



Washington Department of Fish & Wildlife

Pacific Herring Information Summary

Biology

Name: Pacific herring, *Clupea pallasii*



Figure 1. Adult herring.

Geographical range: Baja California, Mexico, to the Bering Sea and northeast to the Beaufort Sea. Also along the Asian coast from the Arctic Ocean to Japan.

Related species: Common local members of the herring family, Clupeidae, are the Pacific sardine, (*Sardinops sagax*) and the introduced American shad, (*Alosa sapidissima*). Other common, but unrelated, Puget Sound forage fish species include surf smelt, sand lance, and northern anchovy. Less common Puget Sound forage fish species include night and longfin smelt, and eulachon.

Life history: Most Washington State herring stocks spawn between mid-January and early April. The notable exception is the Cherry Point stock in north Puget Sound, which spawns from early April through early June. Herring deposit transparent, adhesive eggs on intertidal and shallow subtidal eelgrass and marine algae (Figures 2 and 3). Eggs may be deposited anywhere between the upper limits of high tide to a depth of -40 feet, but most spawning takes place between 0 and -10 feet in tidal elevation. Eggs hatch in 10 to 14 days, depending on water temperature, producing slender, transparent larvae about 7.5 mm (0.25 inches) long. At this stage, they are at the mercy of currents and subject to heavy predation by larger organisms. At about 3 months of age and 38 mm



Figure 2. Adult herring spawning on Nereocystis kelp.

(1.5 inches) in length, herring metamorphose into their adult form and coloration. They will mature and spawn in their second or third year. Herring do not normally die after spawning, and may spawn again in successive years.



Figure 3. Freshly spawned herring eggs deposited on eelgrass.

Natural mortality is quite high, approximately 50-70% of the adult herring from Washington will fall to predation, disease, or other causes each year. Thus, the typical Puget Sound herring is relatively short lived, with most not surviving beyond age four. Some herring stocks appear to have an annual migration from inshore spawning grounds to open ocean feeding areas, while others appear to be more "resident," remaining inside Puget Sound year around. Adult herring feed primarily on planktonic organisms, such as copepods, and in turn are food for many animals such as seabirds, marine mammals, and other

fishes. Many of these predators are protected by State and/or Federal law (e.g., the Endangered Species Act) and herring stock strength is directly linked to the health and status of these populations.

Spawning stocks: Herring stocks are defined by spawning grounds. At least 18 stocks spawn inside Puget Sound (Figure 4), and two additional stocks spawn on the Washington coast in Willapa Bay and Grays Harbor. Spawning has also been reported in the Columbia River estuary near Illwaco. Early meristic studies concluded that heterogeneity exists among herring samples taken from various spawning areas throughout Puget Sound. In addition, WDFW assessment survey results have indicated stock specific characteristics such as different growth characteristics, distinctive spawning location and timing, and prespawner holding area behavior, which have supported the assumption of stock autonomy/discreteness for Puget Sound herring. Recent genetic studies, however, have suggested that only the Cherry Point and Squaxin Pass stocks are genetically distinct from each other and other Washington and British Columbia stocks.

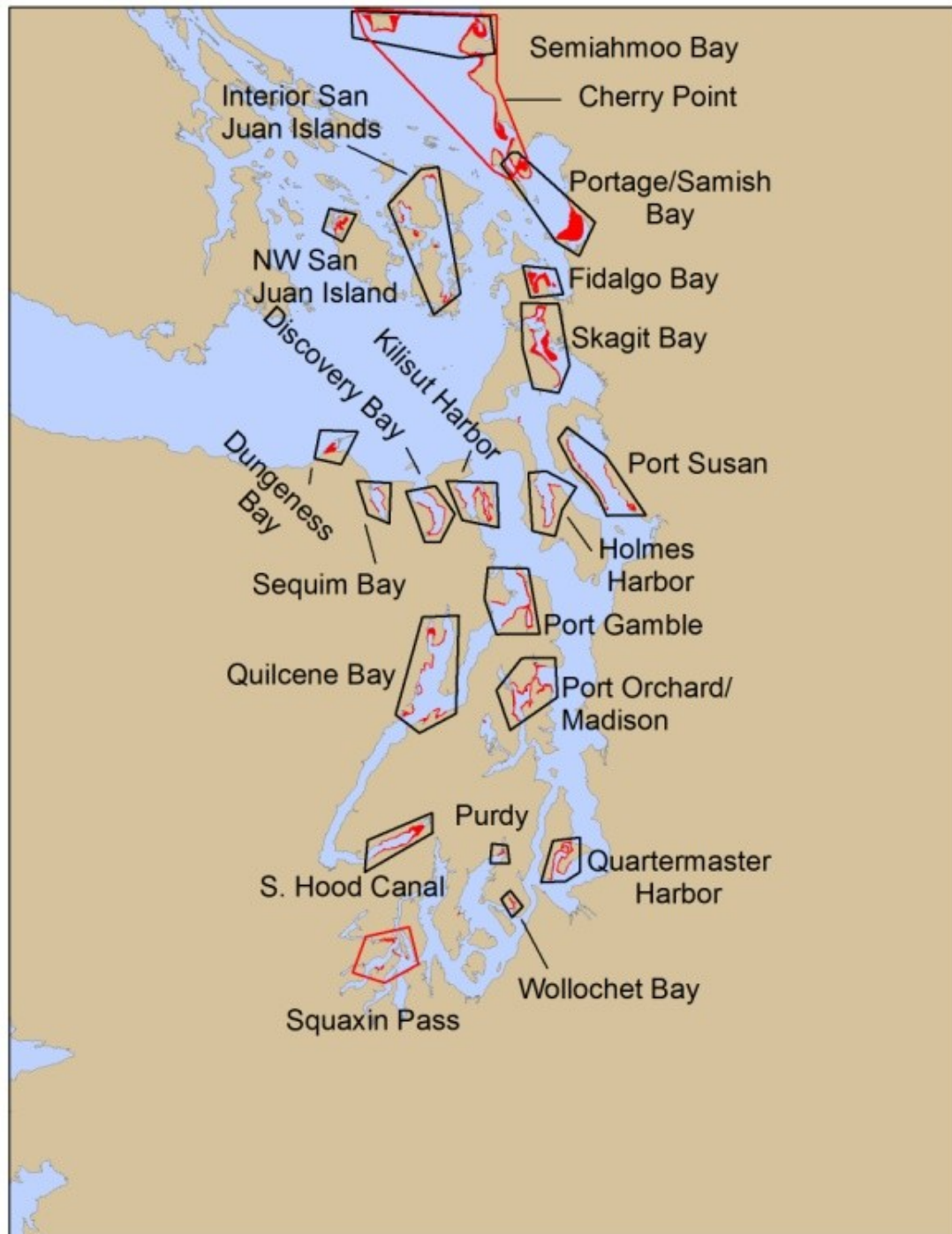


Figure 4. Documented herring spawning grounds in Puget Sound.

Each known herring stock in Puget Sound is currently assessed annually. The annual assessments are published approximately every four years in the Washington State Herring Stock Status Report (see [2008 Washington State Herring Stock Status Report](#)).

Stock Assessment

Two methods have been used by WDFW to provide quantitative estimates of herring abundance: spawn deposition surveys and acoustic/trawl surveys. However, beginning in 2010, WDFW is estimating the annual abundance (spawning biomass) of each of the herring stocks in Puget Sound using spawn deposition surveys only. Occasional assessments have been conducted on the Washington coastal stocks.

Spawn deposition surveys provide an estimate of herring spawning abundance based on the number of eggs deposited on macrovegetation. The vegetation on documented herring spawning grounds is sampled via grapple for the presence of herring eggs. If eggs are present their density and coverage is estimated and data are converted to an estimate of spawning escapement. These surveys are generally conducted weekly during a stock's spawning season to document cumulative spawn deposition.

Acoustic/trawl surveys are conducted on the prespawner holding areas. Prior to spawning, ripening adult herring congregate and hold in a region usually adjacent to the spawning grounds. The schooling process usually begins 3-4 weeks before the first spawning event. Acoustic/trawl surveys are conducted early in the spawning season when holding area stock abundance peaks. This method utilizes echosounding equipment (sonar) with a computer interface. The acoustic gear produces a real-time estimate of total fish abundance. The estimate of total fish abundance is apportioned to herring biomass based on data collected by a mid-water trawl that samples the schooling fish. Analysis of the trawl catch also provides herring size, age, and maturity data.

Puget Sound Herring Spawning Biomass Estimates

Pacific herring abundance, as well as the abundance of other forage fishes, has a tendency to fluctuate greatly. It is likely that there is considerable gene flow between various Puget Sound herring stocks. Therefore, grouping stocks that have not demonstrated genetic divergence may be the most meaningful way to attempt to determine abundance trends and comparisons for the Puget Sound herring resource (Figure 5).

Results of recent genetic studies reveal that herring in Puget Sound are segmented into three genetic groups: Cherry Point spring spawners are distinct from winter spawning Puget Sound herring, and Squaxin Pass herring show some separation from all other winter spawning Puget Sound herring. Characterizing abundance (spawning biomass) by these groupings over time is now considered best available science. See "History of Puget Sound Herring Stock Identification" section in [WDFW 2008 herring stock status report](#) for more details.

Through 2010 the following stock conditions are:

- Cherry Point Spring Spawners: The Cherry Point population has dramatically declined from 15,000 tons in the 1970s to less than 1,000 tons in 2010. Long-term (1986-2010) abundance has averaged 2,800 tons and the recent two-year mean abundance is 1,058 tons, a 62% decline. This stock is in Critical condition. No harvest has been allowed on this stock since 1996.
- Squaxin Pass Winter Spawners: Where data are available, the long-term mean (1986-2010) is 789 tons and the recent two-year mean is 667 tons, a 15.5% decline. This stock is considered moderately healthy (recent two-year mean is within 10-30% of previous 25 year mean).
- Other Puget Sound Winter Spawners: For the other winter spawning locations, the long-term (1986-2010) mean, weighted by individual areas, is 12,084 tons. The recent two-year mean is 8,983 tons, a 26% decline. This stock grouping is also considered moderately healthy.

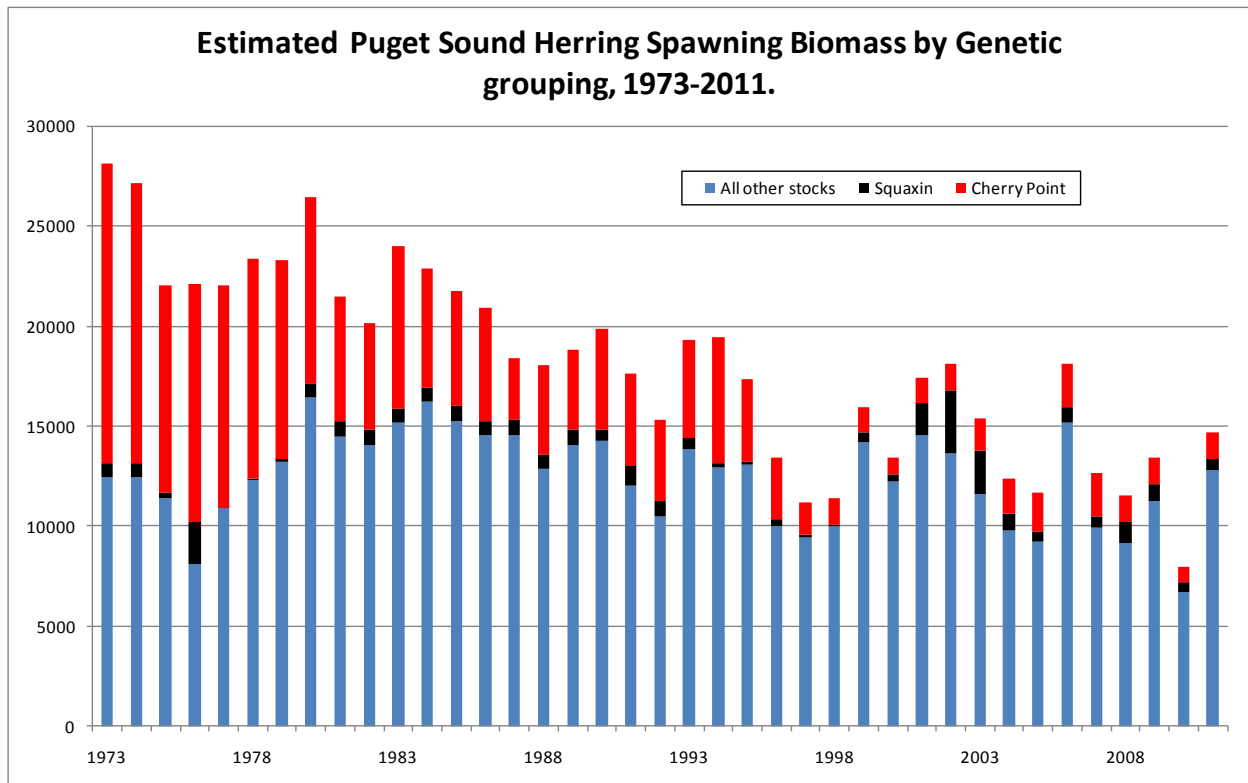


Figure 5. Estimated herring spawning biomass, 1973-2011.

Natural Mortality

The abundance of Puget Sound herring stocks is impacted significantly by mortality rates. Mortality can be attributed to two types: fishing and natural mortality (all causes other than human harvest).

Fish survival and mortality are often expressed in terms of rates or percentages. The mortality rate, based on the number of fish not surviving, is equal to 1 minus the survival rate (e.g., an annual survival rate of 35% would produce an annual mortality rate of 65%). Adult herring mortality rates of 30-40% are considered typical for herring worldwide.

Adult herring mortality and survival has been estimated for the Cherry Point herring stock since 1976. Additional stocks were included in mortality estimates beginning in 1987 when acoustic/trawl survey effort was increased.

The annual mortality rate estimate for the Cherry Point herring stock increased from a range of 20-40% in the late 1970s to an average of 68% since 1990. The mean estimated annual natural mortality rate for other sampled stocks since 1990 has averaged 72%; again, high for herring populations. Fishing mortality since 1997 has averaged about 4% of estimated natural mortality.

While significant gene flow between different stocks would affect the accuracy of calculated mortality rates, there is no question that there has been a decrease in the mean and median age (and size) of sampled adult herring in Puget Sound. Relatively good recruitment has sustained most stocks despite the high natural mortality observed. Potential causes of increased natural mortality include predation, disease, and climatic changes.

Herring in Puget Sound and throughout the eastern North Pacific are impacted by at least three pathogens (*Ichthyophonus hoferi*, viral hemorrhagic septicemia virus, and erythrocytic necrosis virus) that exert population-level effects through different epizootiological mechanisms.

Changes in sea temperatures can have direct and indirect impacts on herring survival. The observed decline of the Cherry Point stock since the mid-1970s coincides with warmer/dryer than average conditions in the Pacific Northwest. Chapman et al. (1941) considered Cherry Point and Discovery Bay populations to be at low levels in the 1930s when similar climatic conditions occurred. Conditions shifted back to cold/wet or average during the 1940s and 1950s. Williams (1959) reported that among others, the Cherry Point and Discovery Bay populations had returned to relatively high levels of abundance during those decades.

Habitat Issues

The location of herring spawn deposition in lower intertidal and upper subtidal habitats and the geographically specific nature of herring spawning behavior make herring

spawning grounds vulnerable to shoreline development. Washington Administrative Code governing hydraulic permit approvals by WDFW, lists herring spawning habitats as “marine habitats of special concern”. A “no net loss” approach is applied to these habitats. Permissible in-water development activities are subject to seasonal work windows that avoid regional herring spawning seasons. Current WDFW stances on forage fish, including herring, have been generally accepted by other agencies and jurisdictions within the region.

Conservation of herring spawning habitat, and minimizing disturbance in the prespawning holding areas is key to the preservation of the herring stocks inside Puget Sound. Herring stock assessment data is very useful for localized habitat management and planning.

Commercial Fisheries

Commercial herring fisheries in Puget Sound have experienced several major shifts since the start of the last century (Figure 6).

Commercial herring fisheries in the early 1900s harvested herring mainly for export, a market that collapsed soon after World War I. During this time purse seines, drag seines, and traps targeted herring with most of the catch coming from Holmes Harbor, Birch Bay, Poulsbo, and Discovery Bay.

From the 1920s through the 1940s the major portion of herring landings were used as bait for commercial halibut, crab, and shark fisheries. Herring traps accounted for much of the landings beginning in the 1920s. Traps were typically located adjacent to or near spawning grounds to intercept adult fish migrating to and from spawning areas. The most successful trap sites were the southwest shore of Holmes Harbor and at Point Whitney near Quilcene Bay in Hood Canal. Total reported herring landings through the 1940s ranged from a low of 36 tons in 1942 to a high of 1,311 tons in 1926.

By the early 1950s, commercial herring fishing emphasis in Puget Sound shifted again to primarily supply bait to growing recreational salmon fisheries. Changing market conditions and trap location restrictions in 1937 decreased the number of operational herring traps to one (in Holmes Harbor) by 1947 and led to a gradual reduction in trap landings, the last of which occurred in 1971.

The next shift in the Puget Sound herring fishery happened in 1957 when the reduction of herring to oil and meal was authorized. This led to a sizable fishery in north Puget Sound, with landings from 1,500 to 3,500 tons. This fishery was phased out in the early 1980s due to concerns about decreased fish size and age and the potential effects on local herring stock abundance.

In 1972, a sac-roe fishery targeting the Cherry Point stock began. Landings in this treaty and non-treaty fishery topped 4,000 tons in 1974. Declines in the north Puget Sound herring stocks, particularly the Cherry Point stock, led to the closure of both the reduction and sac-roe fisheries by the mid-1980s. In 1988, a non-tribal spawn-on-kelp

and treaty sac-roe fisheries were resumed on the Cherry Point stock. Another decline in Cherry Point stock abundance in the mid-1990s again closed this fishery and has remained closed to date. A minimum spawning biomass of 3,200 tons for the Cherry Point stock is currently required before harvest is considered.

The only current commercial herring fishery operating in Puget Sound provides bait for sport salmon and groundfish fisheries. Fishing activity is primarily in south and central Puget Sound and mostly targets juvenile herring assumed to be an aggregate of stocks within the region. Most of the harvest is taken by non-tribal fishers using small (maximum length of 200 feet) lampara seines. Annual landings by this fishery are generally influenced most by market conditions and processing/holding capacities rather than fish abundance.

Annual landings by the herring sport bait fishery for the last ten years (2001-2010) have averaged 382 tons, ranging from a low of 222 tons in 2006 to a high of 592 tons in 2002. Landings for recent years are well below the harvest guideline, ranging from 2% to 6% of the sum of mean adult spawning biomass estimates for south/central Puget Sound stocks for this time period.

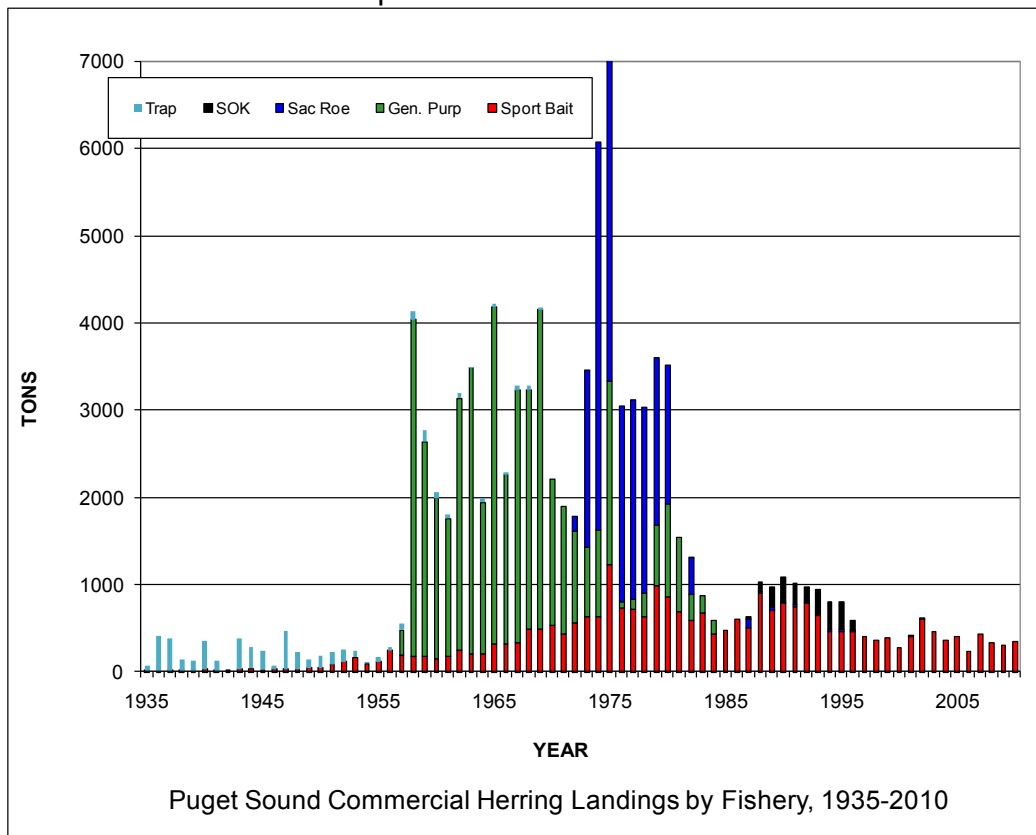


Figure 6. Commercial herring landings, 1935-2010.

Recreational Fisheries

Recreational landings of herring in Washington State are relatively insignificant. Sport anglers occasionally jig herring or dip herring "balls" for salmon bait, but most purchase commercially caught bait herring. Herring are also commonly caught incidentally in surf smelt recreational jig fisheries.

Management

The Pacific herring is of considerable interest to the citizens of the Puget Sound region because of the species' value as forage, its popularity as recreational fishing bait, its cultural and economic importance to local Native American tribes, and its importance as an indicator of the general health and productivity of Puget Sound. For these reasons, the spawning biomass of herring was selected by the Puget Sound Partnership (PSP) as one of twenty dashboard indicators to be used to determine the success of efforts to restore, protect, and prevent pollution in Puget Sound. For more information go the PSP web site: [Puget Sound Dashboard of Ecosystem Indicators](#) .

Management Principles

For herring management purposes, Washington is divided into four geographic regions: South-central Puget Sound, north Puget Sound, Strait of Juan de Fuca and the Washington coast (Figure 7). Profiles have been developed for known herring stocks within these geographic regions. These profiles are detailed in the Stock Status Report referenced above.

Fishery management is based on minimizing adult catches in areas of targeted juvenile harvest and, conversely, minimizing juvenile harvest in areas designated for adult harvest. The north Puget Sound region, particularly the Cherry Point stock, has supported adult harvest and the south-central Puget Sound region has been managed to allow fishery harvest that primarily targets juveniles. Almost all commercial herring harvest is currently taken in the south-central Puget Sound region, with occasional small landings from the Coast region. Herring were included in the 1974 "Boldt Decision" regarding Native American fishing rights, and local stocks and fisheries are cooperatively monitored and managed by Washington Department of Fish and Wildlife (WDFW) and local area Tribal governments.

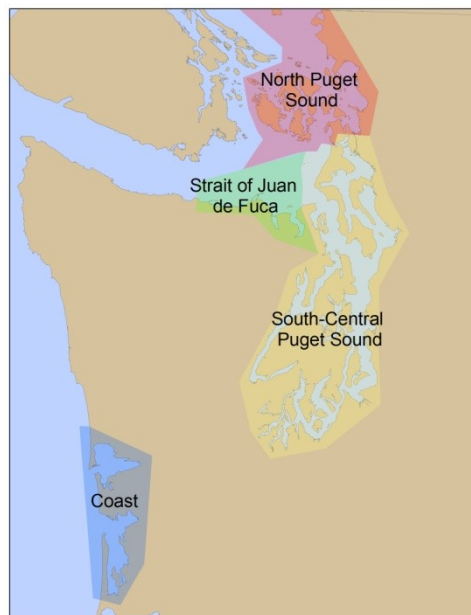


Figure 7. Herring management regions.

The usual accepted harvest rate for Pacific herring is 20% of a spawning stock, and herring are typically harvested at that rate worldwide. Significant fisheries for herring also occur in Alaska, British Columbia, Oregon and California. (To learn more about Canadian herring management visit their web site at [DFO Canada](#).) Presently, Puget Sound herring are fished at what is considered to be a conservative level; the annual maximum harvest guideline is set at 10% of the cumulative adult herring biomass in the south/central Puget Sound region.

As mentioned above, the only current commercial herring fishery operating in Puget Sound provides bait for sport salmon and groundfish fisheries. Fishing activity is primarily in south and central Puget Sound and mostly targets juvenile herring assumed to be an aggregate of stocks within the region. Almost all harvest is taken by non-tribal fishers and most landings are taken by small (maximum length of 200 feet) lampara seines.

Seasonal gear closures of the commercial bait fishery of documented spawning grounds are in place to protect spawning adult herring from harvest. Additionally, fishing is not allowed in north Puget Sound or near Discovery Bay to prevent the harvest of Cherry Point and Discovery Bay herring, respectively. Hood Canal has also been closed since 2004 to all commercial herring fishing due to concerns of the impacts of low dissolved oxygen on herring abundance, although this closure was not based on observed changes in adult spawning biomass estimates of Hood Canal area herring stocks.

Licensing

In 1973, the Washington State Legislature enacted limited entry for non-treaty commercial herring fishing. The maximum number of herring fishing licenses was "frozen" for each gear type (dip bag, lampara seine, purse seine, beach seine and gill net). Anyone interested in commercially fishing for herring must purchase an existing license from a current license holder. The treaty herring fishing fleet is not under growth restriction, although fishing effort is limited by management plans, such as that defined by the North Puget Sound Herring Technical Team, which includes representatives from WDFW and north Puget Sound tribes.

Contaminant Studies

WDFW scientists have monitored toxic contaminants in Pacific herring since 1999, as part of their Puget Sound Assessment and Monitoring Program ([PSAMP](#)). This species is exposed to a wide range of toxic contaminants in Puget Sound; in particular, persistent bioaccumulative and toxic (PBT) contaminants such as PCBs (polychlorinated biphenyls) and DDTs (dichlorodiphenyltrichloroethane) can accumulate in their bodies to high amounts. Pacific herring stocks in Central and Southern Puget Sound have exhibited higher PCB concentrations than congeneric Baltic herring

(*C.harengus*) from some of the most polluted waters in northern Europe ([West et al. 2009](#)).

Spawned eggs of Pacific herring may be exposed to and harmed by other contaminants such as polyaromatic hydrocarbons (PAHs). This sensitive life stage appears to accumulate PAHs from local sediments where the eggs are spawned, a condition which may be linked to chronic spawn-mortality at some sites in Puget Sound (see [figures 4-30 and 4-31, Puget Sound Action Team, 2007](#).)

Toxic contaminants in Pacific herring are also tracked as an indicator of ecosystem health in Puget Sound, in support of Governor Gregoire's initiative to recover the Puget Sound Ecosystem by 2020. This so-called [Vital Sign](#) summarizes major contaminant types in Pacific herring and time trends of contaminants in this and other species.

West, J. E., S. M. O'Neill, et al. (2008). "Spatial extent, magnitude, and patterns of persistent organochlorine pollutants in Pacific herring (*Clupea pallasii*) populations in the Puget Sound (USA) and Strait of Georgia (Canada)." [Science of the Total Environment](#) **394**(2-3): 369-378.