11.0 MONITORING AND ADAPTIVE MANAGEMENT

"It is imperative that California, which is well behind other states in the Pacific Northwest, begin conducting monitoring at spatial scales relevant to recovery planning if we are to have any hope of accurately evaluating status and progress towards recovery."

Spence et al. 2008

11.1 INTRODUCTION

Population-level estimates of abundance and distribution are disparate and currently insufficient; yet, these data are critical to informing recovery criteria. The State of California and NMFS are engaged in the development of the California Coastal Salmonid Monitoring Plan (CMP, Shaffer in prep), which is being designed to collect data that can inform recovery criteria. Adams *et al.* (GRTS, Larsen *et al.* 2008) provides the scientific and statistical foundation for monitoring coastal salmonid populations. While the focus has been on developing a protocol for population monitoring, habitat monitoring is equally important and both are anticipated for inclusion into the monitoring plan.

Population level monitoring is a high priority as these data can be aggregated up to the biological organizational levels of a Diversity Stratum and ESU. The methods recommended and discussed in greater detail below include spatially balanced spawner/redd surveys, population-level life cycle monitoring (LCM) stations to calibrate redd survey estimates and distinguish ocean versus freshwater survival, and juvenile spatial distribution and abundance assessments. All monitoring will be conducted at the population level, which will then be used to inform diversity stratum and ESU-level abundance and viability over time.

Photo Courtesy 46: Adult CCC coho salmon males collected at the Pudding Creek dam Life Cycle Monitoring station, Fort Bragg, California. Pudding Creek maintains one of the stronger remaining runs of coho salmon in the ESU. The lifecycle station is a cooperative effort between Campbell Timberland Management (CTM) and CDFG (partially funded by the Fisheries Restoration Grants Program) and is an important source of information regarding adult coho salmon returns. *David Wright – CTM*

The ultimate goals of the CMP are to finalize a robust and adaptive monitoring program that includes all coho salmon, Chinook salmon and steelhead populations in California. The plan will:

- Provide regional (ESU-level) and population abundance estimates for both status and trend of salmonid populations that will inform recovery criteria;
- Estimate productivity trends from status abundance data;
- Provide estimates of regional and population level spatial structure of coastal salmonids;
- Consider the diversity of life history and ecological differences in the three species of interest;
- Create permanent LCM stations that will allow deeper evaluation of both freshwater and marine fish-habitat relationships and provide long-term index monitoring; and
- Assess freshwater and estuarine habitat conditions.

Currently, only a few organizations (*e.g.* CDFG Region 1 and NMFS's Southwest Science Center) have implemented population-level monitoring programs for adult returns outlined in the CMP; these efforts are critical first steps to build experience and data that can ultimately be used to inform trend data and progress towards recovery abundance targets. Several other organizations (*e.g.* CDFG Region 3, Sonoma County Water Agency, Marin Municipal Water District and National Park Service) have also begun some level of adult return and juvenile distribution monitoring in other coastal populations.

NMFS and CDFG acknowledge the CMP must be built overtime as methods are tested and refined and funding secured. While the fundamental principles of the CMP (*i.e.,* the need for random, spatially balanced sampling and the need for robust population estimates) will remain more or less the same, the specific metrics and procedures used to evaluate recovery will evolve and likely change over time as we learn from early implementation of the plan. To track coho salmon abundance trends; however, we must expand upon our existing monitoring efforts immediately throughout the ESU using the existing CMP framework. NMFS and CDFG have outlined goals for the CMP at one year, five years and 10 years. In 2013, a definitive framework should be in place with continued and expanded monitoring. In 2016, all diversity strata for CCC coho salmon should have LCM stations established and initial trend data being collected. By 2022, adult escapement trends and associated marine survival estimates should provide data that informs recovery goals. Data collected over a broad geographic scope will assist with the refinement of methods, experimentation of other methods, and highlight additional data needs. During 5-Year Status Reviews (required by NMFS) the progress of recovery action implementation will be assessed, specifically those actions aimed at improving habitat conditions and reducing threats to determine their effectiveness. Critically needed, however, are partners and a long term source of funding.

This chapter describes specific research, monitoring and adaptive management strategies necessary to inform the downlisting and delisting criteria provided in Chapter 10.

> "Given the imperiled nature of coho…in California it is critical that coastwide instream monitoring programs be implemented and maintained to allow warning of impending problems to these valuable resources. Without the existing minimal monitoring effort, since coho are not commercially fished or regulated, there would be little notice of their decline."
>
> *MacFarlane et al. 2008*

11.2 MONITORING ABUNDANCE, PRODUCTIVITY, STRUCTURE & DIVERSITY

The most important metric for population viability criteria is spawner abundance measured over time (*e.g.* multiple generations). Spawner abundance will be assessed using a two-staged sampling approach (Adams *et al.* 2011). First-stage sampling is comprised of extensive regional and spatially balanced spawning surveys to estimate escapement in stream reaches selected under a GRTS (Gallagher *et al.* 2010) design. The GRTS is a rotating panel design at a survey level of ten percent of available habitat each year. Second-stage sampling consists of producing escapement estimates in intensively monitored census streams (*e.g.* LCM stations) through either total counts of returning adults or capture-recapture studies. The second-stage estimates are considered to represent true adult escapement and resulting spawner to redd ratios are used to calibrate first-stage estimates of regional adult abundance (Crawford and Rumsey 2011).

The LCM stations consist of either fixed counting facilities, or portable, seasonally installed facilities where fish are either trapped and marked or directed through a viewing chamber and counted. Another method, especially in smaller coastal systems, is the use of DIDSON acoustic cameras. This method for counting adult escapement provides reliable estimates, particularly where species identification is not an issue (Adams *et al.* 2011). For watersheds with more than one salmonid species, the date of capture and size of fish can be used to help differentiate between species. LCM stations are used where smolt and summer rearing abundance can be monitored to estimate freshwater and marine survival and to evaluate life histories that can inform regional status and trend information (the stage one data). These populations (watersheds) are also intended to be focal points for evaluating restoration and encouraging further research. NMFS monitoring guidelines (2011) also recommend using a robust unbiased spawner abundance sampling scheme that has known precision and accuracy. Similar to Adams *et al.* (2011), they offer probabilistic sampling of all accessible spawning areas using unbiased randomized sites with rotating panels (*i.e.* GRTS) as an option that will produce statistically valid estimates of spawner abundance with known certainty. The monitoring needs and recommendations presented below rely heavily on the CMP discussions ongoing between NMFS and CDFG along with guidelines presented in Crawford and Rumsey (2008).

The recommendations outlined below address the VSP criteria of abundance, productivity, spatial distribution, and diversity, at the ESU, diversity strata and population levels. The VSP criteria are described in detail in Chapter 6. Table 24 shows the recommended monitoring that NMFS will use to inform the progress toward meeting specific recovery criteria (Chapter 10) for biological viability.

Table 24: ESU, Diversity Strata and population level biological viability recovery criteria and recommended monitoring.

	ESU	Diversity Strata	Population
Recovery Criteria	-All Diversity Strata criteria are met.	Each Diversity Strata meets Representation, Redundancy and Connectivity criteria	***Independent Populations*** - Effective population size per generation > 500 OR Total population size per generation > 2,500 AND - NO population decline apparent or probable AND - Catastrophic decline not apparent -AND- - Delisting spawner target achieved. -AND- - No evidence of adverse genetic, demographic, or ecological effects of hatchery fish on wild populations. ***Dependent Populations*** Delisting spawner target achieved ***Supplemental Populations*** Confirm presence for at least one year class over a 12 year period -AND- 50% of the recovery actions have been implemented or deemed not necessary
Recovery Criteria – monitoring	Sum of Diversity Strata-level monitoring.	Sum of Population-level monitoring.	- GRTS-based spawner/redd surveys for abundance and productivity (10 percent of habitat assessed annually); - Life Cycle Monitoring stations for abundance, productivity, and diversity; - GRTS-based summer/fall juvenile surveys for spatial distribution, and diversity (10 percent of habitat assessed annually) *Minimum of 12 years (~ 4 generations) of monitoring.

11.2.1 Adult Spawner Abundance

Recommendations for monitoring adult spawner abundance include:

1. Implementation of an unbiased two-stage GRTS based ESU-wide monitoring program (*i.e.*, the CMP) for adult CCC coho salmon that has known precision and accuracy. The monitoring plan should:

a. Provide yearly adult spawner abundance estimates for the ESU, diversity stratum, and where possible, each focus population;

b. Establish a minimum of one (preferably two) LCM stations within each diversity stratum to estimate spawner: redd ratios. These stations will be used for calibrating regional redd counts, and smolt/adult ratios for marine/freshwater survival estimations. Maintain current LCM stations in Mendocino and Santa Cruz counties and seek to incorporate other existing monitoring programs into the master sample GRTS design;

c. Overtime as populations approach recovery strive, to have ESU-level adult spawner data with a coefficient of variation (CV) on average of 15 percent or less (Crawford and Rumsey 2011);

d. Regional spawner data should have the statistical power to detect a change of ± 30 percent with 80 percent certainty within 10 years;

e. Strive to have abundance estimates at the LCM stations with a CV on average of 15 percent or less;

f. Estimate migration rates between basins and tributaries of larger basins to validate assumptions that underlie population delineations and to assess potential role of inter-basin exchange on extinction probabilities;

g. Evaluate hatchery impacts and hatchery-to-wild ratios (this should cover a range of issues from genetic changes to brood stock mining) and implement hatchery recommendations per Spence *et al.* (Johnson *et al.* 2007); and

h. All monitoring should utilize the protocols published in the American Fisheries Society Salmonid Field Protocols Handbook (1998).

11.2.2 PRODUCTIVITY

Recommendations for monitoring population productivity include:

1. Productivity is calculated as the trend in abundance over time. Develop a 12 year[17] or greater data set of accurate spawner information to estimate geometric mean recruits per spawner and evaluate population trends.
2. Using the LCM stations, conduct annual smolt abundance/trend monitoring.
   a. Juvenile monitoring should strive to have data with a CV on average of 15 percent or less;
   b. Power analysis for each monitored juvenile population should be conducted to determine the statistical power of the data to detect significant changes in abundance; and
   c. Estimate apparent marine and fresh water survival (couple adult data with the smolt abundance estimates).

11.2.3 Spatial Distribution

Recommendations for monitoring spatial distribution include:

1. Evaluate changes in adult spawning distribution (stage one sampling) using probabilistic sampling. Annually, compare spawner distribution with the total habitat available to determine the percent occupancy across the species range. Environmental conditions, such as precipitation and stream flow, will influence the distribution of spawners by expanding (wet years) or shrinking (dry years) the amount of habitat available to returning adults. Therefore, analysis of annual spawner distribution must consider both biological (small population) and environmental (weather patterns) factors.
2. Develop and implement a spatially balanced GRTS-based summer and fall sampling strategy for juvenile coho salmon. Crawford and Rumsey (2011) recommend assessments should detect a change of ≥ 15 percent with 80 percent certainty; however, further research is needed to establish which indicator will be most appropriate for evaluating trends.

[17] Approximately four generations.

3. As discussed above, the relationship between environmental factors (particularly stream flow and water temperature) can influence the likelihood of coho salmon presence and spatial distribution. Where necessary and applicable, implement stream flow and water temperature monitoring in order to assess their implications on occupancy during the adult (stream flow) and juvenile (stream flow and water temperature) life stages.

11.2.4 DIVERSITY

"Diversity traits are strongly adaptive for local areas and populations, and these traits allow salmonids to survive in the face of unique local natural and anthropogenic challenges. Higher level diversity traits have been considered in the creation of the listing and stratification units; however, population level diversity traits may be very different from one geographical or population unit to another. Therefore, local diversity traits will need to be surveyed, eventually leading to local diversity monitoring plans. Specific projects targeting both broad and focused levels and patterns of genetic diversity will be developed." Adams *et al.* (2011).

Recommendations for monitoring diversity traits include:

1. Monitor status and trends of spawn timing, sex ratio, age distribution, fecundity, *etc.* (see Adams *et al.* 2011) across populations, diversity strata, and the ESU. Spawn timing, sex ratio, and age distribution should be assessed during both stage-one (spawner surveys) and stage-two (LCM station) adult monitoring. Age distributions for juvenile coho salmon should be assessed during spatial distribution monitoring using length frequencies, analysis of scales, and by mark-recapture PIT-tagging programs.

2. Develop a genetic baseline of DNA micro satellite markers for the CCC coho salmon ESU. Tissue sample collection required for the development of this baseline can be conducted during all sampling activities associated with spawner surveys (carcasses), LCM stations (live adult and juvenile fish), and spatial distribution surveys (live juvenile fish).

3. Compare differences in population abundance, growth rates, habitat use, and juvenile migration timing with overall watershed and in-stream habitat conditions (*i.e.,* water temperature, canopy closure, shelter, and summer base stream flow).
4. Assess the influence (percentage) of hatchery fish in populations (both intended releases and from straying). The presence of adipose fin clips or tags applied at hatchery facilities will be used to identify fish origin.

11.3 COSTS FOR MONITORING BIOLOGICAL VIABILITY

Cost estimates for implementing the CMP have not been developed (Adams *et al.* 2011) although some cost estimates are available for monitoring conducted in the Pudding Creek watershed in coastal Mendocino County, California (Gallagher *et al.* 2010). These existing values were used to form preliminary costs estimates for monitoring needed to inform recovery criteria and trends for the CCC coho salmon ESU.

For streams on the Mendocino Coast, regional spawning ground surveys for CCC coho salmon cost approximately $3,000 to survey one reach a sufficient number of times each season to generate reliable redd counts (Gallagher *et al.* 2010). Sample units, or reach lengths, for both spawner distribution/abundance and juvenile spatial distribution described in Adams *et al.* (2011) range from approximately 1.6 to 3.2 km. Using the total number of kilometers of potential habitat for the focus populations listed Chapter 7 and a ten percent sample of 3 km reaches, the estimated annual cost to conduct spawning ground surveys for CCC coho salmon would be approximately $343,010 (Table 25). This does not include data storage and report preparation. For watersheds with more than one salmonid species, there will be overlap of species monitoring due to differences and overlap in run timing and life history strategies. Coho salmon adult migrations typically begin after Chinook salmon and before steelhead. Depending on the degree of overlap, total costs for monitoring CCC coho salmon spawner abundance would be reduced considerably.

In this Plan, a minimum of one LCM station was recommended for each diversity stratum. We provide cost estimates for CCC coho salmon monitoring for one and two LCM station per diversity stratum. Adult monitoring at the Pudding Creek LCM station costs about $36,000 per year (Gallagher and Wright 2008, Gallagher *et al.* 2010). This estimate does not include smolt or summer rearing abundance estimates nor does it include data analysis and reporting. Based on these values, annual cost estimates for adult monitoring at LCM stations within each diversity stratum would range from $144,000 (1 LCM station per diversity stratum) to $288,000 (2 LCM stations per diversity stratum). These costs were calculated assuming 4 diversity strata, each with a LCM station, at $36,000 per station. These annual costs could also be reduced substantially by selecting drainages with more than one listed salmonid species.

At Pudding Creek, juvenile monitoring at the LCM station costs approximately $15,000 per year to conduct (Gallagher *et al.* 2010). Based on these values, total annual cost estimates for juvenile monitoring (juvenile emigration) at the LCM stations could range between $60,000 and $120,000.

The total annual costs for LCM station (stage two) monitoring for all life stages and applicable VSP criteria could range between $204,000 and $408,000 depending on the number of stations. It is important to note these estimates are based on monitoring costs for Pudding Creek, a relatively small stream and watershed with only one landowner. Life cycle monitoring in larger populations would undoubtedly be more difficult and likely more expensive due to the larger size of the river and, in most cases, a lack of existing infrastructure and access issues.

Table 25: CCC Coho salmon spawning survey cost estimates.

Diversity Strata / populations		Potential Habitat (km)	10% Potential Habitat (km)	# of 3 km reaches sampled annually	Spawning Ground Surveys Annual Cost
Lost Coast - Navarro Point					
Usal Creek		17.6			
Cottaneva Creek		23.3			
Wages Creek		15.8			
Ten Mile River		190.7			
Pudding Creek		42.5			
Noyo River		204.4			
Caspar Creek		20.1			
Big River		345.7			
Albion River		95.2			
Big Salmon Creek		27			
	sub-total	982.3	98	33	$ 98,230
Navarro Point - Gualala Point					
Navarro River		354.7			
Garcia River		166.9			
Gualala River		429.1			
	sub-total	950.7	95	32	$ 95,070
Coastal					
Russian River		736.3			
Salmon Creek		57.8			
Pine Gulch Creek		18.3			
Walker Creek		108.8			
Lagunitas Creek		103.8			
Redwood Creek		11			
	sub-total	1036	104	35	$ 103,600
Santa Cruz Mountains					
San Gregorio Creek		59			
Pescadero Creek		88.4			
Gazos Creek		11.5			
Waddell Creek		12.8			
Scott Creek		22.3			
San Vicente Creek		5.5			
San Lorenzo River		168.3			
Soquel Creek		51.4			
Aptos Creek		41.9			
	sub-total	461.1	46	15	$ 46,110
	Total	3430.1		114	$ 343,010

Assessing juvenile spatial distribution and habitat monitoring for CCC coho salmon using the GRTS based sampling design will likely cost approximately $1,000 per reach to survey. There is a great deal more juvenile habitat than spawning habitat, perhaps twice as much, thus an annual sample of 228 reaches across the ESU might cost about $228,000 per year. This estimate does not include data analysis, storage, or report preparation. Final sample size and reach variance issues will have to be developed for juvenile spatial structure (and habitat monitoring). In watersheds with CCC coho salmon and either NC or CCC steelhead, portions of the juvenile coho distribution will be assessed simultaneously, thereby lowering costs.

Determining actual costs of this monitoring would need to include cost estimates for evaluating habitat conditions, restoration actions, implementing a recovery tracking system, and for developing and maintaining a coordinated data management system. Population or watersheds selected for LCM station placement will also affect totals costs due to watershed size differences and potential for multiple species. Finally, monitoring the recovery of CCC coho salmon will require continuing evaluation of costs, dedicated funding, and a long term commitment of resources by all involved parties.

11.4 MONITORING LISTING FACTORS

In addition to monitoring for biological criteria, recovery plans must also provide monitoring strategies to address each of the Section 4(a) (1) listing factors. These are tracked using the key habitat attributes used in the CAP analysis. In addition, NMFS developed criteria and monitoring recommendations to track reduction in threats and implementation of recovery actions. The criteria and monitoring strategies are organized in Table 26, Table 27, and Table 28). The criteria and recommended monitoring are designed to track the effectiveness of actions specifically implemented to improve current habitat conditions, reduce the impacts of current threats (and the stresses they contribute to), or highlight new and emerging threats.

11.4.1 LISTING FACTOR A: THE PRESENT OR THREATENED DESTRUCTION, MODIFICATION, OR CURTAILMENT OF THE SPECIES' HABITAT OR RANGE

1. Develop and implement a GRTS-based habitat status and trend monitoring program which is coordinated with the juvenile spatial structure evaluations (10 percent of available habitat each year).

   - Develop a standardized survey method for evaluating habitat attributes with a focus on population-specific attributes identified as having a *High or Very High* rating (See Chapter 8). The general methods for assessing habitat attributes should follow those outlined by Flosi *et al.* (2004) and Bleier *et al.* (2003);

   - Select one population within each diversity stratum (preferably a population with a LCM station) to conduct a basin-wide intensive habitat assessment which is repeated every 12 years;

   - Incorporate consistent habitat monitoring protocols that provide comparable watershed information and integrate ongoing habitat assessment work into a master GRTS sample design;

   - Develop and employ suitable habitat assessment criteria and models that provide high level indicators of watershed conditions; and

   - Approximately every 10 years, assess changes in land use and other non-landscape attributes using GIS. In addition to general land use patterns (*i.e.* agriculture, timber, urban), other watershed-specific attributes that should be measured include: extent of impervious surfaces, landslides, watershed road density, and overall riparian conditions.

2. NMFS is currently emphasizing to Oregon, Washington, Idaho, Alaska, Nevada and California the importance of effectiveness monitoring when using Pacific Coastal Salmon Recovery Funds (Whiteway *et al.* 2010; NMFS 2012d). Implementation of all habitat restoration activities should have both implementation and effectiveness monitoring components. Work in populations with LCM stations and other intensively monitored

watersheds should also incorporate validation monitoring.

- The design and implementation of all restoration actions should be reported and correlated with habitat limiting factors so cumulative impacts can be tracked across the ESU;
- Where restoration actions are implemented, effectiveness monitoring should be conducted at both the reach and site-specific scales following the Before After Control Impact (BACI) design. For example, the installation of large woody debris and other habitat enhancement structures should be coupled with long-term monitoring plans that attempt to determine success in terms of habitat enhancement/creation and coho salmon abundance (Isaak *et al.* 2011);
- Establish at least one Intensively Monitored Watershed (as detailed in Crawford and Rumsey 2011) within each diversity stratum (preferably a population with a LCM station). Conduct power analysis early in development to determine amount of watershed required to be treated necessary to detect 30-50 percent change in salmon response; and,
- Use salmonid response (presence, abundance, and fitness monitoring) at restoration sites to inform effectiveness over time.

3. Conduct annual assessments of the status and spatial patterns of water quality and stream flow conditions within individual populations and across diversity strata.

- EPA, state agencies, and local governments should monitor storm-water and agricultural runoff to assess status/trends of turbidity and concentrations of other identified toxins and identify their sources;
- Basin-wide water temperature monitoring using stratified arrays of automated data loggers (Hill *et al.* 2010; Moore *et al.* 2011) should be implemented wherever feasible and particularly within each watershed with an LCM station. In addition, water temperature monitoring using data loggers should be conducted in streams within populations where water temperature has been identified as Fair or Poor; and,

- Annually monitor the status and spatial pattern of stream flows particularly for populations where impaired stream flow was rated as Fair or Poor. Stream flow monitoring should include assessing for stream flow response (*i.e.,* degree of flashiness) in urban and urbanizing watersheds which could affect the potential for redd scour. Where necessary, coordinate with USGS and/or local governments, non-governmental organizations and water agencies to install additional stream flow gages to assist with stream flow tracking.

4. Conduct baseline water-quality and habitat-condition monitoring of estuaries and bar-built lagoons.

   - Lagoon water quality monitoring should be conducted for populations where the quality and extent of estuarine/lagoon habitat were rated as Fair or Poor. This should include diurnal, seasonal, and event-based (*i.e.,* a sudden change in weather, inflow, or management actions) monitoring of water temperature, dissolved oxygen, and salinity profiles, as well as an analysis of seasonal changes in freshwater inflow, lagoon depth, and finally, invertebrate abundance and community composition; and,
   - Monitor the frequency, timing, and associated impacts (see above) of sand bar breaching for all lagoons where authorized and unauthorized manual breaching occurs.

5. Monitor the implementation and effectiveness of Best Management Practices (BMPs).

   - With the assistance of other Federal, State, and local resource agencies, track voluntary and required implementation of best management practices (BMPs) within each diversity stratum, compile any post-implementation data that may indicate the effectiveness of the implemented BMPs, and where necessary, conduct effectiveness monitoring of BMPs.

11.4.2 LISTING FACTOR B: OVER-UTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC OR EDUCATIONAL PURPOSES

1. A comprehensive and coast-wide monitoring program tracking the freshwater and ocean catch/harvest of CCC coho salmon does not exist. NMFS recommends:
   - ❑ Develop Fisheries Monitoring and Evaluation Plans (FMEP) which are specifically designed to monitor and track catch and mortality of wild and hatchery salmon stemming from recreational fishing in freshwater and the marine habitats; and,
   - ❑ Encourage funding for the continued implementation, refinement, and expansion of the GSI monitoring of Pacific salmon. This will help track ocean migrations of CCC coho salmon, origin, and an index of incidental capture and mortality rates of CCC coho salmon in the commercial and recreational salmon fisheries.
2. Encourage continued scientific research on the effects of CCC coho salmon population decline on reduced marine-derived nutrients in freshwater habitats (Walters 1997; Walters 2002).
3. NMFS will continue to coordinate with CDFG on revisions to freshwater sport fishing regulations to ensure adverse effects to CCC coho salmon during migrations are minimized.
4. Annually review results from Steelhead Fishing Report-Restoration Cards and creel surveys conducted by CDFG to assess incidental capture and mortality rates of CCC coho salmon in the recreational freshwater fishery for steelhead.
5. Continue to annually monitor and assess intentional and incidental capture and mortality rates of CCC coho salmon resulting from permitted research to ensure established take limits are adequate to protect these species. Utilize the results of this research to help assess population status.

11.4.3 Listing Factor C: Disease or predation

1. Annually estimate the infection and mortality rates of juvenile CCC coho salmon from pathogens in populations where diseases are identified as a *High* or *Very High* threat.
2. Annually monitor the status and trends of non-native predators in populations where predation is identified as a *High* or *Very High* threat. Coordinate with CDFG to develop and implement plans to track their impacts on CCC coho salmon populations and, where necessary, reduce populations of these predatory, non-native species.
3. During the 5-year status reviews, re-assess the status of non-native predatory species in populations where predation was not originally identified as a *High* or *Very High* threat to ensure expansion of non-native predatory species or the introduction of new predatory species has not occurred.
4. Compile information on predation rates of juvenile coho salmon by birds (freshwater and marine) and pinnepeds, and encourage additional research and monitoring to further evaluate their impacts and potential strategies for predation reduction.

11.4.4 Listing Factor D: The inadequacy of existing regulatory mechanisms

1. Develop a recovery plan tracking system to track the implementation status of specific recovery actions identified in this recovery plan.
2. Develop and implement a randomized sampling program to test whether permits issued under local and State regulatory actions designed to protect riparian and instream habitat are in compliance and that the provisions have been enforced.

11.4.5 Listing Factor E: Other natural or manmade factors affecting the species' continued existence

1. Monitoring the effects of climate change (severe weather patterns) on CCC coho salmon and their habitat should include expanding stream flow and water temperature monitoring and their effects on freshwater and estuarine survival. See monitoring

associated with the CAP attributes (*e.g.* water temperature, stream flow, and estuarine conditions).

2. Tracking ocean conditions (*i.e.* productivity) will rely on monitoring data obtained from the LCM stations (ocean survival), ocean net surveys conducted by the SWFSC as part of their California Current Salmon Ocean Survey (early ocean survival/condition), hatchery returns, and compiling and assessing existing and ongoing oceanic data collected by satellites and buoy arrays along the Pacific Coast.
3. Where applicable, conduct annual assessments of the percent of hatchery origin spawners (pHOS). To achieve broad sense recovery, pHOS should not exceed 10 percent in any population. Provide monitoring and documentation which demonstrates HGMPs have been developed and implemented.
4. Encourage Conservation Hatchery programs for CCC coho salmon that follow criteria outlined in Spence *et al.* 2008.

Table 26: Recovery criteria and recommended monitoring for listing factors and CAP attributes.

	ESU	Diversity Strata	Population
Section 4(a)(1) Listing Factor Recovery Criteria	All Diversity Strata within ESU meet Diversity Strata and Population-level criteria.	75% (or at least 2) of the populations in each stratum must meet Population-level criteria.	***<u>CAP Attributes</u>:*** *Hydrology & Water Quality Indicators:* Rank **GOOD** or better across life stages *Remaining CAP Habitat* Condition Attributes:* Rank **GOOD** or better across populations * excludes landscape and size attributes
Section 4(a)(1) Listing Factor Monitoring	- Sum of Diversity Strata and Population-level habitat monitoring	- Establish at least one Intensively Monitored Watershed habitat condition assessment (preferably a population with a LCM station): Repeat every 12 years. - Sum of Population-level habitat and water-quality monitoring results - Update CAP workbooks;	- Develop and implement a spatially balanced habitat monitoring protocol as part of the CMP to track condition of key CAP habitat attributes; - Assess effectiveness of population-specific Recovery Actions and other restoration projects (using BACI approach). - Conduct water quality and stream flow monitoring - Install and monitor water temperature using data logger arrays in populations with LCM stations. - Develop and implement a comprehensive estuary/lagoon monitoring program that tracks the condition, management scenarios and highlights elements of concern. - Track implementation and effectiveness of BMPs aimed at improving water quality and substrate. - Assess general land-use patterns using GIS every 10 years. Some non-landscape attributes (*e.g.*, extent of impervious surfaces) will be tracked using GIS, others will rely on Habitat Monitoring at the Population level.

Table 27: Recovery criteria and recommended monitoring for CAP threats.

	ESU	Diversity Strata	Population
CAP Threat Condition – criteria	All Diversity Strata within the ESU meet Diversity Strata and Population-level criteria.	75% (or at least 2) of the populations in each stratum must meet Population-level criteria.	***CAP Overall Threat Ranks:*** - Threats Status rank **Medium** or better
CAP Threat Condition – monitoring	- In order to assess the impacts of climate change on salmonid freshwater and estuarine habitats expand assessments of water temperature and stream flow. - Track ocean conditions (productivity) using Life Cycle Monitoring stations, ocean net surveys (SWFSC California Current Salmon Ocean Survey), hatchery returns, and water quality data collected along the Pacific Coast; - Continue/expand the GSI monitoring program for Pacific salmon captured in the ocean fisheries; - Annually assess capture/ mortality rates of CCC coho resulting from permitted research	- Annually assess Diversity Strata-wide impacts of sport fishing pressure through the development of FMEPs, Steelhead Fishing Report-Restoration Card and annual creel survey results. - Assess predation impacts on coho salmon by birds and pinnepeds and develop methods to reduce mortality where applicable. * CMP results should track Diversity Strata level trends	- See also CAP Habitat Attribute Monitoring above. - Address/modify freshwater sport fishing regulation changes. - Monitor infection and mortality rates of juvenile coho salmon from pathogens where diseases are identified as High or Very High; - Assess the abundance and distribution of non-native predators and develop strategies for their reduction. - Assess the distribution and impact of non-predatory species that affect salmonid habitats. - Annually assess pHOS in watersheds with hatchery influences and develop HGMPs where necessary.

Table 28: Recovery criteria and recommended monitoring for recovery action implementation.

	ESU	Diversity Strata	Population
Recovery Action Implementation - Criteria	All Diversity Strata within the ESU meet Diversity Strata and Population-level criteria.	75% (or at least 2) of the populations in each stratum must meet Population-level criteria.	***Actions Assigned to Listing Factors:*** - All Priority 1 Actions Implemented - All Priority 2 Actions Implemented - All Priority 3 Actions implemented for Listing Factor A or plans are in place for implementation - AND - - During status reviews assess existing, and identify new actions, and those no longer relevant due to unforeseen or changed circumstances.
Recovery Action Implementation – Monitoring			- Develop a central tracking database for tracking the implementation of all recovery actions at the Population, Diversity Stratum and Recovery Domain/ESU levels.

11.4.6 DATA MANAGEMENT AND REPORTING

All monitoring data must be coordinated in a regional set of databases or distributed data system using a common set of metadata and data dictionaries that fits within an integrated master sample program. This should be housed and maintained in one place by one entity. All entities collecting habitat and fish monitoring data should coordinate their sampling and data collection to fit into a master sample program for the CCC coho salmon ESU.

11.4.7 POST-DELISTING MONITORING

The ESA requires NMFS to monitor delisted species for at least five years post-delisting to ensure that removal of the protections of the ESA does not result in a return to threatened or endangered status. Section 4(g), added to the ESA in the 1988 reauthorization, requires NMFS to implement a system in cooperation with the states to monitor for not less than five years the status of all species that have recovered and been removed from the lists of threatened and endangered {50 CFR 17.11, 17.12, 224.101, and 227.4}. The development of a post-delisting monitoring plan is, thus, a recommended recovery criterion to ensure a plan is in place at the time of delisting.

11.5 ADAPTIVE MANAGEMENT: LEARNING FROM RECOVERY

Adaptive management is a systematic process that uses scientific methods for monitoring, testing, and adjusting resource management policies, practices, and decisions, based on specifically defined and measurable objectives and goals (Panel on Adaptive Management for Resource Stewardship 2011). Adaptive management is predicated on the recognition that natural resource systems are variable, and that knowledge of natural resource systems is often uncertain. Further, the response of natural resources systems to restoration and management actions is complex and frequently difficult to predict with precision. The CCC Coho Salmon Recovery Plan provides both overall goals in the form of viability criteria and a suite of ESU-wide watershed specific recovery actions. However, there is a need to adapt resource management policies, practices and research decisions to changing circumstances, or a better understanding of natural resource systems and their responses.

The success of an adaptive management program depends on coordination among stakeholders and scientists who develop a shared vision for an undefined future together. The development of a guiding image for recovery will aid in an adaptive management program, align interests, and enhance cooperation in a complex recovery plan process. Focusing on fundamental values can help open up possible alternative solutions.

Adaptive management can be applied at two basic levels: the overall goals of the recovery effort, or the individual recovery or management actions undertaken in pursuit of overall goals. The monitoring sections above are intended to address the first application. The following discussion is focused on the second application of the concept of adaptive management.

11.5.1 ELEMENTS OF AN ADAPTIVE MANAGEMENT PROGRAM

While adaptive management must be tailored to action-, site- and impact-specific issues; any effective adaptive management programs will contain three basic components: 1) adaptive experimentation where scientists and others with appropriate expertise learn about ecosystem functions response to recovery or management actions; 2) social learning (through public education and outreach) where stakeholders share in the knowledge gained about ecosystem functions, and 3) institutional structures and processes of governance where people respond by making shared decisions regarding how the ecosystem will be managed and how the natural services it provides will be allocated. Six specific elements associated with adaptive management have been identified (Thomas *et al.* 2001) and explained below.

1st Element: Recovery Action Strategy and Goals are Regularly Revisited and Revised

The recovery strategy and actions should be regularly reviewed in an iterative process to maintain focus and allow revision when appropriate. Progress and implementation of the recovery actions at the ESU, diversity stratum and population scales, should provide a starting point for the adjustment of recovery strategy and goals. The mandatory five-year review process can serve as a means of conveying any needed modification to the overall recovery goals, as well as individual recovery actions.

2nd Element: Model(s) of the System Being Managed

Four types of models are identified in the use of adaptive management program to test hypotheses regarding the effectiveness of recovery actions (Ruckelshaus *et al.* 2008; Levin *et al.* 2009; Tallis *et al.* 2010). These include:

- **Conceptual model:** Synthesis of current scientific understanding, field observation and professional judgment concerning the species, or ecological system;
- **Diagrammatic model:** Explicitly indicates interrelationships between structural components, environmental attributes and ecological processes;
- **Mathematical model:** Quantifies relationships by applying coefficients of change, formulae of correlation/causation; and,
- **Computational Model:** Aids in exploring or solving the mathematical relationships by analyzing the formulae on computers.

River systems are generally too complex and unique for controlled, replicated experiments per traditional scientific models. However, conceptual models based on generally recognized scientific principles can provide a useful framework for refining recovery actions and testing their effectiveness. Diagrammatic models, such as the one used to characterize the parallel and serial linkages in the coho salmon life cycle, can also be used in lieu of formal mathematical models to test hypotheses regarding the effectiveness of recovery actions. Mathematical and computational models themselves have their limitations in the context of an adaptive management program: they are difficult to explain and they require specific assumptions that may be difficult to justify.

3rd Element: A Range of Management Choices

Even when a recovery goal is agreed upon, uncertainties about the ability of possible recovery or management actions to achieve that goal are common. The range of possible recovery or management choices should be considered at the outset. This evaluation addresses the likelihood of achieving management objectives and the extent to which each alternative will generate new information or foreclose future choices. A range of recovery actions and management measures should be considered, either through a planning process or the environmental review process prior to permitting the individual recovery action.

4th Element: Monitoring and Evaluation of Outcomes

Gathering and evaluating data allow testing of alternative hypotheses and are central to improving knowledge of ecological and other systems. Monitoring should focus on significant and measurable indicators of progress toward meeting recovery objectives. Monitoring programs and results should be designed to improve understanding of environmental systems and models, to evaluate the outcomes of recovery actions, and to provide a basis for improved decision making. It is critical that "thresholds" for interpreting the monitoring results are identified during the planning of a monitoring program. This element of adaptive management will require a design based upon scientific knowledge and principles. Practical questions include which indicators to monitor, and when and where to monitor. Guidance on a number of these issues is provided in the sections above regarding research and monitoring.

5th Element: A Mechanism for Incorporating Learning into Future Decisions

This element recognizes the need for protocols and guidance to disseminate information to a variety of stake-holders and a decision process for adjusting various management measures in view of the monitoring findings. Periodic evaluations of a proposed recovery action, monitoring data and other related information, and decision-making should be an iterative process where management objectives are regularly revisited and revised accordingly. Public outreach, including web-based programs, should be actively pursued. Additionally, the mandatory five-year review process can serve as the process for conveying needed modification to the Recovery Plan as well as individual recovery actions.

6th Element: A Collaborative Structure for Stakeholder Participation and Learning

This element includes dissemination of information to a variety of stakeholders as well as a proactive program for soliciting decision-related inputs. This general framework can be a shared vision to develop and pursue restoration that supports a network of viable coho salmon populations while providing sustainable ecological services to the human communities of northern and central coasts of California (NMFS 2010a). Such a vision also provides opportunities for the protection and restoration of other native freshwater and riparian species which form an integral part of the ecosystems upon which coho salmon depend.