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)]

INTRODUCTION

The goal of the Anadromous Fish Restoration Program (AFRP) is to make all reasonable efforts to at least double natural production of anadromous fish in Central Valley rivers and streams. Presently the Delta is governed by the 1995 Water Quality Control Plan (WQCP; SWRCB, 1995) whose basis was the Delta Accord (1994). A portion of the Central Valley Project Improvement Act (CVPIA) water resources are being used to meet conditions of the Delta Accord and WQCP and the remaining portion is proposed for use to increase production of anadromous fish in the Delta in addition to that provided by the Delta Accord. This document describes proposed flow and habitat objectives for the 1997 water year in addition to those occurring as a result of the Accord, using resources provided by the CVPIA.

Most of the proposed AFRP actions in the Delta would result in extending the time period for protective measures contained within the Delta Accord. These include limiting exports to 35% of inflow, moving the X_2 position downstream, and closing the cross channel gates. The Delta Accord targets protective measures during the late winter and spring period when the majority of anadromous fish are present.

Extending the time period of Delta Accord protective measures would increase the protection of anadromous fish in the fall, winter and summer months. For instance, protecting both the early and late outmigrants of the various salmon races would provide greater life history diversity relative to outmigration timing. Providing life history diversity would decrease the risk of artificially selecting a segment of the population based on outmigration timing, a trait possibly under genetic control. Extending Delta export limitations through the month of July would likewise extend protection to juvenile striped bass and other fish populations, which are vulnerable to entrainment in the summer.

We have selected actions in the Delta to increase the natural production of anadromous fish, but other resident species would likely benefit as well. We believe that the Delta Accord provides some protection to anadromous fish. Given the additional water resources available through the CVPIA, we believe the proposed actions will further improve the natural production of anadromous fish migrating or residing in the Delta, and contribute to the goal of the AFRP to make all reasonable efforts to at least double the natural production of anadromous fish in the Central Valley.

Each action is described in a template that provides a description of the action, including background information, the species and life history stages benefitted, selected key supporting data, monitoring and evaluation needs, and sources of information.

Introduction

Biological justification for the protective measures contained within the Delta Accord are available in a variety of documents, such as EPA's "Review of State of California Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary Under Section 303 of the Federal Clean Water Act" (EPA, 1995), the USFWS's "Measures to Improve the protection of chinook salmon in the Sacramento/San Joaquin River Delta" (USFWS, 1992), California Department of Fish and Game's exhibits to the 1992 SWRCB hearings, and a variety of reports by the Interagency Ecological Program (IEP).

The AFRP is requesting that the interested parties review the actions and relative priorities and make comments to facilitate the most effective use of our water resources in increasing the natural production of anadromous fish in the Delta.

Citations

Delta Accord, 1994. Principles for Agreement on Bay-Delta Standards Between the State of California and the Federal Government. December 15, 1994.

EPA, 1995. Technical Support Memorandum: Review of State of California Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary Under Section 303 of the Federal Clean Water Act.

SWRCB, 1995. Environmental Report. Appendix 1 to Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary.

USFWS, 1992. Measures to Improve the Protection of Chinook Salmon in the Sacramento/San Joaquin River Delta. Expert Testimony of U.S. Fish and Wildlife Service on Chinook Salmon Technical Information for State Water Resources Control Board Water Rights Phase of the Bay/Delta Estuary Proceedings. July 6, 1992 WRINT-USFWS-7.

Octoter 22, 1996 *List of Delta actions*

PROPOSED DELTA ANADROMOUS FISH RESTORATION PROGRAM
ACTIONS FOR THE 1997 WATER YEAR REQUIRING WATER
ABOVE THE BAY/DELTA ACCORD AND 1995 WQCP.

Priority

1. Limit the combined SWP and CVP exports so as to maintain a San Joaquin River at Vernalis inflow total export ratio during the 30 day, April through May pulse flow period (4/15 to 5/15) by water year type as follows: 5:1 wet, 4:1 above normal, 3:1 below normal, 3:1 dry/critical.

   Note: The Service and Bureau of Reclamation are working in conjunction with the Interagency Ecological Program (IEP) agencies, the San Joaquin Tributary group and the California Urban Water Association (CUWA) to determine how best to evaluate the benefits of the proposal action and if the action should be modified to some degree.

2. Continue to evaluate a temporary rock barrier at the head of Old River to improve conditions for chinook salmon migration and survival during the April 15- May 15, or other 30 day pulse period, consistent with the Corps of Engineers Permit to the Department of Water Resources and Fish and Wildlife Services' Biological Opinion on Delta smelt.

3. Increase the level of protection targeted by the May and June X_2 requirements to a 1962 level of development. This represents an increase in numbers of days when X_2 is required at Chipps Island in Table A of the 1995 WQCP as described below. PMI is previous months index.

	1962 LOD		IN WQCP	
PMI	MAY	JUNE	MAY	JUNE
500	0	0	0	0
750	0	0	0	0
1000	0	0	0	0
1250	0	0	0	0
1500	0	0	0	0
1750	1	0	0	0
2000	4	0	1	0
2250	13	1	3	0
2500	24	3	11	1
2750	29	7	20	2
3000	30	12	27	4
3250	31	18	29	8
3500	31	23	30	13
4000	31	28	31	18
4250	31	29	31	25
4500	31	29	31	27
4750	31	30	31	28

List of Delta actions

4. Maintain at least 13,000 cfs daily flow in the Sacramento River at the I street Bridge during May to improve transport of eggs and larval and striped bass and other young anadromous fish and to reduce egg settling and mortality at low flows. Provide 9000 cfs daily flow minimum at Knights Landing during May.

   Note: The 9,000 cfs is requested at Knights Landing since striped bass spawn above the mouth of the Feather and flow is needed there initially.

5. Ramp (linearly) the total CVP/SWP export level from whatever it is on 5/15 to meet Action 1 to those export levels proposed by projects to meet the 1995 WQCP on June 1, when salmon are present.

   Note: This is a new action and meant to prevent a quick rise in exports after May 15 when salmon and other anadromous fishes could be vulnerable to such an operational change.

6. Close the Delta Cross Channel (DCC) starting on November 1.

   Note: This action is meant to supplement that in the Accord and 1995 WQCP where it asks for a closure of up to 45 days based on the NMFS draft guidelines.

7. Limit the average CVP/SWP exports to no greater than 35% of Delta inflow in July. Sub priorities: 1) July 1- July 15, 2) July 16 - July 31.

8. Establish conditions for a CWT late fall run smolt survival experiment in Dec '97/Jan '98 at exports of 65 and 35% of DOF, respectfully.

9. Limit the average CVP/SWP exports to no greater than 35% of Delta inflow in the November-January period. Sub priorities: 1) January, 2) December, 3) November.

Delta Action 1: Limit the combined SWP and CVP exports so as to maintain a San Joaquin River at Vernalis inflow total export ratio during the 30 day, April through May pulse flow period (4/15 to 5/15) by water year type as follows : 5:1 wet, 4:1 above normal, 3:1 below normal, 3:1 dry/critical.

Description: The proposed action establishes ratios of Vernalis flow to combined SWP and CVP exports (VFER) from mid-April to mid-May. Three values of VFER are proposed and vary with water-year type. Attaining the ratios will depend on coordination among SWP and CVP operators that control exports and the USBR and private reservoir operators that regulate dam releases influencing flow at Vernalis. Three tools provided by Section 3406 of the Central Valley Project Improvement Act (CVPIA), that is reoperation 3406(b)(1)(B), 800,000 af of dedicated water 3406(b)(2), and acquired water 3406(b)(3), will be used to implement the action. We acknowledge there is some uncertainty to using a ratio of variables to describe protective criteria. However, it is our intent to increase flows and decrease exports to levels that will benefit the fish. The ratio is a convenient method of identifying conditions to benefit fish even though evidence suggests that the difference between inflow and exports may be a more useful variable.

Background: Recommendations for VFER were addressed in the 1995 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (WQCP; SWRCB 1995) and a formal consultation, pursuant to section 7(a)(2) of the federal Endangered Species Act, between the USFWS and USBR concerning delta smelt (USFWS 1995a). The 1995 WQCP water quality objectives for fish and wildlife beneficial uses include limiting export rate to 1,500 cfs or 100% of San Joaquin River flow at Vernalis, whichever is greater. The objective applies to the period 15 April to 15 May, but the time period can be varied depending on real-time monitoring and the operations group. A recommendation from the consultation for delta smelt was to institute a 1.5:1 VFER. A higher VFER than in the 1995 WQCP was intended to reduce entrainment of delta smelt into the CVP and SWP facilities pumps.

The San Joaquin River Tributaries Association (SJTA) filed suit challenging the 1995 WQCP, and proposed a settlement together with other water interests (SJTA et al. 1996). The U.S. Environmental Protection Agency (EPA) and others are developing studies to reduce uncertainty noted in the proposed settlement.

The proposed action is intended to provide greater protection to fish than afforded by the regulatory documents noted above.

Fish species and life stages benefited:

- juvenile fall-run chinook salmon
- juvenile steelhead
- juvenile striped bass
- juvenile American shad
- adult white and green sturgeon

- juvenile delta smelt and other resident fishes

Supporting data: We present data to support the proposed action from various sources. Three categories of data are present here: 1) survival indices of juvenile chinook salmon derived from studies using smolts marked with coded-wire-tags (CWT), 2) stock and recruitment relationships relative to environmental conditions, and 3) timing of smolt emigration from the San Joaquin River tributaries and through the Delta.

Survival indices--The USFWS has calculated survival indices of CWT juvenile chinook salmon in the San Joaquin Delta since early in the last decade (Table 1; see USFWS 1987, 1992; and SSJEFRO data files). The studies have investigated survival of fish released from various locations to Chipps Island, effects of a barrier at the head of Old River on fish survival, and differential survival of fish from the Merced Fish Facility and Feather River Hatchery. Data from the studies were also used to develop a San Joaquin salmon smolt survival model (Brandes 1994).

Most data generated by the studies have been highly variable and open to multiple interpretations. We believe some of the data provide sufficient information for biologists to develop management recommendations for improving protection of aquatic resources. All recommendations are considered in the context of adaptive management.

Flow at Stockton has generally been correlated to survival indices of CWT smolts released at Dos Reis between 1982, 1985 to 1991 (USFWS, 1992), although in recent years that relationship has appeared to break-down (Figure 1). We believe the relationship is still present based on other evidence, but is masked by combining smolts of Feather River stock with those from Merced River stock. The groups released since 1990 have been from Feather River stock, whereas those released prior to 1989 were all from Merced River stock.

In 1995, under very high flows (20,000 - 25,000 cfs), the average survival index for smolts released at Dos Reis was 0.23, much less than would have been estimated using our previous relationship between survival and flow. Experiments performed in 1996 indicated that smolts released at Dos Reis from Merced River stock survived 5 times greater (0.10 versus 0.02) than those released at the same time and place using Feather River smolts. If we assume that this is a true difference in survival and had Merced River smolts been released in 1995, their expected survival index would have been over 100 percent. The relation between survival of fish released at Dos Reis and flow at Stockton data differed for fish from the Feather and Merced rivers (Figures 2 and 3). Survival was 9 times greater in 1995 at flows of 20,000 - 25,000 cfs than in 1996 when flows ranged between 6,000 and 12,000 for smolts originating from Feather River (Fall 1996 IEP Newsletter, in press).

Stock and recruitment relationships--Annual escapement estimates for chinook salmon (i.e., the number of 2- and 3-year-old fish that return to spawn) have been made by the CDFG for San Joaquin River tributaries. The CDFG used these data and spring flows of tributaries and the San Joaquin River at Vernalis when three-year-old fish were emigrating as smolts, to perform

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regression analyses (CDFG 1987, 1992). The analyses indicated significant ($p<0.05$) positive correlations between spring flow in the tributaries and at Vernalis and escapement of fish 2.5 years later (Figures 4, 5, and 6). Moreover, analyses conducted before state and federal water projects began operation resulted in regression equations for the Stanislaus and Tuolumne rivers with greater slopes and intercepts than equations calculated for the periods after operations, indicating negative effects of water export on salmon survival.

The ratio of Vernalis flow to water export has been suggested as a factor influencing salmon escapement in the San Joaquin River basin, primarily by affecting smolt survival during the peak emigration period, e.g., the AFRP Working Paper (USFWS 1995b). The USFWS performed a regression analysis to describe the relation between adult escapement (3-year-old fish) and VFER during 15 April to 15 May the year fish were smolts (Figure 7). The resulting regression equation was significant ($p<0.01$) and VFER accounted for 40% of the variance in escapement.

To better understand factors affecting chinook salmon in the San Joaquin River basin, Carl Mesick Consultants (CMC 1994, 1995, 1996) performed correlation analyses on existing data to investigate relations among streamflow, exports, VFER, water temperature, stock size (escapement of 3-year-old fish), ocean harvest, water quality, ocean conditions, and recruitment of chinook salmon cohorts (combined number of 2- and 3-year-old fish returning in 1.5 and 2.5 years).

Each report offered further refinements to the analyses, especially concerning discrimination between cohorts. All reports analyzed data from the Stanislaus and Tuolumne rivers separately, and differed from earlier analyses conducted by the CDFG (CDFG 1987, 1992) by accounting for differences in age structure of fish in escapement estimates. Data were analyzed for various time periods within the years 1951-1989, depending on data availability, and the latter two reports (CMC 1995, 1996) developed stock and recruitment relationships, and presented time-series population models to predict recruitment relative to potential restoration activities.

Overall, the analyses indicated that three variable accounted for most of the variance in recruitment of chinook salmon in the Stanislaus and Tuolumne rivers. The variables were VFER, extremely low tributary flows during smolt emigration, and stock levels below 1,000 fish. For example, VFER was typically most closely associated with recruitment. for April, May, and June of all years of record (1951-1989; CMC 1994), VFER alone accounted for >70% of the variance in recruitment for the San Joaquin River, and >50% of the variance in the Stanislaus and Tuolumne rivers. The later reports analyzed data sets truncated at 1960 and reaffirmed associations indicated earlier. Over 80% of the variance in recruitment was explained by VFER when stock ranged from 1,000 to 9,000 fish for the Stanislaus River and 1,000 to 7,000 fish for the Tuolumne river. Furthermore, recruitment appeared to be a nonlinear function of spring VFER, and can be illustrated by holding stock constant (Figures 8 and 9).

Because the proposed action applies only to a 30-day period in April and May and the predictive equations developed by CMC (1994, 1995, 1996) were derived for April through June, we expect that, if the equations are correct, implementing the action would result in recruitment lower than predicted. However, because the 30-d period encompasses the period of peak smolt emigration (see below), we believe that the action would improve smolt survival and recruitment. The action would also provide an opportunity to evaluate the response of chinook salmon to habitat conditions and project operations, and can be integrated with proposed investigations.

Migration timing--The 30-day period between 15 April and 15 May was identified in the Framework Agreement as the time period for export curtailments to allow juvenile salmon to benefit from a pulse flow. Since 1988, the CDFG has observed an annual peak migration of smolts into the Delta between 23 April and 7 May, based on sampling with Kodiak trawls during early April to late June (Figure 10; W. Loudermilk, CDFG, personal communication). In most years between 1988 to 1993, 75% of all juvenile salmon were collected by 15 May (for details, see CDFG 1988, 1989, 1990, 1991, 1992).

Monitoring and evaluation needs: The USFWS and U.S. Bureau of Reclamation are working in conjunction with IEP agencies, the San Joaquin Tributary group and the California Urban Water Association to determine whether the proposed action should be modified and how best to evaluate the action. Also, the IEP real-time monitoring program and sampling conducted in the spring at Mossdale will provide information to assist in evaluating the proposed action. Additional data from CWT fish harvested in the ocean will be used.

Citations

Brandes, P. 1994. The development of a refined San Joaquin delta salmon smolt model, draft. U.S. Fish and Wildlife Service, Sacramento-San Joaquin Estuary Fishery Resource Office, Stockton, California.

California Department of Fish and Game. 1987. The status of San Joaquin drainage chinook salmon stocks, habitat conditions and natural production factors. CDFG Exhibit 15 prepared for the State Water Resources Control Board Bay-Delta Hearing Proceedings, September 1987. Sacramento, California.

California Department of Fish and Game. 1988. Job Performance Report.

California Department of Fish and Game. 1989. Job Performance Report.

California Department of Fish and Game. 1990. Job Performance Report.

California Department of Fish and Game. 1991. Job Performance Report.

California Department of Fish and Game. 1992. Interim actions to reasonably protect San Joaquin fall-run chinook salmon. CDFG Exhibit 25 prepared for the water rights phase of the State Water Resources Control Board Bay-Delta Hearing Proceedings, beginning 22 June 1992, Sacramento, California.

Carl Mesick Consultants. 1994. The effects of minimum streamflow, water quality, Delta exports, ocean harvest, and El Nino conditions on fall-run chinook salmon escapement in the San Joaquin drainage from 1961 to 1989. Prepared for the Stanislaus River Council.

Carl Mesick Consultants. 1995. A reanalysis of the effects of minimum flow requirements, release temperatures, Delta exports, and stock on fall-run chinook salmon production in the Stanislaus and Tuolumne rivers. Prepared for Thomas R. Payne & Associates and Neumiller & Beardslee.

Carl Mesick Consultants. 1996. The effects of minimum flow requirements, release temperatures, Delta exports, and stock on fall-run chinook salmon production in the Stanislaus and Tuolumne rivers. Prepared for Thomas R. Payne & Associates, Neumiller & Beardslee, and Stockton East Water District.

San Joaquin Tributaries Association, Friant Water Users Authority, San Joaquin River Exchange Contractors Water Authority, City and County of San Francisco, and SWP/CVP Export Interests. 1996. Hydrological and biological explanation of the letter of intent among export interests and San Joaquin River interests to resolve San Joaquin River issues related to protection of Bay-Delta environmental Resources. May 7, 1996.

State Water Resources Control Board. 1995. Water quality control plan for the San Francisco Bay/Sacramento-San Joaquin Delta estuary. 95-1WR, May 1995, Sacramento.

U. S. Fish and Wildlife Service. 1987. Exhibit 31. The needs of chinook salmon, Oncorhynchus tshawytscha in the Sacramento-San Joaquin Estuary. Entered by the U.S. Fish and Wildlife Service for the State Water Resources Control Board 1987 water quality/water rights proceeding on the San Francisco Bay/Sacramento-San Joaquin delta. SSJEFRO, Stockton, California.

U.S. Fish and Wildlife Service. 1989. Abundance and survival of juvenile chinook salmon in the Sacramento-San Joaquin estuary. 1989 Annual Progress Report. SSJEFRO, Stockton, California.

U.S. Fish and Wildlife Service. 1990. Abundance and survival of juvenile chinook salmon in the Sacramento-San Joaquin estuary. 1990 Annual Progress Report. SSJEFRO, Stockton, California.

U.S. Fish and Wildlife Service. 1991. Abundance and survival of juvenile chinook salmon in the Sacramento-San Joaquin estuary. 1990 Annual Progress Report. SSJEFRO, Stockton, California.

U.S. Fish and Wildlife Service. 1992a. Abundance and survival of juvenile chinook salmon in the Sacramento-San Joaquin estuary. 1991 Annual Progress Report. SSJEFRO, Stockton, California.

U.S. Fish and Wildlife Service. 1992b. Exhibit 7. Measures to improve the protection of chinook salmon in the Sacramento/San Joaquin River Delta. Expert testimony of United States Fish and Wildlife Service on chinook salmon technical information for State Water Resources Control Board water rights phase of the Bay/Delta Estuary Proceedings, July 6, 1992.

U.S. Fish and Wildlife Service. 1993. Abundance and survival of juvenile chinook salmon in the Sacramento-San Joaquin estuary. 1992 Annual Progress Report. SSJEFRO, Stockton, California.

U.S. Fish and Wildlife Service. 1994. Abundance and survival of juvenile chinook salmon in the Sacramento-San Joaquin estuary. 1993 Annual Progress Report. SSJEFRO, Stockton, California.

U.S. Fish and Wildlife Service. 1995a. Memorandum from Field Supervisor, U.S. Fish and Wildlife Service, Ecological Services, to Regional Director, U.S. Bureau of Reclamation. Formal consultation and conference of effects of long-term operation of the Central Valley Project and State water Project on the threatened delta smelt, delta smelt critical habitat, and proposed threatened Sacramento splittail. Memorandum 1-1-94-F-70, 6 March, Sacramento, California.

U.S. Fish and Wildlife Service. 1995b. Working paper on restoration needs: habitat restoration actions to double natural production of anadromous fish in the Central Valley of California. volume 3. May 9, 1995. Prepared for the U.S. Fish and Wildlife Service under the direction of the Anadromous Fish Restoration Program Core Group. Stockton, California.

Table 1. Chinook salmon smolt survival indices and associated Delta hydrology features for two different stocks of fish, Feather River and Merced rivers, for different years within the time period 1982 through 1996.

Date	Origin	Flow (cfs) at Stockton	Flow (cfs) at Vernalis	Exports (cfs)	Vernalis flow to export ration	Survival Index
April 2, 1989	Feather	112	2274	10297	0.22	0.14
April 16, 1990	Feather	0	1290	9549	0.14	0.04
May 2, 1990	Feather	490	1665	2461	0.68	0.04
April 5, 1991	Feather	60	676	5153	0.13	0.16
April 17,1995	Feather	7345	18479	3743	4.94	0.15
May 5, 1995	Feather	8940	22353	3911	5.72	0.39
May 17, 1995	Feather	9253	23262	4525	5.14	0.16
May 1, 1996	Feather	2375	6269	1500	4.18	0.02
May 9, 1996	Feather	2715	7206	2200	3.28	0
May 16, 1996	Feather	3702	10443	7000	1.49	0
April 23, 1982	Merced	7861	19233	5598	3.44	0.7
April 30, 1985	Merced	513	2597	6311	0.41	0.59
May 29, 1986	Merced	2514	7215	5386	1.34	0.34
April 27, 1987	Merced	471	2386	6093	0.39	0.38
May 2, 1989	Merced	790	2289	2470	0.93	0.14
May 1, 1996	Merced	2375	6269	1500	4.18	0.1

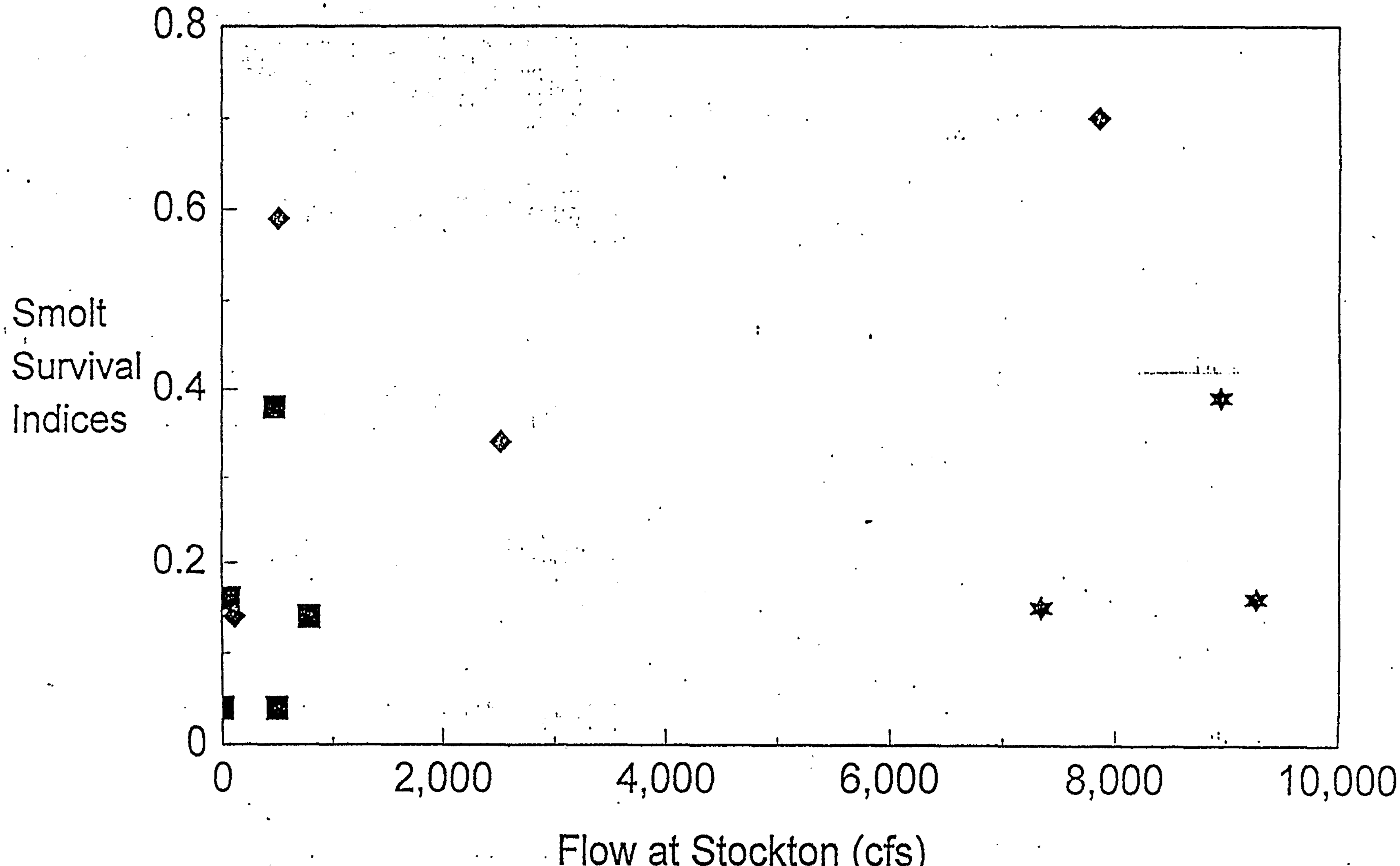

Figure 1: Survival indices for smolts released at Dos Reis between 1982, 1985-1987 1989 - 1991 and 1995. Diamonds represent smolts from Merced River Fish Facility. All others are from Feather River Hatchery. Stars represent data from 1995 (Feather River smolts).

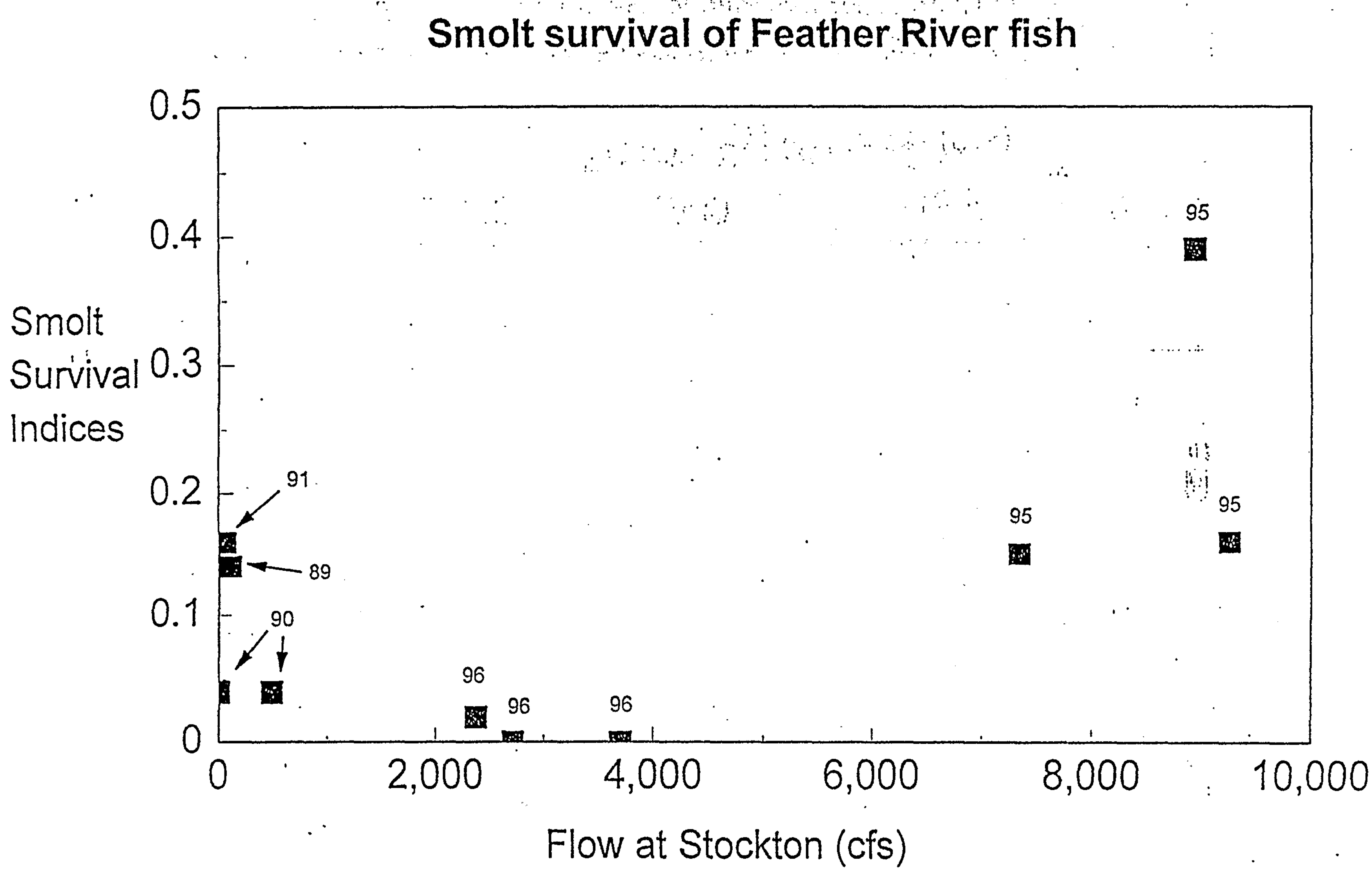

Figure 2: Survival indices for Feather River smolts released at Dos Reis in 1989, 1990-1991, and 1995-1996. The years for each survival value are indicated on the graph.

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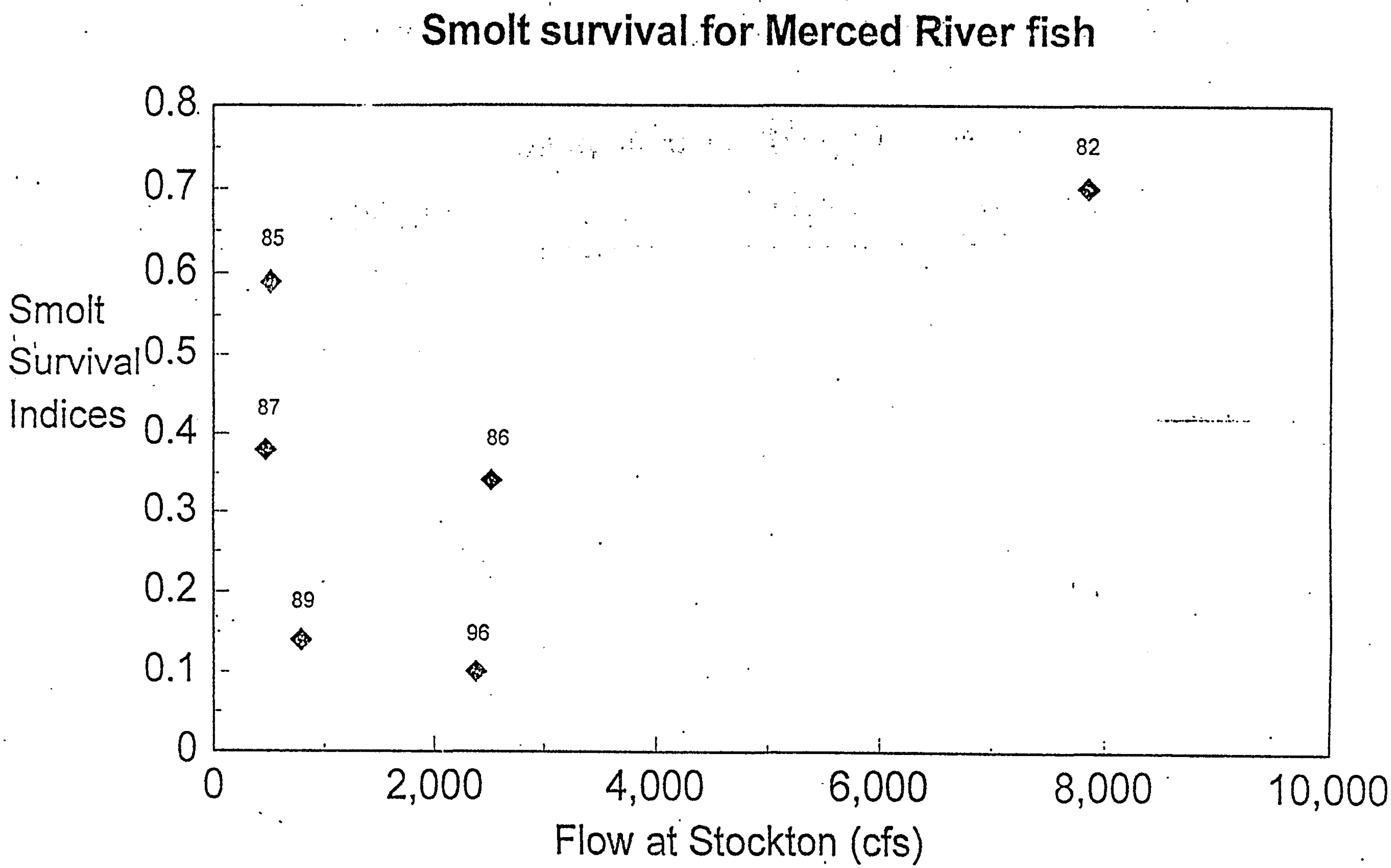

Figure 3: Survival indices for Merced River smolts released at Dos Reis in 1982, 1985-1987 1989, and 1996. The years for each survival value are indicated on the graph.

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Figure 4. Relationship of total escapement in the San Joaquin drainage and Vernalis flows before (upper) and after (lower) the existing State Water project in the south Delta and major storage increases in the San Joaquin drainage (source: CDFG 1987, Exhibit 15, The status of San Joaquin drainage chinook salmon stocks, habitat conditions and natural production factors).

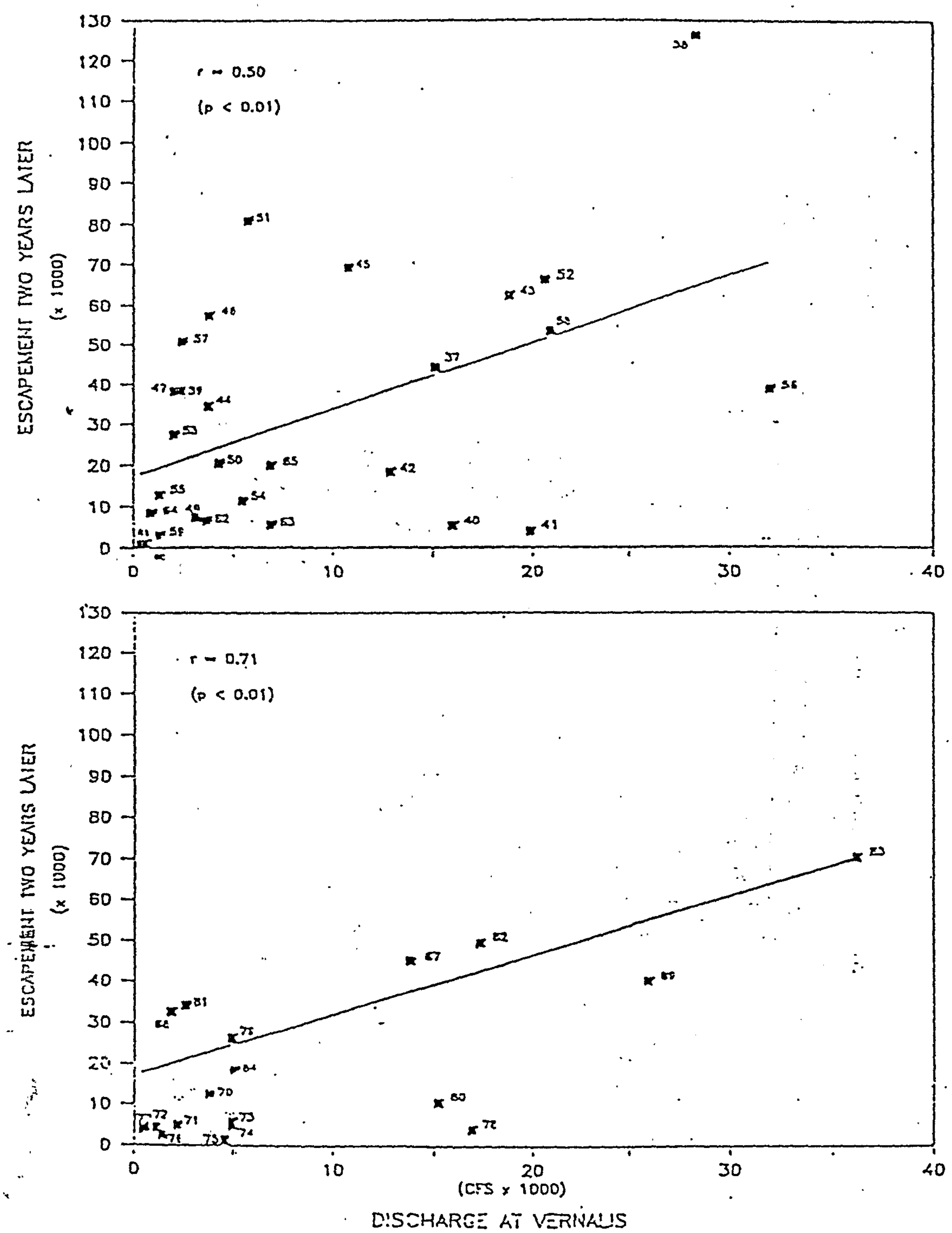

Figure 5. Relationships of Tuolumne River escapement to spring flows prior to Delta water developments (top), after CVP development in the drainage and after the SWP and additional storage development in the drainage (bottom) (source; CDFG 1987, Exhibit 15, The status of San Joaquin drainage chinook salmon stocks, habitat conditions and natural production factors).

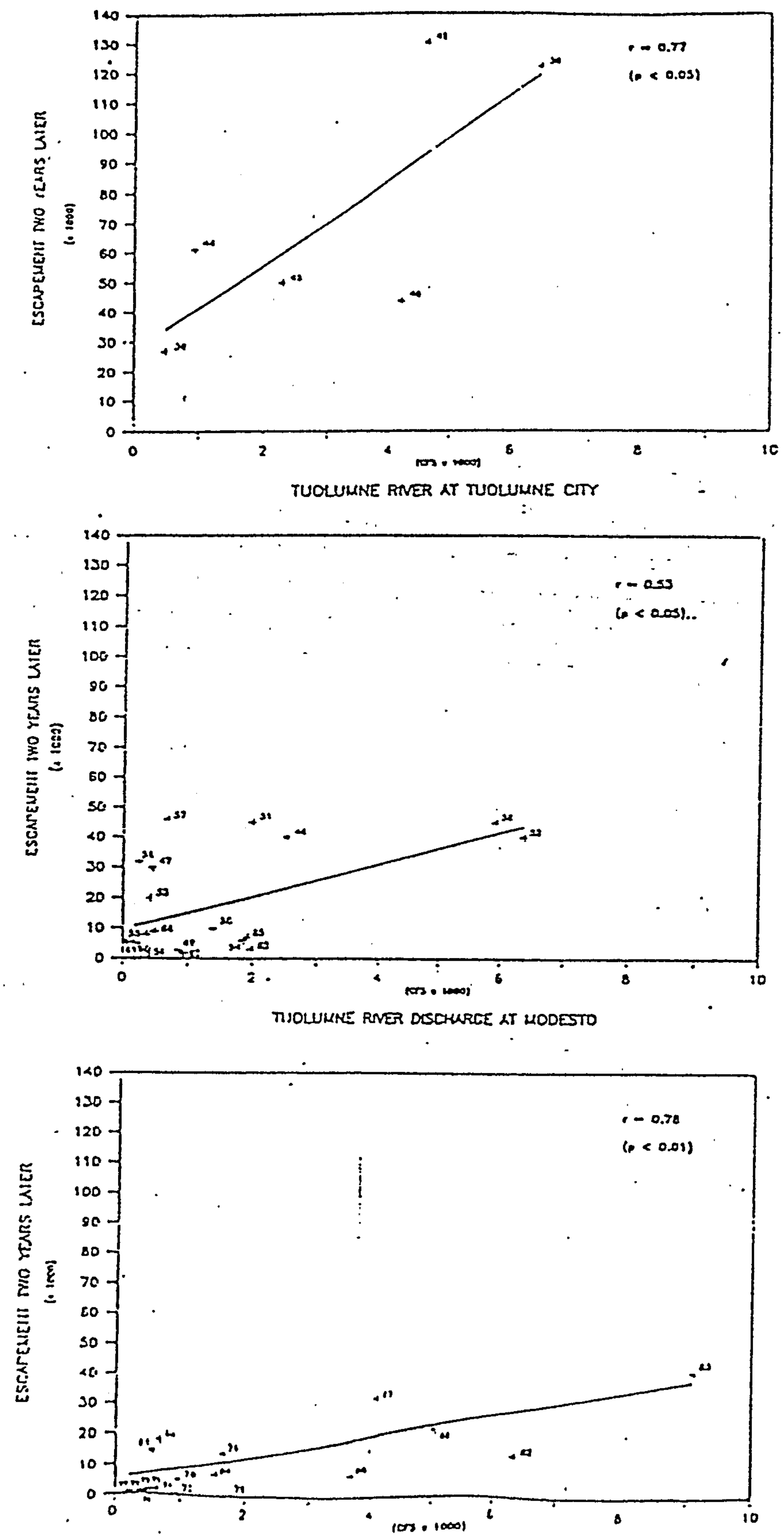

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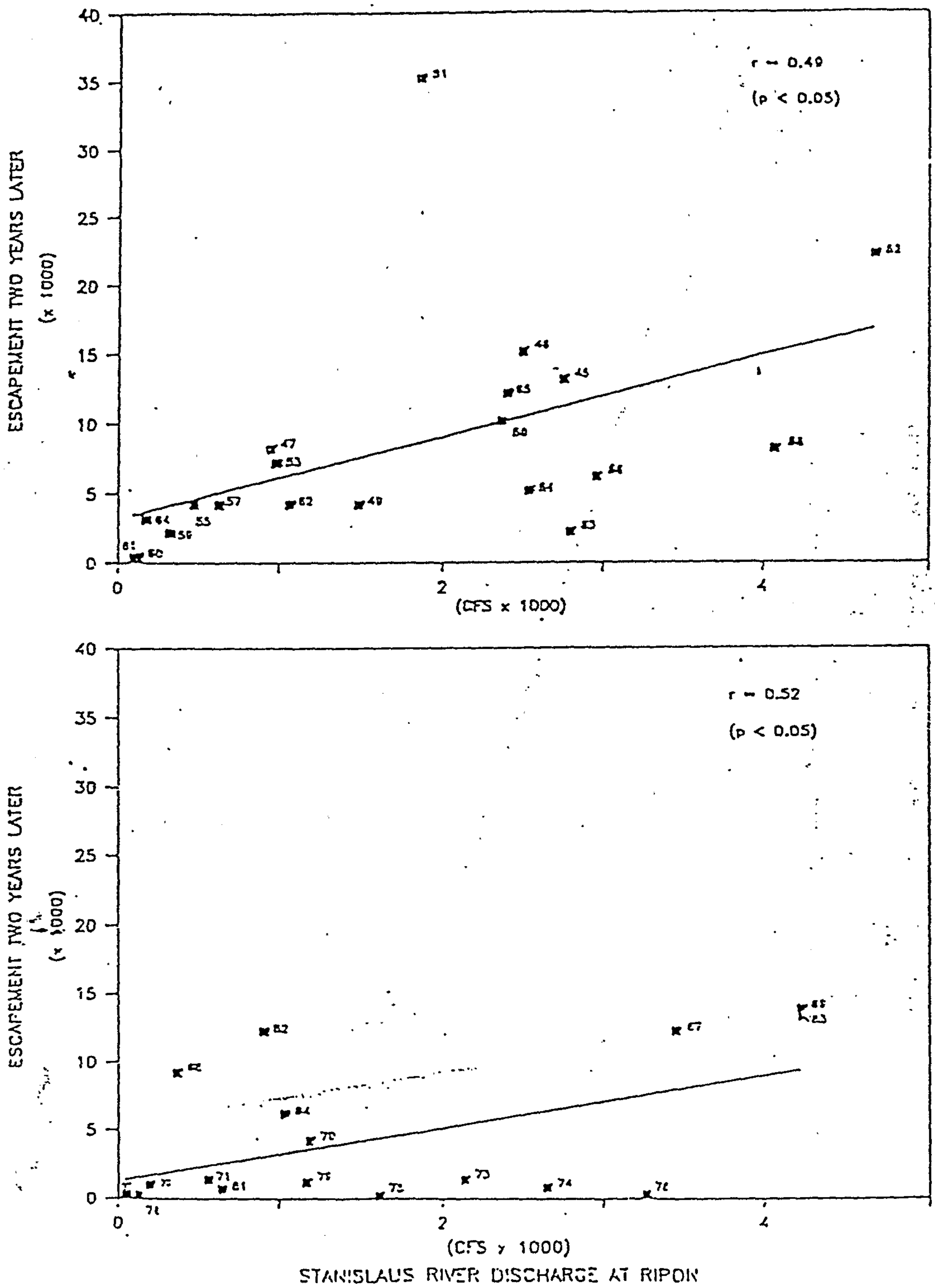
Figure 6. Relationships of Stanilaus River escapement to spring flows before (upper) and after (lower) the existing State Water Project in the south Delta and major storage enlargements in the San Joaquin drainage (source; CDFG 1987, Exhibit 15, The status of San Joaquin drainage chinook salmon stocks, habitat conditions and natural production factors).



...and Estimates of Natural Spawning Fall-run Chinook Salmon during 1969-1989

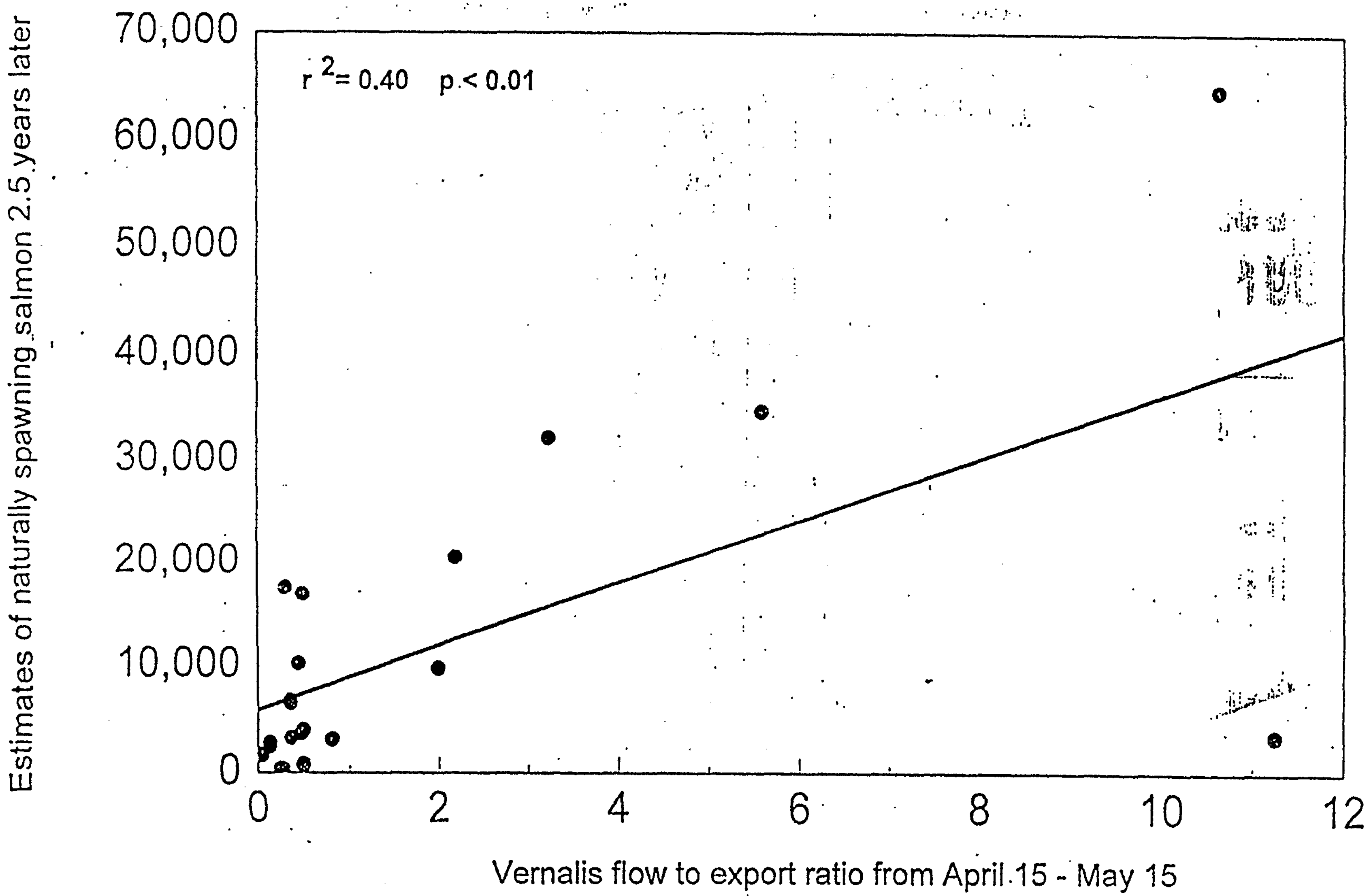


Figure 7. Numbers of naturally-spawning chinook salmon versus Vernalis flow to Delta export ratio when fish emigrated, 1969-1989. Salmon numbers (adults only) were after Mills and Fisher (1994). Vernalis flow to export ratio was calculated from DAYFLOW (CDWR data base).

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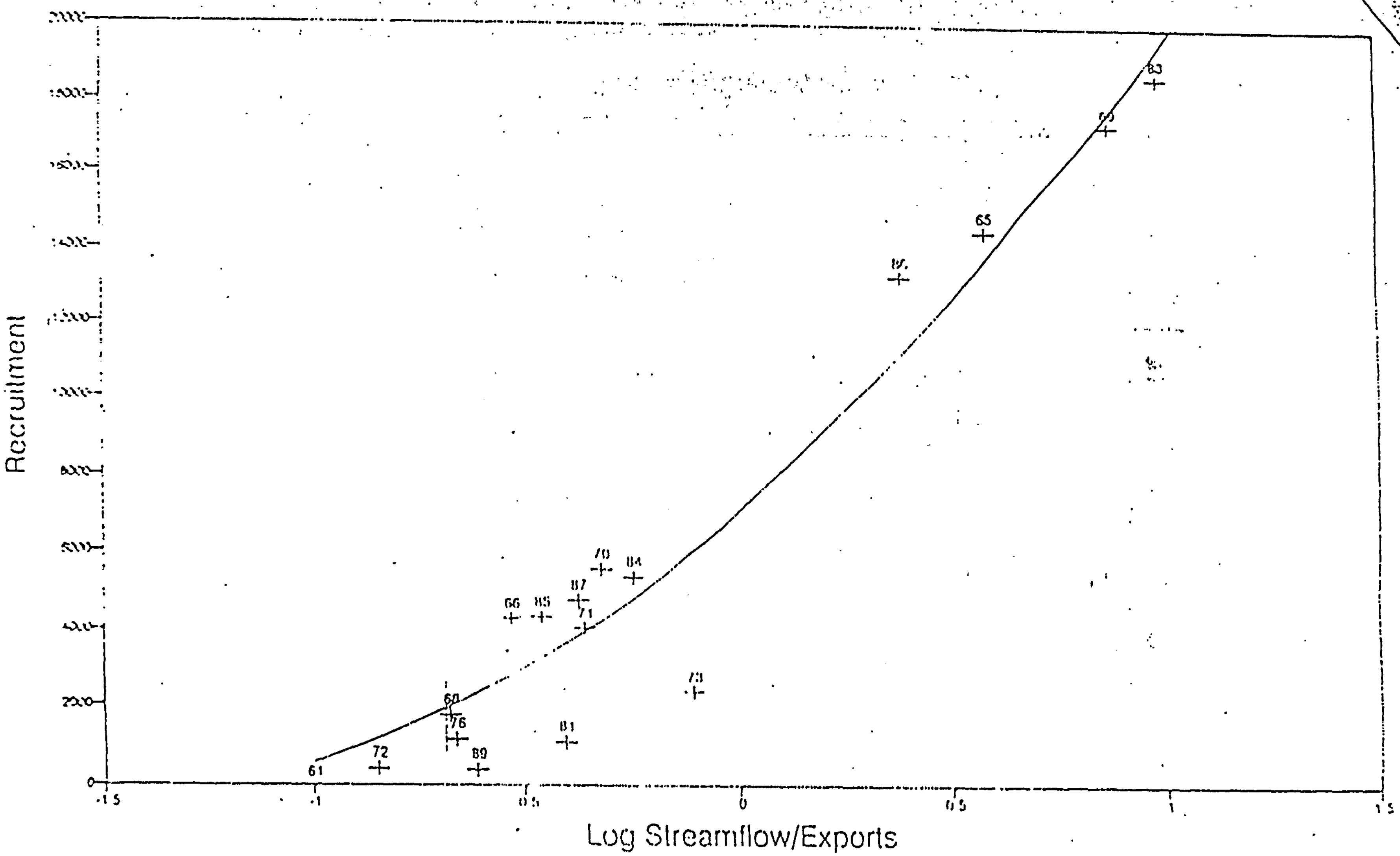

Figure 8. Number of two- and three-year-old fall-run chinook salmon of the same cohort (Recruitment) that returned to spawn in the Stanislaus River versus the log of the ratio of streamflow in the San Joaquin River in the vicinity of Vernalis to the combined SWP and CVP Delta exports during April and May during the year when the salmon cohorts migrated through the Delta as smolts between 1960 and 1989. The effects of stock, the number of three-year-old spawners, were held constant at 6,000 fish and data were not plotted when stock was less than 1,000 fish. Data are identified according to the year when the fish were smolts. (after Mesick 1995)

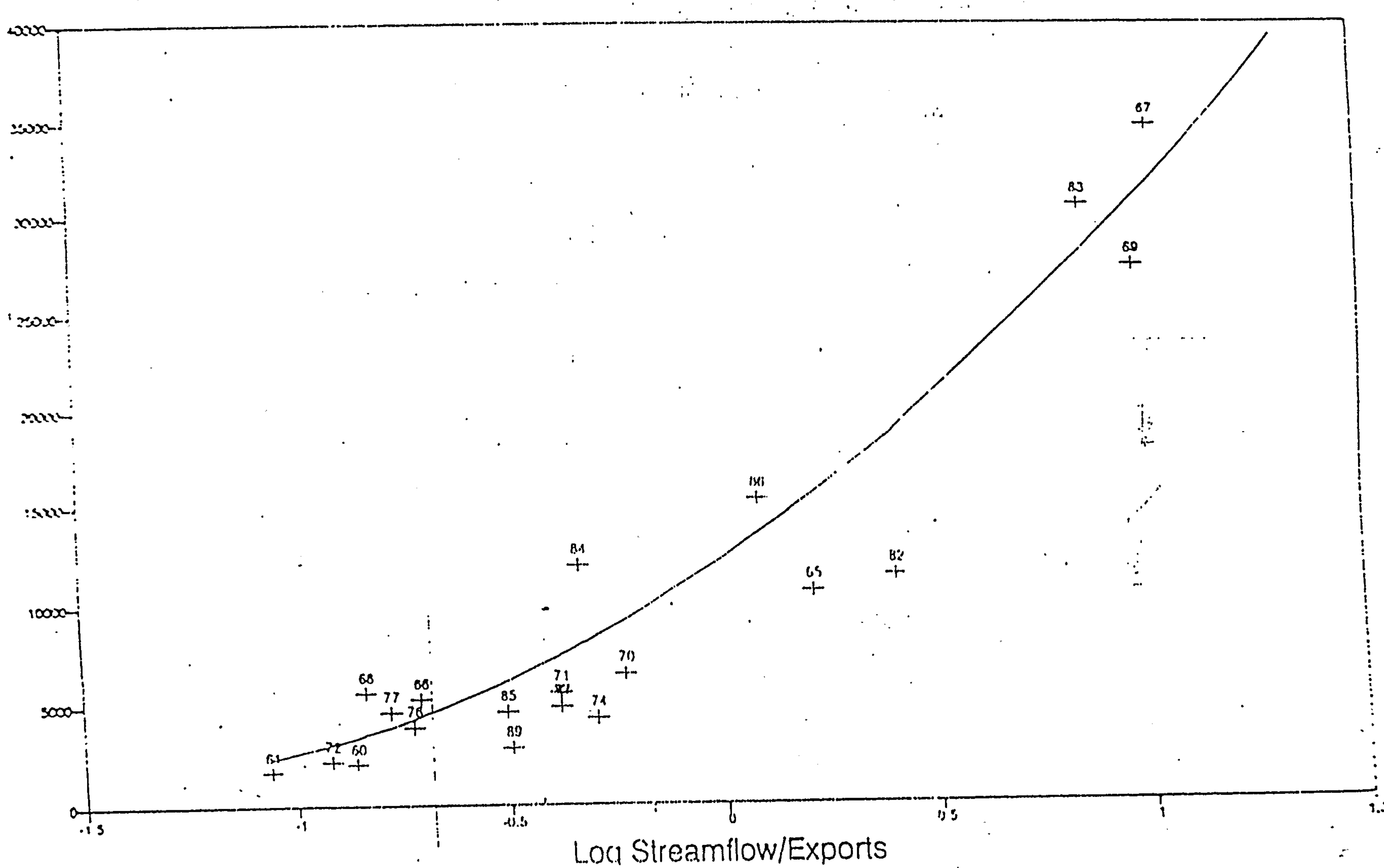

Figure 9. Number of two- and three-year old fall-run chinook salmon of the same cohort (Recruitment) that returned to spawn in the Tuolumne River versus the log of the ratio of streamflow in the San Joaquin river in the vicinity of Vernalis to the combined SWP and CVP Delta exports during May and June during the year when the salmon cohorts migrated through the Delta as smolts between 1960 and 1989. The effects of stock, the number of three-year-old spawners, were held constant at 5,000 fish and data were not plotted when stock was less than 1,000 fish. The effects of flow were constant at a MINFLOW ratio of 100%. Data are identified according to the year when the fish were smolts.

CHINOOK SALMON MEAN DAILY CATCH (KS/10 MINUTE TOW) IN THE KODIAK TRAWL AT MOSSDALE FROM 1988 TO 1993.

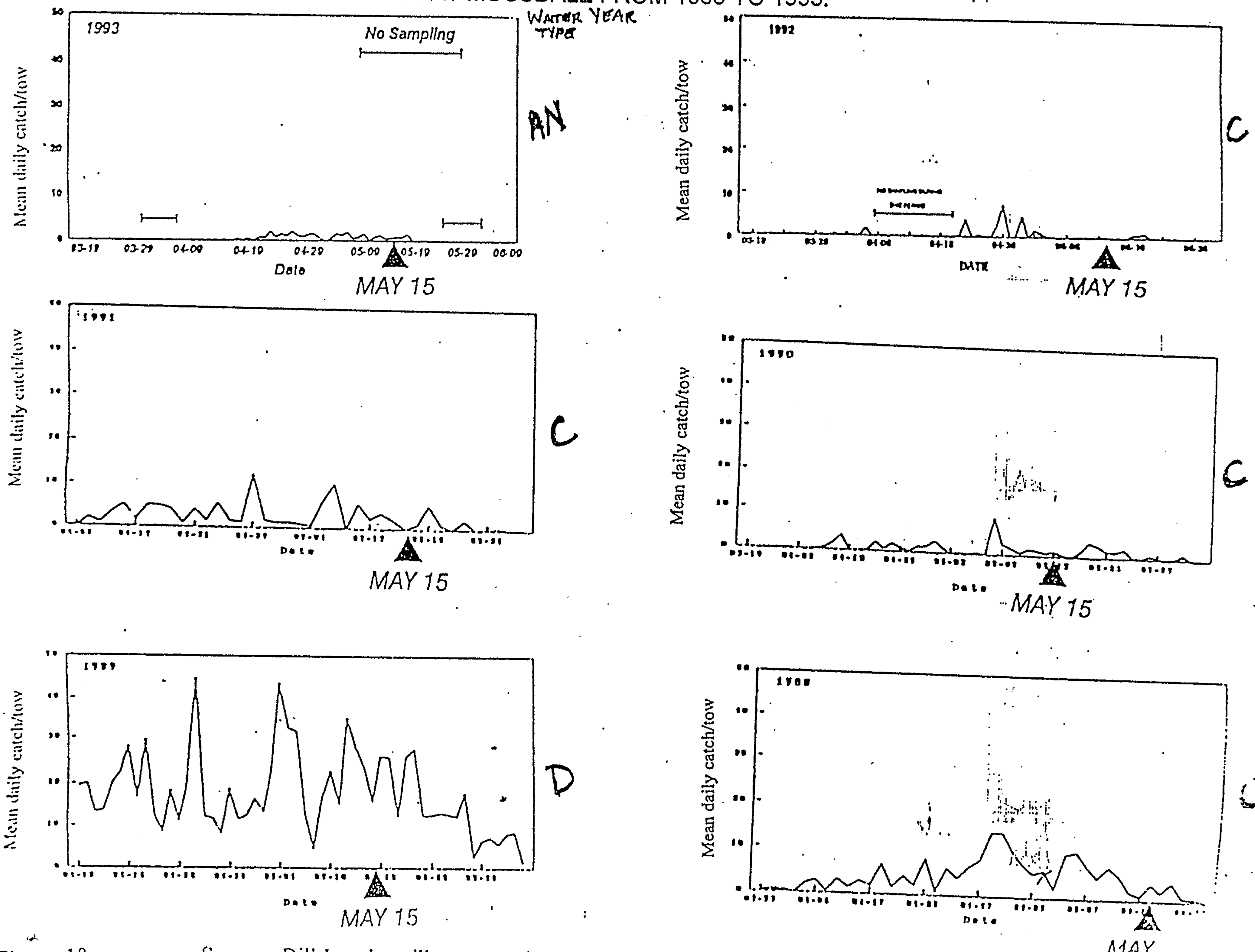

Figure 10. Source: Bill Loudermilk, personal communication

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Delta Action 2: Continue to evaluate a temporary rock barrier at the head of Old River to improve conditions for chinook salmon migration and survival during the April 15-May 15, or other 30 day pulse period, consistent with the Corps of Engineers Permit to the Department of Water Resources and Fish and Wildlife Service's Biological Opinion on delta smelt.

Description: The proposed action consists of constructing a temporary rock barrier at the head of Old River and operating the barrier during the spring when juvenile chinook salmon are emigrating from the San Joaquin River.

Background: As the San Joaquin River enters the Delta, its flow bifurcates at the head of Old River. When CVP and SWP export facilities, which are located in Old River, are not operating, about 60% of the total San Joaquin River flow at Vernalis enters the Old River channel (Morhardt et al. 1995). However, during export operations, flow in Old River can exceed total flow in the San Joaquin River at Vernalis and cause reverse flows in the San Joaquin River and other channels in the south Delta. Fish entering Old River, which have been assumed to be proportional to flow at the bifurcation, are exposed to possible entrainment at the facilities and incur potentially high mortality due to high water temperature and predators inhabiting the area near the facilities, Clifton Court Forebay, and other south Delta channels. To reduce the number of juvenile chinook salmon that enter Old River during emigration, a barrier at the head of Old River has been proposed. The barrier has been identified as a potential management tool in the SWRCB 1995 Water Quality Control Plan (WQCP; SWRCB 1995), the Environmental Protection Agency's (EPA) review of the 1995 Water Quality Control Plan (WQCP), and the Central Valley Project Improvement Act. The barrier has also been investigated by the California Department of Fish and Game (CDFG) as possible mitigation for the South Delta Temporary Barriers Project's agricultural flow control barriers and is a proposed permanent structure in the Interim South Delta Project.

Fish species and life stages benefited:

- juvenile chinook salmon in the San Joaquin River
- juvenile steelhead in the San Joaquin River

Supporting data: We present data to support the proposed action primarily from studies conducted by the Sacramento-San Joaquin Estuary Fishery Resource Office (SSJEFRO) since 1985 (see USFWS 1987, 1989, 1990, 1991, 1992, 1993, 1994; and SSJEFRO data files). The data are also summarized in draft issue papers by the California Department of Fish and Game (CDFG 1995) and the U.S. Fish and Wildlife Service (USFWS 1995). The categories of data presented are: 1) comparisons of survival indices between juvenile chinook salmon released in Old River and the San Joaquin River at Dos Reis, just downstream from the Old River bifurcation; 2) comparisons of survival indices between juvenile chinook salmon released when the barrier was and was not in operation; and 3) number of marked juvenile chinook salmon recovered at CVP and SWP fish salvage facilities when the barrier was and was not in operation.

Delta Action 2

Comparisons of survival indices between Old River and San Joaquin River--From 1985 to 1990, the U.S. Fish and Wildlife Service (USFWS) calculated survival indices for juvenile chinook salmon released in Old River and in the San Joaquin River at Dos Reis, downstream of the Old River bifurcation. All fish were marked with coded-wire-tags (CWT) and released at each location, generally both groups within a two day period. The number of CWT fish collected at Chipps Island was used to calculate survival indices from the release location to Chipps Island.

The survival index for fish released at Dos Reis was greater than the index of fish released in Old River for six of the seven studies (Table 1). For the seven studies, the mean survival index for fish released at Dos Reis was 0.24 (range 0.04-0.59) and the mean survival index for fish released in Old River was 0.16 (range 0.01-0.62). Thus, the mean survival index from Dos Reis to Chipps Island was almost 50% greater than the mean survival index from Old River to Chipps Island.

The difference in the mean survival indices of fish released at both locations may actually be greater because indices for fish released at Dos Reis may be underestimated. Some fish released at Dos Reis apparently moved upstream of the Old River split, and were collected at Mossdale (W. Loudermilk, CDFG, personal communication). Fish moving upstream may have then entered Old River as they moved downstream.

It should also be noted that the survival indices likely overestimate the benefits of a barrier at any one export rate. This is due to increased movement of water toward the CVP and SWP facilities from the lower Old and Middle rivers and other south Delta channels that occurs when a barrier is operated. When the barrier is not operated, fish released at Dos Reis are exposed to differ flow dynamics. Thus, we assume that improvements in fish survival due to a barrier at Old River will be dependent on export levels and flow in the San Joaquin River. See discussion of data for action 1 concerning the relation between chinook salmon survival and escapement relative to flow and exports.

Comparisons of survival indices between juvenile chinook salmon released when the barrier was and was not in operation--Studies to compare survival indices between juvenile chinook salmon released when the a barrier at Old River was and was not in operation were made in 1992 and 1994. In both years, CWT fish were released at Mossdale, upstream of the Old River bifurcation, and collected at Chipps Island. Fish were released before and after a barrier at Old River was constructed.

Five groups of fish were released in 1993, two before the barrier was constructed and three after the barrier was operational. The mean survival index was 0.15 for the period before the barrier was constructed and 0.04 after the barrier was constructed (Table 2). These values were contrary to the expected relation between fish survival and barrier operation. We believe that fish survival may have been influenced by water temperature. Water temperature was 63 and 64°F during the first two studies before the barrier was constructed and increased to 69-72°F during the studies after the barrier was constructed.

To adjust for the effects of water temperature, a correction factor developed for fish released in the Sacramento River (Kjelson and Brandes 1989, USFWS 1991) was applied to the data. The mean survival indices of the adjusted data were 0.10 for fish released before the barrier was constructed and 0.28 for fish released after the barrier was constructed. Conclusions based on these results should be considered tentative because we are uncertain whether the adjustment is appropriate.

In 1994, CWT fish were released at Mossdale on four dates, one before the barrier was constructed and three after the barrier was operational. Survival indices were low for all fish, 0 for those released before the barrier was constructed and 0-0.04 for those released after the barrier was constructed (Table 3). Although survival indices were generally greater for fish released after the barrier was operational than the single value for fish released before the barrier was constructed, we believe these data are inconclusive concerning the effect of the barrier on survival indices. It should be noted that survival indices calculated for fish released at other locations in the San Joaquin River basin and the Sacramento River were relatively low in 1994 (Table 4) and that survival indices of fish released in the San Joaquin River basin have been relatively low in recent years (see tables 1 through 4, Table 5).

Number of marked juvenile chinook salmon recovered at CVP and SWP fish salvage facilities--Numbers of CWT juvenile chinook salmon that were released at Mossdale and recovered at the CVP and SWP fish salvage facilities in 1992 and 1994 were greater for studies conducted before the barrier was constructed than those conducted after the barrier was operational (Table 5). Recoveries before and after the barrier was constructed differed by at least two orders of magnitude in 1992 and at least one order of magnitude in 1994.

Relative to the low survival indices observed for CWT juvenile salmon released in recent years (1992-1996), the number of marked fish recovered at the salvage facilities have similarly declined (Table 5). The decline does not appear to be related to whether the barrier was or was not constructed. The recent low survival indices and recovery of fish at salvage facilities suggest that environmental quality in the lower San Joaquin River and southern Delta has declined relative to conditions in the earlier years of this decade.

Monitoring and evaluation needs: The variable results obtained from studies investigating the relation between survival indices of juvenile chinook salmon and the barrier at the head of Old River indicate that the barrier may improve salmon survival. However, the high variability implies that other factors may be important, or that problems in controlling experimental conditions limit our ability to understand the effects of the barrier on smolt survival.

The variable results may be influenced by differential mortality of study fish from the Merced River Fish Facility and Feather River Hatchery. Studies in 1995 and 1996 indicated that survival indices for Feather River fish were consistently lower than indices for Merced River fish. Existing data are being used to investigate the influence study fish source on survival indices. See Action 1 for details.

Delta Action 2

Because survival indices can be relatively high when a barrier in not constructed and extremely low when the barrier is operational, we assume that factors such as river flow, exports, and water temperature, potentially influence the efficacy of the barrier. The proposed action will evaluate the relation among these factors and the efficacy of the barrier in improving survival indices.

With a barrier at the head of Old River, flow toward the CVP and SWP export facilities may increase in south Delta channels, depending on export levels. The change in flow dynamics in these channels is likely to affect other species, such as delta smelt, winter-run chinook salmon, and striped bass. Improvements afforded by the barrier to survival of chinook salmon emigrating from the San Joaquin River needs to be evaluated relative to the effects on other species and races, and relative to expected export levels.

Some biologists believe that increase in net upstream flows in the central and south Delta can result in fish being drawn toward the export facilities, thus making the fish susceptible to indirect losses such as high temperatures, agricultural diversions, and predation. Losses due to these factors can be exacerbated by an increase in export levels. This may explain the results of our studies in which few CWT fish were captured at Chipps Island or salvage facilities when the barrier was operational. Other biologist believe that a benefit of the barrier is that it reduces direct entrainment of juvenile chinook salmon emigrating from San Joaquin River by preventing fish from entering Old River. The proposed action will assist in reconciling these views.

Citations

California Department of Fish and Game. 1995. Draft head of Old River barrier Department of Fish and Game issue paper. 16 October 1995.

Kjelson, M., and P. Brandes. 1989. The use of smolt survival estimates to quantify the effects of habitat changes on salmonid stocks in the Sacramento-San Joaquin Rivers, California. Pages 100-115, in C. D. Levings, L. B. Holtby, and M. A. Henderson, editors, Proceedings of the National Workshop on Effects of Habitat Alteration on Salmonid Stocks. Canadian Special Publication of Fisheries and Aquatic Sciences 105.

Morhardt, E., P. Baker, and F. Ligon. 1995. Beneficial effects to San Joaquin River salmon smolts of an operable barrier at the head of Old River. 15 November 1995. Prepared for San Joaquin Tributaries Association by EA Engineering, Science, and Technology, Lafayette, California.

State Water Resources Control Board. 1995. Water quality control plan for the San Francisco Bay/Sacramento-San Joaquin Delta estuary. 95-1WR, May 1995, Sacramento.

U. S. Fish and Wildlife Service. 1987. Exhibit 31. The needs of chinook salmon, Oncorhynchus tshawytscha in the Sacramento-San Joaquin Estuary. entered by the U.S. Fish and Wildlife Service for the State Water Resources Control Board 1987 water quality/water rights proceeding on the San Francisco Bay/Sacramento-San Joaquin delta. SSJEFRO, Stockton, California.

U.S. Fish and Wildlife Service. 1989. Abundance and survival of juvenile chinook salmon in the Sacramento-San Joaquin estuary. 1989 Annual Progress Report. SSJEFRO, Stockton, California.

U.S. Fish and Wildlife Service. 1990. Abundance and survival of juvenile chinook salmon in the Sacramento-San Joaquin estuary. 1990 Annual Progress Report. SSJEFRO, Stockton, California.

U.S. Fish and Wildlife Service. 1991. Abundance and survival of juvenile chinook salmon in the Sacramento-San Joaquin estuary. 1990 Annual Progress Report. SSJEFRO, Stockton, California.

U.S. Fish and Wildlife Service. 1992. Abundance and survival of juvenile chinook salmon in the Sacramento-San Joaquin estuary. 1991 Annual Progress Report. SSJEFRO, Stockton, California.

U.S. Fish and Wildlife Service. 1993. Abundance and survival of juvenile chinook salmon in the Sacramento-San Joaquin estuary. 1992 Annual Progress Report. SSJEFRO, Stockton, California.

U.S. Fish and Wildlife Service. 1994. Abundance and survival of juvenile chinook salmon in the Sacramento-San Joaquin estuary. 1993 Annual Progress Report. SSJEFRO, Stockton, California.

U.S. Fish and Wildlife Service. 1995. Draft issue paper on the head of Old River barrier for spring time operations. 6 December 1995. Sacramento-San Joaquin Estuary Fishery Resource Office, Stockton, California.

Table 1. Results of studies comparing survival indices of CWT juvenile chinook salmon from Dos Reis and Old River to Chipps Island.

Release at Dos Reis		Release at Old River	
Date	survival index	date	survival index
30 April 1985	0.59	29 April 1985	0.62
29 May 1986	0.34	30 May 1986	0.20
27 April 1987	0.38[a]	27 April 1987	0.16
20 April 1989	0.14	21 April 1989	0.09
2 May 1989	0.14	3 May 1989	0.05
16 April 1990	0.04	17 April 1990	0.02
2 May 1990	0.04	13 May 1990	0.01
Mean	0.24		0.16

[a]Original survival estimate (0.82) was modified based on the ratio of ocean recovery rates between the Dos Reis and Old River releases.

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Table 2. Results of studies comparing survival indices of CWT juvenile chinook salmon from Mossdale to Chipps Island before and after the barrier at Old River was constructed in 1992.

Date	water temperature (°F)	survival	adjusted survival[a]
	before barrier was constructed		
7 April 1992	64	0.17	0.13
13 April 1992	63	0.12	0.07
Mean	--	0.15	0.10
	after barrier was constructed		
24 April 1992	69	0.08	0.25
4 May 1992	71	0.01	0.28
12 May 1992	72	0.02	0.32
Mean	--	0.04	0.28

[a]Values were adjusted by a correction factor developed for fish released in the Sacramento River.

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Table 3. Results of studies comparing survival indices of CWT juvenile chinook salmon from Mossdale to Chipps Island before and after the barrier at Old River was constructed in 1994.

Date	water temperature (°F)	survival
	before barrier was constructed	
11 April 1994	63	0
	after barrier was constructed	
26 April 1994	60	0.04
2 May 1994	66	0
9 May 1994	68	0.02
Mean	--	0.02

Table 4. 1994 chinook salmon smolt survival indices for fish released at sited other than Mossdale. No values for survival indices indicates that no fish were recovered.

Release location	Release date	Water temperature (F)	Survival index	Combined fish recoveries at the CVP and SWP
Ryde	April 12	62.5	0.20	0
Georgian Slough	April 12	62	0.06	0
Jersy Point	April 13	64	0.19	16
Ryde	April 25	62	0.18	0
Georgian Slough	April 25	62	0.11	0
Jersy Point	April 27	63	0.28	0
Miller Park	May 3	67	0.07	0
Miller Park	May 24	67		
Lower Old River	April 11	62		94
Lower Old River	April 26	62		84
Mossdale	April 11	63		752
Mossdale	April 26	60	0.04	0
Mossdale	May 2	66		36
Mossdale	May 9	68	0.02	13
New Hope Landing	May 23	67	0.16	0
New Hope Landing	May 23	67	0.18	0
combined group survival			0.17	
New Hope Landing	May 10	68	0.09	12
New Hope Landing	May 10	68	0.12	31
combined group survival			0.11	
Merced Hatchery	April 22	not available	0.04	27
Merced Hatchery	April 22	not available	0.04	49
Merced Hatchery	April 22	not available	0.08	28
Merced Hatchery	April 22	not available	0.04	24
combined group survival			0.05	
Lower Merced	April 22	not available		26
Lower Merced	April 22	not available	0.07	54
Lower Merced	April 22	not available		80
combined group survival			0.07	
Upper Tuolumne	April 23	not available	0.07	19
Upper Tuolumne	April 23	not available	0.03	24
Upper Tuolumne	April 23	not available		4
combined group survival			0.03	
Lower Tuolumne	April 24	not available	0.37	48
Lower Tuolumne	April 24	not available	0.37	38
combined group survival			0.37	

Table 5. Water temperature, survival index from Mossdale to Chipps Island, and recovery of CWT fish at CVP and SWP facilities during 1992-1996. Survival indices adjusted for temperature are given in parentheses (see text for explanation). Each release group consisted of about 50,000 fish.

Date	water temperature (°F)	survival	recovery at CVP and SWP facilities[a]
7 April 1992[b]	64	0.17(0.13)	5451
13 April 1992[b]	63	0.12(0.07)	3491
24 April 1992	69	0.08(0.25)	56
4 May 1992	71	0.01(0.28)	36
12 May 1992	72	0.02(0.32)	6
6 April 1993	63	0.04	1332
28 April 1993	64	0.07	1106
4 May 1993	61	0.07	1033
12 May 1993	65	0.07	1445
11 April 1994[b]	63	0	752
26 April 1994	60	0.04	0
2 May 1994	66	0	36
9 May 1994	68	0.02	0
17 April 1995[c]	57	0.22	2768
5 May 1995[c]	62	0.12	1933
17 May 1995[c]	63	0.07	1580
15 April 1996[c]	60	0.02	99
30 April 1996[c]	64	0.01	134

[a]All recoveries are expanded values except those for 1996.
[b]Barrier operational.
[c]Data are from two release groups, survival index is a mean and salvage recovery is a total of the two groups.

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Delta Action 3: This action was not ready for inclusion here at the time of printing, but will be provided separately when available.

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Delta Action 4: Maintain at least 13,000 cubic feet per second (cfs) in the Sacramento River at the I Street Bridge during May to improve transport of eggs and larval striped bass and other anadromous fish, and to reduce egg settling and mortality at low flows. Provide 9,000 cfs at Knights Landing during May.

Description: This action calls for daily minimum flows in the Sacramento River of 13,000 cfs and 9,000 cfs at the I Street Bridge and Knights Landing, respectively, to improve survival of striped bass eggs and larvae and to improve downstream transport of all anadromous fish.

Background: Key involved parties include state and federal resource regulatory agencies, affected water interests, and environmental interests. This proposed action has its foundation in results from long-term monitoring of young striped bass in the Sacramento River. The relationship between an index of survival of Sacramento River spawning cohorts and Sacramento River flow at Sacramento indicates that survival between the egg and 6mm larvae stage is low in the Sacramento River when Sacramento River flows are low, whereas at higher flows (>13,000 cfs) the survival index has been demonstrated to increase in some years. Greater transport flow associated with this standard will also benefit other downstream migrating anadromous fishes. The following is a summary of some of the pertinent biological information to support the daily minimum flow criteria for the Sacramento River of 13,000 cfs at Sacramento, and 9,000 cfs at Knights Landing above the Feather River confluence.

Fish species and life stages benefited: Striped bass, American shad, white and green sturgeon egg and larval life stages, and spring and fall chinook salmon, and steelhead juveniles are the primary beneficiaries of these minimum flow requirements in the Sacramento River during May.

Supporting data:

Historical striped bass population trend--A persistent decline in the juvenile striped bass abundance since the mid to late 1960's and adult striped bass abundance since the early 1970's has been documented by the Department of Fish and Game (CDFG 1987; Exhibit 25). The adult striped bass population has declined from about 1.8 million to about 600,000. The juvenile striped bass index decreased even more, from indices in excess of 100 in the mid-late 1960's to indices averaging less than 20 since the late 1970's (Figure 1). Much of the supporting information for the proposed action that follows is derived from the ongoing annual striped bass monitoring program and subsequent analyses and modeling efforts that have been reported. For more information the reader should refer to the following summary documents: CDFG 1987; Exhibit 2, A re-examination of factors affecting striped bass abundance in the Sacramento-San Joaquin Estuary, and IEP Technical Report 20 1987; CDFG Exhibit 25, Factors affecting striped bass abundance in the Sacramento-San Joaquin River system, and the USFWS Working Paper, 1995 (also see reference section).

Striped bass spawning--Striped bass primarily spawn in two areas: in the Sacramento River mainly from the city of Sacramento to Colusa, and in the western Delta between Antioch and Venice Island (CDFG 1987, Exhibit 25). About one-half to two-thirds of the bass spawn in the

Sacramento River from late April into June (CDFG 1992, Exhibit 2). Survival of eggs and larvae spawned in the Sacramento River is partially influenced by flows in the river (CDFG 1987, Exhibit 25).

Limitations to juvenile striped bass production and its relation to the proposed action--It has been demonstrated that when abundance of early larval life-history stages is low, abundance of the 38mm life stage is also low (Figure 2, and CDFG 1987, Exhibit 25). Thus survival of early larvae partially establishes year class strength in mid-summer, which in turn affects adult recruitment (CDFG 1992, Exhibits 2 and 3). Setting a minimum daily flow requirement in the Sacramento River will benefit egg and larvae survival. Other factors affecting system productivity, such as toxicity and factors affecting increased adult striped bass mortality also may warrant investigation and remediation. However, this proposal specifically focuses on improving river habitat conditions to increase juvenile striped bass survival with the May minimum flow criterium and is consistent with the tools of the CVPIA and its goals for natural fish production.

Relationship between the proposed action and survival of larval striped bass--Information from the early 1970's to the early 1990's documenting the relationship between an index of survival of eggs and larvae in the Sacramento River and flow at Sacramento indicates that survival between the egg and 6mm larva stage is low in the Sacramento River when Sacramento River flows are low (Figure 3). Thus given a minimum daily flow requirement of 13,000 cfs at Sacramento, and a concurrent minimum of 9,000 cfs at Knights Landing, a potential for greater egg and larva survival exists for fish in the Sacramento system during some years. There are four possible mechanisms that may contribute to this relationship.

- At lower flows, eggs and larvae may settle to the river bottom and die when they encounter near zero velocity during periods of flood tides in tidally influenced reaches (CDFG 1992, Exhibit 2).

- Slower transport at low flows may result in lower survival because larvae are delayed in reaching downstream nursery areas where feeding conditions are generally considered to be more favorable (CDFG 1992, Exhibit 2; Figure 4).

- When flows are low, more larvae may die due to longer exposures to higher concentrations of toxic substances that may enter the river (CDFG 1992, Exhibit 2).

- More eggs and larvae would be diverted from the Sacramento River through the Delta Cross Channel and Georgiana Slough (Figure 5 and CDFG 1992, Exhibit 2). While this may not cause immediate mortality, fish will be transported more rapidly to the south Delta where there is a greater risk of entrainment via export operations at the CVP and the SWP pumps (CDFG 992, Exhibit 2).

The relative contribution of these potential mechanisms cannot be sorted out with the existing data, but all are likely to be detrimental (CDFG 1992, Exhibit 2). Thus based on these data, and data summarized for Action 7 relative to juvenile entrainment losses, a reasonable and prudent

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biological approach would be to establish the 13,000 cfs Sacramento flow standard for the month of May.

American shad, sturgeon and chinook salmon production considerations--Juvenile American shad abundance is positively correlated with flow during the primary spawning months, April through June (USFWS, Working Paper, Volume 2, 1995; Figure 6). While this documented relationship is based on Delta outflows, outflow is influenced by, and will sometimes positively co-vary with, Sacramento River inflow; so to some extent outflow is likely a surrogate for inflow. Flow associated factors that may influence juvenile shad survival are likely similar to those influencing juvenile striped bass eggs and larvae. Thus the potential negative effects of lower flows include: reduced survival due to egg and larva settling, greater exposure times to toxins, poor feeding conditions, and greater numbers of juveniles moving to the central and south Delta (USFWS, Working Paper, Volume 2).

Kohlhorst et al. (1991 as cited in the USFWS, Working Paper, Volume 2) found a significant positive correlation between year-class strength of white sturgeon and Sacramento River outflow from April to July. During years with high April to July flow (1982 and 1983), white sturgeon year-class strength was greater than in years between 1975 and 1985 with lower outflows (Figure 7). Mechanisms responsible for increased recruitment are not well defined but are possibly similar to those mentioned above for striped bass and shad.

For chinook salmon, correlation between Sacramento River flows during the smolt emigration period and the number of adults returning to Sacramento River tributaries indicate that flow, or factors related to flow, affect chinook salmon survival and abundance (Dettman et al. 1987). Likewise, mark-recapture studies of fall-run chinook salmon smolts demonstrated that smolt survival through the Delta is positively correlated with Sacramento River temperatures and negatively correlated with the fraction of Sacramento River flow diverted in to the Delta Cross Channel and Georgiana Slough during the April through June emigration period (USFWS 1987). Though no significant relationship between chinook salmon smolt survival and Sacramento River flow has been documented, increases in river flows should contribute to beneficial water temperatures for migrating salmon and possibly reduce the magnitude of negative effects associated with fish migration through the central and south Delta (USFWS 1992). Thus the potential greater flows in May associated with the proposed May daily minimum flows should be beneficial to chinook salmon smolts emigrating through the Sacramento River system during this time. Accrued benefits should also be similar for migrating juvenile steelhead based on life-history similarities between the two species.

Predicted fish benefits: This flow related habitat improvement measure, combined with reductions in juvenile striped bass entrainment, and improvements in water quality will enhance the ability of the striped bass population to recover in future years. The magnitude of striped bass production increase relative to the proposed action is currently unknown and will vary depending on the magnitude of flows that would otherwise be in the river. The information reviewed also suggests that this proposed minimum May flow target should afford survival benefits to sturgeon, American shad, and salmon.

USFWS. 1995. Anadromous Fish Restoration Program, working paper on restoration needs, habitat restoration actions to double natural production of anadromous fish in the Central Valley of California, Volume 2.

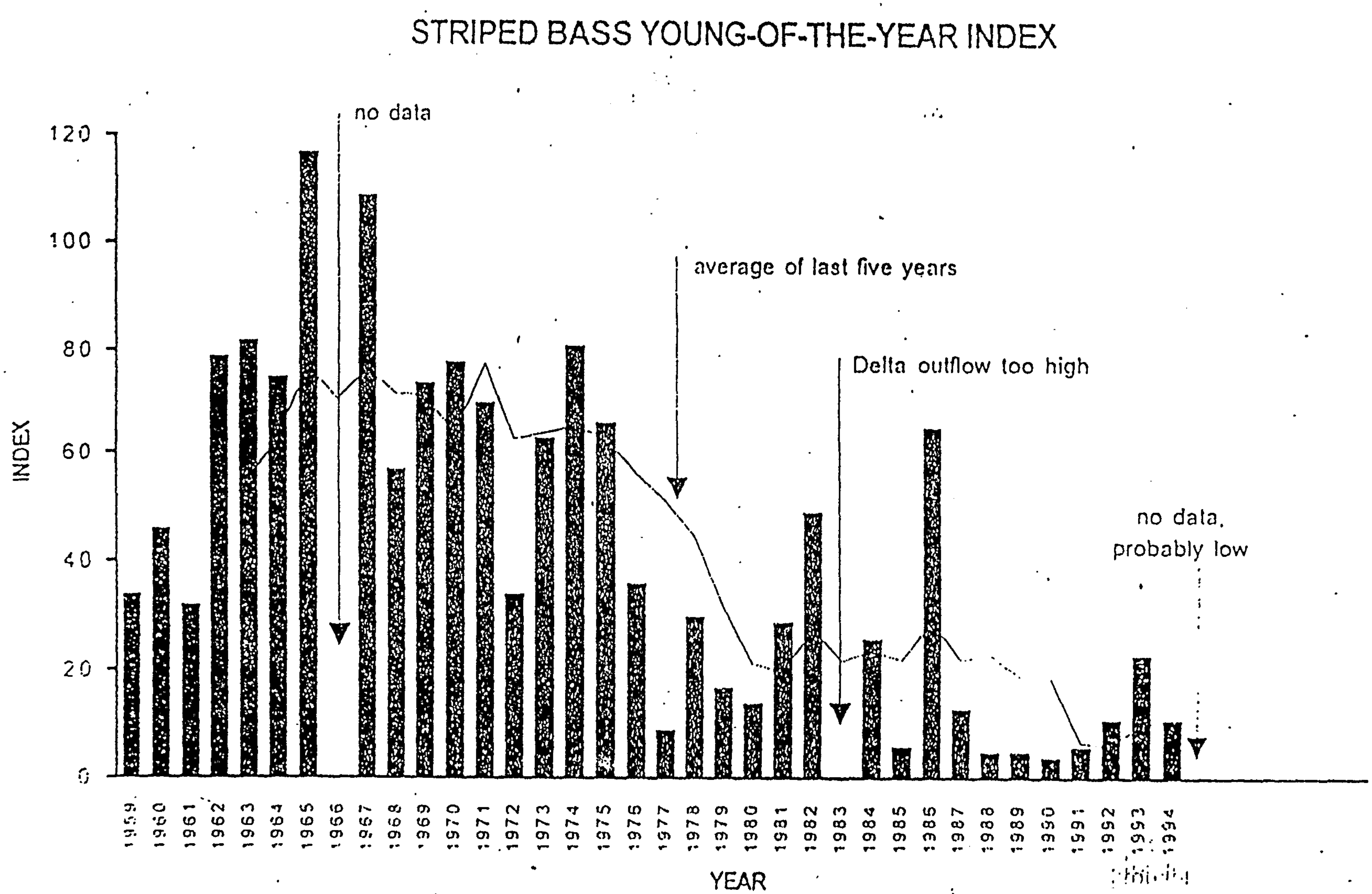

Figure 1. Annual and five year average striped bass young-of-the-year index (mid-summer, 38 mm index) from 1959 through 1994.

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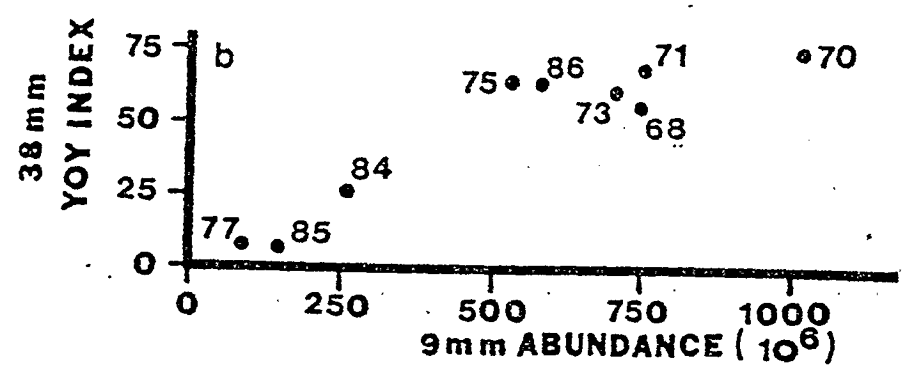

Figure 2. Correlation between abundance of the 9 mm larvae and 38 mm abundance index. The correlation suggests that whatever happens to the larval population is directly reflected in the production of 38 mm bass in mid-summer (source: CDFG, 1987, Exhibit 2).

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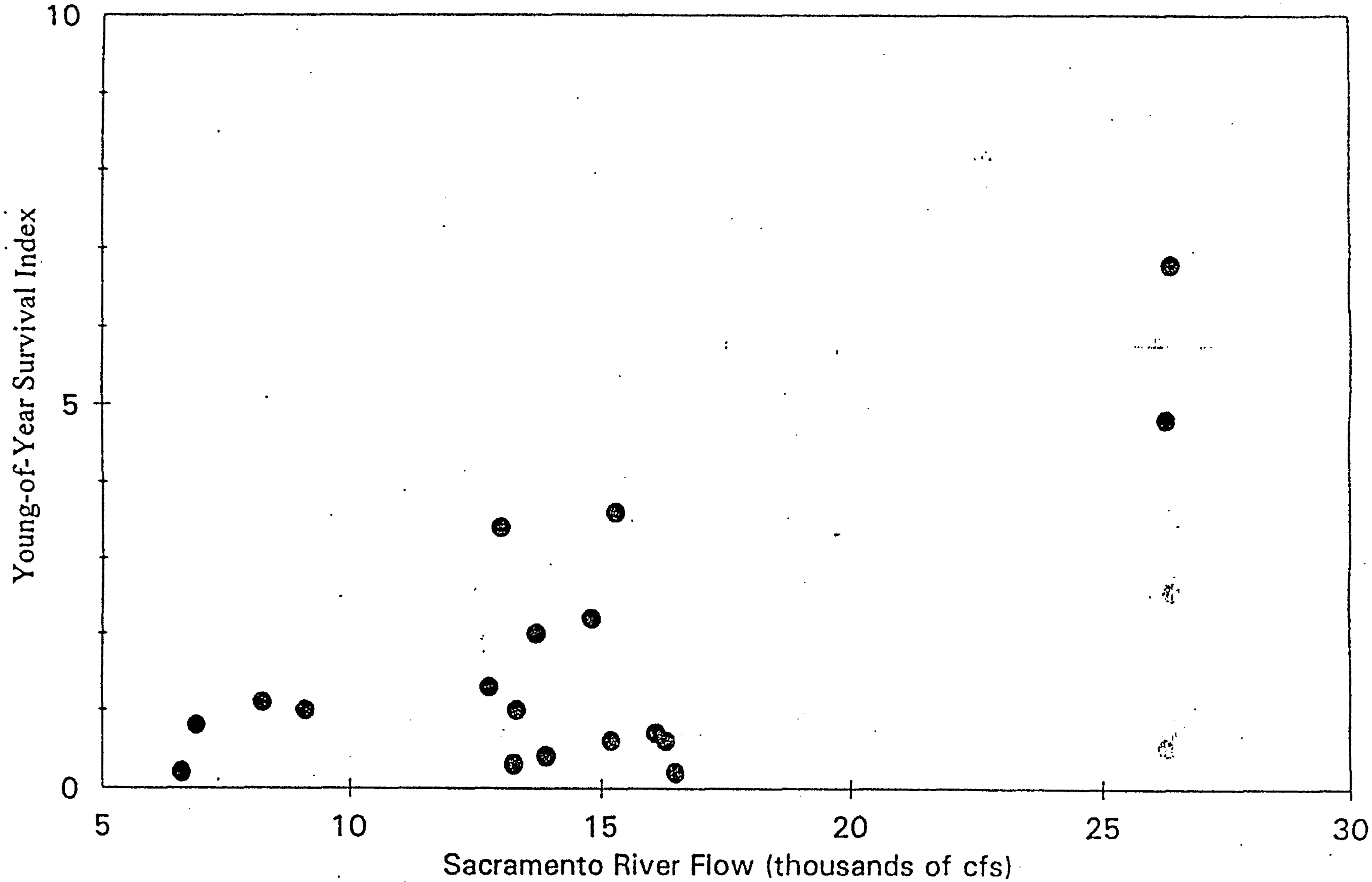

Figure 3. Relationship between survival of striped bass (eggs to 6 mm) and Sacramento River flow (source: USFWS Working Paper, 1995, Volume 2).

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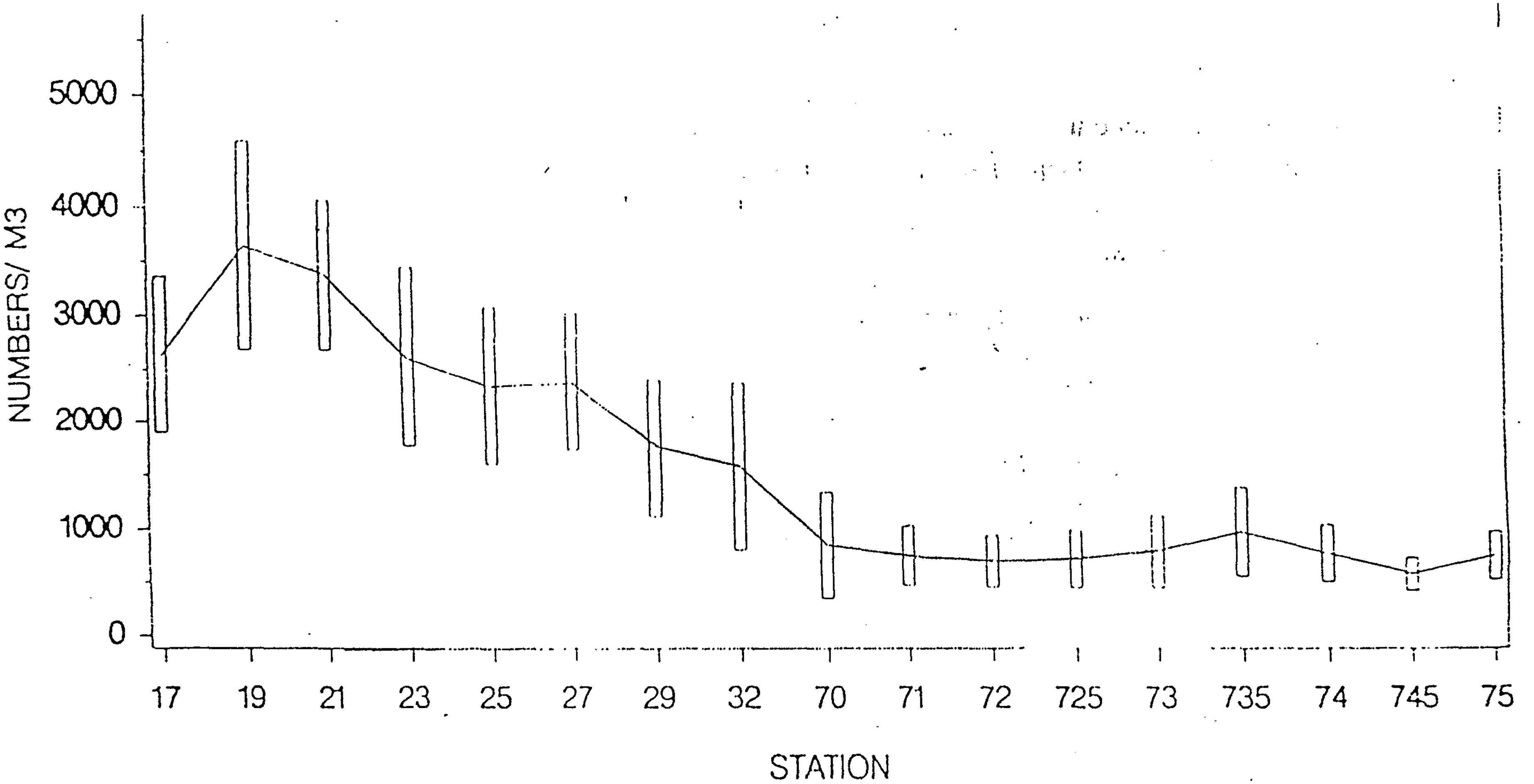

Figure 4. The mean concentration of crustacean zooplankton sampled in the Sacramento River above and below Rio Vista from sampling in 1989, a "low flow" year, by the striped bass egg and larva survey. Stations 70 to 75 and 725 to 745 are located above Rio Vista in the reach between Isleton and Freeport. Stations 17 to 32 are located in the reach from Collinsville to Rio Vista with station 32 located at Rio Vista. The bars represent two standard errors around the mean concentration (source: CDFG 1992, Exhibit 2).

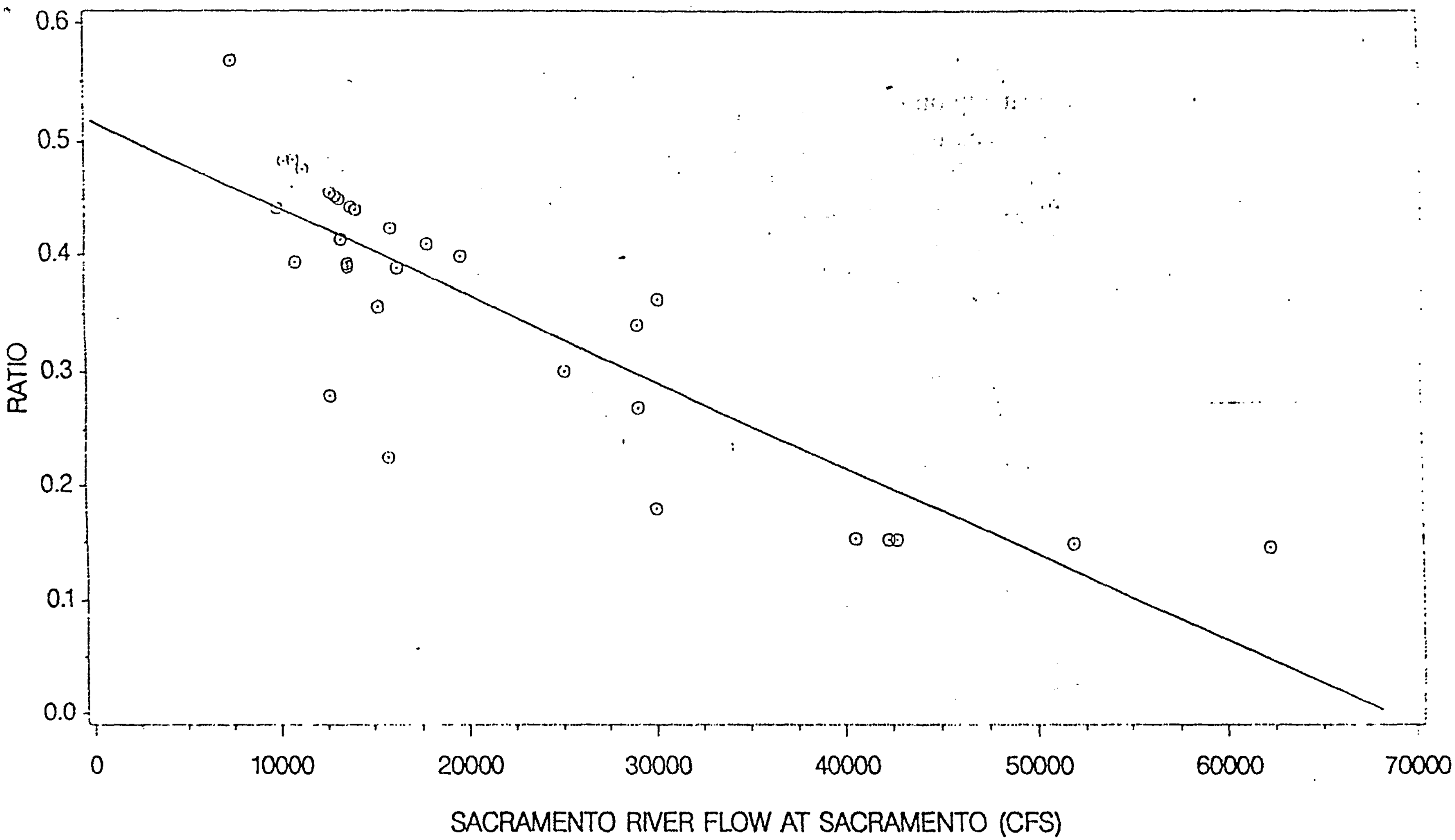

Figure 5. Relationship between the ration of cross delta flow (Delta cross channel and Georgiana Slough flows) to the Sacramento River for the month of May for years 1959-1990 (source: CDFG 1992, Exhibit 2).

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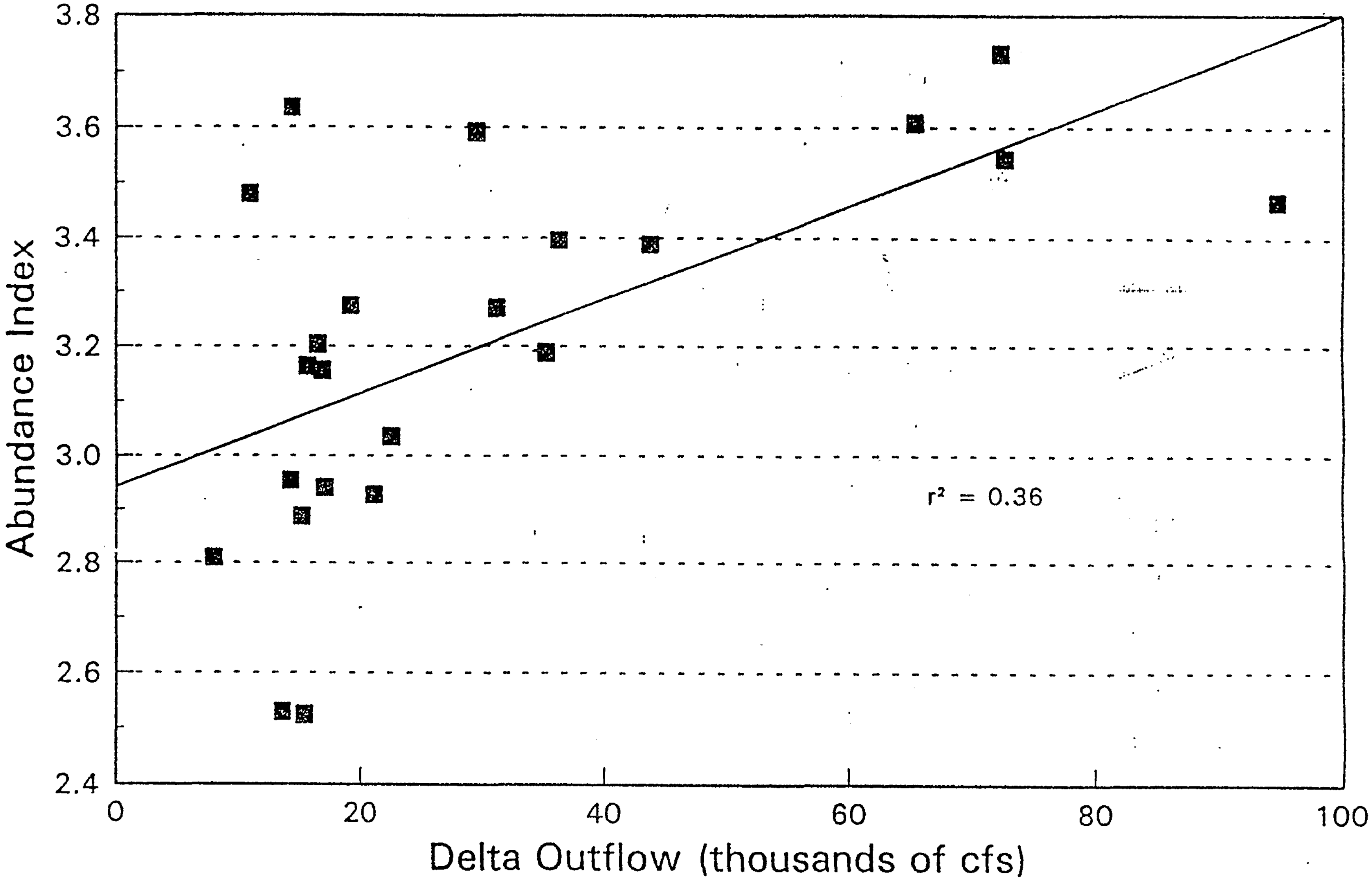
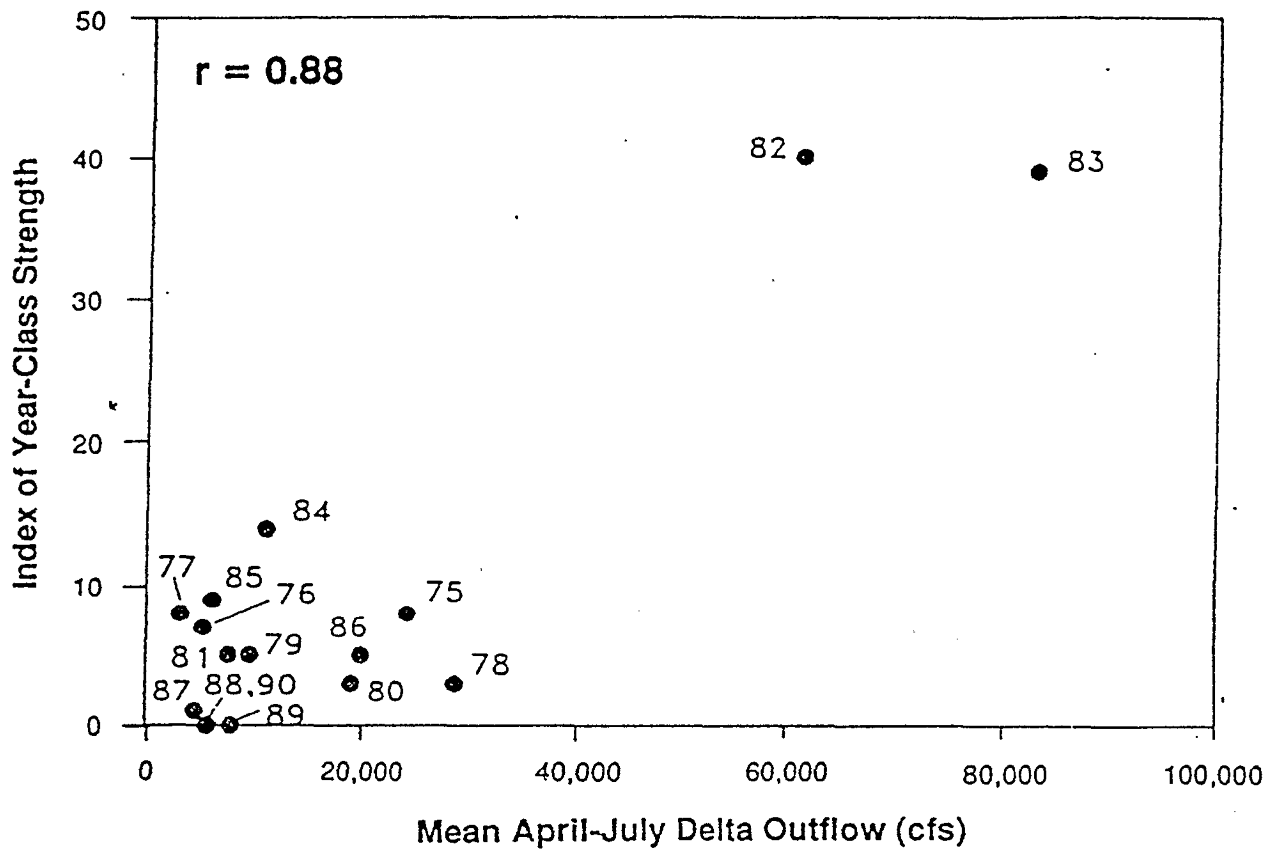


Figure 6. American shad abundance index versus average April through June outflow (cubic feet per second x 1000)from 1967 through 1991 mid-water trawls (source: USFWS Working Paper, 1995, Volume 2).



Note: Year-class index determined from trawl catches.

Figure 7. White sturgeon year-class index versus mean Delta outflow for April through Jul from 1975-1990 (source: Kohlhorst et al. 1991).

Delta Action 5: Ramp (linearly) the total CVP/SWP export level from whatever it is on 5/15 to meet Action 1 to those export levels proposed by projects to meet the 1995 WQCP on June 1, when juvenile salmon are present.

Description: This action is meant to overcome a quick rise in exports in late May when juvenile salmon and other anadromous fish would continue to be vulnerable to a low inflow/export ratio. If temperatures are high and juvenile salmon do not appear to be migrating into the Delta from the San Joaquin basin the action would be suspended. If flow levels and permits allow a barrier at the head of Old River to be used (Action 2), it would continue to be in place with its respective benefits during the proposed ramping.

Background: Between April 15 and May 15, the San Joaquin inflow to CVP/SWP export ratio per the AFRP proposed Delta action 1 can range from 5:1 to 3:1, depending on the water year type. Between May 15 and May 31, exports can increase to levels greater than during the first half of May but still meet the monthly average of 35% of Delta inflow. For example in 1996, the 1995 WQCP allowed export rates to increase from approximately 1500 cfs on May 15 to over 10,000 cfs in less than two weeks time. The extreme change and high absolute level of exports would be detrimental to a variety of anadromous fish that are present in the central and southern delta. Reducing export levels and increasing gradually would provide additional protection for these by allowing a greater fraction of the fall run smolt outmigrants and possible other species to move downstream out of the influence of the pumps.

Fish species and life stages benefited: Juvenile San Joaquin salmon are expected to benefit from the reduction in exports between 5/15 and 5/31. Juveniles of other species such as Striped Bass, steelhead, White and Green Sturgeon and American Shad and other resident species may also benefit.

Supporting data: It is believed that decreasing exports for the later half of May by ramping will benefit the San Joaquin chinook population. The exact benefit for San Joaquin smolts will be contingent on the number of smolts migrating through the Delta and the flow and export levels during the latter half of May.

In some years, at least part of the juvenile salmon population from the San Joaquin basin migrate through the Delta between May 16 and May 31 (figure 1 and 2). Reductions in exports at any one flow level are expected to increase survival of smolts migrating through the Delta (see action 1). This added protection would provide better outmigration conditions for that portion of the population migrating through the Delta during that time. Protecting a greater proportion of the total population would help meet the goals of the AFRP and assure greater genetic diversity within the stock.

Monitoring and evaluation needs: Interagency Ecological Program (IEP) real time monitoring (kodiak trawling) will occur at Mossdale between March 15 and June 30, seven days/week. Daily rotary screw trapping also is proposed for the at the mouth of the Stanislaus. Both sites will provide data to determine if Action 5 is necessary and for how long. See discussions of actions 1 and 2 for additional evaluations.

Citations

California Department of Fish and Game (DFG), 1995. Annual Performance Report, Federal Aid in Sport Fish Restoration Act. Grant Agreement No: F-51-R-6, Project No. 38, Job No. 4: Index and Estimate San Joaquin Drainage Salmon Smolt Production.

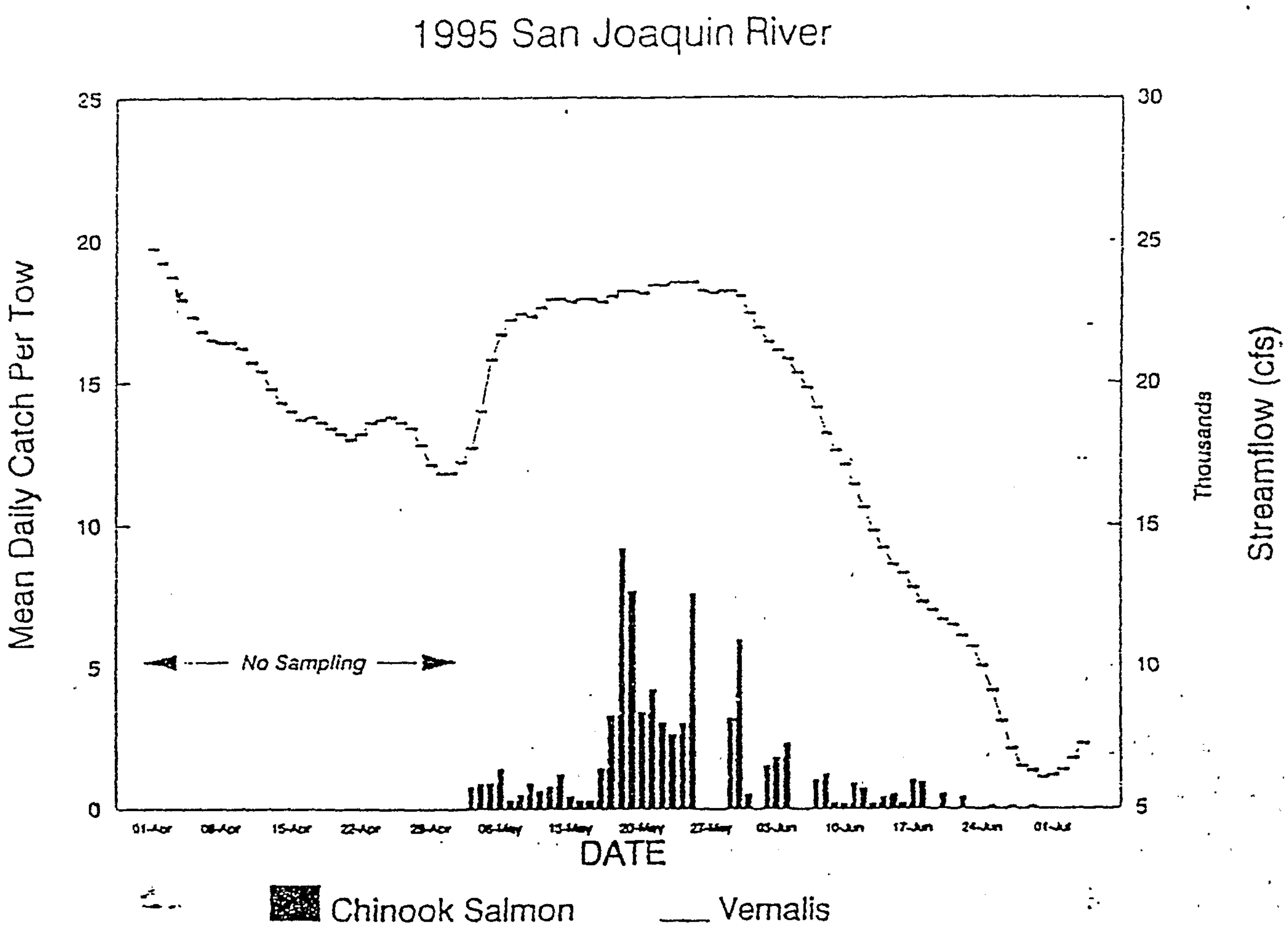


Figure 1. Mean Daily Catch (KS/10-minute Tow) of Natural San Joaquin Fall-Run Chinook Salmon in the Kodiak Trawl at Mossdale and San Joaquin River Mean Daily Streamflow as Measured at Vernalis (U.S. Geological Survey Gauging Station), 1995

Source: CDFG, 1995

CHINOOK SALMON MEAN DAILY CATCH (KS/10 MINUTE TOW) IN THE KODIAK TRAWL AT MOSSDALE FROM 1988 TO 1993.

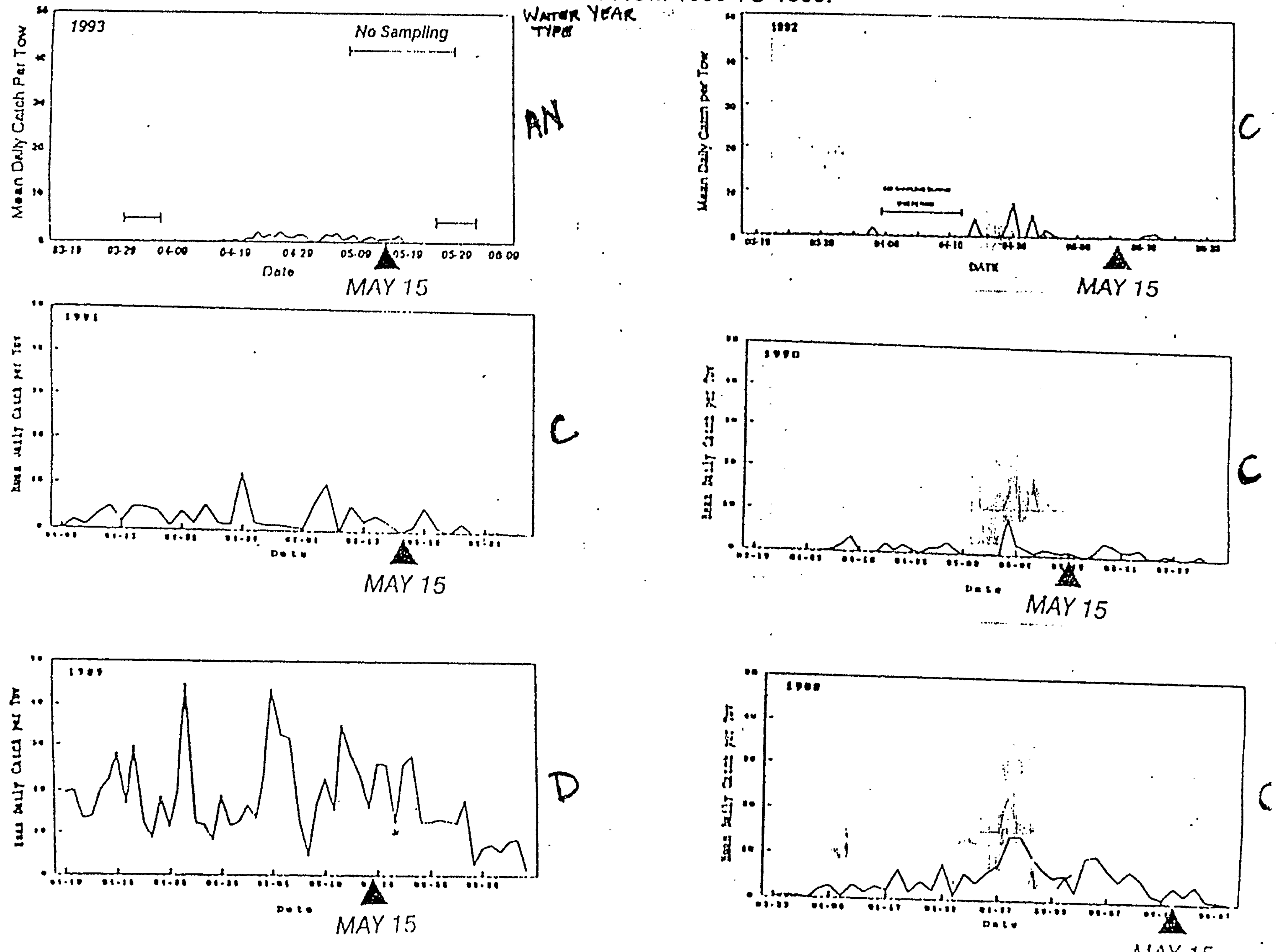


Figure 2 Source: Bill Loudermilk, personal communication

Delta Action 6: Close the Delta Cross Channel (DCC) starting on November 1.

Description: The AFRP action is intended to augment the Accord by providing gate closures for an additional three month period (November 1- January 31).

Background: The cross channel gates have been closed between February 1 and April 30 as a winter run protection measure since 1993. The Delta accord further extended closure of the Delta cross channel until May 20, with provisions for potential closures between November and January and after May 20 until June 14. The Delta Accord and 1995 WQCP call for the closure of the Delta cross channel gates for up to a maximum of 45 days between November 1 and January 31, to be decided by the CALFED operations group. NMFS has provided draft guidelines on triggers for gate closures during this period. Closures are needed for flood control when flows at Freeport are above 25,000 cfs and also have been made in the fall when water quality impacts were negligible (fall of 1995). This action has a potential impact of lessening water quality in the Delta below that required under the 1995 WQCP unless increases in Delta outflow are provided.

Fish species and life stages benefited: Fall, late fall and tributary spring yearling and winter run fry chinook salmon may all benefit from closing the cross channel starting on November 1. Figure 1 and 2 document the abundance of juvenile salmon between November and January entering the Delta and within the Delta.

Supporting data: Several pieces of data based on results of mark and recapture work using juvenile chinook salmon indicate a benefit associated with closing the cross channel gates at a variety of lifestages. Specific data for the various lifestages follows:

Fry: Coded wire half tagged (CW1/2T) fall run salmon fry released between 1981 and 1986, indicate that smolts released into the Central Delta in low flow years survive at a lower rate than those released on the mainstem Sacramento River (table 1).

Smolts: Through mark and recapture experiments, it has been found that fall run chinook salmon smolts released above the cross channel gates on average survive to the western Delta at a greater rate than those released below the cross channel gates. Survival is increased by about 50% by closing the cross channel gates using two independent estimates of survival (table 2). Although critics of this result believe the data is biased from results of one group released above the opened cross channel gates (Courtland) at high temperatures, similar high temperatures were present for the paired below cross channel gate release making relative comparisons generally valid. Furthermore a release into Steamboat Slough on the same day at the same high temperature survived at a much greater rate than those released at Courtland (USFWS, 1996).

Poor relative survival in the Central Delta versus that in the mainstem river is further confirmed from marked smolt releases made at Courtland, Ryde and in the North and South Forks of the Mokelumne river in 1983-1986 (USFWS, 1992) and paired releases made at Ryde and into Georgiana Slough between 1992-1994 (table 3 and table 4).

Yearlings: Additional experiments using marked late fall yearlings in December and January, indicate that survival also is less for late fall juveniles released into Georgiana Slough versus those released at Ryde. There is no indication that the larger late fall released at low temperatures survive at a better rate in the central delta than fall run (table 3). Experiments conducted in December of 1996, also showed high survival for yearlings released at Courtland and Ryde with the gates closed compared to those released into Georgiana Slough (table 5).

Monitoring and evaluation needs: Kodiak or midwater trawl sampling will be conducted on the Sacramento River near Sacramento between October and June to index juvenile salmon immigration into the Delta. Additional monitoring using a rotary screw trap may be done on the Sacramento River near Knights Landing. This combined monitoring can be used to determine if the timing of such action regarding the cross channel gate closure is warranted. Additional mark and recapture work would be necessary to further document the benefits. It has been suggested that the benefit of the closing the cross channel be further tested using CWT late fall or fall run hatchery smolts released at Coleman National Fish Hatchery. Two groups would be released, one with the gate open and one with the gate closed and the survival index to the western Delta (Chipps Island) compared. Both marked late fall and fall run juveniles will be released at Sacramento to index survival through the Delta under conditions of the Delta accord, including closure of the cross channel gates.

Citations

USFWS, 1992 . Measures to Improve the Protection of Chinook Salmon in the Sacramento/San Joaquin River Delta. Expert Testimony of U.S. Fish and Wildlife Service on Chinook Salmon Technical Information for State Water Resources Control Board Water Rights Phase of the Bay/Delta Estuary Proceedings. July 6, 1992 WRINT-USFWS-7.

USFWS, 1996. U.S. Government Memorandum to Lisa Holsinger (NMFS) from Pat Brandes (USFWS) regarding Benefit of closing the cross channel gates dated July 8, 1996.

Table 1: Ocean recovery rates of coded wire half tag (CW1/2T) fry released in the Delta at Ryde or Isleton on the Sacramento River and in the Central Delta (Lower, North Fork or South Fork Mokelumne River). The ratio (Ryde/Mokelumne) reflects the relative difference in survival between the two areas of the Delta.

YEAR	RELEASE SITE	RECOVERY RATE	NORTH & SOUTH FORK MEAN	RATIO
1981	Isleton	0.001013		2.0
	Lower Mokelumne River	0.000506		
1982	Isleton	0.000657		1.2
	Lower Mokelumne River	0.000539		
1983	Isleton	0.000482		0.9
	Lower Mokelumne River	0.000557		
1984	Ryde	0.002440		2.1
	North Fork Mokelumne River	0.001447	.001156	
	South Fork Mokelumne River	0.000866		
1985	Ryde	0.001815		1.2
	North Fork Mokelumne River	0.001506	.001503	
	South Fork Mokelumne River	0.001500		
				$\bar{x}$ ratio 1.5

Table 2: Indices of survival to Chipps Island and ocean recovery rates for CWT fall run smolts released above and below the Cross Channel gates with the gates open and closed between 1984-1989. When the below to above ratio's (B/A) are compared with the gates open versus closed an estimate of the benefit associated with closing the Cross Channel gates is obtained.

Smolt Survival Estimates

	Year	Above	Below	B/A
Cross Channel Open	1984	0.70	0.73	1.0
	1985	0.34	0.77	2.3
	1986	0.37	0.68	1.8
	1987	0.41	0.88	2.1
	1988	0.73	1.27	1.7
	1988	0.02	0.34	17.0
	1989	0.84	1.20	1.4
	1989	0.35	0.48	1.4
	1989	0.22	0.16	0.7
				Average=3.3
Cross Channel Closed	1983	1.22	1.39	1.1
	1987	0.66	0.84	1.3
	1988	0.68	0.93	1.4
	1988	0.17	0.40	2.4
				Average=1.6

Ocean Recovery Rates

	Year	Above	Below	B/A
Cross Channel Open	1984	.0064	.0045	0.7
	1985	.0038	.0086	2.3
	1986	.0171	.0195	1.1
	1987	.0142	.0203	1.4
	1988	.0091	.0248	2.7
	1988	.0007	.0053	7.6
	1989.	.0048	.0082	1.7
	1989	.0008	.0016	2.0
	1989	.0009	.0002	0.2
				Average=2.2
Cross Channel Closed	1983	.0044	.0040	0.9
	1987	.0198	.0315	1.6
	1988	.0111	.0204	1.8
	1988	.0097	.0046	0.5
				Average=1.2

Table 3: Survival indices for smolts released at Ryde and Georgiana Slough in 1994, 1993 and 1992 and the ratio of survival between the two paired groups. Numbers in parentheses are raw recovery numbers at Chipps Island.

Date	Ryde	Georgiana Slough	Ryde/Georgiana Slough ratio
FALL RUN			
4/12/94	0.198 (11)	0.054 (3)	3.7
4/25/94	0.183 (11)	0.117 (6)	1.5
4/14/93	0.41 (23)	0.13 (7)	3.2
5/10/93	0.86 (43)	0.29 (15)	3.0
4/06/92	1.36 (78)	0.41 (23)	3.3
4/14/92	2.15 (97)	0.71 (41)	3.0
4/27/92	1.67 (93)	0.20 (11)	8.4
LATE FALL RUN			
12/2/93	1.91 (37)*	0.28 (5)	6.8
12/5/94	0.57 (15)*	0.16 (4)	3.6
1/4/95	0.33 (11)	0.12 (4)	2.8
1/10/96	0.66 (21)	0.17 (5)	3.9

* Actual release made at Isleton, about 5 miles downstream of Ryde.

Table 4: Ocean recovery rates of the Ryde and Georgiana Slough release groups of 1992, and 1993 also the ratios (Ryde: Georgiana Slough) of these ocean recovery rates.

Release Date	Ryde	Georgiana Slough	Ryde/Georgiana Slough Ratio
4/6/92	0.0066	0.0028	2.38
4/14/92	0.0116*	0.0045	2.26
4/27/92	0.0040	0.0006	6.67*
4/14/93	0.0092	0.0033	2.78
5/10/93	0.0204	0.0056	3.64

*The Ocean recovery Rate for the 1992 release made at Ryde is under estimated due to the fact some (10,500) of the release was inadvertently released at Georgiana Slough by mistake. The ratio then, is also biased low.

Table 5: Survival indices to Chipps Island for late fall run CWT yearlings released in January of 1996.

Release Site	Survival Index
Courtland	.78
Ryde	.66
Georgiana Slough	.17

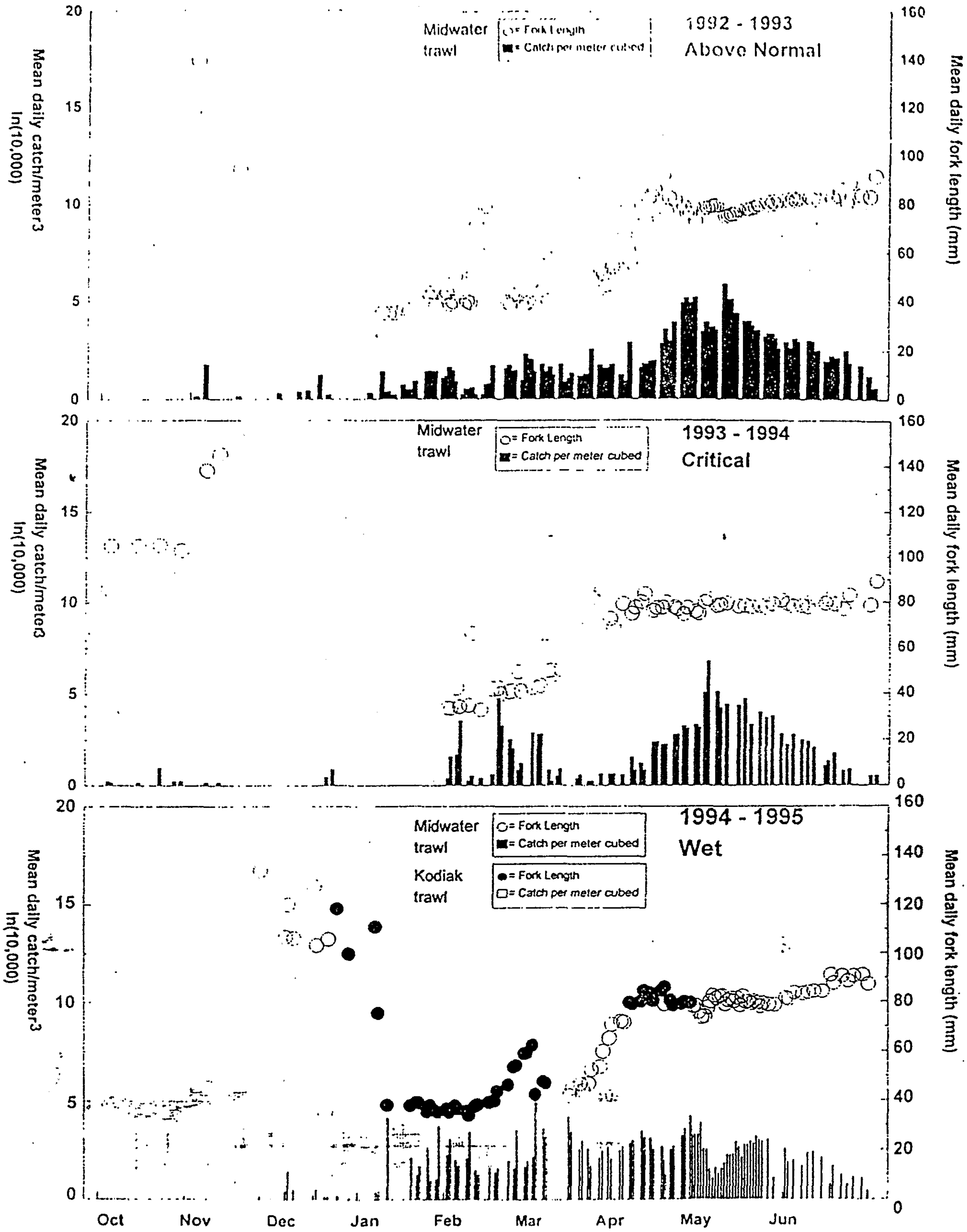
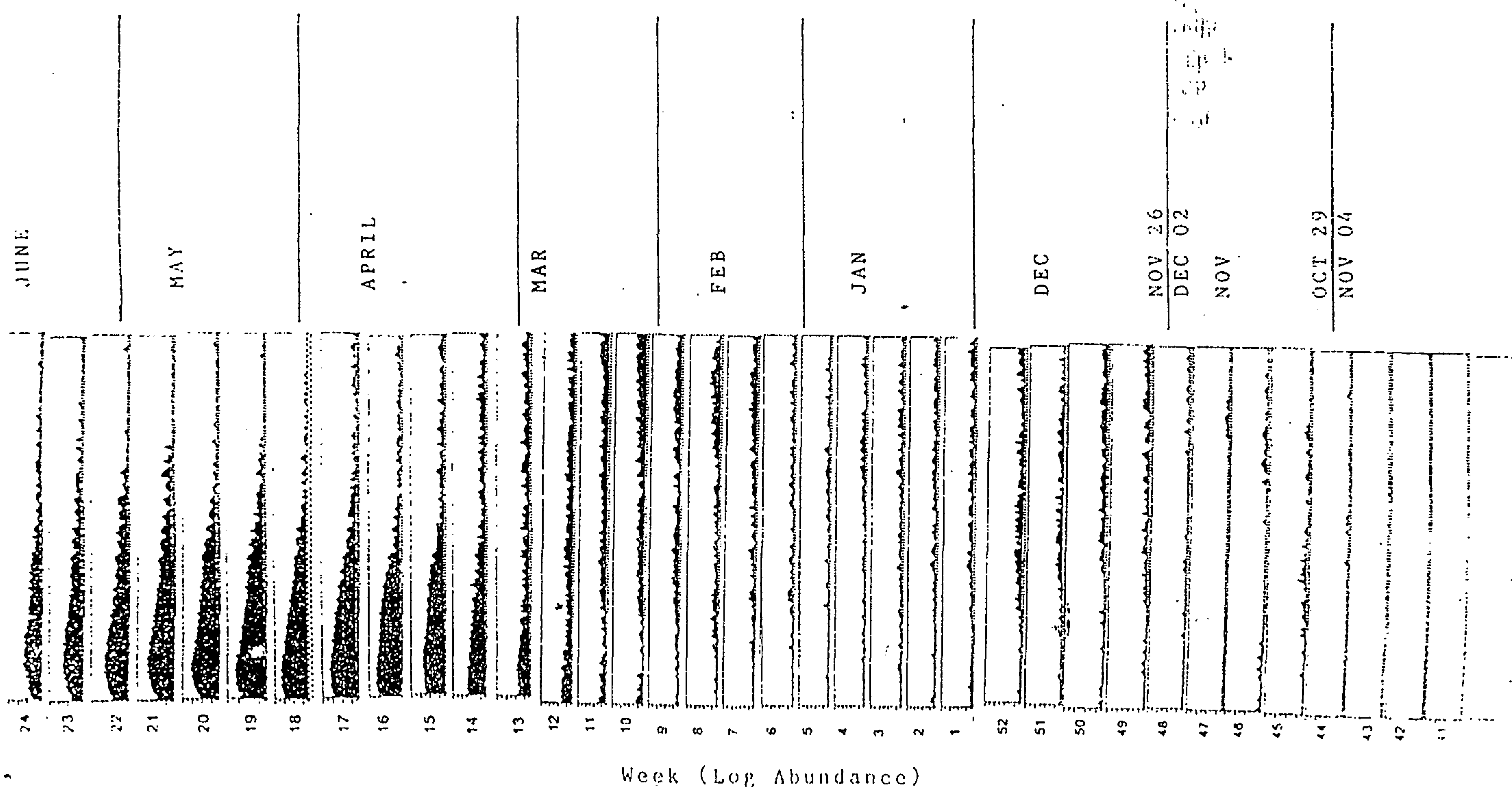


Figure 1. Sacramento midwater and kodiak trawl juvenile chinook catch per cubic meter and mean fork length from October - June for the years 1993, 1994, and 1995.

FIGURE 2

A series of graphs one for each week, between the end of October through June, depicting the log of abundance of juvenile salmon in the Delta (y axis) versus size (between 70mm to 300mm). Data was obtained from several sources, Sacramento trawl, Chipps Island trawl and beach seine (1991-1993), Montezuma Slough and fyke nets at Sacramento (1992-1993), rotary screw trap in the cross channel and push net (throughout Delta, 1993), fish facility recoveries from the CVP and SWP between 1980 and March of 1994. Tagged fish were excluded with the exception of fish facility recoveries between 1980 and 1991.



C-043462

Delta Action 7: CVP/SWP export limitation of 35% or less of Delta inflow during July Action sub-priority: a) July 1 to July 15 and b) July 15 to July 31

Description: This action calls for State and Federal water contractors to limit Delta exports to not more than 35% of total Delta inflow during July, extending juvenile anadromous fish protection from potential entrainment losses at the pumps. This is a continuation of the protective Delta export:inflow ratio of 35% already in place for February through June according to State Water Resources Control Board (SWRCB) water quality standards and operational constraints.

Background: Key involved parties include state and federal resource regulatory agencies, agriculture and urban water interests, and environmental interests. The Delta habitat objective of a 35% limitation on export:inflow ratio in July was preceded by a similar February through June limitation that was established by the 1994 Bay-Delta Accord, and incorporated in the May, 1995 SWRCB Water Quality Control Plan. A goal of these water quality standards is to provide interim comprehensive ecosystem protection for the Bay/Delta system. The export:inflow limitation proposed for the month of July is in addition to the conditions established by the Bay-Delta Accord, with its main objective the maintenance of more favorable Delta hydrology in an effort to reduce juvenile anadromous fish mortality associated with water exports. This habitat objective will further contribute to the goals of the Accord, as well as contribute to the goals of the Anadromous Fish Restoration Program (AFRP).

The following is a summary of some of the pertinent biological information and justification that has led to the development of the July export:inflow ratio limitation to support increased survival of juvenile striped bass and other anadromous fish.

Fish species and life stages benefited: Striped bass, American shad, and white and green sturgeon juveniles are the primary beneficiaries of maintaining the Delta export:inflow ratio at 35% through July.

Supporting data:

Historical striped bass population trend--Persistent declines in the juvenile striped bass index (38 mm index) since the late 1960's and in adult abundance since the early 1970's have been documented by the Department of Fish and Game (CDFG 1987; Exhibit 25). The adult striped bass population declined by two thirds in that time, to a present population of about 600,000. The juvenile striped bass index decreased even more, from indices in excess of 100 in the mid to late 1960's to indices averaging less than 20 since the late 1970's. (Figure 1). During this period, combined Delta exports at State Water Project (SWP) and Federal Water Project (CVP) pumps have continually increased (Figure 2). Much of the supporting information for the proposed action that follows is derived from the ongoing annual striped bass monitoring program and subsequent analyses and modeling efforts that have been reported. For more information, see the following summary documents: CDFG 1992; Exhibit 2, A re-examination of factors affecting striped bass abundance in the Sacramento-San Joaquin Estuary, and IEP Technical Report 20

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1987, CDFG Exhibit 25, Factors affecting striped bass abundance in the Sacramento-San Joaquin River system.

Striped bass spawning--Striped bass spawn in two areas: in the Sacramento River spawning occurs mainly from the city of Sacramento to Colusa; the San Joaquin population generally spawns in the western Delta between Antioch and Venice Island (CDFG 1987, Exhibit 25). Most spawning in the Delta occurs from April through May, with ambient salinity conditions playing an important role in specific location (CDFG 1992, Exhibit 2). After spawning, young striped bass rear in the Delta and Suisun Bay. The distribution of young striped bass in their first few months of life is largely influenced by the magnitude of outflow and Delta water exports. Young striped bass residing in the central and south Delta are vulnerable to being entrained by SWP and CVP pumping operations (CDFG 1987, Exhibit 2).

Production limitations--For fish abundance to decline, productivity must decrease or mortality must increase. The thesis that we predicate our July export:inflow ratio on is that recruitment of 3-year-old striped bass has continued to decline based on an increase in mortality, predominately during the first year of life, and caused largely by increased losses of juvenile fish entrained in water exports by the State and Federal Water Projects (CDFG 1992, Exhibit 2). Other factors affecting system productivity, such as toxicity and increased adult striped bass mortality also may warrant investigation and remediation. However, we propose to create improved Delta habitat conditions in July using the tools of the CVPIA in an attempt to reduce juvenile striped bass entrainment at the SWP and CVP pumps.

Limitations to juvenile striped bass production and its relation to the proposed action--To support the hypothesis that entrainment losses of larval and juvenile striped bass can partially be mitigated by the July export:inflow limitation, we primarily rely on information summarized and presented by the CDFG in their exhibits presented to the State Water Resources Control Board, 1992.

- Losses of young bass entrained in the water project diversions constitute a significant portion of the population. Since 1970 annual total estimated losses of juvenile striped bass (21mm to 150mm) have been conservatively estimated to constitute 14% to 58% of the estimated abundance of young bass in the Estuary depending on assumptions related to sampling efficiencies (CDFG 1992, Exhibit 2, Page 35). The magnitude and annual trend in estimates of juvenile striped bass losses at SWP and CVP Delta pumping facilities from 1957 to 1989 is presented in Figure 3. In terms of yearling equivalents, peak losses occur in July. Large losses also occur in May, June and August, and a secondary peak occurs later in the year from November through January (Brown 1992; Figure 4).

- Prior to 1970, juvenile striped abundance was closely related to the percentage inflow diverted (Figure 5). As percent of effective inflow diverted increased striped bass abundance decreased. This relationship explained nearly 80% of the dependent variable (juvenile striped bass index) response. As export:inflow ratios increased above 35% the YOY index declined.

While these percentages include internal Delta use, this relationship indicates that juvenile striped bass entrainment losses would be reduced if water exports were reduced.

- After the SWP began pumping large amounts of water in about 1970, the abundance of striped bass began to decline (Figure 1). This decline has persisted through the early 1990's and has been most distinct in the Delta, the area most affected by diversions, compared to downstream habitats such as Suisun Bay (CDFG 1992, Exhibit 2, page 19 and Figure 6).

- Regression analysis suggests that during the period of 1959-1990, April through July and May through July, outflow and water exports account for 65% and 73%, respectively, of the variability in the fraction of the young striped bass population residing in the Delta (CDFG 1992, Exhibit 2, Table 4). Delta outflow and water export rates interact to affect the distribution of juvenile striped bass residing in the Estuary and entrainment losses. Over a range of flows, similar export reductions will have a greater relative benefit in drier years, when greater proportions of juvenile striped bass reside in the Delta (Figure 7).

- The magnitude of estimated percentage reductions in abundance due to losses of striped bass eggs and larvae entrained in water projects is substantial. Such losses have been estimated (CDFG 1987, Exhibit 25, pages 70 to 78) to cause from 31% to 99% reductions in the population before young bass reach the 20 mm stage (also see CDFG 1992, Exhibit 2, page 34). This is significant as it has been demonstrated that mid-summer juvenile striped bass abundance, as described by the 38mm index, is at least partially determined by the abundance of larvae. This juvenile index, and subsequent entrainment losses, in turn largely determines subsequent recruitment of adults (CDFG 1992, Exhibits 2 and 3).

Based on these data, water exports reduce abundance of young striped bass, and if a year class gets off to a poor start it reduces adult recruitment. These results are consistent with a conclusion that more restricted July exports will provide additional protection to juvenile striped bass which in turn will benefit adult recruitment.

American shad and sturgeon production considerations--Juvenile American shad are the third most common fish species salvaged at the CVP and SWP pumping facilities with thousands of fish salvaged annually and thousands more lost to other diversions (USFWS, Working Paper, Volume 2, 1995). The bulk of the juvenile American shad entrainment at these facilities occurs from July through December. However, Evaluations of screening efficiencies comparable to studies for striped bass have not been conducted, consequently the proportion of entrained juveniles has not been quantified. It has been estimated that salvaged American shad suffer mortality rates in excess of 50% in the summer months and the proposed July export limitation would help reduce this value (USFWS, Working Paper, Volume 2, 1995).

Larval and juvenile sturgeon are transported downstream primarily by river currents and are susceptible to entrainment associated with water export pumping. Magnitude of these entrainment losses and effects on population abundance are currently unknown (USFWS, Working Paper, Volume 2, 1995).

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Benefits: The magnitude of striped bass production increase relative to the proposed action is currently unknown but could be addressed through modeling simulations using estimates of juvenile entrainment for various water year scenarios. Sturgeon and American shad will also likely benefit from reduced export pumping in July. Changes in flow patterns associated with reduced export pumping also may result in fewer young fish being transported to the south Delta where entrainment and associated losses are great.

Monitoring and evaluation needs: Current fisheries monitoring implemented through the Interagency Ecological Program (IEP) will document effects of the proposed action. Currently, the striped bass monitoring efforts assess both juvenile and adult population attributes and provide valuable long-term population trend information relative to Delta and estuarine conditions.

Summary: The loss of juvenile striped bass to July export pumping in the Delta is well documented. This information suggests that providing additional protection to juvenile striped bass from entrainment losses in July by limiting the export:inflow ratio at 35% will provide increased survival during their first year of life. This is turn will contribute to increased adult abundance which along with other coordinated improvements to Delta operations for the benefit of anadromous fish, will likely allow fishery production benefits to accrue more rapidly.

Citations

Brown, R.L. 1992. Bay/Delta fish resources. WRINT DWR-30, State Water Resources Control Board, 1992 Proceedings, Sacramento, CA.

California Department of Fish and Game. 1987. Factors affecting striped bass abundance in the Sacramento-San Joaquin River system. Exhibit 25, entered by the California Department of Fish and Game for the State Water Resources Control Board 1987 water rights proceeding on the San Francisco and Sacramento-San Joaquin Delta.

California Department of Fish and Game. 1992. A re-examination of factors affecting striped bass abundance in the Sacramento-San Joaquin Estuary. WRINT-DFG-Exhibit 2, entered by the California Department of Fish and Game for the State Water Resources Control Board, 1992, water rights phase of the Bay-Delta estuary proceedings.

Kohlhorst, D.W., D.E. Stevens, and L.W. Miller. 1992. A model for evaluating the impacts of freshwater outflow and export on striped bass in the Sacramento-San Joaquin estuary. WRINT-DFG-Exhibit 3, entered by the California Department of Fish and Game for the State Water Resources Control Board, 1992, water rights phase of the Bay-Delta estuary proceedings.

USFWS. 1995. Anadromous Fish Restoration Program, working paper on restoration needs, habitat restoration actions to double natural production of anadromous fish in the Central Valley of California, Volume 2.

C-043467

STATE AND FEDERAL DELTA EXPORTS

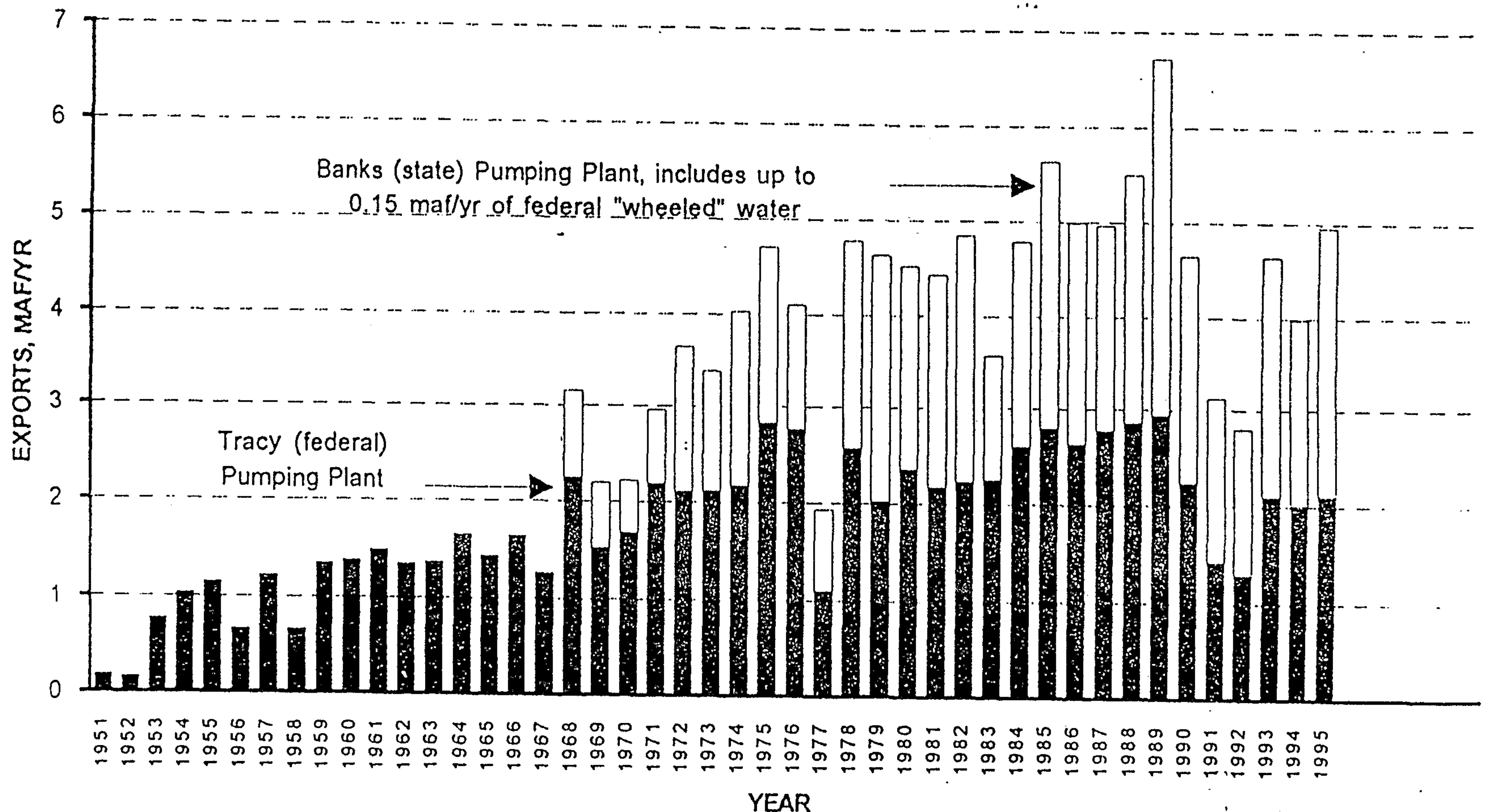

Figure 2. Combined state and federal Delta exports in million acre-feet per year from 1951 through 1995 (wheeled water is water pumped at the state facility but for delivery to another project).

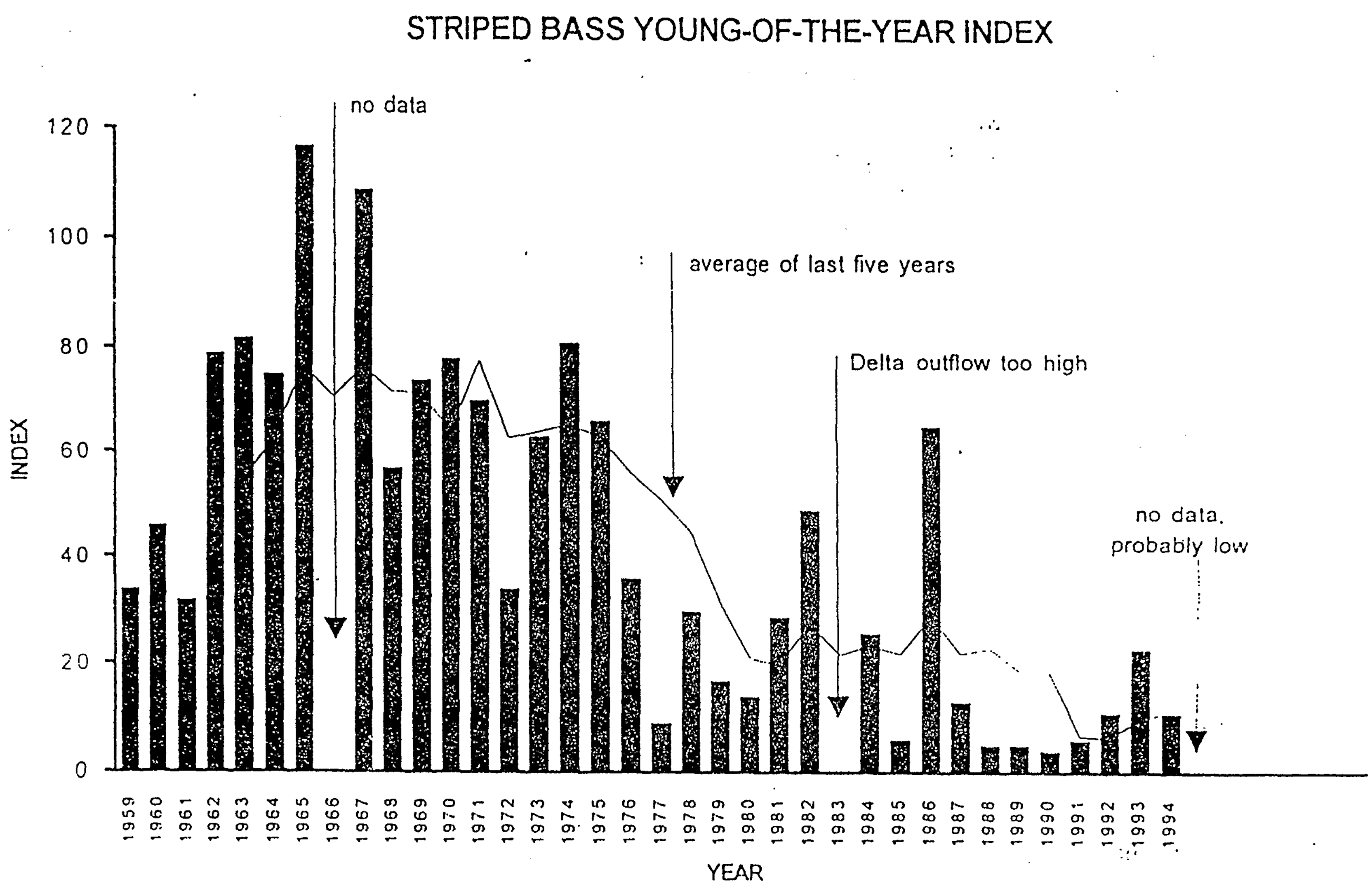

Figure 1. Annual and five year average striped bass young-of-the-year index (mid-summer, 38 mm index) from 1959 through 1994.

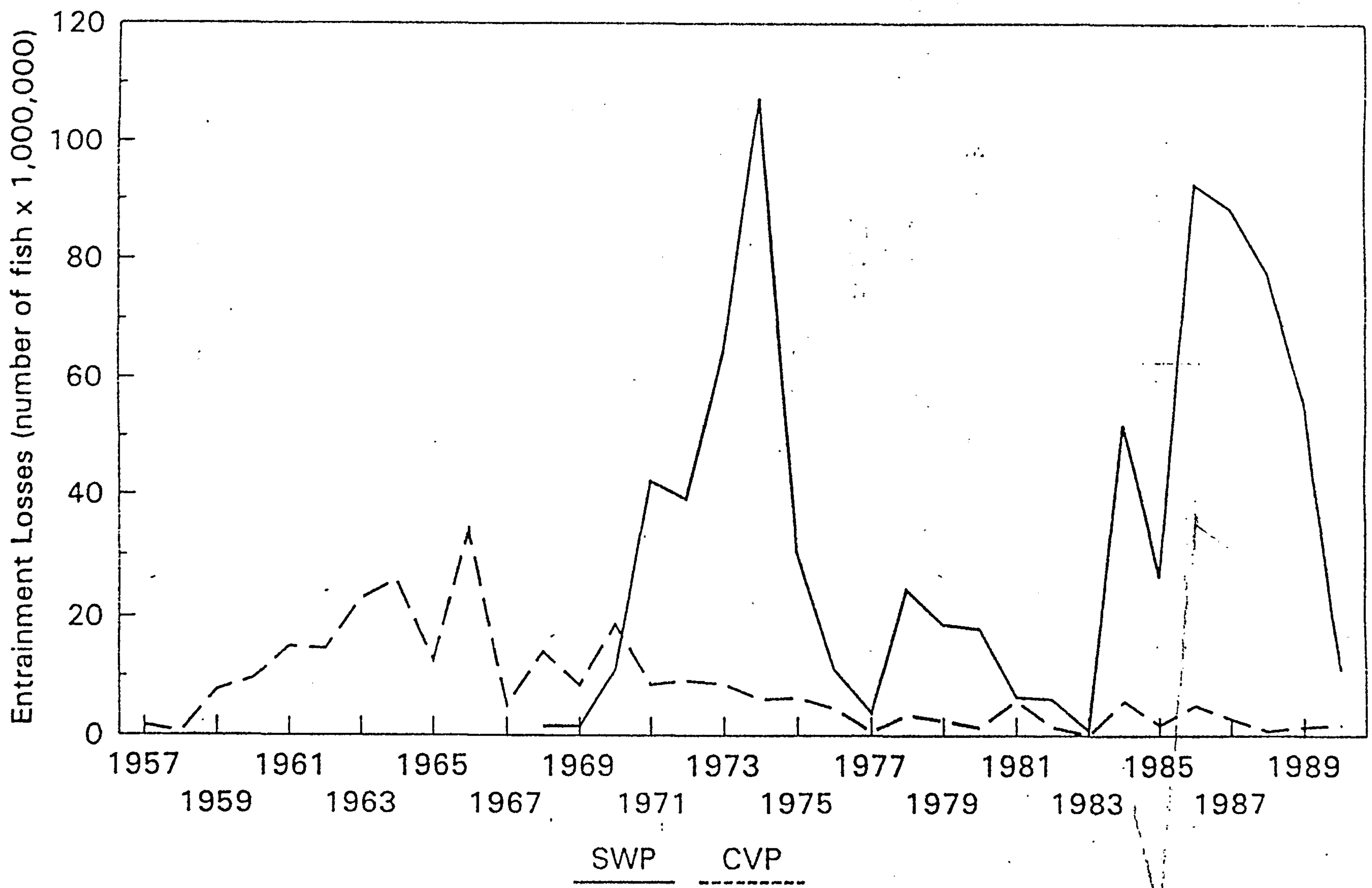

Figure 3. Juvenile striped bass estimated entrainment losses in diversions by the State Water Project and Central Valley Project Delta pumping facilities from 1957 through 1990 (source: USFWS Working Paper, 1995, Volume 2).

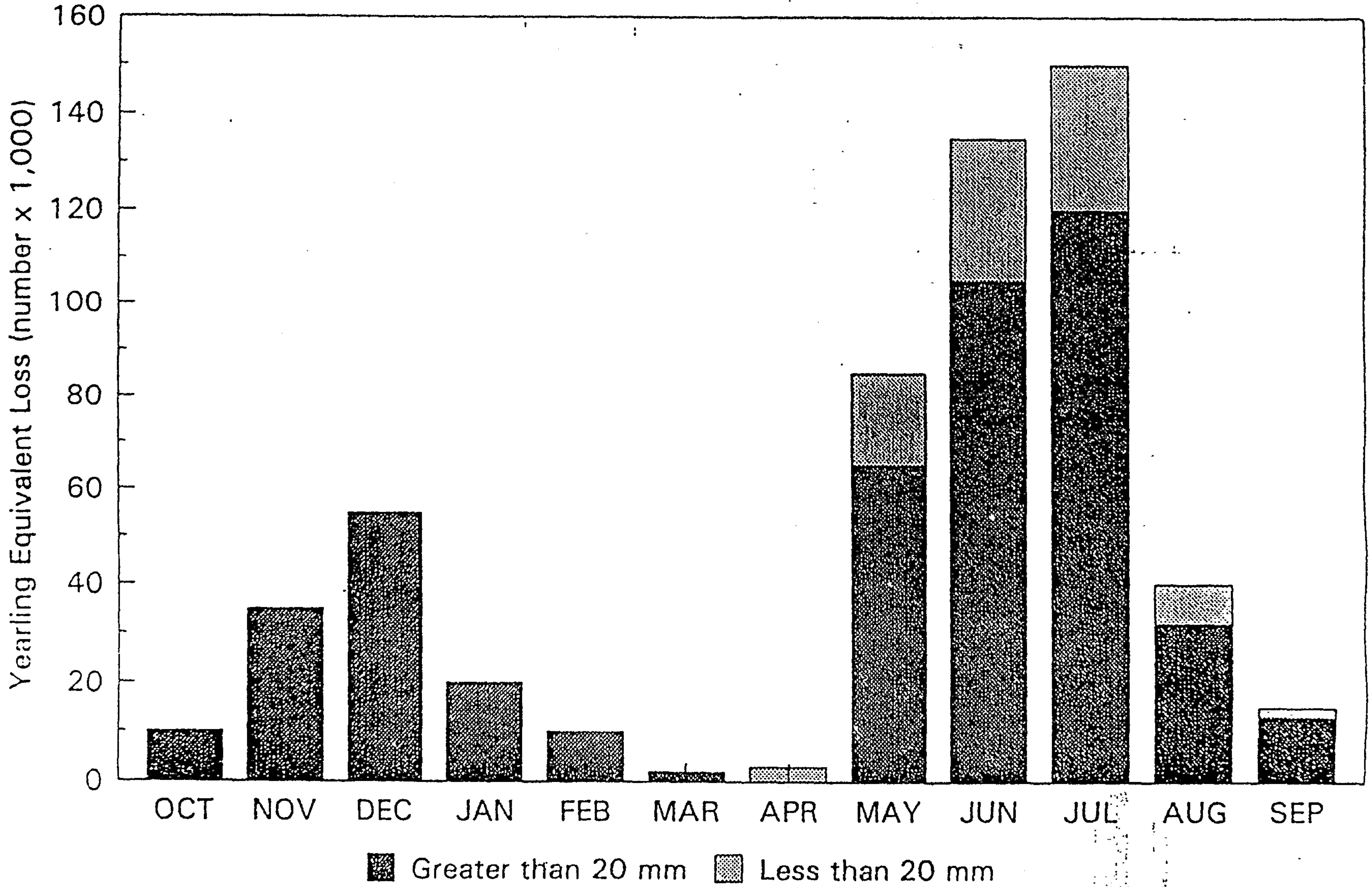

Figure 4. Annual entrainment pattern for striped bass at the State Water Project facility from 1986 through 1991(source: Brown 1992).

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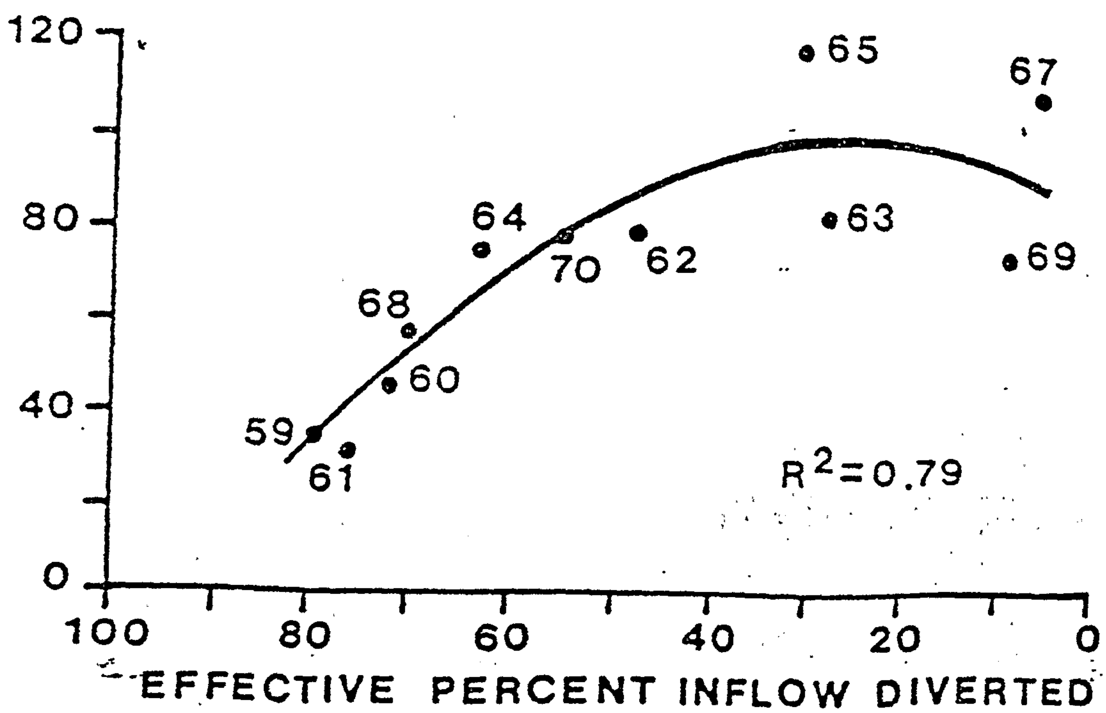


Figure 5. Relationship between total abundance of young striped bass in the Sacramento-San Joaquin Estuary and diversions from 1959 through 1970. Effective percent inflow diverted is the portion of Delta inflow diverted for internal use and exports except that the portion of the San Joaquin River inflow not reaching the western/central Delta is not included in the calculations (source: CDFG 1992, Exhibit 2).

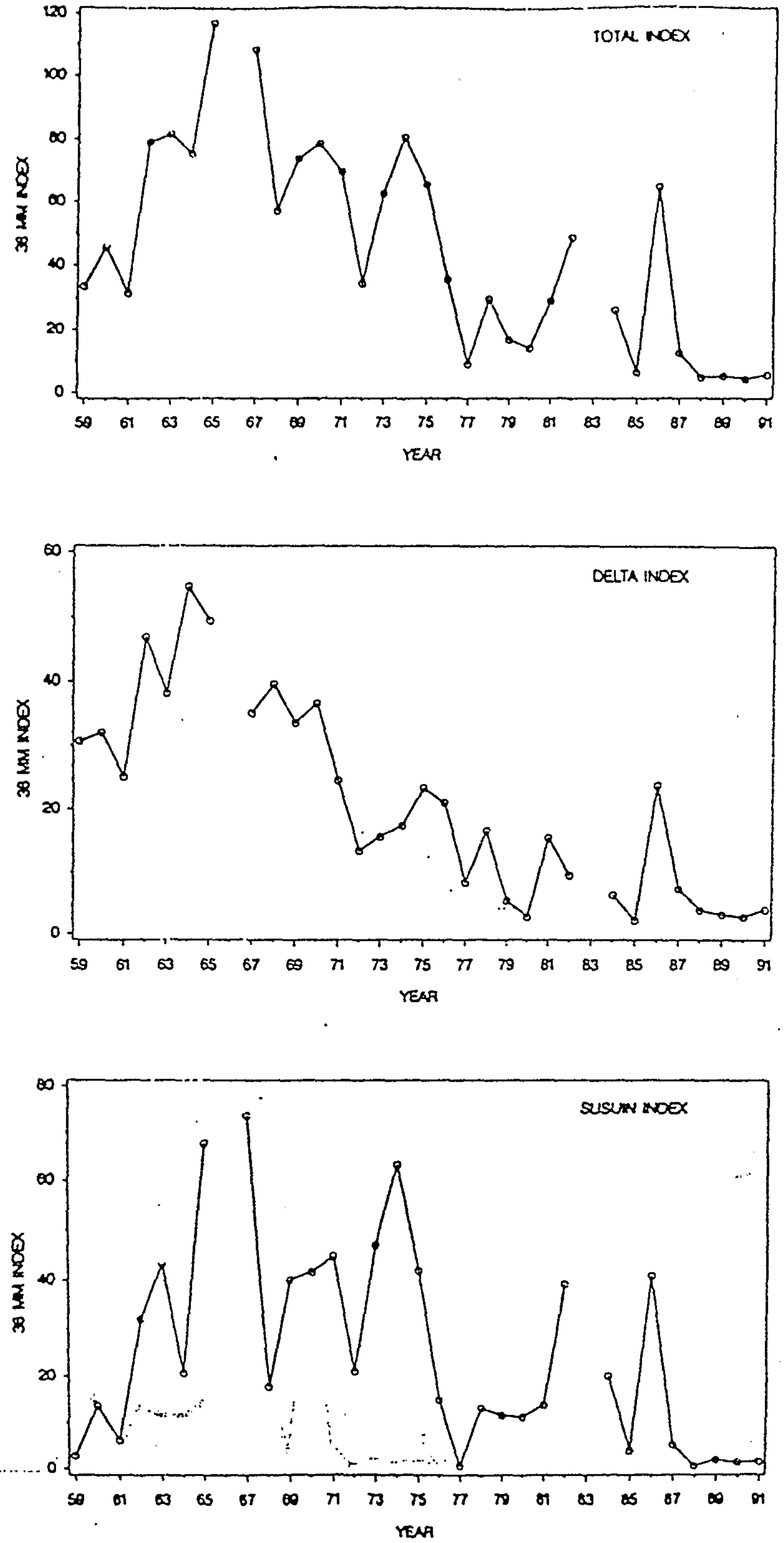


Figure 6. Annual index of young striped bass abundance by area. There has been an unsteady but persistent decline in young bass from the mid-1960's to the present. Lowest abundances have occurred in five of the last seven years presented. The most pronounced decline is in the Delta but it is also clearly visible in Suisun Bay despite greater year to year fluctuations there. No sampling was conducted in 1966, and in 1983 the index was omitted because extremely high flows moved fish downstream of the area efficiently sampled by the tow-net survey (source: CDFG 1992, Exhibit 2).

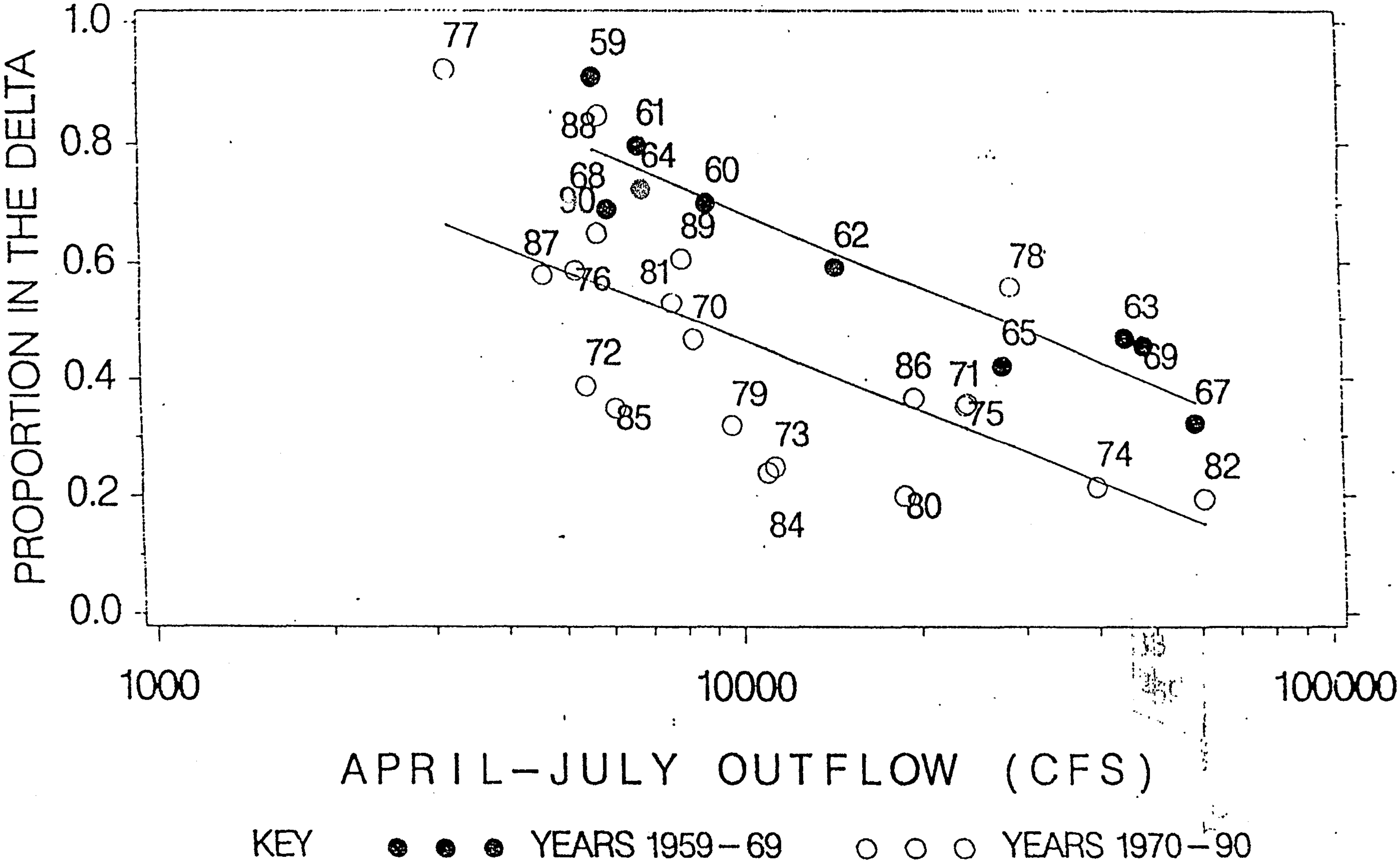


Figure 7. The proportion of striped bass 38-mm index located in the Delta in relation to the mean April through July Delta outflow for two different time periods: from 1959-1969 and from 1970-1990 (source: CDFG 1992, Exhibit 2).

Delta Action 8: Establish conditions for a CWT late fall run juvenile survival experiment in Dec'97/Jan '98 at cxports of 65 and 35% of Delta inflow, respectively.

Description: This action would entail manipulating CVP and SWP exports and potentially flow at Sacramento to meet the desired export/inflow ratios for testing. This action was proposed to estimate the value of the lower export/inflow (E/I) ratio (35%) to survival of juvenile salmon migrating through the Delta between November and January.

Background: The experiment planned for the winter of 97-98 would be the second of three annual experiments designed to determine if survival to Chipps Island is greater for CWT late fall yearlings released at Sacramento during the low export/inflow ratio period than for those released during the higher export/inflow ratio period. To broaden the objectives of the study, releases made as part of this experiment will be timed, if possible to coincide with late fall production releases made at Coleman National Fish Hatchery. The production also is tagged so estimates of survival between Battle Creek and Sacramento can also be made. Estimates of survival are generated from recoveries of marked fish recaptured at Chipps Island. An additional release will be made at Port Chicago/Benecia to allow survival to be estimated from differential recoveries of adults in the ocean fishery from the two groups released at Sacramento. Unfortunately, release group sizes are relatively small and sample variation could influence our ability to detect small differences in survival should they exist. Replication of the experiment in 1998/1999 will provide additional results to test the hypothesis.

Since flows may be variable between the December and January releases, exports will be modified to meet the proposed ratios. The higher ratio was selected for the December period, since inflows will likely be less in December than January, thereby making the ratio more attainable using export modification. The fish may be slightly larger for the later release increasing their survival irrespective of the export/inflow ratio. This is somewhat problematic. The cross channel gates would be closed during both test periods, to minimize the effect of other factors between groups.

The specific proposal has been out for review since June 11, 1996. Specific comments on the proposal included the suggestion of redefining the hypothesis and using a particle tracking model to determine test conditions that are a better reflection of flow movement to the south delta project export facilities than that of the E/I ratio (USFWS, 1996b and 1996c).

Fish species and life stages benefited: If the lower export/inflow ratio increases survival through the Delta for yearling chinook salmon it would suggest that a lower E/I ratio of 35% would benefit outmigrant juvenile salmon during the November - January period and add justification for implementation of Action 9.

Supporting data: There is some evidence that indicates that marked late-fall chinook salmon released at Ryde (or Isleton) and into Georgiana Slough survive more similarly when the export/inflow ratio is lower, both when the cross channel gates are open and when they are closed (table 1). This analyses assumes the Ryde groups are a good index of survival through the

Delta without impacts associated with the pumps. Although some recoveries are made at the fish facilities from fish released at Ryde, indicating they are still influenced to some degree by project pumping they are much less influenced than the releases made into Georgiana Slough.

The experiment proposed is designed to index survival through the Delta with late fall yearlings released at Sacramento with the gates closed at the two ratios. It is uncertain how much decreasing the export/inflow ratio from 65% to 35% would increase survival for juvenile salmon migrating through the Delta.

Monitoring and evaluation needs: Evaluation of the effectiveness of this action will be determined from the results of the experiment. Confirmation of the Chipps Island survival indices will be provided by recovering marked fish in the ocean fishery as adults.

Citations

USFWS, 1996a. Proposal to compare survival indices of coded-wire tagged (CWT) late-fall released in the Delta in December, 1996 and January, 1997 under two levels of Delta export/inflow ratio. Draft 11 June 1996.

USFWS, 1996b. Letter from William J. (BJ) Miller, Consulting Engineer to Marty Kjelson (USFWS), regarding comments on June 11 draft proposal to index juvenile late fall survival at two different export/inflow ratios. Dated July 2, 1996.

USFWS, 1996c. Response from USFWS (Marty Kjelson) to BJ Miller regarding comments on the June 11 late fall proposal. Dated July 23, 1996.

Table 1: Survival indices for late fall yearlings released at Ryde and into Georgiana Slough in 1993-1996 and mean Qwest, CVP and SWP exports and flow at Vernalis for 17 days after release. The cross channel gate status, export/inflow ratio and the Ryde/Georgiana Slough survival index ratio are also included.

Date	Ryde Survival Index	Georgiana Slough Survival Index	Ryde/ Georgiana Slough	Qwest	Exports	Vernalis Flow	Cross Channel Gate Status	Export/ Inflow Ratio	Sacramento Flow at Freeport
12/2/93	1.91	0.28	6.8	1054	10660	1618	Open	50%	21440
12/5/94	0.57	0.16	3.6	-165	7075	1297	Open	37%	19133
1/4/95	0.33	0.12	2.8	10024	11763	3444	Closed	18%	62,900
1/10/96	0.66	0.17	3.9	37	11370	2665	Closed	32%	33,881

* Actual release made at Isleton, about 5 miles downstream of Ryde.

C-043477

Delta Action 9: Limit the average CVP/SWP exports to no greater than 35% of Delta inflow in the November- January period. Sub priorities: 1) January, 2)December, 3)November.

Description: This action is designed to protect a variety of anadromous fish that migrate through the Delta between November and January by reducing the export/inflow ratio from 65% per the Delta accord to 35%. The action would require reduction in exports by the CVP and SWP or an increase in delta inflow or both.

Background: Reducing the export levels to no greater than 35% is designed to reduce the direct and indirect entrainment affects of export pumping. January is given the highest sub-priority because more juvenile salmon are in the system during that month (figure 1) with December of next priority and November being of lowest priority. Fewer fish were observed in November than in December or January.

There is considerable uncertainty as to the quantitative benefits of this action. Based on the late fall experiment conducted in December 1996 and January 1997 and experience with make up pumping, the justification for this action should be better understood. A problem occurs in implementing sub priorities because if one does not take action in November the chance is lost. However, water conditions in early fall may enable operators to determine if November or December reductions are a possibility.

Fish species and life stages benefited: Fall, late fall and spring run yearling chinook migrate through the Delta during these months. Winter and fall run fry may also enter the Delta during this time and rear in the Delta for up to several months. Actions to protect late fall, tributary spring and winter run are of high priority since these races are at extremely low population levels. Other species that could benefit would include juvenile striped bass, steelhead, American shad, white and green sturgeon and adult San Joaquin basin fall-run chinook salmon.

Supporting data: Annual expanded recoveries at the CVP and SWP fish facilities of late fall run yearlings released at Coleman National Fish Hatchery have ranged between 0.09 and 0.26 percent between 1994 and 1996 (table 1). Although, these numbers are relatively low, the fact that they reach the fish facilities is of concern. Assuming that the indirect losses in the Delta associated with being diverted off their main migration path towards the pumps are much greater than the direct losses (estimates have ranged between 4 and 7 times greater) the total impact associated with exports could range as high as 1 to 2 percent of the release.

Modeling based on fall-run smolts indicate that after the variability due to temperature is removed, 17% of the variability in central-delta survival was due to combined CVP/SWP exports (Kjelson, et al., 1989).

Depending on the length of curtailment benefits would vary. It is expected that indirect and direct losses (salvage) of all anadromous fish would decrease during the months of reduction in the export/inflow ratio. Decreases in exports relative to Delta inflow, with the cross channel gates closed would increase QWEST. Increases in QWEST during the November - January period could help juvenile anadromous fish diverted into the Central Delta via Georgiana Slough find their way to the ocean. Limited data has affected our ability to understand the importance of reverse flows in the western San Joaquin River on smolt survival in the central Delta

Monitoring and evaluation needs: Sampling for late fall CWT tags will occur at the fish facilities and at Chipps Island to assess entrainment and survival under the various export/flow conditions between November and January. Salvage also occurs for the other species and races of anadromous fish. Additional work using juvenile salmon with radio tags may assist in understanding the influence of QWEST flow levels on smolt migration in the Delta.

Citations

Kjelson, M.A., Greene, S. and P. Brandes, 1989. A Model for Estimating Mortality and Survival of Fall-Run Salmon Smolts in the Sacramento River Delta Between Sacramento and Chipps Island.

Table 1: Expanded recoveries at the CVP and SWP fish facilities, total number released and the total percent recovered of late - fall run juveniles released in the upper Sacramento River in 1994-1996.

Year	Total Number Released	Expanded SWP	Expanded CVP	Total Number Salvaged Expanded	Percent Recovered at SWP & CVP
1995	497,129	868	246	1,114	0.224
1994	613,565	99	433	532	0.087
1996	797,243	1602	468	2,070	0.259

Stanislaus River Action 1: Implement an interim river regulation plan that meets the following flow schedule (Table 1) by supplementing the 1987 agreement between USBR and CDFG, through reoperation of New Melones Dam, use of (b)(2) water, and acquisition of water from willing sellers as needed.

Description: The implementation of AFRP flow objectives on the Stanislaus River continues to require balancing among improving river flows for the aquatic ecosystem in the basin, meeting temperature criteria, and providing adequate carryover storage in New Melones Reservoir. We recommend that releases from Goodwin Dam be maintained at not less than the flows identified by the AFRP (Table 1) to help the declining salmon and steelhead populations in the Stanislaus River continue to recover from the adverse effects of the recent drought. We are participating in the ongoing process to evaluate the "sustainable" CVP yield in the Stanislaus River basin available for helping to meet the AFRP flow objectives, as well as the potential of acquiring water from willing sellers.

Our flow objectives include the release of increased springtime flows (April to June 1997) to the Stanislaus River below Goodwin Dam. The springtime releases from Goodwin Dam should result in an increase in Stanislaus River flows, lower San Joaquin River flows, and Delta outflow. Combined with the Merced River and Tuolumne River flows; our intention is that these springtime flows will contribute to meeting the Vernalis flow standard for April and May consistent with the Bay-Delta Agreement and the Fish and Wildlife Service's March 6, 1995 biological opinion for delta smelt (USFWS 1995a).

In addition to the springtime flows, the objectives for the Stanislaus River include: 1) flows below Goodwin Dam during October through March to provide spawning and rearing habitat for salmon and steelhead; and 2) minimum base flow in the summer. A fall attraction pulse flow using approximately 15,000 to 30,000 af is being considered for release during October 1997 to facilitate upstream migration of adult fall-run chinook salmon. If we wish to pursue this measure or use the water in another fashion, as indicated by the results of real-time monitoring, we will advise the agencies, stakeholders, and the public at a later date.

Background: Although New Melones Reservoir is the largest impoundment (2.4 maf) in the Stanislaus River basin, Goodwin Dam is located downstream of New Melones Dam and is the upstream barrier for salmon migration (Reynolds et al. 1993, USFWS 1995b). Existing releases to meet needs of chinook salmon in the lower Stanislaus River are specified in a 1987 study agreement between CDFG and USBR (CDFG and USBR 1987, USFWS 1995b). This agreement specifies interim annual flow allocations of 98,300 af to 302,100 af, depending on New Melones Reservoir carryover storage and inflow. Since the agreement was signed, water shortages have limited the quantity of water allocated to meeting fish needs to 98,300 af in all years except 1996. This quantity has proven to be inadequate for survival of all life stages of chinook salmon (Loudermilk 1994, USFWS 1995b).

The 1987 agreement provides for a 7-year study with seven study elements that are in various stages of completion. To date, results of smolt survival studies by CDFG and a 1992 instream flow study by USFWS (Aceituno 1993) has yielded sufficient data to allow formulation of minimum stream flow schedules with increased allotments for fish. In August 1992, CDFG submitted revised flow schedules to USBR and CDWR. The revised flows range from 185,280 af to 381,498 af (Reynolds et al. 1993). CDFG has indicated that these are minimum flows that are subject to revision upon completion of the remaining studies (Reynolds et al. 1993). The purpose of establishing minimum flows is to maintain the current population or prevent further decline as water demands increase (Reynolds et al. 1993). Therefore, a key assumption of the AFRP was that increasing natural production of chinook salmon in the Stanislaus River would require flows higher than the specified minimum flows.

Fish species and life stages benefited:

- spawning adult chinook salmon
- rearing and outmigrating juvenile chinook salmon
- spawning adult steelhead
- juvenile striped bass
- juvenile American shad
- juvenile delta smelt and other estuarine species

Supporting data: Escapement of adult chinook salmon into the Stanislaus River is associated with spring outflow in both the San Joaquin River at Vernalis and the Stanislaus River at Ripon (CDFG 1987, USFWS 1995b). Annual escapement estimates for chinook salmon (i.e., the number of 2 and 3-year old fish that return to spawn) have been made by the CDFG for San Joaquin River tributaries. The CDFG used these data and spring flows of tributaries and the San Joaquin River at Vernalis when three year old fish were emigrating as smolts, to perform regression analyses (CDFG 1987, 1992). The analyses indicated significant ($p<0.05$) positive correlations between spring flow in the tributaries and at Vernalis and escapement of fish 2.5 years later (Figures 1 and 2). An additional concern is that low flows in the fall may delay adult migration and spawning (CDFG 1992, USFWS 1995b).

The ratio of Vernalis flow to water export has been suggested as a factor influencing salmon escapement in the San Joaquin River basin, primarily by affecting smolt survival during the peak emigration period, e.g., the AFRP Working Paper (USFWS 1995). The USFWS performed a regression analysis to describe the relation between adult escapement (3 year old fish) and the Vernalis flow to combined SWP and CVP exports (VFER) during 15 April 15 May the year ,fish were smolts (Figure 3). The resulting regression equation was significant ($p>0.01$) and VFER accounted for 40% of the variance in escapement.

To better understand factors affecting chinook salmon in the San Joaquin River basin, Carl Mesick Consultants (CMC 1994, 1995, 1996) performed correlation analyses on existing data to investigate relations among streamflow, exports, VFER, water temperature, stock size (escapement of 3 year old fish), ocean harvest, water quality, ocean conditions, and recruitment of chinook salmon cohorts (combined number of 2 and 3 year old fish returning in 1.5 and 2.5 years).

Each report offered further refinements to the analyses, especially concerning discrimination between cohorts. All reports analyzed data from the Stanislaus and Tuolumne rivers separately, and differed from earlier analyses conducted by the CDFG (CDFG 1987, 1992) by accounting for differences in age structure of fish in escapement estimates. Data were analyzed for various time periods within the years (1951-1989, depending on data availability, and the latter two reports (CMC 1995, 1996) developed stock and recruitment relationships, and presented time-series population models to predict recruitment relative to potential restoration activities. Overall, the analyses indicated that three variables accounted for most of the variance in recruitment of chinook salmon in the Stanislaus and Tuolumne rivers. The variables were VFER, low tributary flows during smolt emigration, and stock levels below 1,000 fish.

The CDFG (Reynolds et al. 1993) provided interim flow recommendations for the Stanislaus River (Table 2). Recommendations were intended to improve conditions for fall-run chinook salmon, and were based on results of an instream flow study conducted by the USFWS (Aceituno 1993) for October through March and smolt survival studies conducted by CDFG for April through May (CDFG 1992). Recommendations are provided for five water-year types in the San Joaquin 60-20-20 index, ranging from 185,280 to 381,498 af. The recommendations also include blocks of water to be used for spawner attraction in October and outmigration in April and May.

Recommendations from the instream flow study were thought to provide adequate spawning, incubation, and rearing habitats for fall-run chinook salmon. A total of about 155,000 af was recommended, irrespective of water-year type. However, the study noted that to protect and preserve chinook salmon in the Stanislaus River, a comprehensive instream flow regime would need to consider factors that were not included in the study, such as water quality, temperature, attraction flows, and flow for juvenile emigration.

The AFRP identified flow needs that, in conjunction with other restoration actions, would result in at least doubling natural production of fall-run chinook salmon relative to the average attained during 1967-1991 (USFWS 1995b). The needs were based on Aceituno (1993), the proportion of unimpaired flow that the Stanislaus River contributes to the San Joaquin River, and the historic hydrological regime. Assumptions were that flows greater than historical flows in the lower reach of the river are needed to compensate for elimination of access to upstream habitat, and flows should not be reduced between spawning and outmigration to prevent redd dewatering and stranding of rearing juveniles. Needs were then identified for five water-year types, according to the San Joaquin 60-20-20 index. The identified flows ranged from 290,000 to 943,000 af per year.

The AFRP flow objectives were derived from comments and additional information received on the flow needs identified in the Working Paper (USFWS 1995b). The resulting flow objectives are consistently higher than the CDFG recommendations, especially in the spring, but overall, they are similar at other times.

Monitoring and evaluation needs: The monitoring and assessment of these proposed AFRP flow objectives for the Stanislaus River is essential to obtain data on anadromous fish production and to facilitate an evaluation of the effects of this restoration action. The AFRP recommends that CDFG continue its existing monitoring programs, such as escapement surveys. The AFRP also encourages the water districts to continue monitoring juvenile salmon emigration using the rotary screw traps in partnership with the AFRP. Finally, the AFRP recommends the completion of the study elements identified in the 1987 agreement between CDFG and USBR, including CWT smolt survival studies and linking the existing USBR temperature model (Rowell 1993) with the USFWS instream flow model (Aceituno 1993). These proposed monitoring and study efforts can be coordinated with other monitoring and assessment programs in the San Joaquin basin and integrated through the Comprehensive Assessment and Monitoring Program (Section 3406(b)(16) of the CVPIA) with all CVPIA restoration actions and evaluations.

Citations

Aceituno, M. E. 1993. The relationship between instream flow and physical habitat availability for chinook salmon in the Stanislaus River, California. U.S. Fish and Wildlife Service, Ecological Services, Sacramento.

California Department of Fish and Game. 1987. The status of San Joaquin drainage chinook salmon stocks, habitat conditions and natural production factors. CDFG Exhibit 15 prepared for the State Water Resources Control Board Bay-Delta Hearing Proceedings, September 1987. Sacramento, California.

California Department of Fish and Game. 1992. Interim actions to reasonably protect San Joaquin fall-run chinook salmon. CDFG Exhibit 25 prepared for the water rights phase of the State Water Resources Control Board Bay-Delta Hearing Proceedings, beginning 22 June 1992, Sacramento, California.

Carl Mesick Consultants. 1994. The effects of minimum streamflow, water quality, Delta exports, ocean harvest, and El Nino conditions on fall-run chinook salmon escapement in the San Joaquin drainage from 1961 to 1989. Prepared for the Stanislaus River Council.

Carl Mesick Consultants. 1995. A reanalysis of the effects of minimum flow requirements, release temperatures, Delta exports, and stock on fall-run chinook salmon production in the Stanislaus and Tuolumne rivers. Prepared for Thomas R. Payne & Associates and Neumiller & Beardslee.

Carl Mesick Consultants. 1996. The effects of minimum flow requirements, release temperatures, Delta exports, and stock on fall-run chinook salmon production in the Stanislaus and Tuolumne rivers. Prepared for Thomas R. Payne & Associates, Neumiller & Beardslee, and Stockton East Water District.

Loudermilk, W. 1994. Draft Stanislaus River fishery study agreement amendment. California Department of Fish and Game, Region 4. 25 February.

Reynolds, F., T. Mills, R. Benthin, and A. Low. 1993. Restoring Central Valley streams: A plan for action. California Department of Fish and Game, Sacramento.

Rowell, J. H., 1993. Stanislaus River temperature model. Draft, June 1993. U.S. Bureau of Reclamation, Mid-Pacific Region, Sacramento, California.

U.S. Fish and Wildlife Service. 1995a. Memorandum from Field Supervisor, U.S. Fish and Wildlife Service, Ecological Services, to Regional Director, U.S. Bureau of Reclamation. Formal consultation and conference of effects of long-term operation of the Central Valley Project and State water Project on the threatened delta smelt, delta smelt critical habitat, and proposed threatened Sacramento splittail.. Memorandum 1-1-94-F-70, 6 March, Sacramento, California.

U.S. Fish and Wildlife Service. 1995b. Working paper on restoration needs: habitat restoration actions to double natural production of anadromous fish in the Central Valley of California. Volume 3. May 9, 1995. Prepared for the U.S. Fish and Wildlife Service under the direction of the Anadromous Fish Restoration Program Core Group. Stockton, California.

Stanislaus River

Table 1. Flow objectives for the Stanislaus River downstream of Goodwin Dam during 1 April 1997 through 31 March 1998. Water year type is based on the San Joaquin 60-20-20 index.

	Stanislaus River flow objectives (cfs) by water year type				
Month	Wet	Above normal	Below normal	Dry	Critical
October	350[a]	350[a]	250[a]	250[a]	200[a]
November-December	400[a]	350[a]	300[a]	275[a]	250[a]
January-March	400[b]	350[b]	300[b]	275[b]	250[b]
April 1-15	1500[c]	1500[c]	1500[c]	300	300
April 16-30	1500[c]	1500[c]	1500[c]	1500[c]	1500[c]
May 1-15	1500[c]	1500[c]	1500[c]	1500[c]	1500[c]
May 16-31	1500[c]	1500[c]	300	300	300
June	1500[d]	800[d]	250	200	200
July-September	300	300	250	200	200
Total (taf)	467	410	313	257	247

[a]Flow based on IFIM recommendations and the assumption that greater than historic flows are needed to compensate for elimination of access to upstream habitat. A pulse flow using approximately 15,000 to 30,000 af is being considered during October to attract adult chinook salmon.

[b]Flow based on the recommendation that flow should not be reduced between spawning and outmigration to prevent redd dewatering and stranding of rearing juveniles.

[c]Recommended springtime flows to improve survival of emigrating chinook salmon smolts in the Stanislaus River and San Joaquin River basin, benefit delta smelt and other estuarine species, and aid in the downstream transport of striped bass eggs and larvae. The timing, magnitude, and duration of the April-May and October flows must be flexible and responsive to changing hydrologic conditions and coordinated with flows on the Toulumne and Merced rivers.

[d]The June releases may be adjusted in cooperation with CDFG and USBR, depending on "real-time" chinook salmon monitoring, water temperatures in the Stanislaus and San Joaquin rivers, and concurrent flow releases in the Merced and Tuolumne rivers.

Table 2. Flow recommendations for the Stanislaus River downstream of Goodwin Dam (after Reynolds et al. 1993). Water year type is based on the San Joaquin 60-20-20 index.

Month	Stanislaus River flow objectives (cfs) by water year type				
	Wet	Above normal	Below normal	Dry	Critical
October 1-14	300	300	250	250	200
October 15-December 31	400	350	300	275	250
January-March	350	300	250	225	200
April-May	500	450	400	350	300
June-September	350	300	250	200	200
April-May pulse[a] (af)	89,100	68,310	47,520	26,730	5,940
October pulse (af)	15,000	15,000	15,000	15,000	15,000
Total (af)	381,498	325,959	269,034	221,811	185,280

[a]Based on 30 day flow of 400 cfs (100 cfs for 30 days in addition to spring base flow f 300 cfs) for critical year. Stanislaus River flow contribution at Vernalis = 20 percent.
Based on 30 day flow of 800 cfs (450 cfs additional flow for 30 days from base spring flow of 350 cfs) for dry year.
Based on 30 day flow of 1,200 cfs (800 cfs for 30 days in addition to spring base flow of 400 cfs) for below normal year.
Based on 30 day flow of 1,600 cfs (1,150 cfs for 30 days in addition to spring base flow of 450 cfs) for above normal year.
Based on 30 day flow of 2,000 cfs (1,500 cfs for 30 days in addition to spring base flow of 500 cfs) for wet year.

Figure 1. Relation ship of total escapement in the San Joaquin drainage and Vernalis flows before (upper) and after (lower) the existing State Water project in the south Delta and major storage increases in the San Joaquin drainage (source: CDFG 1987, Exhibit 15, The status of San Joaquin drainage chinook salmon stocks, habitat conditions and natural production factors).

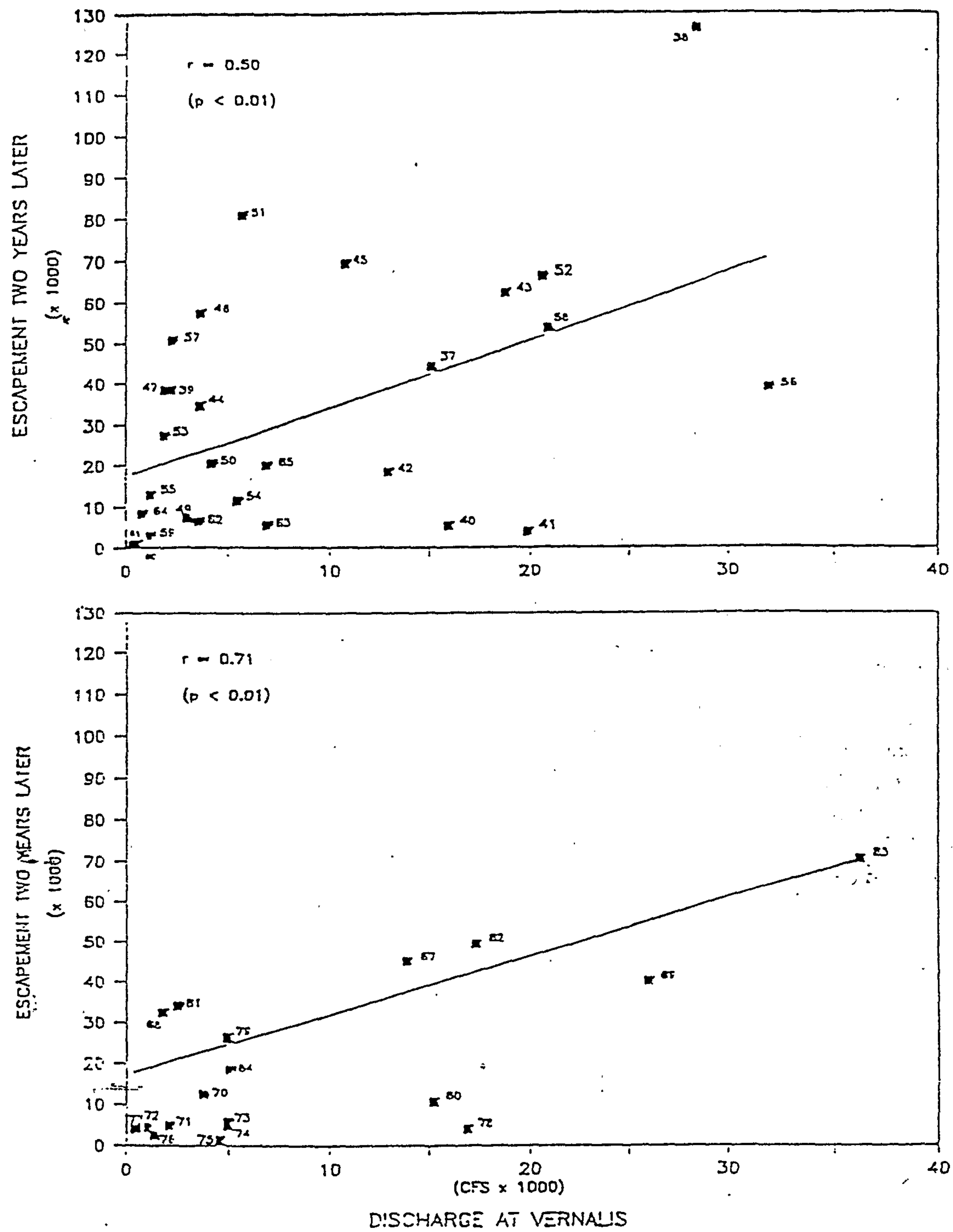
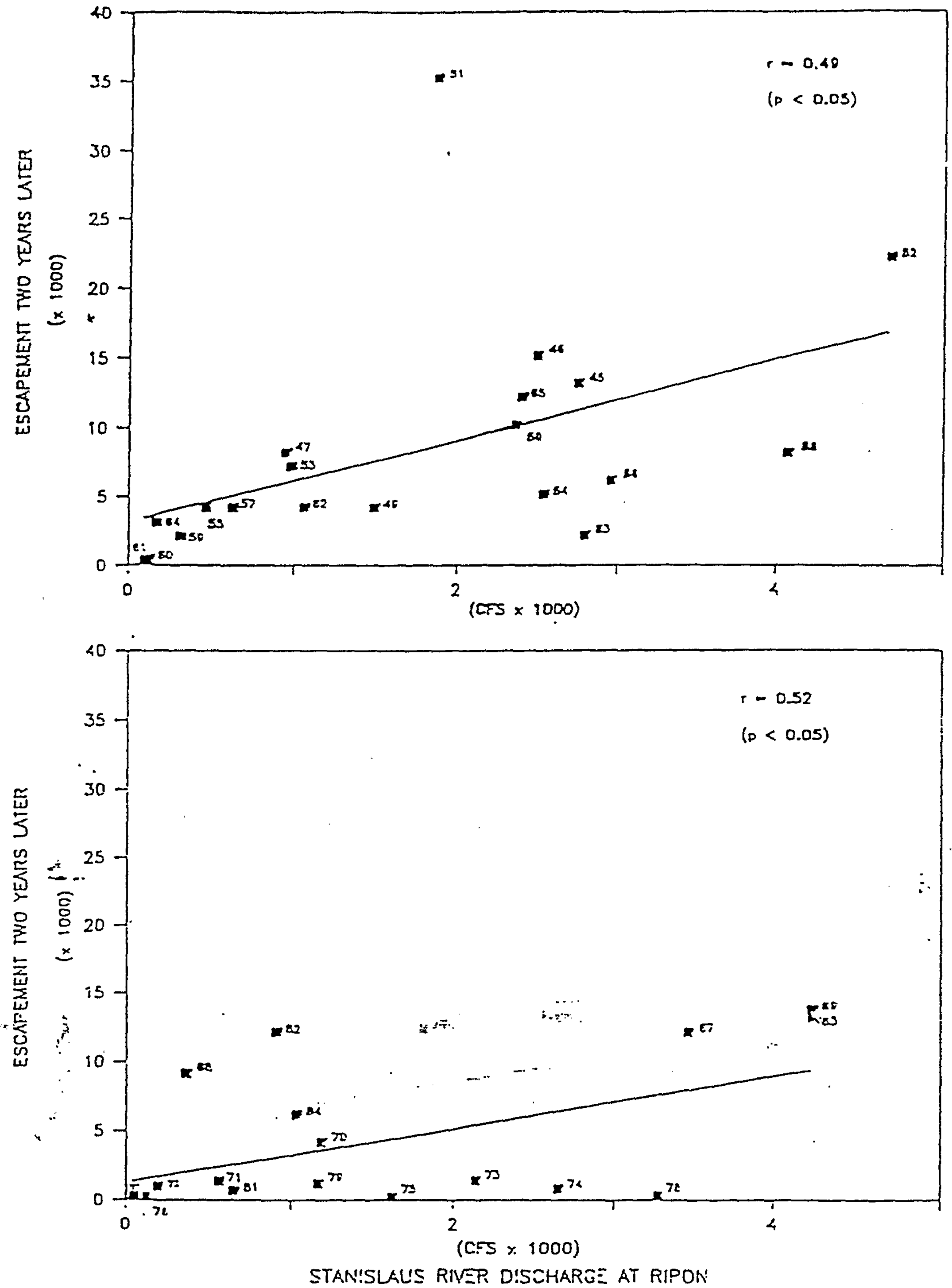


Figure 2. Relationships of Stanilaus River escapement to spring flows before (upper) and after (lower) the existing State Water Project in the south Delta and major storage enlargements in the San Joaquin drainage (source; CDFG 1987, Exhibit 15, The status of San Joaquin drainage chinook salmon stocks, habitat conditions and natural production factors).



C-043489

Vernalis Flow to Delta Export Ratio and Estimates of Naturally Spawning Fall-run Chinook Salmon during 1969-1989

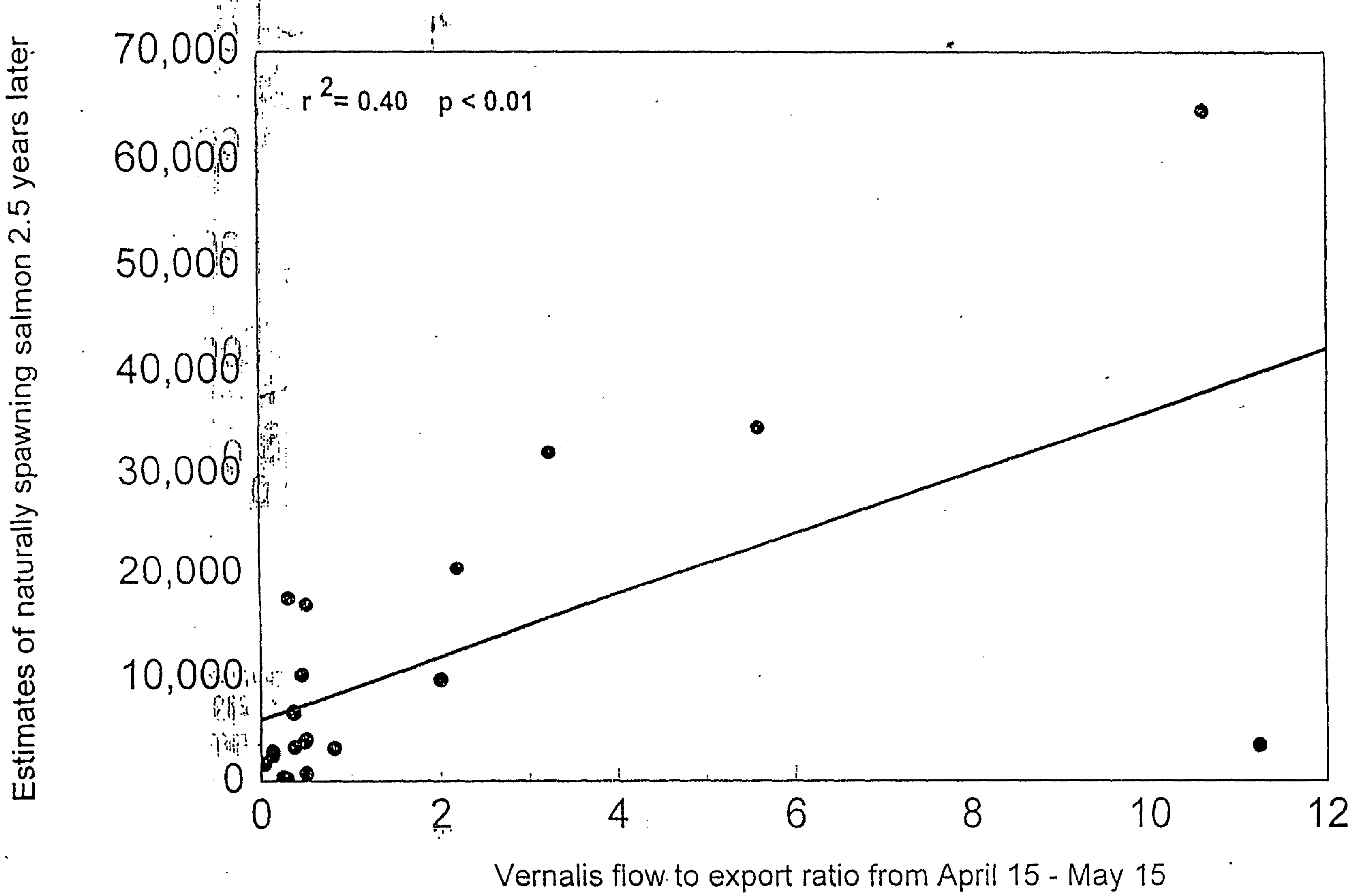


Figure 3. Numbers of naturally-spawning chinook salmon versus Vernalis flow to Delta export ratio when fish emigrated, 1969-1989. Salmon numbers (adults only) were after Mills and Fisher (1994). Vernalis flow to export ratio was calculated from DAYFLOW (CDWR database).

American River Action 1: Develop and implement a river regulation plan that meets the flow objectives in Table 1 by modifying CVP operations, using (b)(2) water, and acquiring water from willing sellers as needed.

Description: To improve immigration, spawning, incubation, rearing, and emigration conditions for chinook salmon and steelhead in the lower American River, develop and implement a river regulation plan that meets the following flow objectives below Nimbus Dam.

Table 1. Flow Objectives (cfs)[1] for the American River for April 1, 1997 through March 31, 1998.

	Year type				
Month	Wet	Above normal	Below normal	Dry	Critical dry
April-June	4500[a]	3000	3000	2000	2000
July	2500[b]	2500	2500	1500	1500
August	2500[b]	2000	2000	1000	1000
September	2500[b]	1500	1500	500	500
October-December[2]	2500[c]	2000	2000	1750	1750
January-February	2500[c]	2000	2000	1750	1750
March	4500[a]	3000	3000	2000	2000

[1]A multi-agency and interested party management team should be formed to review and develop flow objectives in consideration of reservoir carryover storage and hydrologic conditions as needed to provide for the long-term needs of anadromous fish.

[a]Recommended flows to provide appropriate juvenile rearing habitat availability and out migration flows, and temperature control during May and June (i.e., maintain mean monthly river water temperatures below 65°F at H-Street).

[b]Recommended flows to provide some thermal protection (i.e., maintain mean monthly river temperatures at or below 70°F) for steelhead juveniles.

[2]Minimum flows for October 1 through December 31, 1997 will be based on the water year type for 1997 and reservoir storage conditions as of September 30, 1997. To be responsive to changing hydrologic conditions, flows may be ramped up or down in cooperation with CDFG and USBR in January 1997 and 1998.

[c]Flows needed for chinook salmon spawning. The 2500 cfs flow recommendation approaches the maximum release rate that can be sustained throughout this and subsequent months without exceeding water availability.

We understand that operating primarily to meet new water quality standards pursuant to the Bay-Delta Agreement and water supply demands south of the Delta will determine flows in the American River from April through September 1997. This will depend on reservoir inflow, storage, flow in the Sacramento River and other hydrologic conditions. In any event, American River flows (i.e., Nimbus releases) should be maintained at no less than the schedule in Table 1.

Depending on hydrologic conditions, a carryover storage of not less than 600,000 AF at the end of September 1997 should be retained in Folsom Reservoir. This would provide for releases below Nimbus Dam of not less than 2,500 cfs from October 1997 through February 1998, and not less than 4,500 cfs in March 1998. Carryover storage greater than 600,000 AF will help supply the water to meet these instream flow objective, and to meet fall water temperature objectives. We are continuing to work on the relationship among October 1997 through March 1998 flow objectives and the 1997 reservoir storage, inflow and hydrologic conditions. We will coordinate with the agencies, stakeholders, and the public regarding the flow objective in the event Folsom Reservoir is less than 600,000 AF at the end of September. To be responsive to changing hydrologic conditions, flows may be ramped up or down in cooperation with CDFG and Reclamation in January 1997 and 1998. These flow objectives will provide spawning and rearing habitat for salmon and steelhead, improve survival of downstream migrating late fall-run, winter-run, and spring-run chinook salmon through the Delta; and assist in meeting the needs of estuarine species consistent with the Bay-Delta Agreement.

To the extent possible, flow fluctuations should be eliminated during this period. Interim criteria on significant flow thresholds and ramping rates are being prepared by CDFG and the Service in cooperation with Reclamation to assist Reclamation staff in minimizing adverse fishery impacts due to flow fluctuations. We will continue to work together to develop ramping criteria for the long-term.

Fish species and life stages benefited:

- Spawning adult fall-run chinook salmon
- Incubating, rearing and outmigrating juvenile fall-run chinook salmon
- Spawning adult steelhead
- Incubating, rearing and outmigrating juvenile steelhead
- Spawning adult American shad
- Juvenile American shad
- Adult and juvenile striped bass
- Other anadromous and resident fishes (including splittail)

Background: Efforts to implement the American River flow objectives are consistent with the objectives of the Water Forum, a broad-based regional planning effort that includes business and agricultural leaders, environmental groups, citizens groups, regional water managers, and local governments (letter of comment on the draft Anadromous Fish Restoration Plan dated March 1, 1996 and signed by Melvin Johnson, Executive Director of the Sacramento City-County Office of Metropolitan Water Planning).

The American River flow objectives and models for implementation of the objectives were developed and refined by teams of biologists and hydrologists with representation from Save the American River Association, the Water Forum's Surface Water Negotiation Team, the California Department of Fish and Game, the East Bay Municipal Utility District (EBMUD), business interests in the Water Forum, State Water Resources Control Board, Service, Reclamation, and others. The objectives and models for implementation where generally supported by the participants, although concerns were raised about potential effects on over-summering steelhead and late-fall-run chinook salmon.

Prior to development of the American River flow objectives (in 1972), the Environmental Defense Fund (EDF) filed suit against EBMUD challenging a proposed diversion of water from Nimbus Dam through the Folsom South Canal, bypassing the lower American River. A 1990 court decision resulting from this case (known as the Hodge decision) ordered the following flows for the protection of salmonid resources in the lower American River: 2,000 cfs between 15 October and 28 February; 3,000 cfs between 1 March and 30 June; and 1,750 cfs between 1 July and 14 October.

The Hodge flows prescribe conditions that must be met prior to diversion of American River water by EBMUD. In most dry and critical years, those flow conditions could not be met and therefore EBMUD could not divert water. We recommend higher flow objectives to provide greater benefits than the Hodge flows in wet, above, and below normal years and lower flow objectives in drier years, such that flows could reasonably be met in almost all years. In addition, the Hodge flows were to protect all public trust resources and therefore the summertime flows included consideration of recreational activities, including wading, swimming and rafting.

Supporting data: The Hodge flows were established after extensive review of available scientific data concerning the relationship between lower American River flows and salmonid production. Additional information addressing optimal instream flows for salmonid spawning and incubation, rearing, outmigration, and temperature control has been developed subsequent to the Hodge decision, either as part of the retained jurisdiction associated with *EDF et al. v. EBMUD* (Williams 1995), as part of AFRP Technical Team efforts to develop the AFRP Working Paper (USFWS 1995), or as part of the Water Forums regional planning efforts (Bratovich et al. 1995). Bratovich et al. (1995) listed over thirty studies of fish and related hydrology on the lower American River and Williams (1995) summarized and discussed many of these studies, focusing on evidence and analysis bearing on the flows and water temperatures needed to protect chinook salmon in the lower American River. This additional information was used to develop the instream flow recommendations for the lower American River that appear in Table 1.

Monitoring and evaluation needs: Monitoring the effectiveness of the American River flow objectives is essential to obtain data on anadromous fish production and to facilitate an evaluation of the effects of this restoration action. We recommend that existing monitoring programs continue, including escapement surveys, redd surveys, emigrant trapping, and seine surveys. Refinement of existing methods should continue and additional studies should be

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conducted (see Williams [1995] for a discussion of potential additional studies). In a letter of comment on the draft Anadromous Fish Restoration Plan dated January 12, 1996, John Williams identified several assumptions he felt should be the focus of an adaptive management approach to the American River flow objectives. The monitoring and study efforts should be coordinated with other monitoring and study programs in the Central Valley and integrated through CAMP with all CVPIA restoration actions and evaluations.

Citations

Bratovich, P.M., S.L. Taylor, and D.B. Christophel. 1995. Sacramento Area Water Plan Forum: Final Fish Biologists Working Session Summary. Prepared for the Sacramento City-County Office of Metropolitan Water Planning, Sacramento, California.

U.S. Fish and Wildlife Service. 1995. Working paper on restoration needs: habitat restoration actions to double natural production of anadromous fish in the Central Valley of California. Volume 3. May 9, 1995. Prepared for the U.S. Fish and Wildlife Service under the direction of the Anadromous Fish Restoration Program Core Group. Stockton, California.

Williams, J.G. 1995. Report of the Special Master, Environmental Defense Fund v. East Bay Municipal Utility District, Alameda County (California) Superior Court Action No. 425955.

Sacramento River Action 1: Minimum Keswick releases of 5,300 from April 1, 1997 through September 30, 1997 and between 3,250 and 5,300 from October 1, 1997 to March 30, 1998 based on October 1, 1997 Shasta Reservoir carryover storage.

Description: During April, 1997, we recommend that releases from Keswick Dam be maintained at not less than 5,300 with such flows to remain in the river below Red Bluff Diversion Dam. Flows from May to September should be determined by operations required to meet temperature control criteria for winter-run chinook salmon. In any event, Sacramento River flows (i.e. Keswick releases) should be maintained at not less than 5,300 through September 30. Flows from October, 1997 through the following March should be based on October 1, 1997 Shasta reservoir carryover storage according to the following table.

Carryover storage (maf) (October 1, 1997)	Keswick Release (cfs)	Carryover storage (maf) (October 1, 1997)	Keswick Release (cfs)
less than 1.9[1]	3250	2.6	4,500
1.9 to 2.1	3,250	2.7	4,750
2.2	3,500	2.8	5,000
2.3	3,700	2.9	5,250
2.4	4,000	3.0 or greater	5,300
2.5	4,250		

Background:
The flow schedule recommended addresses fluctuations by limiting flow reductions and fluctuations to less than have previously occurred. During the fall, prior to passage of CVPIA, it was not uncommon to have flows running at 5-6 k cfs during October-November primarily for cross-delta deliveries (e.g. to refill San Luis Reservoir). When fall rainfall and natural accretions increased sufficiently to satisfy cross-delta needs, the flows from Shasta were dropped to minimums (3k cfs) regardless of the storage conditions in Shasta (i.e. maximizes storage for next summer's releases). The flow reduction would usually occur over a very short time period and strand many eggs and juveniles. This would occur even flood control operations in January-March required flows to be greatly increased. However, it also makes no sense to drain the reservoir during the winter with increased in-stream releases and not have enough cold water to

[1] In the event forecasted carryover storage drops below 1.9 maf, USBR must reinitiate consultation with NMFS.

provide for winter run spawning during the following summer. The recommended flow schedule is a balance between needs for storage and instream flows is realized.

Fish species and life stages benefited:

- Spawning adult chinook samon
- Rearing and outmigrating juvenile chinook salmon
- Spawning adult steelhead
- Rearing and outmigrating juvenile steelhead

Supporting data: The proposed flow schedule provides the most productive and stable environment that can be attained under the reservoir storage, runoff, and project operation conditions during the water year. Specifically this flow recommendation will provide for improved spawning and rearing of chinook salmon and steelhead, and improved survival of downstream migrating late-fall run, winter-run, and spring-run chinook salmon.

The algorithm for flow is built on the minimum flow and carryover requirements established in the Biological Opinion (BO) for CVP and State Water Project (SWP) effects on Sacramento River winter-run chinook salmon (NMFS 1993, CVPIA Working Paper, Vol. 3) and Water Rights Order 90-5 stipulating minimum instream flows. The BO also requires a minimum instream flow of 3,250 cfs from October 1 to April 30 and temperature control operation from May 1 to September 30 (NMFS 1993).

Clear Creek Action 1: Release a minimum flow into Clear Creek from Whiskeytown Dam of:
150 cfs from April 1, 1997 through May 30, 1997;
50 cfs from June 1, 1997 through September 30, 1997;
150-200 from Oct 1, 1997 through May 30, 1998; and
Release a spring pulse flow in May 1997.

Description: The recommended releases from Whiskeytown Dam to Clear Creek are 150-200 cfs from October to April and 50 cfs for the remainder of the year with variable spring-time releases depending on water year type.

The recommended flows provide habitat and temperature requirements for fall-run and late fall-run chinook salmon and steelhead and, to a lesser extent, for spring-run chinook salmon, which are presently extirpated from the stream. If the spring-run chinook salmon population becomes successfully reintroduced, it may require an even lower summer water temperature regime, necessitating increased flows. The releases are measured at Whiskeytown Dam to provide more precise temperature regulation and prevent harmful flow fluctuations.

A springtime flushing flow recommendation will be developed empirically to accomplish sediment removal, prevent riparian vegetation encroachment, maintain the proper channel configuration, distribute new spawning gravel, facilitate timely juvenile outmigration, and attract adult spring-run salmon and steelhead into the stream. The schedule and amount of flow would be determined by a series of experiments designed to intensify and augment a storm flow at strategic times. The flushing flow releases would not exceed the natural inflow into Whiskeytown Reservoir during the storm.

Background: The cumulative effects of water diversion, gold mining, gravel mining, logging, road building, residential development, and the construction of Whiskeytown Dam have contributed to the decline of the Clear Creek anadromous fishery habitat.

Existing Clear Creek habitat supports an estimated 2% of the Sacramento River's salmon population. Restoration of habitat and increased flow releases from Whiskeytown Reservoir could triple the present production of salmon in Clear Creek. Steelhead populations would similarly benefit.

McCormick Saeltzer (Saeltzer)Dam is located six miles upstream from the Sacramento River on Clear Creek. Whiskeytown Dam is ten miles upstream from Saeltzer Dam. Because the fish ladder on Saeltzer Dam doesn't function very well, the upper ten miles of Clear Creek is currently inaccessible to most if not all salmon and steelhead.

Increased flows were provided in Clear Creek from October 1, 1995 to April 28, 1996, with benefits to the fishery including: 1) improved fish passage into Clear Creek; 2) improved Clear Creek water temperatures in October; 3) increased the amount of spawning and rearing habitat in

Clear Creek; and 4) record numbers of fall-run chinook salmon spawning in Clear Creek. The Service distributed a report (Brown 1996) in the summer of 1996 on the fishery impacts of the flow release, based on field studies conducted by FWS, CDFG and DWR. The FWS and CDFG and again requested similar flows in 96-97 and flows were again increased in October, 1996 and are expected to continue through May, 1997.

Fish species and life stages benefited:

- Spawning adult chinook salmon
- Rearing and outmigrating juvenile chinook salmon
- Spawning adult steelhead
- Rearing and outmigrating juvenile steelhead

Supporting data: The recommended flow releases can nearly double available fall-run and late fall-run chinook salmon habitat over that provided by the present minimum releases of 50 cfs. By increasing the flows below Whiskeytown Dam, it is possible to add back approximately five miles of spring-run habitat and 10 miles of steelhead habitat and to possibly reintroduce spring-run chinook salmon. If successful, another distinct and genetically viable population of spring-run chinook salmon and steelhead could become established in the Central Valley, which would reduce the probability of these species going extinct. In addition, Clear Creek is one of two tributaries in the upper Sacramento River that can provide habitat for three races of salmon and steelhead.

These recommendations (CDFG correspondence report 1993, Working Paper, Vol. 3) are based on attainable temperature objectives and habitat requirements that were determined by an instream flow study (DWR 1986, Working Paper, Vol. 3) and the Clear Creek hydrologic data at Whiskeytown Dam for 1923 to 1994 (USBR Central Valley Project Operations Hydrologic Data, Working Paper, Vol. 3).