# CHAPTER 5: POPULATION STRUCTURE & VIABILITY

*"In summary, the lack of demonstrably viable populations…and substantial gaps in the distribution of coho salmon throughout the CCC ESU strongly indicate that this ESU is currently in danger of extinction."*

*Spence et al., 2008*

## HISTORICAL POPULATION STRUCTURE & BIOLOGICAL VIABILITY CRITERIA

Salmon and have a high fidelity to return to the rivers where they reared as young to spawn, with some occasional straying between neighboring rivers. Thus, multiple populations across river systems are connected by a small degree of genetic exchange which ensures genetic diversity and distribution that provides resilience for the species to persist overtime. Populations within and between neighboring streams will share more genetic characteristics than those separated by hundreds of miles. The biological framework for recovery builds from this hierarchical structure Figure 8 (*e.g.*, an individual, a group of individuals called a population and a group of populations designated into an ESU).

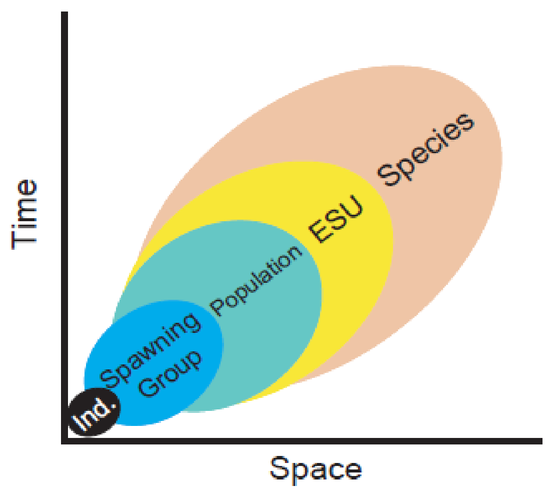


**Figure 8: Hierarchical Structure of Populations**

For the CCC coho salmon ESU to be removed from the Federal Endangered Species list, criteria related to the number, size, trends, structure, *etc.* and the timeframes (*e.g.*, 100 years) to sustain these biological conditions must be met. To inform the recovery or "delisting" criteria, the TRT prepared two NOAA Technical Memoranda characterizing the historical population structure and biological viability criteria for the NCCC Domain salmon and steelhead ESUs/DPSs (Bjorkstedt *et al*., 2005, Spence *et al*., 2008). These memoranda describe this hierarchy and provide criteria to assess the biological status of populations and their risk of extinction.

This Chapter provides a summary of these memoranda including theoretical basis, methods, recovery team application of the TRT materials and final recommended criteria.

## Viable Salmonid Populations

Recovery and long-term sustainability of these populations depend on:

- Ensuring adequate reproduction for replacement of losses due to natural mortality factors (including disease and stochastic events);
- Maintaining sufficient genetic diversity to avoid inbreeding depression and to allow adaptation;
- Providing sufficient habitat (type, amount and quality) for long-term population maintenance; and
- Elimination or control of threats that are affecting their conservation, survival and recovery.

The TRT approach to defining population viability and determining risk of extinction builds from the document "*Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units*" and the viable salmonid population (VSP) concept developed by McElhany *et al*. (2000). McElhany *et al.* (2000) formally outlines evaluation of abundance, productivity, spatial structure, and diversity through two VSP levels: the ESU and the independent population.

An ESU is a Pacific salmon population or group of populations that is substantially reproductively isolated from other conspecific populations and that represents an important component of the evolutionary legacy of the species.

An Independent Population is defined by McElhany et al. (2000) as:

*"…a group of fish of the same species that spawns in a particular lake or stream (or portion thereof) at a particular season and which, to a substantial degree, does not interbreed with fish from any other group spawning in a different place or in the same place at a different season. For our purposes, not interbreeding to a 'substantial degree' means that two groups are considered to be independent populations if they are isolated to such an extent that exchanges of individuals among the populations do not substantially affect the population dynamics or extinction risk of the independent populations over a 100-year time frame."*

The TRT extended the VSP concept by considering two population characteristics independently: "*viability, defined in terms of probability of extinction over a specified time frame and independence, defined in terms of the influence of immigration on a population's extinction probability*" {Bjorkstedt, 2005}. The final TRT criteria are "*intended to provide a framework for planners both to set general biological based targets for recovery and to guide future evaluations of the status of the ESA-listed salmonids…*" {Spence, 2008}.

## Historical Population Structure

Development of viability criteria and recovery goals requires some knowledge of and accounting for "*characteristics that contribute to a populations' viability and thus their contribution to the persistence of the ESU*" {Bjorkstedt, 2005}. Essentially, how the overall hierarchical structure of individuals, populations and aggregate populations contribute to overall ESU dynamics, viability and extinction risk. This analysis of historical structure by the TRT was framed by the premise: "*…historical patterns of population abundance, productivity, spatial structure and diversity form the reference conditions about which we have a high confidence that the ESUs and their constituent independent populations had a high probability of persisting over long periods of time. As populations depart from these historical conditions, their probability of persistence declines and their functional role with respect to ESU viability may be diminished*" {Spence, 2008}.

The development of the historical structure included:

- ❑ Modeling of the historical intrinsic potential of streams to support spawning and rearing coho salmon;
- ❑ Compilation and review of historical records on population size and distribution;
- ❑ Defining populations and their viability in context to the ESU;
- ❑ Grouping populations into geographical units within an ESU and
- ❑ Analyses to inform historical structure that included genetic structure and an assessment of the historical artificial propagation (See Bjorkstedt *et al.* 2005 for more information).

### Intrinsic Habitat Potential

Spawning and rearing habitats for juvenile coho salmon are largely determined by landform, lithology, and hydrology that interact to govern movement and deposition of sediment, large wood and other structural elements along a river network (Agrawal *et al.* 2005). Three primary indicators of landform and hydrology, channel gradient, and index of valley width and mean annual discharge serve as a reasonable predictor of channel morphology and this determined the potential for a particular reach to provide suitable habitat under historical conditions. To account for differences in habitat suitability (and thus population size), the TRT used a GIS habitat model developed by Burnett (2003). This GIS model characterized channel gradient, valley width and mean annual discharge to predict the intrinsic (historical) potential (IP-km) for a particular reach of stream to exhibit habitat for coho salmon. Suitability curves for each of the three IP-km components were used to develop a reach specific value for a particular lifestage and species. These reach specific values, or "suitability scores" were based on a scale of 0-1 (Agrawal *et al.* 2005). IP-km for each reach is calculated as the geometric mean of the suitability scores and describes the likelihood a stream reach will provide habitat with respect to the three variables used. As a proxy for population carrying capacity the TRT used the IP score for each reach in the watershed multiplied by its respective reach length, and summed these values which resulted in a "weighted IP" value. The weighted IP kilometers (IP-km) value estimated the intrinsic potential, or carrying capacity, of the watershed for coho salmon. The IP model seeks to account for the fact that not all stream miles were created equal when it comes to producing salmon. These IP layers are output spatially for each population and all streams reaches. Depending on watershed size between 20 to 40 spawners per IP-km were calculated to determine the low extinction risk criteria for each population

Discrepancies were observed between the predicted IP for CCC coho salmon and historical record accounts. A summer water temperature component was included to address discrepancies in the model for coho salmon because water temperature is a strong indicator of presence and high survival of summer rearing juveniles. Historical records for distribution of CCC coho salmon were reviewed {Spence, 2005} and a mean August air temperature that exceeds 21.5° C (following isolines) was applied to the model (*i.e.,* temperature mask) to exclude areas where streams were likely too consistently warm for coho salmon (Figure 9). The resulting outputs were more consistent with historical records.

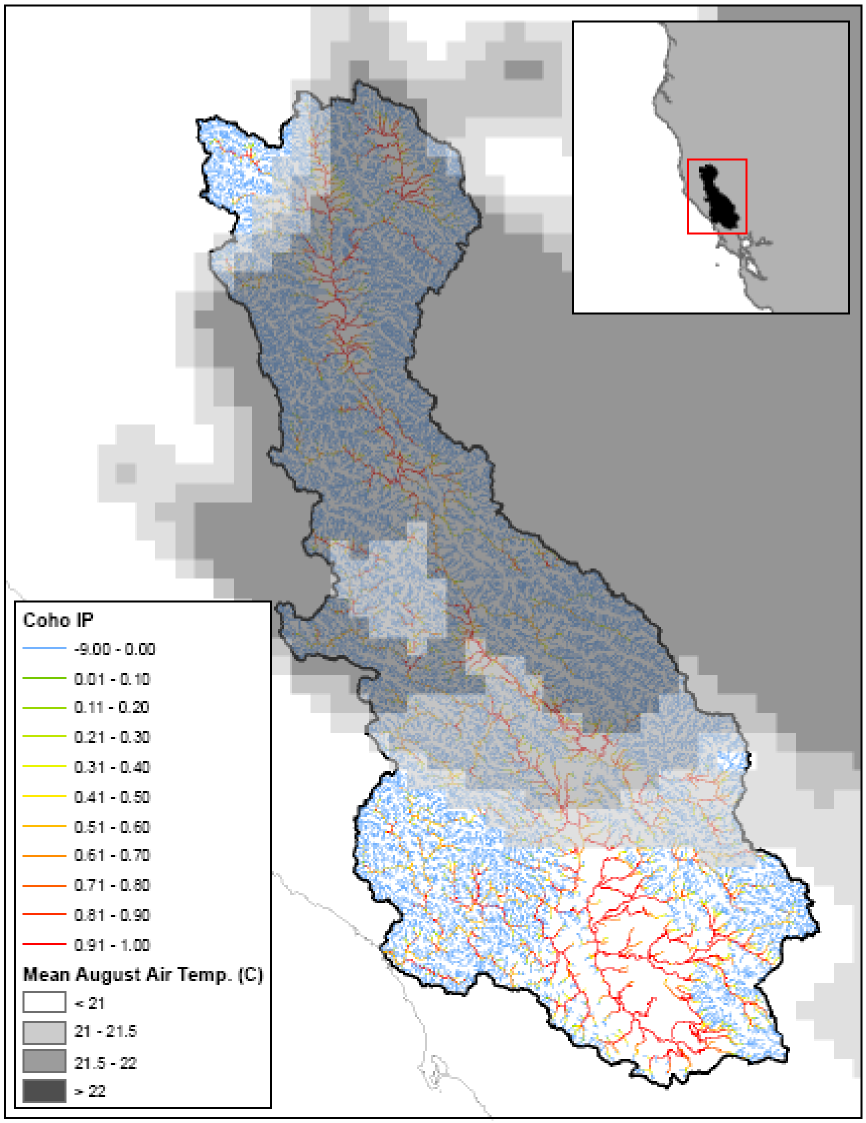


Plate 4: Intrinsic potential for coho salmon rearing habitat in the Russian River with areas from which coho salmon are likely to be excluded by high summer temperatures.

**Figure 9: Temperature Mask Example**

The TRT acknowledged the uncertainty and potential model bias to over or underestimate IP and historical habitat potential. Nonetheless, a benefit of the IP model is that it takes into account differences in intrinsic habitat potential in an objective and transparent manner. This objectivity precluded subjective judgments regarding whether or not habitat historically supported spawning and rearing salmon, which is often very difficult to determine in light of currently degraded habitat conditions. Comparisons of modeled IP-based results of spawner abundance to the few historical records of abundance was conducted by Spence (pers. comm. 2008) which indicated, in the majority of cases, adult abundances projected by the TRT are lower than those observed during the 1930s into the 1950s. Therefore, the TRT concluded projected spawner abundance targets did not overestimate natural carrying capacity of the majority of populations within the ESU.

## Defining Populations for the CCC coho salmon ESU

Spawner abundance across potential IP is the underlying factor determining a population's extinction risk. The TRT defined a population as "*a group of fish of the same species that spawns in a particular locality at a particular season and does not interbreed substantially with fish from any other group*." (Bjorkstedt 2005). A "viable" population is "*a population having a low (<5%) probability of going extinct over a 100-year time frame*" and an "Independent" population "*as one for which exchanges with other populations have negligible influence on its extinction risk"* (Bjorkstedt 2005) or otherwise termed "viable-in-isolation". To distinguish between "viable" and "non-viable" populations the TRT evaluated each populations potential to be "viable-in-isolation" and their measure of "self-recruitment" (Figure 10). Self-recruitment "is the proportion of a populations' spawning run that is of native origin" (Bjorkstedt, 2005).

Population size directly affects an ESU viability and extinction risk; thus, the TRT used the likely historical population carrying capacity as a proxy for assessing viability-in-isolation. The self-recruitment analysis was framed by (1) the understanding that an individual will attempt to return to its natal watershed and (2) whether population dynamics are dominated by internal processes from those strongly influenced by external dynamics (*e.g.*, straying). This analysis assisted the TRT "*in identifying the functional role different populations historically played in ESU persistence*" (Bjorkstedt 2005 *in* Spence 2008).

The TRT determined that at least 32 IP-km were required for a population of coho salmon to be viable-in-isolation. This value was selected for consistency with other TRTs in California and Oregon and was based on a simulation analysis of Nickelson and Lawson (1998).

Three types of populations have been defined:

- "Functionally Independent Populations" (FIPs): Populations with a high likelihood of persisting over 100-year time scales due to their population size and relatively independent dynamics (*i.e.*, negligible influence of migrants from neighboring populations on extinction risk);
- "Potentially Independent Populations" (PIPs): Populations with a high likelihood of persisting in isolation over 100-year time scales due to large population size, but were likely too strongly influenced by immigration from other populations to exhibit independent dynamics; and
- "Dependent Populations" (DPs): Populations with a substantial likelihood of going extinct within a 100-year time period in isolation due to smaller population size, but receive sufficient immigration to alter their dynamics and reduce extinction risk.

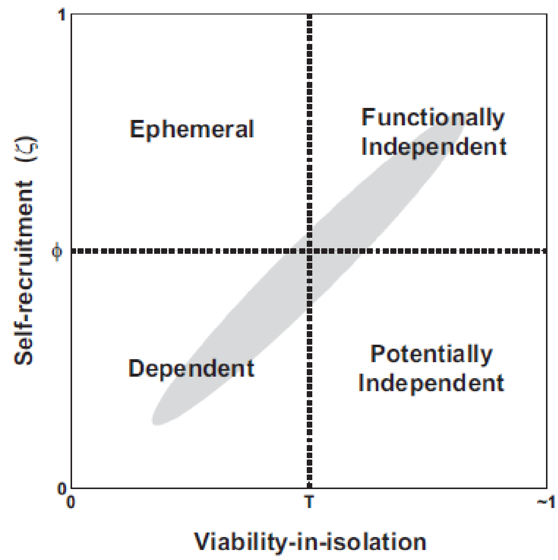


**Figure 10: Viability and Self-Recruitment**

Classification of populations provided the necessary rationale to prioritize each population's importance to viability and recovery based on their relative function and role in the ESU. For example, a large population (*e.g.*, Independent Population) likely functioned as a regular source of surplus individuals (through straying) to smaller populations (*e.g.*, Dependent Populations). Straying added resilience to the ESU when smaller populations may have suffered from the impacts of adverse environmental conditions (*e.g.*, catastrophic wildfire, *etc.*). Surplus individuals from large populations could re-colonize watersheds after those events leading to the extirpation of small populations. This resilience confers more importance onto large populations for their role in the viability and recovery of the ESU.

## Grouping Populations: ESU Diversity Strata

Diversity strata, or boundaries that group populations, were delineated for the ESU and are "*geographically proximate populations that reflect the diversity of selective environments, phenotypes and genetic variation across the ESU*" and are "*described in terms of geography and a generally similar set of environmental and ecological conditions*" {Bjorkstedt, 2005}.

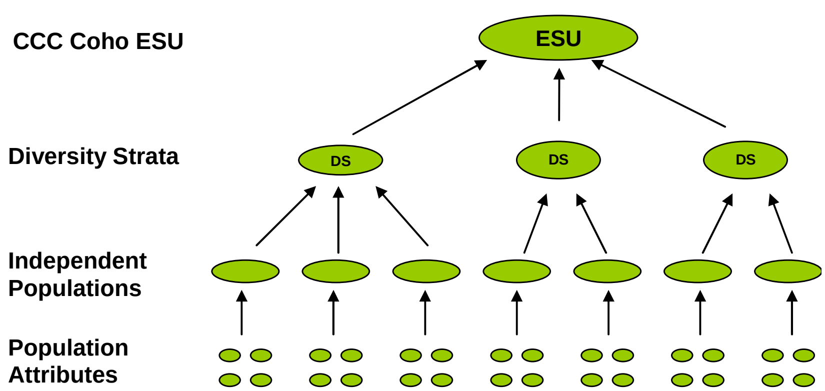


**Figure 11: Populations, Diversity Strata and ESU Levels**

### Results from Historical Structure Analysis

The TRT identified 11 "functionally independent", one "potentially independent" (Figure 12) and 64 "dependent" populations in the CCC coho salmon ESU (Bjorkstedt *et al*. 2005 with modifications described in Spence *et al*. 2008). The 75 populations were grouped into five Diversity Strata. Five thousand one hundred and ninety four (5,194) IP-km were identified across the historical CCC coho salmon ESU[11]. Watershed boundaries delineate each population for CCC coho salmon.

The advised application of the TRT historical structure is outlined in Bjorkstedt *et al*., (2005):

*"Increasing divergence from this baseline almost certainly decreases the ability of the ESU to persist. The functional relationship between departure from historical conditions and extinction risk for the ESU is probably non-linear, such that the loss of a few populations–particularly small populations–from an otherwise intact ESU may not greatly reduce ESU viability, whereas the loss of key populations or the loss of populations from an already diminished ESU will have more profound implications for the persistence of the ESU. Uncertainty associated with the form of this relationship must be accounted for in assessing the viability of any proposed ESU configurations that departs from historical conditions. Understanding the historical population structure of an ESU is essential to reducing the consequences of this uncertainty, as information on the historical role of specific populations in the ESU supports a biologically relevant context for recovery planning.* ***Simply put, populations that were important to ESU persistence in the past, if restored or preserved, are likely to be important to ESU persistence in the future"***(emphasis added).

A more detailed description of the methods and rationale underlying the historical population structure analysis and results are provided in Bjorkstedt *et al*. (2005).

[11] The recovery scenario for CCC coho designated 28 focus watersheds. The total historical IP km of these 28 watersheds is 1736 km or 33 percent of the historical total.

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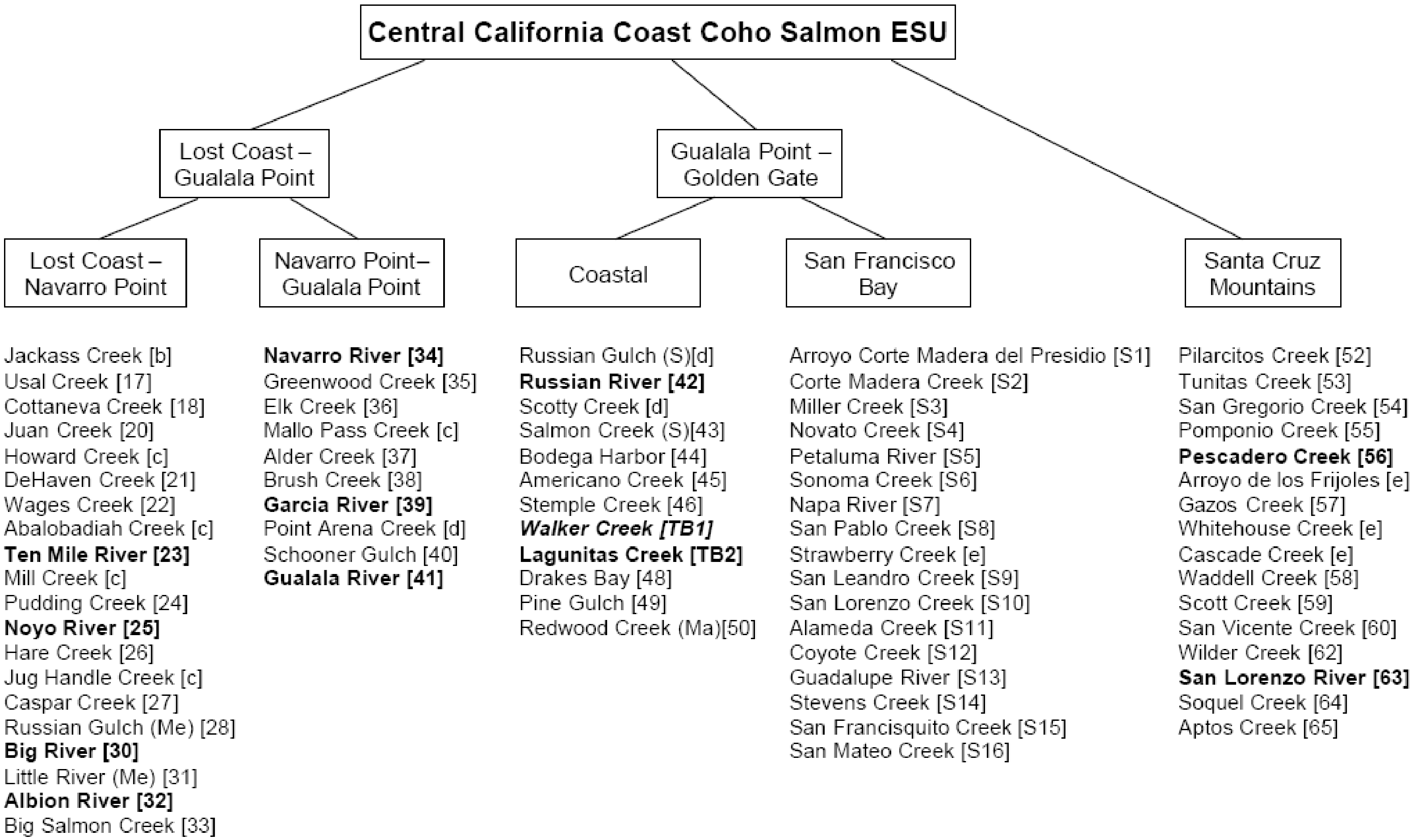


**Figure 12: Historical population structure of the CCC coho salmon ESU, arranged by Diversity Strata. Functionally Independent populations are listed in bold font. Potentially Independent populations are listed in bold italic font. Dependent populations are listed in regular font. All dependent populations are not displayed. From Spence et al., 2008.**

## Biological Viability Criteria

Spence *et al.* (2008) developed biological viability criteria at the three levels of biological organization outlined by Bjorkstedt *et al*. (2005) important for the long term persistence of CCC coho salmon (*i.e.*, populations, Diversity Strata and ESU). These criteria are described in the two categories of: "Population Viability Criteria" and "ESU Viability Criteria". The biological viability criteria "*defines sets of conditions or rules that, if satisfied, would suggest that the ESU is at low risk of extinction*" (Spence *et al*. 2008). These general conditions require: (1) achieving population viability across selected populations and (2) attaining the necessary number and configuration of these viable populations across the landscape. These criteria do not include abundance of dependent populations nor do they provide context on recovering populations under the influence of climate change or ocean conditions.

The biological criteria "…*do not explicitly specify which populations must be viable for the ESU to be viable…but rather they establish a framework within which there may be several ways by which ESU viability can be achieved*" and are "…*intended to provide a framework for planners both to set general biological based targets for recovery and to guide future evaluations of the status of the ESA-listed salmonids…*" {Spence, 2008}. While criteria should be tailored to populations, their biological characteristics and the ability of habitats to support these populations, these data are not available and will likely not be available in the foreseeable future. Thus, in the absence of quantitative data, general objective criteria were recommended by a Recovery Science Review Panel and Shaffer *et al.* (2002) such as those used by the International Union for Conservation of Nature (IUCN 2001). These were applied for these criteria. These criteria inform the final delisting criteria (but are not synonymous with recovery criteria), for CCC coho salmon. They provide the bases to select populations for the recovery scenario relative to the number, size, trends, structure, recruitment and distribution of spawning adults over a 10-12 year moving average.

ESU and population viability was considered by {Spence, 2008} using "*two distinct but equally important perspectives*": (1) population viability in relation to its historical function and (2) minimum population size.

### Population Viability Criteria

Criteria were developed that, combined, constitute a viable population (Tables 8 and 9). To define the key characteristics of what makes a population viable, the TRT classified populations "*into various extinction risk categories based on a set of quantitative and qualitative criteria related*" to the VSP parameters of abundance, population growth rate, population spatial structure and population diversity (McElhany *et al.* 2000). Abundance typically refers to the number of adult spawners measured over a time series relevant to life history. Population growth rate (*i.e.*, productivity) is a measure of a populations' ability to sustain itself overtime (*e.g.*, returns per spawner). Population spatial structure describes how populations are arranged geographically based on dispersal factors and quality of habitats. Population diversity is the underlying genetic and life history characteristics that provide for population resilience and, thus, persistence across space and time. For a population to be viable it must be large enough to: (1) have a high probability of surviving environmental variation, (2) compensate for disturbances, (3) maintain genetic diversity, and (4) functionally contribute to associated ecosystems.

The population viability criteria (also termed extinction risk criteria), when met, are expected to result in populations with a low risk of extinction (*i.e.,* viable). These criteria are: (1) likelihood of extinction; (2) effective population size or total population size; (3) population decline; (4) catastrophic decline; (5) spawner density, and; (6) hatchery influence (Table 7). To inform these criteria it is necessary that monitoring include a lengthy time series of adult abundance at appropriate spatial scales. Life cycle monitoring will be necessary to inform these criteria. Few datasets exist and "*there is an urgent need to initiate monitoring programs that will generate data of sufficient quality to rigorously assess progress toward population and ESU recovery. Development of a comprehensive coastal monitoring plan for salmonids has been underway for several years by the California Department of Fish and Game, with input from NMFS; however, dataset that will allow assessment of status using the criteria described herein are likely more than a decade away. Consequently, the present values of these criteria…are to inform the development of such a monitoring plan and to provide preliminary targets for recovery planners*" (Spence *et al*. 2008). Refer to Spence *et al.* (2008) for additional information regarding methods and criteria that provides an outline of monitoring recommendations.

**Table 11: Population Extinction Risk Criteria**

| Population Characteristic | Extinction Risk: High | Extinction Risk: Moderate | Extinction Risk: Low |
|---|---|---|---|
| Extinction risk from population viability analysis (PVA) | ≥ 20% within 20 yrs | ≥ 5% within 100 yrs but < 20% within 20 yrs | < 5% within 100 yrs |
| | - or any ONE of the following - | - or any ONE of the following - | - or ALL of the following - |
| Effective population size per generation *-or-* Total population size per generation | $N_e \leq 50$ *-or-* $N_g \leq 250$ | $50 < N_e < 500$ *-or-* $250 < N_g < 2500$ | $N_e \geq 500$ *-or-* $N_g \geq 2500$ |
| Population decline | Precipitous decline[a] | Chronic decline or depression[b] | No decline apparent or probable |
| Catastrophic decline | Order of magnitude decline within one generation | Smaller but significant decline[c] | Not apparent |
| Spawner density | $N_a/IPkm^d \leq 1$ | $1 < N_a/IPkm <$ MRD[e] | $N_a/IPkm \geq$ MRD[e] |
| Hatchery influence[f] | Evidence of adverse genetic, demographic, or ecological effects of hatcheries on wild population | | No evidence of adverse genetic, demographic, or ecological effects of hatchery fish on wild population |

[a] Population has declined within the last two generations or is projected to decline within the next two generations (if current trends continue) to annual run size $N_a \leq 500$ spawners (historically small but stable populations not included) or $N_a > 500$ but declining at a rate of ≥10% per year over the last two-to-four generations.
[b] Annual run size $N_a$ has declined to ≤ 500 spawners, but is now stable *or* run size $N_a > 500$ but continued downward trend is evident.
[c] Annual run size decline in one generation < 90% but biologically significant (e.g., loss of year class).
[d] *IPkm* = the estimated aggregate intrinsic habitat potential for a population inhabiting a particular watershed (i.e., total accessible km weighted by reach-level estimates of intrinsic potential; see Bjorkstedt et al. [2005] for greater elaboration).
[e] MRD = minimum required spawner density and is dependent on species and the amount of potential habitat available. Figure 5 summarizes the relationship between spawner density and risk for each species.
[f] Risk from hatchery interactions depends on multiple factors related to the level of hatchery influence, the origin of hatchery fish, and the specific hatchery practices employed.

## ESU Viability Criteria

Four criteria were developed that, collectively, constitute a configuration in the number and distribution of viable and non-viable populations that would likely provide for ESU persistence over 100 year time frame (i.e., viable). Thus, there may be "several plausible scenarios of population viability that could satisfy ESU-level criteria" {Spence, 2008}. The goals of the ESU criteria are to reduce the risk of extinction by ensuring (1) connectivity between populations, (2) representation of ecological, morphological, and genetic diversity, and (3) redundancy in populations to minimize risks associated with catastrophic events.

In characterizing a viable ESU the TRT applied the hypothesis that populations, as they functioned in their historical context, were highly likely of persisting and that "…*increasing departure from historical characteristics logically requires a greater degree of proof that a population is indeed viable*" (Spence *et al*. 2008). Due to the likely historical roles of functionally independent or potentially independent populations these form the foundation of the ESU viability criteria. The "non-viable" or dependent population criteria were designed to ensure reservoirs of genetic diversity, contribute to connectivity, reduce risk of ESU extinction, and provide a source of colonizers to extirpated watersheds and buffer ocean conditions and disturbances to independent populations.

The four ESU viability criteria are:

(1) Representation Criteria;

1.a. All indentified diversity strata that include historical FIPs or PIPs within an ESU should be represented by viable population for the ESU to be considered viable.

-AND-

1. b. Within each diversity stratum, all extant phenotypic diversity (i.e., major life-history types) should be represented by viable populations.

(2) Redundancy and Connectivity;

2.a. At least fifty percent of historically independent populations (FIPs or PIPs) in each diversity stratum must be demonstrated to be at low risk of extinction according to the population viability criteria. For strata with three or fewer independent populations, at least two populations must be viable.

-AND-

2.b. Within each diversity stratum, the total aggregate abundance of independent populations selected to satisfy this criterion must meet or exceed 50% of the aggregate viable population abundance (*i.e*., meeting density-based criteria for low risk) for all FIPs and PIPs.

(3) Remaining populations, including historically dependent populations or any historical FIPs or PIPs that are not expected to attain a viable status, must exhibit occupancy patterns consistent with those expected under sufficient immigration subsidy arising from the 'focus' Independent populations selected to satisfy the preceding criterion.

(4) The distribution of extant populations, regardless of historical status, must maintain connectivity within the diversity stratum, as well as connectivity to neighboring diversity strata.

## APPLYING TRT FRAMEWORK TO COHO SALMON ESU RECOVERY CRITERIA

A total of 75 watersheds, between Mendocino County and Santa Cruz County (including San Francisco Bay tributaries) were identified by Bjorkstedt *et al*. (2005) as historically supporting CCC coho salmon populations. All 12 independent populations and 16 dependent populations (DPs) were chosen across four diversity strata for the CCC coho salmon ESU recovery scenario; no populations were chosen for the San Francisco Bay Diversity Stratum. Recovery targets for spawner abundance for each FIP or PIP within the ESU coincide with the low extinction risk targets identified in Spence *et al.* 2008, except for the Russian River. Occupancy targets for DPs were derived from abundance estimates from Waddell Creek data from the 1930's (Shapavolov and Taft 1954).

The combined abundance targets and recovery criteria for the CCC coho salmon ESU we believe represent the recovery of the species. The reasons for this are threefold: 1) The approach provides redundancy, resiliency and representation in the ESU; 2) We recognize that the salmon provide additional ecological benefits such as maintenance of ecosystem productivity; and 3) Salmon may ultimately be harvested, as they near recovery, for recreational, commercial and tribal uses. It would be unwise not to consider this as part of the broader ecological picture when developing recovery criteria.

The current recovery scenario expects 37 percent of historical populations (28 individual watersheds) to achieve and maintain viability across all potential habitats for CCC coho salmon to meet ESU-level criteria. These 28 watersheds occupy **43 percent** of the total land area in the ESU, and represent **33 percent** of all the stream kilometers with the potential to have provided habitat historically (*i.e*. IP km). Though these 28 populations are the focus of this analysis and subsequent strategy development, recovery and threat abatement actions should not be limited exclusively to these watersheds. In particular, efforts to prevent coho salmon extirpation and facilitate their recovery should be initiated where this species is present. In addition, all coho salmon populations and individuals and their designated critical habitat remain fully protected under the ESA wherever they occur and are therefore still subject to all the protections therein; including prohibitions on take and habitat modifications (unless legally exempted by permit).

IP habitats for coho salmon were output for each population and are displayed on maps that include a range of IP values across three scales: 0.0 to 0.35; 0.35 to 0.7 and > 0.7. These scales represent: (1) relative likelihood for historic channel and flow conditions to provide higher quality rearing habitats for coho salmon; and (2) likelihood of areas within a watershed to historically provide higher or lower abundance per length of stream reach to meet overall abundance target for the population. The IP values across these scales represent the historical potential of channel width, mean annual discharge and gradient to provide suitable habitats and support higher abundances of coho salmon with > 0.7 having a high likelihood, 0.35 to 0.7 having a moderate likelihood and 0.0 to 0.35 having a lower likelihood.

For recovery planning purposes, NMFS is evaluating those areas identified as > 0.7 as having a higher potential for responding to instream restoration actions (e.g., input of large wood and pool formation).

With the current goal to prevent extinction, these areas will be evaluated for their potential to respond quickly to restoration activities and provide immediate or very near term benefits to improve CCC coho salmon survival. These areas are also those most likely to respond negatively as well as upstream conditions degrade. Nevertheless, the overall persistence of this species relies on restoration and maintenance of watershed processes across IP and non-IP areas.

## Recovery Goals for Independent Populations

Table 8 summarizes the Independent Population recovery criteria for CCC coho salmon, including both biological criteria for population viability and recovery and the total IP-km expected to function towards meeting these recovery goals. Viable population abundance is calculated as the product of all stream reaches with intrinsic potential (IP-km) in a watershed and recovery target densities for spawning adults based on Spence *et. al.* (2008).

**Table 12: Independent Population Adult Spawner Abundance Targets for Recovery**

| Diversity Strata | Population | IP-km | Density Targets | Spawning Adult Target |
|---|---|---|---|---|
| **Lost Coast** | **Ten Mile** | **105.1** | **34.93** | 3700 |
| **Lost Coast** | **Noyo** | **118** | **34.03** | 4000 |
| **Lost Coast** | **Big** | **191.8** | **28.91** | 5500 |
| **Lost Coast** | **Albion** | **59.2** | **38.11** | 2300 |
| | | | **Total:** | **15,500** |
| **Navarro Pt.** | **Navarro** | **201** | **28.27** | 5700 |
| **Navarro Pt.** | **Garcia** | **76** | **36.95** | 2800 |
| **Navarro Pt.** | **Gualala** | **251.6** | **24.76** | 6200 |
| | | | **Total:** | **14,700** |
| **Coastal** | **Russian** | **506** | **20.00** | **10,100** |
| **Coastal** | **Walker*** | **76.2** | **36.93** | 2800 |
| **Coastal** | **Lagunitas** | **70.4** | **37.34** | 2600 |
| | | | **Total:** | **15,500** |
| **Santa Cruz** | **Pescadero** | **60.6** | **38.02** | 2300 |
| **Santa Cruz** | **San Lorenzo** | **126.42** | **33.45** | 4200 |
| | | | **Total:** | **6500** |
| | | | | **ESU Total:** **52,200** |

*Potentially Independent Population

Unfortunately, data are insufficient to assess current viability for the 12 independent populations based on the defined criteria. Ancillary data compiled and assessed by the TRT indicate that over half of the independent populations (and many dependent populations) are extirpated, or nearly so (Spence *et al.*

2008). Despite the data limitations, all evidence suggests that the CCC coho salmon ESU is at a high risk of extinction (Spence *et al.* 2008).

## Recovery Goals for Dependent Populations

In order to meet viability criteria and address the extreme decline in the coho salmon population, specific Dependent Populations were included to minimize extinction risk. The inclusion of these Dependent Populations are anticipated to (1) maintain connectivity within and across diversity strata; (2) provide potential sources of colonizers if adjacent populations are eliminated or experience severe declines; and, (3) ensure continued genetic reservoirs in strata where Independent Populations are extirpated. The 16 selected Dependent Populations must exhibit occupancy patterns within targeted ranges (Table 9) consistent with those expected under sufficient immigration subsidy arising from the Independent Populations; and the distribution of extant populations, regardless of historical status, must maintain connectivity within the diversity stratum, as well as connectivity to neighboring Diversity Strata.

**Table 13: Dependent Population**

**Adult Spawner Abundance for Recovery**

| **Dependent Populations** | Current IP-km | Spawer/km | Target Na |
|---|---|---|---|
| **Usal Creek** | 10.6 | 34 | 360 |
| **Cottaneva Creek** | 13.8 | 34 | 469 |
| **Wages Creek** | 10 | 34 | 340 |
| **Pudding Creek** | 28.9 | 34 | 983 |
| **Casper Creek** | 12.8 | 34 | 435 |
| **Big Salmon Creek** | 17 | 34 | 578 |
| **Salmon Creek** | 47.6 | 34 | 1618 |
| **Pine Gulch** | 7.4 | 34 | 252 |
| **Redwood Creek** | 8 | 34 | 272 |
| **San Gregorio** | 40.1 | 34 | 1363 |
| **Gazos Creek** | 8.2 | 34 | 279 |
| **Waddel Creek** | 9.2 | 34 | 313 |
| **Scott Creek** | 15 | 34 | 510 |
| **San Vicente Creek** | 3.1 | 34 | 105 |
| **Soquel Creek** | 33 | 34 | 1122 |
| **Aptos Creek** | 27.4 | 34 | 932 |
| | | | |
| **Lost Coast-Navarro Point** | 6 populations | | 3165 |
| **Navarro Point-Gualala Point** | no populations | | 0 |
| **Coastal** | 3 populations | | 2142 |
| **Santa Cruz Mountains** | 7 populations | | 4624 |
| | | ESU Total | **9931** |

Available data were used to develop a target range for spawner densities in dependent watersheds. Data from 1933-1942 in Waddell Creek, Santa Cruz County, (Shapovalov and Taft 1954) were used as a reference for the spawner target density target[12]. The average

[12] It is important to note that virtually all portions of the Waddell Creek watershed, at the time of the Shapovalov and Taft study in the 1930's, had been were not at a pristine or condition. Shapovalov and Taft (1954) describe Waddell Creek in the following terms: *"Some changes from the primitive condition of the area have taken place as a result of human usage. The redwood forest of the watershed below Big Basin was logged off by 1870 and is now covered by a second growth. The early lumbering operations have resulted in the creation of several semipermanent log jams and temporary accumulations of logs, which have hastened erosion of stream banks, with consequent increase in silting during flood stage."*

spawner population was 312 fish (which ranged from111-748) resulting in a spawner density target of 34 per IP-km (312/9.2 IP-km).

The statements of Shapovalov and Taft (1954) likely understate the degree Waddell Creek had been affected by the removal of the redwood forest. Virtually all portions of the watershed accessible to coho salmon were extensively disturbed prior to the onset of the Shapovalov and Taft (1954) study. Early logging practices were particularly destructive and this level of disturbance likely resulted in a significant reduction in the productive capacity for coho salmon in the watershed.

## Considering the SF Bay Stratum

All CCC coho salmon populations that historically existed in the San Francisco Bay region have been extirpated. The most plausible explanation for the extirpation is the intense urbanization and associated developments in the region. Historical evidence confirms that watersheds that are tributaries to the San Francisco Bay, which collectively comprise the San Francisco Bay Diversity Stratum, supported populations of coho salmon (Spence *et al*. 2005). The first known scientific specimen of a coho salmon from California was collected in the 1860's from San Mateo Creek in San Mateo County. An investigation of the Indian middens in the Emeryville shellmounds revealed remains of coho salmon prior to European contact (Gobalet *et al*. 2004), and adult coho salmon were also observed in Alameda Creek as recently as the 1960s (Leidy *et al*. 2005).

While the historical presence of coho salmon in the San Francisco Bay stratum is established, the degree to which these tributaries were historically capable of supporting coho salmon populations is uncertain. Bjorkstedt *et al.* (2005) identified many watersheds exceeding the minimum 32 IP-km for Independent Population status. According to the model predictions, San Francisco Bay populations represented 16 of 75 watersheds in the ESU with historic potential to support coho salmon. San Francisco Bay watersheds contain 38 percent of all the historic IP mileage in the ESU. Bjorkstedt *et al.* (2005), however, described considerable uncertainty in the IP model prediction results due to the highly altered current condition and the lack of historical evidence of viable populations. The general conclusion reached by Bjorkstedt *et al*. (2005) is the San Francisco Bay watersheds supported only small and/or ephemeral populations, particularly in the drier and warmer interior watersheds. The TRT concluded (Bjorkstedt *et al.* 2005) that no independent populations historically existed and, thus, no viability abundance criteria were developed for populations of the San Francisco Bay Diversity Stratum.

Reasons for the extirpation of CCC coho salmon in the San Francisco Bay region are likely due to multiple factors such as inherently marginal habitats, currently highly degraded watersheds and occupancy by populations that were ephemeral or occasional in nature. The extirpation of CCC coho salmon in this Stratum and the high costs of restoration and/or infeasibility of restoration suggested may be little value in including this Stratum into the recovery scenario. Nonetheless, while the San Francisco Bay Diversity Stratum was not included in the recovery scenario it is recommended that evaluation be done on the feasibility and likelihood of restoring CCC coho salmon populations some San Francisco Bay tributaries (such as Corte Madera Creek) due to some uncertainty regarding the role these populations may have had in the ESU.