranked Technology Need	
Land use	93%	Quantify impact of land use on water quality	60%	Land use change analysis	60%	Affordable remote sensing	61%
Habitat	90%	Evaluate effectiveness of restoration/ protection techniques	70%	Ecological and physical baselines and inventories	86%	Low cost remote sensing platforms to measure change	50%
Sediment management	65%	Prioritize restoration/ protection based on maximum benefit for cost	43%	Sediment transport patterns	55%	Methods for quantifying sediment budgets	69%
Environmental contamination	59%	Identification of sources	68%	Remediation options	51%	Rapid/real time detection	66%
Non-indigenous species	56%	Effectiveness of BMPs	66%	Ecosystem inventory	85%	Rapid detection and monitoring	92%
Nutrient enrichment	51%	Source identification/ tracking	89%	BMP effectiveness or cost/benefit analysis	74%	Effective mitigation strategies	60%
Coastal hazards	50%	Risk and vulnerability assessments	52%	More geospatial data for GIS	72%	Improved models that simulate and predict	69%
Ocean management	44%	Marine managed area effectiveness	60%	More geospatial data for GIS	87%	Nondestructive bottom fishing gear	69%
Marine debris	24%	Ecological impacts	78%	Public outreach and education	57%	Debris removal technology	59%

Table 3: Priority Issues for the Pacific States Coastal Zone Management Programs*

	California	San Francisco Bay	Oregon	Washington
Cumulative and Secondary Impacts	High	High	Medium	High
Coastal Hazards	High	High	High	Medium
Wetlands	High	High	High	Medium
Ocean and Great Lakes Resources	Medium	Low	High	Medium
Special Area Management Planning	High	Medium	High	Low
Public Access	High	High	Medium	Medium
Energy and Government Facility Siting	Medium	High	Medium	Low
Aquaculture	Medium	Low	Low	Medium
Marine and Lake Debris	Medium	Low	Low	Low

***** Note: Priorities are based on the current Coastal Zone Management Program (CZMP) 309 Assessment and Strategy Reports (2006)

3. Thematic Area 1: Resiliency and Adaptation to Climate Change

Coastal areas are vulnerable to climate change due to sea level rise, shoreline erosion, increased storm frequency or intensity, changes in rainfall, and related flooding. Other impacts may include changes in chemical (ocean acidification) and physical characteristics (thermal stratification) of marine systems, saltwater intrusion into groundwater aquifers, increased harmful algal blooms, spread of invasive species, habitat loss (especially coastal wetlands), species migrations, and changes in population dynamics among marine and coastal species. Preparing for these impacts has been termed "adaptation" by the coastal research and management community. As state and local governments consider future climate change policies and strategies, coastal zone management programs will play an important role in identifying vulnerabilities and fostering adaptation to climate change (CSO 2007).

Coastal programs are beginning to address climate change by examining the social, environmental, and economic impacts of accelerated sea level rise scenarios, resulting shoreline changes, and potential adaptation strategies. Existing coastal zone management programs and policies were based upon a relatively predictable rate of sea level rise (CSO 2007). The challenge for coastal managers is to devise adaptation strategies for a variety of sea level rise scenarios and adjust these in the future as forecasting improves. New policies are being developed to address the siting of public infrastructure, site-level project planning, wetland conservation and restoration, shoreline building setbacks, building elevations, and alternatives to shoreline "armoring." Coastal programs are interested in decision-support tools that compile historical shorelines, geomorphology, socioeconomic data, and model projections (CSO 2007). Coastal programs are partnering with Sea Grant and the National Estuarine Research Reserve System for extension and outreach activities (CSO 2007).

3.1 Impacts on Communities

All three west coast states have identified the need to foster resilient coastal communities. While states recognize the value in a community's ability to adapt to coastal changes, no plans have yet specifically discussed climate change impacts on community resiliency. In this section, general information on resiliency is provided; further discussion of community responses to

hazards and community-ecosystem interactions in the face of climate change are located in sections 3.3 and 3.4.

The National Oceanic and Atmospheric Administration (NOAA) identifies a resilient community as one that has the capacity to recover after a natural disaster has occurred (NOAA Office of Communications 2008). Common characteristics of a resilient coastal community are: diverse economic activities; strong community self-management systems, including management zoning to regulate future resource and coastal development; involvement of community members in significant community decisions; well-developed community partnerships and collaborative working relationships; effective management structures for sustainable resource use; support for education; and infrastructure that provides for alternatives, such as multiple access roads and water supply systems (URI 2006). Characteristics that help define an ecologically resilient community are: effective management of areas of natural vegetation; identification and incorporation of areas of high risk into land use planning; and re-establishment of buffer zones in areas of high risk where natural vegetation has been cleared. Many of these impacts will require adaptation solutions that cross federal, state, regional, and local agencies, programs, policies, and political jurisdictions (URI 2006).

Washington's coastal program is investigating how and whether to address climate change through city and county Shoreline Master Programs (SMPs) (CSO 2007). Local SMPs regulate new development and use of shorelines along larger rivers, lakes over 20 acres, and marine waterfronts (WDE 2008b). The state coastal program is examining use of the State Environmental Policy Act (SEPA) to incorporate effects of climate change in project planning (CSO 2007).

Oregon's Coastal Program is working with Oregon Sea Grant, South Slough National Estuarine Research Reserve, and the Governor's Office of Climate Change to convene an interagency forum to develop a climate change report for the 2009 Oregon legislature (CSO 2007).

California's San Francisco Bay Conservation and Development Commission (BCDC) recognizes a need for vulnerability studies that focus on the socio-economic consequences of climate change effects. California's Coastal Program staff are participating in the State's Multi-Hazard Mitigation Plan and urging the Governor's Office of Emergency Services to include

global warming issues in the Plan; and are encouraging coastal communities to amend their local coastal plans to include an element that focuses on sea level rise, erosion, flooding, and other climate change impacts (CSO 2007).

Meanwhile, California's Coastal Commission is working with the California Ocean Protection Council (OPC) to respond to state climate change legislation, namely California Assembly Bill 32. AB 32, the California Global Warming Solutions Act of 2006, mandates reduction of greenhouse gas emissions to 1990 levels by 2020 (California State Assembly 2006). In response, the Commission needs to identify specific actions within its authority to reduce greenhouse gas emissions and adapt to anticipated impacts of global warming (CSO 2007).

3.2 Ecosystems

Ecosystems in all three west coast states will be affected by climate change. Anticipated coastal effects of climate change include sea level rise, erosion, inundation of low lying areas, and water temperature warming. Inland portions of watersheds may also be affected changes in precipitation and hydrologic patterns including decreased snow pack and earlier snow melt. Offshore, hypoxia and harmful algal blooms (HABs) manifest the planet's changing climate in ways that affect marine resources. These offshore issues are discussed in section 5.2: Water Quality. There was no specific needs information on impacts of climate change on ecosystems for Oregon or California. Washington's Puget Sound Partnership (PSP) has elaborated on effects of climate change on ecosystems and associated management needs.

Washington State's needs regarding climate change ecosystem issues are varied and information-based. For the Puget Sound ecosystem, resource managers need more scientific information related to the effects of climate change. The Puget Sound Partnership is a new state agency, created by the 2007 Washington Legislature to lead the recovery of Puget Sound's health by 2020. The Puget Sound Partnership released a report in 2005 developed by the Climate Impacts Group at the University of Washington documenting changes in Pacific Northwest climate and hydrologic patterns to date. The report identified Puget Sound ecosystem conditions and resources likely to experience impacts due to changes predicted by climate models (PSP 2007). The region is likely to experience average warming of several degrees by mid-century (PSP 2007), with modest increases in winter precipitation, but greater runoff in streams because

more precipitation is predicted to fall as rain rather than snow. The snowpack that feeds and cools many rivers in the basin in spring and early summer is predicted to decrease, and the region could experience higher winter flows, including more flooding, and lower flows during spring and summer (PSP 2007).

Impacts on the Puget Sound ecosystem from these changes are predicted to include greater stress for salmon and other freshwater aquatic species, changes to Puget Sound circulation, salinity and stratification patterns, and warmer water temperatures. Fragile marine aquatic species whose life cycles depend on narrow ranges of conditions will be most severely affected. Nearshore salt marshes and other estuarine habitats that many species depend upon at critical life stages will be at risk of erosion and flooding. Increased bluff erosion and human efforts to limit this process could further imbalance the Sound's nearshore habitats (PSP 2007).

The 2007-2009 Puget Sound Partnership Conservation and Recovery Plan developed four strategies to prepare and adapt efforts to a changing climate (PSP 2007). The first strategy is to support, track, and report on science related to the effects of climate change on the Puget Sound ecosystem. This will be achieved by providing two reports annually on the most recent scientific studies relating to climate change and its impact on marine systems; and a workshop will be held for regional scientists and resource managers to exchange research findings on the implications of climate change to the Puget Sound region (PSP 2007).

The second strategy is to provide risk-assessment models to help identify vulnerabilities to existing infrastructure and work with affected entities to prepare for or respond to potential impacts. A risk-assessment model applicable to Puget Sound will be provided to state, local, and tribal government agencies. Key individuals in federal, state, local and tribal agencies will identify how a risk assessment model meets their needs and will apply the model to drafting risk-assessment plans for their areas of responsibility (PSP 2007).

The third strategy is to review state, federal, and local activities and expenditures on conservation and recovery in the Puget Sound basin in light of climate change impacts, and make specific recommendations for changes, if necessary. A report will be produced to address the most recent research relating to implications to conservation and recovery activities, with recommendations for changes to these activities. Regional leaders working on conservation and

recovery projects will incorporate the recommendations on possible climate change impacts into conservation and recovery plans (PSP 2007).

The fourth strategy is to make recommendations on management and planning adaptations in response to climate change for all levels of government in Puget Sound. A strategy will be developed for state agencies to examine how resource management policies would perform in the future if various elements of climate were altered. There will also be a system developed to monitor and report on regional climate and ecosystems with an adaptive management loop built in to incorporate monitoring findings into management and planning decisions (PSP 2007).

3.3 Hazards

Coastal hazards related to climate change can be chronic or episodic and threaten the health of coastal ecosystems and communities. Coastal hazards impact Washington, Oregon, and California at varying temporal and spatial scales and include flooding, episodic storms, erosion, shoreline change, earthquakes, tsunamis, and sea level rise. Here, the first section discusses Washington; the second section lists hazards identified by Oregon's Coastal Zone Management Program; the third section addresses general issues of sea level rise and California's sea level rise response needs; and the final section addresses potential impacts of climate-related hazards, especially sea level rise. Erosion and shoreline change are covered more thoroughly in Section 4.3: Erosion and Sediment Management. For an overview of modeling needs related to coastal hazards, as well as on topics of water quality and coastal habitats, please refer to the 2007 National Ocean Service document, *Establishing National Ocean Service Priorities for Estuarine, Coastal, and Ocean Modeling: Capabilities, Gaps, and Preliminary Prioritization Factors*, by E.T. Cloyd, et al. Since no needs were identified as specific west coast issues, the document is not discussed in detail in this literature review.

Washington's coast is susceptible to a variety of natural threats including storms, flooding, landslides, tsunamis, earthquakes, erosion, and sea level rise (WA OPWG 2006). Washington is one of the most flood-prone states with 25 presidential disaster declarations for flooding between 1971 and 2001. Coastal flooding and landslides occur in low lying places and coastal areas with unstable bluffs when winter storms coincide with high tides, often

accompanied by severe wind and waves (WDE SEAP 2006). Washington Sea Grant recently partnered with the NOAA Coastal Storms Initiative (WA OPWG 2006). They are currently working to improve storm prediction and observations by deploying more buoys and sensors and developing computer models, especially for the Lower Columbia River (WA OPWG 2006). Significant hazard events put lives, property, infrastructure, ecosystems, and the economy at risk. Coastal communities face the complex task of balancing economic development needs with hazard mitigation. Changing existing infrastructure and development patterns to reduce hazard risk presents challenges (WA OPWG 2006).

State, local, tribal, and federal involvement is essential to reduce risks. This includes land use planning, data collection on hazards, hazard avoidance and mitigation, and response planning. While state agencies partner well on some specific issues like tsunamis, they would benefit from continued coordination to comprehensively address all coastal hazards (WA OPWG 2006). Local land use planning in hazardous areas requires solid data and risk protocols. Many local participants in OPWG outreach sessions acknowledged that they and their communities lacked preparedness for hazard events. Some efforts do exist for specific hazard issues, such as the State/Local Tsunami Workgroup but Washington does not have an integrated and coordinated mitigation program for all coastal hazards. This hinders assessments of needs and improvements to response and preparedness (WA OPWG 2006).

The Oregon coast is subject to a variety of natural hazards associated with processes that occur across a wide range of spatial and temporal scales. In Oregon, there is a high risk of flooding, episodic erosion, chronic erosion, earthquakes, tsunamis, and co-seismic subsidence; a moderate risk of sand inundation; and a low risk of hurricane/typhoon, sea-level rise, and storm surge (OCMP 2006). Chronic hazards are those that are local in scale and scope, occur with relative frequency (e.g., monthly, seasonally, or annually), and can be reasonably predicted. Chronic hazards in Oregon, along dune-backed shorelines, include ocean flooding, beach and dune erosion, and sand inundation (OCMP 2006). However, along bluff-backed shorelines, shallow sloughing and deep-seated landsliding/slumping occur. Erosion associated with inlet migration is also considered to be chronic (OCMP 2006).

Previous §309 Assessments for Oregon consistently determined that improvements were needed in the Coastal Hazards program. Strategies focused on developing and implementing

meaningful coastal hazards policies; identifying, quantifying, and assessing hazards; developing mitigation techniques; and educating the public, developers, and local governments about hazards. Additional enhancement areas were not considered high priorities for the OCMP, either because no significant management problems existed or the state already had effective mechanisms for dealing with the resource management issue (OCMP 2006).

Decreasing financial resources impeded new research efforts to increase Oregon's understanding of coastal processes and hazards. The Department of Geology and Mineral Industries (DOGAMI) has only limited staff and funding to accomplish this work. The following describes existing gaps or deficiencies and areas where improvements are needed:

• Continued reliance on site-specific decision-making on the Oregon coast, specifically in regards to upland development and response to erosion events.

• Better understanding of littoral cell sand budgets and the response of beach systems to storms and climatic events.

• New plans and policies to identify beach segments or littoral cells that have not yet been impacted by shoreline armoring.

• Consideration of special policies or planning efforts to prevent the proliferation of shoreline protective structures.

• Specific guidelines or content standards for geologic reports involving coastal hazards (dune and luffbacked shorelines, and coastal landslides) to improve decisions on coastal development in identified hazard areas.

• Ongoing training for professional geological, engineering, and planning consultants to keep current on new studies and data.

• Hazard mapping has been completed for some coastal communities; however local jurisdictions have not yet incorporated this information into their comprehensive plans or ordinances.

• Continued catastrophic hazard identification, planning, and education efforts along the Oregon coast.

• Enhanced and expanded monitoring efforts to increase knowledge of shoreline processes and the effects of shoreline armoring (OCMP 2006).

Region-wide Cascadia Subduction Zone seismic events that cause severe ground-shaking, soil liquefaction, landsliding and land subsidence, and create an accompanying tsunami, fall into the catastrophic hazard category (WA OPWG 2006). Major earthquakes in the Pacific Ocean can generate tsunamis that impact Washington's outer coast and Strait of Juan de Fuca. A local Cascadia Subduction earthquake could cause the level of the coast to fall six feet concurrently increasing sea level. Several tsunamis have struck the state's shoreline throughout history, including three since 1960. Projected tsunami wave heights for Washington's coastal communities vary between 4 and 30 feet. In the next 50 years, there is a 10 to 14 percent chance that a magnitude 9 or greater earthquake and a resulting tsunami will occur in the area directly off the state's outer coast (WA OPWG 2006).

As mentioned, the potential impacts of climate change include increased frequency and intensity for severe weather and winter storms that may result in increased coastal flooding and erosion. All of these hazards may be exacerbated by the predicted rise in sea level. Sea level rise is frequently discussed as the most apparent physical coastal impact from climate change (CA OES 2007). Besides the increasing inundation of coastal areas from sea level rise, coastal managers must address sea level rise in part because it also exacerbates the impact of high tides and wind-driven waves that occur during severe storms (CA OES 2007). Climate change may increase the occurrence of high sea level extremes as storms become more frequent or severe and may increase the rate of sea level rise. With these predictions, the coastline will be subject to more extreme flooding and erosion, damage to coastal structures and buildings, and seawater intrusion into aquifers and deltas (California Climate Change Center 2006).

The predicted continued rise in sea level will increase inundation of low-lying areas. Under these predictions, nearshore wave heights and wave energy will increase, increasing the potential for storm damage, beach erosion, and bluff retreat (CA OES 2007). Ports and harbors will be affected, as will seawalls, other engineered structures, groundwater, wetlands, beaches, and coastal bluffs (CA OES 2007). While sea level rise will affect all west coast ecosystems, California is the only West Coast state in which managers are currently planning for sea level rise impacts to ecosystems in their management strategies. The San Francisco BCDC has identified in its strategic plan a goal to "play an integral role in developing and implementing a regional proactive strategy for dealing with global climate change" (CA OES 2007). To achieve

this goal, BCDC has undertaken a sea level rise mapping project for the San Francisco Bay (CA OES 2007). California has identified a need for quantitative information on sea level rise. The Delta Vision Blue Ribbon Task Force was appointed by Governor Schwarzenegger to "develop a durable vision for sustainable management of the Sacramento-San Joaquin Delta" (Delta Vision Website 2008). The task force has asked Governor Schwarzenegger for an executive order that specifies predicted sea level rise by 2050 and 2100, so that managers can use these estimates in planning. More research is needed to increase certainty regarding the predicted sea level rise, storm frequency and intensity, and coastal erosion rates. There is uncertainty associated with any prediction, and some California scientists predict the sea level to rise up to 55 inches by the year 2100 (Delta Vision Blue Ribbon Task Force 2008).

The potential impacts from sea level rise and other hazards, including erosion, shoreline change, seismic events, and flooding, are anticipated to be significant across the west coast region due to the physical shoreline vulnerability combined with areas of high population density and development (CA OES 2007). To reduce the impacts of climate-related coastal hazards such as erosion, sea level rise, and coastal flooding, agencies can respond through mitigation and adaptation strategies. Governments at all levels can work to mitigate the anticipated effects of climate change by reducing greenhouse gas emissions that may slow rates of climate change, polar ice cap melting, and glacial melting, and thus reduce sea level rise. Federal, state, and local agencies must prepare adaptation plans that take into account anticipated changes. Agencies must understand their options for dealing with sea level rise, including: hard engineering of seawalls, revetments, breakwaters, and levees; soft engineering such as beach nourishment or vegetation buffers; adaptation strategies such as elevation of structures and shifting to salt-tolerant agriculture; and retreat (CA OES 2007). California is the only west coast state with a comprehensive hazard mitigation plan (HMP), and their strategies may be of use to nearby coastal states.

The California HMP characterizes mitigation strategies to reduce greenhouse gas emissions as underdeveloped. Thus, the state places more emphasis on an adaptive approach to resource management by all relevant state agencies. To adapt to anticipated effects of climate change, managers need more information on the impacts of sea level rise. There is a need for more modeling and mapping efforts along the entire coastline as well to identify regions which

would be particularly impacted (CA OES 2007). A long-term strategy for adapting to sea level rise is also needed. California Coastal Commission permits that regulate development and habitat restoration projects must take sea level rise into account. In wetlands restoration projects, for example, permits should require buffer zones to account for potential sea level rise.

3.4 Coastal Processes

Potential impacts of climate change on coastal processes necessitate states to set aside funds for research and data acquisition and to expand permitting, compliance, and enforcement. State coastal management programs call for federal coordination at the regional level to better address shoreline management issues (CSO 2007). The three states have each predicted climate change impacts on coastal processes and each state has identified information needed to successfully manage changes in coastal processes due to climate change, as described in this section. California and Oregon managers recognize that climate change will have impacts along their entire coastlines, whereas Washington's concerns about changing coastal processes center on the densely populated Puget Sound, where the greatest effects will be felt by a large number of inhabitants (PSP 2007).

Global relative sea level rise will accelerate in Puget Sound, especially in the south Sound where the land is sinking compared to the uplift of the Earth's crust in the north and northwest parts of the basin (PSP 2007). Impacts on the Puget Sound ecosystem from these changes will include greater stress for salmon and other freshwater aquatic species, changes to Puget Sound circulation, salinity and stratification patterns, and potentially, warmer water temperatures (PSP 2007).

To address the changes to coastal processes in Puget Sound waters, state managers have identified three shoreline-related informational needs. First, Washington needs shoreline change modeling based on sea level rise projections (CSO 2007). Second, the state needs historic shoreline position maps and erosion rates. Third, the state has indicated a need for inventories of shoreline features and conditions (CSO 2007).

In Oregon, coastal development continues to exacerbate the problems related to climate change. Oregon State University completed a major National Science Foundation (NSF) funded expansion of its research systems at the Hinsdale Wave Laboratory, making it the largest facility

of its kind in the world. Concurrently, a number of new researchers with expertise in coastal engineering have been added to the faculty. Oregon Sea Grant supports ongoing research that leads to improvements in understanding and modeling coastal waves and their effects, and research that enhances the state's ability to predict and prepare for tsunami inundation and seismically induced coastal subsidence (OSU 2005). It also supports the expansion of the use of existing and new coastal hazard information in regional and local coastal community plans and safeguarding human life and coastal and port facilities (Oregon State University (OSU) 2005).

California has placed a technological emphasis on acquiring high resolution bathymetry and sea level rise inundation models. High-resolution bathymetry data are needed to support assessments of shoreline changes, because simple shoreline positions cannot provide accurate information on changing sand volumes and shoreline slope steepness (CSO 2007). California's San Francisco Bay managers also recognize a need to conduct sea level rise vulnerability analyses (CSO 2007).

Regarding policy and climate change, there is a general need for federal support of state and local policy analyses to increase awareness among state coastal program managers of adaptation strategies and policy options, such as those described in this report. Particularly, there is a need for assessments of the social, legal, and economic issues related to sea level rise and shoreline "retreat," armoring, renourishment, and "no action" management alternatives across developed and urbanized coastlines (CSO 2007).

4. Thematic Area 2: Coastal and Ocean Planning

4.1 Regional and State Ocean Planning (Ocean Zoning)

Oregon has several information and program enhancement needs within the theme area of Regional Ocean Planning. The state has identified the following information needs to enable development of appropriate management measures to protect resources and ensure sustainable uses: harvest and non-harvest impacts on marine resources, particularly fisheries in or near rocky reef habitats; the distribution and abundance of various marine species and their habitat associations; and monitoring of nearshore and estuarine physical environments and ecosystems especially with regard to climate change (OCMP 2006). Oregon also is considering designating a limited system of nearshore marine research reserves to test their effectiveness as a management

and research tool; to manage sediment at the mouth of the Columbia River aiming to protect navigational infrastructure; and to develop a legal regime for wave energy siting research (OCMP 2006). California and Washington plans did not explicitly address ocean zoning.

4.2 Land Use Planning (Zoning)

Washington's watershed planning goals include protecting functioning nearshore and freshwater habitats. Population growth in the Puget Sound has changed the landscape in many areas from pristine to urban. Two urgent regulatory needs are to design land-use regulations to protect public resources in the face of development pressures and to develop ordinances and regulations to meet Washington Department of Ecology guidelines set out in the Shoreline Master Program in 2004 (PSP 2007). All of Washington's 39 counties and more than 200 cities with "shorelines of the state" administer Shoreline Master Programs (SMPs) (WDE 2008b). The SMP is a shoreline comprehensive plan and zoning ordinance with a distinct environmental orientation applicable to shoreline areas and customized to local circumstances. Some local governments maintain "stand alone" SMPs, while other SMPs are integrated into Growth Management Act plans and ordinances (WDE 2008b). County and city details of SMPs were not reviewed for this project.

In Oregon, managers lack information for use in creation of land use plans to simultaneously conserve nearshore resources and provide for long term, future use. The lack of data increases the risk associated with management and policy decisions, that may result in managers making more conservative decisions, which may not meet public needs (OR DFW 2006b).

Land uses and resources in the entire Oregon Coastal Zone are managed by local city and county comprehensive land use plans. These local plans comply with Oregon's statewide land use planning program requirements for state agency coordination, citizen involvement, and natural resource protection. Oregon's land use planning needs for research and monitoring are to:

- Improve and expand research and monitoring programs for nearshore living marine resources;
- Develop stock assessment and/or stock status indicator strategies for priority nearshore groundfish and shellfish species;

- Map and characterize nearshore rocky reefs, and determine species-habitat associations, and use this information to improve stock assessments and provide information for management;
- Identify and evaluate conflicts between marine mammals and fisheries, rivers, bays, and the nearshore ocean; and
- Complete a socioeconomic analysis for the Oregon coast, including demographic trends and economic and social contributions of industries dependent directly (e.g., fishing) or indirectly (e.g., tourism) on nearshore resources (OCMP 2006, OR DFW 2006b).

Oregon planners also need to identify which socioeconomic factors are most useful to coastal resource managers; and to obtain information on trends and the impacts of regulatory and other management changes (OR DFW 2006b). California plans reviewed here did not explicitly address land use planning.

4.3 Erosion and Sediment Management

While coastal erosion is a natural geomorphic process, it can be accelerated or exacerbated to the level of disaster in developed or populated areas by winter storms, tidal action, wind-generated high surf, and wave action (CA OES 2007). Heavy rain periods sometimes coincide with high tides, producing the highest sea level readings along the coast. Coastal lands experience flooding, bluff erosion, and landslides during such periods (CA OES 2007). California recently developed the California Coastal Sediment Management Master Plan. This collaboration between local, state, and federal agencies, and non-governmental organizations evaluates their state's sediment management needs on a regional, system-wide basis (California Coastal Sediment Management Workgroup 2008). California has identified the need to better predict erosion rates along its 1100 mile coastline (OPC 2006).

Erosion and sediment problems also exist all along Washington's coast. Coastal erosion has significantly damaged and threatened public parks, private property, and public structures such as roads and sewers. Dealing with erosion and sediment management requires a broader look beyond individual projects to encompass the whole system of regional sediment

management (WA OPWG 2006). Early attempts to address broad erosion and sediment management policy in Washington included the Coastal Erosion Task Force (WA OPWG 2006). The Southwest Washington Coastal Erosion Study is integrating research results and developing information for coastal planning, including results from a shoreline change and wave run-up models to identify problematic areas for future management consideration ((WDE SEAP 2006).

In the Pacific Northwest, the Lower Columbia Solutions Group involves the relevant stakeholders, and local, state (Oregon and Washington), and federal agencies. This group holds promise for advancing regional sediment management. There is a need for adequate funding for continued, long-term erosion, and sediment monitoring and modeling defined state principles and active involvement in regional sediment management. Models of erosion-based setbacks are important tools for local governments to use in their Shoreline Management Program updates in Washington State (WA OPWG, 2006). An independent analysis of sediment transport modeling tools is needed to support these efforts (U.S. Commission on Ocean Policy 2004b).

4.4 Ocean Energy

The three West Coast states are considering development of renewable energy sources from the ocean. Wave and tidal energy, wind energy, and underwater currents may all be transformed into electrical power to be used on land. The states are motivated by a desire to find an alternative to offshore oil and gas leasing, and, in the case of Washington and California, legislation requiring a certain percentage of electricity to be from renewable sources (WCGA 2008). As demand for ocean energy development increases, managers need information about the potential impacts of the various types of development.

First, approval of pilot or long term energy projects require knowledge of the presence and status of sensitive marine and coastal areas; knowledge of the use of the proposed sites; and an understanding of the authorities, regulations, and permitting processes for ocean energy development. Second, the West Coast region needs baseline information for further energy siting studies in state waters and on the continental shelf. Third, permitting authorities need more information on the potential impacts of renewable ocean energy technology to safely allow energy projects. To compensate for this initial lack of data, agencies require intensive monitoring and adaptive management (WCGA 2008).

In Washington, state agencies must develop the regulatory framework for several legislatively-mandated new energy technologies (WCGA 2008). Oregon's state and local governments, federal agencies, and other stakeholders have produced a declaration of cooperation that identifies ocean energy concerns and provides a framework for resolving issues (WCGA 2008). In 2007, Oregon coordinated a scientific workshop to discuss ecological effects of wave energy development (WCGA 2008). The California OPC is currently undertaking a review of the potential environmental impacts of ocean energy. The OPC may recommend developing a permitting process for ocean energy development (WCGA 2008).

4.5 Aquaculture

There are numerous types of aquaculture along the west coast. The aquaculture industry in California primarily produces mollusks, including oysters, clams, mussels, and abalone (CA Resources & CA EPA 2004). In contrast, Oregon policy has not supported commercial aquaculture in its coastal zone. Notwithstanding the lack of support, the Pacific Northwest oyster industry in Oregon and Washington is the largest producer of oysters in the United States (OSU 2005). Washington documents reviewed here do not refer to commercial aquaculture.

Oregon Sea Grant has identified three aquaculture research needs. First, agencies must understand pathogens and diseases of fish and shellfish to develop effective environmentally benign approaches to disease prevention and control. Second, managers could find ways in which agencies and researchers can contribute to developing environmentally sound and sustainable use of marine ornamentals as a hobby, as a global industry, and as an educational tool. Lastly, Oregon managers could identify a plan to enhance the viability and sustainability of the Pacific Northwest oyster industry (OSU 2005).

California's aquaculture information and management needs stem from the fact that all types of farmed mollusks in California rely on natural plant production to grow. Challenges raised by marine aquaculture include the potential for the introduction of aquatic nuisance species; impacts to water quality and wild populations; impacts from expansion of potential new open ocean aquaculture operations; and competition for space within California's port facilities (CA Resources & CA EPA 2004). California officials have developed legislation to ensure that aquaculture activities do not harm native species in state waters (CA Resources & CA EPA 2004). As aquaculture spreads past state waters into federal waters, state resource managers must

work with federal agencies to ensure consistency with state regulations for marine aquaculture operations (CA Resources & CA EPA 2004).

New proposals for larger scale aquaculture operations are anticipated in the future. California needs more research to help determine how best to address the impacts of potential expansion and ensure aquaculture operations are conducted safely within state waters. As with ocean energy, this may be achieved through permits that require monitoring of operations that will supply the data necessary for such evaluation (CA Resources & CA EPA 2004).

4.6 Infrastructure

> "Infrastructure encompasses the things a community requires for health, safety, and commerce. In its broadest sense infrastructure includes roads, bridges, sewer, water, electricity, telecommunications, natural gas, docks, and any other publicly owned facilities. In coastal communities, improvements to physical infrastructure support not only their long-term social and economic survivability and growth, but also the protection of the marine environment."
>
> - Washington's Ocean Action Plan (WA OPWG 2006).

Washington documents specifically prioritized infrastructure while planning uses of coastal resources (WA OPWG 2006). Infrastructure is perhaps best measured by evaluating the health of coastal communities and examining economic and social data. In Washington, decision-makers need economic and social data to adequately address current local infrastructure weaknesses (WA OPWG 2006). Washington uses the National Ocean Economics Program (NOEP) to obtain data on coastal communities; more data, however, is needed for some of Washington's counties. Washington has also identified an infrastructure need to support existing coastally located industries and to diversify the economy of coastal communities (WA OPWG 2006).

California and Oregon documents did not specifically mention needs related to infrastructure.

5. Thematic Area 3: Habitat Conservation, Restoration, and Management at the Ecosystem Level

5.1 Watersheds

Efforts to improve West Coast water quality do not focus solely on the coast, but on each component of a watershed from streams to estuaries to wetlands. The Coastal Zone Management Act (CZMA) 309 category of wetlands is a high-level management priority for Oregon and California and a medium-level priority for Washington. The National Estuary Program (NEP) has created programs to improve estuarine water quality in six west coast estuaries: Puget Sound, Columbia River, Tillamook Bay, San Francisco Bay, Morro Bay, and Santa Monica Bay (US EPA 2008b). The NEP strives to ensure that public resources within an estuary, such as water supplies and a healthy population of shellfish, fish, and wildlife, are protected while allowing recreational activities on land and water (US EPA 2008a). However, this program is not able to adequately address or solve all watershed issues nor does it cover all West Coast watersheds.

Washington recognizes the need to transfer computer-based watershed characterization and analysis tools to local governments (PSP 2007). In particular, these integrative tools provide better information to decision-makers by showing the combined effects of regulatory and voluntary actions from a number of plans on watershed and habitat forming processes (PSP 2007).

As of 2006, there was no management strategy for Oregon's estuarine fish and wildlife resources. There is a need to develop and implement science-based management strategies for these Oregon resources (OR DFW 2006b). From a management and policy perspective, the following needs must be met: 1) Identify priority marine fish species for which conservation plans are needed under Oregon's native fish policy; 2) Develop conservation and harvest management plans for commercially and recreationally harvested shellfish; 3) Review and update the *Interim Management Plan for Oregon's Nearshore Commercial Fishery;* 4) Ascertain management needed for the recreational groundfish fishery and develop options based on scientific information and public input; and 5) Evaluate management and planning for Oregon's estuarine fish and wildlife resources (OCMP 2006).

In general, Oregon watersheds are impacted by development, inadequate local planning and zoning restrictions, and nonpoint source pollution. Oregon managers can consider connecting ongoing and future watershed planning efforts with estuarine restoration and enhancement efforts (OCMP 2006). Specifically, state officials should consider building partnerships with Watershed Councils (OCMP 2006).

California watersheds face infrastructure problems including excessive sedimentation resulting from improper grading, pollution carried by urban runoff, and increased year-round and peak flows due to urban runoff and flood management (CA SCC 2007). The Southern California Wetlands Recovery Project (SCWRP) has prioritized needs to restore riparian habitat along urban streams and river parkways, remove invasive plant species, and remove dams and other barriers to fish passage. To acquire and restore the wetlands, financial contributions from federal and state agencies are needed (CA SCC 2007).

Coastal resource managers have identified the need to develop, improve, or expand the following techniques and measures for coastal watershed enhancement and preservation (CA SCC 2007):

- Watershed assessments – comprehensive examinations of watersheds to determine limiting factors to salmonid production
- Removal or modification of barriers to passage – culverts, weirs, roads, and other transportation crossings
- Erosion control – upslope work to control delivery of sediment to streams and stream bank stabilization
- Road assessments and decommissioning – examination of road systems to determine ways of decreasing fine sediments delivered to streams and potential for decommissioning roads altogether
- Acquisition of real property interests (fee and easement) – to permanently protect sensitive habitat by preventing subdivision and resulting habitat fragmentation
- Restoration of riparian habitat – restore canopy to promote cooler water temperatures and allow recruitment of large woody debris
- Channel modifications – improve geomorphological structure, recreate pools and refuge for fry and smolts
- Fish screens and ladders – all barriers that cannot be modified or removed should have fish ladders, and all instream intakes should have screens
- Modifications to diversions – temporal or structural
- Estuarine habitat assessment, protection, and restoration – wetland restoration for nursery habitat and facilitation of entry and exit to the sea

- Monitoring – temperature, turbidity, population assessments, and after project implementation, continued monitoring to determine project success
- Acquisition or adjudication of water rights – to protect or increase instream flows for the benefit of aquatic resources and hydrologic function
- Assistance and education for landowners in implementing restoration projects – funding and technical assistance in carrying out voluntary restoration on their lands.

5.2 Water Quality

Water quality, both onshore and in the ocean, is a major issue in Washington, Oregon, and California. Oceanic water quality is threatened primarily by contaminants from land activities. In the 2004 CSO survey, 93% of coastal managers ranked land use activities as a top research need to determine impacts on coastal water quality (2004a). Identification of sources of environmental contamination and nutrient enrichment from land use activities were also identified as areas for top research needs that have impacts on coastal water quality (CSO 2004a). Agricultural and stormwater runoff, as well as treated wastewater, are avenues for chemicals, sediment, debris, and other harmful particles originating on land to enter the ocean. There are also direct risks to water quality that originate from ocean activities. For example, oil spills from shipping accidents and introduction of non-native species via ballast water and ship hulls also contribute to the degradation of coastal waters.

In addition to stormwater and nonpoint source polluted runoff, specific water quality concerns of West Coast managers include: harmful algal blooms (HABs) which can impact coastal rivers in addition to the ocean; hypoxia and ocean dead zones; oil refining and transportation and its associated risks; pollution from oceangoing vessels; air pollution; and local impacts of pollution at marinas (WCGA 2008). Below, this section briefly discusses water quality issues of HABs and hypoxia, and then it discusses in-depth polluted runoff issues and management solutions.

Harmful algal bloom hot spots have been identified in Washington, Oregon, and California. In Washington, a collaborative research project known as the Olympic Region Harmful Algal Bloom (ORHAB) partnership formed through collaborations between federal, state, local, and tribal management entities, along with industry, public representatives, and

academia. ORHAB is funded by NOAA to develop collaboration and cooperation to mitigate the effects of harmful algal blooms by: 1) investigating the origins of harmful algal blooms; 2) monitoring for their occurrence; and 3) researching methods to reduce the impacts of harmful algal blooms (WA OPWG 2006). Additional research on HABs is necessary for understanding the drivers of algal blooms and for developing tools for rapid detection and response in all three states (WCGA 2008).

Another emerging water quality management issue is hypoxia. Recently, hypoxic zones off the coast of Oregon and Washington have been increasing, resulting in impacts to natural resources and local economies dependent on those resources. More research and monitoring are needed on hypoxia and its association with nutrient enrichment and climate change to better understand and respond to the new patterns that are emerging (WCGA 2008). Washington, Oregon, and California each have called for developing tools and techniques to predict harmful algal or hypoxic events that will not only improve rapid detection and response, but will facilitate communication and coordination among experts in all sectors throughout the three states (WCGA 2008).

While HABs and hypoxic zones affect coastal water quality, the largest contributors of water pollution on the West Coast are nonpoint sources of pollution (polluted runoff), and stormwater runoff (CA SCC 2007; WCGA 2008). The impact from these polluted waters can be mitigated by numerous management strategies including implementing low impact development (LID). LID is a site design strategy with a goal of maintaining or replicating the predevelopment hydrologic regime through the use of design techniques to create a functionally equivalent hydrologic landscape (US EPA & LIDC 2000). LID employs a variety of natural and built features that reduce the rate of runoff, filter out its pollutants, and facilitate the infiltration of water into the ground. By reducing water pollution and increasing groundwater recharge, LID helps to improve the quality of receiving surface waters and stabilize the flow rates of nearby streams.

Progress in developing and implementing LID has been slow. The Washington estuaries of Puget Sound and Lower Columbia River have worked to bring LID to their communities (WCGA 2008). There is no information available for Oregon. California's OPC is currently undertaking a review to identify barriers to implementing LID techniques in California (WCGA

2008). Other measures to improve water quality include constructed wetlands; best management practices for agriculture and forestry; and restoring creeks, streams, and rivers (CA SCC 2007). To conserve water, officials can strive for a reduction of impervious surfaces; an increase in collection capacity at the individual level; and also creek, stream, and river restoration. These measures have not yet been adequately implemented in California cities (CA SCC 2007). Needs and solutions to water quality problems include the retrofit of existing stormwater systems with treatment devices; treatment wetlands or habitat-providing small detention basins; parks and green space; and pervious pavement in areas of new development (CA SCC 2007).

The West Coast Governors' Agreement on Ocean Health (WCGA) identifies two priorities relating to water quality: 1) clean coastal waters and beaches and 2) healthy ocean and coastal habitats. The WCGA envisions "Clean coastal waters and beaches where marine life thrives and where people can safely enjoy swimming, fishing, and other activities without the detrimental effects of pollution and marine debris" (WCGA 2008).

California's State Water Resources Control Board has created and implemented a Clean Beaches Initiative (CBI). The state requires more funding to address several challenges, including: 1) eliminating sewage spills; 2) reducing contaminated stormwater, urban runoff, and marine debris; 3) developing quicker and more cost effective source identification tools, and 4) maximizing the use of citizen volunteer organizations (CA Resources & CA EPA 2004).

California's San Francisco Bay has initiated several regional plans to improve water quality in the Bay Area (CA SCC 2007). For example, the San Francisco Bay Area Integrated Regional Water Management Plan (IRWMP) aims to improve efficiency, cost-effectiveness, quality, and reliability in all aspects of water resources. To accomplish this, the IRWMP requires coordination of management of water supply, wastewater, flood protection, and watershed habitat. Goals of the IRWMP include 1) promoting environmental sustainability; 2) improving supply reliability; 3) protecting and improving hydrologic function; 4) protecting and improving the quality of water resources; 5) protecting public health and safety and property; and 6) creating, protecting, enhancing, and maintaining environmental resources and habitats (CA SCC 2007). Ecosystem health, including the social, economic, and physical well being of humans, depends on good water quality.

5.3 Conservation and Restoration

Habitat change was a top-ranked management concern in the 2004 CSO survey of the Pacific Region (CSO 2004a). Ninety percent of coastal managers identified habitat as an important or very important issue, and 70% identified a research need to evaluate the effectiveness of techniques that restore or protect habitats. Additionally, 86% of the managers stated that baseline ecological and physical information was needed to manage habitat effectively (CSO 2004a).

Washington's goal for the Puget Sound is to preserve marine and freshwater habitats and the ecological processes that create and maintain them (PSP 2007). Washington's information needs include data on development rates in urban growth areas as compared to rates outside of urban areas. The Puget Sound Partnership would also use information on regional changes in land cover and impervious surfaces; the status and trends of eelgrass and floating kelp in Puget Sound; the effects of stressors on eelgrass abundance and distribution; intertidal biodiversity; and locations of past and future conservation projects in Puget Sound (PSP 2007).

Specific Washington strategies for protecting biological diversity involve addressing declines in the abundance of certain aquatic species that currently contribute to ecosystem imbalance. If Washington chooses to correct these declines to prevent significant degradation of the ecosystem, the Puget Sound Partnership recommends implementing several plans in existence, namely the *Puget Sound Salmon Recovery Plan,* the *Hood Canal Summer Chum Recovery Plan,* the *Recovery Plan for the Coastal-Puget Sound Bull Trout* and the *Proposed Conservation Plan for Southern Resident Killer Whales* (Orcinus orca). Other species that need to be studied for conservation are rockfish and the Puget Sound Olympia oyster (PSP 2007).

Further information needs include assessing the relative abundance and geographic distribution of major forage fish species in Puget Sound; beginning to identify research needs and develop management strategies for marine bird populations considered at risk; recover exploitation rates for salmon; a complete forage fish assessment including harvest impacts on rockfish and groundfish conservation needs (PSP 2007).

Coastal wetlands conservation is a high priority for Oregon as well. Currently needs include a detailed and comprehensive inventory of Oregon's freshwater and estuarine wetlands (OCMP 2006). The inventory should include the location, extent, and condition of wetlands and

is crucial to protecting, managing, and monitoring these resources. Oregon managers need adequate baseline information on historical and existing conditions to conserve and manage wetland ecosystems. Lastly, Oregon's managers call for a coast-wide or regional conservancy to be developed to implement non-regulatory approaches to conservation (OCMP 2006).

In California, new threats to upland habitats and wildlife corridors will appear as development continues and the human population grows. California officials have identified maintaining habitat connectivity as a need (CA SCC 2007). Additionally, California's National Estuarine Research Reserves (NERRs) have written conservation plans detailing problems for conservation and needed actions. In the Elkhorn Slough Watershed Conservation Plan, for example, stressors that reduce existing habitat are listed. Elkhorn Slough's sediment-related stresses include erosion of soil, stream banks, and bluffs; sediment accumulation; and creation of sediment fans over wetlands. Other habitat stressors are: migration of pesticides and nutrients into aquatic habitats; infiltration of nitrates into groundwater; coliform contamination; retreat of freshwater in aquifers resulting in seawater intrusion; seawater infiltration; loss of maritime chaparral; contamination of local creeks and marshes; spread of invasive weeds; and competition with native marine species and vegetation (ESF 1999).

Also relevant to California, the Elkhorn Slough plan lists capacity building, acquisitions, developing incentives, and restoration and enhancement of habitats as their key actions. To do this, the Reserve needs: coordination among agencies and existing conservation programs; development of stream management plans; resources for acquisition; sustainment of agricultural assistance programs; and resources for habitat restoration (ESF 1999).

In the San Francisco Bay, the State Coastal Conservancy and its partners designated each of the 75 major streams that drain to the Bay in need of restoration or enhancement (CA SCC 2007). Historically, thousands of acres of the San Francisco Bay area provided stream and riparian habitat. The Coastal Conservancy urges that ecosystem services be restored on all public lands that historically provided riparian habitat (CA SCC 2007).

Statewide, the quantity and quality of California habitat data are described as "uneven" (CA SCC 2007). In most cases, there is no comprehensive data on certain locales. There are no comprehensive studies of habitat needs or baseline data for coastal scrub communities in the north and central coast regions. Many species are rare and in some cases are in danger of

extinction. For example, there are no baseline calculations for the current extent of salmonid habitat or what the net need is to stabilize and recover the various species which are endangered (CA SCC 2007). In such regions, where no systemic habitat surveys have been conducted, management had to make generalized determinations of baseline data. California has prioritized coastal dune habitat; coastal coniferous forests and oak woodlands; and endangered species habitats (CA SCC 2007).

In California's North Coast Watersheds, the Coastal Conservancy has determined that acquisition of easements to protect stream corridors, restoration of riparian habitat, erosion prevention measures, and estuarine protection are all needed to improve salmon spawning and rearing habitat (CA SCC 2007). The Central Coast watersheds primarily need erosion management and riparian replanting (CA SCC 2007). Southern Coast managers aim to prevent extinction of the remaining natural populations of steelhead in streams including the Ventura River, Malibu Creek, Santa Clara River, and the San Mateo Creek (CA SCC 2007). A list of watersheds throughout California detailing their most significant needs can be found in Appendix A at the end of this review.

California possesses many natural resources such as water, timber, fish, offshore oil, and liquid natural gas (CA SCC 2007). Habitat restoration to repair areas used for resource extraction in California includes road decommissioning, upslope erosion control, instream structures and bank stabilization, and removal of barriers to passage. There is a need to preserve old-growth as well as second-and third-year growth forests. Salmonid restoration would benefit from a comprehensive, coordinated, funded approach to protection and restoration of salmonid habitat. As demand for these resources grows, California must rely on government action to minimize any adverse consequences of resource use and development (CA SCC 2007).

5.4 Mapping

Benthic habitat maps are a vital tool to allow managers to visualize the distribution, diversity, and extent of marine communities under their jurisdiction. Coastal and fishery resource managers must frequently make decisions about development projects or uses of the coastal zone without sufficient knowledge of the marine habitat types that the proposed projects impact. Development projects, such as aquaculture, wind farms, pipeline and cable installations, construction of docks, piers, sewage outfalls, and discharge of pollutants (e.g. nutrients and

heavy metals), can disrupt and degrade the habitat functions and values of the marine environment. Productive habitats for commercially and ecologically valuable species are located throughout the coastal zone and are potentially impacted by these activities.

Benthic habitat maps can be used to aid in siting and reviewing the environmental impacts of a wide variety of development projects on the seafloor. They can also be used as a planning tool to insure future protection efforts are habitat based and representative of all regional habitat types. Future protection efforts could include fishery closures, marine protected areas, and/or ocean use allocation. Managers have a critical need to monitor the individual and cumulative impacts of human activity in the marine environment, which will be greatly facilitated when the spatial distribution of various benthic habitat types are known (CA SCC 2007).

Information on specific needs is available only for Oregon and California. Oregon's coastal resource managers have prioritized obtaining habitat mapping information. Marine resource managers currently lack information regarding groundfish populations, habitat associations, and locations of rocky reef habitat (OR DFW 2006b). A better understanding of the fish-habitat association will help Oregon protect important habitat, assess nearshore fish stocks, and understand the effects of natural and anthropogenic impacts on habitat (OR DFW 2006b).

For the Oregon ocean, there is no single web-based or standalone ocean resource Geographic Information System (GIS). The OCMP Coastal Atlas has an ocean resources visualization tool, but it is not currently a robust portal to ocean resources information. The Oregon State University Geosciences Department is developing a strong geo-sciences approach to an ocean information system for Oregon and the Pacific Northwest, but is not likely to be a comprehensive source of information. The Nature Conservancy is also working toward a GIS for ocean resources throughout the Pacific Northwest (OCMP 2006).

One of California's information needs is to create benthic habitat maps for all state waters from the mean high tide line westward out to three nautical miles (CA SCC 2007). Data are acquired through various collection techniques including side-scan sonar, multi-beam, and light detection and ranging (LiDAR). The California Coastal and Marine Mapping Workshop in 2005 resulted in a statewide coastal and marine mapping strategic plan that specifies the following priorities (CA SCC 2007):

- Prioritization of areas for new fieldwork and data acquisition efforts statewide, with special emphasis on the northern portion of the Central Coast;
- Collection, management, and storage of both existing and newly acquired data;
- Agreed-upon standards and protocols for data collection, post-processing, and interpretation of data;
- Selection of various mapping products appropriate for resource management applications (e.g., hard copy maps, interactive GIS-based online maps, etc.), and
- Dissemination of mapping data and information to end-users and the public.

With direction from this process, the State Coastal Conservancy and the OPC created the California Coastal and Marine Mapping Initiative project to complete habitat maps that will provide cross cutting support to resource managers—in particular for the Marine Life Protection Act. Under that program, habitat mapping has been completed for portions of the central coast, in cooperation with the California Department of Fish and Game. Including this effort, only approximately 33% of the submerged lands in California have been mapped in sufficient detail for the identification of habitats and geologic features. Completing the benthic habitat mapping for the remaining 66% of the coast is a high priority need for state and federal resource managers (CA SCC 2007).

6. Thematic Area 4: Data and Information

Data needs are implicit in nearly all of the documents reviewed for this needs assessment literature review. Only where data needs and the significance of data for management are mentioned explicitly do we discuss the needs. Data needs are assessed from three perspectives: access, usability, and transparency. Due to the strict reading of "data needs" as defined above, data transparency needs were not prevalent in the literature. The following subsections will address access and usability.

6.1 Access

Most coastal resource management programs have a long-term goal to provide access to science to inform environmental policy and management. The only state to define specific data

access issues is Washington (PSP 2007). The state's data access needs are ongoing monitoring and identification of ecosystem trends (PSP 2007). Washington intends to share scientific information with stakeholders, decision-makers, and the public. These data will be used to direct new monitoring activities and will support an adaptive management approach. Developing models to be used by research managers will be the most useful way to utilize data for Washington's Puget Sound region, such as a conceptual model of Puget Sound that changes to reflect potential application of management activities and a mass balance model of nutrient sources, reservoirs, and pathways (PSP 2007).

Coastal programs would benefit from awareness of and access to the research that the United States Army Corps of Engineers (USACE), the Federal Emergency Management Agency (FEMA), the United States Geological Survey (USGS), the Environmental Protection Agency (EPA), NOAA, and others are conducting (or have conducted) in their state or region, as well as management activities and lessons learned by neighboring states. State coastal programs also described a need for a single source for the most up-to-date sea level rise and climate projections and information at the national level, including documented coastal and ocean changes that have occurred or are occurring due to climate change. Beyond a single inventory, state participants expressed an interest in establishing sustained mechanisms for regional collaboration on climate change issues (CSO 2007).

6.2 Usability

Synthesis products, comprehensive databases that document ocean changes, are one way that collected data can become more usable to resource managers (CSO 2007). The CSO compares climate change-related federal synthesis products, which are quite developed, with less organized state coastal program products (CSO 2007). The EPA and other federal agencies provide good synthesis products related to climate change; whereas state coastal programs need a clearinghouse for federal, state, and local programs, research activities, and general information related to climate change in their region (CSO 2007). The 2007 National Ocean Service document, *Establishing National Ocean Service Priorities for Estuarine, Coastal, and Ocean Modeling: Capabilities, Gaps, and Preliminary Prioritization Factors*, by E.T. Cloyd, et al.,

identifies modeling data as useful to managers for several of the issues discussed in this document including coastal hazards, water quality, and coastal habitats.

7. Cross-Cutting Issues and Analysis

7.1 Ocean Observing

A national monitoring network is essential to support the move toward an ecosystem-based management approach that considers the impacts of human activities within the context of the broader biological and physical environment. The coastal component of the Integrated Ocean Observing System (IOOS) is planned as a federation of regional observing systems nested in a federally supported "national backbone" of observations and eleven Regional Associations formed around the country (CA SCC 2007). Ocean observing systems have the potential to provide much needed information to coastal managers and researchers to improve the understanding of coastal processes and inform management decisions.

Climate change creates additional uncertainty in coastal systems increasing the complexity for management and decision makers (CA SCC 2007). Despite the growing threats to our oceans, there is no single, coherent monitoring network in place to assess their status, track changes over time, or determine the success of management efforts.

State and federal documents now endorse substantially increasing investment in ocean monitoring. Coastal ocean observing systems monitor physical, biological, and/or chemical data relating to the coastal ocean. The needed scientific tools and technologies include well-equipped surface and underwater research vessels, reliable and sustained satellites, state-of-the-art computing facilities, and innovative sensors that can withstand harsh ocean conditions. Specific technologies needed include high frequency (HF) radars; automated shore stations; remote sensing; coastal ocean modeling and seafloor bathymetry; underwater gliders; moorings; autonomous underwater vehicles; data management and product development; remotely operated vehicles which are particularly valuable for ocean exploration and marine protected area monitoring; portable underwater observatories; and fish and mammal "smart" tags (CA SCC 2007).

The California OPC supports strategic planning for an integrated state-wide monitoring program. Ongoing operational and financial support is critical. Inland monitoring is needed to

determine the origin of contaminants as well as monitoring along the coast. Improved data integration and product development will contribute to a more effective ocean observing system. Also needed for prediction and forecast tools are the development of new sensors and monitoring devices. Ultimately, creating an integrated ocean monitoring system will allow the development of a more unified, coordinated statewide approach for dealing with issues such as climate change, fisheries management, and pollution control (CA SCC 2007). Ocean observing is a cross-cutting issue because the data it can provide will help address many of the priority areas mentioned in this literature review. Issues of water quality, ocean resource planning, erosion, sea level rise, and other climate change problems can all be better managed with information from ocean observing.

Poor water quality is a result of land-based activities such as urban development, agriculture, and forestry. Ocean observing data can identify sources of contamination that pollute coastal waters and beaches. This information may be particularly useful for areas of special biological significance, critical coastal areas, marine protected areas, and recreational beaches. Surface current trajectory maps and their time histories can help predict where contaminated water will flow, can inform oil spill response and prevention, and aid in search and rescue (CA SCC 2007).

Marine protected areas (MPAs) are being established along the entire west coast and planning for marine resources and marine protected areas may be improved by ocean observing through an increased understanding of connectivity among MPAs (CA SCC 2007). Routine data collection and model development is needed to provide current sea level information and forecasts and can be provided by ocean observing systems from real-time and forecasted wave information to predict storm surge and storm-driven erosion rates. Erosion management approaches would benefit from ocean observing data that measures and predicts the alongshore wave climate and nearshore currents. The prediction of surf zone currents can be applied to models and forecasts of the alongshore transport of sediments, and can define regions of accretion and erosion within a particular littoral cell. This can provide information for risk assessments of areas of high erosion on a local, state, and regional basis (CA SCC 2007).

7.2 Ecosystem-based Management

Ecosystem-based management (EBM) is an approach to managing coastal resources, which includes management of living and non-living resources, habitat, air and water quality, and how humans interact with both ocean and nearshore environments (WA OPWG 2006). Ecosystem approaches to management go beyond single-species or single-issue management by integrating all aspects of the system, including social and economic goals, to evaluate and manage the area and its resources (WCGA 2008). EBM requires monitoring, analysis, integration, and forecasting: "to interpret relationships and interactions among ecosystem components and between human activities and the natural ecosystem" (WA OPWG 2006). Ecosystem-based management also requires the use of adaptive management. Adaptive management is the process of continually evaluating and adjusting management measures based on better scientific understanding and changing circumstances to improve the desired outcome (WA OPWG 2006). Further, an EBM approach assesses cumulative impacts from various sources and strives to balance conflicting uses. It accounts for complexity and uncertainty of natural processes and social systems, and incorporates adaptive policies in the face of uncertainties (COMPASS 2005). Using an EBM approach to manage resources requires the consideration of a wide range of issues and engagement of numerous stakeholders to help define problems and set goals while incorporating scientific, social, and economic understanding to achieve tangible solutions (WCGA 2008).

Washington State currently lacks a specific ecosystem-based strategy or process for managing its marine resources. However, the state recognizes that the effectiveness of its marine resource management could be improved by evaluating ecosystem processes and functions based on an EBM approach. This would allow the use of management measures based on ecosystem health and goals and provide more accurate estimates of impacts of current and proposed human activities. Federal agencies, as well as potential regional ocean governance entities, are currently investigating the use of ecosystem-based management (NOAA Ecosystem Task Team 2006). NOAA's Ecosystem Task Team released a report in 2006, *Evolving an Ecosystem Approach to Science and Management Throughout NOAA and its Partners***,** on how to align the agency's various programs to support and enhance ecosystem-based management (NOAA Ecosystem Task Team 2006). The report concluded that the agency should provide integrated ecosystem assessments at a regional level (WA OPWG 2006).

Oregon's Department of Fish and Wildlife Nearshore Marine Resource Management Strategy is a new initiative that includes a focus on ecosystem-based management. Oregon's governor proposed an Oregon Coast National Marine Sanctuary for the entire continental margin off Oregon. This proposal would enact ecosystem-based management of this area, with assistance from NOAA, and represents a significant shift in the affect of long term conservation of Oregon's ocean resources (OCMP 2006).

Washington, Oregon, and California recognize that governance issues and overlapping jurisdictions will inhibit the implementation of ecosystem-based management. State laws and institutions within each state have not yet been considered from a coast-wide perspective to address the challenges of implementing EBM on the West Coast. NOAA's Coastal Services Center has attempted to account for this deficiency by creating an online interactive West Coast legislative atlas, as part of the larger "Digital Coast" effort, to provide data to coastal resource managers (NOAA CSC 2008; WCGA 2008). It includes "searchable legislative summaries and provides a spatial perspective of ocean and coastal laws and resource agency jurisdictions." This effort will provide a perspective into the regional and state level policy infrastructure allowing the identification of factors that assist or hinder effective EBM. California has inventoried laws relevant to management of ocean and coastal resources, and "other state-specific and region-wide efforts to identify pertinent laws and jurisdictions are being developed" (WCGA 2008). The three states are laying the groundwork for working together to address these issues at a regional level through the West Coast Governor's Agreement on Ocean Health and its implementation plan (WCGA 2008).

The West Coast states are also exploring ways to enhance ecosystem health through ecosystem-based management approaches by incorporating ecosystem-based management principles into local management efforts and through research. Many EBM ventures have begun in the San Juan Islands, Washington; Port Orford, Oregon; and Humboldt Bay, Elkhorn Slough, Morro Bay, and Ventura, California (WCGA 2008). These projects will provide information to the states that will assist regional implementation of EBM. The efforts are "intended to facilitate the exchange of lessons learned and cultivate local, state, and federal agency coordination for regional-level ecosystem management across the West Coast" (WCGA 2008). Another project currently underway is the California Current EBM Initiative (CCEBMI), which works "to

advance science needed for EBM along the West Coast by evaluating and preparing the scientific information required to support effective implementation" (WCGA 2008). Research and monitoring activities, such as sea floor mapping, collection of high resolution remote sensing data and other ocean observing system data, are currently being conducted at academic and other reputable institutions and will contribute to the region's ocean observing systems (WCGA 2008). All of these efforts are important for providing a foundation to understand the ocean and coastal environment and resources.

Ecosystem based management will require synthesis of information from many disciplines that traditionally have not been integrated to provide a comprehensive understanding of coastal ecosystems. EBM is needed to support complex and difficult management decisions but will be challenging to implement. According to the WCGA, to ensure successful implementation of EBM, an "integrated ecosystem assessment (IEA) should be developed for the West Coast, with the assistance of the federal government that will establish standards and indicators for ocean health" (WCGA 2008). IEAs are analytical tools "that use information on natural and socio-economic factors in relation to specified ecosystem management goals. Analytical tools, such as IEAs conducted by NOAA and its partners, are needed to identify how human and natural factors change the ecosystem, and what different management strategies might accomplish. These analytical tools will assure that the EBM process is dynamic, allowing managers to change course and assess potential impacts of these changes, if necessary, as new information becomes available" (WCGA 2008).

However, several aspects of the current single-issue approach to ocean management hinder EBM implementation. EBM proponents in regional management must overcome limited budgets, insufficient data and information, the "need for information at appropriate scales and integration of information," and "the lack of strong connections between research and management needs" (WCGA 2008). Until these needs are met, implementing EBM will be difficult (WCGA 2008).

8. Concluding Remarks

This literature review identified over eighty documents by officials in Washington, Oregon, and California. The complete list of reviewed documents can be found at the end of this review in the Bibliography section. Document types included strategic plans, smaller-scale

needs assessments, fiscal plans, and legally mandated assessments, as in the case of the states' and BCDC's CZMA Section 309 Assessments. The breadth and variety of the documents reviewed reflect the diverse challenges for resource management along the West Coast.

The several documents described in detail in the tables and text above are particularly robust efforts to place management challenges in context. Emerging issues of climate change impacts and ecosystem-based management must now be considered alongside longstanding issues of habitat conservation and water quality. NOAA's Coastal Services Center and its users may find this literature review helpful in identifying major needs trends for the West Coast. This review is a precursor to the West Coast Regional Needs Assessment, which will further address management concerns for Washington, Oregon, and California coastal management officials.

Appendix A: California Watershed Needs

North Coast

In California's North Coast Watersheds, the Coastal Conservancy has determined that acquisition of easements to protect stream corridors, restoration of riparian habitat, erosion prevention measures, and estuarine protection are all needed to improve spawning and rearing habitat for salmon. By watershed, the most significant needs are (CA SCC 2007):

- Smith River – Estuarine enhancement, enhancement of watershed lands to minimize sedimentation, and restoration of large woody debris (LWD) to tributaries
- Klamath/Trinity Rivers – Removal of four lowermost dams on the Klamath River, resolution of major water supply issues, protection of instream flows on key tributary rivers, restoration of tributary habitat.
- MacDonald Creek and Stone Lagoon, and Maple Creek and Big Lagoon – erosion and sedimentation, barriers to passage
- Redwood Creek – erosion and sedimentation, levees enclosing lagoon, riparian replanting, estuarine restoration, LWD
- Little River – wetland restoration
- Mad River – erosion and sedimentation, levees
- Humboldt Bay and feeder streams – erosion and sedimentation, LWD, barriers to passage, wetland restoration
- Salt River – sedimentation, estuarine restoration
- Eel River– Resolve major water supply issues, remove barriers to fish passage, conduct erosion and sedimentation controls, riparian replanting, exotic species control
- Mattole River – estuarine restoration, erosion and sedimentation, riparian replanting
- Cottoneva, Pudding and Wages Creeks – estuarine restoration, erosion and sedimentation, barriers to passage
- Ten Mile River –erosion and sedimentation, riparian replanting
- Noyo River – erosion and sedimentation
- Big River – erosion and sedimentation, LWD
- Albion River – riparian replanting, erosion and sedimentation
- Navarro River – erosion and sedimentation, riparian replanting, barriers to passage, LWD
- Garcia River –erosion and sedimentation, riparian replanting, barriers to passage, estuarine restoration, LWD
- Gualala River – Resolve aggressive timber harvest practices and associated erosion and sedimentation, overdrawn water resources, vineyard conversion of forestlands, riparian replanting
- Russian River – major water supply issues, barriers to passage, erosion and sedimentation, many different interests

- Esteros Americano and Antonio – erosion and sedimentation, riparian replanting
- Salmon Creek – erosion and sedimentation, riparian replanting, estuarine restoration
- Tomales Bay watershed – erosion and sedimentation, riparian replanting, wetland restoration, barriers to passage
- Bolinas Lagoon – erosion/sedimentation
- Redwood Creek (Marin) – estuarine and riparian enhancement, barriers to passage.

Central Coast

The most needed restoration measures in Central Coast watersheds are (CA SCC 2007):

- San Mateo/Santa Cruz County small coastal streams, including: San Gregorio, Pescadero, Gazos, Arana, Waddell, Scott, San Vicente, Soquel, Aptos Creeks, totaling 287 square miles are targeted in the *Strategic Plan for the Restoration of the Endangered Coho Salmon South of San Francisco* (Department of Fish and Game, 1998). Issues include: erosion and sedimentation, riparian replanting, barrier removal, acquisition of fee and easements.
- San Lorenzo River – erosion and sedimentation, barriers to passage, acquisition of fee and easements, number of acres unknown
- Pajaro River – erosion control, riparian replanting, barriers, lagoon management, water quality issues. Targeted in the Regional Water Quality Control Board Region 3's Watershed Management Initiative Chapter 2000.
- Salinas River – acquisition of fee and easements, barriers to passage, water quality issues from agricultural land uses
- Carmel River – barriers to passage (San Clemente Dam), water supply and quality issues, riparian replanting
- San Luis Obispo County coastal streams: Morro Bay Watershed and San Luis Obispo Creek – erosion and sedimentation, riparian replanting, acquisition of approx 320 acres, water quality from agricultural land practices, barrier removal
- Santa Ynez River – barriers to passage, erosion and sedimentation, riparian replanting, water flows. (Historically hosted the largest population of the endangered southern steelhead in southern California.)
- Santa Barbara County coastal streams – barriers to passage, erosion and sedimentation, water quality issues, acquisition of easements and fee, riparian replanting

Southern California Coast

- Ventura River – barriers to passage, erosion and sedimentation, estuarine restoration and water quality, riparian replanting, water flows
- Santa Clara River – water flows, channelization, water quality, erosion and sedimentation, riparian replanting

- Solstice Creek – barriers to passage, riparian replanting, erosion and sedimentation
- Malibu Creek – barriers to passage, riparian replanting, water quality in lagoon, acquisition of approx 400 acres
- Topanga Creek – erosion and sedimentation, estuarine restoration, riparian replanting
- San Mateo Creek – erosion and sedimentation, riparian replanting

Appendix B: Key to Acronyms

Acronym	Meaning
BCDC	Bay Conservation and Development Commission (San Francisco Bay)
BRTF	Blue Ribbon Task Force
Cal EPA	California Environmental Protection Agency
CBI	Clean Beaches Initiative
CCC	California Coastal Commission
CCJV	California Current Joint Venture
CCMP	Comprehensive Conservation and Management Plan
CICEET	Cooperative Institute for Coastal and Estuarine Environmental Technology
COMPASS	Communication Partnership for Science and the Sea
CSC	NOAA Coastal Services Center
CSO	Coastal States Organization
CTED	Department of Community, Trade, and Economic Development (WA)
CZMA	Coastal Zone Management Act
DFG	Department of Fish and Game (CA)
DFW	Department of Fish and Wildlife (OR, WA)
DNR	Department of Natural Resources (WA)
DOGAMI	Department of Geology and Mineral Industries (OR)
DOH	Department of Health (WA)
DWR	Department of Water Resources (CA)
EBM	Ecosystem-Based Management
EMAP	Environmental Monitoring and Assessment Program
EPA	Environmental Protection Agency
ESF	Elkhorn Slough Foundation
FEMA	Federal Emergency Management Agency
GIS	Geographic Information System
HAB	Harmful Algal Bloom
HMP	Hazard Mitigation Plan
ICLEI	International Council for Local Environmental Initiatives
IEA	Integrated Ecosystem Assessment
IOOS	Integrated Ocean Observing System
IRWMP	Integrated Regional Water Management Plan (San Francisco Bay Area)
JPAs	Joint Powers Authorities
JSOST	Joint Subcommittee on Ocean Science and Technology
LID	Low Impact Development

LiDAR	Light Detection And Ranging
LWD	Large Woody Debris
MBARI	Monterey Bay Aquarium Research Institute
MLMA	Marine Life Management Act
MLPA	Marine Life Protection Act
MPA	Marine Protected Area
NEP	National Estuary Program
NERRS	National Estuarine Research Reserve System
NMS	National Marine Sanctuaries
NOAA	National Oceanic and Atmospheric Administration
NOEP	National Ocean Economics Program
NPS	National Park Service
NSF	National Science Foundation
NSGIC	National States Geographic Information Council
NWFSC	Northwest Fisheries Science Center
OCMP	Oregon Coastal Management Program
OCNMS	Olympic Coast National Marine Sanctuary
OES	Office of Emergency Services (CA)
OPC	Ocean Protection Council (CA)
OPWG	Ocean Policy Work Group (WA)
ORHAB	Olympic Region Harmful Algal Bloom
OSPR	Office of Spill Prevention and Response
OST	Ocean Science Trust (CA)
OSU	Oregon State University
PaCOOS	Pacific Coast Ocean Observing System
PCJV	Pacific Coast Joint Venture
PSAT	Puget Sound Action Team
PSP	Puget Sound Partnership
PUC	Public Utilities Commission
RWQCB	Regional Water Quality Control Board (CA)
SCC	State Coastal Conservancy (CA)
SCCWRP	Southern California Coastal Water Research Project
SCOOS	Southern California Ocean Observation System
SCWRP	Southern California Wetlands Recovery Project
SEAP	Shorelands and Environmental Assistance Program
SEPA	State Environmental Policy Act (WA)

SFBJV	San Francisco Bay Joint Venture
SGP	Sea Grant Program
SLC	State Lands Commission (CA)
SWRCB	State Water Resources Control Board (CA)
TNC	The Nature Conservancy
UC	University of California
URI	University of Rhode Island
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WCB	Wildlife Conservation Board (CA)
WCGA	West Coast Governors' Agreement on Ocean Health
WDE	Washington Department of Ecology

Appendix C:

2006 Coastal Services Center Customer Survey Results for Respondents from the West Coast Region

The percentages reported in Appendix C have been rounded to the nearest whole number, so all totals may not add to 100.

To view a report on national results from this 2006 survey, as well as results from past Coastal Services Center customer surveys, please visit the following web address: www.csc.noaa.gov/survey.

Overview of West Coast respondents

Of a total of 433 respondents in the 2006 survey, 71 were from the West Coast region:

- 37 from California
- 18 from Oregon
- 16 from Washington

Respondents represented a variety of organizations, including:

- 7 respondents were from state Coastal Zone Management (CZM) programs
- 9 were emergency managers at either the local or state level
- 17 were from non-CZM agencies involved in coastal and marine resource management (e.g. Departments of Environmental Protection, Departments of Fish & Wildlife, Departments of Water Quality.)
- 8 were from National Estuarine Research Reserves
- 4 respondents were from state Sea Grant offices
- 14 respondents were from federal, non-NOAA agencies including the Department of the Interior, and the US Army Corps of Engineers

Respondents also reported holding a variety of positions within their organizations:

- 6% were in education and outreach
- 9% were in emergency management
- 6% were in information technology (GIS, remote sensing, or a related field)
- 21% were in natural resource management
- 6% were in permitting and regulatory enforcement

- 24% were in planning
- 10% were in program or site administration and management
- 7% were in research
- 13% represented position types not listed on the survey

Nearly one third of respondents have been in coastal resource management positions for five years or less, while roughly another third have been in the field in excess of 15 years:

- 31% have been in the field 5 years or less
- 25% have been in the field 6-10 years
- 9% have been in the field 11-15 years
- 22% have been in the field 16-20 years
- 2% have been in the field 21-25 years
- 12% have been in the field over 25 years

Many respondents were familiar with the Coastal Services Center (CSC), and a significant percentage has used one or more CSC products and services:

- 56% are familiar or very familiar with CSC
- 51% have visited the CSC website
- 41% receive one or more CSC publications
- 21% have attended a Coastal Zone conference
- 39% have attended a CSC workshop or training
- 21% have received technical assistance from CSC
- 30% have used data or other products from CSC
- 34% have partnered with CSC on a project

Priority Topics

Ten issues were identified as high priority by over 40% of West Coast regional respondents:

- Habitat restoration/monitoring (71%)
- Protected area management (57%)
- Land use planning/growth management (56%)
- Protected species management (53%)
- Watershed planning (53%)
- Public access (52%)
- Shoreline change management (45%)
- Nearshore and offshore habitat mapping (44%)
- Invasive species management (44%)
- Erosion (41%)

Hazards Management Topics

Survey results revealed that many respondents feel they need to learn more about hazards management topics:

- 60% said "risk and vulnerability assessment" is a topic they need to know about for their job, and that they need to learn more about.
- 58% said "long term recovery" is a topic they need to know about for their job, and that they need to learn more about.
- 56% said "hazards mitigation" is a topic they need to know about for their job, and that they need to learn more about.
- 52% said "risk communication" is a topic they need to know about for their job, and that they need to learn more about.
- 41% said "response immediately after a disaster" is a topic they need to know about for their job, and that they need to learn more about.
- 38% said "forecasts and warnings" is a topic they need to know about for their job, and that they need to learn more about.

Asked to rank the relative priority of these hazards management topics, "risk and vulnerability" rose to the top, with 18% of West Coast respondents listing this as the number one priority. "Hazards mitigation" came in second with 13% ranking this as their top priority.

Spatial Data Use

(Note: 16% of Northeast respondents said they were not familiar with spatial data use in their office, so the following data are for the 84% of respondents that are familiar.)

- Current shoreline was one of the two most commonly used data layers, with 74% reporting use of this layer in their office. An additional 18% said their office does not use this data layer, but it would be useful.
- Elevation/topography was the other most commonly used data layer, with 63% reporting that their offices use this layer. Similarly, an additional 29% indicated their office does not use this data layer, but it would be useful.
- Protected areas came in third, with 61% reporting use of this layer in their office, and 31% saying it would be useful.
- Additional data layers being used by over 50% of respondents' offices:
    - Coastal land cover
    - Coastal land use
    - Public access
    - Sensitive habitats
- Data layers that over 50% of respondents indicated were not currently being used but which would be useful:

- Shoreline change/erosion
- Tides
- Currents
- Waves
- Wind
- Cultural and historic resources
- Shellfish bed distribution
- Fish habitat distribution maps
- Primary productivity
- Marine and coastal economic data
- Coastal demographics
- Water quality

Technology Tools to Support Coastal Resource Management

Survey data provided insight on West Coast respondents' use of various technology tools, as well as the most common constraints to use. Tool use is described below, listed from most-used to least-used:

- Geographic Information Systems (GIS): 86% reported that they or their offices use GIS. 67% said this tool has high utility. For those who reported constraints to using this tool, conflicting demands on time was the greatest constraint (48%). Another top constraint was lack of required knowledge/skills.
- On-line databases: 75% reported that they or their offices use on-line mapping for browsing or viewing data. 39% said this tool has high utility. For those who reported constraints to using this tool, conflicting demands on time was the greatest constraint (43%).
- On-line Mapping (data portals, data clearing houses): 72% reported that they or their offices use on-line databases. 46% said this tool has high utility. For those who reported constraints to using this tool, conflicting demands on time was the greatest constraint (37%). Other top constraints were lack of inadequate equipment/facilities/technology and lack of required knowledge/skills.
- Decision-support tools (manipulating / analyzing data): 63% reported that they or their offices use decision-support tools. 39% said this tool has high utility. For those who reported constraints to using this tool, lack of required knowledge/skills was the greatest constraint (40%). Another top constraint was conflicting demands on time.
- Remote sensing tools: 55% reported that they or their offices use remote sensing tools. 27% said these tools have high utility. For those who reported constraints, lack of required knowledge/skills (37%) and conflicting demands on time (37%) were the greatest.
- Coastal and ocean observations: 54% reported that they or their offices use coastal and ocean observations. 23% said this tool has high utility. For those who reported constraints

to using this tool, not enough staff (31%) and conflicting demands on time (31%) were the greatest constraints.
- Visualization (GIS-, 3D-, and photo-based): 52% reported that they or their offices use visualization. 30% said this tool has high utility. For those who reported constraints, lack of required knowledge/skills (32%), and not enough staff (32%) were the greatest.
- Models or model outputs (habitat modeling, SLOSH, HURREVAC): 22% reported that they or their offices use models or model outputs. 16% said these tools have high utility. For those who reported constraints, lack of required knowledge/skills was the greatest constraint (40%).

Utility of different types of assistance with technology tools and data:

The survey asked respondents about whether several different types of assistance would have high, medium, low, or no utility. The following list shows the percentage indicating each type of assistance would have high utility, listed from highest to lowest:

- Providing data: 61%
- Providing training on existing software: 47%
- Providing on-site technical assistance in use of software: 42%
- Developing customized applications: 40%
- Evaluating existing software for coastal applications: 31%
- Developing case studies detailing the uses of existing software: 26%
- Inventorying available software: 25%

Human dimensions tools

The survey asked about human dimensions tools (e.g. social science methods, strategic planning tools) and constraints to using these tools. Tool use and constraints are described below, listed from most-used to least-used:

- Performance measures or indicators: 77% reported that they or their offices use performance measures or indicators. 48% said this tool has high utility. For those who reported constraints to using this tool, insufficient number of staff was the greatest constraint (34%).
- Stakeholder engagement processes: 76% reported that they or their offices use stakeholder engagement processes. 59% said this tool has high utility. For those who reported constraints to using this tool, conflicting demands on time (38%) was the greatest constraint. An additional notable constraint was insufficient number of staff (36%).
- Meeting facilitation: 76% reported that they or their offices use meeting facilitation. 42% said this tool has high utility. For those who reported constraints to using this tool, insufficient number of staff was the greatest constraint (30%). An additional notable constraint was conflicting demands on time (20%).

- Strategic Planning: 73% reported that they or their offices use strategic planning. 45% said this tool has high utility. For those who reported constraints to using this tool, not enough staff (32%).
- Surveys: 68% reported that they or their offices use surveys. 22% said this tool has high utility. For those who reported constraints to using this tool, insufficient staff was the greatest constraint (37%). An additional notable constraint was conflicting demands on time (35%).
- Project management: 63% reported that they or their offices use project management. 44% said this tool has high utility. For those who reported constraints to using this tool, conflicting demands on time was the greatest constraint (40%). Additional top constraints included insufficient number of staff (30%) and a lack of required knowledge/skills (21%).
- Evaluation of individual products or projects: 62% reported that they or their offices use evaluation of individual products or projects. 40% said this tool has high utility. For those who reported constraints to using this tool, insufficient number of staff was the greatest constraint (47%). Another top constraints were conflicting demands on time (35%).
- Interviews: 56% reported that they or their offices use interviews. 20% said this tool has high utility. For those who reported constraints to using this tool, insufficient number of staff (25%) was the greatest constraint.
- Needs Assessments: 56% reported that they or their offices use needs assessments. 37% said this tool has high utility. For those who reported constraints to using this tool, conflicting demands on time was the greatest constraint (41%). Other top constraints were insufficient number of staff (33%) and lack of relevant/necessary data (26%).
- Policy/legislative analysis: 49% reported that they or their offices use policy/legislative analysis. 43% said this tool has high utility. For those who reported constraints to using this tool, not enough staff was the greatest constraint (28%).
- Evaluation of entire programs: 44% reported that they or their offices use evaluation of entire programs. 18% said this tool has high utility. For those who reported constraints to using this tool, insufficient number of staff was the greatest constraint (39%). Another top constraint was conflicting demands on time (30%).
- Stakeholder analysis: 42% reported that they or their offices use stakeholder analysis. 18% said this tool has high utility. For those who reported constraints to using this tool, insufficient number of staff and conflicting demands on time were the greatest constraints (19 % each).
- Focus groups: 41% reported that they or their offices use focus groups. 17% said this tool has high utility. For those who reported constraints to using this tool, insufficient staff was the greatest constraint (27%). An additional, notable constraint was conflicting demands on time (25%).
- Observation: 40% reported that they or their offices use observation. 21% said this tool has high utility. For those who reported constraints to using this tool, insufficient amount of staff was the greatest constraint (27%).
- Demographic analysis: 39% reported that they or their offices use demographic analysis. 20% said this tool has high utility. For those who reported constraints to using this tool, conflicting demands on time was the greatest constraint (24%). Additional, notable

constraints were insufficient number of staff and the lack relevant/necessary data (22% each).

- Cost-benefit analysis: 37% reported that they or their offices use cost-benefit analysis. 21% said this tool has high utility. For those who reported constraints to using this tool, conflicting demands on time was the greatest constraint (25%). An additional, notable constraint was insufficient number of staff (23%).
- Social assessments: 28% reported that they or their offices use social assessments. 18% reported this tool as possessing high utility. For those who reported constraints to using this tool, insufficient number of staff was the greatest constraint (40%). An additional, notable constraint was conflicting demands on time (26%).
- Non-market valuation: 18% reported that they or their offices use non-market valuation. 20% said this tool has high utility. For those who reported constraints to using this tool, insufficient number of staff and lack of required knowledge/skills were the greatest constraints (25 % each).
- Content analysis: 17% reported that they or their offices use content analysis. 11% said this tool has high utility. For those who reported constraints to using this tool, the lack of applicability/interest was the greatest constraint (18%). Additional, notable constraints were insufficient number of staff and conflicting demands on time (16% each).
- Logic models: 15% reported that they or their offices use logic models. Only 6% said this tool has high utility. For those who reported constraints to using this tool, conflicting demands on time (28%) was the greatest constraint. An additional, notable constraint was insufficient number of staff (23%).

Methods Used to Obtain or Exchange Information

The following list shows the percentage of West Coast respondents using different methods to exchange information about tools, technology, or other issues related to their jobs:

- Workshops (94%)
- Professional meetings and conferences (91%)
- Talking with colleagues (90%)
- Trainings (78%)
- Websites (77%)
- Technical documents, government reports, conference proceedings (73%)
- Newsletters (61%)
- Scientific journals (58%)
- E-mail discussion groups (list serves) (56%)
- Books (56%)
- Magazines (48%)
- CDs (47%)
- Trade publications or corporate reports (41%)
- Private sector relationships (39%)

- Electronic journals (e-journals) and electronic magazines (e-zines) (33%)
- Web-based discussion groups (25%)

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