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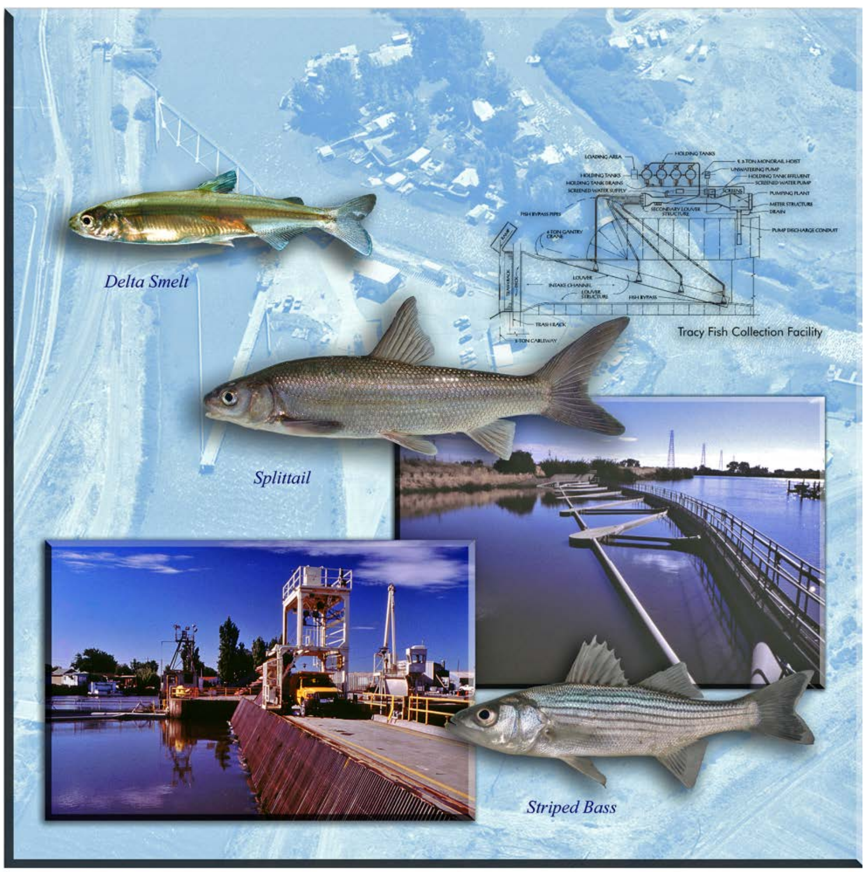
Tracy Series Volume 46

Use of Acoustic Telemetry to Estimate Striped Bass Residence Time and Identify Most Utilized Holding Locations within the Tracy Fish Collection Facility



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14. ABSTRACT Acoustic telemetry was employed to determine striped bass (*Morone saxatilis*) residence time and identify most utilized striped bass holding locations within the Tracy Fish Collection Facility (TFCF). On average (± 95% confidence interval [CI]), striped bass residence time was 75.4 ± 30.6 d (range = 0.01–289.7 d). Regression analysis of number of days present inside the TFCF versus striped bass body size (fork length) showed little statistical significance in the relationship between the two variables ($r^2 = 0.028$ and $P = 0.343$) indicating smaller fish (≤ approximately 500 mm FL) had the opportunity to swim out through the trashrack spacing but remained in the facility. On average (± 95 percent CI), acoustic tagged striped bass were located in the upper primary channel (44.8 ± 13.9), middle primary channel (10.0 ± 4.3), lower primary channel (2.7 ± 1.5), bypass tubes (8.7 ± 7.2), and secondary channel (33.8 ± 16.3) during percent of tracking attempts. Prolonged striped bass residence time suggests velocities in the primary channel, bypass tubes, and secondary channel are not fast enough to guide striped bass into holding tanks; therefore, in order to remove these fish and reduce residence time within the facility, predator removal techniques should be further investigated, refined, and implemented at the TFCF. Results of this study suggest future predator removal efforts should be concentrated in the upper primary channel and secondary channel, which were the areas of the facility where the majority of acoustic detections occurred.

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Use of Acoustic Telemetry to Estimate Striped Bass Residence Time and Identify Most Utilized Holding Locations within the Tracy Fish Collection Facility

Tracy Series Volume 46

by

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Fish photography by René Reyes, Tracy Fish Collection Facility, Tracy, California.
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EXECUTIVE SUMMARY

The Tracy Fish Collection Facility (TFCF; Bureau of Reclamation [Reclamation], Byron, California) is responsible for salvaging fish ≥ 20 mm fork length (FL) from the Sacramento-San Joaquin River Delta (Delta) water destined for export through the C.W. "Bill" Jones Pumping Plant (JPP) and Delta-Mendota Canal (DMC). Striped bass (*Morone saxatilis)*—a nonnative fish species introduced into the San Francisco Bay estuary in 1879 (Dill and Cordone 1997)—are the most abundant large piscivorous fish at the TFCF (Sutphin *et al.* 2014) where they contribute towards predation of smaller entrained fish and negatively impact salvage rates (Liston *et al.* 1994, Fausch 2000). Fish that are potentially preyed upon within the TFCF include native species listed as threatened or endangered under the Endangered Species Act, such as delta smelt (*Hypomesus transpacificus),* winter-run and spring-run Chinook salmon (*Oncorhynchus tshawytscha),* and steelhead trout (*O. mykiss)*. To improve salvage efficiency it is necessary to minimize fish loss from predation; therefore, Reclamation is investigating certain aspects of striped bass behavior within the TFCF, such as residence time and most utilized holding locations, in an effort to obtain information that may be used to further develop or refine predator removal techniques and procedures.

Uniquely encoded acoustic transmitters (Sonotronics, Inc., Tucson, Arizona) were surgically implanted in 38 wild striped bass (284–542 mm FL) collected from the TFCF. Due to tag failure and infection, only 33 of these fish were released. After release, acoustically tagged striped bass were periodically tracked (generally once per day) in the TFCF until fish were recaptured, determined to have left the proximity of the facility, or the transmitter battery life expired. On average (± 95 percent confidence interval [CI]), residence time of acoustically tagged striped bass within the TFCF was 75.4 ± 30.6 d. Regression analysis of the number of days present inside the TFCF versus acoustic tagged striped bass body size (FL) was not significant (P= 0.343). On average (± 95 percent CI), acoustic tagged striped bass were located in the upper primary channel, middle primary channel, lower primary channel, bypass tubes, and secondary channel during 44.8 ± 13.9, 10.0 ± 4.3, 2.7 ± 1.5, 8.7 ± 7.2, and 33.8 ± 16.3 percent of tracking attempts, respectively.

Prolonged striped bass residence time within the TFCF suggests that velocities in the primary channel, bypass tubes, and secondary channel are not fast enough to guide striped bass into holding tanks; therefore, in order to remove these fish and reduce residence time within the facility, predator removal techniques should be further investigated, refined, and implemented at the TFCF. Since the majority of acoustic detections were in the upper primary channel and in the secondary channel, it is recommended that future predator removal efforts be concentrated in these areas of the facility.

INTRODUCTION

The Tracy Fish Collection Facility (TFCF; Bureau of Reclamation [Reclamation], Byron, California; Figure 1) is responsible for salvaging fish ≥ 20 mm fork length (FL) from the Sacramento-San Joaquin River Delta (Delta) water destined for export through the C.W. “Bill” Jones Pumping Plant (JPP) and Delta-Mendota Canal (DMC). Striped bass (*Morone saxatilis)*—a nonnative fish species introduced into the San Francisco Bay estuary in 1879 (Dill and Cordone 1997)—are the most abundant large piscivorous fish at the TFCF (Sutphin *et al.* 2014) where they contribute towards predation of smaller entrained fish and negatively impact salvage rates (Liston *et al.* 1994, Fausch 2000). Fish that are potentially preyed upon within the TFCF include native species listed as threatened or endangered under the Endangered Species Act, such as delta smelt (*Hypomesus transpacificus),* winter-run and spring-run Chinook salmon (*Oncorhynchus tshawytscha),* and steelhead trout (*O. mykiss).* To improve salvage efficiency it is necessary to minimize fish loss from predation. In an effort to obtain information that may be used to further develop or refine predator removal techniques at the TFCF, acoustic telemetry—“the use of an acoustic transmitter attached to or implanted in an aquatic animal to locate and gather information about its presence, movements, and behavior in the underwater environment” (Pincock and Johnston 2012)—was used to determine striped bass residence time, as well as the most utilized striped bass holding locations, within the facility.

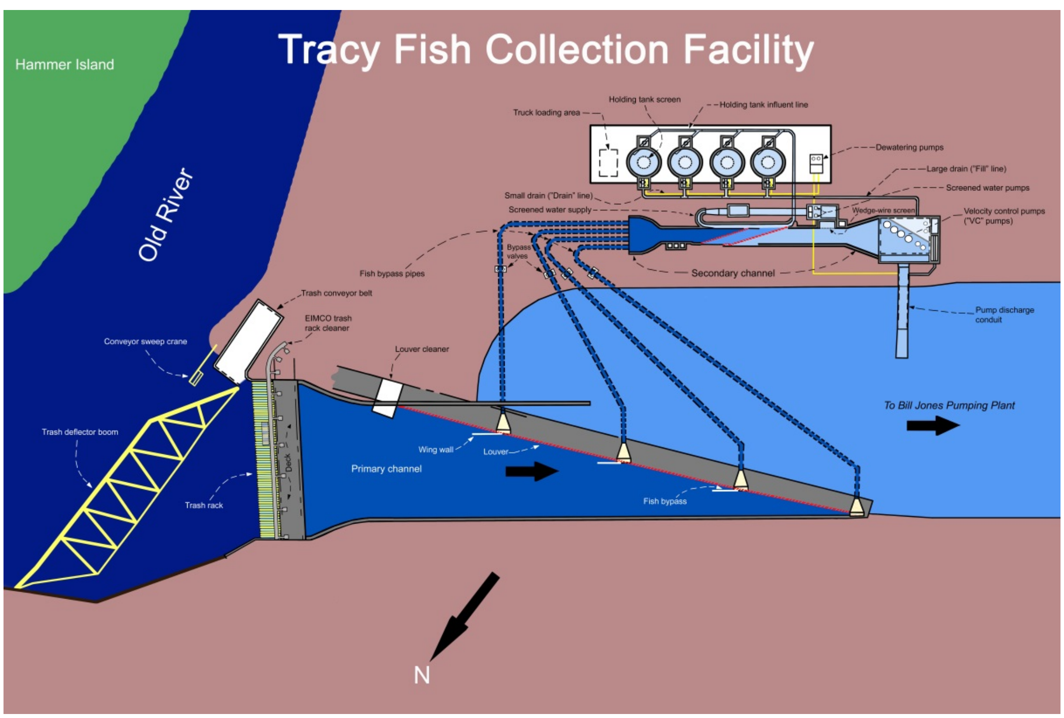

Figure 1.—Diagram of the Tracy Fish Collection Facility (Bureau of Reclamation, Byron, California) showing major facility components, including the trash rack, primary channel, bypass tubes, secondary channel, and holding tanks.

METHODS

Thirty-eight wild striped bass (284–542 mm FL) were collected from the TFCF by angling and equipped with internally implanted acoustic transmitters (Sonotronics Inc., Tucson, Arizona). After a post-surgery recovery and withdrawal period, all surviving striped bass that were void of infection and had working acoustic transmitters (33 fish) were released within the TFCF and tracked throughout the facility to determine residence time as well as most utilized holding locations.

Three models of acoustic transmitters were used based on size of fish: IBT-96-5 (36 mm × 13 mm, 3.2 g, range of 500 m, > 5 month battery life), IBT-96-9 (47 mm × 10.5 mm, 5 g, range of 500 m, 9 month battery life), and CHP-87-S (65 mm × 18 mm, 8 g, range of 1,000 m, 7 month battery life; Figure 2). In general, the IBT-96-5 and IBT-96-9 acoustic transmitters were used for striped bass < 450 mm FL, while the CHP-87-S acoustic transmitter was used for fish ≥ 450 mm FL. Each acoustic transmitter was programmed by the manufacturer to have a unique frequency and code, which allowed for the distinction between acoustically tagged fish. Transmitters were also modified by the manufacturer to reduce the range of each transmitter to less than 100 m, which helped to extend battery life as well as isolate acoustic signals when noise levels were high due to water turbulence, bubbles, and echoes within the steel and concrete structures of the TFCF (Sonotronics, Inc. 2005, personal communication).

Figure 2.—Acoustic transmitters (Sonotronics, Inc., Tucson, Arizona) used for tracking striped bass at the Tracy Fish Collection Facility (Bureau of Reclamation, Byron, California). From left to right: IBT-96-5, IBT-96-9 (Sonotronics 2010), and CHP-87-S.

Striped bass were held in captivity for approximately 30 d prior to implantation of acoustic transmitters. Techniques for surgical implantation of acoustic transmitters were adopted from demonstrations given by California Fish and Wildlife (Derek Stein 2004, personal communication). Prior to surgery, acoustic transmitters were cleaned with 70% isopropyl alcohol (Vi-Jon, Smyrna, Tennessee), dipped in hot beeswax (Yaley Enterprises, Inc., Redding, California) to improve retention (Tyus 1988, Helm and Tyus 1992), and cooled to room temperature. A 100 mg/L tricaine methanesulfonate (MS-222; Finquel®; Argent Chemical Laboratories, Redmond, Washington) anesthetic-water mix was used to anesthetize striped bass. Following anesthetization, striped bass were transported to the surgery station (Figure 3) and a 100 mg/L MS-222 solution was continuously pumped across the gills with a common poultry baster to maintain anesthesia. If necessary, fresh water was also periodically dispensed across the gills to control the extent of anesthesia reached. Using a No. 10 stainless steel

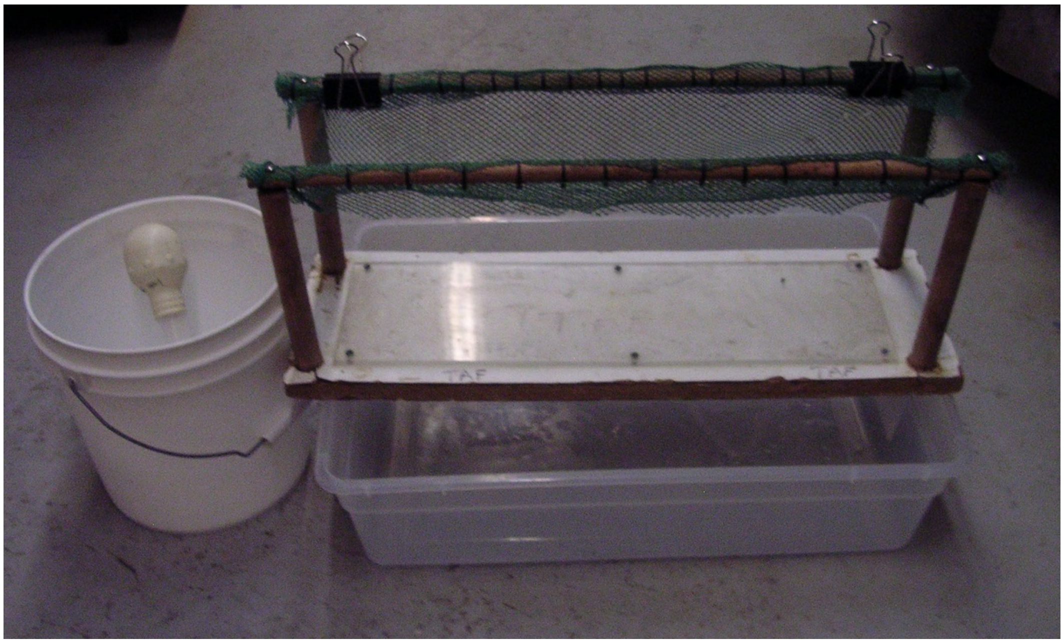

Figure 3.—Surgery station used during implantation of acoustic transmitters in striped bass.

surgical blade (Feather Safety Razor Co., Ltd., Osaka, Japan) attached to a No. 3 scalpel handle (Aspen Surgical™ Products, Caledonia, Michigan), a 2–3 cm incision was made between the anal and pelvic fins offset from the bottom centerline of the fish (Figure 4). The acoustic transmitter was then carefully inserted into the peritoneal cavity. The incision was closed using absorbable violet monofilament sutures (PDS*II; Ethicon, Inc., Cincinnati, Ohio) with 3 to 4 surgeon's square knots (Ethicon, Inc. 2005). A 10 percent povidone-iodine solution (Betadine®; The Purdue Frederick Company, Stamford, Connecticut) and a triple antibiotic ointment (Neosporin®; Johnson & Johnson Consumer Companies Inc., New Brunswick, New Jersey) were applied to the incision. Each surgery took between 5–10 min after which all striped bass were weighed (g) and measured (mm FL). The transmitter to body weight ratio was kept below the generally accepted 2% (Winter 1983, Winter 1996). Immediately after the surgical procedure, numbered T-bar anchor floy tags (FD-68B) were subcutaneously attached near the dorsal fin of each striped bass for visual identification during routine facility activities. Acoustically tagged striped bass were then placed in either 1,514-L (400-gal) circular fiberglass tanks (Frigid Units, Inc., Toledo, Ohio) or 1,325-L (350-gal) plastic tanks (Pentair Aquatic Ecosystems, Apopka, Florida) containing aerated well water. In order to allow

Figure 4.—Typical size and location of incisions made during surgical implantation of acoustic transmitters (Sonotronics, Inc., Tucson, Arizona) in striped bass.

the fish to fully recover from handling and surgery, as well as to prevent the ingestion of MS-222 in the event that a tagged fish should be caught and consumed by anglers (Moore *et al*. 1990, Kelsch and Shields 1996), it was necessary to allow a post-surgery recovery and withdrawal period of at least 21 d before release. During this period, 1-h daily salt baths (15–17 g/L) were administered and tanks were gradually switched from well water to treated (filtered, ultraviolet sterilized, and ozonated) Delta water to acclimate fish prior to release.

Both active tracking—the use of manned, mobile receivers for precise real-time tracking—and passive tracking—the use of stationary automated receivers for long-term detections and logging of deployed transmitters—were used during the course of this study. Equipment used to actively detect hydroacoustic signals consisted of USR-96 narrow band receivers (Sonotronics Inc., Tucson, Arizona), portable speakers (Model 40-1441, Radio Shack Corporation, Fort Worth, Texas), coaxial cables with BNC connectors (Sonotronics Inc., Tucson, Arizona), and DH-4 directional hydrophones (Sonotronics Inc., Tucson, Arizona) attached to 3–6-m (10–20-ft) aluminum poles (Duraframe Dipnet, Viola, Wisconsin; Figure 5). The DH-4 directional hydrophones were modified by placing a foam-rubber beverage can holder on the inside bell of the hydrophone and adhering it in place with duct tape to reduce the receiver's beam width, thus increasing the directionality to isolate acoustic signals (Mueller 2005, personal communication). Submersible ultrasonic receivers (SURs; Model SUR-1, Sonotronics Inc., Tucson Arizona; Figure 6)—long life data logging receivers that are compatible with

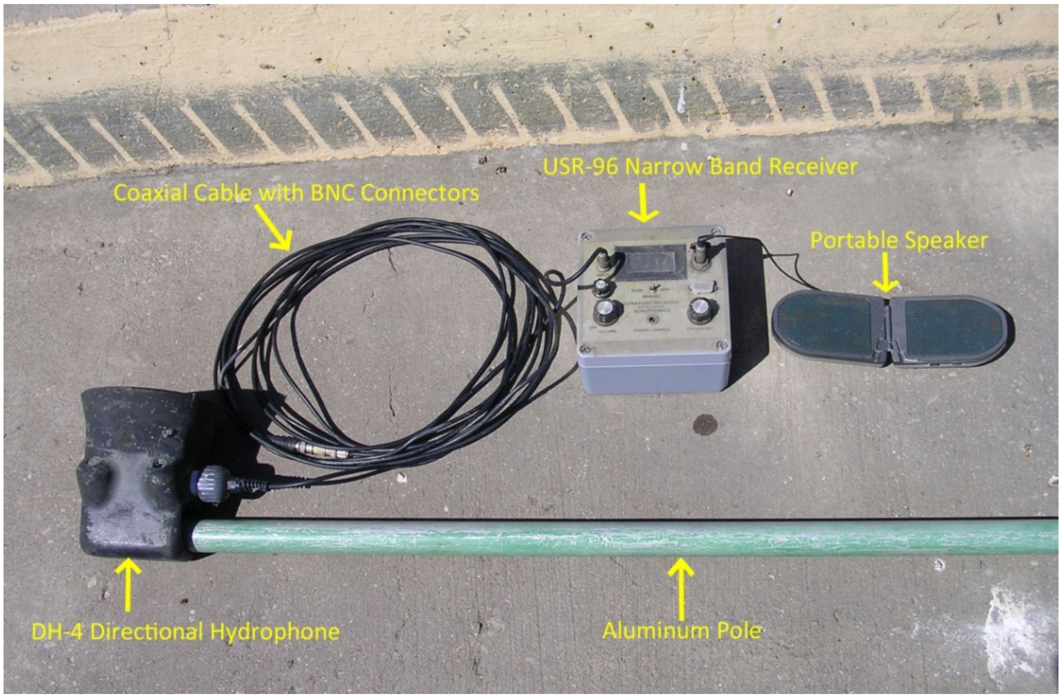

Figure 5.—Equipment used to actively track striped bass containing surgically implanted acoustic transmitters (Sonotronics, Inc., Tucson, Arizona) at the Tracy Fish Collection Facility (Bureau of Reclamation, Byron, California).

Figure 6.—Example of Model SUR-1 submersible ultrasonic receiver used for automated passive detection of acoustically tagged striped bass at the Tracy Fish Collection Facility (Bureau of Reclamation, Byron, California).

Sonotronic Inc. acoustic transmitters—were installed for automated passive detection of acoustically tagged striped bass once they moved out of the primary louver channel. A total of four SUR-1s were installed: one SUR was placed in the canal downstream of the primary louver channel, one inside the secondary louver channel, and one in each of two holding tanks actively used to retain fish during normal TFCF operations (Figure 7).

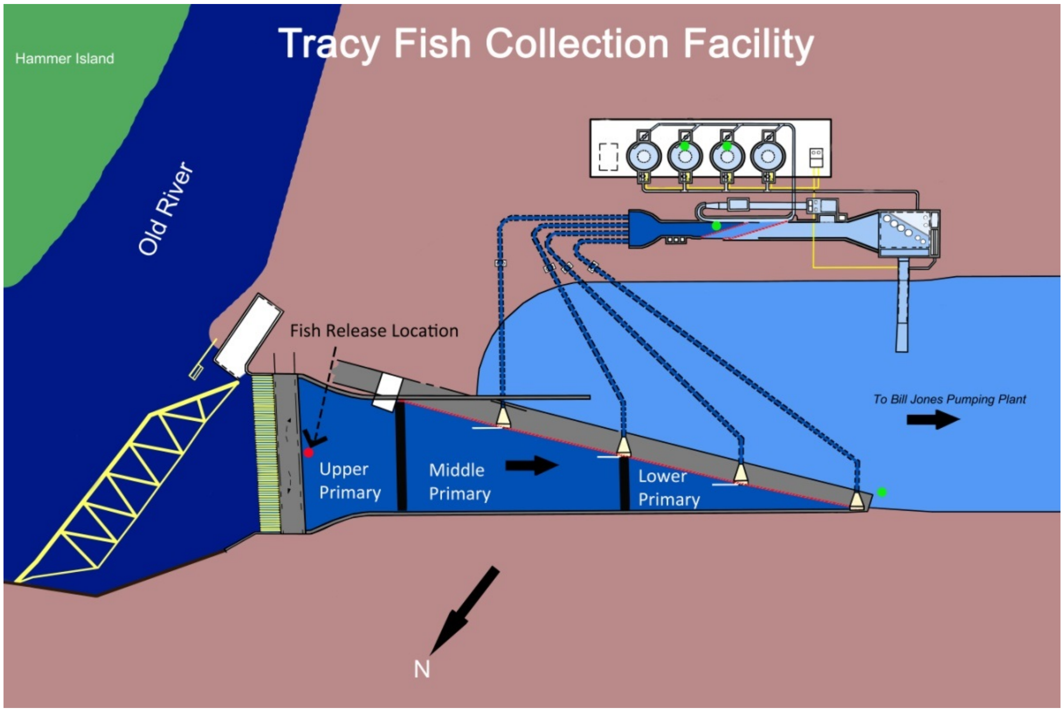

Figure 7.—Diagram of the Tracy Fish Collection Facility (Bureau of Reclamation, Byron, California) showing deployment locations of four submersible ultrasonic receivers (green dots), fish release location (red dot), and division of primary channel into three sections: 1) upper primary channel (from the trash rack to the beginning of the primary louver array), 2) middle primary channel (from the beginning of the primary louver array to the entrance to the second bypass tube),and 3) lower primary channel (from the entrance of the second bypass tube to the entrance to the fourth bypass tube).

Implanted tags were verified to be functioning properly and then fish were released (water-to-water transfer) into the primary channel, downstream of the center of the trash rack deck (Figure 7), using ropes attached to either 75.7-L (20-gal) or 170.3-L (45-gal) plastic containers. Acoustically tagged striped bass were then actively tracked continuously for several hours following release, and daily thereafter, by placing a hydrophone at three or more locations inside each area of the TFCF in an effort to best triangulate position based on maximum strength of signal. The holding tank was actively monitored daily prior to fish haul-outs to determine transmitter frequency of any acoustically tagged striped bass that were present. Striped bass collected in the holding tanks were removed from the study and not re-released. Data logged on SUR-1s was downloaded weekly and used in conjunction with active tracking data. It was assumed that all acoustic tags detected during this study were still in striped bass and had not been expelled from the body cavity.

During active tracking, acoustic tagged striped bass detected in the primary channel were determined to be within one of three specific sub-areas: 1) upper primary channel (from the trash rack to the beginning of the primary louver array), 2) middle primary channel (from the beginning of the primary louver array to the entrance to the second bypass tube), and 3) lower primary channel (from the entrance of the second bypass tube to the entrance to the fourth bypass tube; Figure 7). This was done to determine if acoustically tagged striped bass utilized any portion of the primary channel more than the others.

Data Analysis

Residence time within the TFCF was determined by calculating and summing the amounts of time fish held in each area of the facility until they were verified to have left by active tracking and/or data logged on SURs. Fish exited the facility by being collected in a holding tank, moving downstream through the primary louvers, being removed from the TFCF during routine facility predator removal efforts, and possibly by moving upstream through the trash rack. Linear regression (Minitab version 15) was used to determine if total residence time within the TFCF could be predicted based on body size (FL) of acoustic tagged striped bass.

The percentage of tracking attempts in which each acoustically tagged striped bass was detected in the upper primary channel, middle primary channel, lower primary channel, and secondary channel was determined and used to calculate average (± 95 percent confidence interval [CI]) usage of each area of the TFCF. The percent of time that each striped bass spent in the bypass tubes was also estimated based on deductive reasoning. To do this, it was necessary to assume acoustically tagged striped bass were holding in one of the bypass tubes if fish returned to the primary channel after previous tracking attempts, as well as data logged on SURs, yielded no detections in the primary channel, secondary channel, upstream of the TFCF, or downstream of the TFCF. In these cases, periods of time between disappearance from the primary channel and return to the primary channel were summed to determine the percentage of tracking attempts in which each striped bass was in the bypass tubes. This data was then used to estimate the average (± 95 percent CI) proportion of time that striped bass predators spend in the bypass tubes at the TFCF. The average proportion of time that each area of the TFCF was used was then compared to determine locations within the facility that may be more utilized by striped bass predators.

RESULTS AND DISCUSSION

Of the 38 striped bass implanted with acoustic tags, no fish died or lost their tags during the 21 d recovery and withdrawal period. Despite this, 4 fish were determined to have tags that failed and 1 fish developed an infection; therefore, only 33 striped bass were released and tracked within the TFCF until they exited the facility, were recaptured, or the transmitter battery life expired. Of these, 15 acoustically tagged striped bass (45.5 percent) were removed in the holding tanks, 1 (3.0 percent) was removed from the primary channel during gill netting efforts, 1 (3.0 percent) was removed from the secondary channel during predator removals, 5 (15.2 percent) passed downstream of the TFCF into the intake canal of the JPP (presumably during cleaning of primary louvers when each of the 36 louver panels is lifted, sprayed clean of debris, and replaced), and 4 (12.1 percent) resided in the TFCF until the battery life of the transmitter expired. The fates of 7 acoustically tagged striped bass (21.2 percent) were unknown. However, considering the size of these fish (all were ≤ 500 mm FL and could therefore fit through the 50.8–57.2 mm [2.0–2.25 in] trashrack spacing; TFCF 2010, unpublished data), the lack of detections on stationary SURs located downstream of the primary channel, in the secondary channel, and in the holding tanks, and the relatively short detection period in the TFCF system, it is likely these fish either exited the facility by swimming upstream through the trash rack or had acoustic tags that failed prematurely. No acoustically tagged striped bass were detected moving from the primary channel to the intake canal of the JPP (downstream of the primary louvers) and back upstream into the primary channel, suggesting the extent of striped bass replenishment from downstream of the primary channel during cleaning of the louvers is minimal. Two acoustically tagged striped bass moved from the primary channel into the secondary channel, then back into the primary channel, which suggests striped bass residing within the TFCF utilize different locations within the facility, and the removal of predators from one location may have an effect on the number of predators in other locations (i.e. removal of fish from the secondary channel would ultimately decrease the number of predators that utilize the primary channel).

Acoustically tagged striped bass resided within the TFCF for up to 289 d. On average (± 95 percent CI), residence time of acoustically tagged striped bass in the TFCF was 75.4 ± 30.6 d. It should be noted that residence time was likely biased low during this study due to the expiration of acoustic transmitters and the premature removal of acoustically tagged striped bass during predator removal efforts. Despite this, the prolonged residency of acoustically tagged striped bass suggests that channel velocity is not fast enough to guide striped bass into holding tanks and that other methods must be employed to remove striped bass from the TFCF.

Regression analysis of the number of days present inside the TFCF versus striped bass body size (FL) yielded a positive slope (Figure 8), although an r^2

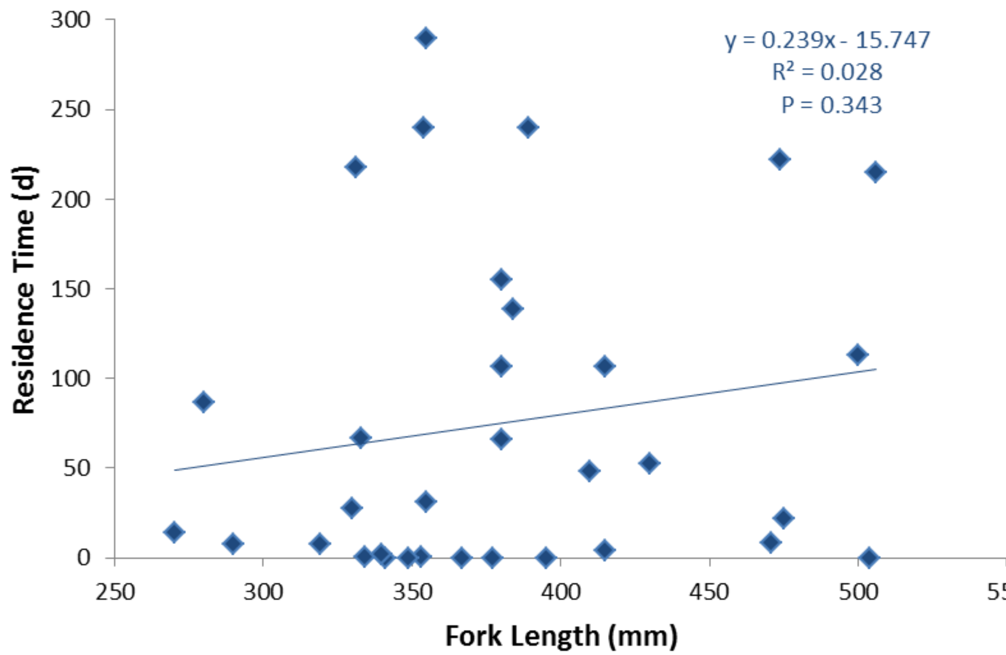

Figure 8.—Linear regression of residence time (days) within the Tracy Fish Collection Facility (Bureau of Reclamation, Byron, California) versus body size (fork length) of acoustically tagged striped bass.

value of 0.028 and p-value of 0.343 indicate little statistical significance in the relationship between the two variables. This result is contrary to what would be expected because smaller fish (≤ approximately 500 mm FL) had the opportunity to swim out through the trashrack since the clear spacing between the bars is approximately 50.8–57.2 mm (2.0–2.25 in; TFCF 2010, unpublished data). This suggests striped bass may have an affinity for the TFCF and supports that predator removal techniques should be further investigated, refined, and implemented at the facility.

On average (± 95 percent CI), acoustically tagged striped bass utilized the upper primary channel 44.8 ± 13.9 percent of the time, the middle primary channel 10.0 ± 4.3 percent of the time, and the lower primary channel 2.7 ± 1.5 percent of the time. The bypass tubes and secondary channel were utilized an average of 8.7 ± 7.2 percent and 33.8 ± 16.3 percent of the time, respectively. These results suggest that the locations within the TFCF that are most utilized by striped bass are the upper primary channel and secondary channel, which implies that, in order to improve salvage efficiency at the TFCF, future predator removal efforts should be concentrated in these areas of the facility.

RECOMMENDATIONS

This study found that striped bass have the ability to maintain residency within the TFCF for extended periods of time. Prolonged residency suggests that primary and secondary channel velocities are not fast enough to guide striped bass into holding tanks. Due to this, it is recommended that predator removal techniques such as angling, electrofishing, electrical guidance systems, chemical treatment, carbon dioxide treatment, or netting be further investigated and implemented at the TFCF as required by Action IV.4.1 of the 2009 National Marine Fisheries Service Biological Opinion and Conference Opinion on the Long-Term Operations of the Central Valley Project and State Water Project (NMFS 2009). Since the majority of acoustic detections were in the upper primary channel and in the secondary channel, it is recommended that future predator removal efforts be concentrated on these areas of the facility.

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