Appendix C

Conservation Action Planning Viability Table Report for CCC Coho Salmon, Draft September 2009

NCCC Recovery Domain
Conservation Action Planning Viability Table Report For CCC Coho Salmon

Perpetual Draft
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INTRODUCTION

As part of recovery plan development for Federally-listed salmonids in the North Central California Coast Recovery (NCCC) Domain[1] (Figure 1), NOAAs National Marine Fisheries Service (NMFS) staff used a software program and analysis process to assess threats and develop recovery strategies for the Domain's salmon Central California Coast (CCC) coho salmon (*Oncorhynchus kisutch*). This report describes this process and its application to CCC coho salmon.

[1] The recovery domain includes all coastal watersheds and the marine environment, including San Francisco Bay, from Redwood Creek in Humboldt County south to Soquel Creek in Santa Cruz County, California. Map attached.

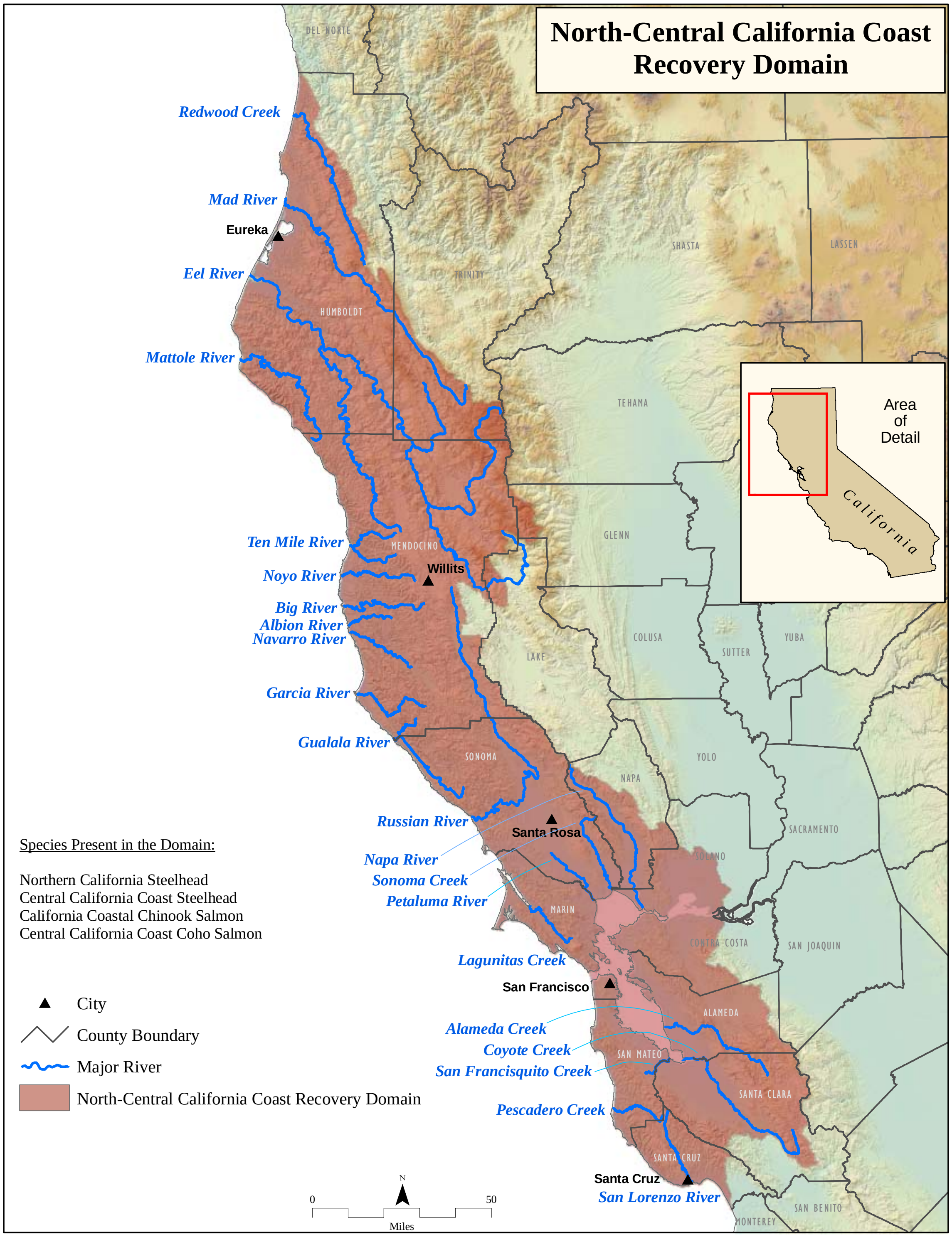

Figure 1. NCCC Domain overview.

The program and process, called "Conservation Action Planning" (CAP), was developed by The Nature Conservancy (TNC) in collaboration with the World Wildlife Fund, Conservation International, Wildlife Conservation Society and others. CAP is a planning tool to evaluate, prioritize, and address threats to ecosystems and species. CAP is aligned with a set of open standards[2] that were developed by the Conservation Measures Partnership; a partnership of 10 different biodiversity non-governmental organizations. CAP has been applied to more than 400 landscapes and 25 countries, and TNC has officially adopted CAP as its standard conservation planning tool. CAP is also recommended in the NMFS Interim Endangered and Threatened Species Recovery Planning Guidance (NMFS 2007) as a preferred method to assess threats and develop recovery strategies for federally-listed marine and anadromous species.

In 2006, NMFS Southwest Region, Protected Resources Division, Santa Rosa area office, partnered with TNC for their assistance and support in applying the CAP framework (e.g., CAP workbook) to NCCC recovery plans. The hands-on training and interactions with TNC staff facilitated development of a CAP workbook template to be used initially for coho salmon, and then for the other three salmonid species in the NCCC Domain. Several other NMFS recovery domains in California are also using the TNC CAP workbook, or a modified version of the process, to develop their recovery plans.

Workbooks were designed to analyze key habitat attributes and their current and future function in each watershed as they relate to specific life stages of coho salmon. A multiple life stage category was developed to address watershed and ecosystem processes. The viability table of the CAP workbook assesses current conditions; future stresses and threats are assessed in other tables within the CAP workbook. All assessments are informed by compilation, analysis, and review of data compiled by NMFS staff and with contract assistance from Sonoma Ecology Center (SEC). The CAP process easily accommodates both quantitative and qualitative analyses.

Recovery actions ultimately target improving poor current habitat conditions and reducing or abating the highest ranked threats. The CAP workbook systematically links recovery actions to specific threats and key habitat attributes. It also provides the logic and transparency required for sound decision-making and prioritization. This type of documentation and adaptability will serve as the foundation for successive generations of planning as we gather more data and improve our knowledge. The end results are clearly defined recovery goals that address the greatest threats to the key populations.

This Viability Table Report provides the rationale behind the habitat and watershed process parameters within the CAP workbook viability table specifically developed for CCC coho salmon.

[2] For more information about the open standards you can go to the web site "conservationmeasures.org".

CAP VIABILITY TABLE OVERVIEW

CAP Conservation Targets

Targets define the focus of the CAP workbook analysis and become the foundation of our future strategies and actions . Targets define discrete conservation units that, when considered properly, will direct us to successful recovery of the species. Because salmonid habitat use varies substantially by life stage, we chose to define targets as five life stages that encapsulate the entire salmonid life-cycle, and a fifth target that ensures consideration of watershed processes. The life stages used in the workbooks and their definitions are:

- Spawning Adults – Includes adult coho salmon from the time they enter freshwater, hold or migrate to spawning areas, and complete the spawning phase of their life cycle. For the purposes of our analysis, we considered November 1 to March 1 the migration period[3];

- Egg – Includes fertilized eggs placed in spawning redds, and the incubation of these eggs through the time of emergence from the gravel as fry. For the purposes of our analysis, we consider December 1 to April 1 to be the incubation period for coho salmon;

- Summer Rearing – Includes rearing of juvenile coho salmon from emergence to the onset of winter rains (typically July - October). This life stage includes juveniles rearing in estuaries prior to smoltification. For the purposes of our analysis, we consider July 1 to October 31 to be the rearing period for coho salmon;

- Winter Rearing – Includes rearing of juvenile coho salmon from the onset of winter rains through the winter months (typically October – March) and including the period of spring freshets, or up to the initiation of smolt outmigration, whichever comes first;

- Smolt – This period is inclusive of the time rearing juvenile coho salmon leave their natal rearing areas and migrate downstream until they enter the ocean. The process of smoltification occurs throughout this entire period, and is strongly influenced by changes in day length (Quinn 2005). This life stage includes estuary residency where smolts undergo physiological changes for adapting to the marine environment. For the purposes of our analysis, we consider March 1 to June 1 representative of this period; and

- Multiple Life Stages – Includes all the freshwater life stages of coho salmon affected by upslope or landscape processes. These processes may have effects which occur at the watershed scale. These key attributes and indicators provided a perspective on watershed processes beyond specific instream habitats. This larger scale component captures issues related to system dynamics and cumulative effects. For example, several key attributes characterize forest stand conditions and therefore, relate to stream temperature and large woody debris (LWD) recruitment (among other things). LWD in turn, contributes cover to summer rearing juveniles, cover and velocity refuge to winter

[3] The purpose in defining discrete life stage periods is to assess habitat attributes during a representative time frame, not to encapsulate the full range of timing possibilities.

rearing juveniles, and creates localized scour and pool formation which provides holding areas for outmigrating smolts.

Key Habitat Attributes, Indicators and Ratings

In general, key habitat attributes are defined as critical components of a conservation target's biology or ecology (TNC 2007). By this definition, if key attributes are missing, altered, or degraded, the result would be the loss of the target over time. We identified the factors with the greatest potential to limit coho salmon production at the population scale, and defined them as key attributes. As an example, pool complexity is a key habitat attribute because lack of pool complexity reduces juvenile survival.

Indicators are measurable expressions of key attributes. A key attribute may have one or more indicators, but each indicator should be an objective, measurable aspect of a key attribute. For example, shelter rating, which is a data product of stream habitat typing surveys, is an indicator for pool habitat complexity.

Once indicators were assessed, the Recovery Team judged the condition of the indicator by comparing it to specific rating criteria. This allowed a rating of Poor, Fair, Good, or Very Good for each indicator. Rating criteria specifically link an indicator to its current condition in a watershed relative to its ability to support salmonids through specific target life stages.

Spatial Analysis

To characterize and rate the status of key attributes, indicator assessments were made at the watershed scale. Because data were often spatially limited, in most cases this required a spatial analysis and some extrapolation of available data.

Our approach assessed all stream reaches historically supporting the target life stage. For example, to characterize water temperature for summer rearing juveniles, the Recovery Team reviewed all stream reaches likely to support summer rearing prior to significant influence of western civilization. The extent and distribution of historic habitat was defined by the North Central California Coast Technical Review Team (TRT) and was termed: Intrinsic Potential (IP). Using a model developed with criteria for gradient, valley width, and mean annual discharge, the TRT estimated reach-specific suitability for supporting spawning and juvenile rearing habitats (Bjorkstedt et al., 2005). For coho salmon, a temperature mask was added to further define the IP. IP values (between 0 and 1) were assigned, indicating the overall value of a specific km to species. The IP model results provide a measure of habitat conditions in each watershed in kilometers (km), and estimate the intrinsic potential of a watershed to support spawning and rearing habitat at the reach scale. Using this model facilitated identification of all stream reaches within a watershed with potentially suitable habitat for each species and life stage target.

The Recovery Team did not limit analyses to the more limited current distribution of coho salmon, but depended on the historical population structure and biological viability criteria developed by the TRT (Bjorkstedt et al. 2005). Instead, the Recovery Team relied on the TRT's assumption that historical distribution represented the appropriate scenario for species recovery.

Confidence Ratings

The assessment of watershed conditions for the indicators defined below relied heavily on the California Department of Fish and Game's stream habitat-typing data, known as the Hab-8 dataset[4]. While this dataset has good coverage throughout the NCCC Recovery Domain, it did not cover all IP-km, and in some cases covered small portions of watersheds.

We analyzed the variable coverage of Hab-8 data across watersheds to measure the confidence in our conclusions at the watershed scale. Two measures were investigated: 1) the percent of IP-km covered by Hab-8 surveys; and 2) the relative distribution of IP values within the surveyed areas compared to the watershed as a whole.

The percent of IP-km covered gave a measure of "sample size". For example, confidence might be low if less than 20% of all IP-km in the watershed were surveyed. This is significant considering we would use that 20% to characterize watershed-wide conditions. Table 1 shows how confidence increased as a function of increased coverage.

Table 1. Confidence ratings for Hab-8 data as a function of percent of IP-km surveyed.

Confidence	Low	Fair	High	Very High
% Coverage	<20	20-50	50-80	>80

To determine whether surveyed areas were representative of habitat throughout the watershed, we compared the distribution of IP values (between 0 and 1) within the surveyed reaches to the overall distribution of IP values in the watershed. For both sets, we calculated the average IP value and standard deviations (SD). The Albion River watershed for example, had an average IP value of 0.58 (SD 0.28). By comparing those values to the watershed average of 0.71 (SD 0.39), we are able to get an indication of how the surveyed reaches compared to the watershed as a whole.

Assessing Habitat Attributes

Due to the urgency in reversing the process of extinction for an endangered species, we used the following principles as guidance in developing assessment methods:

(1) Reviewing existing and relevant literature to understand and articulate biological and ecological requirements of coho salmon. We devoted considerable resources to finding and applying the best scientific and commercial watershed specific data available for the informing the current status of each of the pertinent habitat indicators;

[4]Methods for Hab-8 surveys are described in Flosi, G. and F. L. Reynolds (1998). California salmonid stream habitat restoration manual, California Department of Fish and Game.

(2) Uncertainty or lack of data was managed by reducing it where possible and acknowledging it where it remained. There were several instances, such as with flow-related habitat attributes, where we turned to the use of structured decision making models informed by expert opinion to move forward and reduce uncertainty;

(3) The assessment and development of recovery strategies was treated as an iterative process. By treating methods as tentative and conclusions as hypotheses, we facilitate challenges and revisions as new information becomes available. This creates an adaptive framework allowing learning and improvement that will ultimately result in a more effective recovery effort;

(4) Ratings were based on an average watershed condition, allowing evaluation of conditions experienced by both the populations and the ESU. However, habitats within each watershed likely vary substantially. Therefore, more detailed sub-watershed assessments should still be conducted in some watersheds to inform site specific actions; and

(5) The assessment identified opportunities to recover the species, not to focus blame on any group or individual or land management practice. Recovery planning and implementation is non-regulatory, and success relies on voluntary cooperation and collaboration.

The remainder of this document details all key attributes, indicators, and ratings used in the CAP workbooks and describes methods used to inform those ratings.

TARGETS, ATTRIBUTES, AND INDICATORS

Table 2. Summary of Indicators

Target Life Stage	Habitat Attribute	Indicator
Spawning Adults	Viability (Incidental Mortality)	Freshwater Harvest
Spawning Adults	Hydrology, Adult passage to spawning grounds	Passage Flows
Spawning Adults	Passage	Physical Barriers
Spawning Adults	Passage at Stream Mouth	Entry Period
Spawning Adults	Sediment, Spawning Substrate	Spawning gravel quant. & distribution
Spawning Adults	Viability, Pop. Density	Density Target
Egg	Hydrology	Redd Scour
Egg	Hydrology	Instantaneous Condition
Egg	Sediment	Gravel Quality (Bulk)
Egg	Sediment	Gravel Quality (Embed.)
Summer Rearing	Hydrology	Baseflow
Summer Rearing	Water Quality	Temperature (MWAT or MWMT)
Summer Rearing	Estuary	Hybrid Indicator
Summer Rearing	Pool Habitat	Frequency of Primary Pools
Summer Rearing	Viability	Density (Juveniles)
Summer Rearing	Viability	Distribution
Winter Rearing	Velocity Refuge	Complex Habitat Types

Winter Rearing	Velocity Refuge	Off-channel Habitats
Smolt	Passage	# of Diversions
Smolt	Hydrology	Flow Conditions
Multiple Life Stages	Pool Habitat	Shelter Rating
Multiple Life Stages	Hydrology	Impervious Surfaces
Multiple Life Stages	Hydrology	Stand Age
Multiple Life Stages	Land disturbance	Agriculture
Multiple Life Stages	Land disturbance	Timber Harvest
Multiple Life Stages	Riparian Veg., Stream Shading	Canopy Cover
Multiple Life Stages	Riparian Veg.	DBH (North)
Multiple Life Stages	Riparian Veg.	DBH (South)
Multiple Life Stages	Riparian Veg.	Species Composition
Multiple Life Stages	Sediment Transport	Road Density
Multiple Life Stages	Sediment Transport	Road density (Riparian)
Multiple Life Stages	Pool Habitat	LWD Freq. (BFW 0-10)
Multiple Life Stages	Pool Habitat	LWD Freq. (BFW 10-100)
Multiple Life Stages	Velocity Refuge	Floodplain Connectivity
Multiple Life Stages	Water Quality, Toxins	Toxicity

LIFE STAGE: Spawning Adults

Passage Flows

Target: Spawning Adults

Attribute: Hydrology, Adult passage to spawning grounds
The magnitude, timing, and seasonality of local precipitation and geology largely determine a watershed's discharge patterns; patterns that influence flow and stream depth that are critical factors for successful adult passage to spawning grounds. These patterns can be, and have been, modified by individual and cumulative water use practices in ways that inhibit the ability of salmonids to migrate upstream to spawn.

Indicator: Passage Flows
Passage flows were defined as those that annually provide sufficient depth at the appropriate place, time, and duration to facilitate the upstream migration of all adults in a population. This indicator describes the presence, distribution, and seasonality of surface waters in the watershed.

Ratings: Hydrologic setting for successful passage
Fisheries biologists from DFG and Regional Water Quality Control Boards were invited to participate in a workshop and participate in a structured decision-making process to provide individual opinions regarding flow conditions for summer rearing, instantaneous flow reduction affecting redds, redd scour, smolt outmigration flows and passage flows for adult upstream migration. Workshop participants were asked to individually rate the hydrologic setting, the degree of exposure to flow impairments, and the intensity of those impacts for each CCC coho salmon population. Their scores were averaged to derive a rating for each indicator.

Other Methods:

Prior to the decision to use an expert panel for the instream flow indicators, SEC was requested to collect and process all relevant United States Geological Survey (USGS) stream gage data. Gage data was available for 20 of the target watersheds. SEC targeted and collected all available data for the gage nearest the mouth of each river under the assumption that this would be the one with the most cumulative flow. They downloaded daily flow statistics and compiled them into Microsoft Excel spreadsheets. They calculated average flow for three timeframes; Spawner Passage (November 1 – Feb 28), Smolt Passage (March 1 – June 30), and Summer Baseflow (July 1-October 31). Standard deviation and standard error were also calculated and compiled. Where USGS gages did not exist, SEC contacted various other agencies and researchers to fill in data gaps. SEC attempted to scale-up the data to estimate flow in the upper portions of watersheds, where spawning and rearing typically occur. However, no methods yielded satisfactory results. NMFS staff concluded there were not sufficient data on which to base a rating of flow conditions and, thus, applied results from the professional workshop. This method will be further evaluated using the UC Berkeley Microsoft Data Cube (Discussed in Chapter 6).

Physical Barriers

Target: Spawning Adults

Attribute: Passage, Adult passage to spawning grounds
Physical barriers are structures or sites that prevent or impede the upstream passage of migrating adult salmonids. Excluding spawning salmonids from portions of their IP-km can increase the likelihood of extirpation by reducing the amount of available spawning and rearing habitat and thereby lower the carrying capacity of the watershed .

Indicator: Physical Barriers
Passage was defined as the absence of physical barriers that would prevent access to spawning grounds for migrating adult coho salmon. Physical barriers are structures or sites, and sometimes conditions such as high velocities that prevent or impede the upstream passage of migrating adult salmonids. We defined the indicator as that proportion of IP-km free of known barriers and thereby accessible to migrating coho. The physical barriers attribute included only *Total* barriers which are complete barriers to fish passage for all anadromous species at all life stages at all times of year.

Ratings: Accessible proportion of IP-km
We defined rating thresholds for this indicator in the following manner:

Poor = <50% of historical IP-km currently accessible
Fair = historical IP habitat between 50% and 70%
Good = Between 70% and 90% of historical IP-km
Very Good = ≥90% of historical IP-km

Methods:
SEC queried the DFG Passage Assessment Database (PSMFC 2006) (PAD) to calculate the proportion of IP-km blocked to anadromy by impassable barriers. The PAD contains data and point file coverage for all known fish passage barriers. Each barrier in the database was

identified as full, partial or natural barrier. SEC evaluated only *Total* or complete barriers to avoid overestimating actual impediments to migrating adults.

In each watershed, the complete barrier farthest downstream was identified and listed in a Microsoft Excel spreadsheet. SEC calculated the total IP km lost per barrier. All lost IP km were summed, and divided by the total valid river IP km per watershed to yield the percent IP km behind barriers. The final result was presented as the percent of total watershed accessible to salmonids (*i.e.,* not blocked by barriers).

We considered including passage into the watershed at estuary mouths and flow-related barriers (*e.g.,* at critical riffles) in this key attribute, but separated them into their own attributes due to substantial differences in assessment methods, and development and implementation of strategic actions. Natural barriers were not included in this attribute because they are already taken into consideration in the development of the IP networks. Where IP-km was indicated above natural barriers, we "trimmed" the IP km network to exclude such reaches in advance of the barrier analysis.

Major dams were included as barriers because any IP reaches upstream of these barriers may have value to recovery. Spence *et al*. (2008) presented viable population targets both with and without IP km above major dams, so it may be possible in some circumstances to attain recovery goals without passage over these dams. We are still obliged however, to assess the value of these areas and consider potential recovery strategies at a later time.

<u>Passage at Stream Mouth</u>

Target: Spawning Adults

Attribute: Passage, at stream mouth

Estuaries of some coastal watersheds in the NCCC Domain commonly form ephemeral freshwater lagoons. These lagoons are the products of low summer flow regimes that cannot displace oceans sand deposition at the estuary mouth (Bond 2006). Eventual formation of a sandbar effectively blocks surface connectivity with the ocean, and reduces the tidal influence on the system. Natural breeching of the sandbar during adult migration is essential to allow watershed access.

Indicator: Passage at Mouth, Entry Period

Estuaries that remain closed during the adult migration period preclude the adult spawning population from accessing a watershed. Estuaries that remain closed until late in the spawning season may preclude a proportion of the adult spawning population from accessing a watershed. Spawners waiting for the sandbar to breech are likely more susceptible to offshore predation and other forms of mortality such as incidental offshore recreational fishing. The longer the delay in breeching the more compressed the migration window and likely, the smaller the run. Shapovalov and Taft (1954) reported coho salmon migrated on freshet events throughout the winter period after the sandbar opened.

Ratings: Number of day's stream mouth physically open during spawner entry period (Nov 1 - Mar 31)

NMFS determined the longer a sandbar remained opened the greater the likelihood of ensuring all spawners will access a watershed. If the sandbar remained open for more than 90 days we considered this would represent very good conditions because it encompasses the entire migration period as well as any early of late spawners. We determined a sandbar opened between 60-90 days would allow access for the majority of the population; 30-60 days would allow access for many spawners but may expose the population to greater risk of predation during staging offshore or other risks; and < 30 days would result in significant delays in migration and would likely reduce the total number of successful adult spawners.

The ratings for this attribute is based on the number of day's estuaries are open during adult migration:

Poor = <30 days open
Fair = 30-60 days open
Good = 60-90 days open
Very Good = >90 days open

Methods:
The ratings for this indicator were determined based on NMFS analysis of watershed reports, co-manager documentation and knowledge, literature reviews, and best professional judgment.

Spawning Gravels

Target: Spawning Adults

Attribute: Sediment, Spawning substrate
We define sediment, relative to its function as a key habitat attribute, as streambed gravels with particle size distribution of sufficient quality to allow successful spawning and incubation of eggs. These substrates must be located within spawning habitat as defined by the IP model.

Indicator: Gravel, Quantity and Distribution
We defined the quantity and distribution of spawning substrate as the amount of spawning habitat available to the spawning population. Distribution indicates the degree of dispersion of habitat across IP-km in a watershed.

Ratings: Amount of spawning habitat available to the spawning population
Female coho salmon usually spawn near the head of a riffle, just below a pool, where water changes from a laminar to a turbulent flow and where there is small to medium gravel substrate. The flow characteristics of the redd location usually ensures good aeration of eggs and embryos, and flushing of waste products. The water circulation in these areas facilitates fry emergence from the gravel. Preferred spawning grounds have nearby overhead and submerged cover for holding adults; water depth of 10 to 54 cm; water velocities of 20 to 80 cm/s; clean, loosely compacted gravel (1.3 to 12.7 cm diameter) with less than 20 percent fine silt or sand content; cool water (4 to 10^{o} C) with high DO (8 mg/l); and an inter-gravel flow sufficient to aerate the eggs. The lack of suitable gravel often limits successful spawning in many streams.

We defined rating criteria for the quantity of spawning habitat (*H*), by estimating the amount of spawning habitat (in square meters) needed to support high and low extinction risk target populations for each species. We used the following calculation:

$$H = \frac{N_{er}}{F_{spp} * R_{spp}}$$

where N_{er} is the target adult population abundance for a given extinction risk as defined by the TRT (Spence et al. 2008); F_{spp} is the estimated average number of fish per redd for a given species based on reported values in Gallagher (2005) and updated with the addition of more recent data (Gallagher pers. comm.); R_{spp} is the estimated average area per redd for a given species (Gallagher and Gallagher 2005). N_{er} for low risk of extinction targets are used to calculate the thresholds for very good and good ratings, and high risk targets are used to calculate the fair and poor rating thresholds. An example of the input variables is given in Table 3, and selected results are presented in Table 4. We rated this attribute using extinction targets:

Poor = <High Risk: Poor is less than or equal to the high-end estimate of spawning area needed to support a high risk population (rounded up to the nearest 100).
Fair = High Risk to ½ of Low Risk: Fair is the amount of spawning habitat intermediate between the Poor rating and the Good (rounded up to the nearest 100).
Good = ½ of Low Risk to Low Risk: Good is the amount of spawning habitat from midway between the average area needed to support a low risk and high risk populations and the average amount needed to support a low risk population (rounded up to the nearest 100).
Very Good = >Low Risk: Very Good is any amount of spawning habitat greater than the average needed to support a low risk population (rounded up to the nearest 100).

Table 3. Values used to calculate H for the Noyo River coho salmon with confidence intervals.

N_{lr}	N_{hr}	F_{coho}	**CI(-)**	**CI(+)**	R_{coho}	**Range (-)**	**Range (-)**
4000	119	2.33	1.83	3.87	6.03	0.9	16.5

Table 4. The watershed specific estimated amounts of spawning habitat in square meters needed to support viable populations of coho salmon.

Population	**Poor**	**Fair**	**Good**	**Very Good**
Usal	<100	100-500	500-1000	>1000
Cottaneva	<100	100-800	800-1600	>1600
Ten Mile	<500	500-5000	5000-9600	>9600
Wages	<100	100-500	500-900	>900
Pudding	<200	200-1600	1600-3200	>3200
Noyo	<600	600-5400	5400-10400	>10400
Caspar	<100	100-600	600-1300	>1300

Big	<900	900-7700	7700-14500	>14500
Albion	<300	300-3100	3100-6000	>6000
Big Salmon	<100	100-900	900-1900	>1900
Navarro	<900	900-7800	7800-14800	>14800
Garcia	<400	400-3800	3800-7300	>7300
Gualala	<1100	1100-8600	8600-16100	>16100
Russian	<2200	2200-21800	21800-40400	>40400
Salmon	<300	300-2200	2200-4200	>4200
Walker	<500	500-4900	4900-9400	>9400
Lagunitas	<600	600-6100	6100-11700	>11700
Pine Gulch	<100	100-400	400-800	>800
Redwood	<100	100-400	400-800	>800
San Gregorio	<200	200-1800	1800-3600	>3600
Pescadero	<300	300-3100	3100-6000	>6000
Gazos	<100	100-400	400-800	>800
Waddell	<100	100-500	500-1100	>1100
Scott	<100	100-800	800-1600	>1600
San Vincente	<100	100-200	200-300	>300
San Lorenzo	<600	600-6000	6000-11400	>11400
Soquel	<200	200-1500	1500-3000	>3000
Aptos	<200	200-1300	1300-2600	>2600

Methods:
To assess watershed conditions relative to these criteria, SEC summarized HAB-8 data. SEC estimated the number of spawning sites by summing the number of pool tail outs with embededdness values of 4 or less in Hab-8 surveys. SEC calculated the area of spawning habitat in square meters by squaring the value of 0.79 * (mean) wetted channel width for each summarized reach. The width is used to approximate tail-out length based on the assumption that pool tail-outs tend to be transitional units and therefore do not typically form habitat units of great length, while the multiplier of 0.79 is based on the assumption that riffle units tend to be narrower on average than pools. Once spawning area was calculated for the HAB-8 survey area, SEC extrapolated to the entire IP-km universe within each watershed, assuming the survey area was representative of the watershed as a whole. Extrapolation was achieved by dividing total spawning gravel by total length of habitat survey multiplied by total length of valid IP-km.

For the majority of the watersheds, SEC relied on DFG's reach summary habitat survey database. However for three of the watersheds (Russian River, Salmon Creek, Lagunitas Creek) SEC had access to a new database that allowed them to make adjustments to the methods and more accurately assess and analyze the data. The new database known as Stream Summary was developed by DFG Russian River Fisheries Resources Assessment in partnership with Hopland Research Extension and Center GIS Lab. The Stream Summary database provides summary statistics for reaches at various scales and new queries can be generated quickly. Working closely with the development team, we requested specific queries to inform the indicators. In this circumstance SEC summed the number of pool tail outs with embeddedness values of 4 or less and calculates area of spawning gravel in square meters by squaring the (mean) wetted width of the habitat unit immediately downstream of each qualifying pool tail-out. These data were extrapolated by dividing total spawning gravel by total length of habitat survey multiplied by total length of valid IP-km.

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Freshwater Harvest

Target: Spawning Adults

Attribute: Viability (Incidental Mortality)
Current regulations do not allow retention of CCC coho salmon by freshwater recreational anglers; however, adult coho salmon are nonetheless intercepted, retained or incidentally killed by anglers.

Indicator: Freshwater Harvest
During their immigration adult salmonids can be intercepted (caught) by recreational steelhead anglers. For coho salmon in particular, a high level of steelhead angling effort in migration corridors can contribute to the loss of a relatively high percentage of populations if adult returns are low. According to a number of fisheries management and evaluation plans (ODFW 2007a, ODFW 2007b, ODFW 2007c), the post release mortality rate for steelhead caught in freshwater averaged 5 percent (Hooton 1987), but mortality up to 10 percent has been observed.

ODFW (2007c) reported on population viability simulations conducted by Chilcote (2001) who estimated, for 16 different adult populations, that a 10 percent mortality rate substantially increased the extinction risk. The extinction risk increased from 0.08 at 5 percent to 0.21 at 10 percent population mortality.

Recreational steelhead angling was the principle activity considered for this indicator rating because it is the type of fishing most likely to impact adult salmonids.
We measured the impact of freshwater harvest by tallying the number of fishing trips reported in the Steelhead Report Card during each species' adult migration period (Table 2) for the most recent year of record. Ratings were defined *a posteriori* based on the observed distribution of results. Very Good ratings are reserved for those watersheds that are closed to recreational fishing and that have a low likelihood of poaching.

Table 5. Comparison of fishing season with migration periods for salmonids demonstrating potential exposure to freshwater fishing pressure on ESA listed species.

Category	Dates
Steelhead Fishing Season	November 1 to March 31[5]
Coho Salmon Migration Period	November 1 to March 1
Chinook Salmon Migration Period	October 1 to February 1
Steelhead Migration Period	December 1 to May 1

Ratings: Steelhead angling efforts/month during migration
Ideally, the proportion of a population that suffers mortality can be estimated by using an estimate of annual adult abundance to calculate the fraction of the population intercepted (via the steelhead report card data). That fraction could be multiplied by the estimated mortality rate to figure mortality as a proportion of each population. Unfortunately reliable data is unavailable for a robust estimation. Angler effort therefore provides the most objective and available indication of the effects of freshwater harvest on the species.

Methods:
Due to the lack of population-specific catch data, we were unable to determine the percentage of the population intercepted (interception rate) and pursued the use of steelhead angler effort as a surrogate for rating freshwater harvest impact. The only information available for estimating angling effort is the State-wide steelhead report-restoration card (Steelhead Report Card) available through DFG. Though the rate of return is low, recreational steelhead anglers are required to submit their cards with a note on the location, fishing effort, fish kept and released to DFG. Due in part to the uncertainty associated with the reporting, we supplemented our ratings with best professional judgment when site-specific knowledge of angling pressure was available.

Adult Population Density

Target: Spawning Adults

Attribute: Viability, Population Density (Adults)
As described above, key attributes typically represent components of habitat essential to salmonid survival. However, we also had the need to assess the status of populations. We therefore defined one key attribute as Viability. This attribute covers the suite of demographic indicators that define the status of populations and provide an indication of their risk of extinction. We included the viability attribute in this report, as a population metric and, in conjunction with habitat attributes, as a means of validating our conclusions. For example, habitat quality was rated as Good, and fish density or abundance was Poor, it caused us to re-evaluate conclusions and examine assumptions about causative relationships between populations and habitat.

Indicator: Density
Density was used as an indicator for the spawner life-stage because it is one of the principle metrics used to define population viability in the TRT viability report (Spence *et al.*, 2008).

[5] These represent typical start and end dates prescribed by DFG, but specific regulations vary by watershed.

Ratings: Average spawner density per IP-km
The TRT established criteria of one spawning adult per IP-km as a reasonable threshold to indicate a population at high risk of depensation[6]. This was used this as the threshold for Poor condition. The TRT also developed density criteria for population viability. For the smallest of Independent populations (*i.e.*, those with 32 IP km), adult spawning densities should exceed 40 fish per IP km. Densities may decrease to 20 fish per IP km as the size of independent populations approaches ten times the minimum size (*i.e.*, 320 IP km). This formula was applied to Dependent populations and used it as our criteria for a Good rating (Table 6). Fair rating was any density between Poor and Good. A criterion rating for Very Good was not established.

To assess the indicator by watershed, the estimated annual spawning population (N_a) divided by the amount of IP-km available for spawning (N_a/IP-km). N_a was measured as the geometric mean of annual spawner abundance for the most recent three to four generations (Spence *et al.*, 2008). The TRT evaluated current abundance for all independent populations in the ESU and found data availability was insufficient in most cases. We were therefore forced to make reasonable inferences based on what information was available. Data sources we used for this assessment included the NMFS Fisheries Science Center database, NMFS' recovery library, and previous status assessments (Good *et al.*, 2005).

Table 6. Population specific density criteria for spawning adult coho salmon based on TRT density criteria (Spence *et al.* 2008). Displayed for independent populations only

Population	Poor	Fair	Good	Very Good
Cottaneva Creek	≤1	Between	≥41	None
Ten Mile River	≤1	Between	≥35	None
Pudding Creek	≤1	Between	≥40	None
Noyo River	≤1	Between	≥34	None
Caspar Creek	≤1	Between	≥41	None
Big River	≤1	Between	≥29	None
Albion River	≤1	Between	≥38	None
Big Salmon Creek	≤1	Between	≥41	None
Navarro River	≤1	Between	≥28	None
Garcia River	≤1	Between	≥36	None
Gualala River	≤1	Between	≥24	None
Russian River	≤1	Between	≥20	None
Walker Creek	≤1	Between	≥37	None
Lagunitas Creek	≤1	Between	≥37	None
Pine Gulch	≤1	Between	≥41	None
Redwood Creek	≤1	Between	≥42	None
Pescadero Creek	≤1	Between	≥38	None

[6] At very low densities, spawners may find it difficult to find mates, small populations may be unable to saturate predator populations, and group dynamics may be impaired, *etc*. Small populations may experience a reduction in per-capita growth rate with declining abundance, a phenomenon known as depensation (Spence *et al*. 2007).

Gazos Creek	≤1	Between	≥42	None
Waddell Creek	≤1	Between	≥42	None
Scott Creek	≤1	Between	≥41	None
San Vicente Creek	≤1	Between	≥42	None
San Lorenzo River	≤1	Between	≥33	None
Aptos Creek	≤1	Between	≥40	None

LIFE STAGE: Egg

Instantaneous Condition

Target: Eggs

Attribute: Hydrology, Flow continuity
Hydrology as a key attribute concerns all aspects of the hydrologic cycle relevant to the spawning, incubation, rearing and migration of coho salmon.

Indicator: Instantaneous Condition
Instantaneous condition provided an indication of the degree to which short-term artificial streamflow reductions impact the survival to emergence of incubating salmonid embryos embedded in their redds. This condition is often associated with instream diversions (*e.g.*, for frost protection irrigation for vineyards) in the context of the watershed's natural setting.

Ratings: Hydrologic setting to support incubating eggs in the redd
Fisheries biologists from DFG and Regional Water Quality Control Boards were invited to participate in a workshop and a structured decision-making process. The process was used to provide individual opinions regarding flow conditions for summer rearing, instantaneous flow reduction affecting redds, redd scour, smolt outmigration flows and passage flows for adult upstream migration. Workshop participants individually rated hydrologic setting, exposure of flow impairments, and intensity of impacts for each CCC coho salmon population. These data were averaged and to derive a rating for each indicator[7]. Further protocol details are found in Attachment B.

Redd Scour

Target: Eggs

Attribute: Hydrology, Flow intensity
Hydrology as a key attribute concerns all aspects of the hydrologic cycle relevant to the spawning, incubation, rearing and migration of coho salmon.

[7] Subsequent to the development of this indicator, coho salmon fry stranding and mortality resulting from instantaneous flow reductions associated with vineyard frost protection was observed in the Russian River by NMFS biologists and NOAA OLE.

Indicator: Redd Scour
Periodic sorting of gravel substrate in spawning habitats is essential for maintenance of spawning gravel quality. However, excessive scour can be detrimental to redds and subsequent survival to emergence (Yee 1981). Depth of the egg pockets below the surface of the streambed varies with the size of fish and the size of streambed material. Large fish like Chinook salmon may dig as deep as 43cm below the streambed surface, but average pocket depths are in the 20 to 20cm range. We defined the absence of redd scour as the hydrologic and geomorphic conditions that allow eggs to remain safely in their redds throughout the incubation period.

The propensity for salmon redds to scour is a function of substrate size and channel configuration, and hydrology. However, due to limitations on information regarding channel configuration and substrate size, we associated this phenomenon primarily with hydrology. This associated with hydrology allowed us to use the same method as the other flow-related indicators described for Spawning Adults/Hydrology/Passage Flows.

Ratings: Hydrologic and geomorphic setting to support redd stability
Fisheries biologists from DFG, Regional Water Quality Control Boards, and academia were invited participate in a structured decision-making process to provide individual opinions regarding flow conditions for summer rearing, instantaneous flow reduction affecting redds, redd scour, smolt outmigration flows and passage flows for adult upstream migration. Workshop participants individually rated hydrologic setting, degree of exposure to flow impairment, and the intensity of those impacts for each CCC coho salmon population. In the case of redd scour, they were also asked to consider issues such as parent geology of a watershed, degree of channel incision, *etc*. NMFS staff averaged scores to derive a rating for each indicator.

<u>Gravel Quality / Embeddedness</u>
Target: Eggs

Attribute: Sediment, Incubation & Emergence
We defined sediment, relative to its function as a key habitat attribute for the egg life stage, as streambed gravels with particle size distribution of sufficient quality to allow successful spawning and incubation of eggs. These substrates must be located within spawning habitat as defined by the IP model.

Indicator: Gravel Quality Bulk samples and Embeddedness
Gravel quality was defined using two evaluation methods: bulk sampling and embeddedness (Flosi *et al*. 1998). When bulk sampling data is available, we defined the indicator as that portion of the sampled substrate consisting of >0.85mm and/or <6.4mm (NCRWQCB 2006). For Hab-8 data, we define gravel quality as the distribution of embeddedness values.

Rating 1: Percent pool-tailouts sampled with embeddedness values of 1 and 2
We based ratings on frequency distributions because embeddedness scores (1-5) are ordinal numbers; they cannot be averaged and used in the simple rating of Poor = >2, Fair = 1 -2, and Good = <1. Also, embeddedness estimates are visual, involve some subjectivity, and are not as rigorous as bulk gravel samples in describing spawning and incubation habitat conditions (KRIS Gualala 2003). Our confidence in this indicator was therefore limited.

We modeled our rating criteria for embeddedness after the method used in the North Coast Watershed Assessment Program:

Poor = <25% of the scores were 1s and 2s
Fair = 25% - 50% of the scores were 1s and 2s
Good = >50% of the scores were 1s and 2s
Very Good = Not Defined

Methods:
SEC queried regional data sources for bulk sediment core sample (McNeil) surveys as the preferred method for evaluating spawning gravel quality. However, few watersheds had data sufficient for our needs. In such cases, SEC queried Hab-8 data. Specifically, they calculated the percentage of pool tail-outs within all IP km with embeddedness values of 1, 2, 3, 4, or 5 and presented them as frequency distributions at the watershed scale. As with all the data, it was necessary to interpret the representative nature of the datasets to the overall watershed. A bias analysis was used determine our degree of confidence.

As described in Flosi and Reynolds (2004), a score of 1 indicates substrate is less than 25% embedded; this is considered optimal salmonid spawning habitat. A score of 2 indicates 25-50% embedded and moderately impaired. A score of 3 indicates 50-75% embedded and highly impaired, 4 indicates 75-100% embedded and severely impaired, a 5 indicates the substrate is unsuitable for spawning. The embeddedness ratings used by DFG states the best coho salmon spawning substrate is 0-50 percent embedded. Their target value is 50 percent or greater of sampled pool tail-outs are within this range. Streams with less than 50 percent of their length in embeddedness values of 50 percent or less, are considered inadequate for spawning and incubation.

Rating 2: Percent of fines in bulk samples of potential spawning sites
Ratings criteria for bulk sampling data were developed from a variety of sources, including the regional sediment reduction plans by the U.S. EPA (1998, 1999) and the North Coast Regional Water Quality Control Board (2000, 2006) who developed a threshold of 0.85 mm for fine sediment with a target of less than 14 percent. The NMFS (1996) Draft Guidelines for Salmon Conservation also used fines less than 0.85 mm as a reference and recognized less than 12% as Properly Functioning Condition, 12-17% as At Risk and greater than 17% as Not Properly Functioning. EMDS (Reeves *et al*., 2003) rates surface fine sediment. Surface fines less than 11% are fully suitable, 11-15.5% somewhat suitable, 15.5-17% somewhat unsuitable and over 17% fully unsuitable. McMahon (1983) found that egg and fry survival drops sharply when fines make up 15 percent or more of the substrate.

Rating criteria for bulk samples are:

Poor = >17% 0.85mm and or >30% 6.3mm
Fair = 15-17% 0.85
Good = 12-14% 0.85mm and or <30% 6.3mm
Very Good = <12% 0.85

LIFE STAGE: Summer Rearing

Baseflow

Target: Summer Rearing

Attribute: Hydrology
Hydrology as a key attribute concerns all aspects of the hydrologic cycle relevant to the spawning, incubation, rearing and migration of coho salmon. Summer baseflow provides an indication of the degree a watershed currently provides surface flow during summer months within historical rearing areas. Surface baseflows provide rearing space, allow movement between habitats, maintain water quality, and facilitate delivery of food for juvenile salmonids. Inadequate surface flow may be the result of cumulative water diversions and/or the watershed's natural setting.

Indicator: Baseflow

Ratings: Hydrologic setting to support surface flow during summer
Fisheries biologists from DFG, Regional Water Quality Control Boards, and academia participated in a structured decision-making process to provide an opinion regarding flow conditions for summer rearing, instantaneous flow reduction affecting redds, redd scour, smolt outmigration flows and passage flows for adult upstream migration. Workshop participants individually rated hydrologic setting, the degree of exposure to flow impairments, and the intensity of those impacts for each CCC coho salmon population. NMFS staff averaged scores to derive a rating for each indicator. Further details on this protocol are found in Attachment B.

Other Methods:
An alternative method of analysis was also conducted. Using Hab-8 data, SEC estimated the proportion of stream length composed of dry units within all IP-km. This may give a useful indication of baseflow conditions for rearing salmonids. A bias analysis established the degree of confidence in the survey data. For dry units, water year type, date of survey, and amount of rain in spring will be included in the analysis of bias.

We explored more quantitative estimation methods, but did not find them useful due to lack of data. For example, SEC analyzed gage data for July, August, and September over the most recent 10 year period and expressed the estimated degree of impairment as a proportion of the mean annual discharge (MAD). Estimates of MAD in were generated using a hydrologic model. Unfortunately, the limited gage locations and periods of record were not sufficient to describe flow conditions in rearing habitats because gages were often located outside of rearing and diversion areas. This method will be further evaluated using the UC Berkeley Microsoft Data Cube (Discussed in Chapter 6).

Primary Pools

Target: Summer Rearing

Attribute: Pool Habitat
Pools provide hydraulic and other environmental conditions favoring presence of summer rearing juvenile salmonids. During high flow events, pools are usually scoured, leaving a coarse gravel channel armor and depositing material on the riffles. Because of its importance to salmonids, pool habitat attributes were used to classify several indicators: frequency of primary pools; shelter rating; large woody debris frequency; and pool/riffle ratio.

Indicator: Frequency of Primary Pools
Primary pools are large pools formed by mid-channel scour where the scour hole encompasses more than 60% of the wetted channel. The average frequency of pools across all IP-km provides an indication of the amount of pool habitat available. By including only primary pools in the frequency calculations, we provided a conservative indication regarding the availability of pools providing significant rearing habitat.

Juvenile coho salmon prefer well shaded pools at least one meter deep with dense overhead cover; abundant submerged cover composed of undercut banks, logs, roots, and other woody debris. DFG (1998) habitat typing surveys measure maximum pool depth. Greater pool depth provides more cover and rearing space for juvenile coho salmon and other salmonids. Pool depths of three feet are commonly used as a reference for fully functional salmonid habitat (Overton *et al*., 1993; USFS, 1998; Bauer and Ralph, 1999; Brown *et al*., 1994). Maximum pool depth is partially a function of watershed size, but pool depths and volume can be compromised by sediment over-supply related to land management (Knopp 1993).

Ratings: Percent of primary pools by length surveyed across IP-km
Alaska studies showed ranges of 39-67% percent pools by length (Murphy *et al*., 1984). The Washington State Fish and Wildlife Commission (1997) recommended the following pool frequencies by length: "(f)or streams less than 15 meters wide, the percent pools should be greater than 55%, greater than 40% and greater than 30% for streams with gradients less than 2%, 2-5% and more than 5%, respectively." Peterson *et al*. (1992) used 50% pools as a reference for good salmonid habitat and recognized streams with less than 38% pools by length as impaired.

DFG considers a primary pool frequency of less than 40% inadequate for salmonids (NCWAP 2003). Based on this consideration a rating criteria was established which used a 10% bound from the 40% threshold for a Good rating. The resulting criteria are:

Poor = less than 30% primary pools by length
Fair = 30-40%
Good = 40-50%
Very Good = >50%

Methods:
DFG combined measures of pool depth and frequency in their NCWAP reports by reporting the frequency of primary pools stratified by stream order. Primary pools in first and second order streams are defined as two feet deep or more. Primary pools in third and fourth order streams

were defined as three feet deep or more (NCWAP 2003). This convention was used for the pool habitat indicator. This method will be further evaluated using the UC Berkeley Microsoft Data Cube (Discussed in Chapter 6).

The Frequency of Primary Pools indicator required total pool lengths are applied to two feet deep or greater in first and second order streams[8], and three feet deep or greater in third and fourth order streams. However, the reach-summaries provided only the total length of pools in the survey (regardless of depth). Therefore, SEC calculated the percent of pools greater than or equal to three feet and multiplied by the total length of pools. This method provided a best estimate of the frequency of primary pools in most watersheds. For watersheds in which SEC had access to Stream Summary database (Russian River, Salmon Creek, Lagunitas Creek) SEC calculated the amount of primary pool habitat by length. They summed the total length of pools two feet deep or greater in first and second order streams[9], and three feet deep or greater in third and fourth order streams and presented the results as a proportion of the total surveyed stream length within all IP-km.

Habitat typing surveys (DFG 1998) also provide a measure of pool frequency defined as the percentage of stream reaches in pools. Pool frequency by percent length is preferable to pool frequency by occurrence because the latter may give a false impression of health, if there are numerous, shallow, short pools (a common occurrence in aggraded streams). Reeves *et al*. (1993) found that pools diminished in frequency in intensively managed watersheds. Streams in Oregon coastal basins with low timber harvest rates (<25%) had 10-47% more pools per 100 m than did streams in high harvest basins (>25%).

The DFG Watershed Assessment Field Reference (DFG 1999) states good coho streams have more than 50% of their total available fish habitat in adequately deep and complex pools. Knopp (1993) summarized pool frequency in disturbed streams in Northern California, and found and average of 42%.

<u>Summer Water Temperature</u>

Target: Summer Rearing

Attribute: Water Quality, Temperature
There are many aspects of water quality commonly discussed in relation to salmonids, however, we use water quality in this assessment as an attribute to classify three indicators: water temperature, toxicity, and turbidity.

Indicator: Mean Weekly Maximum Temperature (MWMT) and Maximum Weekly Average Temperature (MWAT)
Water temperature is an important indicator of water quality, particularly with respect to juvenile coho salmon, because the species is sensitive to temperature conditions. Juvenile salmonids respond to stream temperatures through physiological and behavioral adjustments

[8] Stream order is a hierarchal measure of stream size. First order streams drain into second order streams, and so on. The presence of higher order streams suggests a larger, more complex watershed.
[9] Stream order is a hierarchal measure of stream size. First order streams drain into second order streams, and so on. The presence of higher order streams suggests a larger, more complex watershed.

that depend on the magnitude and duration of temperature exposure. Acute temperature effects result in death after exposures ranging from minutes to 96 hours. Chronic temperature effects are those associated with exposures ranging from weeks to months. Chronic effects are generally sub-lethal and may include reduced growth, disadvantageous competitive interactions, behavioral changes, and increased susceptibility to disease (Sullivan *et al.* 2000). We used a measure of chronic temperature because it is more typical of the type of stress experienced by summer rearing juveniles in the CCC coho ESU.

Ratings: Proportion of IP-km in each temperature threshold class
Juvenile coho salmon prefer water temperatures of 12° C to 15° C (Brett 1952, Reiser and Bjornn 1979), but not exceeding 22° C to 25° C (Brungs and Jones 1977) for extended time periods. Chronic temperatures, expressed as the maximum weekly average temperature, in excess of 15° C to 18° C are negatively correlated with coho salmon presence (Welsh *et al.* 2001, Hines and Ambrose 2001). Sullivan *et al.* (2000) recommended a chronic temperature threshold of 16.5° C for this species. Water temperatures for good survival and growth of juvenile coho salmon range from 10 to 15° C (Bell 1973, McMahon 1983). Growth slows considerably at 18° C and ceases at 20° C (Stein *et al*. 1972, Bell 1973). The likelihood of juvenile coho salmon occupying habitats with maximum weekly average temperatures exceeding 16.3° C declined significantly (Welsh *et al.* 2001) in the Mattole River watershed in southern Humboldt County, California.

Temperature thresholds for chronic exposure are typically based on the Maximum Weekly Average Temperature (MWAT) metric. Due to some confusion in the literature regarding the appropriate definition and application of MWAT, we used the seven day moving average of the daily maximum (7DMADM or MWMT) indicator, rather than the seven day moving average of daily average (7DMADA or MWAT), because it correlated more closely correlated with observed juvenile distribution. However, where MWMT data was not available, MWAT was used. We established two sets of rating criteria where the calculation of for MWMT was two degrees Celsius higher than the MWAT.

The temperature ratings are:

Poor = <30% of IP km >17° C MWMT
Fair = Does not meet Good or Very Good
Good = 30-60% of IP km < 15° C MWMT
Very Good = > 60% of IP km < 15° C MWMT

Methods:
To assess conditions throughout each watershed, it was necessary to evaluate temperature conditions throughout all potential rearing areas (*i.e*. across all IP-km). We established a method for spatializing site-specific watershed temperature data by plotting these data on a map of the IP network. Each data point was color coded to indicate the temperature threshold the site exceeded (*i.e.,* sites with MWMT >17° C were colored red, *etc*.). For locations with multiple years of data, we averaged the MWMT or MWAT and indicated the number of years of data and standard deviations. The temperatures were extrapolated to IP reaches using our understanding of typical spatial temperature patterns and staff knowledge of specific watershed conditions. Where temperature data was limited or absent, we used best professional judgment and assigned a low confidence rating to the results.

Juvenile Density

Target: Summer Rearing

Attribute: Viability
In the specific context of a key attribute, viability was defined as the suite of demographic indicators defining the population status (which relates directly to their extinction risk). We included viability attributes as population metrics and, in conjunction with habitat attributes, as a means of validating conclusions. For example, if habitat quality rated Poor, and fish density or abundance was also Poor, confidence in our conclusions increased.

Indicator: Density (Juveniles)
Assessing juvenile density provides a relative indication of species presence and carrying capacity. Density estimates that are consistently low within a watershed may suggest that the watershed is not functioning properly. High density estimates suggest a watershed is properly functioning and can be used by fishery managers to prioritize threat abatement efforts.

Ratings: Average juvenile density in watershed
Numerous methods are used to estimate juvenile density. In the CCC ESU, relatively few estimates of juvenile abundance are ongoing although it is likely the most easily quantifiable lifestage. Estimates of juvenile density provide an indication of life-stage-specific status and habitat quality, particularly if streams are adequately seeded (with adequate fish per unit area).

Rating criteria for juvenile density were established on the assumption that approximately 1.0 fish per square meter is a reasonable benchmark for fully occupied, properly functioning habitat. Our ratings are as follows:

Poor = <0.2 fish/meter^2
Fair = 0.2- 0.5 fish/meter^2
Good = 0.5-1.0 fish/meter^2
Very Good = >1.0 fish/meter^2

Methods:
The juvenile density indicator was informed through a review of the professional literature including DFG reports, NMFS technical memorandums, watershed analyses, Section 10 reports, and fisheries management and assessment reports. Co-managers were also interviewed. The information was compiled and synthesized by NMFS biologists (with extensive field experience) who used best professional judgment to rate the density.

Juvenile Spatial Distribution

Target: Summer Rearing

Attribute: Viability, Spatial structure (Juveniles)
In the specific context of a key attribute, we defined viability as the suite of demographic indicators defining population status and relate directly to their extinction risk. We included

viability attributes in this report, both as population metrics and, in conjunction with habitat attributes, as a means of validating conclusions. For example, if habitat quality rated Poor, and fish density or abundance was also Poor, confidence in our conclusions increased.

Indicator: Distribution (Juveniles)
Current distribution of the population that occupies available habitat is one of the four key factors in determining salmonid population persistence (McElhany *et al.* 2000). Species that occupy a larger proportion of their historic range have an increased likelihood of persistence (Fisheries 2007). To evaluate the current distribution we compared the historic range (IP-km) to the percentage of habitat currently occupied by the juvenile life stage in the watershed. The juvenile life stage was used due to the greater availability of these data in the CCC coho salmon ESU (Jong 2006, Spence *et al.* 2005).

Ratings: Current versus historical juvenile distribution across IP-km
We used those indicator ratings developed by William *et al.* (2006) for a similar conservation assessment described in Fisheries (2007).

Poor = < 20% of historic range occupied
Fair = 20 - 34 %
Good = 35 - 50 %
Very Good = > 50%

Methods:
California Department of Fish and Game, and NMFS data sources and various reports were used to evaluate the percentage of historical habitat currently occupied by the species. The summer rearing life stage was used to comparing current distribution to historical conditions. Other life stages such as adult spawning data were considered, but data is lacking across the ESU and could not be used for this comparison.

LIFE STAGE: Winter Rearing

<u>Off channel Habitats</u>

Target: Winter Rearing

Attribute: Floodplain
Velocity refuge is habitat that provides space and cover for juvenile salmonids during high velocity flood flows. These flows may result in premature emigration and subsequent mortality when these habitats are unavailable or limited in quantity. Refuge habitats may include main-channel pools with LWD (or other forms of complexity), or off-channel habitats such as alcoves, backwaters, or floodplains .

Indicator: Complex Habitat/Off Channel

Velocity refuge habitats unavailable during the summer low flow period were evaluated, specifically, off-channel habitats such as alcoves and backwaters. These habitats are geomorphically distinct from main channel habitats and provide increased survival benefits to winter rearing juveniles. Although main-channel pools with LWD or other forms of complexity have value as winter rearing habitat, they are assessed under Summer rearing and Smolt targets and were not included in this analysis.

Ratings: Shelter Ratings
No widely available source of data was available for this indicator, so SEC queried the following habitat units from Hab-8 data: All Backwater Pool types (6.2, 6.3, 6.4), and the Secondary Channel Pool (6.1) habitat type. We defined ratings *a posteriori* based on the frequency of off-channel habitat types across IP-km. However, the reach summary form of the Hab-8 data precluded queries of specific pool types and we were unable to assess off channel habitats using this method. As a means of last resort, we used shelter rating values from the summer habitat typing surveys as a surrogate. In the Russian River, Salmon Creek, and Lagunitas Creek watersheds SEC was able to assess off channel habitats using the Stream Summary database. Total length of all Backwater, Edgewater and Scour Pool habitat units were summed and presented as a proportion of the total surveyed stream length within all IP-km.

While shelter ratings do not measure off channel winter habitat, preliminary data from the Russian River Coho Salmon Captive Broodstock Program indicates a possible positive relationship between increased shelter ratings and improved over winter survival of juvenile coho salmon from their program (Obedzinski, unpublished data).

Stream complexity that creates low velocity areas during high flow events, whether from LWD, off-channel habitats, or wetland areas, is an important component of winter rearing habitat. Bell (2001) documented increased fidelity and survival of winter rearing juvenile coho salmon in alcoves and backwaters in a Northern California stream. Others have documented increased densities of coho salmon in side-channel pools (Bjornn and Reiser 1991). In British Columbia, juveniles preferred stream flows <15 cm/sec (Bustard & Narver 1975). Bisson *et al.* (1988) indicated a preferred velocity of <20 cm/sec, and <30 cm/sec was cited in a third study (Tschaplinski and Hartman 1983).

NCWAP identified a shelter rating value of <80 as being inadequate, and >100 as being good for salmonids. We integrated these values into our ratings for this indicator:

Poor = <50% Connected
Fair = 50-80% Connected
Good = >80% Connected

LIFE STAGE: Smolt

<u>Quality of Estuary</u>

Target: Smolt
Attribute: Estuary
Indicator: Habitat Availability
Ratings: Quality and Extent

See Attachment C for a full description of evaluation methods for estuary habitat.

Passage Flows

Target: Smolt

Attribute: Hydrology
Hydrology impacts all aspects of the hydrologic cycle relevant to salmonid spawning, incubation, rearing and migration. Precipitation in each watershed coalesces to form stream and groundwater networks, which in turn drive run-off patterns. The magnitude, frequency, timing, and duration of surface flows are vital to the completion of the salmon life cycle.

Indicator: Passage Flows
During late March and early April, coho salmon yearlings begin smoltification and migrate downstream to the ocean. Out migration usually peaks in mid-May, if conditions are favorable. Emigration timing is correlated with peak upwelling currents along the coast. Entry into the ocean at this time facilitates growth due improved feeding conditions (ideally) and, therefore, greater marine survival (Holtby *et al*. 1990).

Smolt passage as an indicator of hydrology considers the effect of flow impairments on smolt migration. In addition to considering impairment precluding passage of fishes over critical riffles, this attribute also considers the degree flow impairments reduce pulse-flows that facilitate successful outmigration; including considerations of diversion impacts on the magnitude, duration, and timing of freshets that facilitate efficient transport of fish.

Ratings: Hydrologic setting to facilitate successful smolt outmigration
Fisheries biologists from DFG, Regional Water Quality Control Boards, and academia participated in a workshop to provide individual opinions (through a structured decision making process) regarding flow conditions for summer rearing, instantaneous flow reduction affecting redds, redd scour, smolt outmigration flows and passage flows for adult upstream migration. Workshop participants individually rated the hydrologic setting, the degree of exposure to flow impairments, and the intensity of those impacts for each CCC coho salmon population. Their scores were averaged to derive a rating for each indicator. Further details on this protocol are found in Attachment B.

Methods:
To supplement our ratings with more quantitative date, SEC to estimate the volume of permitted appropriative water rights for the smolt outmigration period and expressed this as a proportion of the Mean Annual Discharge from IP model. As with the other flow analyses, the existing data was insufficient to meet our needs and these data were not used to inform our rankings[10]. This method will be further evaluated using the UC Berkeley Microsoft Data Cube (Discussed in Chapter 6).

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[10] NMFS is currently working with the Berkeley Water Center and Microsoft to attempt to develop more quantitative analysis methods using available gage data.

Diversions

Target: Smolt

Attribute: Passage Downstream, Outmigration
Passage is defined as the absence of physical barriers or diversions that would prevent coho salmon smolts access downstream along the outmigration route to the estuary. The smolt outmigration period for this attribute is defined as the period of March 1 - July 1.

Indicator: Diversions
Diversions are structures or sites having the potential to cause entrainment or impingement of coho salmon smolts. We defined the indicator as the frequency of diversions along the IP-km smolt outmigration route. The diversion structure or sites included in our analysis were defined as unscreened diversions that are located along the stream channel. Those diversions that do not have an actual structure in the stream were not included in our analysis.

Ratings: Frequency of diversions across IP-km
SEC assessed the density of diversions in each watershed across all IP km, regardless if those areas are currently accessible by salmonids. As with the other attributes and indicators, this allowed us to assess conditions throughout all areas of potential importance to recovery, not just within the species' current distribution.

Due to data limitations this rating only looked at the number of diversions and was not able to identify whether existing diversions are fish passage compliant (screened).

Once the results are in, we established rating criteria to define good, fair, poor, based on the observed distributions (*i.e. a posteriori*).

Poor = > 5 Diversions / 10 IP km
Fair = 1.1 – 5 Diversions / 10 IP km
Good = 0.01 – 1 Diversions / 10 IP km
Very Good = 0 Diversions / 10 IP km

Methods:
SEC queried the DFG Passage assessment database 2006 to identify diversions and estimate their frequency. At first, SEC targeted the California State Water Resources Control Board (SWRCB) Division of Water Rights Point of Diversion (POD) database for acquisition. This resource would have likely provided the best information regarding permitted diversion locations. Several attempts were made to acquire the database through SWRCB; the data is currently being served online through the electronic Water Rights Information Management System but cannot be downloaded for geographic analysis that could associate it with appropriate IP-km. Although this database was complete, SEC was unable to determine the volumes associated with each diversion. We therefore decided to base the diversion indicator on the density of diversions regardless of volume. The diversion density was calculated as the number of diversions per 10 km of IP.

LIFE STAGE: Multiple

Shelter Rating

Target: Multiple Life Stages

Attribute: Pool habitat
Pools provide hydraulic and other environmental conditions, such as protection from predators, necessary for coho survival. When considering the longitudinal profile of a stream, pools are the deep-water areas between riffles. Depending on spring flow conditions, coho require pool habitats with adequate complexity and cover for multiple life stages, including rearing and during smolt outmigration to the estuary. Pool shelter rating was used to evaluate the ability of pool habitat to provide adequate cover for coho survival throughout the watershed.

Indicator: Shelter Ratings
Because of its importance to salmonids, we used the pool habitat attribute to classify several indicators: frequency of primary pools, shelter rating, large woody debris frequency, and pool/riffle ratio. Shelter rating is a measure of the amount and diversity of cover elements in pools and is used by DFG in their stream habitat-typing protocol. It is a useful indicator of pool complexity. Shelter/cover elements include undercut bank, small woody debris, large woody debris, root mass, terrestrial vegetation, aquatic vegetation, bubble curtain, boulders, and bedrock ledges (NCWAP 2003).

Ratings: Pool shelter averaged across IP-km
Shelter rating values were generated by multiplying instream shelter complexity values by estimated percent area of pool covered. By assigning an integer value between 0 and 3 to characterize type and diversity of cover elements and multiplying that value by the percent cover. A shelter rating between 0 and 300 is derived, with 300 being equal to 100% cover with maximum diversity. A bias analysis was included for the watershed shelter rating value reflecting the percent of potential IP-km included in the analysis.

NCWAP identified a shelter rating value of <60 as being inadequate, and >80 as good for salmonids. We integrated these values into our ratings for this indicator, so:

Poor = <60
Fair = 60-80
Good = 80-100
Very Good = >100

Methods:
To assess watershed condition for pool shelter, SEC calculated average shelter rating across all IP-km using Hab-8 reach 'sum' data. 'Sum' data is a query of the shelter rating averaged by reach and total watershed coverage. DFG reach 'sum' data and Stream Summary data were calculated using the same methods.

All IP-km in each watershed were assessed for shelter rating. As with the other attributes and indicators, this allowed an assessment of conditions throughout all areas necessary for recovery, not just within the species' current distribution. The assessment included all rearing areas and migration routes.

<u>Floodplain Connectivity</u>

Target: Multiple Life Stages

Attribute: Floodplain, Hydrologic and geomorphic process and function
Floodplains are geomorphic features frequently inundated by flood flows, and often appear as broad flat expanses of land adjacent to channel banks.

Velocity refuge is habitat providing space and cover for juvenile coho during high velocity flood flows. Refuge habitats may include main-channel pools with LWD (or other forms of complexity), or off-channel habitats such as alcoves, backwaters, or floodplains.

Indicator: Floodplain Connectivity
We defined floodplain connectivity by the frequency of floodplain inundation in unconfined reaches. Frequencies approximating those of an unaltered state retain the ability to support the emergent ecological properties associated with floodplain connectivity. Although this definition goes beyond an indication for velocity refuge, we retained the broader concept because it represents important habitat features for the target life-stage.

Ratings: Percent of floodplain connectivity of flood-prone zones within IP-km
Periodic inundation of floodplains by stormflows provides several ecological functions beneficial to coho salmon, including: coarse sediment sorting, fine sediment storage, groundwater recharge, velocity refuge, formation and maintenance of off-channel habitats, and enhanced forage production. Floodplain connectivity is associated with more diverse and productive food webs. Channel incision can result in the reduction or elimination of access for biota to lateral floodplain habitats.

The United States Forest Service (USFS) (2000) Region 5 watershed condition rating system is aimed at maintaining "the long-term integrity of watersheds and aquatic systems on lands the agency manages." Scores were based on professional judgment, but the staff that did the ranking had decades of experience as professional staff biologists and their criteria are similar to regional standards (USFS 1995; Spence *et al.,* 1996).

The USFS considers channel condition to be properly functioning when more than 80 percent of the low gradient response reaches have floodplain connectivity, while 50-80 percent was considered partially functional and less than 50 percent non-functional. Our ratings are as follows:

Poor = <50% connectivity
Fair = 50-80% connectivity
Good = >80% connectivity
Very Good = Not Defined

Methods:
We assessed this indicator by classifying stream channel incision within flood-prone areas. Using the Federal Emergency Management Agency's (FEMA) delineation of Zone A Flood Zone Designation as our definition of flood-prone areas. The DFG Hab8 dataset was filtered using the FEMA Q3 2005 100-year flood data layer to include only Hab8 survey lengths that fall within the 100 year flood zone. The resulting dataset was then queried to determine its entrenchment ratio, dominant bed material, width/depth ratio, sinuosity, and slope as described in the standard Rosgen channel typing manual.

Our threshold for channel incision is adopted from the DFG stream habitat survey protocol . Our use of the term incision is synonymous with the term entrenchment, used with these survey methods. Entrenchment is defined as the ratio between flood-prone width (FPW) and bankfull width (BFW). Flosi and Reynolds (2004) use 1.4 FPW/BFW as their threshold for an entrenched channel. Though this value is probably not universally applicable, we believe it provides an adequate indication of channel incision in the absence of more detailed site-specific information.

<u>Stand Age</u>

Target: Multiple Life Stages

Attribute: Hydrology, Hydrologic maturity
Hydrology as a key attribute concerns all aspects of the hydrologic cycle relevant to the spawning, incubation, rearing and migration of coho salmon. The magnitude, timing, and seasonality of local precipitation and geology largely determine a watershed's discharge patterns. These patterns can be modified by individual and cumulative water use practices in ways that interfere with salmonids' ability to complete their life cycle. Because stream flow thresholds are rarely measured or targeted throughout a watershed (*i.e*., in tributaries), flow requirements for fish are rarely specified. However, since these species evolved under unimpaired flow conditions, it is reasonable to assume that approximating these conditions will likely foster favorable habitats.

Indicator: Stand Age
Beschta *et al.* (1995) stated that "water yield increased following harvest in western Oregon are expected to return to that of a mature forest or late successional forest in approximately 30-40 years". For forest, agricultural, and range land habitat conservation plans (HCPs) Spence *et al.* (1996) recommended minimizing "…the area in hydrologically "immature" condition and deferring further activities until hydrologic recovery has occurred…" These recovery rates were derived for western Oregon forests in regions with very high precipitation, and fast vegetative growth. It is likely that recovery rates might be somewhat slower in drier climates where trees do not grow at the same rate. We considered the upper limit of the range reported by Beschta *et al* (1995) to support hydrologic maturity in coastal California where Very Good was equivalent to an average age of 50+, Good = 40 years, Fair = 30 years and Poor =< 20 years.

Information on estimated average stand age of the various vegetative communities was only available for only the redwood vegetation type in the recovery domain (Table 7). However, this is a dominant vegetative climax community in many of the focus watersheds and did allow classification of stand age in many watersheds in the ESU.

Ratings: Average age of forested areas in watershed
We used CWHR (California Wildlife Habitat Relationships) to predict average stand age. CWHR is an information system and predictive model for terrestrial species in California. The information in CWHR is based on current published and unpublished biological information and professional judgment by recognized experts on California's wildlife.

Table 7. Hr Size Class Criteria (and estimate equivalent age for redwood)

CWHR Code	CWHR Size Classes	DBH	Years
1	Seedling tree	< 1.0″	<5
2	Sapling tree	1.0″ – 5.9″	5-30
3	Pole tree	6.0 – 10.9″	30-60
4	Small tree	11.0″ – 23.9″	60-100
5	Medium/large tree	≥ 24.0″	100-150
6	Multi-layered stand	A distinct layer of size class 5 trees over a distinct layer of size class4 and/or 3 trees, and total tree canopy of the layers > 60% (layers must have > 10.0% canopy cover and distinctive height separation).	150-2,000

We considered the following CWHR categories the functional equivalent of a hydrologically mature forested watershed (Table 8).

Table 8. CWHR size categories as a measure of hydrologic maturity.

Poor	Fair	Good	Very Good
1	3 S-P	3 M-D	4D
2 S-D	4S	4 P-M	5D
	5S	5 P-M	6

Average watershed conditions were assessed for the DFR (Douglas-fir), redwood (RWD), KMC (Klamath Mixed Conifer), and coastal oak woodland forest types as defined by WHR system. Other vegetation types such as annual grasses and chaparral were not included. All analysis of stand age excluded these vegetative communities.

Methods:
Using CWHR information obtained from CDF (now CalFire) (2002), NMFS used GIS to evaluate conditions in all Independent and Dependent watersheds. Vegetation size class data was analyzed over each watershed and compiled to arrive at a summary for each class.

<u>Impervious Surfaces</u>

Target: Multiple Life Stages

Attribute: Hydrology
Hydrology as a key attribute concerns all aspects of the hydrologic cycle relevant to the spawning, incubation, rearing and migration of coho salmon. The magnitude, timing, and seasonality of local precipitation and geology largely determine a watershed's discharge patterns. These patterns however, can be modified by individual and cumulative water use practices in ways that interfere with salmonids' ability to complete their life cycle. Because stream flow is rarely measured throughout a watershed (*i.e.* in tributaries), flow requirements for fish are rarely specified. However, since these species evolved under unimpaired flow conditions, it is reasonable to assume that approximating these conditions will likely foster favorable conditions.

Indicator: Impervious Surfaces
Modifications of the land surface (usually from urbanization) produce changes in both the magnitude and type of runoff processes (Booth 2002). Manifestation of these changes include increased frequency of flooding and peak flow volumes, decreased base flow, increased sediment loadings, changes in stream morphology, increased organic and inorganic loadings, increased stream temperature, and loss of aquatic/riparian habitat (May *et al*, 1996). The magnitude of peak flow and pollution increases with total impervious area (TIA) (*e.g.* rooftops, streets, parking lots, sidewalks, etc.).

Ratings: Percent of impervious surfaces in watershed
Spence *et al*. (1996) recognized that channel damage from urbanization is clearly recognizable when TIA exceeds 10%. Reduced fish abundance, fish habitat quality and macroinvertebrate diversity is observed with TIA levels from 7.01-12% (Klein 1979; Shaver *et al*. 1995). May *et al*. (1996) showed almost a complete simplification of stream channels as TIA approached 30% and measured substantially increased levels of toxic storm water runoff in watersheds with greater than 40% TIA.

The ratings for Impervious Surface of a watershed are:

Poor = >12% of the total watershed
Fair = 7.01-12% of the total watershed
Good = 3.01-7% of the total watershed
Very Good = 0-3% of the total watershed

Methods:
The primary assessment tool used was the National Land Cover Database (Edition 1.0) which was produced by the Multi-Resolution Land Characteristics (MRLC) Consortium. The rating thresholds apply to the TIA across all 23 focus watersheds. Statistics for percent coverage of each land cover type with an associated imperviousness rating were calculated using GIS Thresholds for TIA are based on Booth (2000), May *et al*. (1996) and Spence *et al* (1996):

<u>**Agriculture**</u>

Target: Multiple Life Stages

Attribute: Land Disturbance, Agriculture
We define land disturbance as any upslope perturbation resulting in direct or indirect effects to watershed processes.

Indicator: Agriculture
We define agriculture as the planting, growing, and harvesting of annual and perennial non-timber crops for food, fuel, or fiber.

Ratings: Percent of watershed area used for agricultural activities
Irrigated agriculture and livestock grazing can negatively impact salmonid habitat (Nehlsen *et al*. 1991) due to insufficient riparian buffers, high rates of sedimentation, water diversions, and chemical application and pest control practices (Spence *et al*. 1996). On level ground, agricultural activities near streams are typically assumed to have more negative effects on streams than agriculture further away from streams due to the potential for stream channelization, clearing of riparian vegetation, and increased erosion. However, vineyards are often planted on steep terrain and may contribute to surface erosion regionally.

Specific methods for conserving salmonid habitats on agricultural lands are not well developed but the principles for protecting streams on agricultural lands are similar to those for forest and grazing practices (Spence *et al.* 1997).

We defined ratings *a posteriori* based on the observed distribution of results. The following rating classes were thus formed:

Poor = >30% of watershed area used for agricultural activities
Fair = 10-30% of watershed area used for agricultural activities
Good = 0.1-10% of watershed area used for agricultural activities
Very Good = <0.1% of watershed area used for agricultural activities.

Methods:
Our assessments of agriculture were conducted via GIS interpretation of digital data layers. Our primary method used to measure the extent of agriculture in a watershed was to query data from the California Department of Conservation, Division of Land Resource Protection, Farmland Mapping and Monitoring Program (FMMP). Where these data were not available, we used the USGS National Land Cover Database Zone 06 Land Cover Layer (Edition 1.0). The FMMP data are presented by county, therefore where a watershed extended into more than one county the layers were merged to create a single dataset. The areas represented by farmland polygons for each watershed were calculated in GIS. Total areas of the watersheds were calculated in GIS from watershed boundary polygons, and these areas used to give a percent agriculture by watershed area.

<u>Timber Harvest</u>

Target: Multiple Life Stages

Attribute: Land disturbance, Forestry
We define land disturbance as any upslope perturbation resulting in direct or indirect effects to watershed processes.

Indicator: Timber Harvest
We define the rate of timber harvest as the percent of a watershed exposed to timber harvest within the most recent 10 year period.

Ratings: Average rate of timber harvesting in watershed over last 10 years
Adverse changes to salmonid habitat resulting from timber harvest are well documented in the scientific literature (Burns 1972, Hicks *et al.* 1991, Hall and Lantz 1969, Holtby 1988a, 1988b, Hartman and Scrivener 1990, Chamberlin *et al.* 1991). The cumulative effects of these practices include changes to hydrology (including water temperature, water quality, water balance, soil structure, rates of erosion and sedimentation, channel forms and geomorphic processes (Chamberlin *et al.* 1991) which affect salmonid habitats. These processes operate over varying time scales, ranging from a few hours for coastal streamflow response to decades or centuries for geomorphic channel change and hill-slope evolution (Chamberlin *et al.* 1991).

Reeves *et al.* (1993) found that pools diminished in frequency in intensively managed watersheds. Streams in Oregon coastal basins with low timber harvest rates (<25%) had 10-47% more pools per 100 meters than did streams in high harvest basins. Additionally, Reeves *et al.* correlated reduced salmonid assemblage diversity to rate of timber harvest.

Ligon *et al*. (1999) recommend a harvest limitation of 30-50% of the watershed area harvested per decade as a "red flag" for a higher level of review. Recent work in the Mattole River suggests a harvest threshold of 10-20% (Welsh, Redwood Sciences Laboratory, pers. comm.). Harvest areas of 15 percent of watersheds are considered excessive for some timberlands (Reid 1999). Based on these findings we defined these ratings for rate of timber harvesting per watershed:

Poor = >35% of watershed area harvested in the past 10 years
Fair = 25-35% of watershed area harvested in the past 10 years
Good = 10 to 25% of watershed area harvested in the past 10 years
Very Good = <10% of watershed area harvested in the past 10 years

Methods:
CalFire's timber harvest history information was used for all dependent and independent watersheds. This information was used to determine the aerial extent of timber harvest plans approved by watershed. However, we only included the aerial footprint once in this analysis regardless of the number of times an area was harvested in the 10 year period.

The 25 categories of harvest associated with timber harvest were initially condensed in the following general categories; even aged harvest, uneven aged harvest, conversion, no harvest, and transition. However, due to the relatively short 10 year period it was determined that the only areas excluded from the rate-of-harvest analysis would be those where "no harvest" was included in the timber harvest plan. We acknowledge the different effects of the various silvicultural techniques (*i.e.*, even aged versus uneven aged harvest) but decided to combine all these harvest methods to capture all the potential cumulative effects of timber harvest within a watershed.

<u>Large Woody Debris</u>

Target: Multiple Life Stages

Attribute: Pool Habitat
Pools provide the hydraulic and other environmental conditions that favor the presence of salmonids at multiple life stages. When considering the longitudinal profile of a stream, pools are the deep-water areas between riffles. Riffles in turn, are the topographic high points in the stream bed profile. During high flow events, pools are usually scoured, leaving a coarse gravel channel armor and depositing material on the riffles .

Indicator: Large Woody Debris (LWD)
We defined the LWD indicator as the number of key pieces of large wood per 100m of stream, and we provided separate rating criteria for channels with bankfull width less than 10m and greater than 10m. We define key pieces as a log or rootwad that: (1) are independently stable within the bankfull width and not functionally held by another factor, and (2) can retain other pieces of organic debris (WFPB 1997). Key pieces must also meet the following size criteria: for bankfull channels 10m wide or less, a minimum diameter 0.55m and length 10m, or a volume 2.5m^3 or greater. For channels between 10 and 100m, a minimum diameter of 0.65m and length 19m, or a volume 6m^3 or greater (Schuett-Hames *et al*. 1999). Key pieces in channels with a bankfull width of >30m pieces only qualify if they have a rootwad associated with them (Fox 2007).

Instream large wood has been linked to overall salmonid production in streams with positive correlations between large wood and salmonid abundance, distribution, and survival . Coho salmon appear to have a strong preference for pools created by LWD (Bisson *et al.* 1982) and their populations are typically larger in streams with abundant wood (Naimen and Bilby 1998). Decreases in fish abundance have been documented following wood removal (Lestelle 1978, Bryant 1983, Lestelle and Cederholm 1984, Dolloff 1986, Elliott 1986, Bisson and Sedell 1984, Murphy et al. 1986, Hicks *et al.* 1991) while increases in fish abundance have been found following deliberate additions of LWD (House and Boehnee 1986, Ward and Slaney 1979, Crispin et al. 1993 in Naimen and Bilby 1998, Reeves *et al.* 1993 in Naimen and Bilby 1998, Roni and Quinn 2001).

Ratings 1: Number of LWD key pieces per 100 meters of stream length (Bankfull Width 0-10 meters)

Ratings 2: Number of LWD key pieces per 100 meters of stream length (Bankfull Width 10-100m)

The frequency of key pieces of LWD will influences the development and maintenance of pool habitat for multiple life stages of coho salmon. We defined LWD as the number of pieces (frequency) per stream length (100 meters). We developed rating criteria for based on the observed distribution of key pieces of LWD in unmanaged forests in the Western Washington eco-region developed by Fox (2007) (Table 9). Fox's (2007) recommendations were followed by using the top 75 percentile to represent a Very Good condition for LWD frequency. The California North Coast Regional Water Quality Control Board (NCRWCB) (2006) used similar information in developing indices for LWD associated with freshwater salmonid habitat conditions.

Table 9. Indicator Ratings for Key Pieces of LWD/100 meters based on Fox (2007).

Target	Habitat Attribute	Indicator	Channel Size	Poor	Fair	Good	Very good
Multiple	Pool Habitat	LWD	(0-10m) BFW	<4	4-6	>6-11	>11
Multiple	Pool Habitat	LWD	(>10m-100m) BFW	<1	1-1.3	>1.3-4	>4

Methods:
Assessing watershed condition using these criteria proved problematic due to the absence of adequate LWD surveys in most areas in the CCC ESU. For those watersheds without LWD survey data, SEC queried the % LWD Dominant Pools attribute from Hab-8 data. SEC also queried % Pools with LWD and % Shelter that is LWD from the Hab-8 data, but % LWD Dominant Pools produced discernable breaks in the distribution of observed values that were consistent with expected results. We therefore used that Hab-8 attribute and assumed it provided a functional equivalent to LWD key piece frequency.

The most challenging aspect of the LWD compilation was distilling data recorded in a variety of ways over a span of years into numbers that could be assigned to our rating system. It is possible that some pieces of LWD recorded on some streams would not meet the criteria set for "key pieces" by this analysis. In some cases, the criteria were not included in the stream inventories; in others, size classifications did not correlate well with our divisions (1-2 foot diameter and more than 20 foot long vs. 0.55 m diameter and 10 m long, for example). Output data for this analysis was used to make the final rankings by NMFS.

Reach distances and bankful widths were converted into meters. Sometimes LWD per 100 feet was provided for the habitat elements of riffles, pools, and flat water. In this case, it was necessary to find the percentage of each element given for a particular reach as well as the length for the whole reach and then back calculate the number of LWD in that reach.

<u>Riparian Composition and Structure</u>

Target: Multiple Life Stages

Attribute: Riparian Vegetation, Departure from historical conditions
Riparian vegetation was defined as all vegetation in proximity to perennial and intermittent watercourses that potentially influences salmonid habitat conditions. Riparian vegetation mediates a variety of biotic and abiotic factors (*e.g.* temperature, sedimentation rates, which interact and influence the stream environment.

Indicator: Species Composition
Healthy riparian vegetation can help filter nutrients and pollutants, create a cool microclimate over a stream, provide food for aquatic organisms, maintain bank stability and provide hard points around which pools are scoured (Spence *et al.* 1996). NMFS (1996a) noted that "studies indicate that in Western states, about 80 to 90 percent of the historic riparian habitat has been eliminated." Changes to the historical riparian vegetative community due to introduction of non-native plants or domination of early seral communities can adversely affect salmonid habitat. Plants such as *Arundo donax* can out-compete native plants and form barriers to migration. Early seral species such as alder can suppress long lived conifers and significantly delay future large woody debris recruitment of these conifers. Hardwoods like alder do not form long lived woody debris elements as do conifers such as redwood and Douglas-fir.

Ratings: Current departure of riparian vegetation (within 100 meters of streams across IP-km) from historical conditions
Ecological status is used to relate the degree of similarity between current vegetation and potential vegetation for a site or watershed. It can be measured on the basis of species composition within a particular community type or on the basis of community type composition within a riparian complex. Ratings were derived from Winward (1989) who developed criteria for potential natural communities.

We define species composition as the presence and persistence (composition and structure) of the historical vegetative community within 100 m of a watercourse within all IP-km of a watershed.

Poor = <25% historical riparian vegetation species composition
Fair = 25-50% historical riparian vegetation species composition
Good = >50% historical riparian vegetation species composition
Very Good = Historical riparian species composition

Methods:
Historical vegetation status per watershed was difficult to obtain. We reviewed CalFire's database on major vegetation communities and determined major differences in historical vegetation species composition based on the percent of watershed in urban, agriculture, and herbaceous categories. We acknowledge some inaccuracy likely exists with this approach because some urban areas and agricultural areas may have some riparian areas within the range of historical vegetation species composition. However, based on the widths of the riparian buffers used in this assessment we believe the majority of the areas in these categories do not maintain the historical vegetation patterns.

<u>Riparian Tree Size Classes</u>

Target: Multiple Life Stages

Attribute: Riparian Vegetation, Process and Function
Riparian vegetation was defined as all vegetation in proximity to perennial and intermittent watercourses that potentially influences salmonid habitat conditions. Riparian vegetation mediates a variety of biotic and abiotic factors (*e.g.* temperature, sedimentation rates, which interact and influence the stream environment.

Indicator: Diameter at Breast Height
Intact riparian zones, often characterized by an adequate buffer of mature hardwood and/or coniferous forests, are an important component of a properly functioning habitat conditions for coho salmon. Buffers mediate upslope processes.

Spence *et al*. (1996) recognized the distance equal to the potential height of riparian trees (one site potential tree height) as a minimum buffer to allow for recruitment of large wood to Pacific salmon streams. FEMAT (1993) extended that zone of influence to two site potential tree heights or to the top of any inner gorge areas. The 100 meter buffer is approximately equivalent to two site potential tree heights in old growth Douglas-fir or forests or 1½ site potential tree heights in mature redwoods. Spence *et al.* (1996) suggested 200-240 feet as an appropriate site potential tree height for redwoods. Beardsley *et al*. (1996) used a diameter of 40" as indicative of old growth forests in the Sierra Nevada. The diameter of coastal riparian redwoods before disturbance may often have been several feet in diameter (Noss *et al.* 2003).

Rating 1: Tree Size (North of SF Bay), Percent of riparian zones (100 meters from centerline of the active channel) in WHR class 5 and 6
Tree diameter was used as an indicator of riparian function based on the average diameter at breast height (DBH) of a stand of trees within a buffer that extends100 meters back from the edge of the active channel.

CWHR was used to determine predominant vegetation patterns and corresponding size class categories to estimate average tree size diameters within 100 meters of all IP km. CWHR is an information system and predictive model for terrestrial species in California. The information in CWHR is based on current published and unpublished biological information and professional judgment by recognized experts on California's wildlife. Using CWHR information obtained from CalFire (2002), NMFS used GIS to evaluate riparian conditions across all IP-km in independent watersheds and all anadromous blue-line streams in dependent watersheds.

-Lost Coast, Navarro – Gualala, Russian R. Diversity Strata
Poor = ≤ 39% CWHR size class 5 and 6 across IP-km
Fair = 40 -54% CHWR size class 5 and 6 across IP-km
Good = 55 – 69% CWHR size class 5 and 6 across IP-km
Very Good = ≥ 70% CWHR size class 5 and 6 across IP-km

Rating 2: Tree Size (South of SF Bay), WHR density classes across blueline streams in watershed
For the Santa Cruz diversity stratum, no comprehensive CWHR classification of the various size classes is currently available. Rather, the data is simply compiled into CWHR density classes of conifer, conifer-hardwood, and hardwood woodland categories. As these data lack a structural element we were forced to use the density criteria as a proxy of riparian structure while acknowledging the data is not as robust as for watersheds north of San Francisco Bay[11]. We compared the high density categories (conifer, conifer-hardwood, hardwood woodland) of the

[11] Recovery staff are familiar with riparian stand conditions in the Santa Cruz diversity strata and those north of San Francisco Bay and their overall tree species structure and composition. Staff determined Santa Cruz structure and composition generally comports to that in the northern diversity strata and was not comprised of inordinate proportions of dense stands of CWHR size class 1-3 trees.

Santa Cruz diversity strata to the equivalent high density categories from the Lost Coast, Navarro-Gualala, and Russian River diversity strata and determined conditions were Good if ≥80% of the watershed had high density categories of conifer, conifer-hardwood, and/or hardwood woodland, on average in the riparian buffer across the watershed. Conditions were determined to be Fair at 70-79%, and Poor at ≤69%.

-Santa Cruz Diversity Stratum-
Poor = ≤ 69% CWHR density rating "D" across IP-km
Fair = 70 -79% CHWR density rating "D" across IP-km
Good = > 80% CWHR density rating "D" across IP-km
Very Good = no rating

Methods:
CWHR characterization exists for three of the four CCC coho salmon recovery domains targeted for recovery actions. Compilation of the Lost Coast, Navarro-Gualala, and Russian River diversity strata was conducted by and as of March 2008, no similar wide scale CWHR categorization data was available for the Santa Cruz diversity stratum. Typically the most current and detailed data were collected for various regions of the state or for unique mapping efforts (farmland, wetlands, riparian vegetation). Cross-walks were used to compile the various sources into the CWHR system classification. The dates for the source data vary from 1970's (urban areas) to 2000. The bulk of the forest and rangeland data was collected by CDF/USFS 1994-1997.

We initially considered the SONCC recovery team's tree size criteria when evaluating riparian condition which stated 100 meter wide riparian stands, where more than 80% of the stand was comprised of trees with average DBH of 20-inches or greater, indicated Very Good conditions. However, we were unable to use the 20-inch DBH criteria because the corresponding CWHR size class (size class 4), encompasses a wide range of tree diameters (11-23.9 QMD (quadratic mean diameter)) (Table 10). This large range rendered size class 4 an unsuitable proxy for SONCC's 20-inch indicator. The difference in size and ecological function in a tree with an 11 inch DBH versus a 24-inch DBH is substantial, where an 11-inch tree (depending on site conditions) is almost always younger (unless it is suppressed and/or located on poor soil types) and smaller (in height as well as diameter than a 24-inch tree). Therefore, we applied size class 5 and 6 when evaluating riparian condition. Overall, we believe CWHR is the best available GIS tool to characterize riparian condition across large landscapes due to it wide-spread application, ease of use via GIS, and its standardization as an assessment tool.

Table 10. WHR Size Class Criteria

CWHR Code	CWHR Size Classes	DBH
1	Seedling tree	< 1.0"
2	Sapling tree	1.0" – 5.9"
3	Pole tree	6.0 – 10.9"
4	Small tree	11.0" – 23.9"
5	Medium/large tree	≥ 24.0"
6	Multi-layered stand	A distinct layer of size class 5 trees over a distinct layer of size class4 and/or 3 trees, and total tree canopy of the layers > 60% (layers must have > 10.0% canopy cover and distinctive height separation).

We reviewed the CWHR size classes in watersheds considered to maintain properly functioning riparian condition in four locations – Smith River at Jedidiah Smith State Park, Redwood Creek in Redwood National Park, Prairie Creek, and the South Fork Eel at Humboldt Redwoods State Park. In total, we reviewed CWHR size classes in the riparian zones of 95 miles of "blue line" streams and used this information to establish criteria for reference conditions. These data indicated at least 70% of the 100 meter wide riparian zones were comprised on CWHR size class 5 and 6 forest. From these results we determined a 100 meter wide riparian buffer consisting, on average, of ≥70% CWHR size class 5 and 6 tree represented Very Good conditions.

<u>Riparian Stream Shading</u>

Target: Multiple Life Stages

Attribute: Riparian Vegetation, Stream Shading
We define riparian vegetation as all vegetation in proximity to perennial and intermittent watercourses that potentially influences salmonid habitat conditions. Riparian vegetation mediates a variety of biotic and abiotic factors (*e.g.* temperature, sedimentation rates, which interact and influence the stream environment.

Indicator: Canopy Cover
Canopy cover was defined as the percentage of stream area shaded by overhead foliage. Riparian vegetation has many influences on the stream ecosystem. Riparian vegetation forms a protective canopy, particularly over small streams that help; (1) maintain cool stream temperature in summer and insulates the stream from heat loss in the winter, (2) contributes leaf detritus, and (3) facilitates insects that fall into the stream and supplement the salmonid diet (Murphy and Meehan 1991). Reduction in canopy cover can result in changes to the stream environment that adversely affect salmonids including; (1) temperature elevation beyond the range preferred for rearing, (2) inhibition of upstream migration of adults, (3) increased susceptibility to disease, (4) reduced metabolic efficiency with which salmonids convert food intake to growth, and (5) shifts of the competitive advantage of salmonid over non salmonid species (Hicks *et al*. 1991).

Ratings: Average canopy closure over the stream across IP-km
DFG (2004) recognized 80% canopy as optimal for salmonid streams. We concluded average canopy closure of 80% across IP-km rated Very Good and average canopy closure below 80% were rated progressively lower.

Poor < 75over IP-km
Fair = 75-85%
Good = 85-95%
Very Good > 95%

Methods:
DFG (2004) habitat typing survey measurements are taken from the middle of the stream, which provides an index of stream shading. This habitat typing data (Hab-8) was summarized for each watershed. A spherical densitometer is used to estimate relative vegetative canopy closure or canopy density caused by vegetation. Four measurements are taken in the four quadrants while

standing on the same point (facing downstream, right bank, upstream, left bank). Typically, canopy is measured from the end of approximately every third habitat unit in addition to every fully-described unit which provides an approximate 30% sub-sample. SEC queried Stream Summary database for mean % canopy cover and averaged over total survey length for Russian River, Salmon Creek and Lagunitas Creek.

Road Density

Target: Multiple Life Stages

Attribute: Sediment Transport, Roads
We define sediment transport as the rate, timing, and quantity of sediment delivered to a watercourse.

Indicator: Road Density
We define road density as the number of miles of roads per square mile of watershed. A series of data layers were used to calculate the road density within each dependent and independent watershed.

Construction of a road network can lead to greatly accelerated erosion rates in a watershed (Haupt 1959; Swanson and Dyrness 1975; Swanston and Swanson 1976; Beschta 1978; Gardner 1979; Reid and Dunne 1984). Increased sedimentation in streams following road construction can be dramatic and long lasting. The sediment contribution per unit area from roads is often much greater than that from all other land management activities combined, including log skidding and yarding (Gibbon and Salo 1973). Sediment entering streams is delivered chiefly by mass soil movements and surface erosion processes (Swanston 1991). Failure of stream crossings, diversions of streams by roads, washout of road fills, and accelerated scour at culvert outlets are also important sources of sedimentation in streams within roaded watersheds (Furniss *et al*. 1991). Sharma and Hilborn (2001) found lower road densities (as well as valley slopes and stream gradients) were correlated with higher (coho) smolt density.

According to Furniss *et al*. (1991) "roads modify natural drainage networks and accelerate erosion processes. These changes can alter physical processes in streams, leading to changes in streamflow regimes, sediment transport and storage, channel bank and bed configuration, substrate composition, and stability of slopes adjacent to streams. These changes can have important biological consequences, and they can affect all stream ecosystem components. Salmonids require stream habitats for food, shelter, spawning substrate, suitable water quality, and access for migration upstream and downstream during their life cycles. Roads can cause direct and indirect changes to streams that affect each of these components."

Ratings: Number of road miles per square mile in watershed
Cederholm *et al.* (1980) found that fine sediment in salmon spawning gravels increased by 2.6 - 4.3 times in watersheds with more than 4.1 miles of roads per square mile of land area. Matthews (1999) linked increased road densities to increased sediment yield in the Noyo River. King and Tennyson (1984) found the hydrologic behaviors of small forested watersheds were altered when as little as 3.9% of the watershed was occupied by roads. NMFS (1996) guidelines for salmon habitat characterize watersheds with road densities greater than three miles of road per square

mile of watershed area (mi/sq mi) as "not properly functioning" while "properly functioning condition" was defined as less than or equal to two miles per square mile, with few or no streamside roads.

Armentrout et al. (1999) used a reference of 2.5 mi/sq. mi. of roads as a watershed management objective to maintain hydrologic integrity in Lassen National Forest watersheds harboring anadromous fish. Regional studies from the interior Columbia River basin (USFS 1996) show that bull trout do not occur in watersheds with more than
1.7 miles of road per square mile. The road density ranking system shown in Figure 2 was developed based on the Columbia basin findings.

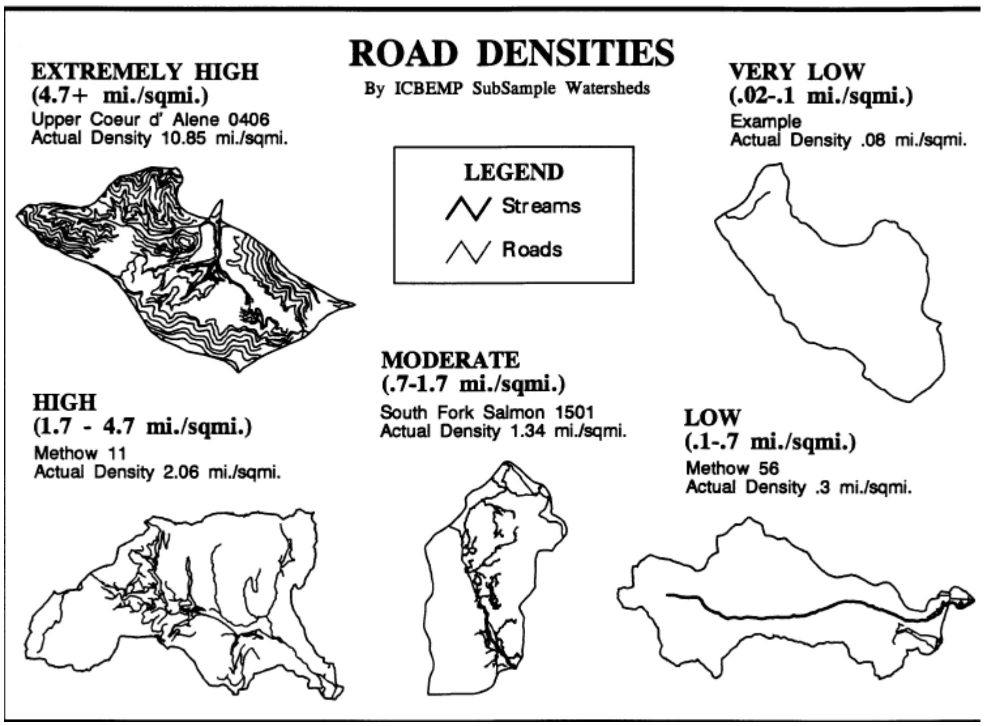

Figure 2. Graphic from Interior Columbia Basin Management Plan (USFS, 1996).

We used the most inclusive datasets available for each watershed (see below). The goal is be as precise as possible for each watershed while acknowledging some inconsistency (due to the use of four datasets) may result from this approach.

Poor = >3 miles/square mile of watershed
Fair = 2.5 – 3 miles/square mile of watershed
Good = 1.6 – 2.5 miles/square mile of watershed
Very Good = <1.6 miles/square mile of watershed

Methods:
GIS analysis of the miles of road networks within a watershed made use of several data sources:

1. CalFire Timber Harvesting History. GIS vector dataset, 1:24,000. 2007. Watersheds between Cottoneva (inclusive) and the Russian River (inclusive).
2. CalTrans, Tana_rds_d04. GIS vector dataset, 1:24,000. 2007. Marin County watersheds.
3. U.S. Census Bureau, Roads. GIS vector dataset., 1:24,000. 2000. San Mateo County watersheds.
4. County of Santa Cruz – Roads; Streets. GIS vector dataset, 1:24,000. 1999. Santa Cruz County watersheds.

The resulting linear measurement (in miles) was compared against the total watershed area in square miles. The product was the road density.

<u>Road Density 100</u>

Target: Multiple Life Stages

Attribute: Sediment Transport, Riparian Roads
We define sediment transport as the rate, timing, and quantity of sediment delivered to a watercourse.

Indicator: Road Density
We define road density 100 as the density of roads, per square mile of a 200 meter riparian corridor (100 meters on either side of the stream centerline) within the watershed.

Roads frequently constitute the dominant source of sediments delivered to watercourses (see *Relevance to target* discussion in *Road density* indicator). Roads constructed within the riparian buffer zone pose many risks to coho salmon habitat including the loss of shade, decreased large wood recruitment, and delivery of fine sediment and initiation of mass wasting (Spence *et al*. 1996). Rock revetments are often used to prevent streams from eroding road beds, resulting in channel confinement that can lead to incision of the stream bed. Roads in close proximity to watercourses may have a greater number of crossings which may act as: (1) impediments to migration, (2) flow restrictions which artificially change channel geometry, (3) sources of substantial sediment input due to crossing failure.

Ratings: Number of road miles per square mile within 100 meters of the watercourse (centerline)
The USFS (2000) provides data for near stream roads in road miles per square mile and a frequency distribution was used to derive values showing very low relative risk as Very Good (<0.1 mi/sq mi) and the opposite end of the frequency spectrum as posing high relative risk to adjacent coho habitat as Poor (>1 mi/sq mi).

Poor = >1 mile/square mile of riparian corridor
Fair = 0.5 – 1 mile/square mile of riparian corridor
Good = 0.1 - 0.5 mile/square mile of riparian corridor
Very Good = <0.1 mile/square mile of riparian corridor

Methods:
We used the most inclusive datasets available for each watershed. The goal is be as precise as possible for each watershed while acknowledging some inconsistency (due to the use of four datasets) may result from this approach.

A series of GIS data layers were used to calculate the riparian buffer and road density within each dependent and independent watershed:

To create the riparian buffer these stream files were used:

1. Streams - CalFire, Hydrograph watershed Assessment; Wahydro. GIS vector dataset, 1:24,000. 1998. Watersheds from Cottoneva Creek (inclusive) to the Russian River (inclusive).
2. Streams - USGS National Hydrography Dataset; Flowline (1801, 1805), vector digital dataset, 1:24,000. 2004. Watersheds in Marin, San Mateo, and Santa Cruz Counties.

To create the road layer these stream files were used:

1. CalFire Timber Harvesting History. GIS vector dataset, 1:24,000. 2007. Watersheds between Cottoneva (inclusive) and the Russian River (inclusive).
2. CalTrans, Tana_rds_d)4. GIS vector dataset, 1:24,000. 2007. Marin County watersheds.
3. U.S. Census Bureau, Roads. GIS vector dataset., 1:24,000. 2000. San Mateo County watersheds.
4. County of Santa Cruz – Roads; Streets. GIS vector dataset, 1:24,000. 1999. Santa Cruz County watersheds.

<u>Toxicity</u>

Target: Multiple Life Stages

Attribute: Water Quality, Toxins
Water Quality is defined as conditions optimal for supporting native aquatic and riparian life. Optimal conditions for salmonids, their habitat and prey, include clean water free of toxins, contaminants, excessive suspended sediments, or deleterious temperatures.

Indicator: Toxicity
We define toxins as substances (typically anthropogenic in origin) which may cause acute, sub-lethal, or chronic effects to salmonids or their habitat. These include (but are not limited to) toxins known to impair watersheds, such as copper, diazinon, nutrients, mercury, polyaromatic hydrocarbons (PAHs), pathogens, pesticides, and polychlorinated biphenyls (PCBs).

All target life stages of coho salmon depend on good water quality, and the water quality attribute is impaired when toxins or other contaminants are present at levels which adversely affect one or more salmonid life stages, their habitat or prey. Coho salmon are sensitive to toxic impairments, even at very low levels (Baldwin and Scholz 2005, Sandahl *et al*. 2004). For example, adult salmonids use olfactory cues to return to their natal streams to spawn, and low levels of copper has been show to impair this ability (Baldwin and Scholz 2005).

Adult salmon typically begin the freshwater migration from the ocean to their natal streams after heavy late-fall or winter rains breach the sand bars at the mouths of coastal streams (Sandercock 1991). These same flows may carry toxins from a variety of point and non-point sources to the stream. The exposure of returning adults to toxins in portions of their IP-km can reduce the viability of the population by impairing migratory cues, or reducing the amount of available spawning and rearing habitat and thereby lowering the carrying capacity of the watershed.

Ratings: Risk of adverse affects to coho salmon due to toxins in watershed
For this analysis, we excluded some constituents from consideration that were assessed by other indicators (*i.e.* Water Quality/Temperature). Since the target is the multiple life stage, we conducted the analysis across all IP km.

We reviewed a variety of materials to derive appropriate ratings, including data from the California Regional Water Quality Control Boards, the U.S. Environmental Protection Agency, and other local and regional sources to inform our ratings of water quality limited segments for any toxins known or suspected of causing impairment to fish.
We also reviewed scientific literature, and available watershed specific water quality reports. Working with SEC and a NMFS staff water quality specialist, we developed the structured decision matrix (see below) to rate each watershed where more specific data were lacking. We also correlated watersheds lacking data with nearby watersheds where similar land use patterns suggested similar pollutants might be present.

Decision Matrix for Multiple Life Stages/Water Quality/Toxicity for Key Independent/Dependent Populations

1. Are toxins/chemicals present in the watershed which could potentially (through direct discharge, incidental spills, chronic input, etc.) enter the water column?

   a. Yes: > 2
   b. No: Toxicity not a threat (assumed to be Good)

2. Is the chemical/substance a known toxin to salmonids?

   a. Yes: >3
   b. No: Toxicity not a threat (assumed to be Good)

3. Are salmonids spatially/temporally exposed to the toxin during any lifestage or is the toxin present in a key subwatershed (where salmonids no longer occur) important for species viability.

   a. Yes: > 4
   b. No: Toxicity not a threat (assumed to be Good/Fair)

4. Potential salmonid presence to toxin established. Use best professional judgment to assign Fair/Poor rating. Consider toxicity of chemical compound, persistence of the compound, spatial extent/temporal exposure, future reintroduction efforts, and potential overlap of land use activities (e.g., pesticide/herbicide intensive farming practices) to species viability/presence when assigning rating.

Figure 3. Decision matrix used to determine the likelihood of toxins being present in a given watershed which could adversely affect coho salmon during any freshwater life history stage.

Poor - Acute effects to fish and their habitat (e.g. mortality, injury, exclusion, mortality of prey items)

Fair – Sublethal or chronic effects to fish and their habitat (e.g. limited growth, periodic exclusion, contaminants elevated to levels where they may have chronic effects). Chronic effects could included suppression of olfactory abilities (affecting predator avoidance, homing, synchronization of mating sues, etc.), tumor development (e.g. PAHs). This could include watersheds without data but where land use is known to contribute pollutants (e.g. significantly urbanized, or supporting intensive agriculture particularly row crops, orchards, or confined animal production facilities).

Good – No acute or chronic effects from toxins are noted and/or watershed has little suspect land uses, and insufficient monitoring data are available to make a clear determination. Many Northern California watersheds (particularly those held in private timber lands) are likely to meet these criteria.

Very Good – No evidence of toxins or contaminants. Sufficient monitoring conducted to make this determination, or areas without contributing suspect land uses (e.g. wild and scenic rivers, wilderness areas, etc.). Available data should support Very Good ratings, and they are likely to be few.

LITERATURE CITED

Not compiled at issuance of this draft

ATTACHMENTS

Attachment A: Master List of Attributes and Indicators
Attachment B: Instream Flow Assessment Briefing Material
Attachment C: Estuaries

Attachment A: Master List of Key Habitat Attributes and Indicators for the CCC Coho Salmon Draft Recovery Plan, September, 2008

CCC Coho Salmon
CAP Viability Table Master Indicator List

Analyst	Source	Result	Rating	Target	Habitat Attribute	Indicator	Poor	Fair	Good	Very Good
Flow Panel	Decision Matrix			Spawning Adults	Hydrology	Passage Flows	>75 (score)	51-75	35-50	<35
SEC	PSMFC Database			Spawning Adults	Passage	Physical Barriers	<50% of IP-km	50-70% of IP-km	70-90% of IP-km	>90% of IP-km
NCWAP	Decision Matrix			Spawning Adults	Passage	Passage at Mouth	<30 days	30-60 days	60-90 days	>90 days
SEC	CDFG HAB 8			Spawning Adults	Sediment	Amount of Gravel*	<High Risk	High Risk to ½ of Low Risk	½ of Low Risk to Low Risk	>Low Risk
NMFS	Best Prof. judgment			Spawning Adults	Viability	Freshwater Harvest	>10% of pop.	5-10%	<5%	
Flow Panel	Decision Matrix			Eggs	Hydrology	Instantaneous Condition	>75 (score)	51-75	35-50	<35
Flow Panel	Decision Matrix			Eggs	Hydrology	Redd Scour	>75 (score)	51-75	35-50	<35
SEC	Many Sources			Eggs	Sediment	Gravel Quality	>17% 0.85mm and or >30% 6.3mm	15-17% 0.85	12-14% 0.85mm and or <30% 6.3mm	<12% 0.85
SEC	CDFG HAB 8			Eggs	Sediment	Gravel Quality (Embeddedness)	<25% of scores 1s&2s	25-50% of scores 1s&2s	>50% of scores 1s&2s	
Flow Panel	Decision Matrix			Summer Rearing	Hydrology	Baseflow	>75 (score)	51-75	35-50	<35
SEC	CDFG HAB 8			Summer Rearing	Pool Habitat	Shelter Rating	<60 avg. rating	60-80	80-100	>100
SEC	CDFG HAB 8			Summer Rearing	Pool Habitat	Primary Pools	<30% pools by length	30-40%	40-50%	>50%
SEC/NMFS	Many Sources			Summer Rearing	Water Quality	Temperature	>30% of IP > 17 C MWMT	Does not meet Good or Very Good	30-60% of IP < 15C MWMT	>60% of IP < 15C MWMT
SEC	CDFG HAB 8			Winter Rearing	Floodplain	Complex Habitat**	<50% Connected	50-80% connected	>80% connected	
NMFS	NCWAP			Smolts	Estuary	Estuary				
Flow Panel	Decision Matrix			Smolts	Hydrology	Passage Flows	>75 (score)	51-75	35-50	<35
SEC	SWRCB			Smolts	Passage	# of Diversions**	>5 / 10 IP km	1.1-5	0.01-1	0
SEC	CDFG HAB 8			Multiple Life Stages	Pool Habitat	Shelter Rating	<60 avg. rating	60-80	80-100	>100
NMFS	Best Prof. judgment			Multiple Life Stages	Floodplain	Floodplain Connectivity	<50%	50-80%	>80%	not defined
NMFS	CDF CWHR			Multiple Life Stages	Hydrology	Stand Age			>40 years old	
SEC	NLCDB			Multiple Life Stages	Hydrology	Impervious Surfaces	>12.01% of WS by area	7.01-12%	3.01-7%	0-3%
SEC	FMMP			Multiple Life Stages	Land disturbance	Agriculture	>30% of WS by area	10-30%	0.1-10%	<0.1%
NMFS	CDF THP Dataset			Multiple Life Stages	Land disturbance	Timber Harvest	>35% of WS by area	25 - 35%	10 - 25%	<10%
SEC	Many Sources			Multiple Life Stages	Pool Habitat	LWD Freq. (BFW 0-10)	<4key pcs/100m	4-6/100m	6-11/100m	>11/100m
SEC	Best Prof. judgment			Multiple Life Stages	Pool Habitat	LWD Freq. (BFW 10-100)	<1/100m	1-1.3/100m	1.3-4/100m	>4/100m
NMFS	CDF CWHR			Multiple Life Stages	Riparian Veg.	Species Composition	<25%	25-50%	>50%	Historical Conditions
NMFS	CDF CWHR			Multiple Life Stages	Riparian Veg.	DBH	<39% Class 5 and 6	40-54%	55-69%	>69%
SEC	CDFG HAB 8			Multiple Life Stages	Riparian Veg.	Canopy Cover	<45 % avg. over IP-km	75-85%	85-95%	>95%
NMFS	CDF THP Dataset			Multiple Life Stages	Sediment Transport	Road Density	>3 miles/sq. mile	3 to 2.5	2.5 to 1.6	<1.6
NMFS	CDF THP Dataset			Multiple Life Stages	Sediment Transport	Road density 100	>1 miles/sq. mile	1-0.5	0.5-0.1	<0.1
NMFS	Many Sources			Multiple Life Stages	Water Quality	Toxicity	Acute	Sublethal or Chronic	No Acute or Chronic	No evidence of toxins or Contaminants
NMFS	Best Prof. judgment			Spawning Adults	Viability	Adult Density	<1 per IP-km	1-20 per IP-km	20-40 per IP-km	>40 per IP-km
NMFS	Best Prof. judgment			Summer Rearing	Viability	Juvenile Density	< 0.2 fish/m^2	0.2-0.5 fish/m^2	0.5-1.0 fish/m^2	>1.0 fish/m^2
NMFS	Best Prof. judgment			Summer Rearing	Viability	Juvenile Distribution	<20% IP-km occupied	20-34%	35-50%	>50%

* = watershed specific numbers (see appendix C)
** = Ratings defined by the distribution of results

Attachment B: Instream Flow Protocol for the CCC Coho Salmon Draft Recovery Plan

Introduction

We employed a structured decision model informed by expert opinion to rate five of the CAP workbook indicators related to instream flows. To implement this system, we invited 16 professionals with local expertise related to salmonid ecology and their instream flow requirements (Table 1). The group met on November 9, 2007 with the goal of providing information and individual opinions to the North Central California Coast (NCCC) Recovery Domain team (in a worksheet format) on flow conditions for Central California Coast (CCC) coho salmon.

Table 1. Participants in the NMFS RT (Recovery Team) flow assessment workshop. Agencies represented include: California Department of Fish and Game (CDFG); the North Coast Regional Water Quality Control Board (NCRWCCB); and NMFS Protected Resources Division (PRD) as well as their Southwest Region Fisheries Science Center (SWRFSC).

Participant	Affiliation
Ambrose, Charlotte	NMFS, RT
Ambrose, Jon	NMFS, RT
Cox, Bill	CDFG
Daugherty, Tom	NMFS, RT
Hanson, Linda	CDFG
Harris, Scott	CDFG
Hayes, Sean	NMFS, SWRFSC
Hearn, Bill	NMFS, PRD
Hines, David	NMFS, RT
Hope, Dave	NCRWCCB
Jones, Weldon	CDFG-Retired
Kittel, Manfred	CDFG
Neillands, George	CDFG
Smith, Jerry	San Jose State University
Snyder, Bob	CDFG-Retired
Young, Alex	Sonoma Ecology Center

This workshop supports NMFS' recovery plan for the CCC coho salmon ESU. The CCC coho salmon ESU watersheds to be considered include all independent populations identified by the NCCC Recovery Domain Technical Recovery Team (TRT) and key dependent populations that meet TRT criteria for connectivity between, and re-colonization of, independent populations.

The planning process involves assessment of current conditions of watersheds within the CCC coho salmon ESU relative to the 32 habitat attributes identified as having the potential to limit production of the species. Of the 32 habitat attributes, 5 relate to instream flows: 1) summer rearing baseflows; 2) instantaneous flow reductions affecting redds; 3) smolt outmigration flows; 4) passage flows for adult upstream migration, and; 5) redd scour. The meeting provided a forum for discussion and exchange of information relevant to the impairment of natural stream flows in terms of these five flow-related attributes.

Attachment B: Instream Flow Protocol for the CCC Coho Salmon Draft Recovery Plan

Flow Attribute Definitions

Summer Rearing Baseflows: This attribute is an indication of the degree to which a watershed currently supports surface flows within historical rearing areas. Surface flows provide rearing space, allow for movement between habitats, maintain water quality, and facilitate delivery of food for juvenile coho salmon. Inadequate surface flow may be the result of cumulative water diversions and/or the watershed's natural setting. We define water diversions as withdrawals from stream surface waters and/or from subterranean stream flows that are likely hydrologically connected to the stream (e.g., pumping from wells in alluvial aquifers that are in close proximity to the stream).

Instantaneous Flow Reductions on salmonid redds: This attribute provides an indication of the degree to which short-term artificial streamflow reductions impact the survival to emergence of incubating coho salmon embryos embedded in their redds. This condition is often associated with instream diversions (e.g., frost protection irrigation) and can be exacerbated in more arid conditions.

Smolt Outmigration Flows: This attribute considers the effect of flow impairments on smolt migration. In addition to considering impairment that precludes passage of fishes over critical riffles, this attribute must also indicate the degree to which flow impairments reduce pulse-flows that facilitate successful outmigration of smolts; including considerations of diversion impacts on the magnitude, duration, and timing of freshets that facilitate efficient transport of fish.

Adult Passage Flows: This attribute is defined as flows sufficient to provide minimum depth, sufficient duration, appropriate timing, and location to facilitate the upstream migration of the annual population of adults.

Redd Scour: Redd scour refers to the mobilization of streambed gravels at spawning sites that result in the dislodging of entombed salmon embryos and subsequent mortality. While this process is not strictly a function of stream flows, stormflow events combined with channel configuration, sediment dynamics, and channel roughness and stability largely control the stability of spawning substrates.

Spatial and Temporal Definitions

Four life stages associated with the above attributes were considered: spawning/incubation, juvenile rearing, smolt outmigration, and adult migration. The distribution and differences in seasonality of these life stages were also considered so as to better assess the nature of flow-related impacts on them.

W defined distribution as the likely historical extent of the species at each life stage in a watershed, as opposed to the current distribution. This decision was based on the TRT historical population structure report and their assumption that historical habitat represents the best case scenario for species recovery. The extent and distribution of historic habitat has been defined by the TRT and is termed Intrinsic Potential (IP). The IP model fits species-specific suitability curves to watershed attributes (gradient, valley width constraint, and mean annual discharge) to estimate reach-specific suitability for supporting spawning and juvenile rearing habitats (Bjorkstedt et al. 2005). The group was provided with maps showing the distribution of IP stream reaches for all key watersheds. This provided for our definition of the extent of all four life stages.

The seasonality of each life stage was another important consideration because seasonality can co-occur with seasonally-specific water demands. For example, flow reductions associated with frost protection are more likely to occur in the early spring, which is in turn more likely to affect incubating embryos than it would summer rearing juveniles. For the purposes of this assessment, we defined the period of each life stage according to the dates in Table 2.

Table 2. Critical period for each flow attribute.

Life Stage	Begin Date	End Date
Incubation	1-Dec	1-Apr
Summer Rearing	1-Jul	1-Oct
Smolt Outmigration	1-Mar	1-Jun
Adult Migration	1-Nov	1-Mar

Scoring Method

Each participant was provided a scoresheet for all key watersheds. They used these to document three risk factors for flow conditions: setting, exposure and intensity.

The potential of each watershed to support any habitat attribute, and thereby provide for the successful completion of the species' life stages, varies and is dependent not only on land use but on watershed size, local precipitation, and other climatic and geologic features. We discussed not only the contribution of human activities (defined by the type and intensity of land use) on degradation of habitat, but also the current condition of habitat in the context of the natural setting.

Setting rates the degree of aridity of a watershed given the natural setting of climate, precipitation, etc. in an undisturbed state. We identified four classes of setting: xeric, mixed, mesic, and coastal (Table 3). We defined xeric watersheds as those dominated by arid environments such as oak savannah, grassland, or chaparral. We defined mixed watersheds as those that have a mix of xeric, mesic, and/or coastal habitats within them; as with large watersheds with inland regions. We defined mesic as those environments with moderate amounts of precipitation; examples include mixed coniferous/hardwood forest and hardwood-dominated forest (*e.g.*, oak woodland, tanoak, etc). Coastal refers to watersheds dominated by the coastal climate regime with cool moist areas. These watersheds typically have high levels of precipitation, are heavily forested, and are predominantly within the redwood zone. We provided maps of each watershed showing vegetation types and average precipitation for review. Participants were then asked to rate watersheds based on their knowledge of the dominant natural setting in the watershed.

Table 3. Rating matrix for assessing flow conditions.

	Poor	Fair	Good	Very Good
Setting	Xeric	Mixed	Mesic	Coastal
Exposure	>15%	5-15%	<5%	None
Intensity	High	Moderate	Low	None

Exposure rates the extent of stream likely impaired relative to each flow attribute. Specifically, exposure is the estimated proportion of historical habitat (by length) appreciably affected by reduced flows (Table 3). A stream reach may be appreciably affected, for example, if the value of summer rearing habitat is degraded by water diversions that reduce space, degrade water quality, reduce food availability, or restrict movement. We provided maps of each watershed showing the spatial relationship between relevant habitat areas and high-risk land uses, such as agriculture.

Intensity rates the likelihood that the land uses within the area of exposure will divert substantial amounts of water during the time in question. We defined High (Table 3) as crops or other activities that regularly require water diversions from the stream. We defined Moderate as crops or other activities that typically require irrigation, or have regular demand, but satisfy that demand often by means other than direct pumping of surface or subterranean stream flows. We defined Low as crops or other activities that only require diversions on rare occasion or in small amounts. Participants were asked to assign the appropriate rating for the intensity based on their knowledge of local land uses.

NMFS Use of Expert Assessments

Subsequent to the workshop, NMFS compiled the results and derived final scores by two simple averaging steps. Each risk-factor rating was first assigned a value as defined in Table 4. Then, the three risk factors scores made by each participant were averaged to determine individual ratings. For example, if Tom Daugherty determined that the Setting in the Navarro River was Mixed (75), the Exposure (of historic potential rearing habitat) to impacts of impaired summer baselfows was >15% (100), and the Intensity was High (100), the values associated with those three conclusions were averaged to give Mr. Daugherty's rating for summer baseflow in the Navarro a final rating of Poor (92).

Next, we averaged all scores from each participant to get a final score and rating for the indicator of interest. For example, all 16 participants scored the Navarro River for summer base flows, and our final rating was based on the average of all 16 scores.

Table 4. Risk-factor scores, and the classes defining Poor, Fair, Good, and Very Good ratings for combined average risk score.

	Poor	Fair	Good	Very Good
Setting	Xeric	Mixed	Mesic	Coastal
Score	100	75	50	25
Exposure	>15%	5-15%	<5%	None
Score	100	75	50	25
Intensity	High	Moderate	Low	None
Score	100	75	50	25
Rating	**Poor**	**Fair**	**Good**	**Very Good**
Score Class	>75	51-75	35-50	<35

Results

The results of the instream flow workshop are summarized in Table 5. These results were copied into the CAP Workbook Viability Tables for all 23 focus populations and became part of the current condition assessment contained in the CCC coho salmon Recovery Plan.

Only 5 of 23 watersheds had poor conditions associated with one or more of the flow attributes. Summer baselfow and redd scour were the most prevalent poor attribute with four watersheds each. Instantaneous baseflows and adult flows had only one watershed in poor condition. Of the five watersheds, the Russian River and San Lorenzo River had four of five flow attributes in poor condition. Salmon and Scott creeks had only one of five flow attributes rated as poor.

Table 5. Final ratings for five instream flow related attributes for all 23 focus populations in the CCC coho salmon recovery plan. Results were derived from professional opinion of local experts applied to a structured decision making model.

Watersheds	Summer Baseflow	Instant. Baseflow	Smolt Flows	Adult Flows	Redd Scour
Cottaneva Creek	Good	Very Good	Very Good	Very Good	Very Good
Ten Mile River	Good	Good	Good	Good	Fair
Pudding Creek	Fair	Good	Good	Good	Good
Noyo River	Fair	Good	Good	Good	Fair
Caspar Creek	Good	Very Good	Good	Very Good	Very Good
Big River	Fair	Good	Good	Good	Fair
Albion River	Fair	Fair	Good	Good	Fair
Big Salmon Creek	Good	Very Good	Very Good	Very Good	Good
Navarro River	Poor	Fair	Fair	Fair	Poor
Elk Creek	Good	Very Good	Very Good	Very Good	Good
Garcia River	Fair	Good	Good	Good	Fair
Gualala River	Fair	Fair	Fair	Fair	Fair
Russian River	Poor	Poor	Poor	Fair	Poor
Salmon Creek	Poor	Fair	Fair	Good	Good
Walker Creek	Fair	Fair	Fair	Good	Good
Lagunitas Creek	Fair	Good	Very Good	Very Good	Good
Pine Gulch	Fair	Good	Good	Good	Very Good
Redwood Creek	Fair	Good	Good	Good	Good
Pescadero Creek	Fair	Good	Fair	Fair	Fair
Gazos Creek	Good	Very Good	Fair	Fair	Fair
Scott Creek	Fair	Very Good	Fair	Good	Poor
Waddell Creek	Good	Very Good	Good	Very Good	Fair
San Vicente Creek	Fair	Good	Good	Good	Fair
San Lorenzo River	Poor	Fair	Poor	Poor	Poor
Aptos Creek	Good	Very Good	Good	Very Good	Fair

Disclaimer
According to the Federal Advisory Committee Act (FACA), NMFS cannot ask for and did not receive consensus recommendations from the participants in the Flow Assessment meeting. This group will not meet again with the same invited participants.

Attachment C: Estuary Rating Protocol for CCC Coho Salmon Draft Recovery Plan, January 2009

Estuaries are important nursery habitat for juvenile salmonids and other juvenile fish species because they are high in habitat diversity, produce large quantities of food and provide a relatively sheltered environment for predators (Busby and Barnhart 1995; Day *et al*. 1989; Healy 1982; McEwan and Jackson 1996; Naiman and Sibert 1979; Reimer 1973; Simenstad 1997; Miller and Simenstad 1997; Nichols and Hankin 1989; Smith 1990; Thorpe 1994; Yoklavich *et al*. 1991, Brown 2006). Furthermore estuaries are transitional areas between fresh water and the marine environments where physiological and behavioral changes associated with smolt transformation occur. Some salmonids deprived of an estuarine residence may suffer from higher degrees of physiological stress adapting to sudden exposure to salt water than those encountering a gradual transition (MacDonald *et al.* 1988). Estuaries also provide habitat suitable for growth of large smolts which may be lacking in small streams with poorly developed pool characteristics or other limiting habitat attributes. Several salmonid studies have indicated that a substantial portion of natural mortality occurs when fish first enter the ocean (Healy 1982; Matthews and Buckley 1976; Fish and Pearcy 1988), and that size of smolts is an important factor in determining overall survival rates (Holtby et al. 1990; Reimers 1973), especially when ocean survival conditions are relatively poor (Fisher and Pearcy 1988; Holtby et al. 1990; Johnson 1982; Nickelson 1983). Estuaries provide a productive area allowing juveniles that use them to recruit disproportionately to the adult population compared to those from other habitats, because of the increased growth and survival occurring in these environments (Beck *et al*. 2001; Bond 2006).

Salmon utilizing estuarine habitats have been well documented fro rivers from British Columbia to central California (Reimers 1973; Levy and Northcote 1982; Dawley *et al*. 1986; McCabe *et al*. 1986; MacFarlane and Norton 2002). However, the time spent in an estuary, and the benefits received from that habitat may vary widely among salmonid species and watersheds. Some salmon move through estuaries in days, while others remain for months (Reimers 1973; Myers and Horton 1982; MacFarlane and Norton 2002; Miller and Sadro 2003; Bottom *et al*. 2005).

Estuaries of smaller coastal watersheds in the southern margin of North American Pacific salmon and steelhead distributions commonly form ephemeral freshwater lagoons. These lagoons are the products of low summer flow regimes that cannot displace oceans sand deposition at the estuary mouth (Bond 2006). Eventual formation of a sandbar effectively blocks surface connectivity with the oceans, and reduces the tidal influence on the system, creating a warm, mostly freshwater, slow moving body of deep water. Summer temperatures in these systems can be substantially greater than temperatures in upstream tributaries, and may at time be near the thermal tolerance limit of steelhead (~ 25° C) (Myrick and Cech 2004). Lagoon conditions are generally present until the first winter freshet increases stream flow and removes the sandbar, opening the estuary to the ocean. The development of lagoon conditions and their effects on salmonids is not well understood, although a recent study has shown a lagoon environment to be very beneficial to overall steelhead production in central California (Bond 2006).

Human activity occurring within the estuary, as well as throughout the corresponding watershed can negatively affect juvenile anadromous salmonids utilizing estuaries (USFWS 1998). In addition, these anthropogenic effects on fish are compounded in the estuarine environment, due to the added physiological stresses of the fresh water to marine transition (Varanasi et al. 1993; Waldichuk 1993). These activities include: 1) loss of intertidal rearing habitat due to structural development, shoreline armoring, jetties, dredging and filling (Levings 1980; Waldichuk 1993; Thom *et al*. 1994; Simenstad and Fresh 1995); 2) decrease in dissolved oxygen due to input of sewage, agricultural practices, and dredging of anoxic sediments (Waldichuk 1993); 3) creating a toxic condition due to toxic chemical spills and discharge of chemical waste from industry and toxic condition due to toxic chemical spills and the discharge of chemical waste from industry and mining (Waldichuk 1993); and 4) an increase in suspended solids due to logging activities upstream, agricultural practices, dredging, and input of sewage and industrial waste (Waldichuk 1993). The magnitude of anthropogenic effects on juvenile anadromous salmonids is dependent on the spatial, temporal, and intensity at which they occur (Simenstad and Fresh 1995). Due to the large benefit derived from properly functioning estuaries/lagoon to salmonid population it was necessary to identify a number of limiting factors. These limiting factors may act singularly or synergistically to reduce the overall productivity of the estuary or lagoon system.

Table 6. Rating Parameters for Coho Salmon Smolt Outmigration Estuaries

Criteria	Watershed Name	Confidence/Source
1. Transition habitat		
2. Habitat complexity		
3. Food production habitat		
4. Tidal Prism		
Overall ranking		

1. Saltwater Transition Habitat (see Table for watershed scaling)

Size Group	Very Good	Good	Fair	Poor
A	½ acre	¼ acre	0.05 acre	none
B	2	1	0.25	none
C	4	2	0.5	0.1
D	8	4	1	0.25
E	16	8	2	0.5
F	32	16	4	1

2. Habitat complexity (% area of lagoon containing SAV, emergent or overhanging vegetation, large or small WD, pools >2 m or other cover)

Very Good	Good	Fair	Poor
>80%	40-80%	15-40%	<15%

3. Food Production Habitat (marsh, sloughs, backwater areas w/organic mater and invertebrates) (see Table for watershed scaling)

Size Group	Very Good	Good	Fair	Poor
A	½ acre	¼ acre	0.05 acre	none
B	2	1	0.25	none
C	4	2	0.5	0.1 acre
D	8	4	1	0.25
E	16	8	2	0.5
F	32	16	4	1

4. Tidal Prism[12] (historical extent intact and properly functioning)

Very Good	Good	Fair	Poor
100%	99-80%	79-60%	< 59%

[12] Tidal prism is a measure of full tidal connection (meanders, wetlands, sloughs, relic creek systems, and depths). NMFS (2005).

Attachment C: Estuary Rating Protocol for CCC Coho Salmon Draft Recovery Plan, January 2009

Criteria rationale:

According to Smith (2008) the significance of the estuary-lagoon is size dependent, in relation to the size of the watershed that it serves. A small productive summer lagoon-estuary for a very large watershed may not be a major factor in watershed steelhead and salmon ecology, whereas a relatively large lagoon for a small watershed may produce a majority of the watershed smolts, even if conditions are less suitable. Functionally and potentially independent populations (and smaller dependent populations) can be broken into several watershed size groups based upon km of intrinsic potential (IP) of historical habitat (Table 1). Therefore, we attempted to scale the ratings for a number of the estuary-lagoon criteria for many of the steelhead and salmon life histories.

Habitat Complexity -

Tidal Prism - Tidal prism is a measure of full tidal connection (meanders, wetlands, sloughs, relic creek systems, and depths) (NMFS 2005). Full tidal connection allows the fish to move into areas of high flood availability and to seek cover under differing tidal conditions.

Winter Food Production Habitat – Smith (2008) defines winter food production habitat area as marsh, sloughs, backwaters and or potholes with organic matter and invertebrates. Alternatively, expert judgment or sampling for invertebrate abundance in spring can be used to indicate food availability.

Transition Habitat - The estuary should provide a brackish environment in part of the estuary that will allow smaller smolts to adjust to saltwater gradually by moving up and down in the stratified water column or up and downstream within the estuary. For some estuaries the availability of this habitat will depend upon partial development of the sandbar; this may be more likely in drier years (Smith 2008).

Deep scour holes at bends or structures that trap saltwater may be the major source of this habitat; these same habitats may be subject to water quality problems in closed summer lagoons, but are crucial to provide this habitat in spring. Determining this parameter will require spring salinity profiles. Amount of habitat can vary substantial with tidal cycle, date and type of rainfall year; expert opinion by those familiar with the system may be needed.

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