CHAPTER 5: NEEDED RESTORATION ACTIONS

The recovery of winter-run chinook would likely be achieved if it were possible to completely remedy the major factors influencing the population, such as adverse water temperatures in the upper Sacramento River, elimination of heavy metal discharges from Iron Mountain Mine, elimination of entrainment at the larger unscreened or inadequately screened diversions along the Sacramento River, and minimizing the adverse effects of the State and Federal Delta pumping plants. Ocean harvest represents an important source of mortality for winter-run chinook as well. However, it is not feasible at this time to completely eliminate such prime sources of mortality. Hence to effectively recover winter-run chinook salmon, it is necessary to minimize adverse effects of the larger sources of mortality while addressing many other smaller sources of mortality such as the Suisun Marsh Salinity Control Structure, dredging operations, and toxic discharges. Consequently, the actions described in this Chapter are extensive and cover a large array of human-induced activities.

Clearly, human activities have had profound impacts on winter-run chinook productivity, leaving no single life stage unaffected. Therefore, an effective means of restoring the depressed population must be based on a principle of broad-scale cooperation directed at improving survival at all life stages. In the past, too much energy has been spent tracking a single culprit, with various interest groups accusing one another of being the real cause for the decline. This contentiousness is further perpetuated by debate over often limited, available information and the variability of nature. Moreover, there are no analysis thus far which indicate that targeting survival improvements at a particular life stage will provide the greatest progress toward recovery. To recover winter-run chinook, primary consideration must be given to the main factors causing their decline and which impede their recovery, and survival must be improved in every segment of their life history. Recovery actions need to cover the total sequence of habitats and life history stages, rather than focusing on a single target for action, e.g., curtailing harvests, improving dam passage, or using hatchery production to augment natural production. In this way, we expect to reverse the trend from a downward spiral to extinction and towards a self-sustaining population.

The overall strategy for this plan is to implement, with careful monitoring and evaluation, those actions that are necessary for the immediate conservation and future recovery of winter-run chinook, rather than to identify extended studies before any actions are proposed. The basic approach is to address immediately important human-induced causes of mortality at each life stage of winter-run chinook, while at the same time conducting additional analysis and research to better understand where and how the greatest benefits can be gained for recovery.

At present, life-stage specific survival information is lacking (as is information regarding specific survival improvements resulting from actions) so it is difficult to establish the degree of improved survival that would result from particular management actions. This scientific uncertainty does not diminish the need to implement without delay the recovery actions identified in this plan. The strategy is to place higher priority on actions that are most likely to provide the most immediate benefits, the greatest long-term benefits, and the best opportunity to identify those factors limiting recovery. This approach ensures that the recovery plan remains dynamic, allowing actions to be added, deleted, or refined based on evolving scientific information and analysis. The proposed recovery objectives and actions are directed at restoring and maintaining the ecosystems upon which winter-run chinook depend, thereby increasing the run's abundance to the point where protections afforded by the ESA are no longer necessary.

Many actions are recommended as interim, short-term measures to reduce impacts, while long-term measures are being developed which will more permanently ameliorate critical problems but require several years of planning and construction. Examples of long-term measures include installation and operation of a temperature control device at Shasta Dam to provide suitable water temperatures below Keswick Dam and fish passage improvements at Red Bluff Diversion Dam. Measures are also needed to restore the overall ecosystem functions of the Sacramento River and Sacramento-San Joaquin Delta to more closely emulate habitat conditions in which the population evolved. Finally, additional measures are needed to develop information which will enhance our ability to recover winter-run chinook through improved understanding of its habitat requirements and life history.

The recovery actions identified in each section of this chapter are assigned priorities based on the established priority system (55 FR 24296) as follow (Table V-1):

Table V-1. Priority Definitions for Recovery Actions to Benefit Sacramento River Winter-run Chinook.

Priority	Type of Action
1	An action that must be taken to prevent extinction or to identify those actions necessary to prevent extinction.
2	An action that must be taken to prevent a significant decline in population numbers, habitat quality, or other significant negative impacts short of extinction, and help achieve rebuilding.
3	All other actions necessary to provide for full and sustained recovery of the species.

Hence, the recovery actions in this plan are designed to take all reasonable measures that will, based on the best scientific information and judgement, avoid extinction (priority 1), achieve rebuilding (priority 2), and ensure sustained recovery of winter-run chinook salmon (priority 3). Actions that should be implemented immediately to avoid extinction of winter-run chinook include: 1) providing suitable water temperature in the upper Sacramento River; 2) reducing pollution from Iron Mountain Mine; 3) improving juvenile fish passage and survival in the upper Sacramento River through the Delta; 4) improving adult fish passage at the Red Bluff Diversion Dam; 5) minimizing adult straying; and 6) reducing ocean harvest impacts.

Actions that can be taken immediately to help achieve rebuilding of the population include: 1) providing optimum flows; 2) protecting and restoring riparian and tidal marsh habitat; 3) reducing pollution from industrial, municipal and agricultural sources and providing suitable water quality; 4) reducing adverse impacts to juveniles and adults at the Suisun Marsh Salinity Control Structure; and 5) improving adult passage at the Anderson-Cottonwood Irrigation District dam.

Finally, some of the main actions that can be implemented immediately to help sustain the recovery of winter-run chinook include: 1) protecting gravel resources; 2) reducing impacts from dredging and dredge disposal; 3) bolstering the population through artificial propagation; and 4) minimizing impacts from the Striped Bass restoration program and salmon and steelhead hatchery programs.

The identification, evaluation, and selection of actions needed to successfully protect and restore winter-run chinook salmon are the first steps toward a comprehensive recovery program. Unfortunately, problem identification is not problem solving and for winter-run chinook, the significant challenge in recovery will be designing the processes and framework by which recovery actions can be efficiently implemented. Mechanisms for the recovery of winter-run chinook salmon will logically be joined with other ongoing habitat restoration programs in the Central Valley. These potential recovery mechanisms are discussed in further detail in Chapter 6: Implementation. However, the recovery process for winter-run chinook must be firmly linked to the broader issues of ecosystem health and the interrelationship and interdependence of all aquatic organisms in the Central Valley and their habitats. This is a significant challenge which must be addressed by fish and wildlife management agencies; agricultural, municipal, and industrial water users; regulatory agencies; stakeholders; conservation organizations, private landowners, and others.

The following sections are structured to provide an introductory outline of necessary actions followed by a more detailed description and narrative for each measure that is needed to promote the recovery of winter-run chinook. The details also include specific tasks that should be completed to accomplish each measure. Recovery measures are presented for each of the seven broad recovery goals (Table V-2).

Table V-2. Recovery Goals for the Sacramento River Winter-run Chinook.

Goal	Description
I	Protect and restore spawning and rearing habitat.
II	Improve survival of downstream migrants.
III	Improve adult upstream passage.
IV	Prevent extinction through artificial propagation.
V	Reduce harvest and incidental take in commercial and recreational fisheries.
VI	Reduce impacts of fish and wildlife management programs.
VII	Improve understanding of life history and habitat requirements

The specific recovery recommendations for the Sacramento River winter-run chinook salmon follow. The time frames indicated for actions associated with each goal are dates for which each action should be completed. In some cases, as indicated, the date signifies when actions should be initiated to implement a long-term program. In addition, it is described whether interim actions are presently occurring which would move towards achieving the proposed action or conversely, that there are no actions currently ongoing.

GOAL I: PROTECT AND RESTORE SPAWNING AND REARING HABITAT

Table V-3. List of Recovery Actions for Sacramento River Winter-run Chinook Salmon Related to Goal I: Protect and Restore Spawning and Rearing Habitat.

Objective/Action	Interim Actions	Long-term Program
1. Provide suitable water temperatures for spawning, egg incubation, and juvenile rearing between Keswick Dam and Red Bluff (Priority 1)		
1. Operate the Central Valley Project to consistently attain the State Water Resources Control Board's Order 90-5 for water temperature objectives to the extent possible under different storage and runoff conditions.	Ongoing	January 2000
2. Install and operate a structural temperature control device at Shasta Dam in conjunction with modifications to Central Valley Project operations.		April 1997
3. Operate and maintain temperature control curtains as permanent installations in Whiskeytown and Lewiston reservoirs, and investigate installing an additional temperature curtain on the upstream side of Lewiston Reservoir.	Ongoing	June1998
4. Actively regulate the river/reservoir system using a comprehensive temperature monitoring program, integrated with a calibrated daily time-step temperature model.	Ongoing	April 1999
2. Reduce pollution in the Sacramento River from Iron Mountain Mine (Priority 1)		
1. Remedy pollution problems from Iron Mountain Mine to meet Basin Plan standards during the winter-run chinook incubation period.	Ongoing	January 2001
2. Develop, implement, and monitor reliable and proven remedies that ensure continued treatment and control of heavy metal waste prior to discharge to the Sacramento River.	Ongoing	January 2000
3. Develop, implement, and monitor remedies that dilute heavy metal waste discharge into the Sacramento River through effective water management.	Ongoing	January 2000
4. Eliminate scouring of toxic metal-laden sediments in the Spring Creek and Keswick reservoirs.	Ongoing	January 2000

Objective/Action	Interim Actions	Long-term Program
5. Monitor metal concentrations and waste flows using approved standard methods.	Ongoing	January 1999
3. Provide optimum flows in the Sacramento River between Keswick Dam and Chipps Island. (Priority 2)		
1. As an interim measure, maintain flows of 5,000 to 5,500 cfs from October through April when possible without compromising Shasta Reservoir carryover storage. When these flows, cannot be achieved, continue to operate the Central Valley Project and State Water Project to meet flow reduction rates and minimum flows as identified in the 1993 Biological Opinion for Operation of the Federal Central Valley Project and the California State Water Project.	Ongoing	June 1999
2. Develop, implement, and monitor final instream flow recommendations and flow reduction (ramping) rates for the upper Sacramento River.	None	January 2001
3. Eliminate adverse flow fluctuations by modifying the Anderson-Cottonwood Irrigation District's dam operations, or by modifying or replacing the facility.	Ongoing	January 2000
4. Complete an inventory and assessment of all water withdrawal sites that affect critical habitat, and take action to conserve irrigation water and increase stream flows.	None	January 2002
4. Preserve and restore riparian habitat and meander belts along the Sacramento River and the Sacramento-San Joaquin Delta (Priority 2)		
1. Avoid any loss or additional fragmentation of the riparian habitat in acreage, lineal coverage, or habitat value, and provide in-kind mitigation when such losses are unavoidable.	Ongoing	January 1999
2. Assess riparian habitat along the Sacramento River from Keswick Dam to Chipps Island and along Delta waterways within the rearing and migratory corridor of juvenile winter-run chinook salmon.	Ongoing	January 2000
3. Develop and implement a Sacramento River and Delta Riparian Habitat Restoration and Management Plan.	Ongoing	January 2001

Objective/Action	Interim Actions	Long-term Program
4. Encourage Congress to reauthorize and/or amend the Sacramento River Flood Control and Sacramento Bank Protection projects to recognize and ensure the protection of riparian habitat values for fish and wildlife.	None	January 1999
5. Preserve and restore tidal marsh habitat		**(Priority 2)**
1. Avoid further loss of tidal marsh habitat in either acreage or habitat value, and provide in-kind mitigation when losses are unavoidable.	Ongoing	January 1999
2. Conserve and restore tidal marsh and shallow water habitat within winter-run chinook salmon rearing and migratory habitats.	Ongoing	January 2000
6. Reduce pollution from industrial, municipal, and agricultural sources		**(Priority 2)**
1. Control contaminant input from Colusa Basin Drain into the Sacramento River.	Ongoing	January 1999
2. Reduce contaminant input to the Sacramento River, Delta, and San Francisco Bay from municipal treatment plants.	Ongoing	January 2000
3. Control contaminant input to the Sacramento River system by constructing and operating stormwater treatment facilities and implementing industrial Best Management Practices for stormwater and erosion control.	Ongoing	January 2000
4. Reduce selenium discharge into the North Bay to levels which protect winter-run chinook and their prey.	Ongoing	January 1999
5. Conduct an assessment/monitoring program of contaminant input from other major agricultural drainages in the Sacramento River watershed.	Ongoing	January 2000
6. Monitor the contaminant input from dormant orchard spraying in the Sacramento River.	None	January 1999
7. Monitor contaminant inputs from rice stubble decomposition flooding and waterfowl habitat development and remedy as needed.	None	January 1999

7. Provide suitable water quality in the Sacramento River watershed and the Sacramento-San Joaquin Delta, and San Francisco Bay-Estuary (Priority 2)		
1. Establish, implement, enforce, and monitor temperature, dissolved oxygen and salinity water quality standards and objectives for the Sacramento-San Joaquin Delta, and San Francisco Bay that protect winter-run chinook.	Ongoing	June 1999
2. Establish numeric water quality objectives for priority pollutants similar to those in the revoked Inland Surface Water Plan and the Enclosed Bays and Estuaries Plan, which protect all life history stages of chinook salmon and their prey.	Ongoing	June 1999
3. Implement, enforce, and monitor all water quality objectives necessary for the protection of fishery uses through the waste discharge permitting process.	Ongoing	June 1999
4. Establish numeric water quality objectives for pesticides, herbicides, and organic and inorganic compounds to protect all like-stages of chinook salmon and their prey.	Ongoing	June 1999
8. Protect and maintain gravel resources in the Sacramento River and its tributaries between Keswick Dam and Red Bluff (Priority 3)		
1. Restore, replenish, and monitor spawning gravel in the Sacramento River.	Ongoing	September 1998
2. Develop and implement a plan to protect all natural sources of spawning gravel in the high water channels and along the flood plains of the Sacramento River and its tributaries.	Ongoing	January 1999
3. Control excessive silt discharges to protect spawning gravel in the main stem by protecting watersheds in the Sacramento River system.	None	January 1999
9. Reduce habitat loss, entrainment, and pollution from dredging and and dredge disposal operations (Priority 3)		
1. Conduct dredging and disposal operations to minimize entrainment of juvenile winter-run chinook salmon, habitat loss, and water quality degradation.	Ongoing	September 1998
2. Minimize the volume of dredge material disposed into the San Francisco Bay and Estuary.	Ongoing	September 1998

GOAL I: PROTECT AND RESTORE SPAWNING AND REARING HABITAT

OBJECTIVE 1:
Provide suitable water temperatures for spawning, egg incubation, and juvenile rearing between Keswick Dam and Red Bluff

Adverse water temperatures in the upper Sacramento River have been a critical factor in the decline of winter-run chinook, and maintaining suitable water temperatures is essential to ensure the population's continued existence and recovery. In most years, summer water temperatures below Red Bluff Diversion Dam have reached levels lethal to incubating eggs. Water temperatures may reach lethal levels above Red Bluff Diversion Dam as well, typically in the late summer and early fall of dry years when reservoir levels are low or cold water supplies are limited. To protect winter-run chinook during spawning and incubation, daily average water temperatures should be less than or equal to 56°F from April 15 through September 30. To protect salmon fry and juvenile life history stages, daily average water temperatures should not exceed 60°F after September 30.

The National Marine Fisheries Service's 1993 Biological Opinion for the Central Valley Project operations[1] established water temperature criteria for successful spawning, incubation, and rearing of winter-run chinook in the Sacramento River from either Keswick Dam to Bend Bridge or from Keswick Dam to Jelly's Ferry depending on the water year type and initial reservoir storage on October 1. These criteria have been developed and implemented to avoid jeopardizing the continued existence of winter-run chinook and are satisfactory for an interim period. However, to allow for the full recovery of winter-run chinook, suitable water temperatures may be needed over a broader reach of the river as the population expands; specifically from Keswick Dam downstream to the Red Bluff Diversion Dam, as outlined in the State Water Resources Control Board Order 90-5 for operation of the Central Valley Project.[2] The temperature criteria discussed above may be attainable in most water year types, except under dry and critically dry conditions. The ability to consistently achieve cool temperatures over this longer reach of river can be achieved through the operation of the newly-installed temperature control device at Shasta Dam, modification to Central Valley Project operations and water allocations to contractors, and continued operation of temperature curtains at Lewiston and Whiskeytown reservoirs.

In some years, cold water reserves in Shasta Reservoir could be exhausted prior to the completion of the winter-run chinook incubation period if the temperature objective remains at Red Bluff Diversion Dam. Experience has shown that once the available cold water pool in Shasta Reservoir is exhasuted and temperatures may quickly climb to sub-lethal and lethal levels for winter-run chinook below Keswick Dam. In addition, exhausting the cold water pool during the fall months can result in significant adverse affects upon fall-run chinook salmon spawning in the upper Sacramento River. Under these conditions, it may be preferrable to control temperatures to a point upstream of Red Bluff Diversion Dam. However, it will be important to ensure that Red Bluff Diversion Dam gate operations and other measures to improve upstream passage of adults have successfully resulted in the distribution of spawners well upstream of Red Bluff. Lake Red Bluff and the reach immediately upstream does not presently offer ideal spawning habitat for winter-run chiinook and these areas have not been utilize by winter-run spawners in recent years. If information on spawning distribution suggests there is no biological benefit for winter-run chinook and managing temperatures to a point upstream of Red Bluff significantly reduces the risk of exhausting the cold water pool, the temperature compliance point should be re-evaluated for that year. However, the 56°F temperature objective should be move upstream of Red Bluff only when there is no biological benefit, and there is a significant risk of exhausting the cold water pool and losing the ability to provide suitable temperature conditions in the upper Sacramento River.

Recommended Actions:

1) Operate the Central Valley Project to consistently attain the State Water Resources Control Board's Order 90-5 for water temperatures to the maximum extent possible under different storage and run-off conditions.

The temperature objective for the upper Sacramento River is ≤56°F from Keswick Dam to the Red Bluff Diversion Dam, for operation of the Central Valley Project in the State Water Resources Control Board’s Order 90-5. However, these criteria cannot be met, at present, on a consistent basis, and other structural facilities and operational measures (outlined in actions 2-4 below) are needed. These facilities and operational measures must be developed and implemented to enable the long-term, reliable attainment of the Board's 56°F temperature criteria for the Central Valley Project operations.

Until all these facilities are in place, the compliance points for water temperature requirements should be adjusted as specified in the 1993 National Marine Fisheries Service Biological Opinion for operations of the Central Valley Project. The U.S. Bureau of Reclamation should also continue to use a conservative approach in forecasting deliverable water supply by determining annual water allocations using at least a 90% exceedance level, as specified in the National Marine Fisheries Service opinion.

Similarly, section 3406(b)(19) of the Central Valley Project Improvement Act[3] requires that the Secretary of the Interior maintain minimum carryover storage at Sacramento and Trinity River reservoirs to protect and restore the anadromous fish of the Sacramento and Trinity rivers. *Implementing Agencies: U.S. Bureau of Reclamation, State Water Resources Control Board, Sacramento Valley Regional Water Quality Control Board.*

2) Install and operate a structural temperature control device at Shasta Dam in conjunction with modifications to Central Valley Project operations.

A temperature control or "shutter device" has been constructed to allow the selective withdrawal of water from Shasta Reservoir over a wide range of depths and temperatures. With this device, warmer water can be withdrawn from the upper lake levels when needed, while conserving the deeper, cold water for release when it would most benefit chinook salmon. Prior to 1997, water was selectively withdrawn from Shasta Reservoir for temperature control, but these withdrawals require the bypass of power turbines, resulting in major losses in electrical power revenues and power generation. Operation of the temperature control device will allow the U.S. Bureau of Reclamation greater effectiveness and flexibility in temperature control operations while maintaining hydroelectric power generation. The temperature control device will also provide a secondary benefit to anadromous fish by controlling turbidity. During the next 2-3 years, operations and carryover requirements must be reassessed and new criteria established to optimize attainment of water temperature objectives in the upper Sacramento River.

Section 3406(b)(6) of the Central Valley Project Improvement Act requires the Secretary of the Interior to install and operate a structural temperature control device at Shasta Dam to control water temperatures to protect anadromous fish in the upper Sacramento River.

Implementing Agency: U.S. Bureau of Reclamation.

3) Operate and maintain temperature control curtains as permanent installations in Lewiston and Whiskeytown reservoirs, and investigate installing an additional temperature curtain on the upstream side of Lewiston Reservoir.

Water temperatures in Lewiston and Whiskeytown reservoirs influence Sacramento River water temperature. Preliminary results show that the use of the Lewiston and Whiskeytown temperature control curtains has reduced the heat gain of water transferred between the Trinity River and the Sacramento River by 50-75%. This reduction in temperature allows for the conservation of cold water in Shasta Reservoir by reducing the need to release Shasta Reservoir water to cool those releases from the Trinity River diversion.

Implementing Agencies: U.S. Bureau of Reclamation, State Water Resources Control Board.

4) Actively regulate the river/reservoir system using a comprehensive temperature monitoring program, integrated with a calibrated daily time-step temperature model.

Development of a comprehensive model (as required by the State Water Resources Control Board's Water Rights Order 90-5) is presently underway by the University of California, Davis[4], entitled the Sacramento River Temperature Modeling Project. The model will incorporate the Shasta and Keswick reservoirs, the Sacramento River from Keswick to its confluence with the

Feather River, and the Feather River from Oroville Dam to its confluence with the Sacramento River. Parameters will consist of: 1) reservoir operations, 2) riparian shading, 3) timing and location of agricultural drains, 4) weather, and 5) hydrology. Upon completion, the temperature model should be used by the U.S. Bureau of Reclamation to effectively budget cold water reserves for temperature compliance, thereby improving the ability of the Central Valley Project to meet temperature objectives that protect winter-run chinook and other salmon populations.

Implementing Agencies: U.S. Bureau of Reclamation, State Water Resources Control Board, California Department of Water Resources.

OBJECTIVE 2:
Reduce pollution in the Sacramento River from Iron Mountain Mine

The drainage from inactive mines on Iron Mountain Mine represents the largest source of pollutant discharge to the Sacramento River. This discharge is at least equal to all the combined industrial and municipal discharges of metal to the San Francisco Bay and estuary system.[5] This mine water is among the most acidic in the world and contains extremely elevated concentrations of copper, zinc, cadmium, and other metals known to be toxic to fish and wildlife. On occasion, fish kills (including salmon) have been documented in the upper Sacramento River due to Iron Mountain Mine waste. More frequently there are documented instances of metal concentrations that exceed chronic toxic levels considered "safe" to early life stages of salmon.

The wastes from Iron Mountain Mine, located in the Spring Creek watershed, are collected in the Spring Creek Reservoir, then metered out into the releases of clean water from Shasta and Whiskeytown reservoirs to achieve the best water quality possible. However, due to the extremely large waste load (averaging over one ton of copper and zinc per day), it has not always been possible to consistently attain the water quality objectives for copper, cadmium, and zinc in the Central Valley Regional Water Quality Control Board Basin Plan and interim criteria has been established until pollution control is completed.[6] Highly toxic conditions are exacerbated when heavy winter rains induce uncontrolled spills from Spring Creek Reservoir, and flows from Shasta and Whiskeytown reservoirs are not made available for dilution due to other Central Valley Project constraints such as flood control.

The task of remedying the Iron Mountain Mine site is being accomplished under the Environmental Protection Agency's Superfund Program. Clean up of Iron Mountain Mine should focus on controlling and treating heavy metal waste at its source to the maximum feasible level, while the remaining waste discharges should be diluted through effective water management.

Recommended Actions:

1) Remedy pollution problems from Iron Mountain Mine to meet Basin Plan standards during the winter-run chinook incubation period.

The long-term remediation of Iron Mountain Mine should produce a system that reliably and consistently achieves the water quality objectives for the Sacramento River below Keswick Dam, as adopted by the State Water Quality Control Board and approved by Environmental Protection Agency. Specifically, these water quality objectives are: a maximum concentration of 0.0056 mg/l for copper, 0.016 mg/l for zinc, and 0.00022 mg/l for cadmium. Implementation of the actions described below should enable these objectives to be met in all but the most extreme rainfall conditions, when even the best available technology is still unable to completely control Iron Mountain Mine toxic discharge.

Implementing Entities: Environmental Protection Agency (Superfund Program), California Environmental Protection Agency, Regional Water Quality Control Board, U.S. Bureau of Reclamation, California Department of Fish and Game, U.S. Fish and Wildlife Service, and National Marine Fisheries Service, the responsible party.

2) Develop, implement, and monitor reliable and proven remedies that ensure continued treatment and control of heavy metal waste prior to discharge to the Sacramento River.

The current Iron Mountain Mine collection and treatment operations must continue to be implemented, maintained and monitored to ensure the reliable and proven control of concentrated acid mine drainage. Further cost-effective collection and treatment remedies also need to be identified, implemented, maintained and monitored to ensure the control of additional contaminated discharge sources. The capacity to treat Iron Mountain Mine discharge must be expanded to enable the collection and treatment of contaminated source flows with the design criteria of a one-hundred year flood event, without relying on dilution flows from the Shasta and Trinity Division of the Central Valley Project. Corrective measures are needed on-site and in the reservoirs downstream of Iron Mountain Mine. The waste material piled around the Iron Mountain Mine site must be remedied to reduce heavy metal discharge (Boulder Creek Operable Unit). Also, Brick Flat Pit and all other capped areas should continue to be maintained and operated to reduce rainwater permeation, which reacts with mineral deposits to produce sulfuric acid and heavy metals.

Implementing Entities: Environmental Protection Agency (Superfund Program), California Environmental Protection Agency, Central Valley Regional Water Quality Control Board, U.S. Bureau of Reclamation, California Department of Fish and Game, U.S. Fish and Wildlife Service, National Marine Fisheries Service, the responsible party.

3) Develop, implement, and monitor remedies that dilute heavy metal waste discharge into the Sacramento River through effective water management.

If heavy metal waste cannot be completely controlled and treated at its source, then water management measures are essential to reduce the toxicity of the uncollectible and untreatable area source discharges through assuring their safe release to the Sacramento River ecosystem. Enlarging the Spring Creek Reservoir is one alternative which would reduce the frequency of spills under all but the most extreme rainfall events, and would also provide a safer structure for containing heavy metal waste during earthquakes and during extreme floods.

The water management facilities, that divert uncontaminated water from the upper branch of Spring Creek and Slickrock Creek away from contaminated areas, should continue to be maintained and operated on a long-term basis. The Spring Creek Diversion increases water management capabilities at the Spring Creek Reservoir. The Slickrock diversion decreases the amount of water flowing into metal laden areas which reduces reactions that produce acid and heavy metals. The option should also be retained to divert water from the South Fork Spring Creek, out of the Spring Creek basin, to further increase water management capabilities for any future needs.

If a toxic spill does occur, water should be *immediately* provided to dilute the toxic discharge into the Sacramento River, because any lag time could decimate spawning and incubating winter-run chinook. To protect winter-run chinook, a provision is needed to afford at least 3-days of dilution water to be immediately released when toxic spills occur at the Spring Creek Reservoir. Specific volumes of water should be purchased to dilute toxic spills for the interim, and following a water marketing study, water rights should be purchased to secure reliable sources of water for diluting toxic discharges.

Implementing Entities: Environmental Protection Agency (Superfund Program), California Environmental Protection Agency, Regional Water Quality Control Board, U.S. Bureau of Reclamation, California Department of Fish and Game, U.S. Fish and Wildlife Service, National Marine Fisheries Service, the responsible party.

4) Eliminate scouring of toxic metal-laden sediments in the Spring Creek and Keswick reservoirs.

Within the lower portion of the Iron Mountain Mine site, remediation must be developed for the metal sludge deposits present in Spring Creek Reservoir, and in the Keswick Reservoir adjacent and downstream of the Spring Creek Powerplant tailrace. Preliminary monitoring in the Keswick Reservoir has documented that the sludge is highly toxic and that the deposits are extensive and up to 15 feet thick. Under certain conditions, flows from the Spring Creek powerplant can mobilize large quantities of the sludge into the river, creating an acute toxicity risk to aquatic species. The sludge deposits can also contribute to chronic toxicity when combined with other sources.

As interim measres, discharges of contaminated sediment from the Spring Creek and Keswick reservoirs must be minimized. Also, the Keswick Reservoir and the Spring Creek powerplant must be operated to insure that toxic deposits are not mobilized. To ultimately remedy the metal sludge deposits, sediment management plans should be developed and implemented for both reservoirs, which will eliminate scouring of toxic sediments. For Keswick Reservoir, the plan should be based on the Remedial Investigation/Feasibility Study for the sediment problem in the Spring Creek Arm of Keswick Reservoir. In addition, source control and treatment must be sufficient to prevent any further deposition of metal precipitates in Keswick Reservoir.

Implementing Entities: Environmental Protection Agency (Superfund Program), California Environmental Protection Agency, Regional Water Quality Control Board, U.S. Bureau of Reclamation, California Department of Fish and Game, U.S. Fish and Wildlife Service, and National Marine Fisheries Service, the responsible party.

5) Monitor metal concentrations and waste flows using approved standard methods.

Monitoring is a key component of the short- and long-term remediation measures for Iron Mountain Mine. Monitoring for metal concentrations must be consistent with the Environmental Protection Agency's methodologies and must be capable of detecting metal concentrations at levels specified in the Basin Plan standards. Also, the monitoring of Spring Creek waste flows must be accomplished according to the U.S. Geological Survey methodologies.

Implementing Entities: Environmental Protection Agency (Superfund Program), California Environmental Protection Agency, Regional Water Quality Control Board, U.S. Bureau of Reclamation, California Department of Fish and Game, U.S. Fish and Wildlife Service, National Marine Fisheries Service, the responsible party.

OBJECTIVE 3:
Provide optimum flows in the Sacramento River between Keswick Dam and Chipps Island

The Sacramento River needs to be actively regulated to optimize instream flows needed by all life stages of winter-run chinook. Flows must be stabilized to prevent large fluctuations that dewater redds, and strand and isolate fry and juveniles in side channels, isolated pools, and shallow near-shore areas. In 1990, the State Water Resources Control Board (Order 90-5) established requirements for minimum instream flows and flow fluctuations, but these have proven to be inadequate to protect winter-run chinook from stranding, isolation, and redd dewatering. Requirements in the 1993 Biological Opinion for the Operations of the Federal Central Valley Project and the California State Water Project improved flow conditions, but these were based on limited information describing the relationship of flow to the biological requirements of the winter-run chinook population.

Research is needed to better characterize the optimum flows required by winter-run chinook. Optimum flows for winter-run chinook can be achieved through actively regulating the Sacramento River to maximize habitat availability during upstream migration, spawning, egg incubation, juvenile rearing, and seaward migration. These optimum flows must be balanced to provide: suitable water temperatures and water quality, flow stability, physical habitat, and reservoir carryover storage.

Recommended Actions:

1) As an interim measure, maintain flows of 5,000 to 5,500 cfs from October through April when possible without compromising carryover storage. When these flows cannot be achieved, at a minimum, continue to operate the Central Valley Project and State Water Project to meet flow reduction rates and minimum flows as outlined in the 1993 Biological Opinion for Operation of the Federal Central Valley Project and the California State Water Project.

The U.S. Fish and Wildlife Service's draft Anadromous Fish Restoration Plan has recommended minimum Sacramento River flows at Keswick Dam based on runoff and storage conditions (Table V-3), which are designed to balance carryover storage with instream flow needs consistent with the 1993 Biological Opinion.[7] This range of flows at the associated carryover storage levels is also recommended for winter-run chinook.

These minimum criteria should provide safe rearing and downstream passage to juvenile winter-run chinook, including protection against dewatering and stranding. Known and potential sites for dewatering and stranding must be monitored during the spawning and rearing season. In the event that project operations result in the dewatering of redds or stranding of juveniles, immediate action must be taken to restore flow to protect winter-run chinook eggs and juveniles in the affected area.

Implementing Agencies: U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, California Department of Fish and Game, National Marine Fisheries Service, State Water Resources Control Board.

Table V-4. Recommended minimum Sacramento River flows (cfs) at Keswick Dam for October 1 to April 30 based on October 1 carryover storage in Shasta Reservoir and critically dry runoff conditions (driest decile runoff of 2.5 million-acre feet) to produce a target April 30 Shasta Reservoir storage of 3.0-3.2 for temperature control.

Carryover Storage (maf)	Keswick Release (cfs)
1.9 to 2.1	3,250
2.2	3,500
2.3	3,750
2.4	4,000
2.5	4,250
2.6	4,500
2.7	4,750
2.8	5,000
2.9	5,250
3	5,500

2) Develop, implement, and monitor final instream flow recommendations and flow reduction (ramping) rates for the upper Sacramento River.

An instream flow evaluation (IFIM) should be conducted to fully quantify flow criteria for winter-run chinook. This action will provide quantitative information to determine the flows needed for the spawning, egg incubation, and juvenile rearing stages. The evaluation must assess the habitat suitability of the entire stream including deep waters (>3 feet) where winter-run chinook may spawn, and critical areas where redds are susceptible to dewatering and juveniles to stranding and isolation. The resulting flow criteria should describe flow quantity, fluctuation, ramping rates, and water temperatures. Based on the revised flow criteria, carryover storage and operational standards for the Shasta and Trinity Divisions of the Central Valley Project should be reassessed over a range of initial reservoir storage conditions combined with different water year types.

Implementing Agencies: U.S. Bureau of Reclamation, California Department of Fish and Game, National Marine Fisheries Service, State Water Resources Control Board, U.S. Fish and Wildlife Service.

3) Eliminate adverse flow fluctuations by modifying the Anderson-Cottonwood Irrigation District's dam operations, or modifying or replacing the facility.

A permanent remedy must be developed and implemented to eliminate flow fluctuations from Keswick Dam presently required for the Anderson-Cottonwood Irrigation District's dam operations. Interim measures to reduce the need for extreme flow fluctuations have been adopted. These include the replacement of old 6" by 12' wood flashboards with new, high strength and low weight 12" by 12' fiberglass boards and the installation of a new safety catwalk to allow board adjustments at higher flows. Interim operational changes to the Anderson-Cottonwood Irrigation District dam have minimize impacts to chinook salmon. If these measures prove ineffective, the facility should be modified or replaced, such that the need for flow fluctuations from Keswick Dam is decisively eliminated. Section 3406(b)(17) of the Central Valley Project Improvement Act also requires eliminating losses of anadromous fish due to flow fluctuations and the resolution of upstream stranding problems related to Anderson-Cottonwood Irrigation District's dam operations.

Implementing Agencies: U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, California Department of Fish and Game, National Marine Fisheries Service, Anderson-Cottonwood Irrigation District.

4) Complete an inventory and assessment of all water withdrawal sites that affect critical habitat, and take action to conserve irrigation water and increase stream flows.

State and Federal agencies should construct an integrated data base that identifies all surface and groundwater irrigation withdrawal sites that affect the critical habitat of winter-run chinook. Reports should include location and quantity. Unperfected municipal and industrial water rights, agricultural water rights, and individual water rights should also be identified. In addition, the State, the National Marine Fisheries Service, and other Federal agencies should fund and complete an evaluation of how water withdrawals, depletions, and return flows affect the natural Sacramento River hydrograph.

Federal and State agencies should also develop incentives (e.g. through cost sharing) to encourage irrigators to modify irrigation techniques and repair and update water delivery systems. Outreach and education programs should be developed to demonstrate the methods and benefits of updating water delivery systems. A public awareness and education program will help irrigators understand the benefits, both for the resource and the irrigator, of using more efficient water application systems. This forum should also be used to solicit input from irrigators on potential ways to modify irrigation techniques.

Section 3405(e) of the Central Valley Project Improvement Act requires the Secretary of the Interior to: *"...establish and administer an office on Central Valley Project water conservation best management practices that shall, in consultation with the Secretary of Agriculture, the California Department of Water Resources, California academic institutions, and Central Valley Project water users, develop criteria for evaluating the adequacy of all water conservation plans developed by project contractors..."*.

Implementing Agencies: U.S. Bureau of Reclamation, California Department of Fish and Game, National Marine Fisheries Service, State Water Resources Control Board, California Department of Water Resources.

OBJECTIVE 4:
Preserve and restore riparian habitat and the meander belts along the Sacramento River and the Sacramento-San Joaquin Delta

Contiguous riparian habitat is an essential requirement for protecting and restoring endangered and threatened species and other fish and wildlife species along the Sacramento River and in the Sacramento-San Joaquin Delta. For winter-run chinook and other salmon stocks, it is essential for successful rearing and migration of juveniles. It provides a terrestrial food source, cover, and shade. A meander belt, particularly in the upper river, would supply important spawning gravel resources through natural erosive processes. More broadly, riparian habitat plays a vital role in determining the river's morphology by providing sediment deposition areas, and influencing erosion rates and channel cutoffs.

During the past 150 years, nearly 98% of the historic riparian forest along the Sacramento River has been lost due to agricultural conversion, timber and fuel harvesting, river channelization, the Federal Sacramento River Flood Control and Sacramento River Bank Protection projects, private levee construction, streamflow regulation, and urbanization[8]. This extreme loss of riparian habitat has likely contributed to the decline of winter-run chinook and may impede recovery of the population.   A comprehensive and aggressive program is needed to halt further loss of riparian habitat, and to restore the riparian corridor along the Sacramento River and Sacramento-San Joaquin Delta to its more original state which allows for natural successional processes. Section 3406(b)(1)(A) of the Central Valley Project Improvement Act has similarly placed a high priority on the protection and restoration of riparian habitat to improve fisheries populations.

Recommended Actions:

1) Avoid any loss or additional fragmentation of the riparian habitat in acreage, lineal coverage, or habitat value, and provide in-kind mitigation when such losses are unavoidable.

Traditional bank protection and levee maintenance practices, and mitigation methods should be reevaluated and modified to better preserve and enhance riparian habitat. Experimental methods that protect and restore riparian resources should be examined and incorporated as appropriate into traditional practices. These methods include the use of setback levees, establishing low berms, using dredge spoil between rock groins, and planting trees in dredge spoils and on low berms. The Army Corps of Engineers should ensure that impacts to existing riparian habitat are avoided to the maximum extent practicable and fully mitigate unavoidable impacts, through its permitting authority under the Federal Clean Water Act Section 404 and through management of the Corps' own flood control activities. The Department of Water Resources, the California Department of Fish and Game, and other implementing agencies (see below) should promote habitat restoration and enhancement projects to increase riparian habitat in the principal salmonid migratory corridors of the Sacramento River and Delta. Section 3406(b)(13) of the Central Valley Project Improvement Act similarly requires the implementation of measures to avoid further losses of instream and riparian values by reestablishing a meander belt and placing limitations on future bank protection activities.

Implementing Agencies: U.S. Army Corps of Engineers, State Lands Commission, Department of Interior, city and local planning agencies, California Reclamation Board, California Department of Water Resources, California Department of Fish and Game, Delta Protection Commission, Delta reclamation districts, U.S. Fish and Wildlife Service, San Francisco Bay Conservation and Development Commission, Natural Resources Conservation Service, Regional Water Quality Control Boards, landowners.

2) Assess riparian habitat along the Sacramento River from Keswick Dam to Chipps Island and along Delta waterways within the rearing and migratory corridor of juvenile winter-run chinook.

The existing condition and extent of riparian habitat along the Sacramento River and in the Delta should be assessed to identify and evaluate opportunities and requirements for riparian restoration. This work should be completed in a manner that is consistent with the statewide Rivers Inventory being conducted by the Resources Agency and should address the following:

Condition of Riparian Habitat. Geographic areas containing high quality, moderate quality, and degraded areas of riparian habitat should be identified. Degraded areas should be categorized as either fully or partially restorable. Partially restorable areas are locations where bank protection and mitigation maintenance are required on a continuous basis due to intensive urbanization or to structural features (such as bridges) along the river which cannot withstand erosion.

Impacts to Riparian Habitat. Ongoing impacts should be identified for the various reaches of the river and Delta. This assessment should include evaluating flow releases from Keswick Dam, which may inundate riparian seedlings becoming established in the spring and summer and thus, reduce the regeneration of riparian vegetation. Flow recommendations should be developed to improve the success rate of riparian seedlings.

Threats to Riparian Habitat. Potential threats to riparian habitat along the Sacramento River and Delta should be identified. This assessment should include new developments along the river and Delta which may preclude restoration opportunities.

Benefits of Riparian Habitat. Many of these benefits have been well described, but a greater understanding is needed of other potential benefits such as: the moderating effects of the riparian habitat on water temperature, and the contribution of terrestrial plant and insect input to the aquatic food chain.

Implementing Agencies: U.S. Army Corps of Engineers, The Resources Agency, State Lands Commission, Department of Interior, city and local planning agencies, State Reclamation Board, Delta Protection Commission, CALFED Bay-Delta Program.

3) Develop and implement a Sacramento River and Delta Riparian Habitat Restoration and Management Plan.

A comprehensive Riparian Habitat Restoration and Management Plan should be developed which:

sets priority areas for riparian habitat restoration according to habitat condition and feasibility;
creates a plan for restoring the Sacramento River meander belt;
creates a Riparian Reserve System to protect riparian habitat between Keswick Dam and Chipps Island, including Delta waterways within the rearing and migratory corridor of winter-run chinook;
recommends bank protection techniques and maintenance practices that benefit fish and wildlife for areas where bank stabilization work is unavoidable:
identifies a schedule of flow releases from Keswick Dam which improves the success rate of riparian seedlings;
preserves and restores the riparian corridor such that high quality habitat is *frequently* available to juveniles throughout their downstream migration.

The Resources Agency developed a management plan to restore riparian habitat along the Sacramento River between Keswick and Verona.[9] This plan characterizes riparian habitat by river reach, and sets specific goals and guidelines and recommended solutions for restoration. This plan should be implemented, and used as a template for developing riparian habitat restoration plans for areas downstream from Verona and through the Delta.

The Riparian Reserve System should also be developed in cooperation with other restoration programs including the Sacramento River Project, a broad-based program seeking to protect 50,000 acres of riparian forest and associated wetlands between Red Bluff and Colusa through the acquisition of fee-title and conservation easements[10]. Recent State legislation also created a new riparian habitat acquisition and preservation program within the Wildlife Conservation Board to acquire riparian lands along the Sacramento River. The Nature

Conservancy also manages about 14,000 acres of riparian habitat in scattered blocks along the Sacramento River.

The Central Valley Project Improvement Act has similarly recognized the impacts of Central Valley Project operations on riparian vegetation, and requires operations to be modified to protect and restore riparian habitat (Section 3406(b)(1)A).

Implementing Agencies: California Department of Fish and Game, U.S. Fish and Wildlife Service, Resources Agency, National Marine Fisheries Service, Upper Sacramento River Fisheries and Riparian Habitat Advisory Council, State Lands Commission, State Reclamation Board, The Nature Conservancy, CALFED Bay-Delta Program, Local Counties.

4) Encourage Congress to reauthorize and/or amend the Sacramento River Flood Control and the Sacramento River Bank Protection projects to recognize and ensure the protection of riparian habitat values for fish and wildlife.

Any reauthorization or amendment of these projects should require the U.S. Army Corps of Engineers to consider fish and wildlife needs as an equal objective to flood control and bank protection, and to provide funding for the restoration of riparian habitat along the Sacramento River and within the Sacramento-San Joaquin Delta.

Implementing Agencies: U.S. Army Corps of Engineers, U.S. Congress, National Marine Fisheries Service.

OBJECTIVE 5:
Preserve and restore tidal marsh habitat

Tidal marshes were once the most widespread aquatic habitat in the Sacramento-San Joaquin Delta and San Francisco Bay, but are now restricted to isolated areas. The present acreage of tidal marshland is about 15% of the historic 1850s acreage in San Francisco Bay (including San Francisco, San Pablo, and Suisun bays)[11], and about 3% of the historic acreage in the Sacramento-San Joaquin Delta[12]. Research in the Pacific Northwest has demonstrated that tidal marshes benefit juvenile chinook salmon by providing nutrients to the detritus-based food chain, rich feeding habitat, refugia from predators, and habitat for the physiological adaptation to seawater. The extreme reduction of tidal marsh habitat in the Bay/Delta system represents an important loss of juvenile chinook rearing habitat that may impede the recovery of winter-run chinook. Any further losses of tidal marsh habitat must be avoided or fully mitigated, and the restoration of tidal marshes is needed in the Sacramento-San Joaquin Delta, and Suisun and San Pablo bays.

Recommended Actions:

1) Avoid further loss of tidal marsh habitat in either acreage or habitat value, and provide in-kind mitigation when losses are unavoidable.

Tidal marsh habitat should be protected within the rearing and migratory corridor of winter-run chinook, including the Sacramento-San Joaquin Delta, Suisun Marsh sloughs, and San Pablo and Suisun bays. Threats to tidal marsh habitat include filling of wetlands associated with highway projects, airports, and residential, commercial and industrial development. The Army Corps of Engineers should ensure that impacts to existing tidal marsh habitat are avoided to the maximum extent practicable and fully mitigate unavoidable impacts, through its permitting authority under the Federal Clean Water Act Section 404 and through management of the Corps' own flood control activities. The Department of Water Resources, the California Department of Fish and Game and other implementing agencies should promote habitat restoration and enhancement projects to increase riparian habitat in the principal salmonid migratory corridors of the Sacramento River and Delta.

Implementing Agencies: U.S. Army Corps of Engineers, local counties and agencies, San Francisco Bay Conservation and Development Commission, Environmental Protection Agency, California Department of Fish and Game, State Land Commission, San Francisco Bay Regional Water Quality Control Board, Central Valley Regional Water Quality Control Board.

2) Conserve and restore tidal marsh and shallow water habitat within winter-run chinook rearing and migratory habitats.

Existing tidal marsh habitat should be protected through wetlands acquisition. Diked marshes and baylands should also be considered for restoration to tidal marsh and shallow water habitat. Tidal marsh restoration plans and designs should allow for the free movement of fish into and out of restored wetlands without restriction by tide gates or other artificial structures. Areas which should be evaluated for tidal marsh restoration and protection include the Sacramento River portion of the Northern Delta, Suisun Marsh sloughs, the northern shoreline of Suisun and Grizzly bays, and the northern shoreline of San Pablo Bay. Various other plans are being developed to restore and protect tidal marsh habitat in the Delta and San Francisco Bay, including the Tidal Marsh Ecosystem Recovery Plan[13], CALFED Bay-Delta Program[14], and the Delta Native Fishes Recovery Plan[15], which should benefit winter-run chinook as their implementation proceeds.

Implementing Agencies: Regional Wetland Planning Program, U.S. Army Corps of Engineers, local counties and agencies, San Francisco Bay Conservation and Development Commission, Environmental Protection Agency, State Land Commission, San Francisco Bay Regional Water Quality Control Board, Central Valley Regional Water Quality Control Board, CALFED Bay-Delta Program.

OBJECTIVE 6:
Reduce pollution from industrial, municipal, and agricultural sources

Water pollution in its various forms affects winter-run chinook both directly and indirectly. Direct effects include acute exposures that cause serious harm or death to winter-run chinook. Indirect effects include: 1) sublethal exposures that impair biological and physiological activity of winter-run chinook, 2) disorientation, 3) impacts on the food web, and 4) biomagnification of pollutants in the food chain supporting winter-run chinook. More specifically, herbicides affect phytoplankton, periphyton and aquatic plants, and insecticides affect crutaceans. Taken together, runoff could potentially alter the food web in the river, Delta, and bay. Such indirect effects may be substantially more important than direct effects on juvenile salmon.

Major sources of pollution include industries, municipalities, and agriculture, which discharge such contaminants as herbicides, pesticides, organic compounds, inorganic compounds, and warm water. Pollution is described as originating from point-sources, such as discharge pipes or other localized sources, or from non-point sources, which are dispersed and largely uncontrollable. Individual sources of non-point pollution may be insignificant, but the cumulative effects can be significant, and contribute high levels of pathogens, suspended solids, and toxicants. Major contributors of non-point source pollution to the Sacramento River, Sacramento-San Joaquin Delta, and San Francisco Bay include sediment discharge, stormwater and erosion, and agricultural drainage.

Recommended Actions:

1) Control contaminant input from Colusa Basin Drain into the Sacramento River.

The Colusa Basin Drain is the largest source of agricultural return flows to the Sacramento River, and has been a major source of pesticides, turbidity, suspended sediments, dissolved solids, nutrients, and trace metals. It is also a major contributor of warm water. The direct effects from this discharge on juvenile chinook have not been demonstrated, but exposure is suspected to be detrimental particularly during smoltification.

A basin management plan should be developed and implemented by the Colusa Basin Drainage District which meets the criteria outlined in the Central Valley Project Improvement Act (Section 3405(a)(2)). Specifically, the plan should include: 1) measures that promote water use efficiency and drainage source reduction, 2) measures which lead to the reduction of pesticide and herbicide use, and 3) monitoring drainwater for the attainment of water quality criteria for thermal, physical, and chemical contaminants.

Implementing Agencies: Regional Water Quality Control Board, Environmental Protection Agency, U.S. Bureau of Reclamation, California Environmental Protection Agency, Department of Pesticide Regulation.

2) Reduce contaminant input to the Sacramento River, Delta, and San Francisco Bay from municipal treatment plants.

A primary point source of pollution is from municipal treatment plants which release heavy metal contaminants, thermal pollution, pathogens, suspended solids, and other constituents. Implementation of enhanced treatment, pretreatment programs, and tertiary treatment should assist in reducing contaminant input.

Implementing Agencies: State Water Resources Control Board, Environmental Protection Agency, Regional Water Quality Boards, cities and local governments.

3) Control contaminant input to the Sacramento River system by constructing and operating stormwater treatment facilities and implementing industrial Best Management Practices for stormwater and erosion control.

Sediments constitute nearly half of the materials introduced into rivers from non-point sources, such as plowed fields, construction and logging sites, and mined land, and are mainly generated during storm events. Stormwater runoff in urban and developing areas is another major source of sediments and contaminants. Sedimentation from non-point sources should be reduced by implementing Best Management Practices for urban and non-urban pollution, and implementing appropriate treatment and technological options that reduce pollutant loads.

Implementing Agency: Regional Water Quality Control Boards.

4) Reduce selenium discharge into the North Bay to levels which protect winter-run chinook and their prey.

Reductions in selenium discharges at industrial facilities should be achieved as rapidly as possible. At a minimum, petroleum refineries should reduce selenium discharges to comply with mass permit limits based on the 5 parts per billion water quality standard and the San Francisco Regional Water Quality Control Board's mixing zone policy limiting allowable dilution to 10:1. These reductions will achieve a significant reduction in the overall mass of selenium entering the estuary. Further reductions in mass loading to the estuary may be necessary if selenium concentrations in benthic organisms and wildlife do not respond to the removal of refinery-related emissions.

The environmental attributes most at risk from selenium discharge to the estuary are those associated with a benthic food chain pathway. In particular, organisms such as diving ducks, sturgeon, and dungeness crab that feed off the Asian bivalve *Potamocorbula amurensis* are most at risk. The risk to organisms dependent on the pelagic food chain are thought to be small. Confirmation of this is planned by measuring selnium levels in zooplankton. However, changes in the estuarine ecological community that may occur from effects on organisms at risk may affect winter-run chinook or their prey.

Implementing Entities: Environmental Protection Agency, San Francisco Regional Water Quality Control Board, Western State Petroleum Association.

5) Conduct an assessment/monitoring program of contaminant input from other major agricultural drainages in the Sacramento River watershed.

An assessment of water quality and impacts from various other agricultural drainages to the Sacramento River is needed. Based on results from these evaluation programs, recommendations for corrective actions should be developed and implemented. Top priority should be given to the Sutter Bypass, which receives drainwater from rice growing areas and has outflows on par with those from the Colusa Basin Drain. Assessments should also be conducted on Butte Slough, Reclamation District 108, and Jack Slough.

Implementing Agencies: Regional Water Quality Control Board, Environmental Protection Agency, U.S. Bureau of Reclamation, California Department of Water Resources.

6) Monitor contaminant inputs from dormant orchard spraying in the Sacramento River watershed.

A monitoring program is needed to evaluate the potential contaminant input to the Sacramento River from the spraying of dormant orchards in the winter. Based on results from this monitoring, recommendations for necessary corrective actions should be developed and implemented.

Implementing Agencies: Regional Water Quality Control Board, Environmental Protection Agency, U.S. Bureau of Reclamation, California Environmental Protection Agency, Department of Pesticide Regulation.

7) Monitor contaminant inputs from rice stubble decomposition flooding and waterfowl habitat development and remedy as needed.

Rice stubble decomposition water released in late winter and early spring may be low in dissolved oxygen, high in organic and inorganic compounds, high in herbicides and pesticides, and could be of a higher ambient water temperature than the Sacramento River. Drainwater should be monitored and analyzed for these characteristics of its water quality, and any water quality problems should be remedied to minimize impacts on winter-run chinook.

Implementing Entities: Regional Water Quality Control Board, Environmental Protection Agency, U.S. Bureau of Reclamation, California Environmental Protection Agency, Department of Pesticide Regulation, U.S. Fish and Wildlife Service.

OBJECTIVE 7:
Provide suitable water quality in the Sacramento River watershed, the Sacramento-San Joaquin Delta, and San Francisco Bay-Estuary

Establishing and implementing appropriate water quality objectives in the Sacramento River, Delta, and Bay are key mechanisms for providing winter-run chinook with suitable habitat. Under the Clean Water Act, the State of California is required to establish: beneficial uses for water bodies, such as spawning and rearing of cold water fish like salmon, and water quality objectives to protect those uses, based on narrative and/or numeric criteria. Water quality objectives are established and implemented by the Regional Water Quality Control Boards with approval by the State Water Resources Control Board and the U.S. Environmental Protection Agency.

Recommended Actions:

1) Establish, implement, enforce, and monitor temperature, dissolved oxygen and salinity water quality standards and objectives for the Sacramento River, the Sacramento-San Joaquin Delta, and San Francisco Bay that protect winter-run chinook.

Temperature. The Basin Plan and Water Rights Order 90-5 specify a water temperature objective of ≤56°F from Keswick Dam to Hamilton City. This temperature regime would provide sufficient protection for winter-run chinook, particularly during the months of December through September 30 when adults, incubating eggs, or emerging fry may be present. Below Hamilton City and through the Sacramento-San Joaquin Delta, a temperature objective of ≤60°F is recommended from mid-July through the end of May, to protect juvenile and adult winter-run chinook from direct chronic and acute exposure to thermal discharge. Achieving specific water temperatures below Hamilton City through flow is difficult because water temperature is most responsive to meteorologic conditions. However, water temperatures can be moderated by controlling agricultural drainage and other sources of high water temperature, and, within a longer time frame, by restoring riparian habitat.

Dissolved Oxygen. The existing water quality criteria for disolved oxygen in the Sacramento River between Keswick Dam and Hamilton City and for the legal Delta below the I Street Bridge, Sacramento, and west of the Antioch Bridge is acceptable to protect adult and juvenile winter-run chinook. However, the existing water quality criteria for all other Delta waters (5 mg/l on a year-round basis)[16] is not sufficient to protect adult and juvenile winter-run chinook. It is recommended that this dissolved oxygen standard be changed to   7 mg/l on a year-round basis in Georgiana Slough, Montezuma Slough, Three Mile Slough, the lower San Joaquin River from its confluence with the Mokelumne River to the Antioch Bridge, lower Old River, and Middle River.

Salinity. Salinity objectives were developed by the State Water Resources Control Board for the Delta, Suisun Marsh, Sacramento Basin, and San Joaquin Basin in the 1995 Water Quality Control Plan[17]. The State Water Project and Central Valley Project are responsible for compliance with these objectives. The Suisun Marsh objectives are similar to those in D-1485, with the addition of deficiency standards for dry and critical years in the western marsh. Before completion of the comprehensive water right proceeding and compliance dates, the Suisun Marsh objectives will undergo a scientific review by the Suisun Ecological Work Group, who will make recommendations to the State Water Resources Control Board on the salinity objectives. The work group should ensure that implementation of their recommended standards will minimize adverse impacts to winter-run chinook, both in the eastern marsh at the Salinity Control Structure, and at any potential facilities in the western marsh. The objectives for salinity in the Sacramento and San Joaquin basins should be protective of winter-run chinook. The Delta salinity objectives were judged by the National Marine Fisheries Service as acceptable to avoid jeopardy to winter-run chinook for a three-year period beginning in December 1994. Additional research is needed to better characterize the optimum salinity conditions and resulting flows required by winter-run chinook in the Delta for rearing and migration.

Implementing Agencies: Environmental Protection Agency, State Water Resources Control Board, Suisun Ecological Workgroup, Regional Water Quality Control Boards, California Department of Fish and Game, National Marine Fisheries Service, U.S. Fish and Wildlife Service, CALFED Bay-Delta Program.

2) Establish numeric water quality objectives for priority pollutants, similar to those in the revoked Inland Surface Water and Enclosed Bays and Estuaries plans, which protect all life history stages of chinook salmon and their prey.

The State's implementation of the Clean Water Act incorporates issues related to toxics, pesticides, and other contaminants. These issues are presented primarily in the Inland Surface Waters Plan and its Enclosed Bays and Estuaries Plan. The State and Regional Boards developed new statewide water quality control plans in 1993 which established specific water quality objectives for the Inland Surface Water and Enclosed Bays and Estuaries plans. However due to litigation, both plans were rescinded with the result that water quality objectives for many pollutants are currently void. Emergency action must be taken by the Environmental Protection Agency or the State Water Resources Control Board to reinstate appropriate water quality objectives protective of aquatic life and winter-run chinook within the population's critical habitat. At this point in time, California is the only state without water quality objectives for priority pollutants.

In reinstating water quality criteria, objectives for heavy metals should be described as "total recoverable metals", as specified in the 1993 Inland Surface Water and Enclosed Bays and Estuaries plans. The Environmental Protection Agency developed nationwide standards for heavy metals in the National Toxics Rule, which specified standards on the dissolved forms of metals only, rather than all forms of metals. The Environmental Protection Agency's methodology could allow dischargers to dispose of greater amounts of metals into California waters and could allow particulate and other non-dissolved forms of metals to increase above what has been previously allowed. Non-dissolved forms of metals can become bound in sediments and later released into the water column in dissolved forms, resulting in increased levels of dissolved metals. Exposure to heavy metal contaminants is detrimental to the survival of winter-run chinook because elevated concentrations can cause mortality, impair physiological functions, and stress both juvenile and adult stages.

Implementing Agencies: Environmental Protection Agency, State Water Resources Control Board, Regional Water Quality Control Boards.

3) Implement, enforce, and monitor all water quality objectives necessary for the protection of fishery uses through the waste discharge permitting process.

Section 402 of the Clean Water Act established a permitting system known as the National Pollutant Discharge Elimination System (NODES), and the State implements the NODES permit program, under the Porter-Cologne Water Quality Act. Accordingly, before the State issues a permit, the Regional Water Quality Control Board must certify that a discharge complies with the appropriate water quality standards. This permitting process should be used as a mechanism to ensure water quality objectives, protective of winter-run chinook and their prey, are being met.

Implementing Agencies: Environmental Protection Agency, State Water Resources Control Board, Regional Water Quality Control Boards.

4) Establish numeric water quality objectives for pesticides, herbicides, and organic and inorganic compounds to protect all life-stages of chinook salmon and their prey.

Certain compounds were not addressed in the Inland Surface Water and Enclosed Bays and Estuaries plans, and need to have water quality criteria developed for them. These include methyl parathion, diazinon, tributyltin, chlorpyrifos, carbofuran, malathion, molybdenum, boron, acrolein, ethyl parathion, and triazines. Criteria for these compounds should be developed to provide long-term protection for sensitive aquatic invertebrates and chinook salmon. The Regional Water Quality Control Boards should implement, monitor, and enforce these water quality objectives through the National Pollution Discharge Elimination System waste discharge permitting process and the implementation of best management practices.

Implementing Agencies: Environmental Protection Agency, State Water Resources Control Board, Regional Water Quality Control Boards, California Department of Fish and Game, California Department of Food and Agriculture.

OBJECTIVE 8:
Protect and maintain gravel resources in the Sacramento River and its tributaries between Keswick Dam and Red Bluff

Spawning gravel in the upper Sacramento River is required for successful salmon reproduction and juvenile rearing, and it is an essential component of the overall functioning of the Sacramento River watershed as a natural ecosystem. The construction of Shasta Dam eliminated the primary source of gravel recruitment in the upper Sacramento River. Gravel supplies have gradually become reduced, which is particularly evident in the first 15 to 20 miles below Keswick Dam where the river's bed is severely degraded. The remaining natural gravel supplies above Red Bluff are derived primarily from tributary streams. These gravel resources continue to decrease due to flood scouring and gravel depletion from mining operations.

Spawning gravel resources in the upper Sacramento River are considered adequate to support the adult spawning population of winter-run chinook at its present low level, although gravel resources may become limiting as the population increases. The reduced gravel supply has caused increased streambed and bank erosion in the upper Sacramento River, which decreases viable rearing habitats for winter-run chinook. To ensure a sufficient gravel supply as winter-run chinook recover, existing gravel resources within tributary streams must be protected, and spawning gravel in the main stem Sacramento River must be replenished. In addition, spawning gravel must be protected from excessive silt deposition. Excess silt enters the Sacramento River during winter storms due to erosion from agriculture, road building, land development for subdivisions, and livestock grazing.

Recommended Actions:

1) Restore, replenish, and monitor spawning gravel in the Sacramento River.

The recommended method of replenishing gravel in the river is the placement of large stockpiles of spawning-sized gravel on the bank where it can be transported by natural processes throughout the river during high flow events. Pilot projects have shown that this method is biologically sound and cost effective, and appears to have an additional benefit of filling in certain depression areas where juveniles have been susceptible to stranding. The source of gravel for replenishing supplies in the river should not include those sources which would naturally contribute spawning gravel to the river, and should be extracted from offstream sites to avoid damage to riparian vegetation, groundwater, water quality, fish, and wildlife. Environmentally preferred sources of gravel have been identified in a recent California Department of Water Resources study[18]. Finally, monitoring programs should be continued which assess the status of natural and supplemented spawning gravel resources, especially after major flood events.

Section 3406(b)(13) of the Central Valley Project Improvement Act has also requires the development and implementation of a continuing program to restore and replenish spawning gravel lost due to the construction and operation of Central Valley Project dams, bank protection, and other actions that have reduced the availability of spawning gravel.

Implementing Agencies: U.S. Fish and Wildlife Service, National Marine Fisheries Service, California Department of Fish and Game, U.S. Bureau of Reclamation, local counties.

2) Develop and implement a plan to protect all natural sources of spawning gravel in the high water channels and along the flood plains of the Sacramento River and its tributaries.

The recent study by the California Department of Water Resources[19] outlined a management plan which identifies out-of-stream gravel sources, and describes the quality and quantity of gravel in the Shasta and Tehama county area. The report also provides important data and recommendations for regulations, mitigation measures and gravel mining projects. Guidelines in this report should be utilized to prepare Aggregate Resource Management Plans (ARMP) for Shasta and Tehama counties. These ARMP plans should also include the following general recommendations:

> To the maximum extent feasible, eliminate instream gravel mining by limiting gravel extraction to offstream terrace areas, rock quarry mining, gravel recycling, and mining gravel only of sizes not used by spawning chinook salmon.

Where instream mining is conducted, gravel extraction should be conducted on a less than sustained-yield basis to allow gravel to be recruited into spawning areas. In addition, the mining of gravel from the high water channels of the river and its tributaries should be prohibited in Tehama County, and should continue to be prohibited in Shasta County. Regulatory agencies should continue to review gravel mining projects to ensure best management practices are implemented which minimize adverse impacts to streambeds, riparian habitat, and fisheries and wildlife resources.

Implementing agencies: U.S. Army Corps of Engineers, State Reclamation Board, California Department of Conservation Division of Mines and Geology, California Department of Fish and Game, National Marine Fisheries Service, U.S. Fish and Wildlife Service, State Lands Commission, California Coastal Commission, Central Valley Regional Water Quality Control Board, CalTrans, and local agencies.

3) Control excessive silt discharge to protect spawning gravel in the main stem by protecting watersheds in the Sacramento River Basin.

Watershed erosion can be a significant contributor of silt and sediment to the Sacramento River. Erosion products entering the upper Sacramento River can infiltrate and clog spawning areas resulting in reduced survival of incubating eggs and alevins. Best management practices for erosion control should be required on both private and public lands to ensure watershed protection, particularly in tributaries. Local government agencies should develop and enforce appropriate grading ordinances for erosion control. For special problem sites, the local Resource Conservation Districts should assist in developing and implementing remedies through a watershed planning process.

Implementing Agencies: local counties, California Department of Forestry, CalTrans, Bureau of Land Management, Central Valley Regional Water Quality Control Board, San Francisco Bay Regional Water Quality Control Board, Natural Resources Conservation Service, Resource Conservation Districts

OBJECTIVE 9:
Reduce habitat loss, entrainment and pollution from dredging and dredge disposal operations

Dredging is routinely conducted to maintain ship channels and port access, to repair and maintain levees, and to excavate commercial aggregate material such as sand and gravel. In the estuary, about 8 million cubic yards of material are dredged annually, and most dredge spoils have been dumped back into the Bay, near Alcatraz Island.[20] Dredging and dredge spoil disposal practices may entrain fish, alter benthic habitat, create turbidity, and resuspend toxic materials. Winter-run chinook migrating through areas with dredge-related activities could be entrained and exposed to adverse water quality and degraded habitat conditions.

Recommended Actions:

1) Conduct dredging and disposal operations to minimize entrainment of juvenile winter-run chinook, habitat loss and water quality degradation.

Dredging and dredge disposal operations for all areas within the rearing and migratory habitat of winter-run chinook should occur when juvenile winter-run chinook are not present. Allowable construction periods have been developed by the fisheries agencies to avoid entrainment. Dredging in new areas should be avoided or mitigation should be conducted to avoid any net loss of riverine or sub-tidal foraging habitat.   Dredging should be particularly avoided at depths shallower than twenty feet to protect valuable foraging habitat in nearshore areas for juvenile chinook salmon. If dredging is conducted in these nearshore areas (<20 ft water depth), the adverse effects of dredging within the critical habitat of winter-run chinook should be fully mitigated.   Overall, clamshell dredging is the recommended method of operation in shallow areas in the presence of juvenile winter-run chinook. Hydraulic dredging should be avoided or minimized, particularly for substrate skimming. In the presence of juvenile fish, hydraulic "pothole" dredging is considered less detrimental, provided the suction intake is operated at or below the substrate bottom, and the intake is not raised greater than three feet above the substrate bottom during suction cleaning operations.

In addition, methods being developed by the Environmental Protection Agency for dredge operations and disposal in the estuary should be implemented. All dredge material disposed in aquatic environments must meet adequate contaminant sampling, testing requirements and quality standards to ensure dredge material does not contain toxic materials harmful to winter-run chinook. Standards for disposal within San Francisco Bay should be at least as stringent as those for ocean disposal.

Disposal methods must be developed for the river and areas in the Delta not presently covered by interim guidelines for the estuary. These methods should include sediment testing criteria, standards, and protocol for dredge disposal similar to testing for estuarine disposal.

In addition, improved infrastructure is needed in the California dredging community to accommodate increased ocean disposal options during most weather conditions and to stockpile materials from smaller dredging operations pending ocean disposal.

Implementing Agencies: U.S. Army Corps of Engineers, Environmental Protection Agency, State Lands Commission, California Department of Water Resources, Bay Conservation and Development Commission, Regional Water Quality Control Boards.

**2)	Minimize the volume of dredge material disposed into the San Francisco Bay and Estuary**

The Long Term Management Strategy (LTMS) program objectives include managing dredge disposal and establishing disposal options and protocols to control accumulation and re-suspension of contaminated dredge spoils in the San Francisco Bay and Estuary. The LTMS program should require that contaminated and uncontaminated dredge material be disposed of at upland sites to the maximum extent possible. Suitable dredge material should be reused for wetlands restoration, construction material, levee maintenance and other beneficial uses, followed by disposal at the deep-water ocean site. Disposal of dredged material into the San Francisco Bay estuary should be limited to progressively smaller volumes of clean material from maintenance projects only. No new in-water disposal sites should be permitted within San Francisco Bay.

Implementing Agencies: Environmental Protection Agency, State Water Resources Control Board, U.S. Army Corps of Engineers, San Francisco Bay Conservation and Development

Commission, Regional Water Quality Control Board, State Lands Commission.

GOAL II: IMPROVE SURVIVAL OF DOWNSTREAM MIGRANTS

Table V-5. List of Recovery Actions for Sacramento River Winter-run Chinook Salmon Related to Goal II: Improve Survival of Downstream Migrants.

Objective/Action	Interim Actions	Long-term Program
1. Maximize survival of juveniles at unscreened or inadequately screened diversions on the Sacramento River, Sacramento-San Joaquin Delta, and Suisun Marsh (Priority 1)		
1. Develop and implement a comprehensive plan to install positive barrier fish screens at unscreened or poorly screened diversions on the Sacramento River, Sacramento-San Joaquin Delta, and Suisun Marsh sloughs.	Ongoing	December 2007
2. Evaluate water rights for operators initiating diversions in the winter for rice-stubble decomposition flooding and waterfowl habitat development.	Ongoing	September 1999
3. Promulgate and implement a Federal Rule to require the screening of water diversions in the critical habitat and natural migratory pathways of winter-run chinook salmon.	Ongoing	January 1999
2. Maximize the survival of juveniles passing the Red Bluff Diversion Dam (Priority 1)		
1. Operate the Red Bluff Diversion Dam in a gates-up position from September 1 through May 14 of each year, until a permanent remedy for the facility is implemented.	Ongoing	September 1998
2. Complete evaluations of the Archimedes screw pump and the helical pump for their the technological and environmental effectiveness in diverting water to the Tehama-Colusa and Corning canals.	Ongoing	September 1998

Objective/Action	Interim Actions	Long-term Program
3. Develop and implement a permanent remedy at the Red Bluff Diversion Dam which provides maximum free passage for juvenile (and adult) winter-run chinook salmon through the Red Bluff area, while minimizing losses of juveniles in water diversion and fish bypass facilities.	Ongoing	January 1999
3. Maximize survival of juvenile winter-run chinook salmon passing the Glenn-Colusa Irrigation District's Hamilton City Pumping Plant (Priority 1)		
1. For the interim, the Glenn-Colusa Irrigation District should maximize the survival of juvenile winter-run chinook by operating the Hamilton City facility as described in the Federal Joint Stipulated Agreement until a new water diversion and fish screening facility is constructed and operational.	Ongoing	January 1998
2. Design and construct new positive barrier fish screens at the Glenn-Colusa Irrigation District's Hamilton City Pumping Plant which meet National Marine Fisheries Service and California Department of Fish and Game screening and bypass flow criteria.	Ongoing	January 1999
4. Protect and restore rearing and migratory habitats of winter-run chinook in the lower Sacramento River and Delta to maximize survival of rearing and emigrating fish (Priority 1)		
1. Implement measures to protect rearing and emigrating winter-run chinook salmon from November 1 through April 30.	Ongoing	November 1998
2. For the long-term protection of winter-run chinook salmon, identify and implement actions to significantly improve hydrodynamic conditions in the Delta.	Ongoing	Initiate plan by November 1999
3. Evaluate the survival of juvenile winter-run chinook salmon in the Delta using experimental mark-recapture experiments with surrogate chinook salmon or other appropriate methods. Using data from these studies, develop a method which assesses survival under varying hydrologic conditions.	Ongoing	Initiate by September 1998

Objective/Action	Interim Actions	Long-term Program
5. Evaluate and reduce adverse impacts associated with operating the Suisun Marsh Salinity Control Structure (Priority 2)		
1. Complete the assessment on the operational effects of the Suisun Marsh Salinity Control Structure on juvenile (and adult) winter-run chinook salmon detailed in the National Marine Fisheries Service's biological opinion for the Federal Central Valley and State Water projects.	Ongoing	January 1998
2. Develop and implement corrective actions to minimize or eliminate adverse impacts to juvenile winter-run chinook resulting from operation of the Suisun Marsh Salinity Control Structure.	Ongoing	September 1998

GOAL II: IMPROVE SURVIVAL OF DOWNSTREAM MIGRANTS

OBJECTIVE 1:
Maximize survival of juveniles at unscreened or inadequately screened diversions on the Sacramento River, Sacramento-San Joaquin Delta, and Suisun Marsh

More than 350 unscreened, or poorly screened agricultural diversions are located on the Sacramento River below Hamilton City and an unknown number exist between Hamilton City and the City of Redding. In the Delta, there are more than 2,050 diversions, essentially all of which are unscreened. Although the majority of the diversions are for agricultural purposes, numerous municipalities and industrial water users have large unscreened diversions as well. Cumulatively, unscreened diversions are likely to entrain significant numbers of juvenile winter-run chinook, because a large proportion of the juvenile population rears in the Sacramento River during the agricultural diversion season (July through November), and when rice fields are flooded to create wintering habitats for waterfowl and for rice straw decomposition (fall to spring). Losses of juvenile winter-run chinook at these unscreened or improperly screened diversions can be remedied by installing and operating positive barrier fish screens..

There has been substantial interest recently in the evaluation of experimental fish guidance devices, such as acoustic barriers, as a lower cost alternative to positive barrier fish screens to minimize juvenile losses at diversions. However, preliminary field evaluations of these systems have not yet proven them to be effective as a fish guidance or avoidance alternative. Before these devices are field tested, they need to undergo rigorous scientific testing under controlled laboratory conditions. Any subsequent field testing must be conducted during times or at locations when winter-run chinook are absent. The available funding resources for installing positive barrier fish screens should not be used on experimental fish guidance evaluations.

Recommended Actions

1) Develop and implement a comprehensive plan to install positive barrier fish screens at unscreened or poorly screened diversions on the Sacramento River, Sacramento-San Joaquin Delta, and Suisun Marsh sloughs.

Positive barrier fish screens should be installed on all diversions of 250 cfs or greater by the year 2000. Also, priorities should be set for screening diversions less than 250 cfs, with the highest priority diversions screened by 2002 and all remaining diversions screened by 2007. The National Marine Fisheries Service should immediately pursue screen implementation through section 7 of the Endangered Species Act. Also, any new diversions must have a fish screen installed.

All newly installed screens should have an easily enforceable commitment to operations and maintenance of screens. Operations and maintenance could be required through incidental take permits, or as part of government assistance programs. Diversions should also be inspected annually during the diversion season by state or Federal agencies, or through a cooperative effort between State and Federal agencies and owners and operators.   Acceptable inspection methods include remote video, diver/video, and dewatering/dry inspection.

An Anadromous Fish Screening Program is being developed as a long-term program required under the Central Valley Project Improvement Act to assist the California Department of Fish and Game in implementing its Unscreened Diversions Program. This plan should effectively use available and future funding to install positive barrier fish screens on water diversions within the critical habitat of winter-run chinook and other areas within their natural migratory pathway. Priorities for screening should be based on diversion location, size, time of diversion, and available Federal, State, and local funding. This plan should also clearly outline the screening process and necessary criteria to irrigators and Federal and State agencies. Specifically, the plan should describe: 1) general site selection criteria and guidelines; 2) design criteria; 3) regulatory and environmental compliance processes; 4) installation and construction criteria; 5) operations and maintenance requirements; 6) evaluation requirements; 7) inspection requirements and 8) reporting needs.

Section 3406(b)(21) of the Central Valley Project Improvement Act states:

> The Secretary of the Interior shall "*...assist the State of California in efforts to develop and implement measures to avoid losses of juvenile anadromous fish resulting from unscreened or inadequately screened diversions on the Sacramento and San Joaquin rivers, their tributaries, the Sacramento-San Joaquin Delta, and the Suisun Marsh. Such measures shall include but shall not be limited to construction of screens on unscreened diversions, rehabilitation of existing screens, replacement of existing non-functioning screens, and relocation of diversion to less fishery-sensitive areas. The Secretary's share of costs associated with activities authorized under this paragraph shall not exceed 50 percent of the total cost of any such activity*."

Implementing Entities: California Department of Fish and Game, National Marine Fisheries Service, U.S. Fish and Wildlife Service, U. S. Bureau of Reclamation, Natural Resources Conservation Service, irrigation districts and diverters within the critical habitat or migratory pathways of winter-run chinook.

2)　Evaluate water rights for operators initiating diversions in the winter for rice stubble decomposition flooding and waterfowl habitat development.

The timing and magnitude of Sacramento River water diversions for rice stubble decomposition coincides with the rearing and migration period of juvenile winter-run chinook (primarily in October or November, but potentially extending into the spring). All water users that initiate winter diversions should be reviewed by the State Water Resources Control Board to determine whether it constitutes a new beneficial use and thereby requiring a new water right. If a new water right is required, then existing California Department of Fish and Game screening regulations require that fish screens are installed. To avoid additional entrainment of winter-run chinook, water should only be diverted through those intakes with screened facilities.

Implementing Entities: State Water Resources Control Board, California Department of Fish and Game, National Marine Fisheries Service, U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service.

3) Promulgate and implement a Federal Rule to require the screening of water diversions in the critical habitat and natural migratory pathways of winter-run chinook salmon.

On October 18, 1993, the National Marine Fisheries Service published an Advance Notice of Proposed Rulemaking stating its intent to consider establishing screening requirements for water diversions on the Sacramento River and Sacramento-San Joaquin Delta to protect winter-run chinook. A rule which requires the installation of positive barrier screens on some or all of the unscreened and inadequately screened diversions within the critical habitat or migratory pathways is needed and should be promulgated. The present screening programs are voluntary, and are likely to extend over many years before ameliorating the entrainment of fish. A Federal Rule which requires screening would make participation in the State and Federal Unscreened Diversions Programs mandatory.

Implementing Agencies: National Marine Fisheries Service, U.S. Fish and Wildlife Service, California Department of Fish and Game.

OBJECTIVE 2:
Maximize the survival of juveniles passing the Red Bluff Diversion Dam

During operation of the Red Bluff Diversion Dam, juvenile winter-run chinook are adversely affected while approaching the dam, passing the dam, and moving downstream of the dam. As juveniles migrate towards the dam, they experience increased predation in Lake Red Bluff from predatory fish and birds. Juveniles passing under the lowered dam gates become disoriented due to high water velocities and turbulence, and are subject to injury and heavy predation downstream by squawfish and striped bass. Juveniles bypassed around the dam through the Tehama-Colusa fish bypass system may have improved survival due to new facilities and positive barrier fish screens, but complete evaluations are needed.

In 1983, a Fish Passage Action Program was initiated to identify and implement interim and permanent corrective measures for improving fish passage at the Red Bluff Diversion Dam. At present, both a low-speed helical pump and a Archimedes screw pump are being tested to determine if they can feasibly divert water while at the same time protect juvenile chinook. If proved feasible, a pumping facility could be constructed which would reduce or eliminate the need for lowering dam gates for water diversions, and thereby improve fish passage conditions for adult and juvenile life stages of all four chinook salmon runs including winter-run chinook. Following investigations on these pumps, a final passage remedy will be identified, which should significantly reduce or eliminate adult and juvenile passage problems.

Recommended Actions

1) Operate the Red Bluff Diversion Dam in a gates-up from September 1 through May 14 of each year, until a permanent remedy for the facility is implemented.

Operating the Red Bluff Diversion Dam in a "gates up" position from September 1 through May 14, reduces the aggregation of predatory squawfish and permits the unobstructed downstream migration of the majority of juvenile winter-run chinook. The operation of Red Bluff Diversion Dam in this manner protects about 89% of juvenile winter-run chinook but does not provide protection for the remaining 11% emigrating past the dam in August.

Implementing Agencies: U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, National Marine Fisheries Service.

2) Complete evaluations of the Archimedes screw pump and helical pump for their technological and environmental effectiveness in diverting water to the Tehama-Colusa and Corning canals.

Both of these types of pumps are being evaluated at the Red Bluff Diversion Dam's Research Pumping Facility to determine their effectiveness in diverting water to the Tehama-Colusa and Corning canals while minimizing adverse affects to juvenile salmon. The rate of fish loss at the Research Pumping Facility should not exceed that found at the existing rotary drum screens at the head of the Tehama-Colusa Canal. If effective, the use of the Research Pumping Facility could greatly reduce or eliminate the need for lowering dam gates for water diversions, clearly benefiting many life stages of all four chinook salmon runs, and particularly juvenile winter-run chinook emigrating during August and early September.

Implementing Agencies: U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, National Marine Fisheries Service.

3) Develop and implement a permanent remedy at the Red Bluff Diversion Dam which provides maximum free passage for juvenile (and adult) winter-run chinook through the Red Bluff area, while minimizing losses of juveniles in water diversion and fish bypass facilities.

Following investigations of the Archimedes screw pump and helical pump, the U.S. Bureau of Reclamation must develop a final remedy which significantly reduces or eliminates juvenile and adult passage problems. The ongoing evaluations and monitoring studies of juvenile chinook fish screening and bypass efficiency at the Tehama-Colusa Canal fish bypass system should also be completed.

The actions implemented to develop a permanent remedy at the Red Bluff Diversion Dam should conform to Section 3406(b)(1)(A) of the Central Valley Project Act which states that the Secretary of the Interior shall "...give first priority to measures which protect and restore natural channel and riparian habitat values through habitat restoration actions, modifications to Central Valley Project operations...". In addition, Section 3406(b)(10) requires the Secretary to "...develop and implement measures to minimize fish passage problems for adult and juvenile anadromous fish at the Red Bluff Diversion Dam...".

Implementing Agencies: U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, National Marine Fisheries Service.

OBJECTIVE 3:
Maximize survival of juvenile winter-run chinook passing the Glenn-Colusa Irrigation District's Hamilton City Pumping Plant

The Glenn-Colusa Irrigation District operates the largest (3,000 cfs) water diversion on the Sacramento River. Their pumping plant is located on an artificially maintained oxbow of the Sacramento River near Hamilton City. The original fish screens in front of the plant were not sufficient to prevent high losses of juvenile winter-run chinook, particularly fry, due to entrainment and impingement at the screens. An interim flat plate screening structure was installed in 1993 which has improved hydraulic conditions at the screen, but the modified facility still fails to meet many important National Marine Fisheries Service and California Department of Fish and Game screening criteria for anadromous fish. Predation of juvenile winter-run chinook is also known to occur in the oxbow's intake and bypass channels, and may occur at high rates during the peak outmigration period.

Recommended Actions

1) For the interim, the Glenn-Colusa Irrigation District should maximize the survival of juvenile winter-run chinook by operating the Hamilton City facility as described in the Federal Joint Stipulated Agreement until a new water diversion and fish screening facility is constructed and operational.

This stipulated agreement, signed by the District, Department of Justice, California Department of Fish and Game, and the U.S. Bureau of Reclamation specifies requirements for lower oxbow bypass flows, screen approach velocity criteria, facility maintenance, monitoring, and reporting.

Implementing Entities: U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, California Department of Fish and Game, National Marine Fisheries Service, Glenn-Colusa Irrigation District, U.S. Department of Justice.

2) Design and construct new positive barrier fish screens at the Glenn-Colusa Irrigation District's Hamilton City Pumping Plant which meet National Marine Fisheries Service and California Department of Fish and Game screening and bypass flow criteria.

The U.S. Bureau of Reclamation should complete its efforts with the Glenn-Colusa Irrigation District and the State of California to implement a permanent remedy for juvenile fish passage problems at the Hamilton City Pumping Plant. A public draft Environmental Impact Report/Environmental Impact Statement (EIR/EIS) is scheduled for release in September 1997 and it will indentify an environmentally superior alternative. The Technical Advisory Group continues to refine the screen design and construction techniques for the environmentally superior alternative. Construction of the best alternative that is identified should be completed by September 2001.

Section 3406(b)(20) of the Central Valley Project Improvement Act also directs the Secretary of the Interior to "...participate with the State of California and other federal agencies in the implementation of the on-going program to mitigate fully for the fishery impacts associated with operations of the Glenn-Colusa Irrigations District's Hamilton City Pumping Plant. Such participation shall include replacement of the defective fish screens and fish recovery facilities...".

Implementing Entities: U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, California Department of Fish and Game, National Marine Fisheries Service, Glenn-Colusa Irrigation District.

OBJECTIVE 4:
Protect and restore rearing and migratory habitats of winter-run chinook in the lower Sacramento River and Delta to maximize survival of rearing and emigrating fish

This objective addresses the lower Sacramento River, the Sacramento-San Joaquin Delta, and the San Francisco Bay Estuary in the area bounded by Georgiana Slough westward from the confluence of the lower Mokelumne River and the lower San Joaquin River, and natural channels north and west of the lower Sacramento River. The overall intent of this objective is to 1) reduce fish movement to the southern and eastern Delta, 2) minimize effects associated with adverse conditions in these waterways, and 3) improve rearing and migration habitat conditions within natural migratory pathways to the Pacific Ocean.

The temporal distribution of juvenile winter-run chinook in the lower Sacramento River and Sacramento-San Joaquin Delta varies from year to year, and is likely influenced by year-class abundance and hydrologic conditions. In general, juvenile winter-run chinook rear and emigrate through the lower Sacramento River and Delta from November through April or May. Adequate flows are needed during this period to provide suitable rearing habitat including access to productive stream margins in the lower Sacramento River, suitable water temperatures and water quality in the river and Delta, and sufficient flows for successful migration to the ocean.

At present, flow conditions in the Delta often adversely affect juvenile winter-run chinook. When the combined exports at the State and Federal pumping plants exceed San Joaquin River flow, the balance of water comes from the Sacramento River system via the Delta Cross Channel, the Mokelumne River, Georgiana Slough, and Three Mile Slough. This water (net flow) then moves upstream from the lower San Joaquin River into Old and Middle Rivers. The resulting hydraulic conditions and net flow reversal increase the probability of juvenile winter-run chinook experiencing lower survival in the central and southern Delta.

The main sources of reduced survival in the central and southern Delta include: 1) an extended migration route during which the fish are exposed to predation for a longer time period, 2) higher water temperatures, 3) unscreened agricultural diversions, 4) poor water quality, 5) reduced food availability, and 6) a complex configuration of channels. Juvenile winter-run chinook that arrive at the Central Valley Project and State Water Project pumping plants experience further mortality. The sources of this mortality include: 1) high predation in Clifton Court Forebay, 2) predation in front of the screens and within the bypass system, 3) entrainment through the louver screens, 4) stress associated with holding tanks, 5) stress associated with trucking to release sites, and 6) predation at release sites.

The CALFED Bay-Delta Program is developing a long-term comprehensive plan to restore ecological health and improve water management for beneficial uses of the Bay-Delta system. To achieve this objective, a Ecosystem Restoration Program Plan is being developed to define a comprehensive whole-system plan for the Bay Delta and its watershed.   CALFED envisions restoring a healthy ecosystem, which among other qualities, will support an abundance of anadromous and resident fish. This healthy, functioning ecosystem would include all habitat necessary for survival of species (including freshwater and brackish tidal marsh, shallow water, riparian woodlands and shaded riverine areas), and these habitats would be large enough and sufficiently interconnected to support sustainable populations.

CALFED's strategy is to reduce or eliminate factors which degrade habitat, impair ecological functions, or reduce the population size or health of species. These factors may cause direct mortality, but more often result in indirect mortality by degrading habitat conditions or functions.   Where there are multiple factors affecting a species, the program's strategy is to take a broad ecosystem approach, making incremental improvements in all the significant factors that affect important species and their habitats. Program results will be assessed by structuring restoration actions so that each one is measurable, and by including monitoring to assess the overall success of many actions. This approach is intended to allow for adaptive management, so that actions can be adjusted to make them more effective and to change emphasis as the condition of the ecosystem improves.

CALFED's specific actions to achieve a healthy ecosystem are currently being developed, and thus, it is too early to evaluate the potential efficacy of this restoration program. However, the overall objective is consistent with NMFS's goal of recovering winter-run chinook.   NMFS supports immediate action to implement habitat restoration and provide improved flows for winter-run chinook**.**

Recommended Actions:

1) Implement interim measures to protect rearing and emigrating winter-run chinook from November 1 through April 30.

Suitable hydrological conditions should be maintained from November 1 through April 30 to protect the majority of juvenile winter-run chinook during their rearing and migratory life stages in the lower Saacramento River and Delta It is not appropriate to solely rely on real-time monitoring of winter-run chinook to trigger protective actions, such as closing the Delta Cross Channel or reducing Delta export levels.   Winter-run chinook are presently at such low levels that field monitoring may not reliably detect the presence of juveniles. Hence, winter-run chinook may be present but not detected, such that measures may not be initiated to protect winter-run chinook when they are needed. Therefore, protective measures should be maintained throughout the period (identified above) when juvenile winter-run chinook are expected to occur. Additional protective measures may be need during the period of smoltification and active outmigration.

At a very minimum, actions identified in the *1994 Principles for Agreement on Bay-Delta*

Standards Between the State of California and the Federal Government should be maintained until the end of 1997 when the agreement expires. These actions includes the following:

> The export/inflow ratios in the Delta are allowed to range up to: 1) 65% from November through January; and 2) 35% from February through June except in critical water conditions when export rates may be increased to 45 percent in February.
>
> The Delta Cross Channel is operated in the closed position: 1) from November 1 through January 31 for a period of up to 45 days; and 2) throughout the period of February 1 through May 20th.

For the existing Central Valley Project and State Water Project facilities, NMFS determined that these protective measures in the Delta would not jeopardize the survival and recovery of winter-run chinook. However, they may prove insufficient to allow for the full recovery of winter-run chinook. The may also be insufficient for additional or expanded water export facilities in the Delta. Moreover, these measures were identified based on limited information and should be viewed as experimental. As the expiration date for the 1994 agreement approaches, managers should review available research and monitoring information to evaluate whether the above Delta operational measures are sufficient for the full recovery of winter-run chinook. If they are not, it is imperative that more protective operational measures are developed and implemented.

Until a long-term solution is identified, general guidelines for developing future, interim operational measures are: 1) actions should prevent winter-run chinook from entering the Central Delta until habitat and hydrologic conditions are restored; and 2) actions should substantially benefit rearing and migratory juvenile winter-run chinook. Actions identified by CALFED to improve Delta rearing conditions should be initiated immediately to trigger the restoration process as soon as possible. New or expanded water export facilities should not proceed until ecosystem restoration actions which benefit winter-run chinook are implemented. To protect winter-run chinook that do enter the Central Delta, hydrologic conditions should be maintained to prevent entrainment into the South Delta and to allow juveniles to emigrate westward out of the system. In addition, a clear adaptive management approach should be used in the future such that from the outset, operational measures are designed to test clearly formulated hypotheses about how winter-run chinook will respond to management actions in the Delta ecosystem.

In addition, the California Department of Water Resource's Interim South Delta Program should be postponed until the CALFED long-term storage and conveyance alternative is selected. The Interim South Delta Program is expected to result in cumulative impacts to Sacramento River salmon, including winter-run chinook, due to incremental increases in transport of salmonids into the Central and Southern Delta. Other significant, short-term impacts are also expected during construction such as dredging. These various impacts may be avoided by delaying project implementation until it is determined that the Interim South Delta Program is consistent with the long-term Bay-Delta storage and conveyance solution selected by CALFED.

Section 3406(b)(4) of the Central Valley Project Improvement Act directs the Secretary of the Interior to "...develop and implement a program to mitigate for fishery impacts associated with operations of the Tracy Pumping Plant.

Implementing Agencies: U.S. Fish and Wildlife Service, California Department of Fish and Game, California Department of Water Resources, State Water Resources Control Board, U.S. Bureau of Reclamation.

2) For the long-term protection of winter-run chinook, identify and implement actions to significantly improve hydrodynamic conditions in the Delta.

The existing architecture of the Delta waterways and the location of the State and Federal Delta pumping plants is ill-suited for protecting rearing and migrating juvenile winter-run chinook. The CALFED Bay-Delta Program should focus on identifying and evaluating alternatives in which the environmental impacts of exporting water is significantly reduced from the present level under the Bay-Delta agreement. A preferred alternative would significantly improve the survival of juvenile winter-run chinook in the Delta, substantially reduce or eliminate entrainment, and improve habitat conditions in the natural migratory corridors and pathways in the Delta.

A long-term solution should result in beneficial rearing habitat for winter-run chinook throughout the lower Sacramento River and Central Delta such that: 1) shaded riverine, tidal and shallow water habitats are restored to provide cover and refugia, and to improve food production (including food web production) and feeding habitat; 2) predation is minimized; and 3) temperatures are sufficiently cool. Juvenile winter-run chinook should be prevented from entering the Central Delta until habitat conditions are restored to provide the benefits described above. Once habitat conditions are restored and winter-run chinook are allowed to emigrate and rear in the Central Delta, hydrologic conditions should be maintained to prevent juveniles from entering the South Delta to avoid entrainment. Hydrologic conditions should also be maintained in the Central Delta to allow winter-run chinook to freely emigrate westward throughout their outmigration period. Finally, until habitat improvements have been demonstrated to significantly benefit winter-run chinook, water exports should not be increased above the levels specified in the 1994 Bay-Delta agreement. If more protective operational measures are identified in the future (after the Bay-Delta agreement expires), water exports associated with these operational conditions should not be increased until habitat improvements can be demonstrated to significantly benefit winter-run chinook and lead to the population’s recovery.

NMFS supports the CALFED process for developing and implementing a program to restore the Delta ecosystem which should substantially contribute to the recovery of winter-run chinook. However, if the CALFED program is not successful in developing a ecosystem restoration plan and Delta rearing conditions are not in the process of becoming substantially restored by the year 2000, then NMFS should reinitiate consultation with the Bureau of Reclamation to implement operational measures that will create adequate hydraulic conditions for the successful rearing and migration of winter-run chinook through the Bay-Delta system.

Implementing Agencies: California Department of Water Resources, U.S. Bureau of Reclamation, CALFED Bay-Delta Program.

3) Evaluate the survival of juvenile winter-run chinook in the Delta using experimental mark-recapture experiments with surrogate chinook salmon or other appropriate methodologies. Using data from these studies, develop a model or method which assesses winter-run chinook survival under varying hydrologic conditions.

Investigations should be conducted to evaluate the survival of juvenile salmon smolts under various hydrological conditions. These studies may include mark/recapture or other methods which would improve our understanding of winter-run chinook migratory behavior and survival. Data from these studies should then be used to develop a model or other appropriate tool to assess survival under various water management strategies. These data would also be important in developing alternatives for implementing the CALFED Bay-Delta Program's efforts to identify suitable measures to protect water supplies and restore aquatic habitat throughout the Central Valley.

In addition, monitoring is needed to evaluate losses of juvenile winter-run chinook during the fish salvage procedures at each facility.

Implementing Agencies: U.S. Fish and Wildlife Service, California Department of Fish and Game, California Department of Water Resources, U.S. Bureau of Reclamation, CALFED Bay-Delta Program.

OBJECTIVE 5:
Evaluate and reduce adverse impacts associated with operating the Suisun Marsh Salinity Control Structure

The Suisun Marsh Salinity Control Structure was built in 1987 as one of several physical structures designed to improve freshwater circulation within the marsh to meet salinity standards, established by the State Water Resources Control Board in Decision 1485. These standards were developed to moderate increases in salinity levels in marsh sloughs resulting from increasing export of fresh water.

The Salinity Control Structure operates to achieve these standards by tidally pumping water from the Sacramento River into Montezuma Slough. Operation of the structure has increased flow into Montezuma Slough, a condition which has likely resulted in increases in the number of juvenile salmonids moving into the slough. Although Suisun Marsh sloughs could provide important rearing habitat, survival of juvenile salmon moving through the marsh sloughs is likely reduced due to entrainment at the large number of unscreened diversions in the marsh. Sixty unscreened diversions exist on Montezuma Slough alone, with a total of about 140 unscreened diversions in all marsh sloughs. A program has recently been initiated to screen diversions within Suisun Marsh which should alleviate entrainment losses in the marsh. Juveniles may also be periodically entrained in the Roaring River Distribution System intake on Montezuma Slough which is screened, but recurrent scouring allows entrainment under the screens. Striped bass and other predators are also known to congregate at the control structure, and may prey upon juvenile winter-run chinook.

Recommended Actions:

1) Complete the assessment on the operational effects of the Suisun Marsh Salinity Control Structure on juvenile (and adult) winter-run chinook, detailed in the National Marine Fisheries Service's Biological Opinion for the Central Valley and State Water projects.

Field investigations need to be completed which evaluate: 1) diversion rate of juvenile salmon into Montezuma Slough, 2) predation rate on juveniles at the control structure, 3) juvenile survival rates during passage through Montezuma Slough, and 4) upstream passage of adult chinook past the control structure.

Implementing Entities: California Department of Water Resources, Suisun Resource Conservation District.

2) Develop and implement corrective actions to minimize or eliminate adverse impacts to juvenile winter-run chinook resulting from operation of the Suisun Marsh Salinity Control Structure.

Operational and/or structural modifications should be identified as a result of the assessment and measures implemented to minimize or eliminate adverse impacts associated with the operation of the Salinity Control Structure. Potential measures include: 1) modifying gate operations when adult winter-run chinook may occur, 2) removing stop logs when gates are not operating, 3) screening diversions within marsh or closing unscreened diversions during gate operations when winter-run chinook could be present, and 4) removing striped bass around structure through angling.

Implementing Agencies: California Department of Water Resources, U.S. Bureau of Reclamation, State Water Resources Control Board, Suisun Resources Conservation District, and California Department of Fish and Game.

GOAL III: IMPROVE ADULT UPSTREAM PASSAGE

Table V-6. List of Recovery Actions for Winter-run Chinook Related to Goal III: Improve Adult Upstream Passage.

Objective/Action	Interim Actions	Long-term Program
1. Eliminate or minimize delay and blockage of adults at the Red Bluff Diversion Dam (Priority 1)		
1. Operate the Red Bluff Diversion Dam in a gates-up position from September 1 through May 14 of each year, until a permanent remedy for the facility is implemented.	Ongoing	September 1998
2. Develop and implement a permanent remedy that provides maximum free passage for adult (and juvenile) winter-run chinook past the Red Bluff area, while minimizing losses of juveniles in water diversion and fish bypass facilities.	Ongoing	January 1999
2. Minimize straying of adult winter-run chinook from their natural migratory corridor (Priority 1)		
1. Minimize diversion of Sacramento River water to areas outside the natural migratory corridors during the upstream migration period of winter-run chinook.	Ongoing	January 1999
2. Develop and implement corrective measures that prevent or reduce the straying of adult fish to the Colusa Basin Drain and the Delta Cross Channel, and allows passage back to the river at the upstream ends of the Sacramento Deep Water Ship Channel and the Sutter and Yolo flood bypass system.	Ongoing	September 1999
3. Eliminate or minimize delay and blockage of adults at the Anderson-Cottonwood Irrigation District dam on the Sacramento River (Priority 2)		
1. Complete a feasibility study to identify, develop, and evaluate alternatives to resolving fish passage problems at the Anderson-Cottonwood Irrigation District dam.	Ongoing	December 1998
2. Develop and implement permanent structural and operational remedies which minimize or eliminate adult passage problems at the Anderson-Cottonwood Irrigation District diversion dam or eliminate passage problems through restoration of the natural channel.	Ongoing	June 1999
4. Evaluate and correct adult passage problems in the Suisun Marsh (Priority 2)		

Objective/Action	Interim Actions	Long-term Program
1. Complete evaluations to assess the effects of Suisun Marsh Salinity Control Structure operations on adult chinook migration.	Ongoing	January 1998
2. Develop and implement corrective actions which minimize delay and blockage of adult winter-run chinook at the Suisun Marsh Salinity Control Structure.	Ongoing	September 1998
5. Eliminate entrapment of adult winter-run chinook at the Keswick Dam Stilling Basin (Priority 3)		
1. Monitor the escape channel for its effectiveness in allowing adults to exit from the Keswick Dam stilling basin.	Complete	September 1997

GOAL III: IMPROVE ADULT UPSTREAM PASSAGE

OBJECTIVE 1:
Eliminate or minimize delay and blockage of adults at the Red Bluff Diversion Dam

Investigations have shown that the operation of the Red Bluff Diversion Dam can delay and block adult winter-run chinook during their upstream migration to spawning grounds. Eggs from adults forced to spawn below the dam are exposed to lethal water temperatures in most years, eliminating important reproductive potential for the population. Also, the physiological stress associated with delays and repeated attempts to pass the dam may contribute to reduced fecundity of spawners that eventually pass upstream.

Recommended Actions

1) Operate the Red Bluff Diversion Dam in a gates-up position from September 1 through May 14 of each year, until a permanent remedy is implemented.

Operating the Red Bluff Diversion Dam in a gates-up position from September 1 through May 14 should provide unimpeded passage for at least 85% of the upstream migrants. The remaining adults (15%) migrating after May 15th will likely experience delay and blockage due to Red Bluff Diversion Dam operation.

Implementing Agencies: U.S. Bureau of Reclamation, National Marine Fisheries Service, U.S. Fish and Wildlife Service.

2) Develop and implement a permanent remedy that provides maximum free passage for adult (and juvenile) winter-run chinook past the Red Bluff area, while minimizing losses of juveniles in water diversion and fish bypass facilities.

A pumping facility should be installed and operated in a manner which permits the maximum period of unobstructed upstream passage for adult winter-run chinook while meeting water diversion needs such that Red Bluff Diversion Dam gates are minimally needed if at all. This permanent remedy must be consistent with Sections 3406(b)(1) and 3406(b)(10) of the Central Valley Project Improvement Act. Section 3406(b)(10) directs the Secretary of the Interior to "... develop and implement measures to minimize fish passage problems for adult and juvenile anadromous fish at the Red Bluff Diversion Dam...".

Implementing Agencies: U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, National Marine Fisheries Service.

OBJECTIVE 2:
Minimize straying of adult winter-run chinook from their natural migratory corridor

Adult winter-run chinook may be attracted into Delta waterways outside their natural migratory corridor due to the diversion water from the Sacramento River. Such straying may delay or prevent the successful upstream migration of adults. Particular areas of concern include: 1) Suisun Marsh sloughs, 2) artificially maintained channels such as the Sacramento Deep Water Ship Channel, 3) the flood bypasses such as Yolo and Sutter bypasses, 4) the Colusa Basin Drain, 5) the North Bay Aqueduct, and 6) the Delta Cross Channel.

In the Suisun Marsh area, there has been a proposal to divert Sacramento River water to western Suisun Marsh sloughs to achieve salinity standards in the western marsh, as part of the Western Suisun Marsh Salinity Control Project. This has been proposed to augment flow to the western marsh using a combination of water from Barker Slough, a Sacramento River water source, and Lake Berryessa water. This project could cause straying of adult winter-run chinook.

The Sacramento Deep Water Ship Channel is a 46.5 mile artificial channel allowing ocean-going vessels access to the Port of Sacramento via the Northern Delta. Sacramento River water is diverted into the channel, and adult chinook salmon have been observed in the ship channel on a year-round basis.

The flood bypasses convey water when the Sacramento River reaches flood proportions during winter storms. Overflow water enters the bypasses, and then returns to the Sacramento River downstream where the bypasses merge with the river. Adults may be attracted into the bypasses and become trapped, as flows recede or because they are unable to navigate back to the river.

In addition, drainwater from the Colusa Basin is discharged into the Sacramento River in the spring, and adults may be attracted into the drain and blocked from returning to the river.

Recommended Actions:

1) Minimize diversion of Sacramento River water to areas outside the natural migratory corridors during the upstream migration period of winter-run chinook.

Any proposed projects which may have the potential to induce straying of adult winter-run chinook should thoroughly evaluate the potential for creating Sacramento River attraction flows. Projects which have the potential to induce straying should not be implemented.

Implementing Agency: California Department of Water Resources, U.S. Bureau of Reclamation, U.S. Army Corps of Engineers.

2) Develop and implement corrective measures that prevent or reduce the straying of adult winter-run chinook to the Colusa Basin Drain and Delta Cross Channel, and allows passage back to the river at the upstream ends of the Sacramento Deep Water Ship Channel and the Sutter and Yolo flood bypass system.

Actions need to be implemented to reduce the incidence of adult winter-run chinook straying from their natural migratory corridors. Straying and blockage at the Colusa Basin Drain, the Sacramento Deep Water Ship Channel, and Delta Cross Channel are problems that can likely be alleviated through operational modifications, or through construction of structures or devices to allow upstream passage, or reduce or eliminate straying.

The following actions are recommended to evaluate the straying of winter-run chinook from their natural migratory corridors:

Assess and develop recommendations to reduce straying of adult winter-run chinook into the Sacramento Deep Water Ship Channel;
Assess methods to allow adult winter-run chinook trapped in the Sacramento River Deep Water Ship Channel to return to the Sacramento River;
Develop and implement actions to provide passage for adults (and juveniles) in the Sutter and Yolo bypasses, including an evaluation for installing fish ladders in upstream ends of bypasses;
Assess and develop recommendations to reduce straying of adult winter-run chinook at the entrance to the Colusa Basin Drain near Knights Landing; and evaluate installation of fish ladders in upstream ends of bypasses;
Assess and develop recommendations to reduce straying of adult winter-run chinook at the Delta Cross Channel.

The resulting recommendations should be implemented to reduce straying of adult winter-run chinook.

Implementing Agencies: U.S. Army Corps of Engineers, California Department of Water Resources, U.S. Bureau of Reclamation.

OBJECTIVE 3:
Eliminate or minimize delay and blockage of adults at the Anderson-Cottonwood Irrigation District dam on the Sacramento River

Adult winter-run chinook must negotiate fish ladders at the Anderson-Cottonwood Irrigation District dam during the irrigation season (typically April through November) to reach upstream spawning habitat. However, an antiquated ladder on the east abutment of the dam is ineffective in providing safe passage, and a recently installed denil ladder on the west abutment has proven only marginally successful. The ladders at this facility do not provide suitable flows for attracting adults, and the ladders are not easily adjusted to compensate for varying flow conditions. A feasibility study is being conducted to identify, develop, and evaluate alternatives for resolving adult passage problems with the Anderson-Cottonwood Irrigation District.

Recommended Actions

1) Complete a feasibility study to identify, develop, and evaluate alternatives to resolving passage problems at the Anderson-Cottonwood Irrigation District dam.

The identification of structural and/or operational alternatives to reduce or eliminate fish passage problems at the Anderson-Cottonwood Irrigation District dam on the main stem Sacramento River is needed. One alternative that should be considered is removing the dam and installing screened pumps to provide water to the Anderson-Cottonwood Irrigation District dam. Remediation of fish passage problems at this structure would benefit winter-run chinook, other chinook runs, and other anadromous species. The Anderson-Cottonwood Irrigation District should also continue to implement interim, remedial measures to minimize delay and blockage of adult winter-run chinook, as specified in the settlement agreement between the District and the National Marine Fisheries Service.

Implementing Entities: Anderson-Cottonwood Irrigation District, U.S. Bureau of Reclamation, California Department of Fish and Game.

2) Develop and implement permanent structural and operational remedies which minimize or eliminate adult passage problems at the Anderson-Cottonwood Irrigation District diversion dam, or eliminate passage problems through restoration of the natural channel.

These efforts should be coordinated and integrated with parallel efforts being conducted pursuant to Section 3406(b)(17) of the Central Valley Improvement Act which directs the Secretary of the Interior to develop and implement a program to resolve fishery passage problems at the Anderson-Cottonwood Irrigation District Diversion Dam as well as upstream stranding problems related to dam operations.

Implementing Entities: Anderson-Cottonwood Irrigation District, National Marine Fisheries Service, U.S. Fish and Wildlife Service, U.S. Bureau of Reclamation, California Department of Fish and Game.

OBJECTIVE 4:
Evaluate and correct adult passage problems in the Suisun Marsh

The Suisun Marsh Salinity Control Structure was constructed in 1987 to achieve minimum salinity standards, as specified in the State Water Resources Control Board Decision 1485, by tidally pumping water from the Sacramento River into Montezuma Slough. However, operation of the Suisun Marsh Salinity Control Structure reverses the net tidal flow within Montezuma Slough from a net eastward to a net westward flow. The altered hydrologic conditions may increase the attraction of adult chinook into the slough. The upstream passage of adults which migrate through Montezuma Slough may be delayed and blocked under certain operations of the control structure.

Recommended Actions:

1) Complete evaluations to assess the effect of Suisun Marsh Salinity Control Structure operations on adult chinook migration.

Complete ongoing studies to evaluate the rate and patterns of adult fall-run chinook migration through the Salinity Control Structure under all operational scenarios, which includes: 1) flashboards in and gates tidally operated, 2) flashboards in and gates out, and 3) flashboards and gates out. These studies should evaluate the percentage of adults delayed and/or blocked by operations of the Salinity Control Structure.

Implementing Agencies: California Department of Water Resources, California Department of Fish and Game, U.S. Bureau of Reclamation, U.S. Army Corps of Engineers, State Water Resources Control Board.

2) Develop and implement corrective actions which minimize delay and blockage of adult (and juvenile) winter-run chinook at the Suisun Marsh Salinity Control Structure.

After evaluations of the Suisun Marsh Salinity Control Structure are completed, measures must be developed and implemented to reduce or eliminate any delay or blockage of adult migration resulting from gate operations. A monitoring program should also be implemented to insure that such measures are effective. The anticipated time of migration for adult winter-run chinook in this area is from November 1 through June 15.[21]

Implementing Agencies: California Department of Water Resources, U.S. Bureau of Reclamation.

OBJECTIVE 5:
Eliminate entrapment of adult winter-run chinook at the Keswick Dam Stilling Basin

Keswick Dam is located about nine miles downstream from Shasta Dam. The dam has no fish ladders and blocks further upstream passage of migrating adult chinook salmon. During normal operations, there is no flow through the dam spillway and the stilling basin below the spillway is separated from the river channel by the end sill and a rock bench. However, during a spill event, the spillway end sill and rock bench become inundated, connecting the stilling basin to the main river channel. In situations where a spill occurs when adult winter-run chinook are present, the adults may be attracted into the stilling basin. When the spill ceases, the stilling basin again becomes isolated from the main river channel and the adult winter-run chinook have had no means of escape. Recently, a channel has been excavated to allow fish to escape from the spillway through the end sill and rock bench, and back to the main river channel. This should allow winter-run chinook to escape and return to the main river channel as potential spawners.

Recommended Actions:

1) Monitor the escape channel for its effectiveness in allowing adults to exit from the Keswick Dam stilling basin.

The U.S. Bureau of Reclamation should continue to monitor the new escape channel to ensure it is successful in allowing adults to exit back to the main river channel.

Implementing Agencies: U.S. Bureau of Reclamation, National Marine Fisheries Service.

GOAL IV: PREVENT EXTINCTION THROUGH ARTIFICIAL PROPAGATION

Table V-7. List of Recovery Actions for Sacramento River Winter-run Chinook Related to Goal IV: Prevent Extinction Through Artificial Propagation Programs

Objective/Action	Interim Actions	Long-term Program
1. Assist in the recovery of Sacramento River winter-run chinook		**(Priority 3)**
1. The Winter-run Chinook Salmon Artificial Propagation and Captive Broodstock programs should continue to be evaluated for their effectiveness in supporting the winter-run chinook salmon population.	Ongoing	In place
2. Develop and implement measures that ensure hatchery produced juvenile winter-run chinook salmon imprint on the main stem Sacramento River.	Ongoing	January 1998
3. Develop and implement methods that positively identify adult chinook salmon as winter-run chinook prior to conducting breeding crosses.	Ongoing	January 1998
4. Continue to develop, implement, and monitor a comprehensive Genetic Management Plan as an integral part of the Artificial Propagation and Captive Broodstock programs to minimize or avoid genetic differentiation of the hatchery population from the wild population.	Ongoing	In place
5. Minimize disease transmission within and among the wild, hatchery, and captively reared populations.	Ongoing	In place

GOAL IV: PREVENT EXTINCTION THROUGH ARTIFICIAL PRODUCTION PROGRAMS

OBJECTIVE 1:
Assist in the recovery of Sacramento River winter-run chinook

The National Marine Fisheries Service has prepared a draft policy which provides guidelines on the use of artificial propagation in listed species' recovery. Current efforts to artificially enhance winter-run chinook should be conducted carefully and conservatively, reflecting the cautions and intent of this policy, as follows:

> "Artificial propagation can benefit the conservation of Pacific salmon. However, artificial propagation entails risks as well as opportunities for salmon conservation, and its ability to restore natural populations of Pacific salmon is largely unknown. Despite the fact that many artificial propagation programs for Pacific salmon have succeeded in producing fish for harvest, these same programs have generally not increased the abundance of natural fish...As a restoration measure for listed species, artificial propagation should be implemented only after the factors contributing to the decline of a listed species are identified, and after options requiring less intervention are evaluated...As a conservation tool, artificial propagation of salmon should be designed to maintain the inherent distinctiveness of species and protect the viability of threatened and endangered species during the recovery process."

The Coleman National Fish Hatchery (operated by the U.S. Fish and Wildlife Service) has developed an artificial propagation (supplementation) program and a captive broodstock program for winter-run chinook. These programs, which were deemed necessary given the extremely low returns of winter-run chinook in recent years, are designed to augment natural production and to prevent the extinction of winter-run chinook salmon. Both the supplementation and captive breeding program are interim measures to be discontinued as the natural population of winter-run chinook stabilizes.

Supplementation is intended to bolster the greatly reduced and fluctuating population and speed the rate of its recovery without compromising the genetic composition of the wild winter-run chinook population. The basis for supplementation is that a hatchery can provide a higher survival in the egg-to-fry and egg-to-smolt life stages than occurs naturally, although hatchery-produced fish may not survive as well as natural fish once they are released into the natural environment. The captive broodstock program is intended to protect a portion of each year-class against potential catastrophes that could decimate the population in the natural environment.

Unfortunately, two key problems have surfaced in the last two years which have precluded any contribution of the supplementation program to increasing natural production: (1) imprinting and (2) hybridization. These issues are summarized below, as well as several other sources of concern for artificial propagation programs.

There are indications, however, that the artificial propagation program could bolster the natural productivity of winter-run chinook if these problems are corrected. Information, collected in 1995, shows the potential for these programs to assist in the recovery of winter-run chinook salmon. In-river surveys in 1995 concluded approximately 88 hatchery-origin brood year 1992 adults migrated back to the Sacramento River system in 1995.[22]   The estimated return of 88 hatchery-origin adults in 1995 originated from a collection of 29 adults in 1992. This return rate (3.0) is far above the apparent replacement levels which the wild population is experiencing, highlighting the program's potential to contribute to the recovery of the population.

In 1995, the captive broodstock program made its first contribution to the artificial propagation program. About 30,000 eggs were collected in 1995 from females raised in captivity. Although the actual number of juveniles produced from these eggs was low due to poor gamete quality, this contribution again emphasizes the progress of this program and its potential for success.

Also, release of the coded-wire tagged juveniles from this program has provided valuable information on incidental ocean harvest impacts on this endangered species[23]. In addition, it appears that the artificial propagation program hasn't reduced the genetically effective population size of the winter-run chinook salmon population.[24]

Imprinting

Hatchery-produced winter-run chinook returned to Battle Creek in 1995 and 1996, apparently having imprinted on Battle Creek water. Thus, adults taken for the artificial propagation program so far have probably not contributed offspring to the wild winter-run population; instead, their take has resulted in depleting the natural spawning population. Measures must be taken to ensure hatchery-produced winter-run chinook imprint on the mainstem Sacramento River so they return as adults to supplement the wild spawning population.

Hybridization

Genetics analyses has shown that winter-run chinook were inadvertently crossed with spring-run chinook in 1993, 1994 and 1995 in the artificial propagation program.   Somewhat fortunately, these hybrids are expected to all return to Battle Creek, where successful natural reproduction is unlikely due to warm water temperatures over the summer. Future collection of broodstock must positively identify adults as winter-run chinook using genetic analyses before proceeding with crosses.

Genetic Integrity, Effective Population Size, and Fitness of the Artificially Augmented Winter-run Chinook Population

A carefully controlled supportive breeding program can benefit the endangered winter-run chinook by increasing population numbers. Also, by maximizing the effective population size resulting from this program, genetic variation should not be greatly affected. However, strict attention to breeding protocols is required to ensure that the contribution from artificial propagation does not reduce the effective population size of the wild population, as can occur under an aggressive hatchery program. Empirical genetic data should be used both to identify adult winter-run chinook and to verify the effective population size of the artificially augmented winter-run chinook population. A population genetics model should also be developed and utilized throughout the course of the artificial propagation program to determine the genetic impact of supportive breeding from both the artificial propagation and the captive broodstock programs.

Disease Associated with Artificial Propagation

Infectious disease occurs in both hatchery-reared and naturally produced salmonids, but higher mortality rates may result in hatcheries due to crowding and other artificial conditions. Disease outbreaks of Bacterial Kidney Disease have caused high losses in the Captive Broodstock Program at the Bodega Marine Laboratory, and to a lesser degree at Steinhart Aquarium. Infections from a Rosette agent, which is a systemic protist, have also been prevalent in the Captive Broodstock Program. The Rosette agent had not previously been observed in Central Valley salmonids but has now been detected in adult late-fall chinook captured at the Coleman National Fish Hatchery. Disease transmission and outbreaks can be minimized through intensive fish health management. Accordingly, protocols have been developed and implemented for the prevention, containment, and treatment of disease within the Captive Broodstock Program and Coleman National Fish Hatchery, but additional research and protocols are needed.

Recommended Actions

1) The Winter-run Chinook Salmon Artificial Propagation and Captive Broodstock programs should continue to be evaluated for their effectiveness in supporting the winter-run chinook population.

The Artificial Propagation and Captive Broodstock programs should continue to be evaluated for their effectiveness, and to identify and implement needed program modifications. If problems identified in the programs cannot be resolved, the programs should be discontinued. The U.S. Fish and Wildlife Service should develop criteria for phasing out the artificial propagation program in cooperation with the National Marine Fisheries Service and the California Department of Fish and Game and other appropriate entities. These criteria should be determined by 1998. One alternative for consideration is to terminate the program when the naturally spawning population has achieved a cohort replacement rate that is statistically, significantly positive. The captive broodstock program should also continue to be assessed for its efficacy and necessity in recovering winter-run chinook, and the program should be terminated once the run size of the wild population reaches 1,000 per year on a sustained basis.

Implementing Entities: U.S. Fish and Wildlife Service, University of California Davis Bodega Marine Laboratory, California Academy of Science Steinhart Aquarium.

2) Develop and implement measures that ensure hatchery produced juvenile winter-run chinook imprint on the mainstem Sacramento River.

Based on the best available data, these measures should sufficiently guarantee that any adults taken for the artificial propagation program will result in supplementation to the wild spawning population in the mainstem Sacramento River. The most viable measure is to rear winter-run chinook on Sacramento River water. If the imprinting problem is not resolved, efforts to supplement the wild winter-run chinook through artificial propagation should be discontinued.

Implementing Agencies: U.S. Fish and Wildlife Service, National Marine Fisheries Service.

3) Develop and implement methods that positively identify adult chinook salmon as winter-run chinook prior to conducting breeding crosses.

Genetics analyses, in combination with adult run-timing and maturity data, will provide the most reliable means to identify winter-run chinook for the artificial propagation program.   Efforts to artificially breed winter-run chinook should continue only when these methods are fully developed.

Implementing Agencies: U.S. Fish and Wildlife Service, National Marine Fisheries Service.

4) Continue to develop, implement, and monitor a comprehensive Genetic Management Plan as an integral part of the Artificial Propagation and Captive Broodstock programs to minimize or avoid genetic differentiation of the hatchery population from the wild population.

The U.S. Fish and Wildlife Service should develop and implement this plan to maximize the genetic diversity of each program's progeny. The plan should establish clear mating protocols. Design and execution of all mating protocols should be conducted with oversight review by the National Marine Fisheries Service and the Genetics Subcommittee of the Winter-run Chinook Salmon Captive Broodstock Program Committee. A pedigree mating system should be implemented upon development of specific genetic markers. The U.S. Fish and Wildlife Service Research Center in Seattle and the Bodega Marine Lab genetics center should continue to develop genetic analysis techniques to further monitor variance through specific genetic markers. In addition, a population genetics model should be developed and used to evaluate the genetic impact on effective population size from both the artificial propagation and captive broodstock programs.

The Coleman National Fish Hatchery artificial propagation program is designed to avoid artificial selection by minimizing mortalities in juvenile production and by restricting the use of broodstock used for the artificial propagation to a very few generations. The Captive Breeding program will be limited to a single generation.

Additional measures should be investigated that could incorporate quasi-natural culture regimes into the Coleman National Fish Hatchery and Captive Breeding programs such as: 1) simulating natural photoperiod, water quality, water flow, and substrate conditions, 2) using low incubation and rearing densities, 3) providing cover and structural heterogeneity for holding facilities, and 4) using variable feeding schedules and rates, and feeding fish from the raceway bottom to simulate natural feeding conditions.

Implementing Agencies: U.S. Fish and Wildlife Service, National Marine Fisheries Service.

5) Minimize disease transmission within and among the wild, hatchery, and captively reared populations.

Disease control protocols and state-of-the-art hatchery practices should continue to be developed and implemented, including the use of multiple water purification systems, and multiple holding tanks and holding facilities at Coleman National Fish Hatchery, Bodega Marine Lab, and Steinhart Aquarium. Disease control protocols should also be developed and implemented through the Captive Broodstock Program committee to control infections such as the Rosette agent and other disease problems that may occur. The U.S. Fish and Wildlife Service should ensure that diseases are not introduced or intensified in the natural population of the Sacramento River as a result of the winter-run artificial propagation program.

Implementing Entities: U.S. Fish and Wildlife Service, University of California Davis Bodega Marine Laboratory, California Academy of Science Steinhart Aquarium.

GOAL V: REDUCE HARVEST AND INCIDENTAL TAKE IN COMMERCIAL AND RECREATIONAL FISHERIES

Table V-8. List of Recovery Actions for Sacramento River Winter-run Chinook Related to Goal V: Reduce Harvest and Incidental Take in Commercial and Recreational Fisheries.

Objective/Action	Interim Actions	Long-term Program
1. Reduce adverse impacts of ocean commercial and recreational salmon fisheries (Priority 1)		
1. Reduce ocean harvest rates on winter-run chinook salmon to allow the population to rapidly grow to stable levels and achieve recovery.	Ongoing	January 2000
2. Assess the feasibility of using genetic Mixed Stock Analysis to improve estimates of harvest rate on winter-run chinook salmon.		January 1999
2. Reduce incidental take from in-river sport fisheries (Priority 3)		
1. The National Marine Fisheries Service and the California Department of Fish and Game should continue monitoring of efforts by State and Federal enforcement personnel to ensure compliance with State fishery regulations.	None	In place
3. Develop information on the ocean distribution patterns of winter-run chinook (Priority 3)		
1. Continue assessment of coded-wire-tag data collected from ocean salmon landings to develop additional information regarding winter-run chinook distribution patterns in the Pacific Ocean.	Ongoing	January 2000

GOAL V: REDUCE HARVEST AND INCIDENTAL TAKE IN COMMERCIAL AND RECREATIONAL FISHERIES

Winter-run chinook are not a target species of any recreational or commercial ocean or inland fishery. However, the incidental harvest of winter-run chinook continues to occur in several fisheries. During the 1993, 1994 and 1995 ocean sport and commercial seasons, coded-wire-tagged hatchery-produced winter-run chinook were harvested. Two hatchery-produced winter-run chinook (produced and coded-wire-tagged at the Coleman National Fish Hatchery) were caught in the California recreational salmon fishery in 1993, 18 during 1994, and 4 in 1995. When these samples are expanded for sampling rate, an estimated 12 hatchery-produced winter-run chinook were caught in the 1993 fishery; 107 in the 1994 fishery; and 22 in the 1995 fishery. These fish were from the 1991, 1992 and 1993 brood years, and were mainly age 2 when captured.

OBJECTIVE 1:
Reduce adverse impacts of ocean commercial and recreational salmon fishery

In 1991, the National Marine Fisheries Service conducted a Section 7 consultation pursuant to the Endangered Species Act on the impacts of the ocean commercial and recreational salmon fisheries on winter-run chinook. The National Marine Fisheries Service concluded that management of ocean fisheries by the Pacific Fishery Management Council did not jeopardize the continued existence of winter-run chinook as long as harvest impact rates did not exceed 1990 levels. Since 1990, ocean salmon fisheries have been restricted by closure of a winter-run chinook conservation zone outside of the Golden Gate, and by shortening the recreational season by one month south of Point Arena to reduce the incidental take of winter-run chinook.

The recent recoveries of coded-wire tagged winter-run chinook, primarily in the 1994 ocean salmon fishery and in the 1995 spawning escapement to the river, provided data to reexamine the impacts of ocean harvest. The coded-wire tag data indicated that the harvest fraction (catch/catch + escapement ratio) on winter-run chinook was 0.54 for the broodyear 1992.[25] This harvest fraction estimate compares well to previous harvest estimates from a fin-clip marking study conducted in the late 1960s/early 1970s.[26] A recent re-evaluation of this study estimated harvest fractions of 0.47 and 0.56 for the 1969 and 1970 broodyears, respectively.[27] Thus, the harvest fraction estimate from the recent coded-wire tag data are consistent and within the range of estimates based on the earlier fin clip data. This suggests that harvest impacts on winter-run chinook may have changed little from catch levels 20 years ago, and that harvest impacts were probably not reduced by restrictions imposed by the 1991 Biological Opinion on ocean harvest.

These harvest impacts are substantial considering the present, very low abundances of winter-run chinook, and they likely limit population growth and impede recovery. Based on these concerns, the National Marine Fisheries Service reinitiated consultation on ocean harvest in 1996, and issued a biological opinion which required that incidental harvest be reduced by 50% from recent, baseline harvest levels.

Recommended Actions

1) Reduce ocean harvest rates on winter-run chinook to allow the population to rapidly grow to stable levels and achieve recovery.

Ocean harvest should continue to be managed according to the 1996 biological opinion, as amended by the February 18, 1997 opinion. These restrictions should result in a 31% increase in the adult 3-year replacement rate above the mean rate observed for the 1989-1993 broodyears. As described in the February 18, 1997 opinion, this requirement should remain in effect through the 2001 salmon seasons unless new and compelling information is obtained. National Marine Fisheries Service will continue to monitor incidental harvest impacts and escapement of winter-run chinook during this period to better define the relationship between harvest impact reduction and escapement. At the end of this period, National Marine Fisheries Service will review the available information and reassess the need for restrictions on ocean harvest. Such harvest reductions are expected to substantially increase escapement, and significantly improve the chances for the survival and recovery of winter-run chinook. Increasing escapement through harvest restrictions is vital to sustaining the winter-run chinook population, while freshwater and estuarine habitat restoration measures are being implemented to improve the long-term chances of survival.

Future harvest levels should continue to be developed based on analyses of the probability of survival and recovery of winter-run chinook . This effort would benefit from the development of a comprehensive life history/survival model (see Goal VII, Objective 2, Action 3). This model could evaluate the contribution of various factors that affect mortality at different life history stages, and evaluate the relative contribution towards population growth from reducing harvest rates.

Additionally, a long-term harvest management strategy should be developed which identifies appropriate harvest harvest levels once the population is delisted.

Implementing Agencies: National Marine Fisheries Service, California Department of Fish and Game.

2) Assess the feasibility of using genetic Mixed Stock Analysis to improve estimates of harvest rate on winter-run chinook salmon.

Alternative methods of monitoring harvest on winter-run chinook may be feasible through genetic Mixed Stock Analyses (MSA).[28] Genetics research is underway to distinguish various Central Valley chinook salmon stocks in the Bay-Delta, and preliminary results suggest the potential to distinguish winter-run chinook from other runs using a MSA.[29] Because salmon populations tend to show fewer genetic differences within the same watershed and greater differences between watersheds, it is probable that winter-run chinook could be genetically differentiated from other Central Valley and coastal chinook salmon stocks in the ocean. This technique may present a more accurate method of measuring harvest and should be explored.

Implementing Agencies: National Marine Fisheries Service

OBJECTIVE 2:
Reduce incidental take from in-river sport fisheries

Since 1987, the California Fish and Game Commission has adopted increasingly stringent regulations to reduce and virtually eliminate the in-river sport fishery for winter-run chinook. Present regulations include a year-round closure to salmon fishing between Keswick Dam and the Deschutes Road Bridge and a rolling closure to salmon fishing on the Sacramento River between the Deschutes Road Bridge and the Carquinez Bridge. The rolling closure spans the majority of months adult winter-run chinook are ascending the Sacramento River to their spawning grounds.

In 1992, the California Fish and Game Commission responded to concerns expressed by the California Department of Fish and Game and the National Marine Fisheries Service that an unacceptable level of incidental take was occurring in the trout fishery. The Commission adopted gear restrictions (all hooks must be barbless and a maximum 2.25 inches in length) to minimize hooking injury and mortality caused by trout anglers incidentally catching winter-run chinook. That same year, the Commission adopted regulations which prohibited any salmon from being removed from the water to further reduce the potential for injury and mortality to winter-run chinook from the trout and steelhead fishery.

Recommended Actions

1) The National Marine Fisheries Service and the California Department of Fish and Game should continue monitoring of efforts by State and Federal enforcement personnel to ensure compliance with State fishery regulations.

The California Department of Fish and Game should continue their creel census of the Sacramento River sport fishery. This information is necessary to monitor various fisheries' harvest rates and regional use patterns in order to assess the efficacy of regulations in reducing both direct harvest and incidental take of winter-run chinook.

Implementing Agencies: California Department of Fish and Game, National Marine Fisheries Service.

OBJECTIVE 3:
Develop information on the ocean distribution patterns of winter-run chinook

The 1991 Biological Opinion which addressed ocean fisheries harvest impacts on winter-run chinook was based on data from fin-clip studies performed in the late 1960s, and harvest impacts inferred from fall-run chinook harvest data. This inference relies on an assumed similarity between the ocean distribution of winter-run chinook and that of fall-run chinook from the Sacramento River system. If harvest monitoring must continue to rely on inference from fall-run chinook data, the assumption of similarity in ocean distributions should be validated through genetic Mixed Stock Analysis.

Recommended Actions

1) Continue assessment of coded-wire-tag data collected from ocean salmon landings to develop additional information regarding winter-run chinook distribution patterns in the Pacific Ocean.

The Department of Fish and Game should increase its port sampling effort in monitoring the ocean harvest of chinook salmon stocks. The existing port sampling program is designed to sample at least 20% of the chinook landed in the commercial and recreational (charterboat and skiff) fisheries. The five major ports sampled include Crescent City, Eureka, Fort Bragg, San Francisco, and Monterey. Each of the major ports is divided into several smaller adjacent sub-ports. The sampling effort in the Fort Bragg, San Francisco, and Monterey port areas should be increased by 50%. Due to the small number of coded-wire-tagged winter-run chinook released from Coleman National Fish Hatchery, the sub-ports closest to San Francisco should be sampled most intensively. It will require 5-10 years to collect sufficient information from coded-wire-tagged winter-run chinook to better understand their ocean distribution patterns.

Implementing Agencies: U.S. Fish and Wildlife Service, California Department of Fish and Game, National Marine Fisheries Service.

GOAL VI: REDUCE IMPACTS OF OTHER FISH AND WILDLIFE MANAGEMENT PROGRAM

Table V-9. List of Recovery Actions for Sacramento River Winter-run Chinook Related to Goal VI: Reduce Impacts of Other Fish and Wildlife Management Program.

Objective/Action	Interim Actions	Long-term Program
1. Minimize impacts from the State and Federal striped bass management and restoration programs (Priority 3)		
1. Review and evaluate the affects of predation on the winter-run chinook population.	Ongoing	June 1998
2. Develop and implement appropriate interim and long-term measures to minimize program impacts on winter-run chinook.	Ongoing	June 1998
2. Reduce impacts of State and Federal salmon and steelhead hatchery programs (Priority 3)		
1. Evaluate impacts and develop, implement, and monitor measures to reduce incidental take resulting from State-operated hatchery programs.	Ongoing	January 1999
2. Continue to implement and monitor measures to reduce incidental take of winter-run chinook resulting from operation of Coleman National Fish Hatchery.	Ongoing	In place
3. Reduce likelihood of disease transmission from hatchery populations to wild winter-run chinook.	None	January 1999
3. Reduce impacts from other fish and wildlife management programs (Priority 3)		
1. State and Federal fish and wildlife management programs should be reviewed to minimize their impacts on winter-run chinook.	None	January 1999
4. Prevent the introduction and establishment of non-indigenous aquatic species (Priority 3)		
1. Develop, implement and enforce regulations to control discharge of ship ballast water within the estuary and adjacent waters.	None	January 1999

Objective/Action	Interim Actions	Long-term Program
2. Develop and implement measures to avoid introductions, particularly by the zebra mussel, via overland transportation vectors and other transport vectors.	Ongoing	January 1999
3. Prohibit the intentional introduction of aquatic non-indigenous species into the Sacramento River watershed and estuary.	Ongoing	January 1999
4. Develop programs to educate the public about the problems with non-indigenous species and their incidental transport or introduction.	None	January 1999
5. Identify high risk potential invaders and implement measures to avoid their introduction.	None	January 1999

GOAL VI: REDUCE IMPACTS OF OTHER FISH AND WILDLIFE MANAGEMENT PROGRAMS

In the course of managing for the diverse fish and wildlife resources associated with California's Central Valley, the potential exists for various State and Federal resource management activities to cause incidental take of winter-run chinook. These programs need to be reviewed and modified to minimize adverse impacts to the winter-run chinook population.

OBJECTIVE 1: Minimize impacts from the State and Federal striped bass management and restoration program

Striped bass are a known predator of juvenile winter-run chinook both in the open water and at physical structures associated with bridge crossings, pilings, diversion structures, and similar structures. Studies have demonstrated important losses of juvenile chinook salmon due to striped bass predation in localized areas such as Clifton Court Forebay and the Suisun Marsh Salinity Control Structure. The cumulative effects on juvenile winter-run chinook from striped bass predation is unknown.

In many respects, the restoration of striped bass is consistent with the recovery of winter-run chinook. The Striped Bass Restoration and Management Plan for the Sacramento-San Joaquin Estuary identified many problems detrimental to striped bass which also impair the recovery of winter-run chinook.[30] These mutual impediments include: (1) Delta water diversions, (2) reduced Delta outflows, (3) low flows in the San Joaquin River, (4) water pollution, toxic chemicals, and trace metals, (5) dredging and spoil disposal, (6) Bay-fill projects, and (7) introductions of exotic aquatic organisms.

Although the two species coexisted at high population levels within the past several decades, efforts to artificially increase the striped bass population at this time may adversely affect the ability of winter-run chinook to recover. Environmental conditions within the aquatic habitats of the Central Valley have undergone profound changes in recent decades, such that the environment that the two species now share no longer has the variety of microhabitats that existed previously. Progress is needed in recovering the winter-run chinook population before efforts are implemented to enhance the striped bass population.

Recommended Actions

1) Review and evaluate the effects of predation on the winter-run chinook population.

The interaction of striped bass and juvenile chinook salmon within the Central Valley is poorly understood. A thorough literature review of the predation on chinook salmon populations should be conducted and directed to potential application within the Sacramento River and Delta. In addition, the potential of conducting comprehensive laboratory and field investigations should be evaluated and implemented as appropriate. Information regarding striped bass predation on winter-run chinook would be valuable data for inclusion in a comprehensive winter-run chinook life history and survival model.

Implementing Agencies: U.S. Bureau of Reclamation, California Department of Water Resources, California Department of Fish and Game, U.S. Fish and Wildlife Service, National Marine Fisheries Service.

2) Develop and implement appropriate interim and long-term measures to minimize program impacts on winter-run chinook.

Striped bass population management and restoration program goals should be designed to complement efforts to stabilize and recover the winter-run chinook population. Resolution of problems that the two species share should be aggressively pursued. However, programs to artificially increase natural production of striped bass should be delayed until such time as the winter-run chinook population has begun to achieve recovery. Increasing striped bass through stocking could possibly proceed when it was determined that the risks to the winter-run population are minimal.

Implementing Agencies: California Department of Fish and Game, U.S. Fish and Wildlife Service.

OBJECTIVE 2:
Reduce impacts of State and Federal salmon and steelhead hatchery programs

The production of salmon and steelhead by State and Federal hatcheries has the potential to affect winter-run chinook by increasing predation and competition, and by exacerbating the risk of disease and parasite transmission. In particular, release of juvenile steelhead may increase predation rates on winter-run chinook due to their larger-size and their potential to become residents in the river (instead of migrating to the ocean).

Recommended Actions

1) Evaluate impacts and develop, implement, and monitor measures to reduce incidental take of winter-run chinook resulting from State-operated hatchery programs.

The California Department of Fish and Game operates four salmon and steelhead production hatcheries in the Central Valley. These hatcheries annually produce and release nearly 19 million juvenile chinook salmon and 1.7 million juvenile steelhead. California Department of Fish and Game should prepare an assessment of the potential impact to winter-run chinook caused by various state owned, operated, and/or funded fish hatchery programs, with recommendations to avoid potential incidental take. As necessary, the California Department of Fish and Game should obtain authorization for incidental take of winter-run chinook pursuant to the Endangered Species Act. The California Department of Fish and Game should implement and monitor program changes intended to reduce the incidental take of winter-run chinook.

Of particular concern is the potential detrimental interactions (competition and predation) between hatchery steelhead and winter-run chinook salmon. These interactions may be minimized by managing the release timing, location and size-at-release of hatchery steelhead to avoid residualism and achieve rapid exit from the Sacramento River system. Releasing steelhead smolts at total lengths between 170 and 200 mm may minimize predation and competition with winter-run chinook salmon. Steelhead larger than 170 mm experience more complete parr-smolt transformation and are therefore more likely to actively migrate. Fish larger than 220 mm are more prone to residualize in the river[31]. Moreover, steelhead larger than 250 mm may be more capable of predation[32].

Also, hatchery production of large numbers of fall run chinook salmon has the potential to increase the impacts of ocean harvest on winter-run chinook because of the overall harvest rate that a hatchery supported fishery is able to sustain. Hatchery production strategies must be closely coordinated with harvest management strategies to reduce the potential for overharvest of winter-run chinook and unharvestable surpluses beyond hatchery broodstock needs

Finally, a comprehensive escapement monitoring program is needed for marked Central Valley chinook salmon in order to assess straying, review population trends, and to more accurately quantify harvest rates. This program should involve monitoring of marked fish returning to both the spawning grounds and to hatcheries.

Implementing Entities: California Department of Fish and Game, U.S. Bureau of Reclamation, California Department of Water Resources, East Bay Municipal Utilities District.

2) Continue to implement and monitor measures to reduce incidental take of winter-run chinook resulting from the operation of the Coleman National Fish Hatchery.

Coleman National Fish Hatchery annually produces and releases over 15 million chinook salmon and 800,000 steelhead. The U.S. Fish and Wildlife Service should continue to implement and monitor measures contained in its Endangered Species Act Section 7 permit to reduce the incidental take of winter-run chinook. Of special concern, production goals for species other than winter-run chinook should not be increased, and research and monitoring should be conducted to determine the impacts of steelhead production on winter-run chinook.

Implementing Agency: U.S. Fish and Wildlife Service.

3) Reduce likelihood of disease transmission from hatchery populations to wild winter-run chinook.

The California Department of Fish and Game and U.S. Fish and Wildlife Service should critically review existing fish culture procedures to eliminate controllable factors that may lead to the transmittal of disease to naturally spawning salmon populations. The importation of gametes or fish from outside Central Valley watersheds must be prohibited to limit the potential for introduction of new diseases via the hatchery. Transfers of gametes or fish between hatcheries within the Central Valley should also be strictly controlled to eliminate the potential for disease introductions.

Implementing Agencies: California Department of Fish and Game, U.S. Fish and Wildlife Service.

OBJECTIVE 3: Reduce impacts from other fish and wildlife management programs

A variety of other State, Federal and private programs are being developed or are ongoing which may adversely affect winter-run chinook. These programs need to be evaluated and modified to minimize impacts on winter-run chinook.

Recommended Actions

1) State and Federal fish and wildlife management programs should be reviewed to minimize their impacts on winter-run chinook.

The California Department of Fish and Game, as part of the Interagency Ecological Program (IEP), has prepared an assessment of the program's potential impact to winter-run chinook and has submitted the assessment to the National Marine Fisheries Service. The National Marine Fisheries Service should complete a Section 7 consultation on the program with the U.S. Bureau of Reclamation which is the federal cooperator to the IEP program. The California Department of Fish and Game should also complete a consultation pursuant to the California Endangered Species Act with itself and with the California Department of Water Resources, another IEP program member. The California Department of Fish and Game should also review its Wild Trout Program to minimize any potential impacts to winter-run chinook through monitoring in the upper Sacramento River.

Implementing Agencies: California Department of Fish and Game, National Marine Fisheries Service, California Department of Water Resources, U.S. Fish and Wildlife Service, U.S. Bureau of Reclamation.

OBJECTIVE 4:
Prevent the introduction and establishment of non-indigenous aquatic species

In the San Francisco Estuary alone, over 200 aquatic species have been introduced with many bringing significant ecological and economic impacts[33]. The introduction of the Asian clam (*Potamocorbula amurensis*) has coincided with very low phytoplankton blooms in the northern Bay[34]. The inland silverside, introduced into Clear Lake to control gnats, spread to the delta where it appears to prey on Delta smelt larvae and eggs (the gnats are still abundant around Clear Lake). The Chinese mitten crab is established in North and South San Francisco Bays, and has the potential to invade upstream rivers, where it may burrow into levees and undermine river banks. Northern Pike, a voracious predator, has been identified in Lake Davis and threatens to invade streams with anadromous fish species in the Central Valley watershed. Other potential introductions include the predatory white bass now present in Pine Flat reservoir on the Kings River, and the zebra mussel. A zebra mussel invasion could radically alter the Sacramento River ecosystem, and could heavily foul fish screens rendering them ineffective.

Pathways by which non-indigenous aquatic species become introduced are varied and often difficult to control. They include: discharging of ship ballast water; intentional illegal introductions of game fish and invertebrates; trailered transport of recreational boats between lakes and waterways; and accidental introductions through shipments of bait (packed in seaweed) and other fish, home aquaria, aquaculture, and scientific research.

It is next to impossible to predict whether the next introduction will have relatively benign impacts or produce costly fouling, eliminate native species, or disrupt ecosystem functions. Once non-indigenous organisms become established, the chances for eradication are usually slim. Chemical, mechanical or biological means to eradicate non-indigenous species have been successful in some areas, but often they are economically and environmentally costly. Hence, non-indigenous introductions should be avoided altogether. The best methods to control introductions include prevention via regulatory and enforcement means, and education.

Recommended Actions:

1) Develop, implement and enforce regulations to control discharges of ship ballast water within the estuary or adjacent waters.

Stronger legislation is needed to require ship operators to take direct actions to preclude species introductions, in particular the zebra mussel. One of the potential actions include the exchange of ballast water at sea (as mandated by Congress for the Great Lakes region and enforced by the Coast Guard). Congress should be petitioned to apply the appropriate ballast water regulations to protect all West Coast ports including Stockton and Sacramento. In addition, consistent biological sampling of ballast water is needed to evaluate the diversity and magnitude of potential harmful species introductions.

Implementing Agencies: California Department of Fish and Game, California Department of Health Services, U.S. Coast Guard, and Bay-Delta Port Authorities.

2) Develop and implement measures to avoid introductions, particularly by the zebra mussel via overland transportation vectors and other transport vectors.

Potential transport mechanisms include the transportation of trailered boats. The California Department of Food and Agriculture needs to quarantine any boats found with zebra mussels attached (dead or alive), to ensure the specimens are eradicated before entering the state. Also, the Interagency Western Council should continue its efforts to prevent the spread of the zebra mussel across the continental divide.

Another transport vector is the importation of live freshwater bait from eastern states, including areas invaded by the zebra mussels. Regulations for the importation of live bait should be reviewed and amended as appropriate to prevent any further introductions.

Marine organisms may also be intentionally or accidentally released and become established, as may have occurred with the Chinese mitten crab. Regulations governing the importation and sale of these organisms should be reviewed and appropriate modifications made to strengthen these regulations.

Implementing Agencies: The California Department of Food and Agriculture, Interagency Western Council, California Department of Fish and Game.

3) Prohibit the intentional introduction of aquatic non-indigenous species into the Sacramento River watershed and the estuary.

The Fish and Game Commission should deny all requests for the introduction of new species into the watershed of the Sacramento River and Sacramento-San Joaquin Delta/Estuary.

Implementing Agency: California Fish and Game Commission

4) Develop programs to educate the public about the problems with non-indigenous species and their incidental transport or introduction.

A long-term program is needed to educate a variety of user groups (anglers, sport clubs, commercial interests, schools and environmental organizations) on the importance of preventing introductions of non-indigenous species into the Central Valley watershed and San Francisco Estuary.

Implementing Entities: Friends of the San Francisco Estuary, California Department of Fish and Game, California Department of Food and Agriculture, and California Department of Boating and Waterways, National Oceanic and Atmospheric Association, California Sea Grant, *San Francisco Estuary Project.*

5) Identify high risk potential invaders and implement measures to avoid their introduction.

A list of high risk potential marine and freshwater invaders, (such as the zebra mussel, northern pike, white bass, the spiny water fleas, the comb jelly *Mnemiopsis leidyi*, etc.) should continue to be developed, and identified as prohibited species. Appropriate biological monitoring, inspection and control measures should be developed to prevent their introduction.

Implementing Agencies: California Department of Fish and Game, California Department of Food and Agriculture.

GOAL VII: IMPROVE UNDERSTANDING OF LIFE HISTORY AND HABITAT REQUIREMENTS

Table V-10. List of Recovery Actions for Winter-run Chinook Related to Goal VII: Improve Understanding and Life History and Habitat Requirements of Winter-run Chinook.

Objective/Action	Interim Actions	Long-term Program
1. Develop information of life cycle and habitat requirements of winter-run chinook (Priority 1)		
1. Develop and implement research programs to further determine life history and habitat requirements of winter-run chinook. Research is needed in the following area: spatial and temporal distribution of winter-run chinook in the river, Delta, and estuary, habitat requirements during spawning, rearing, and migration, juvenile chinook survival rates in Sacramento River reaches, Delta waterways, and Suisun and San Pablo bays, temperature tolerance of chinook salmon environmental factors influencing, emigration, and juvenile chinook microhabitat use in the river, Delta, and estuary.	Ongoing	Initiate by June 1999
2. Develop information for use as management tools (Priority 1)		
1. Develop alternative methods and procedures to estimate annual abundance and genetically effective population size of winter-run chinook returning to the upper Sacramento River.	Ongoing	January 2000
2. Develop alternative method for identifying juvenile winter-run chinook.	Ongoing	January 2000
3. Develop a winter-run chinook salmon life cycle model.	Ongoing	January 2000
4. Develop a Delta hydrodynamic and individual run model.	None	January 2000
5. Develop a winter-run chinook salmon survival probability model.	None	January 2000
3. Evaluate re-establishing additional natural winter-run chinook populations (Priority 2)		

Objective/Action	Interim Actions	Long-term Program
1. Conduct feasibility analysis of establishing viable, naturally self-sustaining populations in other rivers and creeks within the Sacramento River watershed.	None	January 2000
2. Based on information from feasibility analysis, develop and implement recommendations for establishing supplemental winter-run chinook populations.	None	January 2001
4. Evaluate additional factors that may affect the recovery of winter-run chinook (Priority 3)		
1. Evaluate water quality impacts on winter-run chinook. The following evaluations are needed: Impacts of toxic substances Contaminant levels in San Francisco Bay Chronic toxicity data Impacts from turbidity, suspended sediments, and sedimentation Impacts of dredge disposal	Ongoing	Initiate by June 1999
2. Evaluate juvenile entrainment to flood bypasses, and assess the impacts of flood control operations on juvenile chinook.	None	June 1998
3. Evaluate entrainment of juvenile chinook to the Sacramento Deep Water Ship Channel.	None	January 1999
4. Assess diseases found in both hatchery and natural chinook populations in the Sacramento River.	Ongoing	January 2000

GOAL VII: IMPROVE UNDERSTANDING OF LIFE HISTORY AND HABITAT REQUIREMENTS

OBJECTIVE 1:
Develop information of life cycle and habitat requirements of winter-run chinook

More knowledge regarding winter-run chinook life-history and habitat requirements will enhance recovery efforts by allowing managers to focus recovery and management actions to maximize benefits and to minimize or eliminate unneeded actions. Prior to initiating a year-around Central Valley chinook salmon outmigration monitoring program in September 1992, chinook salmon research and monitoring programs for the Central Valley primarily focused on the fall-run chinook. Only two programs were previously conducted which provided life history information on winter-run chinook: monitoring of juvenile distribution and abundance of all four runs of chinook in the Upper Sacramento River, and monitoring of adult winter-run chinook escapement at the Red Bluff Diversion Dam fish ladder. Other basic information on habitat requirements and life-history patterns for winter-run chinook have often been inferred from the more complete information available for fall-run chinook. However, the life history of the two runs is different enough that much of the data collected for fall-run cannot be applied to winter-run chinook.

Recommended Actions

1) Develop and implement research programs to further determine life history and habitat requirements of winter-run chinook.

Research needs to be conducted in the following areas:

- > the spatial and temporal distribution of juvenile and adult Sacramento winter-run chinook in the river, delta, and estuary;
- > the habitat requirements during spawning, rearing, and migration, including dietary needs, the abundance of their preferred prey items, and the effects of habitat alteration such as rip-rap on food availability.
- > the survival rates of juvenile chinook in various reaches of the Sacramento River, the Delta waterways, and in Suisun and San Pablo bays in various water year types;
- > the temperature tolerance of chinook salmon eggs;
- > environmental factors influencing juvenile chinook outmigration;
- > the microhabitat use and feeding behavior of juvenile chinook in the river, delta, and estuary.
- > physical condition of juvenile chinook salmon upon leaving the San Francisco Bay.
- > the effects of estuarine and ocean environmental variability on salmon abundance.

Implementing Agencies: U.S. Fish and Wildlife Service, California Department of Fish and Game, National Marine Fisheries Service.

OBJECTIVE 2:
Develop information for use as management tools

The recovery of winter-run chinook is highly dependent on two types of actions: the implementation of operational and structural measures to provide or restore critical habitat and habitat conditions, and the development and interpretation of biological and physical data on winter-run chinook life history and habitat requirements. The biological, economic, and social impacts of restoring winter-run chinook could be significant. Therefore, future management and restoration recommendation for winter-run chinook salmon would benefit from the continued development of scientifically supportable data and analyses.

Recommended Actions

1) Develop alternative methods and procedures to estimate the annual abundance and genetically effective population size of winter-run chinook spawners returning to the upper Sacramento River.

An estimate of the effective size of the wild winter-run chinook population is needed to evaluate the genetic impact of the artificial propagation and captive brood stock programs as well as recovery of the winter-run population itself (see Goal IV and Chapter IV). To date, only the upper and lower bounds have been determined for the effective population size (Ne) of the wild stock,[35] based on one allozyme study of winter-run chinook[36] and more extensive allozyme data on Snake River chinook populations.[37] Thus, more genetic data are needed annually for the winter-run chinook, in order to better estimate Ne with acceptable precision. The precision of estimating Ne will likely improve because of the availability of highly polymorphic nuclear DNA markers in winter-run chinook.[38]

In addition, precise estimates of Ne may actually provide the best indicator of run size as counts at Red Bluff Diversion Dam diminish in accuracy, because Ne appears to be proportional to run size in chinook salmon populations.[39] At present, annual estimates of winter-run chinook escapement are based on the extrapolation of counts at RBDD as adults pass through the dam's ladders. As operations of the dam are minimized or eliminated during the upstream migration of adults, another approach will need to be developed to estimate adult spawning escapement to the upper river.

Implementing Entities: U.S. Fish and Wildlife Service, California Department of Fish and Game, National Marine Fisheries Service.

2) Develop alternative method for identifying juvenile winter-run chinook.

The ability to identify juvenile chinook by run is important for both fisheries monitoring and management purposes. At present, juvenile winter-run chinook are differentiated from other runs using length criteria, which were developed based on growth and length-frequency data from fall-run chinook. The length-criteria seems to function reasonably well in distinguishing juvenile winter-run chinook in the upper Sacramento River, but the winter-run lengths overlap with both late-fall chinook and fall-run chinook in the Delta, leading to the misidentification of some juvenile salmon.

Other methods are needed to improve juvenile winter-run chinook identification. Genetics research should be continued and expanded to isolate genetic markers for run identification. These genetic markers need not provide diagnosis of individuals to run. That would only be possible if each of the runs were characterized by fixed genetic differences, which seems highly unlikely given allozyme, mitochondrial DNA, and nuclear DNA evidence that these runs are rather recently evolved and still genetically very similar.[40] An alternative approach is a mixed-stock analysis,[41] which can estimate, by maximum likelihood methods, the proportional contributions of the various chinook salmon runs of the Central Valley to the mixed stock of emigrating juveniles in the Sacramento-San Joaquin Delta.

At this time, ongoing genetics research has identified three genetic markers which differentiate winter-run chinook from other Sacramento River chinook stocks.[42] Statistical methods are also being developed that will allow rapid determination of individuals to race, with a statistical confidence estimate. Thus far, these genetics data indicate that winter-run chinook may be the most genetically distinct of the four Sacramento River chinook races.

In addition, scale and otolith analyses should be evaluated for their potential to distinguish juvenile chinook runs.

Implementing Agencies: U.S. Fish and Wildlife Service, California Department of Fish and Game, National Marine Fisheries Service, California Department of Water Resources, University of California.

3) Develop a winter-run chinook life history model.

One of the most important tools needed for the development and analysis of proposed recovery measures for the winter-run chinook salmon is a comprehensive life cycle model that describes all aspects of the winter-run chinook life cycle. This model would serve as a tool by which to rank or set priorities for needed recovery actions. In addition, the model would identify those critical areas in which sound or sufficient biological and physical habitat data are lacking.

Presently, it is unknown how or to what degree many factors individually affect the winter-run chinook population. There are three distinct areas where anthropogenic impacts and environmental conditions may strongly influence the survival of winter-run chinook: 1) the upper Sacramento River, 2) the Delta, and 3) the ocean. The extent that each of these areas influence overall survival, cohort replacement rate and, therefore, population viability is not known. It is essential to gain an understanding of this relationship, so that recovery efforts can be focused in those areas having the greatest influence on survival, cohort replacement rate, and population viability, in order to maximize restoration efforts and assure recovery.

Development of such a model was begun with the population model developed here (see Recovery Goals and Appendix D) to derive the delisting framework. That model explicitly included the variability in the life cycle evident in the variable spawning counts. For the purposes of planning recovery strategies, the specific influences of various factors on the distribution of CRRs need to be incorporated into that model so that the effects of various actions on population viability can be determined.

Implementing Agencies: U.S. Fish and Wildlife Service, California Department of Fish and Game, National Marine Fisheries Service, U.S. Bureau of Reclamation, California Department of Water Resources, Environmental Protection Agency, University of California.

4) Develop a Delta hydrodynamic and individual run model.

The management and recovery of winter-run chinook is highly dependent on habitat conditions in the Delta and estuary. Water projects are the principal controlling, anthropogenic influence in the Delta, and their operations can alter hydrodynamic conditions which greatly affect juvenile chinook survival. An hydrodynamic and individual fish run model is needed to better define and clarify relationships in the Delta between: 1) Delta exports, 2) in-channel depletions, 3) Delta outflow, 4) Delta inflow, 5) Sacramento River flow, 6) percent of Sacramento River flow diverted, 7) San Joaquin River flow, 8) QWEST, 9) Delta Cross Channel gate operations, 10) the influence of Georgiana Slough and Three Mile Slough flows, and 11) other measurable parameters influencing the survival of winter-run chinook in the Delta.

This model would track individual fish or individual cohorts throughout the spawning and downstream migrations. It would include their responses to hydrodynamic and hydrological conditions as water management and other controls were varied. This model would provide input to the Life Cycle Model in terms of the way in which the distribution of CRRs varied with various management actions. This model would be a mechanistic description of the factors that make up the statistical description of variability in the life cycle model. The individual/hydrodynamic model would be run on sub-daily time scales over the time of migration, whereas the life cycle model would run on annual time scales for 50 to 100 years.

An individual run model for winter-run chinook (CPOP-W) has been developed; however it has not been used in management, and needs reevaluation for its applicability. It may form a starting point for the individual run model, but the information developed over the past several years would have to be incorporated.

One of the key factors in development and survival of winter-run chinook is temperature. The precise relationship between controlled releases from the major reservoirs in the Central Valley and river water temperature is unclear. Although the vast losses of riparian forest habitat throughout the Central Valley and Delta have probably reduced opportunities and the ability to control river and Delta water temperatures in the near term, there is a clear need to develop an evaluation tool that will allow the role between water project operations, ambient conditions, and water temperatures to be better understood. Information collected from this tool will form the basis for making future recommendations regarding the control of water temperatures at critical times or locations.

A hydrodynamic model has been developed at U.C. Davis to describe temperature in the Sacramento River and the Delta. This model is undergoing calibration runs now and other variables are being added. U.C. Davis is in the process of adding an individual based chinook salmon model to this hydrodynamic model. This model could form the basis for the individual/hydrodynamic model.

Implementing Agencies: U.S. Fish and Wildlife Service, California Department of Fish and Game, National Marine Fisheries Service, U.S. Bureau of Reclamation, California Department of Water Resources, Environmental Protection Agency, University of California.

5) Develop a winter-run chinook survival probability model.

An analysis is needed to evaluate the escapement level where the probability of persistence of winter-run chinook becomes very low, and survival is at great risk. Quasi-extinction has been defined in Chapter 4 as an escapement level of 100 females, or 200 adults assuming a 1:1 ratio of female to male. However, the probability of winter-run chinook's survival becomes uncertain at even higher escapement levels than this quasi-extinction level.

NMFS performed a qualitative assessment of survival risks, and estimated that winter-run chinook would likely persist and have the potential to recover when escapement levels were no fewer than 500 spawning adults annually. A more thorough quantitative analysis is still needed to better define this threshold escapement level and adjust it as appropriate. Such an analysis may be designed after the survival requirements developed for Snake River salmon by the Biological Requirements Work Group.[43] If winter-run chinook should drop below this threshold escapement level, it would act as a warning signal to the National Marine Fisheries Service that stronger protective measures are needed immediately to ensure the continued survival and recovery of winter-run chinook.

Implementing Agencies: National Marine Fisheries Service, California Department of Fish and Game.

OBJECTIVE 3:
Evaluate re-establishing additional natural winter-run chinook populations

At present, the entire winter-run chinook spawning population is dependent on habitat conditions in the Sacramento River below Shasta Dam. During critically dry or consecutively dry years, complete protection from adverse water temperatures below Keswick Dam throughout the spawning range of winter-run chinook is not possible. Additional natural populations of winter-run chinook in other rivers could reduce the likelihood that a catastrophic event during spawning, egg-incubation, or fry emergence would threaten total failure of a year-class. Supplemental populations could also increase the rate of recovery.

Recommended Actions:

1) Conduct a feasibility analysis of establishing viable, naturally self-sustaining populations in other rivers and creeks within the Sacramento River watershed.

As part of this analysis, potential Sacramento Valley streams should be identified for the introduction or reintroduction of winter-run chinook. Battle Creek, a tributary to the Sacramento River, once supported a population of winter-run chinook during wet water years. Flows in Battle Creek were subsequently diverted for hydropower, but the creek could be re-operated to provide sufficient cold water flows during summer months to protect incubating winter-run chinook eggs and fry, even during severe drought years. The Calaveras River may represent an additional area for reintroducing winter-run chinook. Winter-run chinook were documented in the Calaveras River during periodic surveys in the 1970s and 1980s. Insufficient stream flows during the recent multi-year drought are thought to have extirpated this population.

Implementing Agencies: National Marine Fisheries Service, U.S. Fish and Wildlife Service, California Department of Fish and Game.

2) Based on information developed from the feasibility analysis, develop and implement recommendations for establishing supplemental populations.

For those streams identified for introduction, stream restoration actions should be developed to provide suitable habitat conditions for winter-run chinook, including water quality and flows for adult and juvenile chinook passage, adult holding, spawning, egg incubation, and juvenile rearing. Recommendations need to also consider: 1) the genetic implications to supplemental and overall population of winter-run chinook; and 2) the magnitude of the main Sacramento River population that is needed before introductions begin. This program of developing supplemental populations could be implemented using the “Safe Harbor” concept developed by the U.S. Fish and Wildlife Service.

Implementing Agencies: Fish and Wildlife Service, California Department of Fish and Game.

OBJECTIVE 4:
Evaluate additional factors that may affect the recovery of winter-run chinook

A variety of other factors are thought to adversely affect winter-run chinook, but information documenting and describing these impacts is lacking. Evaluation of potential problems should assist managers in making decisions to remedy adverse impacts and to recover winter-run chinook.

Recommended Actions

1) Evaluate water quality impacts on winter-run chinook.

Research should be conducted to determine potential chemical contaminant uptake by winter-run chinook throughout the Sacramento River and San Francisco Bay/Sacramento-San Joaquin Delta. The biochemical and physiological effects of chemical contaminants should also be studied at key locations throughout the river, Delta, and estuary. Specifically the following studies are needed:

Determine the impacts of toxic substances in the Sacramento River on chinook salmon and their prey items. Expand use of monitoring techniques such as resin column concentrating methods, in-situ bivalve monitoring, and the Environmental Protection Agency's three-species bioassay, using chinook salmon to determine biologically significant levels of various toxic substances.

Complete studies initiated by the National Marine Fisheries Service on contaminant levels and associated biochemical effects on emigrating juvenile chinook in San Francisco Bay. Continue research to determine the effects of chemical contaminants on the immune function, growth, and long-term survival of juvenile chinook migrating through the Sacramento River and San Francisco Bay/Sacramento-San Joaquin Delta. One year's field data has been collected, analyzed, and reported to date. Special attention should be directed at measuring body burdens assimilated at various migration locations and the effects of those burdens.

Develop chronic toxicity data on the sensitivity of chinook salmon to copper, cadmium, zinc, polychlorinated biphenyls, polynuclear aromatic hydrocarbons, chlorinated hydrocarbons, and pesticides.

Develop and implement studies to monitor effects of turbidity, suspended sediment, and sedimentation on chinook salmon.

Develop and implement studies to determine the impacts of dredge spoil disposal on winter-run chinook passing through San Francisco Bay.

Additional toxicity data is also needed on synthetic organic compounds within the Sacramento River and San Francisco Bay/Sacramento-San Joaquin Delta and Estuary. There is little data regarding the levels of trace organic compounds from urban storm drain runoff or from facilities permitted under the National Pollutant Discharge Elimination System.

Implementing Entities: U.S. Fish and Wildlife Service, California Department of Fish and Game, National Marine Fisheries Service, U.S. Bureau of Reclamation, California Department of Water Resources, Environmental Protection Agency, Regional Water Quality Control Board, California Environmental Protection Agency, U.S. Army Corps of Engineers, industrial dischargers, agricultural dischargers, local governments, and municipalities.

2) Evaluate juvenile entrainment to flood bypasses, and assess the impacts of flood control operations on juvenile chinook.

Juvenile winter-run chinook may be conveyed into the flood bypasses with flood flows. As flood flows recede, the connection between the bypasses and the river is cut off, and water is retained, potentially entrapping juvenile chinook. A preliminary review of flood control operations indicates that water is diverted into bypasses frequently, even in critically dry years. Evaluations are needed to assess whether flood control could be modified to improve fish survival and passage rates through the bypasses.

Implementing Agencies: U.S. Corps of Engineers, U.S. Bureau of Reclamation, California Department of Water Resources.

3) Evaluate entrainment of juvenile chinook to the Sacramento Deep Water Ship Channel.

Since Sacramento River water is diverted into the ship channel, juvenile winter-run chinook may also be diverted down this course. Water quality, flow levels and rearing conditions in the channel are extremely poor, and may reduce the survival of juvenile winter-run chinook. Investigations should be conducted to evaluate the extent to which juvenile chinook are diverted into the ship channel under various operational scenarios.

Implementing Agency: U.S. Army Corps of Engineers.

4) Assess diseases found in both hatchery and natural chinook populations in the Sacramento River.

Little is known about the diseases of natural chinook populations in the Sacramento River. Below are two areas of research which would aid restoration efforts:

A multi-year survey of selected pathogens and physiological measurements in upper Sacramento river chinook juveniles (fall and late-fall-run). The incidence of infection and disease due to Infectious Hematopoietic Necrosis Virus and Bacterial Kidney Disease are of particular interest.

Determine if environmental conditions (temperatures, water quality, toxicants) found in winter-run chinook rearing areas induce stress in juvenile chinook. This work would probably make use of both livebox challenges and laboratory experiments.

Implementing Agencies: National Marine Fisheries Service, U.S. Fish and Wildlife Service, California Department of Fish and Game.

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