State of Our Watersheds Report Green-Duwamish River, White-Puyallup River, and Lake Washington Basins

We are the salmon people. For generations, salmon have sustained our way of life. Now we must sustain the salmon.

– PHIL HAMILTON, MUCKLESHOOT FISH COMMISSION

Areas depicted do not necessarily correspond to Muckleshoot Usual & Accustomed fishing grounds and stations.

The Muckleshoot Tribe

The Muckleshoot Indian Tribe is a federally recognized Indian tribe whose membership is composed of descendants of the Duwamish and Upper Puyallup people who inhabited Central Puget Sound for thousands of years before non-Indian settlement. The Tribe's name is derived from the native name for the prairie on which the Muckleshoot Reservation was established. Following the Reservation's establishment in 1857, the Tribe and its members came to be known as Muckleshoot, rather than by the historic tribal names of their Duwamish and Upper Puyallup ancestors. Today, the United States recognizes the Muckleshoot Tribe as a tribal successor to the Duwamish and Upper Puyallup bands from which the Tribe's membership descends. Like all native people of Western Washington, Muckleshoot ancestors depended on fish, animal, and plant resources and traveled widely to harvest these resources.

Village groups were linked by ties of marriage, joint feasting, ceremonies, commerce, and use of common territory. Downriver people intermarried with other groups along the Sound, while people on the upper reaches of the drainages also intermarried with groups east of the Cascade Mountains. This network of kinship tied together ancestral Muckleshoot villages within the Duwamish watershed, extended across watersheds and the Cascade crest, giving Muckleshoot ancestors access to fishing, hunting and gathering sites throughout a broad area extending from the west side of Puget Sound across the Cascade crest.

History of the Basins

The Green-Duwamish, Puyallup-White, and Lake Washington basins in Central Puget Sound continue to support important salmon and steelhead runs despite dramatic habitat alteration and ecosystem decline. However, the abundance and potential production of natural origin salmon has declined sharply. By the early 1900s, navigation and flood control projects split apart the former 1,700-square-mile river basin that included the Green, White, and Cedar rivers and lakes Washington and Sammamish as its tributaries. The White River was diverted into the Puyallup River. The Black River, the historical outlet of Lake Washington and the Cedar River, was eliminated and a new outlet was constructed through the Chittenden Ship Canal and Locks.

The Cedar River was diverted into Lake Washington, permanently extinguishing chum and pink salmon runs unable to migrate through the lake. By the 1940s, the Duwamish estuary marsh and tidelands were filled to create Seattle's industrial port, and the Cedar, White, and Green rivers were dammed. Streams, wetlands, and floodplains were drained, channelized, or confined and the conversion of forest to asphalt began.

Today, the majority of lowland areas are urbanized. Only a small fraction of marine shorelines remain in a natural condition. Now, more than 2 million people live in these basins.

The scarcity of properly functioning freshwater and marine habitat in Central Puget Sound basins means that hatchery fish produced from local brood stock will continue to remain essential for salmon harvest and conservation. In these basins, the Puget Sound Chinook Recovery Plan goal of self-sustaining and harvestable salmon populations is not likely achievable in the foreseeable future. Until enough high quality habitat is reestablished so that much greater numbers of salmon can successfully complete their life cycle, the benefit of hatchery fish to population abundance will outweigh any potential genetic or ecological risks. Without support from hatchery fish, run sizes will dwindle rapidly to unfishable "museum" levels or even extinction given the severity of habitat limitations. At the same time, without sufficient habitat, even hatchery fish may not be sustainable over time.

A Muckleshoot tribal gillnet boat on Elliot Bay underneath the Seattle skyline at sunrise.

Habitat Decline Continues Despite Recovery Plan

Effective habitat protection and restoration efforts are necessary to sustain future salmon runs in these basins regardless of natural or hatchery origin. Local governments in WRIAs 8, 9, and 10 have prepared habitat plans under the Puget Sound Chinook Recovery Plan approved by NMFS in 2005. Significant efforts are being made by the WRIA groups to implement the projects and measures identified in these plans. While some projects are completed, implementation has been limited by funding and other constraints. Even with full funding, however, the ability of these habitat plans to produce a net gain in habitat quality and quantity is uncertain given the impacts of ongoing development and population growth, the small cumulative geographic extent of the proposed actions, and a reliance on voluntary or inadequate habitat protection measures.

The plans identify restoration projects that, while important, are generally small on an individual and cumulative scale relative to watershed needs. In many cases, the potential to fully recover natural habitat processes in restoration projects is constrained by conflict with adjacent land use, recreation, flood control, water supply, or other demands.

Despite significant efforts by the WRIA groups, habitat continues to be lost and degraded. A recent status report commissioned by NMFS to track Puget Sound Recovery Plan implementation found that, while salmon plan harvest limits had been followed, habitat for Chinook is still declining in Puget Sound (M.M. Judge, 2011). The status report concluded that habitat protection needs improvement despite the adoption of the Shoreline Management Act, Growth Management Act, and Forest Practices Act, with forestland conversion and impervious surface area growing by 2 -3% from 2001-2004. Despite critical areas ordinance rules, riparian areas in priority watersheds in the Lake Washington-Cedar-Sammamish Watershed Habitat Plan continued to lose forest cover and gain impervious surfaces with a 5.5% gain in rural areas and 10.6% gain inside Urban Growth Boundaries between 2005 and 2009 (Vanderhoof, J. et al. 2011).

The Lake Washington-Cedar-Sammamish Chinook Salmon Conservation Plan (WRIA 8) contains habitat protection and restoration measures with objectives to maintain or restore watershed processes, functional migration corridors and high-quality refuge habitats, land use and planning recommendations, and public outreach and education. The plan identified 165 high-priority projects for implementation in the first 10 years of the plan. In the first 5 years, 23 of the 165 projects have been completed while 48 are currently active.

Some of the measures in the Green River Salmon Habitat Plan (WRIA 9) are proceeding, although implementation has been hindered by funding shortfalls and staffing capacity. The plan established goals to protect and restore physical, chemical and biological processes and freshwater, marine and estuarine habitats; protect and restore habitat connectivity where feasible; and protect and improve water quality and quantity conditions to support healthy salmon populations. The Puget Sound Chinook Recovery Plan 2011 Implementation Status Assessment prepared for NMFS (M. Judge, 2011) noted that the WRIA 9 planning group has "the disadvantage of attempting to achieve recovery in one of the most highly altered, diked, degraded and urbanized watersheds in Puget Sound." As elsewhere in Central Puget Sound, restoration opportunities in WRIA 9 are challenged by high land costs, conflicting land use, and site availability. The individual and cumulative scale of the habitat plan restoration projects is generally small. For example, the projects identified in the plan that target estuary transition zone habitat (a high-priority action) would restore a total of less than 40 acres, with a long-term goal of just 173 acres.

Patrick Reynolds, left, and Martin Fox, Muckleshoot biologists, survey a pool for salmon habitat on the Green River in Auburn.

Pierce County serves as the lead entity for the Puyallup-White WRIA 10 salmon recovery habitat plan. Key strategies include levee setbacks, floodplain reconnection, creation of off-channel habitat, restoration of estuary and marine nearshore habitat, and protection and restoration of key tributaries, along with programmatic actions such as a Flood Hazard Reduction Plan and Shoreline Master Plan updates. While some projects have been completed, the WRIA group reports that they are not on pace to meet 10 year goals (M. Judge, 2011).

Restoration Progress Slow

Although only one indicator of habitat conditions, a review of recovery progress and trends at the 5-year mark of the Lake Washington, Green-Duwamish, and White River habitat plans indicated mixed results.

Coordination and alignment of the regulatory and programmatic efforts of jurisdictions with the goals and objectives of the recovery plans has not occurred. For example, Shoreline Master Programs governing land use and habitat protection have yet to be updated and made consistent with habitat recovery strategies (WDOE website 3/3/2011).

Despite its value to salmon, large woody debris placement in rivers is restricted to accommodate recreation. Progress with restoration efforts has been slow and few projects have been able to begin to restore characteristic natural riparian and floodplain habitat processes.

At the same time, federal agencies have not adequately met their own responsibilities for salmon habitat. Examples include continued delays in fish passage improvements at U.S. Army Corps' dams Mud Mountain, Howard Hanson, and the Ballard Locks; weak permit terms and conditions for federal actions affecting ESA Critical Habitat; sediment releases and other unmitigated operational fish habitat impacts at Howard Hanson and Mud Mountain dams, and the Corps of Engineers' levee maintenance standards under Public Law 84-99 that require cutting trees on levees despite Clean Water Act listings and Critical Habitat designations.

A ship moves through the U.S. Army Corps of Engineers' Ballard Locks as two smolt passage flumes (foreground) provide the only safe passage route to sea for juvenile salmon from the Lake Washington system. More fish passage improvements are needed, including replacement of 100-year-old lock valve machinery with new equipment to facilitate slower lockage fills that help reduce smolt mortality associated with navigation at the Locks.

Problems with Water Flow, Pollution and Temperatures

Impacts to water quality and quantity continue to be of great concern in WRIAs 8, 9, and 10, with approximately 193 miles of stream being listed as impaired waters by the Department of Ecology. Another 42 stream miles are assumed to have maximum water temperatures that exceed State standards established for protection of salmonids. Temperatures in the Lower Green River are frequently in the range of sub-lethal effects and at times exceed lethal thresholds. Low flow problems are documented along 602 miles of streams in WRIAs 8, 9, and 10. The number of private permit-exempt wells continues to rise along with land development, with a 58% increase in WRIAs 8 and 9 occurring between 2004 and 2010 and a 49% increase in WRIA 10.

Extensive urban, industrial, commercial, and residential development has greatly increased impervious land cover in these watersheds. Impervious surfaces are strongly correlated with degraded stream health and lost salmon production as a result of increased peak flows, erosion, pollution loading and water temperatures; and decreases in pools, woody debris, and gravel quality, and benthic or prey diversity. Available data indicates a 89-square-mile increase in impervious surface area in WRIAs 8, 9, and 10 between 1986 and 2006.

Adult coho are highly sensitive to stormwater runoff containing toxic pollutants, especially copper, pesticides, and hydrocarbons originating from roads and from urban and residential landscapes. Based on a predictive model developed by NOAA, more than half of the 481 stream miles of the known coho distribution in WRIAs 8 and 9 are expected to have elevated pre-spawning mortality (PSM) rates of 5% or greater, with 141 miles at 35% PSM or greater.

Healthy, properly functioning riparian areas require adequate vegetation, accessible floodplains and the presence of large woody debris. Levees and revetments degrade almost 100 miles of river bank or 49% of the total mainstem river miles accessible to salmon in the Green, Lake Washington, and Puyallup-White basins. Riparian shade is severely deficient along the lower Green River as well as in other stream areas. The size and amount of large woody debris in the Green, White and Cedar rivers continues to be extremely low compared to natural conditions, with the exception of the upper Muckleshoot Indian Reservation reach of the White River. Instream wood levels in the Cedar and Green rivers are estimated to be 89% to 95% below NMFS' criteria for properly functioning conditions for salmon habitat (NMFS 1996).

Degraded Shoreline, Nearshore Challenges Habitat Restoration

The Lake Washington-Cedar-Sammamish Chinook Recovery Plan recognizes the need to restore degraded shoreline habitats in Lake Washington and Lake Sammamish. These shorelines are lined with 4,097 docks and piers, and an estimated 82% of Lake Washington is bulkheaded. These structures replace or degrade Chinook rearing habitat, creating migratory obstacles and ideal habitat for predators such as bass and cutthroat trout. A voluntary approach to address this conservation issue has produced minimal results to date.

Nearshore marine habitat is critical to juvenile salmon for growth and survival during the transition to the Pacific Ocean.

Of the 119 miles of marine shorelines in WRIAs 8, 9, and 10, less than five miles is in a natural condition unaltered by bulkheading or riprap. These values fall far short of the objectives indentified in the recovery plans and the levels necessary to ensure sustainable fish populations into the future. Greater progress is needed in implementing the habitat plans to enhance nearshore areas in Central Puget Sound.

Population growth and development impacts in the Green-Duwamish, Lake Washington, and White-Puyallup basins will continue to challenge the effectiveness of salmon conservation and recovery efforts. Trends suggest that loss of critical habitat will continue even as restoration projects are being implemented. Updating and revising the regulatory framework which serves to protect salmon habitat must occur if the goal of securing sustainable salmon populations is to be realized. Climate change and invasive species present serious additional challenges that will require new approaches and funding sources.

Muckleshoot tribal fisherman land sockeye at Rainier Beach in Seattle.

Adult salmon mortality due to poor fish passage at the Mud Mountain Barrier Dam on the White River. A new dam and fish trap is needed to replace the century-old barrier dam and a 1940s-era fish trap used to capture and transport fish around the 432-foot-high U.S. Army Corps of Engineers' Mud Mountain flood control dam located 5 miles upstream.

Looking Ahead

Habitat priorities for the next 5 years are to halt ongoing habitat declines through greater enforcement of habitat regulations by state, local, and federal agencies and an increased rate of habitat restoration. Specific priority objectives include (1) obtain fish passage improvements at the Ballard Locks including replacement of the Stoney Gate Valves to protect smolts, and replacement of the Mud Mountain Barrier Dam and fish trap; (2) complete riparian corridor plans to improve shade and salmon rearing habitat in the Green River including alternatives to the US Army Corps of Engineers levee maintenance standards; (3) protect and restore freshwater and marine shorelines, and floodplain habitat areas; (4) advance projects that restore groundwater inflows to Sammamish River tributaries to reduce summer water temperatures; and (5) legislation to prevent drilling exempt wells where municipal water supplies are available.

Land use and population analysis has identified a linkage between prespawn mortality and stormwater runoff. Adult coho are highly sensitive to toxic pollutants in stormwater runoff from urban and residential landscapes, such as copper, pesticides and hydrocarbons. Based on a NOAA model, more than half of the 481 stream miles used by coho salmon in the Muckleshoot Tribes' area of concern are predicted to have pre-spawning mortality rates (PSM) of 5 percent or higher. Of these, 141 miles are predicted to have rates greater than 35 percent.

Healthy riparian areas require adequate vegetation and large woody debris. The watershed recovery plans call for managing riparian buffers to secure functional stream corridors. The quality and quantity of instream wood in the Green and Cedar rivers (a tributary to Lake Washington) continue to be extremely low compared to natural conditions, due to land use and river management. Estimates of the size and amount of existing instream wood in the Green and Cedar rivers were found to be 89% to 95% less than NMFS criteria required for properly functioning conditions for salmon habitat (NMFS 1996).

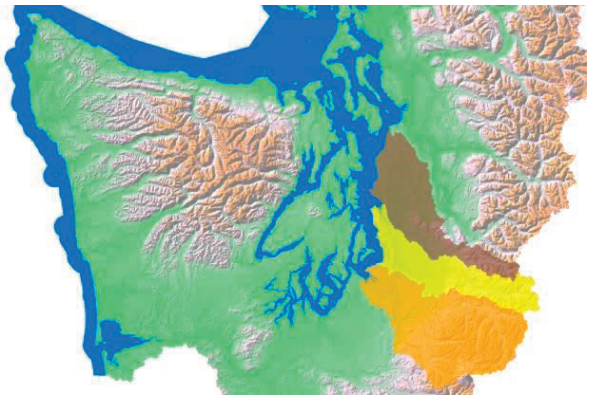
The Lake Washington recovery plan recognizes the need to address degraded shorelines in both Lake Washington and Lake Sammamish. Over-water structures and bank modifications have disrupted the migration and rearing of chinook salmon. The shores of Lake Sammamish and Lake Washington are lined with 4,097 docks, piers, and an estimated 82 percent of Lake Washington has been bulkheaded. These structures are obstacles to migration and are ideal habitat for predators of juvenile Chinook, such as small mouth bass and cutthroat trout. Since 2005, a voluntary approach to address this conservation issue has produced limited results.

Nearshore habitat and vegetation are critical to juvenile salmon for rearing, refuge from predators, transitioning to saltwater habitat and migrating to the open ocean. Greater progress is required in the implementation of the habitat recovery plans to enhance these areas within the watershed. Of the 119 miles of marine shoreline in WRIAs 8, 9, and 10, only 5 percent remains in a natural condition without bulkheads or riprap. Almost 36 miles of the Green River is degraded by levees and revetments; which is 60 percent of the total mainstem river accessible to salmon.

Population growth and development within the Green and Lake Washington watersheds will continue to challenge salmon recovery efforts. Trends indicate that we'll lose critical habitat even as restoration projects are implemented.

Updating and revising regulations that are supposed to protect salmon habitat must occur if salmon populations are to be sustained into the future.

Muckleshoot Indian Tribe Chapter (Lake Washington, Green-Duwamish, & White-Puyallup River Basins)



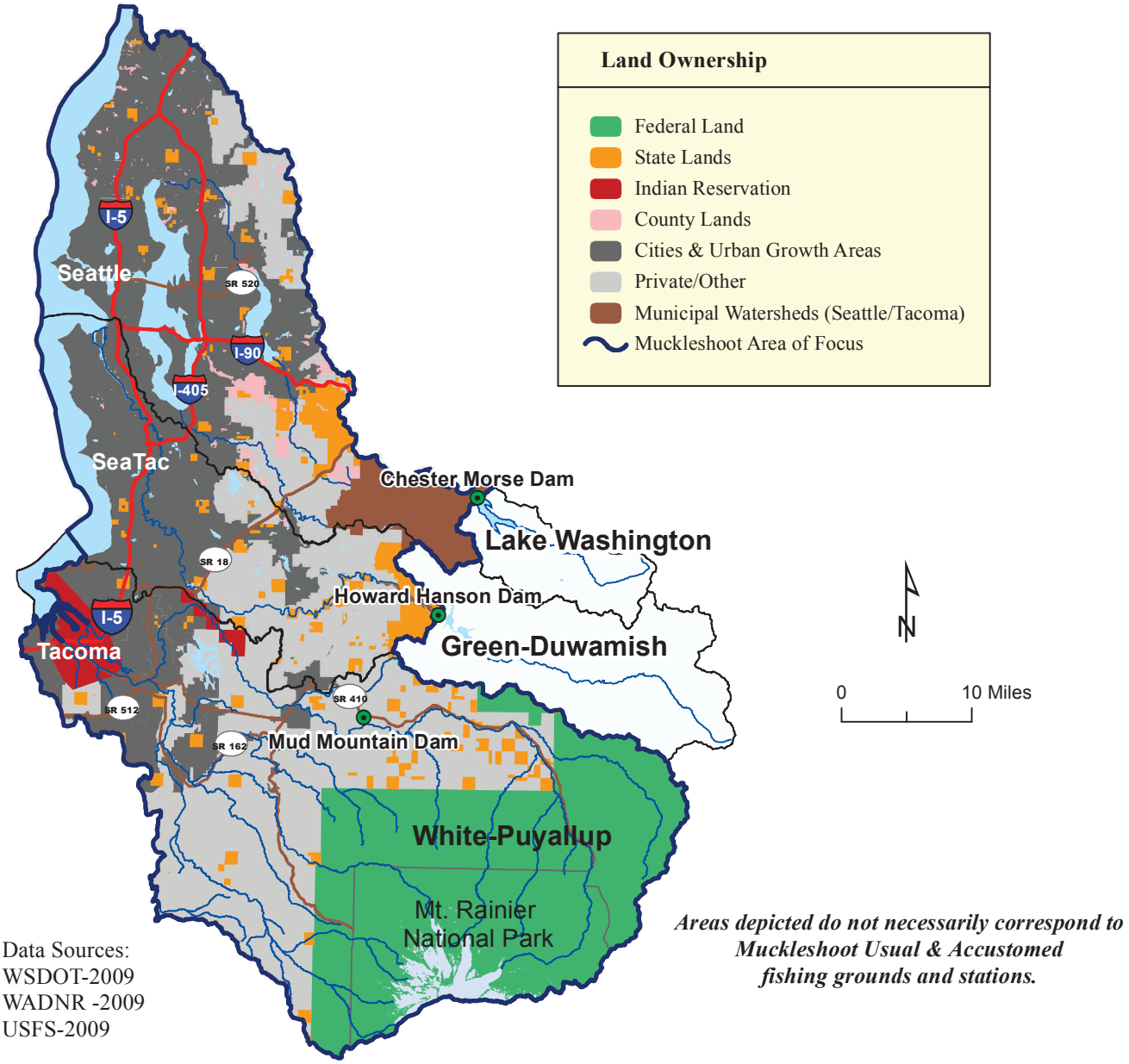
The Muckleshoot Indian Tribe's geographic area of focus includes all of WRIA 8, 9 and 10. In this Chapter, the Tribe's focus is on the White-Puyallup River basin, and on the Lake Washington (WRIA 8) and Green-Duwamish River (WRIA 9) basin areas downstream of the Chester Morse and Howard Hanson dams, in order to highlight the status of salmon habitat at lower elevations largely below forest management areas. Anadromous salmonids in these areas include Chinook, coho, sockeye, chum, pink salmon, steelhead and bull trout.

The Green-Duwamish River Basin was historically 1,736 square miles and included the White and Cedar rivers. The Cedar and White rivers were diverted in the early 1900s, reducing the basin area to 556-square-miles. The Green River's flow regime is altered by flood control and storage at Howard Hanson Dam and by water withdrawals. Approximately 98% of historic intertidal marsh and flats have been replaced with commercial and industrial development. The basin supports more than 500,000 people. About 30% of the basin lies within Urban Growth Area boundaries.

The 686-square-mile Lake Washington Basin includes the Cedar and Sammamish rivers and the lakes Sammamish, Union, and Washington. Major alterations include channelization of the Sammamish River, and the construction of the Lake Washington Ship Canal and the Ballard Locks. The basin is heavily urbanized, leading to highly modified stream hydrology and shorelines. With 25 cities and 1.4 million people, Lake Washington is the most populated basin in Puget Sound with 55% of its land area inside Urban Growth Area Boundaries.

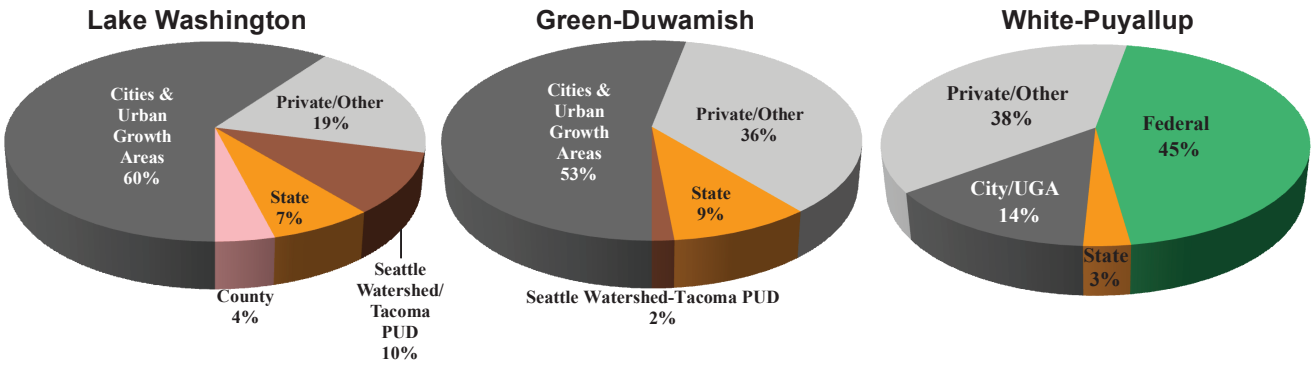
The White River drains a 494-square-mile basin that originates on several glaciers on Mount Rainier. The river flows approximately 68 miles from its origin to its confluence with the Puyallup River at Sumner. Most of the upper White River is managed for timber production and has been intensively logged since 1945, leading to slope stability problems and increased sediment loads in non-glacial tributaries. (M. Judge, 2011) The U.S. Army Corps' Mud Mountain Dam blocks adult fish migration and the river's flow and sediment regime are heavily altered by flood control activities at the dam. From 1911 until 2004, Puget Sound Energy diverted up to 2,000 c.f.s. from the White River into the Lake Tapps reservoir, depleting river flows on the Muckleshoot Indian Reservation and devastating salmon and steelhead populations. A 1986 settlement with the Muckleshoot Tribe required that the diversion meet a minimum instream flow. Hydropower diversion ceased in 2004, and in 2007, an agreement was reached with the Cascade Water Alliance that further limits water diversion to Lake Tapps. The basin includes Commencement Bay, which is highly altered and contaminated from past industrial discharges and urban runoff.

Land development, and hydrologic and channel modification have severely diminished the potential for natural salmon production in these basins. Much of the habitat loss and degradation is not likely to be reversed, and new growth continues to add impacts. As a result, hatcheries continue to play a crucial role in providing salmon for tribal treaty and other harvest, and in maintaining the abundance of naturally spawning fish. Nonetheless, habitat protection and restoration remain essential in order to sustain future salmon populations regardless of hatchery or natural origin.



Data Sources:
WSDOT-2009
WADNR -2009
USFS-2009

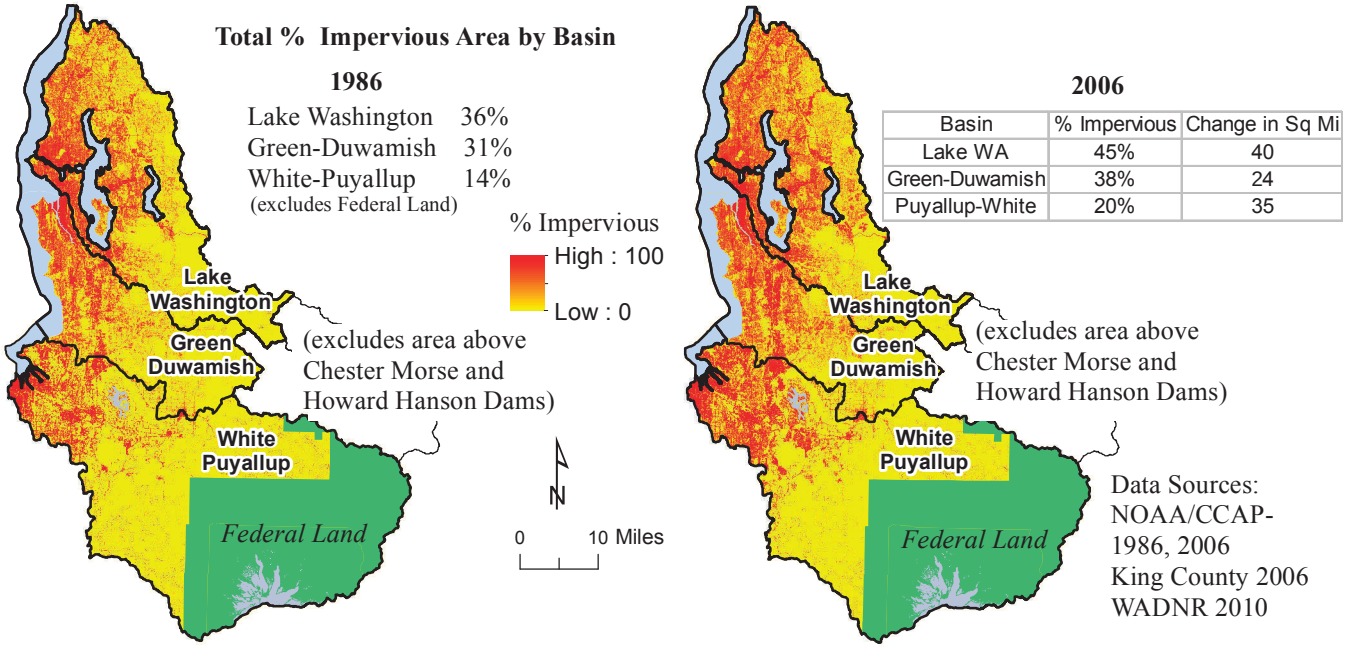
Areas depicted do not necessarily correspond to Muckleshoot Usual & Accustomed fishing grounds and stations.

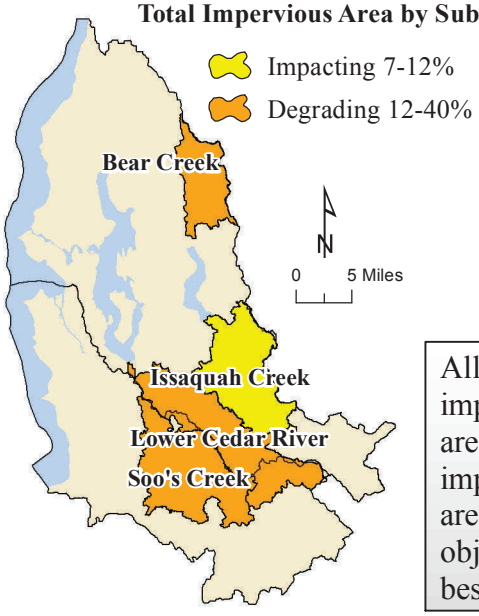


Impervious Surface Continues to Increase

Puget Sound Chinook salmon habitat plans recommend projects to minimize increases in impervious surfaces and promote low impact development. From 1986 to 2006, the Lake Washington, Green-Duwamish, and Puyallup-White basins saw an increase in impervious surface of 24%, 25%, and 47%, a total of 89 square miles. Despite Critical Areas rules, impervious surfaces within riparian areas rose by 5.5% in rural areas and 10.6% in Urban Growth Areas in Lake Washington's high priority subbasins, between 2005 and 2009 (WRIA 8 State of Salmon and the Watershed, 2010).

Impervious surfaces are areas covered with roads, parking lots, roofs and other surfaces that do not allow water to soak into the ground. Total impervious area in a watershed is a general predictor of biological and hydrological conditions (Schueler, 1994; Alberti et al, 2007). Studies in western Washington have found that when impervious surfaces reach 10 - 20% of a watershed, stream stability decreases, flooding and scour increase, large wood decreases, gravel and water quality decrease, macro-invertebrate diversity decreases (Booth and Jackson, 1997; Booth et al., 2002; May, 1996), and loss of aquatic system functioning is likely irreversible (Booth and Jackson, 1997). Impairment can begin as low as 7 to 12% imperviousness (Spence et al, 1996; Snohomish Co., 2005).





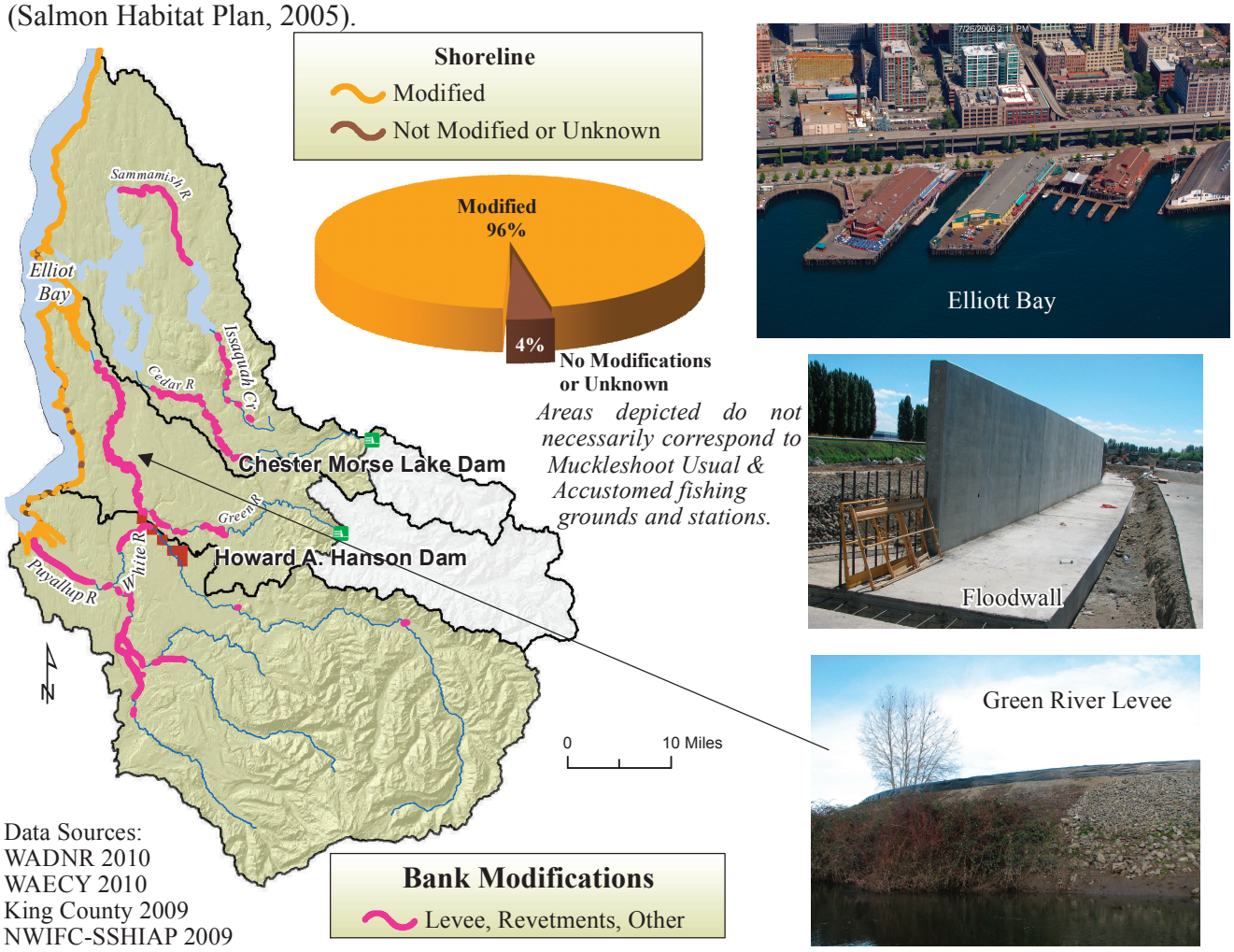
Effective watershed protection and restoration requires maintaining forest cover in at least half of the basin, aggregated around streams and wetlands with intact riparian buffers; less than 20% impervious surface areas with stormwater infiltrated to the ground; riparian protection zones that minimize clearing, road, and utility crossings; and no construction on steep or unstable slopes (Booth et al, 2002; Alberti et al, 2007).

All four of the subbasins depicted have seen an increase in impervious surface area since 1986. Bear Creek, considered a core area in the WRIA 8 Chinook Habitat Plan, saw an increase in impervious surface from 17% to 27%. Issaquah Creek, another core area, saw an increase of impervious surface from 7% to 12%. A key objective in the Chinook Salmon Conservation plan is to protect the best remaining habitat and processes which includes these subbasins.

Shoreline Modifications Limit Fish Rearing Habitat in Fresh and Marine Waters

Salmon produced in Lake Washington, Green-Duwamish, and White-Puyallup basins lack nearshore habitat for juvenile rearing, transitioning to saltwater, and for migration to the Pacific Ocean. Of the 119 miles of marine shoreline, less than five miles are undeveloped or free of bulkheads, riprap, and other structures. According to the Habitat Work Schedule (Jan 2011) only two nearshore restoration projects have been completed with one levee removal started in WRIAs 8 and 9, and one levee setback completed in WRIA 10.

Extensive development along marine shorelines has resulted in loss of productive marine aquatic habitat and vegetation. Bulkheads and seawalls have filled shallow water habitats, resulting in reduced rearing area, food supply, and cover from predators, and has isolated the aquatic environment from natural sediment sources such as feeder bluffs that sustain beach habitats. In Elliott Bay, piers shade shallow water habitat, which reduces habitat productivity and may alter salmon migration patterns (Salmon Habitat Plan, 2005).

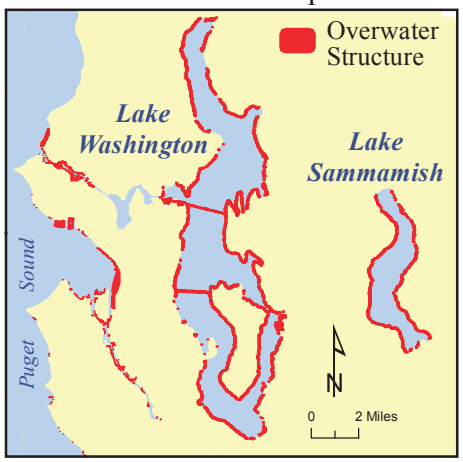


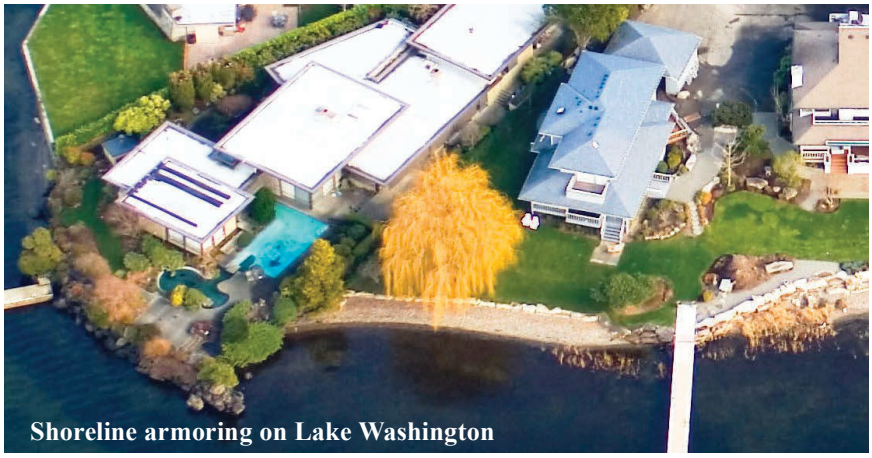
Levees and revetments degrade 36 miles of riparian areas in the Green-Duwamish River, 24 miles in the Lake Washington basin, and 48 miles in the White-Puyallup, amounting to 49% of the total large mainstem river length accessible to salmon. Floodplain development, levees, and revetments have diminished the capacity and productivity of the Green-Duwamish ecosystem for salmon compared to historical conditions. Plans to set back levees to restore floodplain habitats are currently limited in location. Since 2005, the Army Corps of Engineers has enforced policies that restrict vegetation on levees as a requirement for federal funding of levee repairs. In 2009 alone, 461 trees were cut down in the Green River to comply with the Corps' policies (King County DNRP, 2010). Tree removal continues despite Clean Water Act 303-(d) listings for temperatures and dissolved oxygen, a critical habitat designation for Puget Sound Chinook and steelhead, and a lack of evidence that vegetation threatens levee safety.

Overwater Structures Impact Shoreline Habitat in Lake Washington

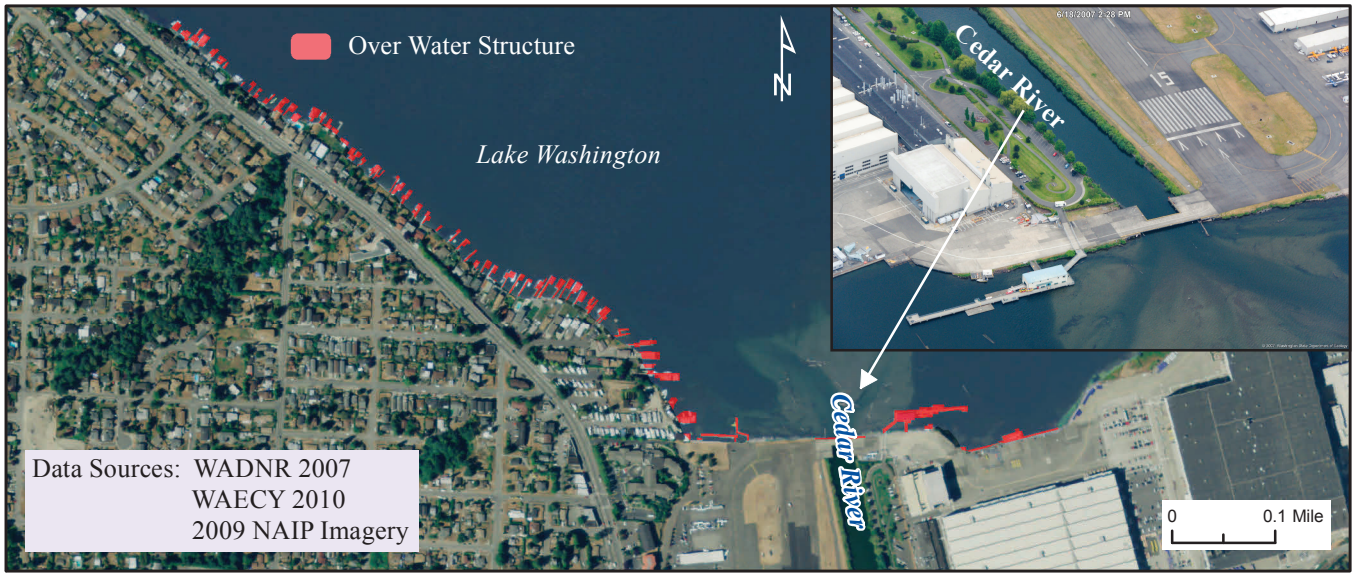
Overwater structures and bank alterations on Lake Washington and Lake Sammamish interfere with the rearing and migration of juvenile Chinook salmon. The lakeshores are lined with 4,097 docks and piers, and an estimated 82% of Lake Washington has been bulkheaded. The Salmon Recovery Plan calls for a reduction in the number and coverage of overwater structures in the Lake Washington basin and to replace bulkheads and riprap. According to the Habitat Work Schedule, three projects to remove bulkhead on Lake Washington have been completed and no docks have been removed.

Docks, piers, and bulkheads provide ideal habitat for ambush predators such as smallmouth bass and cutthroat trout, and are avoided by rearing Chinook. Extensive armoring reduces the amount of gentle sloping shorelines that small juvenile Chinook salmon use from January to May (Tabor and Piaskowski, 2002). Migrating Chinook smolts are also observed to avoid these structures, moving into deeper water where they are more vulnerable to off-shore predators (Celedonia et al, 2006). The perimeter around docks and piers in Lake Washington nearly doubles the natural shoreline length to 163 miles. This longer swimming distance exposes outmigrating Chinook to increased predation, and may delay saltwater entry until midsummer when fish passage efficiency at the Ballard Locks drops due to warm water temperatures.




Shoreline armoring on Lake Washington

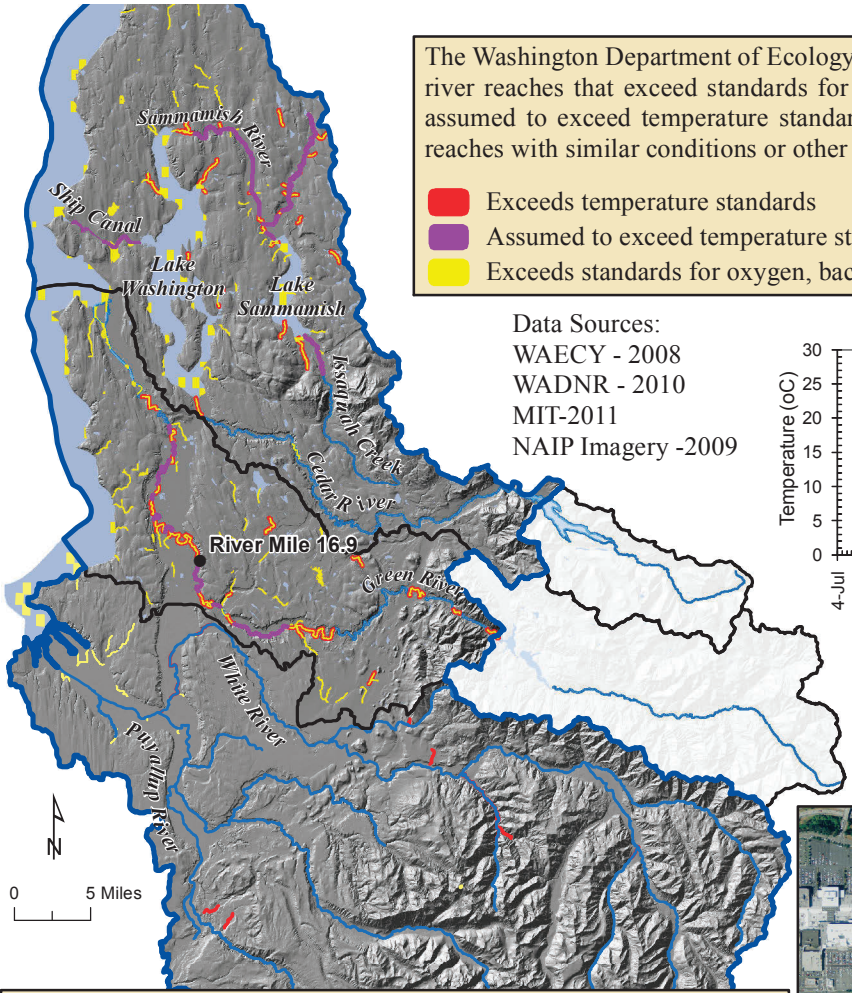
Chinook juveniles leave the Cedar River entering Lake Washington in late winter and spring, and inhabit water less than a meter deep. Most are found in the south end of the lake near the mouth of the Cedar River where they encounter numerous docks and bulkheads. Restoring natural shorelines in the south end of Lake Washington would be beneficial for Chinook but opportunities are limited. (see photo)



Water Quality Conditions Need Corrective Actions

Approximately 193 miles of stream in WRIAs 8, 9, and 10 are listed as "impaired waters" by the Washington State Department of Ecology. An additional 42 miles in WRIA's 8 & 9 are assumed to exceed water temperature standards for fish based on adjacent impairments or other data. Despite near-lethal temperatures and an agreed strategy to "establish and enforce riparian buffers along rivers, streams..." (Shared Strategy for Puget Sound, 2005), more than 461 trees and hundreds of shrubs have been removed from the lower Green River since 2005 to comply with US Army Corps' maintenance policies for federally subsidized levees. Between 2005 and 2009, riparian forests declined by 1.5% in rural areas and by 3.4% in urban growth areas in Lake Washington's high-priority subbasins (Vanderhoof, J. et al, 2011).

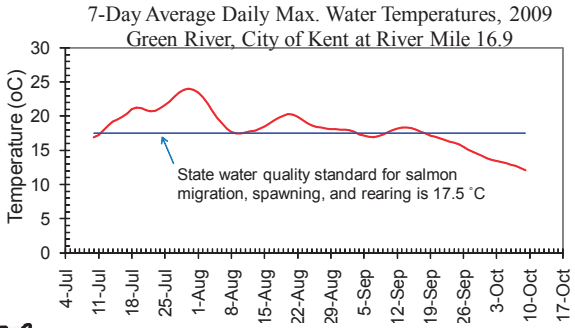
Water temperature and dissolved oxygen are known to be a significant limiting factor for both juvenile and adult salmon (Williams et al, 2001, Kerwin and Nelson, 2000). The Lake Washington Ship Canal, the sole migration route for salmon to and from Lake Washington, routinely reaches temperatures of 21-23+ degrees C by July each year. Summer temperatures in the Lower Green River often reach 7-day average daily maximums greater than 23˚C. A major cause is poor riparian conditions. Shade levels generally range from zero to 20% of natural system potential (King County Shade Assessment Report, 2005).



The Washington Department of Ecology's 2008 Water Quality Assessment identifies river reaches that exceed standards for fish (WAECY, 2008). Additional areas are assumed to exceed temperature standards for fish based on proximity to impaired reaches with similar conditions or other data sets.

- Exceeds temperature standards
- Assumed to exceed temperature standards
- Exceeds standards for oxygen, bacteria, toxics

Data Sources:
WAECY - 2008
WADNR - 2010
MIT-2011
NAIP Imagery -2009



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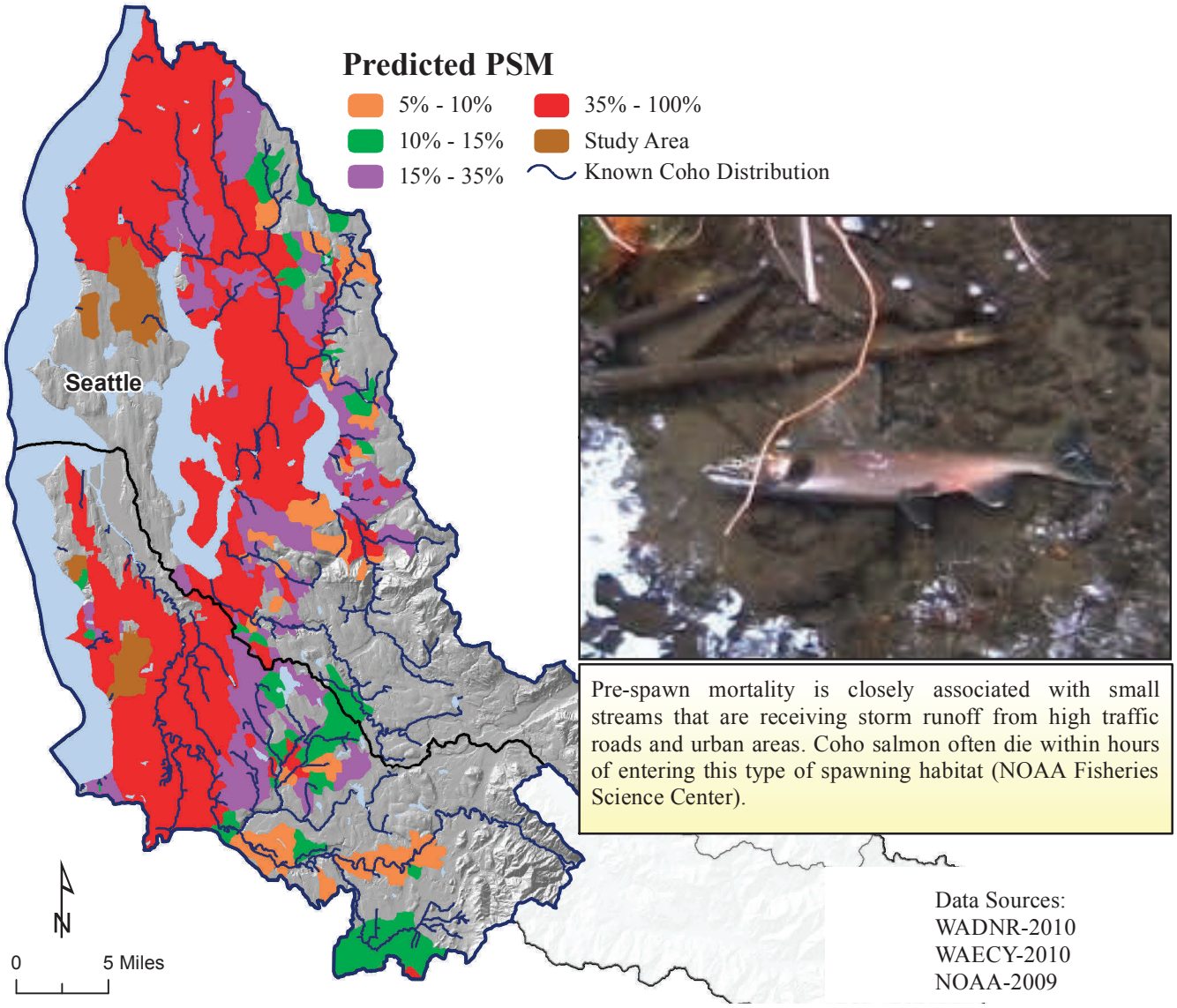
Lack of riparian shade

Loss of riparian vegetation, altered stream flows, and pollution from adjacent land uses limit fish production and survival in much of the Green-Duwamish, Lake Washington, and White-Puyallup basins. While some efforts by local jurisdictions have been made, more action is needed to improve water quality and avoid further degradation.

Stormwater Runoff Implicated in Coho Pre-Spawning Mortality

One of the Lake Washington/Cedar-Sammamish Watershed Chinook Salmon Conservation Plan objectives includes the protection, maintenance and restoration of water quality and natural hydrologic processes (stormwater and instream flows). To date, little has been accomplished to relieve the impacts of stormwater runoff.

Adult coho salmon have been shown to be highly sensitive to stormwater runoff containing toxic pollutants from urban and residential landscapes, such as copper, pesticides, and hydrocarbons. NOAA and USFWS researchers have developed a model to predict areas of coho pre-spawning mortality (PSM) in Puget Sound using spatial analyses of land use and coho PSM data (Nathaniel Scholz, NW Fisheries Science Center). Based on their model, 269 stream miles or 56% of known coho distribution in the Green- Duwamish and Lake Washington basins are predicted to have a PSM rate of 5% or more, with 141 miles predicted to have 35% - 100% PSM. Coho PSM in unaffected streams is generally less than 1% (J.W. Davis, USFWS). The same researchers concluded that copper-containing stormwater from urban landscapes can cause sensory deprivation and increase predation mortality of coho juveniles. In a related experiment, deformities and low growth were observed in coho hatchlings incubated in untreated urban creek water compared to treated water from the creek.

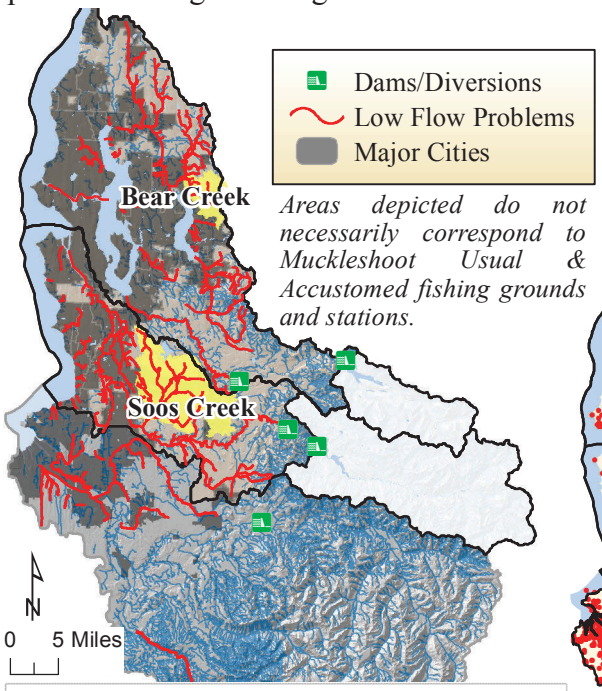


Pre-spawn mortality is closely associated with small streams that are receiving storm runoff from high traffic roads and urban areas. Coho salmon often die within hours of entering this type of spawning habitat (NOAA Fisheries Science Center).

Low Flows Decreasing as Water Resource Development Continues

The 2005 Lake Washington and Green-Duwamish Salmon Conservation Plans call for the maintenance of adequate stream flows. A total of 482 miles of streams in these basins are identified as having low stream flow problems (Lombard and Somers, 2004), while the Puyallup-White have 120 miles. Ground and surface water extractions are estimated to be 37% of the current summer low flows in the Green-Duwamish River Basin (NHC, 2005). In the Lake Washington and Green-Duwamish basins, exempt wells have increased by 58% since 2004, and 49% in the Puyallup-White.

Low stream flows are one of many factors that contribute to low productivity and abundance of Chinook and other salmon. Low flows reduce the available habitat for rearing, migration, and spawning and contribute to warm water temperatures. Instream flows in the Cedar, Green and White river mainstems have been protected and restored through tribal settlement agreements with municipal water suppliers. Many important tributary streams, however, currently lack protection and restoration. Greater enforcement of water rights laws, a halt in the proliferation of exempt wells, and greater use of conservation, source exchange, and other strategies are critically needed for salmon habitat and to protect existing water rights of state and tribal fish hatcheries.

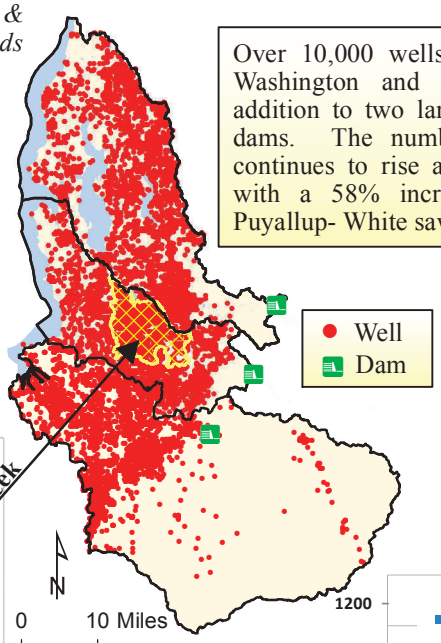


Dams/Diversions
Low Flow Problems
Major Cities

Areas depicted do not necessarily correspond to Muckleshoot Usual & Accustomed fishing grounds and stations.

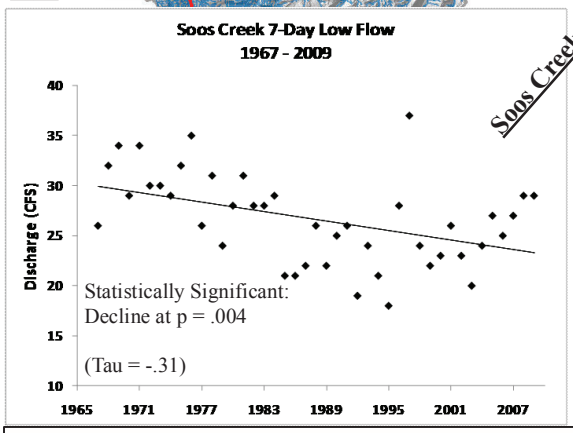
Summer low flows in the Bear Creek drainage have been reduced by 39% (Kerwin, 2001). Private and municipal well extractions in the Soos Creek subbasin were estimated to equal 52% of the current summer low flow (NHC, 2005), reducing habitat for Chinook, coho, and steelhead.

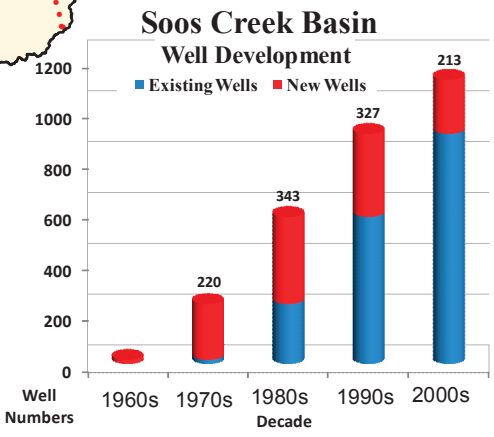
Over 10,000 wells currently exist in the Lake Washington and Green-Duwamish basins, in addition to two large municipal water diversion dams. The number of exempt wells drilled continues to rise as land development proceeds with a 58% increase since 2004, while the Puyallup- White saw a 49% increase.



Well
Dam

Data Sources:
WAECY - 2008/10
WADNR - 2010
King County - 2006
Muckleshoot Tribe - 2011



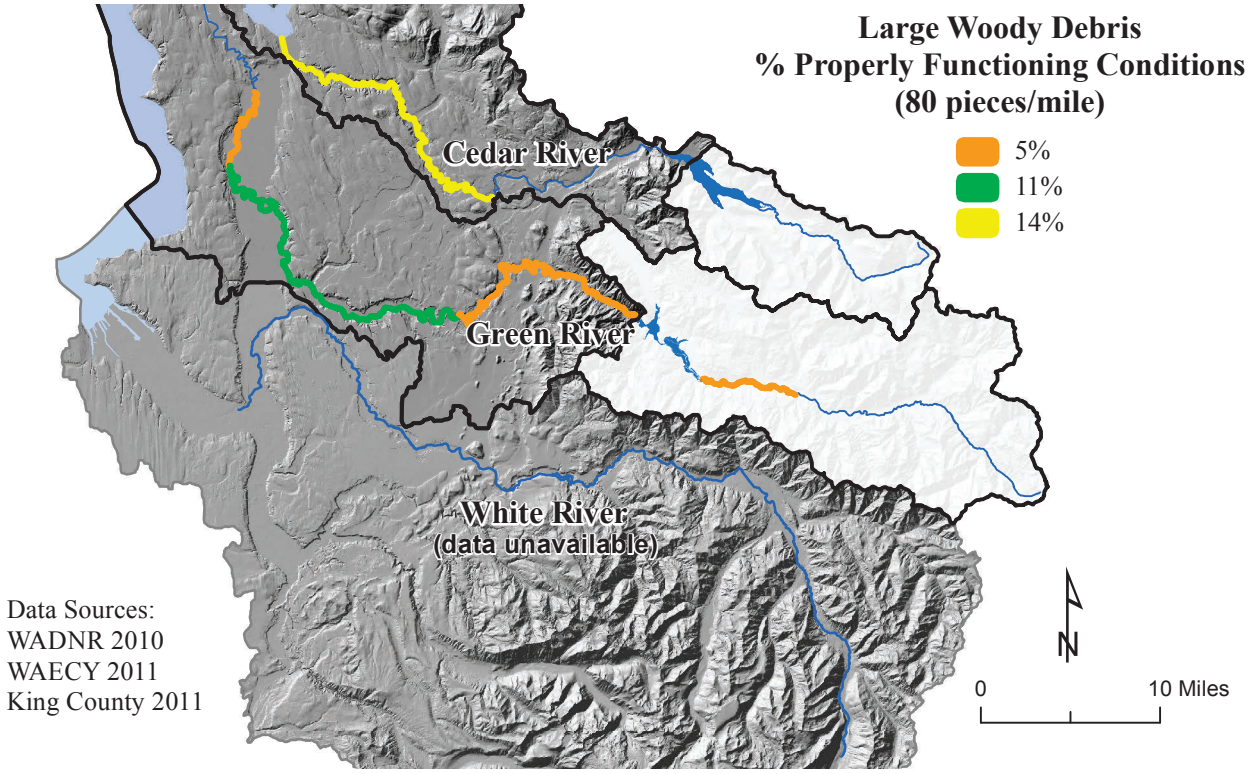


Summer-Fall flows in Big Soos Creek show a statistically significant decline that coincides with development of municipal and private wells in the subbasin.

Streams Lack Large Wood and Important Natural Habitat Features

The Lake Washington, White-Puyallup, and Green-Duwamish salmon habitat plans call for a focus of action to restore sources of large woody debris (LWD), install LWD to restore pool habitat and to protect existing large woody debris. The amount of instream wood in the Green, White, and Cedar rivers is extremely low compared to natural conditions as a result of land use and river management. Estimates of LWD in the Green and Cedar rivers meeting NMFS size and frequency criteria are 89% to 95% below the levels necessary for "properly functioning conditions" for salmon habitat (NMFS, 1996). Data on LWD in the White River is currently unavailable.

The potential to restore large woody debris to improve salmon habitat in the Green-Duwamish and Lake Washington basins is restricted by land use and also by policies that address river recreation safety. The Cedar, Green, and Sammamish rivers are all designated by King County as "Recreational Waterways" where wood placement is restricted and the removal, lopping, or repositioning of wood deemed hazardous to boaters commonly occurs.



Large woody debris provides essential cover and shelter for fish, and helps to form pools, store sediment, and maintain the complex instream habitat required by salmon.

When large woody debris levels are low, fish habitat productivity is diminished.

Riparian areas function properly when adequate vegetation, landform and large woody debris are present.

Summary

The watersheds of the original Green-Duwamish river basin are the most populated and modified watersheds in Puget Sound. Since the original tributaries of the Green-Duwamish River including the Black and White rivers and Lake Washington were diverted for flood control and navigation, thousands of acres of original forest, wetlands, marshes, and floodplain habitats have been converted to urban or other uses. The hydrologic regimes of the Green, White, and Cedar rivers have been altered by large reservoirs and dams, while most tributaries experience damaging peak flows and reduced summer flows as a result of urbanization and groundwater extraction.

Ongoing land development continues to increase impervious surfaces both in and outside of Urban Growth Area boundaries from 2006 levels. Between 1986 and 2006, impervious surfaces rose by 24% in Lake Washington basin (an increase of 40 square miles), by 25% in the Green-Duwamish basin (an increase of 24 square miles), and by 47% in the Puyallup-White (an increase of 35 square miles). Despite Critical Areas rules, impervious surfaces within riparian areas rose by 5.5% in rural areas and 10.6% in Urban Growth Areas in Lake Washington's high priority subbasins, between 2005 and 2009 (WRIA 8 State of Salmon and the Watershed 2010).

Approximately 193 miles of stream in the Lake Washington and Green-Duwamish, and Puyallup-White basins are listed as having impaired water quality by the Washington State Department of Ecology. Based on other information, an additional 42 miles are known or assumed to have high water temperatures. Maximum summer temperatures in the Lower Green River are in the range of those with lethal and sublethal effects for adult and juvenile salmon (21 -23+ ˚C). A total of 482 miles of streams in WRIA's 8 and 9 alone are documented to have low flow problems, with an additional 120 miles in the Puyallup-White. Ground water extractions in the Soos and Bear creek systems have contributed to reduced summer and fall flows available for Chinook, coho, and steelhead. Permit exempt wells continue to be drilled as more land is developed.

Of the 119 miles of marine shorelines, only about 5% in WRIAs 8, 9 and 10 remain natural or unaltered by bulkheads or riprap. Levees and revetments degrade approximately 60 miles of riverbank in the Green-Duwamish and Lake Washington basins representing 49% of the total large mainstem river length accessible to salmon. An additional 48 miles of levees and revetments exist in the Puyallup-White. Overwater structures and bank modifications likely disrupt the growth, migration and survival of Chinook salmon fry and smolts in lakes Washington and Sammamish. Lake shore areas used by Chinook are lined with 4,097 docks, piers, and an estimated 82% of Lake Washington shoreline has been bulkheaded.

Based on a model by NOAA and USFWS researchers, over half of the 481 stream miles of known coho distribution in the Lake Washington and Green-Duwamish basins are predicted to

have elevated pre-spawning mortality rates (PSM) due to polluted stormwater runoff from heavy use roads, with 141 miles predicted to have greater than 35% PSM.

At present, the potential for fish habitat improvement using large woody debris (LWD) is limited by land use and concerns about river recreation safety. The quantity and size of LWD in the Green, White, and Cedar rivers is extremely low compared to natural conditions. Estimates of wood in the Green and Cedar rivers meeting NMFS size and frequency criteria are 89-95% below the levels necessary for Properly Functioning Conditions for salmon habitat (NMFS 1996).

Extensive development has severely diminished the potential for natural salmon production in these basins. Much of the habitat loss and degradation is unlikely to be reversed. As a result, hatcheries continue to play a crucial role in providing salmon for tribal treaty and other harvest, and in maintaining the abundance of naturally spawning fish. Nonetheless, habitat protection and restoration remain essential to sustain future salmon populations regardless of hatchery or natural origin.

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