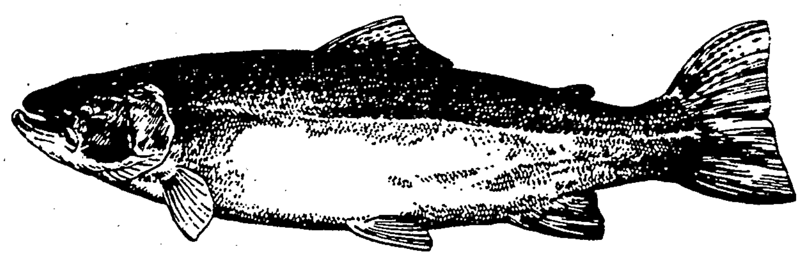
ABUNDANCE AND SURVIVAL OF JUVENILE CHINOOK SALMON IN THE SACRAMENTO-SAN JOAQUIN ESTUARY



1992 ANNUAL PROGRESS REPORT

FY 92 WORK GUIDANCE

JUNE, 1993

SACRAMENTO-SAN JOAQUIN ESTUARY

FISHERY RESOURCE OFFICE

U.S. FISH & WILDLIFE SERVICE

STOCKTON, CALIFORNIA

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1992 Annual Report

Sacramento/San Joaquin Estuary Fishery Resource Office

U.S. Fish & Wildlife Service

Introduction

Work in 1992 by the Sacramento/San Joaquin Estuary Fishery Resource Office was conducted to update and refine our knowledge of the factors influencing young salmon abundance, distribution and survival in the Sacramento/San Joaquin Estuary. Sampling in 1992 was expanded to include juveniles of all races.

Overall objectives of the 1992 Interagency Salmon Study are to:

1. Monitor the abundance of fry and smolt chinook salmon rearing and migrating through the delta.
2. Determine the impacts of water development within the delta on the abundance, distribution and survival of juvenile fall run salmon.
3. Identify management measures that could lessen the impacts of water project operations on salmon using the Delta and lower embayments of the estuary.

We employed our historic sampling methods (midwater trawling at Sacramento and Chipps Island, beach seining). We also sampled experimentally with a variety of new gears and techniques, in part to improve our ability to capture all size ranges of juvenile salmonids. Presumably, different sizes and life stages will have different spatial and temporal distributions within the delta. These new methods represent a pilot effort the results of which should be regarded as tentative.

Elements of the Study in 1992 were:

- A weekly beach seining survey to estimate the abundance of fry, December through May, which is an expansion of our past beach seining program.
- A midwater trawl survey at Sacramento beginning in December 1991 to estimate the abundance of smolts entering the delta.
- Limited tow net sampling was conducted on our trawl vessel at Sacramento to see if fry sized salmon located in the middle of the channel were being effectively sampled with the midwater trawl.
- Fyke sampling was initiated in 1992 to estimate the number of fry entering the delta at Sacramento during the same period of time that the midwater trawl was sampling at the same location.
- Repetitive beach seining was conducted to evaluate how quickly fry immigrate back into the beach seine sites after sampling.

- Trawling was conducted at Chipps Island as in past years to estimate the number of unmarked fish emigrating from the Delta and to recover marked fish released in our mark and recapture experiments.

- Coded wire tagged fry were released at Verona and Miller Park and recovered at Sacramento in our trawl and fyke sampling to estimate the sampling efficiency of our fykes.

- Addition mark and recapture studies were used to determine the survival of fall run smolts under varied environmental conditions.

Specific questions addressed by tag studies in 1992 were:

a. What is the survival of fish migrating down the San Joaquin River with and without a full barrier placed at the head of upper Old River?

b. What is the impact on the Sacramento basin salmon (especially winter run) migrating through the central delta of bringing more water to the export pumps via lower Old and Middle Rivers with a head of Old River barrier in place?

c. What is the impact on salmon smolts of diversion into Georgiana Slough at low to mid range temperatures.

- CWT recovery data generated by the ocean fishery is available to confirm past conclusions based on trawl recovery information, but will be analyzed later.

SACRAMENTO RIVER DELTA

Fry and Smolt Abundance

Beach Seine

A weekly beach seine survey in the lower Sacramento River and northern delta began on 3 December 1991 and continued until 29 May 1992. The central delta stations were added to the survey on 9 January. Table 1 identifies the number of salmon caught by race (based on the daily size criterion developed by Frank Fisher, California Department of Fish and Game, Red Bluff) and the number of seine hauls per month in our 1991-1992 beach seine survey. The majority of salmon recovered in our beach seine survey were fall run which would reflect: 1) larger numbers of fall run salmon in the Central Valley, 2) the fact that fall run are probably smaller than the late fall and winter races when they entered the delta, potentially because of the pattern of runoff in late 1991 and 1992 with few storms until February and March, and 3) the smaller fish would be more vulnerable to our beach seine sampling.

TABLE 1: 1992 beach seine catch by month and race.

MONTH	Fall	Spring	Winter	Late Fall	n
December	0	0	0	0	78
January	367	0	2	5	131
February	1201	38	15	3	98
March	1670	26	3	0	94
April	698	5	0	0	123
May	50	0	0	0	105

n = Number of seine hauls.

The peak seine catches of fall run were in March, with the peak of winter and late fall run in February and January, respectively. We would expect the timing of the peak catches to vary between races due to spawning difference and their vulnerability to the seine.

Comparisons of our catches were made with past years based on the catch per seine haul January through March (the common sampling period for all the data). The abundance of fry in the northern Delta in 1992 was somewhat higher than that observed in 1991, and similar to that observed in 1987 to 1989. The low numbers observed in the central delta are similar to past dry years. The numbers recovered in the lower Sacramento River seining sites are well within the range of recent years. All three areas reflect catches similar to recent dry years. Mean catch per haul for the three areas between January and March since 1977 is shown in Table 2.

The 1992 northern delta data continues to support past findings that fry abundance in the northern delta in general increases as inflow to the delta increases (Figure 1).

As we have observed in previous years, the number of fry entering the lower Sacramento River and delta in 1992 appears to respond to the pulses of flow entering the river. The first minor pulse in mid January did not appear to be enough to move the fry all the way into the delta, but catches in the lower Sacramento River did appear to respond within about 7 days of the pulse. The first major flow pulse in mid February did appear to bring additional fry into the lower Sacramento River and northern and central delta (Figure 2).

TABLE 2: **January through March average catch per seine haul of Chinook salmon juveniles in the Lower Sacramento River, and Northern and Central Delta between 1977 and 1992. Annual means are the three monthly means of weekly means.**

YEAR	SACRAMENTO RIVER	NORTHERN DELTA	CENTRAL DELTA
1992	18	14	3
1991	30	4	3
1990	11	32	5
1989	22	15	3
1988	9	11	5
1987	19	15	5
1986	34	34	12
1985	2	12	3
1984	14	14	5
1983	35	40	11
1982	15	24	5
1981	36*	13	2
1980	**	16	3
1979	**	40	8*
1978	**	24	**
1977	**	0.1	**
n =	7	14	9

* February and March only, no samples in January. This would tend to increase the mean.

** Not sampled.

n = Number of seine sites in area.

The mean fork length of fry entering the three combined areas of the delta in 1992 appeared to increase throughout the course of

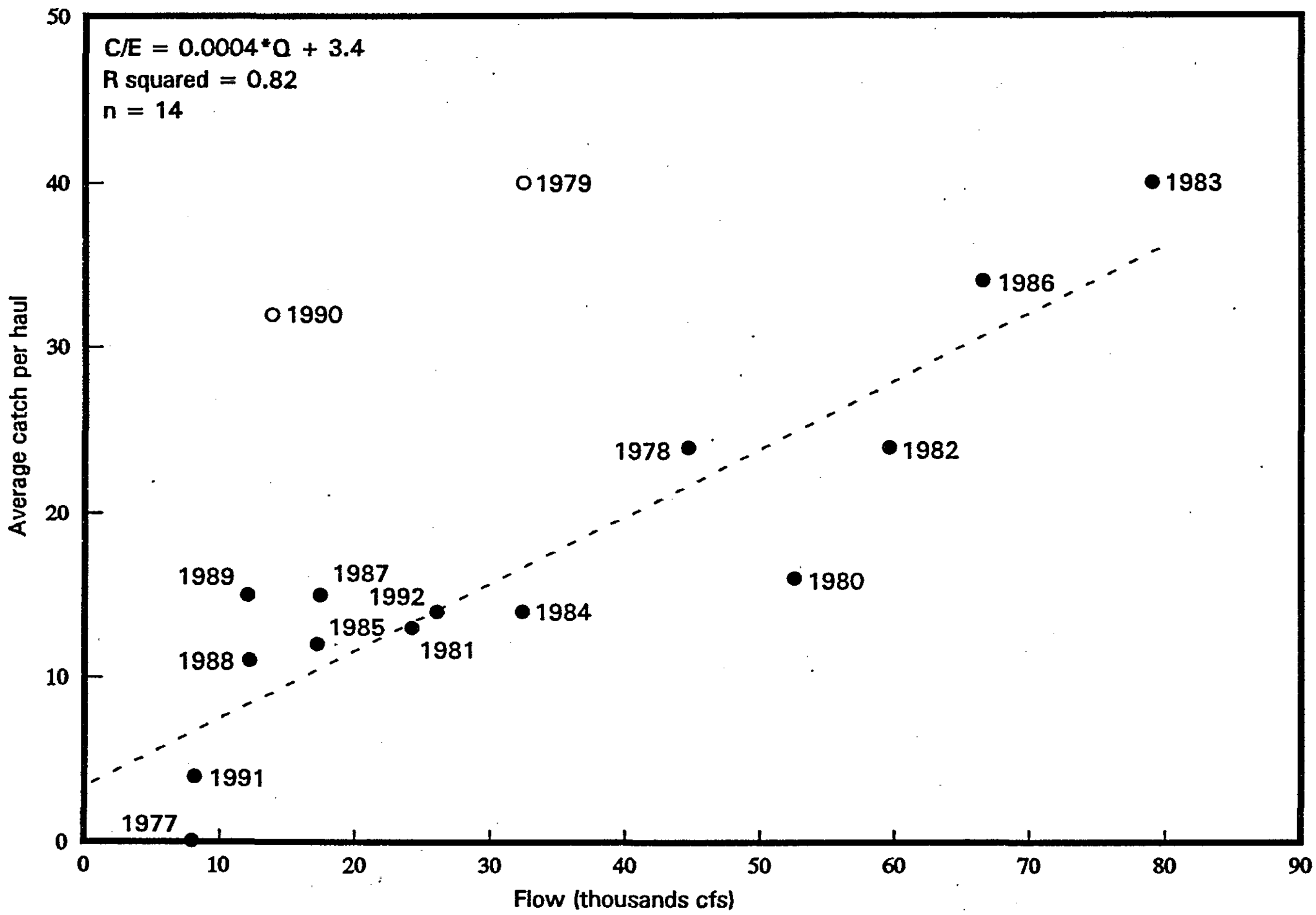

Figure 1. Average catch per seine haul of chinook in the Northern Delta versus February mean flow of the Sacramento River at Freeport.

○ Outlying points not used in regression calculation.

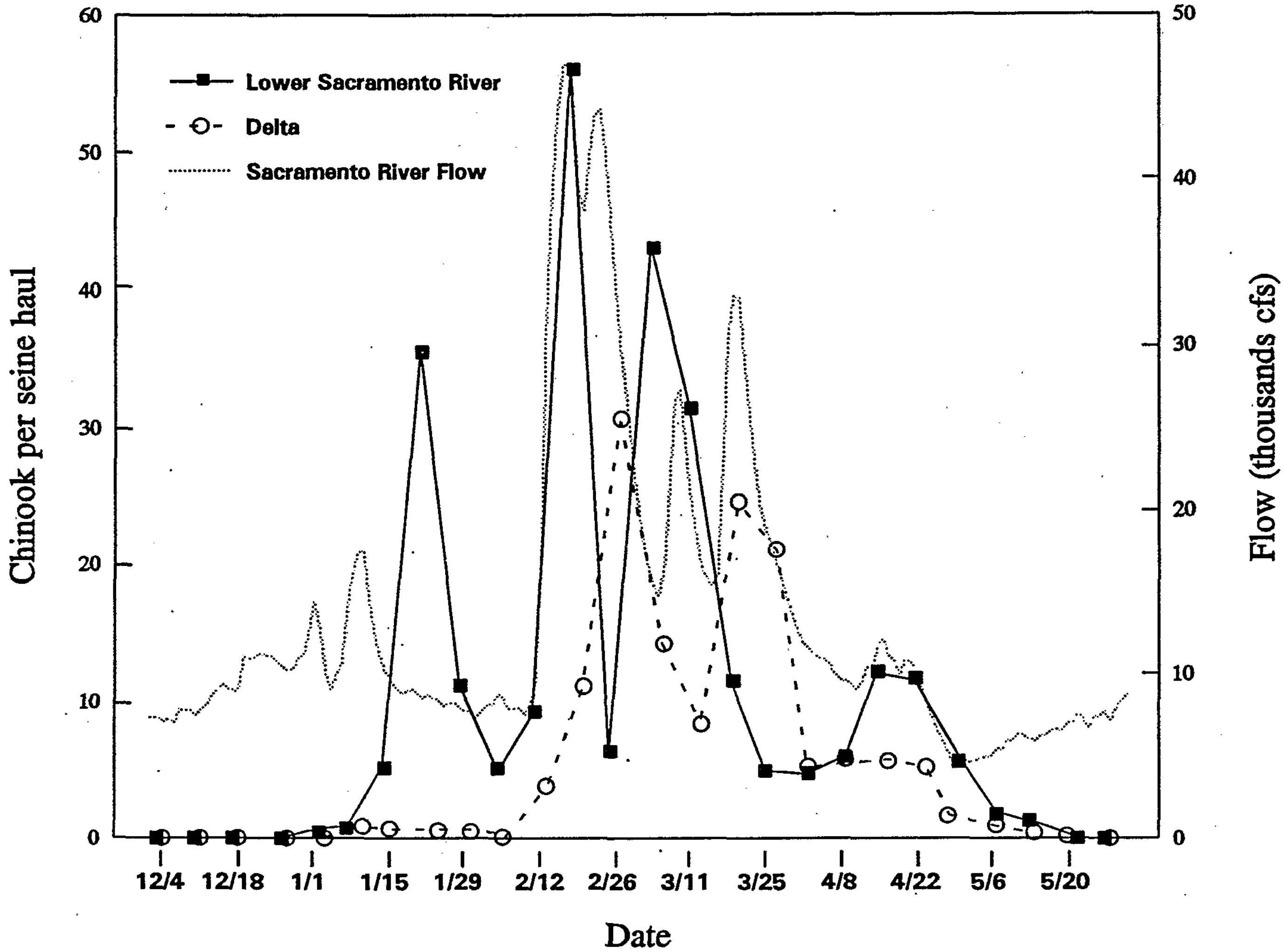

Figure 2. Chinook captured per beach seine in the Delta and Lower Sacramento River in 1992. Northern and Central Delta sites are combined for this graph. Mean daily Sacramento river flow is at Freeport (DAYFLOW).

the season as we would expect. However, just after the three flow pulses in February and March the mean size dropped somewhat (Figure 3) and may reflect the influx of smaller fish into the lower river and delta from the upper river due to the increase in flow. As we have hypothesized in the past, this may be a behavioral response to the increase in turbidity or may reflect involuntary movement downstream due to advection.

Tagged Fry Recaptured By Seining

A total of 183 coded wire tagged fish were recovered that were released as fry in four groups (three of the releases were at Verona and one was at Miller Park) one group per week between 25 February and 16 March. A total of 102,862 coded wire tagged fry were released. During the course of the season we collected 4083 unmarked fish in our seining. Based on the ratio of recaptures to those released, 2,295,002 unmarked fry are estimated to have been in the delta and lower Sacramento River between December 1991 and the end of May 1992. We believe this is a minimum estimate as many of the recaptures (120 of 183) were recovered at Verona seven days after release and most likely biased our recovery rate high and, consequently, our absolute abundance low. Omitting the 120 and using 63 as the recapture value yields an estimate of 6,666,437 unmarked fry.

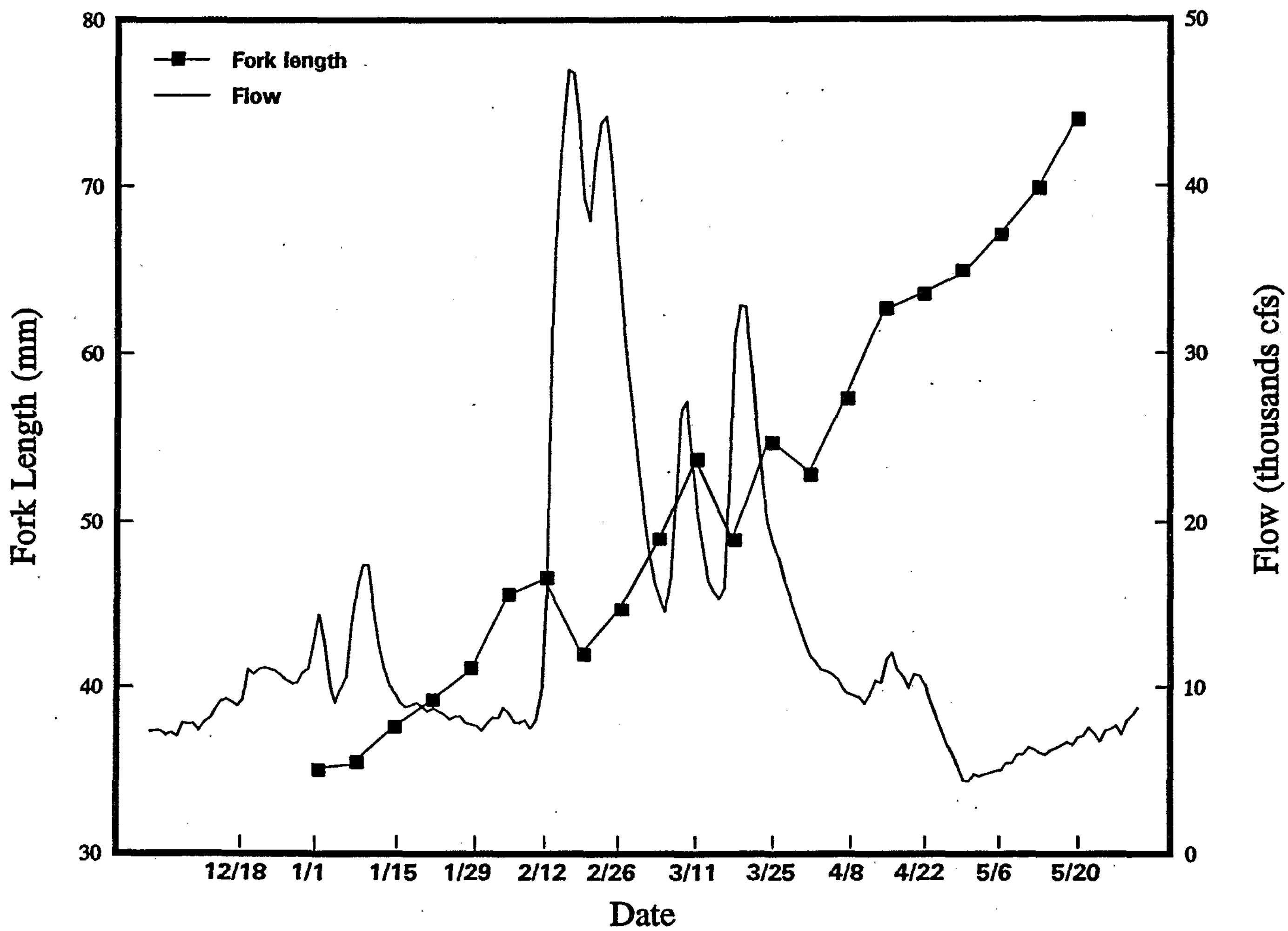

Figure 3. Mean fork length of chinook captured in all areas of the 1992 beach seining survey. Winter-run chinook were excluded from length calculations. Mean daily river flow was measured at Freeport (DAYFLOW).

Proportional expansions like these (and others that follow in this report) depend upon an extensive set of assumptions, few of which are likely to be precisely true. Reported results should be interpreted as approximations of actual population variables.

Repetitive Beach Seining

Multiple seine hauls on a single sampling day were conducted at four stations near Sacramento (Discovery Park, Garcia Bend, Miller Park and Clarksburg) between 28 February and 14 April 1992 to estimate the influx rate of fry moving into these areas. The goal was to seine multiple times until very few fry were caught. After each seine haul the catches were all transported downstream so they would not be resampled. The site was then be revisited within a day to see how many fry had repopulated the area in the roughly 24 hours since the last sampling. In the following analyses, data was not used when the time between the initial day of seining and subsequent day of seining was more than one day.

Based on the number of fry remaining on the initial day of seining compared with the number of fry captured on the first seine haul of the following day, it was estimated that fry move into these areas during March and April on an average 0.0023 fish per minute, and repopulate the area about 3 fold in 24 hours (Table 3). Additional analyses of this data is warranted and may yield additional insight on the influx of fry into the northern delta.

TABLE 3: **Number of salmon caught on the last seine haul on the initial seining day vs. that on the first seine haul the next day at four sites in our repetitive seining survey.**

	GARCIA BEND	
Date	**Last Catch on Day 0**	**First Catch on Day 1**
3/2	0	3
3/9	4	0
3/23	2	16
3/30	13	22
$\bar{X}$ =	5	10

	DISCOVERY PARK	
Date	**Last Catch on Day 0**	**First Catch on Day 1**
3/9	14	2
3/16	3	10
4/13	0	14
$\bar{X}$ =	5.6	8.6

	MILLER PARK	
Date	**Last Catch on Day 0**	**First Catch on Day 1**
3/23	0	10
3/30	0	2
4/6	1	6
$\bar{X}$ =	.3	6

	CLARKSBURG	
Date	**Last Catch on Day 0**	**First Catch on Day 1**
4/13	0	13
$\bar{X}$ =	0	13

Grand mean (all sites combined) $\bar{\bar{X}}$ = 2.7 vs. 9.4

Fyke

Fykes deployed near Sherwood Harbor Marina (within our midwater trawling reach at Sacramento) were used to index and document the influx of near shore fry moving into the delta. Two fyke traps, one on each side of the river, were fished two to three times per week both during the day and at night between 21 January and 10 June 1992.

The mean catch per minute was 0.0247 in our fykes during the six month sampling period. Catch per minute by month ranged between 0.000 and 0.086, with the least caught in June and the most caught in March (Table 4).

TABLE 4: Mean catch per minute by month of salmon caught in our fyke nets at Sacramento between January 21, 1992 and June 10, 1992. The mean catch by day was averaged for each month.

MONTH	MEAN CATCH/MINUTE
JANUARY	.0129
FEBRUARY	.0274
MARCH	.0858
APRIL	.0192
MAY	.0030
JUNE	0
$\overline{X}$ =	.0247

Figure 4 shows the catch per minute by day and illustrates the exceptionally high value we observed on 9 March, in comparison to the days both before and after that peak. Table 5 identifies the salmon caught by race in the fykes based on the most recent size criterion (Frank Fisher, CDFG, 2/28/92).

TABLE 5: Total number of chinook salmon by race caught in the fyke nets at Sacramento between January 21 and June 10, 1992.

FYKE NET

MONTH	FALL	MARKED	SPRING	WINTER	LATE-FALL
JANUARY	93	0	1	0	0
FEBRUARY	374	0	3	0	0
MARCH	1768	91	57	0	0
APRIL	259	2	8	0	0
MAY	93	0	0	0	0
TOTAL	2,587	93	69	0	0

Catches (as number per minute) were less for the fykes than for the midwater trawl at Sacramento. In most months the mean size caught in the fykes was less than that caught in the midwater trawl (Table 6). This could be caused by a distribution difference with smaller salmon tending to stay closer to shore, or by sampling bias with larger salmon avoiding fykes.

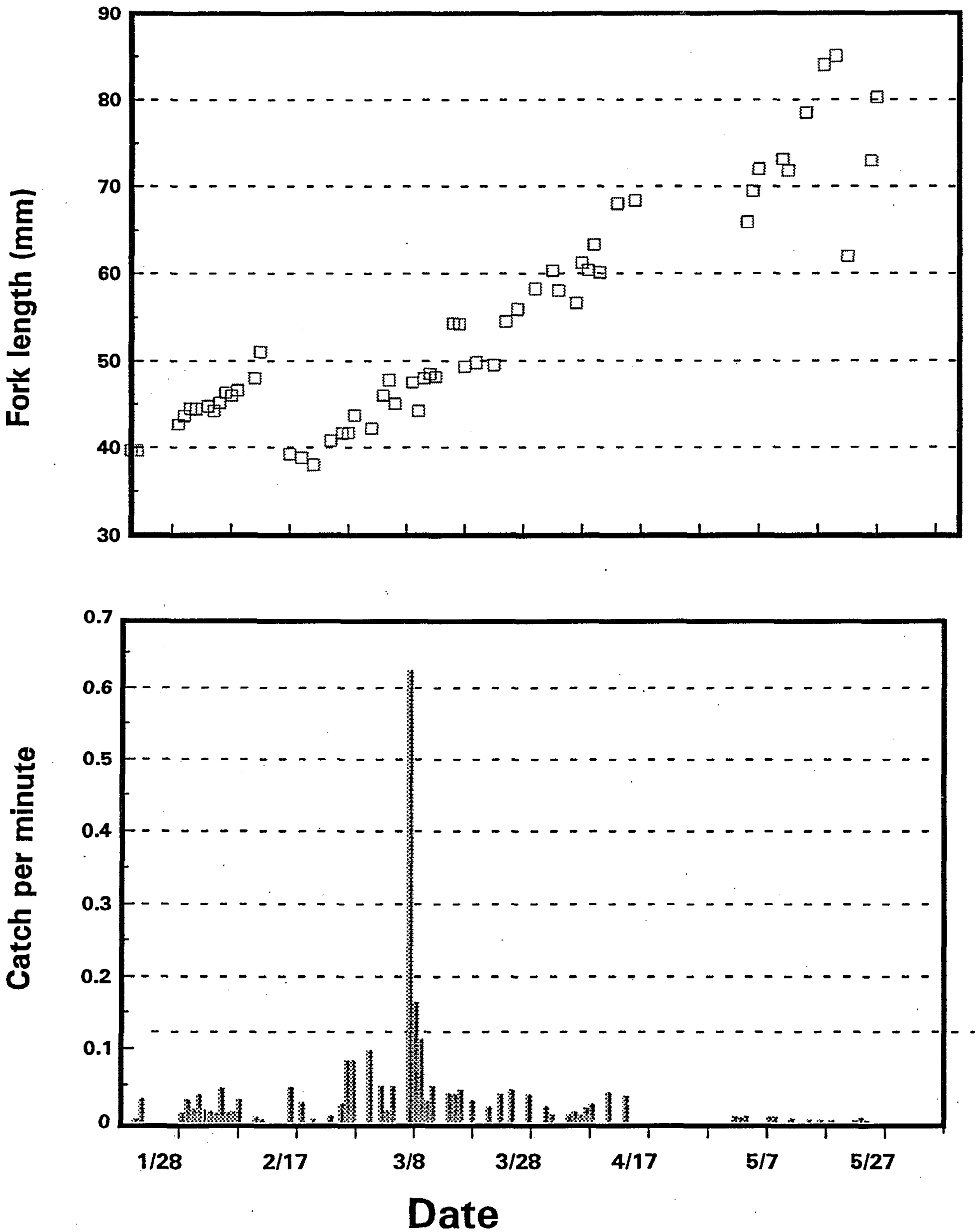

Figure 4. **Mean size and catch per minute of salmon caught in the fyke nets at Sacramento**

TABLE 6: Comparison between the mean size and catch per 20 minute tow (set)/per month in our fyke nets and midwater trawl sampling near Sacramento in 1992.

	MEAN SIZE		CATCH/20 MIN TOW/SET	
MONTH	FYKE NET	SACRAMENTO TRAWL	FYKE NET	SACRAMENTO TRAWL
DECEMBER	-	-	-	0.0
JANUARY	43.1	112.8	.258	0.7
FEBRUARY	44.0	41.9	.548	20.0
MARCH	48.7	54.8	1.716	10.4
APRIL	63.0	-	.384	-
MAY	73.6	80.8	.060	13.2
JUNE	-	83.8	0	0.6

Since we stratified our fyke sampling both in time and space, we evaluated the differential catches between the east and west side of the channel and between night and day. Our night fykes were set in the late afternoon and include some daylight hours.

The fyke on the east side of the river caught significantly ($p < 0.01$) more fish per minute than the west side of the channel (Table 7). The west side drops off rapidly into deep water while the east side offers a broad shoal.

More fish per minute (roughly twice as many) were caught during the day than at night. This implies a faster migration rate during the daylight, however it could reflect a diurnal distribution shift, with the fry moving inshore in the daylight to avoid piscine predators and towards midchannel at night to speed downstream migration. If the latter is true, migration is actually faster at night.

TABLE 7: The mean catch per minute, standard deviation sample size and z values for two areas of the river and by day and night for fyke net sets at Sacramento between January 21 and June 10, 1992.

	EAST vs.	WEST	DAY vs.	NIGHT
$\bar{X}$ =	0.0358	0.0233	0.0357	0.01824
SD =	0.1321	0.0304	0.1184	0.0332
n =	67	65	59	34
Z =	439.86		519.41	

Tagged Fry Recaptured By Fyking

The three groups of coded wire tagged fry released at Verona and the one group released at Miller Park were used to estimate the efficiency of the fykes. Although we realized that the fry released at Verona would have some mortality between Verona and our fyke site at Sacramento, we believed the 25 miles between the two sites would allow the fry to spread out and be more typically distributed than if they were released directly in front of our sampling site. The one release at Miller Park allowed us to evaluate that assumption since it is only about 4 miles north of our fyke site.

For the three releases made at Verona on 25 February, 3 March, and 10 March, the first recoveries were made from one to nine days after release and continued for up to 30 days. We recovered 5 to 10 fry from each of these releases in the midwater trawl at Sacramento and 4 in the tow net. This would indicate that fry from these groups moved down into the delta over a long period of time and that at least some portion were moving downstream via the middle of the channel. Flows during this period were high and may have swept the fry into the middle of the channel, whereas during periods of lesser flow the fry would perhaps move downstream nearer to the shore. Considering the pattern of recovery for these fish, we did not attempt to estimate efficiency from these groups.

The last release group at Miller Park was released on 16 March with the majority of recoveries occurring on 16 March and 17 March in our fykes, with none recovered in our midwater trawl. During 16 March and 17 March, we had fykes on both sides of the river for 47% of the time during these two days. Given that we recovered 37 of these fish during these 2 days (24,350 released), it equates to a efficiency rate of 0.0016, and we estimated an efficiency rate of 0.0032 when corrected for sampling time.

If we expand our unmarked catch (n = 2656) based on this efficiency rate, corrected for the fraction of the time sampled over the course of the season (0.27), then 6,148,148 fry passed

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our fykes during the course of the season. Given the extreme fluctuations of flow in February and March 1992 and the probable responses of the fry immigrating into the delta, our efficiency most likely changed dramatically. Our estimate of efficiency using the Miller Park release group is probably high given the 24 coded wire tagged fry recovered in our midwater trawl from the Verona releases, thus biasing our absolute estimate of abundance low.

Future analysis of fyke trap data will be improved with correction for the fyke mouth width, which can vary between sets.

Sacramento Tow Net

During a six week period between 5 December 1991 and 15 January 1992, and a two week period 11 March to 25 March, we sampled with a fixed frame tow net (mouth 1.5m wide, $2.3m^2$) concurrently with our midwater trawl at Sacramento. Sampling was conducted twice a week with six 10 minute tows per day. We anticipated the tow net would select for the smaller fry in the middle of the channel that the midwater trawl might miss. We initially broke the 6 tows per day into replicates of two tows for each vertical area of the channel (top, middle and bottom) to determine the vertical distribution of the fry caught, but had logistical problems which did not allow us continue this protocol for the entire sampling period.

A total of 76 fry were caught in the tow net ranging in size between 33 and 73 millimeters. The mean size of the salmon and the number caught per 20 minute tow increased in March over that observed in January. This reflects the growth and increased abundance of the fall run fry over time (Figure 5). Table 8 identifies the salmon caught in the tow net by race based on the most recent size criterion (Frank Fisher, CDFG, 28 February 1992).

Comparisons were made with the midwater trawl to evaluate whether the tow net was more efficient for catching smaller fish. During the eight weeks sampled with both nets, we found that the tow net consistently caught less fish in the smaller size range (less than 73 millimeters) than the midwater trawl (76 versus 262). Our concern that the midwater trawl would not effectively catch small fry in the middle of the channel (at least under those flow conditions in the spring of 1992) appears to be unfounded.

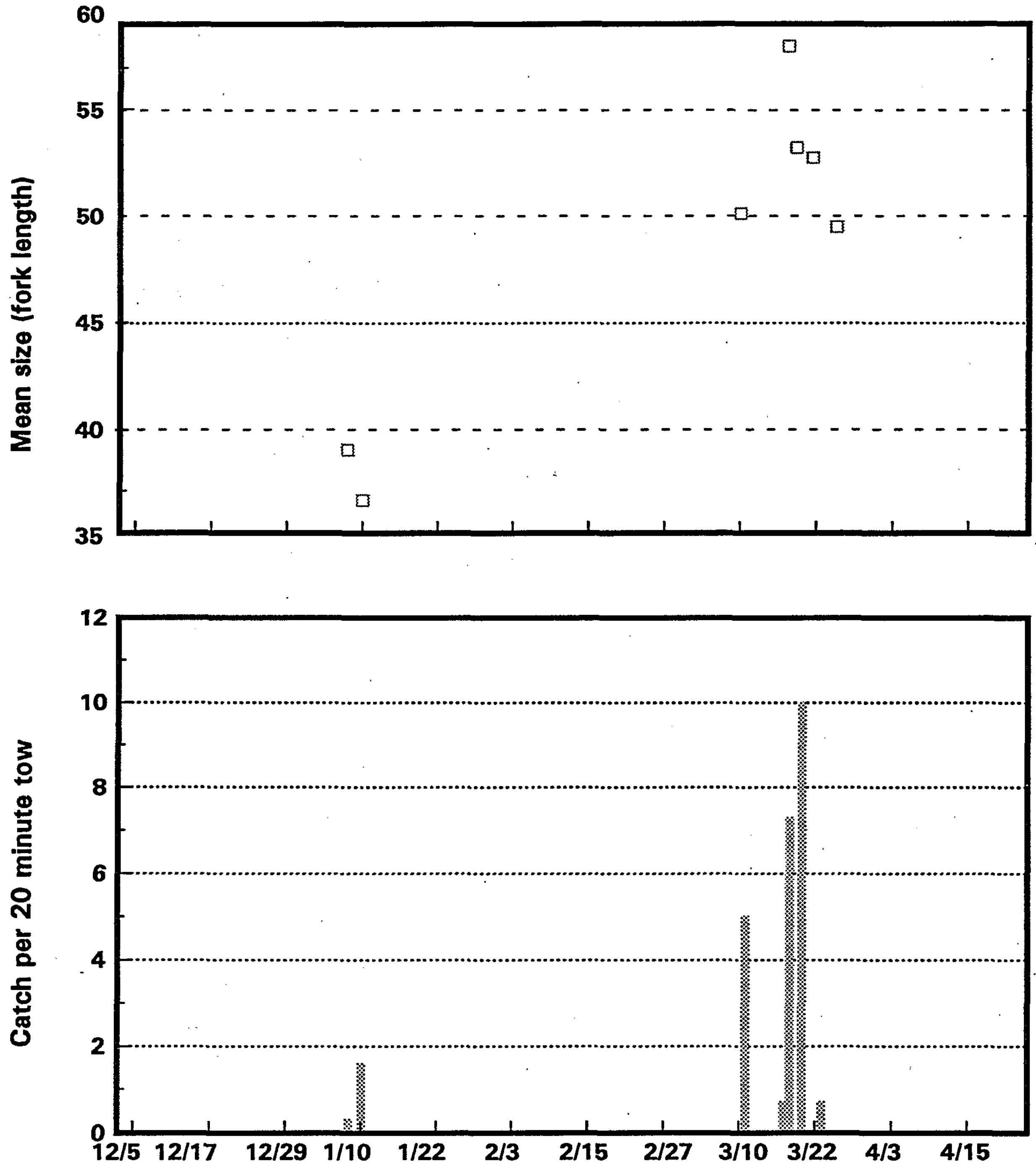

Figure 5. Mean size and catch per 20 minute tow using the townet at Sacramento. Sampling was conducted between 12/5/91 and 1/15/92, and between 3/11 and 3/25, 1992

TABLE 8: Total number of chinook salmon by race caught in the tow net between December 5, 1992 and January 15, 1992 and between March 11 and 25th near Sacramento.

TOW NET

	FALL			SPRING		WINTER		LATE-FALL	
MONTH	UNMARKED	AD CLIP	UNMEASURED	UNMARKED	AD CLIP	UNMARKED	AD CLIP	UNMARKED	AD CLIP
DEC 5 TO DEC 30, 1991	0	0	0	0	0	0	0	0	0
JAN 1 TO JAN 15, 1992	5	0	0	0	0	0	0	0	0
MAR 11 TO MAR 25,7 1992	66	4	0	5	0	0	0	0	0
TOTAL	71	4	0	5	0	0	0	0	0

Midwater Trawl at Sacramento

In 1992, a fifth year of trawling in the northern delta was done on the Sacramento River about four miles downstream of Miller Park, the same site used in 1988, 1989 and 1992. The sampling site in 1990 was near the town of Courtland, about 21 miles closer to Chipps Island, than the Miller Park site.

Six to ten, 10 to 20 minute tows were made 2 or 3 times per week between 5 December 1991 and 12 June 1992 (excluding April) to index the number of juvenile salmon migrating into the delta. We found during our sampling that the midwater trawl, while targeting smolts, caught many fry sized salmon as well.

The monthly catch at Sacramento in our midwater trawl ranged between 0 and 20 fish per twenty minute tow from December 1991 through June 1992 (Table 9). Our largest catches were during the months of February and May at a mean fork length of 41.9 and 80.8 millimeters, respectively. This pattern potentially reflects the peaks of fall run fry and smolts, respectively, entering the delta. Although we caught very few fish in the month of January (averaging less than 1 fish per tow) they had the largest mean size (112.8 millimeters) and appear to reflect the outmigration of the late fall race. Figure 6 shows the mean daily size and catch per 20 minute tow during the sampling period. Table 9 identifies the number of salmon caught by race in the midwater trawl based on the most recent size criterion. Many of the salmon caught in the trawl were not measured, but most likely are fall run for the same reasons discussed above in the beach seining section.

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TABLE 9: Total number of chinook salmon by race caught in the midwater trawl between December 5, 1991 and June 12, 1992 near Sacramento. No sampling was conducted during the month of April.

MIDWATER TRAWL

	FALL			SPRING		WINTER		LATE-FALL	
MONTH	UNMARKED	AD CLIP	UNMEASURED	UNMARKED	AD CLIP	UNMARKED	AD CLIP	UNMARKED	AD CLIP
DEC 91	0	0	0	0	0	0	0	0	0
JAN 92	16	0	0	0	0	0	0	30	5
FEB 92	1951	5	176	12	0	50	9	17	15
MAR 92	454	16	19	47	0	25	1	0	0
MAY 92	641	16	0	36	3	2	0	0	0
JUNE 92	20	0	0	0	0	0	0	0	0
TOTAL	3082	37	195	95	3	77	10	47	20

Table 10 reflects our estimate of the absolute abundance of juvenile salmon passing Sacramento as indexed by our midwater trawl at that location. The lack of sampling during April makes the seasonal estimate much lower than expected, and two to three days sampling per week may not be enough to observe a representative pattern of distribution of salmon moving into the delta over time and may be biasing our results.

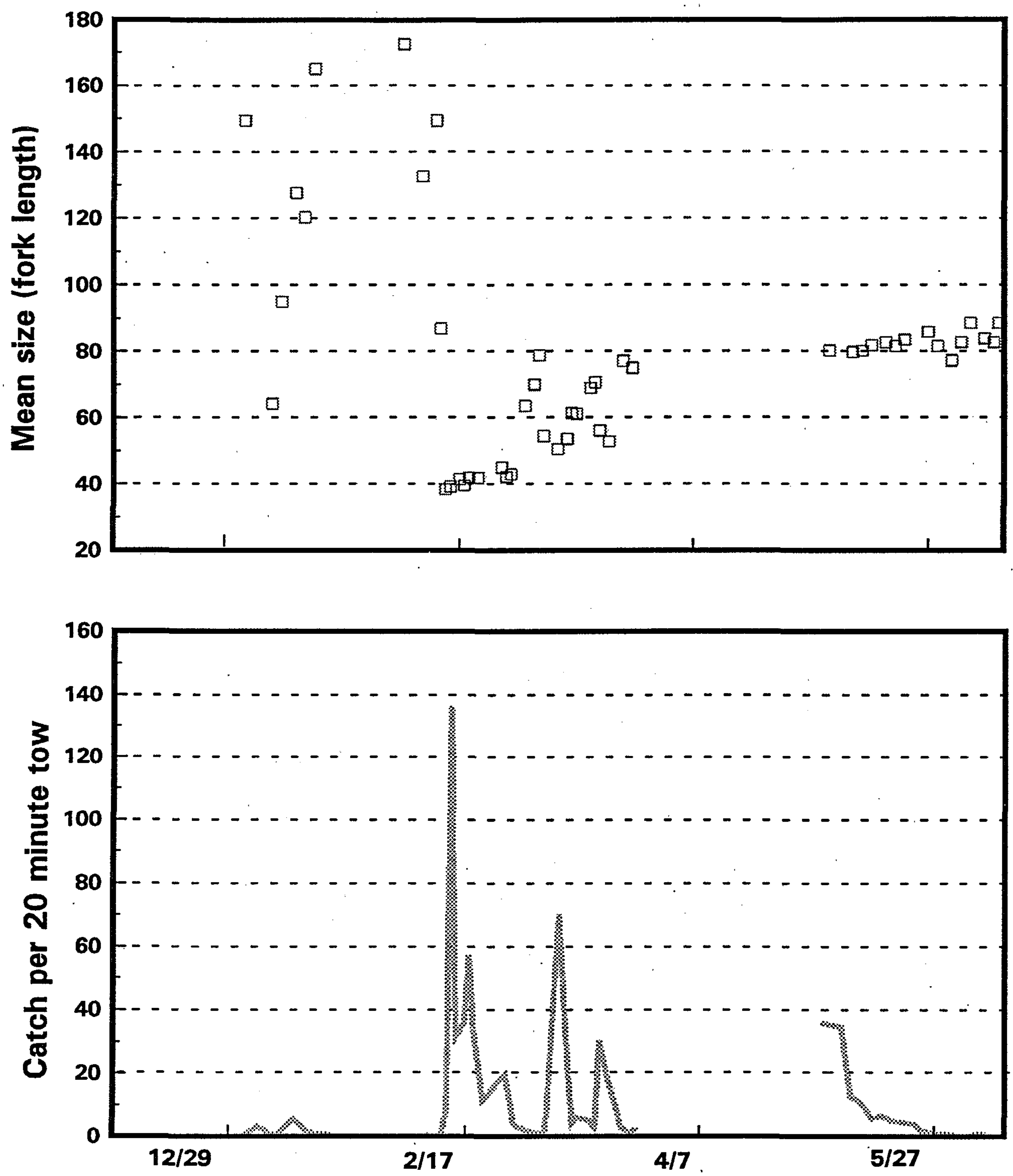

Figure 6. **Mean size and catch per 20 minute tow in the midwater trawl at Sacramento between December 5, 1991 and June 12, 1992. No sampling was conducted during the month of April.**

TABLE 10: The expanded number of juvenile chinook salmon (corrected for the fraction of time sampled by month and the fraction of the cross sectional area (15'/508') sampled) by race estimated near Sacramento using our midwater trawl between December 5, 1991 and June 12, 1992 (no sampling in April).

SACRAMENTO MIDWATER TRAWL

	FALL		SPRING		WINTER		LATE-FALL	
MONTH	UNMARKED	AD CLIP	UNMARKED	AD CLIP	UNMARKED	AD CLIP	UNMARKED	AD CLIP
DECEMBER	0	0	0	0	0	0	0	0
JANUARY	15,408						28,890	4,815
FEBRUARY	982,313	2,309	5,542		23,091	4,156	7,851	6,927
MARCH	682,293	23,080	67,796		36,062	1,442		
MAY	940,541	23,480	52,828	4,402	2,935			
JUNE	16,258							
TOTAL	2,636,912		126,166	4,402	62,088	5,598	36,741	11,742
NUMBER OF AD CLIPS RELEASED UPSTREAM OF SACRAMENTO		501,434		103,477		11,582		119,145

Given that we did not sample in April, we did not attempt to calculate survival indices for the smolts released at Princeton, Battle Creek, and Red Bluff during April that were recovered by trawl at Sacramento.

Midwater Trawling at Chipps Island

Juvenile fall run chinook abundance in the western delta at Chipps Island was higher than we have seen in the last few years with a monthly mean indices for April, May and June of 50.5, 13.1

and 1.3 respectively, and a mean index for the season of 21.6 salmon per 20 minute tow. The seasonal index has ranged between 10.1 in 1984 to 44.2 in 1983 (Table 11). The indices in Table 11 are slightly different than reported in past annual reports due to a difference in the way the averages are generated. The numbers reflected in Table 11 are the means of the three monthly means.

TABLE 11: Mean catch of salmon smolts per 20 minute tow with our midwater trawl at Chipps Island during April, May and June from 1978 to 1992.

YEAR	APRIL	MAY	JUNE	ANNUAL MEAN [1/]
1978	23.1	34.0	27.6	28.2
1979	14.9	41.6	23.2	26.6
1980	5.6	14.0	21.1	13.6
1981	17.3	25.3	8.3	17.0
1982	18.9	51.7	34.6	35.1
1983	24.8	65.0	42.8	44.2
1984	3.2	20.0	7.0	10.1
1985	10.3	24.7	4.1	13.0
1986	22.5	32.9	4.7	20.0
1987	15.4	19.3	0.8	11.8
1988	9.4	24.7	1.1	11.7
1989	23.2	31.5	5.0	19.9
1990	17.0	30.6	6.7	18.1
1991*	5.2	26.9	5.5	12.5
1992	50.5	13.1	1.3	21.6

[1/] The mean of April, May and June divided by three

* These were reported incorrectly in the 1991 USFWS Annual Report

The value observed in 1992 is the largest index since 1983, and likely reflects the change to releasing the fall run hatchery fish from Coleman NFH in early April when temperatures were low and survival through the delta is higher in contrast to late April or May.

Figure 7 shows the mean catch per 20 minute tow and mean size per sampling day between 3 April and 26 June 1992. The majority of the fish did migrate out in April in 1992, earlier than in past years (Table 12).

TABLE 12: Distribution (percent) of total midwater trawl catch of chinook smolts by month at Chipps Island from 1978 to 1992.

YEAR	APRIL	MAY	JUNE
1978	27	40	33
1979	19	52	29
1980	14	34	52
1981	34	50	16
1982	18	49	33
1983	19	49	32
1984	11	66	23
1985	26	63	11
1986	37	55	8
1987	44	54	2
1988	27	70	3
1989	29	62	9
1990	31	56	12
1991	14	72	12
1992	78	20	2
$\bar{X}$ 1978-1992	29	53	18

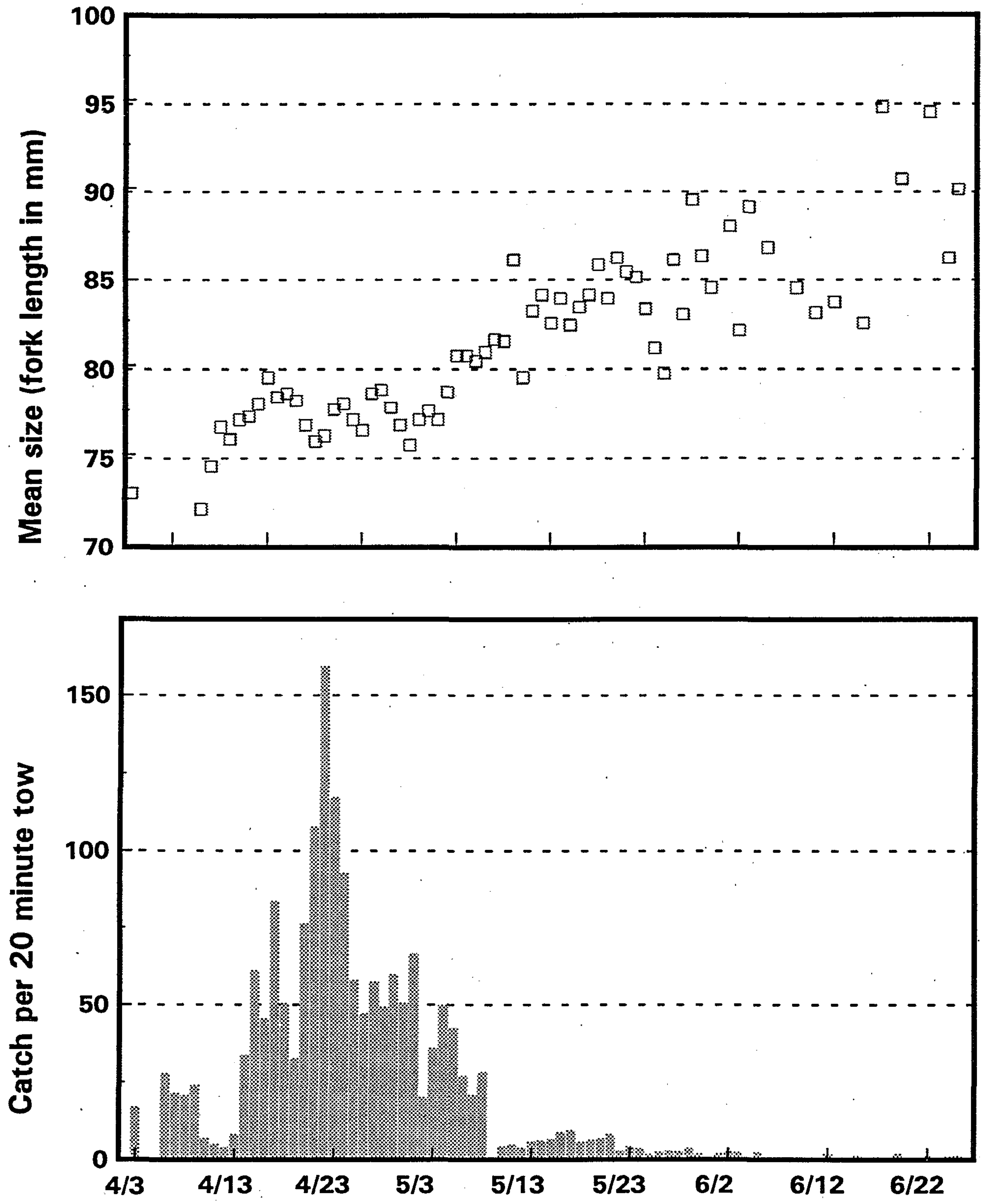

Figure 7. **Mean size and catch per 20 minute tow at Chipps Island between April 3 and June 26, 1992.**

Table 13 identifies the salmon caught at Chipps Island by race using Frank Fisher's (DFG-IFD, Red Bluff) size criterion.

TABLE 13: Total number of chinook salmon by race caught in the midwater trawl at Chipps Island between April 3 and June 26, 1992.

1992 CHIPPS ISLAND

	FALL		SPRING		WINTER		LATE-FALL	
MONTH	UNMARKED	AD CLIP	UNMARKED	AD CLIP	UNMARKED	AD CLIP	UNMARKED	AD CLIP
APRIL	13,290	362	2725	13	66	2	0	0
MAY	3633	175	224	1	1	0	0	0
JUNE	158	0	0	0	0	0	0	0
TOTAL	17081	537	2949	14	67	2	0	0

As in past years we have attempted to estimate the absolute production of juvenile chinook salmon passing Chipps Island in 1992 between April and June. In the past we have used an efficiency rate of 0.0055 based on the average efficiency between 1980 and 1984. Methods for determining efficiency and expanding our catches to absolute estimates are provided in USFWS Exhibit 31, Appendix 12, page 125, 1987. We estimated absolute abundance at Chipps Island in two ways this year.

The first way is by expanding raw catches to correct for the amount of time and area sampled in each month (the fraction of time sampled ranged between 0.065 and 0.132 and the fraction of the channel width sampled is 30'/3900' = 0.007692). We assume in this expansion process that the salmon are equally distributed in time and space and that our net is 100% efficient. The absolute abundance using this method, for all chinook and broken down by race is shown in Table 14.

TABLE 14: The expanded number of juvenile chinook salmon by race (corrected for the fraction of time by month and cross sectional area sampled) using a midwater trawl at Chipps Island, between April 3 and June 26, 1992.

CHIPPS ISLAND

	FALL		SPRING		WINTER		LATE-FALL		
MONTH	UNMARKED	AD CLIP	UNMARKED	AD CLIP	UNMARKED	AD CLIP	UNMARKED	AD CLIP	ALL RACED COMBINED (UNMARKED)
APRIL	15,411,754	379,837	1,427,014	13,640	34,626	2,098	0	0	
MAY	3,602,719	172,355	195,992	984	984	0	0	0	
JUNE	316,012								
TOTAL	19,330,485	552,192	1,623,006	14,624	35,610	2,098	0	0	20,989,101
TOTAL NUMBER AD CLIPS RELEASED		1,546,432							

The second way the catches are expanded, consistent with our methodology of past years, uses the following formula:

$$N_i = n_i / \cdot t_i (0.0055)$$

where N_i = annual number of absolute abundance, n_i = number of salmon caught throughout the season with the midwater trawl at Chipps Island, t_i = fraction of time sampled and 0.0055 = the estimated average fraction of smolts passing Chipps Island that are collected by the midwater trawl. The historical estimates of absolute abundance shown in Table 14 have been generated using method 2, although in the future they should be recalculated based on method 1 to see how different they would be. However, they should still provide a general index of the absolute production passing Chipps Island in these years.

In 1992, the two different methods of estimating absolute abundance yielded estimates of 20,989,101 and 28,617,981 respectively. Considering the number and types of assumptions necessary to make these estimates the values above are remarkably close and serve as a good indicator of the production moving out of the delta between the months of April and June 1992.

Some of the reasons we are now questioning the efficiency method of expansion, are that 1) estimates of survival through the Delta using the differential ocean recoveries of two groups of marked fish (Sacramento or Courtland and Port Chicago) are not always larger than those obtained with the trawl. If we have a consistent bias associated with net efficiency of the trawl we would expect the trawl estimates of survival would always be lower. 2) Although both the ocean and trawl index of survival through the Delta is measuring survival in some years to be over 1, they do track each other very closely (Figure 8), suggesting the correction for net efficiency may be unnecessary.

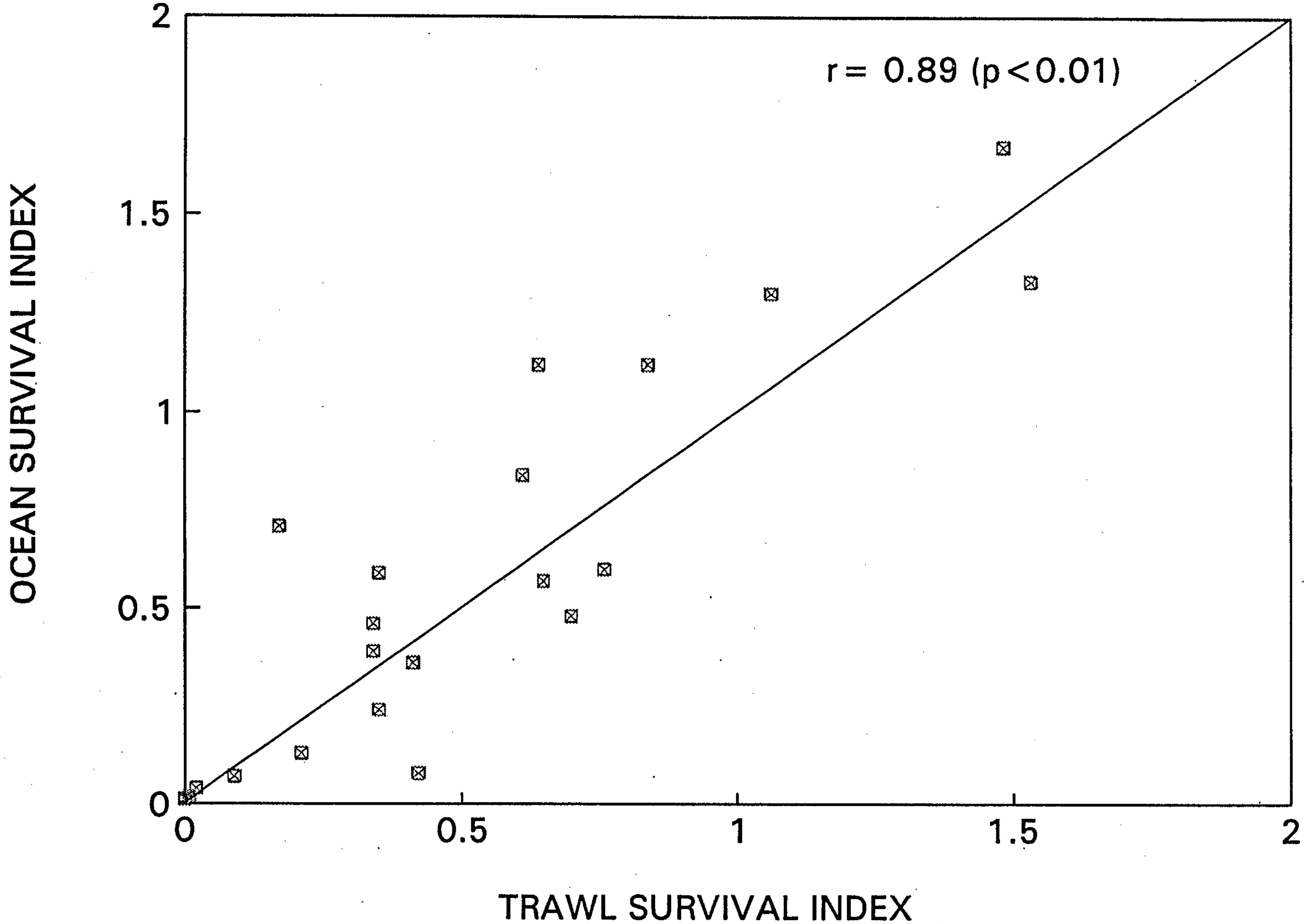

Figure 8: Survival through the Delta for fish released at Miller Park, Sacramento and Courtland (gates open and closed) as indexed by our trawl and ocean index from 1978 to 1989.

Montezuma Slough

Sampling was conducted for a 10 day period in late April in Montezuma Slough, with concurrent trawling conducted at Chipps Island. The trawling in Montezuma Slough was conducted to evaluate the potential impact of the Montezuma Slough Control Structure to smolts migrating from the Sacramento River to the ocean. Similar paired sampling at Montezuma Slough and Chipps Island had occurred in 1987.

Sampling conducted in Montezuma Slough and Chipps Island concurrently in 1987 and 1992 showed that a small, yet equal percentage ($p<0.01$) of the fish leaving the western Delta were diverted into Montezuma Slough both with (1992) and without (1987) the Montezuma Slough Control Structure in place. In both 1987 and 1992, we found between 0 and 2.72 (average .70) percent of the fish leaving the western Delta were diverted into Montezuma Slough, where presumably their survival would be less, since their migration would be delayed or the distance to the ocean increased (Appendix 1).

Coleman Hatchery Smolt Contribution

A release of 13,839,767 unmarked smolts was made by Coleman National Fish Hatchery at Princeton between 6 April and 21 April 1992. We measured a survival index between Princeton and Chipps

Island of 0.42 for a group of marked fish released at Princeton on 17 April. If we assume a similar survival rate for the unmarked fish then we estimate that 5.8 million survived to Chipps Island. This equals 21 to 28% of the 21 to 28 million estimated total smolts passing Chipps Island between April and June.

Survival from Princeton to Chipps Island in 1991 was somewhat lower at 0.36. The release in 1991 (5/2) was about two weeks later than in 1992 so higher temperatures may have contributed to this lower survival.

To further evaluate Coleman's total contribution to chinook production in the Central Valley we need to include the smolts that develop from fry released at Coleman NFH. During February and March of 1992, approximately 11,090,154 unmarked fry were released from Coleman National Fish Hatchery near Red Bluff.

For CNFH fry and smolts released at Red Bluff Diversion Dam in 1987 and 1988, we estimate smolt survival at three times that of fry (1 to 0.29, smolt to fry ratio), and if that is similar to the survival index of fry in 1992, then the 11 million fish released at RBDD in 1992 would equate to 3.2 million smolts. This would increase Coleman's contribution to the overall juvenile production measured at Chipps Island to between 32 and 43%.

Coded Wire Tagged (CWT) Survival - Northern and Central Delta

In 1992, the interagency salmon program released a total of 300,000 fall run coded wire tagged smolts in the northern and central delta at two paired locations, Ryde and Georgiana Slough, on three separate days between 6 April and 27 April. Our goal was to determine the differential survival for fish diverted into the central delta via Georgiana Slough relative to those that remain in the main Sacramento River at low to moderate temperatures and apply the results to assessing impacts to winter run juveniles. A second goal from these release groups was to determine the impacts to winter run of a full barrier installed at the head of upper Old River for the protection of fall run San Joaquin Basin smolts. The barrier was installed on 23 April 1992. Basic information from our 1992 coded wire tag experiment is presented in Table 15.

On average, we found that the Ryde fish survived about five times greater than the corresponding groups of fish released into Georgiana Slough (Table 16). It is not surprising that being diverted into the central delta would increase the mortality of Sacramento River salmon outmigrants. Migration to the ocean via the central delta is more hazardous because it is a longer route and exposes smolts to increased predation, higher temperatures, a greater number of agricultural diversions and to more complex

TABLE 15: CHIPPS ISLAND TAG SUMMARY, SURVIVAL CALCULATIONS AND EXPANDED FISH FACILITY RECOVERIES FOR CODED WIRE TAGGED FISH RELEASED IN 1992.

CODE	SITE	DATE	UOR BARRIER	TEMP	NUMBER RELEASED	SIZE (MM)	NUMBER RECOVERED	FRACTION OF TIME SAMPLED	SURVIVAL INDEX	GROUP SURVIVAL	FIRST DAY RECOVERED	LAST DAY RECOVERED	EXPANDED SALVAGE NUMBER SWP	EXPANDED SALVAGE NUMBER CVP
Upper River Releases														
5-28-12	Coleman NFH	4/14			58593	79	9	0.1366	0.138		27-Apr-92	21-May-92	0	0
5-28-13	Coleman NFH	4/14			54047	76	9	0.1372	0.158		25-Apr-92	20-May-92	0	0
5-28-14	Coleman NFH	4/14			54707	69	3	0.1369	0.052		29-Apr-92	20-May-92	0	0
	Total				167347		21	0.1368		0.117	25-Apr-92	21-May-92	0	0
5-28-18	RBDD	4/15			54556	75	18	0.1370	0.313		27-Apr-92	19-May-92	0	0
5-28-19	Princeton	4/17			54144	74	24	0.1389	0.415		24-Apr-92	03-May-92	2	0
Sacramento Releases														
6-1-14-2-11	Ryde	4/6	N	64	53630	77	78	0.1389	1.361		11-Apr-92	24-Apr-92	0	34
6-1-14-2-10	Georgiana Slough	4/6	N	64	51846	74	23	0.1389	0.415		14-Apr-92	25-Apr-92	10	4
6-1-14-3-1	Ryde *	4/14	N	63	42534	82	97	0.1389	2.135		17-Apr-92	07-May-92	0	0
6-1-14-3-2	Georgiana Slough *	4/14	N	64	52374	81	41	0.1389	0.733		17-Apr-92	06-May-92	12	8
6-31-29	Ryde	4/27	Y	67	53099	81	93	0.1364	1.669		29-Apr-92	28-May-92	0	0
6-31-30	Georgiana Slough	4/27	Y	67	51914	83	11	0.1347	0.204		01-May-92	10-May-92	1	4
San Joaquin Releases														
6-1-14-2-12	Mossdale	4/7	N		54073	78	9	0.1389	0.156		13-Apr-92	05-May-92	25	2603
6-1-14-2-13	Mossdale	4/7	N		53030	79	11	0.1389	0.194		13-Apr-92	01-May-92	46	2777
	Total			64	107103		20	0.1389		0.175	13-Apr-92	05-May-92	71	5380
6-1-14-2-14	Mossdale	4/13	N		53754	81	10	0.1389	0.174		16-Apr-92	27-Apr-92	37	1734
6-1-14-2-15	Mossdale	4/13	N		51830	82	3	0.1389	0.054		21-Apr-92	01-May-92	69	1651
	Total			63	105584		13	0.1389		0.115	16-Apr-92	01-May-92	106	3385

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TABLE 15: CONTINUED

CODE	SITE	DATE	UOR BARRIER	TEMP	NUMBER RELEASED	SIZE (MM)	NUMBER RECOVERED	FRACTION OF TIME SAMPLED	SURVIVAL INDEX	GROUP SURVIVAL	FIRST DAY RECOVERED	LAST DAY RECOVERED	EXPANDED SALVAGE NUMBER SWP	EXPANDED SALVAGE NUMBER CVP
6-1-14-3-3	Mossdale	4/24	Y		53294	85	6	0.1389	0.105		03-May-92	06-May-92	15	24
6-1-14-3-4	Mossdale	4/24	Y		51445	83	2	0.1362	0.037		04-May-92	19-May-92	13	4
	Total			69	104739		8	0.1364		0.073	03-May-92	19-May-92	28	28
6-31-31	Mossdale	5/4	Y		51262	85	1	0.1389	0.018		16-May-92	16-May-92	0	12
6-31-32	Mossdale	5/4	Y		48455	83	0		0.000				8	16
	Total			71	99717		1	0.1389		0.009	16-May-92	16-May-92	8	28
6-31-33	Mossdale	5/12	Y		52454	85	0		0.000				0	0
6-31-34	Mossdale	5/12	Y		54163	87	2	0.1331	0.036		21-May-92	23-May-92	6	0
	Total			72	106617		2	0.1331		0.018	21-May-92	23-May-92	6	0
Mokelumne Releases														
6-63-38	New Hope Marina	4/21		66.2	104500	80.4	15	0.1362	0.137		29-Apr-92	14-May-92	8	4
6-63-39	New Hope Marina	5/6		71.6	100700	90.3	6	0.1389	0.056		12-May-92	19-May-92	0	0

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channel configurations. In addition, upon reaching the mouth of the Mokelumne River on the lower San Joaquin River they are often exposed to upstream flow (reverse flows) that moves the net flow easterly in the San Joaquin and to the south in Old and Middle Rivers.

The first two releases at Ryde on 6 April and 14 April at temperatures of 64 and 63 degrees fahrenheit, respectively, showed 3.3 and 3.0 times greater survival index than the corresponding Georgiana Slough group. For the release made on 27 April, at 67 degrees fahrenheit, there was an 8.3 times difference between the Ryde and Georgiana release groups. Although still a detriment to overall survival, it appears that winter run smolts may not experience the same magnitude of loss in Georgiana Slough that the fall run have shown because they are migrating during lower temperatures.

Results from CWT fish released in Georgiana Slough on 6 April and 14 April 1992 suggest that higher delta exports may have caused the lesser survival for fish released on 6 April relative to the 14 April release which were exposed to lower exports.

To thoroughly evaluate the effect of the barrier at the head of Old River, the impact to winter run juveniles should be considered. Putting a barrier into upper Old River will cause the reverse flows in lower Middle and Old Rivers to increase, which could have an impact on the survival of winter run smolts

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diverted into the central delta through Georgiana Slough or the Delta Cross Channel.

The percent diverted at lower Middle and Old River near Bacon Island with the barrier at the head of Old River is estimated to change from approximately 44 to 55 and 32 to 42 percent, respectively, (Rick Oltman, USGS, personal communication). This change in the percent diverted at these two sites needs to be evaluated in terms of the change in survival of winter run salmon migrating through the central and southern delta.

In order to evaluate the potential impact of the barrier at the head of Old River on winter run, survival indices for the six groups of fish were standardized to a single temperature (63 degrees fahrenheit), since releases were made at different temperatures.

The temperature correction applied was based on a multiple regression equation for the survival in reach 2 (interior delta) and reach 3 (Ryde to Chipps Island via the mainstem river) using the data obtained in years 1983 through 1992.

When results are compared among and between groups, the trends we saw for each site are different.

Temperature corrected survival indices for the Ryde groups ranged from 2.15 on 14 April at the lowest export level to 1.43 on 6 April at the highest export level, with the medium export level yielding a mid-range survival index of 1.93 on 27 April. Based on our past modeling which has shown that exports are important to survival, this is the trend that we would expect.

In contrast, the groups released at Georgiana Slough did not display that trend. The group that had the highest survival (0.71) of the three releases (14 April) had the lowest export level, similar to that experienced by the Ryde groups. However, the group released on 27 April had a lower temperature corrected survival rate (0.32) at the mid-range export level, than the group released on 6 April which had the highest export rate (0.41). Although the temperature was higher on 27 April, survival was lower than expected even after we corrected for the temperature difference.

The barrier placed into upper Old River on 23 April could account for the difference between the expected pattern of survival for the Georgiana Slough release groups and that observed.

The exact difference in survival due to the barrier in upper Old River is unknown, but it is potentially as great as 45 percent. This is based on the assumption that the survival difference between the 6 April and 14 April releases in Georgiana Slough

(0.30) was only due to the increase in exports (2425 - 1093 = 1332 cfs) (Table 17). We estimate that the survival index would have been 0.59, based on the mid-range export level of 1883 cfs for the 27 April group. The difference between what we estimated survival would have been (0.59) and the temperature corrected survival index observed (0.32) is 45 percent, which may be attributable to the installation of the barrier. However, this is greater than the increase in the percent of flow diverted at lower Old and Middle Rivers, which is estimated to be 25 to 30 percent.

The number of expanded recoveries for the Georgiana groups at the fish facilities show that the group experiencing the highest survival had the most recoveries and the group experiencing the lowest survival (the group released on 27 April, during the period the head of Old River barrier was in) had the least number recovered. This would tend to support the hypothesis that the number recovered at the facilities reflects survival.

The group released on 6 April at Ryde was the only one of Ryde's three groups to have any recoveries at the fish facilities. A total of 34 fish from this release group was recovered at the Tracy Fish Facility. Although the survival for this group was high, it was not the highest observed for the Ryde groups in 1992 and may instead reflect the higher exports and lower flows at Antioch than those present for the later releases.

The effects of exports on smolts from the Sacramento Basin would be greatest when both the Delta Cross Channel and Georgiana Slough are open and decrease when one or both are closed since smolts diverted into the central delta would be exposed to greater reverse flows in the western San Joaquin than those at the tip of Sherman Island and Three Mile Slough. As noted earlier, CWT smolts released at Ryde have higher survival than those representing fish diverted into the central delta (Table 16).

Table 16: Survival indices and ratios for CWT salmon smolts released at Ryde and in Georgiana Slough in April of 1992.

	Ryde		Georgiana Slough	
Date of Release	Survival Index	Temperature at Release °F	Survival Index	Temperature at Release °F
4/6	1.36	64	.42	64
4/14	2.14	63	.74	64
4/27	1.67	67	.20	67

Date of Release	Ryde/Georgiana Slough Ratio	Flows at Antioch*	CVP+SWP Exports**	Sacramento River Flow at Freeport**
4/6	3.2	972	4999	9904
4/14	2.9	1321	1085	11212
4/27	8.3	736	1345	4615
	$\overline{X}$ = 4.8	--	--	--

* Average flow (cfs) at Antioch during the time the Ryde fish were recovered at Chipps Island.

** Five day mean flow or export (cfs) starting on the release date.

Analyses of CWT fish released at Ryde, after correcting for temperature (all indices were standardized to 61 degrees fahrenheit), indicated that increased flow at Jersey Point was beneficial to survival ($r=0.49$, $p<0.10$) (Figure 9). The data from 1983 was not included in our analyses as it had flow at Jersey Point of about 35,000 cfs and made a relationship at the lower flows difficult to detect.

We also evaluated the impact of Jersey Point flow on the Ryde raw survival indices by comparing releases made at the same temperatures. We found an average of 39 percent increase in our raw survival index when Jersey Point
(Q West) flows were greater (Table 17).

In addition, for fish released at Jersey Point between 1989 and 1991, we found that temperature corrected survival increased with increased flow at Jersey Point ($r=0.76$, $p<0.10$) (Figure 9). These relationships support the premise that positive net flow at Jersey Point increases the survival of fish migrating down both the Sacramento and San Joaquin Rivers from Ryde and Jersey Point as well as for fish diverted into the central delta and moving to the San Joaquin via the Mokelumne River.

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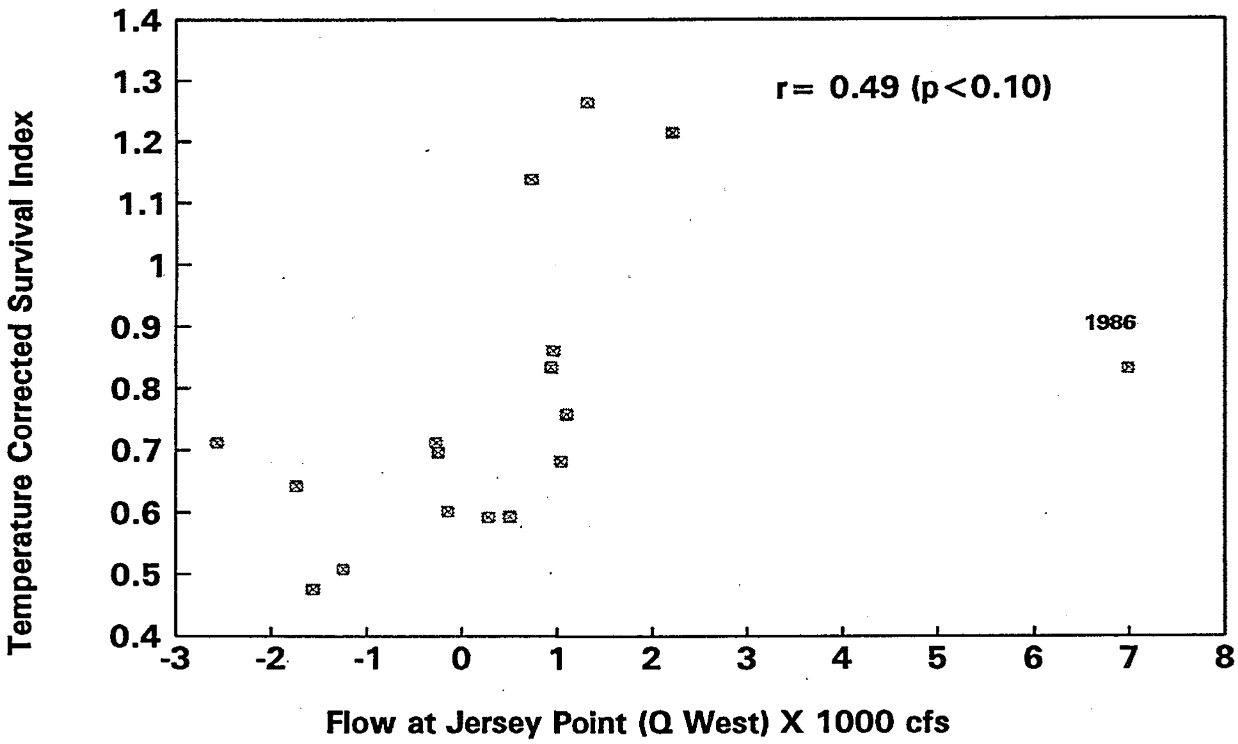

Figure 9: **Temperature corrected survival for fish released at Ryde between 1984 and 1992 versus flow at Jersey Point on the San Joaquin River. The data from 1986 was not used in the regression calculation.**

TABLE 17: FLOW AND EXPORT CONDITIONS DURING THE TIME THE MARKED FISH WERE AT LARGE DURING THE SPRING OF 1992.

	FLOW @ VERNALIS	FLOW @ FREEPORT	EXPORTS CVP+SWP	QWEST ? FLOW ANTIOCH	SURVIVAL	TEMP (°F)	TEMP. CORRECTED SURVIVAL	FISH FACILITIES EXPANDED RECOVERIES	
								SWP	CVP
MOSSDALE FISH * (TEMPERATURE CORRECTED TO 63 °F)									
4/7	1606	9462	3573	-353	0.17	64	0.13	71	5380
4/13	1445	11027	2211	1518	0.12	63	0.07	106	3385
4/24	1393	5985	2365	836	0.08	69	0.25	28	28
5/4	1281	5240	3758	1388	0.01	71	0.28	8	28
5/12	936	6069	2357	929	0.02	72	0.32	6	0
RYDE ** (TEMPERATURE CORRECTED TO 63 °F)									
4/6	1594	9981	3073	53	1.36	64	1.43	0	34
4/14	1325	10984	1097	1410	2.15	63	2.15	0	0
4/27	1486	4637	1578	729	1.67	67	1.93	0	0
			2148	***					
			1433	***					
			1601	***					
GEORGIANA ** (TEMPERATURE CORRECTED TO 64 °F)									
4/6	1497	10341	2425	499	0.41	64	0.41	10	4
4/14	1361	11012	1093	1449	0.71	64	0.71	12	8
4/27	1485	4718	1883	749	0.2	67	0.32	1	4

* RELEASE DATE TO 5 DAYS LATER

** RELEASE DATE TO PEAK RECOVERY AT CHIPPS

*** RELEASE DATE TO COMPLETE RECOVERY AT CHIPPS

* The flows are averages ~~of~~ over the appropriate recovery period

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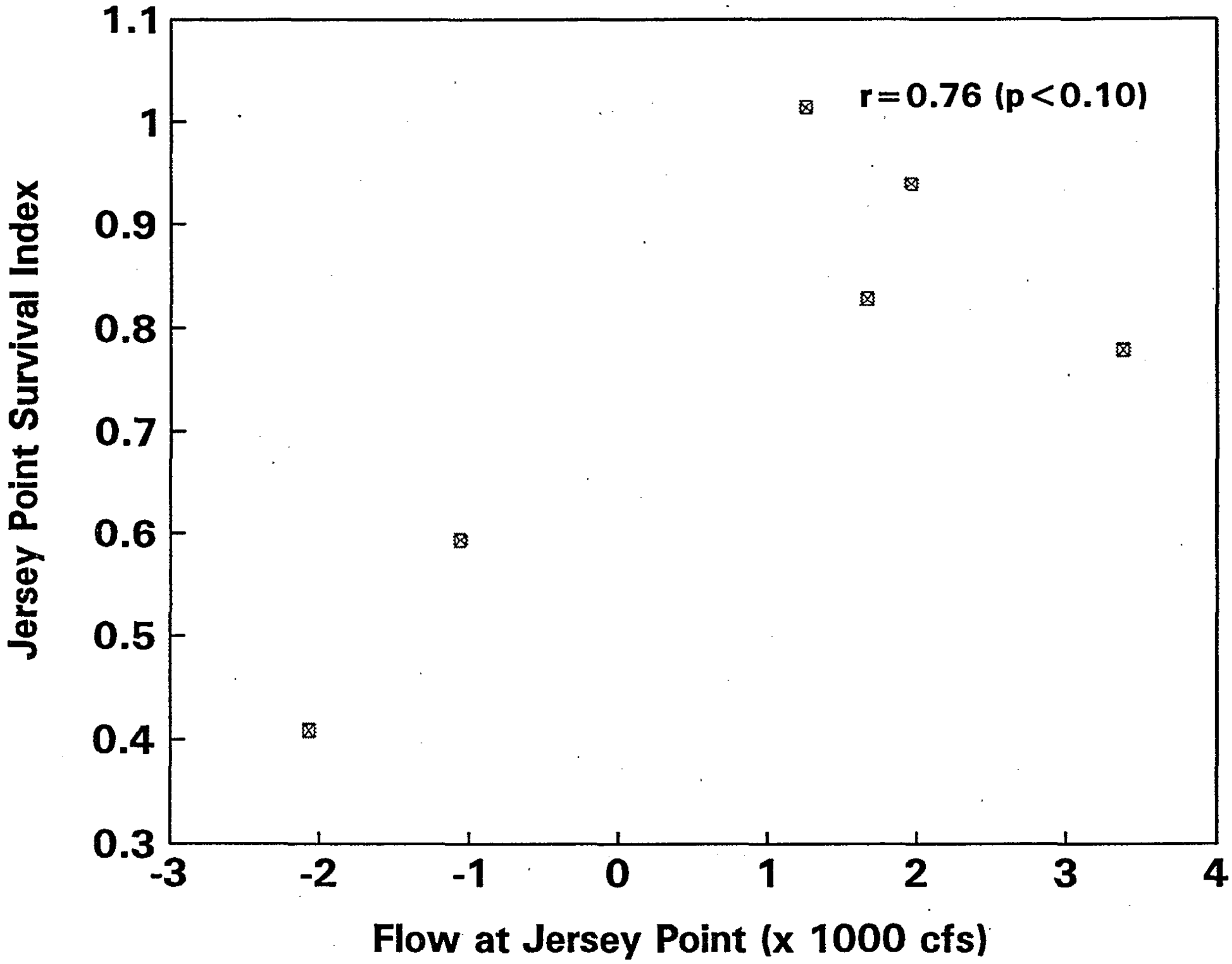

Figure 10. **Temperature corrected (to 61 degrees F.) survival indices for CWT salmon smolts released at Jersey Point and recovered at Chipps Island between 1989 and 1991. Flow estimates were the 5 day mean starting on the release date.**

SAN JOAQUIN DELTA

Coded wire tag data generated since 1985 has shown in general that fish released in the San Joaquin River downstream of the head of Old River survive about 50% better than those released into upper Old River (Table 18), demonstrated by both ocean and trawl data. This implies that any natural smolts diverted into upper Old River would have greater mortality than those migrating down the mainstem San Joaquin.

A barrier at the head of Old River would force all of the migrating salmon down the mainstem San Joaquin and prevent them from being diverted into upper Old River and directly towards the State Water Project (SWP) and Central Valley Project (CVP) pumping plants.

To evaluate the effects of a full barrier at the head of Old River as a management alternative to improve fall run smolt survival down the San Joaquin River, 500,000 fall run coded wire tagged smolts were released in 1992, in 100,000 lots at Mossdale, one group per week for 5 weeks (7 April to 12 May). The full barrier was installed in upper Old River on 23 April, with three groups being released before the barrier was installed and two groups released after the barrier was installed.

TABLE 18: CWT smolt survival indices for smolts released at Dos Reis on the main San Joaquin River and in Upper Old River between 1985-1987 and 1989 to 1991. Ocean recovery rates are in parenthesis.

Upper Old River Release Date	Survived to Chipps Island	Ocean Index Trawl Dos Reis/ Upper Old River	Index Dos Reis/ Upper Old River
4-29-85	.62		0.95
5-30-86	.20 (0.011)	1.9	1.7
4-27-87	.16 (0.005)	2.4	2.4
4-21-89 (High Export)	.09 (0.00073)	.8	1.5
5-03-89 (Low Export)	.05 (0.00044)	2.2	2.8
4-17-90 (High Export)	.02		2.0
5-13-90 (Low Export)	.01		4.0
Mean	.16	1.8	2.2

Dos Reis	Survived to Chipps Island	Flow at Stockton[1/]	CVP & SWP Export[1/]	Temperature on Release Day °F
4-22 and 4-23, 1982	*.70	7861	5598	65
4-30-85	.59	513	6311	70
5-29-86	.34 (0.021)	2514	5386	70
4-27-87	**.38 (0.012)	471	6093	70
4-20-89 (High Export)	.14 (0.00062)	112	10297	69
5-02-89 (Low Export)	.14 (0.00096)	790	2470	71
4-16-90 (High Export)	.04	0	9549	68
5-02-90 (Low Export)	.04	490	2461	68
4-15-91 (High Export)	.16	60	5153	60
Mean (85-87, 89-90)	.24			

1/ 5 day averages after release date, flow and exports in cfs.

* Original survival estimate (0.60) modified based on the ratio of ocean recovery rates between the Dos Reis and Merced River release.

** Original survival between (.82) modified based on the ratio of ocean recovery rates between the Dos Reis and Upper Old River releases.

Survival indices to Chipps Island for the five groups released at Mossdale ranged between 0.01 and 0.17, with the greatest survival estimates obtained for the groups of fish released in early April when temperatures were lower (64 and 63 degrees) and the barrier was not in place (Table 19). This was inconsistent with past Dos Reis and upper Old River data that implied a barrier would be beneficial.

Since the five releases were made over a range of temperatures, we attempted to factor out the influence of temperature on survival by standardizing survival to a constant temperature (63 degrees), as we have done in previous analyses. Resulting temperature corrected survival indices were compared.

Survival, after being corrected for temperature, ranged between 0.07 and 0.32 with the greatest survival experienced by those released during the period the barrier was in place. Average survival, after being corrected for temperature, without the barrier was 0.10 while survival with the barrier was 0.29. This would reflect a three fold benefit with the barrier in place which is somewhat greater than, although of similar magnitude to, the almost doubling we saw in our upper Old River and Dos Reis survival data comparisons. Average exports (1979 and 1665 cfs) during the time the marked fish were released were similar before and after the barrier was installed.

Table 19. **Percentage of the expanded number of CWT Chinook Smolts released that were recovered at the State and Federal Fish Facilities (1985-1987 and 1989-1992).**

Year	Upper Old River	Dos Reis	Jersey Point	Mossdale
1985	20	3	NR	NR
1986	74	3	NR	NR
1987	27	8	NR	NR
1989 (High Export)	6.9	5	0.2	NR
1989 (Low Export)	2	0.6	1.6	NR
1990 (High Export)	2.5	1.7	0.2	NR
1990 (Low Export)	1.3	0.1	0.1	NR
1991 April	NR	8	0.5	NR
1991 May	NR	NR	0.01	NR
1992*				0.0 to 5.0

* This estimate is based on the range of recoveries for the five groups released at Mossdale between 7 April, 12 and May 1992.

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Expanded recoveries at the Tracy and Skinner Fish Facilities indicated that the greatest number of marked fish salvaged at the facilities in 1992 (5451 and 3491 for 7 April and 13 April, respectively) were from the release groups when no barrier was present and uncorrected survival was greatest. In contrast, the later groups released during the period the barrier was in place had fewer recoveries at the fish facilities. The later releases also had higher temperatures at release and lower (uncorrected) survival indices. It is unclear whether the higher number salvaged for the earlier groups is reflective of higher survival or lack of a barrier at the head of Old River or both.

While in a relative sense the 1992 releases without a barrier had the highest number of marked fish recovered at the facilities, the actual combined CVP and SWP expanded number indicate that only 3 to 5 percent of the number released were recovered at the facilities. It appears even at low temperatures (63 and 64 degrees Fahrenheit), we accounted for less than 25 percent (the expanded number recovered at Chipps Island plus the expanded number recovered at the fish facilities) of any of the groups of fish released at Mossdale in 1992. As we have observed in recent dry years, it appears that most of the fish released at Mossdale in 1992 did not survive to be salvaged at the fish facilities and that indirect (in-channel) losses comprise a large fraction of the mortality.

In 1986, although temperatures were higher than in 1992, we saw a large percentage of the fish released in upper Old River at the facilities (74%) when flows were high in all southern delta channels (USFWS Exhibit WRINT-USFWS-7, SWRCB Bay/Delta Proceedings 1992).

Preventing salmon from entering upper Old River by installing a barrier appears to increase the survival of smolts migrating down the San Joaquin River. Additional data needs to be collected with and without the barrier at low temperatures. There is a need to continue to evaluate the benefit of the barrier to smolt survival at similar temperatures under a range of exports and delta inflows.

While the head of Old River barrier alone will increase survival os San Joaquin Basin smolts, the more comprehensive approach to increasing salmon smolt survival would be to reduce exports and increase San Joaquin River flows simultaneously. All three actions used in combination are expected to yield the greatest survival benefit.

Similar experiments need to be repeated to confirm what we saw in our 1992 experiments.

FUTURE NEEDS

Results of these and previous studies in the Sacramento-San Joaquin Delta have been used in the evaluation of the benefit of both operational and structural salmon protective measures for the Scoping and Water Rights phases of the Bay-Delta Water

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Quality Hearings and in planning for future Interagency Salmon Studies. The focus of our 1993 coded wire tag effort will be to further evaluate the effect of the barrier at the head of Old River upon both the winter run from the Sacramento Basin and the San Joaquin Basin smolts.

Additional work is needed in the southern and central delta where great uncertainty remains in our understanding of smolt survival. Evaluation is also needed regarding the impacts of the pumping plants on fry entering the delta and the correlation between adult runs and the amount of water being exported.

Studies on the San Joaquin Delta should include the following:

1) Evaluate San Joaquin smolt survival under a wide range of inflow and export conditions.
2) Test the benefit of a full barrier at the head of Old River to CWT smolt survival under high and low export conditions between 15 April and 15 May. This is scheduled for 1992.
3) Define the pattern of migration through the southern delta under varied flows, export rates, and tidal conditions using hydraulic modelling.
4) Continue evaluating the effect of high cross delta flow on smolt survival through the San Joaquin Delta as would occur if the SWP would utilize their full pumping capacity of 10,300 cfs. A full barrier in upper Old River with high exports would cause more reverse flows in Turner Cut and

lower Old and Middle Rivers, and more closely represent conditions proposed in the SWP delta alternative projects.

5) Evaluate smolt survival in the San Joaquin Delta at varied temperatures (60°F to 70°F).

The information we have to date implies that the indirect mortality associated with the pumps is significant. Perhaps under certain conditions those that live to be salvaged are a large proportion of those we see that survive to Chipps Island. During 1992, the fish facilities committee will be releasing marked fish into Clifton Court Forebay which may provide a way to measure the number of survivors at Chipps Island that are a result of the salvage process.

Our modelling and recent field studies have been successful in helping us to gain a better understanding of the potential factors influencing smolt survival in the Sacramento side of the delta. This work has identified data gaps in need of further research. There is a need in the future to:

1) expand our knowledge to other races of salmon and the impacts of the pumping plants on their survival and distribution,

2) evaluate smolt survival in the central delta under various temperature and flow conditions, particularly reverse flows,

3) evaluate further the reasons for the high unexplained mortality in the central delta.

In early 1992, the cross channel gates were closed to protect winter run salmon from being diverted into the central delta and being impacted by the pumps. Additional work is being proposed to release late fall marked fish in November and December 1993 to evaluate the differential mortality of being diverted into the central delta for the endangered winter run.

The emphasis in central valley chinook research and management has shifted from maximizing production to maintaining (or restoring) the viability of all races and runs of wild salmon. This new emphasis requires a year round monitoring program in the Sacramento/San Joaquin Estuary and development of new techniques to effectively sample the less abundant races. Some of the experimental methods used in this past year's pilot program should be incorporated into the regular monitoring program. More new techniques need to be explored in the future to effectively sample the diverse habitats in the estuary and describe the spatial and temporal distribution of all developmental stages of salmon.

Appendix 1. Midwater trawl catches at Chipps Island and Montezuma Slough expanded for time and channel size and % fish diverted into Montezuma Slough for 1987 and 1992.

1987				
Date	Chipps Island Expanded Catches	Montezuma Slough Expanded Catches	Total Expanded Catches	% Fish Diverted to Montezuma Slough
4/06 4/07	658 --	-- 0	658	0.00
4/08 4/09	1711 --	-- 0	1711	0.00
4/14 4/15	-- 6974	40 --	7014	0.57
4/16 4/18	-- 8158	60 --	8218	0.73
4/21	10658	100	10758	0.93
4/23	25658	60	25718	0.23
4/28	24342	100	24442	0.41
4/29	22632	260	22892	1.14
4/30	43289	560	43849	1.28
5/01	30132	400	30532	1.31
5/02	46316	460	46776	0.98
5/03	67895	260	68155	0.38
5/04	38947	300	39247	0.76
5/05	47632	260	47892	0.54
5/06	45526	660	46186	1.43
5/07	58816	340	59156	0.57
5/08	55526	140	55666	0.25
5/09	27368	440	27808	1.58
5/10	59474	100	59574	0.17
5/11	35789	0	35789	0.00
5/12	30526	240	30766	0.78
5/13	43421	360	43781	0.82
5/14	20921	260	21181	1.22
5/15	15132	140	15272	0.92
5/19	35789	0	35789	0.00
5/21	19474	340	19814	1.72
5/26	4342	60	4402	1.36
5/28	5000	140	5140	2.72
				MEAN ($\bar{X}$) = .81

Appendix 1 (Continued)

1992				
Date	**Chipps Island Expanded Catches**	**Montezuma Slough Expanded Catches**	**Total Expanded catches**	**% Fish diverted to Montezuma Slough**
4/20	104737	200	104937	0.19
4/21	146974	620	147594	0.42
4/22	215789	720	216509	0.33
4/23	155263	1560	156823	0.99
4/24	123553	620	124173	0.50
4/27	77105	1220	78325	1.56
4/29	83684	1100	84784	1.30
4/30	68816	360	69176	0.52
5/01	95395	960	96355	1.00
				MEAN ($\bar{X}$) = .76