APPENDIX A

ESU STRATA— ECOLOGICAL ZONE AND LIFE-HISTORY TYPE

The high degree of local adaptation exhibited by Pacific salmon is thought to be the product of their homing fidelity and the ecological diversity found in the Pacific Northwest. The life-history strategies exhibited by salmonids may reflect adaptations to specific freshwater environments. In the Willamette-Lower Columbia (WLC) recovery domain, there are (Table A.1):

- three major life-history types that are generally recognized for chinook salmon—spring run, fall run, and late-fall run;
- two types for steelhead—winter run and summer run; and
- one for chum salmon—fall run.

The WLC Technical Recovery Team (TRT) felt that each of these life-history strategies

Table A.1 Estimated number of populations in different strata in the WLC domain.

ESU	Ecological Zone[a]	Run Timing[a]	Historical Populations[b]
Lower Columbia chinook salmon	Coast Range	Fall	7
	Cascade	Fall	9
		Late fall	2
		Spring	7
	Columbia Gorge	Fall	4
		Spring	2
Lower Columbia steelhead	Cascade	Summer	4
		Winter	14
	Columbia Gorge	Summer	2
		Winter	3
Columbia chum salmon	Coast Range	Fall	7
	Cascade	Fall	7
	Columbia Gorge	Fall	2
Upper Willamette chinook salmon	Willamette	Spring	7
Upper Willamette steelhead	Willamette	Winter	4
Total			82

[a] Each ecological zone and run timing combination is a separate stratum.

[b] The historical number of populations is based on Myers et al. (2002).

represented a substantial portion of the evolutionary legacy of the evolutionarily significant unit (ESU). Furthermore, there was concern that this subdivision of the ESUs still did not capture the essential diversity elements. For example, fall-run chinook salmon in the short, rainfall-influenced coastal tributaries were distinct from those in the large, snowmelt-influenced tributaries along the Cascade Crest, or the shorter tributaries in the rain shadow of the Cascade Crest. The concept of life-history/ecological strata was developed to describe this important level of between-population life-history diversity.

There are a number of methods of classifying freshwater, terrestrial, and climatic regions. Physiogeographic provinces were described from Washington and Oregon by Baldwin (1964), Fenneman (1931), and Easterbrook and Rahm (1970). Franklin and Dyrness (1973) identified natural vegetation zones in Oregon and Washington. The U.S. Environmental Protection Agency (EPA) has established a system of ecoregion designations based on soil content, topography, climate, potential vegetation, and land use (Omernik 1987). These ecoregions are similar to the physiographic provinces identified by the Pacific Northwest River Basins Commission (PNRBC 1969) for the Pacific Northwest. Furthermore, the National Marine Fisheries Service (NMFS) coastwide status reviews found a high correspondence between life-history trait distribution and Level III EPA ecoregions for coho salmon (Weitkamp et al. 1995), steelhead (Busby et al. 1996), chum salmon (Johnson et al. 1997), and chinook salmon (Myers et al. 1998). Additionally, Waples et al. 2001 indicated a high degree of correlation among ecology (as defined by modified ecoregions), life history, and biochemical genetics for Pacific salmonids. The TRT concluded that the EPA Level III ecoregions provided a useful measure of appropriate scale to characterize ecological diversity within the ESUs. However, the EPA ecoregions do correspond exactly to how salmon experience the environment. For example, all chinook in the Upper Willamette ESU use both the Willamette Valley and the Cascade EPA ecoregions, and it seemed reasonable, from a fish perspective, to identify a new ecological unit encompassing the eastern Willamette Basin above Willamette Falls. To avoid confusion with the EPA ecoregions, the TRT initiated the term ecological zone to describe the modified EPA ecoregions. Using the ecological zone as a reference, in combination with an understanding of the ecological features relevant to salmon, the WLC-TRT designated four ecological areas in the domain: (1) Coast Range zone, (2) Cascade zone, (3) Columbia Gorge zone, and (4) Willamette zone. The boundaries of these regions are shown in Figure A.1.

Another advantage of the ecological zone concept is that it provides geographic structure to the ESU. Maintaining each life-history type across the ecological zones reduces the probability of shared catastrophic risks. Additionally, ecological differences among zones reduce the impact of climate events across the entire ESU. The inclusion of a biologically based ESU substructure into possible recovery scenarios buffers the ESU against uniform declines.

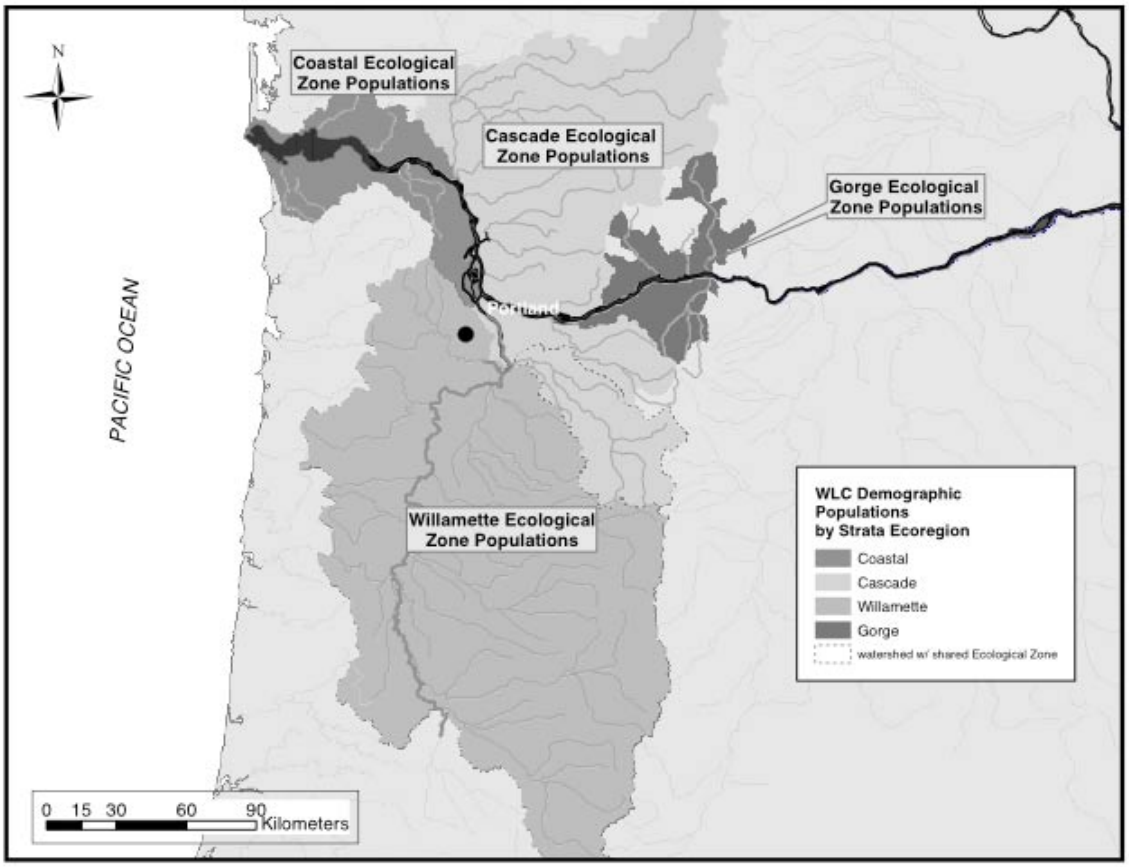

Figure A.1 Ecological zones within the WLC recovery domain. Ecological zones are based on EPA Level III ecoregions and NMFS ESU boundaries. Note that the Clackamas River Basin is shared by the Willamette and Cascade ecological zones.

Ecological Zones

The **Coast Range ecological zone** commences at the mouth of the Columbia River and extends upstream to the mouth of the Cowlitz River in Washington and to the mouth of the Willamette in Oregon (Figure A.1). In Washington these basins drain the Willapa Hills. The climate is dominated by moist Pacific marine air, with wet and mild winters and cool dry summers. Average annual precipitation is 200 to 240 cm, with approximately 80% occurring as rain between October and March. Streamflow is dependent on rainfall since drainage elevations do not exceed 500 m. River flows peak in December and January as a result of winter rainstorms. There is very little precipitation in July or August and corresponding flows are at the lowest with the highest water temperatures occurring in August. These rivers are especially prone to low flow during periods of drought. This region was originally forested with Sitka spruce, western hemlock, Douglas fir, and western red cedar.

The **Cascade ecological zone** extends from the mouth of the Cowlitz and Willamette Rivers to the Washougal and Sandy Rivers. Basin topography is dominated by the volcanic peaks of Mount Rainer, Mount St. Helens, Mount Adams, and Mount Hood, with each peak above 3,000 m. The lower portions of these basins pass through the Puget Lowland or Willamette ecoregion. At lower elevations, climate is similar to the Coast Range ecoregion, with wet mild winters and cool dry summers. Precipitation varies from 114 to 381 cm annually and generally occurs between October and March. Much of the precipitation above 1,000 m occurs as snow. In higher elevation basins, snowmelt adds to the surface runoff and provides a secondary peak in flow during the spring. Vegetation is similar to the Coast Range, except at higher elevations, where Pacific silver fir, noble fir, subalpine fir, mountain hemlock, and lodgepole pine occur.

The **Columbia Gorge ecological zone** encompasses the Columbia River Gorge, which extends from the mouth of the Sandy and Washougal Rivers to the Hood and White Salmon Rivers. The drainages in this region consist of short, steep streams that often limit anadromous passage to less than 1.6 km in smaller creeks. In larger systems, falls in the lower rivers often limit passage of salmon and steelhead. The climate and vegetation in this area are transitional between the high rain/snowfall area of the Cascades and the drier Columbia Plateau to the east. Stream flow is low in the summer except for larger basins influenced by snowmelt. Rivers in the Cascade and Gorge ecoregions are subject to catastrophic risks due to volcanic eruptions, such as occurred at Mount St. Helens in 1980.

The basins in the **Willamette ecological zone** occur in the Willamette Valley and Cascade ecoregions. In general this is an extension of the Cascade zone (Lower Columbia River ESUs), although it also includes presumptive populations that may have existed on the western slope of the Coast Range. The higher elevation portions of the Clackamas, Santiam, McKenzie, and Upper Willamette Rivers drain the Cascade ecoregion, which is described above. The remainder of the streams in the Willamette Valley occur in the Willamette Valley ecoregion. This ecoregion sits in a rain shadow, and annual precipitation is less than 120 cm. River flows peak in December and January, and low flows occur in August and September. Willamette Falls, at RM 42, was a natural barrier at low flow and only allowed for fish passage in the winter and spring for spring chinook and winter steelhead.

Life-History Types

Spring-run chinook salmon enter the Columbia in March and April, well in advance of their spawning time in August or September. Freshwater entry coincided with higher-than-average discharge in snowmelt rivers. Downstream migrant sampling suggests these fish migrate as subyearlings but enter the Columbia River later in the year than fall chinook.

Fall chinook salmon are divided into tule and bright populations. **Tule fall-run chinook salmon** spawn in all Lower Columbia River tributaries. Adults enter freshwater from August to October, with peak spawning in October. When tule fall Chinook enter freshwater, they are in their spawning colors.

Bright fall-run chinook salmon are present in the Lewis and Sandy Rivers. These fall chinook enter the Columbia River from September through January, with peak entry in October. Spawning time is protracted and fish have been observed spawning through the winter in the Lewis River. Current distribution of these fish is limited to the Lewis and Sandy basins.

Winter steelhead are present in most Lower Columbia River tributaries. These fish enter the Columbia River from November to May as mature fish. Spawning occurs from February through June with peak spawning in late April or early May.

Summer steelhead are present in the Kalama, Lewis, Washougal, Wind, and Hood Rivers. They enter freshwater as immature adults between March and October. All native summer steelhead in these basins historically occupied habitat above barrier falls, which excluded other salmon species.

Chum salmon spawn in most Columbia River tributaries from the mouth to Celilo Falls. Presently, chum salmon return to freshwater from October through December. Historic catch data indicate that chum salmon were occasionally caught in August. These may have been the early portion of the large fall run, or they may have been summer chum salmon.

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