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DFG Exhibit #15

The Status of San Joaquin Drainage Chinook Salmon Stocks, Habitat Conditions and Natural Production Factors

California Department of Fish and Game
Region 4
Fresno, California

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Prepared for the State Water Resources Control Board Bay/Delta Hearing Process PHASE I: Determination of Beneficial Uses and Determination of Reasonable Levels of Protection. September, 1987

ERRATA SHEET DFG 15

DFG Exhibit #15: The status of San Joaquin Drainage Chinook Salmon Stocks, Habitat Conditions and Natural Production Factors.

TABLE OF CONTENTS II to read "LIST OF FIGURES".

LIST OF FIGURES, Figure 4 to read "Recent Tributary Contributions to the Spring (March through May) San Joaquin River Flows at Vernalis, 1978-1984". Change page 15 heading for Figure 4.

Page 13, Figure 3. This Figure was obtained from a report prepared jointly by the U. S. Bureau of Reclamation and the South Delta Water Agency in 1980 which assessed the changes in flow and water quality in the south Delta in relation to the CVP and other operations in the San Joaquin drainage. The title will be forwarded and should be added to the Literature Cited.

Page 14, last paragraph regarding Figure 4 should read "A closer look at the recent mean spring flows at Vernalis indicates that San Joaquin River accretion (i.e., all streamflow in the river above the mouth of the Merced River confluence) have contributed significantly to the spring flows". These years (1978-1984) coincide with the most recent improvements in San Joaquin drainage salmon production.

Page 28, Figure 10. This Figure was obtained from a Department of Water Resources report prepared in 1962 entitled "Salinity Incursion and Water Resources, Appendix to Bulletin No. 76 (121 pages plus plates)". The citation should be added to the Literated Cited section.

Page 34, line 7 of paragraph 2. The "0.66" is changed to 0.68.

Page 36, line 6 of paragraph 2. Omit "(40,000 indicated by the dotted line)".

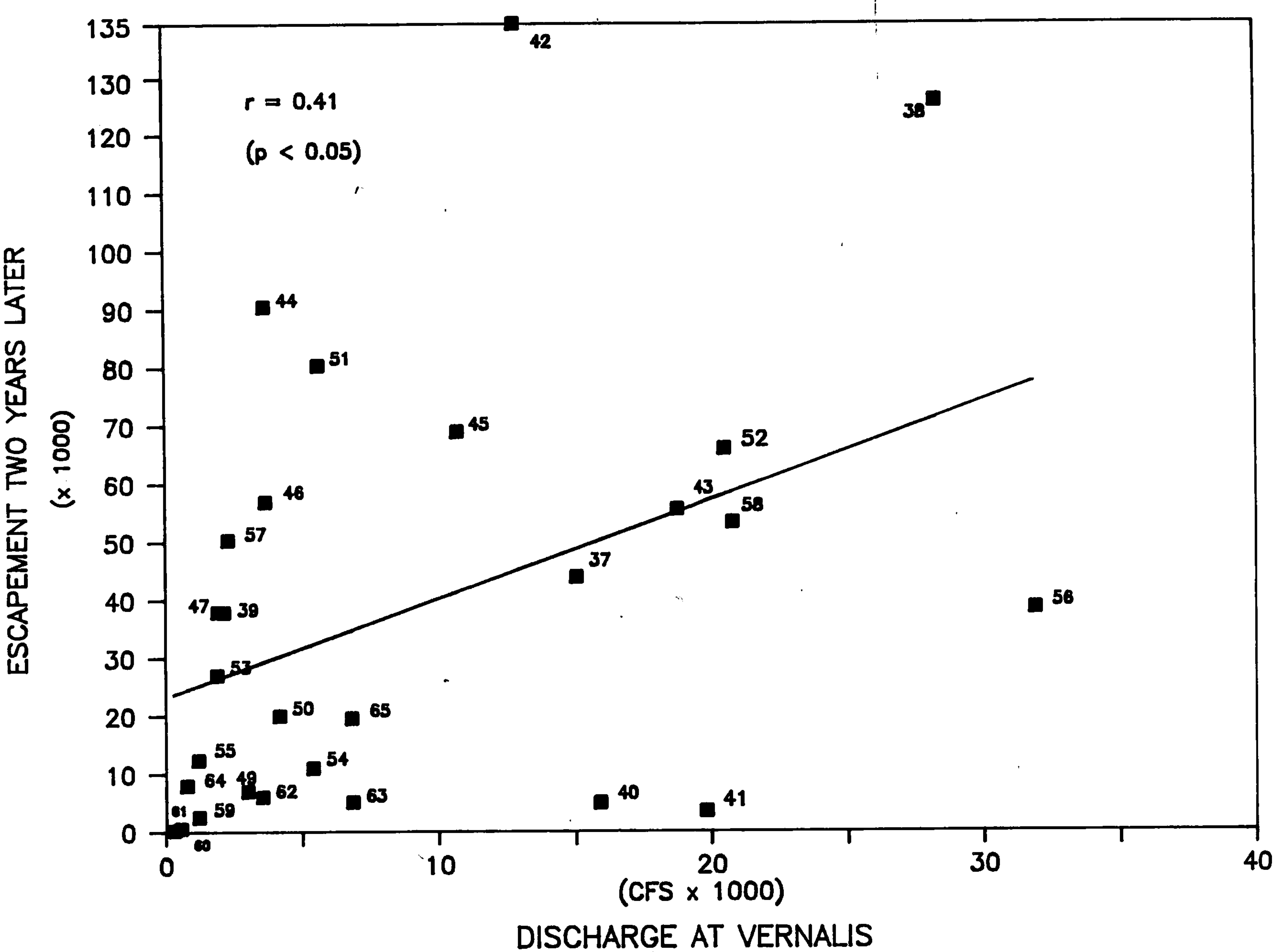
Page 37, Figure 13, Appendix 2. The upper graph on Figure 13 was based on Appendix 2. Typographic errors in Appendix 2 affect the mathematical relationship in Figure 13 (upper). Appendix 2 is changed as follows:

Year	Tuolumne	Total
1944	130,000	135,000
1945	---	56,000
1946	61,000	91,000

The upper part of Figure 13 has been amended and attached for clarification.

Page 42, last paragraph. Omit reference to dotted lines on Figure 16.

Page 49, paragraph 2, last line. Change "1945" to 1946.



r = 0.41
(p < 0.05)
ESCAPEMENT TWO YEARS LATER
(x 1000)
DISCHARGE AT VERNALIS
(CFS x 1000)
135
130
120
110
100
90
80
70
60
50
40
30
20
10
0
0
10
20
30
40
42
38
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I. EXECUTIVE SUMMARY

Chinook salmon, a very significant fishery, may be affected by this action of the State Water Resources Control Board.

The mortality of juvenile salmon is ~~a major~~ limiting factor in the production of fish in the San Joaquin Drainage. Spawning runs in the San Joaquin Drainage are 70% or less of historic levels due largely to inadequate streamflows in the San Joaquin River, its tributaries and the Delta when young migrate to sea.

High water temperatures in May during the seaward migration of young fish results in high chronic thermal stress when San Joaquin River flows at Vernalis are below 5,000 cfs. This, added to the additional stress factors in the river and south Delta, results in poor survival of juvenile salmon enroute to the ocean and consequently, low adult production.

Appropriate improvements in tributary streamflows alone can help reduce temperature stress, but will only be effective in improving the number of adult salmon if combined with measures which improve survival of juveniles in the south Delta.

what do you mean

In the absence of a total water management approach, very large amounts of water would be necessary to recover San Joaquin Drainage Chinook salmon runs to near historic levels. Measures which guarantee and protect acceptable streamflows and habitat conditions in the tributaries, San Joaquin River and Delta are needed.

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III. INTRODUCTION

In previous actions, the State Water Resources Control Board (SWRCB) has confined the scope of this phase of the Bay Delta hearings to the Sacramento River, San Joaquin River Delta and has delineated its southern boundary at the USGS streamflow gauge, located at Vernalis. The SWRCB has requested supplemental information pertaining to upstream beneficial uses which may be positively or negatively affected by its decisions on salinity, diversions, pollutants, habitat requirements, and streamflows in the Delta channels, the estuary and San Francisco Bay.

Chinook salmon (or king salmon) are the primary fishery resource in the San Joaquin River drainage to be affected by this SWRCB action (Figure 1). Total production (adult harvest plus spawning run) has declined by over 70% of the 1940, 1944 and 1945 levels. Since 1968, 0.4% to 20% of the entire Central Valley fall spawning runs have occurred in this drainage (Appendix 1). It is believed that appropriate habitat conditions provided for the chinook salmon resource will also benefit other anadromous species in this drainage such as white sturgeon, and American shad, as well as resident fish populations.

The "Basin Plan" for the San Joaquin drainage as developed by the Central Valley Regional Water Quality Control Board (CVRWQCB) is in the process of revision. It should identify the beneficial uses of anadromous fish migration, spawning and emigration habitat needs throughout the San Joaquin River and all major tributaries.

This report summarizes available technical information on the life

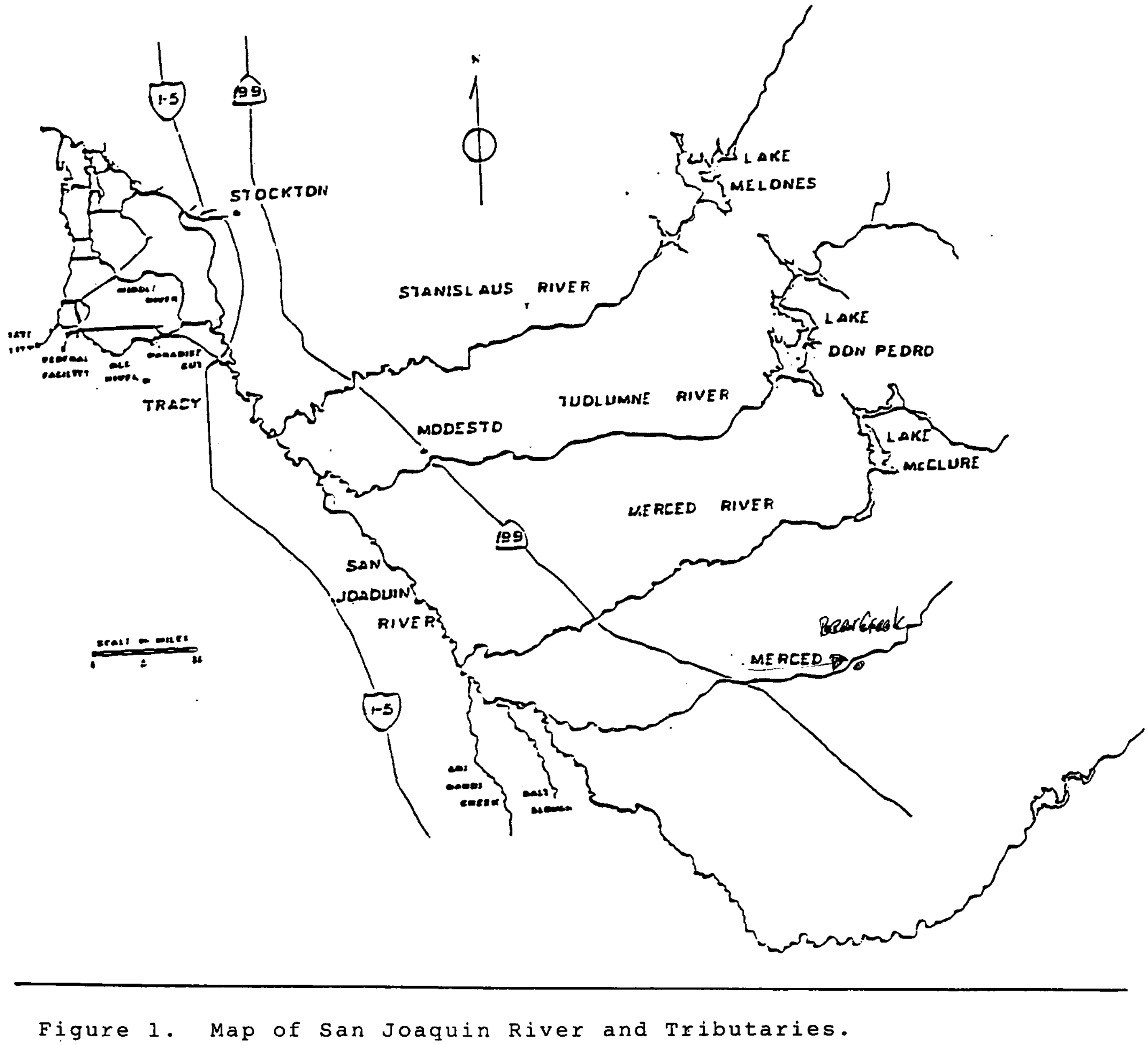


Figure 1. Map of San Joaquin River and Tributaries.

history and status of Chinook salmon and habitat conditions in the San Joaquin River drainage upstream of Stockton. More importantly, it provides available information on minimum protection levels needed for adult migration, spawning and rearing in the tributaries and emigration of young Chinook salmon of San Joaquin drainage origin into and through the Delta.

Under present conditions streamflow requirements for fall-run salmon below the major tributary reservoirs in this drainage are not adequate. All existing Licenses or Agreements fail to provide acceptable streamflow levels for young salmon emigrating to the ocean. High water temperatures on the mainstem San Joaquin are a problem during emigration. The amount of water export in the South Delta during April, May, and June of above average, average, dry and critically dry years is high relative to the San Joaquin River inflow. Consequently, juvenile salmon survival is reduced by export-related impacts.

Clearly, the needs of chinook salmon encompass water quantity and water quality conditions (e.g. streamflow, temperature, dissolved oxygen and discharge standards) in the San Joaquin River drainage and in the South and Central Delta and Estuary. Providing appropriate habitat conditions in only the Delta would result in some improvement in juvenile survival and increased adult numbers. Providing appropriate habitat conditions in the San Joaquin tributaries upstream of the Delta would also result in additional improvements in the salmon runs. Therefore, we believe the approach to recovering and maintaining this important beneficial use should incorporate provisions for the seasonal habitat needs of chinook salmon in the tributaries, the main

San Joaquin River and the Delta.

IV. LIFE HISTORY DIGEST

Chinook salmon are the largest of the five Pacific salmon species. They are anadromous, meaning they return to fresh water to spawn after dwelling in the ocean.

The fall "run" is the principal spawning run remaining in the San Joaquin River tributaries. The distinct timing for each life stage is shown in Table 1. In addition, a small number of late spawning fish have been documented during January through March since 1984.

Table 1. Life Stage Periodicity Chart for Fall-Run Chinook Salmon in the San Joaquin River Drainage

	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
FALL RUN												
Adult Migration	XX	XXX	XXX	XXX	XXX							
Spawning			X	XXX	XXX	XX						
Incubation			X	XXX	XXX	XXX	XXX	XXX	X			
Rearing & Outmigration					X	XXX	XXX	XXX	XXX	XXX	XXX	X

Adults return to their "home stream" to spawn using olfactory cues (smell) and some form of memory acquired during the later part of their juvenile freshwater residence. They instinctively select specific gravel size, substrate porosity, water depth and water velocity for redd (nest) sites. Behavioral and nest excavation activities precede egg deposition. All Pacific salmon adults die after spawning.

Egg incubation and hatching occurs in 50-60 days at water temperatures between 45-55°F (42.5-57.5°F is acceptable).

Thirty days after hatching, fry emerge from the gravel. They range from 30-40 mm FL (fork length) at emergence. Throughout this report we refer to 30-70 mm FL juveniles as "fry".

Fry are not well adapted to high velocity currents and spend much of their first month along the shallow stream margins in slower water. As emergence of fry increases (mid-January to mid-March) a density~~-dependent movement occurs~~. Their increasing number causes dispersal of the fry throughout the rearing habitat of the tributaries and lower San Joaquin River. This movement can be masked by premature dispersal associated with surges or spikes in daily flow or dissolved minerals within spawning areas. Dispersal of fry downstream and into the Delta appears greatest when flows (sustained or spikes) exceed 1,000-2,000 cfs in the nursery tributaries during December, January, February or March. As an example, over 400,000 fry were salvaged at the Tracy Fish Collecting Facility (Tracy Facility) and John E. Skinner Delta Fish Protective Facility (Skinner Facility) in mid-February of 1986 when a major storm resulted in tributary and mainstem discharge increases. The fate of prematurely dispersed fry into the Delta is unknown. We believe many are lost if water exports exceed inflow and flow reversals occur in the San Joaquin Delta.

Fry rear for a few months, both in tributaries and the mainstem San Joaquin River. They gradually increase utilization of deeper water, greater water velocities, and social hierarchies develop.

After a few months of growth, juveniles undergo the physiological transformation termed "smoltification". Once this process begins, "smolts" emigrate (move back) downstream to grow in salt water. The migration rate appears to be related to current velocity. During the smoltification and migration stage, imprinting of the "home stream" water occurs in natural smolts. This process is believed to occur quickly, in less than 10 days (Shirahata and Tanaka, 1969; Carlin, 1968; Jensen and Duncan, 1971; Mighell, 1975; Hasler and Scholz, 1983). Dislocation of young salmon from their "home stream" before or after smoltification can increase the straying rate for returning adults into non-origin waters. Additionally, water diverted from the "home streams" into other accessible channels which discharge into the San Joaquin River upstream or downstream of the normal entrance to the "home stream" also increases the adult straying and production loss due to inadequate habitat for spawning and juvenile survival.

Yearlings are juveniles which remain in tributaries approximately a year and migrate when a secondary "smoltification" occurs. Remaining in the stream beyond the first smoltification is a survival strategy that some chinook salmon have evolved which takes advantage of good rearing conditions when they are present in nursery areas. Yearlings enter the ocean at a larger size and generally have a greater survival rate than fry.

Yearlings have been common in the Stanislaus River in recent years. Fry, smolts and yearlings in both riverine and estuarine environments are exposed to diversions, predation, poor water quality (i.e. water temperature above 68 degrees Fahrenheit), food scarcity and disease. Once they reach the ocean, the greatest natural mortality occurs during the first year of life when salmon are still small enough to be eaten by predators.

Water conditions at the time of adult spawning migration are important, since adult salmon rely on the imprinting/learning obtained as smolts to detect and locate their "home stream". Based on this information, the key periods of concern in the Delta, the San Joaquin River and tributaries for Chinook salmon stocks are:

A) ~~August through January~~: suitable water quality* and "home stream" flow from San Joaquin tributaries is needed in the principal south Delta channels connected to the estuary for fall-run and later adult migration/spawning and both wild and hatchery yearling emigration.

B) December through June: Suitable water quality* and improved streamflow conditions are needed in the upstream tributaries, lower San Joaquin River, and south Delta for fry rearing and acceptable survival of smolts during emigration.

*Water Quality implies (1) acceptable levels of chemical constituents discharge, (2) appropriate streamflow rates to afford an acceptable "receiving water" concentration, and (3) acceptable water temperatures for San Joaquin origin smolts to avoid high chronic or acute stress level for safe movement to the estuary and ocean.

V. SAN JOAQUIN SALMON STOCKS, HABITATS AND WATER CONDITIONS

Status

The Department of Fish and Game is required to protect salmon and their habitat and to monitor the status of salmon runs. The Fish and Game Commission Policy on Steelhead and Salmon, Department of Fish and Game Policy on stock management and the designated spawning areas as defined in Fish and Game Code Section 1505 are appended for clarification (Appendix 3).

Large runs in the early 1940's on the San Joaquin River near Fresno were predominantly comprised of spring-run fish. This run was completely eliminated after 1947 as a result of the Friant Dam closure and operation of the Central Valley Project.

Chinook salmon escapements have been documented by the Department of Fish and Game and the U.S. Bureau of Sport Fisheries (now U.S. Fish and Wildlife Service) using various techniques on one or more San Joaquin River tributaries since 1939 (Fry, 1961; Taylor, 1974; Reavis, 1983 and DFG unpublished data (Appendix 2). These estimates provide the best measure of resource status over time.

Large runs in the early 1940's on the San Joaquin River near Fresno were predominantly comprised of spring-run fish. This run was completely eliminated after 1947 as a result of the Friant Dam closure and operation of the Central Valley Project.

repea

As indicated previously, escapement levels on the Tuolumne and Stanislaus Rivers have declined by more than 70% of the 1940, 1944 and 1945 levels (Appendix 2). Recent escapement levels remain cyclic but dramatically improve as a result of higher flows in the tributaries and the San Joaquin River at Vernalis during wet years (Figure 2). Dams on tributaries are not able to contain all the runoff during wet year periods. The recent increases from 1983 to 1985 associated with previous high spring runoff years are again dwindling to lower production levels. The 1987 run is expected to be back down to 18-25% of the 1940, 1944 and 1945 levels.

A base-level run of approximately 2,000 adults on the Merced River has been partially sustained by production and release of yearling chinook salmon from the Merced River Fish Facility (MRFF) since 1972. Salmon produced in this river also responded favorably during 1981 through 1986 suggesting that in addition to the yearling program there, achieving the full potential of this run is dependent on improved streamflow conditions. The annual production of chinook salmon at MRFF since 1970 is summarized in Appendix 4. Hatchery contribution to the San Joaquin River stocks is less than 5%.

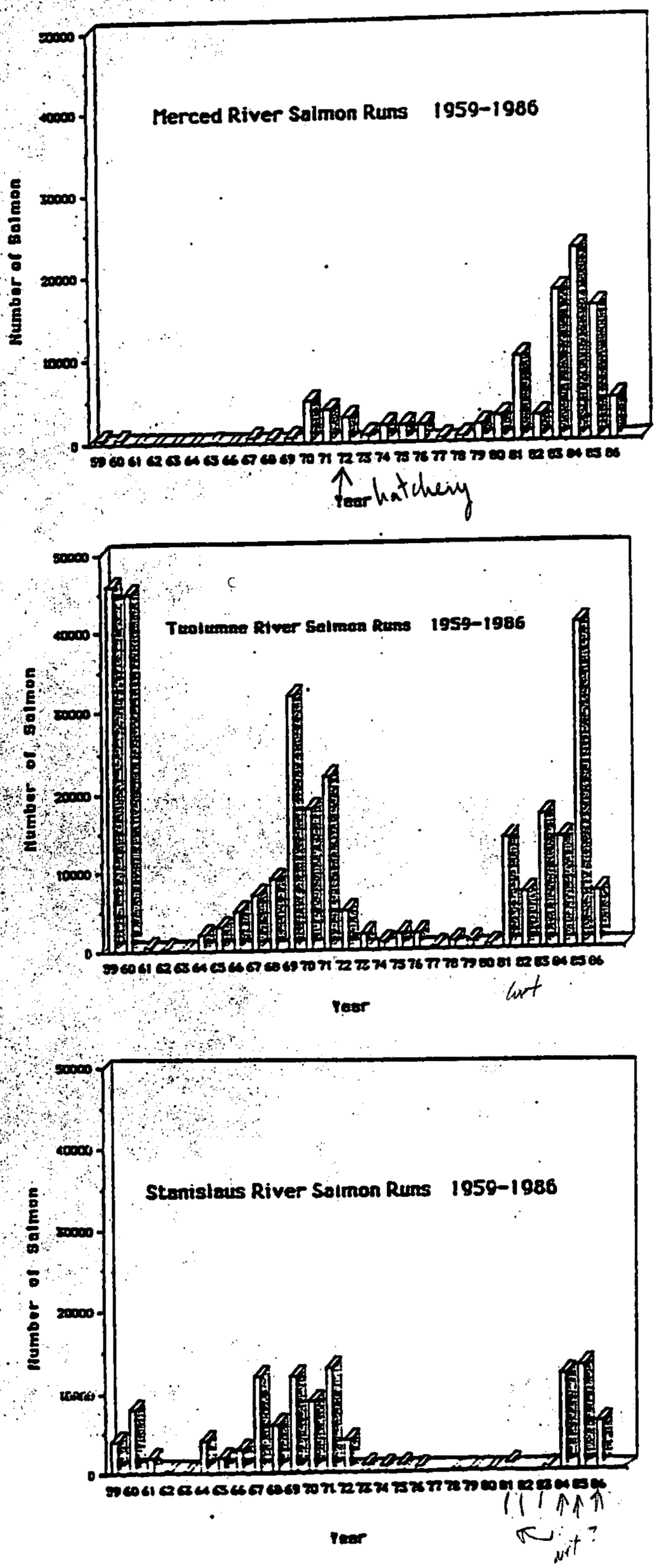


Figure 2. Recent escapement of fall-run chinook salmon in the Merced, Tuolumne and Stanislaus Rivers.

Chinook salmon runs in San Joaquin tributaries represent the southernmost latitude of freshwater existence for this species. Their ocean distribution is generally from California to Southern Canada but the majority of benefit to sport and commercial anglers is from Monterey north to the Marin County coastline. Inland harvest in the estuary and San Joaquin tributaries is less than 10% of the total adult harvest.

May 31

The existing required fishery streamflows in the Merced and end of April Tuolumne rivers are reduced in April and May prior to the end of the juvenile rearing periods (Appendix 5). Few of the fry or smolts that remain in these tributaries beyond this period survive. This is due principally to severe reductions in living space, high water temperatures and predation. In some years this represents a significant loss of annual production. Available water in the Stanislaus drainage has resulted in acceptable streamflow and temperature conditions in this tributary most of the last four years. Rearing and emigration flows on the main San Joaquin River are reduced and water temperatures increase just when smolts critically need suitable conveyance flows to enter the Delta. Agricultural return ~~flows to the~~ San Joaquin River above the Merced River confluence ~~increase in April and~~ May as water and ambient air temperatures rise significantly.

Spawning Gravels

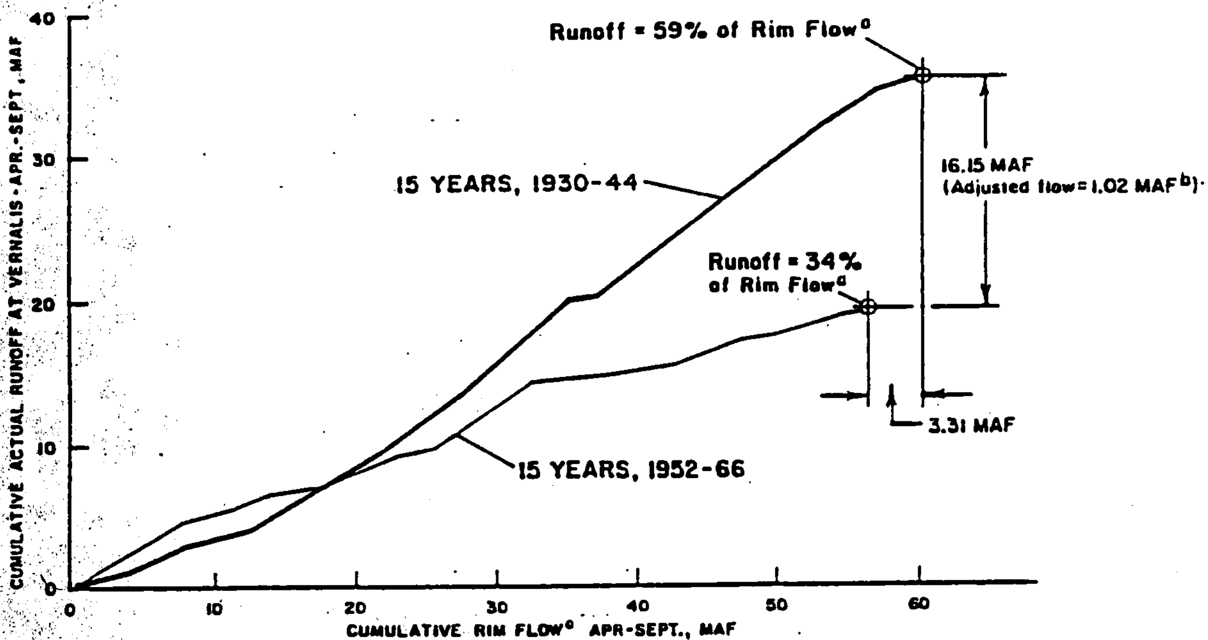
The recent escapements of 23,000, 41,000 and 13,000 adult salmon on the Merced (1984), Tuolumne (1985) and Stanislaus Rivers (1985) provide the best measure of spawning habitat potentials in the San Joaquin tributaries. Redd (or nest) overlap problems which result in increased egg mortality were not documented during those years. The spawning adults were dispersed throughout the available spawning habitats.

Gravel renovation work on the San Joaquin River spawning tributaries in the early 1970's did not immediately result in improved escapement. Even today, spawning area capacity does not appear to be the most important factor limiting recovery of escapements to near historic levels. Increases in spawning habitat area may be needed in the future to offset gravel depletions or vegetation encroachment.

Basin Water Storage Trends

A joint study by USBR and South Delta Water Agency (SDWA) in 1980 identified a pre-and post- CVP reduction of April through September adjusted cumulative runoff at Vernalis of 1.02 million acre-feet (Figure 3). The study determined that the post-CVP change amounted to a 42% reduction in cumulative runoff.

The reduction in quality and quantity of the San Joaquin River streamflows in the Delta has affected San Joaquin chinook salmon production.



a. Unimpaired flow without any diversions.

b. Average annual decrement in April-September runoff between two historic periods. (Adjusted for difference in Rim Flow)

$$= \frac{16.15}{15} \times \frac{56.1}{59.4} \times 10^6 = 1{,}020{,}000 \text{ acre-feet}$$

CUMULATIVE RUNOFF AT VERNALIS FOR APRIL-SEPTEMBER PERIOD
PRE-CVP (1930-44) AND POST (1952-66)

Figure 3. Cumulative runoff at Vernalis for April-September Period Pre-CVP (1930-44) and Post (1952-66) From: USBR/SDWA 1980

The transition of storage development in the San Joaquin drainage is helpful in considering opportunities for protection of beneficial uses and in understanding the affects of runoff reduction (Table 2).

Table 2. Major San Joaquin Drainage Water Developments Affecting Chinook Salmon Habitat or Habitat Conditions

River	Date Established	Reservoir	Storage (ac. ft.)	Estimated % Ave Basin Runoff
Stanislaus 1/	1912	Goodwin	500	
	1926	Melones	112,500	
	1957	Tulloch	56,840	
	1978	New Melones	2,419,523	
				204%
Tuolumne 2/	1894	La Grange	500	
	1923	Don Pedro	290,400	
	1971	New Don Pedro	2,030,000	
				198%
Merced 3/	1910	Merced Falls	900	
	1910	Crocker-Huffman	300	
	1926	Exchequer	289,000	
	1967	New Exchequer	1,024,000	
				98%
San Joaquin 4/	1920	Kerckhoff	4,300	
	1942	Millerton	503,200	
				48%

1/ Additional upstream storage in Strawberry, Lyons, Relief, Beardsley, Donnels, Spicer Meadows and Utica Reservoirs. The latter two are proposed for enlargement.

2/ Additional upstream storage in Cherry, Eleanor and Hetch-Hetchy. Clavey Reservoir(s) planned.

3/ Headwaters of the Merced River protected by Yosemite National Park and the reach between El Portal and Bagby lacks a suitable dam site. Mariposa County interested in potential water development.

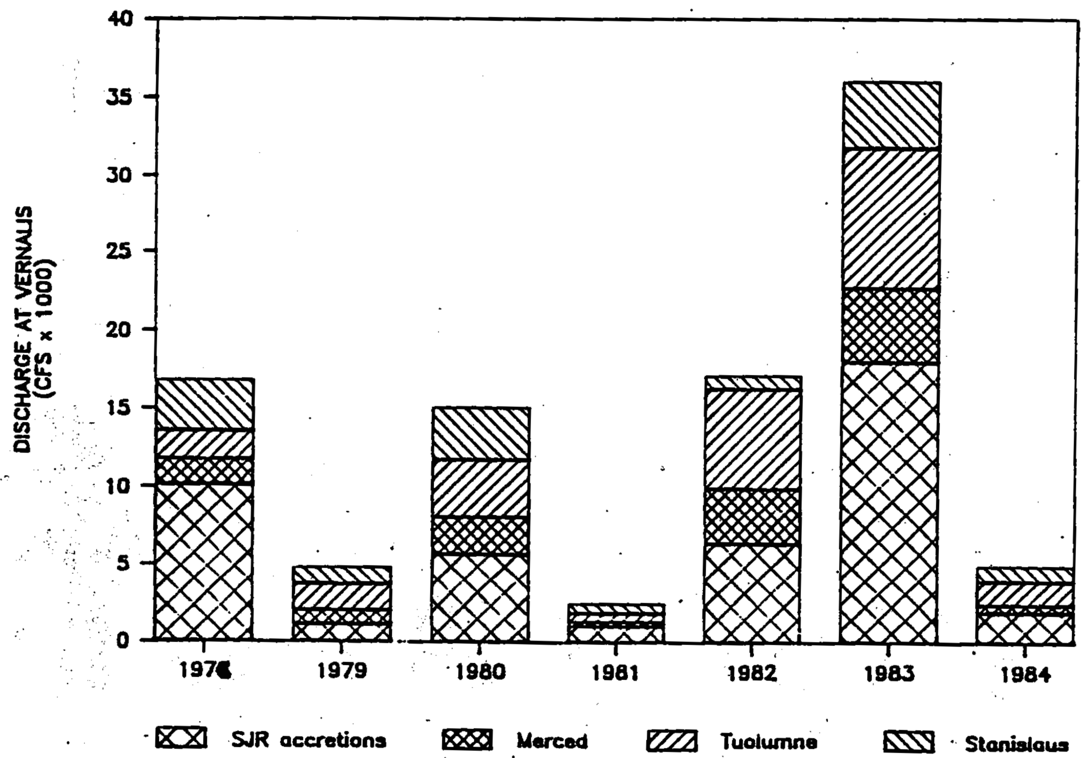
4/ Additional upstream storage in Mammoth Pool, Edison, Shaver, Huntington, Florence, Crane Valley and Redinger Reservoirs. Major pump-storage project planned plus reservoir enlargement(s).

Contribution of Tributaries to Spring Vernalis Outflow

A closer look at the trends in mean monthly flows in the San Joaquin River through the recent history of water development in California indicates a 30% reduction in mean spring Delta inflow from the San Joaquin drainage.
28% 32% 44%
The April, May and June mean flows at Vernalis have been reduced by approximately 28%, 32% and 44%,

respectively (Figure 4).

Figure 4. Mean monthly streamflow in the San Joaquin River at Vernalis during the spring outmigration of fall-run chinook salmon. 1930-1944, 1945-1952 and 1953-1984.



IV. NATURAL PRODUCTION FACTORS

Timing of Juvenile Emigration

The majority of the annual salmon production leaves the San Joaquin tributaries as fry and smolts each spring. Results of our beach seine survey at four sites on the Tuolumne River in 1983, 1984 and 1985 provide one measure of fry and smolt migration timing (Figure

5). Very few fish were sampled beyond May 15 except during the high spring flows in 1983.

Tuolumne River flows in the rearing habitat during the fry rearing periods each year were dramatically different (Appendix 6). This data plotted as hourly flow to show the changes in nursery habitat flows .ch occurred daily (i.e. 400 cfs to 4,500 cfs and back to 400 cfs .ily). In reviewing published streamflow records, the effect of ubstantial flow changes are masked by records depicting mean daily or mean monthly streamflows.

The cumulative seine catch differences between our 1983 (high stable fry period flows), 1984 (high but less stable flows) and 1985 (dramatic fluctuating flows in the fry period) show that differences in tributary rearing periods did occur with different flow regimes. Those differences were most dramatic early in the season when fry dominated the catch. The 80% of cumulative catch level was reached in early March, late March and early April in 1985, 1984 and 1983, respectively.

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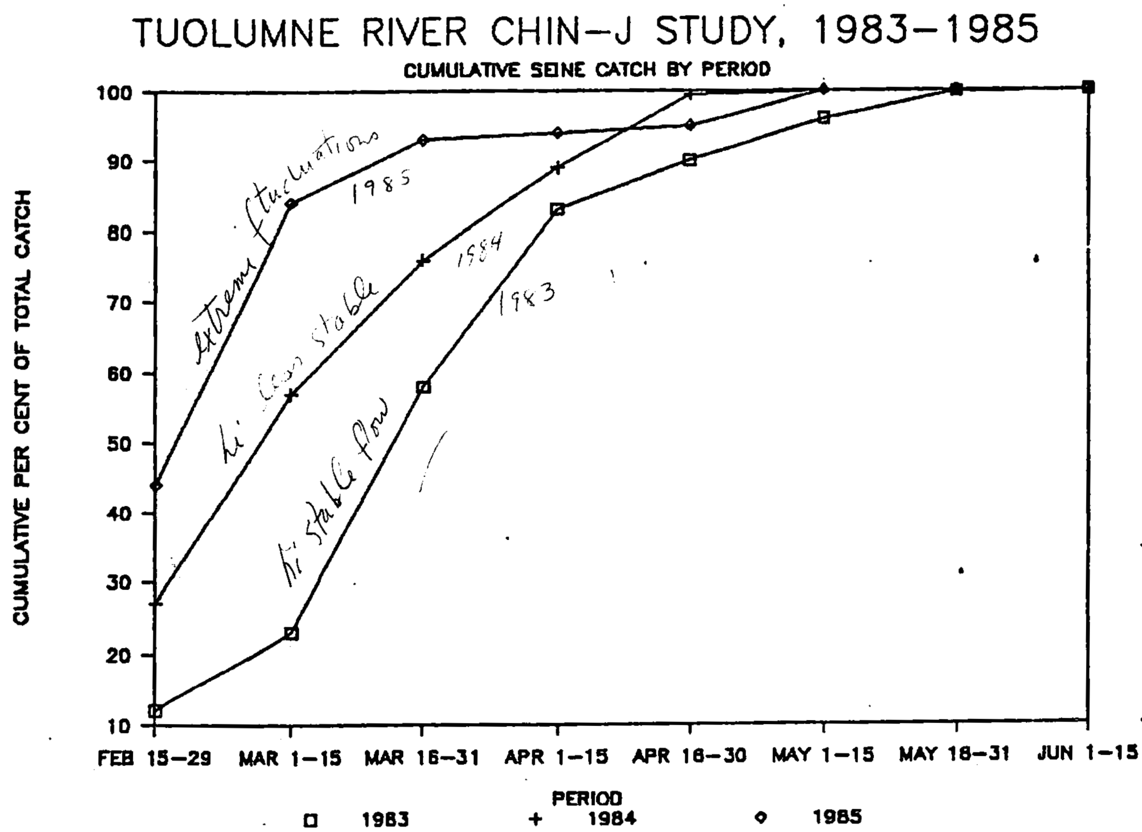
early mar late Mar early Apr

fluctuating [illegible]

Figure 5. Cumulative percent of total chinook salmon juvenile beach seine catch in the Tuolumne River, 1983, 1984 and 1985



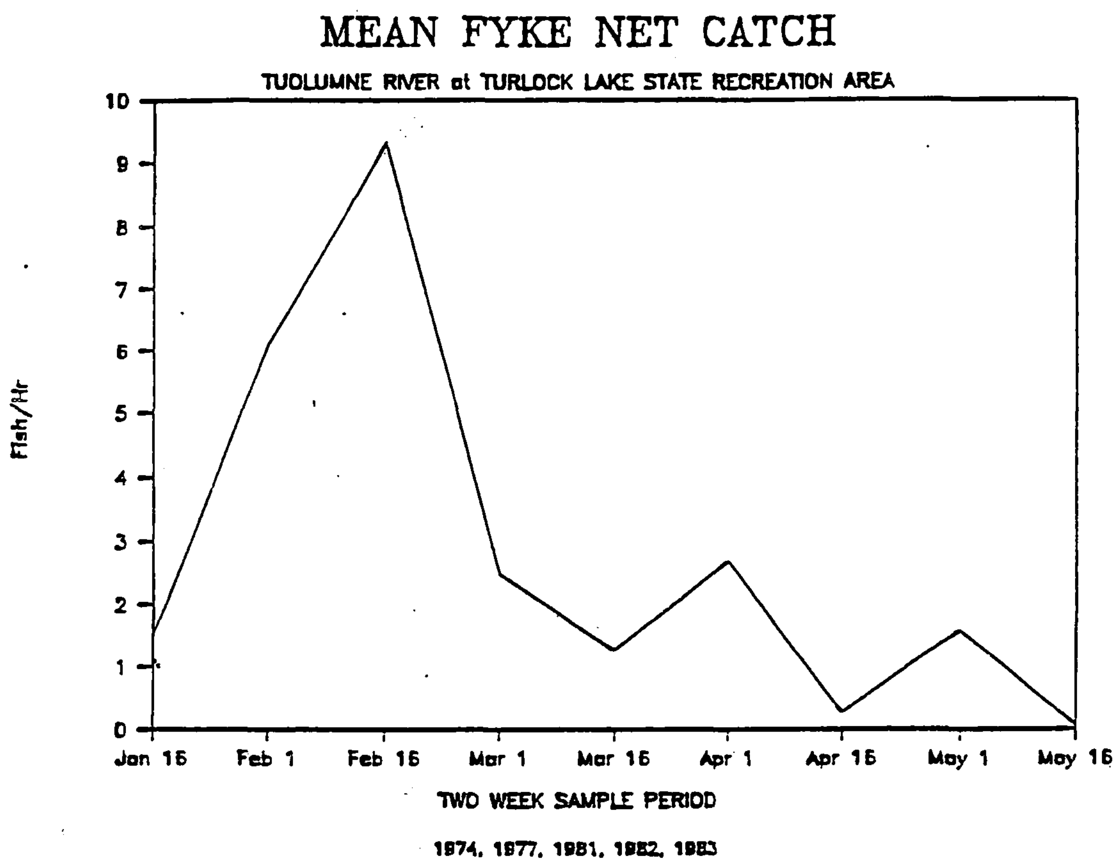
Juveniles were present into June in 1983 but very few remained by early April in 1985. External smolt characteristics and the size distribution data obtained during two years of our Tuolumne River seine survey (Appendix 7) showed many juveniles throughout the Tuolumne River were 70 mm in fork length and had begun their smolt transformation by April 1.

San Joaquin origin smolts migrating into the Delta via Old River arrive at the Tracy Facility first. It can be assumed that in excess why of 90% of the chinook salmon salvaged are of San Joaquin River origin (Knutson 1980). Salvage refers to those fish which are successfully separated from the water to be exported and eventually transported by truck to the estuary. An estimate of the minimum fraction of Sacramento salmon collected at the facilities is provided in Appendix 8; the remainder are of San Joaquin drainage origin.

Since most adult salmon return to spawn in their third year of life, the escapements resulting from the juvenile production years of spring 1983, 1984 and 1985 are in the fall of 1983 1984 1985 1985, 1986 and 1987, respectively. Spawning runs in 1985 and 1986 were 41,000 and 7,000 adults, respectively. The run in the fall of 1987 will coincide with the cumulative seine catch data showing the shortest rearing period.

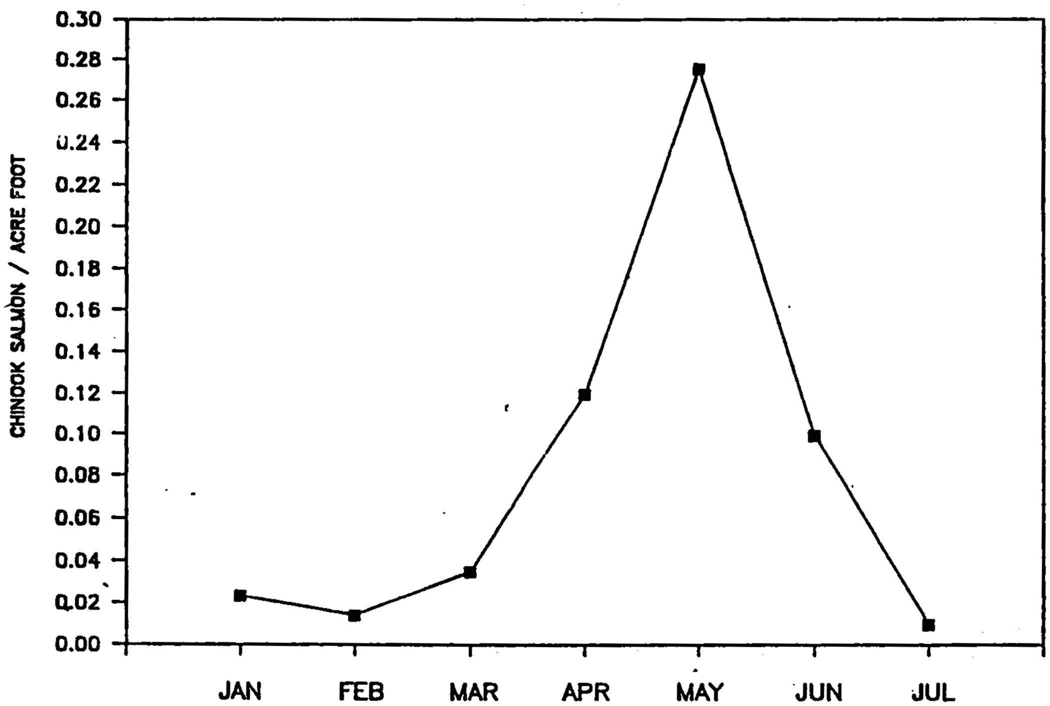
A second measure of fry and smolt migration timing was derived from five years of fyke netting (3′ x 5′ mouth) effort at Turlock Lake State Recreation Area in the Tuolumne River spawning reach (Figure 6). While this net is relatively ineffective for juvenile salmon exceeding 60-65 mm FL it does provide a reasonable description of the density-dependent movement period when fry are distributing to unoccupied rearing habitats. The declining catch into mid-March either infers that more juveniles are reaching the size where net avoidance is significant or fewer fish are actually moving past the net site. We believe both are probably true.

Figure 6. Catch of juvenile chinook salmon in fyke nets at Turlock Lake State Recreation Area (Tuolumne River) in 1974, 1977, 1981, 1982 and 1983



A third and more robust description of the timing of fry and smolt emigration from the San Joaquin tributaries into the Delta was derived from the Tracy Facility mean monthly salvage estimates for the period 1968-1980 (Figure 7).

Figure 7. Chinook salmon salvage rates at the Tracy Facility (CVP) from 1968 to 1980.

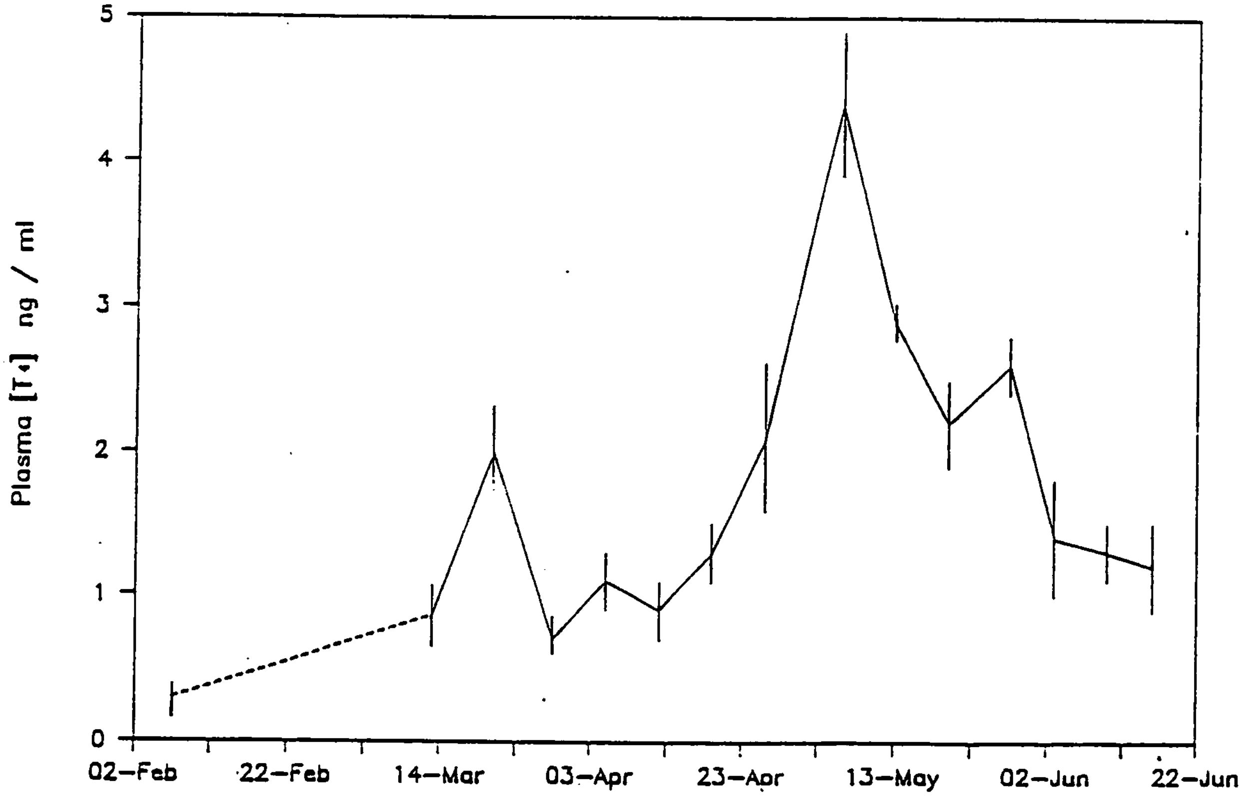


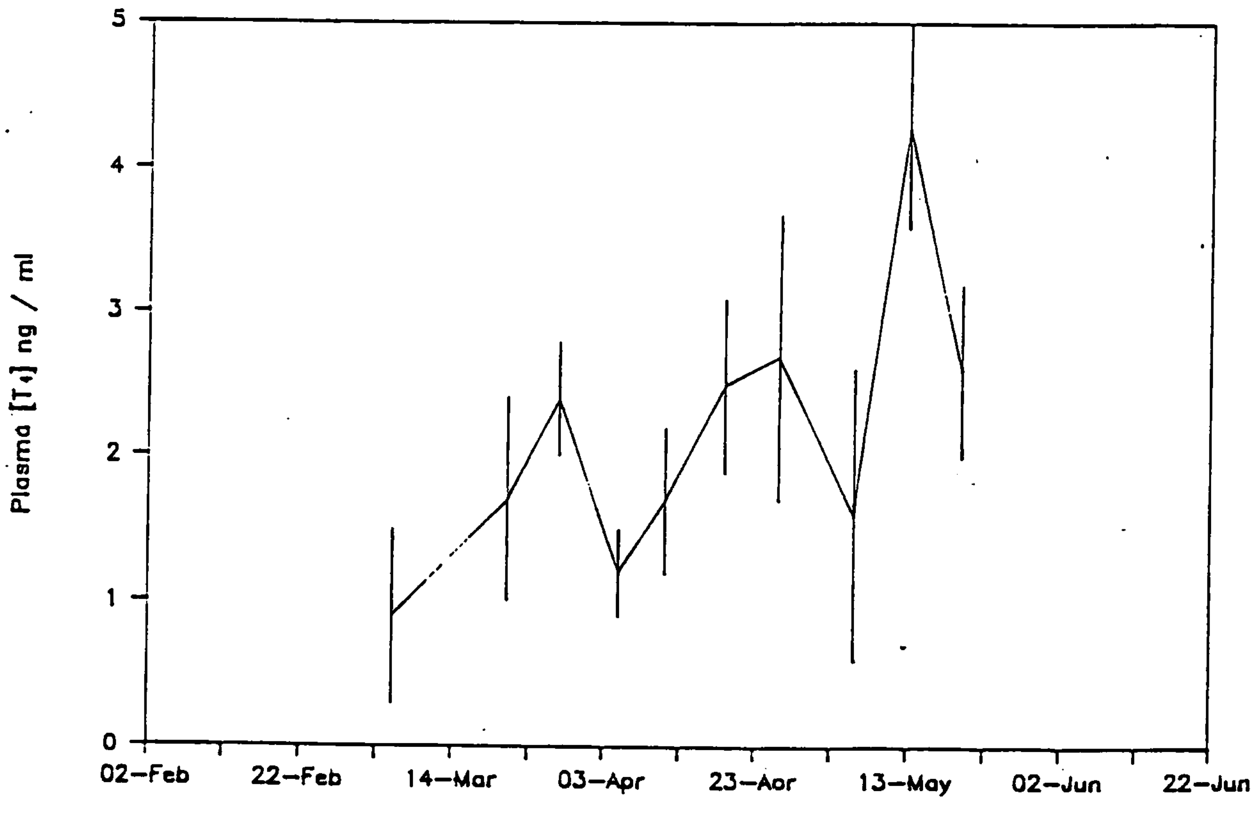
To evaluate if fry movements occurring each spring were passive (density-dependent) or "active" (true emigrations) juvenile salmon blood plasma thyroid hormone thyroxine (T_4), levels were monitored weekly in the lower Stanislaus River (3/6/85 to 4/20/85) and in the spawning channel at Merced River Fish Facility (2/7/85 to 7/3/85). One sample was obtained on 5/7/85 from the Delta at the Tracy Facility to see how hormone levels there compared to those upstream in the tributaries. Increased thyroid gland activity during smoltification (Hoar, 1939, 1976; Baggerman, 1960; Nagahama et al., 1982) generally occurs in parallel to an increase in the blood plasma levels of thyroxine. Levels were measured by radio-immuno assay (Dickhoff et al., 1978). The acute rise of thyroxine levels in spring is normally associated with the peak of smoltification whereas the more gradual increases earlier are a physiological clue that "active" migration is occurring.

We did detect the expected elevation of blood plasma thyroxine levels (Figure 8). Water conditions in the spawning channel were stable throughout the monitoring period but the Stanislaus River flows fluctuated. In the absence of river-related stimuli the thyroxine hormone levels at MRFF spawning channel rose steadily in early April to a peak beginning in early May and stayed high through late May. The Stanislaus River fish thyroxine levels indicate several subtle hormonal responses occurred in late-March and late-April with a peak exceeding 4 ng/ml in mid-May. Chinook salmon sampled in the Delta at the Federal Fish Facility on May 7, 1985 had plasma thyroxine levels exceeding 13 ng/ml more characteristic of the peak of smoltification.

Tracy

Figure 8. Merced Fish Facility (lower) Spawning Channel (~~upper~~) and Stanislaus River (lower) chinook salmon blood plasma thyroid hormone (T_4) levels through the 1985 smoltification period.





Based on these different measures of emigration timing:

A. San Joaquin origin chinook salmon smolts are dispersed throughout the tributaries and lower river by mid-February and generally emigrate to the Delta during the period March 15 through at least the first week of June.

B. Since fry are most abundant and are typically involved in passive, density-dependent movements during the period January through March, they are particularly susceptible to tributary streamflow changes and conveyance into the Delta.

Water Temperature and Vernalis Spring Flows

Water temperatures in the San Joaquin Drainage spawning tributaries and along the mainstem into the Delta is an important factor affecting growth and survival of Chinook salmon juveniles. Salmon maximum and minimum temperature tolerance, rapid-rise tolerance and the effect of acclimatization temperatures on salmon temperature tolerance has been examined (Brett, 1952; Orsi, 1971). Generally, acclimatization increases short-term temperature stress tolerance, but Chinook salmon mortality begins when temperatures reach 75 degrees F. ($23.9^{o}C$). Salmon swimming speeds, feeding, growth and vulnerability to diseases and predation are all affected by increased water temperature (Brett et al., 1958; Shelbourn et al., 1973; Coutant, 1973; Hughes et al., 1978). Wedemeyer (1973) showed that a rapid sublethal rise of 10 degrees C. caused several responses in salmon (eg. increased pituitary activity) and felt that such stress especially in downstream migrants should be avoided. However, substantial water temperature elevation is also one of the factors believed to beneficially stimulate salmon outmigration (Foerster, 1937; Grau et al., 1982; R.S. Nishioka, personal communication).

The sublethal effects of elevated water temperature on fish survival have been measured (Rich, 1987). Chronic stress is generally indicated in juvenile Chinook salmon by:

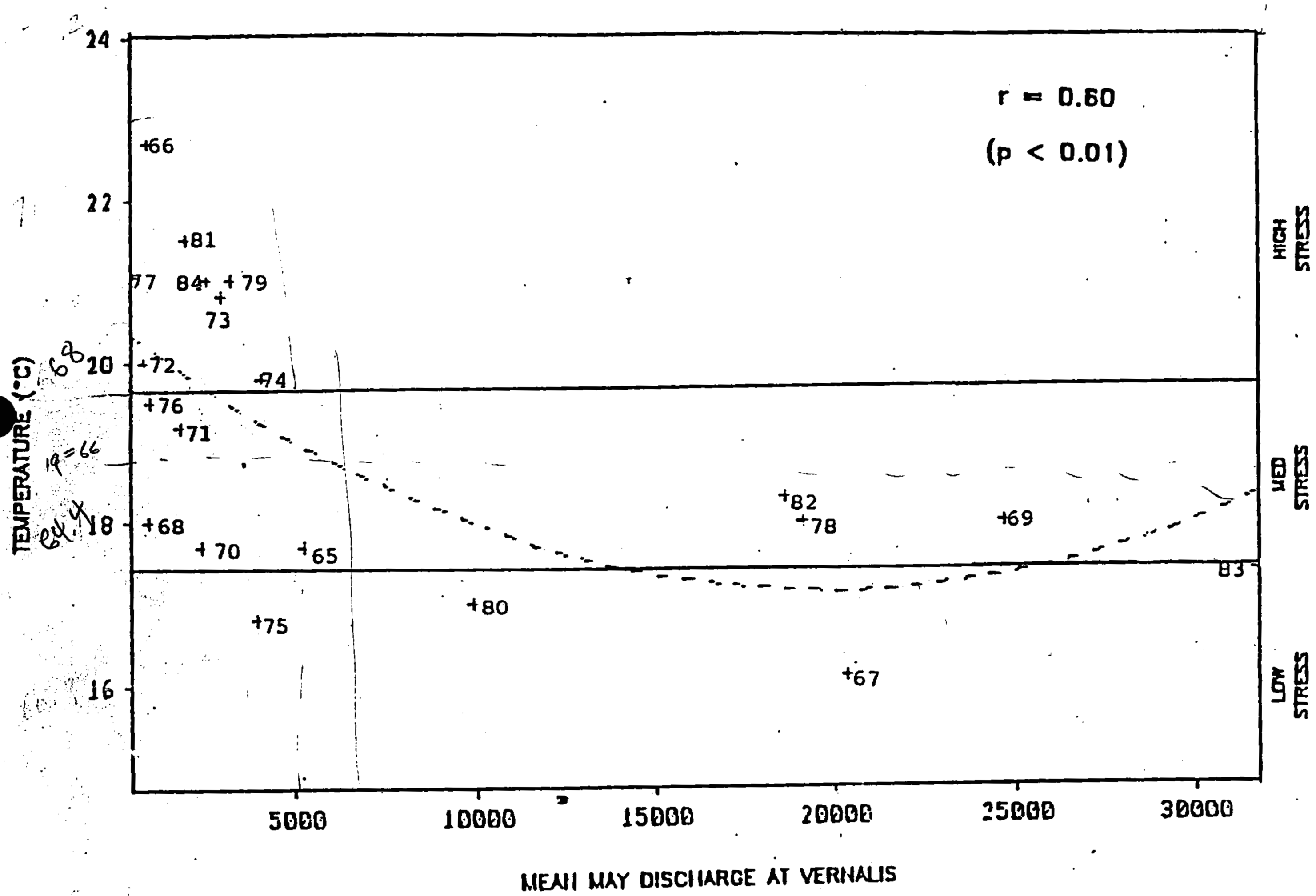
1) increased metabolic activity,
2) lowered resistance to disease,
3) reduced growth rates, and
4) clinical responses (e.g. increased blood hemoglobin).

Each symptom independently may not result in detectable reductions in the survival to adulthood but together and in combination with other stressful conditions, they can result in significant mortality. This is especially harmful if high chronic stress affects significant proportions of the annual juvenile production. Acute thermal stress results in high and direct mortalities or halting of downstream migration. Smolts constantly sense water temperature, therefore excessive temperatures may cause them to delay migration or return to cool water habitats upstream. High natural mortality results when fish remain in the Merced and Tuolumne River beyond May 1. These losses are generally a result of diminished streamflow, high temperatures and predation.

We analyzed the relationship between San Joaquin River flows at Vernalis and March, April and May water temperatures from 1965 to 1984 in conjunction with the chronic temperature stress levels (Rich, 1987) for San Joaquin smolts entering the Delta. The USGS temperature records at Vernalis were reported in different ways so the summary required different treatments. Mean monthly temperatures for the period 1964-1969 were used as published. The mid-point (median) was used when maximum-minimum temperature ranges were provided (1974-1984).

We found no correlation between streamflow and water temperature in March or April. A significant ($p < 0.01$; $r = 0.60$) curvilinear relationship was found in May under the streamflow and weather conditions existing 1965-1984 (Figure 9). Using this relationship and overlaying the chronic temperature stress criteria we found that at Vernalis flows of 5,000 cfs or less in May, chinook smolts entering the Delta are subjected to high chronic temperature stress (Figure 9). In looking at the actual temperature data for all May periods corresponding with Vernalis flows less than 5,000 cfs, in 8 of 13 years the water temperatures were in fact in the high stress range. The years 1971 and 1976 were also very close to the high chronic stress temperature of 67.6°F (19.7°C).

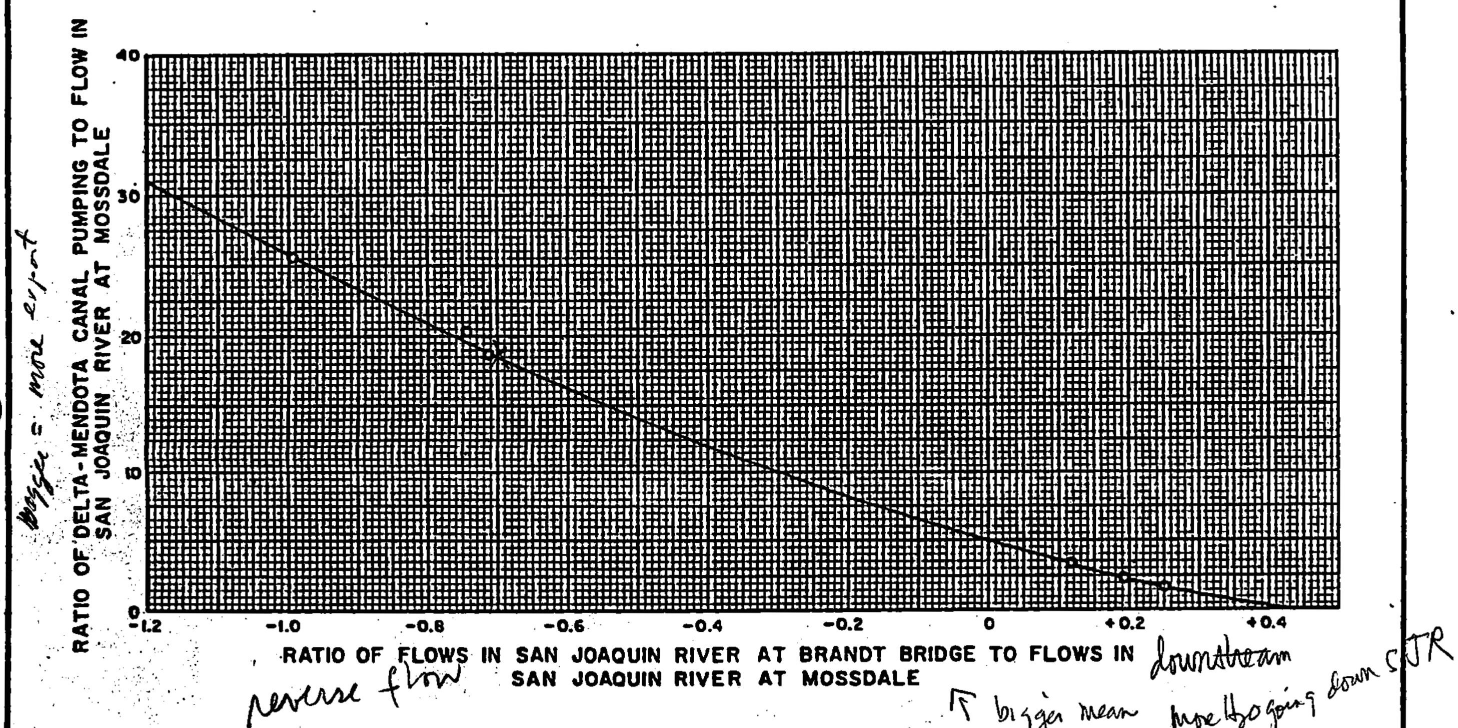
Figure 9. Relationship of San Joaquin River Streamflow (May) and Water Temperatures at Vernalis in Relation to Chronic Thermal Stress for Chinook Salmon Fry and Smolt Development



Recall that the peak migration of chinook salmon smolts from the San Joaquin ~~tributaries is in~~ $\boxed{\text{early May}}$. Therefore, at least half of the annual San Joaquin smolt emigration period would be impacted by high temperatures a minimum of 62% of the years when May streamflows are less than 5,000 cfs (i.e. 8 of 13 years).

Also consider that under current operations in May the Tracy Facility is pumping at 3,000 cfs and the Skinner Facility is filling the forebay on the flood tides and pumping at night. Based on this export rate and the relationships in Figure 10, if the Mossdale flow in May were 5,000 cfs then approximately 3,500 cfs (70%) ~~would be diverted~~ off the San Joaquin River and down Old River to the Tracy Facility. Approximately 1,500 cfs (30% of Mossdale flow) would enter the central Delta via the San Joaquin River past Stockton. This scenario results in temperature stressed salmon from the San Joaquin drainage being subjected to added stress associated with the State and Federal water export processes (see DFG Exhibit #17). Those salmon which remain in the San Joaquin River would also be subjected to high chronic thermal stress but fewer smolts emigrating down this channel are directly impacted by the Water Export process (see USFWS Exhibit #   ).

Figure 10. Ratio of flows at two locations on the San Joaquin River as Influenced by Delta pumping.



NOTE: Flows in northwesterly direction in San Joaquin River at Brant Bridge positive and in opposite direction negative.

STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DELTA BRANCH
DELTA WATER FACILITIES

RATIO OF FLOW AT TWO LOCATIONS ON SAN JOAQUIN RIVER AS INFLUENCED BY DELTA-MENDOTA CANAL PUMPING

APRIL 1962

$20 = \frac{10{,}000}{500} = \frac{\text{DMC pumping}}{\text{Mossdale Flow}}$

$\frac{3500}{5000} = \frac{\text{pumps}}{\text{Mossdale}} \approx .7$

Studies by Schreck et al. (1985) on the Columbia River have documented that stress factors are accumulative. Combining high chronic thermal stress with the rigors of salvage (trash racks, louvre or perforated plate screens, predation, tank handling, trucking and release into water of differing salinity and temperature) during the process of smolt transformation surely accounts for a large proportion of "natural mortality" in the Delta.

Finally, in reviewing the historic salmon runs (Appendix 2) it appears that escapements, two years after each May when high chronic stress occurred (including 1971 and 1976), were consistently lower than the previous or following years. This suggests that temperature conditions in the Delta directly affect the survival of smolts leaving the San Joaquin drainage.

Based on this information:

A) Up to half the production of San Joaquin chinook salmon smolts can be subjected to high chronic thermal stress in the south Delta in most (62%) years when Vernalis flows are 5,000 cfs or less.

B) Given that significant additional stressful factors exist immediately downstream of Vernalis in the Delta, juvenile salmon from the San Joaquin drainage need to enter the Delta in the best possible condition to optimize survival to the ocean.

Agricultural Drainage

Mud and Salt Sloughs (Merced County) are used to convey subsurface agricultural drainage to the San Joaquin River upstream of the Merced River confluence (Figure 1). The SWRCB appointed a technical committee on agricultural drainage in the San Joaquin Valley. The committee identified four primary water quality constituents of concern and recommended that water quality standards be adopted for them. Selenium was identified as the constituent that would most affect fish and wildlife beneficial uses (SWRCB Draft Order #W.Q.85-1, 1986).

Gilliom (1986) monitored concentrations of selenium, dissolved solids, boron and molybdenum at 11 sites on the San Joaquin River and tributaries twice per month from June to September, 1985. Dissolved selenium was lowest in the Stanislaus, Tuolumne and Merced Rivers and the San Joaquin River near Stevinson (all less than 1 microgram per liter except for one sample in the Tuolumne River). Mud Slough had the highest median concentrations of dissolved selenium (21 micrograms per liter).

Selenium exhibits direct toxic effects to fish from exposure to elevated levels in the water column and through bioaccumulation through the food web to harmful tissue levels.

Studies have shown that the survival of chinook salmon swim-up fry was significantly reduced by exposure to two types of dietary selenium of 26 parts per million (ppm) for 60 days and exposure to 6.5 ppm for 90 days. Growth was significantly reduced 10 to 28% in salmon fry fed 13 ppm selenium for 90 days in two different diets (Hamilton et al., 1987). A second chronic toxicity study by the same researchers used 70 mm chinook salmon in water siumlating San Luis Drain water (1.2% brackishwater minus trace elements) and fed similar diets as in the swim-up fry tests. Fingerling survival was not affected by dietary selenium but growth was significantly reduced 20% in fish fed 6.5 ppm selenium in the diet (San Luis Drain mosquito fish) for 120 days. In the other diet test (selenomethionine additions), growth was significantly reduced 16 to 41%. Following 120 days exposure to the experimental diets, a 10-day seawater challenge test was conducted (28% seawater). Survival of fingerlings was 37% in the 26 ppm selenium diet (San Luis Drain mosquito fish) and 24% in the 26 ppm selenomethionine diet compared to a control test survival of 87%.

The authors concluded that if irrigation return flows from the San Luis Drain were disposed of in a freshwater or brackishwater receiving water like the San Joaquin River system, chinook salmon population would be adversely affected by exposure to dietary sources of selenium.

In another study, a balanced diet containing selenium-contaminated mosquito fish from the San Luis Drain was fed to chinook salmon for the month preceeding smolting. The salmon tended to grow less than controls in fresh water. The ability of these salmon to osmogregulate was delayed, and their migratory behavior was reduced (Palmisano, 1987).

From this information we conclude:

> Chinook salmon fry and smolts are sensitive to both dissolved and dietary selenium.
>
> Although levels exceeding 1.0 microgram per liter have not

been detected in the San Joaquin River and tributaries where juvenile salmon reside and feed each spring, a potential problem exists and an appropriate water quality standard for selenium should be established.

Tidal Influence on Smolt Migration

During April 15 through May 15, 1987, downstream migration of CWT and wild chinook salmon in the lower San Joaquin River was measured with a Kodiak trawl net about one mile below Mossdale Landing in the South Delta, San Joaquin County. Ten 10-minute trawls were performed on a daily basis. The time of initiation and total salmon catch per trawl was recorded. A relatively constant water volume was sampled during each 10-minute tow.

The time of each trawl was ranked in relation to the tidal activity on a scale of 1 to 4, with 1 equal to the time of peak high tide (flood) and 4 equal to the time of peak low tide (ebb). These ranks were proportioned equally among the difference in time between the time of peak low tide and peak high tide, and then among the difference between the next successive tidal change. Each ranking included data from 50-75 tows. These ranks ignore the effects of varying tidal heights and account only for the variation due to ??
relative difference in tidal changes by time.

The distribution of total chinook salmon catch per tow for each rank is shown in Figure 11 using non-parametric box plots (Tukey, 1977). These distributions for each rank met the assumptions and were analyzed using a one-way ANOVA (Sokal and Rohlf, 1969).

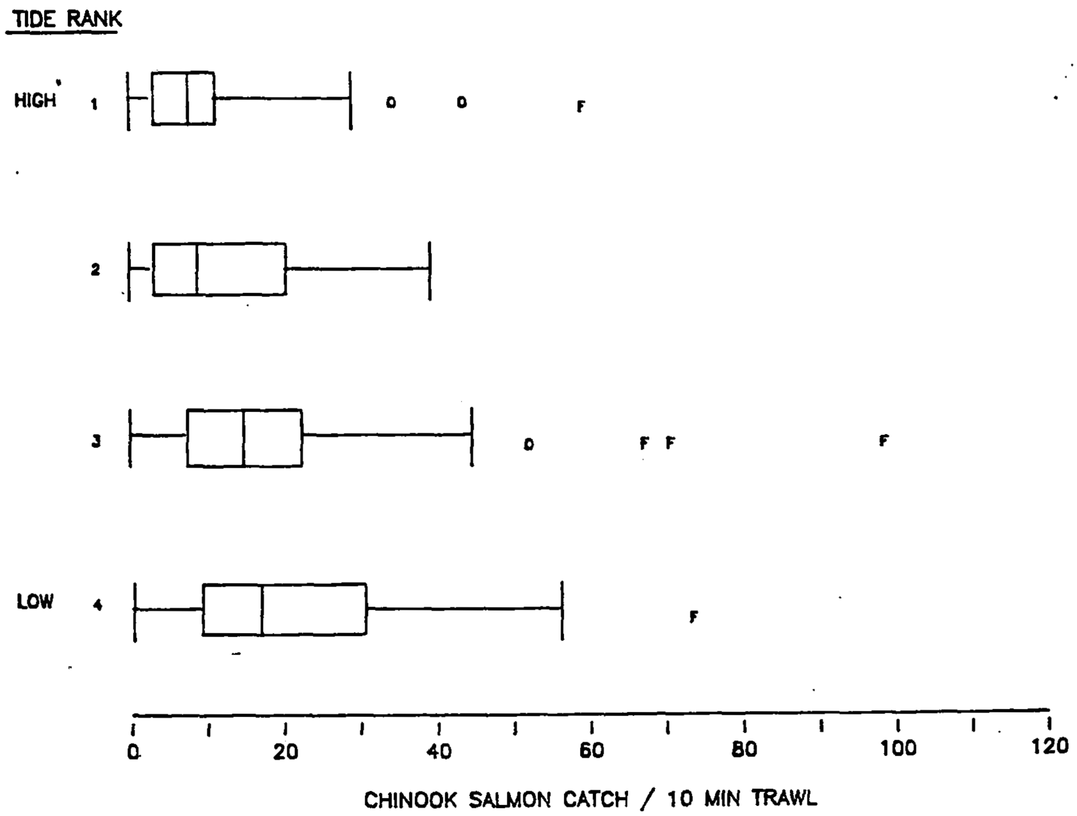
The mean catch per trawl was significantly different ($p = 0.05$)

for each tidal rank. Further analysis using the a posteriori technique of Least Significant Ranges (LSR), showed that each tidal rank was significantly different from the adjacent rank ($p = 0.05$).

Therefore, data from our first year of this evaluation suggest:

<u>On average, significantly more salmon moved past our Mossdale trawl site during ebb tide transitions under the 1987 April-May streamflow conditions. If further study confirms this result then new alternatives to improve juvenile survival through the south Delta may exist.</u>

Figure 11. Catch per tow of chinook salmon in Kodiak Trawl Surveys at Mossdale on the San Joaquin River, April and May, 1987

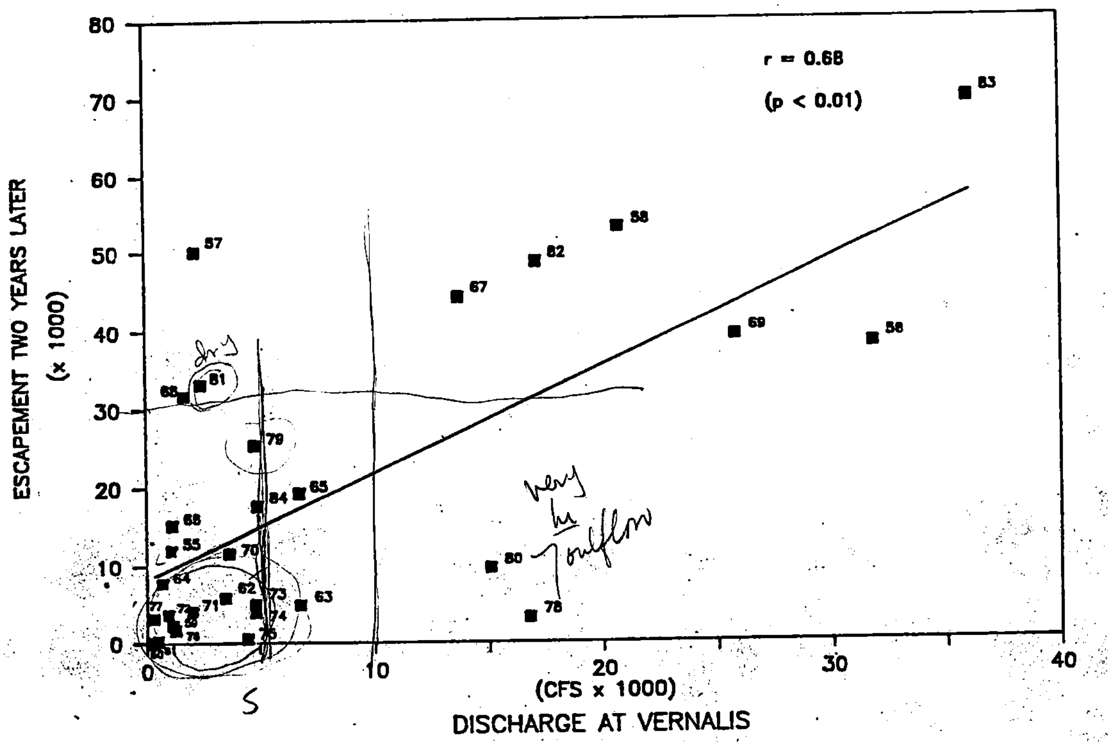


Flow at Vernalis and Adult Numbers

In 1972 the Department of Fish and Game submitted an Exhibit and testimony to the SWRCB regarding the New Melones Project which concluded that spring flows were the most important factor controlling the size of salmon populations in the Stanislaus River, with survival being proportional to flow (DFG, 1972; Appendix 9). A similar relationship existed on the Tuolumne River at that time. Most juvenile salmon emigrate to the Delta in the spring months and the majority of adults resulting from this emigration continue to return to spawn during the fall two calendar years later.

The relationship of streamflows at Vernalis and the total escapement in the drainage continues to indicate that spring flows are still a key factor determining the number of adults produced in the San Joaquin River tributaries (Figure 12). The range of correlation coefficients are from 0 for no relationship to 1.0 for a perfect relationship. The coefficient for the relationship between Vernalis flows and adult escapement 2 years later is 0.66 ($p < 0.01$). Considering all the potential factors affecting juvenile salmon numbers in the tributaries (e.g. streamflow fluctuations, stranding or lack of May rearing flows) in the San Joaquin River (e.g. May temperature stress), the Delta (e.g. predation and water export losses), the estuary and two years in the ocean, an "r" value of 0.68 ($p < 0.01$) indicates that substantial spring flows in the San Joaquin River override most other constraints to salmon production.

Figure 12. Flows in the San Joaquin River during Juvenile Emigration (1955-1984) and Corresponding Adult Spawning Population 2+ Years Later



Based on this information:

<u>The number of San Joaquin drainage salmon produced is largely determined by the spring flows in the San Joaquin River at Vernalis when the young emigrate to the ocean.</u>

We implemented a long-term smolt survival study in 1985 which has as its goal a determination of San Joaquin River and tributary streamflows needed for acceptable salmon production. This program dovetails with a similar program in the Delta and the Sacramento and Mokelumne Rivers through the Interagency Study Program. A summary of the first three years of San Joaquin drainage smolt survival information will be described along with the Sacramento River and Delta smolt survival information for continuity and better understanding.

in the Delta hear'g & hrp

Additional evidence on recent changes in the escapement vs. Vernalis flow relationships helps clarify the importance of resolving the need for improved spring flows in the San Joaquin drainage (Figure 13). There is a subtle but distinct reduction in the regression slope since 1967 suggesting that for a given escapement level (40,000 indicated by the dotted lines) it now requires 16,000 cfs instead of 14,000 cfs. This indicates that even under the established streamflow programs implemented in conjunction with recent water storage enlargements on the tributaries (Table 2) the combination of San Joaquin River and Delta impacts has gotten worse for salmon. In the absence of measures which improve smolt survival in the Delta, increased flows would be required at Vernalis to yield the desired effect.

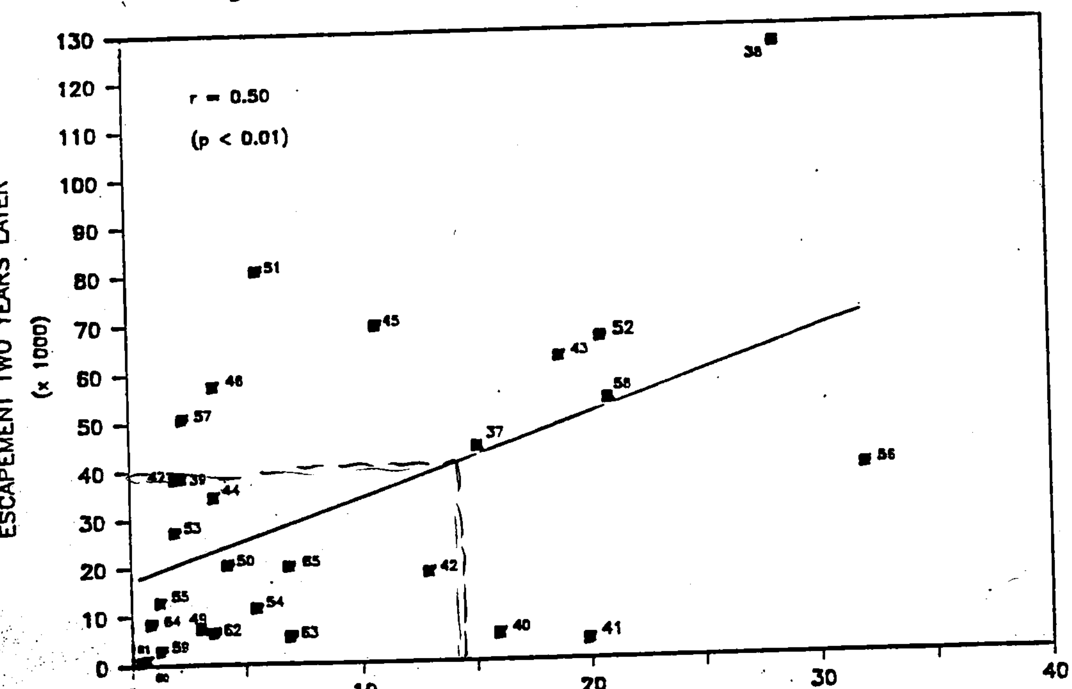
Based on this information:

The number of San Joaquin drainage adult salmon produced is largely determined by the spring flows in the San Joaquin River at Vernalis during the period young salmon emigrate to the ocean.

Figure 13. Relationships 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.

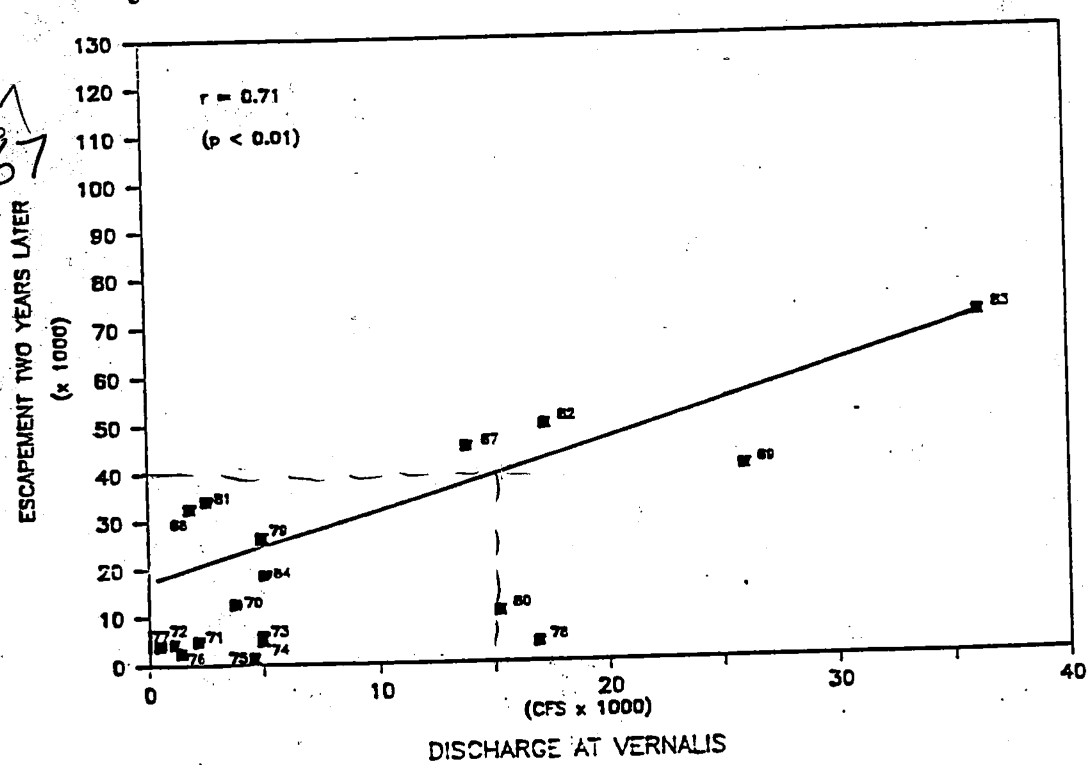
pre 1967

pre '67



post 1967

post 67



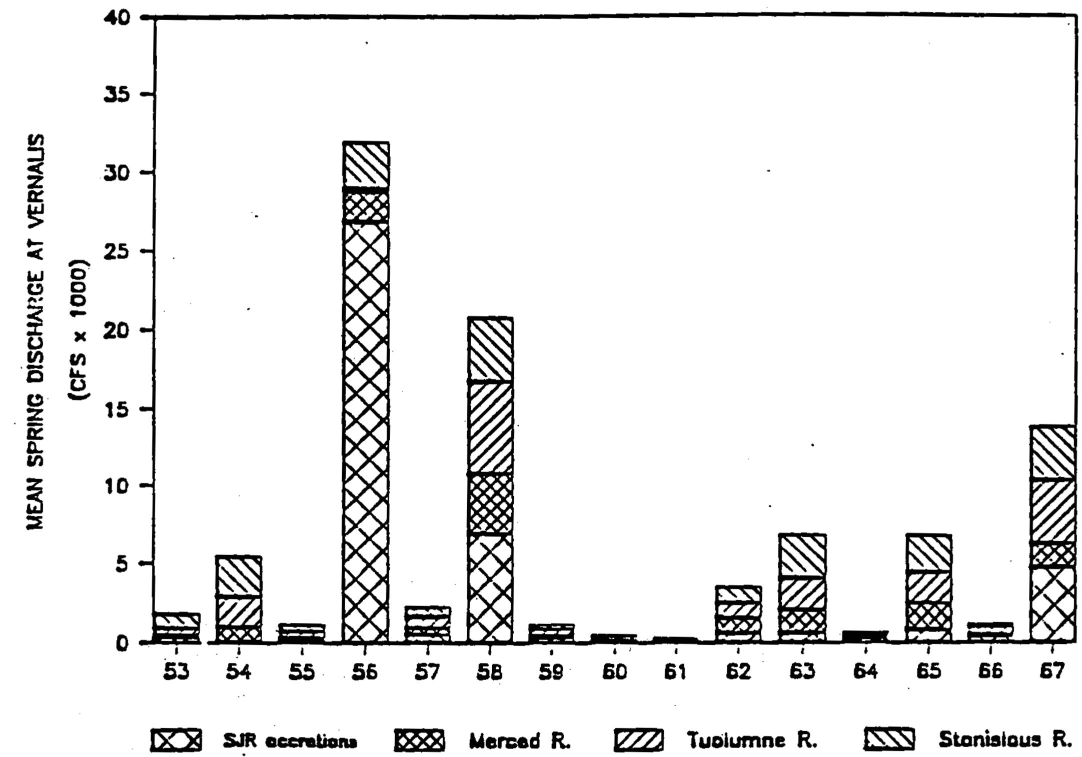
The habitat conditions resulting from limited tributary contributions and impacts in the south Delta are such that it takes approximately 10-15% more spring flow to result in similar escapements which occurred prior to 1967.

Tuolumne River Flow and Adult Numbers

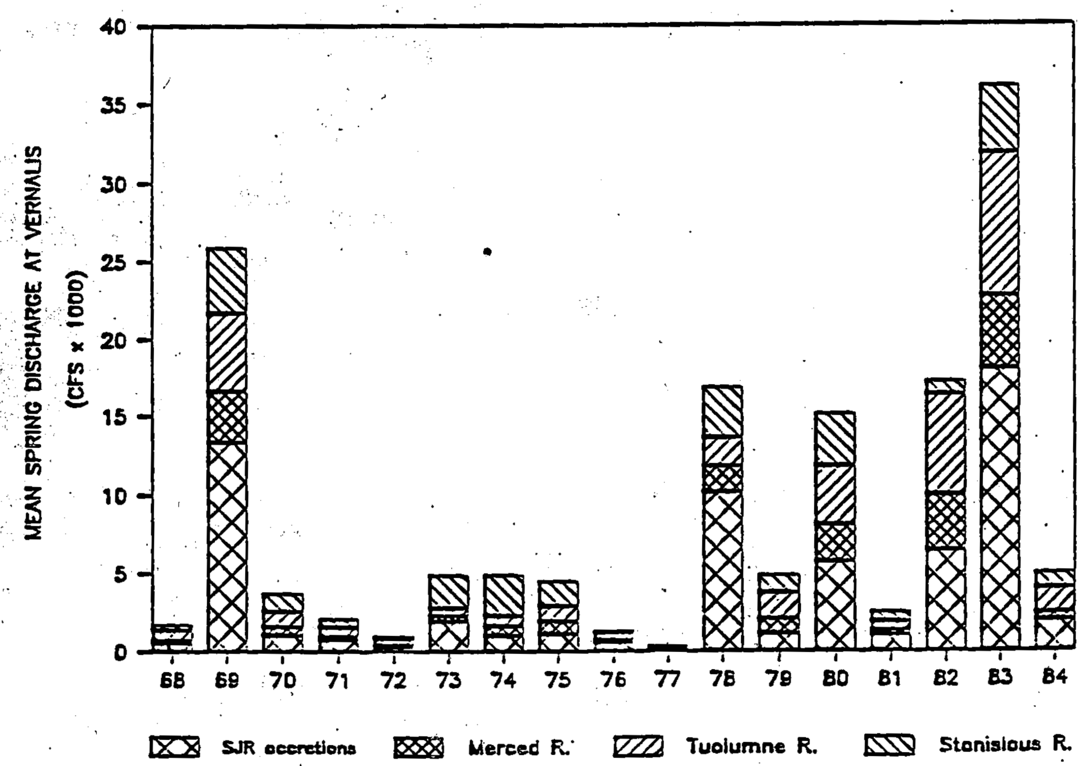
Obviously the spring Vernalis flow is only a composite of the flows leaving the tributaries upstream. An example of the recent contributions is provided in Figure 14.

Figure 14. Tributary Contributions to the Spring (March through May) San Joaquin River Flows at Vernalis, 1953 through 1967 (upper) and 1968 through 1984 (lower)

53-67



68-84



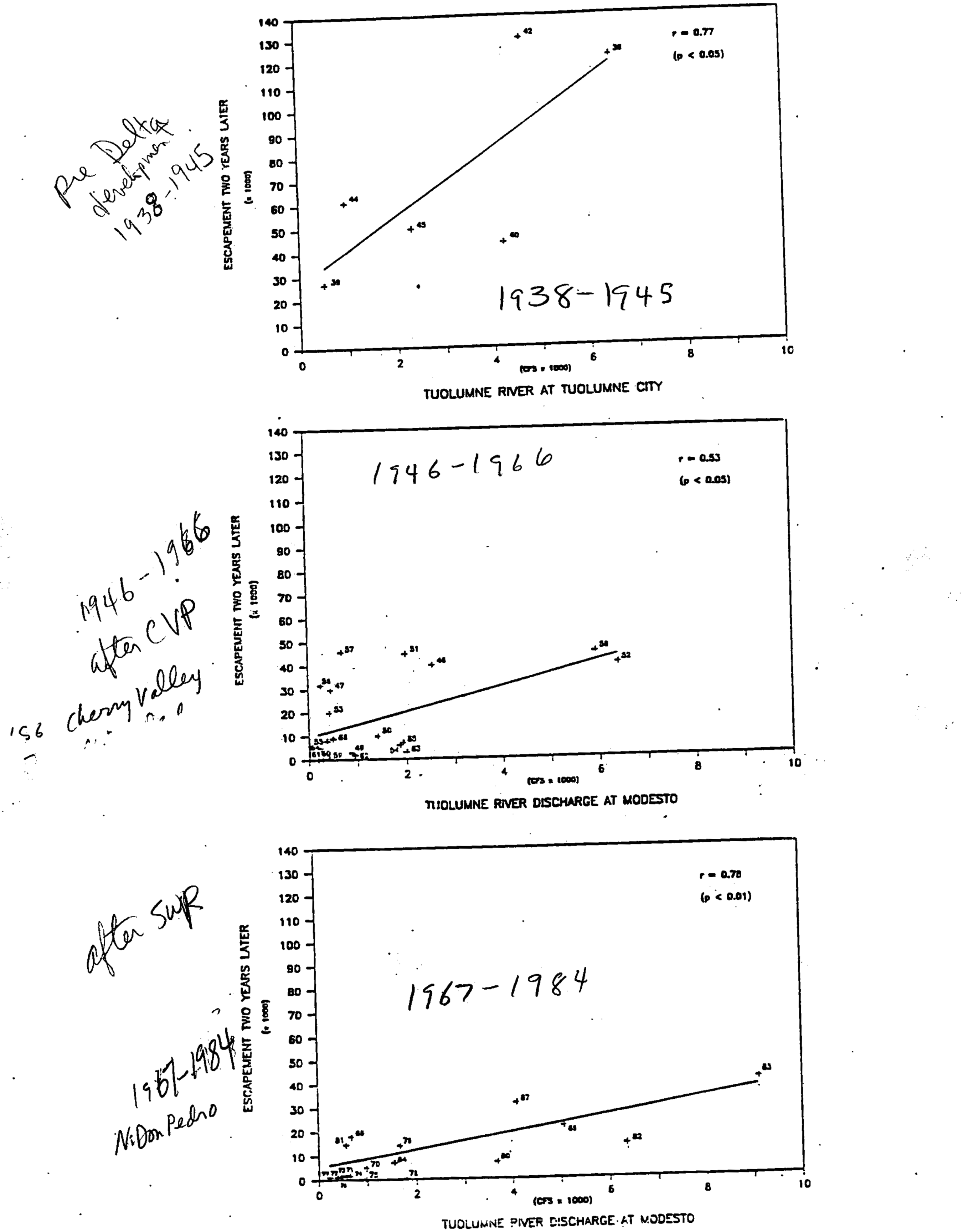
Recall that Table 2 listed the major changes in storage capacity in 1967 (Merced River), 1971 (Tuolumne River) and 1978 (Stanislaus River, filled in 1981). San Joaquin River accretions include the Kings River, Delta-Mendota Canal, Mud and Salt Sloughs, the Eastside Bypass, Berm Check and other minor sources of water.

Escapement estimates and streamflow data for the Tuolumne River are available back to 1938 (Appendix 2; USGS records at Tuolumne City and Modesto). A comparison of the relationships between escapement and mean spring flow in the Tuolumne River during three time intervals more clearly defines how chinook salmon production has responded to changes in spring flows and water exports in the South Delta (Figure 15).

The Tuolumne River escapement generally represents 40% to 50% of the average total escapement in the San Joaquin drainage and therefore provides a fair indication of salmon needs. The declining trend in the slopes of these three relationships in Figure 15 is even more dramatic than similar relationships at Vernalis (Figure 13) and a reduced frequency of escapements exceeding 30,000 adults has occurred. The predicted Tuolumne River spring flows required to produce 30,000 adults has increased from approximately 1,000 cfs (exceeded in all but dry year scenarios during 1938-1945) to 6,000 cfs (now exceeded only in wet years) in 1967-84.

The decline in frequency of escapements exceeding 30,000 adults was 83%, 35% and 11% during these three periods, respectively.

Figure 15. 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)



Based on this and previous information provided:

A. In the absence of improved habitat conditions in the San Joaquin River and Delta, the full potential of Tuolumne River salmon production will only be in wet years when the Tuolumne River mean spring outflow exceeds 6,000 cfs.

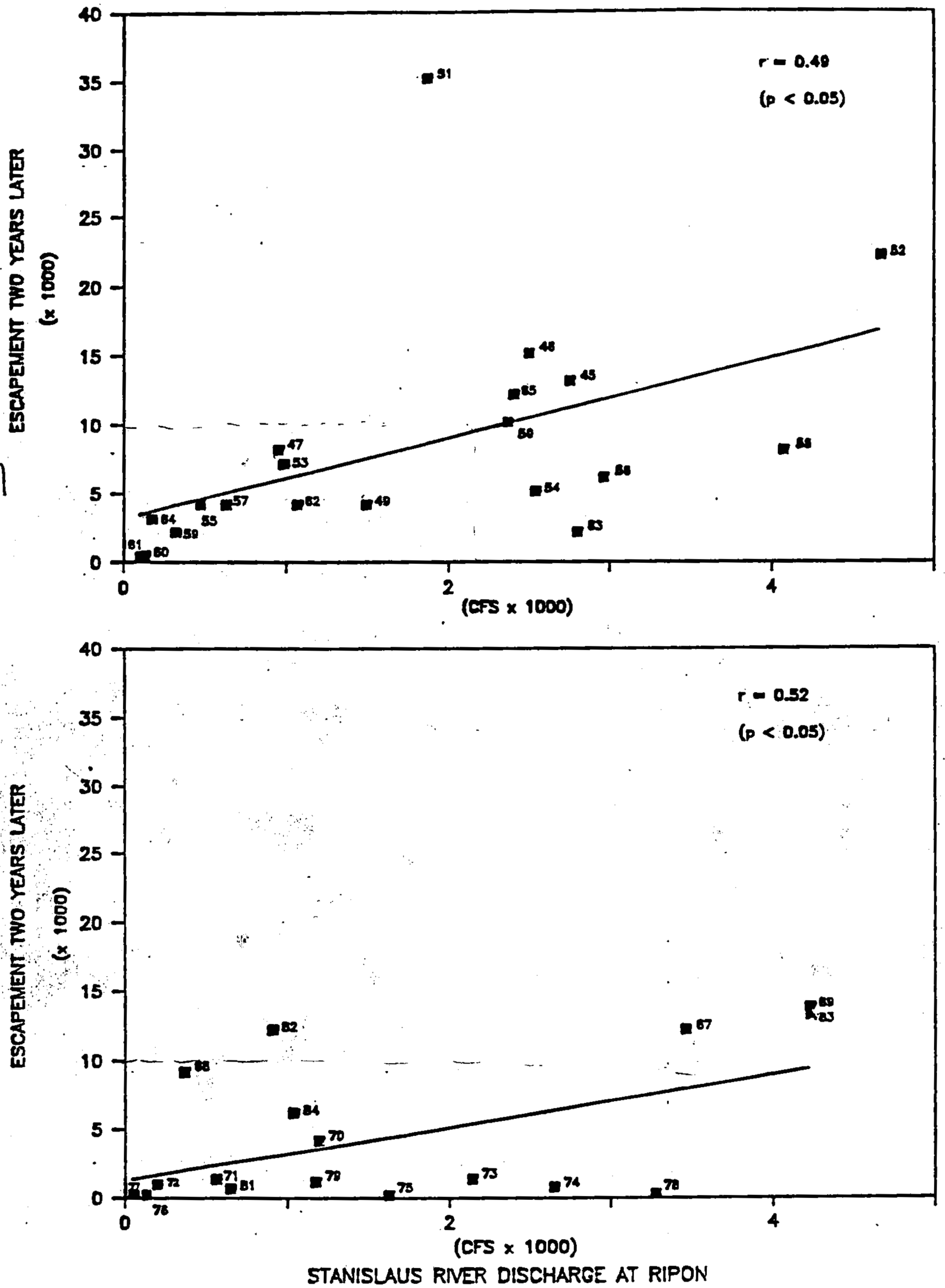
B. Improved tributary flows during the smolt emigration period are important to salmon survival in the tributaries but factors downstream have diminished the positive effects of incremental increases in spring flows.

C. Improvements in emigration flows from the Tuolumne River would also benefit smolts from the Merced and Stanislaus Rivers.

Stanislaus River Flow and Adult Numbers

A similar decline in slope in the relationship between mean spring flow and escapement 2 years later has occurred in the Stanislaus River salmon run (Figure 16). The dotted lines on this Figure indicate that escapements near 10,000 salmon resulted from mean spring outflows near 2,300 cfs at Ripon prior to 1967. After that period, the same escapement results from twice the mean spring flow.

Figure 16. Relationships of Stanislaus 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



Pre 1967

post 1967

New Melones 1979

Based on this and previous information provided:

A. In the absence of improved habitat conditions in the San Joaquin River and Delta, the full potential of Stanislaus River salmon production will only be met in wet years when mean spring flows exceed 4,500 cfs.

B. Improvement in emigration flows from the Stanislaus River could also benefit smolts from the Merced and Tuolumne Rivers travelling down the San Joaquin River if acceptable streamflow requirements were established.

Merced River Flow and Adult Numbers

why?

We found no relationships between mean spring flows at Cressey on the Merced River and escapement 2+ years later. The channel dimensions of this river are most similar to those of the Stanislaus River. Therefore, we assumed that mean spring flows which were predicted to obtain the potential salmon production on the Stanislaus River would also be adequate for the Merced River. Hatchery

Tributary Flow Requirements

As stated earlier, recovery and maintenance of Merced, Tuolumne and Stanislaus River salmon production relies both on streamflow requirements in the spawning and nursery areas, and reasonable conveyance flows into and through the Delta for emigrants enroute to the ocean. Several Agreements, Licenses, or Decisions which provide the existing fishery streamflow requirements are listed below. All but the SWRCB Decisions are provided in Appendix 5.

River	Documents Including Mitigative Measures for Salmon
San Joaquin below Friant	None
Merced	Davis-Grunsky Agreement FERC[1/] License #2179
Tuolumne	FERC License #2299
Stanislaus	SWRCB D1422 plus a recent Civil Agreement between USBR and CDFG
Lower San Joaquin River	SWRCB D1485

1/ FERC = Federal Energy Regulatory Commission previously know as the Federal Power Commission

A brief synopsis of streamflow limitations on the tributaries is helpful at this point.

<u>Upper San Joaquin River</u>	. no salmon streamflow requirements
<u>Merced River</u> 1. Davis-Grunsky Agreement 2. FERC License #2179	. Pre-spawn flushing flow discretionary . Spawning flow 180 to 220 cfs in the spawning area starts too late, November 1 to April 1. Gauge site not reflective of entire spawning area. . 75 cfs provided by FERC #2179 until May 31. June 1 through October 15 is 25 cfs (see "Dry Year" scenario in Appendix 5). . Provision for "Downstream Migration" Flushing Flow for juveniles need to be implemented.
<u>Tuolumne River</u> 1. FERC License #2299 2. Recent Study Amendment	. Refer to Article 37, FERC #2299 for Normal (Schedule A) and Dry (Schedule B) Schedules (Appendix 5). April and May flows result in high temperatures and poor smolt conveyance to the San Joaquin River and Delta. June through September flow is 3 cfs. . Recent Amendment to FERC #2299 to add studies and revise Schedules A and B. Some flushing flow, spawning flow and egg incubation flows shifted to study spring needs for smolt outmigration. . Additional commitment of 2,000 cfs spring flow (60,000 ac.ft. block) for smolt survival evaluation in 2 of 6 study years. . Fluctuation criteria in Article 38 do not provide adequate protection for fry life stage.

Stanislaus River
1. D1422
2. Recent Civil Agreement
3. Pending SWRCB Decision ?, which

- Civil Agreement between DFG and USBR for between 302,100 ac.ft. and 98,300 ac.ft.
- 1250 cfs limitation with provisos
- March 1-15 flows determined by DFG using February forecasts. Preliminary annual schedule developed using March runoff forecast.
- DFG to provide USBR with final streamflow schedule for the period April through February by no later than April 15th each year.

Lower San Joaquin River
1. D1485

- No salmon streamflow requirements.

The net effect of the existing streamflow requirements are that:

A. Adequate flow fluctuation criteria are lacking on the Merced and Tuolumne River during the spawning and fry rearing periods.

B. Streamflows on the Merced and Tuolumne River are severely reduced in April, May and early June just when smolts are emigrating to the ocean. Spring flows on the Stanislaus are only interim and will be determined annually during the defined study period.

C. When Merced River flows reduce to 75 cfs on April 1 and Tuolumne River flows reduce to 100 or 200 cfs on May 1 (3 cfs in Schedule A and B of Article 37, FERC #2299) the juvenile salmon remaining suffer high mortality and production is lost.

D. Only the Stanislaus River has a requirement for streamflow releases to help meet total dissolved solid standards in the lower San Joaquin River at Vernalis.

E. Streamflows released in the San Joaquin tributaries are not guaranteed to improve fish habitat conditions on the San Joaquin River or South Delta in the absence of specific streamflow requirements at Vernalis and other key points.

Flow Improvements Needed

The 1986 revision of FERC License 2299 for the New Don Pedro Project for the Tuolumne River salmon study includes a "Smolt Survival" aspect and a requirement for 60,000 acre-feet of additional water during 2 of 6 study years (Appendix 5). The purpose is to evaluate the affect on smolt survival of short duration high amplitude flushing flow of 2,000 cfs during average runoff conditions on the San Joaquin. The evaluation includes the use of coded wire tagged (CWT) salmon smolts so that survival indices can be developed while they travel through the emigration route. Ultimately ocean returns (2, 3 and 4 years later) provide the final measure of smolt survival. A similar study aspect has been incorporated in the New Melones Fish Study Program on the Stanislaus River under the terms of the recent Agreement between USBR and CDFG (Appendix 5).

Similar studies of smolt survival in relation to flushing flows in the Columbia River System suggest that (1) smolts, if ready, can be stimulated to emigrate with relatively small increases in total discharge (i.e. 25% change), and (2) smolt movement rates were strongly correlated to both river velocity and a measure of turbidity (Scully et. al. 1983; Fish Passage Center, 1986). We believe this approach to water management may provide substantial improvement in habitat conditions for San Joaquin drainage salmon runs.

Based on the relationships between the Tuolumne and Stanislaus Rivers and Vernalis mean spring flows vs. escapement two years later (Figures 15 and 16), we also believe that low spring flows in the San Joaquin River combined with the effects of South Delta exports can negate the benefits of "flushing flows" or only moderately improved tributary flows.

Assuming no change in San Joaquin River and the South Delta conditions in April, May and early June, the following are estimated minimum amounts of water (Table 3), in excess of those provided in current License or Agreement terms, that are needed from the San Joaquin River tributaries to recover and maintain at least 70% of 1940, 1944 and 1945 salmon production.

Table 3. Estimated Spring Flows Required to Recover 70% of Historic (1940, 1944 and 1945) Salmon Production Assuming Current Water and Fisheries Management Program.

	Period	Estimated Spring Flow-cfs	%	Existing Minimum Fishery Flows cfs
San Joaquin River below Friant	All year	6,500	38	35
Merced River	Apr-June October	2,000 220	12	75/25 25
Tuolumne River	Apr-June	6,500	38	550/3
Stanislaus River	Apr-June	2,000	12	900/1200
San Joaquin River @ Vernalis	Apr-June	16,000		0

should be 17,000

15,
16,000
6,500
9,500

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At mean flows of less than 950 cfs, solutions are negative, and provide estimates of the loss sustained by the resource at such flows.

Summer Flows

Summer flows are essential in controlling vegetation encroachment on spawning gravels and assist in maintaining suitable dissolved oxygen and temperature levels for resident fishes and any steelhead and spring-run salmon populations which might develop in the Stanislaus River and will sustain juvenile salmon that stay in fresh water for one year. It is estimated that 100 cfs during the months of July, August and September will minimize vegetation encroachment on the salmon spawning gravels, and also maintain suitable dissolved oxygen and water temperatures. These summer flows will also provide trout habitat in the river below Goodwin Dam to help replace the 12 miles of the Stanislaus River that will be inundated by the project.

Recommended Flows With the Project

Based upon the foregoing considerations and analyses we conclude that the following flow schedule is essential to preserve and maintain the salmon and other fishery resources of the Stanislaus River.

Period	Minimum Flow (cfs)	Acre-feet	
January	150*	9,220	[illegible]
February	150*	8,330	[illegible]
March	700**	43,050	
April	900**	53,550	
May	1200**	73,800	
June	1000**	59,500	
July	100*	6,150	
August	100*	6,150	
September	100*	5,950	
October	200*	12,300	22.7[illegible]
November	200*	11,900	22.02
December	200*	12,300	22.76
		302,200	

* The July through February flows should be released at Goodwin Dam (or Knights Ferry Diversion Dam) and allowed to flow, undiverted, to the San Joaquin River.

** March through June flows should be measured at the Ripon streamflow gage, with, at least, 83 percent of these mean monthly flows to be released from Goodwin Dam. This percentage is based on an average March through June accretion in this reach of 17% of the recommended mean flow of 950 cfs.

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Appendix 1. Historic Salmon Runs, San Joaquin Tributaries and their contribution to the Central Valley Stock Escapement

Year	Merced	Tuolumne	Stanislaus	Total SJR	Total SAC	% SJR
1953	500	45000	35000	80500	500000	13.9%
1954	4000	40000	22000	66000	400000	14.2%
1955		20000	7000	27000	365000	6.9%
1956		6000	5000	11000	145000	7.1%
1957	400	8000	4000	12400	101000	10.9%
1958	500	32000	6000	38500	234000	14.1%
1959	400	46000	4000	50400	419000	10.7%
1960	400	45000	8000	53400	415000	11.4%
1961	50	500	2000	2550	251000	1.0%
1962	60	200	300	560	251000	0.2%
1963	20	100	200	320	292000	0.1%
1964	40	2000	4000	6040	303000	2.0%
1965	90	3000	2000	5090	189000	2.6%
*1966	40	5000	3000	8040	187000	4.0%
1967	600	7000	12000	19600	158000	11.0%
1968	500	9000	6000	15500	190000	7.5%
1969	600	32000	12000	44600	268000	14.3%
1970	5000	18000	9000	32000	201400	13.7%
1971	4000	22000	13600	39600	193400	17.0%
*1972	3000	5000	4000	12000	137500	8.0%
*1973	1100	2000	1200	4300	262800	1.6%
*1974	2000	1100	800	3900	229000	1.7%
1975	2400	1600	1200	5200	187100	2.7%
1976	1900	1700	600	4200	188500	2.2%
*1977	400	400	0	800	195500	0.4%
1978	600	1300	50	1950	153900	1.3%
*1979	2100	1200	110	3410	221000	1.5%
1980	2800	500	100	3400	174700	1.9%
*1981	10400	14300	1000	25700	230100	10.0%
1982	3000	7000	no est	10000	206000	4.6%
1983	18200	14800	500	33500	154300	17.8%
*1984	23000	14000	12000	49000	199600	19.7%
1985	16000	41000	13000	70000	-	
1986	5000	7000	6000	18000	-	

Exchequer

N. Don Pedro

* high May temp. at Vernalis

SJR = 1000 - 100,000

SAC = 100K - 500K

HISTORIC SALMON RUNS SAN JOAQUIN TRIBUTARIES

YEAR	SJR	MERCED	TUOLUMNE	STANISLAU	total SJR		
1939	5000	—	—	—	5000		
1940	—	900	122000	3000	125900		
1941 Friant	9000	1300	27000	600	37900		
1942	—		44000	—	44000		
1943	3500	—	—	—	3500		
1944	5000 ?		13000	—	~~18000~~	135,000	18,000
1945	56000 ?		6100 ~~6100~~	—	~~62100~~	56,000	62,100
1946	30000		4,000 ~~4000~~	—	~~34000~~	91,000	34,000
1947 Fr	6000		50000	13000	69000		
1948	2000		40000	15000	57000		
1949	No fish	No smolt —	30000	8000	38000		
1950	Flood early in year, no estimates made						
1951		—	3000	4000	7000		
1952		—	10000	10000	20000		
1953		500	45000	35000	80500		
1954		4000	40000	22000	66000		
1955		—	20000	7000	27000		
1956		—	6000	5000	11000		
1957		400	8000	4000	12400		
1958		500	32000	6000	38500		
1959		400	46000	4000	50400		
1960		400	45000	8000	53400		
1961		50	500	2000	2550		
1962		60	200	300	560		
1963		20	100	200	320		
1964		40	2000	4000	6040		
1965		90	3000	2000	5090		
1966		40	5000	3000	8040		
1967		600	7000	12000	19600		
1968		500	9000	6000	15500		
1969		600	32000	12000	44600		
1970		5000	18000	9000	32000		
1971		4000	22000	13600	39600		
1972		3000	5000	4000	12000		
1973		1100	2000	1200	4300		
1974		2000	1100	800	3900		
1975		2400	1600	1200	5200		
1976		1900	1700	600	4200		
1977		400	400	0	800		
1978		600	1300	50	1950		
1979		2100	1200	110	3410		
1980		2800	500	100	3400		
1981		10400	14300	1000	25700		
1982		3000	7000	no est	10000		
1983		18200	14800	500	33500		
1984		23000	14000	12000	49000		
1985		16000	41000	13000	70000		
1986		5000	7000	6000	18000		
1987							

FISH & GAME CODE
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81505. Department management powers—spawning areas. In addition to any other powers vested in the department, it may manage, control and protect such portions of the following spawning areas which occupy state-owned lands to the extent necessary to protect fishlife in these areas. In the event of any conflict under this section with the action of another department or agency of the state or any other public agency, the action of the Department of Fish and Game taken pursuant to this section shall prevail except for: (a) action of the state or regional water quality control boards in establishing waste discharge requirements, (b) action as required for commerce and navigation, (c) action by public agencies reasonably necessary for bridge crossings, water conservation or utilization, or flood protection projects, including the construction, maintenance, and operation thereof. The exceptions in subdivision (c) shall not extend to the depositing of materials, other than necessary structural materials, in, or the removing of materials from the streambeds in the areas designated in this section, other than as necessary for the installation of structures. These areas are:

The Sacramento River between Keswick and Squaw Hill Bridge, near Vina.

The Feather River between Oroville and the mouth of Honcut Creek.

The Yuba River between Englebright Dam and a point approximately four miles east of Marysville.

The American River between Nimbus Dam and a point one mile downstream from Arden Way.

The Mokelumne River between Pardee Dam and Lockeford.

The Stanislaus River between Goodwin Dam and Riverbank.

The Toulumne River between La Grange Dam and the Geer Road (J 14) Bridge.

The Merced River between Crocker Huffman Dam and Cressey.

The Trinity River between Lewiston Dam and the confluence of the North Fork Trinity, near Helena.

The Eel River, from Fort Seward to Lake Pillsbury.

The South Fork Eel River.

The Middle Fork Smith River, from its mouth to Knopti Creek.

The South Fork Smith River, from its mouth to Harrington Creek.

The Salmon River, from its mouth to Rush Creek on the South Fork Salmon River, to Carter Meadow on the east fork of the South Fork Salmon River, and to Finley Camp on the North Fork Salmon River.

Battle Creek, from its mouth to Colemean Powerhouse.

The Cosumnes River, from Meiss Road Bridge to Latrobe Road Bridge.

The Van Duzen River, from Yager Creek to the falls 1½ miles above Bloody Run Creek.

The Mad River, from Blue Lake Bridge to Bug Creek.

The Middle Fork Eel River.

The Mattole River.

The Noyo River.

The Big River, Mendocino County.

The Gualala River.

The Gracia River, Mendocino County.

Until ownership of any land in these areas has been legally determined, the director shall disapprove any stream alterations of any prime salmon and steelhead spawning areas when in his opinion such alterations would prove deleterious to fishlife. *(Amended by Stats 1974 ch 352.)*

STEELHEAD AND SALMON

It is the policy of the Fish and Game Commission:

I. To maintain an adequate breeding stock, suitable spawning areas, and provide for the natural rearing of the young to migratory size. Hatchery production shall be limited to areas where it is necessary to supplement natural production in coastal streams.

II. That resident fish will not be planted or developed in coastal steelhead and salmon streams, except after prior Commission approval (a) where the stream is no longer adaptable to anadromous runs, or (b) during the mid-summer period in those individual streams considered on a water-by-water basis where there is a high demand for angling recreation and such planting or development has been determined by the Department not to be detrimental to the anadromous species.

III. That salmon and steelhead may be rescued whenever the water supply in a stream is inadequate to maintain fish life.

STEELHEAD RAINBOW TROUT

It is the policy of the Fish and Game Commission that:

I. The steelhead rainbow trout in California is recognized as a valuable resource with strict environmental requirements and a limited range.

Steelhead waters include all streams or stream sections accessible to steelhead along the California coast and in the Sacramento-San Joaquin River drainage above the Delta, and such other waters as the Commission may designate.

II. The greatest fishery value of this resource is its potential to provide recreational angling for sea-run fish. Management shall be directed toward providing such angling and maintaining a vigorous, healthy resource. Angling for juvenile steelhead will be restricted to the extent necessary to insure optimum spawning stock and angling opportunity for sea-run fish.

III. Resident fish will not be planted or developed in steelhead waters. Resident fish will not be planted or developed in drainages of steelhead waters, where, in the opinion of the Department, such planting or development will interfere with steelhead populations. Programs on threatened or endangered species, within the species natural range, are excepted.

IV. California's steelhead resources are largely dependent upon the quality and quantity of habitat. Because of damage and threats to this restricted habitat, emphasis shall be placed on management programs to inventory and protect and, whereever possible, restore or improve the habitat of natural steelhead stocks.

V. The Department shall seek prevention or alleviation of those aspects of projects, developments or activities which would or do exert adverse impact on steelhead habitat or steelhead populations. All available steps will be taken to prevent loss of habitat, and the Department shall oppose any development or project which will result in irreplaceable losses of fish.

VI. The Department shall develop and implement plans and programs to improve the protection of steelhead habitat including, but not limited to, assessment of habitat status and adverse impacts, land use planning, acquisition of interests in streams threatened with adverse developments, and research on effects on habitat changes caused by activities such as overgrazing, gravel extraction, logging, road construction, urbanization and water development.

VII. The Department shall develop and implement programs to measure and, where appropriate, increase steelhead population size and angler use and success, consistent with the objectives of providing quality angling and maintaining a healthy resource.

VIII. Artificial propagation of steelhead, except for mitigation, shall be for the purpose of improving angling for sea-run fish, and should include strains or varieties of steelhead which have the greatest potential to contribute to recreational angling. Artificial production of rearing and stocking programs shall be managed so as to produce minimal interference with natural salmonid stocks, and such programs shall be periodically reviewed to assess their effects on these stocks.

IX. Juvenile steelhead rescue shall be limited to instances where habitat conditions are temporarily inadequate to maintain fish life and when suitable rearing areas are available with the capacity to rear rescued fish to smolts without impairment of other steelhead populations. Rescue should be undertaken only in special circumstances involving large numbers or steelhead of special significance.

X. The following streams or stream sections are deleted from the steelhead waters described in item I of this policy.

Big Lagoon	Humboldt County
Stone Lagoon	Humboldt County
Arroyo Seco Creek	Monterey County
Nacimiento River	San Luis Obispo County
North Fork Battle Creek	Shasta County, upstream from Manton
Cow Creek	Shasta County, upstream from Fern Road and Ingot
Middle Fork Cottonwood Creek	Shasta County, upstream from Platina
Antelope Creek	Tehama County, upstream from Ponderosa Way
Beegum Creek	Tehama County, upstream from Beegum
Deer Creek	Tehama County, upstream from Highway 32 at Windy Cut
Mill Creek	Tehama County, upstream from Hole in the Ground Camp

APPENDIX 4. Production and Distribution of Chinook Salmon at Merced River Fish Facility

Release Year	Total Production	Fingerling	Smolt	Yearling
1971	389,000	389,000 1/	0	0
1972	730,000	644,000 2/	0	86,000
1973	733,000	501,000 3/	0	232,000
1974	496,000	160,000 3/	0	336,000
1975	116,500	0	0	116,500
1976	0	0	0	0
1977	155,000	75,000	0	80,000
1978	100,000	0	100,000	0
1979	245,000	0	0	245,000
1980	16,940	0	0	16,940
1981	0	0	0	0
1982	379,422	102,572	0	276,850 5/
1983	251,915	0	0	251,915 6/
1984	145,657	0	0	145,657 7/
1985	1,321,439	770,679	317,000 8/	275,380 9/
1986	1,819,706	240,516	1,207,840 10/	371,350 11/

1/ Returned to the Stanislaus River.
2/ 326,000 returned to the Stanislaus River.
3/ 126,000 returned to the Stanislaus River.
4/ All returned to the Stanislaus River.
5/ 172,984 CWT yearlings.
6/ 106,364 CWT yearlings.
7/ 114,790 CWT yearlings.
8/ 316,279 spray-dyed smolts.
9/ 196,830 CWT yearlings.
10/ 738,930 CWT smolts.
11/ 166,788 CWT yearlings.

Note: Up to 1973, Chinook stock from Stanislaus River and eggs hatched at Moccasin. Fry transported to MRFF.

UNITED STATES OF AMERICA
FEDERAL POWER COMMISSION

Before Commissioners: Joseph C. Swidler, Chairman; L. J. O'Connor, Jr., Charles R. Ross, Harold C. Woodward, and David S. Black

Merced Irrigation District) Project No. 2179

ORDER ISSUING LICENSE (MAJOR)

(Issued April 8, 1964)

Application was filed on August 4, 1958, and amended on February 21, 1963, by Merced Irrigation District (Applicant) of Merced, California, for a license under Section 4(e) of the Federal Power Act (Act) for proposed Project No. 2179, to be known as the Exchequer Hydro-Electric Development, to be located on Merced River, County of Mariposa, California, and affecting public lands of the United States. MID Exchequer

The proposed project, which would consist of an enlargement of Applicant's existing licensed Exchequer Project No. 88 and the Exchequer Afterbay Development, is to be used primarily for irrigation, flood control and power. Applicant proposes to finance Project No. 2179 with a contribution from the United States for flood control benefits to be provided and the issuance of revenue bonds based upon a proposed long-term power sales contract with Pacific Gas and Electric Company (Pacific) which has expressed its willingness to negotiate such a contract. Pacific is currently purchasing the power output from Applicant's Project No. 88.

As proposed in the amended application for license, the existing Exchequer concrete gravity arch dam will be raised 155 feet to a total height of 480 feet by placement of a rolled rock fill with a reinforced concrete facing abutting the downstream side of the existing dam. The total reservoir storage would be increased from 281,200 acre feet to 1,010,000 acre feet and the reservoir area would be increased from 2,600 acres to 6,900 acre feet at elevation 865 feet. A middle dyke and a gated spillway will be located on the right abutment about 0.7 miles from the dam. An 18-foot diversion and power tunnel about 1,200 feet long will be in the right abutment. The existing powerhouse of Project No. 88 with a capacity of development; provided said Licensee, its successors or assigns shall be entitled to receive from said more complete development for the unexpired term of the license for Project No. 2179, an amount of electric capacity and energy equal to that generated by the afterbay development with compensation to the downstream developer in an amount equal to the cost to the licensee if the capacity and energy had been received from the afterbay development. In the event the licensee for Project No. 2179 and the owner of such more complete development should be unable to agree, the amount of capacity and energy which the licensee is entitled to receive,. and the amount equal to the cost if it had been generated at the afterbay development, shall be determined by the Commission.

Article 39. The Licensee shall enter into an agreement with the Department of the Army providing for the operation of the project for flood control in accordance with rules and regulations prescribed by the Secretary of the Army. A conformed copy of the agreement shall be filed with the Commission for its information and records prior to commencement of construction of project works.

Article 40. The Licensee shall provide minimum streamflow in the Merced River downstream from the project reservoirs in accordance with the following schedule:

(a) Downstream from Exchequer Dam, a minimum flow of 25 cubic feet per second at all times.

(b) At Shaffer Bridge downstream from Exchequer Afterbay Dam, a minimum streamflow shall be maintained as follows:

Period	Normal Year (c.f.s.)	Dry Year 2/
June 1 through Oct. 15	25	15
Oct. 16 through Oct. 31	75	60
Nov. 1 through Dec. 31 1/	100	75
Jan. 1 through May 31	75	60.

1/ If the average streamflow maintained at Shaffer Bridge from November 1 through December 31 is greater than 150 cubic feet per second exclusive of flood spills and emergency releases, then the streamflows from January 1 through March 31 shall be maintained at 100 cubic feet per second or more.

(Footnotes continued on next page).

Article 41. The Licensee shall, insofar as possible during the period November 1 through December 31, regulate the Merced River streamflow downstream from the Exchequer afterbay development between 100 and 200 cubic-feet per second except during dry years when the streamflow shall be maintained between 75 and 150 cubic feet per second. Streamflow shall be measured at Shaffer Bridge.

Article 42. The Licensee shall operate the powerplants so as to avoid rapid fluctuation of the Merced River. At Crocker-Huffman diversion, the Licensee shall, insofar as possible, restrict the rate of change of release during any one-hour period to not more than double nor less than one-half the amount of release at the start of the change. The Licensee shall, during emergency periods, endeavor to make releases in a manner which will not be detrimental to fish.

Article 43. The Licensee shall make all releases at Exchequer Dam during the period, October 16 through December 31, from the outlets at or below elevation 485 feet insofar as physically possible.

Article 44. The Licensee shall maintain the water surface elevation of Exchequer Reservoir as high as possible from April through October and maintain a minimum pool of not less than 115,000 acre-feet in Exchequer Reservoir except for a drawdown as necessary to maintain previously recommended minimum streamflow.

Article 45. The Licensee shall cooperate with the Bureau of Sport Fisheries and Wildlife of the U.S. Fish and Wildlife Service to determine means of providing up to 15,000 acre-feet of project water and return flow waters to the Merced National Wildlife Refuge.

(Footnotes continued from previous page)

* 1/ (An emergency is defined as an occurrence usually of short duration, such as flood, mechanical, or operational failure which is beyond the control of the Licensee, and during which the Licensee shall not be required to observe the release schedules contained in the license stipulations).

2/ A dry year is defined as a year when the forecasted April 1 through July 31 unimpaired runoff, as published in the May 1 bulletin of the California Department of Water Resources for the station, "inflow to Exchequer" is less than 450,000 acre-feet.

APPENDIX 5B

UNITED STATES OF AMERICA
FEDERAL POWER COMMISSION

OPINION NO. 420

Turlock Irrigation District and Modesto Irrigation District	)))	Project No. 2299

OPINION AND ORDER ISSUING LICENSE

Issued: March 10, 1964

LC 45

Article ~~26~~ 35. The Licensees shall within one year from the date of completion of the project, file with the Commission revised Exhibits F and K to define the final project boundary including transmission line rights-of-way in accordance with the rules and regulations of the Commission.

Article ~~27~~ 36. The Licensees shall, prior to impounding water, dispose of all temporary structures, unused timber, brush, refuse, or other inflammable material resulting from the clearing of the land or from the construction and maintenance of the project works, and shall clear all lands in the reservoir area up to normal water level; except that all lands in the reservoir area shall be cleared according to a plan to be prescribed by the Commission upon the recommendation of the California Department of Fish and Game and the United States Fish and Wildlife Service. The clearing of the lands and the disposal of the material shall be done with due diligence by the Licensees and to the satisfaction of the authorized representative of the Commission.

Study period

Amendment IFM

Sm. Survival Juvenile

Fluctuation

Article ~~28~~ 37. For the first 20 years of project operation, the Licensees shall maintain minimum stream flows in the Tuolumne River at La Grange bridge (river mile 50.5) for fish purposes in accordance with the schedules set forth below or with such monthly schedules as may, with the approval of the Licensees, be prescribed by the California Department of Fish and Game; Provided, that the total volume under Schedule A shall not exceed 123,210 acre feet per water year and the total volume under Schedule B shall not exceed 64,040 acre feet per water year.

New Amendment Schedule 1+2 6 years of study

Period	Schedule A (Normal Year)		Schedule B (Dry Year)	
	cfs	acre feet*	cfs	acre feet*
Pre-season flushing flow	2,500	4,960	-	-
October 1-15	200	5,950	50	1,490
October 16-31	250	7,930	200	6,350
November	385	22,900	200	11,900
December 1-15	385	11,450	200	5,950
December 16-31	280	8,880	135	4,280
January	280	17,210	135	8,300
February	280	15,550	135	7,500
March	350	21,520	200	12,300
April	100	5,950	85	5,060
May-September 31	3	910	3	910
Total acre feet		123,210		64,040

* cfs day equals 1.983 acre feet.

The schedule to apply shall be governed by the water year immediately preceding October 1 of each year. Flows under Schedule A shall apply when the inflow into New Don Pedro reservoir equals or exceeds 1,000,000 acre feet. Schedule B shall apply in like manner if the inflow is less than 1,000,000 acre feet; Provided, that in a water year when the inflow is less than 750,000 acre feet, the amount of water provided under Schedule B shall be reduced by a percentage of the total acre feet equivalent to the percentage reduction in the gravity diversion at La Grange by the Licensees. For this purpose, the diversion shall be defined as 900,000 acre feet to Licensees.

After the first 20 years of project operation, the Licensees shall maintain minimum stream flows in the Tuolumne River at La Grange bridge as may be prescribed hereafter by the Federal Power Commission upon its own motion or upon the recommendation of the Secretary of the Interior or the California Department of Fish and Game, after notice and opportunity for hearing and upon a finding based on substantial evidence that such minimum flows are available and are necessary and desirable and consistent with the provisions of the Act.

Article 29. (a) Flows below La Grange bridge may be altered by the Licensees at any time in connection with the operation of the project for flood control purposes or other emergencies provided that in the 45-day period of November 5 to December 20 (or such other 45-day period between October 15 through December 31 as may be specified on two weeks prior notice by the California Department of Fish and Game), if such flood control or other operations are required, flows shall be increased to 4,500 cfs within 24 hours and shall be reduced as soon as possible after flood control criteria are met.

(b) Subject to the provisions of paragraph (a), so long as fluctuations do not result in reduction of flows below those in the applicable schedule prescribed in Article 28, or such higher minimum daily base flows as may be established in the 45-day period described in paragraph (a) above, fluctuations may be made at any time; Provided:

(1) Fluctuations shall be controlled as closely as possible during such 45-day period so as not to cause a daily increase of river height in excess of 10 inches; Provided, however, for a period not to exceed two hours per day, the increase may exceed 10 inches but not more than a total of 18 inches.

(2) From the end of such 45-day period until March 31 reduction in river height shall not exceed 4 inches below the average height established in the 45-day period, excluding heights reached as a consequence of the daily fluctuation in excess of 4 inches provided in paragraph (b)(1) and those resulting under paragraph (a).

Article 30. The Licensees in cooperation with the California Department of Fish and Game shall make necessary studies aimed at assuring continuation and maintenance of the fishery of the Tuolumne River in the most economical and feasible manner. Such studies shall be completed prior to the end of the 20-year period for which minimum stream flows have been provided in Article 28.

Article 31. In the event water temperatures during the critical months of the spawning season are too high for successful salmon spawning, the Licensees and the California Department of Fish and Game shall confer to determine whether project operations may be adjusted to assist in correcting the situation. If no agreement can be reached, the Commission, upon request and after notice and opportunity for hearing, may order such adjustment as it finds to be necessary and desirable, reasonably consistent with the primary purpose of the project.

Article 32. The Licensees shall, prior to the filling of New Don Pedro reservoir, provide for free passage of water through the existing Don Pedro dam either by opening the low-level outlets or breaching the dam near streambed.

Article 33. Gravels of the river channel downstream from La Grange dam shall not be disturbed during the construction of project facilities except in accordance with a plan developed by the Licensees after consultation with the California Department of Fish and Game and the United States Fish and Wildlife Service with a view toward maintaining the pre-project value of the gravels for salmon spawning. The Licensees shall take all reasonable measures to prevent silt, fines and other construction debris from being released into the Tuolumne River.

Article 34. The Licensees shall, prior to commencement of construction of the New Don Pedro project works, enter into an agreement with the Secretary of the Army or his designated representative providing for the operation of the project for flood control in accordance with rules and regulations prescribed by the Secretary of the Army. A conformed copy of the agreement shall be filed with the Commission for its information and records prior to commencement of construction of the project works.

Article 35. The Commission expressly reserves the right to determine at a later date what transmission lines and appurtenant facilities, if any, shall be included in the license as part of the project works.

Article 36. The Licensees shall construct, maintain and operate or shall arrange for the construction, maintenance and operation of such recreational facilities including modification thereto, such as access roads, wharves, launching ramps, beaches, picnic and camping areas, sanitary facilities and utilities, as may be prescribed hereafter by the Commission during the term of this license upon its own motion or upon the recommendation of the Secretary of the Interior or interested State agencies, after notice and opportunity for hearing and upon findings based upon substantial evidence that such facilities are necessary and desirable, and reasonably consistent with the primary purpose of the project. The Licensees shall within one year from the date of issuance of the license, file with the Commission for approval their proposed recreational use plan for the project. The plan shall be prepared after consultation with appropriate, Federal, State and local agencies, and shall include recreational improvements which may be provided by others in addition to the improvements the Licensees plan to provide.

Contract Amendment
No. D-GGR17-A2

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

AMENDMENT TO
RECREATION AND FISH ENHANCEMENT GRANTS
CONTRACT NO. D-GGR17
BETWEEN THE STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES, AND THE
MERCED IRRIGATION DISTRICT

THIS CONTRACT, entered into this day of , by and between the State of California, acting by and through its Department of Water Resources, herein referred to as the "State", and the Merced Irrigation District, a public agency in the State of California, duly organized, existing, and acting pursuant to the laws thereof with its principal place of business in Merced, California, herein referred to as the "Agency",

WITNESSETH, that:

WHEREAS, on October 31, 1967, the State and the Agency entered into grant contract number D-GGR17 under the Davis-Grunsky Act, as amended by D-GGR17-A1 entered into on October 23, 1968, which contract provides for several grants to assist in financing certain works of the Agency's Merced River Development Project, to wit: a fish enhancement grant not to exceed $2,146,000, a recreation grant for New Exchequer Dam and Reservoir not to exceed $3,532,800, a recreation grant for McSwain Dam and Reservoir not to exceed $1,038,700, a New Exchequer initial water supply and sanitary facilities grant not to exceed $1,243,500, and a McSwain initial water supply and sanitary facilities grant not to exceed $227,200 (such contract is hereinafter referred to as the "Contract"); and

WHEREAS, the Agency has requested amendment of the above contract to delete certain language requiring the Agency to oppose gravel mining in the Merced River spawning area; and

WHEREAS, Section 24(i) of the Contract requires the Agency to replace spawning gravels of the Merced River Area which are destroyed during the term of the contract; and

WHEREAS, the Agency has purchased 293 acres of land which qualifies under the above section and on which the Agency can construct the equivalent spawning gravels; and

WHEREAS, the Department of Fish and Game has indicated its approval of the equivalent spawning gravels as a replacement for natural spawning gravels; and

WHEREAS, the parties wish to amend the contract to allow for the relocation of two fishing access sites; and

WHEREAS, the parties wish to make several other changes in the recreation facilities required by the contract;

NOW, THEREFORE, it is mutually agreed that the Contract is amended as follows:

1. Subdivision (f) of Article 24 as amended by D-GGR17-A1 is amended to read as follows:

"(f) Availability of the Merced River Spawning Area

"The Agency shall use its best efforts to cause the

Merced River Spawning Area to be continuously available for fish enhancement throughout the term of this Contract in a condition substantially the same as on the date of completion of the fish enhancement work described in Article 22.

"In the event a dam is constructed by any entity other than the State of California or the United States below Crocker-Huffman Diversion Dam and such dam prevents the free passage of salmon upstream or downstream, the Agency shall pay to the State a sum of money computed in accordance with the formula set forth in subdivision (b) of Article 11."

2. Subdivision (a)(3) of Article 16 is amended to read:

"(3) immediately below McSwain power plant on the north bank of the Merced River."

3. Subdivision (a)(4) of Article 16 is amended to read:

"(4) in the northwest quarter of Section 12, Township 5 South, Range 14 East, on the north bank of the Merced River."

4. Subdivision (b)(1) (viii)(bb) of Article 15 is amended to read:

"(bb) Fifty-two family picnic units"

5. Subdivision (b)(1)(x)(bb) of Article 15 is amended to read:

"(bb) Forty-four family picnic units"

6. Subdivision (b)(1)(x)(hh) of Article is amended to read:

"(hh) Forty-two ramadas within the campground area and sixteen ramadas within the picnic ground area, provided that the State may review the need for ramadas when the camp and picnic units have been physically located and specify that certain ramadas may be omitted where natural shade is sufficient.

IN WITNESS WHEREOF, the parties hereto have executed this contract as of the date first hereinabove written.

Approved as to legal form
and sufficiency:

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES

____
Chief Counsel
Department of Water Resources

____
Director
P. O. Box 388
Sacramento, California 95802

MERCED IRRIGATION DISTRICT

____
Address: P. O. Box 2288
Merced, California 95340

Fish screening devices will be installed by the Agency at each of such diversion structures. Such screens shall be designed and constructed to keep young fish in the mainstream of the river. The type of fish screening devices used and the place and method of installation of such devices shall be approved by the State Department of Fish and Game before installation.

(c) River Channel Modification

The Agency shall modify the Merced River spawning area as necessary to assure free passage of salmon to and from the Merced River spawning area and to provide maximum availability of the spawning gravels in the Merced River spawning area at the Merced River flows to be provided pursuant to Article 24. Such modification shall include, but not be limited to, the construction of an adult fish barrier in the mouth of the South Channel (SE$\frac{1}{4}$ Sec. 30, T5S, R13E, MDB&M) and in all other dead-end channels in the Merced River spawning area to prevent salmon from migrating upstream in such dead-end channels, the lowering of the North Channel (SW$\frac{1}{4}$ Sec. 28, T5S R13E, MDB&M) to ensure that major flows will follow the river channel rather than the bypass, and the reworking of channel gravels as reasonably may be recommended by the State Department of Fish and Game to improve spawning potential.

23. TIMING, MANNER, AND STANDARDS OF CONSTRUCTION OF FISH ENHANCEMENT FACILITIES

(a) Fish Enhancement Facilities Completion Date

The Agency shall cause the construction of the fish enhancement facilities to be completed and available for the purposes for which they are intended not later than March 15, 1969, provided, that said date for completion may be extended upon written approval of the State.

(b) Construction Pursuant to Plans and Specifications; Construction Under Supervision of Fish and Game

The fish enhancement facilities shall be constructed in accordance with detailed plans and specifications that shall be submitted to, and that are approved in writing by, the State, or with any revisions thereof approved by the State. Construction of the fish enhancement facilities shall be performed under the general supervision of the State Department of Fish and Game.

(c) Basic Construction Standards Guide

The fish enhancement facilities shall be designed and constructed to standards that shall be determined adequate by the State to enhance the fish production of the Merced River and to protect the health, safety, and welfare of the public.

(d) Determination of Completion of Construction

For the purposes of this contract, construction of the fish enhancement facilities shall be considered to be completed or terminated when so determined by the State, and the State shall give the Agency prompt written notice of such determination. The State shall within 45 days from receipt of a written statement from the Agency that, in the opinion of the Agency, the construction of the fish enhancement facilities is completed, notify the Agency of its determination that such construction is, or is not, completed.

24. PROJECT OPERATION AND MAINTENANCE FOR FISH ENHANCEMENT .

(a) Maintenance of Optimum Flows in Merced River Spawning Area

The Agency shall maintain a continuous flow of between 180 and 220 cubic feet per second in the Merced River spawning area each year during the period November 1 to April 1, provided, that the Agency shall not be required to maintain such flow during emergency occurrences, such as a flood condition or mechanical or other operational failure, beyond the control of the Agency; or when to do so would prevent it from fulfilling its obligations under its contract with the Pacific Gas and Electric Company dated June 25, 1964, together with amendments to such contract to the date of this contract, or its obligations under its contract with the United States Department of the Army, Corps of Engineers, providing for flood control on the Merced River, with amendments to such contract to the date of this contract. The Agency shall maintain such flows by making appropriate releases from New Exchequer Dam and McSwain Dam, and a combination of releases from Croeker-Huffman Diversion Dam and the artificial spawning channel, and by diverting excess flows through the Agency's irrigation system at Crocker-Huffman Diversion Dam, to the extent such diversion is physically possible. During the initial five years of project operation, a cooperative study by the Agency and the State Department of Fish and Game will be made to determine the most efficient continuous flow required to maintain the salmon fishery during the period of November 1 to April 1. After such study is completed the continuous flow requirements of this subdivision may be increased or decreased to such continuous flow which is determined to be the most efficient; provided, that such increase or decrease is mutually agreed upon by the Agency and the State Department of Fish and Game. The Agency shall make releases from New Exchequer Dam and McSwain Dam so that insofar as is possible in consideration of project operation for power, irrigation and flood control, water temperatures satisfactory for salmon reproduction in the Merced River spawning area will be provided.

(b) Flushing Flows to Facilitate the Downstream Migration of Young Fish

During the initial five years of project operation, a cooperative study by the Agency and the Department of Fish and Game will determine the most efficient flow regime during February, March and April to assist the young salmon on their migration to the ocean. Once established by this study, this flow regime will be continued annually by the Agency.

(c) Production of Yearling Salmon

The Agency shall cause to be reared and planted in the Merced River 100,000 yearling salmon annually for the initial nine years following completion of the fish enhancement facilities. The Agency shall take eggs for such program from the Stanislaus River until sufficient eggs become available from the Merced River. The rearing of salmon may be done at a State installation at the Agency's expense.

(d) Minimum Storage New Exchequer Reservoir

The Agency shall maintain the water surface elevation in New Exchequer Reservoir as high as is possible, consistent with other project operational demands, throughout the period April through October of each year, and shall maintain at all times a minimum pool of 115,000 acre-feet in such reservoir for maintenance of fishlife.

(e) Achievement of Fish Enhancement Benefits

In operating and maintaining the project for fish enhancement, the Agency shall refrain from intentionally or negligently doing any act, or failing to do any act, which would impair the achievement of the fish enhancement benefits described in the project feasibility report and the supplements thereto.

(f) Availability of the Merced River Spawning Area

The Agency shall cause the Merced River spawning area to be continuously available for fish enhancement throughout the term of this contract in a condition substantially the same as on the date of completion of the fish enhancement work described in Article 22; provided, that the Agency may, with the approval of the State, provide equivalent spawning gravels in lieu of areas of the Merced River spawning area which are destroyed by natural causes or the acts of others. In the event a dam is constructed by any entity other than the State of California or the United States below Crocker-Huffman Diversion Dam and such dam prevents the free passage of salmon upstream or downstream, the Agency shall pay to the State a sum of money computed in accordance with the formula set forth in subdivision (b) of Article 11.

The Agency shall oppose any proposal to change the zoning regulations of the County of Merced so as to allow gravel mining in the Merced River spawning area. The Agency shall promptly notify the State of any such proposal or any attempted gravel mining in the Merced River spawning area.

(g) Maintenance, Operation and Replacement of Fish Enhancement Facilities

The Agency shall cause the fish enhancement facilities constructed pursuant to subdivisions (a) and (b) of Article 22 to be maintained, operated and replaced so that at all times during the term of this contract such facilities shall be in good operable condition.

(h) Compliance with Law

The Agency shall cause the project to be operated and maintained for fish enhancement in compliance with all laws, regulations, orders, and other lawful directives of the State of California and of local agencies that are from time to time applicable to such operation and maintenance.

25. REPORTS ON PROJECT OPERATION FOR FISH ENHANCEMENT

In the year following the year in which construction of the fish enhancement facilities is completed, and in each year thereafter, the Agency shall furnish or cause to be furnished to the State, on or before the fifteenth day of each month, a written report on the operation of the project for fish enhancement during the preceding month. Said report shall consist of:

(1) A continuous streamflow hydrograph indicating the flows at Shaffer Bridge (Montpellier Road crossing about five miles upstream from Cressey);

(2) A continuous streamflow hydrograph indicating the quantities of flow in the artificial spawning channel; and

AGREEMENT BETWEEN CALIFORNIA DEPARTMENT OF FISH AND GAME AND THE UNITED STATES DEPARTMENT OF THE INTERIOR BUREAU OF RECLAMATION REGARDING INTERIM INSTREAM FLOWS AND FISHERY STUDIES IN THE STANISLAUS RIVER BELOW NEW MELONES RESERVOIR

This AGREEMENT is made by and between the State of California, as represented by the Department of Fish and Game, hereinafter referred to as "Fish and Game", and the United States Department of the Interior, Bureau of Reclamation, hereinafter referred to as "Bureau", and both hereinafter collectively referred to as "Parties", for the combined purposes of (1) providing appropriate Stanislaus River instream flows as needed to maintain or enhance the fishery resource during an interim period in which habitat requirements are better defined, and (2) completing studies of the chinook salmon fisheries of the Stanislaus River.

RECITALS

THE PARTIES RECOGNIZE:

A. Chinook salmon stocks of the San Joaquin River and its tributaries represent important fishery resources of the State of California. These include salmon which annually utilize the Stanislaus River, downstream from Goodwin Dam, for the purpose of spawning, incubation, juvenile rearing and migration. All San Joaquin River system salmon stocks have been reduced in recent years, resulting from numerous factors affecting their habitat and reducing their survival, particularly during juvenile stages.

B. Through its operation, the Bureau's New Melones Reservoir can materially affect the amount and timing of instream flows available below (downstream) of Goodwin Dam, thereby affecting the welfare and success of salmon stocks and other fishery resources of the Stanislaus River and of the San Joaquin River in the reach between the Stanislaus River confluence and the San Joaquin-Sacramento River Delta. It is recognized, however, that the adequacy of instream flows in the San Joaquin River and Delta reaches is dependent upon conditions and instream flow releases from other upstream tributaries, in addition to the Stanislaus River.

C. During 1984, the Bureau filed Applications No. 14858, 27319, 27320, and 27321, before the California State Water Resources Control Board (Board), which in part sought permits to directly divert water for beneficial use at New Melones Dam and other points, as described in those applications. Fish and Game, acting on behalf of the people of the State of California, filed a protest to the Bureau's applications on the basis that, lacking appropriately scheduled instream flows, the proposed direct diversions could adversely affect salmon and other resources of the Stanislaus River and the reach of the San Joaquin River described in Recital B above.

D. In its protest, Fish and Game identified the need to perform detailed studies of the Stanislaus River salmon fishery for the purpose of prescribing an appropriate instream flow schedule. The need for such studies had earlier been identified in Decision D-1422 of the Board. The Parties, in coordination with the United States Department of the Interior Fish and Wildlife Service (the Service), have already cooperated, to some extent, in the design, partial funding and partial conduct of said studies, prior to execution of this AGREEMENT. As yet, insufficient study results are available, however to make the intended instream flow prescriptions.

The cooperative studies as agreed to by the Parties and the Service are outlined in the Plan of Study, a copy of which is attached hereto as Exhibit A of this AGREEMENT. The funding responsibilities and budget for the studies are provided for in the document attached hereto as Exhibit B.

E. The purposes of this AGREEMENT are:

1. To commit the Parties, within constraints imposed by Legislative approvals of their budgets, to the completion of a program of studies intended to identify the long-term instream flow and other physical needs of Stanislaus River chinook salmon.

2. To implement an interim instream flow schedule which will (1) protect the chinook salmon stock of the Stanislaus River during completion of said studies, and (2) provide for experimentation in the amount and timing of instream flows to ascertain if acceptable criteria for protection of salmon can be provided conjunctively with other beneficial water uses.

F. This AGREEMENT shall pertain only to fishery resources and habitat within the Stanislaus River and San Joaquin River as described in Recital B above. The Parties further recognize that there are other downstream activities which also materially affect the survival of downstream migrant chinook salmon from the Stanislaus River, and that said downstream aspects need to be addressed in the future. The parties acknowledge that despite the adequacy of instream flows which are provided for the Stanislaus River below Goodwin Dam, recovery of the fishery may be hampered, pending correction of existing problems associated with downstream diversions, Delta diversions and fish passage through the Delta.

G. It is the intention of Fish and Game that this AGREEMENT shall become the instrument through which it will provisionally dismiss its protest against the Bureau's applications, as described in Recital C.

AGREEMENT

NOW THEREFORE, the Parties agree as follows:

I. The Parties agree to implement the following program of fishery instream flow releases from New Melones Dam to provide (1) flows acceptable and reasonable for upstream migration, spawning, incubation, rearing and downstream migration of chinook salmon and (2) the basis for expedient completion of biological studies to identify long-term instream flow needs of the Stanislaus River below Goodwin Dam.

II. Each year the Bureau shall compute the supply available for annual fishery instream flow releases using the procedure described in Exhibit C. For the purposes of this AGREEMENT a year shall begin on March 1 and end on the last day of February of the succeeding calendar year.

An initial appraisal of the supply available for annual fishery instream flow releases will be computed and furnished to Fish and Game on February 1st of each year or as soon as practicable but no later than February 15th. This initial appraisal will be used by Fish and Game to produce a fishery instream flow release schedule for the first 15 days of March. This schedule shall be provided to the Bureau as soon as practicable, but no later than February 20th.

A second estimate of the supply available for annual fishery instream flow releases will be computed and furnished to Fish and Game on March 1st of each year or as soon as practicable but no later than March 10th. A preliminary 12 month fishery instream flow release schedule shall be provided to the Bureau as soon as practicable, but no later than March 15th. The final determination of the supply available will be computed and furnished to Fish and Game on April 1st of each year or as soon as practicable but no later than April 10th. The final fishery instream flow release schedule for the April through February period shall be provided to the Bureau no later than April 15th. Instream flow releases shall be provided by the Bureau in accordance with schedules furnished by Fish and Game.

A. The maximum annual supply available for fishery instream flow releases shall be 302,100 acre-feet and the minimum supply shall be 98,300 acre-feet.

B. Fish and Game agrees that fishery instream flow releases which may be requested, either for the purpose of study, or based upon the results of studies as herein provided, shall not exceed 1,250 cubic feet per second, except at the discretion of the Bureau for compliance with existing guidelines for flood control, water quality requirements, nondamaging flow levels, implementation of the Plan of Study (Exhibit A) and other downstream considerations.

C. Both parties recognize that the determination of target storage as defined in Exhibit C is dependent on the amount of water being consumed by uses upstream of New Melones Reservoir, and by Oakdale Irrigation District and South San Joaquin Irrigation District.

(1.) The annual use of Oakdale and South San Joaquin Irrigation Districts shall be monitored and as the three year average water use increases to the maximum allowed by the 1972 Stipulation and Agreement between the Bureau and the Districts, the target storage specified in Exhibit C shall be modified in accordance with the schedule shown in Figure C-1, to protect authorized inbasin uses. Only those years in which the New Melones inflow equals or exceeds 654,000 acre-feet for the period from November 1 through October 31 of the following calendar year will be used to compute the three year average water use.

(2.) The consumptive use of water in the basin above New Melones shall be monitored on an annual basis. If the use of water under existing or new permits increases by 10,000 acre-feet per year over the present level, the provisions for fishery releases in excess of 98,300 acre-feet per year shall be renegotiated to accommodate the increased upstream use. Dry and critical year shortage criteria may also be considered during these negotiations. The present level of use of water above New Melones Reservoir is estimated to be 36,800 acre-feet per year.

D. Said fishery instream flow releases shall be made in a manner allowing for the implementation of the Plan of Study described in Exhibit A.

* III. The fishery instream flow releases provided for in this AGREEMENT shall be made by the Bureau <u>until long-term salmon protection standards are agreed to or adopted by the Board</u>. At the time of completion of the studies described in Exhibit A, the results, along with other pertinent information shall be considered by the Parties in identifying an acceptable instream flow program. A Final Agreement is anticipated, which would contain mutual recommendations to afford long-term fishery resource protection. Said <u>recommendations would be provided to the Board</u>, together with a mutual request that they be implemented as a condition of any Permit or License issued pursuant to Applications No. 14858, 27319, 27320, and 27321. In the event said Final Agreement cannot be made, within a period of two years following concurrence of the Parties that the Plan of Study is completed, or six years following the last release of coded-wire-tagged salmon as described in Exhibit A, the Parties agree that either Party may submit its independent recommendations and request to said Board.

IV. Fish and Game agrees to dismiss its Protest to the Bureau's Applications No. 14858, 27319, 27320, and 27321, as filed before the Board provided any Permit issued pursuant to said Applications contains provisions sufficient to permit the implementation of paragraph III above. *Key

V. The Parties agree that they will work with other water agencies in an attempt to implement a conjunctive use program that would augment river flows so as to improve habitat conditions for chinook salmon and other fishery resources. In that event, this AGREEMENT will be amended, as appropriate.

VI. Nothing herein shall be construed to require any action which would, of itself, constitute any infraction or violation of either the Constitution of the United States of America or the State of California, or of any Federal or State statute.

* VII. It is the intent of the Parties to implement the Plan of Studies as described in Exhibit A. The Parties agree to diligently pursue approval for funding of the Plan of Studies (Exhibit A). It is recognized that said funding is contingent upon approval of the budgets of Fish and Game, the Bureau and Fish and Wildlife Service, by the State Legislature and United States Congress, as applicable.

VIII. This AGREEMENT may be modified, based upon written concurrence of both Parties, except that in the event this AGREEMENT becomes an instrument of either law or permit, concurrence of all concerned legal and/or permit agencies shall also be required.

(Date)	Jack C. Parnell, Director California Department of Fish and Game
(Date)	David G. Houston, Regional Director U. S. Bureau of Reclamation

EXHIBIT A

PLAN OF STUDY

STANISLAUS RIVER FISHERY STUDY

April 1987

INTRODUCTION

This proposed study is needed to provide more precise information for developing measures to sustain salmon in the Stanislaus/San Joaquin River. The study will include evaluation of the downstream fishery flow requirements in the Stanislaus River. It is contemplated that the evaluations and data gathering will be performed over a period of about 7 years jointly by the Bureau of Reclamation (BOR), Department of Fish and Game (DFG), and U.S. Fish and Wildlife Service (USFWS). The 7 year study period may need to be extended for the salmon tagging studies if hatchery fish are unavailable or waterflows cannot be controlled in certain years.

The New Melones Project, as authorized by Public Law 87-874, provides 98,000 acre-feet of water for downstream fishery purposes in the Stanislaus River. In addition, up to 70,000 acre-feet for water-quality purposes would be made available as releases to the Stanislaus and lower San Joaquin Rivers.

It has been recommended by the DFG that substantially greater flows, possibly up to a total of approximately 302,000 acre-feet at Goodwin Dam, could be needed for fishery purposes in the Stanislaus River. Flows of this magnitude would require the full yield of the project and could significantly alter the project operations and economics. The largest portion of this release is required for spring outflow to improve the survival of juvenile salmon migrating out of the Stanislaus River and through the San Joaquin River and Delta. At the time of the water rights hearings, the BOR proposed an initial period of about 10 years or so be used to study the Stanislaus fishery and maintaining other project accomplishments. It was suggested by BOR that such a study period, beginning with the initiation of New Melones Project operation, be used to determine the needs of the fishery resources, the effects of flow variations, and other possible means of improving the fishery. The proposed study discussed below is consistent with the evaluations previously contemplated at the water rights hearings.

Existing water and power developments on the Stanislaus River include facilities by local irrigation districts and the Pacific Gas and Electric Company (PG&E). Many of the storage reservoirs and the associated ditch systems purchased by PG&E date back to the mining activities of the early 1850's. The PG&E storage developments include Spicer Meadows, Utica, Alpine, and Relief Reservoirs with a total storage of about 30,000 acre-feet on the tributaries of the North and Middle Forks of the Stanislaus River. PG&E's Strawberry and Lyons Reservoirs on the South Fork of the Stanislaus River have a total capacity of approximately 24,000 acre-feet.

In 1926, the Oakdale and South San Joaquin Irrigation Districts, which have diverted substantial quantities of water at Goodwin Dam since 1914, constructed Melones Dam and Reservoir with a capacity of 112,000 acre-feet. This feature augmented water supplies for irrigation use in the San Joaquin Valley for the Districts. In 1957, the two Districts further increased their water supply by developing the Tri-Dam

Project in the drainage. The project includes Donnells and Beardsley Reservoirs on the Middle Fork Stanislaus River, and Tulloch Reservoir located downstream from Melones Reservoir with a total storage capacity of over 230,000 acre-feet. Power developments are included in connection with operation of this project. The Tri-Dam Project was operational by 1960.

The New Melones Project, with a storage reservoir of 2.4 million acre-feet, was constructed by the Corps of Engineers and began operation by the Bureau of Reclamation as part of the Central Valley Project in 1981.

PROBLEM

Historically, the San Joaquin River system, which includes the Stanislaus River, had established populations of both fall-run and spring-run chinook salmon. The spring run moved upstream during periods of heaviest snowmelt (May and June), remained in deep pools during the summer, and spawned in the fall. The fall run moved upstream in the fall or early winter after water temperatures had dropped and flows had increased. These fish spawned within a few weeks of their arrival.

Salmon runs in the main stem of San Joaquin River, south of the Merced River confluence, were completely eliminated when Friant Dam was built in the mid-1940's. The spring runs in the Stanislaus, Tuolumne, and Merced Rivers were probably eliminated by water developments during the 1910-30 period. In the river system above (south of) the city of Stockton, runs of fall-run salmon presently occur in only three main tributary streams--the Merced, Tuolumne, and Stanislaus Rivers.

These fish begin migrating from the Sacramento/San Joaquin estuary in late summer or early fall. Unsuitable oxygen and temperatures in the lower river near Stockton have delayed migration is some years. Improved waste treatment has minimized this problem in recent years. In normal years, conditions become adequate by September. Spawning begins in mid-to-late October, reaches a peak in Mid-November and ends in January. The young begin emerging from the gravel in late December. Some appear to migrate immediately out of the spawning area and others grow to smolting size in the spawning reach near where they were hatched.

The early fish generally reach smolting size in late March or April; the peak of smolt migration from the rivers is from mid-to-late May (June in good water years). Poor survival of outmigration leaving the streams in the later part of the outmigration period in low or average water years is thought to be affected by water diversions and unfavorable water conditions in the lower reaches of the tributaries, main stem San Joaquin River, and the Sacramento-San Joaquin Delta.

Runs in the Merced, Tuolumne and Stanislaus Rivers are capable of being significantly improved. They have been adversely affected by low streamflows, gravel degradation, degraded water quality, water temperature problems, and by State/Federal/District water storage/export projects. A brief summary of 10-year average fall chinook salmon escapement estimates for the major San Joaquin River tributaries including the Stanislaus River depicts the significance of the declines.

Stanislaus River Fishery Study

Period	Merced River	Tuolumne River	Stanislaus River	Mean Total
1953-1962	896	20,265	9,320	30,481
1963-1972	1,301	10,528	6,675	18,504
1973-1982	2,892	3,141	645	6,678

For the Stanislaus River, the pre-Tri-Dam (1953-60) and post-Tri-Dam operations (1961-81) are shown for the fall salmon escapements in the following tabulation:

Period	Stanislaus River Average Escapement
1953-1960 pre-Tri-Dam	10,900
1961-1981 post-Tri-Dam and pre-New Melones	3,450

OBJECTIVE

The primary objective of this study is to determine what measures are necessary to improve survival of the freshwater life stages of chinook salmon in the Stanislaus River and downstream migratory pathways. Tasks within this study are designed to determine the limiting biological factors and develop alternative management programs to improve juvenile salmon survival and ultimately adult salmon runs on the Stanislaus River. These programs will need to be consistent with the other functions and uses of the New Melones Project as specified in Public Law 87-874.

Stanislaus River Fishery Study

Information and alternatives developed by this study will be used by the management units of the Department of Fish and Game, U.S. Fish and Wildlife Service, and U.S. Bureau of Reclamation to improve the Stanislaus and San Joaquin River salmon fishery. Specific objectives of the Stanislaus River Fishery Study will include: (1) Identification of acceptable flow regimes for salmon spawning, juvenile production/growth and outmigration, (2) monitoring of annual spawning escapement, (3) evaluation of available spawning habitat and coordination of renovation and maintenance activities, (4) evaluation of operating scenarios at New Melones and Tulloch Reservoirs, and Goodwin Dam, (5) integration of biological data with BOR temperature and water quality studies, (6) integration of tributary data with existing movement and survival studies in the estuary and San Francisco Bay (Bay/Delta Project) to further define outmigration dynamics and constraints, and (7) coordinaton with Tuolumne River studies (New Don Pedro Project) and general problems (i.e., straying) of San Joaquin salmon.

PROPOSED STUDY PROGRAM

This 7-year proposed study program was developed jointly by representatives from the DFG, USFWS, and BOR. The field work and studies will be conducted by the DFG and the USFWS and to a lesser degree BOR. The study will include seven study elements. This study will also include the integration of tributary data with existing movements and survival studies in the estuary and San Francisco/Bay Delta Projects to further define outmigration dynamics and constraints. Most of the data collection and specific studies relating to river characteristics will be conducted during the first 4 years of the study. Temperature modeling and flow evaluations, including possible renovation plans, will be completed in the later stages of this program. The study elements, study costs, and the proposed distribution of funding between DFG, BOR, and USFWS are discussed below. The study elements and activities are summarized in table 1. Costs are summarized in table 2.

Study Elements

1. Evaluate Instream Flow Requirements. The U.S. Fish and Wildlife Service with assistance from the Department of Fish and Game, will gather information for developing salmonoid habitat preference curves and possible transect locations during the initial years of the study. This will include performing a habitat preference study and an instream flow study scheduled for years 1 and 2, respectively. The USFWS will be the primary agency responsible for conducting the instream flow study to be assisted by representatives from DFG and the BOR. Aerial photography (1"=100' scale) will be obtained by the BOR to support field studies. Flow release evaluations relating to spawning habitat juvenile rearing habitat and downstream outmigration will be an important aspect of this study element. Reports will be prepared for the habitat preference study and the instream flow study.

2. Evaluate Distribution and Growth of Juvenile Salmon. Evaluation of spatial and temporal distribution and growth rates of juvenile salmon in relation to streamflow and habitat. During the study, there would be

Table 1
Stanislaus River Fishery Study

Years:	(1) 86-87	(2) 87-88	(3) 88-89	(4) 89-90	(5) 90-91	(6) 91-92	(7 92-
ELEMENT 1 - EVALUATE INSTREAM FLOW REQUIREMENTS (USFWS)							
A. Obtain information for probability of use curves	Habitat	Instream					
B. Transect selection and field data measurements	Preference	Flow					
C. Data analysis	Study	Study	XXX	XXX	XXX	XXX	XXX
D. Flow release evaluations	XXX	XXX	XXX				
ELEMENT 2 - EVALUATE DISTRIBUTION AND GROWTH (D&G) OF JUVENILE SALMON (CDFG)							
A. Evaluate D&G in Stanislaus River	XXX	XXX	XXX	XXX	XXX	XXX	
B. Evaluate D&G in lower San Joaquin River and South Delta	XXX	XXX	XXX	XXX	XXX	XXX	
C. Monitor thyroxine levels in fingerlings and smolts	XXX	XXX	XXX	XXX			
D. Data analysis	XXX	XXX	XXX	XXX	XXX	XXX	XXX
ELEMENT 3 - DEFINE TIMING AND MAGNITUDE OF DOWNSTREAM MIGRATION (CDFG)							
A. Development of sampling gear and techniques	XXX	XXX	XXX				
B. Introduction of CWT fry from Merced River Fish Facility	XXX	XXX	XXX	XXX	XXX	XXX	XXX
C. Monitor downstream migration of CWT fish at SWP & CVP fish screens, Delta seining, Chipps Island trawling	XXX	XXX	XXX	XXX	XXX	XXX	XXX
D. Monitor ocean catch and spawning escapements for recovery of CWT	XXX	XXX	XXX	XXX	XXX	XXX	XXX
E. Monitor downstream migration of wild and CWT smolts	XXX	XXX	XXX	XXX	XXX	XXX	XXX
F. Data analysis		XXX	XXX	XXX	XXX	XXX	XXX
ELEMENT 4 - DETERMINE ANNUAL SPAWNING ESCAPEMENTS (CDFG)	XXX	XXX	XXX	XXX	XXX	XXX	XXX
ELEMENT 5 - EVALUATE SPAWNING HABITAT SUITABILITY AND IMPROVEMENT NEEDS (CDFG)							
A. Map and evaluate existing spawning habitat	XXX	XXX	XXX				
B. Plan habitat renovation project	XXX	XXX	XXX				
C. Implement renovation plan			XXX	XXX			
D. Evaluate utilization of renovated area			XXX	XXX	XXX		
ELEMENT 6 - TEMPERATURE STATIONS AND MODELING (BOR)	INSTALL EQUIPMENT	T E M P E R A T U R E M O D E L I N					
ELEMENT 7 - COORDINATE AND INTEGRATE STUDIES WITH USBR, USCOE, AFB, BAY DELTA (BOR)	XXX	XXX	XXX	XXX	XXX	XXX	XXX
A. Annual Reports	XXX	XXX	XXX	XXX	XXX	XXX	XXX

Table 2
Stanislaus River Fishery Study
(Costs $)

Entity and Items	(1) 87	(2) 88	(3) 89	(4) 90	(5) 91	(6) 92	(7) 93	Totals
	Fiscal Years							
DFG	(73,000)	(73,000)	(73,000)	(73,000)	(73,000)	(73,000)	(73,000)	(511,000)
BOR	(90,000)	(151,000)	(81,000)	(66,000)	(54,000)	(39,000)	(39,000)	(520,000)
Staff	9,000	20,000	10,000	10,000	10,000	10,000	10,000	79,000
Equip & O&M[a]	23,000	11,000	11,000	11,000	11,000	4,000	4,000	75,000
Instream Flows		80,000[b]	40,000[b]	25,000	13,000	5,000	5,000	168,000
Habitat Preference	58,000[b]	40,000[b]	-0-	-0-	-0-	-0-	-0-	98,000
Temp Model	-0-	-0-	20,000	20,000	20,000	20,000	20,000	100,000
FWS	(10,000)	(10,000)	(8,000)	(5,000)	(5,000)	(1,000)	(1,000)	(40,000)
TOTAL COSTS	173,000	234,000	162,000	144,00	132,000	113,000	113,000	1,071,000
FWS (Transfer Funds) $1,000's	(58)	(120)	(40)	(25)	(13)	(5)	(5)	

[a]Temperature stations will be in for all years ($4,000/yr O&M).
[b]For these years FWS will provide increased funding and BOR will also provide funds for habitat preference and instream flow studies.

possibly 6 years of different flow regimes provided in the river. These may include 2 years with D-1422 or authorized flow levels--98,000 acre-feet, 2 years with DFG flows recommended to the State Water Resources Control Board--260,000-302,000 acre-feet, and 2 other years with the flow release patterns to be mutually developed as a result of the instream flow analysis and other information received from the study. These flow conditions would also be used for evaluating downstream migration - study element 3. An active (boat) and/or passive (stationary) sampling program with appropriate gear will be implemented during January through June periods to determine the presence/absence of juvenile salmon, important parameters of habitats utilized and their distribution patterns under various flow regimes. Growth, condition factors, and physiological parameters associated with outmigration (e.g., thyroxine levels) will be monitored. This study element will cover the Stanislaus River, along with the observance of the juveniles in the lower San Joaquin River and south Delta areas.

3. Define Timing and Magnitude of Downstream Migration. Sampling will consist of seining, electrofishing, trawling and other appropriate methods that will be used to document the relationship of outmigration to various flow regimes. Smolt-sized salmon reared at Merced River Fish Facility (MRFF), marked with coded wire tags (CWT) will be released in the upper and lower ends of the Stanislaus River. They will be subsequently recaptured by (1) trawling in the lower San Joaquin River and Delta, (2) sampling catches at the SWP and CVP fish screens near

Tracy, and (3) in the ocean commercial and sport fisheries. These data will also verify data obtained in study element 2. Implementation of this element will be dependent on availability of fish at MRFF and the ability of BOR to control waterflows during critical periods.

4. Determine Annual Spawning Escapements. Determine annual adult escapement (timing and number) in the Stanislaus River. Weekly salmon carcass enumeration surveys will be run using appropriate boat(s) during mid-October through mid-December each year. Sex and size composition of the run will be determined and an expansion using standard mark-recapture mathematics (with modifications) will be made. Heads from all CWT fish will be preserved for later identification and tag recovery. Subsequent ground and aerial survey redd counts will be made and correlated to the number of females in the run(s).

5. Evaluate Spawning Habitat Suitability and Improvement Needs. Map and evaluate suitability of existing spawning habitat in the Stanislaus River. Aerial photos obtained in element 1 will be used to document suitable existing spawning habitat and this will be compared to previous survey results. Habitat improvement needs and renovation proposals will be determined.

6. Temperature Stations and Modeling. The BOR, during the first year of the study, will install the necessary temperature recording stations at various selected locations primarily in the lower San Joaquin River and southern delta channels. They will be operated throughout the 7-year study. During years 3, 4, 5, 6, and 7, a temperature model will

be developed by BOR and used to evaluate temperature impacts on salmon downstream migration and survival under alternative flow regimes.

7. Coordinate and Integrate Studies with USBR, USCOE, AFB, Bay Delta. Integrate and coordinate Stanislaus River study activities with the operation of New Melones and Tulloch Reservoirs and Goodwin Dam, temperature studies, and other studies of salmon movement and survival in the estuary and San Francisco Bay. The acquisition of input and coordination of studies will be made with DFG Region 4 representatives and other functions. Annual reports are to be prepared by DFG, USFWS, and BOR representatives which are to be completed no later than December of each year. These reports are to summarize the work accomplished as part of this study and to indicate the findings to date and develop recommendations to resolve the problems as appropriate.

Study Costs

A portion of the BOR study costs is for the annual costs to tag 200,000 salmon smolts for 6 years. The estimated study costs are shown in table 2.

The total estimated study cost for the 7 years would be approximately $1,071,000. The annual costs would range from $103,000 in the seventh year to a maximum of $234,000 in the second year. Costs are summarized for DFG, BOR, and FWS.

STANISLAUS RIVER FISHERY STUDY

STUDY COSTS

1. Proposed study funding is proved on page 2 of Exhibit B.
2. The actual funding level is contingent upon approval of the budgets of Fish and Game, the Bureau of Reclamation, and the Fish and Wildlife Service by the State Legislature and United States Congress, as applicable.

Stanislaus River Fishery Study
(Costs $)

Fiscal Years

Entity and Items	(1) 87	(2) 88	(3) 89	(4) 90	(5) 91	(6) 92	(7) 93	Totals
DFG	(73,000)	(73,000)	(73,000)	(73,000)	(73,000)	(73,000)	(73,000)	(511,000)
BOR	(90,000)	(151,000)	(81,000)	(66,000)	(54,000)	(39,000)	(39,000)	(520,000)
Staff	9,000	20,000	10,000	10,000	10,000	10,000	10,000	79,000
Equip & O&M[a]	23,000	11,000	11,000	11,000	11,000	4,000	4,000	75,000
Instream Flows		80,000[b]	40,000[b]	25,000	13,000	5,000	5,000	168,000
Habitat Preference	58,000[b]	40,000[b]	-0-	-0-	-0-	-0-	-0-	98,000
Temp Model	-0-	-0-	20,000	20,000	20,000	20,000	20,000	100,000
FWS	(10,000)	(10,000)	(8,000)	(5,000)	(5,000)	(1,000)	(1,000)	(40,000)
TOTAL COSTS	173,000	234,000	162,000	144,00	132,000	113,000	113,000	1,071,000
FWS (Transfer Funds) $1,000's	(58)	(120)	(40)	(25)	(13)	(5)	(5)	

[a]Temperature stations will be in for all years ($4,000/yr O&M).

[b]For these years FWS will provide increased funding and BOR will also provide funds for habitat preference and instream flow studies.

Exhibit C

Purpose

1. This exhibit defines the equation used to compute the supply available for annual instream flow releases.

Variables

2. When used in this exhibit, the following variable representations shall be applied:

(a) "M" is the variable label that represents the calendar year month number of the current month of calculation. For example, when the calculation is performed in March, M is equal to 3.

(b) "SAAIF(M)" is the variable label that represents the supply available, computed in month "M", for annual instream flow releases in acre-feet.

(c) "AIF" is the variable label that represents the amount of instream flow in acre-feet released since March 1 of the current year.

(d) "EOMS(M-1)" is the variable label that represents the New Melones end-of-month storage in acre-feet for the previous month.

(e) "PI(M)" is the variable label that represents the projected inflow to New Melones reservoir, in acre-feet, for the current month through September of the current year.

(f) "POSWD(M)" is the variable label that represents the projected water demands, in acre-feet, for the Oakdale and South San Joaquin Water Districts from the current month through September of the current year.

(g) "PCWD(M)" is the variable label that represents the projected contracted CVP Stanislaus River water demands in acre-feet for the current month through September of the current year.

(h) "PWQWD(M)" is the variable label that represents the projected water demands in acre-feet associated with supporting downstream water quality and minimum flow committments for the current month through September of the current year. These flow requirements are those contained in SWRCB D-1422 and the Agreement with the South Delta Water Agency.

(i) "EVAP(M)" is the variable label that represents the estimated evaporation from New Melones reservoir in acre-feet from the current month through September of the current year. The evaporation rates applied in projecting New Melones reservoir evaporation in acre-feet per acre are:

MAR	APR	MAY	JUN	JUL	AUG	SEP
.199	.386	.507	.581	.764	.711	.595

(J) "TS" is the variable label that represents the September end-of-month target storage in acre-feet. This value is influenced by the level of upstream and downstream demands for water from New Melones reservoir. Given the assessment of current conditions related to water demands on New Melones a target storage of 1,700,000 acre-feet shall be used. This value can be changed by mutual agreement of the parties as reassessment of these conditions indicate the need for change.

Equation

3. The following equation shall be used to compute the supply available for annual instream flow releases on the Stanislaus River at Goodwin Dam:

$$SAAIF(M) = AIF + EOMS(M-1) + PI(M) - POSWD(M) - PCWD(M) - PWQWD(M) - EVAP(M) - TS$$

Figure C-1

TARGET STORAGE TABLE
(Thousands of Acre-feet)

Oakdale I. D. and South San Joaquin I. D. Demand	-	600	620	640	650	654
Required Target Storage for New Melones Reservoir	-	1700	1700	1700	1750	1750

Friant Dam - Millerton Lake

No required flow release except to provide for prior riparian rights.

USBR-DFG Agreement guarantees 35 cfs to River via San Joaquin (mitigation) fish hatchery.

35 cfs can be rediverted by riparian users.

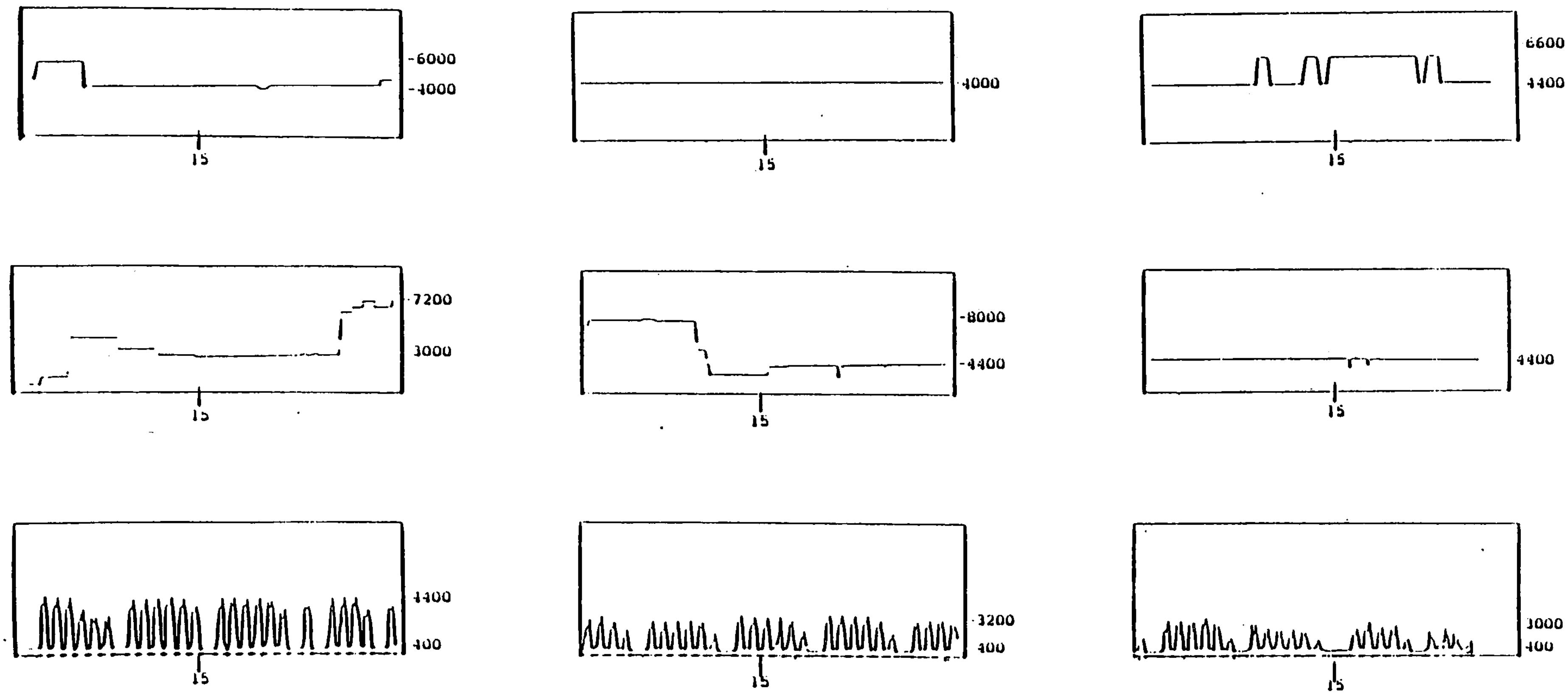
Mendota Dam:

No required flow releases below Mendota Dam.

APPENDIX 6

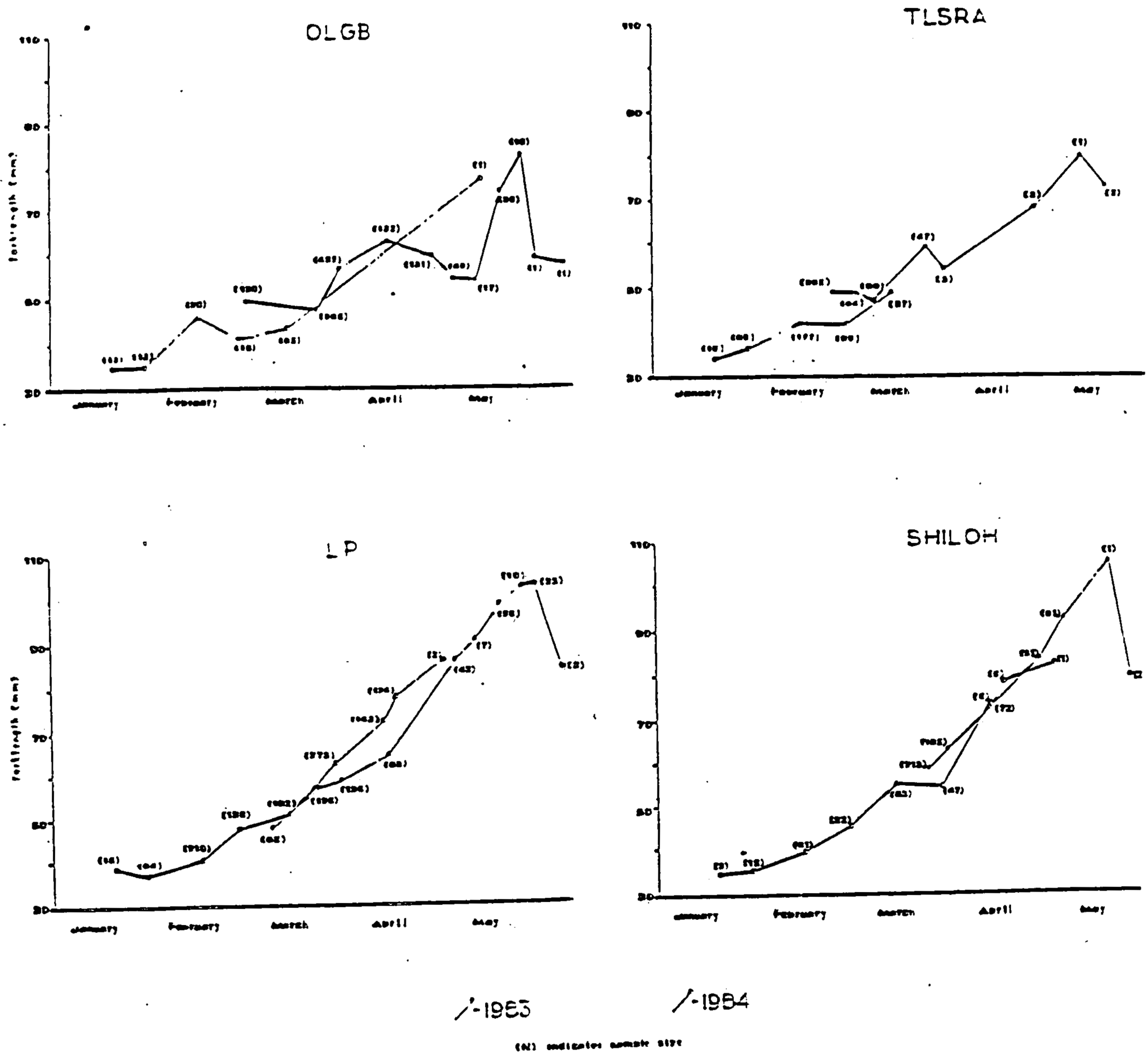
Hourly streamflow on the Tuolumne River below LaGrange Dam (USGS gauge #11289650) during the fall-run chinook salmon fry emergence periods in 1983, 1984 and 1985.

APPENDIX 6



APPENDIX 7

Mean forklength of juvenile chinook salmon seined at four locations in the Tuolumne River below Don Pedro Reservoir, 1983-1984.



APPENDIX 8

Smolts (CWT) released in the Delta recovered during intensive sampling at the CVP and SWP Fish Facilities in 1985, 1986 and 1987[1/]

Year and Release Location	CWT Code	Number Released	Expanded Number Recovered from the CVP	SWP	Unexpanded[2/] Other	Total	Minimum Fraction Recovered[3/]
1985							N=97.
SF Mokelumne	6-62-34	100,386	9	80	8	97	.00097
NF Mokelumne	101,237	6-62-36	4	10	12	26	.00026
Courtland	6-62-38 6-62-39 6-62-40 6-62-41	107,162	0	0	4	4	.00004
1986							
SF Mokelumne	6-62-46	103,750	12	360	—	372	.00359
Courtland	6-62-43	104,000	8	0	—	8	.00008
1987							
Courtland gates closed	6-62-53 6-62-54	49,781 50,421	26 12	28 114	— —	54 126	.0011 .0025
Courtland gates opened	6-62-56 6-62-57	49,083 51,836	0 6	0 180	— —	0 186	0 .0036
Ryde gates closed	6-62-55	51,103	6	0	—	6	.0001
Ryde gates opened	6-62-58	51,008	0	0	—	0	0

X-Channel

1/ This table does not include any fish released in the San Joaquin system or those released by the Interagency Study in Lower Old River.

2/ These fish were recovered in a handling and trucking experiment in 1985 at the SWP facility from 5-16 to 6-13 and could not be expanded in any way.

3/ This is considered the minimum fraction because in 1985, we stopped sampling 3 days after the Delta fish began arriving at the fish facilities Other sporadic sampling at the facilities after 5-15 indicated we missed the majority of marked Delta fish coming through the facilities.

From U.S. Fish & Wildlife Service Exhibit on Chinook Salmon Needs in the Delta & Estuary.

APPENDIX 9

Decision 1422

STATE OF CALIFORNIA
The Resources Agency
Department of Fish and Game
G. Ray Arnett, Director

REPORT TO THE CALIFORNIA STATE WATER RESOURCES CONTROL BOARD ON EFFECTS OF THE NEW MELONES PROJECT ON FISH AND WILDLIFE RESOURCES OF THE STANISLAUS RIVER AND SACRAMENTO-SAN JOAQUIN DELTA

By

Region 4 - Fresno
Anadromous Fisheries Branch - Sacramento
Bay-Delta Research Study - Stockton
and
Environmental Services Branch - Sacramento

OCTOBER, 1972

section was considered "poor" for spawning if its depth was greater than 3.0 feet. Subsequent studies have shown this maximum limit to be invalid. King salmon have been observed spawning in the Sacramento and Feather Rivers at depths of 15 and 8 feet respectively (Kier, 1964). In the Columbia River system, salmon have been observed spawning in depths in excess of 24 feet (Chambers, 1956).

The significance of the deletion of the maximum depth criterion is that a flow larger than 200 cfs (with greater water depths) will provide a greater amount of gravel. Without extensive re-surveys it is not possible to state the flow which will maximize the amount of spawning gravel. However, we feel 200 cfs would still provide sufficient spawning area to maintain the present average run of 8,600 salmon.

Incubation Period, October through February

After the fish have spawned, a continued supply of water over the redds is required to maintain the incubating eggs in the gravel. During incubation, the depth of water required is less than that required for spawning. Too large a drop after spawning, however, would result in stranding of redds and loss of eggs. It is estimated that a flow of approximately 150 cfs is required during the incubation period.

Downstream Migration Period, January through June

Salmon fry emerge from the gravel from January through April. From the time of emergence until they migrate downstream, the young salmon must find food and shelter in the river. The supply of both food and shelter is typically related to flow.

Trapping of downstream migrants shows that the length of time young salmon spend in the river varies widely. The major downstream movement occurs from March to mid-June, with two distinct peaks of movement. The first peak takes place in March and April and is composed of fish only one to two inches long. The second peak occurs in May and the first half of June and is comprised of 3 to 4-inch fish.

It is believed that the larger fish migrating in the later group are more important in contributing to the returning spawning run. One reason for this belief is that the migration of young salmon through the Sacramento-San Joaquin Estuary peaks in May and June and is composed principally of 3 to 4-inch fish (Messersmith, 1966; Sasaki, 1966; and unpublished records).

The available evidence indicates that the size of the salmon run in the Stanislaus River is determined principally by the amount of water flowing down the river in the spring. As a demonstration of this, the correlation coefficient for the relationship between the number of female adult salmon returning to the river to spawn and the mean flow in the spring 2-1/2 years earlier is 0.94 (Figure 1). This correlation indicates that approximately 88% of the variation in the number of adult females is associated with variations in river flow in the spring when they were young-of-the-year living in the river and migrating downstream.

Before considering the meaning of this correlation in more detail, a few words of explanation about the correlation analysis itself are in order. The absolute value of correlation coefficients range from 0 for no relationship to 1.0 for a perfect relationship. The number of females was used rather than the total run of adults, because most females return at three years of age while many males return at age 2. Thus using only females gives a more accurate description of the relationship between flow in a given year and the resulting adult run. The corresponding correlation coefficient for the relationship between flows and total adult runs is 0.81.

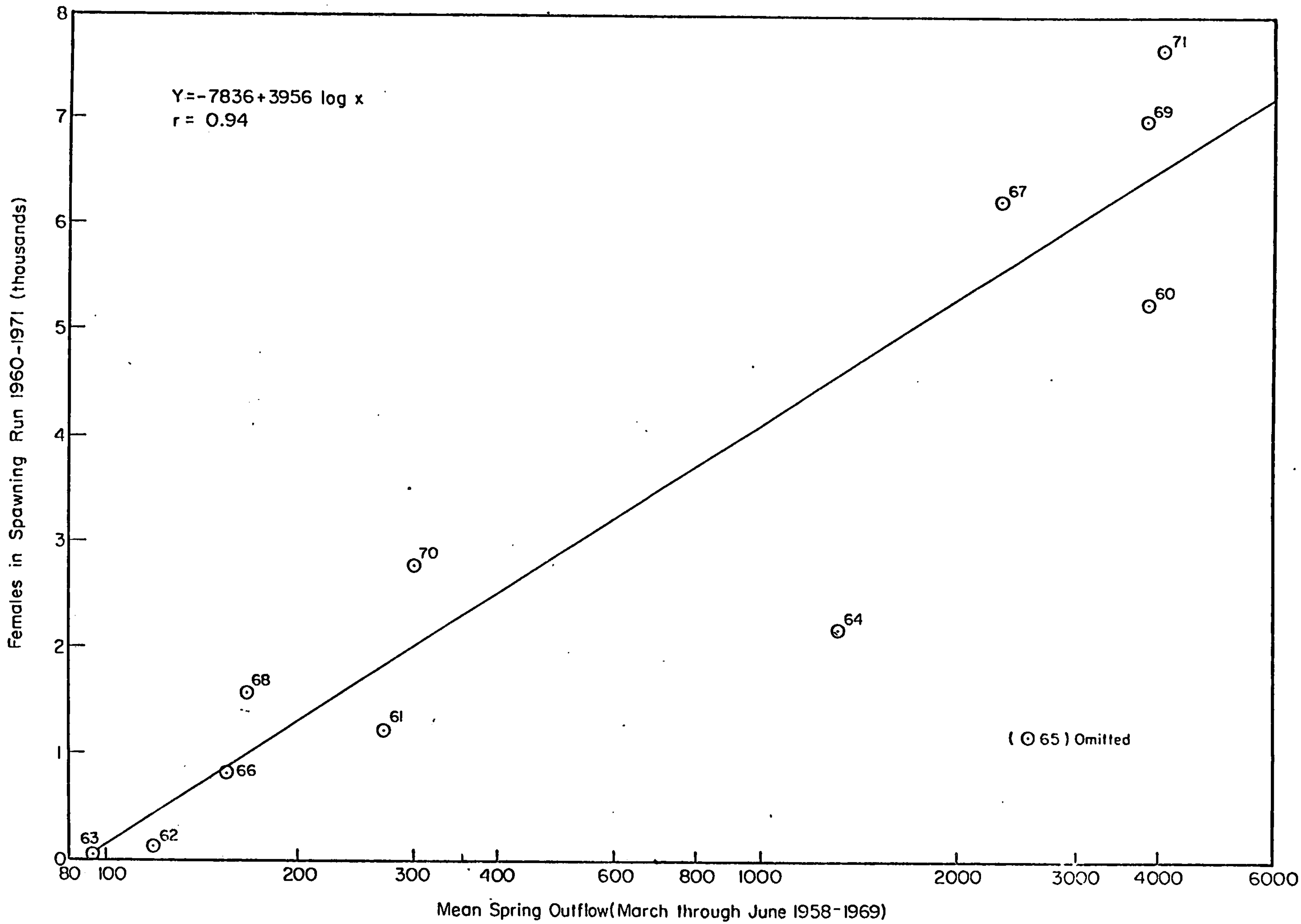


Figure 1 Relationship between spring outflow of Stanislaus River at Ripon and number of spawning females 2½ years later (circled numbers indicate year of spawning).

Flows were plotted on a logarithmic rather than an arithmetic scale even though the corresponding correlation coefficient (0.93) for the arithmetic relationship was not significantly lower, and the standard error for the arithmetic relationship was only slightly greater (987 vs. 945). The logarithmic scale was used because points for the lower flows fitted the line better. That would be expected intuitively because the effect of any given increment in flow on the fish populations should increase as flows decrease. For example, incrementing flows by 200 cfs from 200 cfs to 400 cfs should be more beneficial than incrementing them from 1000 cfs to 1200 cfs. A logarithmic plot gives the desired relative weighting to increments in flow, while an arithmetic plot does not.

Finally, the point for 1965 was not included in the calculated relationship. The small run that year in relation to flow was probably due to the parent stock (1962) being too small to produce enough young to take advantage of the good flows in the spring of 1963. Since the objective is to describe the limit imposed by spring flows, such an omission is reasonable.

Turning now to the meaning of the relationship, the first question is whether the relationship reflects a cause and effect relationship between spring flows and number of adults. Three questions pertinent to this determination are:

1. Does the same relationship exist in other similar but independent situations?
2. Are runs in the Stanislaus River correlated with other conditions which would suggest that the already described correlation is spurious?
3. Can reasonable hypotheses be developed for there being a cause and effect relationship between adult runs and spring flows?

In relation to the first question, a similar relationship exists on the Tuolumne River. The correlation there between total runs and March to June flows from 1940 through 1971 is 0.79.

The prime consideration in relation to the second question is whether conditions at some other time of year might be correlated equally well with adult runs. The analogous correlation with October through December mean flows is 0.51. The marked difference between this and the correlation for spring flows is a strong indication that spring and not fall conditions limit salmon populations in the Stanislaus River.

Finally, several factors associated with increasing spring flows would logically be expected to increase the survival of young salmon. These include increased living space and shelter and decreased vulnerability to predation both in the Stanislaus River and during the downstream migration. Increased rates of flow probably both stimulate downstream migration and facilitate it. Also as flows increase the proportion of water diverted for agriculture and other uses decreases thus increasing survival.

In summary then the most reasonable interpretation of the observed correlation is that spring flows are the most important factor controlling the size of salmon populations in the Stanislaus River, with survival being proportional to flow. The relationship (Figure 1) can be described by the equation:

$$F = -7,830 + 3,955 \log Q \quad \text{(Equation 1)}$$

where: F = number of adult females returning in the fall

Q = mean March through June flow in cfs at Ripon two years earlier

In order to determine the amount of flow necessary to maintain the historical average run of 8,600 adult fish, the proportion of females in the run had to be estimated. For the years 1960 through 1971 the mean proportion of females was 46 percent. Therefore, a run of about 3,950 females is equivalent to a total run of 8,600 fish. From Figure 1, it can now be seen that the mean March through June flow required to maintain an average run of 3,950 females or 8,600 salmon is 950 cfs.

Historically, flows have peaked in May. It would seem most logical to replicate the seasonal pattern. The peak in flows during the peak in the downstream migration of larger fish may well be important both in stimulating the migration and increasing its success. Also increasing flows later in the spring is most compatible with other beneficial uses.

These uses include both fishery benefits downstream, as described in Chapter 3, and agriculture. Based on the monthly distribution of flows at Ripon during the 11-year period, 1960-1970, (Table 1, Chapter 1), March through June mean monthly flows of 700, 900, 1200 and 1000 cfs would generally replicate the historical pattern with a mean flow of 950 cfs.

The foregoing analysis indicates that the enhancement ~~of~~ salmon runs is dependent on providing March through June mean flows exceeding 950 cfs. The enhancement due to any such increase in flow can be estimated by modifying equation 1. Equation (1) should be modified by subtracting the historical female population size of 3956 (0.46 of 8600) and equating females to a total run by dividing the solution to (1) by 0.46, as follows:

$$F = -7{,}830 + 3{,}955 \log Q - 3{,}956$$

$$F = -11{,}786 + 3{,}955 \log Q$$

$$E = \frac{F}{0.46}$$

$$E = 0.46\,(-11{,}786 + 3{,}955 \log Q) \qquad (2)$$

Where: E= average enhancement, in adult fish of both sexes, in the returning run.

Solution of Equation (2) approximates zero at an average March through June flow (Q) of 950 cfs. That is, no enhancement will be achieved at this flow.

At mean flows of less than 950 cfs, solutions are negative, and provide estimates of the loss sustained by the resource at such flows.

Summer Flows

Summer flows are essential in controlling vegetation encroachment on spawning gravels and assist in maintaining suitable dissolved oxygen and temperature levels for resident fishes and any steelhead and spring-run salmon populations which might develop in the Stanislaus River and will sustain juvenile salmon that stay in fresh water for one year. It is estimated that 100 cfs during the months of July, August and September will minimize vegetation encroachment on the salmon spawning gravels, and also maintain suitable dissolved oxygen and water temperatures. These summer flows will also provide trout habitat in the river below Goodwin Dam to help replace the 12 miles of the Stanislaus River that will be inundated by the project.

Recommended Flows With the Project

Based upon the foregoing considerations and analyses we conclude that the following flow schedule is essential to preserve and maintain the salmon and other fishery resources of the Stanislaus River.

Period	Minimum Flow (cfs)	Acre-feet
January	150*	9,220
February	150*	8,330
March	700**	43,050
April	900**	53,550
May	1200**	73,800
June	1000**	59,500
July	100*	6,150
August	100*	6,150
September	100*	5,950
October	200*	12,300
November	200*	11,900
December	200*	12,300
		302,200

* The July through February flows should be released at Goodwin Dam (or Knights Ferry Diversion Dam) and allowed to flow, undiverted, to the San Joaquin River.

** March through June flows should be measured at the Ripon streamflow gage, with, at least, 83 percent of these mean monthly flows to be released from Goodwin Dam. This percentage is based on an average March through June accretion in this reach of 17% of the recommended mean flow of 950 cfs.