2004 Biological Evaluation of the Fish Screens at the Glenn-Colusa Irrigation District's Sacramento River Pump Station

May 2005

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PROJECT LOCATION

The Glenn-Colusa Irrigation District's (GCID) Sacramento River pumping station is located near Hamilton City approximately 100 miles north of the city of Sacramento on the west side of the main stem Sacramento River and 206 river miles upstream from San Francisco Bay. It is located on an oxbow off the main river channel with fish screens positioned upstream of the pumping plant. A Fish Screen Improvement Project (Project) was recently completed at the site which included (among other features): 1) an extension of the flat-plate screens; 2) upgrading the existing facility; 3) an internal fish bypass system to route fish through pipes and back to an oxbow outlet channel a short distance downstream of the new screens; 4) a flow-control weir in the oxbow channel; and 5) reconfiguration of the oxbow outlet channel to route fish back to the Sacramento River. Additionally, a large-scale gradient facility was constructed in 2000 on the main stem Sacramento River near the diversion site to ensure long-term reliability of the fish protective facilities.

INTRODUCTION

A Fish Protection Evaluation and Monitoring Program (FPEMP) was established prior to completion of the GCID Project. A Guidance Manual was developed for the FPEMP to identify the experimental design, field methods, and equipment necessary to evaluate the biological performance of the new fish screen structure and gradient facility (Montgomery Watson et al. 2000). The cooperating agencies developed and agreed to its contents at the GCID Technical Oversight Committee (TOC) Meeting No. 4 on January 30, 2001. The Guidance Manual outlined studies to evaluate overall fish survival at the fish screens, assess fish passage at the gradient facility, and determine relative abundance and distribution of predatory fish at the gradient site and nearby areas. Specifically, field tests were identified, using live fish, to provide empirical data in determining the effectiveness of the fish screen improvements. Biological field testing at the site is performed under a range of riverine and pumping conditions to ensure the Project provides sufficient protection for fish under future, naturally occurring conditions. The field tests are designed to determine if maximal survival of fish and optimal fish passage conditions are achieved.

As described in the FPEMP, a critical design flow condition was determined during project development: 7,000 cfs in the river upstream of the oxbow and 3,000 cfs pumping flows which produces the greatest flow through the screens at the lowest associated water level resulting in the highest approach velocities and lowest sweeping velocities. Other flows are also of concern since they could produce different sweeping and approach velocity patterns. The screen is tested according to the FPEMP at four combinations of river and pumping flows (Table 1) with the internal fish screen bypasses opened and closed. The main factors affecting juvenile fish at the screen are the approach and sweeping velocities, bypass position, and potential predation throughout the facility. Because of the screen design and subsequent testing, entrainment is no longer considered a source of fish mortality.

Table 1. Range of river flows and pumping flows (cfs) identified in the FPEMP Guidance Manual for the GCID Fish Screen Improvement Project. River flow location is upstream of the GCID intake channel (i.e., Sacramento River gauge at Highway 32 plus the GCID pump flow).

Test Condition	Pump Flow (cfs)	River Flow (cfs)
No. 1 Low Pump - High River	500 – 1,000	>15,000
No. 2 High Pump - Low River (Design Case)	>2,600	7,000 – 9,000
No. 3 Normal Pump - Normal River	1,800 – 2,600	10,000 – 13,000
No. 4 Low Pump – Low River	500 – 1,000	<9,000

Initial testing of fish survival at the screens was conducted during 2002 and 2003 and reported in Vogel (2003, 2005). This report describes the results of the biological evaluation of the new screens conducted during 2004. Initial results for 2004 were previously reported and discussed at TOC meetings.

METHODS

Mark/Recapture Experiments

The biological tests of fish mark/recapture to estimate overall fish survival were performed by releasing a known number of differently marked fish[1] at locations in the GCID intake and outlet channel, then recapturing portions of all groups in a large fyke net recapture structure and two rotary screw traps in the lower oxbow outlet channel. The numbers of fish used for each experiment were determined from testing conducted during 2001 and 2002. Based on initial testing of fish screen survival conducted during 2002, the TOC decided to add an additional, separate group of fish to be released just downstream from the flow-control weir for each experiment performed during 2003 and 2004. The weir group was added to compare with test group results. It was assumed that the fish released immediately downstream of the weir could not swim upstream past the weir because of high water velocities.

Because pumping and river flow conditions could not be accurately predicted in advance of fish testing, experiments were performed by scheduling two daytime and two nighttime mark/recapture tests each week during spring and summer of 2004 to encompass the range of pumping and river flow conditions available. The number of experiments conducted each week was largely a function of allowing sufficient time for marked fish to move through the system and the number of different marks available to avoid compromising subsequent experiments.

Fish handling protocols are described in the FPEMP Guidance Manual (Montgomery Watson et al. 2000). All Chinook salmon used for individual test, weir, and control groups were identified through use of a photonic marking device. This equipment employs high pressure injection of a

[1] Fish used for the 2004 study were obtained from the U.S. Fish and Wildlife Service's Coleman National Fish Hatchery and the California Department of Fish and Game's Feather River Fish Hatchery.

fluorescent material into specific locations on the fins of the fish (e.g., caudal fin). Different color marks at different fin placements allowed discrimination between test, weir, and control groups of fish.

Test (experimental) groups of fish were released a short distance upstream of the screens and control groups of fish were released downstream of the flow control structure and upstream of the fyke net recapture structure. The additional group of fish was released immediately downstream of the flow-control weir (Figures 1 and 2). The specific locations of the recapture structure and control fish release site were moved slightly upstream of that originally contemplated in the FPEMP Guidance Manual as described in Vogel (2003). During each experiment, control, weir, and test groups of fish were released in sequence from downstream to upstream to minimize disturbance of downstream fish movements. Control fish were released from a boat, weir fish were released from a catwalk suspended over the weir, and test fish were released from buckets gently lowered into the water off the upstream end of the fish screen structure.

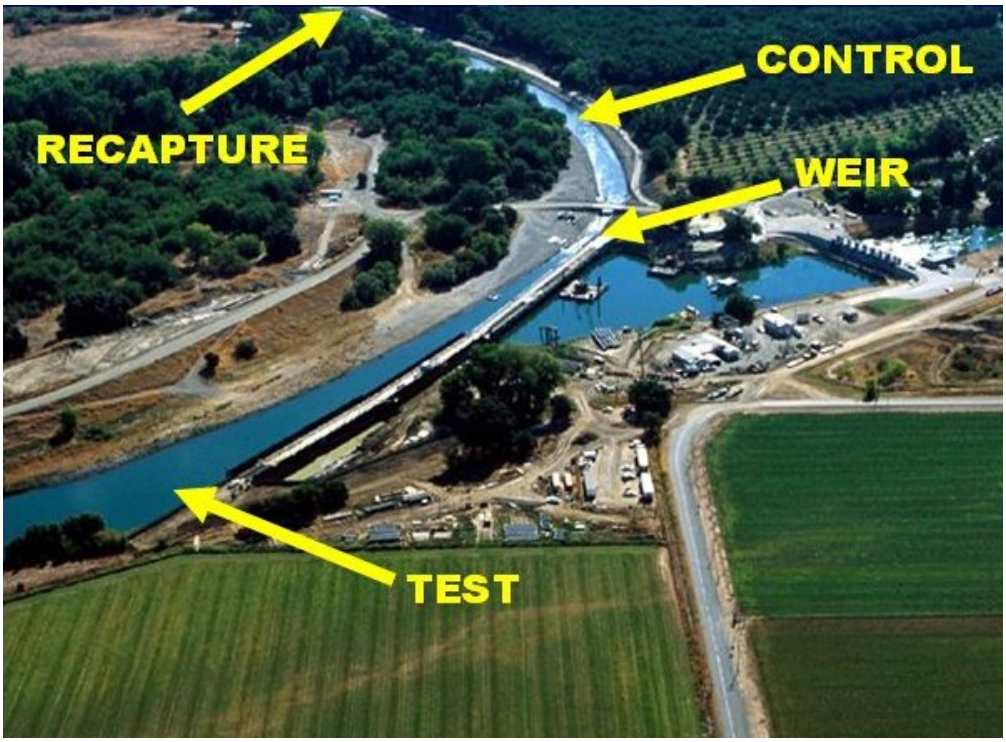

Figure 1. Location of three fish release sites: test group, weir group, control group and the recapture location for the three groups of fish in the GCID oxbow channel. Water flow is from lower left to top of picture. The GCID pump station is shown on the far right.

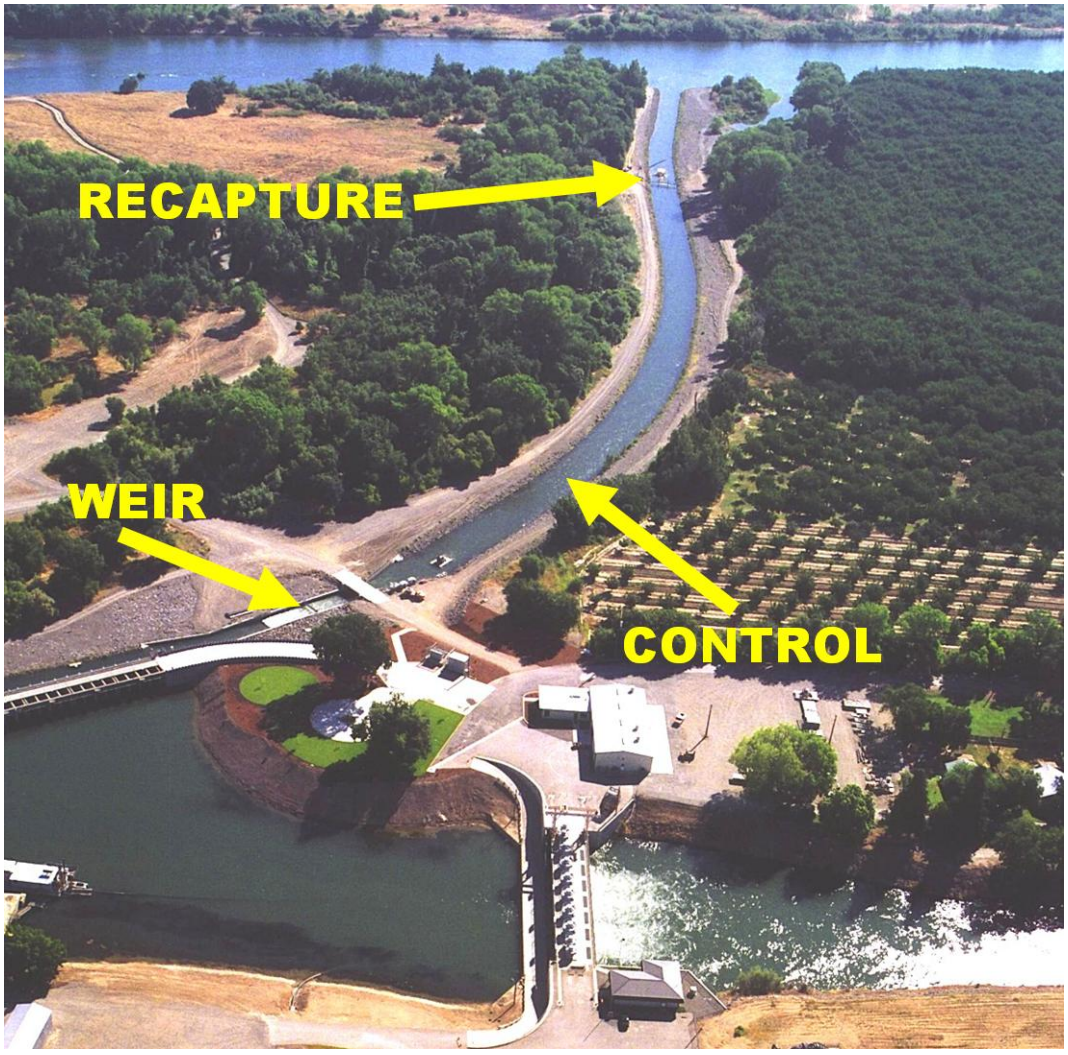

Figure 2. Release locations of the weir and control fish groups and the recapture site in the GCID oxbow channel. Water flow is from left to top of picture. Sacramento River is shown on top of picture and flow is left to right. The GCID pump station is shown on the bottom.

Test, weir, and control groups of fish were recaptured in an 18-ft. wide by 10-ft. deep by 60-ft. long fyke net at the lower end of the oxbow outlet channel. In 2003 and 2004, two additional 8-ft. diameter rotary screw traps were added to the site to increase the numbers of fish recaptured for each experiment and to reduce sampling variability observed during the 2002 testing program (Figures 3 and 4). All recaptured fish were examined for marks and portions of each mark group had fork lengths recorded. The numbers of unmarked salmonids[2] (e.g., wild salmon or unmarked

[2] Up to 25 fish per sampling period were measured for fork lengths.

hatchery fish) and other fish species captured were also recorded and the data were provided to the California Department of Fish and Game. The estimated survival of test groups of fish was made by comparing the proportion of test fish recovered with the proportion of control fish recovered:

$$\text{Est. Survival (\%)} = 100 \times \frac{\text{(Number of test fish recaptured/number of test fish released)}}{\text{(Number of control fish recaptured/number of control fish released)}}$$

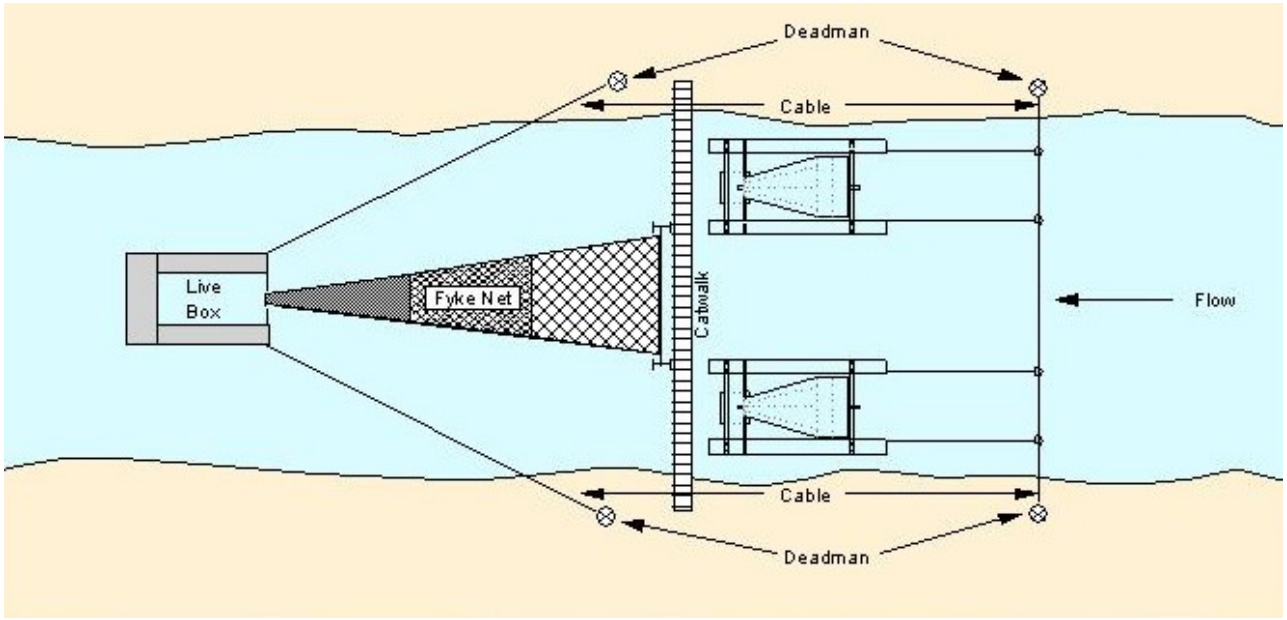

Figure 3. Plan-view schematic of the fyke net apparatus and two rotary screw traps used to recapture test, control, and weir groups of fish in the oxbow outlet channel.

Figure 4. Fyke net and two rotary screw traps used to recapture test, control, and weir groups of marked fish during the 2003 and 2004 biological evaluations at GCID. Prior to release of fish, the 60-ft. long fyke net was lowered in the channel current by crane into the H-pile slots. Recaptured fish were accumulated in the floating live box attached to the end of the fyke net and rotary screw trap live boxes, and then examined for marks to identify initial release location.

During late September and early October 2004, after fish screen survival experiments ended, tests of fyke nets placed over the three fish bypass outfalls were conducted to determine the effectiveness of capturing fish exiting the internal fish screen bypass system. The tests sufficiently assessed the equipment and techniques for the TOC in order to recommend and begin evaluating fish utilization of the internal bypasses during 2005. That element of the FPEMP will be addressed during 2005 and is not covered in this report.

RESULTS AND DISCUSSION

Seventy-three mark/recapture tests were conducted from May 6 to September 14, 2004. Results are shown in Figure 5. Juvenile fall-run Chinook salmon from Feather River Hatchery were used for the experiments conducted from May 6 to July 1, 2004 and juvenile late-fall Chinook salmon from Coleman National Fish Hatchery were used for the experiments conducted from July 6 to September 14, 2004. Of those tests, 38 were performed during daytime and 35 during nighttime; 39 tests were performed when the internal fish screen bypasses were closed and 34

tests when the bypasses were open. Although overall fish recapture efficiency was relatively high for both test and control groups of fish, some variability between tests was evident.

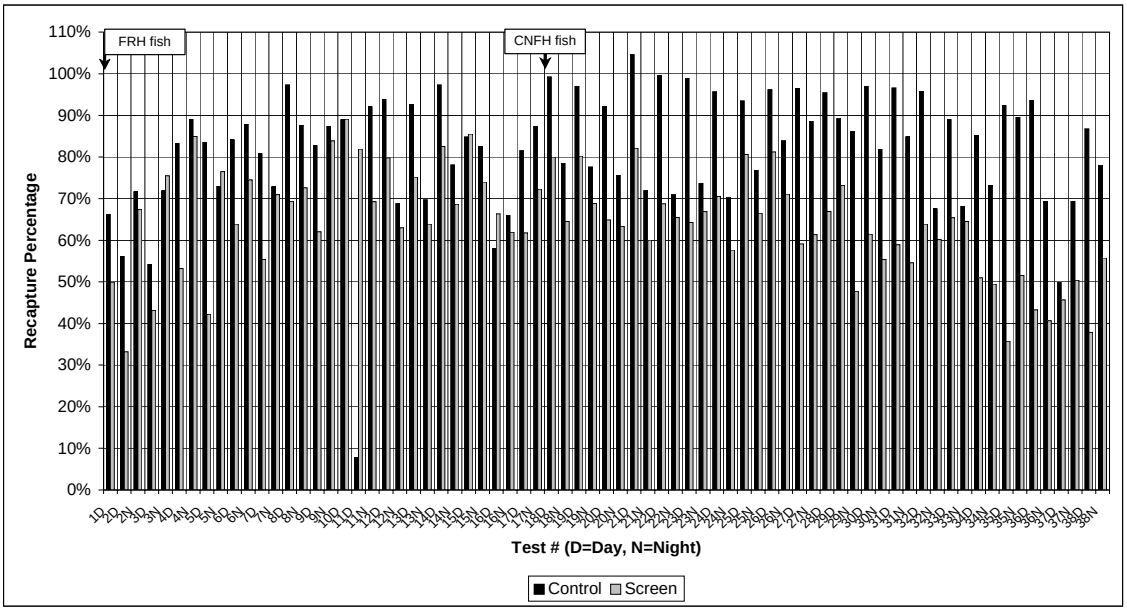

Figure 5. Comparison of the proportion of test fish recaptured with the proportion of control fish recaptured for each of 73 tests conducted during 2004. Labels on the X-axis (in sequence) refer to: experiment number, D=day and N=night.

Based on protocols developed by the TOC, only those tests resulting in greater than or equal to 50% recapture efficiencies were used to compute fish survival. In most instances, recapture efficiencies less than 50% were attributed to factors such as recapture gear problems (e.g., torn net) or weather conditions causing premature curtailment of the experiments (e.g., lightning). Therefore, 63 of the 73 experiments were used to compare the proportion of test fish recaptured to the proportion of control fish recaptured. Those results are shown in Figure 6 and Appendix A. Among these experiments, 30 tests were performed during daytime and 33 tests during nighttime; 33 tests were conducted with the bypasses closed and 30 tests with the bypasses opened.

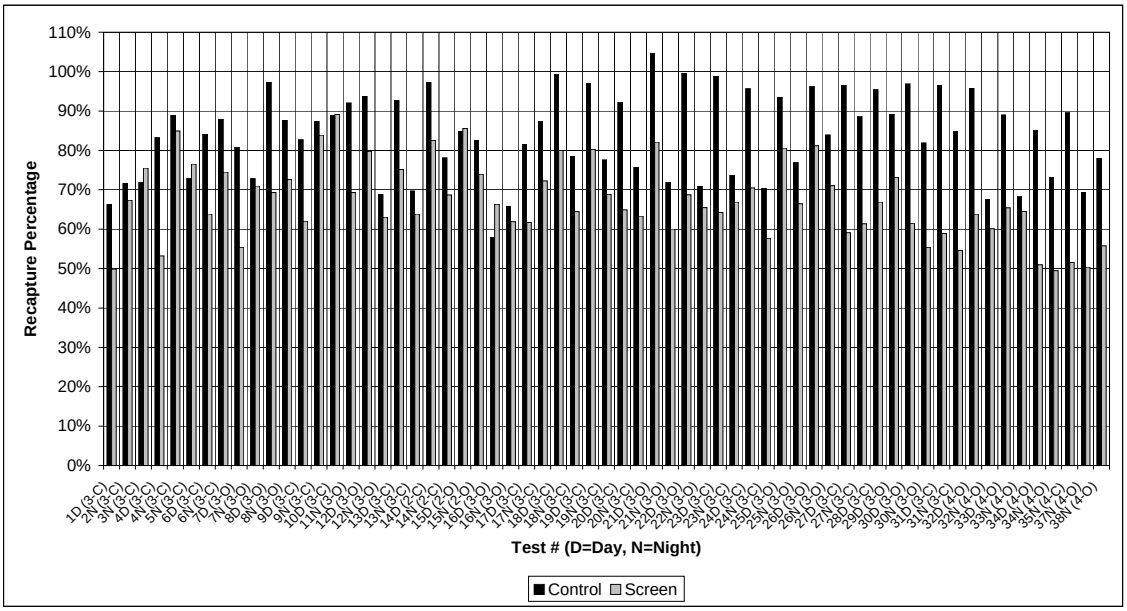

Figure 6. Comparison of the proportion of test fish recaptured with the proportion of control fish recaptured for each of 63 tests where recapture efficiencies were greater than 50% in 2004. Labels on the X-axis (in sequence) refer to: experiment number, D=day and N=night, FPEMP test matrix number (based on pump flow) (see Table 1, page 2), followed by bypass setting (O=open, C=closed).

Figure 7 shows the timing of the 63 experiments in comparison to riverine and pumping flow conditions experienced during 2004. The fish screen survival experiments were delayed until early May to avoid potential conflicts with large fish production releases from Coleman National Fish Hatchery during mid- and late-April.

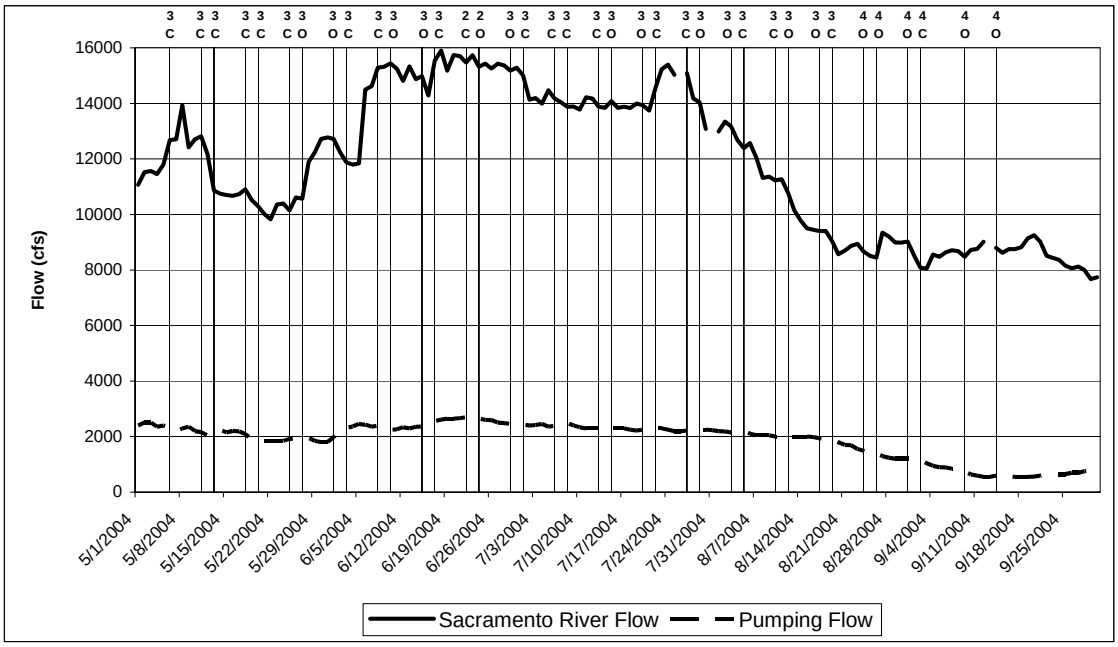

Figure 7. Range of river and pumping flow conditions during each of the mark/recapture experiments during 2004. Vertical lines show date of experiments. Some dates designated by a vertical line had a day and night experiment in the same 24-hour period. Labels on top of the graph represent FPEMP test matrix number (based on pump flow) (see Table 1, page 2) and bypass setting (O=open, C=closed). Sacramento River flow location is upstream of the GCID intake channel.

Fish survival estimates for the 63 experiments are provided in Table 2. There were only four instances where resulting survival rates exceeding 100% were estimated (i.e., the proportion of treatment fish recaptured was higher than the proportion of control fish recaptured). As suggested by the GCID TOC, data were combined in two ways to estimate overall proportion of test versus control groups of fish recaptured: 1) assuming greater than 100% test versus control group recapture actually represents 100%, and 2) use of the actual proportions, even if the values were greater than 100%. Those values and the range in values for both calculation methods are provided in Table 2. The differences between overall averaged survival estimates between the two methods were minor (1%).

Table 2. Comparison of the average proportion of test fish recaptured with the average proportion of control fish captured[1] (all tests weighted equally) and range in results. Non-parenthetical values are computed assuming tests with >100% equaled 100% whereas values in parentheses are computed using actual proportions for those tests >100%

	Bypasses Open	Bypasses Closed	Overall
Day	Number of tests = 14 78% (79%) 60%-100% (60%-114%)	Number of tests = 16 75% 61%-100%	Number of tests = 30 76% (77%) 60%-100% (60%-114%)
Night	Number of tests = 16 84% 68%-97%	Number of tests = 17 85% (86%) 58%-100% (58%-105%)	Number of tests = 33 85% (86 %) 58%-100% (58%-105%)
Overall	Number of tests = 30 81% (81%) 60%-100% (60%-114%)	Number of tests = 33 80% (81%) 58%-100% (58%-105%)	Number of tests = 63 81% (81%) 58%-100% (58%-114%)

$$[1]\text{Est. Survival (\%)} = 100 \times \frac{\text{(Number of test fish recaptured/number of test fish released)}}{\text{(Number of control fish recaptured/number of control fish released)}}$$

As compared to test results obtained during 2002, the installation of the two rotary screw traps used simultaneously with the large fyke trap greatly increased sampling efficiencies in 2003 and 2004 and significantly reduced variability between tests. This phenomenon is not readily apparent when examining the individual recapture rates at each trap shown in Figures 8 and 9 because the vast majority of test, weir, and control fish were recaptured in the fyke net. It is hypothesized that the presence of the two rotary screen traps near the channel edges may serve to guide fish toward the center of the channel making the fish more susceptible to the fyke net. This would suggest some gear avoidance of the two rotary screw traps. It was also evident that the rotary screw traps were slightly more effective at capturing fish at night compared to day that may be attributable to either less gear avoidance or different fish distribution in the channel at night compared to day. Regardless of the reasons for the high recapture rates, it is evident that use of the three fish traps in tandem should continue for future fish screen survival experiments.

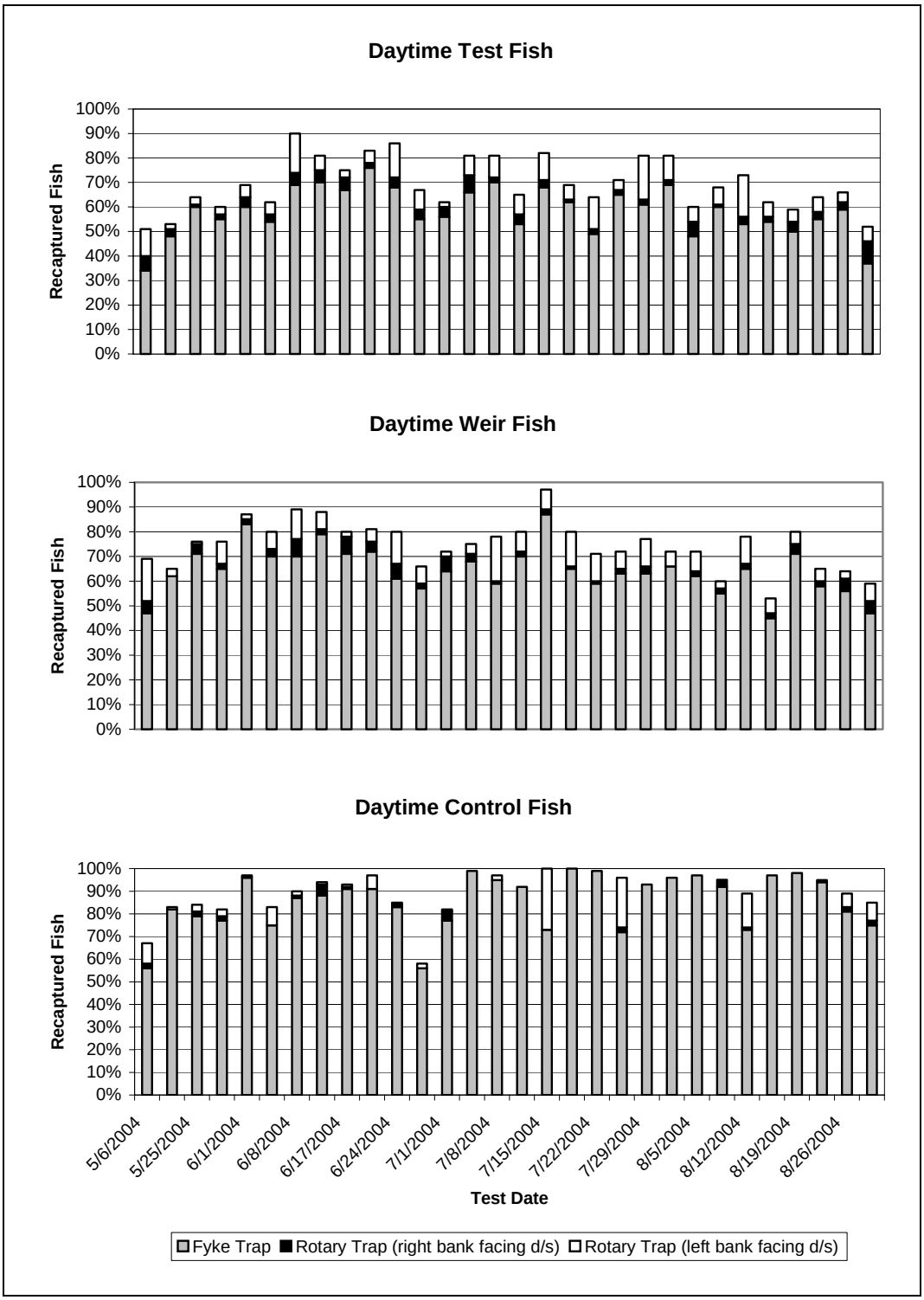

Figure 8. Proportion of daytime test, weir, and control groups of fish recaptured in the fyke net and right and left bank rotary screw traps.

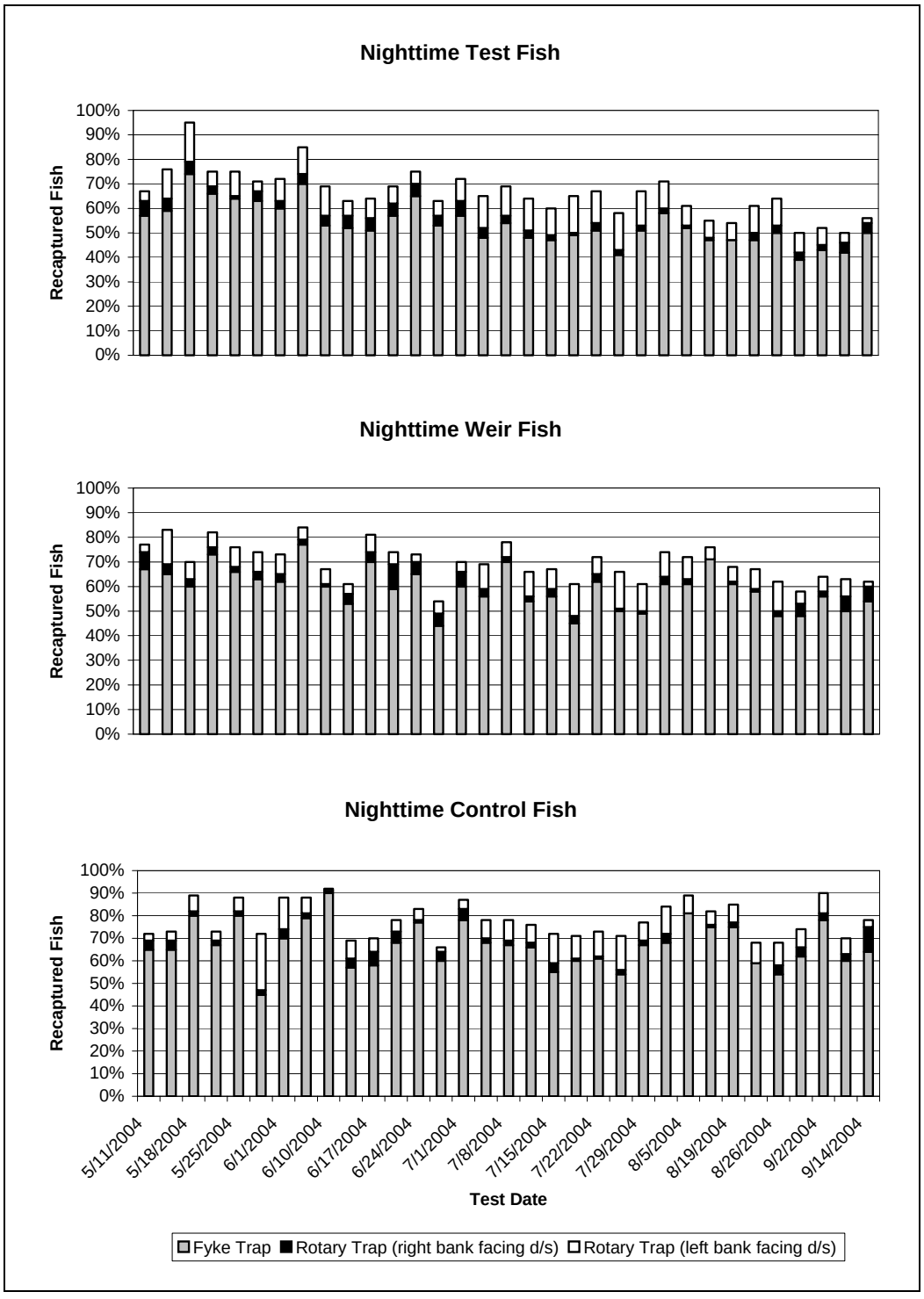

Figure 9. Proportion of nighttime test, weir, and control groups of fish recaptured in the fyke net and right and left bank rotary screw traps.

Figures 10 and 11 show comparisons between the average fork lengths of test and control fish, upon release and at recapture, for daytime and nighttime experiments during 2004. With the exception of some small differences in several daytime control fish recaptures in June and July, differences were minor or not evident in most instances, indicating that there were no size-selective differences for within-experiment results.

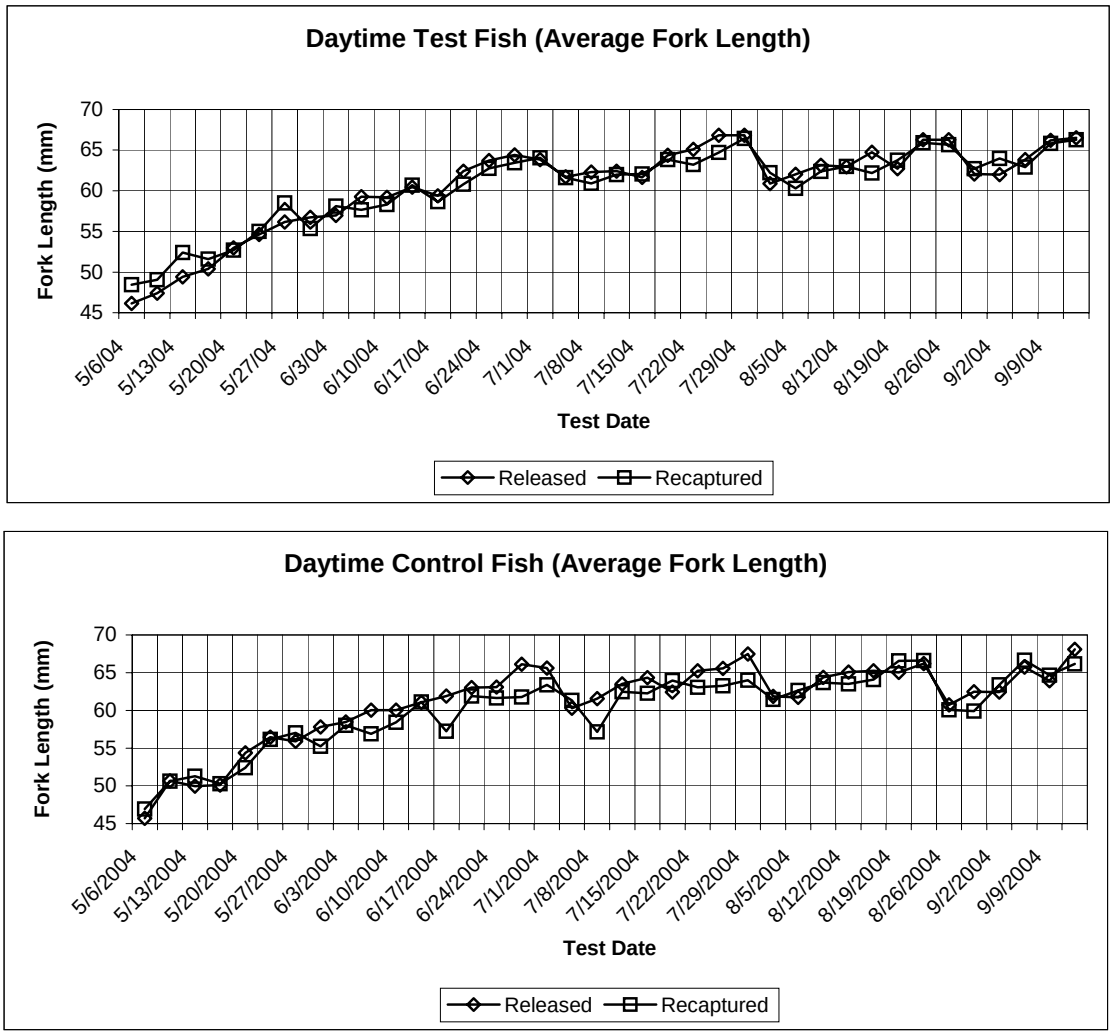

Figure 10. Comparisons between the average fork lengths of control and test fish at release and at recapture for daytime experiments.

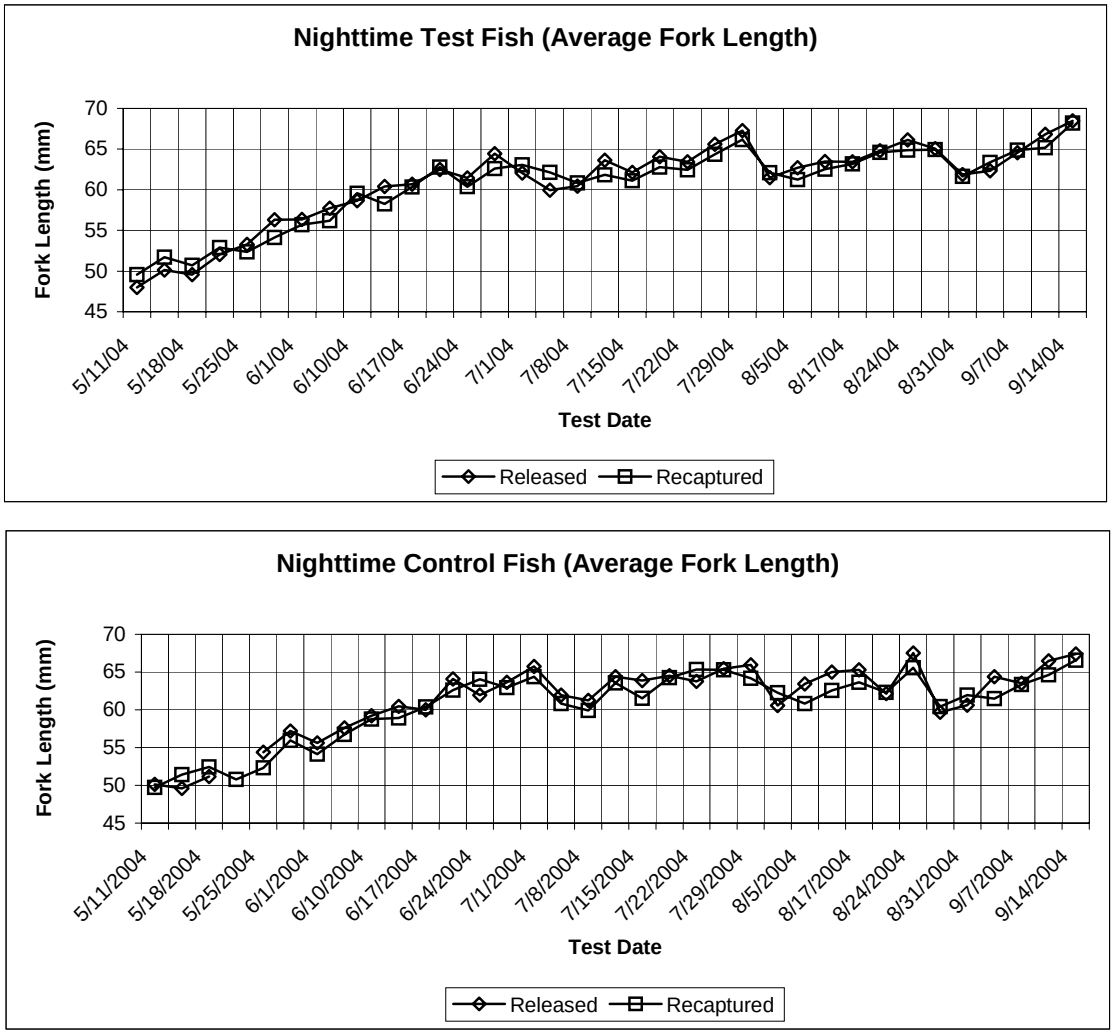

Figure 11. Comparisons between the average fork lengths of control and test fish at release and at recapture for nighttime experiments.

As noted during 2003 experiments (Vogel 2005), striped bass predation on test fish released just upstream of the fish screens was observed during mid- to late-summer. It was hypothesized that the routine release of test fish four times a week may have caused a buildup of predatory fish at the release site resulting from a conditioned feeding response. Although this assumption is speculative, it is plausible based on experiments during 2003 and fish releases conducted elsewhere (e.g., fish experiments at Red Bluff Diversion Dam and fish salvage releases in the Delta). In 2004, the test fish were not released from a boat (as was done in 2003) under the assumption that it would reduce potential predatory fish conditioned feeding response. This potentially significant issue remains unresolved.

Figure 12 provides a comparison of fish survival estimates based on the variables of fish size, day/night tests, and bypasses open and closed. Figure 13 provides a comparison of fish survival estimates based on the variables of date, day/night tests, and bypasses open/closed. During 2004, fish size was auto-correlated with date because of increase in growth. As mentioned above, it appears that late-season tests occurred with a buildup of predatory fish at or near the release site which could have accounted for the reduced survival rates later in the testing season thereby masking the potential effects of diel and fish size variables.

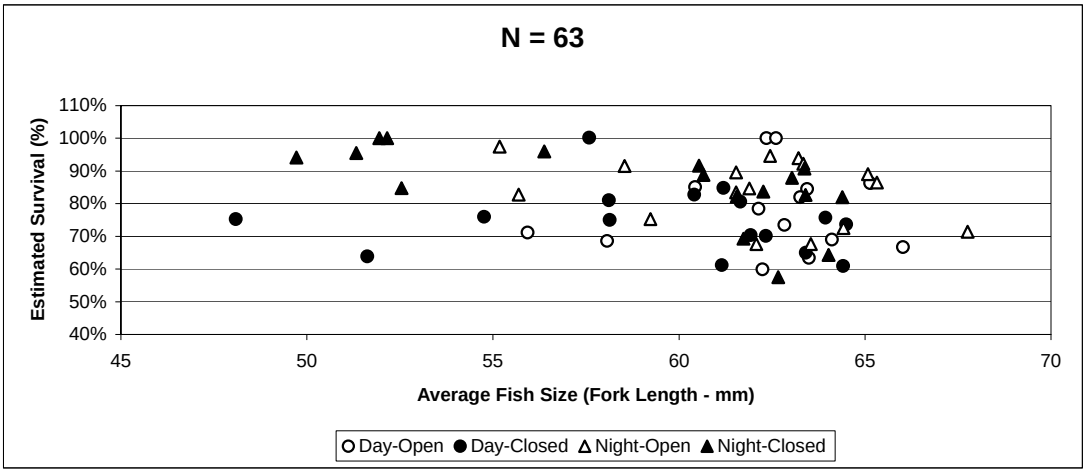

Figure 12. Fish survival estimates for 63 experiments conducted during 2004. Comparisons are based on fish size, day/night, and fish screen bypasses open/closed.

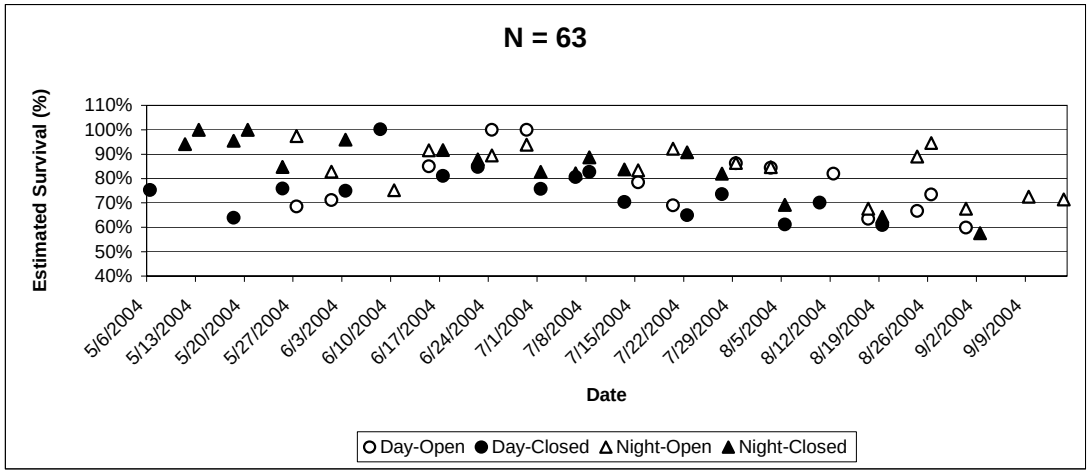

Figure 13. Fish survival estimates for 63 experiments conducted during 2004. Comparisons are based on day/night, fish screen bypasses open/closed, and date of experiments.

In 2004, there were minimal differences in fish survival when comparing fish bypasses open or closed. However, when comparing day versus night fish releases, the nighttime releases generally showed higher survival rates. This latter phenomenon may be attributable to lower predation at night compared to day.

Weir Release Groups

As stated in the Methods section, an additional group of differently marked fish was released immediately downstream of the flow-control weir during each experiment in 2004. The intent was to determine potential differences in estimated survival rates of fish released upstream of the fish screens. There was also the concern that a small portion of fish released upstream of the screens could swim in an upstream direction out of the intake channel and not be subject to recapture as compared to control fish released in the oxbow outlet channel. Although this latter possibility cannot be directly tested, it was assumed that releasing an additional group of fish immediately downstream of the weir may provide additional data and insights into fish behavior and potential fish mortality. Figure 14 shows the results. As previously noted for test and control groups, recapture efficiencies of less than 50% were usually attributed to recapture gear problems (e.g., torn net), or weather conditions causing premature curtailment of the experiments.

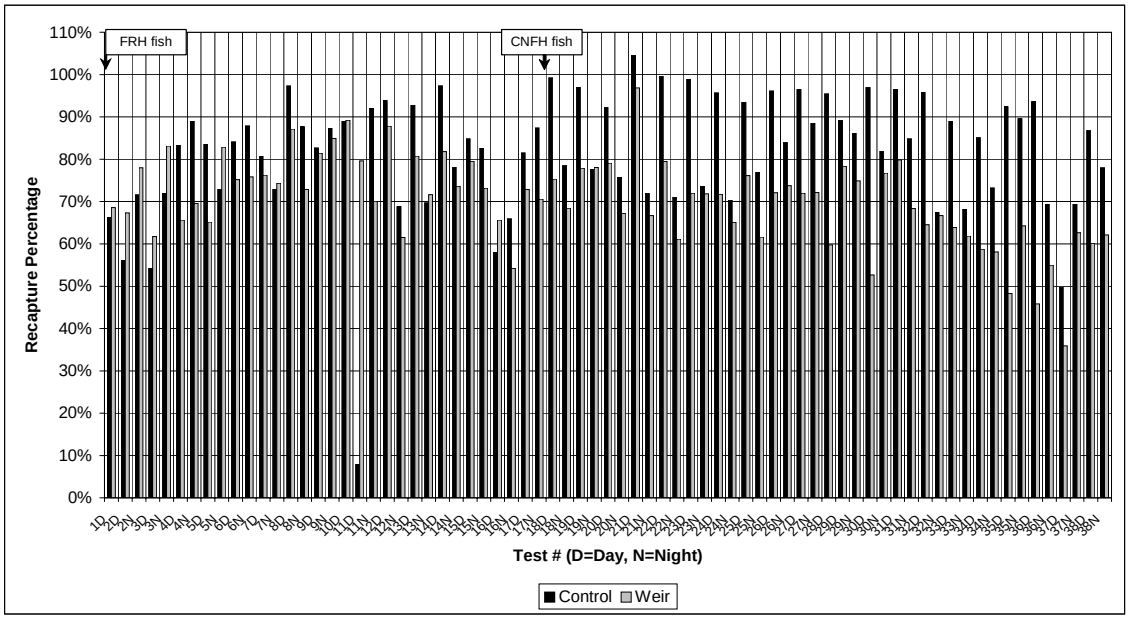

Figure 14. Comparison of the proportion of weir fish recaptured with the proportion of control fish recaptured for each of 73 tests conducted during 2004. Labels on the X-axis (in sequence) refer to: experiment number, D=day and N=night.

There were 69 experiments where greater than 50% recapture efficiencies could be used to estimate survival rates for fish released just downstream of the weir (Figure 15). The estimated survival of weir groups of fish were computed in a similar manner as previously described for test groups of fish released upstream of the fish screens. Those results are provided in Table 3. A direct comparison of survival for fish released upstream of the screens and at the weir was made by determining the differences in recapture rates within each experiment where the recapture rate for each group was more than 50%. Of those 63 experiments meeting that criterion, the results suggest that there is an incremental source of fish mortality between the test, weir, and control fish release sites (Table 4). Those results indicate that slightly less than one-third of the fish mortality may occur between upstream of the fish screens and the flow-control weir with two-thirds of the mortality occurring between the weir and the lower oxbow. In 2003, slightly more than one-half of the mortality was estimated between upstream of the fish screens and the weir (Vogel 2005). In both years, predatory fish were observed just downstream of the weir where the concrete structure flares out into the oxbow outlet channel.

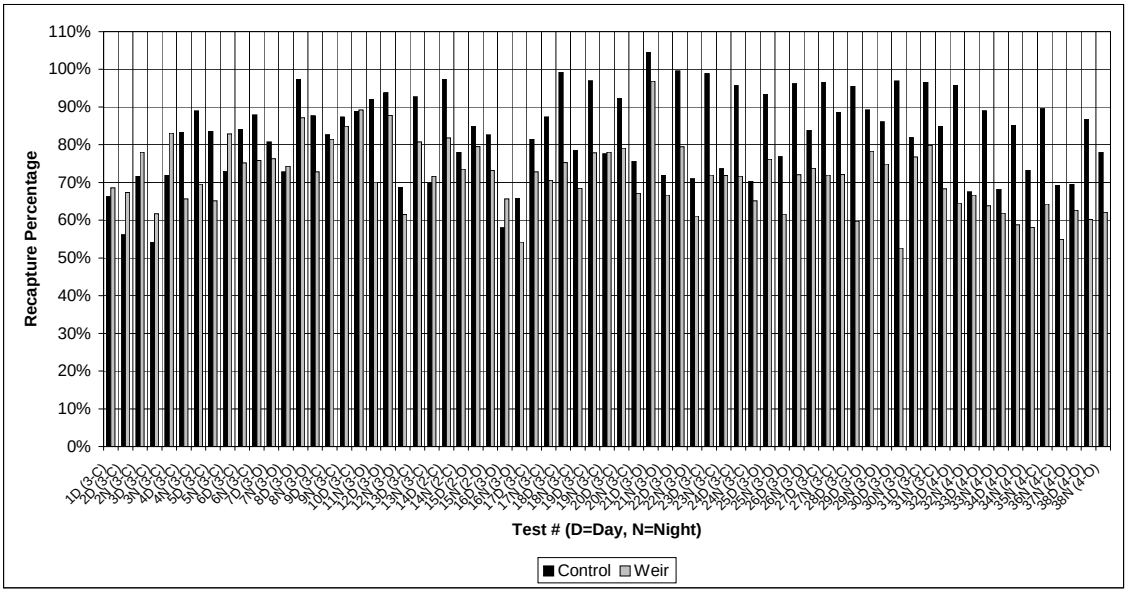

Figure 15. Comparison of the proportion of weir fish recaptured with the proportion of control fish recaptured for each of 69 tests where recapture efficiencies were greater than 50% in 2004. Labels on the X-axis (in sequence) refer to: experiment number, D=day and N=night, FPEMP test matrix number (based on pump flow) (see Table 1, page 2), followed by bypass setting (O=open, C=closed).

Table 3. Comparison of the average proportion of weir fish recaptured with the average proportion of control fish captured[1] (all tests weighted equally) and range in results. Non-parenthetical values are computed assuming tests with >100% equaled 100% whereas values in parentheses are computed using actual proportions for those tests >100%

Day	Night	Overall
Number of tests = 34 83% (85%) 54%-100% (54%-120%)	Number of tests = 35 89% (90%) 72%-100% (72%-116%)	Number of tests = 69 86% (87%) 54%-100% (54%-120%)

[1]Est. Survival (%) = 100 x (Number of weir fish recaptured/number of weir fish released) / (Number of control fish recaptured/number of control fish released)

Table 4. Comparison of the average proportion of test fish and weir fish recaptured with the average proportion of control fish recaptured (estimated survival of test and weir fish)[1] (all tests weighted equally) and range in results. Values are computed assuming estimated survival >100% equaled 100%.

	Test Fish	Weir Fish	Survival Difference
Day **Number of tests = 30**	**76.2%** **59.9%-100%**	**82.9%** **54.3%-100%**	**6.7%** **-9.5% - +25.8%**
Night **Number of tests = 33**	**84.6%** **57.6%-100%**	**88.9%** **71.7%-100%**	**4.3%** **-17.3% - +26.0%**
Overall **Number of tests = 63**	**80.6%** **57.6%-100%**	**86.1%** **54.3%-100%**	**5.5%** **-17.3% - +26.0%**

[1] Est. Survival (%) = 100 x (Number of test fish recaptured/number of test fish released) / (Number of control fish recaptured/number of control fish released)

FPEMP Test Matrix

Table 5 shows the categories where the 63 tests performed during 2004 fit within the FPEMP Guidance Manual testing matrix. During the February 25, 2003 GCID TOC meeting, it was determined that the combination of river flow and pumping flow conditions encountered during most of the tests in 2002 did not fit well into the matrix. Therefore, the TOC decided to use pumping flow as the primary variable to determine where each testing condition fits into the matrix category numbers 1-4 shown in Table 1 (page 2) of this report.

Table 5. Range of conditions occurring during the fish survival experiments conducted during 2002, 2003, and 2004. Testing categories nos. 1-4 are based on pump flow. All test groups used fish averaging >50 mm fork length except those shown in parentheses which used fish averaging <50 mm fork length.

FPEMP Guidance Manual Test Condition (Pump Only)	Bypasses Open						Bypasses Closed					
	Day			Night			Day			Night		
	2002	2003	2004	2002	2003	2004	2002	2003	2004	2002	2003	2004
No. 1 (500-1,000 cfs) (high river)	0	0	0	0	0	0	0	1	0	0	0	0
No. 2 (>2,600 cfs)	1	0	1	2	0	1	5	0	1	4	0	1
No. 3 (1,800-2,600 cfs)	4	10	10	4	10	10	9	7	12 (3)	10	5	12 (3)
No. 4 (500-1,000 cfs) (low river)	0	0	3	0	0	5	0	0	0	0	3	1

RECOMMENDATIONS

Based on results of experiments performed during 2002, 2003, and 2004 and discussions with the GCID TOC, the following are recommendations for work activities to be performed for the biological evaluations on the GCID Fish Screen Improvement Project during 2005.

Mark/Recapture Experiments

- Initiate mark/recapture experiments in April and conduct the tests weekly through August (depending on ESA take limits) to test a wider range of river and pumping flow conditions. It is expected that two daytime and two nighttime tests can be performed each week.

- In addition to use of juvenile fall-run Chinook from Feather River Hatchery, use late-fall Chinook salmon fry from Coleman National Fish Hatchery for the experiments.

- Alternate weeks of opening and closing the internal fish screen bypasses

- Monitor the potential build-up of predatory fish

- Intermittently remove predatory fish at the locations just upstream of the fish screen structure and just downstream of the flow-control weir. Compare fish survival estimates between fish releases before and after predatory fish removal.

- Place covers over the fish screen bypass outfall exits during experiments conducted with the bypasses closed to eliminate potential holding habitat for predatory fish.

- Continue to use the two rotary fish traps in combination with the fyke net at the recapture site

- Measure the flows behind the fish screens using an acoustic Doppler current profiler to determine relative flow distribution through the screens and total pumping flows during the experiments.

- Continue to release a third group of fish at the weir with a different mark than test and control fish

- Perform experiments to determine fish utilization of the internal bypasses by releasing marked fish upstream of the screens and recapturing fish exiting all three bypass outfalls using fyke nets on alternating weeks during the testing season.

ACKNOWLEDGEMENTS

This study was funded by the federal government, the state of California, and GCID. Formal recognition should be given to the GCID TOC for their advice and guidance for the GCID Fish Protection and Evaluation and Monitoring Program and their review of a draft of this report. The California Department of Fish and Game and the U.S. Fish and Wildlife Service deserve special gratitude for making the 2004 biological evaluations possible. In particular, Feather River Hatchery staff and Coleman National Fish Hatchery staff are thanked for making fish available to perform tests and providing hatchery space for fish marking. Appreciation is extended to Rick Moncrief, GCID field crew leader, and the GCID staff including Tom Davison, Diana Menke, Bryan Henderson, Jeff Humble, Matt Bidwell, Eric Rott, Joe Mattis, Nick Henning, Keith Hayashi, Kyle Thompson, and Brett Gregory for performing the field work for this project. Denisa Vogel performed final data compilation and summarization, and produced graphics for this report.

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Appendix A. GCID survival test results for 2004.								
	Time of	Bypass	Screen Group		Weir Group		Bypass Group	
Date	Release	Position	Rel.	Recap.	Rel.	Recap.	Rel.	Recap.
5/6/2004	Day	Closed	1000	499	487	334	462	306
5/11/2004	Day	Closed	512	170	239	161	244	137
5/11/2004	Night	Closed	500	337	264	206	257	184
5/13/2004	Day	Closed	512	221	264	163	238	129
5/13/2004	Night	Closed	441	333	249	207	256	184
5/18/2004	Day	Closed	513	273	265	174	251	209
5/18/2004	Night	Closed	505	429	263	183	263	234
5/20/2004	Day	Closed	512	216	264	172	261	218
5/20/2004	Night	Closed	494	378	263	218	248	181
5/25/2004	Day	Closed	515	329	254	191	258	217
5/25/2004	Night	Closed	514	383	265	201	265	233
5/27/2004	Day	Open	491	272	257	196	265	214
5/27/2004	Night	Open	486	345	257	191	254	185
6/1/2004	Day	Open	515	357	265	231	264	257
6/1/2004	Night	Open	515	374	265	193	260	228
6/3/2004	Day	Closed	511	317	264	215	260	215
6/3/2004	Night	Closed	502	421	265	225	261	228
6/8/2004	Day	Closed	505	450	260	232	262	233
6/10/2004	Day	Open	514	421	265	211	265	21
6/10/2004	Night	Open	492	341	264	185	265	244
6/15/2004	Day	Open	515	411	263	231	259	243
6/15/2004	Night	Open	503	317	265	163	263	181
6/17/2004	Day	Closed	515	387	265	214	260	241
6/17/2004	Night	Closed	515	329	261	187	264	184
6/22/2004	Day	Closed	510	421	264	216	264	257
6/22/2004	Night	Closed	514	353	265	195	265	207
6/24/2004	Day	Open	505	432	264	210	264	224
6/24/2004	Night	Open	508	376	261	191	265	219
6/29/2004	Day	Open	514	341	265	174	262	152
6/29/2004	Night	Open	512	317	262	142	264	174
7/1/2004	Day	Closed	515	318	265	193	265	216
7/1/2004	Night	Closed	512	370	265	187	262	229
7/6/2004	Day	Closed	505	404	259	195	261	259
7/6/2004	Night	Closed	507	327	263	180	265	208
7/8/2004	Day	Closed	511	410	244	190	263	255
7/8/2004	Night	Closed	514	354	255	199	250	194
7/13/2004	Day	Closed	513	333	263	208	258	238
7/13/2004	Night	Closed	513	325	259	174	263	199
7/15/2004	Day	Open	509	418	256	248	260	260
7/15/2004	Night	Open	503	302	264	176	246	177
7/20/2004	Day	Open	512	352	263	209	258	257
7/20/2004	Night	Open	504	330	260	159	262	186
7/22/2004	Day	Closed	512	329	264	190	262	259
7/22/2004	Night	Closed	429	287	263	189	247	182
7/27/2004	Day	Closed	508	358	265	190	256	245
7/27/2004	Night	Closed	508	293	261	170	263	185

Appendix A (continued). GCID survival test results for 2004.								
	Time of	Bypass	Screen Group		Weir Group		Bypass Group	
Date	Release	Position	Rel.	Recap.	Rel.	Recap.	Rel.	Recap.
7/29/2004	Day	Open	511	412	260	198	260	243
7/29/2004	Night	Open	510	339	263	162	264	203
8/3/2004	Day	Open	506	411	265	191	262	252
8/3/2004	Night	Open	501	356	263	194	255	214
8/5/2004	Day	Closed	509	301	264	190	262	253
8/5/2004	Night	Closed	502	308	262	189	262	232
8/10/2004	Day	Closed	505	338	261	156	264	252
8/12/2004	Day	Open	511	374	263	206	260	232
8/12/2004	Night	Open	513	245	263	197	259	223
8/17/2004	Day	Open	509	313	264	139	260	252
8/17/2004	Night	Open	498	276	258	198	265	217
8/19/2004	Day	Closed	511	301	263	210	265	256
8/19/2004	Night	Closed	511	279	259	177	264	224
8/24/2004	Day	Open	515	329	265	171	260	249
8/24/2004	Night	Open	512	308	261	174	265	179
8/26/2004	Day	Open	512	335	263	168	264	235
8/26/2004	Night	Open	513	331	257	159	258	176
8/31/2004	Day	Open	504	257	262	154	262	223
8/31/2004	Night	Open	505	250	265	154	265	194
9/2/2004	Day	Closed	512	183	265	128	263	243
9/2/2004	Night	Closed	512	264	263	169	259	232
9/7/2004	Day	Closed	511	221	264	121	265	248
9/7/2004	Night	Closed	514	209	262	144	264	183
9/9/2004	Day	Open	488	223	259	93	261	130
9/9/2004	Night	Open	512	258	257	161	265	184
9/14/2004	Day	Open	512	194	251	151	265	230
9/14/2004	Night	Open	513	286	264	164	264	206