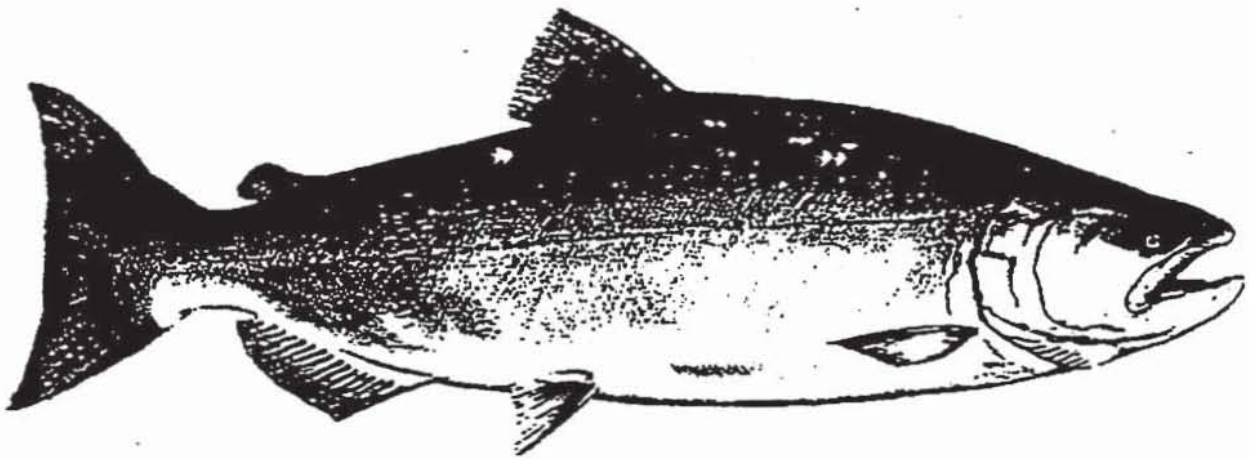
State of California
The Resources Agency
DEPARTMENT OF FISH AND GAME

SACRAMENTO RIVER WINTER-RUN CHINOOK SALMON

Annual Report

Prepared for the Fish and Game Commission



Habitat Conservation Division
Central Valley Bay-Delta Branch
April 1999

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EXECUTIVE SUMMARY

This report summarizes management and recovery actions over the last year and provides an update of the population status for Sacramento River winter-run chinook salmon. Its format has been reorganized to correspond to the seven recovery goals described in the National Marine Fisheries Service's (NMFS) Proposed Recovery Plan for Sacramento River Winter-run Chinook Salmon. It is expected that the recovery plan will be made final in the near future.

The U.S. Bureau of Reclamation (USBR) was able to meet the temperature objective of 56°F from Keswick Dam to Bend Bridge during the main egg incubation period for winter-run chinook salmon due to adequate water storage levels and the operation of the Shasta Dam Temperature Control Device. The temperature control device has been in use since May 1997.

During the winter of 1998 Iron Mountain Mine once again produced an enormous amount of acid and metal. The neutralization plant was able to intercept the bulk of the dissolved metal before it reached the Sacramento River. Construction began on the additional collection system for acid mine drainage in upper Slickrock Creek and for an expansion of the treatment plant. With the addition of Slickrock Creek drainage to the treatment plant it is estimated the total metal load from Iron Mountain Mine will be reduced by approximately 90 percent of the original pre-treatment level.

The CALFED Bay-Delta Program was initiated in May 1995. CALFED is currently in Phase II, which will end in late 1999 at the time of the Final Programmatic Environmental Impact Statement/Environmental Impact Report (EIS/EIR). A programmatic EIS/EIR is typically prepared for a series of actions that can be characterized as one large project and is required for actions proposed by or approved by state and federal agencies. In Phase II, CALFED is developing a preferred program alternative, is conducting comprehensive programmatic environmental review, and is developing the implementation plan focusing on the first seven years (Stage 1) following the Record of Decision on the EIS/EIR.

The Red Bluff Diversion Dam (RBDD) gates are raised for eight months of the year, September 15 through May 14, allowing unimpeded passage of adult and juvenile chinook salmon during those months. The U. S. Bureau of Reclamation (USBR) continued their evaluation of the Research Pumping Plant. They are assessing the potential of the Archimedes and internal helical pumps to deliver water to the Tehama-Colusa and Corning canals when the gates at RBDD are raised. Studies conducted to date show high survival of chinook salmon passing through the pumps.

Glenn-Colusa Irrigation District (GCID) continues to operate under the Federal Joint Stipulation of the Parties which was renewed between GCID and NMFS in July 1993. The facility will operate under the terms and conditions set forth in the stipulation while the implementation of the long-term conservation measures proceed. The final EIR/EIS was completed and construction began on the extended flat-plate fish screen. The construction should be complete by September 2000. The

ANNUAL REPORT

SACRAMENTO RIVER WINTER-RUN CHINOOK SALMON RECOVERY PLAN

The "*NMFS Proposed Recovery Plan for Sacramento River Winter-run Chinook Salmon*" was distributed in August 1997 for review and comment. It is expected that the National Marine Fisheries Service (NMFS) will finalize the plan in the near future.

The draft recovery plan contains seven broad recovery goals:

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.

Each of these goals contains a number of specific recovery actions designed to avoid extinction, achieve rebuilding of the population, and ensure sustained recovery of winter-run chinook salmon. The proposed recovery plan contains a detailed description and narrative for each measure that is needed to promote the recovery of winter-run chinook salmon. Implementation of these recovery actions will require a coordinated effort by the National Marine Fisheries Service (NMFS), other federal agencies, State and local governments, private industry, conservation organizations, and the public.

This report summarizes management and recovery actions over the last year following the seven recovery goals listed above. In the future we will provide more detail on each recovery action specified in the proposed recovery plan. The report also provides an update of the population status.

GOAL I. PROTECT AND RESTORE SPAWNING AND REARING HABITAT

TEMPERATURE CONTROL IN THE UPPER SACRAMENTO RIVER

The water temperature objective for the upper Sacramento River is 56°F from Keswick Dam to Red Bluff Diversion Dam (State Water Resources Control Board Order 90-5). These criteria have not been consistently met and structural facilities and operational measures are needed. The NMFS Biological Opinion for the Central Valley Project and State Water Project contains compliance points for water temperatures that must be used until the structural and operational improvements are implemented.

associated gradient restoration facility design is scheduled for completion by May 1999, with construction to begin by August 1999 and be completed by November 2001.

The propagation program for winter-run chinook salmon was re-authorized by NMFS and the Department in 1998 after construction of the new Livingston Stone National Fish Hatchery at the base of Shasta Dam and considerable advances in genetic analysis to assure genetic integrity. A total of 103 adult winter-run chinook salmon were collected for broodstock from the Keswick Dam fish trap in 1998. Approximately 150,000 juveniles were released from this propagation effort in January 1999.

The Interagency Ecological Program's Central Valley Salmon Project Work Team and its subgroups continue to coordinate and oversee salmon monitoring efforts throughout the Central Valley. The Winter-run Subgroup will be convening a special work team to evaluate the last three years of carcass survey data and to evaluate the procedures of run size estimation at RBDD with the goal of improving escapement estimates.

The Sacramento River winter-run chinook salmon population appears to have stabilized, but remains at a very low level. The 1998 estimated run size was 2,612 of which 828 fish were immature grilse and 1,783 were three- and four-year-old adults. The increase in numbers of adults over the 1995 population level (the primary brood year for adults in 1998) is 1.4. This compares to an average run size, including grilse, of 86,000 in 1967-69, and an average run size of 388 in 1989-91.

implementation has begun through a CALFED Category III grant of approximately twelve million dollars for land acquisition through title or easement and to include riparian restoration. The grant awarded to the U. S. Fish and Wildlife Service (USFWS), California Wildlife Conservation Board and the Nature Conservancy, in a partnership, will initiate acquisitions and restoration actions in harmony with the Sacramento Conservation Area Handbook.

PRESERVATION AND RESTORATION OF TIDAL MARSH HABITAT

Only about 15% of the historic 1850s tidal marsh habitat remains in San Francisco Bay, San Pablo Bay, and Suisun Bay combined, and about 3% of the historic acreage remains in the Sacramento-San Joaquin Delta. Tidal marshes benefit juvenile chinook salmon in many ways; providing feeding habitat, refugia from predators, and habitat for the physiological adaptation to seawater. The extreme loss of tidal marsh habitat in the Bay and Delta represents an important loss of juvenile chinook salmon rearing habitat that may impede recovery of winter-run chinook. A number of recovery and restoration plans are being developed to restore and protect tidal marsh habitat, such as the USFWS Tidal Marsh Ecosystem Recovery Plan, Native Fishes Recovery Plan, and the CALFED Bay-Delta Program, which should benefit winter-run chinook as their implementation proceeds.

CALFED BAY-DELTA PROGRAM

The CALFED Bay-Delta Program began in May of 1995 to address the tangle of complex issues that surrounds the Delta. The CALFED Program is a cooperative, interagency effort of 15 state and federal agencies with management or regulatory responsibilities for the Bay-Delta. In addition, other agencies, such as the California Department of Food and Agriculture, regularly participate in development of CALFED policies which affect their agencies.

The CALFED Program is a collaborative effort including representatives of agricultural, urban, environmental, fishery, business, and rural counties who have contributed to the process. The Bay-Delta Advisory Council (BDAC), a 34-member federally chartered citizens' advisory committee, provides formal comment and advice to the agencies during regularly scheduled public meetings. In addition, the CALFED process has included members of the public in development of every Program component from ecosystem restoration to financing.

The long-range, comprehensive solution for the Bay-Delta Estuary will be composed of many different programs, projects, and actions that will be implemented over 20-30 years. CALFED is currently in Phase II, which will end in late 1999 at the time of the Final Programmatic Environmental Impact Statement/Environmental Impact Report (EIS/EIR). A programmatic EIS/EIR, also referred to as a first-tier document, is typically prepared for a series of actions that can be characterized as one large project and is required for actions proposed by or approved by state and federal agencies. In Phase II, CALFED is developing a preferred program alternative, is conducting comprehensive programmatic environmental review, and is developing the implementation plan focusing on the first seven years (Stage 1) following the Record of Decision on the EIS/EIR.

The Shasta Dam Temperature Control Device was put into operation in May of 1997. By refitting Shasta Dam with this multi-level outlet system the U. S. Bureau of Reclamation (USBR) has the capability to conserve cold water reserves during the cooler months by releasing water from the upper reservoir then maximize the use of cold water reserves from the reservoir during the warmer months by releasing deep reservoir waters. The multilevel outlet works are connected to the powerhouse to facilitate power production while conducting temperature control operations. During the testing period in the summer of 1997 some minor leakage of upper reservoir water was discovered in the outlet towers that limited the cooling performance to below maximum levels. The USBR repaired the area that was leaking prior to the summer of 1998.

With both good water storage levels in Shasta Reservoir and the temperature control device in operation the USBR was able to maintain the temperature objective of 56°F over 45 river miles between Keswick Dam and Bend Bridge during the main winter-run egg incubation period. However, during the latest portion of egg incubation the temperature compliance point was moved 15 miles upstream to Jelly's Ferry.

IRON MOUNTAIN MINE

During 1998 construction commenced on the collection system for acid mine drainage in upper Slickrock Creek and on the expansion of the treatment plant to process this waste. With the addition of Slickrock Creek drainage to the treatment plant it is estimated the total metal load from Iron Mountain Mine will be reduced by approximately 90 percent of the original pre-treatment level.

The level of pollution control during 1998 was generally similar to last year when there was a high amount of run-off that produced enormous amounts of acid and metal from the mine workings inside the mountain and run-off on the surface of the mountain. The treatment plant was able to intercept the bulk of this dissolved metal before it reached the Sacramento River, thereby avoiding a catastrophic loss of fish life.

As in previous years, ongoing legal actions have progressed slowly, however some settlement negotiation attempts are now being ordered by the courts.

THE UPPER SACRAMENTO RIVER FISHERIES AND RIPARIAN HABITAT MANAGEMENT PLAN

The Upper Sacramento River Fisheries and Riparian Habitat Management Plan initiated under the authority of Senate Bill 1086 was completed in January 1989. During 1993, a Riparian Habitat Committee was convened by the California Secretary for Resources to develop and implement a riparian habitat protection and management program, as authorized by Senate Bill 1086. During May 1998, the draft Sacramento River Conservation Area Handbook was completed. The goal of the handbook is to restore and protect a continuous riparian corridor along the 222 miles of Sacramento River between Keswick and Verona. In addition, the Riparian Habitat Committee is developing an enabling management agreement and non-profit organization to facilitate implementation. Interim

About three-fourths of the money was devoted to projects that restore rivers, riparian forests, wetlands, and marshes. The remainder has gone to projects such as installing fish screens to keep endangered fish from being pumped out of rivers; preventing the introduction of exotic species; and researching key questions that must be answered to implement adaptive management. Many of the ecosystem projects also provide benefits to other CALFED objectives such as water supply reliability, levee system integrity, and water quality.

Conservation Strategy - The CALFED Conservation Strategy (Strategy) is a comprehensive species and habitats conservation program that addresses the multiple species and habitat needs and the maintenance of ecological functions within the CALFED Program area. The Strategy addresses species and habitats at the ecosystem level and provides for the integration of species specific conservation strategies at both the site-specific and landscape level.

The Strategy document is in preparation and addresses, at a programmatic level, all of CALFED's actions and provides a framework for site- and action-specific compliance with the Federal and State Endangered Species Acts. An action specific analysis will be conducted in an Action Specific Conservation Strategy addressing the impact and mitigation for specific actions (e.g. Ecosystem Restoration Program actions, levee protection projects, etc.) which in combination with the Strategy, will form the basis for obtaining authorization to incidentally take species (take authorizations) pursuant to Federal Endangered Species Act, the California Natural Community Conservation Planning Act and/or the State Endangered Species Act.

The Strategy includes an evaluation of CALFED actions on 204 evaluation species. The list of evaluation species includes all Federally and California listed, proposed and candidate species that may be affected by the CALFED Program and for which adequate information is available. The evaluation species list also includes other species identified by CALFED that may be affected by the CALFED Program for which there is adequate information and for which take authorization may be requested. The Strategy's evaluation species list includes species which occur in the Ecosystem Restoration Program's 14 Ecological Zones. Information is being compiled for each of the species, including life history, current population status, distribution and habitat requirements, and where available, identified goals/actions for species recovery. Species identified in the Strategy are the evaluation species which are conserved at a level which meets the Strategy's species' goals and which also meet take authorization issuance criteria as set forth in the Acts.

THE INTERIM SOUTH DELTA PROGRAM (ISDP)

As described above, the CALFED Bay-Delta Program is working on Stage 1 actions defined as the seven year period commencing with the final decisions on the Programmatic EIS/EIR. Agreement on Stage 1 actions is only one part of the decision for a preferred program alternative but, it is important that these actions achieve balanced benefits and lay a solid foundation for successful implementation of the CALFED Bay-Delta Program. Due to similarities in the CALFED Stage 1 actions and the ISDP, and through discussions with state and federal agencies, ISDP was dropped and CALFED took it up. Department staff are now involved in interagency meetings on Stage 1 actions to

CALFED Ecosystem Restoration Program Plan (ERPP) - The Ecosystem Restoration Program (ERP) is the principal mechanism that CALFED will use to restore the health of the Bay-Delta ecosystem. The overarching goal of the ERP is to improve and increase aquatic and terrestrial habitats and improve ecological functions in the Bay-Delta to support sustainable populations of diverse and valuable plant and animal species. Through this ecosystem-based approach, the ERP will contribute to or assist in the recovery of endangered and threatened species that use the Bay-Delta, and it will help improve the population abundance and distribution of unlisted plant and animal species. The ERP is described in three volumes: Volume I contains vision statements that describe the ecological attributes and desired future Bay-Delta conditions; Volume II outlines over 700 programmatic restoration actions for the 14 ecological management zones delineated within the Bay-Delta ecosystem; and the Strategic Plan describes the ecosystem-based, adaptive management approach that will be used to implement the restoration program.

Throughout that adaptive management process, CALFED will rely on the advice of expert panels, particularly the ERP Science Review Panel that is identified in the Strategic Plan. These panels would assess the results of CALFED actions, monitoring and research data from the Comprehensive Monitoring, Assessment and Research Program (CMARP), and other relevant information to provide advice to CALFED regarding future monitoring, research, and program actions. Such advice will be particularly relevant to decisions regarding future ERP actions and decisions regarding future conveyance and storage actions that will affect ecosystem restoration.

Category III - On December 15, 1994, the Bay-Delta Accord included a commitment by the agency and stakeholder signatories to develop and fund non-flow related ecosystem restoration actions to improve the health of the Bay-Delta ecosystem. This commitment is commonly referred to as *Category III*. Some of the specific non-flow factors identified to be addressed as part of the Category III commitment include unscreened water diversions, waste discharges, water pollution prevention, fishery impacts due to harvest and poaching, land derived salts, exotic species, fish barriers, channel alternations, loss of riparian wetlands, and other causes of estuarine habitat degradation.

Funding sources for near-term restoration activities include $60 million from state Proposition 204 funds (Bay-Delta Agreement Program) and stakeholder contributions of $31.75 million. In addition, Congress authorized $430 million for fiscal years 1998, 1999, and 2000 to fund the Federal share of Category III and initial implementation of the ERP. In Federal fiscal year 1998, $85 million was appropriated and in Federal fiscal year 1999, $75 million was appropriated for Bay-Delta ecosystem restoration, a portion of which is considered Category III funding. Proposition 204 also includes $390 million for implementation of the ERP.

Projects have been selected through a 1997 Request for Proposals which resulted in the selection of 71 projects totaling more than $85 million, through selection of 12 directed programs targeted at specific issues to be addressed by individual CALFED agencies, and through a 1998 Proposal Solicitation Package which resulted in the selection of 64 projects totaling over $25 million. The number of applications regularly exceeds the available funding by 10 to 1.

permit pursuant to the new Fish and Game Code section 2081 (b). The Department agreed to work with DW through the application process.

SPAWNING GRAVEL RESTORATION EVALUATION

Spawning gravel resources in the upper Sacramento River are considered adequate to support the present low numbers of adult winter-run chinook, 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. The proposed recovery plan recommends restoring, replenishing, and monitoring spawning gravel in the Sacramento River; protecting natural sources of spawning gravel; and, controlling excessive silt discharge to protect spawning gravel. An evaluation of spawning gravel restoration, funded by the Department of Water Resources (DWR), was conducted by the USFWS and a final report completed in April 1996 (Bigelow 1996). Agency representatives continue to participate on Technical Committees in regard to gravel restoration in the mainstem Sacramento River. No additional work on gravel evaluation was conducted in 1998.

LONG TERM MANAGEMENT STRATEGY FOR THE PLACEMENT OF DREDGED MATERIAL IN THE SAN FRANCISCO BAY REGION

Dredging and dredge spoil disposal practices may entrain fish, alter benthic habitat, create turbidity, and resuspend toxic materials. Winter-run chinook salmon migrating through areas with dredge-related activities could be entrained and exposed to adverse water quality and degraded habitat conditions.

In October 1998, the five Long Term Management Strategy (LTMS) agencies - the U. S. Environmental Protection Agency, the U. S. Army Corps of Engineers, the State of California Water Resources Control Board, the San Francisco Bay Conservation and Development Commission, and the San Francisco Regional Water Quality Control Board - announced the publication of the *Final Policy Environmental Impact Statement/Programmatic Environmental Impact Report of the Long Term Management Strategy (LTMS) for the Placement of Dredged Material in the San Francisco Bay Region* (Final EIS/EIR). The LTMS goals are to conduct necessary dredging and dredge material disposal in an environmentally sound and economically prudent manner, to maximize the "beneficial reuse" of dredged material, and to develop a coordinated permit review process for dredging projects.

The LTMS Final EIS/EIR evaluates different long-term approaches for managing the Bay area's dredging for the next 50 years. The alternatives are combinations of different amounts of dredged material placement in three different environmental settings: existing disposal sites in San Francisco Bay; ocean disposal some 50 miles offshore; and beneficial re-use at upland or wetland sites. Alternative 3 is the environmentally preferred alternative, and is also the agencies' preferred alternative. Alternative 3, sometimes called the "20-40-40 plan" (reflecting its long-term targets of 20 percent in-Bay disposal, 40 percent ocean disposal, and 40 percent upland/wetland re-use) best balances the LTMS goals.

resolve technical, policy, and procedural issues The ISDP name is slowly changing and is being referred to as South Delta Improvements (SDI).

CALFED's implementation strategy for the South Delta Improvements to address fisheries, water quality, and water supply issues in the south Delta involves a two step approach to achieve a 10,300 cfs State Water Project pumping capacity; step one, pumping is at a level of 8,500 cfs and step two, pumping is at a level of 10,300 cfs. To address potential delays in the progress on facilities needed to achieve the 10,300 cfs export capacity the environmental documentation is proposed to include both steps incorporated into a draft single supplement, to be released in 1999, with the final ISDP EIR/EIS tiered off of the CALFED Programmatic EIR/EIS and released immediately after the CALFED Record of Decision. The Department will be coordinating with USFWS and NMFS to discuss strategy to achieve a joint opinion on the CALFED Bay-Delta Program Stage 1 Action Alternative .

DELTA WETLANDS PROJECT

The Delta Wetlands (DW) project will divert and store water on two Sacramento-San Joaquin Delta (Delta) islands for later discharge for export sales or to meet outflow requirements for the San Francisco Bay/Sacramento-San Joaquin Delta estuary. It will also seasonally divert water to create and enhance wetlands and to manage wildlife habitat on these two Delta islands. Recreation facilities will be constructed along the perimeter levees on all four DW project islands.

In June 1997, the Department issued a CESA Biological Opinion for the Delta Wetlands Project and from late-June through early August the State Water Resources Control Board (SWRCB) held water rights hearings on the Delta Wetlands Project.

In August 1997, DW filed a complaint and summons against the Department alleging that the Department's Biological Opinion was not based on "good science" and should be invalidated. The Sacramento Superior Court rejected DW's allegation, but ordered the Department to make changes to a few specific provisions of the Biological Opinion. The Department made those changes and issued a revised Biological Opinion for the project on August 6, 1998. Neither party to the litigation appealed the trial court order.

DW submitted the revised Biological Opinion to the SWRCB shortly after its issuance. One party to the hearing objected to the admission of the revised Biological Opinion into the hearing record and requested further hearing dates to address questions raised by the changes to the original Biological Opinion. The SWRCB has not yet ruled on this request. On December 7, 1998 the SWRCB denied DW's application for Section 401 of the Clean Water Act certification. In that same letter, the SWRCB indicated that the Draft EIR for the DW project may have to be revised and recirculated before finalizing and certifying the Final EIR.

In anticipation that the Fish and Game Code Section 2090 will no longer be in effect as of January 1, 1999, DW has indicated to the Department that they would apply for an incidental take

Sacramento-San Joaquin Delta -	Complete 7/97	2209
Suisun Marsh -	Complete 8/96	366
TOTAL TO DATE		3908

CVPIA Anadromous Fish Screening Program - A number of projects have been implemented during the past year. Projects affecting winter-run chinook salmon include:

SACRAMENTO RIVER - Several major projects are in progress, and should be on line in the near future. One major diversion, the Sutter Mutual "Tisdale Pumping Station," a 700 cfs diversion, remains to be incorporated into the program.

Glenn-Colusa Irrigation District Fish Screen - Construction of the fish screen expansion for this 3000 cfs diversion is about half completed. Work continues on schedule, and should be ready for operation in 2000.

The planning work on the Gradient Restoration Facility is in full swing, and should be completed in 1999. This is a key element of the fish screen project, but is being done by the U.S. Army Corps of Engineers.

Provident/Princeton-Codora-Glenn Irrigation Districts Fish Screen - Work on this project, which combined the intakes of two irrigation districts into a single 650 cfs diversion with fish screen is currently in progress. Work on the fish screen has been delayed by high water levels during the 1999 construction season, but completion is anticipated in time for the 2000 irrigation season.

Reclamation District 108 Fish Screen - Work on the fish screen for this 650 cfs diversion, near Grimes, is almost complete. The new fish screen should be operational for the 1999 irrigation season.

Reclamation District 1004 Fish Screen -Work on the fish screen for this 300 cfs diversion, in Princeton, is almost complete. The new fish screen should be operational for the 1999 irrigation season.

M&T Ranch Fish Screen Project - This diversion, originally located on Big Chico Creek, was moved to the Sacramento River, and screened. The installation went into operation in 1998.

SUISUN MARSH - Several fish screens on diversions serving private waterfowl management areas have been completed, working with the Suisun Resource Conservation District. Funding is in place for another group of screens to be completed in 1999.

Other Fish Screening Projects - Several other projects were either completed, or are in

Following a transition period to change from the current practices, Alternative 3 will be practicable to implement and will result overall in the greatest environmental benefit and the least environmental risk. The Final EIS/EIR will be used to develop a detailed Management Plan that implements the selected alternative to the greatest extent possible consistent with existing laws, regulations, and agency authorities. The Management Plan will be updated in the future as environmental conditions or the agencies' authorities and regulations change.

GOAL II. IMPROVE SURVIVAL OF DOWNSTREAM MIGRANTS

UNSCREENED OR INADEQUATELY SCREENED DIVERSIONS

Winter-run chinook salmon encounter numerous unscreened or inadequately screened diversions as they migrate through the Sacramento River and the Sacramento-San Joaquin Delta. Unscreened diversions may entrain significant numbers of juvenile winter-run chinook 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 can be remedied by installing and operating positive barrier fish screens.

Fish Screening Criteria - The Department and the NMFS - Southwest Region, revised their fish screening criteria in 1997. There have been no further changes since then. A revision of the Department criteria, to conform the document to the reorganization of the Department, will be accomplished during 1999.

Department of Fish and Game's Water Diversion and Fish Passage Project Inventory - This project was initiated in 1991. Work continued during the last year, and to date, the following work has been accomplished:

Location		# Diversions
Sacramento River -	Complete 9/96	424
Feather River -	Complete 9/97	81
American River -	Complete 7/96	26
Butte Creek (below Parrot-Phelan) -	Complete 6/98	50
Sutter-Butte Basin -	Complete 6/98	54
San Joaquin R. (below Merced R.) -	Complete 8/96	298
Merced River -	Complete 12/96	134
Stanislaus River -	Complete 11/96	48
Tuolumne River -	Complete 11/96	56
Calaveras River -	Complete 12/98	135
Cosumnes River -	In progress	27

In addition to assessing direct survival of chinook passed through the pumps, studies evaluating indirect effects on survival (e.g., stress, predators) are also being conducted to fully understand the effects of the pumping plant on chinook salmon. Studies addressing the following research objectives were conducted in 1998: 1) Determine survivorship and injury to juvenile chinook salmon entrained into the Archimedes and helical pumps under differing seasonal conditions, (2) Determine residence time, survivorship, and potential injury of young salmon in the bypass pipe leading from the plant to the bypass outlet in the Sacramento River under normal and pulsed flows, (3) Estimate seasonal and annual numbers of downstream migrating juvenile salmon entrained into the pumps, (4) Determine the physiological stress and predator avoidance responses of young salmon following passage through the pumps, (5) Estimate annual entrainment levels of larval and post-larval fishes entrained into the pumps, (6) Investigate predator colonization of the area between the pumping plant trashracks and intake pipes (7) Develop an increased understanding of the timing and abundance of downstream migrating salmon in the Sacramento River near the RPP, (8) Determine seasonal relative numbers of predators near the trashracks and intake structure of the RPP, and immediately below the bypass outlet in the Sacramento River, and (9) Determine seasonal adult squawfish (pikeminnow) movements and behavior near the RPP using radio-tracking techniques.

The USBR's Research Pumping Plant Evaluation Team continued its biological and engineering evaluations of the pumping plant during 1998. High river levels from El Niño storms precluded operating the pumps until March and again shut the pumps down in May. Therefore, studies scheduled to begin in January were delayed while others were interrupted or forced to end before the number of scheduled trials were completed (e.g., Objectives 1 and 2 above). The internal helical pump was down for repairs from May through August which precluded doing comparative studies with the two types of pumps.

Survival of juvenile chinook passing through the Archimedes pumps was high (98-99%). More experiments will be conducted to evaluate survival of small chinook passing through the helical pump since it was inoperable for most of the summer.

A total of 560 winter-run chinook from brood-year 1998 were entrained into the plant during entrainment trials. Based upon the total hours that the pumps operated, the estimated number of winter chinook entrained into the plant was 1,513. Survival of entrained winter chinook was 98%.

Studies on disorientation and stress of fish passing through the pumps showed no difference between treatment and control fish. Behavioral observations were less conclusive with handling effects confounding the results. The internal helical pump was down for repairs during this time; trials will be repeated in 1999 to compare stress between the Archimedes and helical pump.

During 1998 an investigation plan entitled, "Investigation of Predator Colonization Inside the Intake Sump Area of Red Bluff Research Pumping Plant" was completed and work began in August. Relatively large pikeminnow (300-400mm) were found passing through the trashracks suggesting open-water predators may contribute more to total predator abundance in the intake area than resident predators. Sampling will continue in 1999 to determine seasonality of predators in the sump area.

progress at this time.

Anderson-Cottonwood Irrigation District Fish Screen and Ladder Project - This project, to replace the existing fish screen and ladders on the diversion for the main canal is in progress. We hope to complete the design and permitting for the project in 1999, so work can begin on the project.

DWR- Delta Mitigation Fish Screens - To fulfill mitigation obligations in the Delta, the Department of Water Resources has completed the installation of fish screens on about a dozen diversions on Sherman Island. Monitoring of the projects is now in progress.

DFG - Island Slough Fish Screen - The construction of a fish screen, to serve the Island Slough Unit of the Department of Fish and Game's holdings on Grizzly Island (in the Suisun Marsh), is now on line.

GEORGIANA SLOUGH ACOUSTIC BARRIER

The Georgiana Slough acoustic barrier was not installed in 1998, nor will it be installed this year based on a decision by the DWR to discontinue the research following results of evaluations of acoustic systems by other researchers that indicated little or no effectiveness on guidance of salmonids. There will be a final report on the 1994-1996 evaluations at the Georgiana Slough acoustic barrier produced by fall or winter 1999.

RED BLUFF DIVERSION DAM (RBDD) AND TEHAMA-COLUSA CANAL

In February 1998 the USFWS published a supplemental Fish and Wildlife Coordination Act report for RBDD and the Tehama-Colusa Canal. This report serves as a project history reference, assesses the impacts of the project, and also provides recommendations for interim operations which should establish a baseline from which to develop alternatives for the long-term solution at RBDD. The final Environmental Impact Statement for the long-term solution should be completed by 2001.

USBR EVALUATIONS AT RED BLUFF DIVERSION DAM AND RESEARCH PUMPING PLANT

Research Pumping Plant Evaluation Program - The Research Pumping Plant evaluation program continues to assess the potential for utilizing either Archimedes or internal helical pumps as a viable means of delivering water from the Sacramento River to the Tehama-Colusa and Corning canals. Studies conducted to date show high survival of chinook passed through the pumps allowing the pumps to be used during spring and fall irrigation seasons when gates at Red Bluff diversion dam are raised. By raising the dam gates for eight months each year and using the experimental pumps to provide water to the canals, 85% of adult winter-run chinook now have unrestricted passage past the dam.However, for other runs such as the Sacramento spring-run chinook salmon which migrate upstream when the dam gates are lowered, upstream passage using the fish ladders is still problematic.

PRE-SCREEN LOSS EXPERIMENT CONDUCTED AT CLIFTON COURT FOREBAY USING HABITUATED JUVENILE SALMON

In 1996, a pilot study was conducted using habituated hatchery-released juvenile salmon. Previous studies have used hatchery salmon trucked directly from the hatchery to the study site. The preliminary results were described in last year's report. It was expected that the 1996 study would form the basis for further studies to be done in the spring of 1998, however, no additional studies were conducted or are being considered at this time. The IEP Technical Report #55, "Mark/Recapture Experiments at Clifton Court Forebay to Estimate Pre-Screening Loss to Juvenile Fishes: 1976-1993" summarizes the results from studies conducted between 1976 and 1993.

INCIDENTAL TAKE OF WINTER-RUN CHINOOK SALMON AT THE CENTRAL VALLEY PROJECT (CVP) AND STATE WATER PROJECT (SWP) DELTA PUMPING FACILITIES

In April 1998, NMFS provided USBR and DWR with the estimated number of winter-run chinook salmon juveniles entering the Delta during the 1997-98 season. NMFS estimated that 138,316 wild winter-run chinook salmon fry and juveniles and an additional 42,000 hatchery-produced juveniles from the captive broodstock program would enter the Delta. Therefore, the total authorized level of incidental take for the CVP and SWP Delta pumping facilities for the period of October 1, 1997 to May 31, 1998 was 2,766 wild winter-run chinook salmon and 840 hatchery-produced winter-run chinook salmon.

The total estimated loss for 1997-98 at the CVP and SWP Delta pumping facilities was 1,542 wild winter-run chinook sized salmon.

GOAL III. IMPROVE UPSTREAM ADULT PASSAGE

RED BLUFF DIVERSION DAM (RBDD)

Gate Operations - Since 1994 the USBR has operated the RBDD in a gates-up position from September 1 through May 14. This allows for unimpeded passage for approximately 85% of the adult winter-run chinook salmon upstream migrants. The remaining adults (15%) that encounter RBDD with the gates down experience delay and blockage.

Fish Passage Program - A field study of hydrologic conditions in the right bank ladder has been performed to help evaluate performance of the existing ladder. The data will be used to help determine future action. Monitoring adult salmon behavior, movement, and delay time at RBDD and fish ladders using radio telemetry began mid-August 1998. This study is being conducted by the USFWS.

Coordination Activities - A draft report for the water supply/demand study was completed in fiscal year 1998. The information was shared with the Tehama-Colusa Canal Authority (TCCA). The report provides an accurate representation of existing and future water needs. It will assist TCCA in producing a draft report for inter-agency review.

The USBR has formed a Study Management Group with membership from the Interagency Fishery Team and other stakeholders to provide early involvement, build consensus, and formulate alternatives to solving the fish passage problems at Red Bluff. Efforts in 1999 will focus on coordination with CALFED to ensure that alternatives are in accord with potential broader scale efforts.

USFWS INVESTIGATIONS AT RED BLUFF DIVERSION DAM AND THE RESEARCH PUMPING PLANT

Tehama-Colusa Canal Screen Evaluation - The rotary drum screens at the Red Bluff diversion have been examined to determine their effectiveness in preventing entrainment of juvenile salmon into the Tehama-Colusa Canal (Johnson 1991, 1993; Johnson and Croci 1994; Croci and Johnson 1995). Because of the high efficiency of these screens (entrainment ~0) 1998 monitoring consisted of inspections of the screens conducted *in situ* using SCUBA techniques.

Sacramento Squawfish and Striped Bass Studies - Information is being collected on the changes in abundance and movement patterns of predators around the RBDD and new pumping facility. Field investigations of abundance concluded in July 1998. Investigations on movement patterns continued throughout the year. Seasonal abundance of predators at this site may indicate either a feeding concentration below the dam or an upstream passage problem for spawning adults.

GLENN-COLUSA IRRIGATION DISTRICT (GCID)

GCID continues to operate under the Federal Joint Stipulation of the Parties which was renewed between GCID and NMFS during July 1993, and superseded the April 1992 amended stipulation. The stipulation sets forth terms and conditions for operation of GCID's Hamilton City water diversion facility while implementation of long-term conservation measures proceed. The stipulation will remain in effect until GCID's operation of their Hamilton city facility is covered by either an ESA Section 7 Biological Opinion and incidental take statement or a Section 10 Permit.

The final Environmental Impact Report/Environmental Impact Statement was completed and construction was initiated on the extended flat-plate fish screen with construction to be completed by September 2000. The associated gradient restoration facility design is scheduled for completion by May 1999, with construction to be initiated by August 1999 and completed by November 2001.

by July 1999.

MODIFICATION OF THE KESWICK DAM FISH TRAP

Negotiations continued in 1997 between the USFWS and USBR regarding remedies to problems associated with trapping at the Keswick Dam fish trap. A number of physical fixes have been identified which would contribute to the overall efficiency of the fish trap, and more importantly, reduce the potential for mortality of fish retained in the trap and reduce the risk to workers attempting to remove them. Construction at the trap was scheduled to begin in October of 1998, however, contracting delays may have stalled this work.

GOAL IV. PREVENT EXTINCTION THROUGH ARTIFICIAL PROPAGATION

The artificial propagation program and captive broodstock program were deemed necessary given the extremely low returns of winter-run chinook salmon in recent years. The programs are designed to augment natural production and to prevent extinction of winter-run chinook salmon. Both the propagation and captive breeding programs are interim measures to be discontinued as the natural population of winter-run chinook stabilizes. The draft recovery plan recommends that the USFWS, in cooperation with NMFS and the Department, should develop criteria for phasing out the artificial propagation program. These criteria have not yet been developed. In addition, the draft recovery plan recommends that the captive broodstock program continue to be evaluated for its efficacy and necessity in recovering winter-run chinook salmon, and the program should be terminated once the run size of the wild population reaches 1,000 per year on a sustained basis.

WINTER-RUN CHINOOK SALMON PROPAGATION PROGRAM AT COLEMAN NATIONAL FISH HATCHERY

In an effort to restore the winter-run chinook salmon population the USFWS committed to the development of an artificial propagation program in 1988 as part of a multi-agency cooperative agreement between the USFWS, NMFS, USBR, and the Department. Minimal production was achieved in 1989 and 1990 and improvements were made to the program. Between 1991 and 1995, 153,017 juvenile winter-run chinook were released into the mainstem Sacramento River (1991 = 11,582; 1992 = 28,099; 1993 = 18,723; 1994 = 43,346; 1995 = 51,267).

Evaluation of returning hatchery-origin winter chinook salmon adults by the USFWS indicated the release strategy to imprint hatchery-origin juveniles to the mainstem Sacramento River was ineffective. Evaluations conducted in 1994, 1995 and 1996 failed to observe hatchery-origin winter-run chinook salmon in the mainstem Sacramento River. However, the evaluations found over 80 hatchery-origin winter-run chinook salmon returning to Battle Creek (the tributary on which Coleman National Fish Hatchery is located), in 1995 and over 200 in 1996. The finding of the imprinting problem, as well as other concerns surrounding the program (i.e., hybridization with other chinook

ANDERSON-COTTONWOOD IRRIGATION DISTRICT (ACID)

Adult winter-run chinook salmon must negotiate the fish ladders at ACID during the irrigation season (April through November) to reach upstream spawning habitat. The ladders do not provide suitable attracting flows and they are not easily adjusted to compensate for flow changes. A screen and ladder engineering study was completed for two ladders and one screen. The District submitted the project for funding to CALFED under the "designated action" program. The District's proposal included a commitment to own, operate and maintain the screen and ladders as part of the CALFED cost share. According to previous agreements the Department was the owner/operator.

SUISUN MARSH SALINITY CONTROL STRUCTURE

The Suisun Marsh Salinity Control Structure was constructed in 1987 to achieve minimum salinity standards, as specified in the SWRCB Decision 1485, by tidally pumping water from the Sacramento River into Montezuma Slough. Operation of this structure reverses the net tidal flow within Montezuma Slough which may increase the attraction of adult chinook salmon 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.

The Department conducted adult salmon migration studies in 1993 and 1994. A report titled, "Adult Salmon Migration Monitoring, Suisun Marsh Salinity Control Gates, September - November 1994" was published as IEP Technical Report #50.

Adult salmon migration through the Suisun Marsh Salinity Control Gates was evaluated during the facility's three operational phases; Phase I where flashboards are out and gates are raised (nonoperational), Phase II where the flashboards are in and the gates are raised (partial operation), and Phase III where the gates are fully operational.

It appears that the Suisun Marsh Salinity Control Gates may have some effect on salmon movement through Montezuma Slough under partial and full operational conditions (Phases II and III). Both the 1993 and 1994 studies indicate that a larger percentage of salmon are passing through the gates when the facility is in the nonoperational mode (Phase I). The 1993 study showed that some salmon were blocked from migrating through the control gates during full operation and, as a result, migrated back downstream to Grizzly Bay. The 1993 and 1994 studies also indicate that mean fish passage times increased from the nonoperational to the fully operational configuration: however, no statistically significant difference was noted in the 1994 passage times. An analysis of the combined 1993 and 1994 data did show a significant difference in fish passage numbers between phases when Phase I was contrasted against Phases II and III. This analysis also indicated that the highest fish passage proportion occurred in Phase I, followed by Phase III and II.

No studies were conducted between 1995 and 1997. In 1998 an additional study was conducted to assess the effectiveness of proposed modifications to the structure intended to improve adult salmon passage. Data are being analyzed and a preliminary draft report should be available by

- Bodega Marine Laboratory: 2 brood-year 1994, 33 brood-year 1995.
- Steinhart Aquarium: 19 brood-year 1995.

GENETIC RESEARCH ON RUN IDENTITY

In May 1994, DWR contracted a study with geneticists at Bodega Marine Laboratory to genetically distinguish the four runs of Central Valley chinook salmon using a non-lethal sampling technique. Protein variation has been used since the early 1970's to understand the genetic affinity of Pacific salmon species and populations. More recently, variation in the DNA sequence of the mitochondrial genome (mtDNA) has been applied to the task. Variation among chinook salmon stocks of the Central Valley for either of these classes of molecules is insufficient to accomplish run discrimination needed in the Sacramento-San Joaquin Delta and elsewhere. Geneticists at Bodega Marine Lab have isolated and characterized some nuclear DNA markers, known as microsatellites, that undergo evolutionary structural changes three to five times faster than the rate of change for proteins or mtDNA. This class of DNA markers ought, therefore, to reveal differences among the recently evolved and closely related chinook runs of the Central Valley. Five microsatellites isolated from Pacific salmon, named *Ots-2*, *Ots-3*, *Ots-9*, *Ots-10*, and *One-13*, together show strong potential for discrimination of winter-run chinook from the other three Central Valley runs. A manuscript describing these baseline populations is in progress.

Baseline population data for these five most diagnostic microsatellite markers are now complete enough to conduct preliminary run determination using mixed stock analysis (MSA) and individual analysis. Preliminary MSAs were conducted using early versions of the baselines for mixed stocks sampled at Red Bluff Diversion Dam in 1995 and for mixed stocks sampled at the State Water Project's Skinner Fish Facility in 1996. A small, non-randomly chosen sample of juvenile chinook salmon from the State and Federal Delta pumping facilities was also subjected to mixed-stock analysis in Spring 1997. Recently, BML refined the winter-run baseline to include only winter-run chinook genotypes. Samples collected at the two Delta Pumping facilities in 1997/1998 were similarly analyzed; however, using the new, unadulterated baseline populations. The differences between results using the old and new baselines was small. BML will now apply these techniques to the last three years of data from the State and Federal pumping facilities and from Delta monitoring sites.

A blind test of the ability to replicate the run identity calls on individual fish was performed in late 1997. Ninety-five archived samples were submitted to BML for analysis: 29 winter-run, and 22 each of spring-, fall, and late fall-run chinook. For the final analysis, 24 samples failed to yield extractions and four were disqualified based on previous genetic analysis. BML correctly classified (as either winter-run or non-winter-run) all of the 67 samples included in the final analysis.

In the spring of 1997and 1998, a fish trap was installed on Battle Creek to intercept improperly imprinted adults from the Winter Run Propagation Program. The individual identification technique (called WHICHRUN) was used to identify and cull suspected spring-run/winter run chinook "hybrids" from the population of returning fish and to identify potential spawners for the propagation and captive

runs), lead to the program being put on hold in 1996 until these issues were resolved.

Since no winter-run chinook salmon were collected and reared at Coleman National Fish Hatchery for release in 1997, the USFWS released fish produced from the captive broodstock program (BY 1996 = 4,718; BY 1997 = 20,000).

After considerable advances in genetic analysis to assure genetic integrity of artificially propagated winter-run, and the construction of the new Livingston Stone National Fish Hatchery at the base of Shasta Dam, the propagation program was re-authorized by NMFS and the Department in 1998. A total of 103 adult winter-run chinook salmon were collected for broodstock from the Keswick Dam fish trap in 1998. Spawning of the broodstock was completed in August 1998. Gametes from a total of 98 fish contributed to the spawning population which included cryopreserved semen from two fish captured in 1994. Approximately 150,000 juveniles were released from this propagation effort in January 1999.

EXPERIMENTAL CAPTIVE BROODSTOCK PROGRAM

The Winter-run Captive Broodstock Program (WRCBP) was initiated in 1991 when the adult run size was estimated at only 191 fish and it was recognized that it might become impossible to secure wild adults for the artificial propagation program. This experimental program was designed as a hedge against the possibility of catastrophic cohort failure or extinction of the species. The captive breeding program was designed to provide: 1) an "insurance policy" to preserve genetic material, 2) a source of eggs for the Coleman National Fish Hatchery (NFH) program in case enough wild adults couldn't be collected, 3) a potential source to supplement naturally spawning fish, 4) "time" until conditions in the Sacramento river improve, 5) an egg and fry source for experimental purposes, and 6) maximization of future options for the eventual recovery of the species. Each year juvenile salmon are transferred from Coleman NFH to Bodega Marine Laboratory (BML) and Steinhart Aquarium to be reared in captivity until maturity.

Mating protocols and management of progeny are designed to preserve genetic integrity and minimize inbreeding whenever possible. The progeny from captive broodstock matings will not be used in the captive broodstock program, thereby limiting captive rearing to one generation. In addition, the use of captive broodstock as a source of gametes is the least desirable in the hierarchical order of preferred matings. The USFWS recommends that the incorporation of captive broodstock into the propagation program be reconsidered when the estimated run size reaches 1,000 adults.

A committee oversees the direction and management of the WRCBP. The members of this committee include representatives from the department, NMFS, USFWS, University of California at Davis and BML, Steinhart Aquarium, Pacific Coast Federation of Fishermen's Associations, Tyee Club, Golden Gate Fishermen's Association, DWR, USBR, and Arizona State University.

The numbers of captive winter-run chinook salmon remaining on hand at the end of February 1999 include:

During April of 1997 south of point Lopez in a test fishery for Klamath contribution rates and during July of 1998 in a similar test fishery in the Bodega area, intensive sampling was conducted. In addition during July and August of 1997 and 1998 in the San Francisco area sport fishery there was a nc size limit fishery allowed where the project increased sample rates for CWTs and collected fin clips from unmarked fish for the analysis of winter-run chinook. In addition during the 1998 ocean salmon fishery samplers collected coast wide fin clips of unmarked salmon for mixed stock fishery analysis. Even though funds are not available to process these samples the ocean salmon project is archiving these tissues so that when funds are available there will be a number of previous years of tissue collections to analyze providing distributional data which include El Niño years and more normal years.

Since the 1994 ocean salmon season all winter-run chinook CWT recoveries were in the San Francisco and Monterey major port areas. The fish were taken by all fisheries as far south as Ventura and as far north as San Francisco. Although historical fisheries have taken winter run in the Fort Bragg area none have been taken there in recent years. However, it is important to keep in mind that the present commercial fishery in the Northern California ports are very small compared to the earlier years when winters were more abundant.

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

SECTION 10 CONSULTATION ON THE CALIFORNIA DEPARTMENT OF FISH AND GAME STRIPED BASS MANAGEMENT PROGRAM

NMFS, the USFWS and the Department have continued to work together in the development of a Conservation Plan for the Striped Bass Management Plan in an effort to issue Section 10(a)(1)(B) incidental take permits under the Federal Endangered Species Act. NMFS, USFWS and the Department have agreed to allow stocking of hatchery-striped bass to the extent that the adult striped bass population is maintained at the 1994 population level of 712,000 adults. The agencies anticipate that the incidental take permits will be issued by May 1999.

INTERAGENCY ECOLOGICAL PROGRAM (IEP) CONSULTATION

On June 18, 1998 the NMFS issued a Biological Opinion to the USBR pursuant to Section 7 of the Federal Endangered Species Act. It analyzed impacts to winter-run chinook salmon, threatened Central Valley steelhead, and threatened Central California Coast steelhead resulting from IEP studies. The NMFS concluded that the IEP studies were not likely to jeopardize the continued existence of these species or result in the adverse modification of winter-run chinook salmon habitat. The Biological Opinion included an incidental take statement with reasonable and prudent measures designed to minimize incidental take.

The Department has reviewed the IEP studies for impacts to winter- and spring-run chinook

broodstock programs. Of the 81 adipose clipped fish identified as winter-run by BML, 13 were verified as winter-run by coded-wire-tag recovery. The remaining 68 were released in the main stem of the Sacramento River to spawn. Seventeen adipose clipped fish were identified as non-winter run chinook by BML. Of these, 16 were verified using coded-wire-tags as non-winter-run, and one was identified as a likely winter/spring-run hybrid.

BML submitted two papers for publication in the last year. One is entitled, "WHICHRUN: a computer program for population assignment of individuals based on multilocus genotype data", by M.A. Banks and W. Eichert. The other is entitled, "Isolation and inheritance of novel microsatellites in chinook salmon (*Oncorhynchus tshawytscha*)", by M. A. Banks and six other authors. Both articles were submitted to the Journal of Heredity.

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

OCEAN SALMON HARVEST

NMFS issued Biological Opinions on ocean harvest in 1996 and 1997. The February 18, 1997, Opinion required that ocean fishery impacts be reduced sufficiently to target a Sacramento winter chinook adult replacement rate of 1.77, which is 31% above the average replacement rate observed for the 1989 to 1993 brood years. This requirement will remain in effect through the 2001 salmon seasons unless new and compelling information is obtained. At the end of this period, NMFS will review available information and reassess the need for restrictions on ocean harvest. The estimated adult replacement rates for 1997 and 1998 were 3.14 and 1.38 respectively.

OCEAN DISTRIBUTION AND USE OF GENETIC INFORMATION TO IMPROVE ESTIMATES OF HARVEST RATE

The draft recovery plan contains a recommendation that the Department increase its port sampling effort to get information on the ocean distribution of winter-run chinook salmon and to refine information on ocean fisheries harvest impacts. The existing port sampling program is designed to sample at least 20% of the chinook landed in the commercial and recreational fisheries. Five major ports are sampled. Since only a small number of coded-wire tagged (CWT) winter-run chinook have been released from Coleman National Fish Hatchery it is recommended that the ports closest to San Francisco should be sampled most intensively. Another recommendation in the draft recovery plan is to develop genetic methods of distinguishing various Central Valley chinook salmon stocks so that a Mixed Stock Analysis (MSA) of ocean harvest could be conducted.

To date the Department's ocean salmon project has had no additional funding to increase sampling rates for the recovery of CWT fish in the ocean fisheries. However the project has made special efforts to collect fin clips for microsatellite DNA analysis from fisheries with high potential to contact winters. During these fisheries fin clips, muscle tissue, and CWT collections were made.

Juvenile chinook salmon are identified to run by size criteria developed by Department staff (the size criteria were modified to daily, non-overlapping size criteria by Department of Water Resources). Use of the size criteria has been seriously questioned as data from fisheries monitoring in tributaries to the Sacramento River and in the Delta have been analyzed. The size criteria appears to perform well in the upper Sacramento River but not as well in the Delta. Growth rates in the Delta differ from riverine growth rates, size selective factors affecting survival occur at the SWP's Clifton Court Forebay and at the louvers to the fish salvage facilities, and unmarked hatchery releases of yearling fall-run chinook overlap in size with wild winter-run. In addition, due to the unique life history of spring-run chinook salmon on Mill and Deer creeks it appears that the juveniles that emigrate between November and January as "yearlings" may overlap in size with late-fall-run juveniles.

A brief summary of the 1997-98 monitoring elements are given below:

Department monitoring on the upper Sacramento River Juvenile rearing investigations - Intensive snorkel and seining surveys were conducted in the upper Sacramento River as part of a multi-year investigation of salmon and steelhead habitat needs downstream of Central Valley Project facilities. About 20 sites are sampled twice a month when sampling conditions allow. The work is being conducted in cooperation with the USFWS, Central Valley Anadromous Fish Restoration Program and is an integral part of the Central Valley Project Improvement Act.

Department monitoring on the upper Sacramento River Juvenile outmigration monitoring - The outmigration of juvenile salmonids is being monitored near Balls Ferry (RM 278) as part of the intensive investigation to identify salmon and steelhead habitat requirements in the Sacramento River (CDFG 1997, 1998). Rotary screw traps are fished year-long, as conditions permit, to determine the relative abundance, timing, and size (age and race) composition of migration. These data are compared with precedent conditions of spawning, rearing and various habitat attributes within the study reach to identify salmonid habitat requirements.

Emigration of juvenile winter run from the 1997 brood year was monitored from July 1, 1997 through September 15, 1997. (Trapping was terminated on September 15, 1997 due to restrictions placed upon the Department's research by the NMFS pursuant to Section 10 of the Endangered Species Act.) A total of 10,111 winter-run juveniles were collected using two traps operated intermittently through September 15.

Emigration of juvenile winter run from the 1998 brood year was monitored from July 1, 1998 through December 31, 1998. A total of 11,017 winter-run juveniles were collected using only one trap operated at a substantially reduced rate to comply with Section 10 Permit conditions.

As a comparison, the number of winter run that would have been caught in 1997 had one trap been operated full time (through September 15, 1997) is estimated to be 9,051. In 1998, the number of juvenile winter run that would have been collected had one trap been operated full time through September 15, 1998, is estimated to be 12,459.

salmon and is preparing its conclusions using the new California Endangered Species Act regulations.

GOAL VII. IMPROVE UNDERSTANDING OF LIFE HISTORY AND HABITAT REQUIREMENTS

U.S. FISH AND WILDLIFE SERVICE EGG INCUBATION TEMPERATURE TOLERANCE STUDY

No temperature tolerance studies were conducted by the USFWS in 1998. Analysis of previous data is expected to be completed prior to the continuation of this multi-year research effort. A final report on previous work is near completion.

CENTRAL VALLEY SALMON PROJECT WORK TEAM

The Central Valley Salmon Project Work Team (PWT) is composed of representatives from the Department, DWR, USBR, NMFS, USFWS, Urban Water Users, Environmental Interests, Fishing Industry and the Agricultural Water Users. They coordinate and oversee the salmon monitoring efforts and specific issues throughout the Central Valley. The monitoring effort includes year-round sampling of all runs of chinook salmon. Monitoring is conducted for several purposes: for meeting Endangered Species Act Biological Opinion requirements; for the support of the CALFED Operations Group decisions; for testing the effectiveness of the Bay-Delta Plan (water quality standards); for assessing long term trends; for special studies, such as the release and recapture of adipose fin-clipped, coded-wire tagged hatchery salmon; and for other purposes, such as complementing CVPIA monitoring.

Because of the wide ranging issues and geographic scope, the Central Valley Salmon PWT gets assistance from several technical subgroups that provide data analyses, summaries, and recommendations. One subgroup in particular, the Winter-run Subgroup, reviews monitoring and data analyses to improve our understanding of winter-run chinook salmon life history and recovery needs. They review research and monitoring proposals that affect winter-run chinook and they also provide recommendations specifically for the management of winter-run chinook salmon.

In 1997 the IEP published Technical Report #59, "Statistical Model for Survival of Chinook Salmon Smolts Outmigrating through the Lower Sacramento-San Joaquin System", by Ken Newman and John Rice. CWT chinook salmon data collected between 1979 and 1995 were used to develop a generalized linear model having a large number of covariates. The most influential covariates in the model included environmental factors largely outside the control of man such as water temperature, water salinity, and river flow. The position of the Delta Cross Channel gates (open or closed) suggested a strong effect and there was no strong evidence for either adverse or beneficial effects of increasing water exports. Unfortunately, the Technical Report was not reviewed by the Central Valley Salmon PWT or its technical subgroups prior to publication and the model has received strong criticism from Department statisticians and biologists. Since the model is still in the development and testing phase the Department hopes to participate in an interagency work group to develop a more parsimonious model.

Department monitoring at Butte Creek and Sutter Bypass - On April 15, 1998 the Department's Region 2 staff began monitoring juvenile chinook salmon emigration in Butte Creek and the Sutter Bypass. The monitoring program is focused on spring-run chinook salmon, however, winter-run chinook salmon juveniles enter lower Butte Creek from the Sacramento River at the Colusa, Mouton, and Tisdale weirs and at the Butte Slough Outfall Gates during winter flood conditions. A total of 15,480 chinook salmon was captured during the sampling period which ended on July 17,1998. Of that total, 6,893 were in fall-run length category, 8,570 were in spring-run length category, 5 were in winter-run length category, and 7 were in late-fall-run length category.

Department monitoring at Knight's Landing - Juvenile salmon and steelhead migrating from the upper Sacramento River and its tributaries were continuously monitored through 1998. Two rotary screw traps located near Knights Landing (river mile 89.5) were fished 24 hours a day, seven days a week to identify the timing and relative abundance of emigrating salmon (Snider and Titus 1998). The trapping results through December 31, 1998, for winter run juvenile from the 1998 brood year have been very similar to those observed for the 1997 brood year. Winter run first entered the traps at Knights Landing in August and at least one winter run was caught every month thereafter. The first wave of emigration reached Knights Landing in mid-November, and over 500 juveniles were collected by the end of December.

A total of 749 juvenile winter run were collected during the 1997 emigration season; 558 winter run have been collected so far in the 1998 season. The total number of juvenile winter run collected in the 1997 season twice the 1995 and 1996 totals. This was consistent with spawning and emigration trends in the upper Sacramento River during 1997. Spawning and emigration data collected in the upper river during 1998 suggest that the number of juvenile to be caught in the 1998 emigration season should be at least twice the 1997 total.

USFWS monitoring of the lower Sacramento River, Delta, and lower San Joaquin River - The USFWS monitors anadromous salmonids in the Sacramento-San Joaquin Delta. In 1992 the program was expanded to determine the relative abundance and distribution of the different life stages of the four runs of juvenile chinook salmon in the lower rivers and Delta with special emphasis on winter-run chinook salmon. The sampling methods include beach seining throughout the lower rivers, Delta and Bay, midwater trawling at Sacramento and at Chipps Island, and kodiak trawling at Sacramento and Mossdale. The USFWS also conducts coded wire tag (CWT) experiments to evaluate mortality of late-fall run and fall run chinook salmon released into the Delta.

CWT studies using late-fall juveniles have been used to gain additional information on the survival of winter run juveniles in the Delta. Late-fall juveniles have been used as surrogates for winter run because they are larger and more similar to the size of winter run than are fall run when they migrate into the Delta. Late-fall also migrate through the Delta during the winter months when water temperatures are cooler, again more like winter run. Fall run smolts migrate during the spring months when water temperatures can exceed optimal levels.

Between 1992 and 1994, six paired releases of fall run smolts released into the Central Delta

USFWS monitoring on the upper Sacramento River Beach seine sampling - Twelve sampling sites were selected along a 107-mile reach of the upper Sacramento River from RM 193 to 300: four sites below the RBDD and eight sites above. This survey has been conducted year-round since 1981 and is designed to provide managers with outmigration timing and presence/absence information regarding chinook salmon runs in reaches of the upper Sacramento River. Sites were selected empirically on the basis of river current, substrate composition, accessibility, and relative separation from other sites. Sampling generally occurred biweekly and was conducted by the Northern Central Valley Fish and Wildlife Office and the Department's staff at Red Bluff. An 1/8-in stretch mesh beach seine (4 x 75 ft) was used to capture juvenile fish. Haul length varied from approximately 300 ft at gravel bars to 15 to 60 ft at boat ramps. Chinook to be measured were anesthetized with tricaine methanesulfonate. All fish were released back into the river. During the calendar year 1998, 4 broodyear 1997 juvenile winter chinook were captured in this study. Efforts were discontinued in August 1998 due to concerns of exceeding ESA Section 10 take limits. Beach seine sampling will continue during the 1999 calendar year.

USFWS monitoring on the upper Sacramento River Juvenile outmigration monitoring at RBDD - Studies are currently being conducted at the RBDD in conjunction with the evaluation of the Red Bluff Research Pumping Plant (RPP). Study objectives include evaluations of absolute, relative, temporal, spatial and diel patterns of abundance for downstream migrating juvenile chinook salmon and steelhead trout. The results are used to validate patterns of fish entrainment into Red Bluff RPP pumps with patterns of fish abundance at RBDD.

Four 8-ft rotary screw traps were attached to dam gates directly behind RBDD and were positioned to represent three spatial zones within the river channel; west shoreline, mid-channel and east shoreline. Diel distribution patterns were evaluated by comparing salmonid catches throughout 24-h periods. Approximately 130 broodyear 1997 juvenile winter chinook salmon (salmon race was determined from daily length tables; Sheila Greene, Department of Water Resources, 1992) were captured between January - April 1998 and 16,300 broodyear 1998 winter chinook between July - December 1998.

Department monitoring at GCID - The Department's Region 2 staff continues to operate a rotary screw trap in the bypass channel of the GCID intake to monitor juvenile chinook salmon, and other species, emigrating from the upper Sacramento River. Juvenile winter-run chinook were detected in mid-July 1998 as part of the on-going monitoring effort, although the sampling was reduced as the result of the fish screen.

Department monitoring on Mill and Deer creeks - The Department's Region 1 Red Bluff field station monitors juvenile chinook salmon emigration in Mill and Deer creeks. This monitoring is in cooperation with CALFED Operations Groups, "Sacramento River Spring-run Chinook Salmon Protection Plan", and focuses on yearling size spring-run and fry size spring- and fall-run chinook juveniles. For the October 1998 to January 1999 sampling period, yearling spring-run chinook salmon range in size from 67 mm fork length to 122 mm fork length. Spring and fall-run chinook salmon fry range in size from 30 to 42 mm fork length. On Mill and Deer creeks, the outmigrant fish traps are fished upstream of irrigation dams and fish ladders which prohibit the upstream migration of juvenile chinook salmon from the Sacramento River.

conducted by the USFWS and private consultants from late-January through June. In addition, the Turlock Irrigation District monitors juvenile chinook salmon on the Tuolumne River by beach seining. The Merced River Fish Facility releases fall-run chinook salmon production on the Tuolumne and Merced rivers in April. The Department also uses CWT fish for smolt survival studies over discrete reaches of the tributaries and at Mossdale. In past years, when production fish have not been tagged they have been confused for winter-run chinook salmon at the State and Federal fish salvage facilities due to overlapping size ranges.

Department monitoring at Contra Costa Canal, Mallard Slough, and the "New" Old River Fish Screen Facility (Los Vaqueros) - The Department conducts the fishery monitoring programs at all of the Contra Costa Water District (CCWD) diversions in the Delta. The three diversions are the Rock Slough intake of the Contra Costa Canal, the Mallard Slough Pumping Plant, and the Old River Fish Screen Facility. The program at Rock Slough is funded by the U.S. Bureau of Reclamation (50%) and the CCWD (50%). The programs at the Mallard Slough Pumping Plant and the Old River Fish Screen Facility is funded solely by CCWD.

The Rock Slough program consists of fish entrainment monitoring at the Rock Slough intake of the Contra Costa Canal and predatory fish monitoring in the vicinity of the proposed fish screening facility in Rock Slough. The fish entrainment monitoring was initiated in August 1998. Sampling was conducted on a weekly basis using a large sieve-net to capture fish during the flood tides. Only one juvenile chinook salmon was captured in the sieve-net and that was a winter-run-sized juvenile chinook salmon captured on December 10. The predatory fish monitoring program which will be used to collect baseline data for evaluating the fish screening facility will start in early 1999.

Fish entrainment sampling was conducted at the Mallard Slough Pumping plant from May 26 to July 30. The program used a fine mesh sieve-net to sample approximately one third of the diverted water through a bypass structure. Sampling at this diversion was conducted on a weekly basis. No salmon were captured in any of the sampling efforts.

The fish monitoring program at the Old River Fish Screen Facility consists of sampling in front of the facility with a sieve-net and sampling the various bays behind the fish screens with a sieve-net to evaluate the effectiveness of the fish screening facility. Preliminary sampling behind the fish screens was conducted in March and April. Sampling behind the screens was conducted three times per week during May and June. Sampling continued from July through December on a weekly basis except for periods when the Old River Pumping Plant was shut down and repairs were made to the sampling equipment. No salmon were captured during any of the sampling efforts. The monitoring in front of the fish screening facility will start in January 1999.

(Georgiana Slough) had 3 to 8 times greater mortality than smolts released on the mainstem Sacramento River at Ryde. To determine if this differential survival was also occurring for winter run, late-fall have been released since 1993 at the same locations, during the winter when water temperatures are cooler.

The results to date with seven paired groups indicate that the differential survival observed for late-fall run released into Georgiana Slough relative to those released on the mainstem Sacramento River is similar to that observed for fall run.

Recently these experiments have been conducted to determine if CVP and SWP exports are affecting the relative survival of the Georgiana Slough group relative to those released on the mainstem Sacramento River at Ryde or Isleton. Releases have been made during periods of high and low exports at various flow levels. Initial experiments (1993 and 1994) occurred with the Delta Cross Channel gates open, but to better isolate the role of exports they have been closed during the more recent experiments.

Results to date indicate a possible negative relationship between the survival index of the Georgiana Slough group relative to the Ryde group versus exports. Data from the most recent experiment (December, 1998) are still being collected. Results will be forthcoming.

Department fish salvage operations at the John E. Skinner Fish Facilities - The Department's Central Valley Bay-Delta Branch is under contract with the DWR to conduct fish salvage operations at the SWP's Skinner Delta Fish Protective Facility located near Byron in the south Delta. From October 1 through May 31, when winter-run chinook salmon may be present and water is being exported, salvaged fish are sampled for a minimum of 10 minutes every 2 hours. All chinook salmon observed during normal counts or special studies are measured for fork length and a small non-lethal tissue sample is taken for DNA analysis. Subsampling salmon for tissue samples may occur when salvage of salmon is very high. All salvaged fish are trucked back to release sites in the Delta at least once a day and more frequently depending on fish salvage levels, debris load, and special status species procedures. The Fish Salvage Monitoring Program oversees both the State and Federal fish salvage facilities and determines daily estimates of incidental take of all species. In addition, weekly reports are distributed for special status species (winter-run chinook salmon, all chinook salmon, delta smelt, longfin smelt, splittail, and Wakasagi).

USBR fish salvage operations at the Tracy Fish Collecting Facility - The USBR provides staff for the CVP's Tracy Fish Collecting Facility. The fish salvage operation is essentially the same as that at the Skinner Delta Fish Protective Facility. As stated above, the Department determines daily estimates of incidental take of all species and distributes weekly reports for special status species.

Department monitoring on the San Joaquin River - The Department's Region 4 staff conducts monitoring on the San Joaquin River and its tributaries principally for fall-run chinook salmon. Trawling is conducted at Mossdale on the San Joaquin River from mid-March through June and adult escapement data are collected on tributaries from early October through December. Rotary screw trapping for juvenile chinook salmon emigrating from the tributaries is

has historically supported winter-run chinook and shares a number of important characteristics with the former habitats above Shasta Dam. Presently, the main population of winter-run spawns in the Sacramento River which is not resistant to extensive droughts which results in exposing the population to periods of severe mortality due to elevated temperatures.

Coleman National Fish Hatchery installed an ozone water sterilization unit in the summer of 1998 that treats approximately two-thirds of the hatchery's water supply. Installation of the remainder of the water treatment facilities is expected to be completed by the end of 1999.

ADULT RUN SIZE ESTIMATES

Since 1967 adult run size estimates have been made at RBDD (Table1). The RBDD estimate is based on historic run timing when the fish ladders at the dam were operating through the entire season. Under present conditions the dam gates are raised from September 15 to at least May 14 each year allowing unimpeded passage of winter-run adults. Once the gates are lowered, winter-run adults pass through the fish ladders where actual counts are made. The actual observations are then used to estimate the total number that passed the dam throughout the season. The run size estimate does not account for the year-to-year variation in run timing, therefore, there is some error associated with the estimate. 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. In 1998 the estimated number of wild winter-run chinook salmon that passed Red Bluff Diversion Dam (RBDD) was 2,612. Approximately 32% of the run consisted of two year old males (jacks).

The Department conducted a carcass survey for winter-run chinook salmon in the upper Sacramento River from 5 May through 28 August 1998 (Snider et al. 1999). The survey extended from Keswick Dam [river mile (RM) 302] downstream 14 miles to near the Redding Water Treatment Plant (RM 288). The survey section is estimated to support over 90% of winter run spawning. This was the third consecutive year a winter-run carcass survey was conducted as part of a multi- year, CVPIA supported investigation to identify salmon habitat requirements in the Sacramento River system. The information gained on the life history requirements of the species will be used to identify the relationship between management actions and cohort survival and ultimately identify management actions required to optimize survival of anadromous resources. A total of 785 carcasses were observed in 1998. The total winter-run chinook salmon spawner population was estimated to be 5,501, including 111 two-year old salmon and 12 hatchery produced salmon. The effective spawning population (i.e., the number of female salmon that successfully spawned) was estimated to be 4,609, nearly three times the effective spawner population estimate for 1997. The methods used to estimate population size from this type of effort typically result in an overestimate. The true population size probably lies in between the RBDD estimate and the estimate based on the carcass survey.

YOLO BYPASS PROJECT WORK TEAM

In 1997 the DWR initiated salmon studies on the Yolo Bypass, a 59,000 acre engineered floodplain in the Sacramento basin. The project is being coordinated through the IEP Yolo Bypass Project Work Team, whose members include representatives from DFG, USFWS, UC Davis, USGS and San Francisco State University. The long-term objectives are to examine the relationship between the Yolo Bypass and the rest of the Estuary and to develop recommendations for restoration actions that would improve habitat for salmon and other aquatic organisms. Sampling methods included beach seines, screw trap, fyke net and purse seine.

Field studies demonstrate that the Bypass supports at least 40 fish species including delta smelt, steelhead trout, sturgeon and winter run chinook salmon. The Bypass is particularly important habitat for rearing of young chinook salmon, which grow substantially faster on the floodplain habitat as a result of warmer temperatures and an abundant food supply. Preliminary coded-wire-tag studies indicate that survival of young salmon in the Yolo Bypass is similar to survival in the Sacramento River (survival indices of 0.14 and 0.10 respectively). Stranding rates for fish stranded in ponds as floodwaters recede are highly variable. Additional years of study under a range of hydrologic conditions should be performed to further analyze survival and stranding. More detailed studies of food chain effects are desirable as well.

BATTLE CREEK

During 1998 a comprehensive Battle Creek Restoration Project was developed in a process that was open to all the involved and interested parties. The technical aspects of the project were coordinated monthly with the involved parties; including PG&E, Battle Creek Conservancy, fisheries and water agencies and local government representatives. The technical aspects of the hydroelectric project were developed in a collaborative process directed at producing a CALFED proposal that made permanent changes to the anadromous reaches of the entire watershed affected by hydroelectric system.

Substantive agreement has been reached between the resource agencies and PG&E on the flows and facilities for 42 miles of Battle Creek system. Although agreements are not final they were considered sufficient to be submitted as a CALFED Proposal that includes major flow increase and screening and laddering of dams along with some dam removal. The expected completion date is in the year 2001. In the meantime PG&E will continue flow increases under an interim water acquisition program that has been used as a demonstration project in the past.

Restoring the remnant populations of naturally spawning spring-run chinook salmon and steelhead that still occur in Battle Creek (USFWS survey observations) and fostering natural re-colonization of winter-run chinook salmon requires restoring streamflow and stream channel processes while reducing the extent and influence of dams impairing upstream and downstream passage of anadromous fish. Restoring ecological processes will allow habitats to sustain themselves. The Creek

The Winter-run Subgroup has convened a special work team to evaluate the last three years of carcass survey data and to evaluate the procedures of run size estimation at RBDD with a goal of improving escapement estimates.

The 1998 redd distribution of spawning winter-run chinook salmon was determined by weekly aerial flights between April 28 and August 11. A total of 132 redds was observed, 104 of which were found between Highway 44 and the Anderson-Cottonwood Irrigation District diversion on the Sacramento River (Table 2).

Table 1.
Annual Estimated Winter-run Chinook Salmon Run Size at Red Bluff Diversion Dam, 1967 through 1998.

Year	grilse	adults	total	Year	grilse	adults	total
1967	24,985	32,321	57,306	1983	392	1,439	1,831
1968	10,299	74,115	84,414	1984	1,869	794	2,663
1969	8,953	108,855	117,808	1985	329	3,633	3,962
1970	8,324	32,085	40,409	1986	451	2,013	2,464
1971	20,864	32,225	53,089	1987	236	1,761	1,997
1972	8,541	28,592	37,133	1988	708	1,386	2,094
1973	4,623	19,456	24,079	1989	53	480	533
1974	3,788	18,109	21,897	1990	16	425	441
1975	7,498	15,932	23,430	1991	35	156	191
1976	8,634	26,462	35,096	1992	58	1,121	1,181
1977	2,186	15,028	17,214	1993	74	267	341
1978	1,193	23,669	24,862	1994	37	152	189
1979	113	2,251	2,364	1995	66	1,295	1,361
1980	1,072	84	1,156	1996	388	552	940
1981	1,744	18,297	20,041	1997	361	480	841
1982	270	972	1,242	1998	828	1,783	2,612

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Table 2.
Estimated Redd Distribution of Winter-run Chinook Salmon on the Sacramento River DFG Aerial Counts

RIVER REACH	1989		1990		1991		1992		1993*	
	No.	%	No.	%	No.	%	No.	%	No.	%
Keswick Dam to Anderson Cottonwood Irrigation District (ACID) Dam	3	6.5	0	0	0	0	1	1.9	2	4.2
ACID to Highway 44	26	56.5	38	39.2	8	66.9	15	27.8	31	64.6
Highway 44 to Upper Anderson Bridge	9	19.6	45	46.4	4	33.3	22	40.7	11	22.9
Upper Anderson Bridge to Balls Ferry	1	2.2	5	5.1	0	0	8	14.8	1	2.1
Balls Ferry to Jelly's Ferry	0	0	2	2.1	0	0	3	5.6	1	2.1
Jelly's Ferry to Bend Bridge	6	13.0	0	0	0	0	3	5.6	1	2.1
Bend Bridge to Red Bluff Diversion Dam	NS	-	0	0	0	0	0	0	0	0
Red Bluff Diversion Dam to Tehama	NS	-	5	5.1	0	0	2	3.7	1	2.1
Tehama to Woodson Bridge	1	2.2	2	2.1	0	0	0	0	0	0
Estimated Total Number of Redds	46		97		12		54		48	

RIVER REACH	1994		1995		1996		1997		1998	
	No.	%	No.	%	No.	%	No.	%	No.	%
Keswick Dam to Anderson Cottonwood Irrigation District (ACID) Dam	0	0	12	6	3	6.8	0	0	4	3.0
ACID to Highway 44	6	40	175	87.9	25	56.8	25	83.3	104	78.8
Highway 44 to Upper Anderson Bridge	3	20	10	5	15	36.4	5	16.7	21	15.9
Upper Anderson Bridge to Balls Ferry	5	33.3	0	0	0	0	0	0	0	0.0
Balls Ferry to Jelly's Ferry	0	0	1	0.5	0	0	0	0	0	0.0
Jelly's Ferry to Bend Bridge	1	6.7	0	0	0	0	0	0	0	0.0
Bend Bridge to Red Bluff Diversion Dam	0	0	0	0	0	0	0	0	0	0.0
Red Bluff Diversion Dam to Tehama	0	0	1	0.5	0	0	0	0	3	2.3
Tehama to Woodson Bridge	0	0	0	0	0	0	0	0	0	0.0
Estimated Total Number of Redds	15		199		44		30		132	

* Corrected data from previous reports

NS = No survey in this river reach