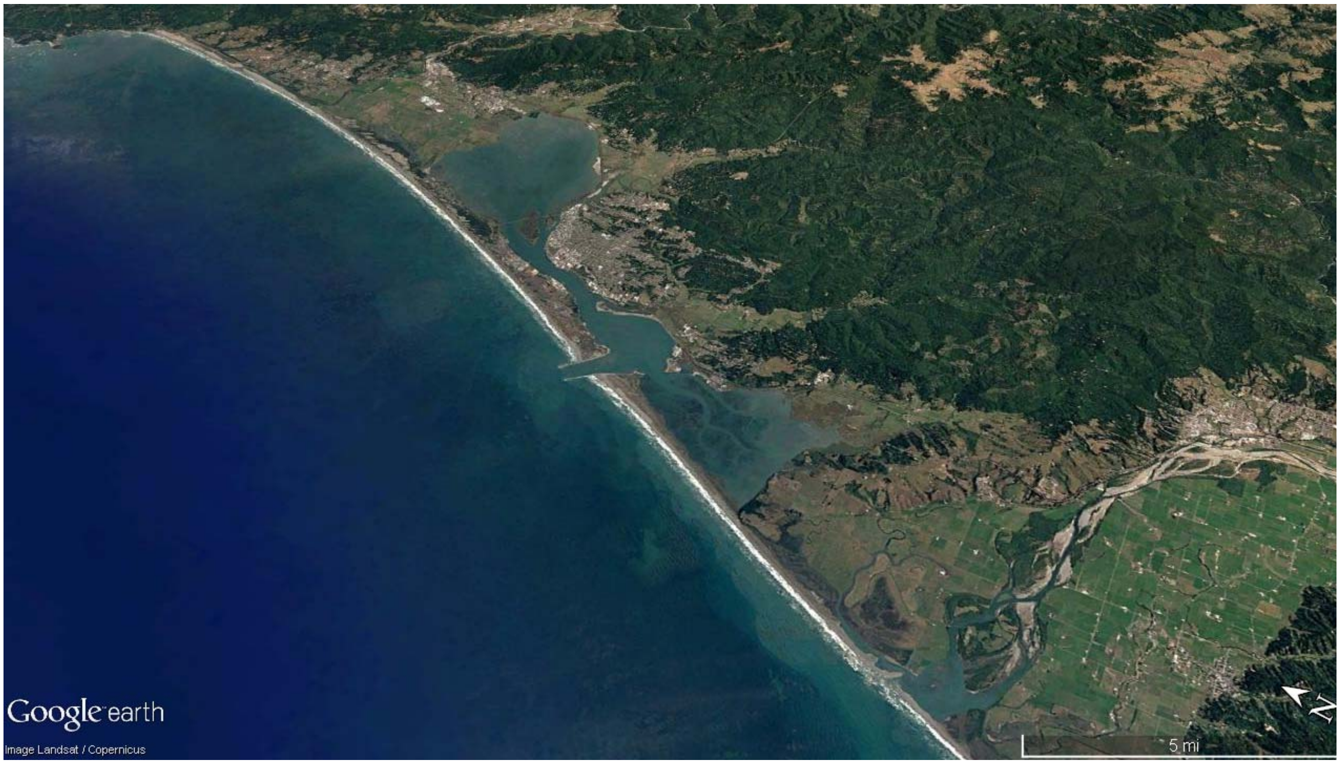
Eureka Littoral Cell, California

Coastal Regional Sediment Management Plan

August 2017



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AMBAG	Association of Monterey Bay Area Governments
BEACON	Beach Erosion Authority for Clean Oceans and Nourishment
BLM	Bureau of Land Management
CalEMA	California Emergency Management Agency
CCC	California Coastal Commission
CCCC	California Climate Change Center
CCP	Comprehensive Conservation Plan
CDFW	California Department of Fish and Wildlife
CEQA	California Environmental Quality Act
CGS	California Geological Survey
CHERT	County of Humboldt Extraction Review Team
CLS	Collecte Localisation Satellites
CNES	Centre National d'Etudes Spatiales
CNRA	California Natural Resources Agency
CRSM	Coastal Regional Sediment Management
CRSMP	Coastal Regional Sediment Management Plan
CSM	Coastal Sediment Management
CSMW	Coastal Sediment Management Workgroup
CSZ	Cascadia Subduction Zone
CWA	Clean Water Act
DEM	Digital elevation model
DMMO	Dredged Material Management Office
DMMP	Dredged Material Management Plan
DPS	Distinct Population Segment
(E)	Existing
EBM	Ecosystem-based management
ECRSMP	Eureka Littoral Cell Regional Sediment Management Plan
ESA	Endangered Species Act
ESHW	Extreme Spring High Water
ESU	Evolutionarily Significant Unit
FLUPSY	Floating Upweller System
ft	Ft or Foot
GIS	Geographic Information System
HBDS	Humboldt Bay Demonstration Site
HBHRCD	Humboldt Bay Harbor, Recreation and Conservation District
HBI	Humboldt Bay Initiative
HBMP	Humboldt Bay Management Plan
HBNWR	Humboldt Bay National Wildlife Refuge
HOODS	Humboldt Open Ocean Disposal Site
HSMP	Humboldt Shoreline Monitoring Program
HSU	Humboldt State University
ICC	Interagency Coordination Committee
in	Inch

IPCC	Intergovernmental Panel on Climate Change
LIDAR	Light Detection and Ranging
LTMS	Long Term Management Strategy
MHHW	Mean Higher High Water
MLLW	Mean Lower Low Water
MPRSA	Marine Protection, Research, and Sanctuaries Act
MTL	Mean Tide Level
NDBC	National Data Buoy Center
NDS	Nearshore Disposal Site
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Ocean and Atmospheric Administration
NRC	National Research Council
NWR	National Wildlife Refuge
O&M	Operations and Maintenance
(P)	Potential
PDO	Pacific Decadal Oscillation
PG&E	Pacific Gas and Electric
PVC	Polyvinyl chloride
RSMWG	Regional Sediment Management Working Group
SANDAG	San Diego Association of Governments
Task Force	Humboldt Bay Management Plan Task Force
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
W	West
WRDA	Water Resources Development Act
yd^3	Cubic Yards
yr	Year

A Coastal Regional Sediment Management Plan (CRSMP) is meant to formulate policy and guidance strategies that will restore, preserve, and maintain beaches and other critical areas of sediment deficit; sustain recreation and tourism; enhance public safety and access; restore coastal sandy habitats; and identify cost-effective solutions for managing areas of excess sediment. This CRSMP (Plan) covers the Pacific shoreline and environs of the Eureka Littoral Cell. It focuses on areas where regional sediment management (RSM) can mitigate existing and expected unbalanced sediment budgets that can lead to coastal erosion, coastal flooding, and habitat loss and degradation. Increased sediment supply contributes to wider beaches and hence mitigates coastal erosion while providing multiple benefits. These benefits potentially include reduced risk of damage to property and infrastructure, sustained beaches and their ecology, and maintained and enhanced recreation. Regional approaches are often more effective, less costly, and easier to fund than multiple local efforts.

ES-1 INTRODUCTION

The Eureka Littoral Cell includes two major rivers (Eel and Mad), the largest protected body of water between San Francisco and the Puget Sound (Humboldt Bay), and the two largest coastal cities in northwestern California (Eureka and Arcata). Humboldt Bay (Bay) has both an active marine transportation system and a variety of natural and anthropogenic environments. Maintaining the navigation channels into and within the Bay requires frequent dredging, which results in annually removing on the order of 1,000,000 cubic yards (yd^3) of clean sand and disposing of it in deep water. When funding is available, USACE also dredges on the order of 100,000 yd^3 per year of fine sediment from interior channels, although there has been insufficient funds to do so in recent years. The fine sediment is also placed at HOODS. Given the variety of natural and anthropogenic features and the abundance of sand, this Plan will focus on

* providing conceptual solutions that beneficially use available sediment to protect infrastructure, promote recreation and public safety, and enhance habitat value;
* fulfilling the statewide coastal sediment management strategy of the California Coastal Sediment Management Workgroup (CSMW) for the Eureka Littoral Cell; and
* establishing a vision, procedure, and governance body to ensure that projects effectively utilize state and federal funding and efficiently meet regulatory requirements.

ES-1.1 BACKGROUND

California's beaches and coastal wetlands are extremely valuable natural resources that provide critical habitats for a wide variety of species, irreplaceable recreational opportunities, infrastructure protection, and over $15 billion annually in tourism-generated tax revenue. Coastal beaches, wetlands, and watersheds, however, have been affected by extensive human alteration of the natural flow of sediment to and along the coast. Most watersheds no longer provide a sufficient sediment supply to maintain beaches; wetlands are often compromised by too much, or too little, sedimentation; and infrastructure and private property are increasingly threatened by a combination of sea level rise and more intense winter storms.

The CSMW is a collaborative entity of federal, state, and local agencies and non-governmental organizations committed to cataloging and addressing California's coastal sediment management needs on a regional, system-wide basis. The overarching goal of the CSMW is improved coastal zone and coastal watershed management. The CSMW identified coastal RSM as a key factor in the development of strategies to restore and maintain California's coastal beaches and watersheds. Central to RSM are cooperative efforts by federal, state, and local entities.

The CSMW identified the need for distinct, region-specific coastal RSM plans (CRSMPs) because challenges and circumstances vary greatly along the California coast. To date, six CRSMPs have been completed and adopted by the sponsors and stakeholders. Four CRSMPs, including this one for the Eureka Littoral Cell, are being prepared at the time of this report.

ES-1.2 Eureka Littoral Cell CRSMP

Specific elements of this CRSMP are

* DATA COLLECTION AND COMPILATION, which consists of compiling a database of information from published coastal studies and reports pertinent to the Eureka Littoral Cell,
* PLAN FORMULATION, which consists of identifying present and future (order of 50 years) sediment-related coastal problems and developing an assortment of potential responses,
* OUTREACH AND COORDINATION, which includes engaging major stakeholders in the process of developing the CRSMP and identifying potential projects reflect the needs of the region and state,
* PREPARING THE CRSMP REPORT, which includes integrating the above tasks to create a plan, which is acceptable to the sponsor and stakeholders, that can be used to guide future coastal activity involving sediment management in the region, and
* IDENTIFYING AND GARNERING SUPPORT FOR A POTENTIAL GOVERNANCE STRUCTURE, which would assist in effectively implementing the ideas contained within this CRSMP.

ES-2 EUREKA LITTORAL CELL

ES-2.1 Physical Setting

California's littoral cells were first delineated in 1966 (Inman and Frautschy 1966). Each littoral cell was described as a "beach compartment", typically with rocky headlands forming the upcoast and downcoast boundaries and little or no sand exchange across the boundaries. Sand enters the beach compartment from a variety of sources (e.g. rivers, bluff erosion, dunes) and leaves through sinks (submarine canyons, offshore transport, dunes). Beaches represent temporary repositories of sand within the littoral cell, widening and narrowing in response to the differential between source and sink volumes.

The Eureka Littoral Cell lies along the northwestern California coast in Humboldt County. The termini of the Eureka Littoral Cell are Trinidad Head to the north and False Cape (just north of Cape Mendocino) to the south. This encompasses approximately 40 miles of coastline that includes major rivers, a coastal dune field, the Eel Submarine Canyon, and Humboldt Bay. Within the littoral cell there are three rivers (Little, Mad, and Eel) that discharge into the Pacific Ocean, and four watersheds that drain into Humboldt Bay (Salmon, Elk, Jacoby, and Freshwater). Several sloughs around the Bay's shoreline support a variety of sensitive habitats.

From Little River south to the entrance to Humboldt Bay, the shoreline consists of beaches backed by large dunes. These wide and flat beaches consist of fine-to-medium-grained sand. Beaches south of the entrance to the Bay are narrow, except for beaches in the vicinity of the Eel River mouth. Dunes within the Eureka Littoral Cell have been noted to be gaining and losing volume in different locations. Between 1992 and 2014, shoreline change analysis by the US Army Corps of Engineers (USACE) found that the beaches are narrowing on the north spit and accreting on the south spit. The dune and beach system on the south spit grew between 1992 and 1998, while the beaches and dunes along the North spit receded during the same six-year period.

The Eel River, in the southern part of the Eureka Littoral Cell, and the Mad River and Little River, in the northern part, contribute most of the sediment to the Eureka Littoral Cell. Although the Eel River is the largest contributor of sand, much of the sand transported through the lower estuary bypasses the beach, settling out on the continental margin or disappearing down the Eel Submarine Canyon (Ritter 1972; Patsch & Griggs 2006).

ES-2.2 Humboldt Bay

Humboldt Bay is central to the region. It is the second largest natural bay in California and is the only harbor between San Francisco and Coos Bay with a channel deep enough to permit passage of large ocean-going vessels. It is a significant harbor for port-related commercial and industrial uses, as well as being valuable to the region because of its natural and environmental resources, aesthetic appeal, and recreational opportunities. It is the US Coast Guard designated harbor of refuge with the deepest entrance north of San Francisco.

Humboldt Bay comprises three basins: Entrance Bay, South Bay, and Arcata Bay. Entrance Bay, which is at the eastern end of the Bay's entrance, is open to waves propagating through the entrance channel. South Bay which lies south of Entrance Bay, consists of shallow water and large mudflats. Arcata Bay, to the north, connects to Entrance Bay via the North Bay Channel, Samoa Channel, and Eureka Channel.

Humboldt Bay's early settlement and industrial development had a major influence on the hydrology, sediment yield, and morphology of the area. In 1870, before significant salt marsh conversion had occurred, there were more than 10,000 acres of salt marsh around the margins of the Bay. Because of a combination of converting wetlands to agricultural lands by constructing dikes and draining the marshes along the Bay margins, building the railroad along the eastern margins of the Bay that functioned as a dike, and constructing Highway 101 east of Humboldt Bay, only about 970 acres of salt marsh currently remain.

USACE efforts to stabilize the harbor entrance and maintain channels into and within the bay began in 1881. Construction of the two jetties stabilizing the entrance to Humboldt Bay began in 1889; the last major modifications were made in 1973 after storms destroyed the heads of both jetties. At present, USACE annually dredges the Bar and Entrance Channel through the ebb shoal bar and between the two jetties. Until recently, the federal channels inside the bay were dredged annually. Now they are dredged less frequently because of funding limitations.

ES-2.3 Coastal Geography

At the entrance to the Bay, the mean tide range is approximately 5 feet (ft), and the diurnal range is approximately 7 ft. Tidal amplification is most pronounced to the north with an increase in range of up to one foot. As a result of the large water-volume flux between high and low tides, approximately 70 percent of the Bay's tidal mud flats are exposed at low tides.

Some of the most severe wave conditions in the contiguous United States occur north of Cape Mendocino. As a consequence, waves are the most significant driving force for coastal sand transport throughout the area. There are strong seasonal differences in wave intensity and direction throughout the year, which results in sand moving in both directions (north and south) in the Eureka Littoral Cell. Large swell waves typically occur in the winter (13 to 18 ft wave heights with periods longer than 10 seconds), and smaller, short-period waves typically occur in the summer. The predominant wave approach direction is northwest. Large winter swells typically come from the west through west-northwest directions and summer conditions are typically from a more northerly direction.

The net result of the wave climate, offshore bathymetry (especially that of the ebb shoal bar), and orientation of the jetties is that swell waves always enter Humboldt Bay and approach the Bay shoreline from the same direction regardless of offshore wave direction. As a result, extreme erosion has occurred along the shoreline of Entrance Bay across from the entrance channel. Much of that shoreline is now heavily armored, including in the vicinity of the town of King Salmon.

Eureka and adjacent communities, which are part of the Coast Ranges Geomorphic Province, sit on a coastal plain of Tertiary marine deposits that is dissected by meandering rivers and streams and abutted by gently sloping beaches. The Cascadia Subduction Zone (CSZ) and the Mendocino Triple Junction (MTJ) lie offshore of the study area, making it one of the most seismically active regions in California – approximately 80 earthquakes of magnitude 3.0 or greater have occurred each year since 1983. Historically, tectonic activity along the CSZ has caused gradual uplift along the coastline for hundreds of years. But a large earthquake can cause almost instantaneous subsidence and, possibly, a tsunami. Estimated uplift rates at Crescent City are about 3 mm/yr for the 1977 to 2010 period. During that time, however, the North Spit along Humboldt Bay subsided at about 1.9 mm/yr, and the Mad River Slough just to the north of the spit subsided at about 0.8 mm/yr. There has also been large uplift measured immediately after an earthquake. The 1992 magnitude 7.1 Cape Mendocino earthquake resulted in a measured uplift of almost 4.5 ft over a 15-mile segment of coast north of Cape Mendocino.

Because of the uncertain tectonic effects in the area, Humboldt Bay is subject to more than the usual uncertainty in projections of relative sea level rise. Based on tide records from 1977 to 2006 at Humboldt Bay's North Spit, NOAA (2011) estimates the rate of local sea level rise to be 4.7±1.5 mm/yr, which is well above the global average rate. In contrast, NOAA estimates the rate at Crescent City to be -0.66±0.36 mm/yr implying that the relative sea level at Crescent City has been falling. As stated in the National Research Council (NRC) 2012 report on sea level rise projections for the coasts of California, Oregon, and Washington, the possibility of subsidence of several feet during an earthquake should be considered by coastal planners. The report recommends adding 60 cm to the sea level rise projections for such an event, which implies a planning level estimate of 70 to 200 cm by 2100 for the coast north of Cape Mendocino.

ES-2.4 Coastal Hazards

A variety of coastal hazards can potentially affect the coastal zone and environs within the Eureka Littoral Cell. Besides ground shaking, earthquakes can produce uplift, subsidence, and tsunamis. Sea level rise, increased storm-driven water levels, and subsidence result in coastal and in-bay structures and property becoming more susceptible to inundation, damage, and destruction.

In 2013, the Coastal Conservancy funded Trinity Associates to conduct a study that included a sea level rise vulnerability assessment for the Humboldt Bay area. The study estimates that for an extreme high tide (EHT) and a 1-foot sea level rise, about 28% of the dikes fronting the Bay and sloughs in the region would be overtopped. It also recommends that the Humboldt Bay region initiate adaptation plans before wide-spread flooding occurs, as this could put land, currently protected infrastructure, and natural resources at risk of permanent flooding.

Intense seismic activity in the Pacific “Ring of Fire”, which is the most active seismic feature on earth, results in frequent tsunamis throughout the Pacific basin. Several studies have concluded that the study region is at risk from both local and distant tsunamis. Significant potential impacts from tsunamis originating along the CSZ can be expected. Such tsunamis have the potential to cause large local wave heights and pose the greatest potential inundation threat to the region. Such impacts were included in the inundation mapping effort conducted for the region by the California Emergency Management Agency (CalEMA) and the California Geological Survey (CGS).

ES-3 SEDIMENT PROCESSES WITHIN THE STUDY AREA

The Eureka Littoral Cell is a complex coastal system with a high-energy wave environment, moderate tides and winds, significant sediment yield from rivers, and offshore features that influence the morphology of the coastline. Rivers and streams transport the majority of the sediment from upland watersheds to the Pacific Ocean and Humboldt Bay. The Eureka Littoral Cell is not well characterized, and there is a lack of consensus on sediment supply rates over annual and decadal time periods, the net longshore transport, and the fate of sand and mud-sized sediment. Most studies indicate that further research is required to adequately characterize sediment dynamics and processes. The lack of consensus makes sediment dynamics a fundamental data gap and emphasizes the need to quantify and assess sediment budgets and uncertainties for sand and fine-sized sediment, which would enable accurate feasibility evaluations for potential solutions suggested in this CRSMP.

ES-3.1 Sediment Sources

The Little, Mad, and Eel Rivers are the main rivers discharging into the Pacific Ocean within the CRSMP area. Preliminary sediment budget studies have concluded that almost 90% of the total sand discharge into the ocean occurs between December and February. The study also estimated that the Eel and Mad Rivers contribute approximately 2.3 million yd^3 of sand per year and approximately 486,000 yd^3 of sand per year, respectively, that is coarse enough to remain on beaches. Most of the sand associated with Eel River discharge, however, does not end up on the beaches. Instead, it likely stays in the estuary at the mouth of the Eel River, is deposited on the continental margin, or goes down the Eel Submarine Canyon (Ritter 1972; Patsch & Griggs 2006)). Another hypothesis is that waves transport a significant portion of the sand into the Bar and Entrance Channel and possibly into Humboldt Bay. Compared to the Eel and Mad Rivers, the rivers and creeks that drain directly into Humboldt Bay have small watersheds and contribute a much smaller volume of sediment: most of it finer material.

ES-3.2 Sediment Sinks

The majority of sediment removal from specific areas within the littoral cell is through redistribution of material from erosion of beaches and dunes, offshore disposal during maintenance dredging of navigation channels, gravel mining, and cross-shore transport (deposition on the continental shelf), or loss to submarine canyons.

Between 1975 and 2016, maintenance dredging of the federal navigation channels at Humboldt Bay by the USACE produced approximately 0.9 million yd³/yr of sediment with greater than 90% being sand (ES Table 1). Starting in 1990, all of that dredged material was placed outside of the littoral cell at the Humboldt Open Ocean Disposal Site (HOODS), the center of which is approximately four miles west of the seaward end of the Entrance Channel.

ES Table 1: Dredged Volumes from the Humboldt Bay federal channels from 1975 to 2016.

Channel	Volume (10^3 yd^3)
Bar & Entrance + Middle Ground	29,275
North Bay	4,050
Samoa	473
Eureka	1,507
Fields Landing	663
Humboldt Bay Undifferentiated†	1,406
Total	37,374
1975–2016 Average	869
1975–2016 B&E + MB + NB Average	775
Total disposal at HOODS‡	25,498
Average disposal at HOODS‡	911

† Various combinations of all federal channels
‡ 1990-2016

Sediment from the Bar and Entrance Channel, Middle Ground (the junction of the Bar and Entrance, North Bay, and Fields Landing Channels) and the North Bay Channel is greater than 95 percent sand and gravel. Sediment from the Samoa Channel and its turning basin is greater than 85 percent sand and gravel. Sediment from the

Eureka Channel and the Fields Landing Channel and its turning basin is between 25 and 80 percent sand and gravel. For almost all of the dredged material, sediment testing conducted prior to past dredging episodes found that all of the material is clean enough to place at HOODS. Placement at HOODS removes sand from the littoral cell that could be beneficially used in the nearshore or on nearby beaches.

The US Environmental Protection Agency (USEPA)-designated aquatic placement site HOODS, which has been in use since 1990, is located in water depths of 160 to 180 ft mean lower low water (MLLW). Approximately 25 million yd^3 of dredged material were placed at HOODS through 2016. As a consequence, there is a mound of sand and silt that has reached the target depth of 130 feet across the site much sooner than predicted. It is clear that HOODS as it is currently configured has effectively reached its physical capacity. There is little room remaining within the existing site boundaries for ongoing disposal of the volumes of material (especially sand) that are typically placed at HOODS without beginning to increase the mound substantially above the 130-foot depth. Therefore, for physical reasons alone, significant changes to the management of HOODS are indicated.

As part of the EPA's expansion plan for HOODS, a nearshore dredged-material placement site is being considered. That site, the Humboldt Bay Demonstration Site (HBDS), is located in water depths of approximately 40 to 70 ft. The center of the site is approximately five miles north of the entrance to Humboldt Bay. The HBDS could receive clean sand dredged from any channel that otherwise would go to HOODS.

Of the total non-federal volume of approximately 200,000 yd^3 dredged each periodic episode, Woodley Island Marina and the Eureka Marina provide approximately 160,000 yd^3 (HBHRCD 2008). In general, the concentrations of metals and other contaminants historically found in those sediments are low enough to meet in-water disposal criteria except for isolated areas near commercial docks. Many of the historic upland disposal sites have been filled to capacity, and the local dredgers, including both the Humboldt Bay Harbor, Recreation and Conservation District (HBHRCD) and the City of Eureka, find it increasingly difficult to maintain their navigation channels in the absence of a designated disposal site with adequate capacity.

Most of the sand transported down the Eel River, which is the main supplier of sand to the Eureka Littoral Cell, passes through the lower estuary, bypasses the beach, and settles on the continental margin in proximity to the Eel Canyon. Much of that sediment spreads over the continental margin as a thin, blanket deposit. Geologic studies have found a buried canyon extending shoreward from the head of the present day canyon, indicating that sediment deposited by the Eel River has filled the shoreward part of the canyon, and sediment continues to fill the current head of the canyon. Other studies have found recent deposits (past several decades) in the deeper portions of the canyon. There is evidence that the head of the canyon receives sediment from the Eel River on decadal time scales, and there is mobilization of this sediment as gravity flows into deeper portions of the canyon. It is evident that more research is needed to estimate the rates of sediment lost to the Eel Canyon.

Commercial gravel mining in the Trinity, Mad, Van Duzen, and Eel Rivers is regulated by the County of Humboldt Extraction Review Team (CHERT). In 2008, approximately 511,000 yd^3 of material – 78% of the total annually approved extraction volume – was mined. The CHERT enforces the concept of "sustainable yield" gravel extraction, which requires that extraction quantities do not exceed mean annual recruitment volumes. This annual recruitment is an estimate of the long-term average annual supply of gravel to a specific reach of the river. Almost all of the extraction volume shown above is for gravels; as such, the effect on sand transport rates in the littoral environment is small.

It is also important to include dams within the context of sediment management at a watershed scale because of the potential for dams to trap sediment that would otherwise make its way to the estuary or coast. Matthews Dam on the Mad River reduces the sediment yield from the watershed by approximately 9%. The Scott and Van Arsdale Dams on the Eel River reduce the sand discharged by the Eel River by about 1.1%.

Within the Eureka Littoral Cell, coastal dunes both gain and lose sand. Based on an extensive monitoring project of the beaches and dunes on the north and south spit undertaken by USACE between 1992 and 1998, the south spit's beach and dune system gained about 270,000 yd^3/yr, and the dune line remained stationary or moved seaward. The beaches and dunes along the north spit, for the most part, decreased in both volume and width, losing about 175,000 yd^3/yr on average over the six-year period resulting in beach and bluff recession.

ES-3.3 Littoral Transport Processes

There has not been consensus on longshore transport rates, direction of transport, or the fate of Eel River sand. Based on a review of the literature, the data indicate that there is northward, storm-driven transport in the winter at deeper depths and southward, wind-wave-driven transport at shallower depths in the summer. Net annual transport can be northward if there are strong El Niño storms, or southward if the winter is mild. This lack of knowledge regarding net littoral drift is a data gap

ES-4 STAKEHOLDER GROUPS WITHIN THE STUDY REGION

As recognized by the CSMW, one of the primary mechanisms of achieving success for a CRSMP is the cooperation and coordination of stakeholders within the region. In the Humboldt Bay area, there are several governmental agencies with jurisdictional authorization or interests. Of those, the HBHRCD has been the lead non-federal agency for this CRSMP.

Shipping, commercial and recreational fisheries, boating, and mariculture are important parts of the economy and culture in Humboldt County. Petroleum products, forest products (wood and chips), and pulp are important types of cargo arriving or leaving Humboldt Harbor. Primary marine navigation stakeholders include USACE, which maintains the federal navigation channels, and the HBHRCD, which maintains navigation and berthing for 12 commercial shipping docks. Seafood is commercially and recreationally harvested from shore and from boats that operate primarily out of Humboldt and Trinidad Bays. Recreational fishermen also harvest seafood from kayaks and while diving. The largest recreational boating facilities are two public marinas, the Woodley Island Marina, owned and operated by the HBHRCD, and the Eureka Public Marina, owned and operated by the City of Eureka. Mariculture is limited to north Humboldt Bay, where oysters and clams are grown. The mariculture industry has a major stake in the maintenance of good water quality because it is critical for growth of oyster and clam seed and adults.

Humboldt Bay and environs include diverse ecosystems. The area's topography, wetlands, riparian, and coastal areas provide a variety of habitats for wildlife and migratory birds. For decades, there has been a strong desire to maintain, restore, and enhance aquatic ecosystem integrity and to work cooperatively to develop and implement a restoration and enhancement plan for Humboldt Bay's aquatic ecosystems. Several regional initiatives and management plans have been prepared by local stakeholder groups, and any region-wide sediment-management option would need to be consistent with the goals and visions of these initiatives:

* *Humboldt Bay Management Plan (HBMP)* was completed in 2007. It was the region's first ecosystem-based plan intended to improve the management of Humboldt Bay. It was a large, cooperative project funded by federal, state, and local agencies.
* *Humboldt Bay National Wildlife Refuge Comprehensive Conservation Plan (CCP)* was completed in 2009. Its goal was to conserve, manage, and, where appropriate, restore coastal habitats for a great diversity of fish, wildlife, and plant resources.
* *Humboldt Bay Initiative (HBI)* is an ongoing effort that seeks to create a coordinated resource-management framework linking the needs of people, habitats, and species by increasing scientific understanding of the ecosystem. The Initiative has brought together local stakeholders to envision the desired future of Humboldt Bay ecosystems and communities, to understand current conditions in the ecosystem, and to implement ecosystem-based projects.

ES-5 CRITICAL SPECIES AND HABITATS

Sensitive coastal, estuarine, and riverine habitats occur throughout the CRSMP area. For the most part, coastal habitats are associated with sandy environments (dunes, beaches, and the nearshore) and coastal bluffs. There are, however, rocky shores and offshore rocks in the vicinity of Trinidad and between False Cape and Cape

Mendocino. Offshore rocks support bird colonies, and pinnipeds haul out on them. Sensitive habitats on the open coast include designated critical habitat for the federally threatened western snowy plover. There is sensitive coastal dune habitat between the township of Manila and the mouth of the Mad River that supports several sensitive plant species. The Eel River and the Mad River contain critical habitat for listed salmonids and the tidewater goby.

Humboldt Bay is a biologically rich coastal lagoon that supports more than 110 species of fishes, 260 species of birds, and 200 subtidal invertebrates. The Bay is designated as an International Site in the Western Hemisphere Shorebird Reserve Network and an Important Bird Area by the American Bird Conservancy. It is a key migratory staging, roosting, and feeding area for migrating and wintering shorebirds using the Pacific Flyway. Over 100,000 shorebirds, belonging to approximately 30 different species, use the Bay as an overwintering area and migration stopover site, and it is the most important location in California for staging Pacific black brant geese (*Branta Bernicia*), which almost exclusively feed on eelgrass. The Bay is an important haulout and pupping area for harbor seals (*Phoca vitulina*). Sensitive habitats within the Bay include eelgrass and tidal marshes, which contain several sensitive plant species. Drainages into the Bay contain critical habitat for listed salmonids and the tidewater goby.

ES-6 REGIONAL SEDIMENT MANAGEMENT SCHEMAS

Extensive data collection and analysis plus wide-ranging input from stakeholders led to seven regional sediment management schemas for the Eureka Littoral Cell (**Error! Reference source not found.**). Because there is an abundance of material in the littoral cell (mostly clean sand), the schemas emphasize the beneficial use of that material.

ES Table 2: Eureka Littoral Cell Schemas

1	Placement in the Littoral Zone
2	Coastal Dune Enhancement
3	Tidal Marsh Restoration
4	Creating Soft Shorelines within the Bay
5	Dike Rehabilitation
6	Recreational Beaches in Humboldt Bay
7	Use of Dredged Material for Local Construction

ES-6.1 Placement within the littoral zone

This schema relies on the development of a nearshore dredged-material placement sitethat would be located in water shallow enough for shoaling waves to be able to transport the placed sand toward the surf zone and beach. A benefit of this schema is enhanced protection of the adjacent beach and dunes caused by inducing large, high-energy waves to break farther offshore.

ES-6.2 Coastal dune enhancement

This schema increases the protection of communities on the bay side of the North Spit by increasing coastal dune elevations with sand from USACE Operations and Maintenance (O&M) dredging of the federal navigation channels. For example, the Samoa stretch of the North Spit is potentially vulnerable to storm- or tsunamis-driven overwash and will become more vulnerable as sea level rises. Placement should be coupled with managing the invasive grasses to encourage the reestablishment of native grasses. Placed sand that moves into the upper shoreface would also support Schema 1.

ES-6.3 Tidal marsh restoration

This schema uses dredged material to reverse subsidence by placing either fine-grained material – or sand capped with fine-grained material – on diked baylands to recreate tidal marsh habitat. Potential sites considered for this application include former diked lands in the vicinity of Hookton Slough, White Slough, and Table Bluff Unit, where the submerged land is too low to just open up to tidal action and still provide a habitat for salt water plants and animals. The expected benefit is that salt marsh development would occur between Mean Tide Level (MTL) and Extreme Spring High Water (ESHW). Cordgrass, preferably the non-invasive species, would dominate the lower part of the range; pickleweed and salt grass would dominate the upper portion of the tidal range. Above the ESHW, seasonal wetland and upland habitat would be sustained.

ES-6.4 Creating soft shorelines within the bay

This schema involves creating a shallow-sloped transitional marsh edge – from mudflats to upland – in place of an armored shoreline. The concept is similar to the Tidal Marsh Restoration option in that the results of this type of project include creation of a new intertidal habitat and a softer shoreline. A softer shoreline is also a natural, in-bay barrier against tidal surges, tsunamis, and sea level rise, in that wave energy would be expended along the almost-flat slopes. Potential locations include the eastern margins of Arcata Bay, Entrance Bay, and South Bay. The most logical location is along the eastern edge of Arcata Bay where the highway and railroad tracks abut the shoreline. An additional benefit of this location is that the project could incorporate a multi-use trail connecting the cities of Arcata and Eureka. This alignment is consistent with the recommendations of the Redwood Community Action Agency (RCAA), who had prepared a Coastal Conservancy funded Bay Trails Feasibility Study.

ES-6.5 Dike rehabilitation

This schema involves placing dredged material on the landward side of vulnerable dikes to stabilize them. The material would act as a stability berm against slope failure of the dikes either under static loading or, more importantly, under earthquake loading. The north edge of Arcata Bay, in particular, consists of tall dikes where the transitional marsh edge cannot be restored. As is typical of dikes built along the margins of Bay shorelines, the underlying soils are weak (usually peat or a mix of clay and silt) and the safety factor against slope failure is not high. Building up the dikes in this manner is an expedient method of stockpiling useful material in the event that conversion to salt marsh becomes a viable option. The schema is particularly useful where dikes need to be raised to protect against sea level rise or where fill cannot be placed on the bay side because of the presence of marsh habitat.

ES-6.6 Recreational beaches within Humboldt Bay

This schema would create beaches inside of the Bay that could be safely used by locals and tourists for relaxing, wind surfing, fishing, bird watching, and general recreation. Beach construction requires placing sand along the Bay's shoreline where it is exposed to waves coming through the entrance to the Bay. Once through the entrance, refraction results in waves that arrive at the Bay's eastern shore at a constant angle of incidence regardless of the direction of offshore waves. This creates the potential for a sandy beach that could persist over a prolonged period of time.

ES-6.7 Beneficial use as local construction fill

This schema involves beneficially using sand from the Bar and Entrance Channel and sand from the North Bay Channel locally for construction purposes. Within the region, representatives of Caltrans; construction contractors; gravel extraction companies; and public works for the Cities of Eureka, Arcata, and Fortuna, and Humboldt County were for input on possible projects. For local end uses, different stockpile locations could be identified and analyzed for feasibility based on several different criteria, such as capacity, proximity to transportation (barge, truck, or rail), effect on aquatic and terrestrial habitats, and cost.

ES-7 IMPLEMENTATION OPTIONS

This section details the seven schemas presented in the previous section. Each schema could be implemented at a variety of locations, but further analysis is required to determine their applicability at a given location. If any of these is constructed to evaluate the value of the schema within the littoral cell, it will be important to choose a project location that has a reasonable likelihood of success yet is representative of the challenges faced. That way project successes and failures can provide applicable lessons on how to proceed. The potential projects described in this section were envisioned based on a variety of reasons including:

* Ancillary benefits – Projects that accomplish more than one goal have a better likelihood of receiving general approval. For example, a project that creates a salt marsh and protects the highway is more favorable than one that only accomplishes one of those goals.
* Ownership of the land – For example, a restoration project situated on land owned by the HBNWR will be simpler to conduct than a similar project situated on several privately owned parcels.
* Previously identified – Some projects, such as restoring Teal Island to salt marsh or creating a multi-use trail connecting Arcata and Eureka, have previously been identified as goals strongly supported by different local organizations. The extent of each schema is in no way limited to the demonstration projects described herein. For instance, salt marsh restoration can happen at a multitude of locations throughout the Bay.

ES-8 POTENTIAL CONSTRAINTS TO BENEFICIAL USE

Some of the common constraints to beneficial use of dredged material experienced by other regions have been the following:

* The Federal Standard and Funding limit which sites USACE can legally use to place material dredged from federal navigation channels during O&M work. The federal standard definition is:

  Federal standard means the dredged material disposal alternative or alternatives identified by the Corps [USACE] *which represent the least costly alternatives consistent with sound engineering practices and meeting the environmental standards established by the 404(b)(1) evaluation process or ocean dumping criteria.*

  Most beneficial-use options cost more to implement than the Federal Standard, which is HOODS for sediment dredged from the Humboldt Bay federal navigation channels. Beneficial use typically also involves site development and management of the dredged material, which increases placement costs. Without Congressional approval, USACE cannot fund additional costs under the O&M program, so the non-federal sponsor would have to bear that full cost.

* Priority of Stakeholders, which requires prioritizing among diverse interests and gaining consensus from a variety of stakeholders, not only on the type of implementation project, but on the use of limited funds that are available in the current economic climate. Delineating the consensus-building process is one of the key objectives of this CRSMP. The HBHRCD has many different responsibilities to balance, and their primary source of revenue comes from the small ports and

marinas in the Bay. Although the federal channels are being dredged by USACE, maintaining the local marinas and docks is getting increasingly difficult, expensive, and time consuming for local entities .

* Public Perception of Use of Dredged Material, which has been one of the biggest challenges because dredged material has traditionally been considered a waste and as being harmful to the environment. The list of successful environmental projects using dredged material is growing, however, and ports, government agencies, and other entities continue to find and take advantage of beneficial-use opportunities. In the Eureka CRSMP region, the Bar and Entrance Channel dredged material has historically not been considered a resource, and so removing the material from the system by placing it at HOODS was determined to be the best available option when HOODS was authorized. Therefore, one of the critical goals of this CRSMP is to bring together data and science, and the interests of various stakeholders, in a manner that will allow that dredged material to be beneficially reused in the future.

ES-9 OPPORTUNITIES AND RECOMMENDATIONS

Based on the efforts of the HBHRCD, the HBNWR, and the HBI, there is an ecosystem scale conservation/enhancement/restoration perspective that is emerging. As a result, beneficial use of dredged material is being emphasized.

The immediate needs in the region, which can be viewed as opportunities for the CRSMP, are addressing coastal flooding threat as well as SLR adaptation and resilience, marsh restoration, improving public access and recreational opportunities along the Bay margin, and mitigating shoreline and dune erosion. Dredged sediment management is an integral part of the Eureka CRSMP, because it represents the largest potential source of sediments for restoring the region's ecosystems.

Several potential schemas for regional sediment management have been identified in this report to assist stakeholders assess what could be accomplished. Stakeholder consensus is needed, however, to prioritize planning and funding efforts for ultimate implementation by the region. A summary of recommended next steps is provided below.

* UNDERSTAND THE SUCCESS OF OTHER CRSMPS. Adoption of any CRSMP by a governance body and acceptance by the stakeholders is the first step towards this goal. Although there have been regional planning efforts in the CRSMP region, most of them have not emphasized beneficial use of dredged material as a priority. Consequently, the significant issues related to cost, feasibility, and potential impacts of beneficial use have not been investigated. Also, a governance structure that encompasses all the agencies that would be involved in beneficial use does not exist.
* ESTABLISH A GOVERNANCE STRUCTURE FOR THE CRSMP. The governance structure establishes the strategic, operational, and technical decision-making

process required to ensure that elements of the CRSMP, which is a guidance document, are implemented in a manner that enables the local communities to effectively respond to coastal erosion, habitat loss, and infrastructure damage or destruction. Those implementing the governance structure are expected to provide strategic leadership, obtain stakeholder consensus, and establish region-wide priorities and cohesive policies.

* HAVE THE HBHRCD AND THE COUNTY OF HUMBOLDT LEAD THE CREATION OF A GOVERNANCE BODY. They could regroup the agencies and stakeholders that participated in the HBMP, the CCP, the DMMP, and the HBI by creating a Joint Regional Sediment Management Committee (JRSMC). The JRSMC would either adopt the CRSMP or set the stage for preparing the appropriate programmatic documents to facilitate adoption. A stakeholder advisory team that would direct CRSM activities should be established to oversee such an adoption.
* DEVELOP A COLLABORATION STRATEGY. Identifying data gaps, prioritizing planning and funding efforts for future activities, and preparing a strategic implementation plan are critical for successful implementation of elements of this CRMSP.
* PREPARE AN INFORMATION SHARING STRATEGY. Such a strategy, which would utilize CSMW resources, would consist of creating publicly accessible databases that would house GIS resources, scientific information, technical reports, monitoring data, and status reports of the RSM Working Group and JRSMC.
* ESTABLISH A VISION FOR THE RESTORATION OF HUMBOLDT BAY. This could be accomplished by documenting lessons learned from other regions that have undergone similar large-scale marsh losses to diking and filling with significant negative impacts to the ecosystem. San Francisco Bay is such a region. Focused research and studies would need to be conducted for the CRSMP region including:

  o characterizing current and future sediment, hydrology, climate conditions relative to ecosystem habitats
  o identifying and prioritizing habitat goals
  o developing a dredged material management plan for all dredged material within the Eureka Littoral Cell, including life-cycle costs
  o developing sediment suitability criteria for in-water and on-marsh placement of fine and coarse sediments
  o developing streamlined permitting strategy for beneficial use of dredged material

* PREPARE A REGIONAL ECOSYSTEM RESTORATION PLAN. This CRSMP, which comes at a time when several planning efforts are underway in the Humboldt Bay region, could provide a nexus between the various objectives articulated by stakeholders and could be of assistance in seeking grants from various sources. Most important, there is an opportunity to align the demand for ecosystem restoration, flood protection, and recreational needs with dredging activities. Creation of a Humboldt Bay Regional Ecosystem Restoration Plan becomes necessary for many of the strategies presented in this document. Such a plan should remain a living

document, and the principles of adaptive management should be applied and updated regularly as new information becomes available and priorities shift.

* IDENTIFY FUNDING SOURCES. This would include local sources for matching purposes, for demonstration and other beneficial use projects including those with environmental, recreational, flood control, and economic and commercial benefits. Improved communication and long-range planning between federal, state, and local agencies and project proponents could support more coordinated project efforts where increased attention is given to beneficial-use alternatives and shared funding opportunities. Dedicated non-federal funding sources would help to ensure that the local funds are available when needed.

There are USACE policies and programs that may allow for some incremental costs to be borne by the federal government including Section 1135 of the Water Resources Development Act (WRDA) of 1986, Section 204 of WRDA 1992 as modified, and Section 207 of WRDA 1996. Potential sources of state funds include the State Coastal Conservancy, and State Parks, Division of Department of Boating and Waterways.

1 INTRODUCTION

Humboldt Bay (Bay) is a natural bay and a multi-basin, bar-built coastal lagoon located on the rugged North Coast of California, entirely within Humboldt County. It is the largest protected body of water on the West Coast between San Francisco Bay and Puget Sound, the second largest enclosed bay in California, and the largest port between San Francisco and Coos Bay, Oregon (Costa and Glatzel 2002). Access to the Bay, which supports a variety of natural and anthropogenic habitats, Is via a channel between two jetties that cut through a long, sandy spit with vegetated dunes. Both that entrance channel and its interior shipping channels are frequently dredged, and the sediment – mostly clean sand – is disposed of in deep water west of the Bay's entrance. Retaining that material in the nearshore zone would benefit beaches and dunes, and using it in the Bay could enhance habitat, protect low-lying bayside areas, and increase recreational opportunities, In that regard, the intent of this CRSMP (or Plan) is to:

1. Facilitate solutions that beneficially use dredged sediment to protect infrastructure, promote recreation and public safety, and enhance habitat value;
2. Fulfill the statewide sediment management strategy of the CSMW within the coastal reach from Trinidad to False Cape (the Eureka Littoral Cell);
3. Establish a vision, procedure, and governance body to ensure that projects effectively utilize state and federal funding and effectively meet regulatory requirements.

1.1 BACKGROUND

The CSMW is a collaborative effort by federal, state, and local agencies and non-governmental organizations committed to evaluating and addressing California's coastal sediment management needs on a regional state-wide basis. It was established in 1999 and is co-chaired by USACE, South Pacific Division and the California Natural Resources Agency (CNRA) Its creation was a response to concerns – raised by the state, representatives of local governments, USACE, and environmental groups – about the piecemeal identification of problems and implementation of site-specific solutions that did not effectively address critical problems along the coastline.

California's beaches are extremely valuable resources that provide critical habitats for endangered species, irreplaceable recreational opportunities, infrastructure protection, and over $15 billion annually in tourism-generated tax revenue (CSMW 2002). Coastal beaches, wetlands, and watersheds, however, have been affected by extensive human alteration of the natural flow of sediment to and along the coast (Figure 1). Watersheds no longer provide a sufficient supply of sediment to beaches; wetlands are often compromised by too much, or too little, sedimentation; and beaches erode because of a lack of sand.

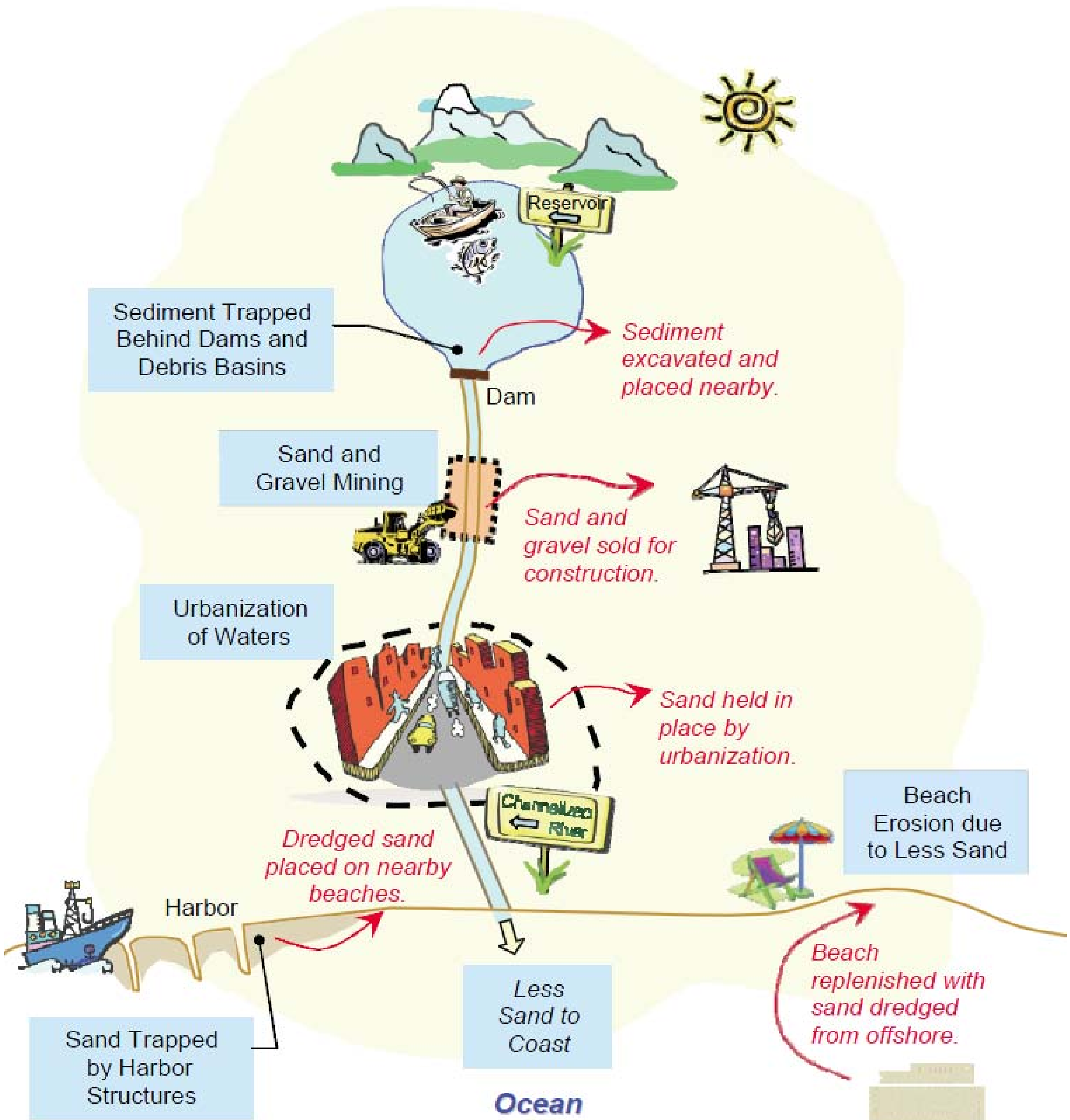


Figure 1: Existing Coastal Sediment Management Practices in Many Regions (Source: CSMW 2012).

Between February and June 2004, the CSMW hosted public workshops to gather input on coastal sediment management issues in California. The consensus at these workshops was that integrated coastal sediment management is a key factor in the development of strategies to conserve and restore California's coastal beaches, wetlands, and watersheds (CSMW 2012). The CSMW identified coastal Regional Sediment Management (RSM) as a key factor in the development of strategies to conserve and restore California's coastal beaches, wetlands, and watersheds (Figure 2).

The overarching goal was to facilitate regional approaches to protecting, enhancing, and restoring those beaches and watersheds through federal, state, and local cooperative efforts.

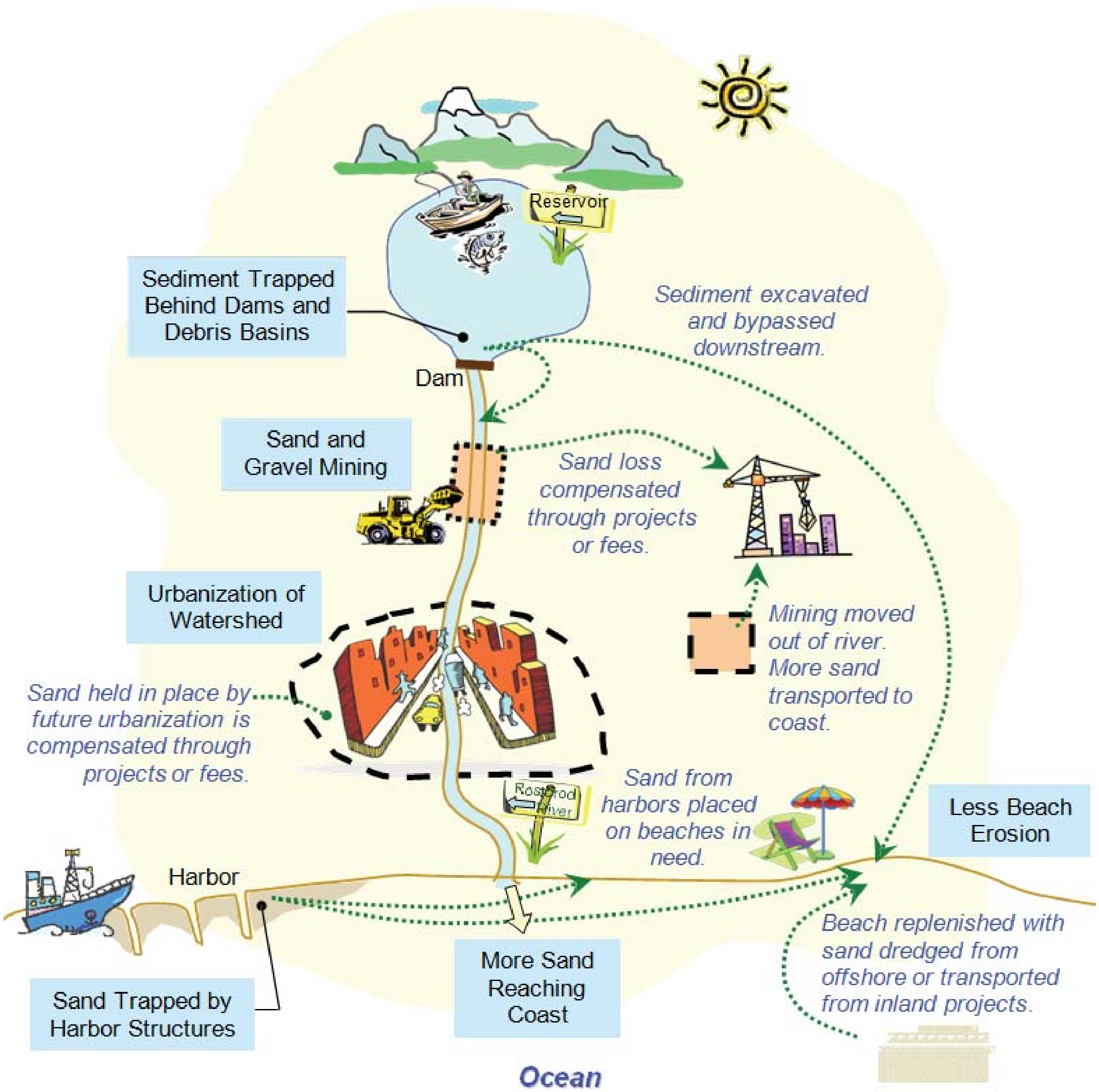


Figure 2: Preferred Holistic Approach to Coastal Sediment Management Practices (Source: CSMW 2012)

This integrated approach to sediment management was formulated to save federal, state, and local funds by developing solutions to sediment problems that will provide lasting benefits and allow agencies to work together to leverage financial and intellectual resources. It is also intended to provide planners and coastal managers with the information needed to develop approaches that generate the greatest environmental and economic benefits for the region as well as the state.

The CSMW's mission as stated in its most recent status report (CSMW 2012) is to:

> *Conserve, restore, and protect California's coastal resources by developing and facilitating regional approaches to managing sediment.*

Its goals are to:

> *Reduce shoreline erosion and coastal storm damages, restore and protect beaches and other coastal environments by restoring natural sediment supply to the coast, and optimizing* [sic] *the use of sediment from ports, harbors, and other opportunistic sources*

The overarching goal of the CSMW is improved coastal beach, wetland, and watershed management. The key to achieving this goal is creating a comprehensive, statewide, coastal Sediment Management Plan (SMP) that has the support of the member agencies and stakeholders. The SMP is a compilation of products – tools, strategies, and informational documents – designed to assist and guide sediment managers and others in implementing CRSM throughout California. These products fall under three general headings (CSMW 2012):

- Educational and informational reports and data,
- Computer based tools,
- A series of CRSMPs that strategize how sediment can be best managed within regions and collectively address differences between regions.

The CSMW has a regularly scheduled forum where member agencies meet and discuss projects and issues related to coastal beaches and watersheds, increase awareness of existing and planned activities, and exchange scientific and other related information. The CSMW is also helping educate both the general public and local and regional governments about current coastal sediment management efforts in California and is soliciting input for identifying ways to fund projects and improve the management of the state's coastal beaches, wetlands, and watersheds.

Initially, SMP efforts focused on compiling and developing informational products or tools of state-wide utility that cover the major concerns related to CRSMPs. The main issues addressed were identification of critical coastal erosion areas and potential sources of sediment to replace or restore lost sediment, examination of the governmental frameworks (policies, procedures, and regulations) concerning sediment management, and assessment of the natural and biological systems involved with or affected by sediment management. In addition, the initial SMP efforts began fostering team building between agencies with disparate missions and objectives, and added to the scientific database regarding issues related to sediment management (CSMW 2012).

The CRSMPs are meant to be issue-driven collaborative efforts between federal, state, and regional partners. Such plans would identify linkages between USACE's multiple responsibilities and state, regional, and local programs, while at the same time lay the groundwork for a strong partnership to constructively identify and implement regional coastal sediment management strategies identified within the CRSMPs.

1.2 Coastal Regional Sediment Management Plans

The CSMW has developed a program that partners with regional stakeholders to create CRSMPs that develop region-specific strategies resolving sediment imbalances along California's coast. Local and regional government sponsorship is essential to develop consensus on how best to address coastal issues and maintain a regional focus during implementation of activities recommended in the CRSMP.

The CRSMPs consist of a stakeholder-driven series of strategies providing consensus on how best to address coastal erosion and sediment imbalance problems within a specific region of the California coast, including coastal watersheds, wetlands, and offshore areas, using "soft" solutions whenever possible. Each CRSMP summarizes existing knowledge on physical processes and biological constraints, provides for input from the public and agency staffs involved in sediment management, and identifies techniques that could facilitate the CRSMP's use in future management decisions. Each CRSMP emphasizes regional solutions involving beneficial use of sediment in an environmentally friendly manner to help restore or augment natural processes within the region.

The CRSMP goals are to identify and prioritize regional sediment management needs and opportunities and to make this information available to resource managers and the general public to assist in addressing coastal sediment management issues. A CRSMP typically includes :

* An assessment of physical conditions (erosion, sedimentation, sand transport patterns, etc.) within the Plan boundary;
* An assessment of environmental conditions within the Plan area, including sensitive biota and habitats;
* A compilation of geospatial data layers of information suitable for inclusion in CSMW's geospatial database and WebMapper;
* An assessment of the potential for restoring sediment-deficient coastal sandy habitats;
* Recommendations for cost-effective solutions for restoring areas affected by excess sediment;
* An assessment of the potential for linking sediment management to sustainable recreation and tourism and enhancing public safety and access.
* Outreach efforts to ensure participation by stakeholders and the public;

* Recommendations for a governance structure best suited to implement recommendations within the CRSMP;
* An analysis of benefits and cost implications associated with sediment management within the CRSMP area.

Because each region has a unique set of challenges and circumstances, early on the CSMW recognized the need for distinct, region-specific CRSMPs. To date, five CRSMPs have been completed and adopted by the sponsors and stakeholders.

1. The Southern Monterey Bay CRSMP – regional partner the Association of Monterey Bay Area Governments (AMBAG) – completed in November 2008
2. The Santa Barbara and Ventura Counties CRSMP – regional partner the Beach Erosion Authority for Clean Oceans and Nourishment (BEACON) – completed in January 2009
3. The San Diego Region County CRSMP – regional partner the San Diego Association of Governments (SANDAG) – completed in March 2009
4. The Orange County CRSMP – regional partner the Orange County Department of Parks – completed in May 2013
5. San Luis Obispo County – regional partner is the San Luis Obispo Council of Governments – completed in April 2016

Four additional CRSMPs are being prepared at this time – Los Angeles County, San Francisco Bay, San Francisco Open Coast Littoral Cell, and Santa Cruz Littoral Cell.

1.3 The Eureka Littoral Cell Coastal Regional Sediment Management Plan

Objectives of the Eureka CRSMP, as described by the CSMW, include:

* Identifying opportunities for beneficial use of material dredged from the ports, harbors, and marinas in the region
* Reducing shoreline erosion and coastal storm damage
* Providing for environmental restoration and protection
* Increasing natural sediment supply to the coast
* Restoring and preserving beaches
* Improving water quality along coastal beaches
* Recommending a governance structure that is designed to facilitate plan implementation
* Assessing regulatory issues and permitting requirements
* Identifying potential funding streams that could provide locally required matches to potential state and federal funds for coastal projects

The elements of the Eureka CRSMP are:

1.3.1 Data Collection and Compilation

This section consists of compiling a database of information from published coastal studies and reports pertinent to the Eureka Littoral Cell. This information is used to support the Plan Formulation phase and also to identify additional information that needs to be obtained by Outreach and Coordination. The database includes general details and applicable references on the topics of coastal processes, sediment supply and sources, identification of erosion areas, sea-level rise, sensitive habitats and species, and historical and present navigation-channel dredging activities and material-placement locations. The task also identifies data needs and gaps.

1.3.2 Plan Formulation

This section consists of identifying present and future (order of 50 years) coastal problems and developing an assortment of potential responses. Identification and development is based on discussions with stakeholders during the Outreach and Coordination component and findings from the Data Collection and Compilation task. Projects are developed to identify availability of appropriate sediment types, feasibility of transport, stockpiling, placement of sediment, and environmental and regulatory issues. Potential funding sources for local match to potential state or federal funds are included with this task.

1.3.3 Outreach and Coordination

This section includes the input from engaging major stakeholders in the process of developing the CRSMP and identifying potential projects that reflect the needs of the region and state. This includes formulating strategies for regional project implementation, developing sustainable strategies for project implementation with local and regional entities, and providing follow-up information for issues raised by stakeholders.

1.3.4 CRSMP Report

This section entails integrating the above tasks to create a CRSMP that the sponsor and stakeholders can use to guide future coastal activity involving sediment management in the region.

Inman and Frautschy (1966) first delineated California's littoral cells. They described each littoral cell as a "beach compartment", typically bounded by rocky headlands. In general, little or no sand crossed the boundaries into or out of the cell. Most of the sand enters the littoral cell from coastal streams and bluff erosion. Then it is transported longshore, as well as onshore and offshore, under the influence of prevailing waves. Beaches represent areas where the sand is temporarily stored, widening or narrowing in response to the sediment supply. Ultimately, the sand leaves the littoral cell through a submarine canyon, coastal dune field, offshore transport, dredging, or mining.

2.1 Extents of the Eureka Littoral Cell

The Eureka Littoral Cell is located along the northwestern California coast in Humboldt County (Figure 3). The major coastal city in the area, Eureka, is approximately 220 nautical miles north of San Francisco and 150 nautical miles south of Coos Bay, Oregon. The generally accepted limits of the Eureka Littoral Cell include Trinidad Head to the north and False Cape (near Cape Mendocino) to the south. This encompasses approximately 40 miles of coastline that includes three major rivers (Little, Mad, and Eel), a coastal dune field, the Eel Submarine Canyon, and Humboldt Bay.

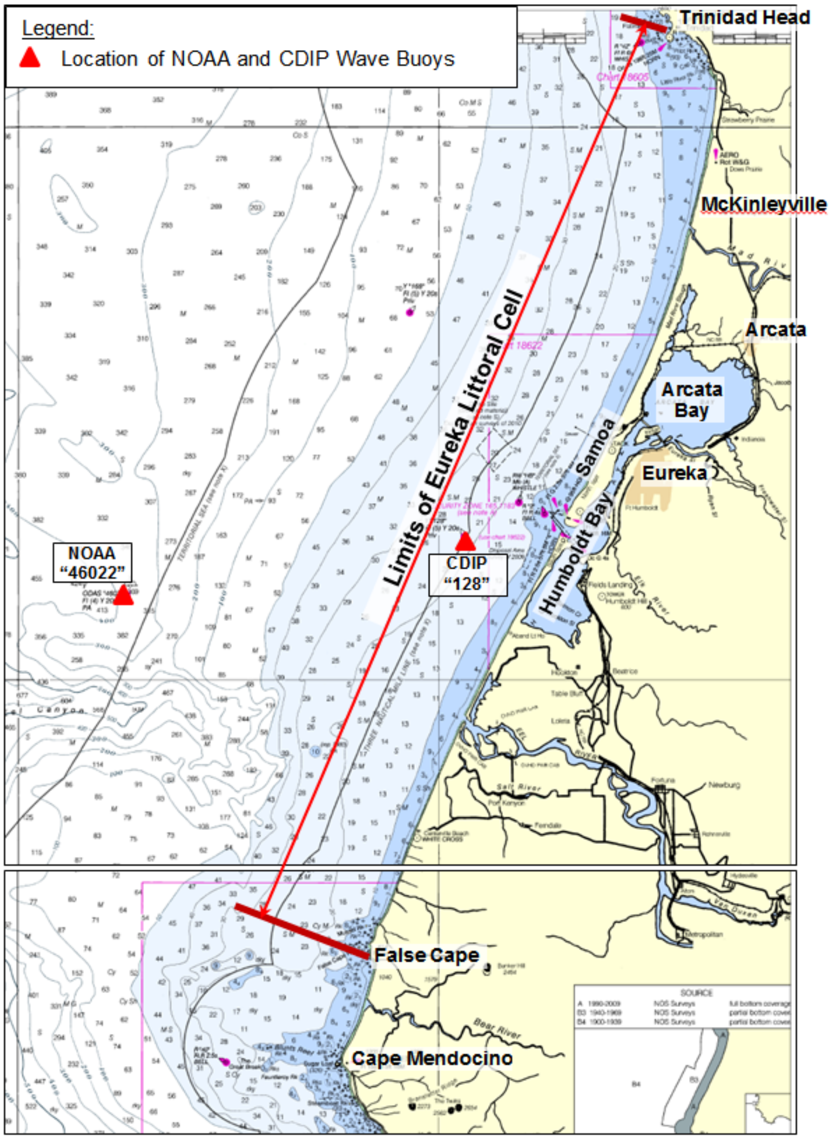


Figure 3: Eureka Littoral Cell Study Area (Source: NOAA Nautical Chart 18620)

2.2 HYDROLOGY

Within the Eureka Littoral Cell and environs, the largest rivers – Little, Mad, and Eel (Figure 4) –discharge into the Pacific Ocean. There are four watersheds that drain into Humboldt Bay (Figure 5):

- Salmon Creek watershed, which drains into South Bay
- Elk River watershed, which drains into Entrance Bay
- Jacoby Creek watershed, which drains into Arcata Bay
- Freshwater Creek watershed, which drains into Arcata Bay via Freshwater and Eureka Sloughs.

There are also several sloughs around the Bay's shoreline that the lower portions of the watersheds drain into. The significant ones are Mad River Slough, McDaniel Slough, Gannon Slough, and Freshwater Slough (Figure 4).

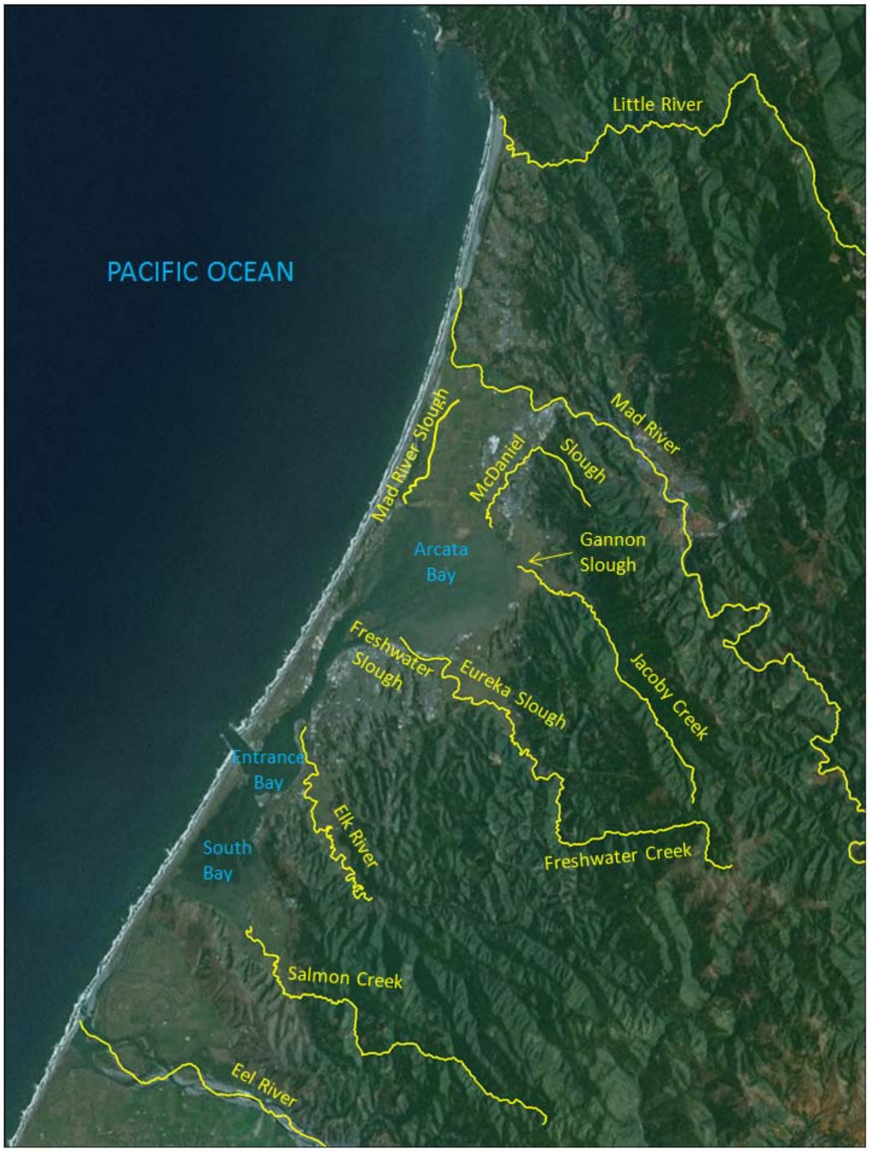


Figure 4: Primary Rivers in the Study Area (Source: HBHRCD 2007)

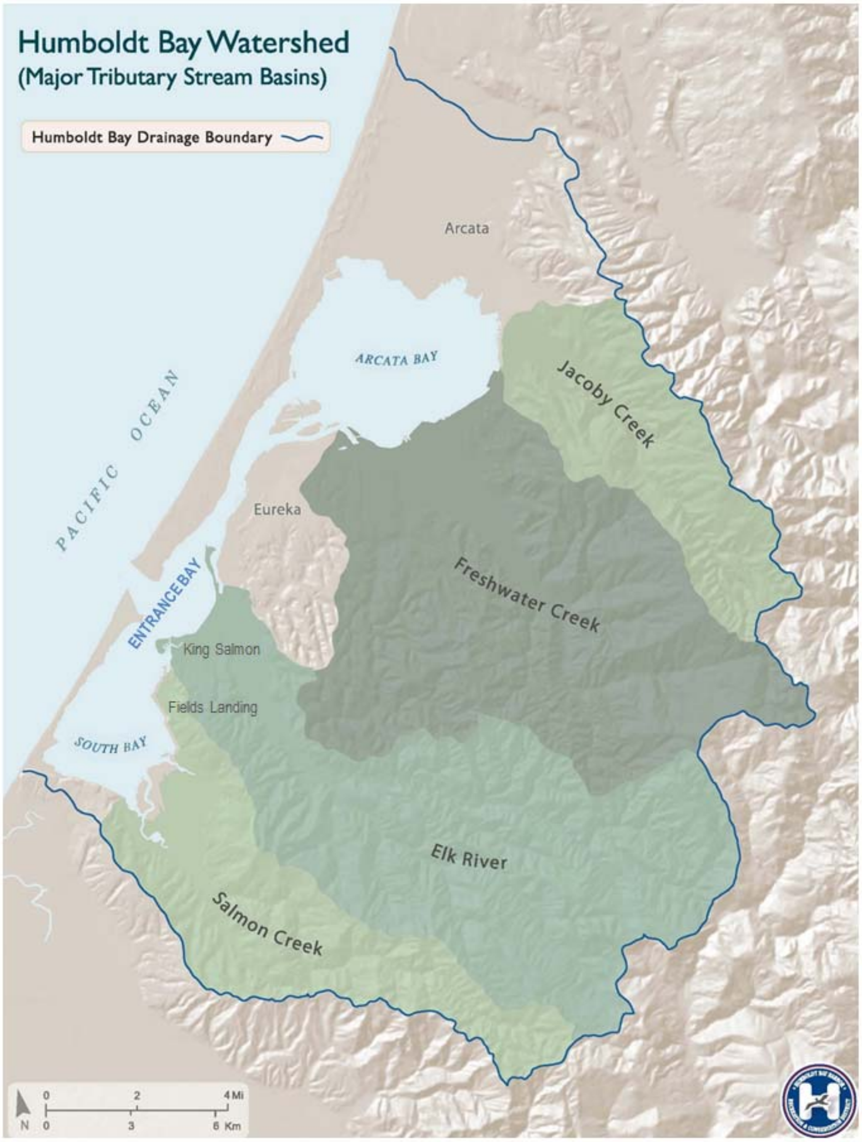


Figure 5: Watersheds within Humboldt Bay (Source: HBHRCD 2007)

2.3 History and Early Settlement

Humboldt Bay's early settlement and ongoing industrial development has had a major influence on the hydrology, sediment yield, and morphology of the area. Although the first Euro-American explorers arrived in 1806, the first settlement took place in the 1850s when Humboldt Bay became a place of departure and supply for the gold mines of Trinity and Siskiyou counties. Also, the local timber industry began, which prompted the start of the timber and agriculture shipping industry. Docks were built in Eureka and Fields Landing. By 1854, fish companies were established at the mouth of the Mad and Eel rivers, and most of the current agricultural lands around Arcata and the Mad River were occupied by settlers.

Early settlers established four bayside communities: Eureka, Union (later renamed Arcata), Humboldt City (today's King Salmon), and Bucksport (near the site of Bayshore Mall in Eureka). As the colonies rapidly expanded, indigenous tribes were removed, surrounding forests were harvested for building supplies, and substantial amount of Bay filling occurred for further expansion. Within a decade, most of the native villages were replaced by a grid system of roads, houses, and commercial buildings.

In 1870, when some minor salt marsh conversion had already occurred, there were over 10,000 acres of salt marsh (Figure 6: HBHRCD 2007). The largest salt marshes were along Mad River Slough, McDaniel Slough, Eureka Slough, Hookton Slough, and Salmon Creek. Many of the wetlands were converted to agricultural lands with seasonal wetlands being used for grazing, overall limiting public access to the Bay. In 1901, the Northwestern Pacific Railroad was built along the eastern margins of Humboldt Bay. The railroad embankment functioned as a dike, and tide gates were placed at most slough crossings. At the time of the completion of the railroad around the eastern margin of the Bay, the areal extent of salt marsh had been reduced by 90 percent.

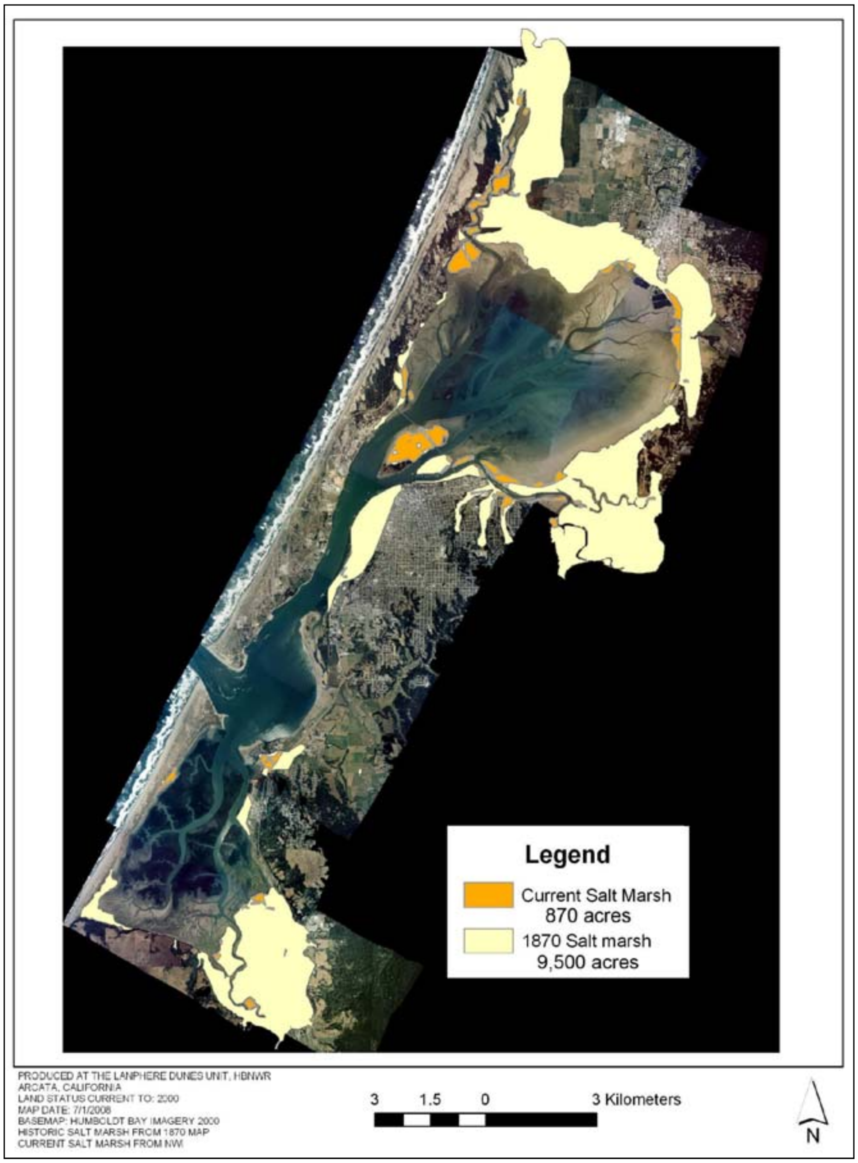


Figure 6: Historic and Present Wetlands Extents in Humboldt Bay (Source: HBHRCD 2007)

With the completion of Highway 101 in 1927, most of the marshes east of Humboldt Bay had been diked and drained. The estimate of the current area of remaining salt marsh is 970 acres (Figure 6). The diking of tidelands for agricultural purposes led to subsidence of these historic salt marshes over time because of draining and settlement of underlying peat and other marsh deposits.

2.4 Geomorphology of the Study Area

2.4.1 Beaches

Between Little River and the entrance to Humboldt Bay, the shoreline consists of beaches backed by large dunes. These beaches, which are typically wide and flat, primarily consist of fine-to-medium-grained sand (Patsch & Griggs 2007). Except for beaches in the vicinity of the Eel River mouth, beaches south of the entrance to Humboldt Bay are relatively narrow. Shoreline aerial photography taken by USACE from 1992 to 2011 during its Humboldt Shoreline Monitoring Program (HSMP) found that there was seaward movement of the beach and accretion of the nearshore face along the South Spit, and shoreward movement of the beach and erosion of the upper beach volume on the North Spit (USACE 2011).

2.4.2 Dunes

Coastal dunes extend unbroken from the Little River to the Eel River except where interrupted by the entrance to Humboldt Bay. Dunes within the Eureka Littoral Cell have been noted to be gaining and losing volume in different locations. Winkelman, et al. (1999) found that the dune and beach system on the south spit grew by approximately 270,000 yd^3/yr from 1992 to 1998. They also found that the North spit lost approximately 175,000 yd^3/yr during the same six-year period. This supports the observation that the beaches on the south spit are accreting while those on the north spit are eroding.

2.4.3 Humboldt Bay and Inlet

Humboldt Bay consists of three basins: Entrance Bay, South Bay, and Arcata Bay (Figure 5). Entrance Bay, which is east of the Bay's entrance, is open to waves propagating through the Entrance Channel. South Bay, which abuts Entrance Bay on the south, consists of shallow waters and large mudflats. Arcata Bay, to the north of Entrance Bay, is connected to Entrance Bay by a long, narrow channel called the North Bay Channel. Before reaching Arcata Bay, the North Bay Channel splits into the Samoa and Eureka Channels.

Before the entrance to Humboldt Bay was stabilized, there was a 3,000- to 5,000-foot-wide opening between the north and south sand spits that formed a natural entrance with a bar located offshore in approximately 18 ft of water. The inlet would typically migrate in response to waves and sediment deposition patterns and rates (Noble 1971).

Improvements to the interior of the harbor began in 1881. It wasn't until 1889, however, that stabilizing the entrance to Humboldt Bay was first attempted. Currently, two rubble mound jetties extend seaward from the ends of the two sand spits (Figure 7). At their seaward end, 2,100 ft separate the 4,500-foot-long North Jetty and the 5,100-foot-long South Jetty.

Figure 7: Humboldt Bay Entrance Channel and Jetties Source (Dredged Material Management Plan, Humboldt Bay [USACE 2013])

2.4.4 Nearshore

As is typical of an inlet with a significant tidal prism and wave exposure, shoaling in the vicinity of the entrance is common, the majority of which is caused by a combination of longshore currents caused by tides and waves and tidal currents through the inlet. The large tidal flux through the entrance and energetic offshore wave activity result in the formation of an ebb tidal bar just seaward of the entrance jetties. To allow safe passage into and out of the Bay, USACE annually dredges a channel through the ebb shoal bar and between the two jetties – collective called the Bar and Entrance Channel(Figure 8).

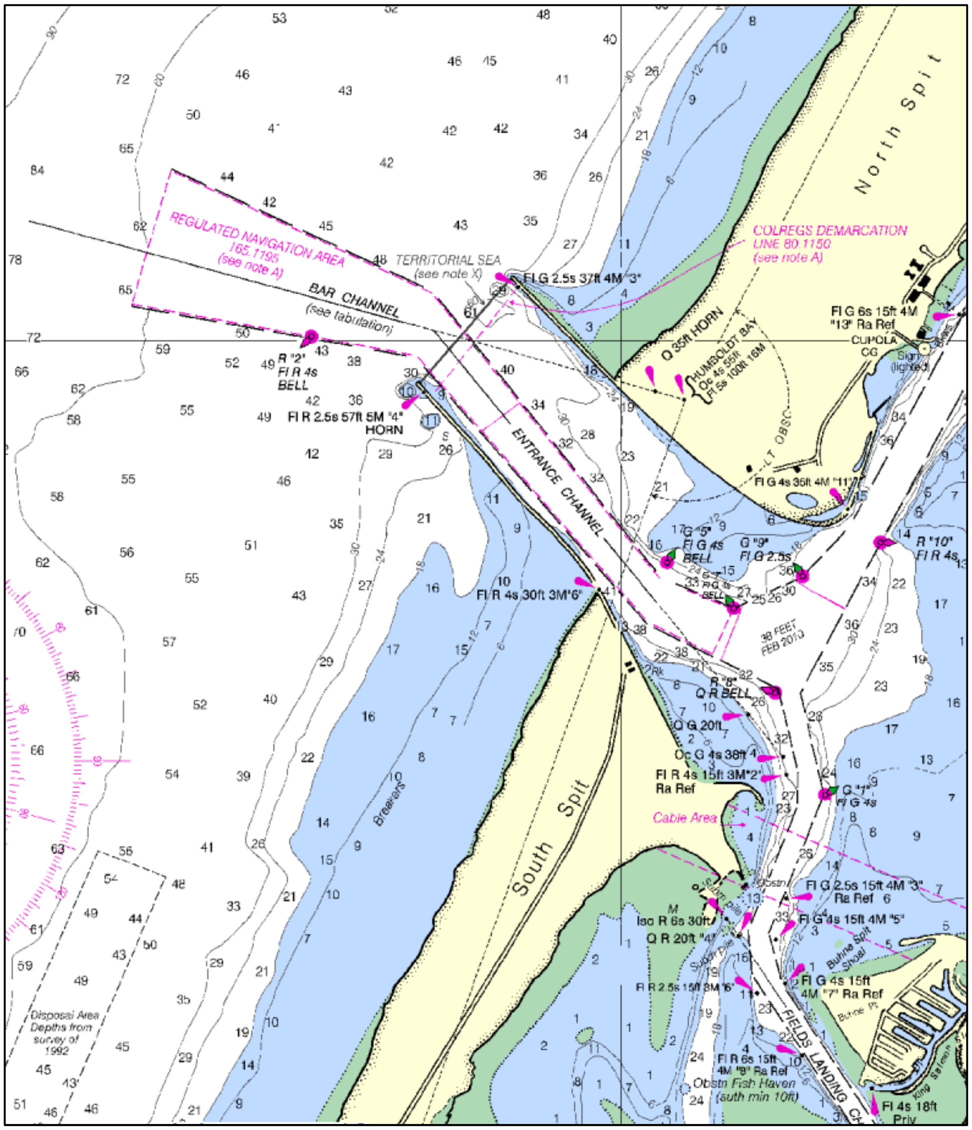


Figure 8: Humboldt Bar and Entrance Channel (depths shown in ft, at MLLW)

The Eel River (ten miles south of the Bay's entrance) and the two rivers to the north (Mad River and Little River) contribute most of the sediment to the Littoral Cell. While the Eel River is the largest contributor of sand, much of the sand transported down the Eel River passes through the lower estuary, bypasses the beach, and settles out on the continental margin or is lost to the Eel Submarine Canyon (Ritter 1972; Patsch & Griggs 2006).

Sediment dredged from the Bar and Entrance Channel consists of medium to fine sand. Going seaward, the sediments are similar up to a depth of approximately 160 ft. Between that depth and 250 ft, bottom sediments transition to silty sands and sandy silts with variable clay contents. In depths greater than 250 ft, bottom sediments are primarily poorly sorted clays and silts. Large waves transport suspended sediment offshore where sediments settle to these depths, where the water is generally too deep to be directly influenced by surface waves (Wheatcroft & Borgeld 2000; Evans 1994).

2.5 Tides and Tidal Prism

Tides in the Humboldt Bay region are classified as mixed semidiurnal (two unequal highs and lows each lunar day). Within the Bay, the tides typically show some amplification and phase lag with increasing distance from the entrance. The mean range – mean high water to mean low water – at the entrance is approximately 5.0 ft and the diurnal range – mean higher high water (MHHW) to MLLW – is approximately 7.0 ft. Amplification is most pronounced to the north with an increase in range of up to one foot.

During extreme tides, maximum flood and ebb currents can reach 2.8 and 3.5 knots respectively, with average maximums in the range of 1.6 to 2.0 knots. Claasen (2003) used a numerical model to confirm these observations (Figure 9 and Figure 10). The strong ebb current within the Bar and Entrance Channels can enhance the already steep waves to the extent that vessels might not be able to safely transit the area when there are large waves during the ebb tide (Costa and Glatzel 2002).

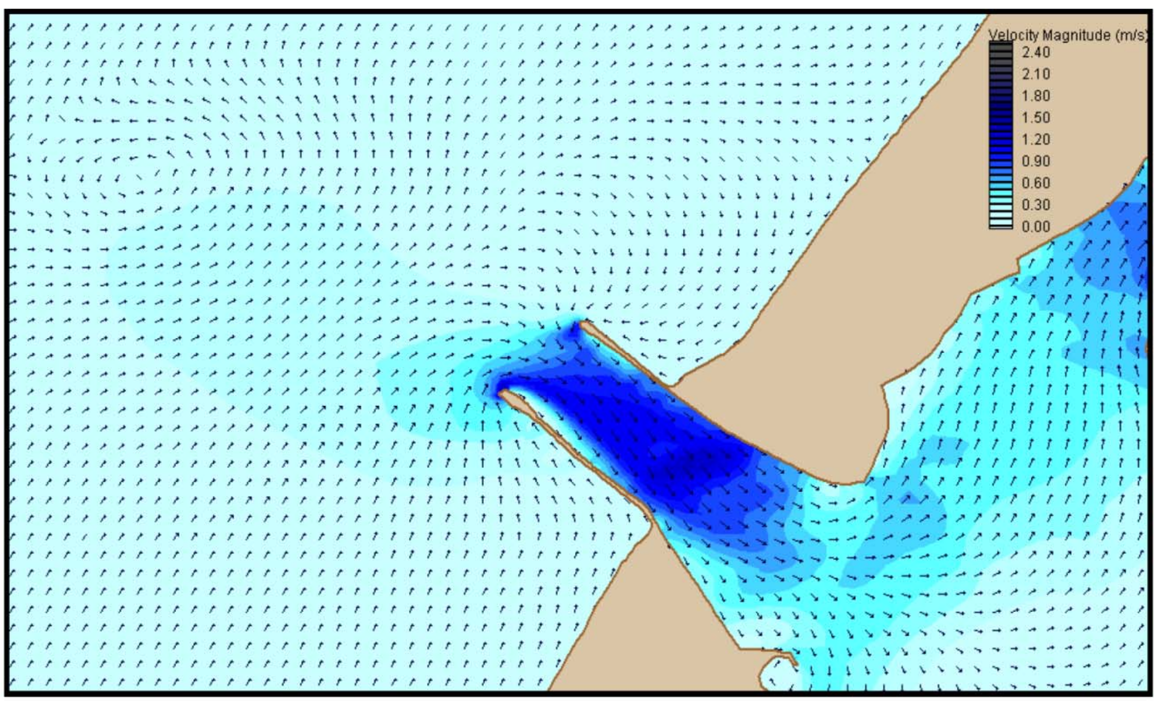


Figure 9: Humboldt Bay Flood Tide Velocity (Source: Claasen 2003)

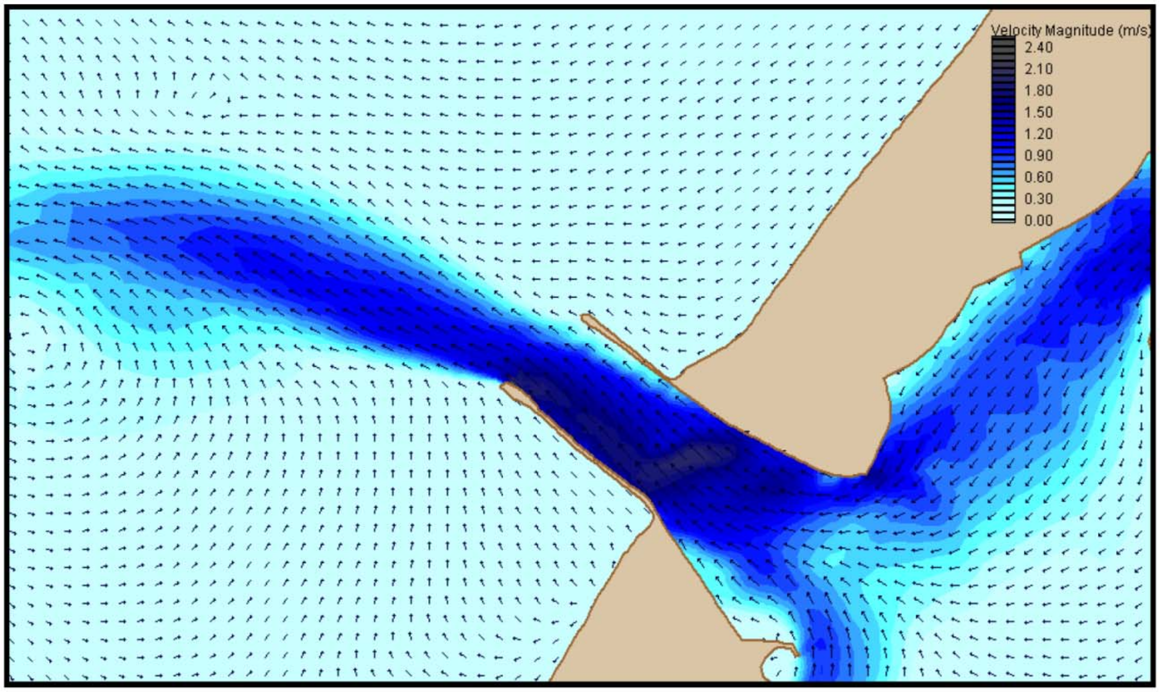


Figure 10: Humboldt Bay Ebb Tide Velocity (Source: Claasen 2003)

The Bay's tidal prism is approximately 3.5 x 10^9 cubic ft during a spring tidal cycle and approximately 70 percent of that value during a mean tidal cycle. Approximately 50 percent of the prism is from Arcata Bay and about 30 percent from the South Bay (Costa and Glatzel 2002). Approximately 44 percent of the Bay's water volume moves in and out of the Bay during flood and ebb tides (Rumrill 2002). During high tides, the surface area of Humboldt Bay reaches approximately 26.5 square miles and during low tides, approximately 7.8 square miles (Rumrill 2002). As a result of the large water-volume flux between high and low tides, approximately 70 percent of the Bay has tidal mud flats exposed at low tides.

2.6 WAVES

Some of the most severe wave conditions in the contiguous United States occur north of Cape Mendocino. As a consequence, waves are the most significant driving force for coastal sediment transport throughout the area (Costa and Glatzel 2002).

Because of differences in wave intensity and direction throughout the year, littoral-zone material moves both directions (north and south) in the Eureka Littoral Cell. For example, a 27-year monthly average of the wave climate at the closest National Data Buoy Center (NDBC) buoy, located 17 nautical miles west of the Humboldt Bay entrance (Buoy 46022; Figure 3), shows a strong seasonal signal (Figure 11). In the late fall and winter, when long-period, storm-driven swell dominates the record, maximum wave heights can reach 32 to 40 ft. In the late spring and summer, when wind waves tend to predominate, maximum wave heights can reach 16 to 23 ft.

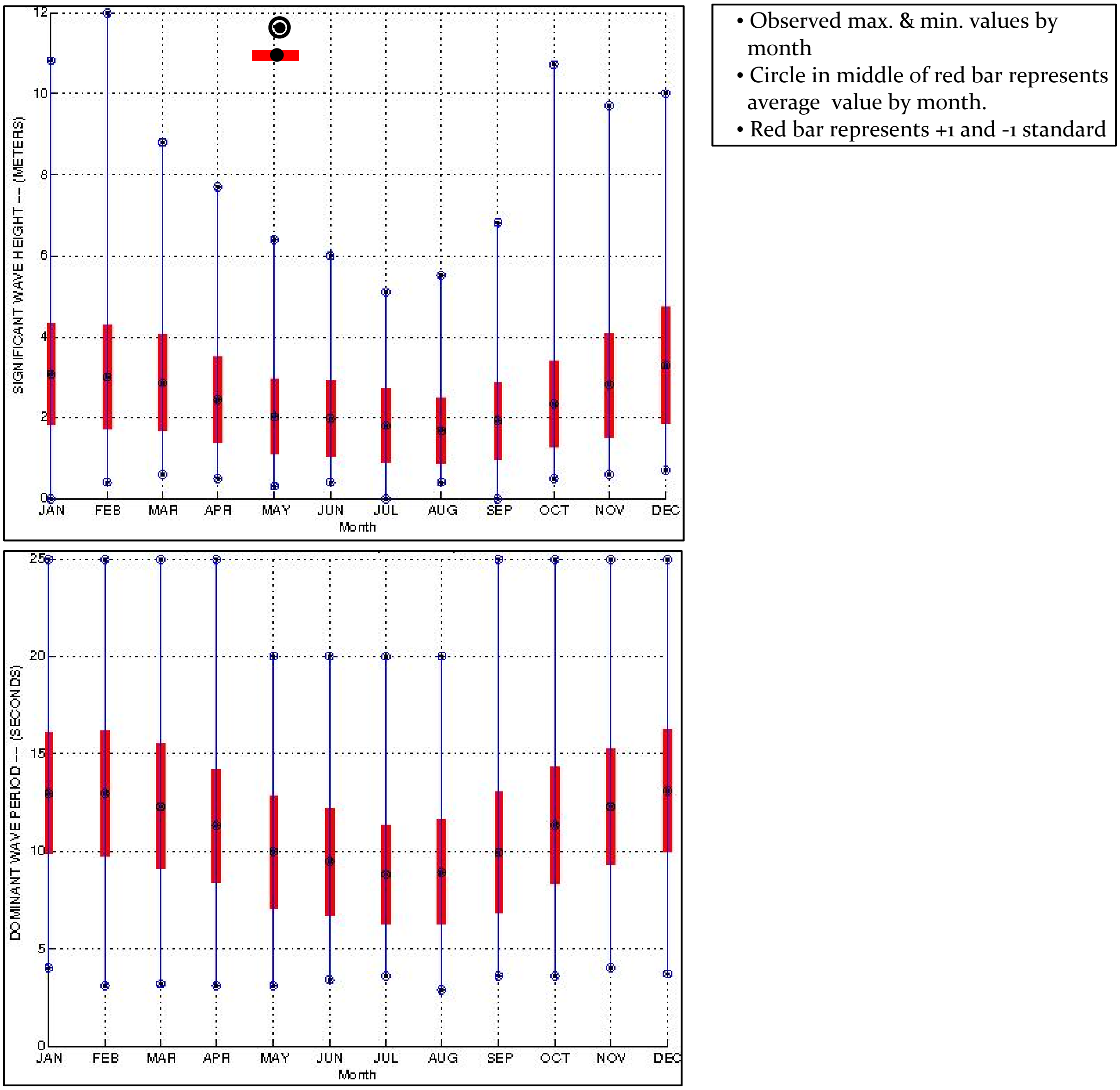


Figure 11: Wave Climate near Humboldt Bay (1/1982 to 12/2008, Station 46022). One meter equals 3.28 ft. (Source: National Data Buoy Center: http://www.ndbc.noaa.gov)

The Coastal Data Information Program (CDIP) has a station closer to shore (Station 128; Figure 3) which also shows this strong seasonal signal (Figure 12). At that buoy, smaller waves typically occur in the summer (6 to 12 ft wave heights with periods shorter than 10 seconds) and larger waves typically occur in the winter (13 to 18 ft wave heights with periods longer than 10 seconds).

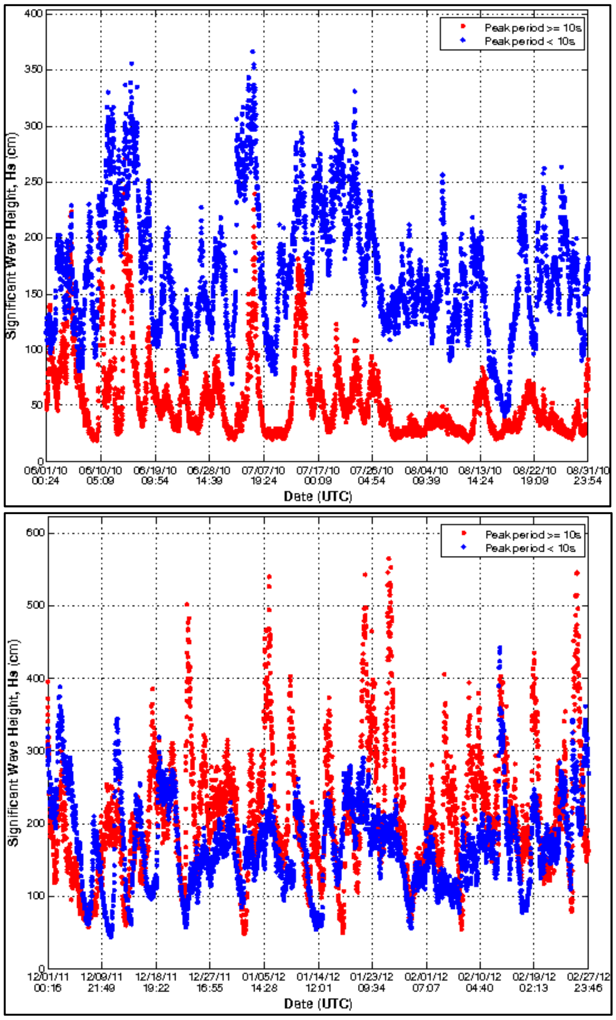


Figure 12: Observed Seasonality in Wave Conditions for Humboldt Entrance Channel (CDIP Station 128) (left: 6/2010 to 9/2010; right: 12/2011 to 3/2012 One centimeter equals 0.0328 ft. (Source: Coastal Data Information Program: http://cdip.ucsd.edu)

The predominant wave approach direction is northwest (Costa & Glatzel 1982; Figure 13). Large winter swells typically come from the west through west-northwest directions (Figure 14) and summer conditions are typically from a more northerly direction (Figure 15). There are significant implications of the wave climate and seasonal signal on sediment transport processes (Section 3.3).

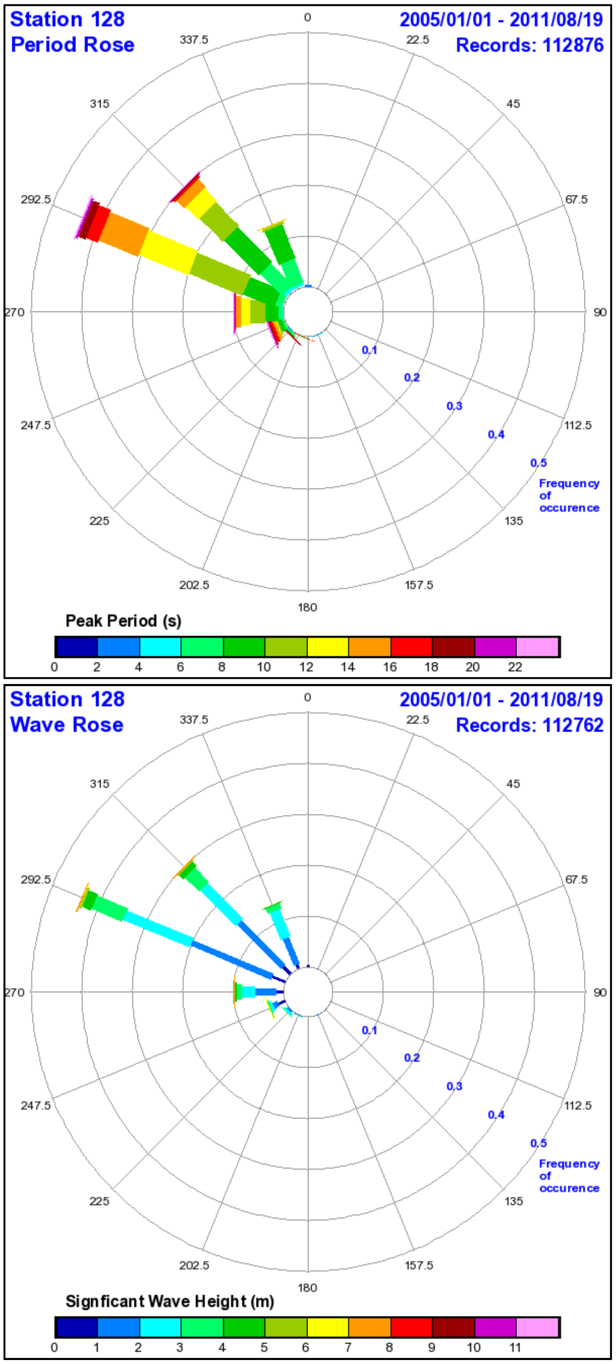


Figure 13: Wave Conditions (Annual Average) for Humboldt Bay Entrance Channel (CDIP Station 128). One meter equals 3.28 ft. (Source: Coastal Data Information Program: http://cdip.ucsd.edu)

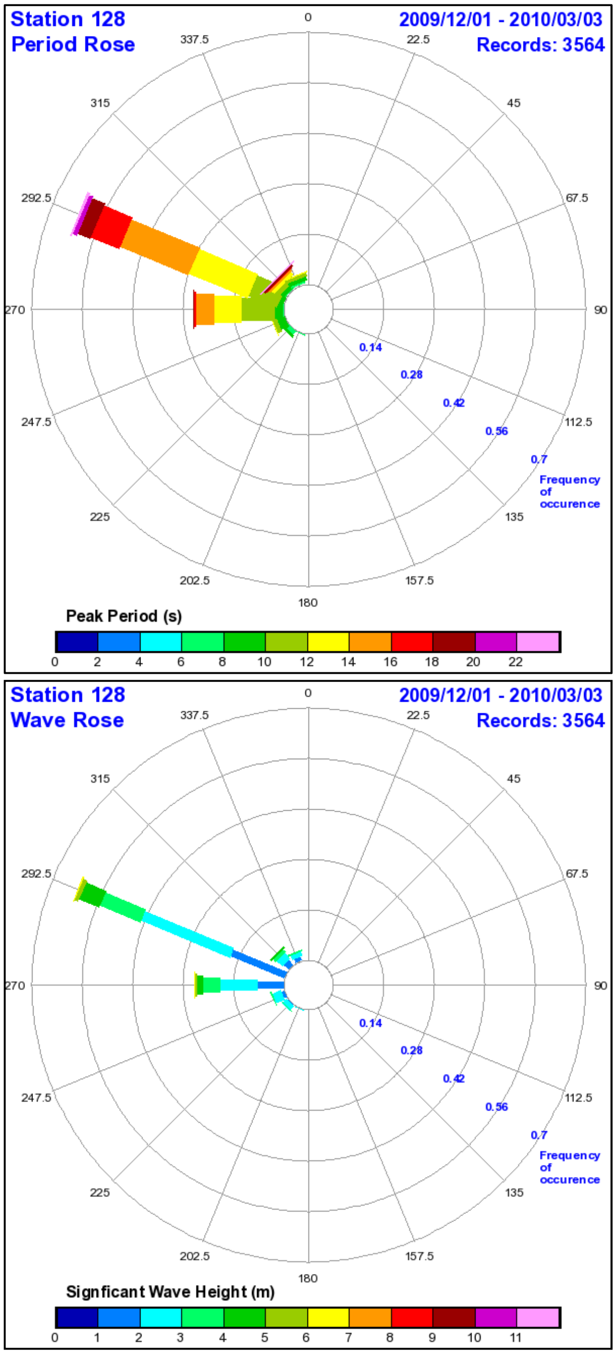


Figure 14: Wave Conditions (typical winter) for Humboldt Entrance Channel (CDIP Station 128). One meter equals 3.28 ft. (Source: Coastal Data Information Program: http://cdip.ucsd.edu)

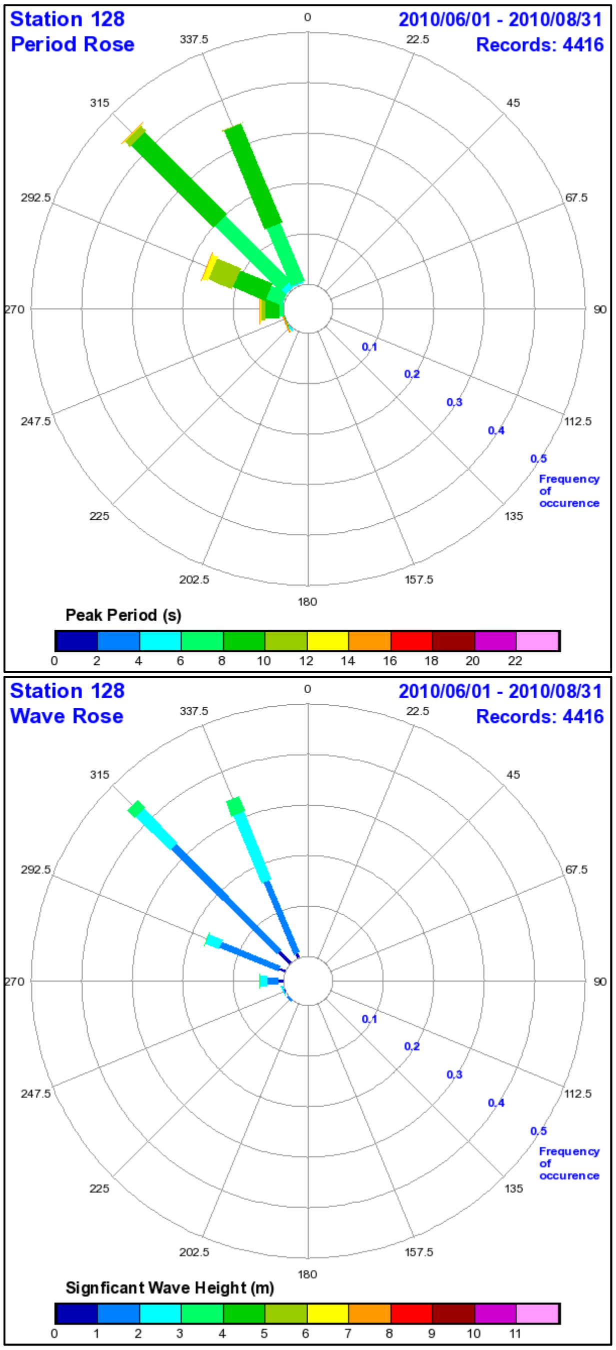


Figure 15: Wave Conditions (typical summer) for Humboldt Entrance Channel (CDIP Station 128). One meter equals 3.28 ft. (Source: Coastal Data Information Program: http://cdip.ucsd.edu)

Between the entrance jetties, a large shoal occurs along the eastern portion of the north jetty, and the navigation channel abuts the south jetty. This configuration of channel and shoal is likely related to the circulation patterns associated with the ebb and flood currents and their redirection to and from the basins to the north and south of Entrance Bay (Costa & Glatzel 2002).

The net result of the wave climate, offshore bathymetry (especially that of the ebb shoal bar), and orientation of the jetties is that swell waves always enter Humboldt Bay and approach the Bay shoreline from the same direction regardless of offshore wave direction (Figure 16). As a result, extreme erosion has occurred along the mainland across from the entrance channel, and much of that shoreline is now heavily armored, including in the vicinity of the town of King Salmon.

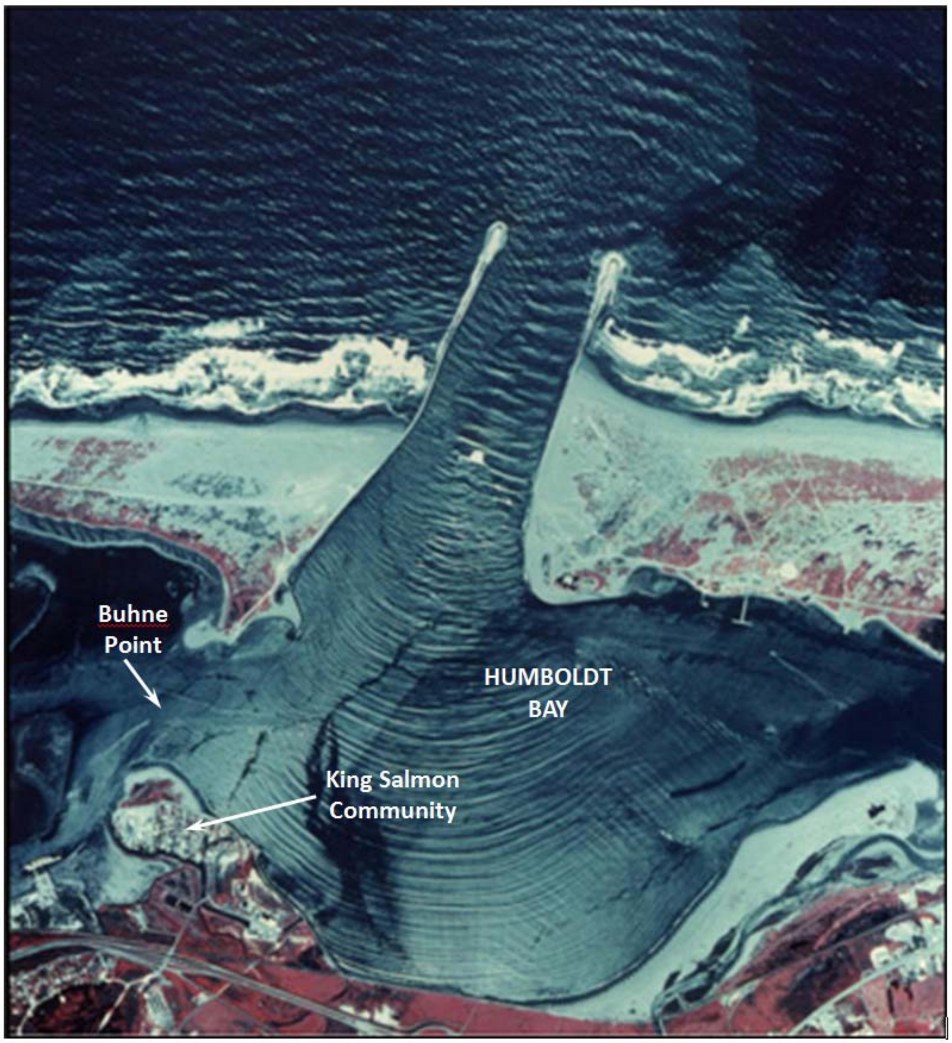


Figure 16: Wave Refraction into Humboldt Bay (Source: Costa & Glatzel 2002 [Aerial Photo: April 29 1974])

2.7 Geology, Tectonics, and Sea Level Rise

2.7.1 Geology & Tectonics

Eureka and adjacent communities sit on a coastal plain of Tertiary marine deposits that is dissected by meandering rivers and streams, and abutted by gently sloping beaches. East of the coastal plain are the Coast Ranges, which run northwest to southeast in northern California. The study area is part of the Coast Ranges Geomorphic Province.

The Coast Ranges formed as a result of the Juan de Fuca Plate (including the Explorer and Gorda segments) subducting under North American Plate. The Cascadia Subduction Zone (CSZ) is the location of the interaction between the two plates (Figure 17). Near Cape Mendocino, the Gorda segment meets the Pacific Plate and the San Andreas fault system, creating the Mendocino Triple Junction (MTJ). The region around the MTJ is one of the most seismically active regions in California, with approximately 80 earthquakes of magnitude 3.0 or greater each year since 1983 (USGS 2011).

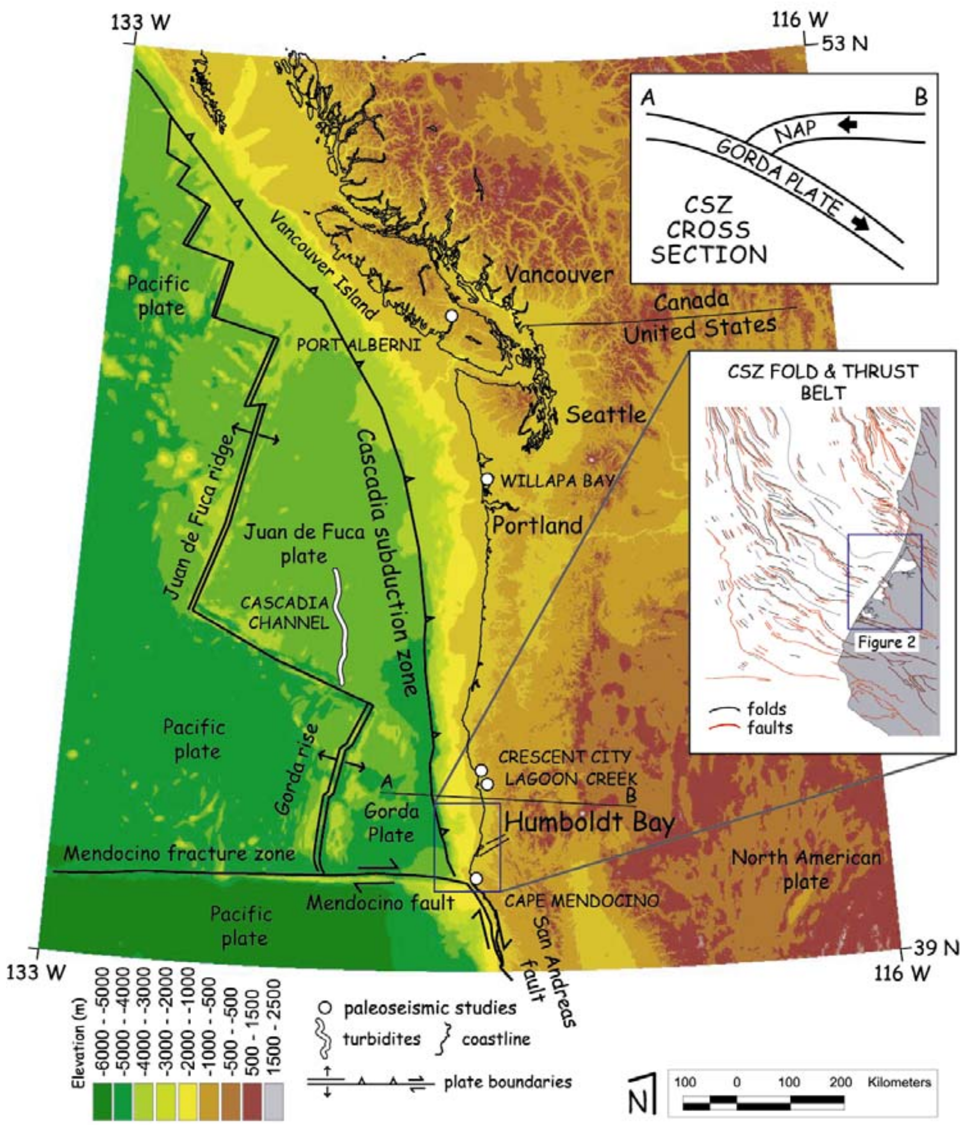


Figure 17: Cascadia Subduction Zone Map (Source: Patton 2004).

Historically, tectonic activity along the CSZ has led to gradual uplift along the coastline over hundreds of years, followed by a large earthquake often resulting in almost instantaneous subsidence and a tsunami. However, because of the complex faulting and convergence of multiple plates, there has also been large uplift measured immediately after an earthquake (Oppenheimer et.al. 1993). The 1992 magnitude 7.1 Cape Mendocino earthquake resulted in a measured uplift of almost 4.5 ft over a 15-mile segment of coast north of Cape Mendocino (Figure 17: *n.b.*, 15 miles equals 24 kilometers).

Several shore-normal faults also exist in this region (Figure 17), which results in substantial variation in the uplift and subsidence rates, and reversals between uplift and subsidence over relatively short distances. Assessing these land motions requires high-resolution survey accuracy; as a consequence, the Humboldt Bay Vertical Reference System Working Group (HBVRSWG) was formed to improve the vertical control of tide gauges in the Humboldt Bay area (Anderson et al. 2011). One of their first tasks was to compare land motions based on NOAA tide gauge measurements to surveyed rates. They estimated uplift rates at Crescent City to be about 3 mm/yr for the 1977 to 2010 period (HBVRSWG 2011). Over the same period, the North Spit along Humboldt Bay subsided at about 1.9 mm/yr, and the Mad River Slough just north of the North Spit subsided at about 0.8 mm/yr.

2.7.2 Eustatic Sea Level Change Projections

This section summarizes peer-reviewed publications on the topic of climate change and associated sea level change, and discusses applications to the CRSMP. Worldwide, factors that contribute to sea level rise include thermal expansion of the oceans, glacial melt, and melting of the ice sheets. It is important to distinguish *eustatic* (global average) sea level changes from *local* sea level changes because of the substantial tectonic activity in the CRSMP region; both are discussed in this section. Projections of global sea level changes are provided in the following documents.

2.7.2.1 Intergovernmental Panel on Climate Change (AR4)

The Intergovernmental Panel on Climate Change (IPCC) regularly assesses the worldwide rate of sea level rise. Their Fourth Assessment Report, AR4, (IPCC 2007) contains an exceptionally detailed synthesis of the available peer-reviewed science of climate change and sea level modeling, and has received contributions and comment from a vast array of respected researchers in the field.

The AR4 gives a widely quoted range of 18 cm (7 inches) to 59 cm (23 inches) for sea level rise in the 21st century. These are considered 5 to 95 percent ranges. The AR4 includes a second set of projections – from 18 cm (7 inches) to 76 cm (30 inches) – including a scaled-up ice discharge term.

The uncertainty in the quoted projections result from

* Different greenhouse gas emission scenarios – the IPCC defines six future scenarios of world population and economy that predict different levels of greenhouse gas emissions. The AR4 stresses that no scenario can be considered more likely than others.
* Limitations to current scientific knowledge – the range of sea level rise projections for a given scenario is based on the range of results from 17 independently developed and peer-reviewed general circulation models (GCMs). Of the two, this produces the greater uncertainty.

The projections cover the period from 1990 to 2095; the AR4 does not provide sea level rise values at intermediate periods (e.g., to 2050). The models described in the AR4 give reasonable hindcasts of observed sea level rise between 1993 and 2003, although they under predict observed sea level rise between 1961 and 2003.

The IPCC's projections do not include potentially large and nonlinear effects – notably the potential instability and loss of the Antarctic and Greenland Ice Sheets. This is because there are no broadly accepted models of these processes. It is not even known whether ice sheet discharge will increase or decrease sea level rise in the short term. In the long term (many centuries), complete loss of the Greenland and Antarctica ice sheets would raise the sea level by approximately 230 ft. The IPCC intends to include ice sheet dynamics in their next assessment (IPCC 2010).

Critics of the IPCC have generally focused on their scientific conservatism. In particular, many planners have expressed concern that the projections are not sufficiently conservative in an engineering sense, and that the upper limits of the IPCC projections do not represent a worst-case scenario.

The report also gives regional variations in projected sea level rise (Figure 18) at the end of the 21st century. Along the Pacific coast of the United States, the projected difference is less than 0.16 ft.

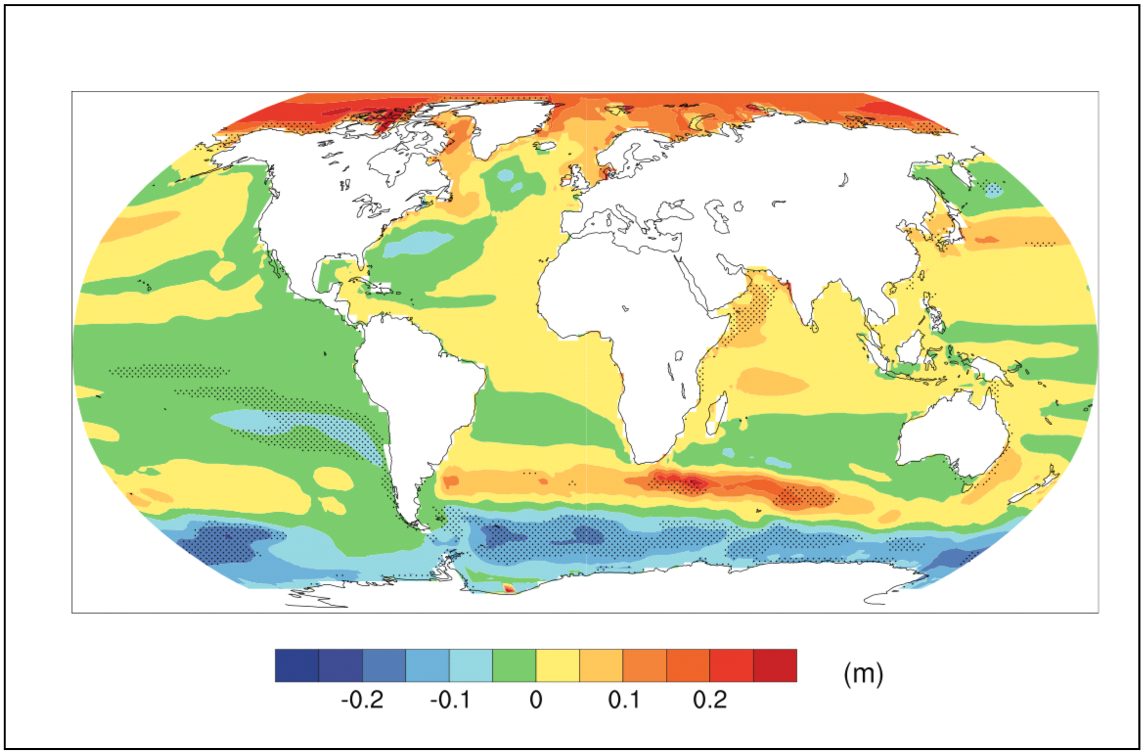


Figure 18: Projected Difference between Local and Global Average SLR in 2090 (Source: IPCC 2007)

2.7.2.2 Semi-Empirical Methods

An alternative approach to the detailed, physically based numerical modeling used by the IPCC is a semi-empirical approach (Rahmstorf 2007a). The approach uses existing temperature projections plus a linear model based on observations from 1880 to 2001 to predict sea level rise directly from temperature changes. It may capture the effect of mechanisms such as the loss of mass from ice caps, which may already be occurring but are not yet understood in detail. The approach is controversial in its application of statistical methods (Holgate et al. 2007; Schmith et al. 2007; Rahmstorf 2007b) and because of the fact that it has little supporting physical basis (IPCC 2010). It has been widely quoted, however, and is regularly used in planning literature. It increases the estimate of 21st century sea level rise to 1.6 to 4.6 ft between 1990 and 2100. A more recent update (Vermeer and Rahmstorf 2009) increases the estimate to 2.5 to 6.2 ft in this period.

2.7.2.3 California Climate Change Center

The California Climate Change Center (CCCC) comprises the California Energy Commission, Scripps Institution of Oceanography at the University of California at San Diego, and the University of California at Berkeley. Its latest report (Cayan et al. 2009) has been used by the California State Coastal Conservancy, the California

Climate Action Team and other California State agencies as a baseline for sea level rise projections. The CCCC makes the following assumptions:

* Sea level rise along the California coast as a whole will continue to match global rates.
* Global warming projections use three of the six greenhouse gas emissions scenarios in IPCC 2007.
* Sea level rise projections use Rahmstorf's (2007a) semi-empirical method to estimate reasonable upper and lower limits to sea level rise based on global temperature.
* An additional contribution is used that is based on the work by Chao et al. (2008) that accounts for the 20th century growth of dams and reservoirs. By impounding water, these structures may have artificially decreased the rate of sea level rise in the 20th century. Correcting for this possible decrease increases the future rate of sea level rise.

The increase of 4.6 ft (55 inches) by 2100, as adopted by the California State Coastal Conservancy (CSCC) for planning in their projects (CSCC 2009) and as recommended by the Climate Action Team (CAT) for use in planning and decision making in California (CAT 2010), is based on the upper limit of these projections: three emissions scenarios, statistical variability in sea level rise based on temperatures, and the inclusion of dam effects.

2.7.2.4 National Research Council

The NRC recently released a report on sea level rise projections for the coasts of California, Oregon, and Washington (NRC 2012). The Committee that prepared the report chose to use GCMs developed for the IPCC Fourth Assessment Report to estimate the effects of thermal expansion (steric contribution) and extrapolation techniques to estimate the effects of melting of glaciers, ice caps, and sheets (cryospheric contribution).

The committee's global projections for 2100 are substantially higher than the IPCC's (2007) projection, mainly because of a faster growing ice melt component, and are somewhat lower than the Vermeer and Rahmstorf (2009) projections. The committee estimates that global sea level will rise 8 to 23 cm by 2030, 18 to 48 cm by 2050, and 50 to 140 cm by 2100, relative to 2000 levels. The major sources of uncertainty in the global projection are related to assumptions about the increase in rapid ice dynamics and the growth of future greenhouse gas emissions.

The projected sea level rise values vary by latitude, with the highest numbers expected off the coast south of Cape Mendocino (4 to 30 cm for 2030, 12 to 61 cm for 2050, and 42 to 67 cm for 2100) and the lowest numbers expected off the coast north of Cape Mendocino (-4 to 23 cm for 2030, -3 to 48 cm for 2050, and 10 to 143 cm for 2100).

The report also states that the biggest variant for future sea-level rise along the U.S. West Coast would be a great earthquake (magnitude greater than 8) along the Cascadia Subduction Zone. Such earthquakes have occurred every several hundred to 1,000 years, with the most recent occurring in 1700. During a great earthquake, some land areas would immediately subside and relative sea level would suddenly rise, perhaps by more than 3 ft. This earthquake-induced rise in sea level would be added to the projected rise in relative sea level (about 60 cm by 2100).

2.7.2.5 US Army Corps of Engineers

The sea level rise considerations policy adopted by USACE (Engineering Circular EC 1165-2-212 2012), emphasizes the use of multi-scenario planning approaches to deal with the uncertainties in sea level rise projections. The report does not make specific projections of sea level rise: rather, it adopts three plausible sea level rise scenarios of low (50 cm), intermediate (100 cm), and high (150 cm) by 2100 and provides guidance on incorporating the multi-scenario approach to civil works projects. The range of estimates from low to high (50 cm to 150 cm) is based on an earlier study (NRC 1987). Despite its age, the information and guidance presented in the 1987 NRC study, in terms of considering how different types of projects may be affected by sea-level change, is useful. EC 1165-2-212 projections are to be considered by USACE planners and engineers throughout the life-cycle of projects.

2.7.2.6 Measured Eustatic Sea Level Change Data

Because many of the afore mentioned studies used GCMs and modeling techniques using sea level data up to about *ca.* 2000, and there is at least 10 more years of data available, it is instructive to also consider measured sea level change data.

Tidal Gauge Analysis: Long-term estimates of measured sea level rise heavily depend on tide records, which are affected by local tectonic activity (uplift or subsidence) and are dominated by sites in the northern hemisphere. Analysis of long-term tide gauge records in the United States shows little or no acceleration in sea level over the 20th century (Houston and Dean 2011a), although these results are controversial (Rahmstorf and Vermeer 2011; Houston and Dean 2011b). The fact that the acceleration is small enough that statistical choices can give rise to completely differing conclusions highlights the fact that the measurement record remains inadequate to choose between different projections.

Satellite Measurements: Since the early 1990s, global satellite altimetry measurements have become available (e.g., Figure 19), and, between 1993 and 2007, the rate of sea level rise is estimated to be 3.3±0.5 mm/yr (Cazenave and Llovel 2010). These satellite altimetry measurements are near the upper end of the IPCC (2007) projections, and near the lower end of the Rahmstorf (2007a) and the Cayan (2009) projections.

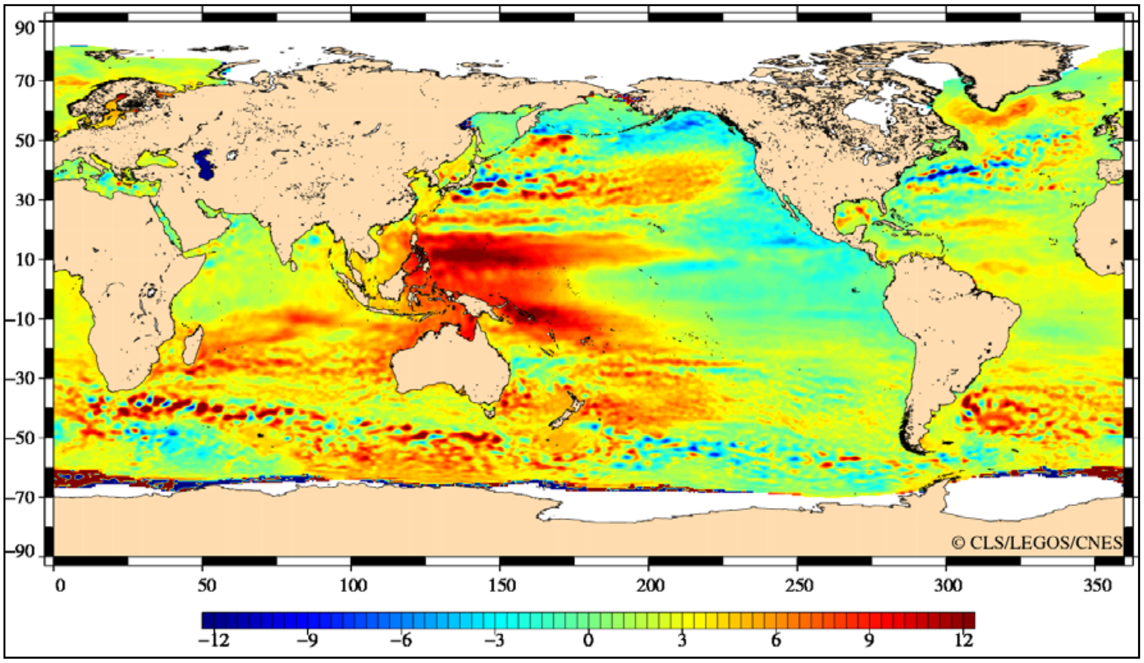


Figure 19: Sea Level Trends from Satellite Altimetry (mm/yr), 10/1992 to 7/2009 (Source: CNES and CLS 2010)

Climate Variability and Anomalies: Since 1993, the rate of sea level increase along the Pacific coast of North America has been substantially lower than the global rate. The sea level in the region actually dropped in this period along the North American West coast (Figure 19). This may be caused by the decadal-scale Pacific Decadal Oscillation (PDO), which switched from a warm to a cool phase in the late 1990s (Figure 20), suppressing sea-surface heights along the North American continent during the latter part of this period (Bromirski et al. 2011). Long-term estimates of sea level rise along the Pacific coast of North America are comparable to global estimates, and regional differences are generally not considered in projections of climate change (e.g., Cayan et al. 2009).

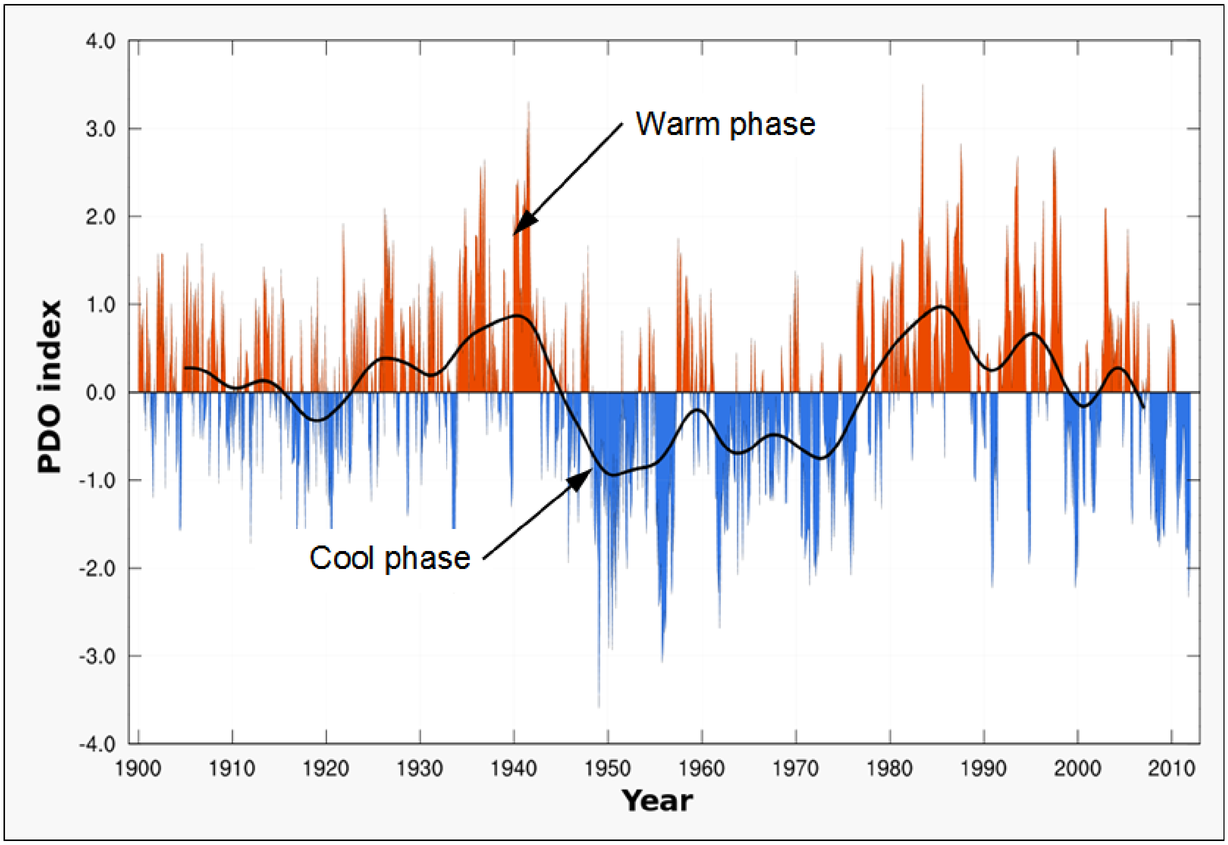


Figure 20: Pacific Decadal Oscillation Index

(Source: MacDonald & Case 2005)

There also appears to be evidence of apparent changes in tidal amplitude and meteorological patterns. Based on tidal records with a length of 50 years or more, tidal amplitudes along the Pacific coast of North America appear to be increasing at an average of 0.59 mm/yr (Jay 2009). Global warming and changes in the PDO index (warm phases) may also be contributing to increases in wave intensity in the North Pacific (Seymour 2011). It is unclear whether future changes in the PDO index will result in changes again in the storminess patterns (i.e., will cooling phases cause reversals in storminess patterns?).

2.7.3 Local Sea Level Rise and Implications to CRSMP

At a given coastal site, other factors must be integrated with the estimated global rate of sea level rise to understand the impact of sea level rise relative to the adjoining land. These include local ocean conditions (e.g., the PDO) and local tectonic conditions (uplift or subsidence).

Humboldt Bay lies close to the southern end of the Cascadia Subduction Zone (CSZ), resulting in large local variations in vertical movement. Gradual changes in sea level in Humboldt Bay have been punctuated by sudden increases in relative sea level associated with earthquake-induced land subsidence, and this can be expected to occur in the future (Patton et al. 2002; Leroy et al. 2010).

Based on tide records from 1977 to 2006 at Humboldt Bay's North Spit, NOAA estimates the rate of local sea level rise to be 4.7±1.5 mm/yr, which is well above the global average rate. In contrast, NOAA estimates the rate at Crescent City to be -0.66±0.36 mm/yr implying that the relative sea level at Crescent City has been falling. In addition, vertical land movements may not be constant across the Bay (HBVRSWG 2011).

Because of the uncertain tectonic effects in the area, Humboldt Bay is subject to more than the usual uncertainty in projections of relative sea level rise. The local mean sea level change trend (4.7±1.5 mm/yr) suggests a rate of sea level rise that is higher than the NRC Curve I projected increase for the 20-year and 50-year project horizon. In its Humboldt Bay Dredged Material Management Plan, USACE proposes to use the NRC Curve I to represent the lower bound of sea level rise, the local trend analysis to represent the intermediate scenario, and the NRC Curve III to represent the high SLR scenario (USACE 2012).

As stated in the NRC (2012), the possibility of subsidence of several ft during an earthquake should also be considered in planning. Their recommendation is to add 60 cm to the sea level rise projections for such an event, which implies a planning level estimate of 70 to 200 cm by 2100 for the coast north of Cape Mendocino.

2.7.3.1 Regional Sea Level Rise Vulnerability Study

The Coastal Conservancy recently funded a study that included a sea level rise vulnerability assessment for the Humboldt Bay area (Trinity Associates et.al. 2013). It provides a geo-spatial inventory of the extent of tidal marshes (Figure 21); shoreline type (Figure 22); elevation of the shoreline relative to the mean monthly maximum water level (MMMW) of approximately 7.7 ft above NAVD88 (Figure 23); and inundation maps showing the extent of flooding associated with the MMMW and 1, 2, 3, and 6 ft of sea level rise above the MMMW.

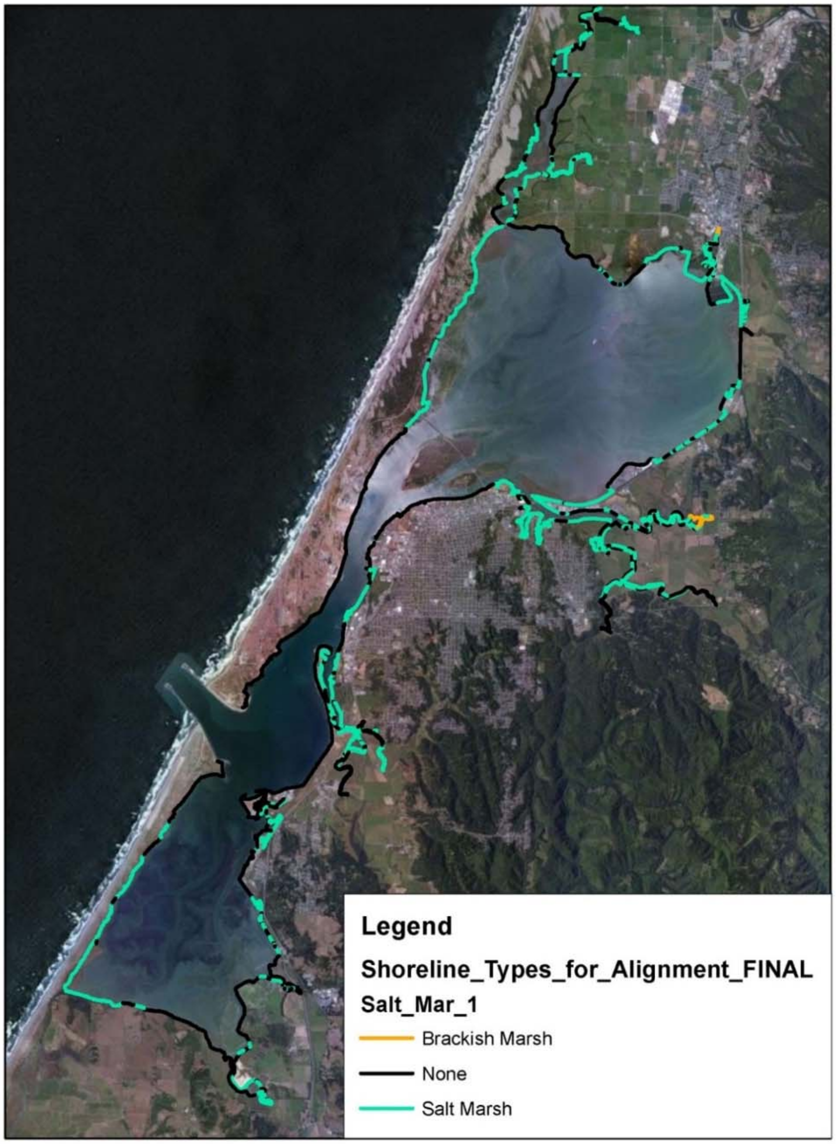


Figure 21: Extent of Tidal Marshes Around Humboldt Bay (Source: Trinity Associates et.al. 2013)

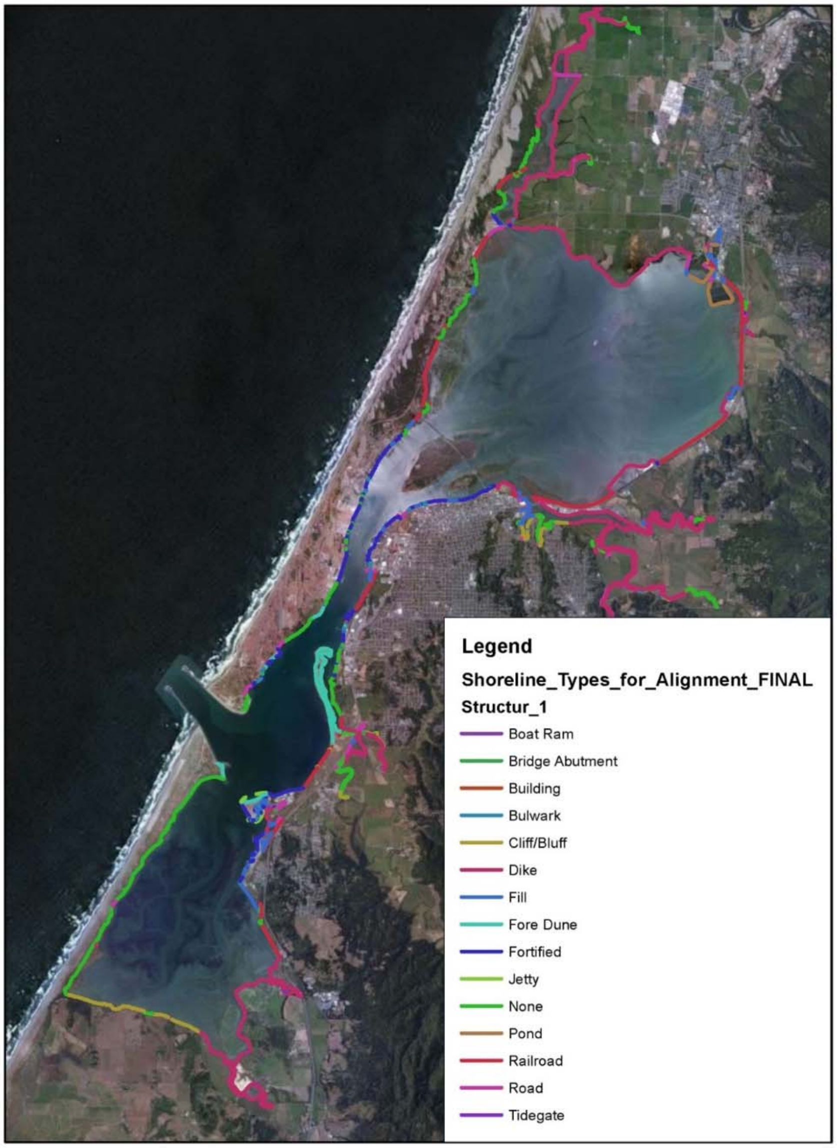


Figure 22: Inventory of Shoreline Types for Humboldt Bay (Source: Trinity Associates et.al. 2013)

Figure 23: Shoreline Elevations For Humboldt Bay Relative to MMMW (Source: Trinity Associates et.al. 2013)

A comparison to the North Spit NOAA gauge shows that the 100-yr return period tidal elevation at the gauge (without effect of stream flows and other tidal phase anomalies within the Bay) is in the range of 2 ft above MMMW (9.7 ft to 10 ft above NAVD88).

The study estimates that for an extreme high tide (EHT) and a 1-foot sea level rise, about 28% of the dikes fronting the Bay and sloughs in the region would be overtopped. It also recommends that the Humboldt Bay region initiate adaptation plans before wide-spread flooding occurs, and land uses, infrastructure, and resources, currently protected, will be at risk of permanent flooding (Trinity Associates et.al. 2013).

2.8 TSUNAMIS

Intense seismic activity in the Pacific “Ring of Fire”, which is the most active seismic feature on earth, results in frequent tsunamis throughout the Pacific basin. Some have minor impact on coastal communities, and others are devastating. The Humboldt County Hazard Mitigation Plan (HMP 2007) summarizes several significant tsunami-related studies. Many of these studies – e.g., Patton & Dengler (2005) – have concluded that the region is at risk from both local and distant tsunamis (Figure 24). Tsunami hazard maps showing potential inundation areas have been prepared for the entire CRSMP shoreline by the California Geological Survey for California Emergency Management Agency (CalEMA 2009; Appendix B).

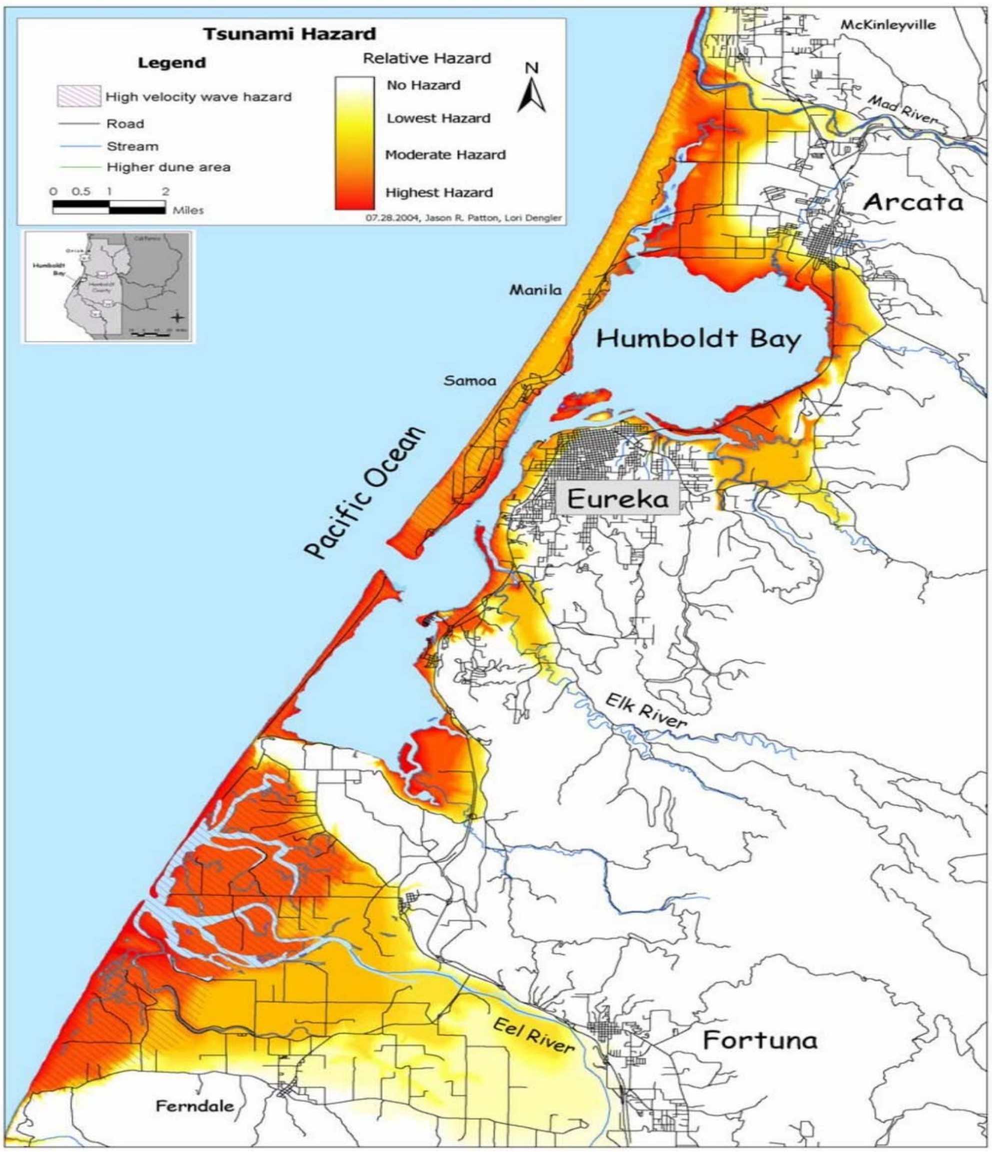
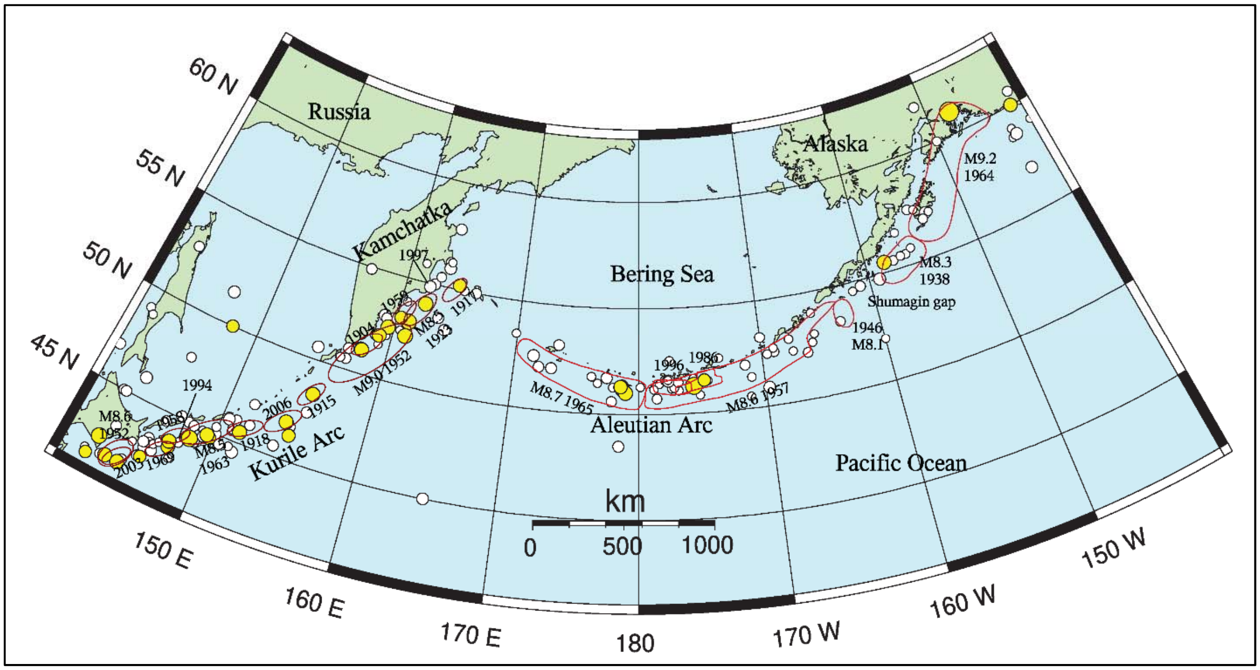


Figure 24: Tsunami Hazard Map for the Humboldt Bay Region (Source: Patton and Dengler 2005)

While the highest tsunami risk is represented by a large event on the CSZ, most of the tsunami damage along the Pacific Northwest has resulted from seismic activity in the Alaska-Aleutian and Kamchatka-Kurile subduction zones (see Figure 25; Borrero et. al. 2006). The most notable absence in the list of tsunamis that have affected Northern California (Table 1) is the Tohoku earthquake-induced tsunami on March 11 2011. The runup from that tsunami was low relative to the runup from many of the tsunamis generated from seismic activity in the Aleutians because the tsunami wave arrived near low tide. Damage caused by strong currents was significant, however, especially in harbors – e.g., there was damage to vessels that were pulled from their moorings (personal communication, HBHRCD).



Notes:

1. Subduction zones shown in red boxes
2. Locations of recorded magnitude 7+ earthquakes shown as circles (M=7.0–7.9 in white; M>=8.0 in yellow)

Figure 25: Rupture Zones of Great Earthquakes Along the Alaska-Aleutian and Kamchatka-Kurile Subduction Zones (Source: Ruppert et. al. 2007)

Table 1: Tsunamis That Have Affected Northern California (Source: Humboldt County Operational Area Hazard Mitigation Plan 2007)

Date	Origin of Tsunami	Impacted Areas	Runup (meters)	Observations/comments
3/19/1855	N. California	Humboldt Bay	Observed	Water in the bay agitated for 1 hour
4/6/1943	N. Central Chili	Crescent City	Trace	
4/1/1946	E. Aleutian Islands	Crescent City	1.0	Three foot amplitude and a twelve minute period were recorded for this event.
12/20/1946	Nankaido, Japan	Crescent City	0.2	
3/4/1952	SE Hokkaido, Japan	Crescent City	0.2	
11/4/1952	Kamchatka Peninsula, Russia	Crescent City	1.0	In Crescent City, 4 boats were overturned and concrete buoys were moved.
3/91957	Central Aleutian Is.	Crescent City	0.7	
5/22/1960	South/Central Chili	Crescent City	1.7	$30,000 in damages. Two ships were destroyed, others were damaged.
10/13/1963	Kuril Islands, Russia	Crescent City	0.5	
3/28/1964	Gulf of Alaska	Crescent City	6.3	Ten people killed, 35 injured, 52 homes and 172 businesses damaged or destroyed. $15 million in damages
		Klamath River		One person killed $4,000 damages to dock and boats at Requa. Damage reported least 2.6 km from mouth of Klamath River.
		Trinidad		Observed runup was 5.4 meters above MLLW.
2/4/1965	W. Aleutian Islands	Crescent City	0.1	
10/17/1966	Peru	Crescent City	0.1	
5/16/1968	Honshu, Japan	Crescent City	0.6	
7/26/1971	New Ireland	Crescent City	<0.1	
10/3/1974	Peru	Crescent City	<0.1	
5/7/1986	W. Aleutian Islands	Crescent City	0.1	
4/25/1992	Northern CA Cape Mendocino	Humboldt Bay	0.3 Observed	Waves arrived at Humboldt Bay about 20 minutes after ground shaking.
		Clam Beach	0.6	Water level changed several feet
		Crescent City	0.9	Oscillations in harbor, the 4th wave were the highest recorded.
		Trinidad		Cars were struck on the beach.
9/1/1994	Northern CA Cape Mendocino	Crescent City	0.14	Recorded on Crescent City tide gauge 45 minutes after earthquake.
11/15/2006	Kuril Islands	Crescent City	1.76	Recorded on Marigram
		Arena Cove	1.18	
		Pt. Reyes	0.62	
01/13/2007	Kuril Islands	Crescent City	0.23	Recorded on Marigram
		Arena Cove	0.25	
		Pt. Reyes	0.12	

There is evidence of significant impacts from tsunamis originating along the Cascadia subduction zone (Borrero et. al 2007). Such a tsunami has the potential to cause large local wave heights, and would pose the greatest potential tsunami inundation threat to the region. Such impacts were included in the inundation mapping effort that CalEMA conducted. In a review of the proposed Master Plan for the town of Samoa (Figure 3), Borrero et al. (2007) conducted numerical simulations to predict the maximum tsunami elevation on the seaward face of the seaward dunes. Their results indicate a maximum predicted tsunami inundation elevation of 24 ft to 28 ft MSL in the general area.

3.1 SEDIMENT SOURCES

The Eureka Littoral Cell is a complex coastal system with a high-energy wave environment, moderate tides and winds, significant sediment yield from rivers, and offshore features that influence the morphology of the coastline. Rivers and streams transport the majority of the sediment in the Eureka Littoral Cell from upland watersheds to the Pacific Ocean and Humboldt Bay (Table 2). Fluvial sediment sources in the CRSMP area are discussed in this section per receiving water body (i.e., Pacific Ocean or Humboldt Bay).

Table 2: Eureka Littoral Cell - Fluvial Sediment Sources

Source Name	Total Sand Volume (yd^3)[1]	Beach-Size Fraction (yd^3)[2]
Rivers Discharging to Pacific Ocean		
Little River	53,000	37,000
Mad River	690,000	486,000
Eel River	3,600,000	2,300,000
Subtotal	**4,340,000**	**2,823,000**
Rivers/Creeks Discharging to Humboldt Bay		
Elk River, Freshwater Creek, Salmon Creek, and Jacoby Creek	Unknown, but small (total yield is about 34,000 yd^3, mostly silt)	

[1] Sand particles per Wentworth scale (coarser than 0.0625 mm)

[2] Beach-size sand particles (coarser than 0.125 mm)

3.1.1 Pacific Ocean Fluvial Sources

The Little, Mad, and Eel Rivers are the main rivers discharging into the Pacific Ocean within the CRSMP area (Figure 4). Almost 90% of the total sand discharge into the ocean occurs between December and February (Patsch and Griggs 2007). These rivers support municipal water supply, power plants, and the local timber. Sediment fluxes from rivers to the ocean are presented below in terms of their grain size and relationship to the *littoral cut-off diameter*. The littoral cut-off diameter is that grain size below which sand typically is removed from the beach because of wave action (only about 1% of sand found on a beach is finer than the littoral cut-off diameter). This size varies based on wave exposure – it is smaller for protected beaches and larger for exposed beaches. Glogoczowski and Wilde (1971) proposed a cut-off diameter for beaches in the Eureka Littoral Cell of approximately 0.125 mm. This was validated by the results of sediment sampling for Samoa Beach (Pacific Affiliates 2007).

3.1.1.1 Little River

The Little River, the northernmost source of sand to the Eureka littoral Cell, has a total drainage area of 40.5 square miles. The present annual sand flux (sediment coarser than 0.0625 mm) from the Little River is approximately 53,000 yd^3/yr (Patsch and Griggs 2007), of which an unknown percentage is sand whose diameter is greater than 0.125 mm.

3.1.1.2 Mad River

The Mad River, which has a drainage area of 494 square miles, discharges a highly variable annual sediment load, ranging from over 14 million tons in 1956 to 8,500 tons in 1977 (Willis 2001). Current estimates are that the Mad River contributes approximately 486,000 yd^3 of sand per year whose diameter is larger than 0.125 mm (Patsch and Griggs 2007).

3.1.1.3 Eel River

On average, the Eel River discharges the most suspended sediment of any river in the contiguous United States. The annual sediment yield, which is highly variable, ranges from approximately 130,000,000 yd^3 of sediment in 1965 to 15,500 yd^3 in 1977 (Patsch and Griggs 2007). The Van Duzen River is a significant tributary of the Eel River that contributes approximately 179,000 yd^3/yr (Brown and Ritter 1971; Willis et al. 2002). The Eel River is estimated to transport approximately 2.3 million yd^3 of sand per year that is greater than 0.125 mm (Patsch and Griggs 2007). However, most of that sand does not end up on local beaches. Ritter (1972) proposed that the sand not deposited on the beaches ends up:

* deposited in the estuary at the mouth of the Eel River
* deposited on the continental margin or is lost to the Eel Submarine Canyon
* deposition on nearby beaches whence it is transported by waves and currents to the Bar and Entrance Channel and into Humboldt Bay

A more detailed description about sediment transport processes is provided in Section 3.3

3.1.2 Humboldt Bay Fluvial Sources

Compared to the Eel and Mad Rivers, the rivers and creeks that drain directly into Humboldt Bay have small watersheds and transport much less sediment. Barrett (2004) estimated the annual sediment yield of the two main watersheds drainages discharging to Humboldt Bay – Elk River and Freshwater Creek – are on the order of 400 to 1,000 tons per square mile with higher rates in the Elk River system than in Freshwater Creek. Estimates of total sediment delivery to Humboldt Bay are in the range of 68,750 tons annually. Of this, approximately 75% is silt, much of which is likely transported through the Bay into the ocean (Barrett 2004). Assuming a bulk density of 140 pounds per cubic foot, the sediment load is approximately 36,000 yd^3/yr.

3.1.3 Beach and Bluff Erosion

There were two areas of bluff or shoreline erosion identified within the region: Buhne Point near the King Salmon community (Figure 16), and the bluffs in the vicinity of the Mad River mouth in McKinleyville (Figure 3). The Buhne Point shoreline is now stabilized with a rock revetment dike and is considered stable (Costa et al. 2002). One area of Mad River bluff erosion was addressed by Caltrans in 1999, and a different area in 2009. Other areas within the CRSMP area that have been, or are currently, erosional include the Humboldt Bay North Spit beach, the South Spit beach, and the marsh edge around Indian Island.

3.2 Sediment Sinks

The majority of sediment removed from specific areas within the cell is through redistribution of material from erosion of beaches and dunes, offshore disposal during maintenance dredging of navigation channels, gravel mining, cross-shore transport (deposition on the continental shelf), or loss to submarine canyons.

3.2.1 Maintenance Dredging

Federal, district, and private navigation channels into and within Humboldt Bay are dredged frequently to provide adequate channel depth for deep-draft vessels (Figure 26). The USACE dredges all of the federal navigation channels, which constitutes the majority of the dredging. The HBHRCD dredges the interior, non-federal channels within its jurisdiction. To evaluate the potential for beneficial use of the dredged material, it is important to understand its volume, location, and characteristics, as well as the equipment that is presently used to remove the material from the navigation channels.

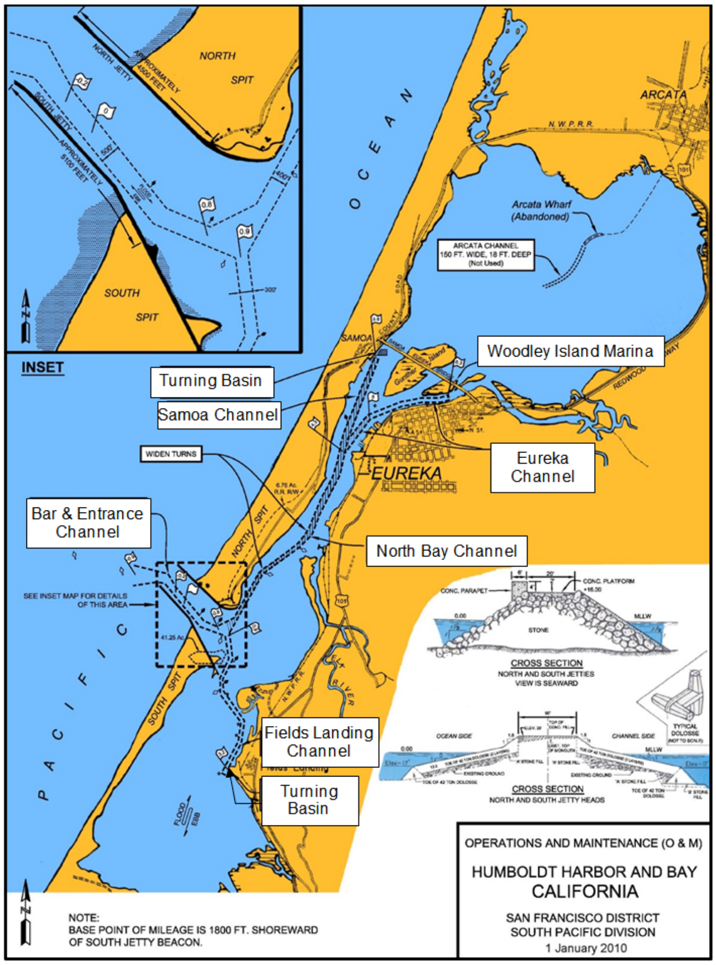


Figure 26: Maintenance dredged navigation channels in Humboldt Bay (Base Map: Humboldt Harbor and Bay O&M Map; USACE 2012b)

Between 1975 and 2016, maintenance dredging of the federal navigation channels at Humboldt Bay by the USACE produced approximately 0.9 million yd^3/yr (~37 million yd^3 in total) of sediment with greater than 90% being sand (Table 3). Starting in 1990, all of that dredged material was placed outside of the littoral cell at HOODS, the center of which is approximately 3.5 mi from the channel entrance.

Table 3: Dredged Volumes from the Humboldt Bay federal channels from 1975 to 2016.

CHANNEL	Volume (10^3 yd^3)
Bar & Entrance + Middle Ground	29,275
North Bay	4,050
Samoa	473
Eureka	1,507
Fields Landing	663
Humboldt Bay Undifferentiated†	1,406
Total	37,374
1975–2016 Average	869
1975–2016 B&E + MB + NB Average	775
Total disposal at HOODS‡	25,498
Average disposal at HOODS‡	911

† Various combinations of all federal channels
‡ 1990-2016

Material dredged from the interior, non-federal channels has been placed at various sites on the North Spit (Figure 27), although none of those sites are active now. Individual property owners carry out private dredging activities, and each project is required to obtain necessary permits for the dredging. Known sites of recent or periodic maintenance dredging include the Chevron Eureka Terminal, Coast Seafood's Dock, Sierra Pacific Dock, Pacific Gas and Electric Intake, and various docks in the City of Eureka.

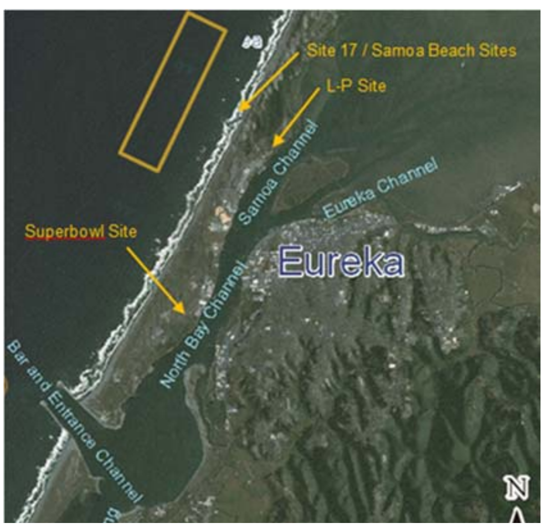


Figure 27: Locations of previously used disposal sites on the North Spit.

3.2.1.1 Dredged Material Characteristics for Federal Navigation Channels

Sediment quality, which is an important factor when considering the disposal of dredge material, is of concern to a number of stakeholders in the area. Repeated tests show that sediment from the Bar and Entrance Channel and the North Bay Channel is greater than 95 percent sand and gravel. Sediment from the Samoa Channel and its Turning Basin is greater than 85 percent sand and gravel. Because of the high sand content in these channels, they only require physical testing in the 5- and 10-year confirmatory test years (USACE 2013).

Sediment from the Eureka Channel and the Fields Landing Channel and its Turning Basin is between 25 and 80 percent sand and gravel. Benthic and water column toxicity tests conducted for past dredging episodes, as well as tissue analyses for bioaccumulation potential, did not indicate significant toxicity. Prior sediment chemistry tests also indicated that the material is clean enough to place at HOODS.

3.2.1.2 Disposal of Dredged Material from Federal Navigation Channels

A number of offshore placement sites have been used since the inception of dredge activities in the Bay (Figure 28).

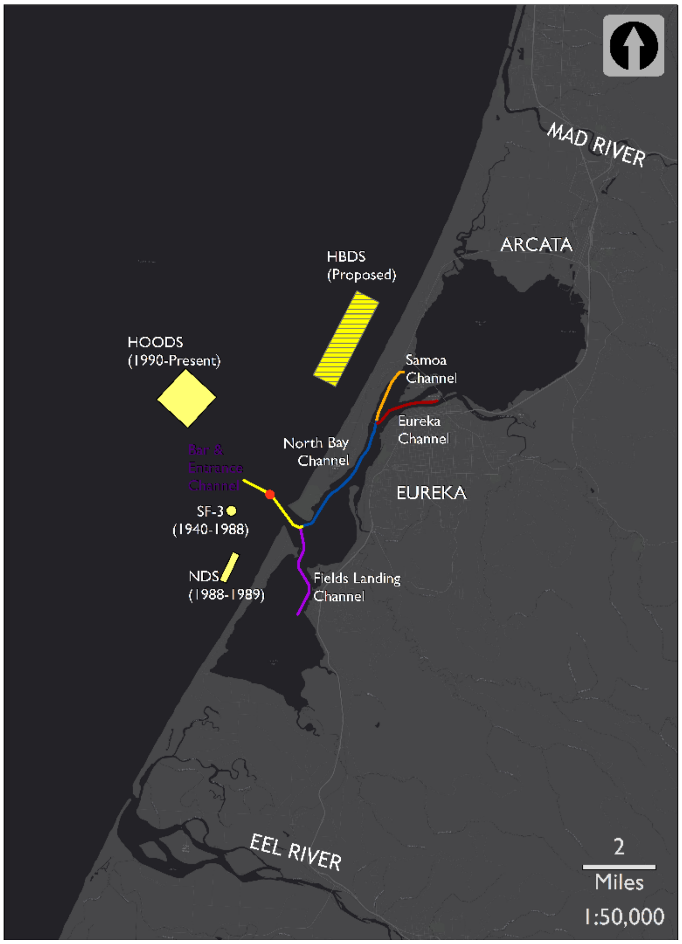


Figure 28: Federal navigation channels and past, present, and proposed aquatic dredged-material placement sites

Red dot locates the seaward end of the Entrance Channel.

* SF-3: The disposal site, which was used prior to 1988, is located in moderate depth (55 ft MLLW) south of the South Jetty. It was abandoned because increased shoaling in the Entrance Channel near the seaward end of the South Jetty created a severe hazard to navigation.
* NEARSHORE DISPOSAL SITE (NDS): In 1988 and 1989, USACE placed material at the NDS, which is located between the 50- and 60-foot MLLW contours, seaward of the South Spit of Humboldt Harbor. The intent of placing sand at the NDS was to alleviate the navigation problems associated with SF-3 and to keep the material in the Littoral Cell. The NDS was abandoned, however, when local stakeholders believed the deposited material migrated north between SF-3 and the end of the South Jetty, continuing the hazardous navigation conditions in the southern approach to Humboldt Bay. In addition, the California Department of Fish and Game and local stakeholders voiced concerns of adverse impacts to commercial fishery resources in the nearshore area.

* Humboldt Open Ocean Disposal Site (HOODS): This site, which has been used from 1990 to the present, is located in water depths of 160 to 180 ft MLLW. The HOODS was designed with an expected life of 50 years or an expected maximum capacity of 400,000,000 yd^3. As of 2016, approximately 26 million yd^3 of dredged material (sand) had been placed at the HOODS. Placement in this area removes sediment from the Littoral Cell.

During the site designation process for HOODS, the involved agencies recognized that this disposal option completely removes sediment from the Eureka Littoral Cell. As part of the Consistency Determination issued by the CCC for Section 102 designation of HOODS, USACE agreed to implement the HSMP (Section 2.4.1) to determine, if possible, the effects of removing sand from the Eureka Littoral Cell by placing it at HOODS. The monitoring area extends from approximately seven miles south of the South Jetty to seven miles north of the North Jetty. As the criterion for determining if there is excessive shoreline retreat, USACE compares recent shoreline movement with the rate from 1974 to 1990

Through 2011, periodic aerial photographs, topographic surveys, and LiDAR surveys indicate that shoreward movement of the upper beach reference line has continued for the North Spit with the 2011 upper beach reference line falling within the acceptable limits of the excessive shoreline retreat criterion. This trend appears to be accelerating, however, with the upper beach reference line retreating over 100 feet at several reference stations from 2005 to 2011. The upper beach volume results also show a clear acceleration in the erosion rate between 2005 and 2011, with a 20-percent decrease in the upper beach volume during that time. Although causes for this trend have not been identified, USACE and the regulatory agencies support precautionary measures to ensure dredged sand – on the order of 1,000,000 yd^3/yr – stays in the nearshore while minimizing impacts to fisheries, navigation, and other human uses.

For the South Spit, the 2011 survey suggests that the previously observed seaward movement of the upper beach reference line has continued, but not necessarily throughout the entire spit. In fact, there were several reference stations where the upper beach reference line had exhibited shoreward movement from 1992 to 2011. Thus, there is no general shoreline movement trend that can be applied to the entire South Spit, as opposed to the more pronounced spit-wide trend for the North Spit. However, the upper beach volume results suggest that there is a modest accretion on the South Spit with the most significant accretion occurring in the middle of the spit.

Although the HSMP documents slight South Spit accretion and North Spit erosion there is no correlation between that shoreline rotation and dredging of the federal navigation channels. USACE (2013) states, however, that:

> *"since it appears that the general trend of the North Spit of Humboldt Shoreline is receding, USACE staff have concluded that regardless of the cause of any*

shoreline erosion in the project area, the adoption of precautionary measures may be appropriate to help ensure that disposal of dredged materials at HOODS does not contribute to shoreline erosion within the project area."

Accordingly, the USEPA is considering a nearshore dredged material placement site that would increase the likelihood of dredged material remaining within the Eureka Littoral Cell. That site, the Humboldt Bay Demonstration Site (HBDS), is located in water depths of approximately 40 to 70 ft. The center of the site is approximately 5 miles north of the entrance to Humboldt Bay (Figure 28). The HBDS would receive clean sand from the Bar and Entrance Channel and parts of the North Bay Channel. Performance monitoring would include pre- and post-dredging bathymetric surveys to determine transport pathways of the placed sand.

3.2.1.3 Dredging Equipment for Federal Navigation Channels

The location and type of placement site has the greatest influence on the type of dredge equipment that can be utilized. For safety and efficiency, self-propelled hopper dredges – e.g., the USACE hopper dredge, *Essayons* – dredge the Bar and Entrance Channel and the start of North Bay Channel. The *Essayons* has drag arms, each fitted with a suction pump, mounted on its sides. When dredging, the drag arms are lowered to the bottom, whence the sediment is sucked up and pumped into the hull in a slurry. Excess water flows for a maximum amount of time that is determined by turbidity-related restrictions set by resource agencies. When the hull is full, the drag arms are lifted out of the water, and the dredge goes to the placement site. When the dredge reaches the site, the bottom of the hull opens, and the material falls through the water column to the bottom. Some hopper dredges can pump the dredged material out of the hull in cases where the dredge cannot reach the placement site (for example, upland or shallow-water placement). The *Essayons* currently does not have this capability and can only place material in water depths exceeding approximately 40 ft MLLW (somewhat dependent on sea state).

Dredging of the federal navigation channels begins in mid-March and generally last for approximately 32 days during an eight-week dredging window. If the *Essayons* is unable to complete the maintenance dredging during the spring maintenance dredging episode, dredging can be resumed in the July to September timeframe. That second dredging operation persists for 30 days or less.

The *Essayons* cannot dredge most of the North Bay Channel and the Eureka, Samoa, and Field's Landing Channels because it draws too much water. Instead, that dredging is usually conducted by the USACE's smaller hopper dredge *Yaquina*, which also does not have pump-out capability. Generally, dredging of the interior channels lasts for approximately 30 days during the March-to-April spring maintenance dredging episode. The interior channel dredged volumes tend to be lower because the Samoa and Field's Landing Channels, and to a greater extent, the Eureka Channel, are ‘spot dredged’ only in the shoaled areas (USACE 2013). The Samoa and North Bay Channels are primarily sand, and the Eureka and Fields Landing Channels are primarily silt.

3.2.1.4 Dredged Material Characteristics for non-Federal Navigation Channels

Woodley Island Marina and the Eureka Marina constitute the largest portion of the non-federal dredging volume in the Bay. Of the total of about 200,000 yd^3/episode, they yield approximately 160,000 yd^3 (HBHRCD 2008). Sediment testing for the 2005 dredging episode, which included dredging of all the non-federal areas in the Bay (Pacific Affiliates 2005) found that the material consisted of about 85% silt and clays and 15% sand. In general, the amount of metals and other contaminants found in the samples was low enough that they met in-water disposal criteria, except one private commercial dock (Coast Dock), which had to be excluded from disposal at the Samoa Beach placement site (see below).

3.2.1.5 Dredging Equipment for non-Federal Navigation Channels

Small-scale dredging activity in Humboldt Bay includes marinas, private docks, and other small projects in water depths less than 18 ft. Because of the limited depth and tight maneuvering areas, maintenance dredging of these facilities typically has required the use of small dredging equipment (usually a cutter-suction dredge) with transport of material via pipeline to one of several placement sites.

Because cutter-suction dredging generates less turbidity than bucket dredging in the immediate dredging area, it has been viewed as the best technology for reducing suspended sediment within the water column (HBHRCD 2008). This method uses a suction pipe with a rotating cutter head that extends to the Bay floor. The cutter head, which is connected to the suction pipe, can be swept back and forth across the work area, and can be extended into confined areas – e.g., slips, under dock faces, around piles. This method precludes additional handling and loss (spillage) of the slurry through the entire route from Bay bottom to disposal area. When dredging using the cutter-suction pipeline method, sediment is loosened by the cutter-head and the sediment-water slurry is then pumped to the disposal site. The lack of disposal capacity at any of the upland disposal sites (see next section) resulted in the 2007 Woodley Island Marina and Eureka Waterfront dredging episode having to place material at Samoa Beach at a significant cost (about $16.50/$yd^3$).

Some small dredging projects have utilized a backhoe excavator or a bucket dredge operating from shore with transport via trucks to upland disposal sites. This type of dredging is significantly challenging in terms of logistics, required staging area, associated costs, and environmental impacts. It is only possible for limited shore-accessible areas.

3.2.1.6 Disposal of Dredged Material from non-Federal Channels

Many of the historic upland disposal sites have been filled to capacity, and the local dredgers, including both the HBHRCD and the City of Eureka, find it increasingly difficult to maintain their navigation channels without a designated disposal site with adequate capacity. The most recent dredging episode resulted in placement of dredged material at Samoa Beach described below:

* SAMOA BEACH: Located approximately four miles north of North Spit Beach. This was a onetime disposal (Samoa Beach Surf Zone Disposal Project) conducted by the HBHRCD and City of Eureka.

Historic upland disposal sites include:

* SITE 17: Located on the beach, nearly opposite the intersection of HWY 255 and the Samoa Bridge. It received material from the North Bay Channel improvement project. It was also used in 1996–1997 for the disposal of material from Woodley Island Marina.
* SUPERBOWL SITE: 60-acre site located on the North Spit adjacent to the Old Eureka Airport/Samoa Drag strip. This site was used as a dredged-material disposal site in the North Bay Channel improvement project of 1978-1979. Much of the site has become a freshwater marsh.
* LOUISIANA PACIFIC SITE (L-P): The site, which is located in Samoa area, is approximately 20 acres including two diked areas of approximately 7 acres each. The site was used for dredged material disposal and is currently under the ownership of the HBHRCD.

3.2.2 Losses to the Eel River Submarine Canyon

Most of the sand transported to the ocean by the Eel River, which is the main supplier of sand to the Eureka Littoral Cell, passes through the lower estuary, bypasses the beach, and settles on the continental margin in proximity of the Eel Canyon (Ritter 1972). Figure 29 is a NOAA nautical chart that shows the convex bulge between the 20- and 30-fathom contours (120- and 240-ft contours), which suggests that much of that sediment spreads over the continental margin as a blanket deposit. By interpreting seismic records, Greene and Conrey (1966) discovered a buried canyon extending shoreward from the present-day canyon, and concluded that sediment deposited by the Eel River filled this shoreward part of the canyon, and now sediment is filling the head of the present canyon. More recent studies using remotely operated vehicles (Drexler et. al. 2006) included radiochemical analysis of samples from the Eel Canyon, which indicated recent deposits (past several decades) within the deeper portions of the canyon. There was evidence that the head of the canyon receives sediment from the Eel River on decadal time scales, and there is mobilization of this sediment as gravity flow into deeper portions of the canyon. It is evident that more research is needed to estimate the rates of sediment lost to the Eel Canyon.

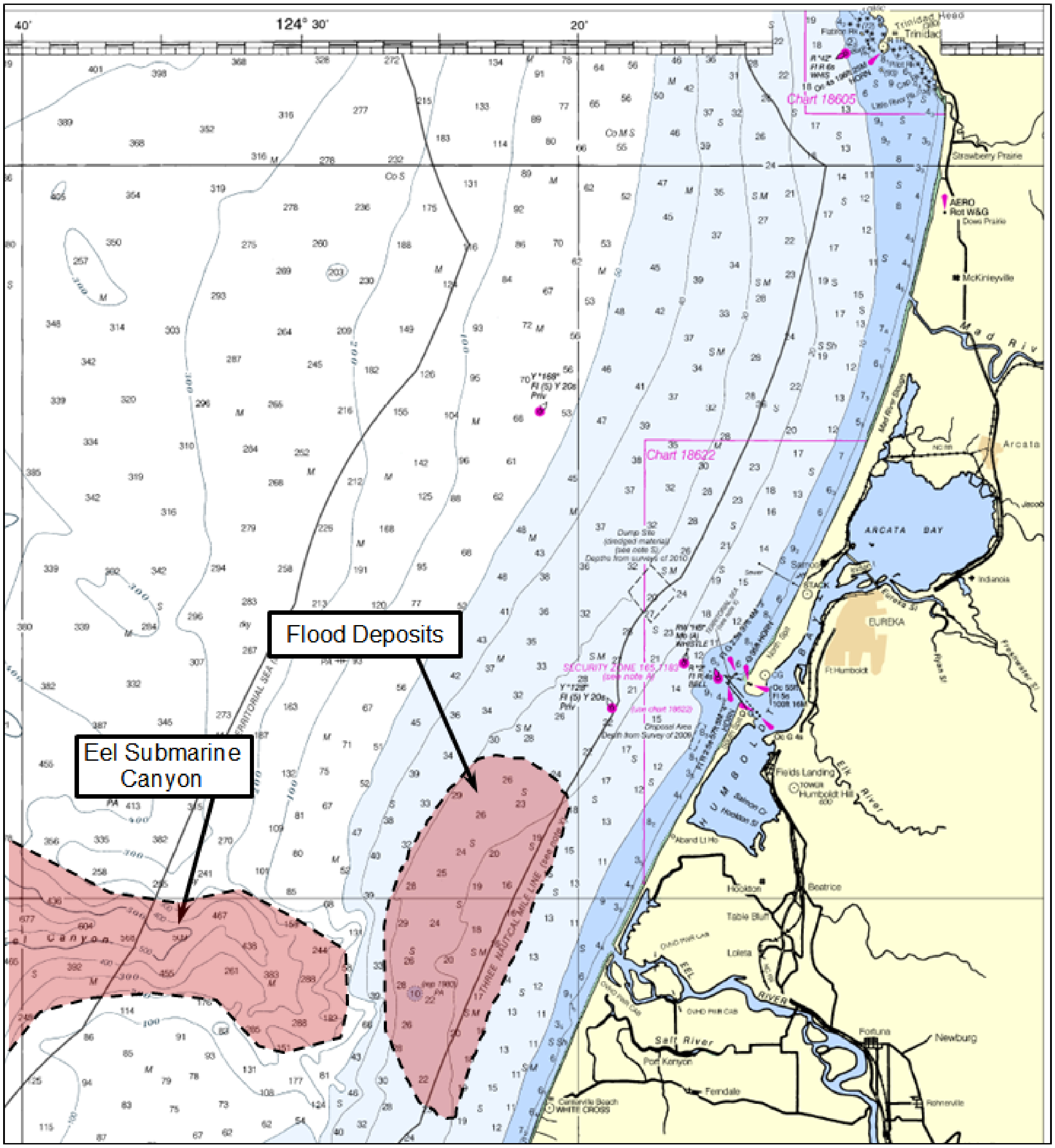


Figure 29: Offshore Bathymetry Showing Eel River Canyon (Depths in fathoms)

3.2.3 Losses from Gravel Extraction

Commercial gravel mining, which occurs in the Trinity, Mad, Van Duzen, and Eel Rivers, is regulated by the County of Humboldt Extraction Review Team (CHERT). In 2008, approximately 511,000 yd^3 of material – 78% of the total annual approved extraction volume – was extracted from Humboldt County rivers (Table 4) (CHERT 2009).

Table 4: Gravel Extraction Operations in Humboldt County in 2008

River Reach	No. of mined areas[2]	No. of mined sites[2]	Approved Volume (yd^3)	Extracted Volume (yd^3)	Percent of Approved Volume
Lower Mad River	14	8	142,043	130,613	92%
Lower Eel River	6	2	237,955	192,379	81%
Middle Eel River	0	0	0	0	n/a
Van Duzen River	9	3	209,176	137,850	66%
South Fork Eel River[1]	3	2	32,358	24,833	77%
Trinity River	2	1	12,490	11,701	94%
Isolated Sites	1	1	25,000	14,064	56%
Humboldt County Total	35	17	659,022	511,440	78%

[1] the South Fork of the Eel River total includes some volume from Mendocino County

[2] CHERT reviewed 35 extraction areas distributed among 17 mining sites in Humboldt County Many sites had more than one extraction area (CHERT 2009).

The CHERT enforces the concept of "sustainable yield" gravel extraction, which requires that extraction quantities do not exceed mean annual recruitment volumes. This annual recruitment is an estimate of the long-term average annual supply of gravel to a specific reach of the river. Almost all of the extraction volume shown above is for gravels; as such, the effect on sand transport rates in the littoral environment is small.

3.2.4 Sediment Stored in Dams

It is important to include dams within the context of sediment management at a watershed scale because of the potential for dams to trap sediment that would otherwise make its way down the valley to the estuary or the coast.

3.2.4.1 Little River:

Currently no dams or diversions exist in this watershed.

3.2.4.2 Mad River:

Two dams have existed in the watershed: Sweasy Dam and R.W. Matthews Dam. Sweasy Dam was built in 1938 and removed in 1970 after it filled with sediment. The Matthews Dam is located east of Forest Glen. The dam, which forms Ruth Lake, impounds about 48,000 acre-ft of water that is released for municipal use. The net effect of the Matthews Dam is a reduction of approximately 9% of the sediment yield from the watershed (Patsch and Griggs 2007).

3.2.4.3 Eel River:

The Scott and the Van Arsdale Dams, which are located on the upper Eel River, impound 11% of the Eel River basin (Patsch and Griggs 2007). Van Arsdale Dam, downstream of Scott Dam, functions as a diversion dam facilitating Pacific Gas and Electric's (PG&E) Potter Valley Project for hydroelectric power generation and irrigation in the Russian River Basin. The diversion has not significantly reduced the flows at Scotia that transport the bulk of sediment, and as such does not significantly affect sediment transport. In contrast, Scott Dam, which impounds Lake Pillsbury, an 80,000 acre-ft reservoir, notably affects flows on the Eel River. The combined impact of the Scott and Van Arsdale Dams only reduces the sand discharged by the Eel River by 1.1% (Willis and Griggs 2003).

The Scotia Log Pond, operated by PALCO, is located on a side channel of the Eel River. This dam impounds 210 acre-ft of water (County of Humboldt 2007) and is not expected to significantly affect sediment transport and retention in the area.

3.2.5 Beach and Dune Erosion

Within the Eureka Littoral Cell, coastal dunes both gain and lose sand. In particular, Costa and Glatzel (2002) describe the Lanphere Dunes (within the Humboldt Bay National Wildlife Refuge) as being a sediment sink. Starting in 1992 USACE began periodically monitoring the North and South Spits to determine whether sand placement at HOODS resulted in shoreline erosion that exceeded the criterion for excessive shoreline retreat established by a draft Memorandum of Agreement between the CCC) and USACE (USACE 1995). The criterion was based on the shoreline movement rate from 1974 to 1990.

Winkelman, et al. (1999) used digital terrain maps based on 1992, 1995, and 1998 surveys to determine changes in sand volume on the beaches and dunes. During that six-year period, the South Spit's beach and dune system gained 1.6 x 10^6 yd^3 of sand (270,000 yd^3/yr), and the dune line remained stationary or moved seaward. For the most part, the beaches and dunes along the North Spit, however, decreased in both volume and width, losing 1.05 x 10^6 yd^3 (175,000 yd^3/yr average rate), resulting in beach and bluff recession.

More recent USACE monitoring (2001, 2005, 2011, 2015, and 2016) shows that the South Spit mostly continues to accrete (except between 2015 and 2016), and the North Spit to erode. For example, comparing the 2015 and 2016 surveys shows considerable erosion along the North Spit from July 2015 to July 2016 with both a shoreward retreat of the upper beach reference line and a decrease in upper beach volume throughout the entire spit. The most pronounced erosion was a significant decrease in upper beach volume from approximately 224,000 cy in 2015 to 52,000 cy in 2016. A qualitative review of cross-shore profiles and recent aerial imagery (from Google Earth) indicates that the shoreward-most set of vegetated dunes (foredunes) eroded during this time period. This erosion is consistent with the scientific understanding that strong El Niño conditions are often associated with enhanced storm activity, elevated water levels, and periods of large and erosive surf (Bromirski et al., 2003).

From 2015 to 2016, the South Spit also experienced considerable erosion that stands in contrast to the trend of spit-wide accretion in the previous two and a half decades. This suggests that the South Spit can be subject to erosion under strong El Niño conditions, and it is an open question as to whether and how long it will take for the South Spit to restore to the 2015 condition. But the South Spit still remains considerably wider than in 1992: the upper beach volume in 2016 is approximately 62 percent greater than in 1992.

3.3 Littoral Transport Processes

Waves, currents, river flows, wind, and dredging operations move sediment within the Eureka Littoral Cell. Gravel mining, dredged-material disposal outside of the system, and transport down the Eel Canyon all remove sediment from the system. There has not been consensus on longshore transport rates, direction of transport, or the fate of Eel River sediments. For example:

* Noble (1971) analyzed historical shoreline positions before and after jetty construction. Based on shoreline change position, Noble suggested a dominant north-to-south longshore transport. This was based on the observation that before the jetties were built the natural location of Humboldt Bay's inlet migrated from north to south along the length of the Bay (through the present day spits) over a period of approximately five years. Then it returned to the north, starting a new cycle. This phenomenon, coupled with predominant waves from the WNW through NW directions (which would produce a southerly drift) led to the conclusions stated in the study.
* Borgeld et al. (1993) suggested that the dominant transport direction is from south to north based on an assessment of the ebb shoal bar and channel configuration of Humboldt Bay after the initial period of jetty construction, and the fact that the Eel River, located in the southern portion of the cell, contributes approximately 77% of the sand to the cell. Their conclusion is based on observations that the South Spit adjacent to the jetty advanced seaward by 1,000 ft and the North Spit eroded immediately after the period of jetty construction.
* Recent monitoring studies of the beaches, related to ongoing dredging activities by the USACE (Winkelman et al. 1999), suggest that transport in the Eureka Cell is characterized by large bi-directional annual gross movements of sand but with a small net transport to the north.
* Costa & Glatzel (2002) completed a comprehensive review of the significant amount of available information including beach surveys, aerial photographs, prior studies on inlet dynamics and littoral transport, and nearshore studies associated

with major projects in the vicinity (wastewater outfalls, HOODS disposal site designation, and monitoring of maintenance dredging activities). The report states that recorded observations of accretion at the north jetty compared to the erosion at the south jetty would support a north to south transport direction. However, evidence also points to the Eel River, located near the south end of the cell, being the primary source of sand material in the cell. Their conclusion, related to the apparent inconsistencies in observations, was that the distinct seasonal variation in wave energy leads to a seasonal shift in the direction of littoral transport whereby:

- net summer transport is to the south (because of northerly wave approach directions) with the surf zone not being wide enough to move sand past the end of the north jetty, thus causing the observed accumulation;
- net winter transport is to the north (because of westerly wave approach directions that would move sediment to the north), with the surf zone extending well beyond the jetties and providing a wide northward transport path that would bypass sand readily from south to north,
- the primary period of sediment delivery is during winter when transport is to the north.

* Patsch and Griggs (2007) stated that there was convincing evidence being presented for both north-to-south and south-to-north transport. They suggested that transport rates are likely different for the coasts north and south of the Humboldt Bay inlet, and that there is strong evidence for dominant north-to-south transport direction north of the inlet and for bidirectional transport direction south of Humboldt Bay. Their conclusion was that:

  - north of the entrance, sand from the Little and Mad Rivers moves southwards along the shoreface, some of it being lost to the dunes, and eventually is deposited into the bar and entrance to the Bay from where it is dredged and removed from the system (HOODS disposal);
  - south of the entrance, the majority of sand from the Eel River is lost to the continental shelf and submarine canyon. Some makes it way northwards along the South Spit feeding beaches along the way, and some southwards where it feeds the narrow beaches between the Eel River and False Cape;
  - the quantities and direction of net littoral drift in this cell could change significantly from year to year, and man-induced activities along the coastline could have far-reaching consequences.

* Preliminary results from analyses of measured wave data for the 2004 to 2010 period from the Coastal Modeling and Prediction System (MoPS) suggest that annual longshore transport patterns vary significantly with the intensity of winter storms (USACE 2013 and CDIP 2010).

A summary based on the above data is presented on Figure 30. The data indicate that there is northward, storm-driven transport in the winter at deeper depths and southward, wind-wave-driven transport at shallower depths in the summer. Net transport can be northward if there are strong El Niño storms, or southward if the winter is mild.

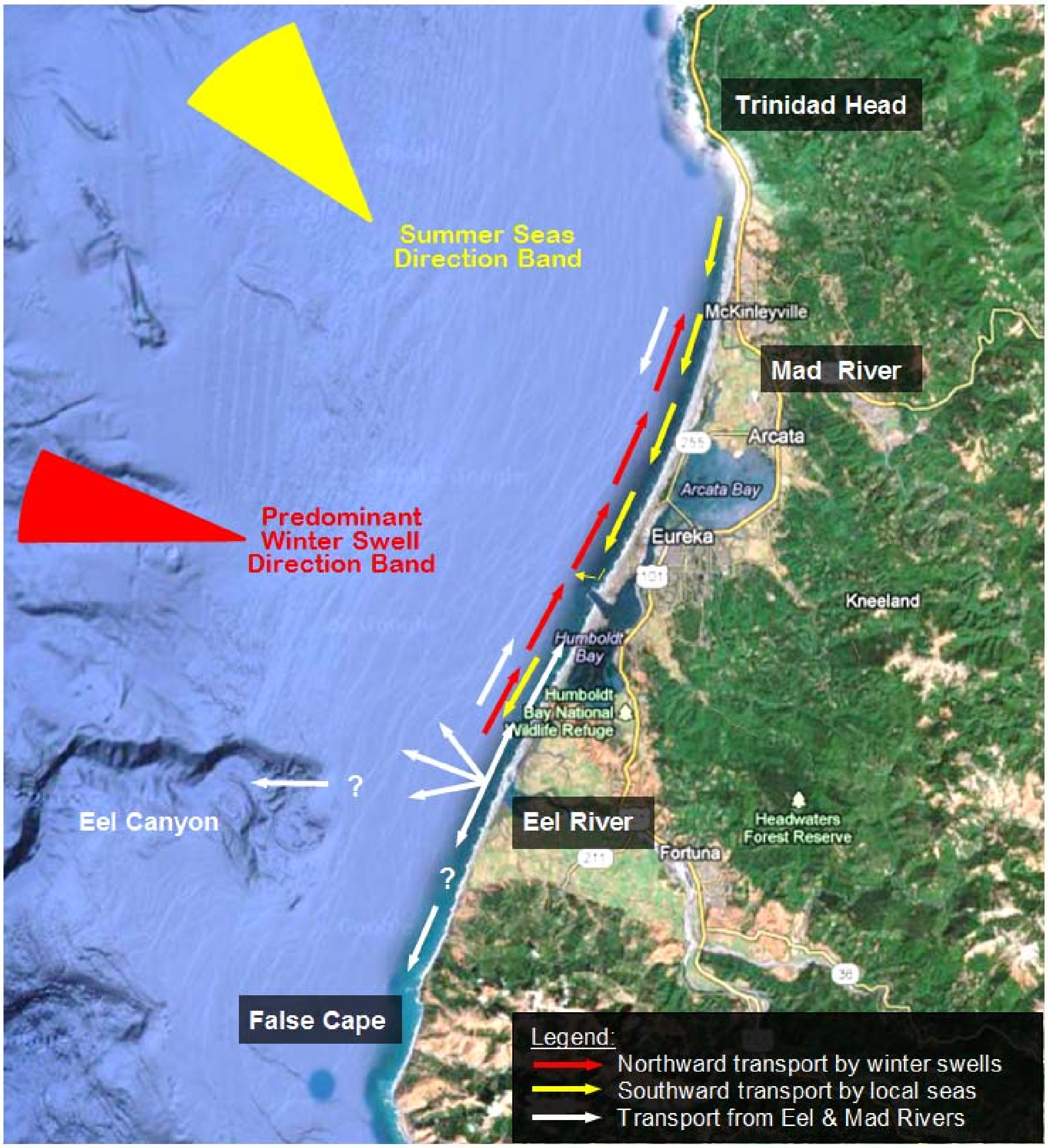


Figure 30: Schematic Transport Patterns in the Study Area

The cooperation and coordination of stakeholders within the region is an essential part of a successful CRSMP. Stakeholder outreach is usually led by CSMW's regional partner to best ensure more comprehensive and regional-focused input to the outreach effort. This section outlines the agencies, stakeholder groups, and organizations whose involvement is critical to the development and implementation of this CRSMP.

Several governmental agencies have jurisdictional authorization or interests within the CRSMP area (Table 5). The table includes brief description of their authorities, interests, and possible affects on sediment management activities.

Table 5: Local, State, and Federal Government Entities

Agency	Jurisdiction or Interest
	Local and Regional Agencies
Humboldt Bay Harbor, Recreation & Conservation District (CRSMP Regional Partner)	County-wide public local agency with regulatory jurisdiction in Humboldt Bay shoreward to MHHW elevation. Manages Humboldt Bay for the promotion of commerce, navigation, fisheries, recreation, and the protection of natural resources. Acquires, constructs, maintains, operates, develops, and regulates harbor works. Retains jurisdiction over the majority of the Humboldt Bay tidelands (lands below MHHW), including lands in undiked major streams and sloughs.
County of Humboldt	Responsible for planning and facilitating land use and coastal development based on the policies of the General Plan, Community Plans, Local Coastal Plan, County Codes and Ordinances as well as State and Federal regulations. Also supports a wide range of issues including water, species conservation, land protection, and regulatory policy.
City of Arcata	Located in the northeastern corner of Arcata Bay. Has jurisdiction over a portion of tidelands in Arcata Bay.
City of Eureka	Located between Arcata and the Entrance Bay. Has jurisdiction over some tidelands within these bays.
City of Fortuna	Located in the southern portion of the CRSMP area along the Eel River watershed. Has jurisdiction over some of the gravel extraction activities.
City of Trinidad	Located at the northernmost limit of the CRSMP area. Has jurisdiction over beaches and shoreline segments within City limits.

Agency	Jurisdiction or Interest
	Native Americans
Wiyot Tribe	The Wiyot Tribe has sovereign rights of self-determination. The Wiyot in the CRSMP area include the Table Bluff Reservation Wiyot Tribe and the Blue Lake Rancheria. They have jurisdiction over beaches and shoreline within their lands.
	State Agencies
California Coastal Commission (CCC)	Public Trust lands jurisdiction in plan area with respect to the 1976 California Coastal Act. Also, jurisdiction of the coastal zone under the federal Coastal Zone Management Act, including federal consistency review authority of all federal actions that could affect the coastal zone (example.g., dredging and disposal).
California State Lands Commission	Retains oversight role with respect to California's sovereign lands. The Commission's specific regulatory areas include offshore oil and gas development, marine oil terminals, ballast water regulation, and state lands leasing and permitting (e.g., lease for beach nourishment area).
California Department of Fish and Wildlife (CDFW)	Trustee agency for fish and wildlife resources under California law. The Department interprets and enforces the requirements of the California Endangered Species Act (ESA) and other state laws and regulations within Humboldt Bay and in the adjacent coastal water, and provides comments to the relevant federal agencies pursuant to the federal ESA and other federal laws. Has jurisdiction over several species and will be a permitting agency for restoration in stream beds, dredging, and beneficial use of dredged material for wetlands restoration.
North Coast Regional Water Quality Control Board	Primary water quality regulatory agency in the Humboldt Bay region. Interprets and enforces both the relevant California water quality law [the Porter-Cologne Act (California Water Code, Division 7)] and the federal Clean Water Act sections regarding water quality (e.g., turbidity limitations during restoration activities).

Agency	Jurisdiction or Interest
CNRA	Oversees policies, activities, and budgets of 25 departments, commissions, boards, and conservancies responsible for conserving, enhancing, and managing the state's natural and environmental resources, including parks, wildlife, minerals, lands, and historic sites.
	Federal Agencies
U.S. Army Corps of Engineers	Carries out maintenance dredging in the federal channels into and inside Humboldt Bay. The USACE has lead regulatory authority for implementing the federal permit processes required pursuant to the Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act. Will be a lead agency for beneficial use of dredged material from federal navigation channels, and a permitting agency for material from non-federal channels.
U.S. Fish and Wildlife Service (Humboldt Bay National Wildlife Refuge; USFWS)	Trustee agency for wildlife and some fishery resources, provides advisory comments to the USACE and other federal agencies regarding proposed actions before those agencies, including state and private actions that include federal participation or approval pursuant to the Fish and Wildlife Coordination Act. Owns tidelands in Humboldt Bay including salt marsh and mudflat areas in Arcata and South Bays. Has jurisdiction over several species and will be a permitting agency for activities related to beneficial use of dredged material that affects these species.
NOAA's National Marine Fisheries Service (NMFS)	Primary responsibility for stewardship of the nation's living marine resources and their habitats. NMFS achieves its responsibility through authority under several federal laws, including consultations regarding "take" of species regulated by the federal ESA. Has jurisdiction over several species and will be a permitting agency for activities related to beneficial use of dredged material that affects these species.

Agency	Jurisdiction or Interest
U.S. Coast Guard	Primary responsibility is for marine search and rescue operations in and outside of Humboldt Bay. Other significant responsibilities include monitoring and maintaining navigational safety and aids to navigation in and outside of the Bay, monitoring and responding to marine pollution events, and monitoring and addressing the potential threats to marine and estuarine waters resulting from exotic species. Will be a reviewing and potentially a permitting authority for navigation obstructions associated with activities related to beneficial use of dredged material such as moorings for booster pumps, pipelines, and other vessel traffic.
Bureau of Land Management (BLM)	Administers public lands for multiple uses, including outdoor recreation. Has jurisdiction on those lands and will need to approve potential activities related to dune nourishment and other placement proposals.

4.1 Industry and Commerce

Humboldt Bay is a significant harbor for port-related commercial and industrial uses, as well as being valuable to the region because of its natural and environmental resources, aesthetic appeal, and recreational opportunities. It is also the only port of refuge between San Francisco and Coos Bay. The Bay is central to the CRSMP area. It is the second largest natural bay in California and is the only harbor between San Francisco and Coos Bay with a deep-draft channel large enough to permit passage of large, commercial, ocean-going vessels. Shipping, commercial and recreational fisheries, boating, and mariculture are important parts of the economy and culture in Humboldt County. Seafood is commercially and recreationally harvested from shore and from boats that operate primarily out of Humboldt Bay and Trinidad Bay (Figure 3). Recreational fishermen also harvest seafood from kayaks and while diving. Mariculture is limited to north Humboldt Bay, where oysters and clams are grown.

4.1.1 Commercial Shipping

Petroleum products, forest products (wood and chips), and pulp are important types of cargo arriving or leaving Humboldt Harbor. Although the throughput in timber supplies has decreased in recent years because of the decline of the homebuilding industry, channel maintenance to authorized depths is critical to provide safe passage for commercial vessels.

Primary marine navigation stakeholders include USACE, which maintains the federal navigation channels, and the HBHRCD, which is the non-federal sponsor for dredging the federal navigation channels as well as the entity that maintains navigation and berthing for 12 commercial shipping docks.

4.1.2 Commercial Fisheries

Humboldt Bay and Trinidad Bay are the principal Ports in the Eureka Littoral Cell. In 2008, Humboldt Bay was the fourth leading port in California in terms of landings, and the third leading California port in terms of ex-vessel value – the post-season adjustment price per pound for the first purchase of commercial harvest (NMFS 2008). Approximately 13.3 million pounds of seafood came ashore in Humboldt Bay that year, with a total ex-vessel value of $9.3 million. Trinidad Bay landings totaled 593,000 pounds in 2008, with an ex-vessel value of $1.3 million.

Local fishermen fish both within and outside the Eureka Littoral Cell. Within the cell the fish habitat is primarily soft bottom, but there are rocky habitats in the vicinity of Trinidad Head (at the northern end of the cell) and False Cape(at the southern end). Over soft-bottom habitats, the primary commercial fisheries are Dungeness crab (*Metacarcinus magister*) and Chinook salmon (*Oncorhynchus tshawytscha*). Over rocky habitats, the primary commercial fisheries are rockfish (*Sebastes spp.*) and lingcod (*Ophiodon elongates*); however, there is also a small fishery for pink shrimp (*Pandalus jordani*) near Trinidad Head. Commercial fishing for surfperch (*Embiotocidae*) and surf smelt (*Hypomesus pretiosus*) occurs from beaches throughout the Eureka Littoral Cell. Within Humboldt Bay, northern Pacific anchovies (*Engraulis moradx*) are commercially harvested as bait, primarily to support the albacore (*Thunnus alalunga*) fishery. In Humboldt Bay there has been a commercial fishery for Pacific herring (*Clupea pallasii*) roe, but it has been inactive since approximately 2006.

4.1.3 Mariculture

Mariculture, which is an important sector of Humboldt County's economy, occurs only in north Humboldt Bay. Oysters have been farmed in Humboldt Bay since the mid-1800s (Planwest Partners, Inc. 2008). Currently, five businesses produce seed and adult oysters and clams in the Bay (Pomeroy et al. 2010). Current methods include long-line cultivation, rack and bag, floating racks, and floating upwelling systems (FLUPSY). Long-line culture consists of ropes with clusters of oysters suspended a foot above mudflats by notched PVC tubes over mudflats. Rack-and-bag culture utilizes plastic mesh bags placed on rebar racks approximately 6 to 10 inches above the mudflat. Floating racks and FLUPSYs are located in subtidal areas and grow shellfish in stacked trays placed under rafts with mechanical or non-mechanical mechanisms to generate a constant current that brings nutrients to the shellfish. The mariculture industry has a major stake in the maintenance of good water quality because it is critical for growth of oyster and clam seed and adults.

4.1.4 Mining

A number of in-stream gravel mining operations exist in the region. These operations extract a fixed annual amount of gravel (Table 4), which is set not to exceed mean annual recruitment from the stream in accordance with their permits from USACE, NMFS, CDFW, and County of Humboldt (CHERT 2008)

4.2 Recreational Fisheries and Boating

Recreational boaters, divers, and kayakers primarily target rockfish, lingcod, kelp greenling (*Hexagrammos decagrammus*), and cabezon (*Scorpaenichthys marmoratus*) in rocky habitats. Along rocky shores, shore-based seafood harvesters target the same species along with California mussels (*Mytilus californianus*). Surf smelt and surfperch are targeted by anglers along beaches. Clamming, primarily for the Pacific razor (*Siliqua patula*), littleneck (*Mercenaria mercenaria*), and gaper (*Tresus spp*.) clams, is especially popular in Humboldt Bay and at Clam Beach near Mckinleyville. Currently, seven charter captains operate out of Trinidad Bay and four out of Humboldt Bay. Charter boats primarily target Chinook salmon, rockfish, kelp greenling, lingcod, and Dungeness crab in the open ocean. In Humboldt Bay, they target California halibut (*Paralichthys californicus*) and occasionally leopard sharks (*Triakis semifasciata*).

The largest of the recreational boating facilities are two public marinas: the Woodley Island Marina, owned and operated by the HBHRCD, and the Eureka Public Marina, owned and operated by the City of Eureka. In addition, there are three public boat launch ramps, two public recreation docks, one public guest dock, and a publicly owned boat repair facility.

4.3 Conservation and Environmental Protection Initiatives

Humboldt Bay and environs include diverse ecosystems. The area's topography, wetlands, riparian, and coastal areas provide a variety of habitats for wildlife and migratory birds. For decades, there has been a strong desire to maintain, restore, and enhance aquatic ecosystem integrity and to work cooperatively to develop and implement a restoration and enhancement plan for Humboldt Bay's aquatic ecosystems. Any region-wide sediment management option would need to be consistent with the goals and visions of the following initiatives and management plans.

4.3.1 Humboldt Bay Management Plan (HBMP)

Lead Stakeholder or Agency: Humboldt Bay Harbor, Recreation, and Conservation District

The HBMP, which originated in 1997, comprises a diverse group of stakeholders who recognized the need to develop a common database for use by regional landowners and agency land managers to guide planning and research around

Humboldt Bay. The HBMP, which is the region's first ecosystem-based management effort intended to improve the management of Humboldt Bay, is a large cooperative project funded by federal, state, and local agencies (HBHRCD 2007). The HBMP contains an extensive amount of information on the history of the development and natural ecology of Humboldt Bay, as well as descriptions of conservation measures. The CRSMP for Eureka would be a complementary document to the HBMP.

4.3.2 Humboldt Bay National Wildlife Refuge Comprehensive Conservation Plan

Lead Stakeholder or Agency: US Fish & Wildlife Service

The Humboldt Bay National Wildlife Refuge (HBNWR) includes units that are distributed around Humboldt Bay. The USFWS manages the HBNWR primarily for the benefit of fish, wildlife, and plant resources and their habitats. The mission of the HBNWR is to administer a national network of lands and waters for the conservation, management and, where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans.

The Refuge was established in 1971 to conserve coastal habitats for a great diversity of animals and plants, especially migratory birds. The Lanphere and Male'l Dunes Units were added later to the Refuge to help conserve the most pristine remaining dune ecosystem on the West Coast of the United States. The Refuge authorized footprint consists of 9,502 acres, with approximately 3,379 acres owned in fee title. It comprises freshwater, brackish, and salt marsh; agricultural wetlands; intertidal mudflats; eelgrass beds; and dune habitats (Humboldt Bay NWR 2009).

4.3.3 BLM Administered Management Areas

Lead Stakeholders and Agencies: BLM and CDFW

The BLM manages the headwaters of Elk River and Salmon Creek, the South Spit Cooperative Management Area south of the South Jetty, the Samoa Dunes Recreation Area, additional lands on the North Spit including part of the Male'l Dunes Cooperative Management Area, and the California Coastal National Monument. The last includes all the rocks, reefs, and islands of the California Coast not owned by the USFWS, National Park Service, or other entities.

4.3.4 Humboldt Bay Initiative

Lead Stakeholders and Agencies: NOAA, Seagrant Office, Humboldt State University, Private Industry

The Humboldt Bay Initiative (HBI) – previously the Humboldt Bay Ecosystem Program – seeks to create a coordinated resource management framework that links the needs of people, habitats, and species by increasing scientific understanding of the ecosystem. The HBI has brought together local stakeholders to envision the desired future state of Humboldt Bay ecosystems and communities, understand current physical and biological conditions in the ecosystem, and to collaborate towards effective implementation of ecosystem-based approaches.

The HBI was originally formed to bring together resource managers, scientists, and community members to address management issues that cross disciplines, and to link science and management for the Humboldt Bay ecosystem. Most recently, the group, which now numbers more than 80 participants, has made substantial progress in developing principles for implementing ecosystem-based management (EBM) in their local area. To address priority threats to the local ecosystem and communities – e.g., climate change, invasive species, and human activities – HBI proposed a set of strategies aimed at creating the conditions necessary to achieve their shared vision of a healthy ecosystem. HBI facilitates ongoing coordination and collaboration among local agencies, resource managers, and local constituencies and develops, integrates, and disseminates key ecosystem information.

5 HUMBOLDT BAY REGION CRITICAL SPECIES AND HABITATS

5.1 HABITATS

Habitats in the Eureka Littoral Cell region can be broadly divided into those associated with Humboldt Bay, the open coast, and rivers and creeks discharging into the open ocean or Humboldt Bay (Figure 31 through Figure 38). This discussion focuses on coastal habitats that may be affected by sediment management alternatives.

Most of the open coast in the project area is sandy, but rocky intertidal and offshore rocks occur at the northern end near Trinidad. Subtidal rocky habitat and offshore rocks are found at the southern end of the project area between False Cape and Cape Mendocino. Offshore rocks support bird colonies and are used for hauling out by pinnipeds. Sensitive habitats on the open coast include designated Critical Habitat for the federal threatened western snowy plover (*Charadrius alexandrinus nivosus*). There is sensitive coastal dune habitat (Lanphere and Ma-le'l Dune Units) between the township of Manila and the Mad River inlet that supports several sensitive plant species. Because these units are presently being mapped by the USFWS and the BLM, they are not available on GIS yet and are therefore not shown on the marine resource maps.

Sensitive habitats within Humboldt Bay include eelgrass and tidal marshes, which contain several sensitive plant species. Drainages into Humboldt Bay, the Eel River, and the Mad River contain Critical Habitat for listed salmonids and tidewater goby.

Figure 31: Humboldt Bay Marine Resources Map 1: Trinidad Head

Figure 32: Humboldt Bay Marine Resources Map 2: Little River mouth

Figure 33: Humboldt Bay Marine Resources Map 3: Mad River mouth

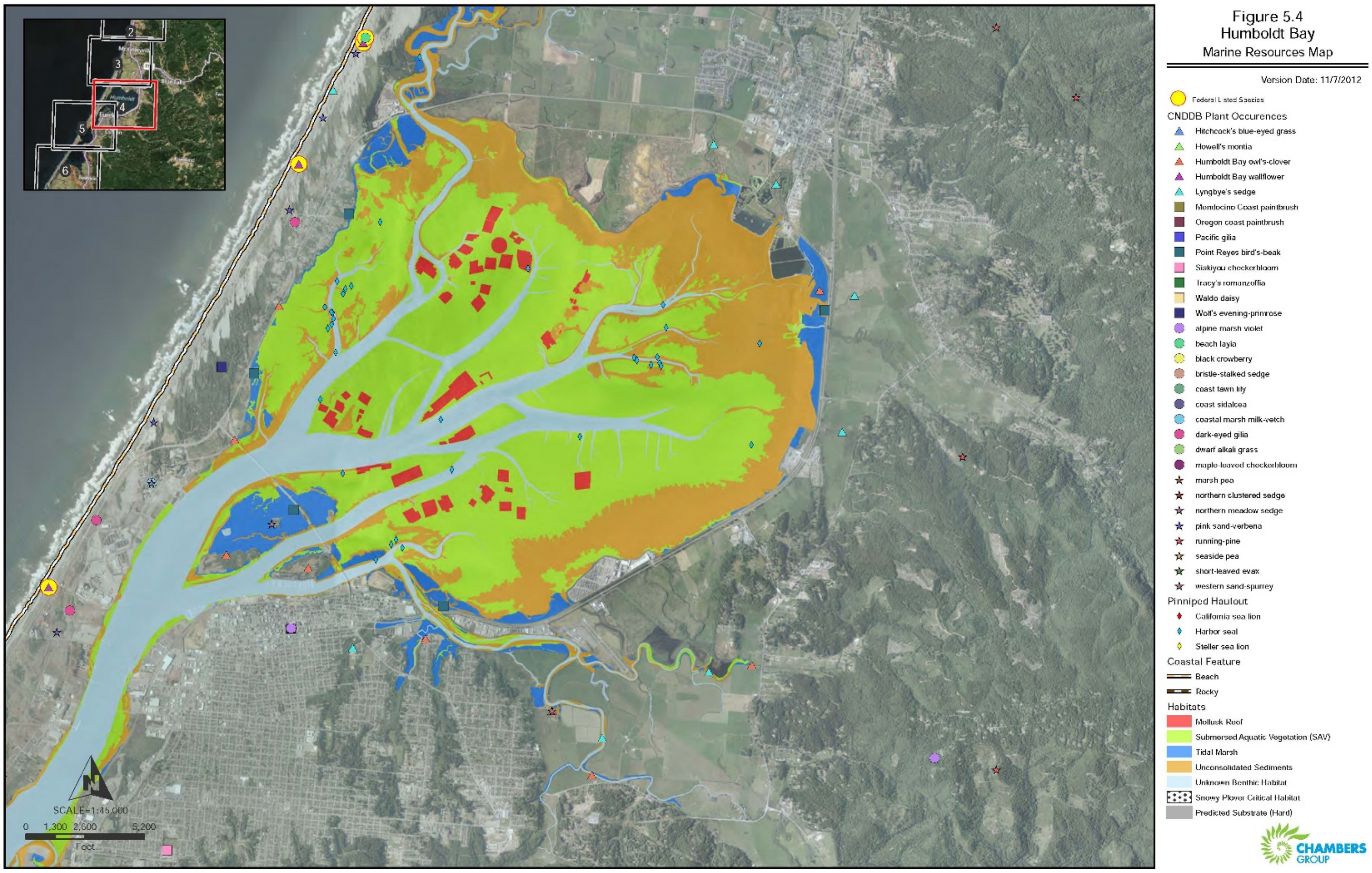


Figure 34: Humboldt Bay Marine Resources Map 4: Arcata Bay

Figure 35: Humboldt Bay Marine Resources Map 5: Entrance Bay

Figure 36: Humboldt Bay Marine Resources Map 6: South Bay and Eel River mouth

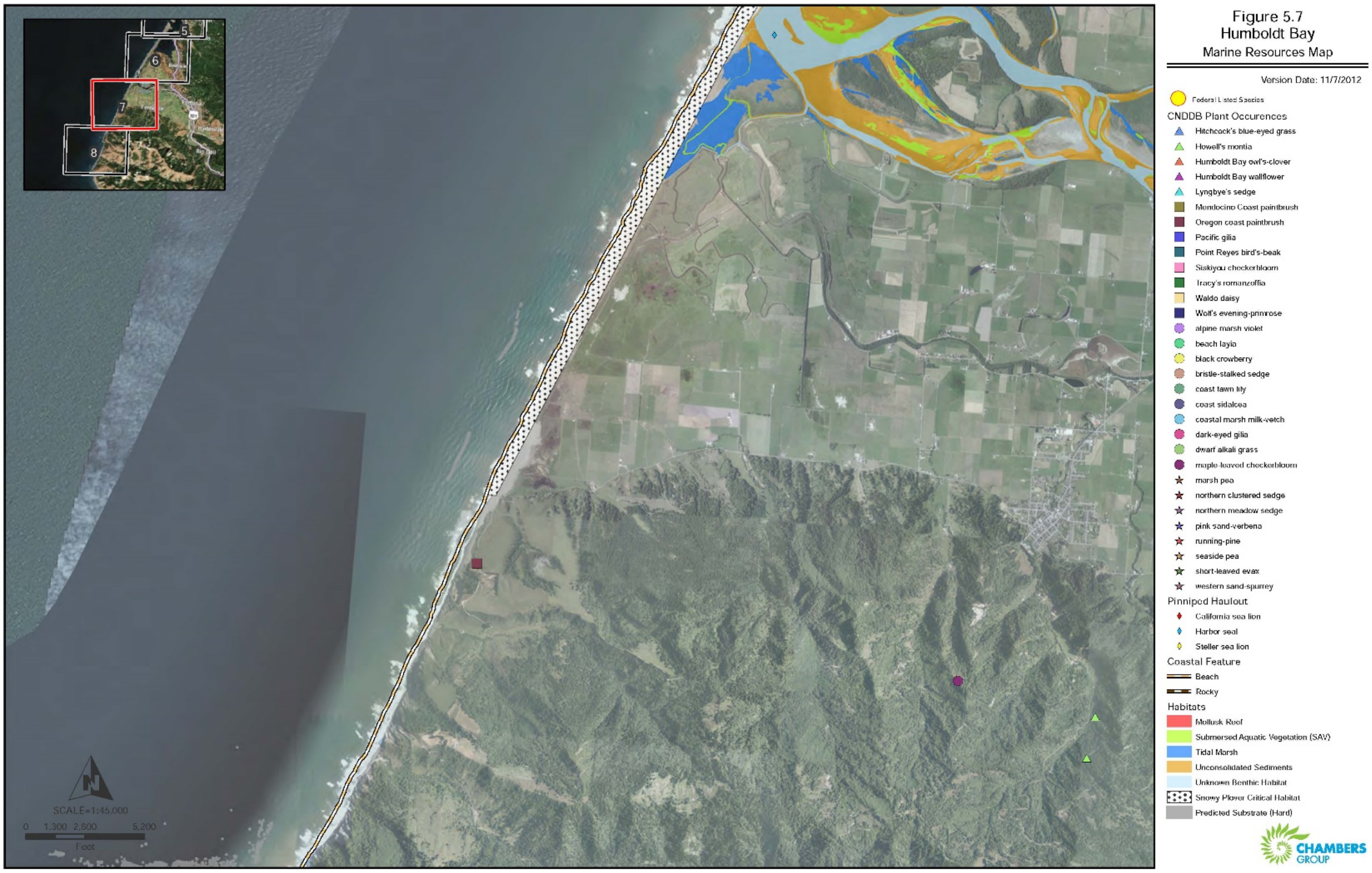


Figure 37: Humboldt Bay Marine Resources Map 7: Eel River

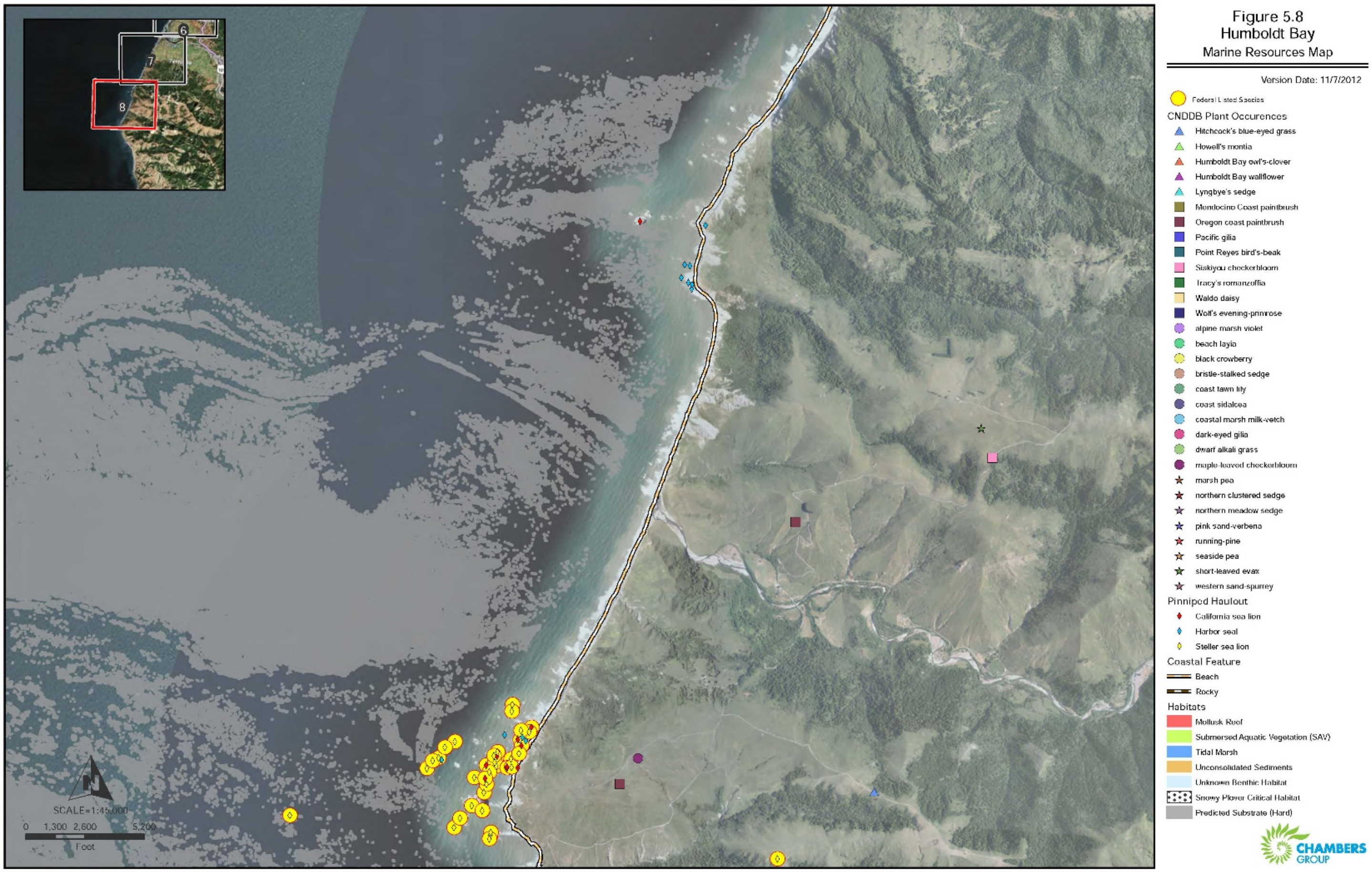


Figure 38: Humboldt Bay Marine Resources Map 8: False Cape

5.1.1 Humboldt Bay

Humboldt Bay, which is the second largest estuary in California (CDFG 2010), is divided into Arcata Bay, Entrance Bay, and South Bay. Arcata Bay covers approximately 13 square miles and is generally shallow with over half the area exposed at low tides (HBHRCD 2007). A series of channels incise the tidal flats. Entrance Bay, which is the most developed portion of Humboldt Bay, includes dredged channels that support commercial and recreational activities. South Bay covers approximately 7 square miles and, like Arcata Bay, is characterized by broad expanses of tidal flats incised by channels.

The Bay is biologically rich, supporting over 110 species of fishes, 260 species of birds, and 200 subtidal invertebrates (Schlosser et al. 2009). Habitats in the Bay include both estuarine and freshwater wetlands with salt marshes, intertidal mudflats, soft-bottom subtidal habitats, and extensive eelgrass beds. Humboldt Bay is designated as an International Site in the Western Hemisphere Shorebird Reserve Network and an Important Bird Area by the American Bird Conservancy. The Bay is a key migratory staging, roosting, and feeding area for migrating and wintering shorebirds using the Pacific Flyway. Over 100,000 shorebirds, belonging to approximately 30 different species, use Humboldt Bay as an overwintering area and migration stopover site (Schlosser et al. 2009). Humboldt Bay also is the most important location in California for staging Pacific black brant geese (*Branta Bernicia*), which almost exclusively feeds on eelgrass. The Bay is an important haulout and pupping area for harbor seals (*Phoca vitulina*; CDFG 2010).

5.1.1.1 Subtidal, Unvegetated Soft Bottom

About 6,000 acres of Humboldt Bay can be classified as subtidal habitat that is rarely, if ever, exposed at low tide (Schlosser and Eichler 2009). The subtidal benthic community is a food source for fishes and aquatic birds. The benthos consumes and decomposes organic materials, recycles nutrients and minerals, and accumulates pollutants. The distribution and abundance of benthic communities is related to grain size, the organic content of sediments, interactions among the biota, and environmental conditions (Schlosser and Eichler 2009). Polychaetes, crustaceans, and mollusks are the dominant forms of infauna in the subtidal benthic habitats of Humboldt Bay. Crabs and shrimp abound on the Bay floor.

At least 110 fish species have been reported from Humboldt Bay, including many commercially important species that spawn within the Bay and several species of salmonid that spawn in the tributary streams (CDFG 2010). Several fish species listed as threatened or endangered inhabit Humboldt Bay and its tributaries. These species include coho salmon (*Oncorhynchus kisutch*), Chinook salmon (*O. tshawytscha*), steelhead (*O. mykiss*), longfin smelt (*Sprinchus thaleichthys*), green sturgeon (*Acipenser medirostris*) and tidewater goby (*Eucyclogobius newberryi*). Humboldt Bay also serves as an important nursery area for a variety of fish and invertebrate species, including English sole (*Parophrys vetulis*), Pacific herring (*Clupea pallasii*), lingcod (*Ophiodon elongates*), Dungeness crab (*Cancer magister*), leopard shark (*Triakis semifasciata*), rock crabs, surfperches, and some rock fishes (*Sebastes spp.*). Bat rays (*Myliobatis californica*) can reach high abundances in Humboldt Bay, especially during the summer months.

5.1.1.2 Eelgrass

Eelgrass is a marine flowering plant that forms dense beds. It grows in muddy to fine-sand substrates around the elevation of MLLW. Over 40 percent of the eelgrass in California occurs in Humboldt Bay (Schlosser et al. 2009). Large eelgrass beds are extensive in Arcata and South Bay, and fringing eelgrass beds approximately 20 to 40 ft wide are found along the navigation channel in the Entrance Bay. The eelgrass meadows in Arcata Bay are typically less dense than those in South Bay (HBHR CD 2007). The most common type of eelgrass is *Zostera marina*. An invasive species, dwarf eelgrass (*Z. japonica*), was recently discovered in Humboldt Bay and the Eel River estuary (CDFG 2010). This non-native species, which has shorter and narrower leaves than *Z. marina*, is of concern because it competes with native eelgrass.

Eelgrass creates an extremely productive habitat that supports an abundant and biologically diverse assemblage of aquatic animals of which many are commercially important (CDFG 2010). Eelgrass is the primary food of black brant geese, and eelgrass beds are spawning habitat for Pacific herring. In addition, eelgrass provides attachment sites for sessile invertebrates and refuges for crabs and small fishes. The long blades of eelgrass and its extensive root system create a stable environment by reducing current velocity and trapping sediment particles, which improves overall water quality.

5.1.1.3 Salt Marsh

In historic time, Humboldt Bay salt marshes have been reduced substantially in area, and they continue to be lost. Nearly 90 percent of the original salt marsh have been diked or filled (Barnhart et al. 1992). Currently, salt marshes exist largely as remnants in a narrow perimeter around the Bay, on low islands in the middle of Entrance Bay, and in the Mad River Slough. Salt marshes in Humboldt Bay are dominated by the introduced dense-flowered cordgrass (*Spartina densiflora*) and native pickleweed (*Salicornia virginica*) (HBHR CD 2007). At higher elevations, freshwater runoff results in brackish conditions, and a variety of other plant species are common.

5.1.1.4 Intertidal Mud Flat

A high biodiversity of invertebrates characterizes the extensive intertidal mud flats of Humboldt Bay (Schlosser et al. 2009). The complex pattern of invertebrate species distribution within Humboldt Bay results from many factors, the most important of which are elevation relative to MLLW, sedimentary structure of the substrate, and seasonal salinity regime (Barnhart et al. 1992). Tens of thousands of shorebirds, waterfowl, and wading birds use the intertidal flats around the Bay for foraging, resting, and roosting. Humboldt Bay supports between 20,000 and 80,000 shorebirds depending on the season (CDFG 2010). Harbor seals haul out on the mudflats in Arcata Bay and South Bay.

5.1.2 Open Coast

The open coast in the vicinity of Humboldt Bay consists of subtidal soft-bottom habitat and sandy beaches backed by dunes. The shoreline is broken by the mouths of three rivers (Little, Mad, and Eel) and the entrance to Humboldt Bay. Rocky shore and subtidal hard bottom are found at the extreme northern and southern ends of the project area, near Trinidad and at False Cape, respectively.

5.1.2.1 Subtidal Soft Bottom

Soft bottom comprises the highly dynamic subtidal habitat offshore of the Eureka Littoral Cell (CDFG 2010). Wave action, bottom currents, and river discharges commonly move the sediment throughout this zone. The sediment in shallow water close to shore tends to be sand populated by a diversity of invertebrates with polychaetes and crustaceans being the most common taxa. Sand dollars (*Dendraster excentricus*) occur at depths of 25 to 50 ft. Dungeness crabs (*Cancer magister*) occur from the intertidal zone to depths of over 100 ft. They migrate from shallower to deeper depths and back.

5.1.2.2 Sandy Beach

Sandy beaches are dynamic systems that change with wind and wave action. With the exception of the headlands at the north and south of the Eureka Littoral Cell, most of the open coast shoreline habitat in the vicinity of Humboldt Bay is sandy beach backed by dunes. Beach sand and the racks of decaying seaweed and other detritus tossed upon the shore support a variety of invertebrates (CDFG 2010). Open-coast sandy beaches are harsh environments because of high abrasion levels and the lack of firm substrate for attachment (Oakden 1999). Characteristic of harsh environments, sandy-beach biological communities exhibit low species diversity with large numbers of individuals of each species. Most of the inhabitants are highly mobile and live buried in the sand much of the time. Sandy-beach invertebrate communities show marked zonal patterns related to the amount of tidal inundation. The characteristic animals of the high intertidal zone are talitrid amphipod crustaceans commonly known as beach hoppers. Beach wrack in this zone also supports insects such as beetles and flies. The dominant species of the mid-intertidal zone is the cirolanid isopod (*Excirolana*). The swash zone, where wave breaking and runup often occur, is subjected to a high degree of water movement. The dominant species in the swash zone is the sand crab (*Emerita analoga*). The low intertidal zone, which is exposed to the air only on the lowest tides, supports the most diverse species assemblage of sandy intertidal beaches. A variety of shorebirds, including the federal threatened western snowy plover, forage on sand beaches in the project area. Woody debris on sand beaches enhances habitat by entrapping windblown sand, thus stabilizing the upper beach and enabling foredune development.

5.1.2.3 Dunes

The beaches in the project area are backed by dunes that develop along the shoreline because of the prevailing winds (Schlosser et al. 2009). Active dunes are sparsely vegetated because the constantly shifting sand makes it difficult for plants to become established. Foredunes are vegetated ridges that parallel the beach. Dune hollows contain seasonal ponds where the sand has eroded below the water table. These ponds support amphibians such as the Pacific tree frog (*Pseudacris regilla*) and the red-legged frog (*Rana aurora aurora*). Willow thickets and dune forests may develop in the dune hollows.

The dunes in the project area support a diverse array of insects including beetles, grasshoppers, thatch ants, and more than 40 species of bees and jumping spiders (Schlosser et al. 2009). Many birds use the dunes, as do mammals such as gray fox (*Urocyon cinereoargenteus*), skunk (*Mephitis mephitis*), and raccoon (*Procyon lotor*). The federal threatened western snowy plover nests in dunes in the project area. The dunes also support sensitive plant species including the federally listed Humboldt Bay wallflower (*Erysimum menziesii* ssp. *Eurekense*) and beach layla (*Layia carnosa*). Dunes in the project area have been invaded by non-native species such as European beach grass (*Ammophila arenaria*).

5.1.2.4 Hard Bottom

Hard bottom habitats occur at the northern end of the project area near Trinidad Head and at the southern end near False Cape. Rock substrate provides attachment sites for algae and sessile marine invertebrates, but kelp beds have not been observed in these areas. Mobile invertebrates and fishes find shelter and protection in crevices and overhangs. Many commercially important fish species such as rockfish congregate around subtidal rocky substrate (CDFG 2010).

Seabirds use rocky headlands and offshore rocks for nesting. Seabirds that nest on Trinidad Head and nearby offshore rocks include pelagic cormorant (*Phalacrocorax pelagicus*), double-crested cormorant (*P. auritus*), black oystercatcher (*Haematopus bachmani*), western gull (*Larus occidentalis*), common murre (*Uria aalge*), Leach's storm-petrel (*Oceanodroma leucorhoa*) and pigeon guillemot (*Cepphus Columba*) (Carter et al. 1992). The False Cape rocks at the south end of the project area support breeding by Brandt's cormorant (*P. pencillatus*), pelagic cormorant, western gull, common murre, and pigeon guillemot.

Harbor seals (*Phoca vitulina*), California sea lions (*Zalophus californianus*), and the federal threatened Steller sea lion (*Eumetopias jubatus*) haul out on offshore rocks near Trinidad Head and south of False Cape. The Steller sea lion breeds on Sugarloaf Island off Cape Mendocino and hauls out in that area.

5.2 Sensitive Species

5.2.1 Sensitive Dune and Tidal Salt Marsh Plants

A number of species considered sensitive (i.e. species that have populations at risk of local or regional extinction) by the California Native Plant Society are found in dune and marsh habitats in the project area (Table 6). Three sensitive plant species that occur in dunes or marshes are listed as federal and state endangered. These species are

Humboldt Bay wallflower, beach layla, and western lily (*Lilium occidentale*). The Humboldt Bay wallflower and beach layla are dune species and could be affected by sediment management activities that placed sand on dunes. The western lily is found in scrub and freshwater habitats and would be less likely to be affected by sediment management activities that placed sediment in coastal habitats.

Table 6: Sensitive plant species occurring in the Humboldt Bay area, in Coastal Salt Marsh or Coastal Dune habitats.

Common Name	Scientific Name	Communities
pink sand-verbena	*Abronia umbellata* ssp. *breviflora*	Coastal dunes
Oregon coast paintbrush	*Castilleja affinis* ssp. *litoralis*	Coastal bluff scrub, Coastal dunes, Coastal scrub/sandy
Humboldt Bay wallflower	*Erysimum menziesii* ssp. *Eurekense* FE,SE	Coastal dunes
dark-eyed gilia	*Gilia millefoliata*	Coastal dunes
short-leaved evax	*Hesperevax sparsiflora* var. *brevifolia*	Coastal bluff scrub (sandy), Coastal dunes
seaside pea	*Lathyrus japonicus*	Coastal dunes
beach layia	*Layia carnosa* FE,SE	Coastal dunes, Coastal scrub (sandy)
coastal marsh milk-vetch	*Astragalus pycnostachyus* var. *pycnostachyus*	Coastal dunes (mesic), Coastal scrub, Marshes and swamps (coastal salt, streamsides)
Lyngbye's sedge	*Carex lyngbyei*	Marshes and swamps (brackish or freshwater)
Humboldt Bay owl's-clover	*Castilleja ambigua* ssp. *humboldtiensis*	Marshes and swamps (coastal salt)
Point Reyes bird's-beak	*Cordylanthus maritimus* ssp. *palustris*	Marshes and swamps (coastal salt)
marsh pea	*Lathyrus palustris*	Bogs and fens, Coastal prairie, Coastal scrub, Lower montane coniferous forest, Marshes and swamps, North Coast coniferous forest/mesic
western lily	*Lilium occidentale* FE,SE	Bogs and fens, Coastal bluff scrub, Coastal prairie, Coastal scrub, Marshes and swamps (freshwater), North Coast coniferous forest (openings)
Wolf's evening-primrose	*Oenothera wolfii*	Coastal bluff scrub, Coastal dunes, Coastal prairie, Lower montane coniferous forest/sandy, usually mesic
dwarf alkali grass	*Puccinellia pumila*	Marshes and swamps (coastal salt)

Common Name	Scientific Name	Communities
western sand-spurrey	*Spergularia canadensis* var. *occidentalis*	Marshes and swamps (coastal salt)

5.2.2 Fishes

5.2.2.1 Tidewater Goby

The tidewater goby, which is federally listed as endangered, lives in shallow lagoons and lower stream reaches. This fish requires fairly still, but not stagnant, water with high oxygen levels. The interface between Humboldt Bay and the creeks that drain into it are listed as Critical Habitat for tidewater goby (USFWS 2008). This critical habitat unit consists of a complex of interconnected estuary channels and human-made structures along the eastern edge of Humboldt Bay that collectively mimic habitat that have been lost to various kinds of development. A 2010 survey by the USFWS for the tidewater goby at north coast locations found tidewater gobies in Gannon Slough, Gannon Pond, Jacoby Creek, Wood Creek, and the Elk River in Humboldt Bay (Figure 4) (Chamberlain 2011). The Eel River delta also is listed as Critical Habitat for the tidewater goby, and gobies were found there in the 2010 survey.

5.2.2.2 Salmonids

Humboldt Bay contains Critical Habitat for three listed species of salmonids: the federal and state threatened Southern Oregon/Northern California Coast Coho Salmon Evolutionarily Significant Unit (ESU), the federal threatened California Coast Chinook Salmon ESU, and the federal threatened Northern California Steelhead Distinct Population Segment (DPS). The Mad River, Jacoby Creek, Freshwater Creek, Elk River, Salmon Creek, and Eel River are designated Critical Habitat for the listed salmonids (Hogarth 2005). A fourth species of salmonid, coastal cutthroat trout (*O. clarkii clarki*) is also present in the Humboldt Bay watershed and, although not listed, is considered sensitive (Humboldt Bay Watershed Advisory Committee and the Natural Resources Services Division of Redwood Community Action Agency 2005).

These sensitive salmonid species are anadromous. They spend their adult lives in the ocean but come into the creeks to spawn. The Chinook salmon are fall run, spawning from October through January (Humboldt Bay Watershed Advisory Committee and the Natural Resources Services Division of Redwood Community Action Agency 2005). The coho salmon typically spawn from November to January. The steelhead and cutthroat trout spawn in late winter through spring. The length of time in freshwater varies amongst species but is anywhere from one year to nine years for the cutthroat trout. The juveniles migrate seaward throughout spring and early summer. As the young salmonids make their way to the ocean, they undergo smoltification, a series of physiological and morphological changes that prepare them for marine life.

5.2.2.3 North American Green Sturgeon

Green sturgeon are anadromous fish that occupy freshwater rivers from the Sacramento River through British Columbia but only spawn in the Rogue River in Oregon and the Klamath and Sacramento Rivers in California (Oliver 2009).The southern Distinct Population Segment (DPS) of the north American green sturgeon, which consists of populations south of the Eel River, is federally listed as threatened. Critical Habitat was designated in 2009 and includes Humboldt Bay and the nearshore waters of the Eureka Littoral Cell (Oliver 2009).

5.2.2.4 Eulachon Southern DPS

The eulachon (*Thaleichthys pacificus*) is a small anadromous fish that typically spends three-to-five years in saltwater before returning to freshwater to spawn. The Southern DPS, which is federally listed as threatened, includes eulachon in Washington, Oregon, and California. Critical Habitat in the project area includes the Mad River (Schwaab 2011). Eulachon consistently spawned in the Mad River as recently as the 1960s and 1970s but now are considered rare in the Mad River drainage.

5.2.2.5 Longfin Smelt

Longfin smelt are small planktivorous fish that are listed as threatened by the State of California. The primary habitat of longfin smelt is estuaries. The species occurs in scattered populations along the Pacific Coast from the San Francisco Bay Estuary to Prince William Sound in Alaska (The Bay Institute et al. 2007). They occur in Humboldt Bay and the Eel River estuary. In Humboldt Bay, they were common in the late 1960s and early 1970s but have declined, and currently are rare. Only eight were collected in recent extensive surveys of Northern Humboldt Bay (Pinnix et al. 2004).They also appear to have declined in the Eel River at approximately the same time and may no longer be present in its estuary.

5.2.3 Birds

5.2.3.1 Western Snowy Plover

Western snowy plover is federally listed as threatened. The snowy plover is a small shorebird that is found on sandy beaches, salt pond dikes, and shores of large alkali lakes. This species needs sandy, gravelly, or friable soils for nesting. Snowy plovers use beaches in Humboldt County and gravel bars on the Eel River as nesting and wintering habitat (Brindock 2009). Studies of snowy plover on Humboldt County beaches found that plovers selected sites with more brown algae wrack and associated invertebrates, wider beaches, and less cover in the foredunes than unoccupied sites (Brindock 2009).

Beaches in both the project area and the gravel bar in the Eel River estuary have been designated as Critical Habitat for snowy plover (USFWS 2005; Figure 31 through Figure 38). Small numbers of snowy plovers breed on the beaches and the Eel River gravel bar. In 2012, 36 adult snowy plovers bred at 5 locations in Humboldt County (Colwell et al 2012). These locations are Big Lagoon, Clam Beach, Mad River Beach, Eel River wildlife Area and Centerville Beach. Within the past decade snowy plovers also have bred at Gold Bluffs Beach, Stone Lagoon, South Spit, and the Eel River gravel bars.

5.2.3.2 Marbled Murrelet

The marbled murrelet (*Brachyramphus marmoratus*) is a seabird that is federally listed as threatened. It spends most of its life at sea but nests in the branches of old-growth redwood forests. Marbled murrelets have been detected in forests inland of the project area (Paton and Ralph 1990). They occur in nearshore ocean waters off Humboldt Bay and sometimes appear in Humboldt Bay.

5.2.3.3 Nesting Waterbirds

Nesting waterbird colonies are considered sensitive by the California Department of Fish and Game. Several waterbirds nest in the project area. The cypress grove on Indian Island supports nesting by great egret (*Ardea alba*), great blue heron (*A. herodias*), snowy egret (*Egretta thula*), and black-crowned night heron (*Nycticorax nycticorax*) (Humboldt Bay Harbor Recreation and Conservation District 2006). Double-crested cormorants (*Phalacrocorax auritus*) nest on the ruins of the old wharf in Arcata Bay. Caspian terns (*Sterna caspia*) historically have nested in a small colony on sand islands in Arcata Bay. In addition, several species of seabirds nest on offshore rocks near Trinidad Head and False Cape.

5.2.4 Marine Mammals

5.2.4.1 Steller Sea Lion

The federal threatened Steller sea lion hauls out on offshore rocks near Trinidad Head and south of False Cape. The Steller sea lion breeds on Sugarloaf Island off Cape Mendocino and hauls out in that area. The ocean waters within 3,000 ft of Sugarloaf Island and Cape Mendocino have been designated as Critical Habitat for Steller sea lions (NMFS 2007).

5.2.4.2 Harbor Seals

Harbor seals haul out and breed on mud flats in Arcata Bay and South Bay and on rocks at the northern end of the project area near Trinidad Head (Figure 31 through Figure 38). Breeding populations of harbor seals typically reach their peak in late spring. Pupping occurs mainly in South Bay (CDFG 2010).

Seven RSM schemas (schema: a large-scale systematic plan for putting a particular idea into effect l) have been identified for the Eureka Littoral Cell. Schemas identified here and discussed in Section 7 are based on existing scientific and historical data as well as extensive input from stakeholders.

Unlike the CRSMP planning areas in Central and Southern California, where sediment deficit is a significant concern, the Eureka Littoral Cell region has an abundance of sand and fine-grain sediment that presently is disposed of outside the littoral zone. Beneficially using that sediment for coastal protection and habitat restoration can help the region respond to the negative impacts of future climate change. The following regional goals form the basis for the CRSMP schemas:

* maintaining littoral zone balance
* providing protection from tsunamis
* providing protection from sea level change and severe storms
* restoring or creating habitat
* restoring natural shoreline
* creating recreational areas
* providing land for a multi-use trail connecting Arcata and Eureka
* protecting existing structures behind dikes
* removing invasive species
* stockpiling dredged material for local construction

The schemas (Table 7) provide the communities and stakeholders with a range of actions that could be refined and prioritized to match a vision for the Eureka Littoral Cell. Every action comes with a unique set of benefits, constraints, timeframes, costs, and funding choices.

Table 7: Eureka Littoral Cell Schemas

1	Placement in the Littoral Zone
2	Coastal Dune Enhancement
3	Tidal Marsh Restoration
4	Creating Soft Shorelines within the Bay
5	Dike Rehabilitation
6	Recreational Beaches in Humboldt Bay
7	Use of Dredged Material for Local Construction

All of the schemas rely on sediment dredged from the entrance to and interior of Humboldt Bay. Without proper maintenance dredging of the Humboldt Bay navigation channels, safe and efficient passage for vessels calling on the port would be impossible. Given that dredging is a critically required activity to sustain local industry, it will continue in the foreseeable future to represent an opportunistic sediment source for the region. Dredged material has been beneficially used in other regions for purposes such as beach and dune nourishment, wetlands restoration, erosion control, and raising dikes. Along with providing additional protection against flooding and erosion, these types of projects can create safer public access to the waterfront, enhance recreational opportunities, and minimize the near-term adverse effects of sea level rise.

6.1 Schema 1: Placement Within Littoral Zone

This schema relies on developinga nearshore dredged-material placement site such as that would be located in water shallow enough for shoaling waves to be able to transport the placed sand toward the surf zone and beach. A benefit of this schema is enhanced protection of the adjacent beach and dunes caused by inducing large, high-energy waves to break farther offshore.

During the site designation process for HOODS, the involved agencies recognized that this disposal option completely removes sediment from the Eureka Littoral Cell. In 1995 as part of the Consistency Determination issued by the CCC for Section 102 designation of HOODS, USACE agreed to monitor the Humboldt shoreline to determine, if possible, the effects of removing sand from the Eureka Littoral Cell by placing it at HOODS (Section 3.2.5. The monitoring area extends from approximately seven miles south of the South Jetty to seven miles north of the North Jetty.

Through 2016, periodic aerial photographs, topographic surveys, and LiDAR surveys indicate that shoreward movement of the upper beach reference line has continued for the North Spit though all of the upper beach reference linesfall within the acceptable limits of the excessive shoreline retreat criterion. This trend appears to be accelerating, however, and the upper beach volume results also show a clear acceleration in the erosion rate between 2005 and 2011, with a 20-percent decrease in the upper beach volume during that time. Although causes for this trend have not been identified, USACE and the regulatory agencies support precautionary measures to ensure dredged sand – on the order of 1,000,000 yd^3/yr – stays in the nearshore while minimizing impacts to fisheries, navigation, and other human uses.

For the South Spit, the surveys suggest that the previously observed seaward movement of the upper beach reference line has continued, but not necessarily throughout the entire spit. Thus, there is no general shoreline movement trend that can be applied to the entire South Spit, as opposed to the more pronounced spit-wide trend for the North Spit. However, the upper beach volume results suggest that there is a modest accretion on the South Spit with the most significant accretion occurring in the middle of the spit.

6.2 Schema 2: Coastal Dune Enhancement

On the North Spit, coastal dunes both protect bayside infrastructure and serve as valuable dune habitat for native grasses. The entire spit, however, is potentially vulnerable to storm-driven flooding and tsunamis and will become more vulnerable as sea level rises. Studies indicate that tsunami inundation elevations of up to 28 ft above MSL could occur in the area (e.g., Borrero et.al. 2007). Dune health is especially critical because beach and dune erosion along the north spit has accelerated since the use of HOODS began.

In addition, invasive grass species are prevalent along the dune system. The HBNWR (2009) has identified the issue as significant:

> *Given the rarity of dune swale habitat and its value to wildlife, removal of invasive plant species and restoration of native plant species is necessary for the maintenance of the biological integrity, diversity, and environmental health of the dune ecosystem as well as to protect many California Species of Special Concern.*
> *The refuge proposes to experiment with the use of heavy equipment to mimic large scale disturbances such as blow-outs to stimulate localized sand movement to sustain early successional communities. By creating blow-outs and monitoring the effects on plant communities, the refuge will increase the understanding of the best methods to manage these communities over time.*

Dune enhancement involves placing sand from USACE O&M dredging of the federal navigation channels on the dunes to increase dune elevations. Placement should be coupled with managing the invasive grasses to encourage the reestablishment of native grasses. Placed sand that moves into the upper shoreface would also support Schema 1.

6.3 Schema 3: Tidal Marsh Restoration

This schema uses dredged material to reverse subsidence by placing either fine-grained material, or sand capped with fine-grained material, on diked baylands to recreate tidal marsh habitat. Historically, there were substantial areas of salt marsh throughout Humboldt Bay; today, approximately 10% of the historical salt marsh remains (HBHRCD 2007; CCP prepared by the HBNWR). A major cause for the loss of salt marsh is the result of extensive diking and subsequent subsidence of the diked lands. Furthermore, existing salt marsh is degraded by the dominant presence of the invasive, dense-flowered cordgrass. Few opportunities exist to regain some of the lost salt marshes around Humboldt Bay, (e.g., former diked lands in the vicinity of Hookton Slough, White Slough, and Table Bluff Unit). The submerged land is too low to just open up the diked lands to tidal action and provide a habitat for salt water fauna and flora. Restoring salt marsh faces substantial challenges including subsidence, invasive plants, and sea level rise. If the submerged ground level is raised with appropriate material, however, salt marsh could be reestablished.

Substantial interest exists among citizens, local agencies, and state and federal agencies to explore the potential for restoring or enhancing habitats in the Humboldt Bay area to conditions that more nearly resemble those that existed a century ago. The interest in additional restoration includes an increased focus on intertidal restoration, or restoring tidal exchange to diked former tidelands. The HBMP clearly articulates the objectives of conservation, enhancement, and restoration of existing habitats in the region (Conservation Policies *CAE-1* through *CAE-5*; HBHRCD 2007), and the number-one goal of the CCP is (HBNWR 2009):

> *Conserve, manage, restore, and enhance estuarine and palustrine wetland habitats representative of the Humboldt Bay area to benefit their associated native fish, wildlife, plants, and special status species*

6.4 Schema 4: Creating Soft Shorelines within the Bay

This schema involves creating a shallow-sloped transitional edge from mudflats to upland buffer in place of an armored shoreline. The schema is similar to the Tidal Marsh Restoration schema in that the results include creation of new intertidal habitat and a softer shoreline.

Construction consists of placing fill material, which could be a combination of silt and sand, against the bayside edge of an embankment. The schema is similar in its overall function to providing protection against wave-induced erosion, creating a transitional edge along the Bay to provide a superior mix of habitat, as well as providing opportunities for recreation and public access with waterfront trails. Tradeoffs between the potential loss of mudflats and fringe marsh edges and the benefits gained from a more natural edge would have to be weighed.

As is typical with historic diking practices, early settlers placed dikes at the edge of high tidal marshes and drained the diked lands for agriculture or settlements. Presently, steep embankments make up the shore edge, which over time need armoring to protect the diked lands from wave action. There are several segments of riprap-protected shoreline around Arcata Bay that are fronted by shallow mudflats. This type of shoreline edge is indicative of a highly altered condition, and even with the high ambient suspended sediment load in Arcata Bay, there is a low potential for natural progression of these mudflats to a more natural marsh edge because of the wave energy reflecting off the armored shoreline.

The benefits of using outboard salt marshes to stabilize sediment and protect shoreline structures from wave impacts make the restoration or enhancement of salt marshes an important concern for the HBHRCD (HBHRCD 2007).

HSM-6: Require the use of non-structural shoreline protection where feasible and appropriate.
Policy: Shoreline protective projects shall include provisions for nonstructural methods (such as marsh vegetation) where feasible. Along shorelines that support marsh vegetation or where marsh establishment has a reasonable chance of success, the District may require that the design of authorized protective projects include provisions for establishing marsh and transitional upland vegetation as part of the protective structure. Designs shall consider elements to enhance public access, where feasible and appropriate.

Potential locations for this schema include the eastern margins of Arcata Bay, Entrance Bay, and South Bay. The most logical location is along the eastern edge of Arcata Bay where the highway and railroad tracks abut the shoreline. An additional benefit of this location is that the project could incorporate a multi-use trail connecting the cities of Arcata and Eureka. This alignment is consistent with the recommendations of the Redwood Community Action Agency (RCAA), which had prepared a Coastal Conservancy funded Bay Trails Feasibility Study (RCAA 2001).

6.5 Schema 5: Dike Rehabilitation

Some dikes adjacent to Arcata Bay are fronted by mudflats and others are fronted by subtidal portions of the Bay. The northern shoreline in particular consists of tall dikes where the transitional marsh edge cannot be restored. As is typical of dikes built along the margins of bay shorelines, the underlying soils are weak (usually peat or a clay and silt mix) and the safety factor against slope failure is low.

This schema involves using dredged material (sand size or finer) to bolster the dikes along the Bay margins, either the ones protecting urbanized areas or along the diked baylands in Arcata and South Bay. It involves placing dredged material on the landward side of dikes to stabilize them such that it would act as a stability berm against slope failure of the dikes either under static loading or, more importantly, under earthquake loading. The potential for liquefaction-induced subsidence caused by seismic activity has also been articulated by several stakeholders. Also, raising the dikes would help counter sea level rise without slope stability issues. The schema is particularly useful where fill cannot be placed on the Bay side because of the presence of marsh habitat. Also, building up the dikes in this manner could support the conversion of agricultural land to salt marsh (Schema 3).

6.6 Schema 6: Recreational Beaches within Humboldt Bay

The goal of this schema is to create beaches inside of the Bay that could be safely used for wind surfing, fishing, bird watching, and general recreation. Such beaches would be especially useful because open-coast beaches can be ill-suited for casual recreation because they are exposed to waves that are, at times, powerful and dangerous. Additionally, access to the ocean beaches requires long drives around the Bay or along the coast.

The schema requires placing sand along the Bay's shoreline where it is exposed to waves coming through the entrance to the Bay. Once through the entrance, refraction results in waves that arrive at the Bay's eastern shore at a constant angle of incidence regardless of the direction of offshore waves. This creates the potential for a sandy beach that could persist over a prolonged period of time. Also, the shoreline immediately east of the entrance (King Salmon community and farther north) is backed by a railroad that is protected by riprap. Creating a beach would soften the shoreline, create regional recreational and public access, and assist with future flood protection.

6.7 SCHEMA 7: USE OF DREDGED MATERIAL FOR LOCAL CONSTRUCTION

This schema involves beneficially using sand from the Bar and Entrance Channel and sand from the North Bay Channel locally for construction purposes. Within the region, representatives of Caltrans; construction contractors; gravel extraction companies; and public works for the Cities of Eureka, Arcata, and Fortuna, and Humboldt County were contacted. For local end users, different stockpile locations could be identified and analyzed for feasibility based on several different criteria, such as capacity, proximity to transportation (barge, truck, or rail), effect on aquatic and terrestrial habitats, and cost.

<u>Potential End Users</u>

* Caltrans did not indicate a near-term need for any significant quantity of sand for roadway improvements; typically, they stockpile only small amounts of construction fill (aggregate base type) at their yards.
* Construction contractors indicated interest, but did not have a need for stockpiling any significant quantity of sand until the project demanded it.
* Gravel extraction companies indicated only mild interest in sand; their interest was more in gravel. If sand were delivered to landside areas and stockpiled, they were interested in pursuing options beyond the Humboldt region if a market for sand existed.
* The Cities and Humboldt County indicated interest – albeit more in the long term. They do not have any large land areas that could be used to stockpile sand for an indefinite period, and management of such a stockpile did not appeal to them.

7 IMPLEMENTATION OPTIONS

This section provides details on the seven schemas presented in the previous section. Each schema could be implemented at a variety of locations, but further analysis is required to determine their applicability at a specific location. If any of these is constructed to evaluate the value of the schema within the littoral cell, it will be important to choose a project location that has a reasonable likelihood of success yet is representative of the challenges faced. That way project successes and failures can provide applicable lessons on how to proceed. The potential projects described in this section were envisioned based on a variety of reasons including:

* Ancillary benefits – Projects that accomplish more than one goal have a better likelihood of receiving general approval. For example, a project that creates a salt marsh *and* protects the highway is more favorable than one that only accomplishes one of those goals.
* Ownership of the land – For example, a restoration project situated on land owned by the HBNWR will be simpler to conduct than a similar project situated on several privately owned parcels.
* Previously identified – Some projects, such as restoring Teal Island to salt marsh or creating a multi-use trail connecting Arcata and Eureka, have previously been identified as goals strongly supported by different local organizations. The extent of each schema is in no way limited to the demonstration projects described herein. For instance, salt marsh restoration can happen at a multitude of locations throughout the Bay.

7.1 Schema 1: Placement Within The Littoral Zone

7.1.1 Sediment Source

The Humboldt Bay federal navigation channels (Figure 28) comprise the Bar and Entrance Channel, which connects the ocean with the bay, and the North, Eureka, Samoa, and Field's Landing Channels, which are inside the bay. Hopper dredges – commonly the USACE dredges, *Essayons* and *Yaquina* – are used to maintain those channels. Typically, dredging occurs during every spring, but if the work is not completed during the spring episode, an additional dredging episode can be added in the fall to remove the remainder of the material.

Since 1990 HOODS has received all federally dredged material from Humboldt Bay – approximately 25,000,000 yd^3 through June 2016. That represents a significant loss of sediment (mostly sand) from the littoral zone that could have been used as a regional resource. As of 2014, mounding at HOODS of dredged material (primarily due to the large volumes of clean sand dredged annually from the Humboldt Bay Entrance Channel) has resulted in the site, as it is currently configured, effectively reaching capacity. Continuation of the past management approach would result in additional mounding that could eventually affect the local wave climate, particularly during large storms. This in turn could at times adversely affect navigation safety for vessels entering and leaving this important harbor of refuge.

Consequently, the USEPA is recommending that expansion of HOODS be pursued and that a nearshore, beneficial-use site be identified. Such as site, provisionally named the Humboldt Bay Demonstration Site (HBDS), would be designed to feed dredged sand back into the longshore transport system. As envisioned, the HBDS footprint would be a shore-parallel rectangle in approximately 40 to 70 ft of water offshore of the North Spit (Figure 28). If deemed environmentally and economically feasible after several years of use, the USEPA could recommend making the HBDS a permanent placement site. This beneficial-use option was proposed with the objective of retaining clean sand in the littoral zone.

7.1.2 Transport and Placement

Ideally, all of the clean sand dredged from the federal navigation channels would be placed at the HBDS, and sediment that cannot be placed at the HBDS because of grain size or dangerous working conditions there would go to HOODS. Within this proposed demonstration site, a smaller target placement area in the southeast quadrant of the site, would the preferred area for dredged material placement because it is the closest area to the entrance to the Bay making travel time for the dredge essentially equal to the travel time to HOODS. In the long term, the larger HBDS footprint will allow USACE to adjust the annual placement area to accommodate concerns of local regulatory agencies and users of the area (e.g., fishermen and crabbers).

7.2 Schema 2: Coastal Dune Enhancement

Between the signing of the draft Memorandum of by the CCC and USACE (USACE 1995) and 2016, periodic shoreline surveys document that the shoreline along the North Spit is eroding. Building up the dunes with dredged sand would provide protection against coastal and tsunami flooding and serve as a stockpile for future sand projects. Sand from the dunes would migrate onto the adjacent beaches during and after significant storms, resulting in a reduction or perhaps even a reversal of the observed beach recession.

Because dunes on the South Spit are narrow, there is a possibility that they could be breached during severe storms or a tsunami. Storm-driven dune destruction is especially likely during winter high tides because the beach tends to be notably cut back and tides are the highest (e.g., in 2013, 18 of the 26 tidal peaks 8 ft or higher occurred in January, February, November, and December). If this were to happen, the ecosystem of the South Bay would sustain extensive damage, especially in the sensitive Table Bluff, Hookton, and White Slough Units of the Refuge.

Locations along the North and South Spits were identified for a demonstration project (Figure 39, Figure 40, Figure 41, and Figure 42). If done appropriately, this could also be a chance to encapsulate invasive grass species, and replant the dunes with desirable native species.

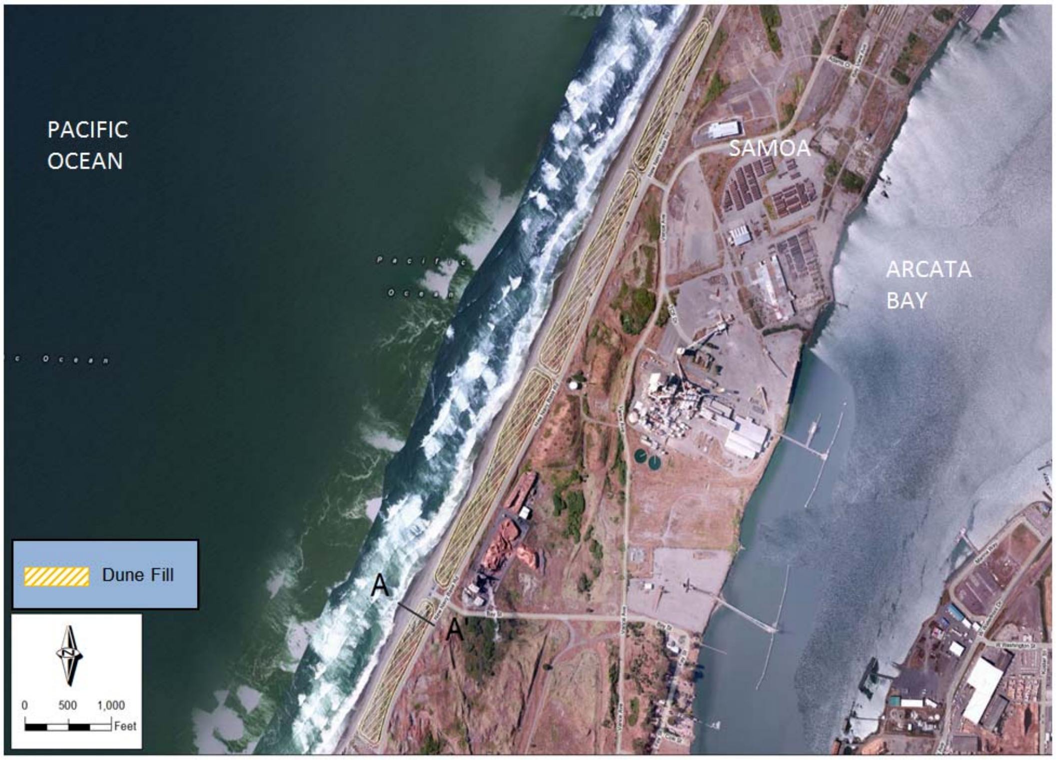


Figure 39: Plan View of North Spit Dunes

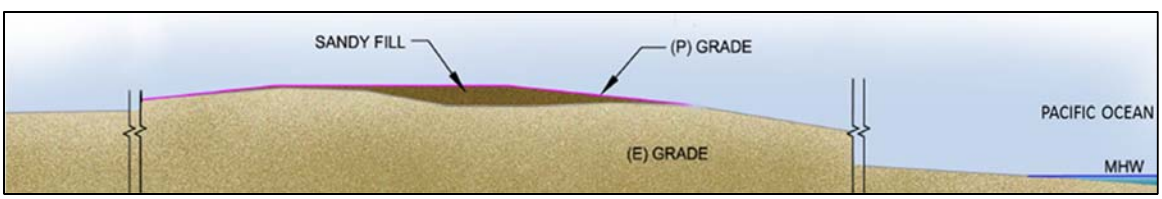


Figure 40: Section View of North Spit Dunes (A-A').

Figure 41: Plan View of South Spit Dunes

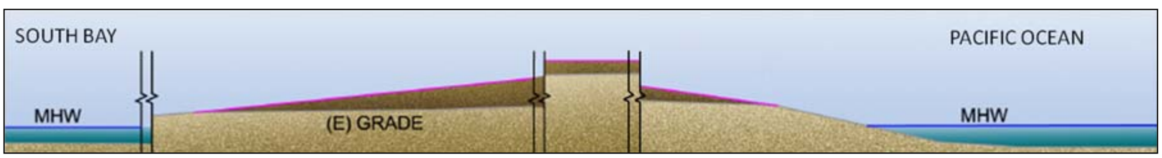


Figure 42: Section View of South Spit Dunes (A-A').

7.2.1 Sediment Source

Both locations have the capacity to hold a large amount of sand, which presumably would come from the Bar and Entrance Channel. A secondary benefit of this type of project is that sand could be stockpiled for future uses associated with enhancing coastal protection. Based on the analysis of existing aerial photographs, approximately 165,000 yd^3 of sand could be placed on the North Spit and approximately 1.5 million yd^3 on the South Spit. Those volumes will likely change over time if the document spit erosion, especially the north spit, continues.

7.2.2 Transport and Placement

This schema proposes to place sand on dunes at both the North Spit and the South Spit to improve flood protection and feed sand into the littoral zone. Sand would be pumped ashore during maintenance dredging of the Bar and Entrance Channel. Because the *Essayons*, which usually dredges the channel, does not have pump-out capability, a dredge with pump-out capability would be contracted to perform the work. Because the material is primarily sand, temporary containment systems, such as geotubes, would have to be constructed, and the water would percolate back to the ocean. This type of operation would be similar to a beach nourishment activity. There will likely be habitat issues associated with native dune grasses for this option, but overall it could benefit the system by capping invasive species and re-planting the newly placed sand with native grasses.

7.3 Schema 3: South Bay Marsh Restoration

This beneficial-use schema proposes using dredged material to mitigate subsidence by placing either fine-grained material, or sand with a fine-grained material cap, within diked baylands to recreate tidal marsh habitat. The San Francisco Bay region has successfully implemented several restoration projects that have effectively employed this concept – e.g., the 300^{+} acre Sonoma Baylands site and the 700^{+} acre Hamilton Wetlands Restoration Project in Sonoma and Marin Counties, respectively. Several Humboldt Bay projects have used this schema:

* The McDaniel Slough Restoration Project led by the City of Arcata, which included the removal of tide gates, deepening of historic slough channels, and removal of failing or obsolete dikes to restore 222 acres of former tidelands and 24.5 acres of freshwater wetlands. Target species were a variety of resident and migratory bird species as well as the federally listed coho and Chinook salmon, tidewater goby, and steelhead, and state listed cutthroat trout.
* The Jacoby Creek /Gannon Slough Wildlife Area Habitat Enhancement Project between Old Arcata Road and Highway 101, also led by the City of Arcata, which included restoration of a three-acre waterfowl pond.
* The Martin Slough/Green DooSwain Slough Enhancement Project in the Elk River watershed – led by the Northcoast Regional Land Trust and funded by the Coastal Conservancy – for the purpose of protecting, restoring and enhancing wetlands, water quality, and fish and wildlife habitat while protecting and enhancing coastal agriculture.
* The Salmon Creek Restoration Project, which was a multi-phase project to restore a degraded stream on former ranch land to quality habitat for salmon and other wildlife. The HBNWR led the decade-long restoration effort, which had been at the top of the refuge's to-do list since 1989, when the former ranchlands became part of the refuge.

Restoring native salt marsh habitat in South Bay likely involves breaching or removing portions of existing dikes. Teal Island in the Salmon Creek Unit is an example of where this type of project could be successful. Teal Island is located at the southern end of South Bay (Figure 43). It is part of an area near the entrance to Hookton Slough that is owned by the HBNWR. It is a designated hunting area and a valuable recreational resource for the community. Teal Island is a 90-acre remnant of an island that was created by diking in the mid-1900s. The land behind the dikes subsided over time, and then the dikes were breached by natural processes. The island is surrounded on all sides by tidal mudflats, and the interior of the island has become a mudflat. Dredged sediment would be used as fill to raise the ground to elevations appropriate for salt water marshes (Figure 44 and Figure 45).

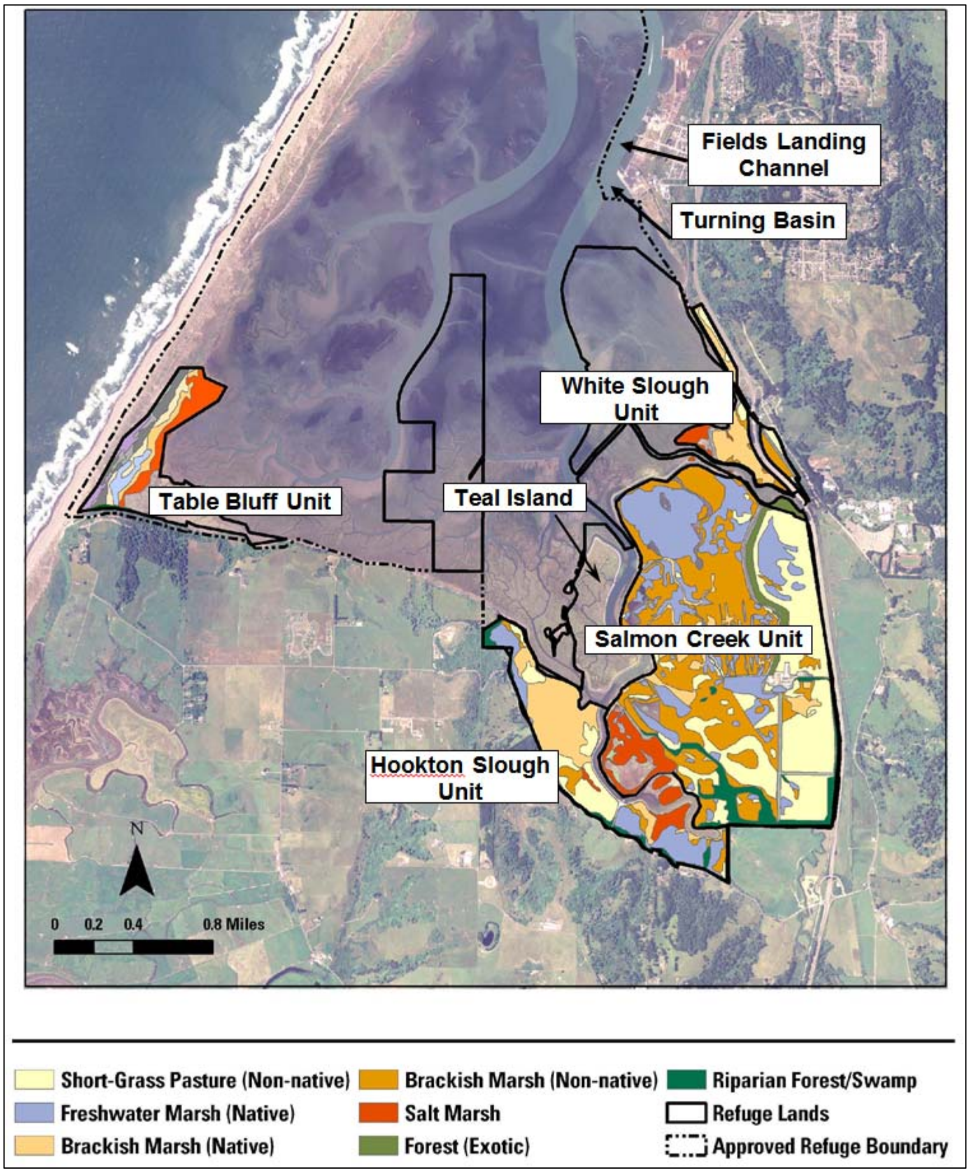


Figure 43: Humboldt Bay National Wildlife Refuge Boundaries (White Slough, Salmon Creek, Hookton Slough, and Table Bluff Units).

Figure 44: Potential Teal Island Salt Marsh Restoration – Plan View.

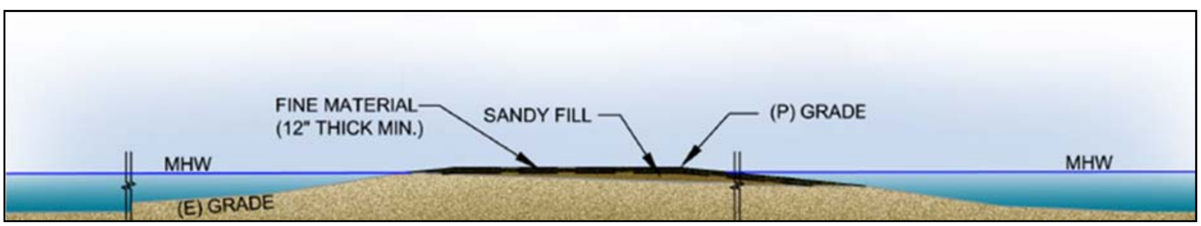


Figure 45: Potential Salt Marsh Restoration – Section.

7.3.1 Design

Possible techniques for salt marsh restoration range from a managed muted tidal exchange through tide gates to completely natural and unmanaged tidal flow. The use of dredged material for wetland restoration should be guided by biological principles including:

* Priority for habitat needs of native species.
* Protection and restoration of wetlands that support threatened, endangered, and other special-status species while ensuring adequate habitat for other species.
* Enhancement of the Bay's ability to support resident and migratory species and reduce fragmentation of existing Bay habitat.

* Recognition that restored tidal marsh should include natural features such as salt pannes, tidal ponds, and large tidal channels that increase the habitat's ability to support large numbers and diversity of shorebirds and waterfowl.
* Provision for connected patches of habitat around existing populations of species of special concern to restore ecological linkages to Bay habitats.
* Provision for a natural transition along an elevation profile from mudflat through tidal marsh to upland. Restoration plans using dredged material will provide for open water, secondary channels, tidal mudflats, low marsh, pickleweed marsh, and high marsh.
* Use of the principles of adaptive management to restore natural function, conditions, and processes to the extent practicable.

Site-specific restoration opportunities for potential beneficial-use sites should be consistent with the above criteria. The site-selection process should typically start with examining the existing physical conditions and the existing habitat at each site. A species-based approach must be used to evaluate the existing and potential habitat values of each site. Sites providing habitat for special-status species or the potential to provide such habitat have higher values than those sites that lack these characteristics.

It is expected that salt marsh development would occur between MTL and ESHW. The non-invasive species of cordgrass would dominate the lower part of the tidal range, whereas pickleweed and salt grass would dominate the upper portion. Above the ESHW, seasonal wetland and upland habitat would be sustained.

The Table Bluff Unit mudflat and Teal Island are similar environments in that both were diked former salt marsh that have now had tidal flow re-established but are mudflat because of subsidence. Methods employed for restoration to salt marsh here would necessitate placing fill on existing mudflat to raise its elevation (HBNWR 2009).

7.3.2 Sediment Sources, Transport, and Placement

A possible source for the sand is the Bar and Entrance Channel, which would become available during USACE O&M dredging. The wave climate in the vicinity of the Bar and Entrance Chanel, combined with the disposal practice at HOODS, are such that a large hopper dredge typically maintains the channel depths. Because the South Bay restoration sites are usually fronted by mudflats that are too shallow for a hopper dredge to cross, delivering dredged material poses a significant challenge for almost all such projects. Such a dredge would have to anchor at the head of the Fields Landing Channel (Figure 43) or at the southern extent of the turning basin, and the sand would be pumped to the restoration site (a distance of more than three miles).

The layer of finer material to be placed as a cap could be dredged from the local marinas and barged to the Fields Landing wharf. From there, a pipeline could be used to transport the material to the restoration site.

Placing material on Teal Island would involve handling a significant amount of water in the slurry. A dredged material slurry in a pipeline is typically four-to-five parts of water to one part sediment. Because the site is not enclosed, the water would have to be contained until the sediment falls out of suspension. This would need to be accomplished by temporarily blocking the existing breaches.

7.3.3 Additional Restoration Sites

There are additional opportunities for a combination of restoration and flood protection in the White Slough Unit of the Refuge (Figure 46). The White Slough Unit totals about 70 acres in size and, like the other units, is a diked former tidal marsh used for pasture. Large areas of the White Slough Unit have subsided as a result of land reclamation, and only about 10 acres of the site function as a salt marsh (cordgrass) with the rest functioning as a brackish marsh. The USFWS has identified opportunities for restoration within the White Slough Unit.

Figure 46: Potential Restoration at White Slough Unit.

Salt or brackish marsh restoration near the entrance to White Slough could be accomplished by raising grades in the form of a transitional edge between the bayside dike and the Highway 101 embankment (Figure 46), and placing dredged material as described above to raise grades for suitable salt marsh plants to establish. The project would also potentially ease the Highway 101 flooding concerns in this area in a manner that still retains a transitional marsh edge between the Highway and the Bay.

7.4 Schema 4: Creating Soft Shorelines within the Bay

The schema is similar to the tidal marsh restoration schema except that it is more appropriate for Arcata Bay, which is much closer to the source of fine-grained, dredged material. Because it is too far from the dredging site and because large dredges are unable to navigate in Arcata Bay, it does not rely on material from the Bar and Entrance Channel. An example location to apply this schema encompasses the shoreline within the Eureka Slough and Jacoby Creek Units of the HBNWR, as well as the area between the two units (Figure 47).

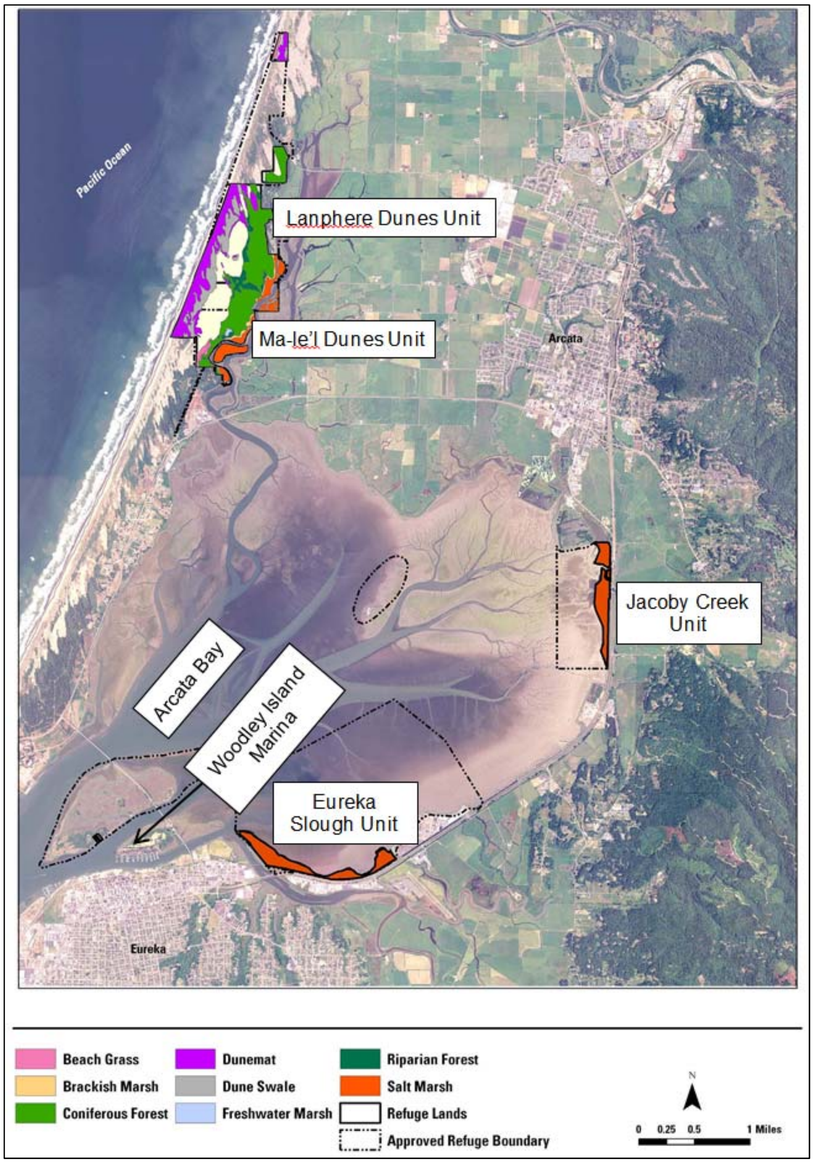


Figure 47: Humboldt Bay National Wildlife Refuge Boundaries (Lanphere Dunes, Ma-le'l Dunes, Jacoby Creek, and Eureka Slough Units).

This schema involves raising the mudflats in the area and creating an upland buffer that would allow for a contiguous marsh to be created along the eastern edge of Arcata Bay. Because the railroad tracks abut the shoreline in this area, it is possible to create a wide enough bay margin to provide flood-control functions and to serve as a multi-use trail connecting the cities of Arcata and Eureka (Figure 48, Figure 49, and Figure 50). There could be potential habitat loss issues related to the presence of fringe marshes and mudflats, so benefits would have to be weighed against habitat loss.

Figure 48: Transitional Marsh Edge - Plan View

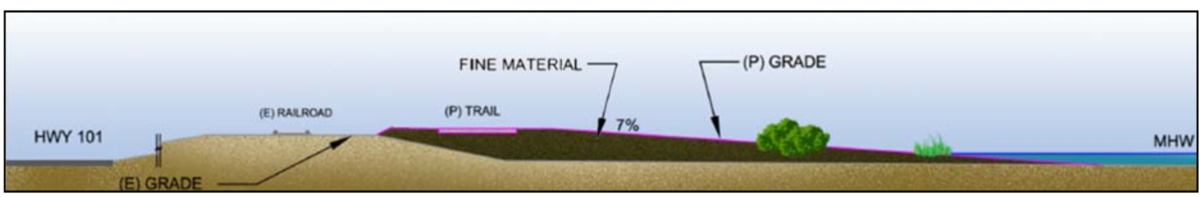


Figure 49: Transitional Marsh Edge – Section View at Fringe Marsh Edge (A-A).

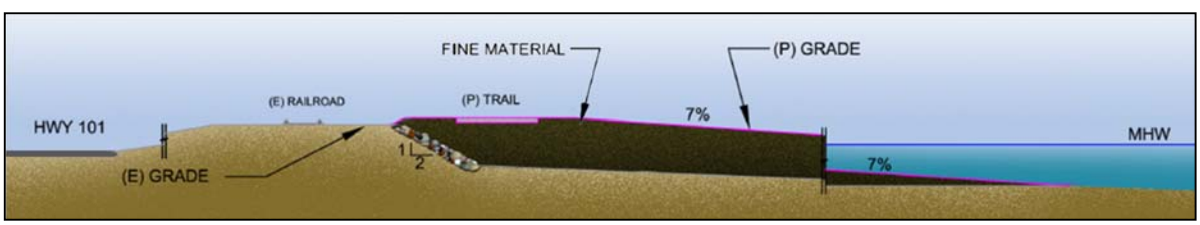


Figure 50: Transitional Marsh Edge – Section View at Armored Edge (B-B).

7.4.1 Sediment Source

For a 150-ft wide buffer along the eastern edge of the Bay, approximately 600,000 yd^3 of dredged material would be required. If the flood control and multi-use trail components are not incorporated because of habitat concerns, the amount of material required would be approximately 300,000 yd^3. The closest sources of material would be local marinas and private docks, which yield approximately 200,000 yd^3 every 8 to 10 years. Material from the Eureka and Samoa Channels, approximately 20,000 yd^3 every year, possibly could be used if the sand content is not too high to prevent proper embankment compaction. The size of the marsh restoration would have to be in keeping with the amount of dredged material per episode unless another source of material can be found.

7.4.2 Transport and Placement

Dredged material could be pumped directly from the Woodley Island Marina dredging areas to the site. Because it would be hydraulic transport and in-water placement, a system of floating or fixed barriers would have to be constructed to control the turbidity created by the slurry (e.g., Figure 51).

Figure 51: Example of a Turbidity Control Barrier for In-Water Placement Of Dredged Material

7.5 Schema 5: Dike Rehabilitation

The premise of this schema is to strengthen and raise the existing dikes protecting the agricultural lands on the north side of Arcata Bay (Figure 52). Typically, these dikes cannot be raised much higher in their current configuration because of slope stability concerns. This concept would take dredged sediment and use it to backfill the borrow ditches behind the dikes, and make the base of the dikes wider (Figure 53). It would also allow a softening of the shoreline by laying back the dikes at a flatter slope because of the wider base. The concept has been successfully implemented in the Sacramento-San Joaquin Delta on several low-lying islands. The most significant issue associated with this schema is the delivery of dredged material to the desired location. If this schema can be implemented in combination with other beneficial-use options, then transportation costs could be shared.

Figure 52: Plan View of North Arcata Bay Flood Protection

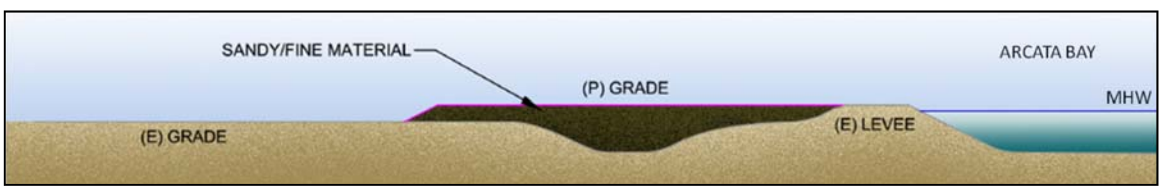


Figure 53: Section View of North Arcata Bay Flood Protection

7.5.1 Sediment Source

The total estimated quantity of sediment required for this project is approximately 130,000 yd³, and could be higher depending on the width of the stability berm created behind the dike. The most likely sources of material for this location would be would be the same as for schema 4. Because the local marinas generate approximately 200,000 yd³ of fine-grained material every 8 to 10 years, one dredging episode would be sufficient to complete this project unless a schema 4 project was being constructed at the same time.

7.5.2 Transport and Placement

The most significant issue associated with this option is the delivery of dredged material to the desired location. If it can be implemented in combination with the previous material transfer option, then transportation would be greatly facilitated. Material could be pumped directly behind the existing dikes after constructing containment berms parallel to the dikes at a fixed distance from the shoreline.

Since this option does not involve in-water disposal, concerns related to turbidity are significantly less than the Intertidal Marsh Edge concept. The biggest issue would be the willingness of the landowner to accept this material (quality of material), and the possibility that the property's drainage system may have to be modified because most of the pump infrastructure behind the dike is close to the Bay edge.

7.6 Schema 6: Recreational Beach in Humboldt Bay

The goal of this schema is to create a safe beach in close proximity to major communities for swimming, kayaking, fishing, and general recreational uses. An ancillary benefit of this option is that a regional stockpile of sandy dredged material can be created to be used in the future as projects get approval and funding. The beaches where this schema would be promising are at Buhne Point and north of King Salmon (Figure 16). One reason these locations are favorable is that incoming wave energy is almost always directed normal to rather than at an angle to the beaches, which would tend to erode the beach. Another reason is that they are close to the City of Eureka, providing easy community access.

A project could extend from the existing beach at Buhne Point (Figure 54 and Figure 55) northward along King Salmon towards Eureka (Figure 56 and Figure 57). That portion of the shoreline currently has a hard straight edge defined by an armored embankment. Removing the riprap and replacing it with a wide sandy beach (or overlaying the riprap with sand) would serve the dual purposes of creating a recreational area and softening the shoreline, which better protects the land behind it. Other locations farther north possibly could work, but they would require more analysis of suspended sediment. The concern is that North Bay has a high ambient suspended sediment load, which would make it less appealing for potential beach goers.

Figure 54: Recreational Beach at Buhne Point – Plan View.

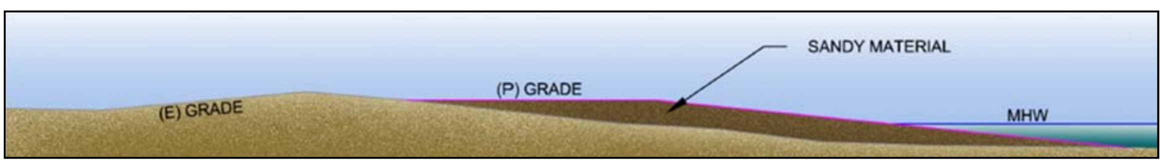


Figure 55: Recreational Beach at Buhne Point – Section View (A-A').

Figure 56: Recreational Beach North of King Salmon - Plan View.

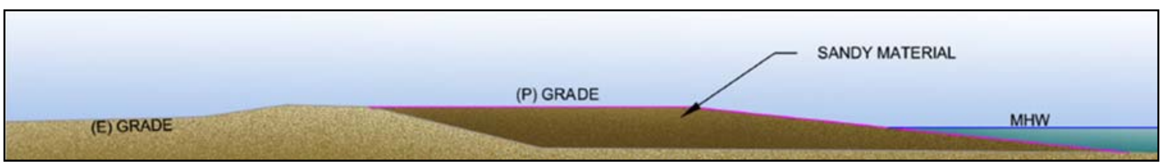


Figure 57: Recreational Beach North of King Salmon – Section View (A-A').

7.6.1 Sediment Source

The total estimated quantity of sediment that this option could accommodate is about 566,000 yd^3 of sandy material, broken down as follows:

* 83,000 yd^3 at Buhne Point
* 483,000 yd^3 north of King Salmon

Given the large amount of sand needed, and the fact that dredged material from local marinas and private dredgers is substantially silt and fine sand, the most reasonable source of material is the dredged sand from the Bar and Entrance Channel, which is also the closest potential source.

7.6.2 Transport and Placement

Sand would have to be pumped from the Bar and Entrance Channel using a hydraulic suction dredge or from a sand holding site in the bay that could be reached by the hopper dredge. Because these locations are closer to the sediment source that those in schema 3, pumping costs would be less.

7.7 Schema 7: Use of Dredged Material for Local Construction

This schema uses dredged sand from the Bar and Entrance Channel for construction in the Humboldt Bay region. Likely this would require stockpiling the sand in a part of the bay not needed for navigation or at a nearby onshore location. The federal channel is historically dredged by deep-draft, ocean-going hopper dredges that have limited ability, especially when loaded, to operate within the bay because of draft limitations. Other methods could be used to facilitate sand storage:

* In-Bay sand transfer –the hopper dredges would come within the Entrance Bay inside the jetties and bottom-dump the sand at near-channel areas. Conventional barges would then pick up the material (sand mining barges for example), and deliver it to existing storage sites along the Samoa Peninsula or to barges that could then go to regions where sand is needed. It is possible that this could be done at no additional cost to the dredging project because the rights to mine an in-water stockpile could be sold to the private sand mining industry.
* Pumping material from the hopper directly to an in-water stockpile (instead of bottom dumping). It would likely require that an in-water containment system be constructed to minimize the impacts of the high-velocity pumps needed to move the sand.

7.7.1 Sediment Source

The primary source of the sand would be the Bar and Entrance Channel where on the order of 1,200,000 yd^3 of sand is dredged annually. The available volume would be limited by the volume needed locally for beneficial-use projects and by the costs incurred to move the sand to where it is needed. The latter is a function of equipment availability and the ability to procure permits to accomplish a cost-effective material transfer.

7.7.2 Transport and Placement

For local stockpiling a 10-acre rehandling area at the head of Fields Landing Channel south of the turning basin, where waves would not spread the mound, could be established. The hopper dredge would bottom-dump the sand in the rehandling area (Figure 58), essentially creating an in-water stockpile. An entire annual dredging episode could be deposited off channel, and the mound itself would only be approximately 3 ft high in a water depth of approximately 30 to 32 ft MLLW. If the water depth at the rehandling area is insufficient for the dredge, the proximity of the rehandling area may make a smaller hopper dredge, e.g., the *Yaquina*, the preferred choice to dredge portions of the Entrance Channel and place the dredged material at the rehandling area.

Figure 58: Potential in-Water Rehandling Areas

Conventional mining barges would pick up the material at the rehandling area and transport it to wherever sand is needed, or to a large regional stockpile north of King Salmon, which would have secondary recreational beach benefits. The stockpiled material could also function as a strategic reserve for the region, and different stockpile locations could be identified and evaluated based on several different criteria, including but not limited to capacity, proximity to transportation infrastructure, effects on aquatic and terrestrial habitats, and cost.

All projects will require permits from various federal, State, and local agencies. Some of those are described below.

8.1.1 Coastal Development Permit/Coastal Consistency Determination

Because each of the seven implementation options involves work in the Coastal Zone, projects of each type will require a Coastal Development Permit or Coastal Consistency Determination from the CCC. If the lead agency is a federal agency – e.g., USACE – and the CCC determines that the project is consistent with the California Coastal Act, it issues a Consistency Determination. If the lead agency is a State or local agency, and the CCC determines that the project is consistent with the California Coastal Act, it issues a Coastal Development Permit. If a CCC-approved Local Coastal Program (LCP) is in place and it includes the beneficial use activity that is being considered, then the agency that has permitting authority over that activity (such as the HBHRCD) could issue the permit instead. However, since many of the beneficial use options described for this CRSMP are not in the approved LCP, it is likely that a CCC permit will be needed.

8.1.2 Section 404/Section 10 Permit

Any project that would involve the placement of sediment below the higher high water line requires a permit from USACE under Section 404 of the Clean Water Act. Any alternative that places sediment below the mean high tide line requires a permit from USACE under Section 10 of the Rivers and Harbors Act. For alternatives below the mean high tide line, USACE processes the Section 10 and Section 404 permits together. The following alternatives would require a Section 404/Section 10 permit:

* Placement site within littoral zone
* Marsh restoration in the Salmon Creek Unit, South Bay
* Transitional marsh edge with multi-use trail along Arcata Bay
* Recreational beach in Humboldt Bay
* Beneficial use as construction fill (assuming a temporary rehandling area within Humboldt Bay)

If the following alternatives do not involve the placement of sediment below the higher high water line, they may not require a Section 404 or Section 10 permit:

* Coastal flood protection with dune enhancement
* Dike rehabilitation along Arcata Bay

To issue a Section 404 permit, USACE must consult with NOAA Fisheries regarding impacts to Essential Fish Habitat. The permit applicant also must demonstrate compliance with the National Historic Preservation Act.

8.1.3 Section 401 Water Quality Certification

Any project that requires a Section 404 permit must also obtain Water Quality Certification under Section 401 of the Clean Water Act from the Regional Water Quality Control Board. Therefore , all alternatives except, possibly, dune enhancement and dike rehabilitation will require Section 401 Water Quality Certification. A monitoring program will be required if a Section 404 permit is issued.

8.1.4 Consultation under Section 7 of the Federal Endangered Species Act

Under Section 7 of the Federal Endangered Species Act, a federal agency must consult with applicable resource agencies (USFWS or NOAA Fisheries in the case of the CRSMP) for any project that has the potential to affect an endangered species. Formal Section 7 consultation requires that the federal agency prepare a biological assessment. The USFWS or NOAA Fisheries uses the information in this biological assessment to prepare a biological opinion. Humboldt Bay has been designated as Critical Habitat for several federally listed fish species. The South Spit is Critical Habitat for federal threatened western snowy plover. The dunes on both the North Spit and the South Spit have the potential to support two federal endangered plant species, Humboldt Bay wallflower and beach layla. Therefore, Section 7 consultation likely will be required for all alternatives (except perhaps placement sites that clearly have no potential for adverse habitat impacts such as dike rehabilitation along certain agricultural lands).

8.1.5 Consultation with NOAA Fisheries on Impacts to Essential Fish Habitat

In accordance with the 1996 amendments to the Magnuson-Stevens Fishery Management and Conservation Act, USACE must consult with NOAA Fisheries on impacts to Essential Fish Habitat. Essential Fish Habitat includes all tidal waters. Therefore all alternatives except dike rehabilitation and dune enhancement will require consultation with NOAA Fisheries. The USACE will prepare an assessment of impacts to Essential Fish Habitat. Based on this assessment NOAA Fisheries will recommend measures to reduce impacts.

8.2 Potential Constraints to Beneficial Use

8.2.1 Federal Standard and Funding

The USACE maintains the congressionally authorized federal navigation channels in the CRSMP region under the Operations and Maintenance (O&M) portion of the federal Civil Works program, based on appropriations from Congress. The channels are dredged based on the *Federal Standard*, which is defined in USACE regulations as the least costly dredged material disposal or placement alternative identified by USACE that is consistent with sound engineering practices and meets all federal environmental requirements, including those established under the Clean Water Act (CWA) and the Marine Protection, Research, and Sanctuaries Act (MPRSA).

This Federal Standard is often expressed as the "least cost, environmentally acceptable" alternative. It defines the *Base Plan* for dredged-material-placement alternatives based on costs that are assigned to the *navigational* purpose of the project. Any costs above or beyond the Federal Standard plan, also referred to as the "incremental costs", have to be borne by the non-federal sponsor.

If a beneficial-use site were identified that had a higher cost compared to the present practice of disposal at HOODS, the incremental cost would need to be borne by the non-federal partner under the O&M program. Also, if the beneficial use includes a site development cost (as would be associated with many of the alternatives using Bar Channel material described in the preceding sections), USACE would typically not pay for it under the O&M program, and the non-federal partner would have to bear that full cost.

The non-federal partner could also lead a beneficial use project for material dredged from the federal navigation channels; in that case, USACE would use the Federal Standard to determine the federal portion of applicable navigational purpose costs and the non-federal partner would fund all the remaining cost. An example of this could be where the non-federal partner desires to implement a habitat-restoration project using material dredged from the federal navigation channels. The USACE would compute the costs for the base plan (disposal at HOODS) and use that to determine how much of the beneficial-use project could be funded by them. The USACE would dredge the channels and deliver the material to a location that costs the same as disposal at HOODS. The non-federal partner would obtain all the approvals and permits needed to place or transfer material at this interim location, and be responsible for all remaining costs. The USACE would still need to complete the due process of preparing appropriate (cost-shared) feasibility analyses, and comply with required environmental regulations.

A non-federal partner under most circumstances would seek federal funding for large-scale restoration projects, because of the large costs involved, which would require partnering with USACE to complete the required studies to demonstrate federal interest. If federal interest is determined, then costs are shared as spelt out in a Project Partnering Agreement, based on guidance from Congress. Depending on the beneficial use, potential non-federal partners that were identified for this study include the HBHRCD, City and County governments, and other state partners such as the State Coastal Conservancy and the Department of Fish & Wildlife.

The present type and size of dredges that USACE uses in Humboldt Bay (the hopper dredge *Essayons* for the Bar and Entrance Channels, and the hopper dredge *Yaquina* for the interior channels) limit their placement options. The *Essayons* cannot access shallow parts of the Bay because of draft limitations, and it does not have the capability to pump material to on-shore locations. The *Yaquina* is too small to work in the rough ocean waters near the Entrance and Bar Channel, and has a small payload capacity to economically move material from the North Bay Channel. Therefore, many of the implementation options require additional handling of material, or use of private dredges, for the beneficial use. Even if the non-federal partner comes up with its portion of the cost-share (typically 25% to 50% of the total, depending on the specific federal program), USACE has to receive federal appropriations from Congress to cover its portion of the cost share. That has become a challenge in recent times because of the number of projects being proposed nationwide.

8.2.2 Priority of Stakeholders

The HBHRCD has many different responsibilities to balance, and their primary source of revenue comes from the small ports and marinas in the Bay. With regard to the CRSMP, their *Harbor* element focus is to have the Humboldt Region channels continue to be maintenance dredged to current authorized depths. While the federal channels are being dredged and taken care of, maintaining the local marinas and docks is getting increasingly difficult, expensive, and time consuming. Their *Conservation* element focus, along with those of a multitude of other agencies, is to enhance and restore the ecosystem in the region. Their *Recreation* element focus, along with those of a multitude of other agencies, is to maintain and improve existing recreational opportunities along the water for the community.

What other regions in California have done is to combine all three focus elements in the form of *beneficial use* of dredged material. This requires prioritizing the various focus elements and gaining consensus from a variety of stakeholders with different interests, not only on the type of implementation project, but on the use of limited funds that are available in the current economic climate. This is essentially one of the key objectives of this CRSMP.

8.2.3 Public Perception of Use of Dredged Material

One of the biggest challenges with the acceptance of dredged material for beneficial use has been the perception of dredged material being a waste and it being harmful to the environment. Until recently, and in many areas even currently, dredged material from channels and harbors was called "spoils" and dredged material disposal was referred to as "dumping." To help people see dredging in a more positive light, starting in the 1980s, USACE and the dredging industry made a special effort to change the dredging vocabulary. They began to substitute more neutral words, like "dredged material," for "spoils" and "dredged material disposal" for "dumping." It helped both the public and the people working in the dredging industry to see dredging not only as a way to improve the economy, but for its potential for environmental enhancement.

Clean dredged material is not a by-product, but a resource for commercial development and environmental restoration (USACE 2002).

The list of successful environmental projects completed in recent times is growing. Ports, government agencies, and other entities continue to find and take advantage of beneficial use opportunities. The focus of maintenance dredging is to provide safe channels in the most economical way – which has implied that USACE could only participate in beneficial use activities if they did not increase costs. Then, in the 1970s and 1980s, USACE began to actively seek out beneficial uses for dredged material that included environmental improvement and reclamation projects. The change in project planning was the result of several factors:

* Social pressure that federal agencies become more environmentally responsible.
* A realization that dredged material disposal sites were almost full at many projects.
* The passage of "cost-sharing" legislation. Under the new laws, USACE can share in the costs of some beneficial uses of dredged material projects, even when the environmental project costs a little more.

Similarly, in the CRSMP region, the Bar and Entrance Channel dredged material has historically not been considered a resource, and removing the material from the system by placing it at HOODS was determined to be the best available option during the site designation and environmental documentation phase. Therefore, one of the critical goals of this CRSMP is to bring together data and science, and the interests of various stakeholders, in a manner that will allow the material to be beneficially used in the future.

The Eureka CRSMP is a guidance document whose purpose is to provide information to those living along or involved in managing the coastline throughout the Eureka Littoral Cell and environs. With respect to the CRSMP, the coastline comprises the outer coast between Trinidad Head and False Cape and all of Humboldt Bay. The intent of the CRSMP is to:

* Provide information on present conditions
* Project conditions over the next fifty years if no action is taken
* Identify erosional hot spots and areas of excess sediment
* Identify a suite of possible management approaches to restore habitat health and enhance resilience throughout the Littoral Cell
* Obtain public input on Plan development and recommendations
* Develop an appropriate governance structure to help ensure that the CRSMP can and will be implemented

The Plan presents a number of regional sediment management opportunities, primarily gathered from prior regional efforts, and a set of specific strategies and solutions. Based on stakeholder input and professional judgment on which potential approach will likely have the greatest impact or be the easiest to implement in a given situation, a prioritized list of strategies and solutions (a "strategic implementation plan") would be a valuable next step.

Adoption of any CRSMP by a governance body and acceptance by the stakeholders is the first step towards this goal. Before taking that step, it is important to explore some of the circumstances that differentiate the Eureka Littoral Cell from the four regions that have adopted a CRSMP – San Diego County, Southern Monterey Bay, Santa Barbara and Ventura Counties, and Orange County. The key differentiators are:

* The adopted CRSMPs for the other regions were for segments of coast without large embayments such as Humboldt Bay. The inclusion of a large estuary brings its own set of complexities, as presented in this CRSMP, that are associated with an estuarine environment (e.g., aquatic, mud flat, and marsh habitats versus sandy coasts).
* The Eureka Littoral Cell has an imbalance of sediment. The Littoral Cell also has significant issues associated with fine sediments, which have been the focus of several regional planning efforts to date (e.g., restoration, local dredging, in-Bay shoreline protection, sea-level rise). The other regions have either significantly more coastal developments and watershed diversions – dams, harbors, recreation beaches – where sand supply has been disrupted (San Diego, Santa Barbara, Ventura counties), or a significant amount of bluff and beach erosion (Southern Monterey region).

* With the history of issues related to sediment management, land uses, and varying jurisdictions within the four other regions, stakeholder groups and Joint Powers Authorities had already been established and goals delineated. These included the San Diego Area Governments (SANDAG), Association of Monterey Bay Area Governments (AMBAG), and the Beach Erosion Authority for Clean Oceans and Nourishment (BEACON). The last comprises Santa Barbara and Ventura Counties. The Eureka Littoral Cell on the other hand does not have such a stakeholder group with varied interests; instead, regional planning efforts to date have emphasized managing the estuary shoreline (HBMP) or tidal marsh conservation and restoration (CCP).

To move towards adoption of a CRSMP for the Eureka Littoral Cell, the interests of a diverse group of stakeholders, many of which do not even directly deal with coastal sediments, will need to be aligned. There have been several regional planning efforts that this CRSMP can leverage, but a significant amount of groundwork and preparation needs to be completed for this CRSMP to be a success.

9.1 Understanding the Success of Other CRSMPs

9.1.1 Southern Monterey Bay CRSMP

The Association of Monterey Bay Area Governments (AMBAG) was CSMW's regional partner for the development of the Southern Monterey Bay CRSMP. The stakeholder group included the Southern Monterey Bay Coastal Erosion Workgroup (SMBCEW), consisting of local jurisdictions and other stakeholders, including local NGOs. The Monterey Bay National Marine Sanctuary (MBNMS) led the discussions.

The CRSMP is driven almost exclusively by erosion concerns. According to the CRSMP, the beaches and dunes in this cell are eroding faster than any others in California. Wide beaches are important for tourism and recreation. The dunes are important for wildlife habitat, and they also provide protection from storms. The CRSMP identified facilities that are at high risk as a result of dune erosion, among them residence complexes and buildings, resorts, and raw sewage pumping stations. If the planning horizon is extended to 100 years to take into account expected sea level rise, other facilities are at risk for loss, including buildings and infrastructure such as the highway and a sewage treatment plant.

The CRSMP identified four major management strategies for the cell:

* Investigate beach nourishment and restoration projects to ameliorate erosion from the stretch of shoreline that contains six of the eight facilities at high risk of exposure. These beaches were promising locations for restoration because they are prominent recreational and tourism areas, and they are located in a subcell characterized by low wave energy and low sand transport.

* Significantly reduce the approximately 200,000 yd^3 of sand mined each year from a pond shoreward of the berm at one beach. This is the last such operation still existing on the U.S. West Coast.
* Allow dune erosion to continue in the northern portion of the cell because the dune erosion provides large quantities of sand to the nearby beaches, and because the area has only two facilities at risk for loss because of erosion.
* Continue current efforts of the local Stakeholder Advisory Group to create a regionally comprehensive erosion abatement approach.

The CRSMP also identified a range of recommended policy changes and projects (which required further analysis for feasibility), aimed at achieving those four actions. One of the key successes of the CRSMP was the ability of the various stakeholders to clearly articulate goals and set management strategies throughout the region. This success was in large part caused by the regional planning efforts that were already underway prior to the initiation of the CRSMP. AMBAG adopted the CRSMP, and it is currently in its environmental documentation phase. Priority areas and pilot projects have also been identified.

9.1.2 San Diego County CRSMP

The San Diego Association of Governments (SANDAG) was CSMW's regional partner for the development of the San Diego County CRSMP. The stakeholder group included SANDAG's Shoreline Preservation Working Group (SPWG), consisting of local jurisdictions, state and federal agencies, and environmental NGOs. Unlike other CRSMPs, which focused on one littoral cell, this one focused on the County's beaches across their three littoral cells.

The primary concern identified in the San Diego CRSMP was insufficient sand along the County's entire shoreline because of regional urbanization and associated development of flood control works and harbors, which have reduced the supply of sand to the shore. As a result, the region was feeling the negative effects of coastal erosion – e.g., narrowing beaches, damage to infrastructure, habitat degradation, and reduced recreational and economic benefits. The CRSMP identified the following:

* Twenty six (26) key potential receiver sites documented to be eroding or with a deficit of sediment, along with an inventory of sand sources in the region.
* Two Management Alternatives for the addition of new sediment to the beaches – one that considered nourishment only (1,000,000 yd^3/yr) , while the other alternative considered nourishment (500,000 yd^3/yr) and installation of sediment management devices to retain more sediment over time
* The potential for wetland restoration throughout the region, and placement of appropriate sediment generated during such restoration on nearby beaches.

* The potential for the release and redistribution of sediment trapped upcoast of Oceanside Harbor, which was thought to significantly contribute to the region's beach-sand deficit .

The CRSMP's overarching goal was to find and place sand on the beaches, and find a way to keep the sand on the beaches. The focus was on locating sources of sand and formulating strategies for how to get the sand to the beaches as needed. The CRSMP also pointed out the need to determine the feasibility and acceptability of different sand retention devices such as submerged reefs. Many of the recommendations were implemented via discrete beach nourishment projects.

One of the key successes of the CRSMP was the consensus on its primary goals – sand nourishment and retention – and the discrete pilot nourishment projects (receiver sites) that were identified along with sand sources. Similar to the Southern Monterey Bay CRSMP, a significant amount of regional planning efforts had already been completed prior to initiating the CRSMP because an established governance structure (SANDAG) was already in place.

9.1.3 Santa Barbara and Ventura County CRSMP

The Beach Erosion authority for Clean Oceans and Nourishment (BEACON) is a Joint Powers Authority comprising Santa Barbara and Ventura Counties and the cities of Goleta, Santa Barbara, Carpinteria, Ventura, Oxnard, and Port Hueneme. It was CSMW's regional partner for the development of the Santa Barbara and Ventura County CRSMP.

The concerns identified for the study region were similar to those of the San Diego region (deficit of sand to beaches) because of dams and submarine canyons, and with an additional concern related to the multitude of shore protection and other structures that have altered natural sediment processes and have deprived the beaches of needed sand. The CRSMP identified the following:

* Six different reaches between Pt. Conception and Pt. Mugu, which had a variety of problems;
* Specific data assessments and studies that should be pursued including sand source investigations.
* Specific management activities that should be initiated to facilitate smoother permitting and identification of revenues.
* Specific policy actions that would be beneficial, including execution of a sand rights policy and development guidelines to enhance and protect the shoreline.
* Need for regional sand stockpiles for use when needed.
* Specific capital improvement projects including beach nourishment and shoreline preservation, use of reefs and other innovative sand retention structures, wind-blown sand management, sand capture before it is lost to submarine canyons.

In January 2009, the strategies identified in the Plan were subsequently adopted by the BEACON Board of Directors. A Strategic Implementation Plan was subsequently prepared to prioritize projects and activities across the region. One of the key successes of the CRSMP was the multi-user dialog that facilitated the development, and in many cases, the implementation of several key management actions, and the creation of policies for diverse segments of shoreline at a regional scale.

9.1.4 Orange County CRSMP

The County of Orange was CSMW's regional partner for the development of the Orange County CRSMP. While some beaches in Orange County are wide and healthy, many others have chronic erosion problems and even some of the wide beaches depend on ongoing nourishment activities. The CRSMP for the region emphasized coastal maintenance needs through a multi-pronged approach ranging across geographic regions and utilizing many possible methods.

The recommended activities were broadly categorized into three types:

* Performance improvements that included monitoring and feedback activities, which could inform other activities for better decision making.
* Construction activities, which are projects that could be built to support coastal RSM objectives.
* Governance and Regulation activities, which are intended to provide the governance structure and improve government regulation to facilitate Plan implementation

Activities were ranked into high, medium, and low priority based on a combination of stakeholder interests, perceived needs, recreational benefits, shore-protection benefits, funding availability, costs, habitat impacts, regulatory requirements, and ability to procure permits.

Recommended actions ranged geographically from the upland streams and rivers of Los Angeles and Riverside County, down to the beaches, and into the nearshore areas of Orange County.

Some of the recommended actions could be carried out through existing institutions and did not necessarily require development of a dedicated JPA. Other recommendations could be carried out by local agencies. Beyond these small or ongoing projects, an organized effort would be required to fully implement the CRSMP.

9.2 Leverage Prior Collaborations and Governance Structures in the Eureka CRSMP Region

There have been recent, multi-user, multi-objective activities in the region that have resulted in substantial dialog between various interest groups and the identification of goals and objectives. It is critical that continuing dialog become the basis for implementing portions of this CRSMP plan. Some of the most significant efforts, which resulted in the creation of regionally important work products, are described below, along with the relevance and applicability to this CRSMP.

9.2.1 Humboldt Bay Management Plan (HBHRCD-led effort)

The HBMP, prepared in May 2007, has the express mission statement to *"Provide a comprehensive framework for balancing and integrating conservation goals and economic opportunities in a cooperative manner for the management of Humboldt Bay's resources."* Initiated by the HBHRCD, it is an ecosystem-based approach for managing the entire Bay. It is broader in scope than HBNWR's CCP because it addresses all activities on the Bay, rather than being limited to conservation or on lands owned by NWR. The plan outlines goals for each aspect of the HBHRCD's mandate: commerce, recreation, and conservation.

The Management Plan covers approximately 27 square miles under the direct regulatory jurisdiction of the HBHRCD (all of the tidelands and submerged lands of the Bay shoreward to a tidal elevation of MHHW). It also includes a broader area, called the Sphere of Interest, surrounding the primary boundary to take into consideration land uses adjacent to the Bay. The Management Plan contains information on the current and historical condition of the lands all around the Bay.

The scope of the Management Plan is much broader than the beneficial use of dredged material, but it does recognize such beneficial use as being an integral part of the regional strategy. It specifically recommends development of a Long Term Management Strategy (LTMS), a recommendation echoed in this CRSMP.

The process of stakeholder outreach and public participation is an important precedent for this CRSMP, and the goodwill created during the process should be reinstituted. The District had created an ad-hoc agency and citizens committee labeled the Interagency Coordination Committee (ICC). To formalize the HBMP planning process, the District Board of Commissioners also appointed the HBMP Task Force (Task Force), made up of agency land managers and representatives of various Bay-user stakeholder groups, many of whom were regular participants in the ICC (Figure 59). As the planning process began to take shape, the depth and importance of this effort became evident.

Relevance to Eureka CRSMP: An opportunity exists to regroup the agencies and stakeholders that worked on the multi-year effort, formally adopt a CRSMP for the area, and, with the County, jointly lead a new effort to implement this CRSMP.

Humboldt Bay Harbor, Recreation and Conservation District Board of Commissioners

District Administrative Core Team

Board Advisory Committee:
Commissioners (2)
Chief Executive Officer
Conservation Specialist
Environmental Planning Consultants

Task Force Representatives

City of Eureka
City of Arcata
County of Humboldt
U. S. Environmental Protection Agency
Bureau of Land Management
Humboldt Bay National Wildlife Refuge
California Department of Fish & Game
Region 1
Marine Region
Humboldt County Resource Conservation District
Recreational User Group Representative
Environmental Group Representative
Commercial/Industrial Group Representative
Mariculture Industry Group Representative
Commercial Fishing Industry Group Representative
Education Group Representative
California State Coastal Conservancy

Figure 59: Project Organization for the Humboldt Bay Management Plan

9.2.2 Comprehensive Conservation Plan (USFWS-led effort)

Written in early 2009, this document is a 15-year plan for the lands owned by the HBNWR in Humboldt Bay. The USFWS prepared the plan to guide management of fish, wildlife, plants, other natural resources, as well as visitor uses of HBNWR lands. The HBNWR boundary extends over 9,500 acres of marsh, agricultural, mudflats, eelgrass beds, and dune lands distributed in many smaller units around Humboldt Bay. The document describes in detail the types of land, and the plants and animals on the land in each of the many individual units of the HBNWR. It also provides a comprehensive overview of the historical acreages of tidal marsh all around the Bay

The CCP emphasizes maintaining, enhancing, protecting, and expanding wildlife areas. It does not address commercial interests or sediment management, but it is a valuable resource from a conservation objective standpoint. The CCP identifies several sites within its purview as candidates for marsh restoration. It also suggests that clean dredged material could be used to bring substrate up to the appropriate levels for marsh vegetation. Any specific marsh restoration or shoreline protection projects that are considered for beneficial-use sites should be consistent with the stated goals of the NWR plan.

A core team of planners, biologists, archeologists and managers from the USFWS, members of tribal governments, and specialists from various relevant disciplines prepared the CCP. Input from elected officials, state resource agencies, and the general public was solicited for the scoping meetings, and the majority of each public meeting was spent documenting public comments.

Relevance to CRSMP: The CRSMP creates an opportunity to regroup the core group of planners and biologists who were instrumental in the preparation of the CCP, to incorporate other areas within the CRSMP region (north to Trinidad and south to False Cape), and for them to actively participate in the implementation of the CRSMP by identifying near-term opportunities for beneficial use of dredged material.

9.2.3 Dredged Material Management Plan (in-progress, USACE-led effort)

The USACE is currently preparing the DMMP for federal dredging in the Humboldt Bay region. As stated in its *coordination* goal: "The DMMP will coordinate all studies, investigations, analysis, and results with interested and mandated government agencies, professional disciplines, project sponsors, non-profits, and concerned citizens. Coordination will include identifying biological and physical process studies required to execute a pilot project, community outreach efforts, and environmental documentation." Based on input from stakeholders, USACE is evaluating the feasibility of alternative placement strategies for the material dredged from the region. The concurrent timing of this CRSMP and the DMMP offers an excellent opportunity to plan implementation projects jointly.

Relevance to CRSMP: The DMMP addresses sediment transport and beach erosion in the region, and the opportunity exists for USACE to continue being the technical lead, to create a data-sharing platform for the monitoring data related to the HBDS that will soon begin, and to lead or participate in regularly scheduled science forums along with the scientific community to disseminate oceanographic data that went into preparation of the DMMP.

9.2.4 Humboldt Bay Initiative (California Sea Grant-led effort)

The Humboldt Bay Initiative (HBI) was formed to bring together resource managers, scientists, and community members to address management issues that cross disciplines and to link science and management for the Humboldt Bay ecosystem. The HBI has already brought together local stakeholders to envision the desired future state of Humboldt Bay ecosystems and communities, to understand current conditions in the ecosystem, and to collaborate towards effectively implementing ecosystem-based approaches. Over the past three years, the group has grown to include over 80 participants and made substantial progress in developing principles for implementing ecosystem-based management (EBM). The HBI facilitates ongoing coordination and collaboration among local agencies, resource managers, and local constituencies. It develops, integrates, and disseminates key ecosystem information.

Relevance to CRSMP: The HBI represents a significant step forward in terms of bringing together various interests with one common goal – that of ecosystem-based management of resources in the region. As such, it is the ideal group to put forth recommendations for pilot projects to address specific challenges that have been recognized and which include the development of holistic approaches to climate change, region-wide restoration, responsible coastal development, and public engagement.

9.3 Establish Governance Structure and an RSM Working Group

The governance structure establishes the strategic, operational, and technical decision-making process required to ensure that elements of the CRSMP, which is a guidance document, are implemented in a manner that enables the local communities to effectively respond to coastal erosion, habitat loss, and infrastructure damage or destruction. Those implementing the governance structure are expected to provide strategic leadership, obtain stakeholder consensus, establish region-wide priorities and cohesive policies, and be accountable and transparent.

9.3.1 Existing Governance Structure and Jurisdictions in Eureka Littoral Cell

Humboldt Bay is the most significant geographic area within the CRSMP planning area, both in terms of population and shoreline length. Thus, logically, a governance structure for the implementation of the CSRMP should be headed by an entity associated with the Bay. Such an entity exists in the form of the HBHRCD. For areas outside the jurisdiction of the HBHRCD, the County of Humboldt serves as the regional lead agency for shoreline management. The County also has oversight over coastal development through the Local Coastal Plan (LCP). Together, those two agencies should be able to ensure that the local cities, communities, and agencies are involved and well appraised over the lifetime of the Plan (~50 yrs) of the relevant coastal processes, sediment management issues, and responses to them.

In 1970, the State of California established the HBHRCD to balance efficiently the variety of uses in Humboldt Bay. The primary mandate of the HBHRCD is to manage Humboldt Bay for the promotion of commerce, navigation, fisheries, recreation, and the protection of natural resources, and to acquire, construct, maintain, operate, develop, and regulate harbor works. The important point in this statement of purpose is the balance among potentially conflicting uses of Humboldt Bay, which the HBHRCD continually strives to achieve (HBHRCD 2007).

The HBHRCD is a county-wide public agency with regulatory jurisdiction over all of the tidal and submerged lands of Humboldt Bay (shoreward to MHHW). Therefore, the HBHRCD's Board of Commissioners exercises development authority over every development project proposed in Humboldt Bay. Within these tidelands, the HBHRCD serves as the "lead agency" for compliance with the requirements of the California Environmental Quality Act (CEQA), application reviews, environmental assessments, and other reviews and approvals authorized for "local agencies" under state law.

Some tidelands were granted to the City of Eureka and other tidelands to the City of Arcata. Accordingly, those cities exercise some original jurisdiction over the primary area covered by this CRSMP. The City of Eureka and the City of Arcata have General Plans (including Local Coastal Plans that implement the Coastal Act's requirements) that have been updated within the past decade. These General Plans constitute the primary policy guidance for the cities' regulation of the tidelands within Humboldt Bay that fall under their jurisdiction.

The HBNWR (part of the USFWS) also owns tidelands, including salt marsh and mudflat, in Arcata Bay and in South Bay. Activities in these tidelands are guided by the HBNWR's management plan. Some of the dunes along the north spit and farther north are administered by the BLM, and management policies are spelled out for these areas. In addition, the Wiyot nation administers lands within the Table Bluff reservation.

9.3.2 Proposed Governance Structure

The CSMW anticipates a local agency (or agencies) to adopt the CRSMP and assume the governance role in its long-term implementation. Because one agency with such a mandate does not presently exist in the Eureka CRSMP region, a governance board is recommended. From a lead agency perspective, development along the region's shoreline is overseen by the County, City governments, and the HBHRCD, making the governance board for implementing the CRSMP plan potentially straightforward. Given that the HBHRCD is a County-wide public local agency with a mandate to oversee development, conservation, and recreation of all tidelands, it could easily be the lead agency for the Humboldt Bay area. The areas outside of Humboldt Bay and within the limits of the Littoral Cell (Trinidad to False Cape) are within the County of Humboldt, which suggests that the County be part of the board of governance. Because the HBNWR, BLM, and the Wiyot nation have jurisdictional authority over some tidelands, their presence on the board should be considered.

Because the HBHRCD and the County of Humboldt are integral to the successful implementation of the CRSMP, they could lead the creation of a board, perhaps in the form of a Joint RSM Committee (JRSMC), or other such non-legal entity, whose primary function would be coordinate and lead recommendations for sediment management within the CRSMP area. The JRSMC could also include other entities, namely the HBNWR, BLM, Wiyot nation, Cities of Eureka and Arcata, and other coastal communities, such as McKinleyville.

The governance board, and more importantly their parent entities, would pass a resolution either adopting the CRSMP, or set the stage for preparing the appropriate programmatic document to facilitate adoption. As a recommended first step, a Memorandum of Understanding (MOU) should be prepared for approval by representatives of the JRSMC, which clearly lays out the organizational structure and management functions of the various representatives, including any shared oversight roles and staffing functions – for example, the Planning Department of the County and the Board of Commissioners for the HBHRCD could each appoint a staff member. The MOU would identify the structure of an Executive Board or a Steering Committee comprised of the leadership of the member agencies and entities who would take the CRSMP forward.

The formation of an entity such as the one described above would allow collaboration across the various government agencies, with the specific objective of sediment management in mind. It would also demonstrate regional interest when applying for grants and other funding from various state, federal, and private agencies. Due to limited fund availability and increased competition from various entities for those funds, regions with an approved regional sediment management plan with governance structure in place are anticipated to have a competitive advantage when pursuing funds for large sediment management projects.

9.3.3 Regional Sediment Management Working Group (RSMWG)

A stakeholder advisory team charged with advising the governance board regarding appropriate RSM activities should be established. A RSMWG is one such group that could be established under the auspices of the JRSMC. The group could potentially include representatives from the JRSMC, local ports, commercial and recreation user groups, resource and regulatory agencies, (e.g., NOAA Fisheries, CDFW, the Water Board, USACE, and the CCC), environmental and community coalitions, academia and scientists, and knowledgeable professionals. The prior regional planning efforts described in Section 8.2 could be used as a starting point to identify the specific agencies and individuals.

The group would not have regulatory authority, but it would help with the coordination of RSM issues to help set the regulatory agenda for members and to steer projects. This working group would address RSM issues including beneficial uses of dredged material throughout the region for multiple projects and set guidelines for implementation. The guidelines would aid project managers, planners, and engineers in developing projects that incorporate CRSMP principles and strategies from inception.

9.4 Develop A Collaboration Strategy

A sample strategy based on similar planning efforts is described below. It assumes that a JRSMC has been created, and that member agencies have agreed upon the goal and objectives, or adopted, this CRSMP.

* The Joint RSM Committee initiates the formation of a RSMWG by inviting stakeholders to participate in the Group. As a start, stakeholders who were already involved in prior regional efforts in the Humboldt Bay region could be approached. The structure of the RSMWG would be clearly spelt out, including member agencies and the nomination of a workgroup chairperson (for example, a rotating chair between the HBHRCD and Humboldt County).
* RSMWG stakeholders conduct a “Visioning Session” to determine both short-term and long-term steps to implement the goals of the adopted CRSMP. The objectives of this session would be to:

    - Discuss and identify Focus Groups for important aspects of the CRSMP (e.g., data inventory, habitat goals, flood protection goals, water quality goals).
    - Create a framework for the preparation of a Strategic Implementation Plan that lays out the process, staffing needs, funding, and timeframe for implementing RSM actions.
    - Agree on a schedule for future meetings and collaboration.

* Each Focus Group creates a set of Goals and Data Gaps, and provides input to the Strategic Implementation Plan.
* The RSMWG holds a public workshop style meeting focused on presenting regional goals related, but not limited to, marsh restoration, flood protection, climate change, and land uses.
* The RSMWG Chair collates focus group reports and public comments into a master Goals Statement, a Data Gaps report, and a Strategic Implementation Plan.
* The RSMWG Chair circulates the documents to the Executive Committee for review and approval.

9.5 Develop an Information-Sharing Platform

As part of the cooperative nature of RSM, information on sediment resources, natural resources, and other factors affecting how sediment resources are managed should be shared among stakeholders. Increased information sharing will aid in allowing all stakeholders to better manage their aspects of sediment resources in the area and will help avoid duplication of efforts for new data gathering and data assimilation.

9.5.1 Share GIS Data

The CSMW has created, and maintains, a public domain GIS database and Webviewer to display relevant sediment management data layers for the California coast. Data from the Eureka Littoral Cell will be incorporated into this system. There are presently several agencies in the Eureka Littoral Cell region with a variety of GIS data resources. Many of these data sources are freely available. To date, there has not been a concerted effort, however, to gather all of the resources relevant to sediment management in the Humboldt Bay region into a unified system.

Building on the CSMW's public domain GIS database would further RSM efforts by allowing stakeholders to access and better utilize dredging records, biological resources data, and information about on-going projects (proposed dredging or restoration activities) or market opportunities (needs and sources of sediment).

For stakeholders outside of the Humboldt Bay region, such a tool would facilitate a better understanding of regional sediment management needs and opportunities. This would likely lead to increased cooperation and generation of new strategies and solutions that may prove effective in meeting the goals and objectives of RSM.

9.5.2 Share Scientific Information

In addition to sharing GIS data, sharing basic scientific information will also help further RSM goals and objectives. At present, there is a wealth of information which has been gathered and generated by various scientific researchers. This information lies in agency reports and internal documents, academic publications, reports by outside consultants, internet sites, and more. Gathering all of this information into a central repository would aid all researchers and users of the information. The CSMW also maintains and updates a searchable reference database that includes references from this and other CRSMPs[1]. The repository could be a physical repository or a digital repository and could be located at the HBHRCD, at the Humboldt State University (HSU) library, and the CSMW website.

9.5.3 Improve Monitoring and Reporting

Many projects, both federal and non-federal, which incorporate some sediment related activities – e.g., dredging and beneficial-use placement – are required to perform regular monitoring. The information gathered from these monitoring reports may be helpful in implementing lessons learned on other projects. Other documentation for projects – e.g., design memoranda, planning reports, permit and National Environmental Policy Act (NEPA) supporting documentation – would also be useful for the larger stakeholder community. As such, sharing these reports would benefit all of the RSM stakeholders in the region, particularly project planners and designers.

9.6 ESTABLISH A VISION FOR THE RESTORATION OF HUMBOLDT BAY

9.6.1 Document Lessons Learned From Other Regions

The San Francisco Bay region has undergone similar large-scale marsh losses to diking and filling that have had significant negative impacts to the ecosystem. In-Bay disposal of dredged material, water quality degradation, and significant habitat losses were the genesis for two significant Regional planning efforts: the *San Francisco Habitat Goals Project*, and the *Long Term Management Strategy* for dredged material. The outcome of those two efforts has been a tremendous success, as evidenced by the implementation of large-scale ecosystem restoration projects such as Sonoma Baylands, Napa Salt Ponds, South Bay Salt Ponds, Bair Island, Montezuma Wetlands, Hamilton Airfield. A summary of the two planning efforts is provided below.

9.6.1.1 San Francisco Bay Habitat Goals Project:

This 1999 report, referred to as the Goals Project, is the culmination of a five-year project to establish habitat goals for the San Francisco Bay region. It is a guide for restoring and improving the baylands and adjacent habitats of the San Francisco Estuary. The basic premise of all the recommendations in the Goals Project is:

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[1] http://www.dbw.ca.gov/csmw/PubDB.aspx

"There should be no additional loss of wetlands within the baylands ecosystem. Furthermore, as filled or developed areas within the baylands become available, their potential for restoration to fish and wildlife habitat should be fully considered."

The Goals Project focuses on the needs of various bayland species and habitats, recognizing that achieving these goals would concurrently provide other valuable and desired wetland services such as nutrient cycling, flood control, and water-quality improvement. The Goals Project selected 120 species of invertebrates, fish, amphibians, reptiles, mammals, and birds to represent the complexity of the baylands ecosystem.

The report looks at the entire Bay, section by section, without regard to current land ownership, costs, and regulatory concerns. It displays the habitat goals for each section of land on a series of maps that cover the different regions of the Bay. Color coding on the maps is used to represent the best use for that land from a fish and wildlife habitat perspective. The Goals Project recognizes that restoring large areas of tidal marsh necessarily reduces the acreage of other types of habitats. The Goals Project gives recommendations for offsetting one type of habitat in favor of another, such as maintaining salt pond complexes and agricultural habitats in some portions of the Bay.

The document as a whole, and the maps in particular, are an invaluable reference tool for restoration projects along San Francisco Bay. As lands surrounding the Bay become available for one reason or another, the Goals Project provides guidance on the best use for that land.

An effort similar to this for the Eureka Littoral Cell region would help identify specific restoration goals for the baylands and habitats along the Humboldt Bay shoreline.

9.6.1.2 San Francisco Bay Long Term Management Strategy (LTMS)

Every year, an average of 3–6,000,000 yd^3 of sediment is dredged to maintain safe navigation in and around San Francisco Bay. The San Francisco Bay LTMS is a cooperative effort of EPA, USACE, the San Francisco Regional Water Quality Control Board, the San Francisco Bay Conservation and Development Commission, and stakeholders in the region to develop a new approach to dredging and dredged-material management in the San Francisco Bay area. The major goals of the LTMS are to:

* Maintain in an economically and environmentally sound manner those channels necessary for navigation in San Francisco Bay and Estuary and eliminate unnecessary dredging activities in the Bay and Estuary;
* Manage dredged material in the most environmentally sound manner;

* Maximize the use of dredged material as a resource; and
* Establish a cooperative permitting framework for dredging and dredged-material management applications.

Over an eight-year period, the LTMS agencies led the development of a significant number of scientific studies and conducted environmental documentation culminating in a new long-term plan for achieving the goals. The new approach calls for reducing disposal within San Francisco Bay over time, and increasing recycling of dredged material for "beneficial uses" including habitat restoration, dike maintenance, and construction fill.

To implement the fourth goal above, the LTMS agencies established an interagency Dredged Material Management Office (DMMO), which serves as a "one stop shop" for Bay Area dredging permit applications. In 1998 the DMMO won a national Vice-Presidential “Hammer” award for its success in streamlining the permitting process for dredging projects.

Given the difficulty faced by local dredgers to obtain permits in Humboldt Bay, primarily because of a lack of disposal sites, a plan such as the LTMS and an entity such as the DMMO would help align the interests of commercial entities, regulatory agencies, and resource agencies, while maximizing the potential for restoration and other beneficial uses of dredged material.

9.6.2 Conduct Focused Research & Studies

9.6.2.1 Characterize Existing Habitats and Prioritize Habitat Goals

Several comprehensive studies related to critical habitats of Humboldt Bay have been completed over the past few decades. The CCP also articulates a vision for NWR lands and has identified several recommendations to pursue including assessment of existing data and information, detailed topographic and bathymetric surveys, resource inventories, and preparation of habitat management plans.

One of the first steps towards the formation of a regional ecosystem restoration plan for Humboldt Bay would be to prepare a detailed assessment of existing habitats, rate their values from a local and regional perspective, and prioritize habitat goals for the entire region.

9.6.2.2 Develop a Regional Dredged Material Management Plan

Coordination with DMMPs could benefit RSM implementation as they provide an immediate vehicle for developing and executing the RSM approach. The DMMPs are updated periodically and can be completed for multiple projects at once. The development of DMMPs with RSM goals and objectives may, therefore, contribute to increased efficiencies and reduced costs. RSM can also be used to support DMMPs by expanding the focus of DMMPs from project to regional decisions, and identifying, quantifying, and managing sediment sources and sinks.

A DMMP for federal dredged material is already underway, and a similar effort should be implemented for the material dredged by the HBHRCD and other private dredgers. In fact, the creation of a LTMS type of document is identified as one of the key steps in this CRSMP, because of the impasse that the local dredgers are currently at, with the absence of a regional disposal site to meet their navigation needs.

9.6.2.3 Develop Sediment Suitability Criteria

Since the quality of dredged material (chemistry and toxicity) is of primary concern for evaluation of water quality, aquatic, and benthic impacts of beneficial use, a bay-wide Sediment Characterization study should be conducted, and suitability criteria should be developed for different beneficial-use options. This would facilitate review of beneficial-use proposals by different entities. The San Francisco Bay Area, for example, has guiding documents for implementation of the Inland Testing Manual authored by USACE (USACE 2001), and for sediment screening criteria to assess suitability of material for beneficial use (SFRQWCB 2000).

9.6.2.4 Develop a Cost Structure for the Beneficial Use of Dredged Material

Management of dredged material requires that a number of elements be investigated – for example, real estate easements and rights of way, dike construction and maintenance, shoreline protection, dewatering structures, dredged-material transport and placement, placement-area management. Each of these activities and elements has an associated cost. A draft DMMP for O&M dredging of the Humboldt Bay federal navigation channels includes an evaluation of project life-cycle costs over a twenty-year period, including an alternatives analysis for different disposal sites. Since none of the potential beneficial-use options (except the HBDS, which is a USACE proposed alternative) were hitherto proposed, the accumulated costs of the elements and activities described above were not included in the DMMP.

Understanding life-cycle costs is an important step to understanding the value of the beneficial use of dredged material. A life-cycle cost analysis would also allow for better comparison of alternatives for dredged-material management on an economic basis. Information on additional constraints such as available environmental windows for loading and transporting material will be critical to developing usable cost information. With this information, an economic model can begin to be developed to determine where and how dredged material might be used.

At a minimum, the life-cycle costs for several different types of placement areas (e.g., upland, intertidal, offshore, nearshore) for multiple projects in the region should be determined. This would aid in understanding the economic costs and benefits of each type of placement strategy in the local context of Humboldt Bay. It would also provide a basis for estimating the benefits of beneficial use to a dredging project.

9.6.2.5 Develop Streamlined Permitting Strategies

The primary issues associated with the beneficial use of dredged material are sediment suitability, turbidity from return water, temporary impacts from construction, and conversion of one type of habitat to another. Setting the conditions for such a general permit would require extensive coordination, which would likely be a lengthy and involved process. The RSMWG could coordinate with resource and regulatory agencies to streamline and abbreviate the permitting process for this complex and specialized activity.

Beneficial-use definitions would need to be developed along with best management practices and conditions to limit the impacts to water quality and other natural resources. It is likely that no "one size fits all" permit could be developed to cover all beneficial-use projects; however, even a permit that covered the most common types of beneficial uses would improve the RSM implementation process.

9.6.3 Prepare a Regional Ecosystem Restoration Plan

Creation of a Humboldt Bay Regional Ecosystem Restoration Plan becomes necessary for many of the strategies presented in this document. Such a plan should remain a living document, and the principles of adaptive management should be applied and updated regularly as new information becomes available and priorities shift.

This CRSMP, which comes at a time when several planning efforts are underway in the Humboldt Bay region, could provide a nexus between the various objectives articulated by stakeholders. Most important, there is an opportunity to align the demand for ecosystem restoration, flood protection, and recreational needs with dredging needs.

One of the goals is for the CRSMP to become part of the "adaptive management" of Humboldt Bay as developed and used by the HBI. The HBI has served to integrate activities, especially related to research and ecosystem restoration efforts, around the Bay region. The CRSMP would become an important part of that integrated planning, which, in turn, may facilitate funding of Humboldt Bay restoration projects.

9.7 Identify Potential Grants and Funding Sources

With USACE acting as the federal agency that maintains the channels around Humboldt Bay, any discussion of sediment management strategy starts with them. The USACE has a mandate to keep the nation's federally authorized navigation channels open for commerce, at no cost to the state or local agencies. The HBHRCD maintains the approaches to, and berths, at individual terminals and marinas in the Bay. The Harbor District also serves as the non-federal sponsor for any deepening projects.

In the process of determining a DMMP for a project, a number of alternatives are typically screened and prioritized. For these alternatives the portion of the cost attributable to the *Base Plan* for *Navigational Purposes* (or Federal Standard) is determined. The remaining portion, which may be attributable to other purposes—e.g., ecosystem restoration, flood control, or flood-damage reduction—may be borne by the non-federal sponsor. Many agencies within the various USACE Districts nationwide have concerns that the Federal Standard prohibits USACE from choosing alternatives that are not the least-cost alternative. The USACE can complete higher-cost alternatives, however, if the project proponents can obtain funding for the incremental project costs.

The Federal Standard was originally intended as a reference point for USACE to address project economics with a certain level of consistency. It was not meant to limit federal participation in projects. Restoration is recognized as a mission of USACE, and the placement option selected for a project should maximize the net economic development and national environmental restoration benefits. Therefore, a beneficial-use option may be selected for a project even if it does not meet the Federal Standard for that project. If a beneficial-use option is selected for a project and beneficial use is part of the Federal Standard or base plan option, the costs of that beneficial use are assigned to the navigational purpose of the project and are shared with the non-federal sponsor. In general, obtaining the non-federal funding is the point where many otherwise viable alternatives flounder. This should be addressed by the non-federal partners and resource agency partners in a systematic way to help assure sources of non-federal funding.

This approach, where the alternative is environmentally desirable and a non-federal sponsor chooses to pay the "incremental cost" for a "locally preferred plan", has been successfully used for a number of dredging projects in California (for example the Bair Island and portions of the Hamilton Wetlands Restoration Projects in San Francisco Bay). Regional non-profit agencies and the State Coastal Conservancy provided the funds to cover the incremental cost. Numerous cities and regions have obtained their local sponsor matching funds through the Department of Boating and Waterways (now a division within California State Parks). This policy could be used on other projects to increase beneficial uses of dredged material and implement CRSMP strategies. The locally preferred alternative can also be applied to non-navigation projects (such as flood-control projects) to improve sediment management.

There are other USACE policies and programs that may allow for some of this incremental cost to be borne by the federal government. These programs include:

- Improvement of the Quality of the Environment (Section 1135 of WRDA 1986)

* Protection, Restoration, or Creation of Aquatic and Related Habitats and Regional Sediment Management (Section 204 of WRDA 1992 as amended by Section 2037 of WRDA 2007)
* Achieving Environmental Benefits (Section 207 of WRDA 1996)

Program 1 has appropriations that limit the total amount spent by the federal government nationwide and also has a local-match requirement of 25%. Program 2 above also limits the total amount spent by the federal government nationwide, but depending on the beneficial use and size of the project, the local match varies from 0% (aquatic habitat restoration in a disadvantaged community) to 35% (all others). The last program, Achieving Environmental Benefits, does not have a programmatic appropriation, but requires specific authorization by Congress for each project. This authorization may be most applicable to larger or new projects.

Of concern to USACE is that with cuts to O&M funding, if a project proponent cannot share incremental costs, USACE must select the least-cost alternative. Improved communication and long-range planning between federal, state, and local agencies and project proponents could support more coordinated project efforts where increased attention is given to beneficial-use alternatives and shared funding opportunities. This is especially true for emergency dredging operations, such as those necessary following storms, and periods of larger than normal sedimentation in federal navigation channels. Dedicated non-federal funding sources would help to ensure that the local funds are available when needed. This would help prevent delays in dredging activities, generally unacceptable to ports and navigation interests, because of funding cycles of other agencies. It may be beneficial for USACE to further define and clarify the original intention of the Federal Standard. This would include clarifying how the Standard has been implemented for the region and how different agencies can better utilize the Standard to support RSM practices in the study area.

The areas surrounding Humboldt Bay include the Cities of Eureka and Arcata, and the unincorporated communities of Fields Landing, Table Bluff, and Manila. Together, these communities comprise the largest population centers within the Eureka Littoral Cell boundaries. With a combination of water-oriented development, commercial uses, recreational uses, and significant ecological resources that are being affected by anthropogenic activities as well as ongoing coastal flooding and climate change, the emphasis of much of this CRSMP is Humboldt Bay. McKinleyville, Trinidad, and other smaller communities also abut the shoreline in the Eureka Littoral Cell.

Humboldt Bay is an important component of the CRSMP area in that it is a significant harbor for port-related commercial and industrial uses, as well as being valuable to the region because of its natural and environmental resources, aesthetic appeal, and recreational opportunities. Shipping, commercial and recreational fisheries, boating, and mariculture are important parts of the economy and culture in Humboldt County. Also, it is the only port of refuge on the California Coast north of San Francisco Bay.

The Humboldt Bay region also comprises diverse ecosystems, and the area's topography, wetlands, riparian, and coastal areas provide a variety of habitats for wildlife and migratory birds. A number of sensitive plant species are found in dune and marsh habitats in the region. In addition, there are a significant number of sensitive and threatened fisheries, birds, and marine mammals that occur around Humboldt Bay.

Specific objectives of the Eureka CRSMP, as described by the CSMW, include:

* Reducing shoreline erosion and coastal storm damage
* Providing for environmental restoration and protection
* Increasing the natural sediment supply to the coast
* Restoring and preserving beaches
* Improving water quality along coastal beaches
* Identifying opportunities for beneficial use of material dredged from the ports, harbors, and marinas in the area
* Recommending a governance structure that is designed to facilitate the implementation of this plan
* Assessing regulatory issues and permitting requirements
* Identifying potential funding streams for recommended actions

A brief summary from each of the preceding sections is provided below, along with recommendations for potential next steps to achieve the objectives of the Eureka CRSMP. Significant issues and challenges are **bolded** in the following text.

10.1 Issues and Challenges

The Humboldt Bay watershed saw significant disturbance starting around the time of the California Gold Rush via diking of marshlands, timber harvesting, and railroad construction, the effects of which are being experienced currently in the form of **subsidence** of former marshlands, vulnerability of low lying areas to **flooding** & future **SLR**, and an **imbalance** in the type of natural resources that presently occur (abundance of low marshlands combined with a deficit of high-value tidal marsh).

The Eureka Littoral Cell is a poorly characterized **complex system** with a high-energy wave environment, moderate tides and winds, significant sediment yield from rivers, and offshore features that influence the morphology of the coastline. The Eel River system also yields one of the largest amounts of sediment per unit area along the West Coast and is the most significant contributor of sand to the Eureka Littoral Cell. Additional **sand is** supplied from the Mad River.

Interruption of natural littoral transport processes along the coast, via construction of harbors within Humboldt Bay that required jetties to stabilize the inlet, has resulted in the need for a significant amount of dredging of sand which is presently being placed outside the active littoral zone. This has caused a sediment imbalance along the north and south spits, which is manifesting itself in the form of **beach erosion and bluff recession**. **Tsunamis** also pose a hazard to urban development along the coast.

Given the modest amount of coastal development within the Littoral Cell outside of Humboldt Bay, there have been **limited quantitative sediment transport processes studies** for the region. Of the studies that were conducted prior to approximately 2002, there was no consensus on longshore transport rates, direction of transport, or the fate of Eel River sediments, and the significant amount of sand removed from the channels (over 1,000,000 yd^3/yr) was removed from the system by placing it in deeper water at HOODS. Because dredged sediment has been considered a **waste** in the region until recently (SHN, Trinity Assoc., and NHE 2015), there has been no impetus or coordinated effort to beneficially use the dredged material from the federal or the non-federal channels.

In addition, within Humboldt Bay, there is a significant amount of wave- and tidal current-driven sediment re-suspension from mudflats. Most of the local marinas and docks need dredging of fine-grained sediments re-suspended from their channels and berth areas to continue functioning. Legacy contaminants at several private docks also resulted in the perspective of dredged material being considered a **waste**, which led to upland disposal of much of these sediments.

The above two disparate sediment regimes (sand in the vicinity of the inlet and along the coast versus fine sediment within North & South Bays) pose dramatically different problems in the vicinity of the inlet and within Humboldt Bay:

* Based on monitoring efforts, USACE, who dredges the Bar and Entrance Channel and other federally authorized navigation channels within Humboldt Bay with disposal at the HOODS, has proposed nearshore placement of dredged material just offshore of the North Spit with the intent of alleviating this erosion. Although placement directly on the beaches could be more beneficial, limitations associated with present equipment do not allow such placement. Although the material could also be placed as a foundation within subsided marshlands, the Federal Standard that is the basis for the USACE to make benefit to cost comparisons restricts placement of the material within the marshlands as this beneficial use is more costly than nearshore disposal.
* The HBHRCD and other local marina dredgers, who dredge the smaller channels, are faced with a significant challenge in terms of finding a disposal site for the fine-grained dredged material because prior upland disposal sites have been filled to capacity and no beneficial use sites are being planned currently. Although the need for beneficial use of this sediment has been identified in several locally prepared wetlands conservation and enhancement plans, significant logistical and economic challenges associated with transport and placement of a relatively small amount of dredged material (less than 25,000 cubic yards per year on average) exist.

While locally there was always a keen desire to maintain, restore, and enhance the ecosystem integrity of Humboldt Bay, it wasn't until about the mid-1990s that region-wide efforts were initiated to work cooperatively to develop and implement a restoration and enhancement plan for Humboldt Bay's aquatic ecosystems. These included the Humboldt Bay Management Plan, the Humboldt Bay National Wildlife Refuge Comprehensive Conservation Plan, and the Humboldt Bay Initiative. Although these efforts included coordination between many of the stakeholders, they were prepared independently by different agencies or interest groups, with lead agency-specific objectives in mind and no region-wide governing entity (such as a Joint Powers Authority) exists to date. They were also limited to the Humboldt Bay region, and the coastal areas outside the Bay were not part of the planning effort.

10.2 OPPORTUNITIES AND RECOMMENDATIONS

Based on the efforts of the HBHRCD, the HBNWR, and the HBI, there is an ecosystem scale conservation/enhancement/restoration perspective that is emerging, and the view of dredged material is now changing where beneficial use of the material is being emphasized.

The immediate needs in the region, which can be viewed as opportunities for the CRSMP, are addressing the coastal flooding threat as well as SLR adaptation and resilience, marsh restoration, improving public access, and recreational opportunities along the Bay margin, and mitigating shoreline and dune erosion. Dredged sediment management is an integral part of the Eureka CRSMP, because it represents the largest potential source of sediments for restoring the region's ecosystems.

Several potential schemas for regional sediment uses have been described in Sections 6 and 7 of this CRSMP to assist stakeholders assess what could be accomplished in the region. Stakeholder consensus is needed to prioritize planning and funding efforts for ultimate implementation by the region. A summary of recommended next steps is provided below:

1. Establish a Governance Structure for the CRSMP. The HBHRCD and the County of Humboldt, as described in Section 8, could take the lead by regrouping the agencies and stakeholders that participated in the HBMP, the CCP, the DMMP, and the HBI and creating a Joint RSM Committee (JRSMC). The JRSMC would either adopt the CRSMP or set the stage for preparing the appropriate programmatic document to facilitate adoption.
2. Establish an RSM Working Group comprised of representatives from the JRSMC that would direct RSM activities.
3. Develop a Collaboration Strategy to identify data gaps, prioritize required planning and funding efforts for future activities, and prepare a strategic implementation plan.
4. Prepare an Information Sharing Strategy that would utilize CSMW resources and consist of creating publicly accessible databases that would house GIS resources, scientific information, technical reports, monitoring data, and status reports of the RSM Working Group and JRSMC.
5. Conduct Focused Research and Studies including:

    - Habitat characterizations of the ecosystem
    - Identification and prioritization of habitat goals
    - Development of a dredged material management plan for all dredged material within the Eureka Littoral Cell, including life cycle costs
    - Development of sediment suitability criteria for in-water and on-marsh placement of fine and coarse sediments
    - Development of streamlined permitting strategy for beneficial use of dredged material

6. Prepare a Regional Ecosystem Restoration Plan that would have the ability to adapt to new information and opportunities, and that could be of assistance in seeking grants from various sources.
7. Identify Funding Sources, including local sources for matching purposes, for demonstration and beneficial-use projects including those with environmental, recreational, flood control, economic, and commercial benefits.

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