CHAPTER FIVE AFFECTED ENVIRONMENT

5. AFFECTED ENVIRONMENT

5.1. Physical Resources

5.1.1. Introduction

The lower Columbia River is bordered on the north or Washington side by the Willapa Hills and on the south or Oregon side by the Coast Range Mountains and the Clatsop Plain, a low area extending along the coast. The Pacific Ocean lies to the west with low sand dunes on the Oregon side and headlands on the Washington side. The Columbia River can be characterized as having an estuarine reach and a riverine reach.

Although tidal influence extends upriver to Bonneville Dam at CRM 145, the saltwater wedge does not go far beyond CRM 25 (near Grays Bay). The upriver estuarine boundary is considered to be the downstream end of Puget Island (about CRM 38). Upstream of Puget Island, the Columbia narrows and becomes more riverine in character. The Willamette River joins the Columbia near CRM 101 and the navigation channel extends up the river to WRM 11.6.

5.1.1.1. Marine Environment

The area offshore of the mouth of the Columbia River is characterized as having a high energy environment subject to continual influence from ocean, tidal and river currents and wave action. As a result, bottom sediments are in a continual state of movement and are primarily sand containing very low levels of silt or organic material. Longshore currents vary seasonally in the offshore area, flowing from the north in July through September and from the south in October through June. Wave direction, frequency and intensity also vary with northwest trending wave patterns occurring from April to November and southwest trending, higher waves occurring typically from December to March.

Generally, sediments in the inshore area are fine-grained sand from 0.15 millimeters (mm) in size whereas the deeper offshore portion contains very fine-grained sands (0.11 mm). This reflects the general trend along coastlines moving from a shallower, higher energy environment to a deeper, lower energy environment where only finer sediments are transported by the combination of currents and gravity. A portion of the area, however, does not conform to this general condition. This is due to the combination of Columbia River outflow and ocean currents that form a large eddy in the vicinity of existing ocean disposal site B (figure 4-2). The eddy effect allows finer sediments to fall out of suspension and settle on the bottom creating an area known as the "mud hole." Sediment sampling studies (Hinton, et al., 1992; Hinton and Emmett, 1996) have located this area of finer sediments to the north of existing site B. This silty depositional zone seems to shift widely to the northwest, probably depending on outflow volume.

Other unique physical features are Astoria Canyon and the shale area. A more detailed discussion of the physical environment in the offshore area is found in Exhibit B of Appendix H, *Columbia River Ocean Dredged Material Disposal Sites*.

5.1.1.2. Estuarine Reach

The Columbia River estuary is 4 to 5 miles wide and contains two main channels, the north and south channels. The south channel is an extension of the main river channel upstream of the estuary and carries most of the upland river discharge. The navigation channel follows the south channel through the estuary. The north channel extends upstream to about CRM 20 (near Grays Bay). Wide and shallow inter-tidal and sub-tidal flats separate these two deep channels. The bed of the south channel is composed of mostly fine and medium sand in the 0.125 to 0.50 mm size range. The shallow flats are also mostly sand with some silt. There are silt and clay layers that occur at various depths around the estuary.

5.1.1.3. Riverine Reach

Upstream of Puget Island, the river channel varies from 1,700 to 3,000 feet in width and has minor side channels. Portions of the river have been constricted by pile dikes and sand fills with the amount of constriction varying from a few hundred to several thousand feet. River bends tend to have very long radii, typically over 15,000 feet. Sharper bends occur where basalt cliffs control the river's alignment, such as near CRMs 32 (near Skamokawa), 40 (near Puget Island), and 54 (near Gull Island).

The bed of the main river channel is composed of deep deposits of mostly fine and medium sand (0.125-0.50 mm). Silt and clay make up less than 5 percent of the main channel's bed material. The natural riverbanks consist of basalt or erosion resistant sand, silt, and clay deposits. The river valley is underlain by deep sand deposits. Sandy beaches occur only where dredged material has been placed along the shore. There has been little change in the river's location in the last 6,000 years (Corps of Engineers, 1986).

Navigation development has had an impact on main channel depths. Current thalweg depths are generally near 50 feet throughout most of the study area, with depths of over 50 feet occurring mainly on the outside of bends and around rock outcroppings. Prior to navigation development, much of the main river channel had natural thalweg depths in the 35- to 45-foot range. However, the controlling depth (minimum depth available anywhere along the navigation channel) was only about 12 feet. The controlling depth is 40 feet for the present channel. The riverbed's side-slopes are very flat and depths across the entire channel have increased in reaches with large pile dike fields or high dredging rates.

The Willamette River reach is heavily developed, with many docks and marine facilities. The lower 11 miles of the Willamette River are generally confined to a single channel that varies in width from 1,300 to 2,000 feet. The Multnomah Channel splits from the Willamette at WRM 3 to form Sauvie Island.

5.1.2. Hydrology

The Columbia River drains 259,000 square miles, originating in Canada's Columbia Lake and flowing 1,214 miles to the Pacific Ocean. The average annual discharge at the mouth is over 210,000 cubic feet per second (cfs). Flow from the upper river is dominated by snowmelt, which causes low winter flows and spring freshets. Heavy winter rainfall in the lower basin can cause winter freshets to occur in the study area. Reservoirs upstream of the study area store water during the spring snowmelt. After completion of the large Canadian storage reservoirs in the early 1970s, the 2-year flood peak at the Dalles, Oregon, was reduced from 580,000 cfs to 360,000 cfs with regulation (Corps of Engineers, 1987). Flows in the study area would be slightly higher due to local inflows. Low flows, typically in the 100,000 cfs range, occur in September and October after the snowmelt runoff but before the winter rains. Stored water is released during the fall low flow period to increase hydroelectric power generation.

The average annual discharge in the Willamette River at Portland is 33,000 cfs. High river stages occur in the winter due to Willamette River flood discharges or in the spring as a result of backwater from the Columbia River freshet.

5.1.3. Hydraulics

Ocean tides produce complex, unsteady flow conditions in the lower 140 miles of the Columbia River. The mean tide range is nearly 8 feet at the mouth and about 2.5 feet at Vancouver. Because of this tide range, instantaneous discharges can range from negative values (upstream flow) during the flood tide, to twice the mean daily value at peak ebb flow. The tidal effects are much greater during low river flows than during high flows.

The estuary has two deep-water channels, one on the north side and one on the south side. The north channel extends upstream to Grays Bay (about CRM 20), but is only connected to the main river channel by shallow cross estuary channels and tidal flats. The north channel is generally a slightly flood dominant channel. The south channel is the main river and navigation channel, and is heavily ebb dominant because of the river discharge.

Between CRMs 20 and 30 (near Grassy Island), the main channel shifts to the north side and numerous smaller channels flow through Cathlamet Bay on the south. These side channels are generally less than 20 feet deep, but have reaches that are over 40 feet deep. Upstream of CRM 40 (near Puget Island), the river has a single main channel, with occasional side channels around islands. In the main channel, typical peak ebb velocities are in the 3 feet per second (fps) range, with freshet velocities over 6 fps. During extreme low flows, flow reversals can occur as far upstream as CRM 90 (Ridgefield National Wildlife Refuge).

5.1.4. Salinity

Salinity (salt water) concentrations within the Columbia River estuary vary continuously with time, location, and depth. In the navigation channel, bottom concentrations decrease from around 32 parts per thousand (ppt), or nearly equal to seawater, in the entrance to about one ppt in the vicinity of CRM 25 to 30. Surface concentrations are generally 5 to 10 ppt less than the bottom concentrations at any specific location along the navigation channel. Salinity concentrations in the shallow areas of the estuary are similar to those of the adjacent navigation channel surface concentrations. The extent of salinity intrusion into the Columbia River estuary is determined by tide stages and freshwater discharge. During high tide and low fresh water runoff, salinity levels usually extend farther upstream and have less mixing with freshwater. The low river discharges that occur in the autumn, coupled with high tides produce the greatest upstream salinity intrusion.

5.1.5. Sedimentation

5.1.5.1. Suspended Sediment

Suspended sediment is sand, silt, and clay transported within the water column. It is carried along at near the velocity of the river current and can move long distances before depositing. The silt and clay would stay in suspension for some time, even at very low velocities, but sand would begin to deposit whenever the velocity drops below 3 fps.

The suspended sediment concentrations in the Columbia River are quite low. Measurements taken during the spring freshet in 1922, before any large dams were built, found an average suspended sediment concentration of 130 parts per million (ppm) downstream of the Willamette River (Hickson, 1961). Measurements taken in 1959 and 1960 by the Corps (1961) and in the 1980s by the USGS (USGS, 1980 to 1986) found similar concentrations. Based on observed concentrations and appropriate flow-duration curves, the Corps estimated that the average annual suspended sediment yield at Vancouver has been reduced from 12 mcy per year before any dams were built, to only 2 mcy per year under today's conditions (Corps of Engineers, 1986).

Not all the suspended sediment in the Columbia River contributes to the shoaling problems. A review of USGS sediment data indicates that 80 to 90 percent of the suspended sediment is silt or clay, material not found in significant quantities in the bed of the navigation channel. Sand, which makes up about 95 percent of the bed material, is generally less than 15 percent of the suspended load, and increases to over 30 percent only when the discharge exceeds 400,000 cfs. The current average suspended bed material transport into the study area is between 0.2 and 0.6 mcy per year.

The Willamette River's average annual suspended sediment load is estimated to be 1.7 mcy per year. Less than 20 percent, or about 0.3 mcy per year, of that material is sand and the rest is silt or clay. The Willamette River's transport capacity is very low and fine sediments are deposited within the Portland Harbor reach.

The eruption of Mount St. Helen's produced extremely high levels of suspended sediment in the Toutle, Cowlitz and Columbia Rivers between 1980 and 1987. The Toutle and Cowlitz Rivers' sediment yield dropped significantly since the completion of the Toutle River Sediment Retention Structure in 1987. The current combined suspended and bedload sediment yield from the Cowlitz River is estimated at less than one mcy per year.

5.1.5.2. Bedload

Bedload is the movement of sand grains rolling and bouncing along the surface of the riverbed. In sandy riverbeds the bedload transport shapes the bed into a series of sand waves. These waves move downstream as sediment erodes from the upstream face, deposits in the downstream trough and is then buried by additional material eroded from the upstream face. This movement occurs in a layer only a few sand grains thick. Through this mechanism, all the individual grains in a sand wave are exposed to flow, eroded, transported, deposited, buried, and then eventually exposed again as the sand wave migrates downstream.

In the Columbia River, the riverbed contains a huge volume of sand and is the main source of bedload transport. Sand waves cover the riverbed in the Columbia, and are typically 4 to 8 feet high and 300 to 400 feet long. There is as much as 100 mcy of sand just within the active sand wave zone. However, bedload moves intermittently, slowly and only short distances, so the entire active sand wave zone is never in motion at one time. When the river discharge is less than 300,000 cfs, bedload transport is small and sand waves move only a few feet per day. However, bedload transport increases rapidly when the discharge exceeds 400,000 cfs; sand wave movement can be in the range of 20 feet per day or higher.

The bedload transport rate is the volume that passes through any given river cross-section over a specific period of time. No attempt has been made to directly measure the bedload transport of the Columbia River. However, estimates have been made using two independent methods. An empirical equation developed by the USGS was used to estimate unmeasured load for pre- and post flow regulation conditions. That equation is based on the modified Einstein equation and relates unmeasured load to river discharge (Corps of Engineers, 1986). Applying this equation to the pre- and post-regulation flow-duration curves resulted in bedload estimates of 1.5 mcy per year pre-regulation and 0.2 mcy per year post-regulation.

A second estimate was made by equating bedload transport to the movement of the sand waves present on the bed. Sequential surveys were made of two sets of sand waves, one during high flow conditions and the second during average discharge conditions. The analyses of the surveys and flow conditions resulted in bedload estimates ranging from 0.1 to 0.4 mcy per year. The analysis also found that large sand waves moved only several hundred feet per year.

The bedload movement is generally directed downstream, but there is a small displacement towards deeper water caused by the side-slopes of the riverbed. This displacement is larger on steeper side-slopes causing several important sediment responses along the navigation channel. The response most important to channel maintenance is the formation of cutline shoals along the edges of the navigation channel. The steep side-slopes of the dredge cuts cause bedload to be deflected into the channel, forming new shoals. Over a period of years this action would cause the side-slope adjacent to a dredge cut to degrade until an equilibrium slope is re-established. In many places the side-slope degradation extends for hundreds of feet from the navigation channel. The same bedload process also contributes to bank erosion by moving sand away from steeper shoreline slopes, such as those commonly found at beach nourishment disposal sites.

The bed material in the Willamette River reach varies from fine and medium sand at the mouth, to over 80 percent silt and clay in the upstream part of the navigation channel. Considering channel dimensions and bed material, bedload transport in the Willamette River is estimated to be insignificant.

5.1.5.3. Bank Erosion

Bank erosion along the Columbia River is caused by wind waves, river currents, and ship wakes. Ship wakes and wind waves can erode exposed sandy banks, but only move sediment within the shallow water zone near the shore. River currents can erode banks and carry sediment away from the bankline as either suspended or bedload. The amount of erosion that would occur at any given location depends on the interaction between the eroding forces of waves and currents, and the resisting forces of the sediment and protective measures. The Columbia's natural banklines are erosion resistant, but the sandy disposal deposits are easily eroded.

Wave action, either wind waves or ship wakes, generates a complex movement of sand along the beach. Sand moves onshore with the wave front and then offshore as the wave recedes. When the waves strike the beach at an oblique angle there is long-shore movement of sand in the direction of the wave. Ship wakes also have an initial draw down component that pulls sand offshore. Waves induce sediment transport only in shallow water because the horizontal water particle velocity produced by waves declines rapidly with depth. There is very little wave-induced water movement below a depth equal to one-half the wave length. Therefore, given the typical wave lengths of wind waves and ship wakes, most of the effects occur above elevation -3 feet CRD.

Wave action plays a major role in shaping beach profiles. The active wave zone moves back and forth across the beach with the tide and is about the area between the high-water level plus one foot and the low-water level minus 3 feet. Within the active wave zone, a smooth beach profile is created by the persistent washing of the beach by wind waves and ship wakes. The beach profile slopes range from 0.02 to 0.10 feet per foot at various locations on the river. In sediment deposits that extend above the high-water line, a steep scarp can be formed near the high-water line. This is caused by waves eroding the toe of the deposit and causing the upper bank to collapse. The collapsed material is then eroded away by waves or currents leaving a steep scarp. Wave action would eventually form a fairly stable beach profile if river currents did not erode the toe of the beach slope.

River currents erode the banklines by entraining material into either suspended or bedload transport. These processes are especially intense during high flows when currents are fast and higher water levels expose more of the bankline to erosion. Erosion rates also vary with location on the river, being higher on the outside of bends and in constricted reaches than on the inside of bends and wide reaches. The erosion caused by river currents extends from the shoreline to the river bottom and completely removes material from the site.

The Columbia's natural banklines consist of basalt or erosion resistant sand, silt and clay deposits. As mentioned earlier, there has been little change in the river 's location over the last 6,000 years. Only in a few isolated locations, such as the upstream end of Price Island (CRM 34-35), has there been erosion of the natural bankline. At Price Island, since 1878 the river has been eroding about a one-mile reach of bankline at an average rate of 10 feet per year. This erosion extends to depths of 70 feet, which indicates that it is caused by river currents.

Dredged material disposal sites line half the Columbia River shoreline between CRMs 21 (near Grays Bay) and 106 (Burlington Northern Railroad bridge). These disposal sites are highly susceptible to erosion by waves and river currents. The fine and medium sized sand placed in these disposal sites is highly erosive material. The beach nourishment disposal also creates steep side-slopes that are less erosion resistant than the bed or beach that existed before disposal. The actual rate of erosion at shoreline disposal sites varies greatly. The river bathymetry, time since last disposal, proximity to the channel, wind fetch, discharge and current pattern, and amount of bank protection all can influence the rate of erosion at a disposal site.

A 1990 study (Abbe, 1990) measured erosion in the first year following beach nourishment at three locations, Price (CRM 34-35), Puget (CRM 38-44) and Gull (CRM 55) Islands. The study found that during that year, the average erosion rates for the sites were approximately 700, 400, and 100 cubic feet per foot of shoreline, respectively. At Puget Island, the erosion rate was much higher on the downstream end of the site (about 1,500 cubic feet per foot) than at the upstream end (50 cubic feet per foot). The study also estimated that ship wakes could account for only 4 to 24 percent of the observed erosion at Puget Island.

Pile dike fields have been built along the river to concentrate flow and stabilize the channel. The dike fields slow the current near the shore, reducing the erosion potential. Most of the shoreline disposal sites are provided some degree of protection from river erosion by pile dike fields. The effectiveness of a pile dike field in reducing bank erosion depends on the length and spacing of the dikes, and the location on the river. Bank erosion increases as disposal deposits extend closer to the end of the pile dikes. There are several pile dike fields, such as Brown Island (CRM 46), Willow Grove (CRM 58), and Sand Island (CRM 86), where erosion increased because material was placed to far out toward the channel. However, the most rapid erosion occurs at unprotected beach nourishment sites located near the channel, such as Miller Sands Spit (CRM 23.5), Skamokawa (CRM 33.5), the downstream tip of Puget Island, and Wallace Island (CRM 47.8).

5.1.5.4. Sediment Discharge

Sediment transport through the mouth of the Columbia River occurs as both suspended and bedload transport. It is likely that most of the estimated 2 mcy per year of total suspended sediment is transported to the ocean during high flows. Hubbell and Glenn (1973) estimated that 30 percent of the fine suspended sediment entering the estuary from up river is retained in the estuary.

The potential beach sand discharge is quite low. Suspended sand transport in the river is estimated to be only 0.2 to 0.6 mcy per year and some of that is likely to deposit in the estuary. Bedload transport contributes additional sand to the estuary, but it is not discharged to the ocean. The shape of the sand waves show downstream transport to about CRM 18. Between CRMs 18 and 10, the sand waves transition from fluvial-dominated to tidal-dominated waves. Bedload transport at the entrance was found by Walter et al. (1979) to have a net inland transport.

5.1.6. Water Quality

The water quality of the Columbia and lower Willamette Rivers has recently been addressed in two studies (Tetra Tech, 1995; Tetra Tech, 1996). The conclusion of these studies relative to the health of the rivers characterize them as 'marginally healthy' based on levels of dissolved oxygen, toxins, and habitat conditions. The primary unregulated sources of pollutants include non-point sources such as urban and agricultural runoff.

Oregon and Washington's 1998 303(d) list of water quality-limited streams shows the Columbia River and the project area as exceeding the following water quality criteria: temperature, bacteria, dissolved oxygen, total dissolved gas, narrative toxic standards, arsenic and pH. In addition, the entire Columbia River Basin is subject to an EPA total maximum daily load for dioxin.

5.1.7. Sediment Quality

5.1.7.1. Background

Sediments in the Columbia and Lower Willamette Rivers may have been exposed to past and ongoing contamination from industrial, urban, and agricultural activities along the river. Contamination can cause unacceptable adverse environmental impacts to biota in and along the river. Human health can also be affected.

The Corps has been collecting sediment data on the Columbia and Willamette Rivers since the 1930s. Samples have been evaluated under the requirements of the CWA and MPRSA since the late 1970s. Sediment evaluations have determined that the material typically dredged during maintenance operations on the Columbia and lower Willamette River is suitable for unconfined in-water disposal, based on the physical and chemical characteristics of the samples. Prior to discharge of dredged material into the river or ocean environment the potential for unacceptable adverse environmental effects must be evaluated. The framework for sediment quality evaluation employs a tiered approach utilizing both chemical and biological analyses as necessary to provide effects-based conclusions (*Dredged Material Evaluation Framework, Lower Columbia River Management Area,* November 1998). The evaluation framework is the result of a cooperative effort of the Corps, EPA, WDNR, and the ODEQ, which supplements joint Corps and EPA guidance for in-water disposal of dredged material.

Existing information is gathered as a first step in the evaluation process. One of the more extensive general evaluations of sediment quality conducted in the study area was that of the Lower Columbia River Bi-State program. The 1991 reconnaissance survey and the 1993 backwater reconnaissance survey collected and analyzed sediments from 69 sampling stations. Only two of these stations were actually located in the Federal navigation channel both were comprised of clean sandy material free of contaminants. If evaluated under the tiered approach only four of the Bi-State stations, all located outside the navigation channel, would require further testing. These stations exceeded the established screening level for total DDT; no other screening level at any station was exceeded.

The Bi-State study did not include the Willamette River. However, at the request of DEQ, in 1977 the EPA conducted a Portland Harbor sediment investigation study where 150 surface and 37 subsurface sediment samples were collected and analyzed, *Portland Harbor Sediment Investigation Report (EPA910/R-98-006),* May 1998. The study area focused on the shorelines of the Willamette River between RMs 3.5 to 9.6. No stations were located within the Federal navigation channel. The DEQ's initial data interpretations state that:

> The data shows highly elevated levels of contamination in discrete areas. The most highly elevated levels occur near existing and pending DEQ cleanup sites, and contaminant migration and resuspension within the study area are very limited (Michael Rosen presentation to Oregon Law Institute, Contaminated Sediments Course, September 1998).

The Corps has conducted numerous sediment quality evaluations on the fine-grained sediment it dredges from the various side-channels and projects it dredges along the Columbia River. With very few exceptions the material has been found to be acceptable for unconfined in-water disposal. This includes the material routinely dredged from the Willamette River.

5.1.7.2. Sediment Quality Evaluation

Sediment was collected and tested for physical and chemical properties from the mainstem Columbia and Willamette Rivers for this study (see Appendix B, *Columbia and Willamette River Sediment Quality Evaluation*). The Corps and the EPA share the regulatory responsibility for the testing, evaluation and disposal of dredged material under the CWA and the MPRSA. Except under specific circumstances, as described in Section 5.1.8, all material dredged by the Corps or under Corps' regulatory permits would be evaluated under CWA or MPRSA[4] guidelines. Except under specific circumstances, testing and assessment of dredged material as a hazardous waste pursuant to the Resource Conservation and Recovery Act (RCRA) is not appropriate. Dredged material as defined in 40 CFR 232.2 is excluded from the definition of hazardous waste as long as it is subject to Section 404 of the Federal Water Pollution Control Act Amendments of 1972, as amended by the CWA or under Section 103 of the MPRSA. National policy reflects consistency with international agreements for the evaluation and management of dredged material, per the London Convention, as amended in 1998.

[4] *Federal Register*, Vol 53, No. 80, April 26, 1988, pp. 14903, 14910, 14913.

The guidelines and specifications for dredged material evaluations and disposal site management were developed jointly by the EPA and the Corps. The evaluation guidelines have evolved over the past 20 years to reflect the results of long-term environmental effects of dredging research and the improvements in the technology. Both the MPRSA Testing Manual (the 'Green Book,' 1991) and the CWA Inland Testing Manual (ITM, 1995) adopt a tiered approach to the testing and management of dredged material. Regional manuals or framework documents are being developed to implement the national approach. The tiered testing framework allows for consistent design of project specific testing programs and the subsequent evaluation of test results meet statutory compliance for dredging and disposal of clean and contaminated sediments. These guidance documents are establishment of Regional Management Team is expected to result in more efficient completion of required evaluations, reduced costs, and data availability in a timely manner to the Corps and resource agencies.

Corps' projects containing fine-grained sediments dredged on a regular schedule are tested regularly (approximately every 5 to 10 years). The testing must provide current sediment quality information to allow dredging to proceed. New projects, projects dredged less often, or sediments that meet exclusionary criteria are sampled and tested as needed.

5.1.7.3. Navigation Channel Sediments

There are two distinct regimes with respect to the physical and chemical properties of sediment in the navigation channel. These are the mainstem Columbia River and the lower 11.6 miles of the Willamette River. Sediments in the mainstem Columbia River typically are composed of sand with less than one to five percent in the silt to clay size classification and less than one percent volatile solids. The two dominant shoal forms are large sand waves and cutline shoals. Sand waves are present throughout the river channel and cause shoals across the channel. Cutline shoals are much larger and run parallel to the channel and develop at the same location year after year. The material present in the mainstem Columbia River meets exclusionary criteria as defined under the MPRSA and CWA and, therefore, would not be subject to testing.

In June 1997, surface grab samples were collected from the Columbia channel and surface and core samples were collected from the Willamette channel. Eighty-nine stations were sampled from the Columbia channel (CRM 3.0 to 106.2) for physical analysis, and 23 were further analyzed for chemical contaminants. Sixty-eight samples were analyzed from 43 stations in the Willamette River (WRM 0.1 to 11.5) for physical analysis, and 45 (including replicate samples) were further analyzed for chemical contaminants. The following chemical tests were performed: 9 inorganic total metals, polynuclear aromatic hydrocarbons (PAHs), total organic carbon (TOC), total volatile solids (TVS), acid volatile sulfide (AVS), pesticides and polychlorobiphenyls (PCBs), pore water tributyltin (TBT), and P450 reporter gene system (RGS), a dioxin/furan screen.

A summary of the physical and chemical test results for Columbia River sediment is presented below. Additional information regarding the sediment testing and results can be found in Appendix B, *Columbia and Willamette River Sediment Quality Evaluation.*

- Physical analysis, total organic carbon, and total volatile solids. Approximately 95 percent of the material recovered was classified as poorly graded sand with a mean grain size of 0.56 mm and an average TVS of 0.62 percent. Of the 90 samples submitted for physical analysis, only 4 (CRMs 12.4, 83.3, 99.2, 100.2) exceeded 20 percent fines and had greater than 5 percent TVS.

- Metals. Twenty-three sediment samples were analyzed for 9 metals: arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc. Of the samples tested, three samples (CRMs 12.4, 83.3, 100.2) showed the highest levels of metals. However, all three samples were well below the established screening levels.

- Pesticides and polychlorobiphenyls. Pesticides were found in 4 of the 23 samples tested (CRMs 12.4, 83.3, 99.2, 100.2). The laboratory considered these values as estimate concentrations because the value was less than the method reporting limit, but greater than the method detection limit. PCBs were found only in one sample (CRM 100.2). None of the pesticide or PCB levels exceeded established screening levels.

- Polynuclear aromatic hydrocarbons. Low levels of PAHs were found in most of the 23 samples submitted for chemical analysis. Three samples (CRMs 12.4, 83.3, 100.2) showed the largest individual amounts of both high and low density PAHs detected. All levels detected, as well as totals of low and high density PAHs, were well below the established screening levels, however.

- P450 reporter gene system. P450 is the designation for a group of enzymes that play a key role in activating or deactivating many toxic chemicals including PAHs, PCBs, dioxins and furans. The sample at CRM 11.0 contained low levels of PAHs above background. The sample at CRM 12.4 contained somewhat higher levels of PAHs and low levels of chlorinated hydrocarbons. The sample at CRM 83.3 contained the highest PAH level, as well as significant amounts of chlorinated hydrocarbons (PCBs or dioxins/furans). Because PCBs were not detected in this sample, it would be likely that the chlorinated hydrocarbons detected were dioxins/furans.

A summary of the physical and chemical test results for Willamette River sediment is presented below. Additional information regarding the sediment testing and results can be found in Appendix B, *Columbia and Willamette River Sediment Quality Evaluation.*

- Physical analysis, total organic carbon, and total volatile solids. Of the 68 samples analyzed for grain size, 43 (63 percent) exceeded 20 percent fines and/or 5 percent volatile solids. The distribution of fines varied within the sampled area, both up and down the river as well as from the surface to the depth of the cores sampled.

- Metals. Fifty-two sediment samples were analyzed for 9 metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc) and for pore water tributyltin. Of the 52 samples submitted, only 2 (both at WRM 11.5) exceeded the screening level for mercury and lead. Tributyltin exceeded the screening level in two samples (WRM 5.9 and 6.5).

- Pesticides and polychlorobiphenyls. Of the 52 samples submitted, the screening level was exceeded for DDT in nine samples from WRMs 0.8 to 11.3. Only one other pesticide, dieldren, exceeded the screening level in one sample (WRM 11.3). PCBs exceeded the screening level in only one sample (WRM 11.5).

- Polynuclear aromatic hydrocarbons. Two samples exceeded almost all of the screening levels and totals for both low and high PAHs. Three samples exceeded the screening levels for two PAHs. One sample exceeded one screening level for PAHs. These samples were from WRM 2.9 to 6.2. The heaviest concentrations of contaminants were found from WRM 5.1 to 6.2.

5.1.8. Hazardous, Toxic, and Radiological Waste Considerations

Upland disposal of dredged material where there is no CWA 404 activity (e.g.) return flow of effluent to surface waters may interface with a variety of statutes that regulate hazardous substances or contamination. This section focuses on the following HTRW-related issues in the study area.

- Effects of dredging on adjacent properties that are regulated under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA or 'Superfund') and state regulations for Oregon and Washington.
- Disposal of dredged material on potentially contaminated sites.
- Potential effects of disposal at upland sites adjacent to contaminated sites.

Portland District historic (1996 and earlier) sediment quality data from the Columbia and Lower Willamette channels was compared to conservative soil cleanup and screening standards in Oregon (SOCLEAN) and Washington (MTCA Method A) cleanup rules and to the Preliminary Remedial Goals (PRGs) used by the EPA for screening contaminant levels. These cleanup screening levels identify contaminants of potential concern and determine if additional investigation or cleanup may be necessary. The sediment sample results compared were for those channel areas that may be dredged.

With the exception of arsenic, all samples contained contaminants or hazardous substances at levels below the state and federal cleanup screening standards. Arsenic levels in channel sediment range from 1 to 9 milligrams per kilogram (or ppm). Arsenic cleanup levels in Oregon are 0.4 ppm in residential soils and 3.0 ppm in industrial soils. While there are no background studies available for the specific study area, Washington has published data on natural background concentrations of metals in state soils. According to this data (Publication 94-115, *Natural Background Soil Metals Concentrations in Washington*), the 90^{th} percentile arsenic concentration in native soils is 7 ppm and ranges between 5 and 9 ppm. Because of the similar geology between Washington and Oregon, it is likely that arsenic concentrations at upland sites are similar to sediment concentrations, and the 0.4 ppm level of arsenic in soils is below background and cannot be reasonably achieved.

In 1997, surface grab samples were collected from the Columbia River while surface and core samples were collected from the Willamette River as part of this study. Columbia River samples were compared to conservative soil cleanup and screening standards in Oregon (SOCLEAN) and Washington (MTCA Method A) cleanup rules and to the PRGs used by the EPA (Region 9) for screening contaminant levels. Because the Willamette River is entirely within the state of Oregon, those samples were not compared with MTCA Method A cleanup standards. Additional information regarding the sediment testing and results can be found in Appendix B, *Columbia and Willamette River Sediment Quality Evaluation*. Based on these data, no HTRW concerns with disposal of sediment dredged from the Columbia River channel. While arsenic concentrations are above Oregon maximum residential soil concentrations, they are below what is normally considered as background levels in Washington and Oregon.

Upland disposal of sediment from the Willamette River would require special consideration. Levels of some PAHs are above Oregon maximum residential soil concentrations over the sampled length of the river. Between WRMs 2.90 and 6.20, levels of some PAHs are above Oregon maximum industrial soil concentrations. Levels of PCBs were detected above Oregon maximum residential soil concentrations between WRMs 7.5 and 11.5. However, no upland disposal of Willamette River sediments is proposed.

5.2. Biological Resources

5.2.1. Introduction

Project-related actions occur in marine, estuarine and riverine environments. Ocean dredged material disposal sites occur in the marine environment offshore of the Columbia River mouth. Detailed descriptions of the marine environment off the mouth of the Columbia River can be found in Appendix H, Exhibit B. The estuarine environment extends from the mouth of the Columbia River upstream to CRM 38 (downstream end of Puget Island). Tidal fluctuation occurs throughout the length of the project but is most pronounced in the estuary. Project actions in the estuary are associated with channel construction and maintenance dredging and disposal. Estuarine disposal actions may occur in-water, on Columbia River beaches or on islands formed by dredged material deposition over the years. The environmental setting for the river upstream of CRM 38 is riverine in character. Project actions are associated with channel construction and maintenance dredging and disposal either in-water, on beaches and islands or at upland locations.

5.2.2. Marine and Estuarine Environment

5.2.2.1. Marine

The offshore area of the Columbia River is a highly productive biological environment that is influenced by a variety of complex physical processes. The major short-term processes affecting the area include tides and, secondly, local winds and currents. River flow also has a major seasonal impact, the extent of which depends on the volume of flow.

During periods of high river flow in the spring, the area directly off the mouth is influenced more by river flow and tidal cycles than by oceanic conditions. In the area of the river plume, water temperature, salinity and percent of light transmission are correlated with the tidal cycle. During ebb tide, water temperature is higher, and salinity and percent of light transmission are lower. During flood tide the reverse is true.

High river flow produces river-induced upwelling of bottom ocean waters at both ebb and flood tide, though the effects differ. During flood tide, the river-induced upwelling entrains nutrient poor bottom waters to the surface, which produces low nutrient concentrations at the surface. During ebb tide, this effect is reduced and nutrients are more evenly distributed in the water column. Generally during high river flow, overall productivity is higher during the flood tide than during ebb tide.

During low flow in the Columbia (late August), the area immediately south of the mouth is affected more by river flow than during the high flow period. This is likely due to the river having lesser force, causing the river plume to spread out closer to shore. Productivity is directly correlated with the tidal cycle. High productivity and salinity occur during flood tide. Low productivity occurs during ebb tide when low productivity bottom water is entrained on the surface as a result of river-induced upwelling. During the transition period (October), local winds and currents cause nearly complete mixing of the water column. Few tidal and river induced effects are apparent.

5.2.2.2. Estuarine

The Oregon shoreline of the Columbia River estuary is represented by a coastal plain (Clatsop Spit), a low lying sand dune environment dominated by an exotic plant, European beachgrass. A narrow, rocky headland, Cape Disappointment, is the dominant feature on the Washington shore opposite Clatsop Spit. The aquatic portion of the estuary totals about 119,000 acres and includes 58,000 acres of medium and deep water habitats below -6 feet MLLW; 45,000 acres of shallows and flats; 9,200 acres of tidal marsh; and 6,950 acres of tidal swamp (Thomas, 1983). Shallows and flats are prevalent in Baker, Trestle, Youngs, Grays and Cathlamet Bays, Desdemona and Taylor Sands. Deeper waters are generally near or adjacent to the navigation channel. The extensive complex of shallow water and intertidal marsh habitats coupled with the gradation from marine to fresh water attracts species that frequent marine, brackish, and/or freshwater systems.

Dominant features of the estuary include large bays with fringing intertidal marshes, such as Baker, Trestle, Alder Cove, Youngs and Grays Bays, and intertidal marshes associated with islands, such as Cathlamet Bay. Landward of the fringing intertidal marshes at Baker and Youngs Bays and the Oregon shoreline of Cathlamet Bay, dikes have been constructed and the former intertidal marsh/spruce swamp sites have been converted to primarily agricultural purposes. Seventeen diking districts comprising of nearly 14,000 acres occur in association with the Oregon shoreline of the estuary from Tenasillahe Island (CRM 35-38) downstream to Warrenton (CRM 11). An unknown number of districts and diked acres occur on the Washington shore at the mouths of the Grays, Deep and Chinook Rivers. Diked lands in Washington are also used for agriculture.

Lands abutting the estuary and not encompassed by the floodplain are typically hilly and forested. This is particularly true for the Washington shoreline upstream of Chinook. Forested lands on the Oregon shoreline abut the estuary in several places, such as Tongue Point and upstream of Aldrich Point. Douglas fir, western hemlock and Sitka spruce are prevalent coniferous tree species in these locations. Commercial harvest of forests along the Columbia River has been extensive, with sites often having been harvested several times. Therefore, the adjacent land base contains only small, remnant stands of mature or old growth timber. Red alder, big-leaf maple and other less commercially valuable species often dominate newly harvested areas not subject to reforestation.

Islands in the estuary are typically intertidal in nature and most occur in Cathlamet Bay. Notable exceptions are East and West Sand Island in Baker Bay; Rice, Miller Sands Spit, and Pillar Rock Islands on the northern (channel) edge of Cathlamet Bay; and Puget and Tenasillahe Islands. East and West Sand Islands were historically a single, transient shoal in the middle of the Columbia River near the mouth. Construction of various navigation improvements transformed the shoal to an island and shifted it north and westward to its present location. A breach, occurring in the 1930s, formed two islands. West Sand Island contains probably the largest and best remaining native sand dune plant community in either Oregon or Washington. Dredged material disposal from the Baker Bay West (Ilwaco) and Chinook channels has occurred on portions of these islands in the past.

Miller Sands, Rice and Pillar Rock Islands (CRMs 21-27) were formed from dredged material originating in the navigation channel. These islands remain active disposal sites for O&M dredging actions. Active disposal areas/islands typically have little vegetation on the upland portion of the site. This is attributable to the general lack of nutrients in the sand deposited at these locations and the xeric (dry) nature of sand. Neither condition is amenable to establishment of plants. The high tide lines at these islands contain lush vegetation communities because of accumulated organic material (debris) and availability of water. The main island at Miller Sands was formed in the late 1920s and early 1930s and is forested with cottonwoods and alders in the lower elevation areas. Dredged material disposal at Miller Sands now occurs on the spit. Higher elevation zones on the main island are still dominated by grasses and forbs and are indicative of the slow successional change in plant communities on sandy, dredged material sites. Dredged material disposal has also occurred in smaller units on or adjacent to Fitzpatrick, Welch, and Tenasillahe Islands (CRMs 31-38) in recent years. Other older sites used in the past but no longer considered for use are present at other islands or on mainland sites.

Karlson (CRMs 25-27) and Tenasillahe Islands were previously diked. The dike at Karlson Island has failed and the site has reverted back to high intertidal marsh habitat on the north side. Much of the island is a mature spruce swamp forest. Tenasillahe remains diked and is part of the Julia Butler Hansen National Wildlife Refuge, which is managed for Columbian white-tailed deer.

Several minor creeks and rivers with small drainage basins enter the estuary from both shores, and because of their small size, do not influence the river. The Chinook, Deep and Grays Rivers are the principal tributaries entering the estuary on the Washington shore. The Youngs and Lewis and Clark Rivers are the principal tributaries on the Oregon shore.

The Julia Butler Hansen Refuge and the Lewis and Clark National Wildlife Refuge are within the estuarine boundaries. The mainland portion of Julia Butler Hansen Refuge lies between Skamokawa and Cathlamet, Washington. This refuge includes Tenasillahe and portions of Hunting and Price Islands (CRMs 34-39). The Lewis and Clark Refuge encompasses the islands, intertidal marshes and open water habitat from Welch Island (CRM 35) downstream to Tongue Point (CRM 18), including virtually all of Cathlamet Bay. The Clatsop County-Wahkiakum County border forms the northern boundary for the Lewis and Clark Refuge; Rice Island (CRM 21) to Tongue Point represents the downstream line. The Lewis and Clark Refuge provides habitat for waterfowl, shorebirds, raptors, water birds, furbearers and numerous other species.

5.2.3. Riverine Environment

Upstream of CRM 38 (downstream end of Puget Island), the Columbia River is presently confined to a more narrow path than the estuary where bays on either shore widen the river considerably. Throughout this section of the lower Columbia River, substantial alteration of fish and wildlife habitat has occurred since settlement. The construction of dikes and associated drainage channels and pump stations has led to the conversion of substantial acreage of riparian and wetland habitat to agricultural and industrial development. Dredging operations, for construction and maintenance of the navigation channel, have contributed to habitat losses and development in some instances. Highways and railroads are present throughout the area and are a contributing factor in loss of habitat. These losses of habitat have been incremental in fashion and are substantial in aggregate.

The construction of 26 diking districts encompassing approximately 36,000 acres has contributed in part to the greater restriction in width of the Columbia River in the reach from Puget Island to Portland, Oregon. Dredged material disposal actions that formed islands such as Brown, Eureka Bar, Hump, Walker, Lord, Sandy, and Sand, or extended shorelines riverward, have also contributed to the narrowing of the river. In concert, these and associated development actions have substantially changed the floodplain and floodplain habitats of the river. These changes resulted in a substantial conversion of riparian forest and wetlands to agricultural, urban, and industrial lands.

Historic habitat losses along the lower Columbia River were obtained from information on historic habitats provided by Graves et al. (1995) and 1991 aerial photography interpretation (Corps of Engineers, 1996). This information was compared with habitats of the 1880s from the mouth of the Willamette River to the mouth of the Columbia River. Although habitat categories are general in nature in the comparison, the information does provide a strong impression of the changes that have occurred in a little over one century.

The estimated historic losses include about 52,000 acres of wetland/marsh and 27,000 acres of forested wetland habitat. Much of this wetland loss can probably be attributed to the 84,000 acres encompassed by diking districts and/or the 20,000 acre increase in urban/developed habitat that has occurred along the lower Columbia River. The nearly 58,000 acres of land devoted currently to agricultural practices also plays a significant role. Agricultural and urban developed lands are strongly associated with diking districts. Without their presence, the impacts to habitat would probably have been less than currently exists. Riparian forest (cottonwood and ash/broad-leaf forest) exhibited a decline of about 14,000 acres. Conversion to agriculture or urban/developed lands has probably been the main impact to riparian forest habitat.

Riverine associated terrestrial and wetland habitats presently occur in a narrow band along the banks of the Columbia River. Riparian forest, specifically cottonwood-Oregon ash stands, are confined to undeveloped islands or remnant strips along the Columbia River. Wetland habitat is similarly restricted. Side channels and backwater habitats are generally associated with large islands such as Wallace, Crims, Willow Grove, Fisher, Hump, Walker, Lord, Howard, Cottonwood, Sandy, Martin, Burke and Sauvie Islands.

Lands incorporated into diking districts are typically in agricultural activities such as pasturelands or hybrid cottonwood production, typically downstream of Longview or row crops (Woodland Bottoms, Vancouver Lowlands, Scappoose Bottoms and Sauvie Island).

A number of federal and state refuges and wildlife management areas are located in the riverine portion of the study area. These include Ridgefield National Wildlife Refuge and Shillapoo Wildlife Management Area in the Vancouver lowlands and the Sauvie Island Wildlife Management Area in Oregon (CRMs 87 to 100). These refuges provide foraging habitat, both natural and cultivated, wetlands, and riparian forest habitat for wintering waterfowl, raptors, shorebirds, furbearers, and other wildlife species. The FWS has also implemented Conservation Agreements with private landowners in the Clatskanie bottomlands near Westport for the management of Columbian white-tailed deer.

5.2.4. Aquatic Resources

5.2.4.1. Primary Production

Primary production is the basis of the aquatic food chain in the Columbia River and Pacific Ocean. The organisms that are the primary producers include phytoplankton (plant species that occur in the water column), benthic microalgae (plant species attached to rocks and other substrates at the substrate-water interface), and vegetation in marshes and on land. Physical conditions that affect these organisms are light, inorganic nutrients and river flow. Phytoplankton provide 57 percent of the net annual primary production in the estuary; plants on land and in marshes provide 38 percent; and benthic microalgae account for the remaining 5 percent (Simenstad et al., 1984).

5.2.4.2. Phytoplankton

The major portion of the phytoplankton community is composed of freshwater species. Marine species are less dominant even in the estuary principally because of the large influence of freshwater from the Columbia River. The freshwater phytoplankton consists primarily of planktonic diatoms that are the main food source for the zooplankton and the benthic and epibenthic filter feeding invertebrates in the river and estuary.

5.2.4.3. Benthic Microalgae

Benthic microalgae communities consist of diatoms species that attach to the substrate. They are found on mud flats and shallow subtidal flats. Benthic invertebrate filter feeders and detritovores (an organism that feeds on dead organic matter) depend on these organisms for food.

5.2.4.4. Plants

The plant communities in the marshes and on the land provide the principal source of detrital plant material to the river. The detrital plant material is broken down by bacteria to produce the nutrients that are used by other organisms. It has long been recognized that a very important value of marshes is their contribution of detrital material into the river. Macroalgae such as the surfgrass (*Phyllospadis scouleri*) which is found on jetties and headlands and eelgrass (*Zostera marina*) which prefers more protected habitat which are found in the estuary also contribute to the detrital material. Eelgrass is found subtidally on the west side of Baker Bay and in low intertidal areas adjacent to the channels in the bay. Trestle Bay also has eelgrass communities but they are relatively sparse.

There are over 9,200 acres (Thomas, 1983) of tidal marshes in the Columbia River estuary. Fringing marshes are found in Baker, Grays, Trestle, and Youngs Bays and in Alder Cove. They are tolerant of freshwater and brackish conditions and are of relatively recent origin. The mature freshwater marshes are found on the large islands in Cathlamet Bay. Terrestrial and aquatic insects that occur in these marshes provide an important source of food both in the estuary and the mainstem river. The marsh islands also provide important habitat for juvenile fish, birds, and furbearers.

5.2.4.5. Invertebrates

Invertebrate populations in the river and estuary utilize the nutrients provided by the primary producers. They are also important food sources for higher food chain species, particularly for those species, which are of value to human populations.

5.2.4.6. Zooplankton

Zooplankton are microscopic organisms that live in the water. In the Columbia River they can be divided into marine, brackish, and freshwater groups. The freshwater group is dominated by three groups; *Daphnia, Bosmina*, and cyclopoids. Several species of rotifers are also abundant on a seasonal basis. Freshwater populations have the greatest abundance in the early fall, decrease over the winter, and then often show a late spring peak.

The marine and estuarine groups consist primarily of marine species with a high tolerance for freshwater conditions. Dominant groups include copepods and amphipods. Dungeness crab, megalops, and zoea also form a major component of the oceanic zooplankton in the winter months. These organisms are prey to juvenile and some adult fish.

5.2.4.7. Benthic Invertebrates

Benthic invertebrate populations consist of organisms that live both on the bottom (benthic) and on the surface of the bottom (epibenthic). Distribution and abundance of these organisms is directly related to sediment grain size and stability of the bottom habitat. In general benthic invertebrate productivity is higher in areas that are more stable and have finer grain sediment than in less stable coarser grain areas. For instance McCabe et al. (1996) found benthic invertebrate populations to be considerably less abundant in the higher current, coarser sediment areas of the main navigation channel than in the shallower fine grained areas in side channels areas where currents are less strong. Salinity can also be a major factor affecting the distribution of some species in the estuary and Lower River.

A species of particular importance in the estuary and the river is the amphipod, *Corophium salmonis*. It is a microscopic organism and important as a prey item for juvenile and adult salmonids and other species of fish. It occurs in both freshwater and estuarine environments and burrows into the bottom in primarily silty sands during the day. It migrates up into the water column at night to feed. This amphipod is abundant in Youngs and Cathlamet Bays and Desdemona Sands in the estuary and throughout the upriver area in suitable habitat. Its distribution in the estuary is dependent primary upon salinity. Holton et al. (1984) found that it prefers a salinity range from zero to 14 ppt and that its distribution in the estuary changes with seasonal changes in salinity patterns. Its abundance can range from zero to as high as 75,000 individuals per square meter. This species is also able to recolonize a disturbed area rapidly. McCabe et al. (1996) determined that population levels recovered relatively rapidly after a ferry access channel was dredged in the upper river. Complete recovery of the disturbed population was evident in less than one year.

Other groups of benthic invertebrates present in the river and estuary include, oligochaetes, polychaetes, and nemertean worms, as well as mysids, and insect larvae (Sandborn, 1975). These groups, particularly the segmented worms, are generally associated with finer grained organic sediments. Two clam species, *Macoma balthica*, and the Asian clam, *Corbicula manilensis*, are also abundant in the Columbia River. *Corbicula* occurs in the freshwater areas while *Macoma* occurs only in the estuary. It is especially prevalent in Baker Bay the most saline bay in the estuary. Epibenthic species (larger invertebrates) in the river and estuary are crayfish, (*Pacifastacus trowbridgii)*, Dungeness crab (*Cancer magister*) and sand shrimp (*Crangon* spp.). Crayfish are distributed throughout the freshwater part of the river while Dungeness crab occurs primarily in the lower estuary and the ocean. Young-of-the-year crabs occur in the entrance channel while juvenile crabs move up and down the estuary depending on salinity levels, and are found as far upriver as Grays Bay. Subadult crabs (1^{st} to 2^{nd} year class) occur in large numbers in the Ilwaco and Chinook channels in Baker Bay in the winter. Adult crabs are found primarily in the lower part of the estuary and ocean (McCabe et al., 1986).

Benthic populations in the ocean offshore of the Columbia River have been studied since the 1970s (Richardson et al., 1977). The first comprehensive study was done as part of a process to designate ocean disposal sites for material dredged from the Columbia River entrance channel. In 1992 another comprehensive study was done to evaluate additional offshore areas and to compare these results with the earlier studies. A comprehensive study of the offshore area was done again in 1995 and 1996 (Hinton, 1998) to help locate a new site or sites for both the MCR and the channel improvement project.

The species composition and abundance of the benthic invertebrate community offshore of the Columbia River is determined by a variety of factors including: river flow, upwelling, downwelling, seasonal winds and sediment type. In general, abundance is greater off shore in the deeper (greater than 100 feet) more stable areas with fine grain sediments than in the inshore areas where the bottom is more dynamic and the organisms are subjected to wave and current effects. Densities also appear to be higher to the north of the mouth of the River particularly in the area known locally as the "mud hole" where fine-grained sediment from the Columbia River accumulates. The offshore area is also highly variable in species composition and abundance (Siipola, 1992). In some years a single species such as the polychaete, *Owenia fusiformes,* can account for a large percentage of individuals present. Juveniles of the razor clam, *Siliqua* spp., have also been extremely abundant at some stations and in fact have resulted in some of the highest densities of benthic invertebrates collected off the Oregon coast.

Epibenthic populations offshore are composed almost entirely of larger macrofauna. Dominant species include Dungeness crab, sand shrimp, and the mysid, *Neomysis kodiakensis*. The shrimp populations tend to be dominated by adults while the crabs are present in all life stages (megalops, small juveniles, and adults). Unlike the Dungeness crab, the sand shrimp spends its entire life cycle in the estuary. Adult and juveniles, however, occupy different areas depending on salinity levels. Juveniles tend to be in brackish shallow water areas while adults occur in deeper more saline areas.

5.2.4.8. Fish Species

The Columbia River, the estuary, and the Pacific Ocean immediately offshore provide habitat for a variety of anadromous and resident fish species. Anadromous fish are present in the river almost year-round either as adults migrating upstream to spawn, or as juveniles migrating downstream to the ocean. Anadromous species include the following salmonid species: spring, summer, and fall chinook; coho; sockeye, chum and pink salmon; winter and summer run steelhead; and sea run cutthroat trout. Other anadromous species include green and white sturgeon, Columbia River smelt, shad and lamprey.

Upriver migrating adult salmon are present in the estuary and river throughout the year. The resident time in the estuary is usually short and they normally do not feed to any extent. Some may hold in the estuary or lower river, however, for some period of time before entering their spawning streams. Juvenile salmonids are present in the lower river in the early spring and summer during their migration to the ocean. Year old juvenile spring chinook, coho and steelhead smolts (migrants that are actively migrating to the ocean) are migrating principally at the surface in the deeper water and move through the river and estuary without stopping. Chum and fall chinook have life stages that are migrating downstream but have not become smolts yet and are referred to as subyearling fish. They migrate downstream at a slower rate and can be present in the lower river and estuary for extended periods of time. They rear in the shallow water areas and bays such as Cathlamet, Youngs and Grays Bays before they become smolts and migrate to the ocean. Most remain in the estuary throughout the summer while some may over winter in the estuary before becoming smolts and migrating to the ocean.

Resident species consists of both cold water and warm water species. Cold water species include rainbow and cutthroat trout and mountain whitefish. Warm water species include squawfish, small and large mouth bass, yellow perch, chub and crappie. Resident species remain in the river and estuary year around during all phases of their life history.

Marine fish are present both in the ocean and the estuary. Larval and juvenile marine fish comprise a significant portion of the offshore planktonic communities. Smelt, tomcod, right-eye flounder, and anchovy are commonly found in the offshore communities during the winter and spring. Marine species that enter the estuary are generally confined to the deeper channels where salinity is high. Some species and in particular juveniles of these species are more tolerant of lower salinity and can be found further upriver and in the shallower areas associated with the bays. The bays are generally more productive than the channel areas and provide feeding and rearing habitat for many of these species. Demersal fish (living near the bottom) are attracted to the bays for this reason. The channel areas can also have high seasonal abundance of benthic and epibenthic species, which can also attract demersal fish. Pelagic fish (living in surface waters to middle depths) are most likely to be found in areas rich in plankton. Fish most often found in the deeper channels of the estuary are white sturgeon, Pacific herring, shad, and surf smelt. Some marine species such as the Pacific herring use the estuary as a spawning area.

From December to April, smelt migrate from the ocean and into upriver spawning areas in the mainstem Columbia and Cowlitz Rivers and occasionally into the Lewis, Kalama and Sandy Rivers. Smelt are broadcast spawners and females release from 20,000 to 60,000 eggs. Both male and female adults die after spawning. The eggs are sticky, settle to the bottom and incubate for 30 to 40 days before hatching. Larval smelt are about 4 mm in size and drift with the bottom currents as they develop, ultimately ending up in the ocean.

The estuary also serves as a nursery and rearing area for some species of marine fish including Pacific tomcod, surfperch, rockfish, sanddabs, smelt, and flounder. These fish are usually confined to the lower estuary where salinity is higher. Starry flounder, however, are tolerant of freshwater and can be found as far upriver as Portland. English sole and Pacific staghorn sculpin are also somewhat tolerant of freshwater and are found upriver to Tongue Point.

White sturgeon populations in the lower Columbia River are the largest in the species range, due primarily to access to marine areas, abundant food resources and consistently favorable hydrologic conditions during the spawning period (DeVore et al., 1995). White sturgeon occur throughout the lower estuary and river during all life history stages.

Spawning occurs in the deeper areas just below Bonneville Dam though some occur in deeper water areas in the lower river. Spawning lasts for 38 to 48 days from late April or early May through June or July. Fertilized sturgeon eggs were collected downstream from Bonneville Dam at depths up to 100 feet over cobble and boulder bottoms with current velocities ranging from 1 to 12 feet per second. Larval sturgeon were collected throughout the river indicating a wide dispersal after hatching. Young-of-the-year white sturgeon were first collected at the end of June less than two months after spawning. Growth appears rapid during the first summer when they reach a length of 7 inches by the end of September. Young-of-the-year and juvenile sturgeon are usually found in water deeper than 36 feet (McCabe and Tracy, 1994).

Two deep-water sites have been proposed as potential dredged material rehandling sumps, Hayden Island and Port Westward. Surveys at these sites found the presence of moderate numbers of juvenile and larval sturgeon at Hayden Island and very few at Port Westward. Samples were also taken at six proposed flow lane sites in the river from CRM 24 to 81. Larval and juvenile sturgeon were collected year-round in small to moderate numbers. The greatest abundance occurred at stations at CRMs 41 and 59.

Run size of salmon in the river have been decreasing since the turn of the century when over-fishing and habitat destruction severely reduced numbers of spawning fish. Further declines in wild salmon numbers in the early 1990s prompted the NMFS to list the upriver runs of sockeye, and spring/summer and fall runs of chinook as endangered. Run size of salmon into the Columbia River for 1993 to 1995 is shown in table 5-1.

Table 5-1. Minimum Numbers of Salmon and Steelhead Entering the Columbia River, 1994 to 1996 (in thousands, including jacks)

	Chinook						Steelhead		
Year	Spring	Summer	Fall	Sockeye	Coho	Chum	Winter	Summer	Total
1994	81.6	17.6	255.3	12.7	170.3	1.2	(55.2)	211.9	805.8
1995	60.4	15.0	244.7	9.2	74.1	1.5	(21.0)	(251.1)	677.0
1996	94.3	16.0	331.0	30.3	111.7	3.3	(33.4)	(237.1)	857.1

Source: Norman and King, 1997; numbers in parentheses indicate incomplete data.

To supplement run size and to provide migration for lost habitat by construction of upriver dams, hatchery fish have been released in the river since the early part of the century. Hatchery releases of juvenile salmonids for 1996 are presented in table 5-2. Hatchery releases have decreased in the last several years because of the change in practice of releasing large fish in smaller numbers. These larger smolts are expected to have a better survival rate and to be worth more to the fishery than the smaller fish. There has also been concern with the effect hatchery fish may have on the wild populations that are protected under the ESA. Consequently, it has been proposed that fewer hatchery fish be released until the extent of there impact on wild fish can be determined. Recovery plans have been developed for the listed species which are expected to further change wild fish numbers and hatchery releases in the lower river.

Table 5-2. Hatchery Releases in the Columbia River Basin for 1996

Species	Snake River	Mid-Columbia	Lower Columbia	Total
Steelhead	10,461,986	1,411,096	573,614	12,446,696
Sockeye	76,027	402,859	0	478,886
Coho	618,000	1,678,209	8,021,423	10,317,632
Chinook				
Summer	676,894	3,889,547	0	4,566,441
Spring	1,471,673	3,242,943	4,748,321	9,462,937
Fall	630,612	12,399,459	26,442,513	39,472,584
Total	13,935,192	23,024,113	39,785,871	76,745,176

Source: Fish Passage Center, 1997

5.2.4.9. Fisheries

The river, estuary and the ocean area all support both recreational and commercial fisheries. Commercial fisheries are principally for salmon, steelhead, white and green sturgeon, and smelt. Commercial salmon and sturgeon fishing is done by gill net in the lower river. The salmon fishery has been severally limited in the last several years because of declining stocks. The fishery now occurs in stages: mid-February to early March (Chinook salmon), late June (sockeye salmon), one or two days in August (Chinook salmon), and mid-September to mid-November (chinook and coho salmon,). Commercial steelhead fishing is done exclusively by treaty Native Americans. Commercial landings and values for the lower Columbia River below Bonneville Dam are show in table 5-3.

Table 5-3. Lower Columbia River Commercial Landings and Value (in thousands of pounds and thousands of dollars)

Year	Chinook		Coho		Chum		Smelt		White Sturgeon		Green Sturgeon	
	lbs.	value	lbs.	value	lbs.	value	lbs.	value	lbs.	value	lbs.	value
1994	64.1	122.4	496.3	411.9	0.5	0.1	43.5	11.7	167.4	209.3	6.4	2.1
1995	7.3	19.7	189.4	119.3	0.1	<0.1	440.0	66.5	162.4	267.1	11.3	5.7
1996	282.8	115.9	229.6	142.4	0.3	0.1	9.1	11.5	229.5	298.3	19.6	9.4

Source: Norman and King, 1997

There has been a recent development of several terminal fisheries for salmon in Youngs and Grays Bays and at several locations in Cathlamet Bay in the lower river. Terminal fisheries involve the rearing of juvenile salmon in pens and then releasing them to the ocean. When the fish return to the pen area, fishing is allowed in the immediate area to target only on these individuals. This type of fishery was developed to provide fish without impacting wild runs.

Commercial sturgeon fishing is done using gill nets. The fishery, originally a bi-product of the salmon gill net fishery, has now become a major fishery in its own right because of the decline of the salmon fishery. Commercially caught sturgeon are used primarily for caviar and to lesser extent as food. The lower Columbia River commercial white sturgeon harvest for 1996 was 8,400 fish. Most of the harvest occurred in the fall although fishing also occurs in the winter and spring. Some sturgeon were also caught during the terminal fishery for salmon in Youngs Bay (Norman and King, 1997).

Smelt are fished commercially primarily for bait for the commercial and recreational sturgeon fishery and as food. All mainstem fishing is done by gill net and to a lesser extent by otter trawl. Fishing in the tributaries is done with dip nets as regulated by the states. Total smelt landings for both the mainstem Columbia and Cowlitz Rivers for 1996 was 9,100 pounds. This was a record low of a trend of low landings occurring over the last several years. The reasons for these low landings are unknown (Norman and King, 1997).

The offshore area of the Columbia River supports a number of valuable commercial fisheries. Major offshore fisheries are for Dungeness crab, salmon and bottom fish. Fishing for salmon and bottom fish, however, has declined in the last several years because of declining stocks of these fish species. There has been a shift to other fisheries including crabs, tuna and halibut. Recreational fisheries occur through out the river for salmon, steelhead, sturgeon and a variety of warm water game fish. Salmon and steelhead fishing occurs at a number of locations in the lower river. Sturgeon sport fishing is also popular throughout the river. Popular fishing locations occur near Crims Island, the Kalama River, Sandy Island, various sites between Deer Island and St. Helens, Kelly Point, and the North Portland Harbor.

The Columbia River supports a sport fishery for a wide variety of warm water game fish such as white crappie, yellow perch, largemouth bass, and brown bullhead. Sport fishing is also done for smelt, sturgeon, and salmon. Sport fishing for smelt occurs in the tributaries using a dip net. Smelt dippers are allowed 20 pounds per person per day in Washington and 25 pounds per day in Oregon. Smelt are used both as food and as sturgeon bait. Annual harvest records are not kept but can be as high as the commercial landings during periods of high smelt abundance. Sport harvest was very low in 1996 because of low smelt abundance, short migration period, and extremely high water levels.

Sturgeon sport fishing occurs throughout the lower river. Major fishing locations occur near Crims Island, the Kalama River, Sandy Island, various locations between Deer Island and St. Helens, Kelly Point, and the north Portland Harbor. A large fishery also occurs in the estuary in the summer when sturgeon are feeding on bait fish that move into the estuary. Sport harvest levels decreased through 1990 due to management actions restricting catch. Landings have increased steadily since 1990 as the population readjusted. Sport harvest in 1995 was about 45,000 fish (Norman and King, 1997).

Recreational fisheries for salmon also occur in the ocean and estuary, although this fishery has declined because of declining stocks. About 9,300 Chinook salmon, 800 coho salmon, and 6,300 steelhead were landed in the recreational fishery in 1996 (Norman and King, 1997). A fishery for rock and bottom fish also occurs off some jetties and piers.

5.2.5. Non-Indigenous Species

Non-indigenous species are introduced to the waters of the United States including the Columbia River through several different modes. The ballast water of deep-draft commercial vessels transports the largest amount of non-indigenous aquatic species. Non-indigenous species can also be transmitted via the bottoms of recreational vessels and other dumping of waters. In regards to ballast water, the potential invasion of zebra mussel (*Dreissena polymorpha*) has been of most concern. Established populations of this species in the Great Lakes region prompted the Non-indigenous National Invasive Species Act (NISA) of 1990 (Public Law 104-332). Because of the consequences this particular species can have on the ecological and economic environment, the Corps monitors for zebra mussels at its dams. To date, no zebra mussels have been found.

Because of the potential broad implications of non-indigenous species, the Corps along with other agencies has taken a regional approach to actively managing these issues. The Western Regional Panel of the Aquatic Nuisance Species Task Force, initiated as a result of the Act, addresses these issues. The Corps participates on this panel. The Bonneville Power Administration, the Bureau of Reclamation, the California Department of Water Resources, and Washington Department of Water Resources have funded coordination efforts for the Columbia River.

In addition to preparing a report on invasive species in the Columbia River (Regan, 1997), the Coast Guard is funding a baseline inventory of aquatic species that occur in the Columbia River. The study is intended distinguish between native and non-native species and their point of origin. The Coast Guard has adopted a new interim rule, effective July 1, 1999, requiring ships operating outside U.S. waters to report their ballast water management practices. These rules implement the National Invasive Species Act of 1996. The information is provided to the Coast Guard and entered into a ballast water clearinghouse database. This new regulation furthers the existing voluntary program of exchanging ballast water at sea in order to prevent the introduction of invasive species. Exchange of ballast at sea has been shown to be the most effective means of preventing invasive species introduction.

The State of Oregon is expected to adopt new legislation (House Bill 3071) prohibiting the introduction of invasive species into state waters. This legislation includes full enforcement authority and civil and criminal penalties.

5.2.6. Wildlife Resources

The wildlife resources in the study area are very diverse and abundant which is a reflection of the riverine, estuarine and ocean environments and associated terrestrial habitats in the study area. Presence of wildlife species in the immediate navigation channel is generally less than for adjacent habitats such as riparian, wetland and agricultural fields. However, disposal practices associated with channel dredging would influence these adjacent habitats and their wildlife populations.

5.2.6.1. Marine Mammals and Sea Turtles

Marine mammals are the most abundant offshore and in the Columbia River estuary. However, harbor seals and California sea lions may range throughout the project length during fish runs. Potentially 30 cetacean species can occur along the Oregon coast (Green et al., 1989) although their numbers are generally limited. Most cetacean species observed by Green et al. (1991) occurred in slope (600- to 6,000-foot depths) or offshore waters (greater than 6,000 feet deep). Harbor porpoises and gray whales were prevalent in shelf waters less than 600 feet deep. The larger cetaceans (whales) typically occur as migrants. The most prominent example is the California gray whale. Essentially, the entire population of approximately 21,000 animals migrates through the offshore areas (Breiwick et al., 1988). Gray whales and harbor porpoises are likely the most prevalent species in the area, occurring immediately offshore and in the lower Columbia River estuary on occasion.

Five species of pinnipeds are known to occur off Oregon and Washington: northern sea lion, California sea lion, harbor seal, northern elephant seal and northern fur seal (Bonnell et al., 1989). Harbor seals are resident whereas the four other species of pinnipeds are more transient in nature (Bonnell et al., 1989). Harbor seals, California sea lions and northern sea lions are the species most frequently associated with the mouth and upstream areas of the Columbia River. All three species are known to forage within the Columbia River, including the estuary and adjacent ocean waters. There are an estimated 6,000 to 7,000 harbor seals that occur in a regional population inhabiting Gray's Harbor and Willapa Bay in Washington, Tillamook Bay in Oregon, and the Columbia River estuary (Jeffries, 1986). Significant numbers (1,000 to 1,500) of harbor seals occur in the estuary, particularly during the smelt run in February and March (Jeffries et al., 1984). Peak numbers are present from December through April and decline thereafter for the pupping season (Jeffries et al., 1984). Desdemona Sands near Astoria is a principal haulout area for harbor seals in the estuary. Other haulout areas occur on Taylor Sands in Grays Bay and near Miller Sands Island.

Four species of marine turtles, loggerhead, green, Pacific Ridley, and Pacific leatherback, have been recorded from strandings along the Oregon and Washington coastline since 1982 (Green et al., 1991). Marine turtles are unusual in their occurrence along the Pacific Coast and are typically associated with warmer marine waters that occur off the Oregon and Washington coasts.

5.2.6.2. Avifauna

The avifaunal resources associated with the Columbia River are diverse and numerous. Seasonal abundance, associated with wintering, migrant and/or nesting birds, can be very high for certain species or groups of species. Ocean, estuarine, intertidal marshes and mudflats, islands, riparian forest, spruce swamp, freshwater marshes, side channels, wetlands, and agricultural habitats all contribute significantly to the diverse array of bird species and populations in the study area. The presence of three national wildlife refuges and two state wildlife management areas along the lower Columbia River also contribute to the diversity and abundance of avifauna.

Pelagic birds are extremely numerous off the Columbia River. Briggs et al. (1992) found that seabird populations were most densely concentrated over the continental shelf (less than 600 feet in depth). Shearwaters, storm petrels, gulls, common murres and Cassin's auklets numerically dominated the pelagic bird fauna from late spring through late summer. Phalaropes, fulmars and California gulls are important constituents of the fall pelagic bird flocks. The principal species or species groups in the winter pelagic bird population are phalaropes, California gulls, fulmars, other gulls, murres, auklets, and kittiwakes (Briggs et al., 1992).

Red-throated, Pacific and common loons occur as spring and fall migrants through the study area. Red-throated and common loons have been observed during winter in the Columbia River estuary and immediately offshore. Pacific loons occur during migration. Loon species are generally most abundant in the lower estuary but also occur throughout the entire reach of the estuary and upstream to Portland.

Western, red-necked, horned, eared, and pied-billed grebes occur in the study area. Western grebes are the most abundant grebe and occur throughout the estuary, particularly in the bays, offshore, and in the main river during migration and in winter. Red-necked, horned and eared grebes occur as migrants and are generally present in the estuary or near shore ocean areas. Pied-billed grebes are present in freshwater ponds and wetlands.

Brown pelicans typically occur from late spring to mid-fall along the Oregon Coast. Concentrations of this species develop at the mouth of the Columbia River at the South Jetty and at East Sand Island-Baker Bay. This species forages in nearshore waters of the Pacific Ocean and estuarine waters of the Columbia River. Concentrations up to 1,000 birds have been reported for the Columbia River (Briggs et al., 1992).

Three species of cormorants occur in the Columbia River estuary and forage in nearshore Pacific Ocean waters, the Columbia River estuary or upriver. Double-crested cormorants are the most numerous. This species occurs all year throughout the estuary, near shore waters and upstream to Portland. East Sand and Rice Islands support large nesting colonies of double-crested cormorants. Pelagic cormorants nest on the cliffs at Cape Disappointment and forage in the lower estuary up to Tongue Point (CRM 18) and seldom occur upstream of that area. Brandt's cormorants generally occur at the mouth and offshore, and nest at Cape Disappointment.

Briggs et al. (1992) reported nine gull species (Bonaparte's, Heermann's, California, Herring, Thayer's, western, glaucous-winged, and Sabine's gulls plus black-legged kittiwake) along the Oregon and Washington coasts. Three other species known to occur are glaucous, mew and ring-billed gulls. A very large gull colony is located at East Sand Island. Other colonies are located at Rice and Miller Sands Islands. Nesting colonies are typically glaucous-winged/western gull hybrids although California and ring-billed gulls nest at Miller Sands (Roby et al., 1998). Gull species occur throughout the study area with concentrations in the estuary around nesting islands, offshore and at garbage dumps in metropolitan areas. Large influxes of gulls occur in the Columbia River during smelt runs.

Three species of terns occur in the Columbia River or over nearshore waters. Caspian terns are present from April to September and occupied a large breeding colony of about 10,000 pairs at CRM 21 at Rice Island (Roby, personal communication, 1999). The Caspian tern colony at Rice Island is the largest in North America and potentially the world (Roby et al., 1998). Foraging by Caspian terns occurs throughout the estuary, although they are concentrated below Crims Island. Management efforts were implemented in 1999 to move the Caspian tern colony to East Sand Island as a means to reduce their predation on juvenile salmonids. Preliminary results indicate that these management actions were only partially successful. Future management efforts are expected in order to shift most of the Caspian tern population from the Columbia River estuary to as yet undetermined locations. Common and Arctic terns occur off the Oregon and Washington coasts from April to September, with peak counts in June and September (Briggs et al., 1992). Migrant common terns have been observed in the lower estuary.

Waterfowl are seasonally very abundant throughout the project length; fall, winter, and early spring are peak periods of abundance. Baker, Grays, and Cathlamet Bays, Sauvie Island including the ODFW Wildlife Management Area, Vancouver Lake lowlands including Shillapoo Wildlife Management Area, Woodland bottoms, and Lewis and Clark, Julia Butler Hansen, and Ridgefield National Wildlife Refuges provide excellent waterfowl habitat and support large concentrations of ducks and geese. Agricultural lands along the river and intertidal marshes in the estuary provide substantial foraging habitat for waterfowl throughout the lower river. Mallards, northern pintails, American wigeon, green-winged teal, Canada geese (several subspecies), and scaup (greater and lesser species) are probably the most abundant wintering species. Mallards and Canada geese are the principal nesting species. Islands, particularly dredged material islands, are important nesting sites for the resident population of Canada geese and appear to be hosting higher numbers of nesting mallards in recent years than in the past. Significant numbers of snow geese and tundra swans along with other waterfowl species also occur in the study area during winter.

Raptors (hawks, owls) occur throughout the area with a number of species present either as residents and/or wintering birds. Bald eagles are relatively abundant and are represented by resident and wintering birds. Peregrine falcons are also present in the study area and occur as resident, migrant and/or wintering birds. The abundance of shorebirds, waterfowl, and non-game birds are attractive to peregrine falcons. Red -tailed hawks are abundant throughout the project reach with substantial nesting and wintering populations occurring on island and mainland upland habitat along the river. Rough-legged hawks are the second most common buteo and occur primarily as winter residents and migrants. Northern harriers are present as residents, migrants, and wintering birds. They are primarily associated with grasslands, marshes, and agricultural fields. Cooper's and sharp-shinned hawks nest in the study area and are probably most abundant in migration. American kestrels are relatively abundant with resident and wintering birds present. Osprey occur throughout the project area. They nest on navigation aids, dolphins, range markers and natural locations such as snags. Their presence along the lower Columbia River has increased markedly since the late 1970s to the point where they are now commonly observed.

Eight species of either resident and/or migrant/wintering owl species would be expected to occur in the study area. Great horned owls and western screech owls are most abundant, particularly in riparian forest habitat. Barn owls are present although abundance is unknown. Short-eared, pygmy and saw-whet owls occur as migrants and wintering birds although some nesting effort by these species may occur.

Upland game birds are associated primarily with upland habitat, particularly upriver of Longview, Washington. Ring-necked pheasant and California quail would be the principal species encountered. Ruffed grouse would occur in riparian and adjacent coniferous forest habitat throughout the project length.

Rails, coots, and sandhill cranes are present throughout the area. Sora and the Virginia rail would be primarily associated with non-tidal freshwater marshes and wetlands. American coots would use intertidal salt and freshwater marshes as well as marshlands, ponds, and lakes not subject to tidal action. Sandhill cranes principally occur in the upper portion of the study area with migrant and wintering birds present at Sauvie Wildlife Management Area, Ridgefield National Wildlife Refuge, Vancouver lowlands, Shillapoo Wildlife Management Area and surrounding private lands.

Substantial numbers of shorebirds make use of the intertidal marsh/mudflat, non-tidal freshwater marshes, and flooded agricultural lands along the river. Most abundant are western sandpipers, sanderlings, dunlins, least sandpipers, dowitchers, common snipe, semipalmated plovers, and red-necked phalaropes. Concentrations of 10,000 to 40,000 birds occur in Cathlamet and Grays Bays, primarily dunlins and western sandpipers. Shorebird surveys (spring, fall and winter) have covered the estuary upstream to Wallace Island (CRM 48). Maximum numbers of shorebirds occur in this reach during spring migration; an estimated 160,000 shorebirds may be present during the peak of spring migration.

Band-tailed pigeons and mourning doves may occur throughout the project length; band-tails are generally associated with the forested uplands whereas mourning doves would occur in riparian forest/agricultural lands in the more upstream portions of the project. Large concentrations of band-tailed pigeons do occur around the grain facilities at Kalama in early spring when the birds apparently take advantage of spilt grain.

Nongame bird species frequent the study area in abundance and would include species such as Vaux's swifts, rufous hummingbirds, belted kingfishers, downy and hairy woodpeckers, northern flickers, six species of swallows, black-capped chickadees, Bewick's wrens, kinglets, Swainson's thrushes, warbling vireos, several warbler species, black-headed grosbeaks, and song sparrows, among others. Riparian, wetland and agricultural habitats are important to many of these species. Grassy uplands and dredged material disposal sites are inhabited by savannah and white-crowned sparrows, horned larks, and western meadowlarks in addition to many other resident, migrant, and wintering birds. Intertidal marsh does not support many nesting passerines due to tidal inundation. Common yellowthroats and song sparrows nest in some of the higher marshes where bulrushes, willows, or other vegetation provides elevated nesting sites. Blackbirds forage within the marsh vegetation and swallows forage on insects over the marshes, mudflats and open water habitat.

5.2.6.3. Terrestrial Mammals

Columbian white-tailed deer are the mammal of most concern in the study area. They principally occur on the Julia Butler Hansen Refuge, Puget Island, and in the Clatskanie bottomlands near Westport. Black-tailed deer occur throughout the study area, inhabiting riparian forest and upland habitat. Roosevelt elk also occur in the area but are generally absent from areas immediately along the river due to human development. A population does occur on the Julia Butler Hansen Refuge and in coniferous forested hills adjacent to the river. Black bears would be expected to share a distribution similar to Roosevelt elk.

Beaver, nutria, raccoon, muskrat, mink, and river otter represent furbearers in the study area. The introduced nutria is very abundant, inhabiting dredged material islands, intertidal marshes and swamps, sloughs, ponds, backwaters, and diked agricultural and wetland habitat. Beavers are abundant and are associated with wetlands and bodies of water with adjacent riparian forest habitat as are the other furbearers noted. A study by Henney et al. (1996) of river otter between CRMs 11.0 and 119.5 found population estimates of 105 to 286 animals prior to fall harvest. River otter was characterized as abundant and well distributed throughout the lower Columbia River. Mink populations in the lower Columbia River were very low with only one family group and 4 individuals noted during summer surveys and only two animals reported by trappers (Henney et al., 1996). Habitat suitability indices for mink were generally excellent along the lower Columbia River, except in urban-industrial areas (Henney et al., 1996). Red foxes, striped skunks, opossums, and coyotes occur throughout the study area, typically on the mainland and infrequently on island habitats.

About 32 small mammal species may occur in the study area, excluding bats. Vagrant shrews and deer mice are expected to be the most abundant species present (Hinchberger, 1978). Vole species are probably most abundant in agricultural croplands, particularly pasturelands and grain stubble left standing over winter. Nine or more species of bats may occur throughout the study area using riparian and coniferous forest habitat, buildings, bridges, and other structures for roost and maternity locations.

5.2.6.4. Open Water and Channel Habitat

Dredging actions would occur within the navigation channel which represents a deep water habitat that is principally used by marine mammals (harbor seals and California sea lions) and piscivorous birds (gulls, Caspian terns, cormorants, loons, grebes, mergansers, brown pelicans). Use by species comprising these groups is most substantial near the mouth of the Columbia River and throughout the estuary. Use upstream of Puget Island is generally substantially less than for the estuary by these groups. An exception would occur during the upstream migration of smelt to the Cowlitz, Lewis and/or Sandy rivers when gulls, cormorants, harbor seals and sea lions occur in abundance to take advantage of this food resource. Although many other wildlife species occur along the shorelines, in adjacent intertidal and shallow subtidal waters, or transit the area of the navigation channel, they do not make direct use of the deep-water habitat.

In-water disposal is being considered for areas greater than 30 feet of depth in and/or adjacent to the channel from CRM 3 to 105. Wildlife at these in-water disposal sites is limited due to the depth of the areas being considered for disposal operations. Gulls, cormorants, terns, grebes, loons, brown pelicans, sea lions, and harbor seals would be expected to make occasional use of this open water habitat area for foraging or while traveling up and down the Columbia River. Use by gulls, terns and cormorants would be highest from CRM 3 to 38 because tidal influence is high, nesting colonies are located here, and large areas are shallow subtidal and intertidal habitats. Use by sea lions and harbor seals would also be highest in the estuarine portion of the Columbia River.

5.2.6.5. Pile Dikes

Wildlife species associations with pile dikes are similar to that for open water habitat. Species that occur in open water habitat such as gulls, terns, cormorants, and grebes often frequent the areas around pile dikes. Pile dikes also provide perching habitat for many species, including cormorants, gulls, terns, bald eagles and various species of shorebirds.

5.3. Threatened and Endangered Species

5.3.1. Aquatic Species

Prior to 1999, the listed stocks of salmonids in the Columbia River included the Snake River fall and spring/summer runs of chinook, Snake River run of sockeye, and the upper and lower Columbia and Snake River runs of steelhead. In March 1999, the NMFS also listed chinook salmon as threatened in the lower Columbia River and upper Willamette River, and the spring run as endangered in the upper Columbia River. Columbia River chum salmon was listed as threatened. Middle Columbia and upper Willamette steelhead were listed as threatened. Proposed stocks include lower Columbia coho salmon and Columbia coastal cutthroat trout. A Biological Assessment containing more detailed information on these species and their use of the study area has been prepared and is located in Exhibit C.

Adults and juveniles of the listed and proposed stocks are present in the lower river in the vicinity of the study area year-round. Adults use the lower river principally as a migration corridor to spawning areas in the upper basin and tributaries. They are actively migrating and normally do not spend time in the lower river resting or feeding. Juveniles occur in the lower river during their out-migration to the ocean. Most juveniles have already become smolts (juveniles that are capable of migrating to the ocean) and are present in the lower river and estuary for only a short period of time. Juveniles that have not become smolts, such as fall chinook subyearlings, spend extended periods of time rearing in the lower river and estuary. They normally remain in the lower river or estuary until fall or the following spring, when they become smolts and migrate to the ocean. They rear primarily in the shallow backwater areas where they feed on benthic invertebrates such as the amphipod *Corophium salmonids*. Juveniles are also prey for a variety of organisms including birds and other fish species. Moralities of juveniles can be high, depending upon the population of predators.

5.3.2. Wildlife Species

Twenty-two federally listed threatened and endangered wildlife and plant species could occur in the study area. Species potentially affected by the project include: blue, finback, sei, right, hump-backed and sperm whales; northern (Steller) sea lion; Columbian white-tailed deer; loggerhead, green, Pacific ridley, and Pacific leatherback sea turtles; brown pelican; peregrine falcon; Aleutian Canada goose; marbled murrelet; western snowy plover; bald eagle; Oregon silverspot butterfly; water howellia; Bradshaw's lomatium; and Nelson's checker-mallow. One proposed threatened species, the golden paintbrush, also may occur in the study area. Biological assessments containing more detailed information on these species and their use of the study area have been prepared and are located in Exhibit C (also see Chapter 6, *Environmental Consequences*, for more information).

The six-listed whale species occur in the Pacific Ocean and may only occasionally transit through the offshore area where dredged material disposal would occur. Whales are not known to congregate for foraging or other uses off the mouth of the Columbia River.

Northern sea lions are know to forage at the Columbia River mouth, in the estuary and river proper, and immediately offshore plus travel through the study area. The Columbia River South Jetty is a known haulout area for Northern sea lions.

Columbian white-tailed deer are a resident species in the Cathlamet-Skamokawa area in Washington and in Westport, Oregon. One of the principal populations occurs on the Julia Butler Hansen National Wildlife Refuge. Puget Island also supports a sizable population of this listed species. Riparian habitat associated with agricultural lands provides important habitat for this species. The species is relatively abundant in its present geographical distribution along the lower Columbia River but not to the extent that the population is secure as defined in the recovery plan for Columbian white-tailed deer.

The four species of sea turtles listed occur only incidentally along the Oregon and Washington coastlines. They are normally associated with warmer ocean waters.

Brown pelicans are seasonally abundant (June to September) at the Columbia River mouth and in the lower reaches of the estuary. Brown pelicans present on the Oregon Coast are principally immature birds and some post-breeding adults that have dispersed northward from breeding locations in California and Mexico. The species loafs/roosts on both jetties and at East Sand Island near Chinook, Washington. Foraging occurs in nearshore and estuarine waters with northern anchovies representing an important prey species.

Peregrine falcons formerly occurred primarily as a migrant or winter resident along the lower Columbia River. Presently, the species has also established a breeding presence throughout the study area, principally associated with urban areas. Prey species are abundant in the study area and encompass waterfowl, shorebirds, songbirds and such common urban species as rock doves and starlings.

The Aleutian Canada goose may occur occasionally in the study area as a fall or spring migrant or as a winter resident. Most Aleutian Canada geese winter in California. A wintering population does occur at Pacific City on the northern Oregon coast. Marbled murrelets occur in nearshore waters and nest inland in old growth coniferous forests. A few individuals are occasionally observed at the mouth of the Columbia River. The species is present in only low numbers because substantial stands of old growth coniferous forest inland along the lower Columbia River no longer exist. The western snowy plover inhabits ocean beach and river spits where expanses of virtually barren sand are present. Western snowy plovers no longer occur on Clatsop Spit beaches nor are they known to occur on the West Sand Island beach. This species no longer occurs in the immediate study area.

Bald eagles are abundant along the lower Columbia River throughout the study area as resident, migrant and wintering birds. The number of resident pairs continues to increase each year based upon annual surveys of territorial occupancy and productivity. About 65 bald eagle territories have been identified in the study area as of 1997 occupancy surveys; 17 occupied nest sites were known in 1985 (Isaacs et al., 1997). Numbers of migrants and wintering birds are variable and are probably influenced by the presence or absence of food resources in other areas and along the Columbia River.

The Oregon silverspot butterfly is a terrestrial species that inhabits coastal headlands or Oregon Coast Range peaks that provide specific habitat features, primarily the presence of *Viola adunca*, the obligate host plant species.

Water howellia occurs in vernal pools or permanent wetlands. Only one population, located on a National Wildlife Refuge, occurs in the study area. Bradshaw's lomatium occurs in low, seasonally wet, native prairies dominated by tufted hairgrass and sedge species in the Willamette Valley. The study area is outside the normal range for this species. Nelson's checkermallow occurs in scattered populations throughout the Willamette Valley and at other locations in Oregon and Washington (CH2M Hill, 1993). Nelson's checkermallow primarily occurs in open, sunny areas with little or no shade (FWS, 1994). The species does not tolerate encroachment of woody species (FWS, 1994). The species occurs in a variety of habitats, such as relatively undisturbed seasonal wetlands, annually mowed roadside ditches, margins of cultivated fields in the Willamette Valley and high meadows in the Coast Range (CH2M Hill, 1993). The nearest known population to the area of golden Indian paintbrush occurs in Vancouver, Washington. Habitat for this species in the Willamette Valley was well drained, xeric (dry) prairie sites. The populations in Washington occur in gravelly soils overlying bedrock.

5.4. Socio-Economic Resources

5.4.1. Port-Related Economy

The navigation channel in the lower Columbia enables deep-draft vessels to call on a number of ports, bringing in imported goods and leaving with goods destined for foreign markets. It has been estimated that the value of waterborne trade of Columbia River ports totaled nearly $14 billion in 1995.

There are five deep-draft ports on the lower Columbia River: Astoria, Longview, Kalama, Vancouver, and Portland. Astoria's deep-draft activity is primarily limited to the export of logs, but the tonnage shipped is limited. Longview's port has multiple cargo docks operated by several entities. The principal commodities are soda ash, wood products and grains. Shipping activity generates a total of 6,000 jobs and creates $250 million in personal income. At Kalama, the Peavey Company and Harvest States Cooperative operate large grain elevators primarily devoted to corn and wheat exports. The extensive facilities at Portland handle a multitude of export and import goods as well as goods destined for or coming from points east on barges or rail. It is estimated that up to 6,200 full time jobs are generated at public and private port facilities at Portland. About $232 million in personal income is directly attributable to port activity. Vancouver has facilities for grain (mostly wheat) exports and general/bulk cargo. It is estimated that 3,000 jobs are related to port activity, which generates a total of $72 million in personal income.

The local economy is dominated by the Portland Primary Metropolitan Statistical Area (PMSA). The Portland PMSA is comprised of five Oregon counties (Clackamas, Columbia, Multnomah, Washington and Yamhill) and Clark County in Washington. The Portland area is Oregon's largest population center with 1.7 million residents in 1995, or about half of the state's residents. Total non-farm payroll employment in the Portland PMSA as of March 1997 was about 900,000 and the unemployment rate was 4.8 percent. The Portland PMSA has a well-diversified economy and employment in the area is expected to continue to grow faster than both Oregon and the United States through the year 2005. Per capita income has grown steadily over the last 10 years, remaining slightly above the United States average and well above the Oregon average.

In Washington, the ports of Longview and Kalama are in Cowlitz County, the next most populous region in the lower Columbia area. Longview, the principal city in Cowlitz County had a population of 33,080 in 1994 or nearly 40 percent of the county total. Total non-farm employment in 1994 was 34,300. Manufacturing is the dominant industrial sector in the county, with the timber industry accounting for two out of every three manufacturing jobs. The 1995 population in Clatsop County was 34,300 with only slight growth since 1980. The key manufacturing sectors are wood, paper, and food products (mainly fish processing.) Per capita income has been and continues to remain below Oregon and United States levels. Wahkiakum and Pacific Counties are similar to Clatsop County in having relatively small populations and resource based manufacturing sectors.

5.4.2. Land Use

Land use patterns in the lower Columbia River region are dominated by forest and farmlands in the lower river and estuary, and urban and industrial areas interspersed with forest and farmlands in the upper Columbia and Willamette Rivers. Since 1975, residential, commercial and industrial development has occurred within existing urban areas and extensive suburban residential development in areas that were farmlands. Land uses immediately adjacent to the river have not changed dramatically. Lower Columbia River agricultural uses include extensive areas of hybrid cottonwood. Continued rapid population growth and development is expected for the metropolitan Portland-Vancouver areas through the foreseeable future.

Both Oregon and Washington have developed planning goals and guidelines. Oregon initiated its statewide planning goals and guidelines in 1977 and established the Department of Land Conservation and Development (DLCD) as its administering agency. All city and county jurisdictions in Oregon have developed comprehensive plans based on the statewide goals. Washington has developed a shoreline master program as part of their Shorelines Management Act of 1971. The shoreline master program has been developed to regulate shoreline uses to minimize land use conflicts and protect scenic and environmental values. The shoreline master program is managed through county jurisdictions. Washington State is the owner and the Department of Natural Resources the manager of the submerged lands within the Sate of Washington. Land and water use planning for the Columbia River estuary and adjacent jurisdictions is coordinated through the Columbia River Estuary Study Taskforce (CREST). The *Columbia River Estuary Plan*, developed by DLCD and CREST, has classified the land and water areas of the estuary into use classifications. The plan identifies shoreline areas suitable for dredged material disposal and classifies the navigation channel as 'aquatic development'. All of the state and local plans applicable to the Columbia and Willamette Rivers recognize the need to maintain the federal navigation channel and provide for suitable shoreline and upland disposal sites.

5.4.3. Aesthetics

The aesthetic character of the lower Columbia and Willamette Rivers has not changed substantially since the 1975 EIS that described most of the river below Portland-Vancouver as rural in character. Additional development has occurred within the urban areas described, some residential development has occurred in rural farm areas, and additional sand has been placed on shorelines, particularly in the Longview area, post-Mount St. Helens eruption. For the most part, existing upland and shoreline disposal sites blend in with the surrounding landscape, and to most observers, have the visual appearance of naturally occurring sand beaches.

5.4.4. Recreation

Recreational activities occurring on and adjacent to the river are similar to those described in the 1975 EIS and include primarily fishing, hunting, boating, including sail, motor, canoe and kayak, sightseeing and wildlife viewing. One major exception is the introduction of the sport of windsurfing. Windsurfers use several access points on the lower Columbia River. The most popular of these is Jones Beach, located near Clatskanie, Oregon. Visitor use of this area is not known at this time but has increased annually over the past several years. A number of informal beach recreation sites have been developed at shoreline disposal sites. Recreational salmon fishing has declined in recent years with reduced fishing seasons and reduced salmon numbers.

5.4.5. Cultural Resources

Cultural resources as discussed here is used to describe any pre-contact or post-contact archaeological, historic, and traditional cultural property or use. This includes sacred and spiritual areas, which may have no physical remnants or visible cultural items to distinguish the cultural site. Shipwrecks also are considered a cultural resource.

The coast area of interest and potential effect is classed as the southern region of the Northwest Coast Culture area (Smithsonian Institution, 1990).

A cultural resource literature search has been completed which identified archaeological, historical, limited traditional use areas, and shipwrecks (Minor and Musil, 1998). There are known recorded sites within the area of potential effect that are listed on the National Register of Historic Places or are considered potentially eligible. Any potential adverse effects to these properties would be addressed through consultation with affected Native American tribes, and suitable recommendations for protection and preservation of resources would then be forwarded to the Oregon and Washington State Historic Preservation Offices for comment and concurrence.

Native American population density in the lower Columbia valley during the late prehistoric period is known to have been very high. This area has also been one of the main corridors of commerce and settlement by Euroamericans in the historic period. Evidence of prehistoric and historic activity may potentially be found almost anywhere along the banks of the lower Columbia River (Minor and Musil, 1998).

The pre-contact economies relied primarily on fishing, with an additional reliance on hunting, shellfish gathering and harvesting of available vegetable foods. Wood working technology was highly developed, as indicated by the plank houses, canoes, and various art forms. Settlements occurred as permanent winter villages or towns, and temporary hunting, fishing and gathering camps. The population within the settlements varied with intertribal communication and trading efforts. The Columbia River provided a route to the economic trade center of the Pacific Northwest.

With the appearance of European and American explorers and visitors in the area, old forms of the economies underwent a transformation. The Hudson Bay Company placed a greater emphasis on trapping certain animals for export and expanded trade. Followed by other immigrants, the emphasis shifted to timber and agriculture, and the production was secured by the military. Increasing flows of humanity relocating into the region brought a re-emphasis on fishing for canneries and shipping or railroad trade, and the communication and transportation lines flourished and expanded. The face of the region was rapidly changing, but with each new alteration, a remnant of the past remained. The great period of cultural resources is represented by hundreds of cultural properties, which tell a portion of the history of the region.