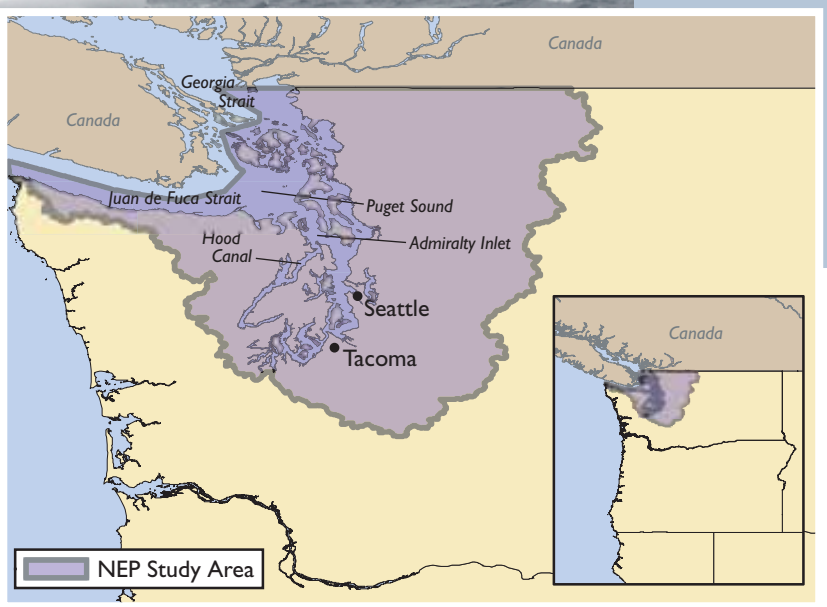
This document contains overall and specific condition of the Puget Sound Action Team from the National Estuary Program Coastal Condition Report. The entire report can be downloaded from
http://www.epa.gov/owow/oceans/nepccr/index.html

National Estuary Program Coastal Condition Report

Chapter 6: West Coast National Estuary Program Coastal Condition, Puget Sound Action Team

June 2007

Puget Sound Action Team



PUGET SOUND ACTION TEAM
Office of the Governor, State of Washington

www.psat.wa.gov

Background

Carved by glaciers, Puget Sound is a place where the salt water of the ocean meets fresh water flowing from about 10,000 rivers and streams (PSAT, 2003a). Together, these waters commingle to form a deep, complex system that provides invaluable habitat for fish and wildlife, including the region's renowned Pacific salmon and orca whales. The Sound covers 2,800 mi^2 of inland marine waters, with an average depth of 450 feet, and encompasses 2,500 miles of shoreline (PSAT, 2003a; 2006).

Much of the promise and potential of the Puget Sound estuarine area is based on natural resources and the industries these resources support, such as tourism, lumber, shellfish, and recreation. The region's natural resources and high quality of life have led to good economic growth, resulting in ever-increasing numbers of people who live and work in the counties surrounding Puget Sound. By 2020, the population in the Puget Sound basin is expected to be greater than five million people—almost 30% more people than the present population (PSAT, 2002). This region supports one of

the leading trade centers on the West Coast and is a gateway to some of the continent's busiest ports, including Seattle, Tacoma, Anacortes, Everett, Port Angeles, and Olympia. The port facilities within Puget Sound collectively handled more than 64 million tons of cargo during 2003 (PSAT, 2002; USACE, 2004b).

EPA declared Puget Sound to be an Estuary of National Significance in 1988, an action that included the Puget Sound in the NEP (PSAT, 2003a). Created in 1996, the Puget Sound Action Team (PSAT) is composed of state agencies and federal, tribal, and local governments. The federal government and the State of Washington have both adopted the *2000 Puget Sound Water Quality Management Plan* (PSAT, 2000) as the comprehensive plan to protect and restore Puget Sound. This partnership is leading efforts to implement the PSAT plan and to protect and restore Puget Sound (PSAT, 2003a).

Environmental Concerns

A growing human population means increasing stress on Puget Sound. Human development has modified significant portions of the Sound's shoreline, and stormwater runoff from developed areas is a substantial water pollution problem because of the contaminants from those surfaces. Toxic contamination, nearshore habitat modifications, habitat loss, declines in some fish and wildlife populations, Endangered Species Act listings of salmon and eight other species in the nearshore habitat, and shellfish bed closures remain among the primary concerns for Puget Sound. The Sound has experienced significant physical changes to its nearshore habitat, as well as population declines in some of its most important plant and animal species (PSAT, 2002).

Population Pressures

The population of the 14 NOAA-designated coastal counties coincident with the PSAT study area increased by about 120% during a 40-year period, from 1.8 million people in 1960 to 4.1 million people in 2000 (Figure 6-10) (U.S. Census Bureau, 1991; 2001). This rate of population growth for the PSAT study area surpassed the population growth rate of 100.3% for the collective West Coast NEP-coincident coastal counties; however, the 2000 population density in the PSAT-coincident coastal counties remained fairly low at 205 person/mi^2, well below the West Coast NEP-coincident coastal county population density of 421 persons/mi^2 (U.S. Census Bureau, 2001). Development and population pressures are especially strong in NEP study areas that serve as major shipping centers for commercial, fishing industry, and recreational activities in their coastal communities.

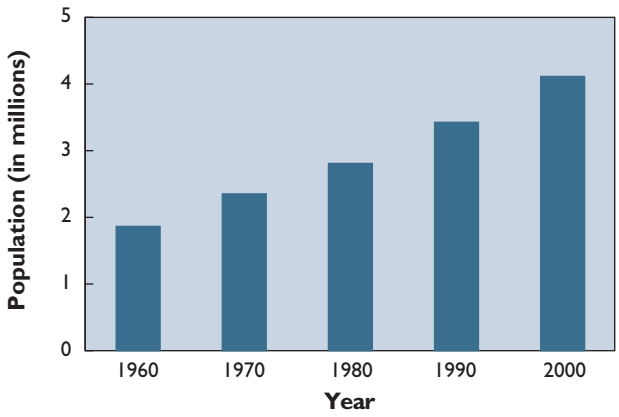


Figure 6-10. Population of NOAA-designated coastal counties of the PSAT study area, 1960–2000 (U.S. Census Bureau, 1991; 2001).

NCA Indices of Estuarine Condition—Puget Sound

The overall condition of Puget Sound is rated fair based on the four indices of estuarine condition used by the NCA (Figure 6-11). The water quality and fish tissue contaminants indices are rated fair, the sediment quality index is rated poor, and the benthic index is rated good. Figure 6-12 provides a summary of the percentage of estuarine area rated good, fair, poor, or missing for each parameter considered. This assessment is based on data collected by the WSDE, in collaboration with NOAA, from 73 sites sampled in the PSAT estuarine area between 1997 and 2000. Please refer to Tables 1-24, 1-25, and 1-26 (Chapter 1) for a summary of the criteria used to develop the rating for each index and component indicator.

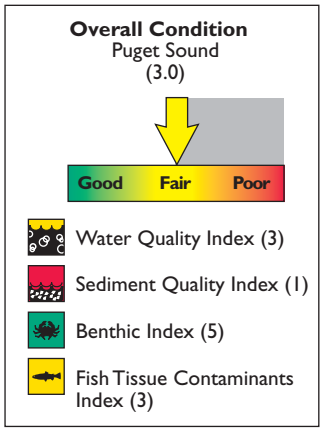


Figure 6-11. The overall condition of the PSAT estuarine area is fair (U.S. EPA/NCA).

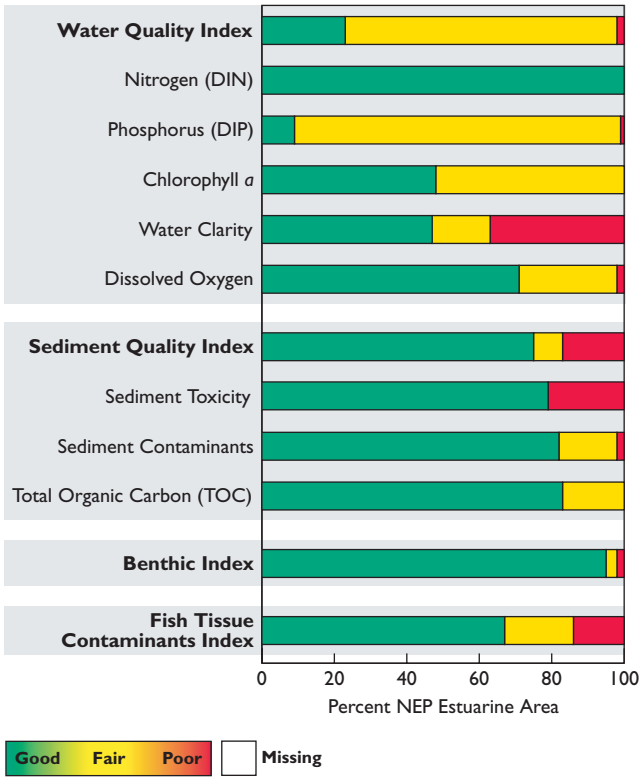


Figure 6-12. Percentage of NEP estuarine area achieving each ranking for all indices and component indicators — Puget Sound (U.S. EPA/NCA).

Water Quality Index

Based on NCA survey results, the water quality index for Puget Sound is rated fair. This index was developed using information from five component indicators: DIN, DIP, chlorophyll *a*, water clarity, and dissolved oxygen. Most (75%) of the estuarine area received fair ratings for water quality, whereas 2% of the area was rated poor because of limited water clarity and moderate levels DIP and chlorophyll *a* (Figure 6-13).

Dissolved Nitrogen and Phosphorus | Puget Sound is rated good for DIN concentrations, but rated fair for DIP concentrations. Concentrations of DIN were rated good in 100% of the PSAT estuarine area. In contrast, fair DIP concentrations occurred in 90% of the estuarine area, and only 1% of the area was rated poor for this component indicator.

Chlorophyll a | Chlorophyll *a* concentrations in Puget Sound are rated fair. Fifty-two percent of the estuarine area was rated fair for this component indicator, and the remaining 48% of the area was rated good.

Water Clarity | Water clarity in Puget Sound is rated poor. Approximately 37% of the estuarine area was rated poor for water clarity, and 16% of the area was rated fair.

Dissolved Oxygen | Dissolved oxygen conditions in Puget Sound are rated good. Twenty-seven percent of the estuarine area was rated fair for this component indicator, and less than 2% of the estuarine area was rated poor, primarily for sites located in Hood Canal. Although dissolved oxygen conditions in Puget Sound appear to be generally good, measured values reflect daytime conditions, and some areas may still experience hypoxic conditions at night.

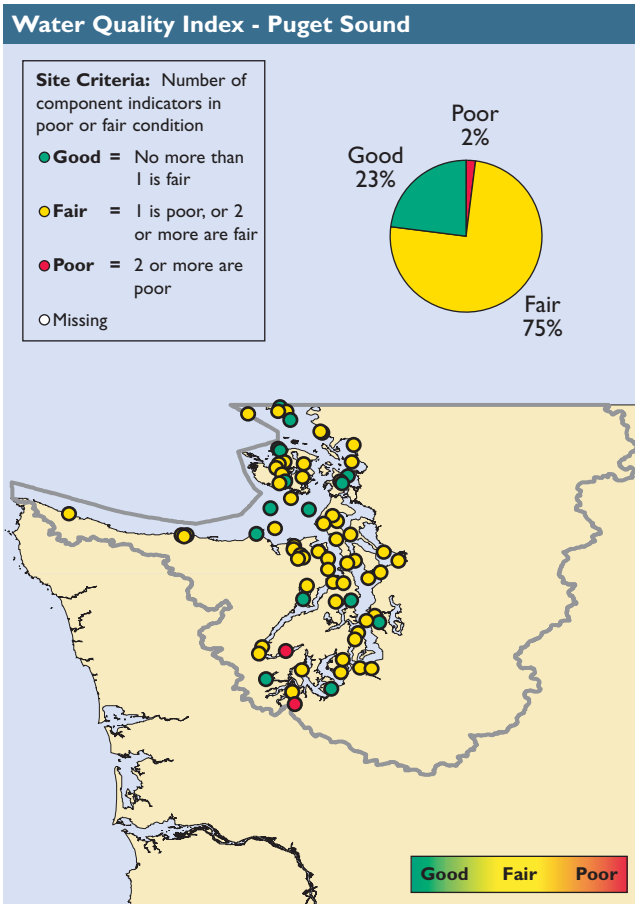


Figure 6-13. Water quality index data for Puget Sound, 1999–2000 (U.S. EPA/NCA).

Sediment Quality Index

The sediment quality index for Puget Sound is rated poor, with 17% of the area exceeding thresholds for one or more of the three component indicators—sediment toxicity, sediment contaminants, or sediment TOC (Figure 6-14).

Sediment Toxicity | Puget Sound is rated poor for sediment toxicity. Sediments in 21% of the estuarine area were rated poor; however, this percentage is based on poor ratings at only two sites, one of which had a 79% survival rate. The effect of these two sites on the area estimate of poor condition was augmented by the fact that both sites were located within the statistical stratum with the largest area and that only five other sites had acceptable sediment toxicity data within the stratum.

Sediment Contaminants | Puget Sound is rated good for sediment contaminant concentrations, with 2% of the estuarine area rated poor for this component indicator and 16% of the area rated fair.

Total Organic Carbon | Puget Sound is rated good for sediment TOC, with sediment concentrations rated good in 83% of the estuarine area and fair in 17% of the area. None of the PSAT estuarine area was rated poor for sediment TOC concentrations.

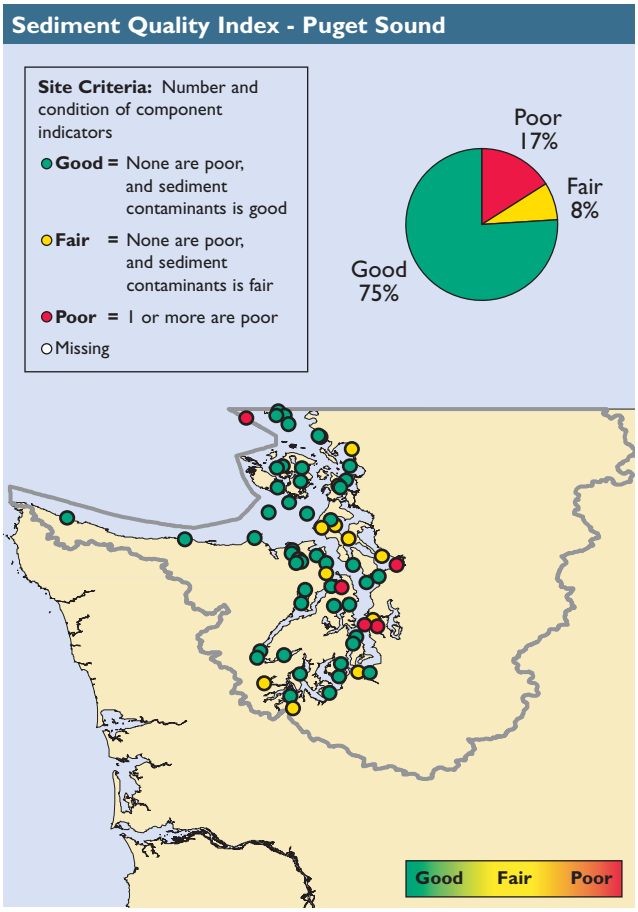


Figure 6-14. Sediment quality index data for Puget Sound, 1997–2000 (U.S. EPA/NCA).

Benthic Index

The benthic condition of Puget Sound is rated good based on deviations from the expected species richness (Figure 6-15). This analysis was based on 62 benthic samples collected in Puget Sound, including 8 samples collected in the embayments along the Strait of Juan de Fuca in 1999 and 54 from within Puget Sound proper in 2000.

A significant linear regression between log species richness and salinity was found in the Puget Sound estuary, although this regression was weak ($r^2 = 0.09$, $p < 0.01$). A potential reason for the weak relationship between species richness and salinity is that bottom salinity ranged only from 25.7 to 33.0 ppt among these sites. Using this regression, four sites (representing 2% of the estuarine area) were rated poor based on a lower-than-predicted species richness, and another four sites, representing 3% of the area, were rated fair. The remaining 95% of the estuarine area was rated good for benthic condition. The cause for the less-than-expected species richness at the sites rated poor is not readily apparent because all of these sites were rated good for sediment contaminant concentrations. In addition, sediment TOC was rated fair at three of the four sites surveyed, although a number of other sites with equivalent TOC measurements did not display depressed species richness.

Fish Tissue Contaminants Index

The fish tissue contaminants index for Puget Sound is rated fair. Fourteen percent of all stations sampled where fish were caught exceeded EPA Advisory Guidance values using whole-fish contaminant concentrations (Figure 6-16). For populations that consume whole fish, these risk calculations are appropriate. The contaminants found in fish tissues in Puget Sound most often included total PCBs.

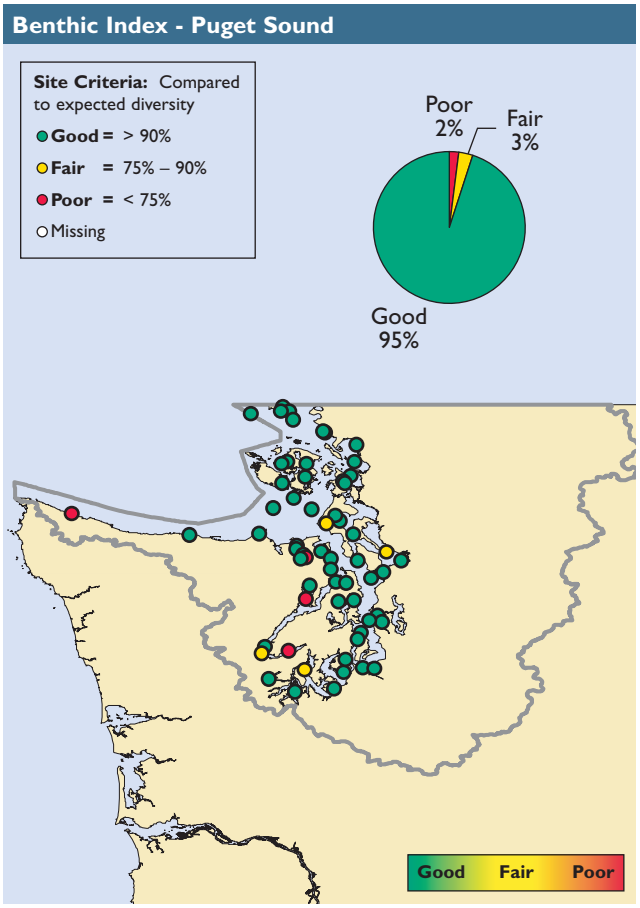


Figure 6-15. Benthic index data for Puget Sound, 1999–2000 (U.S. EPA/NCA).

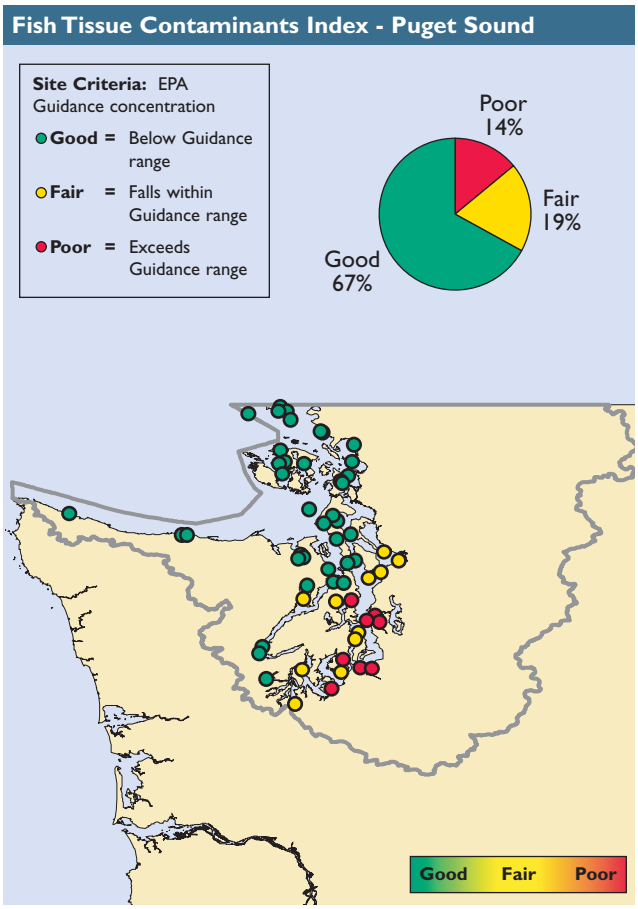


Figure 6-16. Fish tissue contaminants index data for Puget Sound, 1999–2000 (U.S. EPA/NCA).

Puget Sound Action Team

HIGHLIGHT

Efforts to Address Low Dissolved Oxygen Levels in Hood Canal, Washington

Hood Canal, a 60-mile-long, glacially carved fiord (see map), is one of the most scenic marine environments of Puget Sound, a region long renowned for its commercial and sport fishing and shellfish harvesting. Nestled between the Olympic Mountains and the central channel of Puget Sound, Hood Canal is experiencing increased growth and associated development. This activity may be at the heart of the reoccurring hypoxic conditions in Hood Canal, a problem that hit the spotlight in the spring of 2002 and again in the fall of 2003, when dead fish and other marine life washed up on Hood Canal's beaches. During 2004, the oxygen levels in Hood Canal dropped to all-time lows (PSAT, 2005a).

In 2005, the Washington State legislature acted on this problem, designating the PSAT as the state's lead agency for Hood Canal and the Hood Canal Coordinating Council as the local management board. The 2005 legislature charged both entities to work together to restore marine water quality and dissolved oxygen to levels adequate to support healthy marine life. The legislature also designated Hood Canal as the first Aquatic Rehabilitation Zone in Washington State. Most significantly, the legislature and Governor approved $22 million of new funds to scale-up corrective actions for Hood Canal (PSAT, 2005a).

Twenty-eight organizations, including state and federal agencies, universities, local and tribal governments, non-profit organizations, and research institutes, have formed a partnership to address low dissolved oxygen levels in Hood Canal and the effect of this problem on marine life. This partnership, the Hood Canal Dissolved Oxygen Program (HCDOP), will use data from monitoring, computer modeling, and demonstration projects to further develop and target the corrective actions designed to restore and maintain healthy levels of dissolved oxygen in Hood Canal (PSAT, 2005a).

For more information on the HCDOP's coordinated effort to recover Hood Canal, go to http://www.psat.wa.gov/Programs/hood_canal.htm.

Puget Sound Estuary and the Hood Canal (PSAT).

Puget Sound Action Team Indicators of Estuarine Condition

Factors such as water quality and the health of some marine animals signal improvements in the health of Puget Sound. Unfortunately, other environmental indicators warn of concerns for the Sound's overall ecosystem. In 2002, the PSAT issued its third biennial report on the health of Puget Sound, *Puget Sound's Health 2002* (PSAT, 2002). This report summarizes the condition of the Sound's marine waters, shoreline, 200 species of fish, 26 species of marine mammals, 100 species of sea birds, and thousands of species of marine invertebrates, using 19 indicators to determine whether the Sound's health is getting better or worse. As shown in Table 6-1, 8 of the 19 indicators classify Puget Sound's health as improving, 2 indicators classify the Sound's health as declining, 3 indicators show mixed results, 4 indicators document continued concerns about persistent toxic contamination problems, and 2 indicators are new indicators of nearshore habitat conditions. Additional information about recent conditions in Puget Sound and the PSAT's actions to restore the estuary is available at http://www.psat.wa.gov.

Water and Sediment Quality

Freshwater quality in the streams and rivers of the PSAT estuarine area is assessed using 8 parameters measured at 38 sites on a monthly basis. These eight parameters include measures of nutrients (e.g., total nitrogen, total phosphorus), pathogens (e.g., fecal coliform bacteria), and other physical parameters (e.g., water temperature, dissolved oxygen, pH, total suspended solids, and turbidity). Trend analysis for temperature based on data collected from 1995–2004 showed improvements in overall water quality index scores in all areas except the Stillaguamish River. The majority of rivers and streams monitored had good fecal coliform conditions (28 of 38 stations), the remainder of sites were rated fair, and none of the sites were rated poor for coliform conditions. The same percentage of sites were scored in good condition during wateryear 2005 as compared with wateryear 2000 (Personal communication, Brace, 2006).

Marine water quality monitoring in Puget Sound measures temperature, conductivity, salinity, density, dissolved oxygen, pH, light transmission, and nutrient (e.g., nitrate, nitrite, phosphate, silicate, and ammonium) and fecal coliform bacteria concentrations.

Table 6-1. Summary of Indicator Results from *Puget Sound's Health 2002* (PSAT, 2002)

Rating	Results
Improving	Area of commercial shellfish beds approved for harvesting Beaches used by recreational shellfish harvesters Water quality for recreation (measuring bacteria contamination) Size and frequency of major oil spills Reduced acreage of *Spartina* infestation, an aquatic nuisance plant species Freshwater habitat available to salmon (culverts allowing fish migration) Water temperature in rivers and streams Marine survival of Puget Sound wild coho salmon
Mixed	Harbor seal populations Herring populations Marine water quality
Declining	Scoter populations Rockfish populations
Persistent Toxic Contamination	Area of contaminated sediments (bottom of waterways) Contamination in mussels Contamination in harbor seals Occurrence of liver disease in English sole
New	Abundance and distribution of eelgrass beds Modifications to marine shorelines

Most of these parameters are monitored on a monthly basis. In general, regions of high concern with respect to marine water quality were located near urban areas or in poorly flushed areas such as Budd Inlet, Port Gardner, Bellingham Bay, Nisqually Reach, Carr Inlet, Case Inlet, and Henderson Inlet (Personal communication, Brace, 2006).

As of 2001, the WSDE had identified 112 contaminated sediment cleanup sites, representing an estimated 3,400 acres of marine sediments in Puget Sound (Figure 6-17) (WSDE, 2001; PSAT, 2002). Twenty-two of these sites have been cleaned up or require no further action. In 2002, cleanup activities were underway at 11 more sites. Action was still needed at an additional 79 sites, and 65 of these sites were in the investigation and design phases leading to cleanup. Between 1997 and 1999, 8,700 acres (1.5%) of soft sediment in Puget Sound (excluding the San Juan Islands and the Strait of Juan de Fuca) were contaminated, and approximately 83,000 acres were less severely contaminated. Long-term monitoring by the WSDE indicates that concentrations of some contaminants (e.g., naphthalene, low molecular-weight PAHs) have increased during the past few years, whereas concentrations of other contaminants (e.g., copper, mercury) have decreased (PSAT, 2002).

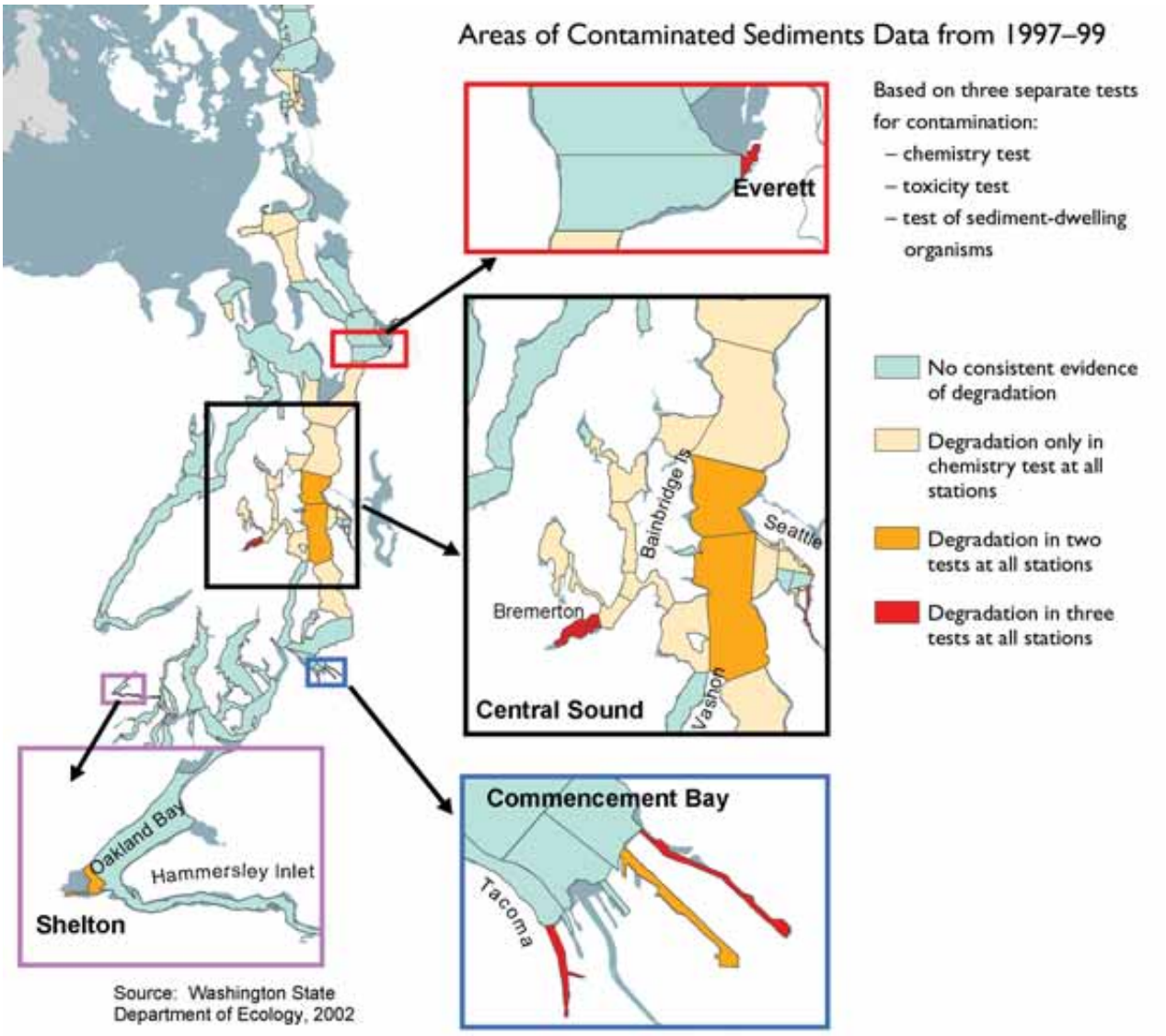


Figure 6-17. Sediment contamination map of Puget Sound (PSAT, 2002).

Habitat Quality

Human development significantly alters the Puget Sound environment, and habitat loss and degradation are major threats to the health of the Sound's fish and wildlife. Protecting and restoring habitat is a key element of the strategy to recover wild salmon and a priority of the PSAT. Habitats at risk from direct human development and construction activities include freshwater habitat for salmon and other fish, as well as Puget Sound's fringe of shallow subtidal, intertidal, and shoreline habitats known as the marine nearshore. For example, infestations of *Spartina*, a salt marsh grass native to the eastern United States, can overtake native western grass species, making these habitats less useful to the area's fish, shellfish, and birds. Between 1999 and 2001, the Washington Department of Agriculture and its partners reduced *Spartina* infestations throughout most of the study area, except in Snohomish County (PSAT, 2002).

Eelgrass beds are also an environment of particular interest in considering habitat quality in Puget Sound. Based on the first year of a new eelgrass monitoring project, the Washington Department of Natural Resources (WDNR) estimates that Puget Sound is home to approximately 26,000 acres (or nearly 41 mi^2) of eelgrass. Eelgrass beds are divided into two habitat types. A significant amount of eelgrass occurs in flats, which can be large shallow bays or small pocket beaches, and close to one-fifth of all the eelgrass in Puget Sound grows in one large flat, Padilla Bay. Eelgrass also occurs in narrow fringing beds along steeper shorelines. These fringing beds are used as corridors for migrating salmon and other wildlife, and about one-half of all eelgrass in Puget Sound occurs in fringing beds. Eelgrass and other seagrass species are used as an indicator of estuary health because they respond to many natural and human-caused environmental variables, and changes in the abundance or distribution of this resource are likely to affect other species that depend on eelgrass habitat (PSAT, 2002).

Living Resources

A variety of living resource indicators are used to assess the health of Puget Sound. Population trends in fish and wildlife can provide insight into the state of the region's ecosystem. The extent of area open to shellfish harvesting is an indicator of the amount of contamination in the Sound. In addition, the PSAT examines the levels of several chemicals in the tissue of mussels and harbor seals to determine how these contaminants are behaving in the food chain. In general, the levels of pollutants in Puget Sound vary regionally, with higher levels found in marine life near urban areas. The effects of contaminants on the health of the area's wildlife is assessed by monitoring the occurrence of liver lesions in English sole (PSAT, 2002).

The PSAT uses the population trends and spawning potential of several key fish and wildlife species as indicators of estuary health. In 2000 and 2001, coho salmon appeared to be returning to Puget Sound in small but increased numbers compared with returns in the late 1990s. Rockfish, which can live for 80 to 100 years, are declining at an alarming rate, and the spawning potential for rockfish measured in 2000 was only 7% to 12% of the levels recorded in the late 1970s (PSAT, 2002; 2005b). Scientists believe that this decline, coupled with the decline of many other marine fish species, may point to significant problems with the entire Puget Sound ecosystem. A number of marine bird species have declined by 50% or more in the past 20 years. Populations of scoters, which are large black diving ducks with orange bills, have declined by 57% in the past 20 years. During the same period, 13 out of 18 other marine diving birds in Puget Sound have shown significant population declines. Some bird species, such as the marbled murrelets, have experienced population declines of more than 90% (PSAT, 2002).

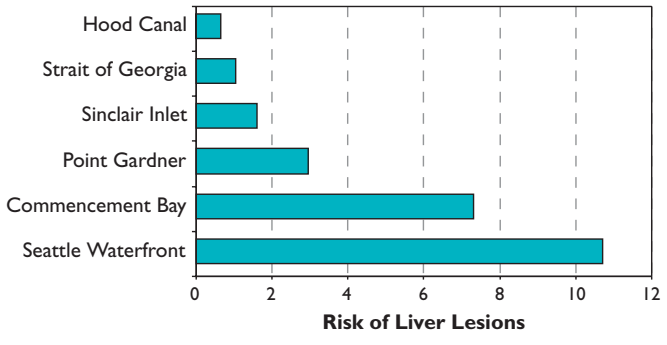
Washington is among the top shellfish-producing states in the nation, and the health of shellfish beds and the suitability of shellfish for consumption closely reflect conditions of the state's shellfish-growing environment. The Washington Department of Health (WDOH) classifies shellfish-growing areas to provide

information about the extent to which contamination restricts the ability to harvest shellfish, and changes in the classification of these areas can reflect problems related to how land is used and cared for in the nearby watersheds. Since 1980, nearly one-quarter of the approximately 140,000 acres available for direct commercial shellfish harvesting has been downgraded in classification because of bacterial contamination. During 2000–2001, the WDOH downgraded 849 acres and upgraded 1,540 acres. These areas were relatively small when compared to the approximately 33,000 acres that were downgraded in the 1980s; however, the net upgrade of 691 acres in 2000 and 2001 indicates that pollution-control efforts appear to be balancing increasing water quality threats (PSAT, 2002).

Mussels filter large quantities of water and can accumulate any toxic contaminants that are present in the water or adsorbed on phytoplankton. The NOAA National Mussel Watch Program data collected through 1998 demonstrated that multiple Puget Sound locations experienced long-term declining trends in the concentrations of banned pesticides (e.g., chlordane, DDT) and several metals (e.g., lead, mercury) in mussel tissue. However, it also appeared that PCB levels in mussels were no longer decreasing and possibly increasing during the mid- to late 1990s. NOAA scientists have used newly available data from 1999–2001 to construct a 16-year record of PCB levels and to identify three important patterns. First, concentrations of PCB in mussels have generally been declining during the two decades following the ban on most PCB uses in the 1970s. Second, the highest concentrations were consistently found in mussels from central Puget Sound sites, such as Four Mile Rock (north Elliott Bay) and adjacent areas, confirming that this urban area is a long-term source for PCBs. Finally, the long-term downward trend was interrupted in the mid-1990s by increases in PCB levels at many locations. Between 1999 and 2000, PCB concentrations in mussels began to decrease again. These patterns indicate that it is uncertain whether PCBs will continue to decline at the rates seen from the 1970s to early 1990s (PSAT, 2002).

Harbor seals feed relatively high in the food chain and accumulate contaminants from their food (primarily fish) in their fatty tissue. As a result of the widespread restrictions placed on PCB and DDT use in the early 1970s, there was a sharp decline in measured levels of these contaminants in Puget Sound harbor seals through the 1970s and afterwards. These declines have leveled off since the mid-1980s as contaminated land and sediments continue to release PCBs into the marine food chain (PSAT, 2002).

Scientists who routinely monitor English sole at six Puget Sound locations have found significantly elevated occurrences of liver lesions at two urban sites and one near-urban site (O'Neill et al., 2001). PAH concentrations in sediments were also elevated at these three sites. These results indicate that the health of bottom-dwelling fish in Puget Sound is worse in areas where sediments are contaminated (Figure 6-18). The risk of developing liver disease increased in English sole sampled along the Seattle waterfront between 1989 and 1998, but decreased in 1999 and remained low in 2000; no increasing or decreasing trends were evident at the other sites. The lower occurrence of liver lesions in English sole during 1999 and 2000 may have resulted from the numerous sediment-capping projects that have been completed to the north and south, as well as in the immediate vicinity of the Seattle waterfront, since 1989. Collectively, these projects may have lowered the PAH concentrations in sediments and reduced exposures to English sole feeding in this area (PSAT, 2002).



Source: Washington Department of Fish and Wildlife

Figure 6-18. Risk of liver disease in English sole based on geographical location (PSAT, 2002).

Environmental Stressors

Shoreline modifications, such as bulkheads or seawalls, tend to harm habitat through the conversion of tidelands to uplands. Modification also indirectly affects habitat by altering nearshore processes. The amount of modified shoreline in an area can be a useful indicator of the effect people have on the nearshore environment. In 2000, scientists with the Nearshore Habitat Program at the WDNR completed a statewide inventory to assess the extent of modification along saltwater shorelines (Berry et al., 2001). Approximately one-third of all saltwater shorelines in Washington have some kind of shoreline modification structure. In the PSAT study area, Snohomish and King counties have the most extensively modified shorelines (PSAT, 2002).

Current Projects, Accomplishments, and Future Goals

Protecting and restoring Puget Sound is a long-term commitment that requires continuing efforts by government, tribes, private industry, environmental and citizen groups, and individual residents throughout the region. Although progress has been made on many fronts, new challenges have emerged, and many existing problems persist as the region's population grows and the area of developed lands expands within the basin. The PSAT's partnership prepared the *Puget Sound Water Quality Work Plan: 2003–2005* (PSAT, 2003b) as the fourth biennial effort to specify and articulate actions to continue implementing the *2000 Puget Sound Water Quality Management Plan* (PSAT, 2000). The work plan outlines a two-year strategy to achieve measurable progress in protecting Puget Sound. More specifically, the plan identifies ongoing issues (that require more than two years to address), as well as associated priorities and recommended actions to pursue during the biennium. These issues for the 2003–2005 work plan include the following:

- Declines in marine species (e.g., salmon, groundfish, and orcas)
- Freshwater and marine habitat loss and alteration
- Water quality problems that continue to threaten the safe harvest of shellfish
- Stormwater runoff impacts on water quality, streams and wetlands, and biological resources
- Bacterial contamination from on-site sewage systems
- Non-native aquatic species that threaten the biodiversity, ecological stability, and commercial, agricultural, or recreational activities that depend on the Sound.

Conclusion

The overall view of the health of Puget Sound is clearly complex, with different indicators demonstrating different environmental quality results and trends over time. Encouraging signs have been noted for about half of the indicators measured by the NCA survey, as well as for the PSAT's shellfish harvesting, swimming, *Spartina* infestation, and salmon population indicators. Mixed or discouraging signals for the other NCA indicators and for a variety of fish, wildlife, and persistent toxic contamination indicators were observed by both EPA and the PSAT. PCB contamination remains a major concern, and several other chemicals are being closely watched to determine potential human health and ecological risks. Based on data from the NCA estuarine survey, the overall condition of Puget Sound is rated fair.

The Puget Sound provides invaluable habitat for orca whales (Captain Budd Christman, NOAA Corps).