Historical documentation of fish presence and abundance was based on harvest information, stream surveys, and observations reported by the Bureau of Commercial Fisheries (the progenitor to NMFS), Washington Department of Fisheries and Washington Department of Game (later Washington Department of Fish and Wildlife), the trade journal Pacific Fisherman, tribal accounts, popular sports literature, and various other sources. State and federal hatchery records also provided valuable insight into historical abundance and life history characteristics.

Hatchery operations in Puget Sound were undertaken in nearly every major basin in the Puget Sound DPS. Where hatchery records were available, the number of returning adults and the timing of their return and maturation were of primary interest. Although studies with Pacific salmon species have documented the relative influence of hatchery introductions on local populations, the situation is less clear for steelhead. Early hatchery operations stressed the release of large numbers of sac fry that provided little benefit to populations they were intended to supplement or the fisheries they were intended to contribute to. The Pacific Fisherman article on "Rearing and Feeding Salmon Fry," summarized this practice (Pacific Fisherman, June 1914 page 23):

> To the thoughtful person, the system in vogue for many years of depositing salmon and other fry in the water as soon as possible after being hatched or after the yolk sac had been absorbed, seemed far from an ideal one… The desire on the part of some fish commissions to make a large statistical showing of fry deposited at a small cost has also aided in perpetuating this method.

Although there were subsequent changes in hatchery protocols during the 1920s and 1930s to extend the rearing period prior to release by a few weeks, it is likely that this provided little benefit in the survival of steelhead that normally reside in freshwater for one to three years. Until late in the 1940s, the majority of hatchery-propagated steelhead was released as subyearling juveniles. Studies by Pautzke and Meigs (1940, 1941) strongly suggested that these releases had little or no positive influence on subsequent runs and may have simply served to "mine" the natural run. Hatchery broodstock collections prior to 1940 therefore give some insight into the size and sustainability of some populations in spite of continuous broodstock mining, which in some cases continued for decades.

Some caution should be used in applying historical hatchery production figures into the overall analysis. For example, a review of hatchery operations in 1915 (WDFG 1916) discovered that "The super-intendant [sic] supposedly in charge [of the Nisqually Hatchery] was discovered to be sojourning in the City of Tacoma with his entire family, although diligently maintaining his place on the state's pay roll." In spite of the likely "padding" of some production numbers, it is clear that for several decades thousands of returning adult steelhead, both natural and hatchery-origin, were intercepted annually from streams in Puget Sound in order to sustain the very artificial propagation programs that were intended to improve the steelhead runs (Appendix 5). More recent genetic studies by Phelps et al. (1994) and Phelps et al. (1997) detected introgression by hatchery steelhead stocks primarily in situations where hatchery fish had been introduced into relatively small stream basins with numerically few natural-origin steelhead. Additionally, hatchery steelhead have been established in some river basins or tributaries following the laddering of, or trapping and hauling operations at, falls or cascades that were natural migration barriers (for example: Granite Falls on South Fork Stillaguamish River , Tumwater Falls on the Deschutes River, Sunset Falls on South Fork Skykomish River).

Furthermore, because of the magnitude of more recent hatchery releases, similarities or differences in abundance trends (especially those based on redd counts) do not necessarily indicate demographic independence or lack thereof. Hatchery fish can influence demographic data in three ways.

- When present on natural spawning grounds, they inflate the abundance of naturally spawning fish.
- Large releases of hatchery fish may reduce the survival of naturally-produced juveniles.
- Hatchery releases reduce estimates of natural productivity by adding more adults to the adult-to-spawner relationship. This is especially true if hatchery fish produce redds, but subsequent progeny survival is not equivalent to that of naturally-produced fish.

For the purpose of population identification, hatchery influence on population demographics may not be as important a factor as it is in the estimation of population viability. In any event, there are few populations where there is sufficient information to test the correlation in abundance trends between populations. Furthermore, a number of TRT members identified ocean conditions as having a major influence on population demographics, enough so to obscure any freshwater-derived differences.

Genetic analysis of spawning aggregations normally provides a quantitative method for establishing population distinctiveness. However, the influence of hatchery fish spawning naturally (potential genetic introgression) and the reduced abundance of naturally-spawning populations potentially has affected the present day genetic structure of steelhead populations in Puget Sound. In the absence of a historical genetic baseline, it is impossible to estimate the effects of hatcheries or abundance bottlenecks on steelhead population structure. Despite these caveats, genetic information available from contemporary samples provided a useful framework for population structure in the Puget Sound DPS.

Population Boundaries for Fish and Habitat

In determining population boundaries, two sets of information were considered for each population. The accessible area of a basin that is used for spawning and initial rearing that the fish directly occupy, and the entire basin (based on topography), a portion of which is occupied by the population. By considering the entire basin, one acknowledges that inaccessible portions of the basin influence stream habitat conditions in the occupied portion of the basin. It is important to consider historical and contemporary conditions in un-occupied headwater areas and their impact on the abundance and life history strategies of downstream fish assemblages. This approach does not affect the boundaries of the DPS, which include only the anadromous portion of each basin (see NMFS 2007).

Historical Documentation

Taxonomic Descriptions and Observations

Specific information on steelhead abundance, distribution, and life history in Puget Sound is fairly limited prior to the 1890s. Early confusion in identifying salmon and trout species prevented the consolidation of abundance and life history information. The fact that steelhead adults return to freshwater in the winter and spring when flows are high and visibility is low also limited observations. Furthermore, because steelhead are iteroparous, early settlers and naturalists were not confronted by streams lined with steelhead carcasses (in contrast to the numerous accounts of rotting salmon carcasses along streams). The Pacific Railroad surveys (also know as the U.S. Exploring Surveys) conducted during the 1850s, provided the first widely available descriptions of fish species in the Pacific Northwest, although Johann Walbaum, a naturalists working for the Russian Imperial Court had described the Pacific salmon species some 60 years previously. Two of the leading naturalists for the Pacific Railroad surveys: Dr. Charles Girard and Dr. George Suckley, compiled species descriptions from their observations or from a number of other sources. Their efforts would later attract considerable criticism. Dr. David Starr Jordan would later comment that, "Girard indeed did all a man could do to make it difficult to determine the trout (Jordan 1931, pg. 157)." Jordan's opinion of Dr. Suckley was equally critical, "He succeeded in carrying the confusion to an extreme, making as many as three genera from a single species of salmon, founded on differences of age and sex" (Jordan 1931, pg. 157). In the Appendices to the Pacific Railroad surveys, Girard (1858) describes at least four species that could have represented the anadromous and/or resident *O. mykiss,* steelhead and rainbow trout, respectively: *Salmo gairdneri, S. gibbsii, S. argyreus* and *S. truncates*. Regardless of their inaccurate taxonomy, the Pacific Railroad surveys provide a number of important early observations of steelhead in the Pacific Northwest, and specifically the Puget Sound area.

In the Pacific Railroad surveys and other documents of the time, steelhead are commonly referred to as salmon-trout, although there is some possibility that the reference could be describing sea-run cutthroat trout (*O. clarki*) or, less likely, sea-run char Bull Trout (*Salvelinus confluentus*) or Dolly Varden[1] (*Salvelinus malma*). For the Puget Sound region, Bull Trout would be the predominant species of the two. It is generally possible to identify the proper species by considering the morphological descriptions and references to run and spawn timing. For example, Girard (1858, pg 326-327) quotes George Gibbs describing a "salmon" that enters the Puyallup at the end of December, holds in the river until the snows begin melting (spring) and then ascends the

[1] Dolly Varden and Bull Trout were not recognized as distinct species until 1980 and most historical references only identify Dolly Varden, also known as the "red-spotted trout" (Girard 1858).

stream. These fish were apparently not abundant [relative to salmon at the time] and did not travel in schools. The fish weighed between 15 and 18 pounds (6.8 to 8.2 kg) and were silver with a bluish gray dorsal surface[2]. Girard (1858) also describes a *S. truncates* caught in the Straits of Fuca [sic] in February 1857, noting that this species rarely achieves weights over 12 pounds and generally less. These fish enter rivers in the beginning of December and continue through January. They do not run up the streams in schools, but the run is more "drawn out. The caudal fin is truncated not forked. The fish was known to the Klallam Tribe as "klutchin" and to the Nisqually Tribe as "Skwowl." Suckley (Girard 1858) described anther square-tailed salmon, *S. gairdneri*, captured in the Green River but which had a later run timing. The fish, known to the Skagetts [sic] as "yoo-mitch," entered freshwater from in mid-June to August, a run timing that corresponds to existing summer-run steelhead or possibly early returning (spring- or summer-run) Chinook. Another account by Girard (1858) described a *S. gairdneri* caught in the Green River as being bright and silvery, 28 inches long (71 cm), and not having a forked tail. Another probable steelhead description was provided to Girard by Dr. J.G. Cooper, but under the "scientific name" *S. gibbsii* (Girard 1858, pg 333). The fish was noted for having a "moderately lunated tail at its extremity" and a heavily spotted fins. Dr Cooper observed this "salmon trout" in the Columbia River Basin east of the Cascades. In addition, he observed one caught in Puget Sound in March of 1855. There is a strong probability that most of these observations were of steelhead.

In addition to descriptions of presumptive steelhead, there are a number of observations of cutthroat trout. Girard (1858) identified *Fario stallatus* as the predominant trout in the Lower Columbia River and Puget Sound tributaries. Girard found this trout to be very abundant and distinguished by a patch of vermillion under the chin. This fish is most likely the cutthroat trout, and these observations support the contention that cutthroat trout were the primary resident trout in Puget Sound and the lower Columbia River. Lord (1866) also noted that *Fario stellatus [sic]* … "lives in all streams flowing into Puget's Sound, and away up the western sides of the Cascades." These observations suggest a complex historical relationship between anadromous and resident *O. mykiss* and *O. clarki*. The presence of large numbers of *O. clarki* in smaller streams likely influenced the distribution and abundance of resident *O. mykiss* and to a lesser extent steelhead. In short, although it is clear that steelhead were historically found throughout Puget Sound there is little basin-specific abundance and distribution information on either anadromous or resident *O. mykiss* to be gleaned from these early accounts.

The taxonomic status of steelhead took on a new importance in the late 1800s when sport and commercial fishers debated whether trout or salmon regulations applied to steelhead caught in fresh water.

> Dr. David Starr Jordan, the renowned piscatorial expert, now at the head of the Stanford Jr. University, has declared that these fish belong to the trout family, but the fishermen, not those who fish for sport, but those who

[2] Gibbs description generally fits steelhead, although he notes that it has a forked tail and there could be some confusion with spring-run Chinook salmon.

> catch fish for a living, have decided that the steelhead is a salmon. Up to 1890 the steelhead was regarded as a salmon, but Dr. Jordan, after an exhaustive research, passed judgment that the public had been in error. (San Francisco Call, 1895).

Ultimately, this taxonomic distinction would have considerable consequences on the future exploitation of steelhead populations. As a "trout", the steelhead were regulated by many states as a game fish in freshwater fisheries.

Historical Abundance

Analysis of historical abundance can be useful in identifying demographically independent population, especially where populations have experienced severe declines or been extirpated. Estimates of historical steelhead abundance in Puget Sound have largely been based on catch records, and it was not until the late 1920s that there was an organized effort to survey spawning populations of steelhead in Puget Sound (WDFG 1932). There are a number of considerations that need to be taken into account in estimating historical run sizes, especially from catch data. Firstly, during the late 1800s and early 1900s, Chinook salmon was the preferred species for canning and whereas there is an extensive database of the cannery packs, the fresh fish markets were not extensively monitored. Secondly, steelhead have a protracted run timing relative to Chinook salmon and do not tend to travel in large schools, making them less susceptible to harvest in marine waters. Finally, winter-run steelhead return from December through March when conditions in Puget Sound and the rivers that drain to it are not conducive to some commercial gear types. In the absence of standardized fishing effort estimates it is not possible to report a time series for historical run size estimates with great accuracy, rather rough harvest estimates must generally suffice. We have only attempted to expand the peak harvest years in order to acquire an estimate of maximum run size.

Collins (1892) in his review of West Coast fisheries noted that steelhead are found in northern Puget Sound, although they are not as numerous as sockeye salmon (*O. nerka*), and that salmon trout[3] are common in Southern Puget Sound, especially near Olympia and Tacoma. In 1888, 23,000 kg (50,600 lbs) of fresh "salmon-trout" were marketed in the Puget Sound area. Catch records from 1889 indicate that 41,168 kg (90,570 lbs) of steelhead were caught in the Puget Sound District (Rathbun 1900). Rathbun (1900) indicated that steelhead were being targeted by fishermen because the winter run occurred at a time when other salmon fisheries were at seasonal lows and steelhead could command a premium price, up to $0.04 a pound. In converting catch estimates to run size the TRT used an average fish weight of 4.5 kg, based on the size range 3.6 to 5.5 kg (8 to 12 lbs) reported by Rathbun 1900. Based on this average, the 1889 catch (41,118 kg) represents 9,148 steelhead, whereas a more conservative (higher) average of 5.5 kg (12 lb) would represent 7,548 steelhead. These estimates do not allow for non-reported catch, sport catch, cleaning or wastage. Analysis of the commercial catch records from 1889 to 1920 (Figure 5) suggests that the catch peaked at 204,600 steelhead in 1895. Sheppard (1972) reported that commercial catches of steelhead in the

[3] It is not clear whether he is referring to steelhead or sea-run cutthroat.

contiguous United States began to decline in 1895 after only a few years of intensive harvest. Using a harvest rate range of 30-50%, the estimated peak run size for Puget Sound would range from 409,200–682,000 fish (@ 4.5 kg average weight). Alternatively, Gayeski et al. (2011) expanded the 1895 harvest data, including estimates of unreported catch and using an average size of 3.6 kg, to approximate historical abundance. Their estimate ranged (90% posterior distribution) from 485,000 to 930,000 with a mode of 622,000. In either case, it is clear that the historical abundance of steelhead was at least an order or magnitude greater than what is observed currently.

Rathbun (1900) reports that the steelhead fishery occurred mainly in the winter and the majority of the harvest occurred in the lakes and rivers. Later reports describe the majority of the harvest occurring in terminal fisheries (i.e., gill nets or pound nets) in Skagit, Snohomish, King, and Pierce Counties (Cobb 1911). The county by county analysis suggests that the level of inclusion of Fraser River steelhead in the catch estimates was fairly low and that the majority of steelhead were likely intercepted in their natal basins (Appendix 7).

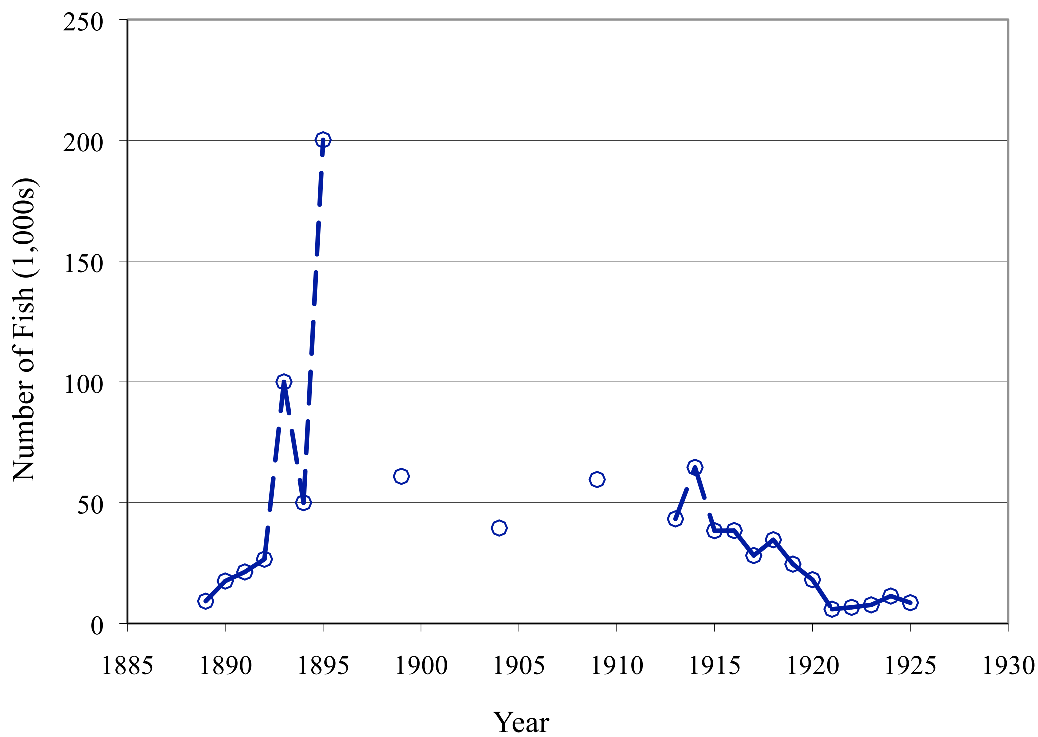

Figure 5. Harvest of steelhead in Puget Sound (1889-1925). The y-axis is total catch in number of fish. In years without data points harvest was reported as a combined salmon/steelhead harvest. Data from Washington Department of Fisheries Annual/Biannual Reports (1890-1920), Wilcox (1898), Rathbun (1900), Wilcox (1905), and Cobb (1911).

Even by 1898, the Washington State Fish Commissioner noted, "The run of this class of fish in the state on the whole has greatly depreciated, and the output for the present season from the best information possible is not fifty percent of what it was two or three years ago. Very little has been put towards the protection of this class of salmon…" (Little 1898). Catches continued to decline from 1900 through the 1920s (Figure 3).

The management of steelhead was ultimately transferred to the newly formed Washington Department of Game in 1921. In 1925, the Washington State Legislature classified steelhead has a game fish, but only above the mouth of any river or stream (WDFG 1928), although by that time the Puget Sound catch was greatly diminished. Commercial harvest of steelhead in Puget Sound fell to levels generally below 10,000 fish. In 1932, the newly formed Washington State Game Commission prohibited the commercial catch, possession, or sale of steelhead (Crawford 1979). After 1932, estimates of Puget Sound steelhead abundance were based on sportfisher catch, tribal catch, and spawning ground surveys.

Pre-1970 Abundance: Basin Specific Information

Nooksack River

Wilcox (1898) reports that the fishery for steelhead in the Nooksack River was carried out up to 18 to 20 miles upstream from the mouth. For the 1895 fishery, Wilcox (1898) notes that 300,000 kg (660,000 lbs) of steelhead were caught in the Nooksack River alone (most other sources present harvest on a county basis). This would represent 66,000 fish (@ 4.5 kg/fish). On a county-wide basis, Whatcom County, continued to report a substantial steelhead fishery into the early 1900s. It is unclear to what extent Fraser River steelhead were captured by Whatcom County fishers.

Biological surveys during June and July 1921 of the North Fork Nooksack River and its tributaries noted that steelhead spawned in most of the tributaries (Norgore 1921). Surveys conducted in 1930 identified several "medium-sized" runs in the North, Middle, and South Fork Nooksack rivers (WDFG 1932). Sport fishery catches in the 1940s and 1950s suggest that abundance has declined considerably and only relatively low numbers of steelhead were present, although glacial sediment in the North Fork and Middle Fork Nooksack River likely limits observation, fishability, and ultimately sport harvest.

Samish River

There is very little information on the early abundance of steelhead in the Samish River and Bellingham Bay tributaries. The Samish River Hatchery was built in 1899, but did not begin intercepting steelhead for broodstock until 1912. Production levels during the initial years would have required a few hundred female broodstock (Appendix x).

Skagit River

Historical accounts indicate that the run of steelhead in the Skagit River extended from November 15th up to the following spring (Wilcox 1895). Only a "scattering" of steelhead were reported prior to December and a light run continued through the winter (Wilcox 1902). In 1899, steelhead marketed in La Conner, Washington (Skagit River) averaged 5 kg (11 lbs.). Little (1898) indicated that large numbers of "Steel-heads" entered the Baker River and spawned from March to April.

Much of the historical information on steelhead in the Skagit River Basin comes from broodstock collection activities in the early 1900s. In 1900, steelhead were first collected at the Baker Lake Hatchery for broodstock. From March 8th to May 9th, 81 adults were captured at the base of the lake (Ravenel 1900). Of these, only 14 survived to spawn. The high mortality rate among the adults and subsequent egg lots was ascribed to maturation difficulties in the net pens. It is also possible that if the fish were summer run steelhead they would not have matured that first spring. Following construction of the Baker River Dam, returning steelhead returned to the trap at the base of the dam from March to July (Harisberger 1931). Riseland (1907) reported that the Sauk River Hatchery collected steelhead spawn from the first part of February until the 15th of June, with over a million eggs collected in 1906 (Riseland commented that the collection would have been higher if the hatchery weir gates didn't need to continually be raised to allow shingle bolts to pass downstream). The Sauk River was characterized as "an excellent spring Chinook and steelhead stream and the principal spawning stream of the Skagit (WDFG 1925)." Within the Skagit River Basin steelhead eggs were collected from the Baker River, Day Creek, Grandy Creek, Illabott Creek, and Phinney (Finney) Creek during the early 1900s. In most cases, these egg-taking stations intercepted hundreds of steelhead during their initial years of operation (Smith and Anderson 1921a). In 1929, the fish trap at Baker Dam collected 813 steelhead (WDG, undated (a)). These fish would have represented the last year of returning of "pre-dam" steelhead (4 year-olds). Subsequent counts at Baker Dam declined to the tens of fish. In the absence of specific information related to the operation of weirs or hatchery traps it is not possible to accurately expand the numbers of fish spawned to total escapement.

Stream surveys, estimating the extent of natural production, were not undertaken until some years after the initiation of the first hatchery programs. Additionally, by this time, river clearing, timber harvest (including splash damming), mining, and land development, in general, had already severely degraded the productivity of a number of streams. Smith and Anderson (1921a) provided detailed descriptions of the Skagit and its tributaries. Steelhead were found in "considerable numbers" up to the construction camp for Ross Dam near Nehalem. At that time they identified Goodell Creek as the farthest branch of the Skagit from the mouth that contained anadromous fish. Steelhead were also reported by Smith and Anderson (1921a) to migrate at least as far as Monte Cristo Lake on the Sauk River. It was thought that releases of mining wastes had eliminated fish from the headwaters of the South Fork Sauk River, near the mining town of Monte Cristo. Through interviews with Forest Service Rangers, Smith and Anderson (1921a) also identified a number of tributaries to the Suiattle that contained runs of steelhead. Although the mainstem Suiattle is normally too ladened with glacial sediment to provide opportunities to observe or fish for steelhead, a number of the tributaries apparently run clear for part of the year. The North Fork Suiattle, Downey Creek, Buck Creek, and Big

Creek were all listed as containing steelhead runs. Stream surveys conducted in 1930 indicated that "large" aggregations of steelhead were found in Finney, Grandy, and Bacon Creeks in the mainstem Skagit River and Jordan Creek in the Cascade River (WDFG 1932). Medium abundances were observed in the Baker River, Sauk River, and Cascade River. Mainstem Skagit River surveys were conducted in May of 1930 and in the Baker, Cascade, Sauk, and Suiattle rivers in August of 1930 (WDF 1932). Donaldson (1943) also observed "numerous" steelhead fingerlings in Tenas Creek during a stream survey in August 1943. The presence of steelhead, often in large numbers, throughout the 1920s and 1930s (despite substantial degradation to the freshwater habitat) suggests that the precontact abundance of steelhead in the Skagit Basin was considerable.

Stillaguamish River

The fishery in the lower Stillaguamish River harvested an estimated 81,820 kg of steelhead in 1895 (18,200 steelhead @ 4.5 kg.), although Wilcox (1898) suggests that the total could be considerably higher. WDFG (1916) recommended establishing an egg taking station on Canyon Creek, where "many eggs could be secured in Canyon Creek, particularly those of the steelhead variety, which are very valuable." Later surveys underscored the decline of salmon and steelhead runs, especially in Squire, Boulder, and Deer creeks (Smith and Anderson 1921a). Smith and Anderson (1921a) also note that the egg taking station in Canyon Creek spawned 245 steelhead in 1916 and the egg taking station in Jim Creek spawned 173 steelhead in 1919, the first years of steelhead collection for each site. In 1925, the Washington Department of Fisheries reported that "for the past four years the station has been operated by the Game Division for the taking of steelhead spawn. It is understood that the eggs when eyed were transferred to other parts of the state with the result that the steelhead run in Canyon Creek is now about depleted" (page 23, WDFG 1925). The Washington Department of Fish and Game surveys in 1929 identified large spawning populations in the main stem North Fork and mainstem South Fork and Deer Creek and Canyon Creek, with medium sized populations in Boulder, French, Squire, and Jim creeks (WDFG 1932).

Snohomish River

Snohomish and Stillaguamish River steelhead were reported to return from November 15th and were fished throughout the winter (Wilcox 1898). Steelhead harvest levels were estimated at 182,000 kg (401,000 lbs) or 40,444 steelhead from the Snohomish River alone in 1895 (Wilcox 1898). Steelhead were identified as the most plentiful and valuable salmonid (better flesh quality allowed longer transportation times). Hatchery records from the Pilchuck River Hatchery indicate that 397 females were spawned in 1916 (WDFG 1917). Surveys undertaken by the Washington Department of Fish and Game in 1929 reported large aggregations of steelhead in the Pilchuck River, Sultan River, Skykomish, and Tolt rivers, and medium aggregations in the NF and SF Skykomish, Wallace, Snoqualmie, and Ragging rivers (WDFG 1932). Spawning at the Sultan River USBF hatchery occurred from April 8 to June 4 (Leach 1923). In general, the Snohomish River Basin was one of the primary producers of steelhead in Puget Sound.

Green River (Duwamish River)

Interpreting historical abundance estimates is more complicated for the Green River due to its history of headwater transfers. In 1895, there were 45,900 steelhead (based on average weight of 4.5 kg) harvested in King County, with the Duwamish/Green River being the only major river in the county. (Wilcox 1898). At this time the Duwamish Basin included the Black, Green, Cedar, and White rivers, in addition to the entire Lake Washington and Lake Sammamish watersheds. In 1906, floodwaters and farmers diverted the White River from the Green River to the Puyallup River. Furthermore, construction of the Headworks Dam (Rkm 98.1) in 1911 on the upper Green River eliminated access to 47.9 km of river habitat. During the first two years of operation an egg-taking station (White River Eyeing Station) operated by the City of Tacoma collected 6,185,000 eggs in 1911 and 11,260,000 eggs in 1912 (WDFG 1913). There were no species-specific egg takes given, other than the 1911 production was from coho salmon and steelhead and the 1912 production included Chinook and coho salmon in addition to steelhead (WDFG 1913).

The Lake Washington Ship Canal (1916) diverted Lake Washington and Lake Sammamish, their tributaries, and the Cedar River directly to Puget Sound. Washington Department of Fish and Game surveys in 1930, well after the major modifications to the watershed, identified large steelhead populations in the Green River and Soos Creek (WDFG 1932).

Puyallup River

Based on the harvest in 1909, approximately 30,000 steelhead were harvested in rivers in Pierce County (Cobb 1911). The WDFG 1930 survey found large steelhead aggregations in the Puyallup and Carbon rivers and medium sized aggregations in Voights Creek, South Prairie Creek, and the White River (WDFG 1932). In 1942, in its second year of operation, nearly 2,000 steelhead were collected below Mud Mountain Dam and transported to the upper watershed. Sport fishery catches for 1946 and 1947 in the Puyallup River, averaged 2,846 fish (WDG undated (b)), all of which were presumed to be of wild origin. During the 1949/1950 tribal harvest, 2,176 steelhead were caught in the White River during January and February.

Nisqually River

Riseland (1907) described the Nisqually Hatchery as having a steelhead "spawn" that is equal to that of most of our large hatcheries. In 1905, 962,000 steelhead fry were produced at the hatchery, a production level that would have required several hundred female steelhead. Hatchery production continued until 1919, when the hatchery was destroyed by floods. At its peak, the hatchery produced 1,500,000 fry in 1912. WDFG (1932) identified the Nisqually and Mashel rivers as having medium sized spawning aggregations. Annual tribal harvest in the Nisqually River from 1935 to 1945 averaged approximately 1,500 steelhead, and the reported sport catch in the late 1940s varied from a few hundred to a few thousand fish (WDG undated(b)).

South Sound Tributaries

The presence of steelhead in the South Sound region was noted by Collins (1888), " Salmon trout occur about the head of Puget Sound in the vicinity of Olympia. Off Johnson Point and near Tacoma are noted fishing grounds for them. Considerable quantities are taken for market." There is relatively little specific quantitative information available on the historical abundance or even presence of steelhead in the small independent tributaries draining into south Puget Sound. Commercial harvest data from 1909 lists steelhead catches for Thurston, Mason, and Kitsap Counties that would represent a total escapement of several thousand fish, some of which are likely to have originated in the small South Sound tributaries (Appendix 7). Numerous other references to salmon trout fishing in the Olympia area were found in the sport literature from the 1800s and early 1900s. For example, an article in the Olympia Record reported that sportsmen were supporting a bill in the state legislature to prohibit netting in Olympia Harbor in order to protect salmon trout that were returning to local creeks (Olympic Record 1909). Sport fishery catch data from the 1940 to 1970s (WDG undated(b)) indicates that steelhead catches varied annually from the 10s to 100s of fish in Goldsborough Creek, Mill Creek, Sherwood Creek, and other smaller creeks. Catch numbers within and among streams varied considerably from year to year. It is not clear to what degree this variation is due to true changes in abundance or differences in angler effort.

Skokomish River

Steelhead were historically present in the Skokomish River; Ells (1877) described salmon-trout as one of the stables of the Twana Tribe. Steelhead were found in both the North and South Forks of the Skokomish, although there is some uncertainty regarding the accessibility of Lake Cushman to anadromous migration. A newspaper article in the Daily Olympian (March 22, 1897) reports that State Senator McReavey was requesting funds to build a fish ladder three miles below Lake Cushman to provide anadromous access to the lake. Although the ladder was never built, McReavey later testified that he had caught salmon in Big Creek, located above the "barrier" falls on the North Fork (Olympia Daily Recorder, November 26, 1921). In 1899, the Washington Department of Fisheries established an egg taking station on the North Fork of Skokomish River below Lake Cushman (WDF 1902). During the first year of operation the station took an estimated 1,500,000 steelhead eggs (representing 533 females @ 2812[4] eggs/female). For unexplained reasons this station was subsequently abandoned two years later, and the 1899 production figures may be viewed with some skepticism. Tribal harvest for winter run steelhead averaged 351 fish from the 1934/35 to 1944/45 return years, with harvests in the late 1950s averaging over 2,000 fish, although there is some hatchery contribution to these later catches. During the late 1940s and early 1950s, adjusted Punch Card-based estimates of the annual sport catch for presumptive wild winter-run steelhead averaged 610 fish with an additional 88 fish caught annually during the "summer-run" harvest window (WDG undated(b)).

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[4] Average steelhead fecundity of 2,812 eggs per female based on hatchery averages reported by WDFG (WDFG 1918).

Hood Canal, East Side Tributaries

There is little information on steelhead abundance in creeks draining from the east side of Hood Canal. In 1920, an egg collecting station was established on the Tahuya River to intercept returning steelhead. In May and June of 1932, the Washington Department of Fisheries surveyed streams throughout the Hood Canal. Of the 26 surveys available for review, all of the larger streams and many smaller creeks were reported to have spawning steelhead from January through March (WDF 1932). Mission Creek and Dewatto Creek [sic] were identified as having "good" runs and the Tahuyeh River [sic] contained a small to medium run. Anderson Creek, Union River, Big Beef Creek were all reported to contain small spawning populations of steelhead. Smaller stream systems, for example Stavis and Rendsland creeks, all supported steelhead spawning, albeit at a low abundance in the 1930s. Additionally, both sea-run and resident cutthroat were observed throughout Hood Canal.

Hood Canal, West Side Tributaries

Records for these west-side tributaries to Hood Canal are somewhat limited. At varying times during the early 1900s the Bureau of Fisheries operated egg collection stations or hatcheries on Quilcene, Dosewallips, and Duckabush rivers. Although the primary objective of these operations was the collection of coho and chum salmon eggs there were a number of steelhead eggs collected, especially from the Duckabush River and Quilcene rivers. It was noted that the greater part of the steelhead run ascended by spring high water when the trap could not be operated, many of the fish collected were "too immature to be retained in ponds" (Leach 1927). Ripe fish were spawned from March 24th to May 1st in 1926.

In the 1932 Washington Department of Fisheries survey the Dosewallips River was specifically mentioned as containing a "large run" of steelhead and the Hamma Hamma was reported to have a small to medium run of saltwater steelhead and cutthroats (WDF 1932). Of the remaining creeks surveyed: Mission Creek, Little Mission, Dabob, Lilliwaup, Waketickeh, Jorsted, Spencer, Jackson, Finch, and Eagle Creeks were all reported to have small spawning populations of steelhead. It was observed that the steelhead run began in January and February, and only a small portion of the steelhead run entered the Little Quilcene River before the hatchery weir was put in place in March. Steelhead were reported spawning during the late winter and early spring. Notably absent were surveys for the Skokomish and Duckabush Rivers. Punch card records from the late 1940s to 1960s report catches of tens to hundreds of fish from several west-side Hood Canal basins.

Dungeness River

In the 1940s, Clarence Pautzke with the Washington Department of Fisheries (undated) described the winter steelhead fishing in the Dungeness River as being among the best in the State. In 1903, during its second year of operation, the Dungeness Hatchery produced 3,100,840 steelhead. This production represents approximately 2,200 females[5]. J.L. Riseland, State Fish commissioner, noted that the steelhead catch (at the hatchery) was the largest of any in the state (output at the time (1905) was 1,384,000 steelhead), in spite of the existence of numerous "irrigation ditches on the Sequin [sic] prairie that destroyed large numbers of young salmon" (Riseland 1907).

Elwha River

With the construction of the Elwha Dam in 1912, access to most of the basin was blocked. There is little information, other than anecdotal accounts of fishing in the river, to describe the pre-dam status of steelhead population(s) in the basin. Rathbun (1900) identifies the Elwha and Dungeness as supporting both Native American and commercial fisheries. Wilcox (1905) reported only that the commercial catch for Clallam County was 52,000 pounds (23,636 kg). It is not clear if these fish were caught in terminal fisheries or in the Strait of Juan de Fuca and destined for other basins.

Puget Sound Steelhead Life History

Of all the salmonids, *O. mykiss* probably exhibits the greatest diversity in life history. In part, this diversity is related to the broad geographic range of *O. mykiss*, from Kamchatka to southern California; however, even within the confines of Puget Sound and the Straits of Georgia there is considerable life history variation. Resident *O. mykiss*, commonly called rainbow trout, complete their life cycle completely in fresh water. Anadromous *O. mykiss*, steelhead, reside in fresh water for their first one to three years before emigrating to the ocean for one to three years. Finally, in contrast to Pacific salmon, *O. mykiss* is iteroparous, capable of repeat spawning.

There are two major life-history strategies exhibited by anadromous *O. mykiss*. In general, they are distinguished by the degree of sexual maturation at the time of adult freshwater entry (Smith 1969, Burgner et al 1992). Stream-maturing steelhead, or summer steelhead, enter fresh water at an early stage of maturation, usually from May to October. These summer steelhead migrate to headwater areas and hold for several months prior to spawning in the following spring. Ocean-maturing steelhead, or winter steelhead, enter fresh water from November to April at an advanced stage of maturation, spawning from February through June. With the exception of Chinook salmon, steelhead are somewhat unique in exhibiting multiple run times within the same watershed (Withler 1966).

The winter run of steelhead is the predominant run in Puget Sound, in part, because there are relatively few basins in the Puget Sound DPS with the geomorphological and hydrological characteristics necessary to maintain the summer run life history. The summer steelhead's extended freshwater residence prior to spawning results in higher prespawning mortality levels relative to winter steelhead. This survival disadvantage may explain why where no seasonal migrational barriers are present winter

[5] Assuming 50% survival from green egg to fry and an average fecundity of 2,812. It should also be noted that these fish would all have been natural-origin.

steelhead predominate (Dan Rawding, WDFW, Vancouver, Washington, personal communication).

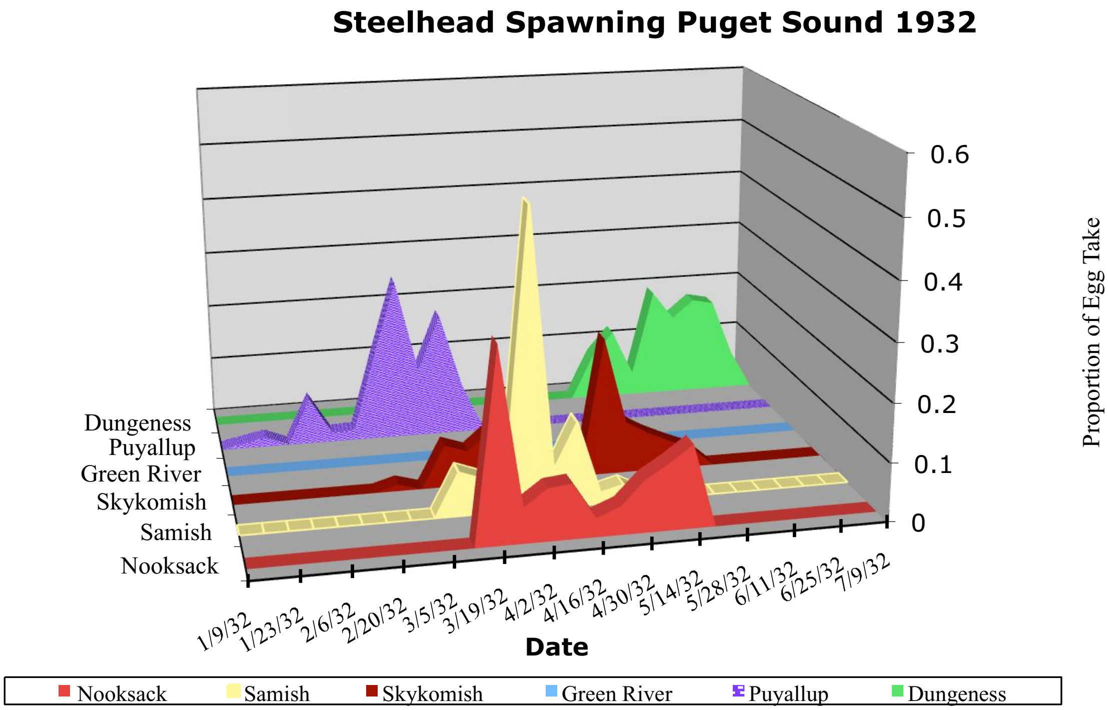
In 1900, a study by the Smithsonian Institution reported that steelhead begin to returning to fresh water as early as November, but that the principal river fisheries occurred in January, February, and March, when "the fish are in excellent condition" (Rathbun 1900). The average weight of returning steelhead was 3.6 to 6.8 kg (8 to 15 lb.), although fish weighing 11.4 kg (25 lb.) or more were reported. The principal fisheries were in the Skagit River Basin, although in "nearly all other rivers of any size the species seems to be taken in greater or less quantities (Rathbun 1900)." The spawning season of (winter-run) steelhead was described as occurring in the early spring, but possibly beginning in the latter part of winter.

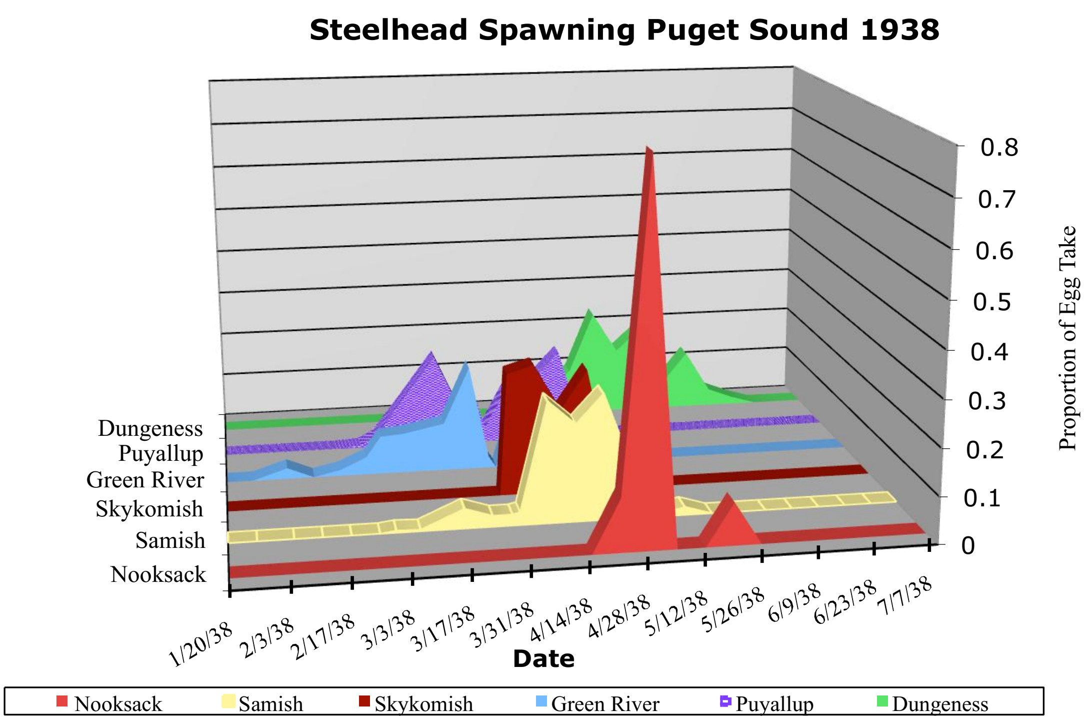
Information on summer-run steelhead in Puget Sound is very limited. In fact, in its 1898 report, the Washington State Fish Commission concluded that the Columbia River was "the only stream in the world to contain two distinct varieties of Steel-heads" (Little 1898). Little (1898) did indicate; however, that the winter run of steelhead continued from December through the first of May and overlapping runs of winter- and summer-run steelhead may have been considered a single population. Evermann and Meek (1898) reported that B.A. Alexander examined a number of steelhead caught near Seattle in January 1897, and that the fish were in various stages of maturation: "a few fish were spent, but the majority were well advanced and would have spawned in a short time." Returning steelhead were historically harvested from December through February, using in-river fish traps rather than trolling in salt water (Gunther 1927).

Much of the early life-history information comes from the collection and spawning of steelhead intercepted at hatchery weirs. The U.S. Fish Commission Hatchery at Baker Lake initially collected steelhead returning to Baker Lake using gillnets. Fish were collected from 9 March to 8 May, few survived to spawn, and no spawning date was given (USDF 1900). Later attempts to collect fish from Phinney [Finney] and Grandy creeks in March met with limited success, based on a survey of these creeks and the Skagit it was concluded that much of the run entered the rivers in January (Ravenel 1902). During the first years of operation of the Baker Dam, 1929-1931, steelhead were passed above the dam from April to July. Peak entry to the dam trap occurred during April. Although a relatively large number of fish were spawned in May 1931 (51 fish), on 15 June 1931, when spawning operations had ceased, 92 "green" (unripe) fish were passed over the dam (Harisberger 1931). It is unclear if these fish would have spawned in late June or July, or if they would have held in fresh water until the next spring (e.g. summer run steelhead). Riseland (1907) reported that the Sauk River Hatchery collected steelhead spawn from the first part of February until the 15th of June. Steelhead were spawned at the Quilcene National Fish Hatchery in Hood Canal from 27 February to 7 June 1922 (USBF 1923). Stream survey reports for Hood Canal indicated that the steelhead spawn during the late winter and early spring (WDF 1932). It should be noted that this spawning time was only noted for tributaries on the east side of Hood Canal (Dewatto Creek, Tahuyeh [sic] River, Big Beef Creek) or smaller tributaries on the west side of Hood Canal (Jorsted Creek, Little Quilcene River, Little Lilliwaup Creek), larger tributaries were generally too turbid to survey. These larger rivers

(Dosewallips and Duckabush) originate in the glacial fields of the Olympic mountains and it is likely that the temperature and flow regimes in these rivers would produce a different run timing from the lowland, rain dominated, rivers on the east side of the Hood Canal.

Pautzke and Meigs (1941) indicated that the steelhead run arrived in two phases: "In the early run the fish are small, averaging 8 or 9 pounds. The later run is composed of fish as large as 16 or 18 pounds." It was unclear whether these phases were distinct runs or different segments of the same run. In general summer-run fish run later in the spring than winter-run fish, but the summer run also tend to be physically smaller than winter run fish. Scale analysis indicates that the majority of first-time spawning summer-run fish have spent only one year in the ocean. Washington Department of Game records from the 1930s indicate a North-South differential in spawn timing (Figures 6a and 6b), although the timing of egg collection in the hatcheries may not be fully representative of natural spawning timing. The egg collection time for the Dungeness River appears to be especially late. Pautzke (undated) states that, "During the Summer and Fall this river is the conductor of large runs of Chinook and humpback salmon, also the steelhead trout." This would suggest the presence of a summer run in the Dungeness River. Pautzke further states that the winter steelhead fishing in the Dungeness River is one of the best in the State. Alternatively, the steelhead spawning/egg take data for the Puyallup Hatchery indicates that this stock of fish spawned earlier than those at other hatcheries (Figure 7). In some years the majority of the spawning took place prior to March 15th, the date presently used to distinguish naturally-spawning hatchery from "wild" fish. Similarities in spawn timing between the steelhead captured at the Puyallup Hatchery and the widely used Chambers Creek winter run hatchery stocks may be related to the close geographic proximity of the two basins. Certainly, given the variation in spawning times between 1932 and 1938 (which was typical of other years) some caution should be used in associating peak spawning weeks at the hatchery with the peak of natural spawning. Historical hatchery spawning records, despite the obvious caveats, provide important information on within and between population differences in spawn timing.





Figures 6a and 6b. Temporal distribution (proportion of total egg take) of egg collection for steelhead returning to Washington Department of Game facilities in 1932 and 1938. Egg collection dates may not be representative of natural spawn timing. There was no egg collection at the Green River Hatchery in 1932 (Washington State Archives, undated.

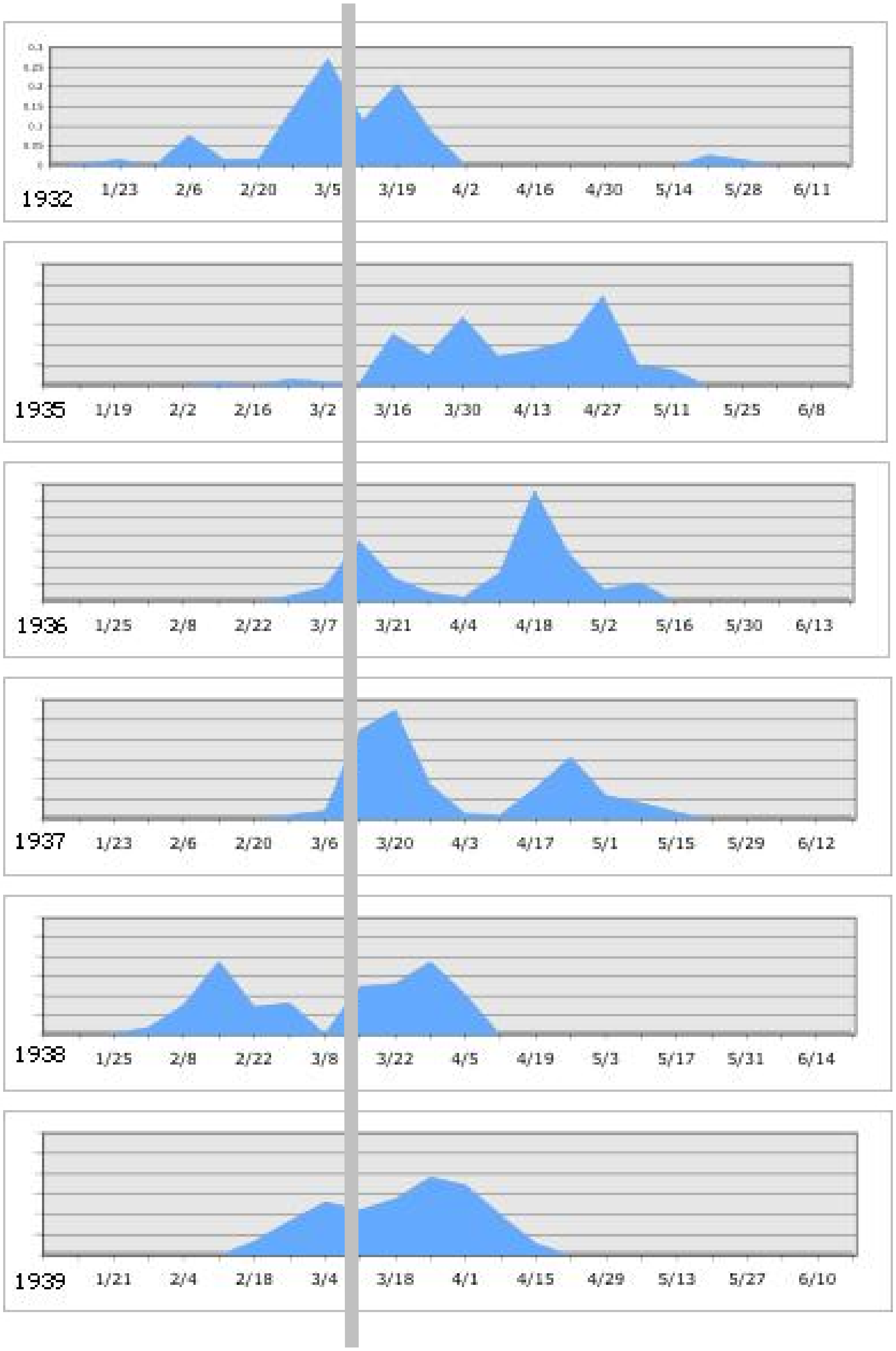


Figure 7. Standardized distribution of steelhead eggs collection at the Puyallup Hatchery from 1932 to 1939 (1934 not included) (WDFW undated). The grey line approximates the March 15th spawning date currently used to discriminate between hatchery and native fish.

There is only limited documentation on the age structure of Puget Sound steelhead from historical (pre-1950) sources. Work by Pautzke and Meigs (1941) indicated that the majority of steelhead from the Green River emigrated to estuary and marine habitats in their second year (third spring) and then remained at sea for two years. Scales from returning adults indicated a minority of the fish had been one-year old or three-year old smolts. Although the historical record is sparse there appears to be little difference in age structure to first spawning between samples from the 1940s and present day collections (see Table 2, pg 38).

Within the Puget Sound DPS both major steelhead life-history strategies are exhibited: summer-run timing (stream maturing) and winter-run timing (ocean maturing). Each strategy includes a suite of associated traits that ultimately provide a high degree of local adaptation to the specific environmental conditions experienced by the population. In some cases there is a clear geographic distinction between spawning areas containing winter or summer-run steelhead; for example, in short rain-dominated streams or above partially impassable barriers. In other areas, winter and summer-run steelhead can be found utilizing the same holding and spawning habitat, and it may appear that there is a continuum of returning adults. In cases where both winter and summer run fish co-mingle on spawning grounds, it is not clear if these two life-history types exist as discrete populations, a diverse single population, or a population in transition. Pending further genetic and life history studies the TRT approach is to treat these populations as single mixed-run DIPs.

Winter-run Steelhead

In general, winter-run, or ocean maturing, steelhead return as adults to the tributaries of Puget Sound from December to April (WDF et al. 1973). This period of freshwater entry can vary considerably depending on the characteristics of each specific basin or annual climatic variation in temperature and precipitation. Spawning occurs from January to mid-June, with peak spawning occurring from mid-April through May (Table 1). Prior to spawning, maturing adults reside in pools or in side channels to avoid high winter flows during the relatively short prespawning period.

Steelhead generally spawn in moderate gradient sections of streams. In contrast to semelparous Pacific salmon, steelhead females do not guard their redds (nests), but return to the ocean following spawning, although they may dig several redds in the course of a spawning season (Burgner et al. 1992). Spawned-out fish that return to the sea are referred to as "kelts". Adult male steelhead may be relatively less abundant among fish returning to the ocean after spawning, and males usually form a small proportion of repeat (multi-year) spawning fish (based on scale pattern analyses). If there is lower post-spawning survival of winter-run males overall, it may be due to the tendency of males to remain on the spawning ground for longer periods than females, and/or fighting in defense of prime spawning areas or mates (Withler 1966).

In Puget Sound winter steelhead are found in both smaller streams that drain directly into Puget Sound and the Strait of Juan de Fuca and in larger rivers and their tributaries. The smaller drainages experience rain-dominated hydrological and thermal regimes, while the larger rivers are influenced by rain and snow-transitional or snow-dominated hydrological regimes. It is likely that differences in habitat conditions would be reflected in the life history characteristics (i.e. migration and spawn timing) of winter steelhead inhabiting these two types of basins. For example, it appears that steelhead spawn earlier in smaller lowland streams where water temperatures are generally warmer than in larger rivers with higher elevation headwaters.

Summer-run Steelhead

In many cases the summer migration timing is associated with barrier falls or cascades. These barriers may temporally limit passage in different ways. Some are velocity barriers that prevent passage in the winter during high flows, but are passable during low summer flows, while others are passable only during high flows when plunge pools are full or side channels emerge (Withler 1966). In Puget Sound winter-run steelhead are predominant, in part, because there are relatively few basins with the geomorphological and hydrological characteristics necessary to establish and sustain the summer-run life history. In general, summer-run steelhead return to fresh water from May or June to October, with spawning taking place from January to April. During the summer-run steelhead's extended freshwater residence prior to spawning, the fish normally hold in deep pools which exposes the fish to prolonged predation risk and seasonal environmental extremes, which likely results in higher prespawning mortality levels relative to winter-run steelhead. This potential survival disadvantage may explain why winter-run steelhead predominate where no migrational barriers are present (Dan Rawding, WDFW, Vancouver, Washington, personal communication). In at least two or possibly three Puget Sound river systems, the Skagit, Sauk, and Dungeness, there appear to be co-occurring winter and summer-run steelhead:. The circumstances in each river are somewhat different and further discussion is provided in the specific population descriptions.

The life history of summer-run steelhead is highly adapted to specific environmental conditions. Because these conditions are not commonly found in Puget Sound, the relative incidence of summer-run steelhead populations is substantially less than that for winter-run steelhead. Summer-run steelhead have not been widely monitored, in part, because of their small population size and the difficulties in monitoring fish in their headwater holding areas. Much of our general understanding of the summer-run life history comes from studies of interior Columbia River populations that undergo substantial freshwater migrations to reach their natal streams. Sufficient information exists for only 4 of the 16 Puget Sound summer-run steelhead populations identified in the 2002 Salmonid Stock Inventory (SaSI; WDFW 2005) to determine their population status. There is considerable disagreement on the existence of many of the SaSI-designated summer-run steelhead populations. In part, this is due to the use of sport and tribal catch data in establishing the presence of summer run steelhead. Steelhead caught after May were thought to be summer-run fish; however, in many basins with colder, glacial-origin, rivers adult return and spawning times for winter-run fish can extend well into June (i.e. Dosewallips River). Additionally, kelts may reside in freshwater for several weeks after spawning and appear in catch records through July. In the absence of a substantial database on summer-run steelhead in Puget Sound considerable reliance was placed on observations by local biologists in substantiating the presence of summer-run steelhead.

In contrast to the classical scenario where summer-run steelhead populations are present only above temporally passable barriers, the TRT considered a number of situations where summer-run and winter-run steelhead were observed holding and spawning in the same river reach, primarily in the Skagit River Basin. Based on the information available, there appears to be some temporal separation between the two runs in spawning times, although genetic information is not available to establish whether there is complete reproductive isolation. Furthermore, this occurrence is not sporadic and has occurred regularly each year. It was unclear how the two run times could persist with overlapping niches. One suggestion was that the summer-run fish might represent anadromous progeny from resident *O. mykiss* above nearby impassable barriers and that the summer-run fish are not self-sustaining but maintained by regular infusions of migrants from above barriers. In the absence of empirical data, such as genetic analysis of winter and summer-run steelhead and resident *O. mykiss*, to establish whether two co-occurring runs in a basin are indeed DIPs, the TRT opted to include both run times as components of an inclusive DIP. Further investigation is warranted to ensure proper management for these fish.