JUNE SUCKER RECOVERY IMPLEMENTATION PROGRAM

Post-stocking fate of June sucker in Utah Lake
2013 Annual Report

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Executive Summary

June sucker *Chasmistes liorus* is an endangered species endemic to Utah Lake UT. The lake historically supported 13 native fish species, but due to human interactions it now supports a suite of non-native species and only two natives, June sucker and Utah sucker *Catostomus ardens*. June sucker once were numerous throughout the lake but numbers declined in the late 1990s to as few as 300 wild individuals. Many factors contributed to their decline including overharvest, habitat degradation, and predation and competition by non-native species. Repatriation of hatchery produced fish is a primary recovery strategy for June sucker, but fate of stocked fish is not well known. The purpose of this study is to detail immediate post-stocking survival and dispersal of hatchery reared June sucker in Utah Lake.

In the first year of this study, 20 June sucker were surgically implanted with sonic tags and 10 fish were implanted with "dummy" tags. The acoustic tagged fish along with 1117 PIT tagged fish were released from the shoreline in two separate stocking events. A directional hydrophone and receiver were used to actively track fish and multiple submersible ultrasonic receivers that continuously scanned for tags were placed throughout the study area for passive tracking. Remote PIT scanners were utilized in the lake to scan PIT tagged fish. Kaplan-Meier survival estimates for each telemetry study were calculated based on the final fate of each acoustic tagged June sucker. Patterns of dispersal were assessed for individual fish by mapping active and passive tracking records in ArcView®.

Kaplan-Meier survival estimates were 0.58, 0.42, and 0.90 for late summer fish, early autumn fish, and dummy tagged fish respectively. In both stockings, fish dispersed into the pelagic (open water) zone of the lake proper. Mean daily movement was 1.73 km for late summer fish and 1.27 km for early autumn fish. A total of 69 PIT tag contacts representing 58 unique fish were recorded over the four month study period using remote PIT scanners.

Overall, fish stocked in late summer exhibited the greatest movement, highest survival, and fewest fish lost to the study. Predation, particularly bird predation, appeared to be a major factor in the post-stocking survival of fish as evidenced by presence and documentation of California gulls consuming immediate post-stocked fish. This was most apparent in the early autumn stocking in which five fish were lost to the study and at least a portion of these were likely consumed by California gulls. With

continued efforts these data coupled with PIT scanning will help to support stocking decisions and ultimately ensure the long term persistence and conservation of the species.

Introduction

June sucker *Chasmistes liorus* is an endangered species endemic to Utah Lake UT (cover photo). June sucker is one of four species of the genus characterized as lakesuckers (Miller and Smith 1981). Lakesuckers are mid-water planktivores that differ from other members of the family Catostomidae by having large, terminal mouths. June sucker are believed to become sexually mature at 5 to 10 years of age (Belk 1998) and adults generally make an annual spawning migration into the Provo River toward the end of June (Modde and Muirhead 1994). Larvae then drift downstream and make their way back into the lake where they grow to adulthood.

Historically, June sucker were numerous throughout the lake but numbers declined in the latter 1990s to as few as 300 wild individuals with little or no recruitment in the population (USFWS 1999). The decline was attributed to many factors including overharvest, habitat degradation, and predation and competition by non-native species. Spawning occurs in major tributaries, but the majority is restricted to the lower portion of the Provo River (UDWR 2011). Due to habitat alterations in the Provo River, most age-0 fish do not successfully transition from larvae to juveniles and those that do are susceptible to predation by non-native fish (Modde and Muirhead 1994, Belk et al. 2001).

Habitat improvements, creation of a refugium population, and augmentation of the wild population with captive reared fish all are part of the June sucker recovery plan (USFWS 1999). More than 350,000 individuals longer than 200 mm have been stocked into the lake with a goal of stocking 2.8 million fish (USFWS and URMCC 1998). Monitoring of June sucker includes use of trap nets, trammel nets, commercial seines, and trawls in the lake proper and a combination of spotlighting and weir operations during spawning runs in the Provo River (USFWS 1999, UDWR 2011). Although hundreds of adult June sucker are captured in the river during spawning each year, juvenile suckers are rarely encountered in the river or in extensive efforts in the lake proper (UDWR 2011).

The lack of encounters with juvenile June sucker post-stocking has resulted in little information on their survival. Rasmussen et al. (2009) estimated survival of stocked June sucker at 5% and found that survival was strongly correlated to size at release and rearing site. In addition, Billman et al. (2011) reported that probability of recruitment was correlated to multiple factors including size at stocking, rearing site, condition factor, season, and release site. Both of these studies based their results on fish recruited to the adult population, which occurs several years after release and may result in bias due to potential site fidelity and unequal distribution of sampling effort (Billman et al. 2011).

This report presents results from year one of a multi-year, acoustic telemetry and remote sensing research project. The purpose of this study is to evaluate immediate post-stocking survival and dispersal of hatchery reared June sucker in Utah Lake. This year provided initial estimates of post-stocking survival and over the course of the three year study, the effect of three factors on post-stocking survival will be investigated: stocking location (shoreline versus mid-lake), season (summer, late summer, and autumn), and family lot or size (length) at stocking. Results of the study will provide a range of estimates among different stocking conditions and will supplement mark-recapture analysis of passive integrated transponder (PIT) data. This information will be incorporated into a cost-benefit analysis that will provide guidance for future stocking efforts and work toward the recovery of the species.

Methods

To obtain survival estimates and movement patterns for captive reared June sucker, intensive acoustic telemetry studies were conducted on Utah Lake. Each discrete segment of the study provided short-term (60 day) survival rates as well as post-stocking dispersal patterns. Twenty (10 for each stocking event) fish were implanted with acoustic tags (see *Surgical Method*, below) at the stocking site and 1200 (600 for each stocking event) additional fish were implanted with 134.2 kHz PIT tags and held in the Fisheries Experiment Station (FES) in Logan UT until stocking. Sixty-four of these latter fish died while being held in the FES, a mortality rate of 5.3%. The first stocking and telemetry investigation was in late summer and ran from 29 July 2013 to 30 September 2013. The second study segment was in early autumn and ran from 17 September 2013 to 15 November 2013. Including surgery fish, 552 June sucker at a mean total length (TL) of 196 mm were stocked in late summer and 570 June sucker at a mean TL of 208 mm were stocked in early autumn. A large number of California gulls *Larus californicus* was present at the stocking site during the early autumn stocking event.

Study Area

Utah Lake (Figure 1) is a natural lacustrine system on the eastern edge of the Great Basin physiographic province. It is a large, shallow, eutrophic water body with a surface area of 38,400 hectares and mean and maximum depths of 2.8 and 4.2 m respectively (Fuhriman et al. 1981). The system historically supported 13 native fish species, but is now home to only two (June sucker and Utah sucker *Catostomus ardens*), plus a suite of non-native fishes.

Surgical Method

Twenty June sucker (10 in late summer and 10 in early autumn; Table 1) were surgically implanted with model PT-4 acoustic transmitters (Sonotronics Inc., Tucson AZ) at the release site each sample period (Figure 2). This tag is small, reliable, and has a battery life of approximately three months. An additional 10 June sucker were implanted with PT-4 "dummy" tags which are the same weight and size as the live tags (Table 2). These latter fish were held simultaneously with 10 untagged fish at the FES for the same 60-day period as fish released in the lake to evaluate the surgical method (Table 2). The 10 late summer fish had a mean TL of 244 mm, the 10 early autumn fish had a mean TL of 252 mm, and the 20 fish held in the FES had a mean TL of 230 mm. Each surgery was performed generally as follows (Mueller et al. 2000; Karam et al. 2008).

> Approximately 20 fish were transferred from the stocking truck into a holding tank and allowed to acclimate for at least 30 minutes prior to surgery. Each fish was anesthetized by immersion in approximately 16-L of fresh water with tricaine methanesulfonate (MS222; 125 mg L-1) in a dark container. Once anesthesia had progressed to the desired depth, indicated by cessation of all fin and muscular movements other than weak operculation, the fish was removed from the container, measured (TL in mm), weighed (nearest gram [g]) and scanned for a 134.2 kHz PIT tag. The fish then was placed on its dorsum on a wetted towel in a specially-constructed cradle and covered with a damp lightweight cloth. Fresh MS-222 from a 20-L reservoir was gently pumped through a 4.7-mm inner diameter tube and onto the exposed gills to maintain anesthesia for the duration of the procedure. A short (< 2 cm) mediolateral incision was made slightly anterior and dorsal to the left pelvic fin and an acoustic transmitter sanitized in 70% ethanol was inserted into the abdominal cavity (Figure 3). The fish was scanned and a PIT tag

was placed into the cavity if none was detected. The incision was sutured with 2-3 knots using 3-0 blue monofilament polypropylene and NRB-1, 17 mm, ½ taper cutting needle (CP Medical, Portland OR). Following surgery, the wound was swabbed with Betadine, a 10 mg/kg dosage of Baytril® (enrofloxacin) was injected into the dorsal-lateral musculature to prevent infection (Martinsen and Horsberg 1995), and the fish was placed in a recovery tank with fresh circulated water. Following surgery, fish were monitored to ensure proper health and transmitter retention and allowed to recover for up to one hour before being stocked.

Passive Tracking

Prior to stocking, 20 submersible ultrasonic receivers (SURs) equipped with weights and buoys were deployed throughout the lake in permanent locations as a method of passive tracking (Figure 4). Initial trials indicated a detection range of approximately 500 meters (m) from the SURs. Taking this nominal range into account, 16 SURs were used to section the lake into three zones with eight SURs deployed 1000 m apart across the lake along two transect lines. Two SURs were also placed at the mouth of Provo Bay and two were placed in the Provo River to detect any movement into and out of these areas (Figure4). Additionally, another four to five SURs were placed at random locations in the lake for approximately 24-hour time periods (Figure 5). Random SUR locations were determined using Hawth's Tools v 3.27, a free open-source tool for ArcView®. Data from SURs were downloaded weekly and any fish detected on the SUR within 12 hours of the time the SUR was downloaded were manually tracked using active methods outlined below.

Active Tracking

During each 60-day release period, fish were manually tracked using a directional hydrophone and programmable active tracking receiver (Sonotronics DH-4 and USR-08, respectively; Figure 2). Initial trials indicated a detection range of approximately 200 m. Immediately after release, an attempt was made to contact each fish at least once per day during the study period. As the fish left the release area, SURs were downloaded to determine if any fish left the central zone. Up to 316 manual tracking fixed points 1000 m apart were visited weekly to pinpoint fish locations (Figure 6). Tracking was conducted at crepuscular transitions at sunrise and sunset and during both daylight and dark periods.

June sucker that were not contacted while visiting the fixed points were recorded as missing. If missing fish were recorded on an SUR along a zone transect, the zone beyond that SUR transect was targeted for the next tracking period. If a fish was recorded missing for more than three tracking periods, a search of the entire lake was initiated. Fish recorded in the same location for three tracking periods without any noted activity were considered mortalities. When an individual was contacted, fish location was determined by triangulation using the directional hydrophone and identified by Universal Transverse Mercator (UTM) coordinates. Location and tag information was recorded on waterproof paper as follows: acoustic tag number and frequency, time and date, general location or site name, water temperature (°C), UTM coordinates, and water depth (m). Contact data were incorporated into a Microsoft Access® database to create an accurate and complete history of each acoustic tagged fish.

PIT Scanning

Test deployments of four to five PIT scanning units at potential locations of juvenile June sucker concentrations were conducted in 2013. Deployments were completed biweekly over the course of both summer and autumn 60-day tracking periods. Submersible PIT scanners were modified from earlier models described in Kesner et al. (2008). Each submersible PIT scanner is comprised of a 1.2 x 0.8 m PVC frame antenna attached to a scanner, logger and a 10.4 amp-hour battery contained in water-tight PVC and ABS piping (Figure 7). The unit is completely submersible and scans continuously for up to 36 hours. Antennas are also equipped with weights so that units can be oriented to lie flat along the bottom of the lake (bottom flat) or to stand upright in the water column (bottom long). On the first day of a scanning sample period, crews set out antennas and then revisited the units the following day. After units had been deployed for approximately 24 hours, crews replaced scanner batteries and downloaded data to a handheld device. During each effort the following information was recorded: date and time of deployment and pick-up, general location, UTM coordinates, depth (m), distance to shore (m), antenna orientation (antenna oriented perpendicular or parallel to the substrate), unit and battery ID, scan time (minutes), and estimated number of contacts.

Additional active PIT scanning using a handheld wand was conducted on Bird Island (Figure 1) and other locations where potential avian predators aggregated or loafed and deposition of a large number of PIT tags was possible. The handheld wand was designed to detect 125 kHz and 134.2 kHz PIT tags. Supplemental PIT scanning data from submersible deployments and active wand scanning in addition to previous data sets provided upon contract initiation were incorporated into a Microsoft Access® database.

Data Analysis

Kaplan-Meier estimates (Kaplan and Meier 1958) of post-stocking survival from each telemetry study were based on the final fate of each acoustic tagged June sucker. To calculate the estimate, each fish was assigned to one of three fates: a fish died before the end of the study, a fish survived the study, or a fish was lost to the study (lost signal). For fish that died or for which the signal was lost, the timing of the death or lost signal was determined. The first date of three consecutive tracking events that a fish was found at the same location was determined as its time of death. The time of the last recorded active or passive (SUR) contact with a fish whose signal was permanently lost during the 60 days was determined as the time the fish was lost to the study.

Patterns of dispersal were assessed for individual fish by mapping active and passive tracking records in ArcView®. Hawth's Tools was used to create paths between tracking events for each fish. The total distance of these paths was then calculated to provide minimum (straight line) total distance moved between contacts for each fish. Repeated contacts at the location of a tag recovery were removed because those contacts likely represented the location of mortality and not that of fish dispersal.

Results

Fate and Survival

Permanent SURs recorded a total of 77,507 telemetry tag contacts representing 18 of the 20 fish and random SURs recorded a total of 4,183 contacts representing 8 of the 20 fish. Manual tracking resulted in 106 contacts representing 17 of the 20 fish. Two fish were not contacted by either passive or active tracking methods. Of the 10 fish stocked in late summer, there were four mortalities, four survivors, and two lost contacts (Table 3). Mortalities for late summer fish occurred 7-29 days post-stocking (Table 1). The two lost contacts occurred 23-43 days post-stocking. Of the 10 fish stocked in early autumn, there were three mortalities, two survivors, and five lost contacts (Table 3). Mortalities for early autumn fish occurred 14-49 days post-stocking (Table 1). Of the five lost contacts, two fish were never contacted post-stocking, two fish were lost 1-2 days post-stocking, and one fish was lost 25 days post-stocking (Table 1). Of the 20 fish held at the FES, one (10%) of the dummy tagged fish died and none of the control fish died. Dummy tagged fish had the highest survival (95% Confidence Interval, CI) at 0.9 (0.54-0.99). Late summer fish had the highest in situ survival (95% CI) at 0.58 (0.27-0.86), and early autumn fish had the lowest survival (95% CI) at 0.42 (0.15-0.74). Survival estimates were not significantly different for any group of fish based on the overlapping confidence intervals (Figure 8).

In both stockings, fish dispersed into the open water, pelagic zone of the lake proper (Figure 9). In the late summer stocking, seven fish moved to the open water 1-3 days post-stocking. Three of the fish moved upstream in the Provo River where two of the fish subsequently died. The third fish moved out of the river where it was contacted in open water 15 days post stocking. In the early autumn stocking, six fish moved to open water 1-21 days post-stocking. Two fish were contacted in the river immediately post-stocking but contact was lost soon after, and two fish were never contacted once they were placed into the water.

Mean daily movement (± 1 Standard Error, SE) was 1.73 km (±0.33 km) for late summer fish and 1.27 km (±0.30 km) for early autumn fish. The greatest individual movement for late summer fish and for the study was Fish 296 which moved a minimum total distance of 308 km in 103 days (Table 4). The smallest individual movement for late summer fish was Fish 297 which moved less than 1 km in 7 days but died early in the study. The greatest individual movement for early autumn fish was Fish 18 which moved a total of 93.2 km in 59 days (Table 4). However, Fish 35 exhibited the greatest daily movement at 2.2 km/day. The smallest measurable[1] individual movement for early autumn fish was Fish 52 which moved less than 1 km but was lost early in the study.

PIT Scanning

Due to the shallow and rough nature of Utah Lake, safe locations of scanner deployments were limited. Submersible units were generally placed in or near the following locations (Figure 1): Provo River, the boulder jetty sheltering Utah Lake State Park Marina, Bird Island (a small rocky island in the southern area of the lake), Long Bar (a sandy area just south of the Provo River mouth), and Pelican Point (A rocky point on the west shoreline of Utah Lake).

[1] Three fish in the autumn sampling did not have enough passive and/or active contacts to calculate movement.

From July to November 2013, crews made a total of 136 deployments of submersible PIT scanning units, resulting in 3,385 hours of scanning with a mean deployment of 24.9 hours. Scanners were generally placed in the same vicinity each sampling week (i.e., Bird Island, Provo River mouth, etc.). A total of 69 PIT contacts was recorded over the four month study period. Of these 69 total contacts, 58 represented unique June sucker and 20 were June sucker that were unique to this study (stocked on either 29 July or 17 September, 2013; Table 5). The remaining 38 fish were stocked prior to the study and 29 of these had a tagging history from a database provided by Utah Division of Wildlife Resources (Table 6). The greatest proportion of fish (21) was contacted near Bird Island. Of the remaining 37 fish, 13 were contacted in the Provo River mouth, 13 on Long Bar, seven in the Provo River, and four on the boulder jetty sheltering Utah State Park Marina. The 13 fish contacted in the Provo River mouth were all contacted within three days of the late summer stocking.

Contact with deposited PIT tags using a handheld wand was limited. No tags were found on Pelican Point or Bird Island (Figure 1) where observed bird density was highest. However, four tags were found in the Provo River mouth where the majority of the fish are stocked. Two of these tags (3DD.003BB8B4D3; 3DD.003BB918A7) were associated with fish stocked in the early autumn tracking event but were not telemetry fish. One fish (3D9.1C2C46CD31) was stocked into the lake on 22 May 2013 and came from the Utah Division of Wildlife Resources Springville UT hatchery. No information for the remaining fish (3D9.1C2C460638) was available in the database provided, but the tag number was transmitted to Utah Division of Wildlife Resources for further investigation.

Discussion

Overall, fish stocked in late summer exhibited the greatest movement, highest survival, and fewest fish lost to the study. Much focus has been put on predation of June sucker by introduced fish species, particularly white bass *Morone mississippiensis* and walleye *Sander vitreus* (USFWS 1999; Belk et al. 2001), and brown trout *Salmo trutta* and northern pike *Esox* lucius were documented in the Provo River near the stocking site. However, avian predation appears to be a major factor in post-stocking survival of fish as evidenced by presence and documentation of California gulls consuming fish immediately post-stocking. Avian predation has been documented on other endangered suckers such as Warner sucker *Catostomus warnerensis* and the cui ui (Scheerer et al. 2012; Scoppettone et al. 2014), both species that utilizes similar lake habitats in Oregon and Nevada. In Utah Lake, this phenomenon was most apparent in the early autumn stocking in which five telemetry fish were lost to the study and at least a portion of these were likely consumed by California gulls. It is unclear if avian predation occurs seasonally at the stocking site. Billman et al. (2011) found that stocking success was higher for late summer (August) fish than autumn (October) fish. If avian predators are more prevalent at the stocking site during the autumn this could explain the lack of survival for fish in this and previous studies. Therefore, the effect of both bird and non-native fish predation on post-stocking survival of June sucker warrants further investigations.

Although one fish died in the dummy tag trial, PIT tagged June sucker held in the hatchery pre-stocking exhibited a 5% mortality rate indicating that the surgical method did not significantly impact survival. The lack of statistically significant differences in survival between dummy tagged fish kept in a hatchery and telemetry fish released into the lake is most likely an artifact of low statistical power. The number of telemetry fish used in each study was kept small to increase the probability of maintaining contact with all study fish throughout the 60 day period. However, this small sample size also decreases statistical power. It is likely that maintaining the current number of telemetry fish per study will continue to provide estimates that have overlapping confidence intervals. Therefore, differences in estimates between release factors important to this study (location, size, and season) will only be suggestive and not definitive. However, these estimates will be supported by the addition of information from PIT scanning contacts as PIT tagged June sucker released along with the telemetry fish mature and enter the rivers to spawn. Given the potential for contact loss, additional statistical models beyond Kaplan-Meier such as a mark-recapture known fate model (Pollock et al. 1989) may be more appropriate and improve statistical power allowing for direct comparisons between groups. In addition, a power analysis (e.g., Cohen 2009, Aberson 2010) based on first year data would provide guidance on sample size required to increase statistical power to telemetry results.

Traditional sampling has resulted in a lack of captures of June sucker in the 200-300 mm size class, and it is unknown if this is a result of behavioral or methodological bias (UDWR 2011). Although a small proportion of telemetry fish utilized the Provo River, most surviving fish were highly mobile throughout pelagic areas of the lake. Greater food availability and growth have been documented in the open waters of Utah Lake (Kreitzer et al. 2011), and sub-adult June sucker may be taking advantage of this relative abundance of resources by utilizing the pelagic zones of the lake. Sampling for June sucker generally focuses on shoreline habitats and relatively little effort is expended sampling the pelagic areas of the lake (UDWR 2011). In addition, initial post-stocking survival estimates indicate that there may be relatively few sub-adult fish in the lake. The combination of June sucker distribution and habitat use, sampling methodology, and the general rarity of sub-adult fish likely explains the lack of success in sampling for sub-adult June sucker using standard fishery gears.

Overall, even with issues encountered during the autumn sampling (i.e., California gull predation and lost contacts), acoustic telemetry was successful in providing post-stocking survival estimates and a general model of June sucker dispersion. Four additional telemetry iterations are scheduled over the next two years, completion of which will build on the current dataset and will ideally provide more insight into release factors and the impact they have on the immediate post-stocking survival.

Recommendations

Release of acoustic tagged fish should continue to further study release factors such as time of year and location. It was apparent that immediate bird predation was negatively impacting stocked fish. This can be easily deterred by using alternate stocking sites and/or stocking at night. Therefore, a flexible stocking protocol that is adaptable to new information should be created in attempt to decrease immediate post-stocking mortality. Additionally, one avian predator was identified in this study, but other species such as Double-crested Cormorants (*Phalacrocorax auritus*) and American White Pelicans (*Pelecanus erythrorhynchos*) could have negative impacts, so the effects of avian predation on June sucker should be further studied. A portion of June sucker stocked in Utah Lake should be PIT tagged. This will be beneficial in determining long-term survival of the species as the surviving fish become sexually mature and move up the tributaries to spawn.

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Table 1. Fate of 20 individual June sucker surgically implanted with a sonic transmitter and stocked into Utah Lake UT in late summer and early autumn 2013. DPS refers to days post-stocking; DPS was not assigned to fish that survived the 60 day study.

Tag ID	Frequency	TL (mm)	Mass (g)	Pit tag #	Season	Fate	DPS
278	76	240	191	3D9.1C2C7F4C2E	Late Summer	Survived	-
279	77	248	194	3D9.1C2C85730B	Late Summer	Mortality	23
280	78	275	245	3D9.1C2C857F90	Late Summer	Lost contact	23
281	79	225	189	3D9.1C2C857431	Late Summer	Survived	-
282	80	248	175	3D9.1C2C850BB8	Late Summer	Mortality	7
293	76	234	160	3D9.1C2C7FDCD2	Late Summer	Survived	-
294	77	240	170	3D9.1C2C7FF292	Late Summer	Lost contact	43
295	78	234	174	3D9.1C2C7F72D2	Late Summer	Mortality	29
296	79	255	213	3D9.1C2C852D23	Late Summer	Survived	-
297	80	238	160	3D9.1C2C7F3D05	Late Summer	Mortality	7
18	71	255	178	3DD.003BB8B4B8	Early Autumn	Survived	-
19	72	256	188	3DD.003BB8B508	Early Autumn	Mortality	49
20	73	248	174	3DD.003BB918C6	Early Autumn	Lost contact	1
21	74	249	172	3DD.003BB919B9	Early Autumn	Lost contact	0
22	75	262	178	3DD.003BB918F2	Early Autumn	Survived	-
33	71	240	141	3DD.003BB8B4F6	Early Autumn	Lost contact	0
34	72	250	176	3DD.003BB919E4	Early Autumn	Lost contact	25
35	73	256	189	3DD.003BB9194A	Early Autumn	Mortality	36
36	74	243	162	3DD.003BB91930	Early Autumn	Mortality	14
52	75	264	187	3DD.003BB91924	Early Autumn	Lost contact	2

Table 2. Fate of ten June sucker surgically implanted with "dummy" tags (Y) and ten untagged control fish (N) held in the Fisheries Experiment Station in Logan UT. Tagged refers to the fish receiving a dummy tag or not. Fish 3DD.003BB8B4AA died while being held in the FES but this occurred after the initial 60 day trial so was not included in the Kaplan-Meier estimate.

TL (mm)	Mass(g)	PIT Tag #	Tagged (Y/N)	Mortality (Y/N)
240	165	3DD.003BB8B4BD	Y	N
251	167	3DD.003BB919C4	Y	N
232	130	3DD.003BB9199E	Y	N
226	127	3DD.003BB8B484	Y	N
241	134	3DD.003BB8B536	Y	N
235	137	3DD.003BB9193A	Y	N
245	154	3DD.003BB91988	Y	Y
256	167	3DD.003BB91A10	Y	N
239	145	3DD.003BB91962	Y	N
276	227	3DD.003BB8B4C9	Y	N
265	237	3DD.003BB8B4AA	N	N
185	70	3DD.003BB91968	N	N
196	78	3DD.003BB919ED	N	N
236	132	3DD.003BB8B507	N	N
210	91	3DD.003BB91996	N	N
221	150	3DD.003BB9193E	N	N
244	167	3DD.003BB91A14	N	N
212	102	3DD.003BB91925	N	N
221	115	3DD.003BB91906	N	N
221	108	3DD.003BB91958	N	N
184	75	3DD.003BB8B48E	N	N

Table 3. Fate of telemetry tagged June sucker stocked into Utah Lake UT, in summer and autumn 2013. This information was used to calculate post-stocking Kaplan-Meier survival estimates.

	Survivors	Mortalities	Lost fish
Late Summer			
Week 1	10	0	0
Week 2	8	2	0
Week 3	8	0	0
Week 4	7	1	0
Week 5	5	1	1
Week 6	5	0	0
Week 7	5	0	0
Week 8	3	0	1
Week 9	4	0	0
Total	4	4	2
Early Autumn			
Week 1	8	0	2
Week 2	6	0	2
Week 3	5	1	0
Week 4	5	0	0
Week 5	4	0	1
Week 6	2	1	0
Week 7	2	0	0
Week 8	2	1	0
Week 9	2	0	0
Total	2	3	5

Table 4. Total and daily movement calculated from passive and active tracking using Hawth's Tools for June sucker stocked into Utah Lake UT, summer and autumn 2013. Days at large refers to the number of days post-stocking that the fish was contacted before it either died or the contact was lost.

Tag #	Season	Movement (km)	Days at Large	Daily movement (km/day)
278	Late Summer	151.3	77	2.0
279	Late Summer	18.5	23	0.8
280	Late Summer	52.4	23	2.3
281	Late Summer	135.8	100	1.4
282	Late Summer	2.6	7	0.4
293	Late Summer	251.8	100	2.5
294	Late Summer	125.5	43	2.9
295	Late Summer	58.5	29	2.0
296	Late Summer	308.4	103	3.0
297	Late Summer	0.0	7	0.0
18	Early Autumn	93.2	59	1.6
19	Early Autumn	56.2	49	1.1
22	Early Autumn	77.6	57	1.4
34	Early Autumn	50.1	25	2.0
35	Early Autumn	80.5	36	2.2
36	Early Autumn	6.2	14	0.4
52	Early Autumn	0.1	2	0.1

Table 5. Summary of PIT scanning performed in Utah Lake UT, 2013. Contacts refer to the total number of contacts, unique refers to the number of individual June sucker that were contacted, and study unique refers to fish stocked specifically for this study.

Month (2013)	Deployments	Total scan time (hours)	Contacts	Unique	Study unique
July	5	128	12	12	11
August	49	1187	11	10	4
September	35	954	20	16	3
October	32	758	18	15	1
November	15	358	8	5	1
Totals	136	3385	69	58	20

Table 6. List of June sucker remotely scanned that were stocked prior to the 2013 telemetry study with a tagging history. Tagging refers to whether the fish was PIT tagged at stocking or as a result of sampling in Utah Lake.

PIT tag number	Length	Weight	Tagging
384.1B795AA423	510	1300	Sampling
3D9.1C2C46E585	503	1380	Sampling
3D9.1C2C4893CB	446	1000	Sampling
3D9.1C2C8CC2F4	546	1700	Sampling
3D9.1C2C922988	470	1480	Sampling
3D9.1C2CAAF119	470	1300	Sampling
3D9.1C2CAAF67A	384	620	Sampling
3D9.1C2CAB0E35	468	1980	Sampling
3D9.1C2CAC1DC9	396	780	Sampling
3D9.1C2CAC5BEB	413	900	Sampling
3D9.1C2CCE5F30	501	1500	Sampling
384.1B795AA620	315	298	Stocking
384.1B795AA69A	278	204	Stocking
384.1B795AA6B1	287	235	Stocking
384.1B795AA6B9	280	212	Stocking
384.1B795AA6E3	291	209	Stocking
384.1B795B133D	294	226	Stocking
384.1B795B17D9	273	92	Stocking
3D9.1C2C456916	402	720	Stocking
384.1B795AA304	463	1260	Sampling
384.1B795AA34A	487	1260	Sampling
3D9.1C2C896951	566	2420	Sampling
3D9.1C2C9230A9	460	1440	Sampling
3D9.1C2C923499	488	1700	Sampling
3D9.1C2CAB0AB1	450	1040	Sampling
3D9.1C2CAC15A2	475	1660	Sampling
3D9.1C2CAC1A42	438	960	Sampling
3D9.1C2CAC4C5B	452	1000	Sampling
3D9.1C2CD42EAD	507	1660	Sampling

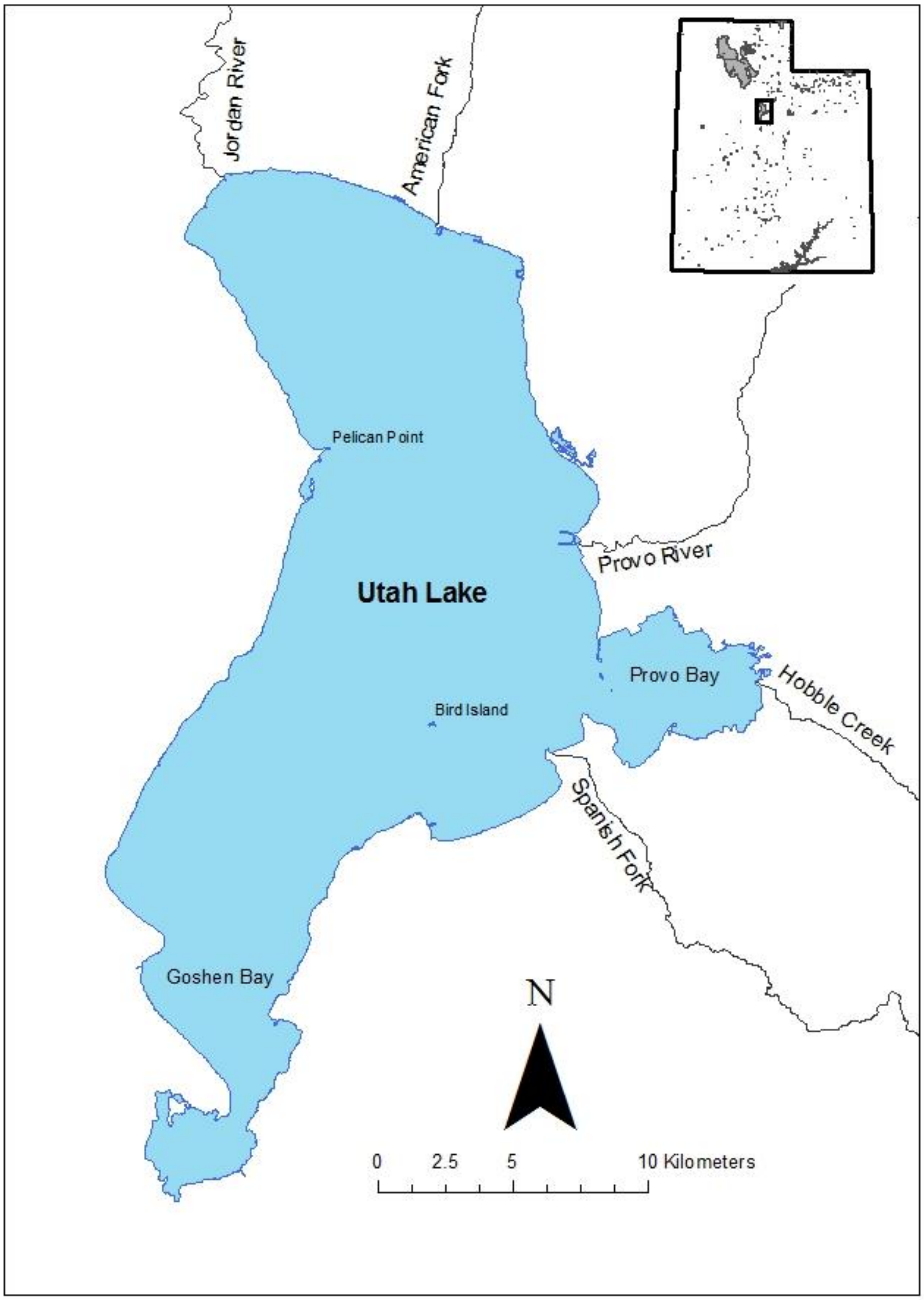

Figure 1. Map of Utah Lake, UT showing major tributaries and place names throughout the lake, and location map (inset).

Figure 2. Telemetry equipment used for the June sucker study. Upper left photo is the Sonotronics Inc. (Tucson, Arizona) model PT-4 acoustic tag. Upper right photo is the directional hydrophone (Sonotronics model DH-4). Lower left photo is the omni-directional towable hydrophone (Sonotronics model TH-2). Lower right photo is the Sonotronics Inc. (Tucson, Arizona) Submersible Ultrasonic Receiver.

Figure 3. Tag implantation procedure. The top picture is the mediolateral incision being made. The middle picture is the tag being inserted, and the bottom picture depicts the suturing of the incision.

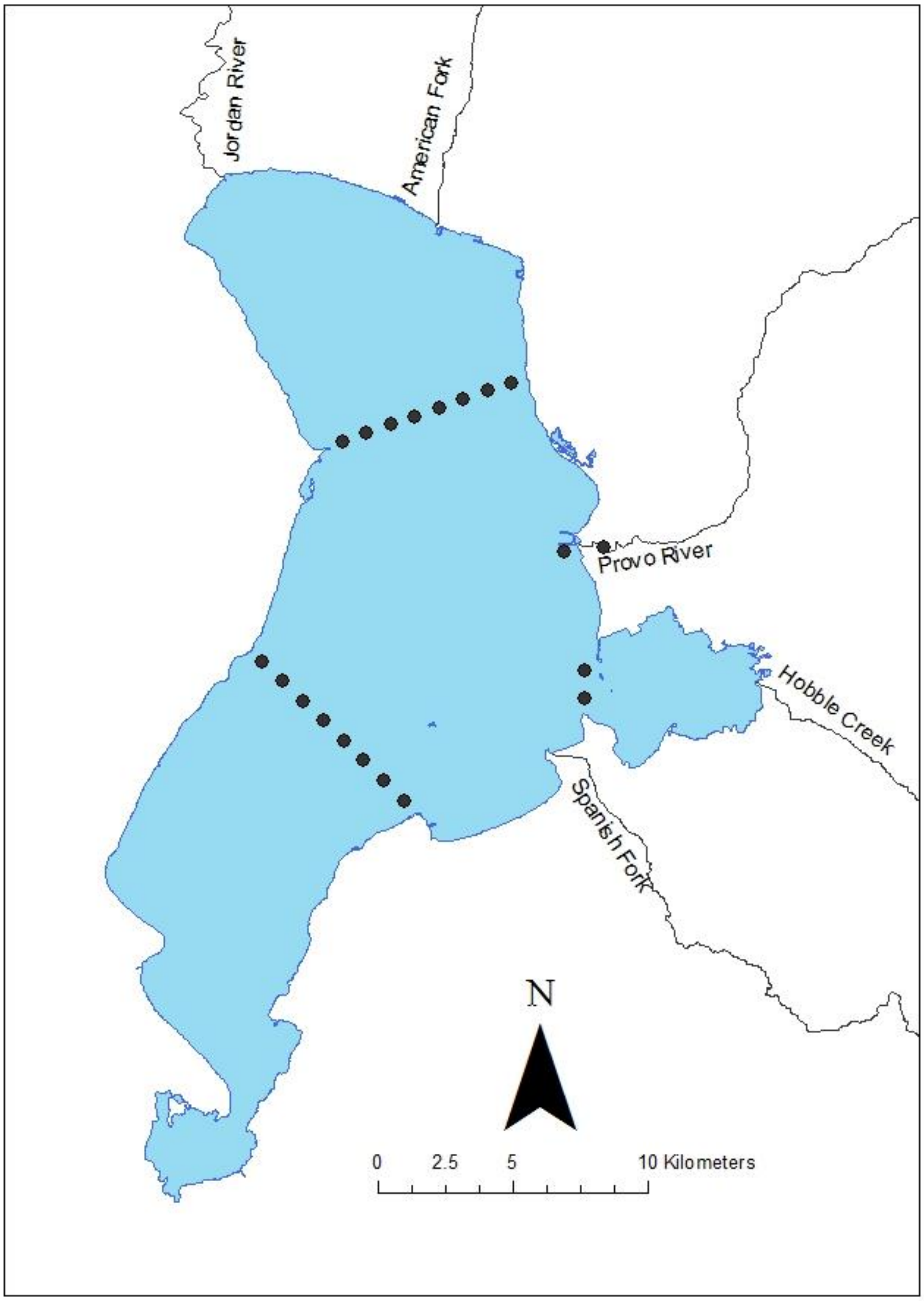

Figure 4. Map of Utah Lake UT, showing locations of the seasonally permanent SUR placements during the 2013 telemetry study.

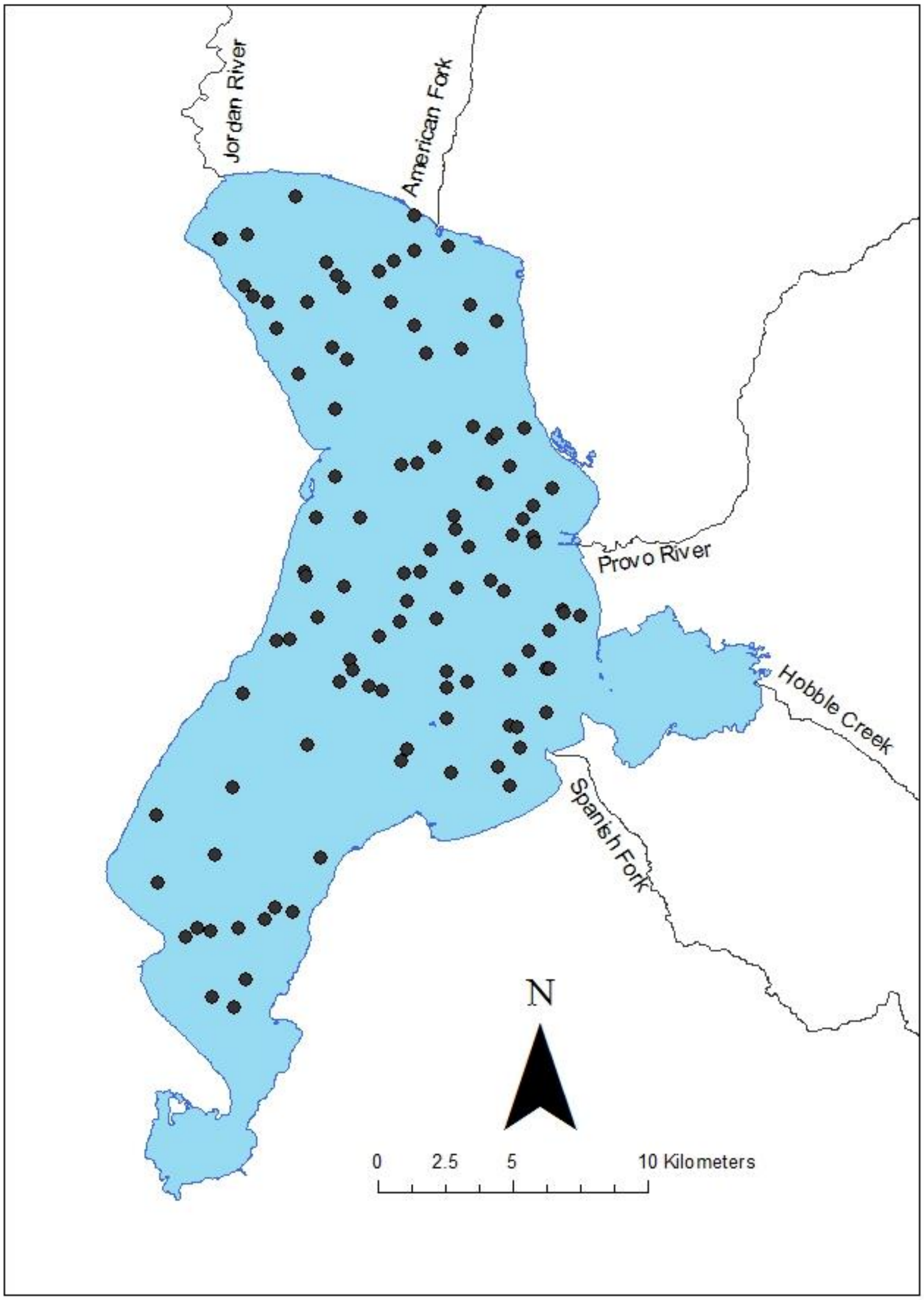

Figure 5. Map of Utah Lake UT, showing locations of the random SUR placements during the 2013 telemetry study.

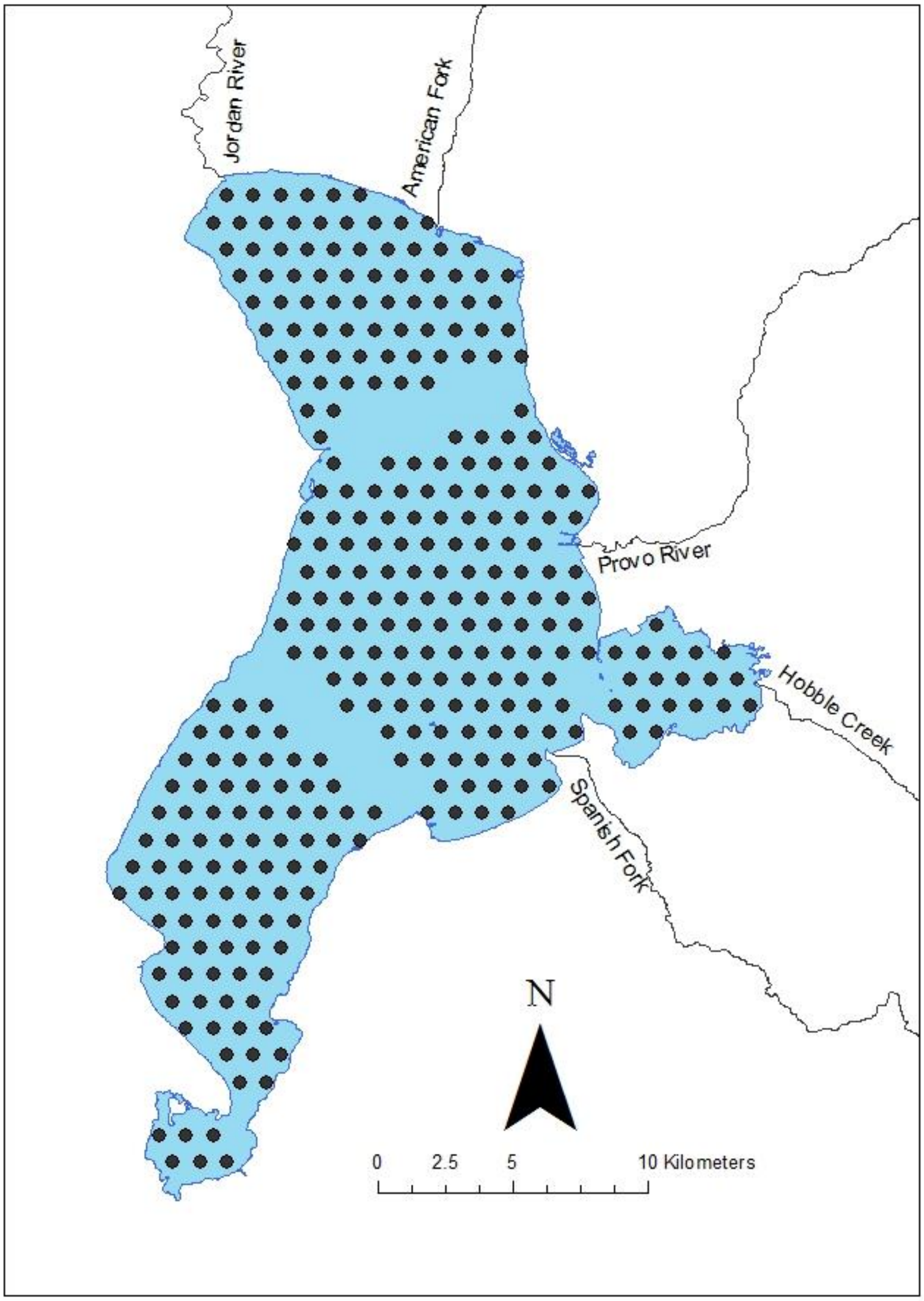

Figure 6. Map of Utah Lake UT, showing locations of the 316 manual tracking points during the 2013 telemetry study.

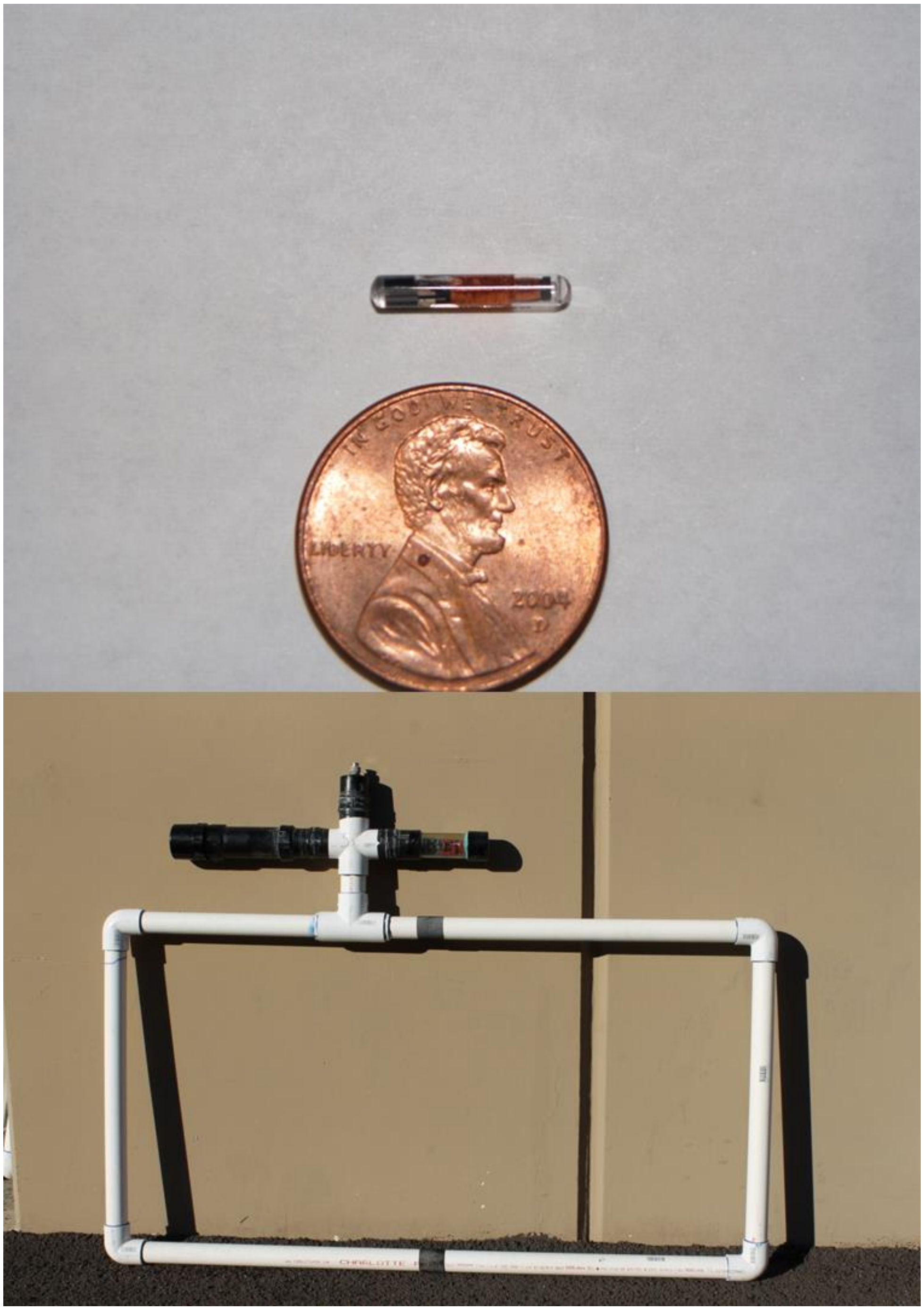

Figure 7. Remote PIT scanning equipment used during the 2013 June sucker study. Top photo is an example of the 134 kHz PIT tag that was implanted in the study fish. Bottom photo is the submersible PIT scanning unit deployed throughout the lake.

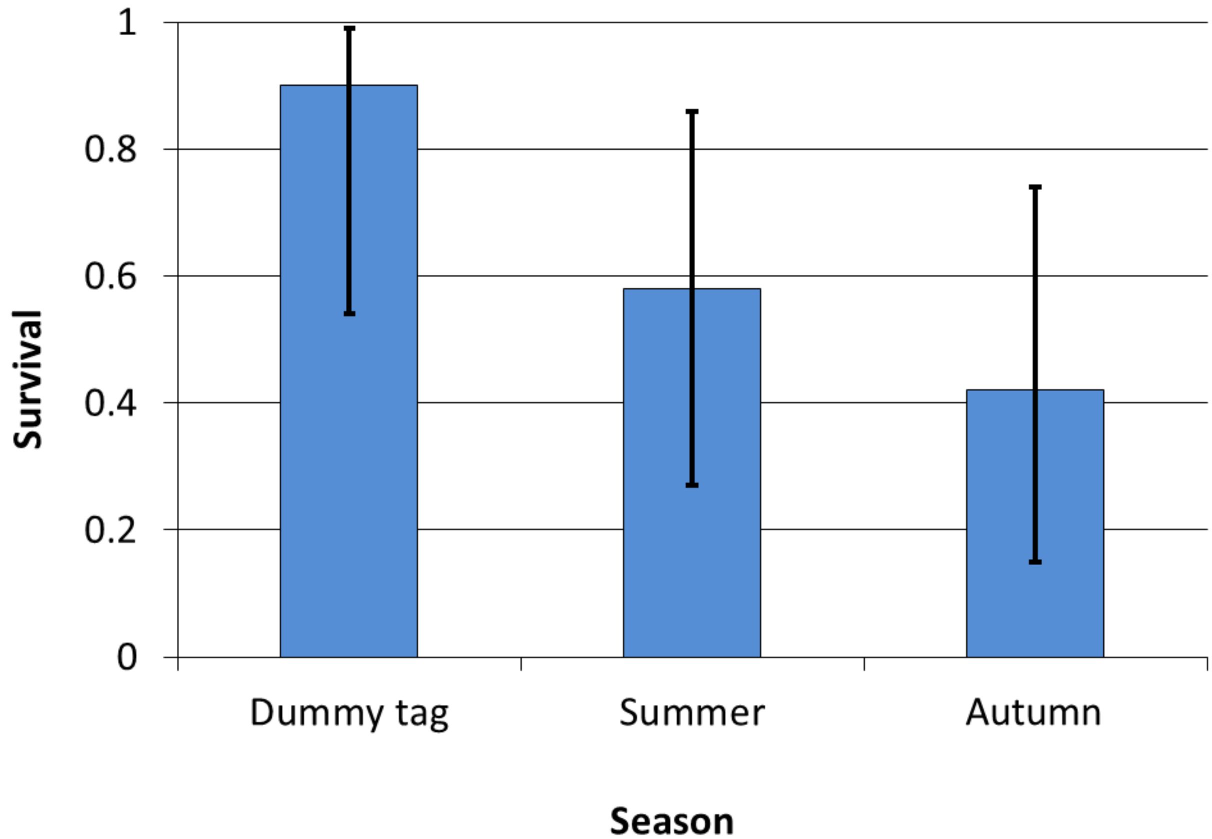

Figure 8. Kaplan-Meier survival estimates for 2013 telemetry June sucker. Error bars represent the 95% confidence intervals.

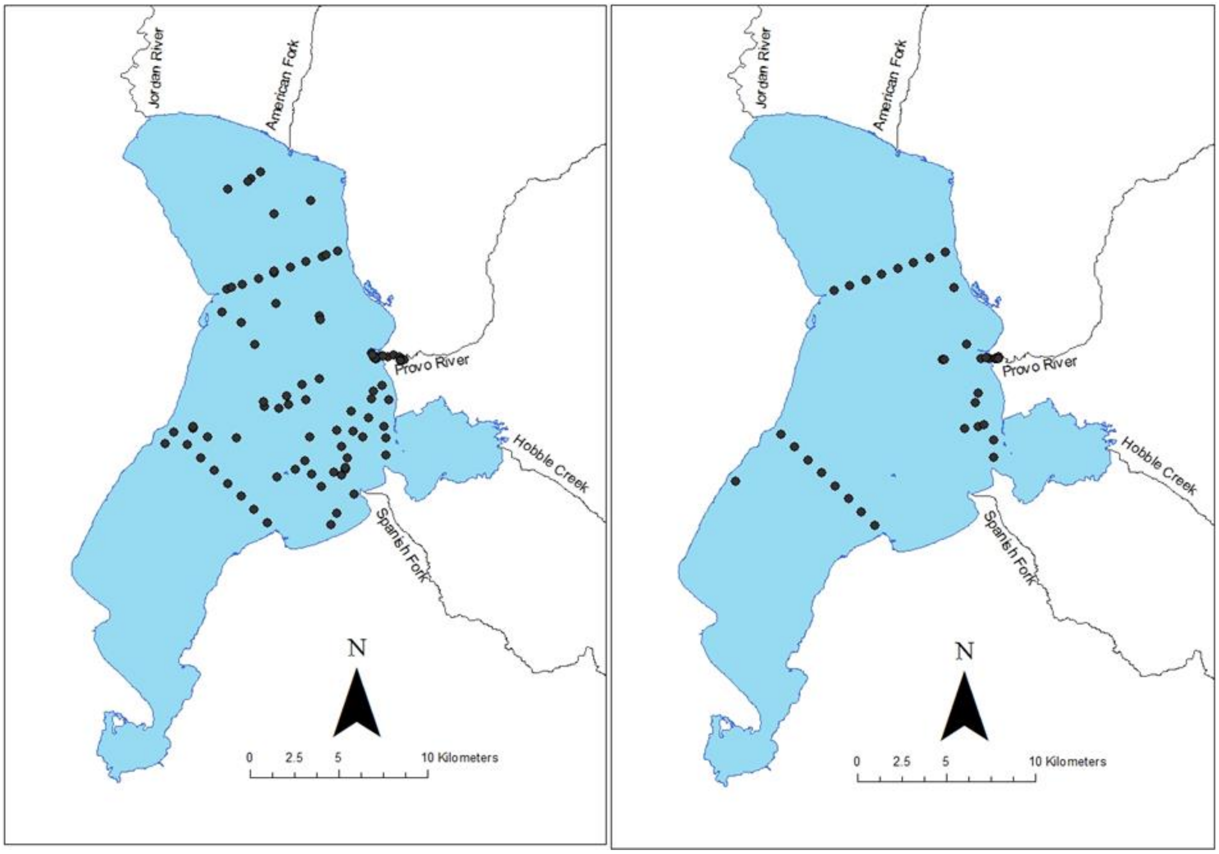

Figure 9. Manual and passive June sucker contacts for late summer (left) and early autumn (right) 2013 telemetry fish.