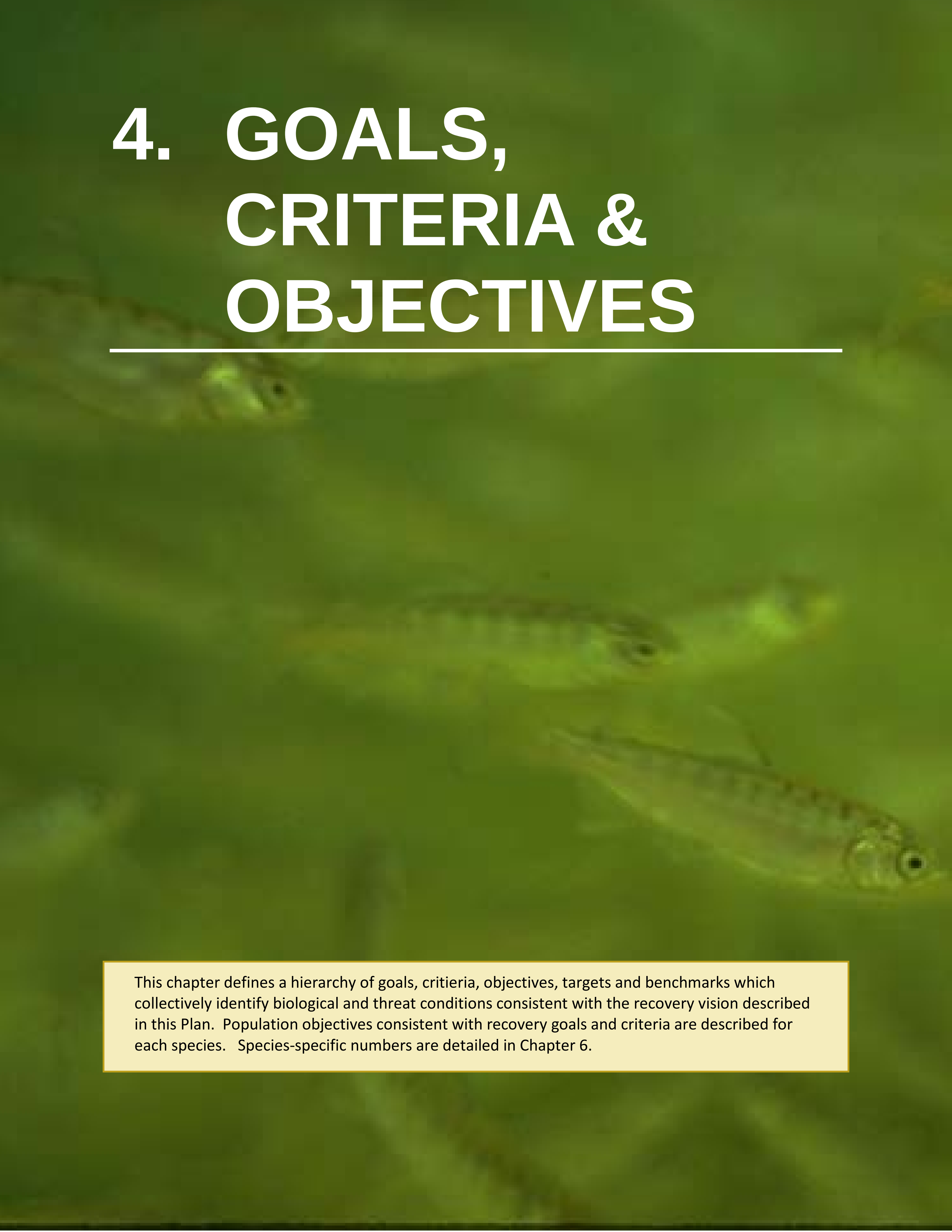

4. GOALS, CRITERIA & OBJECTIVES

This chapter defines a hierarchy of goals, critieria, objectives, targets and benchmarks which collectively identify biological and threat conditions consistent with the recovery vision described in this Plan. Population objectives consistent with recovery goals and criteria are described for each species. Species-specific numbers are detailed in Chapter 6.

4. GOALS, CRITERIA & OBJECTIVES

Tables

Figures

4.1. Overview

It is the overarching goal of this Plan to return all lower Columbia salmon and steelhead populations to healthy and harvestable levels within 25 years.

- Salmon and steelhead species are considered healthy or viable when they are no longer in danger of extinction or likely to become endangered within the foreseeable future and no longer require protection under ESA.
- A species is harvestable when it is viable, and when fish numbers are sufficient to allow direct and sustainable sport, commercial, and tribal harvest without jeopardizing the species' viability.

Criteria for species viability are established by NMFS and are based on risk of extinction over time. The Viable Salmonid Population (VSP) criteria include measures of species abundance, productivity, diversity, and spatial structure. The VSP criteria, in combination with modeling and analysis of available population data, were used to assess baseline[1] status and set recovery objectives for the Lower Columbia ESU. These objectives include population-level, strata-level and ESU/DPS-level recovery objectives. The combinations of population viability objectives that meet NMFS' criteria are called the recovery scenario (Figure 4-1).

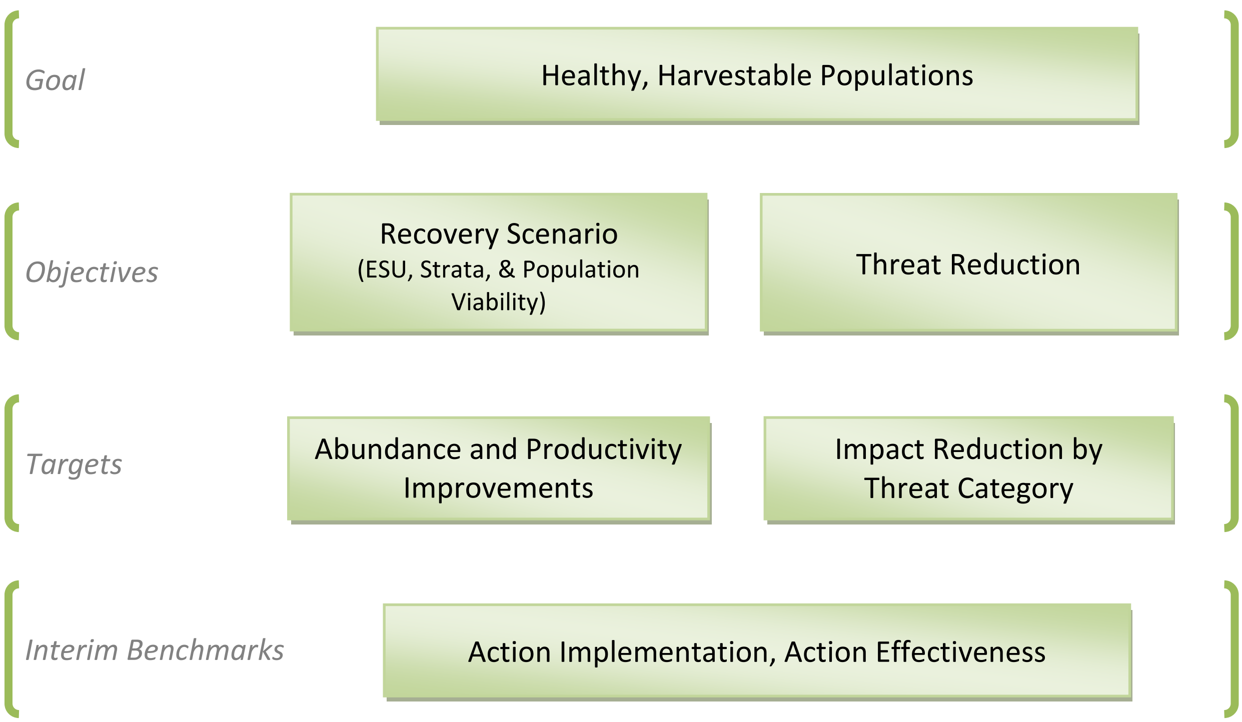

Figure 4-1. Hierarchy of Recovery Plan goals, objectives, targets, and benchmarks identified for Washington lower Columbia River salmon and steelhead.

[1] For the purposes of this Plan, "baseline" refers to conditions prevalent at the the time of initial listings of lower Columbia River salmon and steelhead circa 1998-1999.

Population-level targets for improvements needed to meet the viability objectives have been established. These targets describe relative improvements in population attributes (including abundance and productivity) needed to close the "gap" between baseline status and population objectives.

In addition to improvement targets for VSP parameters, targets for threat impact reduction are identified. As part of the listing process under the ESA, NMFS identified listing factors for each listed species. Listing factors and threats are categories of conditions that affect or limit fish viability at some point in their life cycle. This Plan defines impact reduction targets for each potentially-manageable threat category (stream habitat, estuary habitat, dams, fisheries, hatcheries, and ecological interactions). Collectively, impact reduction targets for the potentially-manageable threat categories identify the overall threat impact reduction needed to achieve the population viability objective. The "recovery burden" is equitably allocated among threat categories in proportion to the significance of the threat. Targets also reflect long-term harvestability goals of the Plan.

The Plan's objectives and targets define desired conditions at the time of recovery. Since recovery will require several decades or longer to achieve goals, the interim benchmarks have been established in order to guide implementation of recovery actions over time and assess progress toward recovery.

4.2. Recovery Goals

The goal of this Plan is recovery of all lower Columbia salmon and steelhead species to healthy and harvestable levels within 25 years. Health is defined based on species status. A species is considered healthy when it is recovered to viable levels where it is no longer in danger of extinction or likely to become endangered within the foreseeable future and can be removed from listing under ESA. A species is harvestable when it is viable and when fish numbers are sufficient to allow direct and sustainable sport, commercial, and tribal harvest without jeopardizing the species' viability.

4.2.1. Viability

Viability is simply the ability of a population or group of populations to persist over an extended period of time. For ESA purposes, a viable ESU is one that is not endangered or threatened with extinction. The ESA defines threatened as likely to become endangered within the foreseeable future. A viable salmonid population has been defined by NMFS as an independent population that has a negligible risk of extinction (<5%) due to threats from demographic variation, local environmental variation, and genetic diversity changes over a 100-year time frame.

Extinction is the irreversible disappearance of a species, subspecies, or population group. Extinction results from the interaction of fish population processes and external factors to reduce population size to critical low levels that are no longer self-sustaining (Figure 4-2). Populations become functionally extinct when they "bottom out" at critical low levels from which they cannot recover. Problems that may preclude recovery of small populations include inability to find mates, skewed sex ratios, increased predation effects, genetic inbreeding, and risks of extinction from natural downturns in survival conditions or catastrophes.

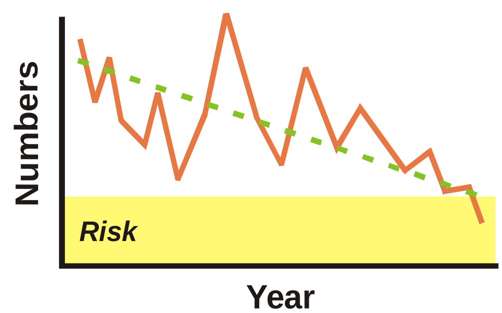

Figure 4-2. Hypothetical example of a population at significant risk of extinction.

This Plan adopts recovery objectives for viability based on criteria recommended by the TRT (McElhany et. al. 2003, 2006). These scientists distinguished five categories of viability and risk using a numerical score from 0 to 4 (Table 4-1). For instance, a viable population was defined as having a "high" level of viability with at least a 95% probability of persistence for 100 years. The equivalent extinction risk for a population of high viability would be low or not more than 5% for 100 years. Thus, hypothetical ly, given 100 populations at high viability (low risk), approximately 5 out of the 100 would be expected to become extinct within the prescribed period.

Table 4-1. Viability and extinction risk categories identified by the Willamette-Lower Columbia Technical Recovery Team.

Score	Viability		Extinction risk	
	Category	Probability[1]	Category	Probability
0	Very low	<40%	Either extinct or very high	>60%
1	Low	40-74%	High	26-60%
2	Medium	75-94%	Moderate	6-25%
3	High[2]	95-99%	Low[2]	1-5%
4	Very High	>99%	Very low	<1%

[1] 100-year persistence probabilities.
[2] Represents a "viable" level.

4.2.2. Harvestability

Harvestability goals are reached when adult production exceeds viability objectives and wild fish can be directly harvested at levels that maintain spawning escapement at or above viability objectives (Figure 4-3). Under the ESA, recovery of an ESU/DPS might be reached when the ESU/DPS viability criteria are achieved. However, the recovery vision in this Plan of healthy, harvestable populations will require improvement to levels greater than the minimum levels identified by viability criteria.

Harvest of listed populations that are not considered viable is typically limited to indirect take in mixed stock fisheries for strong wild runs and hatchery stocks. Indirect harvest impacts are controlled by limits established by NMFS in ESA harvest consultations. This Plan identifies long-term harvest impact reduction targets for each salmon and steelhead population and prescribes a phased strategy to manage harvest impacts. Initially, harvest impacts should be reduced to levels below the long-term target in order to reduce near term-risks. Harvest impacts would then incrementally increase back to long-term targets as actions to address other threat categories improve fish abundance and productivity to the point where natural populations meet and ultimately exceed escapement levels needed to sustain a viable ESU.

The harvest of salmon and steelhead has important cultural, social, and economic implications for the people of the region. While the Plan calls for near-term reductions in fisheries impacts in order to reduce risks to the viability of natural spawning populations, it also calls for the preservation of viable sport, commercial, and tribal fisheries during the recovery period. The Plan includes specific strategies to maintain viable fishery opportunities during the recovery period. The strategies stress the harvest of hatchery and healthy natural stocks and the continuation of hatchery programs needed to produce fish for harvest. Finally, to help ensure that fishery impact rates work for both the fish and the people of the region, the Plan calls for fishery managers to not only ensure that fishery impact rates are biologically sound and supportive of recovery efforts, but also to consider and address relevant cultural, social, legal, and economic factors.

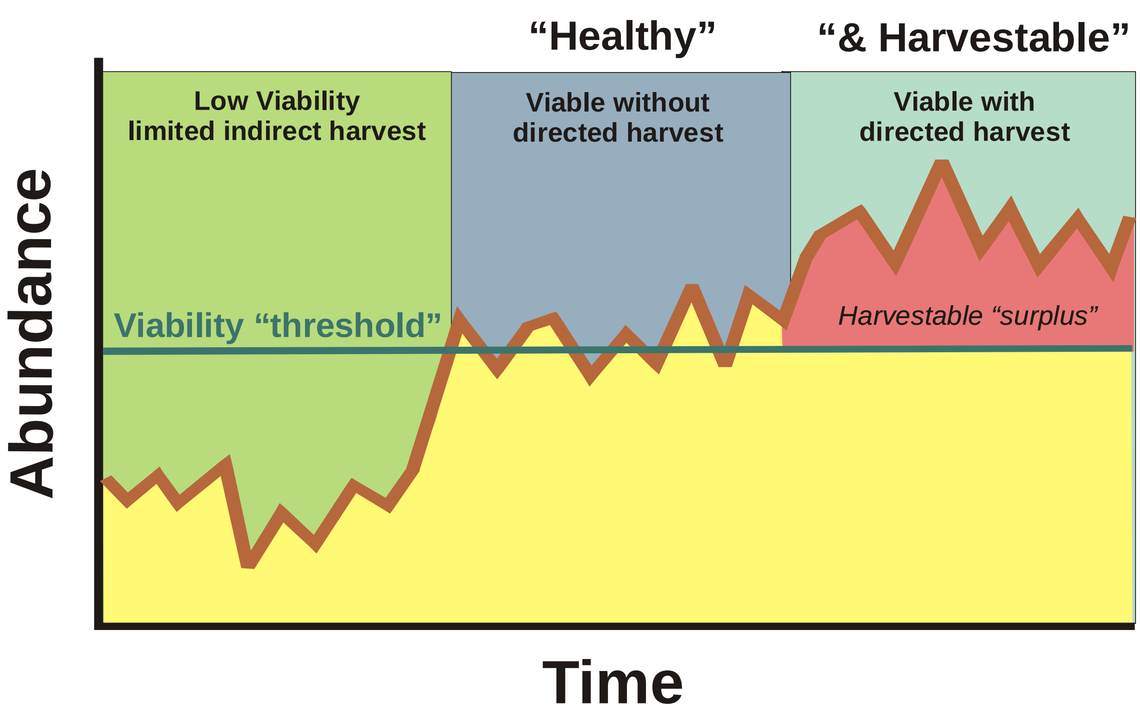

Figure 4-3. Example recovery trajectory illustrating healthy and harvest goals of this Plan.

It should be noted that reduction or even elimination of near-term fishery impacts would alone not be sufficient to achieve recovery. Recovery will require a concerted effort to reduce all threats to listed Lower Columbia salmon and steelhead and this Plan is based on the premise that aggressive near-term action will be taken to address these risks on all levels. Even with immediate, aggressive action to address near-term threats, the results of actions to address habitat and hatchery threats in particular will take years to fully recognize. Fishery reductions are an effective option for reducing near-term risks to the viability of listed salmon and steelhead. However, there is a point beyond which further reduction of fisheries impacts will fail to produce any further significant reduction of risk. This point of diminishing returns should be observed in setting fishery impact rates in order to avoid needless cultural, social, and economic impacts.

The long-term harvest impact reduction targets define harvest opportunity objectives expected to be sustainable once recovery has been achieved. These long-term harvest reduction/ harvest opportunity rates are described in Table 4-2. Once recovery has been achieved, improvements in natural population productivity resulting from effective implementation of recovery actions are expected to allow direct harvest of wild fish. Recovery actions are also expected to increase the frequency of years that wild salmon and steelhead populations produce harvestable numbers. Increasing salmonid numbers can also be expected to provide a variety of other fishery benefits including more consistent seasons and fewer restrictions to access of harvestable numbers of fish of other stocks. Sustainable harvest rates will be based on realized improvements in population viability.

Table 4-2. Fishery opportunity objectives and sustainable fishing rate targets for directed harvest on natural populations consistent with the harvestability goal of this Plan. Ranges reflect annual or population differences.

Species	Fishing rates at recovery	Fishery Opportunities
Spring Chinook	20-30%	• Directed freshwater sport, commercial & treaty tribal fisheries.
Fall Chinook	40-50%	• Directed U.S. ocean & freshwater sport, commercial & treaty tribal fisheries. • Limited incidental harvest in AK & CAN sport & commercial fisheries.
Chum	3-5%[1]	• Incidental impact of limited late fall fisheries in freshwater.
Coho	10-30%[1]	• Directed U.S. ocean & freshwater sport, commercial. & treaty tribal fisheries.
Steelhead	5-10%	• Directed harvest in treaty tribal fisheries above Bonneville Dam. • Catch and release impacts of freshwater sport fisheries. • Limited incidental impacts of spring mainstem commercial fisheries.

[1] Recovery fishing rates for some species are identified in this Plan based on current rates. Sustainable fishing rates at recovery might be greater but will be ultimately determined based on wild population parameters.

4.3. Recovery Criteria

4.3.1. ESU/DPS Viability

This Plan adopts criteria for species viability recommended by the TRT (McElhany et. al. 2003, 2006). The TRT established standards for different viability levels within the Willamette/Lower Columbia domain based on a series of ESU, strata, and population criteria (Figure 4-4). The approach has five essential elements:

Stratified Approach: Every life history and ecological zone stratum that historically existed should have a high probability of persistence. Salmonid ESUs/DPSs in the lower Columbia River were stratified by the TRT into ecological zones (Coast, Cascade, and Gorge), species, and life history types (spring, fall, etc.).

Viable Populations: Individual populations within a stratum should have persistence probabilities consistent with a high probability of strata persistence. The TRT defined high persistence probability based on the presence of at least two populations with a negligible risk of extinction per stratum and other populations in the stratum have persistence probabilities consistent with a high probability of stratum persistence (i.e., the average of all stratum population scores is 2.25 or higher, based on the TRT's scoring system). Population viability depends on naturally-produced fish spawning in the wild.

Representative Populations: Representative populations need to be preserved but not every historical population needs to be restored. Populations selected for high or very high viability should include "core" populations that are highly productive, "legacy" populations that represent historical genetic diversity, and "dispersed" populations that minimize susceptibility to catastrophic events.

Non-Deterioration: No population should be allowed to deteriorate until ESU recovery is assured. Currently productive populations and population segments must be preserved. Recovery measures will be needed in most areas to arrest declining status and offset the effects of potential future impacts.

Safety Factors: Higher levels of recovery should be attempted in more populations than identified in the strata viability criteria because not all attempts will be successful. Recovery efforts must target more than the minimum number of populations and more than the minimum population levels thought to ensure viability.

Each ESU or DPS consists of two or more strata defined by the TRT as groups of populations of an ESU/DPS with

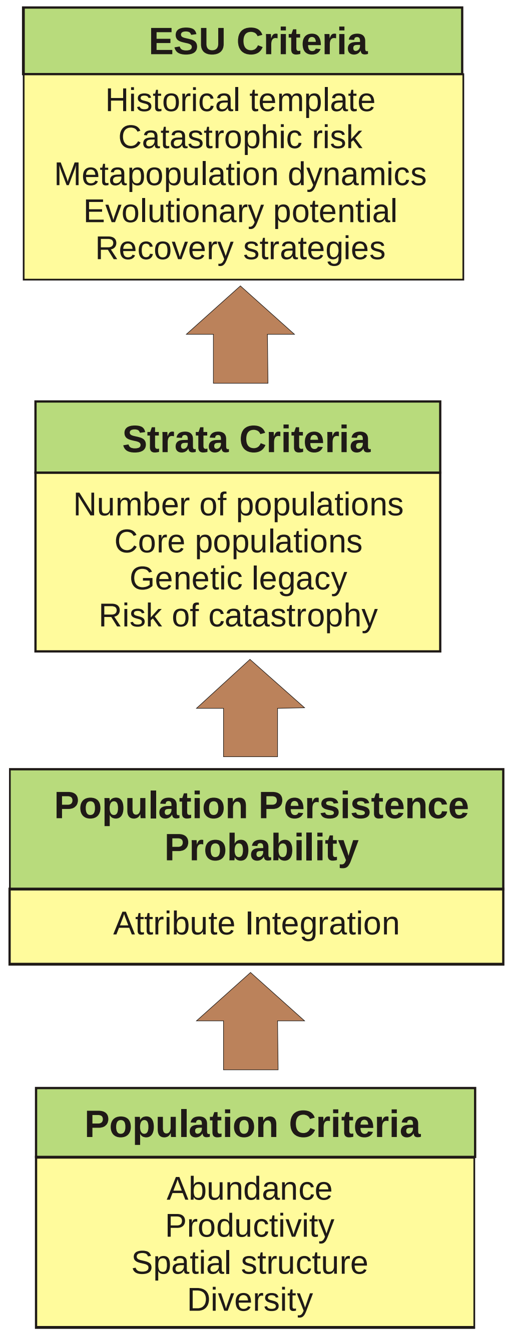

Figure 4-4. TRT viability criteria (from McElhany et al. 2003, 2006).

similar life history traits within the same ecological zone (Myers et al. 2003). Distinct ecological zones in this range include the Coast, Cascades, and Gorge (Figure 4-5). Fish life history traits are associated with different runs of each species typically described based on the season of return. For example, Chinook life history types include stream-type spring run, ocean-type fall run (tules), and ocean-type late fall run (brights). Thus, Chinook salmon strata include Coast fall, Cascade fall, Cascade late fall, Gorge spring, etc. Similar distinctions occur for listed chum, coho and steelhead.

TRT recommendations for ESU/DPS, strata and population criteria are detailed in Box 4-1. According to the standard, an ESU/DPS is viable when every strata in the ESU/DPS is viable. A stratum is viable when it contains at least two populations of high or greater viability (viability score ≥ 3.0) and the strata-wide average viability for all populations exceeds medium (viability score ≥ 2.25). Population viability is determined based on abundance, productivity, spatial structure and diversity parameters according to the Viable Salmonid Population (VSP) concept previously described by McElhany et. al. (2000).

Figure 4-5. Ecological zones identified for recovery strata by the Willamette/Lower Columbia Technical Recovery Team for listed lower Columbia River salmon Evolutionarily Significant Units and steelhead Distinct Population Segments.

Box 4-1. Viability criteria from the Willamette-Lower Columbia Technical Recovery Team.

ESU-Level Viability Criteria

1. Every stratum (life history and ecological zone combination) that historically existed should have a high probability of persistence.
2. Until all ESU viability criteria have been achieved, no population should be allowed to deteriorate in its probability of persistence.
3. High levels of recovery should be attempted in more populations than identified in the strata viability criteria because not all attempts will be successful.

Strata-Level Viability Criteria

1. Individual populations within a stratum should have persistence probabilities consistent with a high probability of stratum persistence.
2. Within a stratum, the populations restored/maintained at viable status or above should be selected to:
   a. Allow for normative meta-population processes, including the viability of "core" populations, which are defined as the historically most productive populations.
   b. Allow for normative evolutionary processes, including the retention of the genetic diversity represented in relatively unmodified historic gene pools.
   c. Minimize susceptibility to catastrophic events.

Population-Level Viability Criteria

<u>Adult Population Productivity and Abundance</u>

1. In general, viable populations should demonstrate a combination of population growth rate, productivity, and abundance that produces an acceptable probability of population persistence. Various approaches for evaluating population productivity and abundance combinations may be acceptable, but must meet reasonable standards of statistical rigor.
2. A population with non-negative growth rate and an average abundance approximately equivalent to estimated historic average abundance should be considered to be in the highest persistence category. The estimate of historic abundance should be credible, the estimate of baseline abundance should be averaged over several generations, and the growth rate should be estimated with adequate statistical confidence. This criterion takes precedence over criterion 1.

<u>Within-Population Spatial Structure</u>

The spatial structure of a population must support the population at the desired productivity, abundance, and diversity levels through short-term environmental perturbations, longer-term environmental oscillations, and natural patterns of disturbance regimes. The metrics and benchmarks for evaluating the adequacy of a population's spatial structure should specifically address:

a. Quantity: Spatial structure should be large enough to support growth and abundance, and diversity criteria.
b. Quality: Underlying habitat spatial structure should be within specified habitat quality limits for life-history activities (spawning, rearing, migration, or a combination) taking place within the patches.
c. Connectivity: spatial structure should have permanent or appropriate seasonal connectivity to allow adequate migration between spawning and rearing habitats.
d. Dynamics: The spatial structure should not deteriorate in its ability to support the population. The processes creating spatial structure are dynamic, so structure will be created and destroyed, but the rate of flux should not exceed the rate of creation over time.
e. Catastrophic Risk: the spatial structure should be geographically distributed in such a way as to minimize the probability of a significant portion of the structure being lost because of a single catastrophic event, either anthropogenic or natural.

<u>Within-Population Diversity</u>

Sufficient life-history diversity must exist to sustain a population through short-term environmental perturbations and to provide for long-term evolutionary processes. The metrics and benchmarks for evaluating the diversity of a population should be evaluated over multiple generations and should include:

a. Substantial proportion of the diversity of a life-history trait(s) that existed historically,
b. Gene flow and genetic diversity should be similar to historic (natural) levels and origins,
c. Successful utilization of all available habitats, and
d. Resilience and adaptation to environmental fluctuations.

4.3.2. Population Viability

This Plan includes assessments of baseline population viability and objectives for population viability consistent with species viability or recovery goals. Baseline population status was assessed in this Plan based on four attributes related to viability: abundance, productivity, spatial structure, and diversity (McElhany et. al. 2000, 2003, 2006, 2007). Population attributes are often correlated and not necessarily independent; however, each attribute merits consideration as a factor that influences extinction risk. For each population, viability scores were estimated individually for abundance/productivity, spatial structure, and diversity attributes based on the best available data. Overall population persistence level was then determined as the lowest of the individual attribute scores (Table 4-3).

Each viability attribute was scored for each population using attribute criteria based on TRT population-level viability criteria (Table 4-4). Although the TRT pointed to all factors as being important, they developed specific population objectives only for abundance and productivity. For other population parameters, the TRT made general recommendations, which were used by the LCFRB to develop specific benchmarks for status assessments and evaluations of progress.

A combination of quantitative and qualitative data was considered in population assessments. Data availability varied substantially among lower Columbia populations. Thus, the assessment involved both rigorous statistical analysis and expert judgment depending on the information available for each population. The assessment was completed by a technical work group comprised of scientists from the Washington Department of Fish and Wildlife and the LCFRB with specific knowledge of lower Columbia River salmon and steelhead populations (Appendix E Chapter 1). Preliminary assessments completed for the interim 2004 Plan were updated in this Plan based on new status information and a more-rigorous quantitative Population Viability Analysis framework developed by scientists from NMFS, Washington, and Oregon since the interim WA Plan was adopted (Appendix E Chapter 12). This included additional TRT products that were developed or completed after the 2004 Plan was completed (McElhany et al. 2006, 2007).

Population assessments describe the most likely risk category for each population but there was significant uncertainty in the status of every population due to limitations in data availability and in our understanding of the basic relationships between population attributes and viability or risk. Information is lacking for a quantitative estimation of the uncertainty associated with each status estimate. However, applications of these assessment results should consider qualitative uncertainty in status estimates equivalent to at least plus or minus one viability level.

Definitions of attributes and descriptions of their application to population status assessment are described below for each attribute. Additional details on the application of population scoring in this Recovery Plan can be found in the Technical Appendix.

Table 4-3. Example calculation of population viability status based on attribute scoring.

Population Attribute	Viability category	Population viability
Abundance/Productivity	Very Low	
Spatial Structure	Low	Very low
Diversity	High	

Table 4-4. Criteria for evaluating fish status relative to TRT population-level viability criteria.

Category	Description	Values[1]
	Adult Abundance and Productivity	
0	Numbers and productivity consistent with either functional extinction or very high risk of extinction	Extinction risk analysis estimates 0-40% persistence probability.
1	Numbers and productivity consistent with relatively high risk of extinction	Extinction risk analysis estimates 40-75% persistence probability.
2	Numbers and productivity consistent with moderate risk of extinction	Extinction risk analysis estimates 75-95% persistence probability.
3	Numbers and productivity consistent with low (negligible) risk of extinction	Extinction risk analysis estimates 95-99% persistence probability.
4	Numbers and productivity consistent with very low risk of extinction	Extinction risk analysis estimates >99% persistence probability.
	Within-Population Spatial Structure	
0	Spatial structure is inadequate in quantity, quality[2], and connectivity to support a population at all.	*Quantity* was based on whether all areas that were historically used remain accessible. Quantity is reduced where significant habitat degradation has eliminated significant habitat components. *Connectivity* based on whether all accessible areas of historical use remain in use. *Catastrophic risk* based on whether key use areas are dispersed among multiple reaches or tributaries. Spatial scores of 0 were typically assigned to populations that were functionally extirpated by passage blockages.
1	Spatial structure is adequate in quantity, quality[2], and connectivity to support a population far below viable size	The majority of the historical range is no longer accessible and fish are currently concentrated in a small portion of the accessible area.
2	Spatial structure is adequate in quantity, quality[2], and connectivity to support a population of moderate but less than viable size.	The majority of the historical range is accessible but fish are currently concentrated in a small portion of the accessible area.
3	Spatial structure is adequate in quantity, quality[2], and connectivity to support population of viable size, but subcriteria for dynamics and/or catastrophic risk are not met	Areas may have been blocked or are no long used but fish continue to be broadly distributed among multiple reaches and tributaries. Also includes populations where all historical areas remain accessible and are used but key use areas are not broadly distributed.
4	Spatial structure is adequate to quantity, quality, connectivity, dynamics, and catastrophic risk to support viable population.	All areas that were historically used remain accessible, all accessible areas remain in use, and key use areas are broadly distributed among multiple reaches or tributaries.

-continued-

Category	Description	Values[1]
	Within-Population Diversity	
0	All four diversity elements (life history diversity, gene flow and genetic diversity, utilization of diverse habitats, and resilience and adaptation to environmental fluctuations) are well below predicted historical levels, extirpated populations, or remnant populations of unknown lineage	*Life history diversity* was based on comparison of adult and juvenile migration timing and age composition. *Genetic diversity* was based on the occurrence of small population bottlenecks in historical spawning escapement and degree of hatchery influence especially by non local stocks. *Resiliency* was based on observed rebounds from periodic small escapements. Diversity scores of 0 were typically assigned to populations that were functionally extirpated or consisted primarily of stray hatchery fish.
1	At least two diversity elements are well below historical levels. Population may not have adequate diversity to buffer the population against relatively minor environmental changes or utilize diverse habitats. Loss of major presumed life history phenotypes is evident; genetic estimates indicate major loss in genetic variation and/or small effective population size. Factors that severely limit the potential for local adaptation are present.	Natural spawning populations have been affected by large fractions of non-local hatchery stocks, substantial shifts in life history have been documented, and wild populations have experienced very low escapements over multiple years.
2	At least one diversity element is well below predicted historical levels; population diversity may not be adequate to buffer strong environmental variation and/or utilize available diverse habitats. Loss of life history phenotypes, especially among important life history traits, and/or reduction in genetic variation is evident. Factors that limit the potential for local adaptation are present.	Hatchery influence has been significant and potentially detrimental or populations have experienced periods of critical low escapement.
3	Diversity elements are not at predicted historical levels, but are at levels able to maintain a population. Minor shifts in proportions of historical life-history variants, and/or genetic estimates, indicate some loss in variation (e.g. number of alleles and heterozygosity), and conditions for local adaptation processes are present.	Wild stock is subject to limited hatchery influence but life history patterns are stable. Extended intervals of critical low escapements have not occurred and population rapidly rebounded from periodic declines in numbers.
4	All four diversity elements are similar to predicted historical levels. A suite of life-history variants, appropriate levels of genetic variation, and conditions for local adaptation processes are present.	Stable life history patterns, minimal hatchery influence, no extended interval of critical low escapements, and rapid rebounds from periodic declines in numbers.

[1] Rules were derived by the LCFRB and WDFW staff based on attribute descriptions developed by the TRT and described in McElhany et al. (2003).

[2] Because recovery criteria are closely related, draft category descriptions developed by the Technical Recovery Team often incorporate similar metrics among multiple criteria. For instance, habitat-based factors have been defined for diversity, spatial structure, and habitat standards. To avoid double counting the same information, streamline the scoring process, and provide for a systematic and repeatable scoring system this application of the criteria used specific metrics only in the criteria where most applicable. This footnote denotes these items.

Abundance

Abundance simply refers to the numerical size of the population. For salmon and steelhead, abundance is typically described based on annual number of spawning adults. This Plan identifies abundance objectives based on population sizes needed for recovery to viability objectives for each population. This population size depends on the safety factor or buffer needed to avoid the risks of extinction in the face of normal environmental variation (Figure 4-6).

Extinction risks become increasingly acute at small population sizes where normal population processes begin to break down. Ideally, two determined fish of the opposite sex could forestall extinction but in practice, many more are needed to ensure population persistence and provide the raw material for recovery. Small population sizes are subject to a variety of factors that affect viability (Lande and Barrowclough 1987, Nelson and Soulé 1987, Lynch 1996). Small numbers risk genetic bottlenecks that reduce diversity. The genetic diversity of salmon populations maximizes population persistence and productivity by allowing the salmon to capitalize on a wide range of habitats and environmental conditions. Small numbers also increase chances of inbreeding, possibly resulting in severe genetic side effects (e.g. expression of deleterious recessive genes). Small numbers increase demographic risks where scattered fish are unable to find mates, sex ratios are skewed by chance, or numbers are too few to escape predators (Hilborn and Walters 1992, Courchamp et al. 1999). Small numbers may also increase risks of extinction from natural downturns in survival conditions or catastrophes (e.g., poor ocean conditions, volcanoes, floods, chemical spills, dam failures, etc.) (Lawson 1993). Small population sizes from which recovery cannot be assured due to the cumulative impacts of small population processes are sometimes referred to as the “quasi-extinction” level.

McElhany et al. (2000) identified key characteristics of viable and critical population abundance guidelines. Viable population size guidelines are reached when a population is large enough to: 1) survive normal environmental variation, 2) allow compensatory processes to provide resilience to perturbation, 3) maintain genetic diversity, 4) provide important ecological functions, and 5) not risk effects of uncertainty in status evaluations. Critical population size guidelines are reached if a population is low enough to be subject to risks from: 1) the breakdown in normal population processes as low numbers (e.g. depensation), 2) genetic effects of inbreeding depression or fixation of deleterious mutations, 3) demographic stochasticity, and 4) uncertainty in status evaluations.

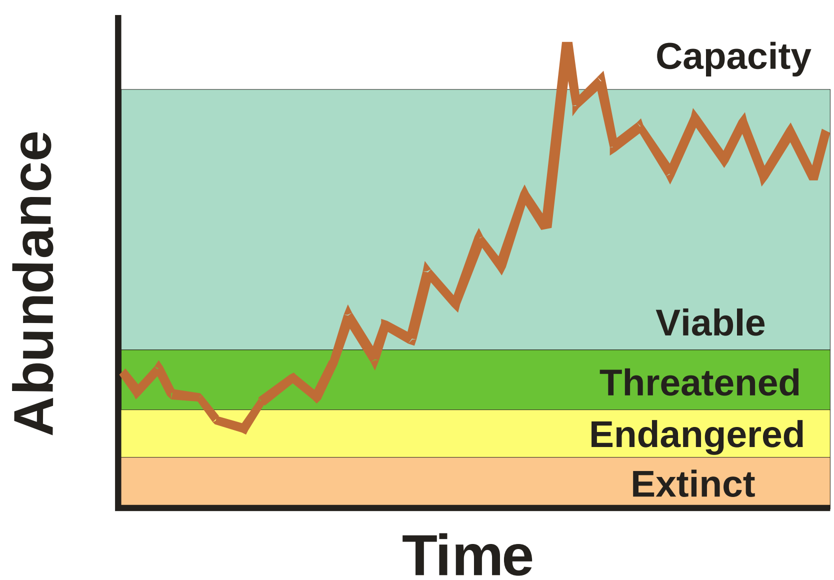

Figure 4-6. Continuum of abundance levels corresponding to potential fish recovery goals.

In this Recovery Plan, estimates of viability levels associated with abundance of each population were based on a quantitative Population Viability Analysis (PVA). PVA provides an explicit quantitative basis for estimating risk level based on a simple life cycle model that considers abundance, productivity, and random demographic variability. A simple stochastic stock-recruitment model (Popcycle) incorporated net annual variation in freshwater production and marine survival to estimate the probability of falling below prescribed thresholds in multiple iterations of potential futures (Figure 4-7). The stock-recruitment function at the core of the life cycle model described the fundamental density-dependent nature of salmon population dynamics. Risks are calculated based on the frequency of spawner numbers falling below critical risk thresholds (CRT) where depensatory small population processes may reduce a population's diversity and resiliency. Risk thresholds are based on spatial structure and diversity considerations.

The PVA approach is consistent with recent recommendations by a team of scientists composed of TRT members and other technical experts (McElhany et al. 2007) and population analyses in the Oregon Management Unit Plan. This approach also provides a consistent analytical framework for quantitative assessment of population viability status, estimation of gaps between baseline status and goals, and development of population objectives for recovery for Washington salmon and steelhead populations.

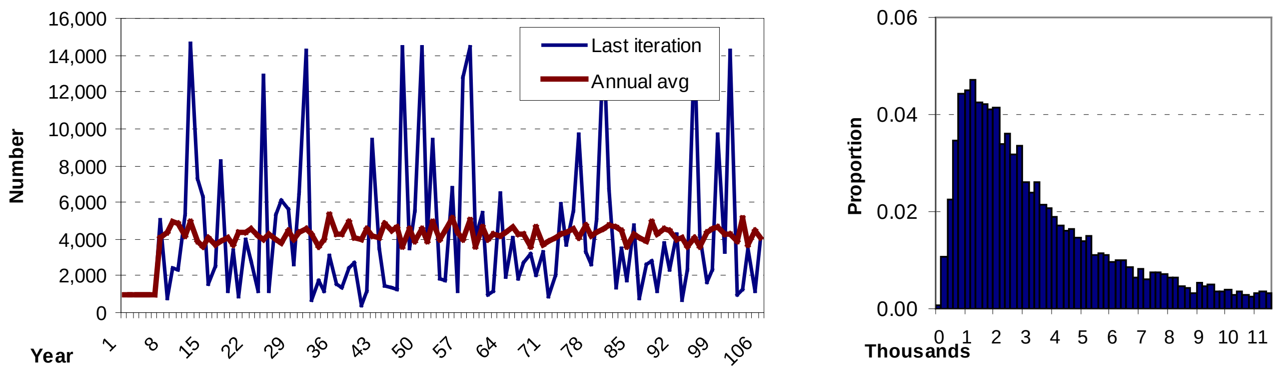

Figure 4-7. Example results of a stochastic 100-year simulation (100 iterations) used in Population Viability Analysis.

This analysis was based on a variety of data available for each lower Columbia River population. Abundance, productivity, and corresponding variance inputs are ideally based on population-specific run reconstructions by year, age, and natural or hatchery origin, and density-dependent stock-recruitment relationships derived from this data. However, comprehensive run data are limited for lower Columbia River populations. Where run reconstruction data were not available population abundance and productivity parameters were inferred from habitat evaluations conducted using the Ecosystem Diagnosis and Treatment model (EDT). This same EDT analysis was the basis for assessments of habitat productivity, limiting factors, priority reaches for preservation and restoration, and habitat improvement measures identified elsewhere in this Recovery Plan. Age schedules of return, variance and autocorrelation in natural recruitment, and fishery harvest rates were based on species averages where population data was not available. Analysis methods, model specifications, data inputs, and results are described in greater detail in the Technical Appendix.

Productivity

Productivity refers to a populations' ability to replace itself and rebound from a low level to the equilibrium population level. Productivity can also be defined in terms of intrinsic population growth rate independent of density dependent population regulating mechanisms. Highly productive populations produce larger numbers of juveniles or recruits per parent and can more readily rebound from low levels following perturbation. Less productive populations produce smaller numbers of offspring or recruits per parent and rebound more slowly or not at all. Highly productive populations generally sustain larger average numbers then unproductive populations. Productivity is directly related to density-independent mortality or survival rates. Greater mortality rates (and lower survival rates) will proportionately reduce population productivity.

While species go extinct when numbers fall to critical low levels, productivity is the engine that regulates risks associated with low numbers. Risks can be much less for a highly productive population even at low spawning escapements than for a larger population where productivity is low. Populations can be predisposed to extinction well before extinction actually occurs when low numbers reduce productivity and resilience. Reduced productivity at low densities is often referred to as depensation (also termed "Allee effects" or "inverse density dependence") (Figure 4-8). McElhany et al. (2000) noted that depensation is a destabilizing influence at very low abundance and can result in a spiraling slide toward extinction. This downward spiral is sometimes referred to as an "extinction vortex." Cumulative effects of periodic poor spawning escapements may also increase chances of future extinction even where numbers temporarily rebound (in good ocean years for instance) (Lawson 1993).

Productivity guidelines for viability are reached when a population's productivity is such that: 1) abundance can be maintained above the viable level, 2) viability is independent of hatchery subsidy, 3) viability is maintained even during extended sequences of poor environmental conditions, 4) declines in abundance are not sustained, 5) life history traits are not in flux, and 6) conclusions are independent of uncertainty in parameter estimates (McElhany et al. 2000). In this Recovery Plan, estimates of viability levels associated with productivity of each population were based on the PVA analysis as described in the preceding section.

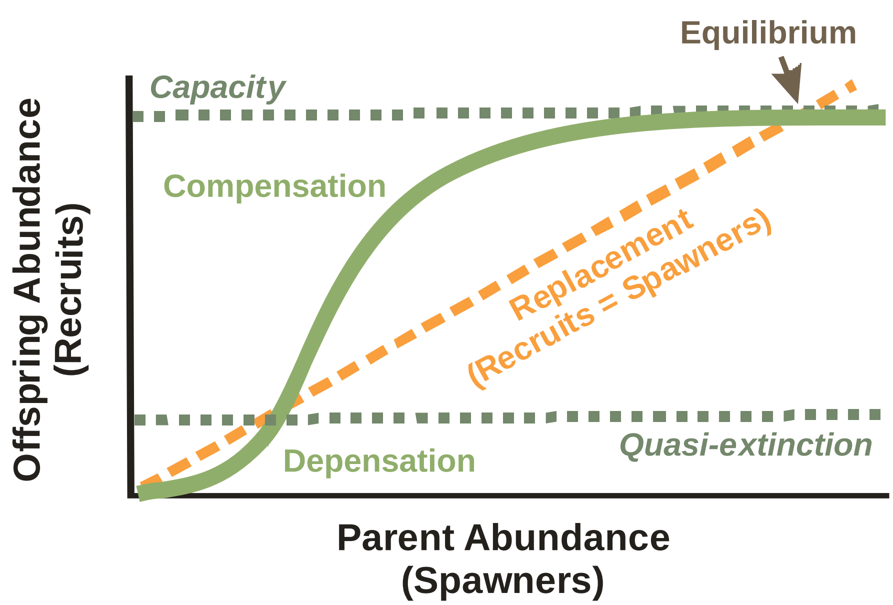

Figure 4-8. Density-related reduction in productivity due to small population processes at low abundance (depensation) and competition for limited resources at high abundance (compensation).

Spatial Structure

Spatial structure refers to the amount of habitat available and utilized, the organization and connectivity of habitat patches, and the relatedness and exchange rates of adjacent populations. Large habitat patches or a connected series of smaller patches are generally associated with a wider species distribution and increased population viability.

Spatial structure of a population is closely related to habitat quantity and quality. Salmonids typically use habitat patches of variable quality and salmon distribution may ebb and flow in response to normal environmental variation. In years of high ocean survival and high spawner numbers, distribution may expand as fish fill the optimum habitats and spread out into other areas of suitable habitat. In years of low ocean survival and low spawner numbers, distribution may contract into areas of high quality habitat. Marginal habitats may support fish under good ocean survival conditions but are not productive enough to sustain numbers under poor ocean survival conditions. Spatial structure is also affected by normal variation the quantity and quality of the available habitat.

Spatial structure guidelines for viability are reached when: 1) the number of habitat patches is stable or increasing; 2) stray rates are stable; 3) marginally suitable habitat patches are preserved; 4) refuge source populations are preserved, and 5) uncertainty is taken into account (McElhany et al. 2000). The spatial distribution and productive capacity of freshwater, estuarine, and marine habitats should be maintained sufficiently to support viable populations. The diversity of habitats for recovered populations should resemble historic conditions given expected natural disturbance regimes (e.g. wildfire, flood, volcanic eruptions, etc.). Historic conditions represent a reasonable template for a viable population; the closer the habitat resembles the historic diversity, the greater the confidence in its ability to support viable populations. At a large scale, habitats should be protected and restored, with a trend toward an appropriate range of attributes for salmonid viability.

In this Recovery Plan, estimates of viability levels associated with spatial structure were based on the quantity, quality, connectivity and proximity of the habitat available and used by each population. Quantity was based on whether all areas that were historically used remain accessible. Quantity is reduced where significant habitat degradation has eliminated significant habitat components. Connectivity is based on whether all accessible areas of historical use remain in use. Proximity considers the potential for catastrophic losses due to rare events based on whether key use areas are dispersed among multiple reaches or tributaries.

Determinations of viability related to spatial structure were based on qualitative analysis and expert judgment based on a review of fish spawning distribution for each population. A scientific basis for quantitative analysis of the relationship between spatial structure and viability has not been derived for salmon. However, the PVA modeling approach used to estimate extinction risks for each population based on abundance and productivity, also directly incorporated spatial structure into the calculation by defining critical risk threshold based on the size and complexity of the habitat available to each population. Thresholds were greater for larger populations which increased risks due to small spawning escapements.

Diversity

Diversity refers to individual and population variability in genetic-based life history, behavioral, and physiological traits. Diversity is related to population viability because it allows a species to use a wider array of environments, protects species against short-term spatial and temporal changes in the environment, and provides the raw material for surviving long-term environmental changes (McElhany et al. 2000). Correlations between diversity and population productivity have been observed in many populations (NRC 1996).

Each salmon species is comprised of many related but different populations, each of which is specifically adapted to the unique local conditions of their natal watersheds and the other habitats they experience during their migratory life. Local adaptations have been naturally selected over hundreds of generations to optimize success under the prevailing conditions. Local populations are typically more productive in their native watersheds than populations introduced from other areas. Salmon that stray or are transplanted among widely separated watersheds do not fare as well as the native stock. Thus, a population of wild coho salmon from the lower Columbia River cannot be replaced with wild coho salmon transplanted from Puget Sound. Differences among populations in adjacent watersheds may be small where habitat conditions are similar but differences typically increase with distance (Riddell 1993).

Adaptations may be expressed in a variety of forms such as run timing that returns adults to streams exactly when spawning conditions are optimal or that allows smolts to arrive at the estuary during the critical physiological window for transition from fresh to salt water. Local adaptation is made possible by the homing of salmon across thousands of miles of ocean and river to spawn in the same river or stream where they were born. Recent studies have shown that homing may be so exact that many salmon even spawn in the same river bend or riffle where they originated. Local adaptation and homing go hand in hand to give each salmon the best chance for reproductive success by returning to the exact conditions to which they are best suited. The degree of difference among populations can often, but not always, be identified by genetic analysis.

According to McElhany et al. (2000), diversity guidelines for viable salmonid populations are reached when: 1) variation in life history, morphological, and genetic traits is maintained, 2) natural dispersal processes are maintained, 3) ecological variation is maintained, and 4) effects of uncertainty are considered.

In this Recovery Plan, estimates of viability levels associated with diversity were based on life history diversity, genetic diversity, and resiliency. Life history diversity was based on the breadth of adult and juvenile migration timing and age composition relative to estimated or assumed historical patterns. Genetic diversity was based on the occurrence of small population bottlenecks in historical spawning escapement and degree of hatchery influence especially by non local stocks. Resiliency was based on observed rebounds from periodic small escapement. Determinations of viability related to diversity were generally based on qualitative analysis and expert judgment using available life history, genetic, and escapement time series data for each population. The PVA modeling approach used to estimate extinction risks for each population based on abundance and productivity, directly incorporated diversity into the calculation by defining critical risk thresholds above population levels believed to reduce diversity through random loss of rare alleles and inbreeding.

4.3.3. Listing Factor & Threat Criteria

Evaluating the potential reclassification or delisting for a species also requires an explicit analysis of listing factors and threats. Listing factors and threats are categories of conditions that affect or limit fish status at some point in their life cycle. Where “limiting factors” include a broad suite of general and specific conditions, listing factors are conditions that specifically contribute to endangered or threatened status. Section 4(a)(1) of the ESA explicitly identifies five listing factors:

1. The present or threatened destruction, modification, or curtailment of its habitat or range;
2. Over-utilization for commercial, recreational, scientific, or educational purposes;
3. Disease or predation;
4. Inadequacy of existing regulatory mechanisms; or
5. Other natural or human-made factors affecting its continued existence.

NMFS has detailed the impacts of various factors contributing to the decline of Pacific salmon and steelhead in their listing notices (69 FR 33102, 70 FR 37160, 71 FR 834). The Federal Register notices concluded that all of the factors identified in section 4(a)(1) of the ESA have played a role in the decline of West Coast salmon and steelhead. The following discussion briefly summarizes findings reported in 69 FR 33102 regarding the principal factors for decline across the range of lower Columbia salmon and steelhead. While these factors are treated in general terms, it is important to underscore that impacts from certain factors are more acute for specific ESUs/DPS. More specific information on limiting and factors and threats may also be found in Chapter 3.

Destruction, Modification, or Curtailment of Its Habitat or Range: West Coast salmon and steelhead have experienced declines in abundance over the past several decades as a result of loss, damage or change to their natural environment. Water diversions for agriculture, flood control, domestic, and hydropower purposes have greatly reduced or eliminated historically accessible habitat and degraded remaining habitat. Forestry, agriculture, mining, and urbanization have degraded, simplified, and fragmented habitat. Significant losses of historical riparian habitat have occurred. The destruction or modification of estuarine areas has resulted in the loss of important rearing and migration habitats. Losses of habitat complexity and habitat fragmentation have also contributed to the decline of West Coast salmonids. Sedimentation from extensive and intensive land use activities (e.g., timber harvests, road building, livestock grazing, and urbanization) is recognized as a primary cause of habitat degradation throughout the range of West Coast salmon and steelhead.

Over-utilization for Commercial, Recreational, Scientific or Educational Purposes: Historically, salmon and steelhead were abundant in many western coastal and interior waters of the United States. These species have supported, and continue to support, important tribal, commercial and recreational fisheries throughout their range, contributing millions of dollars to numerous local economies, as well as providing important cultural and subsistence needs for Native Americans. Over-fishing in the early days of European settlement led to the depletion of many stocks of salmonids, prior to extensive modifications and degradation of natural habitats. However, following the degradation of many west coast aquatic and riparian ecosystems, exploitation rates were higher than many populations could sustain. Therefore, harvest may have contributed to the further decline of some populations.

Disease or Predation: Introductions of non-native species and habitat modifications have resulted in increased predator populations in numerous rivers and lakes. Predation by marine mammals (principally seals and sea lions) is also of concern in areas experiencing dwindling run sizes of salmon and steelhead. Predation by marine mammals may significantly influence salmonid abundance in some local populations when other prey species are absent and physical conditions lead to the concentration of salmonid adults and juveniles. Predation by seabirds can also influence the survival of juvenile salmon and steelhead in some locations.

Infectious disease is one of many factors that can influence adult and juvenile salmon and steelhead survival. Salmonids are exposed to numerous bacterial, protozoan, viral, and parasitic organisms in spawning and rearing areas, hatcheries, migratory routes, and the marine environment. In general, very little recent or historical information exists to quantify changes in infection levels and mortality rates attributable to these diseases. Native salmon and steelhead populations have co-evolved with specific communities of these organisms, but the widespread use of artificial propagation has introduced exotic organisms not historically present in a particular watershed. Habitat conditions such as low water flows and high temperatures can exacerbate susceptibility to infectious diseases.

The Inadequacy of Existing Regulatory Mechanisms: A variety of federal, state, tribal, and local laws, regulations, treaties and measures affect the abundance and survival of West Coast salmon and steelhead, and the quality of their habitats. FR 69 33102 reviewed existing protective measures in Oregon that effect the populations of salmon and steelhead in the lower Columbia, including the Oregon Plan and other state, federal and local plans and actions. FR 69 33102 concluded that the original ESA listings of salmon and steelhead in the 1990 provided the incentive for numerous protective efforts. The notice further concluded that while many causes of decline in salmon and steelhead are being addressed (e.g., providing fish passage above artificial barriers), habitat degradation and destruction has been slowed but not prevented. Cumulative effects of these and other protective efforts, and any additional measures necessary to address the ESUs' factors for decline and extinction risk, need to be evaluated through recovery planning.

Other Natural or Manmade Factors Affecting Its Continued Existence: Variability in ocean and freshwater conditions can have profound impacts on the productivity of salmon and steelhead populations. Natural climatic conditions have at different times exacerbated or mitigated the problems associated with degraded and altered riverine and estuarine habitats. Other factors also include extensive hatchery programs that have been implemented throughout the range of West Coast salmon and steelhead. While some of these programs have succeeded in providing fishing opportunities and increasing the total number of fish on spawning grounds, the long-term impacts of these programs on native, naturally reproducing stocks are not well understood. Artificial propagation may play an important role in salmon and steelhead recovery. FR 69 33102 noted that state fish and wildlife agencies have adopted or are implementing natural salmonid policies designed to ensure that the use of artificial propagation is conducted in a manner consistent with the conservation and recovery of natural, indigenous salmon and steelhead populations. The notice concluded that while these efforts are encouraging, the careful monitoring and management of current programs, and the scrutiny of proposed programs is necessary to minimize impacts on listed species.

"Threats" are categories of human activities or other influences on listing factors. Threat categories were defined in this Plan to include stream habitat, estuary habitat, dams, fisheries, hatcheries, ecological interactions, and climate/global effects. Establishing measureable "threats criteria" for each of the relevant listing/delisting factors helps to ensure that underlying causes of decline have been addressed and mitigated prior to considering a species for de-listing. Legal challenges to recovery plans have affirmed the need to frame recovery criteria in terms of threats as assessed within the five listing factors. Threats may not all be of equal importance in securing the recovery of an ESU or DPS and that therefore every potential threat may not need to be fully addressed before delisting is possible.

In their supplement to the 2004 Washington lower Columbia River Management Unit Plan, NMFS identified a series of qualitative criteria for evaluating listing factors or threats but did not define measurable standards for determining if criteria are met (NMFS 2005). This Plan addresses the need for measurable threat criteria by defining impact reduction targets for each threat category. Targets are derived from population viability objectives and population improvement targets described in the following sections.

4.4. Objectives – The Recovery Scenario

The recovery scenario identifies viability or recovery objectives for each population. The combination of populations and population status levels is designed to meet TRT recovery criteria for a viable ESU. Specific population objectives may be defined anywhere within the range between very low and very high levels of viability. The TRT criteria recognize that not every listed population needs to be restored to high or very high levels of viability to affect recovery.

4.4.1. Definitions

The recovery scenario designates individual population goals at three levels of contribution:

> ***Primary populations*** are targeted for restoration to high or very high viability. These populations are the foundation of salmon recovery. At least two populations per strata must be at high or better viability to meet recommended TRT criteria. Primary populations are typically the strongest extant populations and/or those with the best prospects for protection or restoration. These typically include populations at high or medium viability during the listing baseline. In some cases, populations with low or very low baseline viability were also designated as primary populations in order to achieve viable strata and ESU conditions. Where it appeared feasible, some populations have been targeted for high+ or very high levels of viability. High+ is intermediate between high and very high levels as defined by the TRT.
>
> ***Contributing populations*** are those for which some improvement will be needed to achieve a stratum-wide average of medium viability. Contributing populations might include those of low to medium significance and viability where improvements can be expected to contribute to recovery. Varying levels of improvement are identified for contributing populations. Some contributing populations are targeted for substantial improvements whereas more limited increases are identified for others.
>
> ***Stabilizing populations*** are those that would be maintained at baseline levels. These are typically populations at very low viability during the listing baseline. Stabilizing populations might include those where significance is low, feasibility is low, and uncertainty is high. While stabilizing populations are not targeted for significant improvement, substantive recovery actions will typically be required to avoid further degradation.

The scenario prioritizes populations for recovery based on biological significance, feasibility of improvements, and equitability in sharing of the recovery burden. Both Washington and Oregon populations are considered in the recovery scenario because lower Columbia listing units include populations from both states.

The recovery scenario does not require restoration of all listed populations to historical pristine levels. Figure 4-9 illustrates the relationship between population status and population improvements identified in the recovery scenario. In the example, a population at low baseline viability might be targeted for no (stabilizing), some (contributing) or substantial (primary) improvements in viability. The potential for improvement is constrained by the inherent features of the area in which each population occurs. The baseline potential of most areas is also thought to be well below their pre-development "pristine" production levels. A population may not be viable at the existing habitat capacity where numbers are constrained by low capacity of a small area with poor quality habitat. Conversely, many populations are projected to be viable at levels below the restored potential capacity of a subbasin.

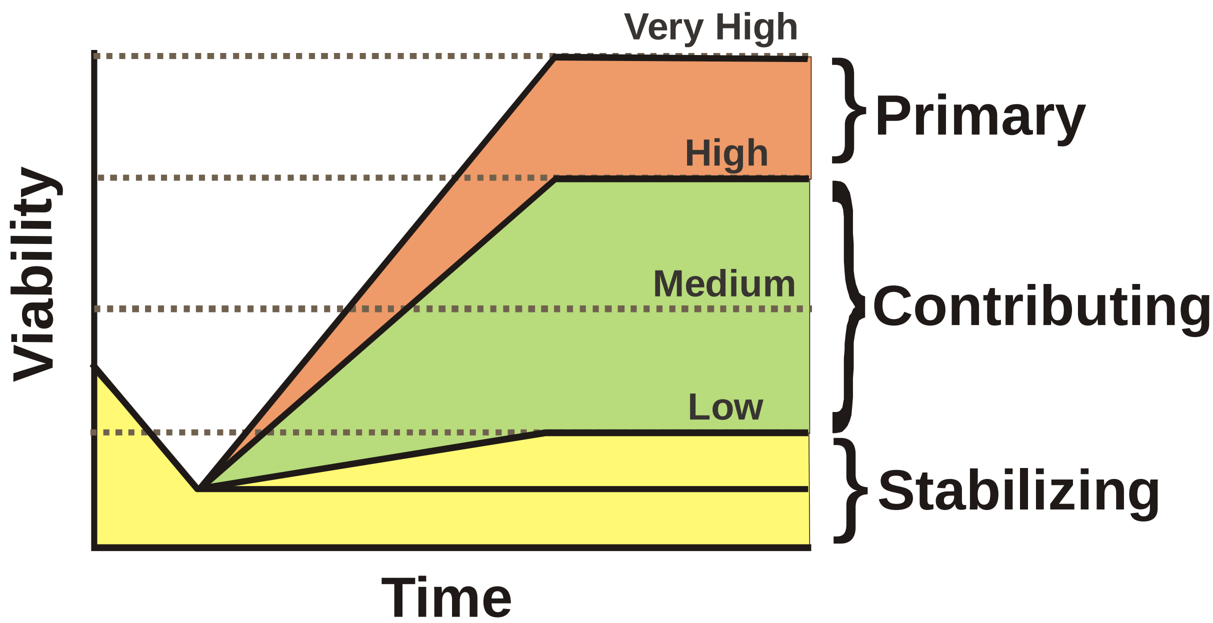

Figure 4-9. Example population trajectories corresponding to scenario designations.

Selection of the scenario was a policy decision made by a representative group of stakeholders in a collaborative process based on scientific, biological, social, cultural, political, and economic considerations. The scenario represents one of several possible combinations of populations and recovery goals that would meet the TRT's ESU- and strata-level viability criteria. Different scenarios may fulfill the biological requirements for recovery but can have unique implications for various stakeholders. Considerations of biological significance and feasibility provided the sideboards for policy choices in the identification of the recovery scenario. Biological significance was based on baseline status, potential for improvement, historical significance, proximity to other selected populations with reference to catastrophic risks, and location relative to strata with reduced expectations. Feasibility of recovery was evaluated based on expected progress as a result of existing programs, absence of apparent impediments toward recovery, and other management considerations (e.g. fish trapping ability).

Oregon objectives are summarized in the recovery scenario for the purposes of evaluating the adequacy of the Washington objectives. Because of different recovery planning schedules, the interim WA Plan previously made assumptions for OR populations in order to evaluate whether WA objectives made an adequate contribution toward ESU-wide recovery goals. Oregon has now developed population objectives for populations occurring in the Oregon Management Unit. The recovery scenario described in this Washington Management Unit Plan was updated to include Oregon's objectives.

4.4.2. Baseline Viability

A total of 103 historical salmon and steelhead populations have been identified within the Lower Columbia River recovery domain which includes areas of both Washington and Oregon (Table 4-5). Of these, 72 populations occur in Washington, including 7 populations that are shared with Oregon. These numbers include 3 Washington and 4 Oregon winter steelhead populations from the coast stratum that are part of the unlisted Southwest Washington Steelhead ESU. The Cascade stratum accounts for the majority of the population total (57 of the total 103 and 48 of 72 Washington populations).

Over half of the historical salmon and steelhead populations in the lower Columbia River are projected to have high to very high (>25%) risks of extinction within the next 100 years under existing conditions. Over 70% of Washington populations and 80% of all populations were of very low or low viability based on assessments of abundance, productivity, spatial structure and diversity[2]. Corresponding extinction risks are very high (>60% for populations of very low viability) or high (26-60% for populations of low viability).

Spring Chinook. Baseline numbers of highly viable populations (0 in both the Cascade and Gorge strata) and average viability scores (Cascade = 0.71, Gorge = 0.25) fall well below the standards established by the WLC-TRT for viability (2 populations per strata at or above 3.0, strata average viability of at least 2.25).

Fall Chinook. Baseline numbers of highly viable tule fall Chinook populations (0 in each of Coast, Cascade, and Gorge strata) and average viability scores (Coast = 0.5, Cascade = 0.6, Gorge = 0.4) fall well below the standards established by the WLC-TRT for viability (2 populations per strata at or above 3.0, strata average viability of at least 2.25). The Cascade late fall Chinook stratum meets the strata average objective (2.5) but includes only one of the two required high or highly viable populations.

Chum. Baseline numbers of highly viable populations (0 in both the Coast and Cascade strata, 1 in the Gorge stratum) and average viability scores (Coast = 0.4, Cascade = 0.4, Gorge = 1.8) fall well below the standards established by the WLC-TRT for viability (2 populations per strata at or above 3.0, strata average viability of at least 2.25).

Coho. Baseline numbers of highly viable populations (0) and average viability scores (Coast = 0.6, Cascade = 0.6, Gorge = 0.3) fall well below the standards established by the WLC-TRT for viability (2 populations per strata at or above 3.0, strata average viability of at least 2.25).

Summer Steelhead. Baseline numbers of highly viable populations (Cascade = 0, Gorge = 1) and average viability scores (Cascade = 1.25, Gorge = 1.50) fall well below the standards established by the WLC-TRT for viability (2 populations per strata at or above 3.0, strata average viability of at least 2.25).

Winter Steelhead. Populations in the unlisted Coast Strata (3 populations at very high viability, strata average of 3.0) meet standards established by the WLC-TRT for viability (2 populations per strata at or above 3.0, strata average viability of at least 2.25). In other strata, baseline numbers of highly viable populations (Cascade = 0, Gorge = 0) and average viability scores (Cascade = 1.0, Gorge = 1.3) did not meet the standard in the baseline period.

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[2] This Plan describes status based on a circa 1999 reference point which represents the period when most lower Columbia River salmon and steelhead were first listed under the ESA. Note that the Oregon Recovery Plan uses a more recent reference period which assumes improvements in status due to actions that have been implemented in the interim since the initial listings.

Table 4-5. Numbers of Washington and Oregon populations and baseline status by ESU and run type in the Lower Columbia Recovery Domain.

Species	Type	State	Strata			Total	Baseline Viability				
			Coast	Cascade	Gorge		VL	L	M	H	VH
Chinook	Fall	WA	3	8	1	12	12	0	0	0	0
		OR	4	2	1	7	5	2	0	0	0
		Shared	0	0	2	2	2	0	0	0	0
		All	*7*	*10*	*4*	*21*	*19*	*2*	*0*	*0*	*0*
	Late Fall	WA	0	1	0	1	0	0	0	0	1
		OR	0	1	0	1	0	0	0	1	0
		Shared	0	0	0	0	0	0	0	0	0
		All	*0*	*2*	*0*	*2*	*0*	*0*	*0*	*1*	*1*
	Spring	WA	0	6	1	7	7	0	0	0	0
		OR	0	1	1	2	1	0	1	0	0
		Shared	0	0	0	0	0	0	0	0	0
		All	*0*	*7*	*2*	*9*	*8*	*0*	*1*	*0*	*0*
	All		***7***	***19***	***6***	***32***	***27***	***2***	***1***	***1***	***1***
Chum		WA	3	6	0	9	8	0	1	0	0
		OR	4	2	0	6	6	0	0	0	0
		Shared	0	0	2	2	1	0	0	1	0
		All	*7*	*8*	*2*	*17*	*15*	*0*	*1*	*1*	*0*
Coho		WA	3	12	1	16	16	0	0	0	0
		OR	4	2	1	7	4	1	2	0	0
		Shared	0	0	1	1	1	0	0	0	0
		All	*7*	*14*	*3*	*24*	*21*	*1*	*2*	*0*	*0*
Steelhead	Winter	WA	3	12	0	15	6	4	5	0	0
		OR	4	2	1	7	1	0	3	2	1
		Shared	0	0	2	2	0	2	0	0	0
		All	*7*	*14*	*3*	*24*	*7*	*6*	*8*	*2*	*1*
	Summer	WA	0	4	1	5	2	0	2	1	0
		OR	0	0	1	1	1	0	0	0	0
		Shared	0	0	0	0	0	0	0	0	0
		All	*0*	*4*	*2*	*6*	*3*	*0*	*2*	*1*	0
	All		***7***	***18***	***5***	***30***	***10***	***6***	***10***	***3***	***1***
All		**WA**	***12***	***49***	***4***	***65***	**51**	**4**	**8**	**1**	**1**
		OR	***16***	***10***	***5***	***31***	**18**	**3**	**6**	**3**	**1**
		Shared	***0***	***0***	***7***	***7***	**4**	**2**	**0**	**1**	**0**
		All	***28***	***59***	***16***	***103***	**73**	**9**	**14**	**5**	**2**

4.4.3. ESU/DPS & Population Viability Objectives

The recovery scenario identifies a total of 63 primary, 27 contributing, and 13 stabilizing populations in Washington and Oregon (Table 4-6). Recovery will require significant actions in most subbasins (Figure 4-10). Several subbasins have been identified with the potential to provide substantial contributions to the viability of multiple species and populations. Substantial improvements are not required in some severely degraded subbasins although recovery goals require additional protection and restoration efforts to prevent further declines until recovery of other populations is achieved. Note that recovery "burdens" are shared between Oregon and Washington across all species but by-species may fall heavier on one side of the river or the other depending on where prospects for recovery are most promising.

Table 4-6. Recovery objectives for lower Columbia salmon and steelhead populations in Washington and Oregon. Viability levels are high or better (Primary), a significant improvement above baseline levels (Contributing), and no further degradation below baseline levels (Stabilizing). Changes in the recovery scenario from the scenario identified in the 2004 interim Plan are noted in strikeout format.

		Chinook			Chum		Steelhead		Coho
		Fall	Late Fall	Spr.	Fall	Sum.	Win.	Sum.	
COAST	Grays/Chinook	~~P~~ C	--	--	P	--	P[2]	--	P
	Eloch./Skam.	P	--	--	P	--	C[2]	--	P
	Mill/Aber./Ger.	~~C~~ P	--	--	P	--	P[2]	--	C
	Youngs Bay (OR)	S	--	--	~~P~~ S	--	P[2]	--	S
	Big Creek (OR)	~~S~~ C	--	--	~~C~~ S	--	P[2]	--	~~P~~ S
	Clatskanie (OR)	P	--	--	~~C~~ P	--	P[2]	--	~~S~~ P
	Scappoose (OR)	~~S~~ P	--	--	~~C~~ P	--	P[2]	--	P
CASCADE	Lower Cowlitz	C	--	--	C	C	C	--	P
	Coweeman	P	--	--			P	--	P
	SF Toutle	~~S~~ P	--	C			P	--	P
	NF Toutle		--				P	--	P
	Upper Cowlitz	S	--	P			~~C~~ P	--	~~C~~ P
	Cispus		--	P	--	--	~~C~~ P	--	~~C~~ P
	Tilton		--	S	--	--	C	--	~~C~~ S
	Kalama	~~P~~ C	--	~~P~~ C	C	--	P	P	C
	NF Lewis	P	P	P	P	--	C	S	C
	EF Lewis		--	--		--	P	P	P
	Salmon	S	--	--	S	--	S	--	S
	Washougal	P	--	--	P	--	C	P	C
	Sandy (OR)	~~S~~ C	P	P	P	--	P	--	P
	Clackamas (OR)	C	--	P[1]	C	--	P	--	P
GORGE	Lower Gorge	C[3]	--	--	P	--	P	--	P[3]
	Upper Gorge	~~S~~ C	--	--	C	--	S[3]	P	~~C~~ P
	White Salmon	C	--	C		--	--	--	
	Hood (OR)	~~S~~ P	--	P		--	P	P	C

[1] Clackamas spring Chinook are part of the Upper Willamette ESU.
[2] Winter steelhead of the Coast Strata are not listed under the Federal ESA.
[3] Designation for shared population based on WA and OR objectives.

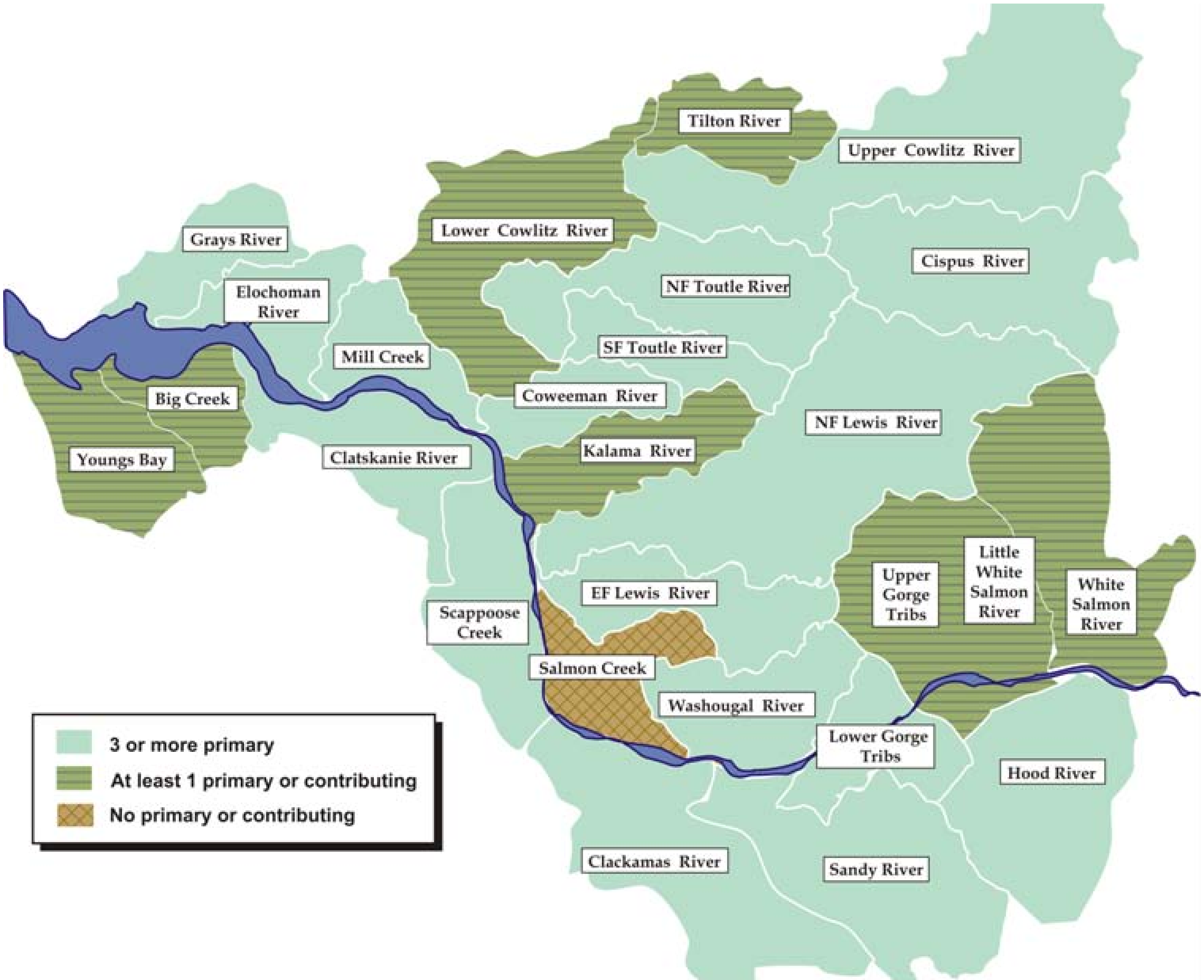

Figure 4-10. Numbers of primary, contributing, and stabilizing salmon and steelhead populations by subbasin.

The recovery scenario meets or exceeds strata-level recovery criteria, except for Gorge fall Chinook, Gorge spring Chinook, and Gorge chum (Table 4-7). These strata fall short due to severe habitat limitations in these areas. In several cases component populations are functionally extinct. Rather than focusing limited restoration resources on populations with low prospects for recovery, the Recovery Plan has targeted other populations in adjacent strata for higher levels of recovery in order to ameliorate ESU-wide risks. This is the same approach taken in the interim Washington Recovery Plan.

Recovery opportunities in the Gorge are limited by the small numbers of populations and the high uncertainty of restoration feasibility because of Bonneville Dam (passage) and reservoir (inundation of historical habitat). Recovery of Gorge populations will be attempted but success will be highly uncertain given the continuing effects of Bonneville Dam. The WLC-TRT's strata delineations between the Gorge and Cascade strata populations are also uncertain and several chum and Chinook populations downstream from Bonneville Dam may be quite similar to those upstream of Bonneville Dam.

Except for chum salmon, the recovery scenario identifies improvement in more than the minimum number of populations, including several in the adjacent strata, in order to provide a safety factor should not all attempts in the Gorge prove successful. This approach mitigates some of the increased risk to the ESU that could occur as a result of not achieving the WLC-TRT's recommendations for strata within the Gorge ecological zone. This is a more precautionary approach to Gorge strata recovery uncertainties than merely assuming they can be effective given the fundamental changes to the Gorge habitats. Monitoring and adaptive management in the course of Plan implementation will provide more information on the feasibility of recovering Chinook and chum populations above Bonneville Dam and can lead to adjustments in expectations and actions.

Table 4-7. Scenario scores relative to Technical Recovery Team viability criteria. Primary population criteria are for at least two populations per strata at high or greater viability (e.g. n ≥ High where n is the number of populations). Strata average criteria are for an average viability score exceeding medium viability (e.g. a viability score of 2.25 or greater).

Species		Primary Population Criteria				Stratum Average Criteria				
Type		Coast	Cascade	Gorge	All		Coast	Cascade	Gorge	All
Chinook										
Fall	n ≥ High	4	4	1	*9*	Avg	2.36	2.35	2.25	*2.33*
	Met?	**Yes**	**Yes**	**No**		Met?	**Yes**	**Yes**	**Yes**	
Late Fall	n ≥ High	--	2	--	*2*	Avg	--	4.00	--	
	Met?		**Yes**			Met?		**Yes**		
Spring	n ≥ High	--	4	1	*5*	Avg	--	2.36	2.75	*2.44*
	Met?		**Yes**	**No**		Met?		**Yes**	**Yes**	
Coho	n ≥ High	4	9	2	*15*	Avg	2.29	2.39	2.50	*2.38*
	Met?	**Yes**	**Yes**	**Yes**		Met?	**Yes**	**Yes**	**Yes**	
Chum	n ≥ High	5	3	1	*9*	Avg	2.29	2.25	3.00	*2.35*
	Met?	**Yes**	**Yes**	**No**		Met?	**Yes**	**Yes**	**Yes**	
Steelhead										
Winter	n ≥ High	6	9	2	*17*	Avg	3.50	2.61	2.33	*2.56*
	Met?		**Yes**	**Yes**		Met?		**Yes**	**Yes**	
Summer	n ≥ High	--	3	2	*5*	Avg	--	2.38	3.50	*2.75*
	Met?		**Yes**	**Yes**		Met?		**Yes**	**Yes**	

4.5. Targets & Benchmarks

4.5.1. Abundance & Productivity Targets – The Gap Analysis

This Plan describes population abundance and productivity improvement targets that close the "gap" between baseline status and viability status objectives for each population. Gaps are the difference between baseline risk levels and risk level identified as viability objectives set forth in the recovery scenario. The gap analysis is used to estimate abundance levels and productivity improvements needed to meet the viability objective for each population. Substantial increases in population viability and reductions in extinction risk will require significant improvements in abundance and productivity. The greater the difference between baseline and viability objectives, the greater the improvement in abundance and productivity to close the gap (Figure 4-11).

Population abundance targets consistent with the gap analysis represent average annual spawning escapements of naturally-produced fish that will achieve objective risk levels. Abundance targets are reached when populations consistently reach or exceed target numbers in most years. Highly variable populations may often produce escapements that temporarily exceed targets but targets are met only when median abundance meets the target over a time period sufficient to account for year-to-year fluctuations due to natural environmental variation. Absent more specific guidance from the TRT, this Plan adopts a 12-year period as an interim standard which is consistent with species generation times and the moving three-year average basis for assessing risk in the population viability analysis. Abundance targets vary among individual populations as a result of subbasin differences in habitat quantity, habitat quality, fish distribution, juvenile production, spatial structure, and life history and genetic diversity.

Productivity improvement targets derived from the gap analysis represent incremental improvements in spawner to spawner replacement rates needed to achieve objective risks levels. Productivity targets are reached when populations consistently exceed a 1:1 replacement rate by a margin sufficient to rebound quickly from periodic low numbers caused by natural environmental variation in survival conditions. Productivity improvement targets are expressed as a percentage increase relative to the baseline value. For instance, a 100% productivity improvement target is equivalent to a two-fold increase in baseline productivity.

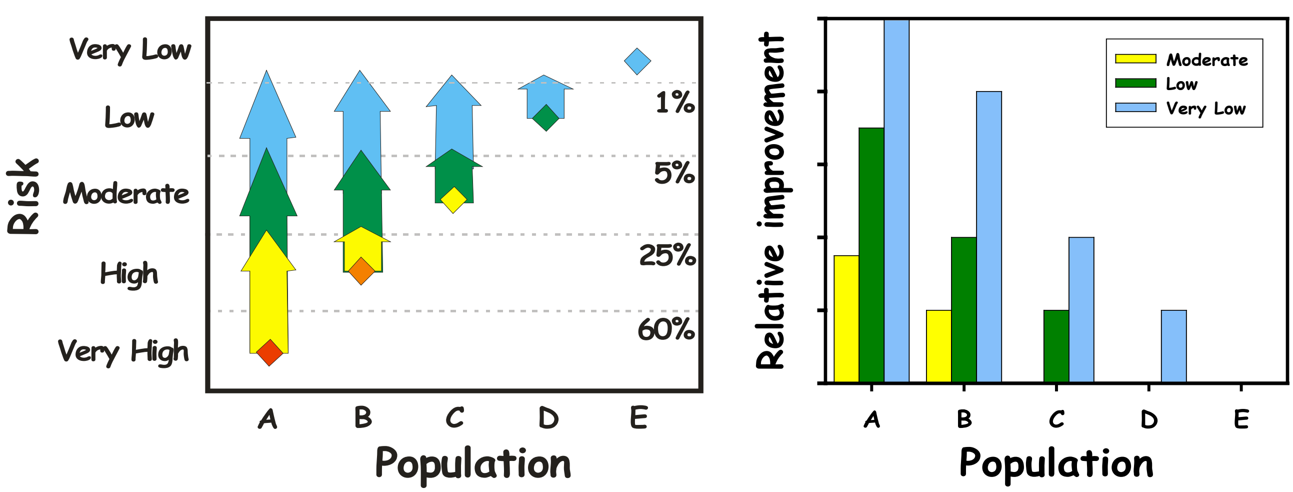

Figure 4-11. Recovery gaps based on baseline and low or very low objective risks (left) and relative improvements to close gaps (right) for hypothetical populations at various baseline risk levels.

Abundance targets and productivity improvement targets assume related increases in all VSP attributes consistent with desired improvements. All four VSP attributes are intimately related such that improvements in one attribute typically depend on and result in improvements in the other attributes. It is also generally not feasible to increase one attribute independent of the others. Thus, an increase in average abundance typically requires a corresponding improvement in productivity. Improvements in productivity generally translate into increased abundance.

Productivity and abundance levels consistent with significant improvements in viability cannot be achieved without also addressing limitations of spatial structure and diversity. Thus, spatial structure and diversity improvements are implicit in the specification of abundance and productivity targets. Specific targets were not identified for spatial structure and diversity because many different combinations of spatial structure and diversity are likely to achieve a given level of viability. Specific values of spatial structure associated with a given level of viability are uncertain and it would be entirely possible to meet the overarching viability goals but fail some of the secondary goals. Definition of subjective tiers of sub goals for every attribute would potentially confound evaluations of progress toward recovery with artificial constraints that may not ultimately be related to overarching viability goals.

Abundance and productivity improvement targets were estimated for each population using the same stochastic life cycle model used in the PVA to estimate the baseline risk status of populations. Net productivity was iteratively scaled upward until risk was reduced to objective viability levels identified in the recovery scenario. Productivity improvements were simply defined as a density-independent multiplier applied to the number of recruits produced at any given spawner level (Figure 4-12). Abundance targets were the median spawner number estimated by the model with productivity improvements that achieve objective risk levels. The improvement increment may be considered to increase both the productivity and capacity parameters of the stock-recruitment relationship. Productivity increases in proportion to the multiplier and average abundance is a function of the new productivity and an implied new capacity. Analysis methods, model specifications, data inputs, and results are described in greater detail in the Technical Appendix.

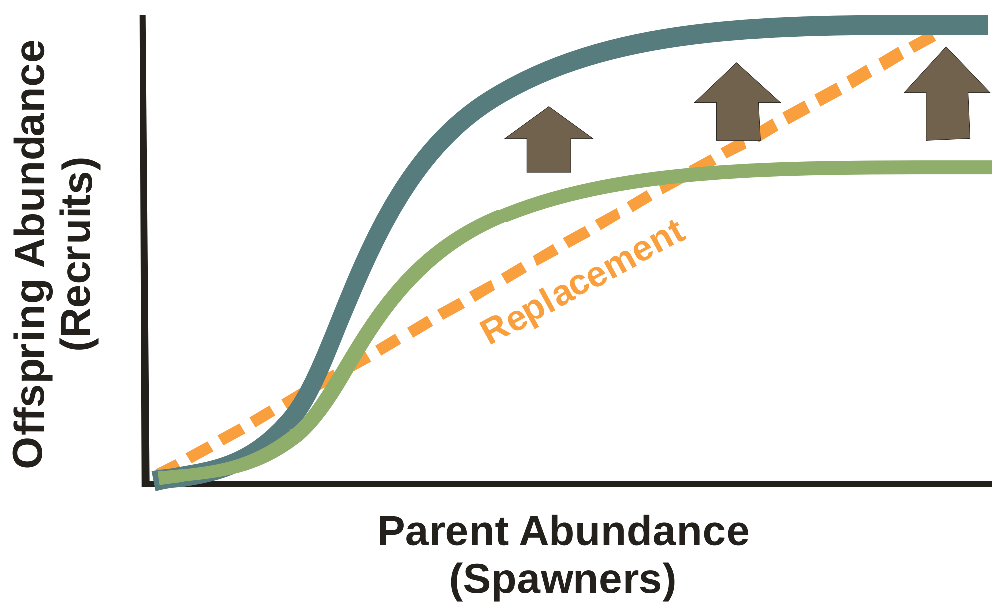

Figure 4-12. Illustration of the effects of a proportional relative improvement (50%) on a salmon stock-recruitment relationships.

In simplified mathematical terms improvement increments are represented in the stock-recruitment model that drives the PVA as:

$$\text{Recruits} = \textit{Function}\left[\begin{array}{l}\text{Spawners}\\ \text{Productivity}\\ \text{Capacity}\end{array}\right] \times (1 + \text{Improvement}) \times \text{Variance}$$

This is essentially the same approach used by Oregon in their conservation curve analyses. Conservation curves are simply a graphical representation of the combination of productivity and abundance corresponding to different risk levels calculated with the PVA model.

One limitation of this approach is that targets are undefined or so large as to be uninformative for populations that have been extirpated and or are at very low levels of productivity (many times nothing or virtually nothing is still nothing or little more). Specific productivity improvement targets were not estimated where they exceeded 500% and abundance targets for these populations were based on species averages for the target viability.

Population-specific targets are subject to uncertainty but may be considered to provide useful order of magnitude first approximations for planning purposes. These estimates provide useful guidance on the scale of improvements that need to be addressed by recovery strategies, measures, and action. The precision is consistent with the ultimate uncertainty in the effects of recovery actions on improvements and the need to implement an adaptive recovery program.

4.5.2. Impact Reduction Targets – Addressing the Threats

Impact reduction targets identify reductions in each potentially-manageable threat needed to meet population abundance and productivity improvement targets consistent with the objective viability level. For example, baseline fishery impacts of 65% in the period prior to listing for the Elochoman/Skamokawa River population of fall Chinook are targeted for reduction to 46% in order to achieve population viability objectives. This overall reduction in the baseline is the impact reduction objective. Based on this overall objective, impact targets are set for each threat category assuming equivalent reductions in impacts (e.g. 29% reduction in baseline value) of habitat, dam, hatchery, and ecological threats affecting the population. Population- and threat-specific impact reduction targets are detailed for each species in Chapter 6. Additional details on this approach can be found in Appendix E Chapter 10.

Impact reduction targets effectively address the need for threats criteria required in the consideration of the statutory listing factors. Targets describe the change in the impact of each threat needed to meet improvement targets for each population. These impact reduction targets provide guidance for the scale of factor-specific improvement (impact reduction) that must be addressed by factor-specific strategies and measures.

"Impacts" are defined in this Plan as proportional reductions in population productivity due to potentially-manageable threats. Impacts are estimated for significant categories of threats including stream habitat, estuary/mainstem habitat, dams, fisheries, hatcheries, and ecological effects. Baseline impact values are established from the period around 1999 when most species were initially listed. Impacts are most intuitively understandable for threats such as fisheries where impact can be defined as the mortality rate associated with harvest and handling. Impacts of other threats are analogous:

- Stream habitat impacts are reductions in smolts produced per spawner caused by tributary habitat degradation relative to historical conditions (1 minus the number supported by the baseline habitat/number supported by the historical habitat with the impacts of all other factors being equal for baseline and historical habitats). Values were derived from Ecosystem Diagnosis and Treatment (EDT) Model estimates of baseline and historical fish numbers.

- Mainstem/estuary impacts are reductions in mainstem and estuary survival of juvenile and adult migrants as a result of habitat (1 minus baseline survival/historical survival). For planning purposes, estimates were based on half of the non-predation related estuary mortality for ocean and stream type life histories estimated in the estuary module.
- Dam-related impacts are reductions in survival of juvenile and adult fish due to dam passage or environmental effects plus the loss of anadromous fish access to blocked areas (1 minus the baseline survival/historical survival plus 1 minus baseline accessible habitat/historically accessible habitat). Estimates were derived from a variety of sources including the FCRPS Biological Opinion, Relicensing documents, and EDT model estimates of historical fish production from blocked areas.
- Fishery impacts are direct mortality due to harvest and indirect mortality due to handling. Values are based on estimates utilized by fishery managers to regulate harvest.
- Hatchery impacts are reductions in natural population fitness due to domestication, etc. Impacts were calculated based on the proportion of hatchery origin spawners in natural spawning areas and the relative fitness reduction due to hatchery practices including broodstock sources. Impacts were based on population-specific estimates derived by the HSRG.
- Ecological impacts include predation rates by northern pikeminnow, marine mammals, and terns (percentage the salmon population consumed). Predation rates were estimated or inferred from available information on predator abundance, daily rations, and prey composition.

Manageable impacts represent a fraction of the total life cycle production and mortality. Figure 4-13 shows an example of the relationship of natural and manageable impact factors and depicts manageable threats in the form of a pie chart in order to illustrate the relative significance of each factor. Impact targets also address only the subset of all threats that can be quantified with productivity impacts. Actual data on manageable impacts of each factor is presented for each species in Chapter 6. Pie charts depicting this data for each species are presented by subbasin in Chapter 7.

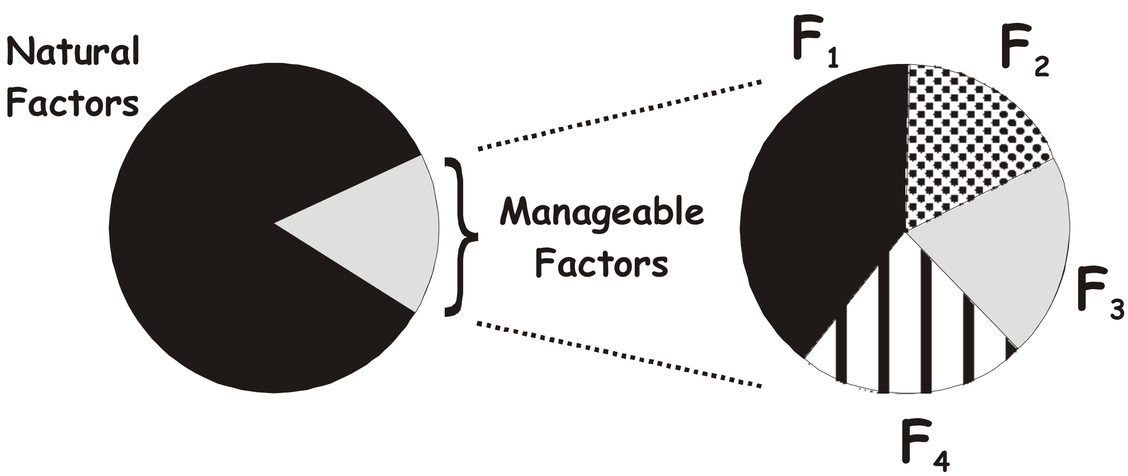

Figure 4-13. Hypothetical example of manageable human threats affecting salmon mortality, productivity, and numbers represented as a portion of all factors and as their own pie.

Impact reduction targets (denoted herein as Δ or "delta") identify the relative change in each impact level needed to achieve the population abundance and productivity improvement objective. For instance, an improvement objective in net population productivity might be calculated to require a Δ =

50% reduction in each threat impact. A 50% reduction objective for a baseline impact rate of 65% would require a reduction to 32.5% to satisfy the target.

Calculations of the net effect of impacts of multiple threats on fish numbers and productivity are more complicated because impacts acting at various stages of the salmonid life cycle are multiplicative and compounded. For instance, a 60% habitat quality impact combined with a 60% fishery harvest rate will reduce population productivity by a net 84% {1-[(1-0.6)(1-0.6)}. The multiplicative nature of impacts means that impact reduction targets (Δ) for each threat are less than the net increase in productivity required for the population. Improvements in multiple threat categories provide compounding benefits as the benefits of improvement in any given threat are multiplied by benefits in other threats. Thus, delta values are determined by net productivity improvement needed to reach the population goal, the total magnitude of human and other potentially manageable impacts, the number of significant threats, and the distribution of impacts among the threats. Calculations are also complicated by the need to translate back and forth between survival rates that can be directly related to productivity and mortality rates that can be directly related to human effects.

In a hypothetical population example, a 100% increase in productivity might be needed to move from low baseline viability to high target viability. Net productivity in this population has been reduced by 74% by the combined effects of six threats, each with a 20% impact $[1-(1-0.20)^6]$. To meet the target 100% net improvement would require a 50% reduction (Δ) in each impact. Thus, a baseline threat impact of 20% would need to be reduced to a 10%.

This approach represents a simple life cycle analysis based on an assumption of density-independent effects of all impacts. This assumption is valid because density-dependent effects for salmon are largely concentrated in freshwater stream habitats and thus do not confound extrapolations of other impacts on net population productivity. This modeling approach (dubbed “Adult Equivalent Impacts Occurring Unconditionally” or ‘AEIOU’) was adapted by the LCFRB for application to this Plan and is described in further detail in the Technical Appendix (Appendix E Chapter 10). Definition of impacts in terms of productivity provides a common metric for quantification of effects from threat categories and a consistent framework with results of the PVA that incorporates density-dependence and parameter variance into the analysis.

The LCFRB strategy for addressing threats involves equitable sharing of “conservation burdens” by identifying impact reductions proportional to the magnitude of the impact. This was a policy decision by the LCFRB. This direction is reflected in the calculation of factor-specific impact reduction targets. Factor categories with large impacts are targeted for large but proportional reductions. Factor categories with small impacts are targeted for small but proportional reductions. Thus, larger impacts would need to make larger net contributions than smaller impacts. For instance, a 10% reduction in a 50% impact translates into a net 5% reduction (0.10 x 0.50 = 0.05), whereas a 10% reduction in a 10% impact translates into a net 1% reduction (0.10 x 0.10 = 0.01).

Impact reduction targets are intended to provide guidance for the development of substantive strategies and measures to reduce threats in every category. Targets are not objectives per se but rather reference points that indicate the general level of effort that will be required from each sector to achieve recovery. Recovery strategies and measures detailed later in this Plan address both quantifiable and unquantifiable threats.

Targets represent impact values effective at such time as recovery objectives are achieved but do not explicitly consider the timing of implementation of factor-specific improvements on extinction risks in the interim. Some impacts are more easily affected in the near term than others. For instance, harvest levels may be regulated on a year-to-year basis but process-based habitat improvements can take a decade or more to be realized. Thus, effective Plan implementation scenarios will incorporate a phased approach to impact reductions.

Some recovery plans have gone so far as to identify more specific desired future conditions consistent with impact or threat reduction criteria. Examples might include historical templates of conditions prior to development or "properly functioning conditions" (PFC's)[3] for salmonid habitat described by NMFS to guide habitat restoration efforts. This Plan does not translate impact reduction targets into more specific conditions because the available scientific information and methods are inadequate for making defensible estimates of these values and because many different combinations of future conditions can be expected to meet the biological objectives. Definition of any given combination of desired future conditions might artificially constrain flexibility in implementation and adaptive management efforts. Historical templates and PFC's provide useful indicators of the direction recovery strategies and actions should take to produce desired improvements in fish status. However, historical templates and PFC's do not represent conditions that must be achieved to meet viability or use objectives. It is likely that many populations would be healthy and harvestable if historical template or PFC's were restored. However, it is also likely that healthy and harvestable objectives can be achieved at levels substantially less than historical template or PFC's in some areas.

4.5.3. Interim Benchmarks – Roadmap to Recovery

Interim benchmarks provide near, intermediate, and long term reference points for evaluating progress toward recovery in the implementation of actions addressing each category of threat (i.e. red light/green light signals). Benchmarks are integral to the adaptive implementation approach identified in this Plan involving periodic checkpoints of progress and course corrections toward recovery goals and objectives. This adaptive implementation process is required by the high degree of uncertainty in scale of recovery action implementation and the benefits of specific actions.

Benchmarks were developed based on impact reduction targets. Benchmarks were established for each threat category (habitat, estuary, harvest, hatcheries, hydro, ecological). Required impact reductions (e.g. improvements) were apportioned over time. Benchmarks:

- Incorporated threat-specific trajectories that consider the need for immediate substantive improvements to reduce near term risks and recognize the lag time in realization of the benefits of many process-based actions.
- Used a 25-year action implementation schedule (consistent with the current Recovery Plan) and a 50-year benefit realization schedule.
- Were established in 12-year intervals corresponding with the adaptive management process identified in the Recovery Plan. Years are counted relative to the listing baseline (1998-1999). Thus years 1-12 include 1999-2010, years 13-24 include 2011-2022, etc.

[3] "Properly functioning conditions" (PFC's) are benchmarks identified by NMFS for habitat protection and restoration efforts. PFC's represent generally favorable conditions for salmonids and are assumed to be consistent with very high levels of viability. However, populations can also be assumed to reach high or very high levels of viability at numbers less than the potential represented by PFC.

Benchmarks based on impact reduction trajectories provide a quantitative basis for the development of effective strategies and measures. Benchmarks also provide standards for evaluation of threat-specific action effectiveness.

Threat-specific benchmarks are based on a front-loaded incremental implementation strategy that involves a combination of actions with immediate effects to reduce near-term risk and actions with longer-term process-based effects for which benefits occur more gradually (Figure 4-14). This strategy is explicitly defined in Chapter 5, Strategy R.S4. The benefits or impact reductions of various recovery actions are often realized at different rates over a given period. Many fishery, hatchery, and hydropower actions can provide significant near-term benefits. Benefits of many habitat and some hatchery actions typically require longer time frames for realization. Population viability analyses demonstrated that population risks are sensitive to the timing of improvements associated with recovery actions. A front-loaded implementation strategy assumes all recovery actions are implemented in the near-term and that impact reductions for fishery actions are recognized immediately while reductions for the other threat categories (hatcheries, hydro, tributary and estuary habitat, ecological interactions) are realized incrementally at a constant rate over a 50-year period. Benchmarks for fisheries and hatcheries were developed based on expected effects of actions identified in the Recovery Plan.

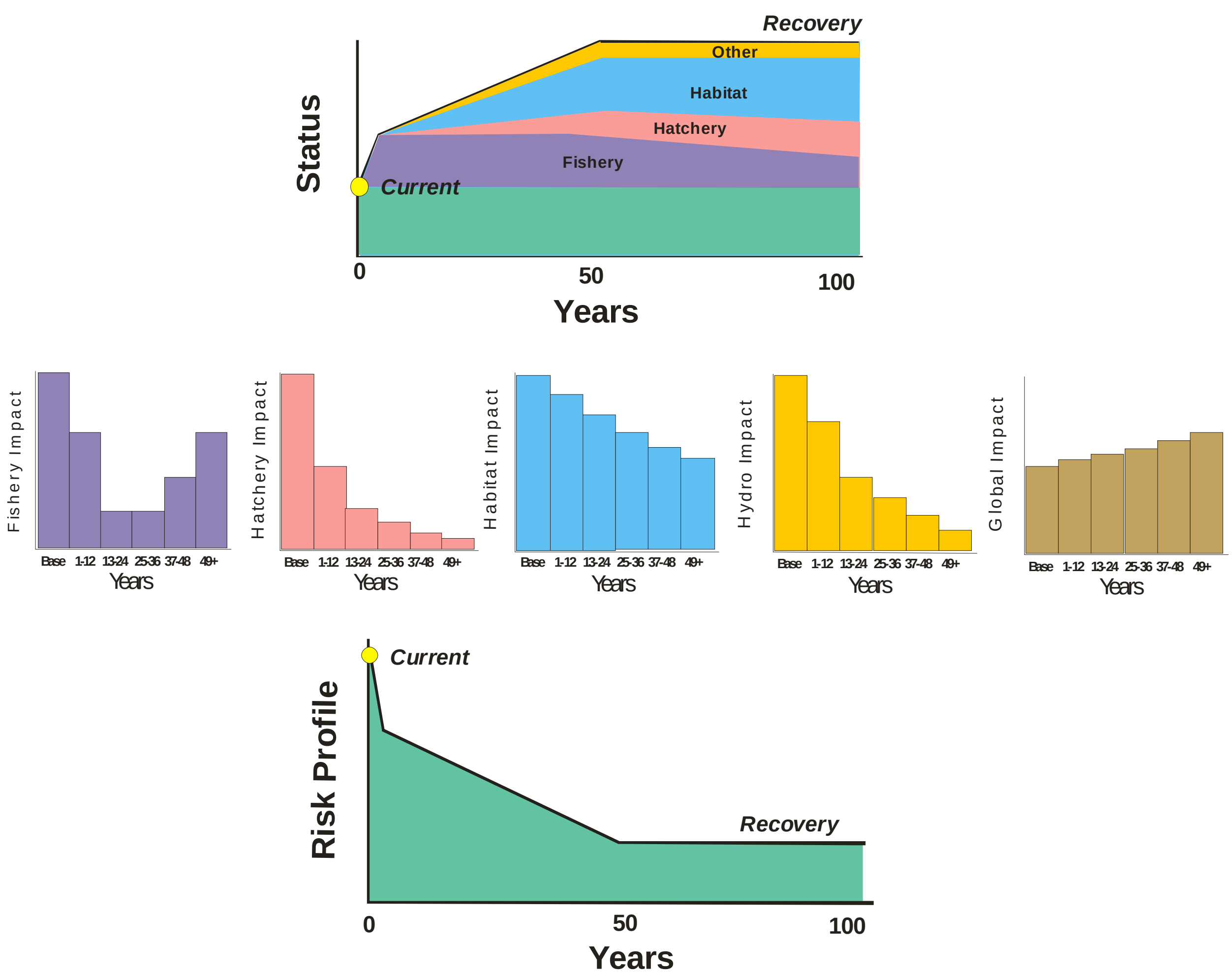

Figure 4-14. Example of threat-specific implementation benchmarks including front-loaded fishery, hatchery, and hydro impact reductions, and incremental reductions in habitat impacts designed to achieve a path to recovery within 50 years.

While the front-loaded implementation strategy is designed to reduce near-term risks by implementing actions with significant immediate benefits, this Plan also recognizes that it is not feasible to meet recovery goals without implementation of a comprehensive suite of strategies and measures across all categories of threats. Elevated levels of risk will continue to occur until all recovery measures can be implemented and the benefits of those measures are accrued. Benchmarks identified as part of the front-loaded implementation strategy include considerations for both the feasibility of measure implementation and near and long term equitability in the sharing of conservation burden among those affected in each category of threat.

Benchmarks were also established for action implementation and status monitoring and evaluation called for in the Recovery Plan. This combination of benchmarks collectively answers questions of whether actions implemented as specified, actions produced the desired effects, and fish status improved as expected. Example metrics for benchmarks are identified in Table 4-8. Implementation metrics typically describe the scope of action, including the percentage of Recovery Plan actions that have been implemented. Effectiveness metrics are threat-specific measures of response. Status metrics include population-specific parameters related to viability and reflect the net effect of benefits of all actions.

Benchmarks include a combination of population-specific numbers for factors such as habitat and aggregate population-values based on constraining populations for factors such as fisheries which are less-amenable to population-specific management. The targets and benchmarks provide initial estimates of the improvements needed to reach recovery goals. Estimates are based on a combination of scientific data and inferences reflecting our current understanding of fish status and limiting factors. Targets and benchmarks will be validated or adjusted through future evaluations, research and adaptive management. The underlying assumptions for the targets and benchmarks are clearly explained.

Table 4-8. Example benchmark metrics by threat category. Note that example effectiveness metrics include a variety indicators at different levels. More detailed descriptions and guidance of monitoring and evaluation indicators and metrics may be found in Chapter 9 (monitoring and research).

	Implementation	Effectiveness	Status
Tributary Habitat	% implemented No. projects by type Affected area	Impact reduction Water quantity & quality Watershed Function Channel & Riparian conditions Accessible area	% biological improvement
Estuary Habitat	% implemented No. projects by type Affected area	Impact reduction Water quantity & quality Channel & Riparian conditions Accessible area Annual survival rate	
Fishery	% implemented	Impact reduction Annual harvest rate (hatchery) Annual impact rate (wild)	
Hatchery	% implemented	Impact reduction Release numbers & sizes % hatchery origin spawners (pHOS) Proportion natural origin broodstock (pNOB) proportion natural influence (PNI)	
Hydropower	% implemented	Impact reduction Juvenile collection/passage efficiencies Adult passage rates	
Ecological	% implemented	Impact reduction Predation mortality rate Predator number, distribution, composition Removal rate	
Global	--	ENSO, PDO, upwelling indices, etc	