2005 Oregon Native Fish Status Report

Volume II

Assessment Methods & Population Results

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Contents

Introduction

This report summarizes methods by which interim criteria were evaluated for many of Oregon's native fish populations consistent with Oregon's Native Fish Conservation Policy (NFCP)[OAR 635-007-0507]. The purpose of the Native Fish Conservation Policy is to ensure conservation and recovery of native fish in Oregon with focus on naturally-produced fish. The policy provides a basis for managing hatcheries, fisheries, habitat, predators, competitors, and pathogens in balance with sustainable natural fish production.

The Native Fish Conservation Policy is implemented through conservation plans tailored to the needs, opportunities, and constraints of each group of fish populations. Interim criteria defined in the NFCP provide temporary guidance to ensure the conservation of native fish prior to completion of conservation plans. The criteria help identify priorities for fish management actions and conservation plan completion. Once a conservation plan is approved, interim criteria are superceded by a broader set of measurable primary and secondary criteria (OAR 635-007-0505 (6) & (7)).

This Oregon Native Fish Status Report is the first statewide assessment of native fish in Oregon since completion of the Biennial Report on the Status of Wild Fish in Oregon in 1995 (Kostow 1995). This report can be considered a supplement to the 1995 report. Fewer native fish species are assessed in this report. For those species not covered in the Oregon Native Fish Status Report, the 1995 report contains the most recent assessment of those species. Species included in this report have received a more consistent assessment than was conducted in 1995. The use of the same six criteria for each species management unit allows for a better comparison of species management unit status.

The interim criteria defined in the NFCP are used in this report to assess the status of many of the fish species native to Oregon. This is one of two complementary volumes prepared as part of this assessment. This volume includes details of data analysis methods and results for each Species Management Unit (SMU). Summaries of resulting assessments for SMUs are detailed in a separate volume.

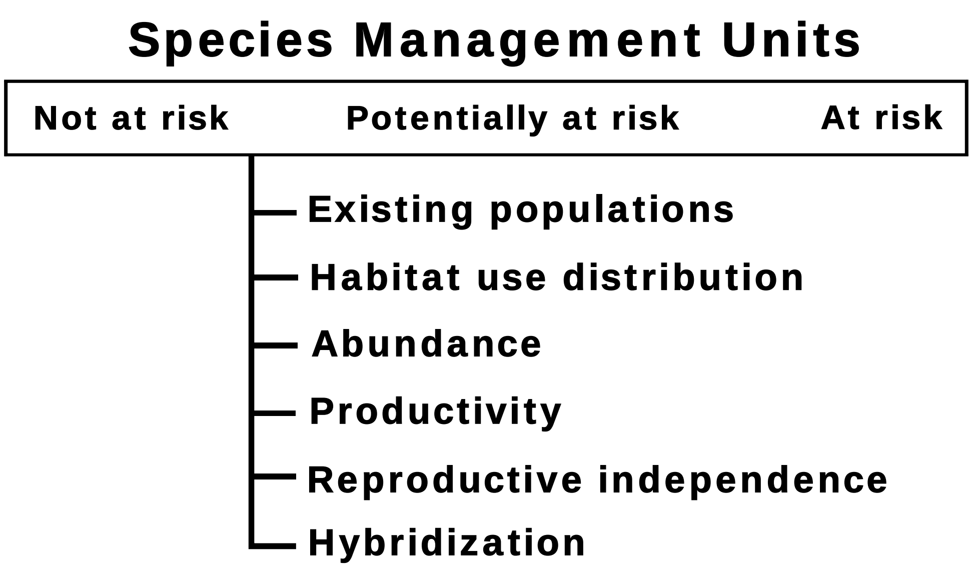

Figure 1. Criteria for assessing conservation risks based on Oregon's Native Fish Conservation Policy.

Species Management Units

Fish species were split for the purposes of this assessment into groups of populations from a common geographic area that share similar life history, genetic, and ecological characteristics. These groups are called *Species Management Units* [OAR 635-007-0501(60)] or SMUs. ODFW defines a fish population as "a group of fish originating and reproducing in a particular time which do not interbreed to any substantial degree with any other group reproducing in a different area, or in the same area at a different time" [OAR 635-007-0501(45)]. For this Status Report, ODFW has identified 33 SMUs of salmon and steelhead including a total of 216 populations (Table 1). Among trout and other species, 36 SMUs and 252 populations have been identified. Not all native Oregon freshwater fishes could be covered within this report due to time and budget constraints. Twenty-two of the 98 freshwater/brackish-water native species are assessed in this report. For a complete list of Oregon native freshwater/brackish-water fishes, see Appendix A of this volume.

Table 1. Species management units assessed in this report. SMUs that met six of the criteria were classified as "Not at Risk". SMUs that met only four or five criteria were "Potentially at Risk". SMUs that met three or fewer criteria were classified as "At Risk".

Group	Management Unit	No. of Populations	Not at Risk	Potentially at Risk	At Risk	Extinct
Coho	Coastal	19	X			
	Rogue	3	X			
	Lower Columbia	8			X	
	Interior Columbia	2				X
	Klamath	1				X
Fall Chinook	Coastal	18	X			
	Rogue	10	X			
	Lower Columbia	8			X	
	Mid Columbia	4		X		
	Snake	1		X		
Spring Chinook	Coastal	9			X	
	Rogue	1		X		
	Lower Columbia	3			X	
	Willamette	6			X	
	Mid Columbia	8		X		
	Lower Snake	8			X	
	Upper Snake	6				X
	Upper Klamath	1				X
Chum	Coastal	13			X	
	Lower Columbia	7				X
Sockeye	Mid Columbia	1				X
	Snake	1				X
Winter Steelhead	Coastal	23		X		
	Rogue	8	X			
	Lower Columbia	9			X	
	Willamette	9		X		
Summer Steelhead	Coastal	2		X		
	Rogue	2	X			
	Lower Columbia	1			X	
	Mid Columbia	11			X	
	Lower Snake	5	X			
	Upper Snake	6				X
	Klamath	2			X	
Redband Trout	Malheur Lakes	10		X		
	Catlow Valley	5			X	

Group	Management Unit	No. of Populations	Not at Risk	Potentially at Risk	At Risk	Extinct
	Warner Lakes	4			**X**	
	Fort Rock	3			**X**	
	Chewaucan	4		**X**		
	Goose Lake	13			**X**	
	Upper Klamath Basin	10			**X**	
Cutthroat	Oregon Coastal	24	**X**			
	Southern Oregon Coastal	12	**X**			
	Lower Columbia Coastal	8		**X**		
	Willamette Coastal	14	**X**			
	Alvord	1				**X**
	Coyote Lake Lahontan	5			**X**	
	Quinn River Lahontan	4			**X**	
	Westslope	17			**X**	
Bull Trout	Klamath Lake	11			**X**	
	Willamette	7			**X**	
	Hood	2			**X**	
	Deschutes	8		**X**		
	Odell Lake	1			**X**	
	John Day	20			**X**	
	Umatilla	2			**X**	
	Walla Walla	2	**X**			
	Grande Ronde	12			**X**	
	Imnaha	4			**X**	
	Hells Canyon	14			**X**	
	Malheur River	2			**X**	
Other species Of Interest	Borax Lake Chub	1			**X**	
	Hutton Springs Tui Chub	1			**X**	
	Oregon Chub	15			**X**	
	Foskett Springs Speckled Dace	1			**X**	
	Pacific Lamprey	3			**X**	
	Western Brook Lamprey	3			**X**	
	Northern Green Sturgeon	1		**Not Assessed**		
	Southern Green Sturgeon	1		**Not Assessed**		
	Oregon White Sturgeon	7		**Not Assessed**		

Populations within an SMU are locally adapted to the specific conditions encountered in their native streams or lakes. Fish from another SMU do not typically fare as well as the native inhabitants. The greater the difference in characteristics, the greater the average disparity in survival, growth, and productivity. Thus, long-term sustainability depends on preservation of the native characteristics and diversity of each unique group of populations. These population and SMU designations are temporary until conservation plans are developed for each SMU. At the time of plan development for each Species Management Unit, further analysis of genetic and life-history differences may result in refinements to population and SMU boundaries.

Species Management Units are similar in concept to Evolutionarily Significant Units (ESUs) upon which the U.S. Fish and Wildlife Service and National Marine Fisheries Service base Endangered Species Act listing decisions. Populations delineated for salmon and steelhead by ODFW are generally consistent with Biological Reviews prepared by NOAA Fisheries Technical Recovery Teams. SMUs identified by ODFW generally reflect finer breakdowns of ESUs where ESUs include multiple stocks (e.g., lower Columbia River spring and fall Chinook) or broad geographical regions with unique subsets of dependent and independent populations (e.g. Coastal coho). SMUs are limited to Oregon stocks, whereas, ESUs include Oregon and non-Oregon stocks.

Coho SMUs and populations generally follow ESU designations. One exception is for coastal coho where the Technical Recovery Team has distinguished a series of dependent and independent populations. Dependent populations occur in localized habitats thought to be too small to independently sustain a population, even under pristine conditions. These populations are thought to rely on colonizers from larger, adjacent populations for their existence. It is not clear how well this concept applies to other species and geographical areas and little data is available on the dependent coho populations. The NFCP assessment is based on the independent populations that drive the health of the SMU.

Chinook SMUs and populations generally follow ESU designations except that spring and fall Chinook are treated separately for the lower Columbia River, Coastal and Rogue SMUs. ODFW believes that spring and fall Chinook life history, distribution, and limiting factors are substantially different. Runs are functionally independent.

Similarly, ODFW believes the ecological and adaptive differences between summer and winter forms of steelhead are such that they belong in separate SMUs, even if they occur in the same basin or geographical region. This is in contrast to the approach of NOAA Fisheries, which is to combine sympatric and regional populations of summer and winter steelhead into a single ESU. Separate summer and winter steelhead SMUs were identified to reflect the low likelihood of replacement. For example, if summer steelhead in the Siletz were lost (and no hatchery broodstock existed), it is unlikely that that winter steelhead from the Siletz would evolve to re-establish the summer steelhead life history within the foreseeable time horizon. The Oregon boundaries for the lower Columbia steelhead SMU are also different than for the lower Columbia ESU. The lower Columbia ESU extends downstream to the Scappoose population and upstream to the Hood River. Based upon ecological similarities and geographic isolation mechanisms (e.g., historic Celilo Falls), we have chosen to expand the SMU to include populations upstream to the The Dalles (Celilo Falls) and downstream to Astoria.

Anadromous steelhead and resident rainbow trout in some basins may be closely related and parents of either life-history type can spawn with each other and produce offspring of the other type. We are just beginning to understand the occurrence and significance of this interaction and effects on steelhead productivity are not considered in this assessment. Steelhead and resident rainbow trout within the same basin are considered for the purposes of this assessment to be different SMUs. Where there are both SMUs in a geographic area, we assessed only the anadromous life history. Steelhead status is evaluated based only on information from the anadromous life history type. Resident redband trout were only assessed in the Oregon Basin of Southeast Oregon where there is no anadromous life-history. ODFW will more thoroughly explore the relationship between the anadromous and resident forms of rainbow trout during the development of conservation plans for those SMUs where both co-exist.

SMUs have also been identified for unlisted species whereas ESUs have not been developed. Delineation of SMUs for non-salmonid species is constrained by the limitations in the available genetic and life history data. High confidence exists in classification of salmonid populations where genetic and life history data abound. Lesser confidence exists in the classification of species such as sturgeon and lamprey for which there are few data. It is likely that finer classifications of other species may be appropriate in the future as more specific data is available.

Interim Criteria

Risk Assessment

This is an interim assessment intended to flag acute problems and identify priorities for more detailed conservation planning evaluations. Risk, as used in this report, refers to the degree of threat to the conservation of a unique group of populations (e.g., SMU) in the near-term (5-10 years). Conservation is defined as maintaining the sustainability of native fish at levels that provide ecological, economic, recreational and aesthetic benefits to present and future generations. The interim assessment is based only on immediate status and is only intended to ensure that SMUs will continue to provide societal benefits until a conservation plan can be developed. It does not consider long-term or extinction risks. For instance, better-than-average ocean conditions might temporarily increase numbers of salmon, but have little effect on long-term risks where other threats remain significant and a species has exhibited a long-term declining trend. Nor does the interim assessment weigh the projected future benefits of recent conservation actions that have not yet been fully reflected in recent fish numbers. The development of conservation plans consistent with the NFCP will provide a more thorough analysis of each SMU's status, including long-term and extinction risks.

The NFCP interim criteria were based on six biological characteristics related to species performance (Table 2). Where possible, each of these attributes were evaluated based on benchmark values related to species viability, persistence probability, and conservation risks. A detailed explanation of population attributes associated with salmonid population viability can be found in McElhany et al. (2000).

Table 2. Interim criteria and standards defined in the Native Fish Conservation Policy risk assessment of Oregon salmon and steelhead SMUs.

Attribute	Interim Criteria
Existing Populations	Population is still in existence (i.e., not extinct) ***and*** not at risk of extinction in the near future.
Habitat Use Distribution	Naturally produced members of a population occupy at least 50% of the predevelopment habitat in at least 3 of the last 5 years.
Abundance	Number of naturally-produced fish that survive to spawn is greater than 25% of average abundance of naturally-produced spawners over the last 30 years in at least 3 of the last 5 years.
Productivity	Intrinsic rate of population increase is at least 1.2 naturally-produced adult offspring (that survive to spawn) per natural spawner in 3 of the last 5 years when total abundance was less than the average abundance of naturally-produced spawners over the last 30 years.
Reproductive Independence	90% or more of spawners are naturally produced in at least 3 of the last 5 years.
Hybridization	Occurrence of hybrids with non-native species is rare or nonexistent in 3 of the last 5 years.

Interim Criteria are designed to flag cases of significant near-term conservation risks. Indicators are highly interrelated and provide some level of redundancy in the detection of potential problems. For instance, declining abundance occurs coincident with reduced productivity and distribution. Significant conservation problems invariably trigger multiple indicators. Thus, while each indicator might suffer from specific limitations of information or interpretation, the suite of indicators provides a robust basis for identifying relative priorities for detailed conservation plans.

Interim risk categories were assigned based on the number of criteria met for each SMU (Table 3). For each interim criterion the designation of "pass" or "fail" was dependent on the percentage of populations within the SMU that met each criterion. Each criterion was independently evaluated based on populations where information was available on that criterion. A criterion was passed if 80% of constituent populations met the standard[1].

Table 3. Near term risks to the Species Management Unit are assessed based on how many criteria are met.

Designation	Number of Criteria Met
Not at Risk	6 of 6
Potentially at Risk	4-5 of 6
At Risk	3 of 6

Standards for this interim risk assessment are typically based on meeting prescribed conditions in at least three of the last five years to flag near-term concerns that should be addressed with conservation plans. Naturally-produced fish numbers may fluctuate substantially from year to year in response to normal variation in environmental conditions. For example, ocean climate cycles can result in extended periods of low or high salmon or steelhead productivity. A decline in abundance during periods of low productivity does not necessarily mean that a population is at risk. Conversely, an increase in abundance during periods of high productivity does not necessarily mean that a population is healthy. Extinction typically occurs when weak populations placed at risk by one or more human-caused stressors "bottom out" during periods of low productivity. Healthy populations also decline during these low productivity periods but rebound quickly when conditions improve. The interim criteria are designed to identify these critical periods where emergency measures are needed to provide a bridge until more comprehensive conservation assessments and plans can be completed.

Assessments of individual populations for each interim criterion were primarily based on available data for that population. In some instances, data were not available to evaluate against a benchmark and inferences from available information were used to determine whether or not the criteria were met. In some cases where data for a population was not available, assessments were inferred from other similar populations. Data limitations sometimes resulted in the need to use the same data for inferences regarding several criteria. While it is scientifically appropriate to apply a given data set to multiple applications, data limitations for some populations may result in a high weight being given to limited information with a corresponding reduction in confidence of the resulting assessment.

The risk assessment for each SMU includes a qualitative evaluation of the uncertainty in the data used to infer risk based on interim criteria. A high level of confidence was identified where extensive and detailed data was available for populations throughout the SMU. A moderate level of confidence was identified where data and other information were generally suitable for assessments of interim criteria for many or most representative populations throughout the SMU. A qualified level of confidence was identified where the assessment was based on limited data sets and inferences from other information for significant populations within an SMU. The

[1] *For SMUs containing fewer than five populations, the 80% criterion results in a precautionary standard where every population must pass.*

qualitative descriptions of uncertainty and detailed descriptions of the methodology, inferences, and assumptions provide a transparent basis for independent evaluation of the accuracy of risk assessments for each SMU and population.

In keeping with the precautionary strategies identified by the Native Fish Conservation Policy, populations for which data were incomplete for an attribute and where inferences could not confidently be made from other similar cases, were treated the same as if that population failed criteria for that attribute. This approach is consistent with an assumption that uncertainty associated with incomplete information increases risks. To avoid over-emphasizing the risk due to a lack of information, no Species Management Unit was designated as "at risk" based solely on a lack of data in the absence of other evidence of significant threats to sustainability.

For example, consider an SMU comprised of 20 populations, eight of which pass the abundance criteria based on specific data for those populations, four of which are inferred to pass based on partial data and extrapolation from other similar populations, six that failed based on specific data or inferences from partial data, and two that could not be assessed from the available data. Thus, 12 of 20 populations (60%) met the criteria for this attribute. The SMU failed the interim abundance criteria which was based on an 80% passage rate. Failure of one attribute criteria ensures that the population will be designated no better than "potentially at risk". Three attribute failures results in an "at risk" designation.

We note that the criteria applied in this assessment as defined by the NFCP were derived primarily for use with anadromous salmon and steelhead. This assessment uses these same criteria for other species including resident salmonids and other endemic fishes. However, data on other species is often quite limited and the salmo-centric criteria may not accurately capture all appropriate elements of status for non-salmonid species. More species-specific standards will be applied in conservation plans for other species.

Existing Populations

Criteria: **At least 80% of historical populations are still in existence (i.e., not extinct) *and* not at risk of extinction in the near future.**

The Species Management Unit identifies groups of similar populations that are uniquely adapted to local conditions. The loss of a significant portion of an SMU's populations inhibits the ability of the SMU to persist over time. Continued persistence is a direct demonstration of a species' performance in the face of historical risks. Conversely, extinction of closely related populations in an SMU is a clear indicator of pervasive problems that may threaten all populations within a region. Many extinct populations identified in this assessment occurred in areas that are no longer accessible to fish, for instance where dams block passage. Other extinct populations were eliminated by the combined effects of a series of stressors such as land and water use, barriers, fishing, and variable ocean conditions. Extinction occurs when numbers and productivity are no longer sufficient to maintain an independent self-supporting population. Functional extinction occurs before the last few fish disappear. Small numbers of fish may continue to return in some areas due to sporadic straying from other hatchery or wild populations. Thus, some fish may occasionally occur within the historical range of extinct populations but numbers and productivity are no longer sufficient to sustain a self-supporting independent population.

The existence or extinction of a population for this assessment was primarily based on previous determinations by ODFW. In certain instances, re-introduction efforts are currently underway and have not been thoroughly evaluated to determine if a naturally reproducing population has been re-established. Those populations were considered to still be extinct.

The existing population criterion is based on whether populations are still in existence (i.e., not extinct) and not at risk of extinction in the near future. An SMU passes this criterion where 80% or more of the historical populations are still present. Where more than 20% of historical populations have become extinct, an SMU is considered potentially at risk even if all other criteria are met for remaining populations. Loss of even a few populations can represent a significant loss of the diversity needed to sustain a group of populations over the long term in the face of variable habitat conditions. This criteria effectively flags SMU risks where populations have been lost. Assessments of remaining criteria are based only on the remaining populations so as to not double weight the significance of the loss of populations.

Selection of 80% as the threshold for percentage of extant populations for the SMU was based upon observations of SMUs under stress. For example, coho belonging to the lower Columbia SMU nearly went extinct in the 1990s. A combination of declining marine survival rates, over-fishing, habitat loss, and adverse interactions with hatchery fish all contributed to this decline. However, the apparent extirpation of two populations belonging to this SMU occurred 15 to 20 years prior to the near extinction event in the 1990s. Essentially, the extirpation of these two populations was a forewarning that other populations in the SMU were also under stress and vulnerable.

In addition to these direct observations, a variety of computer based simulations were performed to examine how the pattern of population extirpations would occur as a SMU might go extinct as a result of extremely poor and deteriorating survival conditions. In these modeling exercises, the probability of extinction was forecast for all populations within an SMU under a scenario of impaired survival. The results were recorded and then the model run was repeated, but with the assumed survival incrementally decreased from the previous run. This procedure was repeated until a survival rate was found that caused all of the populations to fail and essentially the SMU become extinct.

In reviewing the results from these simulations it appeared that as environmental stress was turned up (survival rates decreased), the probability of extinction for most populations would remain low until a critical “tipping point”. Once this critical stress level occurred, relatively small additional increments of stress were sufficient to cause most of the populations in the SMU to be at extinction risk. In other words as environmental stress was increased on an SMU, the loss of populations was not linear, but instead a rather sharp transition from most populations sustainable to most populations at risk. It appeared from looking at the results from such simulations for a number of species, that a 20% extirpation level of an SMU’s populations was a good marker of the critical extinction tipping point. In other words, when more than 80% of the populations remained in the SMU, it was likely that the SMU still had the biological cushion to sustain additional increments of stress. However, fewer than 80% of the populations had become at risk, relatively small increases in environmental stress would result in the majority of the remaining populations also becoming at risk. Essentially the 80% population level appeared to be the tipping point for the SMU. In summary, the support for using the 80% extant population criterion was based on these modeling results and the fact that they seemed to be supported by actual empirical observations of near extinction events (lower Columbia River coho).

Application of an 80% threshold for the population existence criteria does not weight populations by their relative size or contribution to SMU abundance. This screening analysis generally assumes that individuals are distributed among multiple populations within an SMU rather than concentrated in only one or two. Theoretically, an SMU might unreasonably pass this criteria where many healthy small populations dilute the significance of loss of a dominant population. However, in practice the large productive populations are typically the last to disappear except in extreme cases such as blockages of prime habitats. Statistical distributions of population size and relative importance will be appropriate for consideration in subsequent conservation plans completed for at risk SMUs.

Habitat Use Distribution

Criteria: **Naturally produced members of a population occupy at least 50% of the historically-used (pre-development) habitat in at least three of the last five years for at least 80% of existing populations.**

Healthy fish populations benefit from access to large areas of habitat. A lack of habitat makes a population more vulnerable to natural and human-caused disturbances. Fish distribution depends on the amount of habitat that remains accessible and the portion of the accessible habitat that is used for spawning and or rearing in any given year (Figure 2). The most robust fish populations are typically those that access and use all areas historically available (pre development) in most years. Passage into some portions of the historical range may be blocked by dams, culverts, or other barriers. Habitat degradation may also render some accessible habitats unsuitable for migration, spawning, or rearing. Fish densities vary throughout the accessible range in response to differences in habitat quality and fish numbers. During years of low spawning escapement, fish may often concentrate in high quality habitats with proportionately less use of the low-moderate quality habitats. Low-moderate quality habitats are used with greater frequency in years of high spawning escapement when high-quality core areas are filled. Thus, changes in annual distribution patterns are a good indicator of potential changes in risk status.

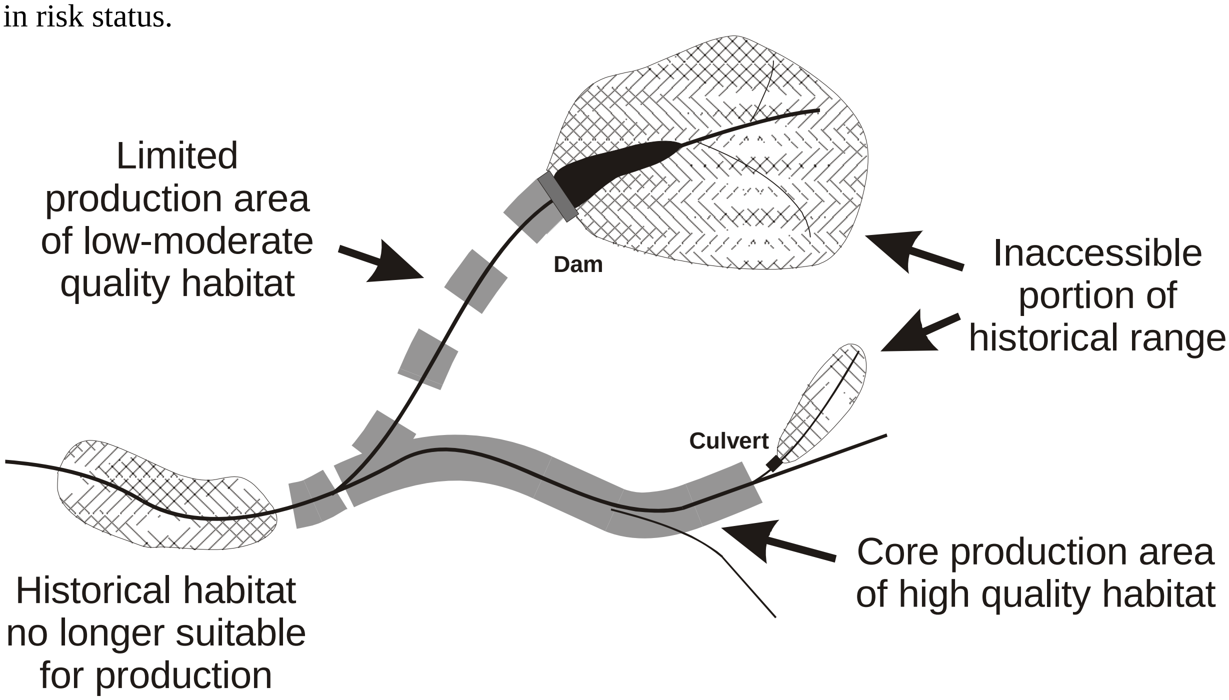

Figure 2. Hypothetical salmon spawning and rearing distribution pattern within the predevelopment historical range.

This criterion was evaluated based on annual distribution data where available and current habitat accessibility when annual data were lacking. A population passed this criterion if fish used at least 50% of the historical range in at least three of the most recent five years (where annual distribution data were available) or at least 50% of the historical range remains accessible. An SMU passed this criterion if 80% or more of the populations passed this criterion. The 50% threshold was based on the assumption that most populations have evolved to accommodate natural variations in habitat access and condition. Even when these natural disturbances are large, it is assumed to be unlikely that spawners would limited to less than 50% of the available habitat prior to development. Although verification for this supposition may not be empirically possible, it was felt that habitat use reductions of habitat greater than 50%, as evidenced by spawner distribution, represent an unnatural state and therefore may place the population at risk.

Evaluations of annual distribution required intensive random or stratified random escapement surveys in representative areas throughout the range of a given population. These data were available only for coastal coho. Most assessments were based on continued access to all historical areas. Accessible areas were defined at the 1:100,000 scale from data provided by the ODFW Fish Habitat Distribution Development Project (ODFW online data 2004). The dataset was updated where regional biologists advised. The habitat use types classified in this dataset that were used in this assessment are summarized in Table 4. Accessible stream reaches identified by ODFW are sometimes disjunct because of habitat suitability for any given species.

Table 4. Aggregation of distribution use types from the ODFW distribution database.

Stock Assessment	ODFW Distribution Database Classification
Current	Spawning and Rearing, Rearing and Migration, Present, use type unknown
Historic	Previous/Historic
Not Incorporated	Migration Only, Absent, Unknown Presence or Use Type, Disputed, Outlier

Habitat accessibility is a less sensitive indicator of fish status than annual use patterns because habitat degradation may preclude use of some accessible areas. This assessment did not try to evaluate the loss of habitat quality. Such an assessment would more appropriately occur during a conservation planning process. Fish may also not occupy all accessible areas because of low escapements. In cases where abundance estimates suggested very low levels of habitat seeding, populations failed this criterion. Estimates of historical distribution are underestimate total habitat availability because they may not include some lower mainstem or headwater areas that once contained usable habitat. Some reaches that are today used only for migration, may in the past have been significant for juvenile rearing or spawning. This has occurred in lowland reaches of many basins where anthropogenic influences have reduced habitat quantity and quality. One instance where these data were available reflects the magnitude of change in habitat possible. Christy (2004) estimated that 74% of freshwater wetland and saltwater marsh habitat has been lost or converted to other habitat types in basins within the Coastal Coho SMU since 1850. These types of habitat may be critical to juvenile coho rearing and are not captured in our assessments based on accessible and inaccessible freshwater spawning and rearing habitat.

The scale at which accessible and inaccessible habitat were evaluated should be noted. In many instances, tables displaying accessible and inaccessible habitat will show “0 miles inaccessible”. Habitat accessibility estimates are derived at the 1:100,000 scale and thus will not capture habitat lost in many smaller (1:24,000) streams resulting from barriers such as culverts. Habitat lost in smaller streams will vary by species and population. Among anadromous species, scale-based effects of not including small streams will be most significant for coho and steelhead and least significant for Chinook. Data presented on accessibility should be viewed as general approximations of reality and not as a definitive analysis on habitat availability/accessibility. These issues will be more thoroughly addressed through the conservation planning process.

Habitat use distribution criteria are based on a broad snapshot representation of freshwater spawning and rearing habitats. Effects of significant changes in specific habitat limiting factors will be manifested in other assessment criteria such as abundance and productivity. Changes in estuary habitats are not directly considered because we have only a qualitative understanding of the linkages between estuary habitat and salmon production. Similarly the habitat criteria does not attempt to capture details of habitat conditions and usage. Exhaustive assessments of habitat limiting factors would require in depth analysis of detailed data which is unavailable in many or most cases. Detailed conservation plans for at risk species are better suited for comprehensive habitat and limiting factor assessments.

Abundance

Criteria: **Number of naturally-produced fish is greater than 25% of average levels in at least three of the last five years for at least 80% of existing populations.**

The intent of the abundance criterion is to identify populations where recent spawner numbers have fallen to critically low levels. At such levels, normal population dynamics might falter, key population elements begin to be lost, and safety factors for chance events or catastrophes are marginal (Figure 3). Critical population sizes are levels below which a population should not go, or should not stay at for more than two years. Populations can rebound from periodic low escapements but recovery is not assured. Even if recovery occurs nine times out of ten, a 10% failure rate inevitably means extinction.

The criterion identifies populations and SMUs at low points in periodic abundance cycles or long-term declining trends. The intent is to determine where recent abundance levels suggest the SMU may not remain viable until a comprehensive conservation plan is developed. At-risk SMUs identified by this criterion may require emergency protective measures and an elevated priority for conservation planning.

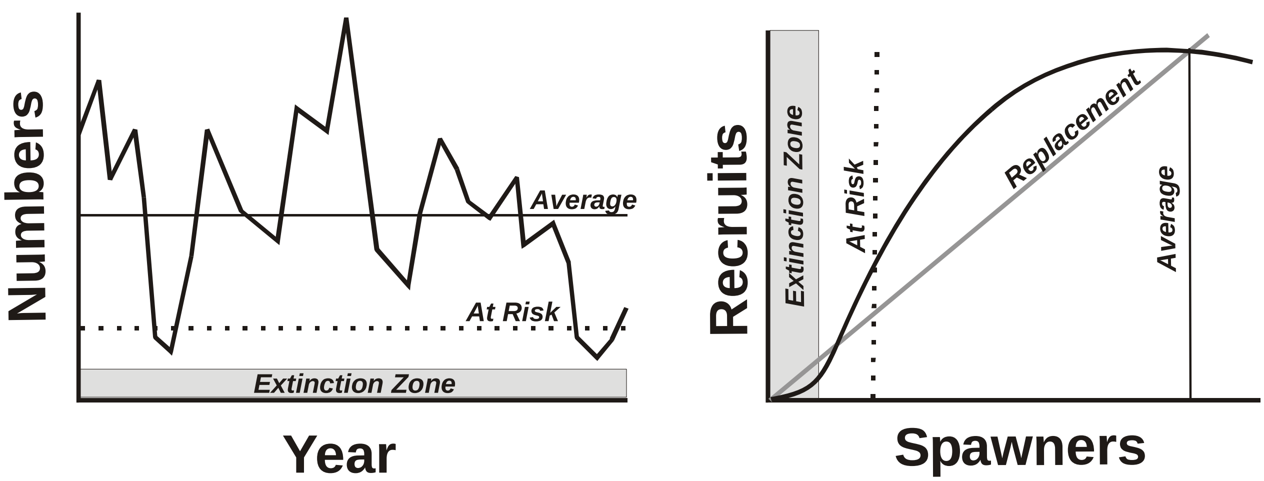

Figure 3. Hypothetical annual spawning escapement patterns (left) and density-dependent relationship between salmon spawner numbers and recruits in the next generation (right) relative to average, at-risk, and extinction population levels.

If hatchery spawners did not dominate the population then the criterion was evaluated by selecting an abundance reference level intended to represent the long-term average capacity of the system. Numbers of naturally-produced fish must be greater than 25% of reference levels in at least three of the last five years. At least 80% of existing populations must pass for the SMU to pass. A hierarchy of reference level selection criteria were used to determine appropriate reference points (Table 5). The reference for each SMU was selected based on population characteristics and data availability.

Table 5. Rules for determining the abundance level to compare recent returns to for the abundance criterion.

ABUNDANCE THRESHOLD DETERMINATION RULES

1) Does hatchery composition data indicate that 50% of the naturally spawning population over the last fourgenerations is hatchery produced?
   - **a)** If yes: Abundance criteria is failed. High hatchery composition indicates that the population abundance trend is driven more by hatchery supplementation than natural fluctuations in population levels.
   - **b)** If no: Go to number 2.

2) Is a valid estimate of basin capacity available for the population?
   - **a)** If yes: Threshold value is based on 25% of the estimate.
   - **b)** If no: Go to number 3.

3) Are a reliable 10-30 years of natural abundance estimates or indices available?
   - **a)** If yes: Go to number 4.
   - **b)** If no: Go to number 5.

4) Is the current time series of estimates confounded by human-caused mortality factors that have reduced numbers to levels that may no longer be viable?
   - **a)** If yes: Use 25% of historical escapement numbers instead of recent average.
   - **b)** If no: Use 25% of the recent average.

5) Can population status be reasonably inferred from other representative populations within the SMU?
   - **a)** If yes: Apply same abundance pass/fail rating.
   - **b)** If no: No determination is made. Precautionary application of criteria treats inconclusive data the same as failure in assessment of risks to the SMU.

Low abundance ranges were defined based on 25% of the reference level. The 25% benchmark represents a point approximately midway between the origin and maximum production on the typical salmon stock-recruitment curve. Data points are often few below the 25% level and the nature of the stock-recruitment relationship becomes highly uncertain. Somewhere in this low range, normal population processes are believed to break down as a result of lost diversity, inbreeding, inability to find mates, or the magnified effects of predation. Spawners are no longer able to replace themselves and a population can begin to spiral downward toward extinction. The stock-recruitment relationship becomes depensatory (productivity decreases with decreasing numbers) rather than compensatory (productivity continuing to increase with decreasing abundance).

Habitat capacity to produce fish was preferentially used as the reference level where empirical estimates were available from spawner-recruit or habitat data. Long time series of spawner-recruit data can be examined statistically to estimate equilibrium population levels where existing habitat is filled and additional spawners provide no added benefit. Habitat capacity can also be estimated from detailed survey data on habitat quantity and quality that can be related to expected fish density by habitat type. In the ideal case, both spawner-recruit and habitat analyses are used to corroborate each other.

Long-term average spawner numbers were used as the reference level where empirical capacity estimates were unavailable. Periods of 30 years were preferred in order to average out the influences of normal variation in environmental conditions and corresponding effects on fish survival. Shorter periods may not be representative of potential population sizes. For instance, many salmon populations were reduced over the last 20 years by an unprecedented series of poor ocean survival conditions. However, in many instances data are limited to periods shorter than the past 30 years and in those cases an average abundance from the entire time period was used. Periods shorter than ten years were not used for salmon and steelhead populations.

In some cases, the 10-30 year average abundance was confounded by human-caused mortality factors that have reduced numbers to levels that may no longer be viable. For instance, returns of spring Chinook to the Snake basin have been depressed since the completion of the Columbia River hydropower system. Using the average abundance from 30 years of data from a depressed population does not provide a good indicator of optimum escapement for these populations. In such a case, the average abundance from a time period prior to significant depression from anthropogenic effects was selected as the reference level. If a reference level could not be selected based on any of the preceding means, then assessment outcomes from other representative populations were used to make the assessment.

For populations at chronically low levels, the specified abundance criteria my overlook declines that predate the 30-year reference period. One alternative might have been to establish a minimum number of fish for a population in addition to existing abundance criteria. However, estimates of absolute abundance are not widely available and abundance estimates are subject to their own limitations of interpretation and application. Estimates of actual abundance will be considered in detailed conservation planning.

Populations failed the abundance criterion when first generation hatchery fish comprised 50% or more of the spawning population for four or more generations. The naturally-produced component of these hatchery-dominated populations likely includes significant numbers of offspring of hatchery fish and resulting numbers provide little information on the status of the wild natural population. Where hatchery fraction was unknown, it was inferred from other information such as hatchery release numbers and release locations. In several cases, a lack of hatchery information contributed to failure of the abundance criteria.

Abundance assessments involve a wide variety of absolute estimates and relative indices including dam or weir counts, mark-recapture estimates, redd counts, peak spawner counts, fish densities. Each of these estimates involves is subject to some degree of sampling uncertainty. This assessment applies the best available data and identifies the type and source of information used. Specific evaluations of the quality of each abundance time series is beyond the scope of this assessment.

Appropriate abundance benchmarks were particularly problematic for resident fish species. As a result, abundance of resident species cannot be be assessed in the same manner as anadromous species. In this case, the most appropriate alternatives were used for each species and benchmarks varied among species depending on the scientific literature on that species. For instance, bull trout benchmarks were based on bull trout viable population sizes identified by Rieman and Allendorf (2001). In contrast, mean density was used as a benchmark for redband populations where the available data consists primarily of fish density. As with many aspects of this assessment, analysis methods are intended to provide guidance on the relative risks and priorities of each SMU and more comprehensive evaluations of risk and limiting factors are appropriate for subsequent conservation planning efforts.

Productivity

Criteria: Population replacement rate for at least 80% of existing populations is at least 1.2 naturally-produced adult offspring per parent in three of the last five years when total abundance was less than average returns of naturally produced fish.

Productivity refers to a population's ability to replace itself with significant numbers of juveniles and adults in the next generation. Productive populations produce more adults in the next generation than are needed to replace the parents (Figure 4). Unproductive populations are unable to consistently replace themselves. Productivity is generally related to high habitat quality and high life history diversity that allows a population to take maximum advantage of a variety of habitat and environmental conditions. For anadromous salmon, productivity is typically expressed as a ratio of recruits-per-spawner and measured when the density of spawners is low and therefore the reproductive potential greatest. For non-anadromous species, estimates of productivity are complicated by the need to also consider age of maturity and spawning periodicity. Because this data is frequently lacking, estimates of productivity of non-anadromous species generally rely on inferences rather than direct quantitative estimates.

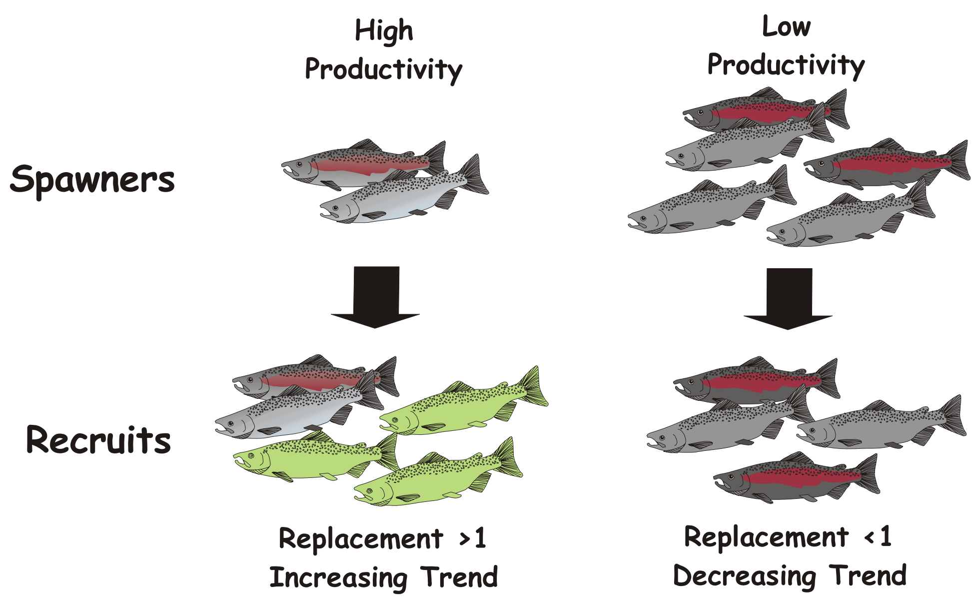

Figure 4. Differences in future recruitment from cohorts of spawners of high and low productivity.

Populations characterized by productivity at low spawner densities (high intrinsic productivity) are typically more "viable" (i.e., not prone to extinction) than populations with low intrinsic productivity. Highly productive populations produce large numbers of recruits-per-spawner that help buffer the population from other mortality factors and allow these populations to rebound quickly from years of poor ocean survival. Unproductive populations are less resilient and subject to extended periods of low escapements where extinction risks can become acute. Productivity may be a much better indicator of long-term population prospects than abundance. Abundance may fluctuate from year to year in response to variable environmental conditions. Productivity is the driver that ultimately determines whether these fluctuations will ultimately prove fatal. Thus a small, highly productive population can be more robust than a large, unproductive population.

Productivity is typically estimated for salmon based on spawner-recruit relationships. Spawners are adults that survive fishing and migration to return to freshwater tributary streams in any year to spawn. Recruits are the naturally-produced offspring from a given cohort of spawners that survive to spawn in subsequent years. Salmon recruits from a given brood year typically include fish of increasing ages returning in subsequent run years (2-year-olds 2 years later, 3-year-olds 3 years later, etc.). Jacks (precocious males) are not typically incorporated into either the parent or recruit portion of the productivity equation because they are much less successful spawners and make up a small percentage of the recruits. Estimates of recruits-per-spawner were completed where spawner and age data were adequate for brood year run reconstruction. Run year age composition data was used unless annual sample sizes were less than 50, whereupon aggregate year age composition was applied. Aged fish sample sizes of at least more than 50 were observed to provide reasonable representation (at least four fish per age) of the less frequent age groups in the return.

Populations were evaluated for the productivity criterion based on a rate of intrinsic productivity that was at least 1.2 naturally produced adult offspring per parent in three of the last five years when total abundance was less than the full seeding level. SMUs passed the criterion if at least 80% of the existing populations passed the criterion. Intrinsic productivity is best measured at low to moderate population sizes when density-dependent effects are not likely to be strong (Figure 5). As densities increase, competition for habitat begins to reduce recruits-per-spawner. Where spawners exceed the available habitat capacity, average replacement falls to less than 1.0.

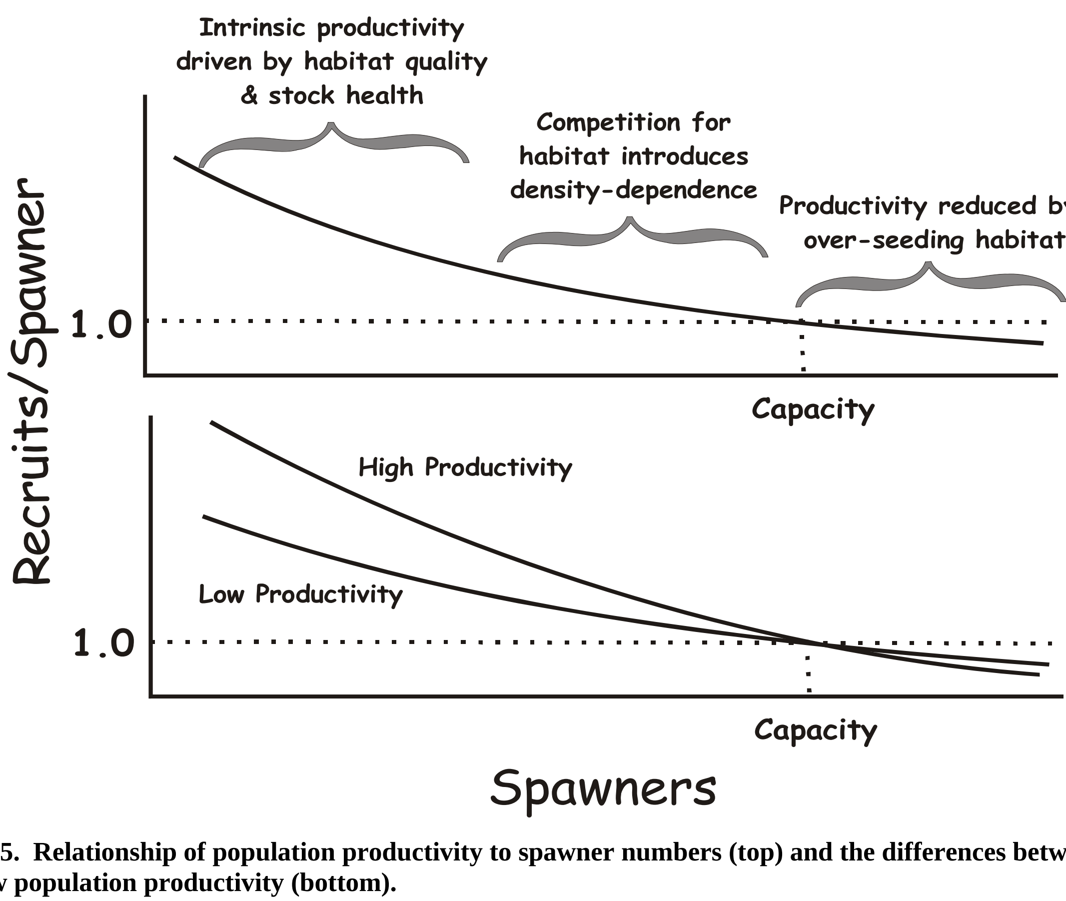

Figure 5. Relationship of population productivity to spawner numbers (top) and the differences between high and low population productivity (bottom).

Average spawner-recruit rates of 1.2 or less during low run years flag very low population productivities for salmon. The average 30-year abundance from the abundance criterion was used as a reference point to identify years where spawner numbers were less than existing habitat capacity. Average salmon escapements are typically less than the hypothetical equilibrium based solely on freshwater habitat capacity because of out-of-subbasin effects, particularly during periods of low ocean survival. A criterion threshold of 1.2 recruits per spawner at low spawner density was developed from an ad hoc inspection of data from a variety of wild populations that were thought to be otherwise viable. This viable condition was verified on basis of meeting the other interim criteria, plus various population viability simulations that indicated the chance of population extinction was very low. For these viable populations it was found that the average values for recruits per spawner associated with spawner levels less than the average abundance level was 1.2 or greater.

Initially, in the development of the productivity interim criterion, the estimation method proposed was based upon spawner-recruit analyses. However, such estimates, technically referred as intrinsic productivity, were often difficult to obtain and susceptible to a number measurement errors. Therefore, as an alternative the present metric was devised (1.2 recruits per spawner for data points from spawner levels less than the 30-year average abundance of wild fish). Essentially, this metric was meant to be a substitute index for intrinsic productivity as estimated via spawner-recruit analyses.

It should be noted, the values obtained for the productivity metric used in this report, average (geometric) recruits per spawner for moderate to low spawner densities, are not directly comparable to estimates of intrinsic productivity as determined from recruitment analysis. For example, the moderate to low spawner data points from a typical population that were found to have an average recruits-per-spawner value of 1.2 would yield a intrinsic productivity estimate via the spawner-recruit analysis in the range of 2.0. This is the case because the two primary spawner-recruit models fit to observed data create a curve where the ratio of recruits-per-spawner increases in relation to decreasing spawner density. Therefore, the highest recruit-per-spawner values will occur at those spawner densities nearest to zero. Typically, intrinsic productivity is reported as the predicted recruits-per-spawner at this near zero spawner abundance. In contrast, the productivity metric used in this evaluation is essentially an average of recruits-per-spawner values for all spawner levels from near zero to the average spawner abundance. Therefore, it is inevitable that from the same raw data, the average productivity metric used here will always be a lower value than the intrinsic productivity estimated via spawner-recruit analysis.

Spawners often include adults of natural and hatchery origin. First generation hatchery fish are not a product of the freshwater habitat and hence are not counted as recruits. Recruits do include offspring of first generation hatchery fish that spawn in natural habitats. The productivity criterion is based on years when <u>total</u> (hatchery plus naturally-produced) spawner abundance is less than the 30-year average abundance of <u>naturally-produced</u> spawners. Large influxes of hatchery fish may consistently increase escapement to levels exceeding the natural habitat capacity. Hence, the natural escapement average provides a more accurate benchmark for identifying intrinsic productivity of a population. Productivity estimates cannot be derived for some populations with consistent high levels of hatchery escapement where total numbers rarely fall below a natural spawner average benchmark.

For some salmon populations, quantifying recruits-per-spawner was not possible because of a lack of data or the inability to separate hatchery fish from naturally-produced fish. Productivity assessments are also constrained by the availability of current data. For instance, accurate estimates of recruits from salmon spawners in a given brood year requires a complete time series of returns from that cohort. Age composition is species-specific but in Chinook or steelhead complete return data is not available until six or seven years. In addition, the productivity criteria are based on years of low spawner numbers to provide a density-independent signal of the inherent potential of a given population. This may require going back several years in time to identify representative cohorts. This factors may create a false impression that the productivity assessment is based on dated information when as a practical matter the assessment is based on the best available current information.

Reproductive Independence

Criteria:	**90% or more of spawners are naturally produced in at least three of the last five years for at least 80% of existing populations.**

Reproductive independence refers primarily to the incidence of hatchery-produced fish in natural spawning populations. The Native Fish Conservation Policy is focused on protection of naturally-produced native fish species. The effects of hatchery and naturally-produced fish interactions are complex and controversial. Hatchery fish can bolster natural population sizes. However, large numbers of highly-domesticated or non-local hatchery fish spawning naturally can also be detrimental to natural population productivity under certain circumstances. Hatchery fish can pose risks to the diversity, productivity, and sustainability of locally-adapted natural populations where hatchery fish characteristics have been altered by hatchery broodstock sources or selective practices. Large numbers of hatchery fish also obscure our ability to accurately evaluate the status of the naturally-produced population component.

This criterion was evaluated based on 90% or more of spawners originating from natural production in at least three of the last five years for at least 80% of existing populations. A 90% threshold was set for this criterion based on both a genetic adaptation and demographic basis. From a adaptive standpoint, the reported rates of natural straying between wild populations is generally lower than 10%. Generally, a spawning population where more than 10% of the members are natural immigrants is rare. Rates in excess of this level are most likely unnatural and therefore pose a risk to the adaptive characteristics of the population. If this holds true for natural straying of wild fish, then it is assumed to also be true for straying of hatchery fish. Although methods have been proposed to fully integrate hatchery-reared fish with wild populations and avoid the supposed two population genetic risk – the practical application of such methods to date have not been demonstrated to be successful.

Further, immigration rates in excess of 10%, regardless of origin, likely cause the population to no longer be demographically independent. The breakdown of demographic independence means that by definition the population may no longer technically exist. Essentially, the population has been blended with another population and the distinctiveness of both lost. Effectively under these circumstances the SMU has lost a population. This represents additional risk.

The interim criterion does not reflect a judgment on the relative significance of or value of hatchery fish relative to naturally produced fish. The interim criteria is intended only to flag cases where significant numbers of hatchery fish potentially interact with or subsidize the naturally-produced population. Of particular concern is our inability to accurately evaluate native fish status where significant numbers of hatchery fish are also found. Specific risks, benefits, and tradeoffs between hatchery and naturally produced fish in each SMU and population may then be more fully considered in appropriate conservation plans.

The incidence of hatchery fish is ideally estimated from observations of marked hatchery fish on the spawning grounds. Current practice involves adipose fin marking of all or most hatchery steelhead, spring Chinook, and coho to allow for selective fisheries for hatchery fish. Portions of fall Chinook hatchery releases are also marked for stock assessment purposes. Hatchery trout are typically non-fin marked although they can often be identified by dorsal fin deformities. Marked hatchery fish are readily identified where trap or carcass surveys allow close inspection of individual fish. In areas where fish are not directly sampled, the potential for hatchery interactions may often be inferred from numbers and sites of hatchery releases. Although hatchery juveniles typically survive at a lower rate than wild juveniles, large hatchery releases are often associated with significant numbers of hatchery fish in local natural spawning areas. Assumptions of significant strays in systems with significant releases provides a precautionary assessment of this criteria where adult sample data are lacking.

Hybridization

Criteria: **Hybridization with non-native species is rare or nonexistent in three of the last five years for at least 80% of existing populations.**

This criterion highlights specific cases where native species are threatened by hybridization. The evaluation was based on whether hybridization and/or significant competition with non-native species was rare or nonexistent in three of the last five years for at least 80% of existing populations. Hybridization involves interbreeding between related species (e.g., cutthroat vs. rainbow trout). Some hybridizations, such as bull trout with brook trout, lead to reduced productivity or a loss of unique genetic characteristics.

The hybridization criterion is generally more pertinent to resident trout than anadromous salmon. Cases of within-species interbreeding of different salmon and steelhead stocks are addressed by the reproductive independence criteria. Because significant hybridization among anadromous salmon and steelhead is not an issue, risk assessments for those species are essentially determined by the other five criteria.

The NFCP does not provide a quantitative definition of acceptable hybridization levels. For the purposes of this evaluation, hybridization of trout was assumed to be potentially significant where non-native species were sympatric with native species unless specific sample data indicated that hybridization was rare or nonexistent. Rare or nonexistent were arbitrarily defined as 2% or less.