APPENDIX C: WINTER SAMPLING REPORT

Susitna-Watana Hydroelectric Project
(FERC No. 14241)

Study of Fish Distribution and Abundance in the Middle and Lower Susitna River Study (9.6)

Appendix C
Winter Sampling Report

Initial Study Report

Prepared for

Alaska Energy Authority

SUSITNA-WATANA HYDRO

Clean, reliable energy for the next 100 years.

Prepared by

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Abbreviation	Definition
ADF&G	
adt	
AEA	
ARIS	
ATS	
AWG	
CPUE	
DIDSON	
DO	
FA	
ft	
GPS	
GRTS	
HDX	
in	
IP	
IR	
joa	
juv	
m	
mm	
NMFS	
NTU	
PIT	
PRM	
PVC	
THHN	
YOY	

1. INTRODUCTION

As presented in RSP 9.6.4.5, a pilot winter study was conducted in 2013 to assess the feasibility of successfully sampling for fish during winter conditions on the Susitna River. The study was conducted at the FA-104 (Whiskers Slough) and FA-128 (Slough 8A) Focus Areas, two of ten Focus Areas located in the Middle River. These sites were selected based on their accessibility from Talkeetna, because they contain a diversity of habitat types, and because sampling in the 1980s and 2012 documented salmon spawning and rearing. Three winter pilot studies were initiated in 2013 focusing on (a) intergravel temperature, dissolved oxygen (DO), and water level monitoring; (b) winter fish observations using dual frequency identification sonar (DIDSON) and underwater video; and (c) winter fish sampling techniques.

1.1. Study Goals

Study goals outlined in the Study Plan specific to the evaluation of fish sampling techniques for the winter pilot study included:

1. Evaluating the effectiveness and feasibility of winter sampling methods for each study including: underwater fish observations with underwater video, and fish populations using minnow traps, seines, electrofishing, trotlines, set lines, and angling.
2. Assessing winter sampling logistics. This included safety, sampling methods in different habitat types under varying degrees of ice cover, transportation and access to and from sample sites, travel time, and winter-specific gear needs.
3. Evaluating the feasibility of sampling during spring break-up.
4. Developing recommendations for 2013–2014 studies.

1.2. Study Area

Given the limited number of daylight hours and potential for extreme weather, the pilot study area was limited to a reach of the Middle Susitna River that was easily accessible from Talkeetna by snow machine. The study area included the Susitna River between PRM 104.4 and PRM 130.1 (Figure C1.2-1). Sample sites were concentrated within the two Focus Areas located within this reach, FA-104 (Whiskers Slough) and FA-128 (Slough 8A); although two sites outside of Focus Areas were also sampled (Figures C1.2-2, C1.2-3). Due to the influence of groundwater at both sites, ice coverage was variable and both study areas contained open water leads (Attachment 1, Figure CA1-1) as well as iced-over lateral habitats for sampling.

2. FISH SAMPLING TECHNIQUES

In an attempt to sample multiple fish species, life stages, habitat types, and various ice conditions, several fish sampling techniques were tested during four sampling events from February to April 2013. Sampling methods included minnow traps, beach seines, backpack electrofishing, angling, trotlines, setlines, and underwater video.

Because sampling efforts occurred in both open-water leads and ice-covered sites, methods varied depending on conditions. In ice-covered sites sampling methods included setlines, trotlines, minnow traps, and underwater video. In open-water sites, methods included baited minnow traps, electrofishing, and beach seines.

2.1. Methods

2.1.1. Angling

Angling was conducted during the February and March sampling events. Spinning gear was used for all angling efforts, which included collapsible pack rods, spinning reels, and lightweight fishing line. Terminal tackle consisted primarily of various sizes of spinners and spoons. All lures were single hooked and barbless to reduce the likelihood of fish injury. To standardize angling efforts, catch per unit effort (CPUE) was quantified by units of time, recorded in 0.25-hr increments. All angling survey locations were recorded with a hand-held GPS unit, and general habitat and environmental conditions were documented including habitat type, water temperature, water chemistry, and site dimensions.

2.1.2. Beach Seines

Beach seines were tested in shallow, open-water reaches free of woody debris and boulders by pulling the seine through the water while walking upstream or by making pulls perpendicular to the flow. Seines were 15 to 25 ft wide by 5 ft deep with ¼- to ½-in mesh. Locations of the habitats seined were marked with handheld GPS units such that transects were standardized and repeatable. Due to poor performance, beach seines were used only during the February sampling trip. All fish captured by beach seining were identified to species, measured for length, and returned to the stream unharmed.

2.1.3. Electrofishing

Single-pass backpack electrofishing surveys were conducted in open-water leads (i.e., sloughs and side channels) during the March and April sampling events. The location of each electrofishing transect was mapped using a handheld GPS unit. The electrofishing, settings (voltage, frequency, and duty cycle), start and stop times, and water conductivity were recorded. To the extent possible, electrofishing reaches were standardized and the methods were repeated during subsequent sampling events at each sample site. Electrofishing followed NFMS (2000) protocol. Captured fish were identified to species, measured, and returned to the stream unharmed. Pelvic fin clips were collected from a subset of juvenile Chinook and coho salmon and delivered to the ADF&G Conservation Genetics Lab for genetic analysis.

2.1.4. Minnow Traps

Minnow traps were a common winter method used by ADF&G in the 1980s and were found to be effective for juvenile salmonid species (Stratton 1986). Minnow traps also captured non-target species such as sculpin, lamprey, and stickleback. For the pilot study, baited minnow traps were used in reaches where electrofishing, seining, and snorkeling were not possible, would have been ineffective, or would have been dangerous due to winter conditions such as ice cover or deep water. Conditions permitting, six minnow traps were placed in a 40 m (131 ft) sampling unit. Minnow traps were set overnight for 18 to 24 h, allowing the gear to fish during both day and night.

Wired two-piece minnow traps were 16.5 in long, with a 9 in diameter, and a 1-in diameter opening, were baited with commercially processed salmon roe. As per ADF&G Fish Resource Permit stipulations, all salmon eggs used as bait were either commercially sterilized or disinfected with a 10-minute soak in a 1/100 Betadine solution. Approximately one tablespoon of roe was placed in a 1-oz plastic Whirl-Pak bag (Fort Atkinson, WI, USA). Filled plastic bags were perforated using a utility knife before bait was placed inside the trap. Traps were placed on the stream bottom, parallel to stream current, along banks, in deep pools, or near structure such as large woody debris. To prevent the loss of traps, each trap was anchored to the ice surface or bank by a tether line connected to the minnow trap and flagged. Baited minnow traps were deployed through auger holes or in open water leads and soaked for 24-hours. Minnow traps were deployed during each sampling event. Minnow trapping locations were marked with handheld GPS units in order to resample the same habitats each month. All captured fish were identified to species, measured, and released to the stream unharmed. Pelvic fin clips were collected from a subset of juvenile Chinook and coho salmon and delivered to the ADF&G Conservation Genetics Lab for genetic analysis.

2.1.5. Set Lines

Set line methods were similar to trotlines and were deployed through auger holes in ice-covered habitats or in open water leads and soaked for 24 hours. In contrast to trotlines, set lines only consisted of 1 or 2 hooks baited with salmon roe or whitefish that were attached to a main line weighted with a 16 oz sinker. Small hooks (sizes 4 to 10) were used with set lines in an attempt to catch resident fish with smaller mouths such as Arctic grayling, Dolly Varden, rainbow trout, and whitefish.

During the February and March sampling events, set lines were fished in slough habitats at FA-104 (Whiskers Slough). Sites were marked with a handheld GPS to ensure that sites could be relocated and sampled during subsequent sampling events.

2.1.6. Trotlines

Trotlines were fished during the February and March sampling events. Trotlines were set in slough and main channel habitats at FA-104 (Whiskers Slough) and at a main channel sampling site several miles upstream (Geomorphic survey site ESS-40, PRM 107.1). Sites were marked with a handheld GPS to ensure that they could be relocated and sampled during all sampling events. In addition, each trotline was flagged and identified with the permit holder's name, company contact information, and the date and time of the set.

Trotline construction and deployment followed the techniques used during the 1980s studies as described in ADF&G (1981). Trotlines consisted of 30 to 36 ft of seine twine with six leaders and hooks lowered to the river bottom using 24 oz and 8 oz sinkers. On one end of the 30 ft seine line a 2/0 snap swivel was connected and an 8 oz sinker was attached. From there, another 2/0 snap swivel was connected 15 ft from the other end and a 24 oz sinker was attached. Six leaders were then connected between the two sinkers, roughly every 3 ft. Trotlines were set up with a range of hook sizes from 10 to 4/0 to target various species. For larger hook sizes, both traditional J hooks and circle or octopus hooks were used. No individual trotline hook had a gap between shank and point greater than 0.75 in (ADF&G 2013). Hooks were baited with salmon eggs, herring, or whitefish depending on the hook size and bait available. As per ADF&G Fish Resource Permit stipulations, salmon eggs used as bait were sterilized either commercially or with a 10-minute soak in a 1/100 Betadine solution prior to use.

To deploy trotlines, holes were drilled in the ice with a two-person ice auger and trotlines were lowered to the bottom. The river current was used to pull the line out in a downstream direction; occasionally various combinations of lead weights had to be used to get lines to deploy properly. Trotlines were checked at least daily, were re-baited after 24 hours, and pulled after 48 hours of soak time. All captured fish were identified to species, measured for fork length, and gonads were examined to evaluate spawning status. Sampling mortalities were returned to the stream.

2.1.7. Underwater Video

Multiple underwater video camera models were tested and evaluated to determine tradeoffs between various features including: low light sensitivity, infrared light sensitivity, image resolution, option for real time viewing, battery life, size, and cold weather performance. To test feasibility, cameras were deployed in various light, depth, water velocity, and ice conditions. Water clarity was generally very good during winter testing.

Video cameras were used to record or observe short duration "spot checks" of fish presence and habitat and record long duration deployments fish presence, behavior and counts. Spot checks had multiple applications: (1) to make quick determinations of fish presence, (2) to observe habitat and ice features and (3) and to observe gear (trot line and minnow trap) placement. Spot checks required a camera type where imagery could be viewed real-time on a view screen and smaller, lightweight, mobile camera models were best suited for this application. Spot checks were done through an auger hole or near the edge of an iced-over area. During a spot check, the camera was either mounted to stationary mount or attached to a rod and panned around in order to observe conditions and fish presence under the ice in different views of field.

Long duration video-recording was sometimes stratified by day/night, covering day, night, and crepuscular periods, by positioning the camera on a stationary mount and letting the camera record for extended periods of time (up to 16 hours). Long duration video was gathered for later playback and did not require real-time viewing capabilities. Depending on the camera model, long duration deployment were done through and auger hole with covered with an ice fishing tent housing a 12-volt battery to run a computer and lighting system overnight. Both white and infrared lighting types were used during night observations.

2.2. Results

Fish capture and observation methods tested during 2013 winter sampling included angling, beach seining, electrofishing, minnow trapping, set lines, trotlines, and underwater video with a variety of camera models. The effectiveness of each method varied across habitat types and ice conditions. Preliminary data indicate that fish capture methods resulted in catch of 268 fish comprised of 10 species: Chinook salmon, chum salmon, coho salmon, pink salmon, sockeye salmon, burbot, Lamprey, rainbow trout, sculpin, and threespine stickleback (Table C2.2-1). Although they were not captured, round whitefish were observed schooling on underwater video and through clear ice in a reach of Whiskers Slough (Table C2.2-2).

2.2.1. Catch by Habitat Type

A diversity of habitat types were sampled including main channel, side channel, side slough, upland slough, slough mouth, tributary mouth, tributary, and other off-channel habitat (Table C2-2-3). Nearly half of the combined catch came from an off-channel habitat feature similar to an upland slough that is seasonally connected to both the Susitna and Chulitna River Systems (PRM 104.5). Many young-of-the-year (YOY) Chinook, coho and sockeye salmon were overwintering in this off-channel habitat feature (Table C2.2-3). Whiskers Creek was the next most productive habitat in terms of numbers of fish caught. Notably, four species of Pacific salmon were caught in Whiskers Creek as well as lamprey ammocetes. Side slough and upland slough habitats supported low numbers of several species and moderate numbers of age-1 Chinook salmon. Fishing under ice in the main channel habitats was infrequent (Table C2.2-4), but consistently yielded adult burbot (Table C2.2-3). Sampling in side channels was limited as it was not productive during the winter.

2.2.2. Catch by Gear Type

2.2.2.1. Angling

Angling was attempted in the mouth of Whiskers Slough on two occasions during the February and March sampling events. Angling efforts targeted adult resident fish species in deep open-water pools. Only one adult rainbow trout was caught using angling. Even when schools of round whitefish were observed through clear ice, angling with salmon roe and spinners was ineffective.

2.2.2.2. Beach Seines

Beach seines did not prove to be an effective method. They were used in an open-water lead within a side channel at FA-104 (Whiskers Slough) during the February sampling event (Table C2.2-4). No fish were captured during the three attempts to seine (Table C2.2-1). The presence of overhanging ice shelves along the channel prevented beach seines from sampling the entire wetted channel and allowed fish to escape. Additionally, beach seines intercepted ice pieces and frazil ice and accumulated ice during use in sub-freezing temperatures making them difficult to handle.

2.2.2.3. Electrofishing

Backpack electrofishing was used frequently during the March and April sampling events in both FA-104 (Whiskers Slough) and FA-128 (Slough 8A). Although limited to open-water habitats, electrofishing was effective for capturing fish in a diversity of habitat types including side channels, sloughs and tributaries. Backpack electrofishing was effective in swift, shallow habitats where other methods were not feasible such as swift shallow reaches and underneath overhanging ice shelves. Backpack electrofishing was a suitable method for sampling deeper glides and pool habitats when they were ice free. However, electrofishing was limited to open-water habitats and waters with conductivity higher than 20 µs/cm. As snowmelt contributed to lower conductivities, use of electrofishing was restricted during the spring.

Backpack electrofishing was effective for capturing a broad spectrum of species and life stages of anadromous and resident fish in the Susitna River. After minnow trapping, electrofishing yielded the second highest catch of any gear type (Table C2.2-5). Backpack electrofishing efforts captured eight total species, the highest number for any method tested (Table C2.2-2). This included four species of juvenile salmon, including age 1+ and 2+ Chinook and coho salmon as well as newly emerged age–0 alevin and fry life stages of chum and pink salmon. Backpack electrofishing also captured several resident fish species, including lamprey, rainbow trout, sculpin and threespine stickleback.

At a subset of sites, backpack electrofishing surveys were repeated during both day and night sampling. Night electrofishing surveys generally yielded higher catches; however, night survey events were too limited to support conclusive comparisons. Night surveys were safe and effective in habitats where the crews were familiar with the substrate and ice conditions from previous daytime sampling experience.

2.2.2.4. Minnow Traps

Minnow traps proved to be a versatile winter method that could be used in both open-water and under-ice habitats and was applied most frequently and at the most locations (Table C2.2-4). Minnow traps were deployed in a range of side channel, slough and tributary habitats (Table C2.2-4). Minnow traps captured more fish than any other gear type (Table C2.2-5). Minnow trap catch consisted of six species including Chinook salmon, coho salmon, sockeye salmon, burbot, sculpin and threespine stickleback (Table C2.2-5). Juvenile salmon catch-per-minnow trap was generally low during the winter. Juvenile salmon catch was less than 1.4 fish per trap for 22 of 24 sampling events; the two instances with higher catch rates (5.1 and 7.7 juvenile salmon per trap) were from the off-channel habitat at PRM 104.5.

Minnow trapping was fast and effective in open water habitats. Placing traps through the ice was more time consuming as it required the use of an ice auger with a 10-in blade to locate areas with sufficient water depth. These efforts determined that a minimum of approximately 2 ft of water was necessary to deploy wire minnow traps under the ice, resulting in the need to drill multiple holes in order to find suitable locations.

2.2.2.5. Set lines

Set lines baited with salmon roe and whitefish were fished in both open water and under ice in FA-104 (Whiskers Slough) during the February and March sampling events. Set lines were deployed in deep-water pools with the intention of capturing adult resident fish. One adult rainbow trout was the only fish caught using set lines baited with salmon roe. Several set lines had their hooks picked clean, possibly indicating that juvenile fish or a fish with a small mouth simply ate the bait around the hook. Smaller hooks may be needed to catch adult resident species with a smaller gape size such as suckers and whitefish.

2.2.2.6. Trotlines

While set in both open-water and ice-covered habitats, trotlines were found to be more effective in ice-covered mainstem habitats. Adult burbot were the only species caught by trotlines using both whitefish and herring as bait and trotlines were the only method that was effective for capturing adult burbot. Unfortunately, the traditional J and circle hooks resulted in unintended mortalities more than half of the time. Because burbot shallow their food, one modification to minimize mortality for future sampling would be to sew line through a frozen of piece of bait instead of using hooks. Other bait types, such as salmon roe, may help to capture more species of fish.

2.2.2.7. Underwater Video

Underwater video was a useful tool for recording fish presence, and in some cases supported definitive species identification. Video cameras were found to be useful for conducting short duration "spot checks" of fish presence, habitat types, ice and habitat features, and gear (trot and minnow trap placement). Occasionally fish were startled during spot checks when the camera was lowered into position or panned.

Longer duration video-recording was also done by positioning the camera on a stationary mount and letting the camera record for extended periods (up to 14 hours) often covering day, dusk, and dark periods. Long-duration recording was done in a variety of habitat types at FA-104 (Whiskers Slough) and FA-128 (Slough 8A). Long-duration video was useful for identifying diel movement patterns and fish behaviors.

Although exact counts are difficult to quantify due to fish milling or moving in and out of the field of view, well over one-hundred (and likely may hundreds) of individual fish were observed with underwater video (Table C2.2-6). Seven fish species were documented with underwater video, a species count second only to backpack electrofishing. Video cameras were also useful for detecting species, such as round whitefish, that were not physically collected by an alternate gear type (Table C2.2-3). When determining species identity from underwater video, image quality was critical; it became evident that high resolution imagery was necessary for detecting subtle physical characteristics that were necessary for species identification. Development of a subsampling procedure to characterize fish behavior, make quantitative counts, and identify individuals to family or species is ongoing.

Several underwater video camera models were tested and evaluated. Cameras varied greatly in performance, features, image quality, and night or low-light performance (Table C2.2-7). Since a major objective of underwater video was to identify species presence, image quality was extremely important. Of the camera models tested, the GoPro had by far the best daytime image quality and clarity and resulted in more species identifications. However, battery life is a critical component of camera performance and the GoPro had limited battery life. Some cameras are powered externally by large batteries and can operate for a day or more whereas the GoPro could only operate for 2 to 3 hours.

Lighting was critical for underwater fish observations at night. Lighting within the visible spectrum of fish appeared to alter fish behavior. When white light was used, yearling salmonids tended to be attracted to the light source for feeding. Infrared lighting was preferred for underwater observations because no obvious change in fish behavior was noted.

3. SONAR

A pilot study was conducted in Whiskers Slough on the Susitna River to evaluate the feasibility of using imaging sonar systems for assessing juvenile salmonid and resident fish habitat use during the winter. The investigation addressed the ability to observe fish presence and behavior through imaging sonar sampling methods in off-channel habitats and did not consider application of sonar in the mainstem Susitna River.

Dual-frequency Identification Sonar (DIDSON) and Adaptive Resolution Imaging Sonar (ARIS) are high-resolution imaging sonar techniques that provide video-type images over a 29-degree field of view and can thus be used to observe dynamic fish behaviors that cannot be identified on static sonar images. To obtain high-quality images of adult salmon, the maximum range was limited to 15 m (49 ft). Within this field of view, evidence of spawning behavior, e.g., redd digging, chasing, and spawning, would be clearly identifiable. Furthermore, on DIDSON images fish could be classified by size category, e.g., small (less than 4 in), medium (4 to 14 in), or large (more than 14 in, respectively). Although this size categorization was not sufficient for definitive species identification, it allowed for grouping of fish into a size bin (small) that approximated the size range of juvenile salmonids (maximum size of juvenile Chinook and coho salmon, 118 and 120 mm (4.7 in), respectively).

DIDSON has been shown to be an effective tool to assess fish passage and behavior (e.g., Johnson and Le 2011); however, most of this work was conducted in open-water conditions. DIDSON has been shown to be effective for sampling fish under the ice (Johnson et al. 2012). In a study assessing habitat association in the Athabasca River, Johnson and others (2012) used DIDSON to image fish, estimate size, and identify fish targets to species including both northern pike and burbot. Mueller et al. (2006) also conducted under-ice winter surveys with DIDSON in the Sagavanirktok River Delta, Alaska. Brown et al. (2010) reported that DIDSON was used to count and estimate size of broad whitefish in a pool under the ice in the Sagavanirktok River. Other under-ice DIDSON applications known to date are feasibility studies assessing its utility for imaging Arctic Lamprey in the Yukon River, and Alaska blackfish in an unnamed lake in the Goldstream Valley, Alaska (Bruce McIntosh, Alaska Department of Fish and Game, personal communication. January 30, 2012).

Mueller et al. (2006) found that DIDSON cameras were useful for counting and measuring fish up to 52.5 ft from the camera and were effective in turbid waters. In contrast, they found that video cameras were only effective in clear-water areas with turbidity less than 4 nephelometric turbidity units (NTU). Thus, a comprehensive approach will combine both imaging tools. An additional advantage of video cameras is that they may be used to characterize micro-habitat attributes such as the presence of anchor ice, hanging dams, macrophytes, structure, and substrate type.

3.1. Study Sites

Three sites within FA-104 (Whiskers Slough) were sampled during March 22 – 25, 2013near the mouth of Whiskers Slough, at the confluence of Whiskers Creek and Whiskers Slough, and at an upland slough site (Figure C3.1-1). The slough mouth and confluence sites were completely ice-covered and had cobble and gravel substrates with some sand. The upland slough site had an open lead, with dense aquatic vegetation (macrophytes) growing atop a silt substrate.

3.2. Methods

Access under the ice was obtained by placing imaging equipment on temporary mounts and deploying the equipment through holes cut in the ice using a chainsaw. Holes were triangular-shaped, at least 28 in wide, and located in areas where water depths ranged from 16 to 32 in. At each site, a DIDSON, or ARIS, and an underwater video camera (Aqua Vu Micro Plus DVR or other model) were fastened to aluminum pole mounts and lowered down into the sample holes (Figures C3.2-1 and C3.2-2). Each sonar system consisted of the sonar head, data transmission cable, switch box, Ethernet cable, laptop computer and an external hard drive. All topside electronic components were housed inside a portable shelter on the riverbank above the slough (Figure C3.2-3); the shelter provided protection for the electronic components from winter weather conditions. The sonar systems were powered using a Honda generator, model EU2000i, placed in a containment pad. The video camera recorded imagery alongside the DIDSON or ARIS unit in the same orientation and heading to determine if positive species identifications could be made while the Sonar imaging was taking place.

The sonar heads were positioned about 10 in off of the river substrate near the bank and aimed towards the opposite bank so the sample volume bisected the flow. The sonar heads were tilted down to allow the sampling beams to spread across the substrate throughout the majority of the sampling window (Figure C3.2-4). The sampling windows typically started 0.4 m (16 in) from the sonars and were 5.0 m (16.4 ft) in length. Data were collected at a rate of 8 to 10 frames per second and ported directly to 1-terrabyte external hard drives. Daytime and nighttime data were collected at each sample site (Table C3.2-1). Data were backed up and archived to additional hard drives each evening.

Data processing involved manually reviewing a subsample of the data from each site. Two 10-minute periods from each hour were randomly selected and reviewed using either the DIDSON or ARIS playback software. The review process entailed playing back the selected files (typically at about five times the data collection rate) and noting the presence and absence of fish observations. A subtraction algorithm was used to remove the static background to allow for easier detection of moving targets. For each fish or school of fish observed, fish lengths were estimated using the software's sizing tool and classified as small (less than 4 in), medium (4 to 14 in), or large (more than 14 in), school size was estimated to be small (fewer than 10 fish), medium (10 to 35 fish), and large (more than 35 fish), movement direction (upstream or downstream) was noted, and observations were made regarding swimming behaviors (milling or holding).

3.3. Results

The sonar systems performed well and data were acquired reliably during the study. Fish were observed during almost all hours at each sample site. The majority of detections were of individual fish. Small and medium-sized schools were observed at all sites, and large-sized schools were only seen at the upland site. Small-sized schools were observed more frequently than other school size classifications across all sites (e.g., Figure C3.3-1). Small fish (down to 2.5 in estimated total length) and medium-sized fish were observed at all sites, and large-sized fish (up to 16 in estimated total length) were only seen at the slough mouth site (e.g., Figure C3.3-2). Medium-sized fish were observed more frequently than other fish size classifications across all sites. Fish were documented milling and actively moving at all sites. Holding behaviors were more frequently observed at the upland site as compared to the other sites. A clear pattern of crepuscular movement was seen at the upland site, with schools of fish observed to head upstream during the dusk period and downstream during the dawn period.

Underwater video conducted side-by-side with sonar imaging detected fish presence and in some instances provided enough resolution to discern between species or family (e.g. salmonid). The built-in underwater video lighting system did not perform well in low-light conditions and fish presence was not detected during night. Generally, sonar systems can detect fish further afield than video and may perform better in low or no light conditions. However, when used in tandem underwater video can yield useful information on fish species identification.

On March 24th at the upland site, the ARIS system abruptly stopped data collection at 20:50. DIDSON data were acquired throughout the evening and into the following morning at the upland site. The cause of the ARIS system failure was unknown. Discussions are ongoing with the manufacturer to prevent such malfunctions from occurring in future applications. One recommendation towards this end will be to implement a function to automatically restart data recording in the event of future disruptions in the connection between the sonar system and the computer.

3.4. Discussion

These results indicated that imaging sonar systems can be used to effectively document juvenile fish presence and behavior under the ice in Whiskers Slough. Fish were readily observed and counted whenever present, and individual fish lengths were estimated. Continuous data collection throughout daytime and nighttime periods allowed for assessing habitat use and fish movement through diel cycles.

Underwater video systems can also be configured to record imagery in tandem with sonar imagery. Although water clarity and lighting can limit the effectiveness of video sampling, a distinct advantage of video over sonar imaging is the ability to clearly identify fish species. In clear water with appropriate lighting, video can also capture a much larger coverage area than DIDSON (Mueller et al. 2006). Video can be combined with a white or infrared (IR) light source; however, we observed that lighting may affect fish behavior. For nighttime underwater imaging we recommend that a digital video recording system using infrared light be employed. Other capture methods such as short duration gill nets sets or fyke netting may also be used in tandem with sonar imaging in order gather a sample for species identification.

4. PIT TAGS

The Study Plan proposed the deployment of fixed PIT tag antenna arrays at six sites in tributary and off-channel habitats to monitor the timing and frequency of fish movement in these areas. For some of these sites, the intent was to operate arrays throughout the year, including during winter conditions. Winter operation poses unique concerns with respect to the performance of arrays during cold temperatures. Thus, the initial goal for the winter pilot study was to determine whether the presence of ice in the antenna field compromised the detection of PIT tags and, if so, to identify the maximum ice thickness through which PIT tags could be detected. An additional concern was the performance in cold temperatures of power supplies (i.e. deep cycle batteries) and the overall system.

Prior to field testing, bench-top testing was necessary to assemble and test the PIT tag equipment and identify appropriate prototype antenna designs that would resemble those that would be deployed in the field during a prolonged study period (i.e., that optimized read distance). Bench-top testing was also needed to understand the general antenna design considerations and performance of the new 12-mm (0.47 in) HDX tag technology. Thus, in addition to describing findings related to winter performance, general conclusions and recommendations related to the feasibility and design of antenna arrays are also provided.

4.1. Study Objectives

4.1.1. Bench-top Testing

As an initial step in developing an effective PIT tag system in support of the Fish Distribution and Abundance Implementation Plan, bench-top testing was performed with the following objectives.

- Evaluate read distance and performance of PIT tags, primarily 12-mm (0.47 in) tag
- Evaluate various prototype antenna designs to identify those that would optimize tag detection. Emphasis was placed on optimizing detection of 12-mm (0.47 in) tags which have the more limited detection range of the two tag types.
- Evaluate different wire types to identify which would optimize tag detection. Again, emphasis placed on optimizing detection of 12-mm (0.47 in) tag.
- Test reader and datalogger assembly and reader configurations.

4.1.2. Winter Field Testing

- Determine whether the performance of the PIT tag system (tag and antenna) is affected by the presence of ice in the antenna field.
- Evaluate the performance and power requirements of prototype antenna designs (identified from bench-top testing) and performance of power supplies in cold weather.
- Identify logistical challenges associated with operating and maintaining PIT antennas during the winter and overall feasibility.

4.2. Methods

Although bench-top testing was not explicitly included in the study plan, it was necessary to evaluate the performance of the new 12-mm (0.47 in) tag and identify appropriate antenna designs that could be used for winter field testing. Likewise, evaluating the overall winter performance of the PIT tag system, including power supply performance, was necessary as these were major concerns in assessing the feasibility of winter operation.

4.2.1. Bench-top Testing

Initial bench-top testing of the PIT tag system, tag performance, and various antenna designs was conducted at the R2 Resources, Inc. office in Redmond, Washington during March 4-8, 2013. The performance of both the 12-mm (0.47 in) and 23-mm (0.9 in) tags were evaluated using a variety of antenna designs and materials. Swim-over and swim-through designs were tested using both 14 AWG THHN wire and 10 AWG duplex marine wire. Testing was initially conducted using a regulated 12-volt (nominal) power supply (13.8-volts actual); although a 12-volt deep-cycle lead-acid battery was also used to simulate the power supply that would be deployed in the field. Read distance was the sole metric by which the performance of each antenna design and tag were evaluated. Read distance, as reported here, indicates the maximum distance in one direction from the antenna plane at which a tag could be detected consistently. Thus, for a swim-through antenna, the read distance reported only reflects half of the detection field since a comparable read distance could be expected on the opposite side of the antenna plane. For a swim-over antenna, the reported read distance reflects the effective detection field since the antenna plane would be lying flush over the substrate.

4.2.2. Winter Field Testing

To test the effect of ice on PIT tag detection, the study plan originally called for drilling holes in the ice, attaching PIT tags to floats at the end of a tethered fishing line and allowing them to drift downstream under the ice past an antenna. However, because tag read distance can vary considerably both as a function of tag orientation and position relative to the antenna loop, and because water velocities at the test site were insufficient to precisely drift a tag, two alternative approaches to testing performance through ice were adopted. These two approaches allowed for a more precise and repeatable means of testing for any effect of ice; these methods are described below.

Field testing was conducted during March 20-25, 2013 in Whiskers Slough, downstream of the confluence with Whiskers Creek. Testing to determine the potential influence of ice on PIT tag performance involved two different antenna designs. The first design was identified during bench-top testing as the optimal swim-through design to date; this was a 10-ft long by 4-ft tall antenna with a twist located in the middle that effectively created two 5-ft x 4-ft loops. The purpose of testing with this design was to determine whether performance of a swim-through antenna would be compromised by the presence of ice within the field. The antenna consisted of 10 AWG duplex marine wire that was spliced together at the ends to create a loop with two wraps. The antenna was fixed to a PVC frame for deployment. Using a chainsaw, slots were cut through the ice such that the antenna could be inserted into the water and then moved in an upstream direction through additional perpendicular slots to a final position with a layer of ice intentionally left in the middle of each antenna loop (Figure C4.2-1). The layer of ice in the center of the antenna was roughly 11 in thick. The antenna was installed on March 20, 2013 and allowed to refreeze in place until testing occurred on March 23, 2013. To test read distance under the ice, a series of 2-in holes were drilled moving upstream from one antenna loop and 12-mm (0.47 in) and 23-mm (0.9 in) test tags fixed to a PVC pipe were positioned just above the ice, in the middle of the ice, and just beneath the ice at each hole to compare read distances at various distances from the antenna. This testing served the purpose of determining whether read distance differed above, within, or beneath the ice. An additional purpose was to compare the read distance on the antenna in ice with the read distance in the absence of ice. Thus, the antenna was subsequently cut from the ice and repositioned in an open-water section to compare read distances in the absence of ice (Figure C4.2-2).

The next test focused on evaluating whether the performance of a mobile wand antenna design would be compromised by the presence of ice. A small 2-ft diameter hoop antenna was constructed out of 14 AWG THHN wire and laid flat over the ice (Figure C4.2-3). A 2 in hole was drilled through the ice at the middle of the antenna. Test tags fixed to a metered PVC pipe were used to determine the read distance below the ice surface as well as above the ice surface. Reduced read distance below the ice would indicate that 11-in thick ice layer was impeding read distance.

A third test was done over the course of the field effort to evaluate the overall performance of a PIT tag antenna system during winter conditions, including the performance of the power supply. This was accomplished using the optimal swim-over antenna design to date, identified during bench-top testing. This was a 22-ft long by 20-in wide antenna with a twist located in the middle that effectively created two 11-ft x 20-in loops laid flat across the channel bottom (Figure C4.2-4). The antenna was powered by one Sun XTender 12V deep-cycle marine battery (part number PVX-1040T) with a 104 amp-hour capacity. This system ran for several days until the power supply could no longer operate the system. Read distance, voltage, and maximum draw (amps) were measured at least once daily, but typically twice daily.

4.3. Results

4.3.1. Bench-top Testing

The read distance of 12-mm (0.47 in) and 23-mm (0.9 in) tags was evaluated for a variety of antenna designs. Each antenna design and the corresponding read distance are described in Table C4.3-1. Based on this initial testing, the largest swim-through antenna that would provide an acceptable read distance for 12-mm (0.47 in) tags (i.e. no holes in antenna field) was 10-ft long by 4-ft tall with a twist located in the middle that effectively created two 5-ft x 4-ft loops. The largest swim-over antenna that would provide an acceptable read distance for 12-mm (0.47 in) tags was 22-ft long by 20-in wide with a twist located in the middle that effectively created two 11-ft x 20-in loops. This design provided swim-over read distances of 12.5 in for the 12-mm (0.47 in) tag and 20 in for the 23-mm (0.9 in) tag. Using 10 AWG duplex marine wire spliced to create two wraps improved read distance as compared to two wraps of 14 AWG THHN wire.

4.3.2. Winter Field Testing

4.3.2.1. Effect of ice on system performance

None of the tests indicated that the presence of ice interfered with or compromised the read distance of either the 12-mm (0.47 in) or the 23-mm (0.9 in) tag. When deployed vertically through ice, the swim-through antenna showed consistent read distances for the 12-mm (0.47 in) tag (24 in) and 23-mm (0.9 in) tag (41 in) regardless of whether the tag was positioned above the ice surface, in the middle of the ice sheet, or under the ice surface. Likewise, when the swim-through antenna was repositioned in an open-water area free of ice, read distances were again comparable for the 12-mm (0.47 in) tag (24 in) and 23-mm (0.9 in) tag (40 in).

Testing with the 2-ft diameter hoop antenna that simulated a mobile wand also provided no indication that the presence of ice reduced the read distance of a tag. With the antenna laid flat against the surface of the ice, the read distance of the 12-mm (0.47 in) tag was recorded as 17 in under the ice and 16 in over the ice. The read distance of the 23-mm (0.9 in) tag was recorded as 20 in under the ice and 19 in over the ice. Ice thickness was approximately 11 in. These small differences were considered negligible and attributed to measurement or rounding error.

4.3.2.2. Performance of system in cold temperatures

The swim-over antenna and overall PIT system, including power supply, reader, and data logger, performed well at cold temperatures. The system began running at16:45 on March 20, 2013 and operated continually through 11:20 on March 24, 2013 before the system shut down due to low voltage. Over this period, the system drew from 0.7 to 0.9 amps, based on the continuous logging of maximum current (Figure C4.3-1). System voltage was recorded using both the data logger and with a volt meter on the battery terminals and decreased in a linear fashion, apparently irrespective of antecedent air temperatures (Figure C4.3-2). Read distance was generally consistent throughout the period of operation and showed no obvious changes associated with air temperature (Figure C4.3-3). Air temperature during the period of operation reached a low of -12°F based on reporting from the Talkeetna Airport weather station. Temperatures at Whiskers Slough were generally considered to be several degrees colder than at Talkeetna. The data-logging equipment associated with the PIT tag reader provided an instantaneous display of both current (in amps) and voltage, but this data does not get recorded by the equipment. Thus, the current, voltage, and read distance during the coldest period are not known.

4.4. Discussion

The design and installation of PIT tag antenna arrays was ultimately dependent on site-specific conditions. Due to the limited detection range of this technology, specific installation sites and antenna designs at each study area were selected following on-site reconnaissance efforts so that the ability to detect tagged fish moving past an antenna was optimized. This optimization was a function of stream width, water depth, water velocity, expected degree of inundation (via backwatering or high-flow events), and anticipated debris loading and ice damage. These considerations dictated the number of individual antennas at a given site, and the appropriate antenna design(s) for a given site. Based on the results of the pilot study, two different antenna designs were possible: a swim-through antenna oriented perpendicular to the channel bottom or a swim-over antenna laid flat over the stream channel substrate. For a swim-through antenna design, the bottom segment would be anchored to the substrate and the top segment would be suspended above the water surface using a rope spanning the channel or other some other support structure (e.g. fence posts). For a swim-over antenna, all four sides of the antenna frame would be anchored to the substrate.

The greatest limiting factor in the successful deployment of a PIT tag antenna is the width and depth of the channel targeted for coverage. Results of bench-top testing demonstrated that the largest swim-over antenna with adequate read distance (approximately 12 in for 12-mm (0.47 in) tag and 20 in for 23-mm (0.9 in) tag) was 22 ft in length and the largest swim-through antenna was 10 ft in length with a vertical member used at in the midpoint of the antenna. Field testing during the winter pilot study indicated antenna size could be increased to 24 ft long and still effectively detect a 12-mm (0.47 in) tag. Additional antenna design improvements developed during the 2013 open water period indicated that swim-over antennas could be used to monitor widths up to 60 ft. However, antennas of this size exceed the capacity of a multiplexer device.

Multiplexers allow a single reader to assign a date and time to tag detections at multiple antennas using the same clock. While the clock may drift by up to several minutes per week, the sequence in which tags are detected at different antennas can be used to determine directionality. However, multiple antennas long enough to require independent readers cannot be synchronized. Thus, long antennas connected to OregonRFID systems cannot currently be used to discern directionality.

With respect to the detection of tags under the ice, pilot testing confirmed that the presence of ice near the antenna did not impede the detection of a tag. However, ice thickness and snow depth on top of a channel would determine how close an antenna could get to flowing water or a tagged fish. For a mobile wand to successfully detect fish under ice with 100 percent efficiency, an antenna would need to have a read distance that exceeded the sum of snow depth, ice thickness, and water depth. A mobile wand may be effective in some shallow water areas where neither the ice nor snow cover is too thick. Researchers on the North Slope recently began using mobile wands to detect fish through ice, though they acknowledge that without knowing ice thickness or the depth of water under the ice, it is difficult to determine what the detection efficiency of such efforts might be (C. MacKenzie, personal communication, May 13, 2013).

In general, temperatures during the study period were representative of typical winter conditions, although minimum values over the course of a full season would certainly be lower. The system functioned as intended with no major problems associated with the cold. One exception was the PDA (personal digital assistant) used to download data and interface with the data logger. At temperatures below approximately 15°F, the touch screen on the PDA no longer functioned. A more cold-resistant device would be needed for routine operation during winter studies. The deep-cycle lead acid battery performed as expected, although the test antenna drew only 0.7 to 0.9 amps. Power requirements for a given antenna vary by antenna design, with some designs drawing up to 2.5 to 3.0 amps. A supplemental battery bank (doubling of capacity) may be required for winter installations. Initial discussions with the preferred remote power station vendor indicate that solar panels may provide enough power through the winter if a sufficient number of panels are used. However, site-specific conditions such as topography and forest canopy may pose a limit on the use of solar panels in the winter given the low angle of the sun. For example, Slough 8A has greater relief to the south as compared to Whiskers Slough. To maintain a system through the winter without solar panels would require either the use of a more expensive and labor-intensive technology such as a propane thermoelectric generator, or the replacement of batteries on a routine basis. A rough approximation would suggest that a set of eight batteries may be needed to run an antenna for two weeks. The weight of such a battery bank would be roughly 560 pounds, which may require considerable logistical support to swap out, whether by helicopter or snow machine.

5. RADIO TAGS

In order to meet objectives outlined in Sections 9.5 and 9.6 of the 2013 Revised Study Plan, it was important to understand the capabilities of the ATS radio telemetry equipment when working in situations where the majority of the Susitna River was ice-covered. Understanding the impacts of ice cover was critical for refining sampling plans and designing telemetry surveys. We assumed that detection efficiency in proximity to open leads would be higher than in completely ice covered areas, and therefore open water areas were not tested during the winter pilot effort.

The primary function of the telemetry component is to track tagged fish spatially and temporally. Radio telemetry is intended to provide detailed information from relatively few individual fish. Locating radio-tagged fish will be achieved by fixed receiver stations and mobile (aerial, boat, snow machine, and foot) surveys. Although wintertime radio-tracking of adult fish was successfully completed during the 1980s studies, some question remains as to the limitations of detecting radio tags under ice cover.

5.1. Methods

On March 23, 2013 AEA conducted an under ice test of Advanced Telemetry Systems (ATS) radio telemetry equipment on the Susitna River upstream of Talkeetna in the vicinity of the FA-104 (Whiskers Slough) Focus Area. ATS model F1840B radio tags were deployed into the river beneath river ice and then a mock aerial survey was flown to determine the limitations of the gear in winter conditions and the best operations for locating tags under the ice. Test holes were augured in ice and radio tag strings were deployed at three off-channel locations in the lower Whiskers Slough/Whiskers Creek area and one mainstem location at ESS-40 (PRM 107.1) where thicker ice conditions and deeper water was present for testing (Table C5.1-1 & Attachment 2, Figures CA3-1-CA3-15). A line with three radio tags and a weight was lowered through each hole and attached to a piece of wood at the top of each hole. Tags were attached to hang at varying depths in the water column. Test holes were covered with ice and snow to mimic the surrounding ice conditions prior to aerial telemetry surveys. Augured study holes were marked with bright orange buckets to aid in locating them from the air and give the testers a better understanding of their location relative to the tags when adjusting settings on the telemetry receivers

Tags were deployed in four groups, with each group comprised of two or three tags connected to a piece of line that was dropped into the river either through auger holes (3 groups) or through an open lead (1 group). Tags were deployed in two primary locations but each set of tags at those locations were placed in a unique location to test a variety of conditions. Further information on the groups of tags and their deployment locations can be found in Table C5.1-1.

After the tags were deployed a helicopter-based crew then made multiple passes over the tags. The crew rode in a Robinson R44 with a forward-oriented 4-element Yagi antenna on one side and a downward -oriented 4-element Yagi antenna on the other side. A bank of four ATS model R4520 receivers was used with each receiver dedicated to one of the four frequencies used in this test. GPS was used to track the geographic position of the helicopter and allow for the calculation of maximum detection distance from the stationary tags. Varying combinations of flight speed and altitude, active antenna configuration and receiver gain were tested to identify the best protocol for locating tags under the ice. The first pass was conducted flying upstream using the standard orientation for surveys during the 2012 field season using the downward antenna with the receivers set at a gain of 5. The second pass was made flying downstream using the downward oriented antenna and a gain of 7. Passes 3 (upstream) and 4 (downstream) were done with the forward facing antenna and gain settings of 5 and 8, respectively.

5.2. Results

The two passes done with the forward oriented Yagi antenna detected the radio tags from further away than the passes made with the downward oriented Yagi antenna, although passes 2 and 3 were not separated by much detection distance (Table C5.2-1). The second pass had the shortest average distance between the known tag location and the location of the flight’s highest power reading at 0.04 mi (211 ft; Table C5.2-2). Only Pass 2 flew directly over tag sets 1, 2 and 4.

Table C5.2-3 is provided with an adjustment to account for passes not flying directly over tag locations.

Pass 1 (Downward antenna, gain=5) did reasonably well but was noticeably less effective than when the same setup was used over open water. The helicopter had to be much closer to locate tags with this setup and one tag was not detected. The distance from the highest power detection to the tag was the second best for tags located under the thickest ice in the study (Tables C5.2-1, C5.2-2, C5.2-3). Power readings on detections were low on average which made it hard be confident that a tag was located correctly while flying.

Pass 2 (Downward antenna, gain=7) provided the best combination of detection range and accuracy in marking the tag locations. The average distance from the highest power detection to the tag was only 25 percent of Pass 1 (Tables C5.2-1, C5.2-2, and C5.2-3). The higher power readings from the increased gain allowed for better inflight confirmation that the tags were correctly located. Especially important was how accurate this setup was in locating tag group 3 which was located under the thickest ice.

Pass 3 (Forward antenna, gain=5) provided the second best combination but offered limited upside in detection range and was less accurate in locating tags than Pass 2. For tag group 3, located under the thickest ice, the average distance from the highest power reading to the tags was three times higher than for Pass 2 (Tables C5.2-1, C5.2-2, and C5.2-3).

Pass 4 (Forward antenna, gain=8) provided very high results for the distance the tags were first detected (Tables C5.2-1, C5.2-2, and C5.2-3). The forward antenna had a detection range of over two miles for most tags (three out of four); these settings would be valuable for detecting fish up tributaries and for covering stretches of river quickly where tagged fish were unlikely to be found. Once fish were detected it would be necessary to switch to the downward antenna for accurately pinpointing the location of the fish.

The goals of this test were to determine if the ATS radio tags could be located under the ice in the Susitna River and to determine what techniques would work best for tracking radio-tagged fish in the winter. The first goal was easily achieved as all passes near the tags resulted in detections. The second goal was also achieved after analyzing the data collected during the test. The recommended standard setup for winter tracking is a downward oriented antenna with the receiver set at a gain of 7. With the exception of a slightly higher gain setting on the receiver, the same tracking protocol used during open water surveys can be utilized during winter tracking.

6. RECOMMENDATIONS FOR FUTURE STUDIES

6.1. Winter Sampling Logistics

6.1.1. Interdisciplinary Field Trips

Interdisciplinary field trips include the following disciplines: fish distribution and abundance (Study 9.6), instream flow (Study 8.5), water quality (Study 5.5), groundwater (Study 7.5), and Riparian (Study 8.6). Data collection is proposed to occur during three monthly trips from February to April 2014. The exact timing of trips will depend on safe and practical winter transportation conditions. The monthly winter group trips will be approximately 15 days in duration including travel, on-site activities, and weather-related delays. The first day of each field trip will be devoted to winter safety planning and training among all resource disciplines. This will include brief winter survival, avoiding frostbite, hyperthermia, snow machine operations and safety, response to falling into open leads, and other safety topics related to the planned field work. No winter sampling events are planned for late November through January during the ice jam and freeze-up process and short photoperiod. Three to four days of sampling effort per Focus Area are planned for each sampling event.

Data collection will be centralized at three of the ten focus areas serving as bases of operation for winter data collection.

- FA-104 (Whiskers Slough) – Logistics based in Talkeetna
- FA-128 (Slough 8A) – Logistics from local winter spike camp at FA-128
- FA-138 (Gold Creek) – Logistics from AEA Gold Creek camp.

Transportation options include snow machine, helicopter, railroad, and airboat. Snow machine transportation is the preferred option but is contingent on snow cover, river conditions, and landuse/access permitting. Helicopter transportation is contingent on weather, land status and landing zone permitting and is restricted to daylight hours. Railroad transportation is contingent on advance scheduling and where the railroad can physically load or offload. Railroad transportation is complicated since passenger and freight must be moved separately with different schedules. Airboat transportation is contingent on river conditions and land access permitting. Within focus areas, transportation will be primarily by snow machine, snowshoe, and on foot.

Trail and ice conditions along travel routes and in work areas will be assessed prior to each sampling trip and monitored during sampling field trips. Trail grooming to prepare work areas for snow machine travel will take two to three days for FA-104 (Whiskers Slough), and two to three days for grooming a trail from FA-138 (Gold Creek) to FA-128 (Slough 8A). For communication in the field, crews will use tracking devices (spidertracks), radios for ground-to-ground and ground-to-air communication, and satellite phones.

Warm-up and latrine tents will be used in areas with concentrated crew activities and areas where field crews may be left by the helicopter for work activities; field crews will hold daily safety meetings, carry emergency safety gear in the field, and use weather reports and online weather stations in field areas to plan daily activities.

6.1.2. PIT Tagging

PIT tag arrays will be inspected and maintained during monthly sampling trips. However; it is anticipated that solar charging will not be able to meet power supply demands during the winter and supplemental battery charging or swapping will be necessary. Battery charging will require travel to the sites by snow machine or helicopter with a generator to charge the batteries. Logistical and safety constraints for these activities will be similar to transportation during scheduled field trips. As an alternative, or to prolong power supply, PIT readers may be programed to operate only during periods when fish are most active.

6.1.3. Radio Telemetry

In addition to weather, the primary logistical constraint for aerial radio telemetry surveys in the winter will likely be the availability of fuel when flying the Upper River.

6.2. Spring Break-up

If site conditions allow and water level monitoring and evacuation safeguards are in place in the event of ice jam flooding, Early Life History fish sampling could potentially take place in off-channel habitats during break-up. Sampling would need to be helicopter supported with an ice jam and water level monitoring system in place to alert field crews in the event of sudden rise in water levels. Evacuation procedures would need to be planned out; preferably with high ground quickly accessible by foot.

While ice did not appear to impede PIT tag detection, its presence generates concern for winter antenna operations in dynamic areas or during breakup. An antenna that is enclosed in ice would be destroyed once that ice began to move. A swim-over design may be less likely to become enclosed in ice as compared to a swim-through design. However, both designs would likely require temporary removal prior to breakup or replacement following breakup. Moreover, a swim-over design would have dramatically reduced detection efficiency at the higher flows associated with breakup, negating the potential benefits of leaving it installed during this period. To reduce risk of equipment loss, we recommend demobilizing the PIT array systems and moving them to high ground during spring break up and reinstalling them as soon as feasible.

Radio telemetry flights would be unaffected by break-up; however, flood conditions may threaten fixed receiver sites and result in loss of land zones to access and download receivers.

6.3. Sampling Techniques

The goal of the winter fish study is to improve our knowledge of the winter ecology of fish species in the Middle Susitna River. Specific fish sampling objectives will include the following:

1) Describe overwintering habitat associations of juvenile anadromous salmonids, non-salmonid anadromous fishes and resident fishes.
2) Describe winter movements of juvenile salmonids and selected fish species such as Arctic grayling, burbot, Dolly Varden, lamprey, northern pike, rainbow trout, humpback whitefish, and round whitefish within select Focus Areas.
    a. Describe seasonal movements using biotelemetry
3) Describe early life history, timing, and movements of anadromous salmonids.
    a. Determine juvenile salmonid diurnal behavior by season.
4) Document the seasonal age class structure, growth, and condition of juvenile anadromous and resident fish by habitat type.
5) Collect tissue samples from juvenile salmon and opportunistically from all resident and non-salmon anadromous fish to support the Fish Genetic Baseline Study (ISR Study 9.14).

Fish sampling data collection is proposed to occur during four trips in the winter of 2013-14, starting in November and followed by monthly trips from February to April 2014. The April sampling trip will include sampling below known salmon spawning areas to determine if fry emergence is occurring. Data collection will not be limited to these Focus Areas but they will serve as remote camp locations where study teams may access satellite locations including important tributary mouths and habitat features that are outside of Focus Areas. The Focus Area field camps will serve as a logistical base for each area.

Each sampling event will include sampling in multiple off-channel macrohabitat types within the three Focus Areas and at select satellite locations, time permitting. To the extent practical, based on ice conditions, sampling will take place at the same stratified macrohabitat locations randomly selected using the GRTS method for the July through October fish abundance sampling within FA-104 (Whiskers Slough), FA-128 (Slough 8A), and FA-138 (Gold Creek). Select satellite locations may include but not be limited to the Cut (upland slough between Susitna and Chulitna Rivers) and important Middle River tributary mouths including: Whiskers Creek, Fourth of July Creek, Gold Creek and Indian River.

Specific fish sampling sites for winter studies cannot be preselected because ice conditions are dynamic and unpredictable. Instead, each 200 m (656 ft) GRTS site will be evaluated, beginning at the downstream end to determine if a 40 m (131 ft) segment has conditions appropriate for sampling. In ice-covered areas, a 2-in diameter ice auger will be used to drill pilot holes every 25 m (82 ft) along the unit to determine suitability based on the presence of flowing water and minimum water depths under the ice. When GRTS units do not have appropriate conditions for sampling, oversample sites will be evaluated. Sampling will also take pace opportunistically to take advantage of slow-moving open water leads in off-channel habitats and areas of sufficient ice thickness and water depths to sample through ice. Generally, a minimum of 24 in (61 cm) of water under ice is necessary to set minnow traps. In addition to minnow trapping, electrofishing, angling, trotlines, hoop traps, small mesh Fyke nets, and underwater video will be used for winter sampling. Gear selection will be determined based on site conditions (ice coverage, ice thickness, depth, velocity, and conductivity). Because of safety concerns, limited mainstem sampling may occur at water quality/ice processes transect locations (e.g. ESS-40) where the ice conditions have been mapped or in other areas evaluated and deemed safe. To characterize diel behavior, in addition to overnight minnow trapping, a select subset (three to four per Focus Area) of sites sampled during the day will be revisited during the night and sampled by electrofishing or underwater video. Underwater video and potentially short duration set gill or Fyke net sets will used to support sonar observations with fish identification.

When ice conditions allow, 40 m (131 ft) sampling units will be sampled with a minimum of one technique and a target of two techniques including:

1) Setting four to eight baited minnow traps overnight.

2) Selecting an additional technique based on site conditions including electrofishing, small mesh Fyke netting, hoop trapping, trotlining, setlining, angling, or underwater video.

3) Repeating sampling of a subset of sites using underwater video or electrofishing to characterize diurnal fish presence and behavior. Day/night stratified Fyke net sets may also be used to characterize diel fish activity.

6.4. Sonar

The demonstrated effectiveness of wintertime sonar pilot sampling has led to recommendations for additional sonar data collection in slough habitats in the winter of 2014.

Goals and Objectives

The primary goal of the 2014 sonar investigations is to assess and characterize fish use of slough habitats in focus areas in the Middle Susitna River. The specific objectives of the sonar studies include the following:

1. Describing relative abundance (as determined by CPUE) and habitat associations for fish in selected macrohabitat types.
2. Describing temporal trends in relative abundance of fish across monthly sampling periods.
3. Characterizing diel movements and behaviors of fish across monthly sampling periods.

Data will be collected during three monthly sampling trips (February to April 2014) to FA-104 (Whiskers Slough) and FA-138 (Gold Creek). Winter logistical support will include snow machines, camp logistics, and ice augers/tools for field sampling. For Whiskers Slough surveys, the sonar field team will be based out of Talkeetna. For surveys near Gold Creek the sonar field team will based out of a local winter camp at FA-138 (Gold Creek). Three to four days of sampling will occur at each Focus Area.

Data will be collected using Adaptive Resolution Imaging Sonar (ARIS). At each site within each Focus Area, 24 hours of continuous ARIS data will be acquired. To describe the mesohabitat type at each sample site, the following physical parameters will be measured: ice thickness, water depth, water velocity, habitat width, presence and type of cover, and dominant substrate type.

ARIS data will be reviewed by counting the number of fish observed and estimating total lengths of individual fish using the ARIS software sizing tool. Directional movements will be noted as well as any observed behaviors (foraging, schooling, milling, predator-prey interactions). Based on estimated total length fish will be classified as small (less than 10 cm, 4.7 in), medium (10 to 35 cm, 4.7 to 13.8 in), or large (more than 35 cm, 13.8 in). CPUE will be calculated in terms of fish per hour for each size class. Data will be analyzed temporally as follows: hourly to assess diel abundance, movement and behavioral patterns; within 24-hr sample periods (daytime, nighttime and crepuscular) to assess differences among periods; and monthly to assess seasonal changes. Data will be analyzed spatially to compare abundance, movement and behavioral patterns among mesohabitat types.

It may be possible to identify fish species based on sonar imagery. Species such as burbot and lamprey have characteristic anguilliform swimming motion and body shape that will be detectable with ARIS sampling. Sculpin can also be identified based on their typical lurching movements along the substrate. However, for the majority of fish images collected with ARIS it will not be possible to differentiate among fish species based on imagery alone. As a result it will be necessary to use information collected by other fish study team members using direct capture and videography methods at the same study site locations to aid in applying fish species data to the sonar data set. Size frequency distribution data acquired from direct capture methods will be useful to inform sonar imagery data. Particularly beneficial for providing species data would be the deployment of an underwater video camera within the field of view of the ARIS, with the orientation of the camera parallel with that of the sonar.

6.5. PIT Tags

The IP (Section 5.6.5) states that, "If the pilot testing is successful, swim-over antennas will remain at Focus Area sites (Whiskers Slough, Slough 8A, and Indian River) during ice-over and will be maintained throughout the winter months." However, based on performance and maintenance required during the 2013 open water period, winter testing, power supply, logistics, and accessibility it is proposed that AEA will continue to operate and maintain three of the most accessible sites located in the Middle and Lower River throughout the winter months. The proposed sites include Montana Creek (Lower River) near RM 2.2, Whiskers Slough below the confluence of Whiskers Creek (FA-104), and Slough 8A (FA-128).

AEA will attempt to operate these three sites to collect data on direction of movement, but success will be determined by channel conditions, equipment constraints and power supply. During the 2013 open water period, it was determined that the power requirements for the Whiskers Slough and Montana Creek stations exceeded the power capacity of a single multiplexer due to the antenna length required to cover the wetted widths.. Dual antennas would require independent readers, which would double necessary power supply. In contrast, the channel configuration at Slough 8A was narrow enough that a multiplexer reader could power two antennas for that site, although further testing under winter light and temperature conditions is needed. An alternative approach to reducing power demand is to program the dataloggers to operate on a set schedule each day when fish are the most active and shut down during periods when fewer fish are detected. This approach is being implemented on a trial basis during winter 2014 to evaluate whether the reduction in power consumption warrants the corresponding reduction in daily operation.

As a part of the active fish sampling during the winter (Section 6.1 above), PIT tagging will continue in proximity to arrays to the extent practical under winter conditions. Post-tagging recovery time and swimming ability will be closely monitored and tagging will be suspended if harmful effects are observed. Tagged fish will be released in the reach where they were collected.

6.6. Radio Tags

The radio-telemetry activities conducted as part of the 2012-13 Winter Pilot Study had the single objective of determining the effectiveness of receivers monitoring from an aircraft to detect tags through ice on the river. In this regard, it was demonstrated that the aerial telemetry methods used to locate radio-tags were highly effective across varying ice thickness and water depth. Therefore, telemetry can be used to support achievement of the overarching study goal of characterizing the seasonal distribution, habitat use, movement, and relative abundance of resident fish.

Over the 2013 open-water season through August, a total of 32 Arctic grayling and 5 longnose sucker were radio-tagged in the Upper River, and 29 Arctic grayling, 16 burbot, 9 Dolly Varden, 38 longnose sucker, 5 northern pike, 34 rainbow trout, 7 humpback whitefish and 39 round whitefish were radio-tagged in the Middle and Lower River. These tags were tracked via fixed stations and aerial surveys at the same time as monitoring was conducted for adult salmon tags.

For the period of October 2013 through April 2014, resident tags will be monitored using four fixed stations (Whiskers, Indian, Devils Island, & Kosina) and by conducting complete aerial surveys of the mainstem Susitna, and in tributaries proximate to tag release locations. Fixed stations will be serviced approximately every three weeks, and three days of aerial surveys will be conducted approximately monthly. Fixed receivers are operationally limited to air temperatures higher than -4°F so it is likely that they will not operate during the period December through February.

7. LITERATURE CITED

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8. TABLES

Table C2.2-1. Total catch by species during winter studies, 2013 (preliminary data).

Species	Catch (February - April)
Chinook Salmon	76
Chum Salmon	6
Coho Salmon	68
Pink Salmon	3
Sockeye Salmon	5
Burbot	8
Lamprey	10
Rainbow Trout	3
Sculpin	39
Threespine Stickleback	50
TOTAL	**268**

Table C2.2-2. Fish species caught or observed by gear type, winter pilot study, 2013 (preliminary data).

	Gear Type					
Species	**Angling**	**Backpack Electrofisher**	**Baited Trot or Set Line**	**Minnow Trap**	**Seine**	**Underwater Video**
Chinook salmon		X		X		X
Chum salmon		X				
Coho salmon		X		X		X
Pink salmon		X				
Burbot			X	X		
Rainbow trout	X	X	X			X
Lamprey		X				
Round whitefish						X
Sculpin		X		X		X
Sockeye salmon				X		
Threespine stickleback		X		X		

Table C2.2-3. Total catch by species by habitat type, 2013 (preliminary data). Other off-channel habitat includes a unique upland habitat between the Susitna and Chulitna Rivers (Figure C1.2-2).

Species	Main Channel	Side Channel	Side Slough	Upland Slough	Tributary Mouth	Tributary	Other Off-Channel Habitat	Total
Chinook Salmon	0	0	32	2	5	16	21	**76**
Chum Salmon	0	0	0	0	0	6	0	**6**
Coho Salmon	0	0	1	2	4	9	52	**68**
Pink Salmon	0	0	0	0	0	3	0	**3**
Sockeye Salmon	0	0	1	0	0	0	4	**5**
Burbot	7	0	0	1		0	0	**8**
Lamprey	0	0	0	0	0	10	0	**10**
Rainbow Trout	0	0	2	0	0	1	0	**3**
Sculpin	0	0	8	5	0	26	0	**39**
Threespine Stickleback	0	0	0	5	0	0	45	**50**
TOTAL	**7**	**0**	**44**	**15**	**9**	**71**	**122**	**268**

Table C2.2-4. Habitats sampled by gear type during the 2013 winter pilot study.

February 1-7	Habitat Type							
Gear Type	Tributary	Tributary Mouth	Upland Slough	Side Slough	Slough Mouth	Side Channel	Main Channel	Other off-channel
Minnow Trap	WS	WS	WS	WS	WS	WS		WS
Electrofishing								
Set Line	WS			WS				
Trotline					WS		WS	
Seine						WS		
Underwater Video	WS			WS	WS		WS	
DIDSON								

March 18-26	Habitat Type							
Gear Type	Tributary	Tributary Mouth	Upland Slough	Side Slough	Slough Mouth	Side Channel	Main Channel	Other off-channel
Minnow Trap	WS	WS	WS	WS	WS	WS, 8A		WS
Electrofishing	WS		WS		WS	8A		
Set Line		WS						
Trotline							WS	
Seine								
Underwater Video		WS	WS		WS		WS	
DIDSON		WS	WS	WS	WS			

April 7-13	Habitat Type							
Gear Type	Tributary	Tributary Mouth	Upland Slough	Side Slough	Slough Mouth	Side Channel	Main Channel	Other off-channel
Minnow Trap	WS	WS	WS, 8A	WS		WS, 8A		
Electrofishing	WS		WS, 8A			8A		
Set Line								
Trotline								
Seine								
Underwater Video		WS	WS	8A		8A		
DIDSON								

Table C2.2-5. Total catch by species by gear type, winter pilot study, 2013 (preliminary data).

Species	Backpack Electrofishing	Minnow Traps	Seine	Angling	Trotline	Set Line	Total
Chinook Salmon	16	60	0	0	0	0	76
Chum Salmon	6	0	0	0	0	0	6
Coho Salmon	5	63	0	0	0	0	68
Pink Salmon	3	0	0	0	0	0	3
Sockeye Salmon	0	5	0	0	0	0	5
Burbot	0	1	0	0	7	0	8
Lamprey	10	0	0	0	0	0	10
Rainbow Trout	1	0	0	1	1	0	3
Sculpin	33	6	0	0	0	0	39
Threespine Stickleback	3	47	0	0	0	0	50
TOTAL	**77**	**182**	**0**	**1**	**8**	**0**	**268**

Table C2.2-6. Preliminary review and fish counts of underwater video observations. The numbers indicated below are a single maximum count of a still screenshot or a short duration event (<10 sec) of fish moving in one direction through the field of view and are a minimum estimate, of fish present during an observation period. Review of long duration videos (>12 hours) is ongoing as is the development of a subsampling protocol when movements are not directed and many fish are milling for long periods of time.

Date	**2/3**	**2/4**	**2/5**	**2/6**	**2/7**	**3/20**	**3/21**	**3/21**	**3/22**	**3/23**	**3/24**	**3/25**	**4/9**	**4/9**	**4/9**	**4/10**	**4/10**	**4/12**	**4/12**
Location	FA-104,SM	FA-104,SS	FA-104,SM	FA-104,MC	FA-104,SM	FA-104,TR	FA-104,SS	FA-104,MC	FA-104,SS	FA-104,SM	FA-104,US	FA-104,US	FA-128,SS	FA-128,SS	FA-128,SS	FA-128,SS	FA-128,SC	FA-104,US	FA-104,US
Video Duration (min)	23	12	341	8	188	114	41	33	471	341	241	207	236	111	82	225	163	99	343
Chinook salmon (juv)							1+					3+	1+		2+	3+			
Coho salmon (juv)							4+		2+										
Rainbow trout (adt)	2+																		
Round whitefish (adt)									2+	8+									
Sculpin (joa)			1																
Unidentified salmonid (juv)							19+		6+	1		6+	3+	2+	6+	20+		18+	1+
Unknown Fish Sp. (joa)									5+		1+								

Location Key: FA-104 (Whiskers Slough), FA-128 (Slough 8A), MC: Main Channel, SC: Side Channel, US: Upland Slough, SS: Side Slough, SM: Slough Mouth, TR: Tributary.

Table C2.2-7 Comparison of underwater video camera features and specifications.

Camera Model	Aqua-Vu Mico plus DVR	Aqua-Vu AV 710	Professional UW CCD Video Camera	Go Pro Hero 3 Silver w/ BacPac	Go Pro Hero 3 Silver Modified IR w/ BacPac
Tested in 2013	Yes	Yes	Yes	Yes	No
Internal power	Yes	No	No	Yes	Yes
Battery Life	5.5 to 7 h	6 h	n/a	3 h	3
External power compatible	No	Yes	Yes	No	No
Internal data storage	Yes	No	No	Yes	Yes
Data storage capacity	8 gb	n/a	n/a	64 gb	64 gb
Lux	0.1	0.01	NR	NR	
Built in lighting	Yes	Yes	Yes	No	0
Light Type	IR LED	White & Red LED	White LED	n/a	n/a
IR sensitive	Yes	No	No	No	Yes
Pixel	648x488		500x582	1920x1080	1920x1080
Sensor size	1/4"	CMOS	1/4"	1/2.7" 11mp	1/2.7" 11mp
Lens	un	un	3.6 mm	2.8 mm	variable
View angle	un	92	92	170	variable
Real-time viewing	Yes	Yes	Yes with computer	Not UW	Not UW
Cost	$500	$350	$200	$400	$1,000

Table C3.2-1. List of imaging sonar data collected at Whiskers Slough, in FA-104, in 2013 by site location and sonar system.

Site	Dates	Hours	Sonar
Confluence	22-Mar	14:42 to 23:59	ARIS
	23-Mar	00:00 to 02:50	
	22-Mar	15:06 to 17:20	DIDSON
	23-Mar	n/a	
Mouth	23-Mar	14:57 to 23:59	ARIS
	24-Mar	00:00 to 11:30	
	23-Mar	15:23 to 23:59	DIDSON
	24-Mar	00:00 to 11:30	
Upland	24-Mar	14:40 to 20:50	ARIS
	25-Mar	10:43 to 14:00	
	24-Mar	14:47 to 23:59	DIDSON
	25-Mar	00:00 to 07:40, 10:42 to 14:00	

Table C4.3-1. Summary of various PIT antenna designs and read distances for 12-mm (0.47 in) and 23-mm (0.9 in) HX PIT tags determined during bench-top testing, March, 2013.

Design	Wire Type and Gage	Length (ft)	Width/ Height (ft)	Antenna Description	Inductance (µH)	Tag Orientation to Antenna Plane	Read distance 12-mm Tag (in)	Read distance 23-mm Tag (in)
1	THHN -14 AWG	16.5’	3.3’	2 windings	61.8	Perpendicular (swim-through)	2-3	8-10
2	THHN -14 AWG	14’	3’	2 windings	51.9	Perpendicular (swim-through)	Large hole	10-12
3	THHN -14 AWG	28’	40”	2 windings with twist	NR	Perpendicular (swim-through)	3-4	NR
4	Duplex Marine Wire - 10 AWG	26.4’	1.7’	1 winding of spliced duplex	23.6	Perpendicular (swim-through)	3	12
5	Duplex Marine Wire - 10 AWG	32’	20”	1 winding of spliced duplex	85.6	Parallel (swim-over)	7	15
5	Duplex Marine Wire - 10 AWG	32’	20”	1 winding of spliced duplex	85.6	Perpendicular (swim-through)	No holes	No holes
6	Duplex Marine Wire - 10 AWG	27’	40”	1 winding of spliced duplex	NR	Parallel (swim-over)	3-4”	7-8”
7	Duplex Marine Wire - 10 AWG	28.5’	20”	1 winding of spliced duplex with twist	80.4	Parallel (swim-over)	11”	18”
8	Duplex Marine Wire - 10 AWG	22’	20”	1 winding of spliced duplex with twist	65.5	Parallel (swim-over)	12.5”	20”
9	Duplex Marine Wire - 10 AWG	25’	20”	1 winding of spliced duplex – no twist	NR	Parallel (swim-over)	3”	11.5”
10	Duplex Marine Wire - 10 AWG	15’	5’	1 winding of spliced duplex with twist	NR	Perpendicular (swim-through)	Hole (8” at wire)	No hole (24” at wire)
11	Duplex Marine Wire - 10 AWG	19’	3.3’	1 winding of spliced duplex with twist	NR	Perpendicular (swim-through)	No hole (but minimal read distance)	NR
12	Duplex Marine Wire - 10 AWG	14’	3’	1 winding of spliced duplex – no twist	52.4	Perpendicular (swim-through)	Large hole (3” at wire)	NR
13	Duplex Marine Wire - 10 AWG	15.5’	20”	1 winding of spliced duplex – no twist	NR	Parallel (swim-over)	3”	11”
14	Duplex Marine Wire - 10 AWG	14.5’	20”	1 winding of spliced duplex with twist	NR	Parallel (swim-over)	12” 16” (DC)	21” 24” (DC)
15	Duplex Marine Wire - 10 AWG	10’	4’	1 winding of spliced duplex with twist	NR	Perpendicular (swim-through)	No holes	No holes
15	Duplex Marine Wire - 10 AWG	10’	4’	1 winding of spliced duplex with twist	NR	Parallel (swim-over)	17” (DC)	NR

Table C5.1-1. Locations of the 11 tags used to test the performance of the ATS radio telemetry gear in winter conditions on the Susitna River, 2013.

Group	Latitude	Longitude	Frequency	Code	Water Depth (ft)	Ice Thickness (in)
1	62.37707	-150.17068	151.974	94	3.94	7.9
				64		
				9		
2	62.37682	-150.16993	151.943	17	2.46	5.9
				44		
				62		
3	62.39898	-150.13610	151.934	94	10.33	45.3
				45		
				68		
4	62.37597	-150.17040	151.963	19	0.49	1.6
				94		

Table C5.2-1. The distance (in miles) away from each tag the receiver in the helicopter first detected the tag for each pass, winter pilot study, 2013.

Group	Frequency	Code	Pass 1	Pass 2	Pass 3	Pass 4
1	151.974	94	0.86	1.51	0.99	2.72
		64	0.86	1.21	1.69	2.55
		9	N/A	0.61	0.56	2.51
2	151.943	17	N/A[a]	1.28	1.06	2.73
		44	N/A[a]	2.22	1.13	2.70
		62	N/A[a]	2.68	1.80	3.41
3	151.934	94	0.40	1.25	1.41	4.29
		45	0.34	0.64	1.46	7.58
		68	0.14	0.37	1.22	0.84
4	151.963	19	0.75	1.02	1.95	5.70
		94	0.87	0.17	1.59	2.48
		Average	0.60	1.18	1.35	3.41

[a] The receiver was not tracking frequency 151.943 during Pass 1.

Table C5.2-2. The distance (in miles) away from each tag the receiver in the helicopter recorded the highest powered detection for each pass, winter pilot study, 2013.

Group	Frequency	Code	Pass 1	Pass 2	Pass 3	Pass 4
1	151.974	94	0.34	0.04	0.26	0.27
		64	0.29	0.06	0.21	0.50
		9	N/A	0.02	0.21	0.40
2	151.943	17	N/A[a]	0.03	0.21	0.31
		44	N/A[a]	0.03	0.20	0.28
		62	N/A[a]	0.02	0.21	0.30
3	151.934	94	0.05	0.04	0.25	1.17[b]
		45	0.08	0.04	0.11	1.10[b]
		68	0.05	0.04	0.16	1.09[b]
4	151.963	19	0.55	0.08	0.16	0.42
		94	0.41	0.06	0.19	0.86
		Average	0.25	0.04	0.20	0.42

[a] The receiver was not tracking frequency 151.943 during Pass 1.

[b] Tags from String 3 were accidentally pulled from the river during a portion of Pass 4 which may have led to abnormally high readings during part of the pass. They are not included in the average.

Table C5.2-3. The distance (in miles) away from each tag the receiver in the helicopter recorded the highest powered detection for each pass. Results in this table were adjusted to account for passes 1, 3, and 4 which did not pass directly over tag strings 1, 2, and 4, winter pilot study, 2013.

Group	Frequency	Code	Pass 1	Pass 2	Pass 3	Pass 4
1	151.974	94	0.19	0.04	0.11	0.12
		64	0.14	0.06	0.06	0.35
		9	N/A	0.02	0.06	0.25
2	151.943	17	N/A[a]	0.03	0.06	0.16
		44	N/A[a]	0.03	0.05	0.13
		62	N/A[a]	0.02	0.06	0.15
3	151.934	94	0.05	0.04	0.25	1.17[b]
		45	0.08	0.04	0.11	1.10[b]
		68	0.05	0.04	0.16	1.09[b]
4	151.963	19	0.40	0.08	0.01	0.27
		94	0.26	0.06	0.04	0.71
		Average	0.17	0.04	0.09	0.27

[a] The receiver was not tracking frequency 151.943 during Pass 1.

[b] Tags from String 3 were accidentally pulled from the river during a portion of Pass 4 which may have led to abnormally high readings during part of the pass. They are not included in the average.

9. FIGURES

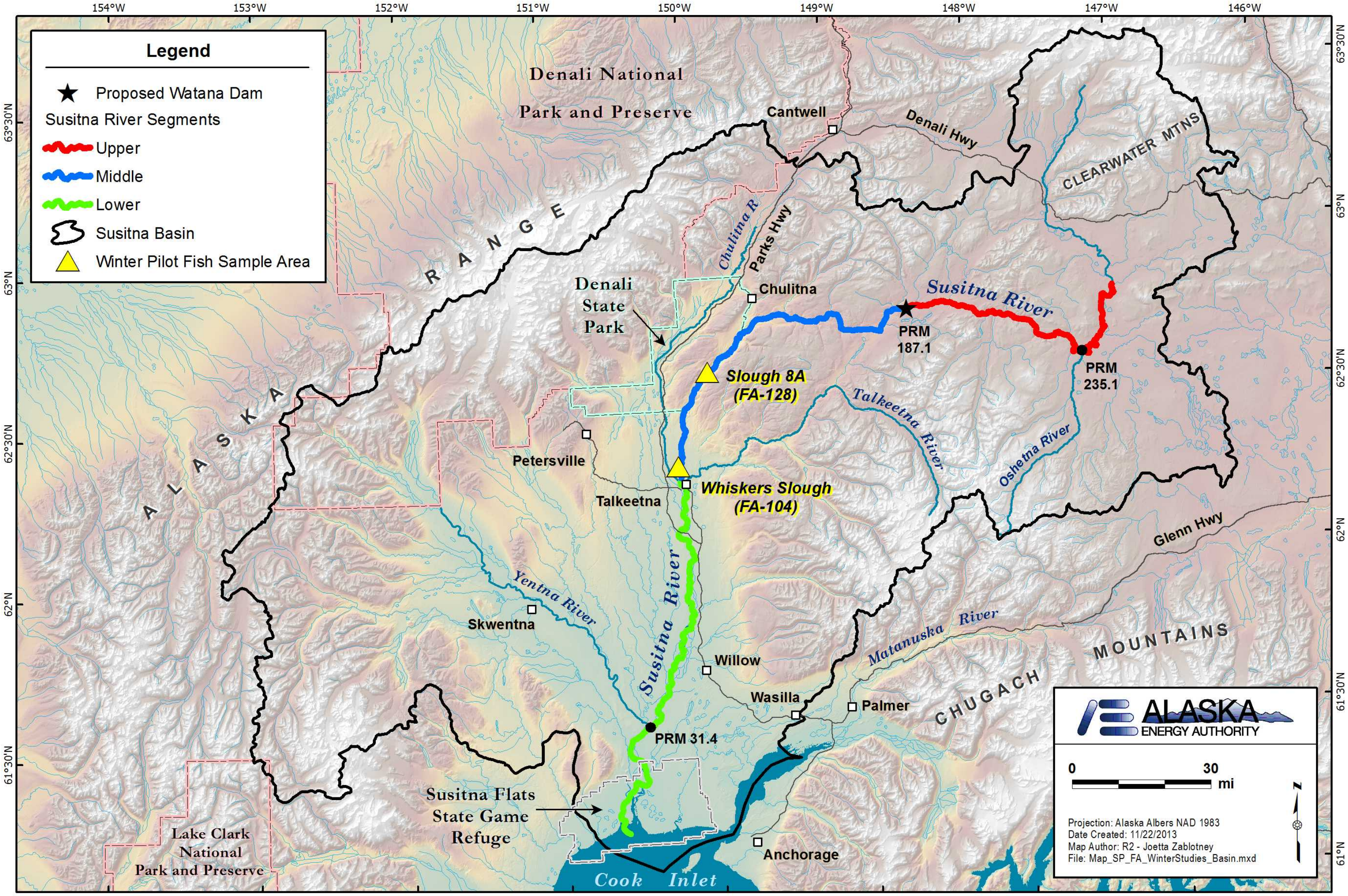


Figure C1.2-1. General locations of winter 2013 pilot study sampling activities in FA-104 (Whiskers Slough) and FA-128 (Slough 8A).

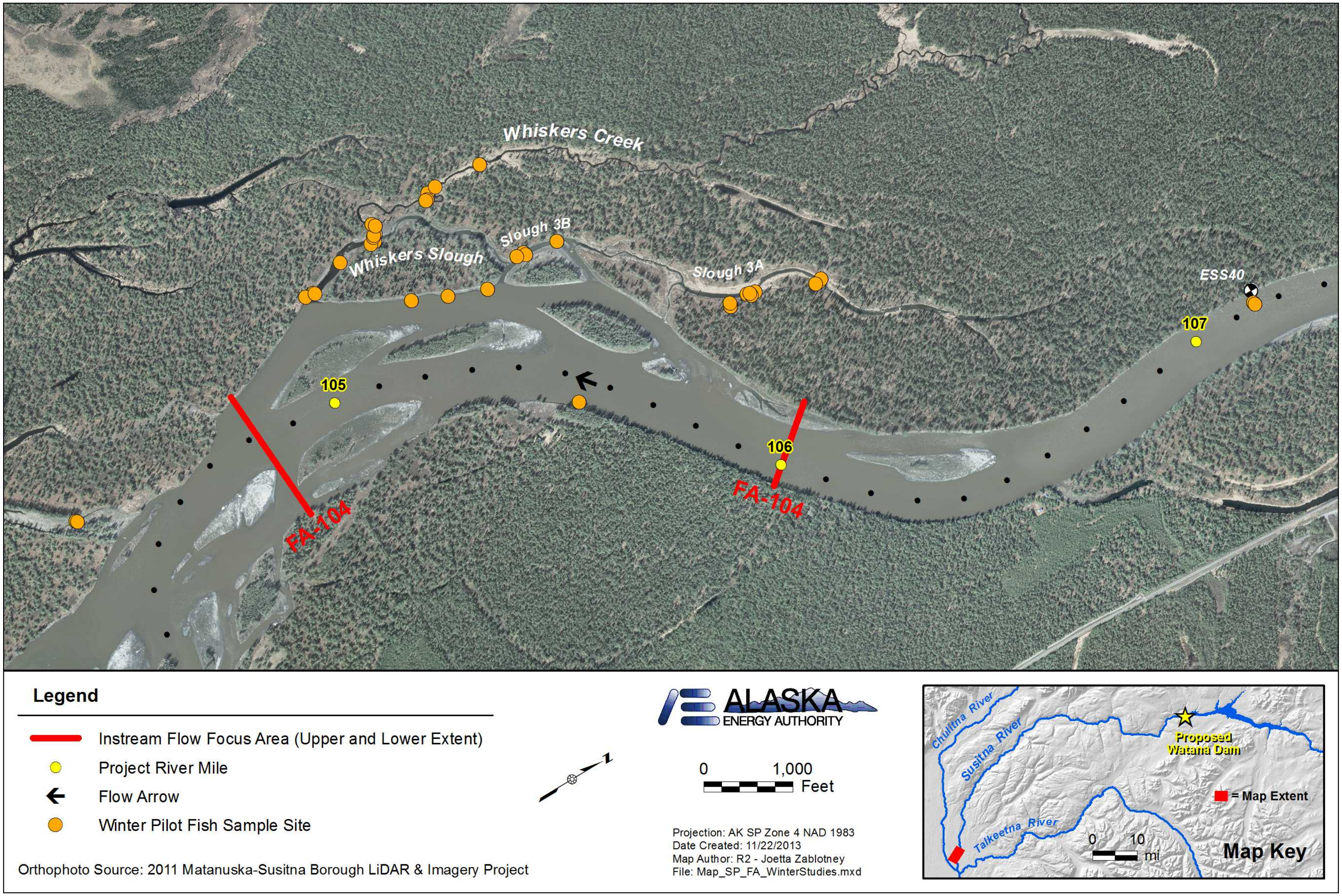
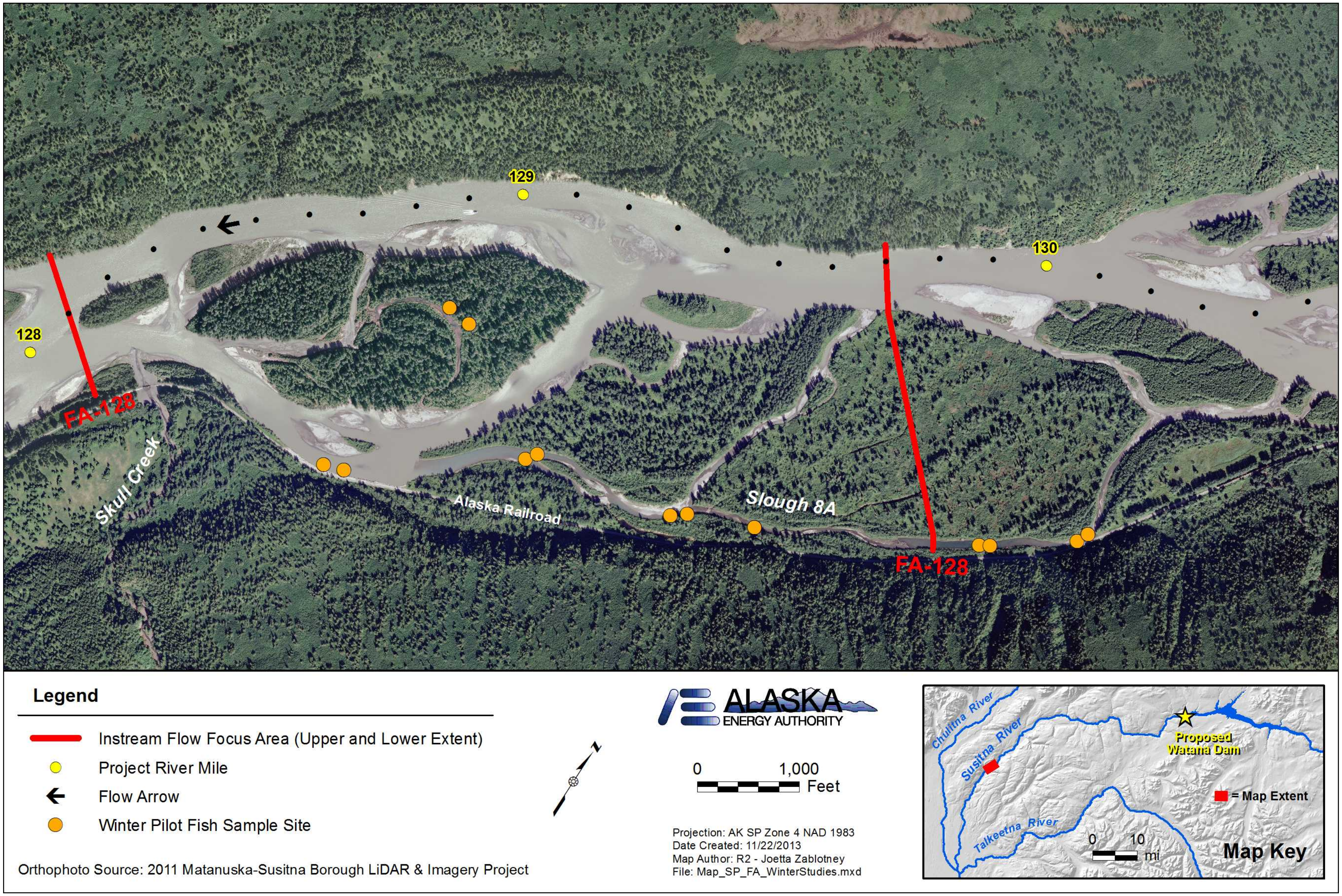


Figure C1.2-2. FA-104 (Whiskers Slough) Study Area and winter sampling sites, February-April, 2013.



Orthophoto Source: 2011 Matanuska-Susitna Borough LiDAR & Imagery Project

Projection: AK SP Zone 4 NAD 1983
Date Created: 11/22/2013
Map Author: R2 - Joetta Zablotney
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Figure C1.2-3. FA-128 (Slough 8A) Study Area and winter sampling sites February-April, 2013.

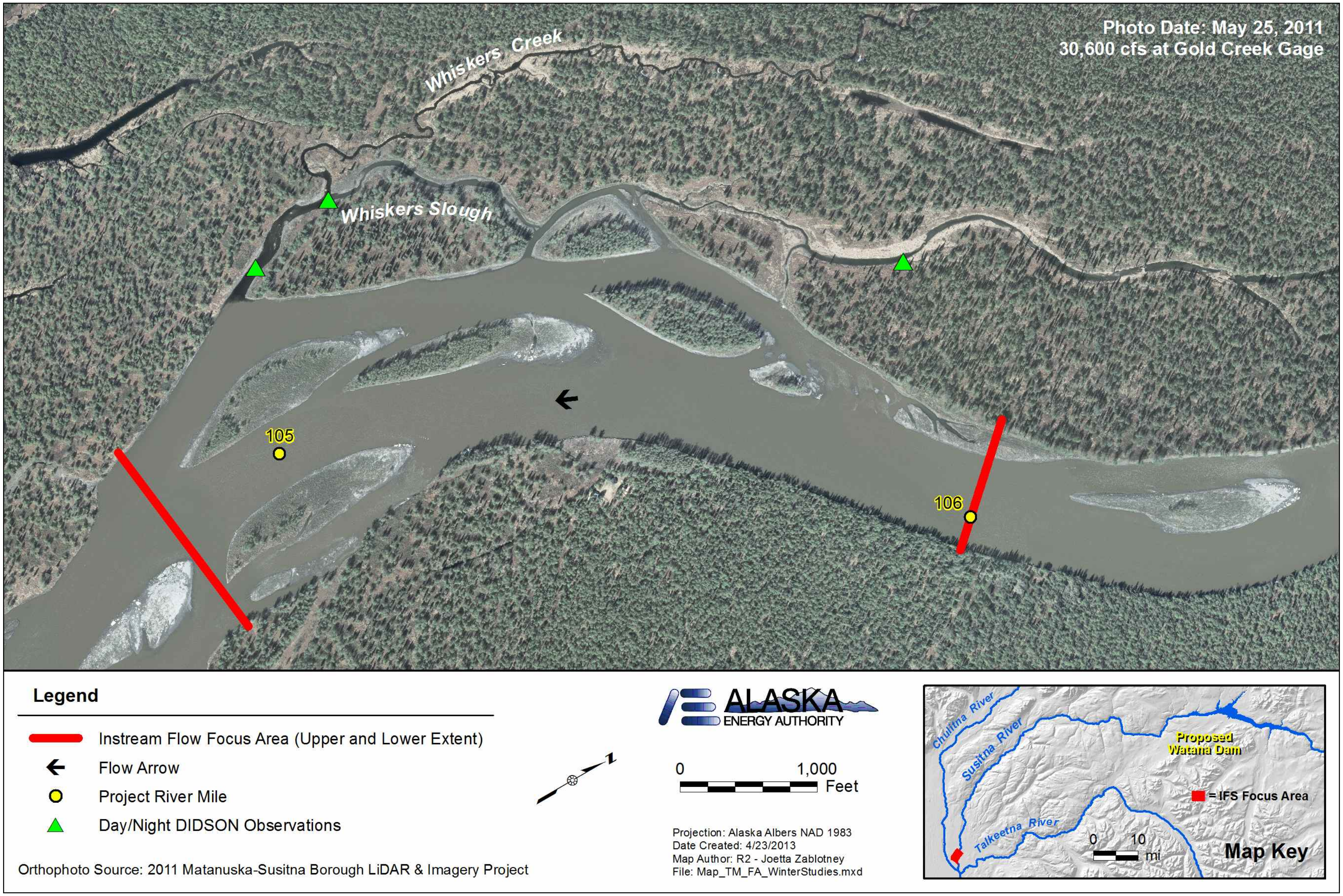

Figure C3.1-1. Locations for sonar (DIDSON) sampling in FA-104 (Whiskers Slough), March, 2013.

Figure C3.2-1. Photograph of the slough mouth site in FA-104 (Whiskers Slough) showing the sonar pole mount deployed in the sample hole. Water flow is from foreground towards background.

Figure C3.2-2 Photograph of the upland slough site in FA-104 (Whiskers Slough) showing the sonar pole mounts and the open water lead. Water flow is from right to left.

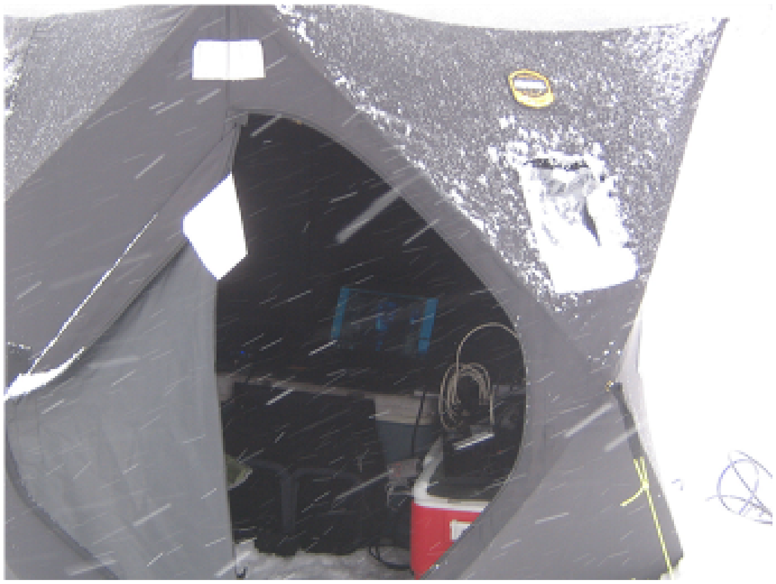

Figure C3.2-3 Photograph showing the sonar system electronic components housed in the portable shelter.

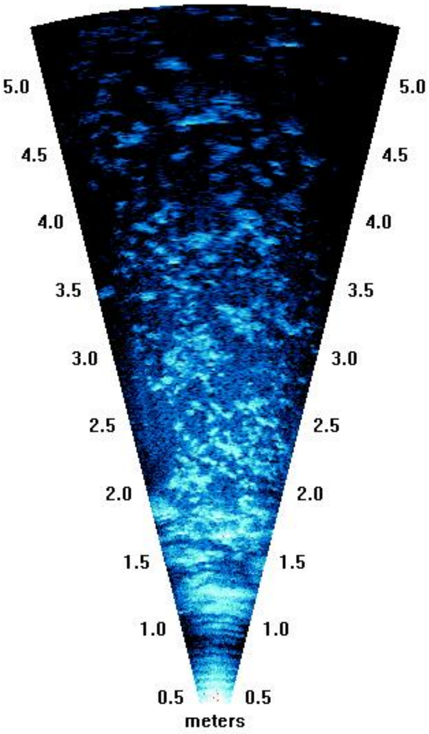

Figure C3.2-4. Still image from DIDSON data collected from the Whiskers Slough confluence site in FA-104 (Whiskers Slough) showing the cobble substrate throughout the field of view. Distance from the sonar is shown with 0.5 m (20 inch) range increments.

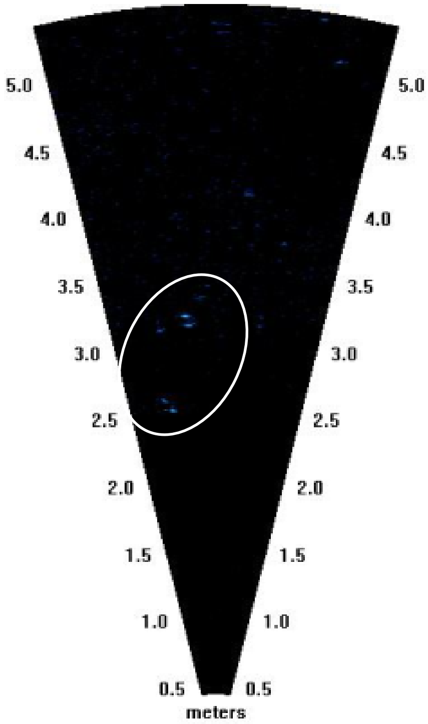

Figure C3.3-1. Truncated still image from DIDSON data collected from the upland slough site in FA-104 (Whiskers Slough) showing a small school of fish (inside white oval); the fish were estimated to have a total length of 8 to 9 cm (3.1-3.5 in). A background subtraction algorithm was applied to the image to allow for better contrast of the fish against the substrate. Distance from the sonar is shown with 0.5 m (20 in) range increments.

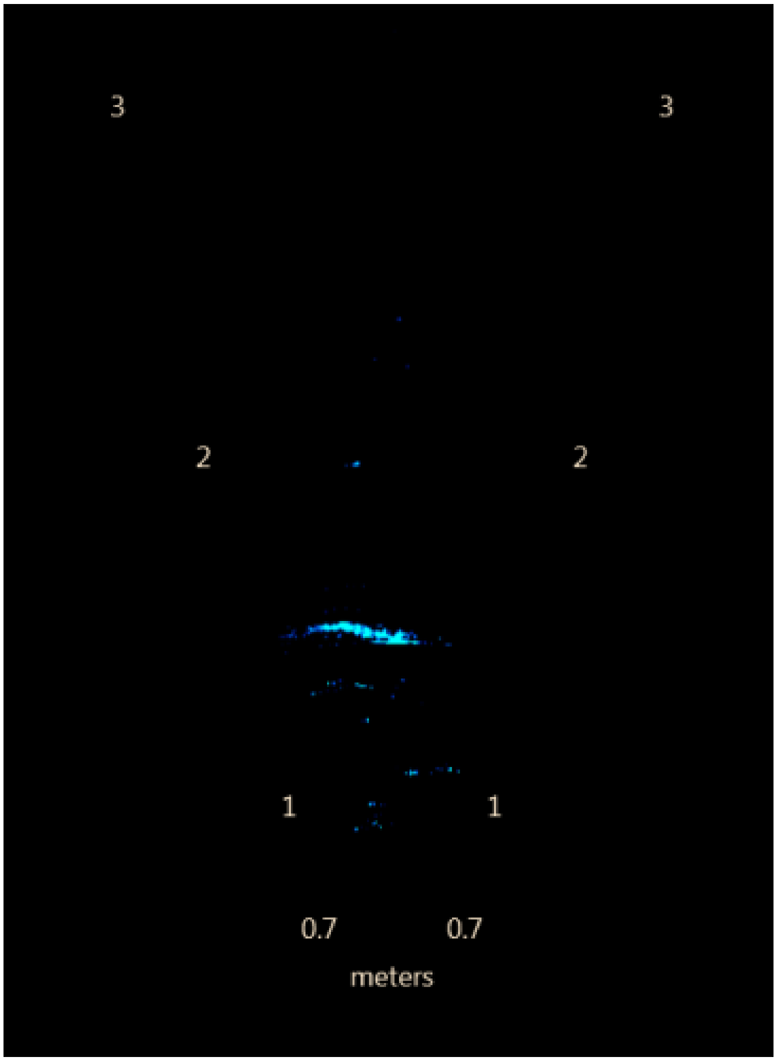

Figure C3.3-2. Truncated still image from ARIS data collected from the slough mouth site in FA-104 (Whiskers Slough) showing a single fish estimated to have a total length of 37 cm (14.5 in). A background subtraction algorithm was applied to the image to allow for better contrast of the fish against the substrate. Distance from the sonar is shown with 1 m (39 in) range increments.

Figure C4.2-1. Swim-through test antenna installation through ice (L) and read distance testing following re-freeze (R).

Figure C4.2-2. Swim-through test antenna repositioned in open water for comparison with through-ice performance.

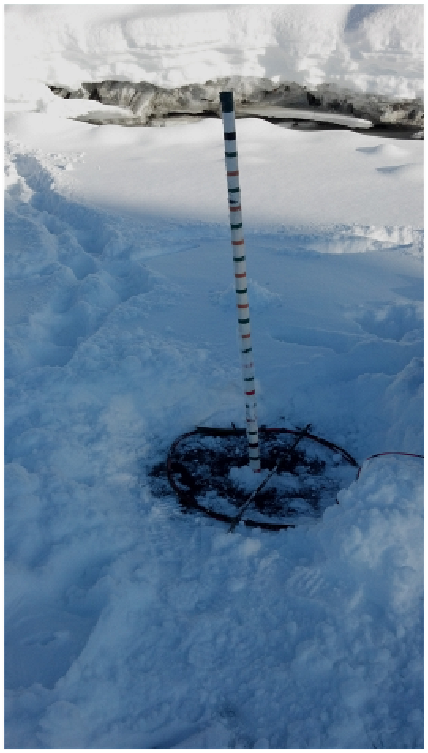

Figure C4.2-3. Prototype of wand antenna to test effect of ice on read distance.

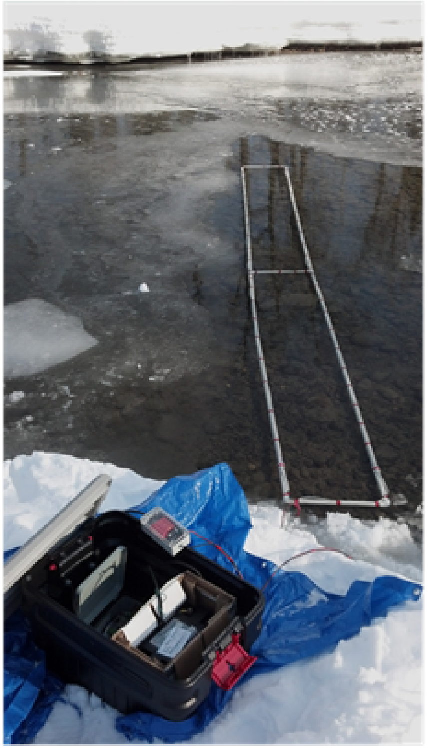

Figure C4.2-4. Swim-over test antenna used to evaluate performance of PIT antenna system (power supply, reader, data logger) in cold temperatures.

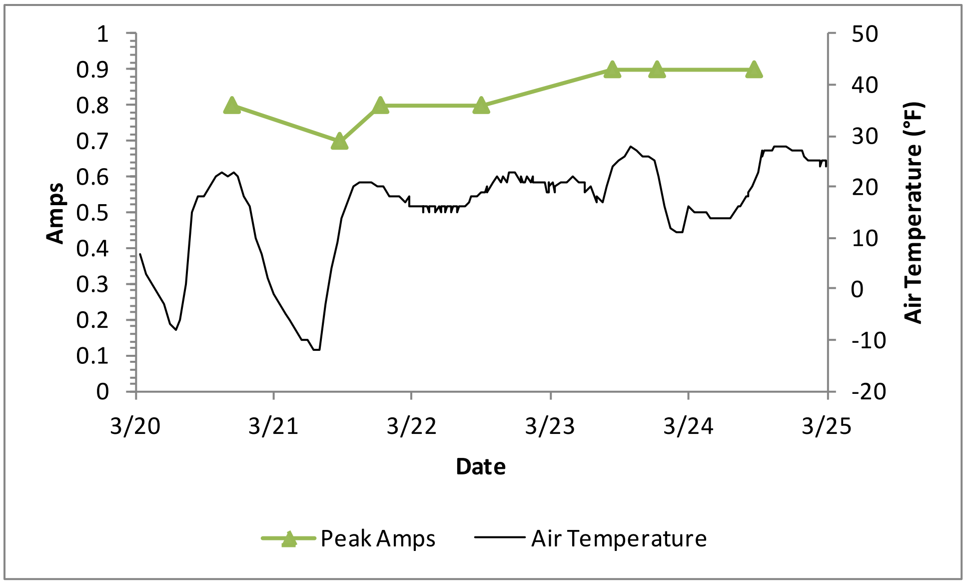

Figure C4.3-1. Current (amps) drawn by PIT antenna system and air temperature at the Talkeetna airport) over the study period.

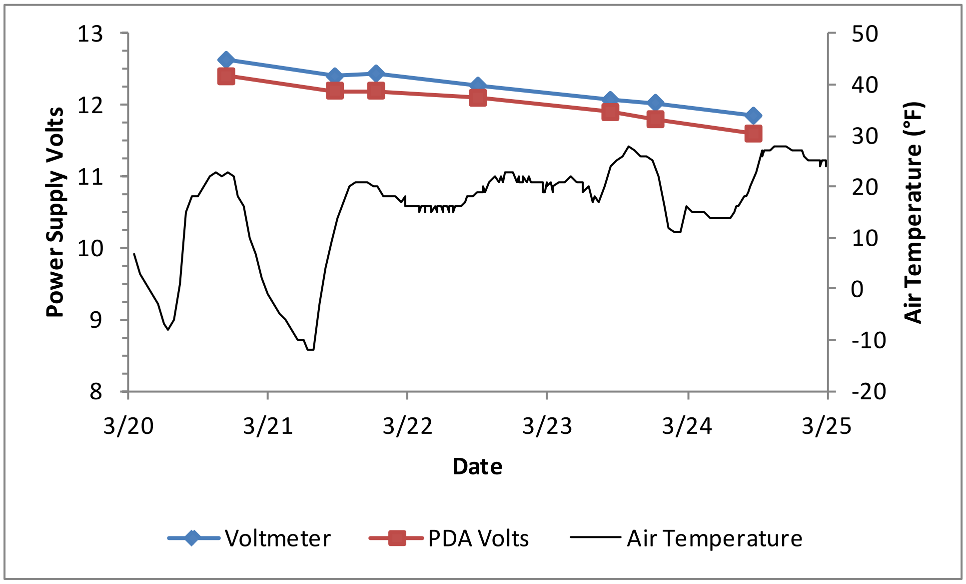

Figure C4.3-2. Voltage of PIT antenna system (from voltmeter and PDA datalogger) and air temperature (at the Talkeetna airport) over the study period.

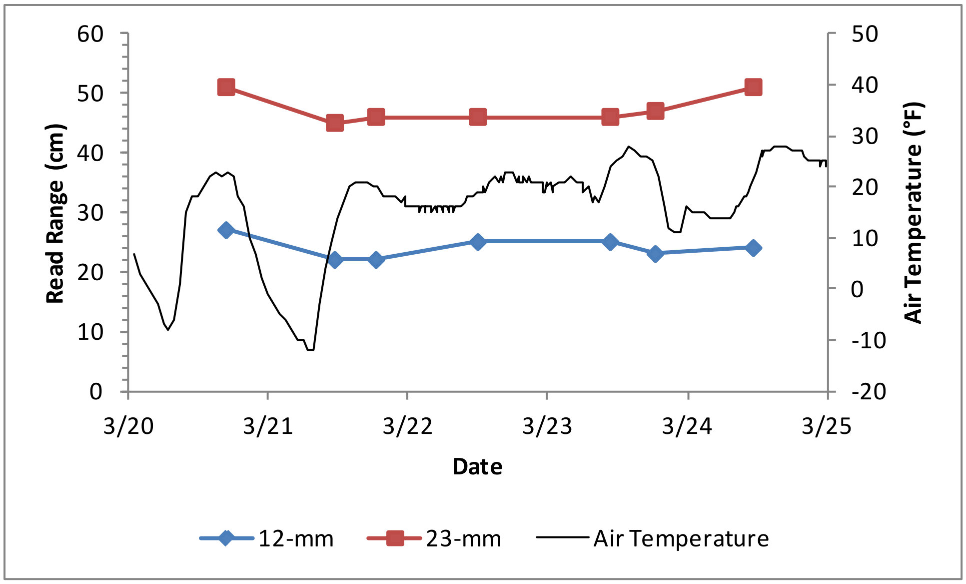

Figure C4.3-3. **Read distance of 12-mm (0.47 in) and 23-mm (0.9 in) tags and air temperature (at the Talkeetna airport) over the study period.**

ATTACHMENT 1. WINTER FISH SAMPLING PHOTOS

Figure CA1-1. Open water lead in split main channel adjacent to FA-104 (Whiskers Slough) in February 2013.

Figure CA1-2. Fish and ISF study participants measuring water chemistry, setting minnow trap, and using underwater video at FA-128 (Slough 8A).

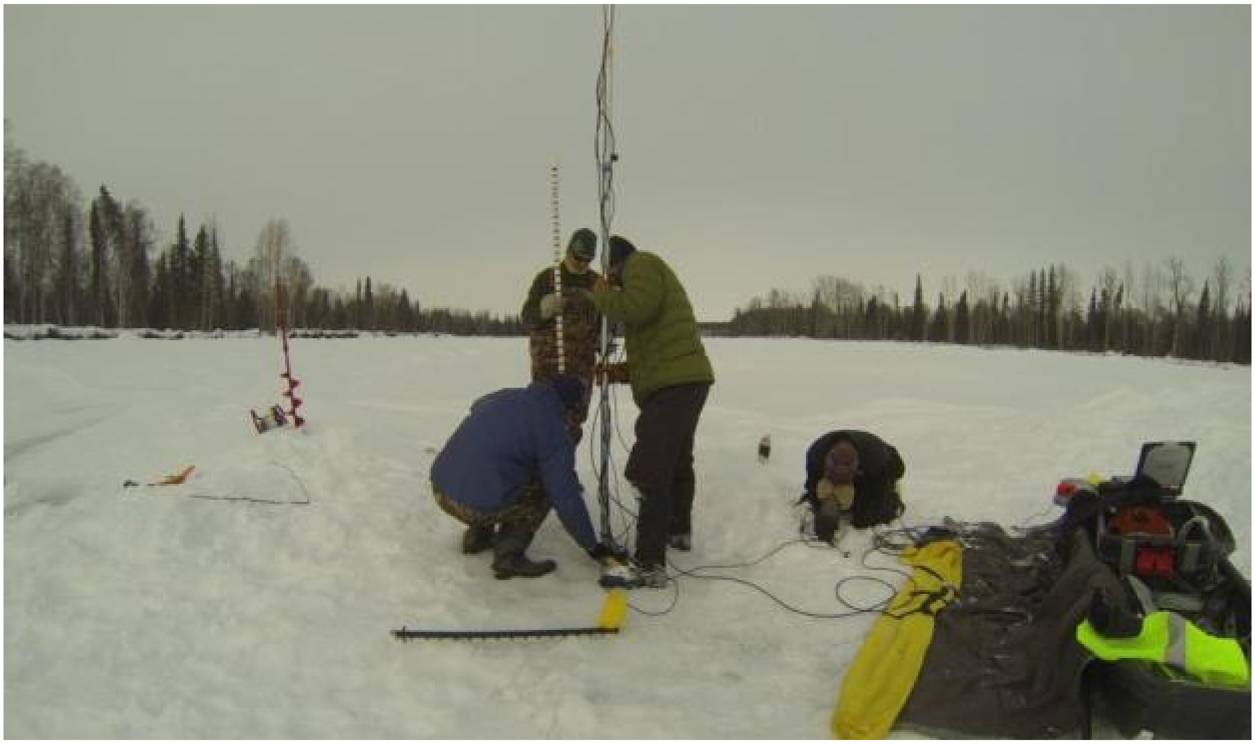

Figure C.A1-3. Study participants from Fish, Groundwater, and Geomorphology studies making side-by-side comparisons of various underwater video cameras.

Figure C.A1-4. Measuring fish collected with baited minnow traps in FA-104 (Whiskers Slough), February 2013.

Figure C.A1-5. A baited minnow trap deployed through the ice.

Figure C.A1-6. Backpack electrofishing an open water lead in FA-128 (Slough 8A), April 2013.

Figure C.A1-7. Drilling a hole through the ice in the mainstem Susitna River with an ice auger.

Figure C.A1-8. Trotline deployment on the mainstem Susitna River in March 2013.

Figure C.A1-9. Set line deployment through the ice in FA-104 (Whiskers Slough), February 2013.

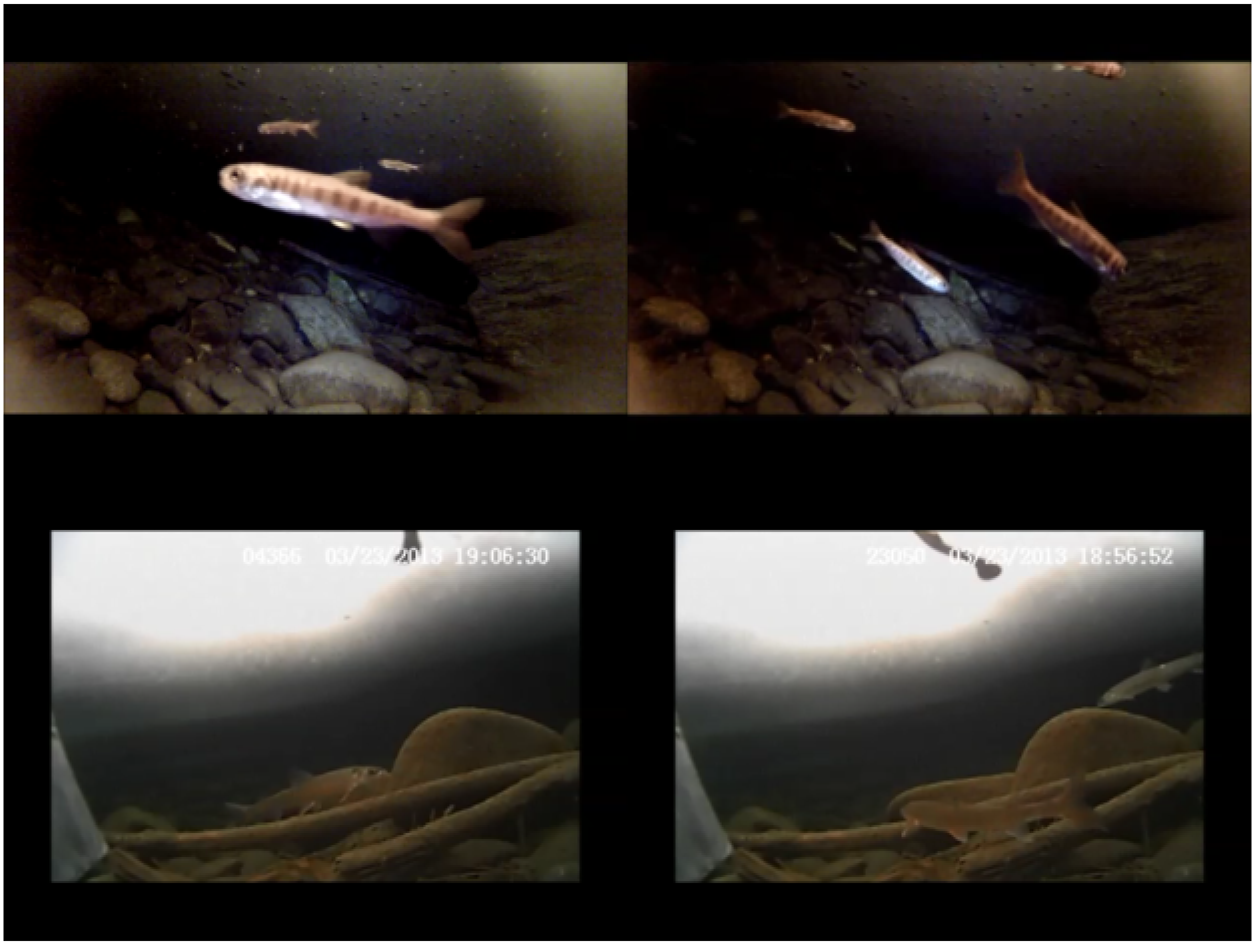

Figure C.A1-10. Underwater video screen shots of juvenile Chinook salmon during night observations taken with GoPro at FA-128 (Slough 8A; top) and round whitefish at during daytime observations with Aqua-Vu Micro at FA-104 (Whiskers Slough; bottom). Sonar unit housing is on lower left hand of bottom images.

Figure C.A1-11. Juvenile Chinook (top) and coho (bottom) salmon collected in lower Whiskers Creek in FA-104 (Whiskers Slough).

Figure C.A1-12. Subadult rainbow trout from the mouth of Whiskers Creek in FA-104 (Whiskers Slough).

Figure C.A1-13. Adult rainbow trout caught by hook and line at the mouth of Whiskers Slough in FA-104 (Whiskers Slough), February 2013.

Figure C.A1-14. Juvenile burbot caught in minnow traps in an upland slough in FA-104 (Whiskers Slough), February 2013.

Figure C.A1-15. Adult burbot caught by trotline in the mainstem Susitna River, March 2013.

Figure C.A1-16. Lamprey ammocoete in Whiskers Creek in FA-104 (Whiskers Slough), April 2013.

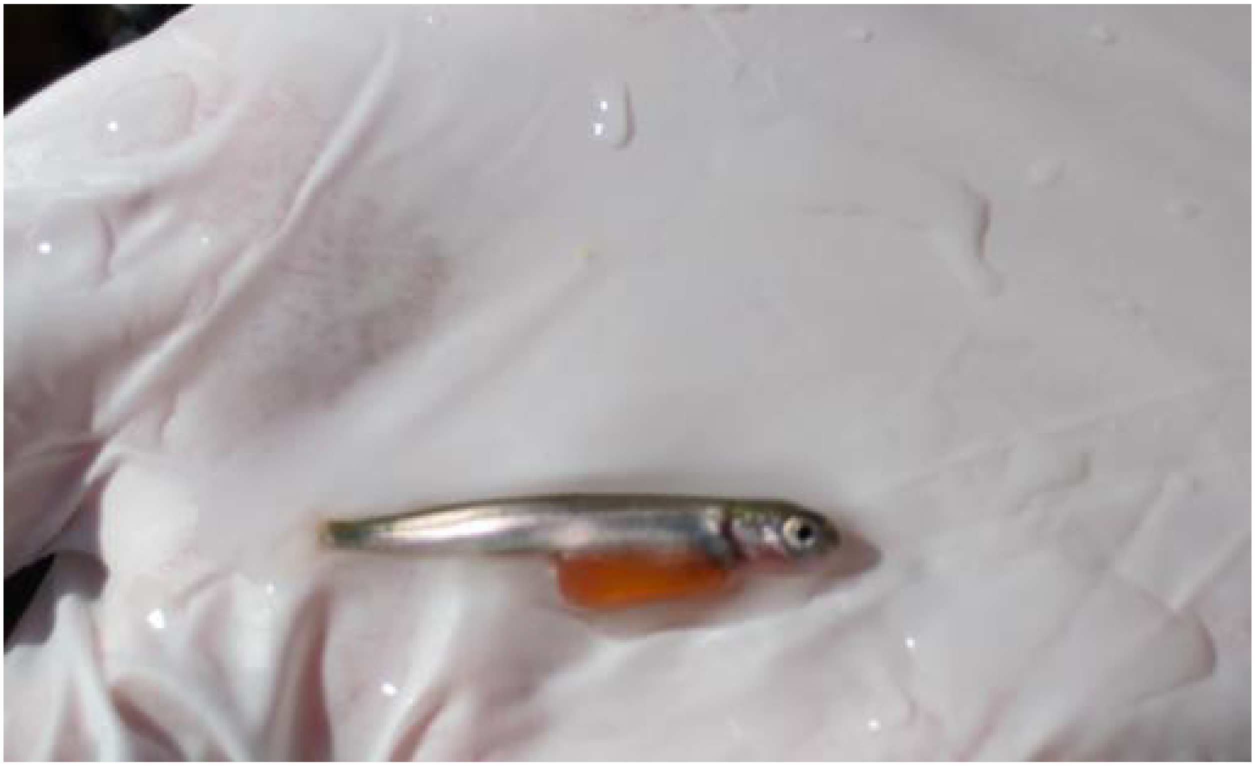

Figure C.A1-17. Newly emerged pink salmon alevin from Whiskers Creek in FA-104 (Whiskers Slough), April 2013.

Figure C.A1-18. Newly emerged chum salmon fry Whiskers Creek in FA-104 (Whiskers Slough), April 2013.

ATTACHMENT 2. RADIO TAG DETECTION MAPS

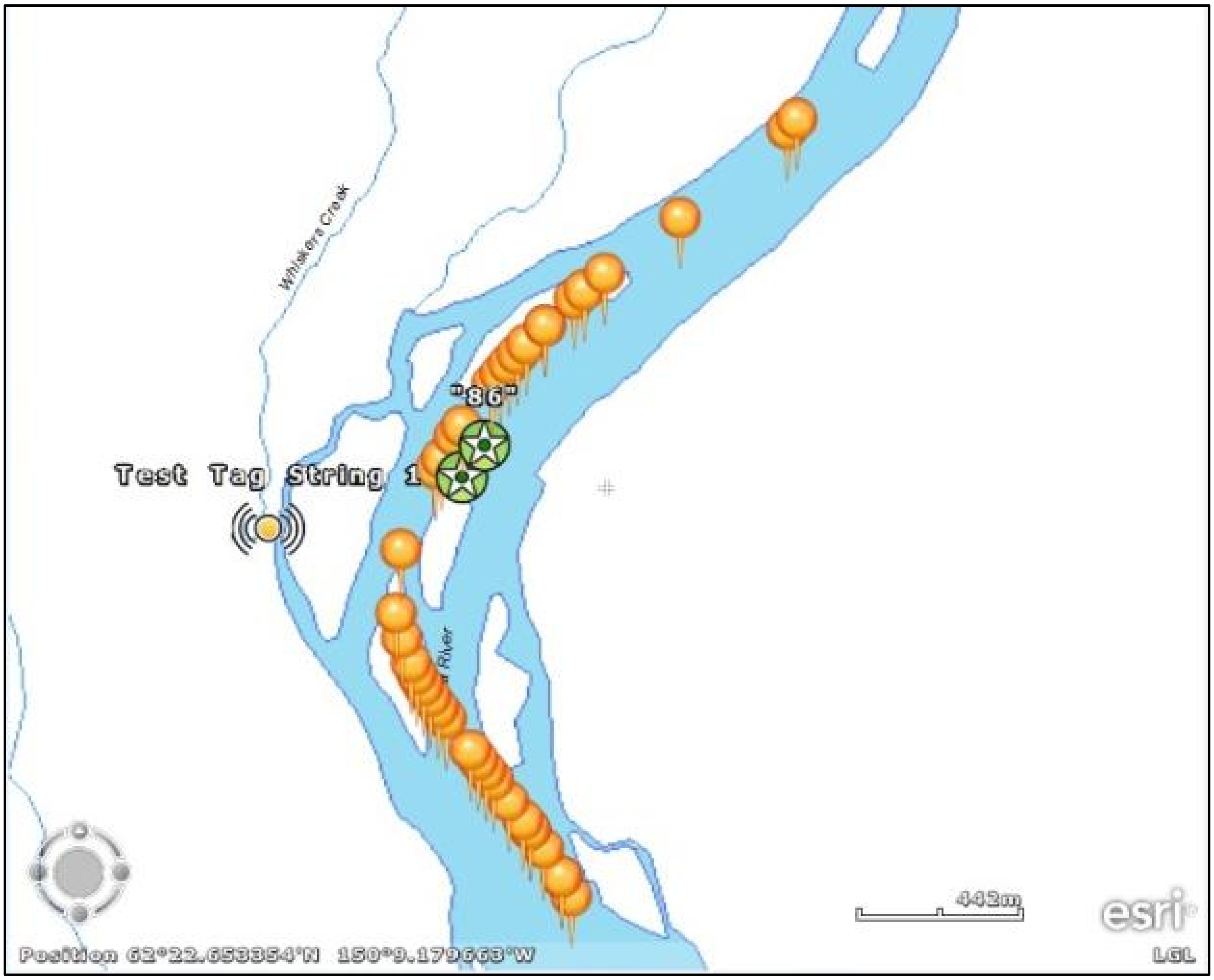

Figure C.A2-1. Detections for radio tag 151.974 Code 94 during Pass 1. The yellow circle indicates the location of the tag and the stars are the locations of the highest power detections. The power of the detection is located above the star and is on a scale from 40 to 154.

Figure C.A2-2. Detections for radio tag 151.974 Code 94 during Pass 2. The yellow circle indicates the location of the tag and the star is the location of the highest power detection. The power of the detection is located above the star and is on a scale from 40 to 154.

Figure C.A2-3. Detections for radio tag 151.974 Code64 during Pass 1. The yellow circle indicates the location of the tag and the star is the location of the highest power detection. The power of the detection is located above the star and is on a scale from 40 to 154.

Figure C.A2-4. Detections for radio tag 151.974 Code 64 during Pass 2. The yellow circle indicates the location of the tag and the star is the location of the highest power detection. The power of the detection is located above the star and is on a scale from 40 to 154.

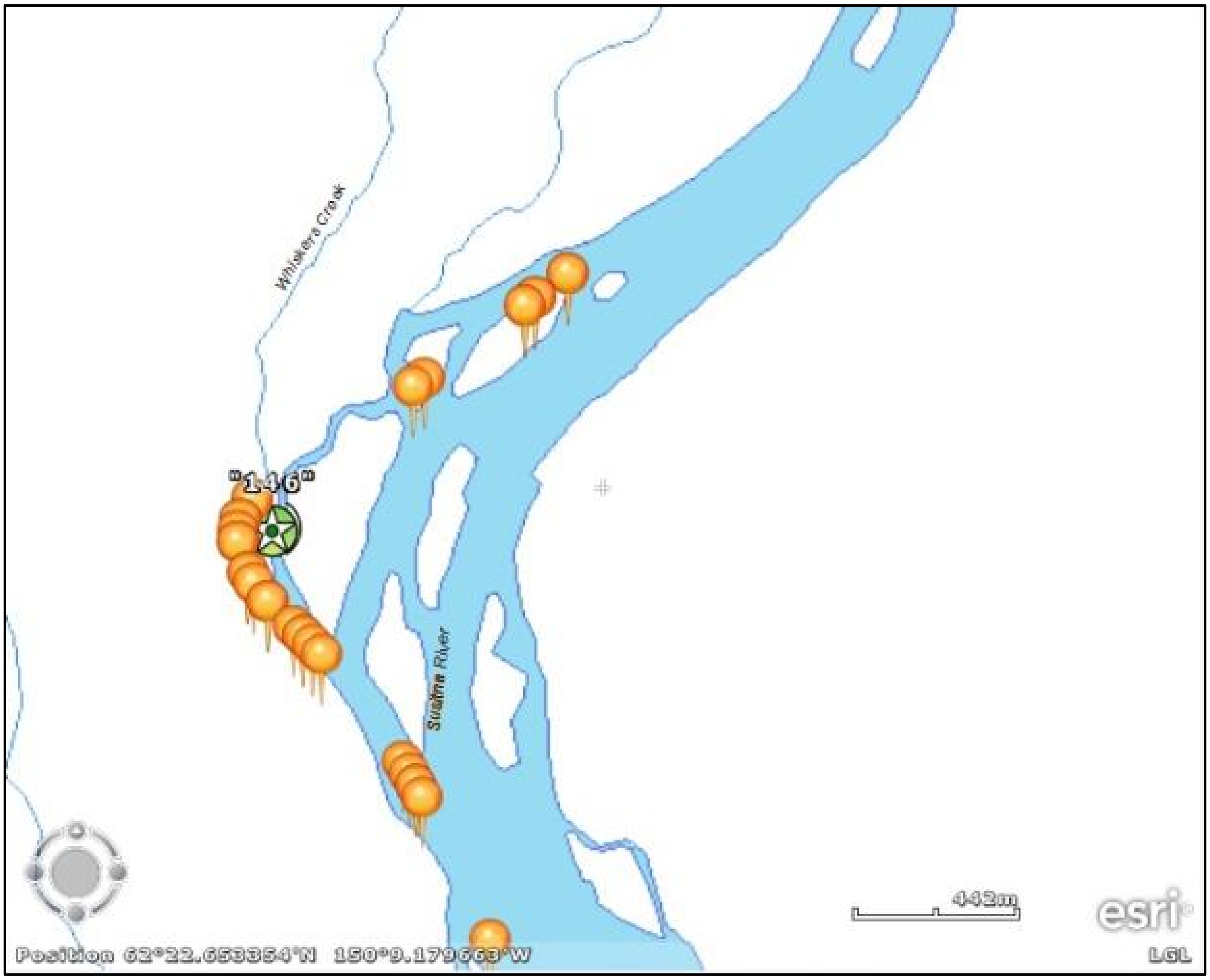

Figure C.A2-5. Detections for radio tag 151.974 Code 9 during Pass 2. The yellow circle indicates the location of the tag and the star is the location of the highest power detection. The power of the detection is located above the star and is on a scale from 40 to 154. Radio tag 151.974 Code 9 was not detected during Pass 1.

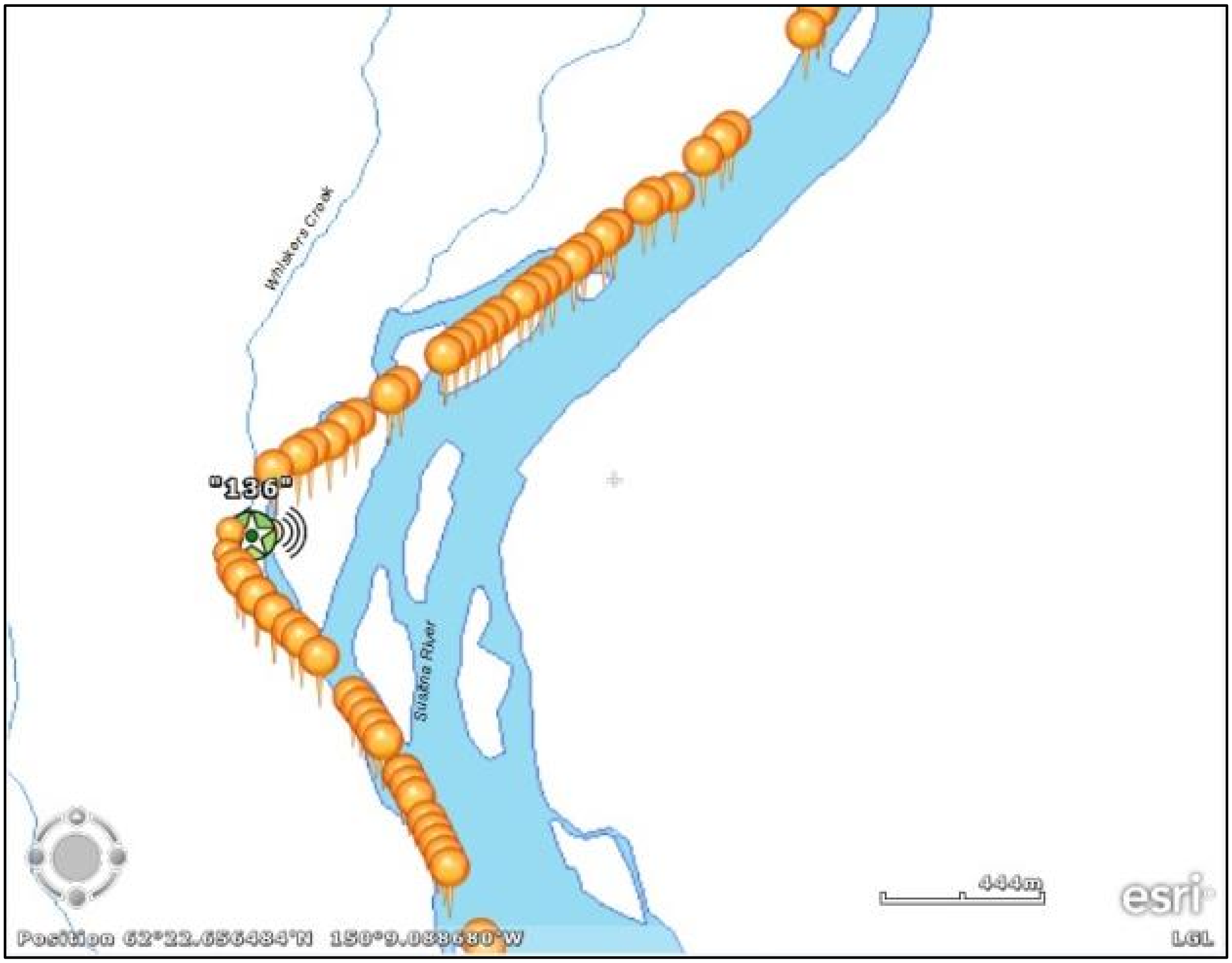

Figure C.A2-6. Detections for radio tag 151.943 Code 17 during Pass 2. The yellow circle indicates the location of the tag and the star is the location of the highest power detection. The power of the detection is located above the star and is on a scale from 40 to 154.

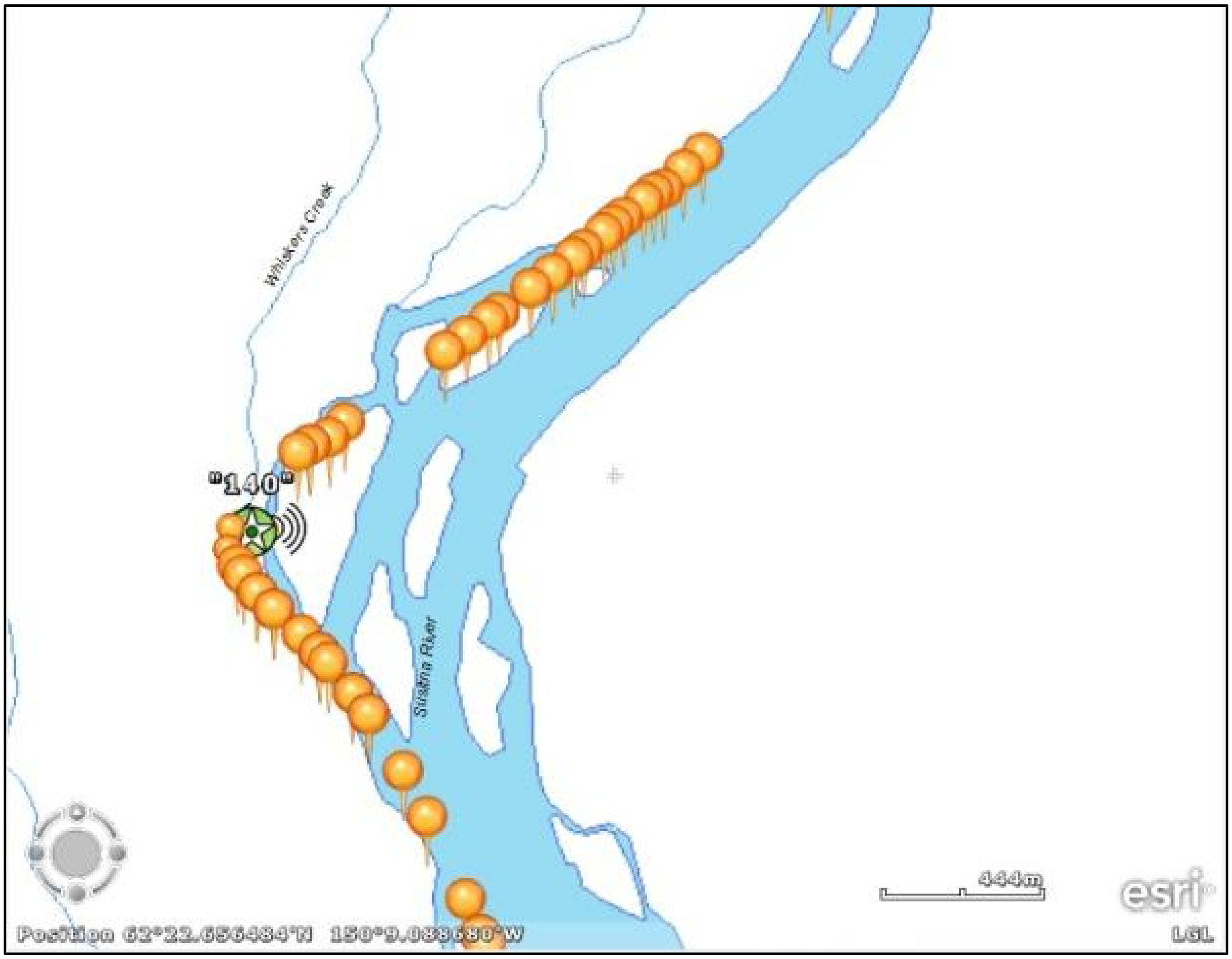

Figure C.A2-7. Detections for radio tag 151.943 Code 44 during Pass 2. The yellow circle indicates the location of the tag and the star is the location of the highest power detection. The power of the detection is located above the star and is on a scale from 40 to 154.

Figure C.A2-8. Detections for radio tag 151.943 Code 62 during Pass 2. The yellow circle indicates the location of the tag and the star is the location of the highest power detection. The power of the detection is located above the star and is on a scale from 40 to 154.

Figure C.A2-9. Detections for radio tag 151.934 Code 94 during Pass 1. The yellow circle indicates the location of the tag and the star is the location of the highest power detection. The power of the detection is located above the star and is on a scale from 40 to 154.

Figure C.A2-10. Detections for radio tag 151.934 Code 94 during Pass 2. The yellow circle indicates the location of the tag and the star is the location of the highest power detection. The power of the detection is located above the star and is on a scale from 40 to 154.

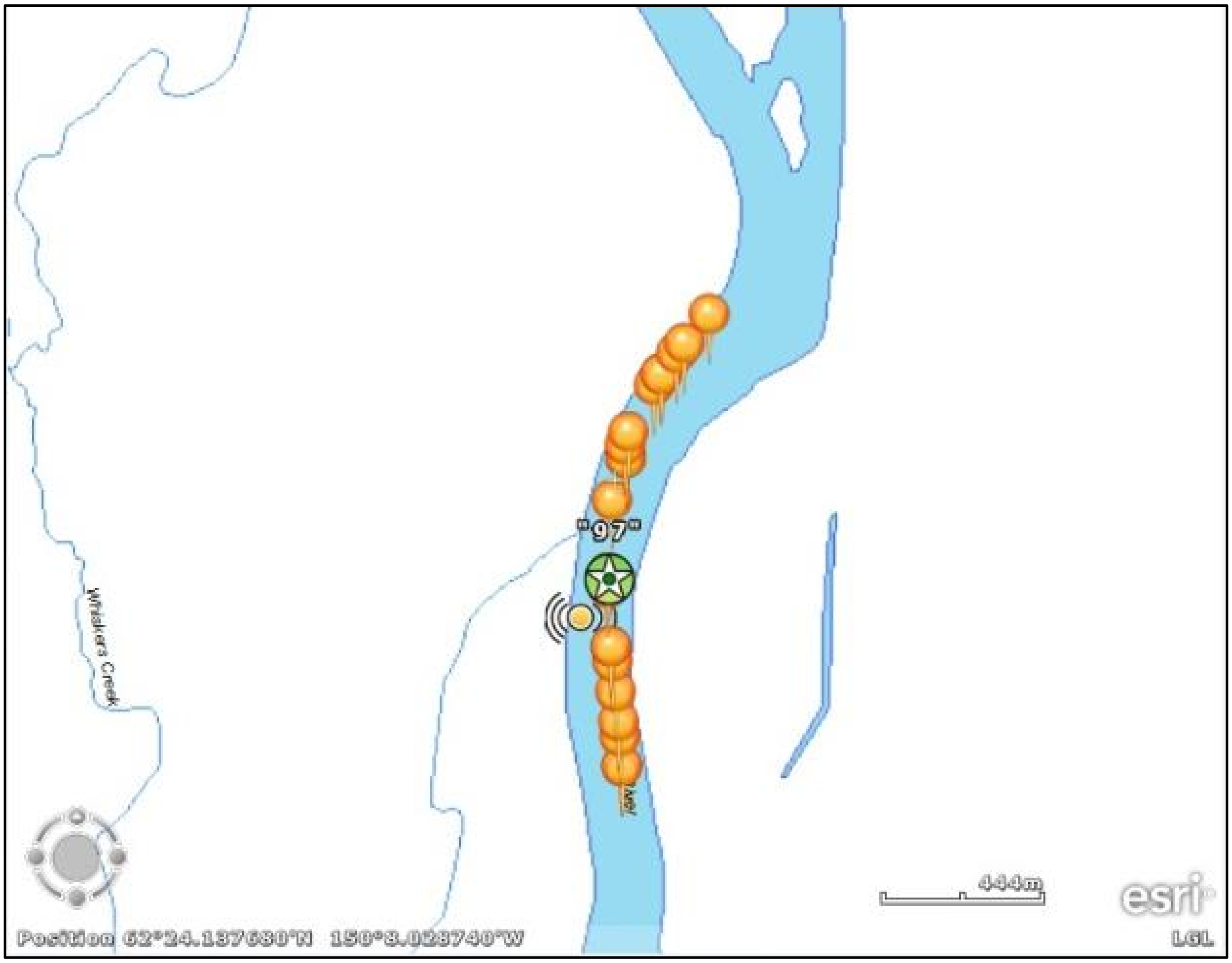

Figure C.A2-11. Detections for radio tag 151.934 Code 45 during Pass 1. The yellow circle indicates the location of the tag and the star is the location of the highest power detection. The power of the detection is located above the star and is on a scale from 40 to 154.

Figure C.A2-12. Detections for radio tag 151.934 Code 45 during Pass 2. The yellow circle indicates the location of the tag and the star is the location of the highest power detection. The power of the detection is located above the star and is on a scale from 40 to 154.

Figure C.A2-13. Detections for radio tag 151.934 Code 68 during Pass 1. The yellow circle indicates the location of the tag and the star is the location of the highest power detection. The power of the detection is located above the star and is on a scale from 40 to 154.

Figure C.A2-14. Detections for radio tag 151.934 Code 68 during Pass 2. The yellow circle indicates the location of the tag and the star is the location of the highest power detection. The power of the detection is located above the star and is on a scale from 40 to 154.

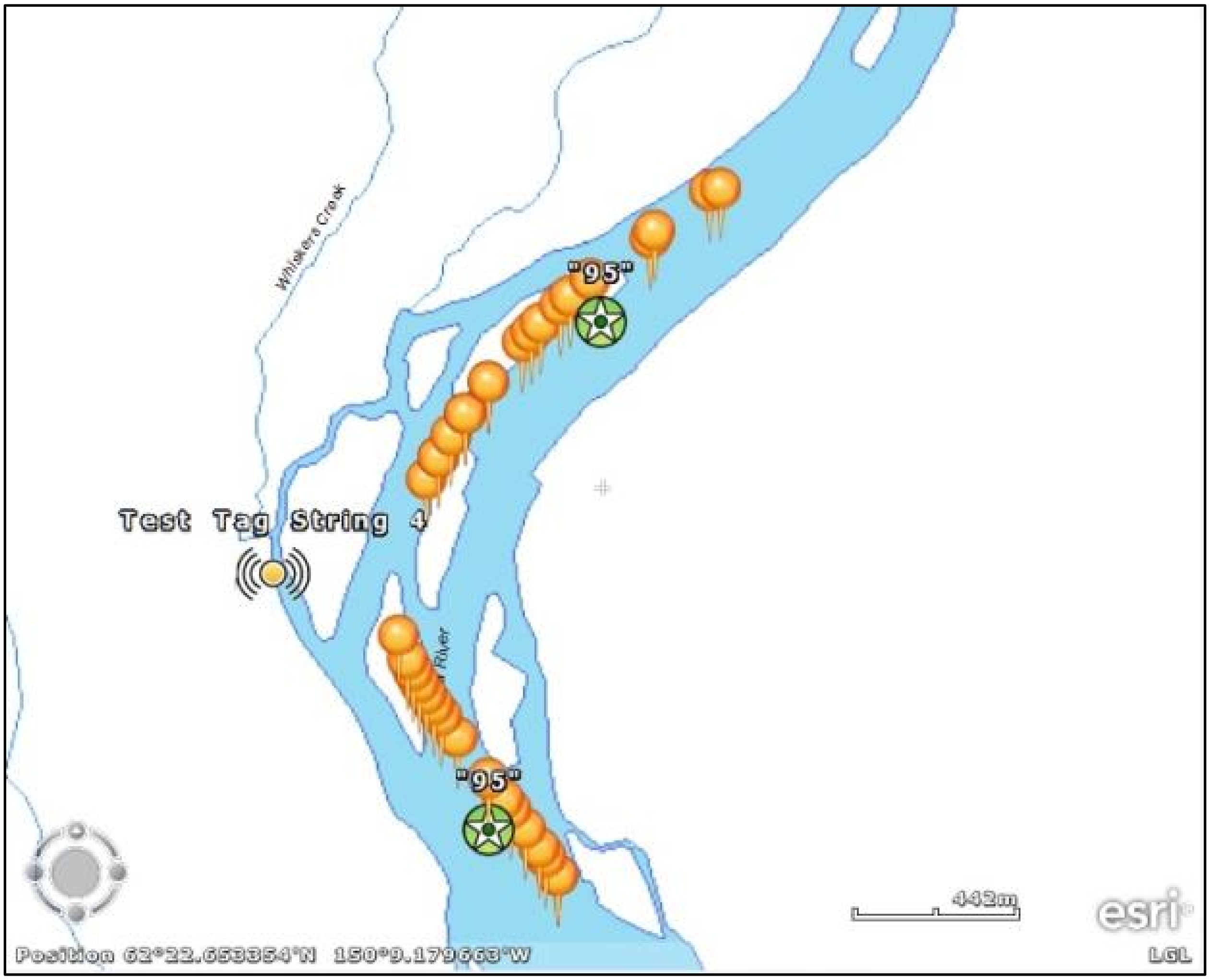

Figure C.A2-15. Detections for radio tag 151.963 Code 19 during Pass 1. The yellow circle indicates the location of the tag and the star is the location of the highest power detection. The power of the detection is located above the star and is on a scale from 40 to 154.

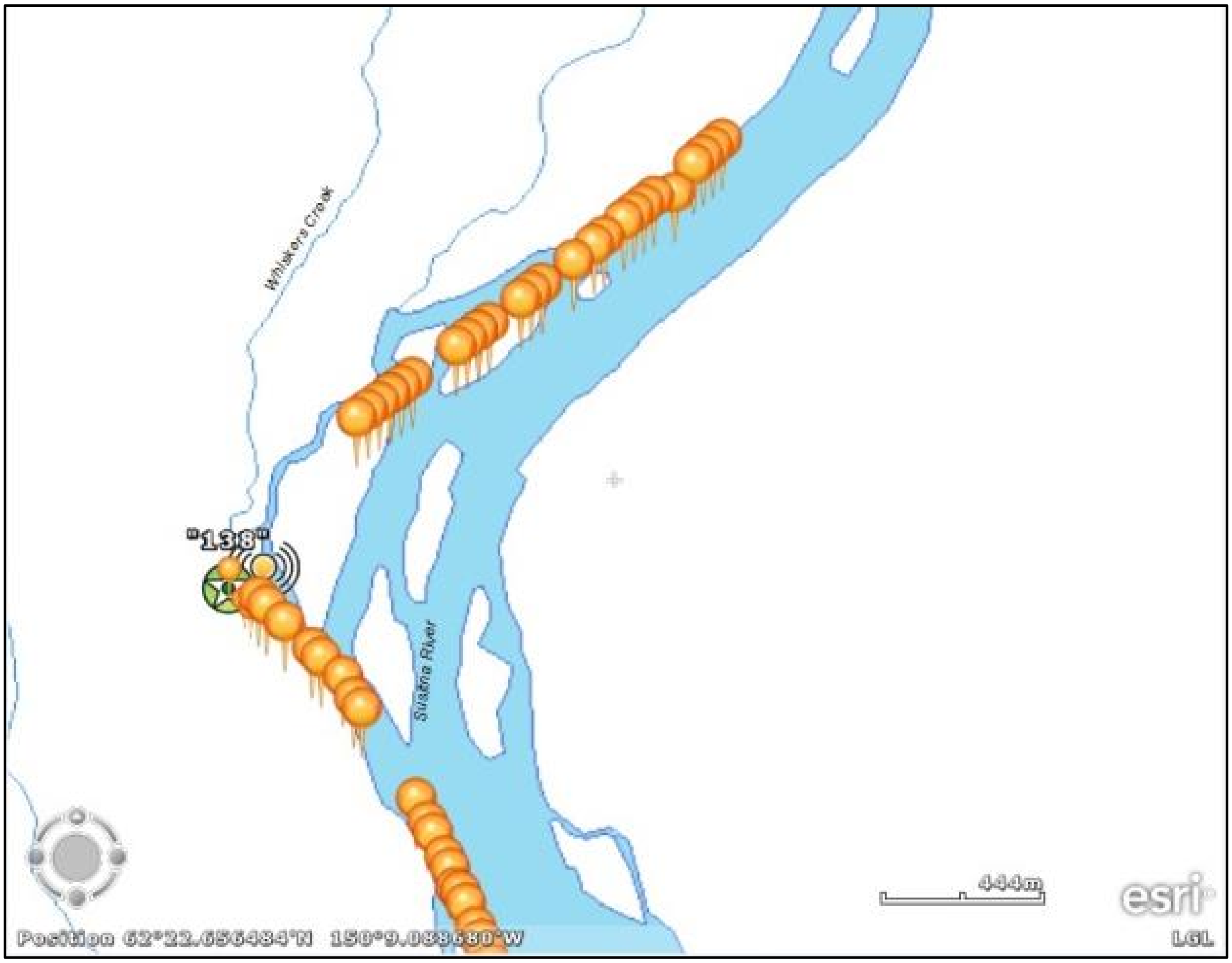

Figure C.A2-16. Detections for radio tag 151.963 Code 19 during Pass 2. The yellow circle indicates the location of the tag and the star is the location of the highest power detection. The power of the detection is located above the star and is on a scale from 40 to 154.

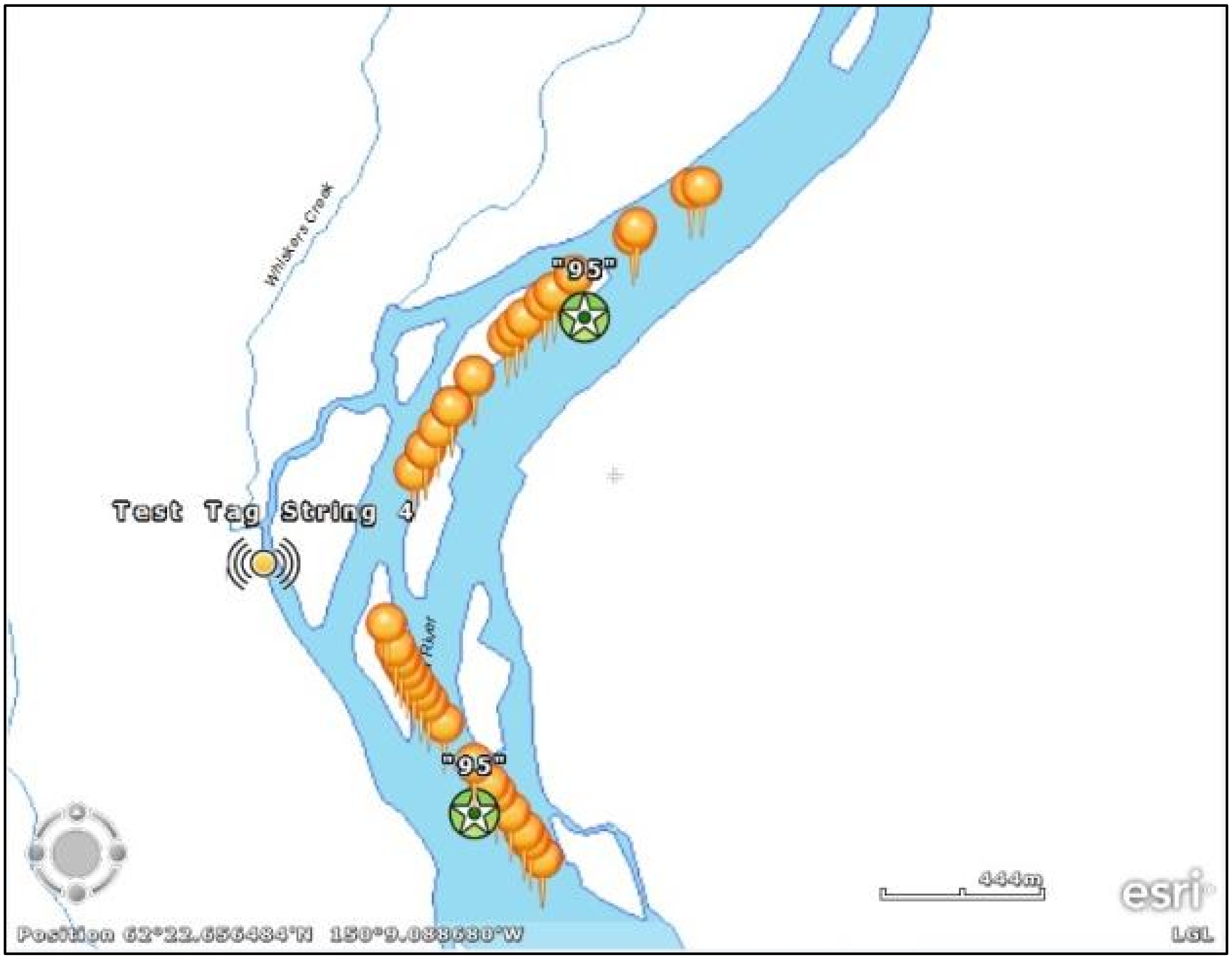

Figure C.A2-17. Detections for radio tag 151.963 Code 94 during Pass 1. The yellow circle indicates the location of the tag and the star is the location of the highest power detection. The power of the detection is located above the star and is on a scale from 40 to 154.

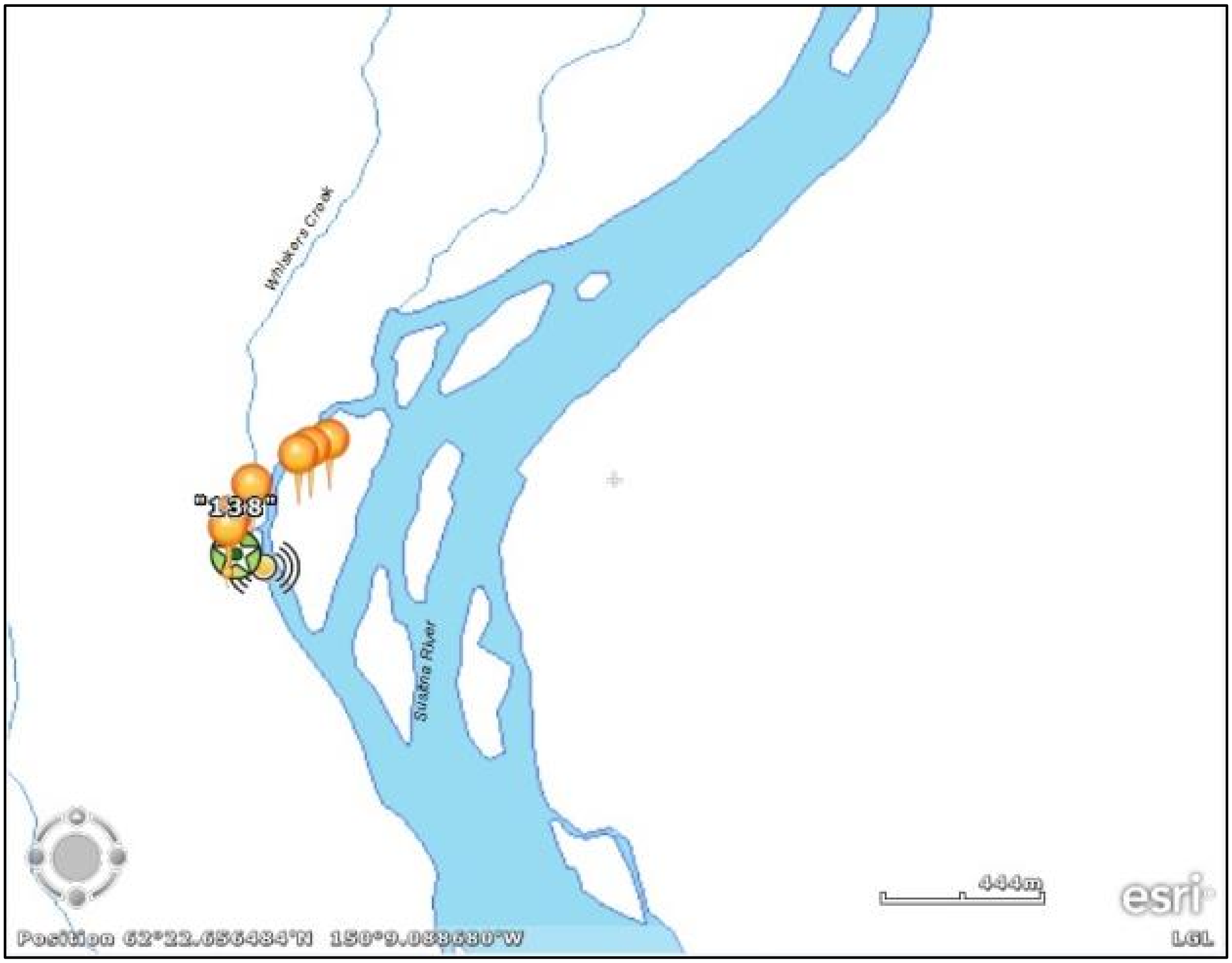

Figure C.A2-18. Detections for radio tag 151.963 Code 94 during Pass 2. The yellow circle indicates the location of the tag and the star is the location of the highest power detection. The power of the detection is located above the star and is on a scale from 40 to 154.