



# Keeyask Generation Project Aquatic Effects Monitoring Plan

## Lake Whitefish Movement Monitoring Report

AEMP-2018-05



# **KEEYASK GENERATION PROJECT**

## **AQUATIC EFFECTS MONITORING PLAN**

REPORT #AEMP-2018-05

### **LAKE WHITEFISH MOVEMENT MONITORING IN THE NELSON RIVER BETWEEN CLARK LAKE AND THE LIMESTONE GENERATING STATION, OCTOBER 2016 TO OCTOBER 2017: YEAR 4 CONSTRUCTION**

Prepared for

Manitoba Hydro

By

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# SUMMARY

## Background

The Keeyask Hydropower Limited Partnership (KHLP) was required to prepare a plan to monitor the effects of construction and operation of the Keeyask Generating Station (GS) on the environment. Besides measuring the accuracy of the predictions made and actual effects of the GS on the environment, monitoring results will provide information on how construction and operation of the GS will affect the environment and if more needs to be done to reduce harmful effects.

Construction of the Keeyask GS began in mid-July 2014 with the construction of cofferdams that blocked flow in the north and central channels of Gull Rapids (see map). During the winter of 2015/2016, the Spillway Cofferdam, which partially blocks the south channel was constructed. Beginning late in 2016 and continuing in 2017, the Tailrace Cofferdam was constructed. Work was completed in fall 2017 with the exception of an opening that was left to allow fish movement into and out of the cofferdam over the 2017/18 winter.

The movements of Lake Whitefish over Birthday Rapids and Gull Rapids were monitored prior to construction, but because different methods are being used to collect data under the Aquatic Effects Monitoring Plan (AEMP), the results of the two programs can't be compared. While pre-construction studies did not record detailed fish movement patterns between Clark Lake and Stephens Lake, the data indicated that the majority of Lake Whitefish continued to live in the area where they had been tagged and did not swim across rapids into different parts of the river. When fish occasionally crossed either Birthday or Gull rapids, they did so in the summer or fall, which suggests that these movements were not a necessary part of spring egg-laying behavior. A small number of Lake Whitefish also moved downstream through the generating stations/spillways along the lower Nelson River.

This report presents results of Lake Whitefish movement monitoring from October 2016 to October 2017 and provides a summary of data collected since the monitoring program was initiated in the fall of 2014. Monitoring fish movements is an important component of the overall plan to monitor the impacts of construction and operation of the Keeyask GS on fish. Lake Whitefish were identified as one of the key species to monitor because they are: of commercial and domestic importance; known to pass through Gull Rapids in either direction; and resilient enough to survive the acoustic tagging procedure.



Map of instream structures at the Keeyask Generating Station site, September 2017.

**Why is the study being done?**

Monitoring during construction is being done to answer two questions:

*Are there Lake Whitefish close to the construction site, particularly during spawning?*

If Lake Whitefish are in the river close to the construction area, they could be harmed by high amounts of mud in the water or they could be trapped inside an area that will be drained.

*How many Lake Whitefish are moving through and/or away from Gull Rapids during construction and how far are they going?*

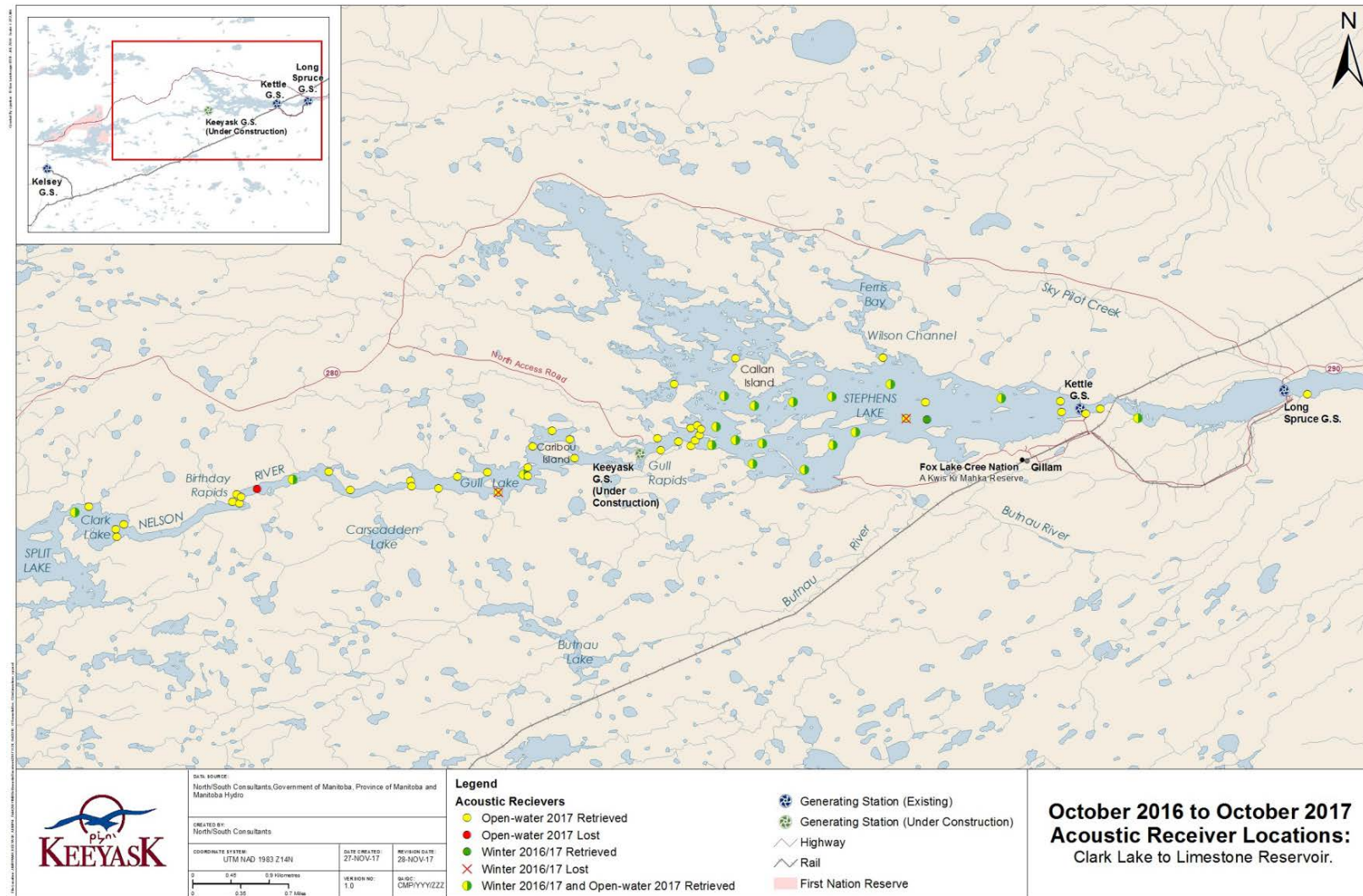
Movement studies tell us how many whitefish are moving up or down through Gull Rapids, how far they travel up or downstream away from the site, whether they are leaving the Keeyask area completely and when they are making these movements. The distance they travel is monitored as far upstream as the inlet to Clark Lake and downstream as far as the Limestone reservoir.

**What was done?**

The movements of Lake Whitefish were tracked using acoustic telemetry. This is a technique in which a tag (transmitter) is surgically implanted inside a fish. Each tag sends out a sound signal (called a “ping”) that is picked up by receivers that were placed along the Nelson River between Clark Lake and the Limestone Generating Station (see study area map below). Each fish is given a transmitter that sends out a unique ping, and the pings can be detected up to 1 kilometre (km) away from a receiver. By looking at the pings recorded by different receivers, the movement of each fish can be tracked.

Sixty Lake Whitefish were tagged in 2014, 20 upstream and 40 downstream of Gull Rapids. In October 2017, 62 additional transmitters were implanted into Lake Whitefish since the original 60 were nearing the end of their battery life. The newly tagged fish were active for less than a month before the end of the monitoring period in 2017, so analysis of the movements by these fish will begin in 2018.





Map showing the study area. The dots represent the locations of receivers in the river. The different colours represent receivers that were in the river at different times of the year.

**What was found?**

How far and where Lake Whitefish moved depended on the individual fish and whether they lived upstream or downstream from Gull Rapids (in Stephens Lake). Their movements also depended on the water temperature/season.

Results from three years of tracking the movements of Lake Whitefish suggest that movement through Gull Rapids is rare. Of the 60 whitefish tagged in 2014 and tracked until the end of the 2017 open-water period, only two moved downstream through the rapids and no upstream movements were recorded.

Upstream of Gull Rapids, fish spent a large part of their time in the upper section of Gull Lake during the open-water period and do not appear to be using habitat directly upstream of the construction site. In the fall, all of the detected fish made upstream movements out of Gull Lake to the base of Birthday Rapids or further into Clark Lake. These upstream movements are believed to be for spawning.

In Stephens Lake, Lake Whitefish were more evenly spread throughout the lake. Many tagged whitefish were located closer to the base of Gull Rapids in the fall, presumably to spawn.

**What does it mean?**

Lake Whitefish are using habitat immediately downstream of the construction site at Gull Rapids. Movements through Gull Rapids have been rare as only two tagged fish have moved downstream through Gull Rapids during the three-year study (one in 2015 and one between 2014 and 2017). Similarly, no Lake Whitefish have moved downstream through the Kettle GS over the three-year period so it does not appear so far that construction is causing fish to leave the area.

**What will be done next?**

This is the last year that the transmitters applied in 2014 are expected to be active. The additional Lake Whitefish tagged in October 2017 will allow movement data to be collected to the end of construction of the generating station in fall 2021. Ongoing tracking of fish during construction will provide additional information about where the fish are moving, what kinds of habitats these fish need to use over several years, when they are spawning and when they are feeding. Tracking will also show where fish are relative to instream construction and if there is the potential that they could be at risk as a result of various construction activities.



# ACKNOWLEDGEMENTS

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# 1.0 INTRODUCTION

The Keeyask Generation Project (the Project) is a 695-megawatt (MW) hydroelectric generating station at Gull (Keeyask) Rapids on the lower Nelson River in northern Manitoba. The Project is approximately 725 kilometres (km) northeast of Winnipeg, 35 km upstream of the existing Kettle Generating Station, where Gull Lake flows into Stephens Lake, 60 km east of the community of Split Lake, 180 km east-northeast of Thompson and 30 km west of Gillam (Map 1). Construction of the Project began in July 2014.

The *Keeyask Generation Project: Response to EIS Guidelines*, completed in June 2012, provides a summary of predicted effects and planned mitigation for the Project. Technical supporting information for the aquatic environment, including a description of the environmental setting, effects and mitigation, and a summary of proposed monitoring and follow-up programs, is provided in the *Keeyask Generation Project Environmental Impact Statement: Aquatic Environment Supporting Volume* (AE SV). As part of the licensing process for the Project, an Aquatic Effects Monitoring Plan (AEMP) was developed detailing the monitoring activities of various components of the aquatic environment including the focus of this report, Lake Whitefish (*Coregonus clupeaformis*) movements, for the construction and operation phases of the Project.

Pre-construction (baseline) movements of Lake Whitefish were monitored from 2001 to 2005 (Barth *et al.* 2003; Murray *et al.* 2005; Murray and Barth 2007). Radio and acoustic telemetry studies focused specifically on detecting the upstream and downstream movements of fish over rapids in the study area (Birthday Rapids and Gull Rapids). Pre-construction movement data revealed that a proportion (28%) of Lake Whitefish did make movements both upstream and downstream over Gull or Birthday rapids. The pre-construction movement data also recorded Lake Whitefish congregating in the area below Gull Rapids during the fall, presumably for spawning. As pre-Project studies were not designed to record detailed movement patterns of Lake Whitefish in the Clark Lake to Stephens Lake reach as a whole, results are not directly comparable to the movement data being collected under the AEMP.

In fall 2014, 60 adult Lake Whitefish were implanted with acoustic transmitters to assess the frequency of movement through Gull Rapids and to monitor the potential impact construction of the Keeyask GS may have on Lake Whitefish. Annual reports detailing the 2014 to 2016 results are provided in Hrenchuk and Barth (2015), Lavergne and Hrenchuk (2016), and Burnett and Hrenchuk (2017). Results from October 20, 2016 to October 16, 2017 are presented in this report.

Lake Whitefish movements in the main flow of the Nelson River near the construction site may be affected by the installation of cofferdams that block upstream and downstream movements (Map 2), altered flow patterns, and disturbances such as blasting that may increase emigration from the construction area. Previous studies have shown that Lake Whitefish congregate in the area below Gull Rapids to spawn (Pisiak 2005a; Pisiak 2005b; Murray and Barth 2007). The broad objective of Lake Whitefish movement monitoring is to better understand their movements

and habitat use during generating station construction, with particular focus on movements in the vicinity of Gull Rapids.

The key questions (presented in the AEMP) related to Lake Whitefish movement monitoring during construction of the Keeyask GS are:

- What number (or proportion) of tagged Lake Whitefish move past the construction site?
- Are whitefish utilizing habitat in the vicinity of the construction site (particularly during spawning)?

## 2.0 STUDY SETTING

The study area encompasses an approximately 110 km long reach of the Nelson River from Clark Lake to the upstream end of the Limestone reservoir (Map 1). This section of river offers a diversity of physical habitat conditions, including a variety of substrate types, and variable water depths (range 0–30 m) and velocities. Water velocities were classified as low (0.2–0.5 metres per second [m/s]), moderate (0.5–1.5 m/s), or high (greater than 1.5 m/s), as described in the Keeyask AE SV.

Clark Lake is located immediately downstream of Split Lake, and approximately 42 km upstream of Gull Rapids (Map 1). Current is restricted to the main section of the lake, with off-current bays outside the main channel. The Assean River is the only major tributary to Clark Lake, and flows into the north side. Downstream from the outlet of Clark Lake, the Nelson River narrows and water velocity increases for a 3 km stretch, known as Long Rapids. For the next 7 km, the river widens, and water velocity decreases.

Birthday Rapids is located approximately 10 km downstream of Clark Lake and 30 km upstream of Gull Rapids (Maps 1 and 3). The drop in elevation from the upstream to downstream side of Birthday Rapids is approximately 2 m. The 14 km reach of the Nelson River between Birthday Rapids and Gull Lake is characterized as a large and somewhat uniform channel with medium to high water velocities. There are a few large bays with reduced water velocity and a number of small tributaries that drain into the Nelson River.

Gull Lake is a section of the Nelson River where the river widens, with moderate to low water velocity. Gull Lake is herein defined as the reach of the Nelson River beginning approximately 17 km upstream of Gull Rapids and 14 km downstream of Birthday Rapids, where the river widens to the north into a bay around a large point of land (Maps 1 and 3), and extending to the downstream end of Caribou Island, approximately 3 km upstream of Gull Rapids. Gull Lake has three distinct basins, the first extending from the upstream end of the lake downstream approximately 6 km to a large island; the second extending from the large island to Morris Point (a constriction in the river immediately upstream of Caribou Island); and the third extending from Morris Point to the downstream end of Caribou Island (Map 3).

Gull Rapids is located approximately 3 km downstream of Caribou Island on the Nelson River (Map 1). The rapids are approximately 2 km in length, and the river elevation drops approximately 11 m along its 2 km length. Two large islands and several small islands occur within the rapids, prior to the river narrowing; these features are within the Project footprint and have been substantially altered during construction (Map 2). A summary of construction activities at Gull Rapids is provided in Section 2.1.

Just below Gull Rapids, the Nelson River enters Stephens Lake. Stephens Lake was formed in 1971 by construction of the Kettle GS. Between Gull Rapids and Stephens Lake, there is an approximately 6 km long reach of the Nelson River that, although affected by water regulation at the Kettle GS, remains riverine habitat with moderate velocity. Construction has altered the flow

distribution immediately downstream of Gull Rapids as all flow now passes via the south channel of Gull Rapids.

Construction of the Kettle GS flooded Moose Nose Lake (north arm) and several other small lakes that previously drained into the Nelson River, as well as the old channels of the Nelson River that now lie within the southern portion of the lake (Map 4). Major tributaries of Stephens Lake include the North and South Moswakot rivers that enter the north arm of the lake. Looking Back Creek is a second order stream that drains into the north arm of Stephens Lake (Map 1). Kettle GS is located approximately 40 km downstream of Gull Rapids.

The Long Spruce reservoir was formed in 1979 by the construction of the Long Spruce GS. It is a 16 km reach of the Nelson River extending from Long Spruce GS upstream to Kettle GS (Manitoba Hydro Public Affairs 1999). Kettle River and Boots Creek are the only major tributaries flowing into Long Spruce reservoir, with both tributaries entering the reservoir on the south shore (Map 1).

The Limestone reservoir was formed in 1990 by the construction of the Limestone GS. It is a 23 km reach of the Nelson River extending from Limestone GS upstream to Long Spruce GS. Four tributaries of the Nelson River enter the reservoir; Wilson Creek and Brooks Creek enter from the south, and Sky Pilot Creek and Leslie Creek enter from the north. Aquatic habitat within the reservoir ranges from a riverine environment in the upper reach, to more lacustrine conditions just upstream of the Limestone GS

## 2.1 CONSTRUCTION SUMMARY

Construction of the Keeyask GS began in mid-July 2014 with the construction of cofferdams in the north and central channels of Gull Rapids (Map 2). These cofferdams resulted in the dewatering of the north and central channels and the diversion of all flow to the south channel. Construction of the spillway cofferdam, which extends into the south channel of Gull Rapids, was completed in 2015. During 2016 there was little instream construction until placement of rock for the Tailrace Cofferdam began in late fall and continued into 2017. Large rocks were placed in the Nelson River to form the inner and outer groins of the Tailrace Cofferdam. An opening was left in the rock groins to allow fish to move into and out of the cofferdam. Placement of fine material between the two sections of the cofferdam began and was completed in late-2017. An opening was created to allow fish to move freely over the winter of 2017/18. The opening will be closed in spring 2018.

## 2.2 FLOWS AND WATER LEVELS

From October 2016 to October 2017, Split Lake outflows ranged from about 3,200–6,600 m<sup>3</sup>/s. Flow exceeded the historical annual median flow of approximately 3,300 m<sup>3</sup>/s each month except for October 2017 when it dropped to about 3,200 m<sup>3</sup>/s. From about October 2016 through mid-September 2017, the flow exceeded the historical 75<sup>th</sup> percentile flow of about

3,780 m<sup>3</sup>/s, and from about May to mid-August 2017 the flow exceeded the 95<sup>th</sup> percentile flow of approximately 5,230 m<sup>3</sup>/s. During the spring melt in May 2017, flow rose to about 6,590 m<sup>3</sup>/s, which is near the historical maximum flow observed in August 2005. Water levels varied in conjunction with flow, ranging from about 154.9–156.6 m ASL on Gull Lake, with the highest level observed during the near historical maximum flow in May.

## 3.0 METHODS

### 3.1 ACOUSTIC TELEMETRY

Acoustic telemetry involves tracking movements of fish surgically implanted with internal acoustic transmitters (tags). Each transmitter emits a unique signal, recognizable by stationary receivers. When tagged fish come into range (generally within 500 m to 1 km, depending on conditions), the transmitter code number, as well as the date and time, are stored in the receiver. Initially, the receiver array was designed to monitor adult Lake Sturgeon (Hrenchuk *et al.* 2018); however, the same array is also used to monitor juvenile Lake Sturgeon (Lacho *et al.* 2018), Walleye (Hrenchuk and Lacho 2018), and Lake Whitefish (the focus of this report).

#### 3.1.1 ACOUSTIC TRANSMITTER APPLICATION

Lake Whitefish, measuring 372–565 millimetre (mm) fork length (FL), were implanted with Vemco V13 acoustic transmitters (1,141-day battery life) between September 25 and October 8, 2014. Due to difficulty in capturing Lake Whitefish in the Gull Lake area, only 20 were tagged upstream of Gull Rapids. Because Lake Whitefish are more abundant in Stephens Lake, 40 were tagged downstream of Gull Rapids (Tables 1 and 2). Lake Whitefish were captured using a boat electrofisher to decrease potential stress and mortality (Hrenchuk and Barth 2015). All Lake Whitefish implanted with acoustic transmitters upstream of Gull Rapids were captured immediately downstream of Birthday Rapids (33 river kilometres [rkm] upstream of Gull Rapids) (Map 3). In Stephens Lake, fish were captured along the north shore of the Nelson River, 0.5 to 1.3 rkm downstream of Gull Rapids (Map 4). Each Lake Whitefish implanted with an acoustic transmitter was measured for FL and weight, and marked with an external Floy® tag. Acoustic transmitters were applied by surgical implantation in the coelomic cavity as described in McDougall *et al.* (2013).

The batteries in the original 60 transmitters were expected to expire at the end of 2017; therefore, an additional 62 acoustic transmitters with a 1,737 day battery life were applied to Lake Whitefish measuring 406–540 mm FL between October 7 and 14, 2017. Since these transmitters were applied to fish less than one month before the end of the reporting period, detailed analyses of movements of these fish will begin in 2018.

#### 3.1.2 ACOUSTIC RECEIVERS

Since 2014, stationary acoustic receivers (VEMCO model VR2 and VR2W) were used to continuously monitor tagged Lake Whitefish between Clark Lake and the Keeyask GS construction site, Stephens Lake, and the Long Spruce reservoir. In spring 2016, the receiver array was extended to the upper Limestone reservoir. The intent of these receivers was to



determine whether fish that had moved into the Long Spruce reservoir the preceding year had continued to move downstream.

During the open-water period, receivers were deployed in calm water with a flat bottom free of large debris to maximize detection range, and spaced along the main river channel throughout the study area to maximize spatial coverage. At constrictions within the river channel, a series of receivers were deployed to create “gates” with the intent of recording all fish that passed by the river cross-section.

The retrieval of receivers deployed during winter has proved challenging; several were lost in previous winters, likely because of ice (Hrenchuk and Barth 2013). Because it appears that receivers will only remain safe from ice if deployed at depths greater than 10 m, the number of possible receiver locations during winter, especially in Gull Lake, is limited.

### **3.1.2.1 WINTER 2015/2016**

The stationary acoustic receiver array for the winter 2016/2017 (October 20, 2016 to April 30, 2017) period consisted of 21 receivers. Four were set upstream of Gull Rapids, 16 throughout Stephens Lake, and one in the Long Spruce reservoir (Maps 3, 4, and 5).

The winter 2016/2017 receiver array differed slightly from the array used in winter 2015/2016. Three receivers that were previously set immediately upstream of the Kettle GS (one at rkm 40.0 and two at rkm 40.8, one on either side of an island) were lost during winter 2015/2016, and two had been lost during winter 2014/2015 and 2013/2014. Given the pattern of loss, these receivers were not reset. Three receivers were added to the array in Stephens Lake in 2016/2017 to increase detection coverage: #125555 at rkm 5.2, #114237 at rkm 5.8, and #107993 at rkm 36.1 (Map 4).

### **3.1.2.2 OPEN-WATER 2017**

An array of 60 receivers was used during the 2017 open-water period (defined as May 1 to October 16, 2017). Twenty-six were set upstream of Gull Rapids, 30 in Stephens Lake, three in the Long Spruce reservoir, and one in the Limestone reservoir (Maps 6, 7, and 8).

The 2017 open-water array differed slightly from arrays used in previous years. One receiver (#125552) was set in a new location in Stephens Lake, in a channel between a small island and the southern shore at rkm 3.8 (Map 7). During the 2016 open-water period, it was suspected that fish were using this channel to move between zones 6 and 7 and were being missed by the receiver gate (described below). During the 2016 open-water period, a receiver was set downstream of the Long Spruce GS along the north shore at rkm 57.6. Due to abnormally high flows observed in 2017, it was not possible to reset this receiver (Map 8).

During winter 2016, the Keeyask Fisheries Regulatory Review Committee (KFRRRC)<sup>1</sup> suggested that a receiver be placed in close proximity to the upstream side of Gull Rapids to monitor potential fish movements adjacent to the construction site. However, due to high flows and safety concerns during the 2017 open-water period, a suitable location was not found.

Receiver “gates” were established in several key areas selected based on river morphology (channel restrictions) and characteristics of habitat (areas with low velocity adjacent to the main flow of the river). Receiver “gates” consisted of two or more acoustic receivers set parallel to flow to provide complete (or nearly complete) signal coverage of a river cross-section. Areas between the “gates” were referred to as river zones. Receiver gates provide confidence that movements past key points are being detected, which allows for extrapolation of coarse-scale positions (*i.e.*, which zone) during periods when fish remain undetected. When analyzing data, fish detected within a zone that subsequently go undetected for a period of time without passing through a gate, are assumed to be within the zone they were last detected.

Four gates were established between Clark Lake and Gull Rapids (44.0, 34.0, 19.0, and 10.0 rkms upstream of Gull Rapids), and two were established in Stephens Lake (4.5 and 40.0 rkms downstream of Gull Rapids) (Maps 6 and 7). The area upstream of Gull Rapids was divided into five zones (Map 6; zones 1–5), while Stephens Lake was divided into two zones (Map 7; zones 6 and 7). The Long Spruce reservoir is referred to as Zone 8 and the Limestone reservoir as Zone 9. The location of the “gates” has remained consistent since first set in 2013.

On October 16, 2017, the majority of receivers were removed and a subset ( $n = 20$ ) were redeployed to monitor movements during winter 2017/2018.

### 3.1.3 DATA ANALYSIS

False detections can arise on acoustic telemetry receivers due to code collisions and/or environmental noise (Pincock 2012). To filter out false detections, a fish was required to be detected at least two times within a 30-minute interval at a given stationary receiver. Single detections were filtered and not used in most analyses; however, in instances when fish went undetected for lengthy periods, and/or rapid movements were suspected, raw data were also explored. In no instance did examination of raw data suggest that consideration of a single detection would result in a different behaviour or movement pattern compared with the result when single detections were removed.

Movements were analysed in terms of rkm distance, with the base of Gull Rapids representing a distance of 0 rkm. The area located downstream of Gull Rapids (*i.e.*, Stephens Lake and the Long Spruce reservoir) were given positive (+) distance values from Gull Rapids, while the area

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<sup>1</sup> The KFRRRC is a committee of representatives from the KHLF, Manitoba Conservation and Water Stewardship (Fisheries Branch), and Fisheries and Oceans Canada. As described in the AEMP, the KFRRRC reviews monitoring results to determine whether adaptive management measures, including changes to mitigation and offsetting measures, maybe required.

located upstream (*i.e.*, Gull and Clark lakes) were given negative (-) distance values (Figures 1 and 2). The average rkm distance from Gull Rapids was calculated over a 4-hour interval and plotted versus time for each fish. Total detection ranges were calculated by subtracting the furthest downstream detection location from the location of the furthest upstream detection. The proportion of time that all fish spent within each river zone was calculated and plotted.

## 4.0 RESULTS

Section 4.1 provides a summary of Lake Whitefish movements between 2014 and winter 2016/2017. Tables 1 and 2 provide acoustic tagging and biological information associated with each tagged fish, while Table 3 summarizes the time fish spent in each river zone during the three years of study. Figures 1 and 2 show the receiver locations upstream and downstream of Gull Rapids during winter 2016/17 and the 2017 open-water period. Figures 3 to 16 provide movement range, and proportional distribution of tagged fish both upstream and downstream of the construction site by season. A detection summary by season and year, including the farthest upstream and downstream detection locations for each tagged whitefish, are presented in Appendices A1-1 to A1-4.

### 4.1 2014–2016 RESULTS SUMMARY

#### 4.1.1 UPSTREAM OF GULL RAPIDS

Twenty fish were tagged upstream of Gull Rapids in 2014 (Table 1), but, since that time, several tags have gone missing and are considered lost:

- #33797 was tagged downstream of Birthday Rapids (rkm -33) on October 8, 2014, and it was not subsequently detected (Appendix A2-2).
- #33800 was tagged downstream of Birthday Rapids (rkm -33) on October 8, 2014, and was last detected one day later at rkm -32.3 (Appendix A2-4).

One fish was captured during an experimental gillnetting program and suffered mortality (Lavergne *et al.* 2016):

- #33820 was tagged downstream of Birthday Rapids (rkm -33) on October 8, 2014, and was last detected at rkm -26.5 on July 29, 2015 before being captured at rkm -21.0 on August 15, 2015 (Appendix A2-17).

One fish moved downstream into Stephens Lake in 2015:

- #33805 was tagged downstream of Birthday Rapids (rkm -33) on October 8, 2014. It was detected in Gull Lake (rkm -11.8 to -5.8) from June 20 to 29, 2015. It was next detected in Stephens Lake at rkm 2.7 on October 5, 2015 (Appendix A2-9).

One fish, which had previously been considered lost, was detected during the open-water period of 2017 in Stephens Lake:

- #33802 was tagged downstream of Birthday Rapids (rkm -33) on October 8, 2014. It subsequently moved downstream and was last detected in Gull Lake at rkm -12.9 on October 29, 2014. This fish went undetected until the open-water period of 2017, when it was detected at rkm 3.8 in Stephens Lake (Appendix A2-6).

Therefore, accounting for the 20 fish originally tagged, the two missing fish, the one gillnetting mortality, and the two fish that moved downstream into Stephens Lake, a total of 15 Lake Whitefish were available to be detected upstream of Gull Rapids during winter 2016/2017.

#### 4.1.2 STEPHENS LAKE

Forty Lake Whitefish were tagged in Stephens Lake in 2014 (Table 2). Twelve are considered missing due to a lack of detections:

- #6360 moved downstream immediately after being tagged at rkm 1.6 on September 30, 2014. It was last detected at rkm 16.8 on October 20, 2014 (Appendix A3-4).
- #6362 and #6369 were tagged downstream of Gull Rapids at rkm 1.3 on September 30, 2014, and were briefly detected at rkm 4.5 immediately after being tagged. Neither fish has been detected since October 12, 2014 (Appendices A3-6 and A3-13).
- #6365 was not detected after being tagged on October 4, 2014, at rkm 1.6.
- #6366 moved downstream immediately after being tagged at rkm 1.6 on September 30, 2014. It was last detected at rkm 16.8 on October 19, 2014 (Appendix A3-10).
- #6368 moved downstream immediately after being tagged at rkm 1.3 on September 25, 2014. It was last detected at rkm 7.7 on October 9, 2014 (Appendix A3-12).
- #6370 was tagged at rkm 1.3 on September 30, 2014. It was detected within Stephens Lake (moving between rkm 2.9 and 14.9) until December 24, 2014 (Appendix A3-14).
- #6371 moved downstream immediately after being tagged at rkm 1.3 on September 30, 2014. It was last detected at rkm 4.9 on October 3, 2014 (Appendix A3-15).
- #6373 was tagged at rkm 1.6 on September 25, 2014 and was detected for a single day at rkm 4.3 on October 7, 2014 (Appendix A3-17).
- #33799 was tagged downstream of Gull Rapids at rkm 1.3 on September 30, 2014 and was last detected on October 24, 2014 at rkm 4.3 (Appendix A3-24).
- #33823 moved downstream immediately after being tagged at rkm 1.6 on October 4, 2014. It was last detected at rkm 7.7 on November 11, 2014 (Appendix A3-33).
- #33828 moved downstream immediately after being tagged at rkm 1.3 on October 4, 2014. It was last detected at rkm 3.4 on October 9, 2014 (Appendix A3-33).

No fish were detected within the Long Spruce reservoir.

Two fish moved downstream through Gull Rapids into Stephens Lake (as discussed in Section 4.1.1).

Therefore, accounting for the 40 fish originally tagged, the 12 missing fish, and the two fish that moved downstream through Gull Rapids, a total of 30 Lake Whitefish were available to be detected in Stephens Lake during winter 2016/2017.

## **4.2 WINTER 2016/2017**

### **4.2.1 UPSTREAM OF GULL RAPIDS**

Three of the four receivers deployed upstream of Gull Rapids during winter were retrieved (Map 3). A single receiver at rkm -12.9 could not be located and was likely moved by ice. Six of the 15 available whitefish were located a total of 2,709 times (range: 2–2,255 detections per individual) (Figure 3; Appendix A1-1). Fish were detected on one to 32 days of the 193 day period, and all detections occurred prior to December 5, 2016. The majority of detections occurred downstream of Birthday Rapids (rkm -29.4) in October and November, 2016 (Figure 4). Two fish (#33803 and #33816) were located for one to three days in Clark Lake (rkm -48.2) at the beginning of the study period (on November 11 and October 2–5, 2016, respectively).

### **4.2.2 STEPHENS LAKE**

Fifteen of the 16 receivers deployed in Stephens Lake during winter were retrieved (Map 4). A single receiver located at rkm 23.5 could not be retrieved due to the buildup of large woody debris that occurred during the winter months. Eight of the 30 available Lake Whitefish were located a total of 52,629 times (range: 10–36,115 detections per individual) (Figure 5; Appendix A1-2). Fish were detected on one to 155 days of the 193 day winter period (1–60% of the time) for an average of 44 days, or 23% of the study period (StDev = 56.7 days). The farthest upstream detections occurred at rkm 5.2 (by four fish; 50%), while the farthest downstream occurred at rkm 18.6 (by one fish; 13%) (Appendix A1-2). The average, overall movement range was 5.8 rkm (range: 0.0–12.1 rkm) (Figures 5 and 6; Appendix A1-2). The majority of detections ( $n = 36,588$ ; 69%) were logged at two receivers in the southern portion of Stephens Lake (rkms 13.9 and 18.6) (Figure 6).

## **4.3 OPEN-WATER 2017**

### **4.3.1 ACOUSTIC RECEIVER RETRIEVAL**

Stationary acoustic receivers deployed in Stephens Lake (30), in the Long Spruce reservoir (3), and in the Limestone reservoir (1) during the 2017 open-water period were successfully retrieved (Maps 7 and 8). One of the 26 receivers deployed upstream of Gull Rapids (#129189;



rkm -32.3) went missing part way through the study period (Map 6). No data were retrieved from this receiver after July 23, 2017.

Due to ice conditions, the majority of the receivers are removed from the water in early October, including the receivers placed near spawning locations at Birthday Rapids and Gull Rapids. Lake Whitefish are known to spawn in the area when the water temperature in the Nelson River falls below 8°C. In 2017, the water temperature measured 6.7°C at the time the receivers were removed. As a result, the receivers were expected to be able to track spawning movements of Lake Whitefish in 2017, similar to 2016 (Section 5.3).

During the 2017 open-water period, the receivers were again deployed and successfully retrieved at known spawning sites: at the mouth of the Assean River and at the mouth of Ferris Bay (Johnson 2005; Michaluk *et al.* 2011; Lavergne and Hrenchuk 2016; Keeyask Hydro Limited Partnership 2014). For the first time in 2017, a receiver was successfully deployed and retrieved in the North Arm of Stephens Lake.

### 4.3.2 UPSTREAM OF GULL RAPIDS

Nine of the 15 available Lake Whitefish were detected between 15 and 1,868 times for 5–71 days of the 169 day open-water period (3–42% of the time; Appendix A1-3). The average movement range was 21.7 rkm (StDev = 12.7 rkm; range: 0–36.3 rkm). The farthest upstream detections occurred in Clark Lake at rkms -48.2, -46.9 and -44.3 (by five fish; 60%), while the farthest downstream detections occurred at rkm -5.8 (by one fish; 11%; Figure 7). None of the tagged Lake Whitefish detected upstream of Gull Rapids during the open-water period moved downstream through Gull Rapids (Table A1-3).

#### 4.3.2.1 PROPORTIONAL DISTRIBUTION

In 2017, as in the past two years of study, individual Lake Whitefish were detected most often in Zone 4 (upper basin of Gull Lake), spending an average of 51% of the study period in this zone (StDev = 34%, range: 0–84%; Figure 8). Lake Whitefish were detected for an average of 19% of the study period in each of zones 1 (Clark Lake; StDev = 32%; range: 0–100%) and 3 (river reach from Birthday Rapids to Gull Lake; StDev = 25%; range: 0–72%). Lake Whitefish spent an average of 10% of the study period in Zone 5, closest to Gull Rapids (StDev = 18%, range: 1–43%). The fish spent very little time (0.5% of the study period) in Zone 2, the river reach from Clark Lake to Birthday Rapids (StDev = 1%, range: 0–4%) (Figures 9 and 10). Fish were detected in Gull Lake (zones 4 and 5) for a greater proportion of time during the spring and summer than in the fall (Table 3; Figure 8):

- Gull Lake was used an average of 72% of the time (StDev = 5%; range: 67–78%) between June 7 and September 20;
- 16% (StDev = 25%; range: 0–7%) after September 20; and
- No Lake Whitefish were detected in Gull Lake after October 1.

### 4.3.2.2 MOVEMENT PATTERNS

The majority of detections during the 2017 open-water period were logged by three receivers: one in the middle of Gull Lake at rkm -12.8 (n = 2,017; 21%); another at the upstream end of Gull Lake near the transition to more riverine habitat at rkm -19.5 (n = 1,268; 13%) and one immediately downstream of Birthday Rapids at rkm -33.8 (n = 2,083; 22%; Figure 10). During the spawning period (September 25 to October 16), the majority of detections (n = 2,111; 56%) were logged at the two receivers immediately downstream of Birthday Rapids at rkm -33.8 (Figure 11). One main movement pattern observed for eight of the nine fish detected during the open-water period was an upstream movement in the late summer/early fall. One fish was only detected at the mouth of the Assean River but also likely moved up the river in the fall.

Of the nine fish detected upstream of Gull Rapids during the open-water period:

- One (#33807) was only detected in Clark Lake. This fish was only detected at the receiver at the mouth of the Assean River at rkm -46.9 between August 9 and September 17. It likely moved upstream into the Assean River, a known spawning tributary for Lake Whitefish (Appendix A2-11).
- Three (#33804, #33816, and #33822) were detected in Gull Lake for most of the open-water period, then moved upstream to Clark Lake at the end of September:
  - #33804 was last detected at the mouth of the Assean River on October 2 and likely moved upstream into the river (Appendix A2-8).
  - #33816 was last detected at rkm -44.3 on September 26 at the downstream end of Clark Lake (Appendix A2-16).
  - #33822 was last detected at the inlet to Clark Lake at rkm -48.2 on October 16 (Appendix A2-19).
- One (#33830) was only detected upstream of Gull Lake during the open-water period. It was detected sporadically between rkms -26.5 and -29.4 during the summer and then was detected at the mouth of the Assean River on September 9 and October 16 (Appendix A2-20).
- Four moved from Gull Lake to Birthday Rapids during the fall:
  - Three (#33798, #33803, and #33808) moved to the base of Birthday Rapids in late September/early October (appendices A2-3, A2-7 and A2-12).
  - #33806 was detected at the base of Birthday Rapids on September 21 and then was detected at the receiver immediately upstream of Birthday Rapids between October 2 and 7. It then moved back downstream and was last detected at the receiver at the base of Birthday Rapids on October 13 (Appendix A2-10).

### 4.3.3 STEPHENS LAKE

A total of 35 tagged Lake Whitefish were available to be detected during the 2017 open-water period. Of these fish, seventeen were detected between two and 9,071 times over 1–92 days of the 169 day study period (1–54% of the time) (Appendix A1-4). The average movement range

was 6.5 rkm (StDev = 7.0 rkm; range = 0–22.1 rkm). The farthest upstream detections occurred at rkm 1.2 (by nine fish; 53%), while the farthest downstream detections occurred at rkm 24.7 (by one fish; 6%) (Appendix A1-4). A single fish (#33832) was detected at the entrance to Ferris Bay (rkm 20.0). No fish moved upstream through Gull Rapids or downstream through the Kettle GS (Figure 12).

#### 4.3.3.1 PROPORTIONAL DISTRIBUTION

As in the previous two years of study, Lake Whitefish used Zone 6 (closer to Gull Rapids) more frequently than Zone 7 (Figures 14 and 15; Table 3). On average, fish spent 56% of the time in Zone 6 (StDev = 48%; range: 0–100%) and 44% of the time in Zone 7 (StDev = 48%, range: 0–100%). The proportion of time spent in the two zones was relatively equal during the spring and summer (Figure 13), but the amount of time spent in Zone 6 started increasing at the beginning of October:

- Zone 6 was used an average of 54% of the time (StDev = 3%; range: 41–65%) between June 7 and October 2; and
- 69% (StDev = 4%; range: 65–76%) between October 3 and 16.

#### 4.3.3.2 MOVEMENT PATTERNS

During the 2017 open-water period, the majority of detections (n=9,791; 39%) were recorded at the receiver at rkm 16.8 in the northern part of Stephens Lake (Figure 15; Map 8). During the spawning period (September 25 to October 16), there were no detections at any receivers downstream of rkm 13.9, and 80% of the detections (n = 6,350) were logged within 4.5 rkm of Gull Rapids (Figure 16). Two main patterns of movement were observed: some spent the majority of time in Zone 6, closer to Gull Rapids, while the rest were mainly detected farther downstream in Zone 7.

Of the 17 Lake Whitefish detected in Stephens Lake during the 2017 open-water period, nine spent the majority of the time (96–100%) in Zone 6:

- Two were detected briefly in Zone 7:
  - #6361 was detected at the receiver at rkm 7.4 in the North Arm of Stephens Lake on September 20, and then moved upstream as far as rkm 1.2, the receiver below Gull Rapids (Appendix A3-5).
  - #33825 was first detected at rkm 20 on July 10, and then moved steadily upstream, reaching rkm 1.2 by October 2 (Appendix A3-35).
- The remaining seven were only detected in Zone 6:
  - #33795 was detected between rkm 1.2 and 4.3 between September 27 and October 1<sup>st</sup> (Appendix A3-22).
  - #33802 had not been detected since being tagged in Gull Lake in 2014. In 2017, it was detected regularly at rkm 3.8 between July 23 and October 2 (Appendix A2-6).

- #33811 was only detected at rkm 1.2 for one day on October 10 (Appendix A2-9).
- #33817 was detected between rkm 1.2 and 3.8 between September 27 and October 2 (Appendix A3-29).
- Three (#33821, #33827 and #33831) were only detected briefly at rkm 1.2 during the spawning period (appendices A3-32, A3-36 and A3-39).

The remaining eight fish were detected in Zone 7 for the majority of the open-water season

- Four of the eight were only detected in Zone 7.
  - Three (#6357, #33796 and #33818) were detected regularly moving throughout Zone 7 during the open-water period (appendices A3-1, A3-23 and A3-30).
  - #33832 was detected at rkm 20 only on June 9 and was undetected for the remainder of the open-water period (Appendix A3-40).
- The other four made movements into Zone 6 during the open-water period:
  - #6364 was first detected at the receiver in the North Arm of Stephens Lake in late July. It moved up to Zone 6 at the end of September and was detected as far upstream as rkm 3.8 (Appendix A3-8).
  - #6372 moved throughout Stephens Lake during the open-water period. This fish was detected as far upstream as rkm 2.6 in June and then moved downstream as far as rkm 24.7 by early August. It then made upstream movements between zones 6 and 7 for the remainder of the open-water period, moving back upstream as far as rkm 2.6 (Appendix A3-16).
  - #33805 was detected at rkm 20 in July, and moved upstream to rkm 1.2 by early October. It was the only fish detected at the new receiver in Stephens Lake at rkm 3.8, and it also briefly moved to the receiver in the North Arm of Stephens Lake (Appendix A2-9).
  - #33829 was first detected by the receiver in the North Arm of Stephens Lake (rkm 7.4) on September 24 and then moved upstream as far as rkm 1.2 by October 9 (Appendix A3-38).

## 5.0 DISCUSSION

### 5.1 EVALUATION OF METHODOLOGY

Fish movement monitoring, via acoustic telemetry, is a significant component of the AEMP for the Keeyask GS Project used to assess potential impacts of GS construction on several fish species including Lake Sturgeon (adults and juveniles), Walleye, and Lake Whitefish. Of these fish species/life stages, the methodology is most effective for monitoring movements of adult and juvenile Lake Sturgeon. Lake Sturgeon have a low natural mortality rate, occupy main channel habitats where the receivers are located, and in the case of juveniles, rarely move. Monitoring movements of Walleye and Lake Whitefish via acoustic telemetry, has been less effective relative to Lake Sturgeon. This is because: i) tagged individuals are detected less frequently due to more frequent utilization of shallow water habitat outside the detection range of receivers; ii) potential use of tributaries and off-current embayments where receivers are not located; iii) stress from the tagging procedure may cause an initial downstream movement of some individuals which complicates data interpretation; and iv) a higher natural mortality rate relative to Lake Sturgeon causes a greater proportion of tags to go missing. Despite this, the data collected to date (2014 to 2017) provide a good understanding of Lake Whitefish movements. This has been facilitated by the extensive array of stationary acoustic receivers spread over a ~100 km length of the Nelson River between Clark Lake and the Limestone GS, and the inclusion of receiver gates which provide confidence that movements of Lake Whitefish past key points are being detected.

In total, 14 of the original 60 Lake Whitefish implanted with acoustic transmitters (23%) went undetected for the entirety of the three-year study, and only 20 (33%) were detected during all three open-water periods. One Lake Whitefish that was tagged near Birthday Rapids in 2014 went undetected until the open-water season of 2017, when it was detected at rkm 3.8 in Stephens Lake.

### 5.2 WINTER MOVEMENT

Similar to the previous two years of data collection, the quantity of data collected on Lake Whitefish upstream of Gull Rapids during the 2016/2017 winter period was limited. As a consequence, overwintering habitat and locations for Lake Whitefish upstream of Gull Rapids are poorly understood. In 2016/2017, only six of the 15 available fish (40%) were detected upstream of Gull Rapids, and all of the detections occurred before December 5, 2016. The majority of these detections occurred downstream of Birthday Rapids in October and November, 2016, and were likely related to spawning and post-spawning movements. This is similar to winter 2015/2016, when the majority of detections also occurred downstream of Birthday Rapids.

Winter receiver coverage in Stephens Lake is more widespread, and therefore, the winter 2014–2017 Lake Whitefish acoustic telemetry dataset has provided some indication as to overwintering locations. Unlike upstream of Gull Rapids, all detections during the winter in Stephens Lake did not appear to be related to spawning, as fish were detected throughout all three winter periods, not just during spawning periods. The majority of winter detections consistently occurred at receivers in Zone 7, farther away from Gull Rapids. Lake Whitefish were detected most often at the same two receivers during all three winter periods, at rkm 13.9 and 18.6, indicating these locations provide suitable overwintering habitat for this species.

## 5.3 OPEN-WATER MOVEMENT

Acoustic telemetry has provided a relatively good understanding of open-water Lake Whitefish movement patterns despite the (relative to Lake Sturgeon) low number of detections and relatively long gaps between detection events. Upstream of Gull Rapids, a general pattern of movement has been observed that has been repeated over the three years of study. Lake Whitefish are generally located in Gull Lake during spring/summer and move upstream to spawning sites during fall. Movement patterns, from both the present study, as well as previous acoustic telemetry and hoopnet studies, suggest that spawning occurs in the Assean River, and in the vicinity of Birthday Rapids and may occur at other locations in the riverine area between Gull Lake and Clark Lake (Johnson 2005; Lavergne and Hrenchuk 2016; Burnett and Hrenchuk 2017). In both 2016 and 2017, Lake Whitefish were detected at the mouth of the Assean River during the spawning period, while fish were detected in the vicinity of Birthday Rapids and farther upstream during the spawning period in all three years of study.

Lake Whitefish in Stephens Lake exhibited two main patterns of movement during the open-water period: i) approximately half spent the majority of their time in Zone 6, close to Gull Rapids; ii) approximately half spent the most time farther downstream in Zone 7. In all three years of study, detection rates in both zones were close to equal for the majority of the open-water period, and then use of Zone 6 increased in the fall. No Lake Whitefish have been located during the spawning period at the receiver in Ferris Bay, despite it being a known spawning site (Michaluk *et al.* 2011; Keeyask Hydropower Limited Partnership 2014). In 2017, four Lake Whitefish were detected at the new receiver deployed in the North Arm of Stephens Lake during the open-water period. Three of these fish were first detected during the open-water period in the North Arm, and then moved upstream towards Gull Rapids. These movement patterns suggest that some Lake Whitefish may spend the majority of their time in the North Arm and then move to Gull Rapids to spawn.

## 5.4 KEY QUESTIONS

The AEMP identified key questions for Lake Whitefish movement monitoring, two of which are relevant to the construction period and are addressed in the discussion below.



*What is the number (or proportion) of tagged Lake Whitefish that move past the construction site?*

The three years of monitoring Lake Whitefish movement have shown that movements past Gull Rapids are rare. Only two of the 20 Lake Whitefish (10%) tagged upstream of Gull Rapids moved downstream through Gull Rapids during the study. One of these fish moved through the rapids in 2015 (Lavergne and Hrenchuk 2016) and it is unknown when the other moved downstream. No Lake Whitefish have moved upstream through Gull Rapids during the three years of monitoring. As discussed in Burnett and Hrenchuk (2017), it is possible that upstream fish movement past the construction site is no longer possible because all flow has been diverted to the south channel. Discharge in the Nelson River has been above median levels since the start of construction, further increasing water velocity in the south channel. Although a tagged Lake Whitefish has never been observed moving upstream through Gull Rapids during this study, six individual adult Lake Sturgeon and one Walleye moved upstream through the rapids between 2011 and 2013 before construction commenced. No fish have moved upstream since construction began in 2014 (Hrenchuk *et al.* 2018; Hrenchuk and Lacho 2018).

*Are Lake Whitefish utilizing habitat in the vicinity of construction activities (particularly during spawning)?*

Upstream of Gull Rapids, Lake Whitefish spent the most time in the upper basin of Gull Lake (Zone 4) during all three years of the study. As in 2016, only one Lake Whitefish was detected at the receiver closest to Gull Rapids in 2017, while none were detected at this receiver in 2015. The results consistently show that Lake Whitefish do not frequently use habitat directly upstream of the construction site.

In contrast, a large proportion of the Lake Whitefish implanted with acoustic transmitters in Stephens Lake has been detected immediately downstream of Gull Rapids during all three years of study. In 2017, ten of 17 fish (60%) in Stephens Lake were detected at the receiver closest to Gull Rapids. During the 2017 spawning period, 80% of detections at receivers were logged within 4.5 rkm of the rapids, indicating that Lake Whitefish spawn in the vicinity of Gull Rapids. This means that Lake Whitefish may be susceptible to construction-related activities like sedimentation and flow alteration, especially during the spawning period.

## 6.0 SUMMARY AND CONCLUSIONS

- In open-water 2017, as in previous years, Lake Whitefish upstream of Gull Rapids mainly inhabited Gull Lake during the spring and summer, then moved upstream to spawning sites at Birthday Rapids and further upstream in the Assean River. In Stephens Lake, a large proportion of the detected whitefish were located near the base of Gull Rapids during this time, including fish that seem to be moving out of the North Arm of Stephens Lake to spawn at Gull Rapids.
- Although Lake Whitefish may go undetected for long periods of time and the number of detections are low compared to Lake Sturgeon, acoustic monitoring does effectively provide data to meet the objectives of the AEMP.
- The key questions as described in the AEMP for Lake Whitefish movement monitoring during construction of the Keeyask GS are:

- *What is the number (or the proportion) of tagged Lake Whitefish that move past the construction site?*

Results suggest that a small proportion of Lake Whitefish in Gull Lake move downstream through Gull Rapids. Over the three year study period, two of the 20 whitefish tagged upstream of Gull Rapids (or 10%) moved downstream into Stephens Lake. There have been no upstream movements through the rapids.

- *Are tagged Lake Whitefish utilizing habitat in the vicinity of construction activities (particularly during spawning)?*

So far, Lake Whitefish tagged upstream of Gull Rapids rarely utilized habitat directly upstream of the construction site. A large proportion of whitefish tagged downstream in Stephens Lake continue to use the area immediately downstream of Gull Rapids, including during the spawning period.

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Pisiak, D.J. 2005b. Results of summer index gillnetting studies in Stephens Lake, Manitoba, and seasonal investigations of fish communities in the reach of the Nelson River between Gull Rapids and Stephens Lake, 2003, year 3. A report prepared for Manitoba Hydro by North/South Consultants Inc. xxi + 289 pp.

## TABLES



**Table 1: Acoustic-tag and biological information for each Lake Whitefish tagged with an acoustic transmitter in the Nelson River upstream of Gull Rapids, fall 2014.**

Acoustic Tag ID	Floy Tag #	Date Tagged	Tag Life (days)	Expiry Date	Fork Length (mm)	Weight (g)
33822	105434	7-Oct-14	1141	20-Nov-17	455	1825
33826	105436	7-Oct-14	1141	20-Nov-17	433	1200
33830	105437	7-Oct-14	1141	20-Nov-17	449	1500
33793	105950	8-Oct-14	1141	21-Nov-17	425	2350
33797	105949	8-Oct-14	1141	21-Nov-17	534	3350
33798	105447	8-Oct-14	1141	21-Nov-17	464	1775
33800	105439	8-Oct-14	1141	21-Nov-17	416	1025
33801	105948	8-Oct-14	1141	21-Nov-17	529	2450
33802	105448	8-Oct-14	1141	21-Nov-17	503	2300
33803	105438	8-Oct-14	1141	21-Nov-17	500	2150
33804	105440	8-Oct-14	1141	21-Nov-17	482	1625
33805	105947	8-Oct-14	1141	21-Nov-17	434	1400
33806	105449	8-Oct-14	1141	21-Nov-17	495	1925
33807	105446	8-Oct-14	1141	21-Nov-17	461	1375
33808	105944	8-Oct-14	1141	21-Nov-17	444	1850
33809	105945	8-Oct-14	1141	21-Nov-17	482	1725
33812	105442	8-Oct-14	1141	21-Nov-17	560	3425
33813	105946	8-Oct-14	1141	21-Nov-17	438	1325
33816	105444	8-Oct-14	1141	21-Nov-17	452	1650
33820	105445	8-Oct-14	1141	21-Nov-17	493	1725

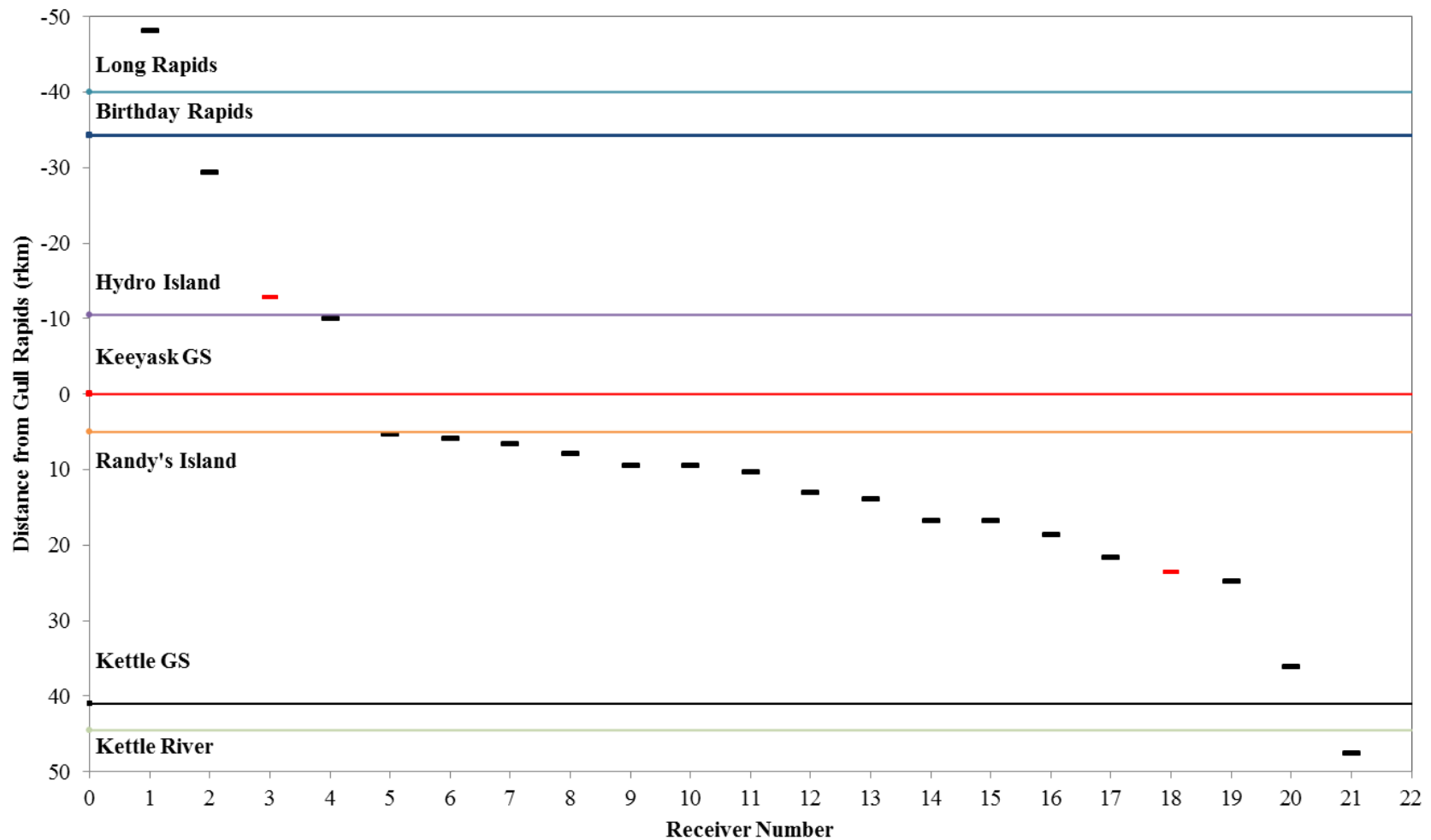
**Table 2: Acoustic-tag and biological information for each Lake Whitefish tagged with an acoustic transmitter in Stephens Lake, fall 2014.**

Acoustic Tag ID	Floy Tag #	Date tagged	Tag life (days)	Expiry date	Fork length (mm)	Weight (g)
6367	99688	25-Sep-14	1141	8-Nov-17	508	2100
6368	99689	25-Sep-14	1141	8-Nov-17	495	2050
6372	99685	25-Sep-14	1141	8-Nov-17	482	1800
6373	99686	25-Sep-14	1141	8-Nov-17	541	2900
6374	N/A	25-Sep-14	1141	8-Nov-17	510	2300
6375	99687	25-Sep-14	1141	8-Nov-17	492	1750
6376	99683	25-Sep-14	1141	8-Nov-17	380	900
6357	99651	30-Sep-14	1141	9-Nov-17	436	1500
6358	99675	30-Sep-14	1141	9-Nov-17	503	2400
6359	99674	30-Sep-14	1141	9-Nov-17	520	2300
6360	99673	30-Sep-14	1141	9-Nov-17	460	1700
6361	99672	30-Sep-14	1141	9-Nov-17	495	2300
6362	99654	30-Sep-14	1141	9-Nov-17	514	2500
6363	99655	30-Sep-14	1141	9-Nov-17	489	1900
6364	99656	30-Sep-14	1141	9-Nov-17	445	1600
6365	99657	30-Sep-14	1141	9-Nov-17	524	3000
6366	99658	30-Sep-14	1141	9-Nov-17	440	1700
6369	99700	30-Sep-14	1141	9-Nov-17	538	3000
6370	99652	30-Sep-14	1141	9-Nov-17	560	3700
6371	99651	30-Sep-14	1141	9-Nov-17	520	3500
33794	99696	30-Sep-14	1141	9-Nov-17	552	2700
33795	99697	30-Sep-14	1141	9-Nov-17	483	2200
33796	99699	30-Sep-14	1141	9-Nov-17	372	950
33799	99698	30-Sep-14	1141	9-Nov-17	549	2900
33810	99694	30-Sep-14	1141	9-Nov-17	551	3250
33811	99670	30-Sep-14	1141	9-Nov-17	448	1600
33814	99692	30-Sep-14	1141	9-Nov-17	446	1600
33815	99693	30-Sep-14	1141	9-Nov-17	538	2600
33817	99671	30-Sep-14	1141	9-Nov-17	508	2400
33818	99690	30-Sep-14	1141	9-Nov-17	456	1850
33819	99691	30-Sep-14	1141	9-Nov-17	565	3150
33821	105450	4-Oct-14	1141	17-Nov-17	459	1575
33823	105432	4-Oct-14	1141	17-Nov-17	454	1750
33824	105430	4-Oct-14	1141	17-Nov-17	519	2650
33825	105426	4-Oct-14	1141	17-Nov-17	442	1325
33827	105433	4-Oct-14	1141	17-Nov-17	410	1800
33828	105429	4-Oct-14	1141	17-Nov-17	494	2150
33829	105427	4-Oct-14	1141	17-Nov-17	506	2400
33831	105431	4-Oct-14	1141	17-Nov-17	538	2700
33832	105428	4-Oct-14	1141	17-Nov-17	549	2725

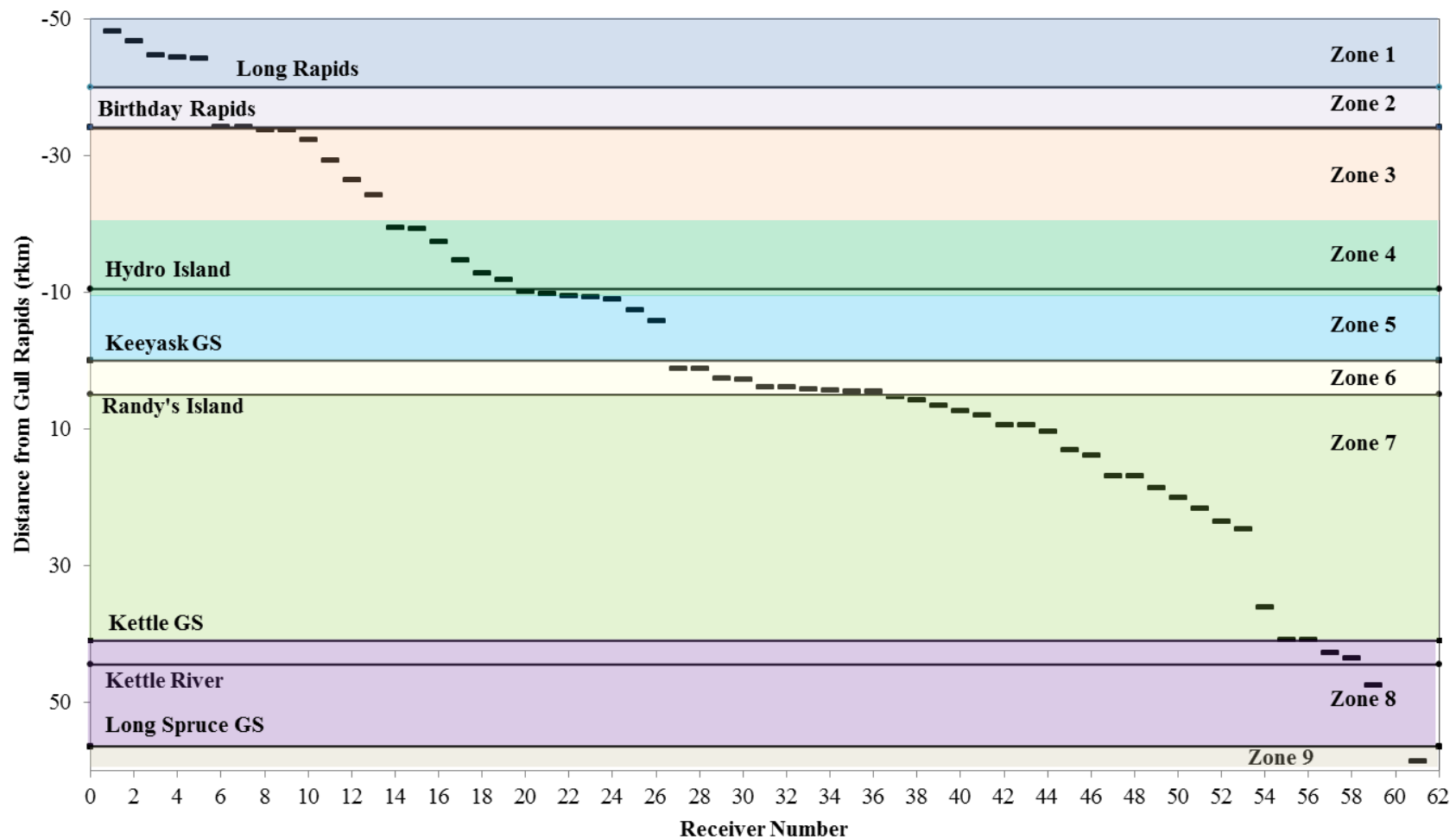
**Table 3: Proportion of time spent in each river zone by Lake Whitefish implanted with acoustic transmitters upstream of Gull Rapids and in Stephens Lake during a portion of the 2015 (June 4 to October 11), 2016 (June 4 to October 19) and 2017 (June 7 to October 16) open-water periods.**

Study Year	Upstream of Gull Rapids					Stephens Lake	
	1	2	3	4	5	6	7
<b>2015</b>	0.2	0.5	32.0	45.4	21.9	66.4	45.2
<b>2016</b>	6.6	5.6	20.8	50.3	16.6	55.3	44.7
<b>2017</b>	18.8	0.5	19.1	51.3	10.2	52.4	47.62

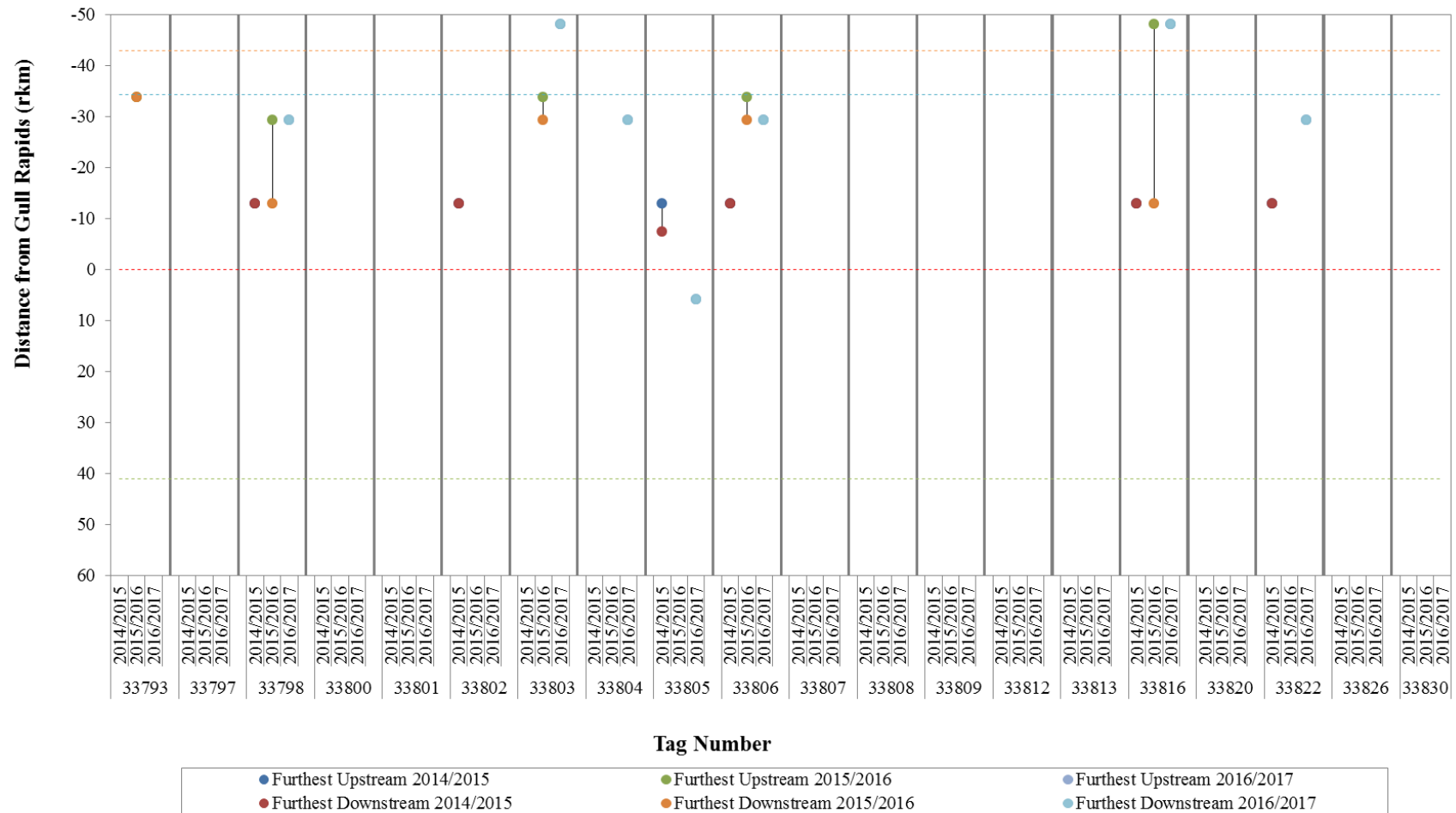
## FIGURES



**Figure 1:** Locations of stationary acoustic receivers (dashes) in relation to the base of Gull Rapids (rkm 0) and other major landmarks (lines) in the Nelson River between Clark Lake and the Limestone GS between October 2016 and June 2017. Red dashes indicate lost receivers.

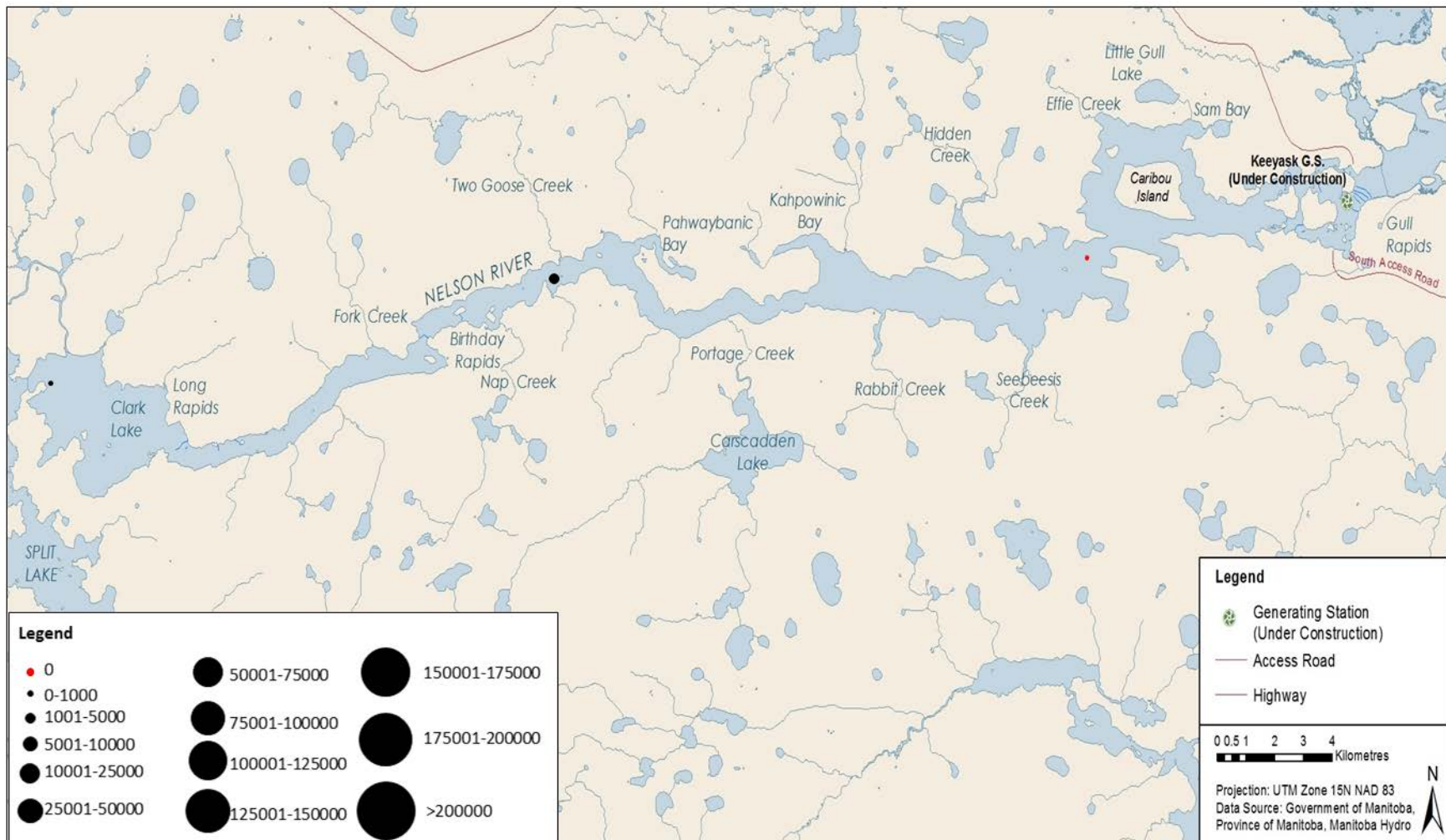


**Figure 2:** Locations of stationary acoustic receivers (dashes) in relation to the base of Gull Rapids (rkm 0) and other major landmarks (lines) in the Nelson River between Clark Lake and the Limestone GS between June and October, 2017. River zones are indicated by shading.

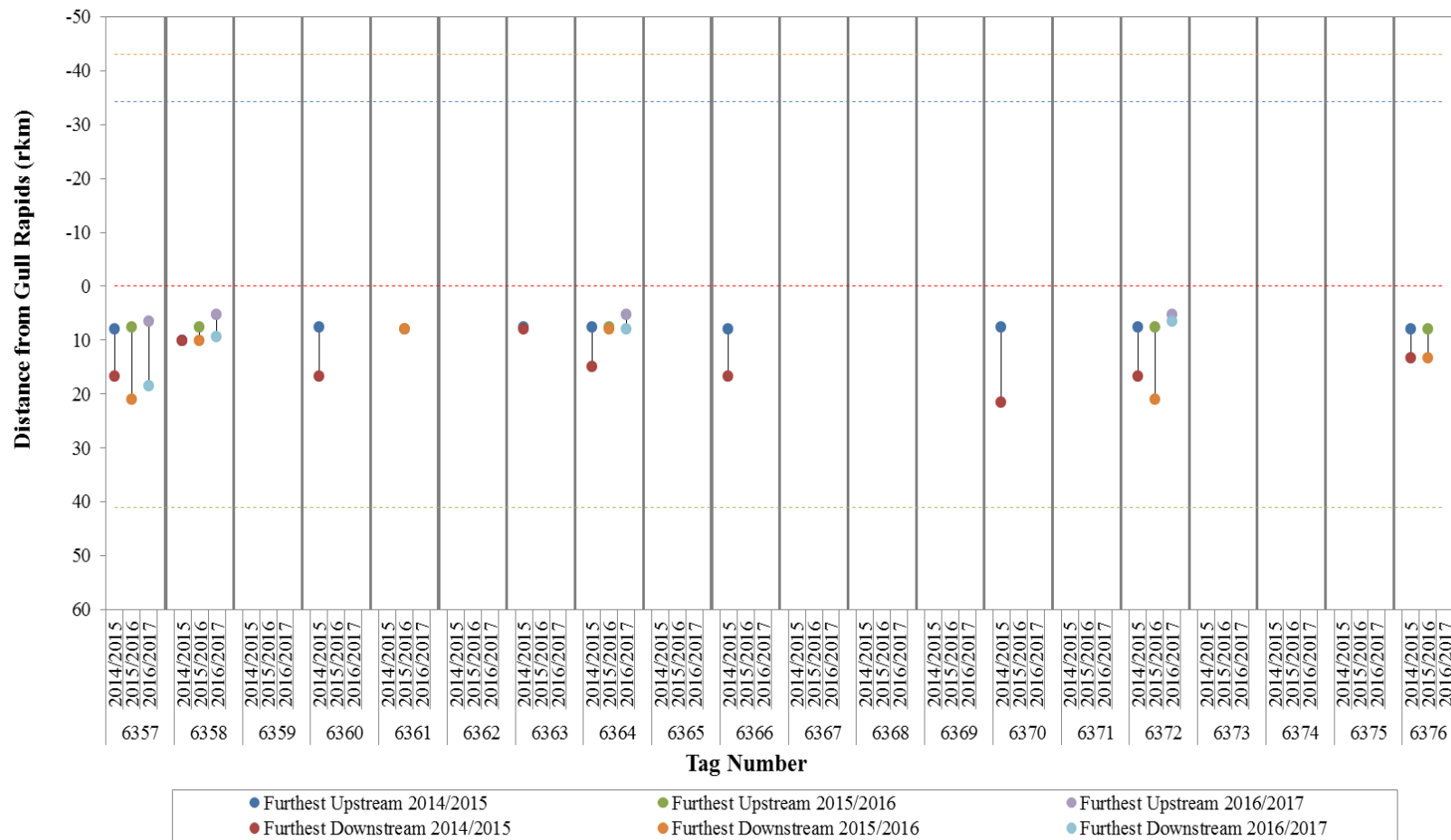


**Figure 3:** Detection ranges for individual Lake Whitefish ( $n = 20$ ) tagged with acoustic transmitters upstream of Gull Rapids during the 2014/15 (October 15, 2014 to April 30, 2015), 2015/16 (October 12, 2015 to April 30, 2016), and 2016/17 (October 20, 2016 to April 30, 2017) winter periods. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS).

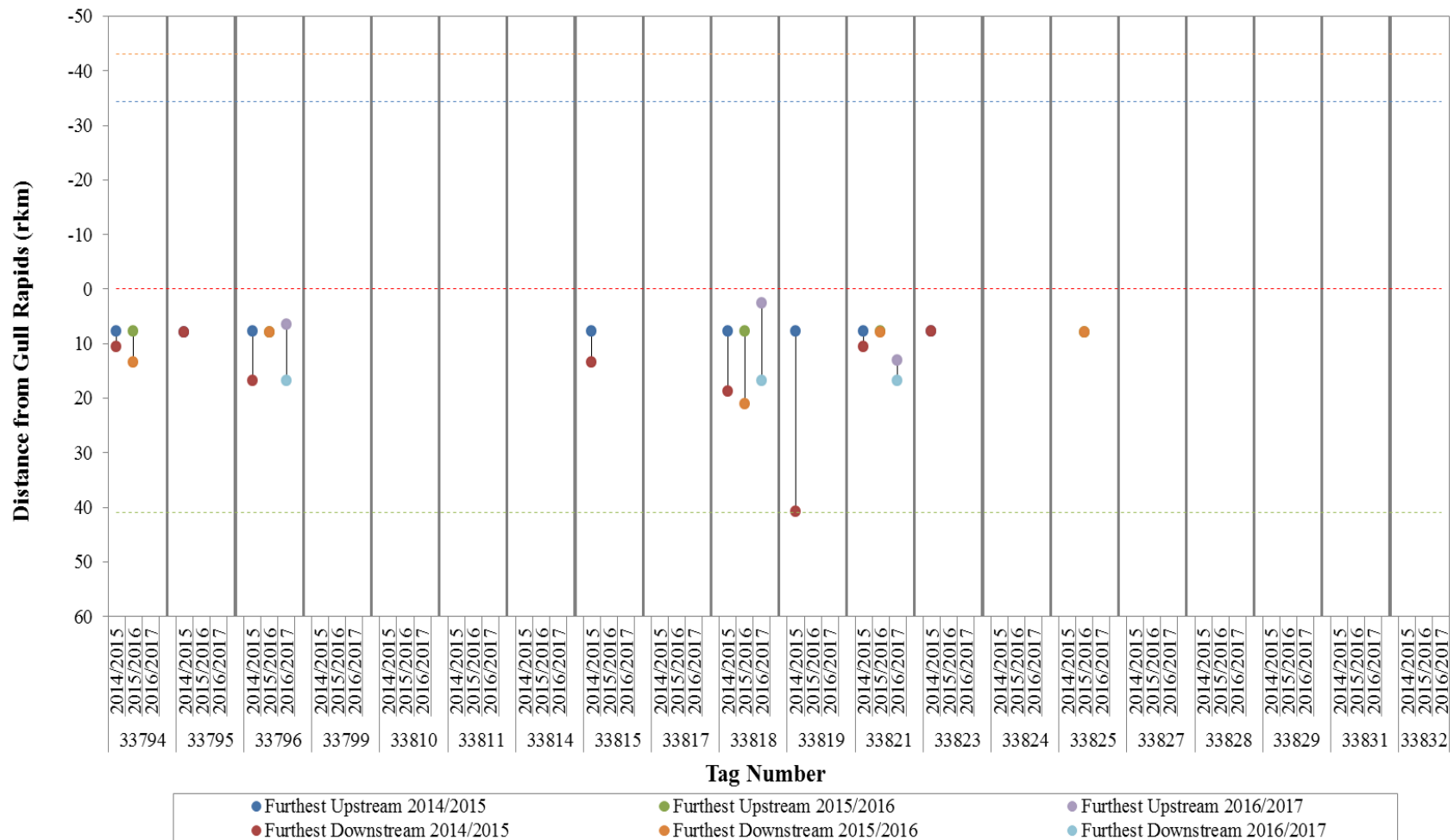




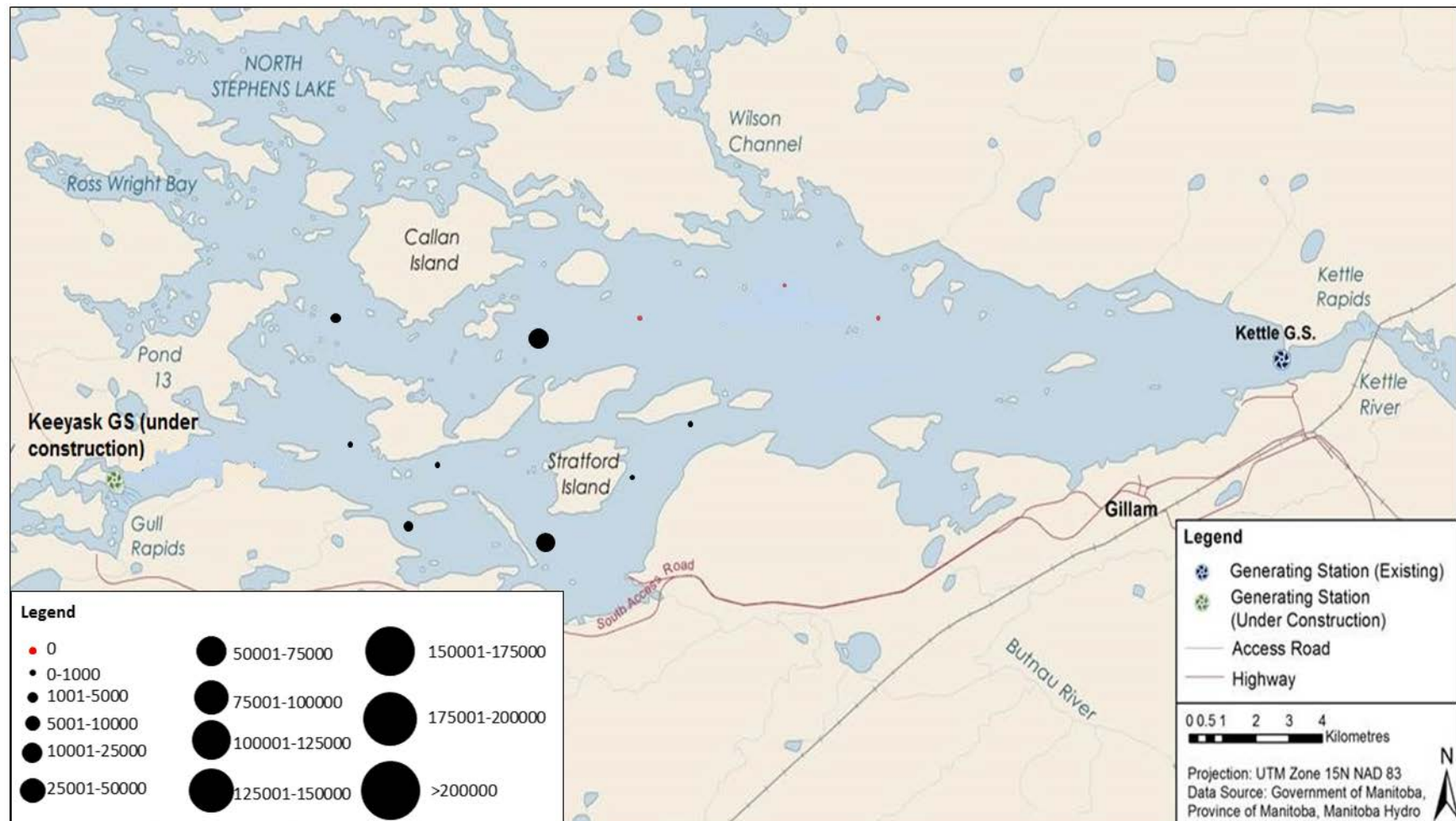
**Figure 4:** Relative number of detections at each acoustic receiver set between Clark Lake and Gull Rapids during winter 2016/2017 (October 20, 2016, to April 30, 2017). Number of detections indicated by size of bubble (defined in legend). Receivers with no detections indicated with red dot.



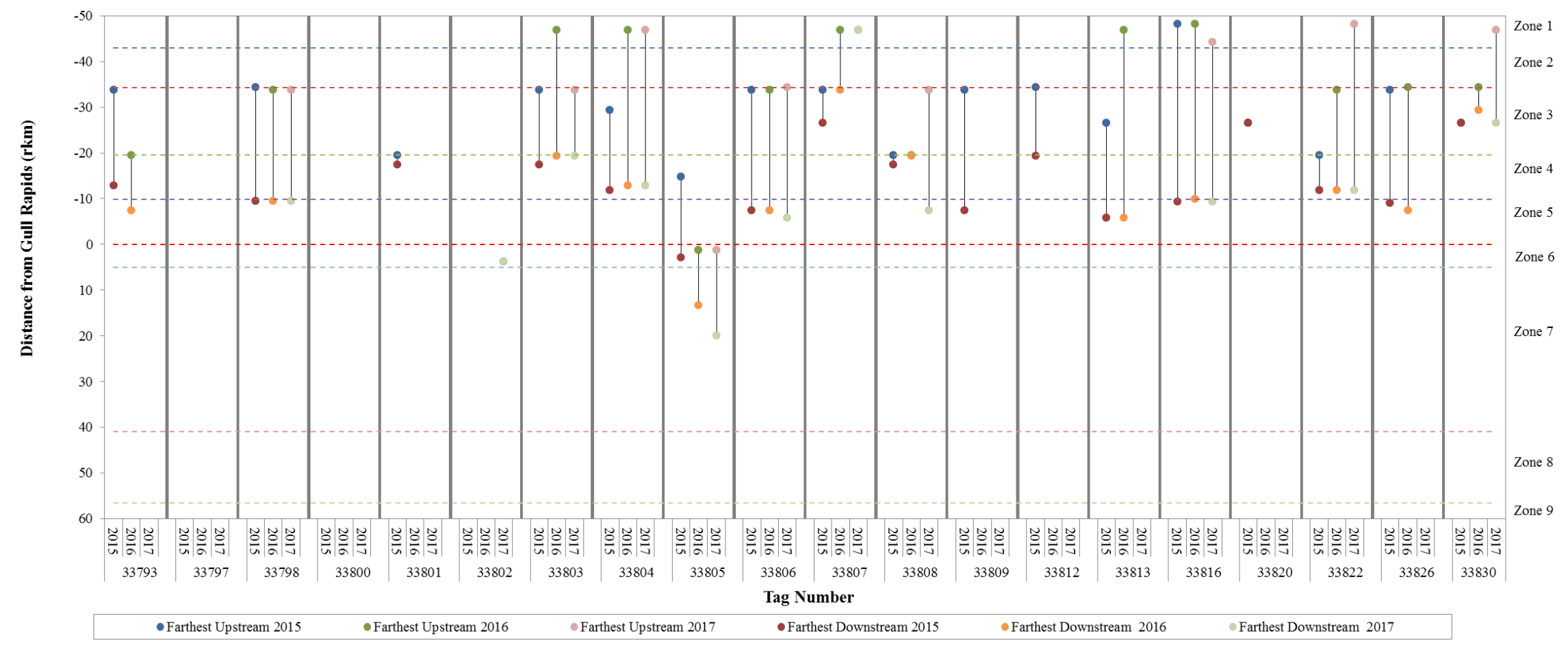
**Figure 5:** Detection ranges for individual Lake Whitefish ( $n = 40$ ) tagged with acoustic transmitters in Stephens Lake during the 2014/15 (October 15, 2014 to April 30, 2015), 2015/16 (October 12, 2015 to April 30, 2016), and 2016/17 (October 20, 2016 to April 30, 2017) winter periods. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS).



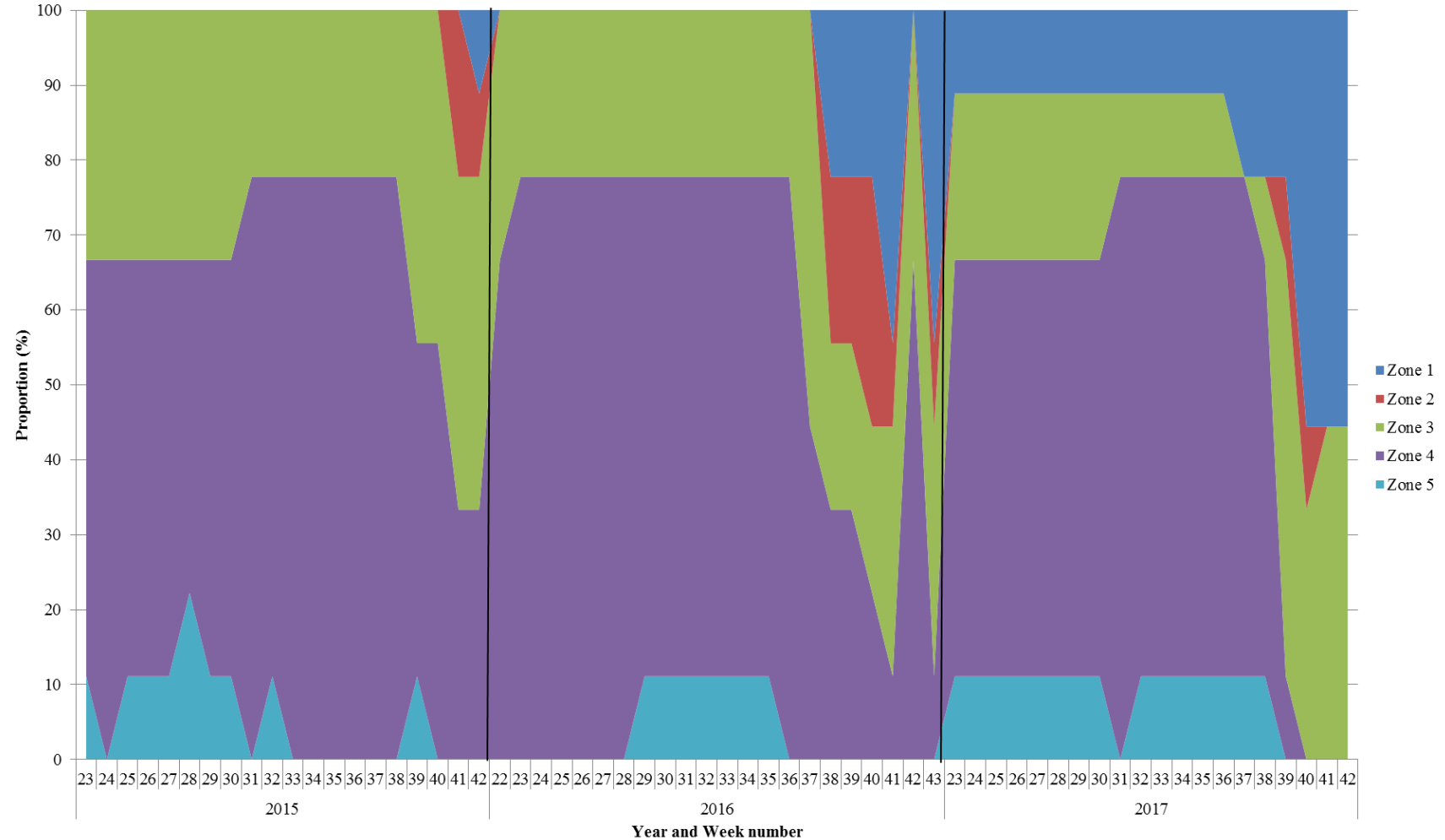
**Figure 5:** Detection ranges for individual Lake Whitefish ( $n = 40$ ) tagged with acoustic transmitters in Stephens Lake during the 2014/15 (October 15, 2014 to April 30, 2015), 2015/16 (October 12, 2015 to April 30, 2016), and 2016/17 (October 20, 2016 to April 30, 2017) winter periods. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS) (continued).



**Figure 6:** Relative number of detections at each acoustic receiver set in Stephens Lake during winter 2016/2017 (October 20, 2016, to April 30, 2017). Number of detections indicated by size of bubble (defined in legend). Receivers with no detections indicated with red dot.

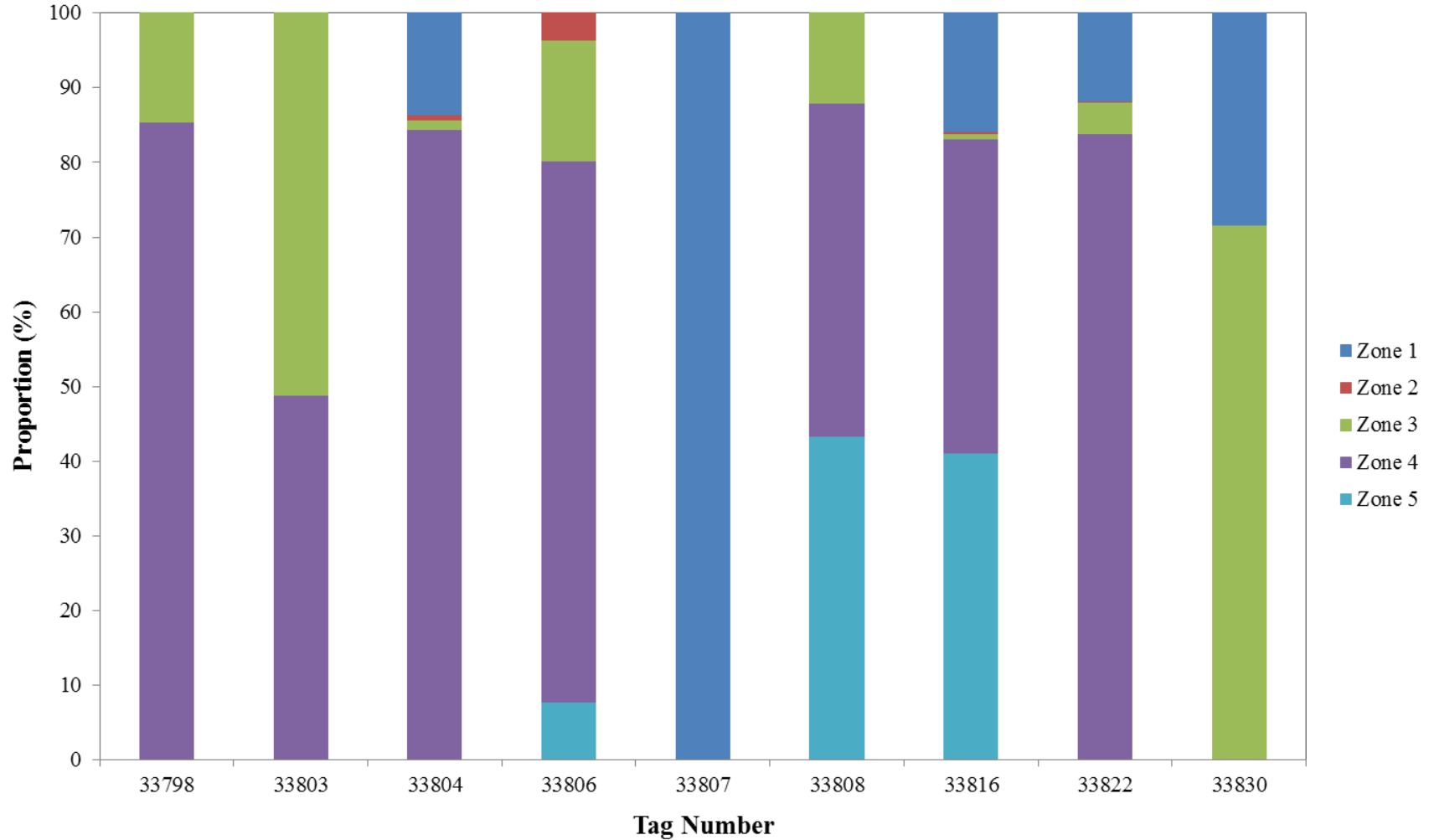


**Figure 7:** Detection ranges for individual Lake Whitefish (n = 20) tagged with acoustic transmitters in Gull Lake during the 2015 (June 4 to October 11), 2016 (May 1 to October 19), and 2017 (May 1 to October 16) open-water periods. Horizontal dotted lines demarcate zones.



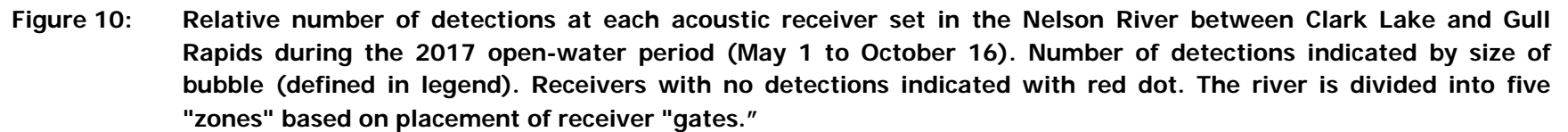
**Figure 8:** Proportional distribution of acoustic-tagged Lake Whitefish within five river zones between Clark Lake and Gull Rapids during a portion of the 2015 (June 4 to October 11), 2016 (June 4 to October 19), and 2017 (June 7 to October 16) open-water periods.

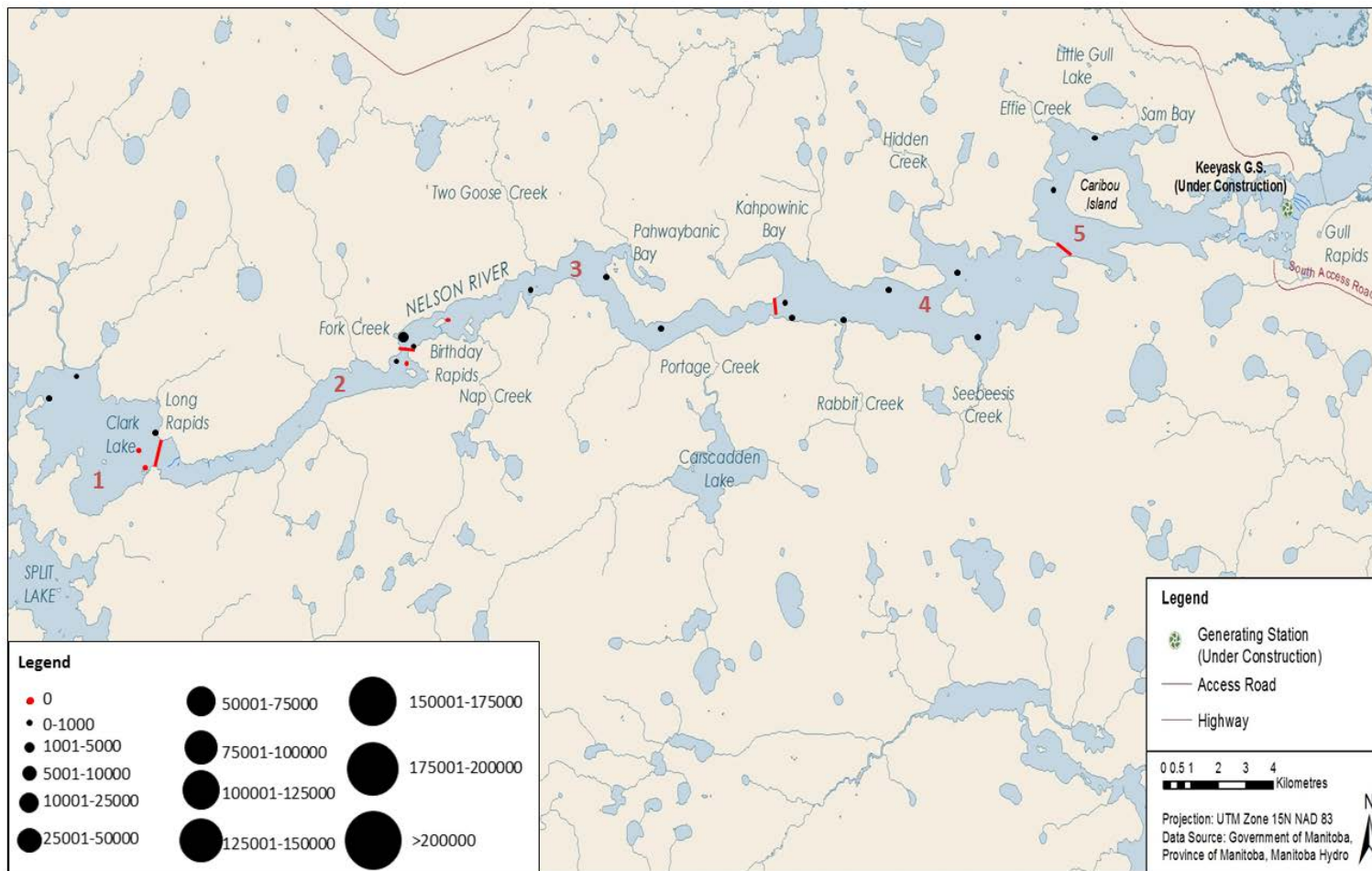




**Figure 9:** Proportion of time spent within five river zones between Clark Lake and Gull Rapids by individual acoustic-tagged Lake Whitefish during the 2017 open-water period (June 7 to October 16).







**Figure 11:** Relative number of detections at each acoustic receiver set in the Nelson River between Clark Lake and Gull Rapids during the 2017 spawning period (September 25 to October 19). Dates were selected based on water temperatures (less than 12°C) in order to capture movement of Lake Whitefish to spawning sites. Relative number of detections indicated by size of bubble. Receivers with no detections indicated with red dot. The river is divided into five "zones" based on placement of receiver "gates."

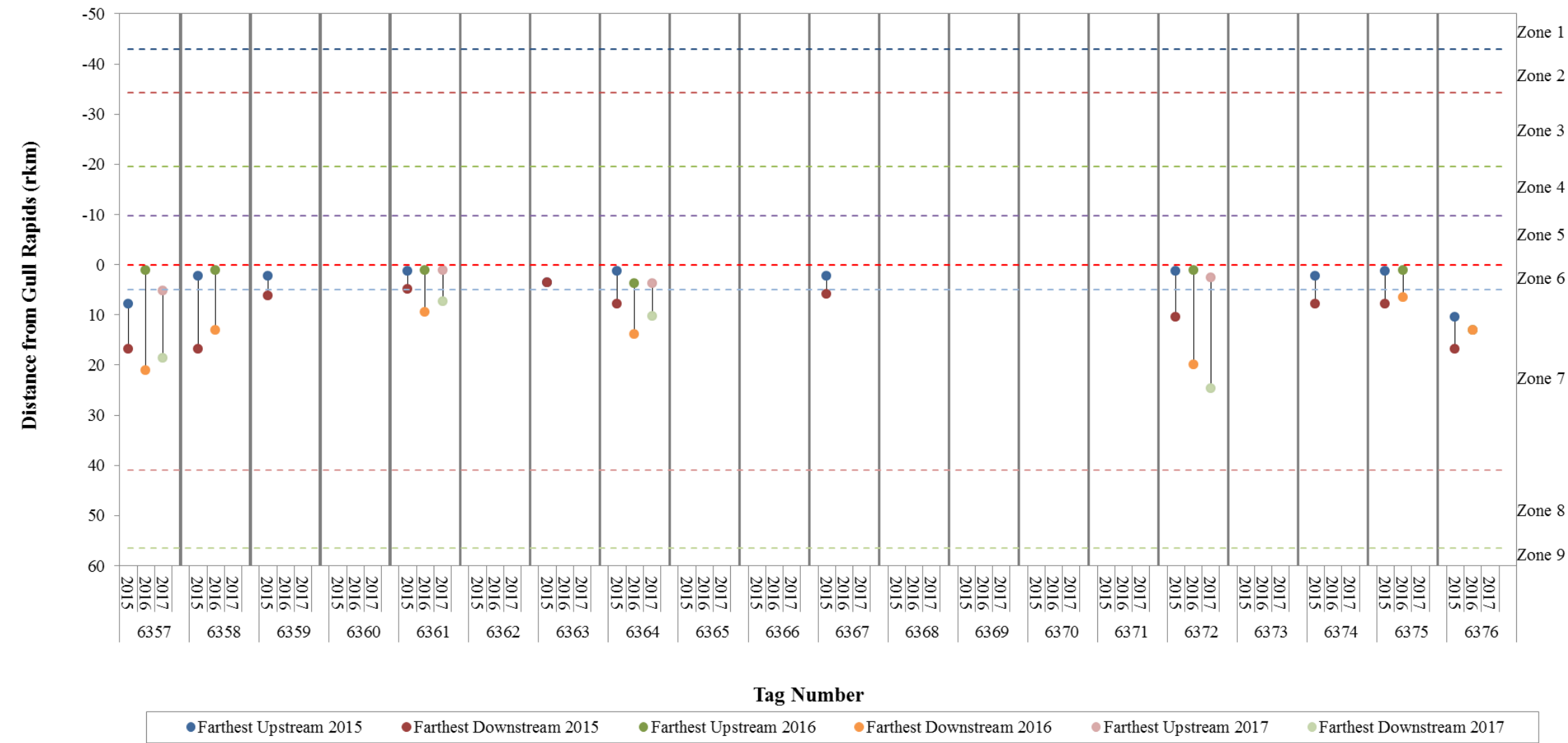


Figure 12: Detection ranges for individual Lake Whitefish (n = 40) tagged with acoustic transmitters in Stephens Lake during the 2015 (June 4 to October 11), 2016 (May 1 to October 19), and 2017 (May 1 to October 16) open-water periods. Horizontal dotted lines demarcate zones.

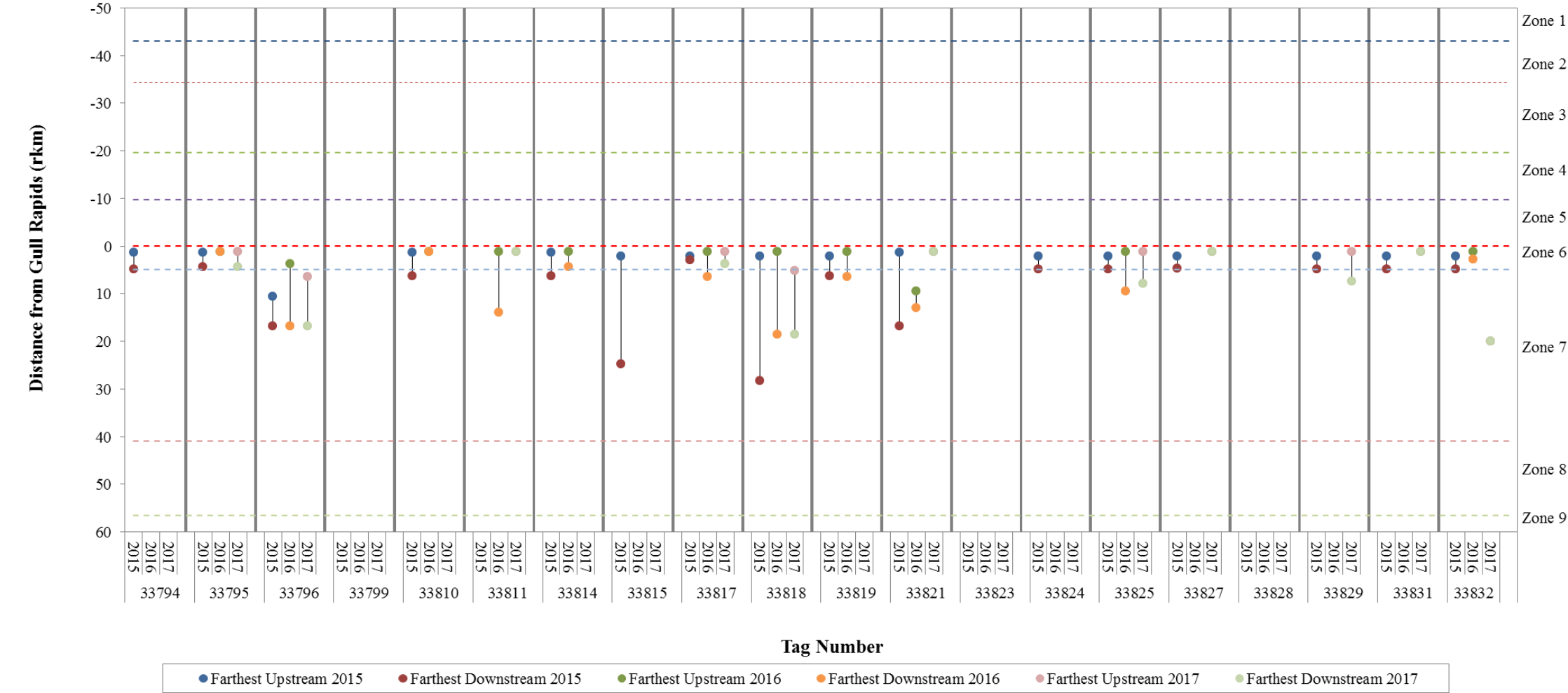
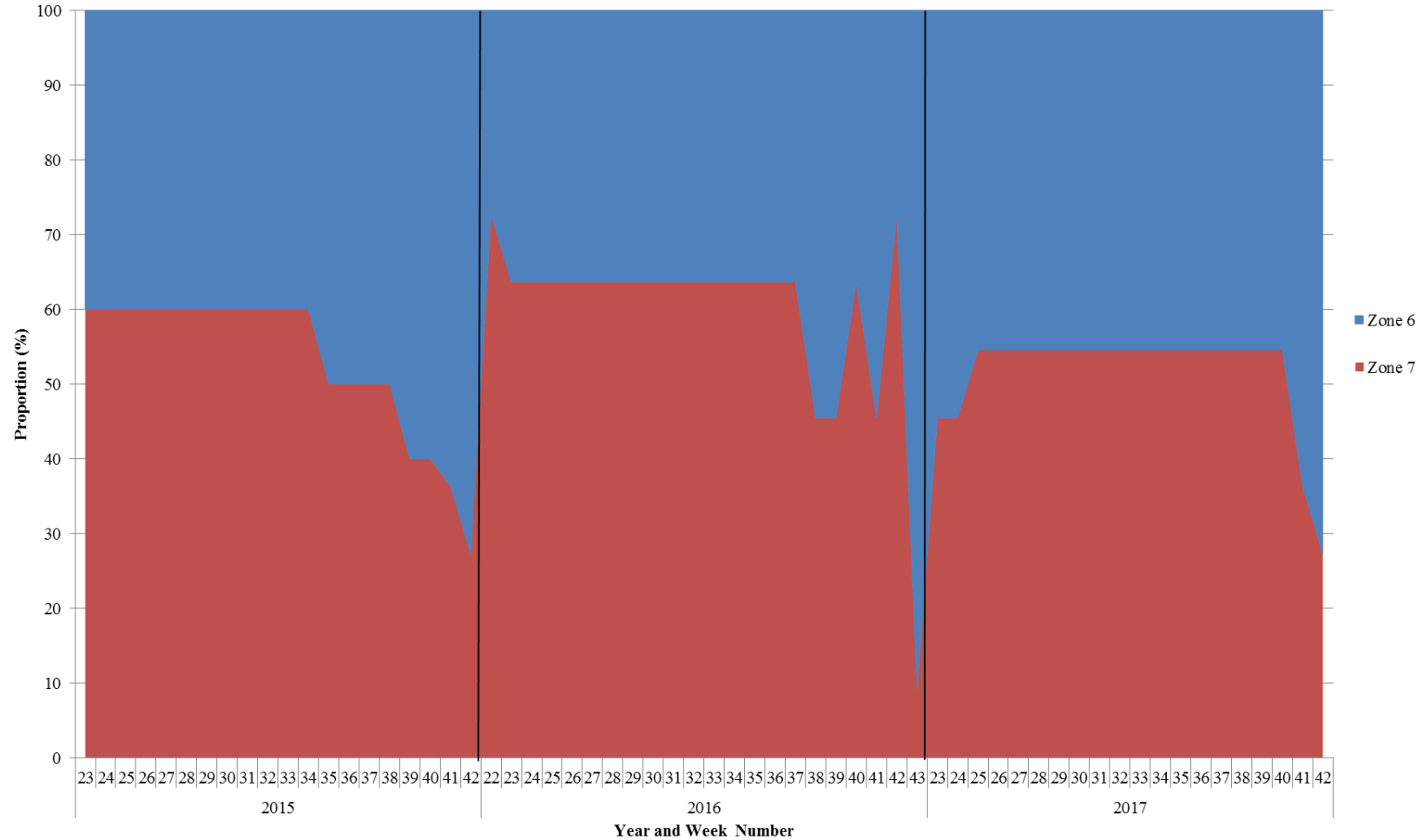
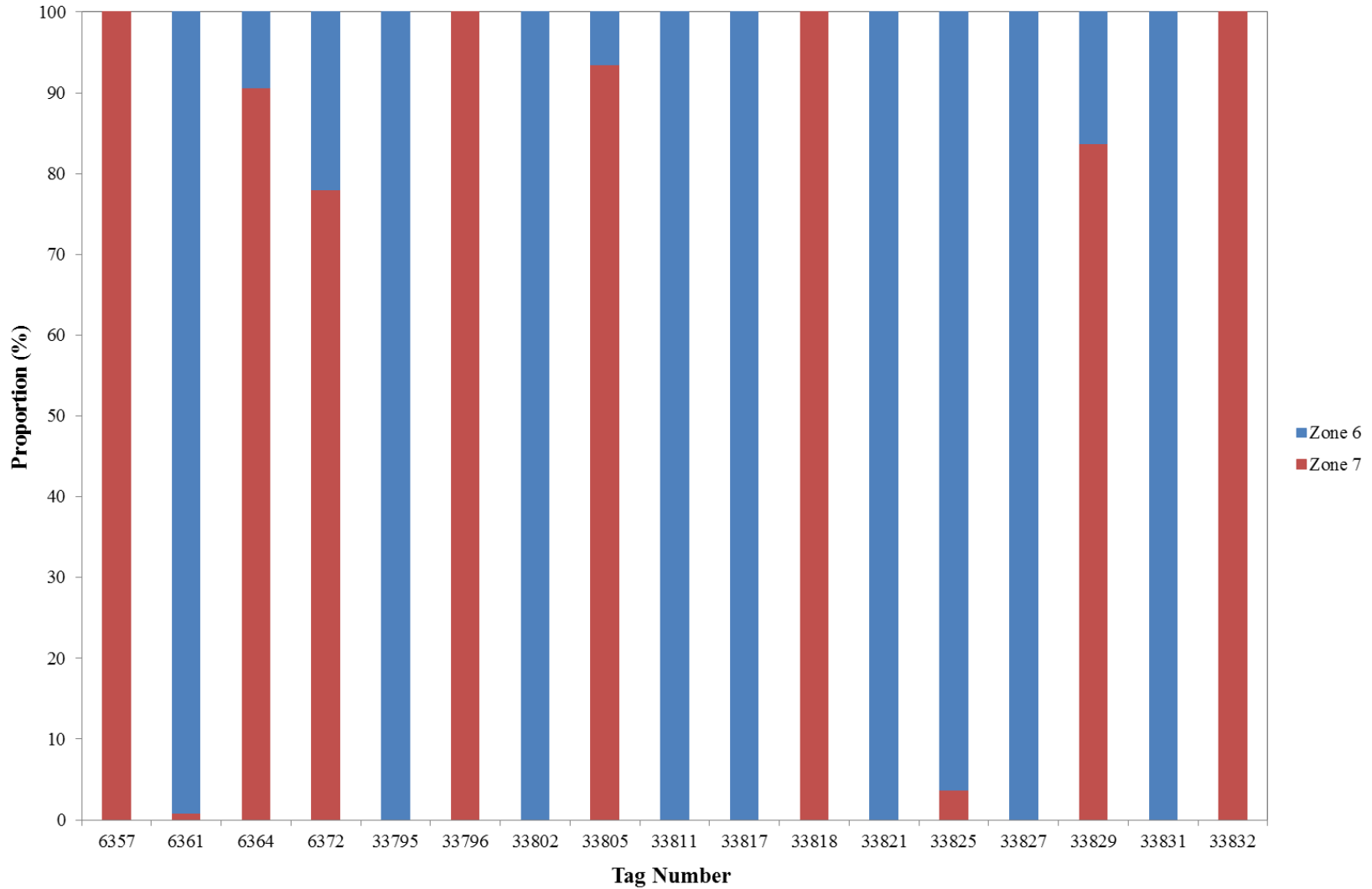


Figure 12: Detection ranges for individual Lake Whitefish (n = 40) tagged with acoustic transmitters in Stephens Lake during the 2015 (June 4 to October 11), 2016 (May 1 to October 19), and 2017 (May 1 to October 16) open-water periods. Horizontal dotted lines demarcate zones (continued).

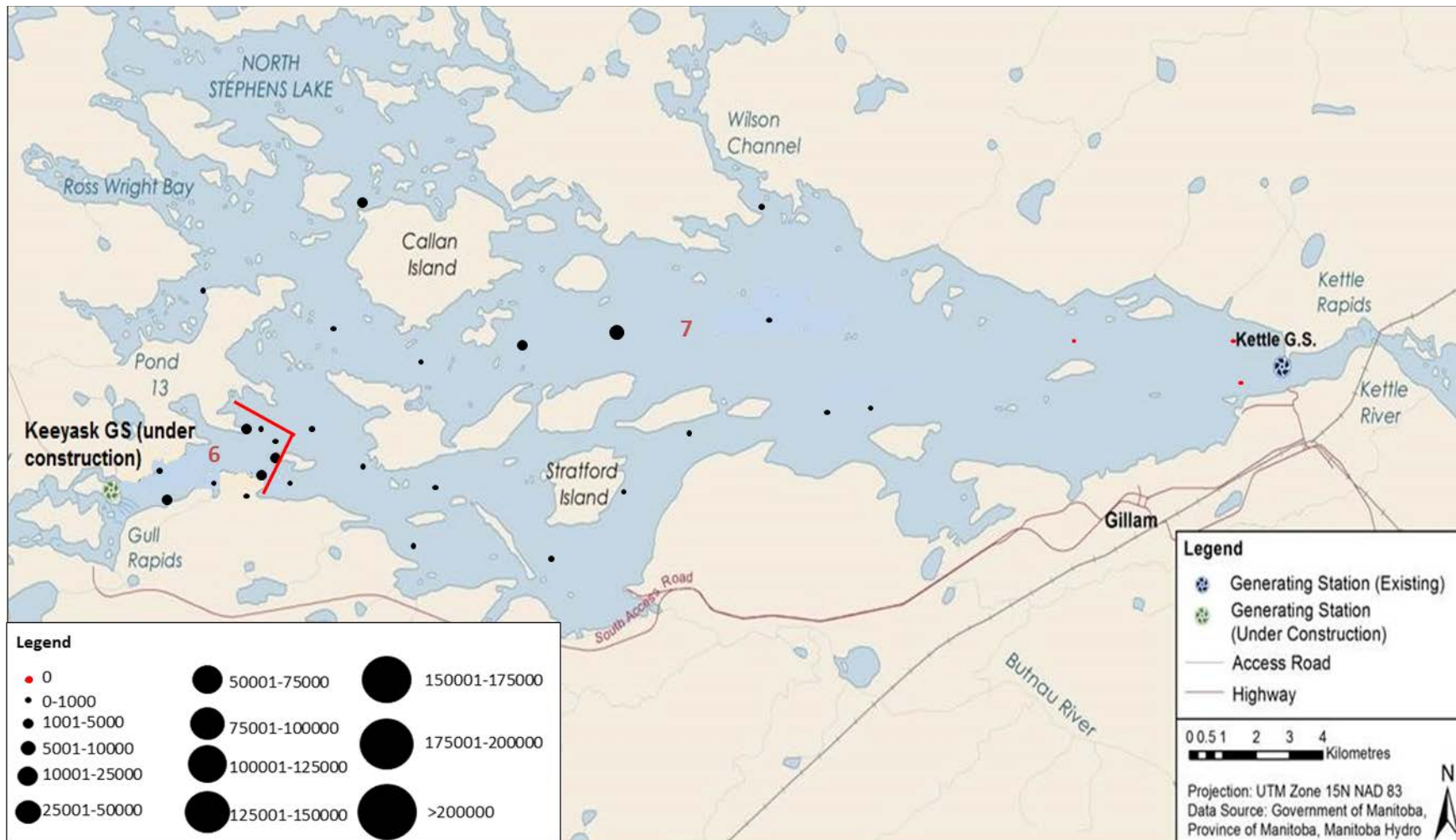


**Figure 13:** Proportional distribution of acoustic-tagged Lake Whitefish downstream of Gull Rapids during a portion of the 2015 (June 4 to October 11), 2016 (June 4 to October 19), and 2017 (June 7 to October 16) open-water periods.



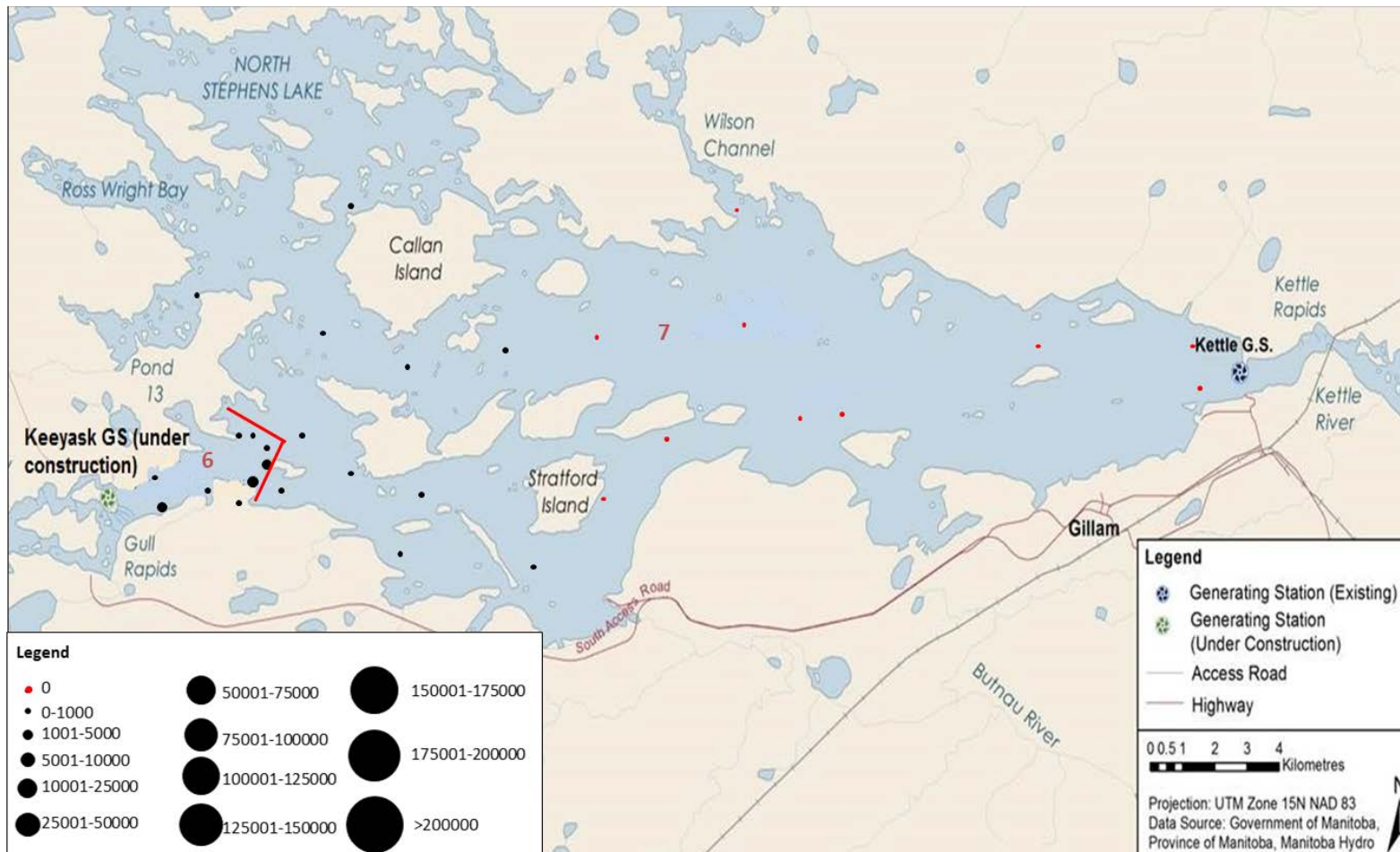
**Figure 14: Proportion of time spent in Stephens Lake between Gull Rapids and the Kettle GS by individual acoustic-tagged Lake Whitefish during the 2017 open-water period (June 7 to October 16).**





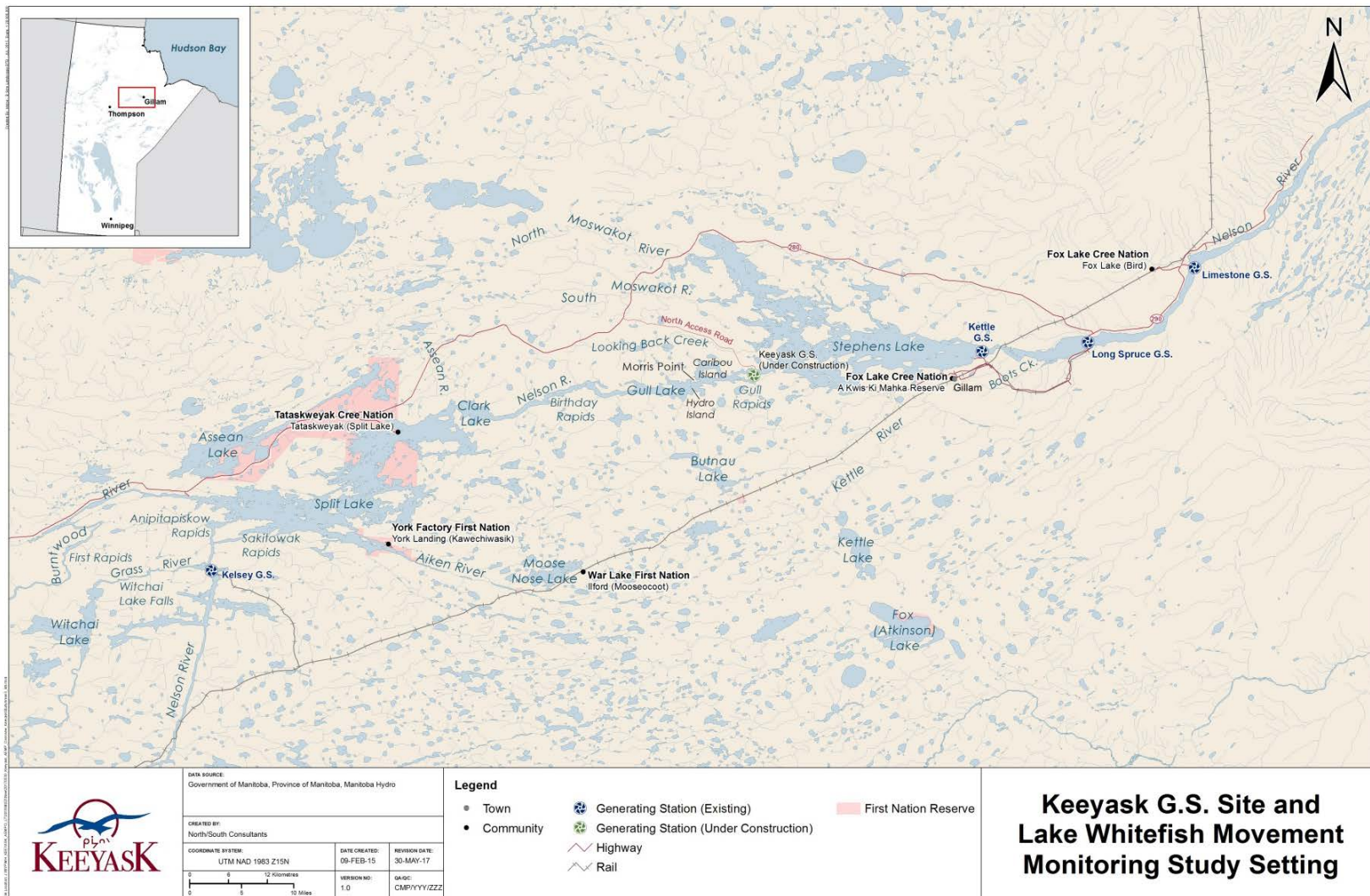
**Figure 15:** Relative number of detections at each acoustic receiver set in Stephens Lake during the 2017 open-water period (May 1 to October 16). Relative number of detections indicated by size of bubble. Receivers with no detections indicated with red dot. The river is divided into two "zones" based on placement of receiver "gates."





**Figure 16:** Relative number of detections at each acoustic receiver set in Stephens Lake during the 2017 spawning period (September 25 to October 16). Dates selected based on water temperatures (less than 12°C) in order to capture movement of Lake Whitefish to spawning sites. Relative number of detections indicated by size of bubble. Receivers with no detections indicated with red dot. The river is divided into two "zones" based on placement of receiver "gates."

## MAPS

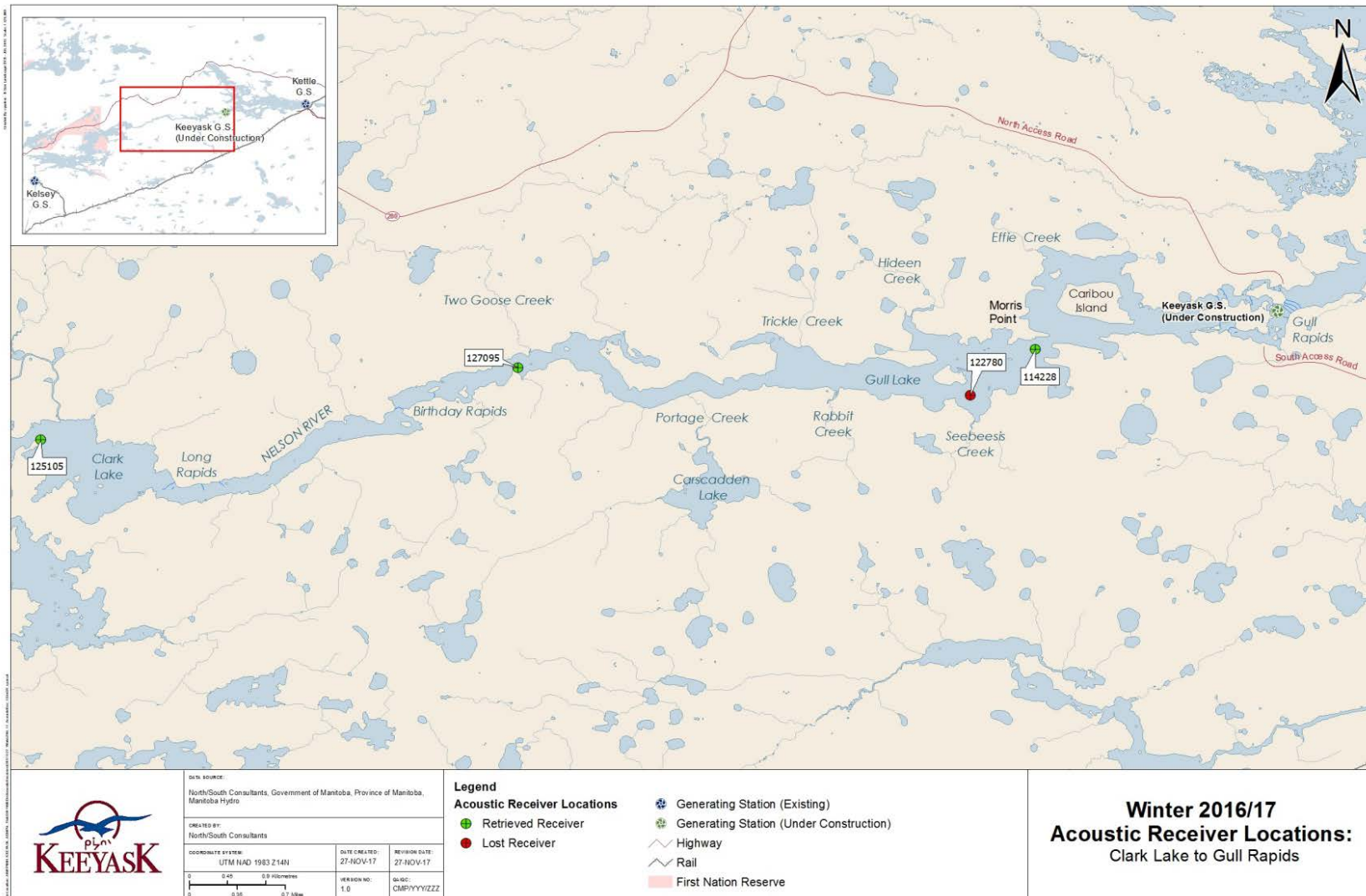


**Map 1:** Map of the Nelson River showing the site of the Keeyask Generating Station and the Lake Whitefish movement monitoring study setting.



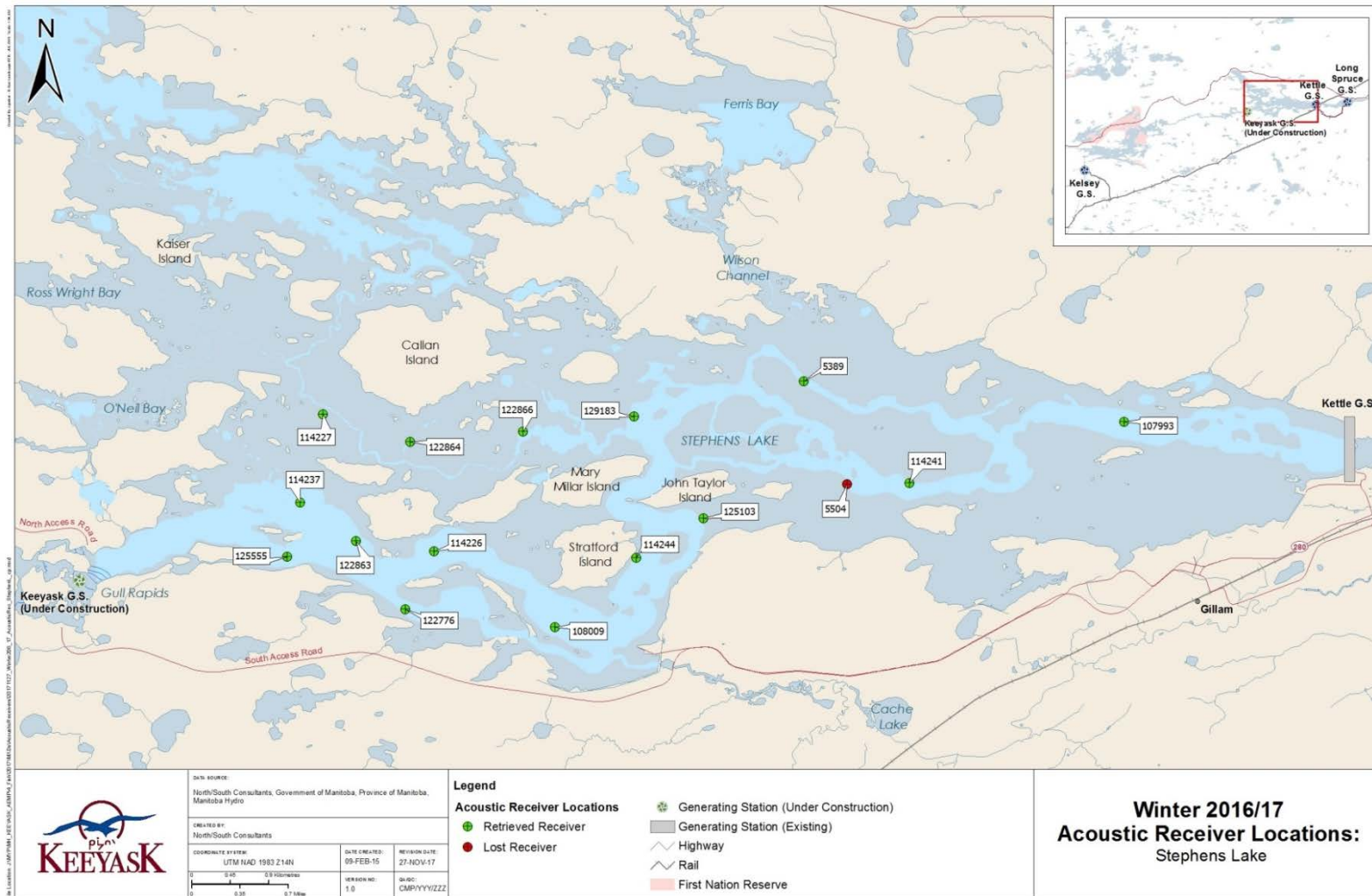


**Map 2:** Map of instream structures at the Keeyask Generating Station site, September 2017.

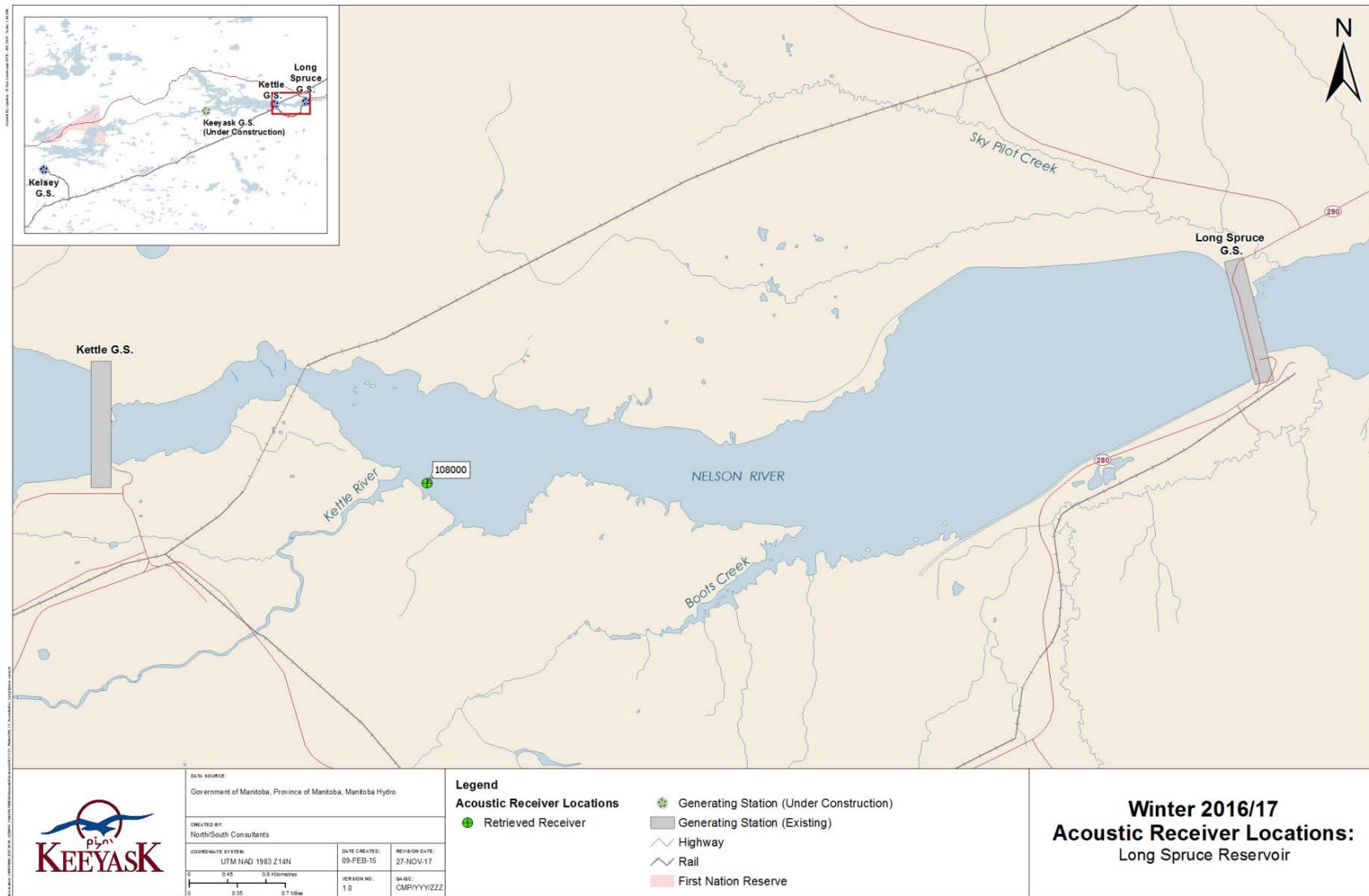


**Map 3: Location of stationary receivers set in the Nelson River from Clark Lake to Gull Rapids between October 2016 and June 2017.**



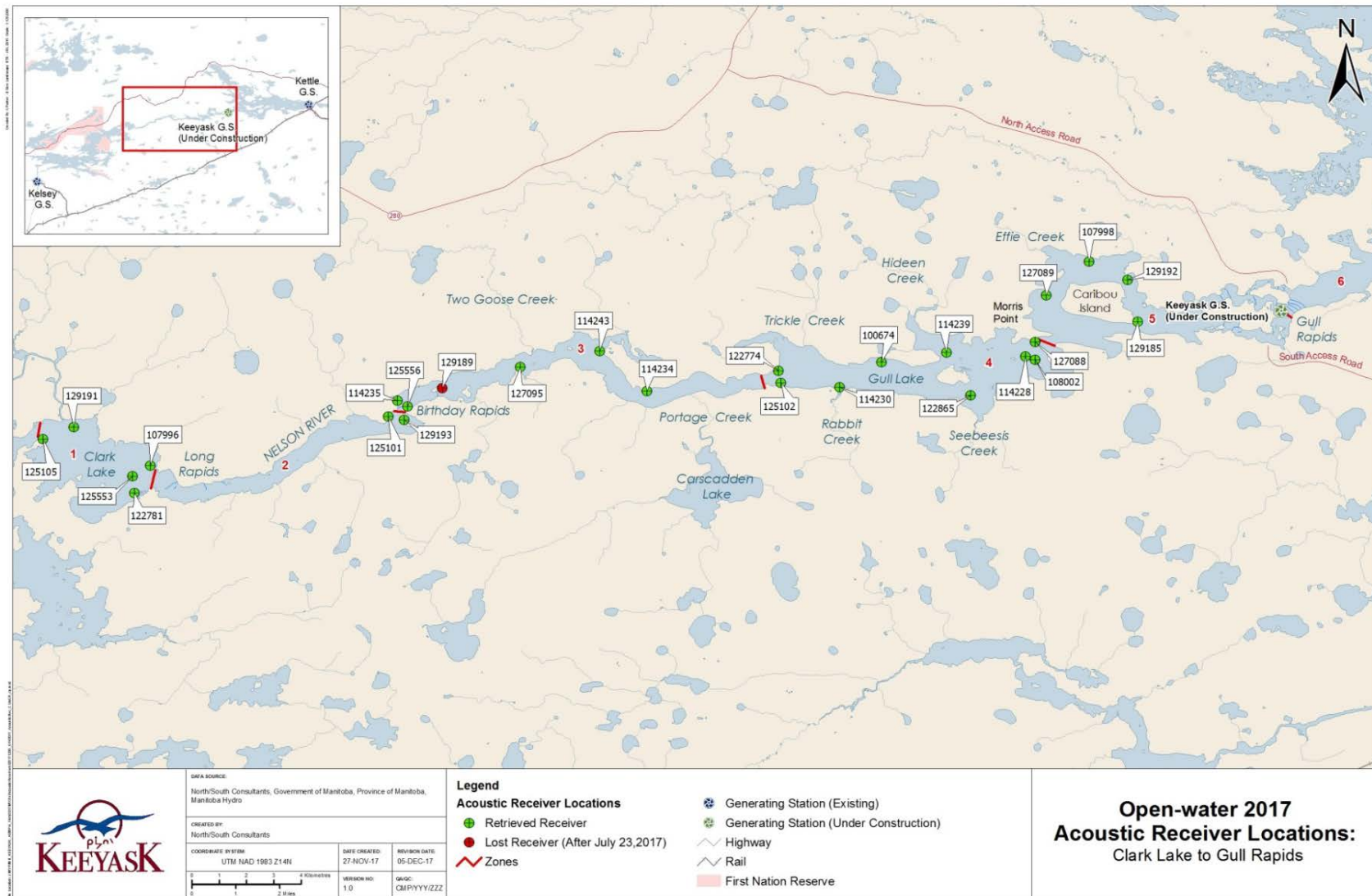


**Map 4:** Location of stationary receivers set in Stephens Lake from Gull Rapids to Kettle GS between October 2016 and June 2017. The former (pre-impoundment) river channel is shown in light blue.

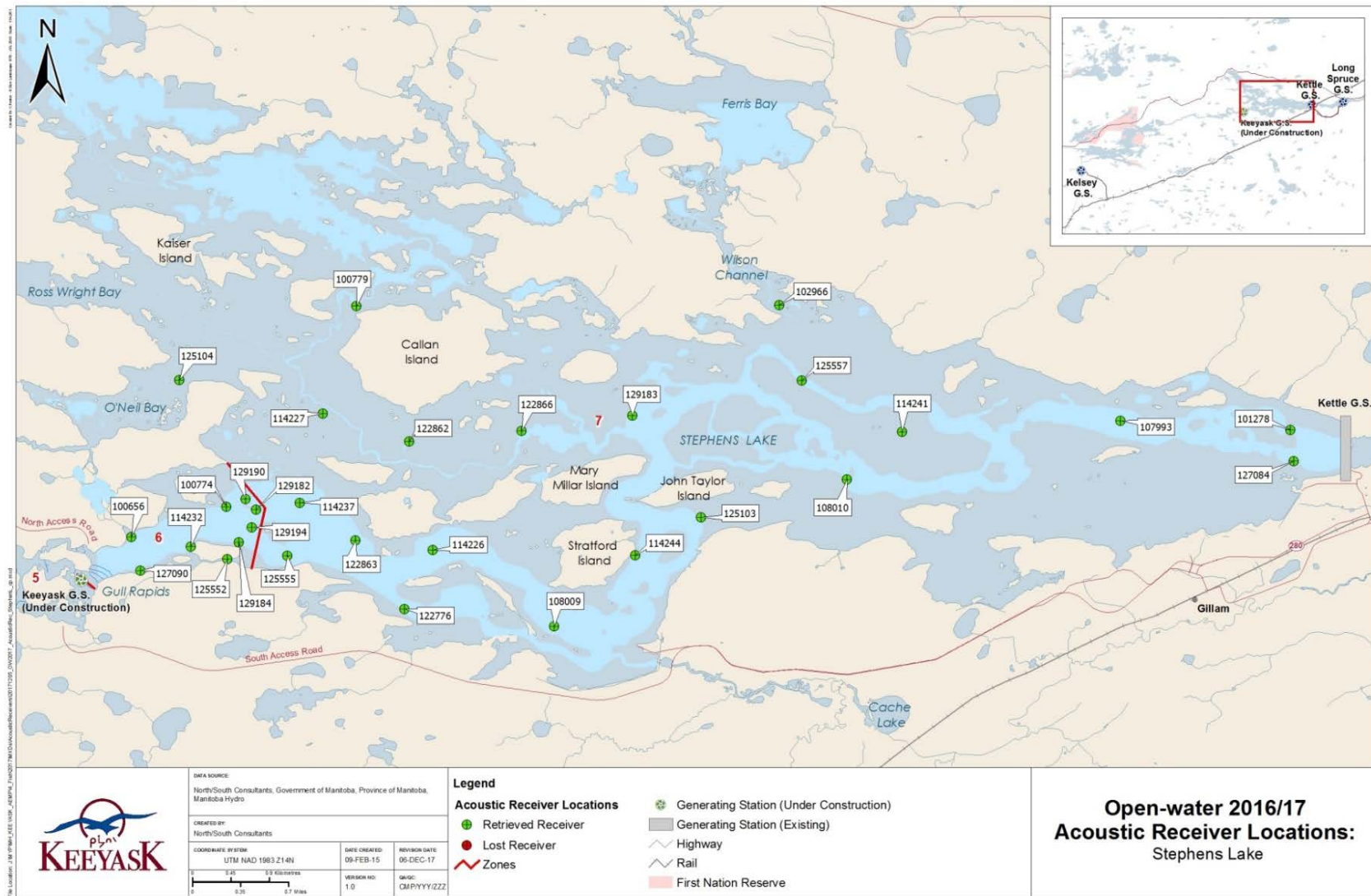


**Map 5: Location of the stationary receiver set in the Long Spruce reservoir between October 2016 and June 2017.**

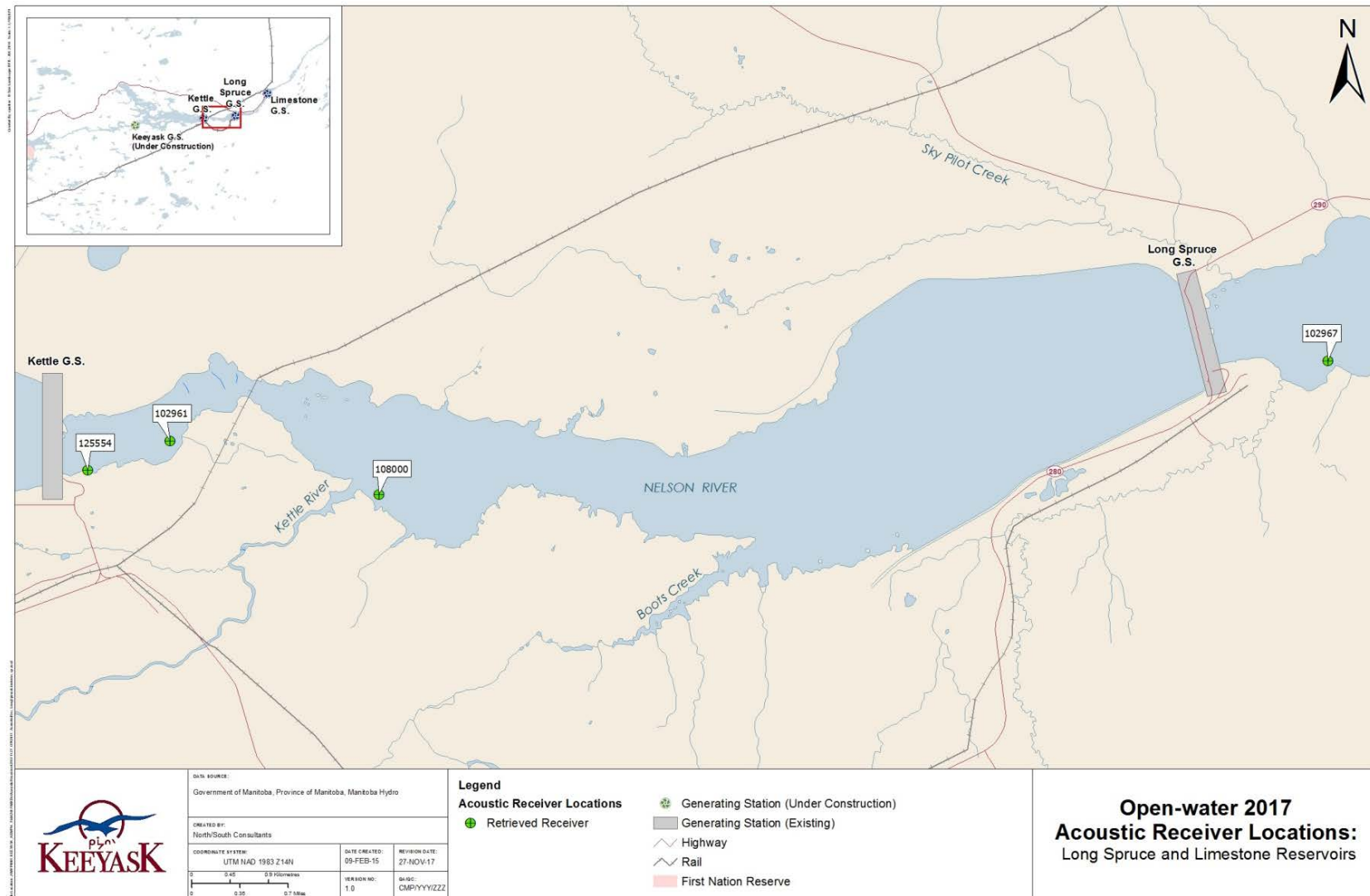




**Map 6:** Locations of stationary receivers set in the Nelson River from Clark Lake to Gull Rapids between June and October 2016. The river is divided into five "zones" based on placement of receiver "gates."



**Map 7:** Locations of stationary receivers set in Stephens Lake between June and October 2017. The river is divided into two "zones" based on placement of receiver "gates." The pre-impoundment river channel is shown in light blue.



**Map 8:** Locations of stationary receivers set in the Long Spruce reservoir (Zone 8) and the Limestone reservoir (Zone 9) between June and October 2017.

# APPENDICES



# APPENDIX 1:

## DETECTION SUMMARIES FOR LAKE WHITEFISH TAGGED AND MONITORED IN THE KEEYASK STUDY AREA BETWEEN 2014 AND 2017.

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Table A1-1:	Number of detections (n), number of days detected, farthest upstream (U/S) and downstream (D/S) river kilometre (rkm) detection sites, and detection range for Lake Whitefish tagged upstream of Gull Rapids during the 2014/15 (October 15 to April 30), 2015/16 (October 12 to April 30), and 2016/2017 (October 19 to April 30) winter periods. ....	58
Table A1-2:	Number of detections (n), number of days detected, farthest upstream (U/S) and downstream (D/S) river kilometre (rkm) detection sites, and detection range for Lake Whitefish tagged in Stephens Lake downstream of Gull Rapids during the 2014/15 (October 15, 2014 to April 30, 2015), and 2015/16 (October 12, 2015 to April 30, 2016) winter periods. ....	59
Table A1-3:	Number of detections (n), number of days detected, farthest upstream (U/S) and downstream (D/S) river kilometre (rkm) detection sites, and detection range for Lake Whitefish tagged upstream of Gull Rapids during the 2015 (June 4 to October 11), 2016 (May 1 to October 19), and 2017 (May 1 to October 16) open-water periods. ....	61
Table A1-4:	Number of detections (n), number of days detected, farthest upstream (U/S) and downstream (D/S) river kilometre (rkm) detection sites, and detection range for Lake Whitefish tagged in Stephens Lake downstream of Gull Rapids during the 2015 (June 4 to October 11) and 2016 (May 1 to October 19) open-water periods.....	62

**Table A1-1: Number of detections (n), number of days detected, farthest upstream (U/S) and downstream (D/S) river kilometre (rkm) detection sites, and detection range for Lake Whitefish tagged upstream of Gull Rapids during the 2014/15 (October 15 to April 30), 2015/16 (October 12 to April 30), and 2016/2017 (October 19 to April 30) winter periods. Movements of fish not detected since tagging in fall 2014 are highlighted in green, those considered lost or dead are highlighted in red and fish that moved downstream through Gull Rapids are highlighted in blue.**

Tag ID	Date Tagged	Winter 2014/2015					Winter 2015/2016					Winter 2016/2017				
		n	# days	U/S (rkm)	D/S (rkm)	Range (rkm)	n	# days	U/S (rkm)	D/S (rkm)	Range (rkm)	n	# days	U/S (rkm)	D/S (rkm)	Range (rkm)
33793	8-Oct-14	0	-	-	-	-	95	2	-33.8	-33.8	0.0	0	-	-	-	-
33797	8-Oct-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
33798	8-Oct-14	37	1	-12.9	-12.9	0.0	34	3	-29.4	-12.9	16.5	4	1	-29.4	-29.4	0.0
33800	8-Oct-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
33801	8-Oct-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
33802	8-Oct-14	137	2	-12.9	-12.9	0.0	0	-	-	-	-	0	-	-	-	-
33803	8-Oct-14	0	-	-	-	-	74	2	-33.8	-29.4	4.4	4	1	-48.2	-48.2	0.0
33804	8-Oct-14	0	-	-	-	-	0	-	-	-	-	2	1	-29.4	-29.4	0.0
33805	8-Oct-14	902	13	-12.9	-7.5	5.4	0	-	-	-	-	10	1	5.8	5.8	0.0
33806	8-Oct-14	208	7	-12.9	-12.9	0.0	994	23	-33.8	-29.4	4.4	2255	32	-29.4	-29.4	0.0
33807	8-Oct-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
33808	8-Oct-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
33809	8-Oct-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
33812	8-Oct-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
33813	8-Oct-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
33816	8-Oct-14	8	1	-12.9	-12.9	0.0	24	4	-48.2	-12.9	35.3	11	3	-48.2	-48.2	0.0
33820	8-Oct-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
33822	7-Oct-14	43	2	-12.9	-12.9	0.0	0	-	-	-	-	433	3	-29.4	-29.4	0.0
33826	7-Oct-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
33830	7-Oct-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-

**Table A1-2: Number of detections (n), number of days detected, farthest upstream (U/S) and downstream (D/S) river kilometre (rkm) detection sites, and detection range for Lake Whitefish tagged in Stephens Lake downstream of Gull Rapids during the 2014/15 (October 15, 2014 to April 30, 2015), and 2015/16 (October 12, 2015 to April 30, 2016) winter periods. Movements of fish not detected since tagging in fall 2014 are highlighted in green and those considered lost or dead are highlighted in red.**

Tag ID	Date Tagged	Winter 2014/2015					Winter 2015/2016					Winter 2016/2017				
		n	# days	U/S (rkm)	D/S (rkm)	Range (rkm)	n	# days	U/S (rkm)	D/S (rkm)	Range (rkm)	n	# days	U/S (rkm)	D/S (rkm)	Range (rkm)
6357	30-Sep-14	21618	139	7.9	16.8	8.9	18168	108	7.7	21.0	13.3	36115	155	6.5	18.6	12.1
6358	30-Sep-14	56	3	10.2	10.2	0.0	103	4	7.7	10.2	2.5	36	1	5.2	9.4	4.2
6359	30-Sep-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
6360	30-Sep-14	132	2	7.7	16.8	9.1	0	-	-	-	-	0	-	-	-	-
6361	30-Sep-14	0	-	-	-	-	6	2	7.9	7.9	0.0	0	-	-	-	-
6362	30-Sep-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
6363	30-Sep-14	153	10	7.7	7.9	0.2	0	-	-	-	-	0	-	-	-	-
6364	30-Sep-14	994	22	7.7	14.9	7.2	264	12	7.7	7.9	0.2	2035	22	5.2	7.9	2.7
6365	30-Sep-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
6366	30-Sep-14	37	1	7.9	16.8	8.9	0	-	-	-	-	0	-	-	-	-
6367	25-Sep-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
6368	25-Sep-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
6369	30-Sep-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
6370	30-Sep-14	3514	42	7.7	37.8	30.1	0	-	-	-	-	0	-	-	-	-
6371	30-Sep-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
6372	25-Sep-14	590	7	7.7	16.8	9.1	88	2	7.7	21.0	13.3	110	5	5.2	6.5	1.3
6373	25-Sep-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
6374	25-Sep-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
6375	25-Sep-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
6376	25-Sep-14	29858	153	7.9	13.4	5.5	19163	68	7.9	13.4	5.5	0	-	-	-	-



Table A1-2: Continued.

Tag ID	Date Tagged	Winter 2014/2015					Winter 2015/2016					Winter 2016/2017				
		n	# days	U/S (rkm)	D/S (rkm)	Range (rkm)	n	# days	U/S (rkm)	D/S (rkm)	Range (rkm)	n	# days	U/S (rkm)	D/S (rkm)	Range (rkm)
33794	30-Sep-14	703	9	7.7	10.5	2.8	101	8	7.7	13.4	5.7	0	-	-	-	-
33795	30-Sep-14	501	4	7.9	7.9	0.0	0	-	-	-	-	0	-	-	-	-
33796	30-Sep-14	8573	59	7.7	16.8	9.1	20	3	7.9	7.9	0.0	10214	80	6.5	16.8	10.3
33799	30-Sep-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
33810	30-Sep-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
33811	30-Sep-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
33814	30-Sep-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
33815	30-Sep-14	5238	33	7.7	13.4	5.7	0	-	-	-	-	0	-	-	-	-
33817	30-Sep-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
33818	30-Sep-14	9928	65	7.7	18.7	11.0	6869	100	7.7	21.0	13.3	3966	85	5.2	16.8	11.6
33819	30-Sep-14	302	6	7.7	40.8	33.1	0	-	-	-	-	0	-	-	-	-
33821	4-Oct-14	23628	119	7.7	10.5	2.8	1170	18	7.7	7.9	0.2	143	5	13.0	16.8	3.8
33823	4-Oct-14	15	2	7.7	7.7	0.0	0	-	-	-	-	0	-	-	-	-
33824	4-Oct-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
33825	4-Oct-14	0	-	-	-	-	5	1	7.9	7.9	0.0	0	-	-	-	-
33827	4-Oct-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
33828	4-Oct-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
33829	4-Oct-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
33831	4-Oct-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
33832	4-Oct-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-

**Table A1-3: Number of detections (n), number of days detected, farthest upstream (U/S) and downstream (D/S) river kilometre (rkm) detection sites, and detection range for Lake Whitefish tagged upstream of Gull Rapids during the 2015 (June 4 to October 11), 2016 (May 1 to October 19), and 2017 (May 1 to October 16) open-water periods. Movements of fish not detected since tagging in fall 2014 are highlighted in green, those considered lost or dead are highlighted in red, and fish that moved downstream through Gull Rapids are highlighted in blue.**

Tag ID	Date tagged	Open-water 2015					Open-water 2016					Open-water 2017				
		n	# days	U/S (rkm)	D/S (rkm)	Range (rkm)	n	# days	U/S (rkm)	D/S (rkm)	Range (rkm)	n	# days	U/S (rkm)	D/S (rkm)	Range (rkm)
33793	8-Oct-14	4121	45	-33.8	-12.9	20.9	68	11	-19.5	-7.4	12.1	0	-	-	-	-
33797	8-Oct-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
33798	8-Oct-14	8810	67	-34.3	-9.5	24.8	3837	65	-33.8	-9.5	24.3	467	35	-33.8	-9.5	24.3
33800	8-Oct-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
33801	8-Oct-14	72	4	-19.5	-17.4	2.1	0	-	-	-	-	0	-	-	-	-
33802	8-Oct-14	0	-	-	-	-	0	-	-	-	-	905	27	3.8	3.8	0.0
33803	8-Oct-14	1462	43	-33.8	-17.4	16.4	873	27	-46.9	-19.4	27.5	1733	40	-33.8	-19.4	14.4
33804	8-Oct-14	3832	60	-29.4	-11.8	17.6	4436	78	-46.9	-12.9	34.0	889	40	-46.9	-12.8	34.1
33805	8-Oct-14	522	12	-11.8	2.9	14.7	407	15	1.2	13.4	12.2	191	26	1.2	20	18.8
33806	8-Oct-14	2839	43	-33.8	-7.4	26.4	2474	44	-33.8	-7.4	26.4	1868	61	-34.3	-5.8	28.5
33807	8-Oct-14	48	4	-33.8	-26.5	7.3	78	4	-46.9	-33.8	13.1	116	18.0	-46.9	-46.9	0.0
33808	8-Oct-14	149	14	-19.5	-17.4	2.1	356	16	-19.5	-19.4	0.1	848	53.0	-33.8	-7.4	26.4
33809	8-Oct-14	2274	30	-33.8	-7.4	26.4	0	-	-	-	-	0	-	-	-	-
33812	8-Oct-14	184	9	-34.3	-19.4	14.9	0	-	-	-	-	0	-	-	-	-
33813	8-Oct-14	4248	50	-26.5	-5.8	20.7	9704	94	-46.9	-5.8	41.1	0	-	-	-	-
33816	8-Oct-14	3743	72	-48.2	-9.3	38.9	189	10	-48.2	-9.9	38.3	44	9	-44.3	-9.3	35.0
33820	8-Oct-14	487	8	-26.5	-26.5	0.0	0	-	-	-	-	0	-	-	-	-
33822	7-Oct-14	4656	68	-19.5	-11.8	7.7	7784	106	-33.8	-11.8	22.0	3441	71	-48.2	-11.9	36.3
33826	7-Oct-14	276	14	-33.8	-9.0	24.8	824	39	-34.3	-7.4	26.9	0	-	-	-	-
33830	7-Oct-14	573	22	-26.5	-26.5	0.0	106	5	-34.3	-29.4	4.9	15	5	-46.9	-26.5	20.4

**Table A1-4: Number of detections (n), number of days detected, farthest upstream (U/S) and downstream (D/S) river kilometre (rkm) detection sites, and detection range for Lake Whitefish tagged in Stephens Lake downstream of Gull Rapids during the 2015 (June 4 to October 11) and 2016 (May 1 to October 19) open-water periods. Movements of fish not detected since tagging in fall 2014 are highlighted in green and those considered lost or dead are highlighted in red.**

Tag ID	Date tagged	Open-water 2015					Open-water 2016					Open-water 2017				
		n	# days	U/S (rkm)	D/S (rkm)	Range (rkm)	n	# days	U/S (rkm)	D/S (rkm)	Range (rkm)	n	# days	U/S (rkm)	D/S (rkm)	Range (rkm)
6357	30-Sep-14	11658	30	7.9	19.0	11.1	4717	45	1.2	21.0	19.8	9071	57	5.2	18.6	13.4
6358	30-Sep-14	297	5	2.2	16.8	14.6	133	8	1.2	13.0	11.8	0	-	-	-	-
6359	30-Sep-14	1278	17	2.2	6.2	4.0	0	-	-	-	-	0	-	-	-	-
6360	30-Sep-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
6361	30-Sep-14	606	8	1.3	4.9	3.6	191	7	1.2	9.4	8.2	1450	37	1.2	7.4	6.2
6362	30-Sep-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
6363	30-Sep-14	685	16	3.6	3.6	0.0	0	-	-	-	-	0	-	-	-	-
6364	30-Sep-14	5070	13	1.3	7.9	6.6	1461	11	3.8	13.9	10.1	7394	92	3.8	10.3	6.5
6365	30-Sep-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
6366	30-Sep-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
6367	25-Sep-14	148	4	2.2	5.8	3.6	0	-	-	-	-	0	-	-	-	-
6368	25-Sep-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
6369	30-Sep-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
6370	30-Sep-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
6371	30-Sep-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
6372	25-Sep-14	1210	15	1.3	10.5	9.2	2291	40	1.2	20.0	18.8	1956	75	2.6	24.7	22.1
6373	25-Sep-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
6374	25-Sep-14	165	9	2.2	7.9	5.7	0	-	-	-	-	0	-	-	-	-
6375	25-Sep-14	1034	10	1.3	7.9	6.6	376	13	1.2	6.5	5.3	0	-	-	-	-
6376	25-Sep-14	1477	20	10.5	16.8	6.3	49	1	13.0	13.0	0.0	0	-	-	-	-
33794	30-Sep-14	1804	17	1.3	4.9	3.6	0	-	-	-	-	0	-	-	-	-
33795	30-Sep-14	498	6	1.3	4.4	3.1	15	2	1.2	1.2	0.0	25	4	1.2	4.3	3.1

Table A1-4: Continued.

Tag ID	Date tagged	Open-water 2015					Open-water 2016					Open-water 2017				
		n	# days	U/S (rkm)	D/S (rkm)	Range (rkm)	n	# days	U/S (rkm)	D/S (rkm)	Range (rkm)	n	# days	U/S (rkm)	D/S (rkm)	Range (rkm)
33796	30-Sep-14	882	8	10.5	16.8	6.3	1167	18	3.8	16.8	13.0	2845	70	6.5	16.8	10.3
33799	30-Sep-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
33810	30-Sep-14	334	10	1.3	6.2	4.9	2	1	1.2	1.2	0.0	0	-	-	-	-
33811	30-Sep-14	0	-	-	-	-	46	4	1.2	13.9	12.7	23	3	1.2	1.2	0.0
33814	30-Sep-14	85	5	1.3	6.2	4.9	34	4	1.2	4.3	3.1	0	-	-	-	-
33815	30-Sep-14	4974	38	2.2	24.7	22.5	0	-	-	-	-	0	-	-	-	-
33817	30-Sep-14	98	4	2.2	2.9	0.7	14	3	1.2	6.5	5.3	33	5	1.2	3.8	2.6
33818	30-Sep-14	6568	67	2.2	28.3	26.1	747	44	1.2	18.6	17.4	809	41	5.2	18.6	13.4
33819	30-Sep-14	292	5	2.2	6.2	4.0	69	4	1.2	6.5	5.3	0	-	-	-	-
33821	4-Oct-14	6240	39	1.3	16.8	15.5	13	3	9.4	13.0	3.6	3	1	1.2	1.2	0.0
33823	4-Oct-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
33824	4-Oct-14	701	10	2.2	4.9	2.7	0	-	-	-	-	0	-	-	-	-
33825	4-Oct-14	413	12	2.2	4.9	2.7	34	5	1.2	9.4	8.2	50	11	1.2	7.9	6.7
33827	4-Oct-14	285	7	2.2	4.7	2.5	0	-	-	-	-	2	1	1.2	1.2	0.0
33828	4-Oct-14	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
33829	4-Oct-14	52	2	2.2	4.9	2.7	0	-	-	-	-	161	8	1.2	7.4	6.2
33831	4-Oct-14	227	8	2.2	4.9	2.7	0	-	-	-	-	5	2	1.2	1.2	0.0
33832	4-Oct-14	632	4	2.2	4.9	2.7	15	2	1.2	2.7	1.5	3	1	20.0	20.0	0.0

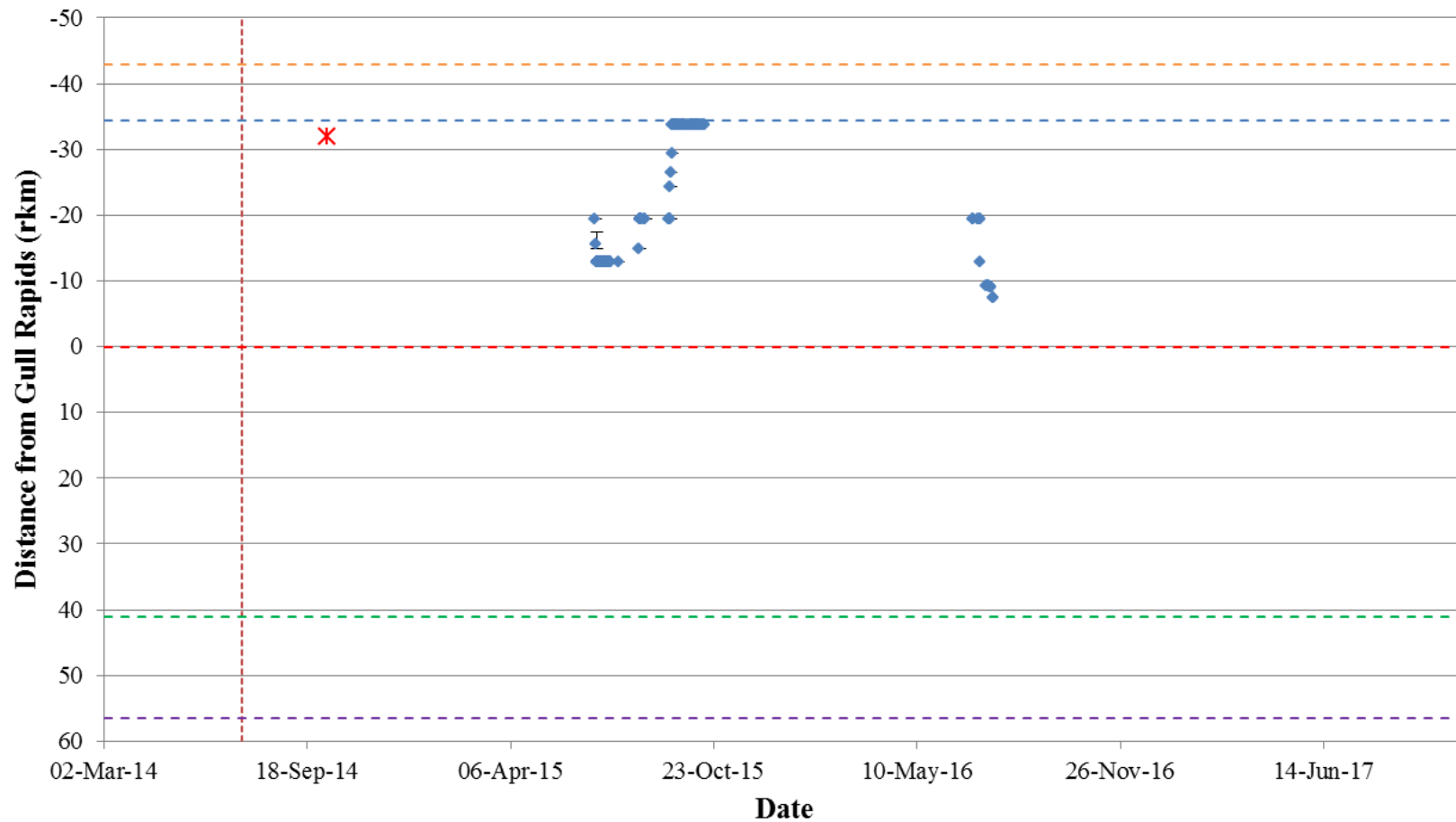
## APPENDIX 2:

# LOCATION SUMMARY FOR INDIVIDUAL ACOUSTIC-TAGGED LAKE WHITEFISH IN GULL LAKE, OCTOBER 2015 TO OCTOBER 2017

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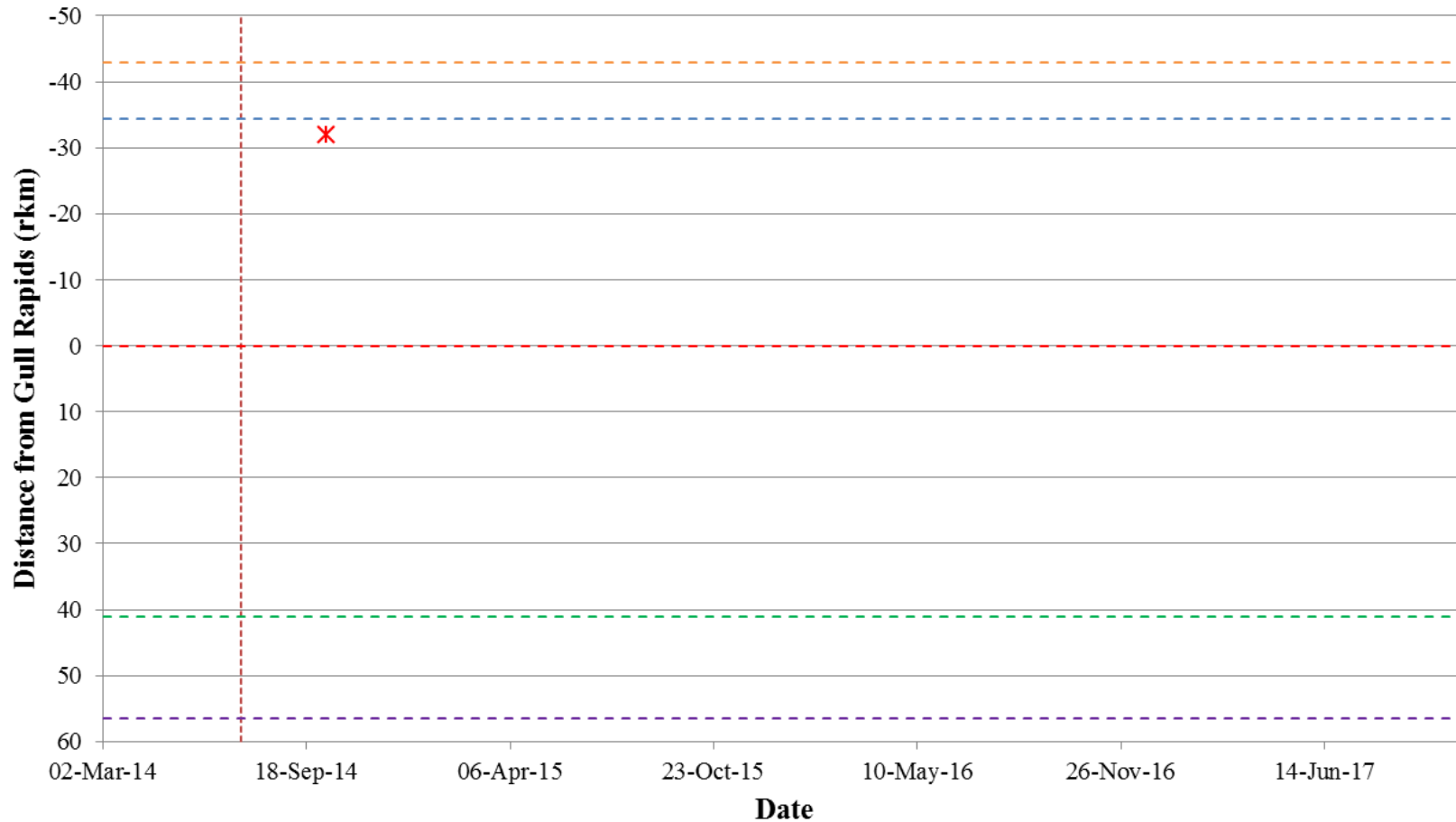
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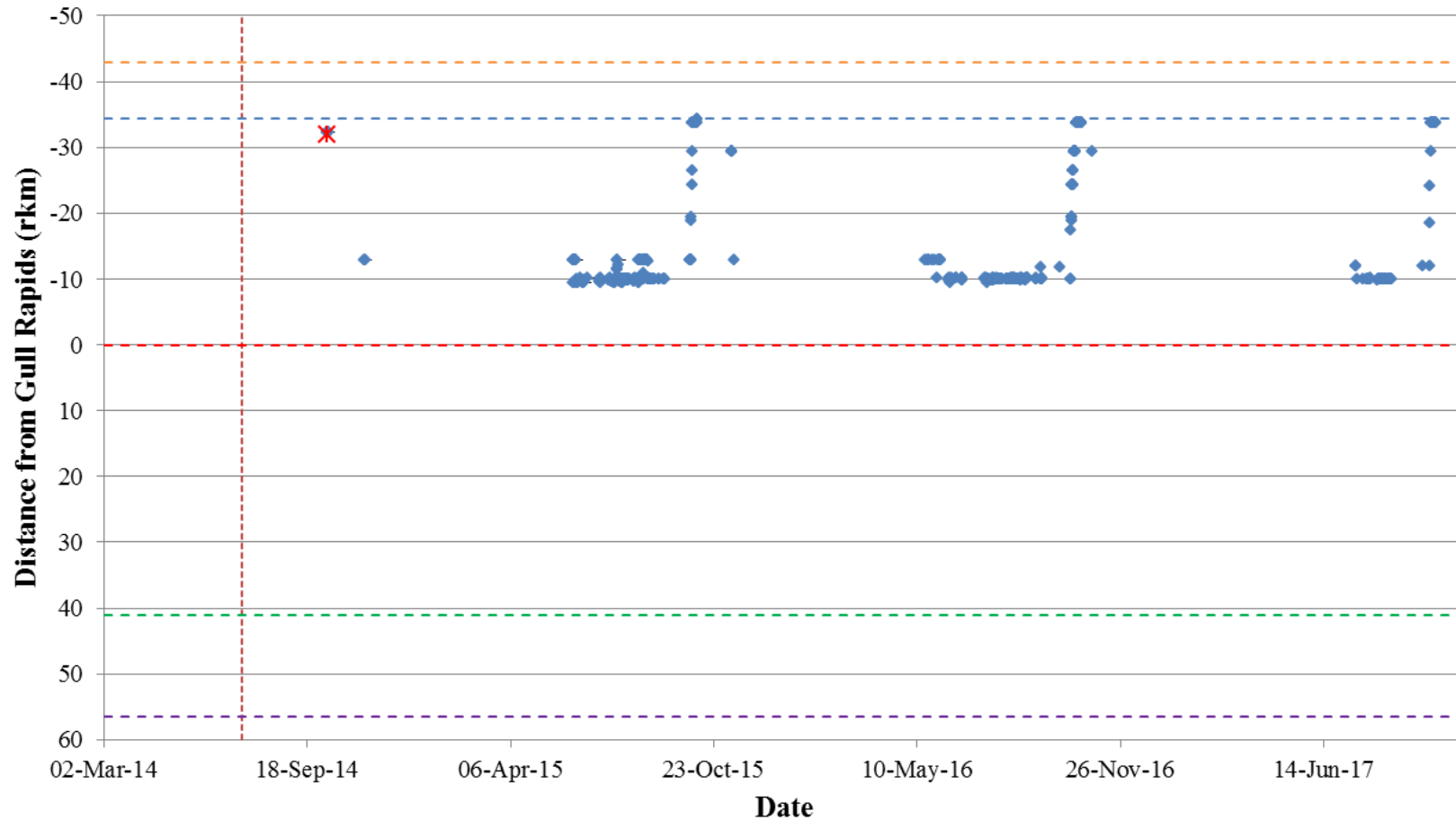


**Figure A2-1: Position of a Lake Whitefish tagged with an acoustic transmitter (code #33793) in the Nelson River between Clark Lake and Gull Rapids, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**

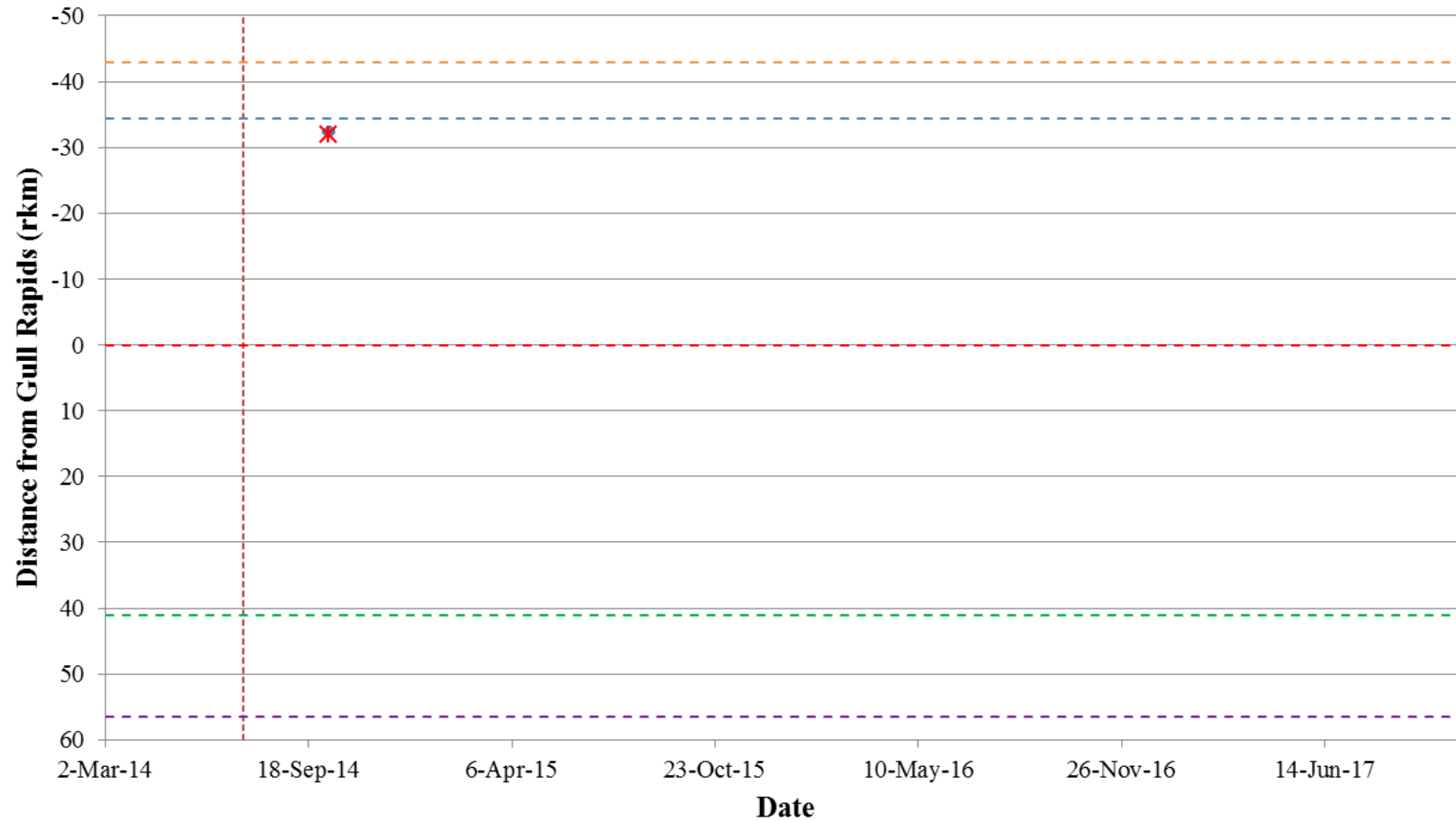




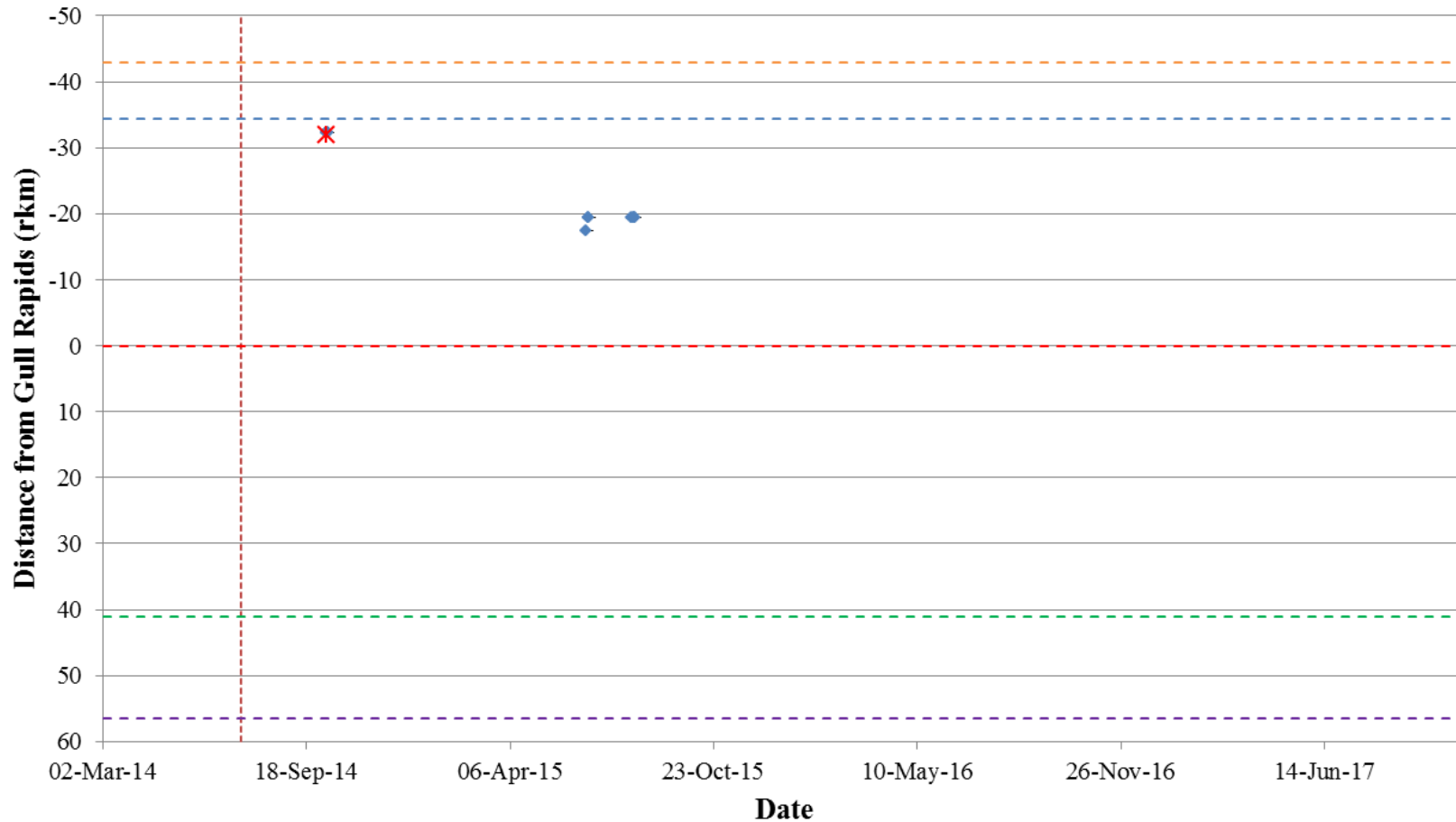
**Figure A2-2: Position of a Lake Whitefish tagged with an acoustic transmitter (code #33797) in the Nelson River between Clark Lake and Gull Rapids, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**



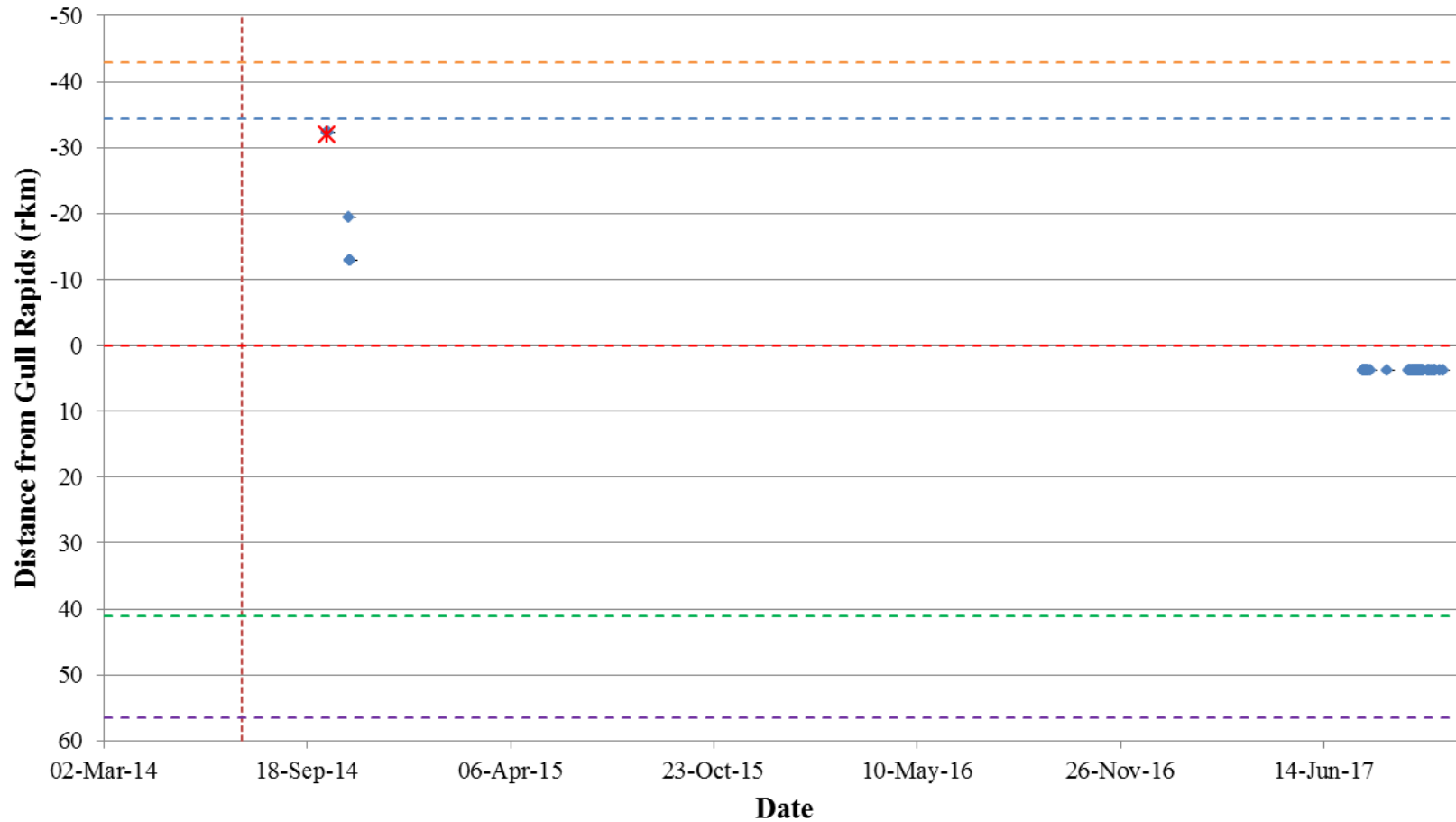
**Figure A2-3: Position of a Lake Whitefish tagged with an acoustic transmitter (code #33798) in the Nelson River between Clark Lake and Gull Rapids, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**



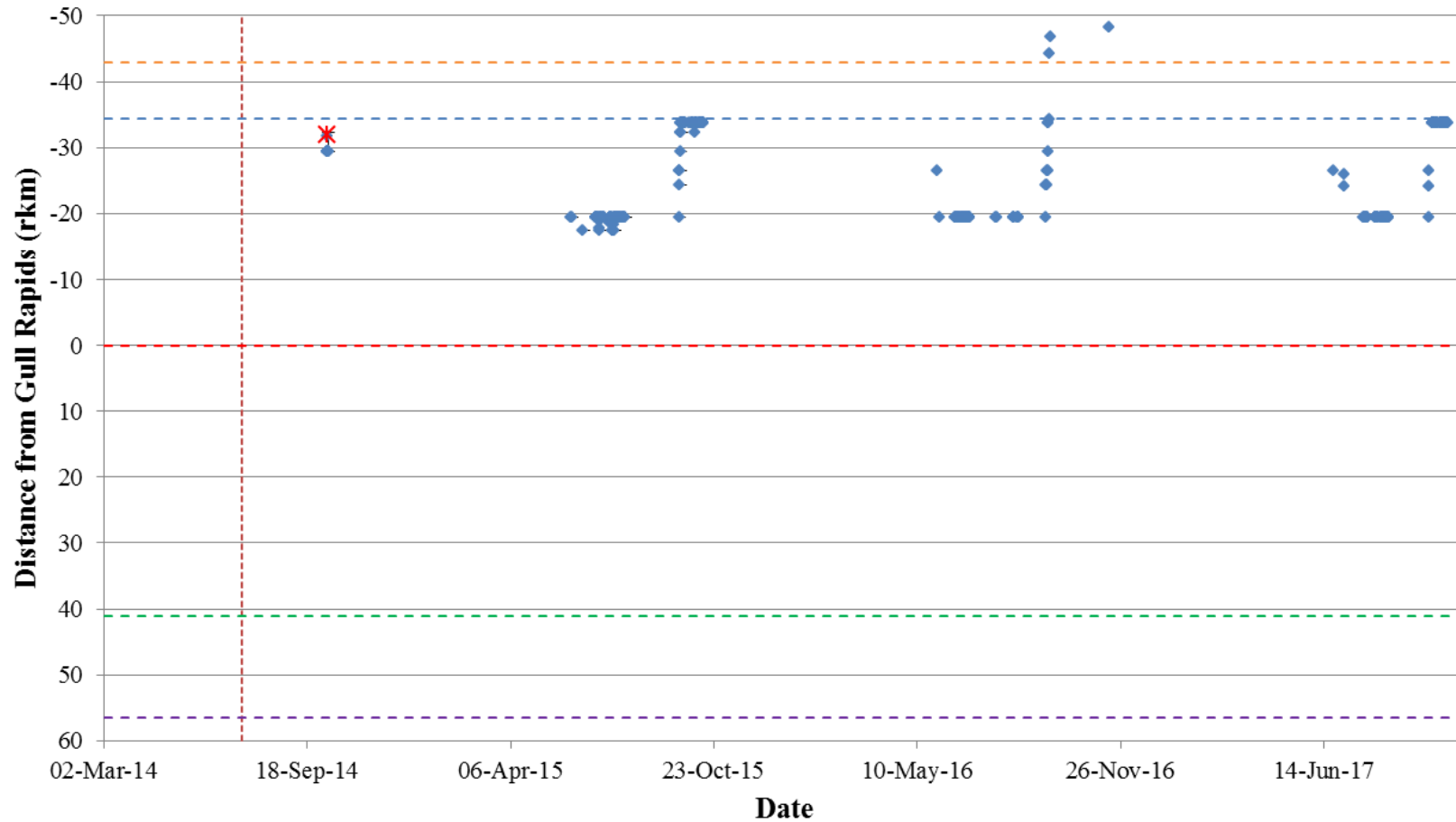
**Figure A2-4: Position of a Lake Whitefish tagged with an acoustic transmitter (code #33800) in the Nelson River between Clark Lake and Gull Rapids, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**



**Figure A2-5: Position of a Lake Whitefish tagged with an acoustic transmitter (code #33801) in the Nelson River between Clark Lake and Gull Rapids, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**

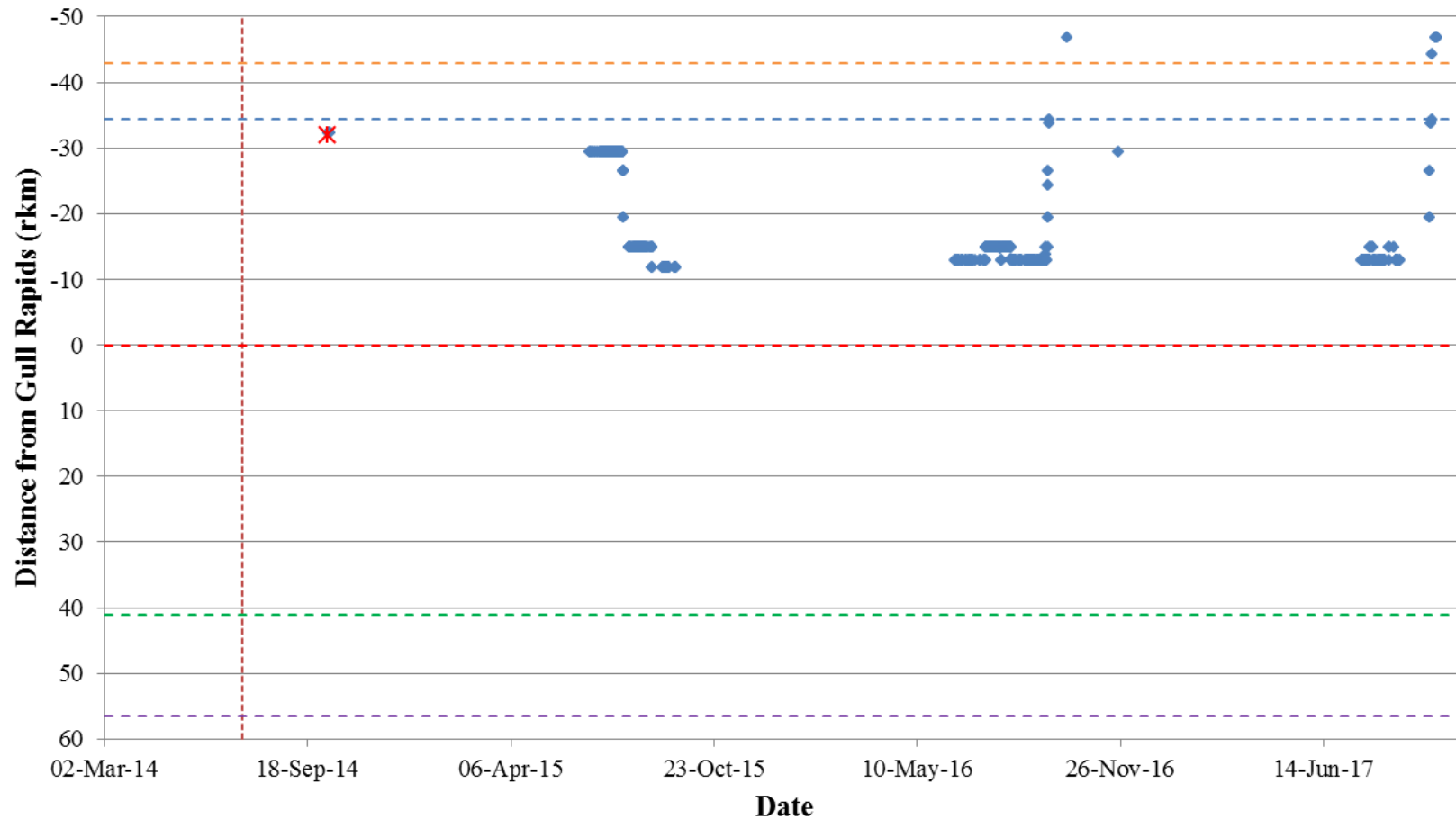


**Figure A2-6: Position of a Lake Whitefish tagged with an acoustic transmitter (code #33802) in the Nelson River between Clark Lake and Gull Rapids, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**



**Figure A2-7: Position of a Lake Whitefish tagged with an acoustic transmitter (code #33803) in the Nelson River between Clark Lake and Gull Rapids, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**





**Figure A2-8: Position of a Lake Whitefish tagged with an acoustic transmitter (code #33804) in the Nelson River between Clark Lake and Gull Rapids, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**

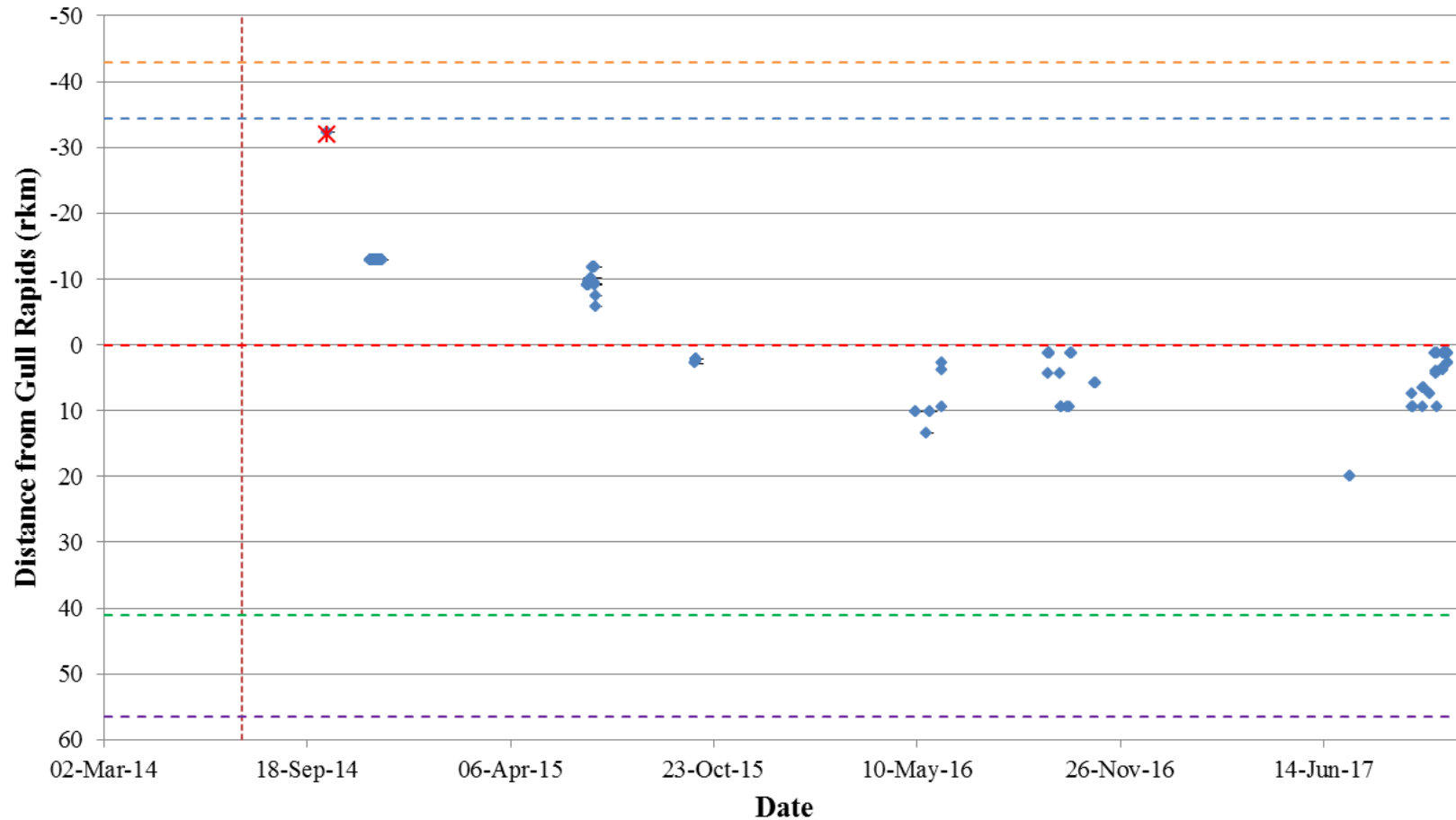
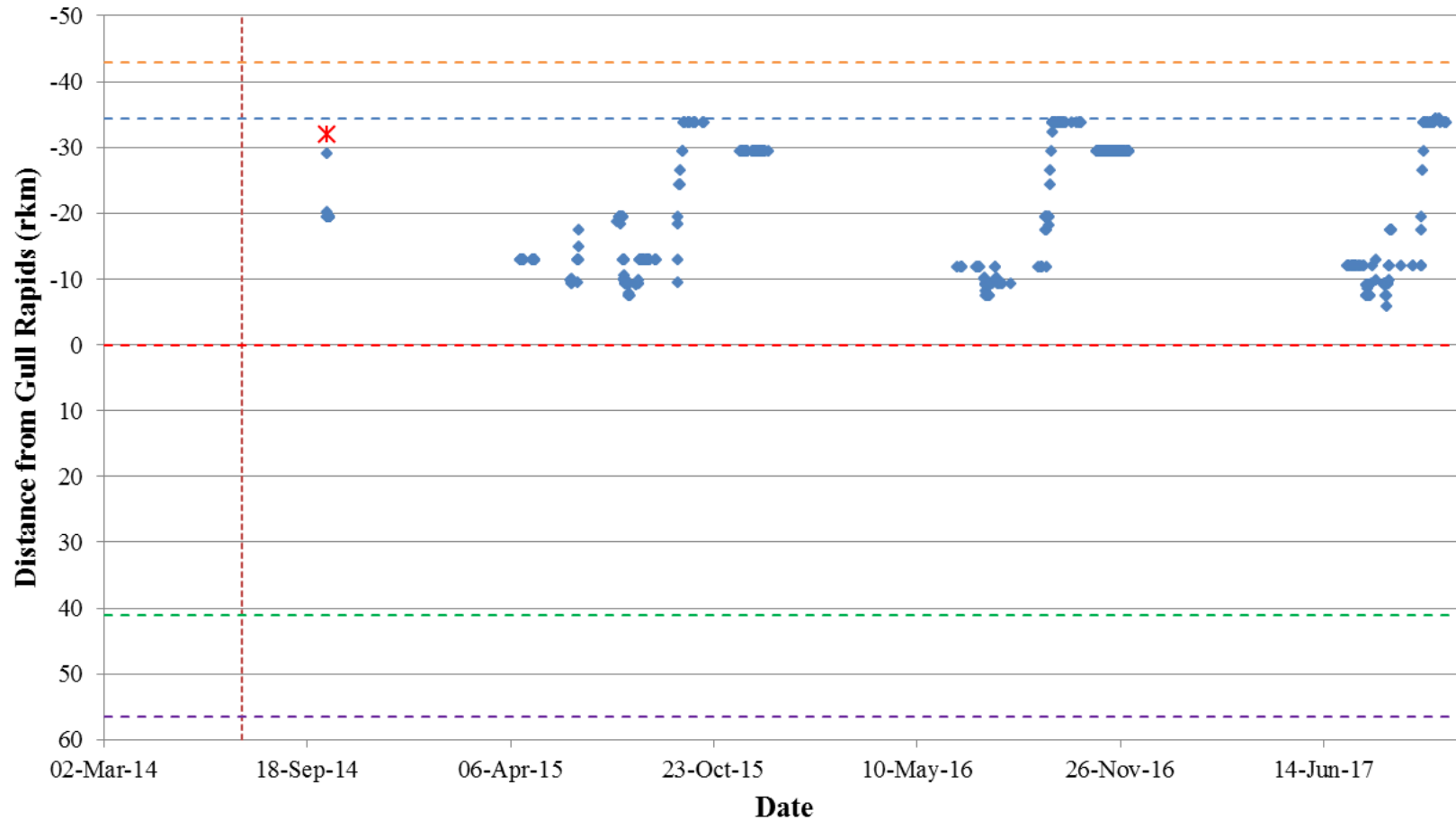
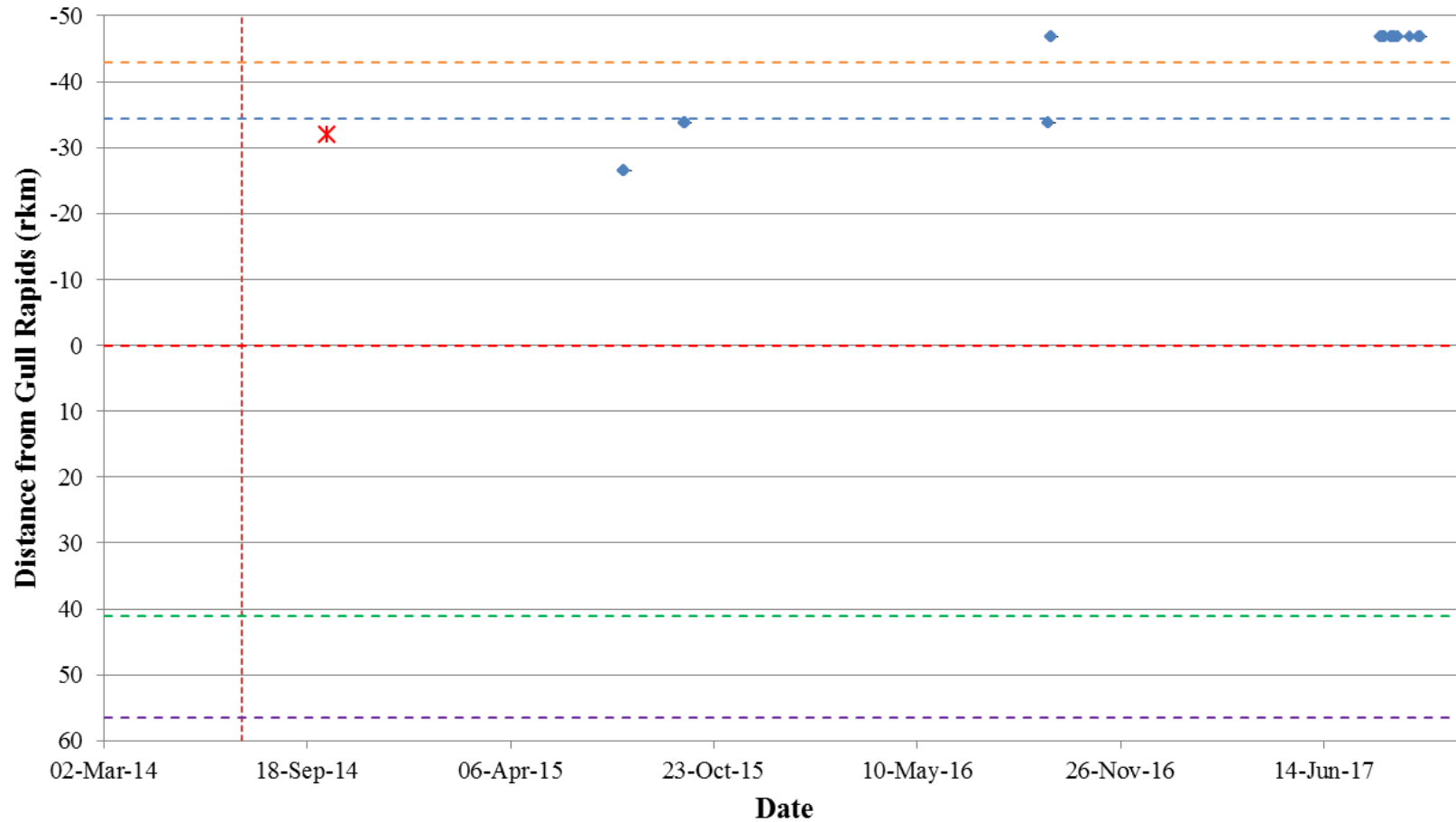


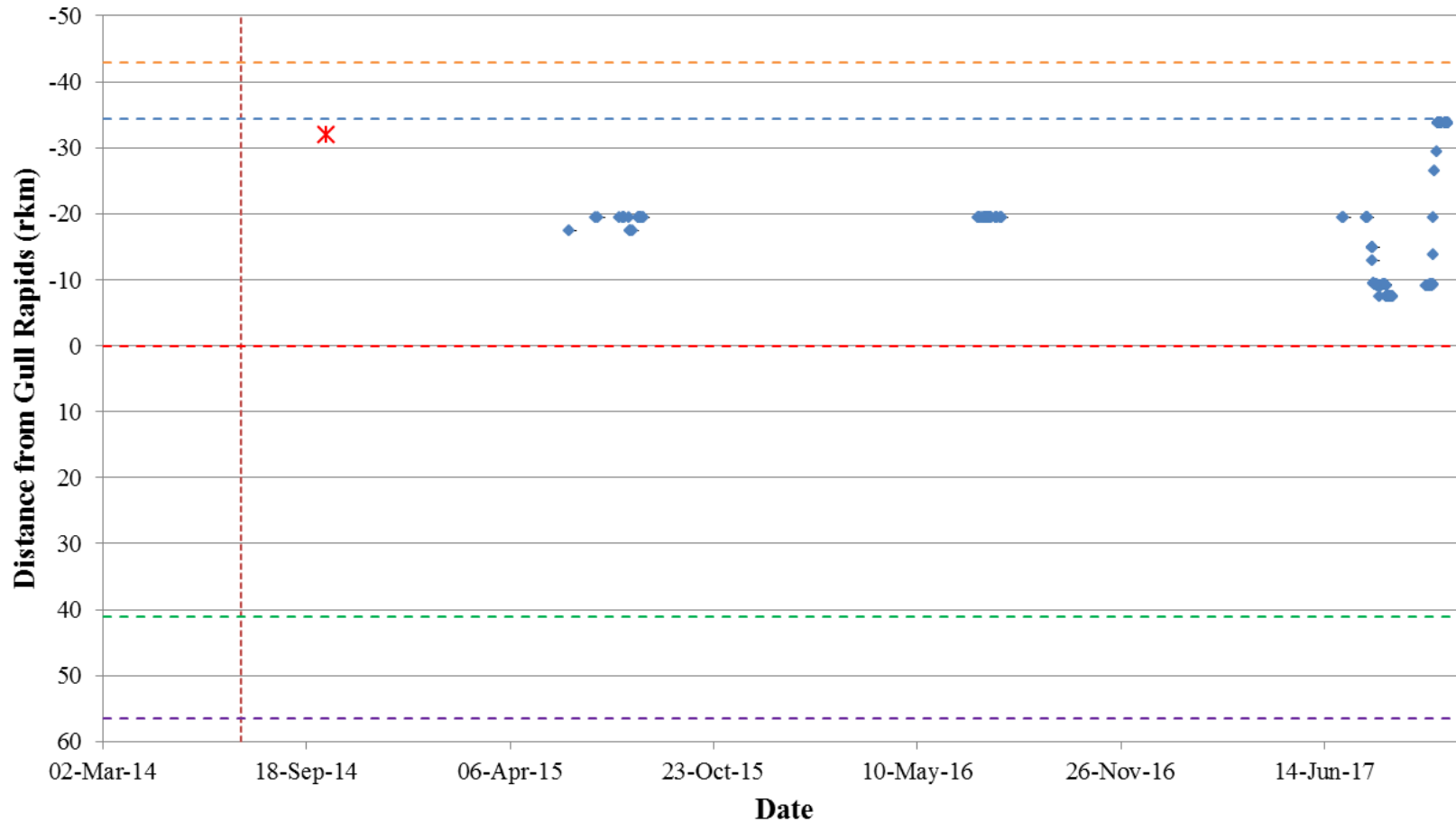
Figure A2-9: Position of a Lake Whitefish tagged with an acoustic transmitter (code #33805) in the Nelson River between Clark Lake and Gull Rapids, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).



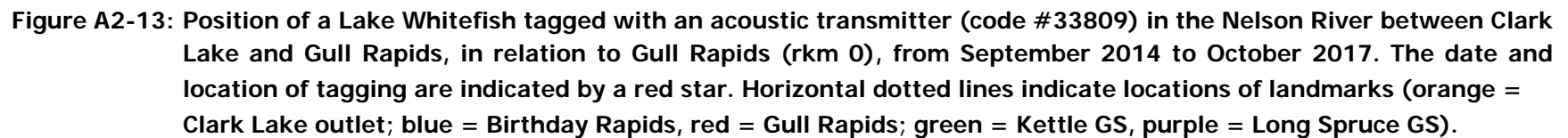
**Figure A2-10: Position of a Lake Whitefish tagged with an acoustic transmitter (code #33806) in the Nelson River between Clark Lake and Gull Rapids, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**



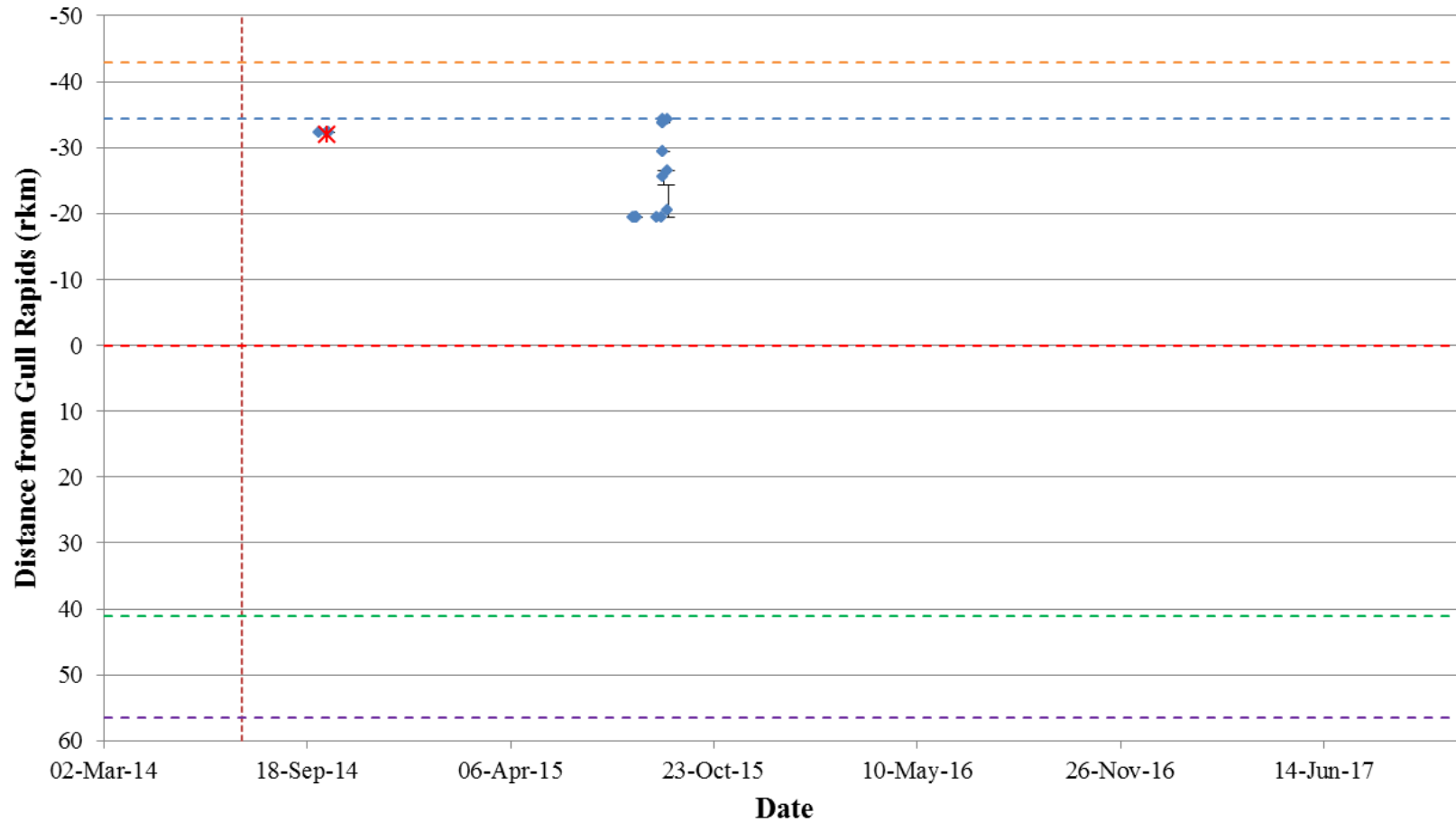
**Figure A2-11: Position of a Lake Whitefish tagged with an acoustic transmitter (code #33807) in the Nelson River between Clark Lake and Gull Rapids, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**



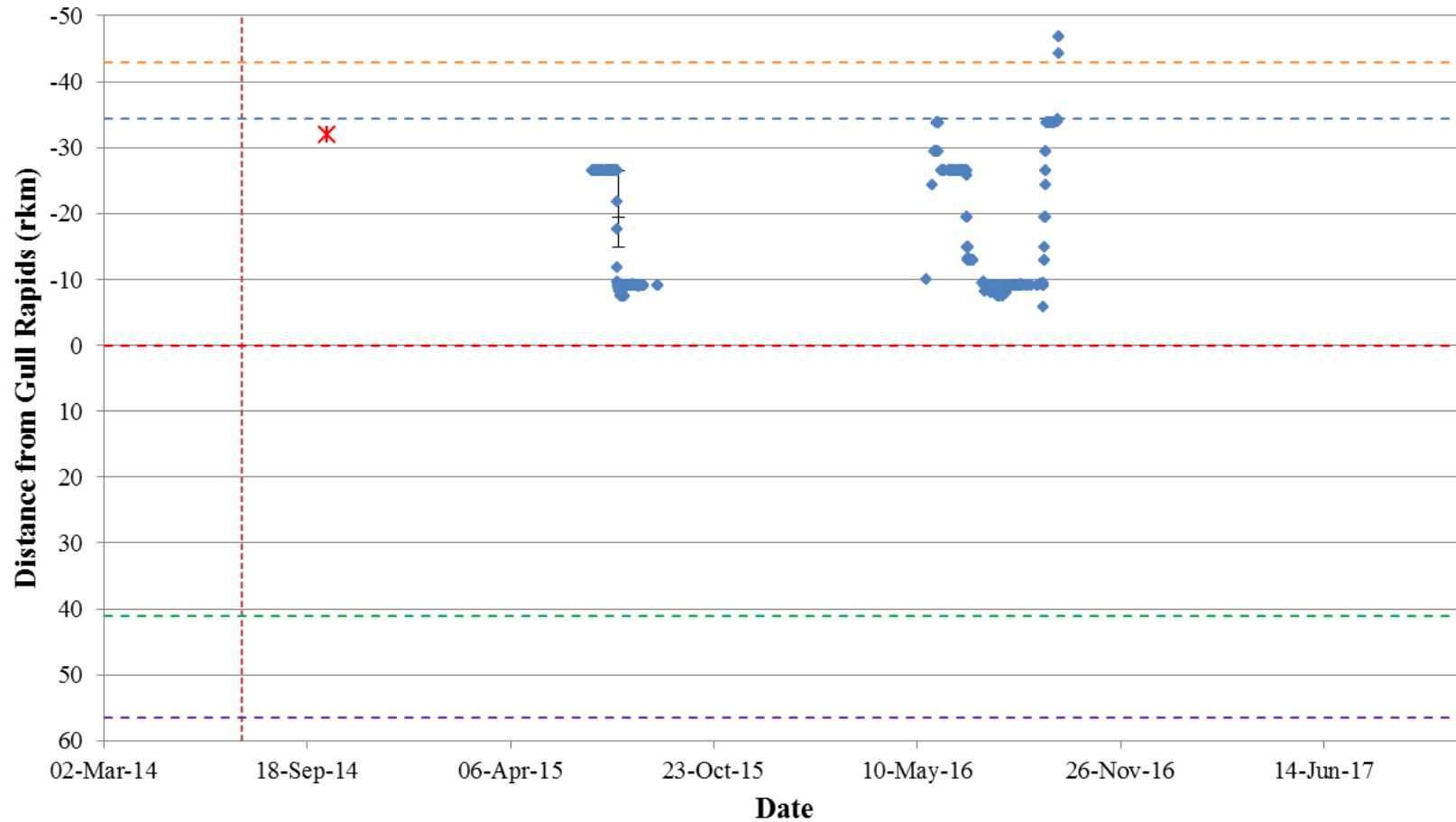
**Figure A2-12: Position of a Lake Whitefish tagged with an acoustic transmitter (code #33808) in the Nelson River between Clark Lake and Gull Rapids, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**



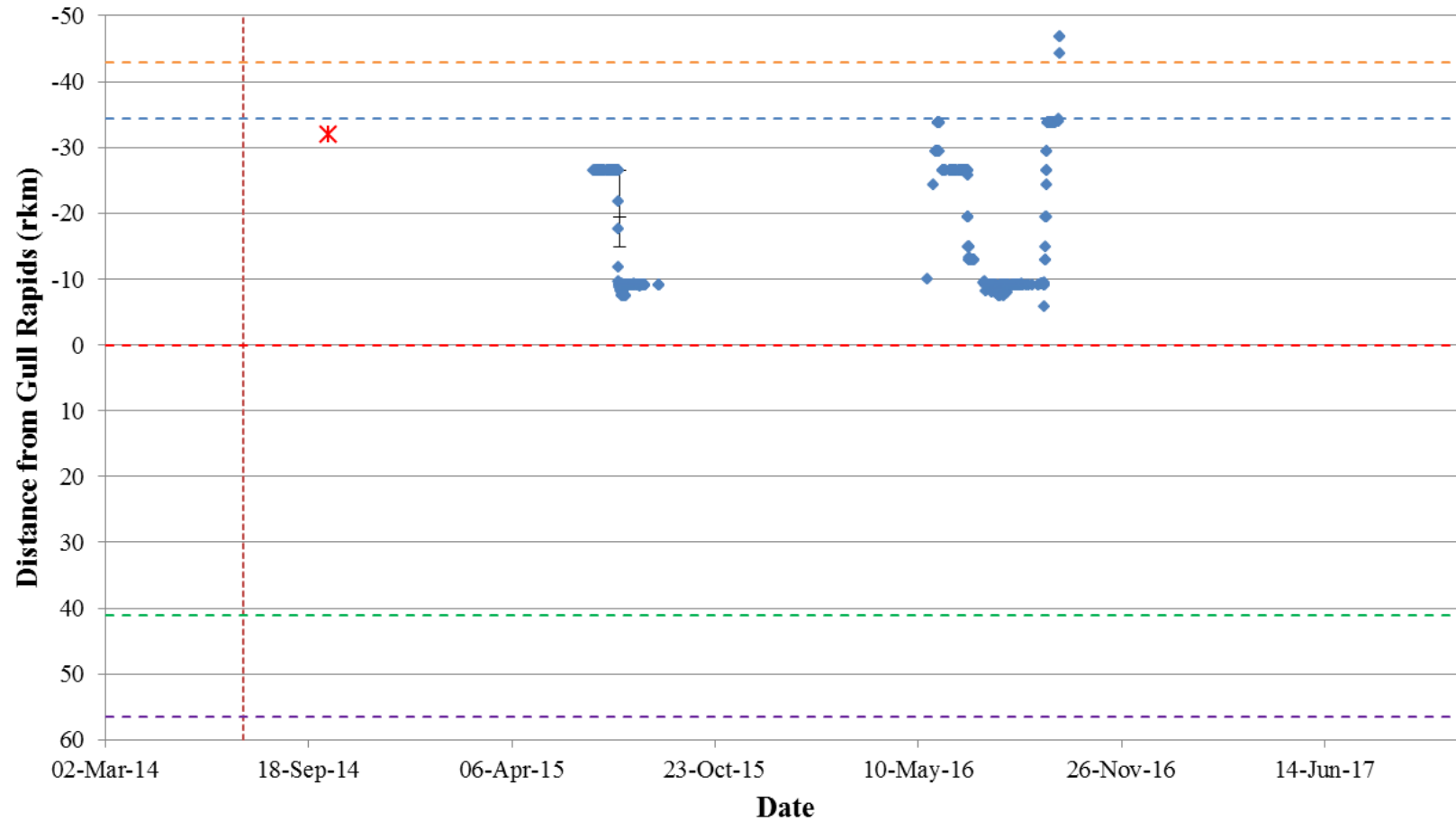




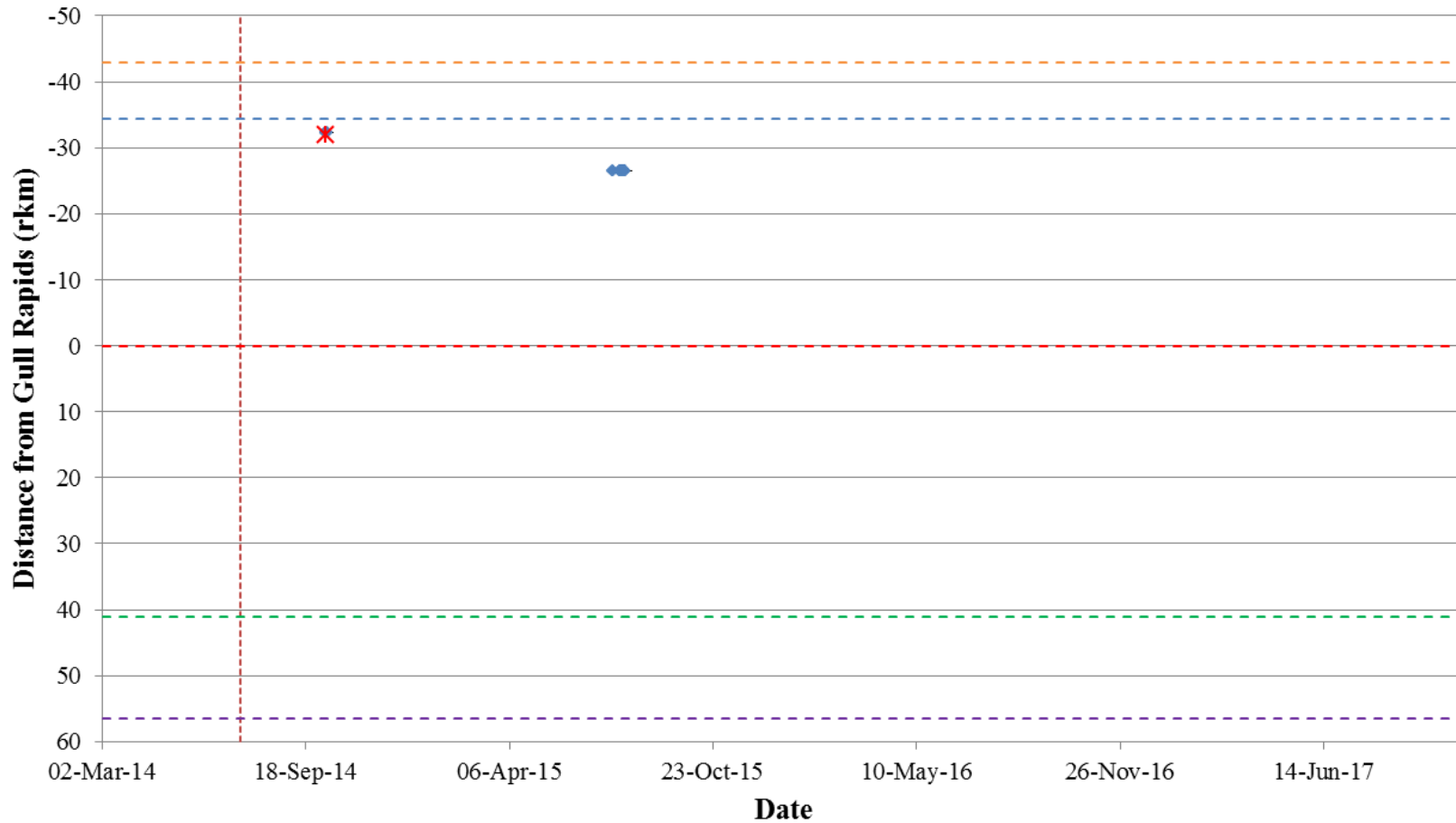
**Figure A2-14: Position of a Lake Whitefish tagged with an acoustic transmitter (code #33812) in the Nelson River between Clark Lake and Gull Rapids, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**



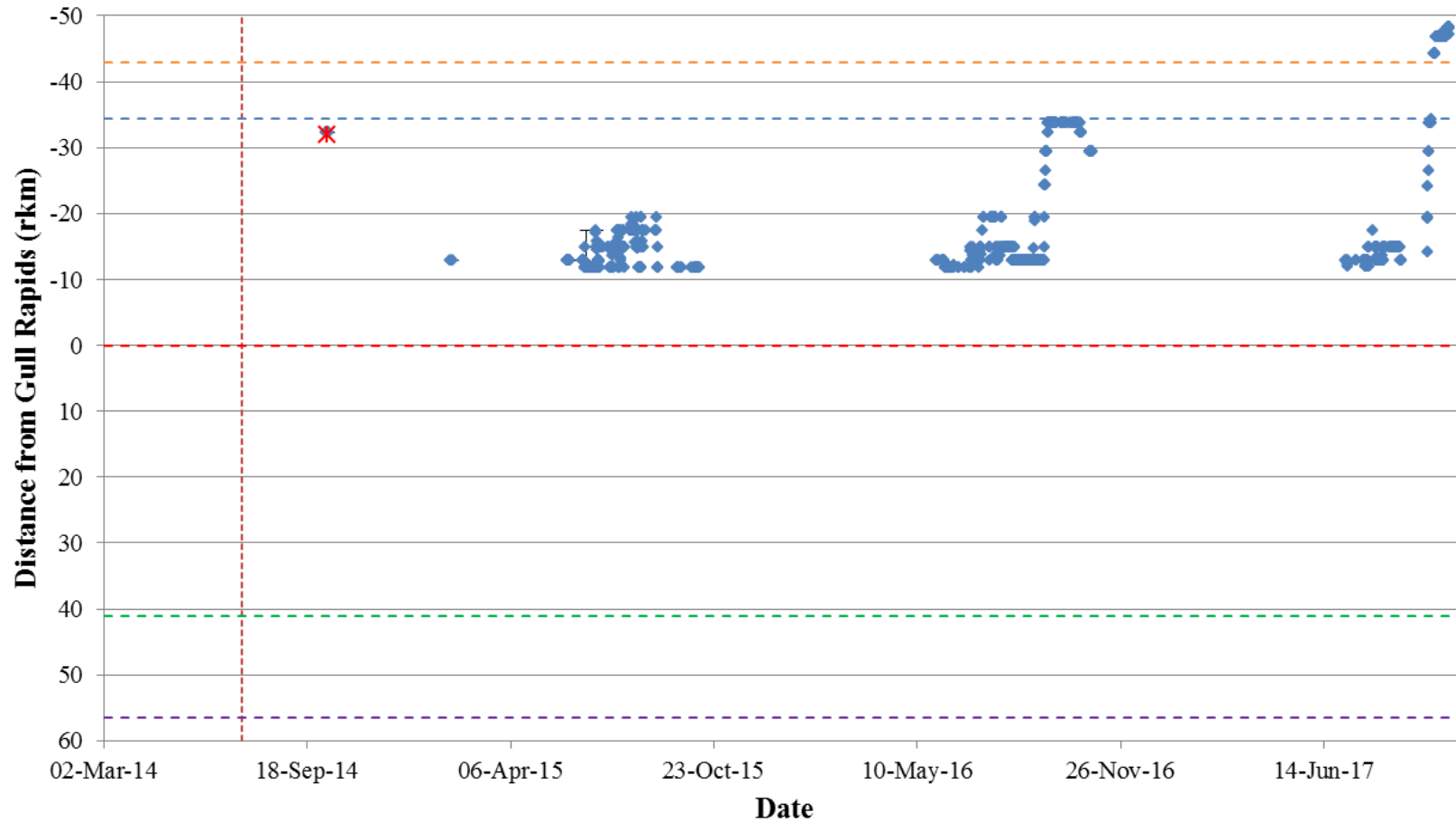
**Figure A2-15: Position of a Lake Whitefish tagged with an acoustic transmitter (code #33813) in the Nelson River between Clark Lake and Gull Rapids, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**



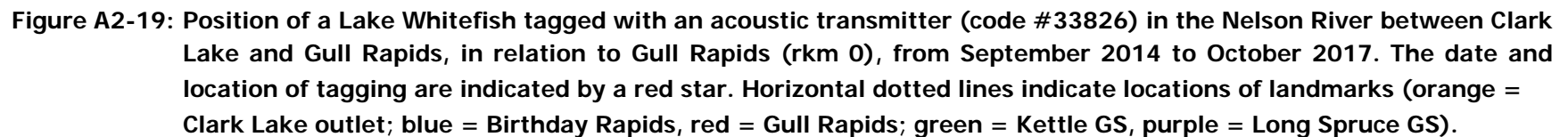
**Figure A2-16: Position of a Lake Whitefish tagged with an acoustic transmitter (code #33816) in the Nelson River between Clark Lake and Gull Rapids, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**



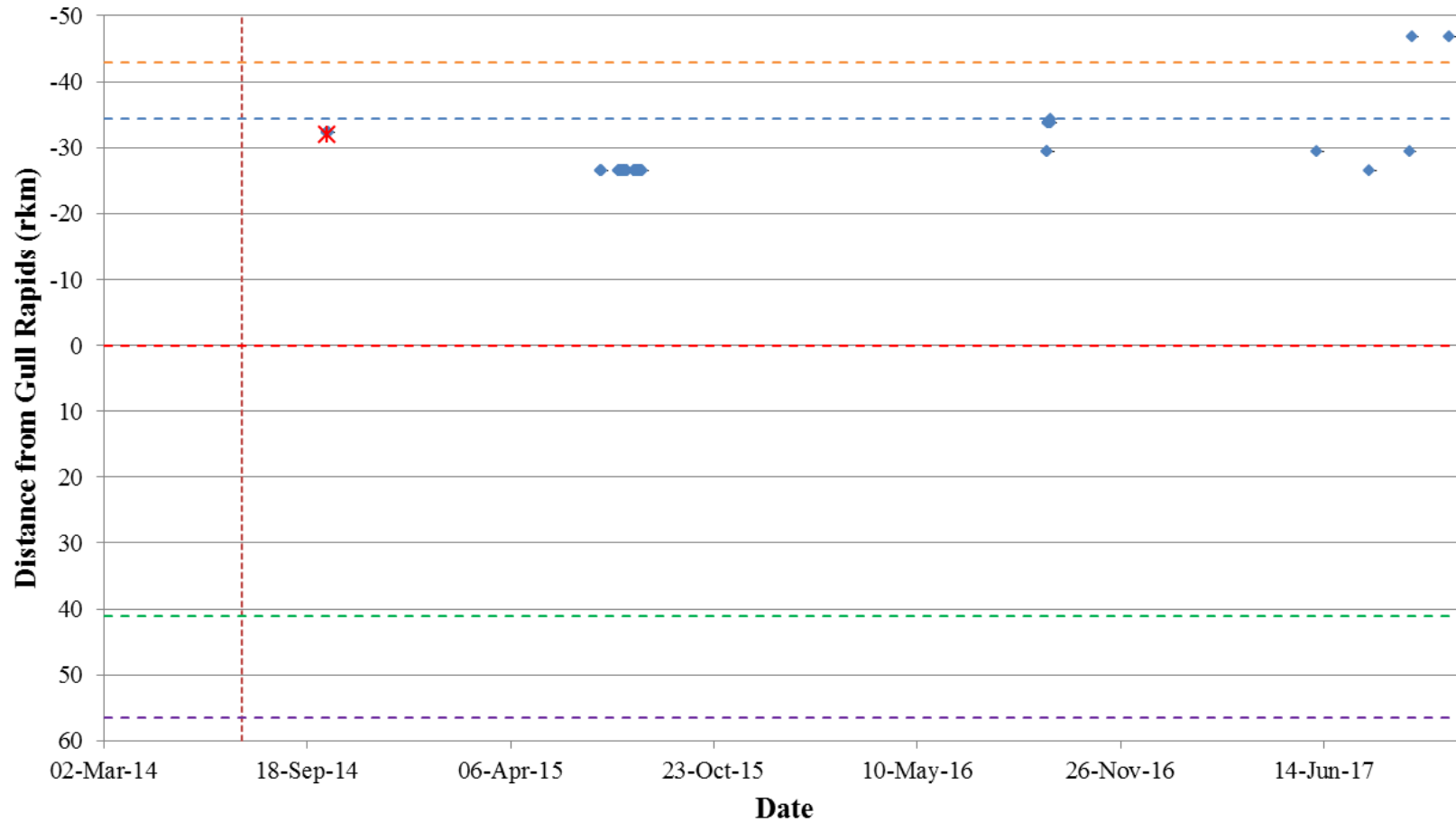
**Figure A2-17: Position of a Lake Whitefish tagged with an acoustic transmitter (code #33820) in the Nelson River between Clark Lake and Gull Rapids, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**



**Figure A2-18: Position of a Lake Whitefish tagged with an acoustic transmitter (code #33822) in the Nelson River between Clark Lake and Gull Rapids, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**







**Figure A2-20: Position of a Lake Whitefish tagged with an acoustic transmitter (code #33830) in the Nelson River between Clark Lake and Gull Rapids, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**

## APPENDIX 3:

# LOCATION SUMMARY FOR INDIVIDUAL ACOUSTIC-TAGGED LAKE WHITEFISH IN STEPHENS LAKE, OCTOBER 2015 TO OCTOBER 2017

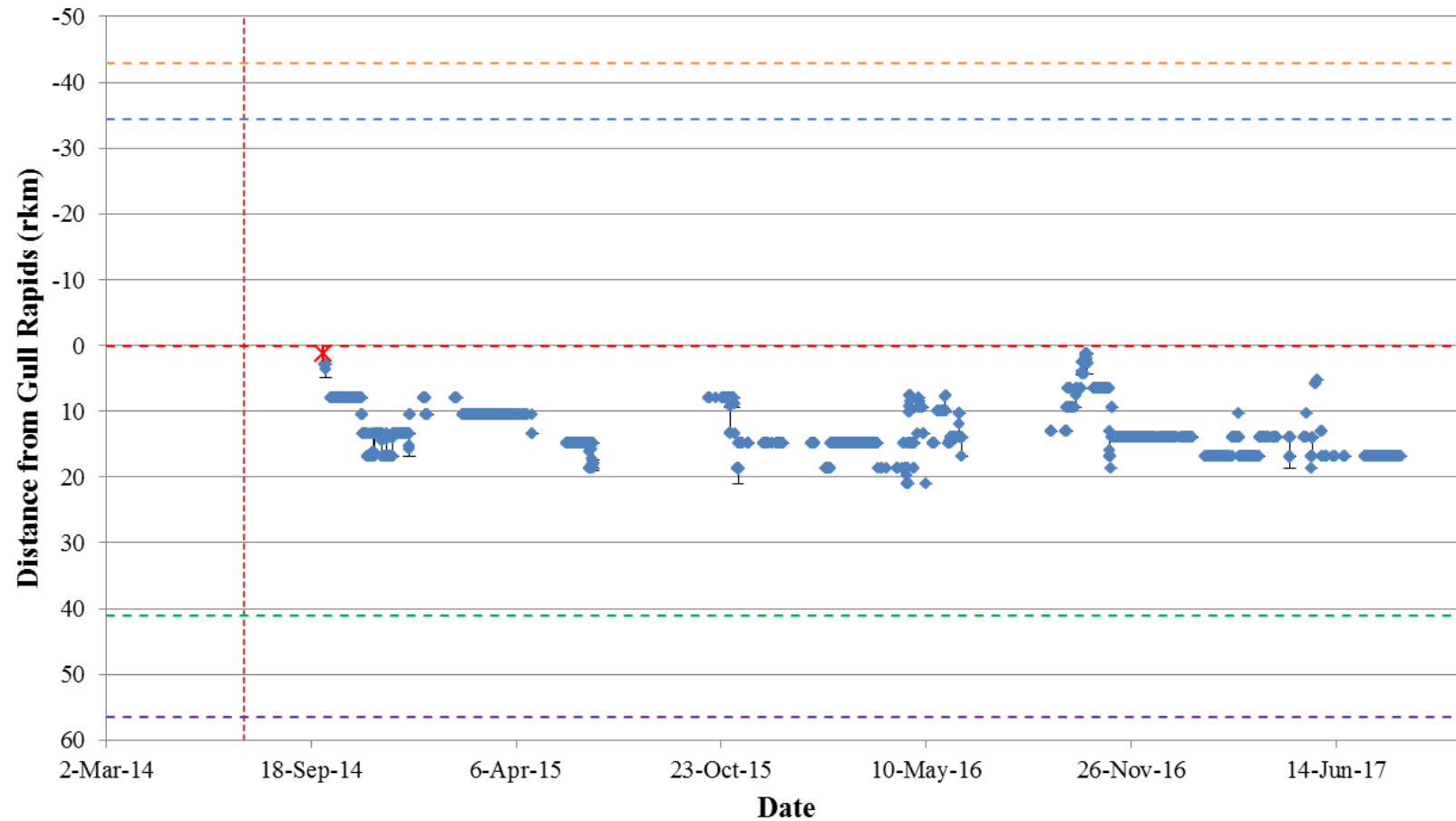
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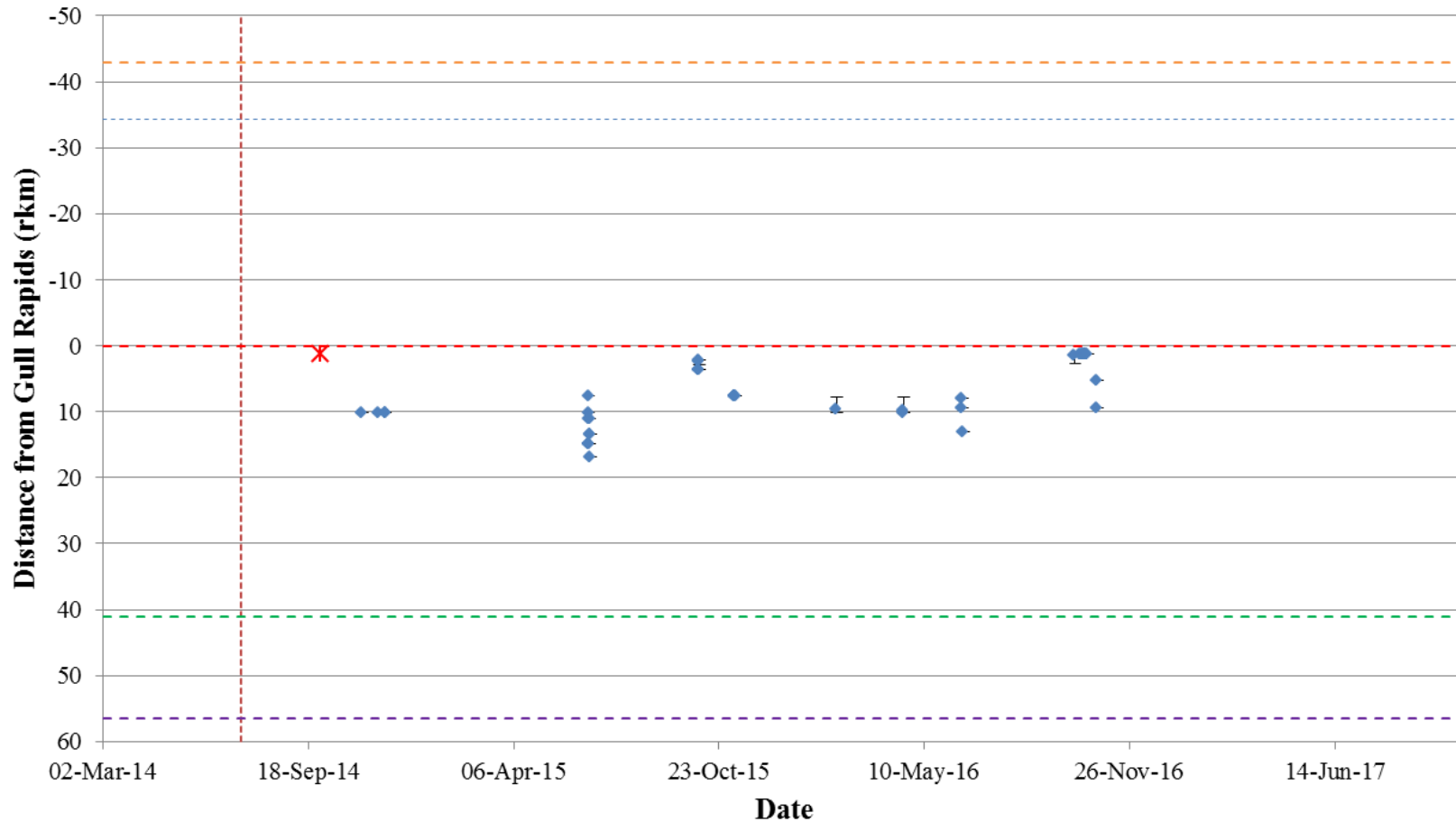
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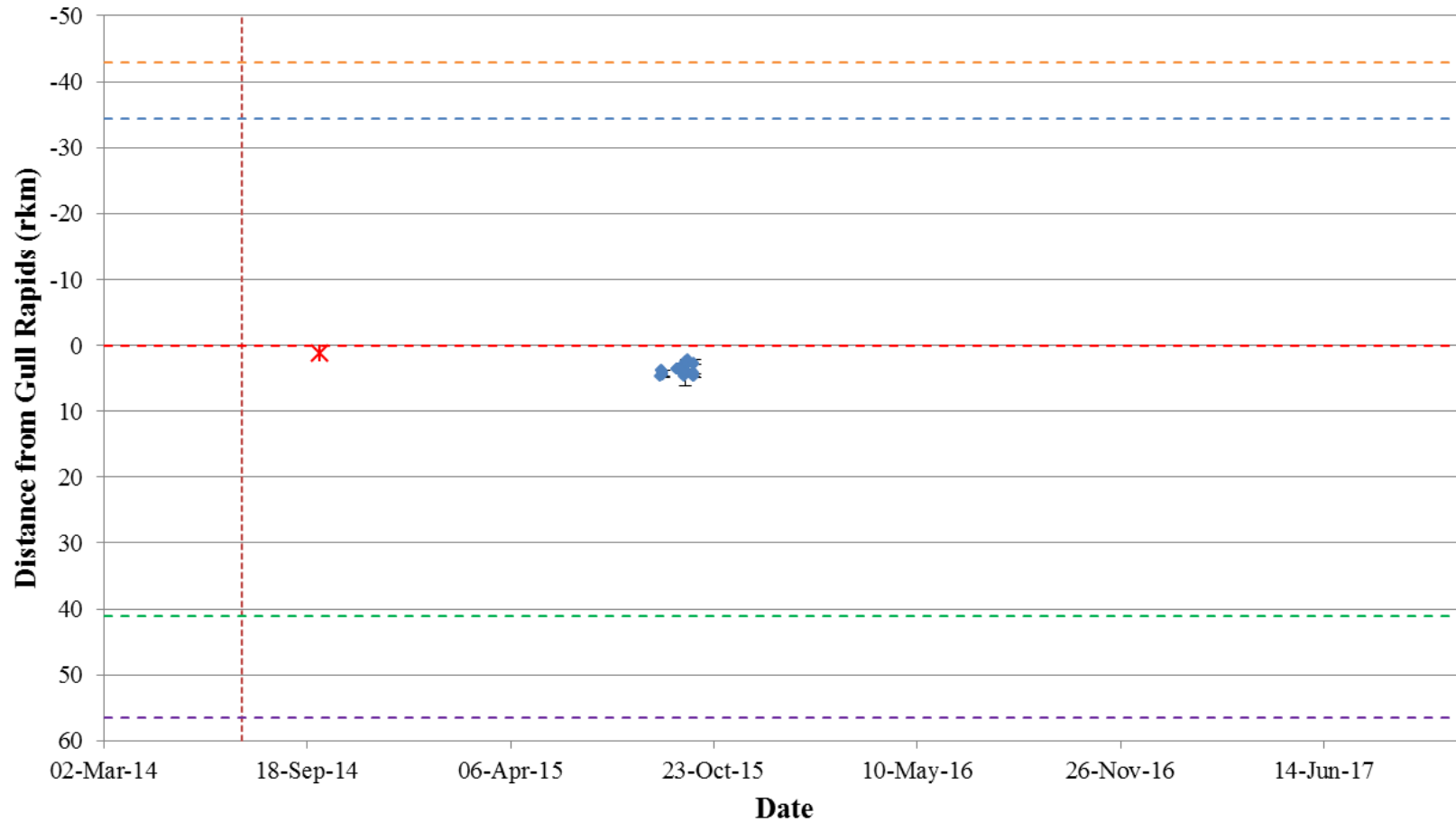


**Figure A3-1: Position of a Lake Whitefish tagged with an acoustic transmitter (code #6357) in Stephens Lake, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**

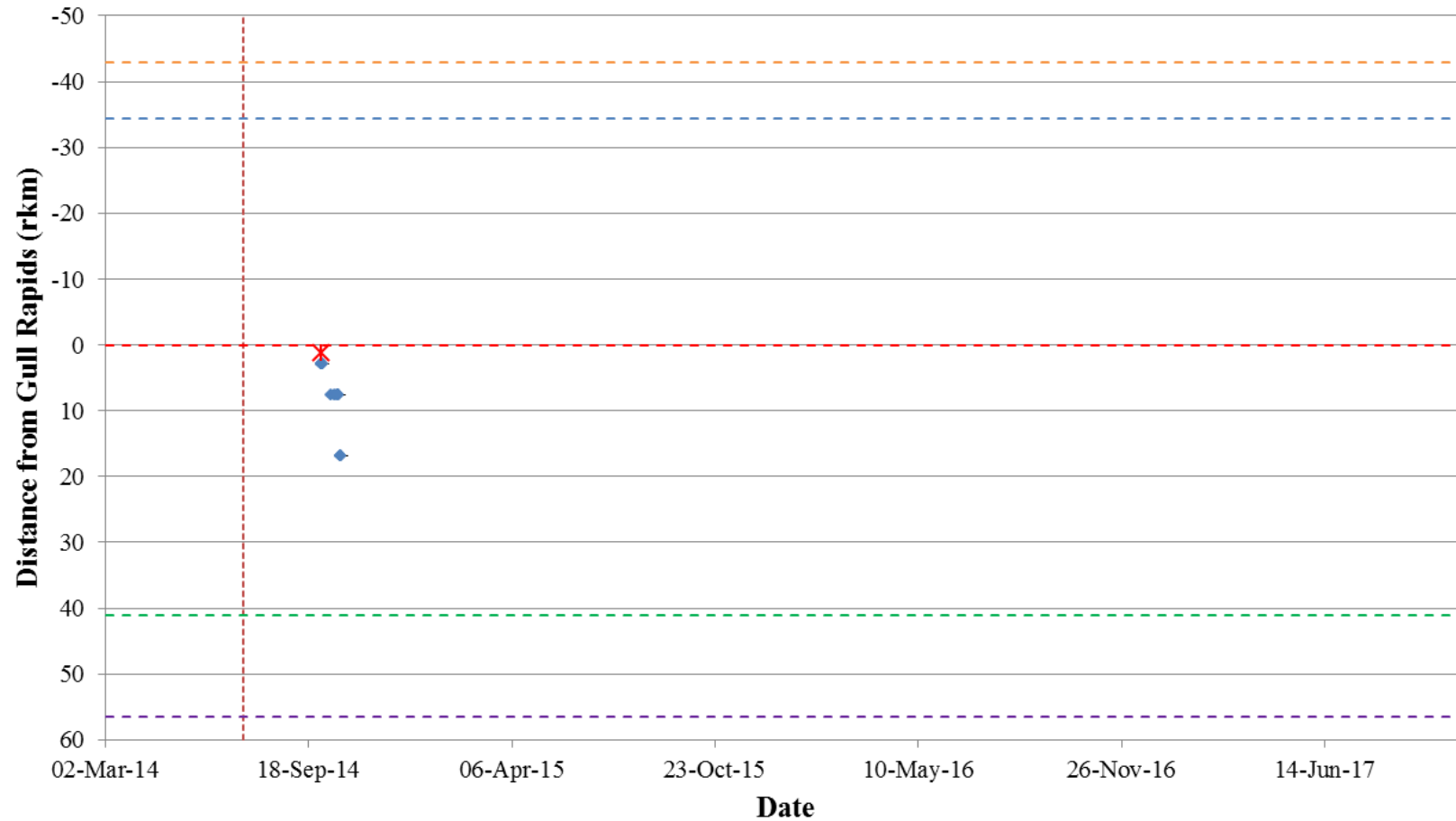


**Figure A3-2: Position of a Lake Whitefish tagged with an acoustic transmitter (code #6358) in Stephens Lake, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**

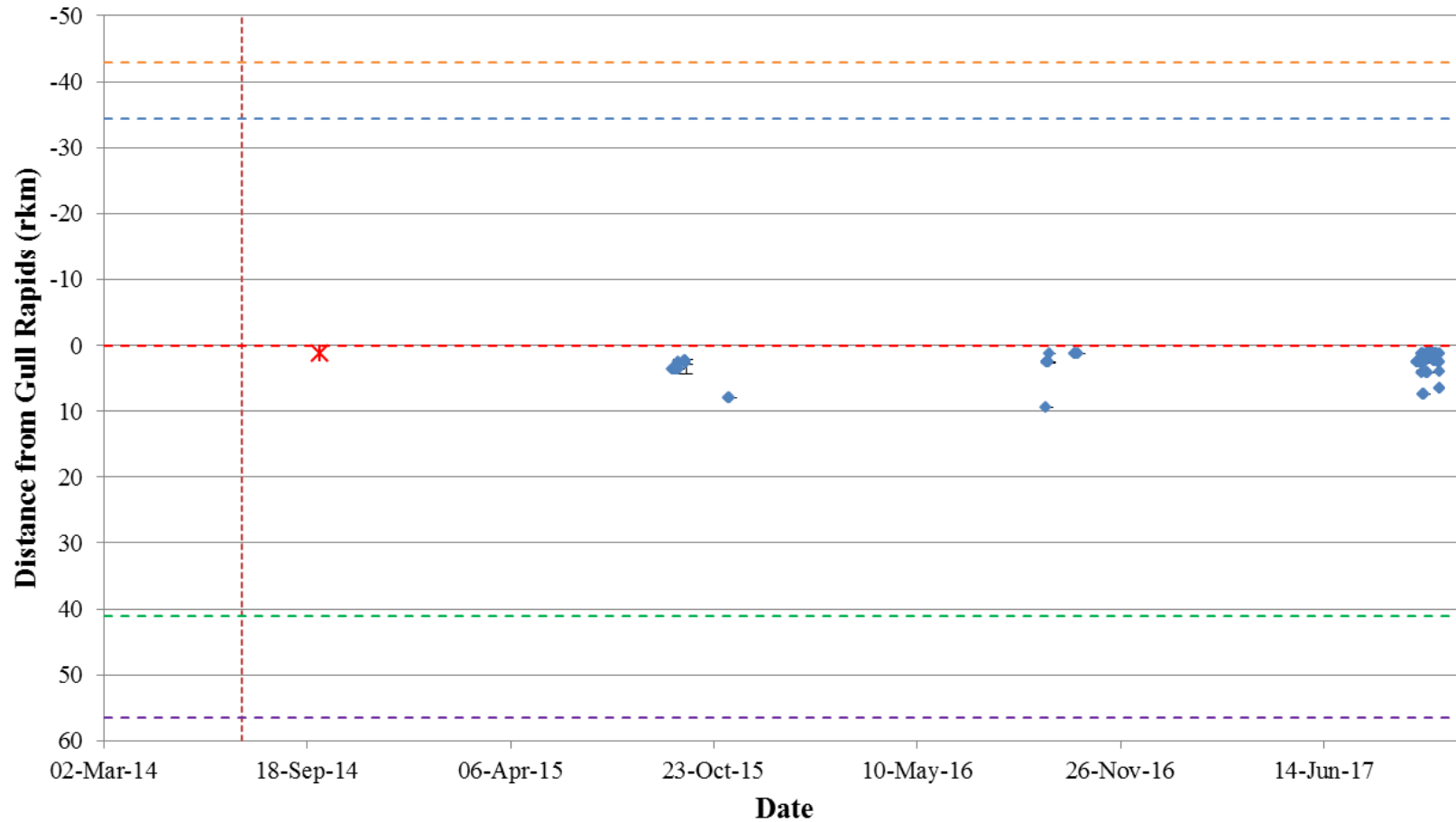




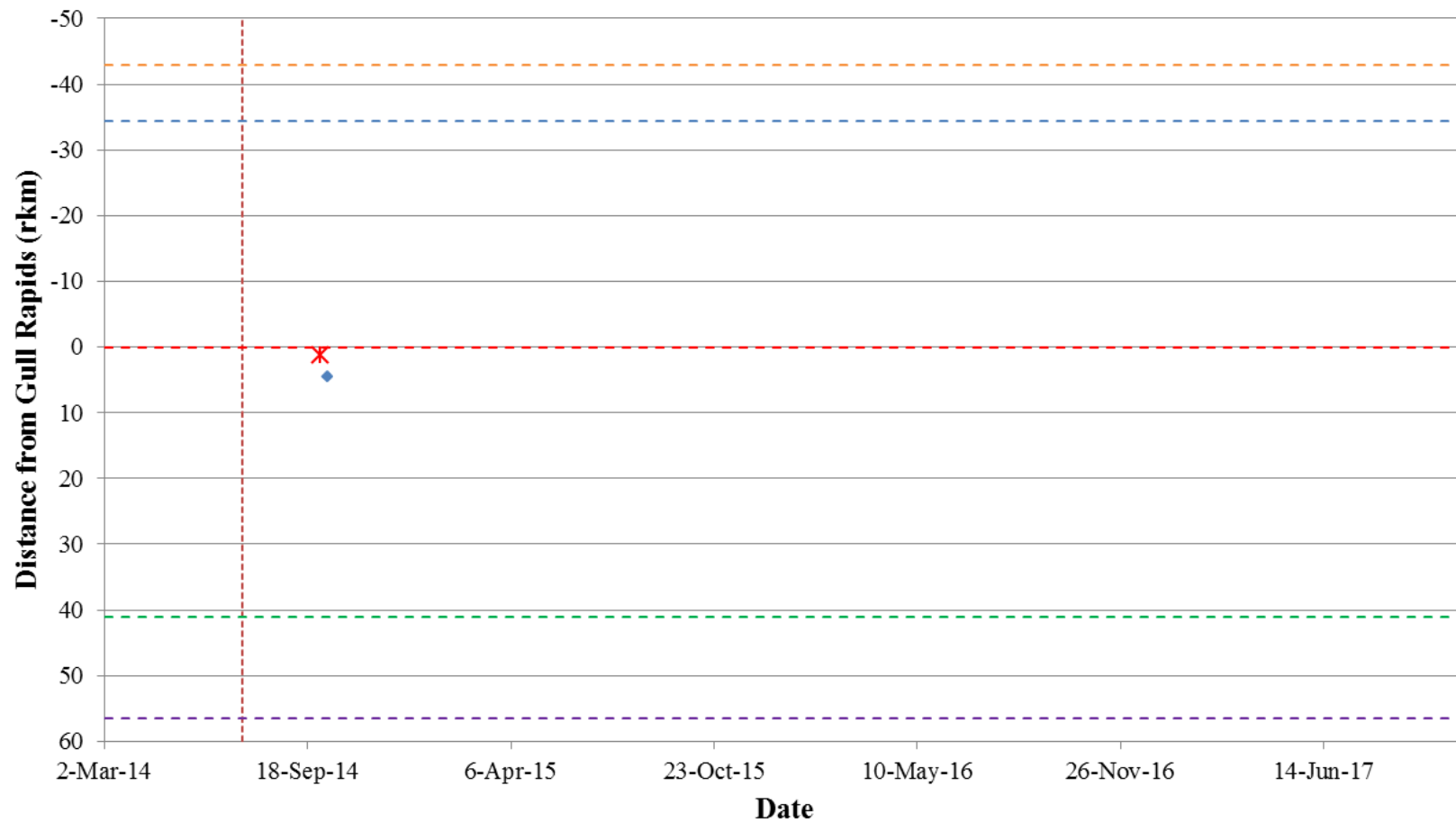
**Figure A3-3: Position of a Lake Whitefish tagged with an acoustic transmitter (code #6359) in Stephens Lake, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**



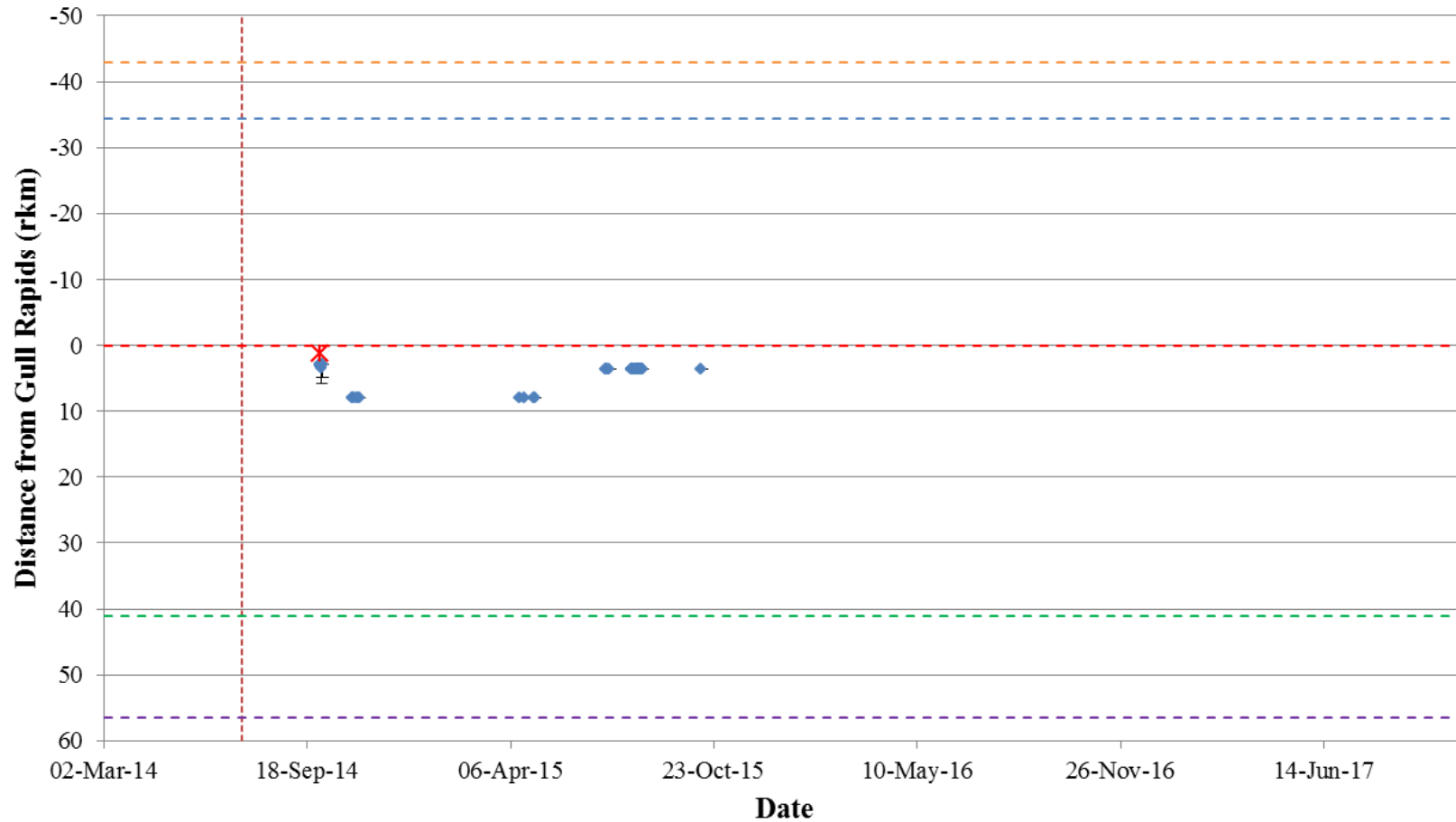
**Figure A3-4: Position of a Lake Whitefish tagged with an acoustic transmitter (code #6360) in Stephens Lake, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**



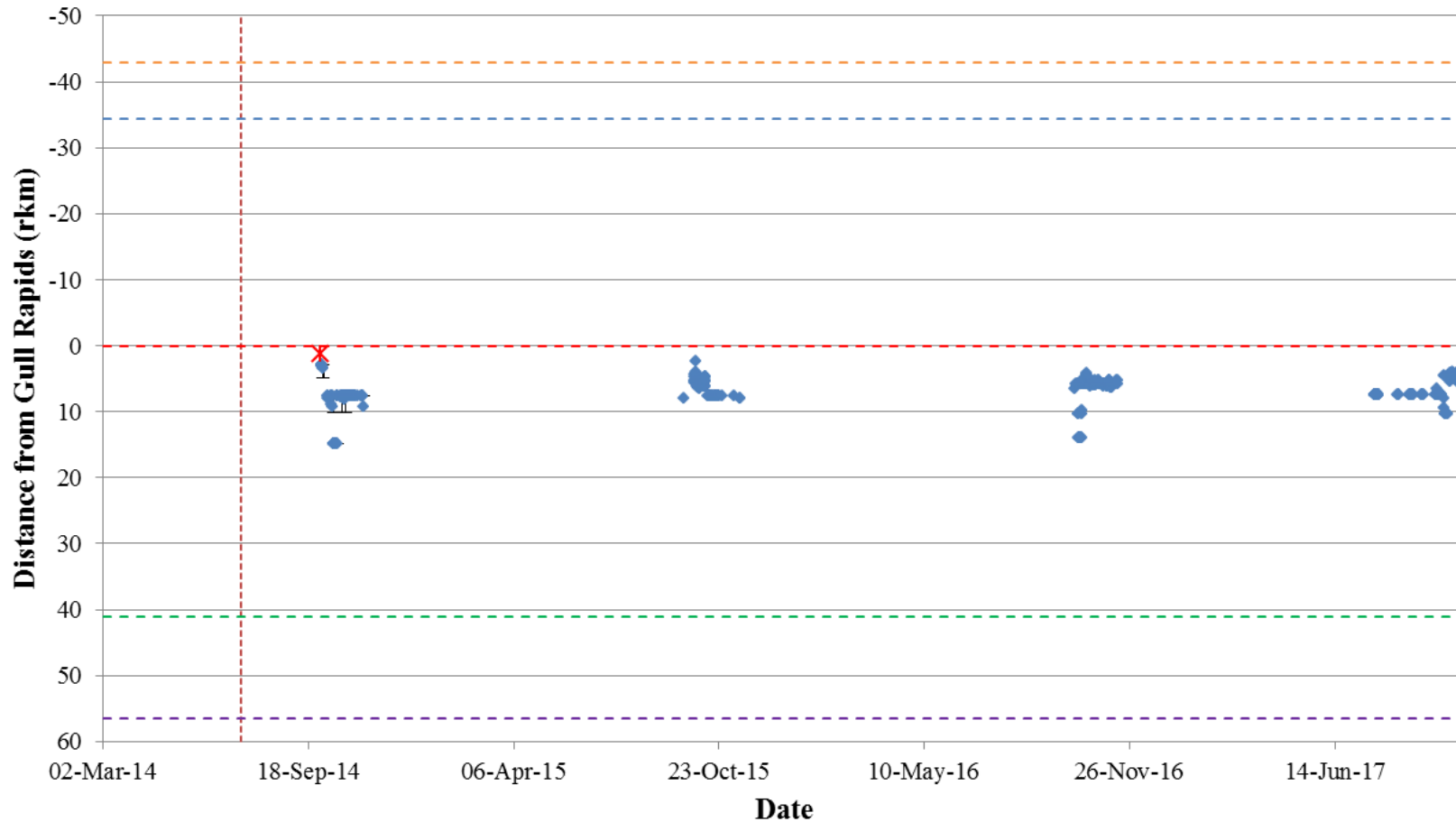
**Figure A3-5: Position of a Lake Whitefish tagged with an acoustic transmitter (code #6361) in Stephens Lake, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**



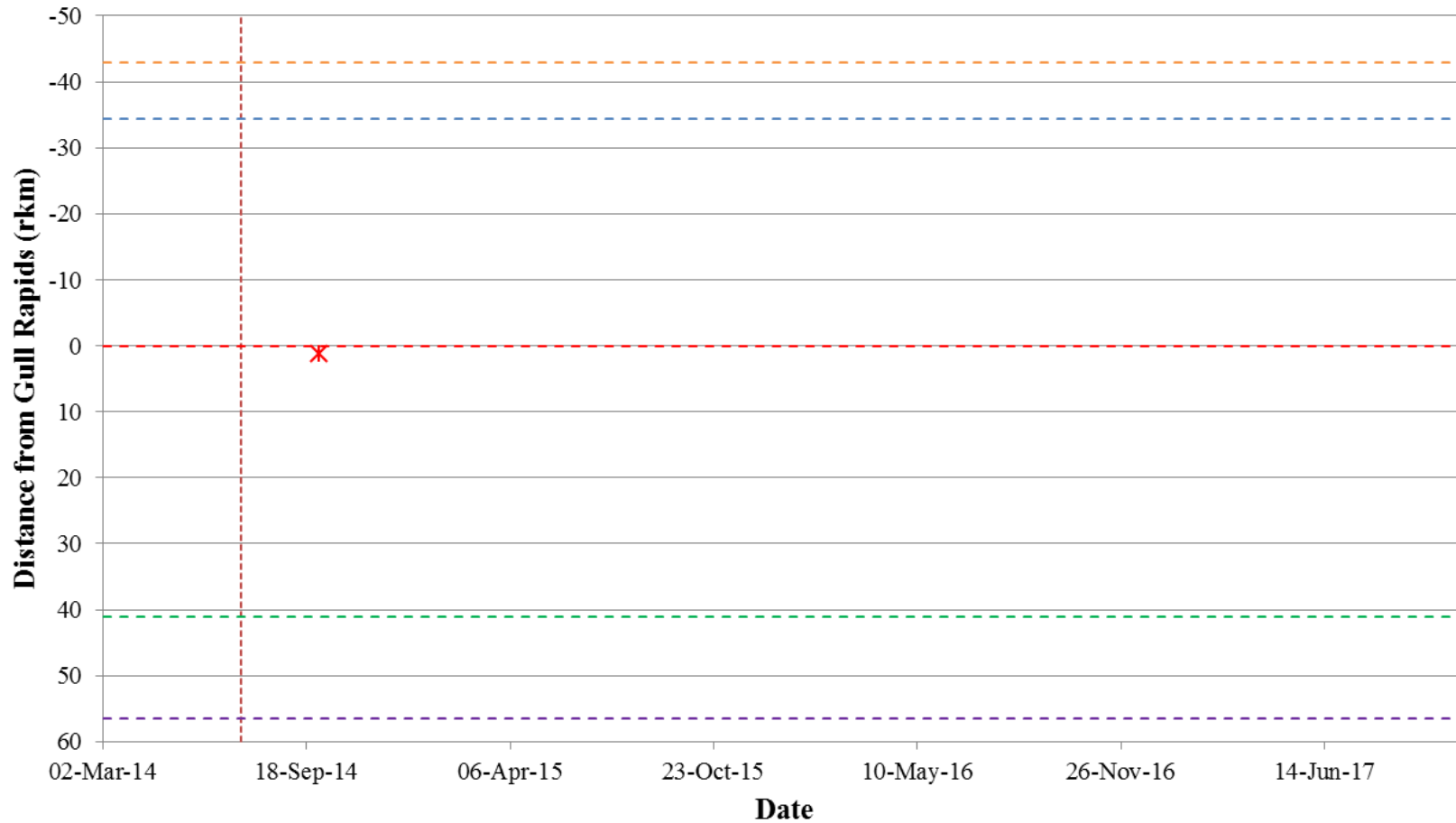
**Figure A3-6: Position of a Lake Whitefish tagged with an acoustic transmitter (code #6362) in Stephens Lake, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**



**Figure A3-7: Position of a Lake Whitefish tagged with an acoustic transmitter (code #6363) in Stephens Lake, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**

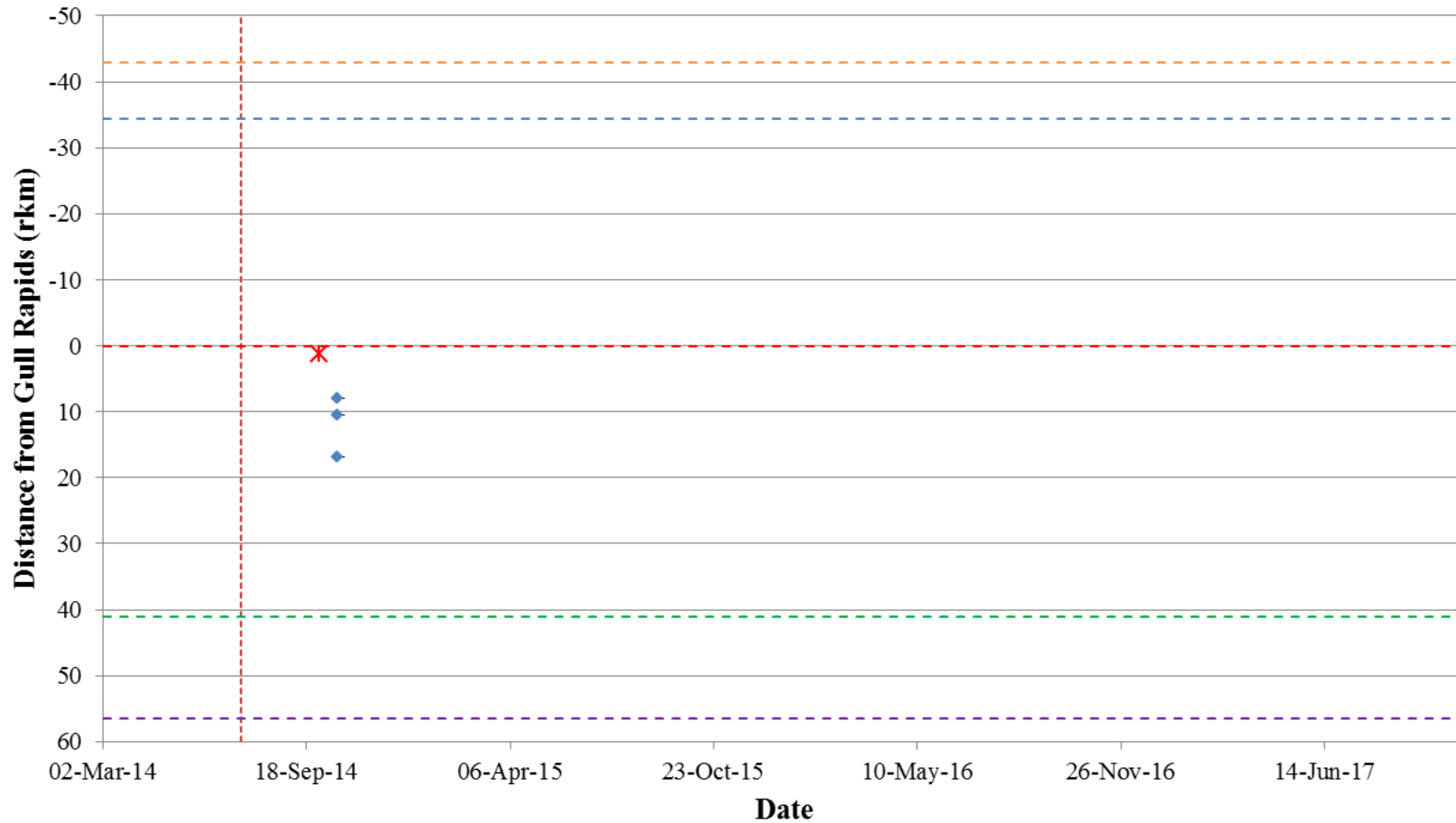


**Figure A3-8: Position of a Lake Whitefish tagged with an acoustic transmitter (code #6364) in Stephens Lake, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**

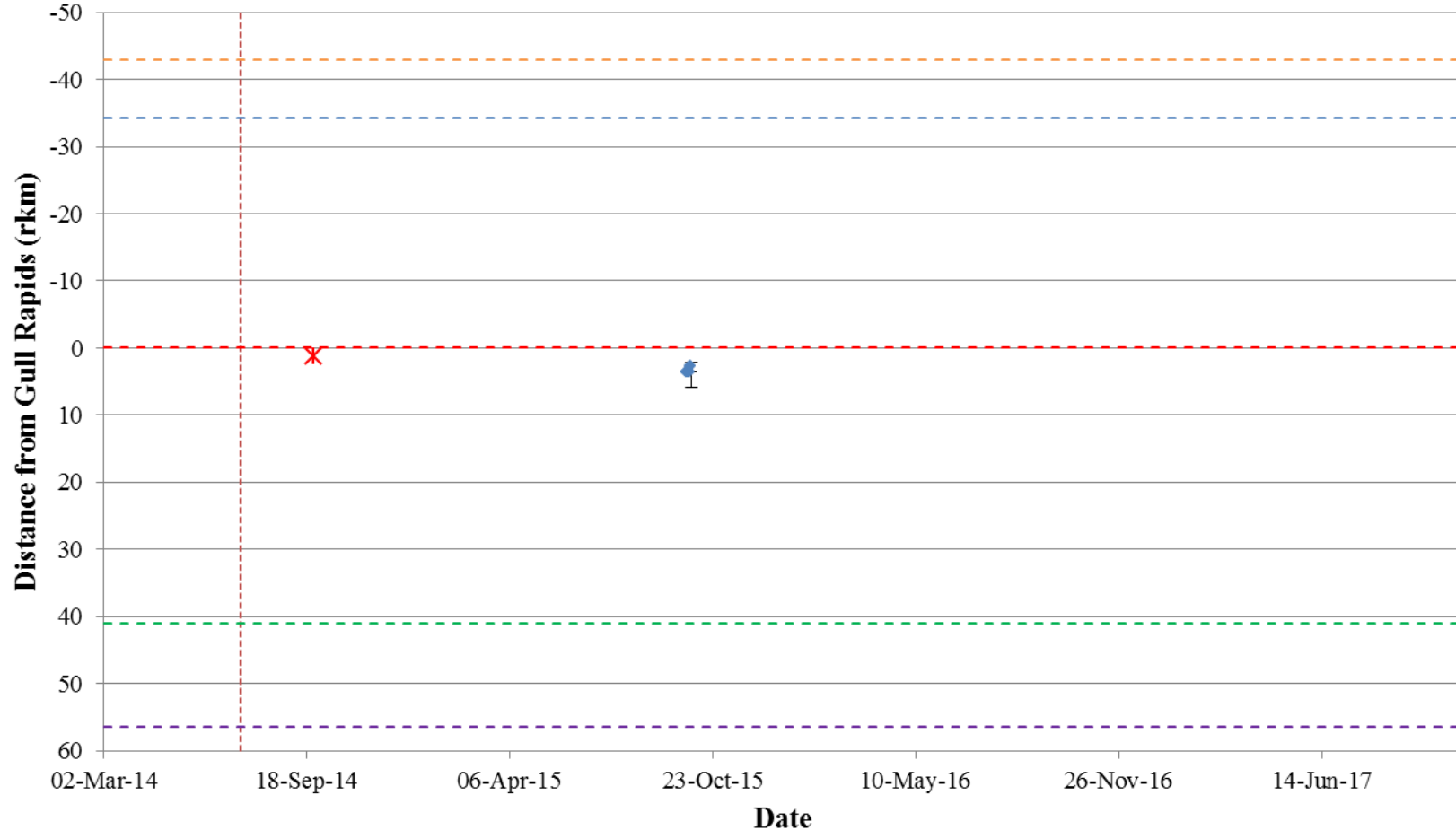


**Figure A3-9: Position of a Lake Whitefish tagged with an acoustic transmitter (code #6365) in Stephens Lake, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**

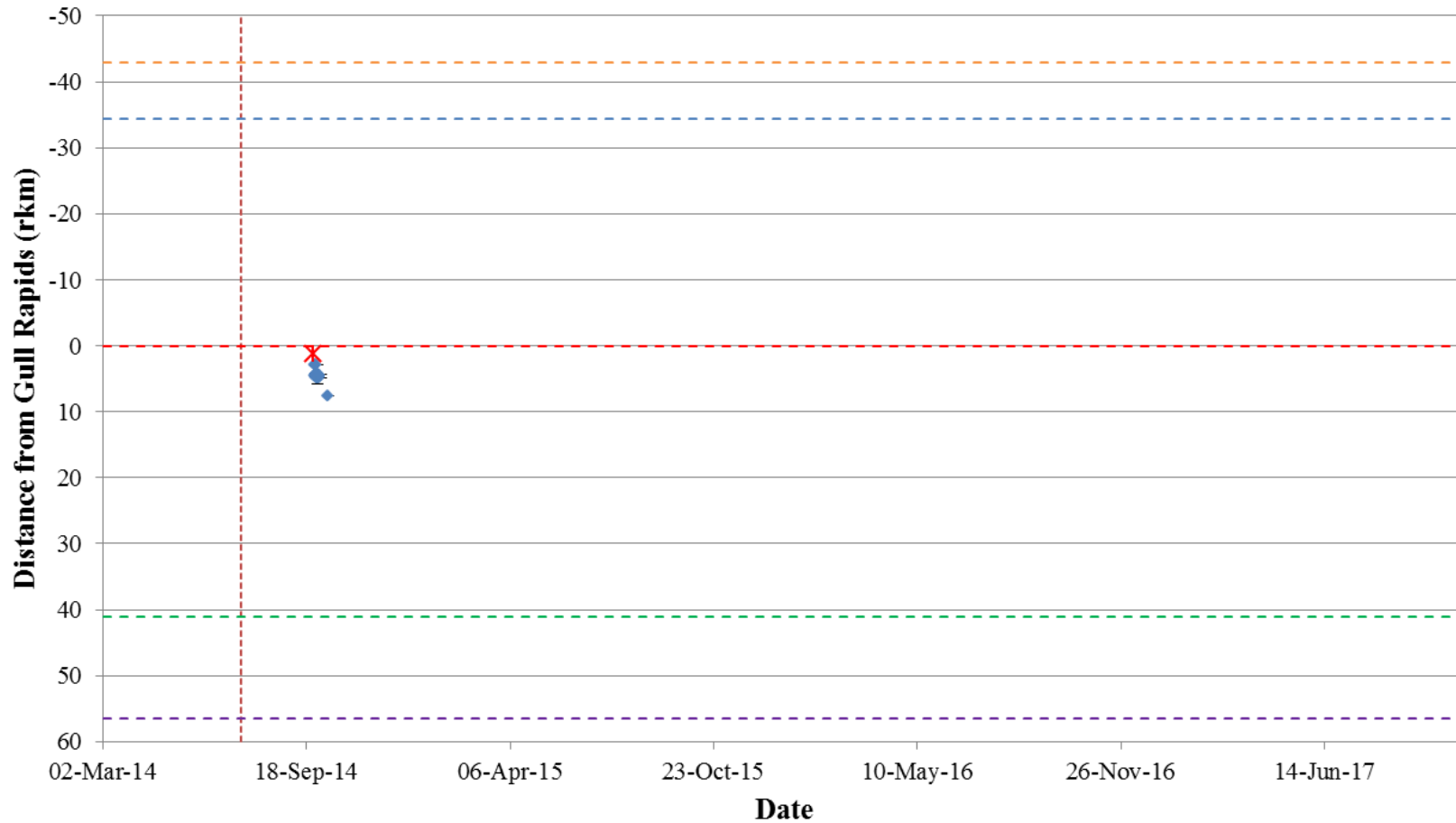




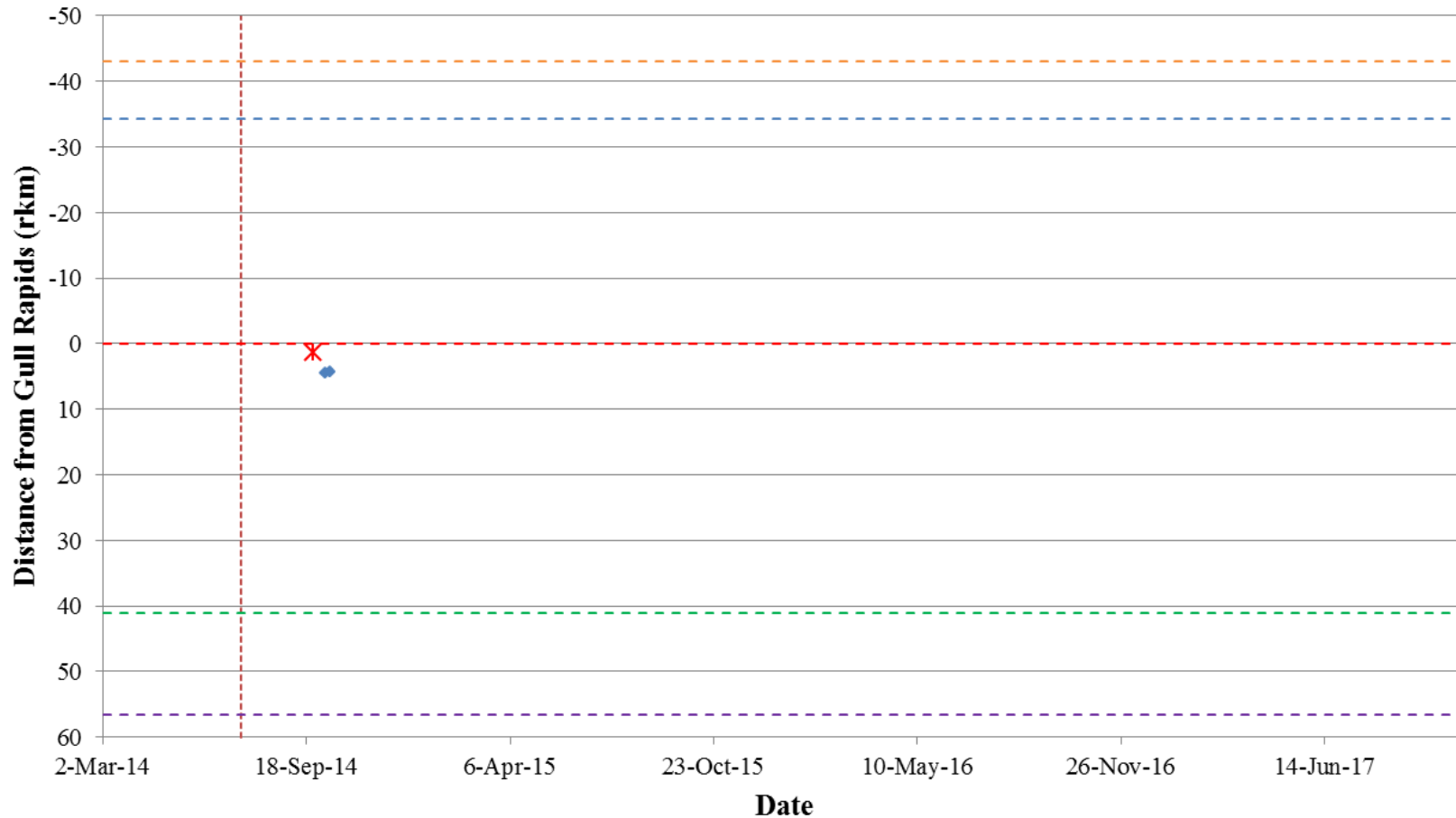
**Figure A3-10: Position of a Lake Whitefish tagged with an acoustic transmitter (code #6366) in Stephens Lake, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**



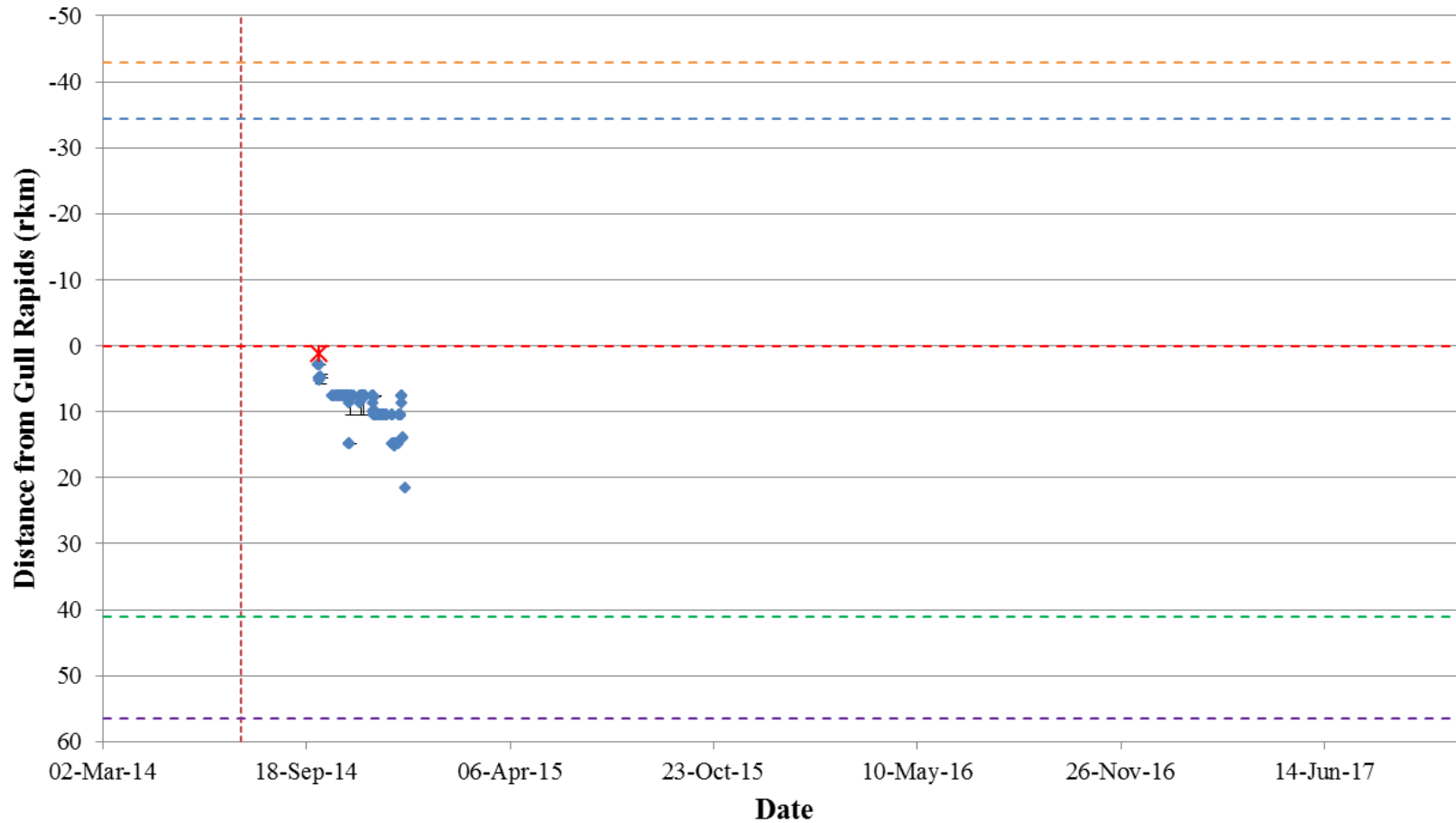
**Figure A3-11: Position of a Lake Whitefish tagged with an acoustic transmitter (code #6367) in Stephens Lake, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**



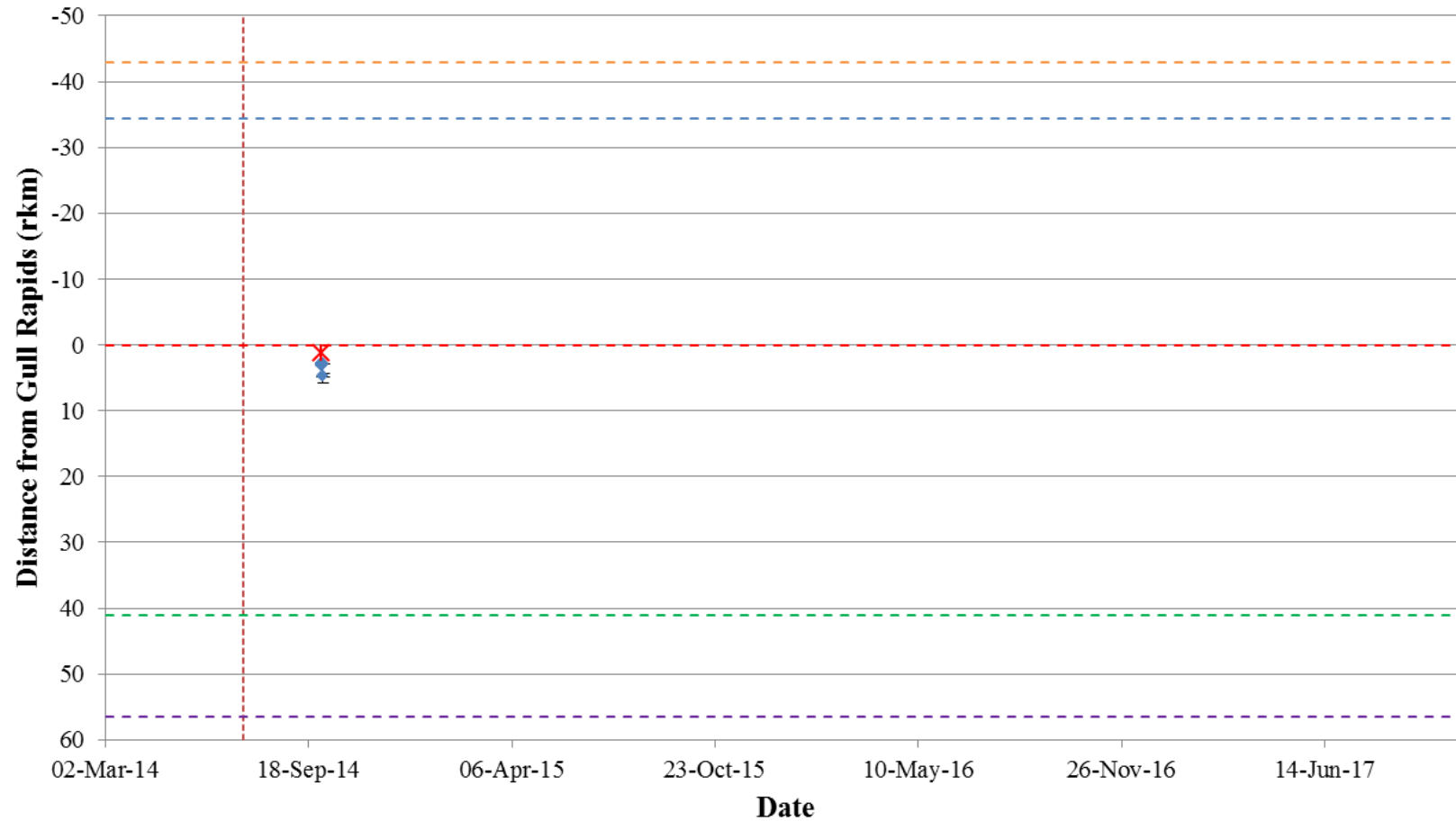
**Figure A3-12: Position of a Lake Whitefish tagged with an acoustic transmitter (code #6368) in Stephens Lake, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**



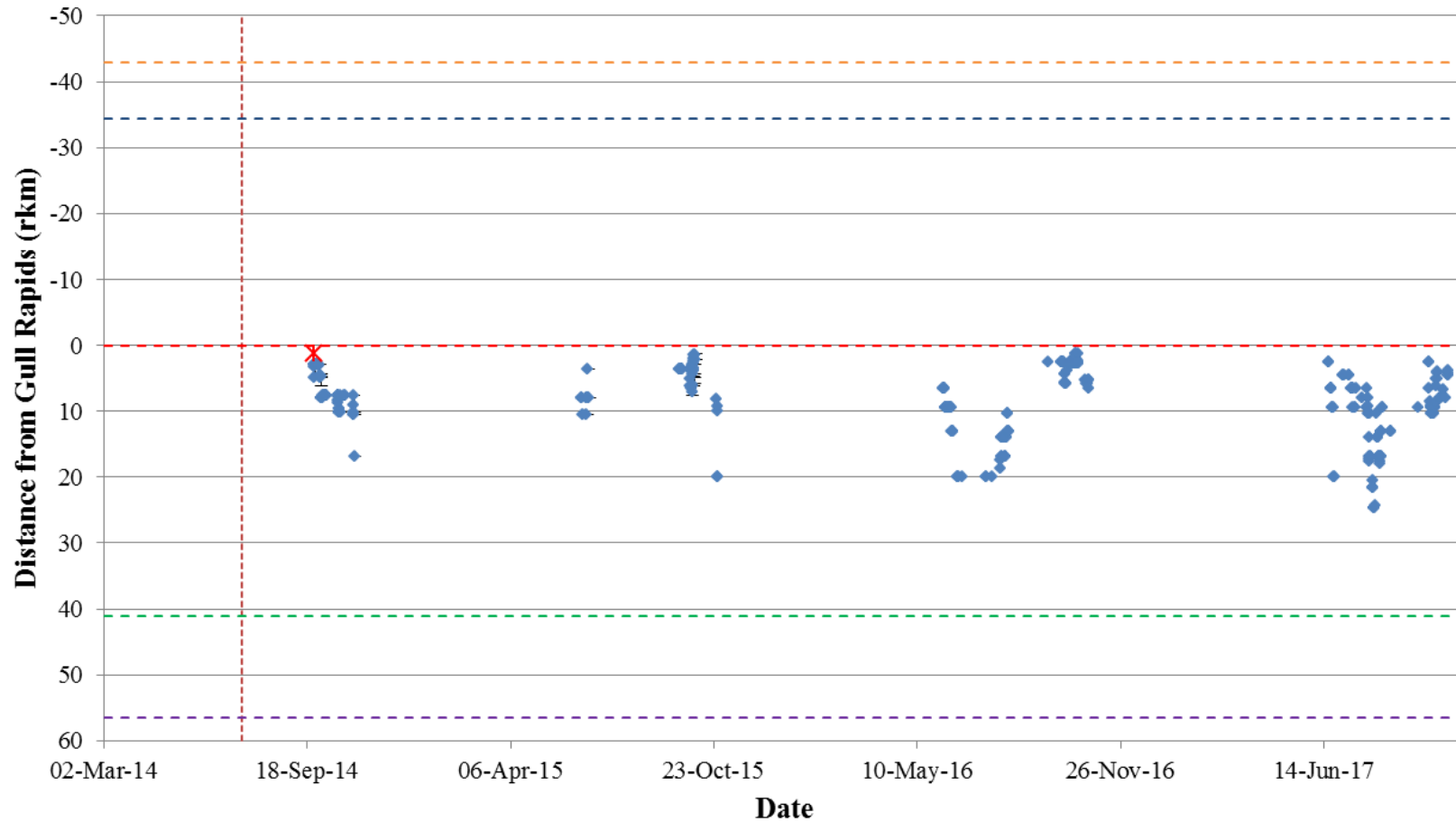
**Figure A3-13: Position of a Lake Whitefish tagged with an acoustic transmitter (code #6369) in Stephens Lake, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**



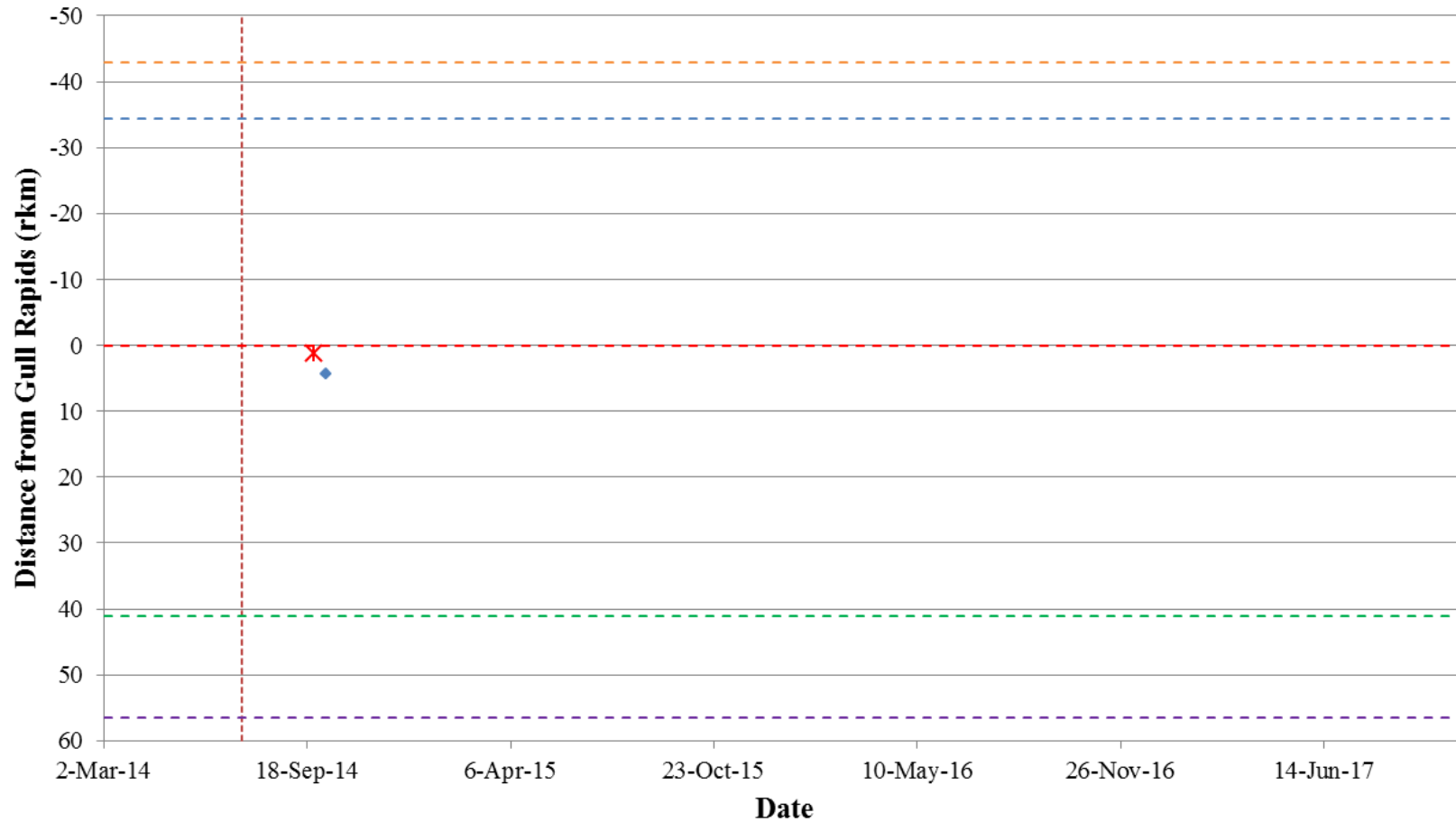
**Figure A3-14: Position of a Lake Whitefish tagged with an acoustic transmitter (code #6370) in Stephens Lake, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**



**Figure A3-15: Position of a Lake Whitefish tagged with an acoustic transmitter (code #6371) in Stephens Lake, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**



**Figure A3-16: Position of a Lake Whitefish tagged with an acoustic transmitter (code #6372) in Stephens Lake, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**



**Figure A3-17: Position of a Lake Whitefish tagged with an acoustic transmitter (code #6373) in Stephens Lake, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**



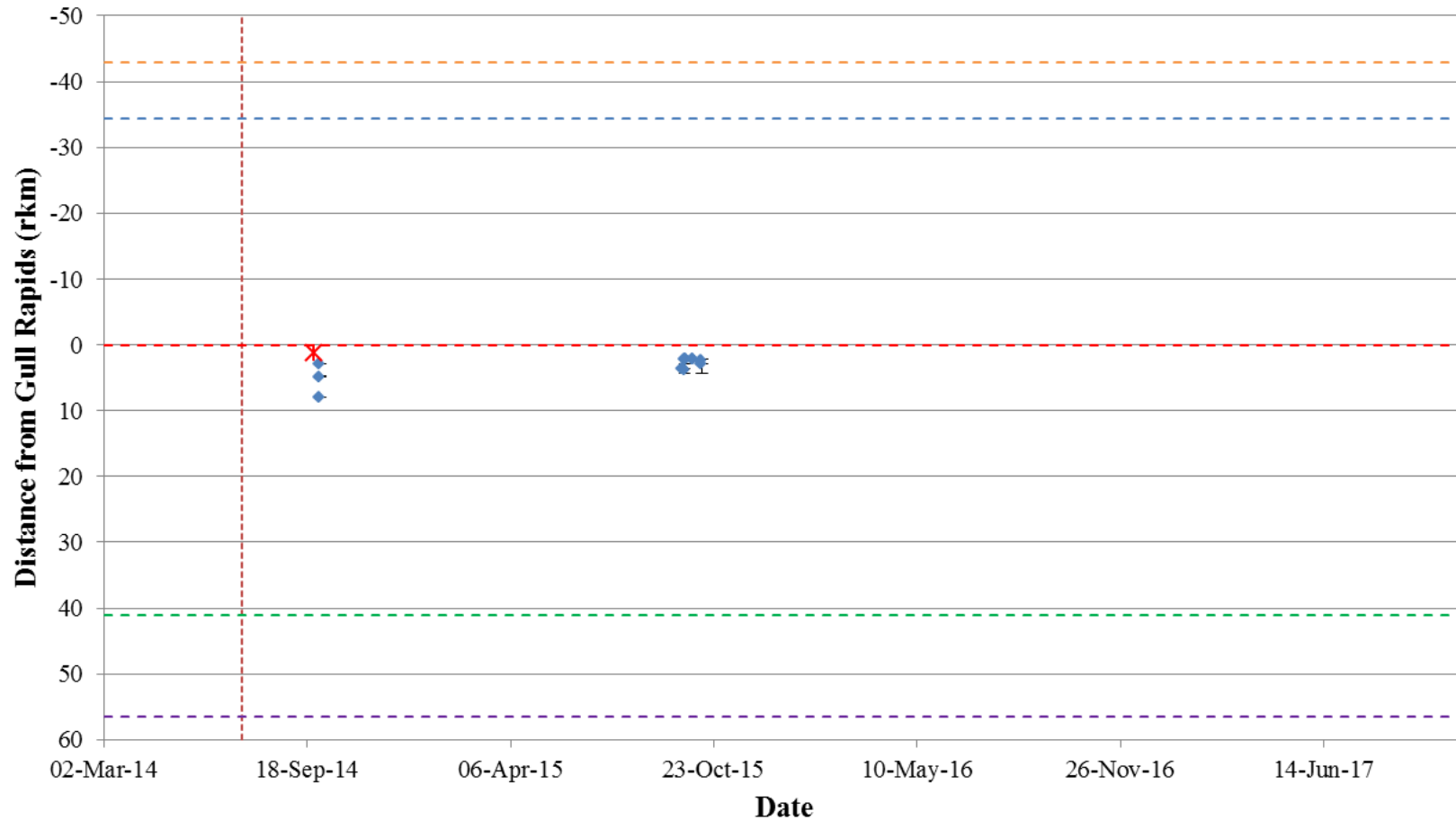
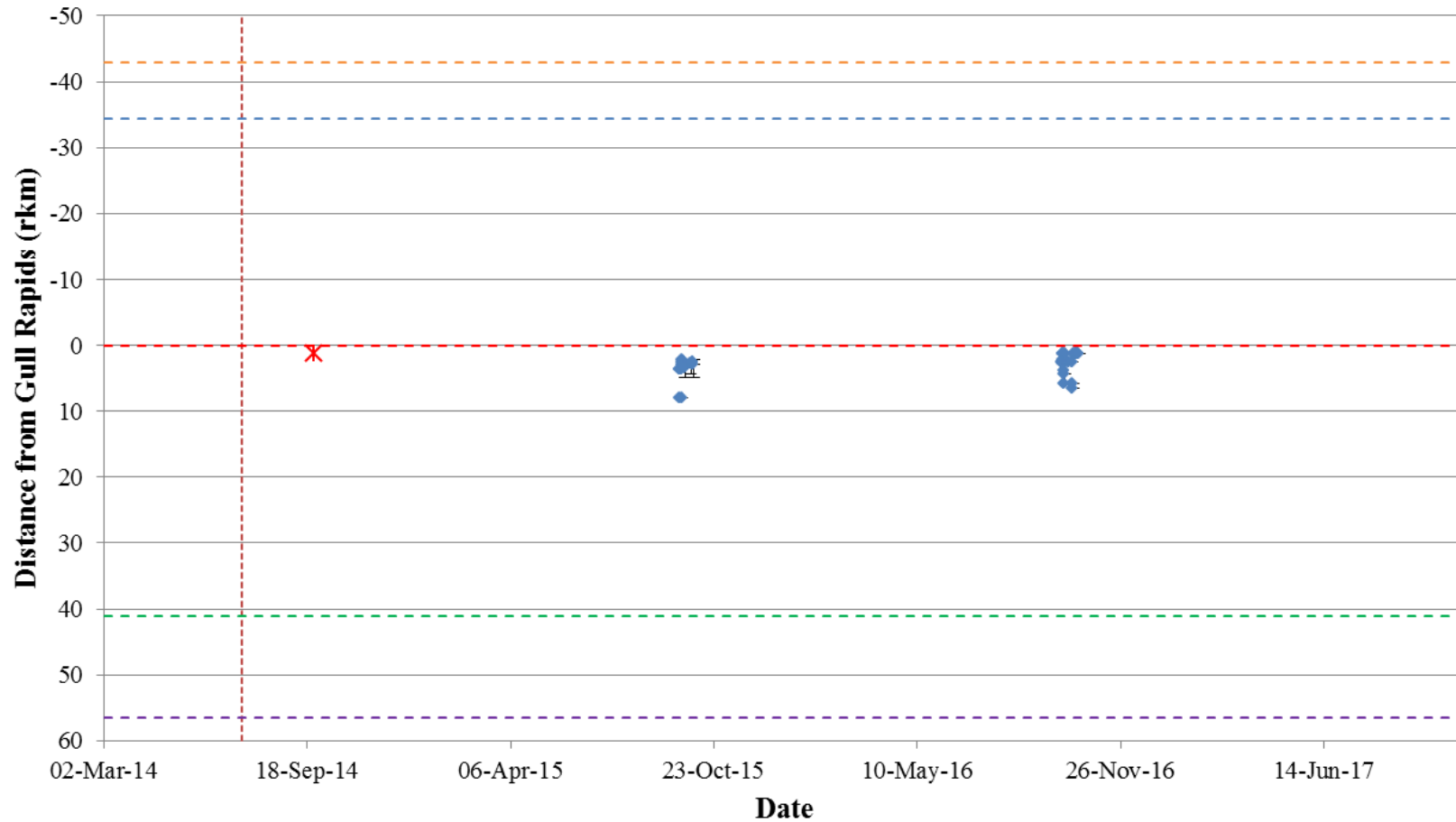
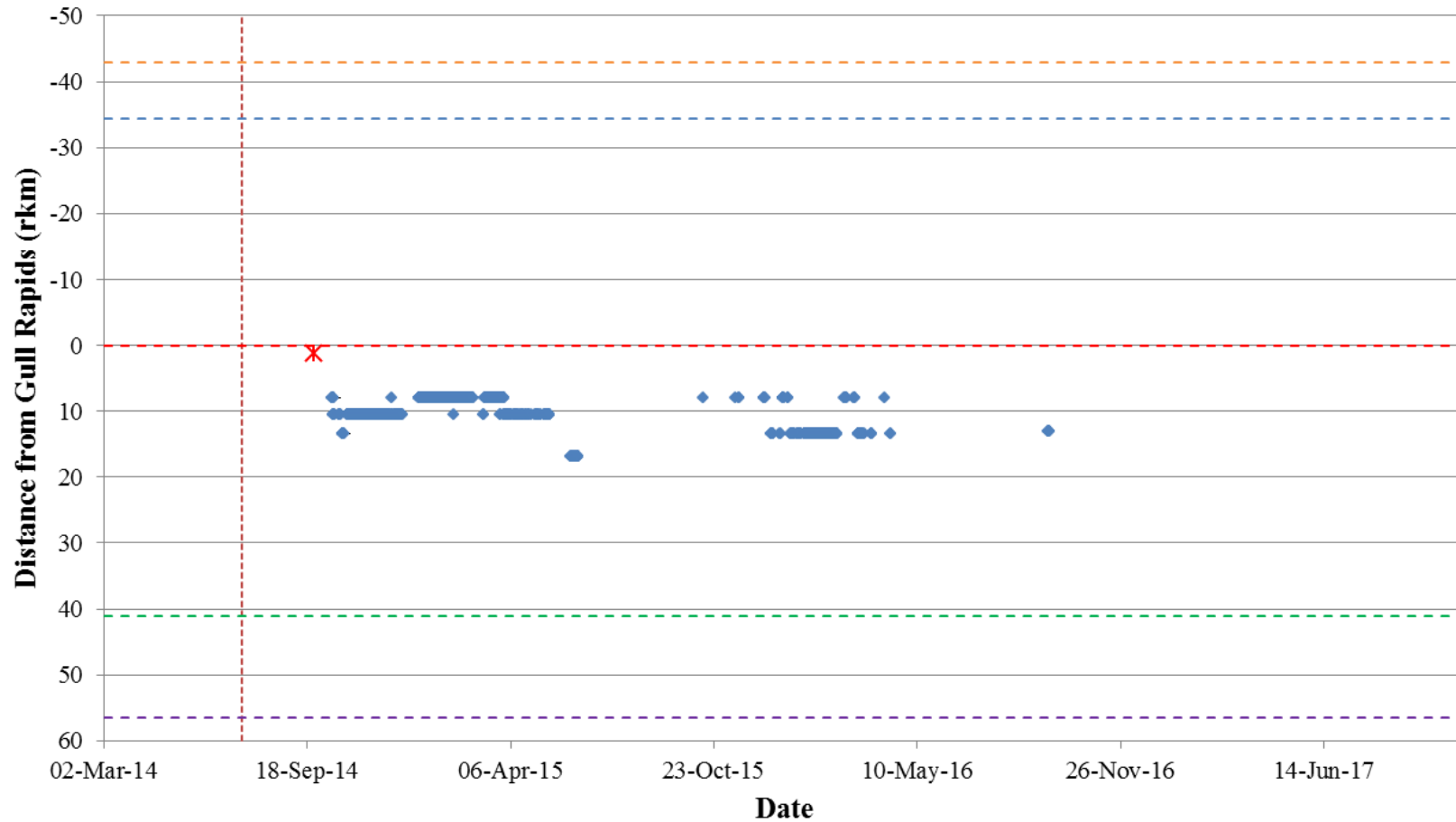


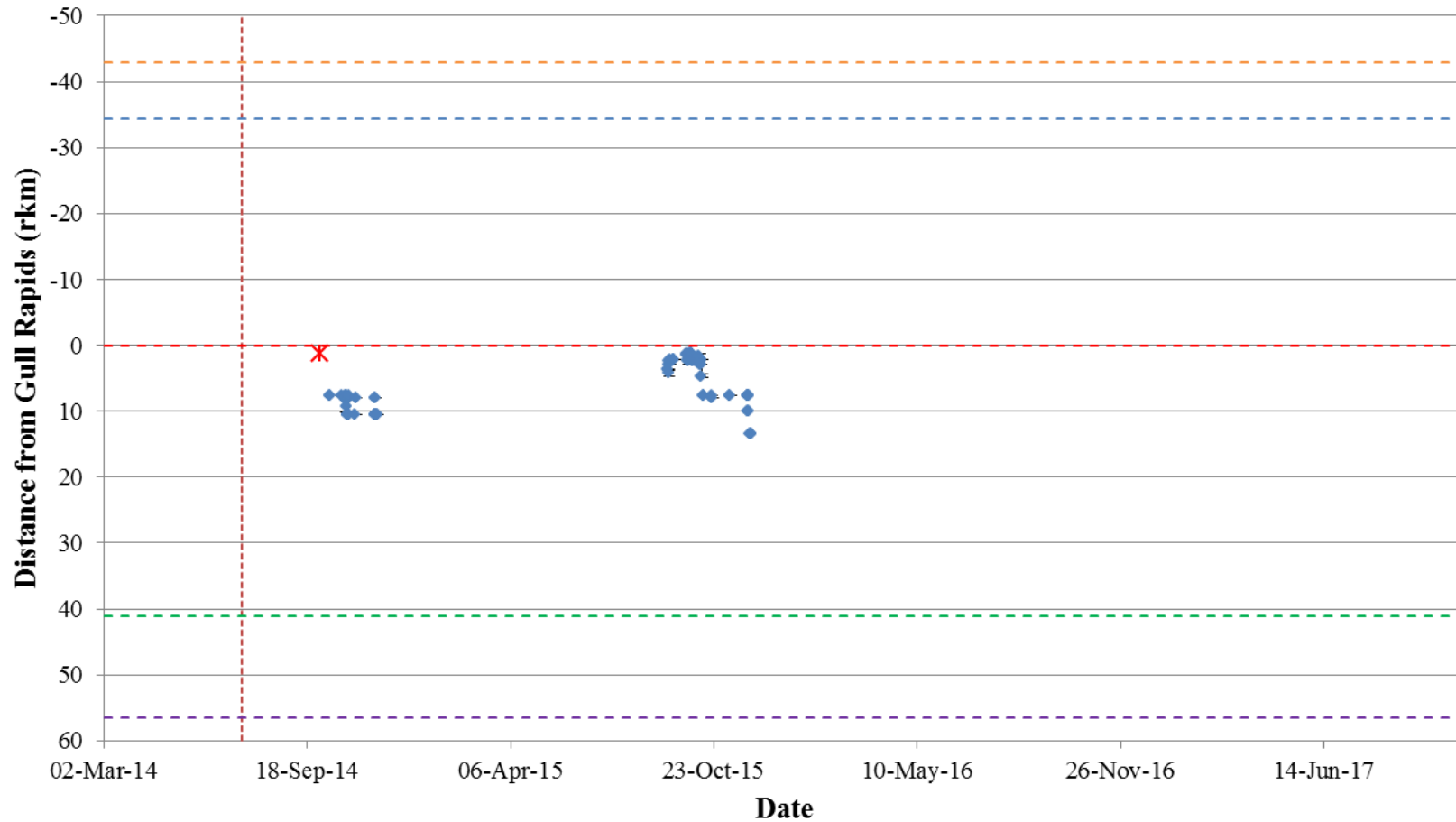
Figure A3-18: Position of a Lake Whitefish tagged with an acoustic transmitter (code #6374) in Stephens Lake, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).



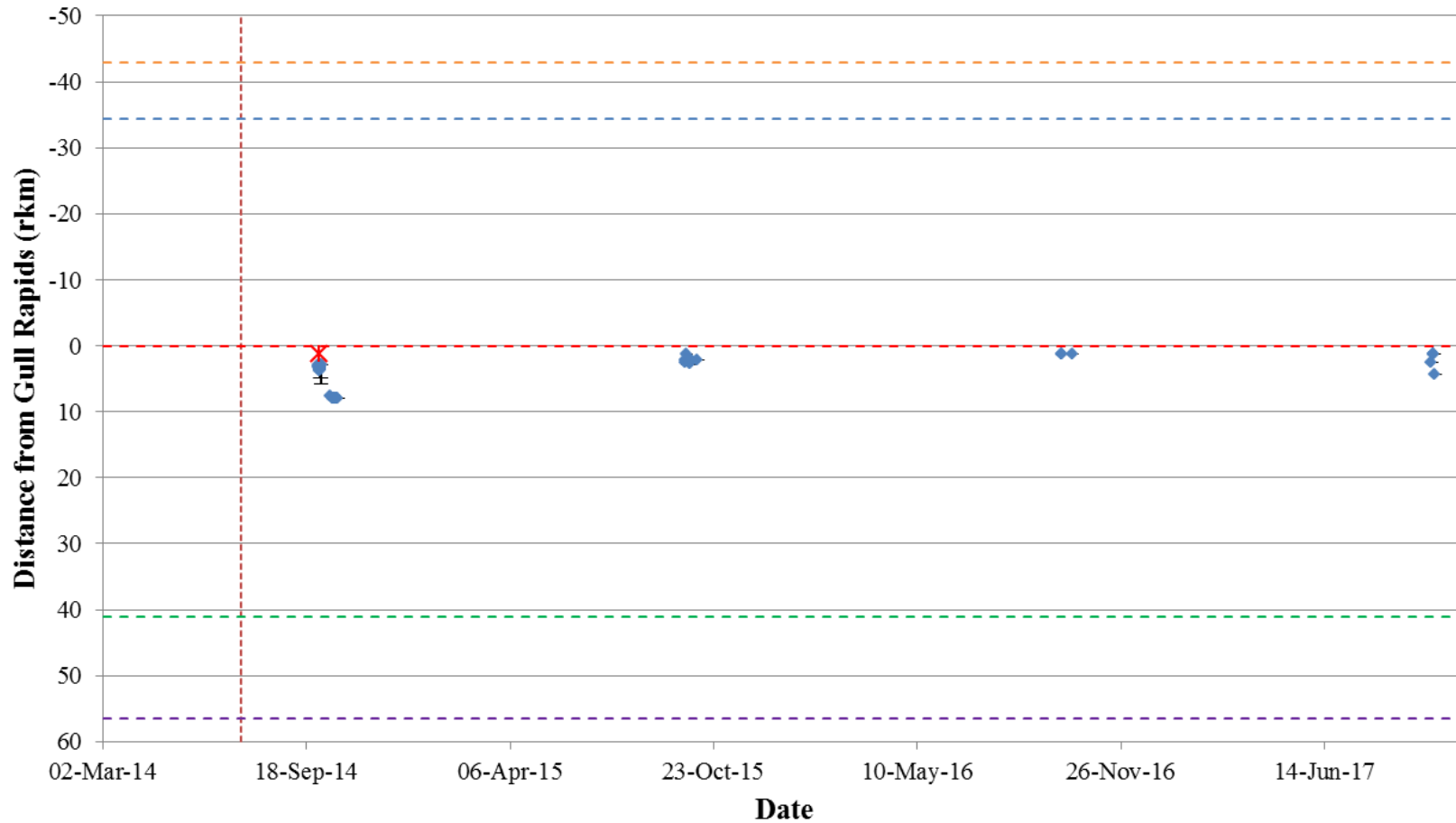
**Figure A3-19: Position of a Lake Whitefish tagged with an acoustic transmitter (code #6375) in Stephens Lake, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**



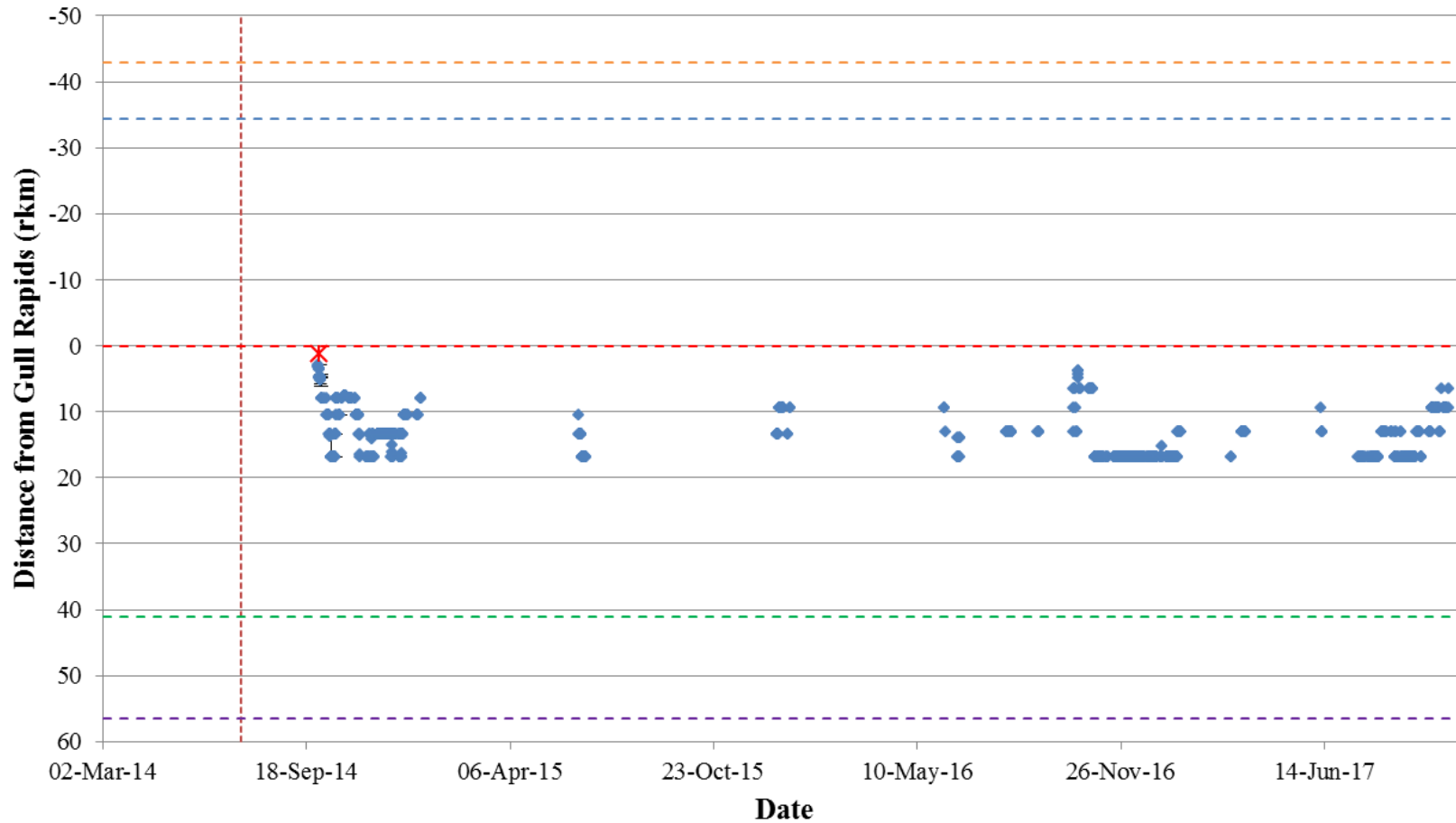
**Figure A3-20: Position of a Lake Whitefish tagged with an acoustic transmitter (code #6376) in Stephens Lake, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**



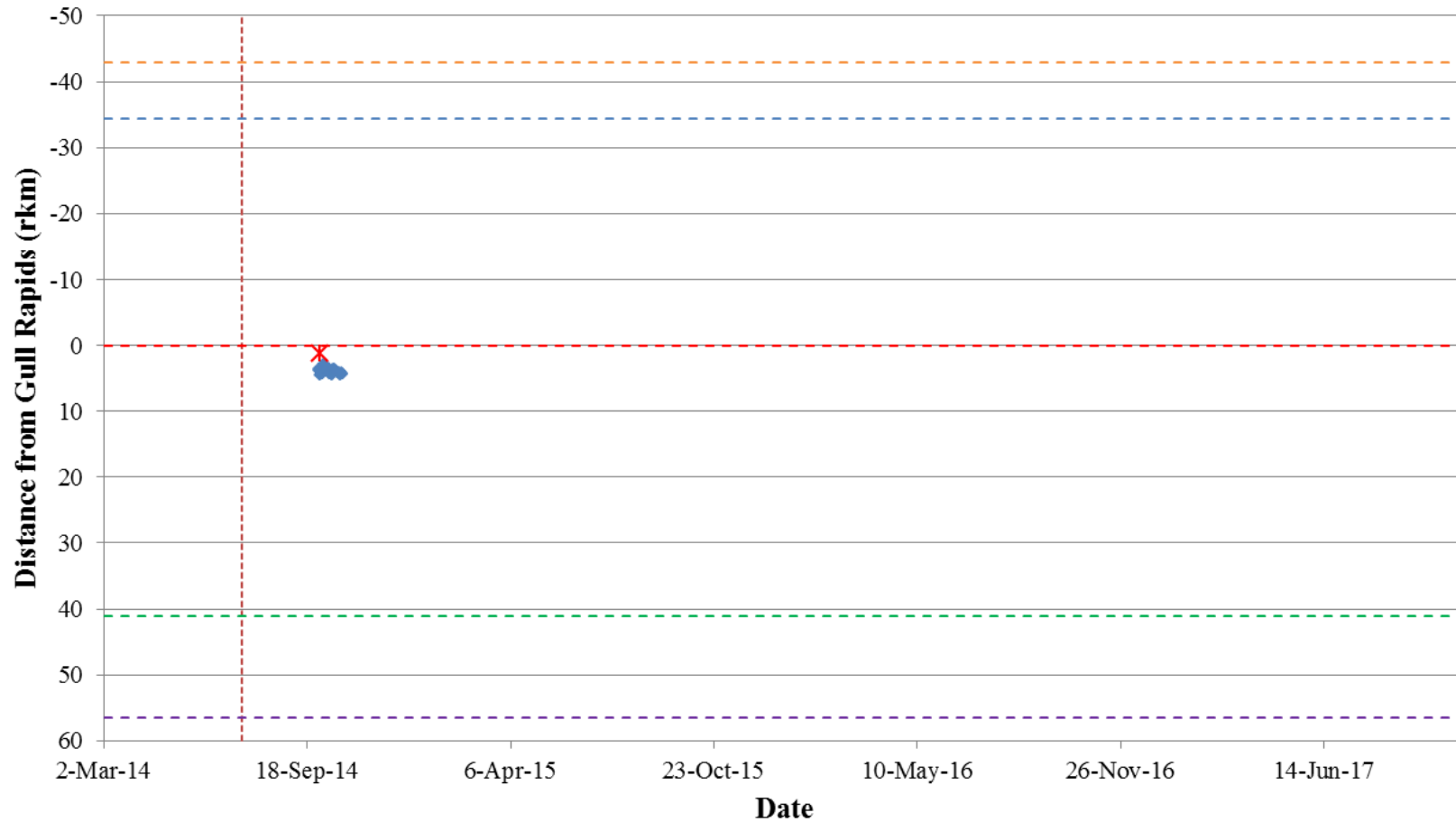
**Figure A3-21: Position of a Lake Whitefish tagged with an acoustic transmitter (code #33794) in Stephens Lake, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**



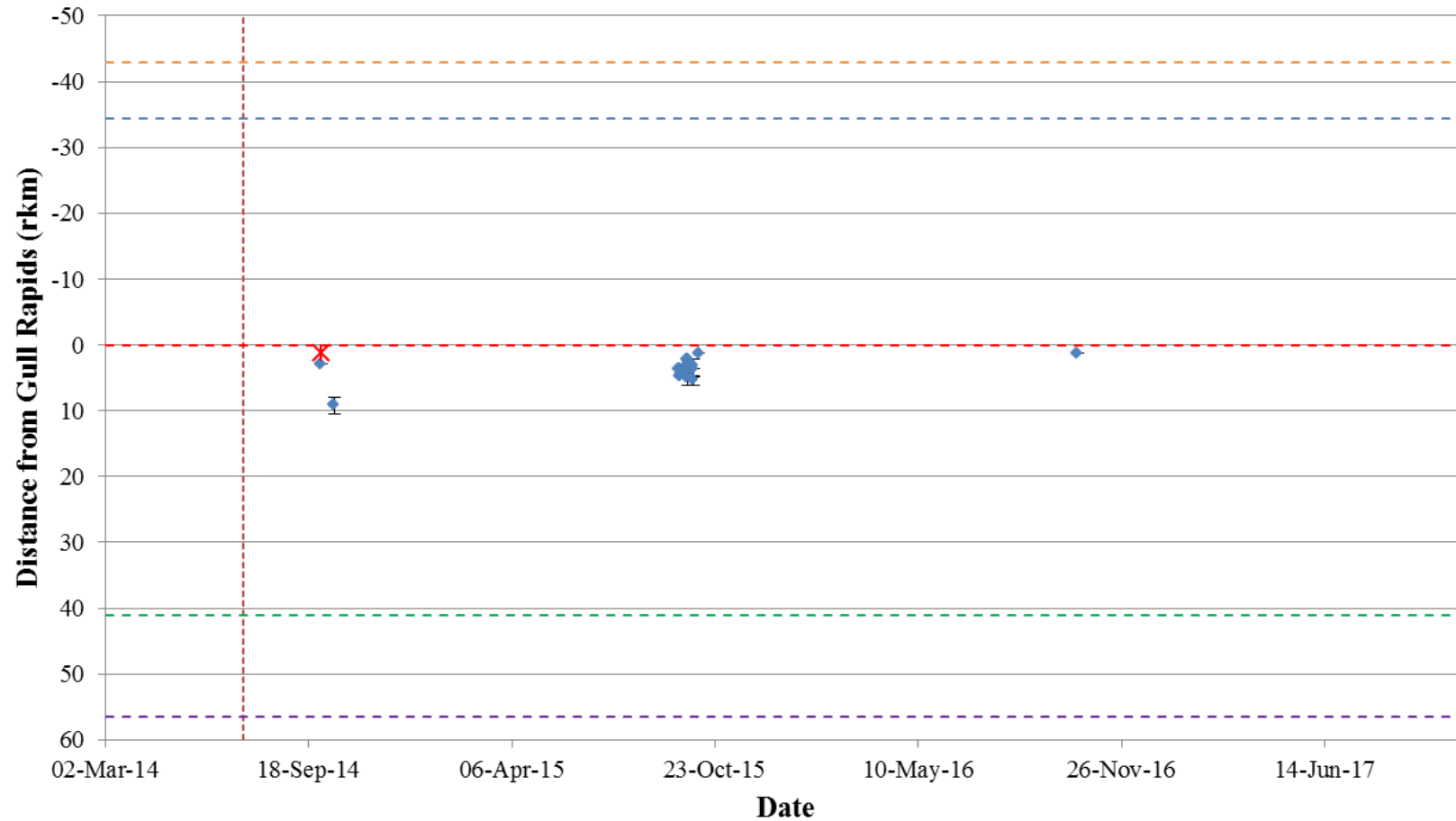
**Figure A3-22: Position of a Lake Whitefish tagged with an acoustic transmitter (code #33795) in Stephens Lake, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**



**Figure A3-23: Position of a Lake Whitefish tagged with an acoustic transmitter (code #33796) in Stephens Lake, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**

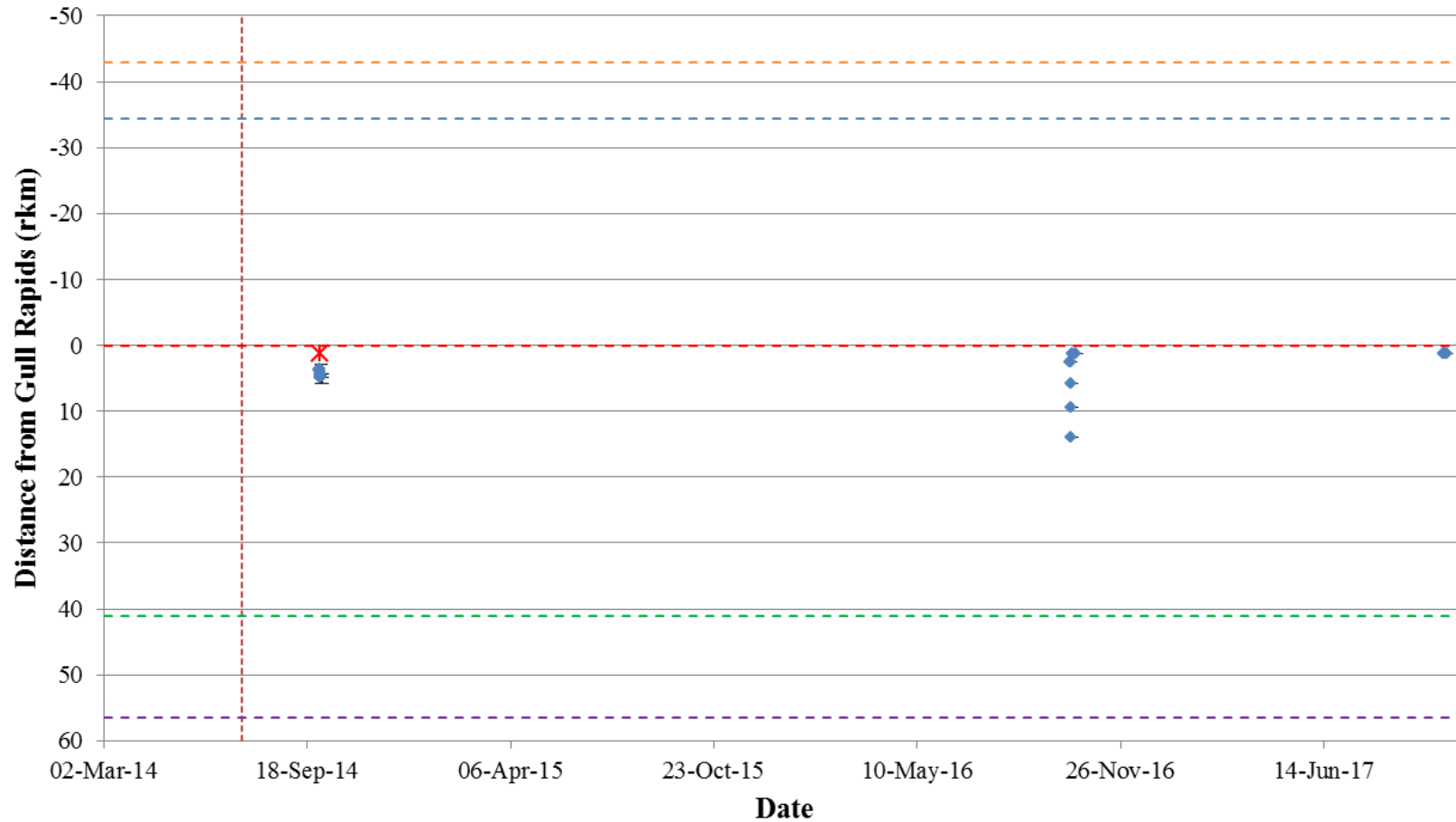


**Figure A3-24: Position of a Lake Whitefish tagged with an acoustic transmitter (code #33799) in Stephens Lake, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**

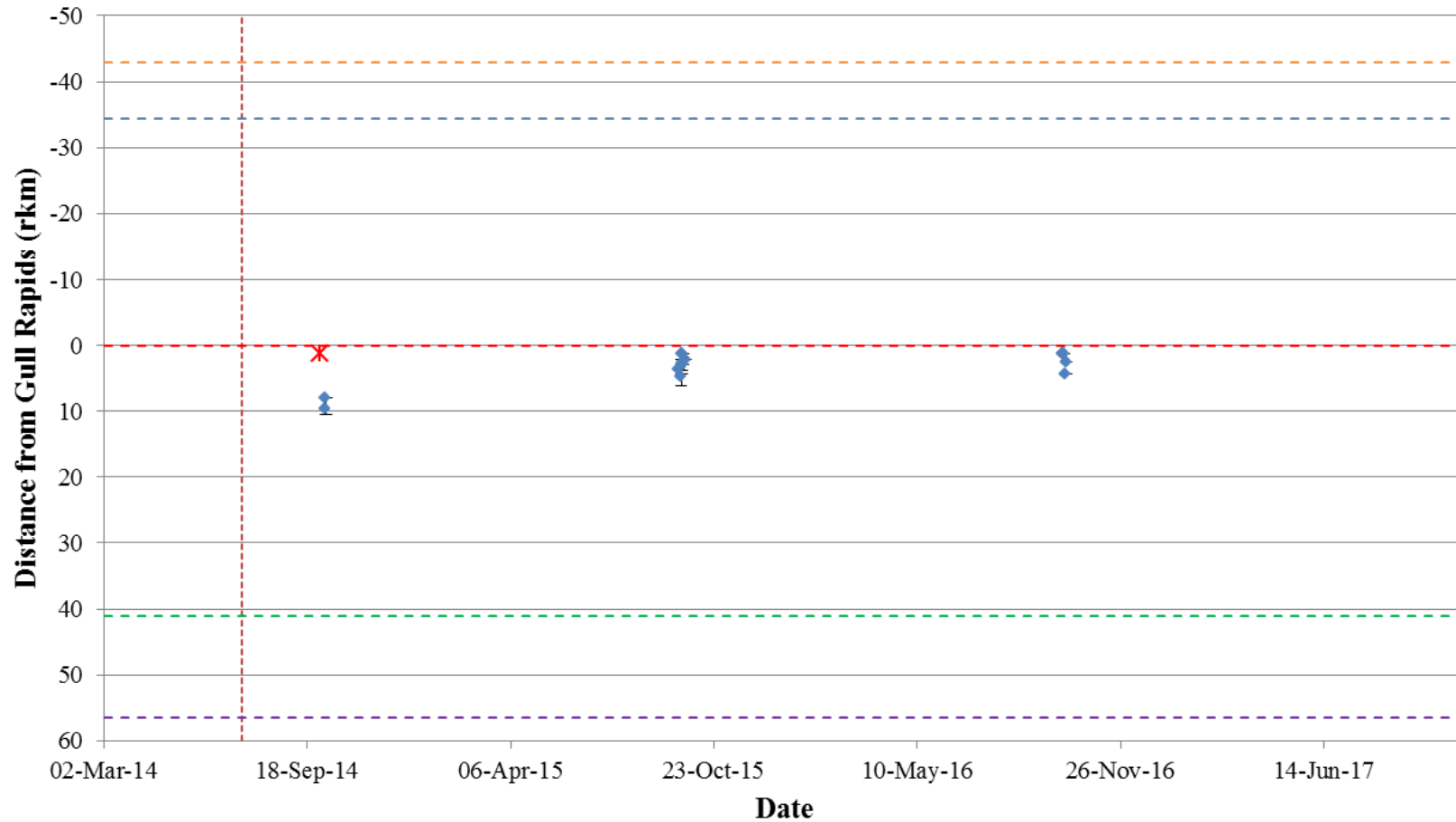


**Figure A3-25: Position of a Lake Whitefish tagged with an acoustic transmitter (code #33810) in Stephens Lake, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**





**Figure A3-26: Position of a Lake Whitefish tagged with an acoustic transmitter (code #33811) in Stephens Lake, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**



**Figure A3-27: Position of a Lake Whitefish tagged with an acoustic transmitter (code #33814) in Stephens Lake, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**

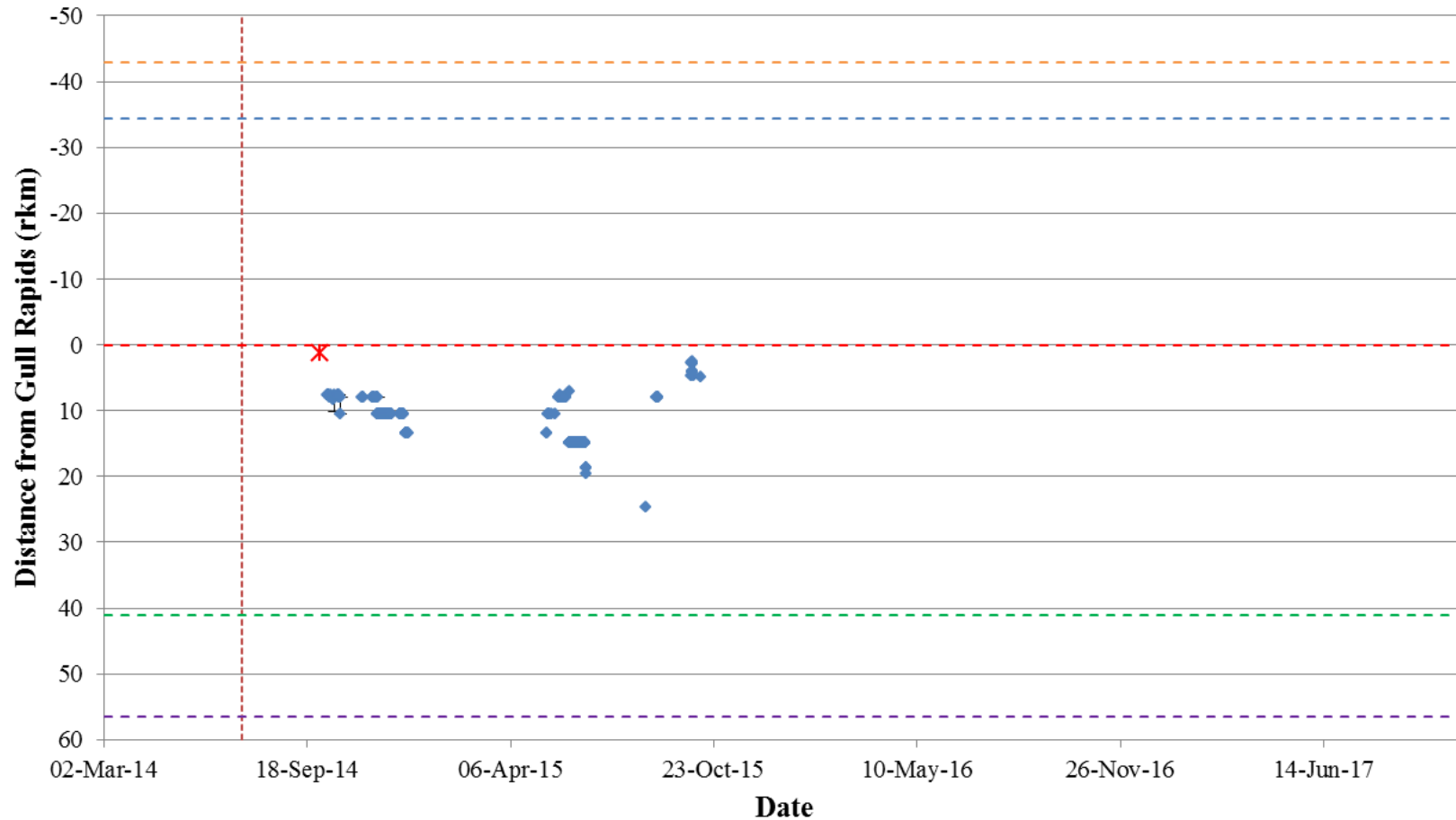
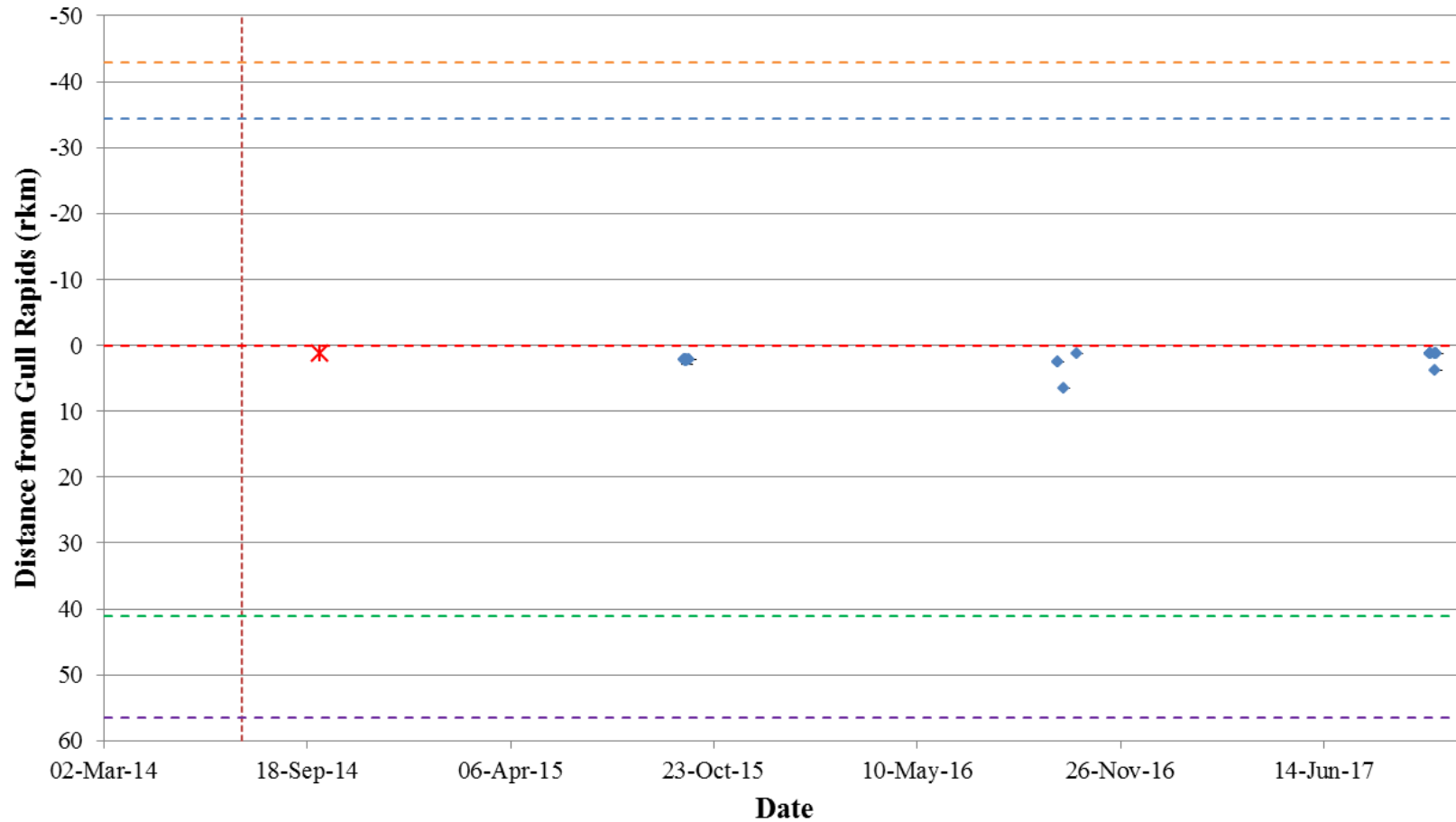
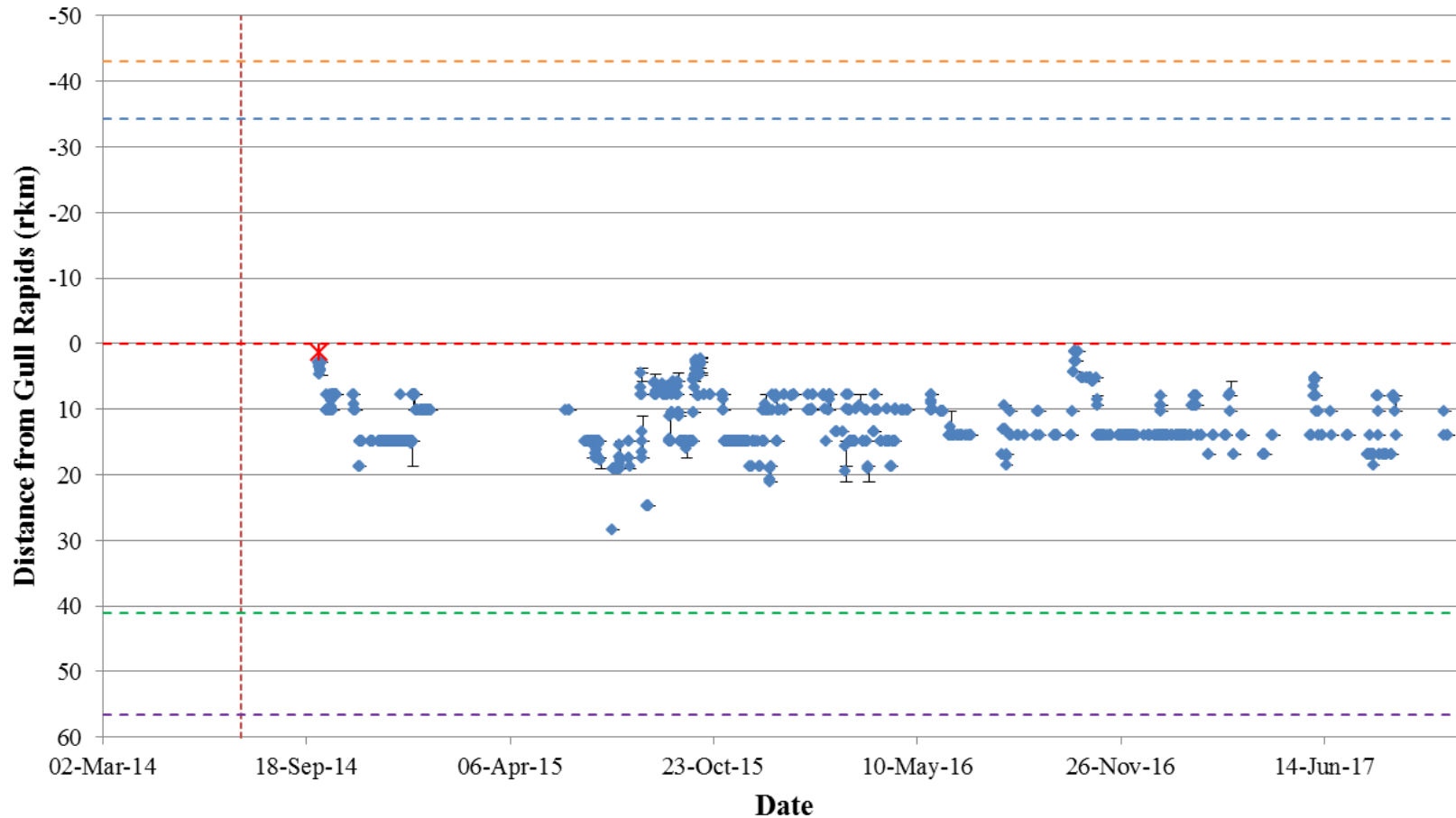


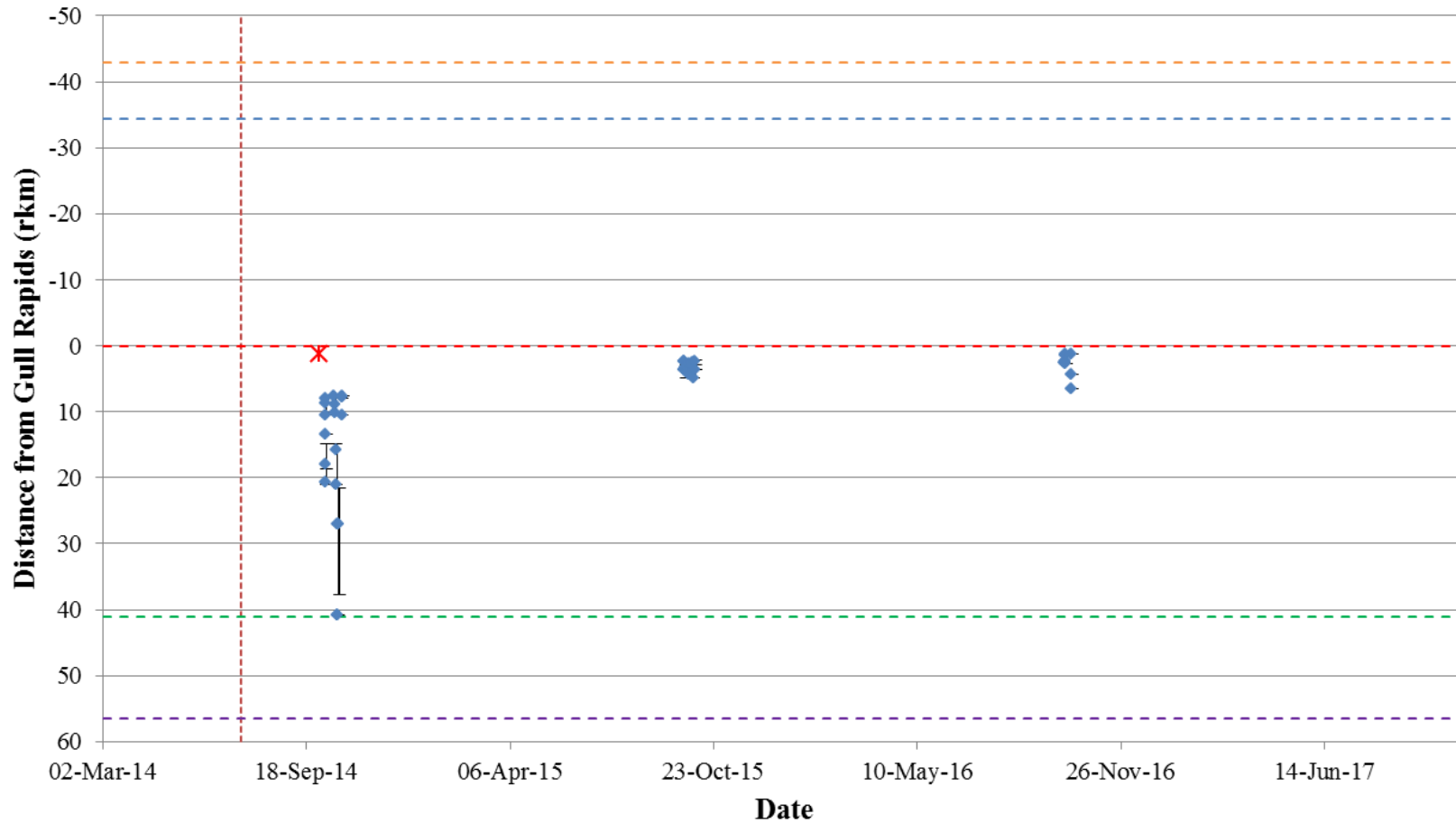
Figure A3-28: Position of a Lake Whitefish tagged with an acoustic transmitter (code #33815) in Stephens Lake, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).



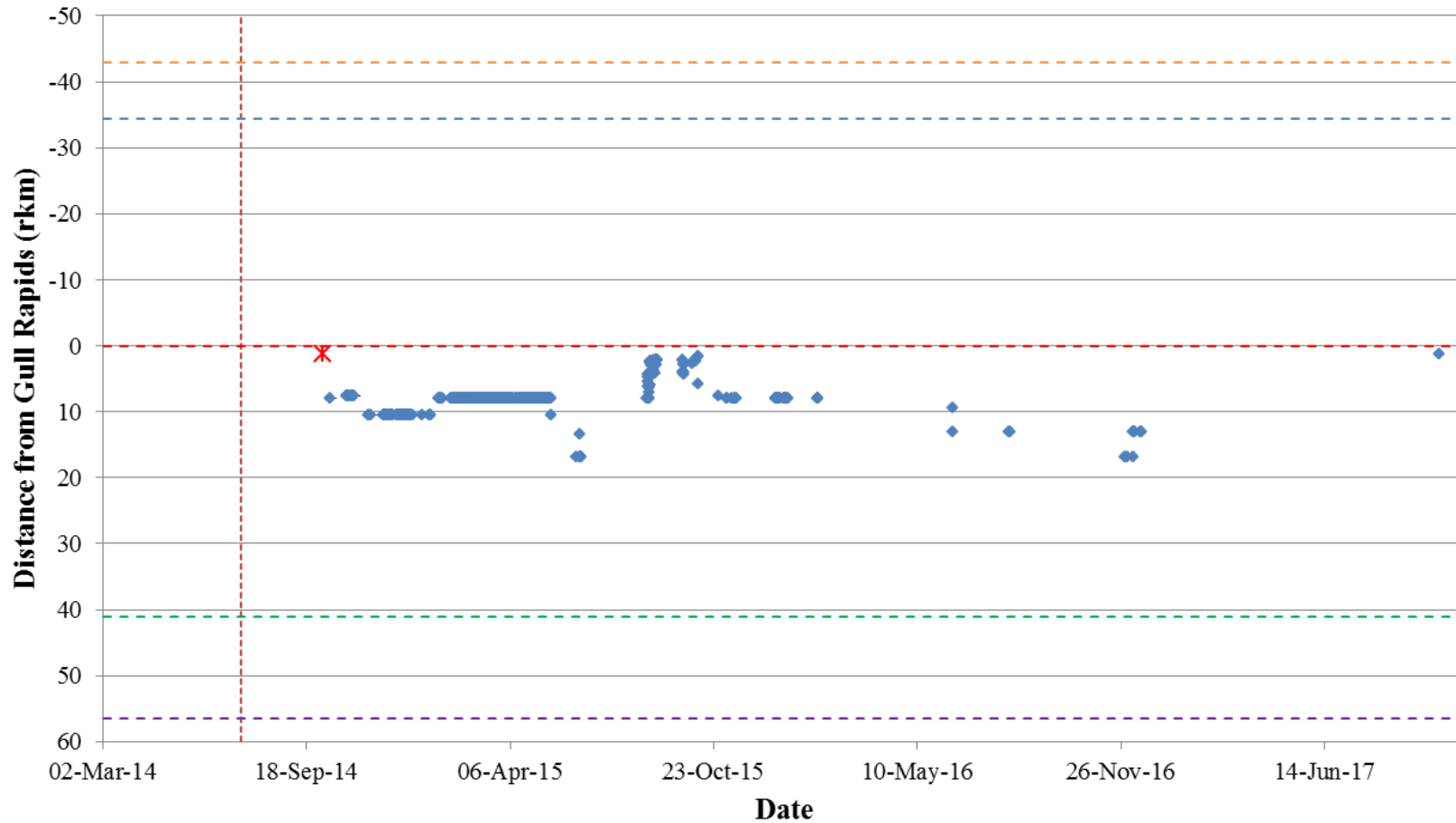
**Figure A3-29: Position of a Lake Whitefish tagged with an acoustic transmitter (code #33817) in Stephens Lake, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**



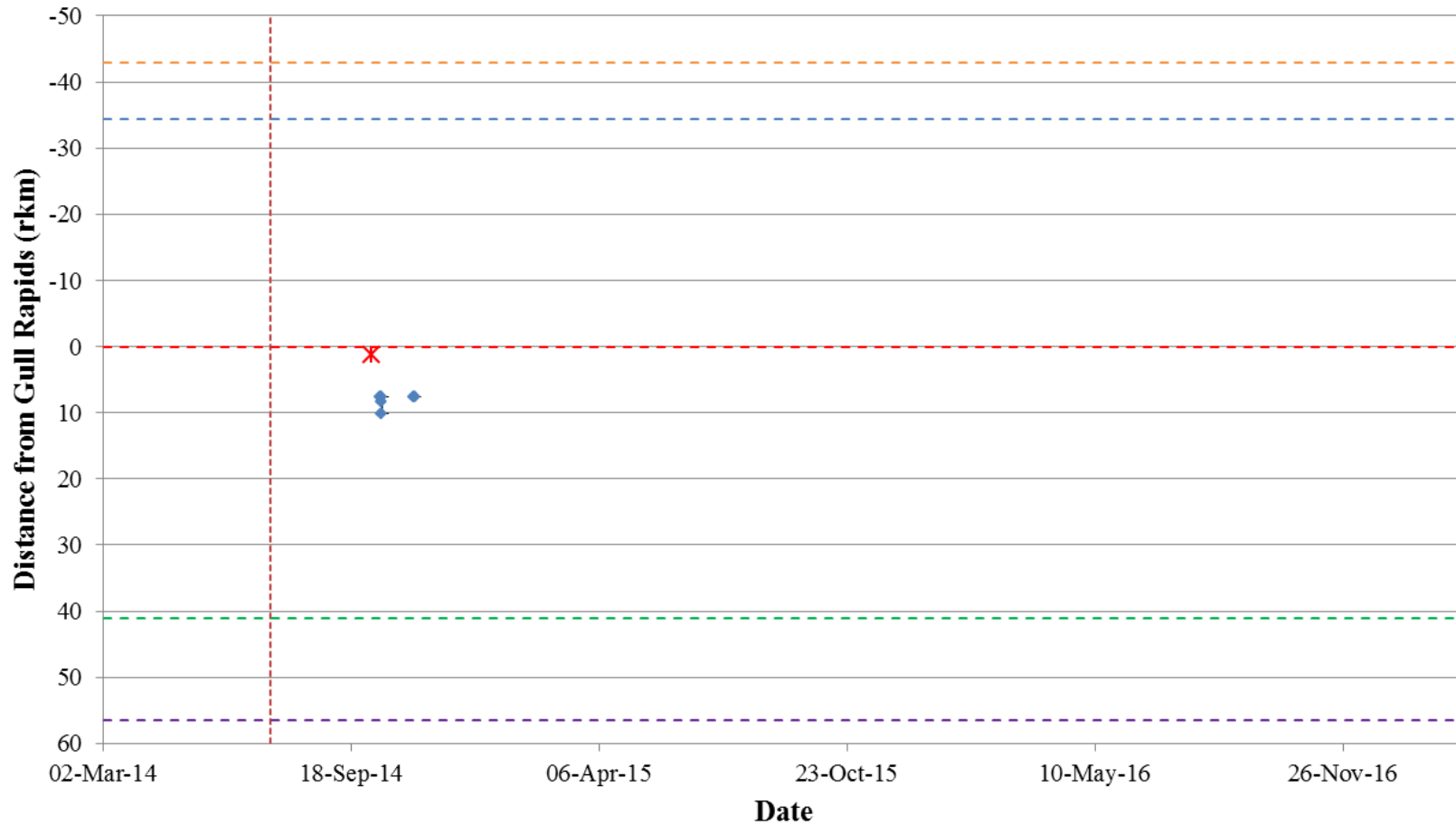
**Figure A3-30: Position of a Lake Whitefish tagged with an acoustic transmitter (code #33818) in Stephens Lake, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**



**Figure A3-31: Position of a Lake Whitefish tagged with an acoustic transmitter (code #33819) in Stephens Lake, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**

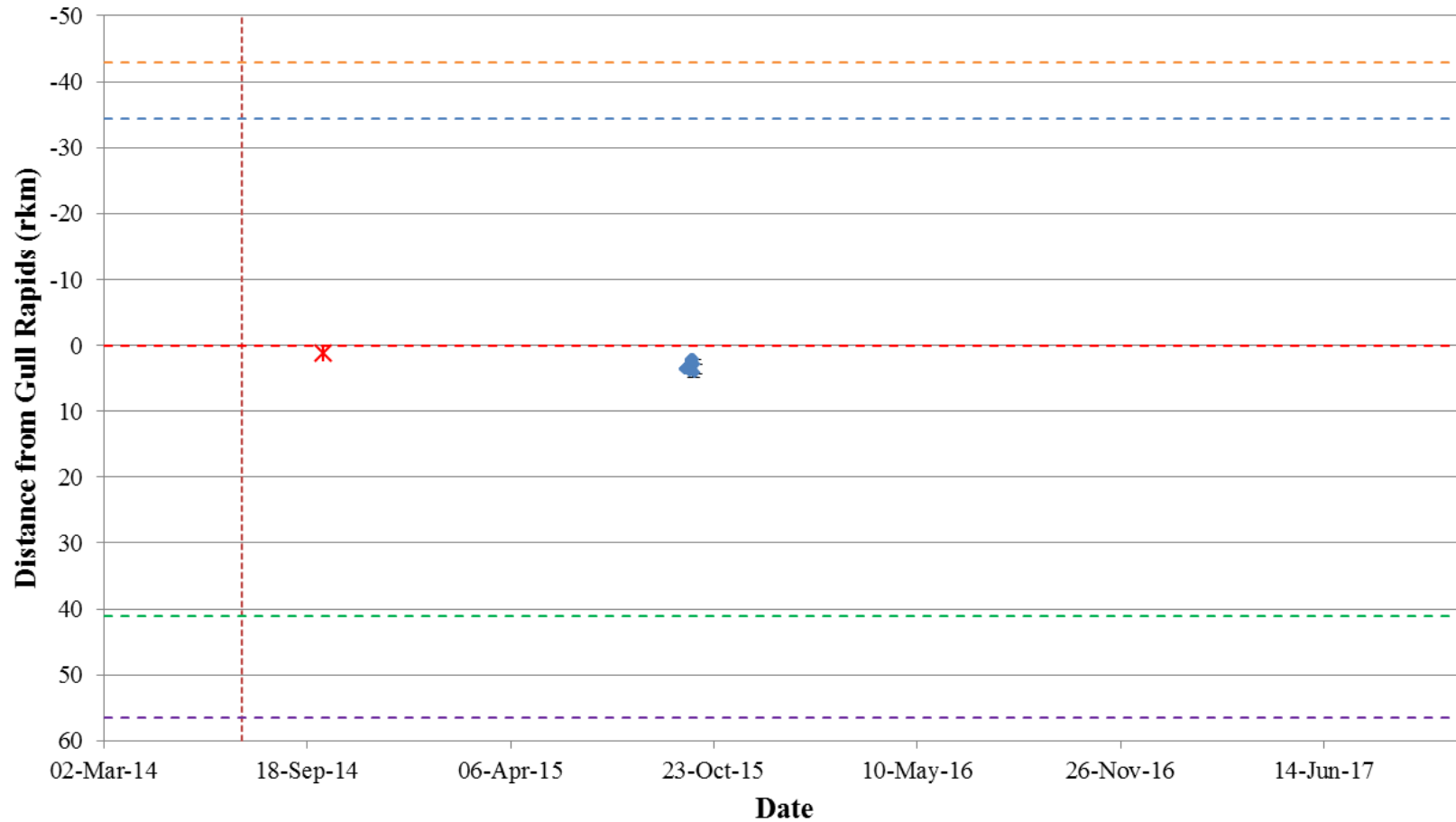


**Figure A3-32: Position of a Lake Whitefish tagged with an acoustic transmitter (code #33821) in Stephens Lake, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**

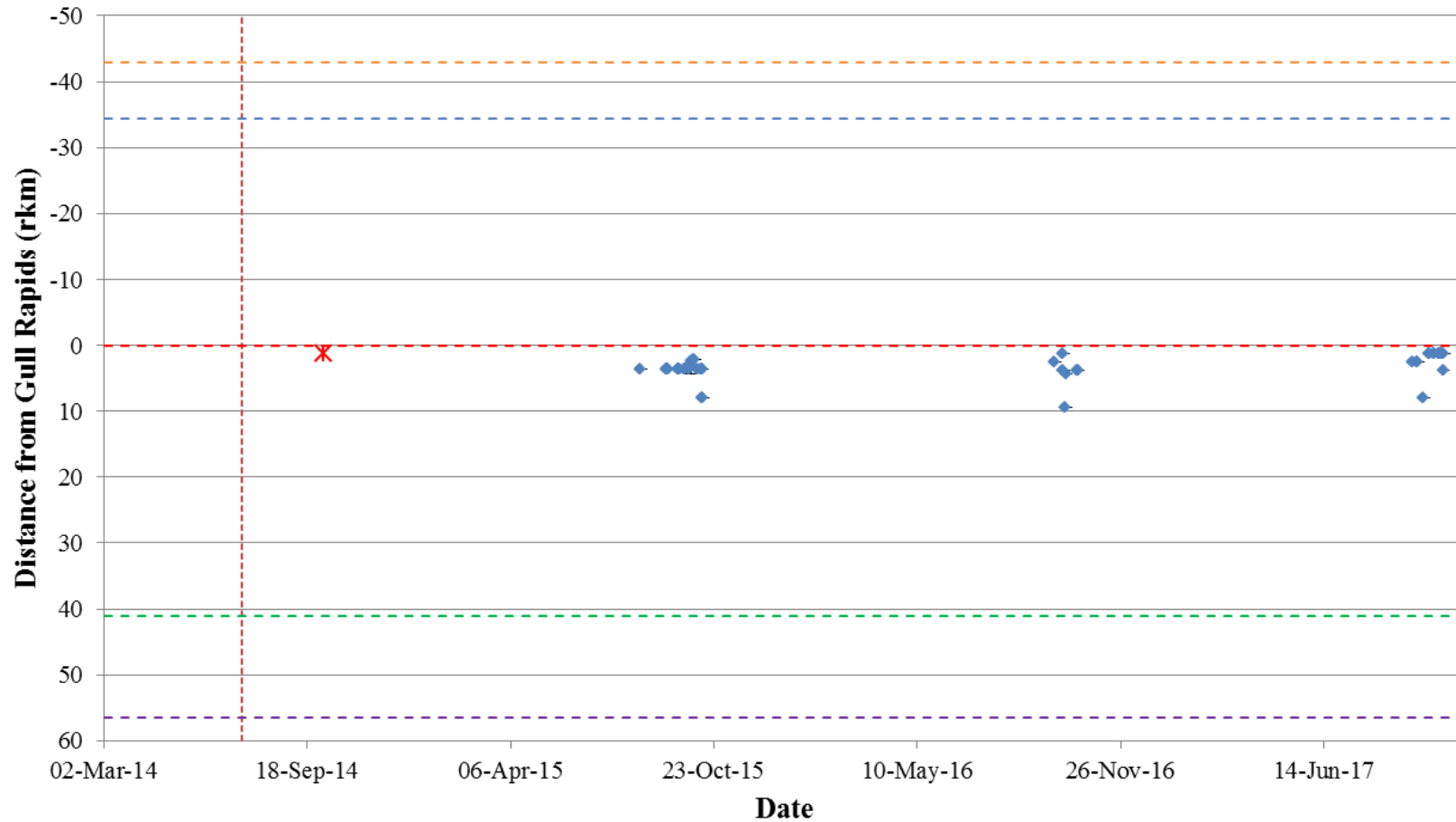


**Figure A3-33: Position of a Lake Whitefish tagged with an acoustic transmitter (code #33823) in Stephens Lake, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**

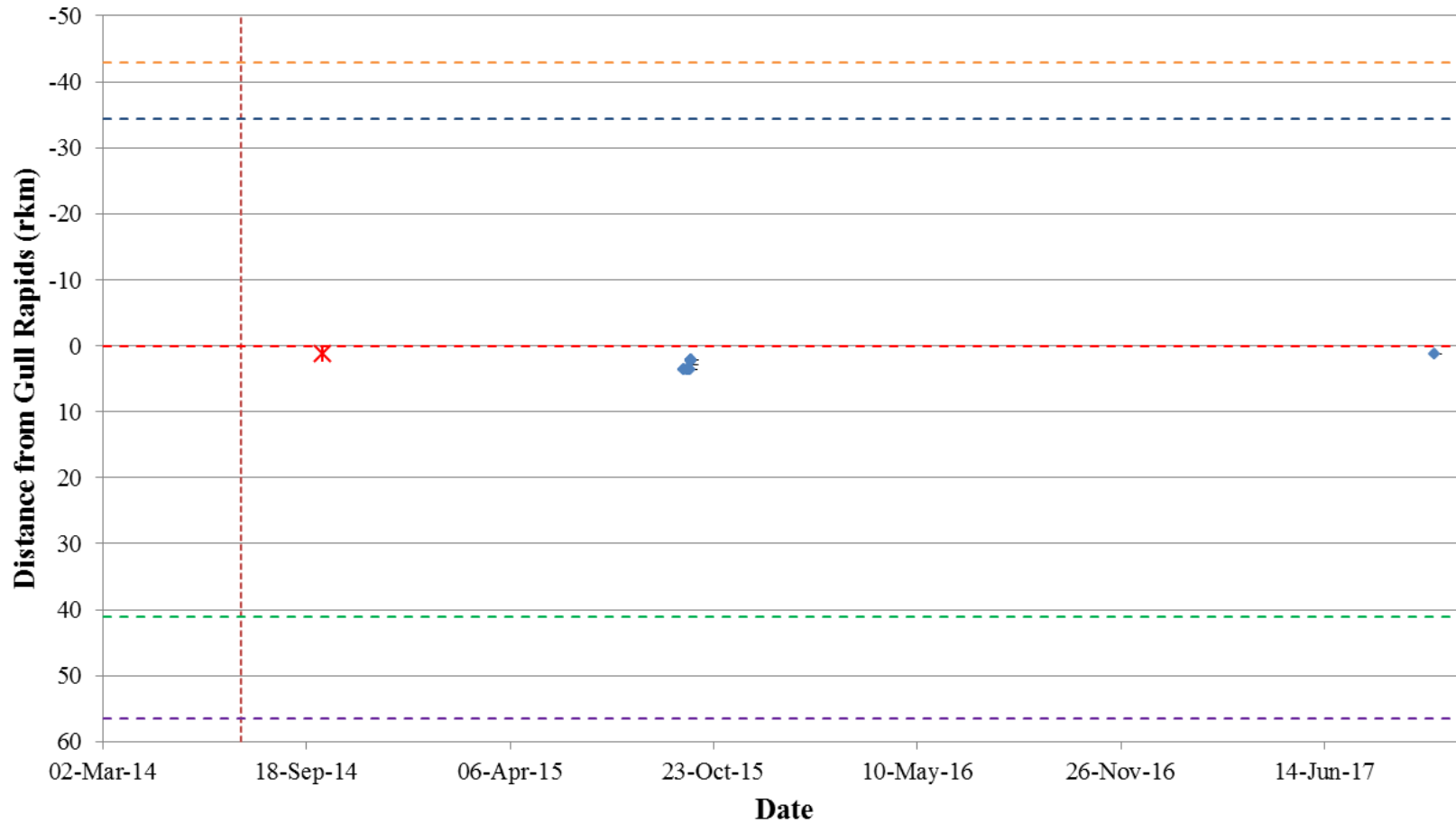




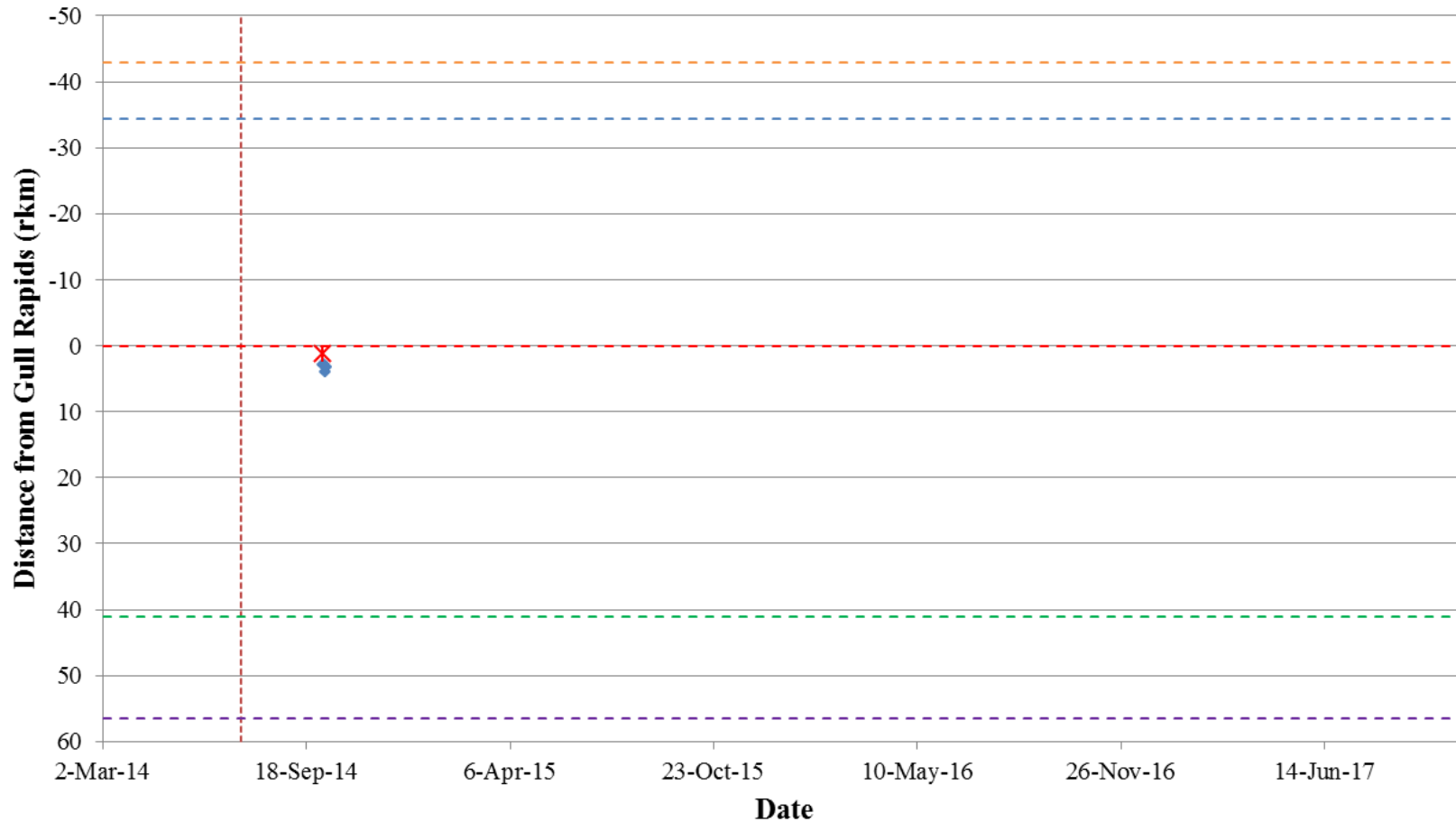
**Figure A3-34: Position of a Lake Whitefish tagged with an acoustic transmitter (code #33824) in Stephens Lake, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**



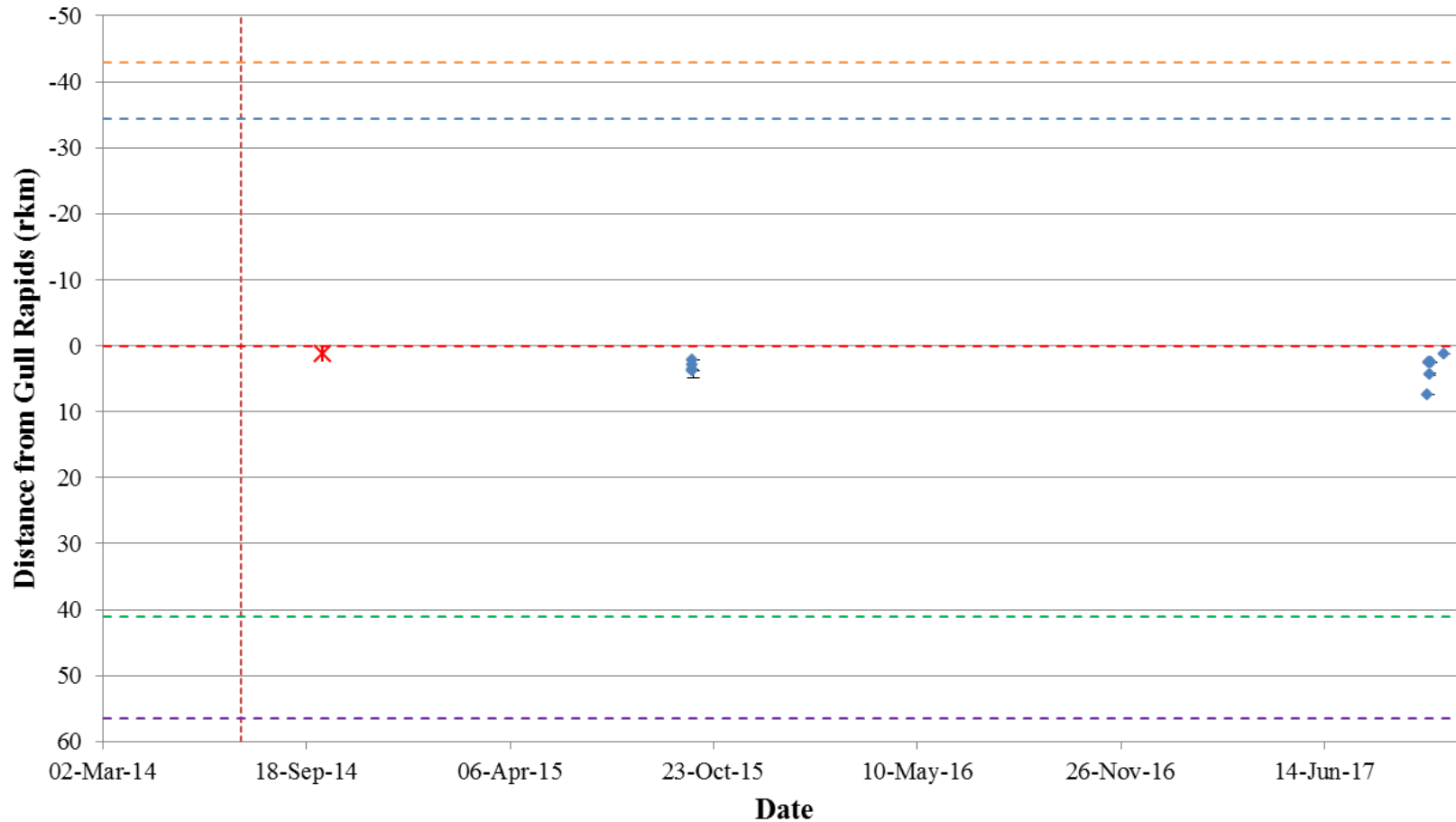
**Figure A3-35: Position of a Lake Whitefish tagged with an acoustic transmitter (code #33825) in Stephens Lake, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**



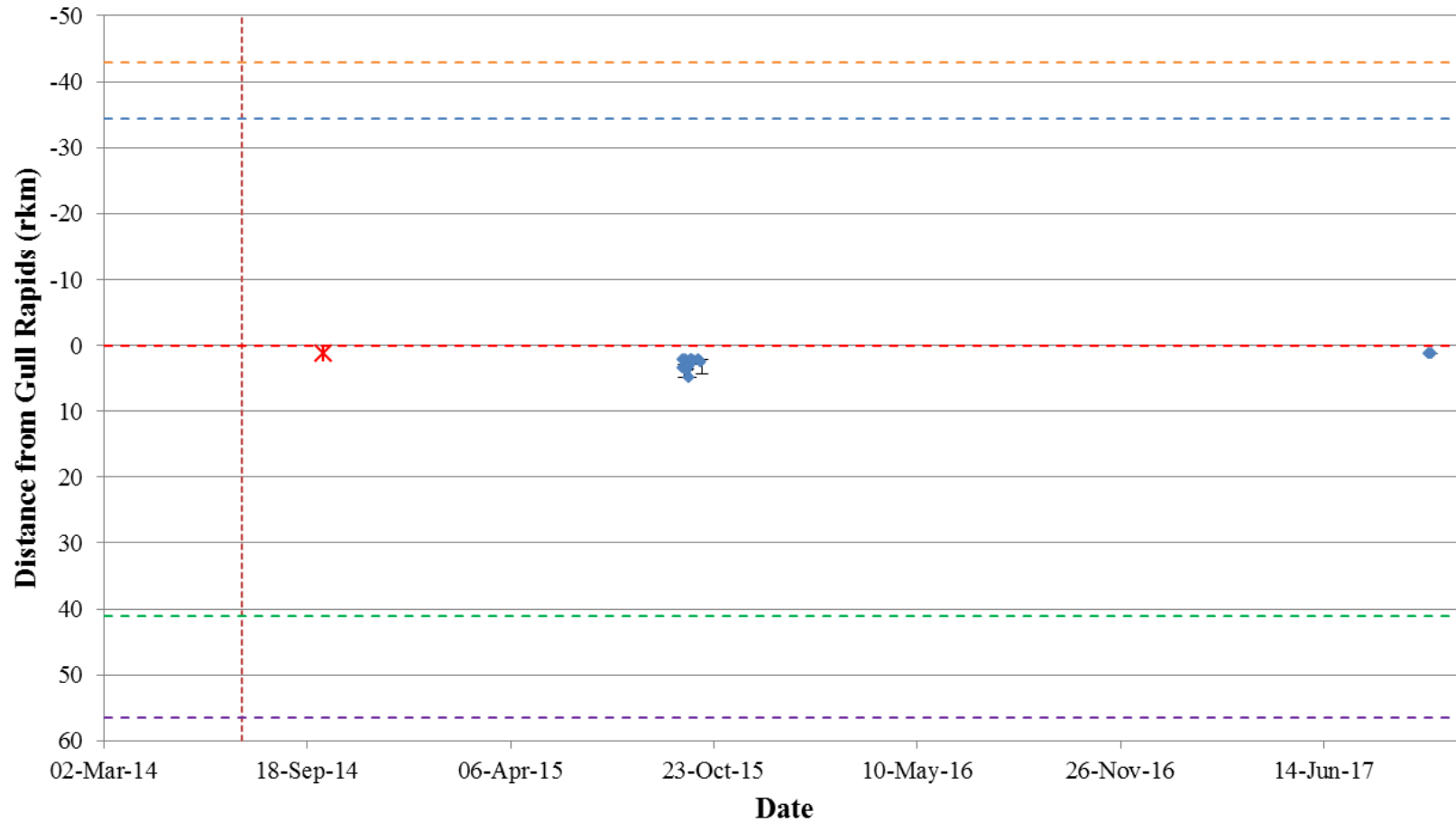
**Figure A3-36: Position of a Lake Whitefish tagged with an acoustic transmitter (code #33827) in Stephens Lake, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**



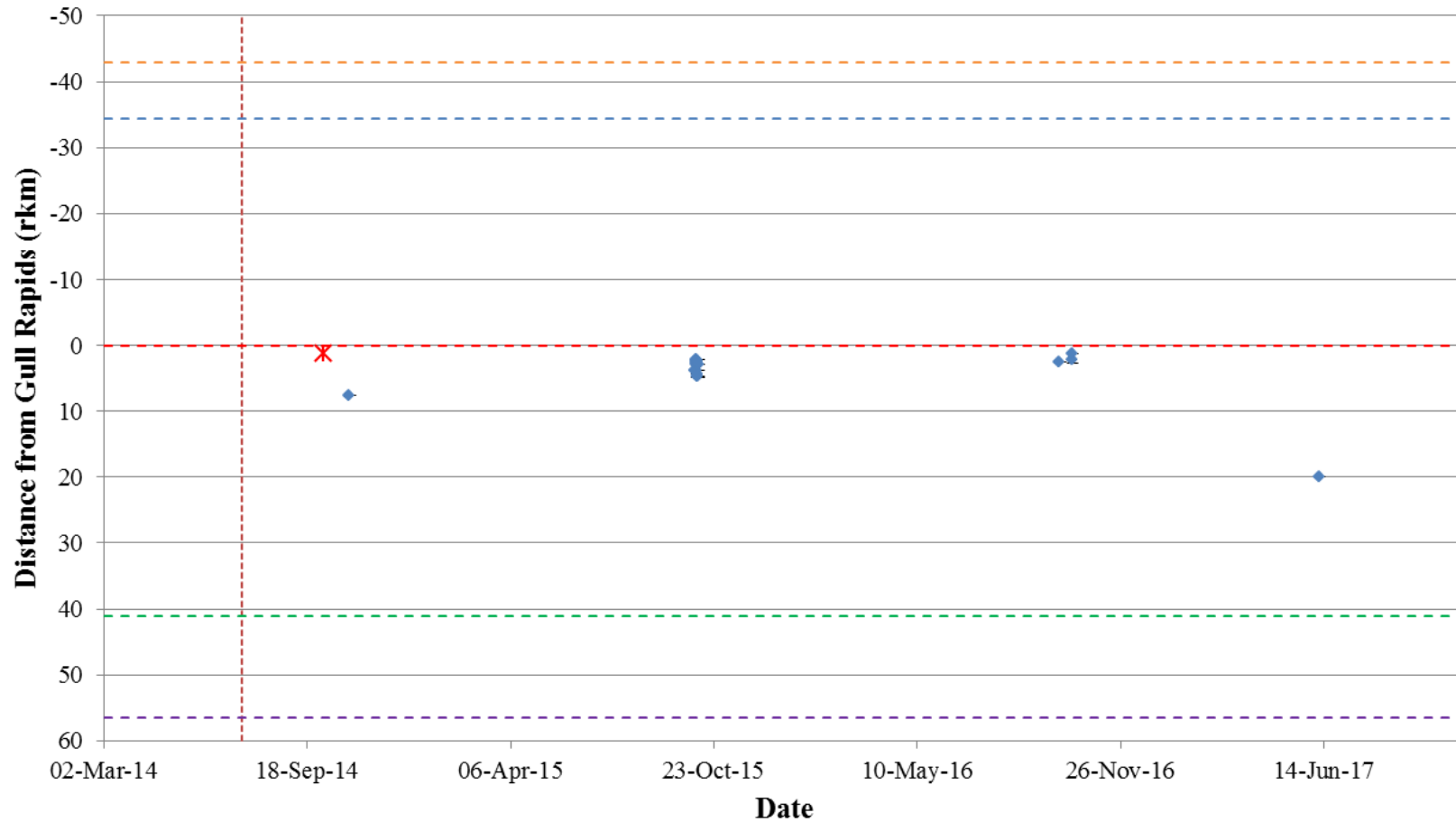
**Figure A3-37: Position of a Lake Whitefish tagged with an acoustic transmitter (code #33828) in Stephens Lake, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**



**Figure A3-38: Position of a Lake Whitefish tagged with an acoustic transmitter (code #33829) in Stephens Lake, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**



**Figure A3-39: Position of a Lake Whitefish tagged with an acoustic transmitter (code #33831) in Stephens Lake, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**



**Figure A3-40: Position of a Lake Whitefish tagged with an acoustic transmitter (code #33832) in Stephens Lake, in relation to Gull Rapids (rkm 0), from September 2014 to October 2017. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS, purple = Long Spruce GS).**