12 Puget Sound

Overview

Puget Sound, located in northwest Washington State of the United States near the border of Canada and the United States, is part of a single large ecosystem that includes the Strait of Juan de Fuca and the Strait of Georgia. For this Guidebook, we have delineated the area of Puget Sound by the northern entrance of Admiralty Inlet.

This basin was carved during the Pleistocene Ice Age by at least one large and probably several small glaciers. The Sound itself is really an estuary where saltwater from the Pacific mixes with freshwater from a multitude of rivers.[1]

Location

Basic information[2, 13]

Surface area : 2,600 ㎢

Volume : 169 ㎢

Maximum depth : 300 m

Nature

< Background >

The glacial carving that shaped the deep channels of Puget Sound also helped shape the steep coastal bluffs, beaches, and relatively narrow, shallow marine terraces.[2]

The Puget Sound Basin covers about 44,000 ㎢, encompassing the Strait of Juan de Fuca, the San Juan archipelago, and Hood Canal. 80 % of the basin is composed of land and 20% is made of water.[2]

Climate

Maritime air masses have a moderating effect in south Puget Sound year round, creating a modified Mediterranean climate. During the fall and spring seasons, the climate is relatively mild. Winters are usually wet and mild. Summers are generally cool and dry.[3]

The 2013 average temperature for the Puget Sound lowlands was 10.4℃ and total precipitation was 972 ㎜.[4]

Topography

The bottom topography of Puget Sound is characterized by a series of basins and sills, which were created by glacial action. A shallow sill (65 m deep) at Admiralty Inlet separates the waters of the Strait of Juan de Fuca from Puget Sound proper. Puget Sound proper is divided into 4 interconnected basins (Main Basin, Whidbey Basin, South Puget Sound, and Hood Canal), and most of them are separated from each other by shallow sills. The largest and deepest basin is Main Basin, which is located south of Admiralty Inlet and extends southward for approximately 96 km. The maximum depth occurs north of Seattle at around 300 m.[2]

South of Main Basin lies South Puget Sound. They are separated by a shallow sill of approximately 45 m depth. This basin is shallow and has numerous islands and inlets. North and east of Main Basin lies Whidbey Basin, but it is not separated by a sill. This basin is relatively deep, ranging between 100 and 200 m in depth.

The smallest of the four basins, in terms of area, is the Hood Canal, which branches from Main Basin, south of Admiralty Inlet, by a 50 m deep sill. This basin is long and narrow, extending southward about 90 ㎞. Except for the central region and entrance this basin is less than 40 m deep.[1, 4]

Hydrology

South Puget Sound oceanographic circulation processes are typical of a fjordal estuary, with landward flow at depth and seaward flow at the surface.

The Nisqually and Deschutes Rivers deliver freshwater which usually flows seaward on the surface. The incoming water from the Pacific Ocean is colder and more saline than the freshwater, causing it to be denser and flow landward along the bottom. Salt water in the Puget Sound enters from the Pacific Ocean through the Strait of Juan de Fuca then diverges south into Puget Sound. Tides in the Puget Sound are semi-diurnal, with two unequal high tides and two unequal low tides daily. As the distance from the Pacific Ocean increases, mean tidal range in the Sound also increases.

Tidal currents are muted within South Puget Sound, particularly within protected Henderson, Budd, and Eld Inlets. The edge of the Nisqually estuary touching Puget Sound is the most exposed portion of the marine shoreline and tidal currents here are typically stronger and directed to the northwest.[5]

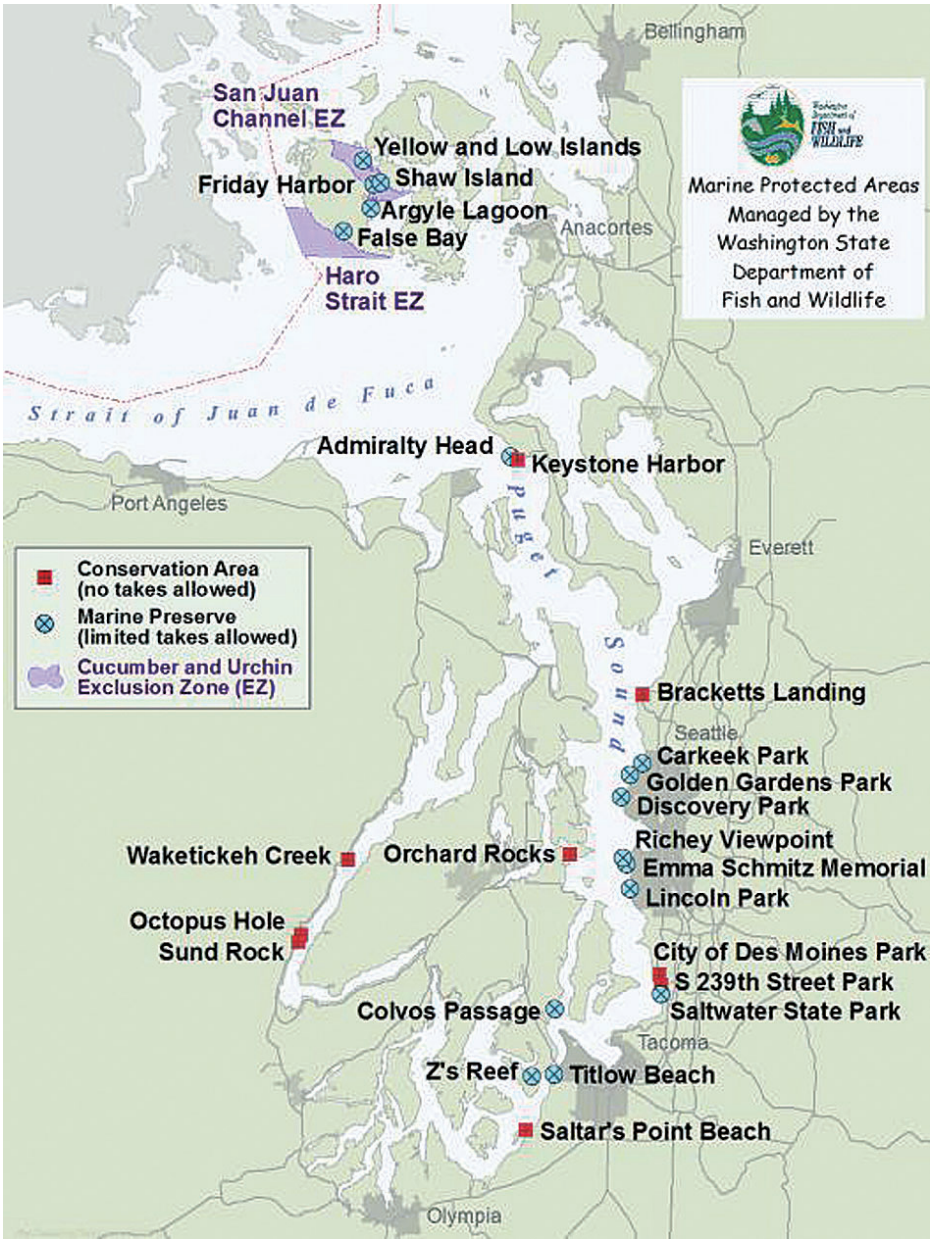
< Surrounding environment >

Habitat

Puget Sound has approximately 104 ㎢ of seagrass. A significant proportion of the seagrass is found on flat bottoms, such as in large shallow bays and small pocket beaches. Close to one fifth of all the seagrass in Puget Sound grows in the Padilla Bay. Seagrass beds are also found as narrow fringing beds along steep shorelines, and this type of seagrass bed is commonly used as a migration corridor by salmon.[6]

Protected Areas

Over 100 marine protected areas (MPA), designated by state and federal agencies, exist in Puget Sound for a variety of goals and objectives, with varying levels of restrictions. MPAs in Puget Sound are mainly categorized into 3 protection levels: No Access, No Take, and Zone with No Take Areas.[7]



Marine protected areas that are managed by the Washington State Fish and Wildlife Service[8]

History and Culture

< History >

The oldest sites of human habitation in the region date back to 10,000 to 12,000 years ago, not long after the last glacial period. The earlier glacial people were gradually replaced by the Salish tribes (native americans). The Salish tribes relied heavily on native salmon for nutrition.

In 1792, Captain George Vancouver charted and explored the bays, harbors and islands of Puget Sound. Then, in the 1850s white settlers moved into the region, attracted by the abundant resources. Logging and fishing became popular industries until the 20th century.

< Culture >

Salmon is a major icon of Puget Sound and has been central to the history and culture of the region. The native tribes geared their food-gathering cycle to the salmon runs and they traditionally celebrated the first salmon catch of the year with the First Salmon Ceremony. Nowadays, several organizations and tribes work together in the fall to put on a Salmon Homecoming festival on the Seattle waterfront. The festival celebrates the return of spawning salmon to the rivers and streams of Puget Sound.

Social Environment

< Population >

The central Puget Sound region grew by 1.4% between 2013 and 2014 as the region added 54,550 new people and total population reached 3,835,450. This marks the third consecutive year of increased annual growth.[9]

< Land use >

The catchment area of Puget Sound is comprised from mountains and coastal lowlands. Urban and agricultural lands cover about 9% and 6% of the catchment area, respectively, and are concentrated in the lowlands. Most parts of the catchment area are dominated by forestland concentrated in the foothills and mountains.[10]

< Industry >

Various industries are established in the Puget Sound region. Key industries in the region include aerospace (e.g. Boeing), advanced technology (e.g. Microsoft), international trade, general manufacturing, shipping and tourism. These industries are mainly concentrated in the urban areas. Major industries in the rural areas are fishing, oyster and salmon aquaculture, agriculture, forestry and wood products manufacturing.[11]

Fisheries

The fishing and aquaculture industries are heavily dependent on the waters of Puget Sound. The aquaculture industries mainly cultivate salmon, clams and oysters. Oysters are particularly important, and the area is one of two major cultivation regions in the United States. Herring, cod, trout, perch, sole and flounder, as well as algae, sea urchin roe and sea cucumbers are also harvested from the Sound.[6] In 1998, the total revenue from commercial fish harvesting in Puget Sound was more than 12 million US dollars, and the industry employed nearly 900 people. Also revenues from commercial shell fishing in the same year hit the 40 million US dollars mark, and the industry employed approximately 1,800 people. Furthermore, many tribes in the region rely on the harvest of fish and shellfish as an important part of their food supply and revenue.[10]

Environmental Problems

< Water and sediment quality >

Water quality

According to the state Department of Ecology monitoring program, water quality in Puget Sound is reasonably good. However, several locations within Puget Sound have water quality problems associated with low dissolved oxygen and high fecal coliform bacteria contamination, and some areas are sensitive to eutrophication. These areas are generally located near urban areas and large rivers, and are characterized by having high river runoff, low mixing and anthropogenic inputs of nutrients and sewage. The areas of highest concern are in Southern Hood Canal, Budd Inlet, Penn Cove, Commencement Bay, Elliott Bay, Possession Sound, Saratoga Passage, and Sinclair Inlet.[6]

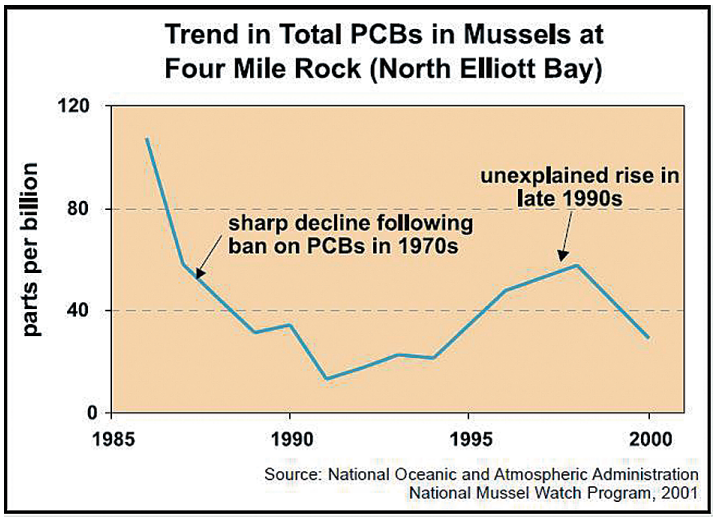
Another water quality problem found in Puget Sound is chemical contamination. As an indicator of chemical contamination, the toxic contamination levels inside mussels, harbor seals and English sole are monitored in Puget Sound. According to the mussel monitoring, concentrations of the long-banned pesticides, chlordane and DDT, and several metals such as lead and mercury, are declining.

Although the concentration of PCBs began declining after their ban in the 1970s, they showed a sudden rise in the mid-1990s at many monitoring stations. According to the NOAA's National Mussel Watch Program during 1997-98, PCB concentration of up to 533 ng/g was detected at Four Mile Rock (North Elliot Bay) near Seattle, the major source of PCBs for the

region. Fortunately, the PCB concentration in Four Mile Rock started to decline again between 1999 and 2000.[6]

Within the same NOAA program, PAHs concentration in mussels were one of the highest in the United States.[6]

Monitoring of harbor seal blubber in 2002 showed high concentrations of PCBs and was significantly higher (approximately 8 times) compared to Strait of Georgia harbor seals. These differences probably reflect the high levels of industrial PCB usage in the Puget Sound Basin before its ban in the 1970's.[6]



Sediment quality

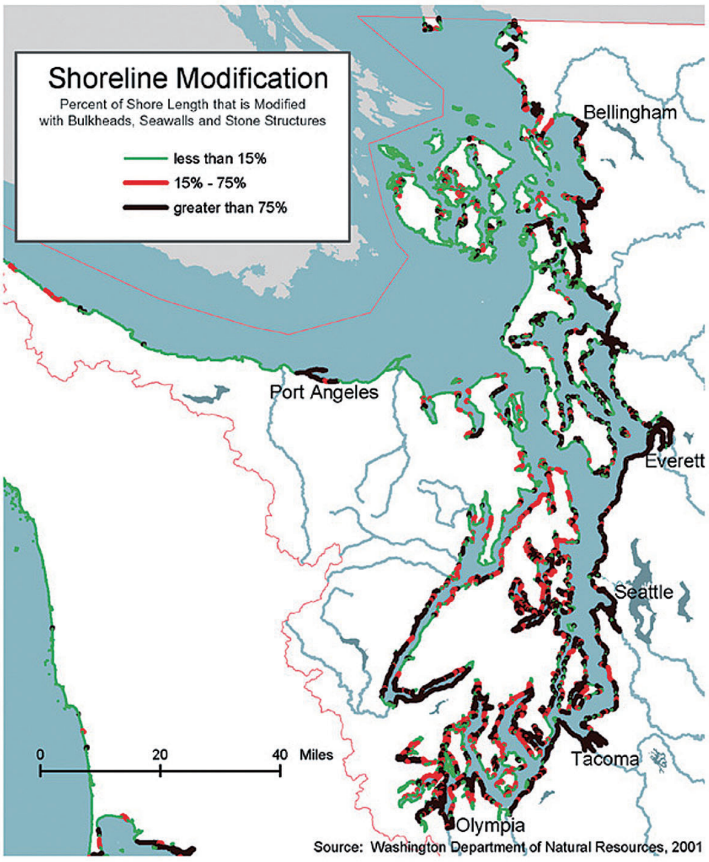
According to a survey conducted between 1997 - 1999 by the Washington State's Department of Ecology, 22 compounds or compound groups were measured in concentrations above sediment quality standards. These included six pollutant metals (arsenic, copper, mercury, lead, silver and zinc), PAHs, PCBs and other contaminants. Compared with past surveys, concentrations of some contaminants, such as naphthalene and other small PAHs showed an increase while concentrations of metals, such as copper and mercury, have decreased significantly.[6,12]

As expected, contamination was most serious in urban and industrial areas, with the central Puget Sound region being the most contaminated, followed by Whidbey Basin. The least contaminated area was in the Admiralty Inlet region.[11]

< Other Environmental Problems >

Shoreline modification

Puget Sound has experienced significant physical changes to its nearshore habitat through human development of port facilities, piers, bulkheads and other shoreline armoring structures. Approximately one-third of the Puget Sound shoreline has been modified and an estimated 70 % of tidally influenced wetlands have been lost in the past century.[6,7] The most modified areas are in the large river deltas such as in Commencement Bay, Puyallup River areas and Elliot Bay.[6,11]



Human alteration of the coastline[4]

< Environmental Protection Measures >

Puget Sound Water Quality Management Plan

The Puget Sound Water Quality Management Plan is Washington State's strategy for protecting and enhancing the water quality and biological resources of Puget Sound, and also serves as a comprehensive conservation and management plan under the federal National Estuary Program. The management plan is prepared and regularly amended by the Puget Sound Water Quality Action Team and Puget Sound Council. Also, every two years the Action Team develops the Puget Sound Work Plan to identify actions needed to gain a cleaner and healthier Sound, which are guided by the Management Plan's long-term goals and specific priorities.[7]

The management plan covers aspects such as aquatic nuisance species, contaminated sediments and dredging, marine and freshwater habitat protection, municipal and industrial discharge, non-point source pollution, shellfish protection, spill prevention and response, storm water and combined sewer overflows.[7]

Puget Sound Ambient Monitoring Program (PSAMP)

To protect the water quality of Puget Sound, various state, local and federal agencies are involved in a wide range of monitoring programs through the Puget Sound Ambient Monitoring Program (PSAMP). The direction, scope and design of

PSAMP are determined by the Puget Sound Water Quality Action Team and Puget Sound Council, and the results of the monitoring program are communicated back to the Puget Sound Water Quality Management Plan.[7]

Monitoring includes fresh and marine water quality, sediment quality, fish and shellfish, nearshore habitat, marine birds, marine mammals and so on.[7]

Puget Sound / Georgia Basin International Task Force

Since the health of Puget Sound is interconnected with the inland waters of British Columbia (Strait of Georgia) and to ensure the protection, conservation and enhancement of these shared resources, a joint organization between Washington State and British Columbia Province was established in 1993, appropriately named as the Puget Sound/Georgia Basin International Task Force. The Task Force will research issues affecting the shared marine waters, adopt joint policies and implement actions, provide cross-border information exchange and organize workshops.[7]

Related organizations and NGO

- Puget Sound Partnership <http://www.psp.wa.gov/>
- People for Puget Sound <http://pugetsound.org/>
- The Association of National Estuary Programs (ANEP) <http://nationalestuaries.org/>

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