Title: Development of a Comprehensive Central Valley Adult Chinook Salmon Escapement Monitoring Plan
Amount Requested: $373,350
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A. Project Description: Project Goals and Scope of Work

1. Problem

Restoration of Central Valley Chinook salmon populations is an important goal of the California Bay-Delta Authority (CALFED) program, Central Valley Project Improvement Act (CVPIA), and several other state and federally-mandated programs. A well-designed monitoring and evaluation program is a critical component of any conservation or restoration activity. Monitoring and evaluation is a key element in the CALFED Adaptive Management process feedback cycle (Figure 1).

Existing adult Chinook salmon escapement monitoring programs in the Central Valley are currently inadequate to estimate population status and evaluate population trends in a statistically valid manner for the following management purposes:

- Providing a sound basis for assessing recovery of listed stocks,
- Monitoring the success of restoration programs,
- Evaluating the contribution of hatchery fish to Central Valley populations, and
- Sustainably managing ocean and inland harvest.

The objective of this proposal is to develop a long-term monitoring plan to estimate population status and trends in abundance of adult Central Valley Chinook salmon at the watershed level in a statistically valid manner. The four Chinook salmon races for which annual estimates of abundance are needed include: fall, late-fall, winter and spring-run. Each race, because of its unique adult run timing and holding conditions, may require different sampling metrics to generate adult population estimates. Each stream will also require development of unique custom escapement monitoring programs, due to the wide variety of habitat types present. While there are recognized needs for improved monitoring of other Chinook life stages, this proposal focuses on the critical need for improved monitoring of adult Chinook returning to Central Valley streams.

The ultimate goal of both the state and federal Endangered Species acts is to delist currently listed species—i.e., to recover them to the point that they are no longer threatened or endangered, at which point they can be removed from the list. For Central Valley salmonids to be delisted, two things are required: 1) a set of criteria has been agreed upon by the listing agency for establishing that recovery has occurred, and 2) a methodology has been implemented to determine whether the species' current (or future) status meets those criteria. NOAA Fisheries has initiated formal recovery planning for listed anadromous

salmonids in the Central Valley domain, pursuant to requirements of the federal Endangered Species Act. (Sacramento River winter-run Chinook – state and federally-listed endangered, Central Valley spring-run Chinook – state and federally-listed threatened, and Central Valley fall/late fall-run Chinook – federal candidate species). Over the next two years, the Central Valley Technical Recovery Team (TRT) will be developing population recovery goals for each listed stock in the Central Valley. Accurate escapement estimates in future years for listed salmon stocks will be essential to monitor progress toward meeting the recovery goals of the plan.

While hundreds of millions of dollars are being spent each year by the CALFED Ecosystem Restoration Program (ERP), CVPIA, and other programs, to restore ecosystems supporting salmon and steelhead populations, current adult escapement surveys are inadequate, as currently designed, to assess progress toward meeting the goals of these programs for increasing natural production of Central Valley Chinook salmon at the watershed scale. Therefore, it cannot be demonstrated with an acceptable degree of precision if restoration money has been wisely spent.

Until recently, hatchery marking programs for Central Valley salmon have been inadequate to evaluate hatchery contribution rates to the Central Valley populations. Currently, an implementation plan for a comprehensive and statistically-sound constant fractional marking and tagging program for hatchery-produced Central Valley salmon is being developed under a CALFED contract (CDFG 1999). Without well-designed recovery programs, however, we will not be able to recover and analyze the marks and tags from returning fish in a statistically valid way. Current tag recovery rates in adult escapement surveys are not adequate to determine hatchery contribution rates or straying rates among streams.

Central Valley fall-run Chinook salmon support major ocean sport and commercial fisheries and inland sport fisheries. Accurate estimates of the numbers of adult Chinook salmon spawning in Central Valley streams (spawner escapement) and harvested in freshwater are critical to sound scientific management of ocean and inland harvest. Currently, salmon escapement estimates in the Central Valley are not accurate enough for development of age-specific models of salmon abundance. Harvest rates for Central Valley stocks are now established based on the unrefined Central Valley Index (CVI), a relationship between 2-year-old and older fish. No information is currently available for the other races of Central Valley Chinook salmon that can be used to estimate ocean abundance and to regulate the ocean fisheries to meet stock rebuilding criteria. If age and race-specific escapement data were available in the Central Valley, as in the Klamath River basin, ocean harvest management could be based on more accurate models and possibly accelerate the recovery of listed stocks.

Monitoring programs for Central Valley salmon must be scientifically defensible. Ultimately, the wider scientific community will make decisions on whether species listed under the ESA (or an evolutionarily significant unit [ESU] of a species) has been recovered, or if ocean harvest goals are being met satisfactorily. Such support is unlikely if data are not collected in a statistically-rigorous way allowing unbiased estimates of trends and abundance.

The state of Oregon has demonstrated that such a monitoring effort can be successfully initiated (e.g. Jacobs et al. 2001). Their “Oregon plan for salmon and watersheds” includes a three-tiered system for estimating the abundance of adult salmon in coastal watersheds. Oregon has demonstrated that a statistically-rigorous monitoring approach is possible. In 2003, NOAA Fisheries and DFG received funding through the Fishery Restoration Grants Program to develop a comprehensive monitoring plan for salmonids in California coastal streams. The plan, to be developed in a series of workshops, will be patterned after the Oregon Plan.

In response to the need to improve escapement monitoring programs in the Central Valley, the Interagency Ecological Program's Central Valley Salmonid Escapement Project Work Team (CVSEPWT) was formed in 2001. The team, which includes biologists working on salmon escapement monitoring surveys throughout the Central Valley, is a satellite team of the IEP Central Valley Salmonid Project Work Team (CVSPWT).

In June 2003, the CALFED Science Program sponsored a Northwest/Central Valley Adult Salmon Escapement Monitoring Workshop. The purpose of this workshop, initiated in discussions of the CVSEPWT, was to provide a forum for biologists from the Pacific Northwest (Columbia River Basin, Puget Sound, and coastal streams) to share their experience with salmon escapement monitoring techniques with biologists working in California's Central Valley, prior to the development of the current escapement monitoring plan for Central Valley salmon. Over 100 scientists, mostly from California, attended the two-day workshop.

This proposal was developed by the CVSEPWT, with review by the parent CVSPWT. Agencies involved in the development of the proposal include California Department of Fish and Game, Department of Water Resources, NOAA Fisheries, U.S. Fish and Wildlife Service, U.S. Bureau of Reclamation, Pacific States Marine Fisheries Commission, Yuba County Water Agency, and East Bay Municipal Water District. Study collaborators include representatives from each of the state and federal fish and wildlife agencies.

Existing Escapement Monitoring Programs in the Central Valley

Existing Central Valley adult salmon escapement monitoring programs are shown in Table 1. Programs have evolved over the years, and vary in methods used, intensity of sampling effort, and reliability of estimates. While mark-recapture carcass surveys are now widely used as the standard method to estimate in-river spawning escapement of most Chinook races, historic data were based on a variety of methods, including carcass surveys, extrapolation based on spatial and/or temporal subsets of an entire run, and expert judgment. For spring-run chinook, snorkel surveys and redd counts have been used to estimate the run size. In some cases, run sizes were been determined from actual live fish counts (e.g., Red Bluff Diversion Dam). For some older data, adequate documentation of sampling and estimation methods does not exist, making it impossible to determine the relative accuracy and reliability of such estimates, or to identify and adjust for sources of bias. The length of the data record varies from run to run, but, in general, data for several runs are available from the early 1950s and in some cases from the 1940s.

The original purpose of most existing programs was to provide general data for ocean harvest management and for evaluating the general status of the individual populations. Surveys were not designed to meet the current broad range of management needs, including recovery of listed stocks, nor to meet rigorous statistical objectives. Some streams have no existing monitoring surveys.

Data from inland harvest surveys are essential to estimating total escapement to the Central Valley; Central Valley sport harvest comprises as much as 21% of the total Chinook salmon spawner escapement into the Central Valley in some years. The Central Valley Salmon and Steelhead Inland Harvest Monitoring Program was initially implemented in the early 1990's. It was funded through a variety of sources including the Federal Aid in Sport Fish Restoration Act and the Central Valley Project Improvement Act. Because funding from these sources was limited, the ability of this program to estimate inland harvest of Chinook salmon and steelhead throughout the Central Valley was never realized. Due to budget cuts, the program was discontinued in 2003.

Adequacy of Existing Survey Methodology

Despite their widespread use in the Central Valley, models to estimate in-river spawning escapement based on mark-recapture carcass survey data require a number of assumptions which may not be met in the surveys. A principal assumption of mark-recapture surveys is that the marked animals will distribute randomly among the population during the interval before the recapture sampling. This assumption is often violated for carcasses, with differing consequences on the final escapement estimate depending on the size of the run, the area sampled, and the degree to which random re-sampling designs are used.

Another assumption in carcass mark-recapture sampling is that all fish are either available for marking or are available for recapture sampling. This assumption is likely not met in large streams with deep pools. In these areas, carcasses may be unavailable to sampling by field crews. This may result in under or over-estimation of the actual run size as it represents an unsampled portion of the run.

An example of these biases is the mark-recapture carcass survey conducted on Battle Creek in the Sacramento River basin. Until 2002, fall-run carcass surveys were typically conducted throughout the spawning period in the six mile spawning reach. Due to the large number of spawners, the survey sometimes took 3 weeks to complete. Time periods were therefore not consistent, violating an assumption of the Schaeffer model used, and biasing the estimate. Coded-wire tag recoveries are also not consistent. Currently, CWT heads are subsampled, but the current subsampling strategy is not statistically random. In 2002, due to an extremely large number of spawners returning, the carcass survey was conducted in only one reach of the stream, and results extrapolated to the entire spawning reach.

Existing programs have not been reviewed for adequacy of statistical power or bias. NOAA Fisheries recovery planning guidance (NOAA 2000) states that a common failing of monitoring and evaluation efforts under the ESA is lack of statistical power. Statistical power can be described as the ability to detect a signal or pattern within a noisy dataset. Lack of statistical power means that the intensity of data collected may be too low, given sampling error and environmental variability, to determine trends and effects with reasonable statistical confidence within time frames that are useful for feedback into management actions. The statistical power of Central Valley salmon escapement monitoring needs to be evaluated to ensure that monitoring adequately assesses progress toward meeting population recovery goals. However, we expect that analysis will substantiate that the current sampling program is inadequate for meeting species de-listing requirements and for evaluating current habitat projects.

In addition, data from existing Central Valley programs have not yet been validated through studies using more than one monitoring method. On Bogus Creek, in the Klamath River basin, a study was conducted to compare estimates made by a carcass survey and a weir count made at the creek mouth (Boydstun 1994). The study found that carcass survey estimates based on the Schaefer (Schaefer 1951) and Jolly-Seber (Seber 1982) models closely estimated the true run size.

In the fall of 2003, four new Central Valley monitoring programs were initiated that may provide further data to evaluate carcass survey estimates. On the lower Stanislaus River, a portable resistance board weir with a Vaki Streamwatcher infrared monitoring system was operated to monitor upstream passage of fall-run Chinook. On the lower Yuba River, a Vaki infrared monitoring system was operated at Daguerre Point Dam to monitor upstream migration of fall-run Chinook. On lower Battle Creek, a weir and video monitoring system was operated throughout the immigration period of fall-run. Video monitoring and trapping continued in 2003 at Woodbridge Dam on the lower Mokelumne River to monitor fall-run escapement. On each of these streams, mark-recapture carcass surveys for fall-run Chinook were also conducted. By comparing the results of the carcass surveys to the weir or dam monitoring, further assessment can be made of the carcass survey estimation method. Analyses of these datasets will be part of the development of the Central Valley monitoring plan (See Subtask 1a).

Currently, data management and reporting in the Central Valley is conducted on a project-by-project basis. No standardized database is available for data storage and retrieval. Most projects prepare an annual report of survey results. However, escapement data and reports are not readily accessible in a timely way by other researchers, stakeholders, or the public.

2. Justification

Monitoring Scales
Monitoring the restoration of Central Valley salmon populations can occur at several scales:

1) **Implementation monitoring** - Determination that restoration actions were implemented as planned.
2) **Project effectiveness monitoring** - Evaluation of the success of individual restoration projects in meeting the goals of the project.
3) **Population monitoring (watershed scale)** - Long-term monitoring and evaluation of population trends in individual watersheds.
4) **Population monitoring (ESU scale)** - Long-term monitoring and evaluation of the status of each ESU throughout its range.
5) **Habitat monitoring** - Monitoring of habitat conditions and evaluation of their effect on salmon populations. (Habitat factors independent of restoration activities, such as oceanic and freshwater environmental fluctuations, will affect salmon population parameters and progress toward recovery.)

CALFED and the CVPIA Anadromous Fish Restoration Program (AFRP) currently require implementation monitoring and project effectiveness monitoring (at scales 1 and 2) to be included in restoration project proposals for funding under the Ecosystem Restoration Program (ERP). Habitat monitoring (scale 5; water temperature, streamflow, etc) is ongoing by several programs and will be linked to monitoring under the current proposal. This proposal specifically addresses planning for critically needed improvement of adult salmon escapement surveys in Central Valley streams to meet needs for population monitoring at the watershed and ESU scales (Scales 3 and 4 above).

Figure 2 illustrates the Chinook salmon life cycle and specific points in the cycle where population monitoring currently occurs in the Central Valley. This proposal focuses on the Immigrating Adult life stage: monitoring of in-river spawning escapement and inland sport harvest.

Conceptual Model
Figure 3 shows the conceptual relationship between stressors and Central Valley Chinook salmon populations. Stressors on salmon populations act to reduce population abundance, population growth rate, spatial structure and diversity. Restoration actions are on-going to reduce key stressors and improve these population parameters.

Figure 4 illustrates a conceptual model relating recovery programs, restoration actions, and monitoring of Central Valley Chinook salmon populations. The model shows the hypothesis that restoration actions for Central Valley Chinook such as those currently being implemented through CVPIA AFRP, CALFED ERP, and mitigation programs, will improve degraded habitat conditions that result in decreased populations. Implementation of restoration actions is designed to reduce stressors and restore and enhance habitat conditions. However, it is only through well-designed, statistically valid field monitoring

activities that informed adaptive management decisions can be made. Estimates of abundance of adult and juvenile Chinook salmon are essential for monitoring the cumulative effects of recovery actions, and data are critical to evaluation of the achievement of population doubling goals and/or delisting criteria.

The statistical approach used in this proposal to develop the Central Valley Escapement Monitoring Plan will provide data to evaluate the following causal linkages between management activities and Central Valley Chinook salmon population status and trends:

- Are restoration actions for Central Valley Chinook salmon funded by CALFED and others successful in restoring Central Valley salmon populations at a stock-specific population scale?
- How are inland and ocean harvest regulations affecting Central Valley Chinook salmon populations? Are conservation objectives for listed stocks in ocean fisheries being met? Can new or improved ocean harvest models be used to better manage Central Valley Chinook salmon populations?
- What is the contribution rate of hatchery fish to overall production of Central Valley Chinook salmon? What is the straying rate of hatchery compared to wild fish on return? How do changes in hatchery operations affect Chinook salmon populations?
- Are recovery goals for listed Central Valley salmon stocks being met on a stock-specific population scale?

Hypotheses

Hypotheses to monitor population status and trends were derived based on the above management needs. In this monitoring plan, there will be two types of signals to detect: 1) Trends—increases or decreases in abundance over time. Ideally, we would like to be able to detect trends at both the watershed and ESU scales, and 2) Status—abundance within a watershed at a particular point in time. More specifically, as part of the development of the plan, we will identify the monitoring effort that would be required to test the following hypotheses with a high degree of statistical power:

1) Instream spawner abundance and inland harvest in each watershed can be estimated with a precision of 25% (standard error of 25% or less of the estimate).
2) Escapement of each stock has changed by 25% from the preceding cohort return.
3) Escapement differs by 25% between two watersheds.
4) The contribution rate of hatchery-origin fish to total spawner escapement in each watershed can be estimated with a precision of 25%.
5) Straying rates of hatchery-origin vs. wild fish can be estimated with a precision of 25%.
6) Conservation objectives established for listed stocks (in ocean harvest management) are being met.
7) Abundance in each watershed is above the thresholds set by recovery goals for listed stocks.
8) There is negligible extinction risk over a 100-year period for populations in each watershed.

The ability to test similar hypotheses at the ESU level is also critical, as well as to use the data as a baseline for watershed and ESU-level effectiveness monitoring of restoration efforts. There is a certain degree of conflict between these multiple goals; we expect that the final plan will include a description of the tradeoffs between them in terms of effort, sampling design, and statistical power.

Monitoring the recovery of Central Valley Chinook salmon needs to be scientifically defensible. Data must be collected and analyzed in a statistically rigorous manner to allow unbiased estimates of trends and

abundance. The state of Oregon has demonstrated that such a monitoring effort can be successfully initiated (e.g. Jacobs et al. 2001). Their "Oregon plan for salmon and watersheds" includes a three-tiered system for estimating the abundance of adult salmon in coastal watersheds. It also includes targeted studies of juvenile abundances and habitat. In the 1990s, Oregon developed a specific monitoring approach based on stratified-random sampling; this method was much more accurate than previous methods based on "index reaches," and is being used to monitor adult coho salmon abundance. Oregon has thus demonstrated that a statistically-rigorous monitoring approach is possible. The benefit of such an approach is that it delivers unbiased estimates of trends and abundance in salmonid stocks.

A thorough statistical review of methods currently used in Central Valley escapement surveys is needed. Sampling designs need to be reviewed and recommendations made for improvement of existing programs. New programs need to be developed as needed on streams with no existing escapement surveys.

3. Approach

A project team consisting of a project coordinator, biologist/planner, database specialist, and biometrician/statistician with a high degree of familiarity with salmon escapement monitoring techniques will develop a Central Valley Adult Chinook Salmon Escapement Monitoring Plan. The plan will include:

- Monitoring program objectives
- Use of escapement data in management and restoration planning
- Existing study designs, field, data analysis, and reporting techniques
- Proposed study designs, field, data analysis, and reporting techniques
- Summary tables

See Table 2 for a detailed outline of the Plan.

Nineteen Central Valley watersheds currently support spawning and rearing habitat for Chinook salmon. The following watersheds will be included in the plan:

Upper Sacramento River Basin

Upper Sacramento River
Clear Creek
Cow Creek
Cottonwood Creek
Battle Creek
Antelope Creek
Butte Creek
Big Chico Creek
Beegum Creek
Deer Creek
Mill Creek

Lower Sacramento River Basin

Yuba River
Feather River
American River

Delta Tributaries

Cosumnes River
Mokelumne River

San Joaquin River Basin

Stanislaus River
Tuolumne River
Merced River

All steps in the development of the plan will be closely coordinated with the CVSEPWT, CVSPWT, and the NOAA Fisheries Central Valley Technical Recovery Team. Development of the plan also will be closely coordinated with development of the California Coastal Salmonid Monitoring Plan.

Proposed work is divided into four primary tasks described below:

Task 1. **Review of Existing Programs.** Project team will review study methodology (sampling design, field and data analysis protocols) proposed and currently used to estimate in-river spawning escapement and in-river harvest in each of the watersheds listed above; the statistical validity of escapement estimates based on these surveys will be evaluated.

Subtask 1a. Project team will conduct a series of meetings with sub-teams of the CVSEPWT. Sub-teams will consist of biologists familiar with existing in-river salmon spawning surveys in each of the watersheds. The project team will document and conduct a comprehensive review of existing escapement monitoring techniques, including study designs, field methods (including coded-wire tag recoveries, otolith, and scale collections), laboratory analysis methods of scales, otoliths and coded-wire tags, data analysis methods, estimation models used, data storage, and data reporting techniques.

The project biostatistician will analyze the statistical validity of Central Valley escapement estimates based on existing surveys. Biases in existing survey estimates will be thoroughly evaluated.

Several existing data sets will be comprehensively reviewed in this subtask. The weir/dam escapement monitoring and carcass surveys conducted on the lower Mokelumne, Yuba, Stanislaus rivers, and Battle Creek in the fall of 2003 will provide data sets for comparing the methodologies and assessing the accuracy of the carcass survey method in Central Valley streams. Department of Water Resources staff has also collected intensive carcass survey data on the lower Feather River that may allow detailed analysis of the problems with mark-recapture methods in estimating escapement.

Subtask 1b. The project team will meet with staff from the former Central Valley Inland Harvest Program to document and conduct a thorough review of the inland harvest program discontinued in 2003.

Subtask 1c. The project team will meet with staff from the CDFG Ocean Salmon Project to determine needs for Central Valley salmon escapement data in the development of improved models for ocean harvest management.

Subtask 1d. The project team will meet with restoration project leaders to determine needs for escapement estimates to meet restoration project evaluation goals.

Subtask 1e. Staff will meet with appropriate NOAA Fisheries staff to identify recovery criteria for listed stocks and appropriate sample sizes needed to evaluate changes in population status and abundance trends in those stocks.

Subtask 1f. Project staff will meet with DFG and NOAA Fisheries staff regarding the status of genetic studies and the archiving of genetic samples for Central Valley stocks.

Task 2. **Development of Revised Monitoring Programs.** Based on a comprehensive review of existing Central Valley adult salmon escapement monitoring methods in Task 1, project team will develop and document revised or new statistically-sound sampling, data analysis, data storage, and reporting protocols for in-river spawning escapement and in-river harvest surveys in each Central Valley watershed listed above, in close coordination with project collaborators, the CVSEPWT and the CVSPWT. Revised programs will be designed to integrate with the constant fractional marking program at Central Valley hatcheries, currently under development. Development of revised monitoring programs also will be closely coordinated with development of the coastal salmonid monitoring plan. Each Chinook salmon race, because of its unique adult run timing and holding conditions, may require different sampling metrics to generate adult population estimates. Each stream will also require development of unique escapement monitoring programs, due to the wide variety of habitat types present.

Subtask 2a. Project team will develop and document revised or new instream escapement and harvest monitoring programs, including field, laboratory, and data analysis methods.

Subtask 2b. Project team will develop statistically valid coded-wire tag recovery, otolith and scale aging programs for each Central Valley watershed as integral components of in-river spawning escapement and harvest monitoring programs. The coded-wire tag recovery program will integrate with the constant fractional marking program currently under development for Central Valley hatcheries.

Subtask 2c. Database expert on project team will develop a coordinated data management system and procedures for analysis of Central Valley salmon escapement monitoring data (escapement estimates, coded-wire tag recoveries, aging data), in coordination with CDFG, NOAA Fisheries, USFWS, PSMFC, and the CALFED Science Program.

Subtask 2d. Project team will develop a consistent, integrated data reporting and communication system for Central Valley salmon escapement monitoring data, in coordination with CDFG, NOAA Fisheries, USFWS, PSMFC, and the CALFED Science Program.

Task 3. **Development of Cost Estimates.** In coordination with the CVSEPWT, project team will develop cost estimates for implementing revised and new instream escapement and inland harvest monitoring programs, including field, laboratory, data management and data reporting. Potential funding sources and funding priorities for each monitoring program will be identified.

Task 4. **Project Management and Reporting**. Project team will prepare quarterly reports, and draft and final versions of the Central Valley Adult Salmon Escapement Monitoring Plan.

Subtask 4a. Project team will submit quarterly fiscal and programmatic reports by the 10th day of the month following the end of each quarter (January, April, July, and October). The reports will summarize the activities and expenditures, separated to specific task level performed during the previous quarter.

Subtask 4b. Project team will prepare and submit draft Central Valley Adult Salmon Escapement Monitoring Plan to the CVSEPWT, CVSPWT, and the NOAA Fisheries Central Valley Technical Recovery Team, for review.

Subtask 4c. Project team will revise draft Monitoring Plan based on comments of the teams listed in Subtask 4b. Project team will prepare and submit final Central Valley Adult Salmon Escapement Monitoring Plan.

Task 5. **Program Review.** At five year intervals, programs implemented through this plan will be reviewed by an independent science panel. Funding for this review is not included in the current proposal.

4. Feasibility

The proposed approach will be both feasible and appropriate to the development of the proposed plan. The proposed work and completion schedule is commensurate with development of previous large-scale plans for Central Valley Chinook salmon.

The CDFG, USFWS, and NOAA Fisheries, study collaborators, are well experienced to guide the development of a Central Valley Chinook Salmon Escapement Monitoring Plan. Biologists have extensive field and data analysis experience with Central Valley escapement surveys.

Since the proposal only includes development of a plan, no permits or agreements will be necessary to complete the tasks. No landowner access is required.

5. Performance Measures

Performance measures for development of this monitoring plan will include:

1) Project activities: Quarterly fiscal and programmatic progress reports (described in Section 7 below). Activities will be measured by the number of meetings held with sub-teams of the Central Valley Escapement Project Work Team, number of stream survey methodologies reviewed, and number of revised methodologies recommended.
2) Project outputs: The primary output of the proposed project is a comprehensive escapement monitoring plan for Central Valley Chinook salmon (described in Section 7).
3) Project outcomes: The proposed plan will provide guidance for revision of Central Valley salmon escapement and harvest monitoring surveys which will improve understanding of Chinook salmon population parameters.
4) Environmental indicators: The proposed plan will provide improved environmental indicator metrics for Central Valley Chinook salmon populations.

6. Data Handling and Storage

No data will be generated as a result of development of the Escapement Monitoring Plan. However, the plan will include a specific data management element (Task 2c). That element of the plan will include a detailed description of how Central Valley salmon escapement data will be managed upon implementation of the plan, from field collection to storage in centralized databases.

7. Expected Products/Outcomes

Quarterly fiscal and programmatic reports will be submitted by the 10th day of the month following the end of each quarter (January, April, July, and October). The reports will summarize the activities and expenditures, separated to specific task level, that were performed during the previous quarter.

As described in Section 3, the plan development team will meet with sub-teams of the Salmon Escapement Project Work Team to discuss existing escapement survey methodologies and potential revised methodologies for each Central Valley watershed.

As described in Section 3, at the end of the planning period, a Central Valley Escapement Monitoring Plan will be provided.

8. Work Schedule

Table 3 outlines start dates, milestones, timeline, and completion dates for each task and subtask on a relative month basis (assuming the contract begins January 2005). Work will be conducted over an 18-month period. Adjustments will be made as needed, should the contract start at an alternate date.

B. Applicability to CALFED ERP and Science Program Goals, Implementation Plan, CVPIA Priorities, and Other Programs

1, 2. ERP, Science Program and CVPIA Priorities and Relationship to Other Ecosystem Restoration Projects.

As stated earlier, this proposal responds to the following management needs for Central Valley Chinook salmon:

A. Providing a sound basis for assessing recovery of listed stocks
B. Monitoring the success of restoration programs
C. Evaluating the contribution of hatchery fish to Central Valley populations
D. Sustainably managing ocean and inland harvest

In responding to these needs, this proposal has direct applicability to CALFED ERP and Science Program goals, the Implementation Plan, CVPIA priorities, and other programs, as described below.

A. Provide a sound basis for recovery planning – The ultimate goal of both the State and Federal Endangered Species acts is to delist currently listed species—i.e. to recover them to the point that they are no longer threatened or endangered, at which point they can be removed from the list. For Central Valley salmonids to be delisted, two things are required: 1) a set of criteria has been agreed upon by the listing agency for establishing that recovery has occurred, and 2) a methodology has been implemented to determine whether the species' current (or future) status meets those criteria.

NOAA Fisheries has initiated formal recovery planning for listed anadromous salmonids in the Central Valley domain, pursuant to requirements of the federal Endangered Species Act. Over the next two years, the Central Valley Technical Recovery Team (TRT) will be developing population recovery goals for each listed stock in the Central Valley. Accurate escapement estimates in future years for listed stocks will be essential to monitor progress toward meeting the recovery goals of the plan. The Viable Salmonid Populations (VSP) concept (McElhany et al. 2000), developed by NOAA Fisheries scientists, will be used by the TRT as a framework for establishing biological delisting goals for Central Valley stocks. The VSP concept is designed to facilitate establishment of ESU-level delisting goals by identifying key parameters related to population viability (abundance, productivity, spatial structure, diversity), providing guidance on how these parameters should be evaluated, and finally relating the viability of individual populations to the viability of the ESU as a whole. The TRT will also identify research, monitoring, and evaluation needs. The monitoring plan described in this proposal will be developed in close coordination with the Central Valley TRT.

B. Monitor the success of restoration programs (CALFED/CVPIA/State of California) – Several state and federal programs have a mandate to increase the natural production of salmon and steelhead in the Central Valley. The 1988 California Salmon, Steelhead Trout, and Anadromous Fisheries Program Act (Fish and Game Code Sections 6900-6924) declares that it is the policy of the state to significantly increase the natural production of salmon and steelhead trout by the end of the century. The federal Central Valley Project Improvement Act (1992) directs the Secretary of the Interior to develop and implement programs and actions to ensure that by 2002, the natural production of anadromous fish in Central Valley streams will be sustainable, on a long-term basis, at levels at least twice the average levels of natural production in the 1967 through 1991 baseline period. The CALFED Bay-Delta Program, ERP, was established to help restore and improve the health of the Bay-Delta system for all native species. The CALFED Record of Decision (2000) states that to be successfully implemented and to achieve Multi-

species Conservation Strategy-Ecosystem Restoration Program (MSCS-ERP) milestones, the ERP must have at least $150 million from dedicated funding sources annually through Stage 1.

While hundreds of millions of dollars are being spent each year by both the state and federal agencies under these programs to restore ecosystems supporting salmon and steelhead populations, current adult escapement surveys are inadequate to assess progress toward meeting the goals of these programs for increasing natural production of Central Valley Chinook salmon. We therefore cannot demonstrate if restoration money has been wisely spent. A recent CALFED-funded statistical study of Central Valley salmon escapement data concluded,

> **"Improving the quality of escapement estimates may be the most beneficial management action that can be taken to increase the chance of determining whether or not progress is being made toward the CVPIA objective of doubling natural production." (Newman 1999)**

In 1998, the CALFED Comprehensive Monitoring, Assessment and Research Program (CMARP) was established, in part, to design and recommend a monitoring program to provide data to assess the success of CALFED restoration actions in the Bay-Delta system. Recommended research and monitoring programs for adult Chinook salmon (CMARP 1999) include:

- **Begin new escapement surveys on streams not now surveyed,**
- **Analyze scales to determine age in escapement, and**
- **Evaluate alternative methods other than carcass surveys to estimate escapement.**

Salmon monitoring programs recommended by CMARP program in 1999 have not yet been funded.

The CALFED Program MSCS-ERP milestones (2000) include:

> **"Through the use of existing, expanded, and new programs, monitor adult anadromous salmonid returns in each watershed within the MSCS focus area. Monitoring techniques, data compilation and analysis, and reporting should be standardized among researchers and watersheds to the greatest extent possible."**

This proposal directly responds to two key goals of the CALFED Ecosystem Restoration Program's (ERP) Draft Stage 1 Implementation Plan (CALFED 2001):

- **At-Risk Species (Goal 1): Achieve recovery of at-risk native species dependent on the Delta and Suisun Bay as the first step toward establishing large, self-sustaining populations of these species; support similar recovery of at-risk native species in the Bay-Delta estuary and its watershed; and minimize the need for future endangered species listings by reversing downward population trends of native species that are not listed.**
- **Harvestable Species (Goal 3): Maintain and/or enhance populations of selected species for sustainable commercial and recreational harvest, consistent with the other ERP strategic goals.**

Sacramento River winter-run Chinook and Central Valley spring-run Chinook are at-risk native species. Central Valley Chinook also support large sport and commercial fisheries.

The CALFED ERP Implementation Plan (2001) also includes as a CALFED Science Program Goal:

> **"*Coordinate and extend existing monitoring*. A strength of the CALFED Program is the monitoring systems already in place in the system. Common questions and subsequent investments are needed to tie together the existing monitoring. New monitoring efforts are needed in some types of environments. Pilot projects testing new monitoring approaches will be an important part of this effort."**

The CALFED ERP Implementation Plan, in its identification of restoration priorities for the Sacramento Region, also included:

> **"*Annual population estimates*. Annual estimates of fish populations on the Sacramento River are a key ingredient in management actions to protect fish in the Delta. A strong need exists to understand and reduce the uncertainties in those estimates via more field studies, and data analysis as well as applying advanced field methodologies and modeling capabilities. Models and basic studies that might allow better connection of management actions and specific stressors to population responses of key species of native fish are critical to managing fish protection and water supplies (Strategic Goal 1, At-risk Species Assessments)."**

The more recent Draft CALFED ERP Indicators Report for Central Valley Chinook Salmon (CALFED 2002) identifies the inadequacies with existing salmon escapement monitoring and concludes:

> **" Population estimates should be statistically rigorous and comparable throughout the system. This will require a substantial investment in improving sampling and data analysis methods, an effort that has just begun through the Salmon Escapement Project Workteam. "**

C. Evaluate the contribution of hatchery fish to Central Valley populations - To evaluate the relative contribution of hatchery fish to chinook salmon populations in the Central Valley, CDFG and USFWS plan to implement a program of constant fractional marking for hatchery-reared Central Valley salmon. Currently, an implementation plan for a comprehensive and statistically-sound marking and tagging program for hatchery-produced Central Valley chinook salmon is being developed under a CALFED contract (CDFG 1999). The tagging of a large proportion of fish began on a pilot basis in 2000. Without statistically designed recovery programs, however, we will not be able to recover and analyze the tags from returning fish in a valid way. Current recovery rates in adult escapement surveys are not adequate to determine hatchery contribution rates, or straying rates. This proposal is therefore an essential component of the Constant Fractional Marking program.

A joint National Marine Fisheries Service/Department subcommittee on hatchery evaluation recently submitted recommendations to the agencies that included the development of adequate sampling programs to recover marked fish in the Central Valley:

> **"The DFG should establish a process to coordinate and oversee the methodologies for estimating salmon escapements to the Central Valley. The process should:**
>
> **1) establish standardized techniques for estimating the size and age-composition of spawning runs;**
>
> **2) standardize the training of stream crews to ensure the goals of CWT sampling are met;**
>
> **3) develop strategies for improving the recovery rate of CWTs in the river recreational fishery." (CDFG/NMFS 2001)**

The CALFED Program MSCS-ERP milestones include:

> **"Assess the impact of hatchery practices on naturally spawning populations of chinook salmon and steelhead and operate hatcheries in a manner consistent with safe genetic practices that will maintain genetic integrity of all Central Valley anadromous salmonid populations."**

The CALFED CMARP report (1999) also includes the following recommendations:

- **Implement a constant fractional marking program for Central Valley chinook salmon, and**
- **Standardize data recording for carcass surveys such that the number of fish examined for marks and tags are consistently recorded and reported on an annual basis.**

D. Contribute to sustainable ocean harvest management – Ocean salmon harvest of Central Valley stocks is managed according to an annual plan developed by the Pacific Fishery Management Council (PFMC) and approved by the Secretary of Commerce. The annual plan provides spawning escapement goals that drive ocean sport/commercial and inland sport harvest regulations. The PFMC uses inland escapement data from spawning surveys and the inland harvest survey to make important management decisions.

Currently, salmon escapement estimates in the Central Valley are not accurate enough for development of age-specific models of salmon abundance. Harvest rates for Central Valley stocks are now established based on the unrefined Central Valley Index, a relationship between 2-year-old and older fish. No information is currently available for the other races of Central Valley Chinook salmon that can be used to estimate ocean abundance and to regulate the ocean fisheries to meet stock rebuilding criteria. If age and race-specific escapement data were available in the Central Valley, as in the Klamath River basin, ocean harvest management could be based on more accurate models and possibly accelerate the recovery of listed stocks. Sustainable ocean and inland harvest is a goal of the CALFED program.

3. Requests for Next-Phase Funding. This proposal is not a request for next-phase funding.

4. Previous Recipients of CALFED Program or CVPIA funding. The Pacific States Marine Fisheries Commission is not a previous recipient of CALFED or CVPIA funding for Chinook salmon work in California.

5. System-Wide Ecosystem Benefits. Because of the wide distribution of Chinook salmon in the Central Valley and the broad scope of the proposed planning effort, this work will have system-wide benefits.

6. Additional Information for Proposals Containing Land Acquisition. The current proposal does not include land acquisition.

C. Qualifications

The CDFG, USFWS, and NOAA Fisheries, study collaborators, are well experienced to guide the development of a Central Valley Chinook Salmon Escapement Monitoring Plan. Biologists have extensive field and data analysis experience with Central Valley escapement surveys.

D. Cost

1. Budget. Proposed budget is shown in Table 4. The total cost requested for this proposal is $373,350. This cost is based on an 18-month planning period.

Cost Sharing. There are no cost-sharing requirements for the proposed project. However, cost-sharing will occur in the form of in-kind services of permanent staff time, equipment, and facilities and through the dedication of miscellaneous resources available from the agencies involved in the CVSEPWT. Specifically, it is estimated that the project collaborators at CDFG, NOAA Fisheries, and USFWS will provide approximately 15% time, or 1,900 hours of permanent biologist staff time over the course of the study to meet with the project team, provide study guidance, and assist the project team in preparation of the plan. Staff time for project collaborators is estimated at approximately $56,000. Several other biologists from Department of Water Resources, U.S. Bureau of Reclamation, Yuba County Water Agency, and East Bay Municipal Water District, involved in Central Valley spawning escapement surveys, will also attend meetings with the project team, review the draft plan, and provide general project guidance. Staff time for these agency biologists is estimated at $40,000.

E. Local Involvement

Field personnel conducting existing salmon escapement surveys will continue to provide contact with local watershed organizations and governments as appropriate through the proposed planning period.

There will be no third-party impacts. The proposal includes planning activities only, no field activities.

F. Compliance with Standard Terms and Conditions

The applicant has reviewed the State and Federal standard terms contained in Attachments D (state) and E (federal) and will comply with all terms.

G. Literature Cited

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Figure 1. Adaptive Management Process for Restoration of Central Valley Chinook Salmon Populations

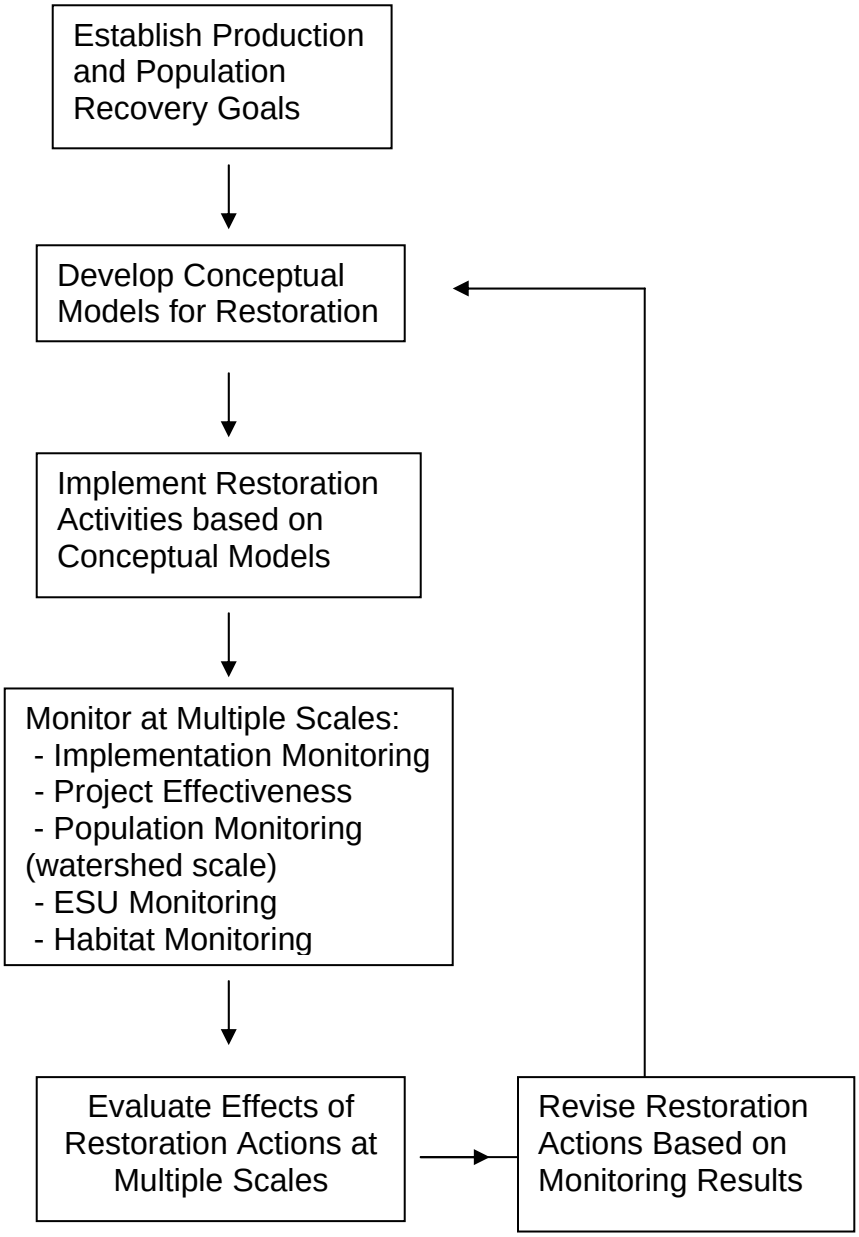


Figure 2. Central Valley Chinook Salmon Monitoring by Lifestage.

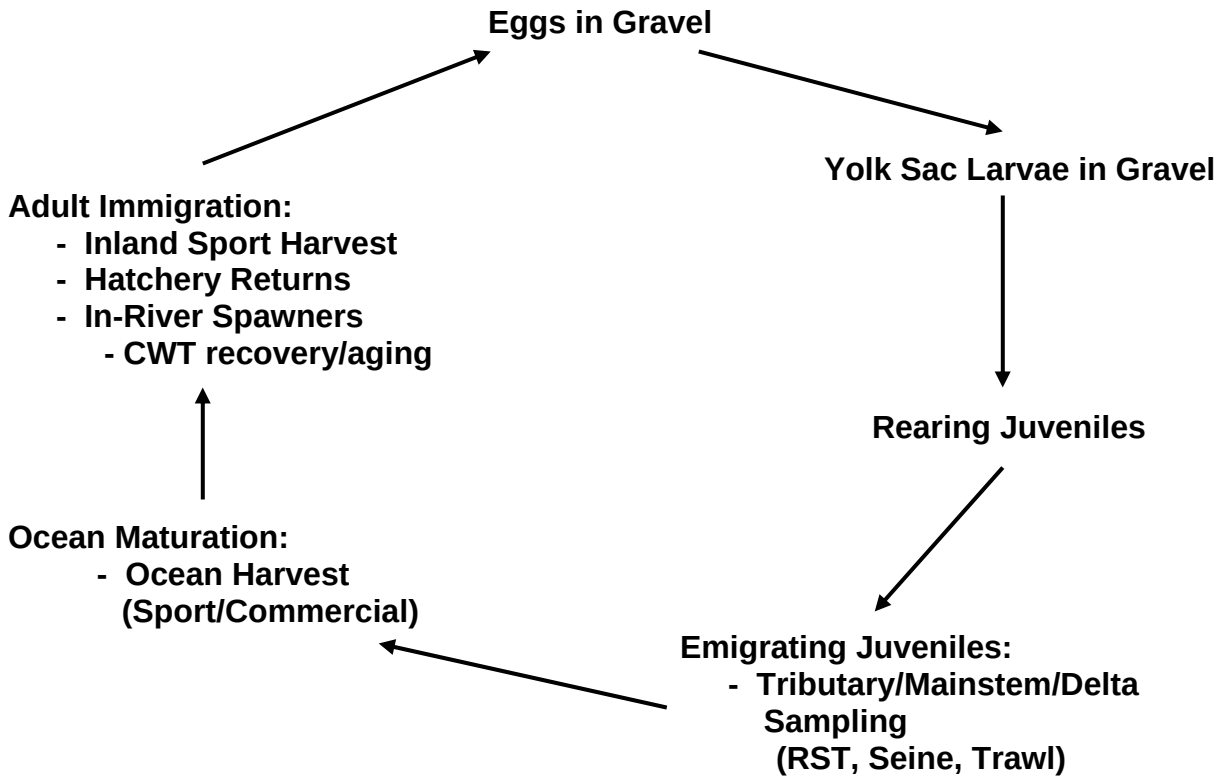
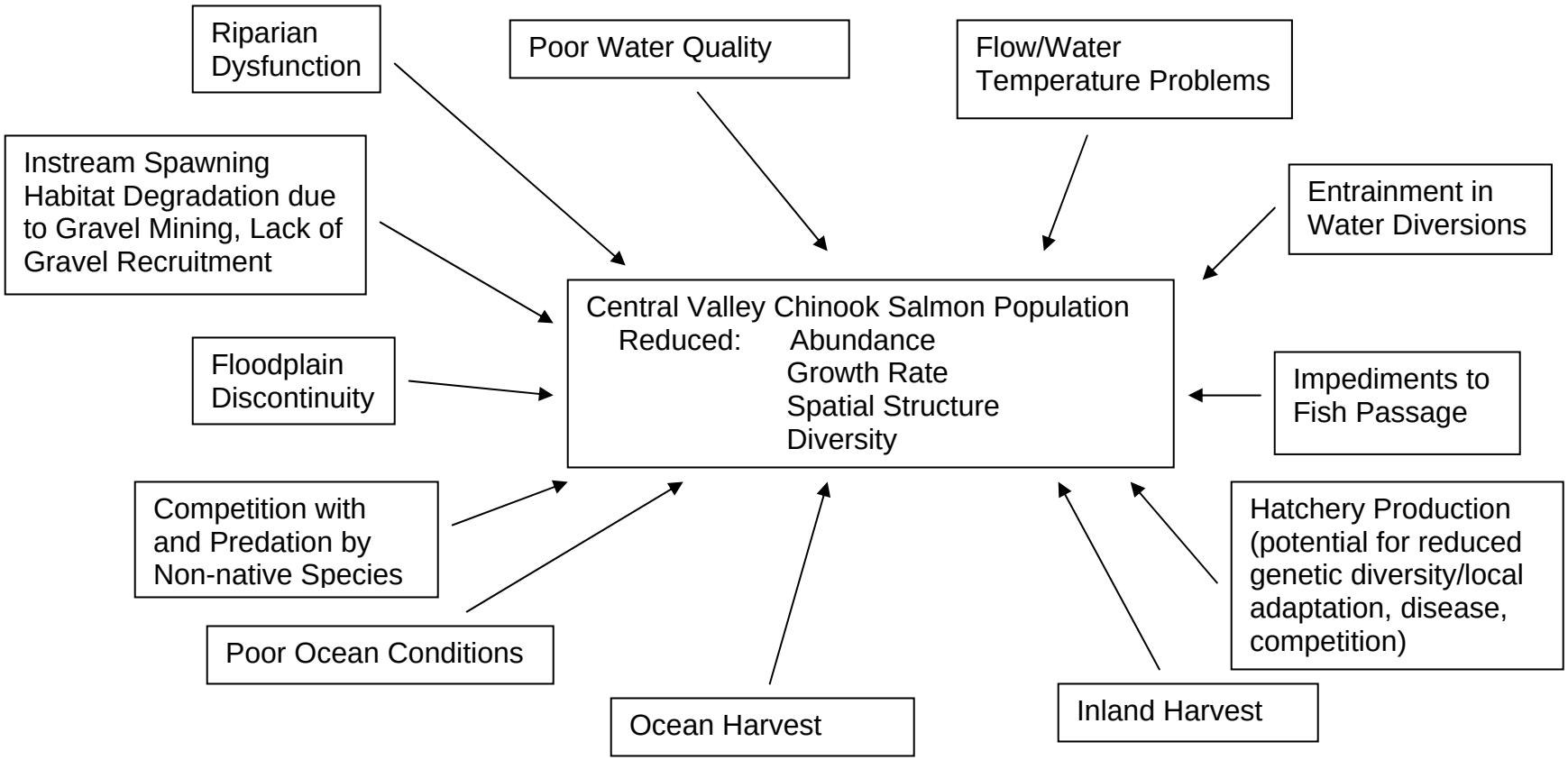


Figure 3. Conceptual relationship between stressors and Central Valley Chinook salmon population parameters.



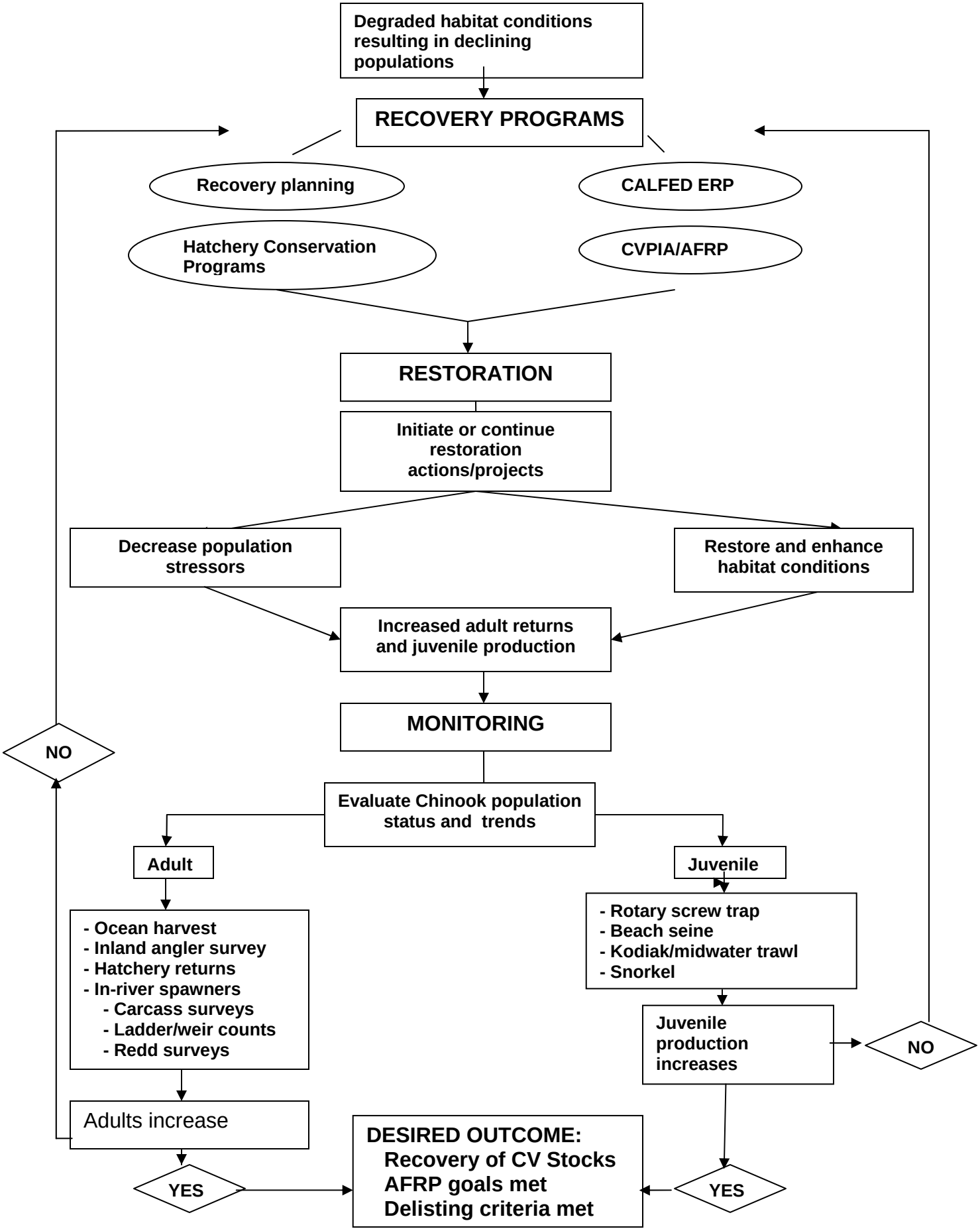


Figure 4. Conceptual model relating Central Valley Chinook salmon restoration and monitoring programs.

Table 1. Existing Central Valley Adult Salmon Escapement Monitoring Programs

Stream	Species/run	Monitoring Method	Variable Measured	Agency
UPPER SACRAMENTO RIVER BASIN				
Upper Sacramento River	Chinook	Carcass counts	Annual escapement (fall, late-fall, and winter-run)	CDFG/USFWS
		RBDD ladder counts	Annual escapement (fall, winter-run)	USFWS
		Trapping (Keswick Dam)	Adult returns (winter-run)	USFWS
		Aerial redd surveys	Spawning distributions (all runs)	CDFG (NOAA Fisheries funding for winter-run)
Clear Creek	Chinook (Fall-run)	Carcass survey	Annual escapement	CDFG/USFWS
	Chinook (Late fall-run)	Carcass survey	Annual escapement	USFWS
	Chinook (Spring-run), Steelhead	Snorkel survey	Annual escapement	USFWS
	Chinook (Fall, late-fall, spring-run), Steelhead	Redd counts	Annual escapement	USFWS
Battle Creek	Chinook (fall-run)	Carcass survey	Annual escapement	CDFG
		Video monitoring	Annual escapement	USFWS/CDFG
		Hatchery counts	Annual returns	USFWS
	Chinook (Late-fall, spring, winter-run), Steelhead	Barrier weir trap	Annual escapement	USFWS
	Chinook (Spring, winter-run), Steelhead	Snorkel survey	Annual escapement	USFWS
		Redd survey	Annual escapement	USFWS
Antelope Creek	Chinook (spring-run)	Snorkel survey	Annual escapement	CDFG
Butte Creek	Chinook (Fall and spring-run)	Carcass survey	Annual escapement	CDFG
	Chinook (Spring-run)	Snorkel survey	Annual escapement	CDFG

Stream	Species/run	Monitoring Method	Variable Measured	Agency
Big Chico Creek	Chinook (Spring-run)	Snorkel survey	Annual escapement	CDFG
Beegum Creek	Chinook (Spring-run)	Snorkel survey	Annual escapement	CDFG
Deer Creek	Chinook (Spring-run)	Snorkel survey	Annual escapement	CDFG
Mill Creek	Chinook (Spring-run)	Redd counts	Annual escapement	CDFG
LOWER SACRAMENTO R BASIN				
Yuba River	Chinook (fall-run)	Carcass counts	Annual escapement	YCWA/JSA
	Chinook (fall, spring-run), Steelhead	Infrared (Vaki) monitoring at Daguerre Pt. Dam	Annual escapement	DFG/USFWS
	Chinook (spring-run)	Redd counts	Spawning distribution	CDFG
Feather River	Chinook	Carcass counts	Annual escapement (fall-run)	DWR/DFG
		Aerial photo survey with ground truthing	Spawning distribution vs flow & escapement	
		Hatchery counts	(Fall and spring-run)	CDFG
	Steelhead	Hatchery counts		CDFG
		Coded Wire Tagging		
American River	Chinook	Carcass counts	Annual escapement (fall-run)	CDFG
		Aerial redd surveys	Spawning habitat use relative to flow conditions	CDFG
		Hatchery counts	Annual returns	CDFG
	Steelhead	Hatchery Counts	Annual returns	CDFG
		Coded Wire Tagging		
	Steelhead	Redd surveys	Annual escapement/spawning distribution	DFG/USBR
DELTA TRIBUTARIES				
Cosumnes River	Chinook	Aerial redd survey		CDFG
		Carcass and redd surveys		TNC

Stream	Species/run	Monitoring Method	Variable Measured	Agency
Mokelumne River	Chinook (fall-run)	Ladder counts / video monitoring	Annual escapement	EBMUD
		Carcass survey	Annual escapement	EBMUD
		Redd counts	Spawning distribution	EBMUD
		Hatchery count	Adult returns (fall and late fall-run)	CDFG
	Steelhead	Ladder counts / video monitoring	Annual escapement	EBMUD
		Redd counts	Spawning distribution	EBMUD
		Hatchery count	Monitor adult returns	CDFG
SAN JOAQUIN RIVER BASIN				
Stanislaus River	Chinook (fall-run)	Carcass counts	Annual escapement	CDFG
		Redd surveys	Spawning distribution	CDFG
	Chinook (fall-run), Steelhead	Weir counts (Vaki infrared monitoring)	Annual escapement	S.P. Cramer and Associates
Tuolumne River	Chinook (fall-run)	Carcass counts	Annual escapement	CDFG
		Redd surveys	Spawning distributions	CDFG
Merced River	Chinook (fall-run)	Carcass counts	Annual escapement	CDFG
		Redd surveys	Spawning distributions	CDFG
		Hatchery counts		CDFG

Table 2. Outline of Central Valley Chinook Salmon Adult Escapement Monitoring Plan

A. Introduction

B. Monitoring Program Objectives

C. Range and Distribution (Central Valley Basin Maps)

1. Current Chinook Salmon Range by Run
2. Spawning Reaches

D. Use of Escapement Data

1. Ocean Harvest Management
2. Inland Harvest Management
3. Recovery Planning for Listed Stocks
4. Monitoring Success of Restoration Programs

E. Existing Escapement Monitoring Programs (Instream Escapement Surveys, Inland Harvest Surveys, and Hatchery Counts)

1. Field Methods
   a) Time periods/reaches sampled
   b) Field Forms
   c) CWT recovery protocol
   d) Biological data protocol (sex, length, scale, otolith, genetic tissue samples)
   e) Public relations
   f) Safety procedures
2. Laboratory Analysis
   a) CWT analysis
   b) Scale and otolith aging
3. Data Storage
   a) Escapement database
   b) CWT, age database
4. Estimation Methods
   a) Model(s) used
   b) Accuracy of estimates
5. Data Reporting
6. Survey Cost
7. Funding Source
8. Years of historic data available
9. Responsible entities/contact information

F. Proposed Monitoring Programs (by Program):

1. Description of Need
2. Field Methods
    a) Dates/reaches to be sampled
    b) Field Forms
    c) CWT recovery protocol
    d) Biological data protocol (sex, length, scale, otolith, genetic tissue samples)
    e) Public relations
    f) Safety procedures
3. Laboratory Analysis
    a) CWT analysis
    b) Scale and otolith aging
4. Data Storage
    a) Escapement database
    b) CWT database
5. Estimation Models
    a) Model(s) used
    b) Target accuracy of estimates
6. Data Reporting
7. Estimated Survey Cost
8. Potential Funding Sources

G. Summary Tables

1. Existing Monitoring Programs
    (Project Title, Year of Initiation, Reporting, Responsible Entity, Contacts, Funding Source, Cost)
2. Proposed Monitoring Programs
    (Project Title, Proposed Responsible Entity, Potential Funding Source, Estimated Cost)

H. Literature Cited

Table 3. Timeline for Development of Central Valley Chinook Salmon Escapement Monitoring Plan. (Relative Schedule and Milestone dates assuming contract signed January 2005)

Task	Task Title	Relative Milestones: Month 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Relative Completion Schedule
	Sign Contract																			January 2005
1	**Review Existing Programs**																			
1a.	Review existing in-river escapement surveys																			March 2005 – June 2005
1b.	Review CV Inland Harvest Program																			March 2005 – June 2005
1c.	Determine data needs for CV ocean harvest modeling																			March 2005 – June 2005
1d.	Determine needs for restoration project evaluation																			March 2005 – June 2005
1e.	Determine recovery criteria for listed stocks																			March 2005 – June 2005
1.f.	Determine status of CV genetic studies																			March 2005 – June 2005
2	**Develop Revised Monitoring Programs**																			May 2005 – January 2006
2a.	Develop revised escapement/harvest monitoring programs																			May 2005 – January 2006
2b.	Develop CWT recovery and scale/otolith aging programs																			May 2005 – January 2006
2c.	Develop centralized data management system																			October 2005 – February 2006
2d.	Develop data reporting system																			October 2005 – February 2006
3	**Develop Cost Estimates**																			December 2005 – March 2006
4	**Project Management and Reporting**																			
4a.	Quarterly fiscal and programmatic reports																			10th day of the month at end of each quarter
4b.	Prepare draft CV Salmon Escapement Monitoring Plan																			March 2006
4c.	Revise draft Plan/prepare final Plan																			June 2006
5	**Program Review**																			Every five years following implementation of the plan

Table 4. Estimated Budget for Development of Central Valley Salmon Escapement Monitoring Plan

SALARIES/BENEFITS

Task	Position	PayRate	Hrs/mo	# of Mos.	Salary Cost	Benefit Rate	Monthly Medical Premium	Benefit Cost	Total Cost
Task 1. Review Existing Programs									
	Biologist/Planner	$ 26.58	174	4	$ 18,500	0.28	$ 606	$ 7,604	$ 26,104
	Database Specialist	$ 21.97	174	4	$ 15,291	0.28	$ 606	$ 6,706	$ 21,997
	Project Coord	$ 42.35	174	1	$ 7,369	0.14		$ 1,032	$ 8,401
Task 2. Develop Revised Programs									
	Biologist/Planner	$ 26.58	174	6.4	$ 29,599	0.28	$ 606	$ 12,166	$ 41,766
	Database Specialist	$ 21.97	174	8.8	$ 33,640	0.28	$ 606	$ 14,752	$ 48,393
	Project Coord	$ 42.35	174	1.6	$ 11,790	0.14		$ 1,651	$ 13,441
Task 3. Develop Cost Estimates									
	Biologist/Planner	$ 26.58	174	2.4	$ 11,100	0.28	$ 606	$ 4,562	$ 15,662
	Project Coord	$ 42.35	174	0.6	$ 4,421	0.14		$ 619	$ 5,040
Task 4. Project Management and Reporting									
	Biologist/Planner	$ 26.58	174	3.2	$ 14,800	0.28	$ 606	$ 6,083	$ 20,883
	Database Specialist	$ 21.97	174	3.2	$ 12,233	0.28	$ 606	$ 5,364	$ 17,597
	Project Coord	$ 42.35	174	0.8	$ 5,895	0.14		$ 825	$ 6,720

TOTAL PERSONNEL COST $226,003

Table 4 (Cont'd). Estimated Budget for Development of Central Valley Salmon Escapement Monitoring Plan

SERVICES/SUPPLIES

Description	Unit	Cost/Unit	Extended Cost
Project Management – Stan Allen			$10,000
Services/Supplies			$15,000
Meeting expenses			$ 5,000

TOTAL SERVICES/SUPPLIES $30,000

TRAVEL

Description	Unit	No. of Units	Cost/Unit	Extended Cost
Mileage	Miles	5,000	$ 0.34	$ 1,700
Rented/Leased Vehicle	Days	15	$ 50.00	$ 750
Air Travel	Trips	20	$ 400.00	$ 8,000
Lodging	Nights	50	$ 84.00	$ 4,200
Per diem	Days	50	$ 40.00	$ 2,000

TOTAL TRAVEL $ 16,650

SUBCONTRACT

Biometrician/Statistician (Tasks 1, 2 and 4) 520 hours @ $100/hour = $ 52,000

TOTAL SUBCONTRACT $ 52,000

SUBTOTAL $ 324,653

PSMFC OVERHEAD (15%) $ 48,698

TOTAL PROJECT COST $ 373,350