Lower Columbia River Coho Status and Risk Assessment:
Oregon Populations

With a Review of Compliance with Oregon Rules and Regulations under the State of Oregon Endangered Species Act

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Introduction

The Oregon Fish and Wildlife Commission (OFWC) listed lower Columbia River wild coho salmon under the State Endangered Species Act (State ESA) as an Oregon endangered species in July 1999. A federal Endangered Species Act (ESA) listing followed in 2005. An Oregon State Endangered Species Management Plan for Lower Columbia Coho was adopted by the Oregon Fish and Wildlife Commission in 2001 (ODFW, 2001 (Appendix 1); OAR 635-100-0190 though 0194 and 0135 (Appendix 2)). This management plan is currently undergoing a scheduled five-year review and amendments to the plan may be adopted in late 2006. The following information is consistent with the 2001 management plan.

Distribution

The Oregon State Endangered Species Management Plan for Lower Columbia Coho identified six wild populations in the lower Columbia Basin, from the mouth of the Columbia to Hood River, excluding the area above Willamette Falls. The population boundaries, as defined by Oregon Administrative Rule (OAR) 635-100-0194, are as follows (also presented in Figure 1):

(a) **The Astoria population** occurs in Youngs Bay tributaries and all Columbia tributaries upstream to and including Gnat Creek.

(b) **The Clatskanie population** occurs in Columbia River tributaries upstream of Gnat Creek to and including the Clatskanie River basin.

(c) **The Scappoose population** occurs in Columbia River tributaries upstream of the Clatskanie River to the mouth of the Willamette River.

(d) **The Clackamas population** occurs in the Clackamas River basin plus tributaries to the Willamette River downstream of Willamette Falls.

(e) **The Sandy population** occurs in the Sandy basin plus Columbia River tributaries downstream to the mouth of the Willamette River.

(f) **The Bonneville population** occurs in Columbia River tributaries upstream of the Sandy River to and including the Hood River basin.

All unmarked coho, regardless of origin, entering the geographic boundaries defined for these populations are considered listed and protected under the State ESA.

The Sandy and Clackamas populations have been continuously present in their historic ranges since historic times and have been monitored since the late 1950s. Most of the fish currently in these populations reside above Marmot Dam (an estimated 95% of the Sandy population) and North Fork Dam (an estimated 65% of the Clackamas population).

All other historic habitats in Oregon's portion of the Lower Columbia ESU may have experienced local extinctions, particularly since mid-1980s. Some habitat blockages, including the Bull Run dam complex in the Sandy Basin and hatchery structures on several small tributaries of the lower Columbia (including Eagle Creek, Gnat Creek and Big Creek) have blocked access to historic habitat. The Oregon Endangered Species Management Plan requires that adequate fish passage be implemented at all state facilities (OAR 635-100-0135; ORS 498.351 and ORS 509.605). We consider most habitats outside of the upper Clackamas and upper Sandy to be undergoing recolonization.

Population Distribution and Structure delisting criteria: The delisting criteria under Oregon's recovery plan (OAR 635-100-0194 (3)(a)) requires that self-sustaining populations be present in the Clackamas and Sandy and in at least two of the other four populations.

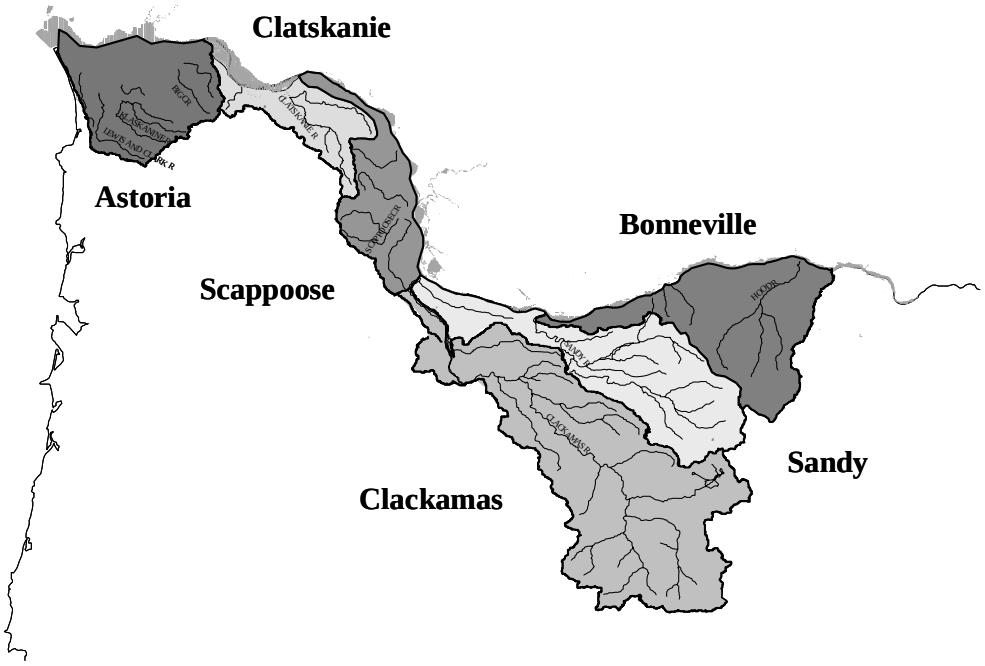

Figure 1. Oregon wild coho populations, as defined by the Oregon State Endangered Species Management Plan (2001) and OAR 635-100-0194.

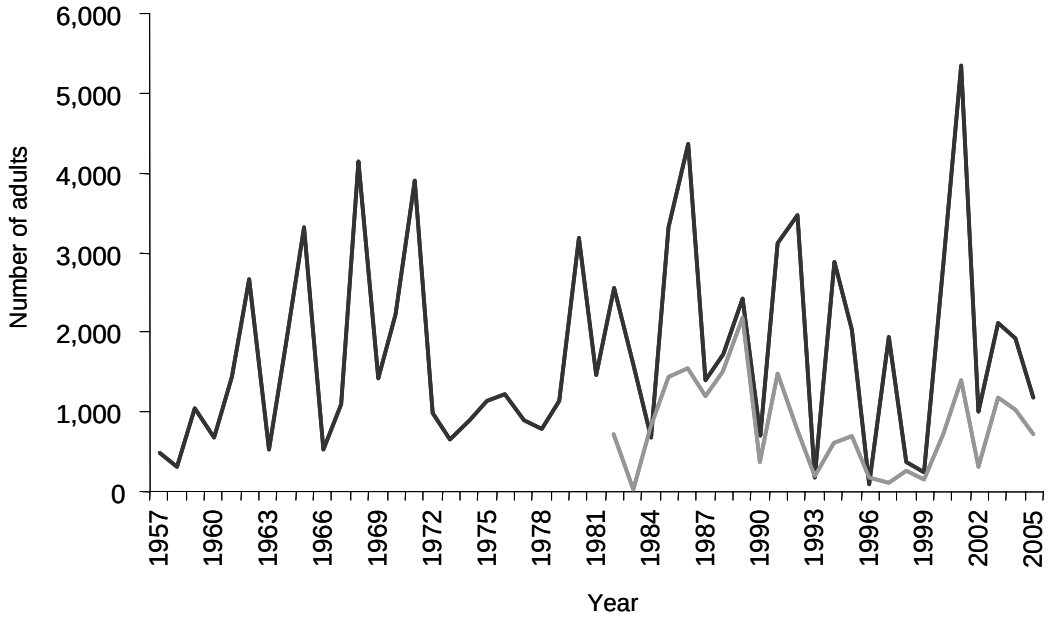

Figure 2. Abundance of wild Coho salmon in the Clackamas River (black line) and Sandy River (grey line).

Abundance

The annual abundances of lower Columbia River coho populations in Oregon are provided in Tables 1, 2 and 3 and Figure 2. Clackamas and Sandy population abundances are based on counts at North Fork and Marmot dams. Abundances for the smaller Oregon basins and for the areas in the Clackamas and Sandy populations that are not covered by the dam counts are based on spawning ground counts and expansions.

The Clackamas population reached a low abundance of 89 fish in 1996, while the Sandy population reached a low abundance of 116 fish in 1997. Both abundance levels were considered to be critically low, particularly since most other historic coho habitat in Oregon may have been vacant during these years. Since 2000, the Clackamas population ranged from 1,137 to 5,528 fish and the Sandy population ranged from 311 to 1,396 fish. Monitoring of Oregon's other four populations began in 2000. Since that year, the populations have ranged from 0 to 590 fish, depending on year and location.

The Sandy and Clackamas populations follow a consistent three-year cycle by cohort. The three cohorts in both basins have significantly different demographics (Tables 4 and 5). The cohort that returned in 2005 historically has been the weakest cohort. Given this consideration 2005 abundances for both basins were considerably improved over those seen for this cohort in the 1990s (including 1990, 1993, 1996, 1999, 2002), yet abundances in 2005 were lower than the 2004 return, which was a stronger cohort. The 2006 cohort is also one of the stronger cohorts.

Abundance delisting criteria: The delisting criteria under Oregon's recovery plan (OAR 635-100-0194 (3)(c)) requires that the number of wild spawners be at least 50% of the level necessary to produce maximum smolt recruits (full seeding) for the Sandy, Clackamas, and in at least two of the other four populations for at least three consecutive years. Full seeding abundance for the Clackamas and Sandy are defined as 3,800 spawners in the Clackmas (50% = 1,900 fish) and 1,340 spawners in the Sandy (50% = 650) (OAR 635-100-0190 (2)(c)(A) and (B)). Full seeding has not been defined for the other four populations.

Table 1. Abundance of wild Clackamas coho, 1957-2005.

Year	Adult count	Jack count	Total count
1957	484	114	598
1958	309	213	522
1959	1,046	284	1,330
1960	670	1,515	2,185
1961	1,449	740	2,189
1962	2,665	454	3,119
1963	513	1,366	1,879
1964	1,879	597	2,476
1965	3,312	625	3,937
1966	527	250	777
1967	1,096	402	1,498
1968	4,154	542	4,696
1969	1,420	434	1,854
1970	2,220	531	2,751
1971	3,912	183	4,095
1972	978	116	1,094
1973	644	96	740
1974	901	36	937
1975	1,133	56	1,189
1976	1,215	19	1,234
1977	893	49	942
1978	790	57	847
1979	1,138	47	1,185
1980	3,192	50	3,242
1981	1,469	112	1,581
1982	2,543	405	2,948
1983	1,599	78	1,677
1984	683	83	766
1985	3,314	592	3,906
1986	4,373	214	4,587
1987	1,402	318	1,720
1988	1,714	210	1,924
1989	2,413	231	2,644
1990	709	162	871
1991	3,123	317	3,440
1992	3,476	210	3,686
1993	168	31	199
1994	2,873	54	2,927
1995	2,036	69	2,105
1996	88	1	89
1997	1,935	37	1,972
1998	367	15	382
1999	238	61	299
2000	2,833	146	2,979
2001	5,344	184	5,528
2002	998	139	1,137
2003	2,117	194	2,311
2004	1,915	124	2,039
2005	1,168	152	1,320

Table 2. Abundance of wild Sandy coho, 1957-2005. No data are available for some years.

Year	Adult count	Jack count	Total count
1957			264
1958			330
1959			68
1960			1670
1961			1733
1962			1458
1963			2199
1964			1126
1965			1018
1966	162	67	229
1967	386	283	669
1968	841	440	1281
1969	411	305	716
1970			
1971			
1972			
1973			
1974			
1975			
1976			
1977			283
1978			426
1979			682
1980			635
1981			620
1982	722	20	742
1983	26	34	60
1984	798	8	806
1985	1445	27	1472
1986	1546	48	1594
1987	1205	198	1403
1988	1506	84	1590
1989	2182	113	2295
1990	376	80	456
1991	1491	1	1492
1992	790	55	845
1993	193	27	220
1994	601	47	648
1995	697	19	716
1996	181	0	181
1997	116	0	116
1998	261	0	261
1999	162	19	181
2000	730	12	742
2001	1388	8	1396
2002	310	1	311
2003	1173	26	1199
2004	1025	7	1032
2005	715	28	743

Table 3. Recent abundance of wild coho in other Oregon population areas, 1999 - 2005.

Year	Astoria area	Clatskanie	Scappoose	Gorge and Hood
1999	0	0	0	12
2000	285	66	0	10
2001	171	131	360	20
2002	334	93	452	178
2003	299	590	312	304
2004	377	318	763	415
2005	62	479	310	400

Table 4. Demographic of the Clackamas Population cohorts showing significant differences between cohorts. Average values by cohort from 1958 – 2004 are shown.

Measure	**Red Cohort**	**Green Cohort**	**Blue Cohort**
Adult Count	**2,600**	**1,900**	**767**
	Red > Green > Blue		
Smolt Count	**96,600**	**78.293**	**55,208**
	Red = Green > Blue		
Smolts/Parent	**41.59**	**53.10**	**88.74**
	Red = Green < Blue		
Smolt-to-Adult Survival	**4.03%**	**3.04%**	**1.08%**
	Red = Green > Blue		
Adults/Parent	**2.11**	**1.43**	**1.40**
	Red = Green = Blue		

Table 5. Comparative demographic data for the Sandy population demonstrating similar patterns as the Clackamas. Average values by cohort from 1977 – 2004 are shown. Smolt data are not available for the Sandy, therefore fewer demographic measures can be made.

Measure		**Red Cohort**	**Green Cohort**	**Blue Cohort**
Adult Count	**Clackamas**	**2,600**	**1,900**	**767**
	Sandy	**990**	**906**	**568**
		Red =/> **Green** > **Blue**		
Adults/ Parent	**Clackamas**	**2.11**	**1.43**	**1.40**
	Sandy	**1.49**	**1.83**	**1.60**
		Red = **Green** = **Blue**		

Productivity

One initial hypothesis for the demographic differences between cohorts in the Clackamas and Sandy coho populations was that different underlying freshwater productivities occur by cohort. This hypothesis was investigated by comparing the recruits/spawner for each cohort (Tables 4 and 5, also Figure 3). In the Clackamas population, the cohort with the chronically lower spawner abundance had a significantly higher smolt recruits/spawner than the two stronger cohorts (Table 4), which would be predicted by a condition of lower spawner abundance and similar productivities. However, in both the Sandy and Clackamas, the adult recruits/spawner are the same for all three cohorts (Tables 4 and 5) indicating that the relatively strong smolt productivity response of the weak cohort is lost sometime between smolt out-migration and adult returns. This is also demonstrated by the significantly lower smolt-to-adult survivals observed for the weak cohort in the Clackamas (Table 4), which suggests that the weakness is caused by chronic low smolt-to-adult survivals in one cohort, but not in the other two. In the Clackamas, all three cohorts significantly fit together on the same smolt productivity curves (Figure 3). At this time, we cannot resolve the cause of the weak cohorts in the Sandy and Clackamas. However, we conclude that it is appropriate to conduct productivity analyses on the entire populations.

The productivities of the Sandy and Clackamas coho populations were analyzed by Ricker and Beverton/Holt spawner/recruit models. These spawner/recruit models produce measurements of basin capacities or number of recruits produced (S_{max} and R_{max}) and measurements of underlying productivities at low spawner densities (Recruits/spawner (R/S) at low spawner densities). Since these productivity functions may vary over time, and long data sets are available for these populations, particularly for the Clackamas, the models were based on a sequence of running twenty-year spawner and adult recruit data sets, producing a series of S_{max}, R_{max} and R/S over time for each population. So for example in the Clackamas, the first models used data from brood years 1957 through 1977, the second models used data from brood years 1958 through 1978, and so on through recent years. This approach probably produces a better demonstration of the productivities of these populations over recent time than would a single point estimate of the parameters calculated from the total data sets. For both populations, spawners were counted as the number of wild coho passing the dams in the basins, while recruits were the number of wild pre-harvest adult recruits produced, reconstructed from published records of harvests.

The results are presented in Figures 4 and 5. Figure 4 plots R_{max}, the maximum number of recruits produced by the populations, as calculated from the Ricker and Beverton/Holt β parameters, and S_{max}, the maximum capacity for spawners as calculated by the Ricker β parameter, both as they occurred over time in the populations. The Clackamas productivity parameters appear to have increased for a period of time in the 1970s and 1980s, then declined to levels observed earlier. A similar time scale is not available for the Sandy, but the Sandy capacity parameters were consistently lower than the Clackamas in the years for which comparable results are available. The number of adult recruits/spawner at low densities also increased in the Clackamas in the 1960s and early 1970s, according to the Beverton/Holt models, but this response was not observed in the Ricker models (Figure 5). Both models indicate that R/S was depressed in the later 1970s and 1980s compared to other years. The Sandy appears to have had similar adult recruits/spawner in years for which comparable results were available.

The productivity analyses for both populations indicate that the populations would be capable of replacing themselves (R/S >1), if adult escapement through harvests were sufficient to allow adequate spawner escapements.

Data are insufficient to do a productivity analysis on the other four Oregon wild coho populations. We believe, however, that some of these populations may have experienced complete recruitment failure in some years since the early 1990s. We consider these populations to be in a recolonization phase, and expect that at least some natural spawners may be hatchery fish that may have depressed reproductive success in natural environments. Therefore productivities, and in particular adult recruits/spawner, are thought to be low for these populations.

Productivity delisting criteria: The delisting criteria under Oregon's recovery plan (OAR 635-100-0194 (3)) does not specify a productivity delisting criteria. Instead, the criteria requires that the probability of extinction in 36 years be less than 5% for the

Sandy and Clackamas populations plus two of the other four populations (OAR 635-100-0194(3)(e)).

Extinction probabilities can be calculated from an analysis that incorporates the results from a productivity analysis. Figures 6, 7 and 8 present examples of conservation curves for the Clackamas and Sandy coho populations developed using a model developed by NOAA's Inland TRT. The example curves are based on an underlying Beverton/Holt productivity function. These curves provide contours that represent some probability that the population would become extinct in the next 100 years, provided the α and β functions from the Beverton/Holt analysis actually occurred for a 100 year time frame. In these graphs, the α and β functions are represented by R/S (R/S at low densities) and R (R_{max}). The extinction probability contours shown are for 100% (lower left), 5% (center) and 0% (upper right) extinction probabilities. The width of the contours (the distance between 100%, 5% and 0% contour lines) is determined by the underlying variability in the population's productivities. Variation is much higher in the Sandy population than in the Clackamas population.

One problem with extinction probability analyses as they have been applied to date, regardless of which model is used to produce the curves (and several are being used across the region), is that it is difficult to compare a real population status to the curve. The curves are based on two important assumptions:

a) That the α and β functions represent "real" productivity parameters for the population (R/S at low densities and R_{max} in this example); and

b) That these productivity parameters do not vary over a 100 year time frame. Variation is captured if multiple iterations are used to calculate the point estimates and can be visually observed in the distance between the contour lines. That is, if one enters the same parameters three times one would calculate three different extinction probabilities for those parameters, with the variance between them based on the variance in the productivities. But each point estimate is based on the assumptions that the value produced in any single iteration is held constant over a 100 year time frame.

These assumptions are not true for real populations. Actual populations have "real" observed R/S and R (as opposed to the modeled R/S at low densities and R_{max}), and the real, observed values vary widely from year-to-year (data points for real annual data are plotted in Figures 6, 7 and 8). The significant differences between cohorts in Oregon's Lower Columbia River Coho populations contribute substantially to this annual variation (Figure 8). Even the modeled productivity parameters vary over time (Figures 4 and 5), and they probably provide optimistic values of R/S at low densities, particularly when produced from Beverton/Holt analyses.

However, the curves may still have utility. They may provide some guidance that population viability would be highest if, in most years, populations had values of observed R and R/S that fell into the upper right quadrant of the plots. Over the years for which data are available (23 years on the Sandy and 43 years on the Clackamas), the

Sandy population was in the 0% extinction probability zone only once (4% of the time), but was in the 100% probability zone 14 times (58% of the time). The Clackamas population was in the 0% probability zone 13 times (30% of the time) but in the 100% probability zone 22 times (51% of the time) (Figures 6 and 7). This pattern suggests that the Sandy and Clackamas populations have been under conditions that have a relatively high extinction probability.

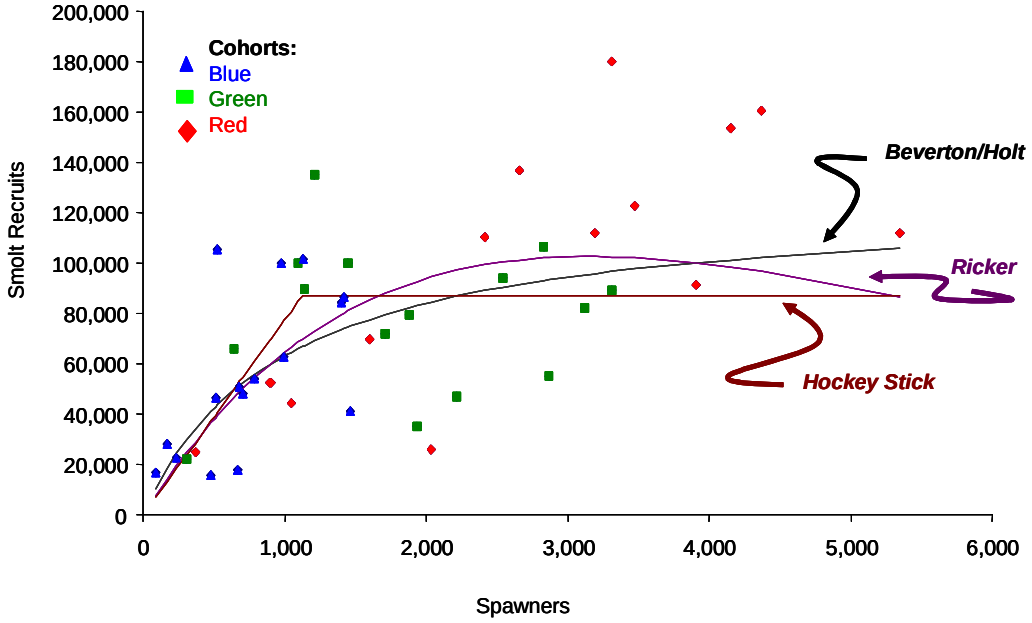

Figure 3. Productivity functions (Beverton-Holt, Ricker and Hockey Stick models) for Clackamas coho, calculated for smolt recruits. Data for the three cohorts are indicated by triangles, squares and diamonds. Although the cohorts are demographically different, their underlying smolt productivities fit the same function, as predicted by differences in spawner abundances.

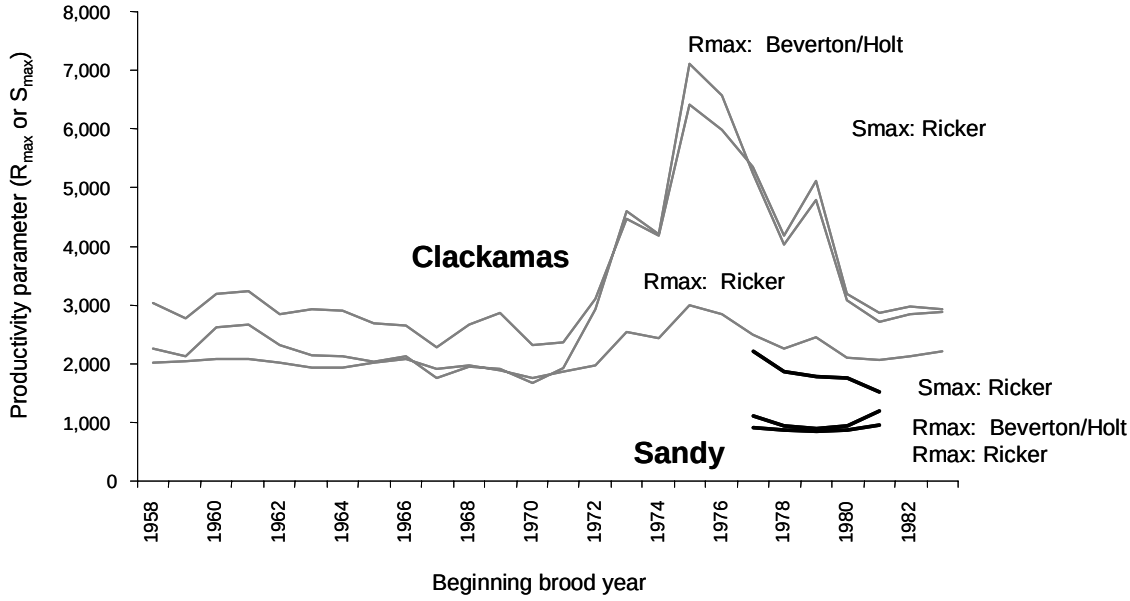

Figure 4. Sequential twenty year running calculations of capacity productivity parameters (R_{max} and S_{max}) for the Clackamas and Sandy coho populations calculated from Beverton/Holt and Ricker productivity models, demonstrating a persistent lower capacity in the Sandy.

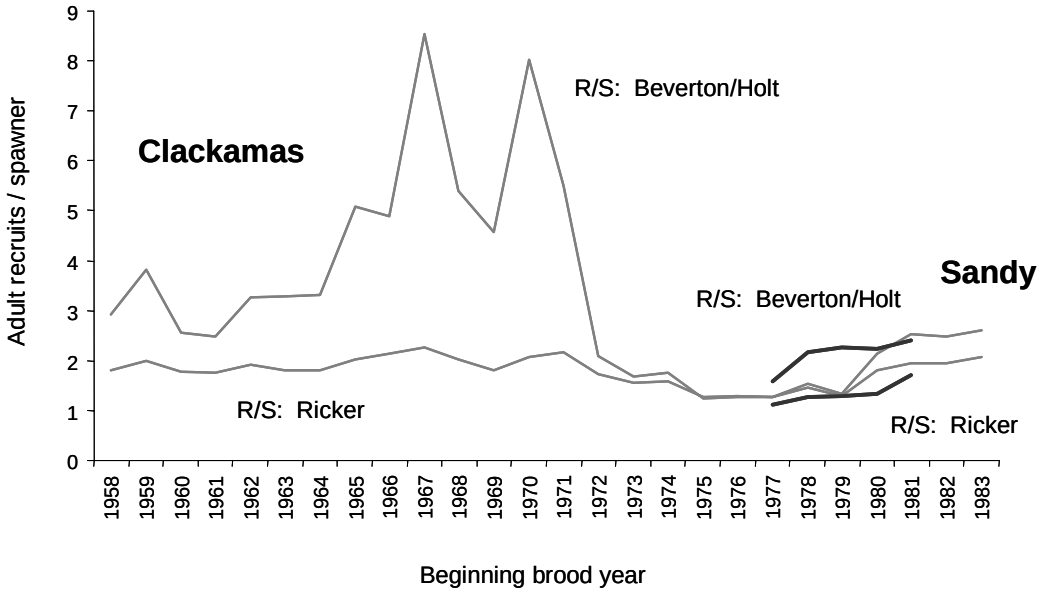

Figure 5. Sequential twenty year running calculations of productivity parameters (recruits/spawner at low densities) for the Clackamas and Sandy coho populations calculated from Beverton/Holt and Ricker productivity models. Over the years that Sandy data are available, the Clackamas and Sandy demonstrated similar productivities at low densities.

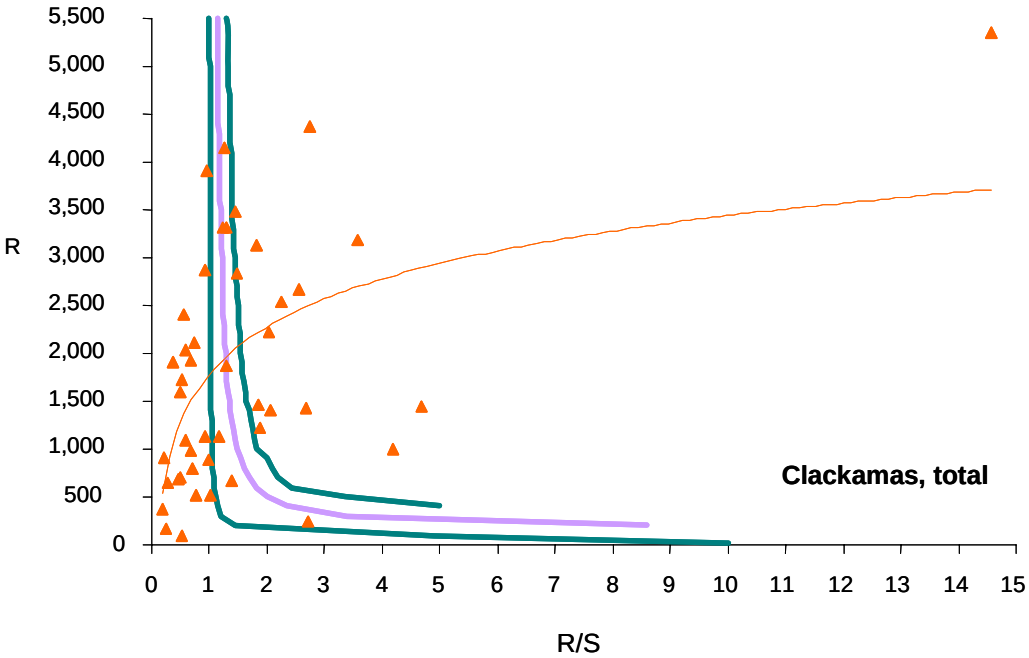

Figure 6. A persistence probability curve for the Clackamas coho, developed using a program provided by NOAA's Inland TRT using a Beverton/Holt function. The actual annual data for the Clackamas is also plotted.

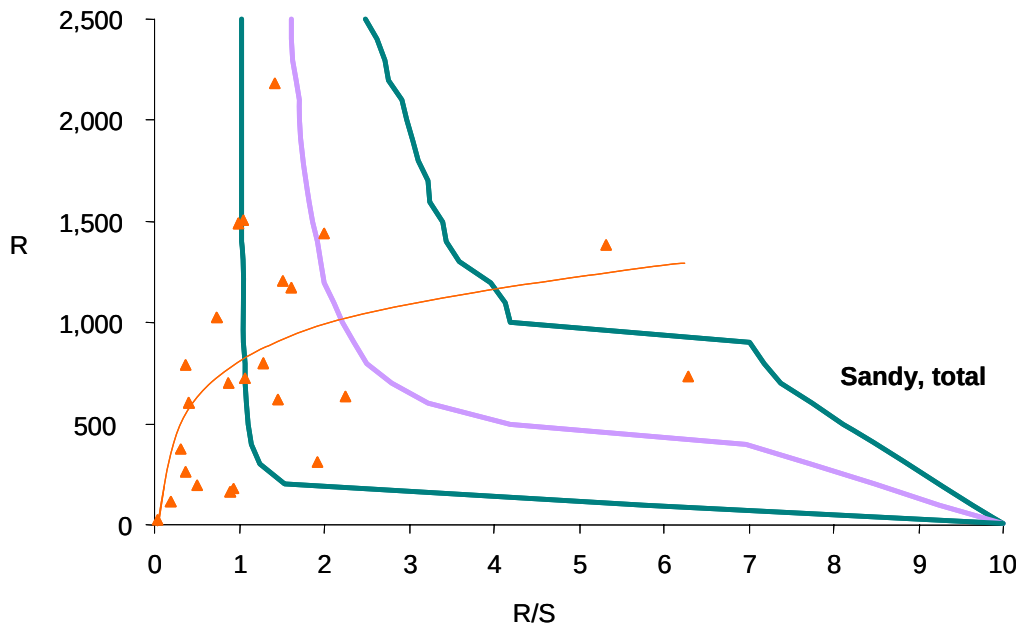

Figure 7. A persistence probability curve for the Sandy coho, developed using a program provided by NOAA's Inland TRT using a Beverton/Holt function. The actual annual data for the Sandy is also plotted.

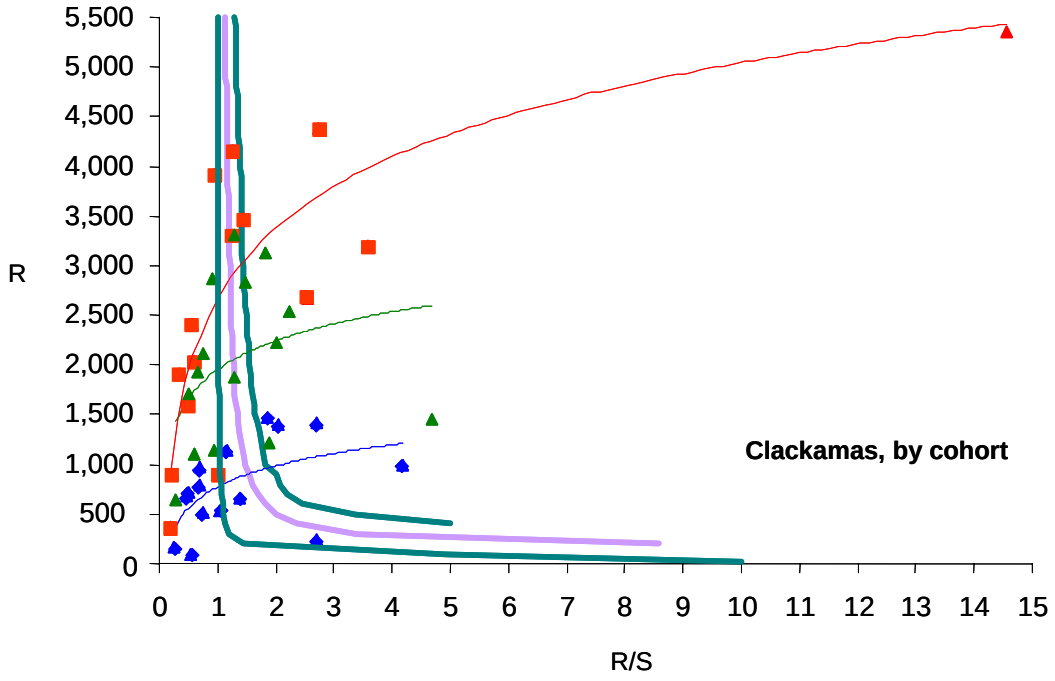

Figure 8. A persistence probability curve for the Clackamas coho, developed using a program provided by NOAA's Inland TRT using a Beverton/Holt function. The actual annual data for the Clackamas, identified by cohort, is also plotted.

Diversity

Diversity across the listed ESU was assessed three ways. The Lower Columbia River Coho ESU faces challenges across all three diversity measures.

a) **Are natural populations present in most historic population areas**, and are they distributed across the diversity of habitats in the historic landscape?

The historic population distribution of coho in the Columbia River Basin has been severely modified by the total extinction of all coho populations above The Dalles Dam. Upper basin populations likely were one or several distinct ESUs, similar to what is seen in Chinook and steelhead in the upper Columbia. Of the six remaining coho populations in Oregon tributaries in the Lower Columbia ESU, four may have fallen to near extinction since 1990. These four populations, Astoria, Clatskanie, Scappoose, and Bonneville, are now considered to be in a recolonization mode.

b) **Is phenotypic diversity naturally maintained in most populations?** Specifically, is artificial selection due to human activity being avoided?

Artificial selection may occur in either hatchery environments or in natural environments. Hatchery programs are addressed in the next section. Artificial selection in natural environments most often are caused by selective harvests that remove individuals from populations based on specific phenotypes (most often size, age and run timing) and/or from specific geographic areas. There is evidence that harvests on Lower Columbia Coho have been selective over a variety of measures.

Ocean distribution: Marked hatchery coho from the lower Columbia Basin have both northerly and southerly ocean distributions depending on hatchery stock, as measured by interception of coded wire-tagged fish. Modeling of ocean fisheries suggests that recent ocean exploitation rates are higher on those fish that migrate north. The ocean distribution of wild coho from the lower Columbia is not known. However, if there is diversity among wild coho in ocean distribution, north-migrating individuals may experience higher impacts due to ocean fisheries. One hypothesis that could explain the persistent differences in smolt-to-adult survival among cohorts in the Clackamas wild population is that the weaker cohort is north-migrating while the other two are south-migrating. This hypothesis has not been tested and would require a specific marked fish sampling design if it were to be investigated.

Geographic location in the Columbia: Coho have been harvested in Select Area Fisheries (SAFE), terminally located in bays and sloughs in the Astoria population, since 1979. The terminal areas include Young's Bay, Blind slough, and Tongue Point, with the heaviest fishery in Young's Bay. Recent measures of harvest impacts suggest that these fisheries have little impact on wild coho from other locations. Estimates made by ODFW of harvest impacts on total unmarked coho entering the Columbia from these fisheries ranged from 1.3% in 2000 to 4.14% in 2003 (1.36% in 2000, 1.50% in 2001, 2.00% in 2002, 4.14% in 2003, 1.77% in 2004 and 4.04% in 2005). However, the harvest impact

on the Astoria population may exceed 70%. Continuance of these Select Area Fisheries may be incompatible with recovery of the Astoria population, but they may also be a viable harvest strategy for the protection of other lower Columbia populations, including the highly valued Sandy and Clackamas populations. Oregon OARs do not provide any guidance on this issue, except to allow the recovery of any two populations from the list of Astoria, Clatskanie, Scappoose, and Bonneville populations.

Size, age and gender: Commercial harvest of coho in the Columbia River (including SAFE) fisheries use gill net gear. Two mesh sizes are used in the river during the harvest of coho. Large mesh gear (minimum of 8 inches) targets Chinook or sturgeon and only incidentally catches coho. Small mesh gear (6 inches) targets coho. The small mesh gear catches coho at a significantly higher rate than the large mesh gear (Figure 8b) presumably since smaller coho escape the larger gear. Since 2000, the catch/hour of unmarked coho has been significantly higher ($p<0.01$) than that of marked coho in large mesh gear (Figure 8c). Marked and unmarked coho are caught at similar rates in the small mesh gear (Figure 8d). These results suggest that unmarked coho are larger than marked coho. However, the marked and unmarked fish caught by the gears are of similar sizes. Size data from non-selective sampling are not available that would allow a size comparison that is independent of the gears.

In addition to potential variable vulnerability of the species depending on size, there could be different vulnerability by age and gender because these characters are related to size. Jack coho (2-year olds, some of the males) are smaller and less vulnerable to these fisheries than the large adult coho (3-year olds, some of the males and all females). The smaller size of jack males makes them less vulnerable to gear that selects for larger fish. The size selectivity of gear may therefore be reflected in the relative escapement of jack and adult coho. The percents of the wild Clackamas and Sandy populations that were jacks are presented in Figure 9. The percent of the spawning population that are jacks in the Sandy and Clackamas has been quite variable over time and has been very high in some years, over 50%. In Oregon coastal coho populations, which may be "typical" for coho, jack males generally are less than 10% of spawning populations and the percent is fairly stable over time. This pattern suggests that a disproportionate number of jack males may be escaping in some years. Or stated in another way, a disproportionate number of adult males and females may have been lost in some years, possibly due to selective fisheries. Extreme proportions of jack males in spawning escapements have occurred less often since the late 1980s.

Run timing: Wild coho populations in the Columbia Basin historically had highly diverse run time phenotypes. This diversity is demonstrated by a comparison of historic dates of passage at Bonneville, Marmot and North Fork dams on the mainstem Columbia, Sandy and Clackamas (Figure 10), and at Gnat Creek weir on Gnat Creek (Figure 11). Coho were passing into their terminal areas from late August through February. Run timing profiles for individual populations (or aggregates) varied from the very narrow, September run timing peak at Bonneville Dam of wild coho destined for upper Columbia Basin tributaries, to the broad run timing from September through February of the

Clackamas population. The Sandy and Gnat Creek populations had run times that peaked in October and November.

Run timing of wild coho through the Columbia River mainstem, where the fishery is located, is not known. However, variable run timing in terminal areas probably corresponds to variable run timing through the mainstem. Thus, depending on the timing and intensity of the fishery, it may disproportionately impact particular populations or components of populations based on their run timing.

Most of the historic wild coho populations in Oregon's portion of the Lower Columbia, including the Gnat Creek population, are either extinct or are now present in numbers that are too few to measure run timing. The current run time at Bonneville Dam is similar to what it was historically, but most of the coho now passing Bonneville are hatchery fish from releases in the upper Columbia. Good run timing data sets are available at Marmot and North Fork dams for the Sandy and Clackamas wild populations.

The run time phenotype for the Clackamas population has not been stable over the time period for which data are available (1958 – 2005). A comparison of "historic" run timing (1960 – 1965) and later run timing (1984 – 1989 and 2000 – 2005) demonstrates a clear change in the relative number of fish passing North Fork Dam over time (Figures 12 and 13). The most notable change was the decrease in the proportion of the run that passed the dam in November, which was the peak of the run in the early 1960s. Both tails of the run were relatively emphasized, particularly in the 1984-1989 time frame. Run time data for the Sandy population is only available since the late 1970s, but there is some indication that the relative proportion of November run-time fish may be slightly decreased in this population also (Figure 14).

There are at least three hypotheses available to explain the changes in the Clackamas population run timing:

a) Water quality in the lower Willamette was notoriously toxic to August – October run timing fish by the 1940s (Dimick and Merryfield 1945). This water quality condition was probably responsible for the loss of fall Chinook in the lower Clackamas and may have impacted Clackamas coho with an August - October run timing. Willamette River water quality improved substantially since the mid-1960s, potentially allowing re-establishment of September-October run timing fish. This hypothesis would not explain the loss of November run timing fish.

b) Hatchery programs in the Clackamas may have introduced earlier run timing fish into the Clackamas population. The hatchery program at Eagle Creek National Fish Hatchery on Eagle Creek, a tributary of the lower Clackamas, was originally founded from Sandy River coho, which have October-November run timing (Figures 10 and 14). However, most of the history of hatchery fish planting occurred in Eagle Creek and after the hatchery stock became 100% marked in the late 1990s it became evident that few hatchery fish from this program were straying above North Fork Dam. The passage of all

hatchery fish was discontinued at the dam in 2000. This hypothesis also would not explain the loss of November run timing fish.

c) Selective harvest in the mainstem Columbia River disproportionately impacted November run timing fish, relatively emphasizing the early and late tails of the run.

It is possible that all three events contributed partially to the shifting run timing observed on the Clackamas. The water quality and hatchery program impacts have been effectively eliminated.

c) **Are genetic influences due to hatchery program avoided?**

Impacts to wild populations due to hatchery programs are addressed in other Biological Opinions. In brief summary, the most of the Sandy and Clackamas wild coho populations are effectively protected from future hatchery program impacts by the removal of hatchery fish at North Fork and Marmot dams. This protocol has been in place since 2000. The current protocol in the other four populations is to allow hatchery fish to contribute to recolonization events.

Diversity delisting criteria: The diversity delisting criteria under Oregon's recovery plan (OAR 635-100-0194 (3)(b)) requires that reproducing wild coho be present in 65% of the named streams that historically contained coho; that human activities impose only minor artificial selection pressures on the phenotypic character of the wild populations; and that the ongoing impact of hatchery fish on the genetic character, evolutionary processes, and innate productivity of naturally reproducing populations is minor.

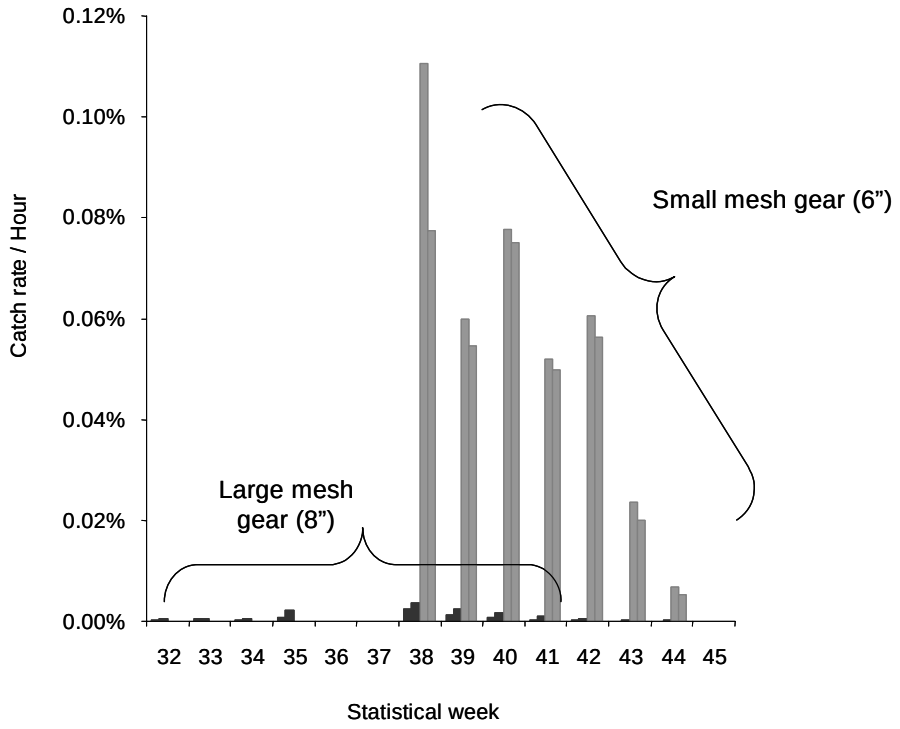

Figure 8b. Relative catch rate, expressed as catch rate/hour, by large (8") and small (6") mesh gill net gear, based on catches from 2000 – 2005, shown by statistical week.

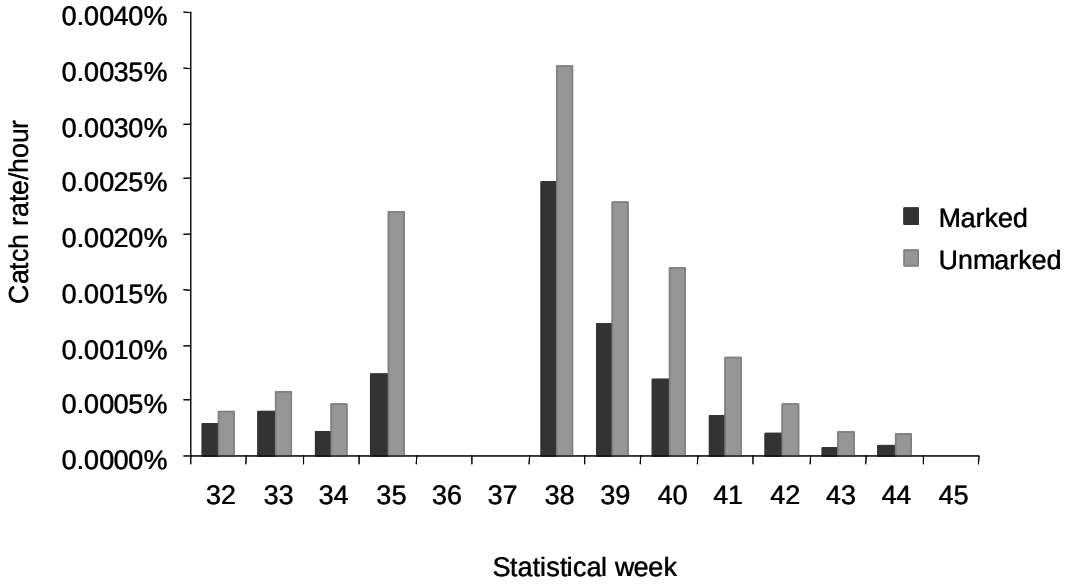

Figure 8c. Relative catch rates of marked and unmarked coho in 8" gear, shown by statistical week. Based on catches from 2000 – 2005. Unmarked fish are caught at a significantly higher rate than marked fish ($P < 0.01$).

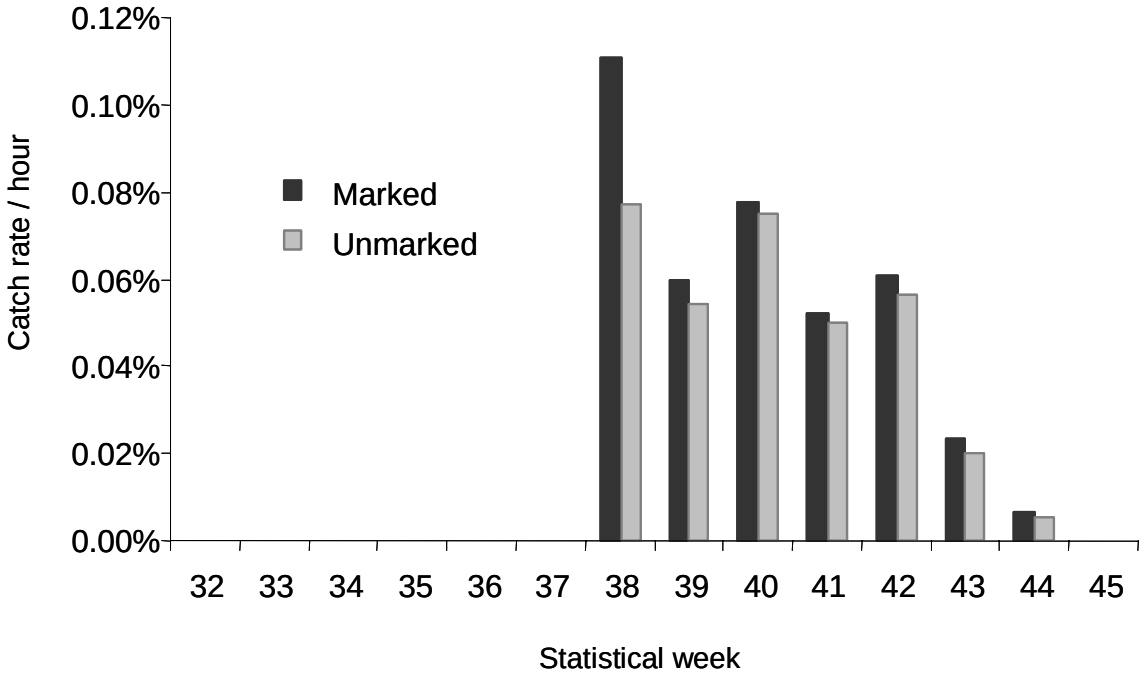

Figure 8c. Relative catch rates of marked and unmarked coho in 6” gear, shown by statistical week. The differences between marked and unmarked fish are not significant.

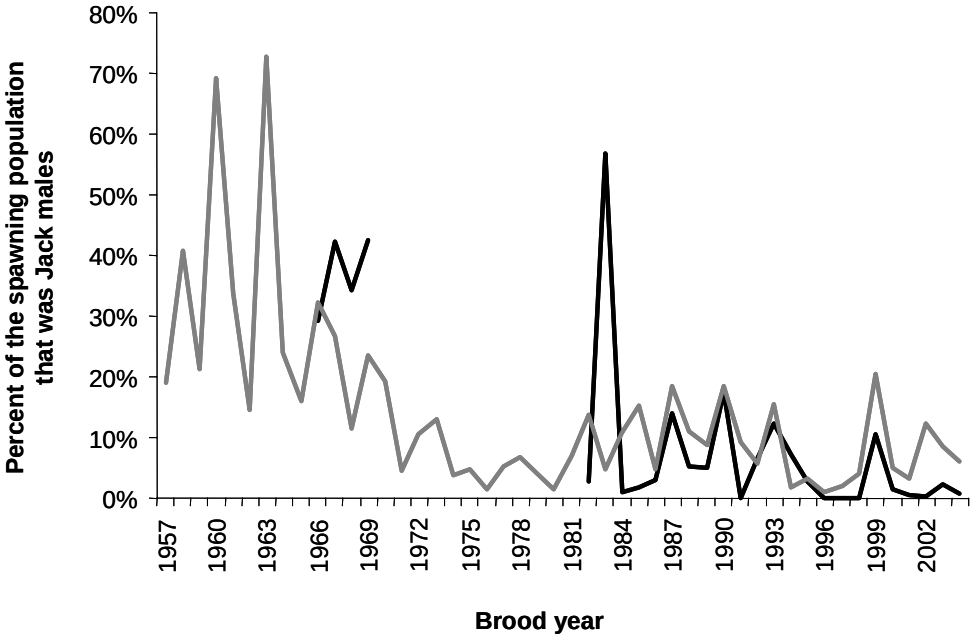

Figure 9**.** The percents of the Sandy (black line) and Clackamas (grey line) coho spawning populations that were jack males over the period for which dam count data are available. In Oregon coastal populations, the percent of jack males in spawning populations is typically less than 10%.

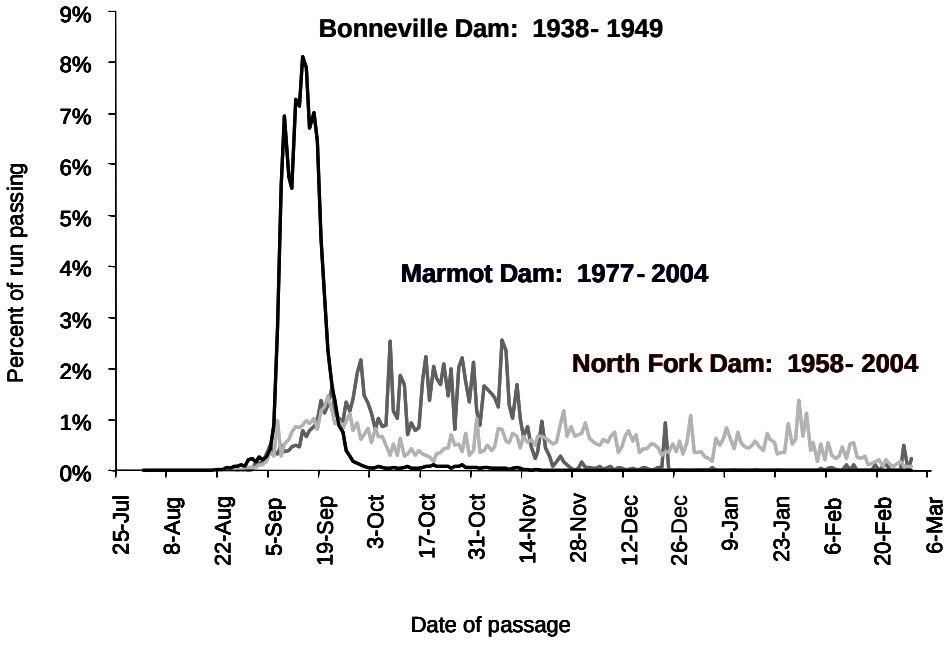

Figure 10. Historic run timing of wild coho in the Columbia River, demonstrating the historic variation in this phenotype.

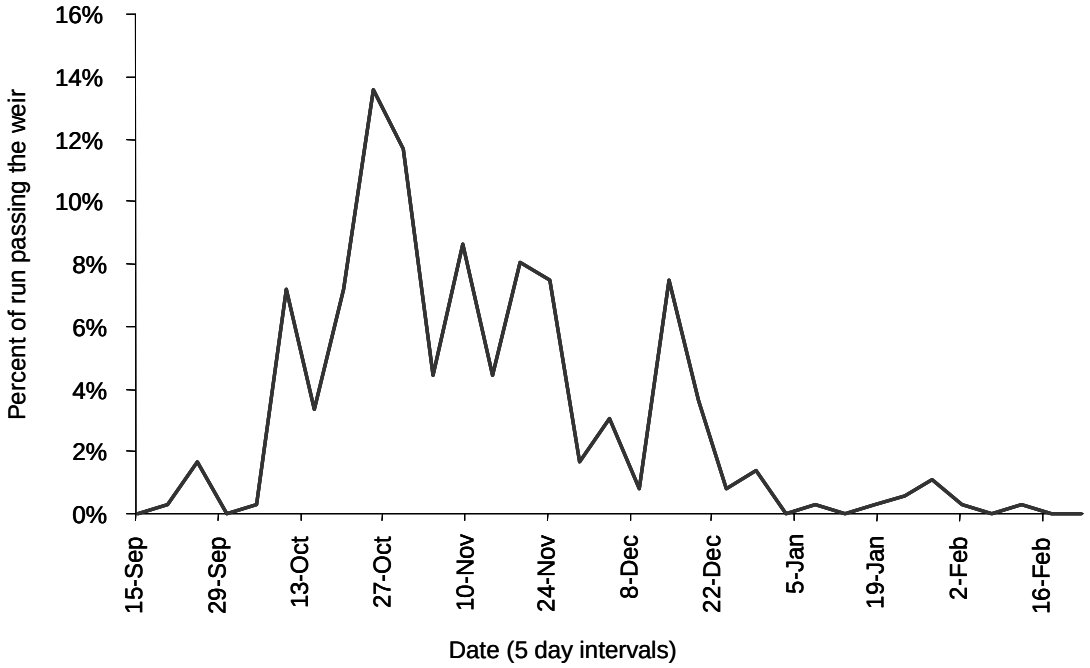

Figure 11. Run timing of wild coho at Gnat Creek Weir in 1950-1961.

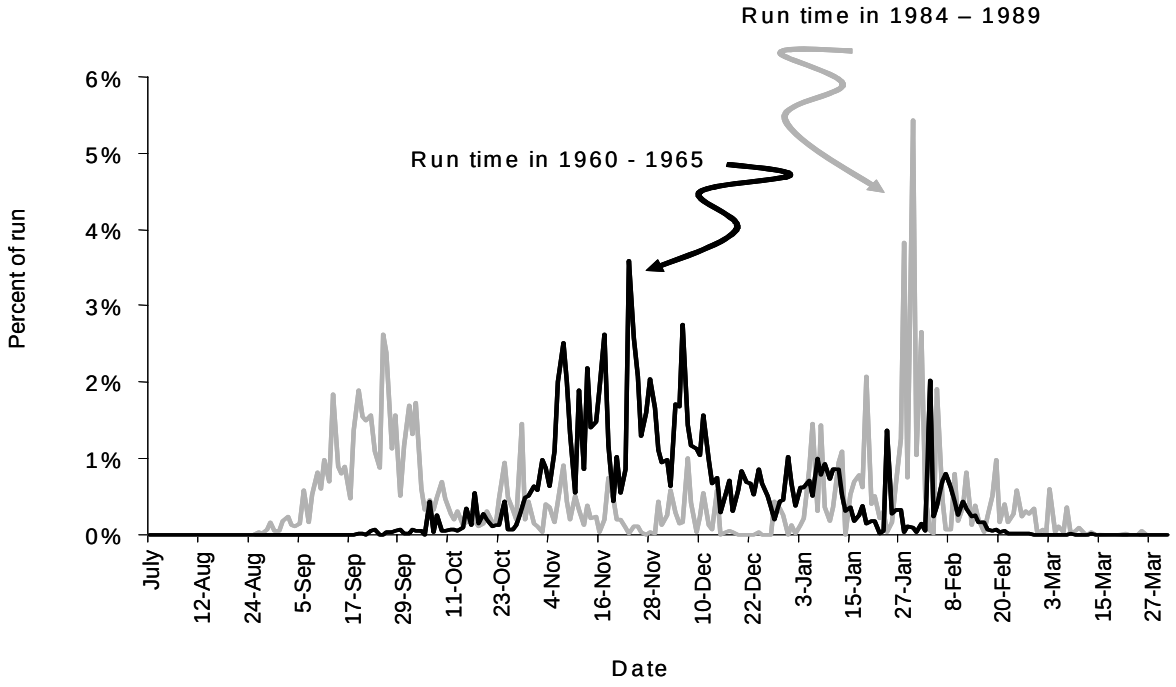

Figure 12. A comparison of Clackamas wild coho run timing in two six year periods, 1960-1965 and 1984 - 1989. A higher proportion of the run passed North Fork Dam in September and January, and a lower portion passed in November in 1984 - 1989 compared to 1960 – 1965.

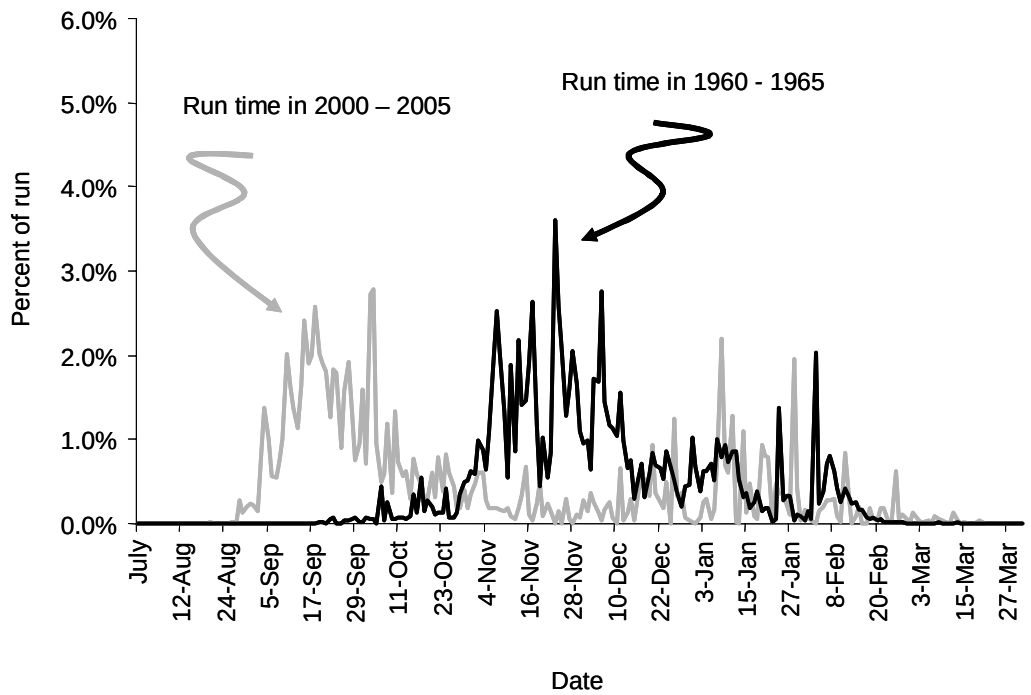

Figure 13. A comparison of Clackamas wild coho run timing in two six year periods, 1960-1965 and 2000 - 2005. The "November Gap" that was evident in the late 1980s is still present.

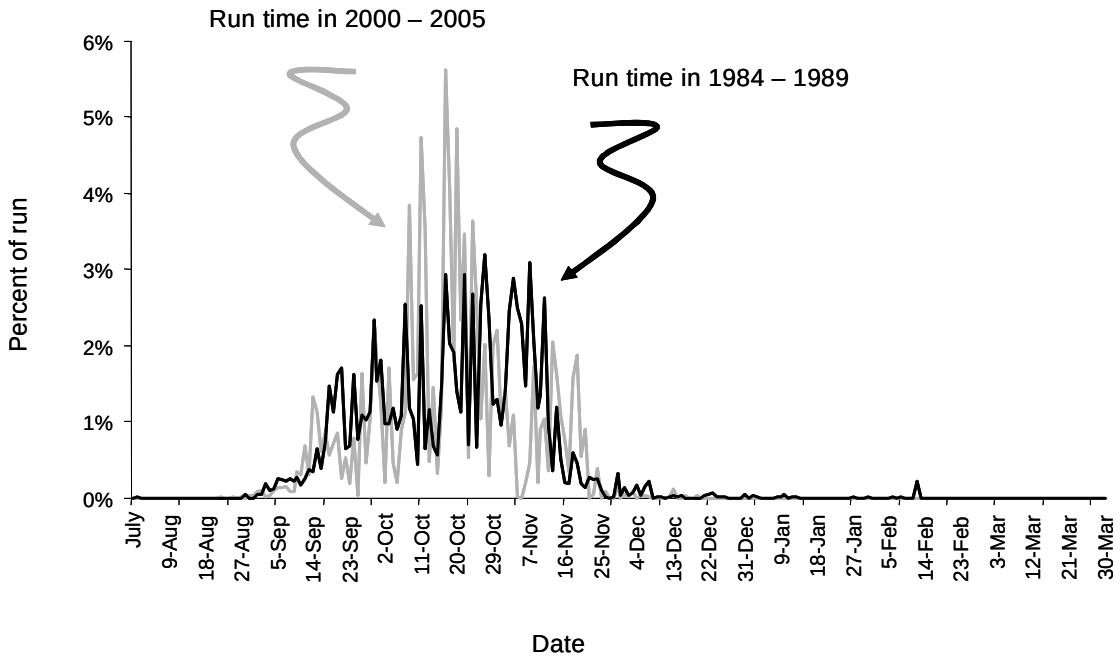

Figure 14. A comparison of Sandy wild coho run timing in two six year periods, 1984 – 1989 and 2000 – 2005. A slight decrease in the relative number of November-running fish may also be evident in the Sandy, although older data comparable to the early 1960s time frame on the Clackamas are not available for the Sandy.

Past Harvest Impacts on Oregon State ESA-listed Coho

The State of Oregon has been required to annually report on harvest impacts on Lower Columbia Coho under the State ESA. In 2004, ODFW staff initiated an expanded effort to empirically assess harvest impacts through post season reconstructions. ODFW has been annually issued a permit by the Oregon Fish and Wildlife Commission for incidental harvest impacts to listed coho. The allowed annual impact rates for ocean and in-river fisheries were determined by a harvest matrix in the state's Endangered Species Management Plan (Appendix 1).

For combined in-river and ocean fisheries, the cumulative allowable harvest impacts since 1999 have ranged from 13.3% in 1999 to 25% in 2003. In some years a separate limit was specified for either ocean or in-river fishery as shown below. In-river impacts included both commercial fisheries (mainstem and SAFE) and recreational fisheries (mainstem and Buoy 10). It should be noted that the survival rates through ocean and in-river fisheries is multiplicative and not additive. Therefore, the cumulative impact rate can not be calculated by simply adding the ocean and in-river impact rates together.

Year	Total Impact Rate	Ocean Impact Rate	In-river Impact Rate
1999	15.0%		
2000	13.3%		
2001	15.0%		
2002	14.0%		
2003	25.0%	13.3%	13.5%
2004	23.5%	13.4%	11.7%
2005	17.7%	12.0%	6.5%

Commercial Harvest Rates: 2000 – 2005

Ocean: Ocean harvest impacts on Lower Columbia Coho for the period of 2000 – 2005 were developed by PFMC for the Oregon Production Index. Estimated harvest rates are as follows (red entries exceeded Oregon's impact limits for that year without consideration of other fisheries also covered by the limit):

2000 – 13%
2001 – 16%
2002 – 14%
2003 – 23%
2004 – 25%
2005 – 12%

Mainstem: ODFW used two methods to reconstruct harvest impact on mainstem fisheries for the period of 2000 through 2005. Mainstem commercial fisheries were selective for unmarked coho during this time frame, so measurements of unmarked catch

were directly available. However, many unmarked coho passing through the lower Columbia mainstem were not listed under the State ESA. The largest portion of unmarked coho entering the Columbia River were unmarked hatchery coho that were being released above The Dalles Dam (>70%). Oregon's listed coho have been less than 10% of the total unmarked run. Since listed unmarked coho could not be distinguished from unlisted unmarked coho in the catch, assumptions were required to account for this uncertainty.

Both methods of harvest impact reconstruction relied on catch sampling data collected from lower river processors, including catches by week and zone, and mark rates by week and zone. Both methods also used measurements of wild and unmarked escapements measured at Marmot Dam (wild), North Fork Dam (wild), Willamette Falls (unmarked unlisted), Bonneville Dam (unmarked, less than 1% of which are listed), and lower Columbia River spawning ground counts in Oregon (listed). Various assumptions were incorporated to account for unmarked escapement of coho into Washington tributaries below Bonneville Dam since abundance data from these areas have not been available. In the following results, a flat estimate of 10,000 fish each year was used for Washington.

Run-timing neutral model: The first method used the simple assumption that the harvest rate on unmarked listed coho was the same as the harvest rate on total unmarked coho entering the lower Columbia. This approach was similar to that used to assess impacts on spring chinook and winter steelhead in mainstem fisheries. The catches, escapements and harvest rates for 2000 – 2005 are provided in Table 6.

Table 6. Estimated Commercial (mainstem gill net and SAFE) harvest impacts on unmarked coho using a run-timing neutral model (red entries exceeded Oregon's impact limits for that year without consideration of other fisheries also covered by the limit).

Year	Unmarked catch	Unmarked escapement	Harvest rate
2000	12,727	66,000	16%
2001	17,734	136,000	12%
2002	18,837	77,000	20%
2003	42,840	120,400	26%
2004	21,288	83,900	20%
2005	8,298*	61,600	12%

* Does not include Eagle Creek SAFE catch

Run timing-adjusted model: In the second method, the effect of run timing on harvest rates was estimated. The approach recognized that although it was not known when fish enter the Columbia River mainstem, or how they behave while in it, it was known that the fish leave the area when they pass over their terminal dam. After fish passed over their terminal dams, they were no longer available to be harvested. This method adjusted the weekly abundance of unmarked fish using run timing profiles at Bonneville Dam (actual dates past applied to the Bonneville escapement), Marmot Dam (actual dates passed

applied to the Sandy escapement, and run time curve also applied to other Oregon and Washington escapements below Bonneville Dam), North Fork Dam (actual dates applied to the Clackamas escapement) and Willamette Falls (actual dates applied to the Willamette escapement). Weekly abundance of each escapement group was also adjusted by weekly harvests. The catches, escapements, and harvest rates are summarized in Table 7.

Summary: The combined results of the two impact assessment methods suggest that impacts on listed coho was higher if run timing was taken into account. The reason was that the Bonneville Dam component of the unmarked escapement, which has averaged more than 70% of the unmarked coho entering the Columbia River but is largely unlisted under Oregon ESA, passed Bonneville early before most of the coho fishery occurred. Approximately 70% of the Bonneville component was already passed the dam by week 40, when the directed coho fishery was underway (Figure 15). The listed Clackamas and Sandy runs, in comparison, were still largely below their terminal dams at the beginning of the coho-directed fishery. Only ~37% of the Clackamas run and ~10% Sandy and "Oregon other" runs were already past their terminal dams when the directed coho fishery was under way.

Sports Fisheries Harvest Rates: 2000 – 2005

Oregon's in-river impact limits also include impacts due to sports fisheries in the Columbia mainstem and at Buoy 10 in the Columbia estuary. Sports fisheries in these areas are catch-and-release for unmarked coho so impacts to wild fish are accrued due to release mortalities. The Buoy 10 release mortality is estimated to be 21% while the mainstem release mortality is estimated to be 10%. Encounter rates on unmarked coho are estimated from Oregon creel data. Release mortalities and impact levels for 2000 – 2005 are provided in Table 8.

Summary of Harvest Impacts Compared to Oregon State Impact Limits:

A comparison of actual harvest impacts rates to Oregon's state impact limits demonstrates that the state's total impact limits apparently were exceeded every year since 2000. In many cases, most of the total impact limits were used up in ocean fisheries, leaving little for in-river fisheries. In 2001 and 2003 the total impact limits were exceeded in ocean fisheries alone, before the additional impacts due to in-river fisheries were considered. In-river commercial fisheries alone also often exceeded the state's total impact limits without considering the additional impacts due to ocean and sports in-river fisheries, particularly when impacts were estimated using a run-time adjusted model.

Table 7. Estimated Commercial (mainstem gill net only) harvest rates on Oregon listed populations using a run timing-adjusted model. The Sandy and Oregon "other" harvest rates are the same because the Sandy run time curve was used for both of them. Red entries exceeded Oregon's impact limits for that year without consideration of other fisheries also covered by the limit.

Year	Clackamas			Sandy			Oregon "other"		
	Catch	Escapement	Harvest rate	Catch	Escapement	Harvest rate	Catch	Escapement	Harvest rate
2000	1,829	2,832	39%	485	741	40%	936	1,430	40%
2001	2,903	5,344	35%	596	1,164	34%	1,365	2,667	34%
2002	377	999	27%	196	290	40%	1,670	2,467	40%
2003	1,737	2,177	45%	1,683	1,199	58%	2,906	2,070	58%
2004	1,503	1,779	46%	999	1,032	49%	3,969	4,100	49%
2005	239	1,223	16%	228	745	23%	303	991	23%

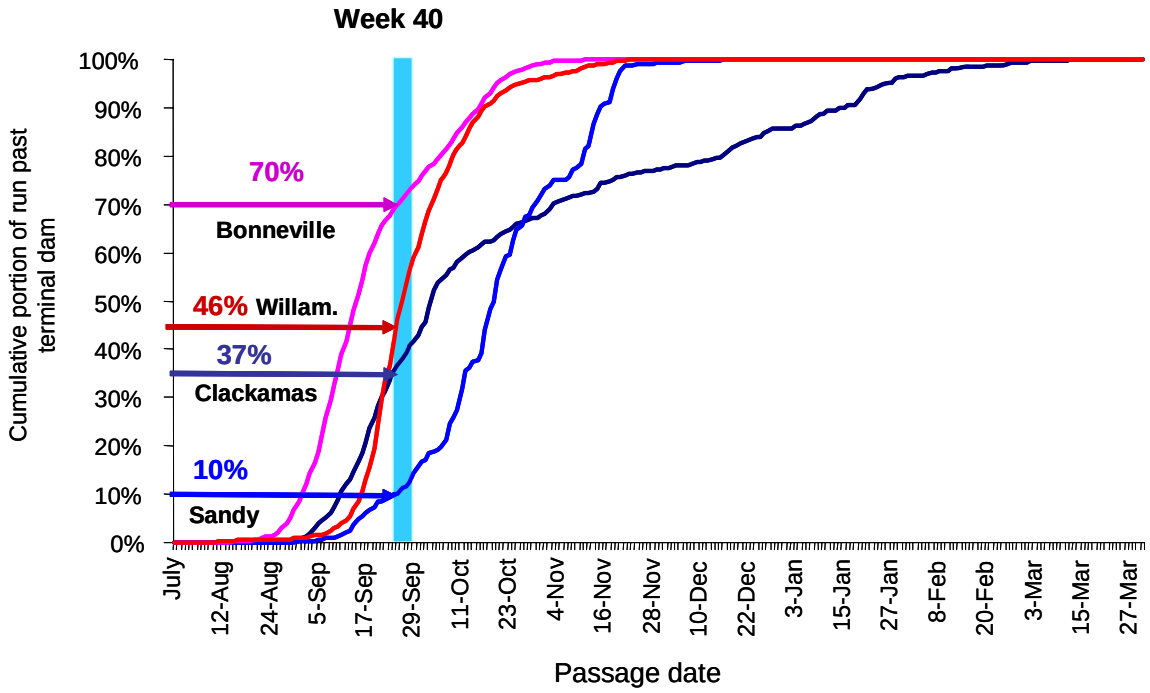

Figure 15. Cumulative run timing of the Bonneville, Willamette, Clackamas and Sandy (also "Oregon other") population components at their terminal dams relative to the beginning of the coho-directed fishery (2000 – 2005).

Table 8. Estimated release mortalities and impact rates due to Buoy 10 and mainstem sports fisheries.

Year	Buoy 10 release mortality	Mainstem release mortality	Estimated sports impact
2000	1,557	22	2.4%
2001	9,217	43	6.8%
2002	809	61	1.1%
2003	3,922	48	3.3%
2004	1,641	43	2.0%
2005	573	20	1.0%

Diversity Impacts

River gill net fisheries tend to be selective for size, age, gender (when gender varies by size and age), run timing and geographic area because the fisheries use size-selective gear and are implemented at specific times during the run and at specific locations. Concerns about apparent diversity impacts due to the fisheries have already been raised (See section on Diversity, above, including Figures 9 through 14). Evidence suggests that the fisheries have been selective by size, and the associated traits of age and gender, selecting against large fish, older fish, and females. Evidence also suggests that the fisheries have been selective by run time, with a disproportionate removal of fish that would pass their terminal site in November. The SAFE terminal fisheries also pose a disproportionate impact on the Astoria population. Strategies for mitigating diversity impacts include keeping harvest rates as uniformly low and as evenly distributed in space and time as possible.

Forecasts for 2006

ODFW has prepared wild coho forecasts for the Clackamas and Sandy populations for 2006. Three forecast methods were explored for the Clackamas (based on 1958 – 2005): Adults forecasted by jacks, Adult forecasted by smolts, and 3 –year average of adults by cohort. Two forecasts methods were explored for the Sandy (based on 1982 – 2005 data): Adults forecasted by jacks and 3-year average of adults by cohort.

The statistical relationship between smolts and adults and between jacks and adults were found to be surprisingly poor. The R^2 values of adults on jacks (in both basins) were all very low ($R^2 < 0.15$). This lack of a relationship between jacks and adults in these basins exists because the relative numbers of jacks and adults produced by brood year in both basins has been highly erratic. The percent jacks by brood year in the Clackamas ranged from 0.1% to 55.6% while the percent jacks by brood year in the Sandy ranged from 0.0% to 23.1% (also see Figure 9). We concluded that the erratic relationship between jacks and adults precludes any predictive power of adults based on jacks.

The R^2 value of adults on smolts in the Clackamas is also very low ($R^2 = 0.16$). This lack of relationship appears to be partly because harvest was non-stationary over the data set. The relationship between smolts and pre-harvest (ocean and river) adults is better ($R^2 = 0.26$), but is still not good enough to make adults predictive based on smolts.

Since the age regression methods had such poor fits, we elected to use a three-year cohort average for our 2006 forecasts. The average error over the last three years for the 2006 cohort on the Clackamas was 20%. The average error over the last three years for the 2006 cohort on the Sandy was much higher, over 200%, due primarily to a sharp decline by the cohort in the mid 1990s. However, over the entire data sets, the variation within the 2006 cohorts has been less than that of the entire populations.

The resulting 2006 forecasts for the two basins are 650 fish in the Sandy and 2,300 fish in the Clackamas.

Two forecasts are available for the total return of unmarked fish to the Columbia River mouth. The FRAM model predicted a return of 82,000 unmarked coho, while a three year average predicts 115,000 fish. Note that the three-year average by total escapement is not a cohort average since there is not enough years of data in many areas.

Forecasted Harvest Risks

Harvest risk assessment methods are still under development. Several methods that are being explored compare preseason forecasts to possible harvest standards (Table 9). The first two standards in Table 8 use the conservation curves and their relationship to actual population data as presented in Figures 6 and 7. The third and fourth standards are the estimates of "full seeding" and 50% of full seeding as provided in OAR 635-100-0190 and 0194. All of these risk assessment approaches require further development, discussion and review. However, these assessments do provide some preliminary indication of the vulnerability of the Sandy and Clackamas populations to harvest risks in 2006. The 2006 Clackamas forecast is above all the standards except the definition of full seeding, suggesting it may be able to tolerate a low harvest impact. The 2006 Sandy forecast is below all the standards, suggesting that it may be vulnerable to harvest impacts. All other Oregon populations are in vulnerable, recolonization modes and are probably well below seeding levels.

Table 9. Adults and R/S standards for Lower Columbia coho harvest standards, based on the Inland TRT Beverton Holt conservation curves. OAR 635-100-0190 definitions for "full seeding" in the Sandy and Clackamas and 50% of full seeding are also shown.

Population	Extinction Standard	Adults	R/S
Clackamas	5% Beverton Holt-based Standard	1,950	1.3
	0% Beverton Holt-based Standard	2,100	1.6
	OAR 635-100-0190 "full seeding"	3,800	
	50% of "full seeding"	1,900	
	forecast for 2006	2,300	
Sandy	5% Beverton Holt-based Standard	1,000	2.2
	0% Beverton Holt-based Standard	1,175	4.0
	OAR 635-100-0190 "full seeding"	1,340	
	50% of "full seeding"	670	
	forecast for 2006	650	

References

Dimick, R.E. and F. Merryfield. 1945. The fishes of the Willamette River system in relation to pollution. Oregon State College Engineering Experiment Station, Bulletin 20. Salem, OR.

Appendix 1.

Oregon Department of Fish and Wildlife's Endangered Species Management Plan for Lower Columbia Coho Salmon

Introduction

The Oregon Fish and Wildlife Commission (OFWC) listed lower Columbia River wild coho salmon as an endangered species in July 1999. Under provisions of Oregon's threatened and endangered Species law, state agencies that have a conservation role must prepare an endangered species management plan and have this plan approved by the OFWC by July 2001. The following document is intended to fulfill this requirement for the Oregon Department of Fish and Wildlife (ODFW). This plan will address the key elements as described by section 6 of OAR 635-100-0140, section 6. In addition, the plan will include portions on the status of the species, biological benchmarks for de-listing, and long-term management goals.

Certain aspects of ODFW's plan will require additional resources to fully implement. In particular those elements related to providing adult coho passage above artificial barriers at hatchery facilities and the expanded monitoring of wild populations. Therefore, it may be necessary to implement such actions over a longer period of time commensurate with the availability of the required financial resources. Regardless, ODFW has the long-term goal of implementing all of the actions contained in this plan.

ODFW is the process of finalizing a new approach to native fish conservation for the OFWC to consider adopting in fall 2001. The lower Columbia River coho endangered species management plan is consistent with most elements of the draft native fish conservation approach, as well as the existing Wild Fish Management Policy (OAR 636-07-525).

Background

For the purposes of this plan, the geographical range for lower Columbia River coho includes all waters historically utilized by wild coho salmon within Oregon's portion of Columbia River basin from Hood River downstream to the Pacific Ocean (Figure 1). Although occurring at one time both in Washington and the Columbia River basin upstream of The Dalles, wild coho populations are thought to remain in only two locations, the Sandy and Clackamas basins (Chilcote, 1999). The total wild coho return to the Columbia River has dwindled from historical

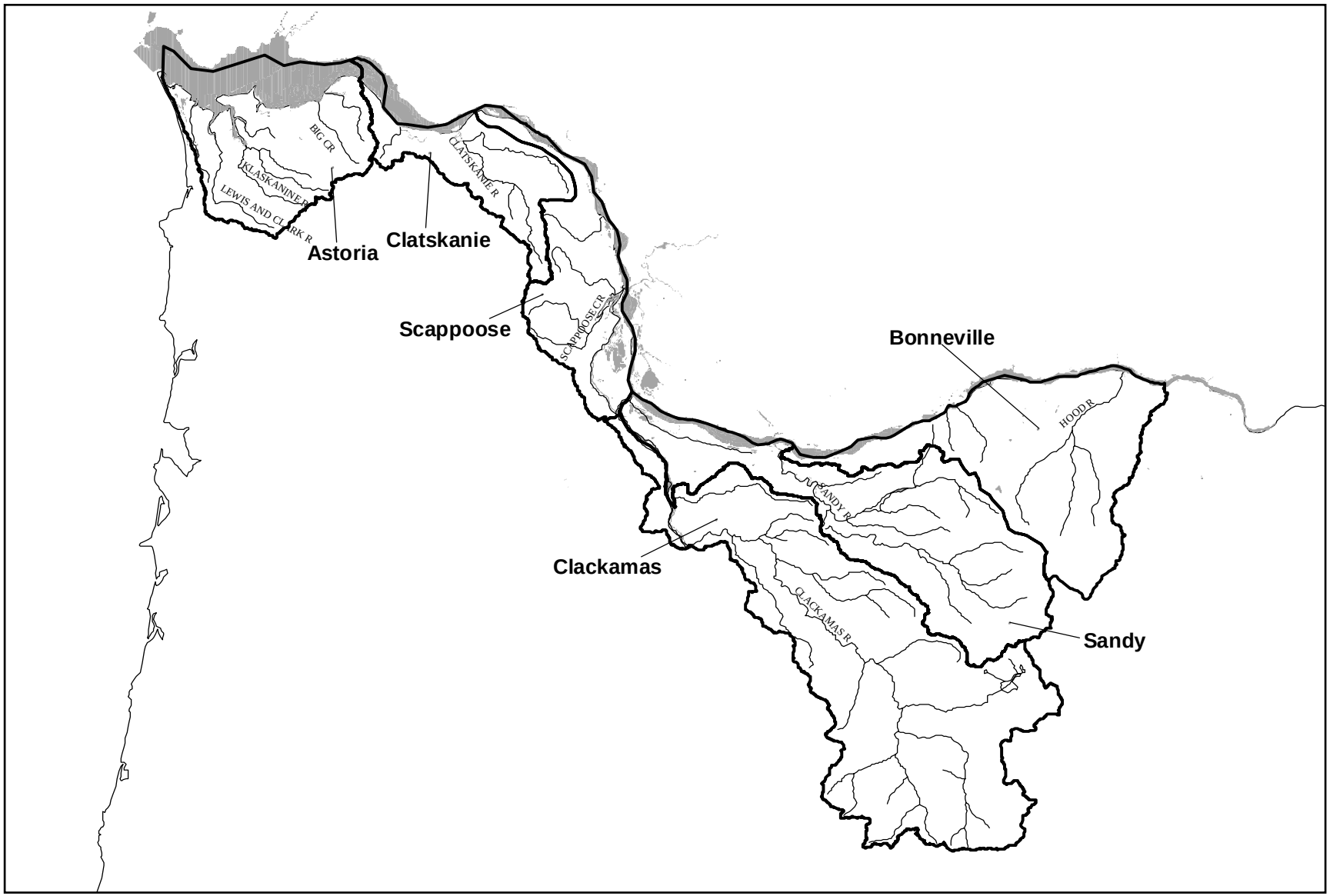

Figure 1. Geographic boundaries of current and expected populations of wild coho in lower Columbia River.

levels of more than 600,000 fish (Chapman, 1986) to less than 400 fish in 1996 (Chilcote, 1999). However, in the last 30 years the production and release of coho smolts from hatcheries in the lower Columbia basin has resulted in substantial adult coho returns. The aggregate return of hatchery coho is as large or larger than the size of the historical wild run. As was the case for the historical wild population, Columbia River hatchery fish contribute heavily to both ocean and in-river commercial, tribal, and sport fisheries.

A variety of factors contributed to the decline of wild populations of lower Columbia River coho. Up until the late 1980s, the cumulative fishery mortality rate on wild coho was approximately 85%. During periods of good ocean conditions most populations were able to sustain this level of fishery impact. However, when ocean conditions deteriorated the density of spawners in many locations declined rapidly. It appeared this decline was so severe that there were not enough spawners for populations to properly rebound as they had in the past.

Two other factors exacerbated this situation. First, habitat conditions in many of the basins had been in a slow decline. Therefore, the innate ability of many basins to produce coho had been impaired. However, superior ocean survival conditions had resulted in so many returning adults that the significance of this habitat decline had been effectively hidden. Secondly, ODFW initiated a hatchery-based program in the 1980s to restore natural production for these depressed populations. This program consisted of releasing large numbers of hatchery pre-smolt and adult coho throughout the lower Columbia basin for a period of almost 10 years. This program failed to restore wild populations. In fact, the ecological and genetic effects caused by a large in-flux of hatchery fish not adapted to local environmental conditions likely caused a further weakening of already depressed wild populations (Chilcote, 1999). Extinction of many local wild coho populations in the lower Columbia basin occurred shortly after this hatchery intervention program was initiated.

Lower Columbia River wild coho became endangered because of the cumulative effect of excessive fishery harvest rates, inappropriate use of hatchery fish, low survival ocean conditions, and reductions in the quality of stream habitat. Although ODFW has been unable to quantify the specific contribution of each of these factors to the overall decline of this species, it is likely that all of them contributed significantly to the problem.

In recent years ODFW has made significant progress in lessening the impact of hatchery programs and fisheries. ODFW stopped planting pre-

smolt and adult hatchery fish into natural production areas in the early 1990s. Now, hatchery coho are released only as smolts and in locations where interactions with natural produced fish are less likely to occur. As a result of these actions the incidence of hatchery fish in natural production areas has been substantially reduced. Fishery mortality rates on wild coho are also substantially lower in recent years. Instead of being in the 80% to 90% range of the past, they have been restricted to the 15% to 25% range since 1994.

The response of wild coho in the lower Columbia basin to these management changes has been disappointing. Throughout the late 1990s their numbers continued to decline, leading to OFWC's decision to add these fish to the Oregon's endangered species list. The likely explanation for this lack of response was the extremely poor ocean survival conditions that coincided with these management changes. The large return of wild coho to the lower Columbia basin in 2000 seems to confirm this explanation. Ocean conditions experienced by these fish in 1999 and 2000 were much better than they have been in the last 10 years. ODFW is hopeful that this reversal of ocean survival conditions in 1999 will continue at least long enough that the management strategies already enacted, plus new strategies contained in this plan, will result in a relatively quick recovery of this species.

Minimum Plan Requirements

As outlined in OAR 635-100-140(6), endangered species management plans must include, at a minimum, several specific elements. The following is a listing of these elements and a discussion how ODFW will address each one in its endangered species management plan for this species.

Element 1 - *A description of the state land that is covered by the plan.* Under an opinion by the State Attorney General, water is classified as "land" for the purpose of Oregon's threatened and endangered species law. Since ODFW is responsible for the management of fish populations, the "land" covered by the plan are all locations where fish occur. This is basically all water inhabitable by fish in the lower Columbia basin from Hood River downstream to the Pacific Ocean, exclusive of the Willamette basin upstream of the falls at Oregon City (Figure 1). In addition, ODFW is the landowner of the Sauvie Island Wildlife Management Area. Finally, the majority of the hatcheries operated by ODFW in the lower Columbia basin that raise coho salmon are not located on ODFW owned land, however these lands are managed by ODFW and are therefore discussed in this plan.

Element 2 - *The role this land will play in the conservation of the species and the process by which the agency determined this role.*
The regulation of fisheries and management of hatchery programs has a direct bearing on the conservation of this species. Activities in both of these areas must not impair the productivity of the wild populations nor reduce the number of spawning fish below critical abundance levels. This role was determined from the interpretation of ODFW's statutory responsibilities under the Oregon's endangered species law and various administrative rules related to the conservation and utilization of naturally produced fish including OAR 635-07-510 (General Fish Management Goals), 635-07-521 (Natural Production Policy), and 635-07-525 (Wild Fish Management Policy).

Element 3 - *A description of how the state agency will manage state land to achieve its defined role.*
The agency will achieve its role by implementing a variety of strategies relating to fishery harvest, hatchery program management, and land management including fish passage.

Strategy 1. Harvest Management
Mortality associated with ocean and in-river fisheries will be managed in a manner that is consistent with the conservation and recovery of the species. The approach to accomplish this goal will be to scale annual fishery impacts to the forecast run strength of each year's return of naturally produced wild coho. The tools used to adjust fishery mortality rates will include selective fisheries, wherein only hatchery fish may be retained, adjustments in number of days open to fishing, and special fishing regulations that allow selective access to hatchery fish by directing fishing effort to times or areas where impacts to naturally produced fish are reduced. Each year a suite of these regulatory actions will be undertaken to ensure that the impact of fisheries is less than the maximum harvest mortality rate determined for that year.

The method to determine the annual maximum harvest mortality rates for wild lower Columbia River coho salmon will be based upon two predictive factors that are known to influence run size: parental spawner abundance and ocean survival (Appendix 1). The integration of these two factors in setting maximum harvest rates will be accomplished using the same harvest matrix approach as currently used in the management of Oregon Coastal Natural (OCN) stocks of coho through the Amendment 13 Pacific Fishery Management Council (PFMC) process.

However, for lower Columbia River coho, two independent harvest matrices will be used: one for ocean fisheries and one for fisheries that occur within the Columbia River. In both cases, to calculate the index of marine survival, the number of hatchery origin jack coho will be divided

by the number of hatchery smolts released in the spring of the same year. This will be referred to as the "marine survival index". The other factor, parental escapement, will be the number of wild adult coho that spawned 3 years prior to the upcoming adult return.

For example, to set the maximum harvest rate for the 2002 fishing season, the two controlling factors would be determined as follows. The marine survival index would be calculated as the number of jacks that returned in the fall of 2001 divided by the number of smolts released in the spring of 2001. The parental abundance would be the number of wild fish that spawned in 1999.

The Sandy and Clackamas populations of wild coho will be used as the index populations to set harvest rates for lower Columbia River coho. The parental escapement for each population will be applied to a harvest matrix and a maximum harvest rate for each population estimated. These two harvest rates will then be averaged to obtain the overall maximum impact rate for wild lower Columbia River coho.

As noted earlier, an ocean and an in-river harvest matrix will be used to set the maximum fishery rates. The matrix used for the maximum ocean rates will be essentially the same as described for OCN coho and shown below in Table 1.

Table 1. Proposed harvest management matrix for lower Columbia River wild coho salmon showing maximum allowable **OCEAN** fishery mortality rates.

Parental Escapement		**Marine Survival Index** (based on return of jacks per hatchery smolt)			
		Critical (<0.0008)	Low (< 0.0015)	Medium (< 0.0040)	High (> 0.0040)
High	> 0.75 full seeding	< 8.0%	< 15.0%	< 30.0%	< 45.0%
Medium	0.75 to 0.50 full seeding	< 8.0%	< 15.0%	< 20.0%	< 38.0%
Low	0.50 to 0.20 full seeding	< 8.0%	< 15.0%	< 15.0%	< 25.0%
Very Low	0.20 to 0.10 of full seeding	< 8.0%	< 11.0%	< 11.0%	< 11.0%
Critical	< 0.10 of full seeding	0 – 8.0%	0 – 8.0%	0 – 8.0%	0 – 8.0%

Within the matrix table, parental escapement is expressed as some fraction of "full seeding." Full seeding for the Sandy and Clackamas populations was estimated by fitting a stock recruitment curve to observed spawner and recruit data for these basins and then determining the theoretical escapement level that corresponded with the

maximum production of recruits. Using this method, number of spawners necessary to fully seed the Sandy and Clackamas was estimated to be 1,340 and 3,800, respectively.

It should be emphasized that ODFW alone does not set or control the ocean harvest rates. Multiple state and federal agencies are involved in making this decision. However, as long as the parental abundance levels for the Columbia and coastal populations are relatively similar, the maximum rates expressed in Table 1 can be expected with some degree of certainty. A problem occurs when the parental escapement for the Columbia population is very low and the escapement for coastal populations very high. Under these circumstances, the maximum allowable harvest rates for OCN coho would be too high for the Columbia population.

To explore the likelihood of this situation occurring, past spawner escapement data for OCN and Clackamas coho populations were compared. In most years the parental escapement matrix category for OCN coho would have been the same as it was Clackamas River coho. Further, when discrepancies occurred they tended to favor the Clackamas population. In other words, the parental matrix category of the OCN coho was at a lower level than for Clackamas coho. Only in 3 of the 27 years was the parental abundance category greater for OCN coho than it was Clackamas coho.

Therefore, in the future it appears unlikely that Columbia wild coho populations will fall into a lower harvest matrix category for spawner abundance relative to coastal populations. However, in the event that such a situation does occur, ODFW will negotiate for an ocean harvest rate that is consistent with the level specified by the matrix for Columbia River coho.

A second harvest matrix will be used to set the maximum harvest rate for Columbia River fisheries. It is based upon the same concepts but has different limits as shown in Table 2. These harvest rate limits were set at levels demonstrated to be considerably less than the maximum sustainable rate for these populations (Appendix 1).

The impact of all fisheries on lower Columbia River coho can be described by combining the ocean and in-river harvest matrices. When combined the two matrices yield a table of maximum overall exploitation rates for all fisheries (Table 3). These exploitation rates were determined to not impair the conservation and recovery of lower Columbia River coho. This determination was based on a population recruitment simulation model that estimated the probability of recovery under the combined harvest matrix protocols (see Appendix 1). This simulation

determined that the probability of the population failing to meet numerical recovery levels (greater than 50% of full seeding) was less than 0.05. This estimate was obtained under the assumption that in the future ocean survival rates will be low. Specifically, the 13 lowest survival rates for wild Clackamas coho observed over the last 39 years were used within the simulation model as the basis for estimating the survival rates expected for the next 36 years.

Table 2. Proposed harvest management matrix for lower Columbia River wild coho salmon showing maximum allowable mortality rates for **COLUMBIA RIVER** fisheries.

Parental Escapement		**Marine Survival Index** (based on return of jacks per hatchery smolt)			
		Critical (<0.0008)	Low (< 0.0015)	Medium (< 0.0040)	High (> 0.0040)
High	> 0.75 full seeding	< 4.0%	< 7.5%	< 15.0%	< 22.5%
Medium	0.75 to 0.50 full seeding	< 4.0%	< 7.5%	< 11.5%	< 19.0%
Low	0.50 to 0.20 full seeding	< 4.0%	< 7.5%	< 9.0%	< 12.5%
Very Low	0.20 to 0.10 of full seeding	< 4.0%	< 6.0%	< 8.0%	< 10.0%
Critical	< 0.10 of full seeding	0.0 – 4.0%	0.0 – 4.0%	0.0 – 4.0%	0.0 – 4.0%

With respect to these harvest matrices, there are several critical points that should be recognized. First, all harvest rates are expressed as maximums and not desired targets. Therefore, a harvest rate lower than maximum can be selected if it is biologically warranted. For example in Table 2, if the observed parental abundance was 0.60 of full seeding and the observed marine survival index was 0.0009, the "low" survival matrix column would be used to find the maximum harvest rate. However, because 0.0009 is much closer to the threshold for the "critical" survival column, the actual harvest rate might be set at 5.0% rather than the maximum indicated this matrix cell (7.5%). The harvest matrix tables are intended to be used in a manner that will provide this kind of flexibility.

Second, when the parental abundance declines below 0.10 of full seeding (critical category), the relationship between spawners and subsequent recruits becomes increasingly uncertain and unreliable. It is possible that at these levels population recruitment will largely fail. Biologically, any additional mortality at such levels is risky. Ideally, when a population gets to these levels, fishery impacts should be scaled back to zero. However, both the ocean and in-river matrices have an allowable

harvest rate within this zone. These rates (8% for the ocean and 4% for in-river) do not represent a threshold of biological risk. They are fishery management thresholds, below which the number and magnitude of fisheries that must be shut down has a very high social and economic cost. Therefore, when the parental escapement is within this range all efforts will be made to reduce fishery impact to as close to zero as possible, recognizing that other practical considerations may make it necessary to allow fishery rates as high as 8% in the ocean and 4% within the Columbia.

As noted earlier, the proposed harvest management strategies for the ocean and in-river fisheries are expected to result in the conditional total exploitation rates for lower Columbia River wild coho as described in Table 3. Although these cumulative harvest rates may appear excessive for the recovery of an endangered species, the analyses performed by ODFW suggests that as long as the structure of the matrix is adhered to, the likelihood and speed to recovery will not be adversely effected (Appendix 1). This, perhaps counter-intuitive, conclusion likely has its origin in several key characteristics of coho salmon in the lower Columbia River and the harvest management strategy that is proposed in this plan.

Table 3. Likely cumulative exploitation rates for lower Columbia River coho under the combined management protocols proposed for setting ocean and in-river fishery harvest rates.

Parental Escapement		**Marine Survival Index** (based on return of jacks per hatchery smolt)			
		Critical (<0.0008)	Low (< 0.0015)	Medium (< 0.0040)	High (> 0.0040)
High	> 0.75 full seeding	**< 11.7%**	**< 21.4%**	**< 40.5 %**	**< 57.4%**
Medium	0.75 to 0.50 full seeding	**< 11.7%**	**< 21.4%**	**< 29.2%**	**< 49.8%**
Low	0.50 to 0.20 full seeding	**< 11.7%**	**< 21.4%**	**< 22.7%**	**< 34.4%**
Very Low	0.20 to 0.10 of full seeding	**< 11.7%**	**< 16.3%**	**< 18.1%**	**< 19.9%**
Critical	< 0.10 of full seeding	**0.0 – 11.7%**	**0.0 – 11.7%**	**0.0 – 11.7%**	**0.0 – 11.7%**

First, ocean survival rates that fall into matrix column category of "high" are relatively rare. For example, over the last 30 years there have been only 4 times when ocean survival rates have been in this range. In contrast, survival rates in the "low" or "critical" matrix categories have been more common (12 of the last 30 years), as have been survival rates

that would fit into the "medium" survival category (14 of the last 30 years). Therefore, if the recent past is predictor of the future, the maximum harvest rates imposed on this species will most likely be those found in the "critical" through "medium" survival columns of the harvest matrix.

Secondly, the capacity of the species to rebuild from very depressed levels appears quite strong as long as the ocean conditions are better than the "critical" matrix category. For example, it can be demonstrated for the Clackamas population, that even when the parental escapement is very low (580 fish or 0.15 of full seeding), recovery is still likely under most ocean survival conditions. More specifically, the number of smolts produced by 580 spawners in the Clackamas basin would be sufficient to yield an adult return 2,733 coho under survival conditions that would be categorized in the matrix table as "low". Under the management scenario described by these matrices, the cumulative harvest rate for this combination of conditions would be 11.7%. This would result in a post-fishery escapement of 2,413 spawners into the Clackamas basin. Such an escapement is 60% of the level necessary for full seeding and would meet the de-listing criteria for spawner abundance described later under Element 9 of this plan.

Using the same example, if ocean survival rates were in the "medium" range, the post-fishery escapement for the Clackamas would be 3,835 spawners and if the survival rates were in the "high" range, 5,330 spawners could be expected. Both of these escapements would exceed the level of spawners necessary for full seeding of the habitat for smolt production.

However, this apparent robust performance deteriorates rapidly when ocean survival rates descend into the "critical" range of the matrix. In fact, if the ocean survivals observed for the worst 3 years in the recent past occurred for the next 30 years, extinction of this species would be virtually assured – even if fishery impacts were reduced to zero.

In summary, variations in ocean conditions can yield extreme differences in the number of returning adult coho, and thereby the trajectory of species recovery. Because this extreme variation in recruitment response is primarily a function of ocean survival rates, a modest scaling up of harvest rates linked to increased ocean survivals when parental escapements are not at critical levels, will not adversely effect the conservation of this species.

Strategy 2. Hatchery Program Management

ODFW's hatchery programs will contribute to the conservation and recovery of lower Columbia River coho in several ways. This includes: utilizing conservation hatchery approaches to aid natural production; allowing passage above hatchery weirs for natural spawning; and minimizing adverse impacts of mitigation and harvest augmentation hatchery programs on the genetic, behavioral, ecological, and pathological characteristics of wild fish stocks.

Conservation Hatchery Programs - Conservation hatchery approaches, will be used in the short-term to help re-establish and rebuild depressed wild coho populations in select areas. These areas will be selected based on the status of wild fish, history of potential hatchery influence, quality of existing habitat, availability of appropriate broodstocks, funding for hatchery program (including evaluation), logistics, prior success of hatchery approaches, and public and co-manager input. Intervention with conservation hatchery approaches will be viewed as experimental and include monitoring and evaluation for adaptive management. Areas selected for implementation will be used to help evaluate the relative success of hatchery intervention approaches.

An immediate opportunity for using hatchery fish to re-establish wild populations exists for those areas upstream of artificial adult migration barriers that currently exist at several ODFW hatcheries (see also Strategy 3 description). Within 9 months from the approval date of this plan ODFW will complete a feasibility study that will identify which locations will be targeted for re-establishment of wild populations through the use of hatchery fish. This feasibility study will consider risks to hatchery operations, availability of funds to construct and operate fish passage infrastructure, the likely net gain to wild fish production resulting from these projects, and the ability to conduct genetic studies to quantify the reproductive success of naturally spawning hatchery fish over multiple generations. A preliminary assessment suggests that the greatest opportunities for these projects may exist for Cedar Creek (Sandy basin), Big Creek, and North Fork Klaskanine River.

The majority of tributary streams in the lower Columbia below the mouth of the Willamette River do not have artificial barriers blocking access to naturally spawning coho. However until 2000, there had been a period of least 6 years during which ODFW had observed virtually no wild fish in these tributaries. The pattern changed abruptly in 2000 when naturally spawning fish were observed in at least 75% of the areas surveyed outside of the Sandy and Clackamas basins. This event appears to be the result of a substantial increase in ocean survival rates

and a background level of natural production that had been too small to be detected in previous years. Similar improvements in ocean survival are expected to continue and will likely benefit the 2001 return, and perhaps the 2002 return as well. If the pattern observed in 2000 continues for these next 2 years, wild populations may be able to re-establish themselves without intervention, or local populations of wild coho may be available for conservation hatchery broodstocks.

ODFW will postpone the addition of hatchery fish to these areas until 2003 when the results from the 2001 and 2002 returns become known. ODFW will develop a hatchery intervention program to begin in 2003 for a subset of those areas where fewer than 2 fish per stream mile are observed in 2000, 2001, and 2002. As part of the plan implementation progress report prepared for 2003, a detailed assessment of the benefits and risks of initiating releases of hatchery fish into these underseeded areas will be presented. The recommendations for proceeding with these hatchery projects will be made under the general consideration that their potential for success is uncertain and therefore should be carried out in a cautious and experimental fashion.

Once wild populations are re-established in-concert with conservation hatchery programs, and as other populations are re-established through natural re-colonization, ODFW will minimize the risk of adverse interactions between hatchery and wild fish, and phase out conservation hatchery programs as appropriate.

Mitigation and Harvest Augmentation Hatchery Programs – The bulk of the hatchery programs for lower Columbia River coho are for the purposes of fishery augmentation and habitat mitigation. The objective of such programs is to produce fish for fisheries in the most efficient way possible while minimizing ecological and genetic impacts to wild fish and natural production. The strategies outlined in this plan are intended to provide the guidance necessary for such hatchery programs to meet the conservation portion of this goal with respect to wild lower Columbia River coho.

Information collected in 1999 and 2000 suggests that while the Sandy population may currently have a level of naturally spawning hatchery fish that is adequately minimized (5% hatchery fish), the level of hatchery fish for the Clackamas population (17%) may be too high (Appendix 2). These calculations were determined from estimates of hatchery percentages observed in spawning areas weighted by the amount of habitat those areas represent in the context of the entire population. For example, in the upper Clackamas above NF Dam the percentage of hatchery fish is essentially zero. Downstream of the NF Dam however, the percentage of hatchery fish in 2000 was 40%. The area downstream

of NF Dam represents only 42% of the coho habitat for this population (117.6 out of the total 279.4 stream miles). Therefore, weighted by available habitat the overall population estimate for hatchery percentage for the Clackamas population is (42%)*(40%) = 17%.

In addition, once wild populations are re-established within the remaining geographical area for this species, there may be problems with too many hatchery fish straying into these natural production areas as well. In general, ODFW's long-term plan for the management of coho hatcheries in the lower Columbia is based on strategies that are intended to more clearly measure the magnitude of the hatchery stray problem and then create and implement solutions to correct problem areas when they are found to exist. The range of possible solutions will include adjustments to the current hatchery program in terms of numbers of smolts produced, the location of where smolts are released, re-establishing abundant wild populations, and creating wild fish sanctuary areas.

For the Clackamas population, federal Mitchell Act funding cuts will reduce the number of hatchery smolts released from Eagle Creek National Fish Hatchery (Clackamas basin) from the level of 1,000,000 smolts in 1999 to 500,000 smolts in 2002. This reduction will likely bring the proportion of hatchery fish in the Clackamas, weighed against the available habitat (above and below North Fork Dam), down to about 8% (Appendix 2), thereby reducing the potential for adverse genetic, ecological, and pathological interactions.

In addition to these measures, certain areas lend themselves to being sanctuaries for wild fish. Such locations are characterized by an artificial barrier and trapping facility at which hatchery fish can be prevented from passing upstream. Obviously, this strategy first depends on a wild population being re-established in these areas. Currently, it is possible to manage the Clackamas and Sandy populations in this fashion. The Hood River may also be managed in this manner after a wild population is re-established. Additional locations will generally take modification of existing barriers and additional provisions for fish trapping. However, the cost of trapping and removing hatchery fish from the population of spawners that go upstream into these areas, once and if wild populations are re-established, will be weighed against the potential of each location in terms of its contribution to future natural coho production and the restoration of natural genetic processes for lower Columbia River coho.

Finally, additional changes in ODFW hatchery programs to reduce the number of stray hatchery fish may be necessary in the future. These changes will be based on the survival and characteristics of wild coho

populations and the overall goal of reducing unintended interactions between hatchery and wild fish. The current production levels and release sites for lower Columbia hatchery coho smolts are presented in Table 4. If additional changes in these programs are found to be necessary they will be highlighted as part of each annual coho recovery plan review and presented to the OFWC for approval as is appropriate.

Table 4. Current and proposed hatchery coho smolt releases in lower Columbia basin tributaries.

Release Site	Current Smolt Release	Proposed Smolt Release
S. Fork Klaskanine	650,000	650,000
Youngs Bay	2,450,000	2,450,000
Tongue Point Net Pen	200,000	200,000
Blind Slough Net Pen	300,000	300,000
Big Creek	335,000	335,000
Eagle Creek NFH[a]	700,000	500,000[b]
Sandy	700,000	700,000
Tanner Creek	1,175,000	1,175,000
All Programs	6,510,000	6,310,000

[a] Eagle Creek National Fish Hatchery is operated by the US Fish and Wildlife Service.
[b] Reduction in smolt production reflects programming decisions made by the US Fish and Wildlife Service.

Strategy 3. Land Management

Within the lower Columbia River basin, ODFW manages 8 hatcheries (Klaskanine, Big Creek, Gnat Creek, Sandy, Clackamas, Bonneville, Cascade, and Oxbow) and the Sauvie Island Wildlife Area. The land associated with these facilities will be managed in accordance with existing survival guidelines approved by the Oregon Fish and Wildlife Commission for lower Columbia River wild coho as described in OAR 635-100-0135(2).

These guidelines include the provision for fish passage and intake screening at all artificial stream barriers. Most ODFW facilities do not currently meet this provision. In correcting this situation, ODFW will proceed on a schedule that is prioritized on the basis of potential gains for natural coho production, the likelihood of obtaining the necessary construction and operational funds, and disease consequences to existing hatchery production.

At passage barriers associated with hatchery weirs, the ability to trap and prevent excess hatchery fish from passing upstream may be a critical and a required feature of the proposed passage facility. This is necessary to manage the proportion of hatchery and wild spawners to maximize natural production potential and minimize risks from adverse genetic, behavioral, and ecological interactions. For example, simply passing all fish that are now blocked by existing barriers will, in most cases, cause a very large number of hatchery fish to enter natural spawning areas. Their potential to greatly outnumber any wild fish that may be produced in these areas could cause an effective loss in the fish production potential of these restored habitats.

Provisionally, it appears that the highest priority for passage and intake screening includes the following hatcheries: Klaskanine, Big Creek, Sandy, and Oxbow. Of lesser priority for similar modifications are Gnat Creek, Cascade, Bonneville, and Clackamas hatcheries, plus Sauvie Island Wildlife Area. To help assist in the implementation of this recovery plan, ODFW will hold quarterly coordination meetings with the lower Columbia River coho public advisory board. One of the major topics addressed at these meetings will be ODFW's progress in providing passage at effected hatcheries and wildlife areas.

Element 4 - *State whether the plan will contain a monitoring component and provide a description of this monitoring effort as appropriate.*
Present monitoring efforts will continue. This includes adult and smolt enumeration at NF Clackamas Dam, Scappoose Creek ladder, and the Hood River basin. Also included will be ongoing adult counting efforts at Marmot Dam. Existing spawning surveys in lower Columbia tributaries will be expanded and revised so that methodologies are consistent with the spawning survey protocol used by ODFW in coastal basins. Juvenile abundance surveys in lower Columbia tributaries will also continue, but with revised methodologies so that the results will be comparable with coho juvenile density estimates measured in coastal basins.

All conservation hatchery program initiatives implemented under this plan will require monitoring and evaluation for adaptive management. This monitoring and evaluation will aid in reducing uncertainties associated with conservation hatcheries and help contain the risks associated with hatchery and wild fish interactions.

For those wild populations that are re-established upstream of existing hatchery barriers, monitoring efforts will be expanded to count the number of wild adults that pass into these areas each year. As is feasible, downstream migrant traps will also be installed at these locations and annual out-migrations of wild coho smolts will be enumerated.

All of the new or modified monitoring actions proposed in this plan will require financial support from as yet undetermined sources.

Element 5 - *State whether the agency will reassess the plan and its implementation on a regular schedule.*
Six years after the Commission adopts the conservation plan, a comprehensive review will be conducted to determine the effectiveness of strategies implemented under this plan to conserve and recover the species. During the interim, informal meetings will be held once every 3 months to report on progress towards implementing plan objectives, including the annual setting of allowable fishery harvest rates on lower Columbia River wild coho. In addition, ODFW will brief the Oregon Fish and Wildlife Commission annually on the status of lower Columbia River wild coho and the progress being made to implement the conservation plan.

Element 6 - *Describe how ODFW's plan relates to other state agency plans, federal recovery plans, and other recovery efforts.*
Strategies implemented by ODFW to conserve lower Columbia River coho focus primarily on the non-habitat related issues of fishery harvest and interactions between hatchery and wild fish. Recovery efforts by other state agencies and other entities relate primarily to the protection and restoration of habitat for coho salmon. ODFW strategies are designed to ensure that fishery impacts and hatchery programs will be managed in such a way that gains in habitat quality and quantity will be fully realized by wild coho populations in the lower Columbia River.

Although lower Columbia coho are not currently listed under the federal endangered species act, they are under review. They may become listed as a threatened or endangered species as early as July 2002. In this event, ODFW believes that the actions carried out under Oregon's endangered species law will be consistent and compliment the recovery of this species under a federal ESA listing.

Element 7 - *Describe the agency's process used to develop the plan, including review and approval process, if any.*
The technical basis for understanding the status of lower Columbia coho was an independently reviewed status report prepared in 1999. From this understanding plus updates for the 2000 return year, a series of ODFW meetings were held to discuss possible conservation options. A non-Department review group comprised of interested publics, conservation groups, fishing organizations, and representatives from city, state, and federal agencies involved with fish management was also

formed. This group reviewed various elements of ODFW's plan and made suggestions for how they might be improved.

Additional Elements of ODFW's Management Plan

Because of ODFW's unique role as the primary agency responsible for the conservation and monitoring of this species, other elements were added to this plan to help provide context for status and recovery. In particular, these additional elements included an update of the status review of the species and a description of short and long-term biological benchmarks by which progress towards conservation and recovery of the species could be measured.

Element 8 – *Describe current biological status of listed species.*
The status of lower Columbia River coho salmon was reviewed most recently in 1999 (Chilcote, 1999). This assessment concluded that within the Columbia River, wild coho were likely extinct from their native range with the exception of the Sandy and Clackamas basins. Further that the wild coho remaining in these two basins were at considerable risk, especially those in the Sandy. This assessment was the technical basis leading to addition of this species to the state endangered list in July 1999.

Since this assessment, data from the 1999 and 2000 return years have become available. In 1999, the observed spawner escapement for the Sandy and Clackamas populations was 162 and 247, respectively. These levels appeared to be a continuation of the extremely poor escapement experienced by these populations during the last 3 years. However, the following year, 2000, the return increased substantially. For the Sandy, the count of wild coho at Marmot Dam was 730 fish. For the Clackamas 2,218 wild coho were observed passing North Fork Dam. In addition, during the 2000 survey season, wild coho were observed in Columbia River tributaries downstream from the mouth of the Willamette River for the first time in at least 6 years. It appears that remnant, previously undetected wild populations may still exist in some of these tributaries.

Although the observations during 2000 were encouraging, three consecutive years of improved returns are necessary before it can be claimed the status of these populations has significantly changed. Therefore, it is concluded that this species remains at great risk and that there is no justification for reconsidering its current designation as a state endangered species.

Element 9 – *Describe measurable criteria that define the minimum conservation goal for this species that if achieved would justify removing the species from Oregon's endangered species list.*

The objective of an endangered or threatened species listing is to facilitate special actions that will result in the recovery and eventual de-listing of an at risk species. ODFW developed criteria to provide a benchmark by which progress towards recovery and de-listing could be objectively measured. If the status of lower Columbia River coho improves sufficiently that the following criteria are met, then an endangered or threatened species designation is no longer biologically appropriate.

Six populations of wild coho were tentatively defined, for the purposes of describing the biological status of lower Columbia River coho. The geographic boundaries for each these populations are presented in Table 5 and illustrated in Figure 1. It is unlikely natural populations currently exist within several of the areas defined by these geographic boundaries.

Table 5. Description of geographic areas within which naturally reproducing, demographic independent populations of wild coho currently exist or for which they will likely exist in the future.

Population	Geographic Description of Habitat	Stream Miles
Astoria	Youngs Bay tributaries and all Columbia tributaries upstream to and including Gnat Creek.	57.3 (75.9)[a]
Clatskanie	All Columbia River tributaries upstream of Gnat Creek to and including the Clatskanie River Basin.	40.6
Scappoose	All Columbia River tributaries upstream of the Clatskanie River to the mouth of the Willamette.	62.6
Clackamas	The Clackamas River basin plus all tributaries to the Willamette River downstream of Willamette Falls.	279.4
Sandy	The Sandy River basin plus all Columbia River tributaries from the mouth to the Willamette River to the mouth of the Sandy River.	150.4 (163.6)[a]
Bonneville	All Columbia River tributaries upstream to and including the Hood River basin.	63.3 (67.8)[a]

[a] Total stream miles if artificial barriers at ODFW hatcheries removed.

However, once recovery goals are achieved and wild coho are common in the lower Columbia River basin, it is expected that they will re-establish populations with a structure similar to the 6 populations described in Table 5.

De-listing Criteria – Minimum Goal for Conservation

Population Distribution and Structure – Self-sustaining wild populations are present in the Sandy and Clackamas basins. In addition, at least 2 of the following populations (Astoria, Clatskanie, Scappoose, or Bonneville) are self-sustaining.

Diversity – Naturally reproducing wild coho are present in 65% of the named streams that historically contained coho. Human activities impose only minor artificial selection pressures on the phenotypic character of the wild populations (e.g., run timing, spawn timing, size, sex ratio, and jack to adult ratio). The ongoing impact of hatchery fish on the genetic character, evolutionary processes, and innate productivity of naturally reproducing populations is minor.

Abundance – For three consecutive years, the number of wild spawners is at least 50% of the level necessary to produce maximum smolt recruits for the Sandy, Clackamas, and in at least 2 of the following populations: Astoria, Clatskanie, Scappoose, and Bonneville. Based upon current estimates of smolt capacity and recruitment this equates to 670 spawners for the Sandy and 1900 spawners for the Clackamas. For the other tributaries, the number of spawners necessary to meet this abundance target is yet undetermined. However, preliminary estimates for these targets based on the production potential of existing stream habitat, will be completed by 2003.

Connectivity – No artificial barriers exist that prevent the dispersing of wild coho between naturally reproducing populations.

Persistence and Resilience – The probability of extinction in 36 years for the Sandy and Clackamas populations, as forecast using a population viability model, is less than 0.05. The probability of extinction for all re-established populations is also less than 0.05 in 36 years. In the case of re-established populations, the method used to forecast the probability of extinction may have to rely on methods other than a formal population viability analyses.

Element 10 - *Describe measurable criteria that define the long-term recovery goal for this species. If the species achieves these criteria it will be considered biologically healthy and fully recovered.*

Desired Future Conditions – Long-term Recovery Goal

Population Distribution and Structure – Self-sustaining wild populations are present in the Sandy and Clackamas basins. In addition, the following populations (Astoria, Clatskanie, Scappoose, and Bonneville) are self-sustaining.

Diversity – Naturally reproducing wild coho are present in 85% of the named streams that historically contained coho. Human activities impose insignificant artificial selection pressures on the phenotypic character of the wild populations (e.g., run timing, spawn timing, size, sex ratio, and jack to adult ratio). The ongoing impact of hatchery populations on the genetic character, evolutionary processes, and innate productivity of naturally reproducing populations is insignificant.

Abundance – Over a 12-year period of normal fluctuations in ocean survival, the number of wild spawners is at least 80% of the level necessary to produce maximum smolt recruits. Based upon current estimates of smolt capacity and recruitment this equates to 1066 spawners for the Sandy and 3042 spawners for the Clackamas. For the other tributaries, the number of spawners necessary to meet this abundance target is undetermined. However, preliminary estimates for these targets based on the production potential of existing stream habitat, will be made by 2004.

Connectivity – No artificial barriers exist that prevent the dispersing of wild coho between naturally reproducing populations.

Persistence and Resilience – Using a population viability model, all populations will be found to have at least a 95% probability that their future abundance will greater than the abundance threshold for listing. The abundance threshold for listing, as described earlier, is defined as 50% of the spawners necessary for maximum production of smolt recruits.

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Appendix 1

Fishery Management Protocol

Analytical Basis and Rationale for Strategies under Oregon's Endangered Species Rules to Manage the Fishery Impact on Endangered Lower Columbia River Wild Coho Salmon

Introduction and Analytical Concepts

Lower Columbia River coho salmon have been listed as an endangered species under Oregon's threatened and endangered species law. As a result, the Oregon Department of Fish and Wildlife (ODFW) has prepared a conservation and recovery plan for this species. One element of this plan is a description of how fisheries will be managed in the future to ensure these fisheries will not adversely impact the recovery of wild coho populations in the lower Columbia basin. The following is a description of the analytical rationale and management protocol that ODFW will use to accomplish its fishery management responsibilities under the endangered species management plan.

Fisheries can have a variety of impacts on a species, but the primarily they increase mortality on adults and thereby reduce overall life history survival. The extent to which a salmon population can withstand such pressures is a function of 3 critical factors:

1. the current abundance and distribution of the wild spawners,
2. the efficiency with which these spawners produce smolt offspring (in other words the number of smolts produced per parent), and
3. the annual ocean smolt to adult survival rate.

For lower Columbia River coho populations these factors can be measured or estimated with varying levels of certainty. Therefore, it is possible to construct a model that will forecast the probability a population will fall below a critical abundance threshold at some point in the future. In addition, this model can be used to assess how the population will respond to a variety of different hypothetical harvest rates over a given time period.

The following is a conceptual description of this model with specific evidence to support its key assumptions. Throughout Appendix 1 the focus will be on the population of coho in the Clackamas basin. This focus is due to the fact that data for the Clackamas population are relatively comprehensive and therefore well suited to the description and development of a population assessment model. However, application of this model to the Sandy population will also be addressed in the latter portion of Appendix 1.

Wild coho are known to exist in the Clackamas basin. Adult fish counting facilities have been operated since the early 1960s and therefore estimates of wild spawners are available for a time series spanning 40 years. Also available are counts of wild coho smolts emigrating from the basin each spring since the 1960s.

These data can be arranged such that the relationship between the number of spawners and subsequent wild smolts produced can be graphically and mathematically described. As shown in Figure 1, it appears that the number of smolts produced is positively related to the number of parental spawners. Although less apparent, the data suggest that maximum smolt production occurs at a spawner escapement level of approximately 3800 spawners.

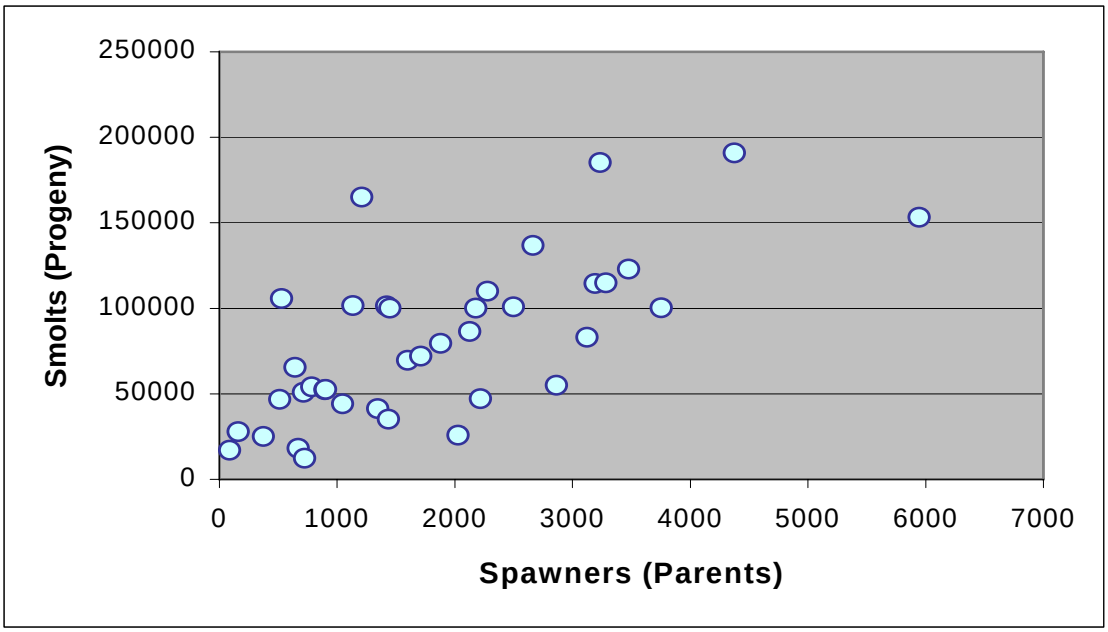

Figure 1. Number of wild coho smolts observed emigrating from the Clackamas River from 1961 to 1999 as a function of parental spawner abundance.

Although the relationship between spawners and subsequent smolt recruits can be described by a simple linear model, the more complicated Ricker recruitment model was used. The rationale for using the more complicated model was that it appeared that as the density of spawners decreased the number of recruits per spawner increased (Figure 2). Such a recruitment behavior is inconsistent with the linear model which yield a fixed recruits per spawner at all spawner abundance levels.

The specific equation describing the relationship between spawners and smolt recruits for Clackamas wild coho was:

$$\text{Smolts}_t = \text{Spawners}_{t-2} * 2.718^{(\alpha - (\beta * \text{Spawners}_{t-2}))}$$

Where ***a*** and ***B*** are the Ricker equation parameters which were estimated, using the linear method, to be 4.365 and 0.000263, respectively (R^2 =0.27, P<0.001).

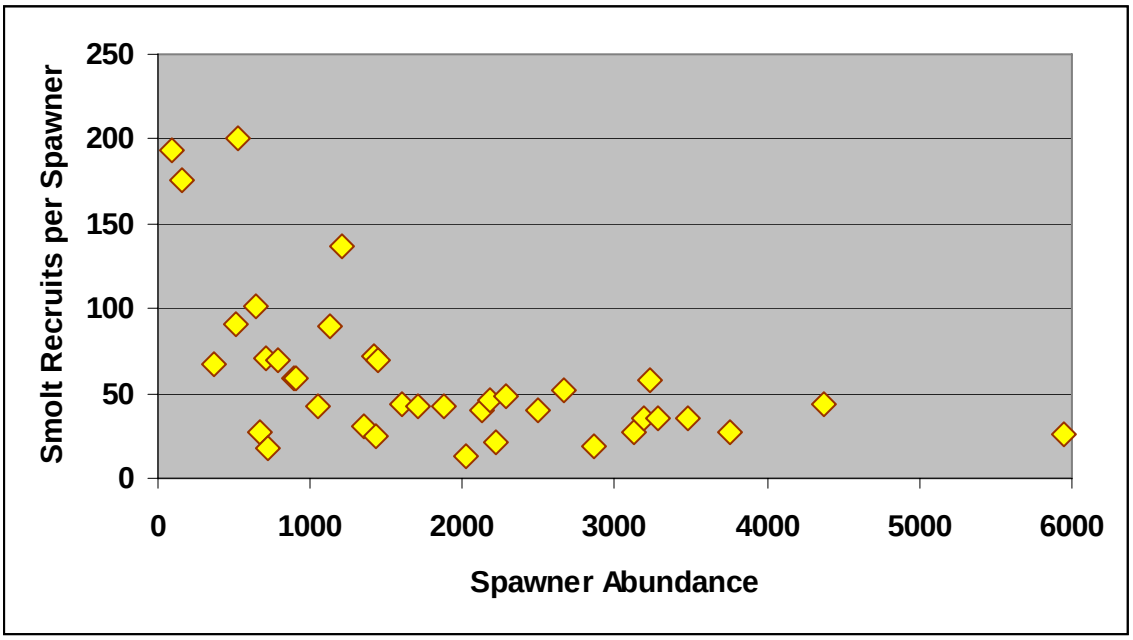

Figure 2. Relationship between spawner abundance and the corresponding ratio of smolt recruits per spawner for wild Clackamas River coho, 1961-1999.

Given this freshwater recruitment relationship, the survival of emigrating smolts to adulthood is strongly influenced by ocean conditions. For wild Clackamas coho these smolt to adult survival has ranged from a high of 22.3% for 1961 to a low of 0.4% in 1995 (Figure 3). This wide of range in survival can have a profound effect on the number of returning adults. For example, an emigration of 100,000 smolts will yield an adult return of over 22,000 fish if ocean survival matches the highest level ever observed for this population. In contrast, if the ocean survival were the same as the lowest level ever observed for the Clackamas population, an out-migration of 100,000 smolts would yield only 400 adults.

It was therefore apparent that in developing a fishery management protocol, the effect of variable ocean survival rates had to be incorporated. It was hypothesized that coho populations could withstand higher rates of fishery mortality during periods of good ocean conditions, and much lower mortality rates when ocean conditions turned bad. The first portion of the fishery management protocol was based on the development of a model to determine the critical fishery mortality rate under a variety of different ocean survival conditions.

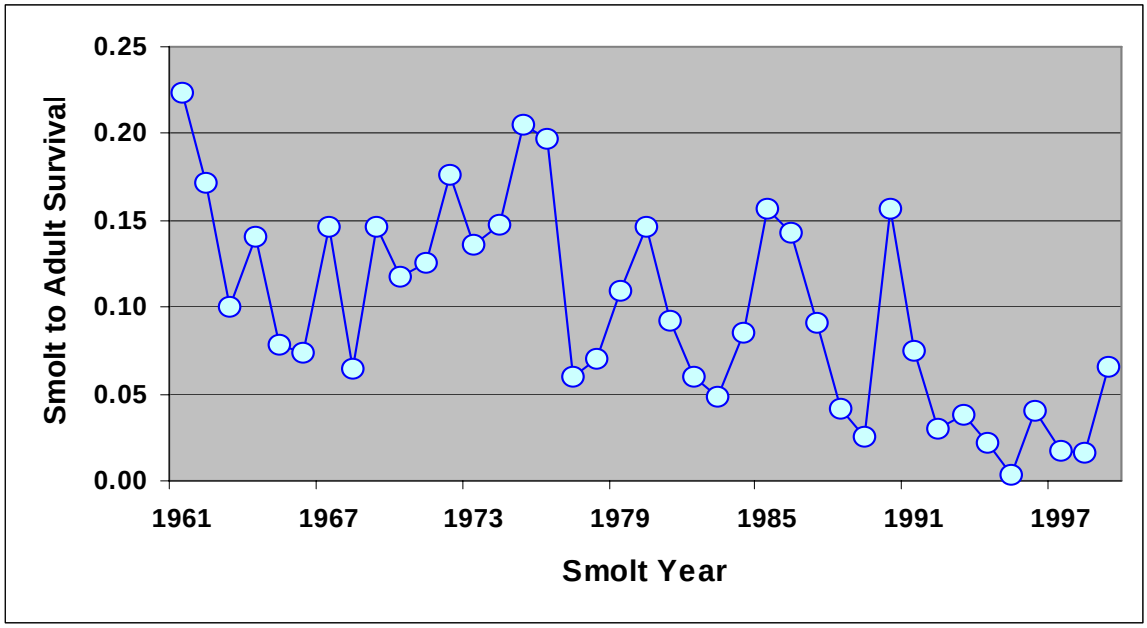

Figure 3. Estimated smolt to adult survival for wild Clackamas coho, 1961-1999.

The critical fishery mortality rate was defined as the mortality rate at which the probability of population extinction would be 5% over a 36-year period. This probability of extinction was determined using a population viability model based upon the adult to smolt recruitment relationship described earlier for Clackamas coho. The primary stochastic effect introduced into this model was the variation associated with the fit of the Ricker recruitment curve to the observed spawner and smolt recruit data points. The critical fishery mortality level was calculated for 10 different ocean survival rates, ranging from 0.03 to 0.18. These results were displayed graphically with the y-axis representing the critical fishery mortality rate and the x-axis representing ocean survival (Figure 4).

It was determined that the relationship between ocean survival and critical fishing mortality rate could be described with a high degree of accuracy ($R^2 > 0.98$) by the equation:

$$\text{Critical Mortality Rate} = 1 - [c * (SA)^b];$$

where *c* and *b* are parameters for a power curve, and *SA* is the ocean smolt to adult survival.

Although ocean survival is a critical factor in determining population recruitment, so is parental escapement. The foregoing critical mortality rate curve (Figure 4) was developed under the assumption that the starting populations size was 50% of the level necessary to produce

maximum smolts. However, it was suspected that the shape of this curve would differ for different levels of initial spawner abundance. In particular, it was expected that a population starting from a very low spawner abundance would not be able to withstand the same fishery impact as would one that was initially more abundant.

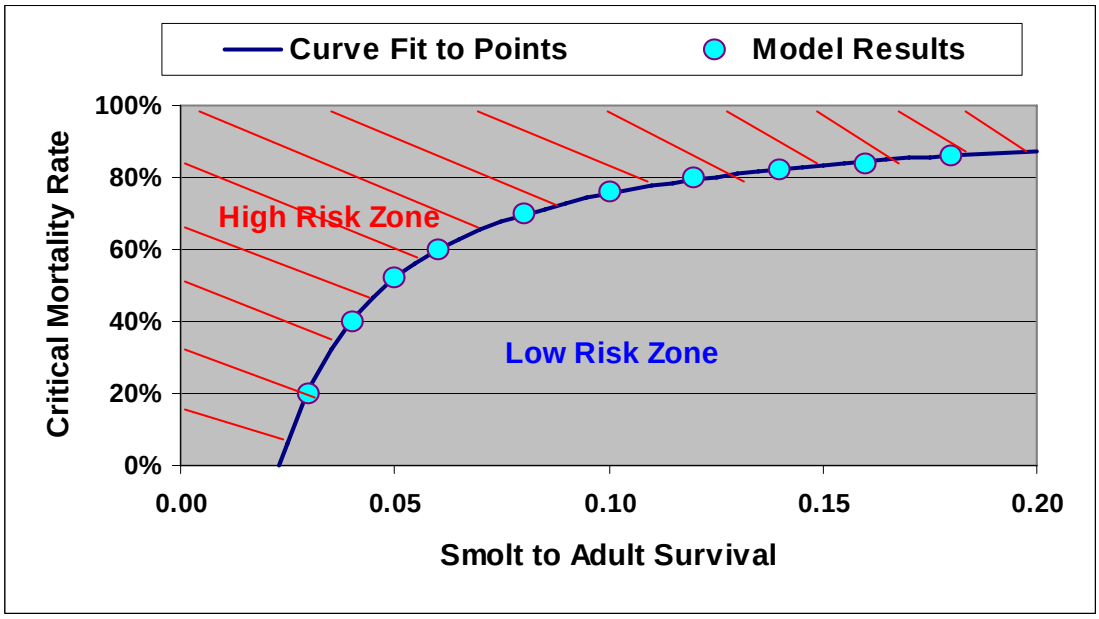

Figure 4. Graphical representation of model results to determine the critical mortality rate over a 36 year period for Clackamas coho under 10 different fixed ocean survival rates and a starting population size 50% of maximum seeding.

Therefore, to assess this additional factor, the sensitivity of the critical mortality rate curve to variations in parental escapement was explored with additional model runs. In these runs, the initial starting population size was set at one of 10 test escapement levels. These levels were standardized with respect to Smax, the number of spawners necessary to yield maximum production of smolts for the basin. Smax was estimated from the ***B*** parameter of the Ricker recruitment equation. For the Clackamas, Smax = 1/-***B*** = 1/.000263 = 3802. The 10 escapement levels evaluated ranged from 0.05*Smax to 0.50*Smax.

This analysis generated a family of critical mortality rate curves, one for each starting abundance level. In general the results suggested that when the starting parental abundance was 0.15 of Smax or greater, the effect of parental abundance on the shape of the critical mortality curve was relatively minor (Figure 5). However, for parental escapements less than 0.15 of Smax (570 spawners) the ability of the Clackamas population to withstand fishing mortality, could be expected to diminish rapidly. For example, when the number of spawners is 0.05 of Smax (170 fish), the extinction probability exceeds that critical level in all but

the highest ocean survival conditions, even in the total absence of additional fishing mortality (Figure 5).

These findings, of course, may not represent the situation in real life. In particular, ocean survival rates never remain constant over a 36 year time period, as this model assumes. However, it was felt these theoretical critical mortality curves could be used as a standardized basis from which a fishery management protocol could be developed. This is the topic of the remainder of Appendix 1.

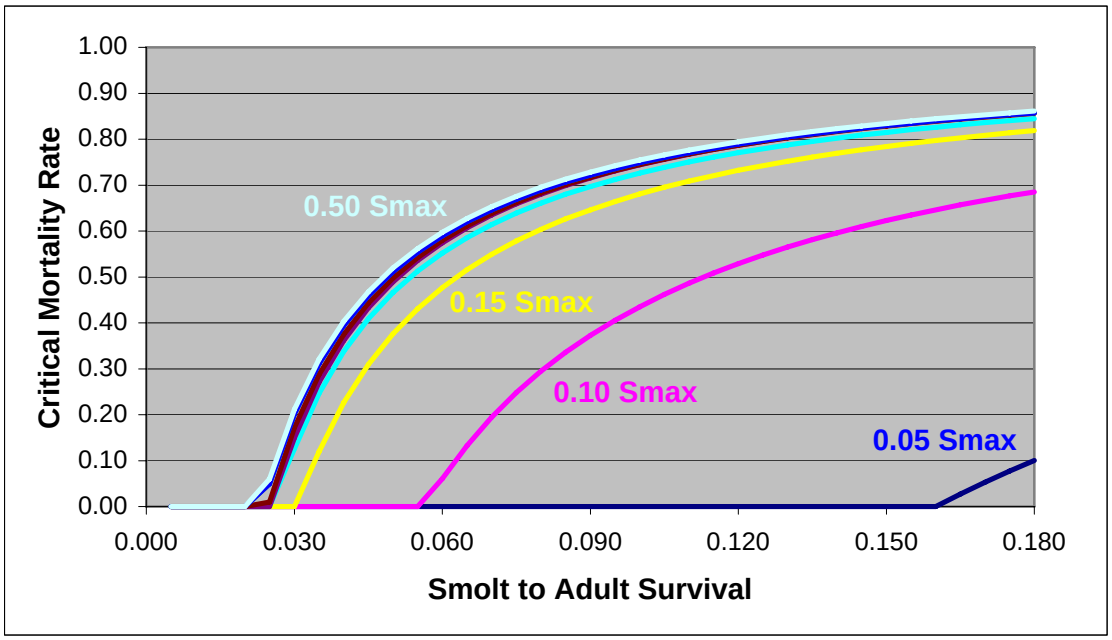

Figure 5. Critical mortality rate curves for 10 different starting escapement levels expressed as a fraction of Smax (see text).

Management Simulation Model and Practical Applications

To be useful in structuring an upcoming fishery, the harvest rate limit on wild coho needs to established before the adults enter the fishery. As discussed previously, two factors seem to be of particular significance in determining this biological limit: ocean survival and parental escapement. Parental escapement can be known with some certainty, especially for a basin like the Clackamas for which direct counts of spawners are made annually. However, ocean survival is problematical. It can be calculated directly only after all the adults have returned to their natal streams. For the pre-season setting of fishing regulations such “after-the-fact” calculations are not useful. Therefore it is necessary to develop a method to forecast survival rates approximately 3 to 6 months in advance of the fishery.

Not all coho return to their natal streams 1.5 years after the enter the ocean. A portion of the population, referred to as "jacks", return after only 4 or 5 months at sea. These jacks can be used as a predictor for the adult return. The reason is jacks in year 0.5x and adults in year 1.5x out-migrated together as smolts. Therefore, they experienced the same initial ocean conditions. Since ocean conditions are a powerful factor in controlling coho abundance it is no surprise that the jack return should be predictive of the adult return one year later. Although there is no index of jack survival for the Clackamas wild coho, there does exist an index for Oregon Production Index (OPI) coho, primarily based on smolts originating from hatcheries within the from the Columbia basin. When this index was regressed against smolt to adult survivals for Clackamas wild coho, the data fit a 2nd order multinomial regression in the form of: $y = -5515.8(x^2) + 57.159(x) + 0.0156$ (Figure 6).

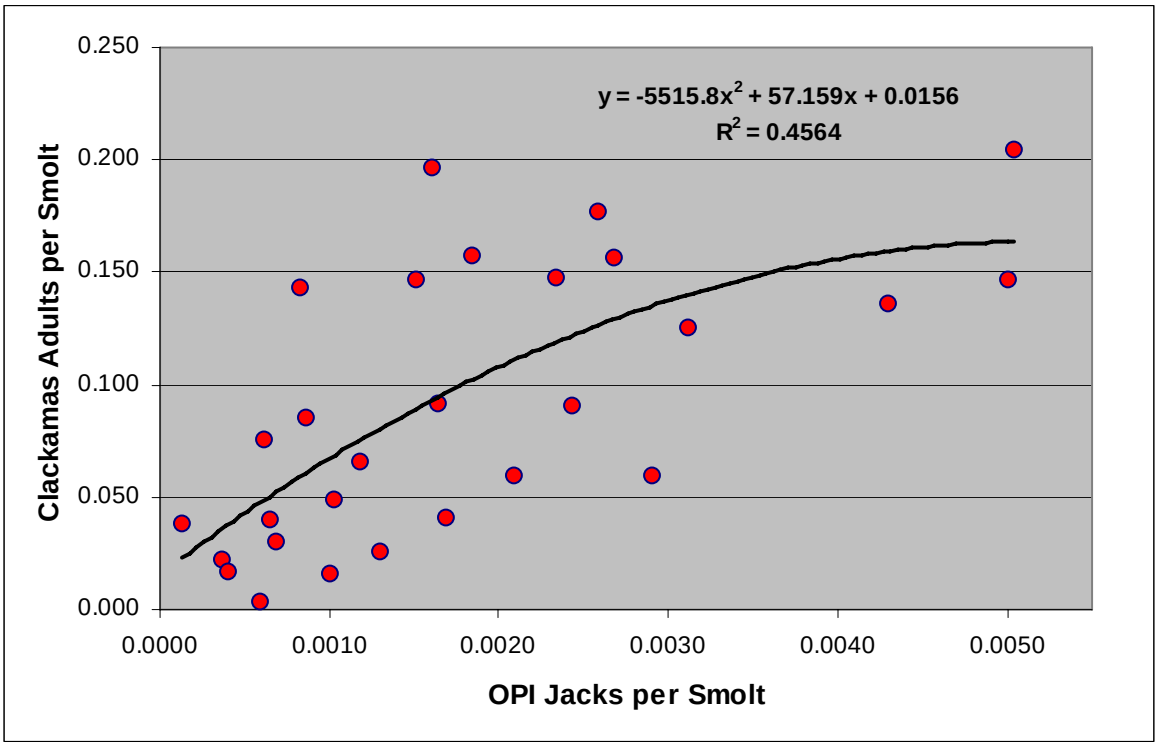

Figure 6. Smolt to adult survival for wild Clackamas coho as a function of the OPI jack survival index (see text).

Although it appeared the OPI jack index could be used to predict Clackamas smolt to adult survival, the relationship between the two variables is not perfect ($R^2 = 0.46$) and therefore the accuracy of these predictions will contain a considerable amount of uncertainty. Given the uncertainties in forecasting smolt to adult survival and those associated with spawner to smolt recruitment, the next question was if a successful management strategy based on these factors could be developed. To examine this question a management simulation model was constructed

to simulate the management of Clackamas wild coho on the basis of the family of critical mortality rate curves illustrated in Figure 5. Of concern was whether it was feasible to implement a management scheme that would stay within the limits defined by the critical mortality curves, given the imprecision inherent with predicting smolt recruitment and ocean survival. Should such an approach prove to be practically unfeasible, then the theoretical conservation benefits of such a management scheme could not be realized.

For each simulation model run, the observed spawner abundance in the most recent 3 years was used as the escapement for the first generation. The production cycle was then run forward 12 generations (36 years). Smolt recruits were calculated based upon the spawner to smolt recruit relationship previously described (Figure 1). The conversion of these smolts to returning adults was accomplished by randomly selecting survival rates from a sub-set of observed smolt to adult survival rates for Clackamas coho. As shown in Figure 3, observed survival rates vary considerably and appear to have been in a long-term decline. Because it appears that lower survival rates more closely represent current conditions, a sub-sample of the 13 lowest rates, from the total of 39 observed, was selected to represent the likely ocean survival rates into the future. This sub-sample of 13 data points was used to generate the mean smolt to adult survival and associated variance from which a normal random sample of ocean survival could be obtained.

Upon completion of each cycle of the model run, the number of spawners in the ending brood years (years 34, 35,and 36) were examined and if they were all zero, then the cycle was recorded as an extinction event. For each model run, these 36 year cycles were repeated 5,000 times. After 5,000 cycles had been completed the number of extinction events were counted and divided by 5,000 to obtain the probability of extinction.

Fishery mortality was also imposed upon simulated populations each reproductive cycle. The level of fishery mortality rate was either fixed at 0%, 10%, 15%, 30%, 40%, and 60%, or it was structured on the basis of the critical mortality rate curves described previously. Additional discussion is necessary to describe how this structuring occurred. First, for each of the 5,000, 36-year cycles that comprised a single model run, a sequence of survival rates were selected from a normal random distribution based upon the 13 lowest observed ocean survivals. This selection process was done before the model began calculating recruitment. This sequence of 36 randomly selected survival rates was used to simulate actual survival rates. The survival rates contained in these sequences were used as the actual survival rate to convert smolts to adults. However, the survival rates used to set the harvest rate limits

were made as if done in real time. In other words, they had to be predicted from an OPI jack survival index rate. Therefore, a sequence of 36 values for the OPI jack index were also needed for each cycle of the model run. These values were generated in the following manner. First, a regression was developed between the smolt to adult survival for Clackamas coho and the OPI jack index for the previous year, essentially this is the reverse of Figure 6, with the jack index on the y-axis and smolt to adult survival on the x-axis.

Using this relationship a sequence of 36 jack survival rates were calculated from the corresponding smolt to adult survival rates that had been randomly selected for each cycle of the model run (as described previously) using the following formula:

$$y = 0.0143(x) + 0.0005 + ((se)(v));$$

where y = predicted jack survival rate, x = the observed smolt to adult survival for wild Clackamas coho, se = the standard error for the regression, and v = represents a randomly selected variable from a normal distribution having mean of 0 and a variance of 1. Therefore, before the management scenario was implemented for each cycle of the model run, a 36-year sequence of "known" jack survival rates and smolt to adult survival rates were artificially created.

Turning now to the real time management portion of the model, smolt to adult survival rates were forecast for the upcoming year from the "observed" jack survival rate in the previous year. The generation of these jack survival rates was as described in the preceding paragraph. Using this survival forecast and the number of parental spawners (previously calculated and recorded in the course of executing the simulation program), the maximum allowable harvest rate was determined using one of the family of critical mortality rate curves illustrated in Figure 5.

To select the proper mortality rate curve corresponding with the simulated parental escapement, the program executed a series of comparisons with the range of escapement values corresponding to each of the 10 curves described in Figure 5. Once the closest match was identified, the corresponding curve was selected and the harvest rate limit calculated. For example, if the parental escapement was 400 adults, then the critical mortality rate curve for 0.10 of Smax was used because this represents the number of spawners, 380, closest to the "observed" parental escapement of 400.

The parameters for the power curve equation describing each of the 10 critical mortality rate curves in Figure 5 are presented in Table 1. It

should be noted than in all cases, a critical mortality rate of zero (no harvest) is generated at ocean survival rates less than 2%. In the case of the curves for the lowest parental escapements, the curve intercepts the zero mortality rate at ocean survivals considerably greater than 5% (Figure 5). Mathematically, the direct computation of maximum harvest rates at such low survivals will yield a negative value for harvest rate, a nonsensical result. To correct this computational problem, when negative harvest rates were estimated, they were set to equal zero.

As shown in Figure 5 and reflected in the equation parameters in Table 1, when the parental abundance becomes greater than 0.45 of Smax, the shape of the curve does not change. Therefore, it was not necessary to expand Table 1 to encompass parental escapement values greater than 0.50 of Smax. When such parental levels were encountered within the model run, the critical mortality rate curve for 0.50 of Smax was used.

Table 1. Parameters used in power curve equations in the form of $y = 1 - c(x^b)$ to describe critical mortality rates (y) based upon smolt to adult survival (x) for 10 different levels of parental escapement.

	Fraction of Smax									
	0.05	**0.10**	**0.15**	**0.20**	**0.25**	**0.30**	**0.35**	**0.40**	**0.45**	**0.50**
c	0.194	0.057	0.035	0.030	0.026	0.027	0.028	0.028	0.026	0.026
b	-0.895	-0.995	-0.965	-0.964	-0.998	-0.978	-0.961	-0.961	-0.969	-0.969

For the model runs with harvest rates structured on the basis of these critical mortality curves, several additional modifications were made. Primarily, these modifications added lower and upper caps to the harvest rate limit determination. This was done in recognition of the fact that harvest rates less than about 5% would be very difficult to obtain for Clackamas coho and that likewise harvest rates in excess of 50% were practically unrealistic. Therefore, model runs were performed for a range of different scenarios having minimum harvest capped at 5% to 15%, and maximum harvest rates limit capped at 30% to 50%.

An example of how these minimum and maximum caps worked in the model runs is as follows. If the minimum harvest rate cap was set at 10% and the critical mortality rate was determined from the equation to be 4%, a 10% harvest rate would be implemented. Likewise, if the critical mortality rate equation yielded a harvest limit of 56% and the maximum harvest rate cap was 30%, then the model would proceed with a 30% harvest rate. For comparison, one model run was performed without any restrictions on minimum or maximum harvest rates, in other words they could range from 0% to 95%.

Simulation Model Results

Results were obtained for 11 different runs of the simulation model under a variety of harvest rate setting scenarios. Of the scenarios tested, only 1 had probabilities of extinction greater than 0.05. This scenario represented the situation where the harvest rate was fixed at 60% (Table 2). All other combinations had extinction probabilities of essentially zero.

However, in addition to the probability of extinction, the probability that the population would not meet the recovery target was also estimated. Recovery, in this case was defined as the population having all three ending brood years with spawner escapements greater than 50% of the level necessary to produce maximum recruitment of smolts, in other words 50% of Smax. Using this standard, the likelihood of not meeting the recovery target was greater than 0.05 for all fixed rate management scenarios except those where the rate was set at 15% or less. In contrast, none of the scenarios where the harvest rate were structured on basis of the critical mortality rate curves were the probabilities of "non-recovery" greater than 0.015. Of particular surprise was the finding

Table 2. Probabilities of extinction and "non-recovery" for Clackamas wild coho under a range of simulated harvest management strategies (see text).

	Minimum Limit	**Maximum Limit**	**Probability of Extinction**	**Probability of Non-Recovery**
Scenario 1	0%	0%	0.000	0.004
Scenario 2	15%	15%	0.000	0.020
Scenario 3	30%	30%	0.001	0.075
Scenario 4	60%	60%	0.621	0.951
Scenario 5	7%	30%	0.000	0.004
Scenario 6	7%	40%	0.000	0.010
Scenario 7	10%	30%	0.000	0.009
Scenario 8	10%	40%	0.000	0.011
Scenario 9	15%	40%	0.000	0.014
Scenario 10	15%	50%	0.000	0.013
Scenario 11	0%	95%	0.000	0.002

that for the management scenario without any minimum and maximum harvest rate caps (scenario 11), the probability of non-recovery was essentially the same as the scenario where harvest was eliminated (scenario 1). Structured management scenarios with minimum and maximum harvest rate caps, did not fare quite as well but were better than the fixed rate scenarios.

It appears a continuous function harvest protocol that incorporates both ocean survival and parental escapement to set maximum allowable harvest rates, can be successfully implemented as practical tool to manage wild coho populations in the Clackamas basin.

Application to Sandy River Coho Population

The Clackamas is the only populations for which annual counts of wild smolts are available. To examine the suitability of the continuous function harvest protocol for managing the Sandy as well as other populations it was necessary to convert adult recruits into smolt recruits. This was done by dividing annual smolt to adult survival estimates for the Clackamas population into the number of adult Sandy River wild coho corresponding to the same smolt year.

The family of critical mortality rate curves generated for the Sandy populations was very similar to those generated for the Clackamas population (Figure 5). Using these curves, the same simulation model runs were performed as had been done for the Clackamas. The results for the Sandy populations were essentially the same as those for the Clackamas population. The probability of extinction and "non-recovery" were less than 0.05 for all of the harvest management scenarios based on the critical mortality rate curves. Likewise, the structured harvest rate scenario without minimum or maximum harvest rate caps (scenario 11) yielded nearly the same result as the no harvest option (Table 3).

Table 3. Probabilities of extinction and "non-recovery" for Sandy wild coho under a range of simulated harvest management strategies (see text).

	Minimum Limit	**Maximum Limit**	**Probability of Extinction**	**Probability of Non-Recovery**
Scenario 1	0%	0%	0.000	0.007
Scenario 2	15%	15%	0.000	0.011
Scenario 3	30%	30%	0.000	0.041
Scenario 4	60%	60%	0.585	0.915
Scenario 5	7%	30%	0.000	0.007
Scenario 6	7%	40%	0.000	0.008
Scenario 7	10%	30%	0.000	0.008
Scenario 8	10%	40%	0.000	0.025
Scenario 9	15%	40%	0.001	0.028
Scenario 10	15%	50%	0.000	0.032
Scenario 11	0%	95%	0.000	0.003

In summary, the application of the continuous function harvest protocol performs equally well for the Clackamas and Sandy populations. Therefore, it will be used as the primary tool to evaluate possible management strategies for this species.

Theoretical Implementation of Continuous Function Harvest Protocol in 1963

To get a better sense for how the continuous function approach to setting fishery harvest rates will perform over a range of escapements and ocean survivals, this method was applied to data for Clackamas coho from 1963 to 2000. Given the method proposed for setting harvest rate limits, this exercise gives some idea what those limits would have been if such an approach had been implemented in 1963.

In this exercise, harvest rate limits were determined under 3 scenarios, all based on the continuous function harvest approach. The first, being without any minimum or maximum constraints placed on the harvest rates determined by the model. The second being otherwise the same except the maximum allowed harvest rate was capped at 40% and minimum allowed harvest rate capped at 10%. Finally, the third scenario was like the second but with the maximum and minimum rates capped at 30% and 5%, respectively. As illustrated in Figure 7, when there were no constraints placed upon the harvest limit calculation (scenario 1), harvest rates for most of the time period were in the range of 55 to 80 percent. However, in the 1990s, there were three years when this scenario would have called for a 0% harvest rate. By contrast, under the other two scenarios, most of the time they were effectively the same as implementing fixed harvest rate of either 40% or 30%. Again, the exception being during the period of the 1990s when lower rates were obtained from the protocol procedure.

These results suggest that during periods of relatively good ocean conditions and parental abundance, scenarios 2 and 3 restrict harvest rates more than necessary to ensure the recovery of the population.

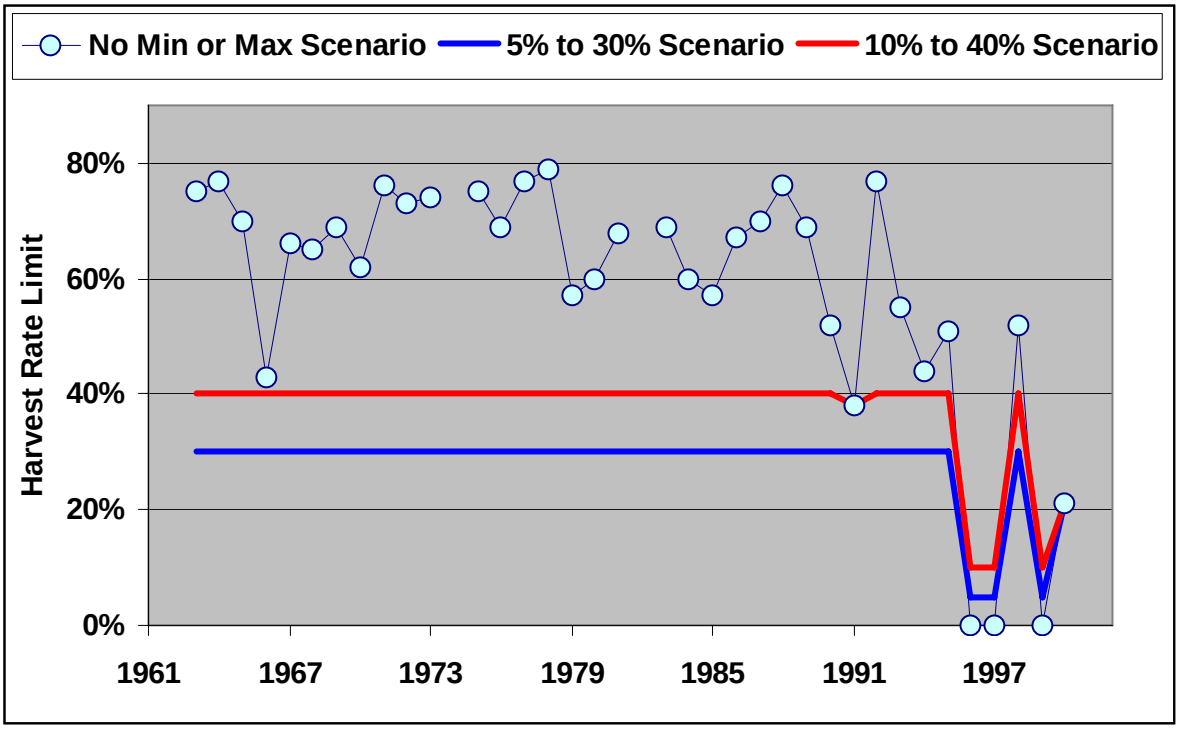

Figure 7. Example of harvest rate limits determined using the continuous function harvest protocol for under 3 different implementation scenarios for Clackamas coho population had these methods been implemented in 1963.

However, when these factors become less favorable, like they did in the 1990s, the unconstrained scenario (scenario 1) would be much more difficult to carry out because it would require harvest rates of 0% in certain years. It is unlikely that such a rate could be achieved in a real life management situation. In this respect scenario 2, 3, or something similar appears to be a better and more practical choice. Especially since the survival rates and parental escapements in the near future is more likely to be in the range of the values observed between 1990 and 2000, than the conditions that characterized the period from 1960 to 1990.

Continuous Function Harvest Protocol and the Harvest Matrix Approach

The harvest management strategy described in ODFW's endangered species management plan for lower Columbia River coho is a harvest matrix that incorporates the effect of parental escapement and smolt to adult survival forecasts. However, the underlying concept of this matrix approach and the evaluation of its potential effectiveness is the continuous function harvest protocol described in Appendix 1. The primary difference being that the matrix is a discontinuous interpretation

of the continuous function model. The matrix approach was selected for use in the endangered species management plan because it is easier to understand and functionally accomplishes the same objective.

The continuous function approach, on the other hand, is conceptually more accurate of the two approaches and was used to evaluate the effectiveness of possible matrices suggested to help conserve this species. These evaluations were relatively straightforward. The continuous function results define a surface of maximum allowable harvest rates that is scaled in one dimension by parental abundance and in the other dimension by forecasted ocean survival. This surface can be thought of as a domed roof on a building. As long as the proposed harvest mortality rate is less than the height of this roof then the population will recover. A harvest strategy that results in mortality rates that under certain combinations of parental escapement and ocean survival exceed the height of this roof are unacceptable because they will put the population at too high of risk.

Therefore, if the maximum rates in a typical harvest matrix are visualized as vertical columns, then this package of columns must fit under the continuous function roof when the two axis, parental escapement and forecast survival, are brought into alignment. Using the critical mortality curves described earlier and results of a variety simulations having different minimum and maximum mortality caps on these curves, it was possible to determine if a proposed harvest matrix would be acceptable in terms of species recovery. The matrices presented in ODFW's endangered species management plan for lower Columbia River coho were subjected to this test and were found to be acceptable.

Appendix 2

Hatchery Management Strategies

Description and Rationale for Strategies Under Oregon's Endangered Species Rules to Manage the Hatchery Programs as they Effect Endangered Lower Columbia River Wild Coho Salmon

Introduction

This paper provides a detailed discussion of the future role of ODFW's hatchery programs in the conservation and recovery of state listed endangered coho salmon in the lower Columbia River basin. It identifies the major hatchery-related issues and program objectives, provides a preliminary assessment of the risks and opportunities posed by hatchery programs, and describes a series of management strategies consistent with the conservation of wild lower Columbia River coho.

Major Issues and Hatchery Program Objectives

1. Minimize interactions that reduce the survival and fitness of wild coho.
2. Maintain key hatchery stocks as additional insurance against the potential failure of wild populations.
3. Utilize hatchery stocks, as necessary, to re-establish wild populations.

Assessment of Risks and Opportunities

1. Minimize Adverse Interactions

Hatchery programs exist in the lower Columbia River basin for the primary purpose of enhancing and maintaining sport, tribal, and commercial fisheries. This purpose is not inconsistent with conservation of wild coho as long as it does not result in excessive fishery mortality on wild fish or cause reduced reproductive success of wild fish, either through genetic changes as a result of interbreeding or adverse ecological impacts.

The harvest concern is best addressed through specific management protocols that limit fishery mortality on wild populations to levels that are consistent with recovery of the species. The approach proposed to accomplish this for lower Columbia River wild coho populations is described in the endangered species management plan and in Appendix 1.

The second concern, direct interaction between hatchery and wild fish, is one of the primary topics addressed in this document. In general, strategies designed to manage this problem for harvest augmentation hatcheries share the feature of limiting the number of hatchery fish that spawn naturally in areas utilized by wild fish. Although the development of new hatchery broodstocks from wild fish is another method that could help reduce genetic and ecological risks of hatchery fish to wild populations, this strategy is difficult to pursue for lower Columbia River coho because so few wild fish are available from which to build such new

hatchery broodstocks. This strategy will certainly be considered in the future as wild fish become more abundant. Another, but related, strategy to reduce risk is to develop spawning, rearing, and releases practices that are more similar to those experienced by wild fish and more consistent with natural stream processes. Although the magnitude of benefits are currently unknown, these types of strategies will be pursued as best possible within current funding, facility, and mitigation constraints. However, as such alternative strategies are developed and implemented the need to minimize unintended interactions of hatchery and wild fish will still exist.

There is no absolute trigger point at which the proportion of hatchery fish spawning with wild fish suddenly becomes biologically critical to the continued survival and recovery of a wild population. However, most scientific studies agree that if the hatchery fish in question originate from a non-local, domesticated broodstock, their percentage in naturally spawning populations should be held to less than 10%. The current hatchery stocks in the lower Columbia basin are of this type and will likely remain so in the near future. As noted earlier, there are simply not enough wild coho to switch to new, wild-type hatchery broodstocks at this time.

It should be emphasized that any recommendation as to the maximum level of naturally spawning hatchery fish must be stated and measured in terms of the entire geographical area occupied by the wild population. As used in this sense, a population is defined as a group of individuals that are largely reproductively isolated from other members of the species. For lower Columbia coho the geographic boundaries for 6 such populations (Astoria, Clatskanie, Scappoose, Clackamas, Sandy, and Bonneville) have been described (see Table 5 and Figure 1, ODFW endangered species management plan). It should be noted it is unknown if the Astoria, Clatskanie, Scappoose and Bonneville currently are self-sustaining populations. However, it is expected than when this species recovers, the distribution of coho will be consistent with population boundaries defined by these “recovery” populations.

For the extant populations in the Sandy and Clackamas, ODFW believes that the hatchery to wild ratio for spawners is currently less than the 1:9 or will be so after the actions identified in this plan are implemented. The basis for this opinion is the following evidence.

Hatchery coho returning to the Columbia River in 1999 and 2000 could readily be distinguished from wild fish because they had been fin clipped as juveniles prior to their release as smolts. Adult counting traps operated at Marmot Dam on the Sandy River and North Fork Dam on the Clackamas River recorded a combined total of 4 hatchery strays for 1999

and 2000. In contrast, the combined count of wild fish in these same years was greater than 3500 fish. The low incidence of stray hatchery fish is even more significant considering that a major coho hatchery exists in the lower portion of both the Sandy and Clackamas basins.

However, it appears that the incidence of strays in basin tributaries downstream of Marmot and North Fork dams may be considerably higher. Although the data are extremely limited, it appears that the proportion of hatchery fish in these areas may be 0.40 or higher (Table 1). Although this high proportion would probably be less if the localized number of wild fish were at recovery levels instead of at the currently very depressed state, how much less is unknown at this point.

For the Sandy basin the amount of habitat downstream of Marmot Dam (15.5 stream miles) represents a relatively small portion of the total available habitat (150.5 stream miles). When the observed proportion of hatchery spawners is weighted by available habitat the proportion of hatchery fish across the entire basin is only 0.05.

The same population-wide assessment for the Clackamas yields a less certain result. A much larger fraction of the habitat for this population is downstream of the counting facility at North Fork Dam (Table 1). When

Table 1. Proportion of hatchery fish observed in natural coho spawning areas in 2000.

Population or Sub-Area	Fish Observed	Hatchery Fish Proportion[a]	Stream Miles
Astoria	74	**0.49**	57.3
Clatskanie	1	**0.00**	40.6
Scappoose	21	**0.29**	62.6
Clackamas	2,227	**0.17**	279.4
Above NF Dam	2,218	0.00	161.8
Below NF Dam	10	0.40	117.6
Sandy	732	**0.05**	150.4
Above Marmot Dam	730	0.00	134.9
Below Marmot Dam	2	0.50	15.5
Bonneville	42	**0.79**	63.3
Hood River	42	0.79	67.8

[a] Hatchery identified by missing adipose fins, except for Hood River where distinction was made of basis of scale reading. Proportion of hatchery fish determined by missing adipose fins

this habitat is considered, the overall percentage of hatchery fish in the natural spawning population is 0.17. This exceeds the general guidance for healthy natural populations. However, starting in 2002 the number of hatchery coho smolts released into the Clackamas Basin (from Eagle

Creek National Fish Hatchery) will be reduced to 500,000 fish. Because this is a 50% reduction from the level of smolt releases in 1999 that contributed to the 2000 return, it is expected that proportion of hatchery fish in natural spawning areas in 2003 will decline to half of what it was in 2000. If this expectation is realized then the Clackamas population will have an overall proportion of naturally spawning hatchery fish of only 0.08.

However, this rationale is predicated on the assumption that the proportion of hatchery fish in those areas downstream of the counting facilities is similar to the level reflected by the very limited information obtained in 2000. Obviously, a more intensive effort over multiple years is needed before this assumption can be substantiated.

For those populations where wild coho are not yet clearly re-established (Astoria, Clatskanie, Scappoose, and Bonneville) the situation was somewhat confusing. In 2000, to the surprise of most ODFW biologists, naturally spawning coho were observed in many streams belonging to these populations. This was a surprise because it was thought that wild populations in these basins had become extinct about 6 years ago. The initial theory was that the fish observed in these areas during 2000 were hatchery strays. At least in part, this turned out to be true. Inspection of dead, spawned-out fish indicated that proportion of hatchery origin fish in the Scappoose, Clatskanie, and Astoria populations was, 0.29, 0.00, and 0.49, respectively (Table 1). Although, the number of fish inspected was small, exceedingly so for the Clatskanie population, it did suggest that spawning populations in these locations in 2000 were comprised of both hatchery strays and naturally produced fish.

While it was encouraging to observe naturally produced fish in these areas, the incidence of stray hatchery fish may cause management problems in the future. However, the magnitude of this problem will difficult to understand until additional years of data are collected and the potential wild run size for these populations can be estimated with more confidence. Certainly, if the number of wild coho spawning in these populations returns to historical levels and the number of strays remains constant, the overall proportion of hatchery fish in the natural spawning population will decline. However, there are too many unknowns to reliably estimate how much the hatchery fish proportion will decline as wild populations recover in these areas.

The Bonneville population appears to have yet another set of problems. Direct count of marked and unmarked coho passing Powerdale Dam on the Hood River suggested that only 26% of the population were hatchery strays (11 out of 42). However, scales were also taken from these fish and read to help confirm the origin of these fish. It appeared that a large

number of the unmarked fish were in fact of hatchery origin. Based upon the scale data, 33 of the 42 fish observed were hatchery fish (Table 1). Essentially, 2/3's of the hatchery fish did not have fin clips. Up until recently, 1.5 million unmarked coho smolts have been raised at Cascade Hatchery and trucked to the Umatilla for direct stream release. Without acclimation in the Umatilla basin, it is likely these fish were more prone to straying than other hatchery coho programs. The fact that they were also unique in not having fin clips, lends support to the theory that a majority of the strays into the Hood system were from these Umatilla releases. This situation should change in the future because, beginning in 2002, all hatchery coho smolts destined for the Umatilla will be first placed into acclimation ponds within the basin prior to their release. This should reduce their tendency to stray. This action plus the ability to sort out hatchery fish at the trap at Powerdale Dam should make it possible to keep the percentage of hatchery fish in the naturally spawning population to essentially zero.

Although stray hatchery coho are found throughout the range of this species, the magnitude of the problem is much less than it could be considering that more than 25 million coho smolts are released into the Columbia system each year. Indeed, there is additional evidence that suggests that at least between major basins, the straying of hatchery coho is quite low.

Over the last 12 years a portion of the smolts released from each coho hatchery in the lower Columbia were tagged with coded wire. Returning adults carrying these wire tags were recovered at each hatchery, the tags decoded and their hatchery of origin determined. In almost all cases, hatchery coho returned to their hatchery origin and did not stray to other hatchery sites.

For example, 13,968 tagged coho were recovered at Washington hatcheries over the last 12 years. However, only 28 of fish belonging to these tag groups were recovered at hatcheries in Oregon (Table 2). Further, the detail on these recoveries indicated that 21 of the 28 strays were fish released from Elochoman Hatchery that strayed to Big Creek Hatchery. Overall, the straying rate of Washington origin hatchery coho to Oregon hatcheries was less than 0.2%.

Among Oregon hatcheries, the straying of adult coho appeared quite low as well, as illustrated in Table 3. The exception to this low straying rate appears to be fish that were released into the area occupied by the Astoria population from facilities at NF Klaskanine, SF Klaskanine, Youngs Bay, Tongue Point, Blind Slough, and Big Creek. However, closer

Table 2. Recovery of coded wire tagged fish of Washington origin at all hatcheries in lower Columbia.

Hatchery	Recovered at Release Hatchery	Recovered at Oregon Hatcheries	Percent Straying
Grays River	553	2	0.3%
Elochoman	1028	21	2.0%
Cowlitz	2661	0	0.0%
Fallert Creek	994	0	0.0%
Kalama Falls	257	0	0.0%
Lewis	7287	4	0.1%
Washougal	1188	1	0.1%
TOTALS	**13,968**	**28**	**0.2%**

Table 3. Recovery of coded wire tagged fish of Oregon origin at Oregon hatcheries.

Hatchery	Recovered at Release Hatchery	Recovered at Oregon Hatcheries	Percent Straying
Klaskanine	181	17[a] (41)[b]	10%[a] (22.6%)[b]
SF Klaskanine	239	37 (75)	15% (31.4%)
CEDC	3078[c]	41 (107)	1% (3.5%)
Big Creek	3838	0	0.0%
Sandy	9486	1	< 0.1%
Eagle Creek NFH	2351	3	0.1%
Bonv/Cascade	4291	0	0.0%
TOTALS	**20,694**	**99**	**0.2%**

[a] Excluded straying among Youngs Bay locations (CEDC, Klaskanine, and SF Klaskanine hatcheries).
[b] Included straying among Youngs Bay locations.
[c] Fish were "recovered" in Youngs Bay terminal fishery and not collected at a hatchery trap as was the case for all other locations.

examination of these data shows that most of this straying was confined to Youngs Bay. The only other location strays from these facilities were recovered was Big Creek Hatchery. For all other Oregon hatcheries in the lower Columbia the straying rate appeared extremely low. A total 19,966 fish were recovered at Big Creek, Sandy, Eagle Creek, and Bonneville, and Cascade hatcheries that carried coded wire tags indicating they were returning to their respective hatchery of origin and release. Only 4 fish were recovered at "non-natal" hatcheries. In other words, only 4 of the nearly 20,000 returning hatchery fish strayed from their hatchery of origin to a different hatchery.

Although interactions between wild and hatchery coho in lower Columbia basin streams is not overly pervasive, there are several localized areas where problems either exist now or are likely to exist in the future as wild

populations become re-established. These problem areas have been discussed in the preceding paragraphs, including, in some cases, a strategy that will correct it.

In general the strategy for addressing these potential problem areas begins with obtaining a better idea of the true magnitude of the interaction taking place between hatchery and wild fish. This would require a determination of how many hatchery fish are spawning naturally in these areas, either through spawning surveys or other methods. Second, the natural production potential for these areas needs to be estimated in order to provide relative context to the level of naturally spawning hatchery fish observed.

Lacking this additional information, the default assumption should be that some level of adverse impact is occurring presently, or will occur to wild fish in the future as a result of the hatchery program. Whether by default assumption or through new information that documents the true presence of a problem, there are three basic alternatives to consider.

1) Significant reductions in the hatchery program or outright elimination.
2) Retain current hatchery production and accept much reduced natural coho production in these problem areas. Use the rationale that sacrificing these areas to hatchery impacts, makes it possible to reserve the primary natural production areas elsewhere exclusively for wild coho.
3) Same approach as alternative 2 above, but utilize newly opened natural coho habitat upstream of fish barriers at hatcheries as wild fish sanctuaries. A integral part of this strategy would be to maintain existing barriers and pass only wild fish upstream once the population had become re-established either through natural straying or direct intervention with a hatchery supplementation program.

<u>2. Maintain Key Hatchery Stocks for Future Re-introduction and Rescue Missions</u>

In 1996 the combined return of wild coho to the lower Columbia was likely less than 400 fish. The return of hatchery fish to Oregon's hatcheries in this same record low year was at least 10 times larger. As a hedge against the possible total loss of the wild population in future years, efforts should be taken to maintain several key hatchery stocks. Such hatchery stocks could provide the spawners to re-establish natural populations should a catastrophic event cause the extinction of the remaining wild populations.

Of primary consideration for this purpose should be the Sandy hatchery stock. Records indicate there this stock was largely derived from the wild Sandy basin coho and has not been mixed with other out-of-basin hatchery stocks. If wild coho in the Sandy became more abundant, there would also be the option to infuse some wild fish into the current hatchery broodstock or perhaps establish a second new broodstock initiated entirely from wild fish.

Other existing hatchery broodstocks may also have the potential for serving in this capacity. Other alternatives might be developing a new wild broodstock from fish returning to the Clackamas system. However, this would be possible only if the wild population was abundant enough to sustain the removal of fish for such a new hatchery program.

3. Utilize hatchery stocks, as necessary, to re-establish wild populations.

This type of use for the hatchery production system is related to the very near term use of hatchery fish from existing broodstocks to re-establish natural production in areas where wild fish are thought to have gone extinct. Prior to 2000, it appeared that wild coho populations had essentially been lost from the Columbia River basin except for the Clackamas and Sandy watersheds. However, in 2000 naturally spawning coho re-appeared in many of these locations. Further it appeared that a majority of these fish were naturally produced and not hatchery strays.

In light of this change in events and the uncertainty surrounding the use of hatchery fish to help rebuild wild populations, the best strategy at this time would be to wait for 2 more return years (2001 and 2002) to see if naturally produced coho return to these streams in the same numbers as in 2000. A full compliment of 3 consecutive brood years of naturally produced fish returning to these basins would signal that these populations are recovering on their own and supplementation with hatchery fish would be unnecessary. However, if the spawner abundance observed in 2000 was an anomaly and wild fish once again became non-existent, then a supplementation program could be planned and implemented. However, such a program would not release hatchery fish into all vacant locations. Many of these locations would not be supplemented to see how natural recolonization would compare to the supplementation streams.

In addition, there are several locations where artificial barriers exist that prevent coho from having access to historical production for example the upper portion of the Klaskanine River, Big Creek, Gnat Creek, Cedar Creek (Sandy), and Eagle Creek(Columbia Gorge). Most of these are associated with operation of ODFW's hatcheries. Hatchery fish could be

used to re-establish natural populations in these areas. Further, because it would be possible to control and monitor the fish which pass above these barriers, such locations could provide excellent opportunities to examine the effectiveness of supplementation strategies and also long-term population monitoring sites.

Depending on adequate funding, ODFW would like to develop one or more conservation hatchery programs that would incorporate the latest scientific thinking on broodstock management, "natural-type" rearing environments, and ecologically attuned release strategies. These pilot programs would require adequate monitoring and evaluation to assess short and long term benefits and risks relative to populations where hatchery invention was not carried out. The process by which ODFW will develop such programs has been described in the "Hatchery Program Management" section of the ODFW's endangered species management plan.

Appendix 2
Oregon Administrative Rules Regarding Coho Management and Recovery

Lower Columbia River Coho

635-100-0190

Fishery Management

(1) The mortality rate limit for wild coho salmon caught in Columbia River fisheries shall be set annually prior to the time these fisheries open. This limit shall not exceed the level specified in Table 1 of this rule corresponding with the observed parental escapement, expressed as a fraction of full seeding, and the index of marine survival for the upcoming adult coho return.

(2) For the purpose of implementing the management strategy described in paragraph (1) of this rule the following definitions apply:

(a) Parental escapement means the number of wild fish in the spawning population, expressed as a fraction of full seeding, that were the parents of the upcoming wild coho return;

(b) Marine survival index means a forecast of ocean survival for 3-year old coho returning in the upcoming year based upon the number of 2-year old hatchery coho (jacks) observed the previous year divided by the number of hatchery smolts released in the spring of the same year the jacks returned;

(c) Full seeding means the number of wild coho in a natural spawning population that is sufficient to produce maximum production of subsequent juvenile smolt offspring;

(A) Pending further revision, full seeding for the Clackamas population means 3,800 wild adult coho as counted passing North Fork Dam;

(B) Pending further revision, full seeding for the Sandy population means 1,340 wild adult coho as counted passing Marmot Dam.

(3) Wild coho populations in the Clackamas and Sandy basins shall serve as the index stocks for the purposes of setting annual fishery mortality rate limits.

(4) In those circumstances when ODFW deems the expected mortality of lower Columbia River wild coho in upcoming ocean fisheries is too high for conservation purposes, ODFW shall actively negotiate through the Pacific Fishery Management Council (PFMC) for regulations that yield a lower fishery mortality rate.

(5) Achievement of fishery management strategies described in this rule is contingent on continuation of fishing regulations and fish marking programs that minimize the impact

on wild fish through selective fishing methods and the manipulation of fishing season time and location. In addition, ODFW shall continue to explore new methods to further reduce the mortality of wild fish in all fisheries.

[ED. NOTE: Tables referenced in this rule are available from the agency.]

Stat. Auth.: ORS 496.004, ORS 496.171, ORS 496.172, ORS 496.182, ORS 496.192 & ORS 498.026
Stats. Implemented: ORS 496.004, ORS 496.171, ORS 496.172, ORS 496.182, ORS 496.192 & ORS 498.026
Hist.: DFW 112-2001, f. & cert. ef. 12-14-01

635-100-0191

Hatchery Programs

(1) CONSERVATION HATCHERY PROGRAMS: ODFW shall take advantage of existing and new hatchery facilities to supply hatchery fish for selected projects to help restore natural production of wild coho. These projects will be treated as interim and experimental until their conservation value is demonstrated.

(a) In 2002 ODFW shall initiate at least 3 projects using hatchery fish to re-establish wild populations in stream sections upstream of artificial barriers at ODFW hatcheries.

(b) In 2003 ODFW shall initiate projects to restore natural production using hatchery fish in selected locations within the portion of coho habitat in the lower Columbia basin that in 2000, 2001, and 2003 had a density of wild spawners less than 2 wild fish per stream mile. Implementation of these projects is conditional on adequate funding for appropriate conservation hatchery approaches and monitoring and evaluation programs to assess project success and to manage the risk to wild populations while the projects are being conducted.

(2) MITIGATION AND HARVEST AUGMENTATION HATCHERY PROGRAMS: ODFW shall operate hatcheries in such a manner that adverse genetic and ecological interactions between hatchery and naturally produced fish are minimized through management of hatchery broodstocks, hatchery rearing environments and fish releases.

Stat. Auth.: ORS 496.004, ORS 496.171, ORS 496.172, ORS 496.182, ORS 496.192 & ORS 498.026
Stats. Implemented: ORS 496.004, ORS 496.171, ORS 496.172, ORS 496.182, ORS 496.192 & ORS 498.026
Hist.: DFW 112-2001, f. & cert. ef. 12-14-01

635-100-0192

Land Management

(1) All ODFW operated hatcheries and wildlife management areas shall comply with the survival guidelines for lower Columbia River coho as described in OAR 635-100-0135, including the fish passage and fish screening provisions. ODFW shall complete a report by March, 2002 that sets priorities for the passage and screening modifications necessary at each hatchery from an evaluation of potential gains for natural coho production, the disease consequences to existing hatchery production, and the likely availability of necessary funds.

(2) The design of adult fish passage facilities shall incorporate the capacity for ODFW to restrict the number of hatchery fish that are allowed to migrate upstream as necessary once naturally self-sustaining populations have become re-established in these upstream areas.

Stat. Auth.: ORS 496.004, ORS 496.171, ORS 496.172, ORS 496.182, ORS 496.192 & ORS 498.026
Stats. Implemented: ORS 496.004, ORS 496.171, ORS 496.172, ORS 496.182, ORS 496.192 & ORS 498.026
Hist.: DFW 112-2001, f. & cert. ef. 12-14-01

635-100-0193

Monitoring

(1) De-listing decisions and the operation of fishery and hatchery programs requires monitoring and evaluation sufficient to measure risks and describe outcomes. ODFW shall implement such a monitoring program as sufficient funds become available.

(2) As funding becomes available, ODFW shall intensify its monitoring of juvenile and adult coho such that the data generated are directly comparable with coho information collected by ODFW from populations on the coast of Oregon.

Stat. Auth.: ORS 496.004, ORS 496.171, ORS 496.172, ORS 496.182, ORS 496.192 & ORS 498.026
Stats. Implemented: ORS 496.004, ORS 496.171, ORS 496.172, ORS 496.182, ORS 496.192 & ORS 498.026
Hist.: DFW 112-2001, f. & cert. ef. 12-14-01

635-100-0194

De-listing Criteria

(1) This rule describes the measurable criteria that define the minimum conservation goal for wild lower Columbia River coho. Upon meeting these criteria, ODFW shall be biologically justified to propose that species be removed from Oregon's endangered species list.

(2) For the purpose of evaluating the biological status of lower Columbia River wild coho with respect to the criteria described in this rule, the following geographic areas where wild coho presently exist or are believed likely to exist in the future are defined as the recovery population boundaries.

(a) The Astoria population occurs in Youngs Bay tributaries and all Columbia tributaries upstream to and including Gnat Creek.

(b) The Clatskanie population occurs in Columbia River tributaries upstream of Gnat Creek to and including the Clatskanie River basin.

(c) The Scappoose population occurs in Columbia River tributaries upstream of the Clatskanie River to the mouth of the Willamette River.

(d) The Clackamas population occurs in the Clackamas River basin plus Columbia River tributaries to the Willamette River downstream of Willamette Falls.

(e) The Sandy population occurs in the Sandy basin plus Columbia River tributaries downstream to the mouth of the Willamette River.

(f) The Bonneville population occurs in Columbia River tributaries upstream of the Sandy River to and including the Hood River basin.

(3) To meet the minimum conservation goal, lower Columbia River coho must be found to meet all of the following biological criteria:

(a) Population Distribution and Structure -- Self-sustaining wild populations are present in the Sandy and Clackamas basins. In addition, at least two of the following populations (Astoria, Clatskanie, Scappoose, or Bonneville) are self-sustaining.

(b) Diversity -- Naturally reproducing wild coho are present in 65% of the named streams that historically contained coho. Human activities impose only minor artificial selection pressures on the phenotypic character of the wild populations. The ongoing impact of hatchery fish on the genetic character, evolutionary processes, and innate productivity of naturally reproducing populations is minor.

(c) Abundance -- For three consecutive years, the number of wild spawners is at least 50% of the level necessary to produce maximum smolt recruits (full seeding) for the Sandy, Clackamas, and in at least two of the following populations: Astoria, Clatskanie, Scappoose, and Bonneville.

(d) Connectivity -- No artificial barriers exist that prevent the dispersing of wild coho between naturally reproducing populations.

(e) Persistence and Resilience -- The probability of extinction in 36 years is less than 5% for the Sandy and Clackamas populations plus two of the following populations: Astoria, Clatskanie, Scappoose, and Bonneville.

Stat. Auth.: ORS 496.004, ORS 496.171, ORS 496.172, ORS 496.182, ORS 496.192 & ORS 498.026
Stats. Implemented: ORS 496.004, ORS 496.171, ORS 496.172, ORS 496.182, ORS 496.192 & ORS 498.026
Hist.: DFW 112-2001, f. & cert. ef. 12-14-01

635-100-0135

Survival Guidelines for Species Listed as Threatened or Endangered

(1) As required by ORS 496.182 and OAR 635-100-0130, this rule describes survival guidelines for those species that were listed as threatened or endangered in OAR 635-100-0125 after enactment of ORS 496.182(2). Survival guidelines described in this rule apply to state agencies that own or manage land where threatened or endangered species are present (OAR 635-100-0130).

(2) Coho salmon with historic distribution in Columbia River tributaries downstream from Hood River qualify, by commission action, as an endangered species (OAR 635-100-0125) effective July 1999. These fish, known as lower Columbia River coho salmon, occur only in the Clackamas River and Sandy River watersheds at the time of listing. The survival guidelines are as follows:

(a) To prevent further degradation of water quality and water quantity, actions shall be avoided that:

(A) Cause a violation of water quality standards established by the Oregon Department of Environmental Quality; or

(B) Reduce stream flows below levels established in in-stream water rights by the Oregon Water Resources Department.

(b) To conserve stream gravel, actions shall be avoided that remove gravel from areas used by naturally spawning coho salmon;

(c) To protect riparian areas along those streams used by coho salmon for either spawning or juvenile rearing, actions shall be avoided that:

(A) Eliminate mature forests within 100 feet of streams;

(B) Prevent the natural re-establishment of mature forests within 100 feet of streams in areas where a mature forest previously existed; or

(C) Degrade vegetative cover within 100 feet of streams in areas where no forest has previously existed.

(d) To ensure survival of migrating coho juveniles and returning adults, activities shall be avoided that are inconsistent with:

(A) Fish passage statutes ORS 498.351 and ORS 509.605. These statutes require adequate upstream and downstream fish passage at dams or artificial obstructions; or

(B) Fish screening statutes ORS 409.301 through ORS 498.346 and ORS 509.615. These statutes regulate water diversions and the prevention of fish from entering water diversions.

(e) The total mortality impacts on ocean and in-river fisheries shall not exceed 15% of the total adult abundance of wild Lower Columbia coho salmon;

(f) The impacts of hatchery programs for coho salmon in the lower Columbia River on wild coho populations shall be consistent with the limits imposed by the Wild Fish Management Policy (OAR 635-007-0527).

Stat. Auth.: ORS 496.004, ORS 496.171, ORS 496.172, ORS 496.182, ORS 496.192 & ORS 498.026
Stats. Implemented: ORS 496.004, ORS 496.171, ORS 496.172, ORS 496.182, ORS 496.192 & ORS 498.026
Hist.: DFW 51-1999, f. & cert. ef. 7-22-99