TOKLAT RIVER, FALL CHUM SALMON RADIO TELEMETRY STUDY, 1997

By

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ABSTRACT

A radio telemetry feasibility study was conducted on the remote Toklat River in Alaska during September and October of 1997. The purpose was to document the movement and spawning locations of adult fall chum salmon (*Oncorhynchus keta*). A total of 123 fall chum salmon were tagged with pulse-coded radio transmitters from September 9 to September 28. Originally, all radio tags were to be deployed internally but because of problems with tag retention attributed to digestive tract resorption, modification of 100 of the 123 tags to an external applicationwas necessary. Fish locations were successfully tracked using radio telemetry equipment from a boat, a stationary remote tracking station, aerial surveys, and spawning ground foot surveys. One hundred fifteen tagged fish traveled upstream of the stationary remote tracking station near study km 11. The stationary receiver documented the passage of 106 tagged fish while nine passed undetected. On average, 95% of the radio-tagged fish were located on each of the seven aerial survey flights separated by four to ten days. Based on the estimated spawning location of 92 early-tagged fall chum salmon, approximately 71% of the run passing the tagging site from September 9-16 may have spawned in the Toklat Springs (confidence interval width approximately 0.170). Eleven original internal tags were returned to the factory and converted to a smaller internal tag size. The smaller sized radio tag is a viable option for tagging fall chum salmon migrating long inriver distances, which would be tagged relatively close to their spawning ground area. Radio telemetry techniques could be used to determine spatial and temporal spawner distribution of fall chum salmon within the Toklat River on a larger scale.

INTRODUCTION

The Toklat River is a glacial system located in interior Alaska draining the north side of the Alaska Mountain Range near Mt. McKinley (Figure 1). The river is remote, and access to the study area is limited primarily to aircraft or a boat with a jet unit. Throughout most of the season, the mainstem water visibility is extremely poor because of turbidity caused by glacial runoff. Chinook (*Oncorhynchus tshawytscha*), chum (*O. keta*), and coho (*O. kisutch*) salmon are known to spawn within this river.

Charles Sheldon (1930) first reported finding dead salmon in open water channels along the Toklat River in January 1908. The Department of Fish and Game (department) began to document Toklat River fall chum salmon spawning abundance and distribution beginning in the early 1970s. These observations consisted of limited aerial and ground surveys conducted during periods of anticipated peak spawning (Barton 1984). Beginning in 1980, an annual ground survey was conducted on the major fall chum salmon spawning area at the Toklat Springs during the period of peak spawning, but it lacked information on the distribution of spawners within the area. In 1985, surveyors began to document the distribution of spawners throughout the floodplain sloughs. The escapement database for Toklat River fall chum salmon consists of annual estimates of total spawning abundance dating back to 1974. Original estimates were expanded from either aerial or ground survey counts of the major spawning area at Toklat Springs, using streamlife and migratory time density data collected from the Delta River fall chum salmon stock. The department established a fall chum salmon minimum biological escapement goal (BEG) for the Toklat River of 33,000 spawners based on the historical database.

From 1980 through 1989, the Toklat River escapements were consistently less than the BEG, despite numerous management actions intended to benefit Toklat River fall chum salmon and Canadian fall chum salmon stocks by the department and the Alaska Board of Fisheries (board). Management actions included reductions in commercial fishing time throughout the drainage and restrictions or closures of commercial and subsistence fishing. At the spring 1990 board meeting, the department identified the Toklat River fall chum salmon stock as a conservation concern to board members. In the spring of 1992, the board issued a "charge" to the Yukon River Drainage Fisheries Association (YRDFA) to work with the department and develop a rebuilding management plan for Toklat River fall chum salmon. YRDFA presented a proposal to the board in the spring of 1993, which the board adopted as the 1993 Toklat River Fall Chum Salmon Rebuilding Management Plan. The board adopted a similar rebuilding plan before the 1994 fishing season, with only slight modifications.

Because of the concern for the Toklat River fall chum salmon stock, the department initiated a hydroacoustic feasibility study in 1994 to obtain a more comprehensive assessment of escapement into the river. The department expected the inseason passage estimate provided by the sonar project to assist managers in assessing the fall chum salmon escapement to the Toklat Springs. The intensive ground surveys continued, providing for historical consistency until the hydroacoustic estimates were evaluated.

The Bendix sonar passage estimate and the chum salmon population estimate based on the ground survey conducted in 1994 were similar at 73,000 and 74,000 respectively, resulting in the recommendation for further investigations of using sonar to replace the ground survey method (Barton, 1997). In 1995, however, the sonar passage estimate (111,000) was approximately twice the ground survey population estimate (55,000). In 1996, the sonar passage estimate of 90,000 fish was approximately five times greater than the ground survey estimate of 18,000 fish (Barton, 1998).

The ground survey and sonar estimates have been characterized as being total population size estimates of the Toklat River fall chum salmon escapement, and their varying discrepancy across years concerns the department. Because of the assessment that the fish being counted are primarily fall chum salmon, a species apportionment program was not initiated for the Toklat River sonar project. It is possible, that large numbers of whitefish and/or coho salmon are inflating the sonar estimates. Although, in 1996, a fyke trap and fish wheel caught mostly chum salmon at the Toklat River Coded Wire Tag Recovery Camp, located 9 km downriver from the Toklat River Sonar Camp. Species other than fall chum salmon accounted for 6.2% of the fyke trap catch (n=226), and 10.4% of the fish wheel catch (n=1397). It is difficult to draw meaningful conclusions with these data, but it is unlikely that the abundance of other species alone can account for the varying discrepancy in the two methods of assessing escapements.

The ground survey is typically conducted during a one-week period in mid-October. The survey numbers are subsequently expanded to estimate the total abundance based upon the percentage of live chum salmon actually observed using an estimated streamlife curve and migratory time density curve developed from data collected on the Delta River. One of the assumptions involved in using the Delta River data is that the residence time of fall chum salmon on the spawning ground is similar in the Toklat and Delta Rivers. A second assumption is that all spawners (dead or alive) that have arrived at the Toklat Springs at or before the time of the survey are counted by the survey. A final assumption is no other significant fall chum salmon spawning ground areas are within the Toklat River drainage.

The department conducted this feasibility radio telemetry project in 1997 with the intention of beginning to address: (1) the discrepancy between the sonar and ground survey estimates, (2) verifying the validity of the current assumptions, and (3) improve the understanding of Toklat River fall chum salmon spawning characteristics. Radio telemetry is an effective technique for studying salmon populations in large, remote, turbid river systems of Southeast Alaska (Eiler et al. 1988, Eiler 1995, Eiler et al., In Prep.). Radio telemetry appears to be feasible for addressing the mechanisms involved in the ground survey and to examine temporal portions of the run over several years. Using radio telemetry, a multiple year study would be necessary to understand the annual variation in spatial distribution and spawner residency time of fall chum salmon spawning in the Toklat River.

METHODS

Study Site

The primary study area is the Toklat River drainage (Figure 2) from its confluence with the Kantishna River upriver 75 kilometers (study km 61). Three specific locations within the Toklat River drainage were important to the logistics of this project. The radio tag deployment site was located at the coded wire tag recovery camp (64.3963° N, 150.2967° W), approximately 14 river kilometers upstream of the confluence with the Kantishna River in Township 6S, Range 14W, Section 15 (study km 0). The selected location for the stationary receiver was 25 kilometers upstream from the confluence at 64.3393° N, 150.2127° W (study km 11) approximately two kilometers upstream of the Bendix sonar site (64.3535° N, 150.2142° W). Toklat Springs is located 57 kilometers upstream (study km 43) from the confluence at 64.1633° N and 149.9942° W and was the expected spawning destination for most of the radio-tagged fall chum salmon.

The project leader had previously obtained various permits for operations at the coded wire tag recovery camp site, which included a Bureau of Land Management (BLM) permit, a letter of nonobjection from Doyon, an ADF&G Habitat Division permit and a Department of Natural Resources (DNR) permit.

Study Design

The sample size of fish to radio-tag was based on fiscal constraints and a 90% confidence interval width that would not exceed 0.015 for the proportion of Toklat River fall chum salmon passing the tagging site while tags were being deployed on fish that spawn at the Toklat Springs area. The confidence interval for the binomial proportion of fish tagged that spawn in the Toklat Springs came from standard statistical methods (Snedecor and Cochran, 1989). Researchers assumed that 10% of the radio-tagged fish would not provide information on spawning ground location because of mortality, regurgitation of tags, or the fish would drop out of the study area. For a given sample size, confidence interval width varies by proportion and is widest at 0.50 (Figure 3). Although a sample size of 134 radio-tagged fish achieves the desired confidence interval width of 0.15 for a proportion of 0.5, a sample size of 125 was selected because of fiscal constraints. However, the consensus of several experienced field biologists was that the proportion of fish spawning in the Toklat Springs would be considerably higher than 0.5, which would result in a sample size of 125 meeting the statistical criteria.

Fish Capture and Handling

Fall chum salmon migrating upriver were captured with two fish wheels at the coded wire tag recovery camp. The fish wheels were located on opposite riverbanks, separated by approximately

0.25 km. The fish wheels were equipped with live boxes, which held captured fish for radio tag deployment.

To minimize fish behavioral problems after tagging that could potentially increase in proportion to the time spent in the live box, only healthy, uninjured, freshly caught fish were tagged. Fish caught during the nighttime hours were released untagged the next morning and fish caught throughout the daylight hours were tagged during periodic checks of the live box. Researchers assumed fish caught in the fish wheel were representative of the population and therefore represented an unbiased sample of the population.

Fish to be tagged were dipnetted from the fish wheel live box and placed in a neoprene tagging cradle submerged in a trough of fresh water without anesthetic (based on a USFWS design). Water in the trough was changed after tagging every two or three fish. Fish were not held any longer than necessary (usually less than five minutes) to determine sex, implant the tag, and obtain a length measurement (mid-eye to fork-of-tail). Radio-tagged fish did not receive a secondary spaghetti tag to avoid any additional trauma to the fish and to eliminate the chance that differential predation rates might have occurred between spaghetti-tagged and untagged fish.

Tagged fish were either released immediately or were transferred to a 0.4 m^3 size fish tote and transported upstream approximately 100 m to a back eddy for release. Holding time in the tote before release was typically between 15 to 30 minutes.

Radio Transmitters and Receivers

Pulse coded radio transmitters made by Advanced Telemetry Systems (ATS)[1] of Isanti, Minnesota were used. One hundred and twenty five internal radio tags were purchased from ATS with 43 unique frequencies spaced a minimum of 10 kHz apart in the 152 MHz to 153 MHz signal range. The standard transmitters were 5.2 cm long and 1.8 cm in diameter, weighed 24.5 g, and had a 30.0 cm external nylon coated wire antenna (Figure 4). Minimum battery life was approximately five months. Forty-one frequencies contained three pulse codes each and two frequencies (one of which was a reference tag) each contained only one pulse code for a total of 125 unique radio signals. One transmitter at the stationary remote tracking station was used as a reference signal and constant check of equipment functioning, leaving 124 transmitters for fish tagging. Radio transmitters able to transmit three types of signals were purchased (Eiler 1990). The signals types indicated normal activity, increased activity, and sustained inactivity by changes in the signal pulse pattern. The standard signal pattern was a wide pulse (20 ms) followed by two short pulses (5 ms). The time interval between the pulses (known as the code) was the same for a given transmitter and unique for each transmitter on a frequency. When a tag detected increased motion, the time interval between the three pulse group was shortened. When a tag was motionless for an 8-hour period, the sustained inactivity signal would begin to transmit. The inactivity signal pattern was identified by altering the signal to a wide pulse followed by

[1] Use of a company's name does not constitute endorsement.

three short pulses. If the motion sensor within the transmitter detected any movement the transmitter reverted back to transmission of the standard signal pattern.

Internal radio tags were selected based upon the advice of Mr. John Eiler of the NMFS, who had used these tags extensively with good success. Internal tags were selected for use rather than external tags because internal tags were perceived to allow the tagged fish to behave as close as possible to an untagged fish. Researchers thought internal tags avoided questions of migration alteration duebecause of physical drag, would be a less invasive technique since the skin and flesh were not punctured, would be less likely to affect the natural washout rate of dead fish from the spawning grounds, and less prone to physical tag loss caused by predators keying on an external cue.

Computer controlled receivers developed by ATS were used that detected signals in the 150 MHz to 154 MHz frequency range. The base receiver unit was responsible for detecting and decoding signals within the scanned frequency range. To decode detected radio signals, the receiver would analyze the signal with a series of pattern-matching routines to determine whether a transmitter was present and to identify the code (decoding). An accessory computer unit called a recording data logger (RDL) complemented the base receiver unit with the ability to store decoded signals and GPS locations into memory with the corresponding time and signal strength of the decoded signal. The receiver and computer were used to detect, identify, and record radio transmitter signals. The frequencies contained in the receivers database were scanned by the receiver at 2-s intervals.

When radio signals were detected during the aerial or ground survey, the surveyor would wait until the acoustic strength of the signal was strong enough to decode and then activate a switch on the RDL to decode the signal. The decoded signal would be automatically entered into the computer memory. Typically, transmitters could be detected at a maximum distance of 5 km and decoded at 1 to 2 km. Both maximum and decoded distances varied depending upon the height and speed of the aircraft, depth of the fish in the water, radio frequency interference, weather conditions, and battery strength.

The remote stationary tracking station receiver continually scanned the frequencies in 2-s intervals and when a signal was detected, the frequency was scanned for 8-s, to identify the radio-tags unique frequency and code combination. Transmitter signals were recorded once per hour by the RDL if they were within reception range of the stationary station.

Fish Tagging

Originally, the plan deployed all radio transmitters internally in a five-day period from September 5-15. The purpose was to minimize any possible effects from the parameters of interest changing through time. On September 8, after arriving at the Toklat River coded wire tag field camp, John Eiler instructed the authors on the proper technique of inserting internal radio tags into chum salmon. The internal placement procedure consisted of threading the antenna through a plastic tube (0.7 cm in diameter), which would allow the tagger to gently press on the tag via the tube.

The tag was gently inserted beyond the fish's pharynx, through the esophagus, and into the stomach until a slight resistance was felt. Insertion of the tag beyond this slight resistance would rupture the stomach wall. Proper tag placement occurred when the transmitter was not visible in the throat. If the tag was not placed deep enough in the digestive tract (i.e. the top portion of the tag was still visible in throat), the risk for regurgitation increased. After tagging 10 male chum salmon, they were sacrificed to examine the internal tag placement.

Upon examination of the tag placement in the sacrificed fish, concerns arose because the internally inserted tags were readily ripping through the stomach lining and were lying within the body cavity. Researchers reasoned inexperience was to blame and attempts were made to be gentle inserting the tags into eight Toklat River fall chum salmon on September 9. John Eiler tagged the first fish, and the authors tagged the next seven. The fish were then tracked a few hours later using an antenna placed in the riverboat.

On September 10, the tagged fish were tracked by boat up to the stationary receiver (study km 11). Because four fish near the fish wheels had not moved from the previous evening, it was suspected those tags were regurgitated. To test whether or not the fish were regurgitating the tags, a large tote was set up as a holding pen with a pump for water circulation. Four more fish were tagged (three with radio transmitters and one with a smaller "dummy tag" created by John Eiler from a AA battery wrapped with electrical tape). One of the fish tagged with a radio transmitter had the tag intentionally inserted far enough to rip the stomach lining. One hour after tagging and releasing these fish into the holding pen that status of the fish was checked and all the fish were doing fine with tags intact. Three hours later, at the second check of the holding pen, two of the fish had jumped out of the tote into the river some time during the last three-hour period. One of the escaped fish had the dummy tag and the other had the radio tag pushed intentionally through the stomach lining. Neither of the two fish remaining in the holding pen had regurgitated their tag; they were released into the river near the tote.

On September 11, a teleconference was initiated to discuss the project concerns with department Regional and Area staff in Anchorage and Fairbanks regarding the problems occurring with internal tag retention. A summary of the findings to date were provided and the following possible options were discussed:

1. Continue as planned with a possible 50% regurgitation or mortality based on the tags thus far deployed.
2. Only tag large fish; most likely males, which would take more time to capture the necessary numbers of fish, and could bias the results.
3. Terminate operations this year and use smaller diameter internal tags next year.
4. Convert the remaining internal tags to an external type similar to those used by Louis Barton on the Tanana River in 1989 (Barton 1992).

After discussing the concerns and possible options, everyone agreed to teleconference the next day for a final decision.

On September 12, with department Regional and Area staff input, it was decided to convert 89 tags to an external design and deploy those as soon as possible while it was still near the mid-point of the chum salmon run. Late that day, Louis Barton arrived by boat with materials to modify the internal transmitters to an external application (epoxy glue, tagging needles, Petersen discs, and cable ties). That evening, modifications were made to the original internal tags for external attachment to the fish (Figure 4). From September 13-16, the radio transmitters were modified and deployed externally on chum salmon. External radio transmitters were attached to the fish by inserting the two Petersen needles through the flesh of the fish near the rear portion of the dorsal fin and placing a Petersen disk over each needle and then twisting the needle into a knot to secure the transmitter to the fish (Barton 1992).

Because one of the purposes for this study was to develop the methods for a large-scale study, the retention of smaller sized internal radio tags was necessary and appropriate to investigate. Therefore 24 radio tags were retained for this purpose. ATS sent John Eiler three smaller sized internal "dummy epoxy tags" to experiment with. On September 15, John Eiler returned to the Toklat River camp with the dummy tags. Dummy tag styles consisted of a large diameter with long body, small diameter with long body, and small diameter with short body (Table 1). These tags were inserted into eight fall chum salmon, which were sacrificed to check on tag placement within the stomach.

Of the 24 tags retained for this experiment, 12 were returned to ATS to be converted to a smaller size while the other 12 tags would be applied externally to function as a control group. The control group would provide a comparison with the previously released external tags. ATS was contacted regarding the preferred tag shape, but an insufficient supply of smaller diameter batteries restricted construction to only seven radio transmitters with a 1 cm diameter and 5.6 cm length (10-35 battery size, Figure 4). The remaining five tags were of an intermediate size with a 1.5 cm diameter and 5.2 cm length (2/3 A battery size, Figure 4). On September 26 through 28, the 12 internal tags, converted by ATS to a smaller size, were deployed along with the remaining 12 external tags.

Aerial Tracking

The study kilometer and area sections on the Toklat River were used for determining aerial survey fish locations and data analyses (Figure 2). This map was created using MapInfo[1] Geographic Information System (GIS) software and was provided to us by the State of Alaska, Department of Natural Resources. The study area was grouped into one-km river sections both upstream and downstream of the deployment site. The Toklat River was also divided into six areas as follows:

- ***Area 0*** - Confluence with the Kantishna River to the coded wire tag recovery campsite (study km -14 to -1).
- ***Area 1*** - Coded wire tag recovery campsite to Barton Creek (study km 0 to 9).
- ***Area 2*** - Barton Creek to the beginning of the braided river section (study km 10 to 27).

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- *Area 3* - Beginning of the braided river section to the lower traditional ground survey section (study km 28 to 40).
- *Area 4* - Lower traditional ground survey section to upper traditional ground survey section (study km 41 to 45).
- *Area 5* - Upper traditional ground survey section to headwaters (greater than or equal to study km 46).

The authors conducted aerial tracking of radio-tagged fish locations every 4 to 10 days, dividing the frequencies between them and thereby decreasing the aerial survey time. Aerial surveys occurred from September 15 through October 24 using R22, R44, and Bell Jet Ranger helicopters flown at approximately 500 feet altitude at a speed of 16-24 kms/hr. Scheduling was dependent on weather, helicopter availability, and work related commitments.

During the aerial surveys, fish locations were ascribed to an individual study kilometer section. Attempts were made to get individual GPS locations for radio-tagged fish and integrate those locations into a Global Information System map to visualizefish locations through time. However, hardware and software problems prevented the receiver from properly decoding frequencies with the GPS unit. Thus, to estimate individual fish locations, progress was tracked manually during the surveys and the time was recorded when a new study kilometer section was entered. Fish location times were later matched to a corresponding time associated with a study kilometer.

A fixed wing aircraft was used on September 30 in an attempt to locate missing radio signals. The survey was conducted from the mouth of the Kantishna River upstream to the Toklat River, and the Toklat River was surveyed to its' headwaters. The plane was flown between 500 and 1,000 feet above the river at an approximate speed of 100 kms/hr.

Stationary Remote Tracking Station

The stationary remote tracking station was borrowed from NMFS and transported from Fairbanks to the Toklat River location via riverboat. The stationary receiver was installed (except for battery and electronics) on July 22 near study km 11. The station components were attached to a 10-m tall aluminum portable tower. Two four element Yagi receiving antennas were positioned at the top of the tower at approximately 120° apart, with one antenna pointed downstream and the other pointed upstream. All electronic cables were encased in flexible metal conduit to prevent damage from bears and rodents. To estimate the stations effectiveness, a riverboat was used to drag a radio tag at 0.3 m and 1.2 m depths from the bottom both upstream and downstream of the station. The tag was effectively detected to a distance of approximately 350 m upstream and 150 m downstream. The stations upriver and downriver combined effective tag detection range was approximately 0.5 km.

On September 8, installation was finalized by the attachment of the receiver, RDL, and lead-acid battery to the unit. The battery was charged during the project by a solar panel mounted on the tower. Satellite up-link capability was not used due to the additional time, weight, and

operational constraints of the more complicated system. Reference tag 151.184 was positioned approximately 150 m downriver from the stationary receiver to provide an hourly record for evaluating station performance.

The authors downloaded the data station information during each aerial survey. Before downloading data from the stationary receiver to the portable computer, checks were completed to ensure that the receiver was detecting the reference tag, all settings were correct, battery voltage was acceptable, and no damage had occurred to the unit. After downloading the data, the equipment was again checked. Migration timing of radio-tagged fish was determined from the capture location to the stationary receiver site, and gave the number of radio-tagged fish continuing upstream.

The stationary receiver received signals transmitted from the radio tags and decoded them when the signal became sufficiently strong. After decoding a transmitter, the receiver would continue to cycle through all the frequencies. The frequency, code, signal strength, and time for each unique signal was recorded into memory the first time during each one-hour interval it was detected by the stationary receiver. However, the exact time a radio tag left the detection area was not recorded. Therefore, the number of hours a radio tag was detected by the station is a maximum value. For example, a fish detected for two hours by the station could have been in the detection zone anywhere from 2 minutes (i.e., entered at 0059 and left at 0100) to 120 minutes (i.e., entered at 0000 and left at 0159).

Ground Tracking

Opportunistic tag recovery on the spawning grounds occurred during the coded wire tag recovery surveys (October 11-14) and the ground population estimate surveys (October 15-19). Additionally, the authors visited the spawning grounds on two occasions (October 15-16 and October 20-21) to locate tagged fish using telemetry equipment and to recover radio transmitters.

Data Analysis

Average migration time from the coded wire tag recovery camp to the stationary remote tracking station was calculated by subtracting the time radio-tagged fish were first detected by the station, from the time they were released after tagging. Tagged fish were released at study km 0 and first detected around study km 10.5 (0.5 km below stationary receiver located at study km 11) for a total distance of 10.5 km. Differences in migration rates were tested using the Kolmogorov-Smirnov test between internal and external tagged fish and between those fish released after tagging at the fish wheel to those released upriver approximately 100 m.

Radio-tagged fall chum salmon spawning locations were estimated from the general area in which an individual fish was located for more than one survey, consistent with known spawning biology.

For fish having highly variable locations between surveys, spawning locations became the area where the sustained inactivity signal first appeared.

Chum salmon spawner residency time was estimated by subtracting the date a tagged fish was first detected in its' spawning location from the first date of sustained inactivity signal transmission. The sample mean and variance were used to estimate the population mean and variance for the portion of the run sampled.

RESULTS

Appendix A is a summary of the tagging and tracking history for all 123 radio tagged fall chum salmon followed during this study.

Fish Tagging

The left bank fish wheel (traveling downstream) operated from August 16 to September 29 with the first fall chum salmon caught on August 20. The right bank fish wheel operated from August 26 to October 1. A total of 1,962 fall chum salmon and 363 other fish were caught by both fish wheels (not including recaptures) during the 1997 fall field season. Species other than fall chum salmon represented 15.6% of the catch. Apparently, the fall chum salmon tagged from September 9-16 were tagged near the mid-portion of the run and those fish tagged on September 26-28 were tagged between the three quarter point and the end of the run (Figure 5).

Of the eight chum salmon initially tagged with internal tags on September 9, four had moved upriver and four remained downriver near the fish wheels, as documented a few hours later by foot and using an antenna in the riverboat. On September 10, the eight fish tagged the previous day were tracked by boat up to the stationary receiver. One fish passed the station around 0700 that morning, two fish were 3 to 4 km below the station, one fish was 1 km upriver from the tagging camp, and four fish remained near the fish wheels. Because the tags near the fish wheels had not moved upriver, perhaps they had been regurgitated. Three more internally tagged fish were released later that afternoon after being tagged and held for several hours in a holding tank.

On September 11, the tagged fish were tracked upriver to the stationary receiver. Of the eleven tagged fish, five were upriver (three upriver of the stationary receiver) and six were still near the fish wheels. Because many of the tagged fish located near the fish wheels had not moved, it was suspected these fish had regurgitated their tags. Apparently larger tagged fish were coping better with the internal tags than smaller tagged fish. The length range of the tagged fish was 52 to 62 cm. Of those fish within 52 to 56 cm, one fish had moved upriver and five remained downriver near the fish wheels. Of those fish 57 and 58 cm, one had moved upriver and one remained downriver by camp. Of the three fish 59 to 62 cm, all had moved upriver.

On September 15, using the internal dummy tags from ATS, eight fish were sacrificed after inserting the transmitters into various sized fall chum salmon. The smaller sized tags could be placed farther into the stomach than the original tags but would again tear the stomach wall if pushed too far. The tag placement in the digestive tract of the sacrificed fish are shown inTable 1.

From September 13-16, eighty-eight fish were tagged with external transmitters (Table 2). One tag (152.282, code 13) was not released because it was not transmitting properly. From September 26-28, the remaining tags were deployed (12 internal and 12 external).

The 123 fall chum salmon tagged on the Toklat River came from the left bank (n = 71) and right bank (n= 52) fish wheels. There were nine separate days of fish tagging, categorized as early (September 9-16) or late (September 26-28). There were 99 early and 24 late-tagged fish. The sample released included 100 externally and 23 internally tagged fish. The first eleven fish had original sized internal tags. The remaining twelve internal tags were deployed in the late tag group and included five intermediate and seven small sized tags.

The authors tagged 115 fish with the remaining eight fish tagged by four individuals. Sixty-eight males and 55 female fall chum salmon were tagged, ranging in size from 500 mm to 685 mm (Figure 6).

Aerial Tracking

Seven aerial surveys were conducted using a helicopter (September 15, 19, 26, and October 2, 6, 14, and 24) and one with an airplane (September 30). The objective of the first five aerial helicopter surveys was to locate all tagged fish in the system. The intention of the October 14 survey was to locate all tagged fish except those remaining below study km 19 because those tags had not been moving upriver in prior surveys and eliminating that search area could reduce costly survey time. The goal of the October 24 survey was to locate only those fish tagged in the late group that had moved upriver above study km 19. The September 30 airplane survey funded by the National Park Service provided us with an opportunity to locate those fish not found on September 26.

During each aerial survey between 83 and 100% (overall average was 95%) of the tagged fish were located (Table 3). On more than one survey only one tag (152.463, code 13) was not located on surveys conducted on September 26 and October 6.

Early and late-tagged fish locations for the first six aerial surveys are provided in Figures 7, 8, and 9 showing the progression of tagged fish upriver. Analyses of fish locations by area are provided in Appendices B and C for each aerial survey. This includes early-tagged versus late-tagged fish locations (Appendix B), externally tagged versus internally tagged fish locations, and tagged male versus female locations (Appendix C). Also included are sustained inactivity signal results based on tag deployment method and date of tagging.

The analysis showing the differences between internally tagged to externally tagged fish and early-tagged to late-tagged fish excluded all fish that likely died or lost their tags near the tagging site. Of the first eleven internally tagged fish, which had original sized radio transmitters, four (37%) either died or regurgitated their tag in the proximity of the tagging site. On September 26 and 27, the smaller modified internal tags were deployed and only one of 12 (8%) internally tagged fish either died or lost it's radio transmitter near the tagging site.

During the aerial surveys, visual observations of spawning activity in Geiger Creek began on September 19 and in the Toklat River mainstem upstream from study km 28 beginning on September 26. Spawning activity was observed as far downstream as study km 24 on October 24. During aerial surveys conducted before mid-October, spawning activity was observed but sightings were obscured by glacial water conditions.

Stationary Remote Tracking Station

The stationary receiver detected 106 of the 115 tagged fish (92%) that passed the station. Eight tagged fish never made it upriver to the station and nine others passed the stationary receiver undetected. All tagged fish traveling by the station that were not detected passed between September 26 and October 2. During this same time period, however, 12 other tagged fish passed the station and were properly recorded. While downloading the data from the tracking station on September 26, the receiver was processing the frequencies abnormally slow. Upon departure the problem was still unresolved. The problem was self correcting because the unit was functioning normally on the next site visit on October 2 when the data was downloaded again.

The line-of-sight distance a tag could be detected by the stationary receiver was approximately 0.5 km. The stationary receiver detected tagged fish as they passed the station anywhere from 1 to 100 hours (Figure 10). The median of the distribution was 2.0 hours. The mean detection time was 8.2 hours with a standard deviation of 16.0.

The average migration time for tagged fall chum salmon from the tagging site to first detection by the stationary tracking station was 3.9 days (median = 3.0 days) with a variance of 6.9. Using the median value of 3.0 days, the migration rate for this distance is 0.15 km/hr.

The distribution of travel time was similar between tagged fish released directly at the fish wheel (average = 3.6 days, median = 2.7 days) and those released approximately 100 m upriver (average = 4.1 days, median = 3.3 days) with and without outliers included in the analysis (Kolmogorov-Smirnov, $p = 0.243$). The distribution of travel time was different between internal (average = 3.1 days, median = 2.1 days) and external (average = 4.0 days, median = 3.1 days) early tagged fish with and without outliers included in the analysis (Kolmogorov-Smirnov, $p = 0.017$). There were only 7 internal and 6 external late-tagged fish detected by the stationary receiver. Excluding a single internal outlier (15.9 days), late-tagged internal and external fish appeared to have similar means at 2.2 days and 2.5 days respectively. Because of the small

sample sizes involved, differences in travel time between late-tagged internal and external fish were not tested.

Ground Tracking

On October 14, after aerial tracking fall chum salmon with a helicopter on the Toklat River, the Fishery Biologist II (FBII) was dropped off at the Sushana River cabin to remain with the foot survey crew. Over the next two days, 40 radio-tagged fish were tracked in the traditional foot survey spawning grounds area (study km 41 to 45) using a hand held directional antenna and receiver. On October 15, the FB II accompanied the foot survey crew as they counted fish beginning in the lower stretches of the survey area (study km 41.5) and working south along the eastern floodplain upriver and into the Sushana River (study km 45). A total of 36 radio-tagged fish were located in the spawning grounds area within approximately 100 m of their true location. On October 16, the east side of Wolf Island Slough, Wolf Island Creek, Roadhouse Extension, and Roadhouse Slough were covered and an additional four tags were located.

Estimated fish locations were compared between the October 14 aerial survey and the October 15 foot survey estimates. Treating the foot survey estimates as the "true" locations and assuming no movements had occurred in the last 24 hours for tagged fish, differences were calculated between the aerial survey locations (study kilometer) and those of the foot survey (Table 4). The resulting differences were normally distributed with a mean of -0.22 and a variance of 2.29 indicating that on average the aerial survey locations were estimated about a quarter of a kilometer less than those estimated from the foot survey. This is the likely result of conducting aerial surveys traveling upstream with two directional antennae's aligned at approximately 30 degrees from the front of the helicopter. Seventy-eight percent of the differences were within one km.

During the two days spent on the spawning grounds, two radio transmitters were physically located. The first (152.375, code 13) was located in the Sushana River near the cabin. The tag was found lying on the bottom of the creek nearly invisible against the matching gravel and not attached to a fish. The front cable tie and pin had separated from the epoxy attachment into top and bottom portions because the bottom part of the epoxy base was well attached to the radio transmitter while the top portion was missing along with the cable tie and pin. The rear cable tie and epoxy base were still firmly attached to the radio transmitter, yet the pinhead had pulled through both of these attachments. Approximately 50 m below the location of the recovered tag, a fish was found wearing a single Petersen disc held in place by the pin and cable tie that had apparently pulled through the epoxy. The fish was a male with a fork length of 590 cm. This, however, did not match the fish with tag 152.375 (code 13), which was a male of 615 cm. It is difficult to determine which transmitter this fish might have been wearing because there were six tagged males with length 585 cm to 595 cm (three with length 590 cm) in the spawning grounds area according to the aerial survey records.

The second recovered tag (152.432, code 19) was found in east Wolf Island Slough in the woods above a cut bank underneath a dead, desiccated fish. The tag was not connected to the fish. The

front cable tie and epoxy base were completely removed from the body of the tag. The rear epoxy base was intact but the cable tie and pinhead had pulled through the epoxy it is not known if the predator caused the damage.

On October 19, during the foot survey count, the foot survey crew found a detached radio tag (153.093, code 10) lying at the bottom of Geiger Creek approximately 1 km upriver from the confluence. The front cable tie and epoxy base were intact but the pinhead had pulled through the epoxy. The rear epoxy base was mostly intact with one large piece missing where the cable tie and pinhead had apparently ripped loose.

Another example of a radio tag becoming detached from a fish occurred during tagging when a male (630 cm) was recaptured in the left bank fish wheel 15 hours after being tagged in the right bank fish wheel. The fish had definite Petersen disc marks and the coded wire tag recovery crew found the radio transmitter in the live box. The epoxy, cable ties, and Petersen needle heads were firmly attached to the radio transmitter. The Petersen needle wires had broken off above the epoxy base. It is likely that the wire of the Petersen disc became entangled in the live box mesh upon recapture and the fish struggled enough to break both wires.

The foot survey crew observed approximately six fish with Petersen discs in the two days spent on the spawning grounds. Of these fish, they could not tell reliably if these fish carried radio transmitters. The FB II did find two of these fish visually and simultaneously track their movements using telemetry gear.

Prior to the FB II's arrival on the spawning grounds, two Fish and Game employees sampling fall chum salmon for coded wire tags over three days captured three fish having Petersen discs without radio transmitters. Similarly, on October 15, in Wolf Island Creek, the FB II found a dead fish in the slough that had one Petersen disc but no tag. The disc was held in place by a pin, which had apparently pulled through the cable tie and epoxy.

On October 20, the authors returned to the spawning grounds to gather more evidence of tagged fish losing their radio transmitters. Unfortunately, a couple days prior to their arrival, an apparent ice jam in the lower Toklat River spawning grounds flooded the area. As the water levels subsided, ice was deposited in layers 0.5 m to 1 m deep over the majority of the flood plain. The Sushana River was murky and the water level was rising at the time, probably because of the Toklat River changing course and diverting much of its silt load into a slough of the Sushana River upriver of the cabin.

During the three-day stay on site, numerous radio transmitter tags were located using telemetry equipment but could not be physically retrieved due to the heavy sheets of ice covering the shorelines, turbid water conditions, and high water levels. At the time the crew was unable to fjord the floodplain due to overflow conditions to reach and survey Geiger Creek, which is typically more stable.

Data Analysis

The spawning locations could be subjectively identified for all 115 radio-tagged fish that had moved upstream past the stationary receiver (Figure 11). Based upon the estimated spawning location of 92 early-tagged fall chum salmon, approximately 71 % of the run passing the tagging site from September 9-16 may have spawned in the Toklat Springs (confidence interval approximately 0.170). In addition, based on a sample size of 23 late-tagged fish, only 32% of the run passing the tagging site from September 26-28 may have spawned at the Toklat Springs.

For the early tagging period, of the 66 tagged fish that may have spawned at the Toklat Springs area, researchers estimated at least two washed out of the area (this does not account for the unknown number that lost their tags and then washed out undetected). For the late tagging period, of the seven tagged fish that may have spawned at the Toklat Springs area, none washed out of the area. This translates to 97% or less for the early tagging period (September 9-16) and 100% or less for the late-tagging period (September 26-28), of those fish passing the tagging site remained in the Toklat Springs area during subsequent ground surveys.

The relationships between the estimated fish spawning locations and the sex, size, and tag design of the radio-tracked fish were tested. Distributions for tagged male and female estimated spawning locations were similar (Figure 12). Any significant relationship between the estimated spawning location and the size of tagged fish were lacking (Figure 13). The pattern of estimated spawning locations for internally and externally tagged fish were similar (Figure 14). The small sample of internally tagged fish, however, prohibits any firm conclusions from this relationship. Further analyses among the estimated spawning locations of late-tagged fish show similar distributions for internal and external tagged fish (Figure 15).

Estimates of the spawning residence time of radio tagged fall chum salmon were not made because the aerial survey budget was not sufficient to provide for the additional flights that would have been necessary to address the issue. To evaluate if early-tagged fish exhibited a significant difference from late-tagged fish in stream residence, the date of tagging was plotted against the number of days between tagging and the date of first detecting a sustained inactivity signal (Figure 16). There is no pronounced visual difference in the number of days from tagging to the documentation of a sustained inactivity signal for early and late-tagged fish.

DISCUSSION

The first portion of this discussion will address four explanations that have been previously discussed by staff as reasons why the Bendix sonar counts differed so greatly from the foot survey estimates in prior years. Possible explanations for the differences were: 1) unknown or underestimated species composition, 2) undocumented spawning locations, 3) multiple sonar counts of single salmon, and 4) salmon spawning ground residency time.

The species composition of the fish wheel catches in 1997 were similar to the 1996 percentage, with species other than salmon comprising 15.6% and 10.4% respectively. It continues to appear unlikely that the abundance of other species alone can account for the varying discrepancy between the ground survey and the sonar passage estimate.

The documentation that potentially significant proportions of Toklat River fall chum salmon spawn in areas other than the traditional ground escapement survey area known as Toklat Springs is of particular interest. Although the surveys did not locate any new tributary spawning areas, the spawning activity was estimated to begin 22 km downstream and continue for 16 km upstream of the Toklat Springs. Likely the percentage of Toklat River spawners that utilize the spawning areas below and above the Toklat Springs is inconsistent from year to year. Even though prior aerial surveys of the Toklat River had documented spawning outside of the Toklat Springs, the level of contribution was previously thought to be very low as compared to the spring area (Louis Barton, personal communication). Possibly, based on this radio telemetry work, these areas may support around 30% of the spawners in any given year, but could be higher for later portions of the run. Previously, the department reported the expanded ground survey estimates as the Toklat River fall chum salmon population abundance. This feasibility study, however, indicates that areas outside of the traditional survey area may, in some years, be important for spawning. This suggests that ground survey counts of the Toklat Springs should be characterized as an index number rather than a population estimate.

One theory for explaining the discrepancy between the sonar and ground survey estimates which has been brought forward, is that Toklat River fall chum salmon migrating past the sonar site may be counted multiple times. Theoretically, the salmon may migrate past the sonar (counted), drop back past the sonar (uncounted), and again migrate past the sonar (counted). A single fish could exhibit this behavior multiple times. This theory appears to be consistent with sonar technician observations on the calibration scope. Technicians reported seeing not only standard salmon type electronic spikes of normal duration during their calibrations but also spikes narrower, shorter, and of less duration. The smaller spikes may have represented salmon returning downstream. This theory appears to be subjectively supported by the radio telemetry data. Since the Bendix side-scan sonar site was only approximately 2 km downstream of the stationary tracking station, the migration speed and fish behavior documented at the tower would expect to be similar to that exhibited at the sonar site.

The migration speed of fall chum salmon has typically been estimated at near 48 km per day. This estimation would require a fish to migrate an average of 2 km/hr. Subjective field observations have indicated that this average migration rate may be considerably less the closer the fish gets to the spawning ground. Two approaches were used to obtain a quantitative estimate of the migration speed of radio tagged fall chum salmon in the Toklat River. One method of examining the migration rate was by calculating the amount of time between the releases to the first record of passage by the stationary receiver. Additionally, the cumulative amount of time was calculated for each fish as it passed through the recording range of the stationary receiver. A median migration speed of 0.15 km/hr (3.6 km/day) was estimated for tagged fish from the time of release to the stationary station. This rate may be somewhat less than for untagged fish since

there was probably an unknown "hold over" for tagged fish before resuming their upstream migration. Possibly tagged fish would seek out slower water and hold for a time before beginning their upstream migration after experiencing the stress from capture, handling, and tagging. This idea seems consistent with the estimation that tagged fish were migrating at a minimum speed of 0.25 km/hr in the location of the stationary receiver.

Having estimated the range of the stationary tracking station to be 0.5 km, researchers expected most radio tagged salmon would be detected one time by the stationary tracking station if most fish are traveling at 2 km/hr. A fish traveling at 2 km/hr will spend 0.25 hours within the range of the stationary receiver.

Because the stationary station only records the time a tagged fish is first detected and not when it leaves the detection area, the number of one-hour intervals a fish is recorded is a maximum value. Most of the radio-tagged Toklat River fall chum salmon were detected for two one-hour intervals. This information suggests that most radio-tagged Toklat River fall chum salmon were migrating at a minimum speed of 0.25 km/hr (0.5 km detection distance by the station and most fish detected for two hours) in this portion of the river. Of the 106 radio tagged salmon recorded moving upstream of the stationary station, 44 were detected for three hours or more.

Relative signal strength records of radio tagged fish were reviewed for fish having more than four hours of receiver detection time between the upstream and downstream pointed antenna. In an attempt to see if the relative signal strength records would clearly document an upstream/downstream movement within the 0.5 km recording distance of the station. Eleven of the 27 fish whose time in within the receiver range was greater than four hours appeared to have returned back downstream one or more times. Unfortunately documentation of signal strength of the control radio tag in various upstream and downstream locations was not collected, therefore the information has no point of reference. If additional research was conducted the remote tracking station could be set up to collect this type of information to provide a better understanding of the migration behavior of fish in the Toklat River.

The possibility for a sonar to produce multiple counts appear supported: by the two independently estimated migration speeds of 0.15km/hr and 0.25km/hr; that 87% of the radio tags detected by the stationary station were recorded for more than one hour; that two radio tags passed the stationary station multiple times; and that the directional antennas of the stationary station appeared to indicate an upstream/downstream movement within the zone of detection.

The radio tracking information collected in this study was insufficient to estimate accurate migration rates or spawner residence time. Two approaches could be utilized to collect this information. Either increasing the number of aerial surveys while decreasing the time between surveys to approximately three days or by increasing the number of stationary tracking stations.

Fish Tagging

The tagging process on the Toklat River began with eleven internally tagged fall chum salmon. This initial test group of eleven fish that received internal radio transmitters into their stomachs on September 9 and 10 appeared to have poor tag retention based on the tag's lack of movement. Regurgitation was suspected resulting from the inability to insert the tag deep enough into the stomach without rupturing the walls because the esophagus and stomach had begun to lose its elasticity in the process of reabsorption.

This lack of elasticity was totally unexpected. Mr. Eiler had radio-tagged salmon throughout much of Alaska, ranging from coastal to interior stocks, often near the spawning grounds. He had never witnessed stomach linings as thin and inelastic as seen on the Toklat River in 1997. This fall from September 17-25, John experimented with fall chum salmon near Rampart on the Yukon River with a portion of the tags not yet deployed on Toklat River fall chum salmon. The purpose was to compare the stomach elasticity of mainstem Yukon River fall chum salmon stocks which would have migrated a similar distance from the ocean but were not as close to their spawning grounds. The standard sized internal tags used for this project were inserted into fish at Rampart with no stomach tearing related problems.

Improved internal tag retention was demonstrated by using smaller internal tags than those originally ordered. Based on the ease of application, depth of insertion, and tag retention, the small internal radio tags were preferred to either the intermediate or the original sized tag. Eleven of the twelve (7 small and 5 intermediate) transmitters (92%) internally tagged fish in this late tag group moved upriver past the stationary receiver as compared to only seven of the first eleven (64%) internally tagged with the standard sized transmitter. These results suggest that internal tag sizes may vary for salmon species depending upon their migration distance and how close the tagging location is to the spawning ground.

The debate of internal versus external tag application continues. This study has demonstrated that external tags can be used with a low initial loss through either death or tag discard. A large percentage (97%) of the externally tagged fish (n=100) moved upriver at least as far as the stationary receiver (study km 11). However, after travelling upriver, an unknown portion of these fish lost their tags. The tag loss appears to be caused by 1) a failure of the epoxy glue used to connect the tagging pins to the radio transmitter, 2) wire failure, and 3) the plastic cable tie breaking. Likely most of the tag loss occurred during or just before the act of spawning when aggressive behavior and salmon susceptibility to predation increases. If this is true, externally tagged fish provided reasonable estimates of spawning locations but may not have given accurate estimates of wash-out rates after expiration. The carcasses would be unavailable to the foot survey abundance estimation but the radio tag signal would still indicate the fish being present in the spawning ground area.

Regurgitation of internal tags is believed to occur during the first 24 hours. After this period, tag loss rates should diminish as tagged fish move upriver to spawn. Assuming this is true, then internally tagged fish may provide reasonable estimates of wash-out rates for dead fish assuming

that sustained inactivity signals are truly representative of dead fish. Further, internal tags are virtually impossible to see on a fish in the water, and therefore, should not increase their predation.

Another concern raised in previous tagging studies suggested externally tagged fish may be preyed upon more heavily by predators such as birds or bears. Based on the limited observations from the Toklat River spawning ground foot surveys this year, it is not believed that predation is likely to be significantly greater for externally tagged fish than those not tagged. The only visible component of the external radio tags was the two orange Petersen discs but even those were often difficult to locate in the river.

Tagged Fish Tracking

Originally, the aerial surveys were intended to occur approximately once every five days with one person in a small R22 two-man helicopter. However, after the September 15 aerial survey conducted by the authors and John Eiler, it was realized that it would be too demanding and time-consuming for one person to track all the radio tags in a single survey. Therefore the study was modified to survey over a longer period of time (every four to ten days) using a larger four-man helicopter. Unfortunately, the necessity of using a helicopter which could transport two individuals for tracking cost more and decreased the total number of surveys.

The seven aerial helicopter surveys conducted on the Toklat River provided sufficient date-specific tagged fish locations to estimate spawning locations. It did not suffice, however, for the estimation of migration rates or spawning residence time. These parameters would require a greater number of aerial surveys, perhaps a survey every three days.

Fish exhibiting a sustained inactivity signal may have less reliable estimated locations than other tagged fish. When a fish dies, often the carcass is carried by the current to the shoreline where it comes to rest and ends up out of water during the natural recession. Because the signal from a transmitter out of water travels farther than a signal originating underwater, it can be decoded from a greater distance which will increase the error between the estimated and true location for a radio tag. On foot surveys, the gain control (how much the incoming signal is amplified) on the receiver can be lowered as the distance to the transmitter decreases. This allows the tracker to better identify the location of the transmitter because the signal is not "peaked out". However, when conducting aerial surveys, rarely does enough time exist to optimize the gain for each incoming signal because of the overwhelming number of tagged fish in most areas and the survey time constraints.

Based on the sample location comparisons of the tagged fish locations on October 14 versus their actual ground locations on October 15, the aerial survey estimated fish locations appear to be good approximations of the true fish locations.

Data Analysis

The authors would like to ensure that readers understand the qualifiers related to this study. This study was conducted during one field season, with limited sample sizes, limited aerial tracking time, and possible tag loss problems (both regurgitation and external separation). The data from this study is a beginning foundation for more fully investigating annual migration rates, annual spawner distribution, annual spawning stream residence, and annual wash-out rates for dead fish. The greatest use of this data would be to incorporate these findings into a multi-year project to understand the inter-annual variation for the parameters of interest.

The number of days from tagging was documented from a sustained inactivity signal (Figure 16). Superficial examination of this information could be misleading because several problems exist with the information. First, the date a sustained inactivity was detected can only occur on a survey date. Unknown is exactly when the signal first began; which could have happened any time from the last survey not producing a sustained inactivity signal. Thus, the number of days from the date of tagging to the documentation of a sustained inactivity signal is a maximum value. Additionally, because of possible tag loss, the proportion of tagged fish that lost their tags before expiring is unknown. A high proportion could cause the number of days from the date of tagging to documentation of a sustained inactivity signal to be lower than reality if the lost transmitters became inactive.

RECOMMENDATIONS

For future radio telemetry projects within the Toklat River on fall chum salmon, the use of the small (10-35 size) or intermediate sized (2/3AA size) internal radio tags is recommended. Internal tag size selection is balancing the needs of finding a tag which has sufficient battery life for the duration of the study, is small enough to be seated within the stomach without rupturing it, yet is large enough to prevent easy regurgitation. The smaller tags deployed in late September were successfully implanted with an acceptable retention percentage. Although presently unquantifiable, researchers believe internal tags minimize problems associated with alteration of migration speed or behavior, tag loss, predation, and wash out rates. An alternative would be to use external tags designed by the radio tag manufacturer where the tagging pins would be molded into the body of the radio transmitter. With the external pins an integral part of the radio-tag rather than a glued on component, less problems with the transmitter becoming detached from the fish would be expected. Further, if an after market modification is necessary to convert internal tags to external use, the heads of the tagging pins should be wider to prevent them from being pulled through the cable tie and/or adhesive.

For this study a single stationary remote tracking station located at study km 11. A single station was used primarily because borrowed equipment was used and the helicopter costs associated with installing and dismantling more than one station for this feasibility phase were prohibitive.

If a larger tagging study were conducted in the future, using two or more satellite compatible stationary tracking stations could drastically reduce aerial survey time. For a two station approach, placing one stationary station below the traditional foot survey area and placing a second station above the foot survey area, would allow determination of which fish were in the spawning area. Aerial surveys could then seek only those fish not having been recorded by the stations. This could dramatically reduce costly aerial survey time. These two stations would enable calculations of spawning ground residency time, time of the first inactivity signal, and carcass wash out rates, without the confounding problem of lag time between aerial surveys. The preferred approach would be to use three satellite compatible stationary tracking stations. The third station, in addition to the two previously mentioned, would be located near study km 11 (as in this study) to provide documentation of tagged fish upstream movement reasonably soon after tagging.

LITERATURE CITED

Barton, L.H. 1984. A catalog of Yukon River salmon spawning escapement surveys. Alaska Department of Fish and Game, Division of Commercial Fisheries. Technical Data Report No. 121. Juneau.

Barton, L. 1992. Tanana River, Alaska, fall chum salmon radio telemetry study. Alaska Department of Fish and Game, Division of Commercial Fisheries. Fishery Research Bulletin No. 92-01. Juneau, AK.

Barton, L. 1997. Salmon escapement assessment in the Toklat River, 1994. Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Regional Informational Report 3A97-35, Anchorage.

Barton, L. 1998. Salmon escapement assessment in the Toklat River, 1995 and 1996. Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Regional Informational Report 3A98-22, Anchorage.

Eiler, J.H., J.J. Pella, M.M. Masuda, H.R. Carlson, R.F. Bradshaw, and B.D. Nelson. *In Prep.* Stock composition and timing of chinook salmon in the Taku River, Alaska and British Columbia.

Eiler, J.H. 1995. A remote satellite-linked tracking system for studying Pacific salmon with radio telemetry. Transactions of American Fisheries Society, 124:184-193.

Eiler, J.H. 1990. Radio transmitters used to study salmon in glacial rivers. American Fisheries Society Symposium 7: 364-369.

Eiler, J.H., B.D. Nelson, R.F. Bradshaw, J.R. Greiner and J.M. Lorenz. 1988. Distribution, stock composition, and location and habitat type of spawning areas used by sockeye salmon on the Taku River. NWAFC Processed Report 88-24. Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA. Auke Bay, AK. nineteen

Sheldon, C. 1930. The wilderness of Denali. Charles Scribner's Sons, New York.

Snedecor, G.W. and W.G. Cochran. 1989. Statistical Methods, Eighth edition. Iowa State University Press, Ames, IA.

TABLES

Table 1. Internal dummy tag placement results for eight Toklat River fall chum salmon sacrificed on September 15, 1997.

Tag Number	Sex	Length (mm)	Tag Size	Comments
1	Male	≥635	Large diameter, long	**Visible in throat, ripped stomach.**
2	Male	≥635	Large diameter, long	Visible in throat (slightly deeper), ripped stomach.
3	Male	635	Small diameter, long	Ripped stomach.
4	Female	530	Small diameter, long	Went down well - pushed farther in.
5	Female	545	Small diameter, short	Ripped stomach - unsure when the rip occurred.
6	Male	600	Small diameter, long	Stomach okay but ripped when pushed farther.
7	Female	610	Small diameter, short	Stomach okay when pushed farther; it went in 3 inches. Much more elastic than others.
8	Female	590	Small diameter, long	Ripe fish (loose, pouring eggs). Pushed in 1 inch before stomach ripped.

Large diameter (1.6 cm), long (5.8 cm).
Small diameter (1.2 cm), long (6.6 cm).
Small diameter (1.2 cm), short (5.6 cm).

Table 2. The date, number, and type of radio tags applied during the 1997 Toklat River fall chum salmon radio telemetry project.

Date	Number Tagged	Tag Type
September 9	8	Internal
September 10	3	Internal
September 13	30	External
September 14	40	External
September 15	10	External
September 16	8	External
September 26	1	Internal
September 27	22	11 Internal, 11 External
September 28	1	External
Total	123	100 External, 23 internal

Table 3. The number and percentage of radio tagged fall chum salmon located during each of seven aerial surveys of the Toklat River, 1997.

Survey Date	Number of Tagged Fish Located	Number of Tagged Fish At Large	Percentage Located
September 15	88	88	100
September 19	95	99	96
September 26	87	99	88
October 2	119	123	97
October 6	119	123	97
October 14	118	123	96
October 24	20	24	83

Table 4. The estimated difference between the locations of radio tag lineal frequencies located during an aerial survey (October 14) and a ground truth survey (October 15) on the Toklat River, 1997.

Frequency, Code	Ground Survey Study Km	Aerial Survey Study Km	Difference (Km)
152.252,13	43	43	0
152.252,19	44	44	0
152.282,19	43	42	-1
152.314,10	44	44	0
152.314,19	42	40	-2
152.344,10	42	42	0
152.344,13	42	42	0
152.344,19	44	42	-2
152.375,13	44	44	0
152.403,13	42	43	1
152.403,19	44	46	2
152.432,13	42	38	-4
152.494,19	44	44	0
152.524,13	43	42	-1
152.554,10	42	42	0
152.554,19	44	43	-1
152.584,13	42	43	1
152.584,19	42	42	0
152.614,10	43	38	-5
152.674,10	42	44	2
152.764,13	42	45	3
152.793,10	43	42	-1
152.793,13	43	44	1
152.823,10	42	42	0
152.853,10	42	40	-2
152.944,10	43	42	-1
153.004,10	43	43	0
153.124,10	44	44	0
153.153,10	44	43	-1
153.183,10	42	43	1
153.273,13	43	43	0
153.273,19	43	44	1
153.304,10	43	43	0
153.333,10	44	44	0
153.393,13	43	43	0
153.453,13	42	43	1

Average = -0.22
Variance = 2.29

FIGURES

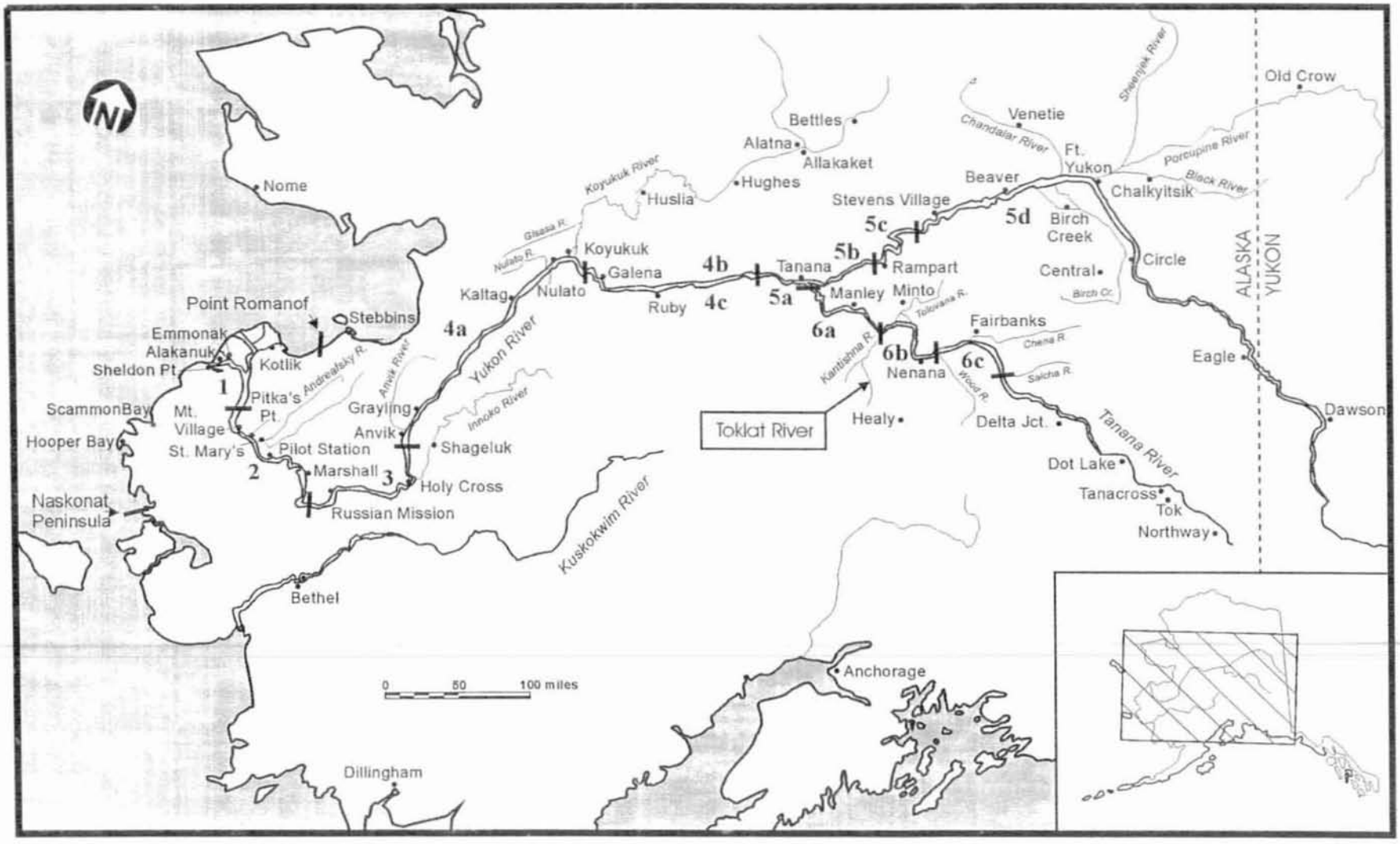


Figure 1. Map of the Alaska portion of the Yukon River drainage emphasizing the Toklat River in relation to the communities and fishing districts.

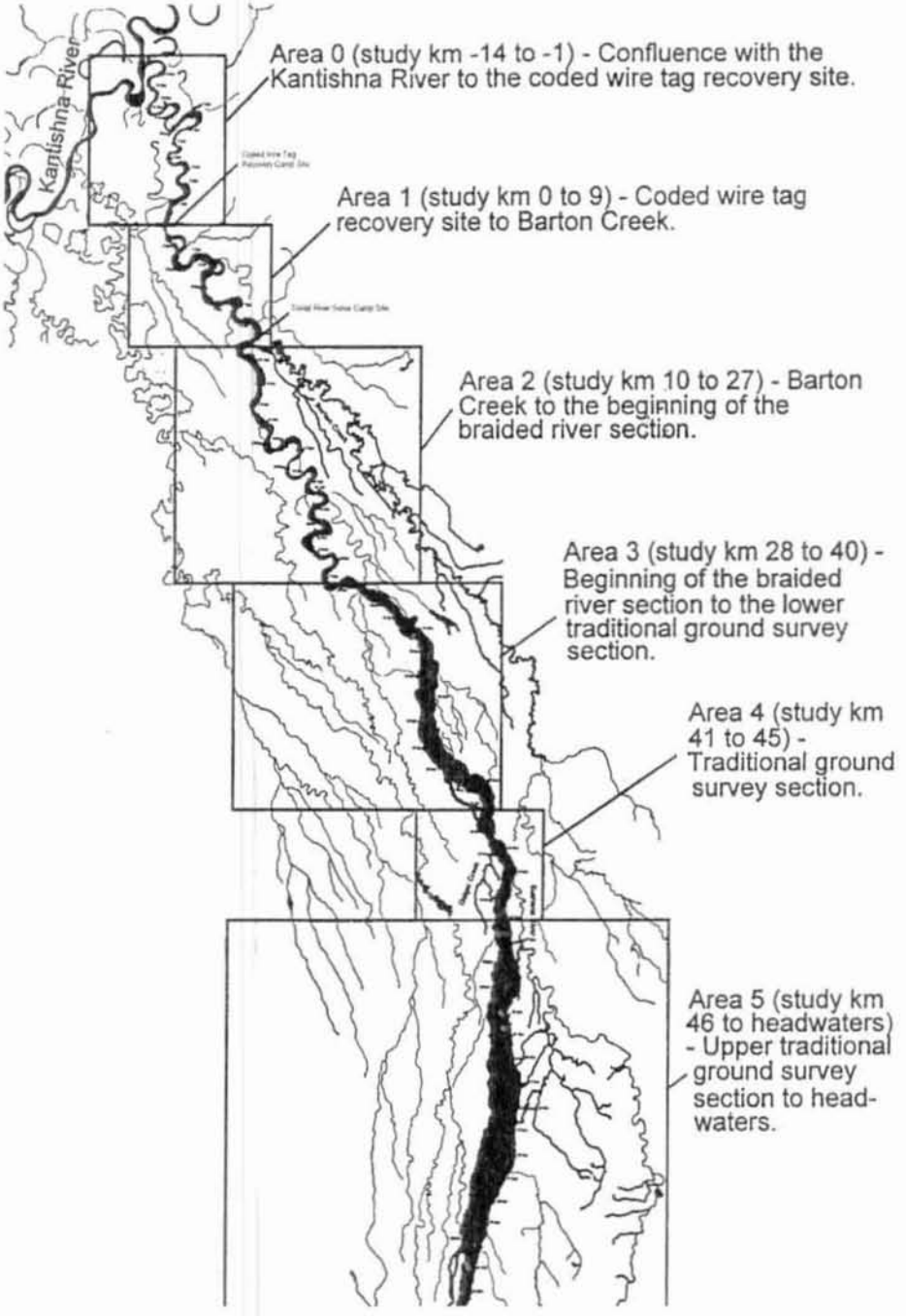


Figure 2. Map of the Toklat River drainage from the Kantishna River confluence to river kilometer 75 showing the six major study areas of the 1997 fall chum salmon radio telemetry project.

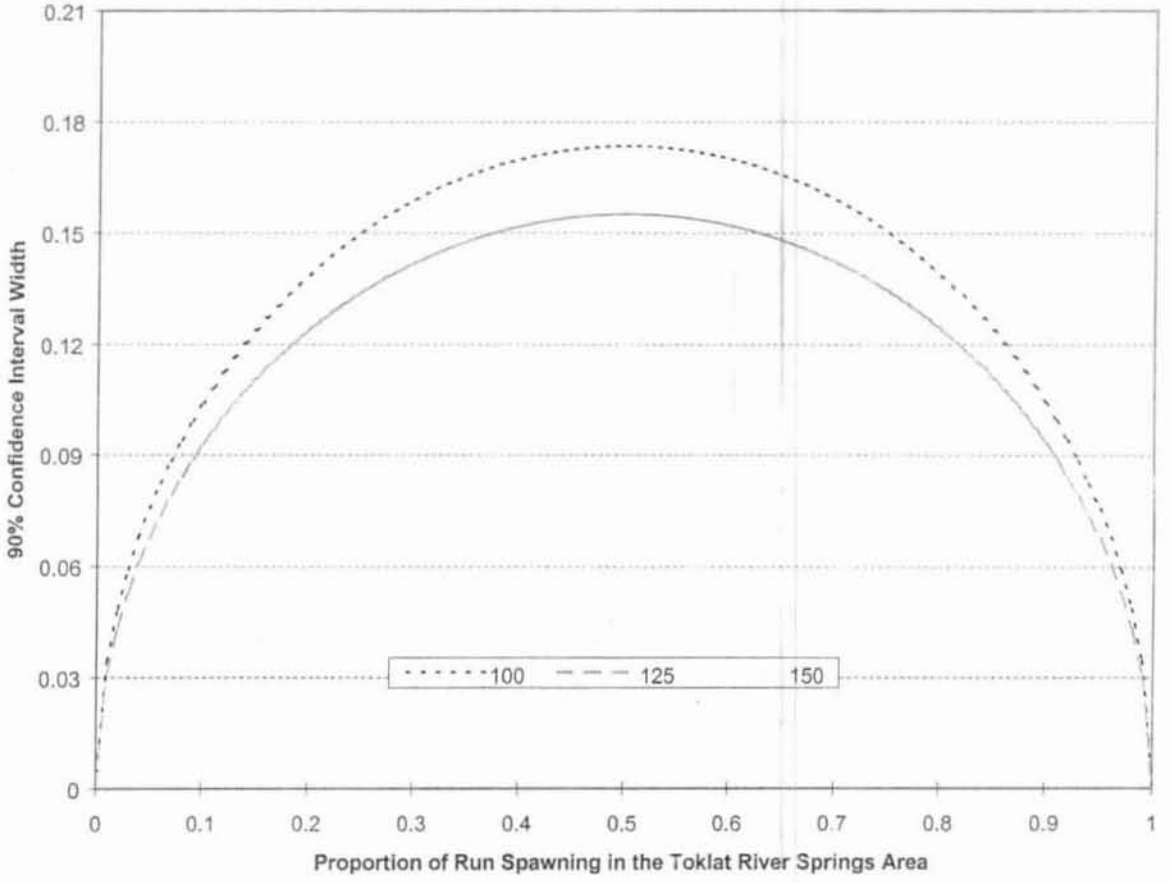


Figure 3. Width of a 90% confidence interval for a binomial proportion for selected sample sizes, assuming a ten percent rate of data loss because of mortality, tag loss, or fish leaving the study area.

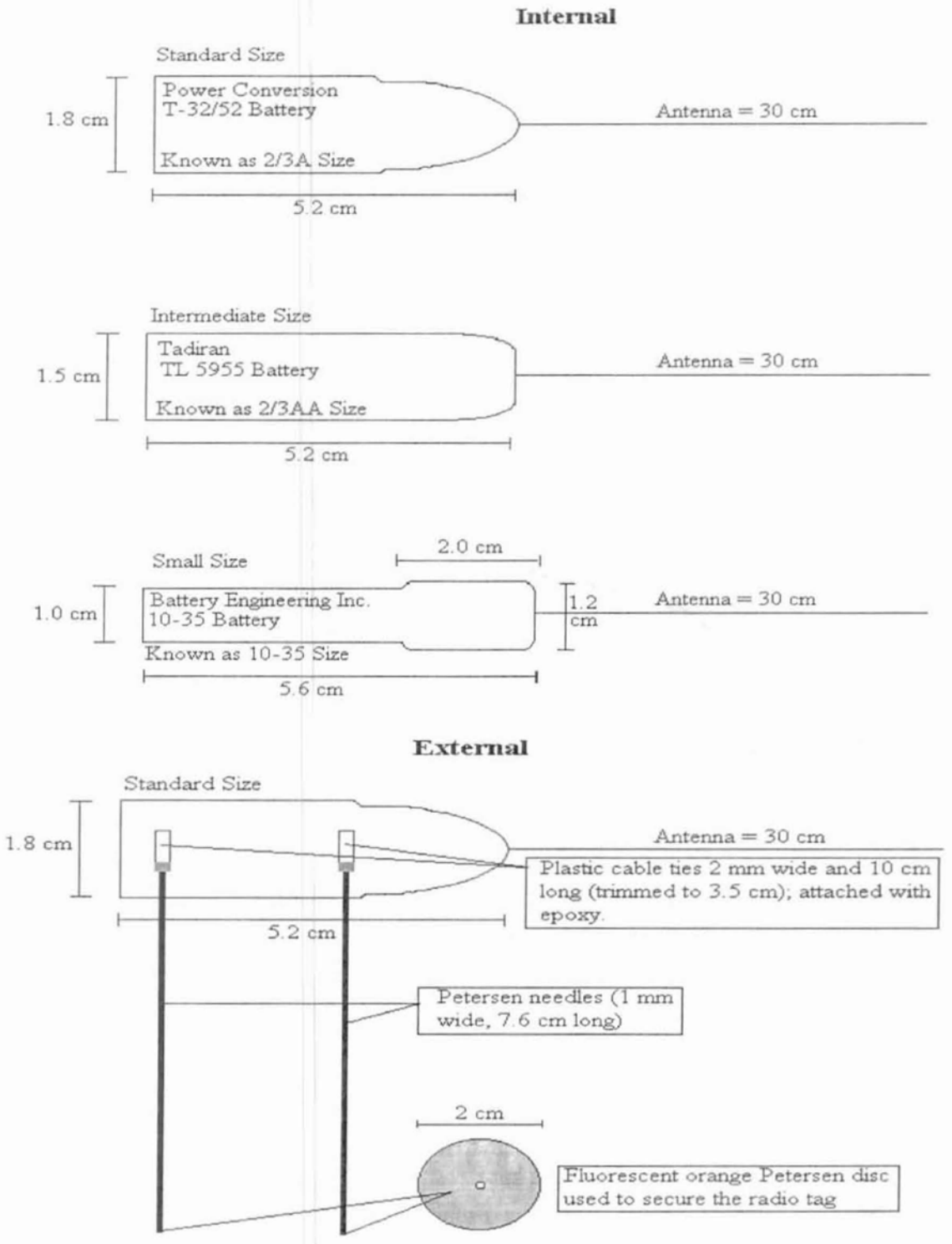


Figure 4. Illustration showing the three radio transmitter designs deployed internally and modification of the 2/3A transmitter for external application on Toklat River fall chum salmon in 1997.

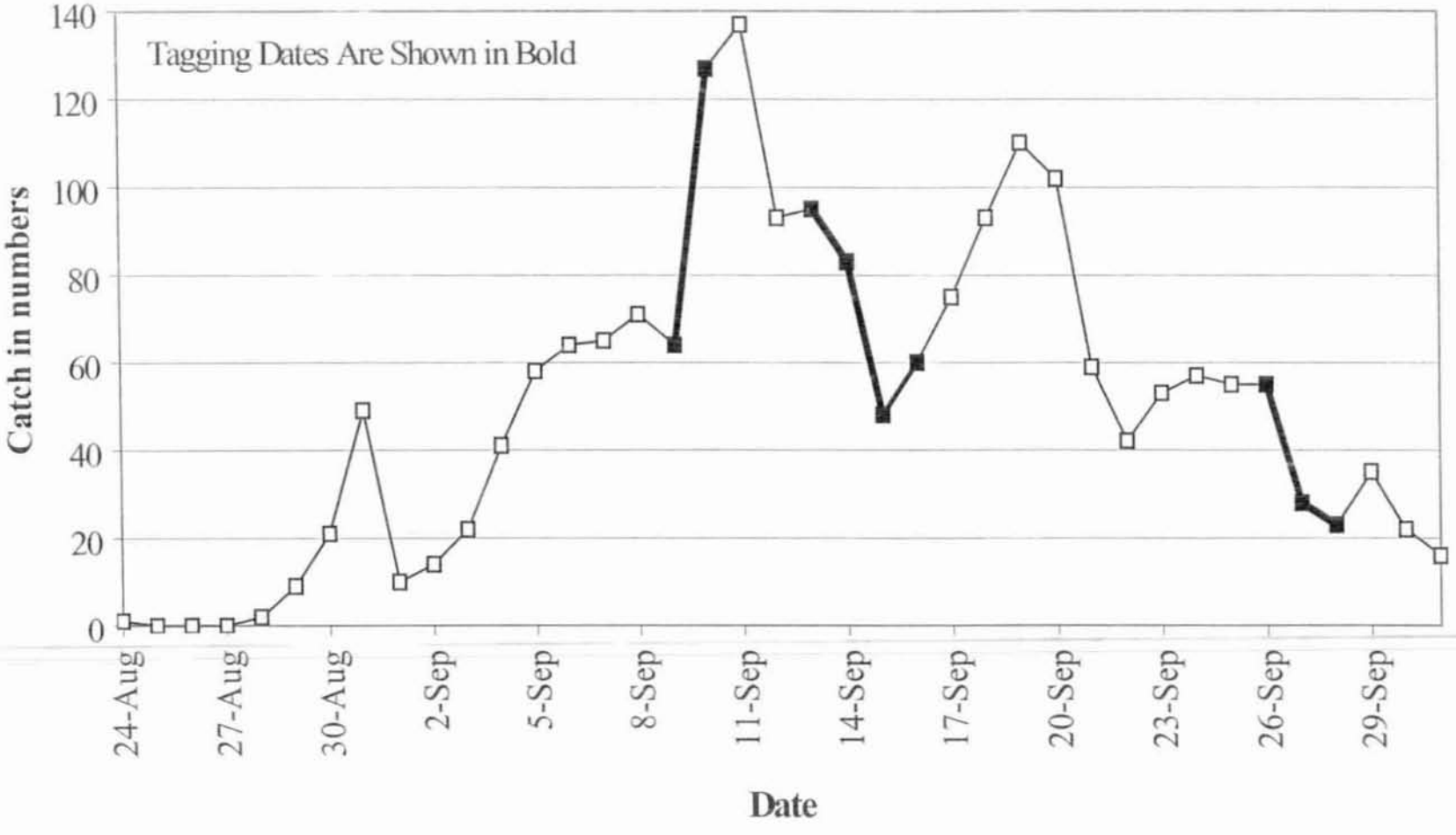


Figure 5. The relationship of the 1997 fall chum salmon catches in fish wheels at the Toklat River coded wire tag recovery camp to radio-tag deployment.

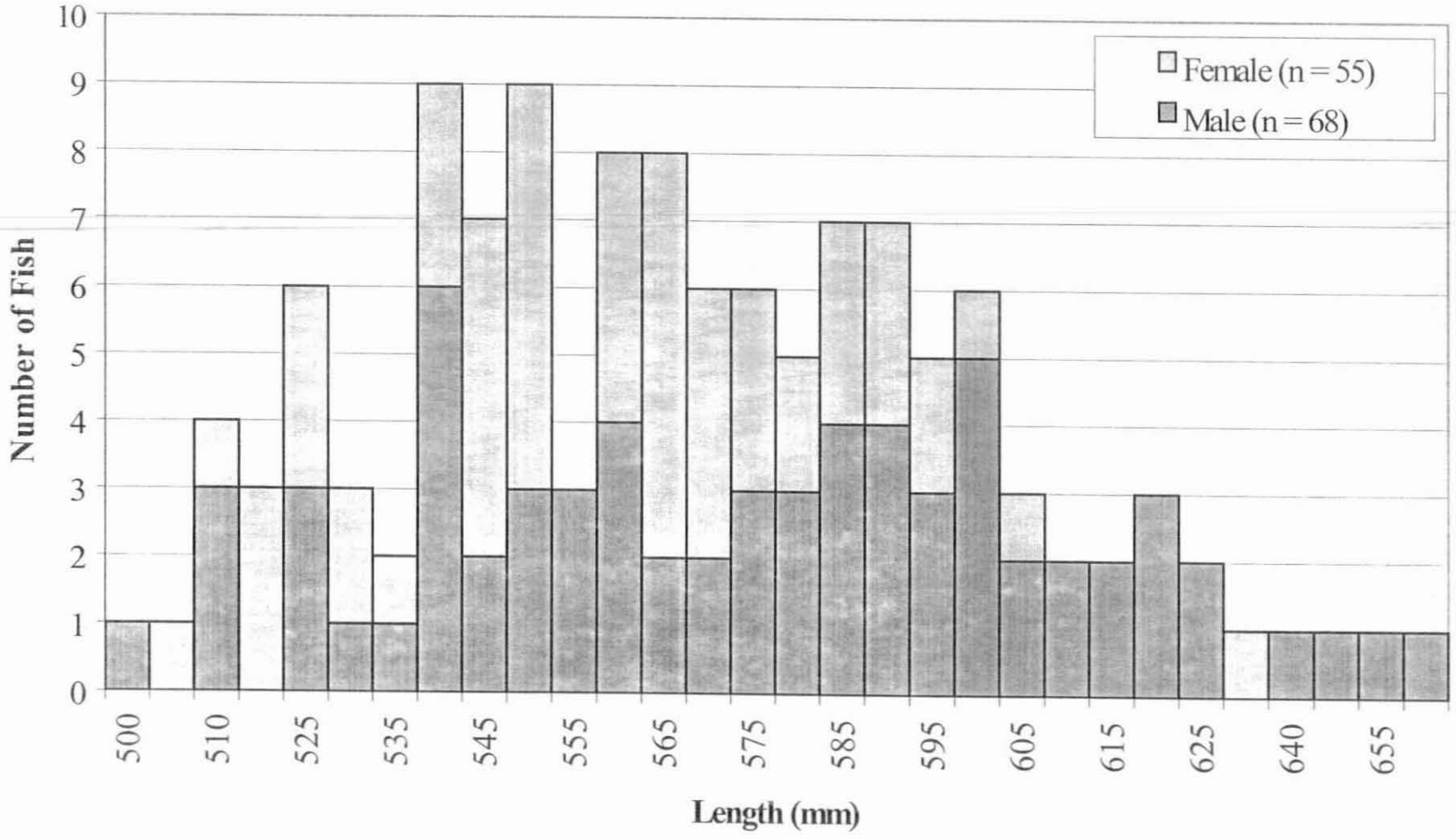
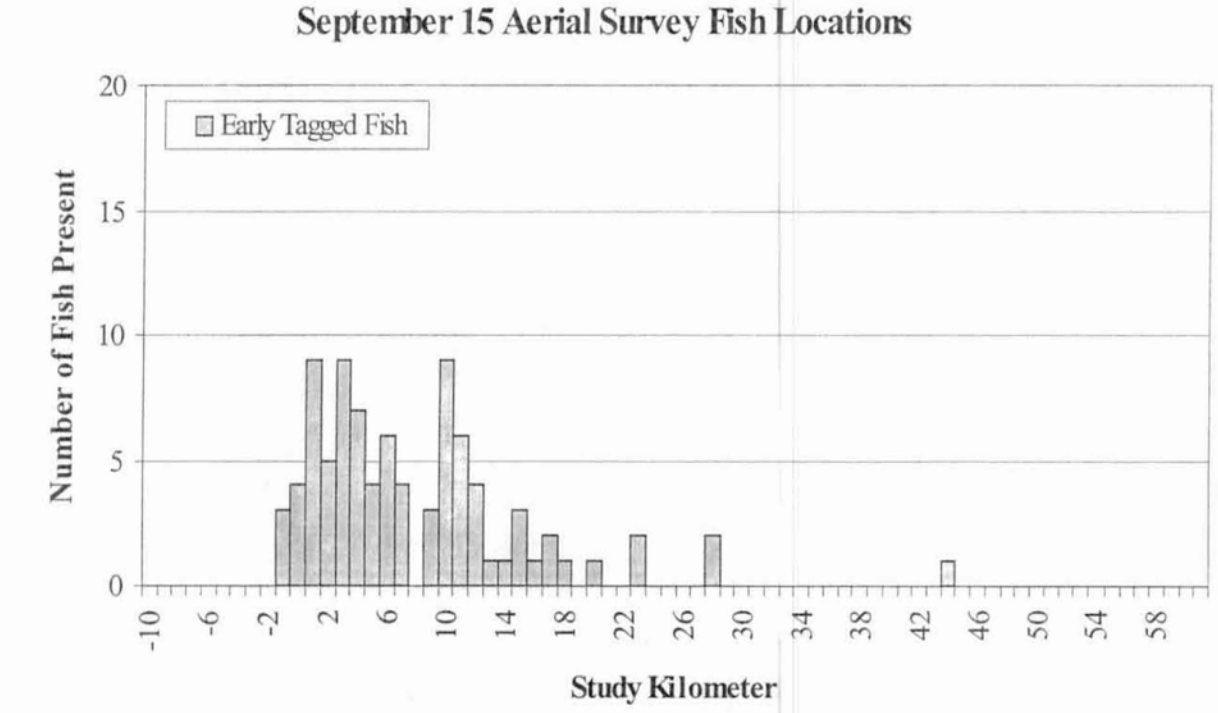


Figure 6. Length distribution of all radio-tagged Toklat River fall chum salmon in 1997.



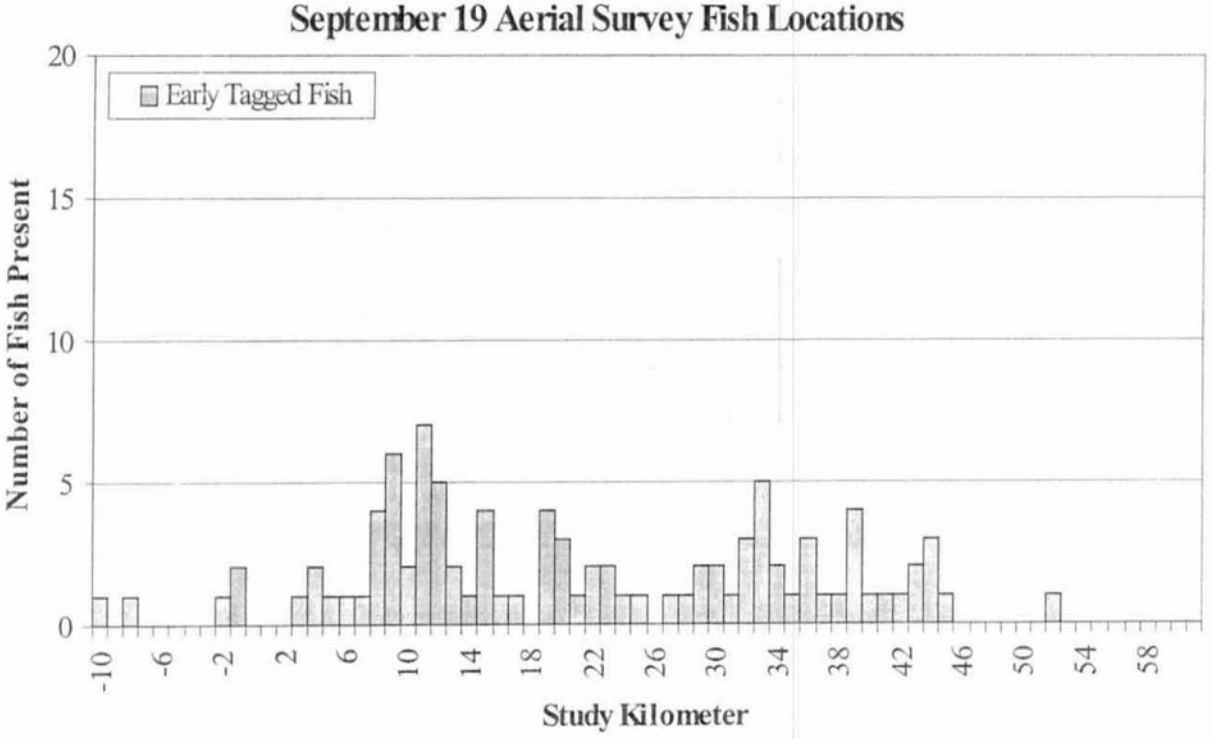
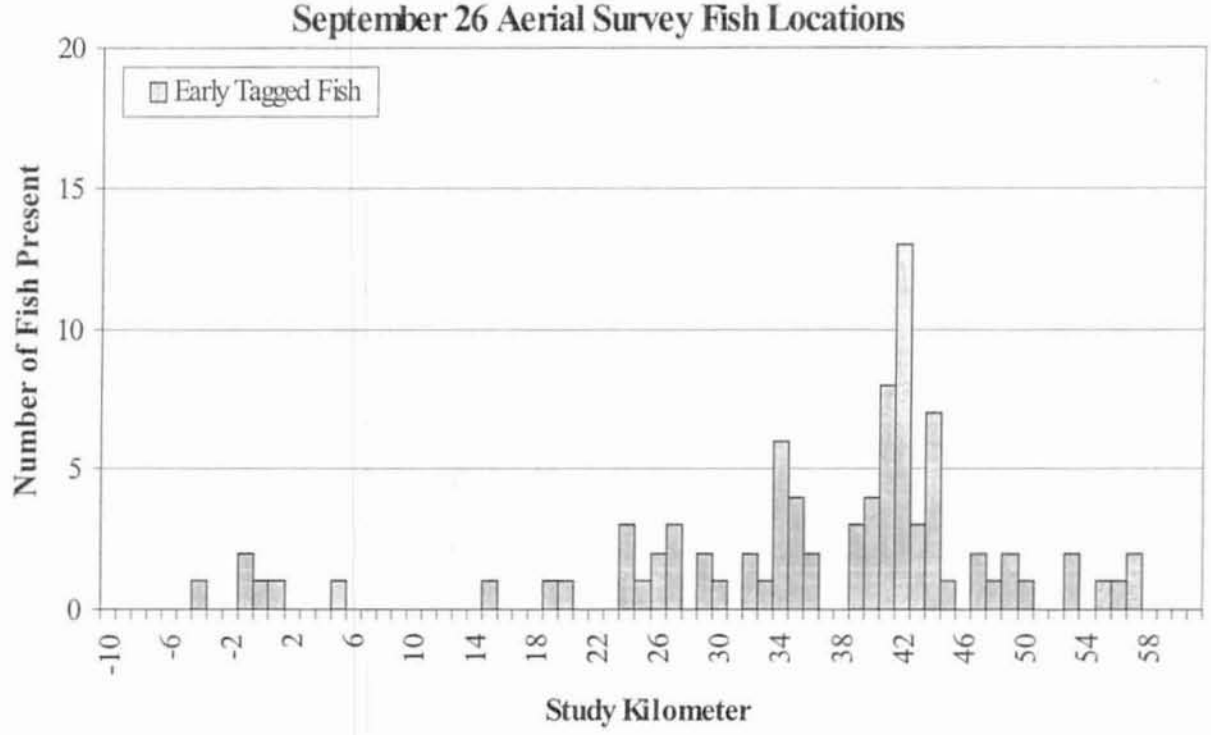


Figure 7. September 15 and 19 aerial survey flights documenting the study kilometer locations of Toklat River radio-tagged fall chum salmon in 1997.



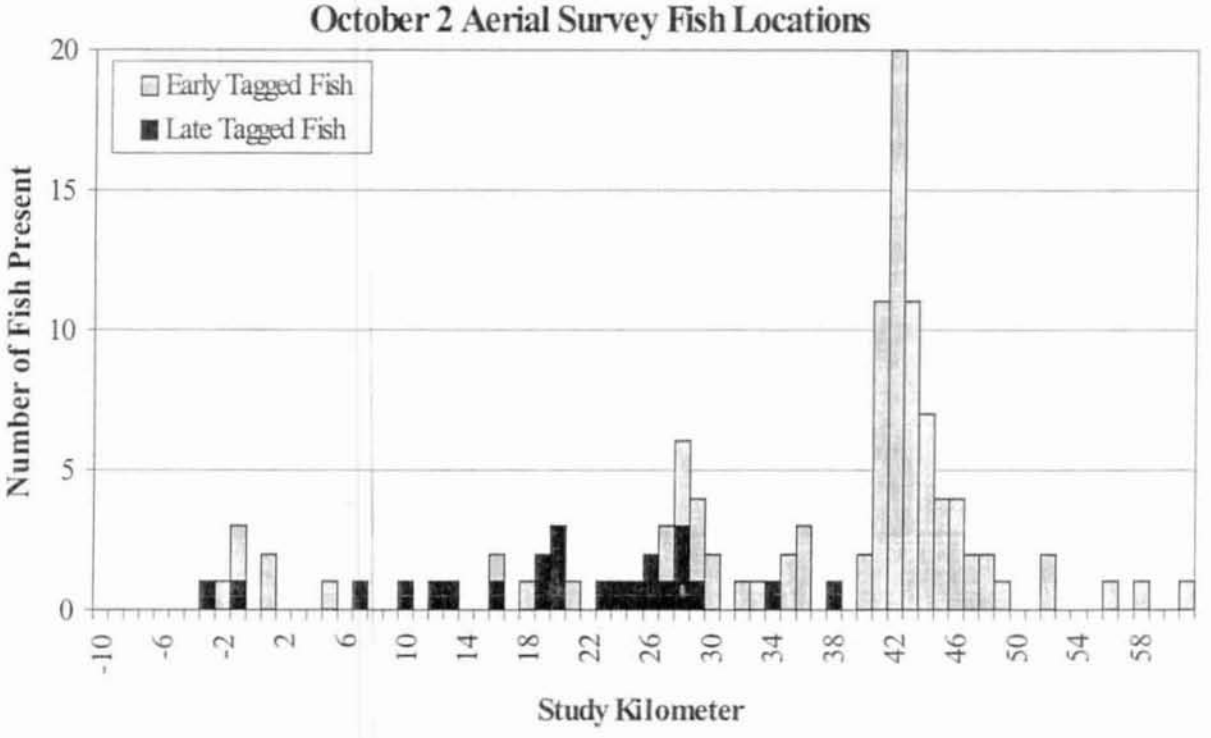


Figure 8. September 26 and October 2 aerial survey flights documenting the study kilometer locations of Toklat River radio-tagged fall chum salmon in 1997.

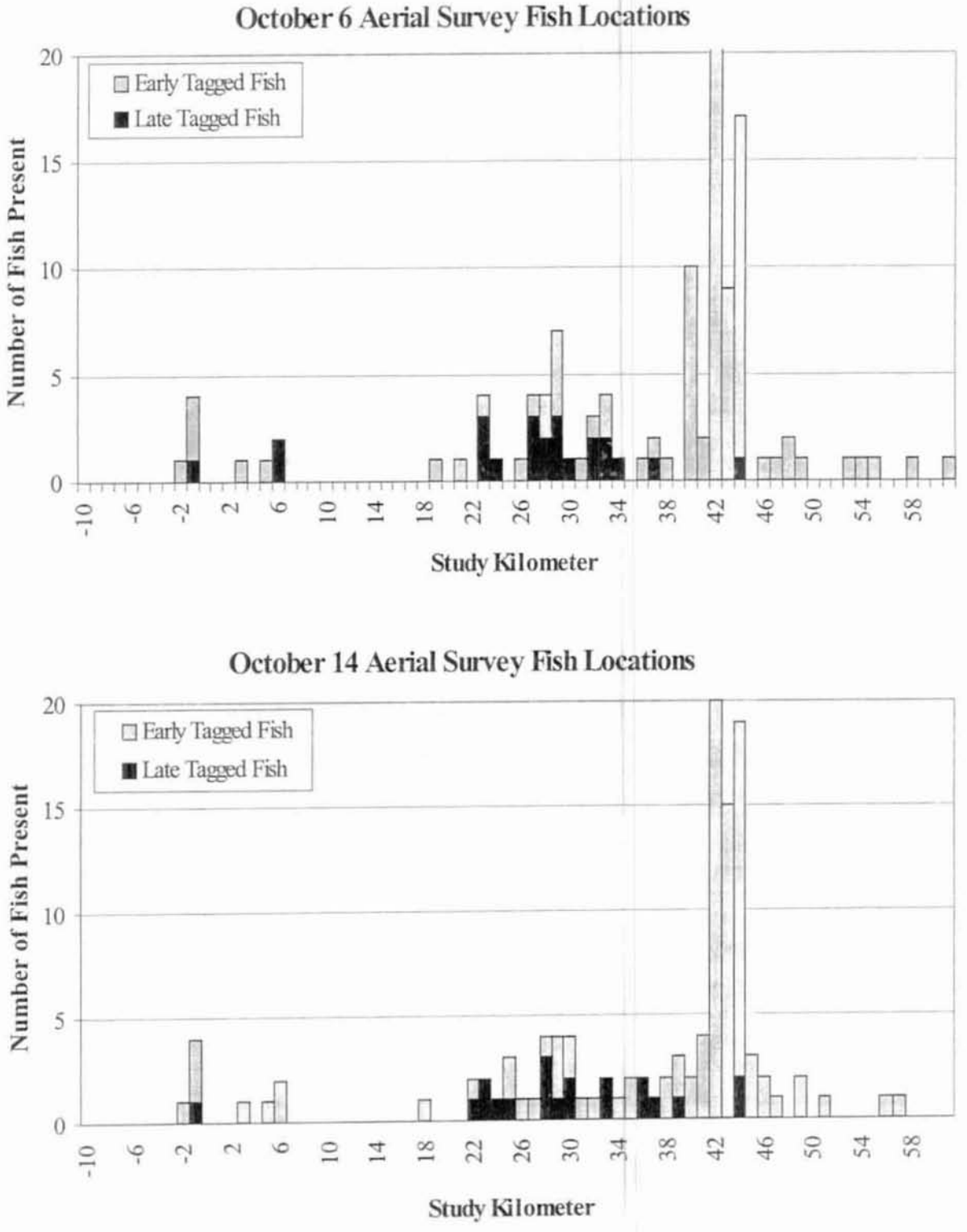
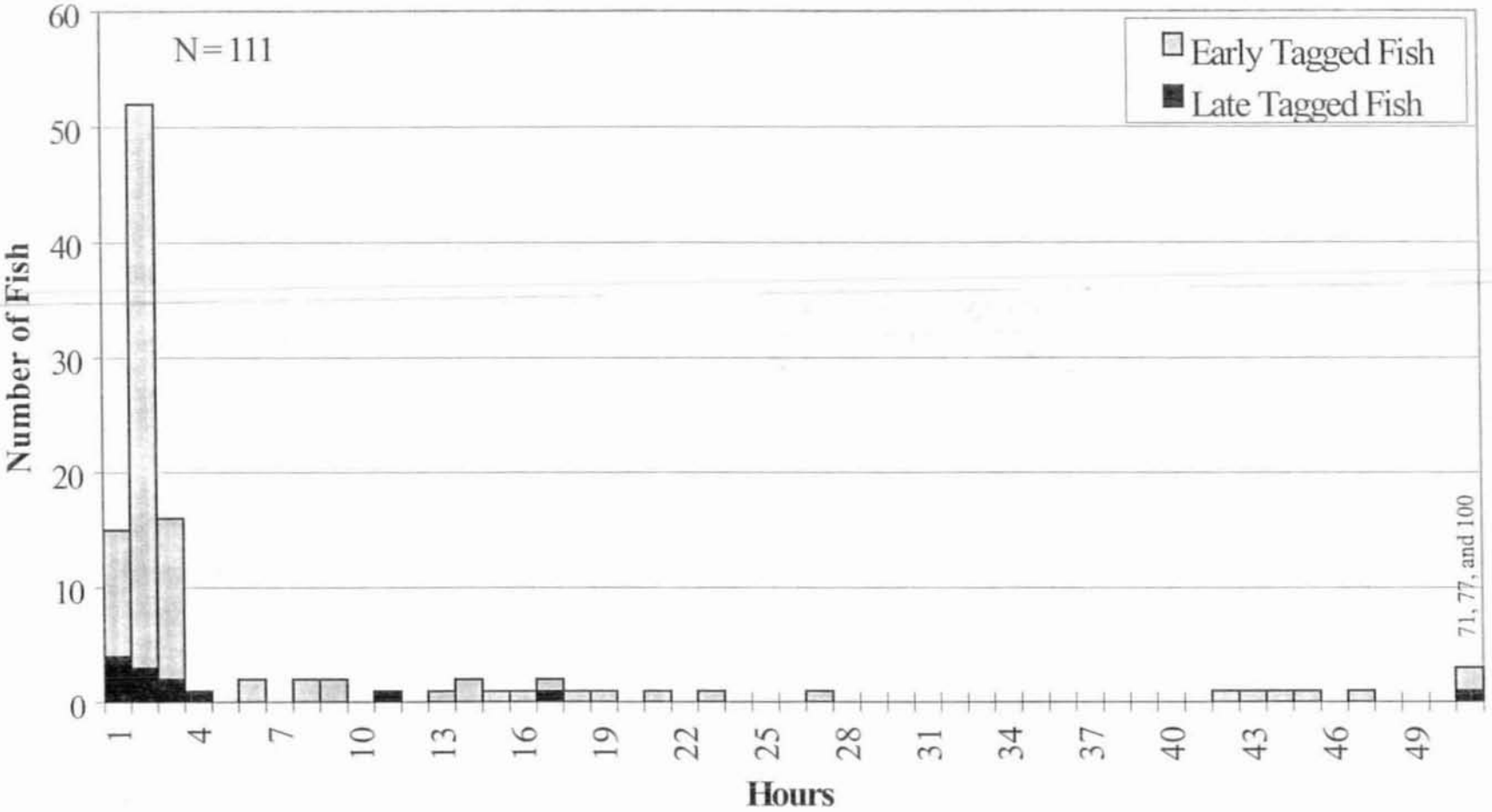


Figure 9. October 6 and 14 aerial survey flights documenting the study kilometer locations of Toklat River radio-tagged fall chum salmon in 1997.



* 106 fish passed the stationary recorder but 152.644 (code 10) passed on 4 occasions and 153.064 (code 13) passed on 3 occasions for a total of 111 occurences.

Figure 10. The number of hours that each migrating radio-tagged Toklat River fall chum salmon was detected by the stationary receiver at study kilometer 11 in 1997.

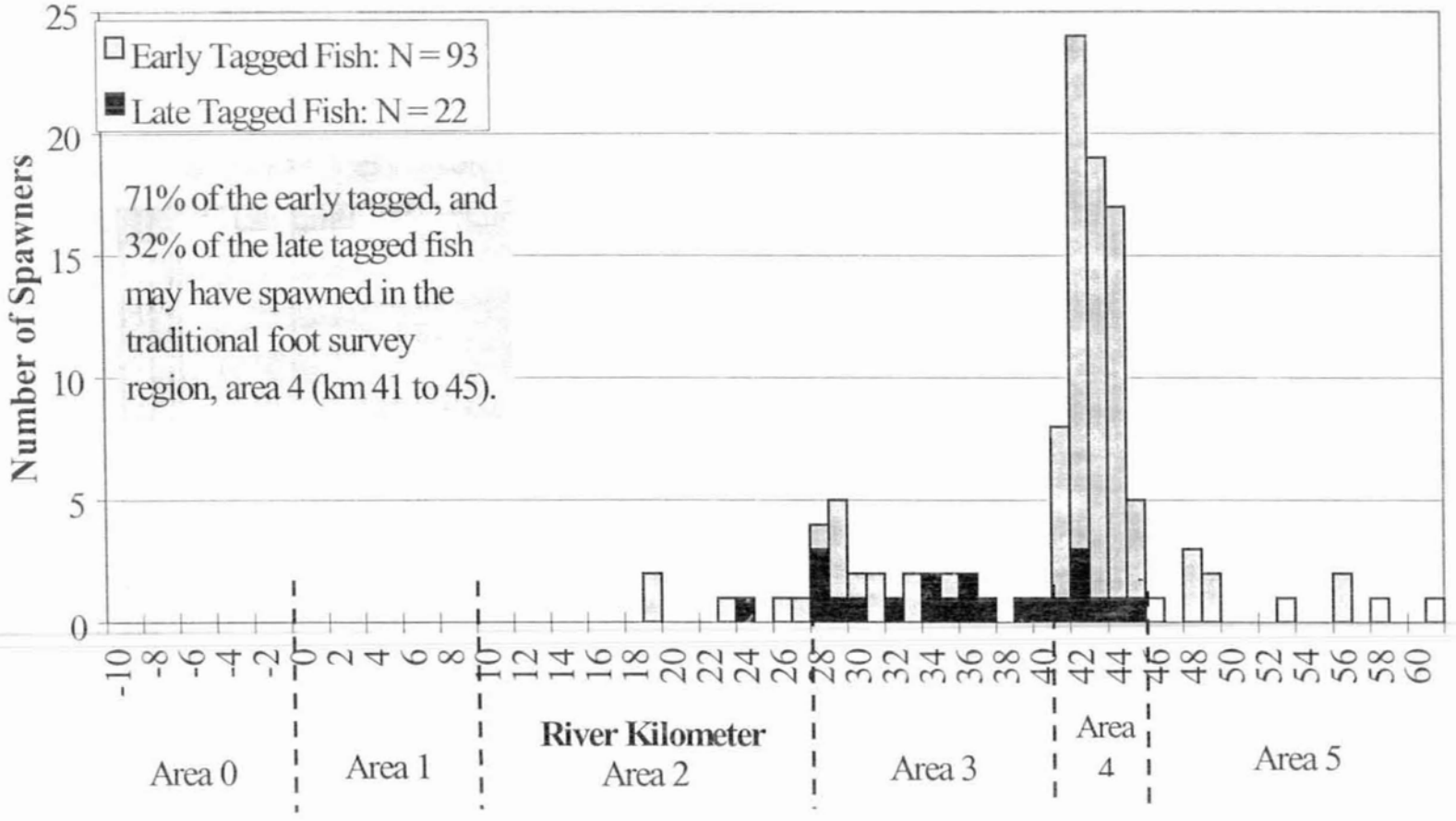


Figure 11. The estimated spawning locations of 115 radio-tagged Toklat River fall chum salmon in 1997.

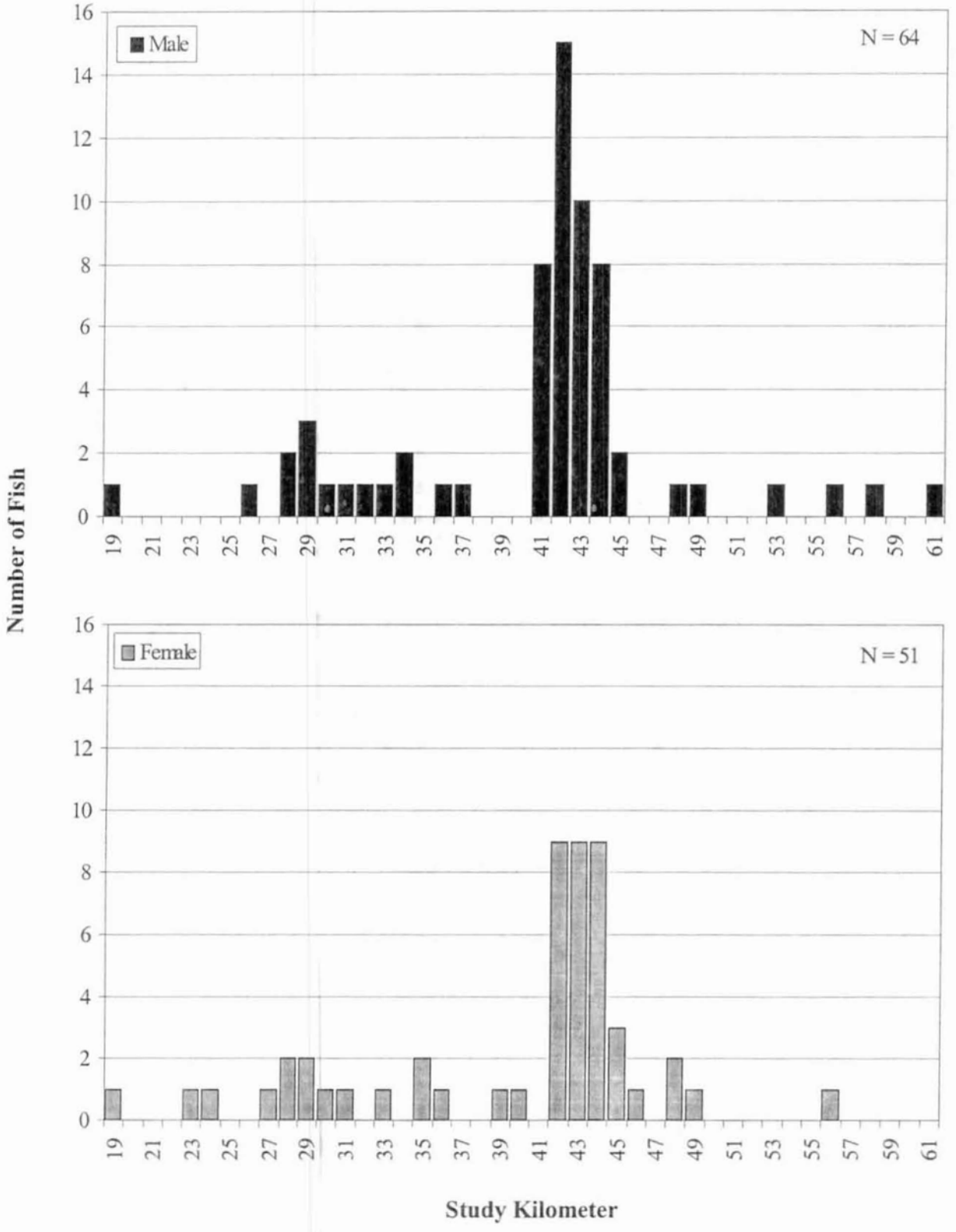


Figure 12. The estimated spawning locations of 115 radio-tagged Toklat River fall chum salmon in 1997, grouped by sex (64 males, top graph and 51 females, bottom graph).

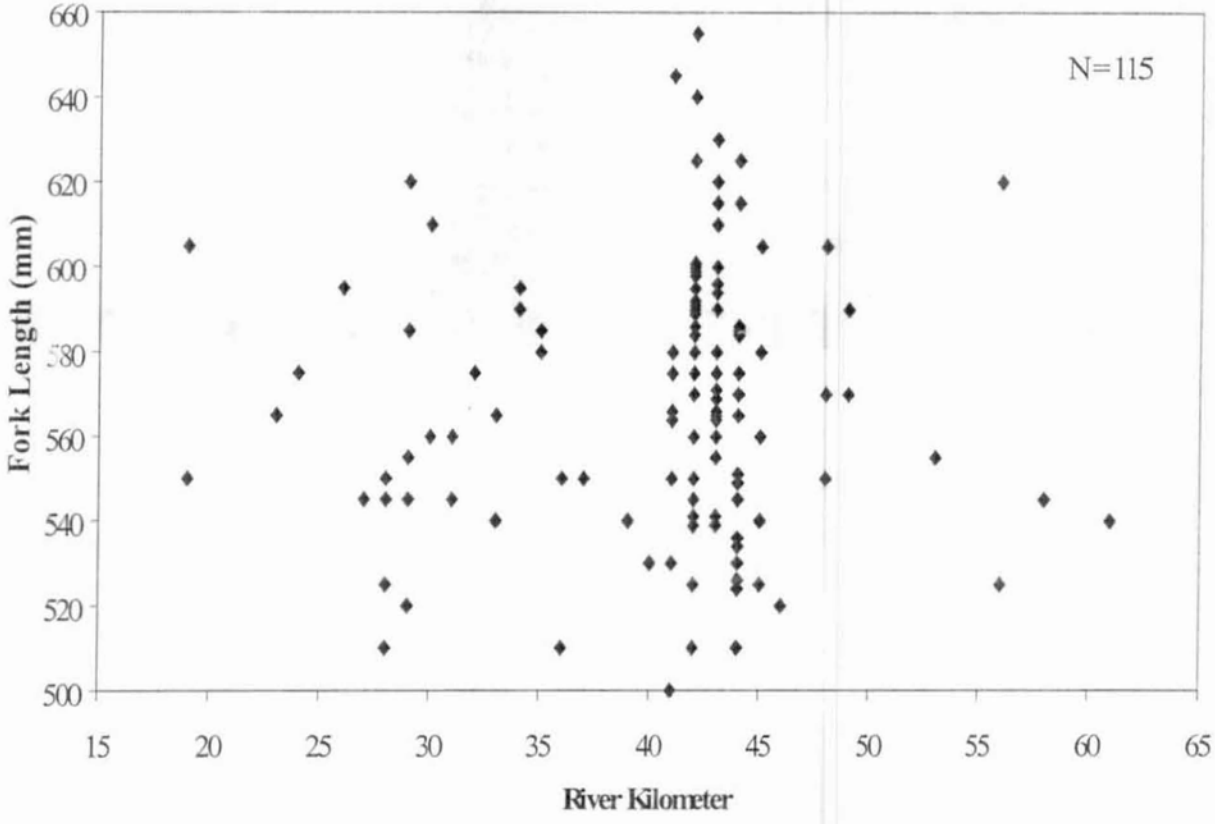


Figure 13. The estimated 1997 Toklat River study kilometer spawning locations of 115 radio-tagged fall chum salmon plotted against fish size.

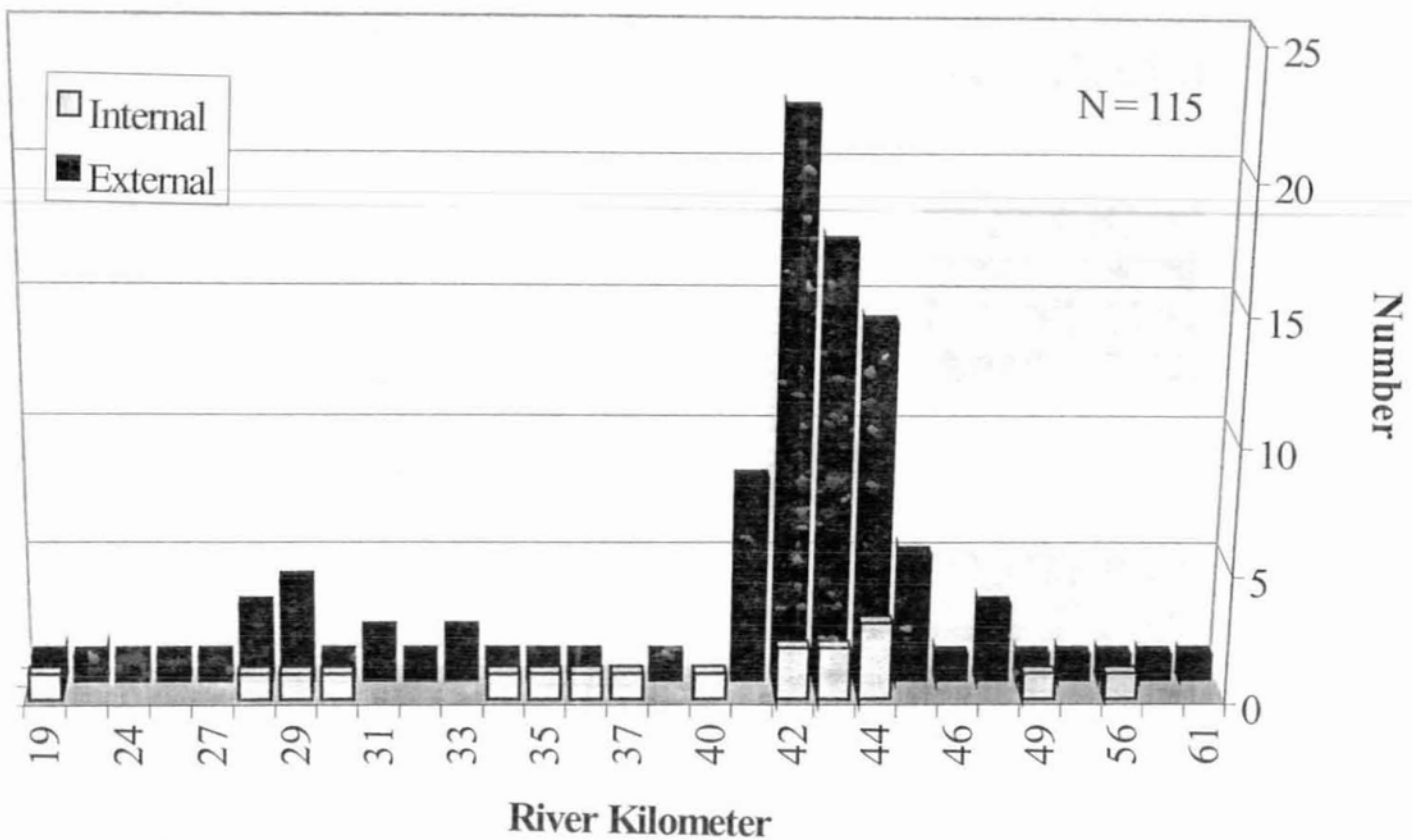


Figure 14. The estimated spawning location of 115 radio-tagged 1997 Toklat River fall chum salmon grouped by internal and external radio tag application.

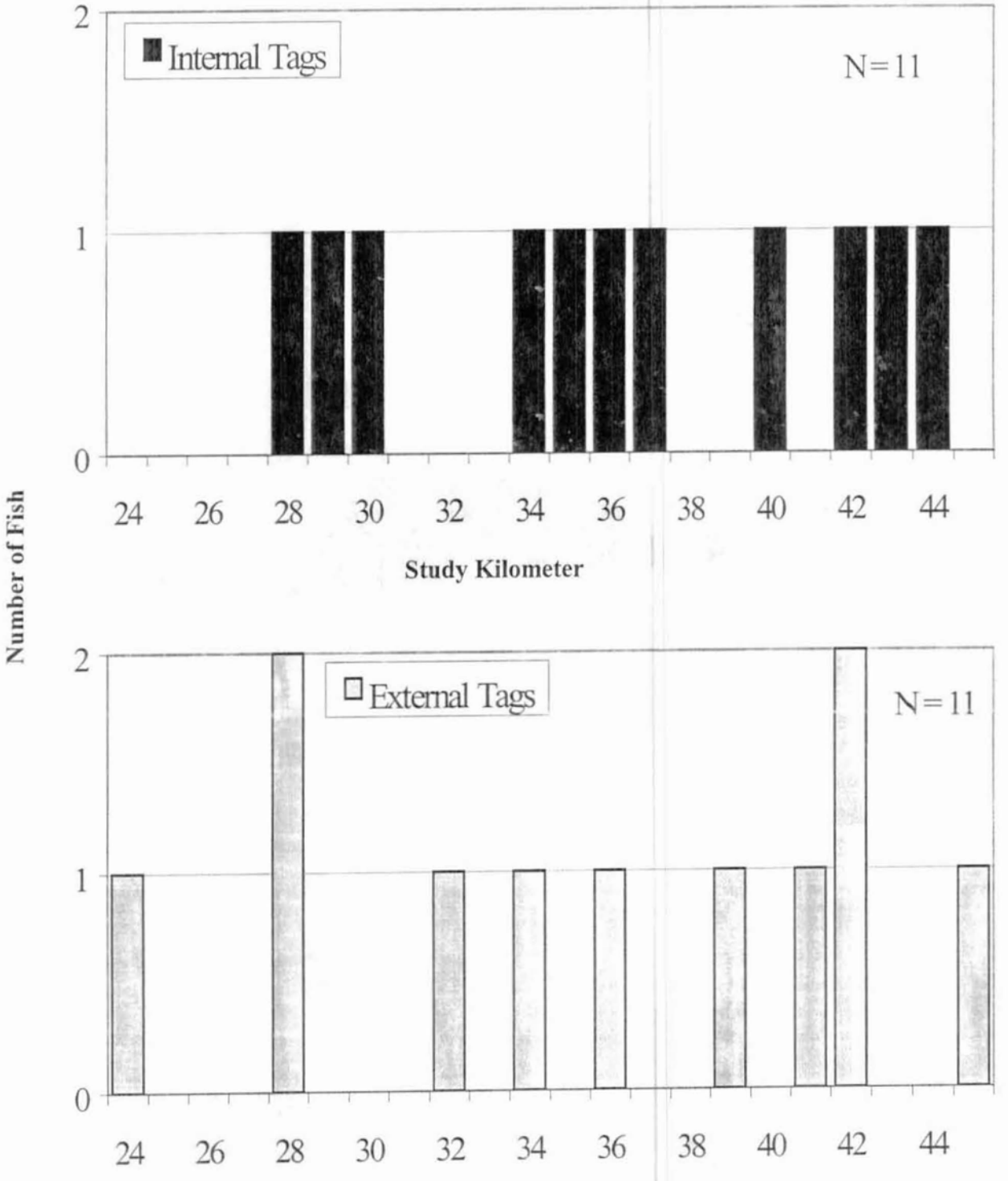


Figure 15. The estimated spawning location of 22 Toklat River fall chum salmon in 1997, radio-tagged September 26-28, grouped by internal versus external radio tag application.

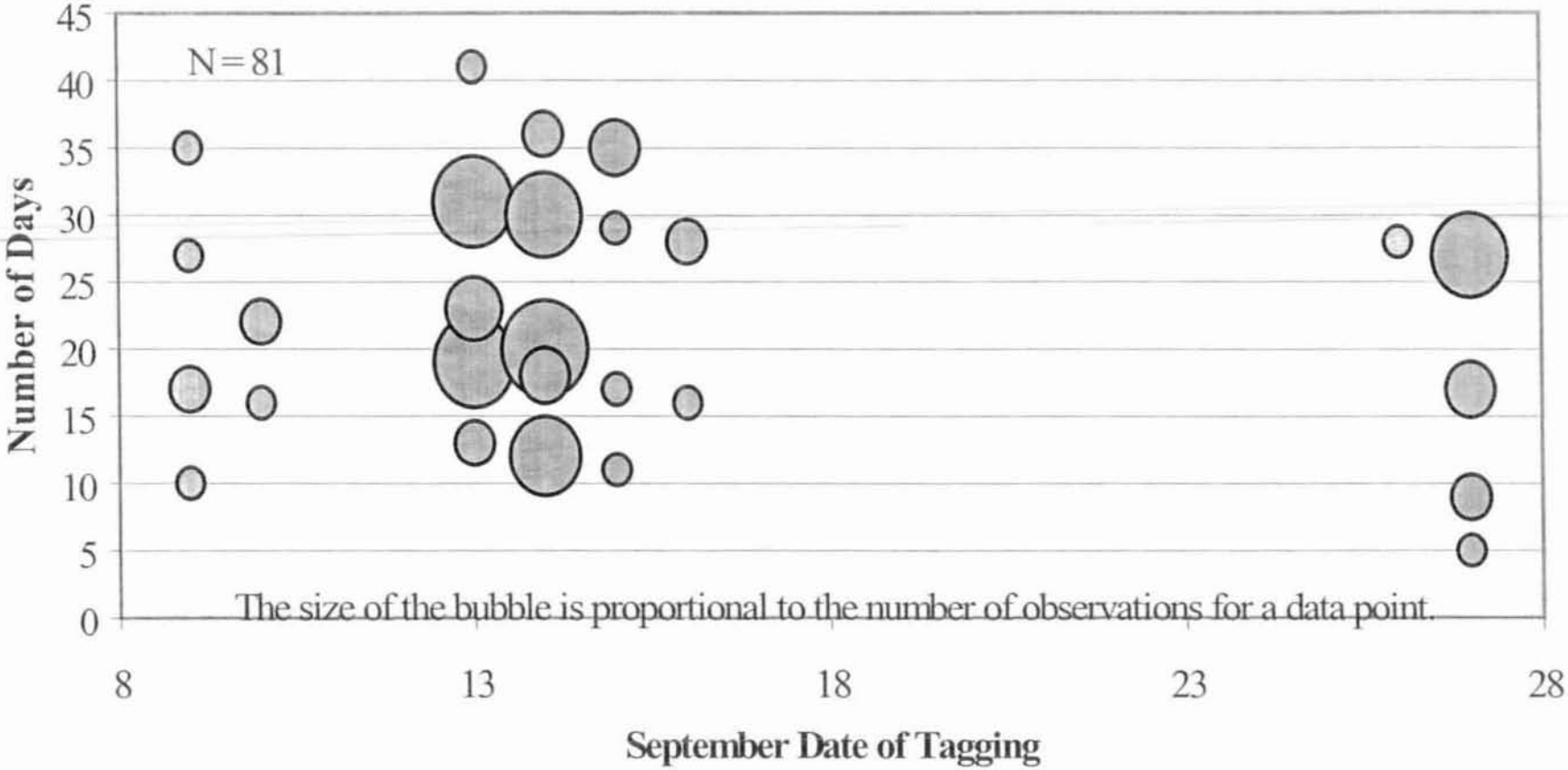


Figure 16. The radio tagging date of 81 Toklat River fall chum salmon plotted against the number of days until a sustained inactivity signal was documented in 1997.

APPENDIX

Appendix A. The tagging and tracking history for all radio-tagged fall chum salmon on the Toklat River in 1997.

Frequency	*Tagging Information*	*Tracking Information*			
		Survey Type	*Date*	*Location*	*Other*
152.222	Tagged at 0950 on 9-Sep	Boat	09-Sep	Area 0, km -1	
Code 10	Standard Size Internal Tag	Boat	09-Sep	Area 0, km -1	
1	Male	Boat	09-Sep	Area 0, km -1	
	560 mm	Boat	09-Sep	Area 0, km -1	
	Tagged fresh off the fish wheel	Boat	10-Sep	Area 0, km -1	
		Boat	10-Sep	Area 0, km -1	
		Boat	10-Sep	Area 0, km -1	
		Helicopter	15-Sep	Area 0, km -1	
		Helicopter	19-Sep	Area 0, km -1	
		Helicopter	26-Sep	Area 0, km -1	
		Helicopter	02-Oct	Area 0, km -1	
		Helicopter	06-Oct	Area 0, km -1	
*	*This tag was likely regurgitated*	Helicopter	14-Oct		Not located
	near the fish wheel.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.252	Tagged at 1651 on 9-Sep	Boat	09-Sep	Area 1, km 0	
Code 10	Standard Size Internal Tag	Boat	09-Sep	Area 1, km 3	
2	Male	Boat	10-Sep	Area 1, km 9	
	620 mm	Station	10-Sep	Area 2, km 11	
	In live box less < 6 hours	Helicopter	15-Sep	Area 4, km 44	
		Helicopter	19-Sep	Area 5, km 52	
		Helicopter	26-Sep	Area 5, km 56	Mortality signal detected
		Helicopter	02-Oct	Area 5, km 56	
		Helicopter	06-Oct	Area 5, km 55	Mortality signal detected
*	*Estimated spawning location*	Helicopter	14-Oct	Area 5, km 51	Mortality signal detected
	is km 56.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.282	Tagged at 1645 on 9-Sep	Boat	09-Sep	Area 0, km -1	
Code 10	Standard Size Internal Tag	Boat	09-Sep	Area 0, km -1	
3	Female	Boat	09-Sep	Area 0, km -1	
	560 mm	Boat	10-Sep	Area 0, km -1	
	In live box less < 6 hours	Boat	10-Sep	Area 0, km -1	
		Boat	10-Sep	Area 0, km -1	
		Boat	10-Sep	Area 0, km -1	
		Helicopter	15-Sep	Area 0, km -1	
		Helicopter	19-Sep	Area 0, km -1	
		Helicopter	26-Sep	Area 0, km -1	
		Helicopter	02-Oct	Area 0, km -1	
		Helicopter	06-Oct	Area 0, km -1	
*	*This tag was likely regurgitated*	Helicopter	14-Oct		Not located
	near the fish wheel.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.314	Tagged at 1655 on 9-Sep	Boat	09-Sep	Area 1, km 0	
Code 10	Standard Size Internal Tag	Boat	09-Sep	Area 1, km 0	
4	Female	Boat	10-Sep	Area 1, km 8	
	550 mm	Station	11-Sep	Area 2, km 11	
	In live box less < 6 hours	Helicopter	15-Sep	Area 2, km 23	
		Helicopter	19-Sep	Area 4, km 43	
		Helicopter	26-Sep	Area 4, km 44	
		Helicopter	02-Oct	Area 4, km 45	
		Helicopter	06-Oct	Area 4, km 44	
		Helicopter	14-Oct	Area 4, km 44	
*	*Estimated spawning location*	Ground	15-Oct	Area 4, km 44	
	is km 44.	Helicopter	24-Oct		Did not attempt to locate for this survey

Frequency	*Tagging Information*	*Tracking Information*			
		Survey Type	*Date*	*Location*	*Other*
152.344	Tagged at 1659 on 9-Sep	Boat	09-Sep	Area 1, km 3	
Code 10	Standard Size Internal Tag	Station	10-Sep	Area 2, km 11	
5	Male	Helicopter	15-Sep	Area 3, km 28	
	590 mm	Helicopter	19-Sep	Area 4, km 45	
	In live box less < 6 hours	Helicopter	26-Sep	Area 4, km 41	
		Helicopter	02-Oct	Area 4, km 42	
		Helicopter	06-Oct	Area 4, km 42	Mortality signal detected
		Helicopter	14-Oct	Area 4, km 42	Mortality signal detected
		Ground	15-Oct	Area 4, km 42	
*	*Estimated spawning location*	Ground	20-Oct	Area 4, km 42	
	is km 42.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.375	Tagged at 1702 on 9-Sep	Boat	09-Sep	Area 0, km -1	
Code 10	Standard Size Internal Tag	Boat	09-Sep	Area 1, km 1	
6	Male	Boat	10-Sep	Area 1, km 1	
	570 mm	Boat	11-Sep	Area 1, km 9	
	In live box less < 6 hours	Station	11-Sep	Area 2, km 11	
		Helicopter	15-Sep		Not located
		Helicopter	19-Sep	Area 4, km 44	
		Helicopter	26-Sep	Area 4, km 42	
		Helicopter	02-Oct	Area 5, km 46	
		Helicopter	06-Oct	Area 3, km 40	
*	*Estimated spawning location*	Helicopter	14-Oct	Area 3, km 32	Mortality signal detected
	is km 44.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.403	Tagged at 1706 on 9-Sep	Boat	09-Sep	Area 0, km -1	
Code 10	Standard Size Internal Tag	Boat	10-Sep	Area 0, km -1	
7	Male	Boat	10-Sep	Area 0, km -1	
	540 mm	Boat	10-Sep	Area 0, km -1	
	In live box less < 6 hours	Boat	10-Sep	Area 0, km -1	
		Helicopter	15-Sep	Area 1, km 0	
		Helicopter	19-Sep	Area 0, km -2	Mortality signal detected
		Helicopter	26-Sep	Area 1, km 0	Mortality signal detected
		Helicopter	02-Oct	Area 1, km 1	Mortality signal detected
		Helicopter	06-Oct	Area 0, km -1	Mortality signal detected
*	*This tag was likely regurgitated*	Helicopter	14-Oct		Not located
	near the fish wheel.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.432	Tagged at 1715 on 9-Sep	Boat	09-Sep	Area 0, km -1	
Code 10	Standard Size Internal Tag	Boat	09-Sep	Area 0, km -1	
8	Female	Boat	10-Sep	Area 0, km -1	
	520 mm	Boat	10-Sep	Area 0, km -1	
	In live box less < 6 hours	Boat	10-Sep	Area 0, km -2	
		Helicopter	15-Sep	Area 1, km 0	
		Helicopter	19-Sep	Area 0, km -8	
		Helicopter	26-Sep	Area 0, km -4	Mortality signal detected
		Helicopter	02-Oct	Area 0, km -2	Mortality signal detected
		Helicopter	06-Oct	Area 0, km -2	Mortality signal detected
*	*This fish likely died near the*	Helicopter	14-Oct		Not located
	fish wheel.	Helicopter	24-Oct		Did not attempt to locate for this survey

Frequency	*Tagging Information*	*Tracking Information*			
		Survey Type	*Date*	*Location*	*Other*
152.463	Tagged at 2050 on 10-Sep	Boat	11-Sep	Area 0, km -2	
Code 10	Standard Size Internal Tag	Station	14-Sep	Area 2, km 11	
9	Female	Helicopter	15-Sep	Area 2, km 15	
	550 mm	Helicopter	19-Sep	Area 2, km 23	
	Released from holding pen	Helicopter	26-Sep	Area 2, km 20	
	after 4.7 hours	Helicopter	02-Oct	Area 2, km 18	Mortality signal detected
		Helicopter	06-Oct	Area 2, km 21	
*	*Estimated spawning location*	Helicopter	14-Oct	Area 2, km 18	Mortality signal detected
	is km 19.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.494	Tagged at 2052 on 10-Sep	Boat	11-Sep	Area 0, km -1	
Code 10	Standard Size Internal Tag	Station	13-Sep	Area 2, km 11	
10	Male	Helicopter	15-Sep	Area 2, km 18	
	570 mm	Helicopter	19-Sep	Area 4, km 43	
	Released from holding pen	Helicopter	26-Sep	Area 5, km 49	Mortality signal detected
	after 4.7 hours	Helicopter	02-Oct	Area 5, km 49	
		Helicopter	06-Oct	Area 5, km 47	Mortality signal detected
*	*Estimated spawning location*	Helicopter	14-Oct	Area 4, km 44	Mortality signal detected
	is km 49.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.524	Tagged at 1900 on 10-Sep	Boat	11-Sep	Area 1, km 1	
Code 10	Standard Size Internal Tag	Station	13-Sep	Area 2, km 11	
11	Male	Helicopter	15-Sep	Area 3, km 28	
	620 mm	Helicopter	19-Sep	Area 3, km 32	
	Escaped from holding tote with	Helicopter	26-Sep		Not located
	intentionally ruptured stomach	Airplane	30-Sep	Area 4, km 43	
	after 1 to 4 hours in captivity.	Helicopter	02-Oct	Area 4, km 42	Mortality signal detected
		Helicopter	06-Oct	Area 4, km 44	Mortality signal detected
*	*Estimated spawning location*	Helicopter	14-Oct	Area 4, km 42	Mortality signal detected
	is km 43.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.554	Tagged at 1115 on 13-Sep	Station	15-Sep	Area 2, km 11	
Code 10	First External Tag Released	Helicopter	15-Sep		Not located
12	Male	Helicopter	19-Sep	Area 3, km 36	
	590 mm	Helicopter	26-Sep	Area 5, km 50	
	In live box less than 1 hour.	Helicopter	02-Oct	Area 4, km 42	
		Helicopter	06-Oct	Area 4, km 42	
		Helicopter	14-Oct	Area 4, km 42	Mortality signal detected
*	*Estimated spawning location*	Ground	15-Oct	Area 4, km 42	
	is km 42.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.584	Tagged at 1118 on 13-Sep	Station	15-Sep	Area 2, km 11	
Code 10	External Tag	Helicopter	15-Sep		Not located
13	Male	Helicopter	19-Sep	Area 3, km 36	
	590 mm	Helicopter	26-Sep	Area 5, km 50	
	In live box less than 1 hour	Helicopter	02-Oct	Area 4, km 42	
		Helicopter	06-Oct	Area 4, km 42	
		Helicopter	14-Oct	Area 4, km 42	Mortality signal detected
*	*Estimated spawning location*	Ground	15-Oct	Area 4, km 42	
	is km 42.	Helicopter	24-Oct		Did not attempt to locate for this survey

Frequency	*Tagging Information*	*Tracking Information*			
		Survey Type	*Date*	*Location*	*Other*
152.614	Tagged at 1122 on 13-Sep	Helicopter	15-Sep	Area 2, km 11	
Code 10	External Tag	Station	16-Sep	Area 2, km 11	
14	Female	Helicopter	19-Sep	Area 3, km 33	
	595 mm	Helicopter	26-Sep	Area 4, km 41	
	In live box less than 1 hour	Helicopter	02-Oct	Area 4, km 43	Mortality signal detected
		Helicopter	06-Oct	Area 4, km 44	
		Helicopter	14-Oct	Area 3, km 38	Mortality signal detected
		Ground	15-Oct	Area 4, km 43	
*	*Estimated spawning location*	Ground	20-Oct	Area 4, km 43	Mortality signal detected
	is km 43.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.644	Tagged at 1230 on 13-Sep	Helicopter	15-Sep	Area 1, km 2	
Code 10	External Tag	Helicopter	19-Sep	Area 1, km 9	
15	Female	Station	24-Sep	Area 2, km 11	
	565 mm	Helicopter	26-Sep	Area 2, km 25	
	In live box less than 1 hour	Helicopter	02-Oct	Area 3, km 28	
		Helicopter	06-Oct	Area 3, km 29	
		Station	10-Oct	Area 2, km 11	Passed station at 0455
		Station	10-Oct	Area 2, km 11	Passed station at 2008
		Station	12-Oct	Area 2, km 11	
		Helicopter	14-Oct		Not located
*	*Estimated spawning location*	Ground	15-Oct	Area 4, km 42	
	is km 43.	Helicopter	24-Oct	Area 4, km 43	Mortality signal detected
152.674	Tagged at 1245 on 13-Sep	Helicopter	15-Sep	Area 1, km 6	
Code 10	External Tag	Station	18-Sep	Area 2, km 11	
16	Female	Helicopter	19-Sep	Area 2, km 19	
	590 mm	Helicopter	26-Sep	Area 4, km 43	
	In live box less than 1 hour	Helicopter	02-Oct	Area 5, km 46	
		Helicopter	06-Oct	Area 5, km 49	Mortality signal detected
		Helicopter	14-Oct	Area 4, km 44	
		Ground	15-Oct	Area 4, km 42	
*	*Estimated spawning location*	Ground	20-Oct	Area 4, km 42	Mortality signal detected
	is km 49.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.704	Tagged at 1630 on 13-Sep	Helicopter	15-Sep	Area 1, km 9	
Code 10	External Tag	Station	16-Sep	Area 2, km 11	
17	Female	Helicopter	19-Sep	Area 3, km 29	
	580 mm	Helicopter	26-Sep	Area 3, km 34	Mortality signal detected
	In live box less than 1 hour	Helicopter	02-Oct	Area 3, km 35	Mortality signal detected
	Released upriver 100 m @ 1630	Helicopter	06-Oct	Area 3, km 36	Mortality signal detected
*	*Estimated spawning location*	Helicopter	14-Oct	Area 3, km 35	Mortality signal detected
	is km 35.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.733	Tagged at 1617 on 13-Sep	Station	14-Sep	Area 2, km 11	
Code 10	External Tag	Helicopter	15-Sep	Area 2, km 15	
18	Male	Helicopter	19-Sep	Area 4, km 41	
	540 mm	Helicopter	26-Sep	Area 4, km 44	
	In live box less than 1 hour	Helicopter	02-Oct	Area 4, km 41	Mortality signal detected
	Released upriver 100 m @ 1630	Helicopter	06-Oct	Area 4, km 43	Mortality signal detected
*	*Estimated spawning location*	Helicopter	14-Oct	Area 4, km 42	Mortality signal detected
	is km 42.	Helicopter	24-Oct		Did not attempt to locate for this survey

Frequency	*Tagging Information*	*Tracking Information*			
		Survey Type	*Date*	*Location*	*Other*
152.764	Tagged at 1622 on 13-Sep	Helicopter	15-Sep	Area 2, km 10	
Code 10	External Tag	Station	15-Sep	Area 2, km 11	
19	Female	Helicopter	19-Sep	Area 4, km 44	
	570 mm	Helicopter	26-Sep	Area 4, km 42	
	In live box less than 1 hour	Helicopter	02-Oct	Area 5, km 47	Mortality signal detected
	Released upriver 100 m @ 1630	Helicopter	06-Oct	Area 5, km 48	Mortality signal detected
*	*Estimated spawning location*	Helicopter	14-Oct	Area 5, km 49	Mortality signal detected
	is km 42.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.793	Tagged at 1923 on 13-Sep	Station	15-Sep	Area 2, km 11	
Code 10	External Tag	Helicopter	15-Sep	Area 2, km 14	
20	Female	Helicopter	19-Sep	Area 4, km 44	
	630 mm	Helicopter	26-Sep	Area 5, km 57	
	In live box less than 2.5 hours	Helicopter	02-Oct	Area 4, km 44	
	Released upriver 100 m @ 1955	Helicopter	06-Oct	Area 4, km 42	Mortality signal detected
		Helicopter	14-Oct	Area 4, km 42	Mortality signal detected
*	*Estimated spawning location*	Ground	15-Oct	Area 4, km 43	
	is km 43.	Helicopter	24-Oct	Area 4, km 43	Mortality signal detected
152.823	Tagged at 1928 on 13-Sep	Helicopter	15-Sep	Area 2, km 10	
Code 10	External Tag	Station	16-Sep	Area 2, km 11	
21	Male	Helicopter	19-Sep	Area 4, km 42	
	550 mm	Helicopter	26-Sep	Area 4, km 42	
	In live box less than 2.5 hours	Helicopter	02-Oct	Area 4, km 42	
	Released upriver 100 m @ 1955	Helicopter	06-Oct		Not located
		Helicopter	14-Oct	Area 4, km 42	Mortality signal detected
*	*Estimated spawning location*	Ground	15-Oct	Area 4, km 42	
	is km 42.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.853	Tagged at 1933 on 13-Sep	Helicopter	15-Sep	Area 2, km 12	
Code 10	External Tag	Station	18-Sep	Area 2, km 11	
22	Male	Helicopter	19-Sep	Area 2, km 15	
	575 mm	Helicopter	26-Sep	Area 3, km 40	
	In live box less than 2.5 hours	Helicopter	02-Oct	Area 4, km 42	
	Released upriver 100 m @ 1955	Helicopter	06-Oct	Area 3, km 40	
		Helicopter	14-Oct	Area 3, km 40	Mortality signal detected
*	*Estimated spawning location*	Ground	15-Oct	Area 4, km 42	
	is km 41.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.884	Tagged at 1938 on 13-Sep	Station	15-Sep	Area 2, km 11	
Code 10	External Tag	Helicopter	15-Sep	Area 2, km 11	
23	Male	Helicopter	19-Sep	Area 3, km 39	
	545 mm	Helicopter	26-Sep	Area 5, km 57	
	In live box less than 2.5 hours	Helicopter	02-Oct	Area 5, km 58	Mortality signal detected
	Released upriver 100 m @ 1955	Helicopter	06-Oct	Area 5, km 58	
*	*Estimated spawning location*	Helicopter	14-Oct	Area 5, km 57	Mortality signal detected
	is km 58.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.913	Tagged at 1942 on 13-Sep	Station	15-Sep	Area 2, km 11	
Code 10	External Tag	Helicopter	15-Sep	Area 2, km 17	
24	Male	Helicopter	19-Sep	Area 3, km 39	
	600 mm	Helicopter	26-Sep		Not located
	In live box less than 2.5 hours	Helicopter	02-Oct	Area 4, km 41	
	Released upriver 100 m @ 1955	Helicopter	06-Oct	Area 4, km 42	
*	*Estimated spawning location*	Helicopter	14-Oct	Area 4, km 43	Mortality signal detected
	is km 42.	Helicopter	24-Oct		Did not attempt to locate for this survey

Frequency	*Tagging Information*	*Tracking Information*			
		Survey Type	*Date*	*Location*	*Other*
152.944	Tagged at 1946 on 13-Sep	Station	15-Sep	Area 2, km 11	
Code 10	External Tag	Helicopter	15-Sep	Area 2, km 17	
25	Male	Helicopter	19-Sep	Area 3, km 36	
	615 mm	Helicopter	26-Sep	Area 4, km 42	
	In live box less than 2.5 hours	Helicopter	02-Oct		Not located
	Released upriver 100 m @ 1955	Helicopter	06-Oct	Area 4, km 43	
		Helicopter	14-Oct	Area 4, km 42	Mortality signal detected
*	*Estimated spawning location*	Ground	15-Oct	Area 4, km 43	
	is km 43.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.973	Tagged at 1957 on 13-Sep	Station	14-Sep	Area 2, km 11	
Code 10	External Tag	Helicopter	15-Sep	Area 2, km 23	
26	Female	Helicopter	19-Sep	Area 3, km 30	
	510 mm	Helicopter	26-Sep	Area 2, km 27	
	In live box less than 2.5 hours	Helicopter	02-Oct	Area 3, km 28	Mortality signal detected
	Released upriver 100 m @ 2010	Helicopter	06-Oct	Area 3, km 28	Mortality signal detected
*	*Estimated spawning location*	Helicopter	14-Oct	Area 2, km 27	Mortality signal detected
	is km 28.	Helicopter	24-Oct		Did not attempt to locate for this survey
153.004	Tagged at 1959 on 13-Sep	Station	15-Sep	Area 2, km 11	
Code 10	External Tag	Helicopter	15-Sep	Area 2, km 13	
27	Male	Helicopter	19-Sep	Area 3, km 39	
	590 mm	Helicopter	26-Sep	Area 4, km 42	Mortality signal detected
	In live box less than 2.5 hours	Helicopter	02-Oct	Area 4, km 43	Mortality signal detected
	Released upriver 100 m @ 2010	Helicopter	06-Oct	Area 4, km 42	Mortality signal detected
		Helicopter	14-Oct	Area 4, km 43	Mortality signal detected
*	*Estimated spawning location*	Ground	15-Oct	Area 4, km 43	
	is km 43.	Helicopter	24-Oct		Did not attempt to locate for this survey
153.034	Tagged at 2003 on 13-Sep	Helicopter	15-Sep	Area 1, km 4	
Code 10	External Tag	Helicopter	19-Sep	Area 1, km 9	
28	Female	Station	21-Sep	Area 2, km 11	
	565 mm	Helicopter	26-Sep	Area 2, km 26	
	In live box less than 2.5 hours	Helicopter	02-Oct	Area 3, km 33	
	Released upriver 100 m @ 2010	Helicopter	06-Oct	Area 3, km 32	
*	*Estimated spawning location*	Helicopter	14-Oct	Area 3, km 34	
	is km 33.	Helicopter	24-Oct		Did not attempt to locate for this survey
153.064	Tagged at 2008 on 13-Sep	Helicopter	15-Sep	Area 2, km 12	
Code 10	External Tag	Station	17-Sep	Area 2, km 11	
29	Male	Helicopter	19-Sep	Area 2, km 27	
	585 mm	Helicopter	26-Sep	Area 2, km 27	
	In live box less than 2.5 hours	Helicopter	02-Oct	Area 3, km 29	Mortality signal detected
	Released upriver 100 m @ 2010	Helicopter	06-Oct	Area 3, km 31	Mortality signal detected
*	*Estimated spawning location*	Helicopter	14-Oct	Area 2, km 26	Mortality signal detected
	is km 29.	Helicopter	24-Oct		Did not attempt to locate for this survey
153.093	Tagged at 2011 on 13-Sep	Helicopter	15-Sep	Area 2, km 10	
Code 10	External Tag	Station	17-Sep	Area 2, km 11	
30	Female	Helicopter	19-Sep	Area 2, km 23	
	570 mm	Helicopter	26-Sep		Not located
	In live box less than 2.5 hours	Helicopter	02-Oct	Area 4, km 43	Mortality signal detected
	Released upriver 100 m @ 2010	Helicopter	06-Oct	Area 4, km 44	
*	*Estimated spawning location*	Helicopter	14-Oct	Area 4, km 42	
	is km 43.	Helicopter	24-Oct		Did not attempt to locate for this survey

Frequency	*Tagging Information*	*Tracking Information*			
		Survey Type	*Date*	*Location*	*Other*
153.124	Tagged at 2140 on 13-Sep	Helicopter	15-Sep	Area 2, km 12	
Code 10	External Tag	Station	17-Sep	Area 2, km 11	
31	Male	Helicopter	19-Sep	Area 3, km 28	
	510 mm	Helicopter	26-Sep	Area 4, km 45	
	Fresh caught	Helicopter	02-Oct	Area 4, km 44	
	Released upriver 100 m @ 2200	Helicopter	06-Oct	Area 4, km 43	Mortality signal detected
		Helicopter	14-Oct	Area 4, km 44	
*	*Estimated spawning location*	Ground	15-Oct	Area 4, km 44	
	is km 44.	Helicopter	24-Oct		Did not attempt to locate for this survey
153.153	Tagged at 2150 on 13-Sep	Helicopter	15-Sep	Area 1, km 6	
Code 10	External Tag	Station	18-Sep	Area 2, km 11	
32	Female	Helicopter	19-Sep	Area 2, km 20	
	535 mm	Helicopter	26-Sep	Area 4, km 43	
	Fresh caught	Helicopter	02-Oct	Area 4, km 42	Mortality signal detected
	Released upriver 100 m @ 2200	Helicopter	06-Oct	Area 4, km 44	Mortality signal detected
		Helicopter	14-Oct	Area 4, km 43	Mortality signal detected
		Ground	15-Oct	Area 4, km 44	
*	*Estimated spawning location*	Ground	20-Oct	Area 4, km 44	Mortality signal detected
	is km 44.	Helicopter	24-Oct		Did not attempt to locate for this survey
153.183	Tagged at 2200 on 13-Sep	Station	14-Sep	Area 2, km 11	
Code 10	External Tag	Helicopter	15-Sep	Area 2, km 15	
33	Male	Helicopter	19-Sep	Area 3, km 40	
	595 mm	Helicopter	26-Sep	Area 4, km 41	
	Fresh caught	Helicopter	02-Oct	Area 4, km 42	
	Released upriver 100 m @ 2230	Helicopter	06-Oct	Area 4, km 42	
		Helicopter	14-Oct	Area 4, km 43	Mortality signal detected
		Ground	15-Oct	Area 4, km 42	
*	*Estimated spawning location*	Ground	20-Oct	Area 4, km 42	Mortality signal detected
	is km 42.	Helicopter	24-Oct		Did not attempt to locate for this survey
153.213	Tagged at 2210 on 13-Sep	Helicopter	15-Sep	Area 2, km 10	
Code 10	External Tag	Helicopter	19-Sep	Area 2, km 10	
34	Male	Station	22-Sep	Area 2, km 11	
	655 mm	Helicopter	26-Sep	Area 3, km 39	
	Fresh caught	Helicopter	02-Oct	Area 4, km 41	
	Released upriver 100 m @ 2230	Helicopter	06-Oct	Area 4, km 42	
		Helicopter	14-Oct	Area 4, km 43	Mortality signal detected
*	*Estimated spawning location*	Ground	16-Oct	Area 4, km 42	
	is km 42.	Helicopter	24-Oct		Did not attempt to locate for this survey
153.243	Tagged at 2213 on 13-Sep	Helicopter	15-Sep	Area 1, km 6	
Code 10	External Tag	Helicopter	19-Sep	Area 1, km 6	
35	Male	Helicopter	26-Sep	Area 1, km 6	
	600 mm	Helicopter	02-Oct	Area 1, km 5	
	Fresh caught	Helicopter	06-Oct	Area 1, km 5	
	Released upriver 100 m @ 2230	Helicopter	14-Oct	Area 1, km 5	Not located
*	*This tag was either lost near*	Helicopter	24-Oct		Did not attempt to locate for this survey
	km 5 or the fish died.				

Frequency	*Tagging Information*	*Tracking Information*			
		Survey Type	*Date*	*Location*	*Other*
153.273	Tagged at 2217 on 13-Sep	Station	15-Sep	Area 2, km 11	
Code 10	External Tag	Helicopter	15-Sep	Area 2, km 16	
36	Female	Helicopter	19-Sep	Area 3, km 31	
	550 mm	Helicopter	26-Sep	Area 4, km 44	
	Fresh caught	Helicopter	02-Oct	Area 5, km 48	
	Released upriver 100 m @ 2230	Helicopter	06-Oct	Area 5, km 48	Mortality signal detected
*	*Estimated spawning location*	Helicopter	14-Oct	Area 5, km 49	Mortality signal detected
	is km 48.	Helicopter	24-Oct		Did not attempt to locate for this survey
153.304	Tagged at 2220 on 13-Sep	Station	15-Sep	Area 2, km 11	
Code 10	External Tag	Helicopter	15-Sep	Area 2, km 20	
37	Male	Helicopter	19-Sep	Area 3, km 38	
	540 mm	Helicopter	26-Sep	Area 4, km 42	
	Fresh caught	Helicopter	02-Oct	Area 4, km 42	Mortality signal detected
	Released upriver 100 m @ 2230	Helicopter	06-Oct	Area 4, km 43	
		Helicopter	14-Oct	Area 4, km 43	
*	*Estimated spawning location*	Ground	15-Oct	Area 4, km 43	
	is km 43.	Helicopter	24-Oct		Did not attempt to locate for this survey
153.333	Tagged at 2230 on 13-Sep	Helicopter	15-Sep	Area 2, km 12	
Code 10	External Tag	Station	17-Sep	Area 2, km 11	
38	Male	Helicopter	19-Sep	Area 2, km 19	
	525 mm	Helicopter	26-Sep	Area 3, km 35	
	Fresh caught	Helicopter	02-Oct		Not located
	Released upriver 100 m @ 2250	Helicopter	06-Oct	Area 4, km 44	
		Helicopter	14-Oct	Area 4, km 44	
*	*Estimated spawning location*	Ground	15-Oct	Area 4, km 44	
	is km 44.	Helicopter	24-Oct		Did not attempt to locate for this survey
153.363	Tagged at 2233 on 13-Sep	Helicopter	15-Sep	Area 1, km 4	
Code 10	External Tag	Helicopter	19-Sep	Area 2, km 11	
39	Female	Station	19-Sep	Area 2, km 11	
	545 mm	Helicopter	26-Sep	Area 4, km 44	
	Fresh caught	Helicopter	02-Oct	Area 4, km 42	Mortality signal detected
	Released upriver 100 m @ 2250	Helicopter	06-Oct	Area 4, km 44	Mortality signal detected
*	*Estimated spawning location*	Helicopter	14-Oct	Area 4, km 44	Mortality signal detected
	is km 44.	Helicopter	24-Oct		Did not attempt to locate for this survey
153.393	Tagged at 2050 on 14-Sep	Helicopter	15-Sep	Area 0, km -1	
Code 10	External Tag	Helicopter	19-Sep	Area 1, km 4	
40	Male	Station	23-Sep	Area 2, km 11	
	580 mm	Helicopter	26-Sep	Area 3, km 34	
	In live box less than 2 hours	Helicopter	02-Oct	Area 4, km 42	
	Released upriver 100 m @ 2115	Helicopter	06-Oct	Area 4, km 42	
*	*Estimated spawning location*	Helicopter	14-Oct	Area 4, km 42	Mortality signal detected
	is km 42.	Helicopter	24-Oct		Did not attempt to locate for this survey
153.424	Tagged at 2239 on 13-Sep	Helicopter	15-Sep	Area 1, km 7	
Code 10	External Tag	Helicopter	19-Sep	Area 2, km 11	
41	Male	Station	20-Sep	Area 2. km 11	
	600 mm	Helicopter	26-Sep	Area 3, km 34	
	Fresh caught	Helicopter	02-Oct	Area 3, km 40	
	Released upriver 100 m @ 2250	Helicopter	06-Oct	Area 4, km 42	
*	*Estimated spawning location*	Helicopter	14-Oct	Area 4, km 43	
	is km 42.	Helicopter	24-Oct		Did not attempt to locate for this survey

Frequency	*Tagging Information*	*Tracking Information*			
		Survey Type	*Date*	*Location*	*Other*
153.453	Tagged at 2244 on 13-Sep	Helicopter	15-Sep	Area 2, km 11	
Code 10	External Tag	Station	16-Sep	Area 2, km 11	
42	Female	Helicopter	19-Sep	Area 3, km 35	
	580 mm	Helicopter	26-Sep	Area 4, km 44	
	Fresh caught	Helicopter	02-Oct	Area 4, km 42	
	Released upriver 100 m @ 2250	Helicopter	06-Oct	Area 4, km 43	
*	*Estimated spawning location*	Helicopter	14-Oct	Area 4, km 43	
	is km 43.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.252	Tagged at 945 on 14-Sep	Helicopter	15-Sep	Area 1, km 3	
Code 13	External Tag	Helicopter	19-Sep	Area 2, km 12	
43	Female	Station	19-Sep	Area 2, km 11	
	595 mm	Helicopter	26-Sep	Area 4, km 42	
	In live box less than 1 hour	Helicopter	02-Oct		Not located
	Released upriver 100 m @ 1010	Helicopter	06-Oct	Area 4, km 43	
		Helicopter	14-Oct	Area 4, km 43	
*	*Estimated spawning location*	Ground	15-Oct	Area 4, km 43	
	is km 43.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.282	This transmitter did not work properly and was not used.				
Code 13					
44					
152.314	Tagged at 948 on 14-Sep	Helicopter	15-Sep	Area 1, km 1	
Code 13	External Tag	Helicopter	19-Sep	Area 1, km 9	
45	Female	Station	23-Sep	Area 2, km 11	
	545 mm	Helicopter	26-Sep	Area 3, km 29	
	In live box less than 1 hour	Helicopter	02-Oct	Area 3, km 30	
	Released upriver 100 m @ 1010	Helicopter	06-Oct	Area 3, km 33	
*	*Estimated spawning location*	Helicopter	14-Oct	Area 3, km 30	
	is km 31.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.344	Tagged at 953 on 14-Sep	Helicopter	15-Sep	Area 1, km 5	
Code 13	External Tag	Helicopter	19-Sep	Area 1, km 8	
46	Male	Station	22-Sep	Area 2, km 11	
	600 mm	Helicopter	26-Sep	Area 4, km 41	
	In live box less than 1 hour	Helicopter	02-Oct	Area 4, km 42	
	Released upriver 100 m @ 1010	Helicopter	06-Oct	Area 4, km 42	Mortality signal detected
		Helicopter	14-Oct	Area 4, km 42	Mortality signal detected
		Ground	15-Oct	Area 4, km 42	
*	*Estimated spawning location*	Ground	20-Oct	Area 4, km 42	
	is km 42.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.375	Tagged at 958 on 14-Sep	Helicopter	15-Sep	Area 2, km 10	
Code 13	External Tag	Station	17-Sep	Area 2, km 11	
47	Male	Helicopter	19-Sep	Area 3, km 33	
	615 mm	Helicopter	26-Sep	Area 4, km 44	Mortality signal detected
	In live box less than 1 hour	Helicopter	02-Oct	Area 5, km 47	Mortality signal detected
	Released upriver 100 m @ 1010	Helicopter	06-Oct	Area 4, km 44	Mortality signal detected
		Helicopter	14-Oct	Area 4, km 44	
*	*Estimated spawning location*	Ground	15-Oct	Area 4, km 44	
	is km 44.	Helicopter	24-Oct		Did not attempt to locate for this survey

Frequency	*Tagging Information*	*Tracking Information*			
		Survey Type	*Date*	*Location*	*Other*
152.403	Tagged at 1002 on 14-Sep	Helicopter	15-Sep	Area 2, km 10	
Code 13	External Tag	Station	17-Sep	Area 2, km 11	
48	Female	Helicopter	19-Sep	Area 3, km 34	
	590 mm	Helicopter	26-Sep		Not located
	In live box less than 1 hour	Helicopter	02-Oct	Area 4, km 42	
	Released upriver 100 m @ 1010	Helicopter	06-Oct	Area 4, km 42	
		Helicopter	14-Oct	Area 4, km 43	Mortality signal detected
*	*Estimated spawning location*	Ground	15-Oct	Area 4, km 42	
	is km 42.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.432	Tagged at 1010 on 14-Sep	Helicopter	15-Sep	Area 1, km 3	
Code 13	External Tag	Station	19-Sep	Area 2, km 11	
49	Female	Helicopter	19-Sep	Area 2, km 16	
	575 mm	Helicopter	26-Sep		Not located
	In live box less than 1 hour	Helicopter	02-Oct	Area 4, km 45	
	Released upriver 100 m @ 1010	Helicopter	06-Oct	Area 3, km 40	
		Helicopter	14-Oct	Area 3, km 38	Mortality signal detected
		Ground	15-Oct	Area 4, km 42	
*	*Estimated spawning location*	Ground	20-Oct	Area 4, km 42	Mortality signal detected
	is km 42.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.463	Tagged at 1018 on 14-Sep	Helicopter	15-Sep	Area 1, km 9	
Code 13	External Tag	Station	16-Sep	Area 2, km 11	
50	Male	Helicopter	19-Sep	Area 2, km 13	
	580 mm	Helicopter	26-Sep		Not located
	In live box less than 1 hour	Helicopter	02-Oct	Area 4, km 41	Mortality signal detected
	Released upriver 100 m @ 1040	Helicopter	06-Oct		Not located
*	*Estimated spawning location*	Helicopter	14-Oct	Area 4, km 41	Mortality signal detected
	is km 41.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.494	Tagged at 1244 on 14-Sep	Helicopter	15-Sep	Area 1, km 7	
Code 13	External Tag	Station	16-Sep	Area 2, km 11	
51	Male	Helicopter	19-Sep	Area 2, km 24	
	555 mm	Helicopter	26-Sep	Area 5, km 53	Mortality signal detected
	In live box less than 2 hours	Helicopter	02-Oct	Area 5, km 52	Mortality signal detected
	Released upriver 100 m @ 1310	Helicopter	06-Oct	Area 5, km 54	Mortality signal detected
*	*Estimated spawning location*	Helicopter	14-Oct	Area 5, km 47	Mortality signal detected
	is km 53.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.524	Tagged at 1021 on 14-Sep	Helicopter	15-Sep	Area 1, km 6	
Code 13	External Tag	Station	19-Sep	Area 2, km 11	
52	Female	Helicopter	19-Sep		Not located
	570 mm	Helicopter	26-Sep	Area 3, km 40	
	In live box less than 1 hour	Helicopter	02-Oct	Area 4, km 42	Mortality signal detected
	Released upriver 100 m @ 1040	Helicopter	06-Oct	Area 4, km 44	Mortality signal detected
		Helicopter	14-Oct	Area 4, km 42	Mortality signal detected
*	*Estimated spawning location*	Ground	15-Oct	Area 4, km 43	
	is km 43.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.554	Tagged at 1025 on 14-Sep	Helicopter	15-Sep	Area 1, km 6	
Code 13	External Tag	Helicopter	19-Sep	Area 2, km 11	
53	Male	Station	20-Sep	Area 2, km 11	
	565 mm	Helicopter	26-Sep	Area 3, km 32	
	In live box less than 1 hour	Helicopter	02-Oct	Area 3, km 36	
	Released upriver 100 m @ 1040	Helicopter	06-Oct	Area 3, km 40	
*	*Estimated spawning location*	Helicopter	14-Oct	Area 4, km 41	
	is km 41.	Helicopter	24-Oct		Did not attempt to locate for this survey

Frequency	*Tagging Information*	*Tracking Information*			
		Survey Type	*Date*	*Location*	*Other*
152.584	Tagged at 1028 on 14-Sep	Helicopter	15-Sep	Area 1, km 3	
Code 13	External Tag	Station	19-Sep	Area 2, km 11	
54	Female	Helicopter	19-Sep	Area 2, km 15	
	585 mm	Helicopter	26-Sep	Area 4, km 42	
	In live box less than 1 hour	Helicopter	02-Oct	Area 4, km 42	
	Released upriver 100 m @ 1040	Helicopter	06-Oct	Area 4, km 42	
		Helicopter	14-Oct	Area 4, km 43	
*	*Estimated spawning location*	Ground	15-Oct	Area 4, km 42	
	is km 42.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.614	Tagged at 2055 on 14-Sep	Helicopter	15-Sep	Area 1, km 0	
Code 13	External Tag	Helicopter	19-Sep	Area 2, km 11	
55	Male	Station	20-Sep	Area 2, km 11	
	645 mm	Helicopter	26-Sep	Area 3, km 36	
	In live box less than 2 hours	Helicopter	02-Oct	Area 4, km 41	
	Released upriver 100 m @ 2115	Helicopter	06-Oct	Area 4, km 41	
*	*Estimated spawning location*	Helicopter	14-Oct	Area 4, km 41	
	is km 41.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.644	Tagged at 1032 on 14-Sep	Helicopter	15-Sep	Area 2, km 11	
Code 13	External Tag	Station	17-Sep	Area 2, km 11	
56	Female	Helicopter	19-Sep	Area 3, km 33	
	525 mm	Helicopter	26-Sep	Area 5, km 55	
	In live box less than 2 hours	Airplane	30-Sep	Area 5, km 59	
	Released upriver 100 m @ 2115	Helicopter	02-Oct	Area 5, km 52	
		Helicopter	06-Oct	Area 5, km 53	Mortality signal detected
*	*Estimated spawning location*	Helicopter	14-Oct	Area 5, km 56	Mortality signal detected
	is km 56.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.674	Tagged at 1013 on 15-Sep	Helicopter	15-Sep	Area 1, km 4	
Code 13	External Tag	Station	19-Sep	Area 2, km 11	
57	Male	Helicopter	19-Sep	Area 2, km 13	
	575 mm	Helicopter	26-Sep	Area 3, km 35	
	In live box less than 2 hours	Helicopter	02-Oct	Area 4, km 41	
	Released upriver 100 m @ 1030	Helicopter	06-Oct	Area 3, km 40	
*	*Estimated spawning location*	Helicopter	14-Oct	Area 4, km 44	Mortality signal detected
	is km 43.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.704	Tagged at 1014 on 15-Sep	Helicopter	15-Sep	Area 1, km 0	
Code 13	External Tag	Helicopter	19-Sep	Area 2, km 12	
58	Female	Station	19-Sep	Area 2, km 11	
	545 mm	Helicopter	26-Sep	Area 3, km 35	
	In live box less than 2 hours	Helicopter	02-Oct	Area 4, km 42	
	Released upriver 100 m @ 1030	Helicopter	06-Oct	Area 3, km 28	
*	*Estimated spawning location*	Helicopter	14-Oct	Area 3, km 29	
	is km 29.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.733	Tagged at 1249 on 14-Sep	Helicopter	15-Sep	Area 1, km 5	
Code 13	External Tag	Station	17-Sep	Area 2, km 11	
59	Female	Helicopter	19-Sep	Area 2, km 21	
	565 mm	Helicopter	26-Sep	Area 2, km 24	
	In live box less than 2 hours	Helicopter	02-Oct	Area 2, km 21	
	Released upriver 100 m @ 1310	Helicopter	06-Oct	Area 2, km 23	
*	*Estimated spawning location*	Helicopter	14-Oct	Area 2, km 22	Mortality signal detected
	is km 23.	Helicopter	24-Oct		Did not attempt to locate for this survey

Frequency	*Tagging Information*	*Tracking Information*			
		Survey Type	*Date*	*Location*	*Other*
152.764	Tagged at 1253 on 14-Sep	Helicopter	15-Sep	Area 1, km 4	
Code 13	External Tag	Station	17-Sep	Area 2, km 11	
60	Female	Helicopter	19-Sep	Area 2, km 25	
	525 mm	Helicopter	26-Sep	Area 4, km 42	
	In live box less than 2 hours	Helicopter	02-Oct		Not located
	Released upriver 100 m @ 1310	Helicopter	06-Oct	Area 3, km 40	
		Helicopter	14-Oct	Area 4, km 45	Mortality signal detected
*	*Estimated spawning location*	Ground	15-Oct	Area 4, km 42	
	is km 45.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.793	Tagged at 2059 on 14-Sep	Helicopter	15-Sep	Area 2, km 10	
Code 13	External Tag	Helicopter	19-Sep	Area 1, km 5	
61	Female	Station	22-Sep	Area 2, km 11	
	565 mm	Helicopter	26-Sep		Not located
	In live box less than 2 hours	Helicopter	02-Oct	Area 3, km 35	
	Released upriver 100 m @ 2115	Helicopter	06-Oct	Area 3, km 37	
		Helicopter	14-Oct	Area 4, km 44	
		Ground	15-Oct	Area 4, km 43	
*	*Estimated spawning location*	Ground	20-Oct	Area 4, km 43	Mortality signal detected
	is km 43.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.823	Tagged at 1255 on 14-Sep	Helicopter	15-Sep	Area 1, km 4	
Code 13	External Tag	Station	19-Sep	Area 2, km 11	
62	Female	Helicopter	19-Sep	Area 2, km 19	
	560 mm	Helicopter	26-Sep	Area 3, km 30	Mortality signal detected
	In live box less than 2 hours	Helicopter	02-Oct	Area 3, km 29	Mortality signal detected
	Released upriver 100 m @ 1310	Helicopter	06-Oct	Area 3, km 29	
*	*Estimated spawning location*	Helicopter	14-Oct	Area 3, km 29	Mortality signal detected
	is km 30.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.853	Tagged at 2101 on 14-Sep	Helicopter	15-Sep	Area 1, km 3	
Code 13	External Tag	Helicopter	19-Sep	Area 2, km 12	
63	Male	Station	19-Sep	Area 2, km 11	
	560 mm	Helicopter	26-Sep	Area 4, km 41	
	In live box less than 2 hours	Helicopter	02-Oct	Area 3, km 30	
	Released upriver 100 m @ 1310	Helicopter	06-Oct		Not located
*	*Estimated spawning location*	Helicopter	14-Oct	Area 3, km 31	
	is km 31.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.884	Tagged at 1300 on 14-Sep	Helicopter	15-Sep	Area 1, km 7	
Code 13	External Tag	Station	16-Sep	Area 2, km 11	
64	Male	Helicopter	19-Sep	Area 3, km 34	
	620 mm	Helicopter	26-Sep	Area 3, km 29	Mortality signal detected
	In live box less than 2 hours	Helicopter	02-Oct	Area 3, km 29	Mortality signal detected
	Released upriver 100 m @ 1310	Helicopter	06-Oct	Area 3, km 29	Mortality signal detected
*	*Estimated spawning location*	Helicopter	14-Oct	Area 3, km 30	Mortality signal detected
	is km 29.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.913	Tagged at 1302 on 14-Sep	Helicopter	15-Sep		Not located
Code 13	External Tag	Helicopter	19-Sep	Area 0, km -10	
65	Female	Station	23-Sep	Area 2, km 11	
	540 mm	Helicopter	26-Sep	Area 2, km 26	
	In live box less than 2 hours	Helicopter	02-Oct	Area 3, km 32	
	Released upriver 100 m @ 1310	Helicopter	06-Oct	Area 3, km 33	Mortality signal detected
*	*Estimated spawning location*	Helicopter	14-Oct	Area 3, km 28	
	is km 33.	Helicopter	24-Oct		Did not attempt to locate for this survey

Frequency	*Tagging Information*	*Tracking Information*			
		Survey Type	*Date*	*Location*	*Other*
152.944	Tagged at 1315 on 14-Sep	Helicopter	15-Sep	Area 1, km 6	
Code 13	External Tag	Station	17-Sep	Area 2, km 11	
66	Male	Helicopter	19-Sep	Area 2, km 14	
	625 mm	Helicopter	26-Sep	Area 3, km 29	
	In live box less than 2 hours	Helicopter	02-Oct	Area 4, km 43	
	Released upriver 100 m @ 1310	Helicopter	06-Oct	Area 4, km 44	
*	*Estimated spawning location*	Helicopter	14-Oct	Area 4, km 44	
	is km 44.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.973	Tagged at 2104 on 14-Sep	Helicopter	15-Sep	Area 1, km 3	
Code 13	External Tag	Helicopter	19-Sep	Area 2, km 12	
67	Male	Station	19-Sep	Area 2, km 11	
	565 mm	Helicopter	26-Sep	Area 4, km 41	
	In live box less than 2 hours	Helicopter	02-Oct	Area 4, km 41	
	Released upriver 100 m @ 2115	Helicopter	06-Oct	Area 4, km 41	Mortality signal detected
		Helicopter	14-Oct	Area 4, km 41	Mortality signal detected
*	*Estimated spawning location*	Ground	16-Oct	Area 4, km 42	
	is km 41.	Helicopter	24-Oct		Did not attempt to locate for this survey
153.004	Tagged at 2116 on 14-Sep	Helicopter	15-Sep	Area 1, km 3	
Code 13	External Tag	Station	17-Sep	Area 2, km 11	
68	Female	Helicopter	19-Sep	Area 3, km 30	
	550 mm	Helicopter	26-Sep	Area 5, km 47	
	In live box less than 2 hours	Helicopter	02-Oct	Area 4, km 44	Mortality signal detected
	Released upriver 100 m @ 2130	Helicopter	06-Oct	Area 4, km 43	Mortality signal detected
*	*Estimated spawning location*	Helicopter	14-Oct	Area 4, km 44	Mortality signal detected
	is km 44.	Helicopter	24-Oct		Did not attempt to locate for this survey
153.034	Tagged at 1318 on 14-Sep	Helicopter	15-Sep	Area 1, km 1	
Code 13	External Tag	Station	17-Sep	Area 2, km 11	
69	Male	Helicopter	19-Sep	Area 2, km 22	
	610 mm	Helicopter	26-Sep	Area 4, km 41	
	In live box less than 2 hours	Helicopter	02-Oct	Area 4, km 44	
	Released upriver 100 m @ 1340	Helicopter	06-Oct	Area 4, km 44	
*	*Estimated spawning location*	Helicopter	14-Oct	Area 4, km 42	Mortality signal detected
	is km 43.	Helicopter	24-Oct		Did not attempt to locate for this survey
153.064	Tagged at 1321 on 14-Sep	Helicopter	15-Sep	Area 1, km 1	
Code 13	External Tag	Helicopter	19-Sep	Area 1, km 8	
70	Female	Station	22-Sep	Area 2, km 11	
	545 mm	Station	25-Sep	Area 2, km 11	
	In live box less than 2 hours	Helicopter	26-Sep		Not located
	Released upriver 100 m @ 1340	Station	27-Sep	Area 2, km 11	
		Helicopter	02-Oct	Area 2, km 27	
		Helicopter	06-Oct	Area 2, km 27	Mortality signal detected
*	*Estimated spawning location*	Helicopter	14-Oct	Area 2, km 25	Mortality signal detected
	is km 27.	Helicopter	24-Oct		Did not attempt to locate for this survey
153.093	Tagged at 1324 on 14-Sep	Helicopter	15-Sep	Area 1, km 7	
Code 13	External Tag	Station	16-Sep	Area 2, km 11	
71	Male	Helicopter	19-Sep	Area 3, km 36	
	530 mm	Helicopter	26-Sep	Area 3, km 40	Mortality signal detected
	In live box less than 2 hours	Helicopter	02-Oct	Area 4, km 41	
	Released upriver 100 m @ 1340	Helicopter	06-Oct	Area 3, km 40	
*	*Estimated spawning location*	Helicopter	14-Oct	Area 3, km 39	
	is km 41.	Helicopter	24-Oct		Did not attempt to locate for this survey

Frequency	*Tagging Information*	*Tracking Information*			
		Survey Type	*Date*	*Location*	*Other*
153.124	Tagged at 1327 on 14-Sep	Helicopter	15-Sep	Area 1, km 2	
Code 13	External Tag	Helicopter	19-Sep	Area 1, km 3	
72	Male	Helicopter	26-Sep	Area 1, km 1	
	685 mm	Helicopter	02-Oct	Area 1, km 1	
	In live box less than 2 hours	Helicopter	06-Oct	Area 1, km 3	
	Released upriver 100 m @ 1340	Helicopter	14-Oct		Not located
*	*This tag was either lost near*	Helicopter	24-Oct		Did not attempt to locate for this survey
	km 2 or the fish died.				
153.153	Tagged at 1331 on 14-Sep	Helicopter	15-Sep	Area 1, km 3	
Code 13	External Tag	Station	19-Sep	Area 2, km 11	
73	Female	Helicopter	19-Sep	Area 3, km 33	
	585 mm	Helicopter	26-Sep	Area 4, km 42	
	In live box less than 2 hours	Helicopter	02-Oct	Area 4, km 43	
	Released upriver 100 m @ 1340	Helicopter	06-Oct	Area 4, km 44	Mortality signal detected
*	*Estimated spawning location*	Helicopter	14-Oct	Area 4, km 44	Mortality signal detected
	is km 44.	Helicopter	24-Oct		Did not attempt to locate for this survey
153.183	Tagged at 1334 on 14-Sep	Helicopter	15-Sep	Area 1, km 9	
Code 13	External Tag	Station	16-Sep	Area 2, km 11	
74	Male	Helicopter	19-Sep	Area 3, km 33	
	595 mm	Helicopter	26-Sep	Area 2, km 24	Mortality signal detected
	In live box less than 2 hours	Helicopter	02-Oct	Area 2, km 27	Mortality signal detected
	Released upriver 100 m @ 1340	Helicopter	06-Oct	Area 2, km 26	Mortality signal detected
*	*Estimated spawning location*	Helicopter	14-Oct	Area 2, km 25	Mortality signal detected
	is km 26.	Helicopter	24-Oct		Did not attempt to locate for this survey
153.213	Tagged at 1337 on 14-Sep	Helicopter	15-Sep	Area 1, km 2	
Code 13	External Tag	Helicopter	19-Sep	Area 1, km 4	
75	Female	Station	24-Sep	Area 2, km 11	
	520 mm	Helicopter	26-Sep	Area 2, km 15	
	In live box less than 2 hours	Helicopter	02-Oct	Area 3, km 28	
	Released upriver 100 m @ 1340	Helicopter	06-Oct	Area 3, km 29	
*	*Estimated spawning location*	Helicopter	14-Oct	Area 3, km 29	
	is km 29.	Helicopter	24-Oct		Did not attempt to locate for this survey
153.243	Tagged at 2120 on 14-Sep	Helicopter	15-Sep	Area 1, km 3	
Code 13	External Tag	Helicopter	19-Sep	Area 2, km 11	
76	Female	Station	23-Sep	Area 2, km 11	
	560 mm	Helicopter	26-Sep	Area 3, km 26	
	In live box less than 1 hour	Helicopter	02-Oct	Area 4, km 43	
	Released upriver 100 m @ 2130	Helicopter	06-Oct	Area 4, km 42	
*	*Estimated spawning location*	Helicopter	14-Oct	Area 4, km 45	Mortality signal detected
	is km 45.	Helicopter	24-Oct		Did not attempt to locate for this survey
153.273	Tagged at 1341 on 14-Sep	Helicopter	15-Sep	Area 1, km 2	
Code 13	External Tag	Helicopter	19-Sep	Area 1, km 7	
77	Male	Station	23-Sep	Area 2, km 11	
	540 mm	Helicopter	26-Sep	Area 2, km 24	
	In live box less than 2 hours	Helicopter	02-Oct	Area 3, km 36	
	Released upriver 100 m @ 1355	Helicopter	06-Oct	Area 3, km 38	
		Helicopter	14-Oct	Area 4, km 43	
*	*Estimated spawning location*	Ground	15-Oct	Area 4, km 43	
	is km 43.	Helicopter	24-Oct		Did not attempt to locate for this survey

Frequency	*Tagging Information*	*Tracking Information*			
		Survey Type	*Date*	*Location*	*Other*
153.304	Tagged at 1345 on 14-Sep	Helicopter	15-Sep	Area 2, km 11	
Code 13	External Tag	Station	16-Sep	Area 2, km 11	
78	Male	Helicopter	19-Sep	Area 3, km 33	
	605 mm	Helicopter	26-Sep	Area 5, km 49	
	In live box less than 2 hours	Helicopter	02-Oct	Area 5, km 48	
	Released upriver 100 m @ 1355	Helicopter	06-Oct	Area 4, km 43	Mortality signal detected
*	*Estimated spawning location*	Helicopter	14-Oct		
	is km 48.	Helicopter	24-Oct		Did not attempt to locate for this survey
153.333	Tagged at 2130 on 14-Sep	Helicopter	15-Sep	Area 1, km 4	
Code 13	External Tag	Station	17-Sep	Area 2, km 11	
79	Male	Helicopter	19-Sep		Not located
	540 mm	Helicopter	26-Sep	Area 5, km 48	
	In live box less than 2 hours	Helicopter	02-Oct	Area 5, km 46	
	Released upriver 100 m @ 2140	Helicopter	06-Oct	Area 4, km 42	
*	*Estimated spawning location*	Helicopter	14-Oct	Area 4, km 44	
	is km 45.	Helicopter	24-Oct		Did not attempt to locate for this survey
153.363	Tagged at 1403 on 14-Sep	Helicopter	15-Sep	Area 1, km 5	
Code 13	External Tag	Helicopter	19-Sep	Area 2, km 11	
80	Male	Station	21-Sep	Area 2, km 11	
	525 mm	Helicopter	26-Sep	Area 3, km 32	
	In live box less than 2 hours	Helicopter	02-Oct	Area 4, km 42	
	Released upriver 100 m @ 1420	Helicopter	06-Oct	Area 4, km 42	
*	*Estimated spawning location*	Helicopter	14-Oct	Area 3, km 35	
	is km 42.	Helicopter	24-Oct		Did not attempt to locate for this survey
153.393	Tagged at 1405 on 14-Sep	Helicopter	15-Sep	Area 2, km 10	
Code 13	External Tag	Station	16-Sep	Area 2, km 11	
81	Male	Helicopter	19-Sep	Area 3, km 39	
	555 mm	Helicopter	26-Sep	Area 4, km 42	
	In live box less than 2 hours	Helicopter	02-Oct	Area 4, km 41	
	Released upriver 100 m @ 1420	Helicopter	06-Oct	Area 4, km 43	Mortality signal detected
		Helicopter	14-Oct	Area 4, km 43	Mortality signal detected
		Ground	15-Oct	Area 4, km 43	
*	*Estimated spawning location*	Ground	20-Oct	Area 4, km 43	Mortality signal detected
	is km 43.	Helicopter	24-Oct		Did not attempt to locate for this survey
153.424	Tagged at 1409 on 14-Sep	Helicopter	15-Sep	Area 1, km 3	
Code 13	External Tag	Station	19-Sep	Area 2, km 11	
82	Male	Helicopter	19-Sep	Area 2, km 15	
	605 mm	Helicopter	26-Sep	Area 2, km 19	Mortality signal detected
	In live box less than 2 hours	Helicopter	02-Oct	Area 2, km 16	Mortality signal detected
	Released upriver 100 m @ 1420	Helicopter	06-Oct	Area 2, km 19	Mortality signal detected
*	*Estimated spawning location*	Helicopter	14-Oct		Not located
	is km 19.	Helicopter	24-Oct		Did not attempt to locate for this survey
153.453	Tagged at 2134 on 14-Sep	Helicopter	15-Sep	Area 1, km 4	
Code 13	External Tag	Station	19-Sep	Area 2, km 11	
83	Male	Helicopter	19-Sep	Area 2, km 19	
	560 mm	Helicopter	26-Sep	Area 4, km 41	
	In live box less than 2 hours	Helicopter	02-Oct	Area 4, km 42	
	Released upriver 100 m @ 2140	Helicopter	06-Oct	Area 3, km 40	
		Helicopter	14-Oct	Area 4, km 43	Mortality signal detected
*	*Estimated spawning location*	Ground	15-Oct	Area 4, km 42	
	is km 43.	Helicopter	24-Oct		Did not attempt to locate for this survey

Frequency	*Tagging Information*	*Tracking Information*			
		Survey Type	*Date*	*Location*	*Other*
152.252	Tagged at 2137 on 14-Sep	Helicopter	15-Sep	Area 1, km 1	
Code 19	External Tag	Helicopter	19-Sep	Area 1, km 9	
84	Female	Station	20-Sep	Area 2, km 11	
	575 mm	Helicopter	26-Sep	Area 3, km 34	
	In live box less than 2 hours	Helicopter	02-Oct	Area 4, km 44	
	Released upriver 100 m @ 2140	Helicopter	06-Oct	Area 4, km 44	
		Helicopter	14-Oct	Area 4, km 44	
		Ground	15-Oct	Area 4, km 44	
*	*Estimated spawning location*	Ground	20-Oct	Area 4, km 43	Mortality signal detected
	is km 44.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.282	Tagged at 1017 on 15-Sep	Helicopter	15-Sep	Area 1, km 2	
Code 19	External Tag	Station	18-Sep	Area 2, km 11	
85	Male	Helicopter	19-Sep	Area 2, km 22	
	640 mm	Helicopter	26-Sep	Area 4, km 43	
	In live box less than 2 hours	Helicopter	02-Oct	Area 4, km 42	
	Released upriver 100 m @ 1030	Helicopter	06-Oct	Area 4, km 42	
		Helicopter	14-Oct	Area 4, km 42	
		Ground	15-Oct	Area 4, km 43	
*	*Estimated spawning location*	Ground	20-Oct	Area 4, km 42	Mortality signal detected
	is km 42.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.314	Tagged at 1020 on 15-Sep	Helicopter	15-Sep	Area 1, km 1	
Code 19	External Tag	Helicopter	19-Sep	Area 2, km 11	
86	Male	Station	20-Sep	Area 2, km 11	
	550 mm	Helicopter	26-Sep	Area 3, km 35	
	In live box less than 2 hours	Helicopter	02-Oct	Area 4, km 41	
	Released upriver 100 m @ 1030	Helicopter	06-Oct	Area 3, km 40	
		Helicopter	14-Oct	Area 3, km 40	
*	*Estimated spawning location*	Ground	15-Oct	Area 4, km 42	
	is km 41.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.344	Tagged at 1025 on 15-Sep	Helicopter	15-Sep	Area 1, km 1	
Code 19	External Tag	Helicopter	19-Sep		Not located
87	Male	Station	22-Sep	Area 2, km 11	
	585 mm	Helicopter	26-Sep	Area 3, km 34	
	In live box less than 2 hours	Helicopter	02-Oct	Area 4, km 43	
	Released upriver 100 m @ 1043	Helicopter	06-Oct	Area 4, km 44	
		Helicopter	14-Oct	Area 4, km 42	
		Ground	15-Oct	Area 4, km 44	
*	*Estimated spawning location*	Ground	20-Oct	Area 4, km 43	Mortality signal detected
	is km 44.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.375	Tagged at 1031 on 15-Sep	Helicopter	15-Sep		Not located
Code 19	External Tag	Station	17-Sep	Area 2, km 11	
88	Female	Helicopter	19-Sep	Area 3, km 37	
	520 mm	Helicopter	26-Sep	Area 5, km 47	
	In live box less than 2 hours	Helicopter	02-Oct	Area 5, km 46	
	Released upriver 100 m @ 1043	Helicopter	06-Oct	Area 5, km 46	
*	*Estimated spawning location*	Helicopter	14-Oct	Area 4, km 45	
	is km 46.	Helicopter	24-Oct		Did not attempt to locate for this survey

Frequency	*Tagging Information*	*Tracking Information*			
		Survey Type	*Date*	*Location*	*Other*
152.403	Tagged at 1036 on 15-Sep	Helicopter	15-Sep	Area 1, km 1	
Code 19	External Tag	Station	19-Sep	Area 2, km 11	
89	Female	Helicopter	19-Sep	Area 2, km 15	
	565 mm	Helicopter	26-Sep	Area 3, km 33	
	In live box less than 2 hours	Helicopter	02-Oct	Area 4, km 41	
	Released upriver 100 m @ 1043	Helicopter	06-Oct	Area 4, km 44	
		Helicopter	14-Oct	Area 5, km 46	
*	*Estimated spawning location*	Ground	15-Oct	Area 4, km 44	
	is km 44.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.432	Tagged at 2005 on 15-Sep	Station	18-Sep	Area 2, km 11	
Code 19	External Tag	Helicopter	19-Sep	Area 2, km 20	
90	Female	Helicopter	26-Sep	Area 3, km 40	Mortality signal detected
	565 mm	Helicopter	02-Oct	Area 4, km 43	Mortality signal detected
	In live box less than 2 hours	Helicopter	06-Oct	Area 4, km 42	Mortality signal detected
	Released at the fish wheel	Helicopter	14-Oct	Area 4, km 44	Mortality signal detected
*	*Estimated spawning location*	Ground	16-Oct	Area 4, km 42	
	is km 43.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.463	Tagged at 2010 on 15-Sep	Helicopter	19-Sep	Area 2, km 10	
Code 19	External Tag	Station	20-Sep	Area 2, km 11	
91	Female	Helicopter	26-Sep		Not located
	605 mm	Helicopter	02-Oct	Area 4, km 45	Mortality signal detected
	In live box less than 2 hours	Helicopter	06-Oct	Area 4, km 42	Mortality signal detected
	Released at the fish wheel	Helicopter	14-Oct	Area 5, km 46	Mortality signal detected
*	*Estimated spawning location*	Helicopter	24-Oct		Did not attempt to locate for this survey
	is km 45.				
152.494	Tagged at 2015 on 15-Sep	Station	18-Sep	Area 2, km 11	
Code 19	External Tag	Helicopter	19-Sep	Area 2, km 20	
92	Female	Helicopter	26-Sep	Area 4, km 42	
	530 mm	Helicopter	02-Oct	Area 4, km 44	
	In live box less than 2 hours	Helicopter	06-Oct	Area 4, km 44	
	Released at the fish wheel	Helicopter	14-Oct	Area 4, km 44	
		Ground	15-Oct	Area 4, km 44	
*	*Estimated spawning location*	Ground	20-Oct	Area 4, km 43	Mortality signal detected
	is km 44.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.524	Tagged at 1005 on 27-Sep	Helicopter	19-Sep		
Code 19	External Tag	Helicopter	26-Sep		
93	Female	Helicopter	02-Oct	Area 1, km 7	
	505 mm	Helicopter	06-Oct	Area 1, km 6	
	In live box overnight	Helicopter	14-Oct		
	Released at the fish wheel	Helicopter	24-Oct		Not located
*	*This tag was either lost near*				
	km 6 or the fish died.				
152.554	Tagged at 1045 on 16-Sep	Helicopter	19-Sep	Area 2, km 12	
Code 19	External Tag	Station	19-Sep	Area 2, km 11	
94	Male	Helicopter	26-Sep	Area 3, km 34	
	535 mm	Helicopter	02-Oct	Area 3, km 36	
	In live box overnight	Helicopter	06-Oct	Area 3, km 40	
	Released at the fish wheel	Helicopter	14-Oct	Area 4, km 43	
*	*Estimated spawning location*	Ground	15-Oct	Area 4, km 44	
	is km 44.	Helicopter	24-Oct		Did not attempt to locate for this survey

Frequency	*Tagging Information*	*Tracking Information*			
		Survey Type	*Date*	*Location*	*Other*
152.584	Tagged at 1049 on 16-Sep	Station	19-Sep	Area 2, km 11	
Code 19	External Tag	Helicopter	19-Sep	Area 2, km 17	
95	Female	Helicopter	26-Sep	Area 4, km 44	
	545 mm	Helicopter	02-Oct	Area 4, km 42	
	In live box overnight	Helicopter	06-Oct	Area 4, km 42	
	Released at the fish wheel	Helicopter	14-Oct	Area 4, km 42	
		Ground	15-Oct	Area 4, km 42	
*	*Estimated spawning location*	Ground	20-Oct	Area 4, km 42	
	is km 42.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.614	Tagged at 1052 on 16-Sep	Helicopter	19-Sep	Area 1, km 8	
Code 19	External Tag	Station	23-Sep	Area 2, km 11	
96	Female	Helicopter	26-Sep	Area 3, km 39	
	600 mm	Helicopter	02-Oct	Area 4, km 43	
	In live box overnight	Helicopter	06-Oct	Area 4, km 42	
	Released at the fish wheel	Helicopter	14-Oct	Area 4, km 42	
*	*Estimated spawning location*	Helicopter	24-Oct		Did not attempt to locate for this survey
	is km 42.				
152.644	Tagged at 1055 on 16-Sep	Helicopter	19-Sep	Area 1, km 9	
Code 19	External Tag	Station	22-Sep	Area 2, km 11	
97	Male	Helicopter	26-Sep	Area 3, km 39	
	585 mm	Helicopter	02-Oct	Area 4, km 43	
	In live box overnight	Helicopter	06-Oct	Area 4, km 42	
	Released at the fish wheel	Helicopter	14-Oct	Area 4, km 42	Mortality signal detected
*	*Estimated spawning location*	Ground	20-Oct	Area 4, km 42	Mortality signal detected
	is km 42.	Helicopter	24-Oct		Did not attempt to locate for this survey
152.674	Tagged at 1059 on 16-Sep	Helicopter	19-Sep	Area 1, km 8	
Code 19	External Tag	Station	22-Sep	Area 2, km 11	
98	Male	Helicopter	26-Sep		Not located
	585 mm	Helicopter	02-Oct	Area 4, km 45	Mortality signal detected
	In live box overnight	Helicopter	06-Oct	Area 4, km 42	Mortality signal detected
	Released at the fish wheel	Helicopter	14-Oct	Area 4, km 44	
*	*Estimated spawning location*	Helicopter	24-Oct		Did not attempt to locate for this survey
	is km 44.				
152.704	Tagged at 1237 on 16-Sep	Station	19-Sep	Area 2, km 11	
Code 19	External Tag	Helicopter	19-Sep		Not located
99	Male	Helicopter	26-Sep	Area 5, km 53	
	540 mm	Helicopter	02-Oct	Area 5, km 61	
	In live box less than 2 hours	Helicopter	06-Oct	Area 5, km 61	
	Released at the fish wheel	Helicopter	14-Oct	Area 3, km 39	Mortality signal detected
*	*Estimated spawning location*	Helicopter	24-Oct		Did not attempt to locate for this survey
	is km 61.				
152.733	Tagged at 1239 on 16-Sep	Helicopter	19-Sep	Area 1, km 9	
Code 19	External Tag	Station	23-Sep	Area 2, km 11	
100	Female	Helicopter	26-Sep	Area 2, km 27	
	560 mm	Helicopter	02-Oct	Area 3, km 40	
	In live box less than 2 hours	Helicopter	06-Oct	Area 4, km 42	
	Released at the fish wheel	Helicopter	14-Oct		Not located
*	*Estimated spawning location*	Helicopter	24-Oct		Did not attempt to locate for this survey
	is km 42.				

Frequency	*Tagging Information*	*Tracking Information*			
		Survey Type	*Date*	*Location*	*Other*
152.764	Tagged at 1511 on 16-Sep	Station	18-Sep	Area 2, km 11	
Code 19	External Tag	Helicopter	19-Sep	Area 3, km 29	
101	Male	Helicopter	26-Sep	Area 4, km 42	
	510 mm	Helicopter	02-Oct	Area 4, km 44	
	In live box less than 2 hours	Helicopter	06-Oct	Area 4, km 42	
	Released at the fish wheel	Helicopter	14-Oct	Area 4, km 42	
*	*Estimated spawning location is km 42.*	Ground	16-Oct	Area 4, km 42	
		Helicopter	24-Oct		Did not attempt to locate for this survey
152.793	Tagged at 1924 on 27-Sep	Helicopter	02-Oct	Area 2, km 20	
Code 19	External Tag	Helicopter	06-Oct	Area 2, km 27	
102	Female	Helicopter	14-Oct	Area 3, km 30	
	590 mm	Helicopter	24-Oct	Area 4, km 42	Mortality signal detected
	Fresh caught				
	Tagged ripped off 26-Sep and then retagged 27-Sep				
*	*Estimated spawning location is km 42.*				
152.823	Tagged at 1015 on 27-Sep	Helicopter	02-Oct	Area 2, km 27	
Code 19	External Tag	Helicopter	06-Oct	Area 3, km 29	
103	Male	Helicopter	14-Oct	Area 2, km 22	
	545 mm	Helicopter	24-Oct	Area 3, km 29	
	In live box overnight				
	Released at the fish wheel				
*	*Estimated spawning location is km 28.*				
152.853	Tagged at 1022 on 27-Sep	Station	30-Sep	Area 2, km 11	
Code 19	External Tag	Helicopter	02-Oct	Area 2, km 10	
104	Male	Helicopter	06-Oct	Area 2, km 23	
	500 mm	Helicopter	14-Oct	Area 2, km 25	
	In live box overnight	Helicopter	24-Oct	Area 4, km 41	Mortality signal detected
	Released at the fish wheel				
*	*Estimated spawning location is km 41.*				
152.884	Tagged at 1031 on 27-Sep	Helicopter	02-Oct	Area 2, km 26	
Code 19	External Tag	Helicopter	06-Oct	Area 2, km 27	Mortality signal detected
105	Male	Helicopter	14-Oct	Area 3, km 28	Mortality signal detected
	525 mm	Helicopter	24-Oct	Area 3, km 29	Mortality signal detected
	In live box overnight				
	Released at the fish wheel				
*	*Estimated spawning location is km 28.*				
152.913	Tagged at 1038 on 27-Sep	Helicopter	02-Oct	Area 3, km 29	
Code 19	External Tag	Helicopter	06-Oct	Area 3, km 32	Mortality signal detected
106	Male	Helicopter	14-Oct	Area 3, km 33	Mortality signal detected
	575 mm	Helicopter	24-Oct	Area 3, km 30	Mortality signal detected
	In live box overnight				
	Released at the fish wheel				
*	*Estimated spawning location is km 32.*				

Frequency	*Tagging Information*	*Tracking Information*			
		Survey Type	*Date*	*Location*	*Other*
152.944	Tagged at 1052 on 27-Sep	Station	29-Sep	Area 2, km 11	
Code 19	External Tag	Helicopter	02-Oct	Area 2, km 26	
107	Male	Helicopter	06-Oct	Area 3, km 32	
	595 mm	Helicopter	14-Oct	Area 3, km 36	
	In live box overnight	Helicopter	24-Oct	Area 3, km 33	Mortality signal detected
	Released at the fish wheel				
*	*Estimated spawning location is km 34.*				
152.973	Tagged at 1101 on 27-Sep	Station	30-Sep	Area 2, km 11	
Code 19	External Tag	Helicopter	02-Oct	Area 2, km 12	
108	Female	Helicopter	06-Oct	Area 3, km 28	
	540 mm	Helicopter	14-Oct		Not located
	In live box overnight	Helicopter	24-Oct	Area 4, km 42	Mortality signal detected
	Released at the fish wheel				
*	*Estimated spawning location is km 42.*				
153.004	Tagged at 1105 on 27-Sep	Helicopter	02-Oct	Area 2, km 24	
Code 19	Intermediate Size Internal tag	Helicopter	06-Oct		Not located
109	Male	Helicopter	14-Oct	Area 3, km 36	
	550 mm	Helicopter	24-Oct	Area 3, km 37	Mortality signal detected
	In live box overnight				
	Released at the fish wheel				
*	*Estimated spawning location is km 37.*				
153.034	Tagged at 1019 on 27-Sep	Helicopter	02-Oct	Area 2, km 13	
Code 19	Small Size Internal tag	Station	05-Oct	Area 2, km 11	
110	Male	Helicopter	06-Oct	Area 2, km 23	
	510 mm	Helicopter	14-Oct	Area 2, km 23	
	In live box overnight	Helicopter	24-Oct	Area 3, km 36	
	Released at the fish wheel				
*	*Estimated spawning location is km 36.*				
153.064	Tagged at 1055 on 27-Sep	Station	29-Sep	Area 2, km 11	
Code 19	Intermediate Size Internal tag	Helicopter	02-Oct	Area 2, km 20	
111	Male	Helicopter	06-Oct	Area 2, km 27	
	610 mm	Helicopter	14-Oct	Area 3, km 28	
	In live box overnight	Helicopter	24-Oct	Area 3, km 30	Mortality signal detected
	Released at the fish wheel				
*	*Estimated spawning location is km 30.*				
153.093	Tagged at 1000 on 27-Sep	Helicopter	02-Oct	Area 2, km 16	
Code 19	Small Size Internal tag	Helicopter	06-Oct	Area 2, km 23	
112	Female	Helicopter	14-Oct	Area 2, km 24	
	530 mm	Helicopter	24-Oct	Area 3, km 40	Mortality signal detected
	In live box overnight				
	Released at the fish wheel				
*	*Estimated spawning location is km 40.*				

Frequency	*Tagging Information*	*Tracking Information*			
		Survey Type	*Date*	*Location*	*Other*
153.124	Tagged at 1035 on 27-Sep	Station	30-Sep	Area 2, km 11	
Code 19	Small Size Internal tag	Helicopter	02-Oct	Area 2, km 23	
113	Female	Helicopter	06-Oct	Area 3, km 28	
	550 mm	Helicopter	14-Oct	Area 3, km 28	Mortality signal detected
	In live box overnight	Helicopter	24-Oct		Not located
	Released at the fish wheel				
*	*Estimated spawning location is km 28.*				
153.153	Tagged at 1114 on 27-Sep	Helicopter	02-Oct	Area 0, km -1	
Code 19	Small Size Internal tag	Helicopter	06-Oct	Area 0, km -1	
114	Male	Helicopter	14-Oct		Not located
	560 mm	Helicopter	24-Oct		Not located
	In live box overnight				
	Released at the fish wheel				
*	*This tag was likely regurgitated near the fish wheel.*				
153.183	Tagged at 1121 on 27-Sep	Helicopter	02-Oct	Area 3, km 28	
Code 19	Small Size Internal tag	Helicopter	06-Oct	Area 3, km 30	
115	Male	Helicopter	14-Oct	Area 3, km 29	
	555 mm	Helicopter	24-Oct	Area 3, km 28	
	In live box overnight				
	Released at the fish wheel				
*	*Estimated spawning location is km 29.*				
153.213	Tagged at 1028 on 27-Sep	Station	29-Sep	Area 2, km 11	
Code 19	Intermediate Size Internal tag	Helicopter	02-Oct	Area 3, km 28	
116	Female	Helicopter	06-Oct	Area 3, km 33	
	585 mm	Helicopter	14-Oct	Area 3, km 37	Mortality signal detected
	In live box overnight	Helicopter	24-Oct	Area 2, km 23	Mortality signal detected
	Released at the fish wheel				
*	*Estimated spawning location is km 35.*				
153.243	Tagged at 1132 on 27-Sep	Station	28-Sep	Area 2, km 11	
Code 19	Small Size Internal tag	Helicopter	02-Oct	Area 3, km 34	
117	Male	Helicopter	06-Oct	Area 3, km 34	
	590 mm	Helicopter	14-Oct		Not located
	In live box overnight	Helicopter	24-Oct		Not located
	Released at the fish wheel				
*	*Estimated spawning location is km 34.*				
153.273	Tagged at 1833 on 26-Sep	Station	28-Sep	Area 2, km 11	
Code 19	Intermediate Size Internal tag	Helicopter	02-Oct	Area 3, km 38	
118	Male	Helicopter	06-Oct	Area 4, km 44	
	600 mm	Helicopter	14-Oct	Area 4, km 44	
	Less than 9 hours in live box	Ground	15-Oct	Area 4, km 43	
	Released at the fish wheel	Helicopter	24-Oct	Area 4, km 42	
*	*Estimated spawning location is km 43.*				

Frequency	*Tagging Information*	*Tracking Information*			
		Survey Type	*Date*	*Location*	*Other*
153.304	Tagged at 1011 on 27-Sep	Station	29-Sep	Area 2, km 11	
Code 19	Intermediate Size Internal tag	Helicopter	02-Oct	Area 2, km 29	
119	Male	Helicopter	06-Oct	Area 3, km 29	
	625 mm	Helicopter	14-Oct	Area 3, km 30	
	In live box overnight	Helicopter	24-Oct	Area 4, km 42	
	Released at the fish wheel				
*	*Estimated spawning location is km 42.*				
153.333	Tagged at 1047 on 27-Sep	Helicopter	02-Oct	Area 0, km -3	Mortality signal detected
Code 19	Small Internal tag - she puked	Helicopter	06-Oct	Area 1, km 6	Mortality signal detected
120	intemediate tag twice first.	Station	12-Oct	Area 2, km 11	
	Female	Helicopter	14-Oct		Not located
	525 mm	Helicopter	24-Oct	Area 4, km 44	Mortality signal detected
	In live box overnight				
*	Released at the fish wheel				
	Estimated spawning location is km 44.				
153.363	Tagged at 1117 on 27-Sep	Helicopter	02-Oct	Area 2, km 25	
Code 19	External tag	Helicopter	06-Oct	Area 3, km 33	
121	Female	Helicopter	14-Oct	Area 3, km 39	Mortality signal detected
	540 mm	Helicopter	24-Oct	Area 3, km 38	
	In live box overnight				
	Released at the fish wheel				
*	*Estimated spawning location is km 39.*				
153.393	Tagged at 1111 on 27-Sep	Station	30-Sep	Area 2, km 11	
Code 19	External tag	Helicopter	02-Oct	Area 2, km 20	
122	Female	Helicopter	06-Oct	Area 3, km 29	
	550 mm	Helicopter	14-Oct	Area 3, km 33	
	In live box overnight	Helicopter	24-Oct	Area 3, km 36	Mortality signal detected
	Released at the fish wheel				
*	*Estimated spawning location is km 36.*				
153.424	Tagged at 1129 on 27-Sep	Station	29-Sep	Area 2, km 11	
Code 19	External tag	Helicopter	02-Oct	Area 2, km 19	
123	Female	Helicopter	06-Oct	Area 2, km 24	
	575 mm	Helicopter	14-Oct	Area 2, km 23	
	In live box overnight	Helicopter	24-Oct		Not located
	Released at the fish wheel				
*	*Estimated spawning location is km 24.*				
153.453	Tagged at 915 on 28-Sep	Helicopter	02-Oct	Area 3, km 28	
Code 19	External tag	Helicopter	06-Oct	Area 3, km 37	
124	Male	Helicopter	14-Oct	Area 4, km 44	
	580 mm	Helicopter	24-Oct	Area 4, km 45	
	In live box overnight				
	Released at the fish wheel				
*	*Estimated spawning location is km 45.*				

Appendix B. Aerial survey results by area for early-tagged (9/9-9/16) and late-tagged (9/26-928) fall chum salmon on the Toklat River in 1997.

Numbers of early-tagged fish.

Date	Area 0	1	2	3	4	5
15-Sep	3	51	31	2	1	0
19-Sep	5	16	38	27	8	1
26-Sep	3	3	12	25	32	12
02-Oct	3	3	5	17	53	14
06-Oct	4	2	5	23	52	10
14-Oct	4	2	6	17	59	8

Numbers of late-tagged fish.

Date	Area 0	1	2	3	4	5
02-Oct	2	1	15	6	0	0
06-Oct	1	2	7	12	1	0
14-Oct	1	2	5	12	2	0
24-Oct	1	0	1	11	7	0

Percentage of early-tagged fish.

Date	Area 0	1	2	3	4	5
15-Sep	3	58	35	2	1	0
19-Sep	5	17	40	28	8	1
26-Sep	3	3	14	29	37	14
02-Oct	3	3	5	18	56	15
06-Oct	-	-	6	26	58	11
14-Oct	-	-	7	19	66	9

Percentage of late-tagged fish located.

Date	Area 0	1	2	3	4	5
02-Oct	8	4	63	25	0	0
06-Oct	-	-	35	60	5	0
14-Oct	-	-	26	63	11	0
24-Oct	-	-	5	58	37	0

Numbers of early-tagged fish exhibiting inactivity signal.

Date	Area 0	1	2	3	4	5
15-Sep	0	0	0	0	0	0
19-Sep	1	0	0	0	0	0
26-Sep	1	1	2	5	2	3
02-Oct	1	1	3	5	14	4
06-Oct	2	0	3	6	19	7
14-Oct	2	1	6	8	31	7
24-Oct						

Numbers of late-tagged fish exhibiting inactivity signal.

Date	Area 0	1	2	3	4	5	Total
15-Sep							0
19-Sep							1
26-Sep							14
02-Oct	1	0	0	0	0	0	29
06-Oct	0	1	1	1	0	0	40
14-Oct	0	0	0	5	0	0	60
24-Oct	0	0	1	7	4	0	12

Shaded boxes indicate these fish were removed from the percentile analysis because they did not move upriver.

Appendix C. Aerial survey results by area for male, female, internally and externally radio-tagged fall chum salmon on the Toklat River in 1997.

Numbers of externally tagged fish.

Date	Area 0	1	2	3	4	5
15-Sep	1	49	28	0	0	0
19-Sep	1	16	37	26	4	0
26-Sep	0	2	11	25	29	10
02-Oct	0	3	13	19	50	11
06-Oct	0	3	8	29	49	8
14-Oct	0	3	8	22	56	7
24-Oct	0	0	0	6	4	0

Numbers of internally tagged fish.

Date	Area 0	1	2	3	4	5
15-Sep	2	2	3	2	1	0
19-Sep	4	0	1	1	4	1
26-Sep	3	1	1	0	3	2
02-Oct	5	1	7	4	3	3
06-Oct	5	1	4	6	4	2
14-Oct	5	1	3	7	5	1
24-Oct	1	0	1	5	3	0

Percentage of externally tagged fish.

Date	Area 0	1	2	3	4	5
15-Sep	1	63	36	0	0	0
19-Sep	1	19	44	31	5	0
26-Sep	0	3	14	32	38	13
02-Oct	0	3	14	20	52	11
06-Oct	0	-	9	31	52	9
14-Oct	0	-	9	24	60	8
24-Oct	0	0	0	60	40	0

Percentage of internally tagged fish.

Date	Area 0	1	2	3	4	5
15-Sep	20	20	30	20	10	0
19-Sep	36	0	9	9	36	9
26-Sep	30	10	10	0	30	20
02-Oct	22	4	30	17	13	13
06-Oct	-	6	24	35	24	12
14-Oct	-	6	18	41	29	6
24-Oct	-	0	11	56	33	0

Numbers of externally tagged fish with inactivity signal.

Date	Area 0	1	2	3	4	5
15-Sep	0	0	0	0	0	0
19-Sep	0	0	0	0	0	0
26-Sep	0	0	2	5	2	1
02-Oct	0	0	2	5	13	4
06-Oct	0	0	4	7	17	3
14-Oct	0	0	5	10	28	6
24-Oct	0	0	0	4	3	0

Numbers of internally tagged fish with inactivity signal.

Date	Area 0	1	2	3	4	5	Total
15-Sep	0	0	0	0	0	0	0
19-Sep	1	0	0	0	0	0	1
26-Sep	1	1	0	0	0	2	14
02-Oct	2	1	1	0	1	0	29
06-Oct	2	1	0	0	2	2	40
14-Oct	2	1	1	3	3	1	60
24-Oct	0	0	1	3	1	0	12

Shaded boxes indicate these fish were removed from the percentile analysis because they did not move upriver.

Numbers of tagged females.

Date	Area 0	1	2	3	4	5
15-Sep	1	25	13	0	0	0
19-Sep	3	9	18	11	3	0
26-Sep	2	0	8	10	14	4
02-Oct	3	1	10	11	23	5
06-Oct	2	2	6	16	23	5
14-Oct	2	2	6	14	23	5
24-Oct	0	0	1	3	3	0

Numbers of tagged males.

Date	Area 0	1	2	3	4	5
15-Sep	2	26	18	2	1	0
19-Sep	2	7	20	16	5	1
26-Sep	1	3	4	15	18	8
02-Oct	2	3	10	12	30	9
06-Oct	3	2	6	19	30	5
14-Oct	3	2	5	15	38	3
24-Oct	1	0	0	8	4	0

Percentage of tagged females.

Date	Area 0	1	2	3	4	5
15-Sep	3	64	33	0	0	0
19-Sep	7	20	41	25	7	0
26-Sep	5	0	21	26	37	11
02-Oct	6	2	19	21	43	9
06-Oct	4	4	11	30	43	9
14-Oct	4	4	12	27	44	10
24-Oct	0	0	14	43	43	0

Percentage of tagged males.

Date	Area 0	1	2	3	4	5
15-Sep	4	53	37	4	2	0
19-Sep	4	14	39	31	10	2
26-Sep	2	6	8	31	37	16
02-Oct	3	5	15	18	45	14
06-Oct	5	3	9	29	46	8
14-Oct	5	3	8	23	58	5
24-Oct	8	0	0	62	31	0