2006 Biological Evaluation of the Fish Screens at the Glenn-Colusa Irrigation District's Sacramento River Pump Station

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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 (Figure 1). 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) an upgrade to 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 rock training wall on the river bank opposite the screens to enhance sweeping velocities past the screens, 5) a flow-control weir in the oxbow channel; and 6) 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 (Figure 2).

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. 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 structured to provide empirical data in determining the effectiveness of the fish screen improvements. Biological field testing at the site (using live fish) 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 a result of the fish screen improvement project” (Montgomery Watson et al. 2000).

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 because 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, internal fish bypass operation (i.e., open or closed), and potential predation throughout the facility. Because of the screen design and subsequent testing, entrainment is probably no longer a significant source of fish mortality.

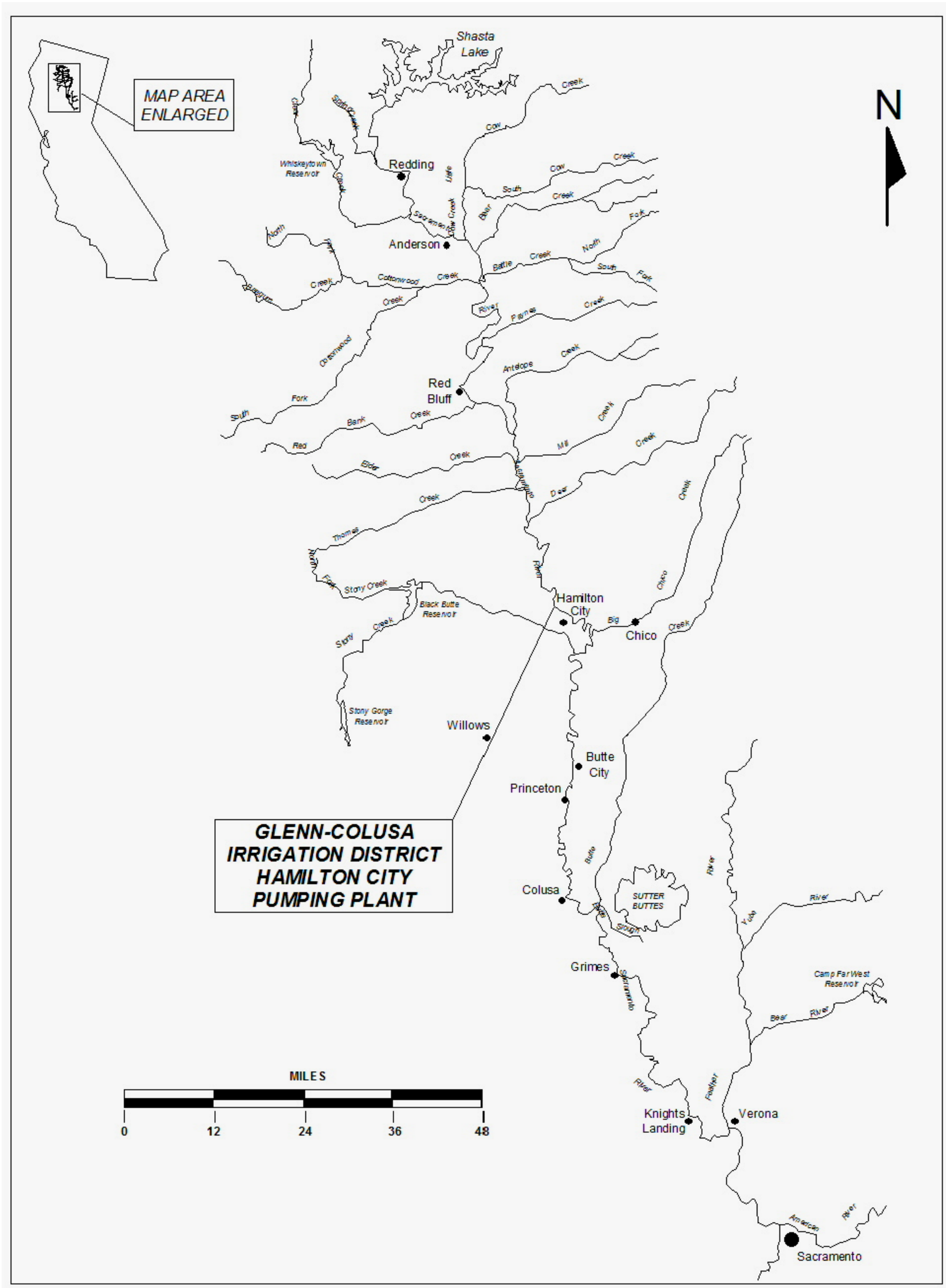

Figure 1. Location of the Glenn-Colusa Irrigation District Hamilton City Pumping Plant on the Sacramento River.

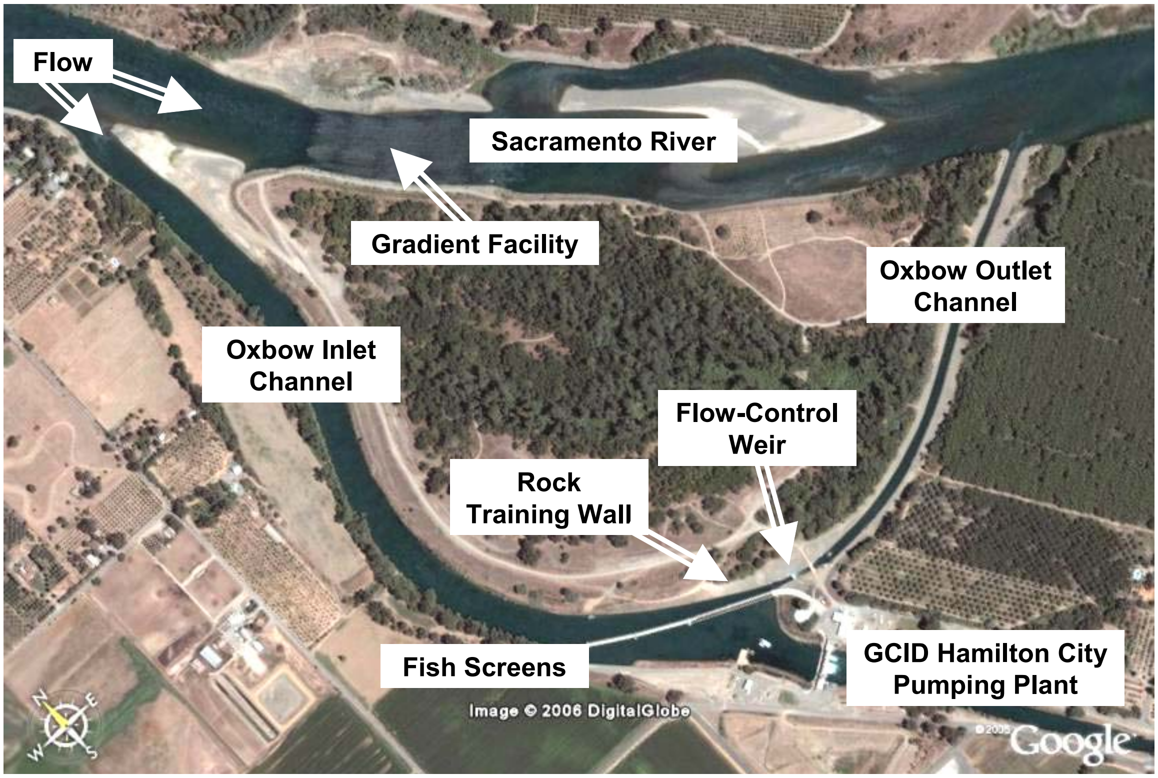

Figure 2. The GCID Hamilton City Pumping Plant and associated features of the Fish Screen Improvement Project.

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 oxbow inlet channel

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

Testing of fish survival at the screens was conducted during 2002, 2003. 2004, and 2005 and reported by Vogel 2003, 2005a, 2005b, and 2006, respectively. This report describes the results of the biological evaluation of the screens conducted during 2006. Initial study results for 2006 were previously reported and discussed at TOC meetings.

METHODS

Fish Mark/Recapture Survival Experiments

The biological tests to estimate overall fish survival by fish mark/recapture were performed by releasing a known number of differently marked fish[1] just upstream of the screens (test group) and outlet channel (control group), then recapturing portions of all groups in a large fyke net structure and two rotary screw traps in the lower oxbow outlet channel. The numbers of fish used for each experiment were determined from initial testing conducted during 2001 and 2002. Based on 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, 2004, 2005, and 2006. 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 2006 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 fluorescent material into specific locations on the fins of the fish. Different color marks at different fin placements allowed discrimination between groups of fish.

Test groups of fish were released adjacent to the upstream end of the screens and control groups of fish were released downstream of the flow-control weir and upstream of the fyke net recapture structure. The additional group of fish was released immediately downstream of the flow-control weir and upstream of the control fish release site (Figure 3). 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 (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 to minimize potential attraction of predatory fish.

[1] Fish used for the 2006 study were juvenile late-fall run Chinook salmon obtained from the U.S. Fish and Wildlife Service's Coleman National Fish Hatchery.

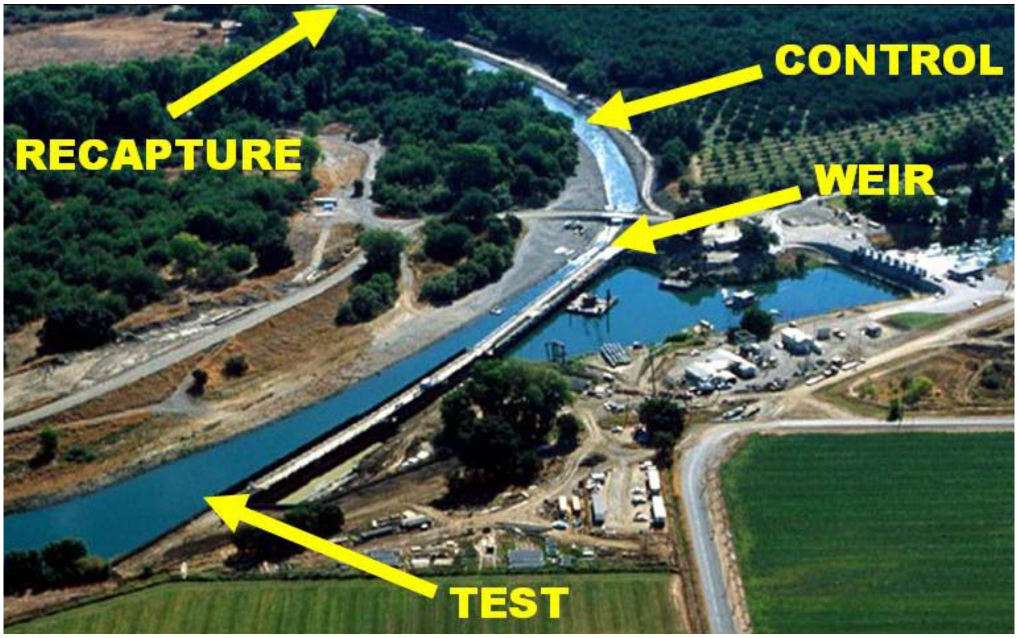

Figure 3. Location of three fish release sites: test group, weir group, control group and the recapture location for the three groups of fish in the GCID oxbow channel. Water flow is from lower left to top of picture. The GCID pump station is shown on the far right. Note that this aerial photograph was taken when the new fish screens were under construction and the pump station forebay had not yet been completely excavated.

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, 2004, 2005, and 2006, 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 4 and 5). 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 hatchery fish) and other fish species captured were also recorded and the data were provided to the California Department of Fish and Game (CDFG).

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

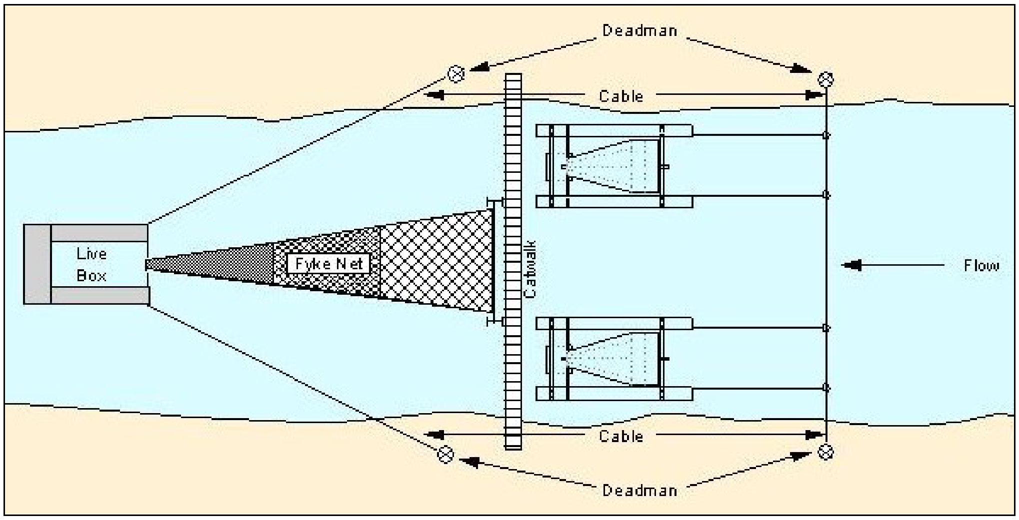

Figure 4. Plan-view schematic of the fyke net apparatus and two rotary screw traps used to recapture test, weir, and control groups of fish in the oxbow outlet channel.

Figure 5. Fyke net and two rotary screw traps used to recapture test, weir, and control groups of fish during the 2003, 2004, 2005, and 2006 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.

The survival of test groups of fish was estimated by comparing the proportion of test fish recovered with the proportion of control fish recovered:

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

The survival of weir groups of fish was estimated by comparing the proportion of weir fish recovered with the proportion of control fish recovered:

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

RESULTS AND DISCUSSION

Fish Mark/Recapture Survival Tests

Thirty-one mark/recapture tests were conducted from June 13 to August 31, 2006[3]; all of those tests resulted in greater than 50% recapture efficiencies for test and control groups of fish. 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. Results are shown in Figure 6 and Appendix A. Of the 31 tests, 15 were performed during daytime and 16 during nighttime; all tests were performed when the internal fish screen bypasses were closed. Although overall fish recapture efficiency was relatively high for both test and control groups of fish, some variability between tests was evident.

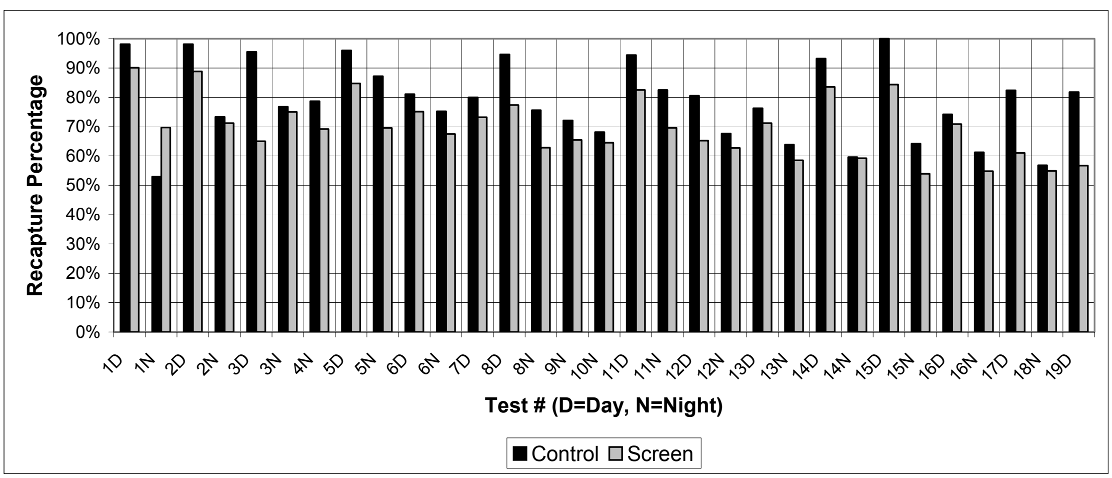

Figure 6. Comparison of the proportion of test fish recaptured with the proportion of control fish recaptured for each of 31 tests conducted during 2006. Labels on the X-axis (in sequence) refer to: experiment number, D=day and N=night.

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[3] Fish survival experiments did not continue after August 31, 2006 to avoid exceedence of the NOAA Fisheries authorized take limits for the endangered winter-run Chinook salmon.

Figure 7 shows the timing of the 31 experiments in comparison to riverine and pumping flow conditions experienced during 2006. The experiments could not be initiated until early June due to high spring-time flows. Biological experiments were not conducted during late July through early August to allow for hydraulic testing of the screens and treatment of diseased test fish at Coleman Hatchery. With the concurrence of the GCID TOC, the flow-control weir blocks were removed on August 7, 2006, to evaluate a potential measure to reduce concentrations of predatory fish residing just downstream of the weir. Removal of the flow-control weir caused the internal fish screen bypass system to become inoperable and resulted in a slight drop in water surface on the fish screens but the approach and sweeping velocity criteria were maintained.

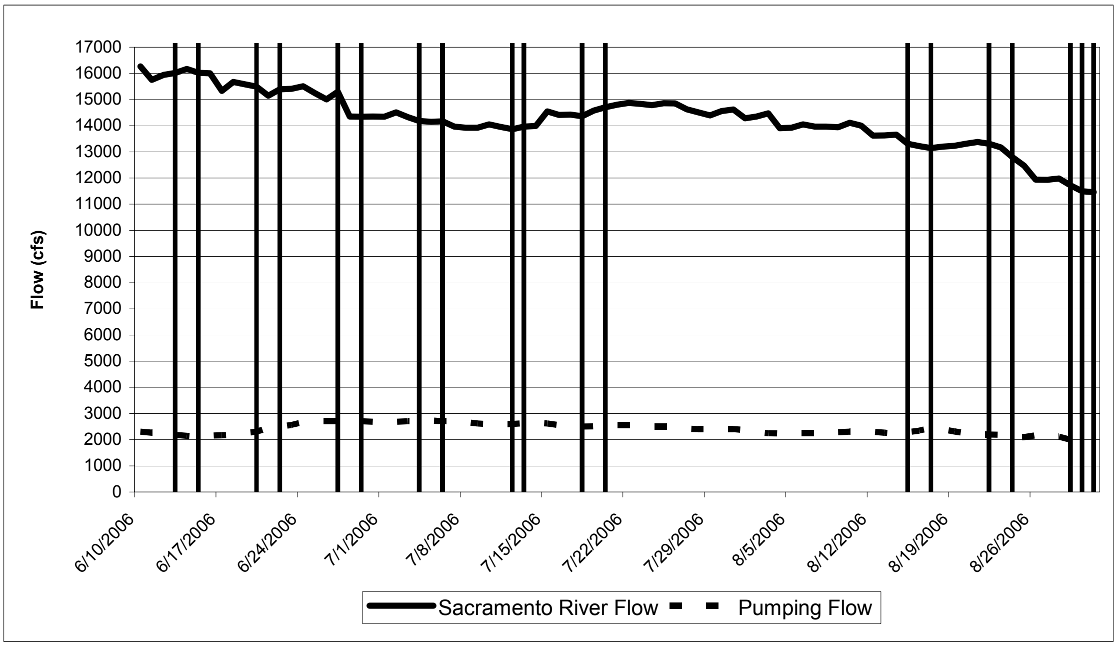


Figure 7. Range of river and pumping flow conditions during each of the mark/recapture experiments during 2006. Vertical lines show date of experiments. Some dates designated by a vertical line had a day and night experiment in the same 24-hour period. All tests were performed with closed bypasses and a FPEMP test matrix number of three (based on pump flow) (see Table 1, page 2). Sacramento River flow location is upstream of the GCID oxbow inlet channel.

Fish survival estimates for the 31 experiments are provided in Table 2. There was only one instance where a resulting survival rate exceeding 100% was estimated (i.e., the proportion of test 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 difference in overall averaged survival estimates between the two methods was minor (1.0 %). There was about a 6% higher survival estimate for nighttime experiments as compared to daytime experiments.

Table 2. Comparison of the average proportion of test fish recaptured with the average proportion of control fish recaptured[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 = 15 **85.3%** **68.1%-95.5%**	**Number of tests = 16** **91.2% (93.2%)** **79.8%-100% (79.8%-131.7%)**	**Number of tests = 31** **88.4% (89.4%)** **68.1%-100% (68.1%-131.7%)**

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

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, 2004, 2005, and 2006 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.

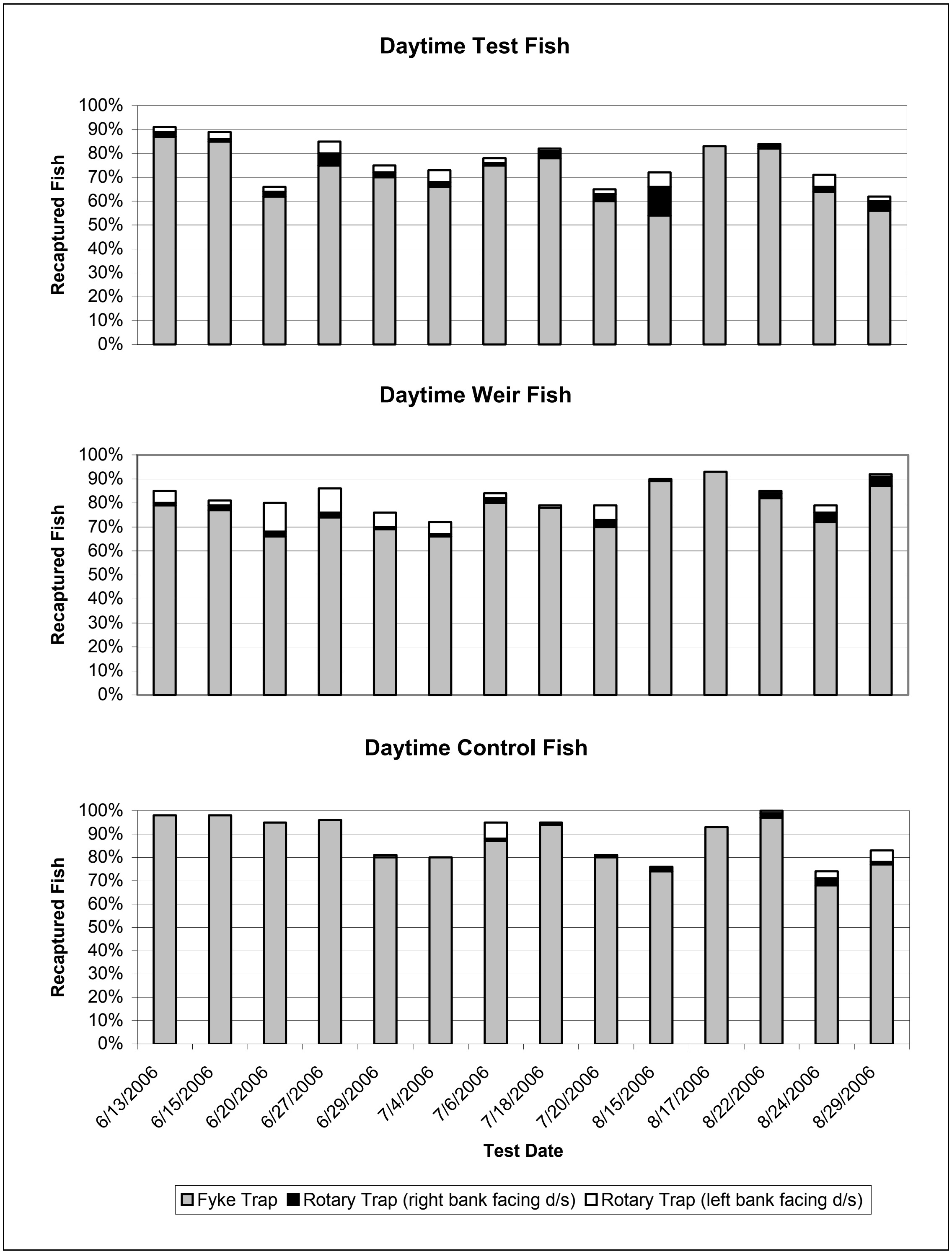


Figure 8. Proportion of daytime test, weir, and control groups of fish recaptured in the fyke net and right and left bank rotary screw traps.

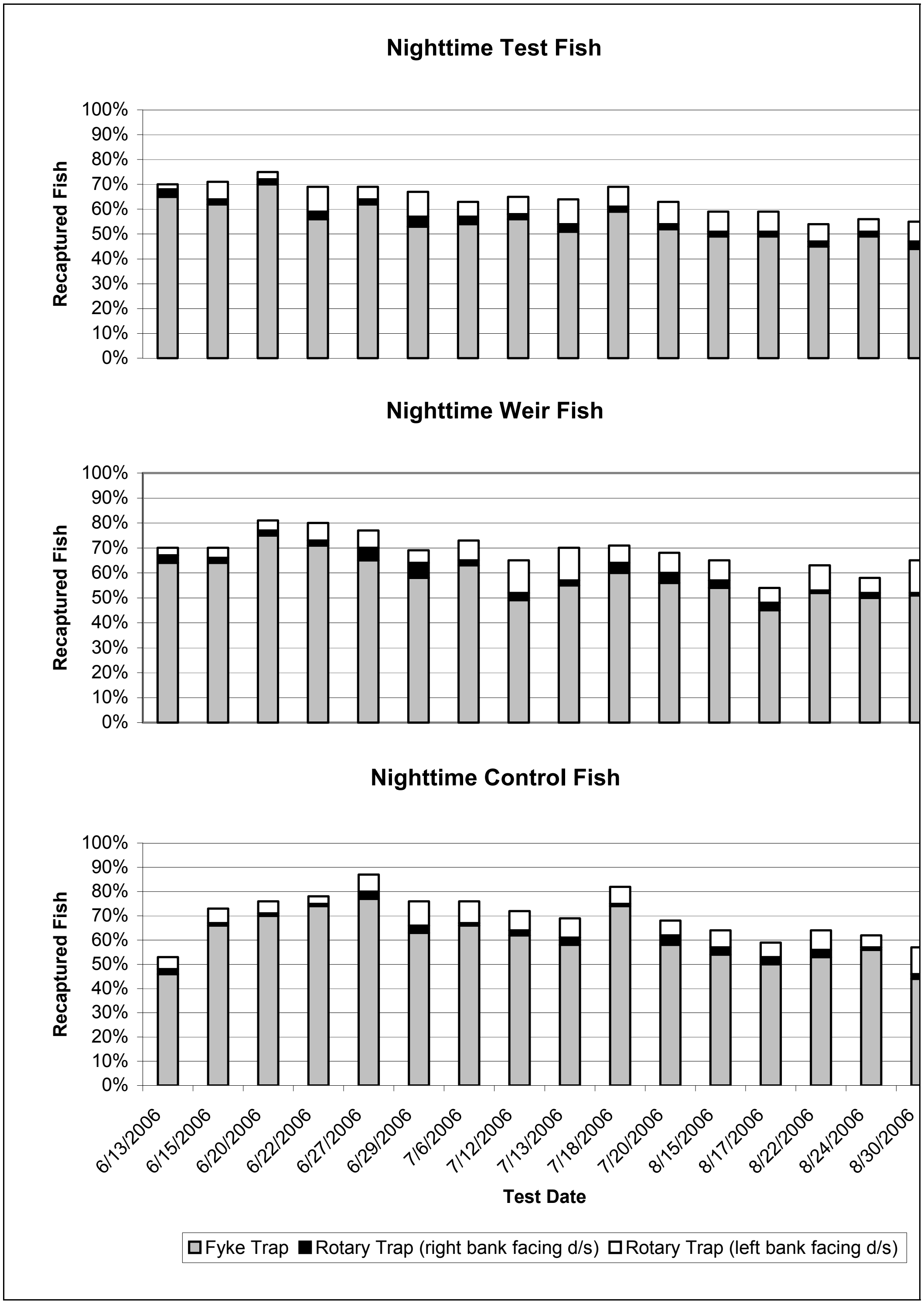
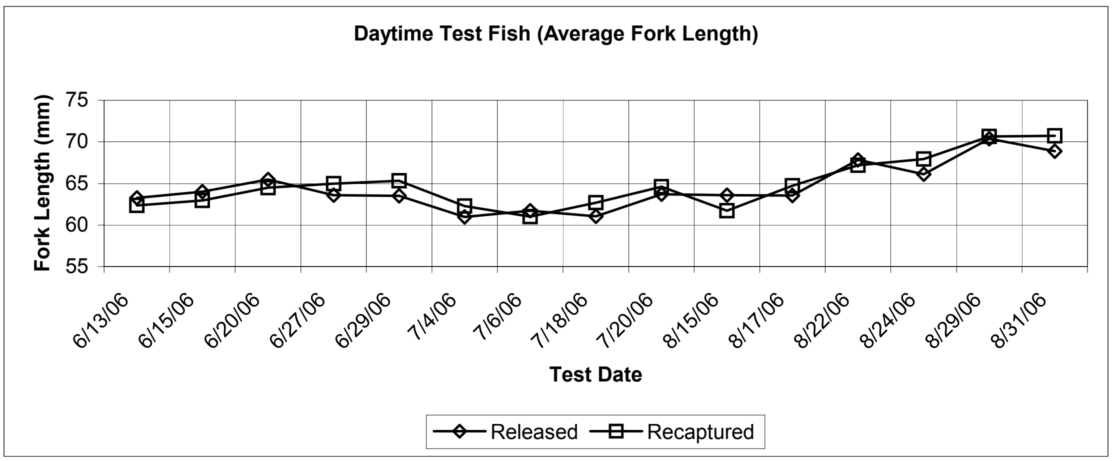


Figure 9. Proportion of nighttime test, weir, and control groups of fish recaptured in the fyke net and right and left bank rotary screw traps.

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 2006. Some of the tests showed slight differences between the average size of fish recaptured compared to average size of fish released but were only about several millimeters differences in fork length.



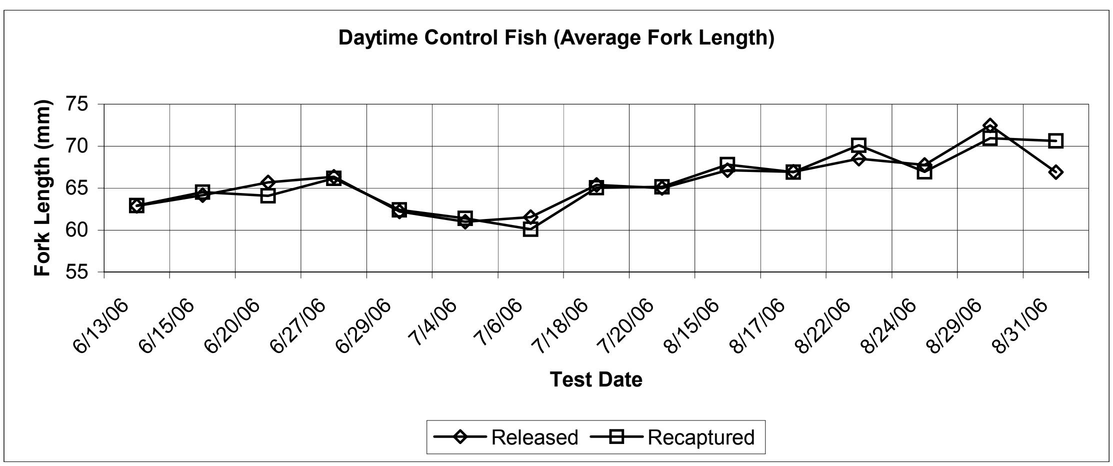
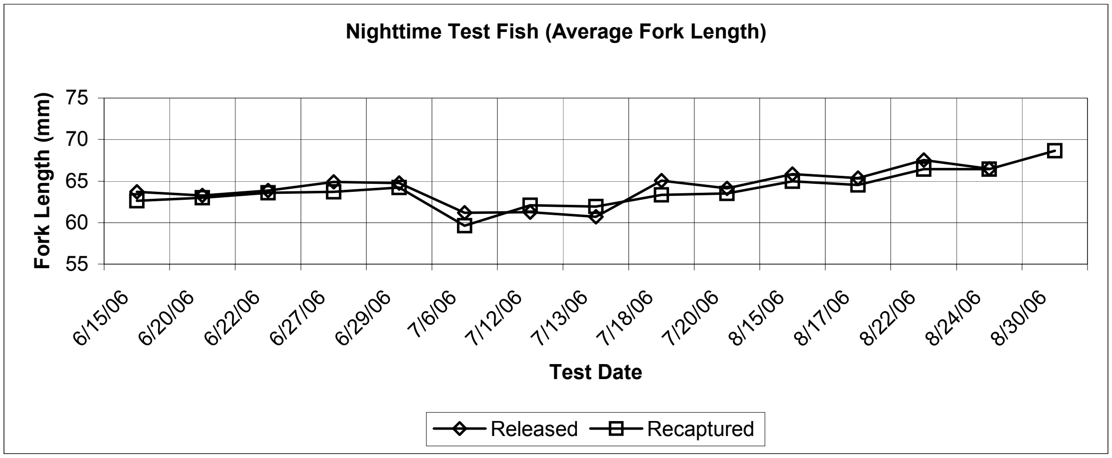


Figure 10. Comparisons between the average fork lengths of test and control fish at release and at recapture for daytime experiments in 2006.



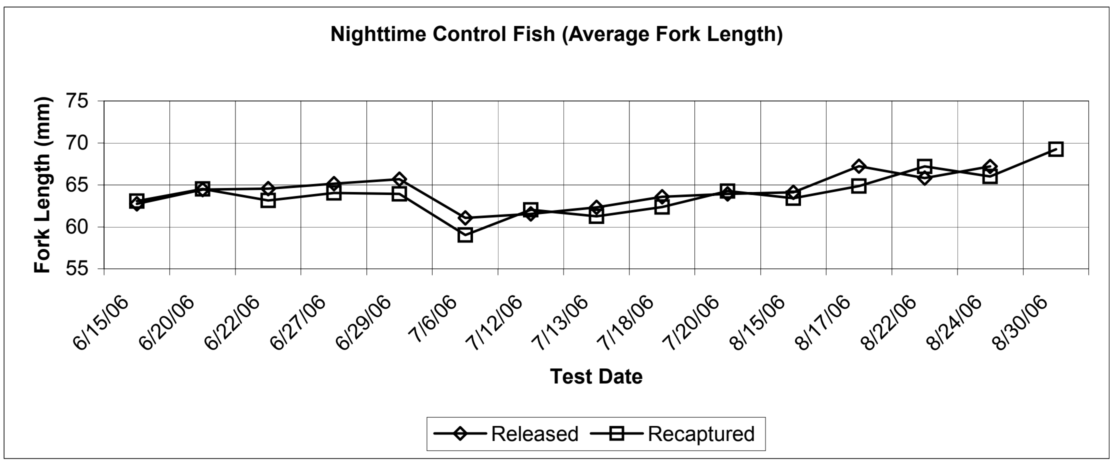


Figure 11. Comparisons between the average fork lengths of test and control fish at release and at recapture for nighttime experiments in 2006.

As noted during experiments during 2003, 2004, and 2005 (Vogel 2005a, 2005b, 2006), striped bass predation on test fish released just upstream of the fish screens was also observed in 2006 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 conducted elsewhere (e.g., fish experiments at Red Bluff Diversion Dam and fish salvage releases in the Delta). In 2004, 2005, and 2006, the test fish were not released from a boat (as was done in 2003) under the assumption that it would reduce the possible conditioned feeding response of predatory fish. This potentially significant issue remains unresolved.

Figure 12 provides a comparison of fish survival estimates based on the variables of fish size and day/night tests. Figure 13 provides a comparison of fish survival estimates based on the variables of date and day/night tests. 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.

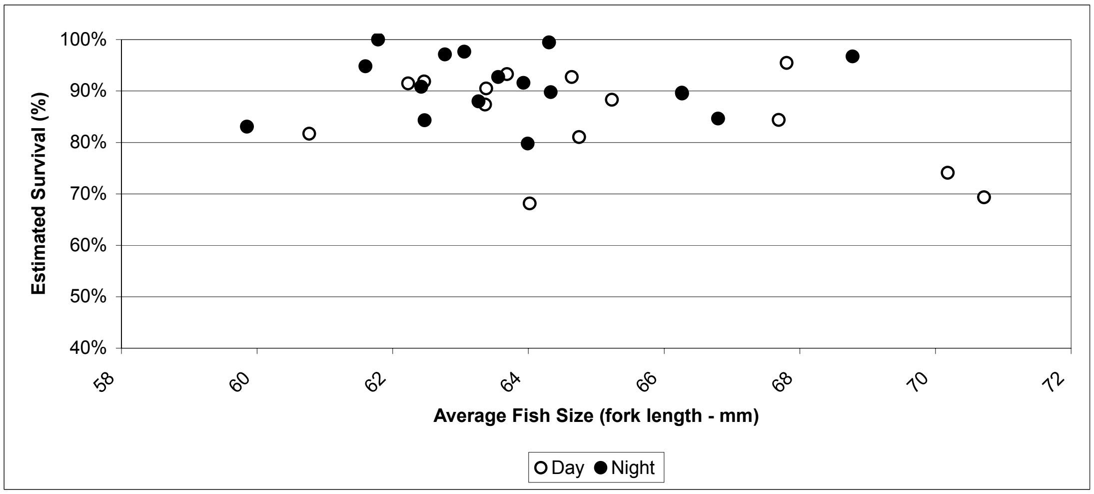


Figure 12. Fish survival estimates for 31 experiments conducted during 2006. Comparisons are based on fish size, and day/night parameters.

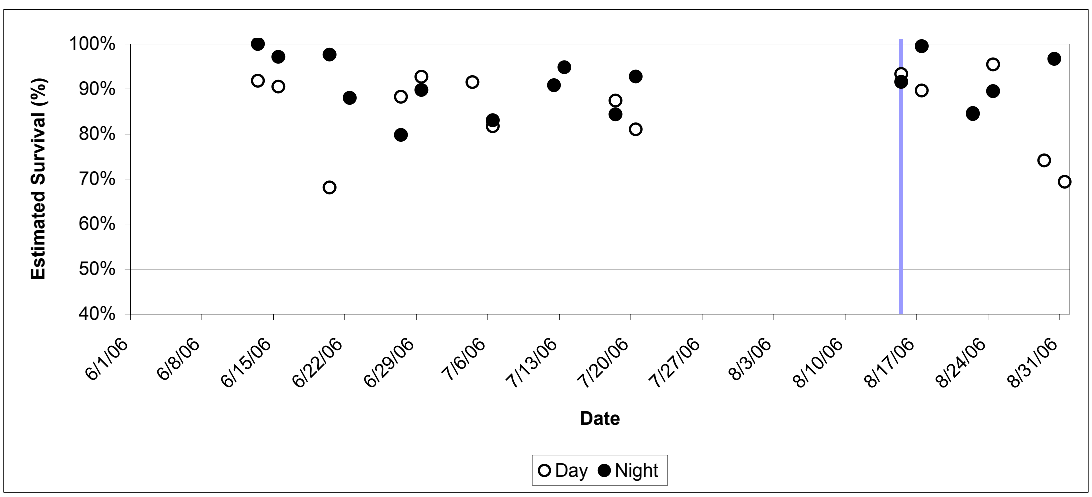


Figure 13. Fish survival estimates for 31 experiments conducted during 2006. Comparisons are based on date of experiments and day/night parameters. Vertical line depicts weir blocks removal date.

Experiments conducted after the weir blocks were removed suggested that there may have been a slight increase in estimated fish survival, although two daytime experiments resulted in two of the three of the lowest fish survival for the season (Figure 13).

As discussed during prior TOC meetings, the fish mark/recapture survival experiments probably result in higher survival estimates than would be expected to occur for wild juvenile salmon migrating past the site. This circumstance is attributable to the fact that wild fish exhibit a more-protracted migration timing and do not migrate *en masse* like the simultaneous release of hundreds of marked hatchery fish for the short-term survival experiments. Predatory fish in the GCID oxbow channel could more readily consume greater numbers of wild fish “trickling” downstream through the oxbow as compared to an instantaneous release of hundreds of juvenile salmon that move rapidly past the site during a very short period. Seasonally, large numbers of wild fish enter the oxbow inlet channel and become concentrated into a lesser amount of flow by the time the fish pass the flow-control weir because the majority of water is removed from the channel through the fish screens. Notably, this time period includes the early portion of endangered juvenile winter-run Chinook salmon migration (Vogel 2006).

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 2006. The intent was to determine potential differences between estimated survival rates of test fish released upstream of the fish screens and fish released downstream of the weir. There was also a concern that a small portion of fish released upstream of the screens could swim in an upstream direction out of the inlet 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 would provide additional data and insights into fish behavior and potential fish mortality. All 31 experiments had greater than 50% recapture efficiencies to estimate survival rates for fish released just downstream of the weir (Figure 14).

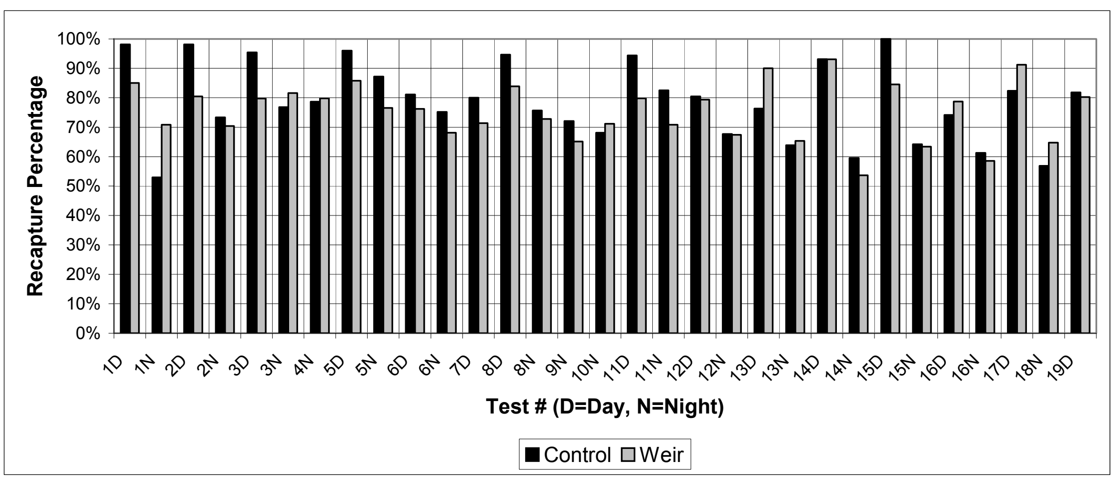


Figure 14. Comparison of the proportion of control fish recaptured with the proportion of weir fish recaptured for each of 31 tests in 2006. Labels on the X-axis refer to experiment number and day/night designation, respectively. All tests were performed with a closed bypasses and a FPEMP test matrix number of three (based on pump flow).

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. There were nine instances where greater than 100% survival was estimated and survival estimates using either method previously described resulted in a maximum difference of about 4%. 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 31 experiments meeting that criterion, the results indicate that there was an incremental source of fish mortality between the test, weir, and control fish release sites (Table 4). These results suggest that about 53% of the overall fish mortality occurred just downstream of the flow-control weir during the 2006 tests. In 2003, 2004, and 2005 approximately 45%, 72%, and 84%, respectively, of the overall fish mortality was estimated to have occurred just downstream of the weir (Vogel 2005a, 2005b, 2006). In all years, predatory fish were observed downstream of the weir where the concrete structure flares out into the oxbow outlet channel. Additionally, underwater videography taken below the weir in 2005 showed that striped bass were found in the area just downstream of the fish screen internal bypass outfall. During 2005, 16 acoustic-tagged juvenile salmon were released into the internal fish screen bypasses; 100% of those fish were eaten by predatory fish just downstream of the flow-control weir (Vogel 2006). However, unlike prior years, fish survival for fish released downstream of the weir in 2006 increased later in the testing season (after the weir blocks had been removed).

Table 3. Comparison of the average proportion of weir fish recaptured with the average proportion of control fish recaptured[1] in 2006 (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 = 15 92% (94.3%) 82%-100% (82%-118%)	Number of tests = 16 95.7% (99.6%) 85.8%-100% (85.8%-133.8%)	Number of tests = 31 93.9% (97%) 82%-100% (82%-133.8%)

[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)

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

Table 4. Comparison of the average proportion of test fish and weir fish recaptured with the average proportion of control fish recaptured for 2006 (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 = 15**	**85.3%** **68.1%-95.5%**	**92%** **82%-100%**	**6.7%** **-8.5% - +28.8%**
Night **Number of tests = 16**	**91.2%** **79.8%-100%**	**95.7%** **85.8%-100%**	**4.5%** **-9.4% - +14.6%**
Overall **Number of tests = 31**	**88.4%** **68.1%-100%**	**93.9%** **82%-100%**	**5.5%** **-9.4% - +28.8%**

[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)

Comparisons between Years

Four years of concurrent testing for overall fish survival and fish survival downstream of the flow-control weir have been completed. Summaries of those results are provided in Table 5 and Figures 15 and 16. The survival for fish traversing the length of the fish screens down to the weir was estimated by comparing results for test and weir groups of fish. Although overall test fish survival declined from 2003 to 2005, fish survival increased in 2006 and was the highest among the four years of testing. A consistent pattern of declining fish survival during the summer months was evident during 2003 to 2005, but not evident in 2006 (Figures 15 and 16). Observations of predation were noted during the 2003 and 2004 testing seasons (Carly 2005) and again during 2005 and 2006 which is believed to be the primary source of fish mortality. Removal of the weir blocks in August 2006 may have improved fish survival by reducing predation but too few experiments were conducted after the weir was removed to provide compelling evidence to support that premise. Therefore, the TOC decided on September 8, 2006, that additional experiments with the weir blocks removed should be conducted during the ongoing evaluations.

Table 5. Comparison of juvenile salmon fish survival estimates in the GCID oxbow for the mark/recapture tests, 2003 – 2006.			
Year	**Overall Test Fish Survival**	**Overall Weir Fish Survival**	**Estimated Survival Along Screens**
2003	86 %	91 %	95%
2004	81 %	86 %	95%
2005	80 %	83 %	97%
2006	88 %	94 %	94%

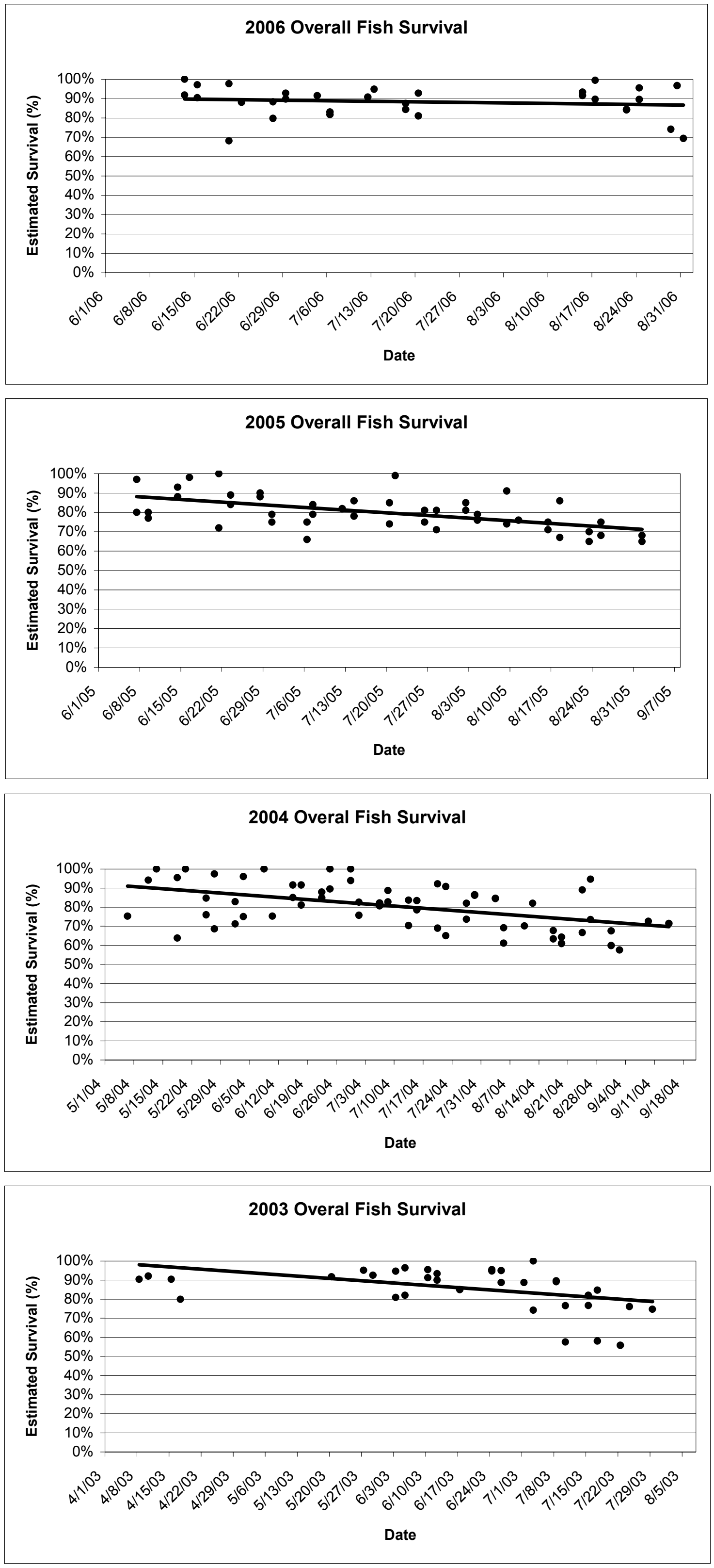


Figure 15. Comparison of overall juvenile salmon survival for test fish released upstream of the screens as estimated by mark/recapture studies at the GCID fish screens during 2003 through 2006.

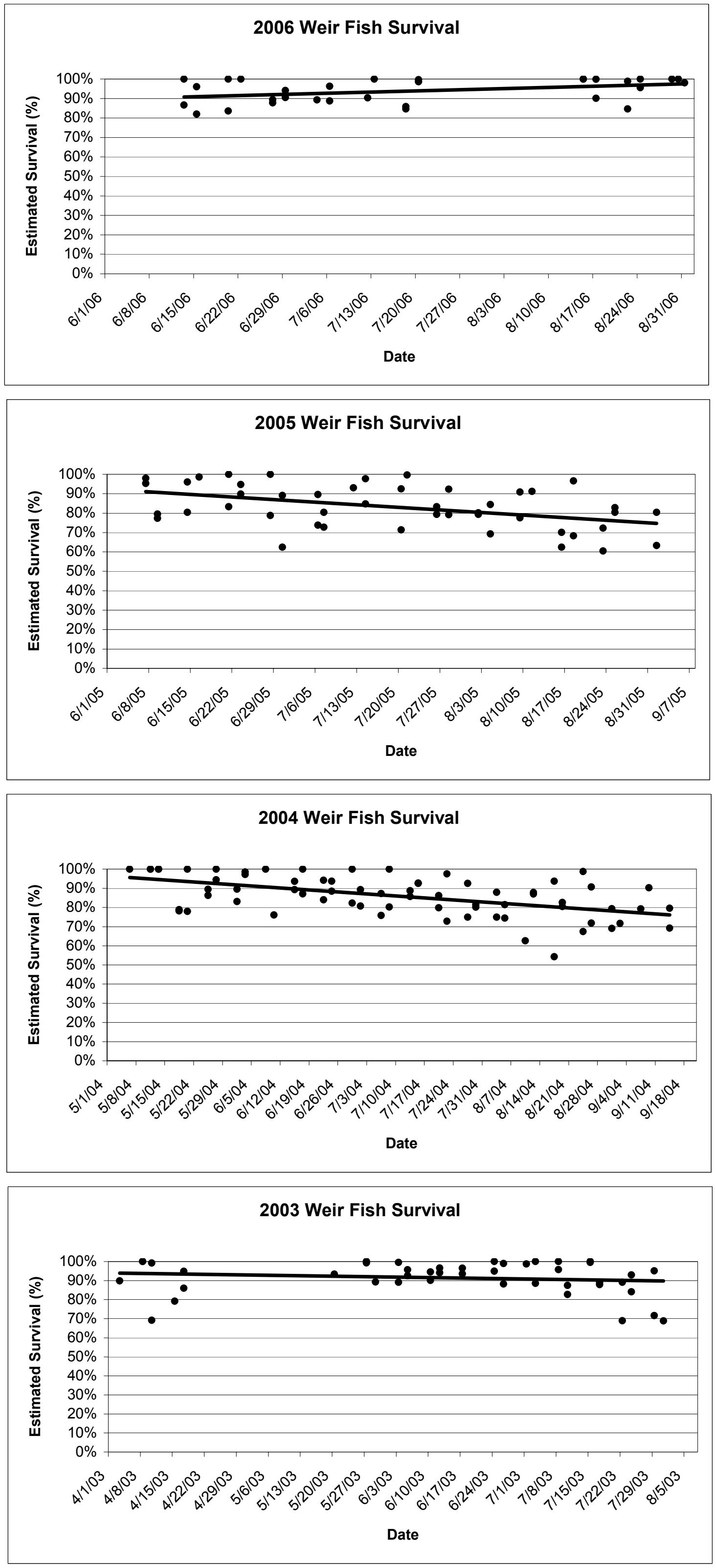


Figure 16. Comparison of juvenile salmon survival downstream of the flow-control weir as estimated by mark/recapture studies at the GCID fish screens during 2003 through 2006.

As described by the FPEMP Guidance Manual, efforts should be made to determine how to significantly reduce fish mortality occurring at the site.[4] Based on information developed to date, it appears that conditions immediately downstream of the weir (when the weir blocks are in place) create an ideal environment for predation on juvenile salmon. Due to high velocities, predatory fish are unlikely to migrate upstream over the weir and may accumulate in areas just downstream. Downstream-migrating juvenile salmon become concentrated in lesser amount of flow because of water diverted through the fish screen and are likely disoriented in the turbulence below the weir. Those juvenile salmon passing through the internal bypasses would be more vulnerable to predation because the fish exit the bypasses into an area where predatory fish can be concentrated. These circumstances make the salmon more vulnerable to predation than compared to a natural riverine environment. On September 8, 2006, the TOC initially contemplated implementing a measure of intermittent, temporary removal of predatory fish at the weir and upstream of the screens where significant predation activity has frequently been observed (Figure 17). However, this potential action was subsequently deemed unfeasible primarily due to regulatory constraints. The TOC suggested measures such as depicted in Figure 18 that could ultimately be implemented to reduce or eliminate predator holding habitat.

Figure 17. Concentrations of predatory fish near the GCID fish screen.

[4] "If lower than expected fish survival and passage conditions are determined as a result of the field tests, the testing protocols are designed to determine where problem areas occur so that site-specific conditions can be improved." (Montgomery-Watson et al. 2000).

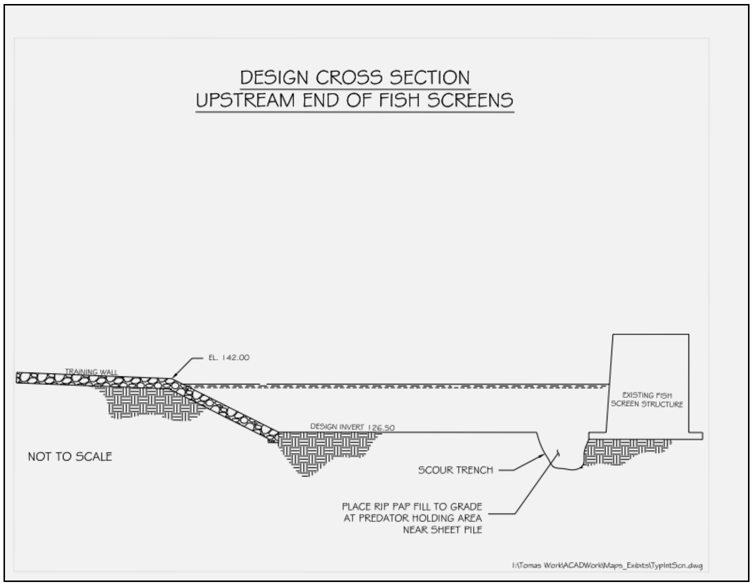


Figure 18. Example measure to reduce predatory fish holding habitat in the vicinity of the GCID fish screens.

FPEMP Test Matrix

Table 6 shows the categories where the 31 tests performed during 2006 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 6. Range of conditions occurring during the fish survival experiments conducted during 2002, 2003, 2004, 2005, and 2006. Testing categories nos. 1-4 are based on pump flow. Note: Bypasses were closed throughout the 2006 testing period.

FPEMP Guidance Manual Test Condition (Pump Only)	Bypasses Open								Bypasses Closed									
	Day				Night				Day					Night				
	02	03	04	05	02	03	04	05	02	03	04	05	06	02	03	04	05	06
No. 1 (500-1,000 cfs) (high river)	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
No. 2 (>2,600 cfs)	1	0	1	1	2	0	1	1	5	0	1	0	0	4	0	1	0	0
No. 3 (1,800-2,600 cfs)	4	10	10	6	4	10	10	7	9	7	15	16	15	10	5	15	14	16
No. 4 (500-1,000 cfs) (low river)	0	0	3	0	0	0	5	0	0	0	0	1	0	0	3	1	1	0

RECOMMENDATIONS

Based on results of experiments performed during 2002 through 2006 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 2007.

- Initiate mark/recapture experiments as early as possible in the spring and conduct the tests weekly into September (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.

- Continue to use late-fall Chinook salmon fry from Coleman National Fish Hatchery for the experiments.

- Conduct all of the mark/recapture tests during 2007 with the flow-control weir blocks removed and internal fish screen bypasses closed.

- Place covers over the fish screen bypass outfall exits 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

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

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Appendix A. GCID fish survival test results for 2006.								
	Time of	Bypass	Screen Group		Weir Group		Control Group	
Date	Release	Position	Rel.	Recap.	Rel.	Recap.	Rel.	Recap.
6/13/06	Day	Closed	749	675	374	318	375	368
6/13/06	Night	Closed	750	523	374	265	374	198
6/15/06	Day	Closed	750	666	374	301	375	368
6/15/06	Night	Closed	747	532	375	264	375	275
6/20/06	Day	Closed	747	486	375	299	375	358
6/20/06	Night	Closed	708	531	375	306	375	288
6/22/06	Night	Closed	741	513	372	297	375	295
6/27/06	Day	Closed	747	633	374	321	374	359
6/27/06	Night	Closed	746	519	375	287	375	327
6/29/06	Day	Closed	745	560	371	283	375	304
6/29/06	Night	Closed	748	505	373	254	375	282
7/4/06	Day	Closed	746	546	374	267	375	300
7/6/06	Day	Closed	746	577	373	313	374	354
7/6/06	Night	Closed	748	470	372	271	374	283
7/12/06	Night	Closed	736	482	347	226	373	269
7/13/06	Night	Closed	680	439	371	264	373	254
7/18/06	Day	Closed	606	500	372	297	375	354
7/18/06	Night	Closed	750	522	343	243	361	298
7/20/06	Day	Closed	739	482	374	297	374	301
7/20/06	Night	Closed	706	443	322	217	371	251
8/15/06	Day	Closed	694	494	350	315	367	280
8/15/06	Night	Closed	721	422	375	245	374	239
8/17/06	Day	Closed	723	604	375	349	367	342
8/17/06	Night	Closed	744	441	356	191	292	174
8/22/06	Day	Closed	653	551	375	317	286	286
8/22/06	Night	Closed	745	402	372	236	374	240
8/24/06	Day	Closed	456	323	372	293	372	276
8/24/06	Night	Closed	746	409	357	209	369	226
8/29/06	Day	Closed	634	387	375	342	352	290
8/30/06	Night	Closed	735	404	372	241	373	212
8/31/06	Day	Closed	749	425	375	301	374	306