CHAPTER 7
Habitat and Biological Communities: Background

This chapter presents the background information that was used to develop the habitat and biological communities characterizations in Chapters 8 and 9. It includes:

- Habitat Reference Conditions
- Habitat Indicators for Characterization
- Historical Salmonid Use in the Lower Willamette River and Tributaries
- Biological Communities evaluated for Characterization

HABITAT REFERENCE CONDITIONS

Fanno Creek Subbasin

Floodplain Condition

The Tualatin River Basin was historically characterized as "a land of marshes, swamps, and floods, surrounded by mountains" (Cass 1993). Fanno Creek originates from these mountains, specifically the southeast facing hillslope of the Tualatin Mountains, today known as the West Hills. The steep West Hills (averaging 25%) bound the northern side and headwater reaches of Fanno Creek; the southern side is relatively unbound by hillsides, but lies within incised terraces of the broader south-facing, Tualatin valley, low sloping, hillside. Stream gradient is low, averaging less than 1%, except in the northern headwater reach, where stream gradient steepens to about 5% (moderately steep).

Floodplain interactions historically maintained watershed functions in Fanno Creek. Mainstem Fanno Creek was likely seasonally constrained by terraces, varying in width, within a broad alluvial creek bottom (VWI averages 20.0% basinwide). The creek likely meandered through these varying terraces, filling the banks and accessing broad floodplain areas during winter, wet months.

Some tributaries to Fanno Creek exhibit similar floodplain condition to mainstem Fanno Creek; they are bound by alternating terraces and hillslopes, and historically flowed through a broader floodplain valley. Stream gradients are low to moderately steep. Notably, tributaries draining southerly (from the Tualatin Mountain hillside) are steeper and historically had a narrower floodplain than those tributaries originating south of Fanno mainstem, and draining westerly. These lower gradient streams had greater riparian and floodplain interactions than the steeper, northerly originating streams.

Based on these landform characteristics, one would expect Fanno Creek to meander through an open valley, while being bound by the Tualatin Mountains on the north. The broader floodplain

to south, allowed the Creek to adapt to higher flows (originating from the steeper, headwater reaches) by forming broad open areas of water and emergent wetlands. In addition, this allowed the Creek to deposit fine silts and sediments (that characterize the systems soils and geology) along the way, which subsequently helped build and forms the terraced banks.

Notably, these alternating terraces and floodplain wetlands would have provided important habitat to juvenile salmon, particularly coho and steelhead, for rearing and high flow refugia. In addition, inundation of this broad floodplain, along with springs, seeps and tributary flows would have provided important off-channel refugia during the winter, and would have provided important cool water and base flow throughout the summer.

Riparian Condition

Vegetation in Fanno Subbasin was likely characterized as closed forest canopy and woodland forest.
Common streamside, riparian and upland species (particularly in the headwater area) would have been red alder, big leaf maple, oak, western red cedar, yellow pine cedar, western hemlock, Douglas-fir and grand fir; and common understorey species would have included vine maple, western ash, hazel, dogwood, salal, snowberry, blackberry and Oregon grape (Cass and Miner 1993) (Shively 1993). In addition prairie grasses and forbes were common.

Historically large wetland complexes, created by abundant beaver populations, resided along the Tualatin River and its stream tributary corridors. Areas of heavy clay deposits from the Bretz floods resulted in drier Oak Savanna and seasonally saturated wet praries. Early settlers occupied the more open savanna's and prairies of the central county before moving into the more densely wooded areas further east towards Portland (CWS 2002).

Stream Connectivity

Historically, there were no natural barriers on Fanno mainstem that would have impeded anadromy. Natural channel forms such as boulder-steps, beaver dams, and log jams may have temporally impacted fish movement, but did not likely block fish passage year-round. Fish have evolved to either navigate thru interstitial spaces within these types of natural channel forms and structures, or time their migrations to periods when flows allow easier passage above these channel forms.

Refugia

In Fanno Creek off-channel refugia was likely found near tributary junctions, backwater pools, side channels, and secondary channels. In addition, floodplain wetlands would have provided key high flow refugia and seasonal rearing opportunities.

In-stream refugia was most notably associated with wood pieces, clusters and jams. Other habitat features that would have provided substantive protective cover include: beaver ponds and associated wood clusters and debris jams, undercut banks, large cobble and boulders, and deep pools. In addition, seeps and springs likely provided important cool-water refugia and helped augment summer baseflows.

Channel Complexity - Channel Conditions and Habitat Structure

In its natural condition, a stream like Fanno Creek would have a sequence of pools and pools and riffles, and side channels and backwater areas and oxbows. In addition, three major types of wetlands existed in the Tualatin River basin: 1) freshwater swamps, 2) freshwater marshes, and 3) riparian areas and wetlands (Shively 1993). All three wetland habitats would have likely been present in Fanno subbasin, however, riparian areas and seasonal wetlands were likely more common in the upper subbasin. Notably, in 1993 Gabriel found that wetland losses throughout the Tualatin River basin totaled 61% for areas below 660-ft elevation.

Logs would have helped form deep pools to shelter adult and juvenile fish while backwaters and off-channel habitats would have provided areas for juvenile fish to escape during winter peak flows. Shively (1993) noted the following:

> *"The Tualatin River, along with other streams draining the east slope of the Oregon Coast range (Yamhill, Luckiamute, Long Tom) contained concentrations of large woody debris in the form of drift jams that completely obstructed major channels for a distance of 100-150 meters at some channel location during the mid 1800;s"*

The physiographic characteristics of the watershed and its soil types most prominently impact hillslope and channel stability, channel configuration, channel incision and undercutting. Historically, Fanno Creek likely changed directions often, reforming itself within the prevalent clay and silt bed substratum. Notably, loss of vegetation and presence of impervious surfaces undoubtedly exacerbate these conditions, yielding proportionally higher erosion than would be expected under historical (or pre-European settlement) conditions. In addition, large wood provided by large conifer and deciduous tree boles historically captured and retained sediment and helped form floodplain terraces and wetlands (via increased hydraulic residence and floodplain expansion) and facilitated nutrient processing and storage.

Fanno Creek drains a watershed that is characterized by a natural abundance of fine silt (Delena soil type); hence suspended and settleable organic material and fine silt have likely always characterized this system. However, unlike today, Fanno Creek was likely longer, with more meanders, and had more interactions with its adjacent floodplains. The result is that suspended solids would have settled and deposited in floodplain areas, rather than in the stream channel; hence, although suspended solids were likely common, settleable solids would not have dominated stream bottom substrate composition, as it does today; hence, pools remained deep and riffles non-embedded.

Tryon Creek Subbasin

Floodplain and Upland Condition

Floodplain interactions historically helped maintain watershed functions in Tryon Creek. Tryon Creek is bound by steep valley walls on the northern and southern facing hillsides. Stream gradients in Tryon Creek are low to moderately steep basin-wide. Downstream from Boones Ferry Rd stream gradient is generally below 2%, while the upper basin averages 2.3%, 3.1% and 2.7% respectively. Lower gradient streams generally have greater riparian and floodplain interactions.

Based on these landform characteristics, one would expect Tryon Creek to flood often, and meander from hillside to hillside within the confines of the valley walls. The area in the Park historically functioned as a depositional reach, with deep soils and a wide historic floodplain (WMSWCD, 2003b). This broader floodplain in the Park allowed the Creek to adjust to higher flows originating from the steeper and more confined upper headwater reaches, by meandering from hillside to hillside.

Alluvial reaches in the Park used to provide important summer and winter rearing habitat to juvenile salmon. Eradication and displacement of beavers, beaver dams, debris jams and associated ponds and off-channel pools has undoubtedly reduced these alluvial stream interactions yielding a less diverse floodway and associated processes: "*..portions of the valley floor were likely inundated under beaver impoundments, which, along with silt transport mechanisms, may explain why much of the valley bottom is fairly level with deep soils composed of fine sediment. The annual recharge to shallow aquifers beneath these small floodplain areas likely contributed to summer base flows, helping to moderate stream temperatures"*. (PHS, 1997).

Presently substantive floodplain interactions are severely lacking in Tryon Creek. The Creek is incised and straight. Flood flows rarely extend far into the floodway, even within the protected areas of the Park. Frequent flood-flows are not capable of reaching the relatively flat floodplain for energy dissipation, sediment deposition, and periodic flooding of riparian vegetation (WMSWCD, 2003b). Disconnection of Tryon Creek from its floodplain can be attributed to several inter-related factors and processes. Notably, the channel is down-cut and has been widened, such that the amount of water that formerly filled the channel and spilled onto the floodplain is now held within the deeper, wider channel. In addition, the channel length is shorter, with fewer bends and meanders and channel complexity is lacking. The National Riparian Services Team (WMSWCD, 2003b) concluded that the reduction in resistance-forces (e.g., loss of large wood and woody, riparian vegetation) and increases in water velocity result in an increase of flow energy that continually erodes the streambed and streambanks. This has been significant enough to produce rapid vertical adjustments to the channel network, effectively disconnecting the channel from its floodplain. Presently the creek seldom accesses its floodplain and is functionally confined. The result is more water remaining in the channel and less water infiltrating into the floodplain and aquifer during moderate storm flows. Only during very high, infrequent floods does flow overtop the creek banks. ODFW field biologists confirmed this in 2002. Specifically, floodprone widths are greater than the active channel widths indicating that flood flows periodically top the creek banks and interact with the floodway; however, the floodprone width rarely exceeds 1.5 times the active channel width; hence does not extend far into the floodplain.

Lack of historic floodplain habitat in Lower Tryon Creek is a key limiting factor effecting the streams ability to function dynamically, particularly given the urban constraints within upland and floodplain areas, and the altered hydrograph; and re-establishment of the full-spectrum of historical stream/floodplain interactions is not likely feasible. However, careful management of existing floodplains in Lower Tryon could restore important ecological functions and provide a means to re-establish channel processes. Specifically, reconnecting floodplain interactions is a

means to restore processes important for slowing velocities, lowering local water surface elevation, and detaining floodwaters via depression, storage, infiltration, and decreased travel time.

Riparian Condition

The forest has converted from a mixed conifer-deciduous forest to one dominated by deciduous trees and shrubs. Common streamside, riparian and upland species would have been red alder, big leaf maple, western red cedar, Douglas-fir and grand fir; and common understorey species would have included: vine maple, western wahoo, and salmonberry.

Presently, riparian condition is relatively good within the Park. Here, riparian widths average 200' or more, tree canopy cover is high, and well-established second growth forest dominates the landscape, averaging 15-30-cm dbh. Red alder and big leaf maple predominate in streamside areas; however, large native conifers (western red cedar, douglas-fir, and grand fir) are rare. However, young western red cedar are beginning to predominate above invasive blackberry. An older aged forest encompasses the lower canyon reach, while a younger forest stand encompasses the middle and upper Park reaches. This is symptomatic of past logging patterns across the landscape.

Stream Connectivity

Marshall Cascade (on mainstem Tryon Creek) and Arnold Falls on Arnold Creek are the only documented natural barriers. Other natural channel forms (steps, beaver dams, and log jams) may have seasonally impacted fish movement, but did not likely block fish passage year-round. Fish have evolved to either navigate thru interstitial spaces within these types of natural channel forms and structures, or time their migrations to periods when flows allow easier passage above these channel forms.

Presently, HWY 43 culvert most prominently effects species diversity and distribution. This culvert severely limits anadromous fish from accessing spawning and rearing habitat in Tryon Creek. The culvert is a concrete box culvert, which has been retrofitted with baffles to improve passage for anadromous adults; yet it remains a partial barrier, particularly for fall spawning coho salmon. During this time flows are not high enough to allow access into the culvert (e.g., the jump height into the culvert remains too high) and passage through the long, baffled culvert is very inhospitable. Winter steelhead return to spawn in late winter – early spring when flows are higher, providing more advantageous opportunities for passage, however, passage likely remains impaired.

Other fish passage barriers exist throughout the basin, however this culvert is most significant because of its closeness to the confluence and its impassability. Improving fish access into Tryon Creek by retrofitting or replacing the HWY 43 culvert could significantly increase anadromous fish productivity and species diversity throughout the watershed (WMSWDC, 2003d).

Refugia

Off-channel refugia was likely found near tributary junctions, backwater pools, side channels, and secondary channels. In addition, floodplain wetlands throughout the Park likely provided substantive high flow refugia.

In-stream refugia was most notably associated with wood pieces, clusters and jams. Other habitat features that would have provided substantive protective cover include: beaver ponds and associated wood clusters and debris jams; undercut banks, large cobble and boulders, and deep pools. In addition, seeps and springs likely provided important cool-water refugia and helped augment summer low flows.

Channel Complexity - Channel Conditions and Habitat Structure

In its natural condition, a stream like Tryon Creek would be expected to have an array of pools, riffles, side channels and backwater areas caused by large amounts of downed wood and trees, and by a meandering stream channel. Logs would form deep pools to shelter adults and juveniles while backwaters and off-channel habitats would provide areas for juvenile fish to escape during winter flow peaks. In contrast, Tryon Creek currently has little large wood in the stream, even within the Park, and for the most part the creek is confined within a single, simplified channel.

Large Woody Debris

The National Riparian Services Team (WMSWCD, 2003b) characterizes Tryon Creek as a wood dependent system, meaning that it developed in conjunction with a large conifer forest stand. The wood provided by larger conifer tree boles historically trapped sediment and formed floodplains, retaining flood flows and promoting rich, diverse riparian vegetation. They likewise concluded that "*large wood material is the most important attribute in this stream type and the processes associated with it are the most important to the function of the watershed*". Large woody material is lacking basin-wide (ODFW 2001), (WMSWCD, 2003a), (WMSWCD, 2003b) (WMSWCD 2003d).

Fine Sediment

Tryon Creek drains a watershed that is characterized by a natural abundance of fine silt. Land use practices have likely exacerbated the natural condition of the stream to transport high levels of fine sediment. In addition, fine sediment originating from the steeper, more urbanized upper watershed settles out in the lower gradient reaches (in the Park). Stormwater run-off sediment loading, along with fine silts that slough into the creek during erosive flows has resulted in a constant layer of fine silt and sediment overlaying stream bottom substrates. These high silt loads overlaying spawning and rearing grounds may significantly impair the carrying capacity of Tryon Creek.

Presently, Tryon Creek is straight, incised and wide and stream banks are eroded. The Creek generally flows through one primary channel; secondary channels and side channels are rare. Because of the simplified channel form, important habitats are lacking, such as undercut banks, backwater pools and off-channel habitats, deep pools and high quality riffle habitats. Lack of

these important spawning and rearing areas significantly reduces potential population productivity.

INDICATORS OF HABITAT CONDITION

Introduction

This section describes habitat indicators of riverine (stream) health. These indicators were used to characterize present stream and aquatic habitat conditions in the Fanno Creek Watershed (Chapter 8) and Tryon Creek Watershed (Chapter 9).

The following indicators were used:

- Floodplain Condition
- Riparian Condition
- Stream Connectivity
- Refugia
- Channel Conditions and Habitat Structure

These indicators are equivalent to ecological functions and are interdependent. Each is briefly described, and associated metrics are identified. The reference conditions or processes indicative of healthy riverine ecosystems are mostly modeled from rural/wildland-type ecosystems. The complexities and nuances of ecosystem dynamics that occur in urban watersheds are not fully understood; however, rural watershed health indicators provide a context from which healthy or normative ecological conditions can be evaluated. These range of conditions presented for Pacific Northwest streams are intended to provide a description of how Tryon and Fanno Creek watersheds would function under varying aquatic health condition.

Floodplain Condition

Adjacent floodplain and riparian environs help maintain hydrologic connections and provides unique benefits suited to aquatic – terrestrial interactions. Floodplain habitats help attenuate stream flows and decrease peak flows, store water, recharge the groundwater and subsequently maintain base flow during the summer. In addition to helping maintain normative hydrologic regimes, floodplains and wetlands filter sediments, supply organic matter (including large wood) and bed-form substrates to the channel and help moderate stream temperatures (via subsurface and hyporheic flows). For example, riparian areas provide shade and source woody material (and leaf matter) to a stream; and trees, shrubs and grasses provide protective cover (overhanging vegetation) to residing aquatic organisms. In addition, vegetated banks stabilize stream banks, and capture and filter sediments. Notably, providing opportunities for flood flows to top the bank and inundate the riparian area and broader floodplain areas are necessary to maintain these aquatic – land interactions.

In addition to these processes that help maintain stream building process, floodplain and wetland environs provide important habitat to aquatic and terrestrial wildlife. Floodplain wetlands (or seasonal wetlands), oxbows, and secondary channels, provide important high flow refugia and overwintering habitat to native fish communities. Coho salmon in particular rely on these slack water, low velocity rearing areas during fall, winter and spring. Salmonids may likewise use off-channel habitats as refuge from adverse instream conditions, such as high flows, high sediment loads, and / or large concentrations of pollutants.

Metrics

Key metrics used to evaluate floodplain conditions were:

- Ratio of floodway to stream width (valley width index, or VWI)
- Stream gradient (%)
- Entrenchment ratio (floodprone width/active channel width)
- Evidence of stream corridor and floodplain connectivity (or lack thereof)

This data was evaluated to determine floodplain function and condition and was gauged according to criteria described in NMFS Matrix of Properly Functioning Condition as described in Making Endangered Species Act Determinations of Effect for Individual or Grouped Actions at the Watershed Scale (1996):

Properly Functioning: Off-channel areas are frequently hydrologically linked to main channel; overbank flows occur and maintain wetland functions, riparian vegetation and succession

At Risk: Reduced linkage of wetland, floodplains and riparian areas to main channel; overbank flows are reduced relative to historic frequency, as evidenced by moderate degradation of wetland function, riparian vegetation/succession

Not Properly Functioning: Sever reduction in hydrologic connectivity between off-channel, wetland, floodplains and riparian areas; wetland extent drastically reduced and riparian vegetation/succession altered significantly

Riparian Condition

Riparian areas are the interface between aquatic-land interactions and provide critical functions to cold water-species and other wildlife. Some of the most apparent are temperature moderation (and reduction of peak temperatures), sediment filtration and reduction, bank stability and erosion control, organic inputs, cover (overhanging vegetation), and sources of large wood, gravels, and cobbles. In addition, riparian habitats provide important rearing habitat and migration corridors for different wildlife species.

Riparian integrity criteria and associated thresholds have not been well defined for urban areas, and often rely on total riparian width, vegetative characterizations (species abundance, density, age structure, and diversity), and percent impervious surface adjacent to the stream bank. Riparian widths vary with local topography, geology, and soils, as well as the type and degree of human use. Optimal riparian widths (necessary to maintain high riparian integrity) therefore vary within each basin, depending on (among other things) stream size, stream gradient, bank slope stability, channel sinuosity, vegetation type and density, and surrounding land use. In Tryon and Fanno Creeks, human uses significantly affect the quantity of effective riparian area and the potential functions the riparian fringe provides.

Existence of wetlands and hyporheic areas in small, low-elevation streams, such as Tryon and Fanno Creeks, has not been substantively evaluated, but is likely of high significance because seeps and springs augment low flows and cool stream temperatures. In addition, hyporheic flows (near springs, seeps, and wetted channel perimeter) provide water quality benefits and are often associated with increased macroinvertebrate production.

Metrics

Key metrics used to assess riparian condition were:

- Percent tree canopy cover and riparian width
- Riparian vegetation: species, composition and size
- Riparian fragmentation (or lack of longitudinal continuity)
- Presence of wetlands, springs and seeps
- Predominant land-use

These data were evaluated according to the following criteria:

Criteria	
Zone of Influence: Width of Riparian Vegetative Zone – Least buffered side 1/ Riparian Condition 4/	Optimal: Vegetative zone > 4 x bank full width (BFW). **NO** impacts in the zone. Sub-Optimal: Vegetative zone > 2 x BFW. Minimal impacts in this zone. Marginal: Vegetative zone > BFW. Serious impacts in the zone up to the stream edge. Poor: Very high disruption of streambank. Vegetation removed to < 2 inches average stubble height. The riparian zone should be at least 30-meters wide and have 65 percent or more forest canopy
Successional Stage (forest only) 1/	Optimal: Old growth-mature: diameter > 53 inches Sub-Optimal: Young: diameter 22 – 53 inches Marginal: Pole saplings: diameter 13 – 22 inches Poor: Seedlings / clearcut: diameter 0 13 inches
Riparian Conifers (30 meters from both sides) 2/	Desirable: > 300 conifers, > 51 cm dbh per 1000-ft stream length **OR** > 200 conifers, > 89 cm dbh / 1000-ft stream length Undesirable: > 150 conifers, > 51-in dbh / 1000-ft stream length **OR** > 75 conifers, > 89-in dbh / 1000-ft stream length
Shade (%) – westside streams 2/	

Stream width < 12-m Stream width > 12-m	Desirable: > 70% Undesirable: < 60% Desirable: > 60% Undesirable: < 50%
Riparian Reserve 3/	Properly Functioning: The Riparian reserve system provides adequate shade, large woody debris recruitment, and habitat protection and connectivity in all subwatersheds, and buffers or includes known refugia for sensitive aquatic species (>80% intact): percent similarity of the riparian vegetation to the potential natural community / composition > 50%. At Risk: Moderate loss of connectivity or function (shade, LWD, recruitment) of riparian reserve system, or incomplete protection of habitats and refugia for sensitive aquatic species (~ 70-80% intact): percent similarity of riparian vegetation to the potential natural community / composition 25-50% or better. Not Properly Functioning: Riparian reserve system is fragmented, poorly connected, or provides inadequate protection of habitats and refugia for sensitive aquatic speies (< 70% intact): percent similarity of riparian vegetation to the potential natural community composition < 25%.

1/ Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

2/ Oregon Watershed Assessment Manual

3/ NMFS Matrix of Properly Functioning Condition as described in Making Endangered Species Act Determinations of Effect for Individual or Grouped Actions at the Watershed Scale (1996)

4/ May 1997

Stream Connectivity

Pacific Northwest salmonids require a variety of habitat types (and conditions) throughout their life. Adults need opportunities to migrate upstream and spawn (late summer through winter, depending on species), and juveniles (and resident trout) require opportunities to move around while rearing to seek food, avoid predators, and seek unique habitat niches.

Stream connectivity is affected by natural and artificial features (usually hard and fixed) within and along the stream channel and/or conditions occurring in the stream. For example, culverts,

dams, sewer lines, and concrete walls can totally, partially, or temporarily block fish passage via physical obstruction (hydraulic control) or by creating hydrologic conditions that impede fish movement.

High water velocities at a culvert inlet, outlet, or within a culvert may overwhelm prolonged and burst swimming speeds, thus creating a velocity barrier. Shallow water depths (e.g., below six inches) within a culvert may limit a fish's ability to swim upstream or downstream, stranding (or isolating) them to specific stream reaches. Depending on the culvert design (high flow versus low flow), stream flows may delay fish from accessing upstream and downstream sites at critical times (such as spawn timing) and may distribute fish into less-than-ideal locations. In addition, the height between a culvert outlet and the water surface may exceed maximum jumping heights for adult salmonids during migration and/or for juvenile salmon and trout during freshwater rearing. Finally, the number, location, and type of road-crossing barriers in a watershed acts as a filter that will determine the amount of habitat available to each species and age-class of fish (ODFW 1999).

Barriers to fish migration can significantly impair a population's ability to persist and reproduce. Specifically, delayed adults may expend a great portion of their energy reserves, resulting in weakened fish that are more disposed to disease or pre-spawning mortality, or, in females, retention of eggs. Additionally, eggs may be deposited during unfavorable environmental conditions for egg and fry survival, and headwater areas may be poorly seeded, while downstream reaches may exceed the stream carrying capacity of an area.

Metrics

The number and impact (e.g., totally impassable, partially impassable, or temporarily impassable) of culverts or other hydraulic breaks (waterfalls, stormwater pipes, irrigation dams, etc.) were inventoried. Criteria described in NMFS Matrix of Properly Functioning Condition as described in Making Endangered Species Act Determinations of Effect for Individual or Grouped Actions at the Watershed Scale (1996) was used to evaluate stream connectivity for each surveyed reach:

> Properly Functioning: Any man-made barriers present in watershed allow upstream and downstream fish passage at all flows.
>
> At Risk: Any man-made barriers present in watershed do not allow upstream and/or downstream fish passage at base/low flows.
>
> Not Properly Functioning: Any man-made barriers present in watershed do not allow upstream and/or downstream fish passage at a range of flows.

Refugia

In the Tryon and Fanno Creek Watersheds, refugia occur primarily in (or immediately adjacent to) the channel and are associated with side channels and tributaries (off-channel refugia) and instream channel features. Both types of refugia are important to fish, allowing them to respond to environmental changes from season to season, or to behavioral stresses (e.g., predator avoidance) throughout their freshwater residency.

Instream structure (such as overhanging vegetation, undercut banks, boulders and cobbles, deep pools, turbulent flows, and large wood) provides important physical refuge (or cover) to aquatic species. The amount, type, and location of instream cover plays an important role in salmonids' selection of habitat for spawning and rearing (USFWS 1983), and allows fish to occupy portions of the creek they may not otherwise have used. Notably, the presence of cover can increase the abundance of salmonids if the amount of suitable habitat is limiting fish productivity (Bjornn and Reiser 1991).

Tributaries, side channels, secondary channels, off-channel pools, and seasonally accessed wetlands provide off-channel refugia to salmonids during periods of environmental change or stress. For example, salmonids will move into tributaries for temporary refuge when water temperatures are high, storm flows are high, or to avoid competition with other fishes.

Metrics

Key metrics used to evaluate instream and off-channel refugia were:

- Number and size of side channels, off-channel areas and tributaries
- Density of large wood and shelters, such as beaver ponds and debris jams, large substrates (boulders), undercut banks, and engineered structures

Criteria	
Off-channel Habitat 1/	Properly Functioning: Backwaters with cover, and low energy off-channel areas (ponds, oxbows, etc.) At Risk: some backwaters and high energy side channels Not Properly Functioning: Few or no backwaters, no off-channel ponds
Instream Cover 2/	Optimal: >50% gravel, cobble, submerged logs, undercut banks: Stable fish habitat Sub-Optimal: 30-50% Stable fish habitat Marginal: 10-30% Stable fish habitat Poor: <10% Stable fish habitat. Lack of habitat is obvious.
Refugia 1/	Properly Functioning: Habitat refugia exists and are adequately buffered (e.g., by intact riparian reserves); existing refugia area sufficient in size, number and connectivity to maintain viable populations or sub-populations. At Risk: Habitat refugia exists but are not adequately buffered (e.g., by intact riparian reserves); existing refugia area insufficient in size, number and connectivity to maintain viable populations or sub-populations. Not Properly Functioning: Adequate habitat refugia do not exist

1/ National Marine Fisheries Service. 1996. Making Endangered Species Act Determinations of Effect for Individual or Grouped Actions at the Watershed Scale. NMFS, Environmental and Technical Services Division, Habitat Conservation Branch: 26 pp.

2/ Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

Channel Conditions and Habitat Structure

Channel form and complexity can have an important influence on local hydrology; and subsequently, hydrologic regimes play a critical role in building pool:riffle sequences; creating deep pools; delivering substrate (gravels, cobbles, and boulders), wood, and nutrients; changing channel dimensions, orientation, and stream length; and creating side-channel and off-channel habitats. Flow also affects streambank stability and erosiveness, and bank slope, and stream bank form (e.g., undercut banks, incised banks). In addition, flow determines the extent of riparian and floodplain hydrologic connectivity.

Stream structure, habitat sequencing, and the amount of each habitat type significantly affects the carrying capacity of a system. Salmon require different physical environments throughout progressive stages of their life (Hawkins 1993). For example, they require gravels of particular size to successfully spawn and for fertilized eggs to thrive. They also require deep pools, side channels, riffles, and off-channel habitats for sustained rearing and feeding. Without these important key habitats, salmonid productivity may be limited.

Habitat quantity and quality is significantly influenced by a variety of instream features and watershed processes, but are likewise influenced by macro scale factors such as basin size and shape, elevation, hillslope gradient and stream gradient, parent material and soil structure. Combined, these factors create and maintain instream habitat and affects a systems ability to support sustainable native fish populations. Key attributes that help define channel condition and habitat structure include: 1) **channel form**; 2) **stream bank condition**, 3) **habitat diversity** (and channel complexity); 4) **substrate** and 5) **key habitats**. These habitat attributes are further described below.

1. Channel Form

One to one pool to riffle ratio is believed to be a natural sequencing of habitat type in PNW streams (Platts 1983) and is believed to provide for optimum aquatic health. Generally, streams with a high number of riffles and few pools are low in biomass and species diversity because they do not provide important shelter habitat for fish during high flow velocities. Conversely, streams with a high number of pools and few riffles lack aquatic diversity due to the lack of larger, exposed substrates for fish to spawn and rear on, and for macroinvertebrate to colonize.

Metrics

Criteria	
Pool / Riffle Ratio 2/	Optimal: 5-7 Sub-optimal: 7-15 Marginal: 15-25 Poor: >25
Width / Depth 1/	Properly Functioning Condition: <10

OR Width / Depth 2/	At Risk: 10-12 Not Properly Functioning: >12 Optimal: <7 Sub-optimal: 8-15 Marginal: 15-25 Poor: >25
Channel Shape 2/	Optimal: Trapezoidal Sub-optimal: Rectangular Marginal: Triangle Poor: Inverse Trapezoid

1/ National Marine Fisheries Service. 1996. Making Endangered Species Act Determinations of Effect for Individual or Grouped Actions at the Watershed Scale. NMFS, Environmental and Technical Services Division, Habitat Conservation Branch: 26 pp.

2/ Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

Stream Bank Condition

Vegetated banks are notably effective at protecting stream banks during erosive flows. They likewise help hold bank material together and ultimately help stabilize stream banks. Notably, natural stream banks are considered stable if perennial vegetation covers the stream banks (e.g., vegetative ground cover and roots are evident), rocks of cobble size substrate protect stream bank surfaces and logs and woody material protect stream bank surfaces. Stream banks are considered unstable if they show indications of breakdown, slumping, fracture, or vertical erosion (Bauer and Burton 1993). Characteristics of unstable bank condition are defined below:

> Breakdown: obvious blocks of bank broken away and lying adjacent to the bank breakage.
> Slumping or False bank: the bank has slipped down, cracks may or may not be obvious, but the slump feature is obvious.
> Fracture: a crack is visibly obvious on the bank indicating that the block of bank is about to slump or move into the stream.
> Vertical and Eroding: the bank is mostly uncovered and the bank angle is steeper than 80' from the horizontal.

In addition to these natural features, human-made alterations to a stream bank should be considered. Altered bank conditions may limit channel and floodplain response to watershed processes, for example the delivery and routing of water, sediment and large wood.

Criteria	
Bank Vegetation Protection 2/	Optimal: > 90% covered by vegetation Sub-optimal: 70-80% covered by vegetation Marginal: 50-79% covered by vegetation

	Poor: <50% covered by vegetation
Lower Bank Stability 2/	Optimal: Stable: NO erosion or failure Sub-optimal: Little erosion, mostly healed Marginal: Erosion moderate in size and frequency Poor: Unstable: Many raw eroded areas
Disruptive Pressures (within Bank Full Width) 2/	Optimal: Vegetative disruption minimal or no evident. Almost all potential plant biomass at present stage of development remains. Sub-optimal: Disruption evident but not effecting community vigor. > 50% potential biomass remains. Marginal: Disruption obvious, some patches of bare soil or closely cropped vegetation; < 50% potential biomass remains. Poor: Very high disruption of streambank. Vegetation removed to < 2 inches average stubble height.
Stream Bank Condition 1/	Properly Functioning Condition: > 90% stable; i.e., on average, less than 10% of banks are actively eroding At Risk: 80-90% stable Not Properly Functioning: <80% stable
Percent actively eroding ?/	30- 60 % indicates moderately unstable banks and signifies high erosion potential

1/ National Marine Fisheries Service. 1996. Making Endangered Species Act Determinations of Effect for Individual or Grouped Actions at the Watershed Scale. NMFS, Environmental and Technical Services Division, Habitat Conservation Branch: 26 pp.

2/ Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

Habitat Diversity (and Channel Complexity)

A variety of habitat features characterize channel complexity and channel roughness; for example undercut banks, overhanging vegetation, deep pools and large boulder and cobble sized substrate, together add different form and functional capacity to a aquatic systems. These are all important, however, channel complexity is most easily evaluated by considering the amount, volume, size and distribution of wood instream. Wood provides critical form and function to a stream system, and ultimately helps determine whether other important habitat forms, such as undercut banks, stream bank vegetation, deep pools and large substrate are retained and function properly.

Large wood, generally defined as downed wood that intercepts bankfull flow, influences channel hydraulics, creates stream meanders (increasing stream length), and helps form and maintain important habitats such as pools and riffles, undercut banks, deep scour areas, and backwater pools. In addition, the presence of wood instream adds channel roughness, protects stream banks and helps capture and retain sediments instream. In addition to these important functions instream, less dynamic wood (such as that buried on the floodplain or embedded along meander belts) help to stabilize and shape creek beds, as they adapt to high flows and build new channels.

Notably, channel complexity functions to increase interactions between the stream and its floodplain by slowing the downstream migration of flood flows, temporarily backing up water and forcing it out onto the floodplain area. Here, where velocities are lower, sediments will settle-out on the riparian and broader floodplain area. These areas subsequently provide rich soils for riparian and floodplain species to establish. Large wood and boulders can likewise deflect flows out of the primary channel, resulting in the creation of new channels, the reactivation of old channels (Sedell and Froggatt 1984; Sedell and Luchessa 1982), and the creation and maintenance of wetlands.

In addition to these more complex, dynamic processes, complex channel forms and features provide cover to fish, and provide important substratum for macroinvertebrates, a food source for fish, and provides source organic material into the creek.

Metric

Criteria	
Number of pieces (per 100-meters of stream length) 1/	Desirable: > 20 Undesirable: < 10
Volume of wood (per 100-meters of stream length) 1/	Desirable: > 30 Undesirable: < 20
Number of "Key" pieces (>60-cm and 10-m long per stream length) 1/	Desirable: > 3 Undesirable: < 1
Number of Pieces: > 20 pieces / mile (> 30 cm diameter x 10.6 m long; **AND** adequate sources of woody debris recruitment in riparian areas 2/	Properly Functioning: Meets the criteria At Risk: Meets the standards for properly functioning, but lacks potential sources from riparian areas of woody debris recruitment to maintain that standard Not Properly Functioning: Does not meet standards for properly functioning and lacks potential large woody debris recruitment.

1/ Oregon Watershed Assessment Manual defines large wood as 15 cm x 3 m minimum size

2/ National Marine Fisheries Service. 1996. Making Endangered Species Act Determinations of Effect for Individual or Grouped Actions at the Watershed Scale. NMFS, Environmental and Technical Services Division, Habitat Conservation Branch: 26 pp.

Substrate

Substrate composition, type, and location is critically important to fish communities during spawning, egg incubation, and juvenile rearing. Salmonids require an array of substrate sizes (from 1.3 to 14.0 –centimeters) to successfully spawn-in, and subsequently for eggs to incubate and fry to successfully emerge and rear.

Gravels and cobbles associated with spawning are often found in riffles and in pool tail-outs. For substrates to be functional, they cannot be embedded or extensively covered in fine silts and sediments. Rather, they must be relatively free-floating (or loose) in order for salmon to successfully dig redds and lay eggs and for eggs and fry to experience optimal flow and dissolved oxygen.

Spawning bed materials and substrate permeability are critical to the development and emergence of salmonid fry. Excess (greater than 20 percent) sand and silt (less than 6.4 –mm in size) in gravel can reduce both survival and emergence of Chinook, steelhead and coho fry. Fine sediment (suspended and deposited) should make up less than 40 percent of riffle substrates. Amassed (or deposited) fine sediment and extreme silt loads (greater than 25 milligrams per liter) (Bell 1973) can clog fish gills and affect a fish's ability to "breathe" (or absorb oxygen), and can trap fry attempting to leave the gravel. Additionally, cobbles and gravels covered with fine sediment reduce interstitial spaces used by aquatic invertebrates (the primary food organisms of salmonids) and cover used by juvenile salmonids in the winter.

Indirect effects that fish may experience include reduced feeding, avoidance reactions and delayed (or ceased) migrations (if a silt curtain persists), destruction of food supplies (via limiting production of benthic invertebrates), and altered habitats (covering of critical spawning or rearing areas). In addition, salmonids often rise to the surface during high-turbidity events, where they are more vulnerable to avian predators. This can be especially important in river reaches that do not have adequate riparian vegetation and associated overstory cover.

Metrics

Criteria	
Substrate Composition 1/	Properly Functioning: Dominant substrate is gravel or cobble or embeddness is <20% At Risk: Gravel and cobble is subdominant, or if dominant embeddness is 20-30% Not Properly Functioning: Bedrock, sand and silt or small gravel dominant, or if gravel and cobble dominant, embeddness >30%
Bottom Substrate - % Fines 2/	Optimal: <10% Fines Sub-optimal: 10-20% Fines Marginal: 20-50% Fines Poor: >50% Fines

1/ National Marine Fisheries Service. 1996. Making Endangered Species Act Determinations of Effect for Individual or Grouped Actions at the Watershed Scale. NMFS, Environmental and Technical Services Division, Habitat Conservation Branch: 26 pp.

2/ Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

Key Habitats

The amount and type of habitat available is significantly affected by flow volume and channel hydraulics, or water depth and habitat type. Notably, the depth of water at each cross section of creek functionally determines how that habitat can be used. For example, migratory fish need water of sufficient depth at critical seasons throughout the year. Adult steelhead and Chinook require water depth of 0.24 meters or greater, and coho adults require depths of 0.18 meters or greater to successfully navigate upstream and spawn (Bjorn and Reiser 1991). In addition, some salmon prefer deeper areas with higher velocities (or turbulent flow) to rear and seek cover; juvenile coho often seek deep waters (0.3 to 1.2 –meters) in submerged riffle habitats (USFWS 1983). Flows fundamentally determine how habitat can be used.

However, if key functional habitats are not available, flow volume and velocity will be inconsequential. Key habitats to Pacific Northwest salmon include riffle, deep pools, side channels and off-channel areas. These habitats all provide important functions during different stages of life. For example, migratory adults require deep pools for resting and to generate swimming speeds (prolonged or burst) to navigate above natural or artificial barriers. If a channel section is dewatered or lacking adequate depth at the base of a falls, culvert or large debris jam, then upstream migrations will be hindered. In addition, spring Chinook (and winter steelhead) enter their natal stream months before spawning. During this interim, they seek deep pools to rest prior to spawning. Deep pools also provide important refuge habitat to juvenile salmon during high storm flows and provide refuge from predators.

Just as deep pools provide important function to adult and juvenile salmon, slack water, shallow water areas provide important function to juvenile salmon during the winter and during high storm flows. Slack water and/or shallow water habitats are especially important for coho salmon. Coho often migrate to lower river reaches during their juvenile maturation, and seek slack water, side channels, and backwater pools to overwinter. These environs provide year-round food sources and cover, and are generally devoid of other competing salmonids. Co-occurring steelhead, Chinook and cutthroat would likely overwinter in deep pools on mainstem (and/or tributary) reaches.

In sum, pool habitats, both deep and shallow provide important function during different times of the year, to different species, and to different age classes of fish. Notably, the National Oceanic and Atmospheric Administration considers habitat structure to be properly functioning (for salmonids) if approximately 70 pools per mile are present, a prevalence of high-quality pools (over 0.91meters deep) are present, and a prevalence of backwater pools and off-channel areas (tributaries and side channels) are present.

The counter to pool habitats in a naturally functioning stream system is riffle habitat. Riffles are critically important as they provide the substrate for spawning beds, provide the environment for eggs to incubate and provide key habitat for fry and juvenile salmon to rear. In the absence of

riffle habitat, spawning area will be limited and will fundamentally limit the systems ability to support sustainable populations of fish.

Metrics:

Pool area and Quality

Criteria	
Pool Area (% total stream area) 1/	Desirable: > 35 percent Undesirable: < 10 percent
Pool Frequency Channel widths between pools 1/ **OR** Channel Width (ft) # Pools / Mile 5/ 5 184 10 96 15 70 20 56 25 47 50 26 75 23 100 18	Desirable: 5-8 Undesirable: >20 Properly Functioning: Meets pool frequency standards and large woody debris recruitment standards for properly functioning habitat. At Risk: Meets pool frequency standards but large woody debris recruitment inadequate to maintain pools over time Not Properly Functioning: Does not meet pool frequency standards.
Average residual pool depth 1/ Small streams, <7 meters wide Medium streams (> 7-m and < 15-m wide) ▪ *Low gradient (slope < 3%)* ▪ *High gradient (slope > 3%)* Large streams (> 15-m wide)	Desirable: > 0.5–m Undesirable: < 0.2-m Desirable: > 0.6–m Undesirable: < 0.3-m Desirable: > 1.0–m Undesirable: < 0.5-m Desirable: > 1.5–m Undesirable: < 0.8-m
Relative pool depth 4/	Pools 75-100 percent deeper than the prevailing channel depth provide protective cover

Complex Pools (with wood complexity > 3 km) 1/	Desirable: > 2.5 pools Undesirable: < 1.0 pools
Fines (% silt-sand and organics) 2/	20-50 percent deposited fines signifies slight deposition
Number of deep pools (>1.0 meter deep) AND pools with good cover and cool water, minor reduction in pool volume by fine sediment 5/	Properly Functioning: Meets pool quality standard At Risk: Few deep pools present or inadequate cover/temperature, moderate reduction in pool volume by fine sediment Not Properly Functioning: No deep pools and inadequate cover/temperature, major reduction of pool volume by fine sediment

1/ Oregon Watershed Assessment Manual

2/ Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

3/ Moore, K., Jones, K. and Dambacher, J. Oregon Department of Fish and Wildlife. 1999. Methods for Stream Habitat Surveys Aquatic Inventory Project. Natural Production Program: Oregon Department of Fish and Wildlife.

4/ NRCS 1999

5/ National Marine Fisheries Service. 1996. Making Endangered Species Act Determinations of Effect for Individual or Grouped Actions at the Watershed Scale. NMFS, Environmental and Technical Services Division, Habitat Conservation Branch: 26 pp.

Riffle Area and Quality:

Criteria	
Riffle Area (percent of total stream area) 1/	Qualitative assessment
Width / Depth (active channel) – riffles only, West side streams 2/	Desirable: < 15 Undesirable: > 30
Gravel (% area) 2/	Desirable: > = 35 % Undesirable: < 15%
Fines (% area) - silt-sand and organics 2/ Volcanic Parent Material Sedimentary Parent Material Channel Gradient < 1.5%	 Desirable: < 8 % Undesirable: > 15 % Desirable: < 10 % Undesirable: > 20 % Desirable: < 12 % Undesirable: > 25 %

OR Embeddedness 4/	Optimal: <25% covered Sub-optimal: 25-50% covered Marginal: 10-30% covered Poor: >75% covered

1/ Moore, K., Jones, K. and Dambacher, J. Oregon Department of Fish and Wildlife. 1999. Methods for Stream Habitat Surveys Aquatic Inventory Project. Natural Production Program: Oregon Department of Fish and Wildlife.

2/ Oregon Watershed Assessment Manual

3/ National Marine Fisheries Service. 1996. Making Endangered Species Act Determinations of Effect for Individual or Grouped Actions at the Watershed Scale. NMFS, Environmental and Technical Services Division, Habitat Conservation Branch: 26 pp.

4/ Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

BIOLOGICAL COMMUNITIES

Salmonids are the focal species because they are indicators of ecosystem health, are native to the Pacific Northwest and the Willamette Basin, and are believed to be surrogates for other aquatic species that inhabit the same (or similar) habitat niches. In addition to salmonid fish communities, Pacific lamprey and brook lamprey, and sculpin species are native to Pacific Northwest streams. Lamprey spp. are presently declining (in population numbers) throughout their historic range and are petitioned for listing under the federal ESA. In addition, torrent sculpin are an indicator species for habitat degradation and poor water quality. They tend to inhabit pristine habitats and therefore are more often found in rural streams than urban streams. Both these species are considered species of interest for this characterization.

- **Tryon Creek**: Target species include those inhabiting the Lower Columbia River and Lower Willamette River evolutionarily significant units (ESUs)[*]: steelhead/rainbow (*Onchorynchus mykiss*), Chinook salmon *(O. tshawytscha*), and coho salmon (*O. kisutch*). Cutthroat trout (*O. clarki*) are also considered a target species, and lamprey (*Lamperta spp*.) and torrent sculpin (*Cottus rhotheus*) are considered species of interest.

- **Fanno Creek**: Target species include those inhabiting the Upper Willamette River and Lower Columbia River evolutionarily significant units (ESUs): steelhead/rainbow (*Onchorynchus mykiss*), Chinook salmon *(O. tshawytscha*), and coho salmon (*O. kisutch*). Cutthroat trout (*O. clarki*) are also considered a target species.

To characterize present status of salmon communities in Tryon and Fanno Creek, it is important to know historical fish presence and distribution unique to each subbasin. Unfortunately, historical data documenting fish communities in Tryon and Fanno Creeks are lacking. However, data exists showing historical salmonid use in the lower Willamette Basin and tributaries. Based on that information and on particular life history traits and habitat preferences (described below), it is possible to surmise which species would have populated Tryon and Fanno Creeks, considering subbasin geomorphology and specific watershed attributes. The summary below describes historic salmonid use of the lower Willamette River and tributaries and describes key species and life history characteristics; this information suggests which species would have populated Tryon and Fanno Creek subbasins. Chapters 8 and 9 provide more detailed characterizations of the biological communities as they exist today.

Historical salmonid use in the lower Willamette River and tributaries

As early as 1903, Oregon state fish biologists noted that Willamette River salmon are an early-run fish that entered the Columbia River system early in the season to navigate above Willamette Falls and get up into remote areas of the upper Willamette River (and its tributaries) (Department of Fisheries 1905).

[*] An ESU is a distinct group of Pacific salmon, steelhead, or sea-run cutthroat that is substantially reproductively isolated and represents an important component in the evolutionary legacy of the species.

Large portions of the Willamette River's anadromous fish runs entered the basin via Multnomah Channel (Hutchison and Aney 1964); and coho, steelhead and cutthroat historically occupied small tributaries to the Channel (Willis et al. 1960). In 1999, residents of the Miller Creek subwatershed noted that both resident and anadromous fish had resided in the creek over the past 40-years (ODFW 2000).

In 1952, the Oregon State Game Commission (1952), as part of their fish salvage activities, collected 1400 salmon from Sauvie Island from July 1 through September 4. Most salmon were of yearling size.

Prior to hydrologic changes in the upper Willamette River Basin and fish passage improvements at Willamette Falls (beginning in the 1880s), winter steelhead, spring Chinook, and pacific lamprey are believed to be the only anadromous fish that had access to and populated areas in the middle and upper Willamette River basin (ODFW 2000(b)). Changes to the hydrologic regime and improved fish passage over the falls is believed to have allowed historically absent anadromous fish runs of summer steelhead, coho and fall Chinook to naturalize in subbasins above Willamette Falls (ODFW 1990b).

Important anadromous fish streams of the lower Willamette River (below Willamette Falls) include Johnson Creek, Crystal Springs Creek, Milton Creek, and Scappoose Creek (Hutchinson et.al. 1964) (Willis 1960). Tryon Creek was historically considered valuable to anadromous fish (Willis 1960). In addition, coho, fall chinook, spring chinook and steelhead have populated the Tualatin River basin.

The Willamette River not only served as a transportation corridor to adults and emigrating smolts, but also provided important rearing habitat to anadromous salmonids, such as Chinook, coho, steelhead, and cutthroat.

SPRING CHINOOK

The Willamette River Basin historically provided important spawning and rearing grounds to Chinook salmon of the Columbia River Basin. In 1946, 55,000 spring Chinook passed over Willamette Falls in April, May, and June. During that same period, 97,543 spring Chinook passed over Bonneville Dam (Fish Commission of Oregon 1948). From 1946 to 1951, annual Chinook runs, (including the mainstem Willamette River sport catch, escapement above Willamette Falls, and escapement to the Clackamas River) averaged 25,100 to 96,800 fish (Mattson 1963); the mean annual run size for this same period was 55,600. The largest run on record was 156,033 adults in 1953 (ODFW 2000b). In the early 1920s, however, an estimated 2.5 million spring Chinook passed over Willamette Falls; historically, this ranked second in importance to the Columbia River Basin spring and summer Chinook (Fulton 1968).

Wild spring Chinook have notably declined as a result of the construction (and ongoing operations) of Willamette Basin dams. Just before the dams were constructed, state biologists estimated that nearly 48 percent of spring Chinook spawning habitat would be lost (Fish Commission of Oregon 1948). Based on historical spawning information, only 400 miles of riverine habitat now remain available to spring Chinook (ODFW 2000a).

The spring Chinook sampled from 1946 through 1951 had the following age composition (Mattson 1963):

- 3-year age fish: 4 percent
- 4-year age fish: 24 percent;
- 5-year age fish: 62 percent
- 6-year age fish: 10 percent

These observations are generally consistent with observations made a quarter century earlier by Rich and Holmes (1929): "5-year old adults predominated, 6-year old salmon returned in larger numbers than 4's, and only a few 3-year olds were recovered."

Spring Chinook were noted rearing predominantly in the mainstem Willamette River and east side tributaries (ODFW 1990a). Adult Chinook were occasionally reported in the Tualatin River, but were believed to be "accidental" strays (Dimick and Merryfield 1945). However, spring Chinook continue to spawn and rear in the Tualatin River. In 2000, the Oregon Department of Fish and Wildlife (ODFW) found Chinook up to the mouth of Gales Creek in river mile 56.0 to 56.5 (Leader 2002).

Native spring Chinook entered the Willamette River in February, peak in April, and completed their migration to natal spawning grounds from late May through July. Passage over Willamette Falls was believed to be related to flow and temperature: passage increased when the river level dropped and water temperatures exceeded 53 degrees Fahrenheit (ODFW 1990a). Although a large portion of the spring run passed and occupied reaches above the falls, historical records show that a run of spring Chinook entered the Clackamas subbasin in March, prior to the upper Willamette fish run.

Spawning generally begins in early September and extends through mid-October. However, Dimick and Merryfield (1945) reported spawning activity in the Clackamas and Molalla Rivers as early as July. Residents of both basins substantiated these findings. Clackamas residents noted that hatchery staff took eggs in early July and August. These findings are consistent with the belief that spawning generally begins earlier in the colder headwaters, and progresses later in the lower stream reaches. Spawning coincides with a slight drop in water temperature, following the first few cool nights (Dimick and Merryfield 1945; Mattson 1963).

Most Chinook fry emerge in February and March. Mattson (1962) observed that it is quite probable that some do not emerge until late spring, yielding a span of four to five months when fry actively emerge from spawning gravels.

Based on field observations and scale analysis of adult returns from 1946 to 1951, Mattson (1962and 1963) reported three distinct emigration periods for Willamette Basin spring Chinook. The first downstream migration of fry occurred during the first spring and summer (soon after emergence). Although fry were noted as early as January and as late as August, peak movement occurred in April. This group was frequently the largest in numbers and constituted up to 55 percent of the year class. The second period of peak emigration occurred in late fall and early winter (October and November) and coincided with high stream flows and reduced stream temperature. This group was the second largest in numbers and constituted up to 50percent of the year class. The third and final peak movement occurred the following spring (March through

May) and constituted the smallest of the year class, with an upper magnitude of 35percent. Notably, Mattson reported presence of spring Chinook emigrants in every month of the year near Lake Oswego, indicating year-round movement into the lower river.

Dimick and Merryfield (1945) noted similar use of the mainstem Willamette River by young of the year fry nearly 20 years earlier. In the early 1940s, large numbers of fry were found from Harrisburg to Independence in February, March, and April. In 1945, many fry were collected from Corvallis to the Sellwood Bridge in Portland. Chinook fry continue to express this behavior; they pass Leaburg Dam on the McKenzie River beginning in January and are regularly observed throughout the year at Willamette Falls (Baker and Miranda 2003).

Of the emigrants observed by Mattson (1962) from 1946 to 1951, fork lengths ranged from 37 to 100 millimeters (mm) for fry and fingerling in late winter to spring; 100 to 130 mm for the late fall/early winter yearling group; and 100 to 140 mm for yearlings the second spring. Field observations showed that as larger fish moved out of the tributary reaches, smaller, newly emerged fry replaced them on rearing grounds. Based on scale analysis of returning adults, Mattson concluded that growth rates of fry and fingerling residing in the lower Willamette River (first group of emigrants) exceeded freshwater growth rates of yearling migrants that remained in their natal streams. Mattson further concluded that a small number of yearling spring migrants (the third group of emigrants) experienced superior freshwater growth in the lower Willamette. Howell et al. (1985) found similar results, noting that juveniles rearing in the lower mainstem Willamette have an accelerated growth pattern and may emigrate seaward up to two months earlier than those reared in upper Willamette Basin tributaries. The combination of these studies over a 40-year period suggests that Chinook emigrants encounter favorable environmental and feeding conditions in the lower Willamette River.

The number of yearling migrants increased proportionally with the age of returning adults (Mattson 1963), indicating that older-age adults reared in fresh water (either in natal streams or the lower Willamette River) at least a year before emigrating seaward. Conversely, fry and fingerling emigrants accounted for a higher proportion of three-year age adults. Hence, the older-age adults included larger-size and older-age juveniles, while the younger-age adults included more smaller, younger-age migrants. .

SUMMER CHINOOK

Summer-run Chinook may have populated tributaries of the Willamette River. Fisherman of the lower Willamette claimed that before 1927, a run of large salmon passed through the lower river each June.The last sizeable run of June migrants passed Willamette Falls in 1934, which notably coincided with the loss of the Clackamas River fall-run Chinook (Mattson 1963). A number of destructive activities in the 1880s and 1890s, along with poor water quality conditions in the lower Willamette River (e.g., low dissolved oxygen) in the 1920s, are believed to have significantly affected these native Chinook runs.

This summer run may have been the later part of the spring-run population; these fish averaged 25 to 30 pounds and were believed to be mostly six-year age fish. Spring Chinook and summer Chinook spawn in similar areas. However, spring-run Chinook are more abundant in upper mainstem reaches (and tributaries), while summer-Chinook are more abundant in middle and

lower mainstem reaches (Fulton 1968). This observation is consistent with the behavior of fall run Chinook that tend to spawn in lower mainstem reaches.

FALL CHINOOK

Most, if not all, fall Chinook native to the Willamette Basin populated reaches below Willamette Falls, most notably the lower Clackamas River, Sandy River, Tanner Creek, and Scappoose drainage (Hutchinson and Aney 1964). In 1945, Dimick and Merryfield reported that "At least up to fifty years ago, an annual run of salmon occurred in the Willamette River during September and October. Most of these fish that escaped the commercial fishery of the Willamette at that time spawned soon after entering the Clackamas River." The Clackamas River fall Chinook run was believed to be quite large, using the lower 18 kilometers of stream. In addition, fall Chinook formerly spawned in the mainstem Willamette River below the mouth of the Clackamas River (Fulton 1968). A number of destructive activities in the 1880s and 1890s, along with poor water quality conditions in the lower Willamette River (e.g., low dissolved oxygen), particularly during adult migrations, are believed to have significantly affected native fall-run populations. By the late 1920s and early 1930s, the native fall Chinook population was believed to have disappeared (Mattson 1963).

In 1964, fisheries managers introduced an early spawning (tule) and a last spawning (Cowlitz) fall chinook stock into streams above Willamette Falls. Currently, fall Chinook spawn and rear in the mainstem Willamette River and lower reaches of eastside tributaries (ODFW 2000a). Spawning surveys conducted from 1976 through 1988 showed 60 percent of the fall run spawning between Corvallis (river mile 132) and Coburg (river mile 175) (ODFW 2000b). Of those fish passing above the falls, 95 percent were three- and four-year olds. Adults generally spawn shortly after returning to freshwater, from mid-September through early October. Fry emerge from gravels beginning in late December, with peak emergence in mid-January. Juveniles emigrate from tributary reaches from mid-April to late June, and are believed to enter the lower Willamette River at five months of age.

STEELHEAD

Two life-history phases of steelhead are native to the Willamette Basin: anadromous steelhead and resident rainbow trout. Both life histories inhabit eastside and westside tributaries of the Willamette River Basin (Dimick and Merryfield 1945). Upstream of Willamette Falls, winter steelhead are believed to be native most predominantly to eastside tributaries and to the Tualatin River on the west side (ODFW 2000a; Fulton 1970). Small wild winter steelhead are also native to eastside tributaries below the falls, most notably the Clackamas River and Johnson Creek. Small wild runs have populated Johnson Creek since the 1950s (ODFW 2000a). Fulton reported that steelhead had spawned and reared in lower Johnson Creek before the mid-1960s, but since then had extended their distribution up to the middle section. Winter steelhead populating the Tualatin River Basin yielded an average annual run size of 500 (Hutchison and Aney 1964).

Winter steelhead enter the Willamette River from October through May (Dimick and Merryfield 1945), with peak passage above Willamette Falls in February and March (Howell et al.1985; ODFW 1990a). Willamette winter steelhead return to spawn in their fifth or sixth year. Spawning begins as early as March; however, peak spawning is believed to be greatest in April in westside tributaries and May in eastside tributaries. Resident rainbow trout spawn in March, April, and May. Juveniles generally spend two years in fresh water before smolting, with peak

juvenile emigration beginning in early April and extending through early June and larger steelhead emigrating earlier than smaller ones (ODFW 2000a).

Summer steelhead are not native to the Willamette Basin. They were introduced into several subbasins in the late 1960s, but have not substantively reproduced; natural production is low (ODFW 2000a).

COHO

Fulton (1970) noted that the Willamette River (and its tributaries) provided the third most important spawning grounds for coho salmon throughout the entire Columbia River Basin.

Coho are believed to be native only to subbasins below Willamette Falls. Although coho were not reported in the Tualatin River Basin before 1931, they were found rearing in the basin up to and including Scoggins Creek in 1945 (Dimick and Merryfield 1945). These fish were believed to be progeny of hatchery coho released in the 1920s (Fulton 1970); however, a formal hatchery program did not begin until 1952. Some populations naturalized, such as those in the Tualatin River Basin, while others did not. Coho populating the Tualatin River Basin had an average annual run size of 6,000 (Hutchinson and Aney 1964). By 1970, the Tualatin River supported the largest run of coho above Willamette Falls (Fulton 1970). Although hatchery-reared coho are no longer released into the Tualatin River Basin, remnant fish continue to persist and occupy the basin. In fall 1999, Oregon state fish biologists observed coho in the upper mainstem, near the mouth of Gales Creek (river mile 56.0 to 56.5) (Leader 2002).

Coho were similarly native to the Clackamas River and Johnson Creek (Fulton 1970) and were reported occupying tributaries to Multnomah Channel from 1951 to 1959 (Willis 1960). Coho spawned and reared throughout all of mainstem Johnson Creek; however, the best spawning areas were believed to be in the upper watershed (Fulton 1970).

Early-run coho pass Willamette Falls from late August through early November, with peak migrations in middle to late September, following periods of considerable rainfall. Coho return as three-year age adults and two-year age jacks. Peak spawning generally occurs from September through December, within days after reaching their spawning ground. Fry emerge from mid-January through April, yielding a four-month emergence period. While a small proportion of fry may emigrate during the first year, most fingerling are believed to emigrate during the second spring (as yearlings), beginning in March and extending through mid-July.

CUTTHROAT

> Coastal cutthroat had the greatest overall distribution of any of the salmonids in the Willamette River Basin, and were known to populate most streams in the basin (Hutchinson and Aney1964). Dimick and Merryfield (1945) reported that “few tributaries of the Willamette system is without cutthroat trout unless blocked by natural barriers.

Two life-history phases of cutthroat trout resided in Portland area streams: migratory and non-migratory. Non-migratory, or resident, cutthroat historically did not migrate far from upper tributary reaches (Hutchison and Aney 1964), remaining in fresh water for their entire lifespan. Migratory, or sea-run, cutthroat were believed to drop down into the mainstem Willamette River

in the spring, rear throughout the summer, then migrate to the ocean in the fall or early winter. Notably, they did not use the mainstem reaches for spawning; rather, they used them for spring, summer, fall, and early winter rearing. Sea-run cutthroat were noted to reside predominantly near tributary confluence regions with the Willamette.

In 1945, Dimick and Merryfield noted that no morphological differences were noted between the two races of cutthroat, except for differences in the size of adults. However, they noted that sea-run cutthroat spawned in January, February, and March (much like native winter steelhead), while resident cutthroat spawned in May, June, and July. Notably, sea-run cutthroat return to their natal freshwater streams (and move out of the mainstem Willamette) before juvenile Chinook emigrate seaward and use lower mainstem habitats.

Tryon Creek Subbasin

Tryon Creek Winter Steelhead

POPULATION DESCRIPTION

The life history of this population is based on other lower Willamette winter steelhead populations, notably the Clackamas and the Tualatin River populations, that took advantage of high flows and cool temperature to access upper reaches of the subbasin. Both are believed to be a late-run population returning to freshwater to spawn during their fifth and sixth year. Native, late-run winter steelhead entered the Willamette River from October through May (Dimmick 1945), with spawning beginning in March and peaking in April thru May. Steelhead spawn in cool, clear, and well-oxygenated streams with small to large gravel (1.3 to 11.4 cm) and suitable flow (0.76 meters/second) (USFWS 1983). These conditions are found in riffle-type habitats and are typical of habitat found in the upper parts of tributaries. After spawning, some steelhead will re-enter the ocean, returning to their natal stream for a second time to spawn again.

Eggs hatch and fry emerge in winter or early spring, depending on habitat, water temperature, and spawning season. After emergence, fry continue to rear in riffle-type habitats through the summer, then move into pools in the winter. Generally, steelhead become inactive in winter months, often burrowing into stream-bottom substrates and other available instream cover. Steelhead, like Chinook, rely on an abundance of instream structure for cover during overwintering months.

Juvenile steelhead generally spend two years in freshwater before smolting, with peak emigration beginning early April and extending through early June. Smoltification is initiated by a combination of environmental factors including photoperiod, water temperature, and water chemistry. Larger steelhead generally emigrate sooner than their smaller cohorts (ODFW 2000a). Marine survival is correlated with smolt size, with the critical minimum size ranging from 14 to 16 cm upon saltwater entry. Steelhead rear in the ocean for one to four years before returning to their natal streams.

RELATIONSHIP TO ESU OR OTHER POPULATION DESIGNATIONS

Tryon Subbasin winter steelhead are part of the Lower Willamette River ESU and are believed to be most closely associated with populations below Willamette Falls: Clackamas River and Johnson Creek.

HISTORICAL ABUNDANCE AND PRESENT STATUS

Winter steelhead populated Tryon Creek basin (WMSWCD 2003(d)). The upstream extent of their anadromy is not known; however based on channel geomorphology and valley hillslope, they likely spawned upto (and perhaps beyond) Marshall Cascades on mainstem Tryon Creek and perhaps upto Arnold Falls on Arnold Creek (RM 0.4).

Tryon Creek Coho

POPULATION DESCRIPTION

Life history of this population is based on similar populations in the Lower Willamette River: Clackamas River and Johnson Creek populations. Native lower Willamette basin coho return as 3-year age adults and 2-year age jacks. They are an early run population, reaching Willamette Falls from late August through early November. Peak migrations occur from middle to late September, following periods of considerable rainfall, and peak spawning generally occurs soon afterwards from September through December. Coho commonly use tributaries to lower river reaches, and spawn in small, low-gradient areas; however, they will spawn in mainstem reaches. Generally, they prefer fast-flowing waters with small to large gravel substrates (1.3 to 10.2 cm).

After eggs are deposited, they incubate for 80-150 days, often depending on stream temperatures. Fry emerge from mid-January through April, yielding a four-month emergence period. During this period they seek shallow water areas, before dispersing downstream into deeper habitats. While a small proportion of fry emigrate during the first year, most fingerling smolts emigrate during the second spring, beginning in March and extending through mid-July. Those that remain in their natal streams will migrate upstream or downstream, seeking slack water habitats often found in side channels, backwater pools, and beaver ponds. These habitats are especially important during overwintering months because they harbor insects and provide a continual source of food for coho. Yearling juvenile coho emigrate seaward in early spring, with peak migrations in April/May. Generally, coho will rear for two additional years in the ocean and return to their natal streams as three- and four-year age adults in the fall.

RELATIONSHIP TO ESU OR OTHER POPULATION DESIGNATIONS

Lower Columbia River coho salmon were listed on the state ESA in July 1999. This population was previously considered for federal listing. On July 25, 1995, NMFS determined that the listing was unwarranted; however, the population remains a “candidate” for listing on the federal ESA. Lower Columbia River coho are listed as endangered under the state ESA. The Willamette River basin, up to Willamette Falls including the Clackamas, contains major spawning and rearing habitat for this population.

HISTORICAL ABUNDANCE AND PRESENT STATUS

Willamette Basin coho are believed to be native only to subbasins below Willamette Falls, notably, the Clackamas River basin, Johnson Creek (Fulton 1971) and Tryon Creek (WMSWCD 2003d), and were reported occupying tributaries to Multnomah Channel from 1951 to 1959 (Willis 1960). Notably, the lower Willamette River basin provided the third most important spawning grounds for coho salmon, throughout the entire Columbia River basin (Fulton 1970).

In Tryon Creek adults generally occupied the lower and middle basin. The upstream extent of their anadromy is not known; however based on channel geomorphology and valley hillslopes,

they likely migrated upto the confluence of Tryon and Arnold Creek and possibly upto the bottom of Marshall Cascades, a natural fish barrier, during high water years.

Tryon Creek Cutthroat

POPULATION DESCRIPTION

In Oregon and Washington, sea-run cutthroat return home to their natal stream anytime from July through March (peaking in September through October). Generally, they migrate to reaches upstream of coho and steelhead (to avoid competition), but will reside sympatrically with resident cutthroat populations. Their preference for upstream reaches spatially segregates them from other co-occurring salmonids and avoids competition for rearing and spawning areas. Some female cutthroat do not spawn in the first winter after returning to freshwater (Johnston 1982). Rather, they overwinter in freshwater, then return to the ocean the following spring.

Cutthroat prefer small- to moderate-size gravel for spawning (depending on their body mass and size) and will optimally seek pool tail-outs. They are repeat spawners; if they survive post-spawning, they will overwinter in fresh water and emigrate downstream from early to late spring. This migration generally begins prior to smolt emigrations.

Eggs incubate for four to six weeks in the gravel. Fry emerge and immediately seek shallow stream margins, with low-velocity flow. During early life history rearing cutthroat are opportunistic feeders, feeding predominately on aquatic invertebrates suspended in the water column. If other salmonids are present, fry can be easily displaced; their distribution and habitat use is therefore highly dependent on interspecific competition with other native fishes.

Juveniles (and adults) prefer deeper pools and slower-velocity water to rear in, but display transitory behavior, moving upstream and downstream into differing habitats (e.g., pools, riffles), depending on local habitat conditions (e.g., food availability, flow, temperature) and competition.

Cutthroat smolt from age one to four (and sometimes later), but generally at age three or four, when they reach a size of 20 to 25 cm (fork length). Downstream emigrations generally occur from March to June, peaking in mid-May. A unique characteristic that cutthroat exhibit (different from other salmonids) is that they form schools before salt-water entry and remain schooled throughout their saltwater migrations and rearing.

Generally, cutthroat remain close to shore and tend to occupy shallow waters while rearing in the marine environ. Although salt-water residence time varies among populations, cutthroat tend to re-enter freshwater in the same year they migrated to sea; hence return to their natal stream during the subsequent fall season.

RELATIONSHIP TO ESU OR OTHER POPULATION DESIGNATIONS

The USFWS previously considered Southwest Washington/Columbia River coastal cutthroat trout a “candidate” species for federal ESA listing. In June 2002, the USFWS determined that the population did not warrant protection under the ESA, based on trends in population abundance and recently enacted fish and habitat protections (that included protections by the City of Portland).

HISTORICAL ABUNDANCE AND PRESENT STATUS

Sea-run cutthroat had the greatest over-all distribution of any of the salmonids in the Willamette River basin, and were known to populate most streams (Hutchinson 1964). Dimmick (1945) reported that "*few tributaries of the Willamette system is without cutthroat trout unless blocked by natural barriers*". Sea-run cutthroat and resident cutthroat likely populated Tryon Creek subbasin at least upto Marshall Cascades on mainstem Tryon Creek and Arnold Falls on Arnold Creek. Cutthroat likely populated upper reaches of Tryon Creek subbasin (above Marshall Cascades). These areas were likely accessed during high flows, which would have allowed trout to navigate through the high gradient cascade reach, by jumping from one pool to the next.

Fanno Creek Subbasin

Chinook and coho did not likely populate Fanno Creek prior to Willamette Falls fish passage improvements in the late 1800's. Only since fish passage improvements at W.F. have coho populated the Tualatin. Chinook are often documented in the Tualatin basin, but are rarely found in Fanno Creek. Although salmon and steelhead now navigate above Willamette Falls, prior to 1880 is was not known whether or not salmon were able to leap the Falls: "…it seems that any salmon in the Tualatin River were insufficient because yearly treks (*by the Kalapuya)* were made to the Falls, to the annoyance of the Clackamas tribe…" (Benson 1975). Regardless, anadromous fish numbers have declined as a result of low, warm rearing flows in the river and its tributaries:

> *"It has been reported that poor summer conditions are suspected to have been a major cause for spring Chinook salmon extinction in the drainage. Coho (silver) salmon and steelhead have maintained runs largely because the adults do not require summer residency, and a number of their progeny, either by adaptation or necessity, rear in headwater streams."*(Hutchison and Aney, 1964).

Anadromous steelhead (winter-run), and sea-run cutthroat likely populated Fanno Creek basin, and resident trout (rainbow and cutthroat) likely populated most subbasins. Sea-run and resident cutthroat likely had the greatest distribution, populating most reaches of the subbasin.

Fanno Steelhead

POPULATION DESCRIPTION

Fanno Creek steelhead were likely a late, winter-run population that took advantage of high flows and cool temperature to access upper reaches of the subbasin. The life history of this population is likely similar to other upper Willamette, late-run, winter steelhead populations. This run returns to freshwater to spawn during their fifth and sixth year. They enter the Willamette River from October through May (Dimmick 1945), with spawning beginning in March and peaking in April thru May. Steelhead spawn in cool, clear, and well-oxygenated streams with small to large gravel (1.3 to 11.4 cm) and suitable flow (0.76 meters/second) (USFWS 1983). These conditions are found in riffle-type habitats and are typical of habitat found in the upper parts of tributaries. After spawning, some steelhead will re-enter the ocean, returning to their natal stream for a second time to spawn again.

Eggs hatch and fry emerge in winter or early spring, depending on habitat, water temperature, and spawning season. After emergence, fry continue to rear in riffle-type habitats through the summer, then move into pools in the winter. Generally, steelhead become inactive in winter months, often burrowing into stream-bottom substrates and other available instream cover. Steelhead, like Chinook, rely on an abundance of instream structure for cover during overwintering months.

Juvenile steelhead generally spend two years in freshwater before smolting, with peak emigration beginning early April and extending through early June. Smoltification is initiated by a combination of environmental factors including photoperiod, water temperature, and water chemistry. Marine survival is correlated with smolt size, with the critical minimum size ranging from 14 to 16 cm upon saltwater entry. Steelhead rear in the ocean for one to four years before returning to their natal streams.

RELATIONSHIP TO ESU OR OTHER POPULATION DESIGNATIONS

Remnant Fanno Creek steelhead are part of the Upper Willamette River ESU and are believed to be most closely associated with populations above Willamette Falls: North Santiam, South Santiam and Calapooia subbasins.

HISTORICAL ABUNDANCE

Steelhead are believed to have historically populated the Tualatin River basin. In 1964, Hutchison and Aney reported that the average annual run size entering the Tualatin River was less than 500 fish. Adult steelhead were widespread and were known to spawn upto rivermile 75 (Lee Falls) and in tributaries East Dairy, Gales, and Scoggins Creek. Poor summer rearing habitat is believed to have led to the decline of this native population.

The upstream extent of winter steelhead anadromy in Fanno Creek is not known; however based on channel morphology and hillslope and valley characteristics, they likely spawned at least upto the headwater reach, just upstream of the confluence with Ivey Creek (ODFW 2002). Although adults may not have spawned above this mainstem reach, juveniles likely moved into these upper areas in the summer (to find cooler water).

Fanno Creek Coho

POPULATION DESCRIPTION

The Fanno Creek coho population did not historically navigate above Willamette Falls; however, with fish passage improvements made to the Falls in the late 1800's along with hatchery coho releases into the subbasin in the early 1900's, populations of coho salmon naturalized in different subbasins of the larger Tualatin River basin.

Life history of this population is based upon native populations in the Lower Willamette River, most notably the Clackamas River and Johnson Creek. Native lower Willamette basin coho return as 3-year age adults and 2-year age jacks. They are an early run population, reaching Willamette Falls from late August through early November. Peak migrations occur from middle to late September, following periods of considerable rainfall, and peak spawning generally occurs soon afterwards from September through December. Coho commonly use tributaries to lower river reaches, and spawn in small, low-gradient areas; however, they will spawn in

mainstem reaches. Generally, they prefer fast-flowing waters with small to large gravel substrates (1.3 to 10.2 cm).

After eggs are deposited, they incubate for 80-150 days, often depending on stream temperatures. Fry emerge from mid-January through April, yielding a four-month emergence period. During this period they seek shallow water areas, before dispersing downstream into deeper habitats. While a small proportion of fry emigrate during the first year, most fingerling smolts emigrate during the second spring, beginning in March and extending through mid-July. Those that remain in their natal streams will migrate upstream or downstream, seeking slack water habitats often found in side channels, backwater pools, and beaver ponds. These habitats are especially important during overwintering months because they harbor insects and provide a continual source of food for coho. Yearling juvenile coho emigrate seaward in early spring, with peak migrations in April/May. Generally, coho will rear for two additional years in the ocean and return to their natal streams as three- and four-year age adults in the fall.

RELATIONSHIP TO ESU OR OTHER POPULATION DESIGNATIONS

Because coho did not likely populate subbasins above Willamette Falls, the current Tualatin basin population is not part of a recognized evolutionarily significant unit (ESU), as defined by the federal ESA. However, naturalized coho in the Tualatin are believed to be closest (in genetic lineage) to Lower Columbia River coho salmon. This population was listed on the state ESA in July 1999 and was previously considered for federal listing. On July 25, 1995, NMFS determined that the listing was unwarranted; however, the population remains a "candidate" for listing on the federal ESA. Lower Columbia River coho are listed as endangered under the state ESA.

HISTORICAL ABUNDANCE AND PRESENT STATUS

Historically, the lower Willamette River basin provided the third most important spawning grounds for coho salmon, throughout the entire Columbia River basin (Fulton 1970). Although coho were not reported in the Tualatin basin, prior to 1931, they were found rearing in the basin, upto and including Scoggins Creek in 1945 (Dimmick, et.al. 1945). These coho were believed to be progeny of hatchery coho released in the 1920's (Fulton 1970). A formal hatchery program did not begin until 1952. By the early 1960's coho populating the Tualatin River basin had an average annual run size of 6,000; and were the most numerous and widespread anadromous fish in the Tualatin River basin (Hutchinson et.al. 1964); and by 1970, the Tualatin River supported the largest run of coho above Willamette Falls (Fulton 1970).

Although hatchery reared coho are no longer released into the Tualatin River basin, resident fish continue to persist and occupy the basin. In Fall 1999, state fish biologists observed coho in the upper Tualatin River mainstem, in Roaring Creek and in lower Gales Creek (Leader 2002).

Fanno Creek Cutthroat

POPULATION DESCRIPTION

In Oregon and Washington, sea-run cutthroat return home to their natal stream anytime from July through March (peaking in September through October). Generally, they migrate to reaches upstream of coho and steelhead (to avoid competition), but will reside sympatrically with resident cutthroat populations. Their preference for upstream reaches spatially segregates them from other co-occurring salmonids and avoids competition for rearing and spawning areas.

Some female cutthroat do not spawn in the first winter after returning to freshwater (Johnston 1982). Rather, they overwinter in freshwater, then return to the ocean the following spring.

Hutchison and Aney (1964) noted the following:

> *"Cutthroat trout enter the Tualatin River each winter to spawn. These fish are both sea-run and Willamette River resident forms. Runs are normally moderate. Smaller resident cutthroat occur throughout the year in most streams in the moderate to high numbers. They are most plentiful in the headwater streams possessing cool summer temperatures."*

Cutthroat prefer small- to moderate-size gravel for spawning (depending on their body mass and size) and will optimally seek pool tail-outs. They are repeat spawners; if they survive post-spawning, they will overwinter in fresh water and emigrate downstream from early to late spring. This migration generally begins prior to smolt emigrations.

Eggs incubate for four to six weeks in the gravel. Fry emerge and immediately seek shallow stream margins, with low-velocity flow. During early life history rearing cutthroat are opportunistic feeders, feeding predominately on aquatic invertebrates suspended in the water column. If other salmonids are present, fry can be easily displaced; their distribution and habitat use is therefore highly dependent on interspecific competition with other native fishes.

Juveniles (and adults) prefer deeper pools and slower-velocity water to rear in, but display transitory behavior, moving upstream and downstream into differing habitats (e.g., pools, riffles), depending on local habitat conditions (e.g., food availability, flow, temperature) and competition.

Cutthroat smolt from age one to four (and sometimes later), but generally at age three or four, when they reach a size of 20 to 25 cm (fork length). Downstream emigrations generally occur from March to June, peaking in mid-May. A unique characteristic that cutthroat exhibit (different from other salmonids) is that they form schools before salt-water entry and remain schooled throughout their saltwater migrations and rearing.

Generally, cutthroat remain close to shore and tend to occupy shallow waters while rearing in the marine environ. Although salt-water residence time varies among populations, cutthroat tend to re-enter freshwater in the same year they migrated to sea; hence return to their natal stream during the subsequent fall season.

RELATIONSHIP TO ESU OR OTHER POPULATION DESIGNATIONS

The USFWS previously considered Southwest Washington/Columbia River coastal cutthroat trout a "candidate" species for federal ESA listing. In June 2002, the USFWS determined that the population did not warrant protection under the ESA, based on trends in population abundance and recently enacted fish and habitat protections (that included protections by the City of Portland).

HISTORICAL ABUNDANCE AND PRESENT STATUS

Sea-run cutthroat had the greatest over-all distribution of any of the salmonids in the Willamette River basin, and were known to populate most stream (Hutchinson 1964). Dimmick (1945) reported that "*few tributaries of the Willamette system is without cutthroat trout unless blocked by natural barriers*".

Life History Characteristics of Salmonids

Key life history characteristics (age at maturity and spawning, egg incubation, fry emergence, juvenile rearing, and smolt emigration) and associated freshwater habitat needs (e.g., instream structure and channel form or condition) are provided below. The life history characteristics are described in general terms per species.

Spring Chinook

Spring Chinook generally inhabit larger river reaches than steelhead, and enter freshwater at age two to five in spring (April-June), during spring freshets. They tend to slowly migrate upstream and hold in deep pools, then spawn in mid- to upper reaches of their natal stream in late summer and fall (between August and November). They typically spawn in coarse gravel and cobble substrates (up to 14 cm diameter) and in pools at least 0.24 meters deep (Reiser and Bjornn 1979; Hutchison and Aney 1964). Chinook seek pool-riffle channel areas versus plane bed or step pool channels (Montgomery et al. 1999).

Eggs usually incubate for 90-150 days and emerge in March/April. Fry rear in fresh water for one to two years, and gradually move downstream to deeper waters as they grow to smolt condition.

Juvenile spring Chinook overwinter in large, deep pools and rely on instream structure such as large boulders and woody debris complexes for cover and refuge. During freshwater rearing, juveniles generally prefer bank edges of deep (greater than 0.5-m), fast flowing waters that enable opportunistic feeding (e.g., they are characterized as drift, benthic feeders that feed primarily on insects).

Juvenile spring Chinook experience an accelerated spring growth rate in early spring, smolt in April and May, then emigrate to lower river estuarine habitats before entering the ocean and beginning their northwesterly migrations. They continue to rear for an additional two to four years in the marine environ before re-entering freshwater.

Fall Chinook

Fall Chinook adults enter fresh water from late summer through fall. They rapidly swim upstream into lower mainstem river reaches and tributaries to briefly hold, and spawn between October and December.

Like spring Chinook, fall Chinook typically spawn in coarse gravel and cobble substrates (up to 14 cm diameter). They prefer to spawn in pools greater than 0.24 meters deep (Reiser and Bjornn 1979), and seek pool-riffle channel areas versus plane bed or step pool channels (Montgomery et al. 1999).

Eggs usually incubate for 90-150 days and emerge in March/April. Fall Chinook fry begin their downstream migration within several weeks of emergence, but may extend their migrations through the summer. Juvenile fall Chinook generally enter estuary environs in late winter (February) through early summer (July) (Beamer et al. 2000).

Potential Interspecific Competition among Target Species

Competition can occur among (intraspecific) and between (interspecific) salmonid populations. This characterization evaluates interspecific competition between differing species. Specifically, individuals may compete for resources (or overlap in their resource use) during varying stages of their freshwater life: adult freshwater entry, adult spawning, freshwater rearing, and smolt emigration.

Freshwater Entry (Timing)

Spring Chinook, winter steelhead, and coho enter fresh water (as adults) during different seasons of the year; timing of adult freshwater entry therefore would not overlap considerably. Specifically, spring Chinook enter fresh water in the spring, followed by coho during late summer/early fall, and finally winter steelhead from early to late winter. Cutthroat adults migrate to fresh water from fall through winter, peaking in September to October; their adult migrations may therefore temporally overlap with coho and steelhead residing in the same stream reach. Adult migrations are closely associated with freshets of high flows and optimum temperature regimes.

Spawn Timing, Location and Habitat Use

The anadromous salmonids that are being considered segregate either spatially (in terms of preferred spawning conditions and locations) or temporally (in terms of optimal spawn timing). Spring Chinook prefer upper mainstem pools (greater than 0.24 meters deep) that contain coarse gravels and cobbles, and spawn from August through November. Winter steelhead prefer small tributary and headwater reaches and seek riffle-type habitats (or pool tail-outs) that contain small- to large-sized gravels. Coho similarly prefer small mainstem reaches and tributaries and small- to large-sized gravels (often found in riffles and pool tail-outs). However, coho tend to spawn in late fall to early winter (late September to early January), while winter steelhead tend to spawn in late winter through early spring (February through May). Although coho and winter steelhead may seek and occupy similar spawning areas, their spawn timing is relatively segregated.

Cutthroat migrate to upper stream reaches, generally above Chinook, steelhead, and coho spawning grounds. It is believed that cutthroat exhibit this behavior specifically to avoid antagonistic interactions and competition for food and space. Cutthroat prefer small- to moderate-sized gravels that are often found in pool tail-outs and riffles, and spawn from late winter to early spring, similar to winter steelhead spawn timing.

Although cutthroat are believed to seek upper stream reaches, away from other salmonids, they are known to interbreed with steelhead. Hybridization between cutthroat and steelhead (especially in areas with limited carrying capacities and available habitat) may significantly affect the recovery and persistence of independent steelhead and cutthroat populations.

Freshwater Rearing and Habitat Use

Steelhead tend to occupy upper river reaches with steep gradients (headwater and tributary reaches), while Chinook tend to occupy mainstem river reaches. If steelhead and Chinook co-exist, they likely partition into available habitat. Juvenile steelhead seek rubble substrate with low water velocities and generally shallow depth (0.15 meter), while juvenile spring Chinook seek deep pools or mainstem reaches (greater than 0.5 meter deep) with fast flowing water. Although steelhead occupy riffle-type habitats more during the summer, they often migrate into pool habitats to overwinter; they therefore may co-exist with Chinook in the winter. However, steelhead seek stream-bottom areas and will often burrow into stream-bottom substrates for additional cover and refuge, while Chinook juveniles continue to occupy the water column. Both species rely heavily on instream structure, such as large boulders and trees for cover and refuge, especially during the winter.

Juvenile coho occupy slack-water habitats year-round. However, they especially seek slack-water environs, such as deep pools, backwater pools, beaver ponds, and side channels, in the winter.

Steelhead, Chinook, and coho occupy different niches in shared habitats. Coho tend to form groups in open waters and occupy space near large stones and boulders, but above the stream bottom. Conversely, steelhead seek stream-bottom areas, often burrowing into (and beneath) cobbles and stones. Additionally, coho will migrate to downstream, freshwater reaches throughout the year, seeking optimal overwintering habitat. If coho and Chinook co-occur, coho are more likely to form strong intraspecific social interactions and defend their habitats more aggressively than Chinook. As a result, Chinook juveniles may be displaced.

Cutthroat reside in isolated headwater streams with sloping stream gradient and small drainage area (generally less than 13 square km). Again, cutthroat optimally reside in stream reaches upstream of co-occurring steelhead and coho. Juvenile cutthroat prefer deep pools with low flows, but will disperse to other habitats if other salmonids are present or if local environmental conditions are suboptimal (e.g., food source, space, cover). If displaced by interspecific competition, cutthroat will often return to their preferred pool environs as winter approaches, temperatures lower, and flows displace them from faster-flowing riffles.

Of the salmonids being considered, cutthroat are most likely to interact with steelhead and coho because of similar habitat preferences, especially during the winter or when food sources are limited. Cutthroat are most likely to overlap with steelhead and rainbow distributions in the Willamette River Basin. Habitat use among the distinct populations appears to be relatively segregated, such that antagonistic competition would not exist unless stream carrying capacities are compromised and/or available habitat of suitable condition is limited. For example, although pools may be present, they may not provide critical function in terms of suitable substrate composition (small- to large-sized gravels), adequate cover (boulders, wood, vegetation) and available sources of food (invertebrate populations).

Smolt Emigration Timing

Salmonid smolts emigrate throughout the spring, with peak migrations in April and May. Coho, Chinook, steelhead and cutthroat emigrations may overlap; however, emigration timing and patterns are not believed to be antagonistic among species.

INDICATORS OF BIOLOGICAL COMMUNITIES

Fish Populations

To date, detailed data that quantify fish population abundance and distribution throughout the Portland metropolitan area are limited. In Tryon Creek and Fanno Creek, biological community structure was characterized by evaluating results from ODFW aquatic inventory surveys from 1999 through 2001. The surveys included extensive summer surveys and intensive seasonal surveys (spring, summer, and fall). The following biological parameters and relationships were evaluated from these data: index of biotic integrity (IBI), fish presence/absence data, and expanded population estimates (based on multiple pass electrofishing surveys). Where data and information gaps exist, anecdotal information and personal communications with expert professionals were considered.

From these results, salmonid populations were characterized according to four interrelated factors: abundance, productivity, spatial structure, and diversity (NMFS 2000). In the absence of robust, long-term data sets that quantify population status and trends, these parameters were only qualitatively assessed (and inferred) where feasible. Each parameter is briefly described below:

Abundance: Also referred to as population size, abundance is an important measure of a population's health and fitness at various life stages. All else being equal, small populations are at greater risk of extinction than large populations because of processes such as environmental variation, genetic variation, demographic stochasticity, and catastrophic events. Viable populations should be large enough to adapt with these processes (over a period of time) and still sustain a healthy population.

Productivity: Also referred to as population growth, productivity provides information about how well an individual population is performing (e.g., number of returning adults produced by the parent spawner) in response to its environment. A population's natural productivity should be sufficient to maintain its abundance above the viable level in the absence of hatchery fish, during poor ocean conditions, and across multiple generations.

Spatial Structure: Spatially structured populations are often referred to as metapopulations. A population's spatial structure is made up of both the geographic distribution of individuals in the population and the processes that generate that distribution (NMFS 2000) and depends on habitat quality, spatial configuration, and dynamics, as well as dispersal behaviors.

Diversity: Salmonids exhibit diverse life history traits within and among populations that significantly affect population viability and persistence. Diversity allows a species to inhabit varying environs, protects a species against short-term catastrophic loss, and provides the genetic makeup to sustain long-term environmental change. Specific traits include anadromy, morphology, fecundity, run timing, spawn timing, juvenile behavior, age

structure, size, developmental rate, ocean distributions, and molecular genetic characteristics (NMFS 2000).

BIOTIC INTEGRITY: Biotic integrity is often used to evaluate human effects on fish assemblages. Biotic integrity has been defined as the ability to support and maintain a balanced, integrated, adaptive community of organisms having a composition, diversity, and functional organization comparable with that of the natural habitats or the region (Frey 1977). A widely used indicator of fish assemblage integrity is the index of biotic integrity, or IBI (Karr et al. 1986). IBI reflects important components of an ecosystem:

- **Taxonomic richness** (number of native families and number of native species present)
- **Habitat guilds** (benthic species, native water column species, hider species, sensitive species, nester species, and proportion of tolerant individuals)
- **Trophic guilds** (percent filter-feeding individuals and percent omnivores)
- **individual health and abundance** (percent of target species and percent of individuals with anomalies)

Fish survey data are queried to make up the IBI rankings and subsequent scores. In addition to absolute IBI scores and what they imply (in terms of biotic integrity), fish presence/absence data can be evaluated to determine relative water quality conditions, based on individual families' tolerance for silty, warm, polluted waters. In general, salmonids tend to be sensitive to water quality condition, while non-native species tend to be more opportunistic and tolerant of degraded water quality.

IBI scores were evaluated to consider biotic health in Tryon and Fanno Creeks. Streams with scores less than or equal to 50 are considered severely impaired; streams with scores of 51-74 are considered acceptable; and streams with scores greater than or equal to 75 are considered acceptable. In addition to the composite score, fish assemblages were evaluated to determine relative proportions of community dominance and makeup, based on sensitive, intermediate, and tolerant species.

Macroinvertebrate Production

Presence, abundance, and diversity of macroinvertebrate communities provide an integrated assessment of general stream conditions, including the physical, chemical, and biological conditions. Maintaining a healthy nutrient bank instream is critical to a population's ability to survive and reproduce. Macroinvertebrates provide a direct food source to salmonids; it is important to have the building blocks (dead and dying organic matter, salmonid carcass, etc.) present instream to attract and retain these aquatic insects. It is imperative to have an appropriate nutrient balance that includes both physical and chemical sources. This gives young fry and juveniles the sustenance (and growth development) needed to successfully emigrate downstream, fend off predators, and survive in the marine environ.

Water quality and nutrient loads are major considerations in Tryon Creek and Fanno Creek. Because Ephemeroptera-Plecoptera-Trichoptera (EPT) taxa are sensitive to water pollution, their presence and taxa richness can be used as biological indicators of poor water quality and pollution, and general stream health (e.g., sedimentation). The number or proportion of EPT taxa would be expected to decrease as environmental disturbances increase. Past studies of the

lower Willamette Basin showed that aquatic and terrestrial insects such as mayflies, stoneflies, caddis flies, midges, blackflies, and crayfish were important instream organisms in the diets of Chinook, steelhead, rainbow, and cutthroat trout (Dimick and Merryfield 1945). Generally, the field investigations surmised that the scarcity of fish in species and numbers from the mouth of the Yamhill River downstream to the Sellwood Bridge could be the result of food depletion in amount and kinds, resulting from the effects of pollution in that area.

Metrics for Macroinvertebrate Production

EPT evaluations were used to evaluate macroinvertebrate species richness and abundance.