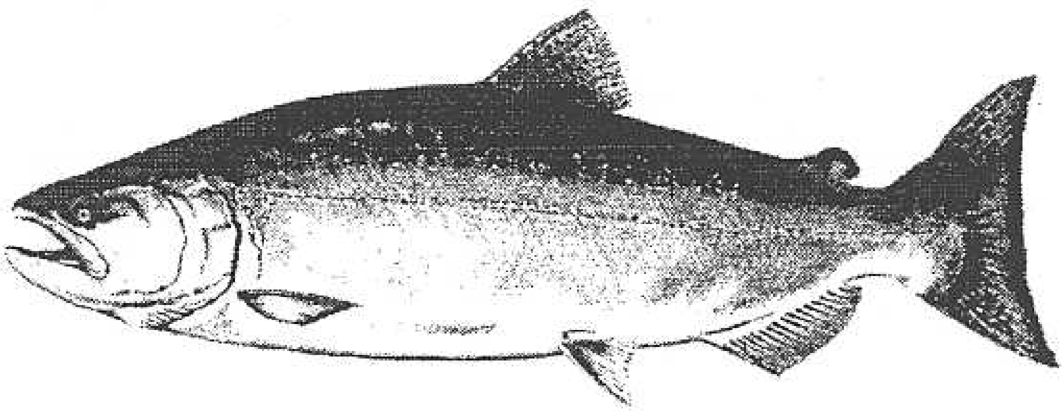
State of California
The Resources Agency

DEPARTMENT OF FISH AND GAME

REPORT TO THE FISH AND GAME COMMISSION:

A STATUS REVIEW OF THE SPRING-RUN CHINOOK SALMON (ONCORHYNCUS TSHAWYTSCHA) IN THE SACRAMENTO RIVER DRAINAGE



June 1998

Candidate Species Status Report 98-01

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Prepared by
Department of Fish and Game

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LIST OF ACRONYMS

Acre-feet	af
Anadromous Fish Restoration Plan	AFRP
Anderson Cottonwood Irrigation District	ACID
Association of Bay Area Governments	ABAG
Bay-Delta Plan	Bay-Delta Plan
Brood Year	BY
Browns Valley Irrigation District	BVID
California Department of Water Resources	DWR
California Endangered Species Act	CESA
California Environmental Quality Act	CEQA
California Fish Commission	CFC
California Fish and Game Commission	Commission
California Department of Fish and Game	Department
California Code of Regulations	CCR
Central Valley Project Improvement Act	CVPIA
Central Valley Project	CVP
Central Valley Index	CVI
Coded-wire tagged	CWT
Cohort Replacement Rate	CRR
Coleman National Fish Hatchery	CNFH
Conservation Plan	CP
Contra Costa Water District	CCWD
Cubic feet per second	cfs
Deer Creek Watershed Conservancy	DCWC
Deer Creek Irrigation Company Dam	DCID
Delta Cross Channel	DCC
Delta Bay Enhanced Enforcement Program	DBEEP
Draft Environmental Impact Report	DEIR
Environmental Impact Statement	EIS
Environmental Impact Report	EIR
Environmental Report	ER
Evolutionarily Significant Unit	ESU
Export-Import Ratio	E:I Ratio
Feather River Hatchery	FRH
Federal Energy Regulatory Commission	FERC
Federal Endangered Species Act	ESA
Fish and Game Code	FGC
Fork Length	FL
Geographic Information System	GIS
Glenn-Colusa Irrigation District	GCID
Interim South Delta Program	ISDP
Memorandum of Understanding	MOU

LIST OF ACRONYMS (CONTINUED)

Mitochondrial DNA	mtDNA
National Marine Fisheries Service	NMFS
National Environmental Policy Act	NEPA
NMFS Biological Review Team	NMFS-BRT
North Bay Aqueduct	NBA
Nuclear DNA	nDNA
Ocean Salmon Project	OSP
Operations Criteria and Plan	OCAP
Pacific Fishery Management Council	PFMC
Pacific Gas and Electric	PG&E
Personal Communication	Pers. Com.
Red Bluff Diversion Dam	RBDD
Stanford-Vina Ranch Irrigation Company Diversion Dam	SVIC
State Water Project	SWP
State Water Resources Control Board	SWRCB
Total Length	TL
U.C. Davis Bodega Marine Laboratory	BML
U.S. Bureau of Land Management	BLM
U.S. Forest Service	USFS
U.S. Fish and Wildlife Service	USFWS
U.S. Environmental Protection Agency	USEPA
U.S. Bureau of Reclamation	USBR
U.S. Army Corps of Engineers	USACOE
Vernalis Adaptive Management Plan	VAMP

LIST OF CONVERSION FACTORS

Quantity	To Convert from Metric Unit	To Customary Unit	Multiply Metric Unit By	To Convert to Metric Unit Multiply Customary Unit By
Length	millimeters (mm) centimeters (cm) meters (m)	inches (in) inches (in) feet (ft)	0.03937 0.3937 3.2808	25.4 2.54 0.3048
Area	square meters (m^2)	square feet (ft^2)	10.764	0.092903
Volume	cubic meters (m^3) cubic decameters (dam^3)	cubic feet (ft^3) acre-feet (af)	35.315 0.8107	0.028317 1.2335
Flow	cubic meters per second (m^3/s)	cubic feet per second (ft^3/s)	35.315	0.028317
Velocity	meters per second (m/s)	feet per second (ft/s)	3.2808	0.3048
Temperature	degrees Celsius (°C)	degrees Fahrenheit (°F)	(1.8 * °C)+32	(°F-32)/1.8

Report to the Fish and Game Commission
A Status Review of the
Spring-run Chinook Salmon (Oncorhynchus tshawytscha)
in the Sacramento River Drainage

I. EXECUTIVE SUMMARY

Background

This status report was prepared in response to a petition to list Sacramento River spring-run chinook salmon (*Oncorhynchus tshawytscha*) as an endangered species pursuant to the California Endangered Species Act (Fish and Game Code Sections 2050 et seq.). The Fish and Game Commission (Commission) received the petition on October 16, 1995, from State Senator Tom Hayden. The California Department of Fish and Game (Department) conducted a 90-day review of the petition and recommended the petition be accepted and considered by the Commission.

At its April 4, 1996, meeting the Commission rejected the petition to list the Sacramento River spring-run chinook salmon. On February 21, 1997, a Writ of Mandate was issued by the Sacramento Superior Court commanding the Commission to accept the petition and designate the Sacramento River spring-run chinook salmon as a "candidate" species. On June 13, 1997, the Commission took formal action to void and set aside its May 6, 1996, rejection of the petition. The twelve-month candidacy period became effective June 27, 1997.

Pursuant to Section 2074.6 of the Fish and Game Code, the Department undertook a review of this petition. Based on the best scientific information available and consideration of existing and proposed future management activities regarding spring-run chinook salmon in California's Central Valley, the Department has evaluated whether or not the petitioned action is warranted. Information and comments on the petitioned action and the species in question were solicited from interested parties, management agencies, and the scientific community.

This report presents the results of the Department's review and analysis.

Findings

Life-history characteristics that separate spring run from the other Central Valley populations have been observed since the last century. These characteristics, together with recently developed genetic analyses, indicate spring run comprise a distinct interbreeding population segment of Central Valley chinook salmon. Spring-run chinook salmon are distinguishable and separable from other runs of Central Valley chinook.

Spring-run chinook salmon once occupied the headwaters of all major river systems in California's Central Valley where natural barriers were absent. Based upon estimates derived from commercial fish landings, the population of Central Valley spring-run chinook salmon in the 1880's ranged from 127,000 to 604,000 fish.

Between the 1880s and the 1940s, a major decrease in spring-run chinook salmon abundance occurred. It is attributable to the commercial gill-net fishery at the turn of the century, water development and dams that prevented or interfered with access by adults to headwater areas, and habitat degradation due to mining and reclamation activities. In the 1940's, the population ranged from 19,000 to 222,000 fish per year. In recent decades, spring run have ranged from 500 to 13,000 fish per year.

Streams that continue to support wild, persistent, and long-term documented populations of spring-run chinook salmon are Mill, Deer, and Butte creeks. These remaining wild populations of Sacramento River spring-run chinook salmon are small, isolated, and their range is restricted. Genetic risks exist due to these small population sizes.

There are other streams which may support Sacramento River spring run but documentation is weak (Battle Creek), their populations are not persistent (Antelope, Cottonwood, and Big Chico creeks), populations may be hybridized to some degree with fall run due to lack of spatial separation of spawning habitat (Sacramento, Yuba, and Feather rivers), or is a hybrid hatchery population (Feather River Hatchery). If unmodified, this hatchery program represents a threat to the genetic integrity of remaining wild spring run in the Sacramento River basin.

Habitat degradation in the lower part of tributaries and in migratory pathways, is considered to be a significant source of ongoing risk to Sacramento River spring-run chinook. Juvenile rearing habitat and juvenile and adult migration corridors have been impacted. Degradation includes: restricted and regulated flows, agricultural and municipal diversions and returns, unscreened or poorly screened diversions, elevated water temperatures, and the poor quality and quantity of remaining habitat. Adult fish passage within the lower reaches of spawning tributaries can be delayed or even blocked under lower flow conditions. Mortality of migratory juveniles is considered a significant factor affecting spring-run abundance. Operations at the State and Federal Delta water export facilities affect the level of juvenile spring run entrainment to the central and southern Delta.

Habitat restoration projects to benefit spring run are being addressed principally under two major restoration plans: the Department's *Restoring Central Valley Streams: A Plan For Action* and the Federal Central Valley Project Improvement Act. Recently implemented restoration actions upstream of the Delta have resulted in improvements to spring-run fish passage through increased streamflows and barrier removal and modifications. The expected benefits to spring-run populations from other recently implemented restoration projects will take time to realize because of the variable nature of the populations and their predominantly three-year life-cycle. Adaptive management for spring run in the Delta, initiated in 1996 through the CALFED Operations Group and the Spring-run Chinook Salmon Protection Plan, if continued, is also expected to reduce impacts on juvenile spring run.

There are a considerable number of future restoration actions proposed in the Department's *Restoring Central Valley Streams: A Plan For Action* and the Central Valley Project Improvement Act's Anadromous Fish Restoration Program. These actions primarily target areas upstream of the Delta. Full implementation of these actions should provide adequate protections for spring run upstream of the Bay-Delta.

The CALFED Bay-Delta Program, which began in June 1995, is charged with developing a long-term solution for restoring the ecosystem health and improving water management for beneficial uses of the Bay-Delta system. The CALFED Bay-Delta Program released a draft Environmental Impact Statement / Environmental Impact Report in April 1998. Following the close of the comment period (July 1, 1998) CALFED will be preparing a Revised Draft Programmatic Environmental Impact Statement / Environmental Impact Report for release by the end of the year; it will identify a draft preferred alternative. One element of the CALFED Bay-Delta Program, the Ecosystem Restoration Program, contains actions that would be generally beneficial for salmon, including spring run.

There are several projects, such as the Interim South Delta Program, the Implementation of the 1995 Bay/Delta Water Quality Control Plan, and others funded by the Central Valley Project Improvement Act, which are currently proposed that could alter the magnitude and timing of water diverted at the State and Federal export facilities in the Delta. These projects are in various stages of environmental review, some of which have yet to define a preferred alternative.

Conclusions

The petition requested listing as endangered. Based on the best scientific information available to the Department and existing and future proposed actions affecting Sacramento River spring-run chinook salmon, the Department concludes that this species is threatened.

Recommendations

The Department recommends the following:

1. The Commission find that the Sacramento River spring-run chinook salmon are threatened.

2. The Commission publish notice of its intent to amend Title 14, California Code of Regulations, Section 670.5 to add Sacramento River spring-run chinook salmon (*Oncorhynchus tshawytscha*) to the list of threatened species.

3. Continue current protective actions. Design and implement new ones in cooperation with the public and government agencies, including State and Federal water project operators, to secure Sacramento River spring run and its habitat.

4. Develop a restoration plan for Sacramento River spring-run chinook salmon that will: (a) protect the existing populations and habitat of the species; (b) restore the habitat and populations of the species; and (c) monitor the populations of the species.

Report to the Fish and Game Commission
A Status Review of the
Spring-run Chinook Salmon (Oncorhynchus tshawytscha) in the Sacramento River Drainage

II. INTRODUCTION

Petition History

The Fish and Game Commission (Commission) received a petition from State Senator Tom Hayden on October 16, 1995, to list Sacramento River spring-run chinook salmon as an endangered species under provisions of the California Endangered Species Act (CESA). The Commission reviewed the petition for completeness and, pursuant to Section 2073 of the Fish and Game Code (FGC), referred the petition to the Department of Fish and Game (Department) on October 18, 1995, for evaluation. The Department had until January 17, 1996, (90 days from the date of referral from the Commission) to evaluate the petition and report one of the following recommendations to the Commission:

(1) Based upon the information contained in the petition, there is not sufficient information to indicate that the petitioned action may be warranted; or

(2) Based upon the information contained in the petition, there is sufficient information to indicate that the petitioned action may be warranted, and the petition should be accepted and considered.

The Department found that the information in the petition was sufficient to indicate the petitioned action may be warranted. Petition information was evaluated according to the criteria specified in FGC Section 2072.3. The Department also relied upon information and data contained in its files to interpret the petition's information. The Department recommended acceptance of the petition to the Commission. At its April 4, 1996, meeting the Commission rejected the petition. The Commission adopted findings outlining reasons for the rejection of the petition at its May 6, 1996, meeting. The Commission determined that:

> "...there was insufficient evidence to find there was an immediate threat to the continued existence of the spring-run salmon or that a listing may be warranted. The Commission finds that the petition does not provide sufficient information in the category of degree of threat and lacks a discussion on taxonomy that would establish the Sacramento River spring-run chinook salmon as a listable entity."

The Commission further declared the spring-run salmon to be a "monitored" species (California Code of Regulations [CCR], Section 670.6) and instructed the Department to gather certain information on the species.

Senator Hayden, the original petitioner, and others challenged the Commission's determination and designation in court. On February 21, 1997, a Writ of Mandate was issued by the Sacramento Superior Court setting aside the Commission's actions of April 4 and May 6, 1996. On March 6 and April 3, 1997, Commission meetings were held. An appeal of the court order was considered during executive sessions. On April 4, 1997, a news release was issued relating the Commission's decision to not appeal the Superior Court ruling.

On June 13, 1997, a Commission meeting was held in Bridgeport. The Commission took formal action to set aside its actions of April 4 and May 6, 1996, and accepted the petition and noticed the spring-run chinook salmon as a candidate species. The Commission also adopted a Special Order, pursuant to FGC Section 2084, to provide for incidental take of spring-run chinook salmon during the candidacy period. On June 17, 1997, the Commission staff submitted a Notice of Candidacy, including the Special Order to the Office of Administrative Law. On June 27, 1997, the notice was published in the California Regulatory Notice Register and the twelve-month candidacy period became effective. A "candidate species" means a native species or subspecies of a bird, mammal, fish, amphibian, reptile, or plant that the Commission has formally noticed as being under review by the Department for addition to either the list of endangered species or the list of threatened species, or a species for which the Commission has published a notice of proposed regulation to add the species to either list (FGC Section 2068).

Department Review

This report contains the results of the Department's review and recommendation to the Commission. It is based on the best scientific information available and a knowledge of current and proposed protective measures. It also contains the Department's recommendation about whether the petitioned action is warranted. Further, it identifies habitat that may be essential to the continued existence of the species and suggests prudent management activities and other restoration actions.

The Department has contacted affected and interested parties, invited comment on the petition, and requested any additional scientific information that may be available, as required under FGC Section 2074.4. Appendix A contains a list of parties contacted, a copy of the Department's Public Notice which was transmitted to all parties, a list of newspapers which published the Public Notice, and a list of individuals, organizations, and agencies that responded.

Federal Status Review and Recovery Planning

The National Marine Fisheries Service (NMFS) is the Federal resource agency responsible for administering the Federal Endangered Species Act (ESA) for anadromous fish. On March 14, 1994, NMFS was petitioned by the Professional Resources Organization-Salmon (PRO-Salmon) to list spring-run populations of chinook salmon in three separate rivers in the state of Washington (the North Fork and South Fork Nooksack River, the Dungeness River, and the White River). Around this same time, NMFS also received petitions to list additional populations of other Pacific salmon species in the Puget Sound area. As a result, NMFS announced on September 12, 1994 that it would initiate status reviews pursuant to the ESA for all species of anadromous salmonids in Washington, Oregon, California, and Idaho.

The status of Sacramento River spring-run chinook salmon is presently under evaluation as part of the NMFS status review of all West Coast chinook salmon populations (NMFS 1996). Sacramento River spring-run chinook salmon is referred to as Central Valley spring-run chinook salmon in the NMFS status review. The NMFS West Coast Chinook Salmon Biological Review Team (NMFS-BRT), completed preparation of a draft status review report in November 1996

(NMFS 1996). NMFS distributed copies of the report to selected private and public individuals and government agencies, including the Department, for review and comment. A final status review report was issued in February 1998 (Myers et al. 1998).

NMFS concluded that, based upon its life-history traits, ecological data, and supported by recent genetic data, Central Valley spring-run chinook salmon constitute a separate Evolutionarily Significant Unit (ESU). The majority of the NMFS-BRT concluded, based upon scientific evidence, that Central Valley spring-run chinook salmon are in danger of extinction.

Within a year of the NMFS-BRT conclusion (by February 1999), NMFS will consider the impacts of the current and planned management activities to protect Central Valley spring run and make their final listing determinations.

The U.S. Fish and Wildlife Service (USFWS) prepared and released a multi-species *Recovery Plan for Sacramento-San Joaquin Delta Native Fishes* in November 1996 (USFWS 1995a). The USFWS included Sacramento River spring-run chinook salmon as one of eight species addressed by the plan. All eight species were determined to be dependent on the Delta for a significant segment of their life history and threatened by: (1) loss of habitat due to increased freshwater exports; (2) loss of shallow-water habitat; (3) introduced aquatic species; (4) entrainment in State, Federal, and private water diversions; and (5) changes in pattern and timing of flows through the Delta. The plan also determined that spring-, late-fall-, and San Joaquin fall-run chinook salmon are affected by sport and commercial harvest, as well as by interactions with hatchery populations.

The Department, in this report for the Commission, reviewed both the NMFS' chinook salmon status review and the USFWS recovery plan.

Public Responses

Appendix A contains: (1) a copy of the Public Notice; (2) a list of parties contacted by Public Notice; (3) a list of newspapers which published the Public Notice; (4) a list of parties who responded to the Public Notice; and (5) a list of Peer Reviewers who reviewed the draft report. Where appropriate, modifications to the document were made to respond to Peer Review comments.

III. LIFE-HISTORY

Species Identification

Chinook salmon are physically distinguished from other species of salmon by their large size (to 99 pounds), the presence of small black spots on both lobes of the caudal fin, black pigment along the base of the teeth, and a large number of pyloric caeca (McPhail and Lindsey 1970, Hart 1973). Juvenile fish are identified by large parr marks that extend well below the lateral line. The adipose fin is unpigmented except for a black edge. The anal fin is usually only slightly falcate, and the leading rays do not reach past the posterior insertion of the fin when folded against the body. The anal fin has a white leading edge that is not outlined by a dark pigment line (as in the coho salmon). Juvenile characteristics are highly variable; reliable identification is often dependent on meristic and pyloric caeca counts. The chinook, like all salmon species within the genus *Oncorhynchus*, is anadromous. Adults spawn in freshwater and juveniles emigrate to the ocean where they grow to adulthood. Upon their return to freshwater, adults spawn and then die.

On the North American Coast, spawning populations of chinook salmon are known to be distributed from Kotzebue Sound, Alaska to Central California (Healey 1991). The southernmost populations of chinook salmon occur in the Sacramento-San Joaquin basins of California. There are two distinct spring-run chinook salmon populations in California: the North Coast Klamath-Trinity population and the Central Valley Sacramento-San Joaquin population. NMFS has recently completed an examination of genetic study results for West Coast chinook salmon populations and determined that the Klamath-Trinity River population is genetically distinct from the Sacramento-San Joaquin population (Myers et al. 1998).

Taxonomy

Taxonomy is the discipline of classifying and naming distinct groups of organisms. The classification system consists of a hierarchy of smaller to larger groups. A group of organisms defined by the classification system, such as a class or species, is called a taxon. A taxonomic "species" is a basic unit in the classification system, consisting of a group of individuals having many characteristics in common and differing from all other life forms in one or more ways.

Chinook salmon, *Oncorhynchus tshawytscha* (Walbaum), is one of nine *Oncorhynchus* species distributed around the North Pacific Rim. The genus *Oncorhynchus* is found within the Family Salmonidae (salmon, trout, and char), in the Class Osteichthyes (bony fishes). Chinook are most closely related to the coho salmon, *Oncorhynchus kisutch* (Walbaum). Chinook salmon is the accepted common name for this species as adopted by the American Fisheries Society and Federal and State natural resource agencies, but they are also known as king salmon and tyee.

Chinook salmon, like all Pacific salmon, exhibit a wide range of characteristics that are not accounted for in classic hierarchical taxonomy. In order to distinguish each group sharing several to many characteristics, data regarding body structure, physiology, embryology, genetics, behavior, and other features, must be included (Storer et al. 1968). Riddell (1993) provides a more detailed description of the hierarchical organization of Pacific salmon that accounts for their biological diversity. Lower levels within the organizational hierarchy have less temporal and spatial variability. Avers (1989) defined subspecies as: "...populations that share most of their characteristics but differ in a few traits, inhabit different geographical or ecological subdivisions of the entire range of the species, and can freely interbreed with one another.... The identification of geographically or ecologically distinct subspecies has genetic validity." Subspecies are categorized below species, but above biological races. Races can be further categorized into populations. The diversity of the species has arisen from a variety of genetic processes (for example natural selection, genetic drift, and mutation) which occur at the level of the individual (Freeman 1998), which is a basic unit of diversity.

In California there are four runs of chinook salmon that are differentiated by the timing of adult spawning migration: fall-, late-fall-, winter-, and spring-run chinook salmon. These four runs, including spring-run chinook, are often called "races" in the sense of Merrell (1981): subdivisions of a population that are somewhat geographically separated and exhibit reduced gene flow. In this report, Sacramento River spring-run chinook salmon as a group will be referred to as a run. Units within this larger group will be referred to as populations.

Species as a Biological Concept and Regulatory Criteria

Spring run and the other chinook salmon runs in the Central Valley are not characterized as separate species by classic taxonomy; however, they are distinct population segments when the cumulative knowledge of each run's spatial, temporal, and behavioral attributes are fully considered along with biochemical data such as protein electrophoresis, cytogenic analyses, and techniques that estimate genetic divergence.

Spring run are differentiated from the other chinook salmon runs (fall-, late-fall-, and winter-run chinook) in the Sacramento River by the time of their spawning migrations, the degree of maturity of adult fish entering freshwater, their spawning areas, and emigration timing of juveniles. Spring run maintain their genetic integrity by being temporally and/or spatially isolated from other runs in the Sacramento River system. Spring run are temporally isolated from winter run. Temporal isolation with fall run is not complete; however spring run were naturally spatially isolated from fall run. Based on their recognized distinctness, State and Federal resource management and conservation agencies have historically managed spring run separately from the other runs of Sacramento River chinook salmon.

As explained in a recent publication by Nehlsen et al. (1991), the greatest challenge in preserving the genetic diversity of salmonid fishes concerns the protection of nontaxa (below the biological species level). Behnke (1993) also voiced this opinion, stating, "Obviously, any conservation program to preserve biodiversity must begin at the lowest nontaxon level." The scientific justification for extending protection to distinct population segments of species is that genetic diversity provides the raw materials for adaptation of a species as a whole to changing conditions. Loss of specific population segments can contribute to the decline of the species as a whole and increase its probability of extinction. Therefore, protection of population segments is biologically appropriate (Ecological Society of America 1996). Wood (1995), in describing the declining trends in number and magnitude of salmon spawning runs in British Columbia, concluded they implied a loss of genetic diversity, through the loss of both locally adapted sub-populations and genetic variation due to low effective population sizes. The same arguments can be made for the Sacramento River spring-run chinook salmon.

The Sacramento River spring run has been formally recognized in the fisheries literature as a distinct run or stock since 1875 when Livingston Stone first described the different runs in the mainstem Sacramento River (Stone 1875). The Commission has defined the State's policy regarding salmon population management and at what level management should be directed, stating: "It is the policy of the Fish and Game Commission that salmon shall be managed to protect, restore, and maintain the populations and genetic integrity of all identifiable stocks..." (FGC, Salmon Policy). This management focus is consistent with current literature on the protection of the genetic diversity of species.

Genetics

Recent genetic research has provided evidence that supports the distinctiveness of spring-run chinook salmon and complements known spring-run chinook life-history. Several researchers have investigated, or are currently investigating, genetic variation in Central Valley chinook salmon runs using a variety of data: protein (i.e., allozyme) electrophoresis, variability in mitochondrial DNA (mtDNA), and highly polymorphic segments of nuclear DNA (nDNA) called microsatellites. Not all tributary spawning populations of spring run have been analyzed. Therefore, the genetic relationships between various spring-run spawning populations in the Central Valley have not yet been evaluated. In addition, because of the reduced population levels, sample sizes are small and baseline data with which to characterize each population are limited. Nevertheless, some general conclusions can be made, using this recent work, that support the distinctiveness of spring-run chinook salmon from fall-, late-fall-, and winter-run chinook salmon.

Bartley et al. (1992) analyzed the genetic structure of 37 chinook salmon populations in California and southern Oregon using allozyme data. Five population clusters were discerned, with the most distinct cluster containing samples from the Sacramento-San Joaquin basins. However, although allozyme data have been successfully used to discriminate chinook salmon populations on a large scale, they cannot discriminate temporal runs within a system.

Geneticists at the University of California, Davis, Bodega Marine Laboratory (BML) are analyzing highly repetitive, highly polymorphic elements of nDNA for genetic differences that can discriminate the four runs of Central Valley chinook salmon. These elements, called microsatellites, undergo evolutionary structural change at a very high rate. Because of this, microsatellite markers hold the potential to reveal recent evolutionary changes that allozyme data cannot. To date, more than 50 microsatellites have been isolated at BML. Five of these show strong potential for discrimination of salmon runs: *Ots-2*, *Ots-3*, *Ots-9*, *Ots-10*, and *One-13*. The four *Ots* microsatellites were isolated from Central Valley chinook by BML; *One-13* was isolated from sockeye salmon at the U.S. Geological Survey (USGS) in Anchorage, Alaska.

An analysis tree, using a technique called an unweighted pair group method with arithmetic averages (commonly referred to as UPGMA), of Nei's (1978) genetic distance for these five microsatellites indicated that fall-run and late-fall run were most similar among the four Central Valley chinook runs. Spring run chinook were next most closely related to fall- and late-fall runs. Significant allele frequency differences between spring-run and fall- or late-fall run chinook were demonstrable at seven of ten statistical comparisons. Winter-run chinook were most distant from the other three runs, showing significant allele frequency differences at 13 of 15 statistical comparisons. The average proportion of genetic variation due to differences between populations over the five loci ($F_{st} = 0.084$) represents considerable divergence among run types. These results are consistent with the conclusion that significant levels of reproductive isolation exist between winter run and the other three runs of Central Valley chinook, and between spring run and fall- and late-fall run chinook. In addition, using these same data, well defined differences between several spring run samples are discernable. Spring run from Mill and Deer creeks appear to be homogeneous, whereas Butte Creek spring run is a distinct population.

Baseline samples for spring run chinook were collected from 1993 to 1997. Within any one collection year sample size for the spring run baseline is low (Table 1). Also, many baseline samples are from juveniles that are very likely spring run, but may confuse analysis because of relatedness. These features highlight the preliminary nature of the analyses based on these baselines.

Table 1. Bodega Marine Laboratory's Spring-run Baseline Sources.

Sample Location	Year Fish Sampled	Life-stage of Samples	Number of Samples
Mill Creek	95	adults	15
	96	juveniles	64
Deer Creek	93	adults	10
	94	adults	2
	94	juveniles	64
	95	adults	29
	96	adults	20
	96	juveniles	223
	97	adults	48
Big Chico Creek			
	95	adults	5
Butte Creek	94	adults	69
	95	adults	5
	94	juveniles	35
	96	adults	50
	96	juveniles	69
	97	adults	48

The work being done at BML focuses on identification of winter-run chinook, and the available data suggest that winter-run chinook can be identified to some level of reliability. However, BML has characterized all four runs of Central Valley chinook to some degree using these five loci. On this basis, although winter run show the best promise for discrimination, spring run are also demonstrably different and can usually be separated based on microsatellite allele frequencies. Geneticists at BML believe that this technique will be useful in separating spring run from other runs (M. Banks pers. com.). They recently initiated a second study that focuses on spring run genetic integrity, relationships between different spring-run populations, and comparisons to other chinook runs in the Central Valley.

Study results (Hedgecock et al. 1995) showed a large genetic distance between winter-run and fall- and spring-run samples. Significant allele frequency differences were also found between the spring-run sample and each of the fall- and late-fall-run samples, and between the two fall-run samples.

Nielsen (1995) also analyzed microsatellite nDNA to evaluate genetic variation in Central Valley chinook salmon. Comparisons between spring-run chinook samples from Deer Creek (1993) and Butte Creek (1994) showed significant differences, suggesting to Nielson possible introgression of spring- and fall-run chinook salmon in Butte Creek. However, as stated in

Nielsen's report, the Department had cautioned that the juvenile samples collected from Butte Creek in 1994 might include some fall-run fish. The dissimilarity of the spring-run populations in Butte and Deer creeks, and the similarity of Butte Creek spring-run fish to fall-run chinook is more likely explained by collection of a mixed sample of the two runs than by introgression among runs in Butte Creek.

Nielsen (1997) investigated genetic variation in spring run at three microsatellites, *Ssa-4*, *Ssa-14*, and *Ssa-289*. Spring-run chinook salmon used in this study were collected from Deer Creek (1992 adults and juveniles, 1993 adults, 1994 juveniles) and Butte Creek (1993 juveniles collected in 1994 but originally reported as adults, 1994 adults). An exclusive allele (*Ssa-289*) found only in the 1993 Deer Creek spring-run chinook population was not found in the same population in the 1994 sample. Some fish collected in Deer Creek in 1994 as "spring-run" chinook were genetically most similar to the Coleman National Fish Hatchery (CNFH) fall-run chinook. Also, a mtDNA haplotype associated with fall-run chinook appeared in 24% of the individuals in the 1994 Deer Creek sample. This haplotype had not been observed in Deer Creek spring run in previous years (1992-93). Nielsen stated that these results were inconclusive, but that they suggested fall-run influence in the 1994 Deer Creek sample. Nielsen further stated that the source of this influence is unclear.

To date Nielsen (pers. com.) has analyzed 138 spring-run chinook from Butte Creek (1993-96), Deer Creek (1994 and 1996), and Mill Creek (1995-96) for seven microsatellite loci. Nielsen has also analyzed 177 fall- and 18 winter-run chinook for comparison. Using these limited preliminary data Nielsen (pers. com.) found that the allelic size distribution for fall-run chinook encompasses the allelic size range for all other races at all seven loci examined. No diagnostic alleles have yet been found that would allow unambiguous race discrimination. Analysis of allelic frequency independence shows significant population genetic structural differences separating fall-, winter-, and spring-run chinook. Initial preliminary analysis of Butte, Deer, and Mill creeks show significant population differences in allelic frequencies by stream and year-class that suggest that populations in these streams are not identical and that significant year-to-year variation exists in these spawning populations.

Nielsen et al. (1994) presented the first published support for significant genetic separation among spring-, fall- and winter-run chinook salmon in the Central Valley. Differentiation among chinook spawning populations was possible based on haplotype frequency (analogous to allele frequency) distributions. The levels of gene flow found among the temporal spawning runs suggested recent evolutionary divergence (within the last 10,000 years) of the Central Valley chinook into unique temporal runs. Overall mtDNA haplotype frequency analyses in Nielsen (1997) similarly support significant genetic separation among the four chinook spawning runs.

Additional mtDNA research by Nielsen (1995) found no significant year-class structure in haplotype frequencies of any chinook temporal runs in a diverse collection of chinook populations in the Sacramento-San Joaquin basin. Eight mtDNA haplotypes were identified. The consistency of haplotype frequencies over three years shows genetic stability in the four temporal chinook runs in the Sacramento-San Joaquin basin. This stability supports a unique evolutionary history for each chinook run. In these analyses, mtDNA haplotype frequencies for Deer Creek spring-run chinook were significantly different from all winter- and fall-run populations. In this study the proportion of genetic variation due to genetic differences between runs (G_{st}) was 15.3%. This value is relatively high, but comparable to estimates of differentiation between runs of chinook salmon in other geographic regions using allozyme data [see summary in Myers et al. (1998)].

Cramer and Demko (1997) speculated that Butte Creek spring-run chinook may be more similar to Feather River Hatchery (FRH) fish than to spring-run chinook from Mill and Deer creeks. However, this is not supported by available, although preliminary, genetics data. Preliminary microsattelite data (M. Banks pers. com.) separates FRH chinook salmon from all other runs including Butte, Mill, and Deer creek spring-run chinook. Nei's (1978) index of genetic similarity placed FRH chinook between fall- and spring-run chinook salmon, as expected if introgression had occurred in this population. Based on these data, FRH chinook are likely introgressed fall- and spring-run chinook. The suggestion that Butte Creek spring-run chinook may be more similar to FRH fish is not supported by the data, but genetic separation of Butte Creek from Mill and Deer creek samples is evident. However, unambiguous genetic evidence of introgression as its cause is lacking.

In summary, while current genetics information is not abundant, and often it is preliminary, the information supports the finding that spring-run chinook salmon comprise a distinct interbreeding population segment of Central Valley chinook salmon. Although the definition of the genetic constitution of spring-run chinook may depend on location and year of collection (J. Nielsen pers. com.), spring-run chinook show consistent moderate genetic differences from other runs of Central Valley chinook. They are genetically distinguishable and separable from other races of Central Valley chinook using mtDNA and nDNA analyses. The data demonstrate that spring-run chinook populations in Mill and Deer creeks are more similar to each other than to those in Butte Creek. However, all three of these populations are distinguishable from winter-run, late-fall, and fall-run populations. Genetic separation is demonstrable on the basis of differences in allele and haplotype frequencies. No alleles or haplotypes unique to spring run have yet been found. Work is currently underway to more fully characterize spring-run chinook genetics.

There is only a small amount of information with which to evaluate the relationship of relict spring-run populations in the Sacramento River tributaries with those in the mainstem Sacramento River and the Feather River. There is no genetic analysis that includes samples from the Yuba River and several other tributaries with non-persistent spring-run occurrence. Therefore, conclusions based on the genetic relationships of these populations are not possible. Current work may shed light on these relationships.

Unique Species Characteristics

Adult Upstream Migration and Spawning

It is estimated that adult Sacramento River spring-run chinook salmon leave the ocean to begin their upstream migration in late January to early February based on time of entry to natal tributaries. Spring-run chinook are sexually immature when they enter freshwater, their gonads maturing over the summer holding period (Marcotte 1984). Adult chinook salmon do not feed upon entering freshwater. Stored body fat reserves are used for maintenance and for gonadal development.

Adults enter their natal tributaries from mid-February through July with upstream migration peaking in May. The most thorough historic records of timing of spring-run migration and spawning are contained in Livingston Stone's reports to the U.S. Fish Commissioners of operations at Baird Hatchery on the McCloud River (Stone 1893, 1895, 1896a, 1896b, 1896c, 1898, Williams 1893, 1894, Lambson 1899, 1900, 1901, 1902, 1904). Spring-run salmon migration in the upper river and tributaries extended from mid-March through the end of July with the peak of migration in late May and early June (Figure 1). Baird Hatchery intercepted returning spring-run adults and spawned them from mid-August through late September (Table 2). Peak spawning occurred in the first half of September. The peaks of spawning for spring- and fall-run salmon were almost two months apart.

Table 2. Dates of Spring-run and Fall-run Chinook Salmon Spawning at Baird Hatchery on the McCloud River.

Year	Spring run	Fall run	Reference
1888	Aug 15 - Sep 24	Oct 29 - Dec 15	(Stone, 1893)
1889	Aug 27 - Sep 26	no egg take	(Williams, 1893)
1890	Aug 27 - Sep 23	Nov 6 - Nov 25	(Williams, 1893)
1891	Aug 31 - Sep 19	Oct 30 - Nov 10	(Williams, 1894)
1892	Aug 13 - Sep 12	Oct 20 - Nov 26	(Stone, 1895)
1893	Aug 22 - Sep 15	Oct 21 - Nov 28	(Stone, 1896)
1894	Aug 24 - Sep 30	Oct 22 - Nov 23	(Stone, 1896)
1895	Aug 26 - Sep 30	Oct 18 - Nov 14	(Stone, 1896)
1896	Aug 22 - Sep 20	no egg take	(Stone, 1898)
1897	Aug 14 - Sep 20	Oct 08 - Dec 08	(Lambson, 1897)
1898	Aug 15 - Sep 17	Nov 05 - Dec 27	(Lambson, 1900)
1899	Aug 21 - Sep 27	Oct 18 - Nov 09	(Lambson, 1901)
1900	Aug 18 - Sep 22	no egg take	(Lambson, 1902)
1901	Aug 16 - Sep 25	Oct 25 - Nov 25	(Lambson, 1904)

Currently, timing of adult spawning is from mid to late August through October. Peak spawning is in late September. It has been observed that within Deer Creek, spawning begins first at higher elevations, which are the coolest reaches. Spawning occurs progressively later at the lower elevations (Harvey 1995a, 1996a, 1997c).

Fry Emergence and Juvenile Emigration

After hatching, larval salmon remain in the gravel living on yolk-sac reserves for another two to three weeks. The length of residency as yolk-sac fry is also influenced by water temperature. Emergence generally occurs after the yolk-sac is absorbed.

The strong influence of water temperature greatly influences the variations observed in egg incubation and time of emergence between different drainages. Water temperatures are warmer in Butte and Big Chico creeks than Mill and Deer creeks. Within Butte and Big Chico creeks, juvenile salmon first appear in late November, some three months after the onset of spawning, with juvenile emergence continuing through January. However, in Mill and Deer creeks, juveniles emerge from January through March, up to six months after the onset of spawning.

Timing of emigration is highly variable. For Mill and Deer creeks, eggs incubate over the winter months and juveniles typically begin to emerge in early March, over six months after the first spawning. The majority of juvenile production continues to rear in the tributaries over the summer months and emigrates the following fall as yearlings, defined in this report as approximately one year old from time of egg deposition. Emigration of yearlings occurs from October through March, with peak movement during November and December. Yearlings

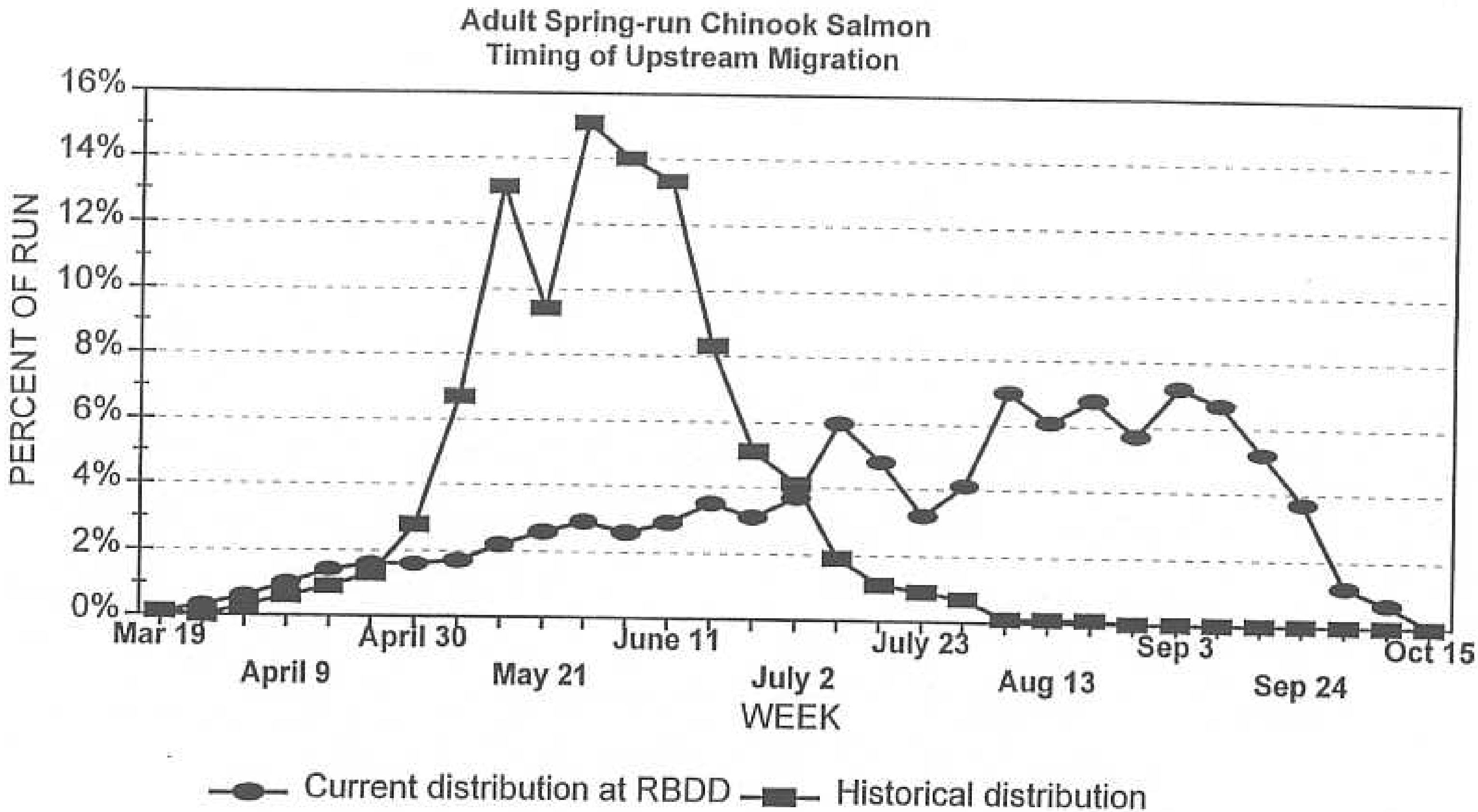


Figure 1. Present timing of spring-run chinook salmon migration past RBDD using a composite of data from 1970-1988 compared to the historical distribution based on a composite of data from Mill and Deer creeks, Feather River, and the upper Sacramento River prior to the construction of Shasta Dam.

appear to be in a smolting condition (i.e., a slimmer fish as indicated by a decreasing condition factor and fading of parr marks). In some years, under certain flow and/or water temperature conditions, juveniles in Mill and Deer creeks may outmigrate as fry and fingerling beginning soon after emergence.

The bulk of the production in Butte and Big Chico creeks emigrate from their natal tributaries as fry in December and January. Some rear in the stream and emigrate as fingerlings from February through May. A few juveniles rear in these two creeks through the summer months (Brown 1995), with yearling emigration starting in October, peaking in November-December, and generally ending in February.

Delta and Ocean Entry of Juveniles

Depending on flow conditions in their natal streams and within the Sacramento River, yearlings can enter the Delta as early as October and as late as March or April based on emigration patterns from natal tributaries (CDFG monitoring data for Mill, Deer, Butte, and Big Chico creeks from 1994-96). Fry and fingerling can enter the Delta as early as January and as late as June. Their length of residency within the Delta is unknown but probably lessens as the season progresses into the late spring months.

Ocean Distribution

Sacramento River spring-run chinook salmon are reported to be distributed primarily between Point Arena and Morro Bay along the coast of California (Figure 2), where they feed, grow, and mingle with other chinook salmon populations that include Central Valley fall-run and winter-run chinook salmon.

Sex and Age Structure of the Population

Fisher (1994) reported that 87% of spring-run adults are three-years-old based on observations of adult chinook salmon trapped and examined at Red Bluff Diversion Dam (RBDD) between 1985-1991. Categorization of adults as spring run was based on coloring and degree of sexual maturity, which is an imperfect method for differentiating winter run from spring run early in the season and spring run from fall run late in the season. Further, the data may include unmarked FRH spring run straying to the upper Sacramento River.

A survey of Deer Creek from 1992 through 1996 indicated that the percentage of two-year-old fish (based on size) ranged from 3% to 14% with a median value of 4% (CDFG 1996). No attempt was made to refine the age distribution of these fish further.

Fecundity

The fecundity for wild spring run was developed by using a geometric mean (GM) regression (Ricker 1973) by regressing fecundity on length for all Sacramento River chinook runs (Figure 3). Data to develop the function came from McGregor (1923), Hanson (1940), Warner (1940), Tehama Colusa Fish Facility, and CNFH winter-run reports. The resultant GM functional equation of fecundity for an adult female at a given fork length is:

$$\text{number of eggs} = -6800.73 + 153.7804 \times \text{FL (cm)}, \ (r^2 = .70).$$

A fecundity for each female was calculated using the derived equation for fork lengths from 172 female carcasses from Mill and Deer creeks. The number of eggs-per-adult-female spring-run chinook in Mill and Deer creeks, derived with the above formula, ranged from 1,350 eggs to

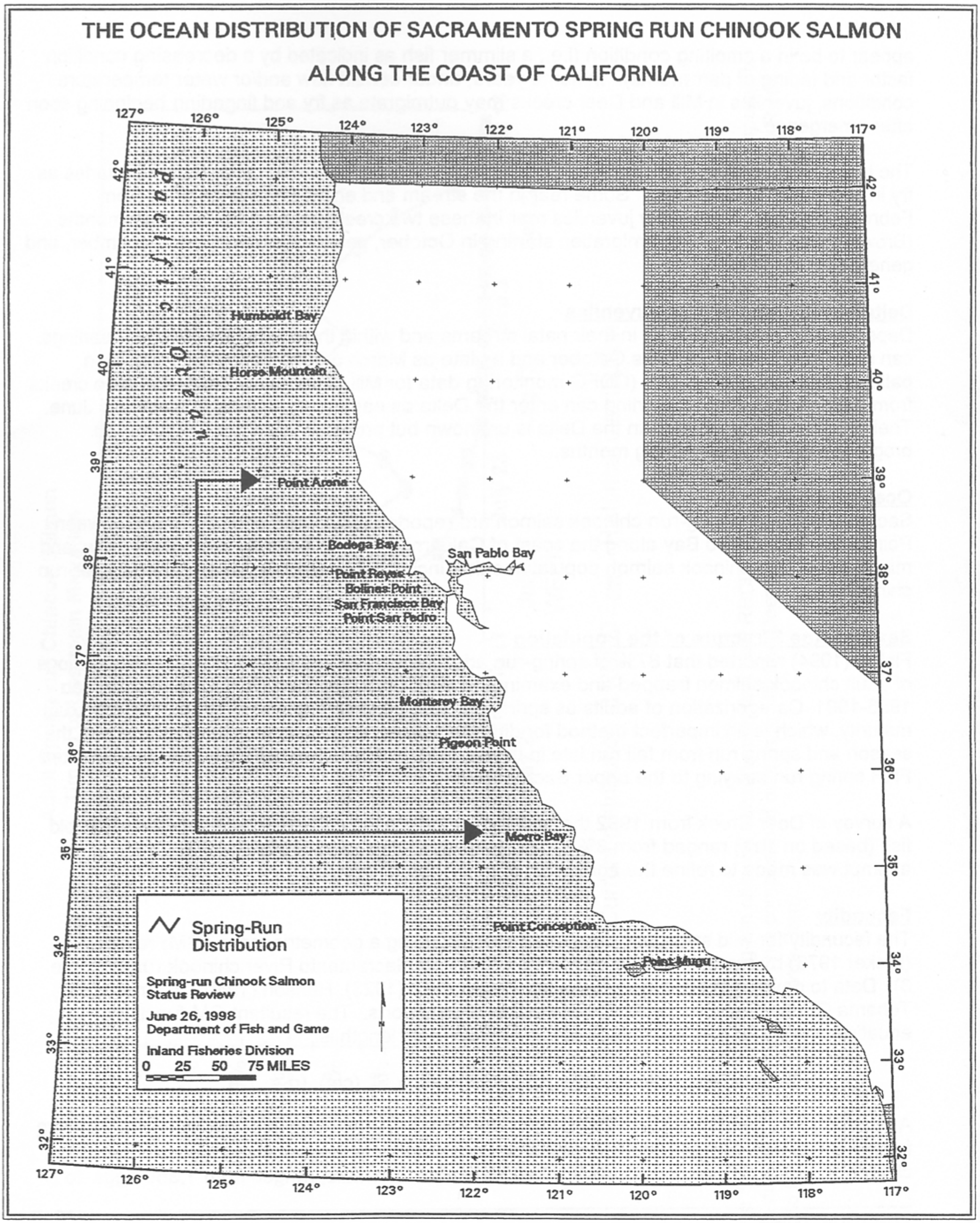


Figure 2. Distribution of Sacramento River spring run in the Pacific Ocean off the coast of California.

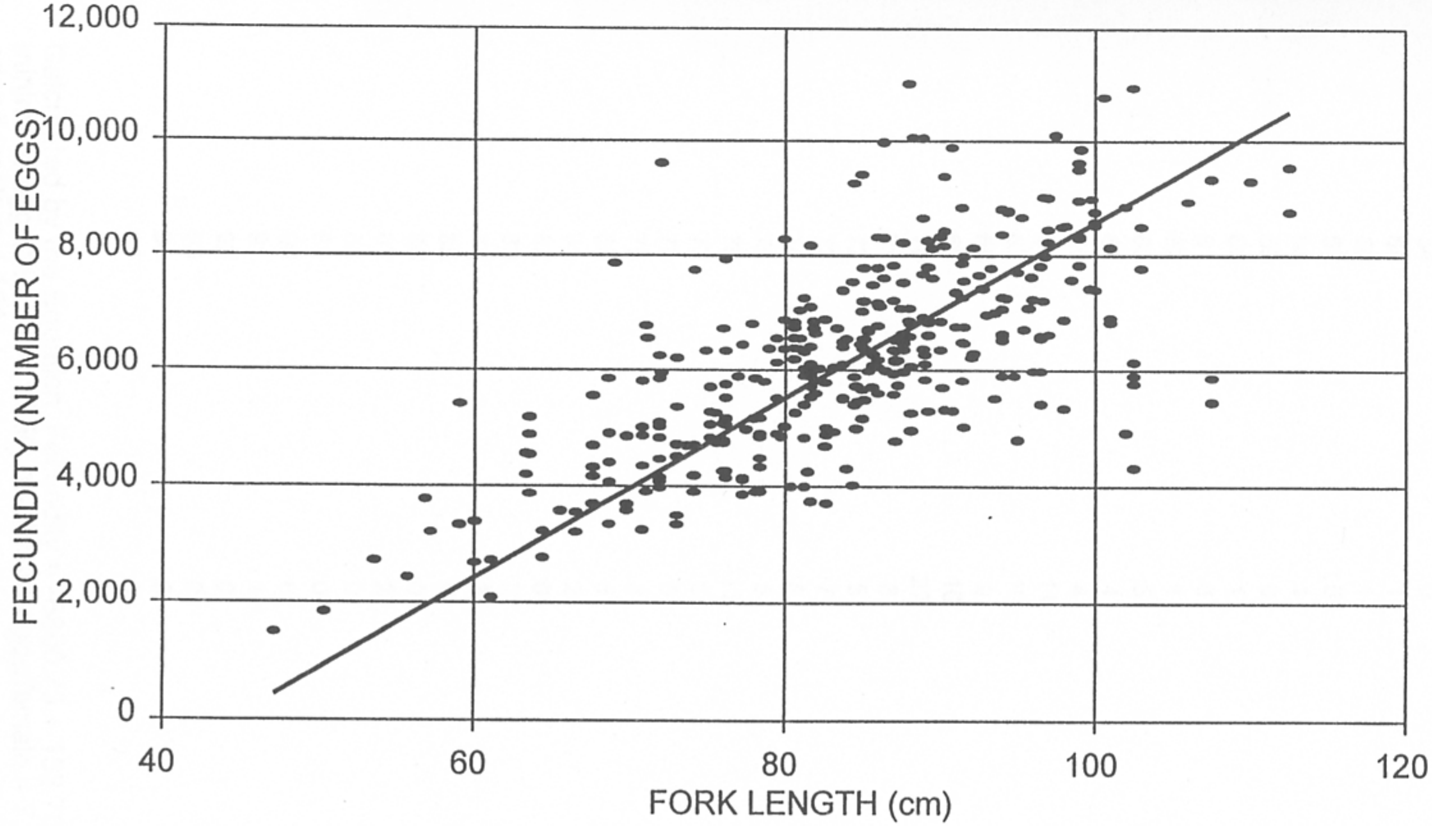


Figure 3. A geometric mean regression of number of eggs on fork length for chinook salmon from the Sacramento River drainage. Data from Hanson et al. (1940), McGregor (1923), Warner (1940), the Tehama-Colusa Fish Facility, and Coleman National Fish Hatchery.

7,193 eggs, with a weighted average of 4,161 eggs (Table 3). The fork lengths of the adult female spring-run chinook ranged from 53 cm and 91 cm. This is comparable to the fecundity of spring-run salmon taken at Baird Hatchery on the McCloud River using the number of females spawned and total egg take. Eggs-per-adult-female ranged from 3,400 to 5,000 and averaged 4,200 eggs (Table 4).

Table 3. Fork Lengths and Calculated Fecundity of Spring-run Chinook Salmon in Mill and Deer Creeks 1991 through 1996.

Fork Length (cm)	Frequency of Observance	Calculated Fecundity
53	1	1350
54	0	0
55	1	1657
56	1	1811
57	0	0
58	1	2119
59	0	0
60	1	2426
61	6	2580
62	1	2734
63	5	2887
64	4	3041
65	4	3195
66	11	3349
67	10	3503
68	9	3656
69	10	3810
70	27	3964
71	8	4118
72	5	4271
73	7	4425
74	8	4579
75	5	4733
76	13	4887
77	8	5040
78	5	5194
79	3	5348
80	5	5502
81	2	5655
82	0	0
83	2	5963
84	3	6117
85	4	6271
86	0	0
87	2	6578
88	0	0
89	0	0
90	0	0
91	1	7193
92	0	0
93	0	0
94	0	0
95	0	0

Calculated by the Equation: Fecundity = -6800.73 + 153.78 x fork length; minimum eggs/female = 1,350; maximum eggs/female = 7,193; weighted average eggs/female = 4,161.

Table 4. Spring-run Chinook Salmon Egg Records at Baird Hatchery

YEAR	EGGS	FEMALES	FECUNDITY
1877	6,008,500	1,460	4,115
1878	12,246,000	3,600	3,402
1879	6,889,859	1,620	4,253
1880	7,396,800	2,144	3,450
1881	7,270,000	1,729	4,205
1882	3,991,150	999	3,995
1883	940,750	287	3,278
1889	1,105,000	252	4,385
1891	3,026,000	678	4,463
1892	834,000	220	3,791
1894	3,294,300	816	4,037
1895	7,678,700	1,497	5,129
1896	5,196,700	1,063	4,889
1897	7,000,000	1,555	4,502
1898	13,445,810	2,878	4,672
1899	6,228,340	1,272	4,896
1900	2,021,000	520	3,887
1901	7,375,520	2,103	3,507
Total	**101,948,429**	**24,693**	**74,856**
			4,159 Mean Over Years

IV. HABITAT NECESSARY FOR SURVIVAL

Adult Migration

Freshwater habitat requirements of spring-run chinook salmon vary with age, life-history phase, and season of the year. Maturing adults are estimated to leave the ocean and begin their upstream migration through the Delta beginning in January. Adult entry into natal streams extends from mid-February through July. Throughout this upstream migration phase, adults require streamflows sufficient to provide olfactory and other orientation cues used to locate their natal streams. Adequate streamflows are also necessary to allow adult passage to upstream holding habitat. The preferred temperature range for spring-run chinook salmon upstream migration is 38°F to 56°F (Bell 1991).

Adult Holding

Habitat requirements for holding adults include: (1) pools sufficiently deep to allow adults to over-summer; (2) adequate cover, such as bubble curtains created by flowing water; (3) proximity to quality spawning gravel (USFWS 1995a); and (4) adequate water temperatures and dissolved oxygen.

Immature adult spring run reach their spawning habitat, then stage for several months before spawning. Adults require cold-water refuges such as deep pools to conserve energy for gamete production, redd construction, spawning, and redd guarding. The upper limit of the optimal temperature range for adults holding while eggs are maturing is 59°F to 60°F (Hinz 1959). Sustained water temperatures above 80.6°F are lethal to adults (Cramer and Hammack 1952).

Adults prefer to hold in deep pools with moderate water velocities and bedrock substrate and avoid cobble, gravel, sand, and especially silt substrate in pools (Sato and Moyle 1989). Optimal water velocities for adult chinook salmon range between 0.5-1.3 feet-per-second (Marcotte 1984). The pools usually have a large bubble curtain at the head, underwater rocky ledges, and shade cover throughout the day (Ekman 1987). The pools where adults over-summer are at least three to ten feet deep (G. Sato unpublished data, Marcotte 1984).

Adult Spawning

Spawning occurs in gravel beds that are often located at tails of holding pools (USFWS 1995a). Spring-run adults have been observed spawning in water depths of 0.8 feet or more, and water velocities from 1.2-3.5 feet-per-second (Puckett and Hinton 1974). Eggs are deposited within the gravel where incubation, hatching, and subsequent emergence takes place. Optimum substrate for embryos is a mixture of gravel and cobble with a mean diameter of one to four inches with less than 5% fines, which are less than or equal to 0.3 inches in diameter (Platts et al. 1979, Reiser and Bjornn 1979). The upper preferred water temperature for spawning adult chinook salmon is 55°F (Chambers 1956) to 57°F (Reiser and Bjornn 1979).

Egg and Larvae Incubation

Length of time required for the egg to develop and hatch is dependant on water temperature. The optimum temperature range for chinook salmon egg incubation is 44°F to 54°F (Rich 1997). Incubating eggs show reduced egg viability and increased mortality at temperatures greater than 58°F and show 100% mortality for temperatures greater than 63°F (Velson 1987). Velson (1987) and Beacham and Murray (1990) found that developing chinook salmon embryos exposed to water temperatures of 35°F or less before the eyed stage experienced 100% mortality.

From the time of egg fertilization a cumulative total of 1550 temperature units (the sum of the average daily temperatures minus 32) are required for an egg to hatch and fry to emerge (Armor 1991). Salmon eggs hatch in 50 days when incubated at 50°,F but require over 110 days at 40°F. After hatching, larval salmon remain in the gravel, living on yolk sac reserves.

The length of residency as yolk sac fry is also influenced by water temperature. Emergence and subsequent free living generally occurs after the yolk sac is absorbed.

Fry Emergence

The strong influence of water temperature greatly increases the variations observed in juvenile spring-run chinook salmon life-history patterns from different drainages. Calculated fry emergence time in Deer Creek for the period 1993-96 ranged from early January through late February (Table 5). Actual emergence times based on field surveys during this same period ranged from January through March (four to six months after spawning). Within Butte and Big Chico creeks, juvenile salmon first appear in late November, some three months after the onset of spawning.

Table 5. Actual Emergence of Fry in Deer Creek with the Calculated Emergence from First Observed Spawning Based on Temperature Units.

	Brood Year			
	1993	1994	1995	1996
Actual Emergence	Early March	Mid March	Early January	no fish observed
Calculated Emergence	Mid-February	Mid-February	Early January	Late January

Newly emerged fry congregate in shallow, low velocity edgewater, especially in areas where organic debris provides a background that makes juveniles difficult to see (Moyle unpublished data: as cited in USFWS 1995a). Juveniles prefer water velocities between 1-1.8 feet-per-second, depths greater than 0.9 feet, and gravel substrate for rearing (Bovee 1978). Optimal temperature conditions for fry are slightly higher than for eggs and larvae, from 50°F to 55°F (Boles et al. 1988, Rich 1997, Seymour 1956).

Juvenile Rearing and Emigration

Juvenile spring-run chinook salmon use natal tributary rearing habitat, the Sacramento River, nonnatal tributaries to the Sacramento River, and the Delta. Juveniles may exit their natal tributaries soon after emergence while some remain throughout the summer and exit the following fall as "yearlings" usually with the onset of storms starting in October. Yearling emigration from the tributaries may continue through the following March with peak movement usually occurring in November-December.

Juvenile spring run rear in nonnatal tributaries to the Sacramento River including the lower reaches of small, intermittent streams. Habitat requirements are the same as for natal tributaries and the mainstem Sacramento River. Juveniles have been located as far as five miles upstream in these tributaries and can remain for weeks until rearing habitat conditions deteriorate (spring flows diminish and water temperatures increase) (Maslin et al. 1997).

Habitat for juvenile rearing must provide adequate space, cover, and food supply. Fry use low velocity areas at the stream margin and where substrate irregularities and other instream habitat features create velocity breaks. As juveniles grow, they move away from the shoreline into higher velocity areas, especially for feeding. Optimal temperatures for fingerlings range between 55°F and 60°F. Dissolved oxygen levels greater than 7 mg/l are required (Rich 1997).

Suitable habitat includes abundant instream and overhead cover (e.g. undercut banks, submergent and emergent vegetation, logs, roots, other woody debris, and dense overhead vegetation) that provides refuge from predators. A sustained abundant supply of invertebrate forage production is required.

Emigration of juvenile salmon alternates between active movement, resting, and feeding. Thus, quality freshwater and brackish resting and feeding habitat is essential for migrating juveniles. Juvenile salmon may rear for up to several months within the Delta before ocean entry (Kjelson et al. 1981).

Juvenile rearing within the Sacramento-San Joaquin Bay-Delta Estuary occurs mostly in freshwater habitat. Juveniles typically do not move into brackish water until they have undergone smoltification (Kjelson et al. 1981, 1982). Sasaki (1966) found that chironomid larvae were important food items for juveniles in the upstream areas of the Delta, whereas *Neomysis* and *Corophium* were important in the lower Delta. Kjelson et. al. (1982) instead found Cladocera, Copepoda, and Diptera to be the most important food items for juveniles in both the upper and lower estuary.

Juveniles undergo physiological transformations (smoltification) that prepare them for the transition to saline water (Hoar 1976). These transformations include changed swimming behavior and proficiency, lower swimming stamina, and increased buoyancy that also make the fish more likely to be passively transported by currents (Saunders 1965, Folmar and Dickhoff 1980, Smith 1982). In general, smoltification is timed to be completed as fish are near the fresh water-salt water transition. Too long a migration delay after the process begins is believed to cause the fish to miss the "biological window" of optimal physiological condition for the transition (Walters et al. 1978). The optimal thermal range during smoltification and seaward migration is 50°F to 55°F (Rich 1997).

V. RANGE AND DISTRIBUTION

The following is a summary of information on historic and current range and distribution of spring-run chinook salmon in the Sacramento River system. For further information, Stone (1874), Clark (1929), and Yoshiyama et al. (1996) provide more detailed descriptions of the historic range and distribution of spring-run chinook salmon. These and numerous other accounts provide a detailed history of habitat destruction and modification throughout California's Central Valley which accounts for the present-day limits of the spring-run chinook salmon's remnant range and distribution.

Historic Range and Distribution

Spring-run chinook salmon populations once occupied the headwaters of all major river systems in California's Central Valley where natural barriers were absent (Figure 4) (Clark 1929, Yoshiyama et al. 1996).

Clark (1929) estimated that originally there were 6,000 miles of salmon habitat in the Central Valley system and that 80% of this habitat had been lost by 1928. Much of this was spring-run headwater habitat. Yoshiyama et al. (1996) calculates roughly 2,000 miles of salmon habitat were actually available before dam construction and mining, but concludes that 82% of what was there is lost today. Clark (1929) did not give details about his calculation. Whether Clark's or Yoshiyama's calculation is used, little remains today of the former spring-run habitat.

Sacramento River and Tributaries above Shasta Dam

Spring-run chinook salmon once ascended the Sacramento River to its headwaters and tributaries (the Pit, McCloud, and Little Sacramento rivers) where chinook salmon habitat conditions were characterized as "ideal" by Clark (1929). Spring-run salmon spawning habitat was spatially isolated from fall-run chinook, although there was some overlap in spawning time. Isolation from winter run was due to different spawning times (Hallock and Fisher 1985).

Upper (Little) Sacramento River: Stone (1874) observed spring run at upper Soda Springs which is above the falls at Sims. Once past these falls, spring run would have been able to migrate upstream as far as the present-day Box Canyon Dam near the town of Mount Shasta (Yoshiyama et al. 1996).

McCloud River: Spring run could have ascended the McCloud River as far as Lower Falls, but probably stopped at Big Springs (Wales 1939). Big Springs provided one-half of the flow as measured at the mouth of the McCloud River. Flows between Lower Falls and Big Springs would have been adequate for adults to over-summer in low water-years (Yoshiyama et al. 1996).

Pit River: Spring run were able to ascend Pit River Falls and migrate to the Fall River (Yoshiyama et al. 1996). Spring run used Hat Creek and Kosk Creek and one mile of Burney Creek.

Sacramento River and Tributaries Below Shasta Dam

Historically spring-run chinook salmon did not use the mainstem Sacramento River below the site of Shasta Dam, except as a migratory route to and from headwater streams.

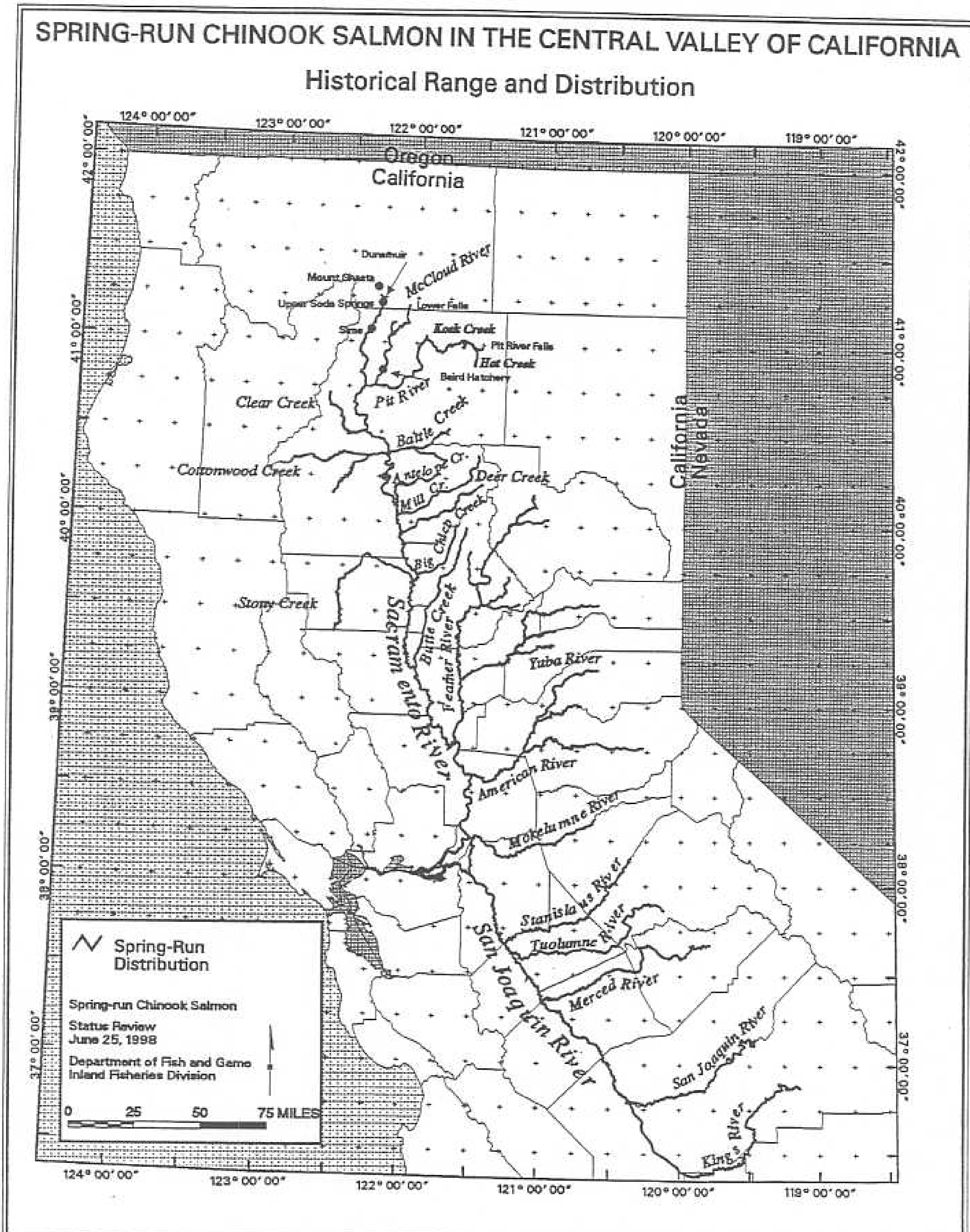


Figure 4. Historic range and distribution of spring-run chinook salmon in the Central Valley of California.

Clear Creek: Spring-run chinook could have historically migrated to the uppermost reaches of Clear Creek above the town of French Gulch (Figure 5) (Yoshiyama et al. 1996). Although there is no documentation of spring run being in this area, spring run would have had to migrate to this elevation to find water cool enough to over-summer. In 1956, Azevedo and Parkhurst (1958) saw spring run in Clear Creek for the first time since 1949. Passage to the upper watershed was severely impaired by the construction of McCormick-Saeltzer Dam around the turn of the century, then permanently blocked by the construction of Whiskeytown Dam in 1964.

Cottonwood Creek: Spring run are known to have migrated to the headwaters of the Middle Fork and into Beegum Creek and South Fork above Maple Gulch (Figure 6). Yoshiyama et al. (1996) and Hanson et al. (1940) did not mention salmon using the North Fork. Even in the 1940s, Cottonwood Creek was noted as having poor habitat conditions with the exception of Beegum Creek (Hanson et al. 1940).

Battle Creek: Spring run were thought to have used the North Fork up to near the town of Manton and the South Fork to a falls near the Highway 36 crossing (Figure 7) (Hanson et al. 1940). Starting in 1900, Pacific Gas and Electric (PG&E) built a series of dams and power plants on Battle Creek. Clark (1929) indicated that some of the ladders at these facilities were inoperable at low flows and that sections of the stream were dewatered.

Antelope Creek: Historically, spring run were thought to ascend the North and South Forks to the vicinity of the Ponderosa Road crossings (Figure 8) (Yoshiyama et al. 1996), although there is no documentation of this. Spring run were observed as far upstream as McClure Place on the North Fork and reported as far upstream as Buck's Flat on the South Fork (Hayes and Lingquist 1966).

Mill Creek: The historic range and distribution of spring-run chinook salmon in Mill Creek is the same as it is today (Figure 9). Adults migrate upstream and hold in a 20-mile reach from approximately the Lassen National Park boundary downstream to the confluence of Little Mill Creek.

Deer Creek: The historic range and distribution of spring-run chinook salmon in Deer Creek was less than it is today (Figure 10). Fish held in a 16-mile reach from Dillon Cove upstream to Lower Deer Creek Falls. In 1943, a fish ladder was constructed around the falls, providing access to an additional six miles of adult holding and spawning habitat.

Stony Creek: Historically, spawning runs of fall- and spring-run chinook salmon occurred in the Stony Creek watershed above the present dams and the reservoirs to the confluence of Stony Creek and Little Stony Creek, approximately five miles below the town of Stonyford (Clark 1929, Yoshiyama et al. 1996).

Big Chico Creek: Historic spring-run habitat within the creek extended beyond Iron Canyon (Figure 11) (CDFG 1958). Access was blocked by large boulders dislodged during the 1906 earthquake and was restored in 1958 with the construction of a series of small fish ladders. The holding area is in the reach upstream of Iron Canyon to Higgins Hole. Higgins Hole is the primary adult holding area. Under certain water flows, fish were able to ascend Higgins Hole falls and proceed upstream approximately 1.5-2 miles until encountering an impassable barrier (White 1958).

Butte Creek: Clark (1929) provides the only known early record of the range of spring run in Butte Creek, although he probably incorrectly refers to them as fall run. Various sources

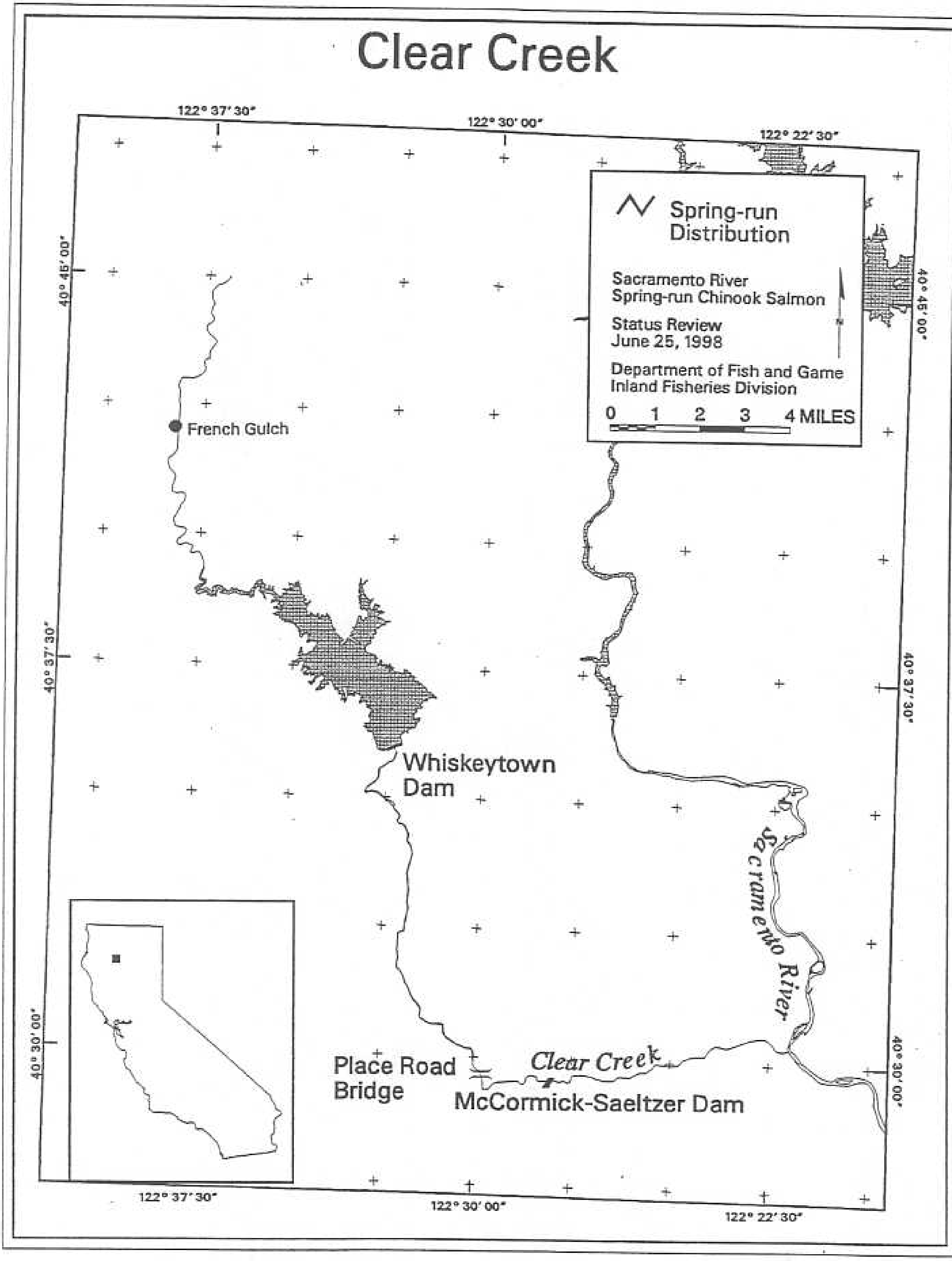


Figure 5. Clear Creek, California.

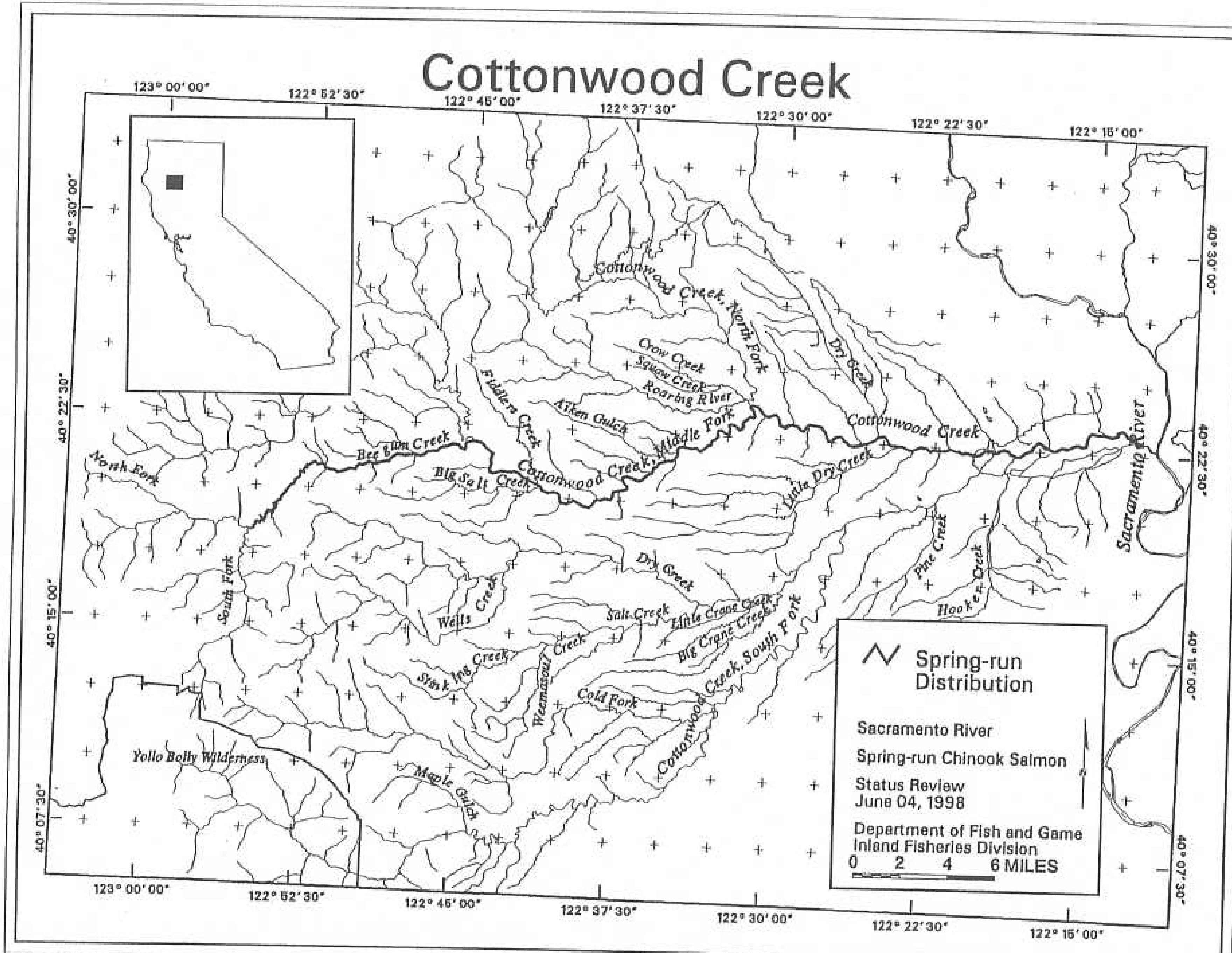


Figure 6. Cottonwood Creek, California.

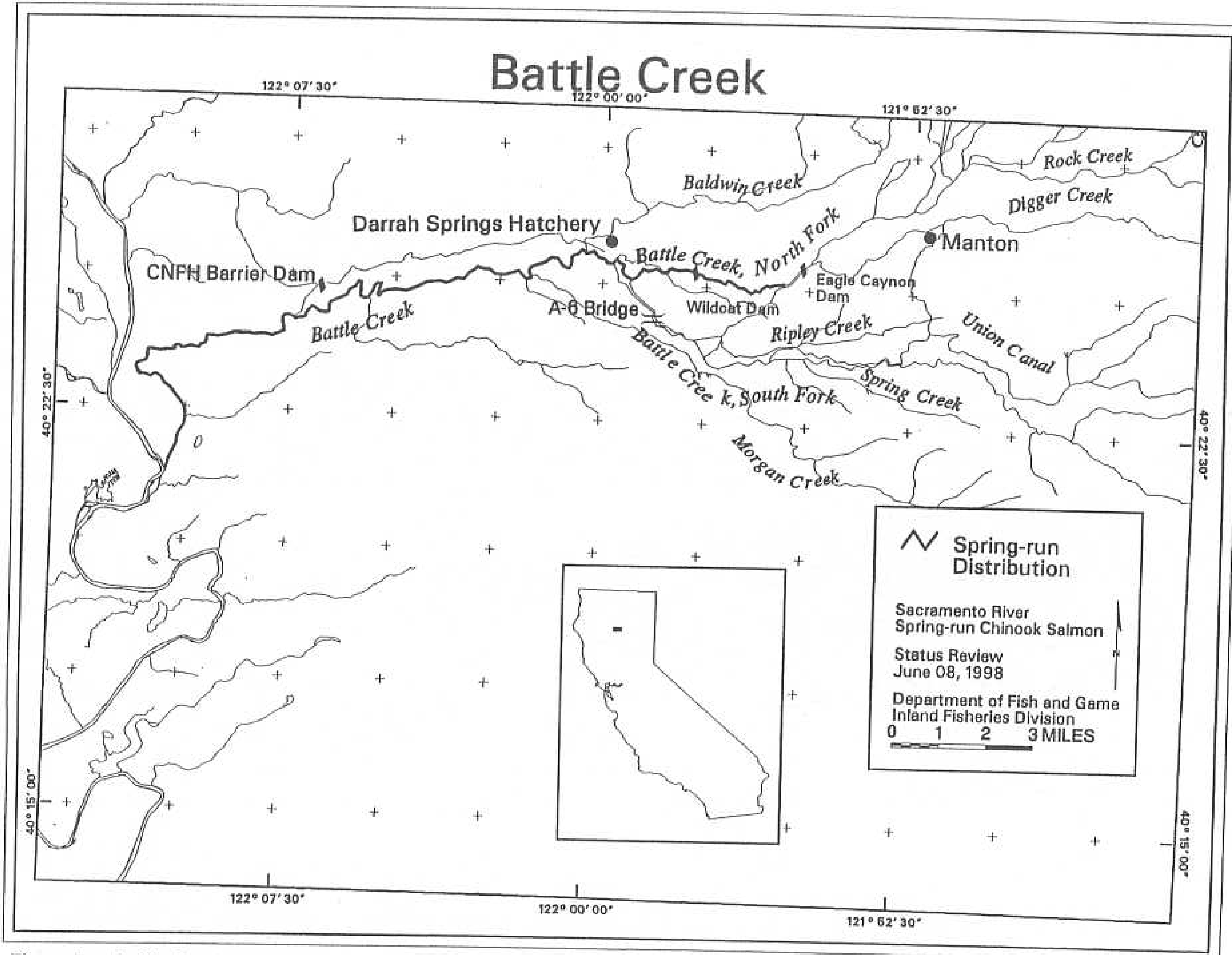


Figure 7. Battle Creek, California.

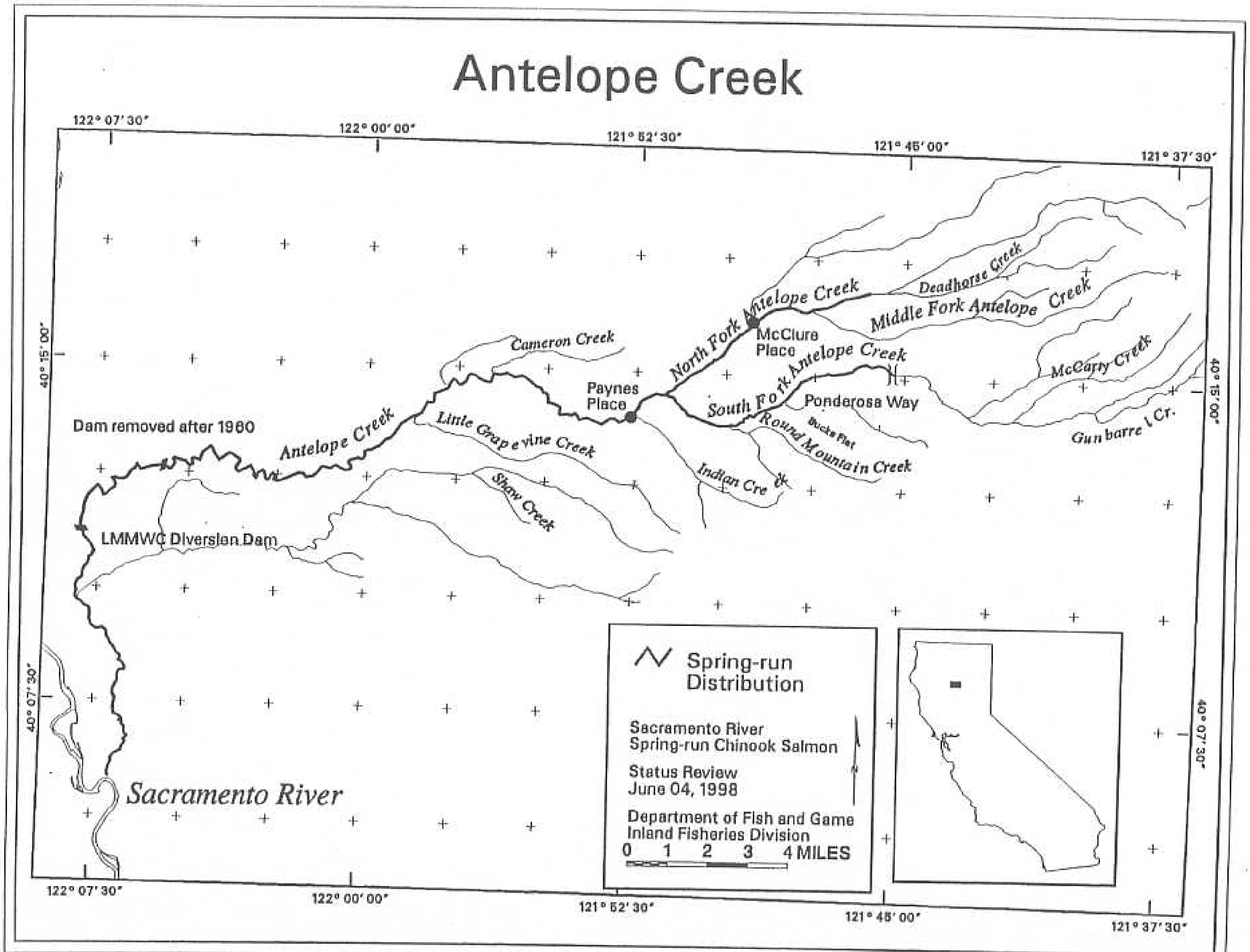


Figure 8. Antelope Creek, California.

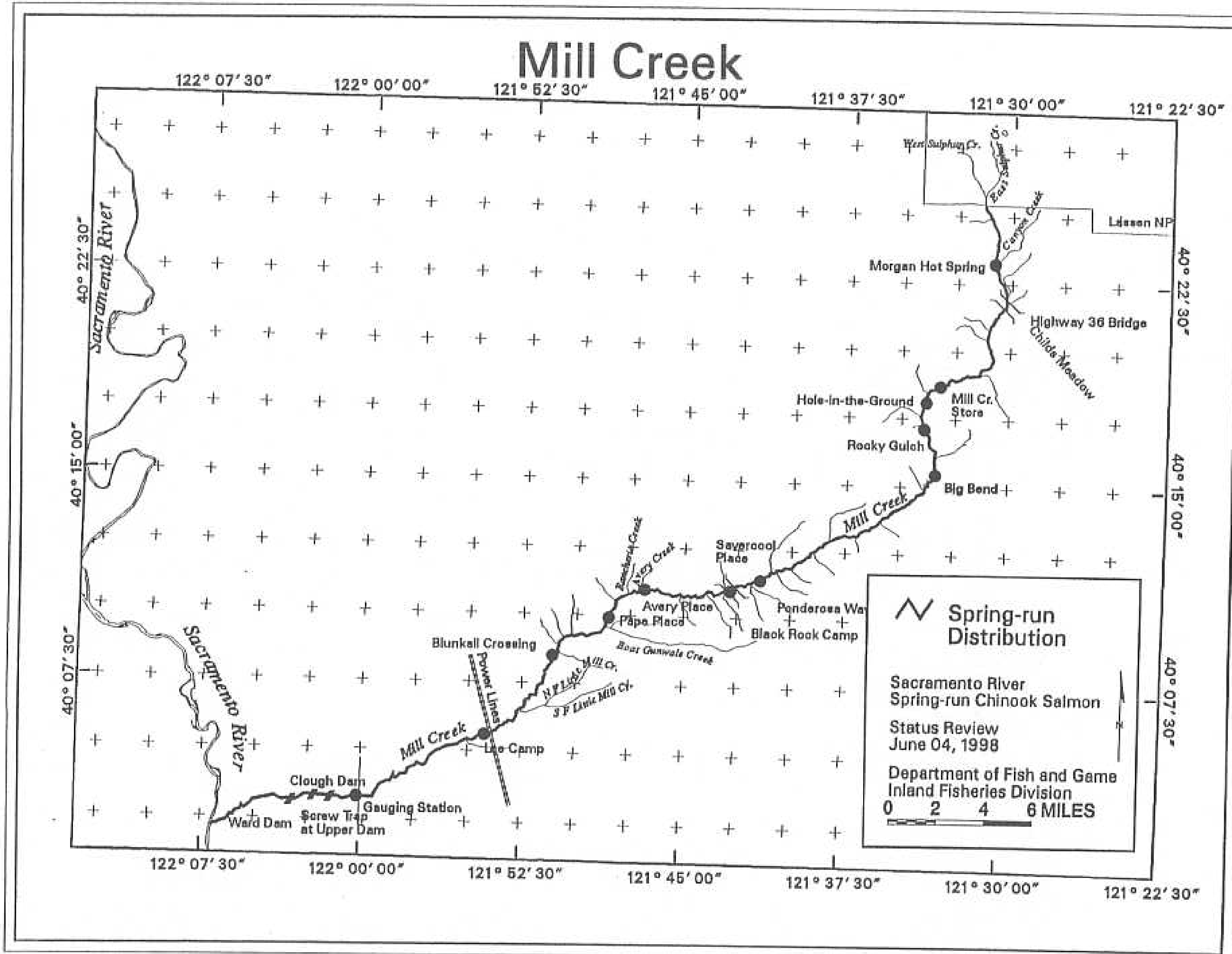


Figure 9. Mill Creek, California.

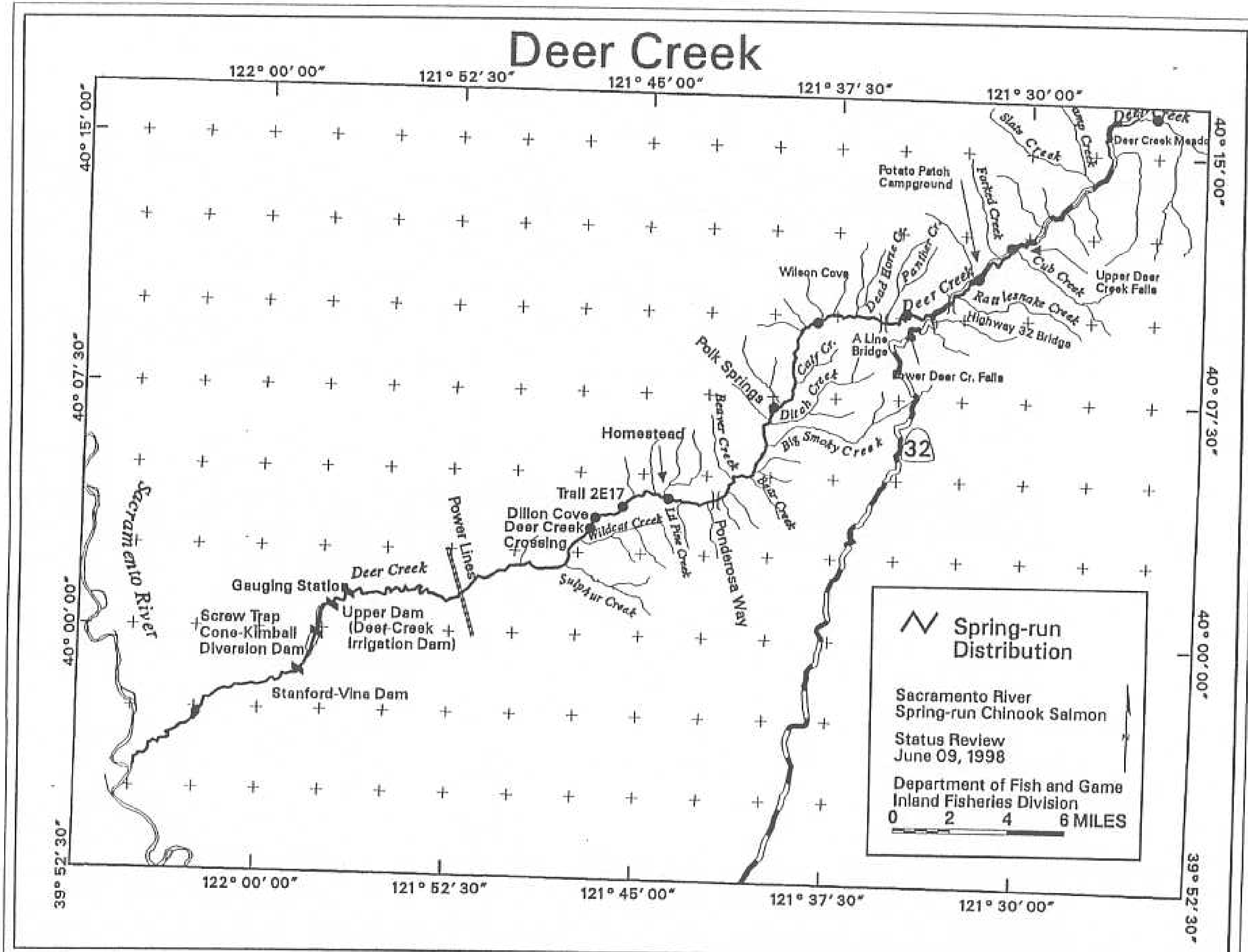


Figure 10. Deer Creek, California.

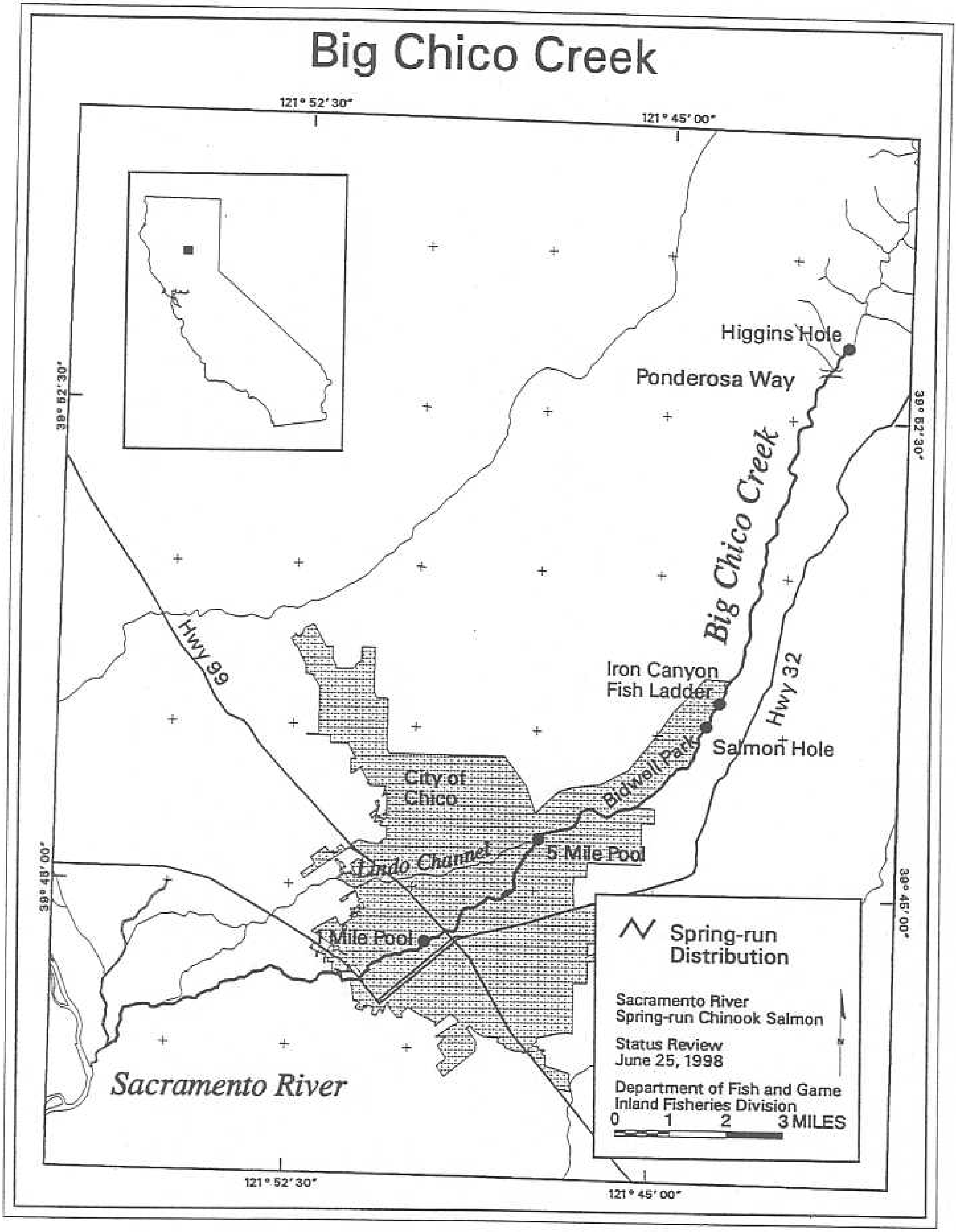


Figure 11. Big Chico Creek, California.

suggest that salmon and steelhead may have reached Butte Meadows (Figure 12). However, a recent review suggests that the upper limit for spring-run salmon was most likely in the vicinity of PG&E's Centerville Head Dam (Holtgrieve and Holtgrieve 1995). Holtgrieve and Holtgrieve referenced observations by a local resident that there were thousands of salmon in the Quartz Bowl, a large pool about one-half mile above Chimney Rock, which had a 15-foot high barrier that was the upper limit of distribution. The barrier was dynamited sometime in the 1930s, which allowed passage to the Centerville Head Dam. The field survey by Holtgrieve and Holtgrieve (1995) found additional impassable natural barriers just upstream of the Centerville Head Dam, further substantiating the conclusion that spring-run salmon probably did not exist in the reach above the Head Dam, and certainly did not migrate as far as Butte Meadows.

Feather River: Spring-run salmon were reported to have ascended to the very highest streams and headwaters of the Feather River watershed (Figure 13) prior to the construction of the various hydropower dams and diversions (Clark 1929). Spring run were reported to have occurred in the West Branch at least to the site of Stirling City, and the North Fork through the present-day site of Lake Almanor into various tributaries, including the Hamilton Branch. Additionally, spring run were known to have ascended Indian Creek, a tributary of the East Branch of the North Fork, and reportedly Yellow and Spanish creeks, two other tributaries of the North Fork. In the Middle Fork, spring-run salmon were reported to have occurred as far as the natural barrier falls at Bald Rock, and potentially to Feather Falls located on Fall River, a tributary to the Middle Fork. Spring run may have ascended to the vicinity of Forbestown on the South Fork (Yoshiyama et al. 1996). Between the installation of the small hydropower dams and the construction of Oroville Dam, naturally occurring spring run in the Feather River were described as primarily spawning in the Middle Fork, although small numbers of fish were occasionally found in the North Fork (Hanson et al. 1940).

Between the time of the installation of the early hydropower diversions and Oroville Dam, spring run were restricted to areas which were also within the range of fall-run chinook salmon, particularly the North Fork and the Middle Fork. Comments included in the Department's annual chinook salmon spawning stock surveys as early as 1958 (CDFG 1959), prior to construction of Oroville Dam, indicated that fall- and spring-run spawners were often not separated, even in the Middle Fork.

Yuba River. Spring run historically occurred in the Yuba River, which is the largest tributary to the Feather River (Figure 14). In the North Fork, salmon were caught by PG&E workers in the Bullards Bar area in 1898-1911 (Coleman 1952: as cited in Yoshiyama et al. 1996). There are no barriers above the Bullards Bar area, and salmon were presumably able to ascend a considerable distance up the North Fork (Yoshiyama et al. 1996). The California Fish Commission (1875: as cited in Yoshiyama et al. 1996) indicated that in 1850 and 1851, large numbers of salmon were taken by miners and Native Americans as far upstream as Downieville on the North Fork Yuba River. There are no natural barriers from Downieville upstream to Sierra City, where Salmon Creek enters. Thus, salmon were most likely able to ascend this reach of the river (Yoshiyama et al. 1996). Except for a 10-foot falls in the lower reach of the Middle Fork Yuba River, there are no significant natural barriers and salmon would have had access to a considerable reach of the Middle Fork (Yoshiyama et al. 1996). Salmon were observed in the lower reach of the Middle Fork during a Department survey in 1938 (CDFG unpublished data). Little is known of the original distribution of salmon in the South Fork.

Salmon were observed within one to two miles upstream of the mouth of the South Fork (CDFG unpublished data). A cascade with a 12-foot drop below the juncture of Humbug Creek may have posed a significant obstruction, but was not a complete barrier (Stanley and Holbek 1984:

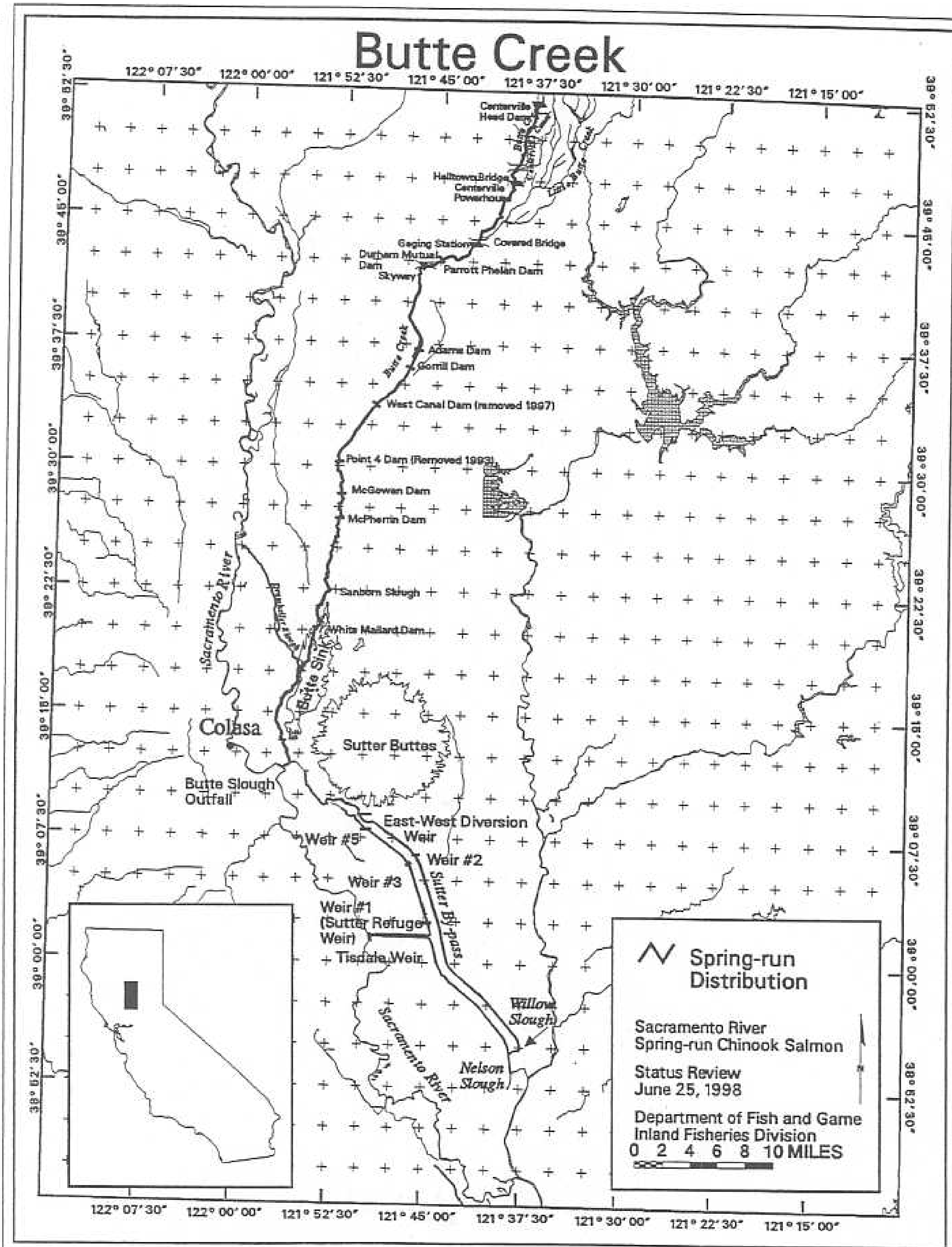


Figure 12. Butte Creek, California.

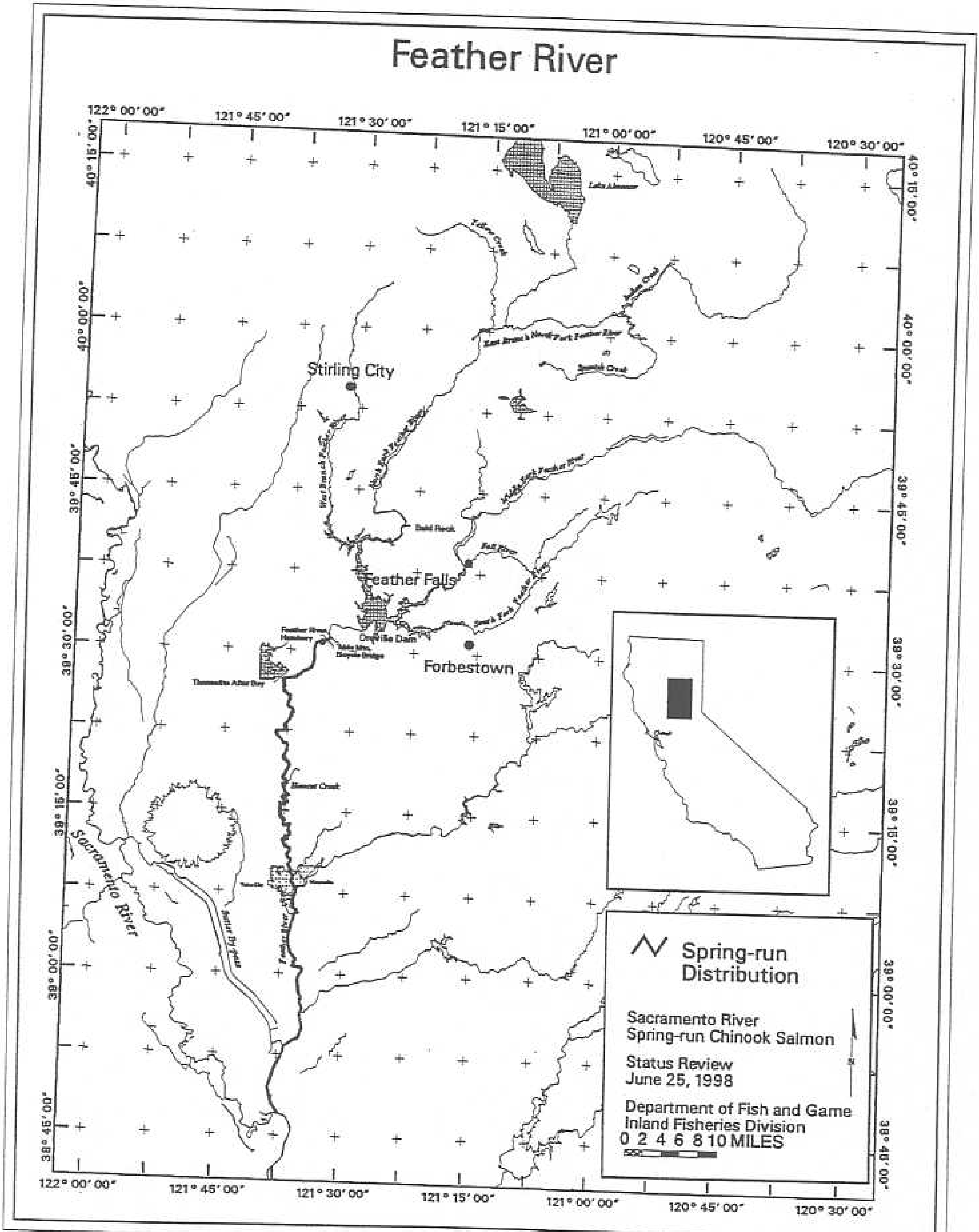


Figure 13. Feather River, California.

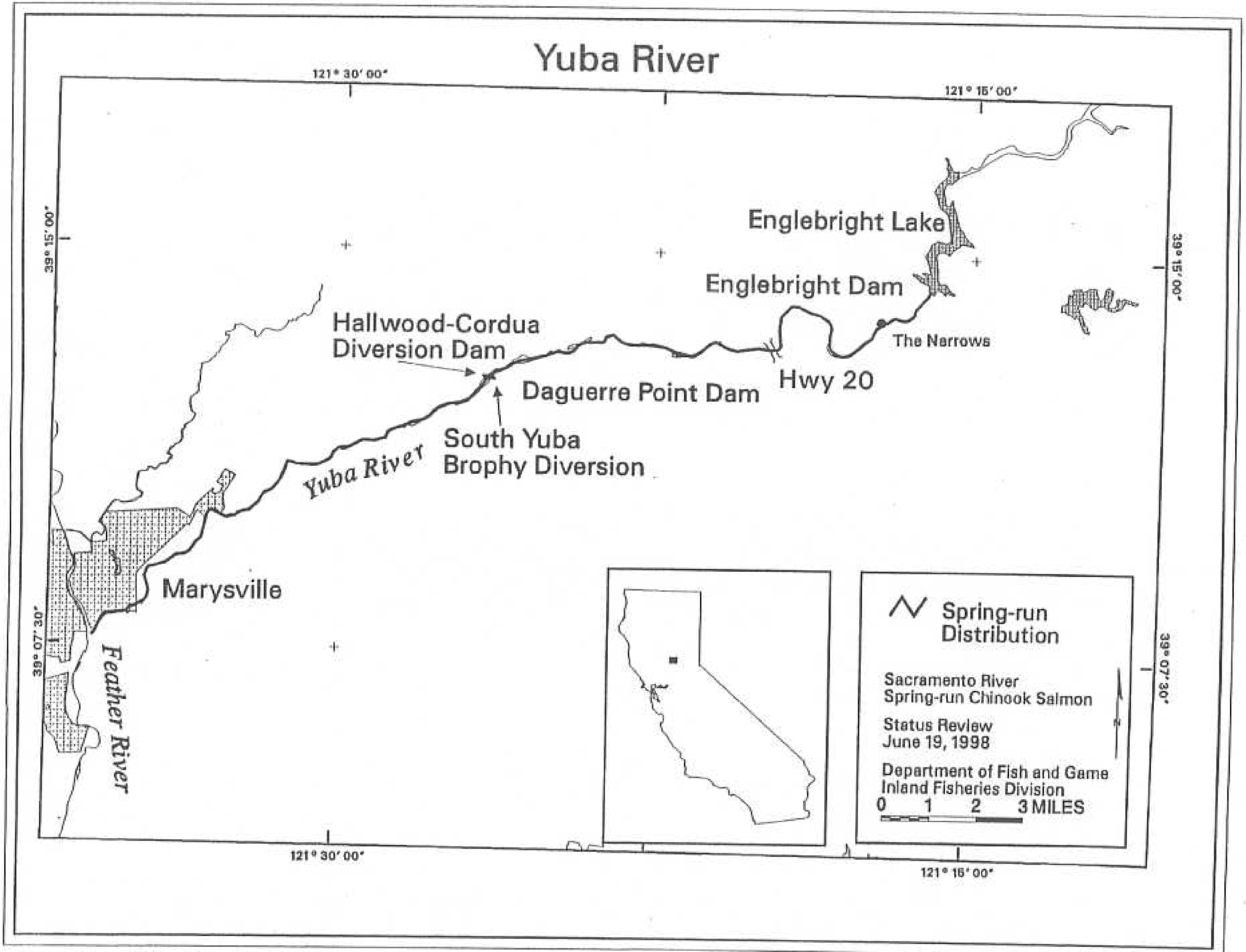


Figure 14. Yuba River, California.

as cited in Yoshiyama et al. 1996). Steelhead were known to have ascended above this area and as far up the South Fork as Poorman Creek near the town of Washington (CDFG unpublished data). Salmon have ascended similar cascading falls on other streams.

Blockage of spring run to their historic range occurred with the construction of Barrier No. 1 Debris Dam in 1904-05 until it was destroyed by floods in 1907. Daguerre Point Dam was completed in 1906. Fish ladders were installed at the dam which were ineffective except during high flows. These ladders were destroyed in the floods of 1927-28 and were not rebuilt until 1938. They were generally ineffective in passing fish. In 1941, Englebright Dam was constructed approximately 12 miles upstream from Daguerre Point Dam. The ladders over Daguerre Point Dam were modified in 1950, allowing substantial passage of salmon. However, Englebright Dam still blocked passage to their historic adult holding and spawning habitat.

American River: Spring run ascended the North Fork at least to Mumford Bar (Beals 1933: as cited in Yoshiyama et al. 1996). Spring run were able to ascend the Middle Fork to its confluence with the Rubicon River and the South Fork to Eagle Rock about 12 miles downstream the from village of Strawberry. Following years of problems with ineffective or absent fish ladders at the historic Folsom Dam, upstream access was completely blocked when the new, present-day Folsom and Nimbus dams were constructed. Spring run no longer exist in the American River.

***Mokelumne River*:** Before the construction of Pardee Dam in 1929, spring run were thought to have migrated to the site of the Electra Powerhouse (Yoshiyama et al. 1996). Spring run no longer exist in the Mokelumne River.

***Stanislaus River*:** An account by Yoshiyama et al. (1996) places spring run in the Stanislaus River historically. Spring run may have ascended the North Fork to the confluence of Griswold Creek. Salmon were thought to ascend the Middle Fork to the site of Beardsley Reservoir. Salmon were not thought to inhabit the South Fork. Spring run no longer exist in the Stanislaus River.

***Tuolumne River*:** Spring run were thought to ascend the Tuolumne River to Preston Falls near the Yosemite National Park boundary, approximately 50 miles upstream of New Don Pedro Dam (Yoshiyama et al. 1996). The Clavey River, the South Fork, and Middle Fork have obstructions a short distance upstream of their confluences and are not thought to have contained salmon (Ford: as cited in Yoshiyama et al. 1996). Spring run no longer exist in the Tuolumne River.

***Merced River*:** Spring run may have ascended the Merced River near El Portal (Yoshiyama et al. 1996). Yoshiyama et al. (1996) give an account that spring run probably never reached Yosemite Valley. Salmon were thought to enter the South Fork to the vicinity of Peach Tree Bar where there is a falls (Bartholomew: as cited in Yoshiyama et al. 1996). The North Fork probably did not contain many salmon because of its low elevation and a falls one mile upstream of the mouth which prevented migration of salmon (Vestal: as cited in Yoshiyama et al. 1996). Spring run no longer exist in the Merced River.

San Joaquin River: Yoshiyama et al. (1996) indicate spring run may have migrated to a point immediately below Mammoth Pool Reservoir, although an obstruction near Redinger Lake may have been a barrier to spring run (Vestal: as cited in Yoshiyama et al. 1996). Vestal indicated that salmon migrated up Fine Gold Creek approximately six miles and up Cottonwood Creek at least two miles. There is evidence that spring run used Willow Creek, but it is not known how far they ascended. Spring run no longer exist in the San Joaquin River.

***Kings River*:** There is strong evidence that spring-run chinook salmon occurred in the Kings River even though the Kings River is not part of the San Joaquin drainage. The Kings River once flowed into Tulare Lake, which in wet years flowed into the San Joaquin River. The following is from Yoshiyama et al. (1996). Most of the salmon migration occurred as far upstream as the North Fork, about 12 miles above the present extent of Pine Flat Reservoir. Some salmon may have reached Cedar Grove approximately 28 miles above Pine Flat Reservoir. The North Fork Kings River is very steep a short distance above its mouth and probably did not support very many fish (Bartholomew: as cited in Yoshiyama et al. 1996). Spring run no longer exist in the Kings River.

Present Range and Distribution

Most of the former spring-run habitat has been eliminated by water development and dams that prevent adult access to headwater areas. Present range and distribution is restricted to the Sacramento River below Keswick Dam and some of its tributaries (Figure 15). Spring-run chinook salmon no longer exist in the San Joaquin River or any of its tributaries, nor in the American River. Mill, Deer, and Butte creeks consistently support spawning populations of spring-run chinook salmon. Several other tributaries occasionally have spring run present or have recently supported small numbers of them. These tributaries include Big Chico, Antelope, and Beegum creeks. There may be some spring run in the Feather River, but these fish, for the most part, have hybridized with fall run. A counting station, operated on Battle Creek in 1995, 1996, and 1997, estimated a run of 50 to 100 salmon was present. The status of spring run in the Yuba River is largely unknown, but a few spring run may persist. A small population of spring-run salmon may persist in the upper Sacramento River above RBDD although there is question as to the genetic integrity of these fish.

Sacramento River and tributaries below Shasta Dam

Sacramento River mainstem: Some spring-run chinook salmon may persist between RBDD and Keswick Dam in the Sacramento River, although there is evidence that a portion of the spring run estimated to have passed upstream of RBDD are hybrids of spring run and fall run (Figure 16). The physical environment below Keswick Dam is adequate for spring run; however in some years high water temperature would prevent egg and embryo survival (USFWS 1990). Even though there is physical habitat available to spring run, spring run depend on spatial isolation to prevent competition and hybridization with fall run. The onset of fall-run spawning occurs simultaneously with the termination of spring-run spawning. This overlap in spawning periods may be evidence of introgression already occurring between the two runs. Also, since fall run use the same spawning riffles as spring run, later spawners may be displacing the redds of earlier spawners during nest construction. Under the current conditions in the Sacramento River, it appears that spring run are not thriving. Redd surveys of the spawning habitat in the mainstem have found little spawning in August or September when spring-run salmon historically spawned (Table 6). The spring run that was observed by Moffett (1947) and to some extent Slater (1963) is, for the most part, no longer found.

Clear Creek: There are no spring run currently in Clear Creek (Figure 5). Habitat in Clear Creek has the potential to support spring run if passage problems at McCormick-Saeltzer Dam are corrected so that adults can ascend to habitat below Whiskeytown Dam. Operation of Whiskeytown Dam can produce suitable cold-water habitat downstream to Placer Road Bridge, depending on the flow releases.

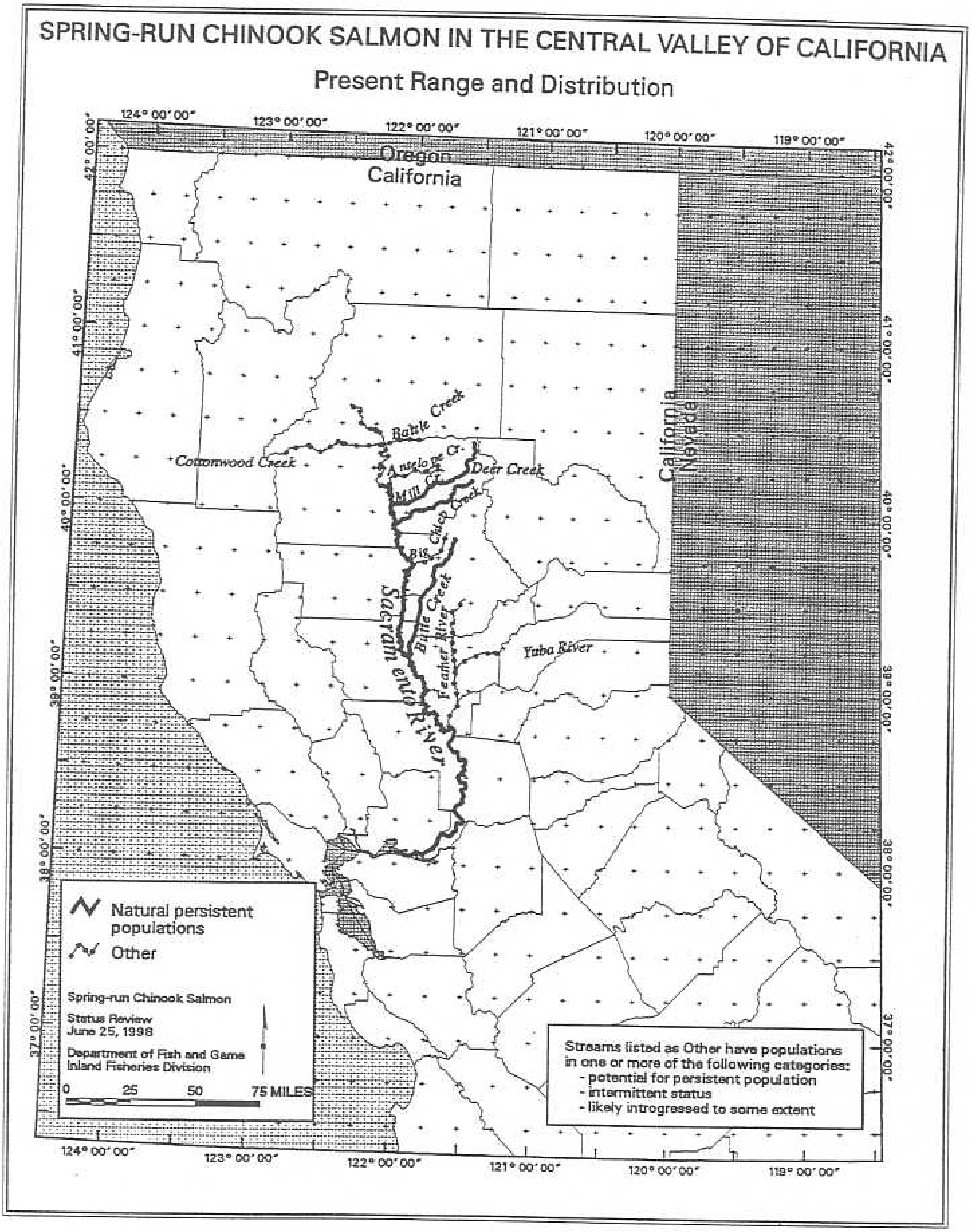


Figure 15. Present range and distribution of spring-run chinook salmon in the Central Valley of California.

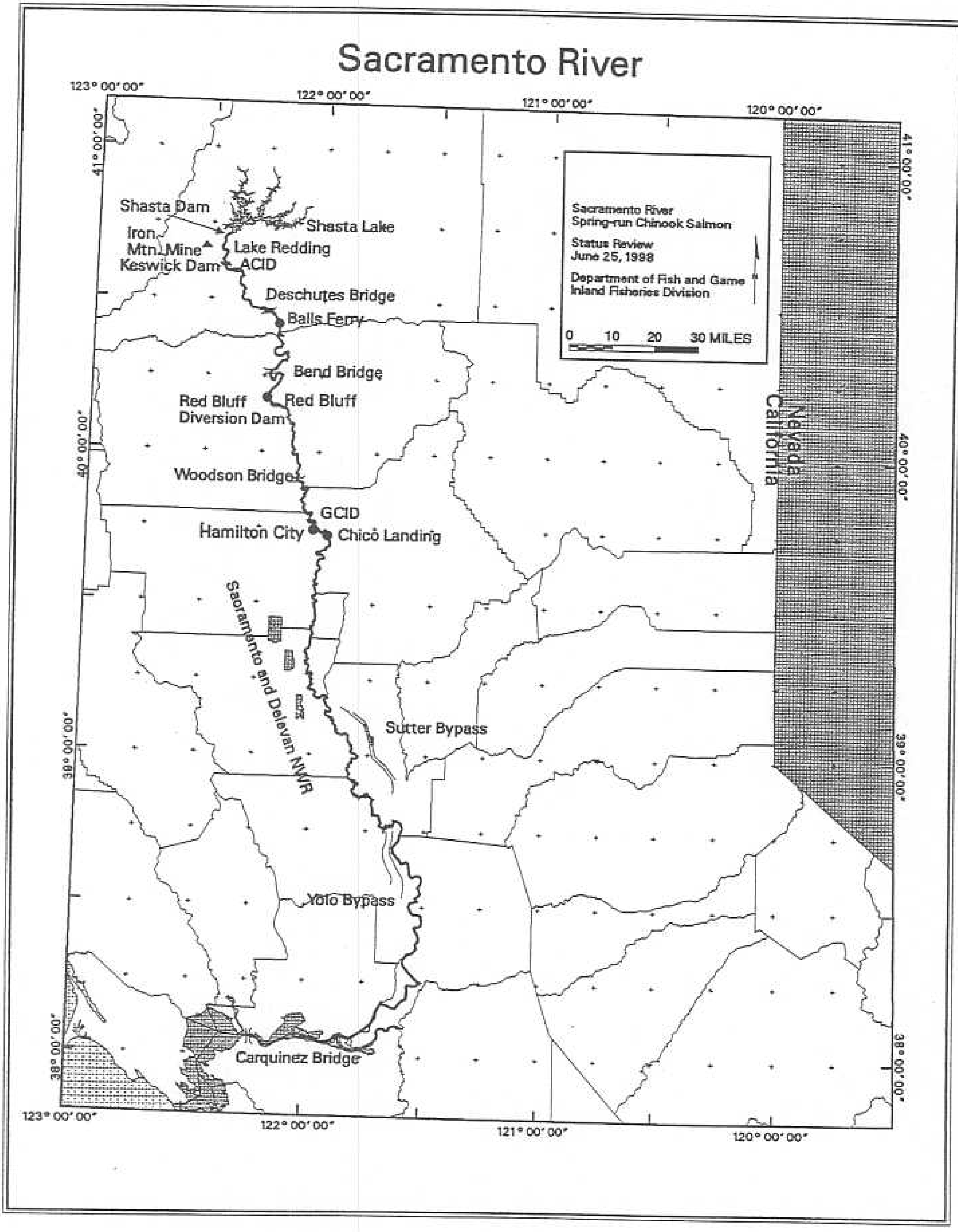


Figure 16. The Sacramento River, California.

Table 6. Redds Counted Using Aircraft from 1983 through 1997. Reach Surveyed Principally from Red Bluff Diversion Dam to Keswick Dam. Each Count Represents Fresh Redds. Blank Cells Indicate No Survey Conducted. Zero Indicates a Survey Was Done But No Fresh Redds Observed. The August and Early September Spawning of Spring-run Chinook Salmon Noted by Livingston Stone is Sparse to Absent.

	NUMBER OF REDDS OBSERVED														
Week	1983	1985	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
13 Aug													0	0	
20 Aug	20												1		0
27 Aug						2							0		0
3 Sep												0	0	0	
10 Sep			14				4	0	3	4	1		0		26
17 Sep	33	15											6		74
24 Sep						149		11				67	4	39	151
1 Oct	186				154	545	97	27	11	176	87		15	159	
8 Oct				213	639	1352	550	312				2076			
15 Oct					1479	4918	1322			776	761		745		
22 Oct	965	1246	1978	1054	2916	4866		1167				2948		875	
29 Oct						5872	2112	2262			1381	3475	2556	2005	2274
5 Nov			2282	2023						1018					
12 Nov				2083	4528			2513			1747				
17 Nov			3085				1297					2495	1382		
24 Nov					5378			1006	111	1068					

Cottonwood Creek: The Cottonwood Creek drainage still supports a few spring run (Figure 6). However, in recent years salmon have been observed only in Beegum Creek. In 1995, eight spring-run salmon were observed and in 1996 six salmon were observed. No fish were observed in the South Fork.

Battle Creek: Currently the most suitable spring run holding and spawning habitat is restricted to the North Fork between Wildcat Diversion upstream to Eagle Canyon Dam, a distance of approximately three miles. Holding adult spring run have been observed in the mainstem of Battle Creek below the confluence of the North Fork (Figure 7) (Croci 1996) . The CNFH Fish Barrier Dam has a functioning fish ladder that is left open April through June, the principal spring-run migration period. In addition, the barrier dam becomes partially passable when flows exceed approximately 350 cubic-feet-per-second (cfs) (USFWS 1995b). There is risk of hybridization with fall run in this reach if flows are high enough to pass fall run. However, hybridization is minimized by keeping the hatchery barrier dam closed during the fall-run migration period (July to December).

Antelope Creek: Spring run are thought to ascend the North and South forks to the vicinity of the Ponderosa Road crossings, as they did historically (Figure 8). Habitat surveys and water temperature monitoring have identified only eight miles of Antelope Creek as having suitable holding and spawning habitat for spring run: (1) in the North Fork from McClure Place to the South Fork confluence; (2) in the South Fork from Round Mountain Creek to the North Fork confluence; and (3) in the mainstem from the North and South Fork confluence to two miles below Payne Place. During the years 1989-97, adult population counts have been made during the month of July in the adult holding areas. Counts range from a low of zero in 1991, 1992, and 1994 to a high of seven fish in 1995.

Mill Creek: The present range and distribution of spring-run chinook salmon in Mill Creek is the same as it was historically (Figure 9). Adults migrate upstream and hold in a 20-mile reach from the Lassen National Park boundary downstream to the confluence of Little Mill Creek.

Deer Creek: The present range of spring run has been extended beyond the historic range (Figure 10). In 1943, a fish ladder was constructed around the Lower Deer Creek Falls, which opened up an additional six miles of spring-run chinook salmon holding and spawning habitat. The present habitat is a 22-mile reach of stream extending from Dillon Cove upstream to Upper Deer Creek Falls. Approximately 20% of the spawning now takes place in the six mile extension. Although a fish ladder was also constructed around Upper Deer Creek Falls, the ladder is managed to allow steelhead passage around the falls, but not spring-run chinook salmon passage. This is because the habitat lacks large holding pools and would not sustain a large population of holding salmon.

Stony Creek: Stony Creek no longer has spring-run chinook salmon. Upstream passage of adults to the upper watershed was blocked by Stony Gorge Dam.

Big Chico Creek: The present range of spring-run chinook salmon in Big Chico Creek does not differ substantially from its historic range, although access to this habitat is currently provided under most flow conditions by a fish ladder located in Iron Canyon east of Chico (Figure 11). Blockage of the historic habitat above Iron Canyon was believed to have occurred in 1906 as a result of the San Francisco earthquake (CDFG 1958). The primary holding area is in the reach upstream of Iron Canyon to Higgins Hole, with most fish holding in Higgins Hole. Under certain water flows, fish were able to ascend Higgins Hole Falls and proceed upstream approximately

1.5-2 miles until encountering an impassable barrier (White 1958), although there is no recent observation of any fish ascending above Higgins Hole.

Butte Creek: The present range of spring-run chinook salmon in Butte Creek does not differ substantially from its historic range and is limited to the reach below the PG&E Centerville Head Dam to as far downstream as the Parrott-Phelan Diversion (Figure 12) (Holtgrieve and Holtgrieve 1995).

Feather River: Since the construction of Oroville Dam, spring-run salmon are now restricted to the area downstream of the fish barrier dam near Oroville, and essentially all are taken into FRH (Figure 13). Based on an assessment of FRH operations, the population within the Feather River, while still called a spring run, is considered a hybrid of spring- and fall-run populations (Brown and Greene 1993). Coded-wire-tagging (CWTing) of spring- and fall-run salmon at FRH (Tables 7 and 8) indicates that in some years, more than 20% of the fish tagged as spring run were subsequently identified as adults from fall-run and visa versa. A further discussion regarding effects of hatchery operations can be found in this report's discussion of competition and hybridization.

Table 7. The Disposition of Chinook Salmon Spawned, Tagged, and Released as Spring-run Salmon from Feather River Fish Hatchery. Shaded Cells Indicate Years When >20% of Returning Progeny from Adults Originally Spawned as Spring-run were Subsequently Spawned as Fall-run.

Year	Number of progeny subsequently spawned as fall-run	Number of progeny subsequently spawned as spring-run	Total	Percent of progeny subsequently spawned as fall-run	Percent of progeny subsequently spawned as spring-run
1987	213	76	289	74%	26%
1988	116	228	344	34%	66%
1989	414	106	147	28%	72%
1990	2	23	25	8%	92%

Table 8. The Disposition of Chinook Salmon Spawned, Tagged, and Released as Fall-run Chinook Salmon from Feather River Fish Hatchery. Shaded Cells Indicate Years When >20% of Returning Progeny from Adults Originally Spawned as Fall-run were Subsequently Spawned as Spring-run.

Year	Number of progeny subsequently spawned as fall-run	Number of progeny subsequently spawned as spring-run	Total	Percent of progeny subsequently spawned as fall-run	Percent of progeny subsequently spawned as spring-run
1987	432	17	449	96%	4%
1988	337	96	133	78%	22%
1989	424	113	537	79%	21%
1990	481	111	592	81%	19%
1991	390	32	422	92%	8%
1992	355	68	423	84%	16%
1993	264	223	487	54%	46%
1994	343	197	540	64%	36%

Yuba River: Historic spring-run chinook salmon holding and spawning habitat was blocked by Englebright Dam (Figure 14). Spring-run chinook salmon are still able to ascend the Yuba River as far as Englebright Dam. However, following the termination of access to their historic holding and rearing habitat, spring run now occupy the same area as fall-run salmon and introgressive hybridization has likely occurred.

Miscellaneous Tributaries to the Sacramento River: Rearing juvenile spring run use various nonnatal tributaries to the Sacramento River, including the lower reaches of small, intermittent streams. After exiting their natal stream, some juveniles ascend nonnatal tributaries and continue rearing (Maslin et al. 1997), a behavior which has been observed in other river systems as well (Murray and Rosenau 1989, Scrivener et al. 1994, and Williams 1987: as cited in Maslin et al. 1997). In tributaries of the Sacramento River that do not support an adult population of spring-run chinook salmon, nonnatal rearing has been observed in Sulphur, Olney, Churn, Stillwater, Bear, Inks, Reeds, Red Bank, Salt, Coyote, Oat, Dye, Elder, McClure, Thomes, Toomes, Pine, Mud, and Stony creeks, as well as in Kusal Slough (Rock Creek) (Maslin et al.1997). Additionally, other tributaries which have not been documented as harboring nonnatal rearing juveniles, but which are believed to provide acceptable conditions, include Jewett, Dibble, Blue Tent, Sevenmile, Paynes, Spring, Frazier, Anderson, Ash, Cow, Clover, and Middle creeks (Maslin et al.1997). Based upon observations of CWT juvenile winter-, fall-, and late-fall-run chinook salmon, the variety of dates juveniles enter the tributaries, and the variety of sizes of juveniles present at any one date, some members of all four chinook salmon runs enter tributaries for rearing (Maslin et al. 1997). Juveniles migrate upstream in these tributaries as far as five miles and can remain until rearing habitat conditions deteriorate (diminishing spring flows and increasing water temperatures).

Sacramento-San Joaquin Delta: The Delta serves as juvenile spring-run rearing habitat and an adult and juvenile migration corridor, connecting inland habitat to the ocean. One of the more significant habitat alterations which has affected the range and distribution of Sacramento River spring run within the Delta occurred in 1951 when the Federal Central Valley Project (CVP) began operations of the Delta Cross Channel (DCC). The DCC is a gated canal structure which diverts water and fish from the Sacramento River into the Mokelumne River drainage (Figure 17).

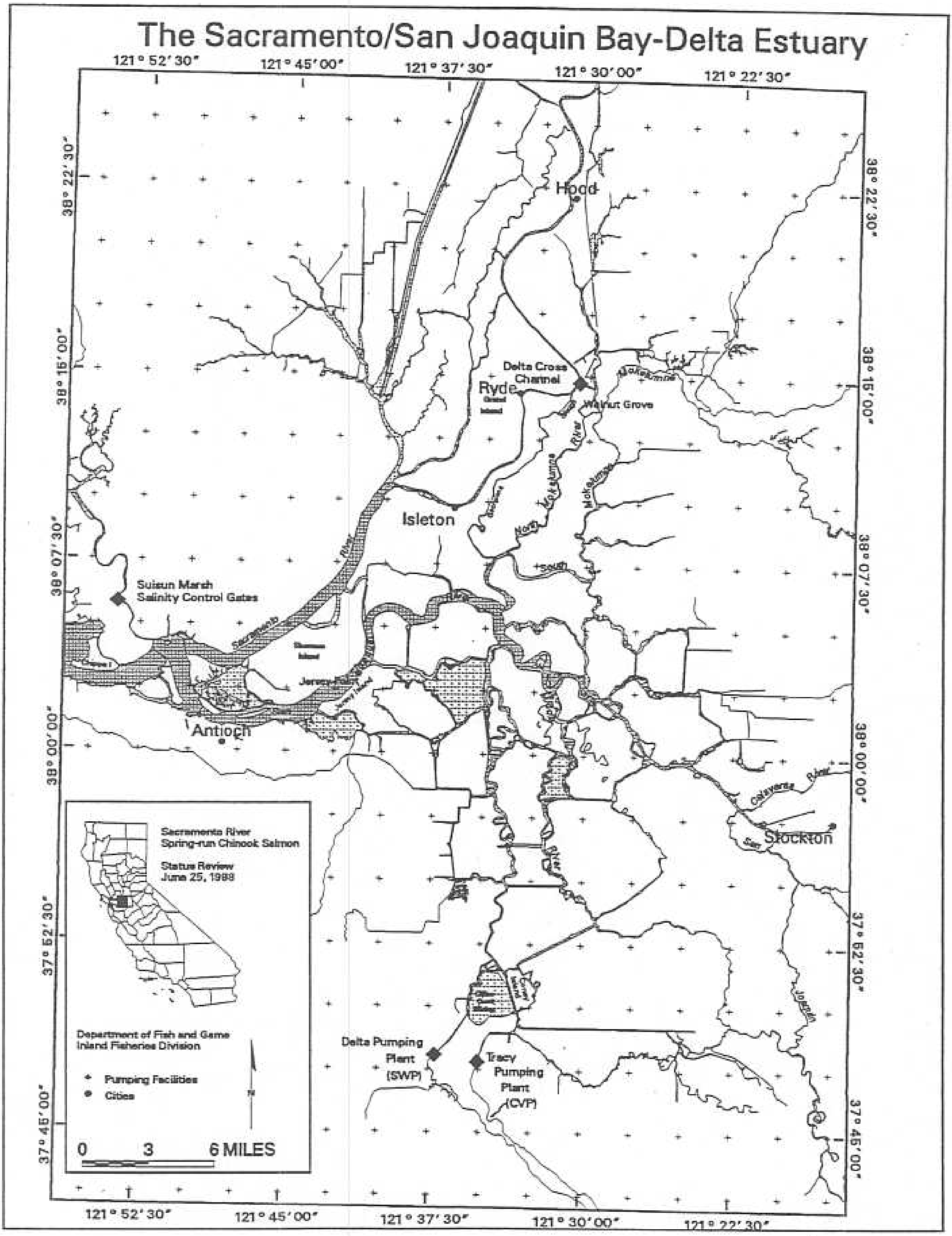


Figure 17. The Sacramento/San Joaquin Bay-Delta Estuary, California.

VI. ABUNDANCE AND POPULATION TRENDS

Historic and Present Population Estimates

Spring-run chinook salmon was once the second most abundant race of salmon in California's Central Valley (Fisher 1994), with fall run the most abundant, as it remains today. The Central Valley drainage as a whole is estimated to have supported spring-run chinook salmon runs as large as 600,000 fish between the late 1880s and 1940s (Table 9, Figure 18). The gill-net fishery, established around 1850 (Clark 1929), operated in the Sacramento-San Joaquin Delta. Initially, the fishery targeted spring- and winter-run chinook salmon due to their fresh appearance and excellent meat quality compared to that of fall run, which are in a more advanced spawning condition upon return to freshwater (Stone 1874). Early gill-net landings were reported in excess of 300,000 spring run (CFC 1882). Before the construction of Friant Dam, nearly 50,000 adults were counted in the San Joaquin River (Table 10, Figure 19) (Fry 1961). This population of spring-run chinook salmon was extirpated after 1949 as a result of the closure of Friant Dam.

__Sacramento River and Tributaries above Shasta Dam__
There are no precise estimates for the total number of spring run that migrated above the site of Shasta Dam. Given that this portion of the watershed was a principal spawning area for Sacramento River spring run, the numbers of spring run which returned to this area must have been large.

***Upper (Little) Sacramento River*:** Stone (1874) reported that in July 1871 "hundreds of salmon, averaging 15 pounds apiece" were caught near Upper Soda Springs just downstream of the town of Dunsmuir. In addition, native Wintu people were said to have fished for salmon in July from a point one mile above the town of Dunsmuir downstream to a point five miles from Dunsmuir (Voegelin 1942: as cited in Yoshiyama et al. 1996). Two to three hundred people fished for two to three weeks, indicating a large run of salmon.

McCloud River: When Stone (1876) was installing a weir at Baird Hatchery in 1874, he made an observation that "tens of thousands, not to say hundreds of thousands which would perhaps be nearer the truth" passed the weir while it was being installed and "thousands more" were blocked after it was installed. Stone (1880) spawned 3,600 female salmon. Clark (1929) reported that by 1928, the run was greatly depleted.

Pit River: There are no population estimates of spring run that ascended the Pit River. Yoshiyama et al. (1996) reported that the run was large and extended at least up to Pit River Falls. Hat Creek was also reported to once have had a large run of spring-run salmon.

Shasta Dam completely blocked access of spring run to the Upper Sacramento, McCloud, and Pit rivers and their tributaries.

__Sacramento River and Tributaries below Shasta Dam__
Sacramento River: Historically the Sacramento River downstream of Shasta Dam was used by spring run only as a migration route to and from cooler tributary streams. After the construction of Keswick Dam in May 1942, Moffett (1947) estimated that 25,000 spring run spawned in the

Table 9. Historical Spring-run Chinook Salmon Abundance. Early Estimates Derived from Annual Commercial Salmon Catch Records. Present Abundance is the Sum of Individual Estimates for Mill, Deer, and Butte Creeks.

Year	Index	Citing	Calculation	Notes
1872	242,000	Clark, 1929, p. 65	(4000000 lbs. * 0.544/18)0.5	Commercial salmon catch in lbs. live weight : (total lbs * %SR by weight / avg wt)/ harvest rate 1/
1873				
1874	247,000	Clark, 1929, p. 65	(4079025 lbs. * 0.544/18)/0.5	Commercial salmon catch in lbs. live weight
1875	308,000	Clark, 1929, p. 65	(5098781 lbs. * 0.544/18)/0.5	Commercial salmon catch in lbs. live weight
1876	321,000	Clark, 1929, p. 65	(5311423 lbs. * 0.544/18)/0.5	Commercial salmon catch in lbs. live weight
1877	392,000	Clark, 1929, p. 65	(6493563 lbs. * 0.544/18)/0.5	Commercial salmon catch in lbs. live weight
1878	394,000	Clark, 1929, p. 65	(6520768 lbs. * 0.544/18)/0.5	Commercial salmon catch in lbs. live weight
1879	268,000	Clark, 1929, p. 65	(4432250 lbs. * 0.544/18)/0.5	Commercial salmon catch in lbs. live weight
1880	604,000	Clark, 1929, p. 65	(10837400 lbs. * 0.502/18)/0.5	Commercial salmon catch in lbs. live weight (%SR by weight changed to .502)
1881	536,000	Clark, 1929, p. 65	(9605000 lbs. * 0.502/18)/0.5	Commercial salmon catch in lbs. live weight
1882	536,000	Clark, 1929, p. 65	(9605280 lbs. * 0.502/18)/0.5	Commercial salmon catch in lbs. live weight
1883	535,000	Fish Comm., 1884, p. 4	(9585672 lbs. * 0.502/18)/0.5	Commercial salmon catch in lbs. live weight
1884	283,000	Fiedler, 1930, p. 357	(5082480 lbs. * 0.502/18)/0.5	packed, canned salmon: (81450 cases * 1.3 x 48)=lbs.
1885	313,000	Fiedler, 1930, p. 357	(5616000 lbs. * 0.502/18)/0.5	packed, canned salmon: (90000 cases * 1.3 x 48)=lbs.
1886	137,000	Fiedler, 1930, p. 357	(2452320 lbs. * 0.502/18)/0.5	packed, canned salmon: (39300 cases * 1.3 x 48)=lbs.
1887	127,000	Skinner, 1962, p. 201	(2277600 lbs. * 0.502/18)/0.5	packed, canned salmon: (36500 cases * 1.3 x 45)=lbs.
1888	369,000	Clark, 1929, p. 65	(6622978 lbs. * 0.502/18)/0.5	Commercial salmon catch in lbs. live weight
1889	361,000	Clark, 1929, p. 65	(6471095 lbs. * 0.502/18)/0.5	Commercial salmon catch in lbs. live weight

1/ Harvest rate of 0.5 derived from spring-run population and gill-net catches 1943 - 1951.

Table 9. (Continued).

Year	Index	Citing	Calculation	Notes
1890	208,000	Clark, 1929, p. 65	(2970111 lbs. * 0.385/11)/0.5	Commercial salmon catch in lbs. live weight (%SR by weight changed to .385)
1891	137,000	Clark, 1929, p. 65	(1957354 lbs. * 0.385/11)/0.5	Commercial salmon catch in lbs. live weight
1892	339,000	Fish Comm., 1894, p. 11	(4848816 lbs. * 0.385/11)/0.5	Commercial salmon catch in lbs. live weight
1893	277,000	Clark, 1929, p. 65	(3950373 lbs. * 0.385/11)/0.5	Commercial salmon catch in lbs. live weight
1894	315,000	Clark, 1929, p. 65	(4494618 lbs. * 0.385/11)/0.5	Commercial salmon catch in lbs. live weight
1895	305,000	Fish Comm., 1896, p. 8, 9	(4350483 lbs. * 0.385/11)/0.5	Commercial salmon catch in lbs. live weight (2713458 catch at San Francisco + 1637025 at canneries)
1896	229,000	Clark, 1929, p. 65	(3276587 lbs. * 0.385/11)/0.5	Commercial salmon catch in lbs. live weight
1897	279,000	Clark, 1929, p. 65	(3979397 lbs. * 0.385/11)/0.5	Commercial salmon catch in lbs. live weight
1898	287,000	Clark, 1929, p. 65	(4079397 lbs. * 0.385/11)/0.5	Commercial salmon catch in lbs. live weight
1899	452,000	Clark, 1929, p. 65	(6458959 lbs. * 0.385/11)/0.5	Commercial salmon catch in lbs. live weight
1900		Fish Comm., 1900, p. 11		Fish markets denied Fish Commission access to records due to antagonism over law enforcement
1901				Incomplete Records
1902				Incomplete Records
1903				Incomplete Records
1904				Incomplete Records
1905				Incomplete Records
1906				Incomplete Records
1907				Incomplete Records
1908				Incomplete Records
1909				Incomplete Records
1910				Incomplete Records
1911				Incomplete Records
1912				Incomplete Records
				Incomplete Records

1/ Harvest rate of 0.5 derived from spring-run population and gill-net catches 1943 - 1951.

Table 9. (Continued).

Year	Index	Citing	Calculation	Notes
1913				ncomplete Records
1914				ncomplete Records
1915		Fish Comm., 1916, p.81		Legislature enacted a law requiring dealers of salmon to provide Commission with monthly fishery statistics
1916	106,000	Fry, unpub., 1916-1947	(952697 lbs./18)/0.5	Commercial salmon catch in lbs. live weight for March-July: (#lbs/avg weight/harvest rate)
1917	1061,000	Fry, unpub., 1916-1947	(955590 lbs./18)/0.5	Commercial salmon catch in lbs. live weight for March-July
1918	98,000	Fry, unpub., 1916-1947	(885326 lbs./18)/0.5	Commercial salmon catch in lbs. live weight for March-July
1919	121,000	Fry, unpub., 1916-1947	(1086204lbs./18)/0.5	Commercial salmon catch in lbs. live weight for March-July
1920	134,000	Fry, unpub., 1916-1947	(1207234lbs./18)/0.5	Commercial salmon catch in lbs. live weight for March-July
1921	104,000	Fry, unpub., 1916-1947	(938482 lbs./18)/0.5	Commercial salmon catch in lbs. live weight for March-July
1922	70,000	Fry, unpub., 1916-1947	(626917 lbs./18)/0.5	Commercial salmon catch in lbs. live weight for March-July
1923	68.000	Fry, unpub., 1916-1947	(607570 lbs./18)/0.5	Commercial salmon catch in lbs. live weight for March-July
1924	87.000	Fry, unpub., 1916-1947	(778775 lbs./18)/0.5	Commercial salmon catch in lbs. live weight for March-July
1925	106.000	Fry, unpub., 1916-1947	(952307 lbs./18)/0.5	Commercial salmon catch in lbs. live weight for March-July
1926	40,00	Fry, unpub., 1916-1947	(364235 lbs./18)/0.5	Commercial salmon catch in lbs. live weight for March-July
1927	30,000	Fry, unpub., 1916-1947	(266094 lbs./18)/0.5	Commercial salmon catch in lbs. live weight for March-July
1928	11,000	Fry, unpub., 1916-1947	(100332 lbs./18)/0.5	Commercial salmon catch in lbs. live weight for March-July
1929	19,000	Fry, unpub., 1916-1947	(173153 lbs./18)/0.5	Commercial salmon catch in lbs. live weight for March-July
1930	61,000	Fry, unpub., 1916-1947	(549366 lbs./18)/0.5	Commercial salmon catch in lbs. live weight for March-July

1/ Harvest rate of 0.5 derived from spring-run population and gill-net catches 1943 - 1951.

Table 9. (Continued).

Year	Index	Citing	Calculation	Notes
1931	49,000	Fry, unpub., 1916-1947	(437351 lbs./18)/0.5	Commercial salmon catch in lbs. ive weight for March-July
1932	48,000	Fry, unpub., 1916-1947	(429588 lbs./18)/0.5	Commercial salmon catch in lbs. ive weight for March-July
1933	20,000	Fry, unpub., 1916-1947	(181565 lbs./18)/0.5	Commercial salmon catch in lbs. ive weight for March-July
1934	16,000	Fry, unpub., 1916-1947	(145286 lbs./18)/0.5	Commercial salmon catch in lbs. ive weight for March-July
1935	12,000	Fry, unpub., 1916-1947	(111030 lbs./18)/0.5	Commercial salmon catch in lbs. ive weight for March-July
1936	42,000	Fry, unpub., 1916-1947	(376809 lbs./18)/0.5	Commercial salmon catch in lbs. ive weight for March-July
1937	16,000	Fry, unpub., 1916-1947	(141398 lbs./18)/0.5	Commercial salmon catch in lbs. ive weight for March-July
1938	6,000	Fry, unpub., 1916-1947	(57905 lbs./18)/0.5	Commercial salmon catch in lbs. ive weight for March-July
1939	45,000	Fry, unpub., 1916-1947	(403117 lbs./18)/0.5	Commercial salmon catch in lbs. ive weight for March-July
1940	68,000	Fry, unpub., 1916-1947	(609179 lbs./18)/0.5	Commercial salmon catch in lbs. ive weight for March-July
1941	19,000	Fry, unpub., 1916-1947	(168326 lbs./18)/0.5	Commercial salmon catch in lbs. ive weight for March-July
1942	73,000	Fry, unpub., 1916-1947	(657866 lbs./18)/0.5	Commercial salmon catch in lbs. ive weight for March-July
1943	46,000	Fry, unpub., 1916-1947	(413760 lbs./18)/0.5	Commercial salmon catch in lbs. ive weight for March-July
1944	17,000	Fry, unpub., 1916-1947	(1558170lbs./18)/0.5	Commercial salmon catch in lbs. ive weight for March-July
1945	166,000	Fry, unpub., 1916-1947	(1491820lbs./18)/0.5	Commercial salmon catch in lbs. ive weight for March-July
1946	222,000	Fry, unpub., 1916-1947	(1995774lbs./18)/0.5	Commercial salmon catch in lbs. ive weight for March-July
1947	72,000	Fry, unpub., 1916-1947	(650866 lbs./18)/0.5	Commercial salmon catch in lbs. ive weight for March-July
1948	59,000	CDFG Bul. 80, p. 33	(528667 lbs./18)/0.5	Monthly landing of commercial ishing boats in Sacramento region: March-June

1/ Harvest rate of 0.5 derived from spring-run population and gill-net catches 1943 - 1951.

Table 9. (Continued).

Year	Index	Citing	Calculation	Notes
1949	30,000	CDFG Bul. 80, p. 63	(267686 lbs./18)/0.5	Monthly landing of commercial fishing boats in Sacramento region: March-June; Friant Dam completed which extirpates San Joaquin Spring-run
1950	19,000	CDFG Bul. 86, p. 93	(173779 lbs./18)/0.5	Monthly landing of commercial fishing boats in Sacramento region: March-June
1951	9,000	CDFG Bul. 89, p. 39	(76744 lbs/18)/0.5	Monthly landing of commercial fishing boats in Sacramento region: March-June
1952				Friant Dam completed 1949 - extirpating San-Joaquin SR; gill net fishery restricted to 7½ mesh
1953				No Data
1954				No Data
1955				No Data
1956				No Data
1957				Gill Net Fishery abolished
1958				Legislation closed gill-net fishery
1959				No Data
1960				No Data
1961				No Data
1962				No Data
1963				No Data
1964				No Data
1965				No Data
1966				No Data
1967				No Data
1968				No Data
1969				No Data
1970	4,000	see Appendix B		Mill, Deer and Butte creeks estimates
1971	3,000	see Appendix B		Mill, Deer and Butte creeks estimates

1/ Harvest rate of 0.5 derived from spring-run population and gill-net catches 1943 - 1951.

Table 9. (Continued).

Year	Index	Citing	Calculation	Notes
1972	1,000	see Appendix B		Mill, Deer and Butte creeks estimates
1973	4,000	see Appendix B		Mill, Deer and Butte creeks estimates
1974	5,000	see Appendix B		Mill, Deer and Butte creeks estimates
1975	13,000	see Appendix B		Mill, Deer and Butte creeks estimates
1976				Incomplete Records
1977				Incomplete Records
1978	2,000	see Appendix B		Mill, Deer and Butte creeks estimates
1979				Incomplete Records
1980	2,000	see Appendix B		Mill, Deer and Butte creeks estimates
1981				Incomplete Records
1982	3,000	see Appendix B		Mill, Deer and Butte creeks estimates
1983				Incomplete Records
1984				Incomplete Records
1985	1,000	see Appendix B		Mill, Deer and Butte creeks estimates
1986	2,000	see Appendix B		Mill, Deer and Butte creeks estimates
1987	500	see Appendix B		Mill, Deer and Butte creeks estimates
1988	2,000	see Appendix B		Mill, Deer and Butte creeks estimates
1989	2,000	see Appendix B		Mill, Deer and Butte creeks estimates
1990	1,000	see Appendix B		Mill, Deer and Butte creeks estimates
1991	1,000	see Appendix B		Mill, Deer and Butte creeks estimates
1992	1,000	see Appendix B		Mill, Deer and Butte creeks estimates

1/ Harvest rate of 0.5 derived from spring-run population and gill-net catches 1943 - 1951.

Table 9. (Continued).

Year	Index	Citing	Calculation	Notes
1993	1,000	see Appendix B		Mill, Deer and Butte creeks estimates
1994	2,000	see Appendix B		Mill, Deer and Butte creeks estimates
1995	9,000	see Appendix B		Mill, Deer and Butte creeks estimates
1996	2,000	see Appendix B		Mill, Deer and Butte creeks estimates
1997	1,000	see Appendix B		Mill, Deer and Butte creeks estimates

1/ Harvest rate of 0.5 derived from spring-run population and gill-net catches 1943 - 1951.

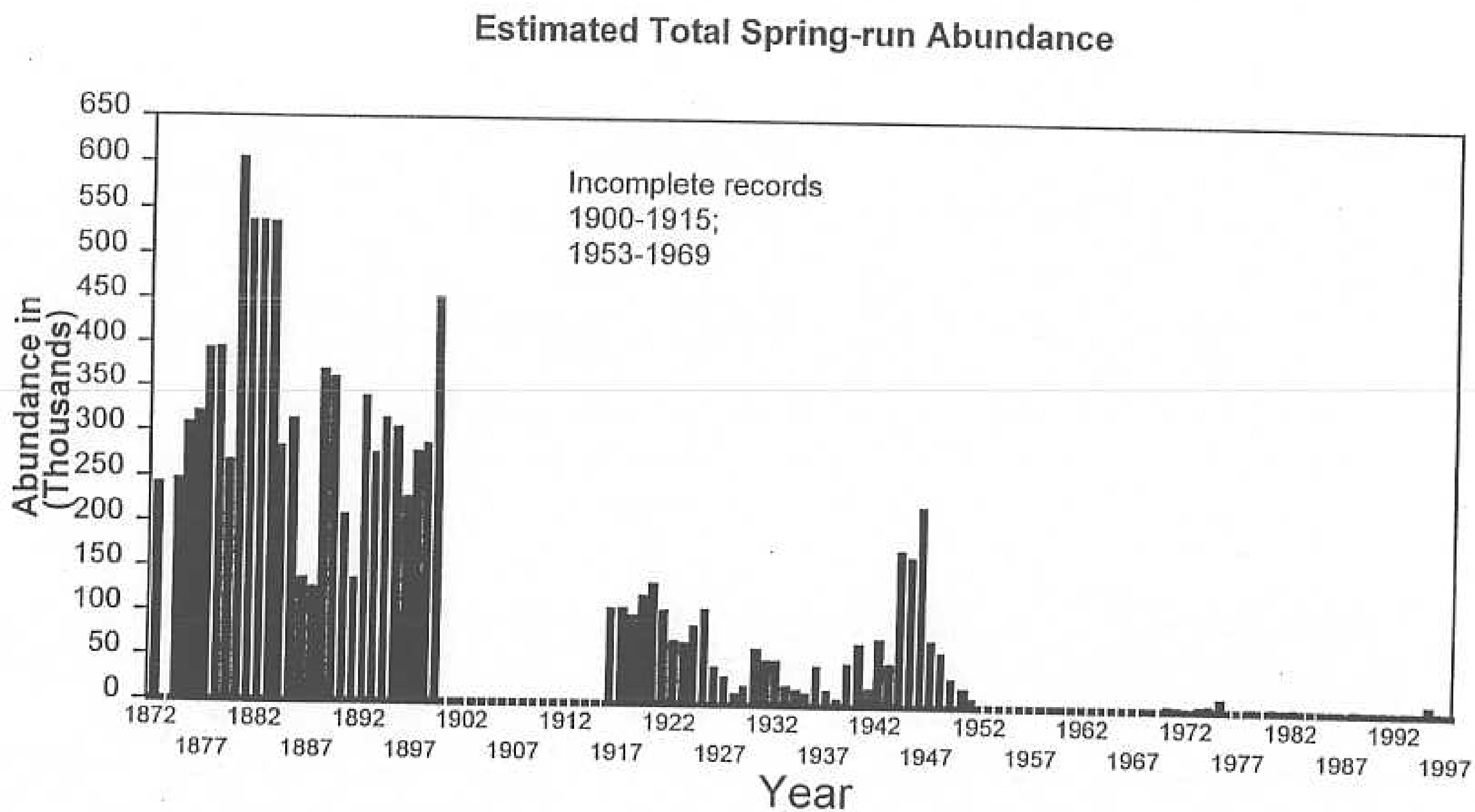


Figure 18. Historical spring-run chinook salmon abundance. Early estimates derived from annual commercial salmon catch records. Present abundance is the sum of individual estimates for Mill, Deer, and Butte creeks.

Table 10. Counts and Estimates of the San Joaquin River Spring-run Population.

YEAR	ESTIMATE	YEAR	ESTIMATE
1940	No survey	1951	0
1941	No survey	1952	0
1942	No survey	1953	0
1943	35,000	1954	0
1944	5,000	1955	0
1945	56,000	1956	0
1946	30,000	1957	0
1947	6,000	1958	0
1948	2,000	1959	0
1949	No survey	1960	Extirpated
1950	No survey		

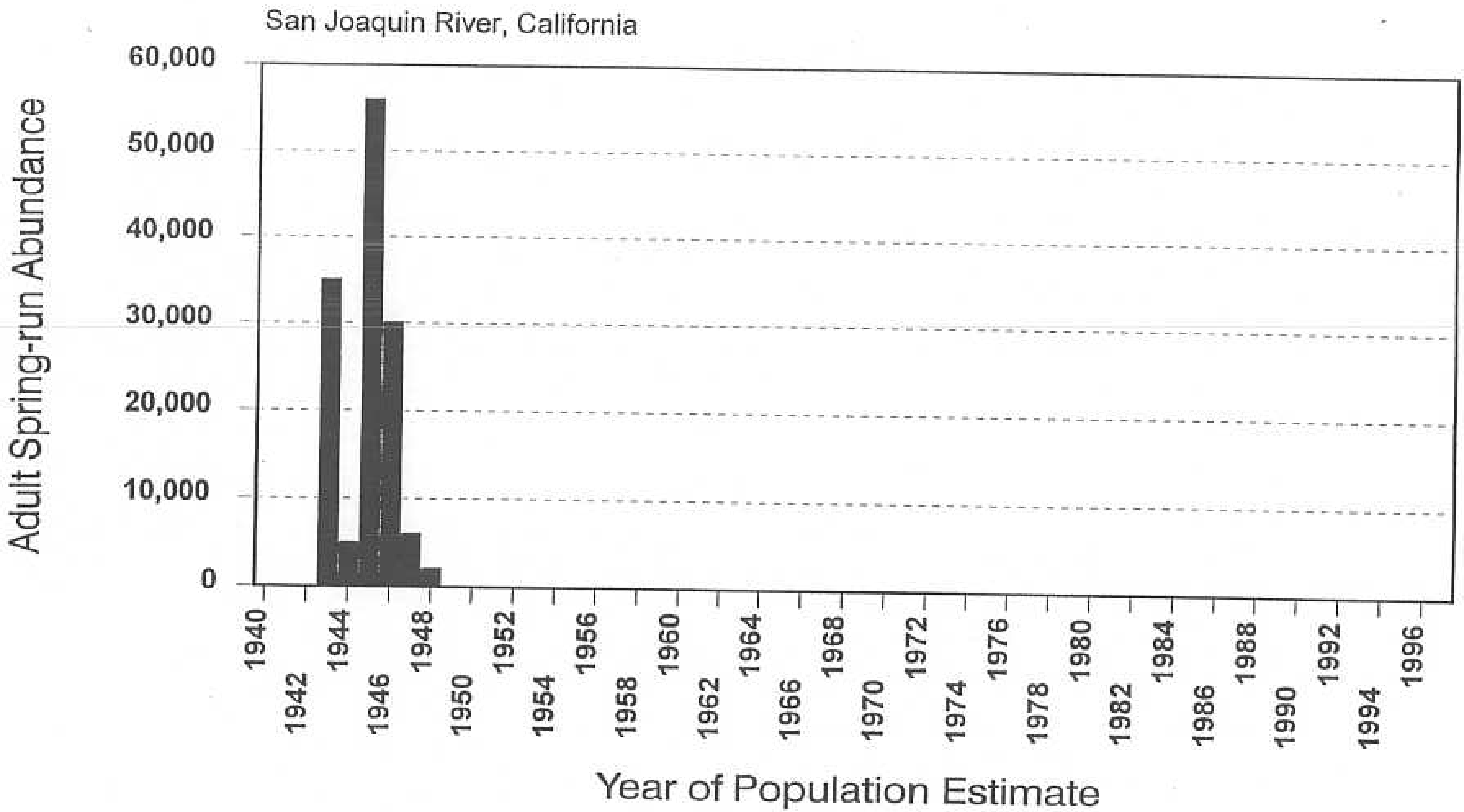


Figure 19. Adult spring-run chinook salmon population abundance in the San Joaquin River, California.

Sacramento River and an additional 2,391 fish were taken at Keswick Dam trap. These fish migrated and spawned at the same time as spring run that migrated through this section of river before Shasta Dam. Adult spring-run abundance was estimated until 1956 based on redd counts. Estimates ranged from 27,000 to 4,000 (Appendix B). During this period, Slater (1963) noted a change in the spring-run population and an increase in what he referred to as early-spawning fall run. Slater (1963) states that early fall-run spawners were competing with spring run for nest sites. He also indicates that fall run may have hybridized with spring run. No estimates were made from 1957 through 1968. Starting in 1969 counts were made at RBDD. RBDD also included fish that were destined for Battle and Cottonwood creeks. Estimates of adult spring-run escapements are also separately generated for each drainage, resulting in "double counting" of these fish. No analysis has been performed to adjust the RBDD estimates to account strictly for the spawners to the mainstem river.

Clear Creek: There is no record of the population size in Clear Creek. Azevedo and Parkhurst (1958) mentioned seeing spring run in 1956 for the first time since 1949, but gave no estimate. Today, there are no spring-run chinook salmon in Clear Creek (Appendix B).

Cottonwood Creek: There are no good estimates of what the population size of spring run was historically in Cottonwood Creek. CDFG (1993) simply states there was a historical population of 500 salmon, but does not cite a source. Now Cottonwood Creek has a remnant population of a few fish. In 1995, eight spring-run salmon were observed in Beegum Creek and six fish were observed in 1996. No spring run were detected during a survey in 1993 of the South Fork of Cottonwood Creek.

Battle Creek: Battle Creek historically supported a spring-run population, but no reliable records exist that document the magnitude (Figure 20). Systemic counts were not made during spring months when adult spring run migrate upstream. Hanson (et al. 1940) reported a small spring run and a larger fall run. Azevedo and Parkhurst (1958) used redd surveys and carcass counts to estimate adult spring run; estimates ranged from 1,700 to 2,200 for 1952-56. These numbers were subsequently used in Fry (1961).

During the last three years (1995-97), the USFWS has generated partial estimates for spring run using ladder counts at the CNFH Barrier Dam (Appendix B). These partial estimates indicate Battle Creek presently has a run of 50 to 100 adult spring run (Baracco 1996, 1997).

Antelope Creek: Historically, Antelope Creek supported "a few hundred" adult fish (Hallock 1956, Van Woert 1959). Hayes and Lingquist (1966) estimated the run to be about 500 fish annually. Today, there are few fish in Antelope Creek. Since 1989, surveys conducted by the Department have counted salmon in holding areas. Counts ranged from a low of zero in 1991, 1992, and 1994 to a high of seven fish in 1995 (Figure 21, Appendix B).

Mill Creek: There are no early records of population size for Mill Creek. Counts of spring run were initiated in 1940 by the USFWS (Appendix B). Though some of these counts are incomplete, there were counts of 3,000 to 4,000 fish. In recent years counts are an order of magnitude lower. In 1997, 200 spring run were estimated to have spawned in Mill Creek (Figure 22).

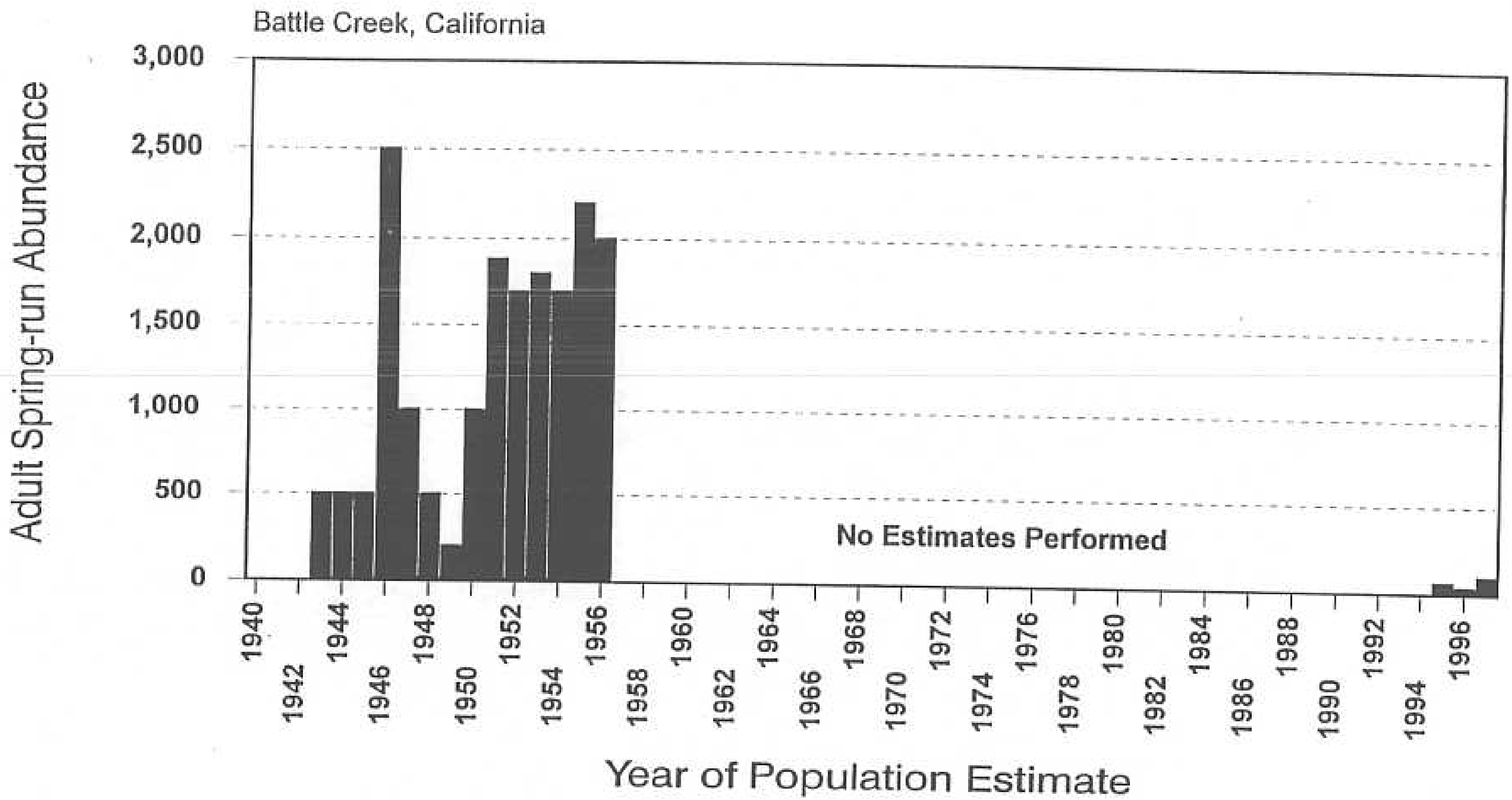


Figure 20. Adult spring-run chinook salmon population abundance in Battle Creek, California.

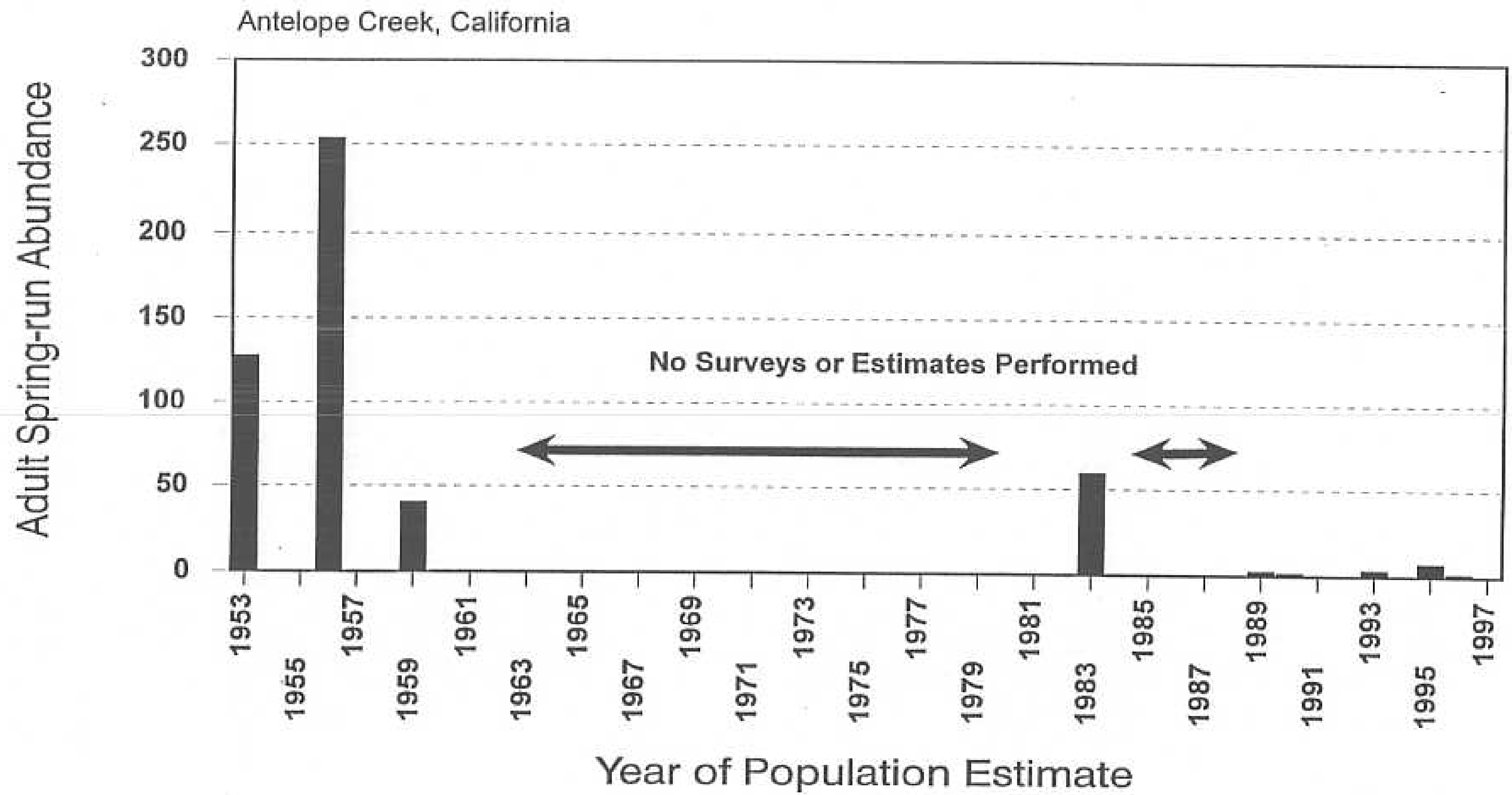


Figure 21. Adult spring-run chinook salmon population abundance in Antelope Creek, California.

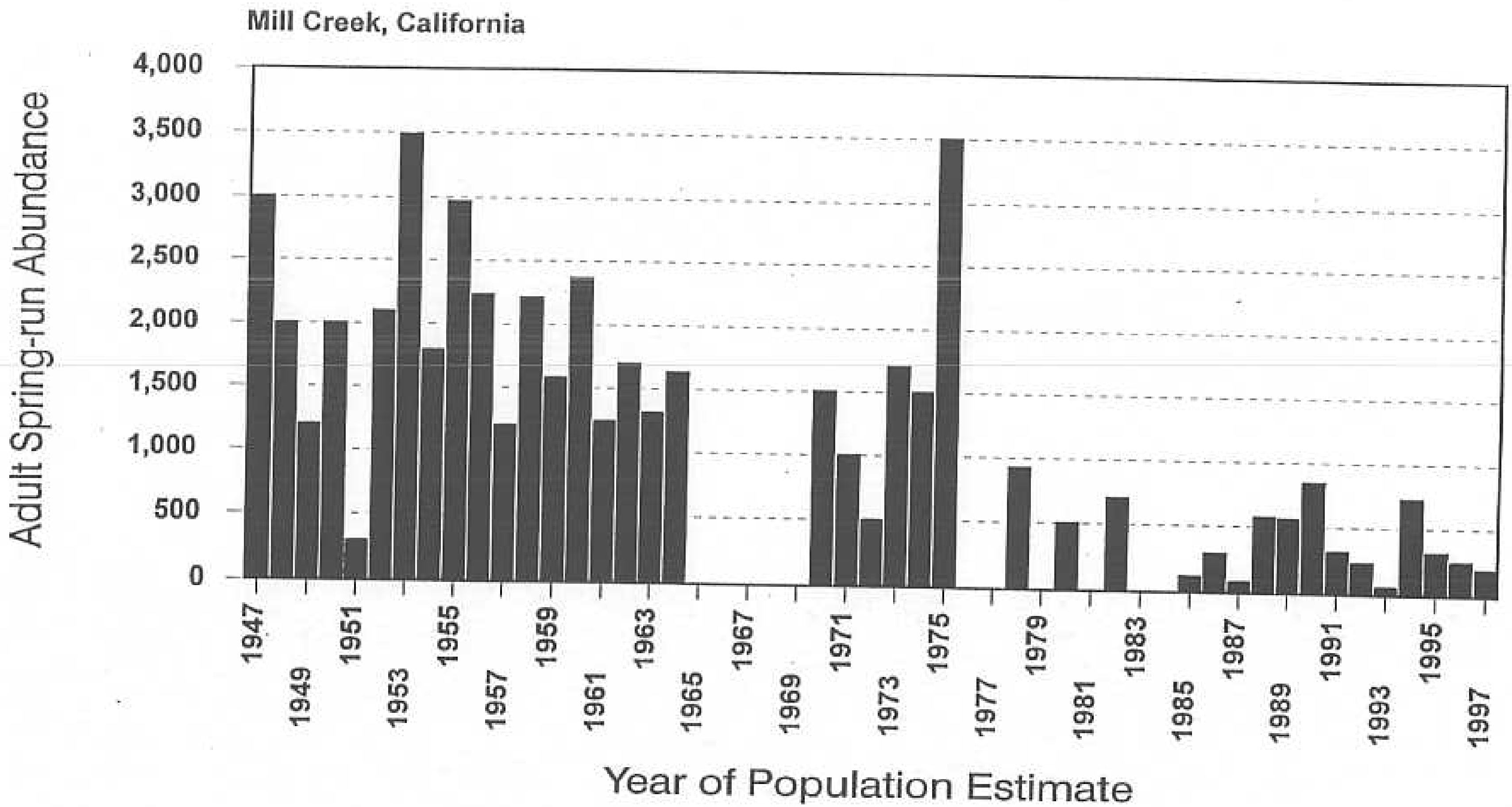


Figure 22. Adult spring-run chinook salmon population abundance in Mill Creek, California.

Deer Creek: There are no early records of population size for Deer Creek. Salmon were abundant enough for the Yahi people to use them as a food source (Yoshiyama et al. 1996). Counts of spring-run chinook salmon in Deer Creek were initiated in 1940 by the USFWS (Appendix B). Although some of these counts are incomplete, there were counts of 3,000 to 4,000 fish. In recent years counts are an order of magnitude lower. In 1997, 466 spring run were counted (Figure 23).

Stony Creek: There are no records of the numbers of spring-run salmon in Stony Creek. Clark (1929) states that Stony Creek was a very good salmon stream prior to the placement of irrigation dams. Spring-run chinook salmon were blocked by Stony Gorge Dam (Hanson et al. 1940). As a result, spring-run chinook salmon are no longer able to access habitat in the upper watershed necessary for adult holding and spawning, leading to their extirpation.

Big Chico Creek: No historical records exist, but the number of spring run in the 1950s and 1960s averaged less than 300 fish. In the last four years, the number of adults seen in Big Chico Creek has ranged from 200 to two fish (Appendix B, Figure 24).

Butte Creek: There are no early accounts of the number of spring-run chinook salmon in Butte Creek. Butte Creek was described in 1929 (Clark 1929) as having been a very fine salmon stream which was almost destroyed by irrigation dams and diversions. Clark further hypothesized that only remnant numbers of fall run remained, with the implication, therefore, that spring run had been extirpated. It appears that Clark based his conclusion upon observations of the valley reach of Butte Creek, which during the summer was described "...as the water is very low and warm ..." He made similar observations for Mill and Deer creeks, and apparently did not recognize that the life history pattern of spring-run salmon was such that low flows and high temperatures in the valley reaches during the summer did not preclude their existence. In 1940, Butte Creek was described as "reported to have been a very fine salmon stream in the past, but mining and hydroelectric power developments in the upper and middle portions, and irrigation diversions in the lower sections have so altered the stream that it is no longer suitable for salmon" (Hanson et al. 1940).

During 1954, a counting station was maintained at the Parrott-Phelan Dam to record adult spring-run salmon passing through the fish ladder (Appendix B). During a 21-day period (May 7 to 27), 830 fish were observed (Warner 1954). Warner further commented that the first salmon were seen in the area during the last week in March, and also that Warden Gene Mercer reported that 300 salmon were taken by anglers in upper Butte Creek on May 1 and 2. Various census techniques have been employed to evaluate the spring-run populations in Butte Creek since 1954. The population has fluctuated significantly, from a high of 8,700 adults in 1960, to a low of ten fish in 1979. The fluctuation may, in part, be explained by the various survey techniques which have varied in rigor and comparability. However, the general trend has been a decline since the 1940s (Campbell and Moyle 1990). In 1995, 7,500 spring run returned to Butte Creek and in 1997, 635 returned (Figure 25).

Feather River: Historically the population in the Feather River was substantial. Letters written by CDFG (as cited in Yoshiyama et al. 1996) indicated that thousands of spring run entered the North Fork. In 1946, the spring-run population in the Feather River was estimated at 2,000

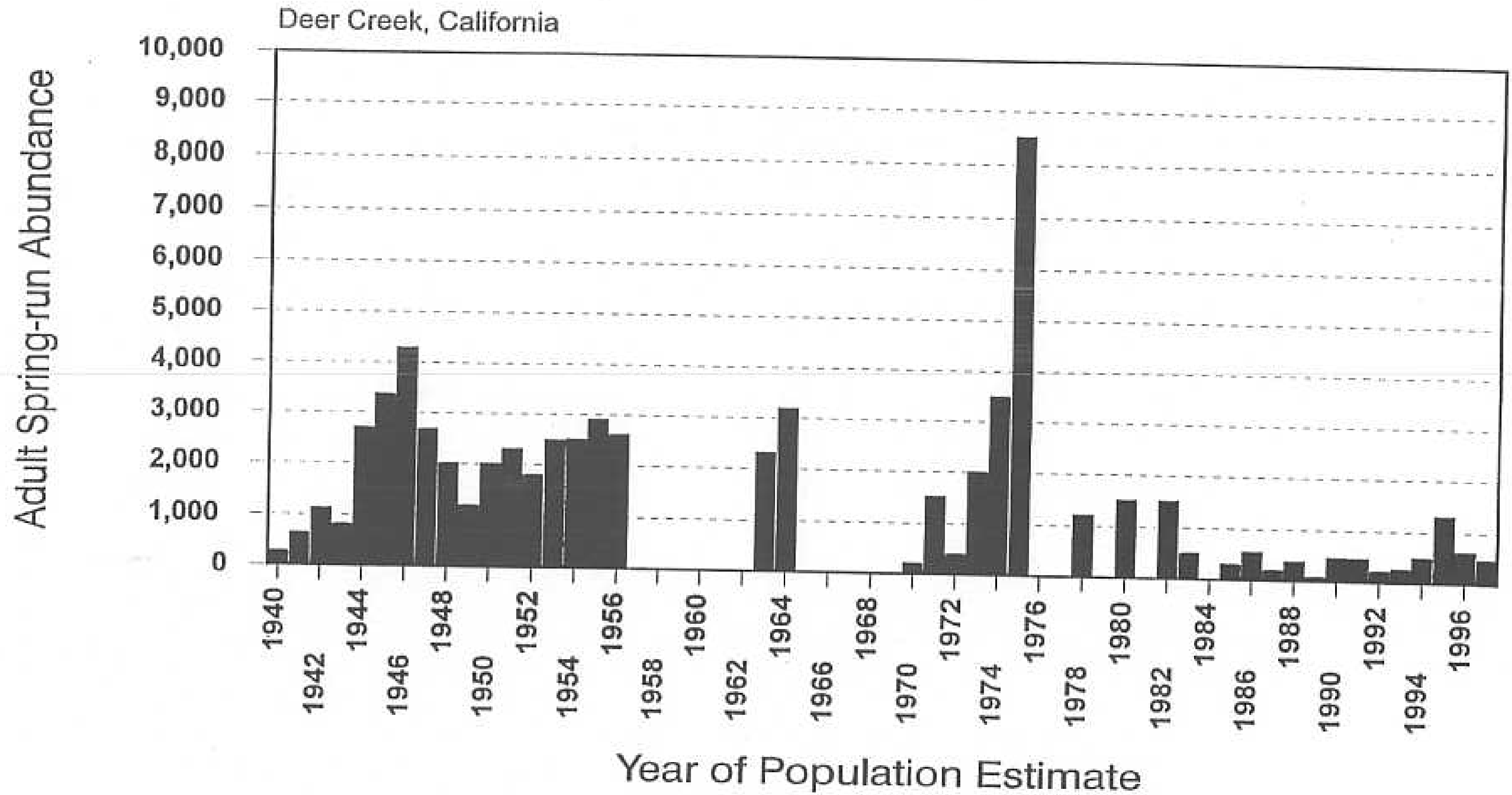


Figure 23. Adult spring-run chinook salmon population abundance in Deer Creek, California.

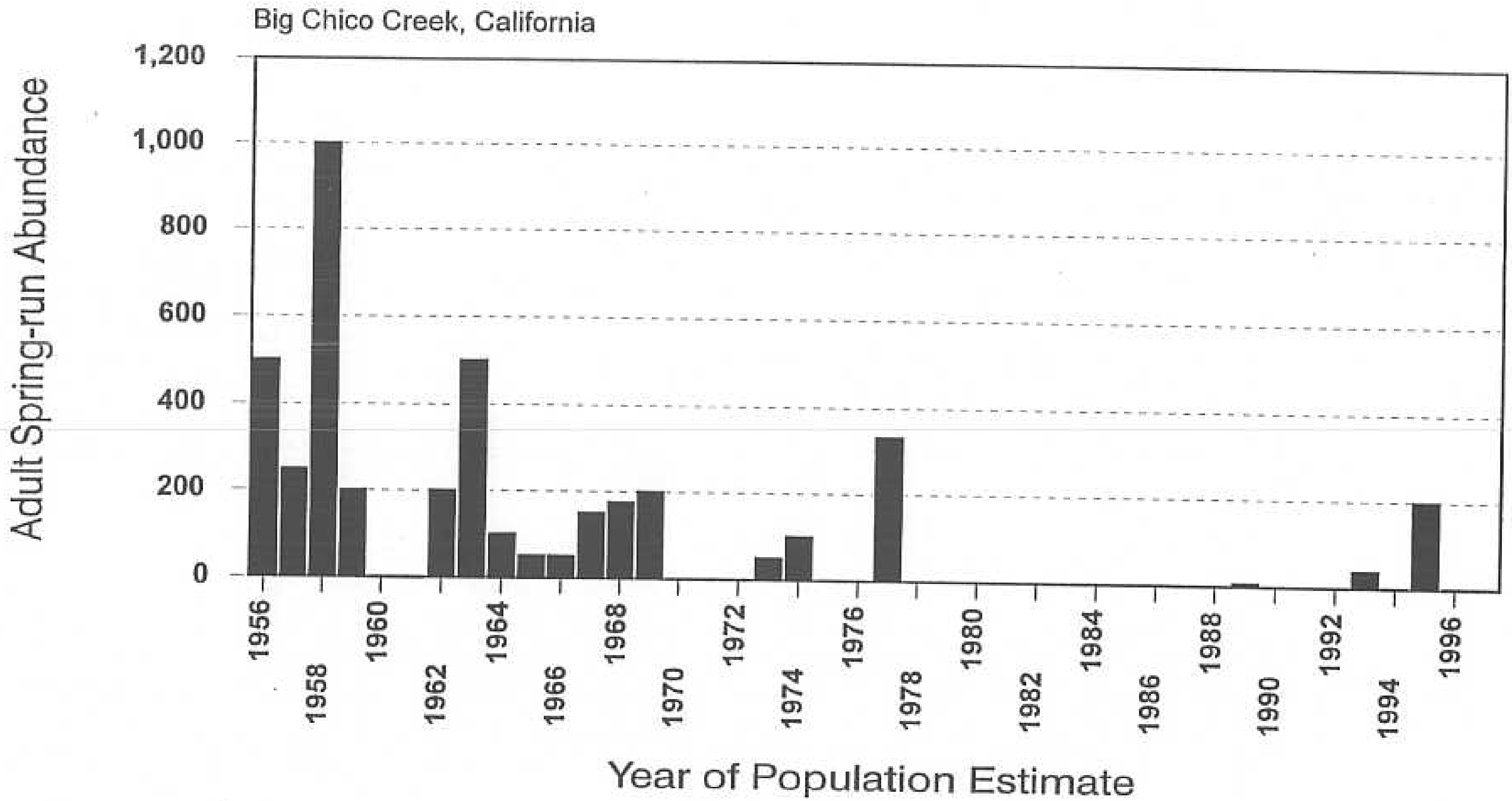


Figure 24. Adult spring-run chinook salmon population abundance in Big Chico Creek, California.

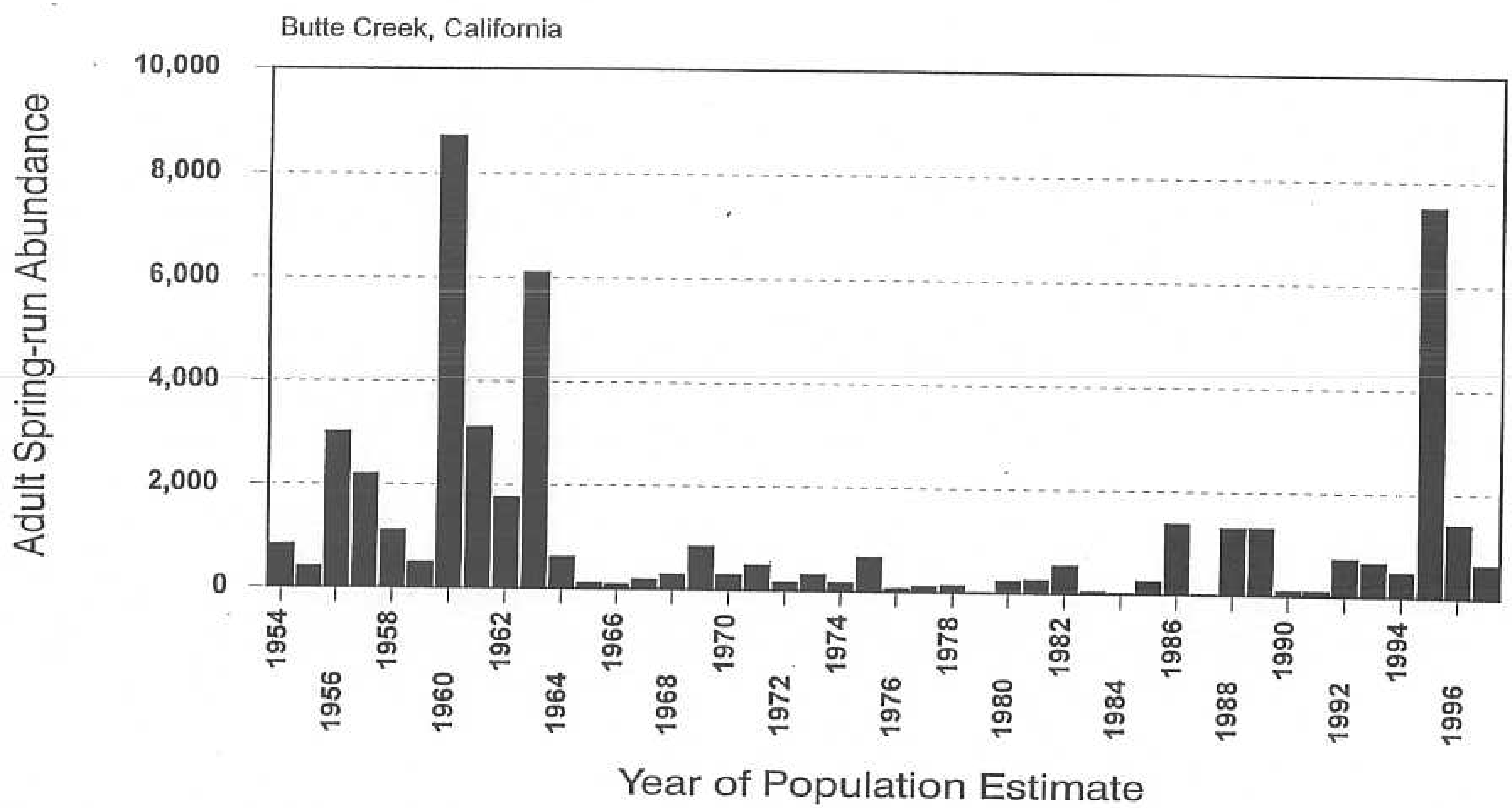


Figure 25. Adult spring-run chinook salmon population abundance in Butte Creek, California.

adults (Fry 1961). Prior to complete blockage resulting from Oroville Dam, the population estimate varied from a low of 500 fish in 1957 (Mahoney 1958), to 4,000 in 1959 (Mahoney 1960) (Appendix B, Figure 26).

Following construction of Oroville Dam, the spring-run population dropped to an all-time low of 146 fish in 1967 (Menchen 1968). The greatest abundance since Oroville Dam was in 1988 (6,833 adults) based on numbers of fish returning to the fish hatchery (Schlicting 1991). Estimates for spring run since the construction of Oroville Dam are counts of salmon entering the FRH. These fish, referred to as spring run for the last two decades, are probably introgressed hybrids of spring and fall run (Brown and Greene 1993). Tables 7 and 8 illustrate how much hybridization has been occurring between fall and spring run at the FRH. A more detailed discussion can be found in this report's section titled *Factors Affecting the Ability to Survive and Reproduce - Competition and Hybridization.*

***Yuba River*:** There are no early accounts of the population size in the Yuba River, but it is thought to have been large. When Bullards Bar Dam was constructed, there were so many spring run congregating below the dam and dying that they had to be burned (Yoshiyama et al. 1996).

A small population of spring-run chinook salmon may exist today in the Yuba River, but the status of its magnitude or introgressive hybridization with fall-run chinook salmon is unknown. Chinook salmon exhibiting spring-run characteristics, early ascending (April, May, and June) and early spawning (September-early October), have been observed in the Yuba River. Observations of fish exhibiting spring-run characteristics have been documented since 1980. Best professional judgement by Department personnel has estimated spring-run populations during the 1980s to number several hundred fish (Appendix B). Surveys since 1992 have been direct observations (aerial in 1992 and snorkeling in 1993-94) in the reach where spring run are considered to hold and spawn, from Englebright Dam downstream to Parks Bar. Snorkel and aerial surveys were generally conducted in September to determine the presence of adults and redds. Spring run were not observed during the snorkel or aerial surveys conducted between 1992 and 1994. Surveys were not conducted in 1995 and 1996. Spring-run chinook salmon were observed to be present in 1997, although an estimate of abundance was not made (J. Nelson, pers. observ.).

American River and Tributaries South

Spring run no longer inhabit the American River, Mokelumne River and any tributaries of the San Joaquin River. All of these rivers have had impassible dams built low in the drainage which blocked spring run from reaching their former habitat. There are no early records of the magnitude of spring run in the American River. From the size of their former habitat as described in Yoshiyama et al. (1996) it could have been large. Stone (1874) indicated the American River was once a prolific salmon river, but mining had made it so muddy that salmon no longer ascended it. Fry (1961) noted a small spring run.

There are no historical records of the size of the spring run in the Mokelumne River. There are no early counts of spring run in the Stanislaus River but it was probably quite large. Historically, the Stanislaus River was primarily a spring-run stream (Yoshiyama et al. 1996). Today there are no spring run in the Stanislaus River. There are no early counts of spring run in the Tuolumne

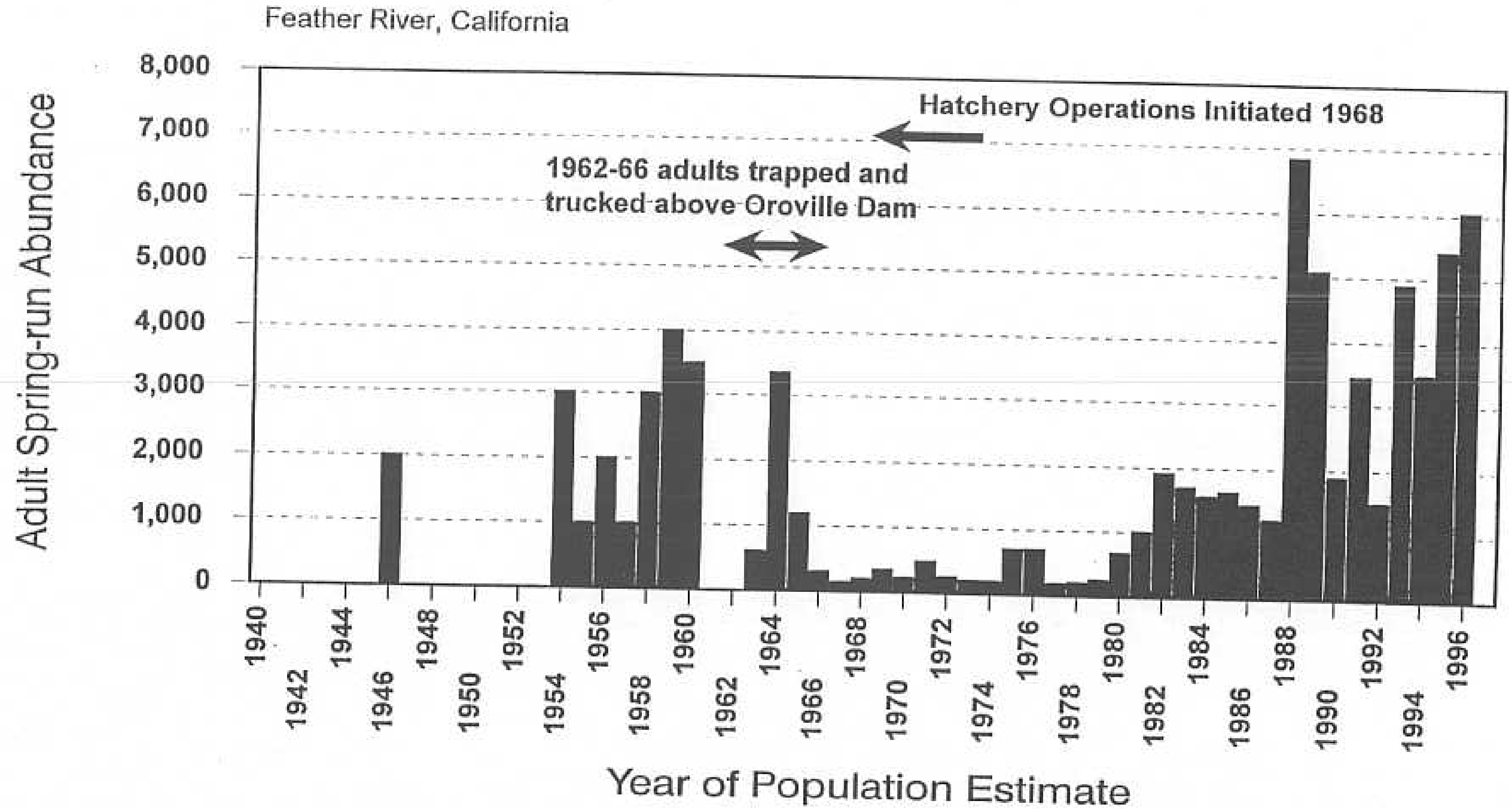


Figure 26. Adult spring-run chinook salmon population abundance in the Feather River, California.

River. Clark (1929) noted that spring run were inconsequential in 1928. There are no early counts of spring run in the Merced River, but the spring run must have been large. Clark (1929) recounts statements from early residents that "great quantities of fish come up the river in the summer and fall." The San Joaquin River once had a tremendous spring run of salmon. Clark (1929) indicates that in the late 1800s "salmon were very numerous and came in great hordes." Fry (1961) estimated a run of 56,000 spring run in 1945. In the Kings River, there are no records of the size of the spring run historically. Apparently, it occurred often enough and was large enough for native people to use salmon as a food staple and hold a ritual praying to salmon for a plentiful supply (Yoshiyama et al. 1996). Ferguson (1914: as cited in Yoshiyama et al. 1996) reported a "very considerable run" occurred in 1912 and 1914 after a channel was dredged between the San Joaquin River and the Kings River.

Magnitude and Rate of Population Decline

The overall population trend for spring run in the Central Valley has been documented as declining for many decades (Table 9, Figure 18). The population initially underwent a significant decline mainly due to loss of upstream habitat caused by barriers and hydropower dams, difficulty in adult and juvenile passage caused by water diversion facilities and lack of instream flows, the commercial gill-net fishery in the late 19th and early 20th century, and habitat degradation from mining and reclamation activities. By 1870, the commercial gill-net fishery had already declined as a result of placer mining in the tributaries, which dewatered and destroyed spawning gravels (Marcotte 1984). Spring-run populations continued to decline drastically in the early 1900s when hydropower and irrigation dams were constructed on nearly every major Central Valley tributary. Although the populations were significantly depleted compared to pre-disturbance conditions, they were not threatened with extinction. Completion of Shasta and Friant dams in the 1940s blocked access to a significant portion of the historic spawning habitat for spring run and resulted in the extirpation of spring run in the San Joaquin River and a further precipitous drop in abundance in the Sacramento River system. Still, spring run have experienced significant losses since this era. More than 20 historically large populations have been extirpated or reduced to nearly zero. By 1997, wild spring-run populations have declined to less that 0.3% of their historic run sizes (Appendix B).

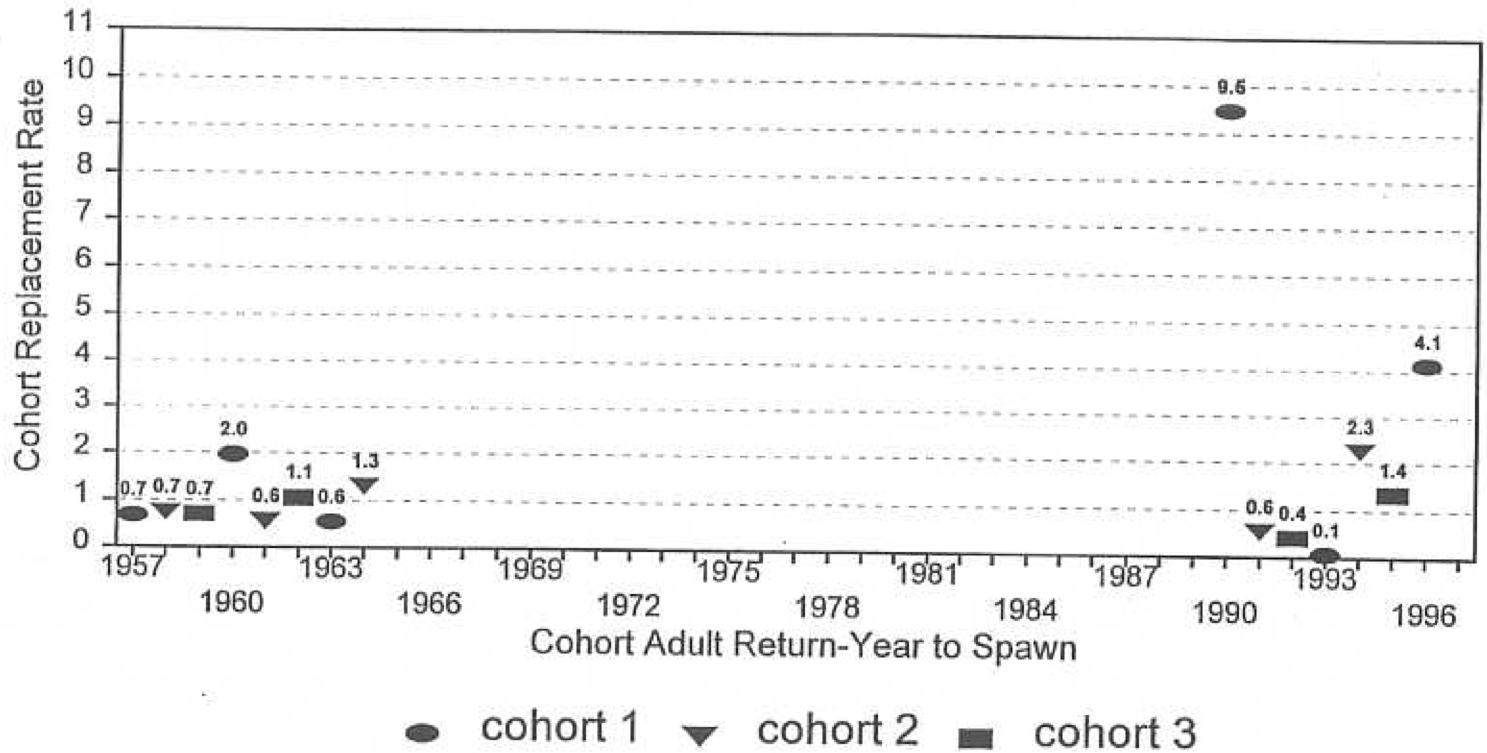
One way to evaluate population trend is to examine the strength of Brood Year (BY) lineages. Due to the varied methods used over the years to estimate population abundance in each tributary, there are few data which are adequate for such an analysis. For Mill, Deer, and Butte creeks, the more recent data are generally most consistent and robust. Individual BY data are lacking altogether on rates of grilse returns, age structure, and sex ratio of returning adults. If one can assume all spawning adults return as 3-year-olds, there is a 1:1 male to female sex ratio, and there is no variation in these factors between BYs one can calculate a cohort replacement rate (CRR). This calculation consists of dividing the number of returning adults in a given BY by the number of returning adults three years prior. A CRR of 1.0 or greater represents a population that would be self-sustaining in a constant environment. A value of 1.0 means the cohort has simply replaced itself. Values greater than 1.0 means the cohort abundance is increasing and values less than 1.0 means the cohort abundance is decreasing.

For Mill Creek (Table 11, Figure 27), all three cohorts (BY lineages) have failed to replace themselves at least 50% of the time. Cohort 1 has exhibited the greatest volatility in CRR

Table 11. Mill Creek Spring-run Chinook Salmon Cohort Replacement Rate

Cohort	Broodyear	Cohort Replacement Rate
1	1957	1203 ÷ 1789 = 0.7
2	1958	2212 ÷ 2967 = 0.7
3	1959	1580 ÷ 2233 = 0.7
1	1960	2368 ÷ 1203 = 2.0
2	1961	1245 ÷ 2212 = 0.6
3	1962	1692 ÷ 1580 = 1.1
1	1963	1315 ÷ 2368 = 0.6
2	1964	1628 ÷ 1245 = 1.3
3	1990	844 ÷ 89 = 9.5
1	1991	319 ÷ 572 = 0.6
2	1992	237 ÷ 563 = 0.4
3	1993	61 ÷ 844 = 0.1
1	1994	723 ÷ 319 = 2.3
2	1995	320 ÷ 237 = 1.4
3	1996	252 ÷ 61 = 4.1

Mill Creek Spring-Run Chinook Salmon



A CRR of 1.0 or greater represents a self-sustaining population in a constant environment. A value of 1.0 means the cohort has simply replaced itself. Values greater than 1.0 means the cohort abundance is increasing. Values less than 1.0 mean the cohort abundance is decreasing.

Figure 27. Cohort replacement rates (CRR) for Mill Creek calculated from spawning abundance estimates.

between BY's. In 1990, the CRR was 9.5, dropping to 0.1 in 1993, and then rebounding to 4.1 in 1996. Cohort 2 is weak with replacement rates between 0.6 and 1.3 in the late 1950s through early 1960s. The CRR has shown little improvement until 1994 then the BY appeared somewhat stronger with a CRR of 2.3. Cohort 3 has consistently failed to replace itself every other BY cycle. The CRR for 1995 was 1.4

For Deer Creek (Table 12, Figure 28), the CRR for Cohort 1 (1990 BY lineage) has fluctuated from 2.3 to 0.6 and back to 2.4 over the last three BY's. Cohort 2 (1991 BY lineage) has been barely maintaining itself with values ranging from 1.0 to 1.2. Cohort 3 (1992 BY) is the strongest of the three cohorts. While the BY had a showed return in 1992, the replacement rate further increased in 1995 with a CRR of 6.2.

CRR for Butte Creek are the most volatile of the three populations analyzed. Two of the three cohorts in Butte Creek are declining and have exhibited large variation in CRR between BY's (Table 13, Figure 29). The third cohort (BY lineage 1995) exhibited as strong CRR of 10.3. In 1995, 7500 adults returned to spawn. The fate of the 1995 BY will be assessed this year.

For all three populations, there has been a large variability in CRR from generation to generation. This pattern of high variability between BYs has been observed for spring-run chinook salmon in the Klamath-Trinity basin and for fall-run chinook salmon in the San Joaquin River system. In the latter case, the population historically exhibited extreme inter-annual variability in population size with no obvious trend. The population then plummeted.

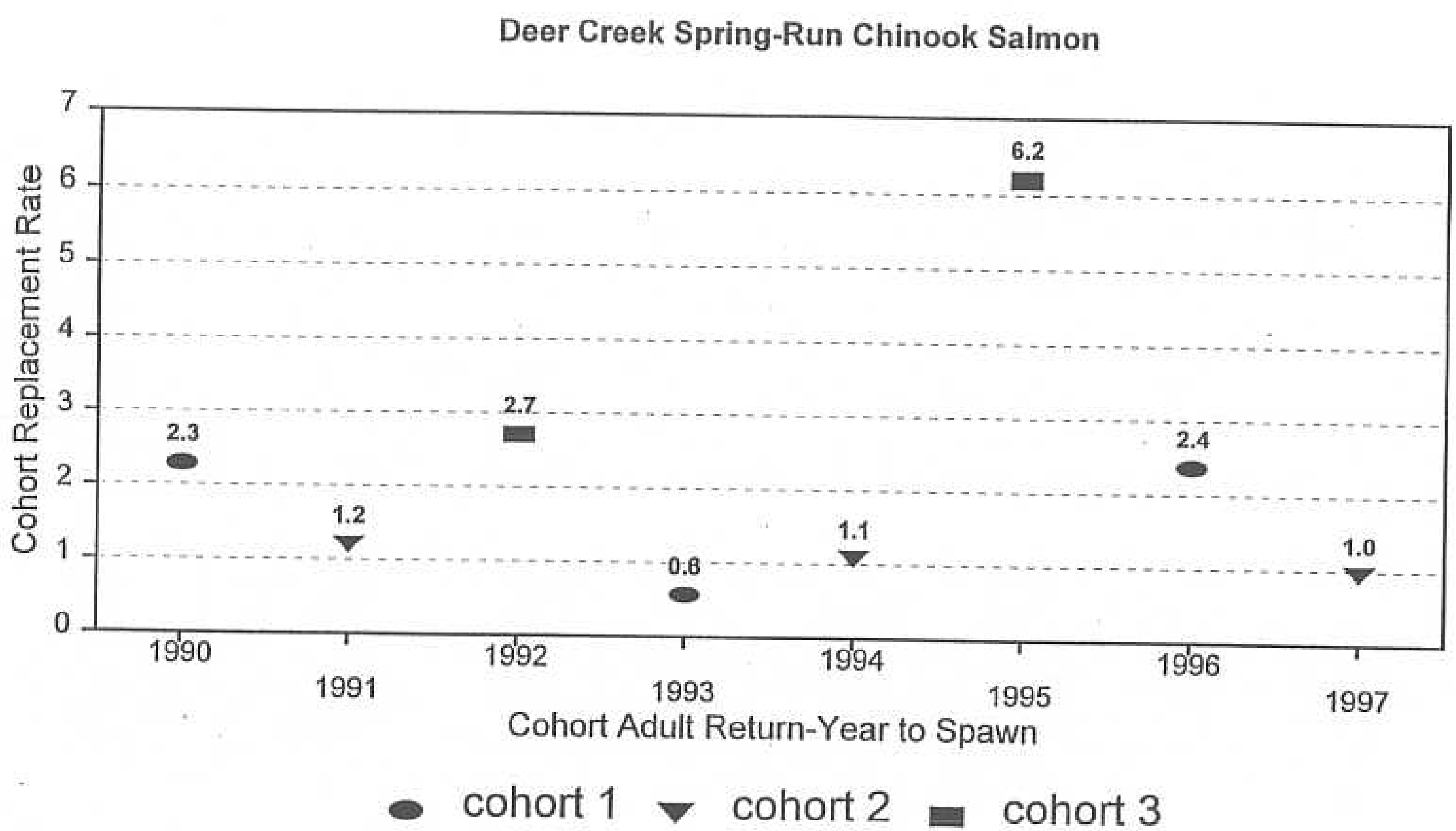
Degree and Immediacy of Threats

The continuing population decline, overall low population abundance, fluctuating CRR, and restricted range place Sacramento River spring-run chinook salmon at risk of becoming endangered in the foreseeable future absent special protection and management efforts. Significant efforts have recently been and continue to be expended to restore habitat in natal tributaries and the Sacramento River below Keswick Dam. These actions are expected to benefit Sacramento River spring run (see this report's section on existing and future management efforts). For each BY lineage in each tributary, it takes a minimum of three years (the length of time for a cohort to emigrate to the ocean, mature, and return to freshwater to spawn) after a significant impact occurs, whether positive or negative, before a population response can be assessed. It will take several generations before a change in population trend can be determined.

Demographic and genetic risks due to the Sacramento River spring run's small population sizes are considered to be high. Given the low population size over many generations and relatively isolated nature of sub-populations from one another, Sacramento River spring-run chinook salmon may have already experienced detrimental genetic effects, such as increased inbreeding and the consequent lowered immediate fitness and loss of genetic variation that may result in a lower long-term fitness and reduced adaptive potential (Hedrick et al. 1994). The total annual abundance of adult Sacramento River spring run (Mill, Deer, Butte, Big Chico, Antelope, and Battle creeks combined) since 1989 has ranged from 867 to 2,282 fish, with the exception of adult returns in 1995 when 7,500 adults returned to Butte Creek alone. A minimum spawning population of 400 to 1,000 fish is considered necessary to maintain genetic diversity in the winter-run chinook salmon population (52 Federal Register 6041), which consist

Table 12. Deer Creek Chinook Salmon Cohort Replacement Rate.

Cohort	Broodyear	Cohort Replacement Rate
1	1990	458 ÷ 200 = 2.3
2	1991	448 ÷ 371 = 1.2
3	1992	209 ÷ 77 = 2.7
1	1993	259 ÷ 458 = 0.6
2	1994	485 ÷ 448 = 1.1
3	1995	1295 ÷ 209 = 6.2
1	1996	614 ÷ 259 = 2.4
2	1997	466 ÷ 485 = 1.0

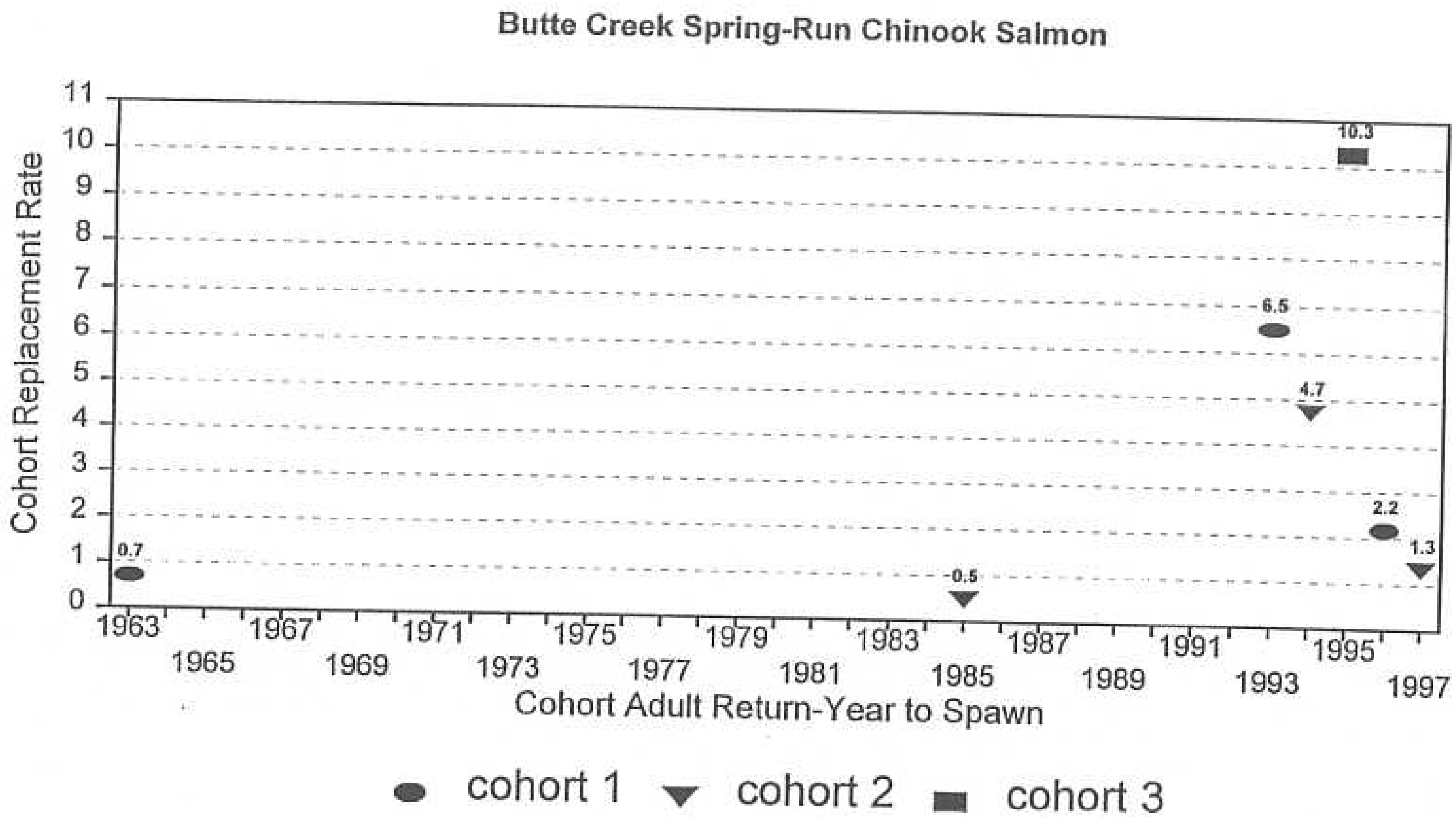


A CRR of 1.0 or greater represents a self-sustaining population in a constant environment. A value of 1.0 means the cohort has simply replaced itself. Values greater than 1.0 means the cohort abundance is increasing. Values less than 1.0 mean the cohort abundance is decreasing.

Figure 28. Cohort replacement rates (CRR) for Deer Creek calculated from spawning abundance estimates.

Table 13. Butte Creek Spring-run Chinook Salmon Cohort Replacement Rate.

Cohort	Broodyear	Cohort Replacement Rate
1	1963	6100 ÷ 8700 = 0.7
2	1988	254 ÷ 534 = 0.5
1	1993	650 ÷ 100 = 6.5
2	1994	474 ÷ 100 = 4.7
3	1995	7500 ÷ 730 = 10.3
1	1996	1413 ÷ 650 = 2.2
2	1997	635 ÷ 474 = 1.3



A CRR of 1.0 or greater represents a self-sustaining population in a constant environment. A value of 1.0 means the cohort has simply replaced itself. Values greater than 1.0 means the cohort abundance is increasing. Values less than 1.0 mean the cohort abundance is decreasing.

Figure 29. Cohort replacement rates (CRR) for Butte Creek calculated from spawning abundance estimates.

of a single breeding population in the upper Sacramento River. Hedrick et al. (1994) noted that a recent re-evaluation of minimum effective population size suggests a population of 5,000 adults may be more appropriate in order to maintain adequate potential adaptive variation.

VII. FACTORS AFFECTING ABILITY TO SURVIVE AND REPRODUCE

Spring-run populations have continued to decline, long after the historic loss of upstream spawning habitat occurred. The Department has concluded that the continuing decline in recent decades is due to a combination of physical, biological, and management conditions as discussed below.

Impacts from Climatic Variation

Weather and ocean conditions can vary substantially in California from year to year. Droughts are a natural phenomenon in California's arid, Mediterranean climate. Tree-ring analysis indicates 11 multi-year droughts in the Central Valley from the mid-16th century through the end of the 19th century (Roos 1992: as cited in NMFS 1997). Since 1906, when continuous collection of data on streamflow, runoff, and precipitation for Central Valley streams began, droughts have occurred from 1918-20, 1929-34, 1976-77, and 1985-94. The most recent drought was continuous with the exception of record outflows in February 1986 and an above-normal water year in 1993. Populations in Mill and Deer creeks dropped to all-time lows during this period. The Butte Creek population did not noticeably increase or decrease during the last drought.

Historically, spring-run populations were likely affected by droughts, but they were sufficiently abundant and resilient so they could survive and rebound after each event. Today, the small, isolated populations of spring run must survive drought conditions which are significantly exacerbated by current degraded habitat conditions, modern-day water supply and delivery systems, and other factors which diminish their survival. Drought conditions cause a natural decrease in runoff, inflow, and thus outflows. Water management operations during the last drought resulted in an increased proportion of inflowing water being diverted by water projects. Increasing the proportion of water diverted degrades physical habitat conditions and increases the risk of entrainment to unscreened diversions and to the central and southern Delta where survival is significantly reduced. The management of water within the Sacramento River and Delta was a primary factor precipitating the endangered status of the winter-run chinook salmon population (NMFS 1997). For adult spring run, reduced flows retarded or completely blocked access to natal tributaries for spawning and stranded adults as they moved upstream to holding areas. Reduced flows also impacted adults, eggs, and juveniles through elevated water temperatures.

Climate fluctuations affect ocean habitat conditions as well. During the period from 1989-92, there were indications of poor ocean conditions off California for salmon. Fall-run chinook salmon spawning escapements throughout California in 1992 were among the lowest on record. In contrast, the 1992-93 ocean conditions were very favorable for salmon, especially south of San Francisco. California's recreational ocean salmon landings for 1995 were the highest on record, especially from Monterey southwards, where landings were eight times the average of the previous five years (PFMC 1998).

The weather phenomenon of El Niño is having a major impact on California's ocean and weather patterns in 1998. With elevated ocean temperatures off central and northern California, salmon mortality could be increased. Ocean survival could be significantly reduced by immigration of warmer water predators such as mackerel; low food supplies due to decreased survival of prey species or increased competition from warm water immigrants; increased susceptibility to disease and infection; or, most likely, a combination of these and other factors. Also, California's salmon runs could emigrate to cooler water temperatures, north of the Oregon/California Border.

In addition to droughts and El Niño events, the Central Valley periodically experiences major flood events such as occurred in 1997. The catastrophic flooding and scouring flows of January 1997 may have caused significant mortality to incubating eggs and pre-emergent fry in Mill and Deer creeks since fry in those creeks do not typically begin emerging from the gravels until January. The high flows may have had a lesser negative effect on spring-run salmon eggs and fry in Butte and Big Chico creeks, fry in these creeks begin to emerge in late November. Though the high flows swept nearly all Butte and Big Chico creeks' fry downstream, some probably survived by rearing in the Sutter Bypass or other tributaries of the mainstem Sacramento River.

In summary, while healthy, abundant runs of chinook salmon have the capacity to rebound successfully from unfavorable climatic and oceanic events, severely diminished runs lack the resiliency to tolerate catastrophic population reductions and rebound from such events.

Competition and Hybridization

Historically, the spring-run salmon migration in the upper river and tributaries extended from mid-March through the end of July with the peak of migration in late May and early June (Table 2). Spawning started in mid-August and ceased in late September, peaking in early September. The peak of spawning between spring- and fall-run salmon were almost two months apart. Under natural conditions (before access was cutoff to many headwater spawning areas due to dams and water diversions), spring-run salmon were spatially isolated from fall-run chinook as well as temporally isolated during spawning from winter run. It was this spawning isolation, in time and space, although not absolute, that maintained the integrity of spring-run populations.

After the completion of Shasta Dam, spring run were no longer able to ascend headwater streams. Fish were stopped at Keswick Dam and spawned in the same area that fall run historically spawned. Immediately after Shasta Dam was completed, a distinct spring run and a distinct fall run was evident (Moffett 1947). Moffett (1947) writes:

> "These salmon began spawning late in August but only scattered females occupied the beds until early September when the peak of egg deposition occurred. Spring-run salmon had virtually completed spawning by the end of September; a full six weeks before the fall-run spawning peak was reached."

About 15 years later, Slater (1963) speculated that there was a greater overlap in the time of spawning between the spring run and fall run than was noted by Moffett (1947) and Stone (1896). Slater hypothesized that early fall run were competing with spring run and that hybridization had occurred. Slater (1963) states:

> "The spring run...is only well started spawning before the early fall-run spawners move in to compete for nest sites. This competition, plus the indicated hybridizing of the spring and fall races, appears to have held down the spring run, perhaps even to have eliminated it as a distinct race in the mainstem Sacramento River. Such hybridizing could not readily be detected through routine field observation,

> for the hybrids would continue to enter the river in both spring and fall and to spawn throughout the overlapping spawning periods. The status of the spring run in the mainstem is thus speculative. Suffice it to state that spring-run chinook salmon have not been noted to have been abundant in the mainstem Sacramento River during the summer holding period of recent years. Small runs of spring-run fish still ascend such tributaries as Mill and Deer creeks however."

Cope and Slater (1957) noted what could have been introgression of spring- and fall-run salmon. They marked spring- and fall-run salmon at CNFH and subsequently recovered these fish in the gill-net fishery in the Delta. Of the 179 recovered fish released as fall run salmon, 81% were identified as fall run and 19% were identified as spring run. Of the 18 recovered fish released as spring-run salmon, 83% were recovered as spring run and 17% were recovered as fall run.

Migration of adults termed "spring-run" passing RBDD is now protracted, starting in March and ending in October (Table 14, Figure 1). The pronounced spring run that passed Redding is no longer identifiable. In contrast, there is still a pronounced fall run passing RBDD (Figure 30). The early spawning, indicative of spring run in the mainstem Sacramento River above Red Bluff as was observed by Moffett (1947) and to some extent Slater (1963), is gone. Currently, aerial redd flights of the spawning habitat in the mainstem have found little or no spawning in the river in August or September when spring-run salmon historically spawned. Under present-day conditions, few salmon migrating to and remaining in the Sacramento River above RBDD are characteristic of the spring-run salmon observed by Moffett (1947) and Slater (1963). Still, there are some spring run that migrate past RBDD that are destined for upper river tributaries.

Hatchery practices probably have also contributed to the intermixing of fall run and spring run in the Sacramento River system. There were early failed attempts to propagate spring-run chinook salmon beginning at the end of the 19th century. The U.S. Fish Commission operated a hatchery on Battle Creek beginning in 1896. This hatchery was initially built by the California Fish Commission (CFC) in 1895 and transferred to the U.S. Fish Commission in 1896. Records (U.S. Fish Commission 1896-1908) indicate that only fall-run eggs were propagated at the hatchery. These eggs were obtained from either a fish rack or seining near the mouth of Battle Creek generally from October until January. In 1901 hatchery records indicate:

> " A large run of fish came into the seining-pool during the late spring and early summer, but owing to the extreme heat they died without ripening. The experiment proved that there is a large summer run [now termed spring run] of fish in the creek, but it also proves that it is impossible to secure eggs from this run at the Battle Creek Station."

After CNFH was built in 1944 and replaced the Battle Creek Station, another attempt was made to propagate spring-run salmon eggs. From 1943-51, adult salmon were collected either in Battle Creek or transferred from Balls Ferry and Keswick Fish Trap on the Sacramento River. Dates of collection were September and October. In 1950 CNFH stopped collecting "spring-run" eggs due to the excessive mortality of the adults in the warm September and early October water temperatures.

FRH was built by the California Department of Water Resources (DWR) to mitigate for the loss of habitat upstream of Oroville Dam. The hatchery was dedicated on October 1, 1967 and is

Table 14. Migration Timing of Spring-run and Fall-run Chinook Salmon. Historic Distribution for Spring-run Based on Composite of Data from Mill and Deer Creeks, Feather River, and the Upper Sacramento River Prior to Shasta Dam. Present Distributions for Spring-run and Fall-run Migrating Past RBDD Using a Composite of Data for Years 1970-1988.

Percent of Adults Migrating Upstream Per Week			
Week	Spring run at RBDD	Spring run Historic	Fall run at RBDD
March 19	0.1%	0.1%	
March 26	0.3%	0.0%	
April 2	0.6%	0.3%	
April 9	1.0%	0.6%	
April 16	1.4%	0.9%	
April 23	1.6%	1.3%	
April 30	1.6%	2.8%	
May 7	1.7%	6.7%	
May 14	2.2%	13.1%	
May 21	2.6%	9.4%	
May 28	2.9%	15.1%	
June 4	2.6%	14.0%	
June 11	2.9%	13.3%	
June 18	3.5%	8.3%	
June 25	3.1%	5.1%	0.1%
July 2	3.7%	4.1%	0.1%
July 9	6.0%	1.9%	0.2%
July 16	4.8%	1.1%	0.4%
July 23	3.2%	0.9%	0.6%
July 30	4.1%	0.7%	0.8%
August 6	7.0%	0.1%	1.5%
August 13	6.1%	0.1%	2.3%
August 20	6.8%	0.1%	2.7%
August 27	5.7%		3.3%
Sept. 3	7.2%		4.4%
Sept. 10	6.7%		5.6%
Sept. 17	5.2%		8.3%
Sept. 24	3.7%		9.3%
October 1	1.2%		10.4%
October 8	0.7%		11.0%
October 15			9.6%
October 22			7.2%
October 29			7.1%
Nov. 4			5.2%
Nov. 12			3.0%
Nov. 18			2.6%
Nov. 25			1.9%
Dec. 3			1.0%
Dec. 10			0.8%
Dec. 17			0.6%

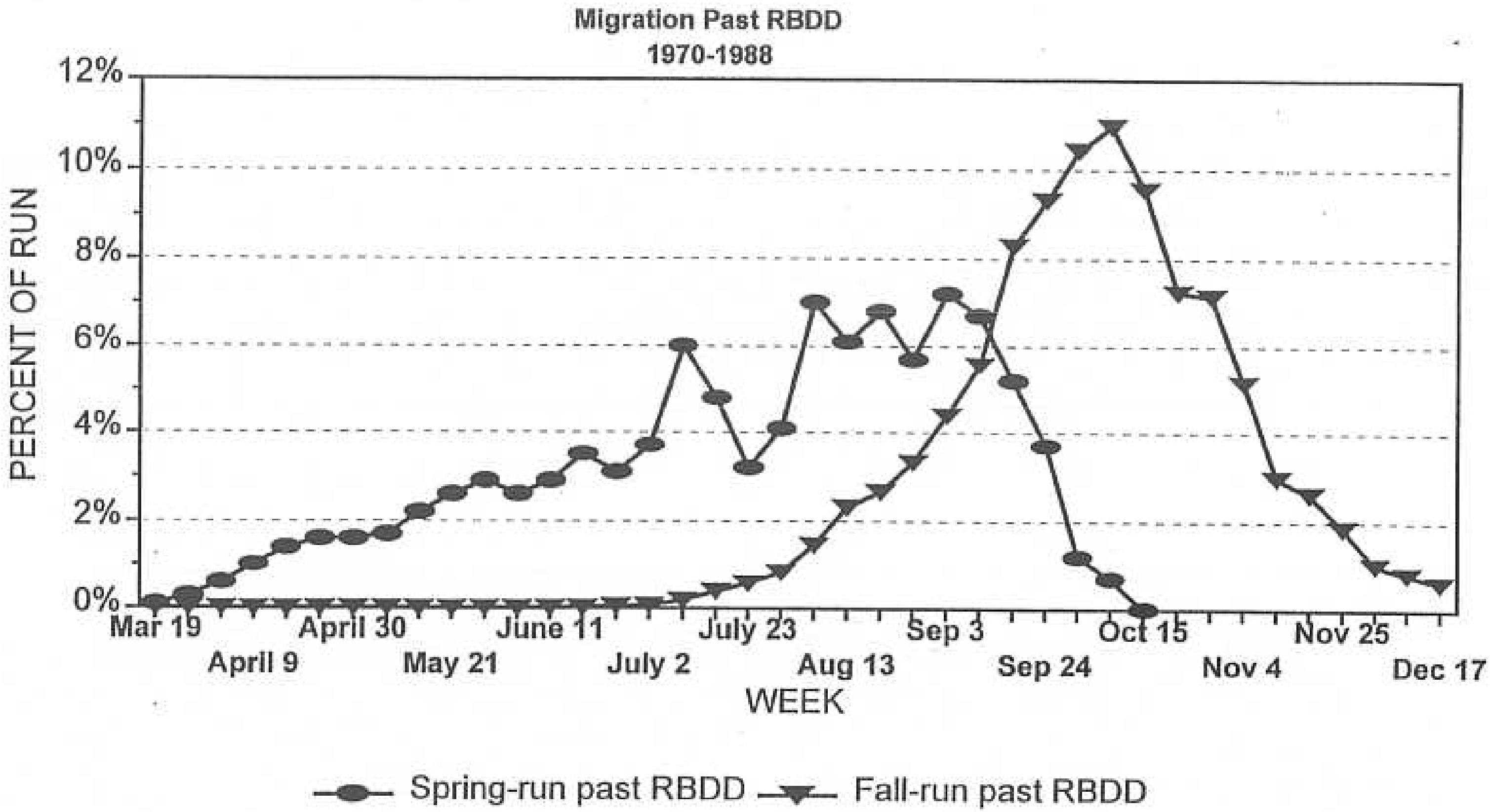


Figure 30. Migration of spring-run and fall-run chinook salmon past RBDD using a composite of the years 1970-1988.

operated by the Department. During the five-year period prior to the opening of the hatchery (1962-66) all adult salmon were trapped and transported above the site of Oroville Dam. During 1968 and 1969 spring-run salmon were allowed to enter the hatchery as soon as they arrived in the river, as early as April and May. The result was significant mortality, due to the inability to hold adults for several months until they were ready for spawning, with greater than 50% losses. As a result, since 1970 hatchery policy has been to exclude spring run entry to the facility until onset of spawning, the period August through October (generally early September to October 1). This practice has resulted in the inability to clearly identify spring-run chinook based on their adult upstream migration timing, which historically has been described as occurring between late February and June. As described earlier in this report, their actual time of spawning overlaps with fall run. Evidence suggests that introgression with fall run in the Feather River actually occurred prior to Oroville Dam, due to early hydropower and agricultural diversions blocking access to spring-run spawning habitat in the upper watershed. Since the hatchery program's inception, practices have fostered this intermixing of fall run and spring run in the Feather River and within the hatchery (Brown and Greene 1993), which has been substantiated by CWT returns (Tables 7 and 8). The pronounced spring-run population increase in 1982 is largely believed to be the result of extending, perhaps arbitrarily, the cutoff date for spring run entering the hatchery (D. Schlicting, pers. com.).

Brown and Greene (1993) reported that approximately 22% of hatchery juveniles tagged as fall run were subsequently identified and spawned in 1988 as spring run when they returned as adults. They reported similarly that approximately 29% of juveniles tagged as spring-run were subsequently identified and spawned as fall-run adults. Subsequent evaluation of fall- and spring-run chinook salmon returns for the entire period 1987-94, further substantiates the magnitude of the overlap (Tables 7 and 8). During 1987, 74% of the adults which had previously been tagged and released as spring run, returned and were identified and spawned as fall run.

During 1994, to assess the current numbers of spring-run chinook which exhibited spring-run adult migration timing, the fish ladder remained open until April 15, was closed and reopened on May 16 and remained open until June 6. Prior to June 6, only one fish had entered the hatchery (on May 23). On June 6, 31 fish entered the hatchery and the ladder was closed (F. Fisher, pers. com.). The implication is that few fish exhibiting the "typical" spring-run salmon adult migration timing existed in the Feather River during 1994. The subsequent spring-run population which entered the hatchery when the ladder was reopened on September 6, 1994, was 3,641.

Today, FRH salmon appear to have an intermixed life history pattern. In 1982, early returning fall-run salmon were observed at RBDD and subsequently identified from FRH CWT as fall run from the 1980 BY. Now it is common place to intercept fish tagged as fall run at RBDD during the spring-run migration (mid-March through the end of July). This intermixed life history pattern was evident when FRH fish were used in an attempt to re-establish spring run in Clear Creek. More than 523,000 FRH spring-run fry were planted at the base of Whiskeytown Dam during the three-year period 1991-93 (Table 15). A portion of the fish were marked. Since 1993, snorkeling surveys have been performed during the adult spring-run holding period to determine if the plants were successful. Three unmarked salmon were observed during the spring-run adult holding period in 1993 and two in 1995. However, 23 CWT adults returned between 1993 and 1995 during the adult fall-run spawning migration.

Based on the conclusion that hatchery practices have resulted in the hybridization of fall- and spring-run chinook salmon in the Feather River and in the FRH, it is recommended that both

Table 15. Feather River Fish Hatchery - Records of Spring-run Chinook Salmon Production

BROOD YEAR	HATCHERY ENTRY / SPAWN	DATE PLANTED	TOTAL NUMBER PLANTED	SIZE	MARK	PLANTING SITE
1969	E May (112) Aug. (233), S (121)	Oct.-Nov. 1970	71,900	45-50 g	None	Feather River
1970	E Aug.13-25 (235), S (65)	Jan. 1971	26,500	1.0 g	None	Feather River
		Nov.-Dec. 1971	233,000	7.0-7.6 / lb	None	Feather River
1971	E Aug. 30-31 (484) S Oct. 6 (211)	Mar. 1972	32,000	800/lb	None	Feather River
		Nov.-Dec. 1972	101,000	44.8-74.5 g	None	Feather River at Yuba City
		Jan.-Feb. 1973	66,605	99.4-112.0 g	None	Feather River at Yuba City
1972	E Sep. 6 -Oct. 1 (256) S Oct. 4-18 (90)	June 1973	50,000	11.2 g	None	Feather River at Yuba City
		Sep.-Dec.1973	211,459	25-56 g	None	Feather River at Live Oak
1973	E Sep. 1-25 (205) S Oct. 1-31 (98)	May 1974	61,600	6 g	None	Sacramento River at Rio Vista
		Oct.-Dec. 1974	175,100	29-45 g	None	Feather River at Gridley/Marysville
1974	E Sep. 3-5 (198) S Oct. 4-21 (29)	Jan. 1976	118,800	63 g	LP-RV	Feather River at Gridley
1975	E Sep. 2-11 (691) S Oct.3-30 (309)	May-June 1976	487,550	5-7 g	None	Sacramento River at Rio Vista
		Dec. 1976	90,825	75.6 g	CWT No. 060107	Feather River at Feather River Hatchery
		Dec. 1976	60,010	63 g	None	Feather River at Gridley

Table 15. (Continued).

BROOD YEAR	HATCHERY ENTRY / SPAWN	DATE PLANTED	TOTAL NUMBER PLANTED	SIZE	MARK	PLANTING SITE
1976	E Sep. 2-15 (713) \$ Sep.26-Oct.25 (354)	Jan. 1977	93,500	44 g	None	Feather River at Oroville
		May 1977	355,950	6-8 g	None	Sacramento River at Rio Vista
		Oct. - Nov. 1977	74,840	50-56 g	None	Feather River at Boyds Pumps
		Dec. 1977 - Jan. 1978	71,105	75-90 g	CWT No. 065809	Feather River at Feather River Hatchery
1977	E Aug.24-30 (121), - Sep. 16 (73) \$ Sep.30-Oct.31 (95)	Oct. 1978	24,000	37 g	Dye	Feather River at Verona
		Dec. 1978	54,700	64.8 g	CWT No. 065811	Feather River at Verona and Yuba City
		Jan. 1979	50,046	56 g	CWT No. 065812.	Feather River at Verona
1978	E Sep.6-Oct.10 (202) \$ Oct.2-30 (32)	Oct. 1979	86,300	56 g	None	Feather River at Hatchery
1979	E Sep. 4-28 (250) \$ Sep. 28-Oct 10 (167)	May. 1980	465,325	7 g	None	Sacramento River at Rio Vista
		July 1980	15,925	34 g	None	Yuba River at Nelson Bar
		Oct. 1980	139	60 g	None	Feather River at Feather River Hatchery
1980	E Sep 1-22 (122) \$ Sep. 22-Oct.31 (41)	Oct.-Nov. 1981	129,000	45 g	None	Feather River at Feather River Hatchery

Table 15. (Continued).

BROOD YEAR	HATCHERY ENTRY / SPAWN	DATE PLANTED	TOTAL NUMBER PLANTED	SIZE	MARK	PLANTING SITE
1981	[E] Sep.1-Oct. 1 (469) [S] Oct. 1. Nov.3 (132)	May 1982	47,250	11 g	CWT No. 065828	Sacramento River at Maritime Academy
		Nov. 1982	260,988	76 g	None	Feather River at Feather River Hatchery
1982	[E] Sep. 1-30 (1910) [S] Oct. 1-26 (426)	Jan. 1983	106,600	0.33 g	None	Yuba River
		Jan. 1983	106,600	0.33 g	None	Butte Creek
		Jan. 1983	205,000	0.33 g	None	Antelope Creek
		Feb. 1983	110,200	1.9 g	None	Chico Creek
		May 1983	46,550	9 g	CWT No. 065836	Sacramento River at Vallejo
		June 1983	251,500	11 g	None	Sacramento River at Vallejo
		Sept. 1983	336,809	52 g	None	Feather River at Hatchery
1983	[E] Sep. 1-29 (1712) [S] Sep. 29 - Oct. 31 (866)	Feb. 1984	212,520	1.7 g	None	Chico Creek
		Feb. 1984	199,956	1.8 g	None	Butte Creek
		Feb. 1984	302,733	1.5 g	None	Antelope Creek
		Feb. 1984	261,120	0.7 g	None	Feather River at Hatchery
		Mar. 1984	51,000	7.4 g	CWT No. 065846	Sacramento River at Vallejo
		May 1984	142,400	7.2 g	None	Sacramento River at Vallejo
		May 1984	157,400	9.1 g	None	Sacramento River at Vallejo
		June 1984	652,300	10.5-17.9 g	None	Sacramento River at Vallejo
		June 1984	2,000	5.6 g	None	Sacramento River at Glenn-Colusa
		Sept. 1984	72,750	28 g	None	Sacramento River at Vallejo

Table 15. (Continued).

BROOD YEAR	HATCHERY ENTRY / SPAWN	DATE PLANTED	TOTAL NUMBER PLANTED	SIZE	MARK	PLANTING SITE
1984	[E] Sep. 1-Oct. 1 (1562) [S] Oct. 1-21 (459)	Feb. 1985	76,800	1.2 g	None	Dry Creek
		Feb. 1985	77,400	1.3 g	None	Auburn Ravine
		Feb. 1985	77,400	1.3 g	None	Doty Ravine
		Feb. 1985	96,800	1.2 g	None	Yuba City
		Feb. 1985	104,720	0.7 g	None	Coon Creek
		Feb. 1985	100,280	1.0 g	None	Secret Ravine
		Apr. 1985	53,179	3.3 g	CWT No. B61002	Big Chico Creek
		Apr. 1985	52,278	3.4 g	CWT No. B61001	Feather River at Feather River Hatchery
		Apr. 1985	32,400	6.2 g	None	Butte Creek
		Apr. 1985	50,117	8.4-8.9 g	CWT No. 065853 065854	Monterey Bay
1984	[E] Sep. 1-29 (1712) [S] Sep. 29-Oct. 31 (866)	Apr. 1985	24,996	7.9 g	CWT No. 065855	Sacramento River at Vallejo
		May 1985	1,100	4.4 g	None	Feather River
		May-June 1985	832,820	10.6-21.3 g	None	Sacramento River at Vallejo
		Sept. 1985	257,350	28.0 g	None	Sacramento River at Vallejo

Table 15. (Continued).

BROOD YEAR	HATCHERY ENTRY / SPAWN	DATE PLANTED	TOTAL NUMBER PLANTED	SIZE	MARK	PLANTING SITE
1985	E Sep. 1-Oct 1 (1632) S Sep. 30 - Oct. 21 (589)	Mar. 1986	105,868	2.2 g	CWT No. B61003	Big Chico Creek
		Mar. 1986	104,895	2.3 g	CWT No. B61004	Feather River at Gridley
		Mar.-May 1986	1,372,600	6.3-7.4 g	None	Sacramento River at Benicia
		July 1986	278,600	15.2 g	None	Sacramento River at Benicia
		Aug.-Sept. 1986	440,725	18.6-24.8 g	None	San Francisco Bay
		Oct. 1986	184,800	37.3 g	None	Feather River
1986	E Sep. 1-Oct. 1 (1433) S Sep. 30-Oct. 21 (408)	Mar. 1987	106,270	4.0 g	CWT No. B61005	Big Chico Creek
		Mar. 1987	102,279	3.7 g	CWT No. B61006	Feather River at Hatchery
		Apr. June 1987	1,052,100	7.9-14.4 g	None	Sacramento River at Benicia
		July-Aug. 1987	526,090	16.5-20.0 g	None	Sacramento River at Benicia/Mare Island
1987	E Sep.2-Oct. 1 (1213) S Oct.2-19 (208)	Feb. 1988	60,400	1.7 g	None	Big Chico Creek
		Mar.-May 1988	803,575	8.4-16.5 g	None	Sacramento River at Benicia/Berkeley

Table 15. (Continued).

BROOD YEAR	HATCHERY ENTRY / SPAWN	DATE PLANTED	TOTAL NUMBER PLANTED	SIZE	MARK	PLANTING SITE
1988	[E] Sep. 7 - Oct. 1 (6833) [$] Sep. 28 - Oct. 13 (1652)	Dec. 1988	502,000	0.4 g	None	Big Chico Creek
		Dec. 1988	293,000	0.4 g	None	Feather River
		Feb. 1989	1,515,500	2.5 g	None	Mokelumne Hatchery
		Apr. 1989	909,200	4.0 g	None	Feather River
		Apr.-Aug. 1989	3,910,450	5.8-20.3 g	None	Sacramento River at Benicia
1989	[E] Sep. 7- Oct. 1 (5078) [$] Oct. 4-20 (1520)	Jan. 1990	178,500	0.3 g	None	Feather River
		Jan. 1990	150,384	0.7 g	None	Chico Creek
		Jan. 1990	966,500	1.1 g	None	Mokelumne Hatchery
		Apr. 1990	719,000	3.4 g	None	Feather River
		Apr.-Aug. 1990	2,603,300	10.6-22.4 g	None	Sacramento River at Mare
1990	[E] Sep. 7-Oct. 1 (1893) [$] Sep. 28-Oct.13 (580)	Feb. 1991	60,000	0.4 g	None	Clear Creek
		Mar. 1991	200,032	2.4 g	None	Clear Creek
		June-Aug. 1991	1,684,850	14.0-26.3 g	None	Sacramento River at Benicia
1991	[E] Sep.7-Oct. 1 (3,448) [$] Sep. 28-Oct. 3 (1491)	Feb. 1992	201,020	2.1 g	None	Big Chico Creek
		Mar. 1992	205,359	3.0-3.5 g	CWT No. 0601120101 0601120102	Clear Creek
		May-June 1992	2,198,075	7.7-7.9 g	None	Sacramento River at Benicia
1992			112,926	2.5 g	CWT No. 0601120103 0601120104	Clear Creek

populations of spring run be considered introgressed. However, it is important to note that fish still exhibiting spring-run characteristics (e.g. early ascending and egg maturity) appear at the FRH. FRH spring run have been documented as straying throughout the Central Valley for many years (Tables 16 and 17) and have intermixed with wild-spawned spring run in the upper Sacramento River, though the extent of hybridization has not been determined. The estimates of adults returning as "spring-run" at RBDD contain these introgressed FRH fish.

Questions regarding the viability and genetic integrity of the Butte creek spring-run salmon continue to surface, particularly in light of the interconnectivity of Butte Creek and the Feather River with the potential for intermixing of the two populations. Butte Creek has several different sources of introduced water, including West Branch Feather River water, mainstem Feather River water, and Sacramento River water. Given the interconnectivity, it is conceivable that some spring-run salmon in Butte Creek could be strays from the Feather River. Examination of the relative numbers of adult spring run entering Butte Creek and FRH, for the period 1964-91, however, does not show a strong relationship and would suggest that they are generally independent.

FRH spring-run fry and juveniles have been released over the years in various locations within the Central Valley (Table 15). Fry and juveniles were released into Butte Creek during 1983, 1984, and 1985 (BY's 1982, 1983, and 1984 respectively). Only BY 1983 releases seem to have affected resultant year-classes, showing large increases in BY 1986 and BY 1989. There was a significant reduction in adult returns for BY 1992 but BY 1995 was the largest observed (7500 adults) since 1960.

During the 1977 drought, adult spring run were trucked from RBDD to Mill, Deer, and Butte creeks. No appreciable effect was seen in the subsequent year class (1980) on Butte and Mill creeks, however there was an apparent single year (1980) increase in the Deer Creek population. The Yuba River was planted with surplus FRH spring run in 1980 (15,925), 1983 (106,600), and 1985 (96,800). In 1980, fish were planted as fingerlings, weighing 34.4 g. Fry were planted in 1983 (weighing 0.33 g) and in 1985 (weighing 1.2 g). Influence of these three introductions on subsequent adult spring-run returns cannot be determined since escapement surveys were not conducted. The extremely small size of the fish planted in 1983 and 1985 significantly decreased their ability to survive, whereas conclusions cannot be drawn regarding the success of the 1980 fingerling plants. In 1984, Antelope Creek was planted with 302,733 FRH juvenile spring run. In 1985, the creek was again planted with 205,000 juveniles. Presently, there is no persistent population of spring run in Antelope Creek, thus the effect of hatchery supplementation in this drainage is now irrelevant.

Disease

Few studies have specifically investigated disease problems in wild adult or juvenile spring-run chinook salmon in California. From hatchery programs at Trinity River Hatchery, CNFH, and the FRH, it is known that spring run are affected by the same pathogens as other runs of chinook salmon (W. Cox, pers. com.). For the Sacramento River basin, pathogens which are known to be endemic and have caused serious health problems in Central Valley hatcheries include Infectious Hematopoietic Necrosis Virus (IHNV), *Renibacterium salmoninarum* (bacterial kidney disease), *Yersinia ruckeri* (enteric redmouth disease), *Flexibacter columnaris* (columnaris disease), *Ceratomyxa shasta* (ceratomyxosis), *Bacterium salmonicida* (furunculosis), and *Ichthyopthirius multifiliis* (Cox 1993). Adults entering in spring months must reside in freshwater for several months prior to spawning. Health problems, such as external fungal infections,

Table 16. Recovery of Coded-wire Tagged Fish at Red Bluff Diversion Dam for Years 1995-1997 (CNFH= Coleman National Fish Hatchery, FRH= Feather River Hatchery, Clr= Clear Creek, Stew= Stewart Road, Delta.)

Date Captured	Brood Year	Race Tagged As	Hatchery of Origin	Released At	Date Captured	Brood Year	Race Tagged As	Hatchery of Origin	Released At
05/28/95	1992	Spring	FRH	Clr	07/25/95	1992	Spring	FRH	Clr
05/28/95	1992	Spring	FRH	Clr	07/28/95	1992	Spring	FRH	Clr
05/19/97	1994	Fall	CNFH	CNFH	07/01/96	1992	Spring	FRH	Clr
05/26/97	1993	Fall	FRH	Ryde	07/15/96	1992	Spring	FRH	Clr
06/06/95	1992	Spring	FRH	Clr	07/15/96	1993	Fall	CNFH	CNFH
06/13/95	1992	Spring	FRH	Clr	07/01/97	1993	Fall	FRH	Ryde
06/14/95	1992	Fall	FRH	Ryde	07/08/97	1993	Fall	FRH	Ryde
06/27/95	1992	Spring	FRH	Clr	07/08/97	1993	Fall	CNFH	CNFH
06/03/96	1992	Spring	FRH	Clr	07/15/97	1992	Spring	FRH	Clr
06/03/97	1994	Fall	FRH	Stew	07/17/97	1994	Fall	CNFH	CNFH
06/09/97	1993	Fall	CNFH	CNFH	07/20/97	1993	Fall	CNFH	CNFH
06/27/97	1993	Fall	CNFH	CNFH	07/21/97	1992	Spring	FRH	Clr
07/07/95	1992	Fall	FRH	Ryde	07/30/97	1994	Fall	CNFH	RBDD
07/09/95	1992	Fall	CNFH	CNFH	08/02/95	1992	Spring	FRH	Clr
07/10/95	1992	Spring	CNFH	Clr	08/15/95	1992	Spring	FRH	Clr
07/10/95	1992	Spring	FRH	Clr	08/07/97	1994	Fall	CNFH	CNFH
07/17/95	1992	Spring	FRH	Clr	08/08/97	1993	Fall	CNFH	CNFH
07/17/95	1992	Spring	FRH	Clr	08/14/97	1993	Fall	CNFH	RBDD
07/17/95	1992	Fall	CNFH	CNFH	08/15/97	1993	Fall	CNFH	CNFH
07/17/95	1992	Spring	FRH	Clr	08/21/97	1994	Fall	CNFH	RBDD
07/22/95	1992	Fall	CNFH	CNFH	09/05/97	1993	Fall	CNFH	CNFH

Table 17. Summary of Recovered Coded-wire Tagged Feather River Hatchery Spring-run Chinook Salmon Released Into the Upper Sacramento River System from 1976 through 1996.

			NUMBER RELEASED					NUMBER RECOVERED AT LOCATION														
CWT CODE	YEAR OF RELEASE	RELEASE TRIBUTARY	Tagged	Untagged	Total	YEAR OF RECOVERY	AGE AT RECOVERY	CLR	CNFH	BAT	RBDD	TCFF	FRH	FEA	YUBA	NBFH	AMN	MRFI	TUO	MRFF	UNK	RCVR
060107	1976	Feather River	90,825	1,854	92,679	1977	2					1										1
						1978	3						34									34
						1979	4						84	16	1							101
						1980	5						1									1
065809	1977-1988	Feather River	71,105	2,963	74,068	1978	2						2									2
						1979	3						56	8	3							67
						1980	4					1	58	23	12							94
						1981	5						2									2
065811	1978	Feather River	54,700	2,811	57,511	1979	2						1									1
						1980	3					1	10		1							12
						1981	4					1	7	2								10
065812	1979	Feather River	50046	3754	53800	1979	2				3	1	25			1						30
						1980	3		1			5	56	3			1					66
						1981	4					1	29	1			1					32
B61001	1985	Feather River	48616	3662	52278	1986	2						30	2								32
						1987	3						149	2			1		1	1		154
						1988	4							25								25
B61002	1985	Big Chico Creek	47908	5271	53179	1989	5						1									1
B61003	1986	Big Chico Creek	98034	7834	105868	1987	2		3													3
						1988	3			3										1		4
						1989	4		2				1									3
B61004	1986	Feather River	100699	4196	104895	1987	2						29	1			1					31

Recovery Locations: CLR - Clear Creek; CNFH - Coleman Hatchery; BAT - Battle Creek; RBDD - Red Bluff Dam; TCFF - Tehama-Colusa Fish Facility; FRH - Feather River Hatchery; FEA - Feather River; YUBA - Yuba River; NBFH - Nimbus Hatchery; AMN - American River; MRFI - Mokelumne River Hatchery; TUO - Tuolumne River; MRFF - Merced River Hatchery; UNK - Unspecified;

Table 17. (Continued).

			NUMBER RELEASED					NUMBER RECOVERED AT LOCATION														
CWT CODE	YEAR OF RELEASE	RELEASE TRIBUTARY	Tagged	Untagged	Total	YEAR OF RECOVERY	AGE AT RECOVERY	CLR	CNFH	BAT	RBDD	TCFF	FRH	FEA	YUBA	NBFH	AMN	MRFI	TUO	MRFF	UNK	RCVR
						1988	3							307	14							321
						1989	4				27		10									37
						1990	5				1											1
B61005	1987	Big Chico Creek	102531	3739	106270	1988	2		2					1								3
						1989	3		3	2	9										1	15
						1990	4			1												1
B61006	1987	Feather River	98392	3887	102279	1988	2							8								8
						1989	3				110		7									117
						1990	4						25									25
0601120101	1992	Clear Creek	52626	50954	103580	1993	2				2											2
						1994	3	1		1	2											4
0601120102	1992	Clear Creek	50859	50920	101779	1993	4											1				1
						1994	5				2											2
0601120103	1993	Clear Creek	48416	7750	56166	1994					1											1
0601120104	1993	Clear Creek	50789	5971	56760	1994			1		2											3

Recovery Locations: CLR - Clear Creek; CNFH - Coleman Hatchery; BAT - Battle Creek; RBDD - Red Bluff Dam; TCFF - Tehama-Colusa Fish Facility; FRH - Feather River Hatchery; FEA - Feather River; YUBA - Yuba River; NBFH - Nimbus Hatchery; AMN - American River; MRFI - Mokelumne River Hatchery; TUO - Tuolumne River; MRFF - Merced River Hatchery; UNK - Unspecified;

protozoan, viral, and various gram-negative bacterial infections, encountered while holding winter-run chinook adults for two to five months at CNFH, may be similar to those facing spring-run adults due to their overlap in spawning migration time and extended holding behavior. Warm water can exacerbate a number of salmonid diseases (columnaris, furnunculosis, *Ichthyopthirius* infection, external fungal infections, enteric redmouth disease, and others) and can seriously reduce adult pre-spawning survival (Becker and Fujihara 1978, Inglis et al. 1992).

Ceratomyxosis

Adult spring-run chinook salmon entering the Sacramento River can be exposed to the intestinal parasite *Ceratomyxa shasta*, a pathogen which may cause pre-spawning mortality in adults due to severe enteritis. This adult and juvenile salmon pathogen is known to be endemic to the Sacramento, Mokelumne, and Feather rivers, as well as Butte Creek (Hendrickson et al. 1989). Warmer water temperatures will accelerate the progress of ceratomyxosis (Udey et al. 1975) and through stress mechanisms reduce the immune defenses of the fish (Maule et al. 1989). Winter-run chinook adults captured in spring and early summer from both the upper Sacramento River and Battle Creek have been observed to have a 27% to 50% incidence of *Ceratomyxa shasta* infection (USFWS, CA-NV Fish Health Center Inspection Records 1993 -97). Up to 40% of these infected fish were judged to be in later stages of this lethal disease. One presumptive spring-run adult sampled at the Battle Creek trap in 1997 was also infected with this enteric parasite. How and to what degree the disease affects juveniles which pass downstream and are exposed to the disease is not well known. *Ceratomyxa shasta* was not observed in histological samples taken from juvenile fall-run out migrants collected at Knight's Landing (primarily CNFH fish) and Chipps Island (unidentified origin) in April of 1996 and 1997.

Bacterial Kidney Disease (BKD)

Renibacteruim salmoninarum is the causative agent of BKD, which affects salmonid fishes worldwide. Infections tend to be chronic and often are lethal for Pacific salmon. This pathogen has been associated with mortality in both wild and hatchery chinook juveniles in the Columbia River basin (Elliott and Pascho 1992). Severe infections have been diagnosed in wild winter-run adults used as broodstock at CNFH. There was a 10% to 40% incidence of infection for the period from 1993-95. Of the eight presumptive spring-run adults tested by the CA-NV Fish Health Center for the *R. salmoninarum* antigen, only one fish had antigen concentrations indicative of an active infection.

Fungal agents

External fungal (*Saprolegnia sp.)* infections are the most serious cause of spring-run chinook salmon pre-spawning loss in Pacific Northwest hatcheries and probably affect wild spring-run chinook in California waters. Immunosuppression associated with senescence is a major factor in external fungal infections (Nash 1977). Rough handling of fish at weirs for tagging or other purposes, or in hatchery programs, could predispose these fish to fungus and place them at high risk for prespawning mortality.

Rosette Agent

A systemic protist called the "rosette agent" was detected in captive winter-run chinook salmon at the BML in 1993. These fish had been transferred from CNFH in 1992. It appears that the infectious stage of the rosette agent is associated with the Battle Creek watershed (S. Foott, pers. com.). Even in the Winter-run Adult Captive Broodstock Program at BML where adults are held for a couple of years, the disease affected the health of only a few individuals and no debilitating infections have been observed for the last two years. After three years of intensive monitoring of returning adult salmonids to CNFH, it appears the rosette agent is mostly associated with hatchery-origin late-fall-run chinook (20% to 30% incidence of infection). The parasite has been detected in only one fall-run adult and not in any of the 13 winter-run returns examined in 1997. It is likely that there is a late spring through summer seasonality to the presence of the infectious stage which would influence which runs are exposed to the parasite. The chronic nature of the infection is such that detection of the rosette agent has only occurred in CNFH chinook after 18 months of captivity. The overall effect on infected individuals released to the wild or on wild-spawned fish (any of the four runs of Central Valley chinook salmon) is unknown.

Infectious Hematopoietic Necrosis Virus (IHNV)

It is unknown to what degree IHNV is a problem for wild spring-run chinook salmon. All runs of Sacramento River salmon are considered to have a high incidence of the disease (W. Wingfield, pers. com.). The virus has been detected by the USFWS in unmarked salmon adults captured in the Keswick fish trap in 1993. It was unknown whether the adults were fall- or spring-run salmon. Investigations of fall-run carcasses and swim-up fry in Battle creek have shown that while carcasses shed the virus, no virus was detected in the fry. The USFWS also examined naturally-spawned fall-run outmigrants in 1992 and 1997 for signs of infection. None was detected. It also does not appear to be a significant problem in naturally spawned salmon fry within the Battle Creek watershed. Overall, it may be that IHNV is less common in naturally-spawned salmon juveniles within the Sacramento River system than previously suspected. IHNV infection is principally a problem in hatchery production where high density conditions cause amplification of the disease. FRH detected IHNV in March 1998, for the first time in 15 years. For CNFH, it is expected that installation of the new ozone water treatment system will reduce the incidence and potential transmission of this disease from anadromous adult fish in the water supply to the production fish.

There is the possibility of an epizootic occurrence in fall-run production (with subsequent release of infected juveniles) infecting wild juvenile spring run. Infected hatchery production would be released in March-May, a time when juvenile spring run can be expected to still be moving downstream through the Delta. In such a case, infected hatchery production could transfer the disease to naturally-spawned outmigrating juveniles of all runs in the system. Transmission of IHNV from adults to highly susceptible progeny has been found to cause significant mortality (Wolf 1988). Latent IHNV infections are commonly expressed in maturing salmon, but do not appear to affect their health (Mulcahy et al. 1984).

Predation

Predation may be a factor in the decline of spring-run chinook salmon. Predation occurs throughout the migratory pathway of spring-run chinook salmon, both the river and ocean phases of its life cycle. Predation is a natural phenomenon and would not normally be considered a significant cause of decline to spring-run chinook salmon. However, there are examples where predation has been enhanced or intensified by human activities.

Avian predators include cormorants, gulls, terns, mergansers, snowy egrets, herons, and osprey (USBR 1983). Native fish predators include squawfish, prickly sculpin, and steelhead. Other fish predators of spring-run salmon include introduced species such as striped bass, white catfish, channel catfish, American shad, killifishes, smallmouth bass, and largemouth bass. Marine mammal predators include harbor seals, sea lions, and killer whales (NMFS 1997).

There are specific locations where predation has become a significant problem. Predatory fish are known to congregate around structures placed in the water, where they maximize their foraging efficiency by using shadows, turbulence, and boundary edges (Cooper and Crowder 1979: as cited in Kano 1987). These structures include dams, bridges, diversions, piers, and wharfs (Stevens 1961, Vogel et al. 1988, Garcia 1989, Decoto 1978). On the Sacramento River, losses to predation occur at RBDD and the Glenn-Colusa Irrigation District (GCID) diversion facility. On the Yuba River losses to predation occur at the Hallwood-Cordua Diversion and at the South-Yuba Brophy diversion. In the southern Delta the water diversion structures at the State Water Project (SWP) and CVP pumping plants also concentrate predator species.

Overall mortality on spring run due to predation at RBDD is probably low. Predation of juvenile chinook salmon at RBDD occurs primarily when the gates are lowered, Lake Red Bluff has filled, and downstream migrants pass through the fish protection facilities at the Tehama-Colusa Canal headworks, or go under the gates. The gates are lowered between May 15 and September 15 each year at the latter part of the juvenile emigration period. It takes a while for the predators to congregate and most juvenile spring run are likely not affected. Juvenile spring run that migrate downstream in winter and early spring encounter RBDD when the gates are still raised and experience near normal river conditions.

The GCID diversion near Hamilton City is one of the largest irrigation diversions on the Sacramento River. Predation at this diversion is likely to be more intense in the spring when squawfish are migrating upstream, juvenile fish are migrating downstream, and irrigation demands are high. Predation may be significant in the oxbow at the GCID diversion, although several improvements have been made recently (P. Ward pers. com., Vogel and Marine 1995). Predation also occurs in the bypass system (P. Ward pers. com.)

On the Yuba River, juvenile salmonids which pass over Daguerre Point Dam can become disoriented by the hydraulic conditions created by the spillway, increasing their vulnerability to predators. The pool directly below the dam attracts and concentrates predators, which results in increased predation. Juveniles entering the Hallwood-Cordua Diversion encounter predators concentrated in the channel between the dam and fish screen. Sacramento squawfish examined during predator control evaluations at the Hallwood-Cordua fish screen contained remains of salmonids (Kano 1987). Juveniles entering the South-Yuba Brophy Diversion encounter predatory fish in the 1.6 acre pool in front of the rock weir. Exposure to predation there may be exacerbated because in excess of 90% of the flow entering the diversion passes through the gabions, with insufficient sweeping flow to return fish to the river.

The USFWS found that more piscivorous predators, such as squawfish and prickly sculpin, were found at rock revetment bank protection sites between Chico Landing and Red Bluff than at naturally eroding bank sites (Michny and Hampton 1984). More juvenile salmon were found adjacent to eroding bank habitat with riparian vegetation than at riprapped sites. Chinook salmon prefer habitat with cover, both overhead and submerged, because it provides a refuge from predators and it provides a major food source (terrestrial insects). Loss of this habitat to rock revetment bank protection may enhance predation.

The ecology of the Delta and the Sacramento River system has been significantly altered by the introduction of exotic fish and invertebrate species. The effects of these introductions on spring-run chinook salmon abundance and distribution have not been quantified. Based on the available information, striped bass, American shad, and white catfish are the principal predators within the Delta on juvenile salmon. Striped bass were introduced into the Sacramento-San

Joaquin estuary in 1879. Both striped bass and chinook salmon were at high levels in the late 1960s and early 1970s. In recent years both species have experienced a decline in abundance. However, naturally produced chinook salmon has had a greater decline.

Between October 1976 and November 1993, the Department conducted ten mark/recapture experiments at the SWP's Clifton Court Forebay (CCF) designed to estimate pre-screen loss (which includes predation) of fishes entrained to the forebay (Gingras 1997). Eight of these experiments involved hatchery-reared juvenile chinook salmon. Pre-screen loss rates for juvenile fall-run chinook salmon ranged from 63%-99% and for late-fall-run chinook salmon they ranged from 78%-99%. Predation by striped bass is thought to be the primary cause of pre-screen loss in CCF (Gingras and McGee 1997). Mark/recapture estimates of predator-sized striped bass suggest that they are abundant in CCF (CDFG in prep). However, recent telemetry studies of striped bass emigration from CCF indicate that the forebay is an open system in which many adult and sub-adult striped bass move through the radial gates over short periods (Gingras and McGee 1997). Such movement violates the assumption of negligible immigration and emigration. Therefore, the abundance estimates based on mark/recapture methods are not valid.

Predation studies have also been conducted at the release sites for fish salvaged from the SWP and CVP Delta pumping facilities (Orsi 1967, Pickard et al. 1982). Striped bass and squawfish were the primary predators in the Delta. They were more abundant and had more fish remains in their gut at release sites than at the nearby control sites.

The Department conducted predator sampling at the Suisun Marsh Salinity Control Structure from 1987-93 and found that the striped bass population had increased dramatically (DWR 1997). The increased predator population at the salinity control structure implies a higher rate of predation. Sampling of juvenile chinook salmon both upstream and downstream of the gates in 1993 indicated there may be loss associated with the structure. Data from a follow-up study in 1994 (DWR 1997) did not corroborate this, but the study design may have precluded obtaining clear results.

The Department is implementing the State's Striped Bass Management Program, with the goals of stabilizing and restoring the striped bass fishery, and restoring and improving habitat for striped bass and other aquatic species in the Delta ecosystem (CDFG 1995). This program has the potential to increase predation on species listed under the ESA. The Department will operate the program with an incidental take permit from NMFS and USFWS pursuant to Section 10(a)(1)(B) of the ESA, as amended. The permit will authorize take of winter-run chinook salmon, steelhead trout, Delta smelt, and Sacramento splittail. The Department has submitted a Conservation Plan (CP) that estimates the level of incidental take expected to occur during proposed activities, and specifies how the impacts of the taking will be minimized, mitigated, and monitored. The Department has also drafted an Environmental Assessment (EA) for use by the Federal agencies that analyzes environmental impacts associated with the issuance of an incidental take permit and implementation of a CP. The EA addresses the listed species as well as candidate or proposed species for Federal or State-listing, including spring-run chinook salmon and fall-run chinook salmon.

The Department proposes stocking a combination of striped bass salvaged from the SWP and CVP fish screens and those reared in floating net-pens for a period prior to release, as well as striped bass cultured and reared in hatcheries. The goal is to subsequently stabilize the striped bass population at the 1994 level. Through successful implementation of the CP, the

Department estimates that 0.5% to 1.0% of the juvenile spring-run chinook salmon may be incidentally taken annually due to predation by stocked striped bass (CDFG 1997).

Ocean predation by marine mammals is a natural phenomenon; however, the extent and impact of this type of predation is unknown. Hart (1987) cites several studies that have found increased abundance of harbor seals in estuaries coincident with seasonal anadromous fish runs. In addition, studies have found that harbor seals are more proficient at capturing salmon confined in estuaries and river systems. Some research on predation rates is available from the Klamath River estuary and the Russian River estuary. During seining and tagging operations for adult salmon by the Department on the lower Klamath River, Stanley and Shaffer (1995) found that the feeding activity of harbor seals was significantly higher on days that seining occurred than on days when no seining occurred. Over five years of study (1978-82) the estimated percentage of seined fish taken by seals was relatively constant, ranging from 3.1% to 5.5%. Similarly, Hart (1987) reported predation rates of 3.6% and 7.9% on the tagged adult salmon migrating upstream in 1981 and 1982, respectively, from harbor seals on the lower Klamath River. The predation by harbor seals during these seining and tagging activities may be explained by the opportunistic feeding strategy of harbor seals. The noise of seining activity, the splashing of entrapped fish, and the acute hearing of seals may enable them to focus in on large concentrations of fish (Hart 1987). Upon release the tagged fish are still in a stressed state and may be more vulnerable to predation.

Harvest

Ocean fishery management and evaluation

Central Valley chinook salmon, primarily Sacramento River fall run, comprise the majority of the salmon harvested in the ocean fisheries off California. The Central Valley Index (CVI) has been used to evaluate Central Valley chinook salmon abundance since 1970. It is the sum of all chinook landings in the ocean fisheries south of Point Arena and the Central Valley adult chinook spawning escapement for the same year. The CVI has ranged from a low of 323,100 in 1992 to a high of 1,312,000 in 1995 (PFMC 1998). Harvest is evaluated by the Central Valley Ocean Harvest Index, which is the total ocean chinook harvest as a percentage of the CVI. The Harvest Index has ranged between 50% and 79% since 1970 (Figure 31).

Sacramento River fall-run chinook, which comprise approximately 90% of the Central Valley chinook salmon spawning escapement, is one of the principle salmon populations by which ocean salmon fisheries south of Cape Falcon (in northern Oregon) are managed under the salmon Fisheries Management Plan (FMP) as authorized by the Federal Magnuson-Stevens Fishery Conservation and Management Act. Based on the FMP, each year the ocean salmon fisheries off Oregon and California must be managed to ensure that 122,000 to 180,000 adult fall-run chinook salmon return to spawn in the Sacramento River and its tributaries. Other chinook salmon stocks on which California's's ocean salmon fisheries are managed under the FMP include, Klamath River fall-run chinook and salmon stocks listed under the ESA, such as the endangered Sacramento River winter-run chinook, the threatened coho salmon populations that originate in coastal rivers from Monterey Bay into southern Oregon, and the endangered Snake River fall-run chinook from the Columbia River basin. Management measures include time and area closures, seasonal quotas, minimum sizes, specific fishing gear restrictions, and maximum allowable take (e.g. daily bag and possession limits). California's recreational and commercial ocean salmon fishing regulations for the years 1996-1998 are in Appendix C.

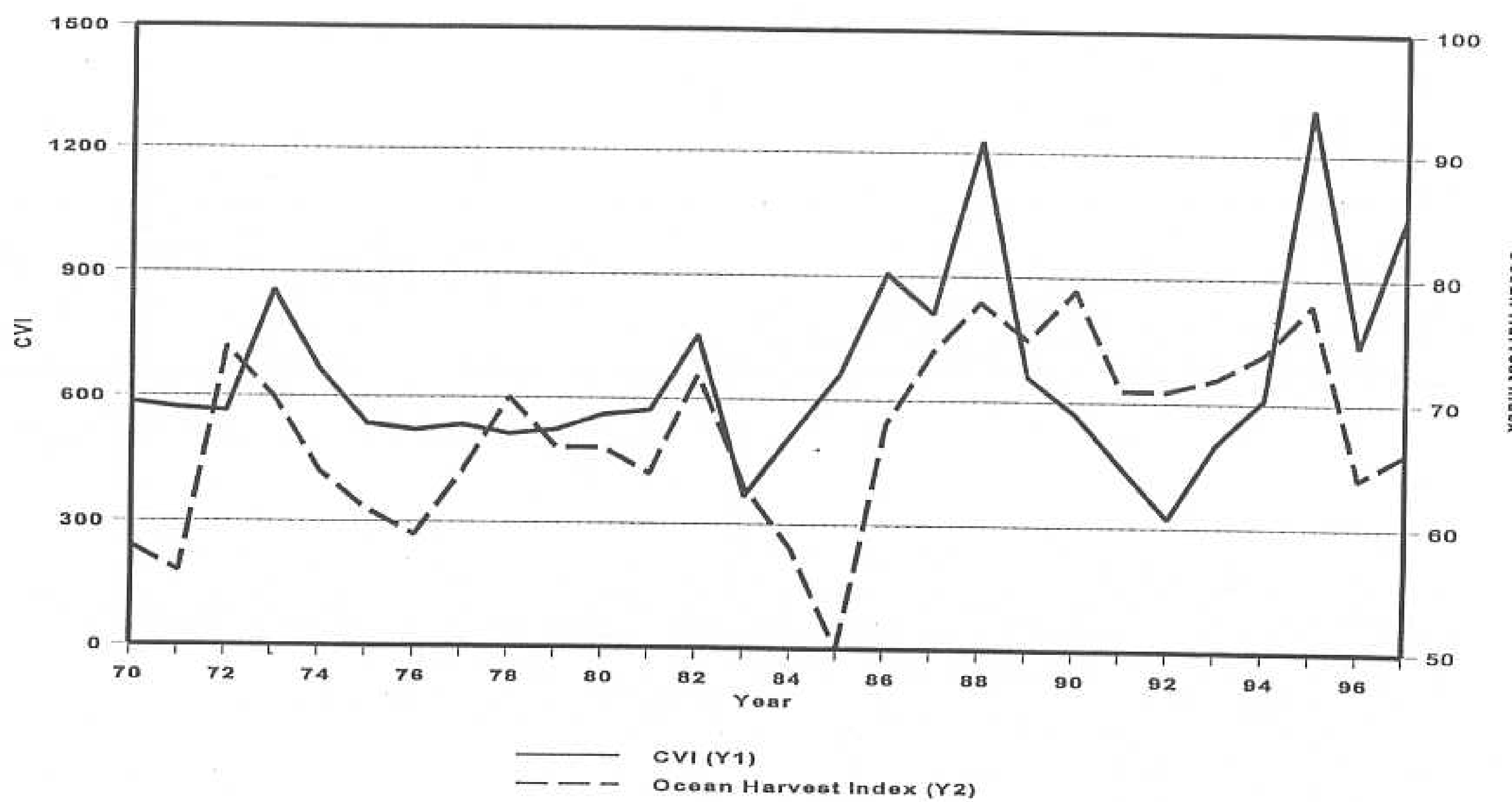


Figure 31. Central Valley Index and Ocean Harvest Index, 1970-97.

Coded-wire tags (CWTs) have been used to mark Pacific salmon since the mid-1970s. Whenever a tagged fish is recovered as part of a sampling program, the tag is extracted and the code deciphered. By referring to the CWT database (maintained at the Pacific States Marine Fisheries Commission's Regional Mark Processing Center in Gladstone, Oregon), the fish's origin, BY, size of release group, and other information can be determined. When tagged fish are recovered through a statistically appropriate, randomized sampling program, an estimate can be made of the total occurrences of that particular release group in all of the fish caught. The composition of Central Valley runs in the ocean landings cannot be extrapolated from the CWT recoveries from landed fish because of inadequate and inconsistent tagging rates among released hatchery fish and naturally produced fish. CWT recovery data are used in conjunction with the number of tagged fish released to estimate the rate of recovery by individual tag code. Recovery rates provide a means of relative comparison between age-classes and between runs.

The only ocean CWT recoveries for Sacramento River spring-run chinook salmon are from releases of fish produced at FRH, which are designated as "spring-run chinook." Because of evidence of intermixing of fall run and spring run in the hatchery (as discussed elsewhere in this report), there is a question as to whether FRH spring run are an appropriate surrogate for evaluation of the effects of ocean harvest on wild Sacramento River spring-run chinook. Tagged releases of FRH spring run date from 1975, and occurred during 11 of the 20 years through 1994. These releases ranged in number from about 40,000 fish to more than 200,000 fish (Table 18 and Figure 32). Recent (1995 BY) tagged releases included approximately 14,450 wild fish from Butte Creek, and 160 and 780 wild fish from Mill and Deer creeks, respectively. None of these 1995 releases has been recovered in the ocean fisheries as of the end of the 1997 sport and commercial seasons.

All tagged salmon, identified by the missing adipose fin, observed in the sport and commercial ocean harvest are measured at the dock before the head is removed to be taken to the lab for tag extraction. Based on the FRH spring-run chinook recovered in California's ocean fisheries from 1978 through 1997, average total length (TL) by month for February through November for ages 2-4 fish are shown in Figure 33 with comparable data for Central Valley fall-run chinook ocean recoveries. FRH age-2 fish range in size from 20.7 inches to 23.5 inches TL, reach their greatest size during the months of July through September, and are slightly larger in size compared to age-2 Central Valley fall-run chinook. The average monthly TL of age-3 FRH recoveries are between 24.5 and 29.6 inches, and tend to be somewhat less than age-3 fall chinook, especially in the early spring and fall months. The average monthly TL of age-4 FRH fish recovered in the ocean fisheries range from a low of about 26 inches to a high of nearly 34 inches TL during June and July, and like age-3 recoveries, tend to be somewhat smaller than similar aged Central Valley fall-run chinook during the spring and fall months. Ocean tag recoveries of FRH spring run for the years 1978-97, expanded for sampling rates, total more than 12,700 fish. In comparison, expanded tag recoveries of Central Valley fall-run chinook harvested by the ocean fisheries total more than 255,000 fish (Table 19). Although FRH spring-run tags were occasionally recovered from ocean landings as far north as British Columbia, the vast majority were recovered in California. Almost 78% of the total recoveries were from landings at ports from Bodega Bay to Monterey (Figure 34). Hatchery tag recoveries are not complete and there are no in river monitoring programs for angler catch and spawning areas. Therefore, comprehensive analysis of harvest impacts is difficult.

Using a subset of the available CWT recovery data for the FRH spring-run chinook, Cramer and Demko (1997) were able to construct a cohort analysis to estimate, by age, such population parameters as survival rates, harvest rates, and maturity rates. They limited their data to the six

Table 18. List of Central Valley Spring-run Chinook Salmon Coded-wire Tagged Releases (PFMC 1998).

Tag Code	Tag	Run-Spec Typ	Bd Yr	Agy	Rel. Hatchery	Release-Site Name	First Release	Last Release	# Tagged	Ad-Clp Only	Unmarked Fish
060107	0	Spri Chin	75	CDFG	FEATHER R H.	FEATHER R H.	7612	7612	90,825	1,854	
0601080408	3	Spri Chin	95	CDFG	(WILD)	DEER CREEK	960501	961205	782		
0601080409	3	Spri Chin	95	CDFG	(WILD)	MILL CR (TRIB SACR)	960502	961119	157		
0601120101	3	Spri Chin	91	CDFG	FEATHER R H.	CLEAR CREEK	920320	920320	52,626	966	49,988
0601120102	3	Spri Chin	91	CDFG	FEATHER R H.	CLEAR CREEK	920320	920320	50,826	966	49,987
0601120103	3	Spri Chin	92	CDFG	FEATHER R H.	CLEAR CREEK	930322	930322	48,416	7,750	
0601120104	3	Spri Chin	92	CDFG	FEATHER R H.	CLEAR CREEK	930322	930322	50,789	5,971	
065809	0	Spri Chin	76	CDFG	FEATHER R H.	FEATHER R H.	7712	7801	71,105	2,963	
065811	0	Spri Chin	77	CDFG	FEATHER R H.	YUBA CITY	781221	781,226	54,700	3,014	
065812	0	Spri Chin	77	CDFG	FEATHER R H.	GRIDLEY	790125	790126	50,046	2,401	3,754
065828	0	Spri Chin	81	CDFG	FEATHER R H.	CALIF. MARIT. ACAD.	820517	820517	40,776	6,474	
065836	0	Spri Chin	82	CDFG	FEATHER R H.	CALIF. MARIT. ACAD.	830527	830527	42,593	3,957	
065846	0	Spri Chin	83	CDFG	FEATHER R H.	CALIF. MARIT. ACAD.	840522	840522	48,552	2,448	
065853	0	Spri Chin	84	CDFG	FEATHER R H.	MONTEREY MINOR PORT	850423	850423	19,533	5,381	
065854	0	Spri Chin	84	CDFG	FEATHER R H.	MONTEREY MINOR PORT	850423	850423	19,183	5,959	
065855	0	Spri Chin	84	CDFG	FEATHER R H.	CALIF. MARIT. ACAD.	850425	850425	22,321	2,675	
B61001	2	Spri Chin	84	CDFG	FEATHER R H.	FEATHER R HATCHERY	850401	850401	48,614	3,662	
B61002	2	Spri Chin	84	CDFG	FEATHER R H.	BIG CHICO CREEK	850401	850401	47,908	5,271	
B61003	2	Spri Chin	85	CDFG	FEATHER R H.	BIG CHICO CREEK	860317	860317	98,034	7,834	
B61004	2	Spri Chin	85	CDFG	FEATHER R H.	GRIDLEY	860317	860317	100,699	4,196	
B61005	2	Spri Chin	86	CDFG	FEATHER R H.	BIG CHICO CREEK	870303	870303	102,531	3,739	
B61006	2	Spri Chin	86	CDFG	FEATHER R H.	FEATHER R H.	870303	870303	98,392	3,887	
B61201	2	Spri Chin	95	CDFG	(WILD)	BUTTE CREEK	960104	960125	5,259	1,339	
B61202	2	Spri Chin	95	CDFG	(WILD)	BUTTE CREEK	960125	960316	5,892	1,501	
B61203	2	Spri Chin	95	CDFG	(WILD)	BUTTE CREEK	960322	960407	68	17	
B61204	2	Spri Chin	95	CDFG	(WILD)	BUTTE CREEK	960408	960429	132	33	
B61205	2	Spri Chin	95	CDFG	(WILD)	BUTTE CREEK	960504	960605	168	43	

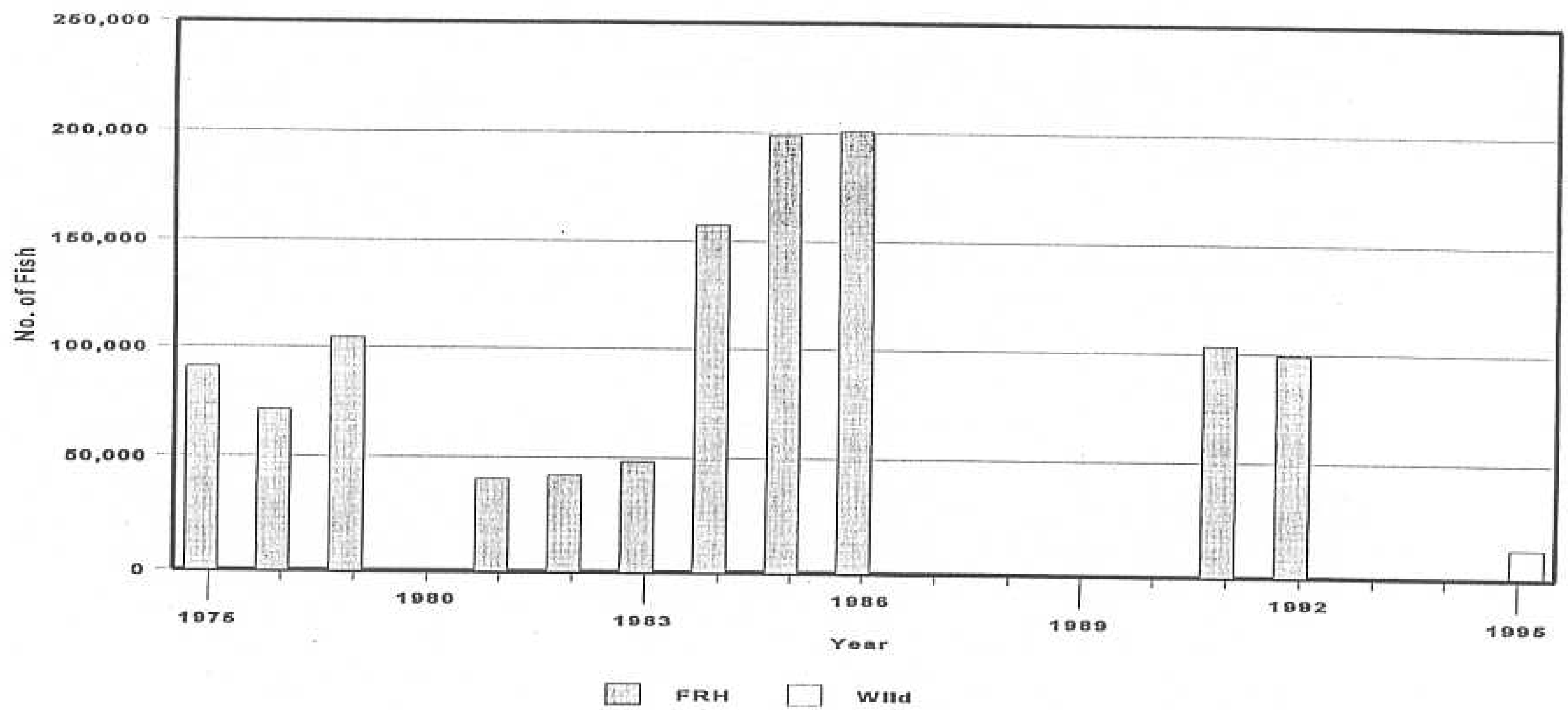


Figure 32. Sacramento River spring-run chinook salmon CWT releases, 1975-95.

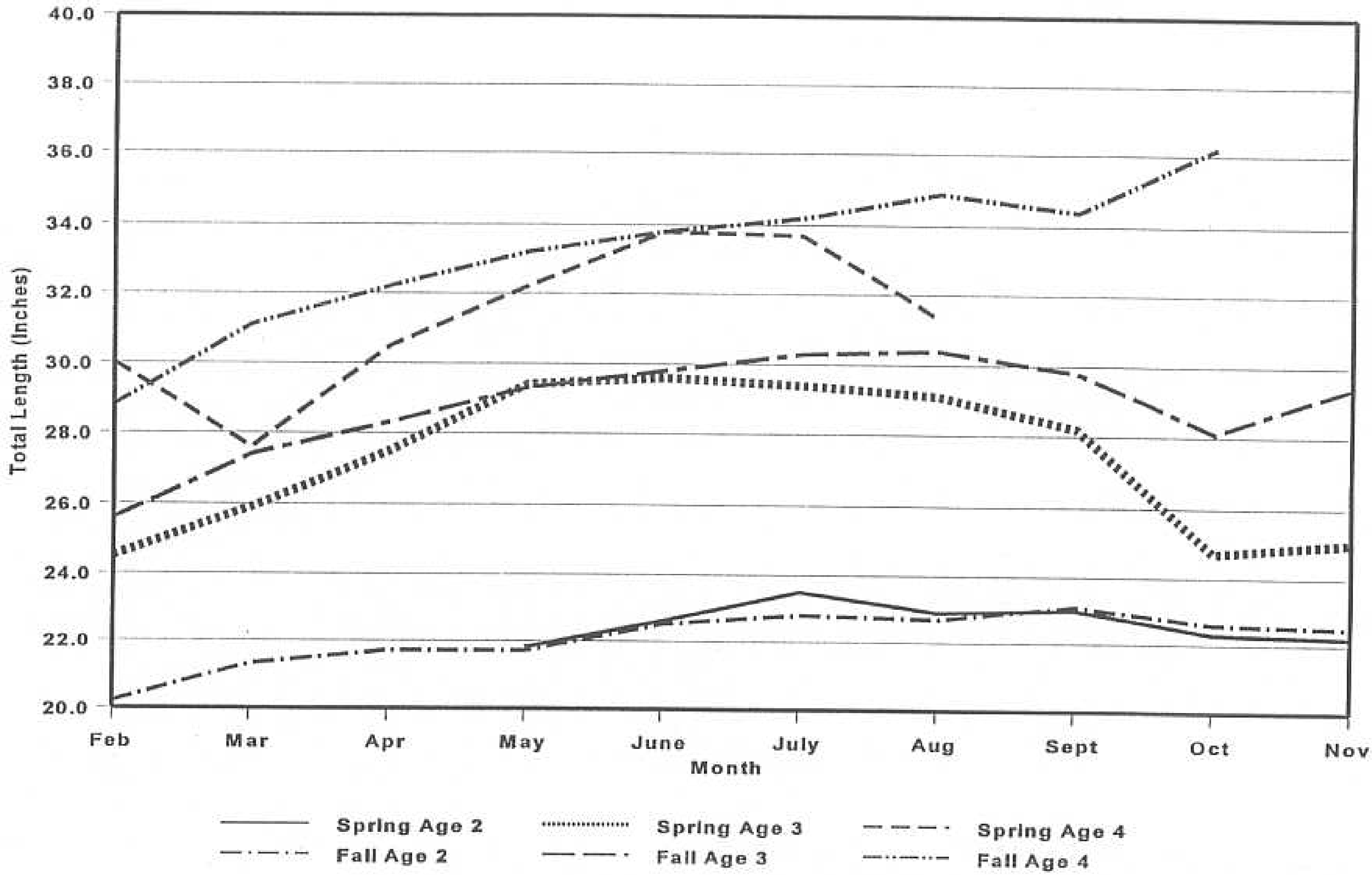


Figure 33. Average size of Central Valley chinook salmon in ocean commercial troll fisheries for 1978-97, by month (California only).

Table 19. Number of Coded-Wire Tag Recoveries (Expanded for Sampling) for Feather River Hatchery Spring-Run Chinook and Central Valley Fall-Run Chinook in California's Ocean Fisheries for 1978-97, by Brood Year and Age Class.

BROOD YEAR	SPRING							FALL						
	TAGGED RELEASE	AGE-2		AGE-3		AGE-4&5		TAGGED RELEASE	AGE-2		AGE-3		AGE-4&5	
		SPORT	TROLL	SPORT	TROLL	SPORT	TROLL		SPORT	TROLL	SPORT	TROLL	SPORT	TROLL
1975	90,825			229	402	20	163	904,661			676	4,255	64	471
1976	71,105	428		1,398	1,441	32	162	975,132	511		1,425	3,354	23	392
1977	104,746	18	10	220	438	5	69	666,797	1,601	184	1,722	11,332	30	514
1981	40,776	15		64	284	13	38	1,298,272	204	20	1,431	4,916	400	1,670
1982	42,593	4		10	112		42	1,338,596	298	10	935	3,284	30	469
1983	48,552	177	6	135	855	5	73	1,380,002	1,563	134	2,566	9,633	140	862
1984	157,559	136	7	151	818	16	156	1,438,839	1,260	93	2,017	10,339	78	938
1985	198,733	94	10	78	932	51	80	1,840,686	2,787	273	2,748	23,574	287	1,720
1986	200,923	96	20	165	632	9	13	1,341,733	669	127	1,939	7,123	204	537
1991	103,452	11		10	71	4	3	1,536,521	310	32	685	2,184	74	210
1992	99,205	56		281	407	19	15	1,547,006	1,142	176	3,733	6,987	259	559
Total	1,158,469	1,035	53	2,741	6,392	174	814	14,268,245	10,345	1,049	19,877	86,981	1,589	8,342

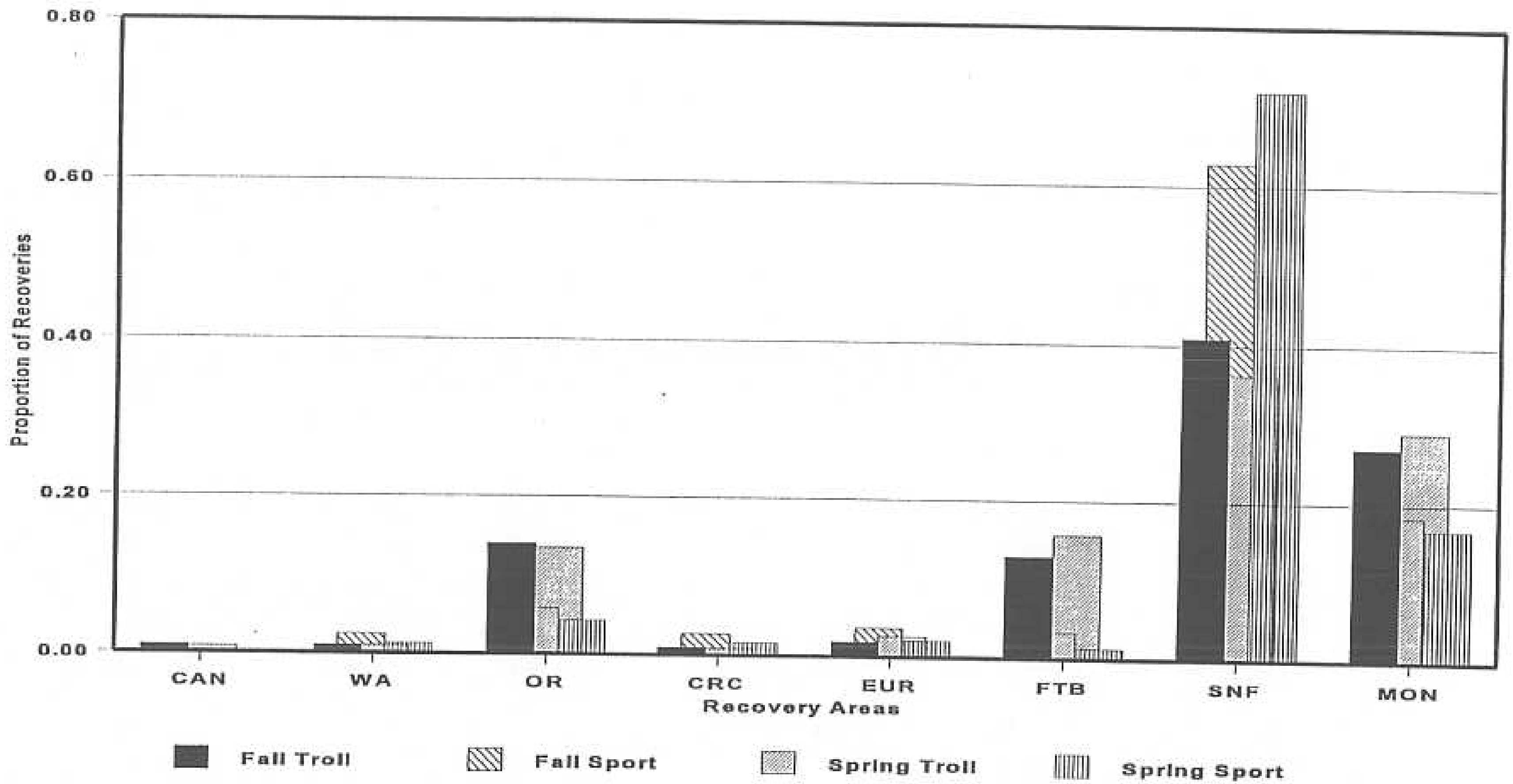


Figure 34. Central Valley chinook salmon ocean recoveries, 1976-97 combined by area (major port in California), run, and fishery.

CWT groups released at or near the hatchery, although a total of 16 CWT groups was released from the 1975-91 broods. To use these data in a cohort analysis, they had to assume that the hatchery and in-river recoveries were complete for those cohorts. Given the absence of an alternative marked spring-run population to evaluate, FRH spring run is considered a surrogate for evaluation of ocean fisheries' impacts on wild Sacramento River spring-run chinook salmon based on the catch timing in the recreational fishery and the availability of Cramer and Demko's cohort analysis.

Spring-run adults are known to enter their spawning tributaries within the Sacramento River system as early as mid-February. In contrast, Central Valley fall-run adults do not enter the river until August. Therefore, a larger proportion of the total annual landings of mature (≥age-3 fish) spring run would be expected to occur during the early spring months, compared to fall run. Table 20 and Figure 35 show that 68% of the total annual harvest of age-3 FRH spring run occurred during the months of February through April, compared to 41% for the fall run. Approximately 59% of the annual harvests of age-4 FRH spring run occurred during February through April compared to 27% for fall run for the same 20-year period (Figure 36).

The timing of FRH spring-run chinook CWT recoveries during the season appears substantially different from that of Central Valley fall run. Although a similar analysis by Cramer and Demko (using recoveries from the 1975-86 broods) indicates that the majority of FRH spring-run landings occur after April, their data include both recreational and commercial landings. The data used for the present analysis were limited to those CWT recoveries from California's ocean salmon sport fishery because it opens in late February/early March and better represents the timing of FRH spring-run chinook landings across the fishing season. With the exceptions of 1983 and 1997, California's commercial ocean salmon fishery has not opened south of Point Arena prior to May 1 since 1979; therefore, it cannot provide catch data for months prior to May (PFMC 1998).

Ocean Commercial Harvest

Californians have been commercially trolling for salmon since the late 1800s. Commercial chinook landings in California since the early 1950s have ranged from 163,400 fish in 1992 to 1,317,200 fish in 1988 (PFMC 1998). Although commercial landings have shown a general declining trend since the 1960s, 1988 had the highest landings on record (Figure 37). The commercial harvest comprises the majority of California's total ocean salmon harvest. Although it is unknown what proportion of the commercial harvest includes Sacramento River spring-run, almost 65% of the FRH tag recoveries in California were from the commercial fishery. The recovery rate for age-3 FRH fish in the commercial fishery is considerably greater than age-4 fish. This is expected because a high fraction of the population matures at age-3. If spring- and fall-run CWT recovery rates are compared for the period, FRH spring-run rates often exceeded fall-run rates during the late 1970s and early to mid-1980s. Since about 1988, the recovery rates for both age-3 and age-4 FRH fish are either comparable to or substantially less than those of Central Valley fall run for those years when recoveries for both runs are available (Table 21, and Figures 38 and 39). Data for FRH spring-run recoveries for the last seven years are sparse and limited to age-3 and age-4 recoveries for 1995 and 1996, respectively, from the 1992 BY release. The FRH age-3 recovery rates in the commercial fishery are based on 6,392 fish; age-4 FRH recovery rates are based on 814 fish (Table 19). Size of fish harvested in the commercial fishery is affected by the fishery's 26-inch TL minimum size limit.

Table 20. Proportion of Total Landings for Coded-wire Tag Recoveries from Feather River Hatchery Spring-run Chinook and Central Valley Fall Chinook in California's Ocean Fisheries for 1978-97, by Age-class and Month.

MONTH	AGE-2		AGE-3		AGE-4	
	SPRING	FALL	SPRING	FALL	SPRING	FALL
FEB			0.13	0.05	0.12	0.06
MAR	0.01	<0.005	0.30	0.17	0.24	0.09
APR		0.01	0.25	0.19	0.23	0.12
MAY	0.05	0.03	0.06	0.11	0.11	0.12
JUN	0.08	0.11	0.12	0.18	0.23	0.23
JUL	0.24	0.35	0.10	0.21	0.06	0.29
AUG	0.18	0.26	0.02	0.07		0.07
SEP	0.05	0.13	0.01	0.02		0.01
OCT	0.27	0.09	0.02	0.01	0.01	0.01
NOV	0.12	0.02	0.01	<0.005		

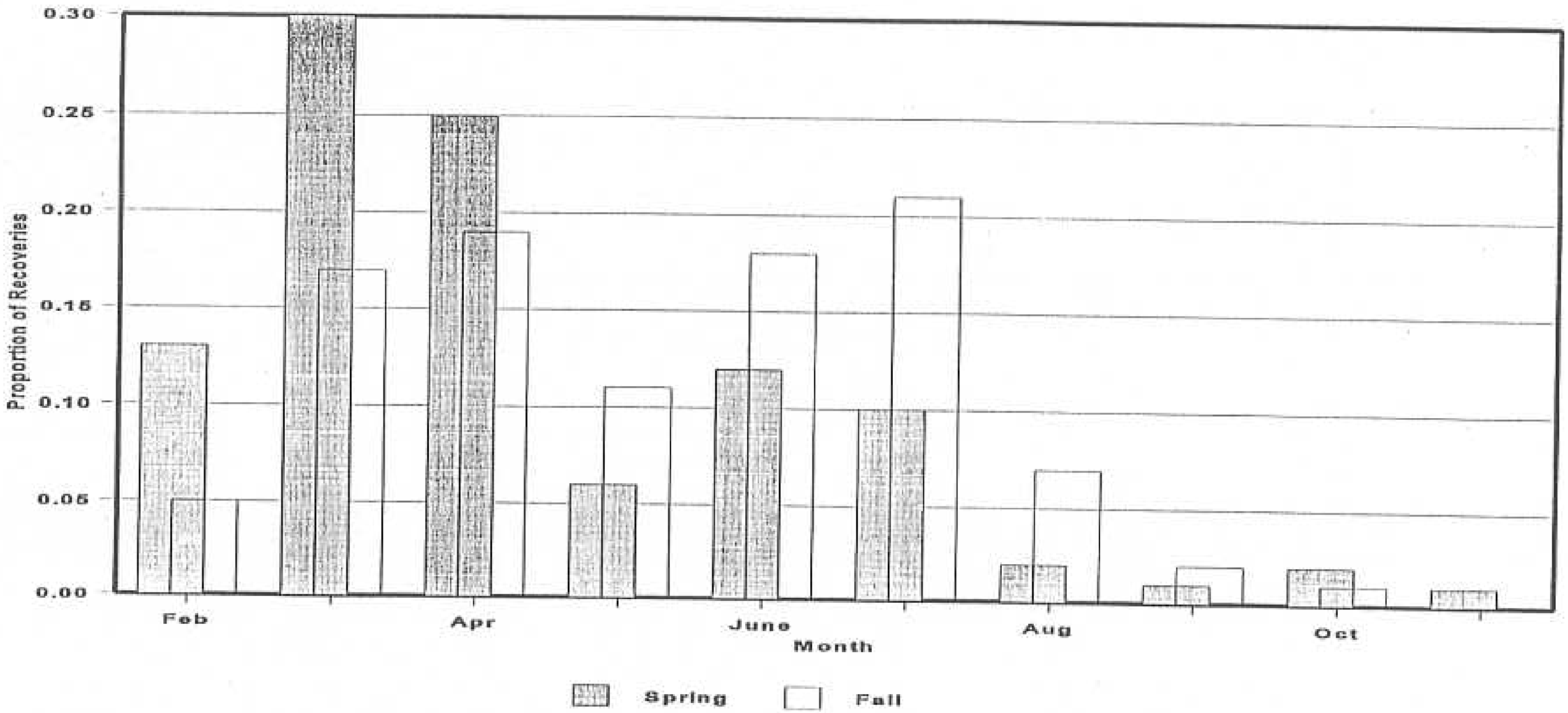


Figure 35. Age-3 Central Valley chinook salmon ocean sport recoveries. Spring-run vs fall-run chinook salmon for 1978-97, by year (California only).

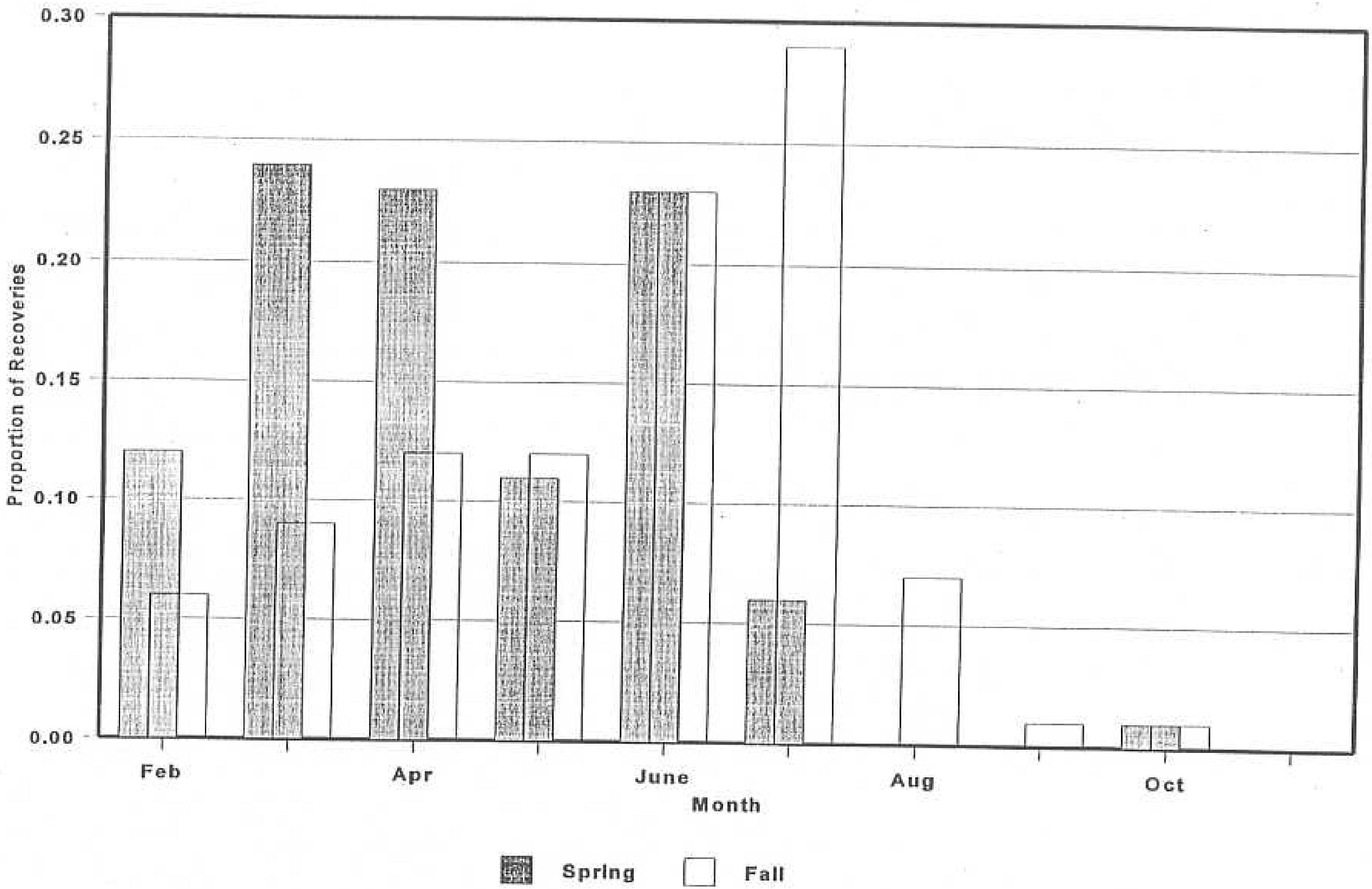


Figure 36. Age-4 Central Valley chinook salmon ocean sport recoveries. Spring-run vs fall-run chinook salmon average recoveries for 1978-97, by month (California only).

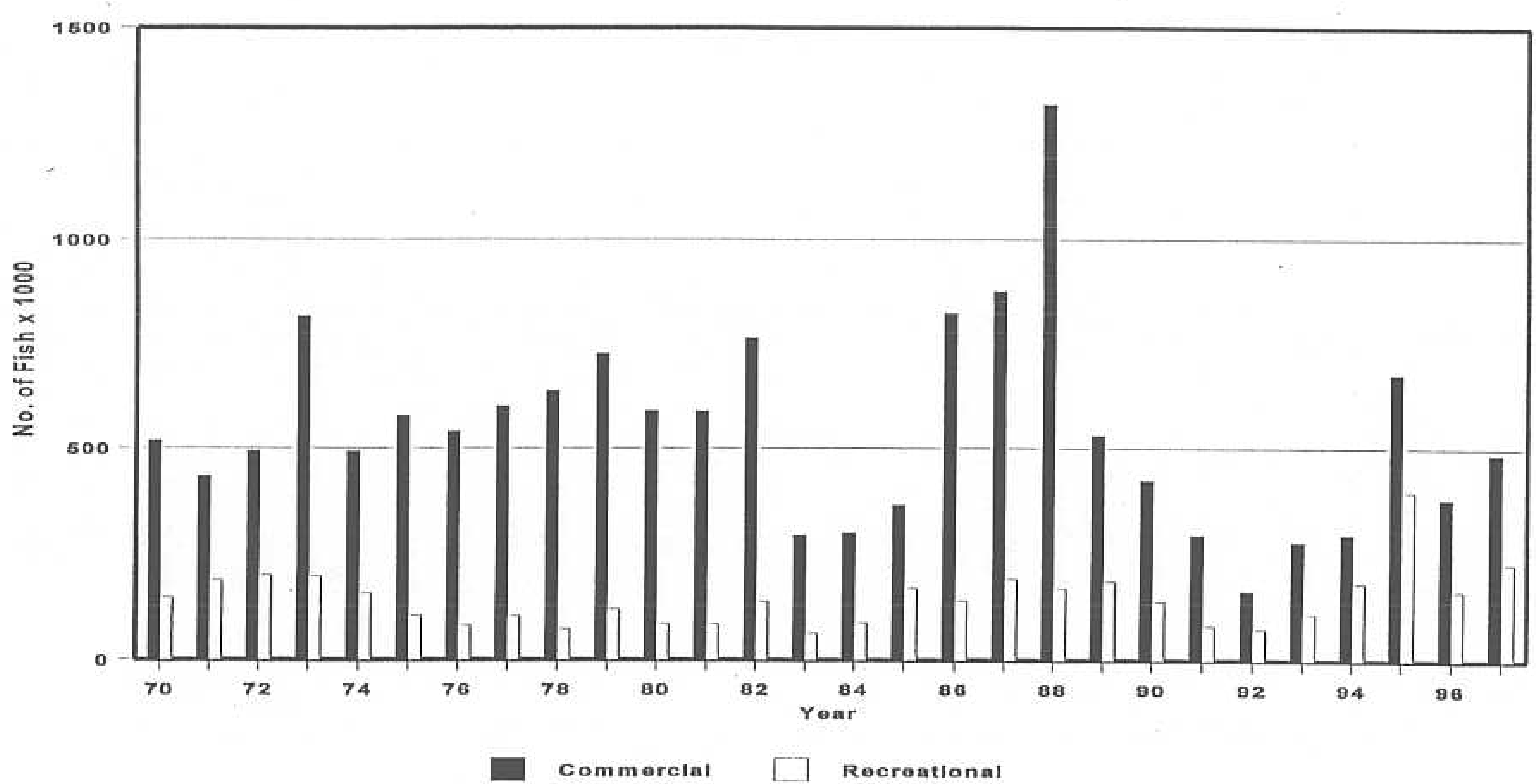


Figure 37. California ocean landings of chinook salmon, 1970-97.

Table 21. Coded-wire Tag Recovery Rates for Feather River Hatchery Spring-run Chinook Salmon and Central Valley Fall-run Chinook Salmon in California's Ocean Fisheries for 1978-97, by Age-class and Year of Recovery.

YEAR	RECREATIONAL						COMMERCIAL					
	AGE-2		AGE-3		AGE-4		AGE-2		AGE-3		AGE-4	
	SPRING	FALL	SPRING	FALL	SPRING	FALL	SPRING	FALL	SPRING	FALL	SPRING	FALL
1978	0.0060	0.0005	0.0025	0.0008		0.0002			0.0044	0.0047		0.0015
1979	0.0002	0.0024	0.0197	0.0015	0.0002	0.0001	0.0001	0.0003	0.0203	0.0034	0.0018	0.0005
1980		0.0002	0.0021	0.0026	0.0004	<0.00005		<0.00005	0.0042	0.0170	0.0022	0.0004
1981		0.0014		0.0007	0.0001	<0.00005		0.0001		0.0071	0.0007	0.0008
1982		0.0016		0.0014		0.0001		0.0002		0.0111		0.0011
1983	0.0004	0.0002		0.0012		<0.00005		<0.00005		0.0055		0.0004
1984	0.0001	0.0002	0.0016	0.0011		0.0001		<0.00005	0.0070	0.0038		0.0006
1985	0.0036	0.0011	0.0002	0.0007	0.0003	0.0003	0.0001	0.0001	0.0026	0.0025	0.0009	0.0013
1986	0.0009	0.0009	0.0028	0.0019		<0.00005	0.0001	0.0001	0.0176	0.0070		0.0003
1987	0.0005	0.0015	0.0010	0.0014	0.0001	0.0001	0.0001	0.0002	0.0052	0.0072	0.0015	0.0006
1988	0.0005	0.0005	0.0004	0.0015	0.0001	0.0001	0.0001	0.0001	0.0047	0.0128	0.0009	0.0007
1989		0.0008	0.0008	0.0015	0.0002	0.0002		0.0001	0.0031	0.0053	0.0004	0.0009
1990		0.0005		0.0011	0.0001	0.0002		<0.00005		0.0048	0.0001	0.0004
1991		0.0001		0.0006		0.0001		<0.00005		0.0024		0.0001
1992		0.0003		0.0002		<0.00005		<0.00005		0.0007		0.0001
1993	0.0001	0.0002		0.0006		<0.00005		<0.00005		0.0018		0.0001
1994	0.0006	0.0007	0.0001	0.0005		0.0001		0.0001	0.0007	0.0014		0.0003
1995		0.0012	0.0028	0.0024		<0.00005		<0.00005	0.0041	0.0045	<0.00005	0.0001
1996		0.0001		0.0018	0.0002	0.0002		<0.00005		0.0031		0.0005
1997		0.0006		0.0019		0.0002		0.0001		0.0048		0.0004

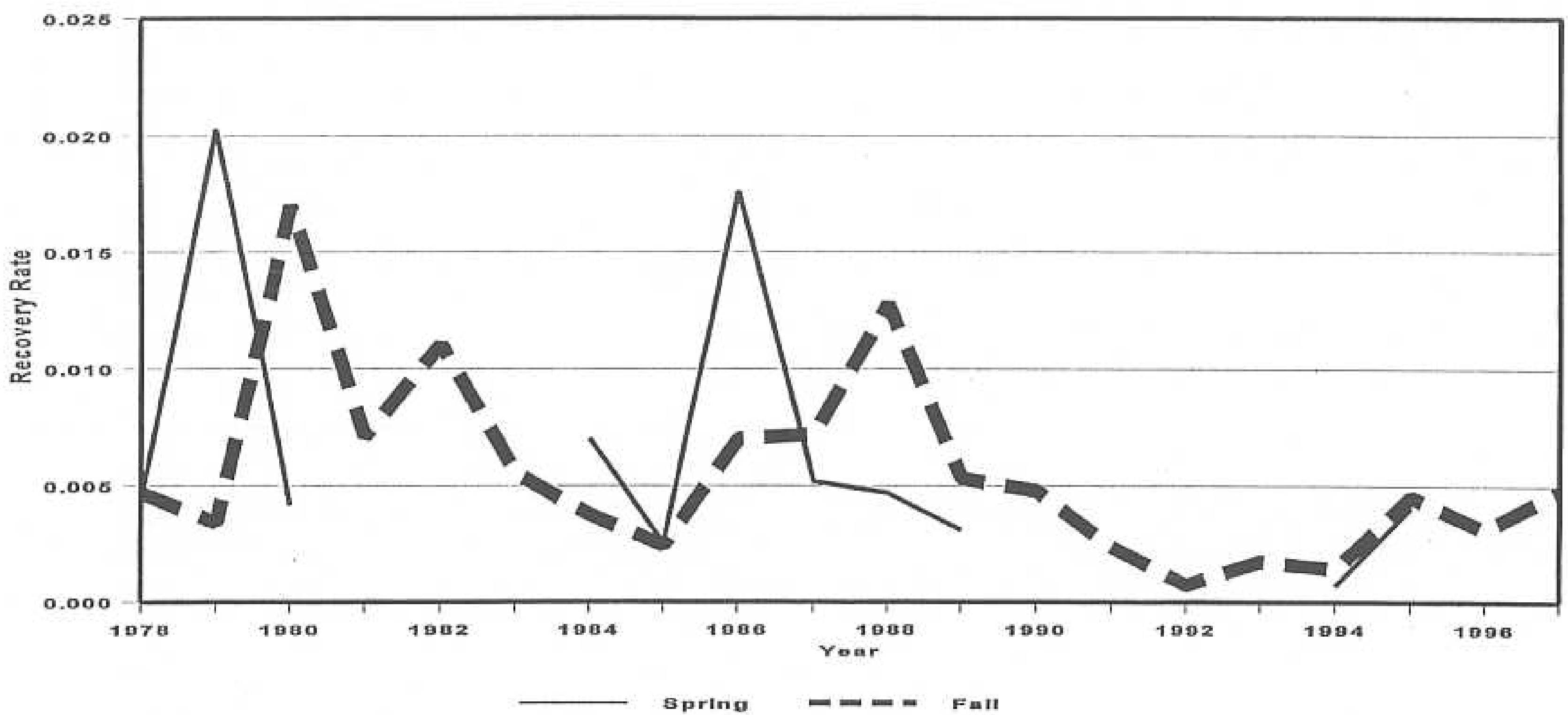


Figure 38. Central Valley age-3 chinook salmon ocean commercial troll CWT recovery rates. 1978-97, by year (California only).

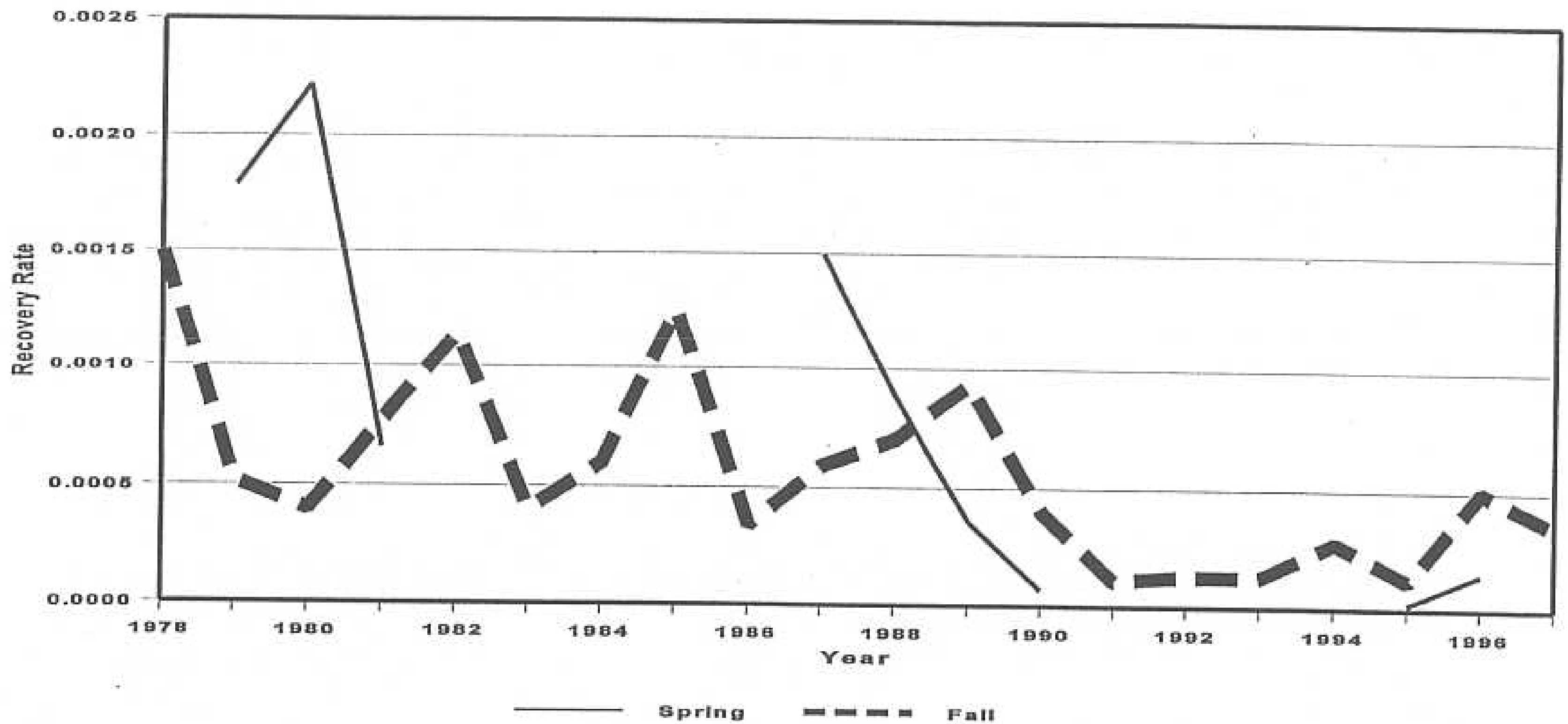


Figure 39. Central Valley age-4 chinook salmon ocean commercial troll CWT recovery rates. 1978-97, by year (California only).

Ocean Sport Harvest
Both age-3 and age-4 FRH spring-run recovery rates in California's recreational ocean salmon fishery exceeded comparable Central Valley fall-run chinook salmon recovery rates during some of the years prior to 1990. In subsequent years, when recoveries for both runs are available, recovery rates are similar (Figures 40 and 41). Expanded recoveries for age-2, age-3, and age-4 FRH fish in the recreational fishery total 1,035, 2,741, and 174 fish, respectively (Table 19). In contrast with the commercial fishery, where age-2 fish comprise less than one percent of the FRH spring chinook recoveries (primarily because of the 26-inch minimum size), age-2 fish comprise more than 26% of the sport harvest of FRH spring-run chinook. As in the commercial fishery, size of fish harvested in the sport fishery is affected by the fishery's minimum size limit of 20 inches TL for 1984 through 1995. In 1996, the minimum size was increased to 24 inches TL south of Horse Mountain to reduce harvest impacts on Sacramento River winter-run chinook, which tend to be smaller than fall-run chinook of the same age; in fact, the minimum size was further increased to 26 inches from mid-July through the end of the 1996 season. After the 1996 season, the minimum size was reduced to 24 inches TL, except between Point Reyes and Pigeon Point, the area adjacent to (San Francisco) during July and August of 1997, when anglers were required to keep the first two fish caught (except coho) regardless of size.

Overall Harvest Rate
There was variation among the ocean harvest rates estimated by Cramer and Demko (1997) on the six tagged groups of FRH spring chinook comprising their cohort analysis. Harvest rates on age-3 fish ranged from 18%-22%; on age-4 fish, they ranged from 57%-85%; and on age 5 fish, they ranged from 97%-100%. Cramer and Demko concluded that fish maturing at age-5 have little chance of surviving the ocean harvest, since the rates were cumulative over the number of years that a fish was in the ocean. Therefore, it appears that the ocean fisheries may have a significant impact on Sacramento River spring-run chinook. The absence of CWT recoveries in the 1996 and 1997 seasons from any of the Sacramento River spring-run releases, either hatchery or wild, when management measures for Sacramento winter-run chinook were implemented (which may be expected to reduce harvest impacts on spring-run chinook to some degree) is problematical.

Inland Sport Harvest
Sportfishing regulations (Appendix D) for the mainstem Sacramento River were instituted to protect the State and federally listed Sacramento River winter-run chinook salmon. Existing regulations protect a portion of the spring-run adults from legal exploitation in the Sacramento River. However, due to the different adult migration timing for the two runs, existing regulations may allow some spring run to be harvested. The Sacramento River from the Deschutes Road Bridge to Bend Bridge (approximately five miles upstream from the town of Red Bluff) is open to fishing from August 1 through January 14, with a daily bag and possession limit of two salmon. From January 15 through July 31 the daily bag and possession limit is zero salmon. Spring-run salmon in this reach could be vulnerable to take from August 1 through mid-October, when winter-run adults are no longer present. The Sacramento River from Bend Bridge to the Carquinez Bridge (includes Suisun Bay, Grizzly Bay, and all tributary sloughs) is open from July 16, through January 14, with a daily bag and possession limit of two salmon. From January 15 through July 15, the daily bag and possession limit is zero salmon. Spring-run salmon in the upper reach of the Sacramento River below Bend Bridge could be vulnerable to take from July 16 through mid-October, when winter-run adults are no longer present.

It should be noted that for the protection of winter-run chinook salmon, regulations prevent removal of any salmon incidentally caught from the water in the reach of the upper Sacramento

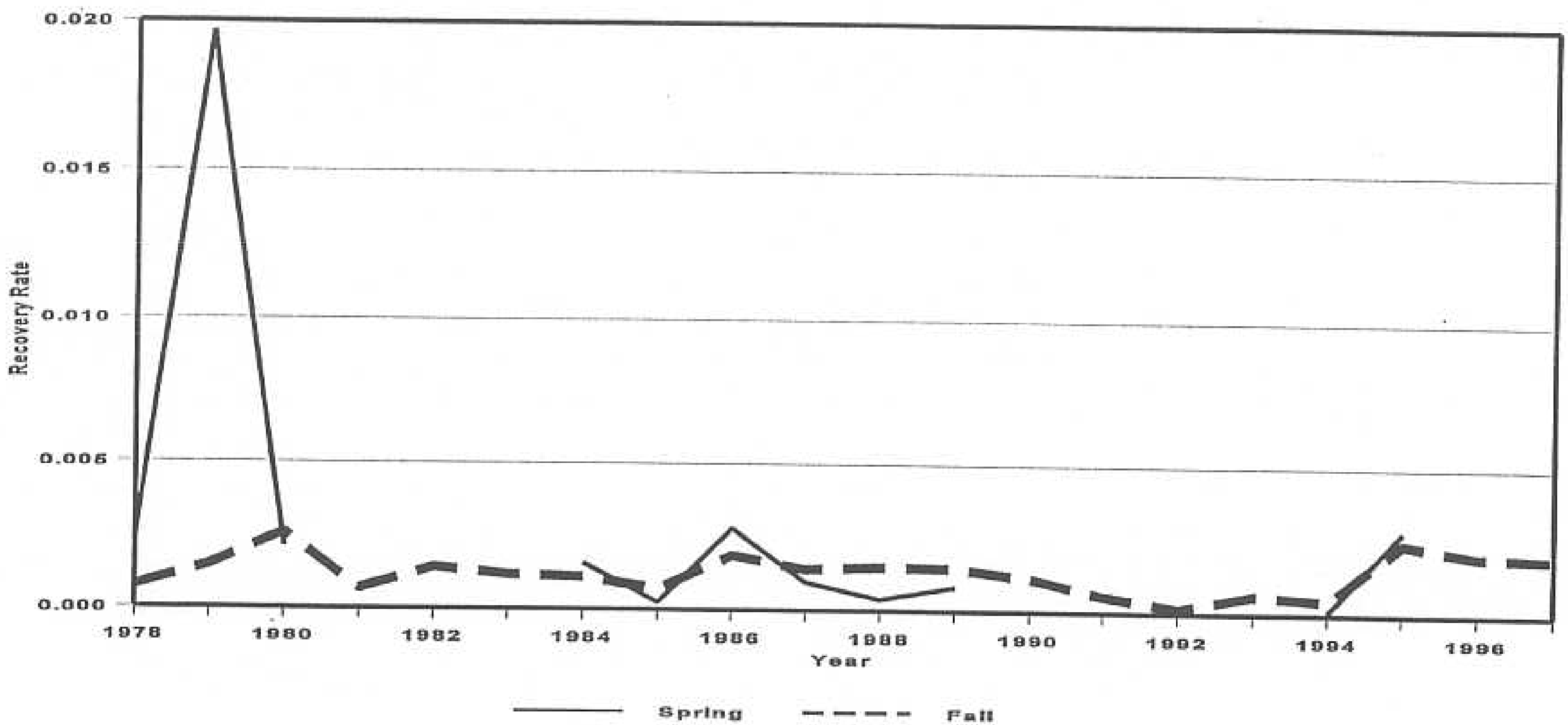


Figure 40. Central Valley age-3 chinook salmon ocean sport CWT recovery rates. 1978-97, by year (California only).

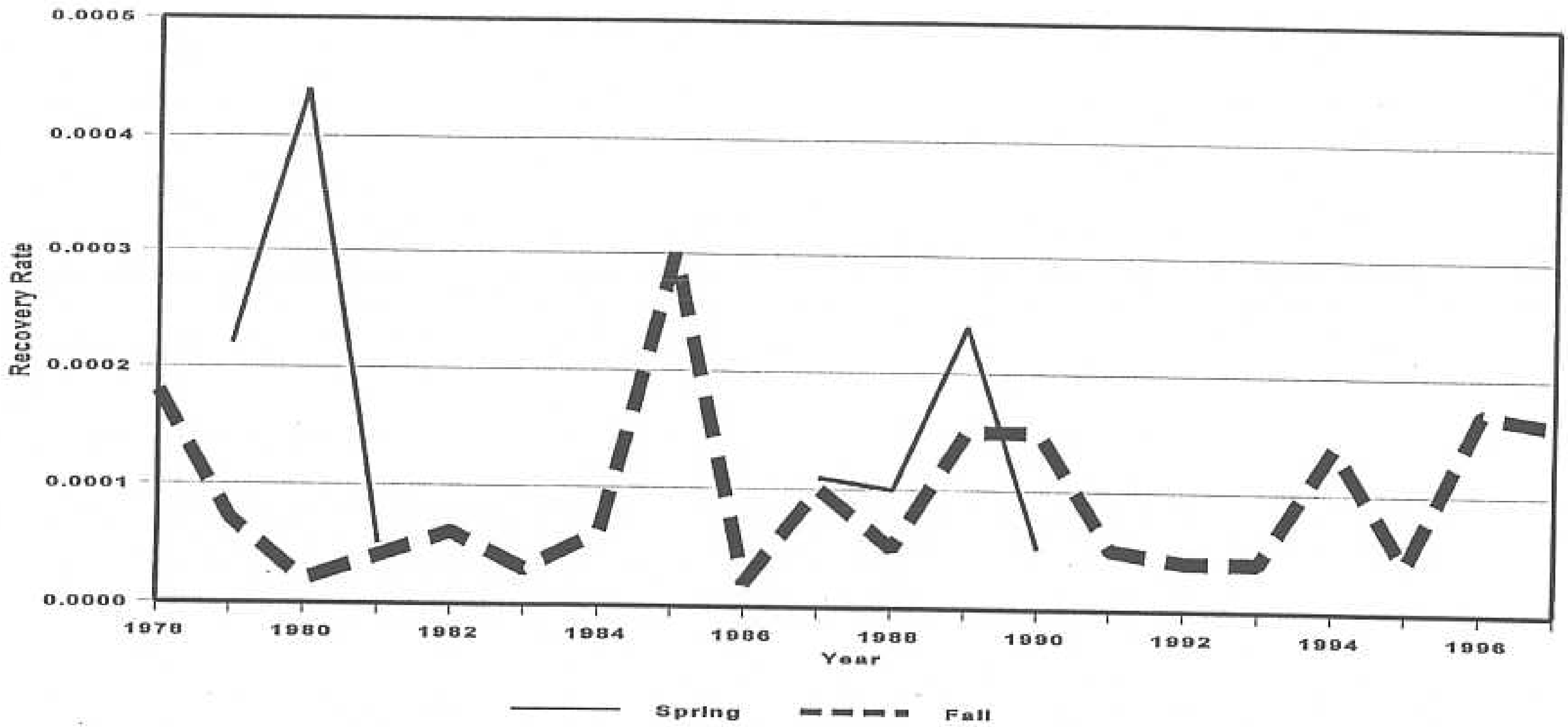


Figure 41. Central Valley age-4 chinook salmon ocean sport CWT recovery rates. 1978-97, by year (California only).

River from the Deschutes Bridge to 650 feet below Keswick Dam during the season closure. This is because fishing in this reach is open for species other than salmon, and winter-run salmon could potentially be exposed to incidental catch. There is currently no similar restriction in place for incidentally caught spring-run salmon in tributary streams .

Salmon may not be taken at any time in any tributary of the Sacramento River below Keswick Dam in Shasta and Tehama counties, unless specifically authorized in the special fishing regulations (CCR, Title 14, Section 7.50). However, all tributaries to the Sacramento River downstream of Tehama County that fall under the general Valley District regulations are open all year to fishing with a daily bag and possession limit of two salmon. Spring run that may occasionally use or occur in those waters would be subject to harvest. Department experience indicates that anglers take advantage of angling opportunities when fish, especially salmon, are discovered in unlikely waters.

Within Mill and Deer creeks, the lowermost reaches (from the U.S. Geological Service [USGS] Gage Stations to their confluences with the Sacramento River) are presently open to fishing from June 16 through September 30 with a zero bag and possession limit for salmon. The majority of adult spring run returning to these creeks have already ascended upstream by June 16 and are no longer present in the lower reaches during the proposed fishing season. The upper reaches are still open to fishing and adults are subject to catch and release impacts.

The upper reach of Butte Creek (Oro-Chico Road upstream to the DeSabla Powerhouse) is closed to all fishing all year, which protects holding and spawning spring-run salmon. The area downstream of the Oro-Chico Road is closed to salmon fishing all year, but open to fishing for all other species. This regulation is considered adequate to protect migrating adult spring-run salmon.

Angling regulations on Big Chico Creek are considered adequate for protecting spring-run salmon. The reach of Big Chico Creek where adult spring-run holding and spawning occur is closed to fishing from March 1 through September 30, the time adults are present. During the remainder of the year, the reach is open with a zero bag and possession limit for salmon. The lower reach (downstream from the upper end of Bidwell Park) is closed when adult spring run are migrating, from March 1 through June 16.

Existing regulations for the Yuba River allow the take of spring run in the reach below the Highway 20 bridge and allow a take of two fish per day. This reach is mainly a migration route for adults to the area above the Highway 20 bridge, which is their primary holding area. The holding area is open to angling with a zero bag limit from December 1 through September 30, when spring-run salmon are holding and spawning. Limited information exists regarding angling activity for spring run in the Yuba River. Angling surveys conducted by the Department in 1993-94 indicate that spring run are harvested. There were 27 chinook salmon harvested in June 1993 with anglers expending 108 hours (Wixom et al. 1995). In 1994, there was no fishing activity during the majority of the spawning migration period (March through July). However, 38 chinook salmon were caught and released in September during initiation of the spring-run spawning season.

Existing regulations for the Feather River allow the take (two fish per day) of spring run in the reach below the Table Mountain Bicycle Bridge. Spring-run salmon in this reach would be vulnerable to take from mid-February through August 30. This area is primarily a migration corridor to the holding area above the bridge. Limited information exists regarding angling activity for spring-run salmon in the Feather River. Angling surveys conducted by the Department from 1991-94 indicate that anglers are targeting chinook salmon during the period when spring run are present in the river. Angler catch during the years surveyed ranged from zero to 62 fish caught in May and from 128 to 3,737 fish caught in September, with the catch of salmon generally increasing each month from May through September (Wixom et al. 1995). The majority of fish caught were not released. It would seem reasonable that Feather River spring run or other spring-run salmon are the sole run caught early in this time period with a greater percentage of the catch composed of fall run as the season progresses.

The Feather River from the Highway 70 bridge to a point 100 yards upstream from the Thermalito Afterbay outlet is open to general fishing all year, with a bag limit of two salmon. However, it is specifically closed to salmon fishing during the period of October 1 through December 31. Spring-run salmon in this reach would be vulnerable to take from mid-February to October 1.

The Feather River from a point 100 yards upstream from the Thermalito Afterbay outlet to the mouth of Honcut Creek is open to general fishing all year, with a bag limit of two salmon. However, it is specifically closed to salmon fishing only during the period October 16 through December 31. Spring-run salmon in this reach would be vulnerable to take from mid-February through October 15.

The Feather River from Honcut Creek to the confluence of the Feather and the Sacramento rivers is open to fishing all year, with a daily bag limit of two salmon. Feather River spring-run salmon in this reach could be vulnerable to take from mid-February through October 15.

<u>Illegal Inland Harvest</u>
Poaching of spring-run salmon undoubtedly occurs at fish ladders and other areas where adult salmon are concentrated, such as pools below dams or other obstructions. Mill, Deer, and Butte creeks as well as other tributary spring-run adult populations, are also vulnerable to poaching during the summer holding months because of the long period in which adults occupy relatively confined areas. The significance of illegal fishing to the spring-run salmon adult population in freshwater, however, is unknown.

Condition of Existing Habitat

<u>Sacramento River</u>
The history of human development within the Central Valley and the degradation of mainstem Sacramento River habitat is the basis for numerous government reports, books, and legislation. More information on the habitat conditions and recommended restoration actions is contained in: *Restoring Central Valley Streams: A Plan for Action* (CDFG 1993), *Status of Actions to Restore Central Valley Spring-run Chinook Salmon: A Special Report to the Fish and Game Commission* (Mills and Ward 1996), and *NMFS Proposed Recovery Plan for the Sacramento River Winter-run Chinook Salmon* (NMFS 1997). Some of this information is discussed in the *Influence of Existing Management Actions* section of this report.

Conditions in the Sacramento River affecting spring-run chinook salmon include: Anderson-Cottonwood Irrigation District's (ACID) seasonal flashboard dam in Redding that diverts approximately 400 cfs; RBDD fish passage delay and losses; Glenn-Colusa Irrigation District (GCID) Pumps that divert 3,000 cfs and approximately one million acre-feet of water per year through fish screens with less than optimum efficiency; hundreds of small unscreened diversions; bank protection projects; discharges of chemical waste from industrial, municipal, agricultural, and mining sources; and chronic contamination from numerous, but widespread sources. In addition, excessive flow fluctuation and elevated water temperatures below Keswick Dam near Redding result in less than optimum survival of salmon (CDFG 1993). Recent, current and planned actions to address these problems are also discussed in the *Influence of Existing Management Actions* section of this report.

The Sacramento River yields 35% of the State's water supply. Most of the Sacramento River flow is controlled by Shasta Dam, which stores up to 4.5 million acre-feet of water. River flow is augmented in an average year by transferring up to one million acre-feet of Trinity River water through a tunnel to Keswick Reservoir. The U.S. Bureau of Reclamation (USBR) operates the Shasta-Trinity Division of the CVP. This division includes Shasta, Keswick, Trinity, Lewiston, Whiskeytown, and the Spring-Creek Debris dams, RBDD, and the Tehama-Colusa and Corning canals.

All of the spring-run adult holding and spawning habitat in the mainstem Sacramento River is upstream of the RBDD and below Keswick Dam. Water temperature below Keswick Dam is a function of flow release volume from Shasta Reservoir, the condition of reservoir storage, depth of water released from the reservoir, and climate. In years with low storage in Shasta Reservoir and under low flow releases, water temperatures exceed 56°F downstream of Keswick Dam during critical months for spring-run spawning and egg incubation. Presently there is a complete overlap of physical spawning habitat for spring- and fall-run chinook salmon in the mainstem Sacramento River. Given that their spawning time also overlaps, it has been concluded that there is hybridization occurring between the two runs.

RBDD is located about two miles southeast of the city of Red Bluff. The fish ladders are inefficient in allowing adult spring-run chinook salmon to ascend to the upper Sacramento River and its tributaries (Hallock et al. 1982, Vogel and Smith 1986, Vogel et al. 1988). To help protect the Sacramento River winter-run chinook salmon, the dam gates have been raised for varying periods since the end of 1986. Presently the gates are raised from September 15 through May 14, allowing free passage for adults during this period. While this allows for approximately 85% of winter-run adults to pass unimpeded upstream, few spring-run adults have migrated past RBDD by the time the gates are closed. The majority of the fish are required to negotiate the inefficient ladders. Adults that are obstructed from passing the dam are forced to either spawn downstream, where temperatures are typically lethal for incubating eggs, or to ascend lower tributaries in search of suitable spawning habitat (Hallock 1987).

When the gates are closed at RBDD (between May 15 and September 14), any outmigrating salmon juveniles pass under the gates and into turbulent waters below the dam where they are heavily preyed upon by squawfish and striped bass (see Predation Section). However, gates-out operations from September 14 until May 15 for adult and juvenile winter run provide unimpeded downstream migration for juvenile spring run.

<u>Clear Creek</u>

Potential spring-run habitat occurs below Whiskeytown Dam to Placer Bridge. There is an adult upstream migration barrier at McCormick-Saeltzer Dam, which precludes use of the area below Whiskeytown Dam. Currently, there are inadequate flows, spawning gravels, and water temperatures below Whiskeytown Dam and accelerated erosion in portions of the watershed (USFWS 1994).

Cottonwood Creek and tributaries

The habitat for spring run is limited by the amount of cold water flows during the summer holding period. Currently, the population of spring run is restricted to Beegum Gorge and occasionally a small section of the South Fork.

Battle Creek

The present condition of physical habitat in Battle Creek is suitable for maintaining a self-sustaining population of spring-run chinook salmon. Habitat conditions in Battle Creek are considered drought resistant due to the geologic and hydrologic characteristics of the basin. Battle Creek has large volcanic formations in the watershed that produce large springs and sustained flows during drought. The base flow of Battle Creek across the valley floor exceeds 300 cfs on average and is still above 200 cfs during droughts, which keeps it well connected to the Sacramento River under all conditions.

PG&E owns and operates the Battle Creek Project (Federal Energy Regulatory Commission Project Number 1211) consisting of two storage reservoirs, four unscreened hydropower diversions on North Fork Battle Creek, three unscreened diversions on South Fork Battle Creek, a complex system of canals and forebays, and five powerhouses. There are also two agricultural diversions in the mainstem of Battle Creek, only one of which is screened.

A primary factor that limits the Battle Creek spring-run population is the large volume of water diverted into unscreened hydroelectric canals that parallel the natural drainage course. The remnants of spring-run habitat in Battle Creek are associated with stream reaches between diversions where there is inflow from the large cold springs that are common throughout the watershed. An instream flow study indicated a need to increase the minimum required flow below the dam by a factor of five to ten in most reaches (Payne 1991). Additionally, upstream migration is impaired by dams with inadequate fish ladders, as well as the CNFH fish barrier that is closed for a small portion of the spring-run migration period. Because of the unscreened diversions and limited instream flow releases, the fish ladders are closed on PG&E's two lower diversions (Eagle Canyon Dam on the North Fork and Coleman Diversion on the South Fork). This prevents fish from ascending into the area above the hatchery water supply and to dewatered and unscreened reaches of the creek. Closure of the fish ladders at Eagle Canyon and Coleman Diversion dams blocks migration of adult spring run into the middle or upper reaches of those streams. As a result, the range of spring run in Battle Creek above CNFH is presently restricted to 17 miles out of a potential 42 miles of habitat. There is evidence that salmon have gotten above the small dams during high flows even with the fish ladders closed, so the range reduction is probably not complete.

Antelope Creek

Department habitat surveys and water temperature monitoring have identified limited but adequate adult holding and spawning habitat for spring-run salmon. Adult passage is a limiting factor across the valley floor during the majority of the adult upstream migration period.

There are two water diversions at the canyon mouth on Antelope Creek. One is operated by the Edwards Ranch and has a water right of 50 cfs. The other is operated by the Los Molinos Mutual Water Company with a water right to 70 cfs. Flow in Antelope Creek is typically diverted April 1 through October 31. Average annual flow during this time of year, measured between 1940 and 1980, was 92 cfs. The lower reach of the stream is usually dry when both diversions are operating. Adult spring run are unable to enter the stream during the irrigation and diversion season.

Mill and Deer creeks

The habitat in Mill and Deer creeks is similar, as is the life-history of spring-run chinook salmon in these two tributaries. Elevations above 2,000 feet in both creeks (like many other eastside tributaries at similar elevations) usually have water temperatures which meet or exceed the minimum requirements for adult spring-run salmon to hold throughout the summer (Figure 42).

Spring-run spawning habitat in Mill Creek ranges from two miles upstream of the State Highway 36 Bridge downstream to Lees Camp, a distance of 24 miles. The range in elevation is 880 feet to 5,300 feet. In Deer Creek, spawning occurs at Upper Deer Creek Falls downstream to Deer Creek Crossing, a distance of 23 miles. The range in elevation is 1,280 feet to 3,600 feet. (Kano and Reavis 1997a, 1997b).

All diversions on Mill Creek are screened. All fish screens on Mill Creek diversions are installed and operated during the irrigation season, typically April through October, by the Department's Red Bluff Fish Habitat Shop. The primary problem in Mill Creek affecting spring-run abundance in recent years is the withdrawal of water at agricultural diversions, affecting adult and juvenile migration due to low flows.

Lower Mill Creek has three water diversions: Ward (Lower Diversion), the Clough Diversion, and the Upper Diversion. The State Water Resources Control Board (SWRCB) fully adjudicated Mill Creek in the 1920s. Decree 3811, issued by the Superior Court of Tehama County, apportioned a total of 203 cfs of the natural flows of Mill Creek. This decree authorized diversion amounts and provision for screening of all diversions. Los Molinos Mutual Water Company is the Water Master for Mill Creek and manages the Upper and Lower diversions. Clough Diversion is a private diversion. There are no major dams or water diversions upstream of the Upper Diversion on Mill Creek.

Ward Diversion (Lower Diversion) is located approximately three miles from the confluence with the Sacramento River. The Decree 3811 authorized 60 cfs to be diverted at this location. The dam at Ward Diversion is a gradual inclined ramp. The slope of this ramp-type dam allows adult salmon to swim up and over the dam at moderate to high flows. The Ward Diversion fish ladder is a cement pool and weir type ladder and was rebuilt in 1997 to operate at a higher range of stream flows. The Ward Diversion is screened by an inclined-diagonal, perforated flat-plate screen with an optional trap or direct fish bypass.

Clough Diversion is located approximately five miles upstream of the confluence with the Sacramento River and is authorized to divert 20 cfs of flow. Flood waters in 1997 breached the diversion dam so that it no longer diverts flow and fish can swim upstream using the natural stream channel. Alternate water delivery solutions are being considered for the Clough Diversion, which may allow for the permanent removal of the dam and any diversions from this site.

Upper Diversion Dam on Mill Creek is located approximately six miles upstream from the confluence with the Sacramento River, and is authorized a maximum diversion of 123 cfs. The dam at Upper Diversion is a gradual inclined ramp and is designed for adult salmon to swim up and over the dam at moderate to high flows. The fish ladder is a concrete pool and weir type ladder. The Upper Mill Creek Diversion is screened by a vertical, perforated flat-plate fish screen.

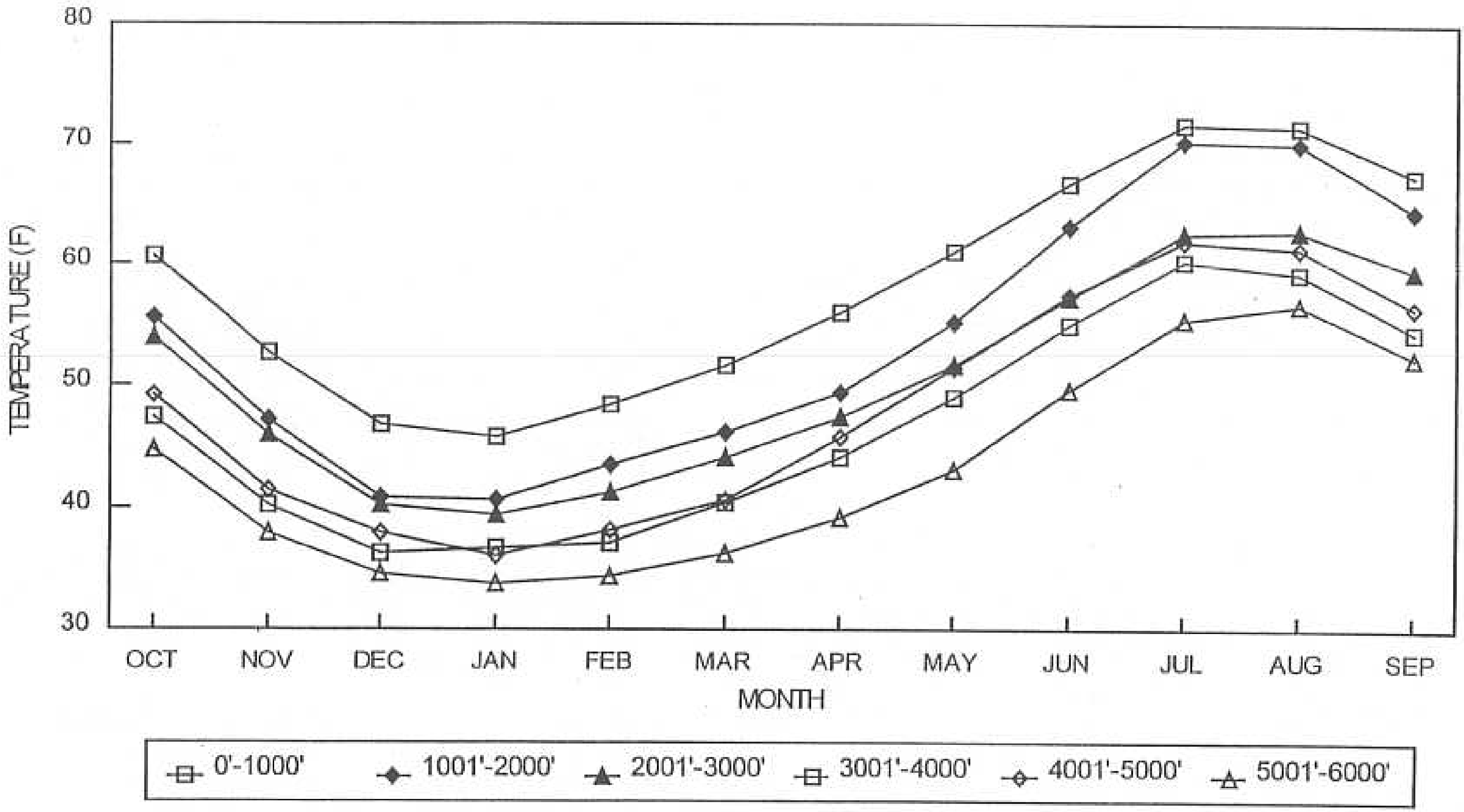


Figure 42. Calculated average water temperature taken from USGS stations in northern Sierra Nevada streams at various elevations. No stations situated below impoundments were included. Note that for elevations less than 2,000 feet temperatures exceed 60° F.

Deer Creek has four water diversions, all of which have been screened since the early 1920s. All fish screens on Deer Creek diversions are installed and operated during the irrigation season, typically April through October. The Department's Red Bluff Fish Habitat Shop maintains all fish ladders and fish screens on Deer Creek.

In 1923, the Tehama County Superior Court adjudicated 100% of the water in Deer Creek. The three water diversions on the lower creek are: the Stanford-Vina Ranch Irrigation Company (SVIC) Diversion Dam, the Cone-Kimball Diversion Dam, and the Deer Creek Irrigation Company Dam (DCID). The SVIC Diversion Dam is located approximately three miles from the confluence with the Sacramento River. SVIC and Cone-Kimball Diversion Dam receive 66.7% of the natural flow in Deer Creek. SVIC diverts from both a north and a south diversion. Each is screened with an inclined diagonal, perforated flat-plate screen. The north diversion has a direct fish bypass. There is a concrete pool and weir-type fish ladder on each end of the diversion dam.

The Cone-Kimball Diversion is located six miles from the confluence with the Sacramento River. The amount of flow diverted is included in the amount adjudicated to SVIC. This diversion is screened with a sloping diagonal, perforated plate screen. Adult salmon can swim over the control boards on this dam and, therefore, a fish ladder is not necessary.

The DCID is located approximately eight miles upstream of the confluence with the Sacramento River and is the uppermost irrigation dam on Deer Creek. This diversion is adjudicated 33.3% of the natural flow in Deer Creek. This diversion is screened with an inclined-diagonal, perforated flat-plate screen with a direct fish bypass. Adult salmon can swim over the control boards on this dam and, therefore, a fish ladder is not necessary.

For both Mill and Deer creeks, the diversion structures can slow salmon from going upstream, but the Department has no evidence that these structures cause undue mortality of migrating adults. At high flows, salmon are able to swim over all dams except Stanford-Vina Dam on Deer Creek. At lower flows, salmon are able to negotiate the fish ladders adequately.

In low water-years, the diversions on Mill and Deer creeks can reduce or eliminate natural flows downstream of the lower diversions to the Sacramento River during the peak of adult spring-run salmon migration (late May through June), thus truncating the adult salmon migration. Through the conservancies on Mill and Deer creeks, the diverters have worked cooperatively to provide flows for migrating adults. On Mill Creek, the Water Exchange Agreement was created to provide 25 cfs of flows for adult and juvenile fall- and spring-run salmon during peak migration and spawning periods. A similar water exchange program is being negotiated for Deer Creek. The Department monitors critical fish passage areas on the lower three miles of Mill and Deer creeks during the spring to ensure adequate flow for migrating adult spring-run salmon. Flows have been adequate to pass adult spring-run salmon in most years throughout the adult migration period in both Mill and Deer creeks.

There is no evidence that degradation of riparian habitat, due to cattle grazing and farm practices in spawning areas, has adversely affected spring-run abundance in recent years. The terrain (i.e., bedrock cliffs, canyons, and steep gradient boulder cascades) is not conducive for livestock grazing. In Deer Creek, cattle grazing occurs in Deer Creek meadows, which is upstream of Upper Deer Creek Falls (a barrier to upstream migration). In the early 1990s, the Department assisted in fencing Deer Creek meadows to exclude cattle from the riparian areas in Deer Creek. Fence condition and repair is monitored and maintained by the Department.

Big Chico Creek

The best summer holding habitat in Big Chico Creek is Higgin's Hole, which is the upstream limit of spring-run salmon habitat. Temperature data from the pools at Higgin's Hole show daily mean temperatures of 64°F to 68°F during the summer months. Other lesser quality holding habitat downstream of Higgin's Hole have even higher water temperatures (K. Hill, pers. com.). During the summer months, flows in Big Chico Creek average 30 cfs, while flows during the winter averages over 300 cfs (CH2M Hill 1993). These low flows and correspondingly high water temperatures during the critical summer holding months are less than optimum for adult spring-run salmon. However, other habitat parameters such as riparian vegetation and isolation from human activity are good in Big Chico Creek.

Butte Creek

Existing habitat conditions have been significantly degraded over those that existed historically. As was stated by Clark in 1929, "...the creek was formerly one of the best salmon streams, but because of the irrigation dams and low water the run has been almost destroyed." This degradation exists today, although restoration actions as discussed below and later within this report have moderated, and in some cases partially remedied, some of the man-caused effects.

Centerville Head Dam to Centerville Powerhouse: Habitat conditions within Butte Creek vary by reach. PG&E virtually dewatered the upper reach between the Centerville Head Dam and the Centerville Powerhouse prior to 1980. The reach, which is about five miles in length, remains one of the prime summer holding and spawning areas for spring-run chinook salmon. PG&E, as part of a Federal Energy Regulatory Commission (FERC) relicense process now provides a minimum of 40 cfs from June 1 to September 15. In dry years, PG&E is required to provide only 10 cfs, with no commitment after September 15. Some additional damage has been caused by miners in this reach, although with existing regulations the situation has been stabilized. The deeply incised canyon, its relative remoteness from human intrusion, and deep spring-fed pools provide the best summer adult holding potential of the entire creek.

Centerville Powerhouse to Parrott-Phelan Dam: The reach from the Centerville Powerhouse down to the Parrott-Phelan Dam near the valley floor, has undergone and continues to undergo significant residential development. This reach contains the remainder of the summer adult holding habitat and the majority of the potential spawning habitat for spring run. Human access is provided by a county road which traverses the entire reach and is heavily utilized by summer recreationalists. In addition, major channel modifications have occurred to repair or prevent flood related damages to roads and houses. These channel modifications, which have attempted to address habitat needs, have degraded the natural processes which serve to recruit spawning gravel, provide instream cover and forage, and provide summer holding pools. It is important that future development and channel modification carefully consider impacts to stream habitat.

At the lower end of this stream reach is the Parrott-Phelan Diversion. At key times, it diverts a significant portion of Butte Creek flows, previously entraining large numbers of juveniles and affecting downstream flows for adult and juvenile passage. A new fish screen, meeting current State and Federal criteria, and a high efficiency fish ladder have recently been installed at this site. In addition, as discussed elsewhere in this report, a recent agreement (1996) with the diverters, M&T Ranch and Parrott Investment Company, has provided 40 cfs of instream flows during the period of October through June. Prior to this agreement, a Superior Court adjudication (Butte County 1942) and previous appropriative water rights frequently resulted in dewatered portions of the creek in the reach below the Parrott-Phelan diversion down to the Sacramento River at either of the two entry points near Colusa or Verona.

Parrott-Phelan Dam to Butte Sink: The valley reach from the Parrott-Phelan Diversion to the Butte Sink has been heavily affected by agriculture. This was recognized by Clark as early as 1929 when he stated: "The dams are unimportant except for the fact that they divert so much water that fish cannot ascend the stream." As within the upper reaches, development has occurred and continues to occur within this reach. The Superior Court water rights adjudication, which was settled in 1942, under many conditions provided diverters the legal right to dewater stream sections between the Parrott-Phelan Diversion and the Western-Canal dam. Low flows, in addition to affecting passage, also have contributed to elevated water temperatures which have been detrimental to both adult and juvenile spring-run salmon. Within this reach, the Western Canal Water District, and its predecessors, have conveyed Feather River water into and across Butte Creek since about 1908.

Prior to recent and scheduled structural changes, there were seven seasonal diversion dams operated by agricultural interests. Each of the diversions had the potential to detrimentally affect migrating spring-run adults and juveniles. During 1997, the two Western Canal dams were removed and replaced with a siphon which now conveys Feather River flows under Butte Creek. Additionally, two downstream dams, McGowan and McPherrin, will be removed during 1998. The three remaining structures (Durham-Mutual, Adams, and Gorrill) are scheduled for installation of fish screens and improved fish ladders during either 1998 or 1999.

Various levee projects have been implemented, extending from approximately Highway 99, near Chico to Highway 162. As with the upper reach above Parrott-Phelan Dam, levee installation, maintenance, and repair have altered the natural stream process and within this reach has affected riparian vegetation. In addition, agricultural development has occurred within the levees, which has further limited channel function and riparian vegetation. Below Highway 162, agricultural drainage flows return into Butte Creek, which may detrimentally affect migration, water temperature, and water quality.

Butte Sink to Butte Slough Outfall: The reach of Butte Creek within the Butte Sink is generally located between the Gridley-Colusa Highway and Butte Slough Outfall gates at the Sacramento River south of Colusa. Within this reach, Butte Creek historically overflowed into a large basin, without a well defined stream channel, although maps from the mid-1800s show a channel along the northwest boundary of the Butte Sink. Within the Butte Sink, even as early as 1929, duck clubs were diverting and rerouting flows (Clark 1929). Impacts from duck clubs and agricultural diversions continue to this day. Potential impact sites include the Sanborn Slough Bifurcation, White Mallard Weir, Drumheller Slough Outfall, Butte Slough Outfall gates and a host of lesser diversions. Lack of fish screens, fish ladders, and operational agreements for flows addressing spring-run migration and rearing needs, impact spring run in this reach. Additionally, major drains and flood overflows converge into the Butte Sink and alter water quality and attraction flows that detrimentally affect migration and rearing of spring-run salmon.

Sutter Bypass: Prior to the various levees associated with the present Sutter Bypass, Butte Creek alternately flowed into the area now within the Sutter Bypass levees and the Sacramento River near the present site of the Butte Slough Outfall gates (DWR 1976, USGS 1912). Butte Creek is currently regulated by gates placed at or near the site of the historic entry into the Sacramento River, approximately five miles south of Colusa. Flows are regulated through the gates to accommodate both flood control and agricultural needs. During much of the year most of Butte Creek flow is directed through the Sutter Bypass East and West channels for agricultural purposes, to rejoin the Sacramento River via Sacramento Slough near Verona. In addition, during flood events originating from the upper Sacramento River, any flows in excess of approximately 22,000 cfs are directed into the Sutter Bypass via Tisdale Weir, Colusa Weir, or Moulton Weir. The net effect is to present changing migrational routes for both juvenile and adult spring-run salmon.

Throughout the Sutter Bypass, there are various flow control structures which directly impact both migrating adults and migrating and rearing juvenile spring run. There are five major structures that divert or regulate water which are unscreened and either do not have fish ladders, or have ineffective fish ladders. There are various other barriers and diversions that under some conditions are detrimental to spring-run adults and juveniles. Various actions are being implemented to address many of the identified passage problems within the Butte Sink and Sutter Bypass. A limited evaluation by the Department has identified rearing potential for juvenile spring run within the Sutter Bypass (Curtis 1996).

Yuba River

Migration of spring run to historic holding and spawning habitat was blocked by the construction of Englebright Dam. Spring run now spend the summer in the area just below the Narrows 1 and 2 powerhouses immediately below Englebright Dam or further downstream, particularly in the large deep pool immediately below the Narrows. This reach provides summer refugia with deep pools and cool water. However, this is historic fall-run spawning habitat. There may be hybridization occurring between the two races.

Adult spring-run chinook salmon encounter Daguerre Point Dam during their upstream spawning migrations. Factors which can inhibit or prevent upstream passage include poor ladder design and operation, sheet flow across the dam spillway confusing fish and hindering attraction to ladder entrances, and increased poaching. The fish ladders are designed to be operated within a limited river flow range, primarily during low flows, when fall-run chinook salmon are present. During higher flows, ladder passage is inhibited, attraction to the ladder entrances are obscured, and flows in excess of approximately 15,000 cfs dictates that the ladders be closed. Ladder closures in excess of a month occur during the spring-run salmon migration periods.

Existing instream flows are less than optimum for adult spawning, juvenile rearing, and juvenile outmigration. The cumulative water diversion rates in the lower Yuba River can exceed 95% of the entire river flow.

Fish health and spawning success can be significantly affected by delays at dams. Sheet flow over the face of Daguerre Point Dam attracts fish which try to ascend the face, and they can be injured and subsequently become diseased. Summer water temperatures below the dam are often not adequate to support juvenile salmon, which remain in the river to yearlings. Passage problems can prevent spring-run chinook salmon from reaching the cold water holding pools above the dam.

Losses of juvenile salmon occur at the Hallwood-Cordua and South Yuba-Brophy diversions. The Hallwood-Cordua fish screen is operated by the Department and is operated only during the estimated peak period for downstream migration of juvenile fall-run chinook salmon (typically April through June). Periods occur when water is diverted but the screen is not operated, and juvenile spring-run salmon which migrate during those times and enter the diversion are lost.

The South Yuba-Brophy Diversion consists of a gabion weir which cannot meet current screening criteria and is ineffective at excluding juvenile salmonids. Studies indicate that juvenile salmonid losses of the fish that enter the South Yuba-Brophy Diversion ranged from 40%-60% (Konnoff 1988). Losses were associated with the entire diversion facility, which included losses to predation, impingement, and entrainment.

Sacramento-San Joaquin Delta

The Delta provides habitat for spring-run salmon in three ways: (1) it is a migration corridor to the upper Sacramento River and its tributaries for adults returning to freshwater to spawn; (2) it is a migration corridor to the ocean for juveniles; (3) and it provides rearing habitat for juvenile salmon that move into the Delta weeks or months before they are able to enter salt water.

Historical Perspective on Habitat Conditions in the Delta: Major changes occurred in the Delta in the 1800s when thousands of acres of tidal marshes were reclaimed through the \construction of levees, changing the character of the landscape permanently. Sedimentation from gold mining also had a substantial impact. More gradual and subtle changes have occurred since the late 1800s affecting the suitability of the Delta as habitat for salmon and other native fishes (ABAG 1992).

Eighty percent of the estuary's fresh water is provided by the Sacramento River basin. Water storage and diversions within the basin affect the seasonal flow of fresh water into the estuary and the volume of water entering San Francisco Bay. Beginning in the late 1850s, flood control projects as well as storage and diversions for agriculture and power generation began to alter the timing and volume of the estuary's inflows. Within the 20th century, major human alterations to flow timing, volume, and destination have occurred during several major time periods (Arthur et al. 1996):

Prior to 1945	-	No major State or Federal dams on the Sacramento River
1945-1950	-	Shasta and Friant dams in operation but no significant Federal water exports from the Delta;
1951-1967	-	Federal water exports from the Delta;
1968-1977	-	State and Federal water exports from Delta. Compliance to SWRCB D-1379 water quality standards;
1978-1992	-	Compliance to SWRCB D-1485 water quality standards;
1993-1994	-	Operations of CVP and SWP modified to comply with Biological Opinions for Sacramento River winter-run chinook salmon and Delta Smelt; and
1995-1997	-	Operations to SWRCB Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (1995 Bay-Delta Plan.)

A review of historic DAYFLOW flow data (averaged by major time period as defined above, by month, and by water-year type) (Appendix E) indicates that water project operations during the last 50 years have shifted the time of peak total Delta inflow, especially in drier years. Summer and fall total Delta inflows have increased, while winter and spring inflows have been reduced (Figure 43, Appendix E-1). The percent of total inflow that is diverted annually by the SWP and CVP continually increased over the last 50 years (Figures 44a and 44b, Appendix E-9). On a seasonal basis, the maximum export to inflow (E:I) ratio once occurred in the summer months, but gradually shifted towards the fall through early spring months (Figure 45). The E:I ratio in the fall, winter, and spring months increased from less than 10% in the 1930-50 period to an excess

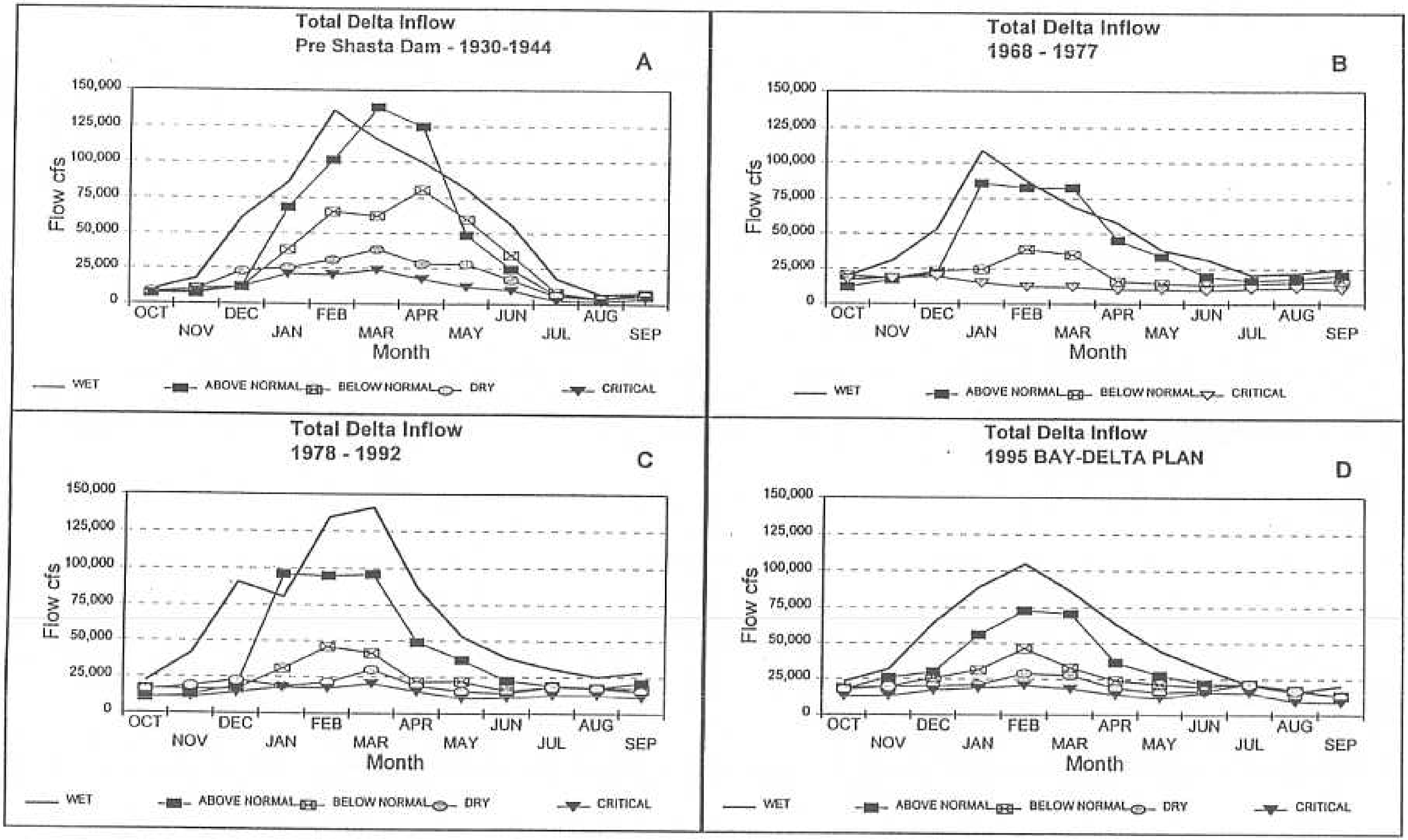


Figure 43. Change in average monthly Delta inflows (cfs) for key time periods in water project operations within the Central Valley. (A) Beginning prior to operations of Shasta and Friant dams; (B) through the 1968-1977 period when water projects operated to SWRCB Decision 1379 ; (C) through the 1978-1992 period of operations to SWRCB Decision 1485 water quality standards; and (D) under simulated operations to 1995 Bay-Delta Plan.

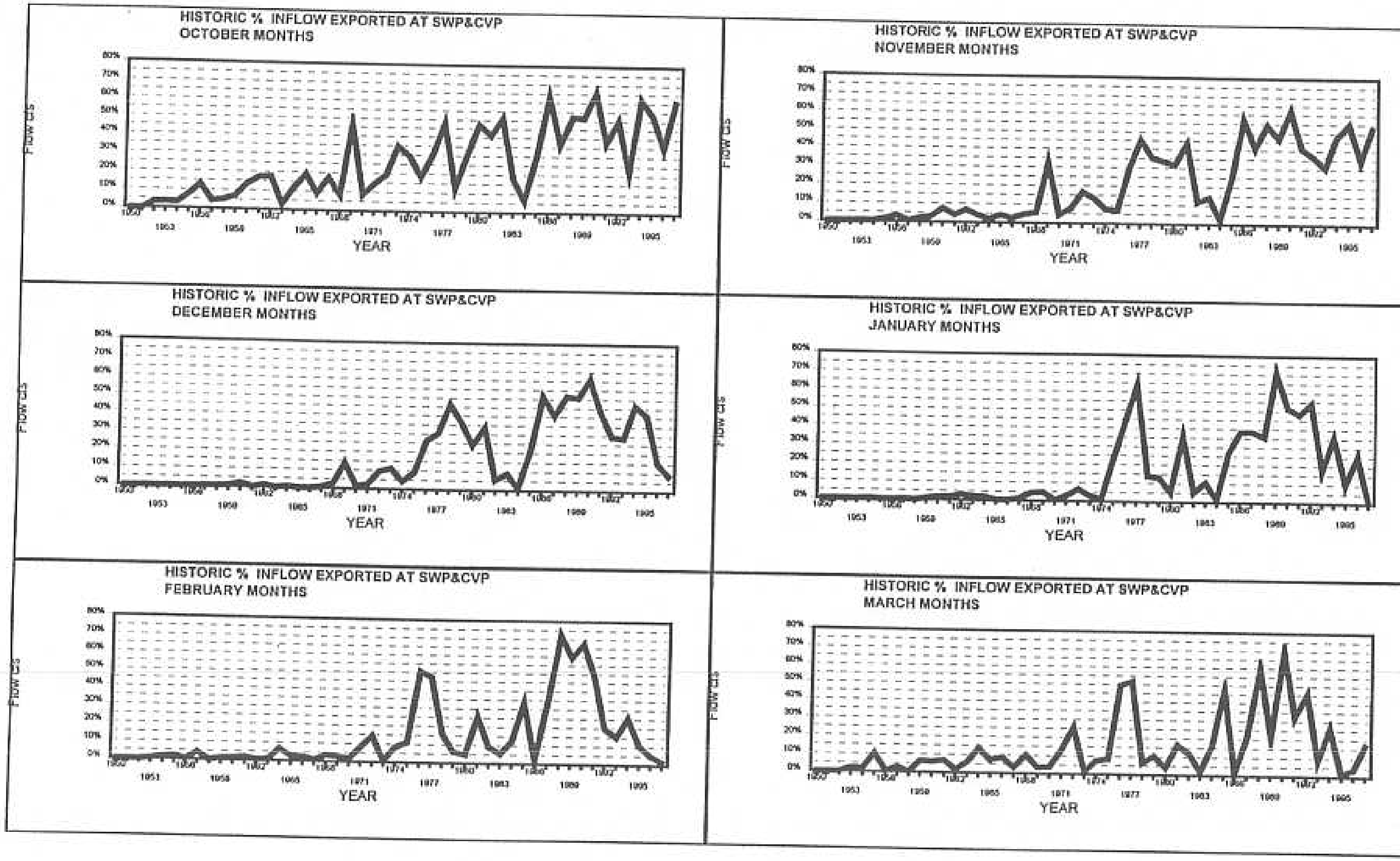


Figure 44a. Change in historic percent of total Delta inflow (cfs) exported at the CVP and SWP for October through March months.

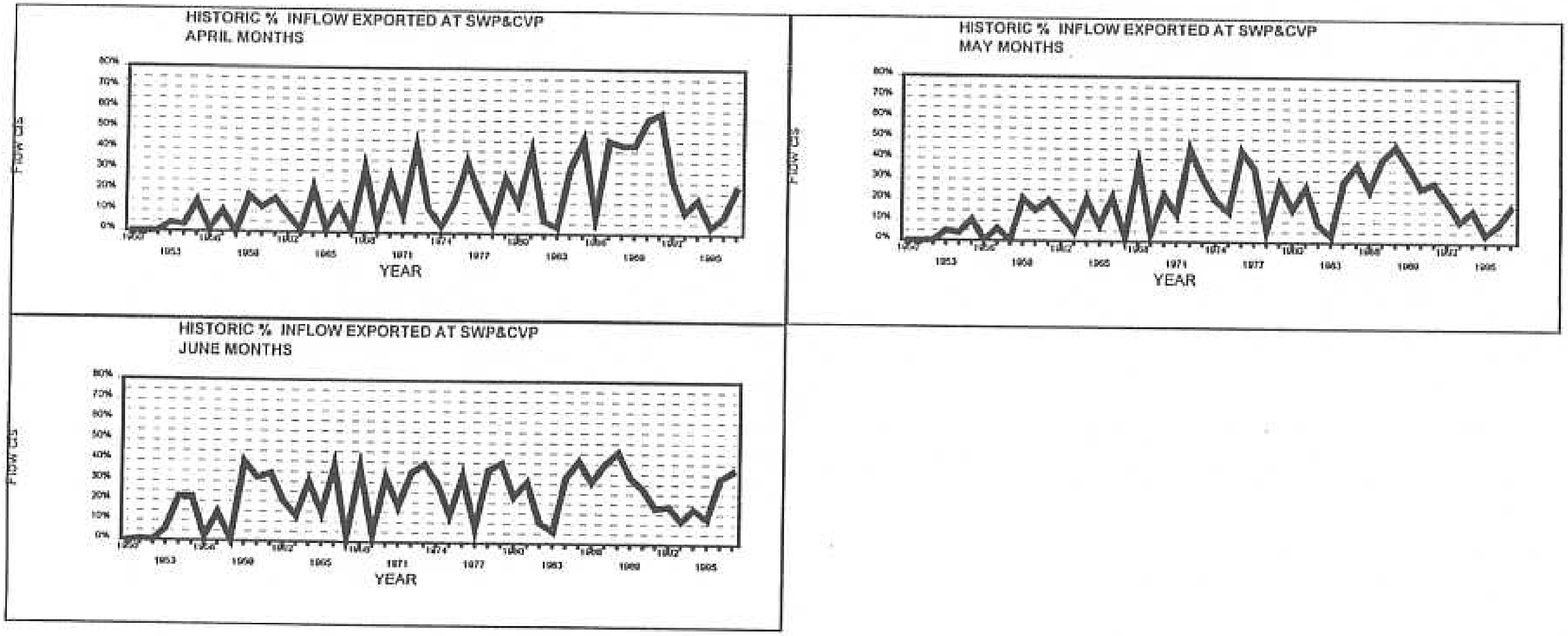


Figure 44b. Change in historic percent of total Delta inflow (cfs) exported at the CVP and SWP for April through June months.

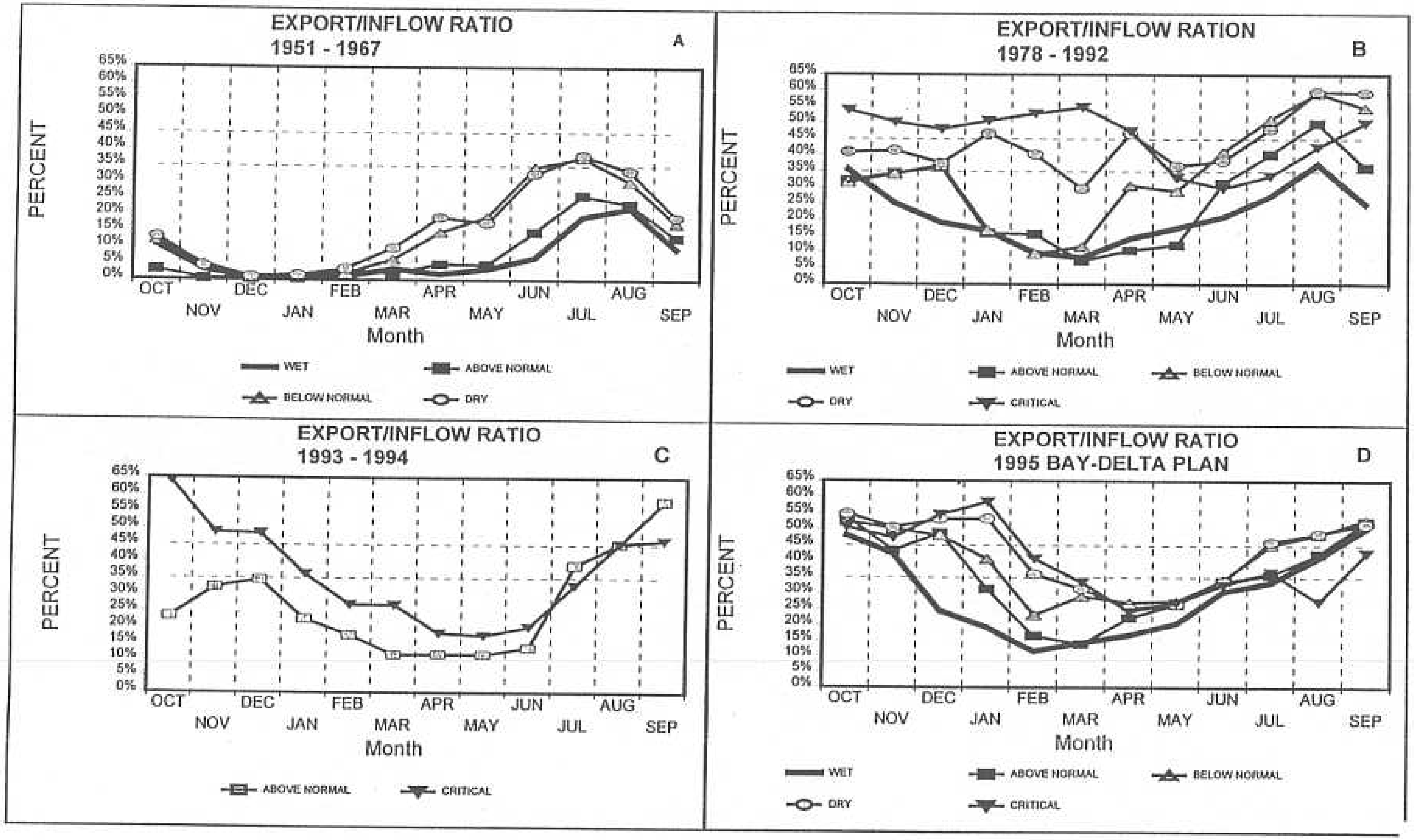


Figure 45. Change in average monthly Delta export/inflow ratio (%) for key time periods within the Central Valley. Beginning (A) with early period of Delta export operations from 1951-1967 through (D) simulated water ptoject operations to SWRCB 1995 Bay-Delta Plan.

of 30% to 60% diverted in the 1978-92 period. In the last five years, there has been a general reduction in the E:I ratio during the late spring months, but a continued increase during the October and November months.

Most of the time, more water is being diverted from the southern Delta by the SWP and CVP pumps than flows in from the San Joaquin River. As a result, the rest of the water exported by the SWP and CVP comes from the Sacramento River and eastside Delta tributaries, resulting in net upstream water movement (reverse flow) in the lower San Joaquin River and through the central and southern Delta (Figure 46). Before major water projects began operations in the mid-1940s, lower San Joaquin River flows remained positive except in the driest years (1931, 1934, 1939) and flow reversals only occurred during late summer and early fall months (Figure 47, E-5). As exports increased over the last 50 years, reverse flows in the lower San Joaquin River became the norm rather than the exception. Since the late 1970s, reverse flows occur in fall, winter, and early spring months (key months for juvenile yearling and sub-yearling spring-run outmigration), especially in dry and critical water-years (Figures 48 and 49).

The recent (1985-94) series of mostly dry years, including the 1987-92 drought, produced severely degraded habitat conditions within the Sacramento River basin and the Delta. At the same time, monthly export volumes continued to increase until 1991 (Figure 50, Appendix E-13). The peak monthly export occurred in the fall of 1989 (699,000 af). Whereas historically water was exported mainly in spring and summer months to satisfy immediate demand for crop irrigation, construction of San Luis Reservoir and other water storage facilities south of the Delta has accommodated shifting peak exports into late fall, winter, and early spring months (Figures 51 through 53; Appendix E-15), the key period for juvenile spring run rearing and yearling out migration within the Delta.

As a consequence, exports have increased over the last half century and Delta outflows have been reduced commensurately (Figure 54, Appendix E-19).

Under present-day operations with the 1995 Bay-Delta Plan and recent Anadromous Fish Restoration Plan (AFRP) Delta actions, water exports are shifted from the spring to the fall and winter months, which are critical to Sacramento River spring run yearling outmigration (Figure 55, Appendix E-16 through E-18). Both the frequency and severity of reverse flows increase throughout the year (Figure 48, Appendix E-6 through E-8). Reduced export levels in spring months will improve conditions for rearing and migrating sub-yearling spring run within the Delta. The 1995 Bay-Delta Plan allows for closure of the DCC more often to protect salmon from entrainment to the central Delta. However, closure of the DCC without commensurate reduction in export levels exacerbates reverse-flow conditions in the lower San Joaquin River. This likely reduces the benefits of DCC closures.

Changes in Delta Ecosystem and Their Effect on Spring Run: Changes in estuarine hydrodynamics have adversely affected a variety of organisms at all trophic levels, from phytoplankton and zooplankton to the young life stages of many fish species (e.g., Delta smelt, striped bass) (Arthur et al. 1996). The ecological processes in the Delta have also been affected by interactions among native and introduced species, the various effects of water management on Delta water quality and quantity, and land use practices within the watershed. Cumulatively, these changes have diminished the suitability of the Delta as juvenile salmon rearing habitat and have reduced the survival of young salmon migrating through the Delta to the Pacific Ocean. While conditions have been more stable in the spring-run tributaries during the last 50 years, substantial modification of flow-related habitat conditions in the Delta has occurred. The

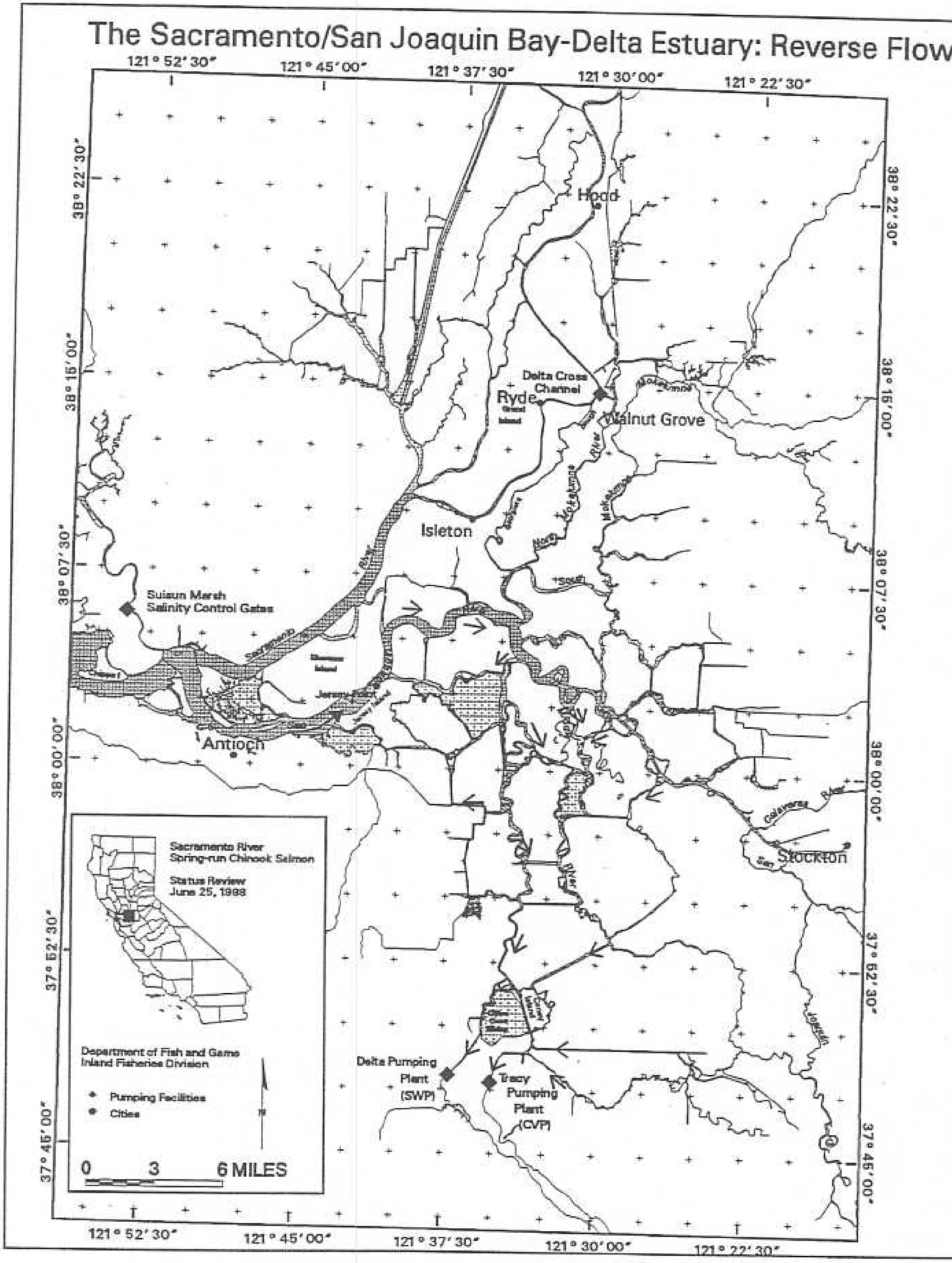


Figure 46. The Sacramento/San Joaquin Bay-Delta water ways and reverse flows.

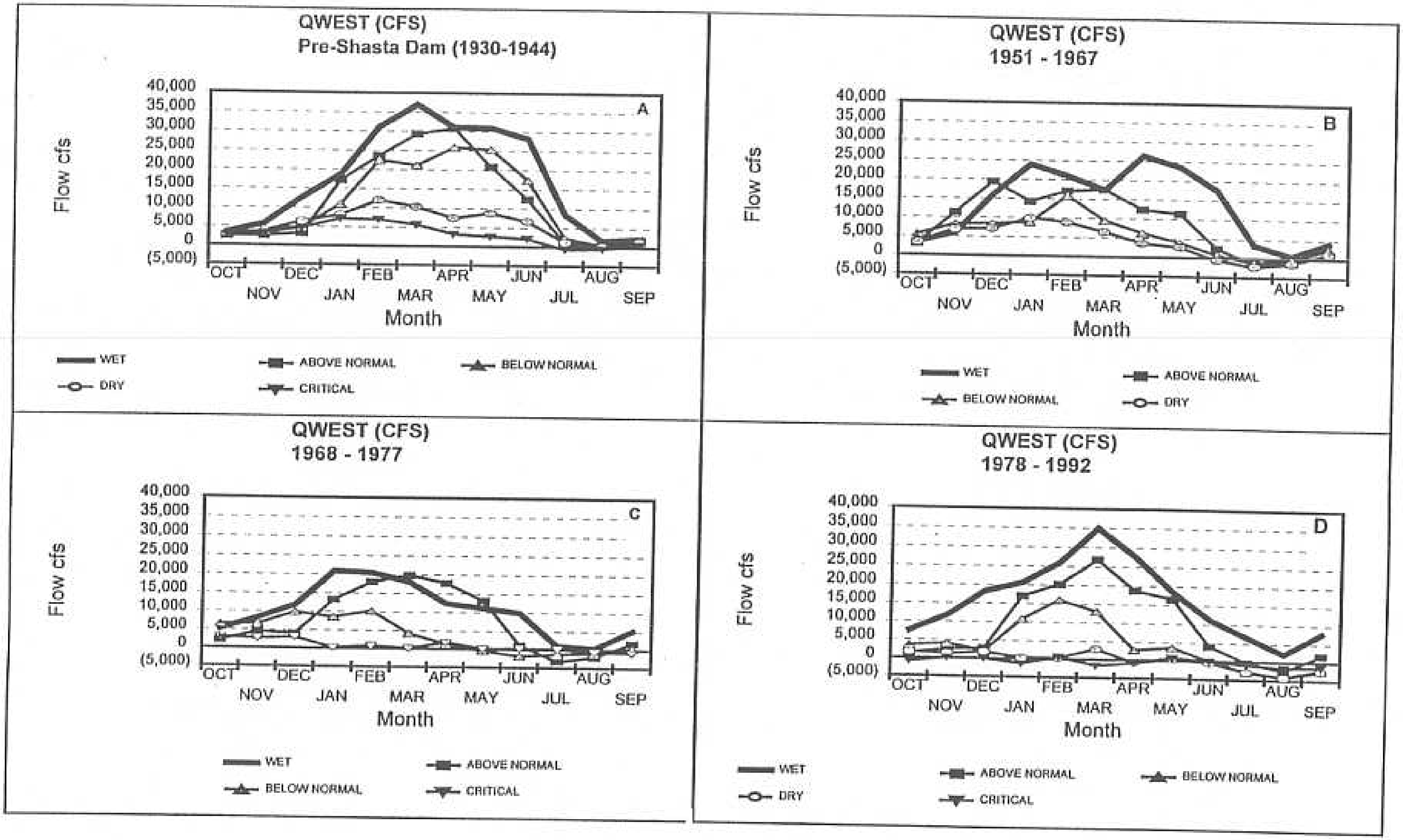


Figure 47. Change in average monthly QWEST flows (cfs) for key time periods in water project operations within Central Valley. (A) Beginning prior to operations of Shasta and Friant dams through (D) the 1978-1992 period of operations to SWRCB D1485 water quality standards.

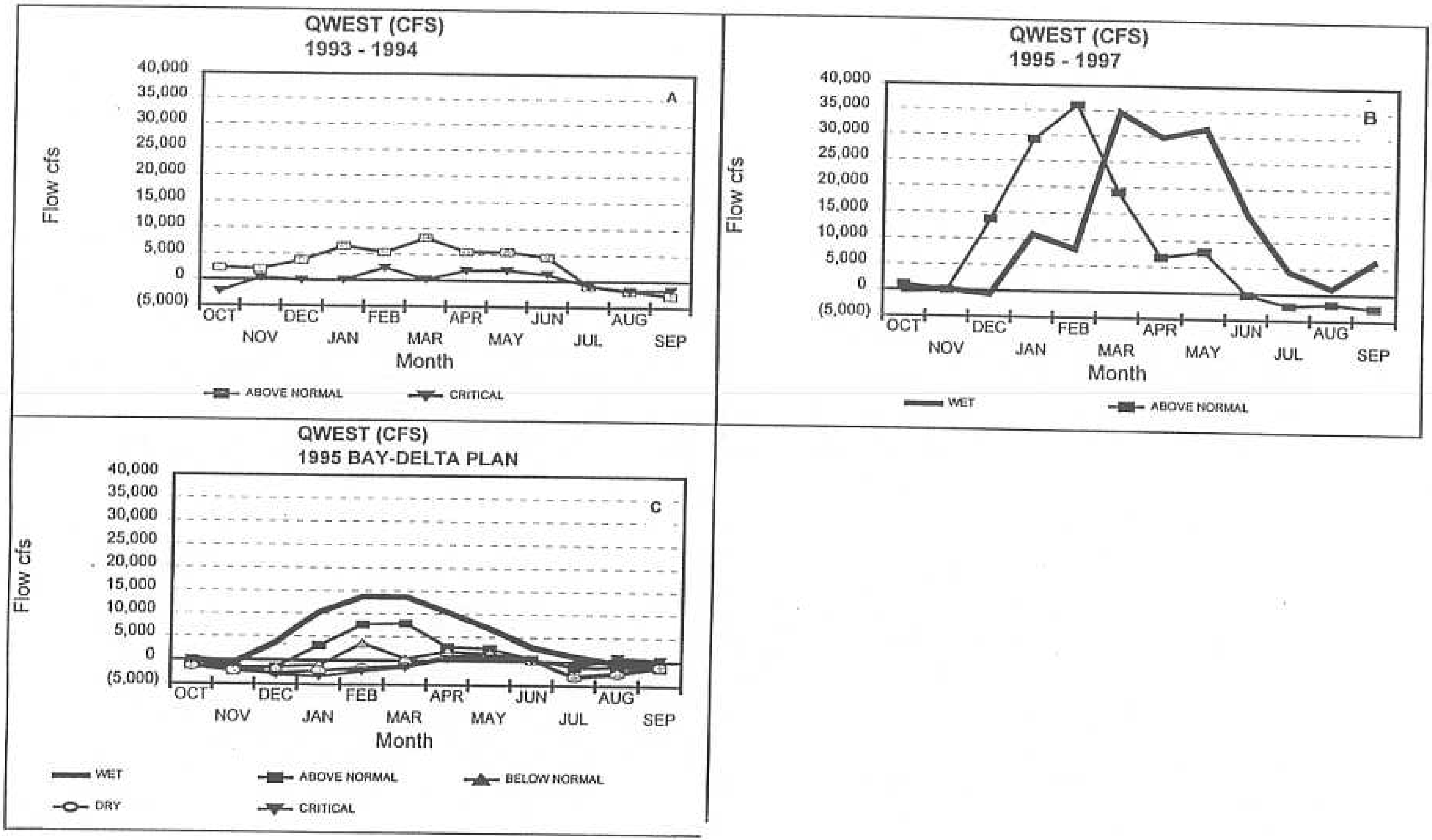


Figure 48. Change in average monthly QWEST flows (cfs) for recent periods in water project operations within Central Valley: (A) operations to State and Federal Biological Opinions for the winter-run chinook salmon which specified minimum QWEST flow criteria; (B) recent operations to the 1995 Bay-Delta Plan; and (C) simulated future operations to 1995 Bay-Delta Plan.

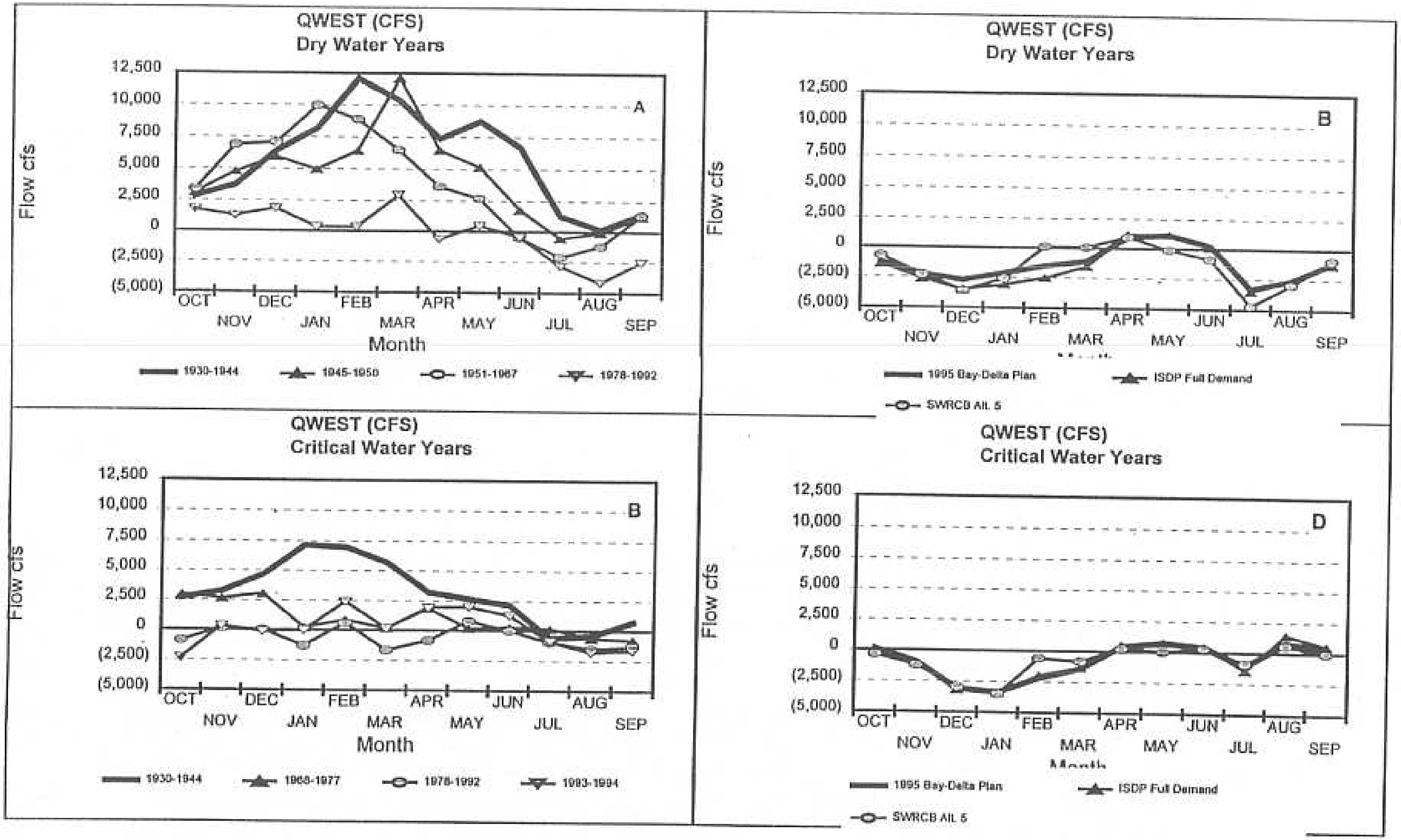


Figure 49. (A & C) Change in average monthly QWEST flows (cfs) for dry and critical water-years since pre-Shasta and Friant dams (1930-1944) through 1992. (B& D) Compared to average monthly QWEST flows (cfs) in dry and critical water-years under simulated operations to 1995-Bay-Delta Plan, simulated operations to Interim South Delta Program at future water demand level and, simulated operations to SWRCB Water Rights Alternative 5.

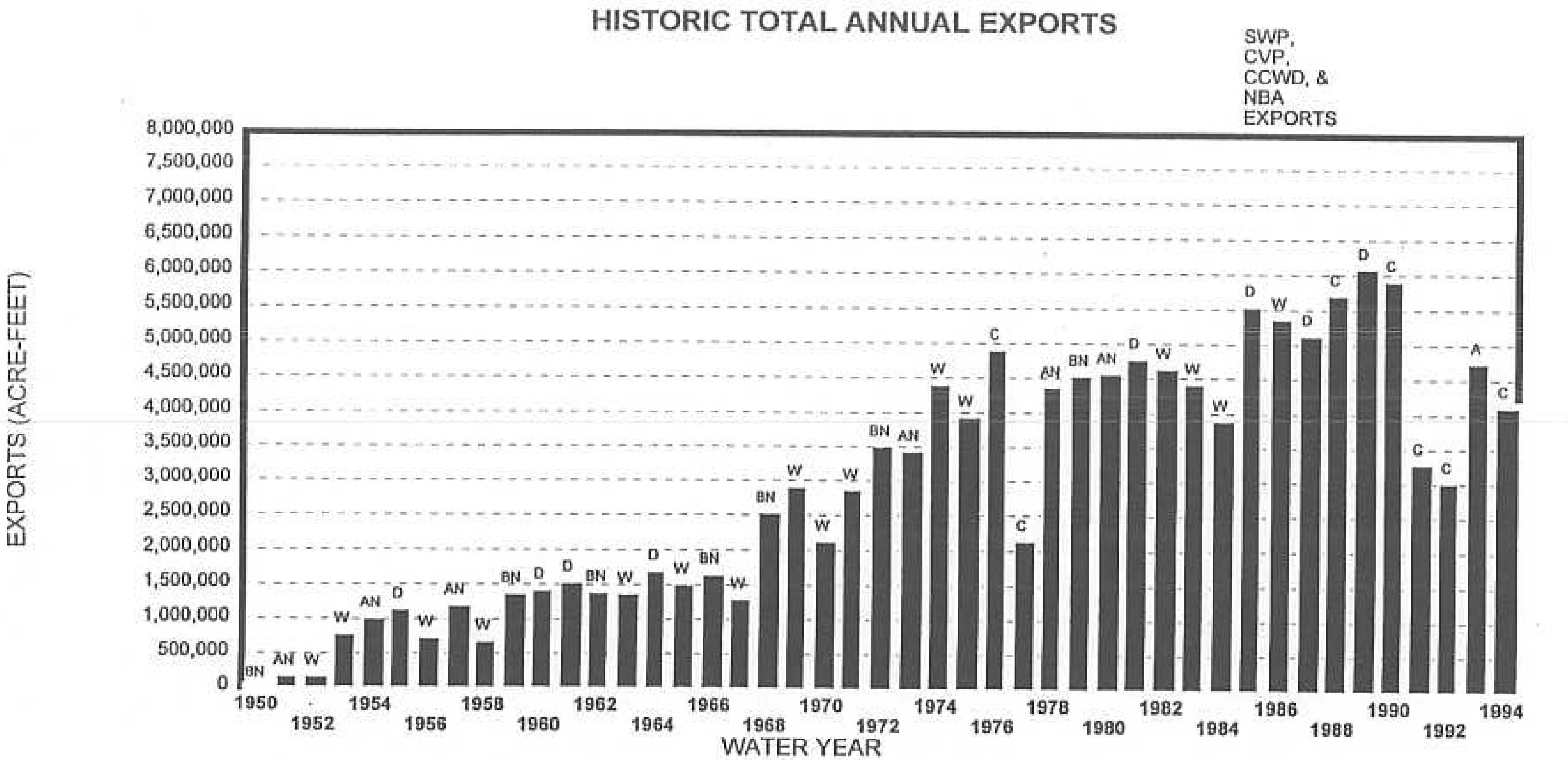


Figure 50. Yearly sequence and increasing magnitude of historic total water exports (acre-feet) from the Sacramento-San Joaquin Bay-Delta Estuary. Exports combined for CVP, SWP, CCWD, and NBA. Water-year type indicated above each graph bar (W=wet, A=above normal, B=below normal, D=dry, and C=critical).

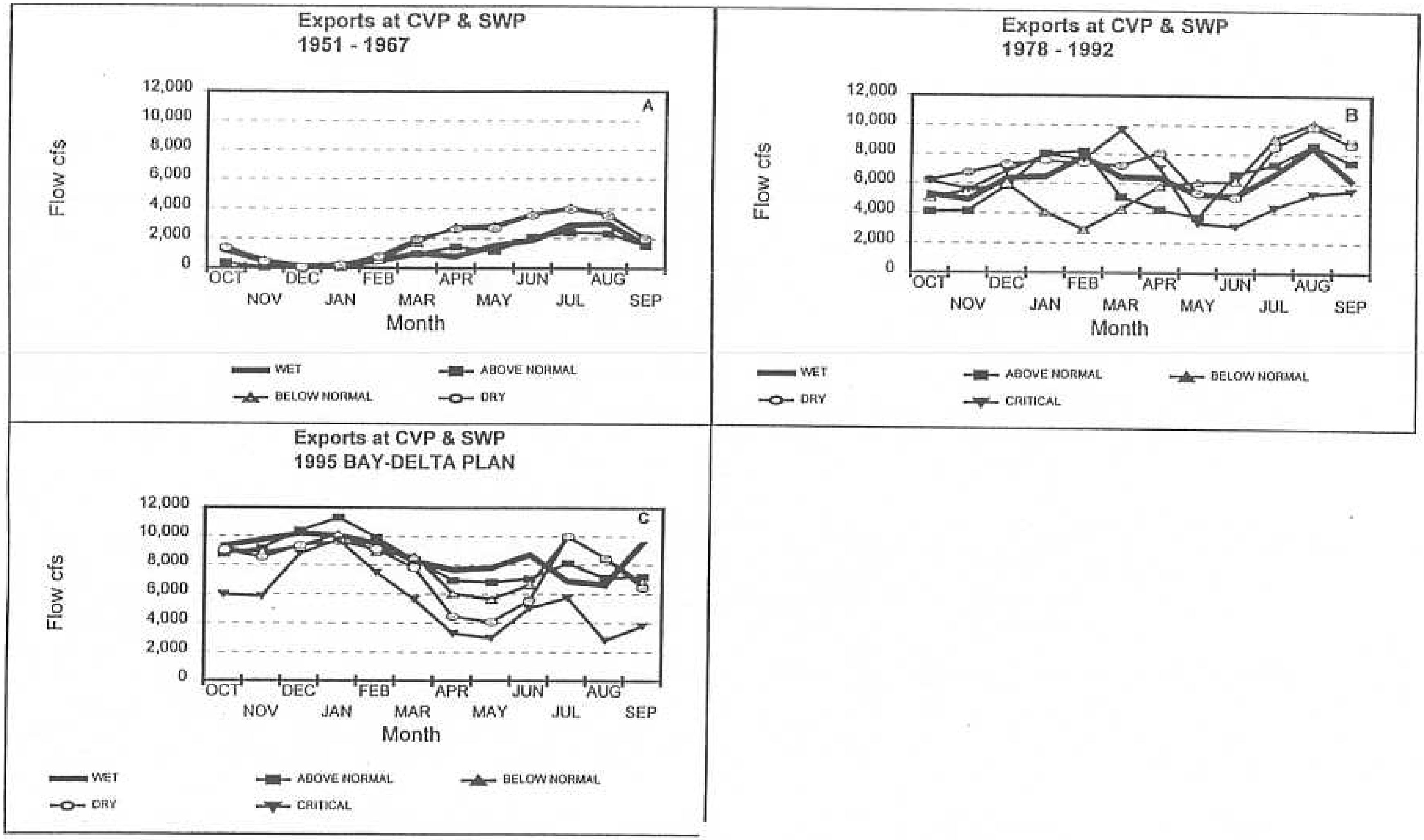


Figure 51. Change in average monthly Delta exports (cfs) at the SWP and CVP Delta water export facilities for key time periods in Central Valley water project operations. (A) Beginning in the 1950's with federal water exports only; (B) projects operated to SWRCB Decision 1485 water quality standards; and, (C) simulated operations to 1995 Bay-Delta Plan.

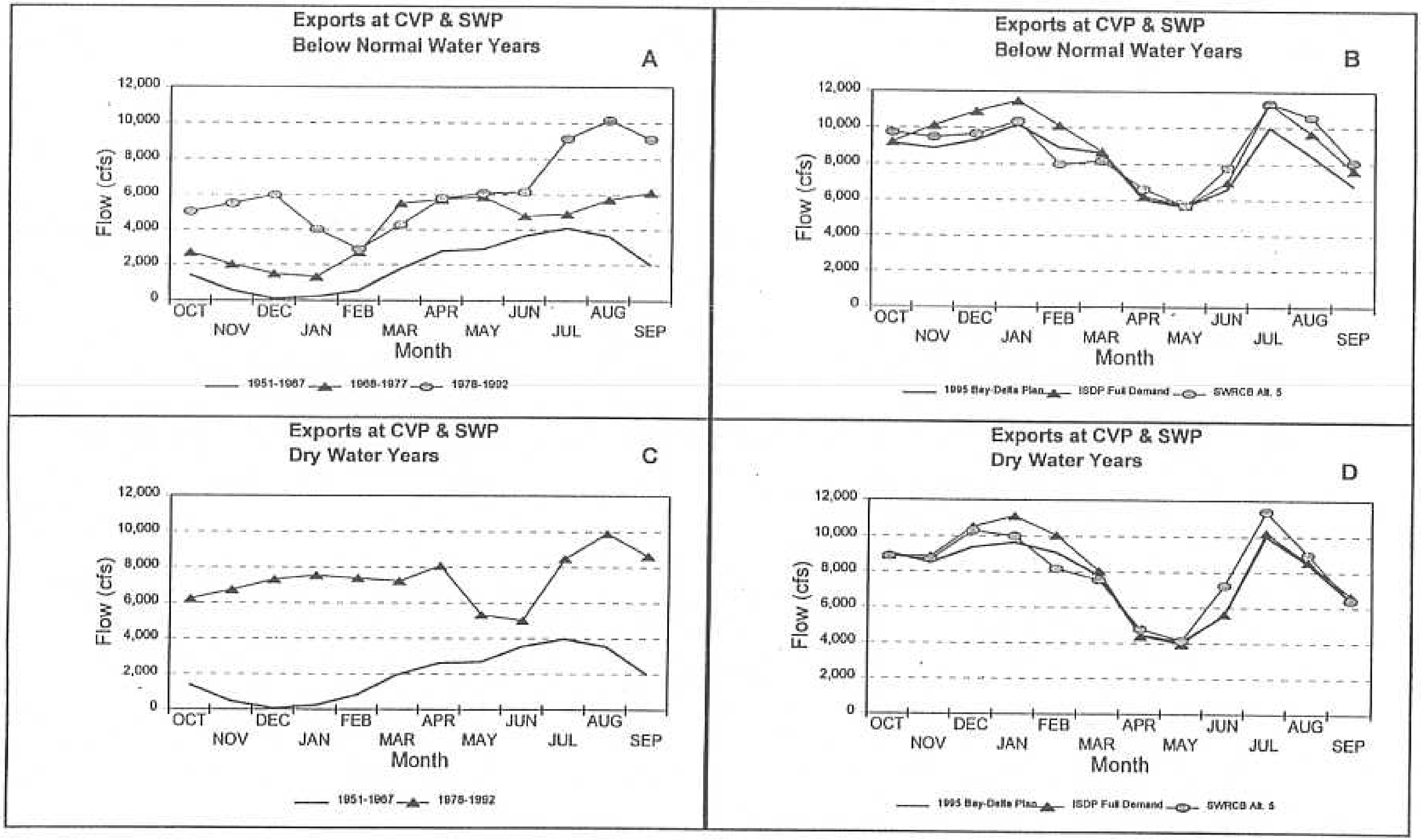
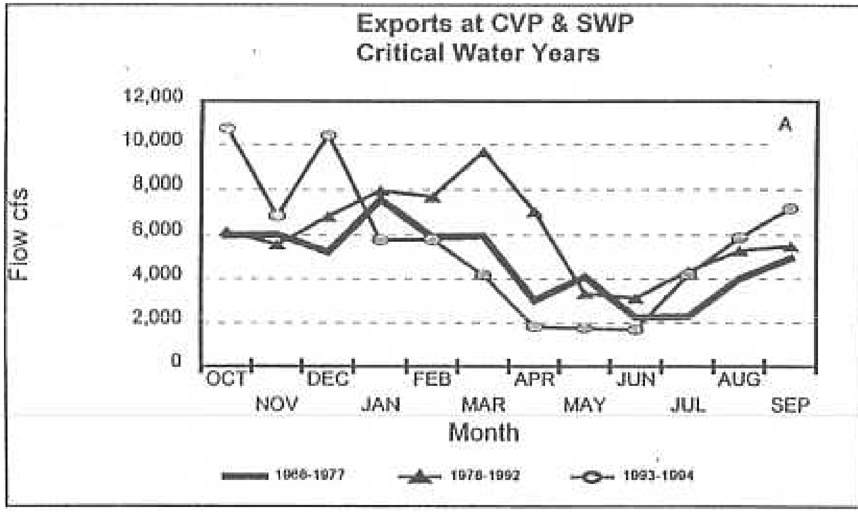


Figure 52. (A & C) Change in average monthly combined Delta exports (cfs) at the CVP and SWP for below-normal and dry water-years the projects began operations through 1992. (B& D) Compared to average monthly combined Delta exports (cfs) in below-normal and dry water-years under simulated operations to 1995-Bay-Delta Plan, simulated operations to Interim South Delta Program at future water demand level and, simulated operations to SWRCB Water Rights Alternative 5.



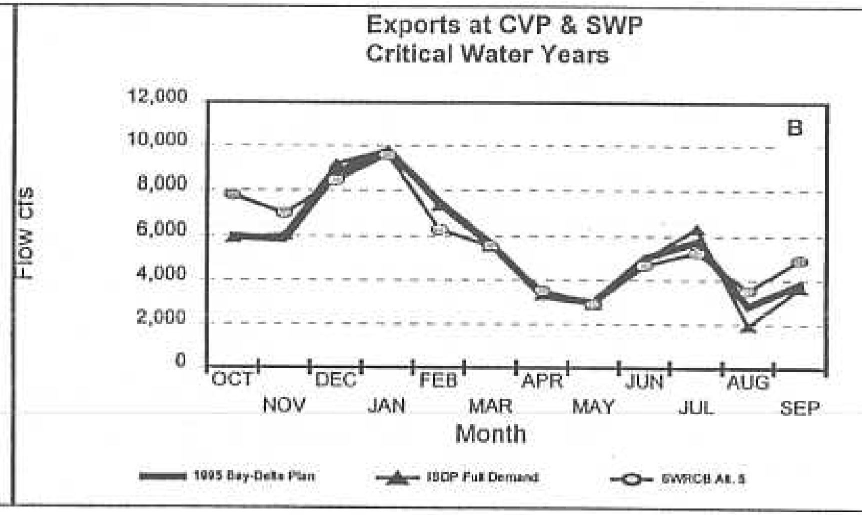


Figure 53. (A) Change in average monthly combined Delta exports (cfs) at the CVP and SWP for critical water-years since the projects began through 1992. (B) Compared to average monthly combined exports flows (cfs) in critical water-years simulated operations to 1995-Bay-Delta Plans; simulated operations to Interim South Delta Program at future water demand level; and, simulated operations to SWRCB Water Rights Alternative 5.

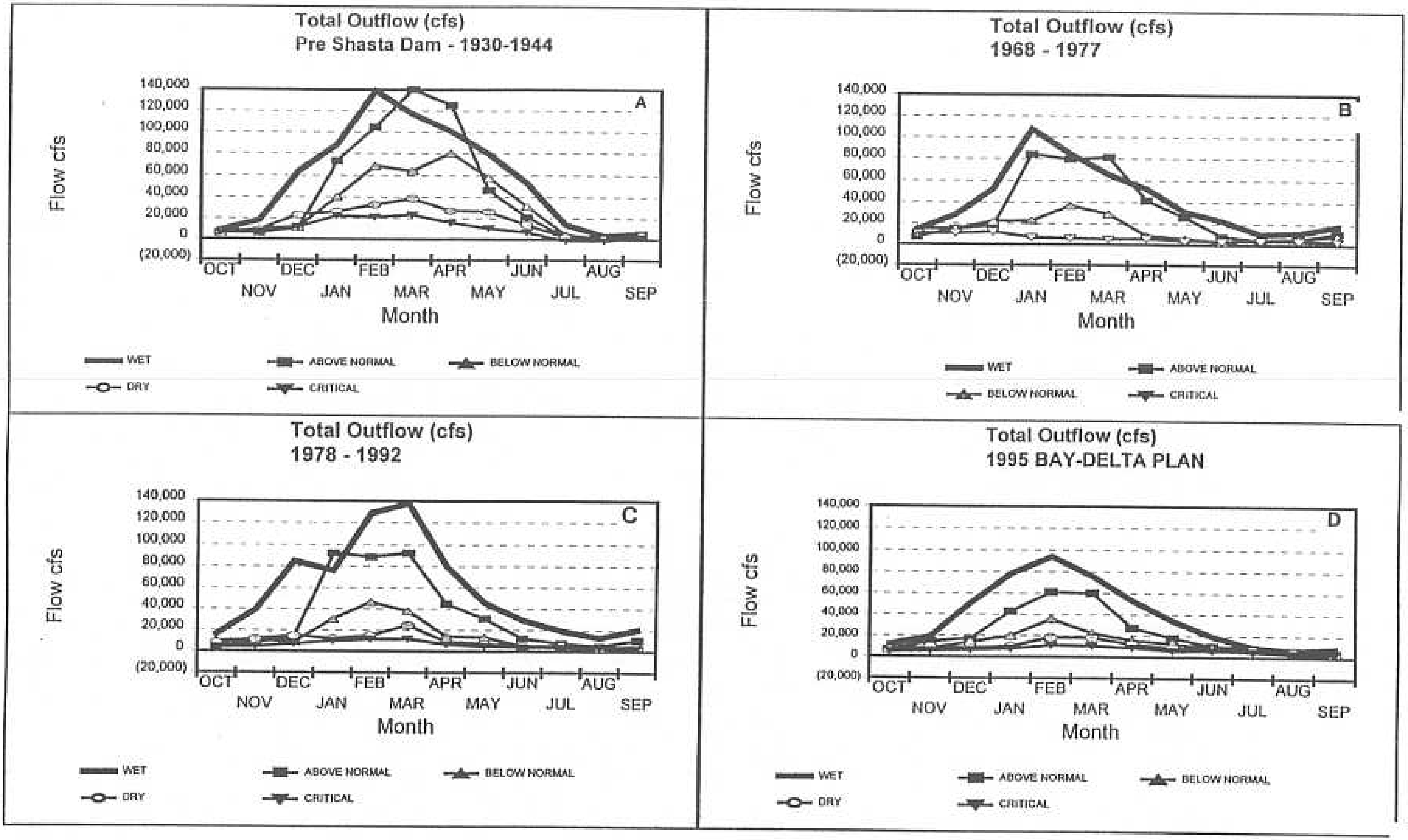


Figure 54. Change in average monthly total Delta outflow (cfs) for key time periods in water project operations within the Central Valley. Beginning (A) prior to operations of Shasta and Friant dams through (D) simulated operations to SWRCB 1995 Bay-Delta Plan.

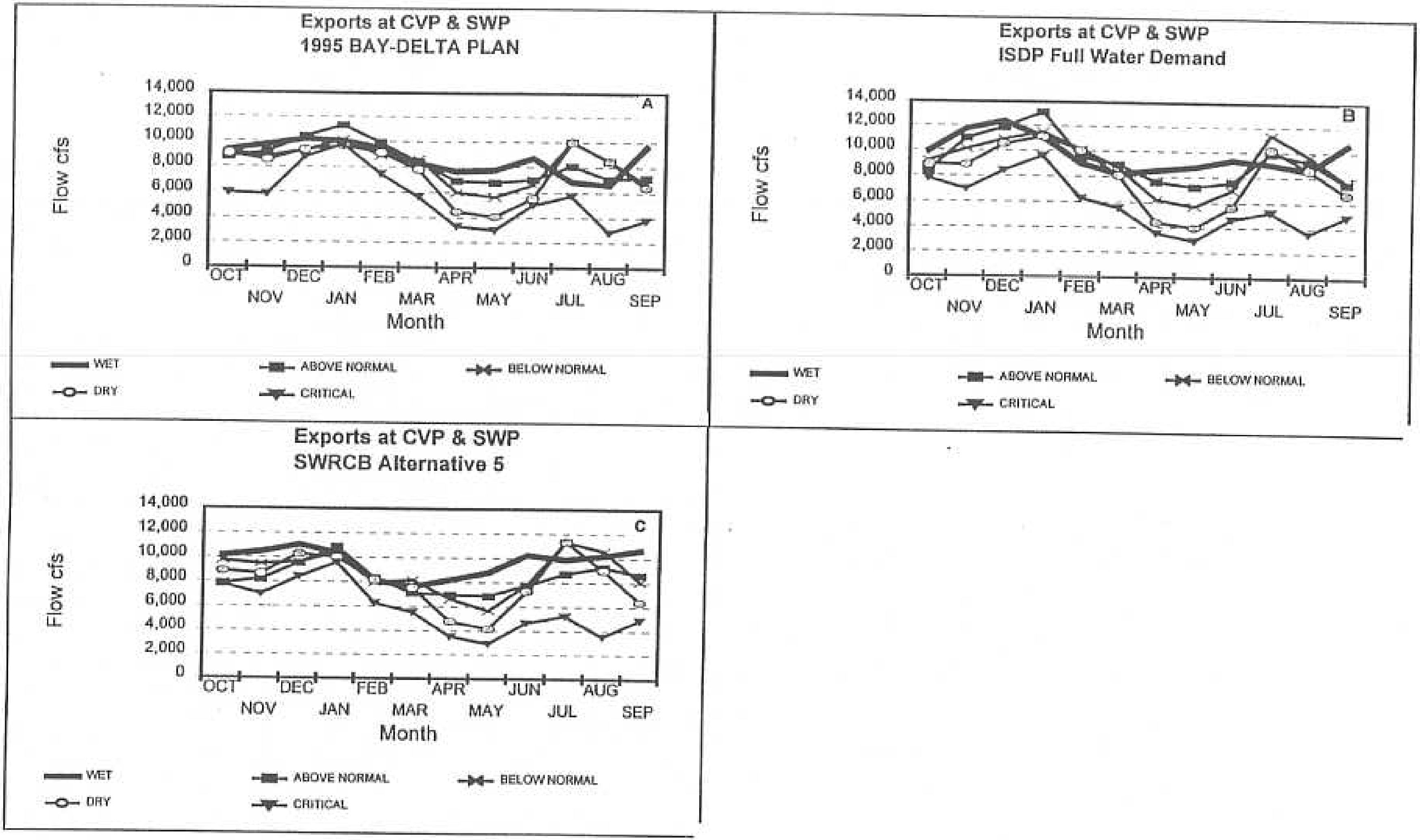


Figure 55. Average monthly exports (cfs) at CVP and SWP under (A) simulated operations to existing State and Federal Bay-Delta water export facility configuration, meeting existing variable-level water demand operated to SWRCB 1995 Bay-Delta Plan water quality criteria with interim water rights agreement; (B) simulated operations to Interim South Delta Program facilities at future water demand level , and; (C) simulated operations to SWRCB 1995 Bay-Delta Plan and SWRCB Rights Alternative 5.

Recovery Plan for the Sacramento / San Joaquin Delta Native Fishes (USFWS 1995a) considers poor survival of outmigrating juvenile spring run, "especially in the Delta" as one of the key factors in the species' continued population decline in recent decades.

Historically, a significant proportion of juvenile Sacramento River salmon was observed to naturally migrate into the central Delta via Georgiana Slough in direct proportion to the volume of water transporting them, estimated to be approximately 20% in March 1948, prior to the construction of the CVP DCC (Figure 17) (Erkkila et al. 1950). Under present day operations, when the DCC is open, as much as 70% of Sacramento River flow (at Walnut Grove) can be diverted into the central Delta, whereas only 20%-30% is drawn in with the DCC closed (USFWS 1987). If juvenile salmon are entrained to the central Delta in direct proportion to the volume of water transporting them, significantly greater numbers of juvenile spring-run chinook salmon can be transported into the Delta on their outmigration journey. When diverted into the central and hence the southern Delta, juveniles are exposed to a highly altered system with manipulated flow conditions, resulting in direct and indirect impacts which reduce survival compared to salmon that remain in the Sacramento River. Within the central and southern Delta, juveniles are exposed to reverse flows, entrainment in small unscreened agricultural diversions, entrainment in the SWP and CVP water export facilities, predation, reduced shallow water habitat for fry, reduced water quality conditions (including higher water temperatures), and reduced river inflows during spring months which decreases available habitat, nutrients, and transport flows for migration (USFWS 1995a, NMFS 1997). The adverse changes in Delta hydrodynamics, particularly the increase in cross-Delta flows (flows from the northern and central Delta to the southern Delta) have dramatically increased since 1968. Those increases have been the most pronounced in the late fall through the early spring months, key periods for outmigrating juvenile and yearling spring run.

The USFWS, within the Interagency Ecological Program (IEP), conducted studies during the 1980s to assess the relative difference in survival of fall-run chinook salmon smolts emigrating down the Sacramento River which were not exposed to entrainment at the DCC and Georgiana Slough (Ryde releases) versus smolts subject to entrainment to both channels leading to the central Delta, as well as smolts which were only subject to entrainment through Georgiana Slough (Table 22) (USFWS 1992). Salmon smolts survived about 3.4 times greater to Chipps Island (western Delta) when they were not exposed to entrainment at Georgiana Slough and an open DCC. When the DCC was closed, the relative difference in survival was reduced by nearly half. However, survival was still 1.6 times greater for those smolts which were not exposed to entrainment at Georgiana Slough.

From 1992-94, the USFWS conducted survival studies where they released one marked group of hatchery-reared juvenile fall-run salmon directly into Georgiana Slough and a second group into the Sacramento River at Ryde (downstream of the DCC and Georgiana Slough). Marked fish recoveries indicated survival for salmon released at Ryde was 1.5 to 8.4 times higher than for salmon released simultaneously in Georgiana Slough (the subsequent migration route for these fish is assumed to be through Georgiana Slough to the central Delta) with a larger difference observed at higher water temperature (Table 23) (USFWS unpublished data).

Since 1993, the USFWS has annually conducted additional studies designed to evaluate the differential survival of larger juvenile winter-run chinook salmon which emigrate through and rear in the Delta during cooler winter and early spring months (Table 24). These studies used juvenile late-fall-run salmon as a surrogate for the State and federally-listed endangered winter run. The results are relevant to survival of yearling spring-run salmon which also migrate in the

Table 22. Comparison of Survival Indices for Coded-wire Tagged Fall-run Chinook Salmon Smolts Released in the Sacramento River Above and Below the Delta Cross Channel and Georgiana Slough between 1983 and 1989 (USFWS 1992).

Cross Channel Operation	Year	Release Above (Walnut Grove)	Release Below (Ryde)	Ratio of Below/Above
OPEN	1984	0.61	1.05	1.7
	1985	0.34	0.77	2.3
	1986	0.35	0.68	1.9
	1987	0.40	0.88	2.2
	1988	0.72	1.28	1.8
	1988	0.02	0.34	17.0
	1989	0.84	1.19	1.4
	1989	0.35	0.48	1.4
	1989	0.21	0.16	0.8
				Average: 3.4
CLOSED	1983	1.06	1.33	1.3
	1987	0.67	0.85	1.3
	1988	0.71	0.94	1.3
	1988	0.17	0.40	2.4
				Average: 1.6

Table 23. Comparison of Survival Indices for Coded-wire Tagged Fall-run Chinook Salmon Smolts Released into Georgiana Slough and at Ryde (below the Delta Cross Channel and Georgiana Slough) from 1992 through 1994 and the Ratio of Survival Between the Two Paired Groups (USFWS, unpublished data).

Year Month Day	Georgiana Slough	Release Below Ryde	Ratio of Below/Above (Georgiana / Ryde)
1992 April 6th	0.41	1.36	3.3
1992 April 14th	0.71	2.15	3.0
1992 April 27th	0.20	1.67	8.4
1993 April 14th	0.13	0.41	3.2
1993 May 10th	0.29	0.86	3.0
1994 April 12th	0.054	0.198	3.7
1994 April 25th	0.12	0.18	1.5
			Average: 3.7

Table 24. Comparison of Survival Indices for Coded-wire Tagged Late-fall Run Chinook Salmon Smolts Released into Georgiana Slough and at Ryde and Isleton (below the Delta Cross Channel and Georgiana Slough) from 1993 through 1996 and the Ratio of Survival Between the Two Paired Groups (USFWS, unpublished data).

Year	Month	Georgiana Slough	Release Below (Ryde[1/], Isleton[2/])	Ratio of Below/Above (Georgiana / Ryde[1/], Isleton[2/])
1993	December	0.28	1.91[1/]	6.8[1/]
1994	December	0.16	0.57[2/]	3.6[2/]
1995	January	0.06	0.39[2/]	6.5[2]
1996	January	0.16	0.66[1/]	4.1[1/]
1997	December	0.03	0.70[1/]	23.3[1/]
1998	January	0.24	0.90[1/]	3.8[1/]
				Average: 8.0

fall and early winter. It was hypothesized that larger juvenile salmon may be less affected than the smaller fall-run juveniles by adverse habitat conditions in the interior Delta, due to their larger size and assumed shorter residency time within the Delta. Also, during winter months water temperatures are lower and less stressful to juvenile salmon, there is a lower risk of entrainment losses for juveniles because local diversions for irrigation are minimal, and mortality due to resident fish predation is expected to be less (due to lower predator metabolic rates and activity levels compared to April and May conditions). Water contractors have stated that negotiators of the water quality objectives in the 1995 Bay-Delta Plan allowed exports up to 65% of inflow in fall and winter months because they believed the larger juveniles would be better able to avoid predators and entrainment at the State and Federal water export facilities than smaller juvenile fall-run salmon in spring months when a lower (35%) export limit was chosen (statement of Charles Hanson, Ph.D.; representing the SWP contractors; October 1997, Commission meeting in San Diego).

Results from the USFWS December and January tests during the last six years do not support the hypothesis of higher interior Delta survival of larger juvenile salmon relative to survival in the Sacramento River during cooler fall and winter months. Late-fall-run salmon released in the Sacramento River below the DCC and Georgiana Slough survived, on average, eight times greater than those released directly into Georgiana Slough (results have ranged from 3.6 to 23.3). These juvenile late-fall-run salmon survival studies indicate low relative survival levels through the Delta, similar to the earlier studies with fall run in April and May (USFWS 1997a, unpublished data).

The above salmon survival experimental results, including those using larger salmon during winter months in the past few years, demonstrate that larger juvenile salmon are not necessarily affected less by deleterious factors encountered in the central Delta. The results also suggest:

(1) from the list of potential causes of mortality, those factors known or suspected to be less harmful in the winter than the spring (i.e., water temperature, entrainment in local diversions, predation) may be relatively less important in both seasons than previously thought; and

(2) deleterious factors usually present in both seasons (i.e., altered or reverse flow patterns due to exports, increased residence time) may act to increase mortality due to other factors and thus, have relatively greater consequences for salmon survival than the factors listed in item 1.

The following is a summary of the various potential causes of the mortality assessed in the salmon survival experiments and which affect spring-run salmon in the Delta as yearling outmigrants in November through January or as sub-yearling salmon between December and June (Table 25). Some factors have not been well studied and specific data related to juvenile salmon are often lacking or inadequate.

Direct (Entrainment) and Indirect Losses at the SWP and CVP Water Export Facilities: Delta impacts of the water projects to rearing and migrating juvenile chinook salmon are both direct (based on observations of salvaged fish at the fish salvage facilities) and indirect (the fish die as a result of degraded habitat conditions before reaching the salvage facilities and are not recovered). The rate of direct entrainment (direct loss) of juvenile salmon at the facilities, by itself, does not provide a complete measure of water project impact to juvenile salmon. Instead, low recovery rates at the fish facilities can be due to: (1) relatively low numbers of juvenile

Table 25. Factors Potentially Affecting Spring-run Chinook Salmon Survival in the Bay-Delta Estuary.

FACTOR	LIFE STAGE			SOURCE OF INFORMATION
	SUB-YEARLING REARING	SUB-YEARLING MIGRATION	YEARLING MIGRATION	
Outmigration Timing	(Dec.- April)	(March-May)	(Oct.-Feb.)	CDFG studies
Hydrodynamics	Yes	Yes	Yes	USFWS studies
Inflow	Yes	Yes	Yes	USFWS studies
Cross Channel Georgiana Sl.	Yes	Yes	Yes	USFWS studies
Reverse flow	Probable	Probable	Probable	USFWS studies
Outflow	Probable	Probable	Probable	USFWS studies
Entrainment to Local In-Delta diversions	Probable	Probable	Probable	DWR sampling
Entrainment to CVP/SWP (Including predation)	Yes	Yes	Yes	Salvage records DFG studies
Water Temperature	Probable (late spring)	Probable (late spring)	No	USFWS studies
Predation	Probable	Potential	Potential	Food habits studies
Contaminants	Potential	Unlikely	Unlikely	
Habitat Condition (cover/food, etc.)	Potential	Potential	Potential	

Yes: effect documented;
Probable: mechanism identified, evidence inconclusive;
Potential: mechanism suggested, evidence lacking;
Unlikely: no mechanism known or factor not relevant to time period.

salmon in the system; (2) a high loss rate of juveniles before they reach the Delta; (3) a high indirect loss rate of juvenile salmon, attributable to water project operation, in the central and southern Delta; or (4) a combination of the above.

Studies have been conducted by the USFWS to assess juvenile salmon survival through the Delta relative to survival for juveniles which remain in the Sacramento River. The USFWS has measured the differences in recoveries at the SWP and CVP Delta fish salvage facilities of the marked late-fall run salmon released into Georgiana Slough versus the Sacramento River (Ryde and Iselton) releases. While the recoveries at the fish salvage facilities of Georgiana Slough releases have not exceeded 3%, no more than 0.6% of any group of salmon released in the Sacramento River (Ryde/Iselton) has been recovered at the fish facilities. A consistently higher proportion (between 5 and 60 times more) of the Georgiana Slough release groups have been recovered at the SWP and CVP Delta fish facilities since 1993. This would indicate that the relative effects of export on Delta salmon survival may be several times greater than indicated by entrainment alone. It also suggests that exports have a greater influence on salmon once they are in the central Delta compared to those remaining in the Sacramento River, at least as far downstream as Three Mile Slough near Rio Vista.

Length of Migration Route/Residence Time in the Delta: To reach Chipps Island from the respective release locations, test salmon have a longer migration route via Georgiana Slough (about 37 miles) than in the Sacramento River from Ryde (27 miles). Increased residence time increases the duration of exposure to hazards during migration and reduces the likelihood for survival to Chipps Island. If the mortality rate per mile was the same on both routes and salmon traveled at a fixed rate directly on each pathway, mortality would be approximately 37% higher for the Georgiana Slough release group.

Altered Flow Patterns in Delta Channels - Reverse Flows: The role of net flow direction within the interior Delta in guiding migrating salmon is a critical issue. Higher entrainment losses demonstrate salmon using the Georgiana Slough migration route are more susceptible to the effects of export pumping. Juvenile salmon that migrate downstream through the interior Delta are subjected to a longer and more complex migration route which increases the fish's residence time and thus, exposure to mortality mechanisms within the interior Delta. In many of the interior Delta channels, net flows are in the upstream direction (i.e., towards the southern Delta from the central Delta, so-called reverse flows). For salmon which are cueing on flows as they migrate through the Delta towards the ocean, substantial confusion and straying into channels leading to the southern Delta could take place.

Increasing salinity westward through the estuary may provide one of many guidance cues to juvenile salmon moving through the estuary. But use of the salinity gradient as a guide may also be a problem for salmon under present-day water management within the Delta since the northern and western Delta can be fresher (less saline) due to Sacramento River influence than the central and southern Delta which is influenced more by the poorer water quality of the San Joaquin River.

Predation Losses: The most comprehensive information on the distribution of piscivorous fish in the Delta is from the Department's resident fish survey begun in the late 1970s. Centrarchid species were substantially less abundant in northern and western Delta areas than elsewhere in the Delta and less abundant in rivers and open sloughs than in other channel types. Largemouth bass were generally less abundant in river habitats than either open-ended or dead-ended sloughs. Largemouth bass are less abundant as salinity increases in the western reach of both migration routes, however other predators such as striped bass may be more abundant. Independent of predator density, there is an increased probability of loss to predation of juveniles that migrate down Georgiana Slough and through the central and interior Delta due to the increased residence time of juveniles and thus exposure to predation (a more detailed discussion of predation is contained in the report section titled *Factors Affecting the Ability to Survive and Reproduce - Predation*).

Water Temperature-Related Mortality: Water temperatures during the fall/winter experiments were cool and no temperature-related impact on survival was expected in either the Sacramento River or in Georgiana Slough and the rest of the Delta migration route. Temperature would not adversely affect spring-run yearlings in the November-January period or sub-yearlings until about May in most years.

Contaminants: The role of potential contaminant-related effects on spring-run salmon survival in the Delta is unknown. The USFWS (1995a) concluded that the effects of contaminants on the biota in the Delta is of major importance. There are no data to determine if contaminant concentrations were different for either of the paired test groups during any of the USFWS survival experiments nor any evidence that acute contaminant-related mortality occurred during these tests. Contaminant-related chronic effects during the relatively short period the test fish were in the Delta seem unlikely, but cannot be ruled out. In general, it is known that selenium from the San Joaquin River and from point sources in the estuary may affect salmon growth and survival. The U.S. Environmental Protection Agency (USEPA) is pursuing reductions in selenium loadings from Bay Area oil refineries and the San Francisco Regional Water Quality Control Board has recommended an additional 30% reduction in selenium levels to adequately protect the Bay's beneficial uses. Municipal wastewater treatment plants release heavy metals, thermal pollution, pathogens, suspended solids, and other constituents. Improved treatment has reduced pollutant loadings, however heavy metals and organic pollutants remain a concern (ABAG 1992). Non-point sources include runoff from urban areas, agricultural lands, construction and logging sites, and mined land. Elevated levels of polychlorinated biphenyls and chlorinated pesticides have been found in the stomach contents of juvenile salmon from the Bay, the Delta, and from hatcheries. Non-point sources are suspected as the origin of these materials in the Delta and Bay environment. Agricultural drainage is another source of contaminants (pesticides and herbicides) that may be affecting lower level food web organisms and bioaccumulating in higher trophic level organisms. This may be detrimental to salmon, particularly during smoltification (NMFS 1997). Dredging may be harmful to juvenile salmon due to re-suspension of contaminant in sediments as well as increased turbidity, increased oxygen demand, and reduced dissolved oxygen concentration.

Food Supply Limitations: In general, it is known that limitation of food supply and changes in the species composition of zooplankton, which may influence food availability for young fish in the estuary, has been suggested as a cause of decline in the abundance of estuarine-dependent species such as Delta smelt and striped bass (ABAG 1992). However, there is no direct evidence of food limitation for salmon in the Delta or lower estuary.

VIII. INFLUENCE OF EXISTING MANAGEMENT EFFORTS

There are a significant number of monitoring and restoration activities being performed on Sacramento River spring-run; some of which have recently been completed and some of which are in progress (Table 26). The following is a synopsis of these efforts, which are also detailed in the Department's update to the Commission on the *Status of Actions to Restore Spring-run Chinook Salmon on the Central Valley* (Baracco 1996).

Disease

Disease control efforts include prohibiting the transportation of infected, diseased, or parasitized fish between drainages (FGC, Section 6307) and the importation of fish into California from areas known to have infected, diseased, or parasitized fish and other organisms (FGC, Section 2270). When fish are found to be infected, diseased, or parasitized, the Department requires them to be destroyed (FGC, Section 6302).

Both State and Federal hatchery programs within California's Central Valley employ various protocols to control infection. Regular health monitoring of production fish is performed to quickly respond to problems. Chemotherapeutics are used for control of most external parasite problems while many bacterial infections can be treated with antibiotics. Avoidance of infectious agents and stressful conditions is the best management practice.

Harvest

Federal Ocean Fisheries Management and Restoration Plans

California's ocean salmon fisheries, as well as those fisheries off Oregon and Washington, are managed by the Pacific Fishery Management Council (PFMC) under the authority of the Federal Magnuson-Stevens Fishery Conservation and Management Act. The states are required to conform their fishing regulations for their State ocean waters (zero to three miles offshore) to those implemented for Federal ocean waters (three to 200 miles offshore), or risk pre-emption of their management authority by the NMFS. Sacramento fall-run chinook is one of the key chinook stocks on which ocean salmon fisheries south of Cape Falcon in Oregon are managed. The salmon Fishery Management Plan (FMP) provides the basis on which the PFMC manages California's ocean salmon fisheries.

Among the management goals of the FMP is the requirement that the ocean fisheries be managed to provide an annual spawning escapement of 122,000 to 180,000 fall-run chinook adults to the Sacramento River's hatcheries and natural areas. On March 8, 1996, NMFS issued a Biological Opinion for the endangered Sacramento River winter-run chinook, under authority of the ESA, that required harvest impacts on Sacramento River winter-run chinook in California's sport and commercial ocean salmon fisheries to be reduced by 50%. This reduction in harvest was estimated to be sufficient to increase adult winter-run chinook spawning escapement by 35% above recent levels. Based on additional spawner escapement data for 1996, NMFS re-evaluated the level of increased spawner escapement required for the restoration of this run; therefore, California's ocean salmon fisheries in 1997 and 1998 were managed for an increase in spawner escapement of 31%. It is expected that management

Table 26. Current Status of Activities to Reduce Risk of Extinction of Spring-run Chinook Salmon.

	Sacramento River	Clear Creek	Cottonwood Creek	Battle Creek	Antelope Creek	Mill Creek	Deer Creek	Big Chico Creek	Butte Creek	Feather River	Yuba River	Delta
MONITORING												
Adult Salmon												
Escapement	P	P	S	P	S	S	S	P	S	P	P	NA
Age Composition	N	N	N	N	N	N	P	N	N	P	N	NA
Run-timing	P	P	N	P	N	S	S	P	P	N	P	P
Spawning period	P	P	N	P	N	S	S	P	P	N	P	NA
Juvenile Salmon												
Fry Emergence	P	N	N	N	N	S	S	P	P	N	N	NA
Outmigrant timing	P	N	N	N	N	P	P	P	P	N	N	P
Size at outmigration	P	N	N	N	N	P	P	P	P	N	N	P
Emigration cues	P	N	P	P	P	P	P	P	P	N	P	P

S = Sufficient Activity; P = Partial Activity; N = No Activity

Table 26. (Continued).

	Sacramento River	Clear Creek	Cottonwood Creek	Battle Creek	Antelope Creek	Mill Creek	Deer Creek	Big Chico Creek	Butte Creek	Feather River	Yuba River	Delta
MANAGEMENT ACTIONS												
Barriers/Passage	P	P	P	P	N	P	P	S	P	S	P	P
Flows	P	P	P	P	P	P	P	P	P	S	P	P
Temperature	P	P	P	P	N	P	P	P	P	S	P	NA
Gravel	P	P	S	P	S	S	S	P	S	P	P	NA
Erosion	P	S	N	P	N	P	P	P	P	P	P	NA
Entrainment	P	S	P	P	N	S	S	P	P	P	P	P
Cover	P	P	P	N	P	P	P	P	P	P	P	P
Local Land Mgmt.	P	S	P	P	P	P	P	P	P	P	P	P
Harvest	P	P	P	P	P	S	S	N	S	P	P	P
Delta Operations	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	P

S = Sufficient Activity; P = Partial Activity; N = No Activity measures enacted to reduce ocean harvest impacts on Sacramento River winter-run chinook are providing some protection for Sacramento River spring-run chinook.

Existing Ocean Harvest Regulations

To achieve the 50% level of impact reduction for the 1996 season, the PFMC recommended increasing the minimum size limit of chinook salmon caught in the recreational ocean salmon fishery between Point Conception and Horse Mountain from 20 inches TL to 24 inches TL from May 1 through mid-July, then further increased it to 26 inches TL thereafter (Appendix C). Prior to the PFMC action, the Commission increased the minimum size limit to 24 inches TL for State waters in early April 1996. Also, the minimum size limit in the commercial fishery was increased from 26 inches TL to 27 inches TL. The 1996 recreational fishing seasons south of Point Arena were shortened by two weeks to two months, depending on area. The opening dates for the 1997 recreational ocean salmon seasons below Point Arena were delayed by two to four weeks, again depending on the area. Because of the slight easing of harvest impact reductions for 1997, the recreational ocean salmon seasons were re-extended by later closing dates. Also, the minimum size limits were 24 inchesTL and 26 inches TL, respectively, for California's sport (south of Horse Mountain) and commercial fisheries.

Two fisheries in 1997 could have had potential impacts on spring chinook: a 10,000 chinook quota commercial fishery during the last half of April between Lopez Point and Point Mugu; and a recreational fishery in the Gulf of the Farallones (between Point Reyes and Pigeon Point) from July 1 through September 1, which required anglers to keep the first two salmon, except coho, regardless of size. The former fishery could provide some risk to spring-run chinook because of its timing, since CWT data have shown that the majority of FRH spring-run chinook recoveries occur prior to May 1; the latter fishery could impact spring-run chinook because of its location and lack of a minimum size limit. Opening dates for the 1998 recreational ocean salmon seasons south of Point Arena are essentially the same as in 1997. South of Pidgeon Point (San Mateo County) the season ended October 19 in 1997. In 1998, further restriction in season length was initiated, with a season ending date of September 7.

Inland Sport Fishing Regulations

California's inland sport fishing regulations are set under the authority of the Commission (FGC, Division 1, Chapter 2, Article 1). Inland sport fishing regulations are reviewed and revised as necessary every two years during even-numbered years. In every odd-numbered year, the Commission devotes its late August, October, November, and December meetings to recommendations for changes in the sport fishing regulations.

Inland sport fishing regulations within several of the primary spring-run tributaries were changed in 1994 to provide specific protection for spring-run chinook salmon. In addition, present regulations covering the remaining inland spring-run adult habitat provide varying degrees of protection (Appendix D).

Enforcement

Enhanced enforcement activities continue to be implemented throughout the spring-run range, with particular attention to the tributaries and adult holding areas. Additional funding for warden overtime is being provided through the Four Pumps Agreement and has resulted in additional hours of enforcement, while the Delta Bay Enhanced Enforcement Program (DBEEP) warden position continues to focus specific enforcement during the spring migration and summer holding periods. Initial reports from the wardens involved indicate that violations have declined significantly, which in part is attributable to the increased enforcement and in part to the increased public awareness and involvement through the emerging watershed conservancy efforts. The DBEEP, in addition to the focused attention in the spring-run tributaries, continues to provide added enforcement in the Delta. The DBEEP program was expanded in 1994, which included three additional wardens assigned specifically to the Delta and upper Sacramento River.

Operations of the State Water Project and Central Valley Project

Factors affecting spring-run chinook salmon related to the effects of SWP and CVP operations in the Delta are: (1) upstream or "reverse" flows in the western, central, and southern Delta; (2) entrainment of rearing juveniles to the Southern Delta, where it is more difficult for juveniles to find their way to the ocean; (3) poor environmental conditions in the central and southern Delta; (4) entrainment of juvenile salmon at the SWP and CVP Delta diversions; and (5) food web production and other potential ecological consequences of altered Delta hydrodynamics.

Recent Bay-Delta Regulatory Setting and CALFED

The late 1980s and early 1990s were characterized by State-Federal disputes regarding water quality protection, continued decline of numerous estuarine-dependent species leading to listing of two species of fish (Sacramento River winter-run chinook salmon and Delta smelt), and increased uncertainty of water supplies derived from the Delta. Growing frustration as to how to meet the diverse human and wildlife needs related to the estuary culminated in the series of events described below.

In June 1994, the California Water Policy Council and the Federal Ecosystem Directorate (ClubFED) signed the Framework Agreement intended to provide for increased coordination and communication with respect to: (1) substantive and procedural aspects of Bay-Delta water quality standard setting; (2) improved coordination of water supply operations with endangered species protection and water quality standard compliance; and (3) development of a long-term solution to fish and wildlife, water supply reliability, flood control, and water quality problems in the Bay-Delta Estuary. The collaboration is known as "CALFED," recognizing the State-Federal partnership.

On December 15, 1994, the *Principles for Agreement on Bay-Delta Standards Between the State of California and the Federal Government* (Principles Agreement, commonly referred to as the "Bay-Delta Accord") was signed by State and Federal agencies and urban, agricultural, and environmental interest representatives. The Principles Agreement articulated the basic tenants on how to accomplish the goals of the Framework Agreement. Initially a three year agreement, the Principles Agreement has been extended though December 31, 1998.

The CALFED Principles Agreement, in conjunction with other Federal and State efforts such as the Central Valley Project Improvement Act (CVPIA), was intended to provide habitat protection sufficient for currently listed threatened and endangered species and to create conditions in the Bay-Delta Estuary that would avoid the need for any additional listings for three years. The Principles Agreement included an understanding that if additional listings were required due to unforeseen circumstances in the Estuary or to factors not addressed in the Bay-Delta Plan, that protections of these species would result in no additional water cost relative to the Bay-Delta protections embodied in the Bay-Delta Plan.

The Principles Agreement also states that additional water needs (to protect species) will be provided by the Federal government on a willing seller basis financed by Federal funds, not through additional regulatory re-allocations of water within the Delta. This includes, but is not limited to, future biological opinions, incidental take statements, recovery plans, listing decisions, and critical habitat designations. The Principles Agreement does not specify similar requirements for existing or future listings under CESA. In recent years, the Department of Interior (USDOI) has bought water with CVPIA Restoration Fund money to meet ESA requirements (Delta smelt in spring months) in the San Joaquin River portion of the Delta. The proposed Vernalis Adaptive Management Program (VAMP) focusing on San Joaquin basin salmon depends on water purchases, potentially involving some State money. Unless Federal money would be spent on water for spring run, Delta export curtailments to reduce impacts to spring-run salmon may depend on State funding and the existence of willing sellers of water to offset water supply costs if increased pumping at another time is not possible.

In May 1995, the SWRCB adopted the 1995 Bay-Delta Plan which identifies municipal, industrial, agricultural, and fish and wildlife beneficial uses of water and specific objectives to ensure reasonable protection of beneficial uses. It includes numeric objectives for flow and water quality constituents (dissolved oxygen and salinity), SWP and CVP operations, and narrative objectives for the protection of salmon and brackish tidal marshes in Suisun Marsh. Objectives for SWP and CVP export limits are included in the 1995 Bay-Delta Plan to protect the habitat of estuarine-dependent species. For the fall/winter months (October through January) when yearling Sacramento River spring-run chinook salmon emigrate through the Delta, up to 65% of Delta inflow may be diverted by the SWP and the CVP. During winter/spring months (February through June) when young-of-the-year spring-run chinook salmon rear in and emigrate through the Delta, up to 35% of Delta inflow may be diverted, except if January is relatively dry, when up to 45% of inflow may be diverted in February. Up to 65% of inflow may be exported from July-September as well. Requirements imposed by the USFWS (Biological Opinion for Delta smelt and operations of the SWP and CVP) to protect Delta smelt limit SWP and CVP exports to 1500 cfs or the flow in the San Joaquin River at Vernalis, whichever is greater, from mid-April through mid-May. SWP and CVP operations at times are controlled by one of the other Bay-Delta Plan objectives (outflow, salinity, etc.) and as a result, exports often are lower than the applicable diversion percentage would allow. Figure 44 shows the average monthly diversion percentage during past years compared to the limits in the 1995 Bay-Delta Plan.

The SWRCB issued interim Water Right Order WR 95-6, which amended portions of Water Right Decision 1485 to conform SWP and CVP water rights permits and licenses with the 1995 Bay-Delta Plan. WR 95-6 expires on December 31,1998. The SWP and CVP agreed to operate to the objectives in the 1995 Bay-Delta Plan until this date or until the SWRCB adopts a water right decision to reallocate shares of this responsibility to other parties. The USFWS and NMFS modified their biological opinions for protection of Delta smelt and winter-run chinook salmon in regards to Delta operations of the SWP and CVP to reflect the new water quality criteria. The Department concurred with the USFWS and NMFS findings with respect to the effect of SWP and CVP operations on winter-run salmon and Delta smelt.

The SWRCB prepared an Environmental Report (ER) on adoption of the 1995 Bay-Delta Plan (SWRCB 1995b) which described the life-history patterns of the four runs of chinook salmon, including spring run. It acknowledged that although upstream effects are responsible for the significant initial decline in spring run, conditions in the estuary may contribute to their continuing decline. The ER did not analyze the effects of the 1995 Bay-Delta Plan on spring-run salmon.

<u>CALFED Operations Group</u>

The Bay-Delta Plan delegates substantial authority, subject to veto by the SWRCB Executive Director, to the CALFED Operations Group (Operations Group) to ensure compliance with take provisions of the Biological Opinions for the Sacramento River winter-run chinook salmon and the Delta smelt, yet avoid additional loss of annual water supply using operational flexibility achieved through adjustment of export limits. Decisions to exercise flexibility may increase or decrease water supplies in any month and must be based on best available data to ensure biological protection, as well as being consistent with the ESA and CESA. Any agreement on variations are effective immediately and remain in effect if the SWRCB Executive Director does not object to the variations within ten days.

Operations Group deliberations are conducted in consultation with water users, as well as environmental and fishery representatives. If the Operations Group disagrees on a particular issue, or there is an action that requires additional water that it is believed cannot be made up within existing requirements, the issue is decided by the CALFED Policy Group (agency/department directors or representatives). If the CALFED Policy Group cannot reach agreement, and if the issue involves protected species, a final decision is up to the appropriate regulatory or resources management agency. While the Sacramento River spring-run chinook salmon is a candidate species for listing under CESA, both the Commission and the Department have authority to regulate the incidental take of spring run. If spring-run salmon is listed by the Commission, the Department becomes the responsible entity for the management, incidental take authorization, and restoration of spring run.

The Operations Group has a relatively brief history during which operations flexibility has been used. Since 1995, the fishery-related actions it has undertaken in the Delta primarily have been to reduce exports in the mid-April to mid-May period to improve salmon survival during part of the outmigration period of San Joaquin basin salmon and, concurrently, to improve rearing and transport conditions for Delta smelt. Exports have been curtailed temporarily in late-May and June (1997) to reduce SWP and CVP entrainment of Delta smelt when loss rates were high. Exports have been reduced (two weeks in January 1998) for a USFWS salmon survival experiment designed to determine the role of export pumping on salmon in the Delta in the fall/winter. These actions, targeted at other species or for studies, have benefitted juvenile spring-run salmon to some degree.

Operations to recover the SWP and CVP export water supply that could have been exported absent the fishery-related actions have occurred primarily in the fall. Water costs of spring

1996 fishery actions were recovered through additional export pumping beginning in October 1996. The increment of export pumping associated with the make-up operation was completed in December just as monitoring indicated spring run and other salmon were entering the Delta, thus avoiding any impact of make up pumping operation on salmon. Because the focus was only on incremental effects of the make up pumping operation and not the baseline project operation, no judgements were made regarding the pumping effects on spring-run salmon after the make-up operation ended.

Spring 1997 fishery actions water costs were to be recovered through a combination of Delta outflow relaxation, reservoir release/pumping adjustments, and a short-term relaxation of the 35% export limit in June 1997. Reductions in Shasta and Oroville reservoir releases in November 1997 through January 1998 were to recover upstream storage. Export impacts were not fully recovered because meeting Delta salinity requirements precluded reducing the outflow. Upstream storage impacts were deemed recovered when reservoirs reached allowable flood reservation levels and releases to maintain flood control capacity began in January 1998.

In summary, the Principles Agreement, and the Bay-Delta Plan promote the use of operational flexibility of the CVP and SWP to provide protection for anadromous and other Delta-dependent fish while, at the same time, not causing additional loss of water supply annually. The Operations Group has the responsibility to use the operational flexibility of the SWP and the CVP in such ways that species using the estuary receive more protection than they would have received by strict adherence to Bay-Delta Plan standards. Supplemental actions that require water will be limited by the water available through management of dedicated water and acquisition of water from willing sellers pursuant to the CVPIA.

1997-98 Spring-run Chinook Salmon Protection Plan

In a 1997 Special Order and later in emergency regulations (CCR Title 14. Section 749), the Commission authorized take of Sacramento River spring-run salmon during its one-year candidacy period that would occur incidental to continuation of specific otherwise lawful activities, including operation of the SWP and CVP facilities in the Delta. In response to the Commission's direction to recommend target levels of protection and measures to achieve them to the CALFED Operations Group, the Department collaborated with the CALFED agencies and other Operations Group participants to develop a Spring-run Chinook Salmon Protection Plan (Spring-run Plan) which established monitoring of both salmon and environmental parameters, set criteria for environmental conditions and salmon detection indicative of risk to spring-run salmon in the Delta, and a set of operations responses related to these criteria. The following describes experiences during implementation of the Spring-run Plan and provides a context for observations about this approach relative to the 1995 Bay-Delta Plan.

Spring-run Plan monitoring began in October 1997. In late-November, the DCC gates were closed (one of the Spring-run Plan responses) pursuant to guidelines for the 45 days of DCC gate closure provided in the 1995 Bay-Delta Plan to reduce mortality of salmon. The closure is triggered when Sacramento River basin juvenile salmon (of any race) enter the Delta. In this instance, the salmon caught were not spring-run. Excessive salinity in the Delta was a concern at the time but gradually improved as Delta inflow increased, making it possible to keep the gates closed in December and January as they normally are when Sacramento River flows exceed about 25,000 cfs (to reduce interior Delta flood risk). The NMFS biological opinion for winter-run salmon requires that the DCC gates be closed continuously from February 1-May 20. Closing the DCC gates when salmon are approaching the Delta prevents them from entering the Mokelumne River portion of the Delta. USFWS studies indicate survival is increased by about 50% by closing the DCC gates (USFWS 1992, unpublished data). Under certain hydrological conditions (low flows in drier years) the adverse effect of gate closure on the ability to control Delta salinity may prevent closing them to reduce salmon impacts in the fall and early winter, especially for all of November-January as recommended by the petitioners and by the USFWS *Revised Draft Restoration Plan for the Anadromous Fish Restoration Program, A Plan to Increase Natural Production of Anadromous Fish in the Central Valley of California* Delta Action 6 (USFWS 1997b). Even with the DCC gates closed, a significant proportion of Sacramento River juvenile salmon still enter the central Delta through Georgiana Slough. At high export pumping rates (with no limits on reverse flows such as the former QWEST requirement) closing the DCC gates increases reverse flows in the western, central and southern Delta, contributing to lower survival for juvenile salmon in these parts of the Delta and partially offsetting the benefits of DCC gate closure.

In mid-January 1998, many salmon fry appeared in the SWP and CVP fish salvage samples. These were most probably fall-run, but some were quite likely spring run since fry were seen both in Butte Creek and in the Sacramento River during the previous several weeks. SWP and CVP exports, which were high during the fall months (up to 11,500 cfs), had just been reduced to less than 4,000 cfs for the low-export phase of a USFWS salmon survival test. A series of intense storms caused the inflow to the Delta to increase substantially (from approximately 30,000 cfs to greater than 150,000 cfs). No action was recommended in reaction to the increase in salmon salvage, which declined after about two weeks. Storms continued, river flows remained high, and SWP and CVP export pumping remained relatively low (about 3500 cfs) even after the salmon experiment ended in late January. Five percent or less of Delta inflow was being exported during most of January and even less in February, a favorable condition for Delta fish.

To date, implementation of the Spring-run Plan in 1997-98 has been relatively simple and not particularly instructive for several reasons. Through January 1998, no specific operations response in the Spring-run Plan was initiated pursuant to a spring-run salmon criteria. The lack of yearling spring run in 1997 made this an unusual season to be implementing such a monitoring/response approach in the Delta. Record high flows in the spring-run tributaries in January 1997 appear to have destroyed a large portion of BY 1996 incubating eggs and pre-emergent fry and displaced most of the remaining emergent fry downstream. Almost no juvenile spring-run were observed in the tributary rearing habitat through the spring and summer of 1997, and monitoring gear did not detect yearling spring run leaving the tributaries in the fall 1997 when storms produced creek flows that normally trigger such downstream movement of yearlings. Thus, because no yearling spring run were seen leaving the tributaries, it was assumed that individual salmon seen at the fish salvage facilities in December were from one of the other chinook salmon runs. In future years when it appears spring-run salmon are being entrained by the SWP and CVP, the certainty that they are spring-run and the significance of the losses to the spring-run salmon population will be undoubtedly be questioned. With the information and methods available today, neither of these questions is easily answerable. Future decision-making regarding export reductions to reduce salvage of spring-run size salmon is likely to be controversial on the basis of uncertainty regarding run identification, documented significance of the impact, and the issue of foregone export recovery.

The Operations Group process has demonstrated the ability to deal with endangered fish protection issues as envisioned in the Principles Agreement and the Bay-Delta Plan. However, the specific hydrological conditions of the past three years (moderately to extremely wet) have not presented many serious challenges, particularly with respect to addressing the needs of yearling spring-run salmon. In 1997-98 there was an uncommon absence of yearlings in the fall months. There were favorable Delta fishery and water supply conditions due to continuous storms. At the same time, a salmon experiment was being conducted, which necessitated low export levels in order to access juvenile survival under such an operations scenario. Otherwise, export levels would have been considerably higher. Losses of juvenile salmon at export facilities during this period would have been higher as well. In such a case, it might have been necessary to recommend a reduction in exports to reduce losses of spring-run salmon. Instead, all of the above combined factors obviated the need for any potentially controversial decisions by the Operations Group.

In future drier years, a consensus decision to reduce exports may be more difficult given the "no net water supply impact" principle and the inevitability that making up foregone water supply later will involve risk to winter-run salmon, Delta smelt, or perhaps spring-run juveniles from another BY. It may be very difficult for the Operations Group to find enough flexibility, given the water supply/demand, to accommodate export reductions to reduce spring-run losses.

Use of the flexibility provided in the Principles Agreement will always involve risk and uncertainty for both water and fishery managers and usually will require biologists to make trade-offs among several species and/or between different life stages of a single species. It should be recognized that there is a real limit on how much flexibility can be found in project operations with current facilities. Furthermore, the drier the water-year, the less flexibility there will tend to be.

Habitat Restoration and Management

Habitat restoration projects to benefit Central Valley spring-run salmon are being addressed under two major restoration plans. The Departments *Restoring Central Valley Streams: A Plan For Action* (Action Plan) was initiated in November 1993 (CDFG 1993). The specific goal of the Action Plan is to restore and protect California's aquatic ecosystems that support fish and wildlife and to protect threatened and endangered species. The USFWS AFRP was initiated in 1995. The AFRP is a component of the CVPIA which directs the Secretary of the Interior to develop and implement a program that makes all reasonable efforts to double natural production of anadromous fish in Central Valley streams. The AFRP incorporates many of the actions recommended in the Action Plan. Implementation of the Action Plan and AFRP will provide significant benefit to Central Valley spring-run salmon, particularly upstream of the Delta. The following sections, arranged by watershed, discuss actions which have been implemented.

Sacramento River
Habitat restoration actions in the mainstem Sacramento River impact each of the tributary populations of spring-run salmon as well as any remnant population remaining in the river. Protection and restoration of riparian and flood plain habitat in the river reach from the mouth of the Feather River to Keswick Dam will improve temperature, cover, and feeding conditions in the river. This action is being addressed by the Upper Sacramento River Advisory Council, which was originally initiated by Senate Bill 1086 (California Resources Agency 1989). Under the direction of the Advisory Council, draft documents for the delineation and management of a Sacramento River Riparian Zone and the creation of a management entity were completed during 1997. Funds from the CALFED Category III process were provided in the fall of 1997 for acquisition, restoration, and management of lands acquired under this plan.

Water quality conditions in the upper Sacramento River have been improved with the completion of the Shasta Dam Temperature Control Device and partial completion of the device to control the toxic metal discharges from the Iron Mountain Mine Superfund site. The CVPIA has improved management of river flows by avoiding inadequate or fluctuating flows that cause losses. Adult and juvenile passage at RBDD is unimpeded from September 15 to May 15, when the dam gates are in a raised position. Efforts are underway to improve passage for spring-run adults which must pass the dam after May 15 when the dam gates are reinstalled. This could be in the form of fish ladder improvements or extending the dam gate removal period under the guidance of an interagency technical team. Construction of a new fish screen and gradient restoration structure at the GCID diversion will be initiated during 1998. During the construction period, GCID will continue to operate the "interim" flat-plate fish screen installed in 1993. Four major Sacramento River diverters, (Reclamation District 1004, Reclamation District 108, Provident Irrigation District, and Princeton-Codora-Glenn Irrigation District) have initiated construction or engineering analysis and design and have been funded for fish screen construction. ACID has modified the operation of their Sacramento River dam near Redding, which will reduce flow fluctuations associated with dam operations. In addition, an engineering analysis of options to improve adult passage and juvenile fish screen performance has been initiated. Predictive models for hydrology, temperature, fish populations, harvest, water development, and wetlands are currently under development by the Ecological/Water Systems Operations Models Project, CVPIA Section 3406(g). The implications and value of juvenile rearing in the lower reaches of small Sacramento River tributaries continues to be under investigation by several researchers (Maslin et al. 1997, Moore 1997).

Battle Creek
The restoration program in Battle Creek is addressing anadromous fish habitat suitable for Sacramento River spring run above CNFH. An instream flow study demonstrated a need to increase the minimum required flow below the dams within the drainage by a factor of ten (Payne 1991). Presently, the flows have been increased to the recommended level below three of the hydroelectric dams that control the flow in 17 miles of stream above CNFH. This is an interim action under an agreement with PG&E. Spring run are now confined to this lower reach to prevent exposure to unscreened diversions and inadequate flows. Negotiations are currently underway to consummate a long-term agreement that would restore flow and ecological function to the entire Battle Creek watershed. If negotiations are successful, the final agreement would have to be embodied in an amendment to the FERC Permit for the project.

The comprehensive plan for development of restoration actions in the watershed is being developed with the assistance of a Technical Advisory Committee, consisting of representatives of the responsible agencies and interested parties. In addition, a watershed planning process is also being conducted with input from the community through a Watershed Conservancy.

The operation of CNFH is being integrated with restoration of the watershed through various planning processes being conducted by the USFWS. DWR Northern District engineers, under a contract funded by the Tracy Mitigation Agreement, completed a draft evaluation of fish passage alternatives at the Eagle Canyon Diversion. Additionally, during late 1997, DWR was awarded a CALFED Category III and USFWS grant to develop an overall fish passage and flow management program for the remaining Battle Creek diversions, including Wildcat and Battle Creek Feeder diversions on the North Fork, and Coleman, Inskip and South diversions on the South Fork.

Clear Creek

The Western Shasta Resource Conservation District, in conjunction with the Bureau of Land Management (BLM), has completed the Lower Clear Creek Watershed Analysis (BLM 1996). The Watershed Analysis was prepared in cooperation with various agencies and local stakeholder groups. The Watershed Analysis developed six major restoration actions focused upon doubling the long-term production of salmon and steelhead in Clear Creek, including facilitating re-introduction of spring-run chinook salmon.

DWR Northern District, with funds provided by the Tracy Mitigation Account, has completed a preliminary engineering technical evaluation and environmental review of fish passage alternatives at the McCormick-Saeltzer Dam. In additional, a CALFED Category III grant was awarded for further development of structural alternatives identified by the DWR evaluation. The USBR continues to release the minimum of 50 cfs into Clear Creek below Whiskeytown Dam, and will provide additional flows when the passage issues at McCormick-Saeltzer Dam are resolved.

Mill Creek

On December 19, 1994, a Memorandum of Understanding (MOU) was created under the auspices of the Mill Creek Watershed Conservancy (Mill Creek Watershed Conservancy 1994). The MOU is a non-binding agreement, signed by the Conservancy, the Department, and many other affected agencies and interested parties. One of the major purposes of the MOU was to publicly recognize the commitment of the signatories to restoring and preserving spring-run chinook salmon in Mill Creek. In 1995, with the efforts of the Mill Creek and Deer Creek Watershed Conservancies, the Deer and Mill Creek Protection Act was passed (AB 1413), which provides State protection against the construction of new dams or diversions on private lands on Mill and Deer creeks. Policies that protect against new dams and diversions on USFS land are provided in the Lassen Land and Resource Plan (USFS 1992).

Lassen National Forest grazing allotments have been reduced from a high of 4112 animal unit months (AUM's) in the 1920s to 360 AUM's in 1995 (Mill Creek Watershed Conservancy 1997). Currently, the only allotment is the Morgan Springs Allotment. The number of cattle that are currently being grazed on the upper watershed has been established by range management techniques that the landowner and the USFS use to achieve a balance of productivity without environmental damage. Cattle are rotated on and off pastures, dependent on the available grasses and the condition of the land. The maximum number of permitted animals could be reduced if warranted by environmental factors, such as drought, forage production, etc. The USFS monitors the condition of pasture areas during, and at the conclusion of, the grazing season (Mill Creek Watershed Conservancy 1997).

During 1997, Department screen shop personnel modified the apron and rebuilt the fish ladder at the Ward Dam on lower Mill Creek. In addition, a supplemental water exchange agreement was finalized which provides (at the Department's option) a total of 25 cfs of additional flows during key migration periods. Telemetry for two real-time flow monitoring stations in the valley reach of Mill Creek was installed during 1997. The new telemetry provides the ability to monitor flows included in the water exchange agreement and also provides the potential to develop and identify juvenile migration cues. One additional gage, and additional telemetry including turbidity and temperature, is scheduled to be installed in the upper watershed during 1998. An evaluation of "critical riffle" passage flows was completed during 1996, which recommended minimum migration flows be between 34 cfs and 157 cfs, dependent upon water-year type and potential annual physical modification of key riffles in the valley reach of Mill Creek (Alley et al. 1996). An evaluation of road-related sediment sources in the upper Mill Creek Watershed was completed during 1997 (Meadowbrook Conservation Associates 1997).

Deer Creek

During January 1995, an MOU was created under the auspices of the Deer Creek Watershed Conservancy (Deer Creek Water Conservancy 1995). The MOU is a non-binding agreement, signed by the Conservancy, the Department, and many other affected agencies and interested parties. One of the major purposes of the MOU was to publicly recognize the commitment of the signatories to restoring and preserving spring-run chinook salmon in Deer Creek. In 1995, under the auspices of the Deer Creek and Mill Creek Watershed Conservancies, the Deer and Mill Creek Protection Act was passed (AB 1413), which provides State protection against construction of new dams or diversions on private lands of Mill and Deer creeks. Policies that protect against new dams and diversions on USFS land are provided in the Lassen Land and Resource Plan (USFS 1992).

Livestock exclusion fencing was installed along both upper and lower Deer Creek. Limited removal of the exotic giant reed was conducted where it was blocking adult and juvenile migration. Water exchange agreements with the SVIC and DCID continue to be developed. Upon implementation, the agreements will provide (at the Department's option), up to 50 cfs of flow during key migration periods. Additionally, telemetry for two real-time flow monitoring stations in the valley reach of Deer Creek was installed during 1997. The new telemetry provides the ability to monitor flows included in the water exchange agreement and also provides the potential to develop and identify juvenile migration cues. One additional gage and additional telemetry, including turbidity and temperature, are scheduled to be installed in the upper watershed during 1998.

Big Chico Creek

Current and recently completed projects to recover spring-run chinook salmon populations in

Big Chico Creek include improvements for adult and juvenile passage, water quality, and reduction in entrainment of juveniles at water diversions.

Modification of One-Mile Pool to decrease downstream siltation and turbidity has been completed. The One-Mile Pool modification involved installing a bypass pipe around the pool to allow removal of bedload deposits. Previous cleaning methods resulted in high turbidity and silt deposition in the reach of the creek immediately below the pool, which were in violation of SWRCB standards and potentially detrimental to migrating salmon.

A new diversion facility to replace the old M&T pump facility on Big Chico Creek was recently completed and began operation in April 1997. The M&T pumps, which were located on Big Chico Creek, were moved to the Sacramento River. Additionally, the new diversion intake was screened. There are multiple benefits of the pump relocation as they relate to spring-run salmon, which include increased flows in Big Chico Creek that directly benefit both juvenile and adult spring-run salmon. Additionally, entrainment of juvenile spring-run salmon from both Big Chico Creek and those migrating from up-river, including Mill and Deer creeks, has been eliminated by the relocation and screening of the pumps.

Evaluation of the Iron Canyon Fish Ladder after the 1997 storm indicated that additional modifications were necessary to improve passage. Interim repairs were made by Department habitat shop personnel and the ladder is now passable under most flows.

Butte Creek

Current efforts to improve spring-run chinook salmon populations in Butte Creek are directed towards reduction of entrainment of juveniles in unscreened water diversions, improvements of adult passage, increased instream flows, and protection of riparian habitat. During May 1996, the Butte Creek Watershed Conservancy initiated a MOU similar to those developed by the Mill Creek and Deer Creek Conservancies. The Butte Creek MOU also has as a central focus the restoration and protection of spring-run chinook salmon in Butte Creek. As with the other watershed MOU's, the Butte Creek MOU was signed by the Department, other affected agencies, and interested parties. It serves as a written commitment on the part of all signatory parties to seek a cooperative solution to the protection and restoration of spring-run chinook salmon. As with the other watershed conservancies, the Butte Creek Conservancy, working with and though the California State University Chico, is developing an analysis of existing conditions within the watershed. Ultimately the conservancy intends to develop an overall watershed management plan, central to which will be the restoration and protection of spring-run chinook salmon. The conservancy has received funding and is in the process of acquiring approximately 300 acres of riparian land located in the lower reaches of the spring run holding and spawning habitat.

As a result of the M&T pump relocation on Big Chico Creek, a component of the project was an agreement to modify diversions from Butte Creek during certain key months to protect spring- and fall-run salmon and steelhead trout in Butte Creek. Under the new agreement, up to 40 cfs of flow (approximately 22,000 acre feet per year) that could be diverted at the Parrott-Phelan Dam will be left in Butte Creek from October 1 through June 30 of each year. The additional flows are dedicated under the provisions of California Water Code Section 1707, which authorizes the use of water to preserve or enhance wetland habitat and wildlife resources. Dedication under Section 1707 was implemented on a temporary basis in 1996-97, and will eventually be covered on a permanent basis under the terms of the agreement with the water right holders. Telemetry for eight real-rime flow monitoring stations along Butte Creek was installed during 1997. The new telemetry provides the ability to monitor flows included in the water agreement and also provides the potential to develop and identify juvenile migration cues. Two additional gages and additional telemetry, including turbidity and temperature, are scheduled to be installed during 1998.

During 1994, the first fish screen on any of the many Butte Creek diversions was installed at the Parrott-Phelan Diversion near Chico. Following installation of the fish screen, a new and improved fish ladder was constructed during 1995. During 1997, an inverted siphon was constructed under Butte Creek to convey flows delivered by the Western Canal Water District, thereby allowing removal of four dams along the valley reach of Butte Creek, south of Chico. Two of the four dams belonging to the Western Canal Water District were removed during 1997, with the remaining two (McGowan and McPherrin) to be removed during 1998. Removal of the dams eliminated the need to screen four major diversions, the largest of which was approximately 1,200 cfs. During 1997, DWR's Northern District engineering staff, under contract to the Department, completed preliminary engineering and environmental analysis for structural modifications to three additional diversion structures (Durham Mutual, Adams, and Gorrill) along the valley reach of Butte Creek. Final engineering and funding for a new fish screen and fish ladder are complete for the Durham Mutual diversion, with completion scheduled for the summer of 1998. Final engineering and funding are nearing completion for Adams and Gorrill diversions, with the possibility that construction can also be completed during the summer of 1998.

The Nature Conservancy, in conjunction with the California Waterfowl Association, has received a grant partially funded and administered by the Department, to work with local landowners along the lower reaches of Butte Creek and the Sutter Bypass to initiate a program to improve fish passage through the Butte Sink and Sutter Bypass. This will include evaluation of each of the 12 water diversion structures located in the study area, including water management procedures and numerous water diversions associated with each structure. Final alternatives for each site will include engineering data, estimated costs of alternatives, site locations, fish passage issues, design and operations issues, and an analysis of the impact of each alternative on waterfowl and other water dependent species. The study is currently in progress and is anticipated to be completed by mid-1998.

<u>Yuba River</u>

Projects and preliminary project evaluations are in progress that will improve habitat and survival of salmon in the Yuba River. Browns Valley Irrigation District (BVID) is proceeding to screen their diversion. Screening should be completed by the summer of 1998. PG&E, as a requirement of their FERC license, is required to implement fishery improvements on the Yuba River. The USFWS has funded the U.S. Army Corps of Engineers (USACOE) to undertake studies for fishery improvements at Daguerre Point Dam. Evaluations will center around improvements in adult and juvenile passage, juvenile predation, entrainment at water diversions, as well as dam removal.

The USFWS has strongly recommended that the USACOE remove Daguerre Point Dam "because this action above all will truly restore the river ecosystem, offering the greatest and longest lasting benefits to fish and wildlife resources which rely on the river" (USFWS 1994). The Department believes that this is a prudent alternative for fishery restoration in the lower Yuba River.

In 1991 the Department presented testimony before the SWRCB to improve instream flows and temperatures for salmonids. However, the SWRCB has not rendered a decision and it does not appear that a decision will be forthcoming in the near future.

Screening of BVID and improvements at Daguerre Point Dam will result in increased salmonid production. However, the lack of adequate flows and temperatures and the lack of adequate screens on the South Yuba-Brophy and Hallwood-Cordua diversions will continue to preclude the significant improvements in salmonid populations, including spring-run chinook salmon in the Yuba River.

Unscreened Water Diversions and Fish Passage Correction

Ongoing surveys by the Department indicate that there may be at least 2,050 unscreened water diversions in the Delta and Sacramento River valley. These unscreened diversions pose a risk of take of anadromous fish, including Sacramento River spring-run chinook salmon.

To ameliorate the problems posed by unscreened diversions, the Department has funded and staffed a California Water Diversion and Fish Passage Program. The following are the key elements of the State's program:

(1) *Inventory Water Diversions and Fish Passage Problems.* The purpose of the inventory is to locate and identify all screened and unscreened diversions. This information will be entered into the Inland Fisheries Division Geographic Information System (GIS). Information will be verified by site visits. The site visits allow the Department to locate the diversion site, and gather information on the size and number of diversions at each site. The presence and condition of existing fish protective facilities are noted.

(2) *Evaluate and Set Priorities for Fish Screening and Fish Passage Problems.* Based on the results of the inventory activities, the Department conducts field evaluations when necessary, and then evaluates and sets priorities for identified problems for funding and resolution.

(3) *Implement and Coordinate Fish Protection Activities as They Relate to Fish Screening and Fish Passage.* Each project is different, both in the nature of the solution and in the manner in which the solution is implemented. First priority is to be given to those sites owned or operated by the Department. Next in priority are to be sites which serve Department owned lands. This would be most critical where those sites have the potential to affect, or are presently affecting, State or federally listed species.

(4) *Evaluate Existing and Proposed Fish Protective Installations.* The Department evaluates existing facilities and newly installed facilities to provide feedback for the program. This feedback allows the Department to document the effectiveness of its actions, and will allow the Department to modify activities to enhance the protection afforded the resource.

(5) *Review Fish Screening and Fish Passage Literature.* The Department maintains an active program of reviewing the literature on fish screening and fish passage research and site evaluations to ensure that the Department is current with recent developments in these fields. The Department closely monitors research and evaluation activities in California, including the activities of the Fish Facilities

Technical Committee of the IEP for the Sacramento-San Joaquin Estuary and the Red Bluff Research Pumping Facility.

In addition to Department efforts to implement corrective actions at unscreened and poorly screened diversions in the Central Valley, the CVPIA requires the Secretary of the Interior to 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 diversions to less fishery-sensitive areas. The Secretary's share of costs associated with activities authorized under this paragraph shall not exceed 50% of the total cost of any such activity.

Both the State and the Federal governments have ongoing programs to abate the unscreened diversion problems. In addition to efforts by the Department, DWR has an ongoing unscreened diversion assessment program in the Delta. The NMFS regularly participates in discussions, project development, and engineering review of proposed screening projects. The USFWS, under the Fish and Wildlife Coordination Act and the USACOE permitting process, reviews and comments on proposed fish screening projects. The USBR, using drought funds, has implemented a Fish Screening Demonstration Project for CVP contractors along the Sacramento River.

All diversions are to be dealt with uniformly on a statewide basis, as outlined in the Department's Fish Screening Policy. The sequence and manner in which diversions are to be addressed is a function of location, diversion rate, diversion timing, compliance with existing fish screening statutes, the National Environmental Policy Act (NEPA), the California Environmental Quality Act (CEQA), the ESA, CESA, and court decisions.

The USFWS has also developed a process and proposed evaluation criteria to be used to identify reasonable restoration actions, which will greatly influence funding priorities for fish passage correction and diversion screening projects. The process and criteria are described in their 1995 *Draft Anadromous Fisheries Restoration Plan.*

Operations of State and Federal Hatcheries

Coleman National Fish Hatchery

The USFWS is currently opening the fish ladder at the barrier dam at the CNFH to allow upstream passage of spring-run adults from March through June. Closure of the ladder after June 30 will generally separate spring run from later arriving fall run. A portion of the hatchery water supply is now sterilized with ozone to remove fish pathogens originating from upstream aquaculture facilities, resident fish, and wild-spawning anadromous fish (USFWS 1997b).

Feather River State Fish Hatchery

Currently, the fish ladder at FRH is opened on or about September 8. Returning adults are allowed free access to the hatchery after that date, consistent with physical constraints and water quality. All adults entering the hatchery between September 8 and October 1, are classified as spring run, while adults arriving after October 1 are classified as fall run. Current production goals include the take of 7,000,000 spring-run eggs, and release of 5,000,000 juveniles at an average size of 60 fish per pound. Once the egg production goal is met, all remaining adults classified as spring run are returned to the Feather River. All juvenile spring run are transported to various release sites in the Carquinez Straits/San Pablo Bay area.

Salmon and Steelhead Stock Management Policy

It is the policy of the Department to maintain the genetic integrity of all identifiable stocks of salmon and steelhead in California (Reynolds et al. 1990). To protect the genetic integrity of California salmon and steelhead stocks, each salmon or steelhead stream shall be evaluated by the Department and the stocks classified according to their probable genetic source and degree of integrity. Management and restoration efforts will be guided by this classification system, and policies relating to artificial production must also be compatible with this classification system.

The classification system shall be employed to define the appropriate stocks and the role of artificial production for management of each salmon and steelhead stream in California. This classification may be applied to drainages, individual streams, or segments of streams as necessary to protect discrete stocks of salmon or steelhead. Only designated appropriate stocks may be placed or artificially produced in any stream within the guidelines specified under this classification system. Exceptions to these management constraints may be allowed only under emergency conditions that substantially threaten the long-term welfare of the fishery. Exceptions may only be granted upon submission of a written request, which details the emergency conditions, by a regional manager or an Inland Fisheries Division Assistant Chief to the Chief of the Inland Fisheries Division. The Inland Fisheries Division Chief will review the request and make recommendations for approval or denial to the Deputy Director of Fisheries who will approve or deny the request.

The Interagency Ecological Program (IEP), Spring-run Salmon Project Work Team

The Spring-run Salmon Project Work Team (Team) has been established to provide a forum to discuss the many issues affecting spring-run chinook salmon. This group is formed under the umbrella of the IEP's Central Valley Salmon Work Team. The Team is also tasked with providing an avenue for discussing issues such as habitat restoration priorities, measurement of the overall health of the spring-run resource, new monitoring actions that are needed and the success of those that are ongoing. Last year, pursuant to Section 670.6 of Title 14, CCR, the Spring-run Salmon Project Work Team produced a report for the Commission entitled *The Status of the Sacramento River Spring-run Chinook Salmon* (Baracco 1997).

Watershed Management Planning

An essential component of salmon management and restoration is strong public support to ensure program success. Successful implementation of any measures, particularly on privately owned land to protect, restore, and enhance habitats for spring-run salmon is facilitated by close coordination and communication with the newly established and forming watershed conservancies in the Central Valley. The following organizations are instrumental in the successful implementation of management activities to restore and protect spring-run salmon in the Central Valley. The following narrative sections have been provided by the respective organizations.

Lower Clear Creek Coordinated Resource Management Plan (CRMP)

The Lower Clear Creek CRMP was formed in 1994 and received funding from CVPIA (administered by USBR) and Natural Resources Conservation Service in September 1996. The CRMP's goal related to fisheries is to "protect and enhance the long-term productivity of the Clear Creek aquatic ecosystem with special emphasis on salmon and steelhead and to restore spring-run salmon and steelhead to the area upstream of McCormick-Saeltzer Dam as soon as possible." Private landowners, stakeholders, concerned citizens, Federal, State, and local government agencies make up the CRMP.

The preferred solution to the fish passage problem at McCormick-Saeltzer Dam appears to be in the form of a new dam or new fish ladder. The CRMP endorses an effort to introduce spring-run spawners to the area upstream of McCormick-Saeltzer Dam so that there will be adults returning when the passage problem is solved.

In the meantime, their focus has been on habitat improvements. Work performed includes: (1) introducing spawning gravel both up and down stream of McCormick-Saeltzer Dam; (2) completing an erosion inventory for the watershed and several demonstration projects; (3) completing a fuels inventory for the watershed and working on shaded fuel breaks and controlled burns; (4) designing channel reconstruction projects for the gravel-mined area downstream of McCormick-Saeltzer Dam; (5) negotiating increased flows from Whiskeytown Reservoir during the October to April period (for fall-run chinook); and (6) monitoring of channel substrates and fisheries by agencies.

Battle Creek Watershed Conservancy

The Battle Creek Watershed Conservancy has been formed with assistance of the local Resource Conservation Districts. Property owners with economic interests and concerns for the environmental health of the watershed will likely be members. Watershed issues and the operating procedures of the group are being identified. Since the Battle Creek watershed is believed to have some of the finest remaining habitat for spring-run chinook salmon, community members want to be involved with the implementation of a fish restoration program. Funding for this local watershed group is provided by the AFRP (50%) and Category III (50%). In addition to the work being initiated by the community conservancy, a technical planning effort has been funded with Category III monies. The Battle Creek Working Group meets regularly to review and discuss the technical issues applicable to restoring wild salmonids while maintaining the CNFH mitigation responsibility of the CVP.

Mill Creek Conservancy

The Mill Creek Conservancy is a non-profit conservation group that is devoted to resource protection and enhancement through cooperative efforts of landowners, agencies, and other groups dedicated to a healthy ecosystem. The Conservancy's mission is to sustain the historical pristine condition, appropriate land uses, and the biological integrity of the Mill Creek watershed. The Conservancy believes that the landowners have been, and will continue to be, the best stewards of the land, and that community stewardship is desirable for long-term resource protection.

During 1997, the Mill Creek Conservancy: (1) participated in storm assessment; (2) submitted a grant proposal for revegetation projects; (3) continued support of the Los Molinos student projects; (4) sponsored an annual Watershed Advisory Committee meeting which was attended by more than 50 concerned citizens; (5) supported Department fish surveys; (6) provided input regarding listing and incidental take regulation for spring-run chinook salmon; (7) submitted comments regarding impacts from CALFED policies on spring-run chinook salmon; (8) pursued a Fire Management Plan for the Mill Creek watershed; (9) and developed an Implementation Plan for the Mill Creek Watershed Management Strategy.

Deer Creek Watershed Conservancy

The Deer Creek Watershed Conservancy (DCWC) was formed in March 1994 by the landowners within the watershed and people who divert water from Deer Creek. The DCWC embraces the following goals: (1) protection of the unique ecological, social, and cultural values of Deer Creek; (2) the preservation of private property rights; (3) the promotion of responsible land stewardship that has preserved the extraordinary resource values and economic uses resulting in watershed stability for generations; (4) a mechanism by which agencies responsible for the management of public trust resources in the watershed can tailor their programs to local conditions; and (5) the education of the community and the general public about Deer Creek. Since its formation, DCWC has committed its efforts toward the enhancement of fish habitat in Deer Creek. An immediate goal of DCWC is to prevent any degradation of an already diminished spring-run salmon population. Early commitment to this goal was demonstrated by DCWC's initiation of State Assembly Bill 1413, which prohibits the construction of new dams, diversions, or water impoundments.

The DCWC has joined with Federal, State, and local resource managers, conservation groups, universities, local schools, and other interested individuals to develop a collaborative process for watershed management planning. DCWC has created, during its Phase I time-frame, a Watershed Action Committee (WAC) comprised of representatives from the above-mentioned entities that met for the first time in May 1996. The WAC has held eight meetings and has successfully completed the following tasks: (1) drafted goals for watershed management and protection; (2) assembled existing information concerning the watershed in an Existing Conditions Report; (3) collected data for the Historical Report; (4) reviewed and compiled the existing plans, programs, and policies affecting Deer Creek; (5) identified concerns and priorities for implementation projects in order to comprise the Watershed Management Strategy Report; and (6) designed and implemented a comprehensive on going monitoring program for Deer Creek. A Watershed Management Strategy Report is in preparation.

Phase II of the planning process will commence upon completion of the Watershed Management Strategy, which is currently being developed. Phase II will focus on implementing the actions identified in the Watershed Management Strategy Report, the on-going monitoring program, and annual progress reports. All above mentioned documents will eventually comprise the Deer Creek Watershed Management Plan. This Plan will be a living document to reflect new information, natural watershed events, and new identified projects, and will provide the framework for the Conservancy to assist the landowners in long-term stewardship of the watershed. DCWC has also applied for funding from CALFED to produce a Fire Plan, a Flood Plan and a Range Management Plan. This phase will be a continuing part of the process to provide hands-on stewardship and commitment toward maintaining and enhancing the condition of the Deer Creek watershed.

<u>Big Chico Creek Watershed Alliance</u>

In response to the reverse flows in Big Chico Creek, caused by in stream pumping at the M&T Chico Ranch, concerned citizens formed a Task Force in 1991 and began meeting on a monthly basis. The Task Force began a process intended to ensure the creek's vitality, and preserve and restore native salmon and steelhead populations. The City of Chico, M&T Chico Ranch, the Department, DWR, Regional Water Quality Control Board, Streaminders, Sacramento River Preservation Trust, Chico Fly Fishers, and local citizens set goals, objectives, and a timeline for implementation of specific projects.

In May 1997, the Task Force changed its name to the Big Chico Creek Watershed Alliance (Alliance) and reconfirmed its commitment to long-term watershed-wide protection employing a strategy of adaptive management.

The Alliance has worked cooperatively to accomplish many of the projects which have been developed to meet the goals and objectives. A major accomplishment was the relocation of the M&T Pumps to the Sacramento River, allowing salmonids and other native fish unrestrained access to the creeks. The initial GIS mapping of the Big Chico Creek upper watershed has been completed. Funding has been sought to map the entire watershed, which includes important nonnatal rearing habitat for salmonids in Rock, Mud, and Sycamore creeks and Lindo Channel.

With the completion of the GIS, the Alliance will start a process to create a comprehensive, holistic management, restoration, and implementation plan for the watershed. The Alliance has completed a MOU that will help build partnerships with landowners, State and Federal agencies, city and county government, conservation groups, and watershed stakeholders. Additionally, the Alliance has applied for funding for a gravel management plan, riparian restoration projects, a coordinated school watershed education program, and a fencing project to exclude cattle from the creek, as well as a restoration project in the upper watershed.

Butte Creek Watershed Conservancy

The Butte Creek Watershed Conservancy was formed in September 1995 to encourage watershed-wide cooperation and communication between residents, landowners, water users, recreational users, and local, State, and Federal agencies. The mission statement of the Conservancy is: "The Butte Creek Watershed Conservancy was established to protect, restore and enhance the cultural, economic, and ecological heritage of the Butte Creek Watershed through cooperative landowner action." The Conservancy has circulated a MOU, which was signed by many of the agencies and groups involved with Butte Creek projects, to develop a watershed management strategy (WMS). The USFWS, CALFED and the National Fish and Wildlife Foundation have funded the initial elements of the WMS through the Department of Geography and Planning at California State University, Chico and the Conservancy. The Conservancy has also received grants for the K-12 education program on Butte Creek from USEPA 319(h) funds and a grant for a full-time watershed coordinator from For the Sake of the Salmon, an Oregon non-profit group dedicated to restoring anadromous fisheries. Stakeholders formed a Watershed Advisory Committee to work with the project at the University in defining important issues and concerns for inclusion in an Existing Conditions Report. This report will form the basis of the WMS to be developed with the stakeholders in 1998. The Conservancy has been most active in raising awareness of the watershed and the desire to promote their mission. These efforts include an annual Spring-run Chinook Salmon Celebration, a silent auction and benefit, a newsletters, and a website for the Conservancy.

Although the projects and plans may seem ambitious, the Alliance members are committed to the restoration and preservation of salmon and steelhead populations in the Butte Creek watershed.

Spring-run Workgroup

The Spring-run Workgroup (Workgroup) was formed in 1992 for the stated purpose of developing a coalition of individuals, groups, and organizations to achieve a grassroots restoration of spring-run chinook salmon. As intended when initially formed, it continues to be a broad amalgam of groups and individuals, all with a common goal of protecting and restoring Sacramento River spring-run chinook salmon.

The Workgroup, which operates by consensus, is facilitated by the University of California at Davis Sea Grant Extension Program, under a grant funded by the Commercial Salmon Stamp Account and administered by the Department. The Workgroup meets on a monthly basis, and has involved over 300 individuals representing private landowners, agencies, agriculture, cities, counties, environmental groups, the timber industry, and commercial and sport fishing groups. The Workgroup's fundamental tenet is inclusion and cooperation, a basis which has served an invaluable role in bringing together the disparate stakeholders and constituencies.

Restoration Programs

Several existing key Federal and State programs are helping to facilitate protection and restoration of spring-run chinook salmon within the Central Valley. The following report section provides a summary of program actions relevant to spring-run salmon.

Central Valley Project Improvement Act

The CVPIA is one of the most important programs, having great potential in the successful funding and implementation of many restoration actions needed to protect and restore spring-run chinook salmon. The CVPIA requires the Secretary of the Interior to implement a wide variety of operation modifications and structural repairs in the Central Valley for the benefit of the anadromous fish resources. Section 3406(b)(1), known as the AFRP, directs the Secretary of the Interior to develop and implement a program that makes all reasonable efforts to double natural production of anadromous fish in Central Valley streams. Sections 3406(b)(1) through (21) of the CVPIA authorize and direct the Secretary, in consultation with other State and Federal agencies, Native American tribes, and affected interests to take the following actions, all of which will ultimately assist in protecting and restoring Sacramento River spring-run chinook salmon:

3406(b)(1)(A) -	Modify CVP operations to protect and restore natural channel and riparian values.
3406(b)(1)(B) -	Modify CVP operation based on recommendations of USFWS after consultation with the Department.
3406(b)(2) -	Manage 800,000 acre-feet of CVP yield for fish, wildlife, and habitat restoration purposes after consultation with USBR and DWR and in cooperation with the Department.
3406(b)(3) -	Acquire water to supplement the quantity of water dedicated for fish and wildlife water needs under (b)(2), including modifications of CVP operations; water banking; conservation; transfers; conjunctive use; and temporary and permanent land fallowing, including purchase, lease, and option of water, water rights, and associated agricultural land.
3406(b)(4) -	Mitigate for Tracy Pumping Plant Operations.
3406(b)(5) -	Mitigate for Contra Costa Pumping Plant operations.
3406(b)(6) -	Install temperature control device at Shasta Dam.
3406(b)(7) -	Meet flow standards that apply to CVP.
3406(b)(8) -	Use pulse flows to increase migratory fish survival.
3406(b)(9) -	Eliminate fish losses due to flow fluctuations of the CVP.
3406(b)(10) -	Minimize fish passage problems at RBDD.
3406(b)(11) -	Implement Coleman National Fish Hatchery Plan and modify Keswick Dam Fish Trap.
3406(b)(12) -	Provide increased flows and improve fish passage and restore habitat in Clear Creek.
3406(b)(13) -	Replenish spawning gravel and restore riparian habitat below Shasta Reservoir.
3406(b)(14) -	Install new control structures at the DCC and Georgiana Slough.
3406(b)(15) -	Construct, in cooperation with the State and in consultation with local interests, a seasonally operated barrier at the head of Old River.
3406(b)(16) -	In cooperation with independent entities and the State, monitor fish and wildlife resources in the Central Valley.

3406(b)(17) -	Resolve fish passage and stranding problems at ACID Diversion Dam.
3406(b)(19) -	Reevaluate carryover storage criteria for reservoirs on the Sacramento and Trinity rivers.
3406(b)(20) -	Participate with the State and other Federal agencies in the implementation of the on-going program to mitigate for GCID's Hamilton City Pumping Plant.
3406(b)(21) -	Assist the State in efforts to avoid losses of juvenile anadromous fish resulting from unscreened or inadequately screened diversions.

In addition to the aforementioned CVPIA actions, Section 3406(e) (1) through (6) directs the Secretary to investigate and provide recommendations on the feasibility, cost, and desirability of implementing the actions listed below. When completed, these actions will provide additional understanding of the overall ecosystem problems and provide additional measures which will benefit spring-run chinook.

3406(e)(1) -	Measures to maintain suitable temperatures for anadromous fish survival by controlling or relocating the discharge of irrigation return flows and sewage effluent, and by restoring riparian forests.
3406(e)(2) -	Opportunities for additional hatchery production to mitigate the impacts of water development and operations on, or enhance efforts to increase Central Valley fisheries: provided, that additional hatchery production shall only be used to supplement or to re-establish natural production while avoiding adverse effects on remaining wild stocks.
3406(e)(3) -	Measures to eliminate barriers to upstream and downstream migration of salmonids.
3406(e)(4) -	Installation and operation of temperature control devices at Trinity Dam and Reservoir.
3406(e)(5) -	Measures to assist in the successful migration of anadromous fish at the DCC and Georgiana Slough.
3406(e)(6) -	Other measures to protect, restore, and enhance natural production of salmon and steelhead in tributary streams of the Sacramento River.

Section 3406(g) of the CVPIA directs the Secretary to develop models and data to evaluate the ecological and hydrologic effects of existing and alternate operations of public and private water facilities and systems to improve scientific understanding and enable the Secretary to fulfill requirements of the CVPIA.

Finally, habitat restoration actions not directly addressed in the aforementioned actions, such as restoration measures on streams tributary to the Sacramento River, will be managed by the AFRP of the USFWS. Section 3406(b)(1) of the CVPIA directs the Secretary to develop and implement a program which makes all reasonable efforts to ensure that, by the year 2002, natural production of anadromous fish in Central Valley rivers and streams will be sustainable, on a long-term basis, at levels not less than twice the average levels attained during the period of 1967-91. The AFRP released its revised draft restoration plan in May 1997, and, similar to the Department's Central Valley Restoration Plan released in 1993, the USFWS plan contains a listing of actions deemed necessary to protect and restore anadromous fish, including Sacramento River spring-run chinook salmon, in the Sacramento Valley.

Section 3407 of the CVPIA established in the Treasury of the United States the "Central Valley Project Restoration Fund". Funds up to $50,000,000 per year are authorized to be appropriated to the Secretary to carry out program, projects, plans, and habitat restoration, improvement, and acquisition. The funds are derived by payments from CVP water and power users.

Agreement Between the Department of Water Resources and the Department of Fish and Game to Offset Direct Fish Losses in Relation to the Harvey O. Banks Delta Pumping Plant

The agreement, also known as the Four-Pumps Agreement, between DWR and the Department has proven to be a mutually beneficial program to protect and restore habitat for anadromous fish, particularly for chinook salmon. The agencies, through the Four-Pumps Agreement, have successfully designed and implemented several projects to benefit Sacramento River spring-run chinook salmon on Mill and Deer creeks. Funding is available through this agreement on a project-by-project basis. Projects that provide quantifiable benefits to Sacramento River spring-run chinook salmon, within specified cost benefit analyses, are generally funded.

Agreement to Reduce and Offset Direct Fish Losses Associated with the Operation of the Tracy Pumping Plant and Tracy Fish Collection Facility

The agreement, also known as the Tracy Agreement, between the USBR and the Department provides a mechanism to identify, develop, and implement habitat restoration measures for anadromous fish in a manner similar to the Four-Pumps Agreement. Its funding was used to develop environmental documentation and permitting for the Western Canal Siphon Project on Butte Creek, and additionally was used to develop preliminary engineering and environmental documentation at six other sites on key spring-run tributaries.

Category III

The "Principles for Agreement on Bay-Delta Standards Between the State of California and Federal Government" called for the development of a program of so-called "Category III" measures. Category I and II measures address water quantity and water operations while Category III measures address non-flow related habitat issues. The "Principles" provide for funding of Category III activities estimated to be $60,000,000 annually (for three years), to be secured through a combination of Federal and State appropriations, user fees, and other sources. It was further agreed that urban and agricultural water suppliers will work with State and Federal agencies and environmental interests in an open process to determine project priorities and financial commitments for the implementation of Category III measures.

Safe, Clean, Reliable Water Supply Act (Act)

The Safe, Clean Reliable Water Supply Act, also know as Proposition 204, passed by the voters of California in November 1996, is equal in importance to the CVPIA in providing the funding to implement restoration actions needed to protect and restore spring-run chinook salmon. The Act, in part, provides the State and local cost share for projects funded under the CVPIA and CALFED Bay-Delta Program, both of which have components that will significantly advance Sacramento River spring-run chinook salmon restoration programs. The Act authorizes a variety of programs that provide both direct and indirect benefits to Sacramento River spring-run chinook salmon. The following sections of the Act are expected to provide benefits to Sacramento River spring-run chinook salmon restoration efforts:

Chapter 4, Article 2. - Central Valley Project Improvement Program: Creates the Central Valley Project Improvement Subaccount ($93,000,000) for the purpose of providing the State's share for the costs for fish and wildlife restoration measures required by Section 3406 of the CVPIA (P.l. 102-575). Preference is given to projects for the purpose of installing fish screens at diversions identified in the CVPIA, for which deadlines have been established by State or Federal agencies or by State or Federal courts.

Chapter 4, Article 3. - Bay-Delta Agreement Program: Creates the Bay-Delta Agreement Subaccount ($60,000,000) for the purpose of implementing non-flow-related projects called for in the Water Quality Control Plan for the Bay-Delta. Those projects are known as "Category III" activities called for in the "Principles for Agreement on Bay-Delta Standards between the State of California and the Federal Government", December 15, 1994. Category III projects have been, and are currently being funded, which have given a priority to restoration of spring-run chinook salmon.

Chapter 4, Article 4. - Delta Levee Rehabilitation Program: Creates the Delta Levee Subaccount ($25,000,000) for the purpose of providing local assistance under the delta levee maintenance subventions program and for special flood protection projects. Funds expended under this article must demonstrate consistency and a net long-term habitat improvement program and have a net benefit for aquatic species in the Delta as evidenced by a written determination by the Department.

Chapter 4, Article 5. - South Delta Barriers Project: Creates the South Delta Barriers Subaccount ($10,000,000) for the purpose of mitigating non-SWP or non-CVP impacts and for the purpose of environmental enhancement in the Delta. Funds expended under this article must be determined in writing by the Department to provide habitat benefits.

Chapter 5, Articles 2-4. Clean Water and Recycling Program: Creates several subaccounts for the purpose of providing funding for projects under the Clean Water Act, Water Recycling Programs, and Drainage Management Programs, which serve to improve water quality and quantity. These programs are expected to provide benefit to spring-run restoration efforts as they relate to projects implemented within the Delta.

Chapter 5, Article 5. Delta Tributary Watershed Program: Creates the Delta Tributary Watershed Program Subaccount ($15,000,000) for the purpose of implementing projects in tributaries which drain into the Delta for the following purposes: (1) reduction in the presence of contaminants; (2) increase yield of water by various means including restoration of upland meadows, and repair to stream channels; (3) improvement, restoration, or enhancement of fisheries habitat; and (4) improvement of overall forest health.

Chapter 6, Articles 2-6. Water Supply Reliability: Creates the Water Supply Reliability Supply Account ($117,000,000) with several subaccounts containing provisions potentially beneficial to spring-run chinook salmon, primarily through the development of increased flows in key spring-run tributaries. Additionally, Articles 5 and 6 provide for general habitat acquisition and water management for the acquisition and restoration of riparian habitat, riverine aquatic habitat, and other lands in close proximity to rivers and streams.

Chapter 7. CALFED Bay-Delta Ecosystem Restoration Program: Creates the Bay-Delta Ecosystem Account ($390,000,000) for the specific purpose of implementing projects, identified in the programmatic EIS/EIR, that are intended to improve and increase aquatic and terrestrial habitats and ecological functions in the Bay-Delta ecosystem. For the purposes of this chapter, the Bay-Delta ecosystem means the Bay-Delta and its tributary watersheds. Eligible projects may include, but are not limited to, the following: (1) protection and enhancement of existing habitats; (2) restoration of tidal, shallow water, riparian, riverine, wetlands, or other habitats; (3) expansion of wetland protection programs; (4) acquisition of water for instream flow improvements; (5) improved habitat management; and (6) protection and management.

Section 78691 authorizes the issuance of bonds in the total amount of $995,000,000 for the express purpose of implementing the various provisions of the Act. Funds are derived from the sale of general obligation bonds supported primarily from personal and corporate income taxes and sales taxes.

Monitoring Programs and Studies

Monitoring programs are currently in progress that are addressing various aspects of spring-run life-history. Table 26 provides a general summary of existing efforts. Additionally, specific details of the various programs may be referenced in several publications which include *Status of Actions to Restore Central Valley Spring-run Chinook Salmon* (Mills and Ward 1996), *The Status of the Sacramento River Spring-run Chinook Salmon* (Baracco 1996), *Central Valley Spring-run Chinook Salmon, A Status Report to the Fish and Game Commission January-June, 1997* (CDFG 1997), and the *Comprehensive Assessment and Monitoring Program (CAMP) Implementation Plan* (USFWS 1997c).

The following specific monitoring activities are discussed to provide information on key areas of investigation.

Sacramento River

Estimates of the total numbers of adult spring-run salmon using the Sacramento River upstream of RBDD continue to be generated through the use of a closed circuit video camera monitoring salmon passing through the ladders. Racial differentiation has, in the past, been based upon coloration, scale embeddedness, sexual maturity, and professional judgement of the observer. In addition, aerial redd counts are generally conducted during September and October.

Battle Creek

The USFWS uses a video monitor to count adult salmon passing upstream through the ladder at the CNFH Barrier Dam during the period April through June. Additionally, surveys of the adult holding areas above the CNFH Barrier Dam are conducted during the summer, as well as limited surveys of spawning activity during September and October.

Antelope Creek

Currently, eight miles of spring-run adult holding habitat are surveyed during July.

Mill Creek

In the recent past, adult spring-run salmon have been counted utilizing a counting station at the Clough Dam fish ladder. Clough Dam was partially destroyed in early 1997, eliminating the use of this method. During 1997, the adult count was based upon observations of redds. In addition, juvenile life-history monitoring is being conducted beginning in December in the spawning and rearing areas of Mill Creek above the valley floor. Relative growth rate and size are monitored through September. Concurrent with the growth studies, non-intrusive tissue samples are taken for DNA analysis. Yearling outmigration is monitored through the use of a rotary screw trap at the Upper Diversion Dam during the period October through December.

Deer Creek

Adult counts in Deer Creek have used three methods since 1986, including ladder counts, estimates from an indicator reach, and snorkel surveys of the entire adult holding area. Currently, a snorkel survey of the entire holding area is the preferred method. Juvenile evaluations in Deer Creek are similar to those being conducted in Mill Creek.

Big Chico Creek

Sporadic surveys of adult holding areas have been conducted since 1986. Starting in 1992, annual snorkel surveys were made of the adult holding area from Iron Canyon to Higgins Hole. Juvenile outmigration is monitored from December through June through the use of fyke nets placed in the creek near the Five Mile Recreation Area.

Butte Creek

Snorkel surveys are performed by Department personnel at least twice each year, between the Quartz Pool and the Parrott-Phelan Diversion Dam. Holding adult salmon are counted in late August, then in late September the survey is repeated and live salmon, carcasses, and redds are counted. In August-September 1998, at least three complete surveys will be conducted to recover CWTs from 1995 BY adult spring-run salmon carcasses.

A study began in 1995 to monitor downstream migrating juvenile spring-run chinook salmon in Butte Creek. Specifically, critical information obtained includes time of emergence, instream rearing and emigration patterns, size at emigration, duration of emigration, and a measure of relative abundance. The purpose of the study is also to CWT as many spring-run juvenile salmon as possible so that growth and timing can be monitored as the juveniles move downstream. Recovery of tagged fish in the mainstem Sacramento River, Sacramento-San Joaquin Delta, and the SWP and CVP is key to understanding the emigration and rearing patterns of spring-run chinook salmon from Butte Creek.

Ocean Harvest

The Department's Ocean Salmon Project (OSP) is responsible for sampling the recreational and commercial ocean salmon fisheries at all California ports where significant numbers of salmon are landed. The OSP typically samples at least 20% of the landings to ensure that the CWT recovery data from California's ocean fisheries is comparable to the CWT data from other Pacific Coast states and Canada that provide data to the Regional Mark Information System. In 1997, the OSP began collecting fin-clip data in the course of its usual port sampling for eventual DNA microsatellite analysis. Specifically, these data were collected from all CWT fish that were recovered; a significant number of salmon less than 24 inches TL were sampled in the recreational fishery in the Gulf of the Farallones, during July through September 1, where anglers were required to keep the first two salmon caught (except coho) regardless of size; and during the late April commercial fishery south of Lopez Point.

IX. SUGGESTIONS FOR FUTURE MANAGEMENT

Disease

Unimpeded passage for adults at fish ladders (like RBDD) and within stream channels is critical in order to minimize the likelihood of physical injury, stress, and subsequent infection. Ensuring adequate flows for adults and juveniles is necessary to ensure adequate passage, as well as adequate water temperatures in order to minimize stress and disease proliferation during adult migration, adult holding, egg incubation (fungus problems), and juvenile rearing and emigration.

Minimizing handling of adults at weirs and establishing a maximum water temperature criteria, after which handling is prohibited (temperature criteria ≤ 59°F), should also be employed.

For handling of juveniles during monitoring and tagging programs, the following protocols should be employed: (1) use of a buffered anesthetic solution; (2) water-water transfers, since exposure to air induces maximal stress response; (3) use of smooth "soft" surfaces for examining fish; and (4) a maximum holding time of one hour.

Harvest

Inland Sport Fishing Regulations
Sport fishing regulations for spring-run chinook salmon within the Central Valley are summarized in Appendix C. Specific protections for spring-run chinook salmon in Mill, Deer, Big Chico, and Butte creeks were added to the regulations in 1994. In addition, existing regulations and changes which were incorporated for the protection of winter-run chinook salmon provide some level of protection for spring-run chinook salmon. The following additional changes, listed by tributary, should be considered to provide complete coverage within the Central Valley.

General: Currently, for the protection of winter-run chinook salmon, in the reach of the upper Sacramento River from the Deschutes Road Bridge to 650 feet below Keswick Dam, where fishing is otherwise open for other species during a period when winter-run salmon are present, regulations prohibit the removal from the water during the process of release, any salmon caught incidentally. This prohibition should be applied uniformly throughout the existing or potential range of spring-run chinook where existing regulations allow the possibility of incidental catch.

Sacramento River: The Sacramento River is currently open to fishing from August 1 through January 14 in the reach from Deschutes Road Bridge to Bend Bridge, with a daily bag and possession limit of two salmon. Spring-run salmon are present within this reach during the period August 1 to October 15. To eliminate any take of spring run, the regulation would need to be changed to a daily bag and possession limit of zero salmon, during that period. Additionally, the Sacramento River is open to fishing with a daily bag and possession limit of two salmon, in the reach from the Carquinez Bridge upstream to Bend Bridge (approximately five miles upstream of Red Bluff) during the period July 16 through January 14. Spring-run salmon, particularly in the reach from Hamilton City to Bend Bridge, are present during the period July 15 through October 15. To prevent any harvest, the regulation would have to be changed to a daily bag and possession limit of zero salmon in the reach from Hamilton City to Bend Bridge during the period July 16 through October 15.

Feather River: The current regulations on the Feather River provide exposure for the take of Feather River spring-run salmon as follows:

(1) in the reach from Table Mountain Bridge to the Highway 70 Bridge, open from January 1 through August 30, the bag and possession limit is two salmon;

(2) in the reach from the Highway 70 Bridge to a point 100 yards upstream from the Thermalito Afterbay, open from January 1 through September 30, the bag and possession limit is two salmon;

(3) in the reach from a point 100 yards upstream from Thermalito Afterbay outlet to the mouth of Honcut Creek, open from January 1 through October 15, the bag and possession limit is two salmon;

(4) in the reach from Honcut Creek to the mouth of the Feather River at the Sacramento River, open all year, the bag and possession limit is two salmon.

Given the issue of FRH hybridization, the contribution of these fish to the sport fishery has no effect on maintenance of remnant wild spring-run populations. In the event that recommended future management of the Feather River includes re-establishment of true spring run, then regulations should be also by modified to reduce exposure of these fish to legal harvest.

There is a potential for take of Yuba River spring run in the lower Feather River. Upon further examination of creel census information, the following regulation change could be considered:

(1) from the mouth at the Sacramento River to the Highway 20 Bridge between Marysville and Yuba City would be open as currently stated in the regulations with the following exception

(2) from March 1 through July 15, a gear restriction of artificial lures with barbless hooks and a daily bag and possession limit of zero salmon.

Yuba River: The current regulations on the Yuba River provide for the potential take of spring-run salmon as follows:

(1) the reach from the mouth at the Feather River to Daguerre Point Dam is currently open to general fishing all year and closed to salmon fishing from October 16 through December 31. However, from January 1 through October 15, the bag and possession limit is two salmon;

(2) the reach from Daguerre Point Dam to the Highway 20 Bridge, open from January 1 through September 30, the bag and possession limit is two salmon.

To prevent any take of adult spring-run salmon during upstream migration, the regulations would need to be changed as follows:

(1) the Yuba River from the mouth at the Feather River to Daguerre Point Dam should remain open to general fishing all year, including the closure to salmon fishing from October 16 through December 31. However, from March 1 through July 15, a gear restriction of artificial lures with barbless hooks, and a daily bag and possession limit of zero salmon should be imposed;

(2) the Yuba River from Daguerre Point Dam to Englebright Dam should be open to fishing from December 1 through September 1 with a gear restriction of artificial lures with barbless hooks and a daily bag and possession limit of zero salmon.

<u>Ocean Sport Fishing Regulations</u>

Based on the ocean recovery data for FRH spring-run chinook, the current minimum size limit of 24 inches TL can be expected to nearly eliminate the take of age-2 fish, thereby reducing the harvest of spring-run chinook by approximately 26%.

The timing of FRH spring-run chinook CWT recoveries during the ocean recreational season suggests that delaying the opening of the recreational ocean salmon seasons south of Point Arena could reduce the harvest of age-3 and age-4 FRH spring-run chinook by at least 24% and 27%, respectively. In reality, the fishing mortality may only be deferred to later in the season if the fish do not leave the ocean to return to their natal tributaries.

The Winter Chinook Ocean Harvest Model (CDFG 1989) should be reviewed for possible modification by including Cramer and Demko's cohort analysis parameters; it could then be used to evaluate the effects of various ocean fishery management measures such as seasons, size limits, fishing methods, etc. on spring-run chinook spawning escapement.

Sport and commercial ocean salmon fishing regulations for 1996-1998 can be found in Appendix C.

Habitat Restoration

The two most recent restoration plans within the Central Valley, *Restoring Central Valley Streams: A Plan for Action* (Action Plan) (CDFG 1993), and the Revised Draft *Restoration Plan for the Anadromous Fish Restoration Program, A Plan to Increase Natural Production of Anadromous Fish in the Central Valley of California* (AFRP) (USFWS 1997b), contain both general and specific actions to benefit spring-run salmon. Many of the actions listed in both the Action Plan and AFRP have already been completed, and are summarized in this document in Section VIII. The following sections list continuing and yet to be completed actions, as identified in the Action Plan or the AFRP, which will provide benefit to spring-run chinook salmon. For additional details or actions, consult either the Action Plan or AFRP.

<u>Sacramento River</u>

In order to maintain or enhance the potential for a sustaining population of spring run in the mainstem Sacramento River, and to maximize the migratory and juvenile rearing habitat for tributary populations, the following actions should be implemented for the Sacramento River:

(1) Implement a river flow regulation plan.
(2) Implement a schedule for flow changes.
(3) Continue to maintain water temperatures at or below 56°F from Keswick Dam to Bend Bridge to the extent controllable.
(4) Continue to raise the gates at the RBDD from September 15 through at least May 14.
(5) Continue to implement the Anadromous Fish Screen Program.
(6) Implement the current reconstruction of the GCID fish screen and delivery channel.

(7) Continue to develop and implement the Senate Bill 1086 (SB 1086) plan to create a meander belt and protected riparian area from Keswick Dam to the mouth of the Feather River.
(8) Continue with the operational and structural changes at the ACID Dam.
(9) Develop and implement a program to restore and replenish spawning gravel in the Sacramento River.

In addition to the above mentioned action items, the gates-out operation at the RBDD should be extended from the present date of May 14 to June 30, to provide maximum protection for spring-run adults migrating into the upper Sacramento River and tributaries above Red Bluff.

<u>Clear Creek</u>
Current management plans include the establishment of a population of spring-run salmon in Clear Creek which will require implementation of the following actions:

(1) Provide flow releases from Whiskeytown Dam.
(2) Remedy channel degradation from past gravel mining.
(3) Resolve passage at McCormick-Saeltzer Dam.
(4) Develop erosion control/stream corridor protection program.
(5) Replenish spawning gravel.

<u>Cottonwood Creek</u>
To continue to provide access for the few remaining spring run, which intermittently use Cottonwood and Beegum creeks, implement the following action for Cottonwood Creek:

(1) Restore stream channel to prevent the ACID Siphon from becoming a barrier.

<u>Battle Creek</u>
Existing restoration plans recognize the excellent habitat potential for Battle Creek to support a sustaining population of spring-run salmon. Restoration of the full potential of Battle Creek requires the following actions:

(1) Continue to allow adult spring-run chinook passage above Coleman weir.
(2) Acquire water from willing sellers.
(3) Construct fish screens on all PG&E diversions as needed.

In addition to these actions, adult passage at Wildcat, Eagle Canyon, and North Fork Battle Creek Feeder dams on the North Fork of Battle Creek, and Coleman and Inskip dams on the South Fork of Battle Creek need to be restored or improved.

<u>Antelope Creek</u>
To improve Antelope Creek's potential to support spring-run salmon, the following action is needed:

(1) Supplement flows with water acquired from willing sellers.

Fully restored access to Antelope Creek will also require evaluation of a more defined stream channel within the valley reach.

Mill Creek
Mill Creek is recognized as supporting one of the three remaining self-sustaining spring-run salmon populations. The condition of spring-run salmon habitat within Mill Creek is generally high quality. Actions intended to ensure the future sustainability of spring-run in Mill Creek are:

(1) Restore and maintain riparian habitat along lower reaches.
(2) Develop a long-term solution for adult passage at Clough Dam.
(3) Develop adequate instream flows in the valley reach of Mill Creek.

Deer Creek
Deer Creek, as with Mill Creek, is recognized as supporting one of the three remaining self-sustaining spring-run populations. As with Mill Creek, the condition of the spring-run salmon habitat is generally high quality. Actions intended to ensure the future sustainability of spring-run salmon in Deer Creek are:

(1) Acquire water from willing sellers or through negotiated agreements to supplement instream flows.
(2) Restore and preserve riparian habitat along Deer Creek.

Big Chico Creek
Management actions to restore and maintain the potential for Big Chico Creek to maintain a self-sustaining population of spring-run chinook salmon require implementation of the following actions:

(1) Maintain the Iron Canyon fish ladder.
(2) Repair Lindo Channel weir and fishway.
(3) Protect spring-run holding pools through easement or title.
(4) Restore and protect riparian habitats along Big Chico Creek.
(5) Screen a diversion just below Higgins Hole, the prime spring-run holding and spawning area.

Butte Creek
Butte Creek is recognized as supporting one of the three remaining self-sustaining spring-run salmon populations. Habitat conditions within Butte Creek are in relatively poor condition as the result of the numerous power generation and agricultural diversions. Significant restoration efforts, as discussed within this report, have already been implemented. To fully restore and protect the Butte Creek spring-run population the following actions should be implemented:

(1) Maintain a minimum of 40 cfs instream flow below Centerville Diversion Dam.
(2) Purchase existing water rights from willing sellers.
(3) Install screens and a new ladder at Durham Mutual Dam.
(4-5) Remove McPherrin and McGowan dams.
(6) Adjudicate water rights and provide water master service for the entire creek.
(7-9) Install screen and ladder at Adams, Gorrill and White Mallard dams.
(10) Eliminate stranding at White Mallard Duck Club outfall.
(11) Rebuild and maintain culvert and riser at Drumheller Slough.
(12) Install screened portable pumps as an alternative to Little Dry Creek diversion.
(13) Restore and maintain riparian buffer zone along creek.

(14-16) Establish operational criteria for Sanborn Slough Bifurcation, East and West channels of Sutter Bypass and Nelson Slough.
(17) Evaluate operational criteria and potential modification to Butte Slough Outfall.
(18) Evaluate alternatives or install a fish ladder at East-West Diversion Weir.
(19-21) Evaluate alternatives and operational criteria at Sutter Bypass weirs # 1, #2, and #5.
(22) Evaluate passage alternatives, including a fish screen, at Sanborn Slough Bifurcation structure.
(23) Evaluate fish passage, including fish screens, within the Sutter Bypass.
(24-27) Evaluate alternatives, including more efficient fish ladders, at Sutter Bypass weirs #1, #2, #3, and #5.

Feather River

There are two basic management needs which should be addressed. The first and most immediate need is to minimize and ultimately eliminate any negative effects of FRH spring run on natural populations within the Central Valley. The planting protocol for FRH produced salmon should be structured to minimize straying and introgression with salmon in other waters. There is also a need to assess the potential for re-establishment of a discrete population of spring-run salmon in the Feather River. The practical constraints of this action require that efforts be directed at the FRH population since it is not possible to separate the races in the river. Efforts at the FRH to manage and select fish exhibiting spring run characteristics should be implemented. Preliminary management tools should be based on segregation of early arriving fish. Only those fish with early egg maturity should then be spawned. Evaluation of techniques and management options to segregate the fall- and spring-run salmon and to best select for a spring-run phenotype should be initiated immediately, with implementation as soon as possible.

Yuba River

Protection of the existing remnant numbers of spring-run and development of the full potential of existing habitat in the Yuba River can be enhanced by implementing the following actions:

(1) Supplement flows with water acquired from willing sellers.
(2) Reduce flow fluctuations.
(3) Maintain adequate instream flows for temperature control.
(4) Screen all diversions to meet current Department and NMFS criteria.
(5) Improve fish bypasses at water diversions.
(6) Improve adult and juvenile passage at Daguerre Point Dam.
(7) Maintain and improve riparian habitat.
(8) Operate reservoirs to provide adequate water temperatures.
(9) The feasibility of removal of Englebright Dam to re-introduce spring run to their historic range should be evaluated.

Miscellaneous Tributaries to the Sacramento River

The miscellaneous small tributaries to the Sacramento River, as listed and discussed elsewhere in this report, may be providing significant habitat for rearing juvenile spring-run salmon. Until the value of these nonnatal rearing areas is specifically defined, all efforts should be made to eliminate any degradation of the existing habitat. In those instances where existing restoration actions have been identified, such as the Action Plan or AFRP, such actions should be implemented. One such action is replacement of the barrier at GCID's main canal crossing on Stony Creek with a permanent siphon. GCID has been selected to supply water to the Sacramento and Delevan National Wildlife Refuges and construction of a permanent siphon at GCID's main canal crossing on Stony Creek is a project feature. Eliminating the GCID barrier on Stony Creek would allow the nonnatal juvenile salmonids (including spring run) to return to the Sacramento River as the flows in the creek gradually subside and temperatures rise.

Bay-Delta Estuary

Improvements to aquatic habitat in the Delta are essential to restore the natural production of anadromous fish in the Central Valley because habitat in the Delta is highly degraded (USFWS 1997b). The following are suggestions for future management actions in the Delta for protecting spring-run chinook salmon:

(1) Increase delta inflows and outflows to improve in-Delta habitat quality and provide transport flows for rearing and migrating juvenile salmon.
(2) Modify CVP and SWP diversions to reduce the zone of influence of the pumping and to lessen the effects of entrainment.
(3) Establish and enforce water quality and flow standards to protect native fish. reconsider the utility of the QWEST criteria (calculated net flow for the lower San Joaquin) for managing flow-related habitat conditions in the Delta for salmon.
(4) Take actions at CVP, SWP, and other public and private diversion facilities to reduce salmon entrainment losses.
(5) Develop additional habitat and vegetation zones within the Delta.
(6-8) Close the DCC gates when juvenile salmon are present.
(7) Increase the total allowable days that the DCC can be closed during fall/winter months beyond 45 days.
(8) Allow closures to begin as early as October, if necessary, to protect spring run.
(9) Reduce fish movement into Georgiana Slough.
(10) Reduce the effects of dredging.
(11) Reduce the effects of contaminants by reducing input from agricultural, urban, and industrial point and non-point sources.
(12) Delta salmon survival experiments should be further evaluated and new information developed in collaboration with the USFWS to assess juvenile salmon mortality levels associated with reverse flows and "indirect losses" in the central and southern Delta.

Implementation of the 1995 Bay/Delta Water Quality Control Plan: The SWRCB Environmental Report - Appendix 1 (ER) to the 1995 Bay-Delta Plan (SWRCB 1995) did not analyze potential impacts on juvenile spring-run chinook salmon of implementation of the water quality standards during the fall/winter period. However, the ER identified closure of the DCC gates for up to 45 days in November-January to protect spring- and possibly winter-run chinook salmon from being diverted off of the Sacramento River.

The SWRCB Draft Environmental Impact Report (DEIR) for Implementation of the 1995 Bay/Delta Water Quality Control Plan (SWRCB 1997a) does not discuss or analyze potential effects to spring-run salmon. The SWRCB did analyze the potential impacts to spring run of seven alternatives for approving the SWP and CVP petition for Joint Point of Diversion (SWRCB

1997b). The SWRCB acknowledges this will result in increased exports and increased reverse flows from July-January and indicates increased fall and winter pumping may negatively affect spring-run salmon because it coincides with smolt migration (Figures 56 and 57, Appendix E-6 through E-8 and E-16 through E-18).

The SWRCB has requested the Department's written finding regarding the effects on listed species of the SWRCB's proposed action for implementing the 1995 Bay-Delta Plan and approving the Joint Point of Diversion petition, and the Department will include spring-run salmon in this finding. The Department will provide comments to the SWRCB on its 1997 DEIR, will testify at water right hearings the SWRCB holds on the subject, and will provide a CESA biological opinion to the SWRCB.

Implementation of the CVPIA - Water Management and Delta Actions: The Central Valley Project Improvement Act Section 3406(b)(2) dedicated 800,000 acre-feet of CVP yield for use at the discretion of the USFWS, in cooperation with the Department, for fish and wildlife purposes. After five years of deliberation and extensive public input, the USDOI issued a Final CVPIA Administrative Proposal for Management of Section 3406(b)(2) Water (800,000 acre-feet) (USDOI 1997) detailing the USDOI approach to implementing this section of the Federal law for the next five years. It clarifies USDOI's intent to use all available tools to minimize the impact of implementing the AFRP, including eight Delta Actions, to CVP water users. All but one of these actions are aimed at improving Delta conditions for fish in the spring and summer.

Seven AFRP Delta Actions targeted for March-July will, in many years, result in reductions in CVP deliveries. The USBR will seek to offset water supply impacts by various means, most involving increasing exports at other times through use of the SWP pumping capacity. The yearling spring-run migrants will likely be adversely affected by some of these make-up operations. The priorities and benefits of these actions should be evaluated in relation to the likely adverse effects of water supply recovery actions on spring-run chinook salmon.

CALFED Bay-Delta Program: CALFED recently released a draft EIR/EIS for a Bay/Delta program to restore the ecological health and improve water management for beneficial uses of the Bay-Delta system. The Bay-Delta Program will address problems in four critical resource categories: ecosystem quality, water quality, water supply reliability, and system integrity. As structured, the Bay-Delta Program consists of common programs for ecosystem restoration, water quality, water use efficiency, and levee system integrity which would be implemented in conjunction with one of several alternative water conveyance and storage packages. One element of the overall Bay-Delta Program is the Ecosystem Restoration Program (ERP). It is a comprehensive effort to 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. The ERP's approach is founded on the restoration of ecological processes associated with streamflow, stream channels, watersheds, and flood plains that create and maintain habitats essential to species dependent on the Delta. Additionally, the ERP aims to reduce the effects of stressors that inhibit ecological processes, habitats, and species.

To date, the Bay-Delta Program has identified a technically superior alternative but has not identified a preferred alternative. Thus, the effect of the Bay-Delta Program on spring-run salmon can't be assessed at this time. The ERP contains actions that would be generally beneficial for salmon, including spring-run. The extent to which adverse Delta hydrodynamic

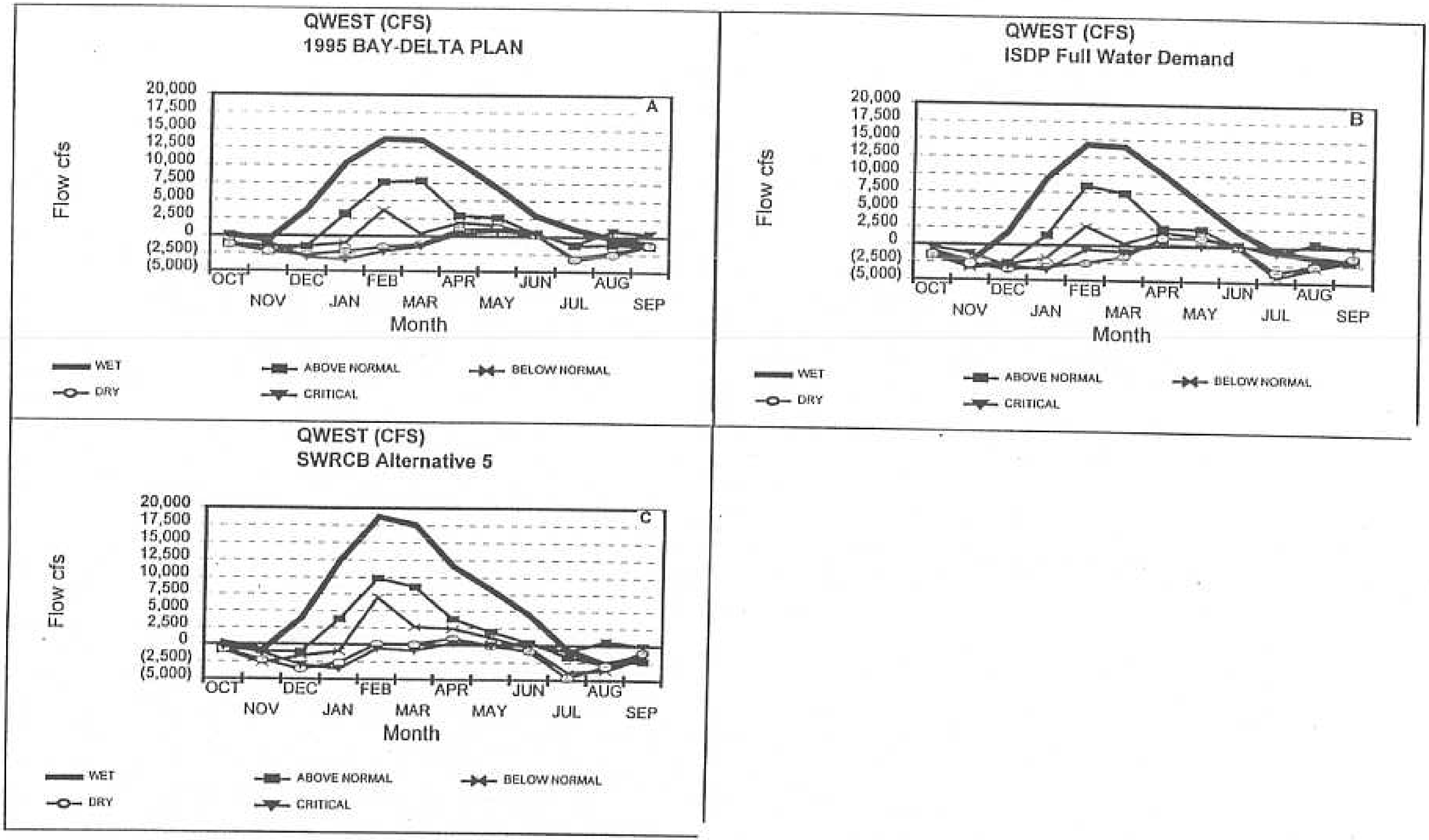


Figure 56. Average monthly QWEST flows (cfs) with (A) simulated operations to SWRCB 1995 Bay-Delta Plan water quality criteria with interim water rights agreement; (B) simulated operations to Interim South Delta Program facilities at future water demand level, and; (C) simulated operations to SWRCB 1995 Bay-Delta Plan and SWRCB Water Rights Alternative 5.

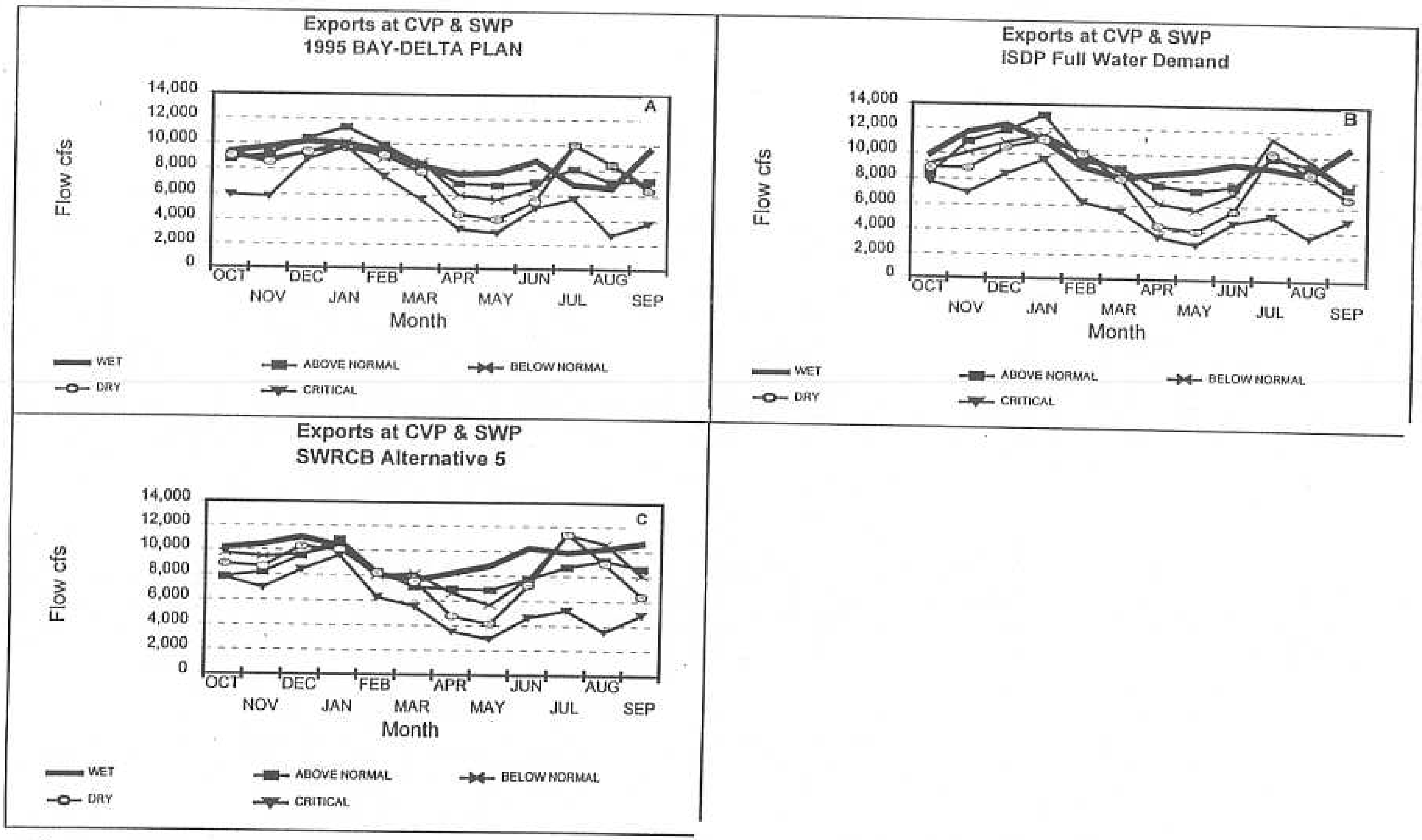


Figure 57. Average monthly exports (cfs) at CVP and SWP under (A) simulated operations to SWRCB 1995 Bay-Delta Plan water quality criteria with interim water rights agreement; (B) simulated operations to Interim South Delta Program facilities at future water demand level , and; (C) simulated operations to SWRCB 1995 Bay-Delta Plan and SWRCB Rights Alternative 5.

conditions and other deleterious factors in the Delta would be alleviated by the Bay-Delta Program depends on which alternative is selected and implemented.

CALFED Operations Group - "Operations Flexibility": The CALFED Operations Group developed and implemented a "monitor-and-response-approach" for minimizing impacts to juvenile spring-run in the Delta during the 1996-97 and 1997-98 outmigration seasons. The Department believes there are improvements needed to this type of approach.

The level of impact to spring-run salmon that would initiate an operational response needs to be fully defined. The only clearly defined indicator of the need for a response is the loss of more than 1% of any group of marked hatchery-reared late-fall run salmon at the SWP and CVP. Other general indicators rely on positive identification of juvenile salmon as spring run at the SWP and CVP. As described earlier, the existing method for run identification of juveniles using size criteria has limitations when applied to spring run. When faced with the question about whether a fish being lost at the SWP and CVP is a spring-run salmon, the Department believes the decision should be an inclusive one, rather than an exclusive one, in order to provide a conservative estimate of the impact and the maximum protection achievable.

The nature of the operational response that would be recommended to reduce observed spring-run impacts at the SWP and CVP in the fall or winter needs to be examined. The operations response has only been generally defined as a change in Delta flows, DCC operations, or SWP and CVP exports. When it is dry and the SWP and CVP are short on water stored south of the Delta, the option of export reductions in the fall or winter to reduce spring-run salmon losses will be controversial, since there will be no certainty that water conditions will improve later. In four years, the projects have taken on some water supply risks to achieve desirable fishery outcomes. However, the dry year circumstance has not yet arisen, but it will and eventually it will happen in a series of consecutive years.

Monitoring Programs and Studies

Ocean Harvest

It appears that some means of genetic stock identification (GSI) is necessary to accurately evaluate the ocean fisheries' impacts on Sacramento River spring-run chinook salmon. The cost and logistics of tagging a sufficient number of wild fish, not to mention the sampling level required to produce reasonably precise estimates of the ocean harvest impacts on this run, make such a program questionable. Although, as discussed elsewhere in this report, even limited returns from either inland sampling or ocean harvest will provide valuable information relative to distribution and migration timing. The Department's OSP is responsible for sampling the recreational and commercial ocean salmon fisheries at all California ports where significant numbers of salmon are landed. The OSP typically samples at least 20% of the landings to ensure that the CWT recovery data from California's ocean fisheries is comparable to the CWT data from other Pacific Coast states and Canada that provide data to the Regional Mark Information System. In 1997, the OSP began collecting fin-clip data in the course of its usual port sampling for eventual DNA microsatellite analysis. Specifically, these data were collected from all CWT fish that were recovered; a significant number of salmon less than 24 inches TL, sampled in the recreational fishery in the Gulf of the Farallones, during July - September 1, where anglers were required to keep the first two salmon caught (except coho) regardless of size; and during the late April commercial fishery south of Lopez Point.

Fresh Water Life History

There are various investigations involving spring-run salmon life-history in Central Valley streams which should be continued, coordinated, or begun.

Adult: Existing adult population evaluations should continue and be standardized where possible. In addition to the more intensive efforts on Mill, Deer, and Butte creeks, standardized efforts and methodologies should be developed for the Yuba River, Battle, Antelope, and Big Chico creeks. The potential for tagging adults identified as spring run ascending the fish ladder at the RBDD should be evaluated, and the benefit of this information weighed against the risk of increasing adult mortality. This information could be incorporated with spring-run spawning surveys in the upper Sacramento River and Battle Creek. Similarly, tagging adults passing through barriers within the Sutter Bypass, could provide valuable information relative to migration routes, migration timing, and straying, if it were determined that the risk to the population from tagging was sufficiently low. Limited carcass surveys should be instituted within each of the spawning tributaries to identify presence of marked fish.

Juvenile: Investigations of emigration path and timing for juvenile spring-run chinook from Mill, Deer, and Butte creeks should continue and be expanded where necessary. Where sufficient numbers of juveniles are available, generally in Butte Creek, tagging and downstream monitoring should also continue. CWT fish from each stream of origin may be recovered at various sampling locations in the Sacramento River, Delta, and potentially in both the ocean and inland adult harvest sampling. Lengths of spring-run fish trapped in Mill, Deer, and Butte creeks at various time intervals should be used to describe a frequency distribution for spring-run salmon. Such an analysis would serve to identify the distribution of lengths from the known tributary spring-run salmon in the overall distribution of lengths from the various sampling stations outside the tributary streams. Sampling outside of the primary tributaries should continue to provide baseline comparative length frequency distribution information. Suggested sites involve the ongoing programs at Red Bluff, GCID Fish Screen, Knights Landing, Sutter Bypass, Sacramento River, and Chipps Island.

Additionally, juvenile emigration sampling should either be continued or initiated on Battle Creek, Big Chico Creek, and the Yuba River. While the intensity of effort might be at a lesser level than the three primary tributaries, the investigations should be similar in scope. Long-term funding should be secured.

Run Discrimination: For Central Valley chinook salmon, the ability to detect, measure, and manage impacts is confounded by the difficulty in distinguishing the runs from one another. The primary method of assigning a juvenile salmon to a particular run is based on a fish's size on a given day of the year. Substantial deliberation about run classification of juvenile salmon salvaged by the CVP and SWP has occurred each year. Size criteria are of limited use in identifying spring-run chinook salmon because they spawn, incubate, and rear under the broadest range of environmental conditions of all of the Central Valley runs (very cold water streams at 5000+ feet elevation to lower elevation foothill streams typically with warmer water temperatures, as described in this report's section on habitat conditions in each spring-run tributary). Furthermore, the size criteria also do not address the spring-run salmon with the yearling outmigration strategy. In the fall, these fish may be incorrectly identified as either winter run or late-fall run based solely on the size criteria.

Substantial effort has been undertaken to develop a genetics-based method for the identification of winter-run salmon. The research has found that some proportion of winter run have genetic markers that are either absent or very uncommon in the other runs. This may one day enable probability-based estimates of the fraction of salmon in a sample that are winter-run salmon or, if unique markers are found, a determination that an individual fish is a winter run. Salmon genetics research is continuing and has been expanded to include spring-run salmon. To date, existing research suggests that spring-run salmon appear to exhibit fewer distinguishing genetic characteristics than in winter run. The work is still in the early stages and its potential to provide a practical, affordable, and reliable method of run classification for Central Valley chinook salmon is still undetermined.

Other research techniques which have the capability for discriminating between Central Valley chinook salmon runs, such as otoliths, should also be conducted. Such information is necessary to improve the Department's ability to manage harvest, develop run-specific escapement estimates, manage habitat, and regulate other factors that may be barriers to the management and restoration of each Central Valley salmon run. The Department is presently conducting a pilot study of Central Valley chinook salmon runs using otoliths for identifying populations and tracking their survival based on known flow and temperature histories through the Delta and ocean fisheries through adult escapement. This study should be continued on a full-scale basis and should include all Central Valley spring-run chinook salmon populations.

Age Composition for Cohort Reconstruction: The determination of the age composition for selected populations of spring-run chinook should be initiated in 1998.

Importance of Delta habitat for salmon: Decisions on water management and habitat restoration in the Delta need to be based on a clear, well-documented understanding of how salmon use the Delta. The Delta has been described by some as only a migration corridor for salmon, connecting riverine spawning habitat to the ocean environment (Arthur et. al. 1996). Based on sampling just upstream from and in the Delta, it has been well documented that juvenile salmon often enter the Delta before they are physiologically able to enter salt water, hence they must spend time, up to several months, in the Delta before migrating to the ocean (Snider and Titus 1996).

The relative importance of the Delta in providing essential rearing habitat for juvenile salmon needs to be better defined, including the extent to which these fish contribute to adult salmon populations. Category III funding has been allocated to the University of Washington, Seattle, and DWR for evaluations of newly created or restored shallow water habitat in the Delta which may yield some information on salmon use of the restored habitat. However, that research is not designed to address the population level consequences of Delta rearing by salmon using existing or restored habitat. IEP has funded the Department to begin a study of salmon growth and survival by examining otoliths. This work needs to be expanded to fully examine habitat availability and use to help determine the relative contribution of fish exhibiting different juvenile life-history patterns to subsequent adult salmon populations and the variation in their habitat use of the Delta. This would facilitate managing the Delta to accommodate the varied life-history strategies of juvenile Central Valley chinook salmon, including spring run.

Range Expansion / Population Re-introductions

There is a need to develop a policy relative to the issue of range expansion and population introductions for Central Valley salmon, particularly populations that are presently listed or proposed for listing under CESA or ESA. Within the existing or proposed spring-run management areas there are several issues to be addressed. Two recent evaluations have identified suitable habitat for spring-run salmon in upper Butte Creek in a reach above the apparent historic limit of travel (Holtgrieve and Holtgrieve 1995, Johnson and Kier 1998). Given the significant reduction of available spring-run habitat as mentioned throughout this document, there is value in developing additional habitat.

In those watersheds which may have historically contained a population which has been extirpated, but which currently possess potential suitable habitat characteristics (such as Clear Creek) there is a need for a policy regarding a donor population source. Presently, management guidance is given under the Salmon and Steelhead Stock Management Policy as presented in the section of this report *Influence of Existing Management Efforts*. While the Stock Management Policy provides general guidance, impacts to a potential donor source and issues of genetic integrity need to be more clearly defined and uniformly applied.

Finally, the issue of physical separation of the various races is relevant to spring-run salmon, particularly in those areas which consistently overlap with fall run. Each of the existing, and proposed spring-run populations has a possible overlap with early spawning fall-run salmon. The magnitude of returning hatchery produced fall run (particularly CNFH and FRH) in relation to the very small numbers of existing spring run, makes any hybridization from even minimal numbers of straying fall run a concern. In the three remaining sustaining spring-run populations in Mill, Deer, and Butte creeks, physical separation of the two races is generally accomplished, as was the case historically, due to low flows and high water temperatures in the valley reach of each of the creeks. There are, however, in some years as was seen in Butte Creek in 1997, large numbers of early arriving fall-run salmon overlapping the spring-run spawning area, both in time and space. Currently, various barriers are either intentionally or coincidentally separating spring run and fall run. In the case of the CNFH Barrier for instance, the ladder over the barrier is intentionally regulated to limit large numbers of fall run from ascending into spring-run habitat. In various other tributaries, including Butte Creek, in most years barriers and flow diversions for agricultural purposes limit fall-run overlap with spring run. There are instances where intentional blockage of spring run and fall run might be considered as a long-term management action, either to protect an existing population, or to re-establish or introduce a new population.

X. RECOVERY CONSIDERATIONS

The Department's recovery objectives for Sacramento River spring-run chinook salmon are:

(1) the protection and enhancement of the existing natural populations;
(2) the re-establishment of additional, viable native populations; and
(3) the restoration and protection of natal, rearing, and migratory streams within the Sacramento River basin.

Natural populations and their essential habitat must be sufficiently abundant to ensure Sacramento River spring-run chinook salmon's long-term survival. In order to achieve recovery, the remaining natural, non-introgressed populations of spring run and any re-established natural populations must be protected, monitored, and proven to be self-sustaining to the satisfaction of the Department and the Commission. Recovery goals must ensure that the individual populations, as well as the collective metapopulation, are sufficiently abundant to avoid genetic risks of small population size. Thus, recovery goals need to address abundance levels (adult spawning escapements), population stability criteria, population distribution, and length of time for determining sustainability.

The petition specifically recommended population recovery objectives within each tributary. The petition's recommendations appear to have been based on population restoration goals contained in the Department's 1993 report titled *Restoring Central Valley Streams: A Plan for Action*. Those restoration goals were established to satisfy the CVPIA anadromous fish doubling goal. They were not developed as, and should not be equated to, recovery goals.

The USFWS *Recovery Plan for the Sacramento-San Joaquin Delta Native Fishes* (1995a) has recommended restoration objectives and criteria for Sacramento River spring-run chinook salmon based on the objective of establishing self-sustaining populations which will persist indefinitely for each species addressed. Additionally, the plan's population goals for chinook salmon runs include extra adult production for allowing sustained limited harvests of each run. The plan states that restoration will be measured by three interacting criteria:

(1) presence of self-sustaining spawning populations in Deer and Mill creeks;
(2) total number of spawners in Deer, Mill, Antelope, Butte, Big Chico, Beegum, South Fork Cottonwood, and Clear creeks (if the Yuba River proves to still have a natural run of spring-run chinook, the population goal should be raised by whatever number of spawners the stream can support); and
(3) smolt survival rates through the Delta.

In conclusion, the plan states that "restoration goals can be achieved only if there is simultaneous improvement of conditions in spawning and rearing streams, in the Delta for passage of juveniles and adults, and improved management of the fishery to allow for increased survivorship of adults during periods of low population size..."

The Department will develop recovery goals and delisting criteria based on the best scientific information available, including consideration of the information provided in the USFWS (1995a) *Recovery Plan for the Sacramento-San Joaquin Delta Native Fishes*. The Department will also annually re-examine the status of Sacramento River spring-run chinook. When, in the Department's judgement, recovery goals and delisting criteria have been met, it will make recommendations to the Commission regarding changing its legally designated status under CESA.

XI. ALTERNATIVES TO THE PETITIONED ACTION

In the absence of listing, the Department would continue to monitor the species' status and oversee implementation of habitat restoration actions where possible. Sacramento River spring-run chinook salmon would receive an additional level of recognition compared to an unlisted species, since it has been designated a "Monitored Species" (CCR Title 14, Section 670.6) by the Commission. However, it is unlikely that protection for spring-run would receive the same level of priority if it was not listed. Without the benefits of listing, Sacramento River spring-run populations could decline further, until their population is no longer viable. Regardless of listing status, without the full cooperation of other agencies and the public in preservation, restoration, and recovery actions, spring run could still continue to decline. Eventually, extinction could occur.

If the Commission finds that listing the Sacramento River spring-run chinook salmon is not warranted, this fish would be deprived of protection provided through recognition and formal consultation available to a listed species. When a species is listed as Threatened or Endangered, a higher degree of urgency is mandated, and its protection and recovery receives more attention from the Department, other agencies, and the public than non-listed species. The species would also receive protection from unauthorized take pursuant to CESA.

In contrast to many other listed species, funding for restoration actions in the upper Sacramento River and tributaries has been forthcoming recently, as a result of State and Federal legislation aimed at habitat and fisheries restoration. It is unlikely, however, that listing would increase restoration funding specifically targeted at Sacramento River spring-run chinook salmon.

XII. PROTECTIONS RESULTING FROM LISTING

If listed as Threatened, the Sacramento River spring-run chinook salmon would receive special considerations and protection under CESA and CEQA that are not generally afforded unlisted species. If listed, spring run will be eligible for the allocation of resources by government agencies to provide protection and recovery.

If listed, spring run will also receive protection from taking as provided for in CEQA and CESA. The status of listing provides a species with recognition by lead agencies and the public, and significantly greater consideration is given to the Department's recommendations resulting from project environmental review. The CEQA review process is designed to provide for full disclosure of potential impacts resulting from proposed development projects. When it is found that a proposed project may result in the loss of individuals or habitat for State-listed species, CEQA requires a mandatory finding of significance and preparation of an EIR. For projects with a State lead agency, the lead agency is required to formally consult with the Department to determine the nature of impacts to the State-listed species and develop mitigation measures to reduce or eliminate such impacts.

LITERATURE CITED

Alley, D.W., R.C. Chapman, S. Meyer, and Y. Sherman. 1996. IFIM Modeling of Critical Passage Riffles, with Recommended Passage Flows for Chinook Salmon in Lower Mill Creek, Tehama County, California, 1995. June 1996. 62 pp. with appendices.

Armor, C. 1991. Guidance for evaluating and recommending temperature regimes to protect fish. U.S. Fish Wildl. Serv. Biol. Rept. 90(22). 13 pp.

Arnold, E. 1966. Salmon Spawning Stock Survey Data Sheets. Calif. Dept. Fish and Game, Mar. Res. Br. in Inld. Fish. Div. files, Red Bluff, CA.

Arthur, J.F., M.D. Ball, and S.Y. Baughman. 1996. Summary of Federal and State water project environmental impacts in the San Francisco Bay-Delta Estuary, California. Pages 445-496 In: James T. Hollibaugh, ed., San Francisco Bay the ecosystem: Further investigation into the natural history of San Francisco Bay and Delta with reference to the influence of man. Calif. Academy of Sci., San Francisco.

Association of Bay Area Governments (ABAG). 1992. San Francisco Estuary Project: State of the Estuary: A report on the conditions and problems in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. Prepared under Coop. Agreement #CE-009486-02 with the USEPA 270 pp. + maps.

Avers, C.J. 1989. Process and Pattern in Evolution. Oxford University Press.

Azevedo, R.L., and Z.E. Parkhurst. 1958. The Upper Sacramento River salmon and steelhead maintenance program, 1949-1956. U.S. Fish Wildl. Serv., Office Rept. 96 pp.

Baracco, A.W. 1996. The Status of the Sacramento River Spring-run Chinook Salmon. A Special Report to the Fish and Game Commission Pursuant to Section 670.6 of Title 14, CCR. Calif. Dept. Fish and Game, Inld. Fish. Div. 28 pp.

Baracco, A.W. 1997. The Status of the Sacramento River Spring-run Chinook Salmon. A Special Report to the Fish and Game Commission Pursuant to Section 670.6 of Title 14, CCR. Calif. Dept. Fish and Game, Inld. Fish. Div. 19 pp.

Bartley, D., B. Bentley, J. Brodziak, R. Gomulkiewicz, M. Mangel, and G.A.E. Gall. 1992. Geographic variation in population genetic structure of chinook salmon from California and Oregon. Fish. Bull., U.S. 90:77-100.

Becker, C.D., and M.P. Fujihara. 1978. The bacterial pathogen *Flexibacter columnaris* and its epizootiology among Columbia River fish: A review and synthesis. American Fisheries Society Monograph No. 2. American Fisheries Society, Washington D.C. 92 pp.

LITERATURE CITED (CONTINUED)

Beecham, T.D., and C.B. Murray. 1990. Temperature, egg size, and development of embryos and alevins of one species of Pacific salmon: a comparative analysis. Trans. Am. Fish. Soc. 119:927-945.

Behnke, R.J. 1993. Status of biodiversity of taxa and nontaxa of salmonid fishes: Contemporary problems of classification and conservation In: J.G. Cloud and G.H. Thorgaard, eds., Genetic Conservation of Salmonid Fishes. Plenum Press, New York.

Bell, M.C. 1991. Fisheries handbook of engineering requirements and biological criteria. Fish Passage Development and Evaluation Program, U.S. Army Corps of Engineers, Sacramento District. 257 pp. + appendices.

Boles, G.L., S.M. Turek, C.C. Maxwell, and D.M. McGill. 1988. Water temperature effects on chinook salmon (*Oncorhynchus tshawytscha*) with emphasis on the Sacramento River: a literature review. Calif. Dept. Water Res. 44 pp.

Bovee, K. 1978. Probability-of-use criteria for the family Salmonidae. Instream Flow Information Paper No. 4. U.S. Fish Wildl. Serv., FWS/OBS-78/07.

Brown, C.J. 1995. The emigration of juvenile spring-run chinook salmon from Big Chico creek in 1993-1994. Calif. Dept. Fish and Game. Bay-Delta Spec. Wat. Proj. Div.

Brown, C.J. 1997. Observations of downstream migration of spring-run chinook salmon in Big Chico Creek in 1994-1995. Calif. Dept. Fish and Game. Bay-Delta Spec. Wat. Proj. Div.

Brown, Julie. 1993. Memo to Files, Butte Creek Spring-run Chinook Salmon Spawning Survey, November 2, 1993. Calif. Dept. of Fish and Game, Rancho Cordova. 2pp.

Brown, R. 1996. Comments on the October 16, 1995 petition to list the spring-run chinook salmon and on a CDFG January 16, 1996 letter to the Fish and Game Commission recommending candidacy. Letter from the California Department of Water Resources to the California Fish and Game Commission.

Brown, R.L., and S. Greene. 1993. An Evaluation of the Feather River Hatchery as Mitigation for Construction of the California State Water Project's Oroville Dam. In: Environmental Enhancement of Water Projects. Proceedings from the 1993 Seminar Sponsored by U.S. Committee on Irrigation and Drainage. Sacramento, CA.

Butte County. 1942. Judgement and Decree. No. 18917. In the matter of the determination of the rights of the various claimants to the waters of that portion of Butte Creek and its tributaries situate above the Western Dam near Nelson, in Butte County, CA. November 6, 1942.

LITERATURE CITED (CONTINUED)

Butte Creek Watershed Conservancy. 1996. Memorandum of Understanding regarding the development of the Butte Creek Watershed Management Strategy. 5 pp.

California Department of Fish and Game (CDFG). 1958. Salmon Get a Freeway up Rugged Canyon. Outdoor California 19(8):4-5.

California Department of Fish and Game (CDFG). 1959. The 1958 King Salmon Spawning Population Estimates for the Sacramento - San Joaquin River Systems. Mar. Res. Br. Dingell-Johnson Project, California F7R. 16 pp.

California Department of Fish and Game (CDFG). 1964. Salmon Inventory Report for Butte Creek. Inld. Fish. Div. files. Red Bluff, CA.

California Department of Fish and Game (CDFG). 1967. Pages 22-30 In: Fish and Wildl., Appendix C to Calif. Dept. Wat. Res. Bull. No. 137, Sacramento Valley east side investigation.

California Department of Fish and Game (CDFG). 1989. Description of Winter Chinook Ocean Harvest Model. Calif. Dept. Fish and Game, Ocean Salmon Project. Sacramento, CA. 28 pp.

California Department of Fish and Game (CDFG). 1990. Status and management of spring run. Inld. Fish. Div. 33 pp.

California Department of Fish and Game (CDFG). 1991. Lower Yuba River Fisheries Management Plan. Stream Evaluation Report No. 01-1.

California Department of Fish and Game (CDFG). 1993. Restoring Central Valley streams: A plan for action. Inld. Fish. Div.

California Department of Fish and Game (CDFG). 1995. Biological Assessment for the California Department of Fish and Game Striped Bass Management Program, June 1995-June 1996. Submitted to the U. S. Bureau of Reclamation. March 1995.

California Department of Fish and Game (CDFG). 1996. Adult spring-run chinook salmon monitoring in Deer Creek 1986 through 1996. Inld Fish. Div. Unpublished Rpt. 13 pp.

California Department of Fish and Game (CDFG). 1997. Environmental Assessment for the issuance of a permit to allow incidental take of the Winter-run Chinook Salmon (*Oncorhynchus tshawytscha*), the Delta Smelt (*Hypomesus transpacificus*), and the Sacramento Splittail (*Pogonichthys macrolepidotus*) under Section 10(a)(1)(B) of the Endangered Species Act to the California Department of Fish and Game for the Striped Bass (*Morone saxitilis*) Management Program. Prepared by Calif. Dept. Fish and Game Bay-Delta Spec.l Wat. Proj. Div. Draft Copy November 13, 1997.

LITERATURE CITED (CONTINUED)

California Department of Water Resources (DWR). 1976. Sutter Bypass Study. State of California, The Resources Agency, Depart. Water Res., Northern District, May 1976. 143 pp.

California Department of Water Resources (DWR). 1997. Suisun Marsh Salinity Control Gates fisheries monitoring. 1995 Annual Report. 59 pp.

California Fish Commission (CFC). 1882. Report of the commissioners of fisheries of the State of California for the years of 1881-1882. Sacramento, CA.

California Fish Commission (CFC). 1900. Fifteenth biennial report of the State Board of Fish Commission of the State of California for the years of 1897-1898.

California Resources Agency. 1989. Upper Sacramento River Fisheries and Riparian Habitat Management Plan. January 1989. 157 pp.

Campbell, E.A., and P.B. Moyle. 1990. Historical and Recent Population Sizes of Spring-run Chinook Salmon in California. Pages 155-216 In: Proceedings, 1990 Northeast Pacific Chinook and Coho Salmon Workshop.

CH2M Hill. 1993. Assessment of Big Chico Creek salmon and steelhead production. April 1993.

Chambers, J. 1956. Fish passage development and evaluation program. Progress Rept. No. 5. U.S. Army Corps of Engineers, North Pacific Division, Portland, OR.

Clark, G.H. 1929. Sacramento-San Joaquin salmon, *Oncorhynchus tshawytscha*, fishery of California. Calif. Dept. Fish and Game. Bull. 17. 73 pp.

Clark, G.H. 1940. California salmon catch records. Calif. Dept. Fish and Game Bull. 26(1): 49-66.

Cope, O.B., and D. W. Slater. 1957. Role of Coleman Hatchery in maintaining a king salmon run. U.S. Fish Wildl. Serv., Res. Rept. 47.

Cox, W.T. 1993. Central Valley chinook hatcheries and their disease concerns. Presentation to workshop on Central Valley chinook salmon. University of California, Davis; January 4 and 5, 1993. Notes available from Dr. J. Cech, Dept. of Wildlife and Fisheries Biology, University of California, Davis, CA 95616 or from William T. Cox, Calif. Dept. of Fish and Game, Inld. Fish. Div., Sacramento, CA 95814.

Cramer, F.K., and D.F. Hammack. 1952. Salmon research at Deer Creek, California. U.S. Fish Wildl. Serv., Spec. Sci. Rept. 67. 16 pp.

LITERATURE CITED (CONTINUED)

Cramer, S.P., and Demko, D.B. 1997. The status of late-fall and spring chinook salmon in the Sacramento River Basin regarding the Endangered Species Act. Submitted to the National Marine Fisheries Service on behalf of the Association of California Water Agencies and California Urban Water Agencies. 111 pp.

Croci, S. 1996. 1996 Battle Creek Stream Surveys. Office Memo, September 18, 1996. U.S. Fish Wildl. Serv., Northern Central Valley Office. 2 pp.

Curtis, Banky. 1996. Letter to Dr. Marty Kjelson, Summary of Butte Creek Spring-run Chinook Salmon Juvenile Life History and Emigration Study. August 6, 1996. 7 pp.

Deer Creek Watershed Conservancy. 1995. Memorandum of Understanding regarding development of the Deer Creek Watershed Management Strategy. 5 pp.

Decoto, R. J. 1978. 1974 Evaluation of the Glenn-Colusa Irrigation District Fish Screen. Calif. Dept. Fish and Game, Anad. Fish. Br. Admin. Rept. No. 78-20.

Ecological Society of America - Ad hoc Committee on Endangered Species. 1996. Strengthening the use of science in achieving the goals of the Endangered Species Act. An assessment by the ecological society. Ecological Applications 6(1):1-11.

Ekman, E.G. 1987. Adult Spring-run Salmon Surveys, 1986 and 1987. Office Memo, November 17, 1987. Lassen National Forest.

Elliott, D.G., and R.J. Pascho. 1992. Juvenile fish transportation: Impact of bacterial kidney disease on survival of spring/summer chinook salmon stocks. Annual Report, 1990, prepared by the U.S. Fish & Wildl. Serv., Seattle, WA for the U.S. Army Corps of Engineers, Walla Walla, WA.

Elwell, R.F., et al. 1961. Spawning Stock Data Sheets. Calif. Dept. Fish and Game, Mar. Res. Br.

Elwell, R.F. 1962. King Salmon Spawning Stocks in California's Central Valley, 1961. Calif. Dept. Fish and Game, Mar. Res. Br. Admin. Rept. No. 62-5. 15 pp.

Erkkila, L.F., J..W. Moffet, O.B. Cope, B.R. Smith, and R.S. Nelson. 1950. Sacramento-San Joaquin Delta fishery resources: Effects of Tracy Pumping Plant and the Delta Cross Channel. U.S. Fish Wildl. Serv. Spec. Sci. Rept. 56:1-109.

Faustini, M. 1989. Adult spring-run chinook in Big Chico Creek. Memorandum, July 19, 1989. Calif. Dept. Fish and Game, Region 2. 1 pp.

Faustini, M. 1990. 1989 Chinook Salmon Surveys. Memorandum, March 7, 1990. Calif. Dept. Fish and Game, Region 2. 1 pp.

LITERATURE CITED (CONTINUED)

Fisher, F.W. 1984. Mill Creek Counts. File Memo, August 7, 1984. Calif. Dept. Fish and Game, Inld. Fish. Div. Red Bluff, CA. 1 pp.

Fisher, F.W. 1992. Butte and Big Chico creeks aerial flight - 1992 spring run. File memo, September 16, 1992. Calif. Dept. Fish and Game. 1 pp.

Fisher, F.W. 1994. Past and Present Status of Central Valley Chinook Salmon. Conserv. Biol. 8(3):870-873.

Flint, R.A. 1989. Butte Creek Salmon Spawning Escapement, 1988. Memorandum, January 20, 1989. Calif. Dept. Fish and Game, Region 2. 2 pp.

Flint, R.A. 1990. Butte Creek Salmon Spawning Escapement - 1990 Spring-run. Memorandum, December 11, 1990. Calif. Dept. Fish and Game, Region 2. 2 pp.

Flint, R.A., and F.A. Meyer. 1977. The De Sabla-Centerville Project (FPC No. 803) and its Impact on Fish and Wildlife. Calif. Dept. Fish and Game, Region 2. 29 pp.

Folmar, L.C., and W.W. Dickhoff. 1980. The parr-smolt transformation (smoltification) and seawater adaption in salmonids: a review of selected literature. Aquaculture 21:1-37.

Freeman, S. 1998. Genetic Diversity. Pages 161-210. In: S.L. Snavely, ed., Evolutionary Analysis. Prentice-Hall, Inc. Upper Saddle River, New Jersey.

Fry, D.H. 1961. King salmon spawning stocks of the California Central Valley, 1940-1959. Calif. Fish Game 47(1): 55-71.

Fry, D.H., and A. Petrovich. 1970. King salmon (*Oncorhynchus tshawytscha*) spawning stock of the California Central Valley, 1953-1969. Calif. Dept. Fish and Game, Anad. Fish. Br. Admin. Rept. 70-11. 21 pp.

Garcia, A. 1989. The impacts of squawfish predation on juvenile chinook salmon at Red Bluff Diversion Dam and other locations in the Sacramento River. U.S. Fish Wildl. Serv., Report No. AFF/FAO-89-05.

Gerstung, E. 1990. California Department of Fish and Game, Status and Management of Spring-Run Chinook Salmon. Calif. Dept. Fish and Game, Inld. Fish. Div. Sacramento, CA.

Gingras, M. 1997. Mark/Recapture Experiments at Clifton Court Forebay to Estimate Pre-Screen Loss of Juvenile Fishes: 1976-1993. Interagency Ecological Program Technical Report #55. 22 pp.

Gingras, M., and M. McGee. 1997. A Telemetry Study of Striped Bass Emigration from Clifton Court Forebay: Implications for Predator Enumeration and Control. Interagency Ecological Program Technical Report #54. 30 pp.

Groh, F. 1970. Annual Report Feather River Salmon and Steelhead Hatchery First Year of Operation, 1967-68. Calif. Dept. Fish and Game, Anad. Fish. Br. Admin. Rept. No. 70-9. 18 pp.

Gundy, et al. 1957. Salmon Spawning Stock Survey Data Sheets. Calif. Dept. Fish and Game. Mar. Res. Br.

Hallock, R. 1956. Letter to file. Calif. Dept. Fish and Game.

Hallock, R. 1960. Monthly Report for October, 1960. C.V. Salmon\Steelhead Project. Calif. Dept. Of Fish and Game, Marine Resources Branch.

Hallock, R. J. 1961. Monthly Report for September, 1961, Calif. Dept. Fish and Game. Mar. Res. Br.

Hallock, R. J. 1962. Central Valley Salmon/Steelhead Project Monthly Report for August, 1962. Calif. Dept. Fish and Game. Mar. Res. Br.

Hallock, R.J. 1987. Sacramento River System Salmon and Steelhead Problems and Enhancement Opportunities. A Report to the California Advisory Committee on Salmon and Steelhead.

Hallock, R. J., and F.W. Fisher. 1985. Status of winter-run chinook salmon, *Oncorhynchus tshawytscha*, in the Sacramento River. Calif. Dept. of Fish and Game, Anad. Fish. Br. 28 pp.

Hallock, R.J., and W.F. Van Woert. 1957. 1956 Fall-run King Salmon, *Oncorhynchus tshawytscha*, Population Estimates for the Sacramento River and Tributaries North of Hamilton City. Calif. Dept. Fish and Game, Inld. Fish. Br. Admin. Rept. No. 57-14. 9 pp.

Hallock, R.J., D.A. Vogel, and R.R. Reisenbichler. 1982. The effect of Red Bluff Diversion Dam on the migration of adult chinook salmon, *Oncorhynchus tshawytscha*, as indicated by radio-tagged fish. Calif. Dept. Fish and Game, Anad. Fish. Br. Rept. No. 82-8.

Hanson, H.A., O.R. Smith, and P.R. Needham. 1940. An investigation of fish salvage problems in relation to Shasta Dam. U.S. Fish Wildl. Serv., Sci. Rept. Fish. No. 10. 200 pp.

Hart, C. 1987. Predation by Harbor Seals, *Phoca vitulina*, on Tagged Adult Chinook Salmon, Coho Salmon, and Steelhead Trout in the Lower Klamath River, Calif. Dept. of Fish and Game, Inld. Fish. Div. Admin. Rept. No. 87-18. 19 pp.

Hart, J.L. 1973. Pacific Fishery of Canada. Fish. Res. Bd. Canada Bull. 180: 740 pp.

Harvey, C.D. 1992. Deer Creek Spring-run Chinook Salmon Survey. Office Memo, August 13, 1992. Calif. Dept. Fish and Game, Inld. Fish. Div. Red Bluff, CA

Harvey, C.D. 1993a. Spring-run Salmon Survey. Field Notes, August 18-19, 1993. Calif. Dept. Fish and Game, Inld. Fish. Div. Red Bluff, CA.

Harvey, C.D. 1993b. Estimate of Spring-run Chinook Salmon Population in Mill Creek - 1993. Office Report. Calif. Dept. Fish and Game, Inld. Fish. Div. Red Bluff, CA.

Harvey, C.D. 1994a. Results of Deer Creek Snorkel Survey. Field Notes, August 2, 1994. Calif. Dept. Fish and Game, Inld. Fish. Div. Red Bluff, CA.

Harvey, C.D. 1994b. Estimate of Spring-run Chinook Salmon Population in Mill Creek - 1994. Draft Office Report. Calif. Dept. Fish and Game, Inld. Fish. Div. Red Bluff, CA.

Harvey, C.D. 1995a. Juvenile spring-run chinook salmon emergence, rearing and outmigration patterns in Deer Creek and Mill Creek, Tehama County for the 1993 Brood Year. Calif. Dept. Fish and Game, Annual progress report for Federal Aide in Sport Fish Restoration Grant No. F-51-R-6. 12 pp.

Harvey, C.D. 1995b. Adult Spring-run Chinook Salmon Surveys in Clear Creek. Office Memo to File. Calif. Dept. Fish and Game, Inld. Fish. Div. Red Bluff, CA.

Harvey, C.D. 1995c. Annual Deer Creek Adult Spring-run Chinook Salmon Survey. Office Memo to File. August 22, 1995. Calif. Dept. Fish and Game, Inld. Fish. Div. Red Bluff, CA.

Harvey, C.D. 1996a. Juvenile spring-run chinook salmon emergence, rearing and outmigration patterns in Deer and Mill creeks, Tehama County for the 1994 Brood Year. Calif. Dept. Fish and Game, Annual progress report for Federal Aide in Sport Fish Restoration Grant No. F-51-R-7. 8 pp.

Harvey, C.D. 1996b. 1996 Antelope Creek Spring-run Chinook Salmon Survey. Office Memo to File. August 6, 1996. Calif. Dept. Fish and Game, Inld. Fish. Div. Red Bluff, CA. 1 pp.

Harvey, C.D. 1996c. Letter to Mr. Jim Edwards. January 12, 1996. Calif. Dept. Fish and Game, Inld. Fish. Div. Red Bluff, CA.

Harvey, C.D. 1996d. Annual Deer Creek Adult Spring-run Chinook Salmon Survey. Office Memo to File. August 15, 1996. Calif. Dept. Fish and Game, Inld. Fish. Div. Red Bluff, CA.

Harvey, C.D. 1997a. Annual Deer Creek Adult Spring-run Chinook Salmon Survey. Office Memo to File. August 18, 1997. Calif. Dept. Fish and Game, Inld. Fish. Div. Red Bluff, CA.

Harvey, C.D. 1997b. 1997 Antelope Creek Spring-run Chinook Salmon Survey. Office Memo to File. August 4, 1997. Calif. Dept. Fish and Game, Inld. Fish. Div. Red Bluff, CA. 1 pp.

Harvey, C.D. 1997c. Juvenile spring-run chinook salmon emergence, rearing and outmigration patterns in Deer and Mill Creeks, Tehama County for the 1995 Brood Year. Calif. Dept. Fish and Game, Annual progress report for Federal Aide in Sport Fish Restoration Grant No. F-51-R-8. 12 pp.

Harvey, C.D., and F.W. Fisher. 1996. Chinook Salmon Spawning Population for the Sacramento River System, 1995. Calif. Dept. Fish and Game. Report to Sport Fish Restoration. 20 pp. + Appendices.

Harvey, C.D., and F.W. Fisher. 1997. Chinook salmon Spawning Population for the Sacramento River System, 1996. Calif. Dept. Fish and Game. Report to Sport Fish Restoration. 20 pp. + Appendices.

Hayes, J.M., and C.E. Lingquist. 1966. Sacramento Valley Eastside Investigation: a Study of Surface Water Development Opportunites in Eastern Tehama and Western Butte Counties. Calif. Dept. Water Res. Bull. 137.

Healey, M.C. 1991. The life history of chinook salmon (*Oncorhynchus tshawytscha*). Pages 312-393 In: Groot and Margolis, eds., Pacific Salmon Life Histories. University of British Columbia Press. Vancouver, B.C.

Hedgecock, D., M.A. Banks, S.M. Blankenship, and M.J. Calvetta. 1995. Genetic evidence for admixture and hybridization of spring- and winter-run chinook salmon in an artificial propagation program. Unpublished manuscript, 23 pp. (Available from Environmental and Technical Services Division, Natl. Mar. Fish. Serv., 525 N.E. Oregon St., Ste. 500, Portland, OR 97232.)

Hedrick, P.W., D. Hedgecock, and S. Hamelberg. 1994. Effective population size in winter-run chinook salmon. Conserv. Biol. 9(3):615-624.

Hendrickson, G.L., A. Carleton, and D. Manzer. 1989. Geographic and seasonal distribution of the infective stage of *Ceratomyxa shasta* (Myxozoa) in Northern California. Dis. Aquatic Organisms 7:165-169.

Hill, K.A. 1995. Butte Creek Spring-run Chinook Snorkel Survey, July 24-26, 1995. Memorandum to Nick Villa. August 1, 1995. Calif. Dept. Fish and Game, Region 2.

Hill, K.A. 1996a. Butte Creek Spring-run Chinook Snorkel Surveys, 9/25/95-10/12/95. Memorandum to Nick Villa. April 10, 1996. Calif. Dept. Fish and Game, Region 2.

Hill, K.A. 1996b. Butte Creek Snorkel Survey, August 19-23, 1996. Memorandum to Nick Villa. September 30, 1996. Calif. Dept. Fish and Game, Region 2.

Hill, K. 1997a. Big Chico Creek Salmon Survey, August 29, 1997. Memorandum to Nick Villa. September 15, 1997. Calif. Dept. Fish and Game, Region 2. 2 pp.

Hill. K.A. 1997b. Butte Creek Salmon Survey, 1997. Memorandum to Nick Villa. September 15, 1997. Calif. Dept. Fish and Game, Region 2. 2 pp.

Hinz, J.A. 1959. Annual Report: Nimbus salmon and steelhead hatchery, fiscal year, 1957-1958. Calif. Dept. Fish and Game, Inld. Fish. Div. Admin. Rept. 59-4.

Hoar, W.S. 1976. Smolt Transformation: evolution, behavior, and physiology. J. Fish. Res. Bd. Can. 33:1233-1252.

Holtgrieve, D. G., and G. W. Holtgrieve. 1995. Physical Stream Survey, Upper Butte Creek, Butte County, California. Report for The Nature Conservancy and the Spring-run Salmon Working Group. December, 1995. 24 pp.

Hoopaugh, D.A. (ed.). 1977. King (Chinook) Salmon Spawning Stocks in California's Central Valley, 1975. Calif. Dept. Fish and Game, Anad. Fish. Br. Admin. Rept. No. 77-12. 29 pp.

Hoopaugh, D.A. (ed.). 1978. King (Chinook) Salmon Spawning Stocks in California's Central Valley, 1976. Calif. Dept. Fish and Game, Anad. Fish. Br. Admin. Rept. No. 78-19. 33 pp.

Hoopaugh, D.A., and A. C. Knutson, Jr. (eds.). 1979. Chinook (King) Salmon Spawning Stocks in California's Central Valley, 1977. Calif. Dept. Fish and Game, Anad. Fish. Br. Admin. Rept. No. 79-11. 36 pp.

Inglis, V., R.J. Roberts, and N.R. Bromage. 1992. Bacterial diseases of fish. Blackwell Scientific Publ. Oxford, Great Britain.

Johnson, J. L., and W. M. Kier. 1998. A Preliminary Assessment of the Salmon Habitat Potential of Butte Creek, a Tributary of the Sacramento River, Between the Butte Head Dam and Centerville Diversion Dam, Butte County, California. Prepared for the Institute for Fisheries Resources, San Francisco, California. January, 1998. 35 pp.

LITERATURE CITED (CONTINUED)

Kano, R.M. 1987. The Effects of Trashrack and Bypass Design and Predator Control on Predation Losses of Juvenile Chinook Salmon at Hallwood-Cordua Fish Screen. Interagency Ecological Studies Program for the Sacramento-San Joaquin Estuary. Technical Report #14. 16 pp.

Kano, R.M. (ed.). 1997. Annual Report Chinook Salmon Spawner Stocks In California's Central Valley, 1988. Calif. Dept. Fish and Game, Inld. Fish. Div. Admin. Rept. No 97-10

Kano, R.M., and R. Reavis (eds.). 1996. Annual Report Chinook Salmon Spawning Stocks in California's Central Valley, 1985. Calif. Dept. Fish and Game, Inld. Fish. Div. Admin. Rept. No. 96-4. 39 pp.

Kano, R.M., and R. Reavis (eds.). 1997a. Annual Report Chinook Salmon Spawning Stocks in California's Central Valley, 1986. Calif. Dept. Fish and Game, Inld. Fish. Div. Admin. Rept. No. 97-2. 40 pp.

Kano, R. M., and R. Reavis (eds.). 1997b. Annual Report Chinook Salmon Spawning Stocks in California's Central Valley, 1987. Calif. Dept. Fish and Game, Inld. Fish. Div. Admin. Rept. No. 97-4. 37 pp.

Kano, R.M., R. Reavis, and F. Fisher (eds.). 1996. Annual Report Chinook Salmon Spawning Stocks in California's Central Valley, 1984. Calif. Dept. Fish and Game, Inld. Fish. Div. Admin. Rept. No. 96-3. 40 pp.

Kjelson, M.A., P.F. Raquel, and F.W. Fisher. 1981. Influences of freshwater inflow on chinook salmon (*Oncorhynchus tshawytscha*) in the Sacramento-San Joaquin estuary. Pages 88-102 In: R.D. Cross and D.L. Williams, (eds.). Proceedings of the National Symposium on Freshwater Inflow to Estuaries. U.S. Fish Wildl. Serv. Biol. Serv. Prog. FWS/OBS-81/04(2).

Kjelson, M.A., P.F. Raquel, and F.W. Fisher. 1982. Life history of fall-run juvenile chinook salmon, *Oncorhynchus tshawytscha*, in the Sacramento-San Joaquin Estuary, California. Pages 393-411 In: V.S. Kennedy, ed., Estuarine Comparisons. Academic Press. New York.

Knutson, A. C., Jr. (ed.). 1980. Chinook (King) Salmon Stocks in California's Central Valley, 1978. Calif. Dept. Fish and Game, Anad. Fish. Br. Admin. Rept. No. 80-6. 32 pp.

Konnoff, D. 1988. South Yuba-Brophy Diversion Study. Memorandum to Fred Meyer. November 18, 1988. Calif. Dept. Fish and Game, Region 2. 10 pp.

Lambson, G.H. 1899. U.S. Commission of Fish and Fisheries. Comm. Rept. 1898. 53 pp.

Lambson, G.H. 1900. U.S. Commission of Fish and Fisheries. Comm. Rept. 1899. 94 pp.

Lambson, G.H. 1901. U.S. Commission of Fish and Fisheries. Comm. Rept. 1900. 85 pp.

Lambson, G.H. 1902. U.S. Commission of Fish and Fisheries. Comm. Rept. 1901 74 pp.

Lambson, G.H. 1904. U.S. Commission of Fish and Fisheries. Comm. Rept. 1902. 71 pp.

Mahoney, J. 1958. 1957 King Salmon Spawning Population Estimates for the Sacramento - San Joaquin River Systems. Calif. Dept. Fish and Game, Mar. Res. Br. 18 pp.

Mahoney, J. 1960. 1959 King Salmon Spawning Population Estimates for the Sacramento-San Joaquin River Systems. Calif. Dept. Fish and Game, Mar. Res. Br. 14 pp.

Mahoney, J. 1962. 1960 King Salmon Spawning Population Estimates for the Sacramento-San Joaquin River Systems. Calif. Dept. Fish and Game, Mar. Res. Br. 14 pp.

Marcotte, B.D. 1984. Life history, status, and habitat requirements of spring-run chinook salmon in California. Unpubl. Report. USFS, Lassen National Forest, Chester, California. 34 pp.

Maslin, P., M. Lennox, J. Kindropp, and W. McKinney. 1997. Intermittent streams as rearing habitat for Sacramento River Chinook Salmon (*Oncorhynchus tshawytscha*). Calif. State Univ. Chico. Dept. of Biol. Sci. 89 pp.

Maule, A.G., R.A. Tripp, S.K. Kaattair, and C.B. Schreck. 1989. Stress alters immune function and disease resistance in chinook salmon (*Oncorhynchus tshawytscha*). Journal of Endocrinology 120:135-142.

McFarland, M. 1991. Spring-run Chinook Salmon Survey, Deer and Mill Creeks-1990. Office Memo, April 24, 1991. Lassen National Forest.

McFarland, M. 1992. Spring-run Chinook Salmon Survey, Deer and Mill Creeks-1991. Office Memo, April 24, 1992. Lassen National Forest.

McGregor, E.A. 1923. Notes on the egg yield of Sacramento River king salmon. Calif. Fish and Game 9(4):134-138.

McPhail, J.D., and C.C. Lindsay. 1970. Freshwater fishes of Northwestern Canada and Alaska. Bull. Fish. Res. Bd. Can. 173:381.

Meacham, C. 1954. Estimated Size of Salmon Runs on Various Central Valley Streams. Memo to Eldon Hughes. Calif. Dept. Fish and Game. 2 pp.

Meadowbrook Conservation Associates. 1997. Survey of road-related sediment sources in the Deer and Mill creek watersheds, Tehama County, California.

LITERATURE CITED (CONTINUED)

Menchen, R.S. 1963. King Salmon Spawning Stocks in California's Central Valley, 1962. Calif. Dept. Fish and Game, Mar. Res. Br. Admin. Rept. No. 63-3. 15 pp.

Menchen, R.S. 1964. King Salmon Spawning Stocks in California's Central Valley, 1963. Calif. Dept. Fish and Game, Mar. Res. Br. Admin. Rept. No. 64-3. 16 pp.

Menchen, R.S. 1965. King (Chinook) Salmon Spawning Stocks in California's Central Valley, 1964. Calif. Dept. Fish and Game, Mar. Res. Br. Admin. Rept. No. 65-2.

Menchen, R.S. 1966. King (Chinook) Salmon Spawning Stocks in California's Central Valley, 1965. Calif. Dept. Fish and Game, Mar. Res. Br. Admin. Rept. No. 66-6. 22 pp.

Menchen, R.S. (ed.). 1967. King (Chinook) Salmon Spawning Stocks in California's Central Valley, 1966. Calif. Dept. Fish and Game, Mar. Res. Br. Admin. Rept. No. 67-13. 26 pp.

Menchen, R.S. (ed.). 1968. King (Chinook) Salmon Spawning Stocks in California's Central Valley, 1967. Calif. Dept. Fish and Game, Mar. Res. Br. Admin. Rept. No. 68-6. 29 pp.

Menchen, R.S. (ed.). 1969. King (Chinook) Salmon Spawning Stocks in California's Central Valley, 1968. Calif. Dept. Fish and Game, Anad. Fish. Br. Admin. Rept. No. 69-4. 22 pp.

Menchen, R.S. (ed.) 1970. King (Chinook) Salmon Spawning Stocks in California's Central Valley, 1969. Calif. Dept. Fish and Game, Anad. Fish. Br. Admin. Rept. No. 70-14. 26 pp.

Menchen, R.S. (ed.) 1972. King (Chinook) Salmon Spawning Stocks in California's Central Valley, 1970. Calif. Dept. Fish and Game, Anad. Fish. Br. Admin. Rept. No. 72-2. 27 pp.

Menchen, R.S., et al. 1963. Salmon Spawning Stock Survey Data Sheets. Calif. Dept. Fish and Game, Mar. Res. Br.

Merrell, D.J. 1981. Ecological genetics. University of Minnesota, Minneapolis, MN. 500 pp.

Meyer, F. 1989. File Memo. May 11, 1989. Calif. Dept. Fish and Game, Region 2. 4 pp.

Meyer, F. 1993. 1992 Feather River Chinook Salmon Run. Memo from Fred Meyer to Nick Villa. March 31, 1993. Calif. Dept. Fish and Game, Region 2. 9 pp.

Meyer, F. 1994. 1993 Feather River Chinook Salmon Spawning Stock Estimate. Memo from Fred Meyer to Nick Villa. March 17, 1994. Calif. Dept. Fish and Game, Region 2. 6 pp.

Meyer, F. 1995. 1994 Feather River Chinook Salmon Run. Memo from Fred Meyer to Nick Villa. June 30, 1995. Calif. Dept. Fish and Game, Region 2. 3 pp.

Meyer, F. 1996. 1995 Feather River Chinook Salmon Run. Memo from Fred Meyer to Nick Villa. January 29, 1996. Calif. Dept. Fish and Game, Region 2. 7 pp.

Meyer, F. 1997. 1996 Feather River Chinook Salmon Run. Memo from Fred Meyer to Nick Villa. March 3, 1997. Calif. Dept. Fish and Game, Region 2. 7 pp.

Michny, F., and M. Hampton. 1984. Sacramento River Chico Landing to Red Bluff Project, 1984 juvenile salmon study. U.S. Fish Wildl. Serv., Division of Ecological Services, Sacramento, CA. 24 pp.

Mill Creek Watershed Conservancy. 1994. Memorandum of Understanding Regarding Development of the Mill Creek Watershed Management Strategy. December 19, 1994. 3 pp.

Mill Creek Watershed Conservancy. 1997. Mill Creek Watershed Management Strategy Report. Prepared by CH2MHill. January 1997.

Mills, T., and F.W. Fisher. 1994. Third Draft Central Valley Anadromous Sport Fish Annual Run Size, Harvest, and Population Estimates, 1967-1991. Revised August 1994.

Mills, T., and P. Ward. 1996. Status of actions to restore Central Valley spring-run chinook salmon: A special report to the Fish and Game Commission. Calif. Dept. Fish and Game. Inld. Fish. Div. 56 pp.

Moffett, J.W. 1947. Annual report of fishery investigations in Central Valley and other projects in California - fiscal year 1947. Memorandum report to Elmer Higgins, Division of Fishery Biology, Washington D.C.

Moore, T.L. 1997. Condition and feeding of juvenile chinook salmon in selected intermittent tributaries of the Sacramento River. M.S. Thesis. California State University, Chico, CA. 66 pp.

Mulcahy, D., C.K. Jenes, and R. Pascho. 1984. Appearance and quantification of infectious hematopoietic necrosis virus in female sockeye salmon (*Oncorhynchus nerka*) during their spawning migration. Arch. Viro. 80:171-181.

Murray, C.B., and M.L. Rosenau. 1989. Rearing of juvenile chinook in nonnatal tributaries of the lower Fraser River, British Columbia. Trans. Am. Fish. Soc. 118(3):284-289.

Myers, J.M., R.G. Kope, G.J. Bryant, D. Teel, L.J. Lierheimer, T.C. Wainwright, W.S. Grant, F.W. Waknitz, K. Neely, S.T. Lindley, and R.S. Waples. 1998. Status review of chinook salmon from Washington, Idaho, Oregon, and California. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-35. 443 pp.

Nash, G. 1977. Observations on saprolegniasis of adult sockeye salmon, *Oncorhynchus nerka* (Walbaum). J. Fish Biol. 10:513-522.

National Marine Fisheries Service (NMFS). 1996. Review of the status of chinook salmon (*Oncorhynchus tshawytscha)* from Washington, Oregon, California, and Idaho under the U.S. Endangered Species Act. Prepared by the West Coast Chinook Salmon Biological Review Team, November 22, 1996. Draft Internal Document. 164 pp. with attachments.

National Marine Fisheries Service (NMFS). 1997. NMFS Proposed Recovery Plan for Sacramento River Winter-run Chinook Salmon. August 1997.

Nehlsen, W., J.E. Williams, and J.A. Lichatowich. 1991. Pacific salmon at the crossroads: stocks at risk from California, Oregon, Idaho and Washington. Fisheries 16(2):4-21.

Nei, M. 1978. Estimation of average heterozygosity and genetic distance from a small number of individuals. Genetics 89:583-590.

Nelson, J. 1997. File memo. Calif. Dept. Fish and Game, Region 2.

Nielsen, J. L. 1995. Mitochondrial DNA frequency distributions in chinook salmon from the Sacramento-San Joaquin basin and Guadalupe River, 1992-1994. Technical Report submitted to Calif. Dept. Fish and Game, Inld. Fish. Div. Aug. 1995.

Nielsen, J. L. 1997. Mitochondrial DNA and nuclear microsatellite polymorphisms in chinook salmon from the Sacramento-San Joaquin basin, 1991-1995. Technical Report submitted to Calif. Dept. Fish and Game, Inld. Fish. Div. Feb. 1997.

Nielsen, J. L., D. Tupper, and W. K. Thomas. 1994. Mitochondrial DNA polymorphism in unique runs of chinook salmon (*Oncorhynchus tshawytscha*) from the Sacramento-San Joaquin River basin. Conserv. Biol. 8(3):882-884.

Oates, et al. 1958. Salmon Spawning Stock Survey Data Sheets. Calif. Dept. Fish and Game, Mar. Res. Br.

Orsi, J. 1967. Predation study report, 1966-1967. Calif. Dept. Fish and Game.

Pacific Fishery Management Council (PFMC). 1993. Historical ocean salmon fishery data for Washington, Oregon and California. Compiled by the Salmon Technical Team of the Pacific Fishery Management Council. 254 pp.

Pacific Fishery Management Council (PFMC). 1998. Review of the 1997 ocean salmon fisheries. 285 pp.

Painter, R. 1988. Mill Creek Spring-run Chinook Counts 1988. Office Memo. Calif. Dept. Fish and Game, Inld. Fish. Div.

LITERATURE CITED (CONTINUED)

Painter, R. 1989. Mill Creek Spring-run Chinook Counts 1989. Office Memo. Calif. Dept. Fish and Game, Inld. Fish. Div.

Painter, R. 1990. Mill Creek Spring-run Chinook Counts 1990. Office Memo. Calif. Dept. Fish and Game, Inld. Fish. Div.

Painter, R. 1991. Mill Creek Spring-run Chinook Counts 1991. Office Memo. Calif. Dept. Fish and Game, Inld. Fish. Div.

Painter, R. 1992. Mill Creek Spring-run Chinook Counts 1992. Office Memo. Calif. Dept. Fish and Game, Inld. Fish. Div.

Payne. T. 1991. Battle Creek Fisheries Studies. Unpublished report prepared forCalif. Dept. Fish and Game, Region 1. Redding, CA.

Philipp, D.P., J.M. Epifanio, M.J. Jennings. 1993. Conservation genetics and current stocking practices--Are they compatible? Fisheries 18(12):14-16.

Pickard, A., A. Grover, and F. Hall. 1982. An Evaluation of Predator Composition at Three Locations on the Sacramento River. Interagency Ecological Study Program for the Sacramento-San Joaquin Estuary. Technical Report #2. 20 pp.

Platts, W.S., W.F. Megahan, and G.W. Minshall. 1979. Methods for evaluating stream, riparian, and biotic conditions. USDA General Technical Report INT-138. Ogden, UT. 78 pp.

Preston, L. 1984. File Memo. January 26, 1984. Calif. Dept. Fish and Game, Region 2. 3 pp.

Preston, L. 1985. File Memo. March 28, 1985. Calif. Dept. Fish and Game, Region 2. 5 pp.

Preston, L. 1987. File Memo. January 16, 1987. Calif. Dept. Fish and Game, Region 2. 4 pp.

Puckett, L.K., and R.N. Hinton. 1974. Some measurements of the relationship between streamflow and king salmon spawning gravel in the main Eel and South Fork Eel rivers. Calif. Dept. Fish and Game, Env. Serv. Br. Admin. Rept. 74-1.

Reavis, R.L. (ed.). 1981a. King (chinook) salmon spawning stocks in California Central Valley, 1980. Calif. Dept. Fish and Game, Anad. Fish. Br. Admin. Rept. 81-7. 36 pp.

Reavis, R.L. (ed.). 1981b. Chinook (king) salmon spawning stocks in California's Central Valley, 1979. Calif. Dept. Fish and Game, Anad. Fish. Br. Admin. Rept. No. 81-4. 31 pp.

Reavis, R.L. (ed.). 1983. King (chinook) salmon spawning stocks in California's Central Valley, 1981. Calif. Dept. Fish and Game, Anad. Fish. Br. Admin. Rept. 83-2. 41 pp.

LITERATURE CITED (CONTINUED)

Reavis, R.L. (ed.). 1984. King (chinook) salmon spawning stocks in California's Central Valley, 1982. Calif. Dept. Fish and Game, Anad. Fish. Br. Admin. Rept. 84-10. 41 pp.

Reavis, R. (ed.). 1986a. Annual report chinook salmon spawning stocks in California's Central Valley, 1983. Calif. Dept. Fish and Game, Anad. Fish. Br. Admin. Rept. No. 86-1. 39 pp.

Reavis, R. (ed.) 1986b. Annual report chinook salmon spawning stocks in California's Central Valley, 1982. Calif. Dept. Fish and Game, Anad. Fish. Br. Admin. Rept. No. 86-10, 39 pp.

Reiser, D.W., and T.C. Bjornn. 1979. Habitat requirements of anadromous salmonids. Pages 54-58 In: W.R. Meehan, ed. Influence of Forest and Range Management on Anadromous Fish Habitat in Western North America. Pacific N.W. Forest Range Exp. Stn. USDA Forest Serv., Portland. Gen. Tech. Rept. PNW-96.

Reynolds, F.L., R.L. Reavis, and J. Schuler. 1990. Central Valley salmon and steelhead restoration and enhancement plan. Calif. Dept. Fish and Game.

Rich, A.A. 1997. Testimony of Alice A. Rich, Ph.D. regarding water rights applications for the Delta Wetlands Project, proposed by Delta Wetlands Properties for Water Storage on Webb Tract, Bacon Island, Bouldin Island, and Holland Tract in Contra Costa and San Joaquin Counties. July 1997. Calif. Dept. Fish and Game Exhibit DFG-7. Submitted to State Water Resources Control Board.

Ricker, W. E. 1973. Linear regressions in fishery research. J. Fish. Res. Bd. Can. 30:409-434.

Riddell, B.E. 1993. Spatial organization of pacific salmon: What to conserve? Pages 23-40 In: J.G. Cloud and G.H. Thorgaard, eds. Genetic Conservation of Salmonid Fishes. Plenum Press, New York.

Sasaki, S. 1966. Distribution and food habits of king salmon, *Oncorhynchus tshawytscha*, and steelhead rainbow trout, *Salmo gairdnerii*, in the Sacramento-San Joaquin Delta. Calif. Dept. Fish and Game Bull. 136:108-114.

Sato, G.M., and P.B. Moyle. 1989. Ecology and conservation of spring-run chinook salmon. Annual Report, Water Resources Center Project W-719, July 30, 1988-June 30, 1989.

Saunders, R.L. 1965. Adjustment of buoyancy in young Atlantic salmon and brook trout by changes in swim bladder volume. J. Fish. Res. Bd. Can. 22:335-352.

Schlicting, D. 1973. Annual Report Feather River Salmon and Steelhead Hatchery, 1971-72. Calif. Dept. Fish and Game, Anad. Fish. Br. Admin. Rept. No. 73-11. 24 pp.

Schlicting, D. 1974. Annual Report Feather River Salmon and Steelhead Hatchery, 1970-71. Calif. Dept. Fish and Game, Anad. Fish. Br. Admin. Rept. No. 74-11. 23 pp.

LITERATURE CITED (CONTINUED)

Schlicting, D. 1976. Annual Report Feather River Salmon and Steelhead Hatchery, 1972-73. Calif. Dept. Fish and Game, Anad. Fish. Br. Admin. Rept. No. 76-5. 25 pp.

Schlicting, D. 1978a. Annual Report Feather River Salmon and Steelhead Hatchery, 1973-74. Calif. Dept. Fish and Game, Anad. Fish. Br. Admin. Rept. No. 78-12. 22 pp.

Schlicting, D. 1978b. Annual Report Feather River Salmon and Steelhead Hatchery, 1974-75. Calif. Dept. Fish and Game, Anad. Fish. Br. Admin. Rept. No. 78-13. 19 pp.

Schlicting, D. 1978c. Annual Report Feather River Salmon and Steelhead Hatchery, 1975-76. Calif. Dept. Fish and Game, Anad. Fish. Br. Admin. Rept. No. 78-14. 21 pp.

Schlicting, D. 1982a. Annual Report Feather River Hatchery, 1977-78. Calif. Dept. Fish and Game, Anad. Fish. Br. Admin. Rept. No. 82-35. 20 pp.

Schlicting, D. 1982b. Annual Report Feather River Hatchery, 1978-79. Calif. Dept. Fish and Game, Anad. Fish. Br. Admin. Rept. No. 82-36. 19 pp.

Schlicting, D. 1982c. Annual Report Feather River Hatchery, 1979-80. Calif. Dept. Fish and Game, Anad. Fish. Br. Admin. Rept. No. 82-33. 21 pp.

Schlicting, D. 1991. Annual Report Feather River Hatchery, 1988-89. Calif. Dept. Fish and Game, Anad. Fish. Br. Admin. Rept. No. 91-12. 11 pp.

Schlicting, D. 1993a. Annual Report Feather River Hatchery, 1989-90. Calif. Dept. Fish and Game, Anad. Fish. Br. Admin. Rept. No. 93-4. 10 pp.

Schlicting, D. 1993b. Annual Report Feather River Hatchery, 1990-91. Calif. Dept. Fish and Game, Anad. Fish. Br. Admin. Rept. No. 93-5. 10 pp.

Schlicting, D. 1993c. Annual Report Feather River Hatchery, 1991-92. Calif. Dept. Fish and Game, Anad. Fish. Br. Admin. Rept. No. 93-7. 11 pp.

Scrivener, J.C., T.C. Brown, and B.C. Anderson. 1994. Juvenile chinook salmon (*Oncorhynchus tshawytscha)* utilization of Hawks Creek, a small and nonnatal tributary of the upper Fraser River. Can. J. Fish. Aquatic Sci. 51:1139-1146.

Seymour, A.H. 1956. Effects of temperature on young chinook salmon. Ph.D. thesis. University of Washington, Seattle, WA.

Slater, D.W. 1963. Winter-run chinook salmon in the Sacramento River, California with notes on water temperature requirements at spawning. U.S. Fish Wildl. Serv., Spec. Sci. Rept. 461. 9 pp.

LITERATURE CITED (CONTINUED)

Smith, L.S. 1982. Decreased swimming performance as a necessary component of the smolt migration in salmon in the Columbia River. Aquaculture 28:153-161.

Snider, B., and R. Titus. 1996. Evaluation of juvenile anadromous salmonid emigration monitoring in the Sacramento River near Knights Landing November 1995-July 1996. Calif. Dept. Fish and Game, Env. Serv. Div.- Stream Flow and Habitat Program. 20 pp. + appendices.

Stanley, W. T., and K. E. Shaffer. 1995. Harbor Seal (*Phoca vitulina*) Predation on Seined Salmonids in the Lower Klamath River, California. Marine Mammal Science 11(3):376-385.

State Water Resources Control Board (SWRCB). 1995. Environmental Report, Appendix 1 to Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. May 1995.

State Water Resources Control Board (SWRCB). 1997a. Draft Environmental Impact Report for Implementation of 1995 Bay/Delta Water Quality Control Plan. November 1997.

State Water Resources Control Board (SWRCB). 1997b. Draft Environmental Impact Report for Implementation of 1995 Bay/Delta Water Quality Control Plan. Vol. 2, Ch XIII. Alternatives for Implementing the Joint Points of Diversion. November 1997.

Steitz, C. 1992. Field notes regarding PG&E snorkel survey. PG&E. Location of Spring-run Salmon Observed in Butte Creek During Snorkeling Surveys Conduted by PG&E on June 10 and August 26, 1992.

Steitz, C. 1994a. Revisions for third draft of Central Valley Anadromous Sport Fish Annual Run-Size, Harvest and Population Estimates, 1967 through 1991. PG&E Office Memo, May 10, 1994, to Terry Mills (CDFG). 2 pp.

Steitz, C. 1994b. Butte Creek Spring-run Salmon Snorkeling Survey. PG&E Electronic Memo to Mr. Bob Potter et al. (DWR), July 5, 1994. 1 pp.

Stevens, D. E. 1961. Food habits of striped bass, *Roccus saxitilis* (Walbaum), in the Rio Vista area of the Sacramento River. Master's Thesis, University of California, Berkeley.

Stone, L. 1874. Report of operations during 1872 at the United States salmon hatching establishment on the McCloud River. U.S. Comm. Fish and Fisheries, Report for 1872 and 1873, Part II: 168-215.

Stone, L. 1875. Pages 377-429 In: Report of operations in California in 1873 - field work in the winter of 1872-1873, Appendix XX. Report to the U.S. Comm. 1876. Washington, D.C.

LITERATURE CITED (CONTINUED)

Stone, L. 1883. Report of operations at the United States salmon hatching station on the McCloud River, California, during the season of 1880. U.S. Fish. Comm. Report: 597-612.

Stone, L. 1893. Baird Station, California. U.S. Fish Comm. Rept. for 1888: XXXV-XXXVI.

Stone, L. 1895. U.S. Commission of Fish and Fisheries. Comm. Rept. 1893. 117 pp.

Stone, L. 1896a. U.S. Commission of Fish and Fisheries. Comm. Rept. 1896. 66 pp.

Stone, L. 1896b. U.S. Commission of Fish and Fisheries. Comm. Rept. 1895. 44 pp.

Stone, L. 1896c. U.S. Commission of Fish and Fisheries. Comm. Rept. 1893. 49 pp.

Stone, L. 1898. U.S. Commission of Fish and Fisheries. Comm. Rept. 1897. 64 pp.

Storer T.I., R.L. Usinger, and J.W. Nybakken. 1968. Elements of Zoology. McGraw Hill Book Company. New York.

Taylor, S.N. (ed.). 1973. King (Chinook) Salmon Spawning Stocks in California's Central Valley, 1971. Calif. Dept. Fish and Game, Anad. Fish. Br. Admin. Rept. No. 73-2. 36 pp.

Taylor, S. N. (ed.). 1974a. King (Chinook) Salmon Spawning Stocks in California's Central Valley, 1972. Calif. Dept. Fish and Game, Anad. Fish. Br. Admin. Rept No. 74-6. 32 pp.

Taylor, S.N. (ed.) 1974b. King (Chinook) Salmon Spawning Stocks in California's Central Valley, 1973. Calif. Dept. Fish and Game, Anad. Fish. Br. Admin. Rept. No. 74-12. 32 pp.

Taylor, S.N. (ed.). 1976. King (Chinook) Salmon Spawning Stocks in California's Central Valley, 1974. Calif. Dept. Fish and Game, Anad. Fish. Br. Admin. Rept. No. 76-3. 33 pp.

U.S. Bureau of Land Management (BLM). 1996. Lower Clear Creek Watershed Analysis. January 1996.

U.S. Bureau of Land Management (USBR). 1983. Predation of Anadromous Fish in the Sacramento River, California. Central Valley Fish and Wildlife Management Study, Special Rept. 77 pp. +appendices.

U.S. Department of Interior (USDOI). 1997. Final CVPIA Administrative Proposal for Management of Section 3406(b)(2) Water (800,000 acre-feet), November 20, 1997.

LITERATURE CITED (CONTINUED)

U.S. Fish and Wildlife Service (USFWS). 1987. The needs of chinook salmon, *Oncorhynchus tshawytscha*, in the Sacramento-San Joaquin Estuary. Entered for the State Water Resources Control Board 1987 Water Quality/Rights Proceedings on the San Francisco Bay/Sacramento-San Joaquin Delta. USFWS Exhibit 31.

U.S. Fish and Wildlife Service (USFWS). 1990. An analysis of fish and wildlife impact of Shasta Dam water temperature control alternatives. Fish and Wildlife Coordination Act Report. U.S. Fish Wildl. Serv. Region 1. December 1990.

U.S. Fish and Wildlife Service (USFWS). 1992. Measures to improve the protection of chinook salmon in the Sacramento-San Joaquin River Delta. Expert testimony of the US. Fish and Wildlife Service on chinook salmon - Technical information for the State Water Resources Control Board, Water Rights Phase of the Bay/Delta Estuary Proceedings, July 6, 1992. WRINT-USFWS-7. 61 pp.

U.S. Fish and Wildlife Service (USFWS). 1994. Working Paper on Restoration Needs - Habitat Restoration Actions to Double Natural Production of Anadromous Fish in the Central Valley of California, Volume 3.

U.S. Fish and Wildlife Service (USFWS). 1995a. Sacramento-San Joaquin Delta Native Fishes Recovery Plan. U.S. Fish Wildl. Serv. Portland, Oregon. 195 pp.

U.S. Fish and Wildlife Service (USFWS). 1995b. October 1995 Report of Escapement of Hatchery Origin Winter Chinook Salmon to the Sacramento River in 1995. As included in Application for a Permit to Enhance the Propagation or Survival of Endangered or Threatened Species Under Endangered Species Act - Coleman National Fish Hatchery Winter Chinook Salmon Propagation Program 1995.

U.S. Fish and Wildlife Service (USFWS). 1996a. Escapement of Hatchery Origin Winter Chinook Salmon (*Oncorhynchus tshawytscha*) to the Sacramento River, California in 1995, with notes on Spring Chinook Salmon in Battle Creek. U.S. Fish Wildl. Serv., Northern Central Fish and Wildlife Office, January 1996.

U.S. Fish and Wildlife Service (USFWS). 1996b. Letter titled "Anadromous Fish Restoration Program, Draft Justification of 1997 Delta Flow and Habitat Objectives using CVPIA tools [Section 3406(b)(1)(B),(b)(2),(b)(3).]" October 25, 1996.

U.S. Fish and Wildlife Service (USFWS). 1997a. Abundance and survival of juvenile chinook salmon in the Sacramento-San Joaquin Estuary - 1994 Annual Progress Report. Sacramento-San Joaquin Estuary Fishery Resource Office. Stockton, California. 60 pp.

U.S. Fish and Wildlife Service (USFWS). 1997b. A Plan to Increase Natural Production of Anadromous Fish in the Central Valley of California. Revised Draft Restoration Plan for the Anadromous Fish Restoration Program. May 30, 1997. 112 pp. + appendices.

LITERATURE CITED (CONTINUED)

U.S. Fish and Wildlife Service (USFWS). 1997c. Comprehensive Assessment and Monitoring Program (CAMP) Implementation Plan. A Comprehensive Plan to Evaluate the Effectiveness of CVPIA Actions in Restoring Anadromous Fish Production. March 1997.

U.S. Fish and Wildlife Service (USFWS). 1998. Supplemental Fish and Wildlife Coordination Act Report. Red Bluff Diversion Dam and the Tehama-Colusa Canal. February 1998.

U.S. Forest Service (USFS). 1992. Land and resource management plan. Lassen National Forest.

U.S. Geological Survey (USGS). 1912. Surface Water Supply of the United States, 1910, Part XI. Pacific Coast in California. Department of the Interior, United States Geological Survey.

Udey, L.R., J.L. Fryer, and K.S. Pilcher. 1975. Relation of water temperature to Ceratomyxosis in rainbow trout (*Salmo gairdnerii*) and coho salmon (*Oncorhynchus kisutch*). J. Fish. Res. Bd. Canada. 32:1545-1551.

Van Woert, W. 1959. Memo to Harry Hanson, regarding observation of salmon at dam on Antelope Creek, April 21, 1959. Calif. Dept. Fish and Game.

Van Woert, W. 1964. Mill Creek counting station. Office memorandum to Eldon Hughes, May 25, 1964 Calif. Dept. Fish and Game, Water Projects Branch, Contract Services Section. 7 pp.

Velson, F.P. 1987. Temperature and incubation in Pacific salmon and rainbow trout, a compilation of data on median hatching time, mortality, and embryonic staging. Canadian Data Rept. of Fisheries and Aquatic Sciences. No. 626.

Vogel, D.A., and J.G. Smith. 1986. Fish passage action program for the Red Bluff Diversion Dam; Interim report on fishery investigations. U.S. Fish Wildl. Serv. Rept. No. FR1/FAO-86-5. 52 pp.+ appendices.

Vogel D.A., and K.R. Marine. 1995. 1994 biological evaluations of the new fish screen at the Glenn-Colusa Irrigation District's Sacramento River pump station. Natural Resource Scientists, Inc., Red Bluff, CA. February 1995. 77 pp. + appendices.

Vogel D.A., K.R. Marine, and J.G. Smith. 1988. Fish passage action program for Red Bluff Diversion Dam. Final Report, U.S. Fish Wildl. Serv. Rept. No. FR1-FAO-88-19. 77 pp. + appendices.

Wales, J. H. 1939. General report of investigations on the McCloud River drainage in 1938. Calif. Fish and Game 25:272-309.

LITERATURE CITED (CONTINUED)

Walters, C.J., R. Hilborn, R.M. Peterman, and M.J. Stanley. 1978. Model for examining early ocean limitation of Pacific salmon production. J. Fish. Res. Bd. Can. 35:1303-1315.

Warner, G. H. 1954. Memorandum to D. H. Fry and R. J. Hallock, May 28, 1954. Calif. Dept. Fish and Game, Mar. Res. Br.

Warner, G. H. 1957. The 1956 King Salmon Population Estimates for the Rivers of the Sacramento-San Joaquin River System from Butte Creek South. 6 pp.

Warner, G.H. 1940. Salmon fecundity at Clarksburg. Calif. Dept. Fish and Game. Unpublished data collected May 1940.

White, B. 1959. Salmon Spawning Stock Survey Data Sheets. Calif. Dept. Fish and Game, Mar. Res. Br.

White, W. 1958. Intra-office correspondence. Recommendations for development of Big Chico Creek, Higgins Hole to Bear Lake, September 12, 1958, Calif. Dept. Fish and Game, Region 2 Files. 1 pp.

Williams, G.B., Jr. 1893. U.S. Commission of Fish and Fisheries. Comm. Rept. 1889-91. 49 pp.

Williams, G.B., Jr. 1894. U.S. Commission of Fish and Fisheries. Comm. Rept. 1892. Part XVIII. LVII.

Wixom, L.H., J. Pisciotto, and C. Lake. 1995. Final performance report as required by Federal Aid in Sport Fish Restoration Act, Inland and Anadromous Sport Fish Management and Research. Federal Aid Project F-51-R. Project 27. Sacramento River Systems Sport Fish Catch. 76 pp.

Wolf, K. 1988. Fish viruses and fish viral diseases. Cornell University Press. Ithaca, NY.

Wood, Chris C. 1995. Life history variation and population structure in sockeye salmon. Pages 195-216 In: J.L. Nielsen, ed., Evolution and the Aquatic Ecosystem: Defining Unique Units in Population Conservation. American Fisheries Society Symposium 17, Bethesda, Maryland.

Yoshioka, G. 1990. Big Chico Creek spring-run chinook survey. File Memo, October, 16, 1990. Calif. Dept. Fish and Game. Region 2, 3 pp.

Yoshioka, G. 1991. Problems and Issues: Potential solutions and needed investigations for anadromous salmonid restoration on Big Chico Creek. Calif. Dept. Water Res. Bay Delta Project.

LITERATURE CITED (CONTINUED)

Yoshiyama, R.M., E.R. Gerstung, F.W. Fisher, and P.B. Moyle. 1996. Historical and present distribution of chinook salmon in the Central Valley Drainage of California. Cited in: Sierra Nevada Ecosystem Project, Final Report to Congress, vol. III, Assessments, Commissioned Reports, and Background Information (University of California, Davis, Centers for Water and Wildland Resources, 1996.)

Young, C., et al. 1960. Salmon Spawning Stock Survey Data Sheets. Calif. Dept. Fish and Game, Mar. Res. Br.

Young, C., et al. 1968. Salmon Spawning Stock Survey Data Sheets. Calif. Dept. Fish and Game, Anad. Fish. Br., in Inld. Fish. Div. files, Red Bluff, CA.

Young, C., et al. 1969. Salmon Spawning Stocks Survey Data Sheets. Calif. Dept. Fish and Game, Anad. Fish. Br., in Inld. Fish. Div. files, Red Bluff, CA.

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State of California
The Resources Agency

DEPARTMENT OF FISH AND GAME

REPORT TO THE FISH AND GAME COMMISSION:

A STATUS REVIEW OF THE
SPRING-RUN CHINOOK SALMON (ONCORHYNCHUS TSHAWYTSCHA)
IN THE SACRAMENTO RIVER DRAINAGE

APPENDICES

Prepared by
Department of Fish and Game

June 1998

Candidate Species Status Report 98-01

APPENDIX A

Section 2074.4 of the Fish and Game Code requires the Department of Fish and Game to notify affected and interested parties and landowners and to solicit data and comments on petitions accepted by the Fish and Game Commission. To fulfill this requirement, the Department sent Public Notices (Appendix A-1) to persons and organizations listed herein (Appendix A-2). Legal Notices were placed in the newspapers indicated below (Appendix A-3): A list of individuals, organizations, and government agencies that responded to the Public Notice is provided herein (Appendix A-4). Title 14, Section 670.1 CCR requires the Department solicit Peer Review of the draft Status Report. A list of Peer Reviewers is contained in Appendix A-5. A summary of Peer Review comments is contained in Appendix A-6. The Department's responses to Peer Review Comments is contained in Appendix A-7.

APPENDIX A-1
PUBLIC NOTICE

STATE OF CALIFORNIA—THE RESOURCES AGENCY

PETE WILSON, *Governor*

DEPARTMENT OF FISH AND GAME
1416 NINTH STREET
P.O. BOX 944209
SACRAMENTO, CA 94244-2090
(916) 653-6194

October 9, 1997
PUBLIC NOTICE

TO WHOM IT MAY CONCERN:

Pursuant to Section 2074.4 of the California Fish and Game Code (FGC), NOTICE IS HEREBY GIVEN that on June 13, 1997 the California Fish and Game Commission (Commission) accepted a petition from the Department of Fish and Game (DFG) to amend the official State list of endangered and threatened species (Sec. 670.2 and 670.5, Title 14, California Code of Regulations) as follows:

Species	Proposal
Sacramento River Spring-run Chinook Salmon *(Oncorhynchus ishawytscha)*	Endangered

NOTICE IS FURTHER GIVEN that, effective June 27, 1997, the Sacramento River Spring-run Chinook Salmon is a "candidate species" pursuant to Sec. 2074.2, FGC, and pursuant to Sec. 2085, FGC, may not be taken or possessed except as provided by Sec. 2081 and 2091 of the FGC, or other applicable statutes, or in accordance with the terms of the Special Order Relating to Incidental Take of Sacramento River Spring-run Chinook Salmon During Candidacy Period (Special Order), adopted by the Commission on June 13, 1997. The Special Order was published in the California Regulatory Notice Register, Register 97, No. 26-Z, on June 27, 1997. A copy of the Special Order is available from the Commission, 1416 Ninth St., Sacramento, CA 95814, (916) 653-4899.

The California Endangered Species act (Sec. 2050 et seq., Chp. 1.5 FGC) requires that DFG notify affected and interested parties that the Commission has accepted the petition for the purpose of receiving information and comments that will aid in evaluating the petition and determining whether or not the above proposal should be adopted by the Commission. DFG will review the petition, evaluate the available information, and report back to the Commission whether the petitioned action is warranted (Sec. 2074.6, FGC). DFG's recommendation must be based on the best scientific information available to the Department. DFG must provide its recommendation to the Commission not later than June 26, 1998. Therefore, NOTICE IS FURTHER GIVEN persons with data or comments on the taxonomic status, ecology, biology, life history, management recommendations, distribution, abundance, threats, habitat that may be essential for the species, or other factors related to the status of the above species, is hereby requested to provide such data or comments to:

Inland Fisheries Division
California Department of Fish and Game
1416 Ninth Street
Sacramento, California 95814

Copies of the petition may be requested from the above address.

Responses received by the November 21, 1997 will by included in DFG's final report to the Commission. If DFG concludes that the petitioned action is warranted, it will recommend that the Commission adopt the above proposal. If DFG concludes that the petitioned action is not warranted, it will recommend that the Commission not adopt the proposal. Following receipt of the DFG's report, the Commission will allow a 45-day public comment period prior to taking any action on the DFG's recommendation.

Timothy C. Farley, Chief
Inland Fisheries Division

APPENDIX A-2
PERSONS AND ORGANIZATIONS CONTACTED

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CALIFORNIA STATE UNIVERSITY CHICO
SCHOOL OF AGRICULTURE, CSU, CHICO
CHICO CA 95929-0310

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FAMILY WATER ALLIANCE
1819 COUNTY ROAD R WILLOWS,
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APPENDIX A-3
NEWSPAPERS WHICH PUBLISHED
THE SACRAMENTO RIVER SPRING-RUN CHINOOK SALMON LEGAL NOTICE

Publication	Dates Published
The Sacramento Bee -	published October 16 through 17, 1997.
The Stockton Record -	published October 16 through 17, 1997.
The Sun (San Bernadino) -	published October 16 through 17, 1997.
The San Diego Union -	published October 16 through 17, 1997.
The Fresno Bee -	published October 16 through 17, 1997.
The Oakland Tribune -	published October 18 through 19, 1997.
Daily News Los Angeles -	published October 17 through 18, 1997.

APPENDIX A-4
LIST OF INDIVIDUALS AND AGENCIES THAT RESPONDED TO PUBLIC NOTICE

Document 1: Edwards, W. James. Letter regarding comments to aid in evaluating the petition to list the Sacramento Spring-run chinook salmon as endangered and its status as a distinct species or subspecies. Dated October 20, 1997. To California Department of Fish and Game, Inland Fisheries Division.

Document 2: Cheesman, Gail and Doug. Letter regarding need to protect spring-run chinook salmon. Dated October 21, 1997. To Jacqeline Schafer, Director, California Department of Fish and Game.

Document 3: Baumann, Richard. Letter providing information and comments regarding the proposed listing of Sacramento spring-run chinook salmon. Representing Lower Clear Creek Coordinated Resource Management and Planning Group. Dated November 18, 1997. To California Department of Fish and Game, Inland Fisheries Division.

Document 4: State Water Contractors. Report titled *Comments of the State Water Contractors regarding the listing of spring-run chinook salmon as an endangered species.* Dated November 20, 1997. To Robert R. Treanor, Executive Director, California Fish and Game Commission.

Document 5: Northern California Water Association. Letter providing information that may help the Department determine whether the spring-run chinook salmon should be listed as threatened or endangered pursuant to the California Endangered Species act. Dated November 18, 1997. To Timothy Farley, Chief, Inland Fisheries Division. California Department of Fish and Game.

Document 6: Cole, Roger W. Letter providing comments regarding spring-run chinook salmon and habitat requirements. Representing Streaminders-A Chapter of the Izaak Walton League. Dated November 21, 1997. To Deborah McKee, Inland Fisheries Division, California Department of Fish and Game.

Document 7: Crothers, Cathy. Memorandum from Department of Water Resources replying to Public Notice requesting data and comments on the Sacramento River spring-run chinook salmon. Dated November 21, 1997. To Tim Farley, Inland Fisheries Division, California Department of Fish and Game.

APPENDIX A-5
LIST OF PEER REVIEWERS

Name	Title/Organization
David G. Hankin, Ph.D.	Chairman and Professor, Department of Fisheries Humboldt State University, Arcata, California
Fred M. Utter, Ph.D.	Affiliate Professor, School of Fisheries University of Washington, Seattle, Washington Co-editor, Transactions of the American Fisheries Society
Michael C. Healey, Ph.D.	Professor, Earth and Ocean Sciences (Oceanography) / Institute for Resources and Environment (Westwater Research Unit) / Fishery Centre The University of British Columbia, Vancouver, B.C. Canada

APPENDIX B

APPENDIX B

History of Spring-run Chinook Salmon Population Estimation Methods by Drainage

		SACRAMENTO RIVER
YEAR	RUN SIZE	METHODOLOGY/REFERENCE
1940	11,000	Incomplete counts made at Anderson Cottonwood Irrigation District Dam at Redding by U. S. Bureau of Reclamation in 1940-41, and by the U. S. Fish and Wildlife Service in 1942, Fry (1961).
1941	15,000	Incomplete counts made at Anderson Cottonwood Irrigation District Dam at Redding by U. S. Bureau of Reclamation in 1940-41, and by the U. S. Fish and Wildlife Service in 1942, Fry (1961).
1942	3,000	Incomplete counts made at Anderson Cottonwood Irrigation District Dam at Redding by U. S. Bureau of Reclamation in 1940-41, and by the U. S. Fish and Wildlife Service in 1942, Fry (1961).
1943	6,000	Count by U. S. Fish and Wildlife Service at Keswick Dam, Fry (1961).
1944	12,000	Incomplete counts at Balls Ferry counting rack by the U.S. Fish and Wildlife service, includes fish transferred from Balls Ferry to Coleman Hatchery (10,000 adults); Count by U. S. Fish and Wildlife Service at Keswick Dam (2,000 adults), Fry (1961).
1945	4,000	Incomplete counts at Balls Ferry counting rack by the U.S. Fish and Wildlife service, includes fish transferred from Balls Ferry to Coleman Hatchery (3,000 adults); Count by U. S. Fish and Wildlife Service at Keswick Dam (1,000 adults), Fry (1961).
1946	27,000	Count by U. S. Fish and Wildlife Service at Keswick Dam (1,000 adults); Estimate by U. S. Fish and Wildlife Service based on spawning area surveys and/or aerial redd counts, Fry (1961).
1947	25,000	Estimate by U. S. Fish and Wildlife Service based on spawning area surveys and/or aerial redd counts, Fry (1961).
1948	9,000	Estimate by U. S. Fish and Wildlife Service based on spawning area surveys and/or aerial redd counts, Fry (1961).
1949	7,000	Estimate by U. S. Fish and Wildlife Service based on spawning area surveys and/or aerial redd counts, Azevedo and Parkhurst (1958), Fry (1961).
1950	18,000	Estimate by U. S. Fish and Wildlife Service based on spawning area surveys and/or aerial redd counts, Azevedo and Parkhurst (1958), Fry (1961).

SACRAMENTO RIVER		
YEAR	RUN SIZE	METHODOLOGY/REFERENCE
1951	5,000	Estimate by U. S. Fish and Wildlife Service based on spawning area surveys and/or aerial redd counts, and Parkhurst (1958), Fry (1961).
1952	7,000	Estimate by U. S. Fish and Wildlife Service based on spawning area surveys and/or aerial redd counts, Azevedo and Parkhurst (1958), Fry (1961).
1953	8,000	Estimate by U. S. Fish and Wildlife Service based on spawning area surveys and/or aerial redd counts, Azevedo and Parkhurst (1958), Fry (1961).
1954	9,000	Estimate by U. S. Fish and Wildlife Service based on spawning area surveys and/or aerial redd counts, Azevedo and Parkhurst (1958), Fry (1961).
1955	17,000	Estimate by U. S. Fish and Wildlife Service based on spawning area surveys and/or aerial redd counts, Azevedo and Parkhurst (1958), Fry (1961).
1956	7,000	Estimate by U. S. Fish and Wildlife Service based on spawning area surveys and/or aerial redd counts, Azevedo and Parkhurst (1958), Fry (1961).
1957-1968	No estimate	Population estimates were made primarily for fall-run fish due to the overlap in spawning period, it was felt that there was no basis for a separate count of spring run.
1969	20,000	Estimate is based upon periodic sampling at the U.S. Fish Wildlife Service's fish trapping facility at the Red Bluff Diversion Dam during the spring of 1969, Menchen (1970).
1970	3,652	Estimate is based upon counts through the fishway at Red Bluff Diversion Dam. Salmon were assigned to a particular run dependent upon the time of year they passed the dam, plus external appearance, and examination of the gonads of a subsample of the fish passing through the ladder. Spring run were observed passing the Dam from April 19, through July 18, 1970, Menchen (1972).
1971	5,830	Estimate is based upon counts through the fishway at Red Bluff Diversion Dam. Salmon were assigned to a particular run dependent upon the time of year they passed the dam, plus external appearance, and examination of the gonads of a subsample of the fish passing through the ladder. Spring run were observed passing the Dam from March 21, through August 21, 1970, Taylor (1973).
1972	7,346	Estimate is based upon counts through the fishway at Red Bluff Diversion Dam. Salmon were assigned to a particular run dependent upon the time of year they passed the dam, plus external appearance of the fish passing through the ladder. Spring run were observed passing the Dam from March 26, through September 9, 1972, Taylor (1974a).

SACRAMENTO RIVER		
YEAR	RUN SIZE	METHODOLOGY/REFERENCE
1973	7,762	Estimate is based upon counts through the fishway at Red Bluff Diversion Dam. Salmon were assigned to a particular run dependent upon the time of year they passed the dam, plus external appearance of the fish passing through the ladder. Spring run were observed passing the Dam from April 1, through September 22, 1973, Taylor (1974b).
1974	3,800	Estimate is based upon counts through the fishway at Red Bluff Diversion Dam. Salmon were assigned to a particular run dependent upon the time of year they passed the dam, plus external appearance of the fish passing through the ladder. Spring run were observed passing the Dam from April 14, to September 8, 1974, Taylor (1976).
1975	10,705	Estimate is based upon counts through the fishway at Red Bluff Diversion Dam. Salmon were assigned to a particular run dependent upon the time of year they passed the dam, plus external appearance of the fish passing through the ladder. Spring run were observed passing the Dam from April 6, through September 27, 1975, Hoopaugh (1978).
1976	25,983	Estimate is based upon counts through the fishway at Red Bluff Diversion Dam. Salmon were assigned to a particular run dependent upon the time of year they passed the dam, plus external appearance of the fish passing through the ladder. Spring run were observed passing the Dam from April 4, through October 10, 1976, Hoopaugh (1978).
1977	13,730	Estimate is based upon counts through the fishway at Red Bluff Diversion Dam. Salmon were assigned to a particular run dependent upon the time of year they passed the dam, plus external appearance of the fish passing through the ladder. Spring run were observed passing the Dam from March 20, through August 27, 1977. This total includes 1,908 fish that were trapped at Keswick and Red Bluff Diversion dams and transported to other streams, Hoopaugh and Knutson (1979).
1978	5,903	Estimate is based upon counts through the fishway at Red Bluff Diversion Dam. Salmon were assigned to a particular run dependent upon the time of year they passed the dam, plus external appearance of the fish passing through the ladder. Spring run were observed passing the Dam from March 19, through October 7, 1978, Knutson (1980)
1979	2,900	Estimate is based upon counts through the fishway at Red Bluff Diversion Dam. Salmon were assigned to a particular run dependent upon the time of year they passed the dam, plus external appearance of the fish passing through the ladder. Spring run were observed passing the Dam from March 18, through October 6, 1979, Reavis (1981a).
1980	9,969	Estimate is based upon counts through the fishway at Red Bluff Diversion Dam. Salmon were assigned to a particular run dependent upon the time of year they passed the dam, plus external appearance of the fish passing through the ladder. Spring run were observed passing the Dam from March 30, through October 4, 1980, Reavis (1981b).
1981	21,025	Estimate is based upon counts through the fishway at Red Bluff Diversion Dam. Salmon were assigned to a particular run dependent upon the time of year they passed the dam, plus external appearance of the fish passing through the ladder. Spring run were observed passing the Dam from April 12, through October 10, 1981, Reavis (1983).

		SACRAMENTO RIVER
YEAR	RUN SIZE	METHODOLOGY/REFERENCE
1982	23,438	Estimate is based upon counts through the fishway at Red Bluff Diversion Dam. Salmon were assigned to a particular run dependent upon the time of year they passed the dam, plus external appearance of the fish passing through the ladder. Spring run were observed passing the Dam from April 4, through October 9, 1982, Reavis (1986a).
1983	5,647	Estimate is based upon counts through the fishway at Red Bluff Diversion Dam. Salmon were assigned to a particular run dependent upon the time of year they passed the dam, plus external appearance of the fish passing through the ladder. An estimated 3,854 spring run were observed passing the Dam from April 10, through October 8, 1983. In addition, two aerial surveys on August 25, and September 19, showed an estimated 1,793 spring run spawning in the main stem Sacramento River between Red Bluff Diversion Dam and Princeton Ferry, Reavis (1986b).
1984	8,147	Estimate is based upon counts through the fishway at Red Bluff Diversion Dam. Salmon were assigned to a particular run dependent upon the time of year they passed the dam, plus external appearance of the fish passing through the ladder. Spring run were observed passing the Dam from April 1, through September 22, 1984, Kano, et al. (1996).
1985	13,460	Estimate is based upon counts through the fishway at Red Bluff Diversion Dam. Salmon were assigned to a particular run dependent upon the time of year they passed the dam, plus external appearance of the fish passing through the ladder. An estimated 10,747 spring run were observed passing the Dam from April 7, through October 12, 1985. In addition, an aerial surveys on September 16, showed an estimated 2,713 spring run spawning in the main stem Sacramento River downstream of Red Bluff Diversion Dam, Kano and Reavis (1996).
1986	22,753	Estimate is based upon counts through the fishway at Red Bluff Diversion Dam. Salmon were assigned to a particular run dependent upon the time of year they passed the dam, plus external appearance of the fish passing through the ladder. An estimated 16,691 spring run were observed passing the Dam from March 23, through September 27, 1986. In addition, an aerial survey on October 8, showed an estimated 6,062 spring run spawning in the main stem Sacramento River between Red Bluff Diversion Dam and Woodson Bridge, Kano and Reavis (1997a).
1987	12,844	Estimate is based upon counts through the fishway at Red Bluff Diversion Dam. Salmon were assigned to a particular run dependent upon the time of year they passed the dam, plus external appearance of the fish passing through the ladder. An estimated 11,205 spring run were observed passing the Dam from April 12, through October 3, 1987. In addition, an aerial survey on October 5, showed an estimated 1,639 spring run spawning in the main stem Sacramento River between Red Bluff Diversion Dam and Woodson Bridge, Kano and Reavis (1997b).
1988	9,781	Estimate is based upon counts through the fishway at Red Bluff Diversion Dam. Salmon were assigned to a particular run dependent upon the time of year they passed the dam, plus external appearance of the fish passing through the ladder from Feb. 14 through Dec 3. An estimated 11,205 spring run were observed passing the Dam, Kano and Reavis (1997a).

SACRAMENTO RIVER		
YEAR	RUN SIZE	METHODOLOGY/REFERENCE
1989	5,255	Estimate is based upon counts through the fishway at Red Bluff Diversion Dam. Salmon were assigned to a particular run dependent upon the time of year they passed the dam, plus external appearance of the fish passing through the ladder from Apr.16 through Nov. 25.
1990	3,922	Estimate is based upon counts through the fishway at Red Bluff Diversion Dam. Salmon were assigned to a particular run dependent upon the time of year they passed the dam, plus external appearance of the fish passing through the ladder from Apr. 8 through Dec. 1.
1991	773	Estimate is based upon counts through the fishway at Red Bluff Diversion Dam. Salmon were assigned to a particular run dependent upon the time of year they passed the dam, plus external appearance of the fish passing through the ladder from May 5 through Nov. 30.
1992	431	Estimate is based upon counts through the fishway at Red Bluff Diversion Dam. Salmon were assigned to a particular run dependent upon the time of year they passed the dam, plus external appearance of the fish passing through the ladder from Apr. 3 through Oct. 31
1993	388	Estimate is based upon counts through the fishway at Red Bluff Diversion Dam. Salmon were assigned to a particular run dependent upon the time of year they passed the dam, plus external appearance of the fish passing through the ladder from May 7 through Oct. 16.
1994	740	Estimate is based upon counts through the fishway at Red Bluff Diversion Dam. Salmon were assigned to a particular run dependent upon the time of year they passed the dam, plus external appearance of the fish passing through the ladder from May 21 through Sep. 17.
1995	395	Estimate is based upon counts through the fishway at Red Bluff Diversion Dam. Salmon were assigned to a particular run dependent upon the time of year they passed the dam, plus external appearance of the fish passing through the ladder from May 14 through Sep. 16.
1996	292	Estimate is based upon counts through the fishway at Red Bluff Diversion Dam. Salmon were assigned to a particular run dependent upon the time of year they passed the dam, plus external appearance of the fish passing through the ladder from May 12 though Sep. 14.
1997	189	Estimate is based upon counts through the fishway at Red Bluff Diversion Dam. Salmon were assigned to a particular run dependent upon the time of year they passed the dam, plus external appearance of the fish passing through the ladder from May 11 through Sep. 13.

CLEAR CREEK		
YEAR	RUN SIZE	METHODOLOGY/REFERENCE
1956	No estimate	Spring run were observed for the first time since 1949, Azevedo and Parkhurst (1958).
1957-1959	No survey	No surveys were conducted in the spring run habitat above Saeltzer Dam during these year, Hallock and Van Woert (1957), Mahoney (1958), CDFG (1959).
1960	0	Aerial surveys and one survey on the ground were made upstream of Saeltzer Dam with no salmon or evidence of spawning observed, Mahoney (1962).
1961-1963	No survey	No surveys were conducted in the spring run habitat above Saeltzer Dam during these years, Elwell (1962), Menchen (1963), Menchen (1964).
1964	No survey	No surveys were conducted in the spring run habitat above Saeltzer Dam, however a trap was installed in the upper end of the tunnel fishway which collected nine salmon between October 30 and November 4, which were all identified as fall run, Menchen (1965).
1965-1976	No survey	No surveys were conducted in the spring run habitat above Saeltzer Dam during these years, Menchen (1966), (1967), (1968), (1969), (1970), (1972): Taylor (1973), (1974a), (1974b), (1976); Hoopaugh (1977), (1978).
1977	158	Fish were hauled to Clear Creek from Keswick Dam, Hoopaugh and Knutson (1979).
1978-1992	No survey	No surveys were conducted in the spring run habitat above Saeltzer Dam during these years, Knutson (1980); Reavis (1981a), (1981b), (1983), (1986a), (1986b); Kano, Reavis and Fisher (1996); Kano and Reavis (1996), (1997a,b).
1993	No estimate	One fish observed below Saeltzer Dam in the period April-June, as part of evaluation of Feather River Hatchery juvenile (brood year 1990) introductions, Harvey (1995b).
1994	No estimate	No fish observed below Saeltzer Dam in the period April-June, as part of evaluation of Feather River Hatchery juvenile (brood year 1990, 1991) introductions, Harvey (1995b).
1995	No estimate	Two fish observed below Saeltzer Dam in the period April-June, as part of evaluation of Feather River Hatchery juvenile (brood year 1991, 1992) introductions, Harvey (1995b).
1996-1997	No estimate	

BATTLE CREEK		
YEAR	RUN SIZE	METHODOLOGY/REFERENCE
1943-1945	>=500	Count by U.S. Fish and Wildlife Service at Coleman Hatchery, Fry (1961).
1946	>=2500	Count by U.S. Fish and Wildlife Service at Coleman Hatchery of 500 fish or less, and 2,000 natural spawners based on spawning area surveys and/or redd counts, Fry (1961).
1947	1,000	Estimate by U.S. Fish and Wildlife Service based on spawning area surveys and/or aerial redd counts, Fry (1961).
1948	>=500	Estimate by U.S. Fish and Wildlife Service based on spawning area surveys and/or aerial redd counts, Azevedo and Parkhurst (1958), Fry (1961).
1949	200	Estimate by U.S. Fish and Wildlife Service based on spawning area surveys and/or aerial redd counts, Azevedo and Parkhurst (1958)
	>=500	Estimate was based upon rounded number from U.S. Fish and Wildlife Service, Fry (1961).
1950	1,000	Estimate by U.S. Fish and Wildlife Service based on spawning area surveys and/or aerial redd counts, Azevedo and Parkhurst (1958), Fry (1961).
1951	1,832	Estimate by U.S. Fish and Wildlife Service based on spawning area surveys and/or aerial redd counts, Azevedo and Parkhurst (1958)
	2,000	Estimate was based upon rounded number from U.S. Fish and Wildlife Service, Fry (1961).
1952	1,700	Estimate by U.S. Fish and Wildlife Service based on spawning area surveys and/or aerial redd counts, Azevedo and Parkhurst (1958)
	2,000	Estimate was based upon rounded number from U.S. Fish and Wildlife Service, Fry (1961).
1953	1,800	Estimate by U.S. Fish and Wildlife Service based on spawning area surveys and/or aerial redd counts, Azevedo and Parkhurst (1958)
	2,000	Estimate was based upon rounded number from U.S. Fish and Wildlife Service, Fry (1961).
1954	1,700	Estimate by U.S. Fish and Wildlife Service based on spawning area surveys and/or aerial redd counts, Azevedo and Parkhurst (1958)
	2,000	Estimate was based upon rounded number from U.S. Fish and Wildlife Service, Fry (1961).

BATTLE CREEK

YEAR	RUN SIZE	METHODOLOGY/REFERENCE
1955	2,200	Estimate by U.S. Fish and Wildlife Service based on spawning area surveys and/or aerial redd counts, Azevedo and Parkhurst (1958)
	2,000	Estimate was based upon rounded number from U.S. Fish and Wildlife Service, Fry (1961).
1956	2,000	Estimate by U.S. Fish and Wildlife Service based on spawning area surveys and/or aerial redd counts, Azevedo and Parkhurst (1958), Fry (1961).
1957-1993	No estimate	Annual Department spawning stock reports consistently mention spring run in Battle Creek. Spring run were observed in North Battle Creek, near the Mouth of Digger Creek during the spring and summer of 1970, Menchen (1972). Several spring run were seen near the Coleman Fish Hatchery barrier in June 1971, Taylor (1973). Several spring run were seen near the Coleman Fish Hatchery barrier in June 1972, Taylor (1974a). Several spring run were seen near the Coleman Fish Hatchery barrier in May and June 1973, Taylor (1974b). Several spring run were seen near the Coleman Fish Hatchery barrier in June 1974, Taylor (1976). Several spring run (less than 10) were seen on upper Battle Creek near Darrah Springs Hatchery after a high run-off period during June 1975, Hoopaugh (1977).
1994	No estimate	
1995	66	Estimate is based upon U.S. Fish and Wildlife Service counts of fish passing the Coleman Hatchery barrier from March through July, Croci (1996).
1996	40	Estimate is based upon U.S. Fish and Wildlife Service counts of fish passing the Coleman Hatchery barrier from March through July. Adult were observed in the upper sections of Battle Creek through the end of August, while two redds were observed in the North Fork between Wildcat Dam and County Road A-6 bridge on September 17, Croci (1996).
1997	101	Estimate is based upon U.S. Fish and Wildlife Service counts of fish passing the Coleman Hatchery barrier from March through July. Tissue samples of the first fourteen fish were analyzed, with five identified as winter run, and the remainder exhibiting significant uncertainty as to race. Croci (pers. com.)

ANTELOPE CREEK

YEAR	RUN SIZE	METHODOLOGY/REFERENCE
1953	127	Fish seined from below dam (removed after 1960), Unpublished Memo (Region 1, CDFG)
1956	253	Fish seined at dam on June 12, 1956, Hallock (1957).
	800	Azevedo and Parkhurst (1958), Fry (1961).
1959	40	Fish observed at dam on April 21, 1959, Van Woert (1959).
	50	Azevedo and Parkhurst (1958).
1960-1982	No surveys	Annual CDFG spawning stock reports consistently mention that spring-run salmon are known to enter Antelope Creek, however no surveys were conducted during this period.
1983	59	U.S. Forest Service personnel estimated the population based upon visual observation of 20 live fish, Reavis (1986a).
1984	No estimate	U.S. Forest Service personnel observed 1 carcass and 3 redds. Annual CDFG spawning stock reports consistently mention that spring-run salmon are known to enter Antelope Creek, however no surveys were conducted during this period.
1985	No estimate	Annual CDFG spawning stock reports consistently mention that spring-run salmon are known to enter Antelope Creek, however no surveys were conducted during this period.
1986	No estimate	CDFG snorkel survey found 1 adult spring run, Harvey (1996c).
1987	No estimate	CDFG snorkel found 0 adult spring run, Harvey (1996c)
1988	No estimate	CDFG observed 4 spring run at LMMWC Diversion Dam, Harvey (1996c).
1989	2	A Snorkel survey was conducted on August 1 and 15 from McClure Place to 2 miles downstream of Paynes Place crossing, Harvey (1996c).
1990	1	A Snorkel survey was conducted on August 6 and 7 from South Fork Antelope Creek Campground to North and South Fork confluence, and from North and South Fork conflence downstream to Paynes Place crossing, Harvey (1996c).
1991	0	A snorkel survey was conducted on August 12 from North and South Fork confluence downstream to Paynes Place crossing, Harvey (1996c).
1992	0	A snorkel survey was conducted on August 13 from North and South Fork confluence downstream to Paynes Place crossing, Harvey (1996c).

ANTELOPE CREEK		
YEAR	RUN SIZE	METHODOLOGY/REFERENCE
1993	3	A snorkel survey was conducted on August 9 and 13 from North and South Fork confluence to two miles downstream of Paynes Place crossing, Harvey (1996c).
1994	0	A snorkel survey was conducted on August 1 from Round Mountain Creek on South Fork downstream to North and South Fork confluence, and from North and South Fork confluence downstream to Paynes Place crossing, Harvey (1996c).
1995	7	Snorkel surveys conducted on July 26, 28, 31, and August 2, which included reaches from McClure Place to South Fork confluence; South Fork at falls below South Fork Campgrounds and the main stem from the North and South Fork confluence to 2 miles downstream of Paynes Place crossing, Harvey (1996c).
1996	1	A snorkel survey was conducted on July 31 from McClure Place to South Fork confluence, South Fork from Round Mouuntain Creek to North Fork confluence, and mainstem from North and South Fork confluence to two miles downsteam of Paynes Place crossing, Harvey (1996b).
1997	0	Snorkel survey was conducted on July 30, in the reach from McClure Place to South Fork confluence; South Fork from Round Mountain Creek to North Fork confluence, the main stem from North and South Fork confluence to 2 miles downstream of Paynes Creek crossing, Harvey (1997b).

MILL CREEK		
YEAR	RUN SIZE	METHODOLOGY/REFERENCE
1947	3,000	Estimate by U.S. Fish and Wildlife Service based on spawning area surveys and/or aerial redd counts, Fry (1961).
1948	2,000	Estimate by U.S. Fish and Wildlife Service based on spawning area surveys and/or aerial redd counts, Fry (1961).
1949	1,200	Estimate by U.S. Fish and Wildlife Service based on spawning area surveys and/or aerial redd counts, Azevedo and Parkhurst (1958), Fry (1961).
1950	2,000	Estimate by U.S. Fish and Wildlife Service based on spawning area surveys and/or aerial redd counts, Azevedo and Parkhurst (1958), Fry (1961).
1951	300	Estimate by U.S. Fish and Wildlife Service based on spawning area surveys and/or aerial redd counts, Fry (1961).
1952	2,100	Estimate by U.S. Fish and Wildlife Service based on spawning area surveys and/or aerial redd counts, Azevedo and Parkhurst (1958), Fry (1961).
1953	3,485	Estimate by U.S. Fish and Wildlife Service based on spawning area surveys and/or aerial redd counts, Azevedo and Parkhurst (1958), Fry (1961).
1954	1,789	Estimate was based upon ladder counts at Clough Dam, Azevedo and Parkhurst (1958), Fry (1961), Van Woert (1964).
1955	2,967	Estimate was based upon ladder counts at Clough Dam, Azevedo and Parkhurst (1958), Fry (1961), Van Woert (1964).
1956	2,233	Estimate was based upon ladder counts at Clough Dam, Azevedo and Parkhurst (1958), Fry (1961), Van Woert (1964).
1957	1,203	Estimate was based upon ladder counts at Clough Dam, Azevedo and Parkhurst (1958), Fry (1961), Van Woert (1964), CDFG (1967).
1958	2,212	Spring run were counted passing through the fish ladder on Clough Dam, CDFG (1959), Van Woert (1964).
1959	1,580	Spring run were counted passing through the fish ladder on Clough Dam, Mahoney (1960), Van Woert (1964).
1960	2,368	Spring run were counted passing through the fish ladder on Clough Dam, Mahoney (1962), Van Woert (1964).
1961	1,245	Spring run were counted passing through the fish ladder on Clough Dam, Elwell (1962), Van Woert (1964).
1962	1,692	Spring run were counted passing through the fish ladder on Clough Dam, Menchen (1963), Van Woert (1964)..
1963	1,315	Spring run were counted passing through the fish ladder on Clough Dam, Menchen (1964). Van Woert (1964).

MILL CREEK

YEAR	RUN SIZE	METHODOLOGY/REFERENCE
1964	1,628	Spring run were counted passing through the fish ladder on Clough Dam between February 25 and June 28 1964, Menchen (1965).
1965	No estimate	Menchen (1966).
1966	No estimate	Menchen (1967).
1967	No estimate	Menchen (1968).
1968	No estimate	Menchen (1969).
1969	No estimate	Menchen (1970).
1970	1,500	Three survey trips were made on upper Mill Creek on October 4, 11, and 17, 1970. The reach covered ran from 4.5 miles above the Ponderosa Way Bridge at Blackrock to the mouth of Little Mill Creek. Sixty six carcasses and 162 live salmon were observed. No basis is given for the expansion, Menchen (1972).
1971	1,000	Eleven days were spent (September 27-29, October 4-7, 12-15) surveying upper Mill Creek from 3 miles above Black Rock downstream to the mouth of Little Mill Creek. Recovery conditions were reported to be good. The counts totaled 110 live salmon, 4 dead salmon and 115 redds. Additional fish were observed just upstream of the Highway 36 road crossing on October 9 and included 5 carcasses, 2 live, and 2 redds. Estimate was based only on the first survey with no basis given for the expansion, Taylor (1973).
1972	500	Six days were spent (October 2-7) surveying upper Mill Creek from 3 miles above Black Rock to Pape Place near the mouth of Little Mill Creek. Recovery conditions were reported as good, with 12 carcasses and 8 live fish observed. No basis was given for the expansion, Taylor (1974a).
1973	1,700	Sixteen days were spent between September 10 and October 3, surveying upper Mill Creek between Black Rock and the mouth of Little Mill Creek. Recovery conditions during three of the trips were described as excellent, while during the fourth visibility was poor. Thirty carcasses were recovered and 198 live salmon were observed. No basis was given for the expansion, Taylor (1974).
1974	1,500	Thirteen days were spent between September 17 and October 16, 1974 surveying upper Mill Creek between Black Rock and the mouth of Little Mill Creek. Recovery conditions were described as excellent with 5 carcasses and 119 live salmon observed. No basis was given for the expansion, Taylor (1976).
1975	3,500	Thirteen days were spent surveying upper Mill Creek between the upper end of Childs Meadows and the mouth of Little Mill Creek, between September 4, and October 21, 1975. Recovery conditions were described as excellent with 12 carcasses and 330 live salmon observed. No basis was given for the expansion, Hoopaugh (1978).

MILL CREEK

YEAR	RUN SIZE	METHODOLOGY/REFERENCE
1976	No estimate	One survey was conducted on September 29, 1976, with 87 live fish observed. No estimate was made, Hoopaugh (1978).
1977	563	It was assumed that no spring run migrated into Mill Creek during 1977 due to the drought conditions, however, 563 spring run were transported from the Keswick trap into Mill Creek. Fifteen survey trips were conducted on upper Mill Creek between August 2, and October 10, 1977, during which 14 carcasses, 11 live salmon and 23 redds were noted, Hoopaugh and Knutson (1979).
1978	925	Eight surveys were made on upper Mill Creek from Highway 36 to Blackrock, between September 13, and October 10, 1978. A total of 37 carcasses and 76 redds were counted. Estimate is based upon a 4% recovery rate, with no discussion of how recovery rate was developed, Knutson (1980).
1979	No estimate	No survey was conducted during 1979, Reavis (1981a).
1980	500	Three survey trips were conducted in upper Mill Creek from Highway 36 to Blackrock with eleven redds and two live salmon observed. No basis was given for the expansion, Reavis (1981b).
1981	No estimate	One survey was conducted from Highway 36 to Blackrock with 15 live salmon and 2 redds observed. No estimate was made, Reavis (1983).
1982	700	Seven surveys were conducted from Highway 36 to 2 miles below Blackrock. Thirty-seven redds and 33 live salmon were observed. No basis was given for the expansion, Reavis (1986a).
1983	No estimate	Four surveys were conducted between Highway 36 and 2 miles below Blackrock, with only 1 carcass observed. No population estimate was made, Reavis (1986b).
1984	191	Four survey trips were made between Highway 36 and 2 miles downstream of Blackrock from September 12-28, 1984, with 13 carcasses observed. No estimate was made, Kano, et al. (1996). In addition ladder counts were conducted at Clough Dam from April 5, to July 6, 1984, during which 191 adult spring run were counted, Fisher (1984).
1985	121	Eight surveys were made between Highway 36 and 2 miles downstream of Blackrock from September 6, to October 23, 1985, during which 59 live adults were observed. No population estimate was made, however U.S. Forest Service personnel conducted a snorkel survey and estimated the population to be 121 fish, Kano and Reavis (1996)
1986	291	U.S. Fish and Wildlife Service based the estimate upon fish passing through the fish ladder at Clough Dam, Kano and Reavis (1997a). No surveys were conducted by CDFG.
1987	89	Estimate was based upon counts made at the Clough Dam fish ladder by U.S. Fish and Wildlife Service, Kano and Reavis (1997b).

MILL CREEK		
YEAR	RUN SIZE	METHODOLOGY/REFERENCE
1988	572	Electronic counter was installed in the fish ladder on Clough Dam, and periodically verified through visual observation, Painter (1988).
1989	561	Electronic counter was installed in the fish ladder on Clough Dam, and periodically verified through visual observation, Painter (1989).
1990	844	Electronic counter was installed in the fish ladder on Clough Dam, and periodically verified through visual observation, Painter (1990).
1991	319	Electronic counter was installed in the fish ladder on Clough Dam, and periodically verified through visual observation, Painter (1991).
1992	237	Electronic counter was installed in the fish ladder on Clough Dam, and periodically verified through visual observation, Painter (1992).
1993	61	Electronic counter was installed in the fish ladder on Clough Dam, and periodically verified through visual observation, Harvey (1993b).
1994	723	Electronic counter was installed in the fish ladder on Clough Dam, and periodically verified through visual observation, Harvey (1994b).
1995	320	Electronic counter was installed in the fish ladder on Clough Dam, and periodically verified through visual observation, Harvey and Fisher (1996).
1996	252	Electronic counter was installed in the fish ladder on Clough Dam, and periodically verified through visual observation, Harvey and Fisher (1997).
1997	200	Estimate based upon redd count (100 redds) of entire spawning habitat, Harvey (Personal communication 1997).

DEER CREEK		
YEAR	RUN SIZE	METHODOLOGY/REFERENCE
1940	268	Weir counts were conducted by U.S. Fish and Wildlife Service from April 12, through May 22, 1940, during which 268 spring run adults were counted, Cramer and Hammack, (1952).
1941	635 (636)	Weir counts were conducted by U.S. Fish and Wildlife Service from May 20, through July 6, 1941, during which 635 spring run adults were counted. In addition 636 fish were transported from Keswick Dam on the Sacramento River, Cramer and Hammack, (1952).
1942	1,108	Weir counts were conducted by U.S. Fish and Wildlife Service from May 13, through July 2, 1942, during which 1,108 spring run adults were counted, Cramer and Hammack, (1952).
1943	812 (3,972)	Weir counts were conducted by U.S. Fish and Wildlife Service from February 20, through June 16, 1943, during which 812 spring run adults were counted. In addition 3,972 fish were transported from Keswick Dam on the Sacramento River, Cramer and Hammack, (1952).
1944	2,692 (6,604)	Weir counts were conducted by U.S. Fish and Wildlife Service from January 1, through June 30, 1944, during which 2,692 spring run adults were counted. In addition 6,604 fish were transported from Keswick Dam on the Sacramento River, Cramer and Hammack, (1952).
1945	3,363 (1,504)	Weir counts were conducted by U.S. Fish and Wildlife Service from April 13, through June 23, 1945, during which 3,363 spring run adults were counted. In addition 1,504 fish were transported from Keswick Dam on the Sacramento River, Cramer and Hammack, (1952).
1946	4,271 (147)	Weir counts were conducted by U.S. Fish and Wildlife Service from April 11, through June 19, 1946, during which 4,271 spring run adults were counted. In addition 147 fish were transported from Keswick Dam on the Sacramento River, Cramer and Hammack, (1952).
1947	2,669	Weir counts were conducted by U.S. Fish and Wildlife Service from April 11, through May 15, 1947, during which 2,669 spring run adults were counted, Cramer and Hammack, (1952).
1948	2000	Estimate by U.S. Fish and Wildlife Service based on spawning area surveys and/or aerial redd counts, plus incomplete weir count, Fry (1961).
	419	Weir counts were conducted by U.S. Fish and Wildlife Service from May 11, through June 30, 1948, during which 419 spring run adults were counted, Cramer and Hammack, (1952).
1949	1,200	Estimate by U.S. Fish and Wildlife Service based on spawning area surveys and/or aerial redd counts, Azevedo and Parkhurst (1958), Fry (1961).

DEER CREEK		
YEAR	RUN SIZE	METHODOLOGY/REFERENCE
1950	2,000	Estimate by U.S. Fish and Wildlife Service based on spawning area surveys and/or aerial redd counts, Azevedo and Parkhurst (1958), Fry (1961).
1951	2,300	Estimate by U.S. Fish and Wildlife Service based on spawning area surveys and/or aerial redd counts, Azevedo and Parkhurst (1958), Fry (1961).
1952	1,800	Estimate by U.S. Fish and Wildlife Service based on spawning area surveys and/or aerial redd counts, Azevedo and Parkhurst (1958), Fry (1961).
1953	2,475	Estimate by U.S. Fish and Wildlife Service based on spawning area surveys and/or aerial redd counts, Azevedo and Parkhurst (1958), Fry (1961).
1954	2,500	Estimate by U.S. Fish and Wildlife Service based on spawning area surveys and/or aerial redd counts, Azevedo and Parkhurst (1958), Fry (1961).
1955	2,900	Estimate by U.S. Fish and Wildlife Service based on spawning area surveys and/or aerial redd counts, Azevedo and Parkhurst (1958), Fry (1961).
1956	2,600	Estimate by U.S. Fish and Wildlife Service based on spawning area surveys and/or aerial redd counts, Azevedo and Parkhurst (1958), Fry (1961).
1957	No estimate	No surveys were conducted for spring run during 1957, Mahoney (1958).
1958	No estimate	Survey was conducted in September in the reach between Highway 36 and lower Deer Creek Falls, with 3 live salmon and 2 redds observed. An attempt was made to examine lower reaches of Deer Creek by air, however this technique was judged to be unsatisfactory for the conditions, CDFG (1959).
1959	No estimate	No surveys were conducted for spring run during 1959, Mahoney (1960).
1960	No estimate	No surveys were conducted for spring run during 1960, Mahoney (1962).
1961	No estimate	No surveys were conducted for spring run during 1961, Elwell (1962).
1962	No estimate	No surveys were conducted for spring run during 1962, Menchen (1963).
1963	2,302	Counting station was installed at Stanford Vina Dam with 1,702 fish counted fish passing through the fish ladder between March 20, and June 12, 1963. In addition it was estimated that 300 to 500 salmon died below the dam due to low flows and high water temperatures in June, Menchen (1964).

DEER CREEK		
YEAR	RUN SIZE	METHODOLOGY/REFERENCE
1964	3,188	Counting station was installed at Stanford Vina Dam and counted 2,878 fish passing through the fish ladder from February 19, through May 19, 1964. In addition 210 salmon were rescued in lower Deer Creek in May due to low flows and high water temperatures, with 60 placed back in Deer Creek and the remainder released in the Sacramento River. An additional 100 fish were observed in the pool below the dam during June, Menchen (1965).
1965	No estimate	No surveys were conducted for spring run during 1965, Menchen (1966).
1966	No estimate	No surveys were conducted for spring run during 1966, Menchen (1967).
1967	No estimate	No surveys were conducted for spring run during 1967, Menchen (1968).
1968	No estimate	No surveys were conducted for spring run during 1968, Menchen (1969).
1969	No estimate	No surveys were conducted for spring run during 1969, Menchen (1970).
1970	2,000	Two surveys were made during late September in the reach near lower Deer Creek Falls, during which 30 carcasses and 200 live fish were observed. No basis for the expansion was presented, Menchen (1972).
1971	1,500	Ten days (September 13-17, 20-24, 1971) were spent surveying Deer Creek from Ponderosa Way to Deer Creek Meadows. Survey conditions were rated as good with a total of 85 live salmon and 122 redds observed. It was noted that salmon were reported spawning below Ponderosa Way in the area not surveyed. No basis was given for the expansion, Taylor (1973).
1972	400	Sixteen days from September 3 to 26 were spent surveying Deer Creek from one mile below the PG&E power line crossing to upper Deer Creek Falls. Salmon were seen spawning as early as September 3, Ponderosa Way, and as late as September 27, at the A-line crossing. Survey conditions were rated as good with 2 carcasses, 9 live salmon and 6 redds observed. No basis was given for the expansion, Taylor (1974a).
1973	2,000	Nine days were spent from September 7 to October 12, 1973, surveying Deer Creek from 1 mile below the PG&E power line crossing to upper Deer Creek falls. Salmon were noted spawning as early as September 27 at Graham Crossing and as late as October 12 near upper Deer Creek Falls. Survey conditions were rated as good with 20 carcasses, 98 live salmon and 107 redds observed. No basis was given for the expansion, Taylor (1974b).
1974	3,500	Seven days were spent between September 18, and October 18, 1974, surveying Deer Creek from 1 mile below the PG&E power line crossing to upper Deer Creek Falls. Survey conditions were rated as good with 212 live salmon and 158 redds observed. No basis was given for the expansion, Taylor (1976).

DEER CREEK		
YEAR	RUN SIZE	METHODOLOGY/REFERENCE
1975	8,500	Spring run salmon were observed from one mile below the PG&E power line crossing to upper Deer Creek Falls. Recovery conditions were rated as excellent with 268 carcasses and 936 live salmon observed. No basis was given for the expansion, Hoopaugh (1977).
1976	No estimate	No complete survey was done, however on September 30, the reach between A-Line Bridge and Lower Deer Creek Falls was surveyed with 2 carcasses, 42 live salmon and 21 redds observed. No estimate was made, Hoopaugh (1978).
1977	(467)	It was assumed that no spring run entered Deer Creek in the spring of 1977 due to drought conditions, however 467 spring run adults were transported from the Red Bluff Diversion Dam to Deer Creek. Subsequent surveys between August 19 and September 30, 1977, in the reach from Ponderosa Way to Upper Deer Creek Falls observed 3 carcasses, 6 live salmon and 17 redds, Hoopaugh and Knutson (1979).
1978	1,200	Five survey trips between September 15, and October 5, 1978 were made in the reach from Ponderosa Way to Upper Deer creek Falls, with 48 carcasses, and 155 redds observed. The population estimate was based upon an estimated 4% carcass recovery rate, Knutson (1980).
1979	No estimate	Two survey trips were made on Upper Deer Creek in the reach between Ponderosa Way and Upper Deer Creek Falls. No estimate was made due to insufficient data, Reavis (1981a).
1980	1,500	Seven survey trips were made in the reach from Ponderosa Way to Upper Deer Creek Falls, with 89 live salmon and 105 redds observed. No basis was given for the expansion, Reavis (1981b).
1981	No estimate	Four survey trips were made in the reach from Ponderosa Way to Upper Deer Creek Falls, with a total of 9 redds observed. Based upon the limited observation, no estimate was made, Reavis (1983).
1982	1,500	Eight survey trips were made in the reach from Ponderosa Way to Upper Deer Creek Falls, with 129 live salmon and 86 redds observed. No basis was given for the expansion, Reavis (1986a).
1983	500	Eleven survey trips were made between September 12 and October 11, 1983, in the reach from Ponderosa Way to Upper Deer Creek Falls with 16 live salmon and 90 redds observed. No basis was given for the expansion, Reavis (1986b).
1984	No estimate	Five survey trips were made between September 12, and October 11, 1984, in the reach from Ponderosa Way to Upper Deer Creek Falls, with 9 live salmon and 22 redds observed. No estimate was made based upon the limited observations, Kano, et al. (1996).

DEER CREEK		
YEAR	RUN SIZE	METHODOLOGY/REFERENCE
1985	301	A limited survey of the reach from Ponderosa Way to Upper Deer Creek Falls was conducted with 103 live salmon and 26 redds observed. No estimate was made based upon the limited observations, however based upon U.S. Forest Service snorkel surveys the population estimated to be about 301 salmon, Kano and Reavis (1996).
1986	543	Surveys were made between September 12 and October 11, 1986, in selected areas within the reach from Ponderosa Way to Upper Deer Creek Falls, with 107 live salmon observed. No population estimate was made based upon the observations, however USFWS made counts at the Stanford Vina Dam fish ladder and estimated the population at 543 fish, Kano and Reavis (1997a).
1987	200	Estimate was made based upon snorkel survey conducted by U.C. Davis staff and the ratio developed for the 1986 run between fish seen in an index stream reach and adults immigrating past Stanford Vina Dam, Kano and Reavis (1997b).
1988	371	U.S. Forest Service personnel survey developed estimate from snorkel survey and the 1986 indicator reach population ratio value determined by Ekman (1987), as reported by McFarland (1991).
1989	77	U.S. Forest Service personnel survey developed estimate from snorkel survey and the 1986 indicator reach population ratio value determined by Ekman (1987), as reported by McFarland (1991).
1990	458	U.S. Forest Service personnel survey developed estimate from snorkel survey and the 1986 indicator reach population ratio value determined by Ekman (1987), as reported by McFarland (1991).
1991	448	U.S. Forest Service personnel survey developed estimate from snorkel survey and the 1986 indicator reach population ratio value determined by Ekman (1987), as reported by McFarland (1992).
1992	209	Estimate was based upon snorkel survey of entire holding habitat, Harvey (1992).
1993	259	Estimate was based upon snorkel survey of entire holding habitat, Harvey (1993a).
1994	485	Estimate was based upon snorkel survey of entire holding habitat, Harvey (1994a).
1995	1,295	Estimate was based upon snorkel survey of entire holding habitat, Harvey (1995c).
1996	614	Estimate was based upon snorkel survey of entire holding habitat, Harvey (1996d).
1997	466	Estimate was based upon snorkel survey of entire holding habitat, Harvey (1997a).

BIG CHICO CREEK		
YEAR	RUN SIZE	METHODOLOGY/REFERENCE
1956	500	Estimate based upon observations of local warden Gene Mercer.
1957	248	Warden Gene Mercer observed 208 spring run move past One Mile Pool Dam by May 5, 1957. In addition, he knew of 40 adults that died at One Mile Pool and heard of at least 40 more being poached, Yoshioka (1991).
1958	1,000	Three hundred spring run were trapped below the Iron Canyon barrier and transported above the barrier. Two survey trips were made in the fall from the below Iron Canyon to Higgins Hole. Estimate is based primarily upon counts of fish rescued with no basis given for expansion, CDFG (1958), Fry (1961).
1959	200	No basis for the estimate is given, Mahoney (1960), Fry (1961).
1960	No estimate	One survey was conducted with several spring run adults observed, however no estimate was made, Mahoney (1962).
1961	No estimate	No surveys were conducted for spring run during 1961, Elwell (1962).
1962	200	Two survey trips were conducted on September 19, and October 10, 1962, in the reach from Salmon Hole to Higgins Hole, with 3 carcasses and 13 live salmon observed. Estimate is based upon an assumed 8% observation rate, with no basis for how the rate was derived, Menchen (1963).
1963	500	Two survey trips were made in the reach from Salmon Hole to Higgins Hole with the comment that most of the fish were seen near Higgins Hole, while 20 live salmon were seen in the Iron Canyon area. No basis was given for the expansion, Menchen (1964).
1964	100	One survey was made with most fish seen in the area near Higgins Hole, however the numbers of fish were not given. The estimate is based upon live fish, Menchen (1965).
1965	50	One survey was made with most fish seen in the area near Higgins Hole, however the numbers of fish were not given. The estimate is based upon live fish, Menchen (1966).
1966	50	One survey was made in the reach between Ponderosa Way and Higgins Hole, with 7 live salmon and 2 redds observed. No basis was given for the expansion, Menchen (1967).
1967	150	One survey was conducted on September 25, 1967, from Ponderosa way to Higgins Hole, 22 live salmon observed. No basis was given for the expansion, Menchen (1968).
1968	175	One survey was made on September 27, from just below Ponderosa Way to Higgins Hole, with 35 live salmon and 14 redds observed. No basis was given for the expansion, Menchen (1969).

BIG CHICO CREEK		
YEAR	RUN SIZE	METHODOLOGY/REFERENCE
1969	200	One survey was made on October 14 from just below Ponderosa Way to Higgins Hole, with 13 carcasses, 13 live salmon and 6 redds observed. No basis was given for the expansion, Menchen (1970).
1970	No estimate	Surveys were conducted on October 1 and 14, 1970, in the reach from Ponderosa Way to Higgins Hole, with no salmon observed. A few salmon were reportedly observed in Bidwell Park in the spring, Menchen (1972)
1971	0	Three surveys were conducted in select reaches on October 19, October 28, and November 5, 1971, with no salmon or other signs of previous spawning observed, Taylor (1973).
1972	No estimate	No survey was conducted during 1972, Taylor (1974a).
1973	50	Twenty salmon were observed in Higgins Hole on September 18, while during a second survey on October 10, no live salmon or carcasses were observed. No basis was given for the expansion, Taylor (1974b).
1974	100	Thirty-five salmon were observed in Higgins Hole on September 6, 1974, while no additional surveys were conducted. No basis was given for the expansion, Taylor (1976).
1975-76	No estimate	No surveys were made, Hoopaugh (1977), Hoopaugh (1978).
1977	(332)	Adult Sacramento River spring run (332) were transported from Red Bluff into Big Chico Creek. Substantial mortalities occurred during the summer and it was estimated that 100 fish survived to spawn, Hoopaugh and Knutson (1979).
1978-1982	No estimate	Knutson (1980), Reavis (1981a), Reavis (1981b), Reavis (1983), Reavis (1986a).
1983	No estimate	Limited surveys were conducted with on carcass seen by the local warden during the summer. No salmon were observed during a survey of Higgins Hole, Reavis (1986b).
1984	0	One survey was conducted on October 2, 1984 from Ponderosa Way to Higgins Hole, with no salmon observed. It was concluded that no spring run spawned in Big Chico Creek this year, Kano, et al. (1996).
1985	0	One survey was conducted on July 19, 1985, in the reach from Bidwell Park to Higgins Hole with no salmon observed. It was felt that low flows prevented spring run salmon from entering the creek this year, Kano and Reavis (1996).
1986-1988	No estimate	No surveys were made, Kano (1997), Kano and Reavis (1997a,b).
1989	7	A snorkel survey was conducted, Faustini (1989).
1990	0	A snorkel survey was conducted, Yoshioka (1990).

BIG CHICO CREEK		
YEAR	RUN SIZE	METHODOLOGY/REFERENCE
1991	No estimate	Brown (1995)
1992	0	A snorkel survey was conducted, Fisher (1992).
1993	38	A snorkel survey was conducted, P. Ward (Pers. Com.).
1994	2	A snorkel survey was conducted, Brown (1997).
1995	200	Cooperative helicopter rescue - 100 salmon were moved from Salmon Hole to Higgin's Hole and 100 were visually observed upstream of Salmon Hole in an area in which they could not be captured and moved, P. Ward (Pers. Com.).
1996	2	Survey conducted by Charlie Brown, Brown (1996).
1997	2	One snorkel survey was conducted on August 29, 1997. In the reach between Higgins Hole and Salmon Hole, two salmon were seen - one adult female and one male grilse, Hill (1997a).

BUTTE CREEK

YEAR	RUN SIZE	METHODOLOGY/REFERENCE
1943-1952	No surveys	Prior to 1953 there are no reliable population surveys. Fry (1961) is apparently the reference for the estimate of 500 fish or less, an estimate often referenced apparently in error by other reviewers, Campbell and Moyle (1990), Gerstung, (1990).
1953	No estimate	Previous estimate is based upon one carcass seen on November 23 between the Covered Bridge and Parrott-Phelan Dam which would therefore represent fall run rather than spring run. In addition no justification is given for the expansion factor (1:500), Meacham (1954)
1954	830	Warner (1954) documented 830 adult salmon passing the Parrott-Phelan Dam during a 21 day period from May 7, through May 27. Late rains and high flows delayed the counting effort with the likely result that many fish entered the system prior to May 7.
	500	No surveys were made during 1954. Fry (1961) is apparently the reference for the estimate of 500 fish or less, an estimate often referenced in error by other reviewers, Campbell and Moyle (1990), Gerstung (1990).
	2,000	Estimate expanded from annual carcass, redd and live salmon counts, Flint and Meyer (1977).
1955	400	Fry and Petrovich (1970).
	500	Fry (1961) is apparently the reference for the estimate of 500 fish or less, an estimate often referenced apparently in error by other reviewers, Campbell and Moyle (1990), Gerstung (1990).
	300	Estimate expanded from annual carcass, redd and live salmon counts, Flint and Meyer (1977)
1956	3,000	Hallock and Van Woert (1957), Fry (1961), Fry and Petrovich (1970), Flint and Meyer (1977), Carcass count (608 carcasses) was conducted between September 26, and October 8, which was estimated to represent 20% of the population, Warner (1957).
1957	2,192	Carcass counts (63 carcasses) were conducted from September 24, to October 8, between the Centerville Head Dam and the Centerville Powerhouse, while an additional count (194 carcasses) was conducted on September 25, from the Centerville Powerhouse to Parrott-Phelan Dam. Carcass numbers were expanded by a factor of 4 for Centerville Head Dam to Centerville Powerhouse and a factor of 10 for Centerville Powerhouse to Parrott-Phelan Dam. No justification was given for expansion factors. Live fish and redds were observed but were not included in calculation of population estimate, Mahoney (1958), Gundy et al. (1957).
	2,000	Fry (1961), Fry and Petrovich (1970).
	1,400	Estimate expanded from annual carcass, redd and live salmon counts, Flint and Meyer (1977).

BUTTE CREEK

YEAR	RUN SIZE	METHODOLOGY/REFERENCE
1958	1,100	One carcass count (104 carcasses) was conducted on October 1, between Centerville Powerhouse and Parrot-Phelan Dam, on October 2, from Centerville Head Dam to Centerville Powerhouse (1 carcass), and from Parrot-Phelan Dam to Highway 99 (6 carcasses). All carcasses were expanded by a factor of 10 with no justification given for the expansion factor. Live fish and redds were observed but were not included in calculation of the population estimate, CDFG (1959), Oates et al. (1958).
1968	1,000	Fry (1961), Fry and Petrovich (1970).
	436	Estimate expanded from annual carcass, redd and live salmon counts, Flint and Meyer (1977).
1959	500	Carcass counts were conducted on September 22, and October 6, between the Centerville Bridge and the Covered Bridge (51 carcasses), on September 23, from the Covered Bridge to Parrott-Phelan Dam (2 carcasses), and on September 24 from the Helltown Road to Centerville Bridge (1 carcass). Carcass counts were expanded by a factor of 10 without explanation. Live fish and redds were observed but were not included in the calculation of the population estimate, Mahoney (1960), White (1959), Fry (1961), Fry and Petrovich (1970).
	170	Estimate expanded from annual carcass, redd and live salmon counts, Flint and Meyer (1977).
1960	8,700	Carcass counts were conducted on September 27 and 28, between Centerville Head Dam and Centerville Powerhouse (4 carcasses); on September 28,29,30, October 3, 11, and 12 between Centerville Powerhouse and the Covered Bridge (2,630 carcasses); on October 4 and 12, between the Covered Bridge and Parrott-Phelan Dam (606 carcasses); on October 4 and 13 between Parrott-Phelan Dam and the Skyway (76 carcasses). During the month of September 280 live adults were tagged, Hallock (1960) and 128 subsequently recovered during the carcass surveys. Carcass counts were expanded based upon the mark/recapture ratio to an estimated spawning population of 6,700 adults. In addition, it was estimated that 2,000 adults died from high water temperatures in the area between the Centerville Head Dam and the Centerville Powerhouse during the summer and prior to spawning. Live fish and redds were observed throughout but were not included in the computation of the population estimate, Mahoney (1962), Young et al. (1960).
	6,700	CDFG (1990).
	7,000	Fry and Petrovich (1970).
	21,900	Estimate expanded from annual carcass, redd and live salmon counts, Flint and Meyer (1977).

BUTTE CREEK		
YEAR	RUN SIZE	METHODOLOGY/REFERENCE
1961	3,100	Carcass counts were conducted on September 21, and October 2, in the area between Centerville Head Dam and Centerville Powerhouse (259 carcasses); on September 26, 27, and October 9, and 10, in the area from the Centerville Powerhouse to the Covered Bridge (802 carcasses); on September 28, and October 10, in the area from the Centerville Powerhouse to the Covered Bridge (113 carcasses); on September 29, and October 11, from Parrott-Phelan Dam to the Skyway,(23 carcasses). On September 7, 8, 342 adults were captured and tagged, Hallock (1961), with 127 tags recovered during the carcass survey. Carcass counts were expanded based upon the mark/recapture ratio to an estimated spawning population of 3,100 adults. Live fish and redds were observed throughout but were not included in the computation of the spawning population estimate, Elwell (1962), Elwell et al. (1961), CDFG (1990).
	3,000	Fry and Petrovich (1970).
	5,400	Estimate expanded from annual carcass, redd and live salmon counts, Flint and Meyer (1977).
1962	1,750	No carcass counts were conducted in the reach from the Centerville Head Dam to the Centerville Powerhouse. Carcass counts were conducted on September 10, 17, 18, 25, 26, and October 1, 2, 8, and 9, in the reach from the Centerville Powerhouse to the Covered Bridge (339 carcasses); on September 11, 18, 26, and October 2, 3, and 10, in the reach from the Covered Bridge to the Parrott Phelan Dam (83 carcasses); on October 3, in the reach from Parrott Phelan Dam to the Skyway (2 carcasses). During the month of August 302 adults were captured and tagged, Hallock (1962), with 89 tags recovered during the carcass survey. Carcass counts were expanded based upon the mark/recapture ratio to an estimated population of 1750 adults. Live fish and redds were observed throughout but were not included in the computation of the spawning population estimate, Menchen (1963), Menchen et al.(1962), Flint and Meyer (1977), CDFG (1990).
	2,000	Fry and Petrovich (1970).
1963	6,100	No carcass counts were conducted in the reach between the Centerville Head Dam and the Centerville Powerhouse. Carcass counts were conducted on August 28, September 24, 26, and October 2, and 3, in the reach between Centerville Powerhouse and the Covered Bridge (1244 carcasses); on September 25 and October 3, in the reach between the Covered Bridge and Parrott-Phelan Dam (500 carcasses); on September 25, and October 4, in the reach between Parrott-Phelan Dam and the Skyway (71 carcasses). On August 20, 21, 480 adults were captured and tagged, Hallock (1963), with 196 tags recovered during the carcass survey. Carcass counts were expanded based upon the mark/recapture ratio to an estimated adult spawning population of 4,600 fish. There were an additional 1,500 fish estimated to have died from high water temperatures in the reach between the Centerville Head Dam and the Centerville Powerhouse. Live fish and redds were observed throughout but were not included in the computation of the estimated spawning population, Menchen (1964), Menchen et al (1963).
	4,600	CDFG (1990).

BUTTE CREEK

YEAR	RUN SIZE	METHODOLOGY/REFERENCE
1963	5,000	Fry and Petrovich (1970).
	5,333	Estimate expanded from annual carcass, redd and live salmon counts, Flint and Meyer (1977).
1964	600	No carcass counts were conducted in the reach between the Centerville Head Dam and the Centerville Powerhouse. Carcass counts were conducted on September 28, 29, and October 13, in the reach between Centerville Powerhouse and the Covered Bridge, (67 carcasses); on September 29, and October 14, in the reach between the Covered Bridge and Parrott-Phelan Dam, (29 carcasses); on September 30, and October 14, in the reach between Parrott-Phelan Dam and the Skyway, (2 carcasses). No mark recapture was attempted, carcass numbers were expanded by a factor of 3, apparently based upon recovery rates established during 1961-1963. Live fish and redds were observed throughout but were not included in the computation of the estimated spawning population, Menchen (1965), CDFG (1964), Fry and Petrovich (1970), CDFG (1990).
	422	Estimate expanded from annual carcass, redd and live salmon counts, Flint and Meyer (1977).
1965	1,000	One aerial and one ground survey was conducted with no recorded information on numbers of live fish/carcasses or redds seen. The adult spawning population was estimated to be 1,000 adults with no explanation for the basis of the estimate, Menchen (1965), Fry and Petrovich (1970), Flint and Meyer (1977), CDFG (1990).
1966	80	No carcass survey was conducted in the reach from the Centerville Head Dam to the Centerville Powerhouse (barrier). Carcass counts were made on September 27, and October 12, in the reach between the Centerville Powerhouse and the Covered Bridge (13 carcasses); on September 28, and October 13, in the reach between the Covered Bridge and Parrott-Phelan Dam (15 Carcasses); on September 28, and October 13, in the reach between the Parrott-Phelan Dam and the Skyway (0 carcasses). The carcass count was expanded by a factor of 3, apparently based upon the mark/recapture rate established during the period 1961-1963, Menchen (1967), Arnold (1966), CDFG (1990).
	100	Fry and Petrovich (1970).
	124	Estimate expanded from annual carcass, redd and live salmon counts, Flint and Meyer (1977).
1967	180	Carcass surveys were conducted on September 26, and October 20 in the reach between the Centerville Head Dam and the Centerville Powerhouse with no carcasses observed; live fish and redds were seen on both surveys. Two carcass surveys, dates unknown, were conducted in the reaches below the Centerville Powerhouse during which 50 carcasses were recovered. The population estimate was however, based upon live fish counts, Menchen (1968), CDFG (1990).
	200	Fry and Petrovich (1970).
	211	Estimate expanded from annual carcass, redd and live salmon counts, Flint and Meyer (1977).

BUTTE CREEK

YEAR	RUN SIZE	METHODOLOGY/REFERENCE
1968	280	One carcass count was conducted on September 26, in the reach between the Centerville Head Dam and the Centerville Powerhouse with no observed carcasses; 180 live fish had been observed during a preliminary survey on August 13 and 14. Carcass counts were conducted on September 25, and October 9, in the reach from the Centerville Powerhouse to the Covered Bridge (18 carcasses); on September 26, and October 10, in the reach from the Covered Bridge to the Parrott-Phelan Dam (1 carcass); on September 26 and October 10, in the reach from the Parrott-Phelan Dam to the Skyway (1 carcass). Live fish and redds were observed throughout with population estimate based upon a combination carcass expansions and live fish counts, including the 180 fish which apparently died in the upper section, Menchen (1969), Young et al. (1968), CDFG (1990).
	300	Fry and Petrovich (1970).
	80	Estimate expanded from annual carcass, redd and live salmon counts, Flint and Meyer (1977).
1969	830	The reach between Centerville Head Dam and Centerville Powerhouse was surveyed on August 13, 14, with 23 holding adults observed. Carcass counts were conducted on October 1, 15, in the reach between the Centerville Powerhouse and the Covered Bridge (57 carcasses); on October 2, in the reach between the Covered Bridge and the Parrott-Phelan Dam (27 carcasses); on October 2, in the reach between the Parrott-Phelan Dam and the Skyway (6 carcasses). Live fish and redds were seen throughout, however observations were hampered by turbid water. The population estimate was based upon carcasses, live fish, and redds, Menchen (1970), Young et al. (1969), CDFG (1990).
	800	Fry and Petrovich (1970).
	670	Estimate expanded from annual carcass, redd and live salmon counts, Flint and Meyer (1977).
1970	285	No survey was conducted in the reach between the Centerville Head Dam and the Centerville Powerhouse. Surveys were conducted on September 29, 30, and October 15, 16, in the reach from the Centerville Powerhouse to the Skyway (57 carcasses). Spawning redds were observed throughout. The population estimate was based upon carcasses and redds observed, Menchen (1972), CDFG (1990).
	240	Estimate expanded from annual carcass, redd and live salmon counts, Flint and Meyer (1977).
1971	470	No survey was made in the reach between the Centerville Head Dam and the Centerville Powerhouse. Surveys were conducted on September 30, October 1, 14, 15, 20, in the reach between the Centerville Powerhouse and the Skyway (72 carcasses, 2 skeletons, 106 single redds, 28 multiple redds, 15 live fish), Taylor (1973), CDFG (1990). No information is available regarding the basis for the population estimate.
	227	Estimate expanded from annual carcass, redd and live salmon counts, Flint and Meyer (1977).

BUTTE CREEK		
YEAR	RUN SIZE	METHODOLOGY/REFERENCE
1972	150	One survey was conducted on September 29, in the reach between the Centerville Head Dam and the Centerville Powerhouse (1 live fish, 1 redd). Two boat surveys were conducted on October 4, 5, and 17, 18, in the reach from the Centerville Powerhouse to the Covered Bridge (18 carcasses, 20 single redds, 10 multiple redds, 1 live fish), Taylor (1973), CDFG (1990). No information is available regarding the basis for the population estimate.
	62	Estimate expanded from annual carcass, redd and live salmon counts, Flint and Meyer (1977).
1973	300	No survey was conducted in the reach between the Centerville Head Dam and the Centerville Powerhouse. Three surveys were conducted between October 2 and 12, in the reach from the Centerville Powerhouse to the Covered Bridge (164 carcasses, 32 multiple redds, 57 single redds, 173 live fish), Taylor (1974b), CDFG (1990). No information is available regarding the basis for the population estimate.
	314	Estimate expanded from annual carcass, redd and live salmon counts, Flint and Meyer (1977).
1974	150	No survey was conducted in the reach between the Centerville Head Dam and the Centerville Powerhouse. Surveys were conducted on October 1, 2, in the reach between the Centerville Powerhouse and the Skyway (16 carcasses, 35 multiple redds, 19 single redds, 31 live fish), Taylor (1976), CDFG (1990). No information is available regarding the basis for the population estimate.
	148	Estimate expanded from annual carcass, redd and live salmon counts, Flint and Meyer (1977).
1975	650	No survey was conducted in the reach between the Centerville Head Dam and the Centerville Powerhouse. A survey was conducted on September 29 and 30, in the reach between the Centerville Powerhouse and the Skyway (73 carcasses, 99 multiple redds, 31 single redds, 216 live fish), Hoopaugh (1978), Flint and Meyer (1977), CDFG (1990). No information is available regarding the basis for the population estimate.
1976	46	No survey was conducted in the reach between the Centerville Head Dam and the Centerville Powerhouse. A survey was conducted on September 30, and October 1, in the reach between the Centerville Powerhouse and the Skyway (5 carcasses, 7 multiple redds, 4 single redds, 13 live fish). Note is made that recovery conditions were only fair and the peak of spawning appeared to have occurred prior to the survey, Hoopaugh (1978), Flint and Meyer (1977), CDFG (1990). No information is available regarding the basis for the population estimate.
1977	100	No surveys were conducted. Mention is made of extremely dry conditions, early diversions and dead and stranded salmon in lower Butte Creek. Fish were trapped and transported into upper Butte Creek from the Sutter Refuge Weir (70 fish) and Red Bluff Diversion Dam (388 fish), Hoopaugh (1979), CDFG (1990). No information is available regarding the basis for the population estimate, although given the fact that no survey was conducted or that 458 fish were transported into upper Butte Creek, the population estimate is probably questionable.

BUTTE CREEK		
YEAR	RUN SIZE	METHODOLOGY/REFERENCE
1978	128	No survey was conducted in the reach between the Centerville Head Dam and the Centerville Powerhouse. One survey was conducted on October 3 and 4, in the reach between the Centerville Powerhouse and the Skyway (11 carcasses, 49 multiple redds, 4 single redds, 14 live fish). Weather and recovery conditions were described as being fair to good, although the spawning peak was thought to have occurred prior to the survey, Knutson (1980), CDFG (1990). No information is available regarding the basis for the population estimate.
1979	10	No survey was conducted in the reach between the Centerville Head Dam and the Centerville Powerhouse. One canoe survey was conducted on October 2 and 3, in the reach between the Centerville Powerhouse and the Skyway. No dead or live salmon were seen, while 5 multiple redds were observed. Recovery conditions were described as being the best in ten years, Reavis (1981a), CDFG (1990). No information is available regarding the basis for the population estimate.
1980	226	No survey was conducted in the reach between the Centerville Head Dam and the Centerville Powerhouse (barrier not installed). Surveys were conducted by canoe on October 1 and 2 in the reach between the Centerville Powerhouse and the Skyway (13 carcasses, 106 live fish, 43 multiple and 3 single redds) Reavis, (1981b). Comment is made that the minimum number of salmon accounted for was 119, with no information available regarding the basis for the population estimate.
	119	CDFG (1990).
1981	250	The Centerville Barrier was not installed this year. CDFG conducted canoe surveys in the reach between the Centerville Powerhouse and the Covered Bridge on June 2, (2 live fish), in the reach between the Covered Bridge and Durham Mutual Dam on October 1 (4 single redds, 4 carcasses, 68 live fish). Mention was made of the PG&E surveys but no indication whether PG&E numbers were included in estimate, Reavis (1983), CDFG (1990).
	312	PG&E conducted a helicopter survey of the reach from the Centerville Head Dam to Parrott Phelan Dam on October 2 (25 single redds, 6 multiple redds, 1 carcass, 50 live fish), Reavis (1983). Based upon the PG&E survey of the reach between the Centerville Head Dam and the Centerville Powerhouse, which was not surveyed by CDFG, PG&E recommended adding 62 additional fish to the CDFG estimate, Steitz (1994a).
1982	534	Centerville Barrier was not installed. CDFG conducted a canoe survey on September 30, and October 1, in the reach between the Centerville Powerhouse and the Skyway (7 single redds, 124 multiple redds, 20 carcasses, 141 live fish). Recovery conditions were described as poor, Reavis (1986a), CDFG (1990).
	589	Based upon the PG&E survey of the reach between the Centerville Head Dam and the Centerville Powerhouse, which was not surveyed by CDFG, PG&E recommended adding 55 additional fish to the CDFG estimate, Steitz (1994a).

BUTTE CREEK		
YEAR	RUN SIZE	METHODOLOGY/REFERENCE
1983	50	Centerville Barrier was not installed. CDFG conducted a survey (method unknown) in the reach between the Centerville Powerhouse and the Covered Bridge, and part of the reach between the Parrott-Phelan Dam and Skyway, on October 5 (5 carcasses, 9 single redds, 3 multiple redds, 6 live fish). Recovery conditions were described as good. No information on how population estimate was calculated, Reavis (1986b), CDFG (1990).
	51	Based upon the PG&E survey of the reach between the Centerville Head Dam and the Centerville Powerhouse, which was not surveyed by CDFG, PG&E recommended adding 1 additional fish to the CDFG estimate, Steitz (1994a).
1984	23	Centerville Barrier was not installed. CDFG conducted a canoe survey in the reach between the Centerville Powerhouse and the Parrott-Phelan Dam on October 1, (1 single redd, 5 multiple redds, 5 live salmon), and in the reach between the Parrott-Phelan Dam and the Skyway on October 2, (no redds or salmon). No information on how population estimate was calculated, Kano and Reavis (1996), CDFG (1990).
	43	PG&E conducted a snorkel survey in the reach between the Centerville Head Dam and the Centerville Powerhouse during August, (5 live salmon), and an aerial survey on the same reach on October 1 (1 multiple redd, 3 live salmon), Kano and Reavis (1996). Based upon the PG&E survey of the reach between the Centerville Head Dam and the Centerville Powerhouse, which was not surveyed by CDFG, PG&E recommended adding 20 additional fish to the CDFG estimate, Steitz (1994a).
1985	254	Centerville Barrier was not installed. CDFG conducted a canoe survey of the reach between the Centerville Powerhouse and the Covered Bridge on October 1 (89 carcasses, 51 single redds, 1 multiple redd, 116 live salmon), and the reach between the Parrott-Phelan Dam and the Skyway on October 2 (1 redd, 6 carcasses, 4 live salmon). No information on how population estimate was calculated, Kano and Reavis (1996), CDFG (1990).
	262	PG&E snorkel survey was conducted in the reach between the Centerville Head Dam and the Helltown Bridge on July 17, 18 (8 live salmon), and an aerial survey of the reach between the Centerville Head Dam and the Centerville Powerhouse on October 3, (11 single redds, 3 multiple redds, and 12 live salmon), Kano and Reavis (1996). Based upon the PG&E survey of the reach between the Centerville Head Dam and the Centerville Powerhouse, which was not surveyed by CDFG, PG&E recommended adding 8 additional fish to the CDFG estimate, Steitz (1994a).

BUTTE CREEK		
YEAR	RUN SIZE	METHODOLOGY/REFERENCE
1986	1,371	Centerville Barrier was not installed. Aerial redd counts were conducted on October 1, in the reach between the Centerville Head Dam and the Centerville Powerhouse (71 redds), Centerville Powerhouse to Covered bridge (109 redds), Covered Bridge to Parrott-Phelan Dam (34 redds), Parrott-Phelan Dam to Skyway (3 redds). Canoe surveys were conducted on October 2, 3, in the reach from the Centerville Powerhouse to the Covered Bridge (318 redds); Covered Bridge to the Parrott-Phelan Dam (65 redds). Canoe survey counts were added to the two counts from reaches surveyed only by air for a total redd estimate of 457. Each redd was assumed to represent 3 adult salmon, resulting in overall estimate of 1,371, Kano and Reavis (1997a), CDFG (1990).
	1,846	Based upon the PG&E survey of the reach between the Centerville Head Dam and the Centerville Powerhouse, PG&E recommended adding 475 additional fish to the CDFG estimate, Steitz (1994a). The CDFG estimate does however, appear to include an estimate for the entire reach.
1987	14	Centerville Barrier was not installed. Surveys (method unknown) were conducted on October 1, 2, in the reach between the Centerville Powerhouse and the Skyway Bridge (7 redds). Not information is available on how population estimate was made, Kano and Reavis (1997b).
1988	1,300	Centerville Barrier was not installed and no survey was conducted between the Centerville Head Dam and the Centerville Powerhouse. A canoe survey was conducted in the reach between Centerville Powerhouse and the Parrott-Phelan Dam on October 3,4, (24 single redds, 367 multiple redds, 540 live fish, 177 carcasses). It is stated that the usual estimation method would result in a population estimate of 1,834, however excellent visibility and the fact many fish had already spawned caused the estimate to be reduced to 1,294. In addition, no estimate was included for fish spawning above the Centerville Powerhouse, Flint (1989), CDFG (1990).
	1,440	Based upon the PG&E survey of the reach between the Centerville Head Dam and the Centerville Powerhouse, PG&E recommended adding 140 additional fish to the CDFG estimate, Steitz (1994a).
1989	1,300	Centerville Barrier was not installed. Snorkel surveys were conducted on June 29-30, and August 24-25, resulting in a maximum estimate of 1,010 adult salmon. CDFG and PG&E jointly conducted spawning stock surveys on October 3-5 in the reach from the Centerville Head Dam to the Centerville Powerhouse (275-300 redds, 270 carcasses, 230-240 live salmon); from the Centerville Powerhouse to the Covered Bridge (289 multiple redds, 14 single redds, 79 carcasses, 267 live salmon). The spawning population estimate was based primarily upon redd counts in the lower reach, resulting in an initial estimate of 590 fish, Faustini (1990). No rationale was given for the estimate for the remainder of the fish.
	2,384	Based upon the PG&E survey of the reach between the Centerville Head Dam and the Centerville Powerhouse, PG&E recommended adding 1084 additional fish to the CDFG estimate, Steitz (1994a). Existing documentation brings into question whether or not fish in the upper survey reach were included in the CDFG estimate.

BUTTE CREEK

YEAR	RUN SIZE	METHODOLOGY/REFERENCE
1990	100	Centerville Barrier was not installed. CDFG conducted a canoe survey in the reach between the Centerville Powerhouse to one mile below the Covered bridge on October 1, (64 multiple redds, 28 carcasses, 48 live salmon). Recovery conditions were rated as excellent. The minimum count was stated as 76 fish, with the spawning escapement estimate stated as 250 fish, Flint (1990).
	183	Based upon the PG&E snorkel surveys of the reach between the Centerville Head Dam and the Centerville Powerhouse on June 14, 15,(83 live salmon); on August 15 (60 live salmon, 2 carcasses), PG&E recommended adding 83 additional fish to the CDFG estimate, Steitz (1994a).
1991	100	CDFG snorkel survey, Mills and Fisher (1994).
	150	Based upon the PG&E survey of the reach between the Centerville Head Dam and the Centerville Powerhouse, PG&E recommended adding 83 additional fish to the CDFG estimate, Steitz (1994a).
1992	730	PG&E snorkel survey on June 10, 1992, in the reach from Centerville head Dam to Helltown Bridge (321 live adults); Centerville Powerhouse to steel bridge (91 live adults); steel bridge to covered bridge (259 live adults), Steitz (1992).
1993	650	Snorkel surveys were conducted between September 16 and October 21, 1993. Total count of entire reach from Centerville Head Dam to Parrott-Phelan Dam was 358 redds, 108 live fish, and 44 carcasses, Brown (1993).
1994	474	PG&e snorkel survey, Steitz (1994b).
1995	7,500	Snorkel Survey was conducted on July 24-26, 1995, in the reach from the centerville Head Dam to Chimney Rock (1270-2080 live adults, 1 carcass); in reach from Chimney Rock to Centerville Powerhouse (1760-1880 live adults); reach from Centerville Powerhouse to covered Bridge (2970-3520 live adults, 1 carcass), Hill (1995). A second snorkel survey was conducted on Sept. 25, in the reach from the Centerville Head Dam to Chimney Rock (1282 live adults, 208 carcasses, too many redds to accurately delineate); Sept. 27, in reach from Chimney Rock to Helltown (725 live adults, 174 carcasses, no estimate of redds); Oct. 11, in reach from Centerville Head Dam to natural barrier (9 redds); Oct. 12, in reach from Covered Bridge to Parrott-Phelan Dam (5 live adults, 60 carcasses, 56 redds), Hill (1996a). Estimate was based upon maximum count of live adults during July survey.
1996	1,413	Snorkel survey was conducted from August 19-23, 1996; reach from centerville Head Dam to Chimney Rock (551-681 live adults); reach from Chimney Rock to Centerville Powerhouse (385-455 live adults); reach from Centerville Powerhouse to Covered Bridge (242-275 live adults); reach from Covered Bridge to Parrott Phelan Dam (2 live adults); reach from Parrott-Phelan Dam to Highway 99 (0 adults). Estimate is based upon maximum count of live adults, Hill (1996b).

BUTTE CREEK		
YEAR	RUN SIZE	METHODOLOGY/REFERENCE
1997	635	Snorkel survey was conducted from August 18 - September 5, 1997; in reach from natural barrier pool to Chimney Rock (280-328 live adults, 2 carcasses); reach from Chimney Rock to Centerville Powerhouse (147-154 live adults); reach from centerville Powerhouse to Covered Bridge (143-153 live adults); Covered Bridge to Parrott-Phelan Dam (0 adults). Estimate is based upon maximum count of live adults, Hill (1997b).

FEATHER RIVER

YEAR	RUN SIZE	METHODOLOGY/REFERENCE
1946	2,000	Estimate by U.S. Fish and Wildlife Service based on spawning area surveys and/or aerial redd counts, Fry (1961).
1954	3,000	Estimate by California Department of Fish and Game based on spawning area surveys and or/ aerial redd counts, Fry (1961), Fry and Petrovich (1970).
1955	1,000	Estimate by California Department of Fish and Game based on spawning area surveys and or/ aerial redd counts, Fry (1961), Fry and Petrovich (1970).
1956	2,000	Estimate from CDFG redd counts and live fish counts that 1,000 to 2,000 spring run spawned in Middle Fork, which was thought to be only a portion of the actual total. In addition, 7 carcasses and 46 live fish were observed in the North Fork which were identified as spring run, Warner (1957), Fry (1961).
1957	500	Estimate from CDFG aerial redd counts and live fish counts that 500 spring run spawned in Middle Fork, Mahoney (1958), Fry (1961).
1958	3,200	Estimate was based upon CDFG aerial redd counts of the North Fork with 1,000 fall and spring run, and aerial redd counts and two ground surveys of the Middle Fork with 3,200 primarily spring run with some fall run, CDFG (1959), Fry (1961).
1959	4,000	Estimate from CDFG based upon live counts with 50 spring run in West Branch, based upon aerial redd counts 3,000 spring and fall run in Middle Fork, and aerial redd counts with 1,500 spring and fall run in North Fork, Mahoney (1960), Fry (1961).
1960	3,500	CDFG aerial survey identified 2,000 fall and spring run in the North Fork, and 3,500 fish thought to be primarily spring run in the Middle Fork, Mahoney (1962).
1961	No estimate	CDFG aerial redd counts of the Middle Fork found 900 fish with most thought to be fall run, and an aerial survey of the North Fork with 1,100 fish, most thought to be fall run, Elwell (1962).
1962	No estimate	CDFG aerial redd counts of the Middle Fork found 330 fish with most identified as fall run, and 800 fish in the North Fork, with most thought to be fall run, Menchen (1963).
1963	600	Based on CDFG aerial redd counts is was estimated that 600 spring run spawned the Middle Fork, and that 4,500 fish, described as mostly fall run spawned in the main stem below the North Fork, Menchen (1964).
1964	2,908	Feather River Hatchery Barrier Dam was put in operation and spring run were trapped and transported above Oroville Dam, , Menchen (1965).
1965	738	Spring run were trapped at Feather River Hatchery Barrier and transported above Oroville Dam, Menchen (1966).

FEATHER RIVER		
YEAR	RUN SIZE	METHODOLOGY/REFERENCE
1966	297	Spring run were trapped at Feather River Hatchery Barrier and transported above Oroville Dam, Menchen (1967).
1967	146	A total of 146 adults entered the Feather River Hatchery (FRH) between August 22 and September 1, 1967: Surviving fish were 81 females and 21 males. Annual Report Feather River Salmon and Steelhead Hatchery, First Year of Operation, 1967-1968. Groh (1970),Menchen (1968).
1968	208	Spring estimate was based upon fish taken into the Feather River Hatchery,with mention that a few fish may have spawned in the river but no attempt was made to separate them from fall run, Menchen (1969).
1969	348	Spring estimate was based upon fish taken into the Feather River Hatchery,with mention that a few fish may have spawned in the river but no attempt was made to separate them from fall run, Menchen (1970).
1970	235	A total of 235 adults entered the Feather River Hatchery between August 13 and August 25, 1970: 153 females and 82 males. Annual Report Feather River Salmon and Steelhead Hatchery 1970-71, Schlicting (1974). Menchen (1972) mentioned that a few fish may have spawned in the river but no attempt was made to separate them from fall run,
1971	481	A total of 484 fish entered Feather River Hatchery between August 30 to August 31, 1971: 212 females and 272 males. Annual Report Feather River Salmon and Steelhead Hatchery Fifth Year of Operation 1971-1972, Schlicting (1973). Spring estimate was based upon fish taken into the Feather River Hatchery, with mention that a few fish may have spawned in the river but no attempt was made to separate them from fall run, although weekly survey trips were conducted during July and August, Taylor (1973).
1972	256	A total of 256 fish entered Feather River Hatchery between September 6 and October 1, 1972: Surviving fish sexed on Oct 6 - 116 females and 128 males. Annual Report Feather River Salmon and Steelhead Hatchery 1972-1973, Schlicting (1976). Spring estimate was based upon fish taken into the Feather River Hatchery, with mention that a few fish may have spawned in the river but no attempt was made to separate them from fall run, although nine weekly survey trips were conducted during July and August to evaluate the summer loss of spring run. Five carcasses were found during the summer surveys and 32 carcasses described as spring run were found on the first day of the fall run survey, Taylor (1974a).
1973	205	A total of 205 fish entered Feather River Hatchery between Sept 1 to Sept 25, 1973: 101 females and 104 males, Schlicting (1978a). Spring estimate was based upon fish taken into the Feather River Hatchery, with mention that a few fish may have spawned in the river but no attempt was made to separate them from fall run, although eight weekly survey trips were conducted during July and August to evaluate the summer loss of spring run. Four carcasses were found during the summer surveys, Taylor (1974b).

FEATHER RIVER		
YEAR	RUN SIZE	METHODOLOGY/REFERENCE
1974	198	A total of 198 fish entered Feather River Hatchery between Sept 3 to Sept 5, 1974: Surviving fish were sexed on Oct 4, 1974: 69 females and 83 males, Schlicting (1978b). Spring estimate was based upon fish taken into the Feather River Hatchery, with mention that a few fish may have spawned in the river but no attempt was made to separate them from fall run, although weekly survey trips were conducted during July and August to evaluate the summer loss of spring run. Eight carcasses were found during the summer surveys , Taylor (1976).
1975	691	A total of 691 fish entered Feather River Hatchery between Sept 2 to Sept 11, 1975: Surviving fish sexed on Oct 3 - 330 females and 283 males, Schlicting (1978c). Spring estimate was based solely upon fish taken into the Feather River Hatchery , Hoopaugh (1977).
1976	699	A total of 713 fish entered Feather River Hatchery between Sept 1 to Sept 15, 1976: 432 females and 281 males. Annual Report Feather River Hatchery 1976-77. Spring estimate was based upon fish taken into the Feather River Hatchery, although a survey trip was conducted on September 22, 1976, no carcasses were observed, Hoopaugh (1978).
1977	185	A total of 121 fish entered Feather River Hatchery between August 24 to August 30. The ladder was opened again September 16, 1977 and 73 fish entered that day. Total fish entering the hatchery was 194: 116 females and 78 males, Schlicting (1982a). Spring estimate was based upon fish taken into the Feather River Hatchery, Hoopaugh (1979).
1978	202	A total of 202 fish entered Feather River Hatchery between September 6 to October 10, 1978. The surviving fish were sexed on October 2, 1978: 112 females and 90 males. Only 32 females were successfully spawned from October 2 through October 30, 1978, Schlicting (1982b). Surveys were conducted on October 9 and 23, with two carcasses recovered in the spawning channel on October 23, with the remainder of the fish identified as spring run having entered Feather River Hatchery, (Knutson 1980).
1979	250	250 fish entered Feather River Hatchery Sept 4 to Sept 28, 1979: 167 females and 83 males, Schlicting (1982c). Spring estimate was based upon fish taken into the Feather River Hatchery, (Reavis 1981a).

FEATHER RIVER		
YEAR	RUN SIZE	METHODOLOGY/REFERENCE
1980	669	The total run entering the Feather River Hatchery was recorded as 269 fish with an estimated 400 fish spawning in the river. Twenty six CWT spring run from FRH were recovered during the weekly spring run river surveys, (Reavis 1981b).
1981	1000	Spring run estimate was based upon fish taken into the Feather River Hatchery (469) and the assumption that an equal number spawned in the river, although no surveys were made of the river, (Reavis 1983).
1982	1,910	Spring run were identified as those that entered the Feather River Hatchery between September 1, when the ladder was opened, and October 1. Coded wire tags taken from fish identified as spring run were shown to include some were marked as fall run. It was estimated that an additional 90 spring run spawned in the river with no basis given for how the estimate was derived, (Reavis 1986a).
1983	1,702	Spring run estimate was based solely upon fish which entered Feather River Hatchery from September 1 to 30, 1983, with no estimate for the river, (Reavis 1986b).
1984	1,562	Spring run estimate was based solely upon fish which entered Feather River Hatchery from September 1 to 30, 1984, with no estimate for the river, (Kano, et al. 1996).
1985	1,632	Spring run estimate was based solely upon fish which entered Feather River Hatchery from September 1 to 30, 1985, with no estimate for the river. Two salmon which were tagged (CWT) as spring run were recovered in the river during the early fall run surveys, (Kano and Reavis 1996).
1986	1,433	Spring run estimate was based solely upon fish which entered Feather River Hatchery from September 1 to 30, 1986, with no estimate for the river, (Kano and Reavis 1997a).
1987	1,213	Spring run estimate was based solely upon fish which entered Feather River Hatchery from September 2 to 30, 1987, with no estimate for the river , (Kano and Reavis 1997b).
1988	6,833	Spring run estimate was based solely upon fish which entered Feather River Hatchery from September 7 to October 1, 1988, with no estimate for the river, (Schlicting 1991).

FEATHER RIVER		
YEAR	RUN SIZE	METHODOLOGY/REFERENCE
1989	5,078	Spring run estimate was based solely upon fish which entered Feather River Hatchery between September 7 and October 1, 1989, (Schlicting 1993a).
1990	1,893	Spring run estimate was based solely upon fish which entered Feather River Hatchery between September 7 and October 1, 1990, (Schlicting 1993b).
1991	3,448	Spring run estimate was based solely upon fish which entered Feather River Hatchery between September 7 and October 1, 1991, (Schlicting 1993c).
1992	1,497	Spring run estimate was based on spring run entering the Feather River Hatchery. The ladder was opened Sept 8 no closing date given, (Meyer 1993).
1993	4,885	Spring run estimate was based on fish entering the Feather River Hatchery. The ladder was opened on Sept 7 no closing date given, (Meyer 1994).
1994	3,489	Spring run estimate was based on fish entering the Feather River Hatchery. The ladder was opened on Sept 6 no closing date given, Meyer (1995).
1995	5,414	Spring run estimate was based on fish entering the Feather River Hatchery. The ladder was opened on September 11 and closed Sept 22 when the holding pond capacity was reached Meyer (1996).
1996	6,031	Spring run estimate was based on fish entering the Feather River Hatchery. The ladder was opened Sept 9 no closing date given. Spring run estimate was based on fish entering the FRH. The ladder was opened Sept 9 no closing date given, Meyer (1997).

YUBA RIVER		
YEAR	RUN SIZE	METHODOLOGY/REFERENCE
1961	No estimate	The Yuba is known to have had spring run but no estimate of its size has been made. This run has virtually disappeared, Fry (1961)
1969	No estimate	CDFG states that "it is felt that run is extinct, but there should be a further examination of the river system", Menchen (1970).
1972	No estimate	CDFG reports that residents observed a few spring-run salmon below Englebright Dam but no estimate was made, Taylor (1974a).
1980	200	CDFG survey found 14 coded wire tagged Feather River Hatchery spring run and estimated that 200 Feather River spring run had spawned in the Yuba, Reavis (1981b).
1981	200	CDFG made estimate with no supporting surveys or other information, Reavis (1986a).
1982	No estimate	CDFG reports that spring run were observed negotiating the Daguerre Point Dam fish ladder in May and June, however no surveys or estimates were made, Reavis (1984).
1983	No estimate	U. S. Corps of Engineers personnel observed spring run negotiating the Daguerre Point Dam fish ladder in May and June, however no surveys or estimates were made, Preston (1984), Reavis (1986a).
1984	No estimate	Spring run were observed below Daguerre Point Dam in late April and early May, Preston (1985).
1985	No estimate	Survey was made of reach from mouth of Deer Creek to the Highway 20 bridge on October 9, 1985, during which 4 dead salmon, 50 live salmon and 50 redds were observed. No estimate for spring was made because of uncertainty of distinguishing spring run from fall run, Kano and Reavis (1996).
1986	No estimate	Seven salmon were counted passing the dam during the spring run migration period, however no other surveys or estimates made although comment was made that the run is believed to be maintaining itself at 100-200 adults, Preston (1987), Kano and Reavis (1997a).

YUBA RIVER		
YEAR	RUN SIZE	METHODOLOGY/REFERENCE
1988	No estimate	Spring run were observed during the summer, but could not be separated from fall run during the subsequent survey, Meyer (1989).
1989	No estimate	Survey was conducted on October 6, 1989 during which 140-160 multiple redds, and 150 live fish, Faustini (1990).
1997	No estimate	CDFG personnel observed fish at Daguerre Point Dam during April and May, and redds near the Highway 20 bridge on September 24, 1997, Nelson (1997). In addition, carcasses were observed near Englebright Dam, Hill (1997b).

APPENDIX C

OCEAN HARVEST REGULATIONS

C-1 1996 California Ocean Salmon Sport Fishing Regulations
C-2 1997 California Ocean Salmon Sport Fishing Regulations
C-3 1998 California Ocean Salmon Sport Fishing Regulations
C-4 1996 California Ocean Salmon Commercial Fishing Regulations
C-5 1997 California Ocean Salmon Commercial Fishing Regulations
C-6 1998 California Ocean Salmon Commercial Fishing Regulations

APPENDIX C-1

1996 CALIFORNIA OCEAN SALMON SPORT FISHING REGULATIONS

27.80. Salmon.

(a) Methods of take:

(1) General Provisions. Only by angling as defined in Section 1.05. No sinkers or weights exceeding four pounds may be used, except that a fishing line may be attached to a sinker or weight of any size if such sinker or weight is suspended by a separate line and the fishing line is released automatically by a mechanical device from the sinker or weight when any fish is hooked. See sections 1.74, 28.65 and 28.70.

(2) Hook Restrictions. Only single point, single shank barbless hooks may be used to take salmon in the ocean north of Point Conception (34°27'00" N. lat.). When fishing with bait in the ocean between Horse Mountain (40°05'00" N. lat.) and Point Conception after June 30, no more than two hooks may be used with any combination of weights measuring one pound or less. When using two hooks, the terminal (lower) hook must be no less than 3/4 inch when measured from the hook point to the shank and the upper hook no less than 5/8 inch when measured from the hook point to the shank; the distance between the two hooks must not exceed five inches, and both hooks must be permanently tied in place (hard tied). When using a single hook, the hook size cannot be less than 3/4 inch when measured from the hook point to the shank.

EXCEPTION: Hook size restrictions do not apply when artificial lures are used or when bait is attached to an artificial lure (a man-made lure designed to attract fish, not including scented or flavored baits).

(3) One Rod Restriction north of Point Conception. Salmon may be taken by angling with no more than one rod in ocean waters north of Point Conception. See section 28.65.

(b) Season:

(1) South of Pigeon Point. All waters of the ocean south of Pigeon Point (37°11'00" N. lat.) are open to salmon fishing from the Saturday nearest March 1 through August 25 (Note: In 1997, the season will open on March 15).

(2) Between Point San Pedro and Pigeon Point. All waters of the ocean between Point San Pedro (37°35'40" N. lat.) and Pigeon Point are open to fishing from the Saturday nearest March 1 through August 25 (Note: In 1997, the season will open on the Saturday nearest April 1).

(3) Between Point Arena and Point San Pedro. All waters of the ocean and San Francisco Bay District between Point Arena (38°57'30" N. lat.) and Point San Pedro are open to salmon fishing from the Saturday nearest March 1 through October 14 (Note: In 1997, the season will open on the Saturday nearest April 1).

(4) Between Horse Mountain and Point Arena. All waters of the ocean between Horse Mountain and Point Arena are open to salmon fishing from the Saturday nearest February 15 through July 7 and August 1 through the Sunday nearest November 15.

(5) North of Horse Mountain and Humboldt Bay. All waters of the ocean north of Horse Mountain and Humboldt Bay are open to salmon fishing from May 12 through July 7 and August 18 through September 21.

EXCEPTION: The ocean area surrounding the Klamath River mouth bounded on the north by 41°38'48" N. lat. (approximately 6 nautical miles north of the Klamath River mouth), on the south by 41°26'48" N. lat. (approximately 6 nautical miles south of the Klamath River mouth), and extending 3 nautical miles offshore is closed to salmon fishing.

(c) Limit:

(1) North of Horse Mountain: One salmon per day, and no more than four fish in seven consecutive days (See subsection (c)(3) below).

(2) South of Horse Mountain: Two salmon per day (See subsection (c)(3) below).

(3) Statewide Silver Salmon Restrictions: No silver salmon may be retained after April 30, 1996, except in those areas south of Point Arena from their respective openings of the 1997 ocean salmon seasons through April 30, 1997 (Note: In early 1997, the Pacific Fishery Management Council will evaluate silver salmon abundance to determine if the take of silver salmon south of Point Arena will be prohibited in 1997 through April 30. If the retention of silver salmon is prohibited south of Point Arena, the Department shall notify the Commission and the public via available news media of any changes in the provisions of subsection (c)(3) above).

(d) Minimum size:

(1) North of Horse Mountain: Twenty inches total length.

(2) Horse Mountain to Point Arena: Twenty-four inches total length.

(3) South of Point Arena: Twenty-four inches total length through July 14 and twenty-six inches total length thereafter.

NOTE

Authority cited: Sections 200, 202, 205, 220, 240, 2084 and 7891, Fish and Game Code.
Reference: Sections 200, 202, 205 and 2084, Fish and Game Code.

APPENDIX C-2

1997 CALIFORNIA OCEAN SALMON SPORT FISHING REGULATIONS

27.80. Salmon.

(a) Methods of take:

(1) General Provisions. Only by angling as defined in Section 1.05. No sinkers or weights exceeding four pounds may be used, except that a fishing line may be attached to a sinker or weight of any size if such sinker or weight is suspended by a separate line and the fishing line is released automatically by a mechanical device from the sinker or weight when any fish is hooked. See sections 1.74, 28.65 and 28.70.

(2) Barbless Hooks. Only single point, single shank barbless hooks may be used to take salmon in the ocean north of Point Conception (34°27'00" N. lat.).

(3) Other Hook Restrictions. When fishing with bait in the ocean between Horse Mountain (40°05'00" N. lat.) and Point Conception after April 30, no more than two hooks may be used with any combination of weights measuring one pound or less. When using two hooks, the terminal (lower) hook must be no less than 3/4 inch when measured from the hook point to the shank and the upper hook no less than 5/8 inch when measured from the hook point to the shank; the distance between the two hooks must not exceed five inches when measured from the top of the eye of the top hook to the inner base of the curve of the lower hook, and both hooks must be permanently tied in place (hard tied). When using a single hook, it must be no less than 3/4 inch when measured from the hook point to the shank. Beginning September 2, 1997 and thereafter, no more than two hooks may be used per line; and all hooks must be barbless circle hooks which are defined as a hook with a generally circular shape, and a point which turns inward to the shank at approximately a 90° angle.

EXCEPTION: Subsection (a)(3) does not apply in the ocean between Point Reyes (37°59'44" N. lat.) and Pigeon Point (37°11'00" N. lat) from July 1 through September 1, or when artificial lures are used or when bait is attached to an artificial lure. Artificial lures include, but are not limited to, any lure constructed with a lead head, metal bars, or spoons designed to attract fish. Artificial lures do not include "J" hooks with only beads, yarn, feathers, and bait attached, including scented and flavored baits.

(4) One Rod Restriction north of Point Conception. Salmon may be taken by angling with no more than one rod in ocean waters north of Point Conception. See section 28.65.

(b) Season:

(1) South of Pigeon Point. All waters of the ocean south of Pigeon Point are open to salmon fishing from March 15 through October 19 (Note: In 1998, the season will open on March 14, the Saturday nearest March 15).

(2) Between Point Arena and Pigeon Point. All waters of the ocean between Point Arena (38°57'30" N. lat.) and Pigeon Point are open to fishing from March 29, the Saturday nearest April 1, through November 2 (Note: In 1998, the season will open on March 28, the Saturday nearest April 1, except for the waters of the ocean inshore of a straight line drawn from Bolinas Point (Marin County) south to Duxbury Buoy, then to Channel Buoy #1, then to Channel Buoy #2, then to Point San Pedro (San Mateo County), and including all of San Francisco and San Pablo bays between the Golden Gate Bridge and the Carquinez Bridge including the entrance area from the Golden Gate Bridge to Seal Rocks to Point Bonita which are closed to salmon fishing from March 28 through March 31).

(3) Between Horse Mountain and Point Arena. All waters of the ocean between Horse Mountain and Point Arena are open to salmon fishing from the Saturday nearest February 15 through July 6 and August 1 through November 16, the Sunday nearest November 15 (Note: In

1998, the season will open on February 14, the Saturday nearest February 15).

(4) North of Horse Mountain and Humboldt Bay. All waters of the ocean north of Horse Mountain and Humboldt Bay are open to salmon fishing from May 24 through May 30, June 17 through July 6, and August 12 through September 14.

EXCEPTION: The ocean area surrounding the Klamath River mouth bounded on the north by 41°38'48" N. lat. (approximately 6 nautical miles north of the Klamath River mouth), on the south by 41°26'48" N. lat. (approximately 6 nautical miles south of the Klamath River mouth), and extending 3 nautical miles offshore is closed to salmon fishing between August 12 and August 31.

(c) Limit:

(1) North of Horse Mountain: One salmon per day, and no more than four fish in seven consecutive days (See subsection (c)(3) below).

(2) South of Horse Mountain: Two salmon per day (See subsection (c)(3) below and section 1.17). From July 1 through September 1, between Point Reyes and Pigeon Point, the limit is the first two fish taken (see EXCEPTION under subsection (d)(2) below).

(3) Statewide Silver Salmon Restrictions: No silver salmon may be retained.

(d) Minimum size:

(1) North of Horse Mountain: Twenty inches total length.

(2) South of Horse Mountain: Twenty-four inches total length.

EXCEPTION: Between Point Reyes and Pigeon Point, from July 1 through September 1, there is no minimum size.

NOTE

Authority cited: Sections 200, 202, 205, 220, 240, 2084 and 7891, Fish and Game Code.
Reference: Sections 200, 202, 205 and 2084, Fish and Game Code.

APPENDIX C-3

1998 CALIFORNIA OCEAN SALMON SPORT FISHING REGULATIONS

27.80. Salmon.

(a) Methods of take:

(1) General Provisions. Only by angling as defined in Section 1.05. No sinkers or weights exceeding four pounds may be used, except that a fishing line may be attached to a sinker or weight of any size if such sinker or weight is suspended by a separate line and the fishing line is released automatically by a mechanical device from the sinker or weight when any fish is hooked. See sections 1.74, 28.65 and 28.70.

(2) Barbless Hooks. Only single point, single shank barbless hooks may be used to take salmon in the ocean north of Point Conception (34°27'00" N. lat.).

(3) Other Hook Restrictions. When fishing with bait in the ocean between Horse Mountain (40°05'00" N. lat.) and Point Conception, if angling by any other means than trolling, then no more than two (2) single point, single shank, barbless circle hooks shall be used. The distance between the two hooks must not exceed five inches when measured from the top of the eye of the top hook to the inner base of the curve of the lower hook, and both hooks must be permanently tied in place (hard tied). A circle hook is defined as a hook with a generally circular shape, and a point which turns inwards, pointing directly to the shank at a 90 degree angle. Trolling is defined as angling from a boat or floating device that is making way by means of a source of power, other than drifting by means of the prevailing water current or weather conditions. See Section 28.65.

(4) One Rod Restriction north of Point Conception. Salmon may be taken by angling with no more than one rod in ocean waters north of Point Conception. See Section 28.65.

(b) Season:

(1) South of Pigeon Point. All waters of the ocean south of Pigeon Point are open to salmon fishing from March 14 through September 7 (Note: In 1999, the season will open on March 13, the Saturday nearest March 15).

(2) Between Point Arena and Pigeon Point. All waters of the ocean between Point Arena and Pigeon Point are open to fishing from March 28, the Saturday nearest April 1, through November 1 (Note: In 1999, the season will open on March 27, the Saturday nearest April 1, except for the waters of the ocean inshore of a straight line drawn from Bolinas Point (Marin County) south to Duxbury Buoy, then to Channel Buoy #1, then to Channel Buoy #2, then to Point San Pedro (San Mateo County), and including all of San Francisco and San Pablo bays between the Golden Gate Bridge and the Carquinez Bridge including the entrance area from the Golden Gate Bridge to Seal Rocks to Point Bonita which are closed to salmon fishing from March 27 through March 31).

(3) Between Horse Mountain and Point Arena. All waters of the ocean between Horse Mountain and Point Arena are open to salmon fishing from February 14, the Saturday nearest February 15, through July 5 and August 1 through November 15, the Sunday nearest November 15 (Note: In 1999, the season will open on February 13, the Saturday nearest February 15).

(4) North of Horse Mountain and Humboldt Bay. All waters of the ocean north of Horse Mountain and Humboldt Bay are open to salmon fishing from May 23 through June 10, June 21 through July 5, and August 11 through September 13.

EXCEPTION: The ocean area surrounding the Klamath River mouth bounded on the north by 41°38'48" N. lat. (approximately 6 nautical miles north of the Klamath River mouth), on the south by 41°26'48" N. lat. (approximately 6 nautical miles south of the Klamath River mouth), and extending 3 nautical miles offshore is closed to salmon fishing between August 11 and August 31.

(c) Limit:

(1) North of Horse Mountain: One salmon per day, and no more than four fish in seven consecutive days (See subsection (c)(3) below).

(2) South of Horse Mountain: Two salmon per day (See subsection (c)(3) below and Section 1.17). From July 1 through September 7, between Point Arena and Pigeon Point, the limit is the first two fish taken (see EXCEPTION under subsection (d)(2) below).

(3) Statewide Silver Salmon Restrictions: No silver salmon may be retained.

(d) Minimum size:

(1) North of Horse Mountain: Twenty inches total length.

(2) South of Horse Mountain: Twenty-four inches total length.

EXCEPTION: Between Point Arena and Pigeon Point, from July 1 through September 7, there is no minimum size.

NOTE

Authority cited: Sections 200, 202, 205, 220, 240, 2084 and 7891, Fish and Game Code.
Reference: Sections 200, 202, 205 and 2084, Fish and Game Code.

Section 28.65, Title 14, CCR, is amended to read:

APPENDIX C-4

1996 CALIFORNIA OCEAN SALMON COMMERCIAL FISHING REGULATIONS

Section 182. Commercial Salmon Fishing.

Under the authority of Section 7652 of the Fish and Game Code, Section 8210.2 and 8215 of said Code are made inoperative for the period May 1, 1996 through April 30, 1997 and the following regulations are adopted, such regulations to be effective May 1, 1996 through April 30, 1997 and at midnight on April 30, 1997 are repealed. Upon expiration of these regulations in any district or portion thereof, Section 8210.2 and 8215 of the Fish and Game Code shall become effective in such districts or portions of districts.

(a) In Districts 6, 7, 10, 11, 16, 17, 18, and 19, and except as modified in subsection (c), no king (chinook) salmon may be possessed that is less than 26 inches in length from May 1, 1996 through June 30, 1996 and from April 15, 1997 through April 30, 1997, and that is less than 27 inches in length from July 1, 1996 through September 30, 1996, such length to be measured from the tip of the snout to the extreme tip of the tail without resorting to any force other than swinging or fanning the tail. Salmon may be taken only by hook and line.

(b) In Districts 6, 7, 10, 11, 16, 17, 18, and 19, only single barbless hooks may be used to take salmon. Single barbless hook means a hook with a single shank and point, with no secondary point or barb curving or projecting in any other direction. Hooks manufactured with barbs can be made "barbless" by removing or completely closing the barb.

(c) Frozen salmon may be possessed in a dressed, head-off condition, subject to the following minimum size limit: king salmon, 19-1/2" in dressed, head-off length when salmon no less than 26 inches total length may be possessed and 20-1/4" in dressed, head-off length when salmon no less than 27 inches total length may be possessed. Dressed, head-off length is the distance measured along the lateral line between the mid-point of the clavicle arch and the fork of the tail.

(d) In Districts 6, 7, 10, 11, 16, 17, 18, and 19, no more than six troll lines may be used on any commercial salmon fishing vessel.

(e) In Districts 10, 11, 16, 17, 18, and 19, south of Point Reyes (37°59'44" N. lat.), under the authority of a commercial fishing license, all salmon other than silver salmon, may be taken from May 1 through June 30 and July 3 through September 15.

(f) In Districts 10 and 11, between Bodega Head (38°17'58" N. lat.) and Point San Pedro, under the authority of a commercial fishing license, all salmon other than silver salmon, may be taken from September 16 through September 30.

(g) In Districts 7, 10, and 11, between Point Arena (38°57'30" N. lat.) and Point Reyes, under the authority of a commercial fishing license, all salmon other than silver salmon, may be taken from June 1 through June 30 and August 1 through September 15.

(h) In District 7, between Point Arena and Horse Mountain (40°05'00" N. lat.), under the authority of a commercial fishing license, all salmon other than silver salmon, may be taken from August 1 through September 30.

(i) In Districts 18 and 19, between Point Lopez (36°01'15" N. lat.) And Point Mugu (34°05'12" N. lat.), under the authority of a commercial fishing license, all salmon other than silver salmon, may be taken from April 15 through April 28, or the date the Regional Director of the NMFS determines that a total of 10,000 king salmon will be taken.

(j) In Districts 6 and 7, between the California/Oregon Border (42°00'00" N. lat.) And Humboldt South Jetty (40°45'53" N. lat.), under the authority of a commercial fishing license, all salmon other than silver salmon, may be taken from August 15 through August 31 or the date the Regional Director of the NMFS determines that a total of 2,500 king salmon will be taken, and from September 1 through September 15 or the date the Regional Director of the NMFS determines that a total of 6,000 king salmon will be taken. All salmon taken in this area at this time must be landed within the area and no more than 30 salmon per day may be landed.

(k) In Districts 6, 7, 10, 11, 16, 17, 18, and 19, it is unlawful for any person on a vessel with an ocean salmon permit from any state having salmon on board to have troll fishing gear in the water during those times that commercial salmon fishing is prohibited.

(l) Troll fishing gear is defined as one or more lines that drag hooks with bait or lures behind a moving fishing vessel.

(m) In District 6, no salmon may be taken for commercial purposes in State waters off the mouth of the Klamath River within an area bounded on the north by 41°38'48" N. lat. (approximately 6 nautical miles north of the Klamath River mouth) and on the south by 41°26'48" N. lat. (approximately 6 nautical miles south of the Klamath River mouth).

(n) It is unlawful for any person to take or take and retain any species of salmon in districts 6, 7, 10, 11, 16, 17, 18, and 19: I) during closed seasons or in closed areas, except that legally caught salmon may be landed in closed areas unless otherwise prohibited by these regulations; ii) while possessing on board any species of salmon not allowed to be taken in the area at the time; iii) by means other than hook and line.

(o) All other provisions, exceptions and restrictions for commercial salmon fishing off California are described in Title 50--Code of Federal Regulations, Part 661 and apply to State waters as in effect May 1, 1996.

NOTE

Authority: Section 7652, Fish and Game Code.

Reference: Sections 1700, 7600, 7650, 7652, 7652.1, 7652.2, 7652.3, 8210.2, and 8215, Fish and Game Code; Title 50, Code of Federal Regulations, Part 661.

APPENDIX C-5

1997 CALIFORNIA OCEAN SALMON COMMERCIAL FISHING REGULATIONS

Section 182. Commercial Salmon Fishing.

Under the authority of Section 7652 of the Fish and Game Code, Section 8210.2 and 8215 of said Code are made inoperative for the period May 1, 1997 through April 30, 1998 and the following regulations are adopted, such regulations to be effective May 1, 1997 through April 30, 1998 and at midnight on April 30, 1998 are repealed. Upon expiration of these regulations in any district or portion thereof, Section 8210.2 and 8215 of the Fish and Game Code shall become effective in such districts or portions of districts.

(a) In Districts 6, 7, 10, 11, 16, 17, 18, and 19, and except as modified in subsection (c), no king (chinook) salmon may be possessed that is less than 26 inches in length from May 1, 1997 through September 30, 1997, such length to be measured from the tip of the snout to the extreme tip of the tail without resorting to any force other than swinging or fanning the tail. Salmon may be taken only by hook and line.

(b) In Districts 6, 7, 10, 11, 16, 17, 18, and 19, only single barbless hooks may be used to take salmon. Single barbless hook means a hook with a single shank and point, with no secondary point or barb curving or projecting in any other direction. Hooks manufactured with barbs can be made "barbless" by removing or completely closing the barb.

(c) Frozen salmon may be possessed in a dressed, head-off condition, subject to the following minimum size limit: king salmon, 19-1/2" in dressed, head-off length when salmon no less than 26 inches total length may be possessed. Dressed, head-off length is the distance measured along the lateral line between the mid-point of the clavicle arch and the fork of the tail.

(d) In Districts 6, 7, 10, 11, 16, 17, 18, and 19, no more than six troll lines may be used on any commercial salmon fishing vessel.

(e) In Districts 10, 11, 16, 17, 18, and 19, south of Point San Pedro (37°35'40" N. lat.), under the authority of a commercial fishing license, all salmon other than silver salmon, may be taken from May 1 through May 31, June 23 through July 18, and September 1 through September 30.

(f) In Districts 10 and 11, between Point Reyes (37°59'44" N. lat.) and Point San Pedro, under the authority of a commercial fishing license, all salmon other than silver salmon, may be taken from July 1 through September 30.

(g) In Districts 10 and 11, between Point Arena (38°57'30" N. lat.) and Point Reyes, under the authority of a commercial fishing license, all salmon other than silver salmon, may be taken from July 1 through September 30.

(h) In District 7, between Point Arena and Horse Mountain (40°05'00" N. lat.), under the authority of a commercial fishing license, all salmon other than silver salmon, may be taken from September 1 through September 30.

(i) In Districts 18 and 19, between Point Lopez (36°01'15" N. lat.) and Point Mugu (34°05'12" N. lat.), under the authority of a commercial fishing license, all salmon other than silver salmon, may be taken from April 15 through April 28, or the date the Regional Director of the NMFS determines that a total of 10,000 king salmon will be taken.

(j) In Districts 6 and 7, between the California/Oregon Border (42°00'00" N. lat.) And Humboldt South Jetty (40°45'53" N. lat.), under the authority of a commercial fishing license, all salmon other than silver salmon, may be taken from September 1 through September 30 or the date the Regional Director of the NMFS determines that a total of 6,000 king salmon will be taken. All salmon taken in this area at this time must be landed within the area and no more than 30 salmon per day may be landed.

(k) In Districts 6, 7, 10, 11, 16, 17, 18, and 19, it is unlawful for any person on a vessel with an ocean salmon permit from any state having salmon on board to have troll fishing gear in the water during those times that commercial salmon fishing is prohibited.

(l) Troll fishing gear is defined as one or more lines that drag hooks with bait or lures behind a moving fishing vessel.

(m) In District 6, no salmon may be taken for commercial purposes in State waters off the mouth of the Klamath River within an area bounded on the north by 41°38'48" N. lat. (approximately 6 nautical miles north of the Klamath River mouth), on the west by 124°23'00" W. long. (approximately 12 nautical miles off shore), and on the south by 41°26'48" N. lat. (approximately 6 nautical miles south of the Klamath River mouth).

(n) It is unlawful for any person to take or take and retain any species of salmon in districts 6, 7, 10, 11, 16, 17, 18, and 19: I) during closed seasons or in closed areas, except that legally caught salmon may be landed in closed areas unless otherwise prohibited by these regulations; ii) while possessing on board any species of salmon not allowed to be taken in the area at the time; iii) by means other than hook and line.

(o) All other provisions, exceptions and restrictions for commercial salmon fishing off California are described in Title 50–Code of Federal Regulations, Part 661 and apply to State waters as in effect May 1, 1997.

NOTE

Authority: Section 7652, Fish and Game Code.

Reference: Sections 1700, 7600, 7650, 7652, 7652.1, 7652.2, 7652.3, 8210.2, and 8215, Fish and Game Code; Title 50, Code of Federal Regulations, Part 661.

APPENDIX C-6

1998 CALIFORNIA OCEAN SALMON COMMERCIAL FISHING REGULATIONS

182. Commercial Salmon Fishing.

Under the authority of Section 7652 of the Fish and Game Code, Section 8210.2 and 8215 of said Code are made inoperative for the period May 1, 1998 through April 30, 1999 and the following regulations are adopted, such regulations to be effective May 1, 1998 through April 30, 1999 and at midnight on April 30, 1999 are repealed. Upon expiration of these regulations in any district or portion thereof, Section 8210.2 and 8215 of the Fish and Game Code shall become effective in such districts or portions of districts.

(a) In Districts 6, 7, 10, 11, 16, 17, 18, and 19, and except as modified in subsection (c), no king (chinook) salmon may be possessed that is less than 26 inches in length from May 1, 1998 through September 30, 1998, such length to be measured from the tip of the snout to the extreme tip of the tail without resorting to any force other than swinging or fanning the tail. Salmon may be taken only by hook and line.

(b) In Districts 6, 7, 10, 11, 16, 17, 18, and 19, only single barbless hooks may be used to take salmon. Single barbless hook means a hook with a single shank and point, with no secondary point or barb curving or projecting in any other direction. Hooks manufactured with barbs can be made "barbless" by removing or completely closing the barb.

(c) Frozen salmon may be possessed in a dressed, head-off condition, subject to the following minimum size limit: king salmon, 19-1/2" in dressed, head-off length when salmon no less than 26 inches total length may be possessed. Dressed, head-off length is the distance measured along the lateral line between the mid-point of the clavicle arch and the fork of the tail.

(d) In Districts 6, 7, 10, 11, 16, 17, 18, and 19, no more than six troll lines may be used on any commercial salmon fishing vessel.

(e) In Districts 18, and 19, south of Point Sur (38°18'00" N. lat.), under the authority of a commercial fishing license, all salmon other than silver salmon, may be taken from May 1 through September 30.

(ef) In Districts 10, 11, 16, 17, and 18 between Point San Pedro (37°35'40" N. lat.) and Point Sur, under the authority of a commercial fishing license, all salmon other than silver salmon, may be taken from May 1 through May 31, June 16 through September 30.

(g) In Districts 10 and 11, between Point Reyes (37°59'44" N. lat.) and Point San Pedro, under the authority of a commercial fishing license, all salmon other than silver salmon, may be taken from July 1 through September 30.

(h) In Districts 10, and 11, between Point Arena (38°57'30" N. lat.) and Point Reyes, under the authority of a commercial fishing license, all salmon other than silver salmon, may be taken from August 1 through September 30 with exception of a test fishery between Fort Ross (38°31'00" N. lat.) and Point Reyes for July 5 thru earlier of July 31 or an overall 3,000 chinook quota. Season to be opened as follows: July 5 thru earlier of July 11 or 1,000 chinook quota; July 12 thru earlier of July 18 or 1,000 chinook quota; and July 19 thru earlier of July 25 or the lesser of a 1,000 chinook quota or the remainder of the overall 3,000 chinook quota. If sufficient overall quota remains, the fishery will reopen on July 26 thru the earlier of July 31 or achievement of the overall quota. Open only inside 6 nautical miles. Landing limit of no more than 30 fish per day. All fish caught in this area must be landed in Bodega Bay within 24 hours of each closure. Open only inside 6 nautical miles. Fish taken outside the test fishery may not be landed at Bodega Bay during the time authorized for test fishery landings.

(i) In District 7, between Horse Mountain (40°05'00" N. lat.) and Point Arena, under the authority of a commercial fishing license, all salmon other than silver salmon, may be taken from September 1 through September 30.

(j) In Districts 6 and 7, between the California/Oregon Border (42°00'00" N. lat.)and Humboldt South Jetty (40°45'53" N. lat.), under the authority of a commercial fishing license, all salmon other than silver salmon, may be taken from September 1 through September 30 or the date the Regional Director of the NMFS determines that a total of 6,000 king salmon will be taken. All salmon taken in this area at this time must be landed within the area and no more than 30 salmon per day may be landed.

(k) In Districts 6, 7, 10, 11, 16, 17, 18, and 19, it is unlawful for any person on a vessel with an ocean salmon permit from any state having salmon on board to have troll fishing gear in the water during those times that commercial salmon fishing is prohibited.

(l) Troll fishing gear is defined as one or more lines that drag hooks with bait or lures behind a moving fishing vessel.

(m) In District 6, no salmon may be taken for commercial purposes in State waters off the mouth of the Klamath River within an area bounded on the north by 41°38'48" N. lat. (approximately 6 nautical miles north of the Klamath River mouth), on the west by 124°23'00" W. long. (approximately 12 nautical miles off shore), and on the south by 41°26'48" N. lat. (approximately 6 nautical miles south of the Klamath River mouth).

(n) It is unlawful for any person to take or take and retain any species of salmon in Districts 6, 7, 10, 11, 16, 17, 18, and 19: i) during closed seasons or in closed areas, except that legally caught salmon may be landed in closed areas unless otherwise prohibited by these regulations; ii) while possessing on board any species of salmon not allowed to be taken in the area at the time; iii) by means other than hook and line.

(o) All other provisions, exceptions and restrictions for commercial salmon fishing off California are described in Title 50--Code of Federal Regulations, Part 661 and apply to State waters as in effect May 1, 1998.

NOTE

Authority: Section 7652, Fish and Game Code.

Reference: Sections 1700, 7600, 7650, 7652, 7652.1, 7652.2, 7652.3, 8210.2, and 8215, Fish and Game Code; Title 50, Code of Federal Regulations, Part 661.

APPENDIX D

APPENDIX D

Inland Sport Fishing Regulations

The following general description of inland sport fishing regulations, which either afford protection for, or in some way affect Sacramento Valley stocks of spring-run chinook salmon is taken from the California Sport Fishing Regulations, effective March 1, 1998 through February 28, 2000.

Shasta and Tehama Counties: Within Shasta and Tehama Counties there is a general restriction which prevents the take of salmon at any time in any tributary of the Sacramento River which enters the Sacramento River below Keswick Dam in Shasta and Tehama counties. This general restriction affects several spring-run salmon tributaries with existing or potentially restorable populations and includes Clear Creek, Battle Creek, Cottonwood Creek, Antelope Creek, Mill Creek, and Deer Creek. Additionally, for the above mentioned tributaries, and which are not covered under special restrictions as listed below, fishing is permitted from the last Saturday in April through November 15, with the general restriction of no take of salmon at any time.

Sacramento River: Special restrictions in effect on the Sacramento River which provide protection for spring-run salmon are as follows:

(1) The Sacramento River from Keswick Dam to 650 feet below Keswick Dam is closed to all fishing all year.

(2) The Sacramento River from 650 feet below Keswick Dam to the Deschutes Road bridge is open all year with barbless hooks only, with a daily bag and possession limit of 0 salmon. Additionally, during the period January 1 through August 15, any lure having a total length over 2.25 inches is prohibited, and no incidentally hooked salmon may be removed from the water.

(3) The Sacramento River from the Deschutes Road Bridge to Bend Bridge (approximately 5 miles upstream from the town of Red Bluff) is open to fishing from August 1 through January 14, with a daily bag and possession limit of two salmon. From January 15 through July 31 the daily bag and possession limit is 0 salmon.

(4) The Sacramento River from 500 feet upstream from Red Bluff Diversion Dam to 1,375 feet below the Dam is closed to all fishing all year.

(5) The Sacramento River from Bend Bridge (approximately 5 miles upstream from the town of Red Bluff) to the Carquinez Bridge (includes Suisun Bay, Grizzly Bay and all tributary sloughs) is open from July 16, through January 14, with a daily bag and possession limit of 2 salmon. From January 15 through July 15, the daily bag and possession limit is 0 salmon.

Battle Creek: Battle Creek from the mouth at the Sacramento River to Coleman Fish Hatchery Weir is closed to all fishing all year, except when the Department determines that the total number of steelhead passing Red Bluff Diversion Dam from July 1 through September 30 exceeds 1200. When the number of steelhead passing Red Bluff Diversion Dam exceeds the specified number, Battle Creek is open to fishing from the mouth to the Coleman Hatchery Weir from October 5 from 250 Feet upstream from the Coleman National Fish Hatchery to the Coleman Powerhouse is open to fishing from the last Saturday in April through September 30, while the daily bag and possession limit is 0 salmon as imposed by the special restriction for Shasta and Tehama Counties. Battle Creek in the remainder of the existing and potential spring-run salmon habitat is open to fishing from the last Saturday in April to November 15, with a daily bag and possession limit of 0 salmon as imposed by the special restriction for Shasta and Tehama Counties.

Antelope Creek: Antelope Creek from confluence with North Fork downstream to the U.S. Geological Survey gauging station cable crossing at the mouth of Antelope Creek Canyon is open to fishing from the last Saturday in April through November 15. Only artificial lures with barbless hooks may be used while the daily bag and possession limit is 0 salmon. Antelope Creek from the U.S. Geological Survey gauging station cable crossing at the mouth of Antelope Creek Canyon downstream to the mouth of Antelope Creek at the Sacramento River is open to fishing from June 16 through September 30, with no special gear restrictions, while the daily bag and possession limit is 0 salmon.

Mill Creek: Mill Creek from the Lassen National Park boundary downstream to the U.S. Geological Survey gauging station cable crossing at the mouth of Mill Creek Canyon is open to fishing from the last Saturday in April through November 15, with a gear restriction of artificial lures and barbless hooks, and a daily bag and possession limit of 0 salmon. Mill Creek from the U.S. Geological Survey gauging station cable crossing at the mouth of Mill Creek Canyon downstream to the mouth of Mill Creek at the Sacramento River, is open to fishing from June 16 through September 30, with a daily bag and possession limit of 0 salmon.

Deer Creek: Deer Creek from 250 feet below Upper Deer Creek Falls downstream to the U.S. Geological Survey gauging station cable crossing at the mouth of Deer Creek Canyon, is open to fishing from the last Saturday in April through November 15, with a gear restriction of artificial lures with barbless hooks only, and a daily bag and possession limit of 0 salmon. In addition, fishing within the area between Upper Deer Creek Falls and 250 downstream of the falls is closed to all fishing under the general regulation restricting fishing within 250 feet of any fishway. Deer Creek from the U.S. Geological Survey gauging station cable crossing at the mouth of Deer Creek Canyon downstream to the mouth of Deer Creek at the Sacramento River, is open to fishing from June 16 through September 30, with a daily bag and possession limit of 0 salmon.

Big Chico Creek: Big Chico Creek from the mouth at the Sacramento River to the upper end of Bidwell Park is open to fishing from June 16 through the last day in February, with a gear restriction of artificial lures with barbless hooks only and a daily bag and possession limit of 0 salmon. Big Chico Creek from the upper end of Bidwell Park to Higgins Hole Falls, located about one half mile upstream from Ponderosa Way is open to fishing from October 1 through February 29, with a daily bag and possession limit of 0 salmon.

Butte Creek: Butte Creek from the Oro-Chico Road Bridge crossing south of Chico to the DeSabla Powerhouse below the DeSabla Reservoir, is closed to all fishing all year. Butte Creek from the Oro-Chico Road Bridge crossing south of Chico to the points that Butte Creek enters the Sacramento River both via Butte Slough outfall gates at Moon's Bend and through Butte Slough, the East and West Canals of the Sutter Bypass, and Sacramento Slough to the Sacramento River, is closed to salmon fishing all year, but is open all year to fishing for other species.

Feather River: Special restrictions on the Feather River which may affect spring-run salmon are as follows:

(1) The Feather River from the fish barrier dam to the Table Mountain bicycle bridge in Oroville is closed to all fishing all year.

(2) The Feather River from the Table Mountain bicycle bridge to the Highway 70 bridge is open to fishing from January 1 through August 30, with a bag and possession limit of 2 salmon.

(3) The Feather River from the Highway 70 bridge to a point 100 yards upstream from Thermalito Afterbay outlet is open to general fishing all year, with a bag and possession limit of 2 salmon, however it is specifically closed to salmon fishing during the period October 1 through December 31.

(4) The Feather River from a point 100 yards upstream from Thermalito Afterbay outlet to the mouth of Honcut Creek is open to general fishing all year, with a bag and possession limit of 2 salmon, however it is specifically closed to salmon fishing only during the period October 16 through December 31.

(5) The Feather River from Honcut Creek to the mouth of the Feather River at the Sacramento River is open to fishing all year, with a daily bag and possession limit of 2 salmon.

Yuba River: Special restrictions on the Yuba River which may affect spring-run salmon are as follows:

(1) The Yuba River from the mouth at the Feather River to Daguerre Point Dam is open to general fishing all year with a bag and possession limit of 2 salmon, however it is specifically closed to salmon fishing from October 16 through December 31.

(2) The Yuba River from Daguerre Point Dam to the Highway 20 bridge is open to fishing from January 1 through September 30, with a bag and possession limit of 2 salmon.

(3) The Yuba River from Daguerre Point Dam to the Highway 20 bridge is open to fishing from October 1 through December 31, with a bag and possession limit of 0 salmon.

(4) The Yuba River from the Highway 20 Bridge to Englebright Dam is open to fishing from December 1 through September 30, with a gear restriction of artificial lures with barbless hooks, and a daily bag and possession limit of 0 salmon.

APPENDIX E

DWRSIM FLOW MODEL DATA
AND
DAYFLOW DATA

Appendix E-1. Average Historic Monthly Delta Inflow (cfs) by Water-year Type and Time Periods Representing Changes in Water Flow management Within the Sacramento River system ând Sacramento-San Joaquin Bay-Delta Estuary, California. Data from Department of Water Resources DAYFLOW.

HISTORIC DELTA INFLOW (CFS)
AVERAGE MONTHLY INFLOW BY WATER-YEAR TYPE

WATER-YEAR TYPE	PERIOD	WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
ABOVE NORMAL	PRE-1945	1940	7,093	7,248	11,950	68,382	101,581	138,220	124,929	48,634	24,367	6,127	4,285	7,478
	1945-1950	NO ABOVE NORMAL WATER YEARS												
	1951-1967	1951	11,371	69,991	127,922	76,409	88,165	53,067	30,490	35,713	14,328	9,412	10,305	11,172
		1954	13,036	16,571	16,971	32,242	71,971	59,698	61,122	33,301	13,189	8,910	10,437	12,232
		1957	14,807	17,532	15,789	14,487	23,957	64,505	22,453	35,862	22,358	10,370	10,658	13,633
		AVG	13,071	34,698	53,560	41,046	61,364	59,090	38,021	34,959	16,624	9,564	10,467	12,346
	1968-1977	1973	18,231	26,341	30,864	100,445	100,905	75,981	27,115	20,603	18,313	18,644	17,522	19,346
		1978	4,749	7,151	12,526	70,897	63,704	88,588	63,742	46,246	20,453	18,414	18,138	21,664
		AVG	11,490	16,746	21,695	85,671	82,305	82,284	45,428	33,425	19,383	16,529	17,830	20,505
	1978-1992	1978	4,749	7,151	12,526	70,897	63,704	88,588	63,742	46,246	20,453	18,414	18,138	21,664
		1980	16,035	18,181	24,317	120,991	125,777	103,281	34,672	27,586	24,577	21,852	17,250	20,216
		AVG	10,392	12,666	18,421	95,944	94,741	95,935	49,207	36,916	22,515	19,133	17,694	20,940
	1993-1994	1993	7,712	7,593	13,838	64,085	61,110	67,711	51,318	30,492	34,465	22,672	24,165	19,027
	1995-1997	1996	20,682	15,739	28,432	39,665	129,684	91,804	47,712	51,850	28,829	24,332	24,318	20,345
		1997	16,027	18,962	87,256	261,255	120,074	40,385	20,125	17,643	19,215	23,672	21,555	16,931
		AVG	18,355	17,351	57,844	150,460	124,879	66,095	33,919	34,747	24,022	24,002	22,937	18,638

Appendix E-1. (Continued).

HISTORIC DELTA INFLOW (CFS) AVERAGE MONTHLY INFLOW BY WATER-YEAR TYPE														
WATER-YEAR TYPE	PERIOD	WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
BELOW NORMAL	PRE-1945	1935	5,396	13,996	12,814	43,385	30,295	47,263	107,231	67,552	38,592	6,005	4,403	6,041
		1936	8,939	9,537	11,756	58,501	106,053	65,646	62,449	48,953	31,622	8,388	4,383	6,320
		1937	7,725	8,228	10,628	13,412	59,937	74,157	71,863	63,275	33,212	7,856	3,421	5,454
		AVG	7,353	10,587	11,733	38,433	65,428	62,355	80,514	59,927	34,475	8,083	4,069	5,938
	1945-1950	1945	7,151	17,544	23,650	20,973	78,706	39,717	38,464	43,129	28,130	11,273	8,776	10,337
		1946	12,476	20,866	73,831	80,123	31,903	33,438	40,905	42,242	18,858	8,727	8,342	10,153
		1948	10,890	12,832	10,659	24,047	12,711	20,171	58,838	59,989	44,008	10,869	9,618	11,438
		1950	8,326	10,402	9,681	29,282	51,586	33,225	44,730	36,832	23,930	8,358	7,388	9,869
		AVG	9,711	15,411	29,455	38,606	43,721	31,638	45,734	45,548	28,747	9,806	8,531	10,474
	1951-1967	1959	16,034	16,968	15,896	30,801	55,686	30,750	15,183	12,398	8,633	10,918	12,405	11,829
		1962	7,529	8,898	16,773	11,438	68,984	48,538	31,757	23,210	17,862	11,375	12,515	13,267
		1966	18,692	25,868	30,118	43,545	35,252	27,702	23,562	15,350	10,261	12,103	12,911	11,810
		AVG	14,085	17,245	20,929	28,594	53,307	35,663	23,494	16,986	12,252	11,465	12,610	12,302
	1968-1977	1968	20,228	18,512	21,087	24,918	51,525	43,821	16,778	14,642	12,121	13,203	13,918	14,239
		1972	19,310	17,833	25,150	23,849	25,859	26,036	14,889	13,979	14,573	15,564	16,328	18,560
		AVG	19,769	18,172	23,118	24,384	38,692	34,929	15,834	14,311	13,347	14,383	15,123	16,399
	1978-1992	1979	16,620	16,414	16,335	30,791	45,683	41,627	21,618	22,038	15,413	18,224	17,623	16,952

1993-1994 NO BELOW NORMAL WATER YEARS

1995-1997 NO BELOW NORMAL WATER YEARS

Appendix E-1. (Continued).

HISTORIC DELTA INFLOW (CFS) AVERAGE MONTHLY INFLOW BY WATER-YEAR TYPE														
WATER-YEAR TYPE	PERIOD	WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
CRITICAL	PRE-1945	1931	8,757	10,060	10,089	15,499	15,991	17,253	8,951	5,323	2,740	697	1,221	3,357
		1933	5,902	6,792	9,561	13,953	16,616	25,791	24,875	22,224	21,928	4,295	2,591	4,598
		1934	6,510	8,692	16,056	33,149	28,412	28,016	18,389	8,346	4,453	2,035	1,941	3,815
		AVG	7,056	8,514	11,902	20,867	20,340	23,687	17,405	11,964	9,706	2,342	1,918	3,923
	1945-1950	NO CRITICAL WATER YEARS												
	1951-1967	NO CRITICAL WATER YEARS												
	1968-1977	1976	24,647	27,059	29,674	18,615	15,081	16,618	14,200	11,987	11,782	12,804	14,481	13,938
		1977	9,405	9,059	8,767	10,946	8,833	7,150	6,199	8,029	7,007	8,409	7,828	7,030
		AVG	17,026	18,059	19,220	14,781	11,957	11,884	10,199	10,008	9,395	10,606	11,155	10,484
	1978-1992	1988	11,025	9,815	17,202	28,789	13,763	13,880	19,370	12,991	12,537	16,238	15,052	13,141
		1990	15,802	16,503	16,945	20,356	15,474	15,136	16,967	12,000	11,901	14,712	15,074	11,105
		1991	8,863	9,065	11,626	9,894	8,993	29,652	12,602	8,895	9,810	10,332	10,253	10,751
		1992	10,364	8,387	10,385	11,640	30,486	22,891	11,303	7,609	9,260	9,000	9,423	10,600
		AVG	11,514	10,943	14,089	17,670	17,179	20,390	15,060	10,374	10,877	12,571	12,450	11,399
	1993-1994	1994	17,388	14,369	22,455	16,317	22,903	16,108	10,866	11,383	9,648	13,364	13,374	15,637
	1995-1997	NO CRITICAL WATER YEARS												

Appendix E-1. (Continued).

HISTORIC DELTA INFLOW (CFS)
AVERAGE MONTHLY INFLOW BY WATER-YEAR TYPE

WATER-YEAR TYPE	PERIOD	WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
DRY	PRE-1945	1930	6,916	7,171	37,235	32,311	33,249	56,446	35,971	24,840	13,104	4,558	3,935	6,968
		1932	4,898	7,037	22,845	36,262	39,921	35,913	34,725	48,903	36,795	10,770	3,697	4,529
		1939	11,783	15,244	18,768	17,408	19,799	26,798	21,430	10,391	4,204	2,206	2,263	5,497
		1944	10,111	11,308	12,671	15,366	30,613	35,200	20,972	28,203	13,506	4,734	4,451	6,812
		AVG	8,427	10,190	22,879	25,337	30,896	38,589	28,275	28,084	16,902	5,567	3,586	5,951
	1945-1950	1947	10,701	15,843	21,750	14,884	26,436	33,189	25,077	12,600	9,160	5,447	5,969	8,125
		1949	12,008	12,616	14,536	14,129	16,551	58,583	35,419	28,664	12,716	6,843	7,510	9,355
		AVG	11,354	14,230	18,143	14,506	21,494	45,886	30,248	20,632	10,938	6,145	6,739	8,740
	1951-1967	1955	11,690	17,093	27,044	28,187	18,567	15,716	15,334	22,948	13,899	9,789	9,960	10,475
		1960	8,836	8,426	8,431	12,690	47,674	36,101	20,430	17,073	11,418	10,691	10,072	10,147
		1961	8,450	12,901	20,244	14,577	41,961	29,651	17,402	13,671	11,197	10,680	11,636	10,080
		1964	17,125	26,589	24,907	29,496	23,259	15,664	13,811	15,149	12,038	12,099	12,685	14,292
		AVG	11,525	16,252	20,157	21,237	32,865	24,283	16,744	17,210	12,138	10,815	11,088	11,248
	1968-1977	NO DRY WATER YEARS												
	1978-1992	1981	15,880	14,723	19,917	23,286	28,180	29,233	20,227	16,045	12,375	16,695	16,261	14,119
		1985	18,057	31,819	39,733	21,381	22,683	18,008	15,831	16,028	15,291	18,751	16,222	14,352
		1987	20,058	16,284	17,406	15,985	20,150	26,322	15,166	12,595	12,428	17,133	16,436	13,492
		1989	10,519	12,739	13,886	14,236	13,511	47,293	23,898	16,138	15,067	20,223	19,664	17,981
		AVG	16,128	18,891	22,736	18,722	21,131	30,214	18,780	15,201	13,790	18,200	17,146	14,986
	1993-1994	NO DRY WATER YEARS												
	1995-1997	NO DRY WATER YEARS												

Appendix E-1. (Continued).

HISTORIC DELTA INFLOW (CFS)
AVERAGE MONTHLY INFLOW BY WATER-YEAR TYPE

WATER-YEAR TYPE	PERIOD	WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
WET	PRE-1945	1938	9,528	27,254	88,349	46,304	170,950	173,159	121,362	115,733	84,192	26,475	9,098	8,863
		1941	8,921	13,308	62,650	117,831	137,192	126,217	113,462	84,671	49,442	18,700	7,039	7,213
		1942	9,616	12,571	62,989	89,792	155,863	50,930	89,511	75,362	60,353	18,144	6,169	8,073
		1943	10,727	18,013	32,599	89,794	80,792	112,565	76,784	48,543	29,747	7,814	4,871	6,826
		AVG	9,698	17,786	61,647	85,930	136,199	115,718	100,285	81,077	55,933	17,763	6,794	7,744
	1945-1950	NO WET WATER YEARS												
	1951-1967	1952	11,763	16,046	46,746	101,767	103,514	83,363	104,874	108,021	68,238	22,113	12,277	13,601
		1953	12,165	13,410	40,630	117,509	39,202	26,013	33,104	41,411	38,696	13,323	9,938	14,218
		1956	8,716	11,184	122,456	184,332	98,352	65,091	41,032	61,506	40,423	16,394	13,822	15,932
		1958	20,792	21,482	26,466	42,081	178,421	108,422	150,833	81,152	54,955	19,291	16,177	16,784
		1963	44,394	16,645	35,242	22,111	96,893	29,703	101,789	57,393	26,294	14,189	12,689	17,940
		1965	11,267	16,670	106,371	134,013	58,215	29,890	58,284	37,957	23,631	14,577	15,837	17,610
		1967	10,378	20,398	59,083	59,633	84,613	56,568	76,757	78,770	66,915	30,913	17,904	21,760
		AVG	17,068	16,833	62,428	94,492	94,173	57,293	80,924	66,601	45,593	18,686	14,092	17,121
	1968-1977	1969	13,174	15,425	27,076	125,525	159,488	96,730	73,267	69,928	52,546	20,746	21,281	25,034
		1970	22,274	22,001	46,101	188,895	112,760	58,170	17,072	17,178	14,824	14,838	16,341	20,308
		1971	17,224	25,409	84,076	66,332	37,792	38,105	42,384	32,524	30,695	22,515	23,474	26,192
		1974	19,751	63,291	79,012	139,274	64,756	83,123	113,459	35,108	29,571	23,957	26,042	28,668
		1975	24,398	26,812	30,721	23,540	60,242	71,361	41,473	36,812	30,754	20,565	21,746	23,839
		AVG	19,364	30,587	53,397	108,713	87,008	69,098	57,527	38,310	31,678	20,524	21,773	24,808
	1978-1992	1982	11,441	39,338	91,853	98,112	100,549	86,350	149,356	66,304	36,044	25,011	25,319	31,759
		1983	28,817	42,769	95,552	96,881	183,046	266,621	121,793	103,031	79,795	53,418	35,542	37,543
		1984	36,150	71,675	155,567	103,431	46,831	42,147	23,780	19,566	17,950	24,061	21,565	21,387
		1986	12,012	12,681	19,091	23,316	207,820	168,598	50,073	23,530	19,144	20,308	18,871	23,021
		AVG	22,105	41,615	90,516	80,430	134,562	140,929	86,250	53,108	38,233	30,699	25,325	28,423
	1993-1994	NO WET WATER YEARS												
	1995-1997	1995	9,883	11,098	16,153	112,460	82,108	196,794	95,321	104,068	57,795	41,815	24,125	29,765

Appendix E-2. Simulated Average Monthly Delta Inflow (cfs) by Water-year Type for Existing Operations to 1995 Bay-Delta Plan. W-Wet, B-Below Normal, D-Dry, C-Critical, A-Above Normal.

TOTAL DELTA INFLOW (CFS) DWRSIM - DELTA ACCORD MODEL RUN 420													
WATER YEAR	WATER YEAR TYPE	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1922	A	12,188	14,292	23,728	24,189	53,685	41,132	29,324	55,738	42,352	15,881	13,060	12,308
1928	A	17,865	34,330	20,874	29,248	33,621	110,285	33,366	21,993	18,039	23,954	16,970	12,382
1940	A	14,941	12,783	15,001	35,781	64,165	115,279	73,886	23,951	18,042	25,277	18,783	12,595
1951	A	18,971	59,314	96,287	74,519	75,256	37,313	21,520	25,038	17,990	25,183	17,509	12,959
1954	A	23,445	28,400	18,830	37,224	69,077	55,200	48,927	27,139	18,028	25,294	17,682	13,102
1957	A	28,266	18,640	14,252	20,331	45,964	51,359	23,795	22,362	19,351	25,292	20,561	12,828
1973	A	18,981	30,617	31,852	86,259	103,644	69,424	24,119	24,250	22,272	20,720	16,694	13,229
1978	A	8,586	10,374	21,206	71,589	67,226	76,220	49,292	26,810	19,547	15,363	13,056	15,722
1980	A	14,423	23,412	26,849	122,092	141,988	77,473	24,769	21,444	17,387	15,887	13,456	18,073
	AVG	**17,518**	**25,796**	**29,875**	**55,692**	**72,736**	**70,409**	**36,555**	**27,636**	**21,445**	**21,428**	**16,419**	**13,689**
1923	B	24,729	26,793	47,758	40,676	27,182	17,415	32,518	20,578	18,790	23,541	18,895	12,629
1935	B	9,122	16,621	16,384	34,038	18,919	33,043	47,744	38,794	20,666	23,320	17,177	11,132
1936	B	13,841	13,747	15,647	37,227	80,811	38,793	27,475	20,138	18,974	22,990	16,224	11,460
1937	B	12,675	12,605	21,798	19,778	51,825	57,908	29,438	20,768	20,396	16,856	14,001	11,305
1945	B	16,480	20,575	22,338	17,999	60,499	36,076	18,611	17,724	21,375	17,701	15,143	11,885
1946	B	18,578	23,973	85,176	57,442	30,551	27,069	18,814	19,549	20,080	21,698	16,710	12,249
1948	B	17,147	15,104	15,026	17,750	19,351	19,936	29,339	37,028	23,835	23,634	21,260	19,024
1950	B	14,185	13,955	14,209	26,877	40,634	25,966	23,915	19,446	20,018	23,632	21,290	13,269
1959	B	27,910	19,961	15,655	44,019	63,520	23,811	14,246	14,342	16,929	22,800	15,920	14,732
1962	B	13,896	15,150	19,272	14,329	63,898	30,255	15,539	19,036	16,905	23,628	18,700	13,263
1966	B	19,155	33,798	22,715	35,759	33,317	30,277	18,254	18,886	16,940	23,634	18,560	12,994
1968	B	27,814	21,182	20,181	35,721	73,825	42,518	17,012	14,187	16,945	22,405	16,016	13,031
1972	B	21,656	19,590	29,242	21,415	29,428	35,157	16,947	14,422	16,945	23,636	19,759	13,212
1979	B	21,999	20,688	12,883	34,999	53,892	39,732	23,695	22,005	23,140	17,770	14,203	11,708
	AVG	**18,513**	**19,553**	**25,592**	**31,288**	**46,261**	**32,711**	**23,825**	**21,207**	**19,424**	**21,946**	**17,418**	**12,992**
1924	C	14,029	14,468	20,210	19,415	19,668	17,135	10,780	11,133	12,455	16,785	11,437	8,880
1929	C	12,306	17,656	20,866	15,937	19,866	16,234	12,479	12,405	17,268	18,682	9,549	9,031
1931	C	10,864	11,945	12,245	18,579	15,730	13,136	12,967	10,321	12,427	12,866	6,884	8,358
1933	C	10,632	11,203	13,478	21,232	16,891	15,530	15,995	12,542	16,121	12,328	7,586	8,865
1934	C	9,912	8,466	19,628	21,738	21,298	19,229	16,167	11,558	16,921	12,334	7,392	9,125
1976	C	28,955	23,760	18,314	14,762	21,687	17,918	13,048	12,673	16,927	14,249	10,332	9,486
1977	C	10,316	11,793	19,752	15,071	15,285	12,445	11,945	10,402	9,184	10,286	7,508	8,378
1988	C	12,276	13,523	21,395	30,447	18,786	13,669	12,733	12,587	16,990	17,180	11,633	9,579
1990	C	11,277	9,697	15,219	20,603	19,339	13,450	15,987	12,503	16,572	17,193	11,871	8,542
1991	C	8,848	9,638	13,500	11,633	16,911	36,211	17,011	11,164	17,124	17,417	9,202	9,718
1992	C	10,012	9,086	13,945	14,304	38,958	23,922	15,958	11,269	16,729	18,042	10,638	9,555
	AVG	**12,675**	**12,858**	**17,141**	**18,520**	**20,402**	**18,080**	**14,097**	**11,687**	**15,338**	**15,215**	**9,457**	**9,047**
1925	D	16,174	14,023	17,950	13,889	58,322	23,896	30,274	19,979	18,709	21,516	16,342	12,325
1926	D	16,184	13,863	15,140	21,237	43,931	17,992	28,497	18,781	15,783	21,761	16,225	12,274
1930	D	14,513	12,766	18,566	28,097	21,244	34,537	16,329	14,374	15,777	17,787	11,966	10,440
1932	D	11,452	12,050	24,701	21,317	24,780	15,998	18,414	16,581	16,936	12,600	10,543	10,836
1939	D	28,944	21,030	18,727	18,638	18,761	17,360	16,588	14,467	16,049	21,878	15,224	11,826

Appendix E-2. (Continued).

TOTAL DELTA INFLOW (CFS) DWRSIM - DELTA ACCORD MODEL RUN 420													
WATER YEAR	WATER YEAR TYPE	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1944	D	16,914	18,422	14,922	19,654	42,830	27,605	15,791	14,445	19,188	21,109	15,152	11,759
1947	D	14,619	16,964	20,347	18,501	24,888	25,412	17,461	14,324	15,835	22,965	18,698	12,398
1949	D	18,417	15,073	17,929	15,169	17,257	57,820	17,257	18,756	17,700	18,774	14,921	12,823
1955	D	12,959	21,632	31,358	27,550	22,109	13,578	14,220	14,967	18,710	22,970	20,690	17,528
1960	D	15,324	13,355	20,313	17,225	34,491	23,759	17,471	13,736	16,044	22,999	20,125	12,820
1961	D	14,411	17,777	19,575	16,729	35,663	22,580	15,885	13,642	15,902	23,016	20,313	12,669
1964	D	21,398	39,138	17,509	32,653	18,449	15,322	13,195	14,451	16,741	22,964	20,637	13,647
1981	D	21,812	18,415	21,061	32,601	33,121	39,387	19,336	14,142	15,817	21,920	15,205	11,808
1985	D	23,299	46,794	33,254	18,850	24,871	23,733	13,743	17,088	15,828	22,979	19,171	12,639
1987	D	17,407	16,052	14,309	16,574	24,962	38,274	16,067	13,773	15,793	22,956	17,088	11,753
1989	D	8,835	12,940	14,967	14,756	16,440	44,941	25,712	17,083	15,804	23,063	20,328	13,759
	AVG	**17,041**	**19,393**	**20,039**	**20,840**	**28,895**	**27,637**	**18,515**	**15,662**	**16,664**	**21,329**	**17,039**	**12,582**
1927	W	16,322	27,499	19,506	36,225	129,845	49,164	56,537	30,527	18,776	18,176	15,772	11,401
1938	W	12,984	38,803	84,535	39,649	152,277	172,332	74,806	71,277	46,876	17,433	13,753	21,825
1941	W	14,318	15,457	57,082	110,192	129,924	106,346	90,507	49,474	24,189	15,572	13,495	17,403
1942	W	26,563	25,136	77,084	90,247	152,239	33,896	61,231	45,812	32,179	15,615	13,499	18,359
1943	W	27,790	29,778	36,746	89,907	68,850	89,633	37,282	25,083	17,255	18,328	15,014	11,342
1952	W	16,525	21,604	58,847	100,775	88,100	71,498	73,475	71,510	47,150	20,977	14,709	24,290
1953	W	27,312	21,842	54,968	107,593	31,134	25,784	25,024	31,304	30,532	19,520	14,393	16,822
1956	W	12,347	15,488	91,268	167,264	101,255	42,868	28,095	50,556	28,601	17,893	17,688	20,024
1958	W	22,819	21,427	31,610	44,534	169,110	134,753	114,100	51,187	45,213	18,414	16,213	23,366
1963	W	44,029	22,936	32,088	21,126	79,437	38,362	101,153	37,179	20,180	19,571	16,772	16,030
1965	W	13,179	19,988	88,209	125,689	39,892	25,705	56,590	31,705	18,067	23,581	16,546	12,484
1967	W	14,973	22,086	48,878	60,677	67,254	65,435	59,172	55,817	52,097	25,100	14,949	23,337
1969	W	16,174	17,838	28,287	131,401	143,949	65,313	56,392	69,657	40,654	19,100	14,137	27,144
1970	W	31,278	23,788	66,257	211,398	97,310	43,541	19,436	15,385	18,081	22,444	16,092	12,603
1971	W	16,142	31,911	79,458	57,757	32,602	57,062	25,109	37,253	25,792	20,777	17,653	18,474
1974	W	19,589	76,298	78,695	138,324	51,956	116,919	81,335	31,812	25,578	19,603	15,936	23,945
1975	W	25,889	21,509	23,074	18,621	76,521	95,630	31,308	40,125	29,860	19,117	17,356	20,393
1982	W	15,849	43,336	101,337	90,664	108,948	92,972	153,979	60,411	32,502	21,112	17,205	30,367
1983	W	45,144	59,295	99,644	114,637	195,121	269,908	119,833	92,228	86,374	44,353	23,193	36,929
1984	W	46,344	93,051	166,723	88,920	55,169	44,093	21,429	17,582	19,097	20,832	15,888	18,641
1986	W	15,515	17,869	20,806	23,605	233,086	163,114	41,653	20,767	18,058	17,163	14,982	14,540
	AVG	**22,909**	**31,759**	**64,052**	**89,010**	**104,951**	**85,920**	**63,259**	**44,602**	**32,243**	**20,699**	**15,964**	**19,987**

Appendix E-3. Simulated Average Monthly Delta Inflow (cfs) by Water-year Type for Future Operations to Interim South Delta Program Meeting Future Water Demands. W-Wet, B-Below Normal, D-Dry, C-Critical, A-Above Normal.

TOTAL DELTA INFLOW (CFS) DWRSIM MODEL RUN 414 - INTERIM SOUTH DELTA PROGRAM AT FUTURE DEMAND													
YEAR	WATER-YEAR TYPE	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1922	A	12,072	12,946	21,619	22,010	49,585	39,427	29,192	55,947	42,357	16,325	16,585	12,189
1928	A	13,131	28,300	19,436	26,931	30,014	106,061	32,862	21,913	18,401	21,245	22,988	10,320
1940	A	12,317	12,559	15,445	30,564	51,587	110,085	73,367	23,982	18,519	24,259	17,758	15,421
1951	A	15,412	54,091	102,656	72,173	73,557	35,207	20,892	25,318	18,384	28,120	19,534	17,458
1954	A	17,579	24,259	17,449	33,675	67,983	53,780	48,249	27,191	18,249	24,471	23,069	12,407
1957	A	24,242	18,535	13,392	19,241	43,903	50,424	22,980	20,495	19,596	28,902	19,420	17,609
1973	A	13,750	25,741	29,326	78,022	99,477	68,068	24,209	23,884	22,778	26,035	19,827	12,559
1978	A	8,439	9,495	18,312	66,439	65,999	67,546	47,912	27,761	20,825	18,573	17,514	12,458
1980	A	13,196	19,579	23,395	106,272	138,618	75,920	24,310	21,636	18,401	24,308	18,003	14,141
	AVG	**14,460**	**22,834**	**29,003**	**50,592**	**68,969**	**67,391**	**35,997**	**27,570**	**21,945**	**23,582**	**19,411**	**13,840**
1923	B	17,612	24,798	43,858	39,312	31,584	16,585	29,798	20,300	19,108	22,141	18,133	15,774
1935	B	8,830	14,714	14,418	30,205	18,182	29,912	44,259	40,306	21,229	21,163	17,400	13,350
1936	B	13,017	14,091	15,037	34,702	72,348	36,722	26,987	19,453	18,956	25,464	17,889	14,983
1937	B	12,203	13,552	22,532	17,758	46,735	52,183	29,108	20,609	24,091	19,110	16,325	11,397
1945	B	13,669	18,855	20,186	17,269	51,587	28,935	19,630	17,351	21,650	21,848	14,907	11,330
1946	B	13,832	21,481	73,965	55,735	30,285	24,617	18,670	18,931	20,455	20,365	18,345	11,044
1948	B	15,836	14,209	14,744	17,644	18,416	16,764	26,414	34,474	23,266	29,488	20,642	16,886
1950	B	12,529	13,316	12,985	23,623	39,159	24,145	23,451	18,850	20,455	21,685	18,638	15,505
1959	B	26,295	19,798	15,119	42,164	60,335	25,106	13,754	14,321	17,306	24,145	20,593	15,034
1962	B	11,616	13,300	18,573	13,457	56,584	28,641	17,306	18,996	17,357	23,949	21,245	11,886
1966	B	16,813	31,044	20,414	33,545	32,071	27,696	18,300	18,671	17,290	26,344	22,613	14,630
1968	B	27,094	20,640	19,453	33,219	72,727	40,534	16,751	14,011	17,273	24,959	20,088	15,909
1972	B	18,312	18,367	22,792	20,609	28,860	35,158	15,875	14,321	17,172	26,979	19,778	16,869
1979	B	18,508	17,963	15,771	27,517	50,884	39,019	23,872	21,685	23,687	25,350	20,495	12,441
	AVG	**16,155**	**18,295**	**23,560**	**29,054**	**43,554**	**30,430**	**23,155**	**20,877**	**19,949**	**23,785**	**19,078**	**14,074**
1924	C	11,877	14,040	20,837	15,314	18,506	15,249	10,303	11,144	12,525	13,066	8,113	7,795
1929	C	11,958	15,724	18,117	15,233	19,084	14,418	11,852	12,414	16,380	18,280	8,341	8,906
1931	C	10,134	9,983	16,895	15,624	14,430	12,023	12,643	9,400	12,306	12,138	6,631	8,519
1933	C	10,606	9,226	11,079	17,286	14,989	13,148	16,330	11,926	16,919	16,194	8,553	9,091
1934	C	9,303	8,923	16,944	19,013	16,071	19,306	15,892	11,307	15,774	13,783	7,641	8,670
1976	C	24,910	22,290	18,833	14,695	20,815	15,771	12,407	12,594	16,987	20,968	11,144	8,704
1977	C	9,775	11,364	19,029	9,661	14,809	12,333	11,717	9,140	9,259	10,508	7,413	7,862
1988	C	9,123	12,020	19,257	28,201	14,719	13,799	11,481	11,013	15,657	19,062	8,798	8,283
1990	C	10,753	9,495	17,612	19,616	17,370	12,333	15,421	10,166	16,734	20,121	8,732	8,451
1991	C	8,684	10,051	13,359	11,975	15,422	32,405	16,700	10,541	16,044	15,005	9,254	10,657
1992	C	8,700	8,468	10,362	13,050	34,794	21,440	15,404	11,307	16,633	15,412	8,537	8,721
	AVG	**11,438**	**11,962**	**16,575**	**16,333**	**18,274**	**16,566**	**13,650**	**10,996**	**15,020**	**15,867**	**8,469**	**8,696**
1925	D	13,604	12,609	14,989	12,773	52,922	22,010	28,300	18,214	19,040	19,453	14,158	11,700
1926	D	12,740	12,912	14,370	18,573	38,709	18,980	25,774	18,003	16,212	22,467	18,166	15,505
1930	D	13,897	11,835	17,416	25,138	19,210	31,672	15,640	14,272	16,229	16,227	11,486	10,067
1932	D	10,671	10,606	18,459	19,094	20,635	15,591	17,946	15,461	16,785	13,913	10,704	10,909
1939	D	28,006	20,875	18,589	17,970	17,929	15,331	16,263	14,011	16,212	23,509	20,251	13,401

Appendix E-3. (Continued).

TOTAL DELTA INFLOW (CFS)

DWRSIM MODEL RUN 414 - INTERIM SOUTH DELTA PROGRAM AT FUTURE DEMAND

YEAR	WATER-YEAR TYPE	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1944	D	13,799	17,121	21,668	18,687	33,351	25,155	13,502	13,702	19,310	21,538	20,153	12,441
1947	D	12,985	14,916	19,013	18,719	23,611	23,216	17,256	14,125	15,842	21,945	20,349	11,751
1949	D	15,168	14,495	16,113	14,386	16,234	55,393	17,391	18,589	17,626	19,583	12,056	11,902
1955	D	12,968	18,047	28,902	24,259	21,086	12,186	12,845	14,500	18,973	23,053	21,978	12,542
1960	D	13,376	13,434	15,575	15,445	32,359	21,522	16,566	13,457	16,145	26,035	17,775	15,438
1961	D	12,040	15,286	18,948	14,500	30,375	21,245	15,505	13,522	16,246	20,398	19,583	10,774
1964	D	20,039	33,754	17,595	27,729	18,525	14,761	12,896	14,337	16,397	24,536	20,121	13,906
1981	D	20,805	17,626	19,013	24,503	30,429	34,441	17,593	14,044	16,195	24,128	20,283	15,303
1985	D	21,326	39,343	32,323	17,498	20,491	16,406	14,327	17,041	16,044	26,214	17,742	16,633
1987	D	16,439	12,727	19,811	18,573	21,338	30,808	16,549	13,767	16,145	21,685	12,822	10,101
1989	D	8,244	11,397	12,903	14,288	15,133	42,734	25,825	17,188	16,128	21,180	17,807	11,902
	AVG	**15,382**	**17,312**	**19,105**	**18,883**	**25,771**	**25,091**	**17,761**	**15,265**	**16,846**	**21,616**	**17,214**	**12,767**
1927	W	12,610	25,303	18,719	32,193	128,842	49,153	55,673	30,205	18,923	25,106	19,567	11,566
1938	W	12,887	33,788	69,192	34,506	139,791	169,990	74,613	71,733	47,222	17,090	17,351	19,141
1941	W	12,284	14,966	48,664	107,625	125,938	104,448	88,670	48,925	24,646	18,475	18,133	15,842
1942	W	20,756	22,896	71,668	86,624	150,253	31,818	59,882	45,047	31,616	17,188	18,345	16,734
1943	W	22,955	24,714	35,745	85,272	66,901	87,357	36,734	26,442	18,401	24,585	19,648	13,384
1952	W	12,496	18,418	52,444	92,392	87,103	69,176	72,458	71,848	47,391	20,414	14,467	23,535
1953	W	26,703	20,589	51,515	106,289	31,061	24,878	24,495	30,922	29,848	24,471	20,365	16,549
1956	W	12,382	14,815	81,997	164,467	100,577	42,375	26,818	49,723	28,081	19,143	18,719	18,771
1958	W	19,778	20,370	29,456	41,284	156,439	131,688	114,276	51,254	45,152	17,726	17,921	20,842
1963	W	37,537	22,441	30,922	18,801	80,105	36,250	98,872	36,494	20,640	23,379	18,850	13,485
1965	W	11,893	17,458	82,388	124,829	39,466	23,835	56,448	31,541	18,451	24,324	19,029	12,475
1967	W	12,691	18,098	45,064	50,929	64,141	63,392	59,074	56,435	51,414	24,487	14,435	22,542
1969	W	13,311	15,421	25,676	118,442	139,755	64,679	56,229	69,583	37,896	18,557	15,591	24,461
1970	W	28,869	23,215	64,109	206,598	96,501	42,294	19,394	15,314	18,300	27,045	21,652	16,380
1971	W	13,131	26,145	69,567	54,659	33,189	53,601	24,731	36,347	25,387	25,073	19,713	18,805
1974	W	15,738	66,650	76,735	137,634	52,363	115,054	80,337	31,346	24,966	22,988	18,752	20,253
1975	W	21,375	21,162	22,385	18,475	75,325	92,864	30,690	39,655	29,377	20,104	18,801	20,000
1982	W	12,659	35,017	95,503	86,347	106,357	89,296	152,475	60,150	32,071	20,658	17,025	28,249
1983	W	43,614	56,229	97,817	110,166	190,981	264,516	118,670	92,033	85,892	43,825	22,955	35,707
1984	W	45,699	90,505	163,213	88,759	54,095	43,320	21,195	17,269	19,529	28,413	18,850	18,872
1986	W	11,893	14,108	19,420	21,717	221,374	160,492	41,044	20,544	18,434	25,138	17,742	14,226
	AVG	**20,060**	**28,681**	**59,629**	**85,143**	**101,932**	**83,832**	**62,513**	**44,420**	**32,078**	**23,247**	**18,472**	**19,134**

Appendix E-4. Simulated Average Monthly Delta Inflow (cfs) by Water-year Type for Future Operations to State Water Resources Control Board Water Rights Alternative 5. W-Wet, B-Below Normal, D-Dry, C-Critical, A-Above Normal.

TOTAL DELTA INFLOW (CFS) STATE WATER RESOURCES CONTROL BOARD ALTERNATIVE 5 - DWRSIM MODEL RUN 524													
Water Year	Water-Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
1922	A	13,620	14,310	21,489	21,717	48,069	39,785	31,128	56,533	45,118	19,436	16,080	15,135
1928	A	17,579	22,357	20,316	29,472	33,827	106,191	35,640	25,073	16,296	23,851	19,469	12,946
1940	A	11,470	10,219	9,661	30,629	62,816	113,425	76,751	25,806	20,539	23,851	19,241	13,165
1951	A	14,695	61,195	105,784	81,020	78,574	40,046	21,549	25,725	21,246	23,851	19,094	14,781
1954	A	19,648	22,946	16,846	35,842	67,022	55,572	47,037	30,890	17,256	23,851	19,306	14,882
1957	A	25,464	17,559	16,341	20,935	37,708	52,835	26,397	22,825	22,795	23,835	18,996	12,559
1973	A	14,695	25,741	28,772	82,437	102,563	71,212	27,071	22,255	23,013	23,851	19,045	14,680
1978	A	9,384	8,586	14,907	64,011	67,509	76,572	57,424	32,910	24,343	16,993	15,184	16,599
1980	A	16,455	18,535	24,471	114,549	148,646	69,127	27,963	23,672	24,815	18,100	14,060	16,684
1993	A	10,606	9,158	16,781	61,030	59,332	63,131	47,172	35,239	35,084	19,909	15,298	13,401
	AVG	13,965	19,146	25,033	49,240	64,188	62,536	36,194	27,357	22,773	19,775	15,979	13,167
1923	B	19,225	20,640	43,874	39,752	28,357	20,039	32,104	20,903	21,801	22,353	18,475	10,960
1935	B	10,981	11,178	10,606	31,672	16,426	32,079	49,899	35,745	22,121	22,353	15,054	12,071
1936	B	15,217	11,936	11,942	36,478	93,538	40,779	29,865	21,163	22,778	22,353	18,475	10,960
1937	B	15,575	13,737	14,940	19,143	52,347	53,014	33,519	25,937	21,953	18,687	14,598	10,892
1945	B	11,502	16,768	18,654	16,585	56,372	38,351	19,495	17,775	20,556	22,353	18,475	12,441
1946	B	16,976	20,960	79,228	59,906	30,993	29,945	19,091	18,850	19,833	22,336	18,475	14,444
1948	B	11,665	11,987	11,437	16,276	17,906	21,815	28,535	31,753	25,741	22,353	18,475	14,798
1950	B	15,363	13,148	12,724	23,493	38,610	25,758	24,781	19,518	23,266	21,440	13,799	14,360
1959	B	26,947	18,687	17,025	38,759	59,874	26,947	14,040	13,262	20,572	22,353	18,475	12,441
1962	B	13,539	13,064	18,605	16,862	57,040	33,741	20,589	19,322	19,529	22,336	18,475	14,848
1966	B	17,335	30,657	22,858	36,869	34,513	33,855	21,448	18,117	17,896	22,271	18,491	14,832
1968	B	26,246	16,519	19,273	34,751	68,755	43,646	20,152	13,066	20,118	22,353	17,905	12,744
1972	B	20,300	17,273	23,086	22,450	28,520	36,005	16,818	14,353	19,478	22,336	18,459	12,391
1979	B	20,088	16,768	16,064	33,643	55,289	44,444	24,562	19,420	23,030	22,304	16,487	11,364
	AVG	17,211	16,809	22,880	30,474	45,610	34,316	25,350	20,656	21,341	22,013	17,437	12,825
1924	C	14,467	12,946	15,966	16,732	20,307	14,321	10,589	11,144	12,508	10,834	7,999	9,613
1929	C	15,803	14,848	15,771	16,960	20,467	16,373	11,566	12,349	12,660	10,476	8,211	9,613
1931	C	11,584	11,397	10,785	14,027	13,123	10,606	11,700	12,447	15,051	11,404	8,065	9,646
1933	C	12,740	11,296	10,459	15,331	15,704	12,805	16,111	10,688	12,660	9,449	8,130	9,697
1934	C	9,775	9,646	14,956	19,225	16,119	16,504	15,438	11,372	16,077	15,331	10,215	9,630
1976	C	26,735	21,566	19,078	18,719	22,816	20,772	11,902	12,398	21,263	18,736	12,626	9,512
1977	C	11,486	10,690	10,036	9,368	13,845	9,221	11,869	9,791	11,380	8,749	8,618	9,343
1988	C	12,382	10,303	18,312	28,576	19,783	12,643	10,960	11,975	16,465	12,854	7,950	9,697
1990	C	14,451	13,081	16,048	23,183	19,296	16,520	15,168	10,003	21,347	17,351	9,400	10,421
1991	C	11,176	9,495	10,182	8,097	11,895	34,246	18,081	11,013	12,593	12,040	9,808	9,579
1992	C	10,248	9,192	9,107	13,848	37,726	23,574	15,522	11,323	15,774	13,946	7,788	9,529
1994	C	17,579	25,438	20,283	19,339	31,931	17,856	12,677	10,720	21,616	19,860	17,400	10,623
	AVG	14,036	13,325	14,249	16,950	20,253	17,120	13,465	11,269	15,783	13,419	9,684	9,742
1925	D	10,231	8,990	13,962	12,186	62,274	35,745	27,256	16,650	16,481	19,110	13,604	10,051
1926	D	11,567	12,508	14,614	20,381	42,292	18,671	25,152	18,524	17,189	18,622	9,498	11,785
1930	D	10,867	8,687	16,194	23,526	18,394	34,181	16,077	14,435	19,899	20,821	15,640	9,646
1932	D	9,270	9,747	19,860	22,255	26,733	15,999	18,215	16,422	22,104	20,039	12,724	10,084
1939	D	31,704	22,340	21,619	21,717	23,556	20,218	15,960	12,089	21,162	20,837	17,498	10,051
1944	D	16,455	16,734	16,390	20,560	37,726	30,987	14,798	12,773	21,027	20,837	17,970	11,414
1947	D	15,934	16,818	21,750	17,775	24,692	25,692	18,114	12,056	20,774	20,821	17,954	12,071
1949	D	15,494	16,094	18,019	17,172	18,718	49,560	18,165	18,426	19,394	20,789	14,484	11,212

Appendix E-4. (Continued).

TOTAL DELTA INFLOW (CFS) STATE WATER RESOURCES CONTROL BOARD ALTERNATIVE 5 - DWRSIM MODEL RUN 524													
Water Year	Water-Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
1955	D	16,129	22,492	29,032	26,523	19,639	20,495	13,350	13,734	20,673	20,821	15,086	10,101
1960	D	16,129	13,030	11,826	16,357	33,484	25,106	16,801	13,587	20,185	20,821	11,828	10,219
1961	D	14,093	15,168	19,045	16,390	34,296	22,858	15,219	11,013	21,987	20,821	17,628	9,545
1964	D	19,192	32,340	17,367	29,717	22,635	19,501	12,357	13,653	20,051	20,821	17,905	14,781
1981	D	21,196	15,522	18,247	32,991	33,700	37,488	21,431	12,252	20,572	20,837	17,970	11,498
1985	D	18,931	37,997	26,442	18,768	23,863	25,823	15,892	16,357	18,704	20,837	17,970	14,495
1987	D	17,335	13,434	15,868	18,752	26,029	33,024	14,832	10,720	22,155	20,821	17,090	9,815
1989	D	9,743	10,185	10,720	13,441	13,502	46,139	26,734	16,781	18,754	20,837	11,877	12,593
	AVG	15,892	17,005	18,191	20,532	28,858	28,843	18,147	14,342	20,069	20,531	15,420	11,210
1927	W	14,272	23,923	18,589	34,050	142,563	50,929	57,862	33,545	23,889	23,851	17,660	13,535
1938	W	15,673	27,155	73,135	41,365	153,394	180,156	87,727	86,331	52,795	19,436	15,705	23,064
1941	W	15,575	15,976	50,815	109,840	133,231	103,829	87,071	53,796	31,195	17,954	15,200	21,077
1942	W	27,273	20,976	73,819	90,730	152,960	38,319	58,300	46,628	35,421	19,681	16,129	18,047
1943	W	26,849	26,246	34,457	93,662	69,910	98,159	40,774	28,902	22,155	19,550	15,526	14,057
1952	W	15,233	18,923	51,743	98,648	89,495	78,348	78,047	79,896	50,993	21,717	17,856	24,495
1953	W	29,244	19,242	48,925	107,087	36,444	29,831	21,616	32,454	29,714	23,851	18,736	15,859
1956	W	14,744	12,559	88,156	181,215	100,740	47,898	28,687	48,892	32,660	23,688	17,709	19,815
1958	W	23,803	21,195	25,937	39,378	160,523	133,855	112,323	61,730	47,340	20,886	19,485	26,717
1963	W	34,995	22,189	29,668	20,381	83,394	38,237	98,603	37,846	24,680	23,851	18,850	15,000
1965	W	12,235	15,657	80,026	129,391	44,278	27,142	56,077	33,024	23,788	22,353	16,292	14,747
1967	W	15,428	17,290	40,469	53,535	65,144	68,915	65,707	67,188	56,616	27,387	17,302	25,337
1969	W	15,754	15,875	27,191	130,173	150,614	77,387	71,077	76,865	45,253	20,007	16,064	28,956
1970	W	28,478	20,724	60,964	211,779	99,386	48,892	23,013	18,964	19,478	23,851	19,339	12,845
1971	W	14,744	25,320	68,003	56,663	32,617	58,781	27,222	35,288	27,576	23,851	18,736	20,758
1974	W	17,204	67,593	77,175	139,394	53,556	120,414	78,519	35,174	27,273	23,574	18,736	25,421
1975	W	24,894	20,067	20,577	21,310	70,776	98,762	35,337	36,950	33,249	23,770	18,345	21,195
1982	W	14,288	37,071	96,090	88,025	112,635	96,204	150,589	57,967	36,616	21,815	17,302	27,071
1983	W	38,547	53,064	92,701	112,952	189,332	252,590	109,293	83,610	97,626	39,475	23,672	35,960
1984	W	37,993	88,013	161,030	81,052	51,191	44,884	24,512	20,153	22,189	23,851	18,752	12,896
1986	W	12,333	11,919	18,622	24,715	226,065	162,447	33,300	23,412	22,929	17,954	15,331	15,067
	AVG	21,408	27,666	58,957	88,826	105,631	88,380	64,079	47,553	36,354	22,969	17,749	20,568

Appendix E-5. Average Historic Monthly QWEST Flows (cfs) by Water-year Type and Time Periods Representing Major Changes in Water Flow Management Within the Sacramento River system and Sacramento-San Joaquin Bay-Delta Estuary, California. Data from Department of Water Resources DAYFLOW.

HISTORIC QWEST (CFS) - AVERAGE MONTHLY BY WATER-YEAR TYPE														
WATER-YEAR TYPE	PERIOD	WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
ABOVE NORMAL	PRE-1945	1940	2474	2530	3179	17265	23698	29429	30829	20881	12507	1104	455	2083
	1945-1950		NO ABOVE NORMAL WATER YEARS											
	1951-1967	1951	3199	22505	45544	24704	24554	18581	7708	12310	3676	-411	-738	717
		1954	2759	6510	8036	12690	20154	21337	21823	13424	-1149	-3381	-2474	-325
		1957	3282	4792	4507	5599	6619	12699	7700	8532	4945	-579	210	3379
		AVG	3073	11269	19362	14331	17109	17539	12410	11422	2491	-1457	-1001	1257
	1968-1977	1973	2597	7428	6462	18739	25431	20068	8905	2413	-1115	-3973	-2034	1696
		1978	1656	1540	1618	7814	10783	19682	26734	24040	3519	-2539	-1954	2037
		AVG	2127	4484	4040	13276	18107	19875	17819	13227	1202	-3256	-1994	1866
	1978-1992	1978	1656	1540	1618	7814	10783	19682	26734	24040	3519	-2539	-1954	2037
		1980	1179	3559	4015	26298	29672	34148	10839	9281	4644	2049	-2899	1673
		AVG	1418	2550	2816	17056	20228	26915	18787	16660	4081	-245	-2426	1855
	1993-1994	1993	2238	2028	3772	6601	5402	8202	5541	5588	4602	-917	-2008	-2809
	1995-1997	1996	4128	2144	6000	1220	24597	25508	10697	11457	-177	-1804	-1984	-2093
		1997	-1925	-2073	21476	57314	47612	12416	2903	4421	-279	-2674	-1693	-3306
		AVG	1101	36	13738	29267	36105	18961	6800	7939	-228	-2239	-1839	-2700

Appendix E-5. (Continued).

HISTORIC QWEST (CFS) - AVERAGE MONTHLY BY WATER-YEAR TYPE														
WATER-YEAR TYPE	PERIOD	WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
BELOW NORMAL	PRE-1945	1935	1736	4624	4311	11537	8756	12959	28822	25054	19543	2117	410	1629
		1936	3812	3600	4789	13573	33527	23203	23918	23156	14836	2488	525	1796
		1937	2827	3130	5453	7825	25060	27529	24851	28029	18152	2533	362	1585
		AVG	2792	3784	4851	10979	22448	21230	25864	25413	17511	2379	432	1670
	1945-1950	1945	2398	7516	8705	7250	26769	17808	14406	19484	13851	3275	1392	2480
		1946	5149	7258	18196	19994	11695	10525	12860	18726	6801	693	719	1960
		1948	3258	3894	3198	4899	3417	6152	12239	14549	14595	832	377	1701
		1950	2195	3335	3458	9388	13528	8577	13220	10870	7586	-113	-37	1648
		AVG	3249	5501	8389	10383	13852	10716	13181	15910	10708	1172	613	1947
	1951-1967	1959	6758	8144	7103	8602	13950	6890	4094	2154	-957	-1295	135	4297
		1962	1978	4490	7021	5724	21892	15059	9955	6952	4465	-851	-725	1407
		1966	7928	11911	11165	12163	11845	6449	4911	2597	-946	-1426	-437	2136
		AVG	5555	8182	8430	8830	15896	9466	6320	3901	854	-1191	-342	2613
	1968-1977	1968	7986	8371	10373	8048	12212	6970	2046	164	-986	-1610	-522	-287
		1972	5216	4974	9324	9070	8335	1496	697	-1041	-2602	-809	-1520	1045
		AVG	6601	6673	9848	8559	10273	4233	1372	-438	-1794	-1209	-1021	379
	1978-1992	1979	3541	4131	2055	10865	16122	13058	2834	3605	79	-2919	-4207	-2237
	1993-1994		NO BELOW NORMAL WATER YEARS											
	1995-1997		NO BELOW NORMAL WATER YEARS											

Appendix E-5. (Continued).

HISTORIC QWEST (CFS) - AVERAGE MONTHLY BY WATER-YEAR TYPE

WATER-YEAR TYPE	PERIOD	WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
CRITICAL	PRE-1945	1931	3236	3551	2935	5702	5265	4094	1525	1361	-360	-1194	-617	119
		1933	2328	2809	4328	6717	6522	6719	4811	5005	6745	215	-99	1292
		1934	2501	3345	6664	9080	9162	6211	3206	1584	67	-855	-550	785
		AVG	2688	3235	4642	7160	6983	5675	3181	2650	2151	-611	-422	732
	1945-1950		NO CRITICAL WATER YEARS											
	1951-1967		NO CRITICAL WATER YEARS											
	1968-1977	1976	5482	4682	4608	1054	449	-264	2042	-745	-426	-583	-1744	-2411
		1977	395	607	1447	-639	1206	603	1595	1082	992	919	493	880
		AVG	2939	2635	3028	208	827	169	1819	169	283	168	-626	-766
	1978-1992	1988	-1088	382	-45	-2514	-3255	-1104	1359	-1281	-1369	-2921	-3593	-2834
		1990	-2995	-2724	-3693	-3437	-1560	-2918	-2332	2660	758	-1916	-1845	-1599
		1991	767	1328	869	27	2669	1461	-1973	668	374	239	-715	-232
		1992	-287	1495	2989	675	4623	-4090	-433	935	245	600	142	-524
		AVG	-900	120	30	-1312	619	-1663	-845	800	2	-950	-1503	-1297
	1993-1994	1994	-2359	328	-124	-8	2401	155	1929	1988	1259	-903	-1780	-1835
	1995-1997		NO CRITICAL WATER YEARS											

Appendix E-5. (Continued).

HISTORIC QWEST (CFS) - AVERAGE MONTHLY BY WATER-YEAR TYPE														
WATER-YEAR TYPE	PERIOD	WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
DRY	PRE-1945	1930	2031	2223	6144	8851	7869	11747	8002	6203	3714	198	266	1822
		1932	1028	2413	7896	9515	20581	10633	9798	18138	18990	5333	498	1178
		1939	4797	6387	6782	7730	8901	7664	5448	3188	316	-448	-237	1501
		1944	3390	3844	4855	6598	10973	11450	6303	7539	3816	92	204	1378
		AVG	2812	3717	6419	8174	12081	10374	7388	8767	6709	1293	183	1470
	1945-1950	1947	2893	6262	7196	5513	7708	8499	5087	3051	876	-677	-191	1317
		1949	3297	3297	4685	4437	5193	15719	7878	7300	2721	-465	-1	1217
		AVG	3095	4780	5940	4975	6450	12109	6482	5176	1799	-571	-96	1267
	1951-1967	1955	1399	6903	12470	15762	9710	3711	2091	2174	-1339	-3317	-2941	-774
		1960	2820	3516	4360	7839	11613	7651	5609	3777	-467	-1525	-770	1662
		1961	2312	6923	5402	8000	7576	9684	3797	2140	-847	-2183	-720	1662
		1964	7046	10215	6100	8421	6712	5112	2951	2726	509	-1455	-527	2988
		AVG	3394	6889	7083	10005	8903	6519	3612	2704	-536	-2120	-1240	1384
	1968-1977		NO DRY WATER YEARS											
	1978-1992	1981	1743	-304	2997	3303	190	5077	-635	1595	394	-1920	-3947	-1350
		1985	4817	3287	2607	1493	238	268	720	352	-1482	-2790	-3768	-2471
		1987	1189	1424	1502	-176	1509	4585	308	143	-263	-3306	-3976	-3437
		1989	-756	658	343	-3256	-462	1850	-3068	-136	-535	-3411	-5023	-2827
		AVG	1748	1266	1862	341	369	2945	-669	489	-472	-2857	-4178	-2521
	1993-1994		NO DRY WATER YEARS											
	1995-1997		NO DRY WATER YEARS											

Appendix E-5. (Continued).

HISTORIC QWEST (CFS) - AVERAGE MONTHLY BY WATER-YEAR TYPE														
WATER-YEAR TYPE	PERIOD	WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
WET	PRE-1945	1938	3169	6848	14910	12581	43323	54321	37467	41937	44023	15243	3113	2902
		1941	2992	3846	11269	19735	26102	33492	29932	32215	26343	9093	1623	1977
		1942	3828	4694	13839	23172	27542	17068	20947	28404	28235	8081	1146	2344
		1943	3696	7512	10411	19748	25946	42760	29876	21393	14263	1609	668	1916
		AVG	3421	5725	12607	18809	31228	36910	31056	30987	28216	8507	1687	2285
	1945-1950		NO WET WATER YEARS											
	1951-1967	1952	3283	5139	13175	27968	26230	29687	35466	42230	30697	4404	517	2113
		1953	2763	4843	11049	18970	9189	7897	10234	12711	13001	-1275	-1980	1320
		1956	519	2812	36345	52711	28819	16060	12650	22852	15369	383	-1058	2352
		1958	4634	4698	7132	11225	26354	30603	53349	32695	21477	5153	2513	5990
		1963	7240	7134	8243	8092	25844	10430	23945	16331	8915	627	317	4864
		1965	3639	6240	21685	33380	15297	11598	20195	8358	8200	880	1541	4948
		1967	2895	7550	13455	15020	15449	16025	28951	29767	24848	13668	2580	6368
		AVG	3568	5774	15869	23909	21026	17471	26427	23564	17529	3406	633	3993
	1968-1977	1969	-185	3320	6905	29445	50953	40470	30054	30222	31285	6627	2853	8193
		1970	10021	10305	10969	33002	21702	16334	3145	3561	1202	-461	751	4466
		1971	5125	7523	18630	13086	8966	6474	4356	5032	4944	420	516	5387
		1974	4241	9080	13155	22973	8611	13061	15310	6982	2947	-3099	-1414	6214
		1975	6821	10815	9265	6005	12089	14259	6620	10055	9112	1766	-1046	1909
		AVG	5205	8227	11785	20902	20464	18119	12337	11170	9898	1051	332	5234
	1978-1992	1982	409	5328	8935	19562	14938	19739	37562	22517	9813	7888	2246	10581
		1983	11655	13931	26777	26707	46544	67378	48520	42361	30127	20937	10246	16804
		1984	19719	27141	38325	36089	12819	7538	1312	2069	804	-1450	-1611	3990
		1986	-1460	608	-1103	200	29838	45184	23440	7149	4289	-993	-2169	-545
		AVG	7581	11752	18234	20635	26035	34960	27708	18524	11258	6595	2176	7708
	1993-1994		NO WET YEARS											
	1995-1997	1995	-107	208	-769	10951	8202	34773	29762	31608	15035	4298	1115	6234

Appendix E-6. Simulated Average Monthly QWEST Flows (cfs) by Water-year Type for Existing Operations to 1995 Bay-Delta Plan. DWRSIM Model-run 420 Using 71-year Period of Record. W-Wet, B-Below Normal, D-Dry, C-Critical, A-Above Normal.

QWEST (CFS) DWRSIM MODEL RUN 420 - 1995 BAY-DELTA PLAN													
WATER YEAR	WATER YEAR TYPE	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1922	A	-594	-1427	-2594	-1692	6796	4526	2341	5863	21	2024	1001	-729
1928	A	-2252	-3659	-3848	-1727	-371	10792	1463	1552	-123	-2793	-1714	-1110
1940	A	-1636	-1737	-2453	755	3979	5745	4045	2059	103	-3234	-2047	-1017
1951	A	-2862	4108	13840	8462	6416	2450	1815	2439	163	-3294	-1767	-1273
1954	A	-1804	-2263	-4207	-2219	3443	2513	3024	1458	-78	-3358	-2057	-1374
1957	A	1468	-4311	-2041	-3698	-65	2675	1172	2204	-10	-3359	-3191	-1252
1973	A	-2660	-1446	-4500	5060	10477	8353	1806	2251	-179	-1691	-1512	-1296
1978	A	843	73	-4438	7784	10073	9490	7897	3814	2118	2182	769	-1728
1980	A	-1041	-2465	-2913	15731	27751	23860	3061	2475	2045	2268	496	-1937
	AVG	-1171	-1459	-1462	3162	7609	7823	2969	2679	451	-1251	-1114	-1302
1923	B	-1359	-2111	3162	4584	5753	-12	2629	2274	247	-3728	-2598	-1031
1935	B	500	-1867	-2419	-2735	-765	-841	5387	1450	964	-3571	-1886	-647
1936	B	-1246	-1723	-2048	-1745	11669	-1896	2116	2309	445	-3444	-1534	-756
1937	B	-916	-1446	-4103	-2511	6603	10666	2337	2619	2527	-178	-431	-655
1945	B	-2142	-3288	-2975	-2847	5417	2212	1813	1812	60	-739	-1125	-809
1946	B	-1928	-2718	5172	-452	900	-976	1893	1795	14	-2976	-1825	-957
1948	B	-2090	-2213	-2654	-4664	-1938	-840	2009	915	363	-3797	-3889	-3817
1950	B	-1584	-1666	-1826	-2003	-1809	-2001	1646	1788	-129	-3818	-4075	-1392
1959	B	1514	-950	-1952	2312	8397	-718	639	728	-158	-3514	-1859	-1722
1962	B	-1480	-1614	-4304	-2036	3298	-3084	1092	1183	-300	-3829	-2746	-1412
1966	B	-2058	-2718	-2454	-2313	-1223	-1014	1173	1008	-126	-3907	-2955	-1352
1968	B	2667	-738	238	3927	8887	2384	1062	953	-150	-3399	-1670	-1320
1972	B	-2081	-4447	-2287	-2587	-2534	-2066	1183	901	-103	-3986	-3609	-1123
1979	B	-1068	-3915	-1498	-838	8824	3829	1886	2428	-145	-997	-833	-835
	AVG	-948	-2244	-1425	-993	3677	403	1919	1583	251	-2992	-2217	-1273
1924	C	-1349	-2000	-4373	-4468	-3027	-1067	228	334	165	-1610	-669	461
1929	C	-522	-2382	-4233	-2851	-2656	-172	538	623	313	-2388	668	324
1931	C	698	-692	-1367	-3155	-1113	-591	138	773	281	-286	2559	916
1933	C	605	-787	-1231	-3470	-2292	-849	842	1267	626	303	2325	570
1934	C	168	273	-3102	-3505	675	-2411	130	488	29	122	2223	470
1976	C	75	-2795	-4096	-3092	-4838	-2129	333	344	-39	-1167	234	92
1977	C	-231	-1061	-4971	-2896	-2430	-347	372	863	2456	1181	2064	1044
1988	C	-567	-1275	-4452	-4705	-2497	-1442	624	783	151	-1919	-738	8
1990	C	389	347	-2796	-4547	-1744	-1161	279	1254	-48	-2019	-820	783
1991	C	890	-240	-1608	-1718	-2855	-3594	397	876	382	-2077	965	-86
1992	C	684	-9	-1668	-2293	-1556	-1835	463	564	53	-2213	-42	61
	AVG	76	-966	-3082	-3336	-2212	-1418	404	743	397	-1098	797	422

Appendix E-6. (Continued).

QWEST (CFS) DWRSIM MODEL RUN 420 - 1995 BAY-DELTA PLAN													
WATER YEAR	WATER YEAR TYPE	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1925	D	-1672	-1536	-2510	-1300	1398	-1630	2251	2223	119	-3289	-2240	-1086
1926	D	-2137	-1436	-1920	-4192	-1309	-1248	2382	1376	-40	-3407	-2218	-1089
1930	D	-1452	-1791	-3452	-2421	-876	-3505	582	828	40	-1810	-309	-493
1932	D	-629	-262	-2624	-3259	3151	1604	1231	2376	3951	1096	1006	-536
1939	D	877	-3468	-489	1151	1630	-621	585	902	-42	-3469	-1786	-995
1944	D	-2152	-4169	-1785	-3700	-881	-2032	1080	1516	25	-3068	-1719	-904
1947	D	-1564	-1936	-3837	-4431	-3618	-1764	721	881	104	-4026	-3352	-1143
1949	D	-3358	-2529	-2863	-2515	-2053	1275	1246	1411	-72	-2163	-1688	-1180
1955	D	-1109	-4088	-4590	-489	-3497	-826	1218	1389	-108	-4028	-4450	-3152
1960	D	-1975	-2042	-5110	-2940	-3578	-1832	436	713	-28	-4130	-4150	-1263
1961	D	-1681	-2576	-4923	-2506	-4502	-2457	185	660	-17	-4280	-4286	-1146
1964	D	-2758	-3210	-3574	-3566	-1752	-1408	761	971	247	-4012	-4423	-1568
1981	D	-456	-3123	-1530	828	153	2227	879	931	-24	-3516	-1768	-904
1985	D	-1270	-685	-1247	759	-1789	-597	1044	1025	59	-4023	-3538	-1058
1987	D	-193	-2296	-1034	-2913	-3789	-2670	257	488	-22	-4203	-2602	-916
1989	D	832	-1058	-1937	-2966	-3078	-2418	391	629	82	-4436	-4191	-1086
	AVG	-1294	-2263	-2714	-2154	-1524	-1119	953	1145	267	-3298	-2607	-1157
1927	W	-2017	-3216	-5061	-3456	7641	2584	5693	2349	364	432	-621	-744
1938	W	-763	-3695	1025	-1831	30396	34443	9792	14185	5650	2037	935	-1377
1941	W	-1450	-2650	-1567	5773	11055	13333	12333	3862	1251	2271	1138	-2098
1942	W	-101	-2897	7096	13190	16386	1483	7047	3492	-3896	2307	1101	-2024
1943	W	1503	-1475	16	13651	12690	20922	2738	3768	743	268	-138	-731
1952	W	-2196	-3730	1692	12926	5838	9643	10088	9619	1768	-637	259	-725
1953	W	1599	-746	3137	11503	3261	-456	1407	-37	-5738	-709	87	-2405
1956	W	-661	-2436	3680	23987	8387	-1315	2022	4015	2123	602	-1360	-3193
1958	W	-2312	-3745	-4628	-1116	11701	18606	23527	4632	1274	218	-1014	-1901
1963	W	-4387	-4061	-4856	-3593	6739	-800	11008	1541	1032	-855	-1377	-2295
1965	W	-843	-3885	3353	12650	-1788	-1472	5710	2532	222	-2553	-1023	-1085
1967	W	-1807	-4292	-518	3675	1137	7566	10646	6752	4086	2304	-118	-1365
1969	W	-2191	-2837	-2701	14284	27425	10934	10599	22307	12383	2295	432	-519
1970	W	4912	1098	5146	32049	13897	4575	1533	1379	154	-2359	-1152	-1150
1971	W	-2040	-1108	5039	-675	-1599	-587	1325	671	-127	-1670	-1598	-3239
1974	W	-2599	1670	3723	8634	1954	12977	4999	2716	699	-648	-961	-2498
1975	W	-818	-3205	-3344	-832	11676	12443	2379	2416	802	-471	-1400	-3165
1982	W	-1735	-3255	3514	10337	12011	22912	38733	18523	4497	885	-816	2372
1983	W	6521	10930	29442	36695	58485	72956	40015	33069	31521	19117	1859	11480
1984	W	14898	22538	38970	31768	15830	8068	2163	1771	816	-1382	-407	-2501
1986	W	-1700	-2249	-3970	-2512	34679	37062	13505	3981	2275	1344	195	-932
	AVG	86	-631	3771	10338	13705	13613	10346	6835	2948	1086	-285	-957

Appendix E-7. Simulated Average Monthly QWEST Flows (cfs) by Water-year Type for Future Operations to Interim South Delta Program Meeting Future Water Demands. W-Wet, B-Below Normal, D-Dry, C-Critical, A-Above Normal.

QWEST (CFS)
DWRSIM MODEL RUN 414 - INTERIM SOUTH DELTA PROGRAM AT FUTURE DEMAND

YEAR	WATER-YEAR TYPE	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1922	A	-538	-1414	-4497	-3698	10660	5132	2694	4106	-2963	1776	-880	-859
1928	A	-1238	-5118	-4871	-4692	-1335	11160	1566	1531	-320	-1906	-3975	-522
1940	A	-880	-1667	-2916	-1271	866	3552	3030	2036	-152	-2802	-1662	-1987
1951	A	-2216	673	12838	12643	9271	1922	1987	2476	-34	-10003	-2525	-3081
1954	A	-2933	-6515	-3731	-7168	2417	2118	1684	1450	-253	-2981	-4266	-1162
1957	A	-3193	-4428	-1743	-3943	271	1890	1313	2281	-168	-10557	-2623	-3215
1973	A	-1694	-4731	-7836	4480	14809	9726	2121	2313	-286	-3666	-2607	-1162
1978	A	880	-152	-4334	3780	11544	7934	6465	3258	2795	16	-1401	-1010
1980	A	-1173	-3906	-5914	12724	27291	23297	2492	2623	1566	-2753	-1727	-943
	AVG	-1443	-3028	-2556	1428	8422	7415	2594	2453	21	-3653	-2408	-1549
1923	B	-2623	-5404	1092	4154	2201	-978	2997	2330	34	-3063	-2248	-2323
1935	B	456	-1987	-2476	-2656	-776	-554	3822	212	707	-2607	-1939	-1195
1936	B	-1369	-2121	-2542	-4040	10299	-1955	2273	2379	202	-4562	-2151	-1869
1937	B	-880	-1869	-6272	-2590	4906	11828	2508	2656	17	-1711	-1515	-690
1945	B	-1499	-3737	-4448	-2835	6439	1890	1953	1857	-135	-2981	-1026	-690
1946	B	-896	-5253	1597	1483	1010	-668	2104	1857	-185	-2476	-2493	-657
1948	B	-2183	-2088	-2786	-4790	-1966	-733	2222	407	168	-11388	-3568	-2778
1950	B	-831	-1684	-1841	-4578	-3662	-1808	1835	1531	-387	-2998	-2770	-2340
1959	B	-2753	-5017	-2493	-228	7558	-1303	808	733	-354	-4106	-3877	-2660
1962	B	-130	-1751	-4431	-1955	1407	-2916	1515	1173	-539	-3959	-3910	-1027
1966	B	-1825	-5943	-3861	-2183	72	-1988	1397	1010	-320	-5181	-4936	-1953
1968	B	-2134	-1751	-1450	2085	7359	1564	1263	945	-320	-4529	-3780	-2407
1972	B	-3112	-4394	-5979	-4383	-1623	-1694	1178	896	-286	-5539	-3552	-2677
1979	B	-2362	-3485	-2933	-1955	4708	3943	2054	2476	-387	-4643	-3421	-1010
	AVG	-1581	-3320	-2773	-1748	2709	330	1995	1462	-127	-4267	-2942	-1734
1924	C	-114	-1970	-5279	-2949	-3247	-342	438	277	135	-440	1678	1178
1929	C	-261	-2424	-4008	-2819	-2742	342	791	603	286	-2232	1548	404
1931	C	733	185	-3389	-2916	-1082	-619	337	733	236	244	2770	791
1933	C	668	572	-717	-3047	-1966	-652	673	1287	101	-1531	1662	404
1934	C	114	152	-3307	-4659	1227	-2493	152	489	690	-880	2069	623
1976	C	-4220	-5892	-1564	-2558	-3662	-1825	556	358	-101	-3438	-733	286
1977	C	-98	-1094	-5002	-652	-2615	-1124	303	749	2340	1043	2134	1027
1988	C	1303	-1128	-4790	-7836	505	-1564	774	1450	758	-2476	1254	909
1990	C	81	-101	-4220	-5735	-1659	-1059	505	1254	-118	-3128	1287	808
1991	C	896	-539	-1939	-1971	-3066	-3486	471	847	303	-1385	863	-522
1992	C	652	84	-717	-2216	-3716	-1694	657	521	0	-1466	1450	606
	AVG	-22	-1105	-3175	-3396	-2002	-1320	514	779	421	-1426	1453	592

Appendix E-7. (Continued).

QWEST (CFS)

DWRSIM MODEL RUN 414 - INTERIM SOUTH DELTA PROGRAM AT FUTURE DEMAND

YEAR	WATER-YEAR TYPE	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1925	D	-1254	-1515	-2476	-1238	-1479	-1369	2290	2281	-84	-2411	-1401	-926
1926	D	-1043	-1414	-2102	-4757	-4113	-2248	2660	1108	-286	-3731	-3095	-2222
1930	D	-1287	-1380	-3829	-5067	-866	-3421	640	782	-219	-1434	33	-354
1932	D	-521	-269	-2981	-4334	3427	1466	1296	2965	4125	212	929	-556
1939	D	-1010	-5488	-2281	196	162	-635	741	880	-84	-4301	-4122	-1498
1944	D	-1303	-3519	-5979	-3975	-3463	-1890	2508	1580	-202	-3258	-4008	-1061
1947	D	-1092	-2003	-3943	-4855	-3716	-1645	859	880	-101	-3454	-4187	-960
1949	D	-2134	-2340	-3128	-2639	-2128	-1597	1448	1401	17	-2411	-326	-993
1955	D	-1043	-3889	-7527	-3258	-3535	-456	1364	1434	-303	-4057	-5002	-1229
1960	D	-1254	-2071	-3063	-3210	-6025	-2102	606	717	-17	-5930	-2916	-2222
1961	D	-440	-2626	-4936	-2542	-7089	-2525	471	766	-219	-2867	-3698	-724
1964	D	-4171	-6970	-3747	-2493	-1876	-1450	943	1010	51	-4888	-4138	-1667
1981	D	-2900	-2896	-3943	-3829	-1209	1173	1128	896	-236	-4659	-4106	-2121
1985	D	-4317	-4259	-782	179	-1912	521	1229	1010	-152	-5881	-2802	-2609
1987	D	-733	-625	-3812	-4936	-3445	-3210	387	489	-236	-3519	-912	-320
1989	D	1189	-976	-1857	-3063	-2976	-5637	438	619	-185	-3389	-2933	-1162
	AVG	-1457	-2653	-3524	-3114	-2515	-1564	1188	1176	117	-3499	-2668	-1289
1927	W	-1173	-6195	-5099	-5784	12753	2118	4495	2411	67	-3079	-2053	-758
1938	W	-945	-7727	-3454	-1531	31006	34588	8670	13392	4660	2411	-929	-2374
1941	W	-538	-2660	-4415	3943	9740	16439	11229	1727	1145	310	-1303	-1818
1942	W	-3715	-6734	2379	12496	15025	33	6313	1613	-3838	1271	-1271	-1751
1943	W	-3519	-5522	-1369	11942	11382	19583	2256	2688	84	-2900	-2118	-1195
1952	W	-1140	-3855	-1352	10948	6494	10785	9209	8618	-152	-179	505	-4478
1953	W	-3210	-3855	2721	9482	1407	-1874	1667	179	-5741	-3128	-2574	-2626
1956	W	-749	-2593	798	23444	11382	1140	2205	2134	2071	-196	-1694	-3199
1958	W	-4138	-5455	-7592	98	13167	20202	25875	3910	236	798	-1336	-3754
1963	W	-8276	-7508	-3307	375	7774	1026	9966	749	675	-2590	-2020	-1532
1965	W	-782	-3552	244	12170	902	-863	4865	2558	135	-2802	-1922	-1044
1967	W	-749	-3990	-3486	831	2832	7152	11549	6044	2357	1124	326	-4209
1969	W	-1401	-2475	-5702	11535	28986	10671	9495	20609	7576	2753	-521	-4983
1970	W	147	-1902	4513	31313	12284	3438	1717	1369	-135	-4171	-3144	-2542
1971	W	-1254	-4545	1320	-2232	-938	1238	1650	0	-253	-3291	-2281	-3502
1974	W	-1792	-1987	1352	10541	2453	12757	4024	2770	690	-2493	-1890	-3990
1975	W	-4611	-5017	-1955	-1059	12807	12561	2576	1059	774	-1206	-1922	-3653
1982	W	-1271	-7172	-130	9873	15584	23623	38788	17986	4276	1401	-652	-1734
1983	W	2867	10522	29065	36038	58153	72581	39360	31134	28838	16585	-244	8973
1984	W	13050	21145	37260	29879	13997	6647	2357	1825	354	-9624	-1645	-2879
1986	W	-244	-1768	-4562	-4953	32179	39329	14394	4089	2189	-2981	-1303	-1111
	AVG	-1116	-2516	1773	9493	14256	13961	10127	6041	2201	-580	-1428	-2103

Appendix E-8. Simulated Average Monthly QWEST Flows (cfs) by Water-year Type for Future Operations to State Water Resources Control Board Water Rights Alternative 5. W-Wet, B-Below Normal, D-Dry, C-Critical, A-Above Normal.

QWEST (CFS) STATE WATER RESOURCES CONTROL BOARD ALTERNATIVE 5 - DWRSIM MODEL RUN 524													
Water Year	Water-Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
1922	A	-1414	-2806	-2543	-2559	8293	5277	2658	6805	1550	67	-2104	-2719
1928	A	-1187	-2726	-3483	-4128	1331	12560	2540	-166	-490	-4044	-4348	-2039
1940	A	74	64	60	1198	8506	12082	5570	2342	1129	-3209	-3647	-1530
1951	A	-2275	7447	18821	13744	10057	5813	2008	1383	-64	-3396	-3845	-2879
1954	A	-2629	-3062	-5091	-3433	5093	3647	3246	-290	-209	-3654	-4079	-3234
1957	A	1094	-4336	-4688	-4387	2079	4103	1207	1308	-130	-3551	-4129	-1611
1973	A	-2340	-1469	-4888	6308	16246	12127	1909	901	-451	-3702	-4190	-2903
1978	A	2347	10	-3944	5155	9240	15785	15613	5497	2687	1596	-1763	-3231
1980	A	-2314	-3923	-2790	21214	40704	17680	3736	2154	2897	2239	-219	-2670
1993	A	1893	-216	-2770	8407	6691	5632	3621	1897	-2770	-595	-1785	-1646
	AVG	-614	-1002	-1029	3774	9840	8610	3828	1966	377	-1659	-2737	-2224
1923	B	-1172	-2642	3076	3414	4845	-371	3513	1190	-48	-3649	-3940	-183
1935	B	1595	-1792	-1809	-2191	1399	-1658	6483	4380	693	-4255	-2086	-1238
1936	B	-1763	-1143	-1581	-1502	21924	727	2860	1819	124	-3919	-4132	-139
1937	B	-2365	-2438	-3607	-3475	15666	16519	5130	4037	-10	-1358	-1402	-33
1945	B	17	-3648	-3845	-4434	11439	8142	2327	1085	159	-3531	-3809	-893
1946	B	-1693	-2639	6884	1451	3906	1785	2063	820	40	-3702	-3907	-2436
1948	B	-231	-1295	-1463	-5107	-1519	-1761	2279	584	-728	-4384	-4546	-3250
1950	B	-2676	-2179	-2433	-2707	-1148	-2055	1857	655	-713	-3488	-937	-2793
1959	B	1619	-3727	-4066	3989	8906	1372	706	-67	-973	-4229	-4506	-2050
1962	B	-1893	-2373	-5264	-5337	7586	1855	1158	-95	-864	-4524	-4744	-3450
1966	B	-1581	-2785	-911	1237	4458	680	809	-400	-964	-4557	-4693	-3446
1968	B	1345	-2354	-189	3642	8501	2647	992	109	-883	-4245	-4291	-1856
1972	B	-2437	-4492	-2947	-4163	-3247	-310	892	-394	-1114	-4852	-4947	-2063
1979	B	-1061	-4095	-4683	1518	15323	9488	2188	1539	-238	-3764	-2592	-353
	AVG	-878	-2686	-1631	-976	7003	2647	2376	1090	-394	-3890	-3609	-1727
1924	C	-1132	-1908	-4654	-4856	-3754	560	157	847	2174	938	1530	37
1929	C	-2970	-3333	-4233	-4925	-2940	-222	256	-556	939	1038	1269	26
1931	C	-479	-1018	-1033	-3420	-1027	-538	117	-324	174	552	3083	26
1933	C	62	-784	-651	-3280	-2324	4	334	680	2401	1819	3076	25
1934	C	19	1715	-3941	-4571	329	100	140	-469	-550	-2232	-40	38
1976	C	1348	-3175	-4672	-5177	-669	-1880	227	-890	-1356	-4598	-1966	56
1977	C	1182	-765	-456	-682	1290	509	224	1609	2850	2351	1063	17
1988	C	-781	-30	-4502	-4370	-2425	-615	449	-389	-858	-482	2004	26
1990	C	-2646	-2294	-5190	-2442	-2762	-1836	132	315	-1350	-3695	540	-473
1991	C	284	-670	-944	224	2743	-2333	187	-342	913	23	160	23
1992	C	2245	-294	-657	-3811	2661	-1467	746	-511	-363	-1100	1533	29
1994	C	-1522	-1928	-4284	-4553	1814	-2125	281	-15	-1152	-5176	-4913	-492
	AVG	-366	-1207	-2935	-3489	-589	-820	271	-4	319	-880	612	-55

Appendix E-8. (Continued).

QWEST (CFS)

STATE WATER RESOURCES CONTROL BOARD ALTERNATIVE 5 - DWRSIM MODEL RUN 524

Water Year	Water-Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
1925	D	2125	27	-3103	-1359	3876	262	3119	1523	1628	-3601	-1668	36
1926	D	-52	-1648	-3739	-4585	-467	-1294	2396	-20	-827	-3578	1741	-1341
1930	D	2058	18	-4991	-3417	-1336	1291	755	-474	-1319	-5198	-3389	53
1932	D	14	1599	-1360	-2559	5559	3123	1091	178	-766	-4301	-1066	62
1939	D	5996	-2626	-2555	3181	2151	-217	636	120	-841	-4537	-4138	74
1944	D	-2160	-4270	-4410	-3191	5545	1591	1708	545	-501	-4476	-4405	-673
1947	D	-2770	-3586	-3192	-4791	-2593	304	649	-198	-1122	-5026	-4832	-1510
1949	D	-2863	-4373	-4914	-5164	-3247	1184	1071	-353	-866	-4923	-2306	-799
1955	D	-3096	-3146	-4638	-899	-2532	-2065	1215	-14	-1075	-5015	-2851	-258
1960	D	-3229	-2170	-1919	-4647	-3381	-556	551	-503	-1192	-4979	-571	-296
1961	D	-1943	-3779	-5032	-4107	-4669	-2858	297	-502	-1459	-5016	-4736	57
1964	D	-2286	-3555	-4985	-3494	-2028	-2110	532	-320	-840	-5104	-4873	-3531
1981	D	42	-3395	-4557	3857	2110	2939	956	114	-853	-4680	-4547	-939
1985	D	-2911	-2372	-2249	-4749	291	-174	802	-388	-964	-4999	-4818	-3238
1987	D	-2171	-2018	-4584	-1961	1397	1413	80	-606	-1459	-5016	-4282	54
1989	D	1355	-1138	-1179	-3795	1127	-1531	4	-748	-1119	-5059	-658	-2204
	AVG	-743	-2277	-3588	-2605	113	81	991	-103	-848	-4719	-2962	-903
1927	W	-2111	-1965	-4786	-3110	14036	3909	6729	1078	860	-3511	-2698	-1740
1938	W	-2080	-1930	2086	1980	42141	46291	21451	25703	8048	1395	-1714	-1109
1941	W	-2522	-4048	-705	6501	17974	14476	9789	6200	4112	1247	-893	-2291
1942	W	1778	-2979	3662	17780	21816	4410	7687	5243	-1484	305	-1853	-2987
1943	W	3001	-453	-2341	20017	16907	32457	5399	2647	1075	-40	-430	-2050
1952	W	-2624	-3689	1813	15034	10201	19481	16106	17911	3642	-722	-3120	-922
1953	W	4656	-3391	2909	12445	5375	835	1605	81	-5278	-3421	-4025	-3379
1956	W	-2295	-1753	16614	34211	17560	5646	2401	4886	3778	-2803	-3236	-2523
1958	W	-1084	-3542	-3069	-1465	14879	24081	24900	11840	4180	-824	-3383	-480
1963	W	224	-3456	-5298	-3573	5315	-1219	11219	2597	594	-3488	-4105	-2880
1965	W	-624	-3788	5653	17287	2140	1054	6566	2746	1085	-1991	-1447	-2616
1967	W	-2693	-3964	-1651	4040	3219	12089	18044	16981	8644	3059	-2758	-207
1969	W	-2940	-3997	-2312	23797	46297	24000	23824	27008	14976	1314	-2010	585
1970	W	4707	-2790	3955	37335	15401	8118	1582	966	-70	-3556	-3926	-1550
1971	W	-2119	-1240	3584	-516	754	4797	1452	868	-471	-3412	-4010	-2734
1974	W	-2218	1163	4178	11051	4546	17684	5981	1910	795	-3032	-3706	-998
1975	W	148	-3407	-3781	-2733	12139	16829	3049	2316	2521	-3029	-3642	-2214
1982	W	-2015	-3523	2938	13711	26671	26071	39805	12625	6525	-420	-2696	1466
1983	W	5444	7650	23314	38922	57283	66812	28260	24667	36003	10567	-1755	400
1984	W	9898	23253	38166	21489	13339	5735	1782	1266	-62	-3222	-3020	-1286
1986	W	-599	-1066	-4319	-2161	44987	35634	6557	2867	4123	1077	-700	-2551
	AVG	187	-901	3839	12478	18704	17580	11628	8215	4457	-691	-2625	-1527

Appendix E-9. Average Historic Monthly Delta Export/Inflow Ratio (%) by Water-year Type and Time Periods Representing Major Changes in Water Flow Management Within the Sacramento River system and Sacramento-San Joaquin Bay-Delta Estuary, California. Data from Department of Water Resources DAYFLOW.

HISTORIC DELTA EXPORT/INFLOW RATIO(%) - AVERAGE MONTHLY BY WATER-YEAR TYPE														
WATER-YEAR TYPE	PERIOD	WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
ABOVE NORMAL	PRE-1945	1940	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	1945-1950	NO ABOVE NORMAL WATER YEARS												
	1951-1967	1951	1%	0%	0%	0%	0%	0%	0%	0%	1%	6%	12%	9%
		1954	4%	0%	0%	1%	2%	2%	4%	5%	24%	37%	29%	16%
		1957	5%	1%	1%	1%	8%	4%	11%	9%	19%	35%	30%	15%
		AVG	3%	0%	0%	0%	3%	2%	5%	5%	15%	26%	23%	13%
	1968-1977	1973	35%	15%	12%	4%	1%	2%	14%	32%	41%	46%	44%	30%
		1978	16%	36%	44%	24%	21%	9%	5%	8%	39%	49%	46%	34%
		AVG	25%	25%	28%	14%	11%	6%	10%	20%	40%	48%	45%	32%
	1978-1992	1978	16%	36%	44%	24%	21%	9%	5%	8%	39%	49%	46%	34%
		1980	49%	33%	29%	8%	10%	5%	16%	17%	24%	31%	54%	38%
		AVG	32%	35%	36%	16%	16%	7%	11%	12%	32%	40%	50%	36%
	1993-1994	1993	23%	32%	35%	23%	18%	12%	12%	12%	14%	39%	45%	58%
	1995-1997	1996	38%	38%	19%	33%	6%	5%	9%	9%	35%	44%	45%	52%
		1997	62%	55%	15%	1%	2%	20%	23%	18%	38%	42%	42%	61%
		AVG	50%	46%	17%	17%	4%	13%	16%	14%	37%	43%	44%	57%

Appendix E-9. (Continued).

HISTORIC DELTA EXPORT/INFLOW RATIO(%) - AVERAGE MONTHLY BY WATER-YEAR TYPE														
WATER-YEAR TYPE	PERIOD	WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
BELOW NORMAL	PRE-1945	1935	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		1936	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		1937	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		AVG	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**
	1945-1950	1945	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		1946	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		1948	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		1950	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%	1%
		AVG	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**
	1951-1967	1959	8%	3%	1%	1%	2%	7%	21%	22%	41%	37%	28%	17%
		1962	19%	8%	2%	4%	1%	2%	9%	13%	22%	37%	30%	16%
		1966	10%	3%	0%	0%	3%	9%	15%	23%	40%	38%	33%	20%
		AVG	**12%**	**5%**	**1%**	**2%**	**2%**	**6%**	**15%**	**19%**	**34%**	**37%**	**30%**	**18%**
	1968-1977	1968	9%	6%	3%	5%	4%	12%	35%	39%	39%	39%	35%	39%
		1972	20%	17%	10%	7%	15%	27%	44%	47%	38%	33%	43%	38%
		AVG	**14%**	**12%**	**7%**	**6%**	**10%**	**20%**	**39%**	**43%**	**38%**	**36%**	**39%**	**39%**
	1978-1992	1979	32%	34%	37%	17%	10%	12%	31%	29%	41%	51%	59%	55%
	1993-1994	NO BELOW NORMAL WATER YEARS												
	1995-1997	NO BELOW NORMAL WATER YEARS												

Appendix E-9. (Continued).

HISTORIC DELTA EXPORT/INFLOW RATIO(%) - AVERAGE MONTHLY BY WATER-YEAR TYPE														
WATER-YEAR TYPE	PERIOD	WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
CRITICAL	PRE-1945	1931	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		1933	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		1934	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		AVG	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	1945-1950	NO CRITICAL WATER YEARS												
	1951-1967	NO CRITICAL WATER YEARS												
	1968-1977	1976	31%	30%	27%	46%	52%	52%	37%	46%	35%	32%	47%	60%
		1977	48%	47%	32%	64%	48%	53%	21%	37%	11%	10%	20%	26%
		AVG	39%	38%	29%	55%	50%	53%	29%	41%	23%	21%	33%	43%
	1978-1992	1988	54%	56%	56%	41%	75%	62%	45%	48%	47%	50%	59%	62%
		1990	69%	63%	62%	58%	70%	71%	58%	30%	31%	43%	45%	55%
		1991	41%	43%	44%	49%	49%	37%	61%	31%	20%	25%	38%	40%
		1992	52%	38%	30%	54%	18%	49%	26%	24%	21%	17%	28%	43%
		AVG	54%	50%	48%	51%	53%	55%	47%	33%	30%	34%	42%	50%
	1993-1994	1994	64%	49%	48%	38%	27%	27%	18%	18%	20%	33%	45%	46%
	1995-1997	NO CRITICAL WATER YEARS												

Appendix E-9. (Continued).

HISTORIC DELTA EXPORT/INFLOW RATIO(%) - AVERAGE MONTHLY BY WATER-YEAR TYPE														
WATER-YEAR TYPE	PERIOD	WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
DRY	PRE-1945	1930	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		1932	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		1939	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		1944	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		AVG	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	1945-1950	1947	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		1949	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		AVG	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	1951-1967	1955	8%	2%	0%	0%	2%	11%	19%	11%	25%	33%	31%	18%
		1960	14%	8%	3%	2%	2%	7%	15%	16%	35%	38%	35%	20%
		1961	19%	5%	0%	2%	2%	7%	20%	21%	38%	44%	34%	22%
		1964	12%	2%	1%	2%	7%	14%	24%	22%	33%	38%	34%	17%
		AVG	13%	4%	1%	2%	4%	10%	19%	17%	33%	38%	33%	19%
	1968-1977	NO DRY WATER YEARS												
	1978-1992	1981	42%	44%	35%	45%	28%	20%	47%	29%	33%	42%	58%	48%
		1985	31%	30%	22%	28%	35%	49%	47%	39%	43%	51%	62%	61%
		1987	38%	42%	42%	40%	37%	25%	46%	42%	42%	52%	60%	67%
		1989	52%	50%	52%	74%	61%	25%	47%	37%	38%	48%	59%	62%
		AVG	41%	41%	38%	47%	40%	30%	47%	37%	38%	48%	60%	59%
	1993-1994	NO DRY WATER YEARS												
	1995-1997	NO DRY WATER YEARS												

Appendix E-9. (Continued).

HISTORIC DELTA EXPORT/INFLOW RATIO(%) - AVERAGE MONTHLY BY WATER-YEAR TYPE

WATER-YEAR TYPE	PERIOD	WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
WET	PRE-1945	1938	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		1941	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		1942	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		1943	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		AVG	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	1945-1950	NO WET WATER YEARS												
	1951-1967	1952	4%	0%	0%	0%	0%	0%	0%	0%	0%	4%	8%	4%
		1953	4%	1%	0%	0%	1%	2%	5%	5%	6%	24%	25%	6%
		1956	14%	4%	1%	0%	0%	1%	2%	1%	4%	21%	22%	11%
		1958	6%	2%	1%	0%	0%	0%	0%	1%	2%	16%	20%	10%
		1963	9%	4%	0%	3%	1%	8%	1%	5%	15%	30%	31%	12%
		1965	20%	5%	0%	0%	3%	8%	2%	9%	16%	30%	25%	12%
		1967	18%	6%	1%	3%	2%	5%	2%	2%	3%	11%	24%	12%
		AVG	11%	3%	1%	1%	1%	3%	2%	3%	7%	19%	22%	10%
	1968-1977	1969	48%	33%	15%	9%	3%	4%	4%	5%	5%	17%	24%	10%
		1970	9%	5%	2%	1%	2%	5%	28%	24%	34%	35%	28%	15%
		1971	15%	8%	2%	3%	10%	16%	11%	14%	19%	29%	29%	15%
		1974	30%	13%	4%	2%	9%	8%	5%	21%	32%	45%	37%	18%
		1975	19%	7%	10%	24%	13%	11%	16%	15%	15%	25%	42%	33%
		AVG	24%	13%	7%	8%	7%	9%	13%	16%	21%	30%	32%	18%
	1978-1992	1982	52%	24%	7%	6%	13%	12%	7%	9%	11%	17%	32%	17%
		1983	19%	16%	11%	15%	6%	2%	3%	3%	6%	11%	20%	11%
		1984	7%	3%	2%	2%	13%	17%	35%	31%	34%	39%	44%	26%
		1986	64%	58%	57%	43%	7%	2%	12%	27%	33%	42%	53%	47%
		AVG	36%	25%	19%	17%	10%	8%	14%	18%	21%	27%	37%	25%
	1993-1994		NO WET YEARS											
	1995-1997	1995	53%	55%	44%	19%	12%	4%	4%	5%	13%	26%	38%	24%

Appendix E-10. Simulated Average Monthly Delta Export/Inflow Ratio by Water-year Type for Existing Operations to 1995 Bay-Delta Plan. DWRSIM Model-run 420 Using 71-year Period of Record. W-Wet, B-Below Normal, D-Dry, C-Critical, A-Above Normal.

DELTA EXPORT/INFLOW RATIO(%)
DWRSIM MODEL RUN 420 - 1995 BAY-DELTA PLAN

WATER-YEAR	WATER-YEAR TYPE	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1922	A	55%	54%	57%	56%	26%	24%	28%	16%	27%	21%	34%	53%
1928	A	59%	34%	60%	42%	27%	8%	23%	27%	35%	43%	44%	51%
1940	A	57%	50%	53%	40%	21%	10%	11%	29%	35%	45%	48%	53%
1951	A	60%	20%	13%	18%	15%	23%	30%	29%	35%	44%	46%	51%
1954	A	47%	40%	59%	27%	12%	16%	15%	25%	35%	45%	45%	51%
1957	A	40%	58%	53%	61%	23%	15%	26%	27%	35%	45%	49%	52%
1973	A	60%	42%	37%	14%	12%	14%	28%	29%	35%	40%	45%	52%
1978	A	46%	43%	60%	13%	8%	7%	13%	25%	34%	18%	34%	53%
1980	A	60%	49%	48%	11%	6%	9%	27%	32%	33%	21%	36%	56%
	AVG	54%	43%	49%	31%	17%	14%	22%	27%	34%	36%	42%	53%
1923	B	46%	46%	26%	25%	15%	35%	26%	30%	35%	48%	51%	53%
1935	B	49%	54%	57%	38%	35%	35%	18%	22%	35%	48%	49%	53%
1936	B	57%	52%	55%	35%	17%	31%	27%	31%	35%	47%	48%	53%
1937	B	55%	51%	60%	65%	27%	23%	28%	32%	24%	35%	43%	53%
1945	B	57%	62%	57%	65%	21%	26%	32%	29%	35%	38%	47%	53%
1946	B	63%	48%	14%	21%	25%	35%	32%	28%	35%	46%	48%	53%
1948	B	60%	54%	53%	63%	35%	35%	24%	22%	35%	48%	53%	58%
1950	B	58%	53%	52%	50%	30%	35%	25%	28%	35%	48%	53%	52%
1959	B	40%	40%	52%	17%	10%	27%	27%	27%	35%	47%	46%	55%
1962	B	57%	54%	57%	56%	21%	35%	27%	26%	35%	48%	50%	52%
1966	B	58%	36%	58%	36%	32%	26%	28%	26%	35%	48%	49%	51%
1968	B	34%	38%	36%	13%	7%	16%	28%	28%	35%	46%	47%	51%
1972	B	51%	58%	43%	51%	34%	26%	28%	27%	35%	48%	51%	55%
1979	B	50%	58%	51%	35%	16%	21%	29%	30%	35%	38%	44%	52%
	AVG	53%	50%	48%	41%	23%	29%	27%	28%	34%	45%	49%	53%
1924	C	59%	54%	58%	65%	45%	29%	26%	27%	35%	41%	42%	42%
1929	C	54%	57%	61%	64%	45%	29%	25%	26%	35%	44%	31%	43%
1931	C	47%	50%	50%	65%	45%	35%	25%	28%	35%	34%	4%	38%
1933	C	47%	49%	51%	65%	45%	35%	23%	29%	32%	31%	13%	42%
1934	C	52%	44%	57%	56%	35%	35%	23%	27%	35%	31%	11%	43%
1976	C	41%	46%	59%	58%	45%	35%	25%	26%	35%	38%	36%	45%
1977	C	55%	49%	57%	58%	41%	31%	25%	27%	12%	18%	12%	38%
1988	C	54%	51%	60%	40%	35%	35%	26%	26%	35%	42%	43%	46%
1990	C	49%	38%	51%	60%	35%	35%	23%	28%	35%	41%	43%	40%
1991	C	48%	43%	49%	54%	43%	35%	23%	27%	35%	41%	28%	47%
1992	C	52%	40%	49%	59%	35%	35%	23%	27%	35%	43%	38%	46%
	AVG	51%	47%	55%	59%	41%	34%	24%	27%	33%	37%	27%	43%

Appendix E-10. (Continued).

DELTA EXPORT/INFLOW RATIO(%)
DWRSIM MODEL RUN 420 - 1995 BAY-DELTA PLAN

WATER-YEAR	WATER-YEAR TYPE	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1925	D	58%	52%	60%	57%	22%	35%	24%	29%	35%	47%	48%	51%
1926	D	57%	54%	55%	61%	30%	35%	24%	27%	35%	47%	48%	51%
1930	D	55%	50%	55%	47%	35%	35%	23%	25%	35%	42%	39%	51%
1932	D	55%	51%	61%	57%	35%	20%	28%	27%	14%	25%	31%	49%
1939	D	39%	52%	43%	39%	30%	35%	25%	28%	35%	48%	47%	50%
1944	D	58%	58%	54%	65%	32%	34%	28%	29%	35%	46%	47%	52%
1947	D	57%	58%	60%	65%	45%	35%	25%	28%	35%	49%	52%	51%
1949	D	61%	54%	57%	62%	45%	21%	29%	26%	35%	44%	47%	51%
1955	D	57%	55%	40%	47%	45%	35%	28%	27%	35%	49%	55%	56%
1960	D	58%	50%	58%	64%	37%	35%	23%	25%	35%	49%	54%	51%
1961	D	58%	56%	58%	65%	33%	35%	23%	25%	35%	49%	54%	53%
1964	D	54%	30%	58%	38%	35%	35%	28%	27%	35%	49%	55%	52%
1981	D	51%	60%	47%	25%	24%	20%	27%	28%	35%	48%	47%	52%
1985	D	50%	26%	35%	42%	38%	35%	27%	26%	35%	49%	53%	53%
1987	D	63%	57%	58%	61%	45%	30%	24%	25%	35%	49%	49%	51%
1989	D	48%	46%	53%	59%	45%	27%	21%	24%	35%	49%	54%	56%
	AVG	55%	51%	53%	53%	36%	31%	25%	27%	34%	46%	49%	52%
1927	W	58%	46%	59%	33%	10%	17%	15%	26%	35%	31%	43%	53%
1936	W	56%	30%	14%	33%	7%	4%	9%	11%	22%	28%	34%	52%
1941	W	59%	54%	23%	12%	10%	11%	9%	16%	35%	20%	33%	56%
1942	W	43%	46%	11%	8%	5%	22%	15%	19%	35%	20%	33%	58%
1943	W	40%	40%	24%	9%	12%	8%	24%	25%	32%	32%	40%	53%
1952	W	58%	56%	21%	13%	14%	12%	10%	12%	21%	40%	39%	46%
1953	W	37%	39%	15%	5%	16%	26%	25%	24%	35%	36%	37%	53%
1956	W	54%	54%	14%	8%	12%	25%	29%	18%	35%	30%	45%	58%
1958	W	51%	52%	39%	29%	7%	8%	8%	17%	24%	32%	44%	48%
1963	W	28%	48%	37%	62%	11%	30%	8%	23%	35%	36%	44%	54%
1965	W	56%	58%	13%	10%	30%	35%	16%	27%	35%	43%	46%	53%
1967	W	58%	60%	25%	22%	18%	10%	14%	15%	20%	43%	40%	48%
1969	W	57%	57%	44%	10%	9%	10%	12%	11%	24%	34%	36%	42%
1970	W	36%	34%	12%	2%	5%	15%	31%	31%	35%	42%	44%	52%
1971	W	58%	41%	15%	20%	28%	20%	25%	21%	35%	40%	45%	56%
1974	W	61%	15%	15%	9%	16%	8%	11%	27%	35%	36%	43%	47%
1975	W	44%	52%	53%	43%	8%	8%	27%	22%	35%	34%	46%	55%
1982	W	58%	28%	11%	14%	12%	10%	6%	16%	35%	41%	47%	39%
1983	W	25%	15%	8%	6%	2%	2%	6%	7%	9%	18%	44%	23%
1984	W	15%	6%	3%	4%	8%	15%	30%	29%	35%	40%	43%	57%
1986	W	58%	58%	60%	53%	6%	6%	24%	35%	35%	27%	40%	58%
	AVG	48%	42%	25%	19%	12%	14%	17%	21%	31%	33%	41%	51%

Appendix E-11. Simulated Average Monthly Delta Export/Inflow Ratio (%) by Water-year Type for Future Operations to Interim South Delta Program Meeting Future Water Demands. W-Wet, B-Below Normal, D-Dry, C-Critical, A-Above Normal.

DELTA EXPORT/INFLOW RATIO(%) DWRSIM MODEL RUN 414 INTERIM SOUTH DELTA PROGRAM AT FUTURE DEMAND													
YEAR	WATER-YEAR TYPE	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1922	A	54%	55%	65%	65%	18%	23%	28%	16%	35%	23%	45%	55%
1928	A	59%	52%	65%	54%	31%	8%	22%	27%	35%	41%	50%	50%
1940	A	56%	50%	53%	48%	28%	12%	11%	29%	35%	43%	47%	55%
1951	A	61%	26%	14%	12%	11%	24%	30%	28%	35%	47%	48%	56%
1954	A	60%	60%	58%	43%	13%	16%	15%	25%	35%	44%	52%	51%
1957	A	61%	59%	52%	62%	25%	17%	26%	27%	35%	48%	47%	57%
1973	A	60%	57%	50%	15%	9%	12%	28%	29%	35%	45%	48%	52%
1978	A	46%	47%	62%	20%	8%	10%	17%	31%	35%	31%	45%	52%
1980	A	60%	61%	62%	14%	8%	10%	30%	31%	35%	44%	47%	59%
	AVG	57%	52%	53%	37%	17%	15%	23%	27%	35%	41%	48%	54%
1923	B	60%	60%	34%	26%	26%	35%	26%	30%	35%	46%	50%	56%
1935	B	49%	56%	59%	48%	35%	35%	18%	21%	35%	47%	48%	52%
1936	B	58%	52%	57%	42%	20%	32%	27%	31%	35%	49%	49%	55%
1937	B	55%	52%	65%	65%	31%	22%	28%	32%	35%	41%	48%	53%
1945	B	57%	63%	65%	65%	20%	29%	31%	29%	35%	46%	46%	54%
1946	B	63%	62%	19%	17%	25%	35%	32%	28%	35%	44%	50%	53%
1948	B	60%	54%	53%	63%	35%	35%	24%	22%	35%	51%	52%	56%
1950	B	55%	53%	53%	62%	35%	35%	25%	26%	35%	45%	49%	55%
1959	B	56%	61%	55%	24%	11%	29%	27%	27%	35%	48%	52%	58%
1962	B	51%	55%	57%	56%	26%	35%	29%	26%	35%	48%	53%	52%
1966	B	60%	47%	65%	36%	28%	30%	28%	26%	35%	50%	54%	53%
1968	B	51%	43%	45%	19%	9%	18%	28%	27%	35%	49%	54%	54%
1972	B	61%	59%	64%	59%	30%	25%	27%	27%	35%	51%	50%	58%
1979	B	60%	61%	55%	53%	26%	23%	28%	30%	35%	50%	52%	53%
	AVG	57%	56%	53%	45%	26%	30%	27%	27%	35%	48%	51%	54%
1924	C	53%	54%	60%	63%	45%	26%	27%	27%	35%	36%	20%	37%
1929	C	52%	58%	62%	64%	45%	26%	25%	26%	35%	44%	21%	43%
1931	C	47%	45%	54%	65%	45%	35%	25%	28%	35%	31%	1%	40%
1933	C	46%	39%	49%	65%	45%	35%	26%	29%	35%	42%	22%	43%
1934	C	53%	43%	59%	65%	35%	35%	23%	27%	31%	38%	13%	42%
1976	C	59%	63%	46%	54%	39%	35%	25%	26%	35%	47%	40%	44%
1977	C	54%	50%	57%	53%	41%	35%	26%	28%	12%	19%	11%	38%
1988	C	41%	52%	62%	52%	19%	35%	26%	20%	31%	45%	25%	40%
1990	C	51%	42%	55%	65%	35%	35%	23%	28%	35%	46%	25%	40%
1991	C	48%	45%	50%	55%	44%	35%	23%	27%	35%	39%	29%	50%
1992	C	52%	39%	47%	60%	42%	35%	22%	27%	35%	40%	23%	41%
	AVG	51%	48%	55%	60%	40%	33%	25%	27%	32%	39%	21%	42%

Appendix E-11. (Continued).

DELTA EXPORT/INFLOW RATIO(%) DWRSIM MODEL RUN 414 INTERIM SOUTH DELTA PROGRAM AT FUTURE DEMAND													
YEAR	WATER-YEAR TYPE	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1925	D	60%	53%	62%	57%	27%	35%	24%	28%	34%	44%	46%	51%
1926	D	56%	54%	56%	65%	38%	35%	24%	25%	35%	47%	51%	54%
1930	D	56%	50%	57%	58%	35%	35%	23%	25%	35%	40%	36%	48%
1932	D	56%	51%	65%	65%	35%	21%	28%	23%	11%	31%	32%	50%
1939	D	52%	62%	53%	46%	39%	35%	26%	27%	35%	50%	54%	52%
1944	D	59%	56%	62%	65%	44%	35%	21%	29%	35%	47%	54%	52%
1947	D	57%	59%	61%	65%	45%	35%	25%	27%	35%	48%	54%	52%
1949	D	59%	53%	58%	63%	45%	26%	29%	26%	33%	44%	39%	52%
1955	D	56%	58%	50%	60%	45%	33%	28%	27%	35%	48%	55%	52%
1960	D	57%	50%	54%	65%	45%	35%	23%	25%	35%	53%	50%	54%
1961	D	53%	57%	58%	65%	45%	35%	23%	25%	35%	45%	52%	53%
1964	D	62%	43%	59%	46%	35%	34%	26%	27%	35%	50%	52%	52%
1981	D	63%	60%	61%	56%	29%	23%	27%	27%	35%	51%	54%	55%
1985	D	65%	37%	33%	47%	43%	35%	27%	26%	35%	54%	50%	56%
1987	D	65%	55%	60%	65%	45%	35%	23%	25%	35%	47%	43%	49%
1989	D	44%	49%	54%	60%	45%	34%	21%	24%	35%	45%	50%	57%
	AVG	58%	53%	56%	59%	40%	33%	25%	26%	33%	47%	48%	52%
1927	W	58%	58%	60%	42%	6%	18%	15%	26%	35%	46%	48%	53%
1938	W	57%	43%	21%	34%	6%	5%	11%	14%	26%	26%	44%	61%
1941	W	55%	54%	30%	13%	11%	8%	11%	18%	35%	36%	46%	57%
1942	W	63%	64%	18%	10%	6%	27%	14%	19%	35%	37%	47%	60%
1943	W	64%	61%	30%	10%	13%	10%	23%	29%	35%	43%	47%	53%
1952	W	57%	60%	28%	16%	14%	11%	12%	13%	26%	38%	37%	63%
1953	W	55%	54%	17%	7%	21%	32%	25%	24%	35%	44%	48%	55%
1956	W	55%	54%	18%	9%	9%	19%	29%	17%	35%	40%	46%	59%
1958	W	63%	61%	49%	27%	6%	7%	9%	17%	31%	29%	45%	60%
1963	W	39%	64%	32%	41%	10%	25%	8%	23%	35%	45%	47%	53%
1965	W	56%	58%	17%	12%	21%	33%	15%	27%	35%	45%	48%	53%
1967	W	55%	60%	32%	28%	15%	11%	14%	15%	27%	48%	37%	62%
1969	W	57%	58%	57%	12%	8%	11%	15%	14%	31%	32%	42%	61%
1970	W	51%	47%	13%	3%	7%	18%	31%	30%	35%	46%	49%	55%
1971	W	58%	56%	21%	24%	26%	17%	25%	21%	35%	45%	47%	57%
1974	W	61%	22%	19%	8%	17%	8%	11%	27%	35%	43%	46%	58%
1975	W	64%	64%	44%	44%	9%	8%	27%	22%	35%	40%	47%	59%
1982	W	58%	42%	15%	15%	6%	10%	6%	17%	35%	39%	47%	53%
1983	W	34%	17%	9%	6%	3%	2%	7%	9%	12%	23%	54%	30%
1984	W	19%	8%	4%	6%	11%	18%	30%	29%	35%	48%	48%	59%
1986	W	53%	59%	63%	65%	6%	5%	22%	35%	35%	45%	47%	59%
	AVG	54%	51%	28%	21%	11%	14%	17%	21%	32%	40%	46%	56%

Appendix E-12. Simulated Average Monthly Delta Export/Inflow Ratio (%) by Water-year Type for Future Operations to State Water Resources Control Board Water Rights Alternative 5. W-Wet, B-Below Normal, D-Dry, C-Critical, A-Above Normal.

DELTA EXPORT/INFLOW RATIO
STATE WATER RESOURCES CONTROL BOARD ALTERNATIVE 5 - DWRSIM MODEL RUN 524

Water Year	Water-Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
1922	A	60%	62%	53%	54%	24%	18%	27%	15%	25%	35%	55%	65%
1928	A	63%	49%	56%	40%	21%	7%	21%	25%	35%	47%	57%	60%
1940	A	53%	45%	43%	40%	20%	10%	11%	24%	35%	47%	58%	61%
1951	A	65%	18%	11%	18%	15%	20%	30%	28%	35%	47%	58%	65%
1954	A	57%	48%	65%	30%	10%	14%	16%	24%	35%	47%	58%	65%
1957	A	44%	63%	65%	55%	18%	14%	24%	26%	35%	47%	59%	60%
1973	A	65%	43%	39%	14%	10%	11%	28%	29%	35%	47%	59%	65%
1978	A	26%	49%	65%	18%	13%	8%	13%	25%	35%	26%	49%	65%
1980	A	65%	59%	46%	10%	3%	7%	25%	32%	35%	32%	45%	65%
1993	A	37%	50%	65%	21%	15%	12%	18%	25%	32%	37%	52%	61%
	AVG	49%	44%	46%	27%	14%	11%	19%	23%	31%	37%	50%	57%
1923	B	58%	53%	26%	25%	16%	35%	25%	30%	35%	51%	61%	55%
1935	B	38%	61%	62%	38%	28%	35%	17%	15%	34%	51%	52%	57%
1936	B	65%	53%	55%	32%	14%	29%	28%	30%	35%	51%	60%	54%
1937	B	65%	59%	65%	62%	18%	12%	24%	26%	35%	41%	50%	52%
1945	B	54%	65%	60%	65%	16%	19%	32%	29%	35%	51%	61%	58%
1946	B	65%	52%	15%	21%	22%	26%	31%	28%	35%	51%	61%	64%
1948	B	56%	54%	51%	65%	33%	35%	24%	24%	35%	51%	60%	65%
1950	B	64%	58%	57%	49%	31%	35%	25%	28%	35%	49%	47%	65%
1959	B	41%	59%	60%	13%	10%	23%	27%	28%	35%	51%	61%	65%
1962	B	59%	59%	60%	65%	18%	23%	27%	28%	35%	51%	60%	65%
1966	B	64%	36%	51%	27%	19%	23%	26%	26%	35%	51%	60%	65%
1968	B	42%	51%	37%	14%	9%	16%	26%	28%	35%	51%	62%	59%
1972	B	55%	64%	48%	51%	37%	21%	28%	27%	35%	51%	61%	61%
1979	B	55%	65%	65%	30%	10%	16%	28%	31%	35%	51%	56%	54%
	AVG	56%	56%	51%	40%	20%	25%	26%	27%	35%	50%	58%	60%
1924	C	62%	57%	65%	65%	44%	23%	26%	12%	12%	21%	23%	46%
1929	C	64%	64%	65%	65%	40%	29%	26%	25%	25%	19%	25%	46%
1931	C	54%	52%	48%	65%	40%	33%	25%	26%	28%	25%	4%	46%
1933	C	56%	50%	48%	65%	45%	35%	26%	24%	13%	10%	4%	47%
1934	C	55%	27%	65%	59%	36%	24%	23%	27%	33%	44%	39%	47%
1976	C	42%	51%	59%	61%	28%	31%	25%	25%	35%	54%	54%	48%
1977	C	47%	56%	48%	51%	15%	23%	25%	8%	4%	3%	28%	48%
1988	C	56%	47%	61%	39%	35%	30%	26%	26%	35%	34%	16%	47%
1990	C	63%	58%	65%	41%	40%	35%	23%	27%	35%	51%	34%	50%
1991	C	45%	51%	48%	42%	4%	33%	24%	27%	26%	29%	38%	46%
1992	C	34%	50%	50%	65%	22%	35%	24%	27%	32%	39%	21%	46%
1994	C	63%	43%	55%	59%	20%	35%	25%	27%	35%	57%	64%	51%
	AVG	53%	51%	56%	56%	31%	31%	25%	23%	26%	32%	29%	47%

Appendix E-12. (Continued).

DELTA EXPORT/INFLOW RATIO STATE WATER RESOURCES CONTROL BOARD ALTERNATIVE 5 - DWRSIM MODEL RUN 524													
Water Year	Water-Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
1925	D	38%	50%	65%	55%	18%	22%	24%	29%	24%	50%	50%	49%
1926	D	52%	56%	62%	56%	28%	35%	24%	27%	35%	49%	21%	56%
1930	D	33%	47%	65%	48%	37%	21%	24%	25%	35%	54%	57%	47%
1932	D	51%	29%	58%	54%	38%	23%	30%	29%	35%	52%	47%	48%
1939	D	35%	49%	47%	22%	24%	33%	26%	29%	35%	54%	61%	49%
1944	D	65%	65%	65%	52%	14%	23%	29%	29%	35%	54%	62%	54%
1947	D	65%	65%	52%	65%	39%	26%	27%	29%	35%	54%	62%	57%
1949	D	65%	65%	62%	65%	45%	23%	28%	26%	35%	54%	53%	54%
1955	D	65%	49%	38%	43%	41%	35%	28%	28%	35%	54%	55%	50%
1960	D	65%	57%	53%	65%	35%	27%	24%	25%	35%	54%	43%	49%
1961	D	60%	65%	58%	65%	33%	35%	23%	26%	35%	54%	62%	47%
1964	D	58%	34%	65%	39%	35%	35%	28%	28%	35%	54%	62%	65%
1981	D	52%	64%	62%	16%	17%	19%	25%	29%	35%	54%	62%	56%
1985	D	58%	29%	42%	61%	28%	30%	26%	26%	35%	54%	62%	65%
1987	D	63%	58%	65%	44%	21%	20%	24%	27%	35%	54%	60%	47%
1989	D	36%	57%	53%	65%	20%	24%	21%	23%	35%	54%	43%	65%
	AVG	54%	52%	57%	51%	30%	27%	26%	27%	34%	53%	54%	54%
1927	W	63%	46%	60%	34%	7%	15%	14%	25%	35%	47%	54%	62%
1938	W	65%	40%	16%	28%	3%	3%	9%	11%	21%	35%	54%	49%
1941	W	65%	65%	23%	11%	10%	8%	11%	19%	35%	30%	49%	53%
1942	W	41%	52%	16%	8%	4%	19%	15%	19%	32%	36%	54%	62%
1943	W	41%	42%	33%	9%	9%	6%	22%	27%	35%	36%	45%	63%
1952	W	65%	58%	22%	13%	11%	9%	10%	12%	22%	42%	59%	46%
1953	W	38%	57%	16%	5%	17%	24%	26%	24%	35%	47%	60%	65%
1956	W	62%	56%	13%	7%	8%	14%	26%	18%	35%	47%	58%	56%
1958	W	46%	52%	43%	29%	4%	6%	8%	17%	24%	40%	57%	42%
1963	W	32%	50%	37%	56%	15%	30%	8%	22%	35%	47%	59%	65%
1965	W	57%	65%	14%	10%	29%	28%	15%	24%	35%	44%	51%	65%
1967	W	63%	64%	28%	22%	14%	9%	13%	14%	20%	41%	58%	44%
1969	W	65%	65%	41%	10%	3%	7%	11%	12%	25%	37%	55%	39%
1970	W	39%	53%	13%	2%	5%	15%	29%	31%	35%	47%	58%	60%
1971	W	63%	43%	17%	20%	22%	14%	24%	22%	35%	47%	60%	54%
1974	W	64%	16%	15%	9%	15%	7%	12%	25%	35%	48%	60%	44%
1975	W	45%	55%	55%	47%	9%	8%	25%	24%	34%	48%	61%	53%
1982	W	64%	30%	12%	14%	7%	8%	6%	19%	31%	42%	58%	41%
1983	W	29%	21%	13%	5%	2%	2%	6%	9%	11%	28%	47%	31%
1984	W	16%	6%	4%	5%	10%	16%	28%	30%	35%	47%	56%	60%
1986	W	56%	56%	60%	47%	6%	6%	23%	35%	35%	30%	47%	65%
	AVG	51%	47%	26%	19%	10%	12%	16%	21%	30%	41%	55%	53%

Appendix E-13. Historic Monthly Total Combined Water Exports (acre-feet) From CVP, SWP, CCWD, and NBA. Data from Department of Water Resources DAYFLOW. W-Wet, B-Below Normal, D-Dry, C-Critical, A-Above Normal.

HISTORIC TOTAL COMBINED WATER EXPORTS (ACRE-FEET) AT CVP, SWP, CCWD, and NBA													
Water Year Type	Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
D	1930	0	0	0	0	0	0	0	0	0	0	0	0
C	1931	0	0	0	0	0	0	0	0	0	0	0	0
D	1932	0	0	0	0	0	0	0	0	0	0	0	0
C	1933	0	0	0	0	0	0	0	0	0	0	0	0
C	1934	0	0	0	0	0	0	0	0	0	0	0	0
B	1935	0	0	0	0	0	0	0	0	0	0	0	0
B	1936	0	0	0	0	0	0	0	0	0	0	0	0
B	1937	0	0	0	0	0	0	0	0	0	0	0	0
W	1938	0	0	0	0	0	0	0	0	0	0	0	0
D	1939	0	0	0	0	0	0	0	0	0	0	0	0
A	1940	0	0	0	0	0	0	0	0	0	0	0	0
W	1941	0	0	0	0	0	0	0	0	0	0	0	0
W	1942	0	0	0	0	0	0	0	0	0	0	0	0
W	1943	0	0	0	0	0	0	0	0	0	0	0	0
D	1944	0	0	0	0	0	0	0	0	0	0	0	0
B	1945	0	0	0	0	0	0	0	0	0	0	0	0
B	1946	0	0	0	0	0	0	0	0	0	0	0	0
D	1947	0	0	0	0	0	0	0	0	0	0	0	0
B	1948	0	0	0	0	0	0	0	0	0	0	0	0
D	1949	0	0	0	0	0	0	0	0	0	0	0	0
B	1950	0	0	0	0	867	1,588	1,402	2,566	3,334	3,875	4,166	3,509
A	1951	3,101	2,037	1,293	1,107	939	1,097	2,208	1,980	10,371	37,246	73,832	58,016
W	1952	25,041	2,740	4,431	2,327	1,501	1,598	7,750	5,982	10,439	35,232	63,497	35,790
W	1953	27,785	4,702	2,012	1,948	10,848	36,149	84,443	129,498	137,315	178,271	153,848	50,498
A	1954	27,811	3,875	3,283	7,635	52,300	71,326	121,895	84,174	178,224	202,067	180,212	112,040
D	1955	57,622	15,796	2,679	2,445	22,364	98,703	135,622	150,175	189,728	196,747	190,159	113,975
W	1956	72,565	23,926	10,973	2,368	11,101	27,843	41,823	25,963	70,025	199,375	184,546	98,502
A	1957	44,777	6,532	6,315	4,891	58,335	110,341	139,753	134,189	194,623	220,438	194,686	117,992
W	1958	67,855	29,398	8,611	3,369	4,955	17,703	9,007	36,798	45,863	179,878	194,392	111,895
B	1959	76,024	32,860	9,732	18,506	34,937	124,154	163,743	163,329	211,697	245,825	210,845	115,069
D	1960	79,059	40,360	15,848	15,638	36,187	139,976	154,719	164,965	227,180	251,378	218,243	119,702
D	1961	98,522	35,324	3,307	18,833	45,096	126,243	172,266	174,154	237,106	285,799	240,815	128,590
B	1962	88,406	40,641	15,527	24,796	14,269	55,553	163,996	181,846	225,630	259,549	228,452	127,161
W	1963	87,806	47,759	3,515	31,129	45,198	111,870	73,100	170,265	210,479	257,682	237,248	127,686

Appendix 13. (Continued).

HISTORIC TOTAL COMBINED WATER EXPORTS (ACRE-FEET) AT CVP, SWP, CCWD, and NBA													
Water Year Type	Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
D	1964	127,724	32,345	10,053	35,427	91,204	133,320	182,066	200,180	225,410	283,508	260,356	144,572
W	1965	139,260	44,326	3,745	13,761	86,533	136,116	71,508	195,985	219,442	267,658	239,631	123,067
B	1966	110,861	39,443	3,531	7,087	50,654	152,497	184,624	207,533	242,038	282,174	262,724	137,498
W	1967	116,845	60,944	30,725	50,072	42,394	122,891	71,704	117,931	128,411	165,572	263,431	156,464
B	1968	110,157	67,243	41,402	71,700	104,979	275,385	319,557	344,416	279,664	317,199	298,809	332,791
W	1969	383,535	299,533	231,107	352,831	260,929	208,861	190,815	200,717	148,122	207,593	312,912	152,095
W	1970	123,156	63,663	50,398	68,502	108,085	139,033	276,367	246,231	298,836	320,858	282,842	183,503
W	1971	158,636	120,615	117,523	116,908	174,043	288,592	263,175	279,224	342,628	309,524	411,282	232,075
B	1972	234,002	180,987	149,478	99,136	214,220	410,127	377,562	398,880	317,810	311,444	428,778	416,417
A	1973	393,568	210,713	211,857	181,818	65,300	78,685	199,092	399,024	436,887	472,220	477,159	342,612
W	1974	383,767	291,244	204,911	121,194	302,418	385,158	249,628	437,632	542,305	656,194	581,488	300,289
W	1975	282,020	115,755	172,738	335,869	372,365	373,110	374,436	342,659	268,494	318,222	551,685	463,252
C	1976	464,085	475,794	479,982	506,975	447,493	512,584	299,221	336,826	240,599	252,228	419,611	494,834
C	1977	282,722	252,064	170,858	432,241	240,328	234,038	76,941	183,327	43,912	51,886	93,842	110,259
A	1978	46,828	157,431	362,897	604,291	571,539	383,285	194,319	187,680	452,680	496,416	517,139	444,748
B	1979	314,499	330,999	371,413	251,898	162,925	266,852	349,383	383,335	376,641	573,242	636,022	550,144
A	1980	474,474	347,891	366,619	391,437	355,156	266,430	317,387	284,210	354,087	421,624	565,411	456,358
D	1981	410,853	383,508	415,119	507,258	401,335	296,713	480,515	274,858	239,516	432,463	571,762	403,743
W	1982	364,008	280,203	317,119	317,687	524,021	639,408	570,425	367,901	233,757	247,485	496,905	313,866
W	1983	324,365	360,714	517,320	618,990	568,015	329,675	226,567	202,156	297,622	319,591	441,338	249,680
W	1984	153,222	104,166	131,487	105,576	331,159	424,518	456,474	363,904	368,208	580,472	584,035	326,576
D	1985	344,053	474,963	519,537	358,164	422,143	526,845	436,110	381,498	387,861	580,991	620,611	517,931
W	1986	472,815	435,339	605,094	556,724	336,738	196,356	278,948	384,232	386,883	528,305	610,773	623,112
D	1987	464,398	407,489	445,605	383,702	379,496	343,728	417,074	326,117	307,890	549,484	601,515	536,743
C	1988	362,624	324,321	551,558	639,542	575,514	518,119	509,135	364,597	352,031	492,658	542,973	485,770
D	1989	348,675	383,718	442,646	627,599	456,140	631,200	622,217	384,645	316,417	588,463	698,780	641,701
C	1990	647,687	617,966	642,331	653,523	586,303	649,659	576,631	210,712	210,776	387,119	413,614	355,319
C	1991	221,145	232,773	322,028	303,880	253,029	601,938	447,968	167,609	117,784	161,598	237,303	254,969
C	1992	328,922	189,900	196,191	394,784	351,589	643,314	184,499	110,233	118,874	95,187	166,517	269,359
A	1993	116,919	147,034	251,366	716,320	517,313	370,533	340,603	208,252	252,245	538,051	666,873	653,726
C	1994	671,515	417,233	649,149	362,794	328,140	268,645	119,719	121,094	117,780	274,415	378,779	441,612

Appendix E-14. Simulated Future Combined Total Water Exports in the Sacramento-San Joaquin Bay-Delta Estuary at SWP, CVP, CCWD, and NBA According to 1995 Bay-Delta Plan, DWRSIM Model Run TP6. Model Assumes Hydrologic Sequence for Past 71 Years Repeated. W-Wet, B-Below Normal, D-Dry, C-Critical, A-Above Normal.

1995 BAY-DELTA PLAN
COMBINED TOTAL EXPORTS (ACRE-FEET) AT SWP, CVP, CCWD, and NBA AT EXISTING VARIABLE WATER DEMAND
(ASSUMES HYDROLOGIC SEQUENCE FOR PAST 71 YEARS REPEATED)

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1922	420,514	427,680	716,550	756,386	719,611	646,209	487,080	556,655	691,297	229,070	299,473	407,603
1923	695,313	665,577	729,194	593,422	234,622	384,546	469,973	403,819	409,207	715,814	717,471	399,584
1924	513,382	460,469	687,947	721,276	454,553	268,599	180,457	201,265	277,398	420,023	319,606	234,214
1925	540,574	409,682	557,821	459,184	663,340	498,344	409,860	337,529	410,038	715,814	540,574	380,754
1926	581,330	427,442	481,526	715,691	660,900	393,569	370,121	332,802	348,559	714,770	512,523	374,933
1927	564,389	664,805	696,811	706,607	638,392	498,897	492,545	512,953	405,049	475,941	380,802	384,556
1928	594,649	665,577	709,860	733,552	469,909	536,523	449,658	377,303	396,376	715,814	488,892	395,545
1929	439,113	530,739	653,636	606,005	477,948	263,934	194,891	215,444	356,638	608,644	189,603	214,612
1930	480,360	366,617	571,448	714,831	378,822	698,995	223,700	234,901	347,906	636,818	231,096	328,601
1931	331,759	283,991	361,958	626,628	361,801	276,701	202,257	181,930	270,864	332,618	51,375	225,423
1932	394,489	334,481	702,494	714,586	430,991	209,674	318,562	272,282	165,904	234,103	232,446	340,600
1933	332,250	317,552	383,625	710,719	415,966	310,460	237,422	232,692	342,203	289,959	71,017	226,195
1934	290,266	232,670	557,637	717,287	365,350	414,929	231,422	202,186	354,618	273,018	59,600	230,353
1935	281,427	461,657	508,226	732,816	361,912	656,705	492,545	532,103	451,024	715,814	576,174	371,191
1936	467,531	421,918	481,403	739,015	719,611	728,642	438,253	391,911	407,068	715,814	451,327	376,121
1937	430,642	397,980	621,473	692,244	719,611	749,388	488,506	434,018	367,211	440,893	336,669	380,101
1938	450,591	665,577	709,123	768,969	476,839	452,125	413,424	518,109	630,709	324,393	315,002	689,218
1939	695,313	653,935	487,112	417,138	292,501	341,580	259,697	256,998	355,034	715,814	485,639	339,768
1940	526,825	390,852	464,831	729,379	681,967	730,238	492,545	438,683	396,376	715,814	652,776	392,337
1941	513,873	453,578	715,384	775,045	719,611	653,145	489,456	498,099	523,255	210,288	299,228	597,089
1942	695,313	665,577	485,884	460,043	439,806	450,468	519,572	556,655	690,466	212,682	299,473	654,885
1943	695,313	665,577	531,121	468,575	453,610	452,432	519,572	433,834	380,279	437,578	334,889	377,665
1944	614,537	633,382	464,647	712,008	695,606	523,940	250,549	263,136	414,909	715,814	439,849	382,180
1945	568,993	665,577	713,358	703,660	614,442	533,638	361,152	329,549	465,043	581,330	385,773	399,109
1946	666,587	665,577	719,558	745,460	414,026	563,898	361,271	347,963	438,788	715,814	460,411	403,920
1947	523,326	513,691	706,238	682,055	588,385	514,794	269,438	258,348	344,104	715,814	717,471	400,356
1948	612,695	490,822	489,199	680,397	365,183	380,004	394,416	492,329	512,444	715,814	717,471	662,072
1949	695,313	561,865	539,653	544,072	399,002	718,023	304,663	315,984	388,773	639,273	378,899	409,147

Appendix E-14. (Continued).

1995 BAY-DELTA PLAN
COMBINED TOTAL EXPORTS (ACRE-FEET) AT SWP, CVP, CCWD, and NBA AT EXISTING VARIABLE WATER DEMAND
(ASSUMES HYDROLOGIC SEQUENCE FOR PAST 71 YEARS REPEATED)

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1950	580,287	435,224	418,673	720,110	660,290	541,126	363,884	350,296	437,362	715,814	717,471	398,336
1951	695,313	665,577	739,936	792,170	597,144	541,556	382,655	447,276	395,307	715,814	581,453	413,959
1952	576,297	665,577	706,238	792,170	698,988	471,460	442,827	528,789	606,652	541,924	382,950	689,218
1953	629,084	484,169	484,288	306,593	276,147	412,105	365,072	478,948	648,173	494,293	384,607	544,163
1954	695,313	665,577	668,183	539,776	460,097	525,290	449,658	434,264	392,693	715,814	613,063	420,552
1955	500,247	665,577	703,108	725,082	532,335	288,179	221,681	260,926	410,513	715,814	717,471	473,656
1956	509,147	477,279	706,054	792,170	711,351	528,666	462,488	556,655	616,097	543,213	409,773	689,218
1957	695,313	655,895	469,803	709,062	468,523	481,281	355,450	362,694	421,918	715,814	717,471	439,441
1958	695,313	665,577	710,412	735,762	621,815	504,912	537,986	556,655	661,122	384,668	465,076	689,218
1959	695,313	489,575	490,733	450,284	326,652	404,801	235,343	260,313	373,329	715,814	512,093	434,689
1960	570,834	419,661	697,031	585,627	662,563	498,835	237,362	227,781	355,153	715,814	668,121	410,038
1961	554,446	501,098	679,599	566,722	656,631	458,570	223,819	228,395	352,183	715,814	614,782	413,483
1962	537,873	423,997	648,787	474,467	688,232	636,020	260,647	320,956	373,210	715,814	474,774	428,749
1963	695,313	665,577	703,906	714,463	519,972	542,906	492,782	532,103	439,382	640,562	396,699	508,226
1964	695,313	665,577	642,833	701,942	365,738	321,754	226,967	260,313	354,796	715,752	717,348	461,360
1965	460,350	631,006	706,422	792,109	672,155	531,428	519,631	551,622	396,970	715,814	453,844	408,494
1966	695,313	665,577	721,706	751,905	478,281	489,506	313,038	317,519	372,735	715,814	677,021	415,384
1967	553,586	649,598	719,865	742,268	606,680	400,382	465,815	518,109	630,709	684,387	388,474	689,218
1968	591,887	469,557	434,448	271,054	276,867	408,238	288,922	256,753	373,329	715,814	487,357	418,414
1969	575,438	523,373	702,862	770,319	653,693	418,489	411,345	491,224	591,683	426,775	353,672	689,218
1970	695,313	484,169	468,268	299,350	276,147	412,105	367,567	308,066	393,763	715,814	412,842	409,028
1971	574,210	665,577	712,806	723,977	509,327	635,958	375,052	492,083	557,707	715,814	432,238	619,007
1972	695,313	665,577	703,783	679,354	478,558	528,727	283,694	260,067	370,121	715,814	717,471	454,648
1973	639,211	665,577	702,924	721,215	695,273	491,470	414,018	444,575	483,932	704,949	400,566	429,224
1974	685,246	665,577	709,185	688,315	470,020	531,735	519,631	553,279	547,965	518,047	448,995	689,218
1975	695,313	665,577	619,631	479,807	342,453	479,685	502,762	556,655	641,520	616,562	407,747	689,218
1976	695,313	665,577	662,167	530,262	478,281	386,878	197,921	220,661	369,468	491,347	238,032	262,013
1977	353,365	398,158	692,796	309,294	348,219	272,098	180,992	164,314	80,428	132,090	75,252	231,898
1978	288,363	211,583	675,917	646,270	312,626	334,582	386,753	430,212	414,256	197,275	299,228	509,593

Appendix E-14. (Continued).

1995 BAY-DELTA PLAN
COMBINED TOTAL EXPORTS (ACRE-FEET) AT SWP, CVP, CCWD, and NBA AT EXISTING VARIABLE WATER DEMAND
(ASSUMES HYDROLOGIC SEQUENCE FOR PAST 71 YEARS REPEATED)

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1979	695,313	665,577	400,996	668,060	443,243	508,533	404,039	418,919	502,583	567,090	343,053	384,734
1980	498,958	665,577	707,957	785,541	456,826	384,668	383,724	434,877	358,895	221,398	323,780	641,817
1981	695,313	665,577	574,946	460,043	439,806	454,826	310,306	256,998	350,163	715,814	488,155	378,081
1982	532,963	665,577	700,898	748,345	658,849	547,080	523,017	617,176	691,297	550,210	523,265	689,218
1983	695,313	508,583	499,510	385,712	265,391	314,204	403,445	404,249	477,576	501,536	649,339	519,631
1984	451,941	330,442	334,153	208,385	238,558	399,707	384,199	332,495	417,285	667,814	384,116	629,818
1985	695,313	665,577	731,036	489,628	453,887	465,199	231,304	290,389	346,955	715,814	654,311	403,861
1986	554,077	485,654	707,220	711,210	719,611	639,457	507,573	470,600	396,970	418,734	334,705	501,039
1987	695,313	546,480	490,242	575,499	549,798	675,732	237,481	231,341	350,163	715,814	562,057	378,972
1988	422,785	378,853	698,320	702,801	361,968	299,473	186,516	208,815	362,518	470,785	322,859	227,680
1989	301,069	335,432	436,596	520,380	386,916	709,860	335,788	267,064	347,371	715,016	716,673	406,831
1990	353,549	248,351	493,188	701,205	345,225	289,038	228,631	189,910	361,746	470,969	326,173	248,767
1991	304,077	243,243	323,964	389,272	364,518	698,811	238,847	194,329	341,015	329,488	277,622	289,753
1992	315,739	186,813	399,707	487,603	666,389	479,807	226,611	202,677	360,558	561,566	278,174	223,879

Appendix E-15. Average Historic Monthly Combined Exports (cfs) at CVP and SWP Delta Water Export Facilities by Water-year Type and by Time Periods. The Time Periods Represent Major Changes in Water Flow Management Within the Sacramento River system and the Sacramento-San Joaquin Bay-Delta Estuary, California. Data from Department of Water Resources DAYFLOW.

HISTORIC EXPORTS (CFS) AVERAGE MONTHLY BY WATER-YEAR TYPE														
WATER-YEAR TYPE	PERIOD	WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
ABOVE NORMAL	PRE-1945	1940	0	0	0	0	0	0	0	0	0	0	0	0
	1945-1950	NO ABOVE NORMAL WATER YEARS												
	1951-1967	1951	0	0	0	0	0	0	0	0	113	544	1,124	913
		1954	406	24	14	84	905	1,123	2,008	1,311	2,915	3,196	2,843	1,809
		1957	657	68	56	31	1,004	1,756	2,288	2,122	3,174	3,471	3,050	1,875
		AVG	354	30	23	38	636	960	1,432	1,145	2,067	2,404	2,339	1,532
	1968-1977	1973	6,300	3,472	3,384	2,899	1,114	1,216	3,268	6,311	7,181	7,461	7,557	5,601
		1978	628	2,527	5,802	9,794	10,273	5,883	3,209	2,968	7,484	7,895	8,247	7,384
		AVG	3,464	3,000	4,593	6,347	5,694	3,549	3,238	4,639	7,323	7,678	7,902	6,482
	1978-1992	1978	628	2,527	5,802	9,794	10,273	5,883	3,209	2,968	7,484	7,895	8,247	7,384
		1980	7,578	5,745	5,894	6,318	6,131	4,286	5,269	4,494	5,796	6,695	9,015	7,502
		AVG	4,103	4,136	5,848	8,056	8,202	5,084	4,239	3,731	6,640	7,295	8,631	7,433
	1993-1994	1993	1,709	2,327	3,960	11,570	9,231	5,945	5,604	3,197	4,011	8,503	10,582	10,748
	1995-1997	1996	7,249	5,458	4,386	9,979	6,563	3,474	4,179	4,615	9,431	10,441	10,529	10,099
		1997	9,703	9,976	7,674	2,656	2,267	6,889	4,472	3,023	7,038	9,637	8,834	10,077
		AVG	8,476	7,717	6,030	6,318	4,415	5,182	4,326	3,819	8,235	10,039	9,682	10,088

Appendix E-15. (Continued).

HISTORIC EXPORTS (CFS) AVERAGE MONTHLY BY WATER-YEAR TYPE														
WATER-YEAR TYPE	PERIOD	WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
BELOW NORMAL	PRE-1945	1935	0	0	0	0	0	0	0	0	0	0	0	0
		1936	0	0	0	0	0	0	0	0	0	0	0	0
		1937	0	0	0	0	0	0	0	0	0	0	0	0
		AVG	0	0	0	0	0	0	0	0	0	0	0	0
	1945-1950	1945	0	0	0	0	0	0	0	0	0	0	0	0
		1946	0	0	0	0	0	0	0	0	0	0	0	0
		1948	0	0	0	0	0	0	0	0	0	0	0	0
		1950	0	0	0	0	0	0	0	0	0	0	0	0
		AVG	0	0	0	0	0	0	0	0	0	0	0	0
	1951-1967	1959	1,149	496	97	250	584	1,962	2,687	2,546	3,418	3,842	3,289	1,833
		1962	1,320	581	191	343	201	857	2,687	2,874	3,668	4,081	3,561	2,006
		1966	1,700	586	0	60	857	2,419	3,006	3,244	3,894	4,398	4,083	2,156
		AVG	1,390	554	, 96	218	547	1,746	2,787	2,888	3,660	4,107	3,644	1,998
	1968-1977	1968	1,693	1,040	595	1,077	1,768	4,435	5,250	5,452	4,484	4,944	4,674	5,417
		1972	3,694	2,962	2,344	1,549	3,661	6,588	6,196	6,282	5,121	4,893	6,771	6,817
		AVG	2,694	2,001	1,470	1,313	2,714	5,511	5,723	5,867	4,803	4,918	5,722	6,117
	1978-1992	1979	5,023	5,484	5,963	4,038	2,885	4,280	5,794	6,088	6,143	9,116	10,153	9,090

1993-1994 NO BELOW NORMAL WATER YEARS

1995-1997 NO BELOW NORMAL WATER YEARS

Appendix E-15. (Continued).

HISTORIC EXPORTS (CFS) AVERAGE MONTHLY BY WATER-YEAR TYPE														
WATER-YEAR TYPE	PERIOD	WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
CRITICAL	PRE-1945	1931	0	0	0	0	0	0	0	0	0	0	0	0
		1933	0	0	0	0	0	0	0	0	0	0	0	0
		1934	0	0	0	0	0	0	0	0	0	0	0	0
		AVG	0	0	0	0	0	0	0	0	0	0	0	0
	1945-1950	NO CRITICAL WATER YEARS												
	1951-1967	NO CRITICAL WATER YEARS												
	1968-1977	1976	7,474	7,949	7,778	8,158	7,628	8,207	4,865	5,280	3,930	3,876	6,624	8,140
		1977	4,471	4,082	2,659	6,927	4,175	3,688	1,176	2,877	557	701	1,388	1,734
		AVG	5,973	6,015	5,218	7,543	5,901	5,947	3,020	4,079	2,244	2,289	4,006	4,937
	1978-1992	1988	5,726	5,307	8,861	10,289	9,695	8,256	8,364	6,069	5,691	7,720	8,539	7,896
		1990	10,351	10,224	10,297	10,484	10,405	10,405	9,465	3,175	3,276	6,007	6,448	5,692
		1991	3,364	3,708	5,057	4,766	4,384	9,852	7,399	2,555	1,770	2,401	3,850	4,074
		1992	5,153	3,045	3,045	6,284	5,993	10,362	2,905	1,536	1,753	1,316	2,469	4,320
		AVG	6,149	5,571	6,815	7,956	7,669	9,669	7,033	3,334	3,122	4,361	5,276	5,496
	1993-1994	1994	10,739	6,835	10,432	5,772	5,782	4,172	1,816	1,760	1,689	4,186	5,880	7,172
	1995-1997	NO CRITICAL WATER YEARS												

Appendix E-15. (Continued).

HISTORIC EXPORTS (CFS) AVERAGE MONTHLY BY WATER-YEAR TYPE														
WATER-YEAR TYPE	PERIOD	WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
DRY	PRE-1945	1930	0	0	0	0	0	0	0	0	0	0	0	0
		1932	0	0	0	0	0	0	0	0	0	0	0	0
		1939	0	0	0	0	0	0	0	0	0	0	0	0
		1944	0	0	0	0	0	0	0	0	0	0	0	0
		AVG	0	0	0	0	0	0	0	0	0	0	0	0
	1945-1950	1947	0	0	0	0	0	0	0	0	0	0	0	0
		1949	0	0	0	0	0	0	0	0	0	0	0	0
		AVG	0	0	0	0	0	0	0	0	0	0	0	0
	1951-1967	1955	890	227	8	9	365	1,569	2,208	2,376	3,088	3,101	2,997	1,821
		1960	1,203	594	175	185	576	2,206	2,532	2,590	3,665	3,926	3,395	1,873
		1961	1,449	503	0	245	760	2,005	2,818	2,712	3,834	4,466	3,762	2,025
		1964	1,995	483	109	524	1,528	2,100	2,947	3,091	3,636	4,434	4,060	2,283
		AVG	1,385	452	73	241	807	1,970	2,626	2,692	3,556	3,982	3,553	2,000
	1968-1977	NO DRY WATER YEARS												
	1978-1992	1981	6,529	6,338	6,687	8,178	7,162	4,755	7,983	4,267	3,793	6,808	9,112	6,825
		1985	5,456	7,893	8,407	5,756	7,517	8,487	7,194	5,997	6,300	9,209	9,884	8,545
		1987	7,432	6,712	7,112	6,130	6,737	5,468	6,837	5,075	4,940	8,707	9,560	8,845
		1989	5,435	5,936	7,037	10,057	8,065	10,136	10,302	6,014	5,044	9,252	11,057	10,534
		AVG	6,213	6,720	7,311	7,530	7,370	7,211	8,079	5,338	5,019	8,494	9,903	8,637
	1993-1994	NO DRY WATER YEARS												
	1995-1997	NO DRY WATER YEARS												

Appendix E-15. (Continued).

WATER-YEAR TYPE	PERIOD	WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
HISTORIC EXPORTS (CFS) AVERAGE MONTHLY BY WATER-YEAR TYPE														
WET	PRE-1945	1938	0	0	0	0	0	0	0	0	0	0	0	0
		1941	0	0	0	0	0	0	0	0	0	0	0	0
		1942	0	0	0	0	0	0	0	0	0	0	0	0
		1943	0	0	0	0	0	0	0	0	0	0	0	0
		AVG	0	0	0	0	0	0	0	0	0	0	0	0
	1945-1950	NO WET WATER YEARS												
	1951-1967	1952	368	12	41	0	0	0	100	58	129	517	975	539
		1953	416	31	0	0	165	555	1,379	2,068	2,249	2,837	2,438	781
		1956	1,123	350	138	6	159	413	650	362	1,083	3,169	2,914	1,566
		1958	1,035	440	98	15	55	251	104	531	684	2,832	3,083	1,779
		1963	1,348	746	6	455	763	1,769	1,172	2,708	3,429	4,055	3,698	2,014
		1965	2,145	655	0	170	1,500	2,150	1,136	3,090	3,578	4,220	3,725	1,943
		1967	1,776	924	424	735	685	1,938	1,147	1,828	2,055	2,566	4,156	2,506
		AVG	1,173	451	101	197	475	1,011	812	1,520	1,887	2,885	2,996	1,590
	1968-1977	1969	6,099	4,928	3,677	5,688	4,647	3,349	3,139	3,162	2,381	3,228	4,921	2,421
		1970	1,902	994	727	1,067	1,866	2,193	4,524	3,845	4,800	5,018	4,394	2,928
		1971	2,469	1,952	1,852	1,841	3,074	4,631	4,351	4,452	5,627	6,344	6,520	3,779
		1974	5,822	4,819	3,283	1,917	5,397	6,209	4,125	7,015	8,942	10,493	9,281	4,940
		1975	4,496	1,878	2,755	5,405	6,634	6,005	6,207	5,471	4,353	5,010	8,817	7,662
		AVG	4,158	2,914	2,459	3,183	4,323	4,478	4,469	4,789	5,221	6,018	6,787	4,346
	1978-1992	1982	5,787	4,632	5,127	5,127	9,402	10,369	9,550	5,859	3,765	3,860	7,913	5,167
		1983	5,202	6,004	8,367	10,045	10,155	5,221	3,755	3,198	4,841	5,035	7,018	4,050
		1984	2,415	1,686	2,088	1,674	5,700	6,856	7,542	5,739	5,950	9,204	9,265	5,312
		1986	7,518	7,202	9,751	8,925	6,002	3,141	4,612	6,080	5,954	8,378	9,727	10,296
		AVG	5,231	4,881	6,333	6,443	7,814	6,397	6,365	5,219	5,127	6,619	8,480	6,206
	1993-1994	NO WET YEARS												
	1995-1997	1995	5,228	6,074	7,434	11,648	8,790	2,905	3,439	4,199	7,431	10,383	9,133	7,209

Appendix E-16. Simulated Average Monthly Combined Exports (cfs) by Water-year Type at the CVP and SWP Delta Water Export Facilities. Projected Existing Operations to 1995 Bay-Delta Plan. W-Wet, B-Below Normal, D-Dry, C-Critical, A-Above Normal.

AVERAGE MONTHLY COMBINED EXPORTS AT CVP & SWP (CFS) - DWRSIM MODEL RUN 420 -1995 BAY-DELTA PLAN													
WATER YEAR	WATER YEAR TYPE	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1922	A	6,573	6,936	11,472	12,147	12,821	9,624	8,002	8,755	11,277	3,357	4,477	6,502
1928	A	9,590	10,941	11,364	11,774	8,790	8,572	7,372	5,844	6,317	10,346	7,492	6,307
1940	A	8,196	6,317	7,421	11,706	12,142	11,726	8,095	6,836	6,320	11,287	8,975	6,636
1951	A	10,530	10,941	11,853	12,729	10,914	8,131	6,243	6,975	6,302	11,206	7,985	6,600
1954	A	11,027	10,941	10,685	9,663	8,140	8,342	7,372	6,771	6,256	11,271	7,972	6,708
1957	A	11,027	10,778	7,452	11,393	10,038	7,670	5,804	5,587	6,754	11,280	10,076	6,548
1973	A	10,113	10,941	11,251	11,573	12,400	9,341	6,772	6,929	7,803	8,196	7,560	6,833
1978	A	3,915	3,778	10,857	8,178	5,319	5,279	6,313	6,696	6,622	2,839	4,473	8,219
1980	A	7,827	10,941	11,332	12,729	8,642	6,482	6,337	6,772	5,682	3,233	4,873	10,445
	AVG	8,755	9,168	10,410	11,321	9,912	8,352	6,923	6,796	7,037	8,113	7,098	7,200
1923	B	11,027	10,941	11,678	9,532	4,079	6,096	7,713	6,265	6,534	11,282	9,604	6,446
1935	B	4,254	7,730	8,128	11,763	6,332	10,528	8,095	8,356	7,237	11,118	8,392	5,875
1936	B	7,319	6,831	7,640	11,863	12,821	11,700	7,181	6,071	6,485	10,857	7,736	5,985
1937	B	6,714	6,424	11,350	11,101	12,821	12,064	8,027	6,703	4,845	5,828	6,052	6,039
1945	B	8,967	10,941	11,420	11,287	12,263	8,523	5,881	5,055	7,473	6,674	7,081	6,340
1946	B	10,550	10,941	11,521	11,968	7,317	9,018	5,884	5,358	7,031	9,918	7,977	6,442
1948	B	9,171	7,766	7,604	10,897	6,433	6,021	6,573	7,708	8,266	11,287	11,287	10,995
1950	B	8,128	6,942	6,607	11,567	11,762	8,644	5,929	5,395	7,004	11,287	11,287	6,717
1959	B	11,027	7,978	7,793	7,159	5,733	6,378	3,765	3,930	5,929	10,658	7,254	6,953
1962	B	7,971	6,856	10,385	7,528	12,255	10,191	4,190	4,917	5,924	11,287	9,378	6,860
1966	B	11,027	10,941	11,557	12,208	10,126	7,731	5,072	4,863	5,924	11,276	9,096	6,623
1968	B	9,343	7,641	6,876	4,238	4,835	6,481	4,673	3,872	5,929	10,382	7,167	6,663
1972	B	11,027	10,941	11,264	10,520	9,646	9,175	4,606	3,928	5,878	11,287	10,007	6,986
1979	B	11,027	10,941	6,323	10,635	7,914	8,117	6,604	6,512	8,100	6,710	6,255	6,111
	AVG	9,111	8,844	9,296	10,162	8,881	8,619	6,014	5,638	6,619	9,989	8,470	6,788
1924	C	8,063	7,558	11,327	11,574	8,041	4,734	2,791	2,977	4,363	6,828	4,842	3,699
1929	C	6,654	8,667	11,303	9,690	8,461	4,346	3,049	3,215	5,713	8,167	2,950	3,848
1931	C	4,762	5,482	6,075	10,047	6,382	4,266	3,172	2,663	4,261	4,375	297	3,187
1933	C	5,012	5,338	6,029	11,380	7,285	4,809	3,695	3,492	5,183	3,828	991	3,666
1934	C	4,801	3,683	9,270	11,508	6,238	6,719	3,665	2,999	5,830	3,834	797	3,844
1976	C	11,027	10,941	10,586	8,448	9,183	6,038	3,081	3,266	5,879	5,372	3,501	4,045
1977	C	5,442	5,466	10,733	8,214	5,900	3,454	2,862	2,396	1,078	1,806	932	2,965
1988	C	6,311	6,124	11,175	11,273	6,371	4,729	2,965	3,113	5,768	7,150	4,958	4,415
1990	C	4,977	3,381	7,664	11,255	6,083	4,469	3,625	2,805	5,794	7,093	5,148	3,370
1991	C	4,086	4,077	6,052	6,161	6,371	11,142	3,791	2,873	5,582	7,185	2,564	4,544
1992	C	4,370	3,471	6,339	7,798	11,827	7,571	3,577	3,007	5,787	7,681	4,041	4,356
	AVG	5,955	5,835	8,778	9,759	7,467	5,662	3,298	2,982	5,022	5,756	2,820	3,814

Appendix E-16. (Continued).

WATER YEAR	WATER YEAR TYPE	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
AVERAGE MONTHLY COMBINED EXPORTS AT CVP & SWP (CFS) - DWRSIM MODEL RUN 420 -1995 BAY-DELTA PLAN													
1925	D	8,510	6,622	8,873	7,305	11,762	7,948	6,701	5,185	6,535	10,130	7,894	6,280
1926	D	9,187	6,921	7,586	11,483	11,762	6,268	6,038	5,130	5,527	10,311	7,795	6,234
1930	D	7,937	6,371	9,135	11,467	6,635	11,234	3,591	3,539	5,525	7,462	4,628	5,196
1932	D	6,189	5,303	11,235	11,466	7,583	3,095	5,100	4,298	2,298	3,103	3,292	5,362
1939	D	11,027	10,747	7,734	6,620	5,116	5,393	4,175	3,876	5,621	10,410	7,133	5,897
1944	D	9,711	10,398	7,364	11,423	12,388	9,179	4,040	3,983	6,634	9,806	7,116	6,078
1947	D	8,235	8,386	11,229	11,645	10,462	8,217	4,339	3,896	5,428	11,287	9,676	6,323
1949	D	10,821	7,979	8,588	8,696	7,125	11,538	4,945	4,858	6,202	8,205	6,933	6,522
1955	D	7,340	10,941	11,254	11,636	9,451	4,524	3,535	3,938	6,553	11,287	11,287	9,760
1960	D	8,925	6,736	11,131	9,382	11,792	7,957	3,799	3,401	5,623	11,287	10,831	6,570
1961	D	8,316	8,177	10,875	9,055	11,685	7,300	3,560	3,411	5,563	11,287	11,003	6,617
1964	D	11,027	10,941	10,097	11,602	6,441	5,072	3,627	3,933	5,618	11,287	11,271	7,084
1981	D	11,027	10,941	9,167	7,318	7,774	7,239	5,032	3,876	5,541	10,445	7,132	6,011
1985	D	11,027	10,941	11,064	7,680	8,930	7,407	3,696	4,421	5,483	11,287	10,073	6,506
1987	D	11,027	9,146	7,785	9,191	9,758	10,839	3,787	3,456	5,531	11,280	8,425	6,039
1989	D	4,175	5,517	6,844	8,336	6,832	11,402	5,467	4,051	5,499	11,287	10,989	6,506
	AVG	9,030	8,504	9,373	9,644	9,094	7,788	4,465	4,078	5,574	10,010	8,467	6,437
1927	W	8,914	10,941	11,194	11,346	12,231	8,357	8,095	8,045	6,448	5,652	6,751	6,034
1938	W	7,039	10,941	11,351	12,352	9,510	7,196	6,762	8,129	10,258	4,910	4,730	11,243
1941	W	8,093	8,050	11,453	12,450	12,821	11,372	8,043	7,802	8,449	3,047	4,473	9,693
1942	W	11,027	10,941	7,719	7,318	7,774	7,169	8,550	8,755	11,263	3,090	4,477	10,665
1943	W	11,027	10,941	8,455	7,457	8,023	7,201	8,549	6,332	5,500	5,804	5,992	5,997
1952	W	9,077	10,941	11,304	12,729	12,599	8,529	7,258	8,302	9,853	8,454	5,688	11,243
1953	W	10,098	7,887	7,688	4,818	4,821	6,544	5,948	7,490	10,551	6,996	5,355	8,940
1956	W	6,633	7,725	11,301	12,729	12,447	10,549	7,588	8,755	10,011	5,369	7,883	11,243
1958	W	11,027	10,941	11,372	11,811	10,909	9,851	8,860	8,756	10,770	5,891	7,175	11,243
1963	W	11,027	10,941	11,266	11,463	8,639	10,654	8,098	8,356	7,055	7,048	7,433	8,516
1965	W	6,672	10,336	11,308	12,729	11,916	8,659	8,549	8,680	6,328	10,211	7,411	6,596
1967	W	8,732	10,941	11,526	11,916	12,157	6,367	7,644	8,129	10,258	10,776	5,927	11,243
1969	W	9,063	9,057	11,249	12,373	12,487	6,648	6,727	7,690	9,601	6,576	5,115	11,243
1970	W	11,027	7,887	7,427	4,946	4,821	6,544	5,995	4,706	6,275	9,362	7,040	6,514
1971	W	9,053	10,941	11,411	11,618	9,063	11,342	6,116	7,704	9,027	8,253	7,997	10,304
1974	W	11,027	10,941	11,352	12,044	8,474	8,649	8,549	8,701	8,864	6,933	6,914	11,243
1975	W	11,027	10,941	11,013	7,640	6,017	7,644	8,267	8,755	10,440	6,545	7,790	11,243
1982	W	8,384	10,941	11,217	12,015	12,821	8,837	8,615	9,779	11,277	8,588	8,123	11,243
1983	W	11,027	8,298	7,937	6,107	4,628	4,947	6,684	6,273	7,680	7,796	10,178	8,389
1984	W	7,062	5,299	5,241	3,218	4,143	6,342	6,270	5,104	6,673	8,309	6,850	10,689
1986	W	8,737	8,560	11,320	11,410	12,821	10,248	9,684	7,194	6,321	4,640	5,961	8,071
	AVG	9,323	9,733	10,195	10,023	9,482	8,269	7,660	7,783	8,710	6,869	6,632	9,600

Appendix E-17. Simulated Average Monthly Combined Exports (cfs) at the CVP and SWP by Water-year Type for Future Operations to Interim South Delta Program With Future Water Demands. W-Wet, B-Below Normal, D-Dry, C-Critical, A-Above Normal.

EXPORTS (CFS) DWRSIM MODEL RUN 414 - INTERIM SOUTH DELTA PROGRAM AT WATER FUTURE DEMAND													
YEAR	WATER-YEAR TYPE	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1922	A	6,566	7,071	14,044	14,304	9,073	9,140	8,081	10,590	14,158	3,519	7,266	6,599
1928	A	7,706	14,596	12,610	14,549	9,470	8,244	7,492	5,816	6,431	8,635	11,502	5,152
1940	A	6,859	6,195	8,162	14,549	14,502	13,669	9,327	6,826	6,481	10,378	8,276	8,468
1951	A	9,319	14,596	14,549	8,700	8,225	8,602	6,263	7,071	6,448	13,311	9,319	9,764
1954	A	10,476	14,596	10,085	14,549	9,325	8,928	8,990	6,777	6,380	10,622	11,779	6,330
1957	A	14,695	10,842	7,022	11,942	9,993	8,635	5,892	5,572	6,869	13,978	9,156	9,983
1973	A	8,227	14,596	14,581	12,007	8,568	8,423	6,801	6,810	7,980	11,714	9,580	6,498
1978	A	3,861	4,428	11,258	13,099	5,483	7,120	8,333	8,651	7,290	5,767	7,771	6,431
1980	A	7,934	11,919	14,581	14,500	10,480	7,494	7,290	6,777	6,448	10,818	8,456	8,283
	AVG	8,405	10,982	11,877	13,133	9,458	8,917	7,608	7,210	7,609	9,860	9,234	7,501
1923	B	10,427	14,596	14,581	10,427	8,405	5,816	7,727	6,175	6,684	10,166	9,026	8,788
1935	B	4,317	8,165	8,456	14,549	6,349	10,476	9,832	9,791	7,441	9,303	8,325	6,886
1936	B	7,445	7,458	8,488	14,549	14,538	11,665	7,273	6,028	6,650	12,496	8,798	8,165
1937	B	6,696	7,003	14,581	11,535	14,646	11,258	8,081	6,615	8,434	7,983	7,820	6,094
1945	B	7,771	11,886	13,115	11,225	10,660	8,341	6,061	5,018	7,593	10,085	6,908	6,061
1946	B	8,700	13,266	14,581	9,954	7,341	8,618	5,892	5,311	7,155	8,993	9,091	5,791
1948	B	9,417	7,643	7,820	11,062	6,457	5,865	6,465	8,097	8,148	14,923	10,753	9,343
1950	B	6,908	7,071	6,777	14,549	13,709	8,439	5,960	4,839	7,172	9,857	9,189	8,401
1959	B	14,695	12,003	8,309	10,134	6,872	7,168	3,737	3,877	6,061	11,616	10,639	8,620
1962	B	5,979	7,290	10,622	7,543	14,628	10,036	4,949	4,888	6,077	11,518	11,241	6,061
1966	B	10,068	14,596	13,262	12,072	8,892	8,374	5,118	4,822	6,061	13,392	12,252	7,694
1968	B	13,946	8,788	8,716	6,435	6,584	7,413	4,714	3,845	6,044	12,252	10,769	8,603
1972	B	11,127	10,808	14,581	12,300	8,820	8,830	4,276	3,894	6,010	13,832	9,954	9,764
1979	B	11,062	10,875	8,651	14,549	13,546	9,140	6,768	6,419	8,300	12,577	10,655	6,498
	AVG	9,183	10,103	10,896	11,492	10,104	8,674	6,204	5,687	6,988	11,357	9,673	7,626
1924	C	6,272	7,508	12,577	9,580	8,333	3,894	2,761	2,981	4,377	4,676	1,613	2,845
1929	C	6,272	9,040	11,176	9,726	8,586	3,698	3,013	3,226	5,741	7,950	1,776	3,805
1931	C	4,725	4,478	9,107	10,150	6,494	4,220	3,131	2,672	4,310	3,763	65	3,384
1933	C	4,904	3,569	5,458	11,225	6,746	4,594	4,175	3,470	5,926	6,777	1,939	3,939
1934	C	4,888	3,855	9,873	12,366	5,628	6,761	3,670	3,014	4,865	5,181	1,026	3,636
1976	C	14,695	14,343	8,684	8,032	8,225	5,507	3,098	3,258	5,943	9,889	5,051	3,805
1977	C	5,246	5,673	10,932	5,099	6,133	4,317	3,013	2,525	1,162	1,971	831	3,013
1988	C	3,780	6,195	11,958	14,549	2,886	4,839	2,946	2,248	4,899	8,456	2,216	3,300
1990	C	5,425	3,990	9,612	12,740	6,097	4,317	3,603	2,802	5,859	9,107	2,151	3,434
1991	C	4,171	4,495	6,615	6,549	6,746	11,339	3,805	2,867	5,623	5,767	2,704	5,269
1992	C	4,513	3,333	4,888	7,788	14,592	7,511	3,468	3,014	5,825	6,093	1,922	3,586
	AVG	5,899	6,044	9,171	9,800	7,315	5,545	3,335	2,916	4,957	6,330	1,936	3,638
1925	D	7,999	6,667	9,205	7,299	14,556	7,641	6,768	5,148	6,633	8,439	6,403	5,943
1926	D	7,120	6,902	7,950	12,072	14,628	6,647	6,162	4,562	5,690	10,622	9,221	8,333
1930	D	7,739	5,875	9,873	14,549	6,710	11,079	3,620	3,552	5,690	6,403	4,138	4,815
1932	D	5,914	5,438	12,007	12,414	7,215	3,258	5,101	3,519	1,852	4,350	3,421	5,438
1939	D	14,695	13,013	10,020	8,309	7,071	5,376	4,158	3,845	5,673	11,698	10,997	6,953
1944	D	8,016	9,579	13,408	12,154	14,646	8,798	2,626	3,910	6,768	10,085	10,850	6,431

Appendix E-17. (Continued).

EXPORTS (CFS)
DWRSIM MODEL RUN 414 - INTERIM SOUTH DELTA PROGRAM
AT WATER FUTURE DEMAND

YEAR	WATER-YEAR TYPE	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1947	D	7,331	8,721	11,567	12,170	10,624	8,113	4,310	3,845	5,556	10,394	10,981	5,976
1949	D	8,798	7,694	9,254	9,026	7,287	14,663	4,983	4,606	5,909	8,667	4,741	6,111
1955	D	7,250	10,455	14,581	14,484	9,488	4,040	3,603	3,910	6,650	11,307	12,235	6,431
1960	D	7,808	6,734	8,309	10,036	14,556	7,527	3,771	3,405	5,657	13,734	8,895	8,300
1961	D	6,338	8,636	10,932	9,417	13,672	7,429	3,603	3,421	5,690	9,091	10,215	5,724
1964	D	12,349	14,596	10,297	12,968	6,494	5,165	3,603	3,894	5,741	12,610	10,850	7,273
1981	D	13,115	10,522	11,486	13,995	8,892	8,065	4,848	3,845	5,673	12,219	10,948	8,333
1985	D	13,864	14,596	10,769	8,162	8,748	5,751	3,838	4,383	5,623	14,060	8,879	9,293
1987	D	10,688	6,970	11,942	12,089	9,596	10,785	3,855	3,454	5,673	10,134	5,474	4,966
1989	D	3,649	5,539	6,908	8,504	6,764	14,695	5,522	4,073	5,657	9,466	8,814	6,700
	AVG	8,905	8,871	10,532	11,103	10,059	8,065	4,398	3,973	5,633	10,205	8,567	6,689
1927	W	7,283	14,596	11,176	13,506	7,937	9,009	9,613	7,950	6,633	11,144	9,286	6,111
1938	W	7,331	14,596	14,581	11,795	8,460	8,048	8,468	9,889	12,071	4,464	7,641	11,532
1941	W	6,745	8,047	14,581	14,549	14,286	8,553	9,680	9,889	8,620	5,833	8,260	8,956
1942	W	13,099	14,596	12,675	8,244	8,820	8,635	9,832	10,590	11,061	4,562	8,260	9,916
1943	W	14,695	14,596	10,166	8,244	8,820	8,635	9,310	7,657	6,448	10,769	9,319	7,071
1952	W	7,071	10,943	14,581	14,500	11,995	7,836	8,384	9,889	12,071	7,788	5,376	14,798
1953	W	14,695	11,178	8,716	6,940	6,584	7,983	6,128	7,429	10,455	10,655	9,759	9,057
1956	W	6,745	8,030	14,581	14,402	9,524	7,999	7,677	10,590	9,832	6,533	8,504	11,027
1958	W	12,300	12,458	14,581	11,095	8,820	8,684	9,747	10,378	12,071	5,116	8,032	12,391
1963	W	14,695	14,343	9,889	7,755	8,189	8,993	9,613	9,091	7,222	9,906	8,651	7,054
1965	W	6,647	10,084	14,581	14,435	9,253	7,967	9,832	8,586	6,465	10,688	9,123	6,616
1967	W	6,989	10,892	14,581	14,484	10,065	7,185	9,040	9,889	12,071	11,861	5,327	13,855
1969	W	7,511	8,838	14,581	14,451	11,147	7,054	8,384	9,645	11,818	5,847	6,484	14,933
1970	W	14,695	10,993	8,456	6,289	6,584	7,690	6,027	4,643	6,414	12,512	10,671	9,007
1971	W	7,527	14,596	14,581	12,936	8,550	9,335	6,162	8,423	8,889	11,127	9,286	10,690
1974	W	9,596	14,596	14,581	11,030	8,712	9,172	9,832	8,537	8,754	9,857	8,651	11,734
1975	W	13,718	13,418	10,476	8,309	7,071	7,771	8,316	10,052	10,286	7,592	8,830	11,667
1982	W	7,380	14,596	14,565	12,985	8,351	8,928	8,923	10,313	11,229	8,032	7,934	14,933
1983	W	14,695	9,444	8,537	7,038	5,141	5,930	7,980	8,358	10,034	10,150	12,317	10,640
1984	W	8,798	7,492	7,217	5,132	6,043	7,690	6,330	4,985	6,835	13,555	8,961	11,195
1986	W	6,354	8,249	12,252	14,125	14,358	8,635	8,973	7,201	6,465	11,290	8,260	8,367
	AVG	9,832	11,742	12,378	11,059	8,986	8,178	8,488	8,761	9,321	9,018	8,521	10,550

Appendix E-18. Simulated Average Monthly Combined Exports (cfs) by Water-year Type for Future Operations to State Water Resources Control Board Water Rights Alternative 5. W-Wet, B-Below Normal, D-Dry, C-Critical, A-Above Normal.

EXPORTS (CFS) AT CVP & SWP
STATE WATER RESOURCES CONTROL BOARD ALTERNATIVE 5
DWRSIM MODEL RUN 524

Water Year	Water-Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
1922	A	8,423	9,057	11,502	11,975	11,643	7,136	8,569	8,993	11,633	7,266	9,189	10,166
1928	A	11,388	11,246	11,502	11,844	7,184	7,722	7,559	6,680	6,044	11,681	11,584	8,064
1940	A	6,240	4,747	4,252	12,366	12,888	11,991	8,485	6,566	7,542	11,681	11,584	8,367
1951	A	9,824	11,195	12,007	12,903	12,076	8,130	6,549	7,429	7,795	11,681	11,584	9,933
1954	A	11,388	11,229	11,144	10,964	6,787	8,032	7,559	7,722	6,380	11,681	11,584	10,000
1957	A	11,388	11,229	10,818	11,632	7,022	7,739	6,599	6,256	8,316	11,665	11,567	7,811
1973	A	9,824	11,195	11,323	11,844	10,560	8,097	7,643	6,810	8,401	11,681	11,584	9,882
1978	A	2,639	4,360	9,873	11,355	9,097	6,175	7,710	8,504	8,872	4,822	7,869	11,128
1980	A	10,981	11,229	11,404	11,812	4,856	5,327	7,071	7,771	9,040	6,142	6,712	11,178
1993	A	4,187	4,764	11,111	12,887	9,386	7,706	8,737	8,993	11,650	7,739	8,407	8,519
	AVG	**7,844**	**8,205**	**9,540**	**10,871**	**8,318**	**7,096**	**6,953**	**6,884**	**7,788**	**8,731**	**9,242**	**8,641**
1923	B	11,388	11,229	11,730	9,922	4,711	7,168	6,266	6,566	7,980	11,681	11,584	6,347
1935	B	4,399	7,071	6,826	12,040	4,819	11,355	8,838	5,718	7,912	11,681	8,162	7,222
1936	B	10,182	6,582	6,712	11,812	12,924	11,991	8,485	6,615	8,316	11,681	11,584	6,212
1937	B	10,411	8,316	9,906	11,958	9,639	6,745	8,182	7,071	8,030	8,032	7,706	6,027
1945	B	6,435	11,145	11,388	10,948	9,278	7,511	6,448	5,376	7,542	11,681	11,584	7,559
1946	B	11,323	11,229	12,023	12,903	7,022	8,032	6,145	5,572	7,323	11,681	11,584	9,579
1948	B	6,843	6,650	6,028	10,720	6,083	7,755	6,953	7,885	9,360	11,681	11,584	9,966
1950	B	10,036	7,811	7,413	11,535	11,931	9,156	6,347	5,653	8,485	10,769	6,908	9,630
1959	B	11,388	11,229	10,459	5,099	6,047	6,289	3,973	3,975	7,542	11,681	11,584	8,418
1962	B	8,195	7,929	11,290	11,095	10,181	7,865	5,808	5,637	7,189	11,681	11,584	9,983
1966	B	11,339	11,212	11,893	10,264	6,588	8,032	5,808	5,002	6,616	11,681	11,584	9,966
1968	B	11,388	9,680	7,299	5,083	6,209	7,299	5,421	3,943	7,391	11,681	11,584	7,862
1972	B	11,388	11,229	11,355	11,535	10,704	7,788	4,865	4,171	7,155	11,665	11,567	7,845
1979	B	11,388	11,145	10,639	10,134	5,632	7,348	7,037	6,289	8,418	11,681	9,596	6,498
	AVG	**9,722**	**9,461**	**9,640**	**10,361**	**7,983**	**8,168**	**6,613**	**5,677**	**7,804**	**11,354**	**10,585**	**8,080**
1924	C	9,221	7,576	10,573	11,013	9,152	3,503	2,997	1,613	1,768	2,672	2,102	4,731
1929	C	10,459	9,747	10,459	11,160	8,412	5,002	3,165	3,372	3,401	2,330	2,330	4,714
1931	C	6,500	6,094	5,327	9,254	5,361	3,747	3,165	3,470	4,478	3,242	570	4,747
1933	C	7,315	5,909	5,213	10,117	7,236	4,692	4,327	2,786	1,869	1,287	652	4,815
1934	C	5,653	2,811	9,922	11,470	5,975	4,220	3,788	3,291	5,522	7,168	4,334	4,832
1976	C	11,388	11,229	11,404	11,600	6,480	6,582	3,232	3,438	7,744	10,573	7,168	4,882
1977	C	5,735	6,263	5,002	4,953	2,310	2,297	3,182	994	690	587	2,737	4,747
1988	C	7,217	5,067	11,290	11,421	7,058	3,910	2,980	3,307	6,044	4,692	1,662	4,798
1990	C	9,449	7,811	10,622	9,694	7,852	6,012	3,754	3,030	7,761	9,189	3,503	5,572
1991	C	5,295	5,084	5,116	3,552	686	11,518	4,444	3,210	3,569	3,877	3,975	4,680
1992	C	3,747	4,815	4,774	9,156	8,303	8,456	3,939	3,275	5,320	5,784	1,890	4,630
1994	C	11,388	11,246	11,355	11,535	6,534	6,500	3,384	3,193	7,879	11,698	11,518	5,791
	AVG	**7,781**	**6,971**	**8,422**	**9,577**	**6,280**	**5,537**	**3,530**	**2,915**	**4,670**	**5,258**	**3,537**	**4,912**
1925	D	3,959	4,714	9,270	6,875	11,101	8,081	6,717	5,116	4,242	9,938	7,217	5,152
1926	D	6,256	7,205	9,286	11,453	11,895	6,680	6,229	5,344	6,347	9,466	2,346	6,902
1930	D	3,845	4,242	10,720	11,470	7,004	7,299	4,074	3,812	7,290	11,665	9,270	4,798

Appendix E-18. (Continued).

EXPORTS (CFS) AT CVP & SWP STATE WATER RESOURCES CONTROL BOARD ALTERNATIVE 5 DWRSIM MODEL RUN 524													
Water Year	Water-Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
1932	D	5,002	3,081	11,616	12,219	10,361	3,943	5,606	5,132	8,047	10,883	6,338	5,135
1939	D	11,388	11,229	10,345	5,002	5,704	6,859	4,327	3,763	7,744	11,681	11,095	5,168
1944	D	10,981	11,128	10,650	10,834	5,578	7,168	4,428	4,040	7,710	11,681	11,584	6,532
1947	D	10,639	11,162	11,567	11,698	9,892	6,729	5,084	3,747	7,609	11,665	11,551	7,205
1949	D	10,362	10,707	11,323	11,307	8,556	11,486	5,253	5,034	7,121	11,665	8,113	6,364
1955	D	10,769	11,229	11,339	11,567	8,213	7,299	3,838	4,040	7,559	11,649	8,700	5,354
1960	D	10,769	7,609	6,566	10,769	11,679	6,843	4,192	3,633	7,391	11,665	5,442	5,354
1961	D	8,749	10,084	11,307	10,802	11,336	8,130	3,704	3,177	8,030	11,665	11,274	4,731
1964	D	11,388	11,229	11,404	11,714	8,087	6,973	3,687	4,057	7,374	11,681	11,584	9,933
1981	D	11,339	10,118	11,453	5,295	6,011	7,299	5,640	3,796	7,542	11,681	11,584	6,768
1985	D	11,355	11,229	11,388	11,600	6,913	7,869	4,276	4,545	6,902	11,681	11,584	9,747
1987	D	11,290	8,013	10,525	8,472	5,666	6,647	3,670	3,112	8,081	11,665	10,688	4,882
1989	D	3,780	5,960	5,849	8,879	2,888	11,307	5,842	4,220	6,919	11,681	5,556	8,519
	AVG	**8,867**	**8,684**	**10,301**	**9,997**	**8,180**	**7,538**	**4,785**	**4,161**	**7,244**	**11,376**	**8,995**	**6,409**
1927	W	9,286	11,178	11,404	11,649	10,018	7,771	8,283	8,618	8,704	11,681	9,873	8,653
1938	W	10,476	11,229	11,958	11,812	5,325	6,191	7,912	9,726	11,633	7,266	8,814	11,515
1941	W	10,411	10,640	11,763	12,545	12,978	8,961	9,949	10,459	11,263	5,784	7,820	11,515
1942	W	11,372	11,229	11,844	7,315	5,794	7,608	9,108	8,993	11,633	7,511	9,107	11,515
1943	W	11,372	11,229	11,698	8,244	6,173	6,044	9,327	7,983	8,098	7,380	7,331	9,175
1952	W	10,199	11,229	11,535	12,903	10,379	7,315	8,030	9,531	11,633	9,563	10,964	11,515
1953	W	11,372	11,229	8,244	5,067	6,227	7,445	5,842	7,983	10,741	11,681	11,584	10,640
1956	W	9,433	7,256	11,991	12,903	8,105	6,940	8,165	9,091	11,633	11,518	10,769	11,532
1958	W	11,339	11,212	11,339	11,632	7,365	7,690	9,680	10,932	11,633	8,716	11,584	11,532
1963	W	11,388	11,246	11,323	11,632	12,744	11,649	8,283	8,618	8,990	11,681	11,584	10,084
1965	W	7,331	10,421	11,779	12,887	12,942	7,771	8,721	8,081	8,653	10,215	8,716	9,865
1967	W	10,068	11,229	11,551	12,072	9,134	6,663	8,670	9,726	11,633	11,681	10,411	11,515
1969	W	10,525	10,556	11,388	12,659	4,747	5,474	7,694	9,303	11,633	7,836	9,172	11,515
1970	W	11,388	11,229	8,179	4,871	5,415	7,364	6,785	6,207	7,172	11,681	11,584	8,013
1971	W	9,547	11,212	11,470	11,746	7,419	8,309	6,751	7,983	10,000	11,681	11,584	11,515
1974	W	11,388	11,246	11,567	12,903	8,159	8,046	9,512	8,993	9,899	11,681	11,584	11,515
1975	W	11,388	11,229	11,437	10,297	6,462	8,309	8,956	8,993	11,633	11,681	11,584	11,532
1982	W	9,384	11,212	11,437	12,903	7,978	7,739	9,141	11,013	11,633	9,645	10,411	11,532
1983	W	11,388	11,229	12,023	5,718	4,350	4,822	7,155	7,836	10,640	11,518	11,584	11,515
1984	W	6,354	5,623	6,305	4,399	5,505	7,429	7,037	6,435	8,114	11,681	10,850	8,047
1986	W	7,152	6,919	11,372	11,698	12,906	10,427	7,710	8,423	8,384	5,800	7,559	10,118
	AVG	**10,122**	**10,466**	**11,029**	**10,374**	**8,101**	**7,618**	**8,224**	**8,806**	**10,255**	**9,899**	**10,213**	**10,684**

Appendix E-19. Average Historic Monthly Delta Outflow (cfs) by Water-year Type and by Time Periods. The Time Periods Represent Major Changes in Water Flow Management Within the Sacramento River system and the Sacramento-San Joaquin Bay-Delta Estuary, California. Data from Department of Water Resources DAYFLOW.

HISTORIC DELTA OUTFLOW (CFS) AVERAGE MONTHLY BY WATER-YEAR TYPE														
WATER-YEAR TYPE	PERIOD	WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
ABOVE NORMAL	PRE-1945	1940	5,854	5,963	10,687	73,107	104,857	140,077	125,376	46,570	21,209	2,377	1,023	5,237
	1945-1950	NO ABOVE NORMAL WATER YEARS												
	1951-1967	1951	10,600	72,398	129,259	77,517	88,562	53,514	29,012	34,396	10,440	4,495	5,352	7,588
		1954	10,922	15,453	15,892	32,308	71,866	59,963	58,670	30,233	6,865	1,314	3,757	7,743
		1957	12,701	16,191	13,925	15,719	24,490	63,622	20,480	32,732	15,581	2,427	3,701	9,073
		AVG	11,408	34,680	53,025	41,848	61,639	59,033	36,054	32,454	10,962	2,745	4,270	8,134
	1968-1977	1973	11,919	25,943	27,133	101,685	102,165	76,907	22,191	11,699	7,211	4,599	5,963	11,153
		1978	2,075	4,004	8,488	66,171	56,159	85,544	61,276	40,874	9,086	3,974	5,927	11,793
		AVG	6,997	14,974	17,810	83,928	79,162	81,225	41,734	26,286	8,148	4,287	5,945	11,473
	1978-1992	1978	2,075	4,004	8,488	66,171	56,159	85,544	61,276	40,874	9,086	3,974	5,927	11,793
		1980	7,821	12,176	19,029	118,212	121,653	99,171	28,689	20,912	14,870	11,191	4,253	9,902
		AVG	4,948	8,090	13,759	92,191	88,906	92,357	44,983	30,893	11,978	7,583	5,090	10,847
	1993-1994	1993	4,374	4,127	11,603	57,888	55,022	63,969	44,319	25,292	27,181	9,555	9,515	5,390
	1995-1997	1996	11,404	8,384	27,709	32,145	126,915	89,148	42,050	46,098	15,373	9,249	9,697	7,359
		1997	4,625	8,625	82,007	259,536	117,070	33,157	13,566	12,038	8,143	9,352	8,623	3,958
		AVG	8,015	8,505	54,858	145,841	121,993	61,153	27,808	29,068	11,758	9,301	9,160	5,659

Appendix E-19. (Continued).

HISTORIC DELTA OUTFLOW (CFS) AVERAGE MONTHLY BY WATER-YEAR TYPE														
WATER-YEAR TYPE	PERIOD	WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
BELOW NORMAL	PRE-1945	1935	4,158	14,477	12,947	44,792	30,249	49,290	108,101	65,596	35,435	4,340	1,214	3,824
		1936	8,385	8,471	11,307	60,976	112,563	64,949	82,358	47,443	29,179	4,718	1,191	4,350
		1937	6,152	6,770	10,972	15,760	63,891	78,348	70,887	61,389	30,155	4,202	227	3,233
		AVG	6,232	9,906	11,742	40,509	68,901	64,196	80,442	58,143	31,590	4,420	877	3,802
	1945-1950	1945	5,680	19,323	24,491	20,271	81,916	41,883	38,834	41,086	24,872	7,256	5,291	7,908
		1946	12,484	20,847	75,723	79,819	32,343	33,841	39,876	40,909	15,340	4,687	4,788	7,682
		1948	10,434	12,225	9,419	23,120	12,613	21,948	58,947	58,799	41,224	6,636	5,936	8,878
		1950	6,738	9,468	8,975	31,526	52,622	33,316	43,339	34,497	20,179	3,978	3,587	7,607
		AVG	8,834	15,466	29,652	38,684	44,874	32,747	44,749	43,823	25,354	5,639	4,898	8,069
	1951-1967	1959	13,051	14,716	14,437	32,890	58,739	27,692	11,607	7,303	1,322	2,561	5,194	9,958
		1962	4,260	8,251	16,140	11,132	74,766	47,503	27,385	18,173	10,317	2,795	5,028	8,515
		1966	15,091	27,350	30,136	43,464	36,316	24,328	18,946	9,835	2,460	3,155	4,846	6,905
		AVG	10,801	16,773	20,238	29,162	56,607	33,174	19,313	11,770	4,700	2,837	5,022	8,459
	1968-1977	1968	16,749	16,202	20,498	24,257	52,061	40,314	9,932	6,737	3,666	3,684	5,264	6,004
		1972	13,957	13,743	23,967	21,339	21,968	18,078	7,542	5,140	2,891	6,211	6,470	10,476
		AVG	15,353	14,972	22,233	22,798	37,014	29,196	8,737	5,938	3,278	4,947	5,867	8,240
	1978-1992	1979	9,633	10,928	8,779	30,522	46,341	38,086	14,485	13,435	5,326	5,364	3,475	5,058
	1993-1994	NO BELOW NORMAL WATER YEARS												
	1995-1997	NO BELOW NORMAL WATER YEARS												

Appendix E-19. (Continued).

HISTORIC DELTA OUTFLOW (CFS) AVERAGE MONTHLY BY WATER-YEAR TYPE														
WATER-YEAR TYPE	PERIOD	WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
CRITICAL	PRE-1945	1931	7,995	9,528	8,330	17,440	16,880	17,181	7,494	4,362	(218)	(2,971)	(1,970)	1,138
		1933	4,331	5,378	9,790	16,345	16,929	26,041	23,402	21,097	18,780	635	(599)	2,380
		1934	5,208	7,996	17,066	34,054	30,274	27,223	16,861	6,618	1,447	(1,634)	(1,251)	1,960
		AVG	5,844	7,634	11,728	22,613	21,361	23,482	15,919	10,692	6,670	(1,323)	(1,273)	1,826
	1945-1950	NO CRITICAL WATER YEARS												
	1951-1967	NO CRITICAL WATER YEARS												
	1968-1977	1976	16,900	17,921	19,953	9,346	7,495	7,858	8,833	4,066	3,915	4,343	4,509	3,670
		1977	3,623	3,644	4,213	4,365	4,924	3,070	3,083	3,999	2,521	3,212	2,514	2,791
		AVG	10,262	10,782	12,083	6,855	6,210	5,464	5,958	4,032	3,218	3,777	3,512	3,231
	1978-1992	1988	3,789	4,291	9,454	19,591	3,045	4,542	11,496	4,745	3,170	3,861	2,420	2,332
		1990	4,902	5,478	4,400	9,888	6,793	3,880	6,000	7,798	4,942	4,053	4,550	2,530
		1991	3,444	4,496	6,384	3,974	7,377	24,582	3,744	3,952	4,111	3,420	2,647	3,827
		1992	3,938	3,910	7,623	6,414	28,766	13,283	6,317	3,380	3,570	3,098	2,925	3,433
		AVG	4,018	4,544	6,965	9,966	11,495	11,572	6,890	4,968	3,948	3,608	3,135	3,030
	1993-1994	1994	5,145	7,381	12,361	10,788	20,557	10,612	8,232	8,011	3,919	4,541	3,417	5,570
	1995-1997	NO CRITICAL WATER YEARS												

Appendix E-19. (Continued).

HISTORIC DELTA OUTFLOW (CFS) AVERAGE MONTHLY BY WATER-YEAR TYPE														
WATER-YEAR TYPE	PERIOD	WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
DRY	PRE-1945	1930	5,459	5,768	37,193	35,034	34,421	57,082	35,113	22,908	9,881	814	780	4,800
		1932	3,567	7,130	25,902	36,872	42,162	35,161	33,391	47,299	33,898	7,139	507	2,311
		1939	11,074	14,508	18,230	18,144	21,335	27,733	19,998	8,740	1,009	(1,506)	(966)	3,634
		1944	8,630	10,280	12,134	16,540	34,451	35,902	20,740	26,462	10,279	831	1,055	4,480
		AVG	7,182	9,417	23,365	26,648	33,092	38,969	27,311	26,353	13,717	1,820	344	3,806
	1945-1950	1947	8,950	16,655	21,224	14,370	27,091	33,829	23,485	10,435	6,005	1,288	2,351	5,609
		1949	10,999	11,354	14,829	13,971	17,184	61,567	33,573	26,404	9,038	2,578	3,842	6,942
		AVG	9,974	14,004	18,026	14,170	22,138	47,698	28,529	18,419	7,521	1,933	3,096	6,275
	1951-1967	1955	8,908	17,246	27,833	30,398	18,257	13,584	13,343	19,156	6,999	2,280	3,118	5,963
		1960	5,683	6,016	6,938	14,231	49,316	33,273	16,878	12,407	3,847	2,244	2,731	5,500
		1961	5,013	13,543	19,090	15,580	41,997	28,425	13,397	8,580	3,541	1,672	4,007	5,649
		1964	14,978	27,945	22,825	29,970	20,915	13,073	9,187	9,784	5,302	3,185	4,704	9,442
		AVG	8,645	16,188	19,171	22,545	32,621	22,089	13,201	12,482	4,923	2,345	3,640	6,638
	1968-1977	NO DRY WATER YEARS												
	1978-1992	1981	7,368	6,670	12,488	18,326	21,174	26,467	11,653	9,143	4,596	5,296	3,161	4,890
		1985	11,916	25,953	31,067	15,120	15,590	10,432	6,913	7,378	5,215	4,934	2,325	3,211
		1987	10,628	7,732	8,987	10,819	16,859	22,916	6,291	4,952	3,496	3,829	2,851	1,790
		1989	3,177	6,624	7,231	3,604	6,379	38,929	11,780	7,484	6,281	6,284	4,568	6,505
		AVG	8,272	11,745	14,943	11,967	15,001	24,686	9,159	7,239	4,892	5,086	3,226	4,049
	1993-1994	NO DRY WATER YEARS												
	1995-1997	NO DRY WATER YEARS												

Appendix E-19. (Continued).

HISTORIC DELTA OUTFLOW (CFS)
AVERAGE MONTHLY BY WATER-YEAR TYPE

WATER-YEAR TYPE	PERIOD	WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
WET	PRE-1945	1938	8,084	27,494	90,348	46,568	175,980	175,632	120,413	113,874	81,028	22,801	5,900	6,825
		1941	7,802	12,115	65,921	120,056	139,992	126,238	114,990	82,999	46,178	14,909	3,742	4,821
		1942	6,848	12,035	64,769	93,793	156,866	51,663	91,077	74,701	57,058	14,317	2,840	5,797
		1943	9,346	20,070	32,670	92,766	82,870	114,620	76,502	46,805	26,446	3,947	1,507	4,467
		AVG	8,520	17,929	63,427	88,301	138,927	117,038	100,745	79,595	52,678	13,994	3,497	5,507
	1945-1950 NO WET WATER YEARS													
	1951-1967	1952	10,442	16,117	48,869	105,640	104,196	84,888	104,461	105,610	64,397	17,248	7,529	10,420
		1953	9,865	13,050	42,680	118,348	38,155	26,987	31,143	37,831	33,076	6,109	3,889	10,773
		1956	5,801	10,313	127,768	188,311	98,145	63,542	40,217	59,687	35,498	8,795	7,030	12,056
		1958	19,507	19,732	26,826	44,482	184,221	111,577	153,782	78,859	50,529	12,009	9,224	14,393
		1963	42,900	16,351	35,013	20,995	103,173	29,180	102,776	53,124	19,180	5,639	5,038	13,480
		1965	8,118	17,243	108,447	135,616	56,241	27,860	56,912	32,370	18,190	5,865	8,467	12,917
		1967	6,610	21,505	60,456	62,522	84,142	56,325	77,685	74,550	61,265	23,864	9,827	16,556
		AVG	14,749	16,330	64,294	96,559	95,468	57,194	80,997	63,144	40,019	11,361	7,258	12,942
	1968-1977	1969	5,453	11,120	25,882	123,140	159,046	93,508	69,375	64,564	46,596	13,143	12,456	20,188
		1970	19,484	19,964	46,190	193,121	111,326	55,986	11,027	10,761	8,214	5,256	7,947	14,587
		1971	13,423	26,117	85,369	64,152	34,211	32,069	36,983	26,406	21,218	11,654	12,988	19,659
		1974	14,071	59,945	76,406	136,699	59,178	77,575	109,547	25,544	16,943	9,365	12,783	20,981
		1975	18,529	23,991	28,017	17,489	57,330	66,834	34,519	26,796	22,508	11,129	9,523	13,419
		AVG	14,192	28,227	52,333	107,320	84,218	65,194	52,290	31,214	22,696	10,109	11,140	17,767
	1978-1992	1982	5,218	35,971	86,579	97,706	92,770	80,089	142,203	57,876	28,515	16,849	13,438	25,926
		1983	22,986	39,152	88,937	89,755	175,757	266,688	118,109	98,707	71,036	43,860	24,587	31,501
		1984	32,293	74,138	155,458	100,906	41,515	34,929	14,732	11,204	8,038	10,252	8,272	13,650
		1986	3,378	6,891	9,431	15,209	205,414	169,448	46,572	15,911	9,322	7,384	5,135	10,778
		AVG	15,969	39,038	85,101	75,894	128,864	137,788	80,404	45,924	29,228	19,586	12,853	20,464
	1993-1994 NO WET YEARS													
	1995-1997	1995	11,098	5,357	9,633	107,488	72,838	200,645	90,871	98,112	46,819	26,865	10,952	19,694

Appendix E-20. Simulated Average Monthly Delta Outflow (cfs) by Water-year Type at the CVP and SWP Delta Water Export Facilities. Projected Existing Operations to 1995 Bay-Delta Plan. W-Wet, B-Below Normal, D-Dry, C-Critical, A-Above Normal.

AVERAGE MONTHLY DELTA OUTFLOW (CFS) - DWRSIM MODEL RUN 420 - 1995 BAY-DELTA PLAN													
WATER YEAR	WATER YEAR TYPE	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1922	A	4001	4976	8444	11149	39225	29791	19274	44198	26900	8002	5302	3814
1928	A	5470	20454	7194	16809	23483	99281	23762	13494	7579	9086	6197	3882
1940	A	4751	5228	5654	20320	50441	101381	63761	14460	7579	9468	6527	3732
1951	A	5836	44349	61991	61340	62943	27433	13145	15230	7579	9455	6243	4150
1954	A	10735	15464	6382	25856	59048	44589	39037	17583	7579	9501	6413	4201
1957	A	15084	6691	5444	7215	33138	41729	15457	13161	8673	9491	7205	3987
1973	A	5737	15513	19017	73956	89842	57993	15653	14633	10310	8002	5853	4170
1978	A	2992	4044	6849	62011	60480	68770	40511	17638	8766	8002	5302	5227
1980	A	4001	10258	12128	108178	131764	69112	16217	12001	7579	8002	5302	5436
	AVG	6,512	14,109	17,011	42,982	61,152	60,009	27,424	18,044	10,283	8,779	6,038	4,267
1923	B	11579	12261	32804	30707	22061	10287	21430	11771	8047	7738	6011	3772
1935	B	2992	5634	5540	21010	11400	20245	36593	28043	9270	7680	5504	3065
1936	B	4285	5224	5381	23349	65832	25425	18029	11167	8262	7594	5207	3182
1937	B	4001	5010	6831	6955	37080	43607	19516	11475	11258	6505	4668	3074
1945	B	5326	6044	8423	6290	46311	25397	11053	9818	9726	6505	4781	3352
1946	B	5124	10887	70086	45069	21940	16236	10967	11259	8889	7258	5453	3615
1948	B	5169	5559	5783	6410	11400	10952	19886	25892	11569	7833	6701	5827
1950	B	4398	5175	5240	12745	27308	15577	15810	11368	8843	7828	6728	4230
1959	B	15199	10762	6131	34129	55124	16221	8416	7579	6840	7620	5385	4359
1962	B	4307	5103	6909	6001	48632	18376	9571	11401	6840	7838	6061	4228
1966	B	6493	18896	8403	22918	21825	21415	11151	11124	6840	7788	6183	4179
1968	B	16772	11631	11135	28915	67390	33947	10325	7579	6840	7502	5243	4175
1972	B	8945	6890	14100	10327	18542	24722	9941	7579	6840	7827	6471	3765
1979	B	9354	6862	4993	21520	44378	29636	15027	12903	10882	6505	4668	3405
	AVG	7,425	8,281	13,697	19,739	35,659	22,289	15,551	12,783	8,639	7,430	5,647	3,873
1924	C	4168	5403	6989	6379	9614	10430	5837	5221	4000	5458	3415	3008
1929	C	4001	5599	6710	5712	10111	10012	7309	6432	7107	6013	3415	3008
1931	C	4001	4504	4879	6029	7800	7068	7819	4505	4000	4001	3415	3008
1933	C	4001	4504	4761	7217	8489	8555	10399	6036	6830	4001	3415	3008
1934	C	2992	3645	6440	9436	12775	11401	10399	5577	6897	4001	3415	3008
1976	C	14959	11497	6355	5893	10669	9758	7522	6367	6897	4370	3415	3008
1977	C	2992	4679	7111	5797	7852	6788	6897	4505	4000	4001	3415	3008
1988	C	4001	4844	6904	17933	11400	7800	7300	6496	6897	5546	3431	3008
1990	C	4001	4504	6391	7867	11400	7309	10251	5911	6897	5610	3551	3008
1991	C	2992	4244	5388	5025	8027	21264	11258	5364	7037	5724	3415	3008
1992	C	2992	4162	5512	5375	23697	14087	10377	5700	6765	5860	3415	3008
	AVG	4,645	5,235	6,131	7,515	11,076	10,407	8,670	5,647	6,121	4,962	3,429	3,008

Appendix E-20. (Continued).

AVERAGE MONTHLY DELTA OUTFLOW (CFS) - DWRSIM MODEL RUN 420 - 1995 BAY-DELTA PLAN													
WATER YEAR	WATER YEAR TYPE	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1925	D	5057	5069	5792	6001	44581	14229	20771	11427	8322	6885	5189	3873
1926	D	5299	4980	5333	7883	29682	10656	18833	11210	6117	6950	5170	3868
1930	D	4910	5271	6486	14077	12970	21213	10544	8268	6117	5828	4066	3008
1932	D	3477	4221	9032	9469	15639	11401	11259	9426	10541	4993	4066	3297
1939	D	15746	8743	9099	10475	11919	9698	10399	7579	6269	6946	4811	3869
1944	D	5422	8383	5192	6396	27563	17051	9233	7579	8378	6782	4755	3488
1947	D	4635	5356	6639	6370	12826	15083	11259	7579	6131	7157	5759	3899
1949	D	5562	5728	5811	5472	8645	43592	10575	11124	7369	6060	4721	4104
1955	D	4001	7941	16633	14729	11400	7600	7986	8232	8069	7165	6126	5495
1960	D	4780	5482	7174	5714	20540	14127	11400	7579	6291	7187	6026	4070
1961	D	4471	5683	7026	6073	22927	13284	10210	7579	6182	7226	6032	3794
1964	D	8069	24690	6154	19426	11400	8490	7579	7579	6703	7163	6062	4379
1981	D	9134	6253	9480	22568	24088	29668	12223	7579	6117	6952	4792	3467
1985	D	9792	31119	20638	10749	14610	14122	8185	10012	6117	7170	5817	3822
1987	D	4746	5635	4598	5775	12344	25028	10398	7579	6117	7168	5397	3536
1989	D	2992	4936	5310	5795	8175	31153	18368	10267	6117	7276	6031	3821
	AVG	6,131	8,593	8,150	9,811	18,082	17,900	11,826	8,787	6,935	6,807	5,301	3,851
1927	W	5108	12345	6855	23983	115721	39033	45857	19941	8052	8002	5741	3174
1936	W	4001	25061	69680	26438	141095	162964	65947	60575	32476	8002	5741	8322
1941	W	4216	5799	40548	97207	115701	92835	79543	39001	11632	8002	5741	5518
1942	W	13381	12016	65389	81907	143045	24849	49525	34288	16856	8002	5741	5485
1943	W	14819	15515	25796	80987	59424	80261	26501	16226	7579	8002	5741	3152
1952	W	5261	7576	43974	87413	74261	60732	63867	60716	33104	8002	5741	10855
1953	W	15595	11339	42964	102273	25722	17525	16340	21029	15704	8002	5741	5690
1956	W	4001	5654	74937	154181	87517	31286	17586	38886	14515	8002	5741	6320
1958	W	9328	9114	17108	30644	156494	122731	102118	39711	30334	8002	6525	9897
1963	W	26326	10620	18762	8571	69245	25569	89965	26201	9016	8002	5741	5237
1965	W	4001	6655	73614	112333	26976	15363	45171	20516	7579	8002	6059	3695
1967	W	4622	6630	34841	48144	54145	56637	48506	45277	37462	8833	5741	9901
1969	W	5281	5879	13843	117615	130059	56981	47432	59410	26877	9802	5741	13658
1970	W	17934	14092	55147	204924	91231	35249	11579	7958	7579	8002	5741	3879
1971	W	5178	15900	65991	45799	22695	43743	16812	26488	12689	8560	5771	5961
1974	W	5854	61296	65124	125762	42495	105870	70319	20652	12454	8002	6375	10509
1975	W	12707	9011	9062	10316	67661	85521	20860	28861	15245	8002	5741	6958
1982	W	4935	28283	88016	77838	94724	81963	142610	48204	16999	8002	6171	16124
1983	W	31392	46767	89976	107962	189091	262790	110346	83414	74552	8002	5801	26028
1984	W	37420	83001	159165	85443	49714	36150	13095	9791	8231	32035	9718	5760
1986	W	4817	5501	7088	11204	218610	150695	29906	10967	7579	8002	5741	4042
	AVG	11,342	18,955	50,851	78,140	94,077	75,655	53,042	34,196	19,358	9,298	6,038	8,103

Appendix E-21. Simulated Average Monthly Delta Outflow (cfs) at the CVP and SWP by Water-year Type for Future Operations to Interim South Delta Program With Future Water Demands. W-Wet, B-Below Normal, D-Dry, C-Critical, A-Above Normal.

DELTA OUTFLOW (CFS)DWRSIM MODEL RUN 414 - INTERIM SOUTH DELTA PROGRAM AT FUTURE DEMAND													
YEAR	WATER-YEAR TYPE	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1922	A	4,008	4,983	7,299	9,254	43,146	29,700	19,630	42,978	23,771	8,016	5,865	3,401
1928	A	4,236	12,811	6,488	12,936	20,418	98,583	24,057	13,853	7,593	8,016	8,162	3,013
1940	A	4,008	5,202	6,224	18,948	41,522	97,312	62,879	14,728	7,593	9,123	6,142	4,832
1951	A	4,888	39,125	89,736	65,282	65,657	26,067	13,350	15,950	7,593	10,199	6,891	5,522
1954	A	5,425	8,603	6,256	19,241	58,550	44,673	38,114	17,840	7,593	9,238	7,999	3,906
1957	A	8,113	6,498	5,213	7,348	34,199	41,251	15,976	13,294	8,670	10,297	6,924	5,556
1973	A	4,448	11,532	14,793	71,163	93,849	59,726	15,892	14,370	10,370	9,710	6,891	3,889
1978	A	2,998	4,158	6,810	58,260	62,121	62,089	38,923	16,650	9,276	8,016	6,224	3,737
1980	A	4,008	6,599	8,716	94,314	131,584	68,003	15,825	12,463	7,593	9,091	6,207	3,653
	AVG	4,681	11,057	16,835	39,638	61,227	58,600	27,183	17,992	10,006	9,078	6,812	4,168
1923	B	5,735	9,394	31,427	30,384	22,709	9,677	21,616	11,600	8,114	7,364	5,784	5,084
1935	B	2,998	5,724	5,556	17,709	11,418	20,104	34,596	28,087	9,360	7,071	5,556	4,091
1936	B	4,171	5,522	5,670	21,522	61,905	24,422	18,535	11,209	8,256	8,179	5,735	4,714
1937	B	4,008	5,354	7,299	7,266	34,722	43,760	19,764	11,404	11,279	6,517	5,197	3,098
1945	B	4,545	6,212	6,908	6,224	42,226	21,082	12,054	9,922	9,714	7,152	4,676	3,098
1946	B	4,008	7,205	60,085	45,976	22,619	15,445	11,162	11,274	8,906	6,794	5,930	3,098
1948	B	5,279	5,488	5,833	6,452	11,418	10,704	19,343	24,519	11,077	9,971	6,582	5,387
1950	B	4,008	5,202	5,262	10,215	25,703	15,168	16,077	11,421	8,855	7,217	6,142	5,067
1959	B	9,906	6,616	5,702	32,437	54,672	16,960	8,434	7,592	6,852	7,918	6,631	5,118
1962	B	4,008	5,202	6,973	6,012	45,833	18,035	10,774	11,421	6,852	7,885	6,663	3,636
1966	B	5,051	15,741	7,201	22,418	23,268	18,328	11,566	11,144	6,852	8,456	7,022	4,731
1968	B	11,486	10,774	9,694	27,696	66,288	32,926	10,589	7,592	6,852	8,113	6,598	5,101
1972	B	5,523	6,465	7,690	8,374	19,697	25,073	10,084	7,592	6,852	8,553	6,484	5,219
1979	B	5,556	6,145	5,947	15,086	39,610	29,456	15,859	12,740	10,943	8,211	6,500	3,737
	AVG	5,448	7,217	12,232	18,412	34,435	21,510	15,747	12,680	8,627	7,814	6,107	4,370
1924	C	4,008	5,404	7,165	5,767	9,975	10,443	5,842	5,279	4,007	4,008	3,421	3,013
1929	C	4,008	5,842	6,598	5,702	10,245	10,036	7,323	6,452	7,121	5,881	3,421	3,013
1931	C	4,008	4,512	6,663	6,175	7,937	6,957	7,828	4,513	4,007	4,008	3,421	3,013
1933	C	4,008	4,512	4,692	7,217	7,792	8,179	10,421	6,093	6,835	4,855	3,421	3,013
1934	C	2,998	3,869	6,517	6,891	11,670	11,421	10,421	5,621	6,902	4,040	3,421	3,013
1976	C	9,091	6,768	8,993	6,435	12,013	8,781	7,795	6,386	6,902	6,663	3,421	3,013
1977	C	2,998	4,714	7,136	4,513	7,955	6,973	6,902	4,513	4,007	4,008	3,421	3,013
1988	C	4,008-	5,017	6,957	15,054	11,418	7,967	7,306	6,500	6,902	6,224	3,421	3,013
1990	C	4,008	4,512	6,908	7,250	11,418	7,006	10,269	5,947	6,902	6,533	3,421	3,013
1991	C	2,998	4,444	5,718	5,230	8,135	21,701	11,279	5,360	7,054	4,692	3,421	3,232
1992	C	2,998	4,040	4,448	5,327	22,330	13,962	10,522	5,718	6,785	4,757	3,421	3,013
	AVG	4,103	4,878	6,529	6,869	10,990	10,311	8,719	5,671	6,129	5,061	3,421	3,033

Appendix E-21. (Continued).

DELTA OUTFLOW (CFS)DWRSIM MODEL RUN 414 - INTERIM SOUTH DELTA PROGRAM AT FUTURE DEMAND													
YEAR	WATER-YEAR TYPE	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1925	D	4,627	5,000	5,767	6,012	40,639	13,783	21,044	11,518	8,316	6,240	4,448	3,586
1926	D	4,008	4,966	5,425	6,957	26,100	11,307	19,680	11,079	6,128	7,071	5,637	5,017
1930	D	4,659	4,949	6,761	11,746	13,113	20,707	10,707	8,276	6,128	5,051	4,073	3,013
1932	D	3,193	4,226	8,341	7,576	14,953	11,421	11,279	9,466	10,556	5,002	4,073	3,333
1939	D	11,893	6,717	7,494	9,775	10,642	9,661	10,421	7,592	6,296	7,234	6,012	4,360
1944	D	4,138	6,414	7,266	6,810	20,527	15,510	9,781	7,592	8,401	6,859	5,995	3,638
1947	D	4,008	5,387	6,663	6,484	13,005	14,891	11,279	7,592	6,145	6,973	6,061	3,636
1949	D	4,888	5,657	6,175	5,588	8,620	41,349	10,808	11,144	7,357	6,370	4,073	3,687
1955	D	4,008	6,650	13,930	11,404	11,418	7,299	8,434	8,358	8,030	7,168	6,452	4,074
1960	D	4,073	5,522	6,240	5,930	18,633	13,327	11,414	7,592	6,330	7,543	5,572	4,983
1961	D	4,008	5,976	7,038	6,338	16,378	13,522	10,539	7,592	6,195	6,712	6,109	3,013
1964	D	6,370	18,367	6,224	15,673	11,418	8,618	7,593	7,592	6,734	7,348	6,012	4,478
1981	D	5,979	5,926	6,533	11,241	21,194	26,572	11,330	7,592	6,128	7,299	6,012	4,916
1985	D	6,191	24,848	21,261	9,580	11,724	10,997	9,024	10,036	6,128	7,543	5,539	5,286
1987	D	4,040	4,562	6,794	6,484	12,175	20,169	11,128	7,592	6,128	6,973	4,073	3,013
1989	D	2,998	4,933	5,230	5,849	8,189	28,022	18,586	10,362	6,128	6,957	5,572	3,906
	AVG	4,943	7,506	7,946	8,340	16,183	16,697	12,065	8,811	6,945	6,771	5,357	4,009
1927	W	4,008	10,303	6,517	19,632	123,846	39,492	45,370	19,827	8,098	9,335	6,940	3,249
1938	W	4,008	18,283	54,659	23,786	136,706	163,669	65,034	59,368	30,774	8,016	6,354	5,488
1941	W	4,008	5,808	35,549	96,514	114,448	96,188	79,091	36,901	11,734	8,016	6,533	4,697
1942	W	6,240	7,239	59,058	81,362	142,027	22,825	50,387	32,421	16,263	8,016	6,745	4,646
1943	W	6,696	9,276	25,041	79,619	58,315	79,277	26,481	16,325	7,593	9,189	6,973	4,125
1952	W	4,008	6,582	38,970	82,421	75,000	62,040	63,232	59,498	30,976	8,016	5,751	6,549
1953	W	10,280	8,434	43,532	100,472	23,864	16,048	17,374	21,147	15,387	9,009	7,299	5,269
1956	W	4,008	5,774	70,218	154,317	90,873	33,317	18,215	36,901	13,939	8,016	6,859	5,842
1958	W	6,191	6,717	14,109	32,551	152,381	124,829	105,269	38,807	28,838	8,016	6,598	6,296
1963	W	22,141	7,003	20,528	12,757	72,926	27,713	89,781	25,187	9,108	8,879	6,843	4,327
1965	W	4,008	6,481	68,671	112,089	29,726	15,119	45,943	20,430	7,593	9,075	6,761	3,653
1967	W	4,008	6,684	30,922	41,577	53,589	56,777	50,219	44,135	35,354	8,016	5,751	6,481
1969	W	4,220	5,673	10,622	108,553	131,999	56,989	46,633	57,380	21,684	8,016	5,751	7,374
1970	W	12,822	11,128	55,474	204,692	89,899	33,887	11,801	7,950	7,593	9,938	7,657	5,185
1971	W	4,073	11,481	56,582	42,131	24,080	43,695	17,189	25,758	12,189	9,335	7,071	5,926
1974	W	4,936	51,768	62,968	127,941	43,146	106,191	69,747	20,316	12,003	8,781	6,745	6,330
1975	W	6,224	6,616	11,013	10,150	69,571	86,136	21,229	27,077	14,714	8,016	6,810	6,128
1982	W	4,024	20,084	81,248	77,550	98,539	83,089	143,418	47,393	16,515	8,016	5,751	11,785
1983	W	27,745	47,407	89,883	107,511	189,105	262,968	110,606	81,378	71,515	29,049	7,331	23,215
1984	W	35,305	82,778	157,755	83,643	47,998	34,865	13,401	9,563	8,316	10,248	6,566	5,488
1986	W	4,008	5,168	6,875	8,912	212,825	153,291	30,926	10,932	7,593	9,270	6,142	3,939
	AVG	8,712	16,223	47,628	76,580	94,327	76,114	53,397	33,271	18,466	9,632	6,630	6,476

Appendix E-22. Simulated Average Monthly Delta Outflow (cfs) by Water-year Type for Future Operations to State Water Resources Control Board Water Rights Alternative 5. W-Wet, B-Below Normal, D-Dry, C-Critical, A-Above Normal.

DELTA OUTFLOW (CFS)
STATE WATER RESOURCES CONTROL BOARD ALTERNATIVE 5 - DWRSIM MODEL RUN 524

Water Year	Water-Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
1922	A	4,008	4,512	9,840	11,421	39,224	32,225	21,229	45,455	29,680	8,016	4,008	3,114
1928	A	5,393	10,488	8,813	18,381	26,733	99,365	26,818	16,243	6,431	8,016	5,018	3,013
1940	A	4,089	4,579	4,562	21,180	54,513	102,574	67,155	17,139	9,192	8,016	4,774	3,013
1951	A	4,008	49,781	85,503	70,121	66,986	31,558	13,771	16,292	9,697	8,016	4,659	3,013
1954	A	6,957	10,926	4,822	25,155	60,289	47,524	38,384	20,886	7,172	8,016	4,855	3,013
1957	A	13,001	5,421	4,594	9,514	31,065	44,705	18,704	15,200	10,960	8,016	4,545	3,013
1973	A	4,138	15,084	17,693	75,888	95,072	63,376	17,997	13,066	10,791	8,016	4,594	3,013
1978	A	5,425	3,519	4,888	57,641	60,199	72,206	49,209	22,255	11,650	8,016	4,431	3,687
1980	A	4,594	6,566	13,099	105,409	147,383	63,555	19,714	13,816	11,987	8,016	4,464	3,636
1993	A	5,409	3,502	6,109	54,643	53,538	55,849	37,222	24,568	20,286	8,016	4,008	3,013
	AVG	5,184	10,398	15,430	40,848	57,727	55,721	28,200	18,629	11,622	7,287	4,123	2,867
1923	B	6,761	8,838	34,392	31,525	23,375	11,975	23,350	12,105	10,084	6,517	4,008	3,013
1935	B	5,360	3,502	3,503	21,799	11,426	21,554	41,347	27,908	10,370	6,517	4,008	3,013
1936	B	4,008	4,512	4,513	26,132	84,856	28,315	20,236	12,594	11,010	6,517	4,008	3,013
1937	B	4,008	4,512	4,513	8,341	45,487	49,234	24,141	16,569	10,152	6,517	4,008	3,013
1945	B	4,024	5,067	7,217	6,012	48,502	31,476	11,582	10,264	9,209	6,517	4,008	3,013
1946	B	4,871	8,956	68,019	47,361	23,809	21,538	11,380	11,225	8,788	6,517	4,008	3,013
1948	B	4,008	4,512	4,513	5,621	11,426	13,962	20,993	22,255	12,929	6,517	4,008	3,013
1950	B	4,008	4,512	4,513	13,148	27,076	18,259	17,071	11,584	10,960	6,517	4,008	3,013
1959	B	14,239	6,549	5,670	34,197	55,144	19,876	8,535	6,729	9,192	6,517	4,008	3,030
1962	B	4,008	4,512	6,517	6,012	50,794	25,448	13,266	11,290	8,519	6,517	4,008	3,013
1966	B	4,659	18,973	11,160	27,729	28,195	25,024	14,074	10,704	7,475	6,517	4,024	3,013
1968	B	13,539	8,030	11,160	30,694	62,870	36,298	13,300	6,826	8,906	6,517	4,008	3,013
1972	B	7,625	5,202	11,355	11,160	17,653	27,142	10,455	7,657	8,603	6,517	4,008	3,013
1979	B	7,348	4,949	4,513	25,692	52,076	36,966	16,330	10,916	10,808	6,517	4,008	3,013
	AVG	6,319	6,616	12,968	21,102	38,764	26,076	17,576	12,759	9,786	6,517	4,009	3,015
1924	C	4,008	4,512	4,513	5,914	11,083	10,117	5,875	6,908	6,902	4,008	2,998	3,047
1929	C	4,008	4,512	5,116	6,175	11,986	10,916	6,869	6,484	6,044	4,008	2,998	3,030
1931	C	4,008	4,512	4,513	5,539	7,888	6,224	6,835	7,006	6,902	4,008	4,611	3,030
1933	C	4,073	4,512	4,513	6,468	8,231	7,950	10,101	5,784	6,987	4,008	4,611	3,030
1934	C	3,030	5,909	4,643	8,130	11,498	11,421	10,034	5,686	6,902	4,008	2,998	3,047
1976	C	14,581	9,428	6,729	7,087	15,921	12,968	7,172	6,191	9,764	4,008	2,998	3,064
1977	C	4,562	3,586	4,171	4,513	11,029	6,077	7,020	6,908	6,902	4,008	2,998	3,030
1988	C	4,008	4,512	6,761	18,638	12,437	7,885	6,768	6,647	6,902	4,008	3,421	3,030
1990	C	4,008	4,512	4,513	13,978	11,715	9,743	9,848	5,784	9,966	4,008	2,998	3,013
1991	C	4,627	3,519	4,236	4,513	10,830	23,509	12,189	5,767	5,960	4,008	2,998	3,030
1992	C	5,637	3,502	3,503	4,888	31,606	15,363	10,370	5,767	6,717	4,008	2,998	3,030
1994	C	5,002	13,519	8,211	8,390	26,534	10,492	7,963	5,995	9,983	4,008	2,998	3,013
	AVG	5,129	5,544	5,118	7,853	14,230	11,055	8,420	6,244	7,494	4,008	3,302	3,033

Appendix E-22. (Continued).

DELTA OUTFLOW (CFS) STATE WATER RESOURCES CONTROL BOARD ALTERNATIVE 5 - DWRSIM MODEL RUN 524													
Water Year	Water-Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
1925	D	5,376	3,535	4,757	6,012	53,574	27,256	20,152	10,231	8,754	5,002	3,503	3,047
1926	D	4,008	4,512	4,513	9,498	32,509	11,160	18,973	11,111	7,003	5,002	4,285	3,013
1930	D	5,702	3,519	4,757	13,294	12,220	27,142	10,842	8,439	8,788	5,002	3,503	3,064
1932	D	3,014	5,926	10,182	11,095	18,105	11,421	11,212	9,091	10,236	5,002	3,503	3,064
1939	D	19,257	10,253	10,394	16,993	17,798	13,180	9,966	5,995	9,579	5,002	3,503	3,064
1944	D	4,203	4,781	4,741	10,117	34,079	23,151	9,293	6,810	9,731	5,002	3,503	3,081
1947	D	4,008	5,034	9,563	6,191	15,181	18,931	11,414	5,898	9,562	5,002	3,503	3,013
1949	D	4,008	4,512	6,158	6,240	10,253	38,807	11,313	11,013	8,451	5,002	3,503	3,013
1955	D	4,008	10,589	17,449	16,716	11,426	12,512	8,721	7,739	9,360	5,002	3,503	3,013
1960	D	4,008	4,512	4,513	6,207	22,762	17,742	11,246	7,755	8,990	5,002	3,503	3,013
1961	D	4,008	4,596	6,940	6,940	22,780	14,581	10,168	5,588	10,135	5,002	3,503	3,064
1964	D	6,843	20,539	5,099	19,062	14,152	11,714	7,003	7,038	9,293	5,002	3,503	3,013
1981	D	8,521	4,512	6,012	28,527	27,527	30,515	14,428	6,142	9,192	5,002	3,503	3,013
1985	D	6,663	27,037	14,972	7,608	17,094	18,459	10,202	9,466	8,098	5,002	3,503	3,013
1987	D	4,708	4,512	4,513	10,459	20,921	26,621	9,596	5,148	10,253	5,002	3,503	3,064
1989	D	4,659	3,502	4,220	4,757	10,578	34,946	19,327	10,085	8,081	5,002	3,503	3,081
	AVG	5,812	7,617	7,424	11,232	21,310	21,134	12,116	7,972	9,094	5,002	3,552	3,037
1927	W	4,008	12,525	6,533	23,477	135,632	42,783	48,956	22,809	11,582	8,016	4,904	3,013
1938	W	4,008	15,286	61,339	30,792	153,538	175,872	78,771	74,438	37,357	8,016	4,008	9,764
1941	W	4,008	4,512	40,567	100,912	123,213	95,308	77,239	41,512	16,195	8,016	4,497	7,694
1942	W	14,842	8,973	62,138	86,543	147,942	30,515	49,529	35,891	20,067	8,016	4,138	4,697
1943	W	14,272	14,428	22,369	88,139	64,134	92,832	30,539	18,785	10,253	8,016	5,295	3,013
1952	W	4,008	7,071	41,398	90,453	79,206	71,896	69,226	68,198	35,572	8,016	4,008	11,111
1953	W	16,520	7,306	41,512	103,324	29,801	21,733	14,832	22,353	15,404	8,016	4,301	3,350
1956	W	4,008	4,512	78,983	172,711	92,617	40,143	19,630	37,862	17,273	8,016	4,073	6,751
1958	W	11,567	9,091	13,995	30,173	158,051	128,087	103,384	49,039	32,054	8,016	5,083	13,384
1963	W	23,183	10,118	18,003	10,573	71,805	27,191	90,842	27,338	11,953	8,016	4,383	3,165
1965	W	4,008	4,579	69,208	118,361	31,047	18,801	46,717	22,727	11,313	8,016	4,904	3,013
1967	W	4,008	5,724	29,521	46,758	55,722	62,968	57,222	55,360	41,515	11,551	4,008	11,970
1969	W	4,008	4,663	15,445	122,206	149,440	71,457	62,222	65,298	29,798	8,016	4,008	15,640
1970	W	16,113	8,687	52,721	211,339	94,116	41,072	14,731	10,313	8,586	8,016	4,871	3,013
1971	W	4,008	14,192	58,309	45,503	24,819	50,098	19,125	25,432	13,838	8,016	4,268	7,391
1974	W	4,985	56,279	66,585	127,990	45,108	112,838	68,300	23,998	13,704	8,016	4,285	12,037
1975	W	12,447	7,997	8,456	11,160	65,758	91,642	25,286	25,725	17,811	8,016	4,057	7,795
1982	W	4,008	25,707	85,109	79,472	105,343	91,251	141,330	44,803	21,246	8,016	4,008	14,327
1983	W	26,328	42,609	81,460	111,795	188,430	252,281	102,071	73,770	83,199	23,803	9,254	22,912
1984	W	30,401	82,290	156,663	76,849	45,848	36,901	16,061	11,323	10,269	8,016	5,018	3,013
1986	W	4,008	4,512	7,087	14,467	219,097	153,649	24,495	12,871	10,741	8,016	4,888	3,333
	AVG	10,226	16,717	48,448	81,095	99,079	81,396	55,262	36,659	22,368	8,936	4,679	8,114