STRATEGIC PLAN

ENHANCED COASTAL OBSERVATIONAL SYSTEM AND PREDICTIVE HYDRODYNAMIC MODEL FOR IMPROVED MANAGEMENT OF THE COOS BAY ESTUARY, OREGON

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A Strategic Plan for an Enhanced Coastal Observational System and Predictive Hydrodynamics Model for Improved Management of the Coos Bay Estuary, Oregon

Introduction

A multi-disciplinary team of technical experts met on 24-25 May, 2005 to define a strategy and identify specific requirements for development of an enhanced coastal observational system for the Coos Bay estuary to support a variety of stakeholder needs. The purpose of this report is to present the strategy in an effort to stimulate proactive thinking, creative partnerships, and leverage resources to acquire, maintain and disseminate the data to address needs identified in this strategy.

The technical team capitalized on the outcomes of two key prior events. The first was a Coos Bay stakeholder meeting (1997) that explored an integrated strategy to model the estuary and watershed, including identifying requirements, opportunities and limitations to characterize issues spatially and temporally, and to provide advice on the next necessary steps towards developing an integrated modeling capability. The second was a Coos estuary stakeholders' meeting (29 April, 2005) that introduced local users to the Integrated Ocean Observing System (IOOS) and the Pacific Northwest Association of Networked Ocean Observing Systems (NANOOS). This meeting provided further opportunity to identify current issues and their associated data needs for Coos Bay and its near-shore environment. The NANOOS workshop also capitalized on the ongoing efforts to develop a real-time observational network in support of a hydrodynamic model of Coos Bay and the near-shore Pacific waters.

The strategy developed by the technical team offers a roadmap for development and implementation of the Coos estuary observation system, and enhancement of the predictive numerical modeling tools to address a variety of issues of critical concern. The recommendations spotlight opportunities to use specific data to support many user needs. This report identifies these overlapping opportunities so that data can be acquired efficiently and have the broadest possible usefulness. The strategy builds on historical data sets, current modeling activities and observational networks, and identifies the data framework and analysis needed to ensure that the highest quality data will be applied to decisions regarding, among others, matters of public health and safety and national security.

The mechanism by which this strategy is pursued will be determined by the stakeholders of the Coos Bay watershed and estuary; however, it will be advantageous to develop a local inter-agency oversight committee to provide leadership and coordination in acquiring the data and providing it to users. The oversight team would decide governance issues and ensure that quality standards associated with the acquisition and use of the data are maintained. This is an integral process that needs to be addressed by agencies and organizations responsible for management of the estuary. Data developed from the hydro model will play a critical role in many applications, among them, ensuring safe navigation; search and rescue and emergency response; contingency planning; protecting public health on beaches and when consuming shellfish; restoring estuarine habitat, and maintaining harbors and shipping channels.

Funding strategies should focus on, among other things, acquisition and maintenance of sensors and infrastructure; quality assurance and control protocols for acquiring data; maintenance and dissemination of data, development of models and methods for delivering information.

Description of the Study Area

Physical Characteristics of the Coos Estuary

Detailed descriptions of the Coos Bay estuary can be found in the Pacific Northwest Coastal Ecosystems Regional Study (PNCERS) *Where the River Meets the Sea: Case Studies of Northwest Estuaries* (Little and Parrish 2003) and the *Site Profile of the South Slough Estuary* (Rumrill 2005). These summary documents provide a detailed description of the geomorphology of the Coos Bay estuary. In contrast, this report provides only enough of a description of the bay's physical characteristics to provide context for a bay tour that was arranged to provide the technical team with a first-hand glimpse of modeling needs and issues.

The Coos Bay estuary covers 54 square miles of open channels and periodically inundated tide flats located near the town of the same name on the southern Oregon coast. About half of the estuary is dominated by marine waters that enter on flooding tides. The remaining half is composed of a mixture of mesohaline and riverine waters (Figure 1). Nearly 50 percent of the total volume of the estuary is within the tidal prism. A 42 ft. deep (MLLW), sixteen-mile-long ship channel is maintained from the harbor entrance to the Port of Coos Bay. At low tide, a substantial portion of water in the bay is held within the ship channel (Figures 2 and 3). Extensive tide flats flanking the ship channel are exposed at low tide.

The narrow estuary is maintained at its mouth by two rock jetties extending from North Spit on the north and Coos Head on the south. The north jetty is vulnerable to separation from the sandy spit due to the action of high energy waves and surf that can cause severe erosion during winter storms. Immediate and expensive corrective responses (by the U.S. Army Corps of Engineers) are necessary following breaching of the spit adjacent to the jetties. The bayside shoreline of North Spit immediately behind the north jetty has been steadily eroding. Improved understanding of the sediment transport mechanisms in this region of the estuary, in particular, of regimes of erosion and deposition, can support decision-making on strategies to stabilize the spit's shoreline and reduce its vulnerability to erosion.

From the harbor entrance the main channel bears northward past the communities of Charleston, Barview and Empire, then east around the city of North Bend, and south past downtown Coos Bay (Figure 1). At Coos Bay the channel bears east again and encounters a deltaic zone at the mouth of the Coos River. About two miles upstream the river divides into the Millicoma River on the left and the South Fork of the Coos River on the right. The estuary ranges between a mile and a mile and a half wide. The head of tide extends inland to the Elliott State Forest on the Millicoma River and to below the logging camp of Dellwood on the South Fork of the Coos River.

Numerous slough systems and freshwater channels flow into Coos Bay (Figures 1 and 4). The South Slough sub-estuary is located directly south of the mouth of Coos Bay in Charleston (Figure 4). This convergence of the South Slough, greater Coos Bay, and the nearshore waters of the Pacific Ocean presents a very complex hydrodynamic regime. This area is also a region where many public resource and estuarine management issues converge including recreational boating, maritime commerce, deep-draft navigation, dredge disposal, commercial and sport shellfish harvesting, water quality degradation, development of total maximum daily load (TMDL) water pollution limitations, deposition of hazardous materials in sediments, shoreline maintenance, contingency planning, habitat restoration, and search and rescue.

North Slough and Haynes Inlet enter the bay from the north, across from the city of North Bend. Pony Slough drains northward through the city of North Bend to the bay. Kentuck Inlet and Willanch, Catching, Isthmus, Coalbank, and Shinglehouse sloughs flow into the eastern and southern portions of the bay.

The Coos and Millicoma Rivers above the head of tide contribute approximately 60 percent of the fresh water entering Coos Bay. The other 40 percent is contributed by the slough systems and runoff apparently originating below the heads of tide. Understanding the origin of the 40 percent of ungauged fresh water contribution below the heads of tide is critical to understanding the hydrological inflows into Coos Bay, which in turn are necessary to model the flow regimes within the estuary. Data acquisition to describe inputs from the slough systems will require gauging in order to support hydrodynamic modeling in the mesohaline and deltaic portions of the estuary.

The hydrology in most of the slough systems has been modified by dikes maintained by tide gates in various stages of operational effectiveness. Behind the dikes lie extensive pasture lands that provide forage for cattle. Many of these lands have subsided significantly since they were diked a century or more ago. A few of the tide gates have been modified to allow passage of salmon during outgoing tides. Figures 1-4 depict the key hydrologic and geomorphic features of the Coos Bay estuary.

The estuarine influence of Coos Bay (the estuarine plume) extends offshore to the south during the spring and summer driven by northerly winds, and north during the winter driven by southerly winds and periods of high river discharge. The intensity of the winds strongly impacts currents within the estuary as well; however, the local estuarine variation in wind patterns needs to be better understood to quantify its impact on local hydrologic circulation patterns.

Stakeholder Issues in Coos Bay

Coos County is home to a population of approximately 62,500 people. The primary urban centers located along the shoreline of the estuary include the cities of Coos Bay (ca. 15,000), North Bend (ca. 9,000), and the unincorporated towns of Charleston and Barview (ca. 6,000). The local economy is transitioning from a traditional base of extractive industries such as timber and fishing to one based on tourism, service industries and transfer payments linked to a growing retirement sector. The Coos estuary supports the largest port facility fully within Oregon state boundaries outside of the Port of Portland. The Oregon International Port of Coos Bay averages 70-80 ships per year. Faced with reduced shipping, the Port is seeking ways to remain competitive by diversifying, maintaining safe passage into and out of Coos Bay, and minimizing dredging costs.

It is unknown how disposal of contaminated sediments dredged from the upper bay impact shellfish beds within the estuary, or whether, and to what extent, contaminated sediments re-suspend and become distributed throughout the bay. Nor is it known whether modifying the configuration of the channel near the entrance will increase erosion from the North Spit. These issues, of critical interest to the Port, are particularly acute in the marine-dominated portions inside the jetties.

Coos Bay is the largest commercial producer of shellfish in the state of Oregon. Commercial shellfish operations are located in the South Slough, North Slough, and in the expansive mesohaline region of the bay north and east of the city of North Bend. Intertidal mud flats flanking the main channel extend from the mouth of the bay to North Bend, and from Charleston into South Slough, and support the state’s richest recreational shellfish beds. Potential commercial shellfish growing areas are located across the channel from the city of Coos Bay, but they are closed to commercial and recreational shellfish harvests much of the year due to the lack of information on water quality and flows patterns within the area that could signal shellfish contamination.

Acquisition of this information could have an immediate socioeconomic benefit if these beds can be opened for harvesting. Aquaculture development in Oregon is limited by few protected coastal areas – the estuaries. Oregon’s estuaries have highly variable salinity levels, wind and waves. Oyster culture in Oregon accounted for sales totaling

$4 million in 2000 (Langdon, 2000).
Lack of information on the magnitude and direction of water movement inside the bay also hampers the Oregon Department of Environmental Quality from issuing dredge disposal permits in a timely fashion because of the unknown impacts of contaminants in sediments on these nearby shellfish beds. Information on currents would dramatically speed up the permit review process and reduce the permit-related costs.

Restoration of diked tidelands and habitats above the tide gates is a high priority for stakeholders in the bay, which has lost about 84 percent of its historic tidal wetlands. The bay once supported many runs of salmon, including Oregon coastal coho (*Oncorhynchus kisutch*), which is under review by NOAA National Marine Fisheries Service for protection as a threatened species under the U.S. Endangered Species Act (NOAA, 2005). The Coos Watershed Association is engaged in a bay-wide grass-roots planning process to work with communities to target restoration opportunities behind the dikes. Understanding the hydrology of these systems is important for restoration planning, and for engaging land owners in the restoration process which must be sensitive to their concerns. Observational networks and modeling tools can help engage landowners in identifying and supporting restoration strategies.

Due to the extensive tidal range and the complex geomorphology of the estuary, contingency planning and search and rescue operations require understanding of the circulation patterns in Coos Bay both at surface and depth. A spill of hazardous material in any part of the watershed has the potential to migrate into all portions of the bay. Data on circulation patterns with high vertical resolution would provide emergency responders and search and rescue personnel with timely information to support decisions regarding the placement of response equipment and in targeting search and rescue efforts.

COOS ESTUARY, OREGON

Figure 1.

Overview of the Coos Bay estuary and the system of sloughs and tidal inlets, illustrating the spatial extent and location of the marine-dominated, mesohaline, and riverine hydrographic regions. The boundaries of these distinct regions are dynamic and vary considerably in response to changes in ocean forcing, wind stress, precipitation, and freshwater inflow.

Marine Dominated

Mesohaline

Riverine

COOS ESTUARY, OREGON

Figure 2.

Lower Coos Bay showing harbor entrance and shipping channel

Marine Dominated

Mesohaline

Riverine

Shipping Channel

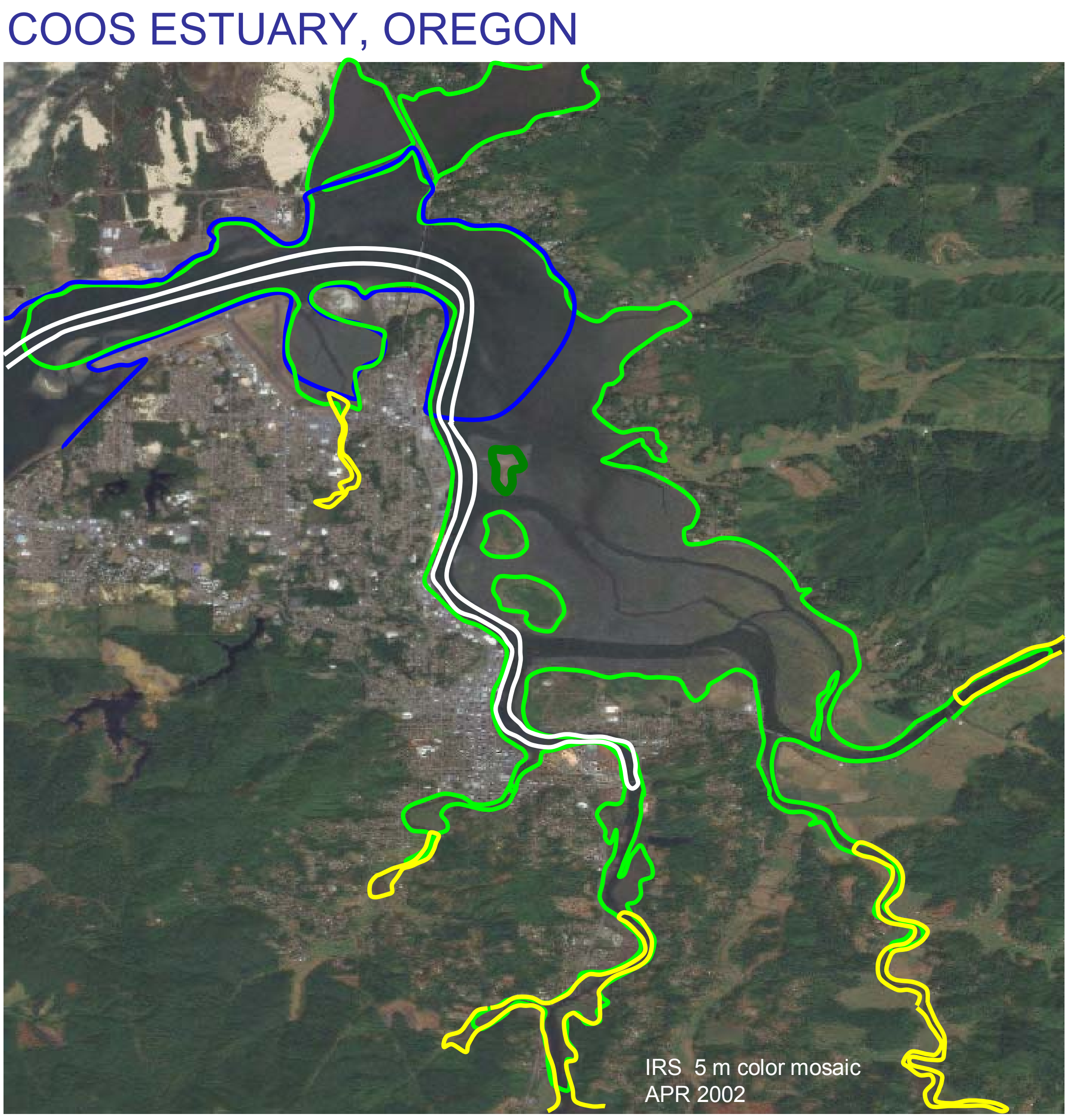

Figure 3.

Upper Coos Bay showing the extent of dredging necessary to maintain the shipping channel in the soft sediment deltaic region

- Marine Dominated
- Mesohaline
- Riverine
- Shipping Channel

SOUTH SLOUGH ESTUARY, OREGON

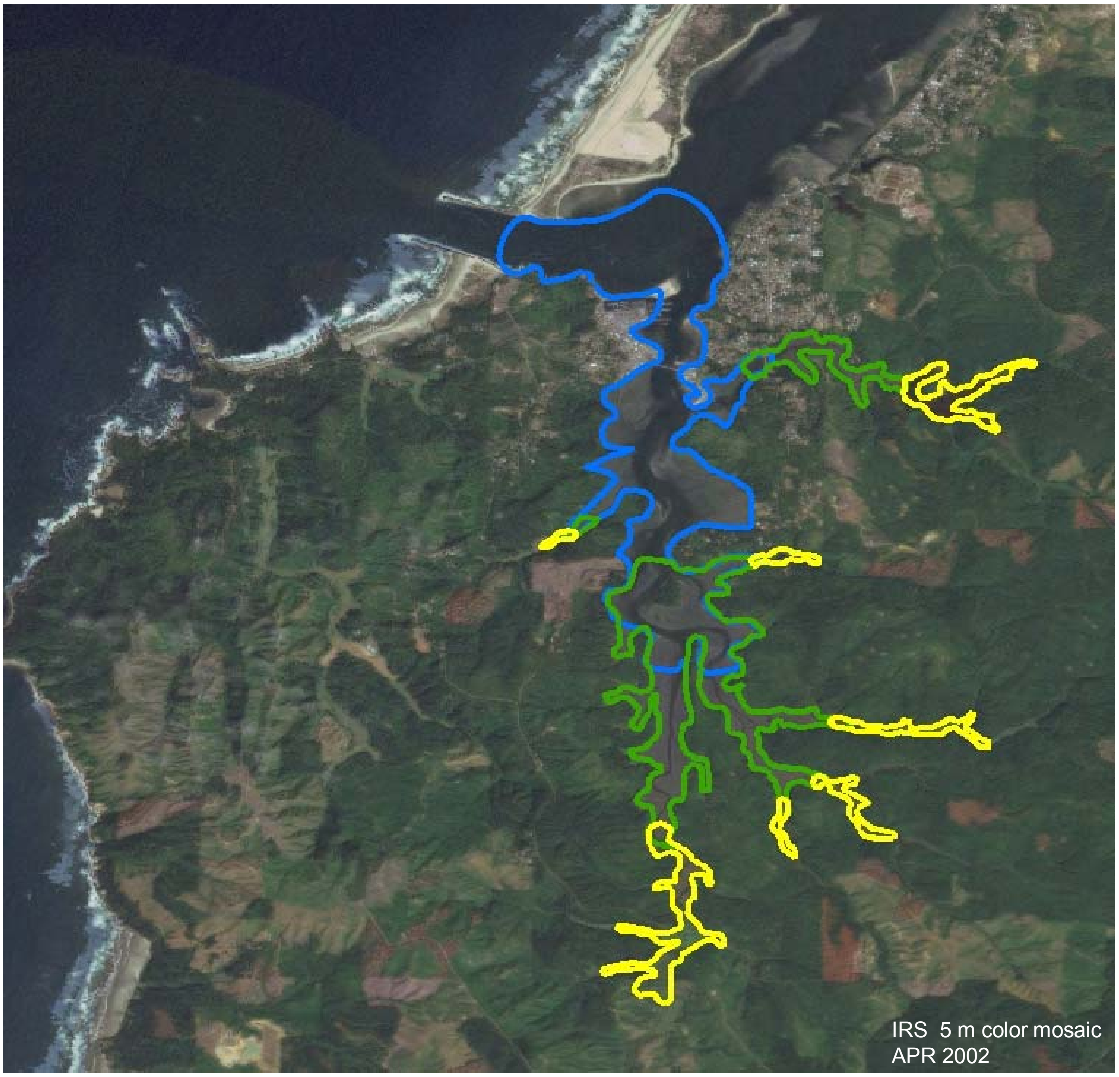

Figure 4.

Location and spatial extent of three distinct hydrographic regions located along the estuarine gradient of the South Slough tidal basin

Marine Dominated

Mesohaline

Riverine

Meeting Summary

A Tour of the Coos Bay Estuary

The first day of the meeting began with an orientation to give the technical team an overview of the physical characteristics and stakeholder issues within the Coos Bay estuary. The remainder of the day was devoted to a tour of the estuary to examine local areas of interest related to issues including navigation, fisheries, restoration, search and rescue, contingency planning, water quality management and erosion. The tour began at the mouth of the estuary on Coos Head where discussion with Don Yost, harbormaster of the Charleston Marina of the Port of Coos Bay focused on deep-draft maritime commerce, navigational safety, dredge material disposal, specific requirements for commercial fishing vessels, recreational boating, sediment deposition and re-suspension, water quality problems, search and rescue operations, and emergency contingency-planning. The team then traveled up the bay to the North Bend airport to discuss ship terminals and facilities issues on the North Spit, recreational clamming beds in the tide flats, and dredge disposal adjacent to the ship channel. In the marine-dominated region of Coos Bay these issues are directly related to the extent of tidal flushing. The primary requirements for input to numerical models for this region of the estuary are detailed bathymetry, water surface elevations, current velocities, and wind stress. Accurate clearance measurements are also needed to assure adequate ship clearances for safe passage of the Highway 101 bridge and railroad bridge.

The technical team then proceeded into the mesohaline and riverine region of the estuary. At the state-of-the-art tide gate on Larson Slough the team discussed restoration challenges above tide gates with Jon Souder, director of the Coos Watershed Association. Souder emphasized the need to model hydrology above the tide gates and explore restoration opportunities with land owners. Restoration must be balanced with a variety of management interests.

Next the team traveled up the Millicoma River to the Marlow Creek stream flow gauge, located within the Elliott State Forest, where they discussed fresh water hydrology and fish habitat with Jennifer Feola of the Oregon Department of Fish and Wildlife. There is a need to connect data from freshwater inflows at the stream gauges with NOAA’s National Water Level Observation Network (NWLON) station, located at Charleston.

On the return to Coos Bay the team paused at Catching and Isthmus sloughs, where they discussed dikes, tide gates and land uses behind the dikes, much of which is used for pasturing cattle. The team viewed extensive tide flats at the Coos River delta that support fisheries and discussed related water quality issues.

The final stop on the tour was at the Coos Bay City Docks, where the team discussed navigation and sedimentation as it relates to management of the harbor as a deep draft port. After viewing the harbor the team returned to Charleston, ending the first day of the meeting.

The tour enabled the team to explore the interaction of the hydrology, estuarine circulation, and land and water uses throughout the Coos estuary, and begin formulating ideas and strategies that would address these information gaps in a hydro model.

Meeting Outcomes

In addition to the technical team, participants on the second day of the meeting included representatives of the U.S. Army Corps of Engineers, Oregon Health Sciences University’s Oregon Graduate Institute, South Slough National Estuarine Research Reserve, Oregon Department of Environmental Quality, Oregon Department of Fish and Wildlife, Coos Watershed Association, Southwest Oregon Community College, and Oregon International Port of

Coos Bay. Representatives of the U.S. Coast Guard, U.S. Fish and Wildlife Service, National Marine Fisheries Service, U.S. Environmental Protection Agency, recreational users, and the commercial fishing industry were not present; but since many of this latter group had participated in the NANOOS meeting on 29 April, 2005, their interests were made known during those discussions and subsequently were available for the technical team to consider. (See the Appendix for a complete list of invited participants.) The second day's sessions were planned to include a small number of users who would be the direct recipients of data, as well as the multi-disciplinary technical team. The intent of the meeting planners was to limit the size of the group so that focused and detailed discussions might occur. While the meeting was planned to last three days, the preparedness of the participants (having come fresh from the April NANOOS meeting) and success of the estuary tour meant that the summary of issues, their geographic scope, and data needs were covered more rapidly than expected. The participants were ready to begin the data planning process sooner than expected, and in fact were able to finish their work by the end of the second day.

To set the stage, key participants provided an introduction to some of the technical aspects that must be considered in developing hydrodynamic models. Antonio Baptista, from the Oregon Graduate Institute of Oregon Health and Sciences University, discussed his modeling efforts on the Columbia River and in Coos Bay. This provided an opportunity to learn about the data sources Baptista uses to develop hydro models. Kristen Tronvig from the NOAA Center for Operational Oceanographic Products and Services (CO-OPS) discussed the value of water level information and geodetic markers, especially as they relate to habitat restoration and navigation. Gary Perasso, the Washington and Oregon State Advisor for the National Geodetic Survey, discussed the importance of geodetic markers and accurate vertical data as it relates to a variety of issues.

The group next clarified the geographic scope of the issues identified at the April 29th NANOOS meeting using a hydrologic classification that included five categories: Marine-dominated (R-1), mesohaline/deltaic (R-2), riverine/tidal fresh (R-3), sloughs/tidal inlets (R-4), and tide flats (R-5). The issues were summarized by themes. Specific regions of the estuary corresponding to each category were identified, and the particular issues that were relevant to those areas were identified. As a follow up, participants identified socioeconomic benefits that would result from accurately addressing the data gaps associated with each issue.

The intent of this exercise was to ensure that the issues identified in the April 29th NANOOS workshop were comprehensive; to establish common ground before initiating the planning process; to define geographically where various issues overlap; which issues are bay-wide, and which are more localized. This analysis was critical to determining the location of required data sources, the scale of resolution that was necessary for various types of data, and the priority of acquiring various data for various uses.

Table A summarizes the outcomes of this discussion and lists the issues by region and socioeconomic benefits.

Figure 5 depicts these issues geographically on a map of the Coos estuary.

Table A: Summary of Issues by Estuary Region and Socioeconomic Value

Theme	Issue	R-1	R-2	R-3	R-4	R-5	Socio-economic value
Oregon International Port of Coos Bay; Maritime operations	1. Sediment deposition in the ship channel 2. Erosion at southern end of North Spit and breaching of the north jetty during storm events 3. Dredge material disposal sites and impacts at various locations 4. Maintenance of the ship-turning basin(s) 5. Other issues particularly acute at entrance to bay and near the North Bend Airport	x	x	x	x (South Slough)		1. Commerce, landing fees, longshore industry 2. Safety benefits (i.e. will help with road and bridge closures) 3. Prevention of vessel groundings, etc. 4. Makes Coos Bay more competitive as a port; will attract businesses and new industries (e.g.: liquified natural gas storage terminal) 6. Retain infrastructure 7. Observations will help port identify potential projects. 8. More efficient and effective decision making for dredging, channel management. 9. Minimize need for (and costs of) emergency jetty repairs following storm events.
Commercial fishing	1. Location of fisheries and primary catch areas 2. Contamination of fish 3. Vessel safety 4. Fish management; loss of fleet and jobs 5. Infomation on upwelling and currents 6. Lack of adequate ecological information to make informed decisions 7. Add information from ODFW seining of juvenile fish data (collected for the last 25 years, but unquantified)	x (Issue outside of Coos Bay entrance)	x				1. Accurate forecasting of bar conditions will imrpvoe safety and save lives 2. Improve vessel operations through improved predictions 3. Improved fishery management 4. Improved monitoring of stocks
Commercial crabbing	1. Dynamics between ocean and estuary 2. Fish tissue 3. Vessel safety 4. Track location of pots	x	x			x	1. Improved management of both recreational and commercial catch 2. Positive impact on local economy
Shellfish mariculture (oysters)	1. Growth and productivity 2. Product safety 3. Oyster contamination 4. HAZMAT spills 5. Lack of detailed current information for areas where oyster beds are located near former or current industrial sites 6. Lack of information for potential additional oyster-growing areas	x	x	x	x	x	1. Increase the extent of shellfish growing areas with better data 2. Better management of time and extent of closures due to pollution.

	7. Impact of chemical discharges from shore-based facilities 8. Areas of interest include South Slough, Haynes Inlet, and tide flats from Haynes Inlet to Marshfield Channel.						
Marine safety; Search and rescue	Entrance and nearshore ocean are areas of particular concern	x (hot spot in beach area)	x	x	x	x	1. Safety benefits (i.e. will help with road and bridge closures) 2. Prevention of groundings, etc. 3. Improved response time 4. Saving lives
Hazardous materials (HAZMAT)	1. Points of discharge into the bay (land based and fuel facilities) 2. Upstream points of discharge; 3. Hot spots include Charleston boat basin, docking facilities across from the airport, port of Coos Bay, and Isthmus and Catching sloughs	x (hot spots in marine terminals and fueling facilities)	x	x	x	x	1. Continued clean water 2. Reduce cost of managing HAZMAT operations 3. Better placement of HAZMAT emergency response equipment and operations bases
Assessment and improvement in water quality; Public health	1. Accurate assessments of water quality in bay 2. Bacterial and chemical contaminants 3. Eutrophication 4. Hypoxia in Isthmus Slough and the tidally-influenced portion of the Coos River 5. Bacteria in the upper bay 6. EMAP sites are scattered 7. Improved understanding of extent of eel grass beds and their influence on water quality 8. Need information about water quality behind tide gates	x	x	x	x	x	1. Improved management decisions 2. Required technical decisions will be made 3. Recreational and commercial resource protection
Seafood processing plant discharges	1. Water quality impacts from industry (Charleston area) 2. Waste stream is difficult to treat 3. Fate of discharge – what is the extent of impacts in the region?	x			x		1. Recreational uses near outfall 2. Commercial benefits 3. Public health
Habitat restoration and mitigation	1.Where are the locations of potential successful restoration sites? 2. Opportunities for coupling multiple sites and projects 3. How can project design, implementation, etc. be improved with knowledge of hydrodynamics? 4. How can hydrodynamic information improve decision making? 5. Need high-resolution site-	x	x	x (goes up to head of valley, need to understand hydrology	x (likeliest focus of restoration projects	x	1. Improvement in success rates of mitigation sites 2. Economic benefits – new bridges, terminals, etc. 3. Enhanced infrastructure 4. Improved public support and confidence 5. Reduced uncertainty for decision-making

	based information						
Habitat assessment; Environmental integrity; Habitat for living resources	1. Accurate assessment of condition and status of habitats 2. No accurate habitat mapping of sub-tidal parts (Most currently-used maps are 30 years old.) 3. This system is extensively invaded by non-native species. Would like to predict where colonizations are likely.	x	x	x (spawning salmon)	x	x	1. Healthier estuary will provide habitat for diverse plants and animals 2. Eco-tourism, recreation 3. Waterfowl production 4. Healthy habitats 5. Reduced incidence of endangered species will allow business, commerce and other economic development room to advance.
Marine science education; Training; Research	1. Knowledge of physical and ecological dynamics increases literacy and understanding	x	x	x	x	x	Potential partnerships
Recreational uses (boating, clamming, kayaking, bird-watching, beaches	1. Increased use of natural resources for ecotourism and recreation 2. Water quality, public health, aesthetics	x	x	x	x	x	Revenue from ecotourism is not known, but appears to be about 25 to 30 percent of local economy and is increasing.

COOS ESTUARY, OREGON

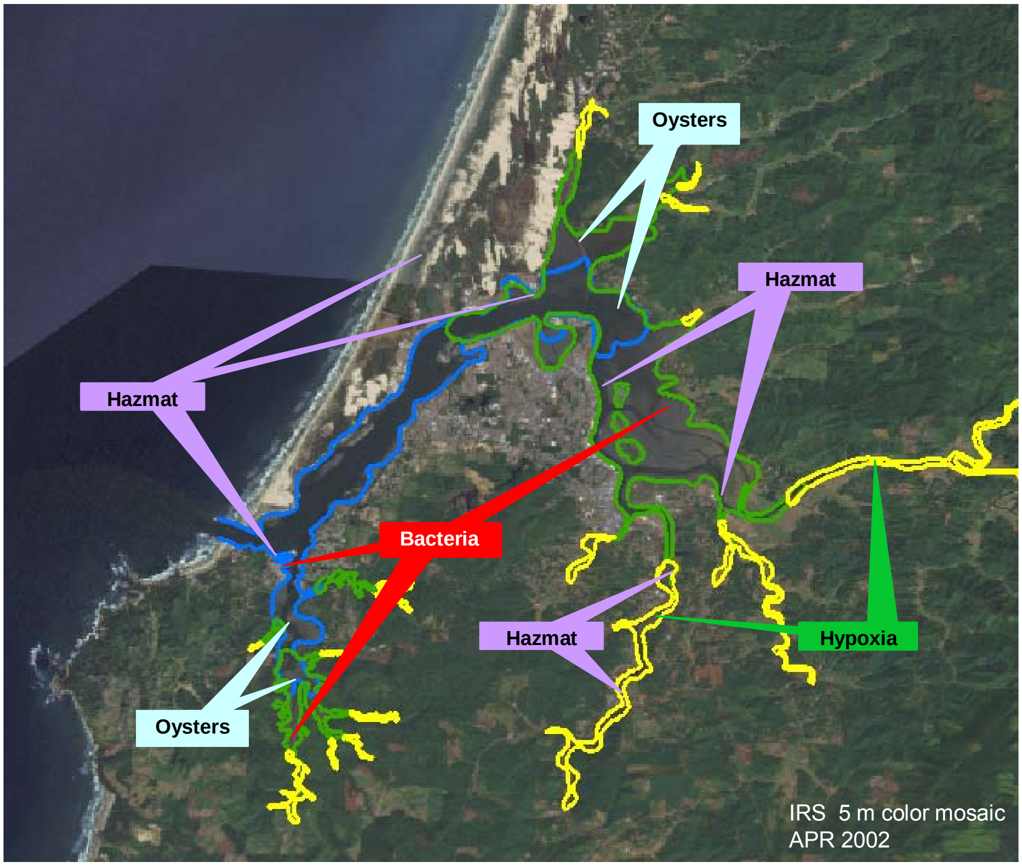

Figure 5.

Estuarine management issues by hydrodynamic region

HAZMATS Denotes locations of a variety of hazardous material or sediment toxicity issues where high concentrations of heavy metals, oils and grease, and PAHs (polyaromatic hydrocarbons) have been identified.

HYPOXIA Denotes locations of tidal inlets where chronic levels of low dissolved oxygen are problematic for estuarine ecological communities.

BACTERIA Denotes locations of site where concentrations of total coliform, fecal coliform, *E. coli* and *Enterococcus* bacteria frequently exceed standards for recreational waters.

OYSTERS Denotes locations of commercial oyster cultivation operations.

Marine Dominated
Mesohaline
Riverine

Table B. Recommendations regarding placement of observational sensors

Table B captures recommendations of the workshop participants regarding where sensors should be located and what data must be acquired to support the users' needs. This part of the discussion involved extensive debate and resulted in a prioritization of the sequence of data acquisition, as well as identifying which data can be acquired locally and immediately. In many instances, more than one recommendation was given the same priority because acquisition of both was found to be necessary for the success of the phased approach that will likely be used in developing the strategy. The data recommendations were then specified on a map of the bay, as shown in Figure 6. Not all prioritizations are shown in the table.

Recommendation	Issues Addressed	What Should Be Done	Where	Benefit	Source of Data	Sequence of Implementation (Prioritization)
Establish a series of real-time sensors (long-term deployment).	1. Water quality 2. Channel maintenance 3. Contingency planning 4. Safe navigation 5. Invasive species management 6. Emergency planning 7. Navigation safety	1. Water level, temperatures and salinity measured at surface and at depth (mid-level and bottom) 2. Currents 3. Short waves	1. Outside of channel entrance near jetties (Note: offshore sites are more costly, especially for maintenance) 2. South Slough 3. Ship channel north of Fossil Point 4. Ship channel near North Bend Airport 5. Convergence of Coos River and Catching Slough		Charleston Water Level Station (NWLON) station is due to be upgraded to the Xpert System (in FY06); Could be an opportunity to add additional sensors	2 (without offshore station)
Conduct seasonal monitoring using vessel transects (vessel-based hydrographic surveys). Include turbidity on vessel transects.	1. Water quality 2. Channel maintenance 3. Contingency planning 4. Safe navigation 5. Invasive species management	1. Longitudinal transects (temperature, salinity and turbidity) Run transects at SBF (slack before flood) and at SBE (slack before ebb) 2. Vertical transverse transects also run SBF and SBE 3. Time series transects (13 hr.)	1. Offshore of jetties 2. Along the ship channel 3. In South Slough		OHSU (NANOOS)	4
Conduct comprehensive series of seasonal observations along horizontal transects.	1. Water quality 2. Channel maintenance 3. Emergency contingency planning 4. Navigation safety 5. Invasive species management 6. Restoration	1. Salinity, temperature, water levels, turbidity 2. Apply water level measurements to NOAA standards (temporary water levels will eventually improve nautical charts). 3. Tidal benchmarks required for temporary stations– including time series CTD stations.	1. From offshore to mouth of Coos River 2. Nearshore zone across estuary entrance 3. Across South Slough from Charleston to Long Pt. 4. Across estuary from Fossil Pt. to North Spit 5. Across the estuary just below Empire	1. Model validation 2. Improved understanding of Coos Bay estuary dynamics	Baseline will be established by EPA in the summer of 2005.	3

Recommendation	Issues Addressed	What Should be Done	Where	Benefit	Source of Data	Sequence of Implementation (Prioritization)
Link existing tidal benchmark network to geodetic benchmark network. Establish vertical and horizontal control points to look at North Spit dynamics (precursor to LIDAR (LIDAR: light detection and ranging) aerial survey)	1. Vertical reference system 2. Shoreline stabilization 3. Mapping for restoration 4. Baseline information for DEM 5. Channel maintenance	1. Add geodetic benchmark network including 4 to 5 reference sites. 2. Secondary choice – establish a grid.	Throughout area (Pigeon Point, Empire; North Bend Airport; North Point; Haynes Inlet entrance)	1. Link water level data and sea levels with land elevations and geodetic data. 2. Baseline information can produce DEMs. 3. Enables monitoring of shoreline change 4. Sediment budget estimates 5. Provides reference points for LIDAR imaging. 6. Use for pressure transducer location on tide gates.	NOAA/NOS/NGS CWA SSNERR, Coastal Training Program	2
Develop inventory of all data (including historical).	1. Water quality – public health (shellfish harvesting) 2. Channel maintenance 3. Emergency ontingency planning and search and rescue 4. Restoration 5. Safe navigation 6. Invasive species management	Physical, biological and sediment transport data		Validate the hydro model; adapt or refine locations where monitoring is conducted.	Literature search (PAGIS or GRF support from the SSNERR)	On-going
HF radar	1. Safe navigation 2. Water quality 3. Sediment transport, dredging and impacts to shellfish areas	1. Antenna that produces a grid of surface currents 2. X-band radar (wave direction and frequency)	Entrance area (Channel mouth and harbor entrance)	Improved understanding of hydrodynamics at the entrance of the estuary		5 4
1. Horizontal looking ADCP at key causeway and throughways. 2. Air gap at bridge This is essentially requesting a PORTS	Safe navigation	Install a current meter and an air gap sensor	McCullough Bridge	Currents, water level under bridge for navigation purposes	NOAA/NOS	6

Recommendation	Issues Addressed	What Should be Done	Where	Benefit	Source of Data	Sequence of Implementation (Prioritization)
LIDAR imagery to develop a digital elevation model (DEM) (need geodetic benchmarks to implement this recommendation)	1. Watershed restoration 2. Mapping	1 m horizontal resolution and ¼ m to 1/10 m vertical resolution	Haynes Inlet, Kentuck, Willanch, Catching, Isthmus, Coal Bank, and Pony slough watersheds	Will enable hydrologic modeling of sub-watersheds to focus restoration efforts and improve estimation of fresh water inflows below the heads of tide.	Contracts	2
Hydrologic model calibrated with monitoring sites including the four that currently exist and additional site at a small watershed(e.g., Winchester Creek)	1. Watershed restoration 2. Mapping	1. Combine watershed models at one or two targeted monitoring sites. 2. Possibly use water level transducers to calculate flow at one site (i.e. Larson Slough).	All watersheds identified above. (Alternatively, may be able to identify one representative watershed and extrapolate information in simulation exercises.)	Will be able to support restoration assessments in sub-watersheds and calculate contribution of fresh water to estuary below heads of tide.	1. Correlation model (OHSU) 2. Network model (NWS, contractor, River forecasting center) 3. Four gauges calibrated to USGS standards; real time in Winchester Creek.	1B 1C 1A
Perform analysis which compares NWS 12km wind model with our meteorological in-situ measurements.	1. Public health 2. Emergency response 3. Navigation safety, search and rescue 4. Invasive species management 5. Restoration		Use meteorological station at North Bend Airport and/or in Charleston.	Examine the most accurate and cost-effective data to use to model surface flows as influenced by localized winds.	SSNERR, QC with meteorological data.	2
VDatum – Vertical Datum Transformation Tool	1. Restoration 2. Mapping 3. Develop a digital elevation model (DEM)	Tool to transform between different data	Whole area	Capability to transfer between different data and can produce a DEM	NOAA/NOS	4

Recommendations	**Issues Addressed**	**What Should be Done**	**Where**	**Benefit**	**Source of Data**	**Sequence of Implementation (Prioritization)**
Refine high resolution bathymetry shore to shore.	1. Emergency contingency planning 2. Shoreline stabilization 3. Water quality	1.Must be at appropriate resolution 2. Multi-beam survey	Entire Coos estuary including inlets and tidal sloughs	Improve the accuracy of the hydrodynamic model	COE/LIDAR/ Aerial photography	2-3
Development of a rapid response tool to address HAZMAT and oil or chemical spill incidents.	1. Emergency contingency planning 2. Placement of spill response equipment	1. Use hydrodynamic model output to support rapid response planning.	Entire estuary and near shore waters	Real-time assessment of impacts from spills.	Partnership with the Coast Guard, NOAA Office of Response and Restoration	
Analyze frequency and duration of inundation from the Charleston NWLON Station	1. Restoration				NOAA/NOS/ CO-OPS	1

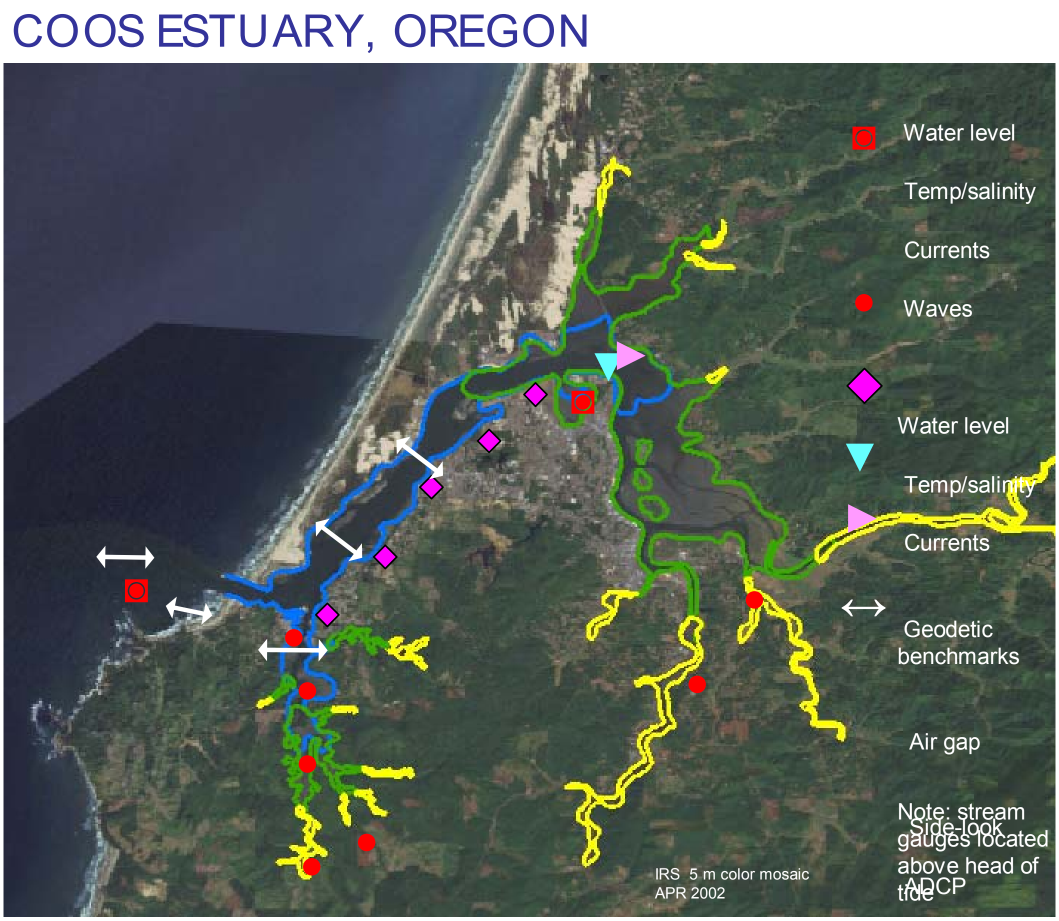

Figure 6.
Map identifying proposed observational network for the Coos Bay estuary.

Marine Dominated
Mesohaline
Riverine

Conclusion

The strategy outlined in this report supports the effort to develop a hydrodynamic model of the Coos estuary and to establish an Integrated Ocean Observing System for the estuary and nearshore waters. Developing the strategy involved analyzing the existing data sources (such as stream flow gauges, weather stations and water quality monitoring stations such as the NWLON gauge at Charleston and water quality monitoring stations within the South Slough National Estuarine Research Reserve) as well as information gaps. This analysis provided recommendations on what additional monitoring tools will be useful to guide future data collection.

The intent is to produce a framework for decision-making that provides crucial information for a wide range of needs within the Coos estuary and the nearshore ocean, including public health and safety, restoration, industrial development and management, pollution control, economic development, recreation and natural resource use and management.

Embedded in the strategy are several opportunities to demonstrate the efficacy of a hydro model quickly, including:

- The placement of geodetic benchmarks along the eastern side of the lower Coos Bay shipping channel;
- The development of DEMs of local watersheds to characterize sub-watershed hydrology and fresh water inputs below the heads of tide;
- Assessments of currents near shellfish beds through the placement of current meters at critical locations (e.g., North Point);
- Assessment of wind models as a component of hydro model validation;
- Inventory of historical data for model validation;
- Frequency and duration of inundation analyses from the Charleston NWLON station.

Participants identified the need to develop rapid response efforts during hazardous spill incidents. Development of an effective and efficient spill response plan would be a welcome outcome of the modeling effort and could be pursued in partnership with the U.S. Coast Guard.

Developing an integrated ocean and estuarine observing system to support decision-making and scientific research in and near the Coos estuary is timely, doable, and can have an immediate impact on the ecology and socioeconomic character of the region. There has been extensive dialogue between stakeholders and technical experts to explore opportunities for developing a comprehensive model that addresses users' needs. The size and configuration of the estuary is such that nearly all data have multiple applications, creating diverse opportunities to apply and benefit from the information the model develops.

This strategy will serve as a blueprint for pursuing data acquisition, maintenance and delivery. We anticipate the strategy will provide excellent opportunities for training, outreach, and education that will support more efficient and cost-effective decision-making and enhanced educational opportunities for state, regional, and local school systems and universities.

Since the workshop, both the Environmental Protection Agency and NOAA have conducted aerial photography flights to develop new images of the Coos estuary for several purposes, including mapping of eelgrass beds and updating color and black and white infrared photographs. The NOAA flight lines encompass the entire South Slough watershed and all of the Coos Bay estuary.

Additionally, the Coos Watershed Association this summer coordinated LIDAR (Light Detection and Ranging) imaging flights.

These images will provide additional data that will be useful in developing the hydromodel.

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