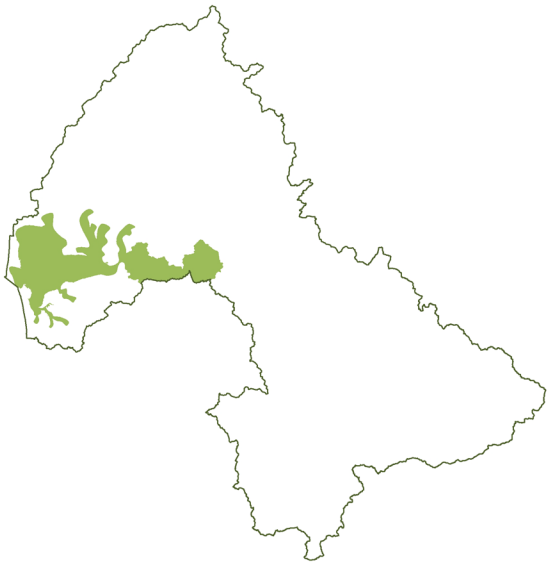
5.9 Estuary Ecological Region



This Estuary Ecological Region supplements the *Aquatic Species Restoration Plan* (ASRP; ASRPSC 2019) to include the Grays Harbor estuary. This supplement replaces the Chehalis Tidal Ecological Region Section 5.9 in that document and incorporates the Chehalis River tidal segment into this new ecological region.

5.9.1 Overview

The Estuary Ecological Region encompasses Grays Harbor, the tidally influenced portions of its tributaries (including both tidal saltwater and tidal freshwater reaches of the Humptulips, Hoquiam, East Fork Hoquiam, West Fork Hoquiam, Little Hoquiam, Wishkah, Johns, and Elk rivers, as well as smaller creeks and tidal sloughs), and the mainstem Chehalis River and its floodplain from approximately river mile (RM) 0 to RM 20 (Satsop River confluence; Figure 5-17). This ecological region encompasses 183 square miles (greater than 117,000 acres) and represents approximately 7% of the overall Chehalis Basin. The entire Estuary Ecological Region is within the harbor embayment or the lower ends of the multiple alluvial valleys ranging from 0 to 200 feet in elevation.

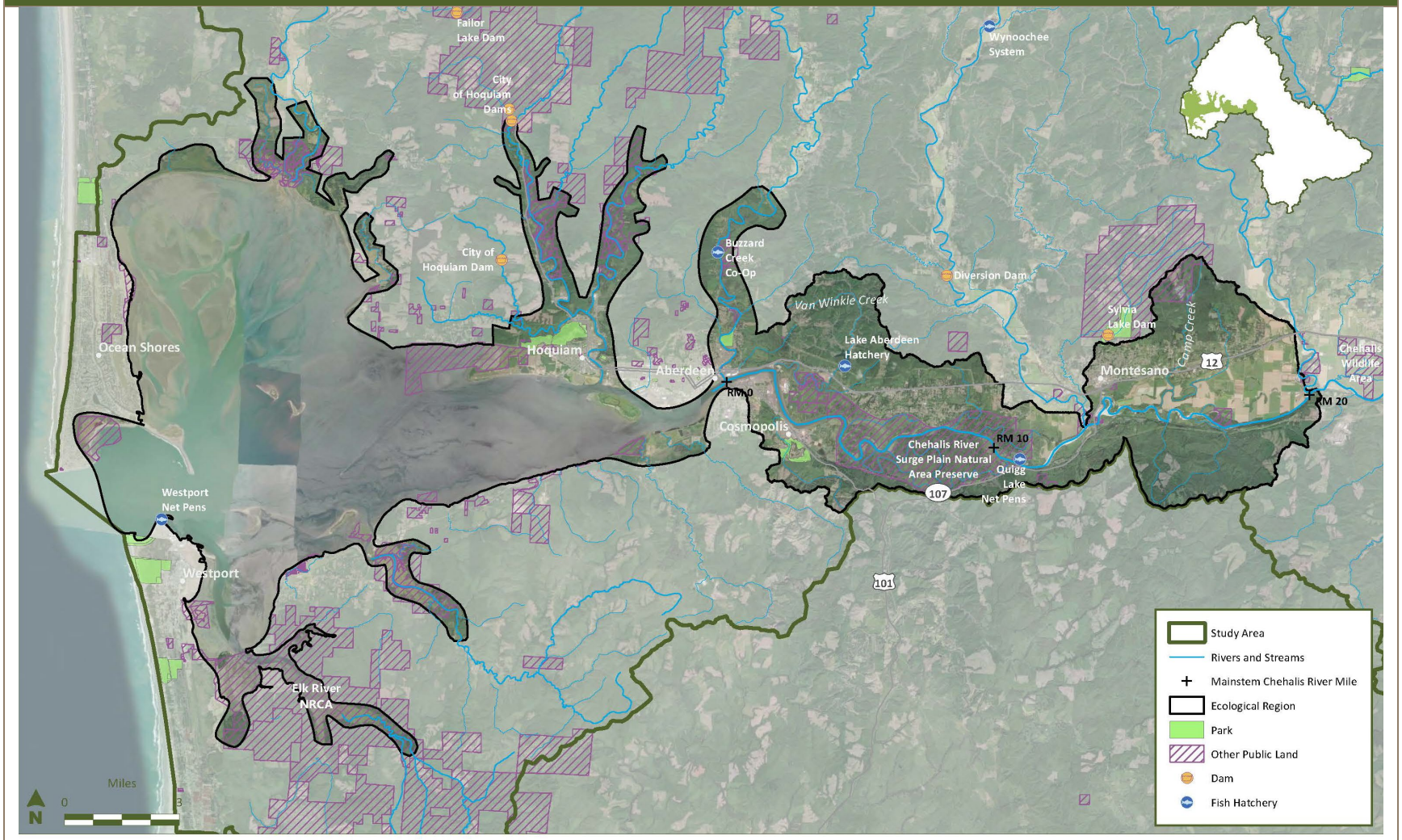
The Estuary Ecological Region is defined by tidal flux, from the broad shallow bay of Grays Harbor and its tidal flats and wetlands, through the tidal extent of the rivers and streams that flow into Grays Harbor, and small tributaries that enter these lower river tidal zones. The estuary has been significantly modified for industrial purposes, including the substantial port and adjacent development and the federal navigation channel from the mouth of Grays Harbor to Aberdeen that is maintained for deep-draft vessel traffic by the U.S. Army Corps of Engineers (USACE).

The Estuary Ecological Region is entirely within Grays Harbor County. The towns of Aberdeen, Hoquiam, Montesano, Cosmopolis, Ocean Shores, and Westport are within this ecological region.

Important Features and Functions

- All Chehalis Basin anadromous salmonids that pass through this ecological region and estuary habitats are used extensively for rearing by in-basin (as well as out-of-basin) juveniles, making its function essential to their viability.
- Other ASRP focal fish species, such as eulachon and green sturgeon, are only found in this ecological region.
- The tidally influenced surge plains include the freshwater wetland type Sitka spruce swamp, which is a rare habitat type.
- Tidal marsh and slough areas of this ecological region are important habitat for several ASRP indicator species including great blue heron, Barrow's goldeneye, and wood duck.
- The Washington Department of Natural Resources (WDNR) Surge Plain Natural Area Preserve provides protection for 5,500 acres of high-quality tidal surge plain that includes expansive sloughs, mudflats, marshes, scrub-shrub, and forested wetlands.

Figure 5-17
Estuary Ecological Region Map



Aerial Photo Source: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

5.9.2 Historical Conditions and Changes

The spits at Westport and Ocean Shores forming the outer boundary and enclosing Grays Harbor were formed from the "river of sand" transported out of and northward from the Columbia River (Phipps 1990). The earliest General Land Office and T-sheet mapping[1] available for Grays Harbor and the tidal portions of its tributaries from the late 1800s and early 1900s indicates the harbor was generally shallow throughout most of its expanse and fringed by a diversity of mudflat, marsh, and wooded marsh habitats (BLM 2024; NOAA 2024). The multiple tributaries flowing into Grays Harbor would have contributed sediment for thousands of years creating the vast shallow bay. Early mapping also shows the lowest reach of the Chehalis River as a much wider river prior to placement of fill and piers in Aberdeen (GLO 1883 map for T17NR9W from BLM 2024).

The Grays Harbor estuary is in the traditional territory of the Quinault language-speaking and Lower Chehalis language-speaking peoples, who also had close ties to Upper Chehalis and Shoalwater Bay peoples (Ruby and Brown 1986). The harbor and tributaries were used extensively by Native Americans for food, materials, and cultural purposes. Cultural resources including weir and fish trap artifacts have been documented in intertidal areas within Grays Harbor highlighting the importance of and sensitivity of the area for tribes.

From approximately 1892, USACE began taking actions to improve navigation within Grays Harbor and the lower end of the Chehalis River (USACE 1895) to support the export of timber, agricultural, and other products and the import of food, fuel, and materials to the beginnings of the port in Aberdeen and surrounding basin communities. The mouth of the Chehalis River was noted at that time as having two primary channels, a north and south channel, as well as a secondary middle channel that connected the north and south channels (in the vicinity of the current Rennie's Island [Figure 5-18]). The earliest actions were removing shoals and installing pilings and brush dikes to divert flows toward and scour sediments from the north channel and close off the middle channel and various small sloughs. The intent was to dredge or scour a channel with a depth of 16 feet at half-tide. The pile and brush dikes required numerous repairs, as they would easily break or wash away during high winter flows or from large volumes of woody debris coming down the river. Dredging the Chehalis River shoals up to Montesano was also considered in 1890 and 1891, but the construction of a railroad line to Aberdeen reduced the need for river navigation, and work done to remove some of the logs in the river showed that it would be difficult to dredge the river, as the shoals consisted of buried logs, roots, and similar debris in both sands and clays.

The entrance to the harbor between the two sand spits had a naturally deep channel (up to 100 feet in depth) scoured by the tidal forces filling and emptying the harbor. This naturally scoured channel continued west into the ocean for nearly 2 miles, gradually shallowing in depth to about 30 feet. A long sand bar arcs out from each sand spit to the end of the channel. Shallow and variable channels extended

[1] The General Land Office (GLO) conducted surveys in the western states as part of the transfer of land titles from the federal government to individuals. In 1850 the Donation Land Law was passed by Congress to grant land to settlers that cultivated the land within the Oregon Territory, the northern half of which became Washington. The Bureau of Land Management houses these records online, and they provide some of the earliest mapping in Washington. The T-sheets were shoreline surveys conducted by the National Geodetic Survey within harbors and other shoreline areas dating back to the mid-1800s in western states.

across the bar with depths of about 12 feet (USACE 1905). A 3-mile-long jetty was constructed from the south side of the entrance out past the bar to promote scour of the bar and maintenance of a navigable channel (USACE 1905).

Estimates of historical habitat area and changes to the mid-twentieth century (1956 and 1960 from Borde et al. [2003] and Boule et al. [1983], respectively) are shown in Table 5-2. The dredging of the navigation channel accounts for the increase in subtidal habitat, and the placement of dredged spoils have contributed to the increase in tidal marsh by converting some areas of tidal flat to marsh habitat. Both dredging and placement of dredged spoils have contributed to the decline in tidal flats. The increase in potential eelgrass habitat documented by Borde et al. (2003) has occurred through widening along numerous tidal channels throughout the harbor, which has converted tidal flat to the slightly deeper water potentially suitable for eelgrass. They identified that potential causes of this widening of tidal channels include increased tidal exchange from the deepened and widened navigation channel and loss of sediment input from the Columbia River system. Of note, since the construction of the jetties, sediment dynamics have changed, including recent erosion of sediment around Damon Point (Figure 5-18) sediment deposition on the east side of the north spit and sediment erosion and redistribution in the south bay.

Table 5-2
Changes in Grays Harbor Tidal Zones and Habitats from Late 1800s to Mid-1900s

TIDAL ZONE/HABITAT TYPE[1,2]	LATE 1800S/EARLY 1900S AREA (ACRES)	MID-1900S AREA (ACRES)	MID-1980S AREA[3] (ACRES)	% CHANGE
Below extreme low water (subtidal)	14,072	15,083		+7%
Potential eelgrass habitat (MLLW to extreme low water; approximately 1.2-m MLLW)	3,227	7,658		+137%
Tidal flat (MHW to MLLW)	38,874	30,243		-22%
Tidal marsh (MHW to extreme high water)	3,580 (loss of at least 500 acres by this time)	4,690	3,130	-23%
Total	59,753	57,674		-3%

Notes:
1. Estimates for all zones/habitat types from Borde et al. (2003) except tidal marsh, which is from Boule et al. (1983)
2. m: meter; MLLW: mean lower low water; MHW: mean high water
3. Loss reported by Boule et al. (1983).

Boule et al. (1983) noted that at least 500 acres of tidal flats had been converted to uplands before 1916 from fill placed for industrial development. After the 1960s, a net loss of 1,560 acres of marsh habitat occurred (as documented up to 1983), meaning at least a net loss of over 1,000 acres as Borde et al. (2003) indicated a temporary increase in marsh habitat in the first half of the 1900s, for a net loss of 23% of this habitat, and Boule et al (1983) also noted a total of 900 acres of forested tidal swamp habitat had also been filled or diked from roads and other development. Due to the differences in the study area and the

types of habitats analyzed between the Borde et al. (2003) and Boule et al. (1983) studies, it is difficult to know the changes from historical habitats conclusively.

The inner harbor of the estuary at the mouth of the Chehalis River near the cities of Aberdeen and Hoquiam has been substantially altered through filling and industrial and commercial development, including lumber and pulp mills, sewage treatment plants, and other large facilities requiring access to the shoreline. These facilities also led to a legacy of contaminated water and sediment in the harbor that have degraded habitats for the foodweb and the fish and wildlife using harbor resources.

For example, a study of coho salmon smolt survival from the Chehalis River from 1987 to 1990 noted that there appeared to be much lower survival of smolts from the Chehalis River compared to the Humptulips River and potential concern that industrial pollution could be causing this. The study did not identify an obvious cause for this difference in survival, and the authors speculated that the lower survival rate could be related to both industrial pollutant discharges in the lower river and a parasite (fluke [*Nonophyetus salmincola*]) that was documented in high numbers infesting the coho smolts as they migrated through the lower Chehalis River (Schroder and Fresh 1992). Since that study, significant progress has been made in reducing the discharge of pollutants. The original concern about the effects of pollutants and/or the parasite was never confirmed; however, more recently, predation by the native northern pikeminnow (*Ptychocheilus oregonensis*) has been implicated as a key source of mortality in the lower Chehalis River, especially on hatchery coho smolts (Fresh et al. 2003).

5.9.3 Current Conditions

Current conditions reflect ongoing agricultural, residential, commercial, and industrial land uses. However, in recent years, numerous tidal wetlands and a significant area of the Chehalis surge plain (nearly 5,500 acres) have been protected by conservation organizations and natural resource agencies with the goal of maintaining these high-quality habitats, comprising over 16,000 acres in total. Land cover is approximately 25% wetland, 22% coniferous forest, 17% developed, 10% scrub-shrub, 6% agriculture, 5% deciduous forest, 4% herbaceous, 3% mixed forest, and small percentages of other cover (Figure 5-18).

Water quality in Grays Harbor is variable depending on location, and there are several locations in the harbor where water temperature, dissolved oxygen, and bacteria do not meet water quality criteria (Ecology 2024a, 2024b). Near Westport, two pollutants were frequent and persistent enough to require water quality improvement plans: bacteria and dieldrin, a legacy pesticide. There are two Total Maximum Daily Load (TMDL) plans (Ecology 1992, 2004): one for dioxin pollution in the inner harbor and one for dissolved oxygen, temperature, and fecal coliform. Significant strides have been made in reducing dioxin pollution since the TMDL was developed, but much further progress is needed for dissolved oxygen, temperature, and fecal coliform, and climate change will likely exacerbate high-temperature and low-dissolved-oxygen conditions.

Salinity has been measured as far upstream in the Chehalis River tidal zone as the Wynoochee River confluence (although typically very low salinity at <0.5 part per thousand [WFC 2014; USGS 1969]).

Estuary Current Snapshot

Condition of Watershed Processes (*in Chehalis Tidal reach, not assessed for Grays Harbor*):
Hydrology – moderately impaired
Floodplain connectivity – impaired
Riparian condition – impaired
Water quality – impaired

Restoration Potential: Moderate

Protection Potential: Moderate

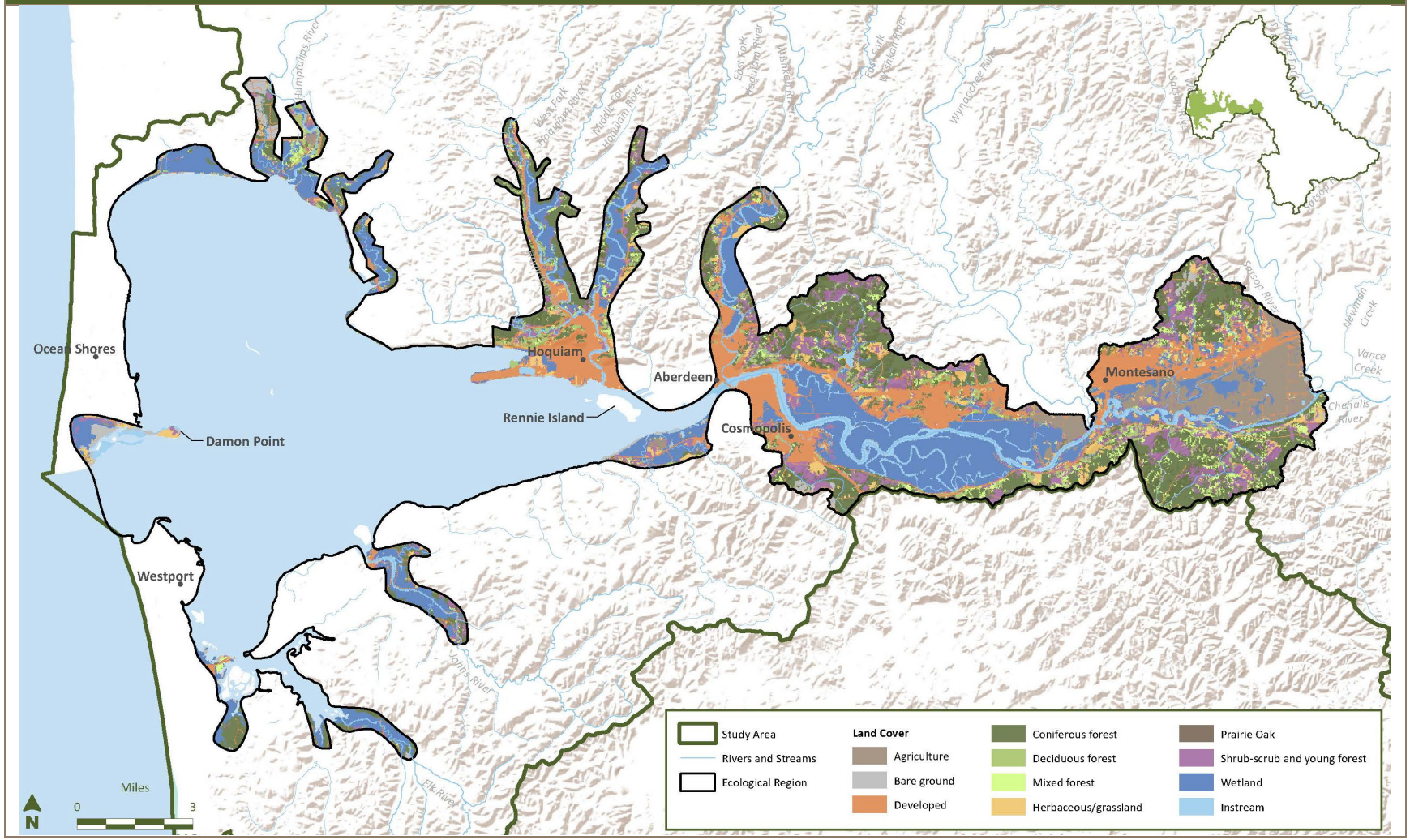
Geographic Spatial Units: Chehalis River from Wynoochee River to Mouth of the Chehalis River, Chehalis River from Satsop River to Wynoochee River, Lower Hoquiam River, Little Hoquiam River, Lower Humptulips Mainstem River, Campbell Slough, Grass Creek, Chenois Creek, Gillis Slough, Jessie Slough, Charley Creek, Newskah River, Wishkah Mainstem River, Elk River, and Johns River

Salmon Use and Potential: Fall-run Chinook salmon, spring-run Chinook salmon, coho salmon, chum salmon, and steelhead

Non-Salmon Use and Potential: Northern red-legged frog, North American beaver, Pacific eulachon, Pacific lamprey, white and green sturgeon, surf smelt, herring, sand lance, bald eagle, great blue heron, Barrow's goldeneye, osprey, and wood duck

Watershed condition rankings from Beechie 2018.

Figure 5-18
Estuary Ecological Region Land Cover



Sediment dynamics have changed in Grays Harbor with the combined changes from the navigation channel dredging, changing and episodic sediment delivery from tributaries, resuspension and redistribution of sediments within the harbor from waves and currents, and burrowing shrimp activities (Stantec 2021). A major component of sediment dynamics, the navigation channel is maintained to support recreational, commercial, and industrial shipping in and around the Port of Grays Harbor. It extends 22 miles from the entrance bar through Grays Harbor to South Aberdeen (approximately RM 2 of the Chehalis River) with an average width of 350 feet and depth of 36 feet, widening to 1,000 feet over the bar. A second jetty on the north side of the entrance channel extends for 2.6 miles. The channel requires annual dredging to maintain its depth, with nearly 1.7 million cubic yards of material removed each year (USACE 2024), that is contributed by the Chehalis River and other tributaries to the harbor. Dredging typically occurs from December 1 to February 15 and July 16 to September 15 to avoid Tribal fishing periods and reduce impacts on sturgeon. Dredged material is placed at designated disposal sites to both the north and south sides of the south jetty. Dredging at the mouth of the harbor is typically done in April and May and includes monitoring for sturgeon (USACE 2024).

Sediment quality in the inner harbor has been of concern for many decades; however, increased restrictions on and treatment for discharges from point sources and water and sediment cleanup have resulted in most of the inner harbor sediments no longer being of concern. There are three sediment impairment listings near the Highway 101 bridge in Aberdeen for polycyclic aromatic hydrocarbons (PAHs) and mercury that are the subject of current pollution control efforts, and there is a requirement for a sediment quality improvement plan for mercury on the north side of Rennie Island. Lower levels of metals and organic pollutants are found in the sediment in much of the inner harbor and in sampled areas of the central harbor, but levels are within acceptable standards now (Ecology 2024b). Numerous pilings (both creosote-treated and non-treated) are present in this ecological region along the lower tributaries and in the inner harbor; Washington Department of Natural Resources (WDNR) documented over 21,000 pilings in the harbor and lower 2 miles of the Chehalis River, with 5,039 creosote-treated and another 1,237 that were not identified as treated or untreated (WDNR 2012).

The Washington Department of Fish and Wildlife (WDFW) recently conducted an analysis of coho salmon smolt survival data from 1980 to 2019 and found that concerns raised in earlier studies about water and sediment quality problems in the lower Chehalis River do not appear to be a concern currently for salmonid survival. The analysis results show that coho salmon smolt-to-adult return rates in the Chehalis River (from Bingham hatchery fish) are higher than they are in the Humptulips River.

Habitats. The most recent estimate of intertidal habitat area within the estuary ecoregion is 14,277 acres of mudflat; 3,469 acres of sandflat; 245 acres of eelgrass, 5,713 acres of emergent marsh; 257 acres of scrub-shrub wetland; and 6,074 acres of forested wetland (this includes the tidally influenced lower ends of all tributaries to Grays Harbor, WFC 2014). Habitats that have been most affected or reduced by development and dredging activities include forested, shrub, and marsh wetlands and mudflats. The development of Aberdeen and Hoquiam and the Port of Grays Harbor filled in many areas of marsh and mudflat, converting them to uplands, frequently with hard shoreline armoring. Highways fringe Grays Harbor

on both the north and south sides (Highways 101 and 109 on the north side and Highway 105 on the south side), and their associated fill and stream and slough crossings are another major factor contributing to the loss of intertidal habitats and wetlands and fish passage concerns. It is not known to what extent tide gates are present in the estuary. Tide gates can cause fish passage barriers and reduced tidal exchange.

Blue Slough is part of the Chehalis River Surge Plain Natural Area Preserve. It is not known to what extent historical piles are affecting habitat and natural processes.

Compared to the estimated area of eelgrass by Wild Fish Conservancy (WFC 2015), monitoring by the WDNR in 2014 and 2015 indicated that there were approximately 25,000 square meters (m^2; 6 acres) of the native eelgrass (*Zostera marina*) in Grays Harbor in 2014, but the area declined precipitously to about 1,000 m^2 (<1 acre) in 2015. The non-native eelgrass (*Zostera japonica*) is more widespread, with nearly 50,000 m^2 (12 acres) in 2014, slightly declining to approximately 45,000 m^2 (11 acres) in 2015 (WDNR 2015). The potentially depth-suitable eelgrass habitat mapped by Borde et al. (2003) was 7,000 acres; however, eelgrass does not appear to colonize the majority of areas with suitable depths in Grays Harbor, and there can be high annual variation in the extent of eelgrass based on factors such as waves and currents, sediment erosion and deposition, sediment characteristics, boat damage, burrowing from ghost shrimp or the non-native green crab, and water quality factors. Considering the quite small scale of eelgrass that may be present, this is concerning as eelgrass provides multiple important functions including carbon storage and cycling into the foodweb, three-dimensional structure and stabilization in soft sediments, habitat and cover for macroinvertebrates, shellfish, and juvenile fish (including salmonids and forage fish and numerous marine fish species), spawning habitat for Pacific herring, and foraging habitat for shorebirds and waterfowl (Mumford 2007).

Grays Harbor has been identified by WDNR as an area with high ecological and economic values for kelp and eelgrass and is one of the pilot sub-basins to be investigated in detail through the Statewide Kelp Forest and Eelgrass Meadow Health and Conservation Prioritization Plan effort in 2024 (WDNR 2023). This Plan is being implemented because of significant declining trends in kelp and eelgrass habitats in both coastal areas and Puget Sound.

Salmonids. The WFC (2014) sampled fish via beach seining throughout the harbor from 2011 to 2013, focusing on salmonids but also capturing many other fish species. Juvenile salmonids were captured throughout the estuary, including Chinook, coho, and chum salmon and steelhead and cutthroat trout, and they documented individuals from other watersheds using the estuary, including Willapa Bay, north coast drainages, the Oregon coast, the Columbia River, and Puget Sound. Chinook and chum salmon spend more time in the estuary (Chinook salmon unmarked young of year are present from March to September, and chum salmon are present from March to May, although they are not sampled in February) than other

salmonid species and are found in greater densities. Other fish captured included three-spine stickleback, surf smelt, Pacific staghorn sculpin, shiner perch, flatfish, herring, anchovy, and sand lance.

Bull trout are also documented to occur in Grays Harbor and some tributaries in the Chehalis Basin, including the Humptulips, Wishkah, Wynoochee, and Satsop rivers and presumed present in the lower Chehalis River (WDFW 2024a). The Grays Harbor estuary and lower Chehalis and Satsop rivers have been designated as foraging, migration, and overwintering areas that can provide important connectivity and genetic mixing areas for bull trout populations in the Columbia River and Olympic Peninsula and Puget Sound areas (USFWS 2015).

Pacific lamprey are present in the estuary, as well as most of the Chehalis Basin. Much less is known about lamprey use of estuarine habitats, but an analysis of Pacific and western river lamprey captured in Columbia River estuary fish studies indicates that adult Pacific lamprey were present in estuaries from December to May as they move into rivers for spawning, and juvenile Pacific lamprey are present from December through June, corresponding to their outmigration to the ocean. Western river lamprey were present from April through September, consistent with the concept that they feed and rear in estuaries both as juveniles migrating downstream and adults migrating upstream. Both juveniles and adults are parasitic/predatory in marine waters and feed on a wide variety of fish, including juvenile salmonids, forage fish, and many demersal fish (all information in paragraph summarized from Weitkamp et al. 2015).

Larval lamprey bury themselves in fine sediments to filter feed in streams and were captured in tidal sediments, in the Skagit Delta. Juvenile (transforming) western river lamprey were also captured in tidal scrub-shrub wetland beaver ponds (Hood 2012).

Tidal Beaver Pond Habitats and Fish Use. Multiple species of fish, including lamprey, are found in tidal beaver ponds indicating the importance of these ponds during low tides and the importance of woody tidal wetlands that provide food and building materials to allow beaver colonization (beavers did not build dams with herbaceous materials in non-woody tidal wetlands). In the Skagit Delta, tidal beaver ponds contained higher proportions of fish than in shallow tidal channels. Beaver dam densities in these woody tidal channels were similar to densities documented in other studies across North American rivers, and beaver dam lodge densities in tidal channels were higher than in North American rivers, which further highlights the importance that woody tidal channels have in a watershed (all information in paragraph summarized from Hood 2012).

Eulachon. Additional indicator fish species that primarily occur in this ecological region include eulachon and green sturgeon. The southern distinct population segment (DPS) of eulachon is listed as a threatened species under the Endangered Species Act. Eulachon primarily spawn in freshwaters with snowmelt or glacial runoff prior to the spring freshet (spawning temperatures of 4°C to 10°C typically; WDFW 2023a; NMFS 2010). Eggs are mobile and incubate while drifting downstream (about 1 month for development). Larvae drift into the estuary and likely first begin feeding in the estuary. Eulachon are important prey for

multiple species, including humpback and gray whales, pinnipeds, white sturgeon, and both juvenile and adult Chinook salmon. Eulachon are also a culturally important species for northwest tribes.

Grays Harbor and the Chehalis Basin are not included as critical habitat; however, eulachon have been documented (and were likely to be spawning) in the Humptulips, Hoquiam, Wishkah and Chehalis rivers (WDFW 2023a; Gustafson et al. 2016) and larvae drift downstream to Grays Harbor. Eulachon use Grays Harbor for foraging. The top five factors of decline for this species in the Columbia River include climate change effects on ocean conditions, eulachon bycatch in offshore shrimp fisheries, climate change effects on freshwater habitat conditions (reduced snowpack, temperature, streamflow timing and volume), modifications to flows from dams and water diversions, and water quality conditions (NMFS 2010). In the Chehalis Basin, some similar factors contribute to adverse habitat conditions for eulachon, including temperature conditions in the estuary, changed flows and water temperatures from Wynoochee Dam operations, and potential effects from dredging in Grays Harbor (WDFW 2023a).

North American green sturgeon southern DPS is listed as a threatened species and spawns in the Sacramento River watershed, whereas the northern DPS spawns primarily in Northern California and Southern Oregon rivers (although it is possible they spawn in the Columbia River and Grays Harbor [rarely]). Individuals from both populations can be present in Grays Harbor and the Washington Coast (WDFW 2023b). Green sturgeon found in Grays Harbor are primarily rearing in the summer, and Grays Harbor is designated as critical habitat for the southern DPS (NMFS 2009). Green sturgeon feed on benthic invertebrates and fish in shallow areas of estuaries and bays (typically less than 10 meters [m]; NMFS 2009) and are resident in Grays Harbor up to 150 days of the year (WDFW 2023b). Potential factors that affect green sturgeon in estuaries include sediment and water quality pollutants, dredging, climate change effects on water flows and quality, benthic prey populations, and invasive species (WDFW 2023b).

Invasive species are numerous in the estuary and include invasive plants such as cordgrass (*Spartina anglica, S. alterniflora, S. densiflora, and S. patens*), common reed (*Phragmites australis*), knotweed (*Polygonum sp.*), and purple loosestrife (*Lythrum salicaria*) and invasive animals such as European green crab (*Carcinus maenas*) and New Zealand mud snail (*Potamopyrgus antipodarum*). Other invasive plant species that are widespread throughout the Chehalis Basin such as reed canary grass (*Phalaris arundinacea*), Himalayan blackberries (*Rubus armeniacus*) are also present in some areas of the estuary. *Spartina* has been present in Grays Harbor for decades, but significant eradication efforts by the Washington Department of Agriculture have reduced its presence to under 1 acre distributed across very small sites in Grays Harbor that will continue to be tracked and eradicated (WSDA 2024). Green crabs are present in most areas of Grays Harbor; key concerns for native aquatic species are that green crab feed on native shellfish (e.g., clams, juvenile oysters, crabs) and they also dig up or destabilize eelgrass beds, potentially affecting juvenile salmon, marine fish, shellfish, and waterbirds (WDFW 2024b). New Zealand mud snails are present in multiple sites throughout the Chehalis River surge plain and in Duck Lake near Ocean Shores. They feed on algae and detritus that are the base of the aquatic foodweb and may compete with other native invertebrates, but they do not themselves provide a good food source for fish, as they lack nutritional value (WDFW 2023b).

Predators. Potential predators of salmonids are present in Grays Harbor, including piscivorous birds such as Caspian terns, double-crested cormorants, gulls, and great blue herons (eBird 2024) and native marine mammals such as harbor seals (*Phoca vitulina*), Steller sea lion (*Eumatopias jubatus*), and California sea lion (*Zalophus californianus*). Predation within Grays Harbor has not been quantified, but it is an ongoing issue on the lower Columbia River (Zamon et al. 2014; Tidwell et al. 2023). There are substantial differences between the lower Columbia River and Grays Harbor, including the presence of large nesting colonies of Caspian terns and double-crested cormorants on islands in the lower Columbia River and the presence of the Bonneville Dam, which aggregates and may slow adult salmon and steelhead while they find and enter the fish ladder to continue their migration upstream. However, both adult and juvenile salmonids could be susceptible to predation where they may be concentrated in Grays Harbor, such as through the harbor entrance or at river and stream deltas.

Diagnostic Snapshot

- The ecological region is lacking large wood in tidal reaches of tributaries, shorelines, and marsh.
- The New Zealand mud snail is present in the tidal surge plain and near Ocean Shores and affects the foodweb. European green crab is present in Grays Harbor and competes with and preys on native shellfish and destabilizes eelgrass beds.
- The lower 3 miles of the Chehalis River channel are dredged and largely industrial, reducing shallow shoreline and prey resources for migrating fish.
- The Chehalis River surge plain is of high quality and mostly protected, but it is at risk with sea level rise that may convert currently forested swamps to emergent marsh.
- Sea level rise will significantly alter the Grays Harbor shoreline and lower reaches of the tributaries.

5.9.4 Limiting Factors

The estuary is a significant area affecting the abundance of anadromous fish throughout the basin. Limiting factors for salmonid use of estuarine habitat were identified by Smith and Wenger (2001), GHLE (2011), and WFC (2015)[2]. Key issues for salmonids in the region are as follows:

- Water quality (temperature, dissolved oxygen, pollutants)
- Cumulative loss of estuarine swamp, shrub, marsh, and mudflat habitats from development, dredging, and ongoing sea level rise
- Invasive exotic species (currently green crab and New Zealand mudsnail are of most concern)
- Lack of large wood in the tidal reaches of tributaries and along shoreline and marsh habitats

[2] The Ecosystem Diagnosis and Treatment and National Oceanic and Atmospheric Administration (NOAA) life-cycle modeling conducted for the ASRP did not include estuarine or tidal habitats, thus limiting factors could only be partially included from those identified for the lower tributaries in this region. The primary sources for identifying limiting factors included Smith and Wenger (2001), GHLE (2011), and Wild Fish Conservancy (2015).

- Mudflat and channel stability
- Shoreline armoring (primarily in the lower Chehalis River and Aberdeen/Hoquiam area)
- Roadways present along the shorelines that isolate sloughs, wetlands, and floodplains from the harbor
- Fish passage barriers, such as tide gates and roadways
- Sediment quality and modified sediment processes (e.g., via dredging)

Key concerns for eulachon and green sturgeon in estuarine habitats include the following (WDFW 2023a, 2023b):

- Water and sediment quality (temperature, pollutants)
- Prey species abundance and availability
- Dredging effects (entrainment, sediment/turbidity, reduction in mudflats)
- Flow timing and magnitude

Climate change is anticipated to have substantial effects on water quality and habitats in the estuary, including increasing temperatures (particularly in shallow habitats), subsequent decreases in dissolved oxygen, sea level rise converting existing mudflats to deeper water and transitioning marshes to mudflats and scrub-shrub and forested habitats to marshes, and reducing shoreline habitats overall where there is no space to transition to other accessible habitats (e.g., where development or steep slopes preclude habitat development upslope). WFC (2015) has identified the likely transition of the Chehalis Surge Plain habitats to marsh and other shoreline habitat transitions with sea level rise.

5.9.5 Strategies and Actions in the Ecological Region

5.9.5.1 Habitat and Process Protection

Many of the protection actions described in Section 4.2.1 are appropriate in the Estuary Ecological Region. Based on existing known conditions, the following areas and actions are recommended for a protection focus:

- Protect high-quality habitats adjacent to the Chehalis River Surge Plain protected area (particularly upstream of the surge plain) to allow natural tidal inundation and expansion of the forested tidal floodplain with sea level rise.
- Protect high-quality habitats in the tidal reaches of the Wishkah, Hoquiam, and Humptulips rivers to protect forested and shrub-dominated tidal channels and wetlands, and plan/protect adjacent suitable areas for continued natural tidal inundation and the expansion of forested tidal floodplain with sea level rise.
- Protect small sloughs and wetlands/marshes along the Grays Harbor shoreline to provide foraging habitats throughout Grays Harbor for migrating salmonids and other fish.

The Estuary Ecological Region is entirely within Grays Harbor County, which has regulations and policies in place to protect wetlands, floodplains, riparian areas, and fish and wildlife habitat conservation areas

from degradation and development and to manage invasive species. Grays Harbor County's recently adopted Shoreline Management Program (adopted in November 2023) includes regulations to protect shoreline ecological functions; minimize the use of hard shoreline armoring; and protect wetlands, river deltas, shoreline riparian buffers, and fish and wildlife habitats. As part of the community planning strategy (see Section 5.9.5.3), funding support to Grays Harbor County and local cities to evaluate opportunities to collaborate further with the ASRP in their zoning and regulatory processes (possibly biologist staff) or conduct enforcement will be considered.

5.9.5.2 Restoration

The restoration actions described in Section 4.2.2 are mostly appropriate in the Estuary Ecological Region. Based on known existing conditions, the following actions are recommended for a restoration focus:

- Remove hard shoreline armoring and/or replace with bioengineered techniques.
- Remove creosote-treated pilings.
- Set back roads that function as dikes along the shoreline or expand openings to reconnect tidal and floodplain habitats.
- Restore shrub and forest tidal wetlands that are currently rare and expand upstream to accommodate sea level rise.
- Remove/reconfigure tide gates to reconnect tidal sloughs and wetlands for fish access and to increase foraging opportunities and export of detritus and invertebrates for foodweb support.
- Restore and expand tributary delta habitats for cold-water refugia.
- Restore shoreline riparian buffers.
- Install large wood on shorelines and in tidal wetlands for cover and invertebrate production.
- Restore/expand foraging habitats (e.g., marshes, tidal channels) along the shorelines to provide "stepping stones" for migratory fish species.
- Opportunistically restore industrial portions of the estuary (e.g., through piling removal, bank armoring removal, bank shaping, or riparian restoration).
- Collaborate with partner agencies and organizations to support the management of European green crab and other invasive species of emerging concern.

To fill key data gaps and support ASRP project development and actions, the following follow-up studies are recommended:

- Conduct inventory of tide gates creating barriers to include in the Chehalis Basin Barrier Prioritization Tool.
- Support WDNR in updated mapping of eelgrass in Grays Harbor to support protection and restoration actions.
- Partner with relevant agencies to determine whether any further optimization of the navigation channel dredging schedule can be done to avoid impacts to native fish species such as eulachon.

- Conduct study of relative impact of predation on juvenile salmonids (by birds, pinnipeds, and native and non-native predatory fish) in the lower Chehalis River and Grays Harbor.
- Conduct telemetry study of migration routing, timing, and behavior of salmonid smolts in the estuary to better understand need and locations for restoring foraging areas.
- Conduct focused water quality study to understand seasonality of concerns in shallow water and shoreline habitats and identify potential cold-water refugia.
- Evaluate salmonid prey abundance in varying habitat types to help inform needs to create/restore foraging hot spots for migrating salmonids.
- Conduct project effectiveness monitoring for large wood placements in the estuary, as the benefits to fish and the ecosystem are not well understood.

Priority areas and actions within the Estuary Ecological Region include restoration of sloughs and wetlands along the Grays Harbor shoreline; removal of armoring and restoration of shallow shoreline habitats in the lower Chehalis River and in the tidal reaches of the Wishkah, Hoquiam, and Humptulips rivers; and reconnections/restoration of lower Charley and Newskah creeks. All of these actions contribute to improving migratory corridors and rearing areas for salmonids and other native fish as well as habitats for other species of interest.

5.9.5.3 Community Planning

Just as in Section 4.2.3, community planning actions for the Estuary Ecological Region would be coordinated with state and local governments, landowners, and other stakeholders to ensure the long-term success of the ASRP. Programs and policies that could be developed or investigated in the Estuary Ecological Region include the following:

- Discuss with Grays Harbor County and the Washington Department of Transportation additional planning measures that could effectively promote and protect the following:
  - Opportunities to realign roadways and improve tidal and fish passage into sloughs and tidal wetlands as part of long-range planning
  - Riparian and shoreline protection
  - Replacement of hard shoreline armoring with bioengineered techniques
  - Opportunities to restore habitats while promoting adaptation and resilience to sea level rise
  - Potential funding for staff to cooperate more explicitly with ASRP in zoning and regulatory processes and/or conduct enforcement
- As the Chehalis Basin Strategy becomes more integrated, coordinate the ASRP with the erosion management program, local flood protection activities, the Voluntary Acquisition Program, and the Community Flood Assistance and Resilience Program to build habitat restoration and protection actions into community flood risk reduction efforts (such as restoring areas where structures and people have been relocated from floodplains or setting back levees and dikes with improved habitat along the shoreline).

5.9.5.4 Community Involvement

As noted in Section 4.2.4, community involvement and voluntary landowner participation are essential to the success of the ASRP, and the actions described in that section will be further developed as the ASRP is implemented. The community involvement strategy is intended to support and expand the work of existing organizations, as well as support creativity in how local organizations approach working toward the goals of the ASRP. Based on the specific issues in the Estuary Ecological Region, the following actions are recommended for focused community involvement:

- Conduct educational outreach at public access recreation and fishing sites in the estuary regarding ASRP, invasive species and other key topics. Signage and/or community events at the access sites would present opportunities for communication and education regarding restoration activities and connections to the fisheries that are supported by these activities.
- Engage in outreach to industrial landowners to identify non-regulatory opportunities for habitat restoration when land is being redeveloped or developed.
- Develop greater partnerships with public and non-profit landowners to leverage greater protection and restoration opportunities.
- Develop partnering opportunities with Grays Harbor College to supplement monitoring and adaptive management, such as evaluating natural and disturbed processes within the tidally influenced area.
- Continue outreach, engagement, and involvement activities to incorporate landowner and shellfish operator expertise into ASRP planning and local implementation efforts.

5.9.5.5 Institutional Capacity

The institutional capacity strategy is intended to support and expand the work of existing organizations, as well as support creativity in how local organizations approach working toward the goals of the ASRP. The actions described in Section 4.2.5 will be further evaluated for the Estuary Ecological Region as the ASRP is implemented. Based on the specific issues in this area, the following focused institutional capacity actions are recommended:

- Work with local jurisdictions to identify remaining water and sediment quality problems from industrial pollution that are affecting aquatic species.
- Consider funding for local enforcement and/or biologist staff to further collaborate with ASRP.
- Provide technical training on process-based restoration practices and principles specific to estuarine habitat types.
- Provide funding for groups and individuals interested in restoration projects in the estuary.
- Provide funding for invasive species management as it aligns with ASRP priorities.
- Provide funding for monitoring of eelgrass, eulachon, and/or green sturgeon as it aligns with ASRP priorities.
- Build on and support the work of existing organizations with missions that overlap with the ASRP vision (see Appendix E for a list of potential groups).

5.9.6 References

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