AVISTA CORPORATION

LAKE SPOKANE CARP POPULATION ABUNDANCE AND DISTRIBUTION STUDY
2014 ANNUAL REPORT
PHASE I

Prepared By:

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Attachment A Summary of CART Tag Detections

List of Acronyms, Abbreviations, and Definitions

%	percent
±	plus or minus
≥	greater than or equal to
Avista	Avista Corporation
carp	common carp (*Cyprinus carpio*)
CART	combined acoustic radio transmitter
CPUE	catch per unit effort
DO TMDL	Dissolved Oxygen Total Maximum Daily Load (report)
DO WQAP	Dissolved Oxygen Water Quality Attainment Plan
Ecology	Washington State Department of Ecology
Fall 2013	October through December 2013
Fall 2014	October into November 2014
FERC	Federal Energy Regulatory Commission
g	gram(s)
Golder	Golder Associates Inc.
IDs	identification numbers
kg	kilogram(s)
L	total length
mg	milligram(s)
mm	millimeter(s)
PIT	passive integrated transponder
r^2	r-squared
RKM	river kilometer
SD	standard deviation
Spring	April through June
Summer	July through September
TP	total phosphorus
WDFW	Washington Department of Fish and Wildlife
WGS84	World Geodetic System 1984
Winter	January through March
Wr	relative weight
Ws	standard weight

1.0 INTRODUCTION

Common carp (*Cyprinus carpio*), referred to in this document as carp, influence phosphorus loading and phosphorus bioavailability in Lake Spokane. Carp transfer phosphorus from lake sediment into the water column through feeding and excretion, and also cause phosphorus loadings during die-offs. In addition, carp can negatively affect native aquatic vegetation, native fauna, and popular warmwater fish like bass and panfish (crappie, perch, and sunfish) that are targeted by anglers. Avista Corporation (Avista) recognized a potential for reducing phosphorus releases within Lake Spokane by reducing the lake's carp population and worked with Golder Associates (Golder) to prepare a study plan for this purpose (Avista and Golder 2012a), which is a component of the Lake Spokane Dissolved Oxygen Water Quality Attainment Plan (DO WQAP) developed by Avista and Golder (2012b) to address its proportional level of responsibility as determined in the Spokane River and Lake Spokane Dissolved Oxygen Total Maximum Daily Load (DO TMDL).

The carp population reduction study was initiated in 2013 and actions conducted in 2013 were summarized in a 2013 annual report (Golder Associates 2014). This report summarizes the Lake Spokane Carp Population Abundance and Distribution Study tasks funded by Avista in 2014.

Avista conducted a Phase I analysis to obtain a better understanding of carp seasonal behavior, biological measures, whole-body phosphorus concentrations, and abundance as described in detail below. Given the results of Washington Department of Fish and Wildlife's 2001 warmwater fisheries survey of Lake Spokane (Osborne et al 2003; Donley 2011), which suggest carp use shallow water and primarily concentrate in the upper end of the lake, the study area focused on Lake Spokane inshore habitat generally less than 30 feet deep.

The Phase I components addressed in this report include the following four items.

1. **Carp Seasonal Behavior (movement and aggregation)**
2. **Carp Abundance**
3. **Basic Carp Biological Measures**
4. **Whole-Body Carp Phosphorus Accumulated Load**

2.0 METHODS

The methods and procedures employed during the Phase I monitoring and analysis were managed for quality control by implementing commonly-accepted procedures for capture, measurement, and analysis of fish-tissue samples. As part of this process, Avista worked with Washington Department of Fish and Wildlife (WDFW) and Washington Department of Ecology (Ecology) to obtain all required permits before sampling fish.

Golder was contracted by Avista to lead implementation of this carp population reduction study, which began in October 2013.

2.1 Carp Seasonal Behavior

2.1.1 Field Sampling and Tracking

This study was initiated with a crew being mobilized to collect and tag carp for tracking their seasonal distribution. First, a test was conducted of the boat electro-fishing system and the following day sampling was conducted to collect carp for tagging. On October 17, 2013, a crew of staff from Golder and Avista Corporation (Avista) captured 20 carp, surgically implanted combined acoustic radio transmitter (CART) tags into them, and released them after the carp had recovered from the anesthesia and could swim on their own volition. Boat electro-fishing was conducted at two sites that were selected to maximize carp captures.

A passive integrated transponder (PIT) tag was inserted in each of the 20 carp on the left side into musculature below the dorsal fin, and a 16-gram CART tag surgically implanted in its abdominal cavity through a 15-millimeter incision posterior of the anal fin. The CART tags selected for this study were Lotek Model MM-RC-11-45, which are 12 millimeters diameter, 78 millimeters long, have a dry weight of 16 grams, with an expected battery life of 736 days when programmed for 60-second (±2 seconds) interval acoustic signals and 10 to 10.5 second radio signals. Following each surgery, the carp's recovery from anesthesia and general condition was monitored, and once the surgery team determined the carp had recovered from anesthesia, the fish was released.

The Golder-Avista crew conducted range testing of the CART tags on October 16, 2013 to facilitate development of tracking procedures based on the detectability of the radio and acoustic signals from CART tags under different boat operations. Results of these tests demonstrated that radio detection worked well for tags that were shallow (even when in a weed bed), and acoustic detection was better for deep tags. Adverse effects of hydraulic noise and boat speed on acoustic detection would prevent effectively detecting locations with the motor running, and would therefore not be as efficient as long as radio detections were possible. Therefore, radio signals were tracked as long as detection levels remained at or above 75 percent of the tags. For tag detection levels of 50 percent or less in a single

tracking session or less than 75 percent for two consecutive tracking sections, we planned to switch to tracking acoustic signals.

A period of approximately two weeks was allowed to give the tagged carp time to redistribute throughout Lake Spokane after the tags were implanted. The tagged carp were released on October 17, 2013. The tracking events were conducted at roughly one-week intervals during November 2013 followed by two-week intervals in December 2013 through September 2014, and one-week intervals during October 2014. Some minor adjustments were made to the tracking schedule based on availability of the tracking crew and boat.

In May 2014, the Golder-Avista crew deployed an Onset ProV2 thermograph programmed to record temperature at 15-minute intervals approximately one meter below the water surface at each of the four locations identified in Table 2-1. The thermographs were deployed to gain more information in order to better predict the spawning timeframe for the mark event. These thermographs were downloaded on tracking sessions and recovered at the end of the study period. The accuracy of each thermograph was verified before deployment and after recovery. All thermographs were placed into a water bath near 10°C and 25°C along with a certified thermometer in order to verify that the thermograph temperature was within 0.2°C of the corresponding certified thermometer temperature.

Table 2-1: Locations of near Surface Continuous Temperature Measurements

Station Code	Description	Latitude (WGS84)	Longitude (WGS84)
Felton	Felton Slough	47.848435	-117.656586
SportParad-BW	Sportsman's Paradise Backwater	47.830768	-117.641262
Granger-Riv	Granger River	47.800871	-117.558344
Granger-BW	Granger Backwater	47.797398	-117.55911

2.1.2 Data Analysis

Plots of detection river kilometer (RKM) vs. date of detection were constructed for each CART-tagged carp. These plots were used to identify tags that stopped moving suggesting either fish mortality or shedding of the tag. Tags identified as stationary, based on movements of less than 0.5 km upstream for detections across sampling events, were omitted from further analysis starting from the first detection in the stationary time period.

All carp movement patterns were evaluated using change in RKM values along the thalweg. Movement distance was calculated as change in RKM values along the thalweg, for each pair of consecutive detections for each tag and then plotted for visual interpretation. A box plot was created to display movement for each tracking session. Plots were also created for changes in RKM vs. difference in time between detections for each season, with October through December 2013 designated as "Fall 2013", January through March 2014 as "Winter 2014", April through June 2014 as "Spring 2014", July through

September 2014 as ”Summer 2014”, and October into November 2014 as ”Fall 2014”. Distances moved between sessions were summarized using mean, standard deviation, median, and minimum/maximum statistics within each sampling season. Total movement was calculated by summing absolute movement distances calculated by each individual fish within each season.

Aggregation was assessed by estimating the number of fish at each RKM location for each session using fish that were within 500 m of each other. The number of fish at each RKM location at each sampling session was plotted to visualize spatial and temporal aggregation patterns. In addition, the distance between each tag and its nearest neighbor (along the thalweg) was calculated for each tracking session. Nearest neighbor data were summarized (mean, SD, median, and range) for each sampling season.

2.2 Carp Abundance

2.2.1 Field Sampling

Results of the carp tracking program guided selection of the sampling locations for a mark-recapture program aimed at estimating carp abundance in Lake Spokane (Table 2-2). Sampling locations were based on detected CART-tag locations just before each sampling program and the extent of aggregation of the CART-tagged carp.

Table 2-2: Adaptive Sampling Decision Tree

CART Tag Distribution	Marking Strategy	Recapture Strategy
Highly Clumped* (≥90%)	Mark 80% at clumped site, 20% at random sites based on habitat type	Recapture effort 80% at clumped site, 20% at random sites based on habitat type
<90% and >50% Clumped	Randomly stratify marking effort based on both CART tag distribution and habitat type. (50% effort at clumped sites)	Randomly stratify recapture effort based on both CART tag distribution and habitat type. (50% effort at clumped sites)
Random (≤50% clumped)	Randomly stratify marking effort based on habitat type, but weighted for CART tag abundance	Randomly stratify recapture effort based on habitat type, but weighted for CART tag abundance

Note: Clumped % refers to percentage of CART tags detected at a single area that can be sampled using proposed gear as a single unit.

The marking program was scheduled to target the carp spawning period to maximize the number of fish marked and the recapture program targeted sampling carp aggregations in the late summer based on the success of sampling in October 2013. The specific schedule for the marking program in June was triggered by observations of carp activity by the Golder-Avista tracking crew along with Lake Spokane shoreline residents, and the thermograph temperature records.

2.2.1 Data Analysis

The capture method for both the marking and recapture programs was boat electro-fishing following the WDFW standard boat speed of 18.3 m/minute (Bonar et al. 1993). Sampling efficiency was measured as:

Catch per unit Effort (CPUE) = Number of Carp Captured / electro-shocking time (hour)

Captured carp were processed following methods described in Section 2.3.

2.3 Basic Carp Biological Measures and Sampling

2.3.1 Field Sampling

The Golder-Avista crew collected biological measurements, including total length, fork length, and weight during the October 2013, June 2014, and September 2014 sampling programs. Table 2-3 summarizes the parameter targets for the three sampling programs.

Table 2-3: Parameter Targets for Biological Measurements and Sampling

Parameter	October 2013	June 2014	September 2014
PIT tag to uniquely identify particular fish	All	All	None
Total Length (mm)	All	All	All
Fork Length (mm)	All	100 fish across the full range of sizes	100 fish across the full range of sizes with emphasis on PIT-tagged carp
Weight (grams)	All	Target 10 non-CART-tagged carp in each 100-mm size category	Target 10 non-CART-tagged carp in each 100-mm size category with emphasis on PIT-tagged carp
Dorsal Spine for ageing	None to minimize impacts on movement evaluation	None to minimize impacts on abundance estimate	Same fish as weighed
Whole-body sample for total phosphorus (TP) analysis	None	None to minimize impacts on abundance estimate	First non-CART-tagged carp in each 100-mm size category
Sexual maturity and sex of fish	None	None to minimize impacts on abundance estimate	All fish sacrificed for other analyses

Dorsal spine samples were collected from carp in September 2014 and ageing analyses were conducted by North/South Consultants. The initial spine, which is the largest, was removed with side-cutters then placed in a labeled coin envelope. Following air drying of the dorsal spine samples, they were shipped to North/South Consultants. The spine samples were first dipped in an epoxy resin (Cold Cure™) and

allowed to harden for 48 hours. Then a low-speed-sectioning saw was used to prepare two sections per spine that were between 0.50 and 0.75 mm thick. These sections were then permanently mounted to a labelled glass slide using Cytoseal-60™, and the mounted sections were viewed under a microscope with transmitted light by an experienced ageing technician. An ageing technician categorized the confidence in ageing each sample by applying characteristics in Table 2-4, and then aged the sample. As an additional quality control and quality assurance measure, an alternate ageing technician evaluated the age for a randomly-selected subset of >10 percent of the spine samples.

Table 2-4: Qualitative and Quantitative Confidence Indices for Ageing Carp Dorsal Spines

Confidence Indices	Qualitative Characteristics (Pattern Clarity)	Quantitative Characteristics (Repeatability)
Very Good	Annuli are clear with no interpretation problems	Reader always gets the same age
Good	Annuli are clear with a few easy interpretation problems	Reader would get the same age most of the time for fish <10 years, within one year for fish 11-20 years
Fair	Annuli are fairly clear with some areas presenting easy and moderate interpretation problems	Reader would be within 1 year most of the time for fish<10 years and 2-3 years for fish >10 years
Poor	Annuli are fairly unclear presenting a number of difficult interpretation problems	Reader would be within 2-3 years most of the time for fish <10 years and 4-5 years for fish >10 years
Very Poor	Annuli are very unclear presenting significant interpretation problems	Reader has little confidence in repeatability of age within 4-5 years

Whole-body carp samples were collected in September 2014 for TP analysis. These fish were humanely sacrificed and placed on ice in a cooler. At the end of each day, the fish collected were taken to a butcher shop and flash frozen. Following the September 2014 sampling program, all frozen samples were placed in a cooler with ice and shipped for next-day delivery to ALS Environmental in Kelso, Washington. ALS followed standard operating procedures for preparation and TP analysis of the whole-body tissue samples (ALS 2014, 2012).

In September 2014, the crew also determined the sexual maturity and sex of all sacrificed fish by incising their abdomen and inspecting their gonads.

2.3.2 Data Analysis

Length frequencies and weight-length regressions were performed using R. The linear relationship between fork and total length was estimated. Plots of length and weight at age were constructed for all carp that were analyzed for age (September 2014 samples). Relative weight was calculated for each captured fish. Standard weights (Ws) were calculated using the following equation developed by Bister et al. (2000) that was developed using carp data from 167 different populations:

$$\log_{10}(Ws) = -4.639 + 2.920 * \log_{10}(L)$$

where Ws is the standard weight, and L is the total length (mm).

Relative weight (Wr) for each carp was calculated by dividing its measured weight by its standard weight and multiplying by 100 (i.e., Wr = W / Ws * 100).

Total phosphorus concentrations for Lake Spokane carp were compiled with literature values for carp fed and used to refine the estimate of RP accumulated in Lake Spokane carp.

3.0 RESULTS

3.1 Carp Seasonal Behavior

The Golder-Avista crew captured 20 carp, surgically implanted CART tags into them, and released them after the carp had recovered from the anesthesia and could swim on their own volition in October 2013. The boat electro-fishing system was tested on October 16, 2013. The following day, a site near Sportsman's Paradise was sampled and another site located near the Lake Forest Community (referred to as Felton Slough) was sampled (Figure 3-1). The October 17 average catch per unit effort (CPUE) was 27.9 carp per hour.[1] Total lengths of the 20 CART-tagged carp ranged from 590 to 795 millimeters (23.2 to 31.3 inches). Ten of the 20 carp weighed more than 5.0 kilograms, kg, (11.0 pounds), which was the upper limit for the scale used. All carp with fork lengths greater than 625 millimeters (24.6 inches) weighed greater than 5 kg (11.0 pounds). The minimum carp weight was 3.2 kg (7.2 pounds) resulting in the 16-gram Lotek Model MM-RC-11-45 CART tag being 0.5% of the weight for this carp and less for all other carp.

Fish-specific detections ranged from 53 percent to 100 percent of the tracking sessions. Data of 15 of the 20 CART tagged carp were collected throughout the study period (Attachment A). Two CART tags ceased being detected during the study; tag IDs 14 and 30 were last detected on August 6, 2014 and June 20, 2014, respectively. In addition, three fish (tag IDs 18, 26, 28) were determined to have died or shed their tags on June 9, June 20, and July 12, respectively (Figure 3-2).

There were no apparent relationships between time differences and RKM differences between detections in any seasons of this study (Figure 3-3). Most between-detection time differences were ≤ 20 days, although they ranged from 3 to 71 days between detections. The median time difference was 12 days, the 75th quantile was 16 days, and the mean ± SD were 12.5 ± 6.9 days.

Movement patterns changed among tracking events (Figure 3-4). Throughout most of fall 2013, movement was limited as can be seen by 50 percent of the fish (the extent of the box in the boxplot) moving less than 1 km between detections. From December 30, 2013 to February 20, 2014 which included lake level drawdown from within 1 foot of normal full pool to 13.4 feet below normal full pool, movement ranges increased, with carp moving both up- and down-reservoir from their previous locations. Throughout March, when the lake was refilled by significant inflows, to mid-July 2014, movement was somewhat variable, but remained similar across most sessions. In late July and early August 2014, movement and variability in movement increased substantially. Between July 12 and 21, fish moved mainly down-reservoir (most of the box is below 0 RKM). In comparison, by August 6, the majority of fish

[1] Additional detail for the CPUE is provided below with CPUE for the June 2014 and September 2014 sampling programs.

moved several kilometers up-reservoir.. In late September to mid-October 2014, most fish moved down-reservoir from their previous locations.

All 20 CART tags were last accounted for and believed to still be in live carp on May 28, 2014, before the carp spawning period. During the carp spawning period of June to early July of 2014, one CART tag ceased to be detected and three CART-tagged carp were determined to have died or shed their CART tag. An additional CART tag ceased being detected in August 2014. These factors contributed to detection rates decreasing to as low as 10 active CART tags on September 23, 2014. In summer 2014, the proportion of active tags detected in a session was as low as 67 percent, but averaged 85 percent with a median of 88 percent. Fall 2014 active tag detections were as low as 73 percent in a session, but averaged 85 percent and had a median of 87 percent.

When plotted by season (Figure 3-5), movement in winter 2014 had slightly wider distribution (seen as wider box and longer whiskers) than movement in the other four seasonal periods, which were similar to one another. For all seasons, within-season movements did not show an up- or down-reservoir movement trend as evidenced by boxplots being symmetrical around zero RKM. Median values of seasonal movement ranged from -60 to 10 m (Table 3-1). Mean movement ranged from -370 m in fall 2014 to 87 m in fall 2013.[2] Seasonal movement was least variable in spring 2014 (SD of 1,848 m) and most variable in summer 2014 (SD of 2,500 m).

Table 3-1: Seasonal Summary Statistics for CART-Tagged Carp Distances (meters) Moved along the Thalweg between Detections

Season	Mean	SD	Median	Minimum	Maximum
Fall 2013	87	2,018	0	-8,390	7,110
Winter 2014	-60	2,221	-40	-5,840	6,590
Spring 2014	35	1,848	-60	-6,920	8,370
Summer 2014	-38	2,500	10	-6,660	9,890
Fall 2014	-370	2,110	-60	-7,150	6,490

Note: Seasonal summary statistics of distances moved along the thalweg between sessions, calculated across all fish. All values are in meters.

Tagged carp were highly aggregated during most of the fall 2013 and some of the winter 2014 sessions (Figures 3-6 and 3-7). Aggregations were evident for all tracking sessions between October 30 and December 16 of 2013 when the number of detected tags at any location ranged from 6 (November 13) to 19 (November 21). Following this period, the tagged carp spread out. On February 4, carp were once again aggregated with 19 of the tagged fish at the same location (Figures 3-6 and 3-7). On March 22 of 2014, carp were aggregated again, with 18 fish found between RKM 79.7 and 80.6. From May 2014

[2] This represents mean movement of 370 m toward Long Lake Dam in fall 2014 and 87 m away from Long Lake Dam in fall 2013. This difference may be due to fall tracking being limited to the end of October through December in 2013, but only October in 2014.

through the end of the study, aggregation was less distinctive, with a maximum of 6 tagged carp within 500 m of each other. However, the majority of fish were repeatedly detected between RKM 78 and 83.

For each season, minimum distance between fish was zero (nearest neighbor; Table 3-2), which indicates that at least two tagged fish were aggregated at least once during each season. Seasonal maximum distance to nearest neighbor ranged from 406 m in fall 2014 to 3,077 m in fall 2013, even though carp were highly aggregated during fall 2013. The high maximum distance between neighbors in fall 2013 is also the reason for the high mean and standard deviation during that season.

Table 3-2: Seasonal Summary Statistics (meters) for Estimates of Nearest Neighbor

Season	Mean	SD	Median	Minimum	Maximum
Fall 2013	96	385	0	0	3,077
Winter 2014	36	85	0	0	535
Spring 2014	33	125	6	0	1,492
Summer 2014	43	137	8	0	1,113
Fall 2014	17	56	3	0	406

Note: These statistics are based on estimates of nearest neighbor along the thalweg calculated for each tracking session.

Total movement distance within seasons varied by tag and season (Figure 3-8). Tag ID 12 had the greatest total movement recorded, with 34.1 km traveled during fall 2014. Tag ID 19 had the least total movement, with total seasonal movement ranging from 510 m in fall 2014 to 4.2 km in spring 2014.[3]

Carp spawning activity was reported for several sites, from Nine Mile Flats (most up-reservoir) to the Woody Slough shoreline (most down-reservoir; Figure 3-1). Carp spawning activity was observed during June and early July 2014 (Figure 3-9). However, no carp spawning activity was observed in the extended vegetated flats near RKM 64 (Figure 3-1), which WDFW had identified as having enhanced carp activity in late spring of other years (Whalen 2014). During the observed carp spawning activity, near surface water temperature ranged from 14.5°C to 19.3°C at Felton (mean±SD of 16.8±1.05°C), from 13.7°C to 21.8°C, with large daily fluctuations, at Granger-BW (mean±SD of 17.6±1.78°C), from 14.1°C to 18.6°C at Granger-Riv (mean±SD of 16.3±1.03°C), and from 14.6°C to 21.2°C at Sportsman's Paradise-BW (mean±SD of 17.2±1.46°C).

During the study period, near surface hourly average water temperature increased from a range of 11.5 to 12.4°C, depending on station, in early May to a range of 19.1 to 23.5°C in August. The maximum water temperature, which was recorded in July at Sportsman's Paradise, was 26.0°C. Starting in early August, near surface water temperature began declining and reached an average of 13.7 to 17.5°C, depending on station, in October.

[3] Low detection rates for tag 19 throughout many seasons contributed to its lower total movement than other tagged carp (refer to Attachment A).

Air temperature slowly increased from May to July, and decreased from August to October. Throughout the study period, air temperature was highly variable, with mean daily temperatures fluctuating up to ~ 10°C. Within each month, the difference between minimum and maximum temperatures was greater than 20°C, with the largest range in October of 2014, when the maximum was 26.1°C and minimum was -4.4°C. The range of daily fluctuations was highest in September, with 20.5°C difference between the maximum and minimum temperatures.

The Lake Spokane inflow ranged from 1.3 kcfs to 6.8 kcfs in October 2013 through February 2014, and then increased to a high of 26.2 kcfs on March 15, 2014 (Figure 3-10). The inflow remained at 16 kcfs or greater until June 2014 and then decreased to approximately 2 kcfs in late summer. Following the typical hydrologic pattern, the reduction in inflow occurred throughout June and July, and coincided with reported carp spawning activity. From mid-July until end of October, inflows remained relatively stable.

Lake Spokane's elevation remained relatively stable within 1 foot of normal full pool from October 2013 through early December 2013. Then seasonal drawdown reduced the level to 13.4 feet below normal full pool. The lake elevation remained near this level until high inflows in March 2014 resulted in refilling the lake to with 2 feet of normal full pool. It remained near full pool throughout the remainder of this study.

Fish aggregation, as defined by ≥10 of the 20 tagged fish (Figure 3-10), was detected when mean daily air temperature ranged from -15.5°C to 8.9°C (median of -1.1°C), minimum daily air temperature ranged from -20.6°C to 5°C, and maximum daily temperature ranged from -12.8°C to 13.3°C. Fish were aggregated (≥10 tagged fish) when lake inflow ranged from 3.3 kcfs to 26.2 kcfs (mean±SD of 6.4±5.8 kcfs; median of 4.4 kcfs), and when water elevations ranged from 1522.6 feet to 1535.6 feet (mean±SD of 1530.5±5.4 ft; median of 1534.5 ft). Although this does not demonstrate a direct link between fish aggregation and Lake Spokane inflow or water elevation, the timing of two of the four aggregation dates suggests there may be a link with these environmental factors. February 4, one of the periods with 19 tagged carp aggregated, was the first tracking session following a rapid drawdown of the lake to near its minimum level. In addition, air temperature was near its lowest on this day. The March 22 carp-aggregation event followed the peak inflow event for the study period.

3.2 Carp Abundance

During the 2013 – 2014 study period, three carp sampling programs were conducted. Electro-shocking site-specific catch per unit effort (CPUE) results are displayed in Figure 3-11, and summary statistics for each sampling program are provided in Table 3-3.

Table 3-3: Catch per Unit Effort (CPUE), as carp per hour, for the Three Carp Sampling Programs

Sampling Program	Number of Sites	Mean CPUE	SD CPUE	Median CPUE	Minimum CPUE	Maximum CPUE
2013-October	3	20.1	14.5	27.2	3.4	29.7
2014-June	48	44.3	29.9	38.3	3.4	145.7
2014 September	15	6.7	8.6	6.9	0.0	28.6

The October 2013 sampling program was conducted to implant CART tags in 20 carp to enable tracking their movement as described above. This program consisted of three sampling sites, which included a test of the boat-electrofishing unit in the afternoon of October 16 followed by sampling the next day to obtain 20 carp for the CART-tag implantations. The CPUE for these three sampling sites varied widely, with a minimum of 3.4 carp per hour in Nine Mile Flats during testing of the boat-electroshocking system to 29.7 carp per hour at Felton Slough on the afternoon of October 17.

The June 2014 marking program was conducted during carp spawning on June 10 through 13, based on carp aggregating at known spawning areas and aggregation of CART-tagged carp. To increase the number of carp marked with PIT tags, additional sampling was conducted near some sites that had a large number of observed carp that were not captured on the first pass. The marking program consisted of 48 sites sampled on June 10-13 with 616 individual carp being marked with PIT tags Figure 3-11 displays CPUE by sampling area. CPUEs for this program ranged from 3.4 carp per hour at Woody Slough to 145.7 carp per hour near RKM 79 and had a median of 38.3 carp per hour. The shallow active spawning area along the left downstream bank near RKM 79 had four of the five greatest CPUEs, all of which were greater than 83 carp per hour.

The September 2014 sampling program was designed as a recapture program to be used for estimating carp abundance in the lake based on recaptures of previously marked (i.e., PIT-tagged) carp. Sample timing was aimed at capturing carp before they moved to deep water where capture efficiencies would be low. This program consisted of sampling 15 sites on September 28 and 29 resulting in a total of 26 carp being captured, with no previously PIT-tagged carp captured. CPUE was lower for this sampling program than either of the other two sampling programs. Sample site CPUE ranged from zero to 28.6 carp per hour with seven (47%) of the 15 sample sites having CPUE of zero carp per hour. Only four (27%) of the 15 sample sites had CPUE of 10 or more carp per hour (Figure 3-11). Based on the extremely low CPUE under a variety of conditions and locations,[4] it was concluded that continuing the sampling program with the end goal of providing a reliable carp population estimate was not feasible and therefore the sampling program was terminated.

[4] In September 2014, seven areas (Figure 3-11) ranging from shallow to deep water sites were sampled between early morning and late afternoon hours.

Since no previously PIT-tagged carp were captured during the September 2014 sampling program, a standard population size estimate could not be calculated.

3.3 Basic Carp Biological Measures

Measurements of carp total length (mm), fork length (mm), and weight (g) were recorded during the three sampling programs. The scale used in October 2013 had a maximum capacity of 5000 g. Ten of the 20 fish CART tagged had weights greater than the scale's capacity and were therefore recorded as ">5000 g" and omitted from summary statistics, length-weight regressions, etc.

Table 3-4 provides summary statistics for length and weight measurements of carp captured during the October 2013, June 2014, and October 2014 sampling programs. Considerably more carp were measured and weighed in June 2013 than either of the other sampling programs; therefore, it is not surprising that the ranges for lengths and weights are smaller for the other two sets. The overall measurement ranges were 168 to 810 mm (6.6 to 31.9 inches) for total lengths, 150 to 748 mm (5.9 to 29.4 inches) for fork lengths, and 60 to 10,450 g (0.1 to 23.0 pounds) for weights. The fish sampled in June 2014 had the full range of total lengths measured with a small length-frequency peak around 220 mm (9 inches) and a large length-frequency peak around 600 to 750 mm (24 to 30 inches; Figure 3-12).

Table 3-4: Summary of Carp Length and Weight Measurements by Sampling Session

Parameter	Session	Total length	Fork length	Weight [1]
N fish	Oct 2013	20	20	10
	Jun 2014	624	125	108
	Sep 2014	26	24	22
Range (minimum – maximum; units)	Oct 2013	590 – 795 mm	545 – 705 mm	3250 – 4376 g
	Jun 2014	168 – 810 mm	150 – 748 mm	60 – 10450 g
	Sep 2014	569 – 798 mm	511 – 717 mm	2660 – 7820 g
Mean (SD); units	Oct 2013	662 (53) mm	608 (47) mm	3790 (412) g
	Jun 2014	645 (114) mm	516 (176) mm	3805 (2835) g
	Sep 2014	670 (57) mm	599 (55) mm	4547 (1434) g

Note:
[1] The scale used in October 2013 had a maximum capacity of 5 kg, so the ten carp weighing > 5 kg were omitted from this analysis.

The relationship between fork lengths and total lengths remained virtually the same for all three sampling programs and had an r2 value of 0.998 for the combination of all three sampling programs (Figure 3-13). This relationship was:

$$\text{Fork Length} = -1.588 + 0.902 * \text{Total Length}$$

The relationship between length and weight of fish measured throughout the entire study period was strong with an r^2 value of 0.985) (Figure 3-14), with:

$$\text{Weight (g)} = 2.642 \times 10^{-5} \times \text{Total Length}^{2.91}$$

The relative weight (Wr) of carp sampled during the June 2014 carp spawning period ranged from 53.2 to 177.5, with a mean±SD of 109.2±18.6 and a median of 107.8 (Figure 3-15). For comparison, the 22 fish with length and weight measurements in September 2014 had relative weights that varied much less, ranging from 91.7 to 119.2 with a mean±SD of 106.1 ± 9.0. The median relative weight for September 2014 fish was virtually the same as for June 2013 (105.0 September versus 107.8 for June). Evaluation of relative weights based on total length categories of less than 600 mm, 600-800 mm, and greater than 800 mm suggested minimal trends; the relative weight was greater than 100 for all fish greater than 800 mm total length during the June 2014 spawning period (Figure 3-15).

Relative weight of greater than 100 represents a fish that is heavier than would be expected for a given length, compared to the mean values from other populations (Bister et al. 2000). Generally, high relative weights are viewed as a sign of health. However, seasonality (especially egg development and spawning) has a profound effect on relative weight, and likely contributed to the greater variability in relative weights for carp collected during the June 2014 spawning period.

Carp age analysis was based on dorsal spine samples removed from carp captured in September 2014. NSC's ageing technician categorized confidence indices as good for 15 (68%) and fair for 7 (32%) of the 22 samples aged. The aged fish, which had total lengths of 569 to 798 mm (22.4 to 31.4 inches) and weights of 2,660 to 7,820 g (5.9 to 17.2 pounds), were determined to have ages from 5 to 17 years (Table 3-5, Figure 3-16). Three (13.6%) fish were age 5, two fish were age 7 to 9 (9%), sixteen (72.7%) fish were age 10 to 14, and only one (4.5%) fish was age 17. The age of greater than half (5 of 9) of the females was at least 13; whereas, only one of 13 males was older than 13.

Table 3-5: Summary of Carp Age for Carp Collected in September 2014

Age	Female	Male	Total	Percent
5	1	2	3	13.6%
7	0	1	1	4.5%
9	1	0	1	4.5%
10	2	4	6	27.3%
11	0	5	5	22.7%
13	2	0	2	9.1%
14	2	1	3	13.6%
17	1	0	1	4.5%
Total	9	13	22	

Figure 3-16 displays carp length-at-age and weight-at age relationships based on 22 carp collected in September 2014. All four aged carp weighing greater than 6000 g in September were females (Figure 3-16).

3.4 Whole-Body Carp Phosphorus Concentration

Three carp collected in September 2014 were analyzed for whole-body TP concentrations to compare the TP proportion of carp in Lake Spokane with values used from a study of characteristics for carp fed different diets (Nwanna et al. 2010) and used to calculate rough estimates of TP accumulated in Lake Spokane carp. The TP proportion of the three whole-body carp from Lake Spokane ranged from 0.0039 to 0.0103 and averaged 0.0065 (Table 3-6). In comparison, the TP proportion of carp was reported as 0.0121 for carp fed a non-supplemented diet and 0.0200 for carp fed a diet supplemented with 20 g TP / kg. The average Lake Spokane TP proportion was 54 percent of the non-supplemented diet and 33 percent of the phosphorus-supplemented diet. Application of these percentages of measured TP content in Lake Spokane carp to earlier rough estimates based on literature values reduces the estimates for TP content (in the entire carp estimated population, assuming Donley's population estimate of 125,000 carp in Lake Spokane) from a range of 6,375 to 10,500 kilograms TP (Avista and Golder 2012a) to approximately 3,494 kg TP.[5]

[5] This calculation retains the application of Lake Spokane carp population and average weights reported by (Donley 2011).

Table 3-6: Potential Total Phosphorus Load Reductions from Carp Carcass Removal

Carp Description	Dry Matter (%)	TP Proportion of Carp (decimal)	Notes
Non-Supplemented Diet	30.0	0.0121	1, 3
Phosphorus Supplemented Diet	26.4	0.0200	2, 3
Lake Spokane Sept. 2014 Fish #656: 680 mm total length Female weighing 3.93 kg	27.0	0.0103	
Lake Spokane Sept. 2014 Fish #658: 585 mm total length Male weighing 2.82 kg	25.5	0.0052	4
Lake Spokane Sept. 2014 Fish #659: 731 mm total length Female weighing 6.14 kg	31.5	0.0039	
Lake Spokane Sept. 2014 Average	28.0	0.0065	
Lake Spokane Sept. 2014 Average / Non-Supplemented Diet Carp (%)	93%	54%	
Lake Spokane Sept. 2014 Average / Phosphorus Supplemented Diet Carp (%)	106%	33%	

Notes:
1 Carp with uncontrolled diet.
2 Carp with diet supplemented with 20 g TP / kg.
3 Source: Nwanna et al. 2010a.
4 Fish ID 658 results are the average of the initial (4,520 mg/Kg phosphorus) and duplicate (5,910 mg/Kg phosphorus) analyses.

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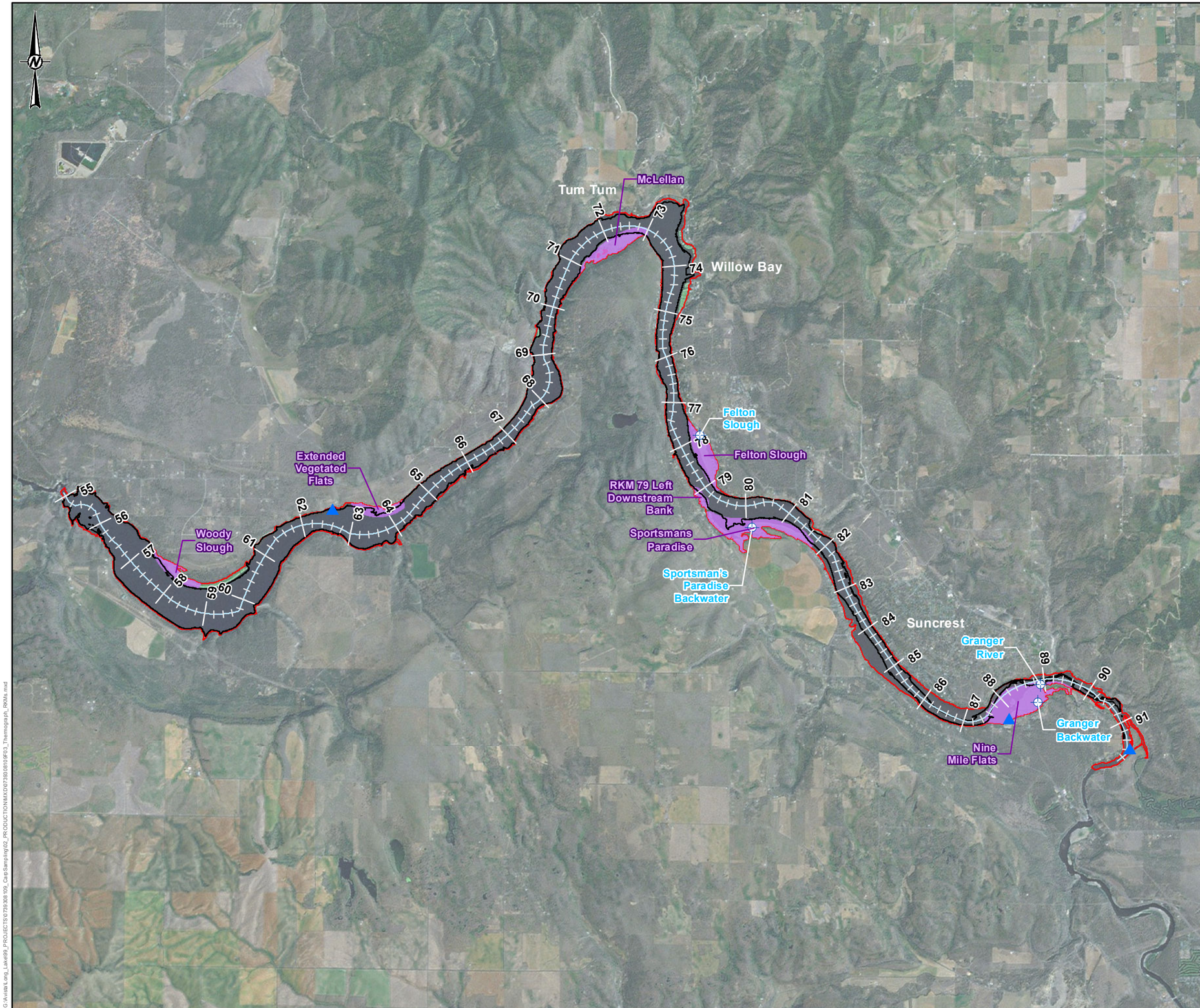
FIGURES



LEGEND

- THERMOGRAPH SITE
- CARP SPAWNING AREA
- LONG LAKE THALWEG (KM)
- 14FT DRAW DOWN (CONTOUR 1524, DATUM: NAVD 1988)
- PUBLIC BOAT LAUNCH
- LONG LAKE HED PROJECT BOUNDARY

REFERENCES

BACKGROUND: ESRI, ARCGIS ONLINE (WORLD IMAGERY), DATE ACCESSED: 2014-01-23
STATE PARKS: WA PARKS AND REC, WA STATE PARKS, DATE ACQUIRED: 2014-01-23

0 2 4
MILES

CLIENT
AVISTA

PROJECT
LAKE SPOKANE CARP POPULATION ABUNDANCE AND DISTRIBUTION STUDY 2014 ANNUAL REPORT

TITLE
LAKE SPOKANE RIVER KILOMETERS, THERMOGRAPH SITES, AND SPAWNING AREAS

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-01-26
PREPARED	GVL
DESIGN	GVL
REVIEW	BC
APPROVED	BLM

PROJECT No.	PHASE	Rev.	FIGURE
07393081-09	005	0	3-1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET HAS BEEN MODIFIED FROM: ANSI B

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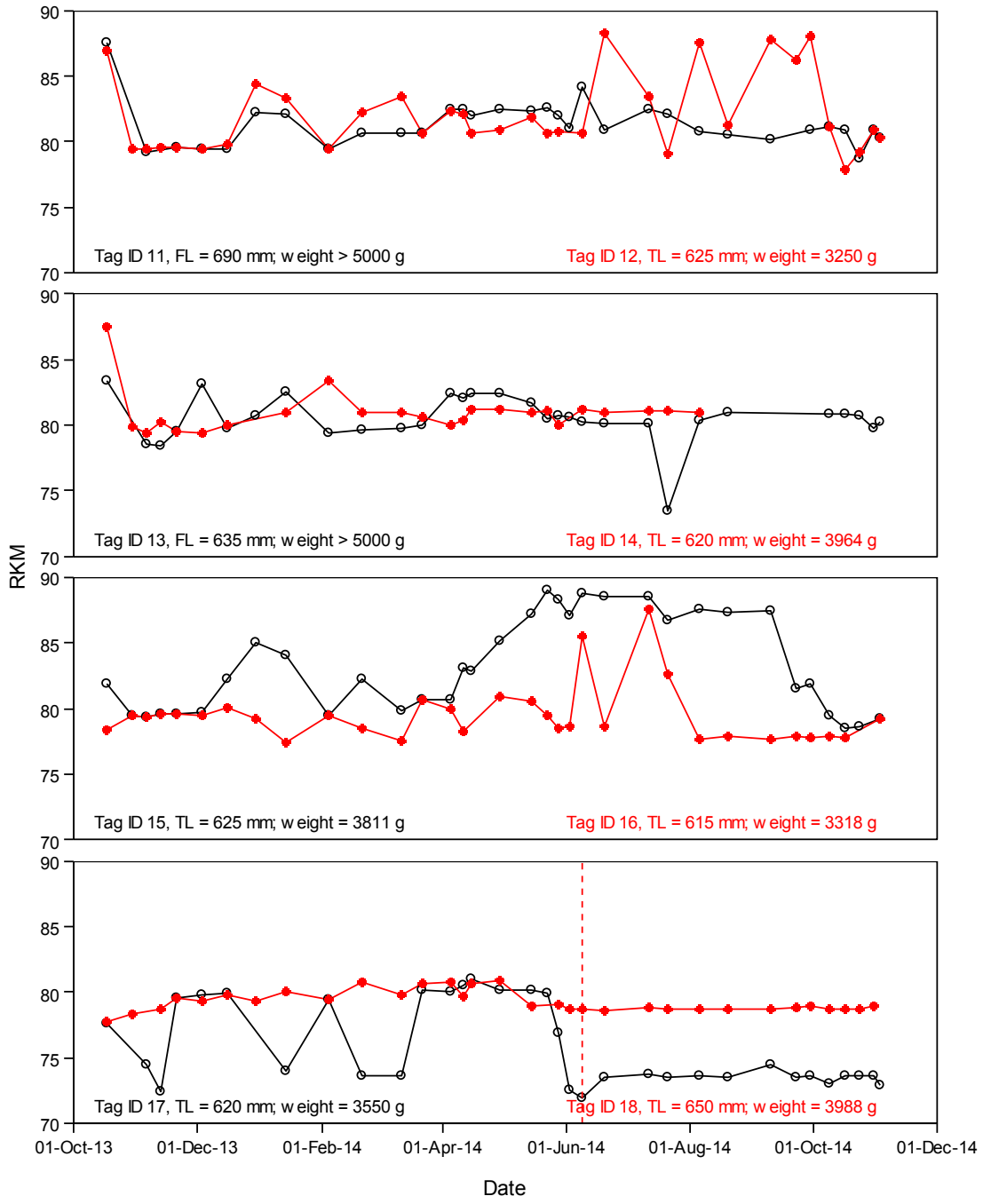

Figure 3-2A: River Kilometer (RKM) Locations at Each Tracking Session for CART-Tagged Carp, 2013-2014 Study Period for Tag IDs 11-18

Notes:

Each panel provides fish-specific details for two carp. The first point is for the CART-tagging session, and all subsequent points indicate tracking detections. Dashed vertical lines, corresponding in color to the tag, represent the time carp died or shed their tags.

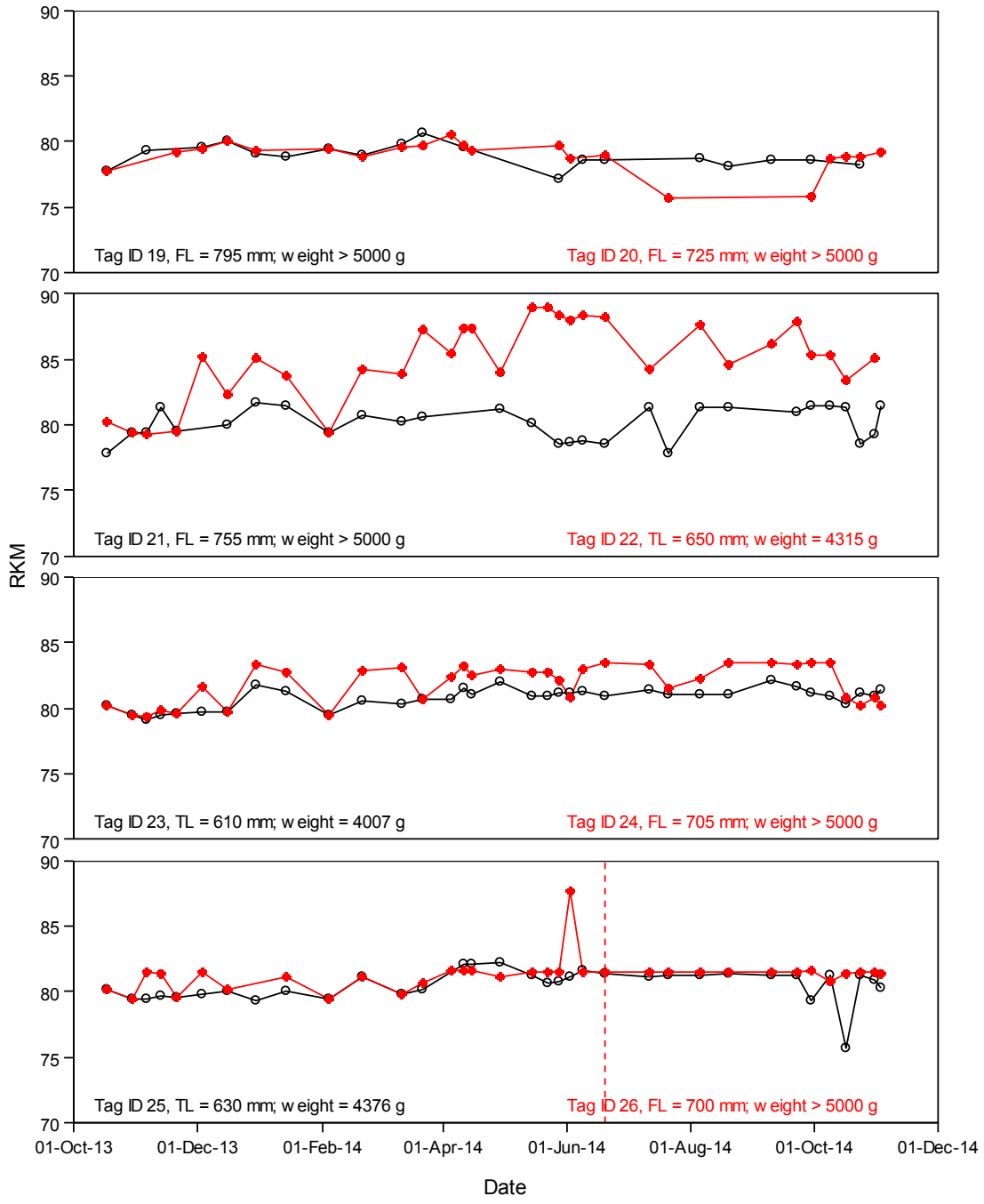

Figure 3-2B: River Kilometer (RKM) Locations at Each Tracking Session for CART-Tagged Carp, 2013-2014 Study Period for Tag IDs 19-26

Notes:

Each panel provides fish-specific details for two carp. The first point is for the CART-tagging session, and all subsequent points indicate tracking detections. Dashed vertical lines, corresponding in color to the tag, represent the time carp died or shed their tags.

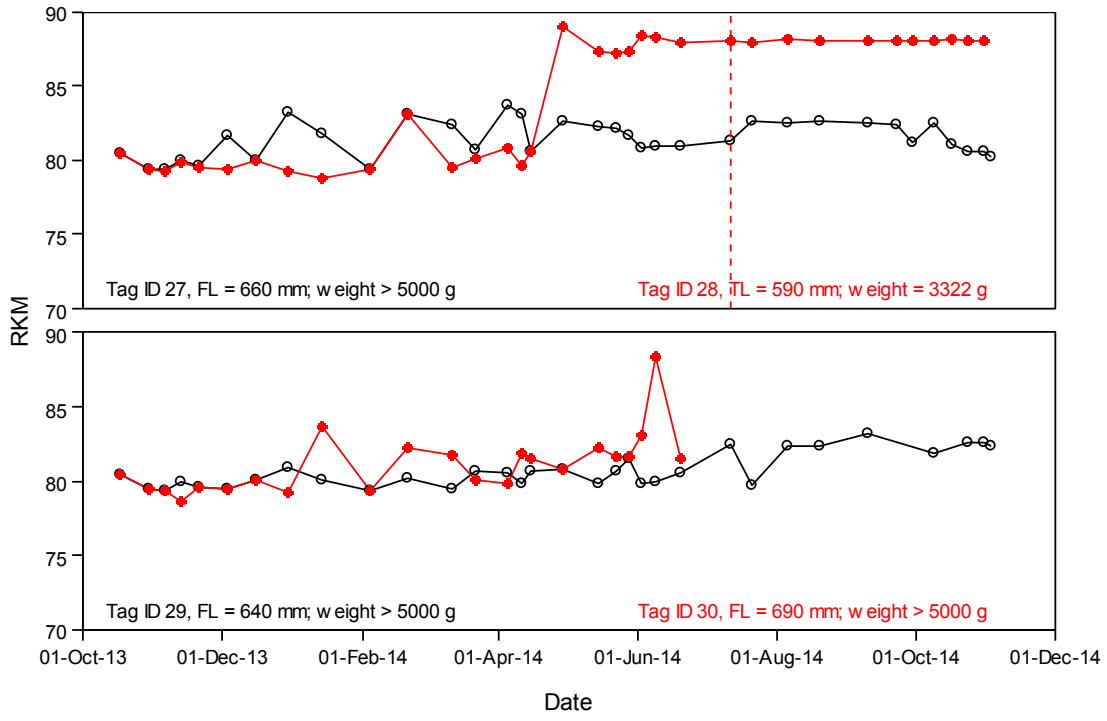

Figure 3-2C: River Kilometer (RKM) Locations at Each Tracking Session for CART-Tagged Carp, 2013-2014 Study Period for Tag IDs 27-30

Notes:

Each panel provides fish-specific details for two carp. The first point is for the CART-tagging session, and all subsequent points indicate tracking detections. Dashed vertical lines, corresponding in color to the tag, represent the time carp died or shed their tags.

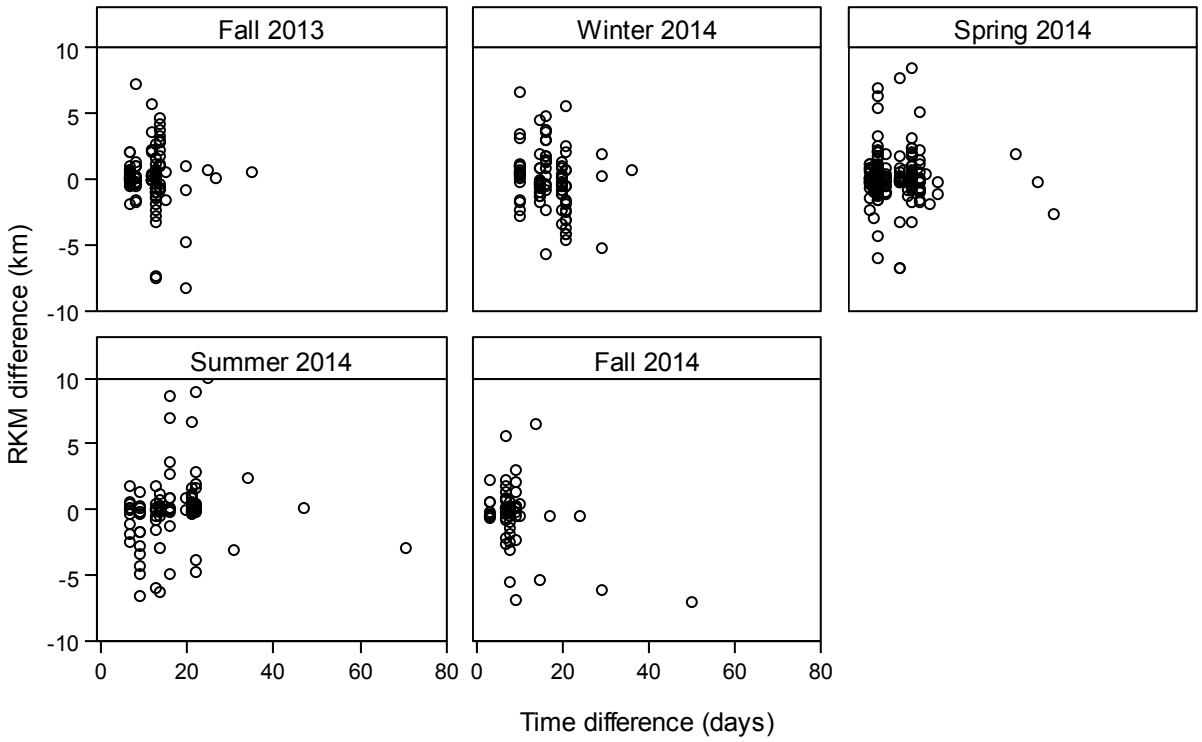

Figure 3-3: Movement of CART-Tagged Carp along the Thalweg by Season, 2013-2014 Study Period

Notes:

These are composites of change in detected river kilometers (RKM) for individual CART-tagged carp from the previous detected location, calculated along the thalweg. Therefore, RKM differences that are negative values indicate movement toward Long Lake Dam and positive values indicate movement away from Long Lake Dam.

Fall 2014 tracking was completed on November 3, 2014.

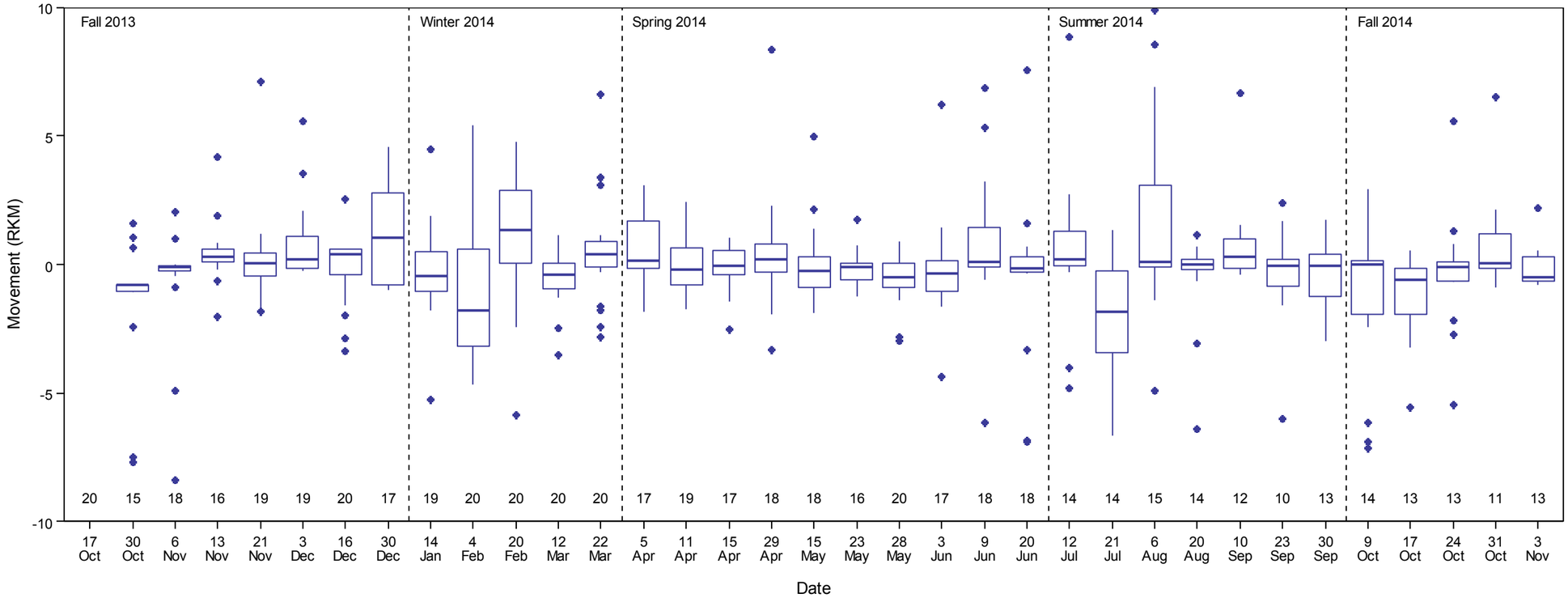

Figure 3-4: Boxplots of Movement (calculated along the thalweg) by Tracking Session with Seasons Depicted, 2013-2014 Study Period

Notes:

Movement was calculated as the change in detected river kilometers (RKM) for individual CART-tagged carp from the previous detected location. Therefore, RKM differences that are negative values indicate movement toward Long Lake Dam and positive values indicate movement away from Long Lake Dam.

Movement is shown as boxes with 25th and 75th quantiles as the bottom and top lines, respectively, the median as the bold line, whiskers extending to 1.5 times the interquartile distance, and outliers shown as individual points. The number of CART-tagged carp recorded during each tracking session is provided below each box.

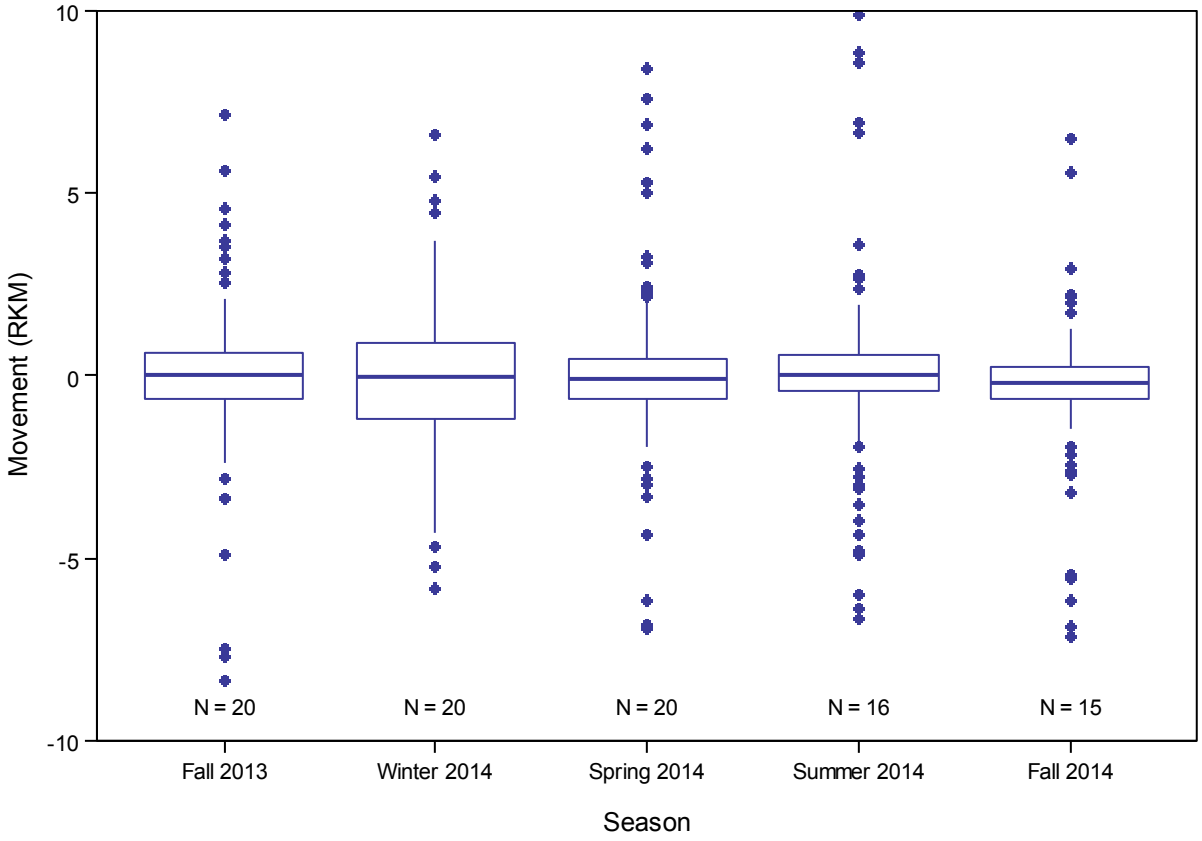

Figure 3-5: Boxplots of Distances Moved along the Thalweg between Sessions, by Season

Notes:

Movement was calculated as the change in detected river kilometers (RKM) for individual CART-tagged carp from the previous detected location. Therefore, RKM differences that are negative values indicate movement toward Long Lake Dam and positive values indicate movement away from Long Lake Dam.

Movement is shown as boxes with 25th and 75th quantiles as the bottom and top lines, respectively, the median as the bold line, whiskers extending to 1.5 times the interquartile distance, and outliers shown as individual points. The number of CART-tagged carp recorded during each tracking session is provided below each box.

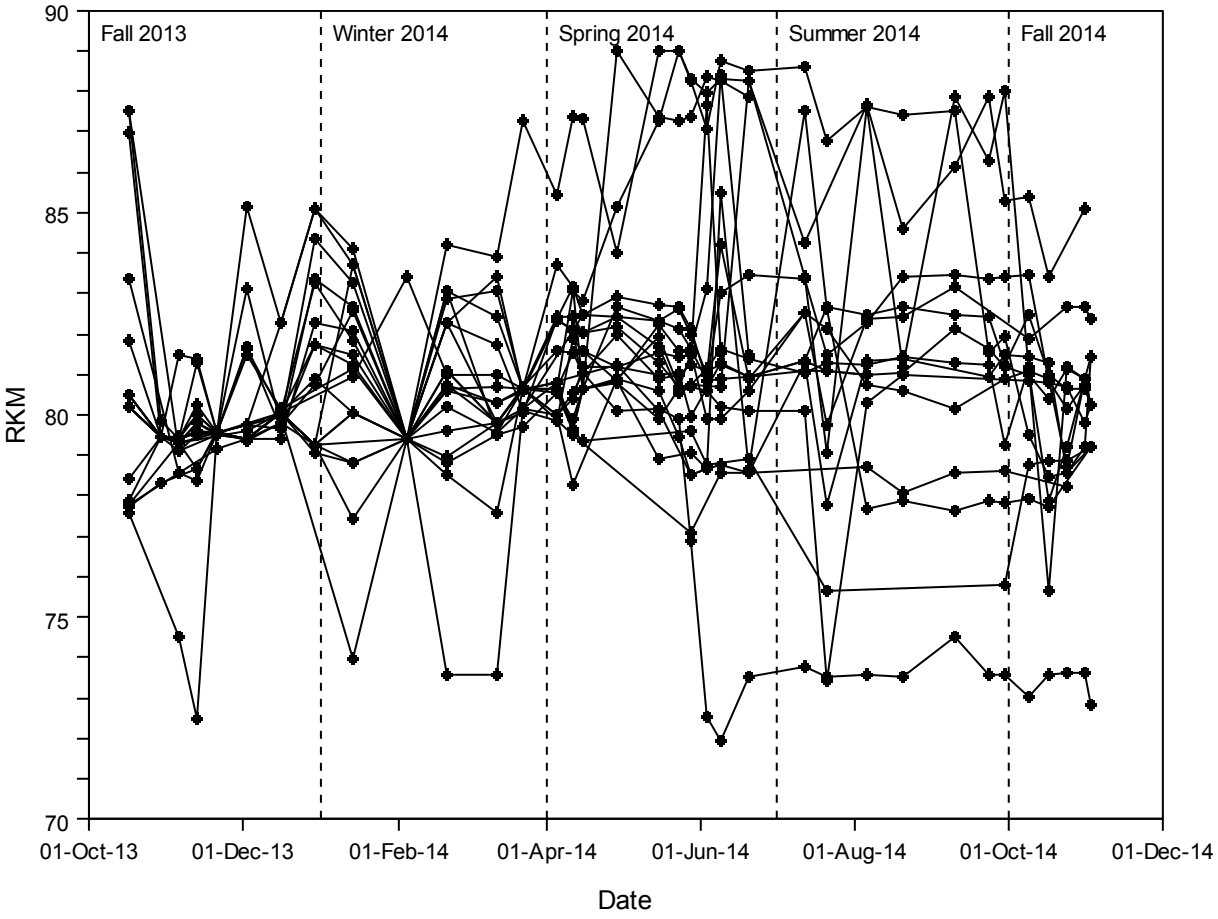

Figure 3-6. Aggregation of Distribution of CART-Tagged Carp along the Thalweg, 2013-2014 Study Period

Notes:

Each CART-tagged carp is represented by a line.

Tracking events, when fish were detected, are shown as points.

Dashed lines denote seasons.

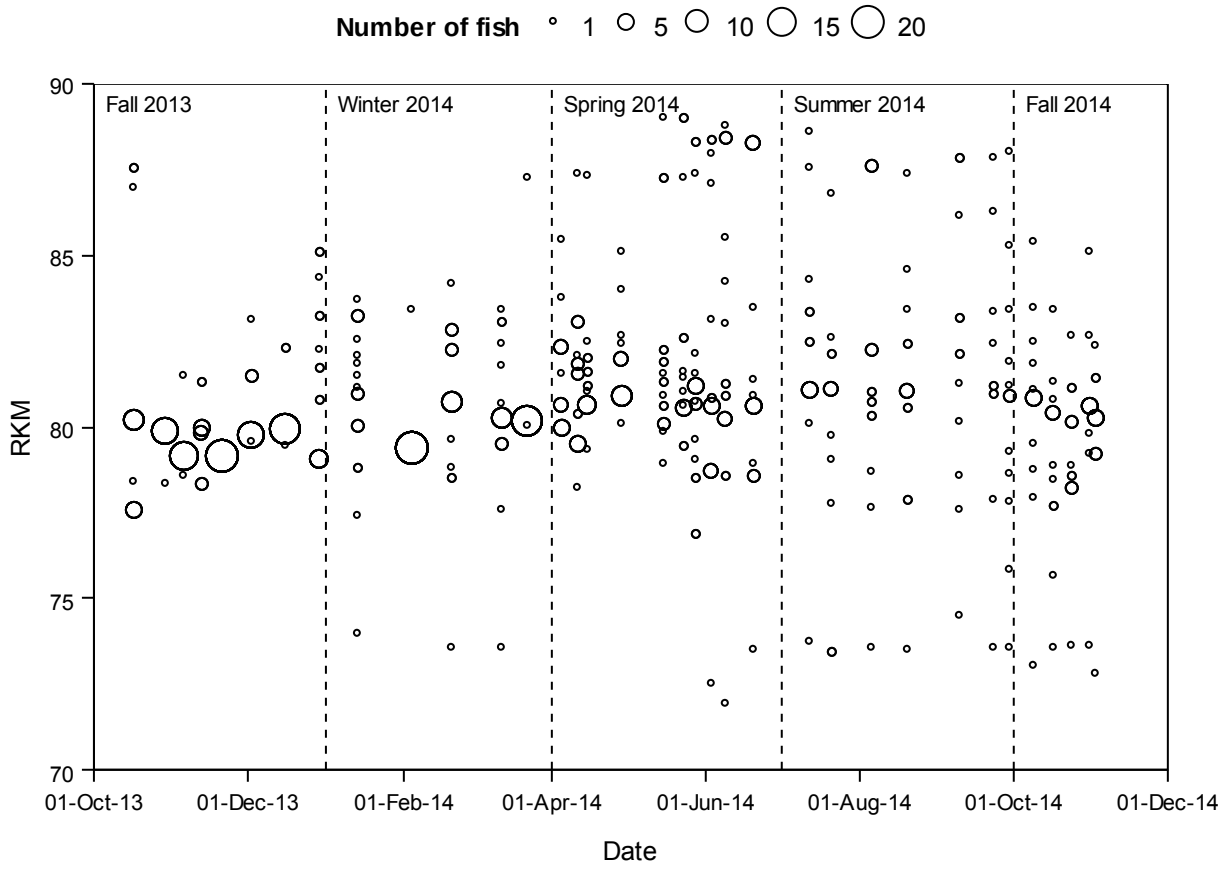

Figure 3-7. Distribution and Concentration of CART-Tagged Carp, 2013-2014 Study Period

Notes:

Bubble size is relative to number of fish observed during tracking at each location by session.

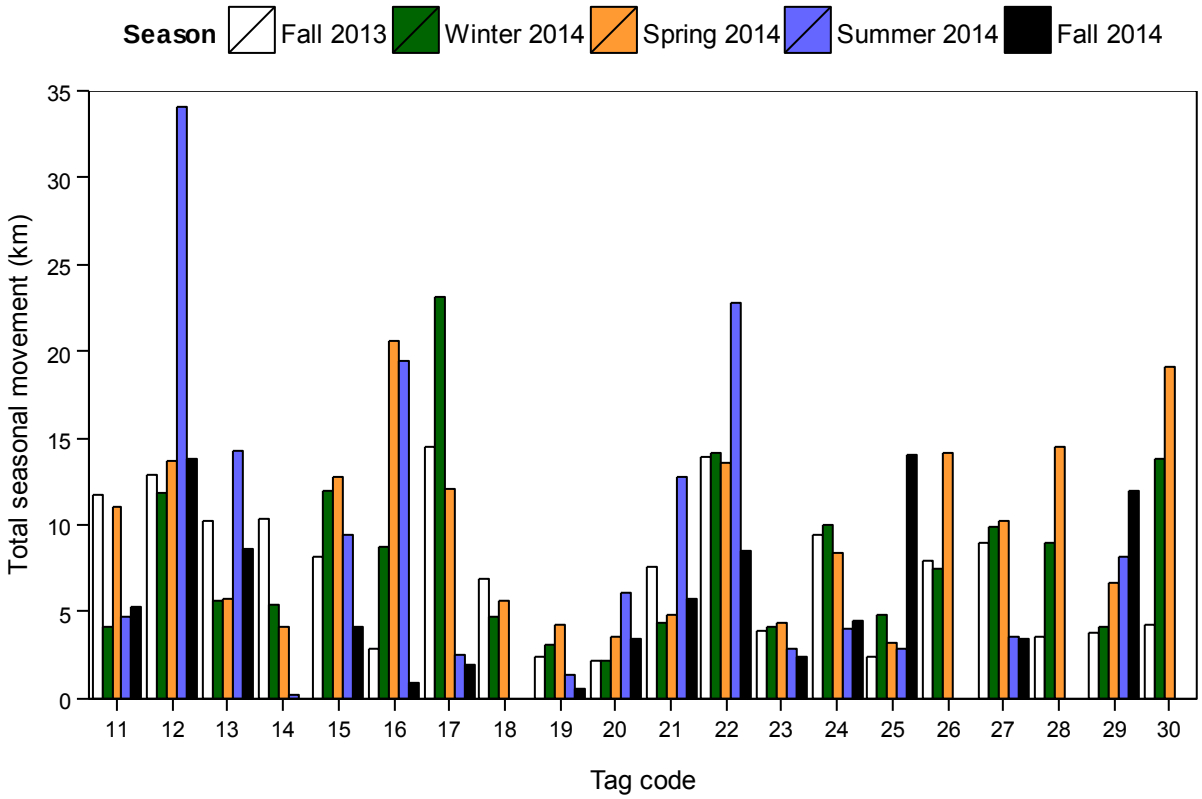

Figure 3-8. Total Movement, Calculated along the Thalweg, for Each CART-Tagged Carp by Season, 2013-2014 Study Period

Notes:

Seasonal movement was calculated as the summed absolute values of movement between session-specific detections.

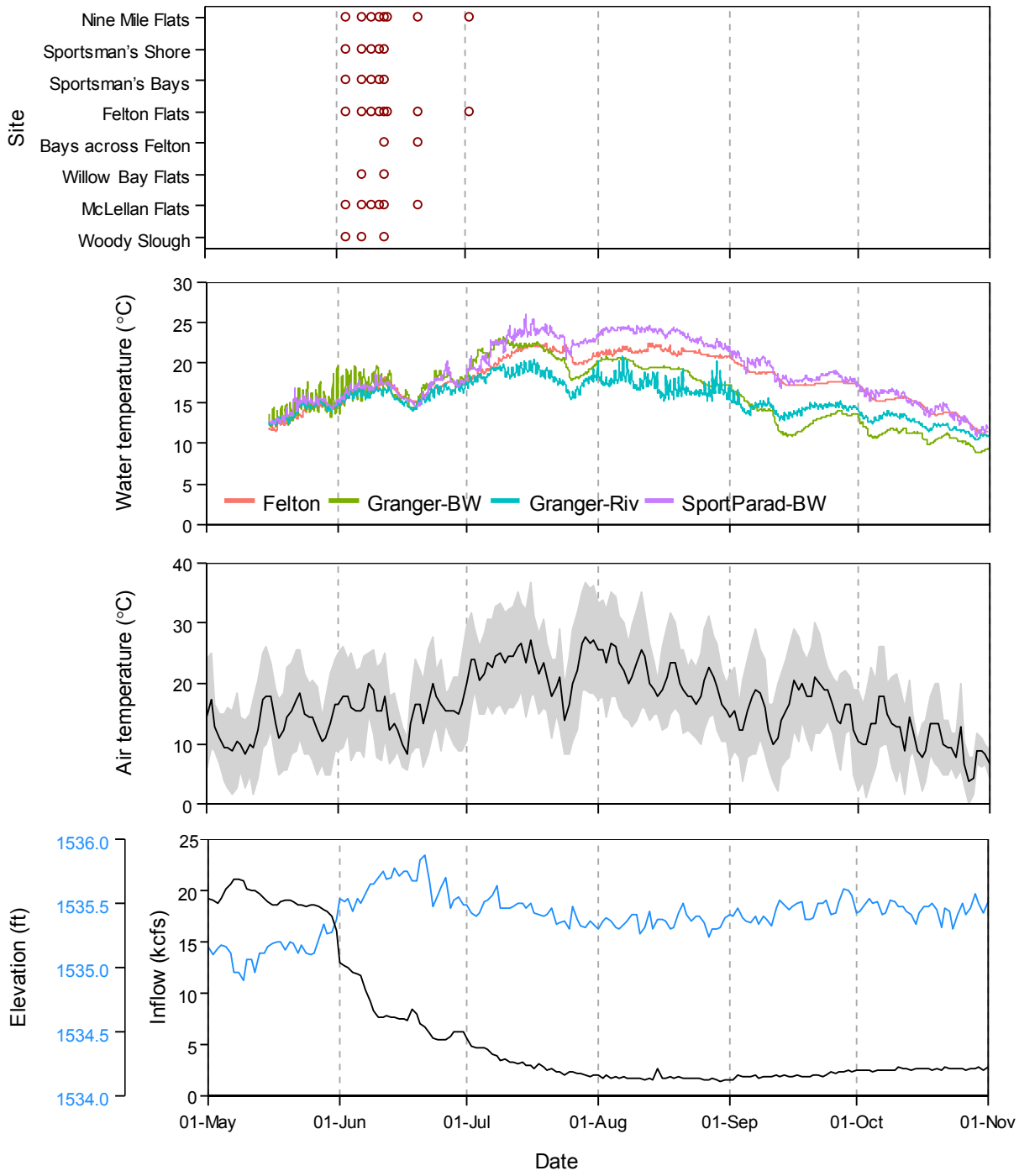

Figure 3-9. Time Series for Observed Carp Spawning Activity and Environmental Conditions, May – October of 2014

Notes:

Days with observed carp spawning activity by location (top panel), hourly water temperatures by thermograph site (second panel), Spokane International Airport air temperature with daily

average as black line and range as grey ribbon (third panel), and Lake Spokane inflow and elevation (bottom panel).

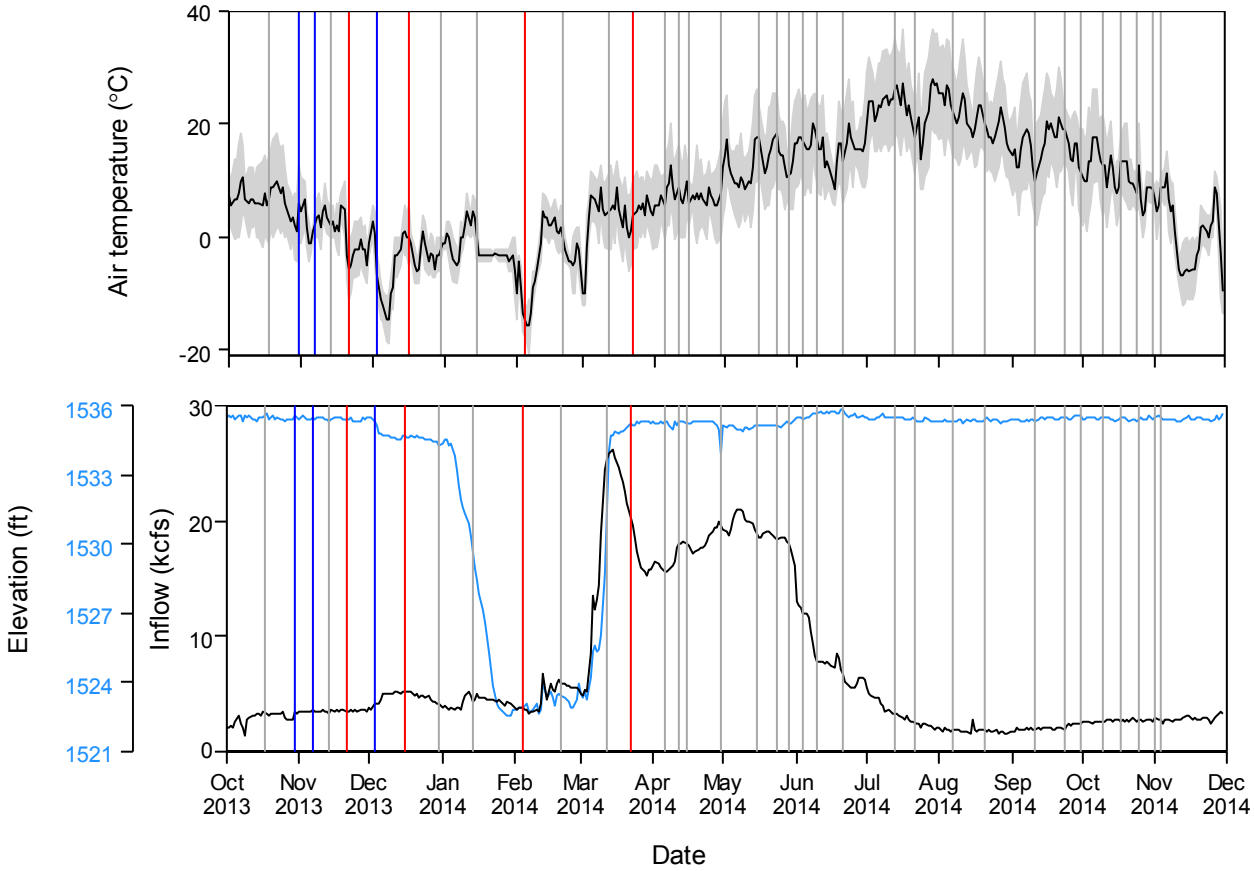

Figure 3-10. Time Series for Environmental Conditions with Relative CART-Tagged Carp Aggregation, 2013-2014 Study Period

Notes:

Spokane International Airport air temperature with daily average as black line and range as grey ribbon (top panel), and Lake Spokane inflow and elevation (bottom panel). Each vertical line represents a tracking session with its color indicating the maximum number of CART-tagged carp within 500 meters of one another. Grey lines represent <10 fish, blue lines are 10-15 fish, and red lines are >15 fish.

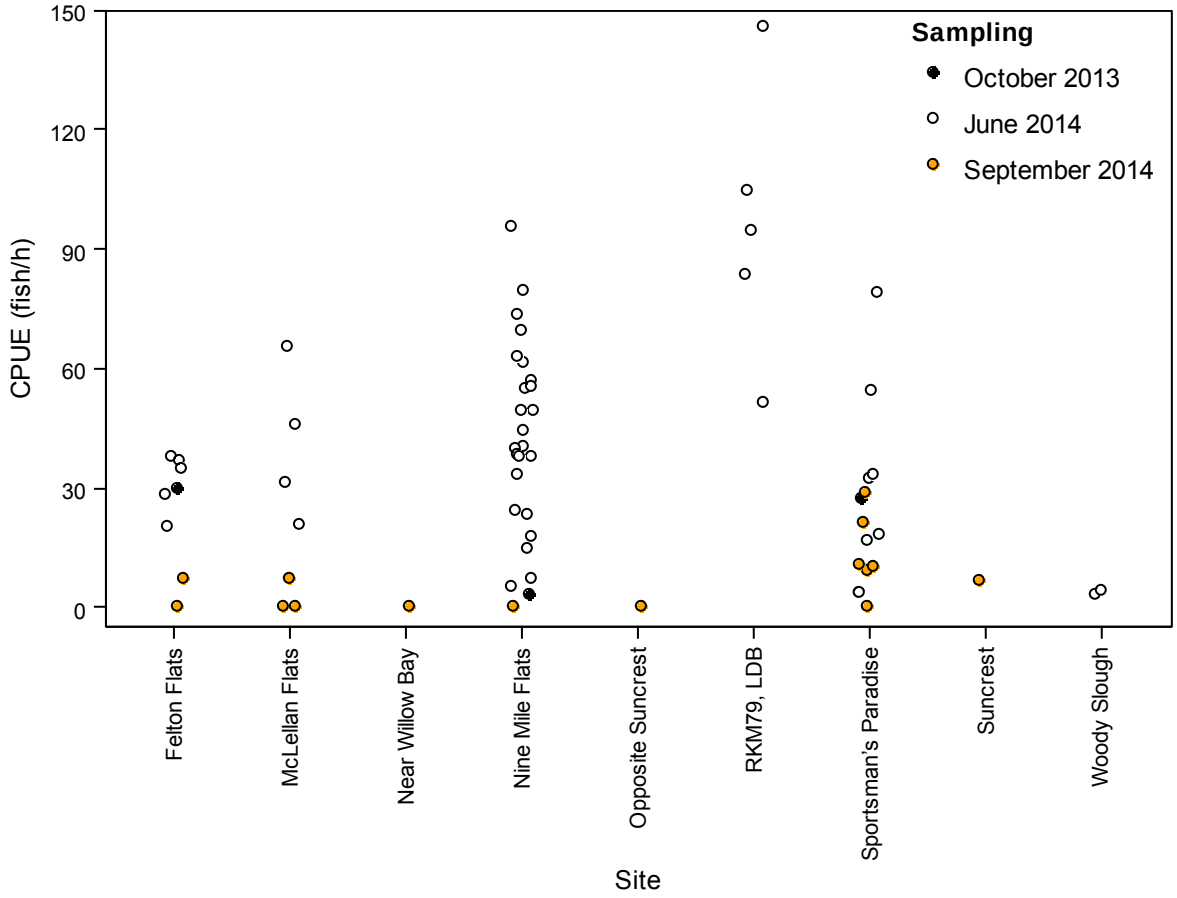

Figure 3-11. Catch per Unit Effort (CPUE) for Each Sampling Site and Period, 2013-2014 Study Period

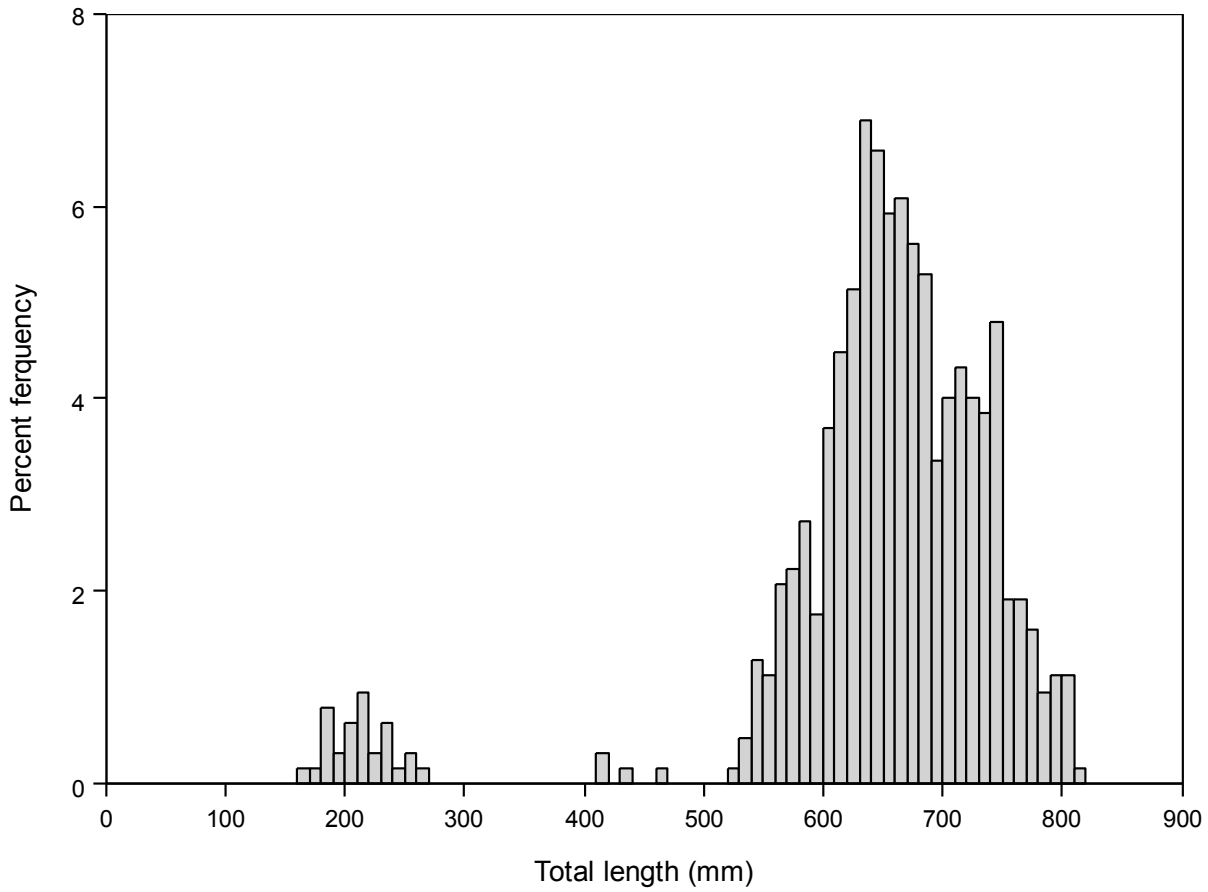

Figure 3-12. Carp Length-Frequency Distribution

Notes:

Length-frequency distribution is for the 624 carp sampled for length in June 2014.

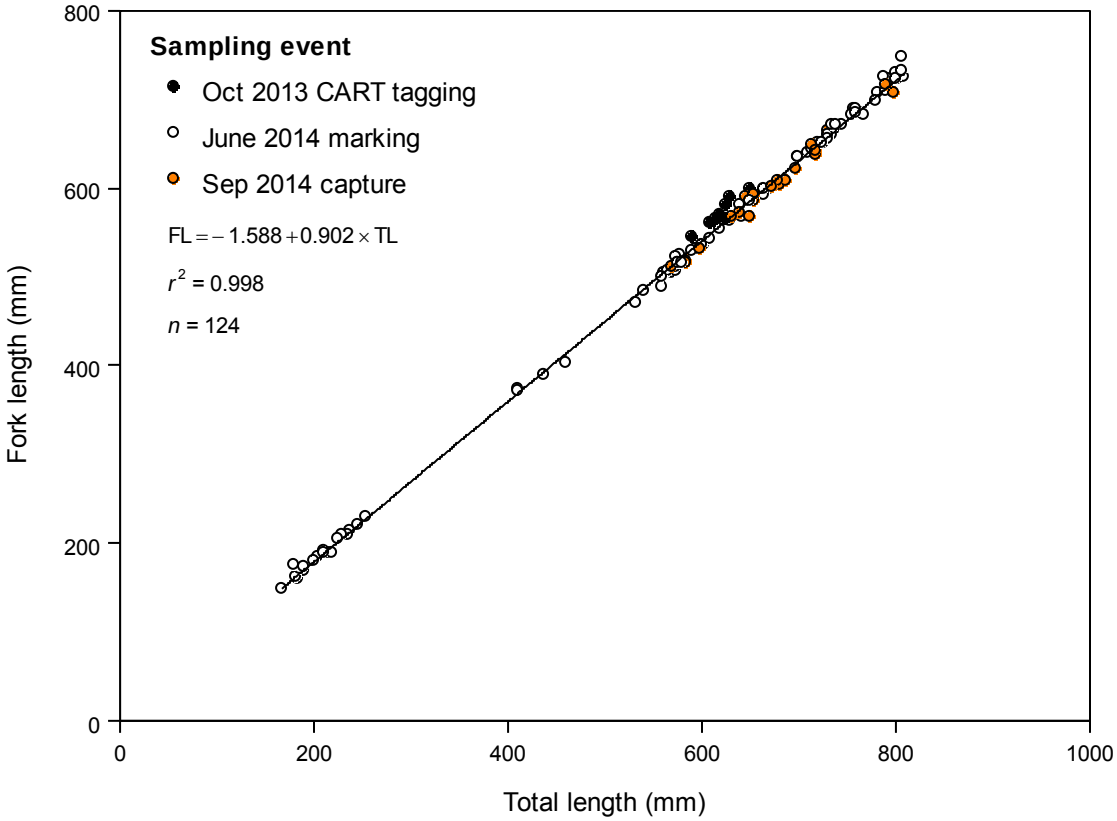

Figure 3-13. Carp Fork Length-Total Length Relationship, 2013-2014 Study Period

Note: The regression line is shown along with r^2 value and number of fish.

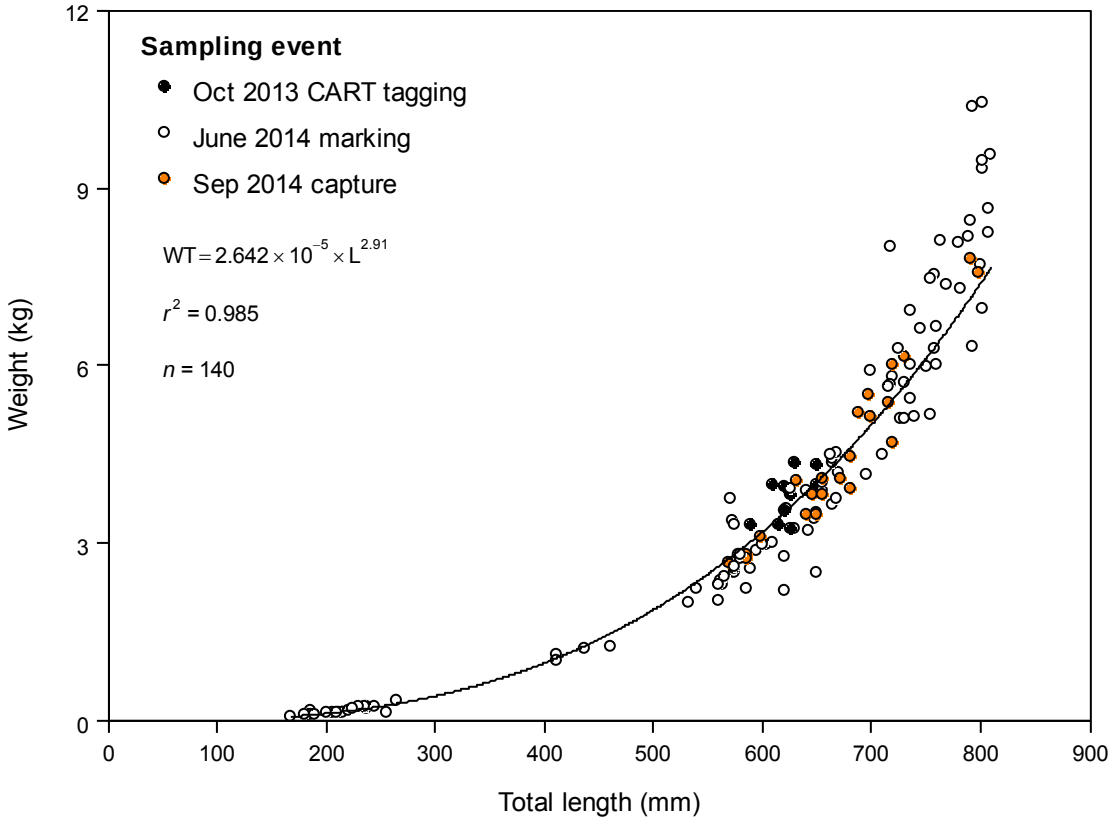

Figure 3-14. Carp Weight-Total Length Relationship, 2013-2014 Study Period

Notes:

The regression line is shown, together with r^2 value and number of fish.

In October 2013, the scale used had a maximum capacity of 5 kg, so carp weighing > 5 kg were recorded as "> 5000 g" and were omitted from this graph.

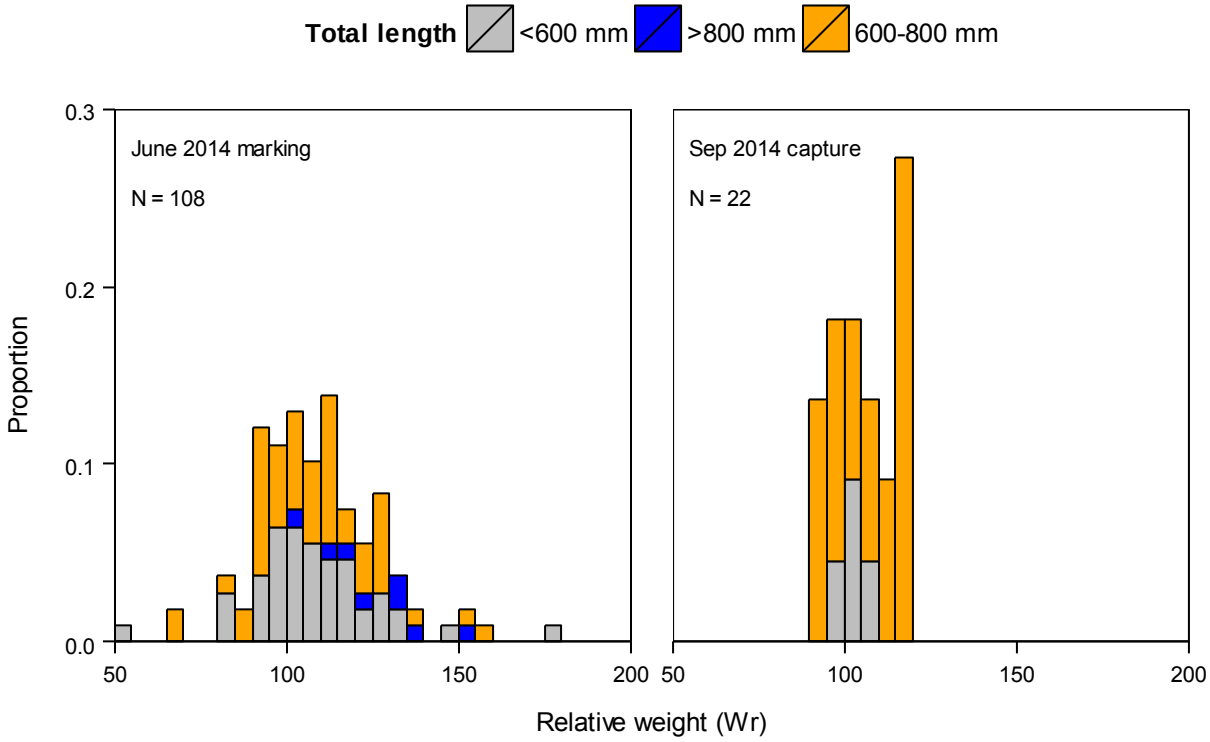

Figure 3-15. Histograms of Relative Weights, Estimated for June and September 2014 Sampling Periods by Total-Length Categories

Note:

Separate panels are provided for carp captured in June and September of 2014, and the number of carp used for each sampling period is provided.

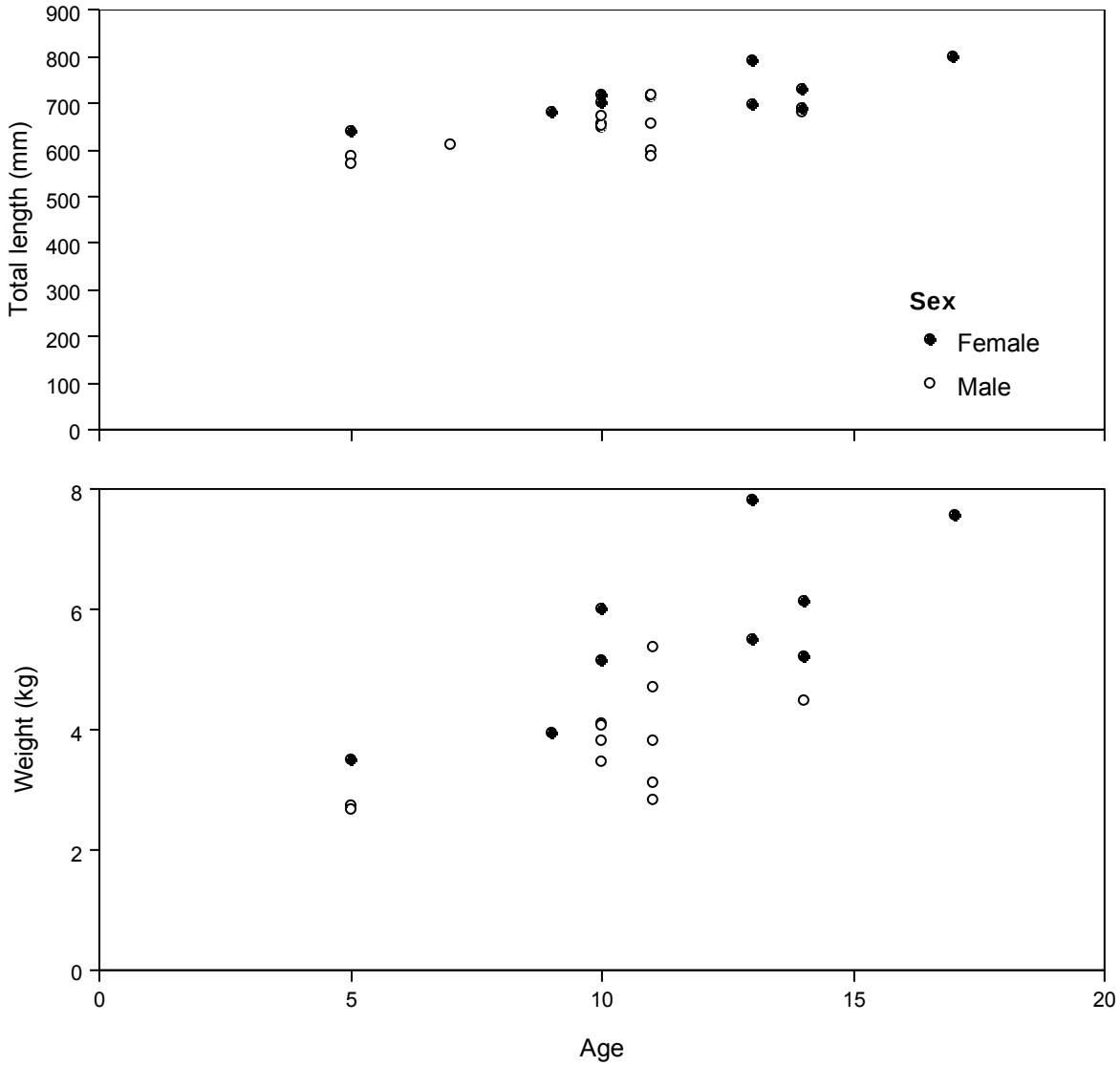

Figure 3-16. Carp Length-at-Age (top) and Carp Weight-at-Age (bottom)

Notes:

Age of carp is based on dorsal spine samples collected in September 2014.

ATTACHMENT A

SUMMARY OF CART TAG DETECTIONS

Table A-1. Summary of CART tag detections, by Tracking Session

# of Sessions Detected	% of Sessions Detected	RMK Min	RKM Max	Tag Code	Fork Length (mm)	10/30/13	11/6/13	11/13/13	11/21/13	12/3/13	12/16/13	12/30/13	1/14/14	2/4/14	2/20/14	3/12/2014	3/22/2014	4/5/2014	4/11/2014	4/15/2014	4/29/2014	5/15/2014	5/23/2014	5/28/2014	6/3/2014	6/9/2014	6/20/2014	7/12/2014	7/21/2014	8/6/2014	8/20/2014	9/10/2014	9/23/2014	9/30/2014	10/9/2014	10/17/2014	10/24/2014	10/31/2014	11/3/2014
31	91%	79.1	87.5	11	625	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
33	97%	79.4	87.0	12	565	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
30	88%	78.4	83.3	13	595	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
23	68%	79.4	87.5	14	560	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No	No	No
33	97%	79.4	85.1	15	580	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
31	91%	77.4	80.0	16	565	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes
32	94%	72.5	79.9	17	570	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
31	91%	77.7	80.8	18	585	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
18	53%	77.7	80.0	19	705	No	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	No	No	Yes	No	Yes	Yes	No	No	Yes	Yes	Yes	No	Yes	No	No	Yes	No	No
20	59%	77.8	80.0	20	680	No	No	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	No	Yes	No	Yes	No	No	No	No	Yes	Yes	Yes	Yes	No	Yes
28	82%	77.9	81.7	21	700	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
30	88%	79.3	85.1	22	600	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No
34	100%	79.1	81.7	23	560	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
34	100%	79.3	83.4	24	650	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
33	97%	79.2	81.1	25	590	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
33	97%	79.4	81.5	26	630	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
33	97%	79.4	83.2	27	615	Yes	Yes.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
33	97%	78.8	83.1	28	545	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
31	91%	79.4	80.9	29	595	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No	Yes	Yes	Yes	Yes
22	65%	78.7	83.7	30	640	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No	No	No	No	No	No
																			Sup.			Sup.		Sup.			Sup.					Sup.							
593	N/A			Total # Detected	N/A	15	18	16	19	19	20	17	19	20	20	20	20	17	19	17	18	18	16	20	17	19	20	17	17	18	17	15	13	16	17	16	16	14	14
N/A	87%			% Detected	N/A	75%	90%	80%	95%	95%	100%	85%	95%	100%	100%	100%	100%	85%	95%	85%	90%	90%	80%	100%	85%	95%	100%	85%	85%	90%	85%	75%	65%	80%	85%	80%	80%	70%	70%
				Warning Level	N/A	Y	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	Y	Y	G	G	G	G	Y	Y
				RKM Min	77.6	78.3	74.5	72.5	79.2	79.3	79.4	79.1	74.0	79.4	73.6	73.6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
				RKM Max	87.5	79.8	81.5	81.4	79.6	85.1	82.3	85.1	84.1	83.4	84.2	83.9	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Notes:

1. Red highlighted cells indicate latitude or longitude within 23 meters of previous detected location
2. Sup. Indicates supplemental tracking conducted solely by Avista
3. Fork length measured on October 17, 2013.

Table A-2. Summary of depth to Bottom for CART tag detections, by Tracking Session

# of Sessions Measured	% of Sessions Measured	Tag Code	Fork Length (mm)	10/30/13	11/06/13	11/13/13	11/21/13	12/03/13	12/16/13	12/30/13	01/14/14	2/4/2014	2/20/2014	3/12/2014	3/22/2014	4/5/2014	4/11/2014	4/15/2014	4/29/2014	5/15/2014	5/23/2014	5/28/2014	6/3/2014	6/9/2014	6/20/2014	7/12/2014	7/21/2014	8/6/2014	8/20/2014	9/10/2014	9/23/2014	9/30/2014	10/9/2014	10/17/2014	10/24/2014	10/31/2014	11/3/2014
20	77%	11	625	N/A	11.6	N/A	N/A	9.6	14	8	7.6	12.2	N/A	N/A	3.9	7	4.7	N/A	4.8	4.2	4.63	4.9	2.74	2.5	2	5.15	6.1	4.3	3.7	5.79	N/A	4	2.2	1.3	5.9	4.6	7.7
23	88%	12	565	9	N/A	9.2	9.4	9.6	12	2.7	7	12.2	7.0	2.4	N/A	8.0	6.5	3.6	5.7	4.5	2.7	1.6	N/A	0.5	1.0	4.1	0.7	1.4	2.1	1.8	5.5	1.1	1.2	1.5	4.4	4.6	7.7
24	92%	13	595	N/A	7	6.9	9.4	8.1	15	8.6	5.6	12.2	N/A	4.9	4.0	7.5	9.1	9.8	4.8	4.4	6.7	11.5	2.4	1.8	6.0	3.9	4.7	4.3	2.4	N/A	N/A	N/A	2.7	2.4	2.7	4.3	7.7
20	77%	14	560	7.5	8	N/A	9.4	9.6	12	N/A	7	9.1	N/A	2.4	N/A	5.4	6.6	5.4	2.5	3.5	3.2	1.1	N/A	0.7	1.5	2.7	2.3	2.6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
22	85%	15	580	N/A	8	9.2	9.4	N/A	9.9	7	2.1	12.2	N/A	3.0	3.9	6.7	7.3	N/A	5.0	5.3	1.5	0.8	2.7	0.5	0.5	1.6	1.8	1.3	5.9	2.1	3.4	3.5	6.2	1.7	6.5	N/A	10.4
21	81%	16	565	N/A	N/A	9.2	9.4	9.6	12	14.9	5.7	12.2	N/A	N/A	2.0	6.2	9.1	N/A	3.8	7.9	16.2	2.6	2.2	8.3	0.5	1.5	3.6	2.3	0.8	3.4	4.3	1.1	2.0	1.2	N/A	N/A	10.4
22	85%	17	570	N/A	8	9	9.4	10.5	13.7	N/A	8.5	12.2	N/A	3.4	N/A	6.2	6.6	4.7	7.4	7.9	12.8	15.7	2.2	1.3	0.8	10.0	0.8	1.3	2.3	3.7	3.0	2.5	7.5	2.3	5.3	4.7	21.0
22	85%	18	585	3	N/A	8.2	N/A	5.2	12	14.9	4	12.2	N/A	3.0	3.9	1.2	4.7	4.4	0.9	14.4	N/A	7.4	2.7	0.6	1.7	3.9	6.1	3.2	2.5	6.4	2.4	4.6	1.2	3.2	2.2	1.5	N/A
14	54%	19	705	N/A	6	N/A	N/A	9.8	12	12.6	12	12.2	4.9	3.0	3.9	N/A	N/A	N/A	N/A	N/A	N/A	17.8	N/A	3.7	4.0	N/A	N/A	3.2	2.2	4.3	N/A	2.6	N/A	N/A	N/A	N/A	N/A
11	42%	20	680	N/A	N/A	N/A	9.5	9.6	12	14.9	N/A	12.2	N/A	N/A	4.9	N/A	N/A	7.3	N/A	N/A	N/A	15.1	2.8	N/A	2.6	N/A	12.1	N/A	N/A	N/A	N/A	20.7	5.0	7.0	6.6	N/A	10.4
18	69%	21	700	N/A	N/A	10	9.4	N/A	12	9.2	8.8	12.2	N/A	3.4	2.4	N/A	N/A	N/A	9.7	12.5	N/A	2.6	2.2	0.6	4.1	1.8	3.8	3.7	3.1	N/A	3.0	7.2	4.2	2.3	3.5	4.2	14.0
23	88%	22	600	7.3	6	N/A	9.4	7.6	9.9	7	4.6	12.2	3.7	N/A	5.5	5.1	4.4	4.5	8.1	4.0	1.4	3.4	2.7	0.7	1.0	4.3	N/A	1.4	4.2	6.1	2.4	4.7	4.4	N/A	N/A	6.8	N/A
22	85%	23	560	N/A	N/A	N/A	9.4	10.5	15	9.2	7	12.2	N/A	3.4	3.9	6.7	7.5	4.8	8.4	6.2	2.6	2.8	1.5	1.0	1.5	4.7	4.8	4.2	1.7	5.2	4.0	2.9	2.4	6.7	3.4	4.6	14.0
23	88%	24	650	N/A	6	8	9.4	8.2	15	9	5	12.2	N/A	2.4	3.9	9.1	4.8	N/A	7.1	4.5	6.2	5.0	2.7	4.9	3.7	4.5	1.2	3.7	3.3	5.8	4.3	3.0	4.4	2.7	5.6	4.7	7.7
23	88%	25	590	N/A	8	9.2	9.4	10.5	12	14.9	4	12.2	N/A	3.0	4.5	N/A	10.2	5.5	8.4	4.1	2.7	0.9	1.5	3.7	0.9	3.9	13.2	16.2	5.0	6.4	3.0	3.6	1.2	20.0	2.2	4.6	7.7
21	81%	26	630	N/A	N/A	N/A	9.4	14	9.7	N/A	7	12.2	N/A	3.0	2.0	8.7	6.9	8.2	7.3	2.4	4.6	8.6	4.9	10.1	4.1	6.6	1.0	8.6	5.1	5.5	3.0	3.1	1.2	3.4	8.4	9.2	14.0
24	92%	27	615	N/A	N/A	7.2	9.4	9	12	8.4	6.6	12.2	4.0	6.4	3.9	3.8	8.6	5.2	8.6	10.0	5.0	4.2	2.7	0.9	2.5	4.7	8.1	2.7	7.8	6.4	2.7	1.2	3.6	2.1	4.0	4.4	7.7
25	96%	28	545	N/A	6	8	10	9.6	12	14.9	12	12.2	4.0	3.4	3.6	1.2	5.3	4.7	4.2	4.6	6.7	4.4	2.7	0.8	1.2	2.2	1.1	0.7	1.2	1.8	2.4	1.6	1.6	0.9	1.4	1.1	N/A
24	92%	29	595	N/A	8	7.2	9.4	9.6	12	8	4	12.2	N/A	3.4	3.9	4.6	5.4	5.5	0.9	3.3	5.2	7.6	2.7	1.8	2.4	3.4	5.2	2.9	2.9	3.0	N/A	N/A	N/A	N/A	8.2	8.4	9.8
21	81%	30	640	N/A	6	8.2	9.4	9.6	12	14.9	4.6	12.2	7.0	3.7	4.1	5.5	7.7	8.4	0.9	4.1	3.0	4.3	2.7	1.1	6.6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
																		Sup.			Sup.		Sup.	Sup.		Sup.					Sup.						
		Total # Measured	N/A	4	12	13	17	18	20	17	19	20	6.0	16	17	16	17	14	18	18	16	20	17	19	20	17	17	18	17	15	13	16	16	15	15	14	14
		Min	N/A	3.0	6.0	6.9	9.4	5.2	9.7	2.7	2.1	9.1	3.7	2.4	2.0	1.2	4.4	3.6	0.9	2.4	1.4	0.8	1.5	0.5	0.5	1.5	0.7	0.7	0.8	1.8	2.4	1.1	1.2	0.9	1.4	1.1	7.7
		25%	N/A	4.1	6.0	7.6	9.4	8.8	12.0	8.0	4.6	12.2	3.9	3.0	3.8	4.7	5.1	4.7	3.5	4.1	2.7	2.6	2.2	0.7	1.0	2.5	1.2	1.4	2.2	3.0	2.6	1.8	1.3	1.5	2.7	4.3	7.7
		50%	N/A	7.4	7.5	8.2	9.4	9.6	12.0	9.2	6.6	12.2	4.4	3.2	3.9	6.2	6.6	5.3	5.4	4.5	4.6	4.4	2.7	1.1	1.9	3.9	3.8	3.1	2.9	5.2	3.0	3.1	2.6	2.3	4.4	4.6	10.1
		75%	N/A	8.6	8.0	9.2	9.4	10.0	13.3	14.9	7.6	12.2	7.0	3.4	4.1	7.4	8.2	7.5	8.2	7.9	6.6	8.4	2.7	3.7	3.9	4.7	6.1	4.2	4.6	6.1	4.1	4.5	4.4	3.4	6.5	5.2	14.0
		Max	N/A	9.0	11.6	10.0	10.0	14.0	15.0	14.9	12.0	12.2	7.0	6.4	5.5	9.1	10.2	9.8	9.7	14.4	16.2	17.8	4.9	10.1	6.6	10.0	13.2	16.2	7.8	6.4	5.5	20.7	7.5	20.0	8.4	9.2	21.0

Notes:

1. Sup. Indicates supplemental tracking conducted solely by Avista.
2. Fork length measured on October 17, 2013.