**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

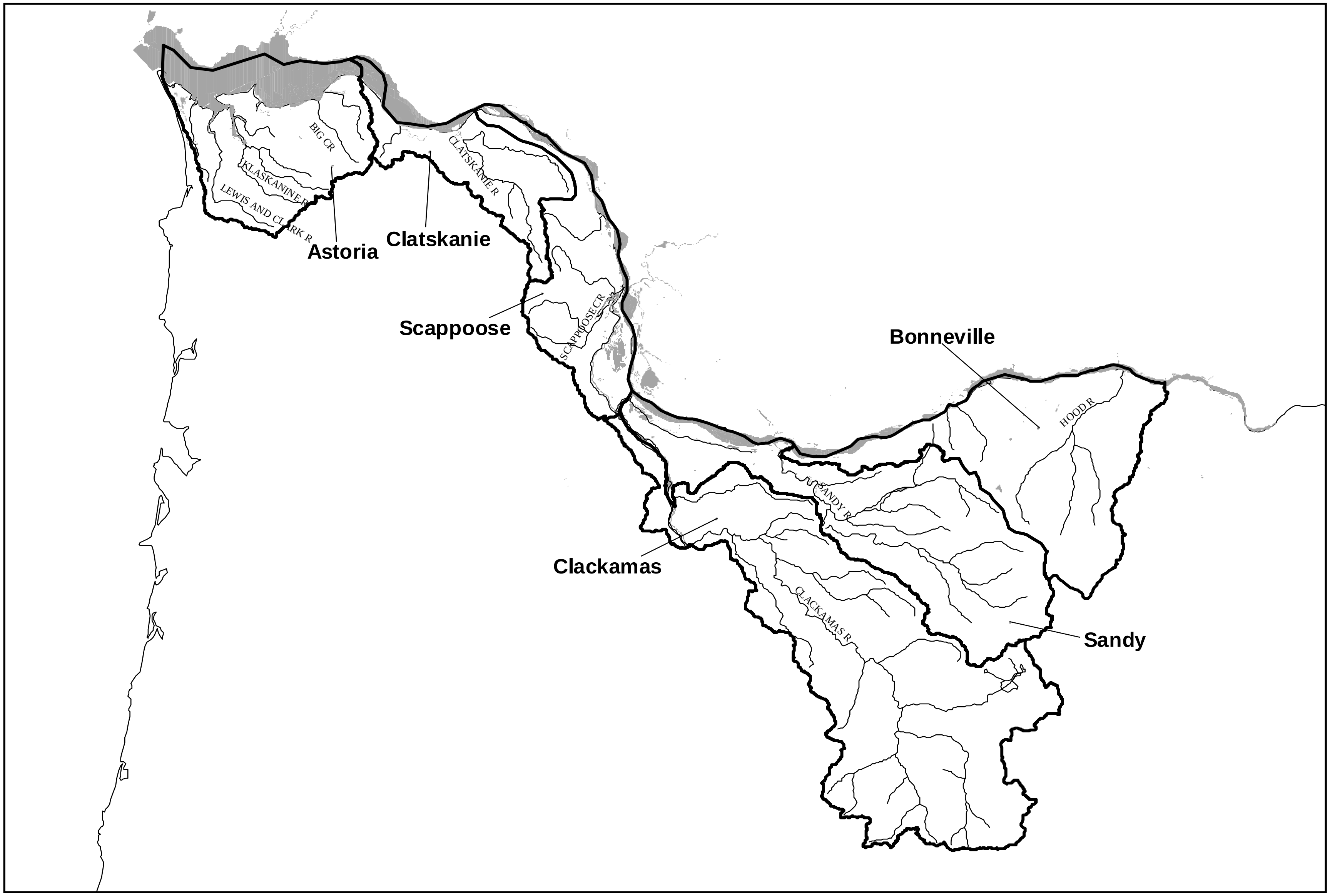


Figure 1. Geographic boundaries of current and expected populations of wild coho in lower Columbia River.

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.

<u>De-listing Criteria – Minimum Goal for Conservation</u>

*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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Chapman, D.W. Salmon and steelhead abundance in the Columbia River in the nineteenth century. Trans. Am. Fish. Soc. 115:662-670.

Chilcote, M.W. 1999. Conservation status of lower Columbia River coho salmon. Oregon Department of Fish and Wildlife, Fish Division Information Report 99-3, 41p. Oregon Department of Fish and Wildlife, Portland, Oregon.

# 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.

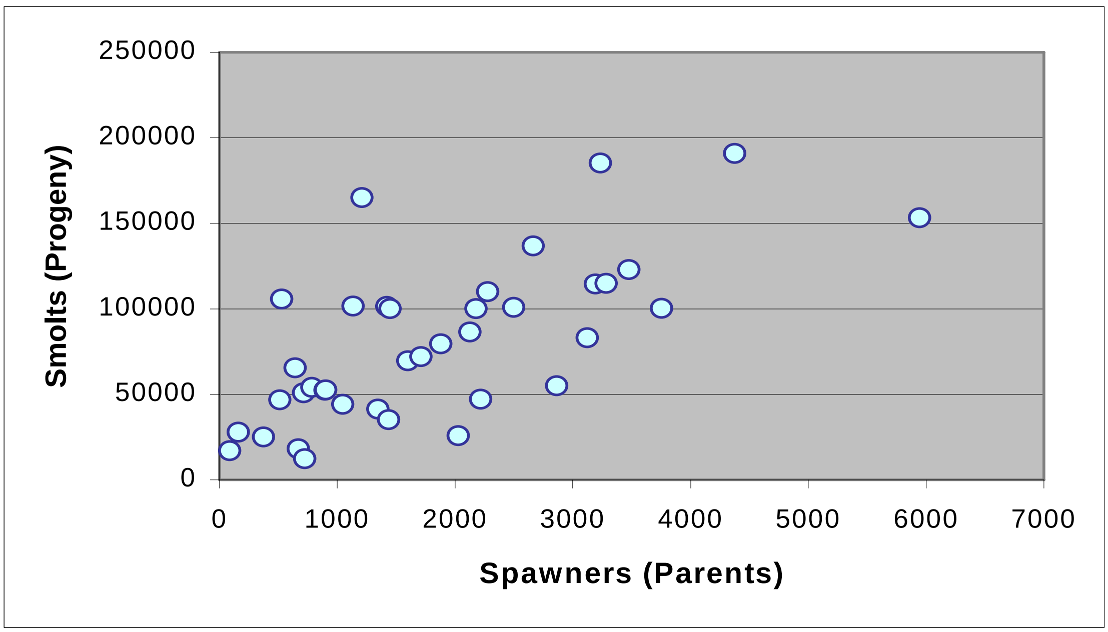


Figure 1. Number of wild coho smolts observed emigrating from the Clackamas River from 1961 to 1999 as a function of parental spawner abundance.

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:

$$Smolts_t = Spawners_{t-2} * 2.718^{(\boldsymbol{\alpha} - (\boldsymbol{B} * Spawners_{t-2}))}$$

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).

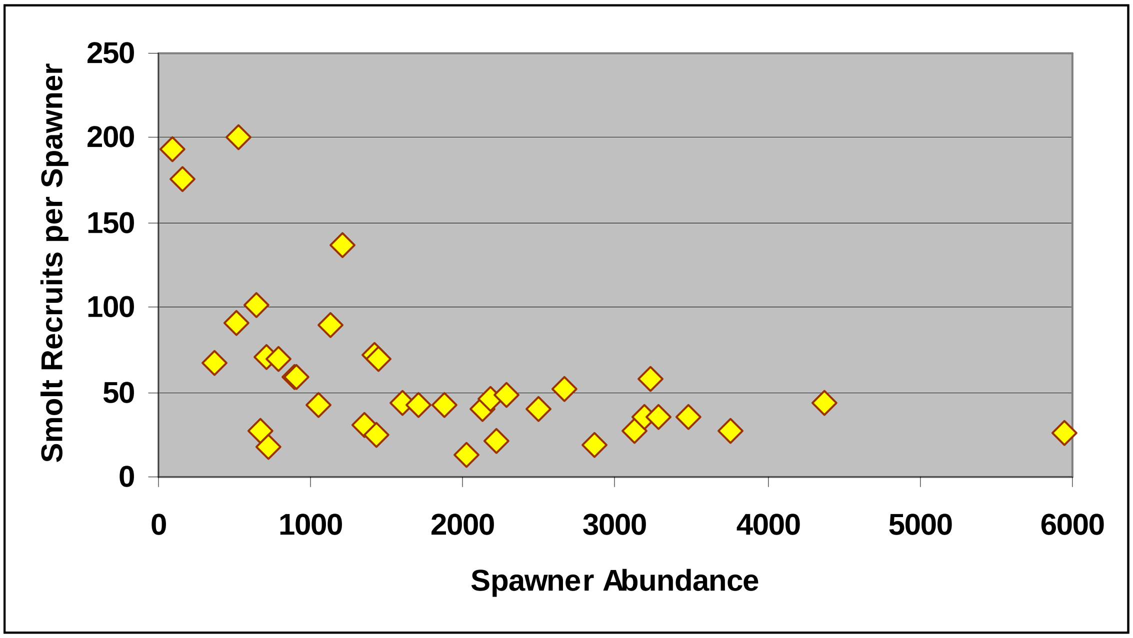


Figure 2. Relationship between spawner abundance and the corresponding ratio of smolt recruits per spawner for wild Clackamas River coho, 1961-1999.

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.

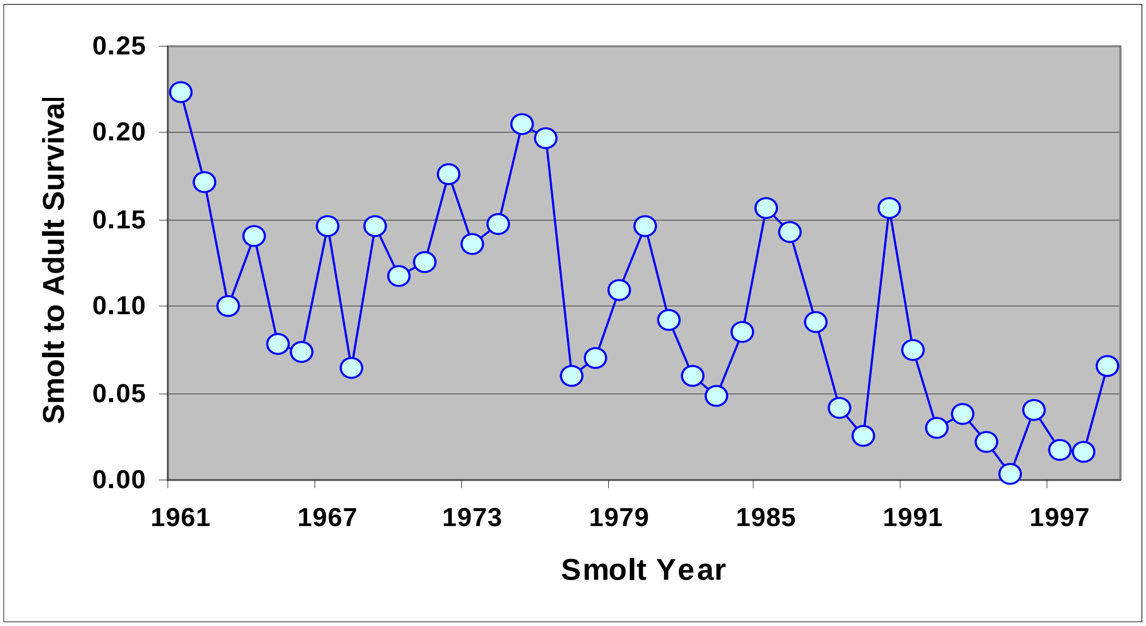


Figure 3. Estimated smolt to adult survival for wild Clackamas coho, 1961-1999.

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.

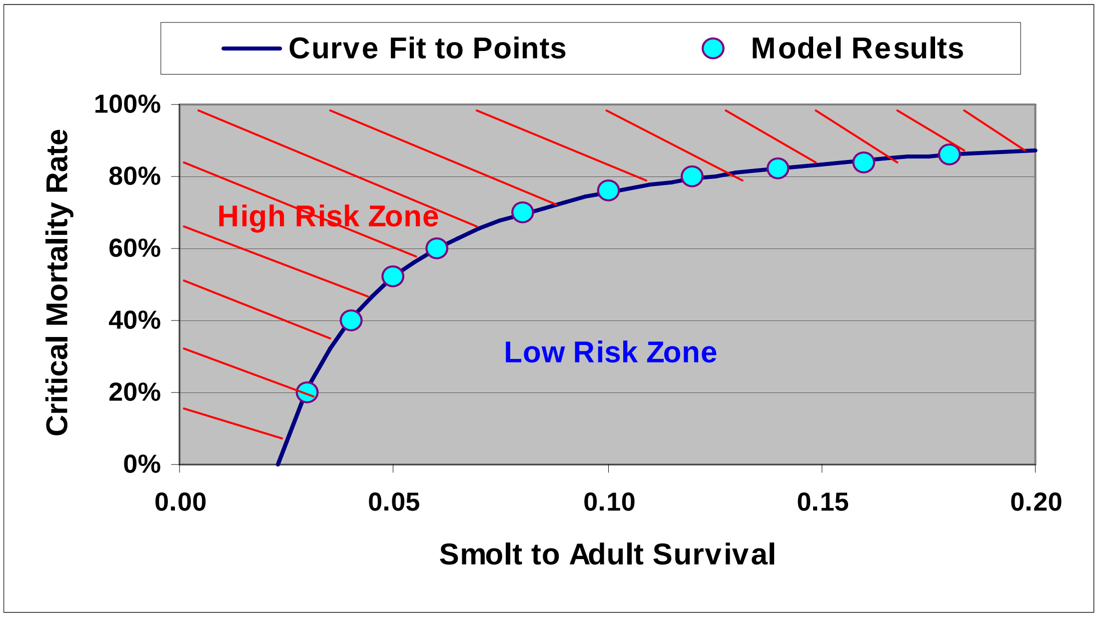


Figure 4. Graphical representation of model results to determine the critical mortality rate over a 36 year period for Clackamas coho under 10 different fixed ocean survival rates and a starting population size 50% of maximum seeding.

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.

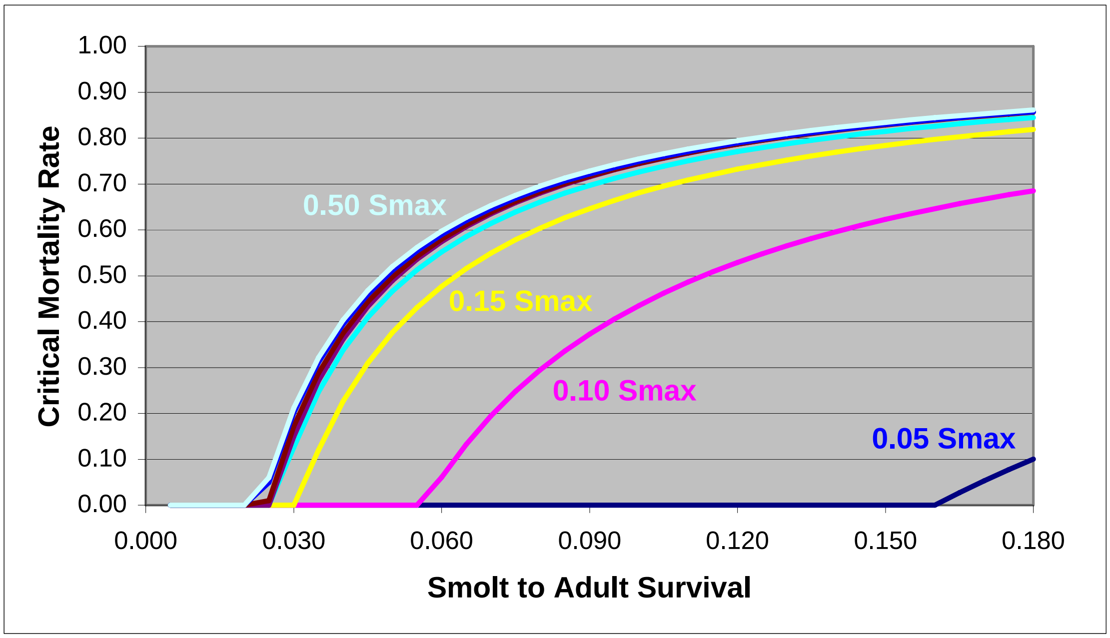


Figure 5. Critical mortality rate curves for 10 different starting escapement levels expressed as a fraction of Smax (see text).

## 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).

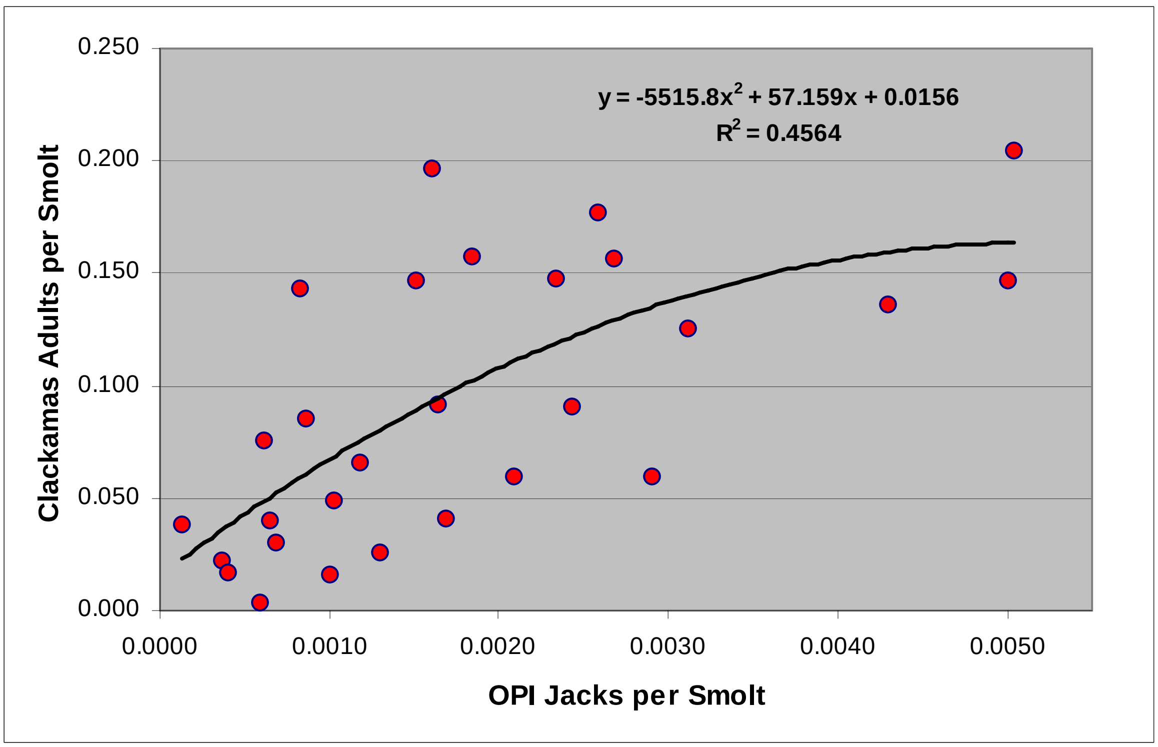


Figure 6. Smolt to adult survival for wild Clackamas coho as a function of the OPI jack survival index (see text).

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 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.

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 |

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.

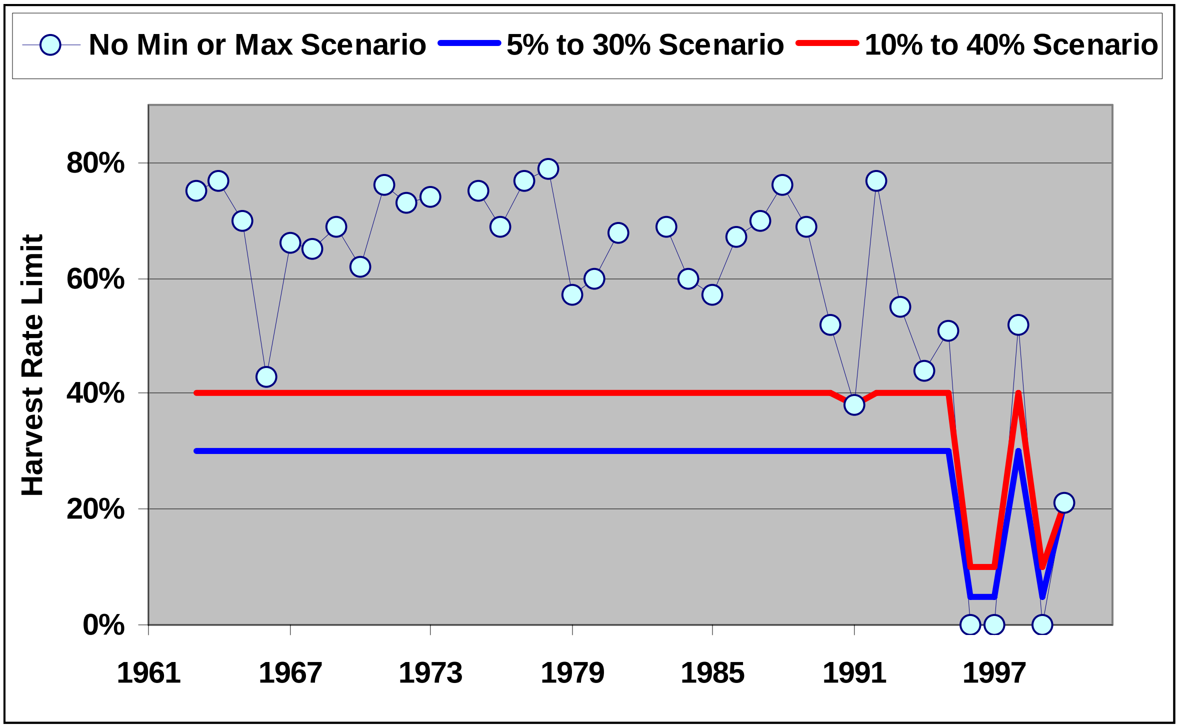


Figure 7. Example of harvest rate limits determined using the continuous function harvest protocol for under 3 different implementation scenarios for Clackamas coho population had these methods been implemented in 1963.

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.

<u>Continuous Function Harvest Protocol and the Harvest Matrix Approach</u>

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.