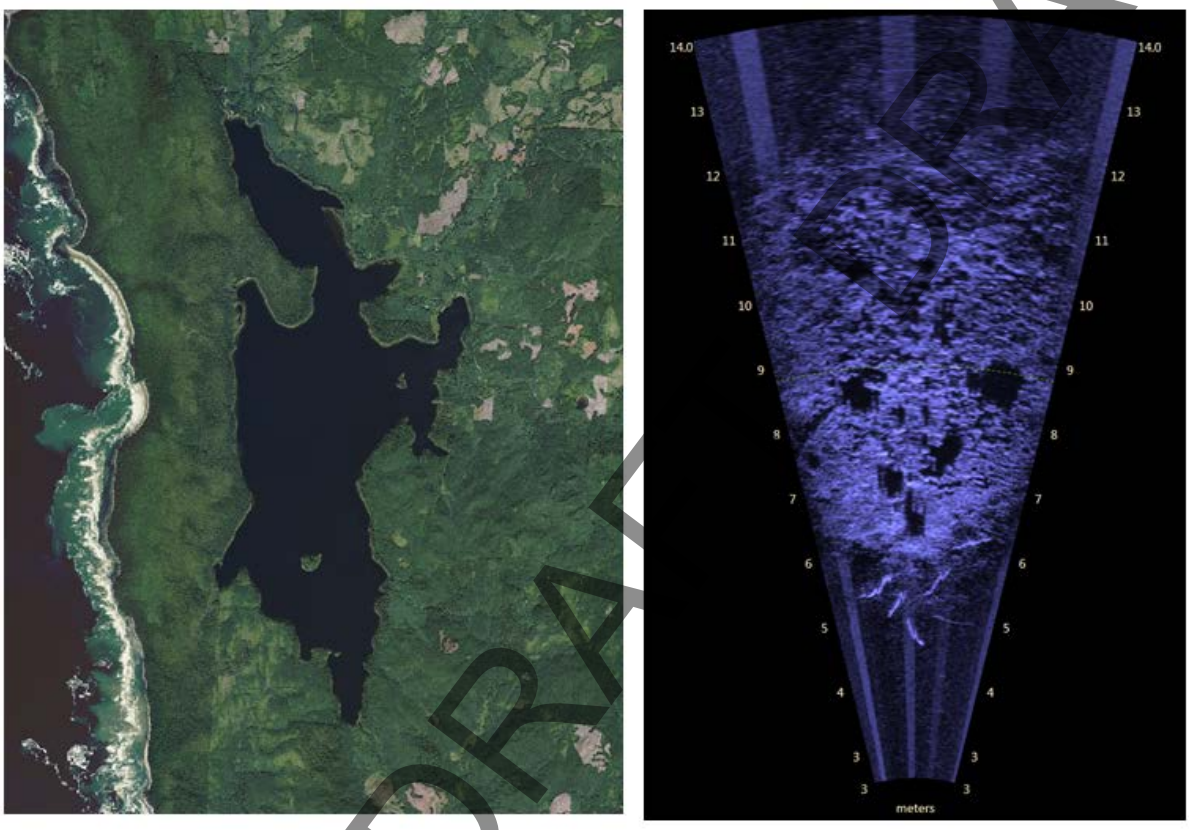
Field Testing the Use of Imaging Sonar Technology as a Tool for Beach Spawning Ground Surveys: Year 3



DRAFT REPORT VERSION 2.0

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August 5, 2014

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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 further 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, 2012 and 2013. 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.

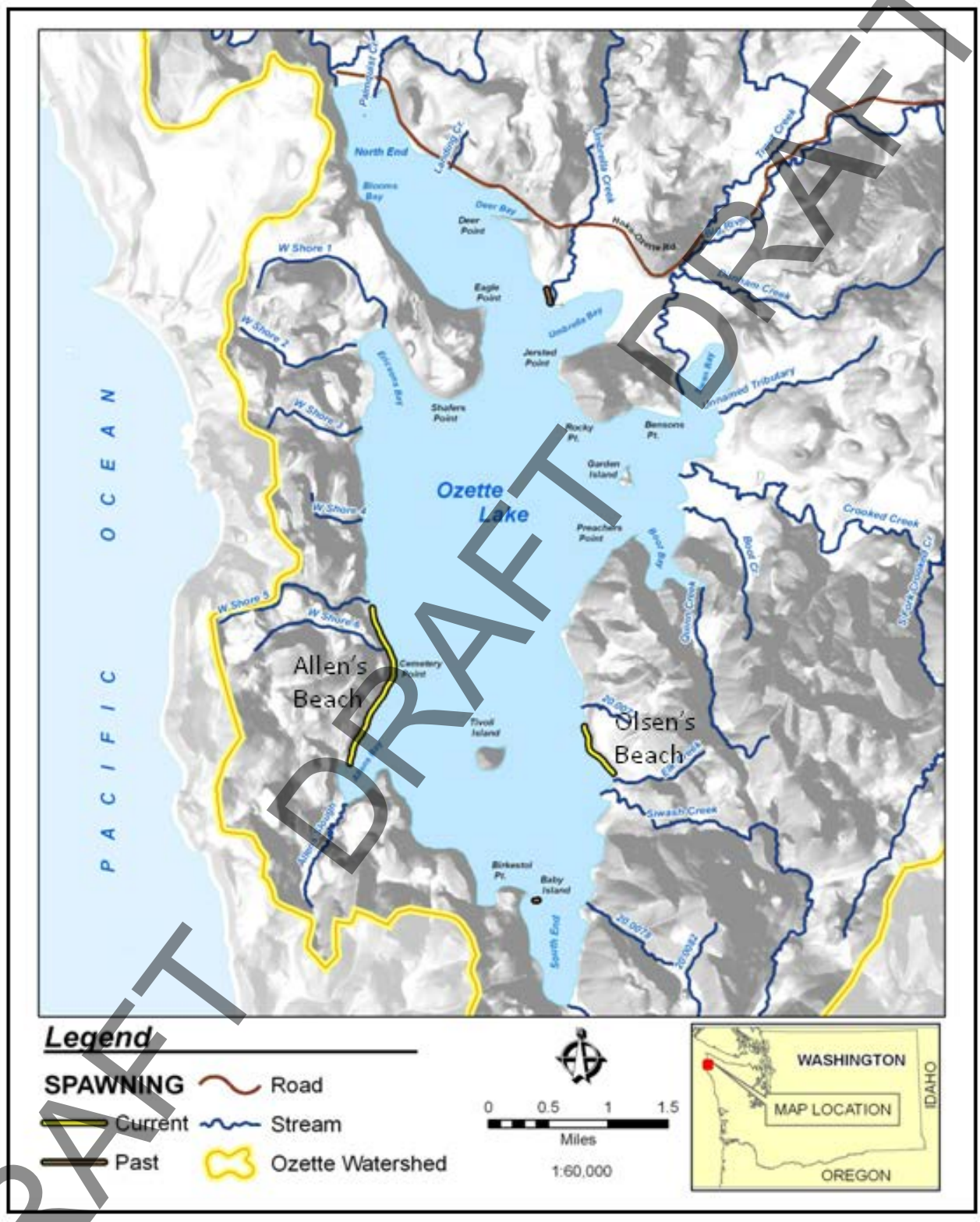

Figure 2.1. Current and historical Lake Ozette sockeye beach spawning locations (source: Haggerty et al. 2009)

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).

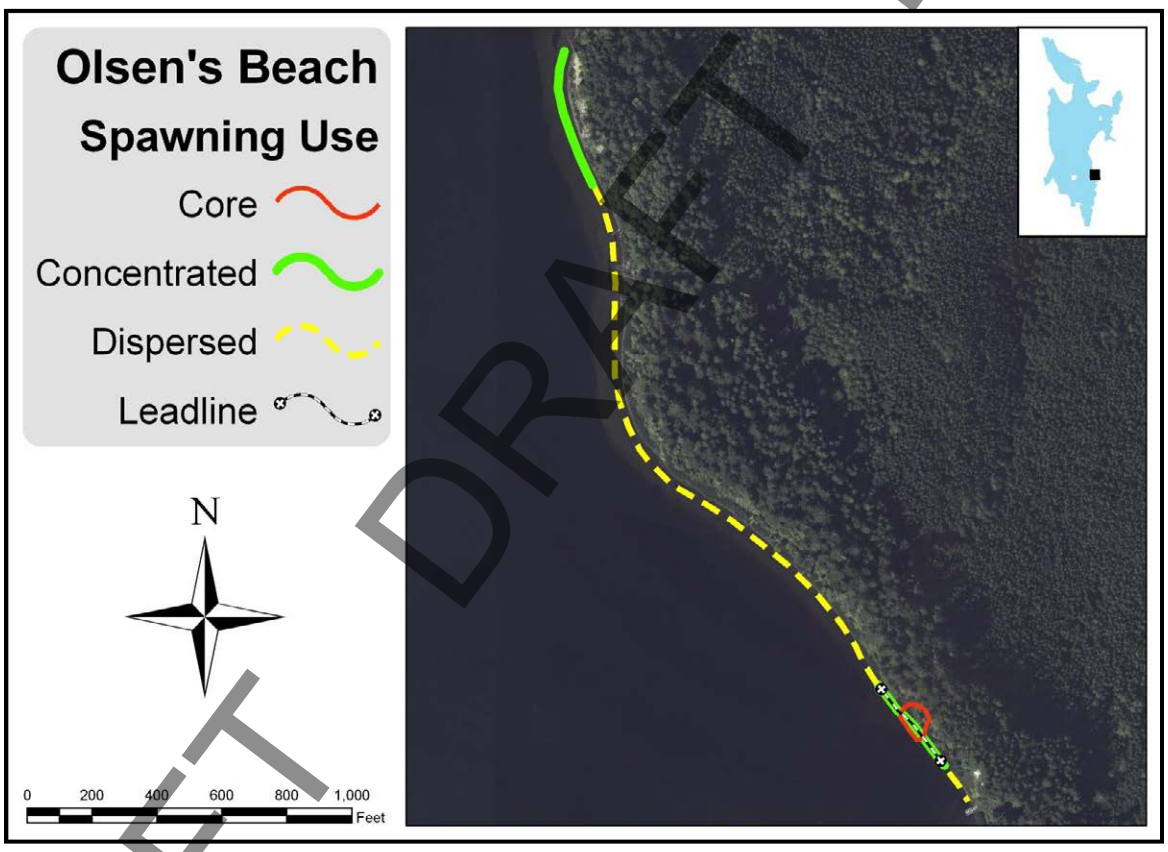

Figure 2.2. Current Olsen's Beach sockeye spawning use categorized as concentrated, core, and dispersed (From: Haggerty et al. 2009). Note: the lead line in the figure was used for snorkel and scuba surveys conducted 1999, 2000, and 2001.

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.

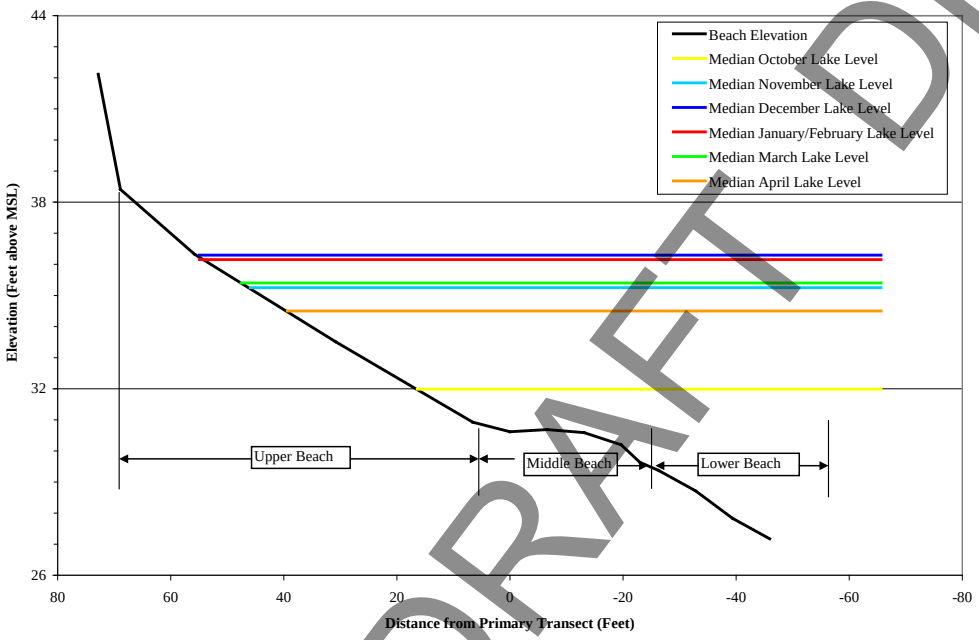

Figure 2.3. Cross-section of upper, middle, and lower beaches within the core spawning area at Olsen's Beach contrasted with median monthly lake level data from water years 1981 through 2004 (From: Haggerty et al. 2009).

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 dominated by 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).

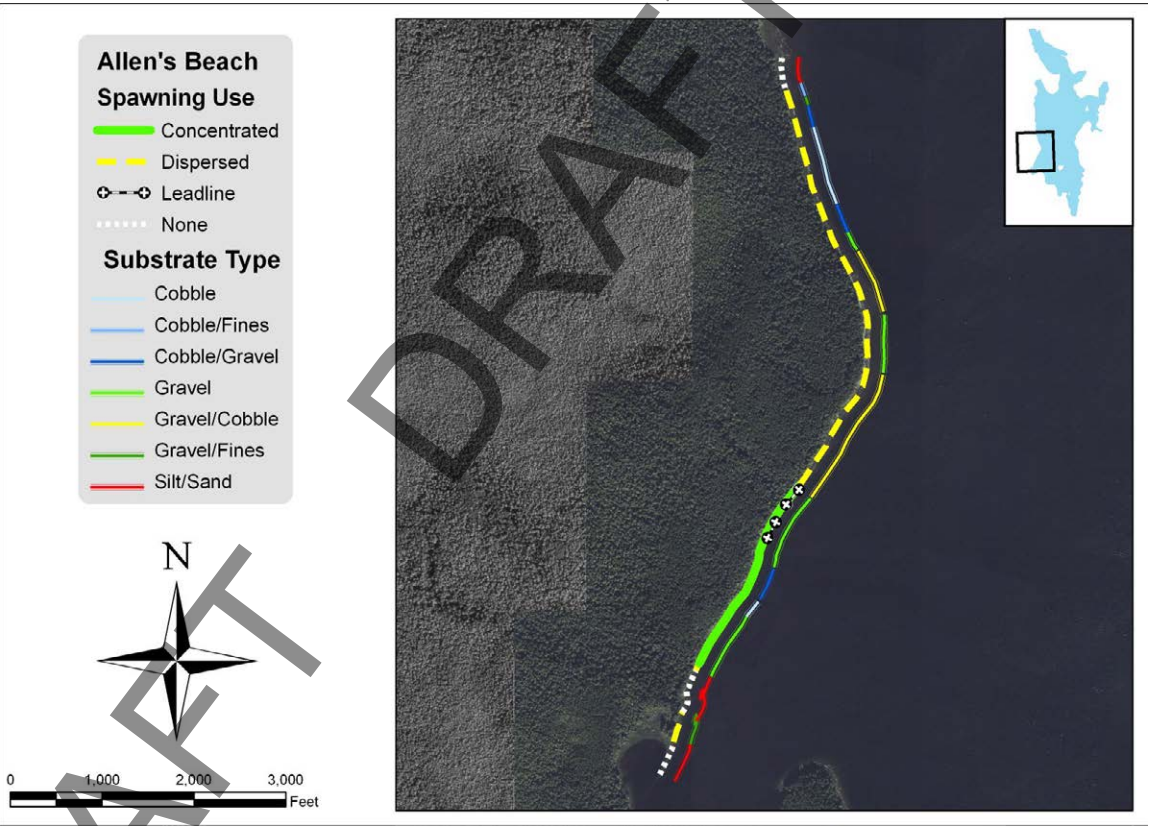

Figure 2.4. Allen's Beach spawning use classification and dominant substrate size (From: Haggerty et al. 2009).

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.

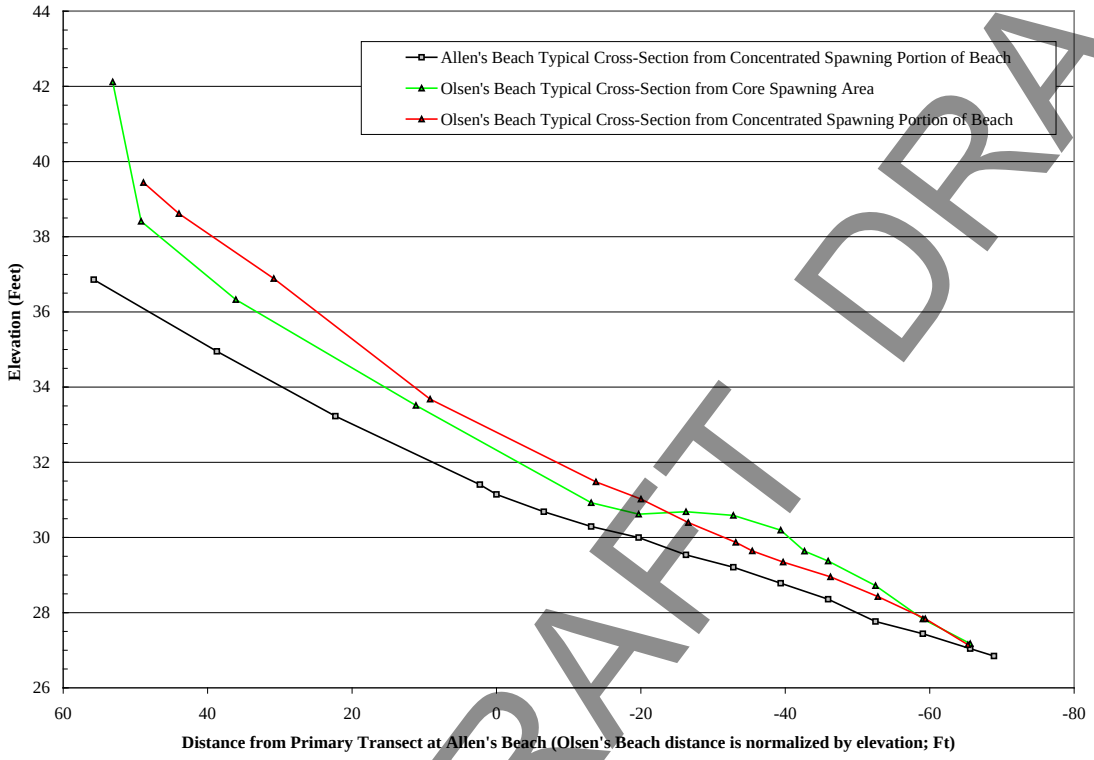

Figure 2.5. Comparison of beach profiles from Olsen's Beach core and concentrated spawning areas and Allen's Beach concentrated spawning use area. (From: Haggerty et al. 2009).

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 imaging sonar used for counting beach spawning sockeye salmon. We attempted to locate other sources of information related to this specific use of imaging sonar by contacting experts throughout the Pacific Northwest and Alaska. We were unable to find a single example of imaging sonar used for counting spawning sockeye on lake beaches. However, we did get recommendations for attempting the use of imaging sonar to enumerate beach spawning sockeye. The input from various experts and stakeholders was incorporated into the development field methods used to test DIDSON/ARIS technology at Lake Ozette during the winter of 2011/2012. The 2012/2013 and 2013/2014 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.

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

Summary from 2012/13 Field Testing

The methods used during the 2012/2013 field season were the same as the methods used in 2013/14 (see below). 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. Survey results for the 2012/13 field season are included below in Table 3.1.

For more details on the 2011 survey see Haggerty (2013).

Table 3.1. Summary of 2012-2013 ARIS surveys for Lake Ozette sockeye salmon spawning beaches.

Date	Location	Pass ID	No. of Sockeye Size Targets Detected
12/12/12	Olsen's Beach	1	56
12/12/12	Olsen's Beach	2	68
12/12/12	Olsen's Beach	3	97
12/12/12	Allen's Beach	5	99
12/12/12	Allen's Beach	6	17
12/20/12	Olsen's Beach	2	49
12/20/12	Olsen's Beach	3	49
12/20/12	Olsen's Beach	4	70
12/20/12	Olsen's Beach	5	54
12/20/12	Olsen's Beach	6	50
12/20/12	Olsen's Beach	7	49
12/20/12	Allen's Beach	10	60
12/20/12	Allen's Beach	11	57
01/04/13	Olsen's Beach	1	16
01/04/13	Olsen's Beach	2	25
01/04/13	Olsen's Beach	3	24
01/04/13	Olsen's Beach	4	36
01/04/13	Olsen's Beach	5	26
01/04/13	Olsen's Beach	6	32
01/04/13	Allen's Beach	10	8
01/04/13	Allen's Beach	11	7

3.2 Field Methods (2013/14)

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 attached to a mount assembly which was attached to 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 command module 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 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. The length of

each target was measured when imagery was sufficiently clear to make accurate measurements. Additional notes were recorded where applicable.

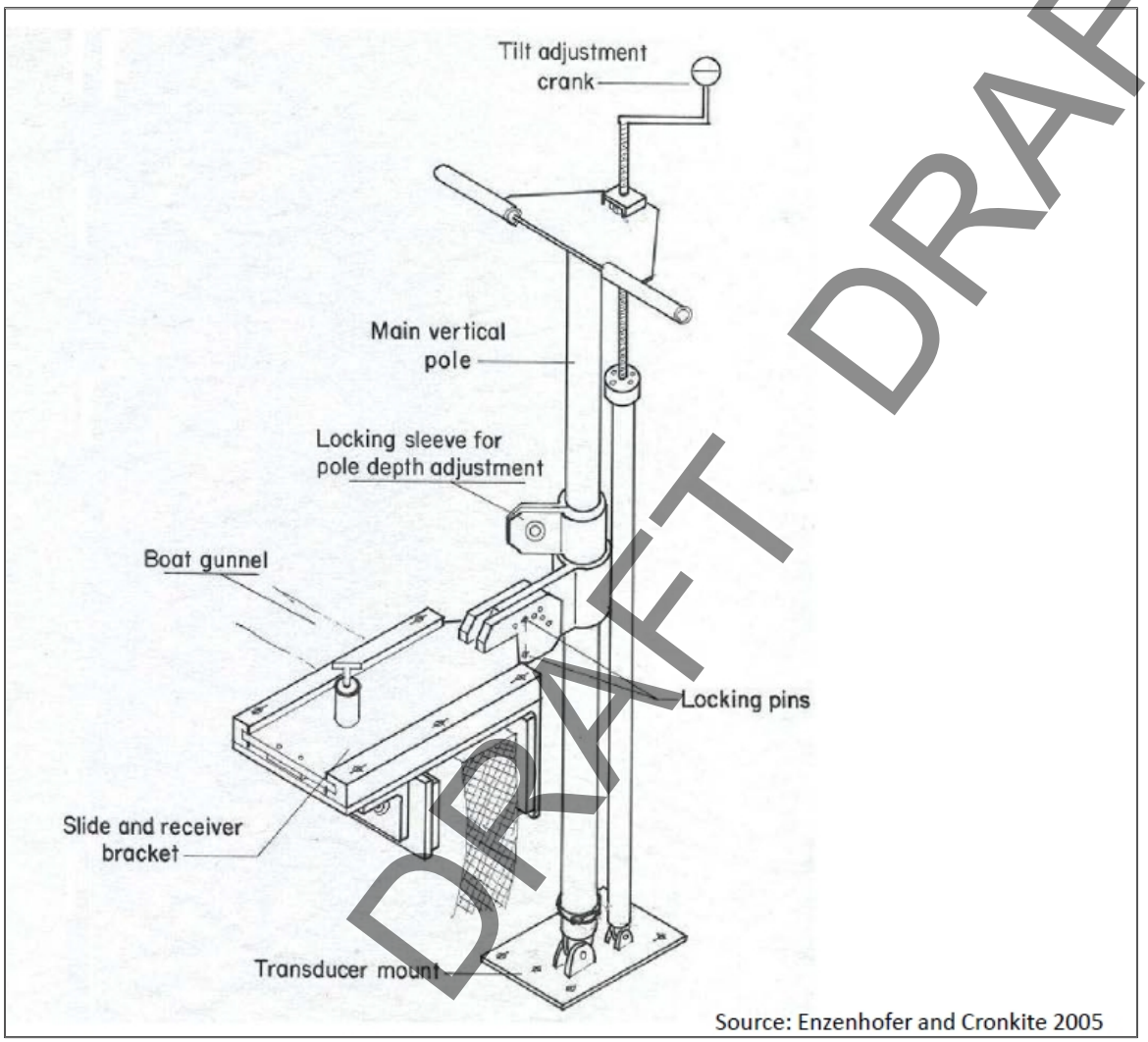

Figure 3.1. Diagram showing the adjustable pole mount used for mounting the DIDSON unit to a boat (Source: Enzenhofer and Cronkite 2005).

4 RESULTS and DISCUSSION

Three surveys were attempted during the 2013-2014 spawning season. The surveys were attempted on November 22, 2013, December 18, 2013, and January 15, 2014. The survey attempt on November 22, 2013 was unsuccessful due to a broken connection between the ARIS sonar unit and the command module. Repairs to the connection were made and surveying resumed in mid-December. Sections 4.1 and 4.2 describe the results from the surveys conducted on December 18, 2013 and January 15, 2014.

4.1 December 18, 2013

The lake level on December 18, 2013 was 33.95 feet measured at the Olympic National Park (ONP) staff gage located at the lake's outlet near the ranger's station. Weather conditions included light rain and a moderate north-northwest wind to 15 knots. The wind generated 1 to 2 foot waves at Olsen's Beach creating poor survey conditions. Most of the Allen's Beach survey was lee of the wind; conditions were fair to good at Allen's Beach 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 three 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 focused on the concentrated and core areas of Olsen's Beach south (see Figure 4.1). The sonar was set to record images at a starting distance of 2.0 m and an ending distance of 17.6 m. Ony 2 sockeye size targets were detected during Pass 1 (see Table 4.1). The quality of the imagery collected during Pass 1 was very poor. Pass 2 started at the south end of Olsen's Beach and ended at the mouth of unnamed tributary WRIA 20.0073. Pass 2 looked up the beach and a total of 42 sockeye size targets were detected. All 42 sockeye were detected in or adjacent to the southern core and concentrated spawning area. Pass 3 focused on the concentrated and core areas of Olsen's Beach (south). Pass 3 looked up the beach and a total of 53 sockeye size targets were detected. All 53 sockeye were detected in or adjacent to the southern core and concentrated spawning area. Pass 3 took place in the same area as Pass 1. No passes from the brush line looking lakeward were made due to wind waves coming from that direction making surveys impossible. Sockeye densities in Pass 2 and 3 ranged from 3.5 to 4.5 sockeye per 100 square meters in the concentrated and core spawning areas.

Table 4.1. Summary of survey passes and observations at Olsen's Beach (12/18/13).

Pass ID	Look Direction	Start Dist. (m)	End Dist. (m)	No. of Sockeye Size Targets Detected	Other Observations
1	East (up)	2.0	17.6	2	One unknown target detected. Visual survey detected 18 live and 5 dead sockeye.
2	East (up)	2.0	17.6	42	Four small targets and 2 unknown fish detected.
3	East (up)	2.0	17.6	53	One small target detected.

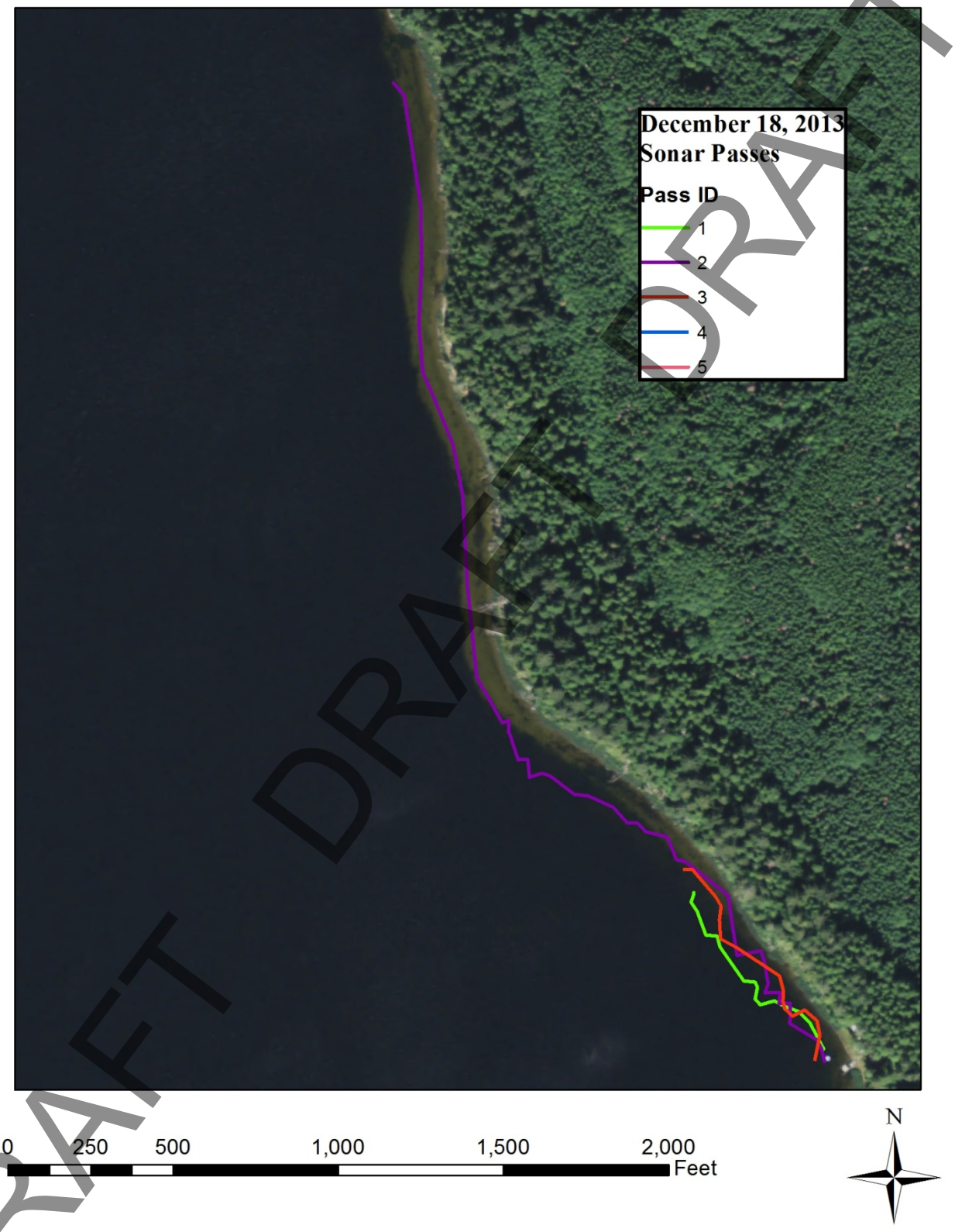

Figure 4.1. Map depicting Olsen's Beach survey passes 1 through 3 (12/18/13).

Allen's Beach

We made a total of two survey passes at Allen's Beach (passes 4 and 5). Pass 4 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 record images at a starting distance of 2.0 m and an ending distance of 17.6 m. A total of 53 sockeye size targets and 1 trout size target were detected (see Table 4.2). All targets were detected within the mapped concentrated spawning area of Allen's Beach (see Figure 2.4). Pass 5 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 28 sockeye size targets were observed (see Table 4.2). All targets detected during Pass 5 were within the mapped concentrated spawning area of Allen's Beach. The highest densities were at the north end of the concentrated spawning area. Of the 81 sockeye size targets detected 60% were in the north end of the concentrated spawning area. Approximately 32% of the detected sockeye size targets were using the southern end of the concentrated spawning area.

Note that differences in counts between pass 4 and 5 are likely attributable to differences in areas surveyed. Much of the area contained within pass 5 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 (12/18/13).

Pass ID	Look Direction	Start Dist. (m)	End Dist. (m)	No. of Sockeye Size Targets Detected	Other Observations
5	West (up)	2	17.6	53	One additional small target
6	East (down)	2	24.8	28	

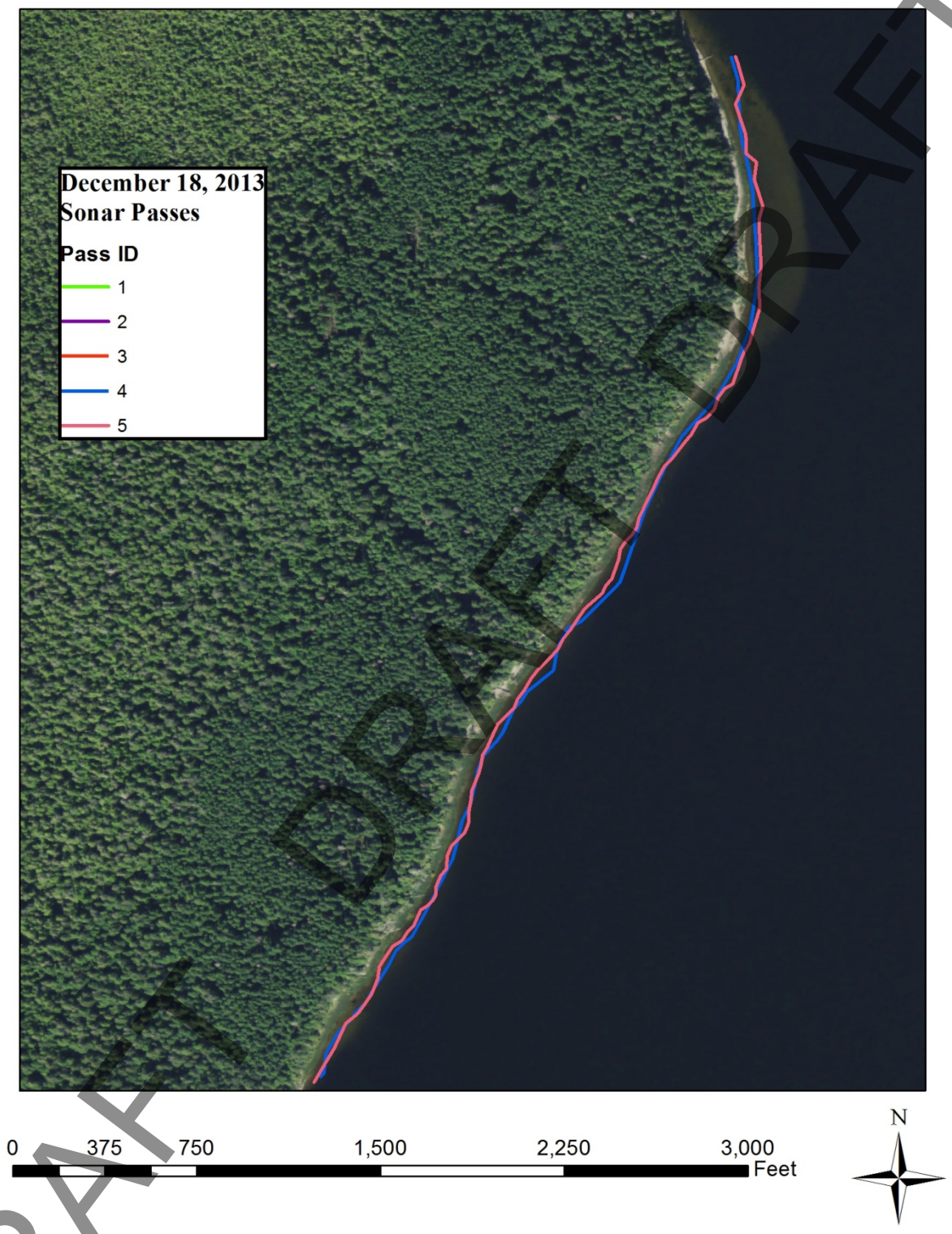

Figure 4.2. Map depicting Allen's Beach survey passes 4 and (12/18/13).

4.2 January 15, 2014

The lake level on January 15, 2014 was 36.70 feet measured at the Olympic National Park (ONP) staff gage. The weather was mixed, a light wind with very heavy fog. Overall survey conditions were good at both Olsen's and 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 survey area included the core and concentrated areas at south Olsen's Beach (see Figure 4.4). Passes 1 and 2 did not detect any sockeye size targets. Pass 3 detected 2 sockeye size targets. Both targets detected during Pass 3 were within the Olsen's Beach core spawning area. Pass 3 extended north, ending at the mouth of unnamed tributary WRIA 20.0073. No sockeye size targets were observed outside the core spawning area. Numerous smaller targets were detected during Pass 1 and Pass 3. Over 72% of the smaller targets detected during Pass 3 were within or adjacent to the core and concentrated sockeye spawning grounds.

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 2.1 meters and ending at 25 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 January 15, 2014 survey represents the first time smaller and unknown targets have been detected at Olsen's Beach. It is unclear what species of fish these targets are. Interestingly, 86% of these smaller targets were detected within or directly adjacent to the core spawning area which represents less than 10% of the length of beach surveyed in the six passes (Figure 4.5).

Table 4.3. Summary of survey passes and observations at Olsen's Beach (01/15/14).

Pass ID	Look Direction	Start Dist. (m)	End Dist. (m)	No. of Sockeye Size Targets Detected	Other Observations
1	East (up)	2.1	17.8	0	13 smaller targets and 1 unknown target also detected.
2	East (up)	2.1	17.8	0	
3	East (up)	2.1	17.8	2	20 smaller targets and 2 unknown targets also detected.
4	West (down)	2.1	17.8	1	38 smaller targets also detected
5	West (down)	2.1	17.8	0	53 smaller targets also detected
6	West (down)	2.1	17.8	0	41 smaller targets also detected

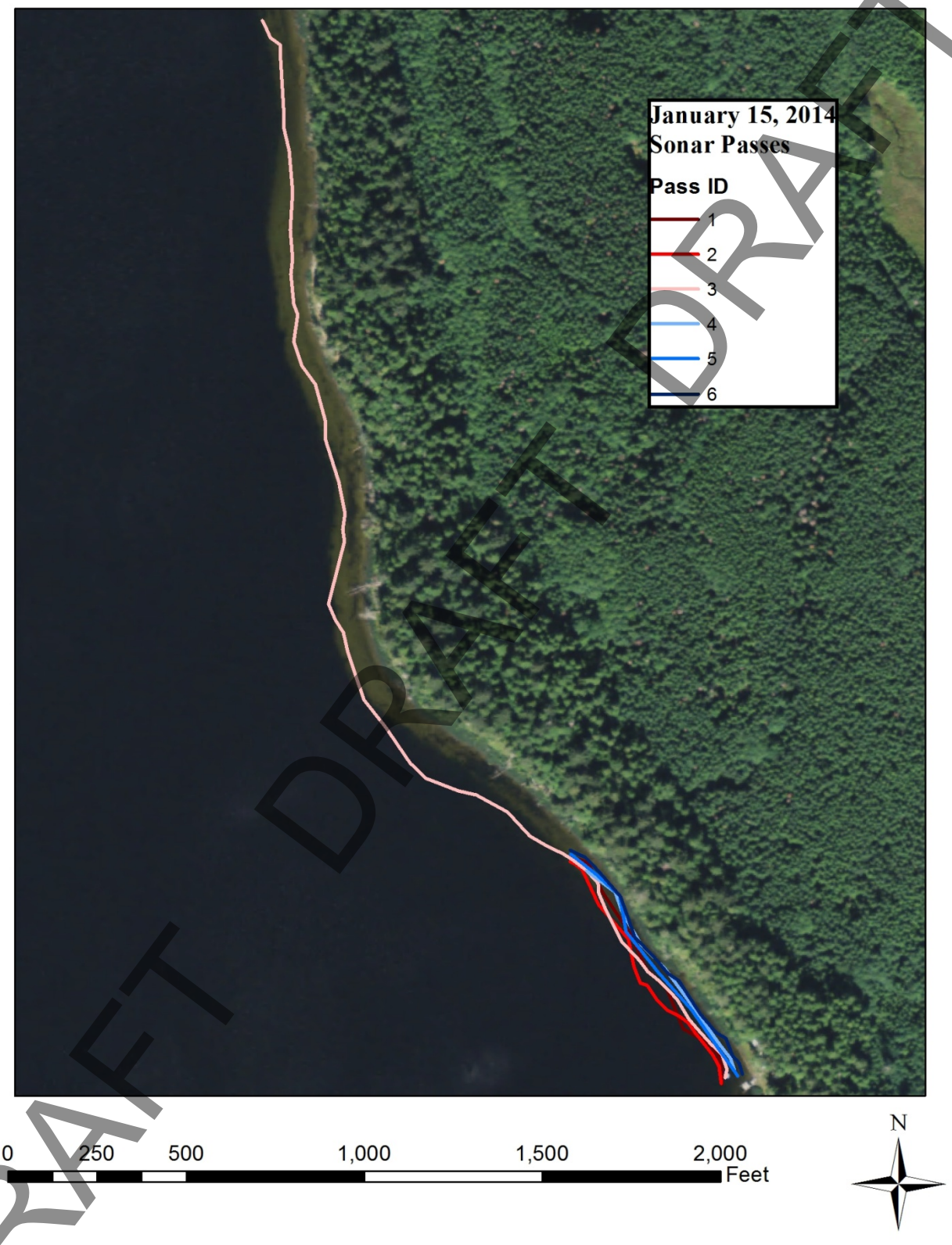

Figure 4.3. Map depicting Olsen's Beach survey passes 1 through 6 (01/15/14).

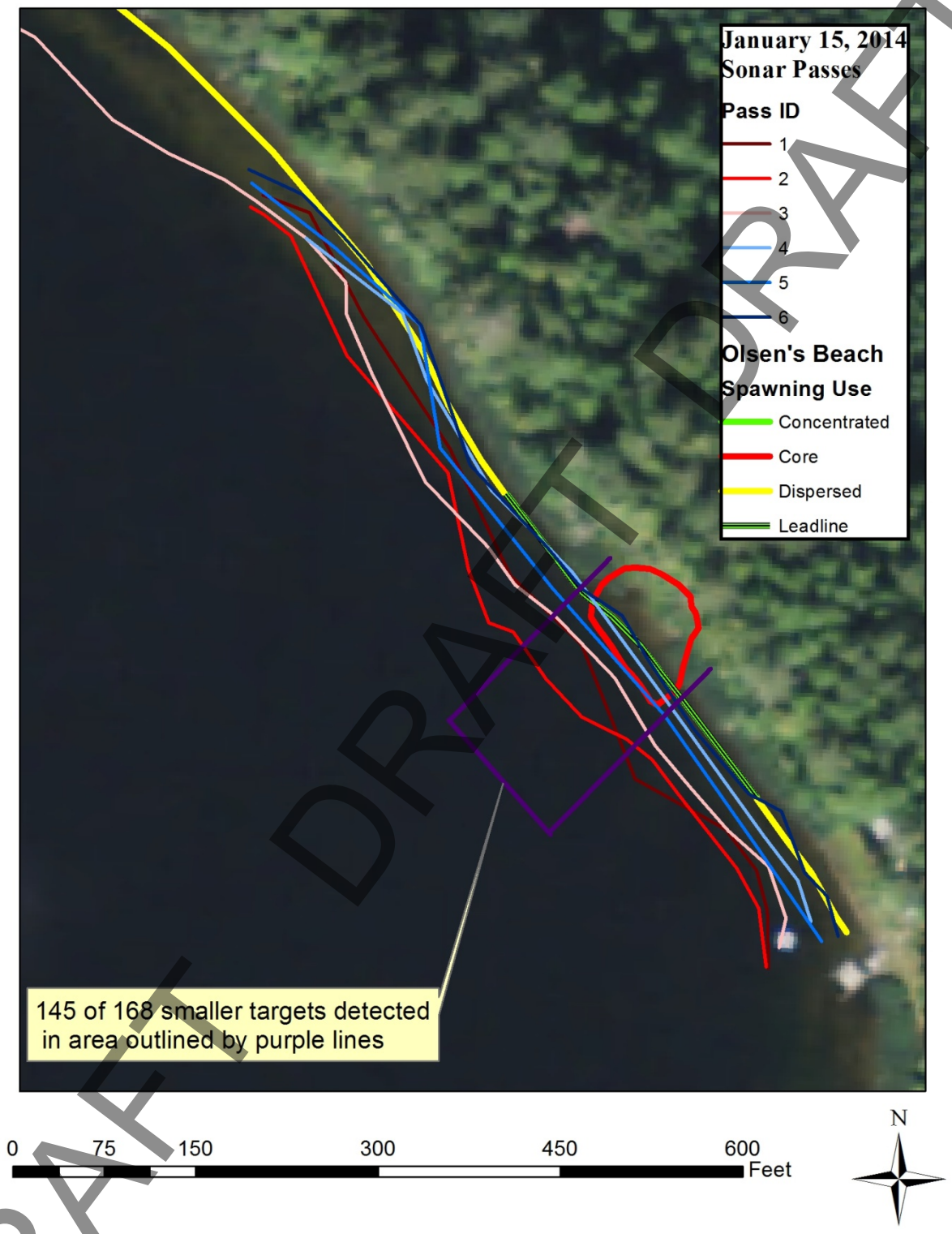

Figure 4.4. Map depicting Olsen's Beach survey passes 1 through 6 (01/15/14), Olsen's Beach spawning use map (source: Haggerty et al. 2009), and the area of concentrated smaller targets of unknown species.

Allen's Beach

We made two survey passes at Allen's Beach (Passes 7 and 8). Pass 7 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 2.1 to 17 meters. No sockeye size targets were detected (see Table 4.4). Fifteen smaller targets and 1 unknown target were detected. All but one of these targets was detected within the Allen's Beach concentrated spawning area (see Figure 2.4). Pass 8 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 2.1 to 24.9 meters. Three sockeye size targets were detected (see Table 4.4). There were additional targets detected during this pass; 44 smaller targets and 2 unknown targets. 24 of these targets were in the concentrated spawning area and the remaining 22 targets were to the north in the dispersed spawning area. Poor viewing conditions prohibited visual counts of spawning sockeye salmon.

Table 4.4. Summary of survey passes and observations at Allen's Beach (01/15/14).

Pass ID	Look Direction	Start Dist. (m)	End Dist. (m)	No. of Sockeye Size Targets Detected	Other Observations
10	West (up)	2	17	0	15 smaller targets and 1 unknown target detected.
11	East (down)	2.1	24.9	3	44 small targets and 2 unknown targets detected.

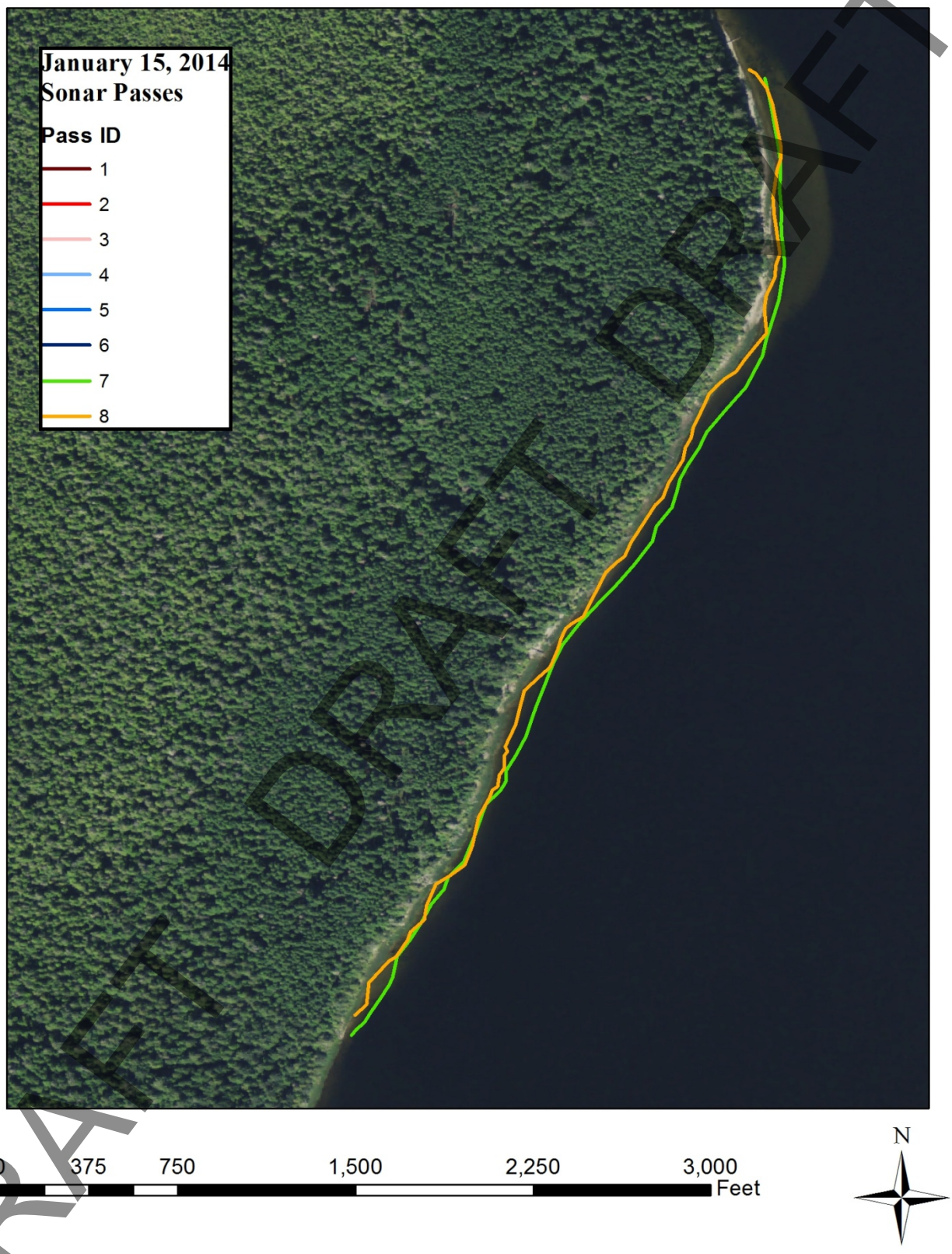

Figure 4.5. Map depicting Allen's Beach survey passes 7 and 8 (01/15/14).

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 2014/2015 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).
- 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.
- The high number of smaller targets detected at both Olsen's and Allen's Beaches following the peak sockeye spawn timing should be investigated. This could be done during mid-January using the ARIS to detect the smaller targets. Once the location of the targets is identified scuba or snorkel surveys could determine fish species and behavior. These smaller targets could be predators (e.g., northern pikeminnow) preying on sockeye eggs, however at this time the species and behavior remains an unknown.
- Incorporate new data field in the imagery review form that incorporates target length.
- Document results and refine methodologies as appropriate.

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