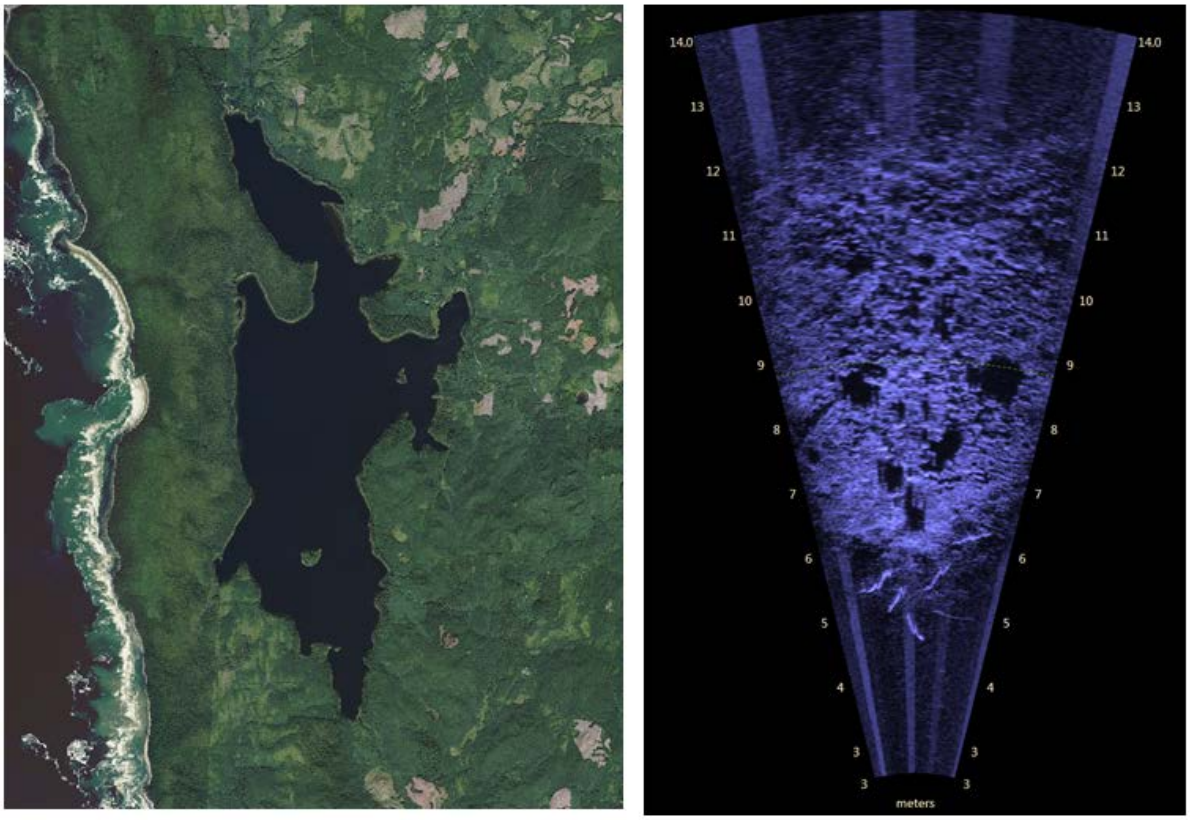
Field Testing the Use of Imaging Sonar Technology as a Tool for Beach Spawning Ground Surveys: Year 2



FINAL REPORT VERSION 4.0

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CONTENTS

FIGURES

TABLES

1 INTRODUCTION

In 2009, National Marine Fisheries Service (NMFS) adopted the Lake Ozette Sockeye Salmon Recovery Plan (NMFS 2009) which identifies a broad range of actions needed to recover this ESA-listed species. The Recovery Plan and 2011 five-year status review for Lake Ozette sockeye (NMFS 2011) identify the current lack of sufficient data regarding abundance and distribution of the beach spawning portion of this population as a critical uncertainty preventing NMFS from fully understanding the viability status of the species.

Estimates of sockeye returning to Lake Ozette each year are generally made based on May-July weir counts (the weir is located at the outlet of the lake in the Ozette River) and represent the total number of beach and tributary-origin adults migrating into the lake. Fish counted at the weir subsequently hold in Lake Ozette for up to eight months prior to occupying beaches or entering tributaries in the fall and winter to spawn. The number of sockeye that die each year before spawning in the lake due to natural causes or predation is unknown. Identifying the abundance and distribution of the beach-spawning component of the population has been especially problematic due to adverse lake visibility and weather conditions that disrupt and often prevent stock assessment surveys based on visual observations of fish. The lack of reliable spawning estimates makes it difficult to assess current beach spawner status, or any changes in status that might be occurring over time for this population.

The purpose of this project is to help develop methods that can be used to enumerate Lake Ozette sockeye on the spawning beaches. This was accomplished by field testing dual frequency identification sonar (DIDSON and ARIS) along the shorelines of Lake Ozette during the sockeye salmon spawning period in 2011 and 2012. Imaging sonar technology uses sound pulses and converts the returning echoes into digital images, similar to the technology used in ultrasounds (Sound Metrics 2011). Imaging sonar does not use or need light to "see" and therefore can be used in dark and turbid water with limited or no visibility.

2 BACKGROUND

There are two known active beach spawning sites along the shores of Lake Ozette: Allen’s Beach and Olsen’s Beach (Figure 2.1). Beach spawning sockeye stage offshore of the spawning beaches in mid- to late-October and begin spawning as early as November 1 (MFM unpublished spawning ground surveys). Sockeye continue to aggregate in deeper water just off-shore of spawning beaches until maturation, then move onto the beaches to commence spawning.

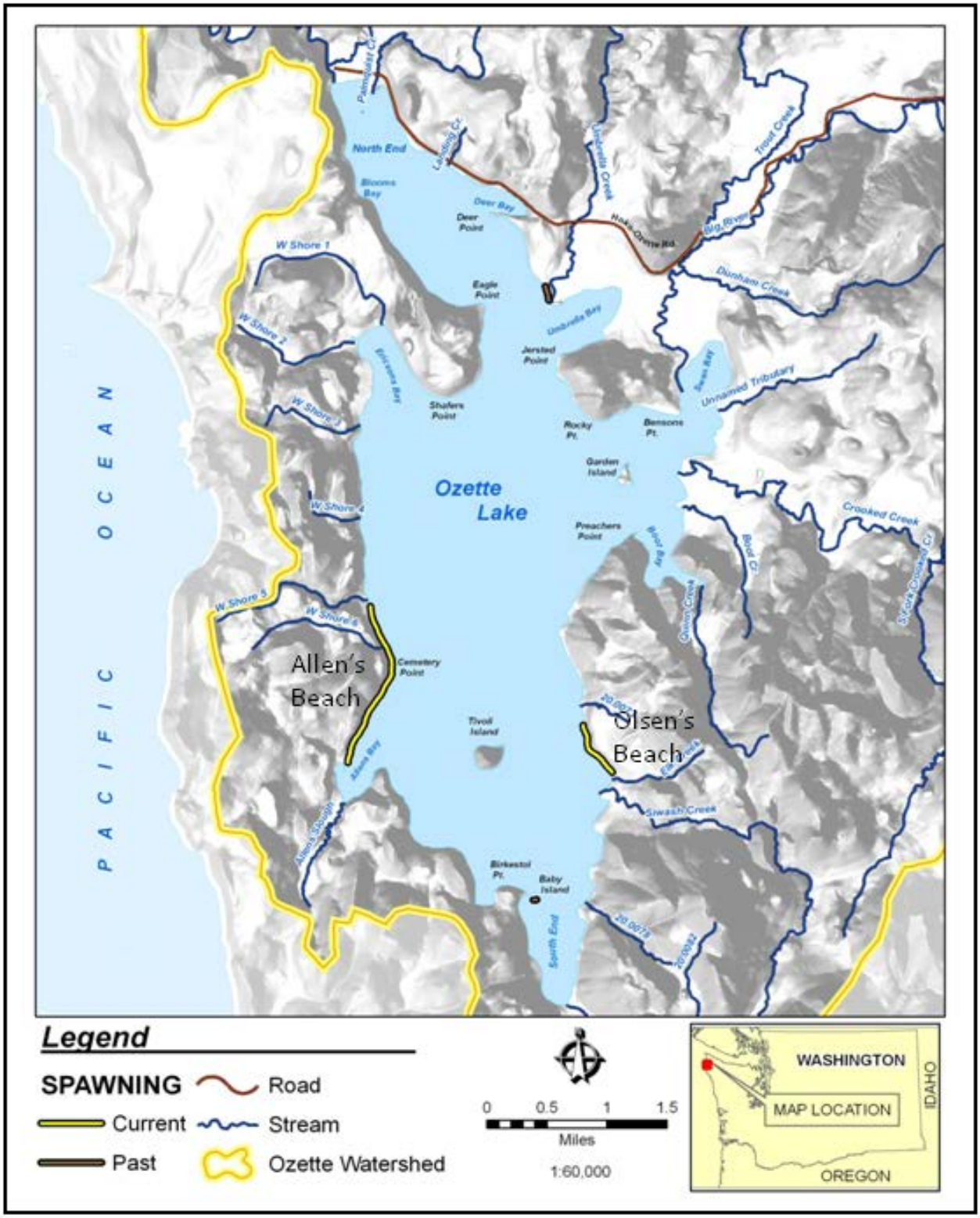

Figure 2.1. Current and historical Lake Ozette sockeye beach spawning locations (source: Haggerty et al. 2009)

2.1 Olsen's Beach Description

At Olsen's Beach the core spawning area is centered on a relatively small upwelling zone (spring) and encompasses approximately 6,400 ft^2 (600 m^2) of beach. Substrate conditions along the entire spawning beach grade from small cobble/large gravel to coarse sand and silt. Haggerty et al. (2009) characterized suitable spawning habitat in three utilization categories: core, concentrated, and dispersed. The core habitat is approximately 100 feet (30 m) in length and 66 feet (20 m) in width. The concentrated spawning use occurs for about 115 feet (35 m) on either side of the core area, as well as a zone approximately 425 feet (130 m) long at the northern tip of Olsen's Beach (Figure 2.2).

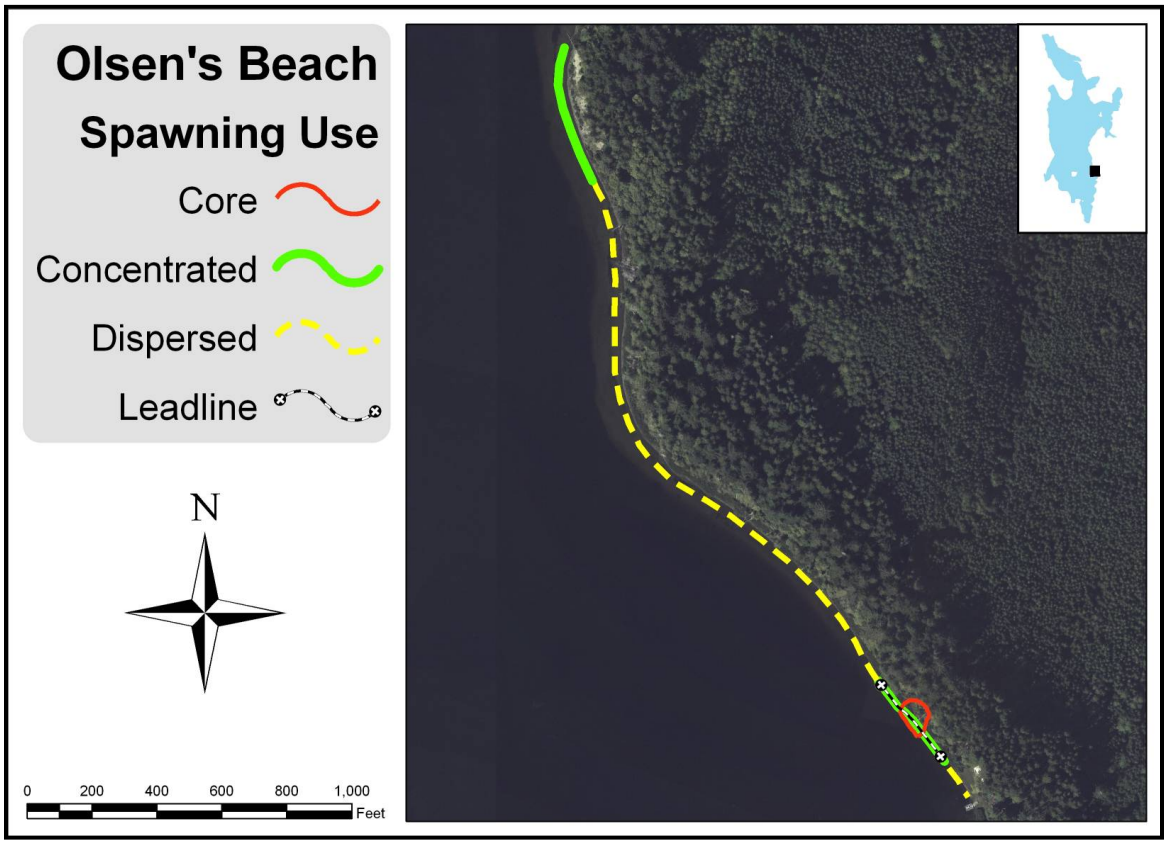

Figure 2.2. Current Olsen's Beach sockeye spawning use categorized as concentrated, core, and dispersed (From: Haggerty et al. 2009). Note: the lead line in the figure was used for snorkel and scuba surveys conducted 1999, 2000, and 2001.

Haggerty et al. (2009) described three discrete beach zones within the core spawning area at Olsen's Beach. These zones included the following: the upper beach, middle beach, and lower beach. Beach slope, substrate, and vegetation conditions vary between each

zone. The highest spawning concentrations have been observed in the middle beach zone. The core area within the middle beach is approximately 26 feet (8 m) wide and 100 feet (30 m) in length, and has a slope of 2.7% (Figure 2.3). The core area upper and lower beaches have slopes of 11% and 12% gradient respectively. The spawning areas to the south of the core area have a more uniform beach slope. The spawning areas to the north have a slope similar to the core area, with the exception that the low gradient beach sections occur at an elevation 3.3 feet (1 m) higher.

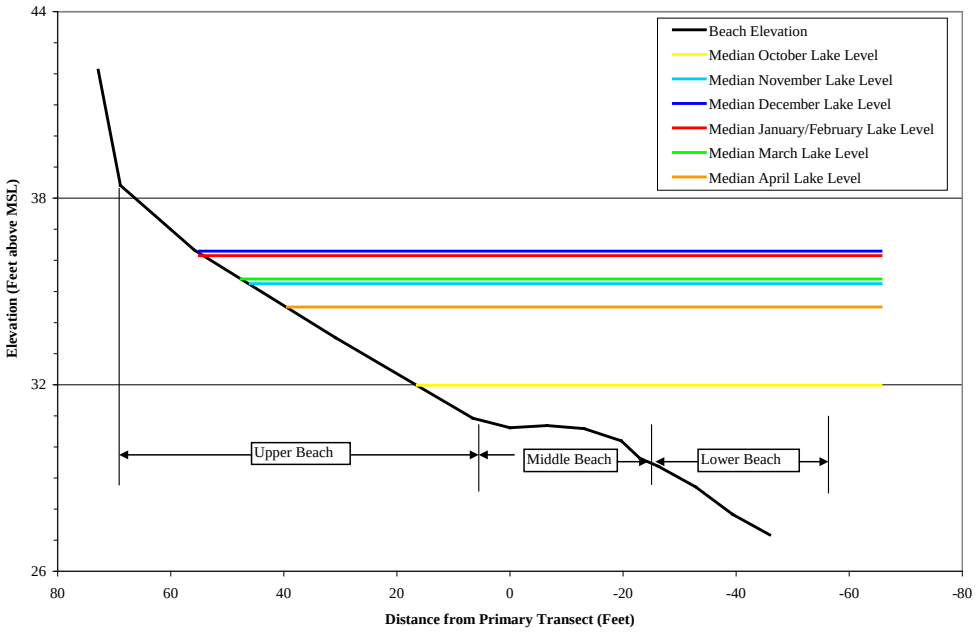

Figure 2.3. Cross-section of upper, middle, and lower beaches within the core spawning area at Olsen's Beach contrasted with median monthly lake level data from water years 1981 through 2004 (From: Haggerty et al. 2009).

2.2 Allen's Beach Description

Allen's Beach sockeye salmon spawning is much more dispersed than at Olsen's Beach. Based on spawning ground surveys conducted from 1999 through 2004 one area was classified as having concentrated spawning use (Figure 2.4). There may be other small areas with concentrated spawning use that have not yet been detected by surveys (such as Cemetery Point). The spawning area at Allen's Beach is approximately 1.4 miles long (2.2 km).

Substrate size and condition is variable along Allen's Beach. Substrate along the southwest end of the beach is composed primarily of fine sand, silt, mud, and organic detritus. Substrate size quickly grades into a matrix of coarse sand, pebbles, and gravel in the northeast direction. This area is sometimes referred to as South Allen's.

Moving north-northeast from South Allen's Beach, substrate size generally increases, with cobbles becoming a dominant component near Cemetery Point. Moving in the offshore direction, the substrate grades to sand and the bottom gently slopes to a depth of about 4 meters (13 ft) (relative to winter lake levels), where a distinct slope break occurs between about 4 and 6 meters (13 to 20 ft). Below about 6 meters (20 ft), the slope decreases again, and in some areas gravel can be found. Sockeye salmon have been observed spawning on this lower "shelf" at Allen's Beach to depths of approximately 10 meters (32 ft). At least some spawning site selection appears to be associated with numerous seeps and springs along the shoreline, which were mapped during the summer of 1999 (See Haggerty et al. 2009).

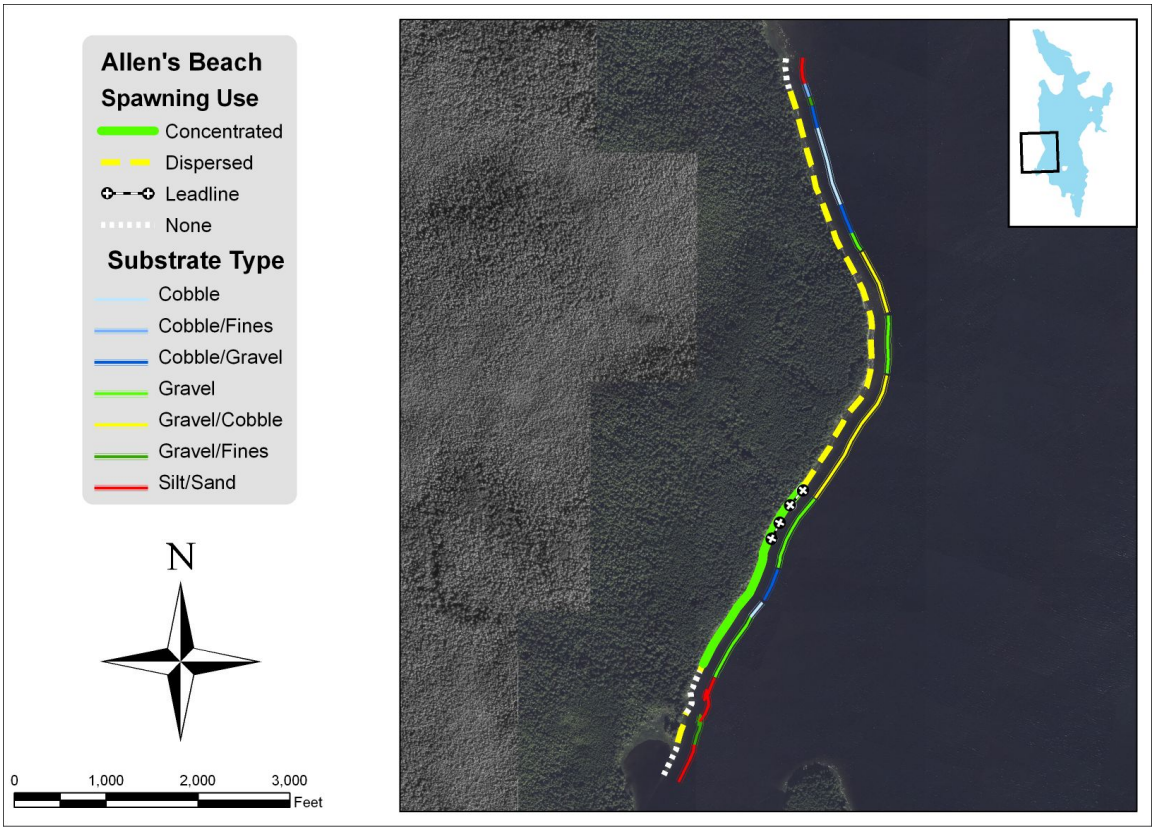

Figure 2.4. Allen's Beach spawning use classification and dominant substrate size (From: Haggerty et al. 2009).

Beach slope at Allen's Beach ranges from 8% to 9% gradient. Figure 2.5 depicts the differences in beach slope between Olsen's and Allen's beaches based upon typical cross-sections from the core and concentrated spawning areas.

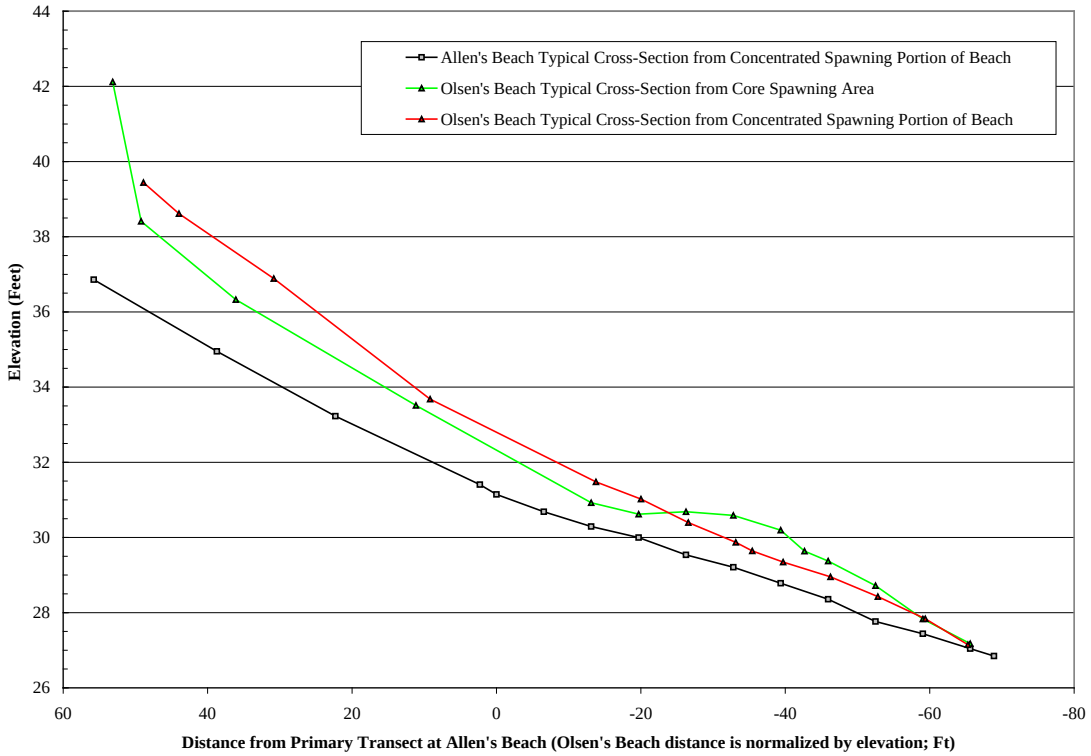

Figure 2.5. Comparison of beach profiles from Olsen's Beach core and concentrated spawning areas and Allen's Beach concentrated spawning use area. (From: Haggerty et al. 2009).

2.3 Recent and Past Methods used to Enumerate Beach Spawning Sockeye

Various methods have been used to count the number of spawning sockeye along the shorelines of Lake Ozette. The first fully documented surveys took place in 1973. Since then several different survey methods have been used. No systematic method for counting beach spawning sockeye has been developed. Past methods used to count spawning sockeye have included: seine and gill netting (mostly for broodstock collection, but also used to retrieve tissue samples for various genetic collections), foot, snorkel, scuba, and boat surveys. A detailed summary of past methods and results is included in Haggerty et al. (2009).

In 1999, lead line survey transects were established along the spawning beaches. These transects have been used for snorkel and scuba surveys where the number of sockeye are counted by divers. Additionally, divers collected data on the number, size, and position of redds along the lead lines. Boat surveys have supplemented dive surveys. These efforts resulted in annual estimates of the minimum number of sockeye observed spawning, as well as detailed information on the location and characteristics of redds. At times inclement weather conditions, high lake level, and poor water visibility make dive, snorkel, and boat surveys very difficult.

3 METHODS

3.1 Development of Beach Spawning Ground Survey Methods

During the sockeye salmon spawning period Lake Ozette often has poor visibility making counting fish from the surface difficult or impossible. Dive surveys are also limited by viewing conditions and are labor intensive, which limits the amount of area than can be surveyed. Since the fish are listed under the ESA, standard mark and recapture techniques to assess the population have been discouraged by fishery managers and are unlikely to be permitted.

Over the course of the last several years the idea of using DIDSON/ARIS (dual-frequency identification sonar) to count sockeye along the spawning beaches has been discussed by co-managers and stakeholders. The purpose of this project is to help advance those discussions into a field tested set of methods that can be used to enumerate sockeye on the spawning beaches. A thorough review of the literature yielded no examples of a DIDSON used for counting beach spawning sockeye salmon. We attempted to locate other sources of information related to this specific use of a DIDSON by contacting experts throughout the Pacific Northwest and Alaska. We were unable to find a single example of a DIDSON used for counting spawning sockeye on lake beaches. However, we did get recommendations for attempting the use of a DIDSON to enumerate beach spawning sockeye. The input from various experts and stakeholders was incorporated into the development field methods used to test DIDSON technology at Lake Ozette during the winter of 2011/2012. The 2012/2013 testing incorporated results and recommendations from the 2011/2012 field testing.

Summary from 2011 Field Testing

The 2011 survey was conducted using an 18 ft fiberglass boat with a small cabin. The boat was equipped with a 90hp outboard motor, an 8hp motor, and smaller electric motor.

A DIDSON Model 300 LR was used for data acquisition. The DIDSON 300LR operating in identification mode operates at 1.2 Mhz and 0.8 Mhz in detection mode. The DIDSON utilizes 96 beams spaced at 0.3 degrees. Beam width is 0.3° in the horizontal plane and 14° in the vertical plane. The DIDSON was attached to an adjustable pole mount clamped to the boat's gunnel. The DIDSON was powered by a small 1 kilowatt gas powered generator. The power was fed into a Sound Metrics power supply box where the DIDSON cable was also attached. The DIDSON signal was delivered to a Panasonic Toughbook computer where data files were stored using DIDSON software. A handheld GPS unit (Garmin GPSmap 76Cx) was also attached to the computer with its signal interfaced with the DIDSON software so that the unit's position could be recorded on each image.

All surveys were conducted on December 14, 2012. Two survey methods were used: station and slow pass. The station method used multiple fixed stations. The boat was held in position and DIDSON images were recorded for 1 to 5 minutes. The total number of sockeye salmon observed at each station was recorded. The slow pass method used a slowly moving boat with the DIDSON pointed at the spawning beaches, looking either shoreward or lake-ward. Distance from spawning grounds varied from 10 to 25 meters. Only areas lake-ward of the low water vegetation line were targeted. The DIDSON was set to record 6 to 10 images per second. Sockeye were counted only if the their direction of travel through the image screen was opposite of the direction of the pass.

The station method was used at Olsen's Beach with the DIDSON set to ranges of 20 and 10 meters. When set to the 20 meter range the DIDSON was recording images from 3 to 23 meters away from the instrument. The DIDSON was used to target the middle beach of the core spawning area where high densities of sockeye could visually be seen. At the 20 meter range the DIDSON was difficult to aim without getting interference from the surface and lake bottom. Images were quite grainy and difficult to interpret. Sockeye were detected intermittently making counting and individual fish identification difficult. The sockeye within the target area were also milling around further complicating the counting of individual fish. At the 10 meter range DIDSON images were recorded at 3 to 13 meters away from the instrument. The DIDSON was easier to aim without getting interference and the images were clearer than those from the 20 meter setting. The field of view significantly limits the area surveyed from a single monitoring station. Individual fish were much easier to identify when using the DIDSON at the 10 meter range as compared to the 20 meter range.

The slow pass tests at Olsen's Beach found that the best results came from transects looking lake-ward from the brush line. However, many of the targets were visually seen directly below the boat and shoreward of the boat and therefore could not be detected with the DIDSON unit. Image quality was better looking down the beach slope versus looking up the beach. When looking up the beach the DIDSON images became less and

less clear despite high target density. Brush and shallow water prevented sockeye detection in the upper portion of the beach where high sockeye salmon densities could be seen.

The slow pass tests at Allen's Beach detected sockeye salmon spawning or staging more than 30 meters lake-ward of the low water vegetation line. Sockeye salmon in these areas were previously very difficult and/or impossible to detect. Depths in this area ranged from 5 to 15 meters. Rough water conditions limited our ability to visually observe sockeye at depths greater than one or two meters. The DIDSON looking up the beach did well relative to our ability to visually observe sockeye at the south end of Allen's Beach. At north Allen's and Cemetery Point the wind was stronger, which made it difficult to control the boat at slow speeds. Higher travelling speeds and big wind waves yielded low quality DIDSON images.

The DIDSON testing in 2011 resulted in the following list of recommendations:

- Continue testing and developing DIDSON survey methods on lake beaches during the 2012/2013 spawning season.
    - Conduct surveys throughout the spawning season; weekly during the peak spawning period(s).
    - Surveys should focus on using the slow pass method. Effort should include looking both lake-ward and shoreward. Very slow speeds appear to be especially important for capturing high quality images.
    - Surveys should target weather windows where wind waves will not negatively affect image quality. If not possible consider testing the use of stabilizers on the boat used for surveying.
    - Include survey staff on boat that can visually count sockeye salmon high on the beach (that are outside of the DIDSON imaging range).
    - When time permits conduct surveys along habitats that may be utilized by sockeye salmon but are currently not known to be utilized (e.g., Umbrella Beach).
- Use the standard DIDSON 300 unit- compare image quality between the standard 300 and the 300LR.
- Document results and refine methodologies as appropriate.

For more details on the 2011 survey see Haggerty (2012).

3.2 Field Methods (2012/13)

Equipment Used

Surveys were conducted using a 25 foot aluminum boat with a large cabin. The boat was equipped with a 250 hp outboard motor and a 15hp backup motor. An ARIS 1800 imaging sonar was used for data acquisition. When operating in identification mode the instrument operates at 1.8 Mhz. When in detection mode the instrument operates at 1.2 Mhz. The ARIS utilizes 96 beams spaced at 0.3 degrees. Beam width is 0.3° in the horizontal plane and 14° in the vertical plane. The ARIS was attached to an adjustable pole mount (Figure 3.1). The adjustable pole mount was mounted to a mount assembly which was mounted the boat's gunnel rail using a flange mounting system and eight screws. A 3/8 inch rope was tied to the mounting system near the locking pin and to the boat in case the pole mount became disconnected from the boat's gunnel rail. The ARIS transducer was mounted to the transducer mount using four screws. The ARIS was lowered and raised vertically along the main vertical pole using the locking sleeve to adjust position. The ARIS can be moved left or right using the aiming bars located at the top of the main pole. The ARIS can be tilted vertically up and down using the tilt adjustment crank. The ARIS unit measures view direction (magnetic azimuth) and vertical tilt with each image captured.

The ARIS was powered by a small 350 watt inverter connected to the boat's electrical system. The power was fed into a Sound Metrics power supply box where the ARIS cable was also attached. The ARIS signal was delivered to a Panasonic Toughbook computer where data files were stored using ArisScope software. A handheld GPS unit (Garmin GPSmap 76Cx) was used to collect position data. The ARIS software currently does not allow the GPS signal to be interfaced with the ARIS software. The next version of the software will allow for GPS signal interface via the platform function.

Survey Methods

All surveys were conducted using the slow pass method. Surveys utilized boat mounted ARIS imaging sonar at Olsen's and Allen's beaches (as well as additional sites) to count spawning sockeye salmon. The ARIS was mounted along the side of the boat (as described above) in such a way that it could look "sideways" on the spawning grounds. The ARIS was pointed at the spawning beaches and the boat was driven very slowly past the targeted areas. Speeds were typically between 0.5 and 1.5 miles per hour. Distance from spawning grounds varied from 15 to 25 meters. Only areas lake-ward of the low water vegetation line were surveyed. Sockeye size targets were counted only if their direction of travel through the image screen was opposite of the direction of the pass. This reduced or eliminated double counting sockeye that passed through the image frame more than once. Each target identified was recorded at the time it passed the right hand

side of the image screen. Distance from the ARIS transducer was recorded for each image. Additional notes were recorded where applicable.

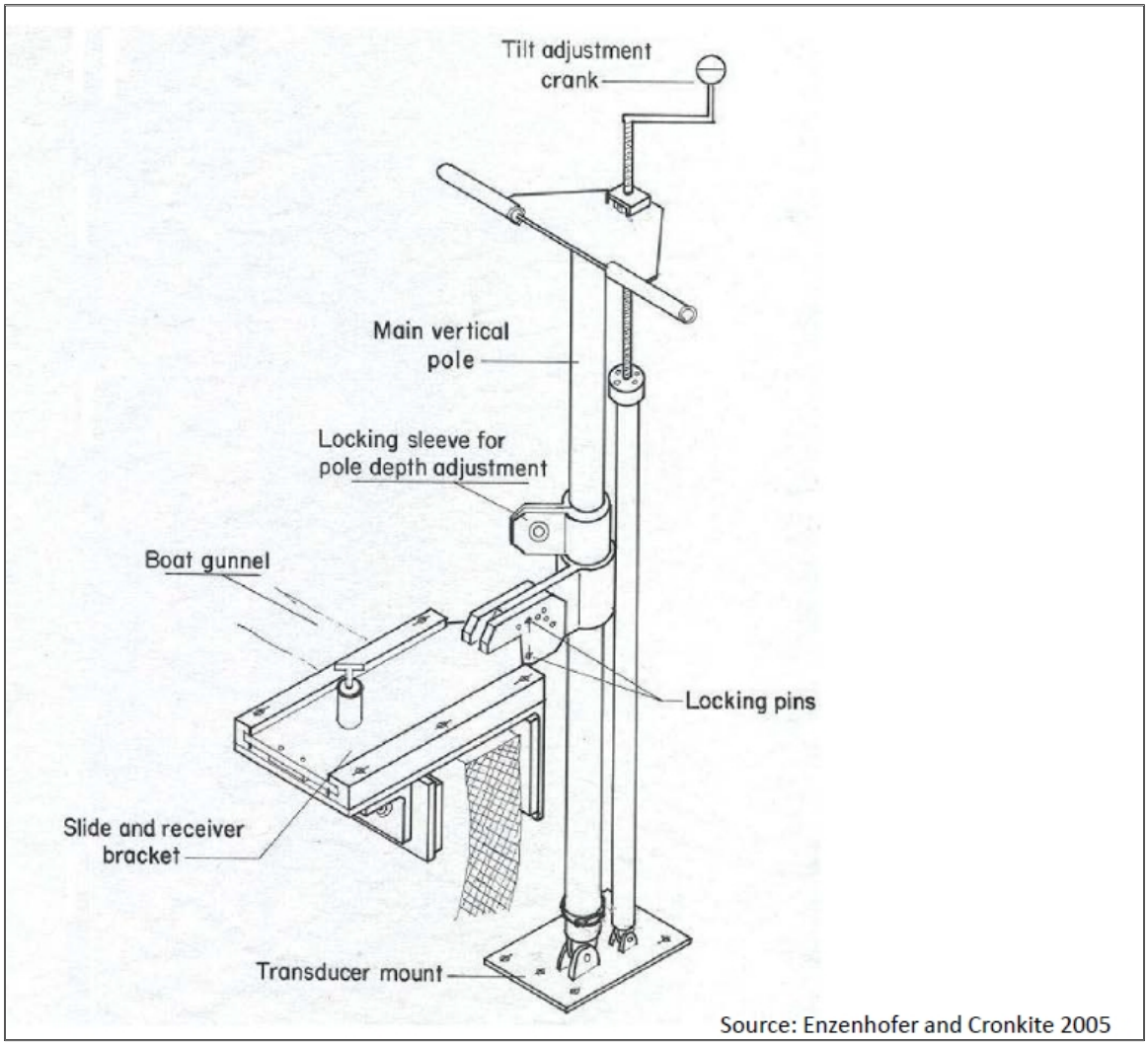

Figure 3.1. Diagram showing the adjustable pole mount used for mounting the DIDSON unit to a boat (Source: Enzenhofer and Cronkite 2005).

4 RESULTS and DISCUSSION

Three surveys were conducted during the 2012-2013 spawning season. The surveys were conducted on December 12, 2012, December 20, 2012, and January 4, 2013. Sections 4.1 through 4.3 describe the results from surveys.

4.1 December 12, 2012

The lake level on December 12, 2012 was the 37.1 feet measured at the Olympic National Park (ONP) staff gage located at the lake's outlet near the ranger's station. It was a nice sunny December day, there was little if any wind and the lake was quite calm for the entire survey. Overall survey conditions were excellent. The boat was launched at Rayonier Landing (off of Hoko-Ozette Road), approximately 5.8 miles north of Olsen's Beach.

Olsen's Beach

We made a total of four survey passes at Olsen's Beach. Pass 1 started at the south end of Olsen's Beach with the sonar looking up the beach as the boat slowly passed by the spawning grounds from south to north. Pass 1 ended at the mouth of unnamed tributary WRIA 20.0073 (see Figure 4.1). The sonar was set to record images at variable starting distances (3.5-6.8 m) and ending distances (17.9-35 m). A total of 56 sockeye size targets were observed, 50 of which were in or adjacent to the southern core spawning area (see Table 4.1). Pass 2 focused on the concentrated and core areas of Olsen's Beach (south). Pass 2 looked down the beach and a total of 68 sockeye size targets were. Pass 2 identified sockeye using and potentially spawning in deeper habitat. Sockeye size targets were identified 25- 30 meters lake-ward of the brush line. Pass 3 took place in the same area as Pass 2 but looked up the beach. A total of 97 sockeye size targets were observed. Pass 4 was a very, very, slow pass directly through the core area only. No counts were made for this pass as it was only testing image quality. Figure 4.2 depicts sockeye size target observations per 100 square meters for passes 1 through 3.

Table 4.1. Summary of survey passes and observations at Olsen's Beach (12/12/12).

Pass ID	Look Direction	Start Dist. (m)	End Dist. (m)	No. of Sockeye Size Targets Detected	Other Observations
1	East (up)	Varied	Varied	56	Most fish in or near core area.
2	West (down)	3.5	29	68	83 live and 20 dead observed visually between boat and shoreline
3	East (up)	3.5	23	97	

Figure 4.1. Map depicting Olsen's Beach survey passes 1 through 4 (12/12/12).

Figure 4.2. Map depicting Olsen's Beach sockeye size targets per 100 square meters for passes 1 through 3 (12/12/12).

Allen's Beach

We made a total of two survey passes at Allen's Beach (passes 5 and 6). Pass 5 started at Cemetery Point and ended just south of south Allen's Beach (see Figure 4.3). The sonar was pointed to the west, looking up the beach. The sonar was set to start capturing images at 3 meters and end range varied from 13 to 22 meters. A total of 99 sockeye size targets and 1 kokanee size target were observed (see Table 4.2). Pass 6 started at the south end of Allen's Beach and went to the north, ending just north of Cemetery Point. The sonar was pointed to east looking down the beach. A total of 17 sockeye size targets and one kokanee size target were observed (see Table 4.2). Figure 4.3 depicts sockeye size target observations per 100 square meters for passes 5 and 6. Note that differences in counts between pass 5 and 6 are likely attributable to differences in areas surveyed. Much of the area contained within pass 6 was deeper habitat; further lake-ward than the known concentrated spawning areas. No systematic visual counts of sockeye salmon were made at Allen's Beach due to poor viewing conditions.

Table 4.2. Summary of survey passes and observations at Allen's Beach (12/12/12).

Pass ID	Look Direction	Start Dist. (m)	End Dist. (m)	No. of Sockeye Size Targets Detected	Other Observations
5	West (up)	3	13 to 22	99	One additional kokanee size target
6	East (down)	2.5	24	17	One additional kokanee size target

Other Observations

One additional survey pass was made on December 12, 2012. Pass 7 was made near the mouth of Umbrella Creek. The pass started approximately 220 meters east of Umbrella Creek and ended 550 meters north of Umbrella Creek. The total length of the pass was 900 meters. The sonar was point up the beach. No fish targets were detected in any of the images collected. Sonar images collected show that much of the habitat is dominated by fine sand (as seen by fine ripples on the lake bottom). Some areas also had a lot of aquatic vegetation. Few areas of coarser sediment were observed.

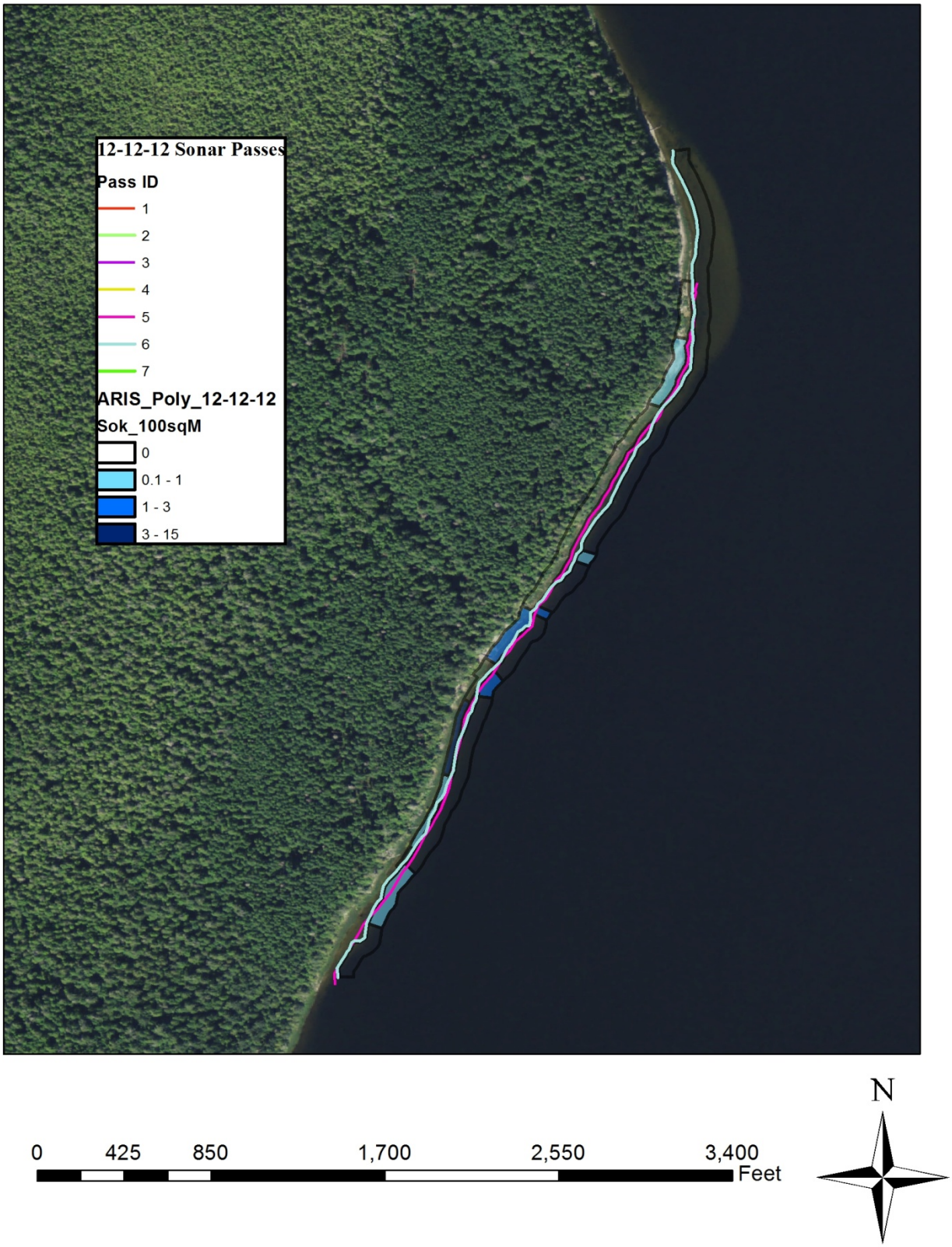

Figure 4.3. Map depicting Allen's Beach survey passes 5 and 6 and sockeye size targets per 100 square meters (12/12/12).

4.2 December 20, 2012

The lake level on December 20, 2012 was the 38.0 feet measured at the Olympic National Park (ONP) staff gage. The weather was mixed, slightly above freezing with a light to moderate breeze in the morning. The wind picked up in the afternoon to a moderate wind (maybe 15 mph). We saw rain and showers, thunder and lightning, and hail. Overall survey conditions were fair-to-good at Olsen's and fair at Allen's Beach. The boat was launched at Rayonier Landing (off of the Hoko-Ozette Road).

Olsen's Beach

We made a total of seven survey passes at Olsen's Beach. Passes 1 through 4 started at the south end of Olsen's Beach with the sonar looking up the beach as the boat slowly passed by the spawning grounds from south to north. The survey area included the core and concentrated areas at south Olsen's Beach (see Figure 4.4). Pass 1 was aborted half way through the survey due to technical problems. Passes 2 and 3 both detected 49 sockeye size targets. Pass 4 detected 70 sockeye size targets. However, during a separate investigation into the repeatability of counts it was determined that the sonar unit paused for several seconds, during this period the sonar viewing direction was adjusted and some of the fish (up to 15) may have been repeat counts. Poor viewing conditions caused by rain and choppy water inhibited our ability to make a visual count of spawning sockeye.

Passes 5 through 7 started just to the north of the concentrated and core area of Olsen's Beach with the sonar looking down the beach. The sonar was set to capture images starting at 3.5 meters and ending at 17 meters. The survey area included the core and concentrated areas at south Olsen's Beach (see Figure 4.4). Results are included in Table 4.3. The image capture range and area surveyed were the same as those used in passes 2 through 4 with only difference being look direction (looking down versus up the beach). These survey passes were designed to test the repeatability of survey methods and target counts. Approximately 90 percent of the sockeye size targets were detected in a short survey segment averaging 52 meters (see Figure 4.5)

Table 4.3. Summary of survey passes and observations at Olsen's Beach (12/20/12).

Pass ID	Look Direction	Start Dist. (m)	End Dist. (m)	No. of Sockeye Size Targets Detected	Other Observations
2	East (up)	3.5	17	49	
3	East (up)	3.5	17	49	
4	East (up)	3.5	17	70	Potential error in count
5	West (down)	3.5	17	54	
6	West (down)	3.5	17	50	
7	West (down)	3.5	17	49	

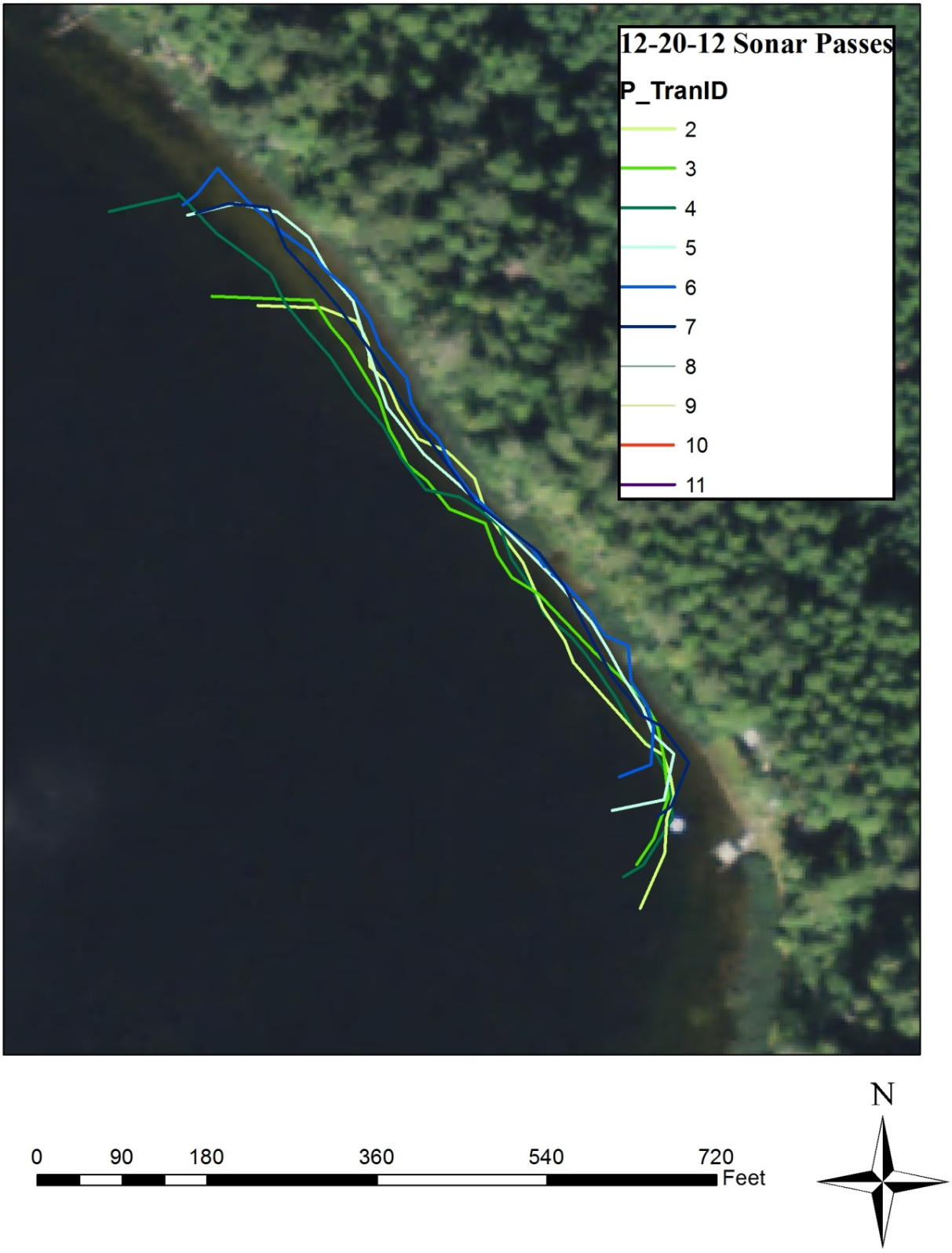

Figure 4.4. Map depicting Olsen's Beach survey passes 2 through 7 (12/20/12).

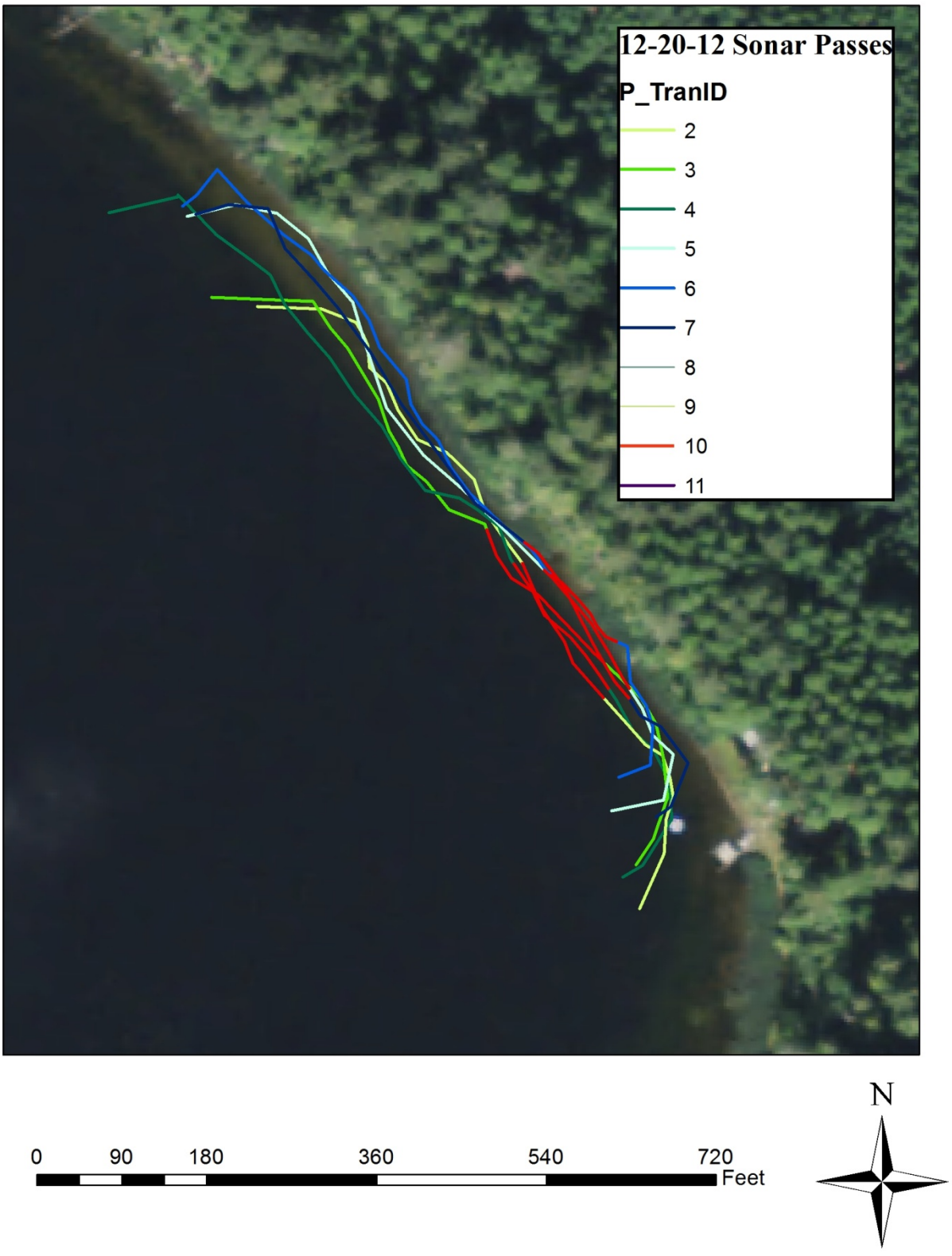

Figure 4.5. Map depicting Olsen's Beach survey passes 2 through 7 (12/20/12). Concentrated sockeye detections are depicted with bright red lines.

Allen's Beach

We made two survey passes at Allen's Beach (Passes 10 and 11). Pass 10 started at Cemetery Point and ended just south of south Allen's Beach (see Figure 4.6). The sonar was pointed to the west, looking up the beach. The sonar was set to capture images from 3.5 to 17 meters. A total of 60 sockeye size targets were observed (see Table 4.4). Pass 11 started at the south end of Allen's Beach and went to the north, ending just north of Cemetery Point. The sonar was pointed to the east looking down the beach. The sonar was set to capture images from 3.5 to 25 meters. A total of 57 sockeye size targets were observed (see Table 4.4). Figure 4.6 depicts sockeye size target observations per 100 square meters for passes 10 and 11. Moderate wind and waves affected the survey quality. The boat was difficult to control at low speeds for the north half of Pass 10. Wind waves negatively affected image quality. Image quality was improved after ARIS unit was moved further below the water surface. Surface waves had been lifting the sonar unit to the water's surface. The remaining portion of the survey was also affected by waves. Poor viewing conditions prohibited visual counts of spawning sockeye salmon.

Table 4.4. Summary of survey passes and observations at Allen's Beach (12/20/12).

Pass ID	Look Direction	Start Dist. (m)	End Dist. (m)	No. of Sockeye Size Targets Detected	Other Observations
10	West (up)	3.5	17.9	60	
11	East (down)	3.5	25	57	

Other Observations

On August 9, 2006 during a field survey of potential beach spawning habitat we identified potential spawning habitat, as well as a redd-sized depression in area referred to as Area 409 (based on waypoint ID). The potential spawning habitat at this site has been a high priority for supplemental spawning ground surveys. We attempted to survey this area on December 20, 2012 (Passes 8 and 9). The locations of the surveys are depicted below in Figure 4.7. Both passes on December 20, 2012 were made looking up the beach. The ARIS was set to capture images from 3.5 to 17.9 and 3.5 to 20.5 meters for passes 8 and 9, respectively. No fish or spawning habitat was identified during Pass 8. No fish, but some potential habitat was identified during Pass 9. After comparing survey tracts with GPS data from 2006 it was determined the survey missed the primary habitat area identified in 2006.

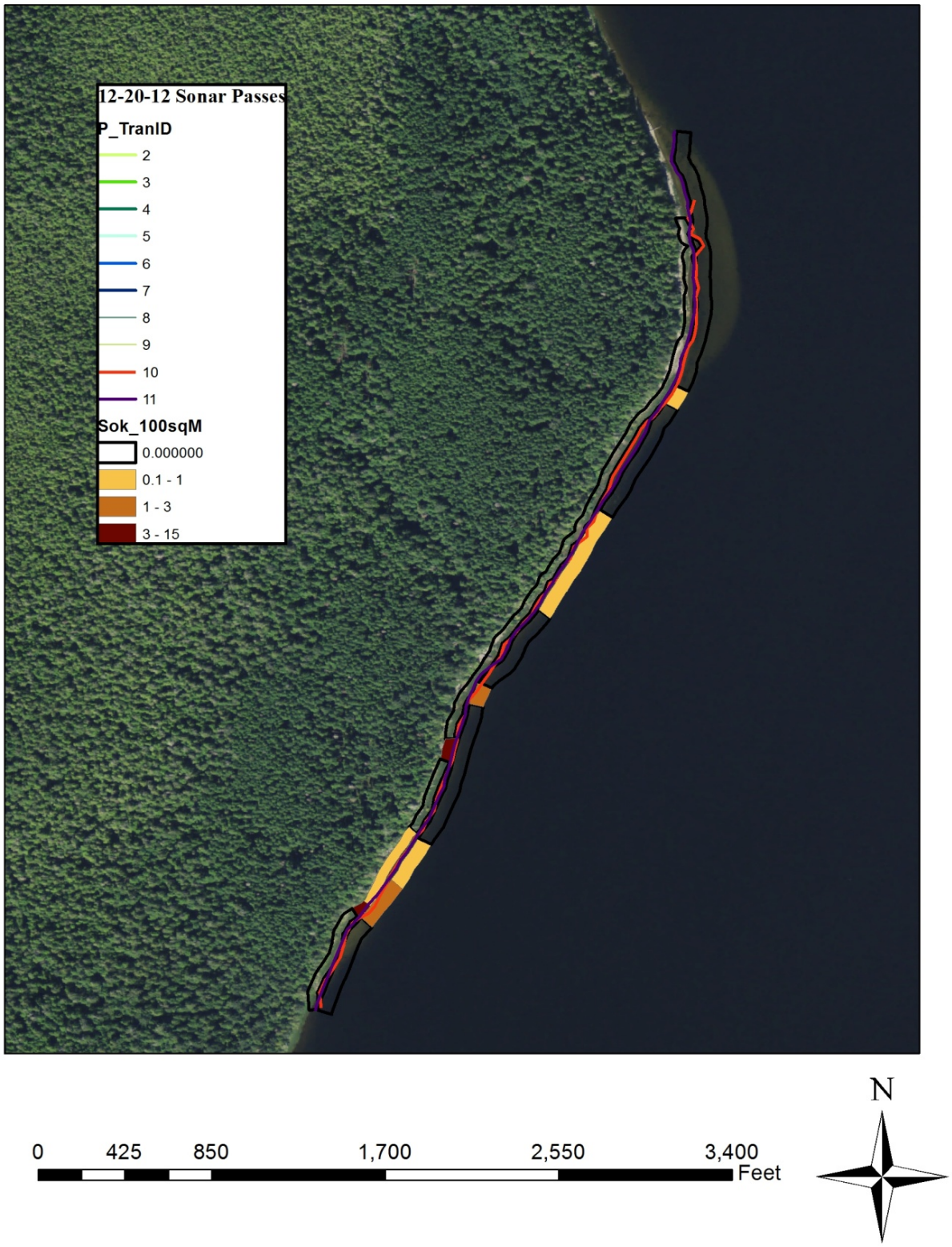

Figure 4.6. Map depicting Allen's Beach survey passes 10 and 11 and sockeye size targets per 100 square meters (12/20/12).

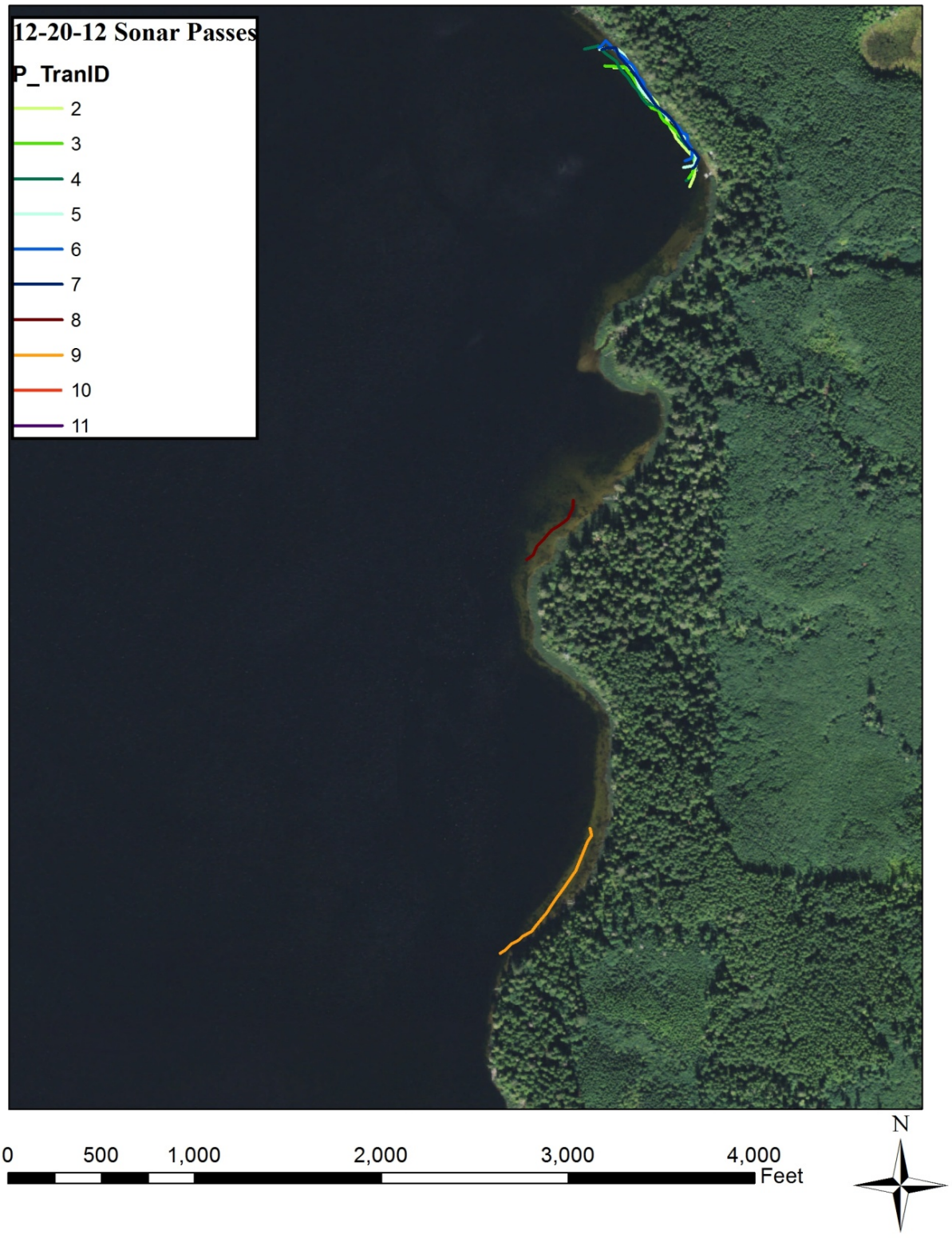

Figure 4.7. Map depicting the location of survey passes 8 and 9 (12/20/12). Note the location of these passes relative to Olsen's Beach passes 2 through 7 to the north.

4.3 January 4, 2013

The lake level on January 4, 2013 was the 37.3 feet measured at the Olympic National Park (ONP) staff gage. The weather was mixed. The temperature was above freezing with a light to moderate breeze in the morning. The wind picked up in the afternoon to a moderate breeze (maybe 15 mph). We saw sporadic rain showers. Overall survey conditions were good at Olsen's and fair at Allen's Beach. The boat was launched at Rayonier Landing (off of the Hoko-Ozette Road).

Olsen's Beach

We made a total of six survey passes at Olsen's Beach. Passes 1 through 3 started at the south end of Olsen's Beach with the sonar looking up the beach as the boat slowly passed by the spawning grounds from south to north. The sonar was set to capture images starting at 3.5 meters and ending at 17 meters. The survey area included the core and concentrated areas at south Olsen's Beach (see Figure 4.8). Pass 1 and 2 detected 16 and 25 sockeye size targets respectively. Pass 3 continued to the north and ended just past north Olsen's Beach. Pass 3 detected 20 sockeye size targets in the core and concentrated area and 4 additional sockeye size targets to the north.

Passes 4 through 6 started just to the north of the concentrated and core area of Olsen's Beach with the sonar looking down the beach. The sonar was set to capture images starting at 3.5 meters and ending at 25 meters. The survey area included the core and concentrated areas at south Olsen's Beach (see Figure 4.8). Results for passes 4 through 6 are included in Table 4.5. These survey passes were designed to test the repeatability of survey methods and target counts. A visual survey was conducted during Pass 4 where sockeye between the boat and brush line were visually counted. A total of zero live sockeye and 3 dead sockeye were observed.

Table 4.5. Summary of survey passes and observations at Olsen's Beach (01/04/13).

Pass ID	Look Direction	Start Dist. (m)	End Dist. (m)	No. of Sockeye Size Targets Detected	Other Observations
1	East (up)	3.5	17.8	16	
2	East (up)	3.5	17.8	25	
3	East (up)	3.5	17.8	24	Plus one unknown target detected
4	West (down)	3.5	25	36	0 live and 3 dead observed visually between boat and shoreline
5	West (down)	3.5	25	26	
6	West (down)	3.5	25	32	

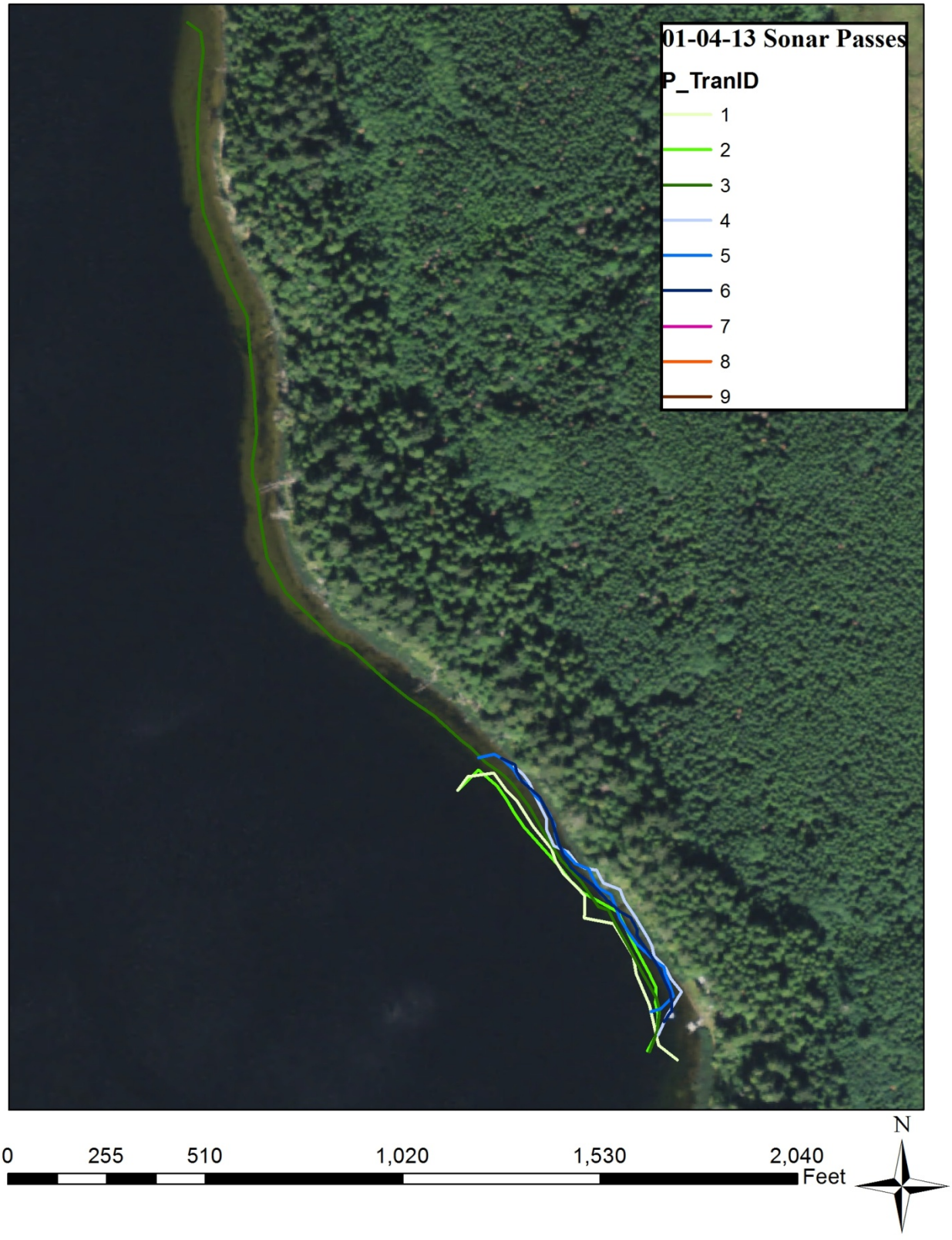

Figure 4.8. Map depicting Olsen's Beach survey passes 1 through 6 (01/04/13).

Allen's Beach

We made two survey passes at Allen's Beach (Passes 8 and 9). Pass 8 started at Cemetery Point and ended just south of south Allen's Beach (see Figure 4.9). The sonar was pointed to the west looking up the beach. The sonar was set to capture images from 3.5 to 17.9 meters. A total of 8 sockeye size targets were observed (Table 4.6). Pass 9 started at the south end of Allen's Beach and went to the north, ending just north of Cemetery Point. The sonar was pointed to the east looking down the beach. The sonar was set to capture images from 3.5 to 25 meters. A total of 7 sockeye size targets were observed (see Table 4.6). Moderate wind and waves affected the survey quality. Fair viewing conditions enabled a visual survey to be made through the concentrated spawning areas during Pass 9. No live or dead sockeye were observed visually.

Table 4.6. Summary of survey passes and observations at Allen's Beach (01/04/13).

Pass ID	Look Direction	Start Dist. (m)	End Dist. (m)	No. of Sockeye Size Targets Detected	Other Observations
10	West (up)	3.5	17.9	8	
11	East (down)	3.5	25	7	Visual count zero live and zero dead

Other Observations

One additional survey pass was made on January 4, 2013 (Pass 7). Pass 7 targeted the 409 area we attempted to survey on December 20, 2012. The location of Pass 7 is depicted in Figure 4.10. The ARIS was set to capture images from 3.5 to 17.9 meters with the ARIS pointed up the beach. Three fish targets were identified, two of which appeared to be sockeye size targets.

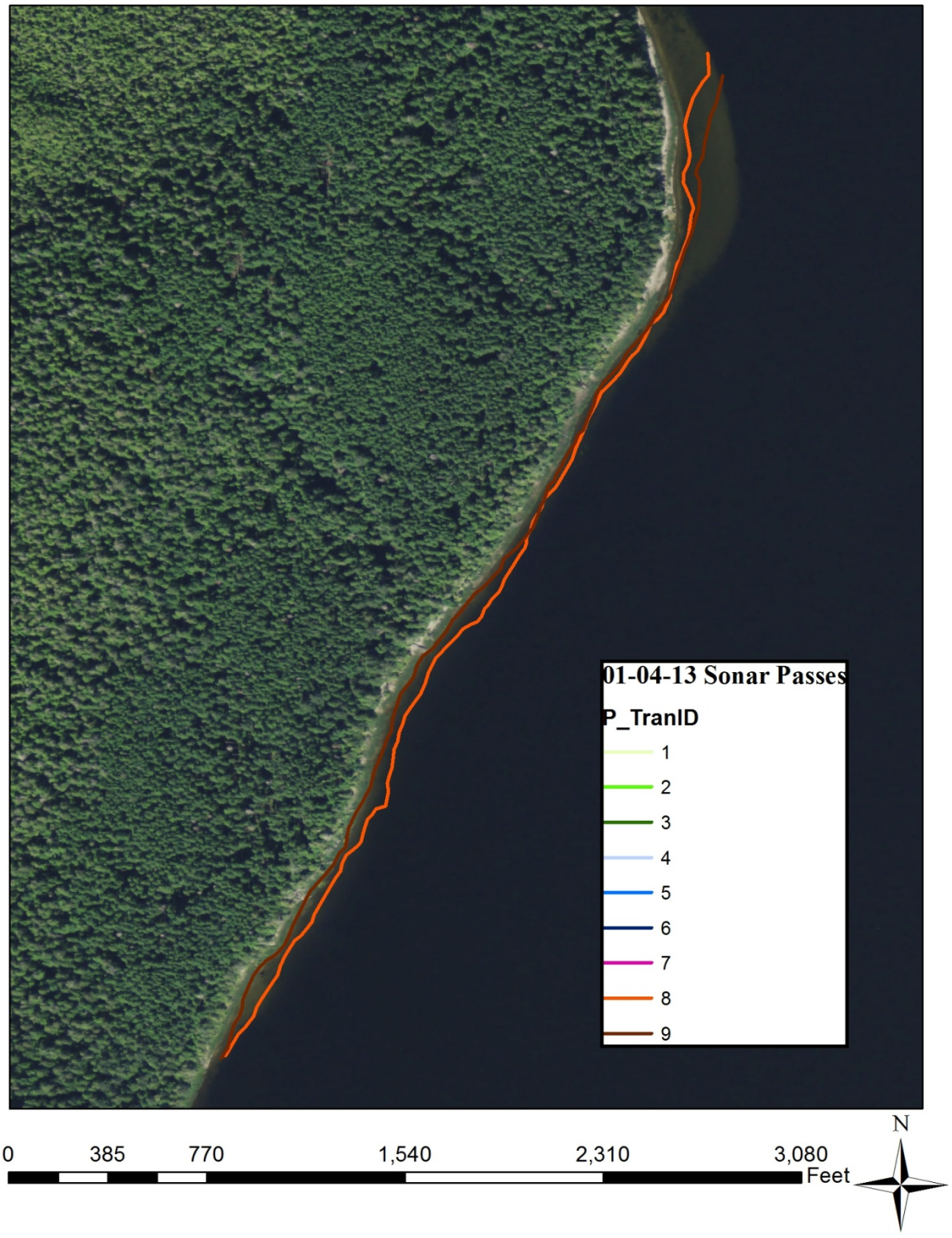

Figure 4.9. Map depicting Allen's Beach survey passes 8 and 9 (01/04/13).

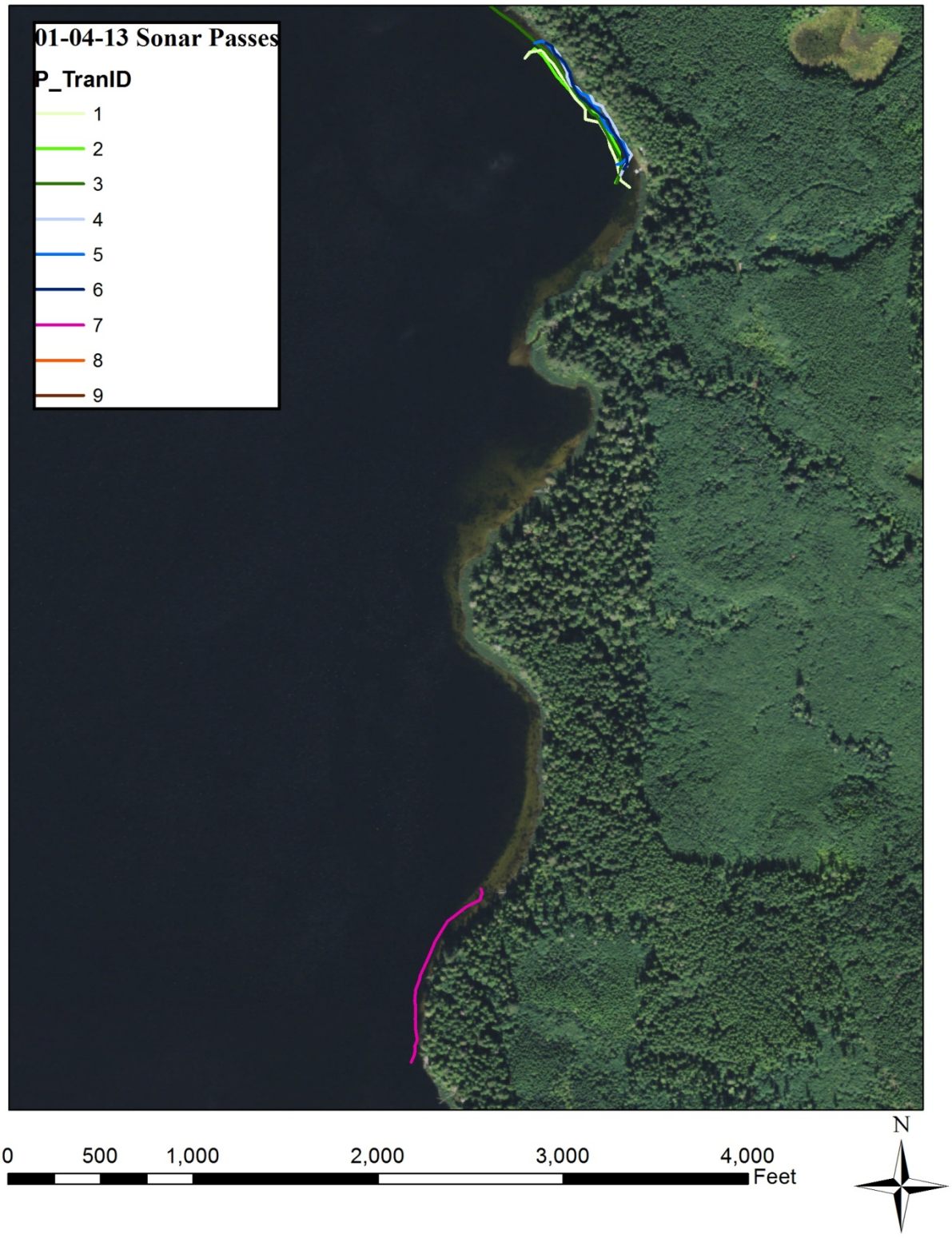

Figure 4.10. Map depicting the location of survey Pass 7 (01/04/13). Note the location of this pass relative to Olsen's Beach passes 1 through 6 to the north.

5 RECOMMENDATIONS

Included below is a brief list of recommendations that will help improve enumeration methods for beach spawning sockeye salmon in Lake Ozette.

- Continue testing and developing ARIS survey methods on lake beaches during the 2013/2014 spawning season.
    - Conduct surveys throughout the spawning season; weekly during the peak spawning period(s).
    - Surveys should focus on using the slow pass method. Effort should include looking both lake-ward and shoreward. Very slow speeds appear to be especially important for capturing high quality images. No significant differences in image quality or counts could be detected between up and down look directions.
    - Continue to conduct three passes in each direction at Olsen's Beach. Sonar capture ranges should be approximately 3.5 to 17.9 meters when looking up the beach and 3.5 to 25 meters when looking down the beach.
    - Survey passes at both Olsen's and Allen's beaches should include the routes depicted in the figures contained in this report. Note: it is important that the ARIS operator is in continual verbal contact with the boat operator when submerged vegetation is not visible from the surface. Submerged vegetation can often not be seen by the boat operator, making it difficult to judge the distance to the edge of the targeted survey area. When looking up the beach the preferred distance from submerged vegetation is 15 to 18 meters. The vegetation is easy to detect on the fly with the imaging sonar.
    - Surveys should target weather windows where wind waves will not negatively affect image quality. If not possible consider testing the use of stabilizers on the boat used for surveying. Also, when moderate wind waves are present, position the transducer at the greatest depth possible. This will reduce surface interference.
    - Include survey staff on boat that can visually count sockeye salmon high on the beach (that are outside of the ARIS imaging range).
    - When time permits conduct surveys along habitats that may be utilized by sockeye salmon but are currently not known to be utilized (e.g., Umbrella Beach).
- The power supply on the boat should be re-wired to ensure a steady uninterrupted supply of power. This can be done by purchasing a new cigarette lighter port

(power port) and rewiring using the exiting power supply. Another solution to this problem would be to hard wire the inverter to the boats power supply.

- Investigate using a rubber flange between the main vertical pole and locking sleeve to remove up and down play between the locking sleeve and the man vertical pole. In addition, this system should be modified so that the look direction can be locked in place so the ARIS has no left or right movement.
- Investigate an alternate power supply for the boat, such as an electric motor. If this is not possible there should be a system between boat operator and ARIS operator that insures the boat will not be put into gear when multiple sockeye size targets are being captured. This will help with image quality and the repeatability of counts.
- Document results and refine methodologies as appropriate.

6 CITATIONS

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