Keeyask Generation Project

Aquatic Effects Monitoring Plan

Juvenile Lake Sturgeon Movement Monitoring Report

AEMP-2017-04

KEEYASK

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KEEYASK GENERATION PROJECT

AQUATIC EFFECTS MONITORING PLAN

REPORT #AEMP-2018-04

JUVENILE LAKE STURGEON 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.

Lake Sturgeon were identified as one of the key species for monitoring. They were chosen because they are culturally important to local people, the local populations have been previously impacted, and construction and operation of the GS will change or negatively impact important habitat. The plan to monitor the impacts of GS construction and operation on sturgeon includes several types of studies:

- Estimating the number of adults;
- Estimating the number and growth of juveniles up to ten years old (less than 800 mm);
- Identifying spawning locations and numbers of spawning fish; and
- Recording seasonal habitat use and long distance movements (*i.e.*, over GS's or rapids) through movement studies.

The movement of juvenile Lake Sturgeon in Stephens Lake were monitored in 2011 and 2012, but because different methods are being used for the Aquatic Effect Monitoring Plan (AEMP) data collection, the results of the two programs cannot be compared. Results of the 2011/2012 study showed that young Lake Sturgeon prefer to live in the deep water during the spring, summer and fall, but move into nearby, shallower habitat outside the old river channel in winter. Also, it was unusual for juvenile Lake Sturgeon to travel large distances; instead they generally stayed on the west side of the lake where water flows decreased as they entered the lake. None of the 20 tagged juvenile Lake Sturgeon in this study went upstream through Gull Rapids or downstream past the Kettle GS.

Monitoring of juvenile sturgeon movement using the same methodology as described in the AEMP began in August 2013. A Lake Sturgeon is considered to be a juvenile if it is over one year, but less than 800 mm long. This report provides results of juvenile sturgeon movement

monitoring conducted from October 2016 to October 2017. The movements of juvenile Lake Sturgeon were monitored for 10.5 months prior to changes to the river (pre-construction), and have been monitored for approximately three years and three months following the start of construction.

Because the original acoustic tags are now reaching the end of their battery lives, 40 juvenile Lake Sturgeon were implanted with acoustic tags in September 2017 and tracked for one month before downloading the receivers in fall 2017.

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 three questions:

Is construction affecting the area that juvenile Lake Sturgeon occupy upstream and downstream of the construction site?

Monitoring sturgeon movement shows what areas of the river the sturgeon are using and where they are choosing to stay relative to the construction site.

Are there juvenile Lake Sturgeon close to the construction site?

If sturgeon 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 juvenile Lake Sturgeon are moving through and/or away from Gull Rapids during construction and how far are they going?

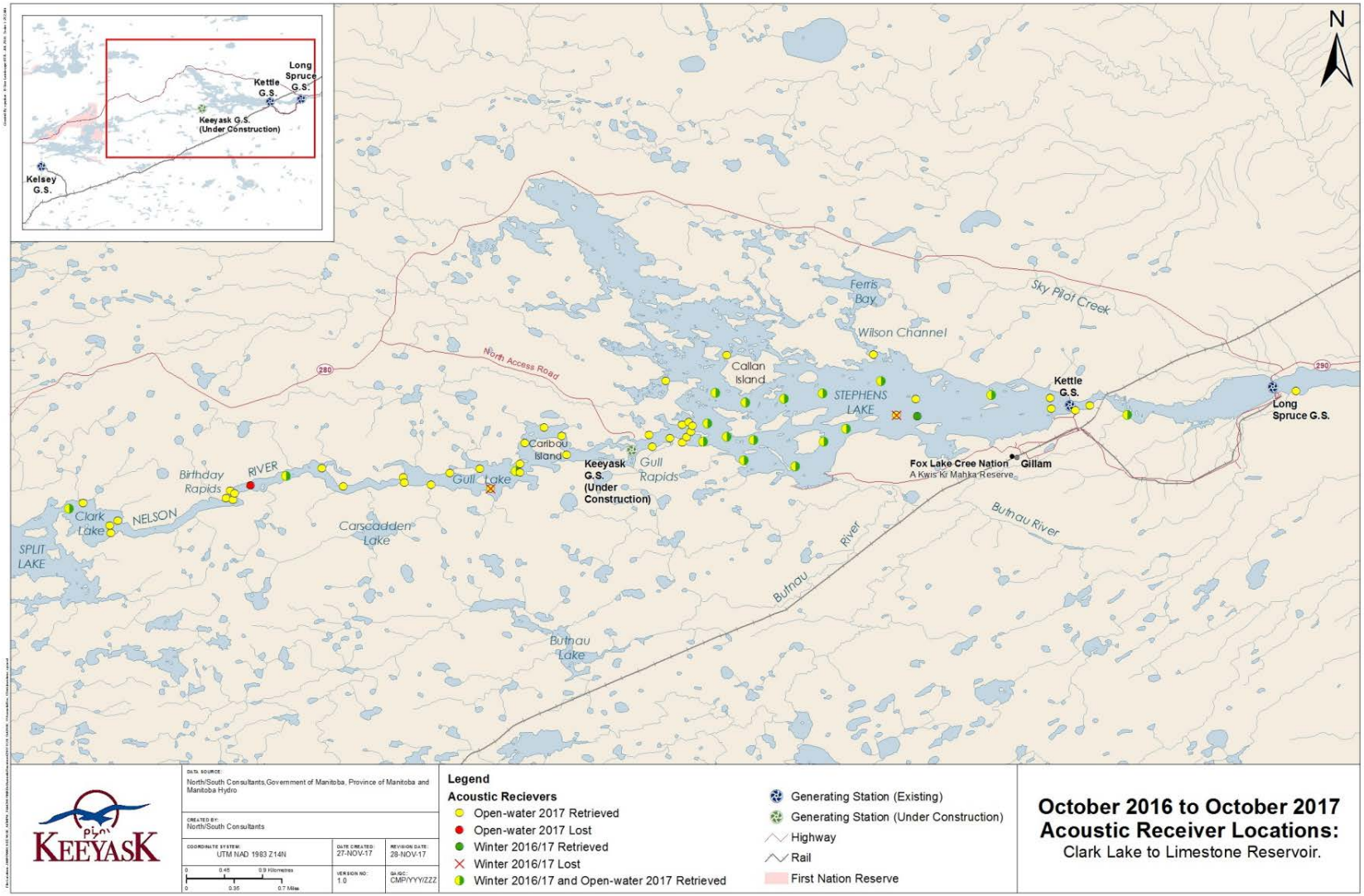
Movement studies tell us how many juvenile sturgeon are moving down through Gull Rapids, how far they travel up or downstream away from the site, whether they are leaving the Keeyask area completely and when they are making these movements. The distance they travel is monitored as far upstream as the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

What was done?

The movements of juvenile sturgeon were tracked using acoustic telemetry. This is a technique in which a tag is surgically implanted inside a fish. The tag emits a sound signal (called a “ping”) that is picked up by receivers placed along the Nelson River between Clark Lake and the Limestone GS (see study area map below). Each fish is given a tag that transmits a unique ping which can be detected up to 1 km away from a receiver. By looking at the pings that were recorded by different receivers, the movement of each fish can be tracked. The tags are powered by batteries with a four-year life-span.

During fall 2013, 20 tags were applied to juvenile sturgeon in Gull Lake and 20 were applied to juveniles in Stephens Lake. Since these tags are nearing the end of their battery life, an additional 40 fish were tagged in September 2017 (20 in Gull Lake and 20 in Stephens Lake).

Surgery on a juvenile Lake Sturgeon to implant an acoustic tag.



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 sturgeon moved depended on the individual fish and whether they lived in Gull Lake or Stephens Lake. The sturgeon that were tagged in Gull Lake in 2013 stayed in Gull Lake. The sturgeon that were tagged in Stephens Lake stayed in Stephens Lake, except for two fish. One fish moved downstream past the Kettle GS into the Long Spruce reservoir in 2014 and then moved downstream through the Long Spruce GS during late summer in 2017. Another fish moved out of Stephens Lake through Kettle GS in 2016. This fish was detected moving around the Long Spruce reservoir during the summer of 2016 and then it moved downstream through the Long Spruce GS in September 2016. It is unknown whether the fish that moved past the two generating stations moved over the spillway or through a turbine.

Juvenile Lake Sturgeon

Juvenile sturgeon in Stephens Lake moved farther than sturgeon in Gull Lake, both during the winter and open-water seasons. This is probably because Stephens Lake has more of the deep water areas that juvenile sturgeon like to live in. In Gull Lake, there are fewer areas with deep water and so sturgeon stay in these areas.

None of the tagged juvenile sturgeon moved from Gull Lake to Stephens Lake or Stephens Lake to Gull Lake through Gull Rapids. This is different from adult Lake Sturgeon, as some adults have moved upstream and downstream over the rapids. The fast current of the rapids likely blocks the smaller juveniles from moving upstream from Stephens Lake to Gull Lake, but they should be able to move downstream easily if they wanted to. Juvenile sturgeon in Gull Lake do not spend very much time close to the construction site but the ones in Stephens Lake do spend time right below the rapids.

Monitoring movements in winter is challenging because of ice conditions. Ice has damaged receivers set in channels as deep as 17 m. For this reason, receivers are left in only a few locations, making it less likely that sturgeon will be detected. However, during winter in both Stephens and Gull lakes, juvenile sturgeon have been detected in deeper areas with little current, and most appear to move very little.

What does it mean?

For the most part, monitoring has shown that juvenile sturgeon tend to stay in the same area year after year. Since monitoring began in August 2013, no tagged, juvenile Lake Sturgeon have moved upstream or downstream through Gull Rapids. However, two fish tagged in Stephens Lake moved downstream past the Kettle GS. Juvenile sturgeon in Gull Lake do not use the area around the construction site very much, but the sturgeon in Stephens Lake do spend time near the site. The movement of juvenile sturgeon will continue to be monitored as construction of the Keeyask GS continues.

Information collected so far shows that juvenile sturgeon usually do not move great distances and that they live in similar locations year after year. How far sturgeon move may also depend on the habitat that they have. For example, they may move farther when they have access to a long stretch of deep river channel. For this reason, the movements of sturgeon may change after the GS is built and Gull Lake becomes part of a deep reservoir.

What will be done next?

This is the last year that acoustic tags implanted in 2013 are expected to be active. The 40 new tags applied this year will allow the movements of juvenile Lake Sturgeon to be tracked until 2021. Tracking a new group of individual fish over the next four years will provide more information about what kinds of habitats juvenile Lake Sturgeon use over many years. It will also be possible to see if the behaviour of the fish changes over time as the construction of the Keeyask GS continues.

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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 licencing 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, juvenile Lake Sturgeon movement, for the construction and operation phases of the Project.

Monitoring of juvenile Lake Sturgeon movements was initiated in 2011, but the program was specifically focused on gaining a better understanding of juvenile Lake Sturgeon habitat preferences (water depth, water velocity, and substrate type) within Stephens Lake (Map 1). As pre-Project studies were not designed to record detailed movement patterns in the Clark Lake to Stephens Lake reach as a whole, results were not directly comparable to the movement data being collected under the AEMP, but they provided valuable insight into the behaviour of this life history stage in Stephens Lake (McDougall *et al.* 2013a, b). Data were collected across three seasons (open-water 2011, winter 2011/2012, and open-water 2012), and results suggested that during periods of open water, juvenile Lake Sturgeon preferred deep-water habitat within the old river channel in the upper 6 km of Stephens Lake, in an area where velocity decreases and substrate transitions from cobble, to gravel, to sand, and silt. During winter, juveniles moved further downstream. None of the 20 tagged juvenile Lake Sturgeon in this study were observed to go upstream through Gull Rapids or downstream through the Kettle GS.

The Keeyask AEMP juvenile Lake Sturgeon movement monitoring program was initiated in August 2013 when 40 juvenile Lake Sturgeon were tagged with acoustic transmitters with a four-year battery life, 20 in Gull Lake and 20 in Stephens Lake (Map 1). In Gull and Stephens lakes, Lake Sturgeon are classified as juveniles if they have a fork length measuring less than 800 mm (Henderson *et al.* 2015). The original 40 transmitters were set to expire in August 2017. Therefore, in order to continue the study (after the batteries expired in the original 40 transmitters), an additional 40 transmitters were applied to juvenile Lake Sturgeon in September 2017, again with 20 applied in both Gull and Stephens lakes.

The overall aim of this monitoring study is to describe juvenile Lake Sturgeon movement during the pre-construction (2013 – July 2014) and construction (July 2014 – 2021) phases of the

Project and to determine if disturbances associated with construction alter habitat use and coarse-scale movement patterns upstream and downstream of the Project (Map 2). Results will assist in identifying the use of key habitats (*i.e.*, rearing and foraging) during construction, the potential vulnerability of sturgeon to activities at the construction site (*i.e.,* if sturgeon use the area in the immediate vicinity of the construction site they may be vulnerable to stranding during dewatering), and the potential for increased emigration or avoidance of the construction site due to disturbance (*i.e.,* blasting, suspended sediment inputs, *etc*.).

The key questions for juvenile Lake Sturgeon movement monitoring during construction include:

- Do disturbances associated with construction alter coarse-scale movement/habitat use upstream and/or downstream of the construction site?
- Are sturgeon using habitat in the immediate vicinity of the construction site?
- Does the frequency of long-distance movements (and subsequent downstream emigration/entrainment) by juvenile Lake Sturgeon increase during construction?

This report provides results from October 2016 to October 2017, which is the third winter and fourth open-water period of monitoring conducted since construction of the Keeyask GS began in July 2014. The study area for the Lake Sturgeon movement study in 2017 extended from Clark Lake to the upper portion of the Limestone reservoir (Map 1). Results from previous years dating back to 2013 are presented in Hrenchuk and Barth (2014), Lacho *et al.* (2015), Lacho and Hrenchuk (2016), and Lacho and Hrenchuk (2017).

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. 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 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^3/s. Flow exceeded the historical annual median flow of approximately 3,300 m^3/s each month except for October 2017 when it dropped to about 3,200 m^3/s. From about October 2016

through mid-September 2017, the flow exceeded the historical 75th percentile flow of about 3,780 m^3/s, and from about May to mid-August 2017 the flow exceeded the 95th percentile flow of approximately 5,230 m^3/s. During the spring melt in May 2017, flow rose to about 6,590 m^3/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 of a receiver (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, Walleye (Hrenchuk and Lacho 2018), and Lake Whitefish (Lacho and Hrenchuk 2018).

3.1.1 ACOUSTIC TRANSMITTER APPLICATION

Acoustic transmitters (model # Vemco V13-1x, estimated 1480 day battery life) were applied to 40 fish in August and September 2013; 20 upstream and 20 downstream of Gull Rapids (Tables 1 and 2). Tagged Lake Sturgeon had fork lengths ranging from 450 to 668 mm. As these tags are nearing the end of their expected battery life, an additional 40 tags were applied to juveniles in September 2017; 20 upstream and 20 downstream of Gull Rapids (Tables 3 and 4). Sturgeon tagged in September 2017 had fork lengths ranging 360 to 578 mm. A detailed description of acoustic transmitter application can be found in Hrenchuk and McDougall (2012).

3.1.2 ACOUSTIC RECEIVERS

Since 2011, stationary acoustic receivers (VEMCO model VR2 and VR2W) have been used to continuously monitor tagged adult Lake Sturgeon in the Nelson River between Clark Lake and the Long Spruce GS. In spring 2016, the receiver array was extended to the upper Limestone reservoir, with the placement of two receivers downstream of the Long Spruce GS. The intent of adding these receivers was to determine whether fish that had moved into the Long Spruce reservoir had continued to move downstream.

During the first four years of the construction phase of the Project (beginning in July 2014), receivers were deployed at the same sites as those established during the pre-construction phase (2011–2013). 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. In Stephens Lake, receivers were placed at locations within pre-flood river channels, based on the observation that sturgeon tend to stay within river channels, even in flooded environments. 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 (described in Section 3.1.2.2).

The retrieval of receivers deployed during winter has proven challenging and several were lost in previous winters that were believed to have been moved by ice (Hrenchuk and Barth 2013). Because it appears that receivers will only remain safe from ice if deployed in calm areas 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 PERIOD 2016/2017

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, on either side of an island) were lost during the winter of 2015/2016 and two others had been lost during winter 2014/2015 and 2013/2014. Given the pattern of loss, the receivers were not reset at this location. 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 PERIOD 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, thirty 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, which is 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 (KFRRC)[1] suggested that a receiver be placed in close proximity to the upstream side of Gull Rapids to monitor

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

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 (Map 8). 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 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. Proportion of time all fish spent within each river zone was calculated and plotted.

4.0 RESULTS

Section 4.1 provides a summary of movements since the study began in 2013 to the end of the 2016 open-water period (October 2016). Numbers of fish tagged upstream of Gull Rapids and Stephens Lake are provided in Tables 1 and 2 for fish tagged in 2013 and Tables 3 and 4 for fish tagged in 2017. Tables 1 to 11 provide detection summaries, acoustic tag and biological information associated with each tagged fish. Figures 1 to 14 show movement range and proportional distribution of tagged fish both upstream and downstream of the construction site by season. Maps 3 to 10 provide maps of receiver and 2017 tag application locations. Appendices 1 and 2 provide movement summaries, by rkm, for each of the originally-tagged sturgeon since the study began in late August 2013. Appendices 3 and 4 provide movement summaries for the juvenile Lake Sturgeon tagged in September 2017.

4.1 2013–2016 RESULTS SUMMARY

4.1.1 UPSTREAM OF GULL RAPIDS

Twenty juvenile Lake Sturgeon were tagged in Gull Lake in August 2013 (Table 1). All juveniles tagged upstream of Gull Rapids have remained upstream of the rapids; none have been detected in Stephens Lake. All fish have been detected for multiple seasons since being tagged, however, one (#32686) has not been detected since the open-water season of 2015 (Appendix A1-11). This fish is not included in analyses and will not be discussed further in this report. Therefore, there were 19 juvenile Lake Sturgeon available for detection upstream of Gull Rapids at the beginning of the winter 2016/2017 season.

4.1.2 DOWNSTREAM OF GULL RAPIDS

Twenty juvenile Lake Sturgeon were tagged in Stephens Lake in September 2013 (Table 2). One (#32699) has not been detected since November 2013 (Appendix A2-19). This fish was not included in analyses and is not discussed in the remainder of the report. Another juvenile (#32662) tagged in Stephens Lake moved downstream through the Kettle GS into the Long Spruce reservoir between December 2013 and July 2014 and has been regularly detected in the reservoir since then (Appendix A2-2). During the open-water season of 2016, another juvenile Lake Sturgeon (#32685) moved downstream through both Kettle GS and Long Spruce GS into the Limestone reservoir (Appendix A2-15). Therefore, there were 17 juvenile Lake Sturgeon in Stephens Lake, one in the Long Spruce reservoir, and one in the Limestone reservoir available to be detected at the beginning of the winter 2016/2017 period. There were no receivers deployed in the Limestone reservoir over winter.

To date, the two tagged juvenile Lake Sturgeon that have moved downstream past generating stations on the Nelson River did so when the spillway was operational, so it is unknown whether these fish moved over the spillway or through one of the turbines. Both survived passage.

4.2 WINTER 2016/2017

4.2.1 UPSTREAM OF GULL RAPIDS

The winter receiver array consisted of four receivers deployed in the Nelson River between Clark Lake and Gull Rapids at rkms -48.2, -29.4, -12.9, and -10.1 (Figure 1). Three of the four acoustic receivers were retrieved; the receiver at rkm -12.9 could not be located and was likely moved by ice (Map 3). Eleven fish (of the 19 available for detection) were detected during the winter, with a total of 32,757 detections logged (Table 5). Juvenile sturgeon were detected exclusively at the receiver at rkm -10.1 (Figures 3 and 4). Fish were detected for an average of 19 days of the 193 day winter period (StDev = 32.6 days), with a range of five to 93 days detected (Table 5). Individual movements are summarized in Appendix 1.

4.2.2 STEPHENS LAKE

Sixteen receivers were deployed in Stephens Lake during the winter 2016/2017 period, between rkms 5.2 and 36.1 (Figure 1). Fifteen of these receivers were retrieved; the receiver deployed at rkm 23.5 was not retrieved due to the buildup of large woody debris that occurred during the winter months (Map 4). A total of 130,123 detections were logged by 13 of the 17 juveniles available for detection in Stephens Lake, with a range of 383 to 2,648 detections per individual (Table 6, Figures 5 and 6). Fish were detected between 12 and 162 days of the 193 day winter period (mean = 91.1 days, StDev = 52.0 days). The mean detection range was 2.6 rkm (StDev = 2.4 rkm; range = 0.0 – 8.1 rkm) (Table 6; Figure 5).

Three patterns of movement were observed:

- Eight of the thirteen fish remained in the upper end of Stephens Lake at, or upstream of rkm 9.4 for the entire winter period (Section 4.2.2.1).
- One was detected in both the upstream and downstream (downstream of rkm 9.4) areas of Stephens Lake (Section 4.2.2.2).
- Four fish were only detected at or downstream of rkm 10.3 (Section 4.2.2.3)

4.2.2.1 UPPER STEPHENS LAKE

Eight juvenile Lake Sturgeon remained in the upper reaches of Stephens Lake throughout the winter (Table 6; Figure 5).

- Two (#32666 and #32670) were detected between rkm 5.2 and 7.9 throughout the winter (appendices A2-6 and A2-10).
- #32661 was detected regularly between rkm 5.2 and 7.9 (Appendix A2-1).
- #32697 was only detected at rkm 5.8 (Appendix A2-17).
- #32675 was detected between rkm 5.8 and 7.9 until the end of February 2017. It then went undetected until the open-water period (Appendix A2-13).
- #32700 moved between rkm 5.8 and 9.4 (Appendix A2-20).
- #32680 was detected throughout the winter at rkm 6.5, in the former channel of the Moosenose River (Appendix A2-14).
- #32665 was detected at the receivers at rkm 7.9 and 9.4 (Appendix A2-5).

4.2.2.2 MOVEMENTS THROUGHOUT STEPHENS LAKE

Only one juvenile Lake Sturgeon (#32698) moved between upper (rkm 5.8 – 9.4) and lower (at or downstream of rkm 10.3) Stephens Lake during the winter period (Table 6). During late-October 2017, it made upstream and downstream movements between rkm 5.8 and rkm 13.9. It was later detected at rkm 10.3 on December 9, 2016 and was not detected again until the open-water period of 2017 (Appendix A2-18).

4.2.2.3 LOWER STEPHENS LAKE

Four juvenile Lake Sturgeon were located exclusively in lower Stephens Lake (at or downstream of rkm 10.3) over the winter (Table 6).

- #32668 was detected consistently at rkm 10.3 until February 25, 2017. It later moved downstream to rkm 13.9, where it was detected regularly for the remainder of the winter period (Appendix A2-8).
- Two (#32669 and #32696) were detected exclusively at rkm 13.9. #32669 was detected regularly at this location for the entire winter period (Appendix A2-9). #32696 was detected at rkm 13.9 until mid-November, 2017 and then went undetected for the remainder of the study (Appendix A2-16).
- One (#32673) was detected consistently at rkm 13.9 until the end of December 2017. It then moved downstream to rkm 18.6 in mid-January 2017 and was not detected again until the open-water period (Appendix A2-11).

4.2.3 LONG SPRUCE RESERVOIR

The single receiver set in the Long Spruce reservoir at rkm 47.5 was retrieved after the winter (Map 5).

The single, tagged juvenile Lake Sturgeon (#32662) in the Long Spruce reservoir was detected a total of 26,395 times. It was detected consistently at this receiver throughout the winter period. (Table 6, Appendix A2-2).

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 (Figure 2).

4.3.2 UPSTREAM OF GULL RAPIDS

Eighteen of the nineteen juvenile Lake Sturgeon available for detection upstream of Gull Rapids were detected during the open-water period (Table 7). These fish were detected between 219 and 25,237 times; days detected ranged from three to 114 of the 169 day open-water period (average = 72.8 days, StDev = 31.3 days) (Table 7). The one sturgeon that was not detected in 2017, #32690, was last detected at rkm -9.3 on June 19, 2016 (Appendix A1-15).

Juvenile Lake Sturgeon upstream of Gull Rapids had a mean movement range of 3.4 rkm (StdDev = 3.3 rkm; range: 0.3 – 10.0 rkm; Table 7; Figure 7). Fish were only detected in the two zones closest to Gull Rapids (Zones 4 and 5). The majority of detections occurred at the receivers at rkm -9.5 and -9.9 (Figure 8). No juvenile Lake Sturgeon were detected at the receiver closest to Gull Rapids at rkm -5.8, and only two were detected as far downstream as rkm -7.4 (Map 6). No fish were detected farther upstream than rkm -19.5, where the Nelson River enters Gull Lake (Table 7).

Juvenile Lake Sturgeon spent more time in Zone 4 (mean = 77.8%; StDev = 42.8%) than Zone 5 (mean = 22.2%; StDev = 42.8%) (Table 9; Figure 9). Juvenile Lake Sturgeon spent less time in Zone 5 during 2017 than in any other year (Table 9; Figure 10). Juvenile Lake Sturgeon made no inter-zone movements in 2017.

Four fish were detected exclusively in Zone 5 during the open-water season (Figure 9):

- #32689 and #32692 were detected regularly at rkms -9.0 and -7.4 (appendices A1-13 and A1-17).
- #32694 and #32695 were detected at rkms -9.3 and -9.0. #32694 was detected regularly during the open-water season, while #32695 was only detected between June 12 and

July 6 and went undetected for the remainder of the open-water season (appendices A1-19 and A1-20).

Fourteen fish were detected solely in Zone 4. All of these fish were detected at the farthest downstream receiver in the zone, at rkm -9.5 (Figure 9):

- Two juveniles (#32679 and #32682) were detected at the farthest upstream receiver in Zone 4 at rkm -19.5 (Appendices A1-6 and A1-8).
- Two (#32681 and #32683) were detected as far upstream as rkm -17.4 (Appendices A1-7 and A1-9).
- #32672 moved upstream to rkm -14.8 (Appendix A1-2).
- Three (#32687, #32691, and #32693) were detected as far upstream as rkm -12.8 (Appendices A1-12, A1-16, and A18).
- Two (#32671 and #32677) moved as far upstream as rkm -11.9 (Appendices A1-1 and A1-4).
- Four (#32676, #32678, #32684, and #32688) only moved as far upstream as rkm -10.1 (Appendices A1-3, A1-5, A1-10, and A1-13).

4.3.3 STEPHENS LAKE

Thirteen of the seventeen juvenile Lake Sturgeon available for detection in Stephens Lake were detected during the open-water period. These fish were detected between 1,364 and 10,511 times over 37 to 112 days of the 169 day study period (average = 79.1 days; StDev = 24.6 days) (Table 8). Detected fish had a mean movement range of 11.7 rkm (StDev = 4.4 rkm; range: 6.5 – 17.4 rkm; Figure 11). No fish were detected farther downstream than rkm 18.6. The highest number of detections was logged by the receiver at rkm 5.8, followed by the receivers at rkm 6.5 and 13.9 (Figure 12). On average, fish spent more time in Zone 7, farther from Gull Rapids (average = 57.3% of time, StDev = 26.3%), than in Zone 6 (average: 42.7%; StDev = 26.3%) (Figures 13 and 14; Table 9). As in previous years, the relative amount of time fish spent in Zone 6 increased during the middle of the summer, then decreased after mid-August (Figure 14). All thirteen fish were detected in both Zones 6 and 7 during the open water period.

Four fish were not detected during the 2017 open-water period:

- #32696 was last detected during the winter 2016/2017 period. It was last detected at rkm 13.9 on November 16, 2016 (Appendix A2-16).
- Three (#32664, #32667 and #32674) were last detected during the 2016 open-water period, between rkms 4.5 and 13.9 (appendices A2-4, A2-7 and A2-12).

Of the 13 fish located during the open-water period, the majority were only detected at receivers in the southern portion of Stephens Lake. Only two fish were detected in the northern part of the lake, in the channel of the former Moosenose River:

- #32698 was detected mainly in the southern part of the lake, between rkms 1.2 and 16.8. It was detected at the receiver at rkm 16.8 in the northern part of the lake on June 21 and on July 17 and 18 (Appendix A2-18).
- #32680 was detected regularly at the receiver at rkm 6.5 until July 1. It then moved into the southern portion of the lake, making upstream (as far as rkm 2.7) and downstream movements (to rkm 10.3) until returning to rkm 6.5 in the beginning of September (Appendix A2-14).

The remaining eleven fish were detected exclusively at receivers in the southern portion of the lake:

- Nine were detected at the closest receiver to Gull Rapids, at rkm 1.2:
    - Three of these fish (#32665, #32669, and #32673) were detected as far downstream as rkm 18.6, exhibiting the greatest movement range observed in Stephens Lake in 2017 (Appendices A2-5, A2-9, and A2-11).
    - Two (#32668 and 32700) moved as far downstream as rkm 13.9 (Appendices A2-8 and A2-20).
    - #32670 moved downstream to rkm 10.3 (Appendix A2-10).
    - #32666 was detected as far downstream as rkm 9.4 (Appendix A2-6).
    - Two (#32661 and #32697) were detected as far downstream as rkm 7.9 (Appendices A2-1 and A2-17).
- #32663 moved between rkm 2.7 and rkm 16.8 (Appendix A2-3).
- #32675 was detected only as far upstream as rkm 3.8, at the new receiver between the island and southern shore of Stephens Lake. It was detected as far downstream as rkm 10.3 (Appendix A2-13).

4.3.4 LONG SPRUCE RESERVOIR

The juvenile Lake Sturgeon (#32662) that moved into the Long Spruce reservoir in 2016 was detected consistently at the receiver at rkm 47.5 until June 21, 2017. It was next detected on September 21 at the receiver in the Limestone reservoir (Appendix A2-2). Therefore, none of the originally-tagged juvenile Lake Sturgeon remained in the Long Spruce reservoir at the end of the open-water period.

4.3.5 LIMESTONE RESERVOIR

The juvenile (#32685) that moved into the Limestone reservoir in 2016 was again detected in 2017. It was only detected at the receiver at rkm 58.6 on one day of the open-water season (June 12). As described in Section 4.3.4, another juvenile moved downstream through the Long

Spruce GS in 2017 and was detected on September 21 at the receiver in the Limestone Reservoir (Figure A2-15).

4.4 FISH TAGGED IN 2017

Acoustic transmitters were applied to 40 juvenile Lake Sturgeon in September 2017 to enable continuation of the study, as the tags applied to the 40 fish in 2013 will expire in 2017. Lake Sturgeon were captured in gillnets as part of juvenile Lake Sturgeon population monitoring conducted during fall 2017 in Gull and Stephens lakes (Burnett *et al.* 2018). Tagging information for these juveniles can be found in Tables 3 and 4. As less than two months of data was collected after these fish were tagged, no data analyses were performed; however, observed movements are discussed briefly below. Individual movement graphs can be found in Appendix 4 (fish tagged upstream of Gull Rapids) and Appendix 5 (fish tagged in Stephens Lake).

4.4.1 UPSTREAM OF GULL RAPIDS

Juvenile Lake Sturgeon (n = 20) were captured at eleven locations (Map 9) upstream of Gull Rapids between September 9 and 14, 2017. Tags were applied to fish in Zones 4 and 5 of Gull Lake. Lake Sturgeon had very limited detection ranges after being tagged, and only moved between 0.3 and 1.9 rkm from their tagging locations (Table 10; Appendix 3). All 20 juveniles were detected after transmitter application, between 14 and 35 days (42–94% of the days available for detection).

4.4.2 STEPHENS LAKE

The 20 juvenile Lake Sturgeon tagged in Stephens Lake were caught at 13 locations (Map 10) between September 13 and 16 (Table 11).

Two of the juveniles moved downstream immediately after acoustic transmitter application:

- #31691 was tagged on September 14 at rkm 5.3. After this, it moved downstream through the southern portion of Stephens Lake. On September 23, it was detected at one of the receivers immediately upstream of the Kettle GS and the next day was detected at the receiver immediately downstream of the Kettle GS (Appendix 4-4).
- #31761 was tagged on September 13 at rkm 4.7. This fish moved steadily downstream and was last detected at rkm 40.9, immediately upstream of the Kettle GS (Appendix 4-14).

The remaining 18 fish made both upstream and downstream movements after being tagged. The majority of fish tended to move downstream initially after tagging, followed by movement back upstream. Each of the fish were detected upstream of their original tagging location. Eight

were detected as far upstream as the receiver at rkm 1.2, close to Gull Rapids, while three fish moved as far downstream as rkm 13.9. These 18 fish were detected between 17 and 33 days (between 52 – 97% of the time they were available to be detected) (Table 11; Appendix 4).

5.0 DISCUSSION

This study was initiated in 2013 with the long-term objective of assessing the impacts of construction and operation of the Keeyask GS on juvenile Lake Sturgeon movement. As predicted in the AEMP and the Keeyask EIS, potential impacts include increased emigration from the population, mortality at the GS structure, and the loss of critical habitats.

2017 is the final year the acoustic transmitters implanted in 40 juvenile Lake Sturgeon in 2013 are expected to be active. From the four years of movement data collected from these fish, it is clear that these juvenile Lake Sturgeon occupy relatively small home ranges and rarely move long distances. This limited movement is consistent with the observed behaviour of juvenile sturgeon prior to construction (McDougall *et al*. 2013a, b), as well as what has been observed in other systems (Holtgren and Auer 2004; Smith and King 2005; Barth *et al.* 2011; Trested *et al*. 2011).

Of the fish tagged upstream, only one moved out of Gull Lake. In 2015 this fish moved from Gull Lake into the riverine area upstream and returned to Gull Lake later that year. It did not make any more long distance movements. Of the fish tagged downstream in Stephens Lake, only two juveniles made long-range movements out of the study area during the first four years of monitoring. Both fish moved from Stephens Lake, downstream through the Kettle GS, into the Long Spruce Reservoir; one moved before construction started and the other moved after. These fish spent approximately one year in the Long Spruce Reservoir before moving downstream through the Long Spruce GS to the Limestone Reservoir. Given that the remaining, 38, tagged fish were found to occupy small home ranges, long distance movements appear to be rare for juvenile Lake Sturgeon in Stephens Lake.

Juveniles in Stephens Lake were found to have larger movement ranges on an annual basis relative to those in Gull Lake. This is attributed to the availability of deep water habitat, which is continuous in the old river channel in Stephens Lake, versus being patchy in Gull Lake (McDougall *et al.* 2013a, b).

Forty juveniles were tagged in 2017, two of which moved downstream shortly after tagging. Tracking the additional fish will allow continued monitoring through the remainder of construction and reservoir impoundment.

5.1 EVALUATION OF METHODOLOGY

Acoustic telemetry continues to be an effective method for monitoring juvenile Lake Sturgeon movement during the 2017 open-water period. Since 2014, the number of available fish detected has remained consistently high and in general, the proportion of days detected for each individual fish has also remained high. In 2017, there was a decrease in the mean percentage of time that juveniles were detected as only 18 were detected for more than 50% of the open-water period (compared to between 27 and 31 in the past three years). It is possible

that this could be explained by the expiry or decreased signal strength of several transmitters during their final year of operation.

The quantity of data collected during winter is comparably less relative to the open-water period given that fewer receivers are used (only four upstream of Gull Rapids and 16 in Stephens Lake). Overall, fewer fish were detected during this period than in winter 2015/2016 (68% of available fish in 2016/2017 vs. 72% in 2015/2016), and fewer detections per receiver were logged (189,275 in 2016/2017 and 274,349 in 2015/2016).

One additional receiver was added to the receiver array during the 2017, open-water period; it was deployed at rkm 3.8 in Stephens Lake in a channel between a small island and the southern shore. During open-water 2016, it was suspected that fish were using this channel to move between Zones 6 and 7 and were being missed by the receiver gate. During open-water 2017, three juvenile Lake Sturgeon were detected between 17 and 59 times at this receiver. This receiver will continue to be deployed as part of the Stephens Lake receiver gate.

5.2 KEY QUESTIONS

The key questions, as described in the AEMP, for juvenile Lake Sturgeon movement monitoring during construction of the Keeyask GS are as follows:

Will the frequency of long-distance movements (and subsequent downstream emigration/ entrainment) by juvenile Lake Sturgeon increase during construction and operation of the Project?

Results of four years of monitoring indicate that juvenile Lake Sturgeon very rarely make long-distance movements and there has not been an observed increase in the frequency of movements since construction began. Upstream of the construction site, the extent of movements decreased slightly as the study progressed. Since 2013, a single juvenile moved upstream out of Gull Lake. This fish moved back into Gull Lake in the same year and did not repeat this movement. No tagged juvenile Lake Sturgeon have moved downstream through Gull Rapids since the start of the study.

Similar to upstream, the fish in Stephens Lake generally occupy a small home range, albeit a larger home range relative to those tagged in Gull Lake. Only two juvenile Lake Sturgeon have moved downstream past the Kettle GS during the four-year study period. One moved through the GS before construction began (between December 2013 and July 2014) and the second fish moved through the GS during construction in 2016 (Lacho *et al.* 2015; Lacho and Hrenchuk 2017). Both fish survived passage past the generating stations.

Are juvenile Lake Sturgeon using habitat in the immediate vicinity of the construction site?

Four years of monitoring juvenile Lake Sturgeon movements has consistently shown that juvenile Lake Sturgeon in Gull Lake do not spend much time in the vicinity of the construction site. Although juveniles frequently occupy the farthest downstream zone of Gull Lake, they are

rarely detected by the two receivers closest to Gull Rapids. In 2017, none of the juvenile Lake Sturgeon were detected at the receiver closest to the rapids, while only two were detected at the second-closest receiver. Juveniles are consistently detected most often between rkms -10.1 and -9.5, near the transition between Zones 4 and 5, a pattern that has been seen since the beginning of the study.

In contrast, juvenile sturgeon in Stephens Lake are frequently detected in the vicinity of the construction site. This means that juveniles in Stephens Lake are likely more susceptible to the potential effects of construction activities like sedimentation and changes in flow.

Will disturbances associated with construction of the Keeyask GS alter coarse-scale movement upstream or downstream of the GS?

Movement monitoring has consistently shown that juvenile Lake Sturgeon tend to exhibit similar movement patterns from year to year, and these patterns have not widely varied since the study began. Upstream, juveniles spend most of their time in the area near the boundary of Zones 4 and 5. A few fish do move upstream in the summer, but these fish do not leave Gull Lake and return to the lower end of the lake in the fall. A single juvenile moved upstream out of Gull Lake, but came back the same year. In Stephens Lake, only two juvenile Lake Sturgeon have moved downstream over the Kettle GS and one of these movements was made before the start of construction.

6.0 SUMMARY AND CONCLUSIONS

- Acoustic telemetry continues to be an effective method for monitoring movements of juvenile Lake Sturgeon in the study area. In 2017, 34 of the 40 sturgeon tagged in 2013 were detected during the open-water period. Although this represents a decrease in the proportion of tagged fish detected relative to 2016 (38 of 40 were detected), it is likely that some of the acoustic transmitters may have expired or the signal strength was fading near the end of the study, given that the end of their 4-year battery life occurred in August 2017. During winter, the proportion of fish detected is lower relative to the open-water period, given that fewer receivers are used. Although this results in a lower proportion of fish being detected and a lower number of detections for each fish, the results are sufficient to achieve the objectives of the study and respond to the key questions presented in the AEMP.
- Due to the original 40 tags reaching the end of their battery lives, 40 new juvenile Lake Sturgeon (20 upstream of Gull Rapids and 20 in Stephens Lake) were implanted with acoustic transmitters in September 2017. Since they have only been monitored for one month, detailed movement analysis of these fish will begin in 2018.
- The key questions, as described in the AEMP, for juvenile Lake Sturgeon movement monitoring during construction of the Keeyask GS are as follows:
    - *Will the frequency of long-distance movements by juvenile Lake Sturgeon increase during construction and operation of the Project?*

      Since monitoring commenced, only two juvenile Lake Sturgeon have moved downstream out of the study area. The first fish likely moved downstream through Kettle GS before construction began at Keeyask. The second fish moved downstream through the Kettle and Long Spruce generating stations in 2016. Therefore, there has not been an observed increase in the frequency of long-distance movements by juvenile Lake Sturgeon.
    - *Are juvenile Lake Sturgeon using habitat in the immediate vicinity of the construction site?*

      Data collected to date suggest that juvenile Lake Sturgeon tagged upstream of Gull Rapids do not frequently utilize habitat in the vicinity of Gull Rapids. In Stephens Lake, however, juveniles do use the area immediately downstream of the construction site and could be susceptible to construction-related activities.
    - *Will disturbances associated with construction of the Keeyask GS alter coarse-scale movement upstream or downstream of the GS?*

      Qualitatively and quantitatively, there has been no observed change in the movement patterns of juvenile Lake Sturgeon since the study began. Juvenile

sturgeon upstream of Gull Rapids and in Stephens Lake have remained in similar areas during each year of study and the average distance moved has also remained similar.

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TABLES

Table 1: Acoustic tagging and biological data for the 20 juvenile Lake Sturgeon tagged upstream of Gull Rapids in 2013.

Tag ID	Date Tagged	Fork Length (mm)	Total Length (mm)	Weight (g)
32671	29-Aug-13	498	577	850
32672	29-Aug-13	485	545	800
32676	29-Aug-13	518	607	875
32677	29-Aug-13	492	559	750
32678	29-Aug-13	512	583	950
32679	29-Aug-13	570	638	1450
32681	29-Aug-13	572	650	1250
32682	29-Aug-13	550	618	1100
32683	29-Aug-13	536	610	900
32684	29-Aug-13	496	562	750
32686	28-Aug-13	668	768	2450
32687	28-Aug-13	490	557	800
32688	28-Aug-13	480	535	725
32689	28-Aug-13	487	561	825
32690	28-Aug-13	475	553	725
32691	28-Aug-13	518	590	950
32692	28-Aug-13	585	650	1350
32693	28-Aug-13	565	647	1225
32694	28-Aug-13	470	532	750
32695	28-Aug-13	483	555	700

Table 2: Acoustic tagging and biological data for the 20 juvenile Lake Sturgeon tagged in Stephens Lake in 2013.

Tag ID	Date Tagged	Fork Length (mm)	Total Length (mm)	Weight (g)
32661	17-Sep-13	500	571	1075
32662	17-Sep-13	515	554	900
32663	21-Sep-13	539	610	1000
32664	22-Sep-13	530	596	900
32665	23-Sep-13	580	657	1375
32666	16-Sep-13	594	666	1510
32667	17-Sep-13	518	564	1000
32668	21-Sep-13	495	564	900
32669	21-Sep-13	558	634	1350
32670	17-Sep-13	559	648	1475
32673	21-Sep-13	576	643	1250
32674	21-Sep-13	549	621	1300
32675	22-Sep-13	450	514	575
32680	22-Sep-13	450	510	600
32685	22-Sep-13	573	654	1275
32696	16-Sep-13	497	557	800
32697	16-Sep-13	572	660	1425
32698	16-Sep-13	610	699	1800
32699	17-Sep-13	470	525	750
32700	21-Sep-13	620	690	1800

Table 3: Acoustic tagging and biological data for the 20 juvenile Lake Sturgeon tagged upstream of Gull Rapids in 2017.

Tag ID	Date Tagged	Fork Length (mm)	Total Length (mm)	Weight (g)
31683	12-Sep-17	505	579	800
31684	09-Sep-17	432	501	600
31685	09-Sep-17	410	460	550
31686	09-Sep-17	504	584	1100
31687	09-Sep-17	545	624	1200
31768	14-Sep-17	459	532	700
31769	14-Sep-17	462	516	600
31770	14-Sep-17	442	511	650
31771	14-Sep-17	470	541	600
31772	15-Sep-17	518	598	1100
31773	12-Sep-17	545	616	1000
31774	12-Sep-17	481	559	800
31775	13-Sep-17	459	519	600
31776	13-Sep-17	410	479	400
31777	13-Sep-17	578	662	1350
31778	12-Sep-17	435	504	800
31779	12-Sep-17	490	549	800
31780	12-Sep-17	448	494	650
31781	12-Sep-17	468	544	850
31782	12-Sep-17	448	506	600

Table 4: Acoustic tagging and biological data for the 20 juvenile Lake Sturgeon tagged in Stephens Lake in 2017.

Tag ID	Date Tagged	Fork Length (mm)	Total Length (mm)	Weight (g)
31688	16-Sep-17	436	498	625
31689	15-Sep-17	445	515	625
31690	14-Sep-17	433	480	525
31691	14-Sep-17	487	554	750
31692	14-Sep-17	453	529	400
31693	13-Sep-17	494	553	900
31694	14-Sep-17	390	445	375
31695	15-Sep-17	455	521	650
31696	15-Sep-17	440	496	700
31697	16-Sep-17	433	500	600
31758	16-Sep-17	375	429	425
31759	14-Sep-17	445	508	575
31760	14-Sep-17	363	398	280
31761	13-Sep-17	435	507	500
31762	15-Sep-17	434	487	525
31763	15-Sep-17	457	520	725
31764	14-Sep-17	440	503	500
31765	16-Sep-17	505	569	950
31766	14-Sep-17	360	400	300
31782	15-Sep-17	455	505	675

Table 5: **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 each of 20 juvenile Lake Sturgeon tagged and monitored upstream of Gull Rapids during the 2013/2014 (October 16 – April 30), 2014/2015 (October 13 –April 30), 2015/2016 (October 12 –April 30), and 2016/2017 (October 20 to April 30) winter periods.**

Tag ID	2013/2014					2014/2015					2015/2016					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)	n	# Days	U/S (rkm)	D/S (rkm)	Range (rkm)
32671	9727	69	-12.9	-12.9	0.0	2479	44	-12.9	-12.9	0.0	2678	39	-9.9	-9.9	0.0	6189	91	-10.1	-10.1	0.0
32672	3696	48	-12.9	-9.9	3.0	126	15	-12.9	-12.9	0.0	-	-	-	-	-	1094	13	-10.1	-10.1	0.0
32676	2528	29	-12.9	-9.9	3.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
32677	4785	59	-12.9	-9.9	3.0	-	-	-	-	-	19370	113	-9.9	-9.9	0.0	6541	37	-10.1	-10.1	0.0
32678	17388	135	-9.9	-9.9	0.0	-	-	-	-	-	4949	41	-9.9	-9.9	0.0	10416	91	-10.1	-10.1	0.0
32679	31	7	-12.9	-12.9	0.0	-	-	-	-	-	30	3	-11.8	-11.8	0.0	-	-	-	-	-
32681	8205	76	-12.9	-9.9	3.0	-	-	-	-	-	9728	78	-9.9	-9.9	0.0	14	4	-10.1	-10.1	0.0
32682	270	12	-9.9	-9.9	0.0	136	6	-12.9	-12.9	0.0	3	2	-9.9	-9.9	0.0	25	6	-10.1	-10.1	0.0
32683	2864	42	-12.9	-9.9	3.0	42	10	-12.9	-12.9	0.0	-	-	-	-	-	-	-	-	-	-
32684	2941	57	-9.9	-9.9	0.0	-	-	-	-	-	1683	42	-9.9	-9.9	0.0	66	13	-10.1	-10.1	0.0
32686	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
32687	-	-	-	-	-	-	-	-	-	-	707	31	-9.9	-9.9	0.0	340	17	-10.1	-10.1	0.0
32688	-	-	-	-	-	-	-	-	-	-	4339	58	-9.9	-9.9	0.0	32	5	-10.1	-10.1	0.0
32689	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
32690	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
32691	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	337	9	-10.1	-10.1	0.0
32692	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
32693	-	-	-	-	-	-	-	-	-	-	14165	108	-19.5	-9.5	10.0	7734	93	-10.1	-10.1	0.0
32694	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
32695	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 6: **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 each of 20 juvenile Lake Sturgeon tagged and monitored downstream of Gull Rapids during the 2013/2014 (October 16 – April 30), 2014/2015 (October 13 – April 30), 2015/2016 (October 12 – April 30), and 2016/2017 (October 20 to April 30) winter periods.**

Tag ID	2013/2014					2014/2015					2015/2016					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)	n	# Days	U/S (rkm)	D/S (rkm)	Range (rkm)
32661	567	19	6.1	7.7	1.6	4883	46	7.7	10.2	2.5	5021	52	7.7	7.7	0.0	7181	132	5.2	9.4	4.2
32662	484	10	6.1	21.0	14.9	1422	24	47.5	47.5	0.0	7702	55	44.9	44.9	0.0	26395	159	47.5	47.5	0.0
32663	10755	87	6.1	16.8	10.7	8428	63	7.7	10.2	2.5	-	-	-	-	-	-	-	-	-	-
32664	3531	52	6.1	7.7	1.6	93	19	7.7	7.7	0.0	2724	40	7.7	7.7	0.0	-	-	-	-	-
32665	272	10	6.1	7.7	1.6	1276	48	7.7	10.2	2.5	1675	42	7.7	21.0	13.3	973	36	7.9	9.4	1.5
32666	1242	27	6.1	10.5	4.4	2860	26	7.7	10.2	2.5	5437	59	7.7	10.2	2.5	11863	132	5.2	7.9	2.7
32667	4980	54	6.1	10.2	4.1	-	-	-	-	-	13210	87	9.9	9.9	1.0	-	-	-	-	-
32668	-	-	-	-	-	963	25	14.9	14.9	0.0	14723	145	14.9	18.7	3.8	14275	95	10.3	13.9	3.6
32669	1089	10	7.9	7.9	0.0	-	-	-	-	-	33216	192	14.9	14.9	0.0	26480	162	13.9	13.9	0.0
32670	27731	141	6.1	7.7	1.6	2770	54	7.7	10.5	2.8	58	58	7.7	7.7	0.0	11884	162	5.2	7.9	2.7
32673	1548	17	6.1	21.0	14.9	1404	19	14.9	40.8	25.9	12889	96	14.9	21.0	6.1	14199	91	13.9	18.6	4.7
32674	243	8	7.7	14.9	7.2	399	14	14.9	14.9	0.0	17596	117	9.9	14.9	5.0	-	-	-	-	-
32675	6497	66	6.1	7.7	1.6	4218	43	7.7	7.7	0.0	5624	87	7.7	10.2	2.5	9582	96	5.8	7.9	2.1
32680	11457	115	6.1	10.5	4.4	8863	97	7.9	10.5	2.6	15103	139	7.9	7.9	0.0	21383	106	6.5	6.5	0.0
32685	8417	101	6.1	14.9	8.8	1319	16	7.7	21.0	13.3	7093	86	14.9	26.0	11.1	-	-	-	-	-
32696	2027	23	10.2	21.0	10.8	2284	23	7.7	21.0	13.3	31092	187	9.9	21.0	11.1	867	15	13.9	13.9	0.0
32697	10294	87	6.1	7.7	1.6	371	14	7.7	10.2	2.5	23211	93	7.7	10.2	2.5	539	34	5.8	5.8	0.0
32698	2153	71	6.1	14.9	8.8	275	14	7.7	14.9	7.2	20321	148	9.9	18.7	8.8	383	12	5.8	13.9	8.1
32699	877	17	6.1	7.7	1.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
32700	12749	122	6.1	10.5	4.4	11466	88	7.7	10.2	2.5	2	1	7.7	7.7	0.0	10517	111	5.8	9.4	3.6

Table 7: **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 each of 20 juvenile Lake Sturgeon tagged and monitored upstream of Gull Rapids during the 2013 (August 28 – October 15), 2014 (May 1 – October 12), 2015 (May 1 – October 11), 2016 (May 1 – October 19), and 2017 (May 1 – October 16) open-water seasons.**

Tag ID	2013					2014					2015					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)	n	# Days	U/S (rkm)	D/S (rkm)	Range (rkm)	n	# Days	U/S (rkm)	D/S (rkm)	Range (rkm)
32671	8302	46	-12.9	-9.9	3.0	9056	98	-19.4	-9.5	9.9	12115	126	-19.5	-9.5	10.0	10091	128	-19.5	-9.5	10.0	5057	92	-11.9	-9.5	2.4
32672	676	35	-12.3	-9.9	2.4	7601	88	-12.9	-9.5	3.4	8996	86	-17.4	-9.5	7.9	4483	67	-14.8	-9.5	5.3	2033	43	-14.8	-9.9	4.9
32676	5460	39	-10.3	-9.9	0.4	5176	100	-17.4	-12.9	4.5	10299	79	-17.4	-9.5	7.9	3261	82	-17.4	-9.5	7.9	219	3	-10.1	-9.5	0.6
32677	1648	40	-12.3	-9.9	2.4	8866	96	-12.9	-9.5	3.4	16278	120	-17.4	-9.5	7.9	12182	114	-12.9	-9.5	3.6	10945	101	-11.9	-9.5	2.4
32678	4925	46	-10.3	-9.9	0.4	22368	135	-10.1	-9.5	0.6	41794	134	-10.1	-9.5	0.6	24792	130	-12.9	-9.5	3.4	14105	104	-10.1	-9.5	0.6
32679	637	35	-12.9	-9.9	3.0	9726	100	-19.5	-9.5	10	12607	82	-19.5	-9.5	10.0	7829	77	-19.5	-9.5	10.2	5484	62	-19.5	-9.5	10.0
32681	834	38	-12.9	-9.9	3.0	12817	100	-17.4	-9.5	7.9	12201	125	-12.9	-9.5	3.4	17724	135	-14.8	-9.5	5.3	8602	79	-17.4	-9.5	7.9
32682	4736	44	-10.3	-9.9	0.4	15245	98	-12.9	-9.5	3.4	11238	128	-12.9	-9.5	3.4	6592	84	-12.9	-9.5	3.4	4785	64	-19.5	-9.5	10.0
32683	258	40	-12.3	-9.9	2.4	4684	98	-17.4	-9.5	7.9	7347	97	-14.8	-9.5	5.3	2510	65	-19.5	-9.5	10.0	4020	53	-17.4	-9.5	7.9
32684	16091	46	-10.3	-9.9	0.4	14878	102	-10.8	-5.8	5.0	28581	125	-14.8	-9.5	5.3	29743	143	-12.9	-9.5	3.4	15519	114	-10.1	-9.5	0.6
32686	131	2	-10.9	-10.9	0.0	140	3	-5.8	-5.8	0.0	4028	26	-9.3	-7.4	1.9	-	-	-	-	-	-	-	-	-	-
32687	70	16	-7.4	-7.4	0.0	14680	120	-9.0	-7.4	1.6	27075	121	-17.4	-9.0	8.4	36590	144	-12.9	-9.5	3.4	25237	89	-12.8	-9.5	3.3
32688	-	-	-	-	-	9142	63	-11.8	-7.4	4.4	31073	120	-10.1	-9.5	0.6	13267	89	-10.1	-9.5	0.6	3832	56	-10.1	-9.9	0.6
32689	2	1	-7.4	-7.4	0.0	9835	112	-9.0	-7.4	1.6	9662	78	-9.0	-7.4	1.6	3918	104	-9.0	-7.4	1.6	3123	89	-9.0	-7.4	1.6
32690	12027	35	-10.9	-10.9	0.0	34865	129	-10.9	-9.0	1.9	3884	34	-9.3	-9.0	0.3	3	1	-9.3	-9.3	0.0	-	-	-	-	-
32691	-	-	-	-	-	23712	110	-10.9	-9.0	1.9	-	-	-	-	-	4595	91	-19.5	-5.8	13.7	4190	83	-12.8	-9.5	3.3
32692	126	17	-7.4	-7.4	0.0	16704	122	-10.9	-7.4	3.5	17810	131	-9.3	-7.4	1.9	14974	131	-9.3	-7.4	1.9	14849	103	-9.0	-7.4	1.6
32693	777	24	-10.9	-10.9	0.0	26300	117	-10.9	-9.0	1.9	20360	120	-26.5	-9.0	17.5	12907	110	-19.5	-9.5	10.0	8259	78	-12.8	-9.5	3.3
32694	2582	30	-10.9	-7.4	3.5	38932	130	-14.8	-9.0	5.8	3808	67	-10.1	-9.0	1.1	16324	115	-9.9	-7.4	2.5	12647	90	-9.3	-9.0	0.3
32695	1203	22	-10.9	-7.4	3.5	6974	61	-10.9	-7.4	3.5	9706	95	-9.3	-7.4	1.9	8804	80	-9.3	-7.4	1.9	285	7	-9.3	-9.0	0.3

Table 8: 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 each of 20 juvenile Lake Sturgeon tagged and monitored downstream of Gull Rapids during the 2013 (August 28 – October 15), 2014 (May 1 – October 12), 2015 (May 1 – October 11), 2016 (May 1 – October 19), and 2017 (May 1 – October 16) open-water seasons.

Tag ID	2013					2014					2015					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)	n	# Days	U/S (rkm)	D/S (rkm)	Range (rkm)	n	# Days	U/S (rkm)	D/S (rkm)	Range (rkm)
32661	644	11	2.5	12.1	9.6	12372	92	1.3	14.9	13.6	6280	107	1.3	17.4	16.1	7440	102	1.2	10.3	9.1	2072	37	1.2	7.9	6.7
32662	4164	26	2.5	14.9	12.4	11682	74	44.9	47.5	2.6	8910	71	42.7	44.9	2.2	16855	102	44.9	44.9	0.0	5035	44	47.5	58.6	11.1
32663	2690	25	2.5	7.7	5.2	10771	121	0.5	13.4	12.9	3745	82	1.3	10.5	9.2	6675	88	1.2	13.9	12.7	1364	43	2.7	16.8	14.1
32664	1890	15	2.5	10.2	7.7	14347	111	2.9	10.2	7.3	17796	115	1.3	11.0	9.7	5200	49	1.2	10.3	9.1	-	-	-	-	-
32665	360	4	2.5	4.9	2.4	7433	85	2.9	21.0	18.1	4196	61	1.3	19.0	17.7	3411	100	1.2	18.7	17.5	3722	85	1.2	18.6	17.4
32666	396	7	0.7	10.0	9.3	9527	81	0.5	10.2	9.7	7921	85	1.3	11.0	9.7	9022	101	1.2	7.9	6.7	6152	94	1.2	9.4	8.2
32667	3633	21	2.5	7.7	5.2	4660	26	4.4	10.2	5.8	259	7	11.0	11.0	0.0	196	9	9.9	10.3	0.4	-	-	-	-	-
32668	2768	21	2.5	12.1	9.6	8076	79	4.3	14.9	10.6	8016	94	2.2	14.9	12.7	10610	128	1.2	14.9	13.7	9659	107	1.2	13.9	12.7
32669	75	7	2.5	4.9	2.4	12559	93	1.3	14.9	13.6	19628	117	1.3	14.9	13.6	9335	122	1.2	14.9	13.7	5344	111	1.2	18.6	17.4
32670	4289	23	0.7	7.7	7.0	25924	135	1.3	10.2	8.9	18930	131	1.3	11.0	9.7	14227	132	1.2	7.9	6.7	6056	94	1.2	10.3	9.1
32673	2191	25	2.5	14.9	12.4	11506	83	2.9	21.0	18.1	11254	105	1.3	19.0	17.7	9784	127	1.2	21.0	19.8	5024	87	1.2	18.6	17.4
32674	2468	22	2.5	12.1	9.6	13328	111	2.9	10.2	7.3	10650	105	1.3	14.9	13.6	8052	106	1.2	14.9	13.7	-	-	-	-	-
32675	2933	22	2.5	7.7	5.2	19778	134	2.9	10.2	7.3	16380	126	1.3	7.7	6.4	16763	142	1.2	14.9	13.7	6600	61	3.8	10.3	6.5
32680	1579	18	0.7	10.0	9.3	1238	59	7.9	10.5	2.6	2273	62	7.9	7.9	0.0	2432	38	6.5	7.9	1.4	10511	112	2.7	10.3	7.6
32685	2034	21	2.5	10.0	7.5	18830	130	2.9	18.7	15.8	20054	135	1.3	21.0	19.7	11354	66	42.7	58.6	15.9	9	1	58.6	58.6	0.0
32696	3803	25	2.5	18.7	16.2	9650	81	2.9	21.0	18.1	11864	133	1.3	14.9	13.6	13886	130	1.2	21.0	19.8	-	-	-	-	-
32697	1623	21	0.7	4.9	4.2	9822	108	1.3	6.1	4.8	14190	120	1.3	11.0	9.7	13186	102	2.2	10.3	8.1	3576	82	1.2	7.9	6.7
32698	2082	18	2.5	14.9	12.4	9414	99	1.3	21.0	19.7	14110	116	1.3	14.9	13.6	11868	111	1.2	16.8	15.6	6533	108	1.2	16.8	15.6
32699	556	11	2.5	6.3	3.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
32700	2830	21	2.5	14.9	12.4	14196	112	0.5	14.9	14.4	11478	120	1.3	19.0	17.7	5913	103	1.2	23.5	22.3	4528	86	1.2	13.9	12.7

Table 9: Proportion of time spent in each river zone by juvenile Lake Sturgeon implanted with acoustic transmitters upstream of Gull Rapids and in Stephens Lake during a portion of the 2014 (June 4 to October 3), 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
2014	0.0	0.0	0.0	63.4	36.6	42.1	57.9
2015	0.0	0.0	1.9	44.6	53.4	51.0	49.0
2016	0.0	0.0	0.0	73.2	26.8	46.7	53.2
2017	0.0	0.0	0.0	77.8	22.2	42.7	57.3

Table 10: 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 each of 20 juvenile Lake Sturgeon implanted with acoustic transmitters and monitored upstream of Gull Rapids in 2017.

Tag ID	n	# Days	U/S (rkm)	D/S (rkm)	Range (rkm)
31683	4718	33	-9.3	-7.4	1.9
31684	5706	34	-9.3	-7.4	1.9
31685	12846	35	-9.3	-7.4	1.9
31686	9918	34	-9.3	-9.0	0.3
31687	9880	32	-9.3	-9.0	0.3
31768	1050	14	-10.1	-9.9	0.2
31769	18816	28	-10.1	-9.5	0.6
31770	17899	31	-10.1	-9.5	0.6
31771	13740	31	-10.1	-9.5	0.6
31772	9198	30	-10.1	-9.5	0.6
31773	5954	32	-9.3	-7.4	1.9
31774	8289	33	-9.0	-7.4	1.6
31775	8804	17	-10.1	-9.5	0.6
31776	14995	31	-10.1	-9.5	0.6
31777	18412	31	-10.1	-9.5	0.6
31778	12574	33	-9.3	-9.0	0.3
31779	11059	33	-9.3	-7.4	1.9
31780	5304	30	-9.0	-7.4	1.6
31781	10304	33	-9.3	-7.4	1.9
31782	13002	33	-9.3	-9.0	0.3

Table 11: 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 each of 20 juvenile Lake Sturgeon implanted with acoustic transmitters and monitored downstream of Gull Rapids in 2017.

Tag ID	n	# Days	U/S (rkm)	D/S (rkm)	Range (rkm)
31688	6642	30	2.7	7.9	5.2
31689	4861	30	1.2	13.9	12.7
31690	5300	32	1.2	7.9	6.7
31691	1255	7	4.1	42.7	38.6
31692	10971	32	1.2	13.9	12.7
31693	8761	33	3.8	9.4	5.6
31694	8619	32	3.8	9.4	5.6
31695	10767	31	2.7	7.9	5.2
31696	10532	31	1.2	13.9	12.7
31697	7764	30	3.8	10.3	6.5
31758	31758	28	3.8	13.9	10.1
31759	10329	32	2.7	10.3	7.6
31760	938	17	1.2	3.8	2.6
31761	394	6	4.3	40.9	36.6
31762	8175	30	3.8	9.4	5.6
31763	14228	31	1.2	10.3	9.1
31764	5769	32	3.8	10.3	6.5
31765	9509	30	2.7	9.4	6.7
31766	3533	31	1.2	5.8	4.6
31782	2549	24	1.2	4.4	3.2

FIGURES

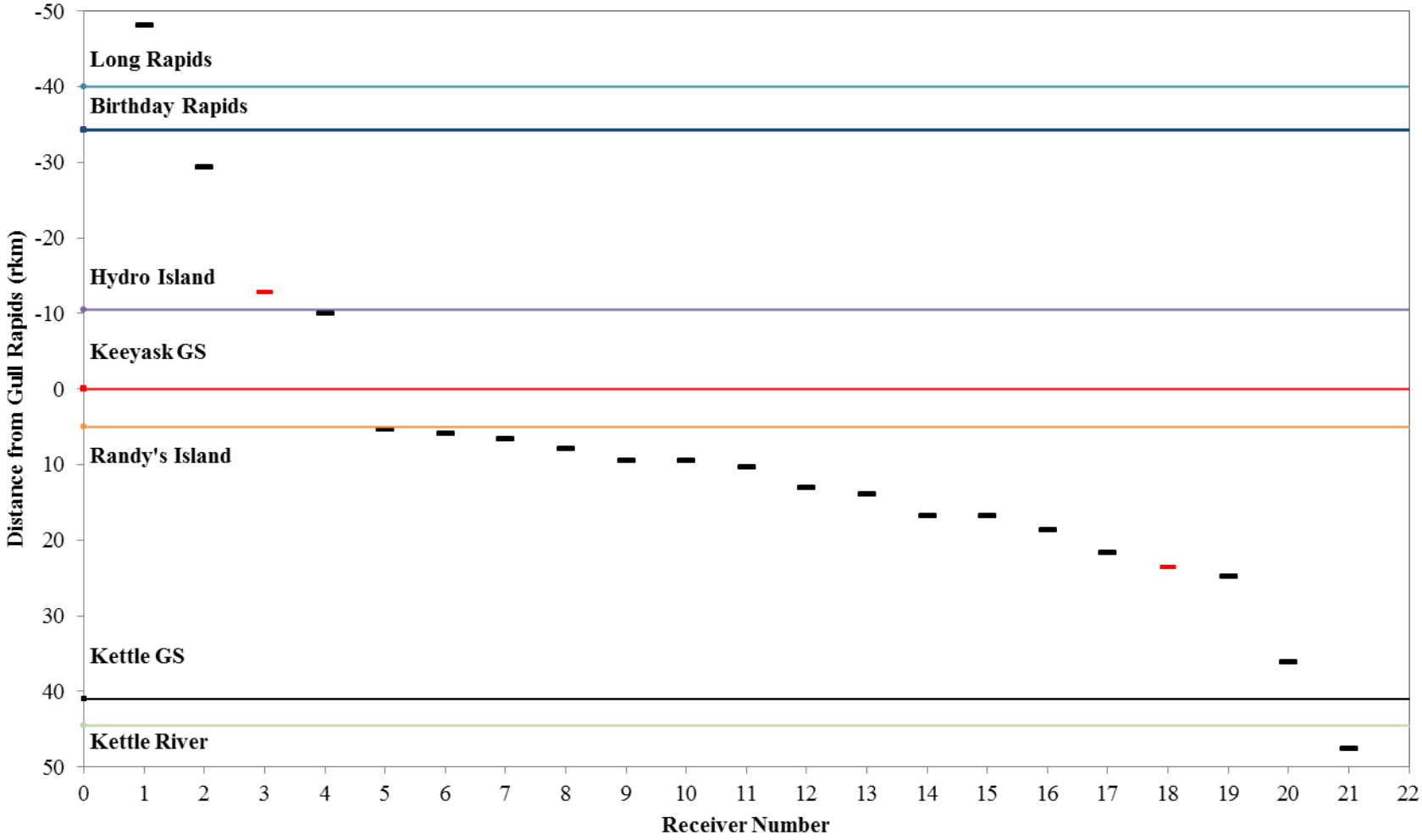


Figure 1: **Locations of stationary acoustic receivers (dashes) in relation to the base of Gull Rapids (rkm 0) and other major landmarks (lines) in the Nelson River between Clark Lake and the Long Spruce GS between October 2016 and June 2017. Red dashes indicate lost receivers.**

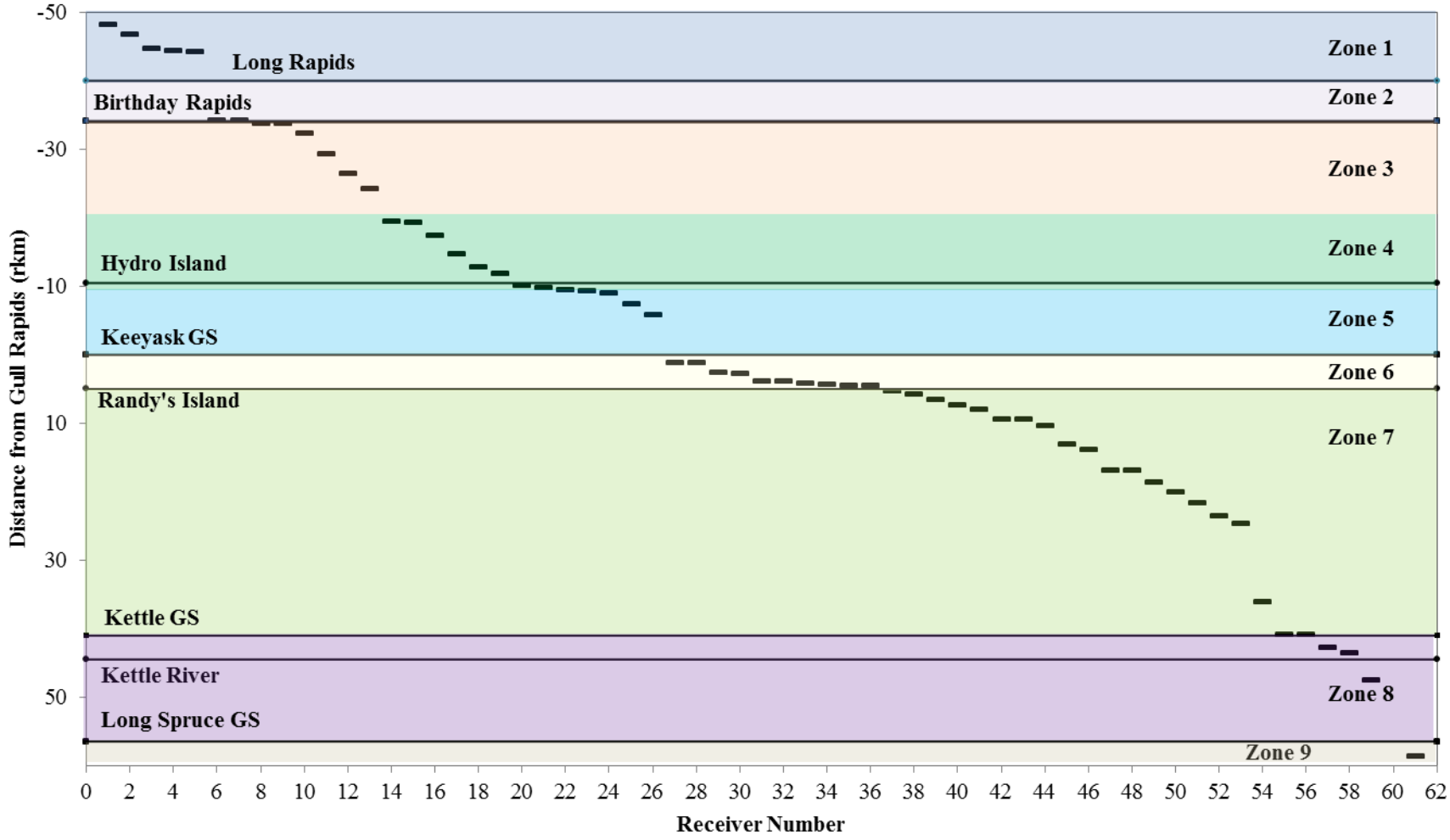


Figure 2: **Locations of stationary acoustic receivers (dashes) in relation to the base of Gull Rapids (rkm 0) and other major landmarks (lines) in the Nelson River between Clark Lake and the Long Spruce GS between June and October, 2017. River zones are indicated by shading.**

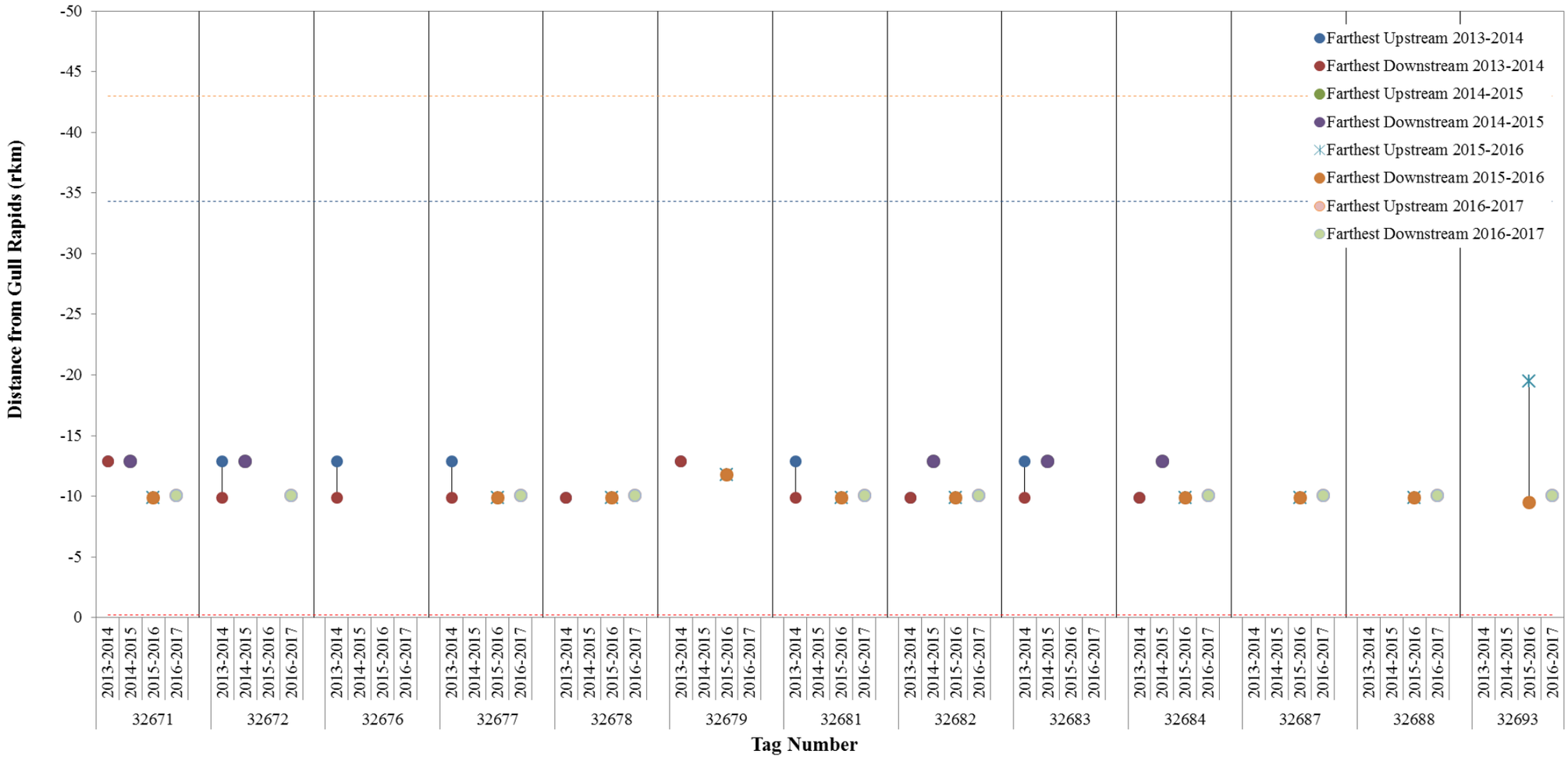


Figure 3: Detection ranges for acoustic tagged juvenile Lake Sturgeon detected between Clark Lake and Gull Rapids during the winter 2013/2014, 2014/2015, 2015/2016, and 2016/2017 periods. Dashed horizontal lines represent location of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

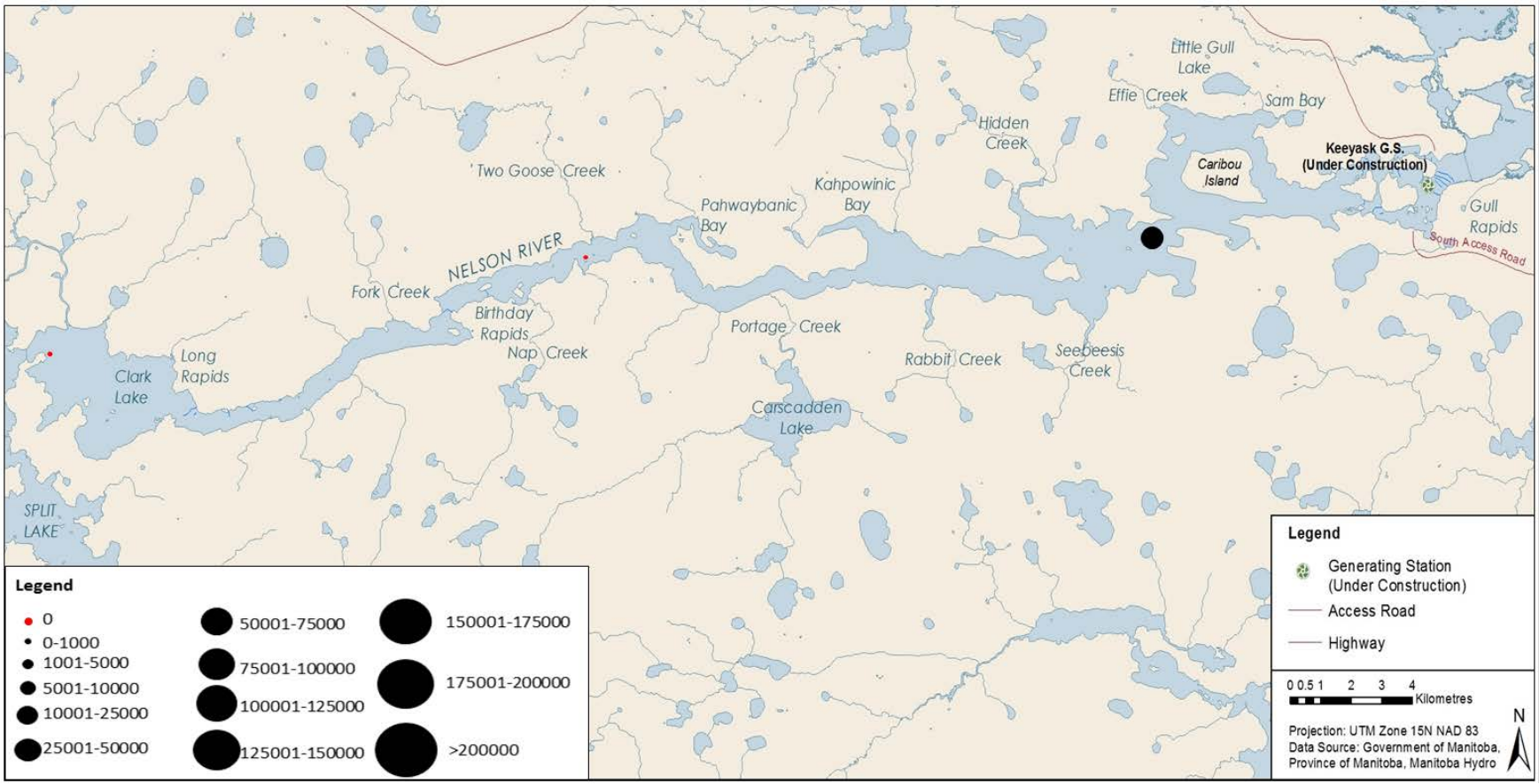


Figure 4: Relative number of detections at each acoustic receiver set between Clark Lake and Gull Rapids during winter 2016/2017 (October 20 to April 30). Number of detections indicated by size of bubble (defined in legend). Receivers with no detections indicated with red dot.

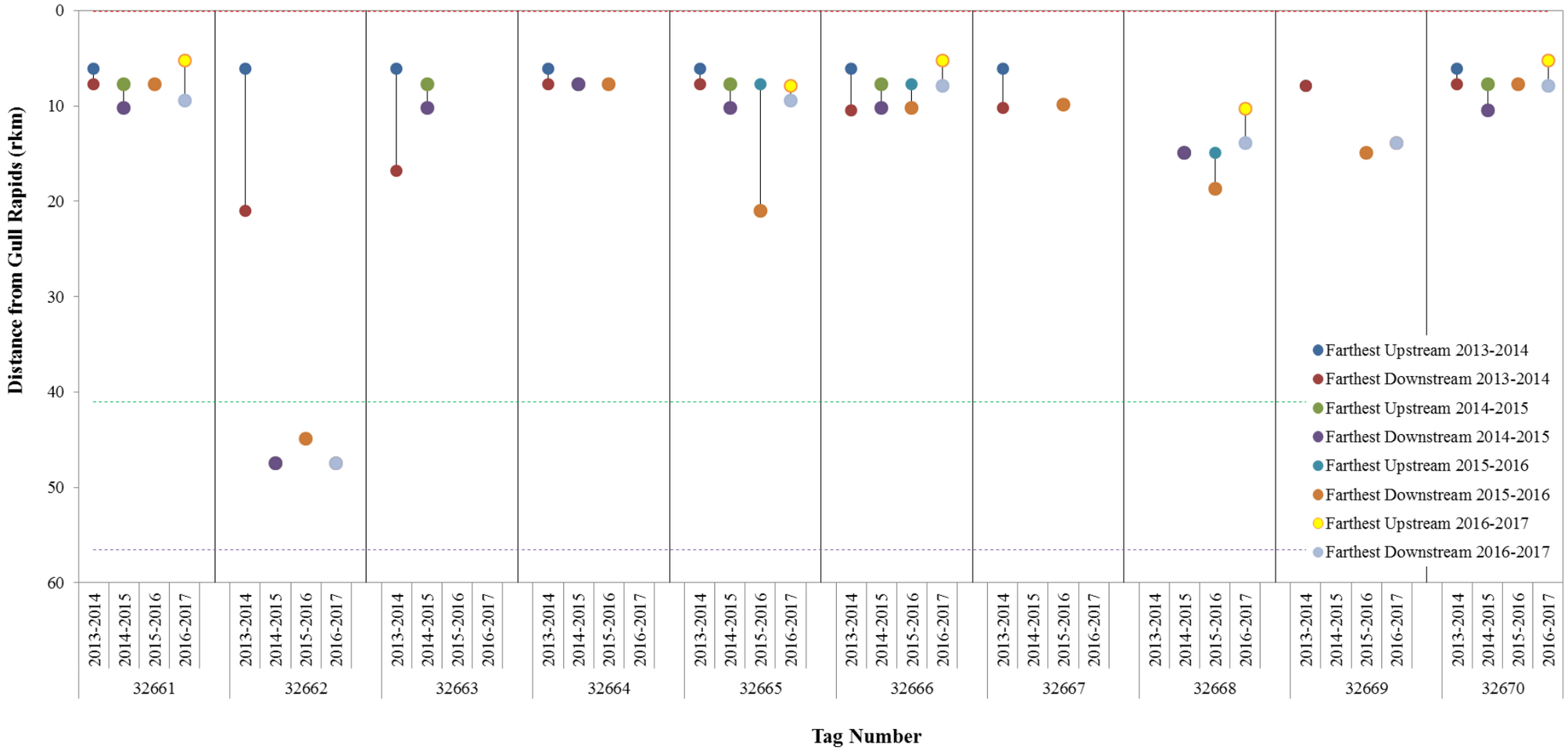


Figure 5: Detection ranges for acoustic tagged juvenile Lake Sturgeon detected downstream of Gull Rapids during the winter 2013/2014, 2014/2015, 2015/2016, and 2016/2017 periods. Dashed horizontal lines represent locations of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple).

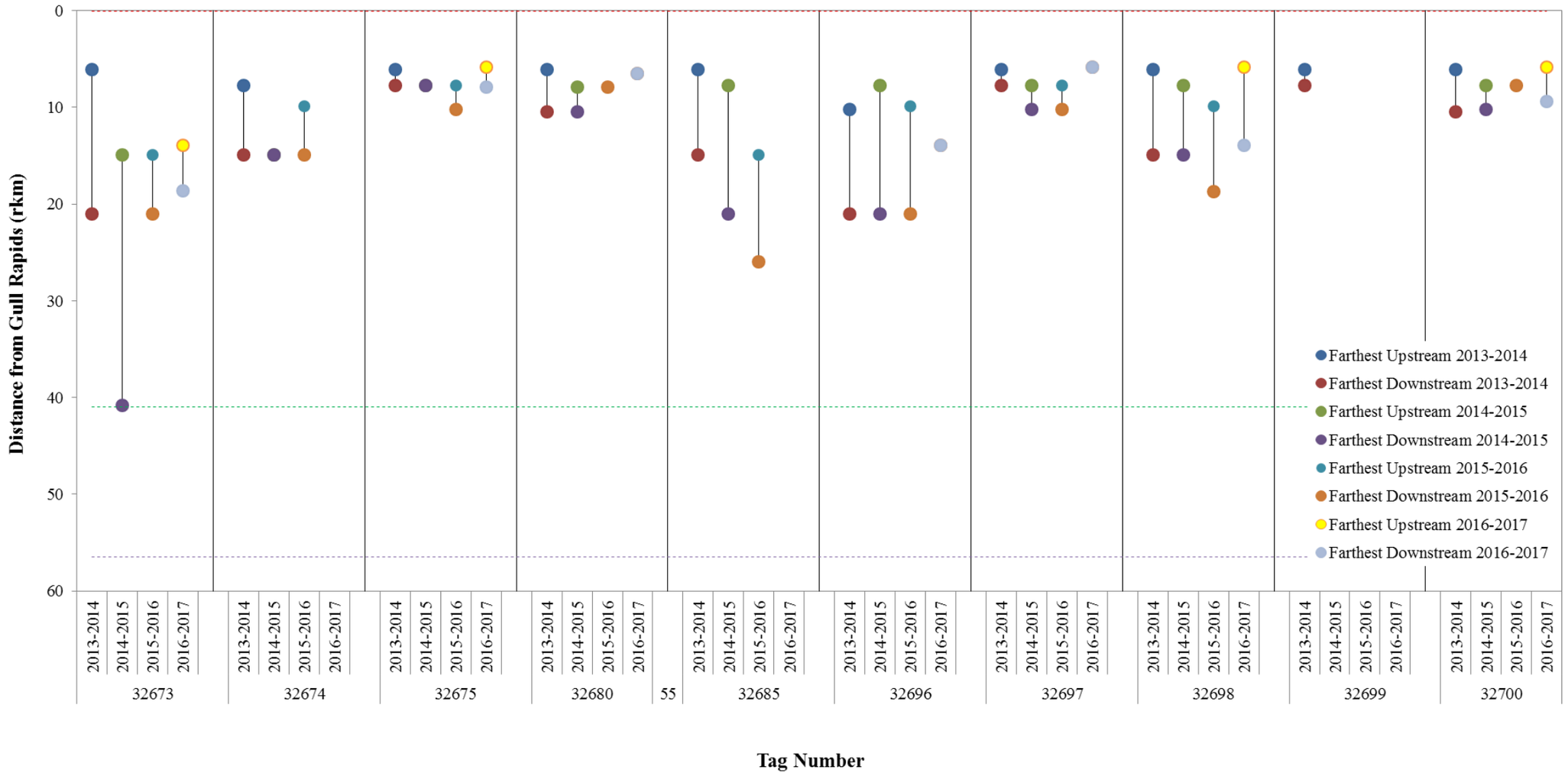


Figure 5: Detection ranges for acoustic tagged juvenile Lake Sturgeon detected downstream of Gull Rapids during the winter 2013/2014, 2014/2015, 2015/2016, and 2016/2017 periods. Dashed horizontal lines represent locations of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple) (continued).

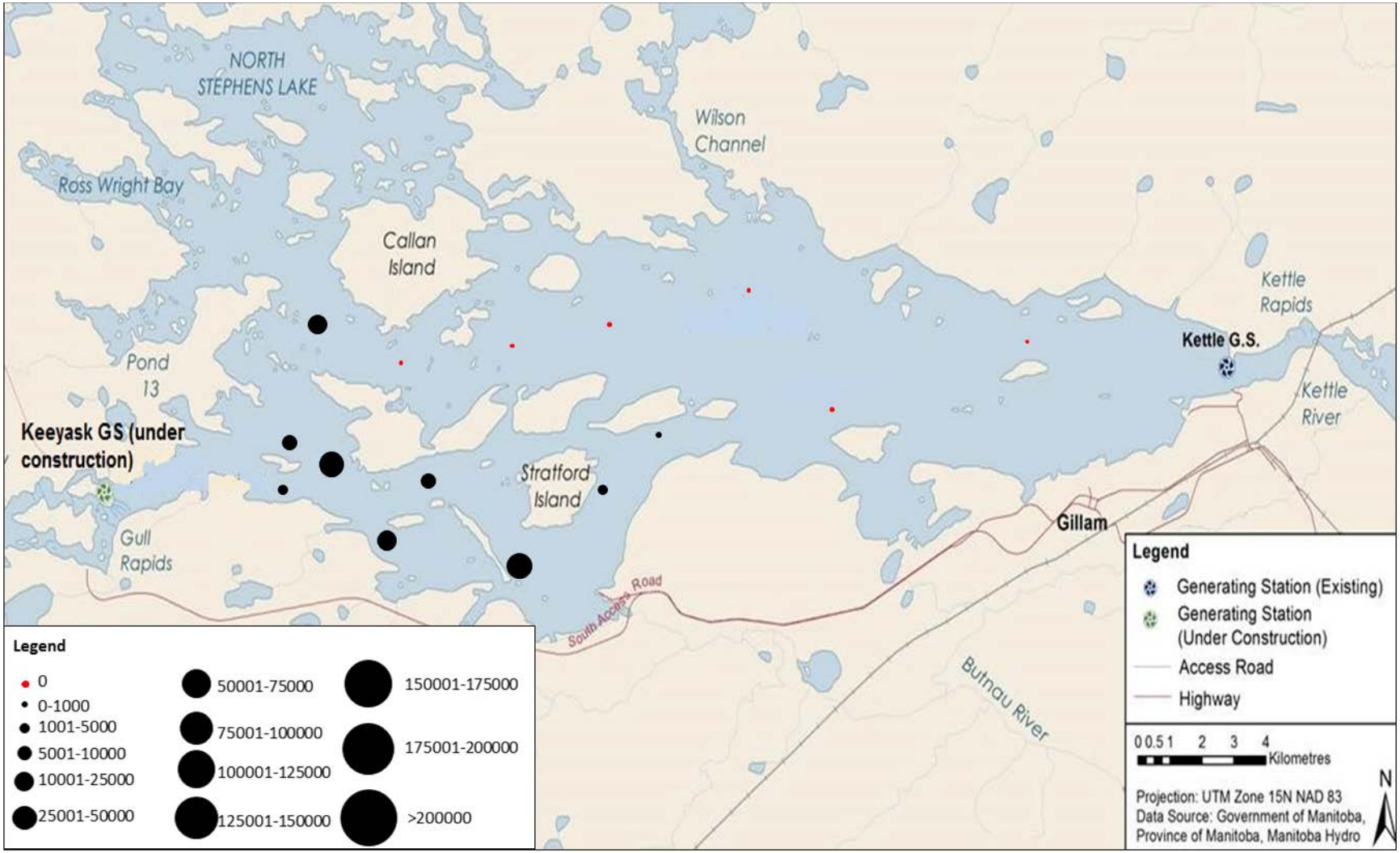


Figure 6: Relative number of detections at each acoustic receiver set in Stephens Lake during winter 2016/2017 (October 20 to April 30). Number of detections indicated by size of bubble (defined in legend). Receivers with no detections indicated with red dot.

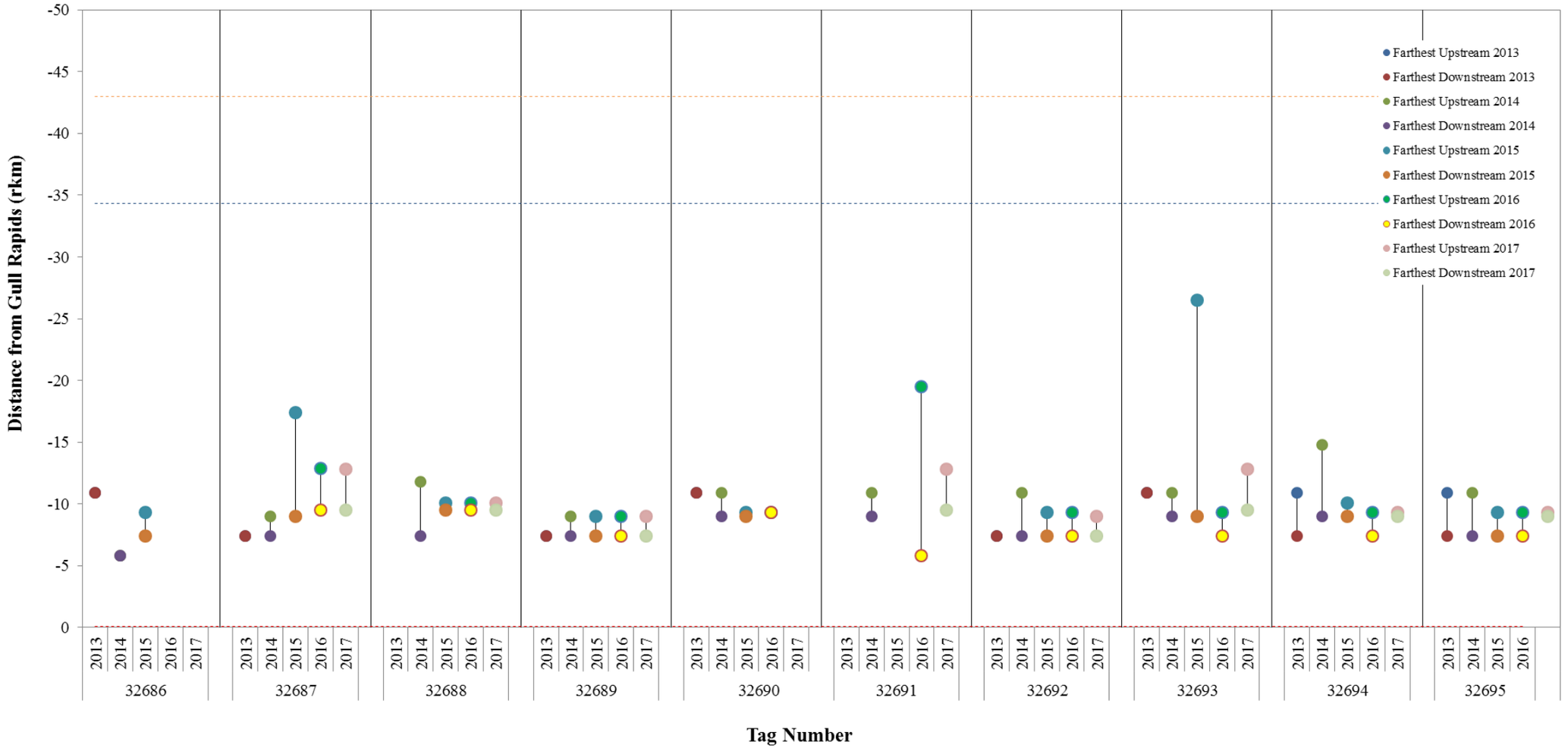


Figure 7: Detection ranges for acoustic tagged juvenile Lake Sturgeon between Clark Lake and Gull Rapids during the open-water periods of 2013–2017. Dashed horizontal lines represent location of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

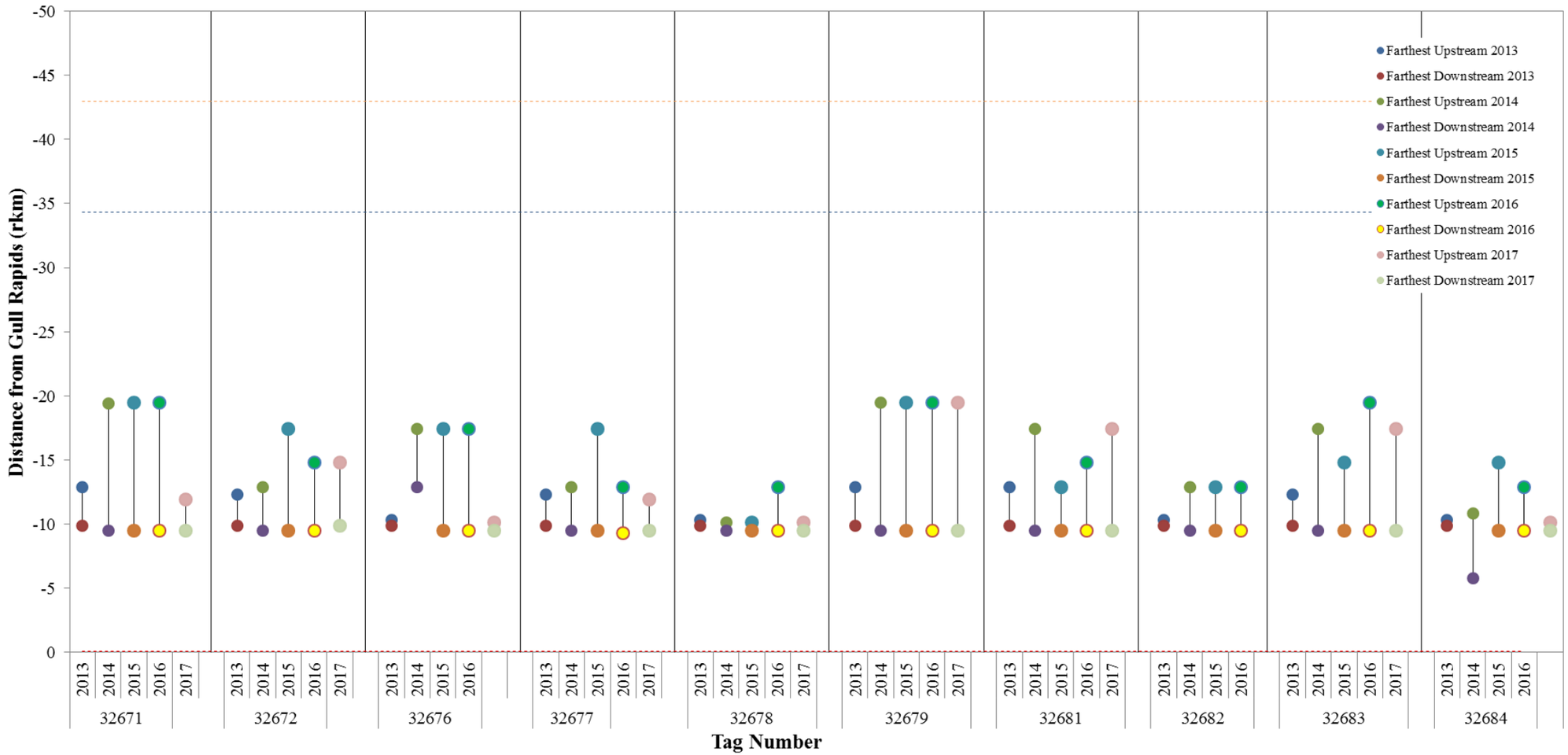


Figure 7: Detection ranges for acoustic tagged juvenile Lake Sturgeon between Clark Lake and Gull Rapids during the open-water periods of 2013–2017. Dashed horizontal lines represent location of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange) (continued).

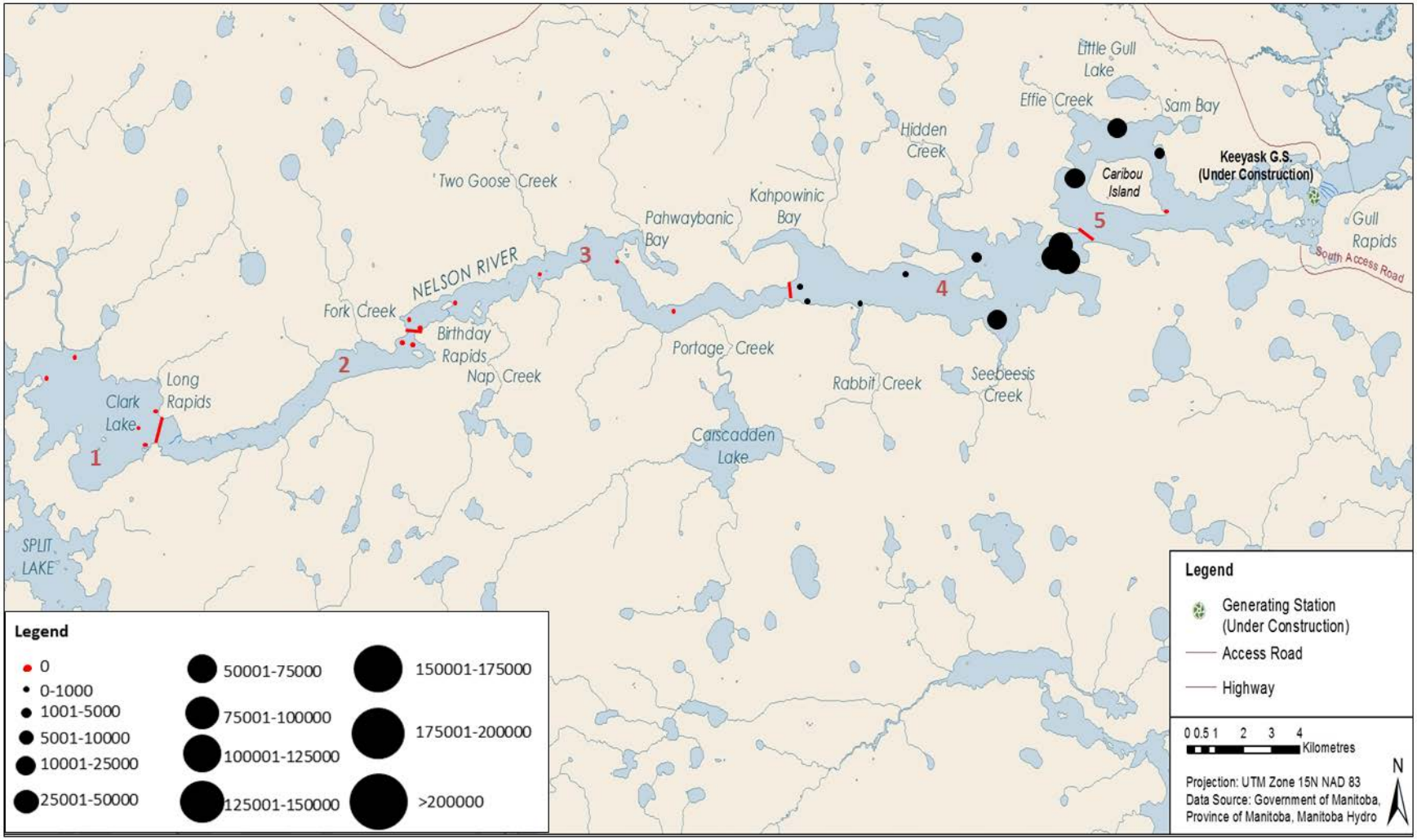


Figure 8: Relative number of detections at each acoustic receiver set in the Nelson River between Clark Lake and Gull Rapids during the 2017 open-water period (May 1 to October 16). Number of detections indicated by size of bubble (defined in legend). Receivers with no detections indicated with red dot.

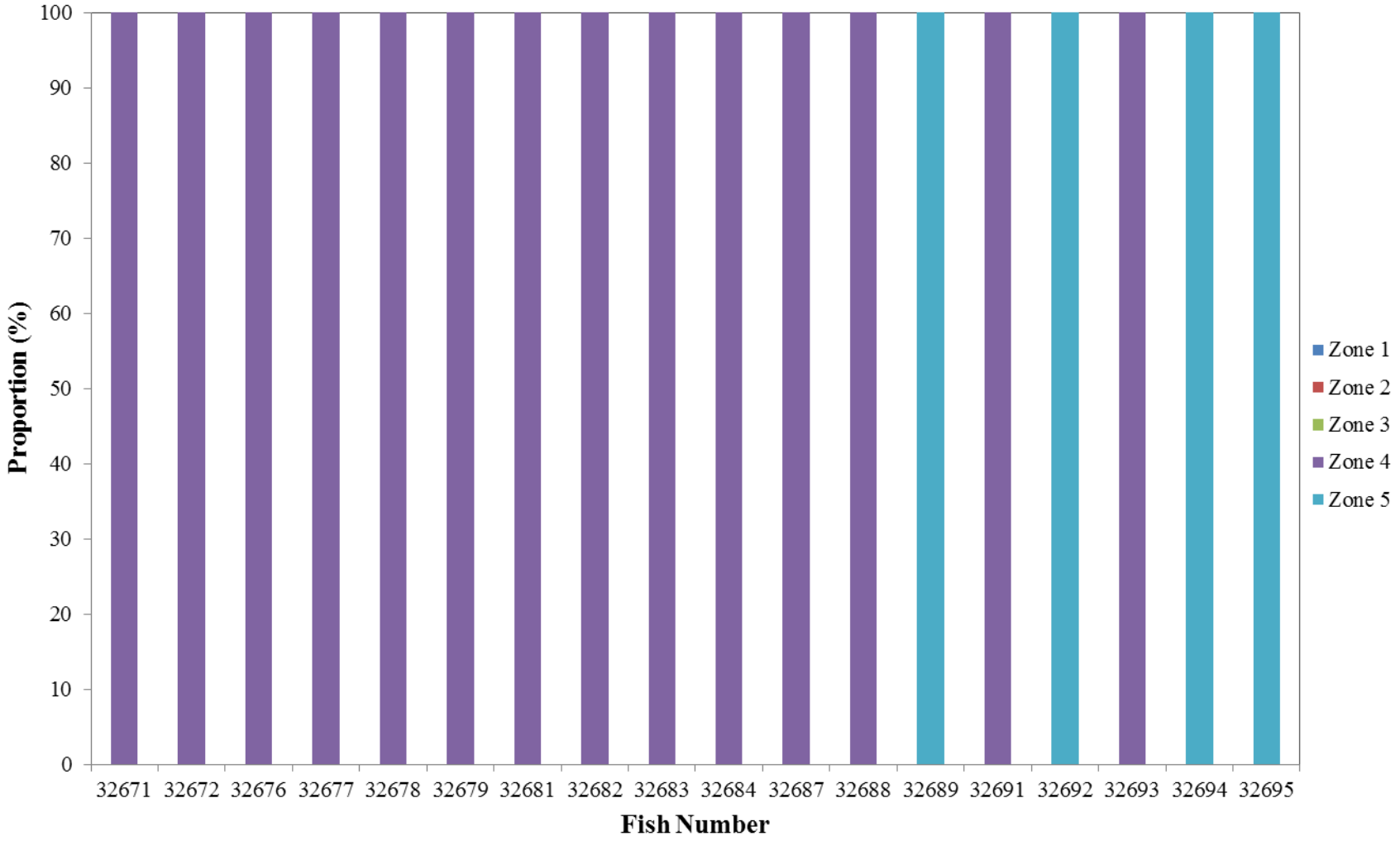


Figure 9: Proportional distributions by zone for individual juvenile Lake Sturgeon between Clark Lake and Gull Rapids during a portion of the 2017 open-water period (June 7 to October 16).

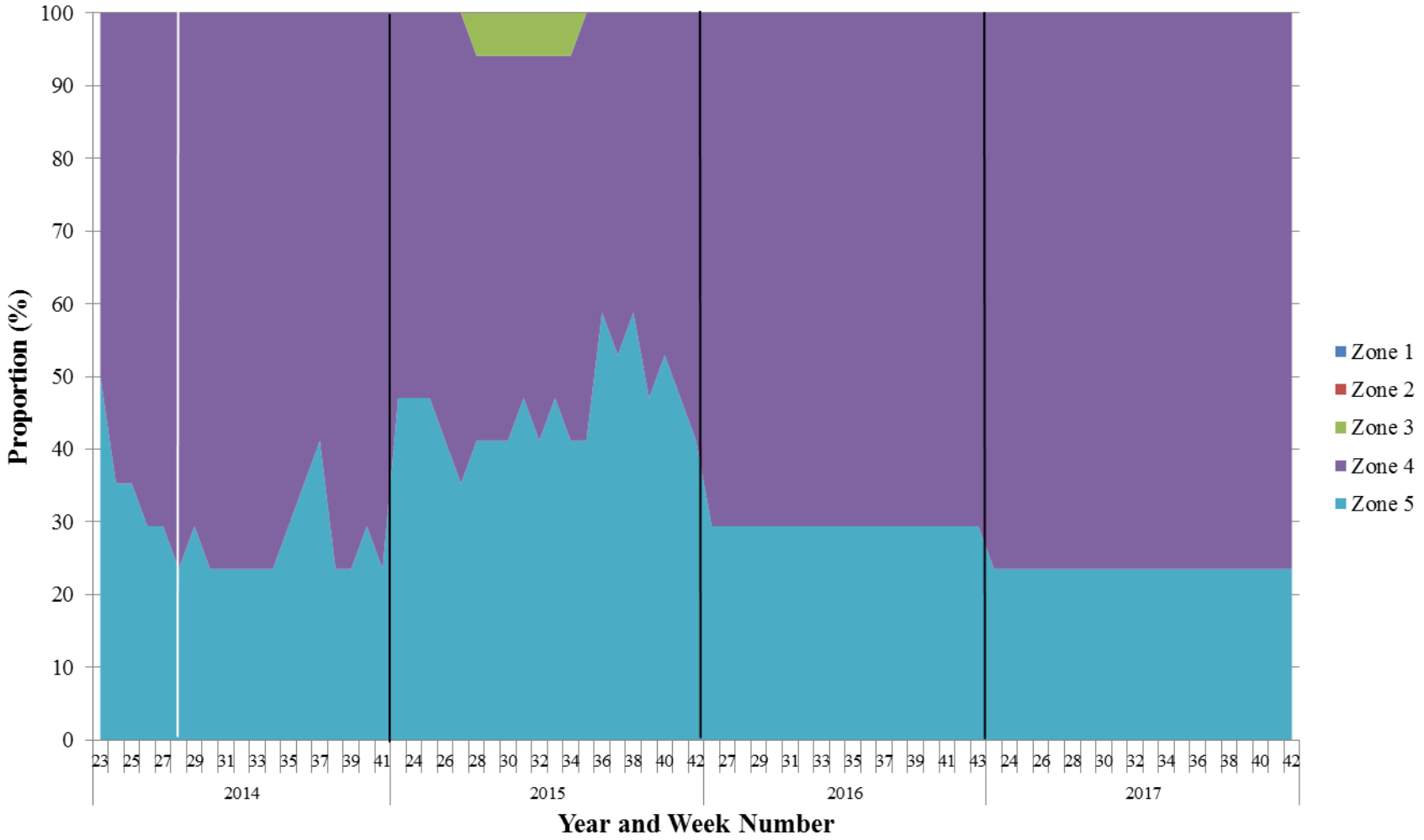


Figure 10: Proportional distribution by zone per week for juvenile Lake Sturgeon between Clark Lake and Gull Rapids during portions of the open-water periods of 2014 (June 4 to October 10), 2015 (June 4 to October 11), 2016 (June 25 to October 19), and 2017 (June 7 to October 16). Black vertical lines demarcate years. White vertical line indicates start of construction of Keeyask GS.

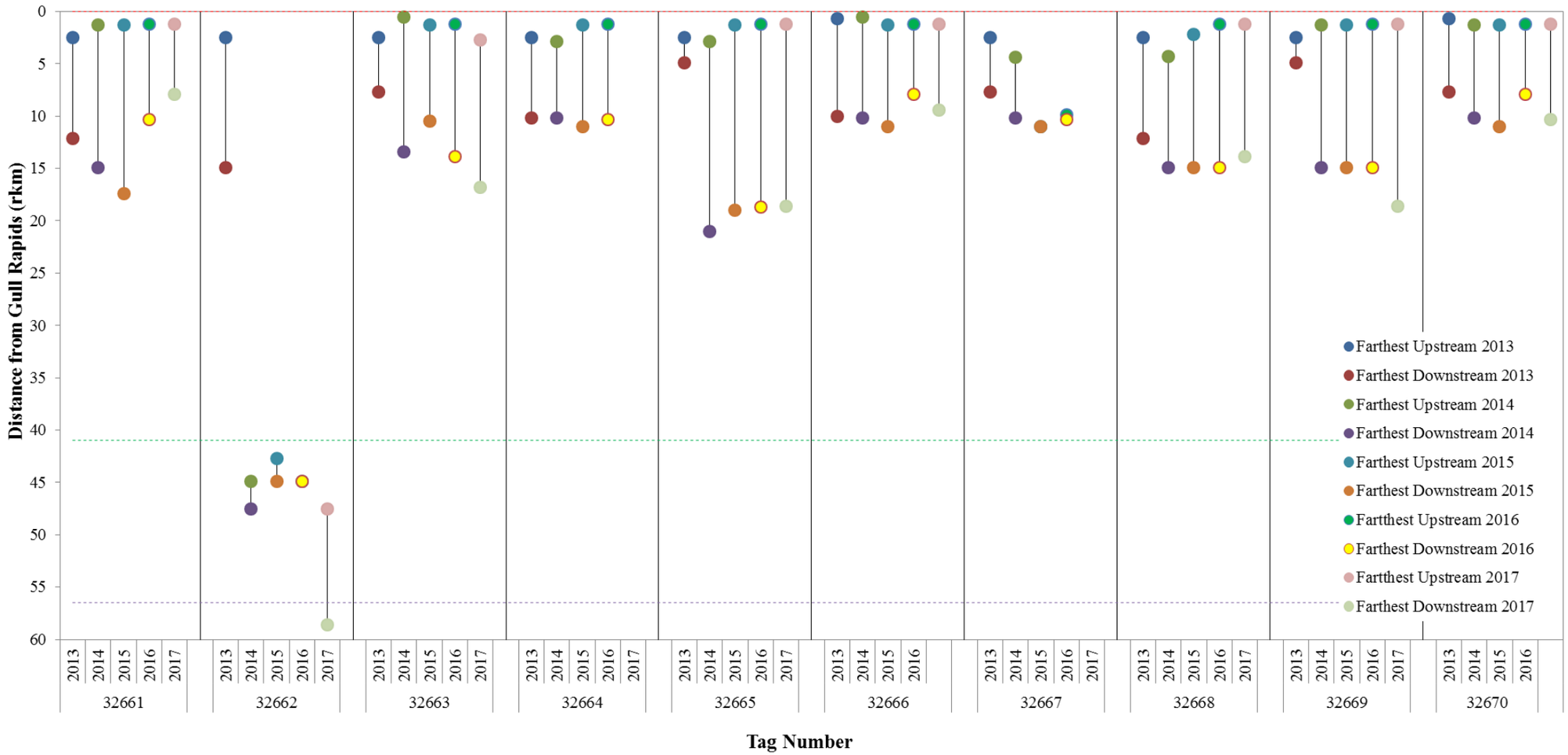


Figure 11: Detection ranges for acoustic tagged juvenile Lake Sturgeon downstream of Gull Rapids during the open-water periods of 2013–2017. Dashed horizontal lines represent locations of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple).

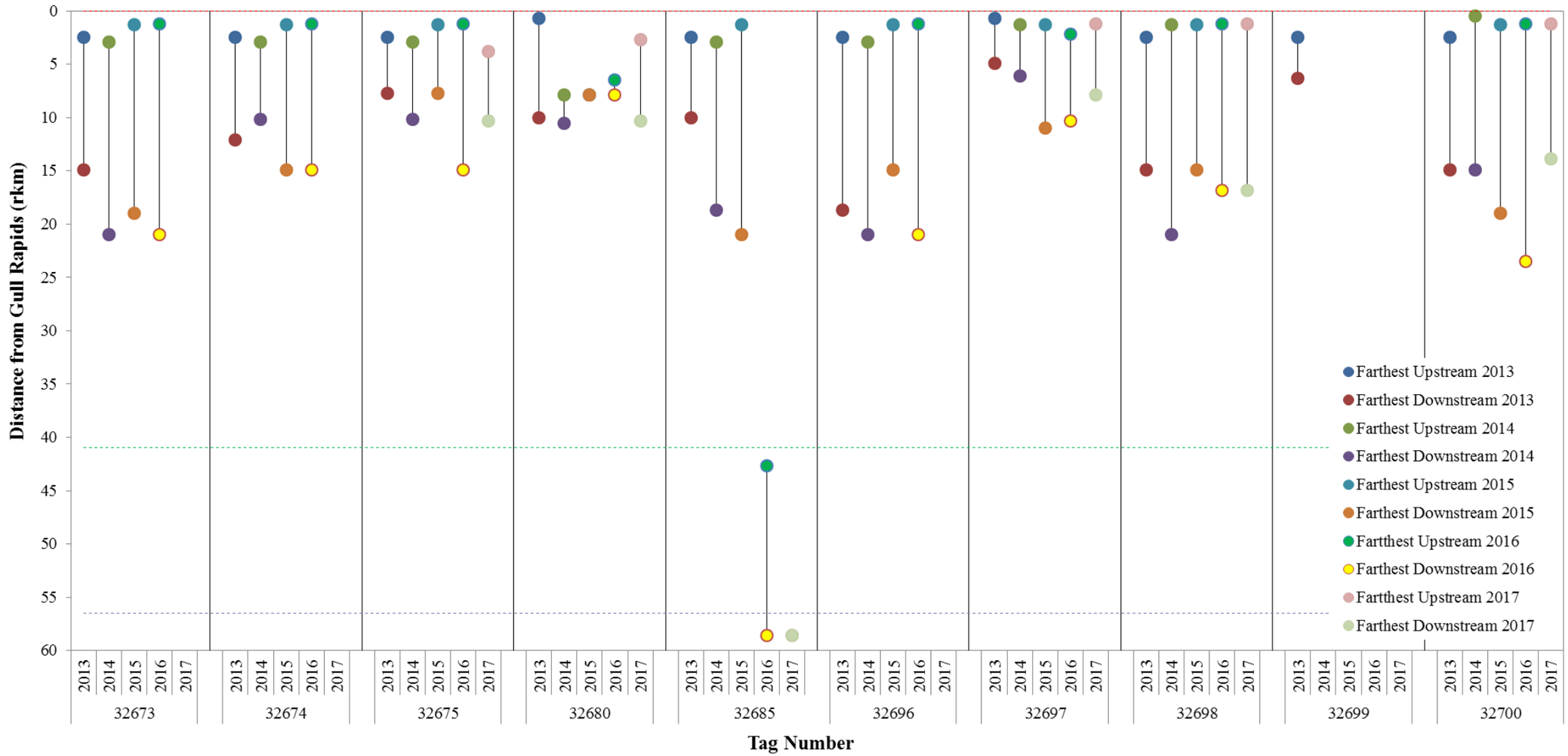


Figure 11: Detection ranges for acoustic tagged juvenile Lake Sturgeon downstream of Gull Rapids during the open-water periods of 2013–2017. Dashed horizontal lines represent locations of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple) (continued).

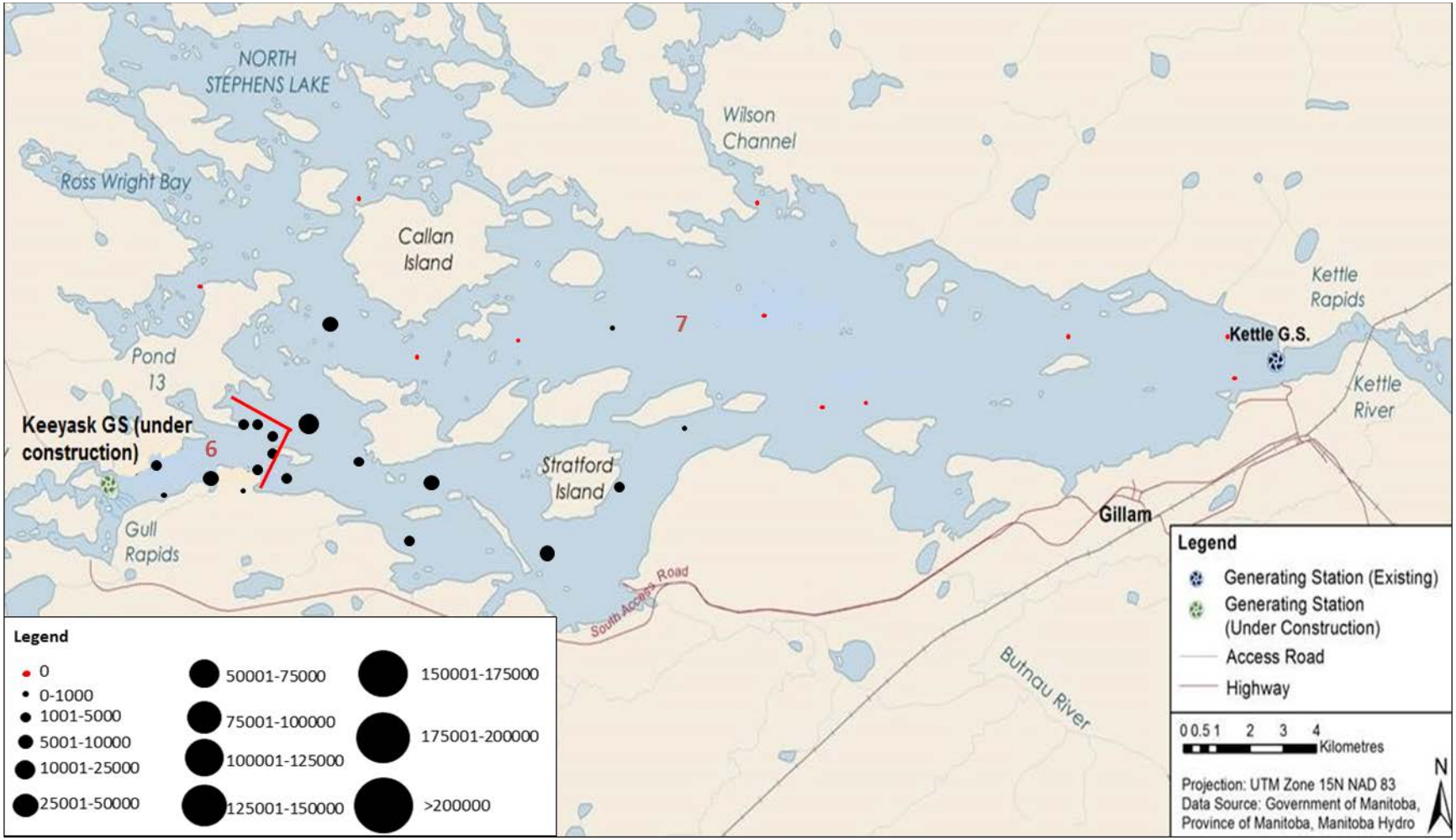


Figure 12: Relative number of detections at each acoustic receiver set in Stephens Lake during the 2017 open-water period (May 1 to October 16). Number of detections indicated by size of bubble (defined in legend). Receivers with no detections indicated with red dot.

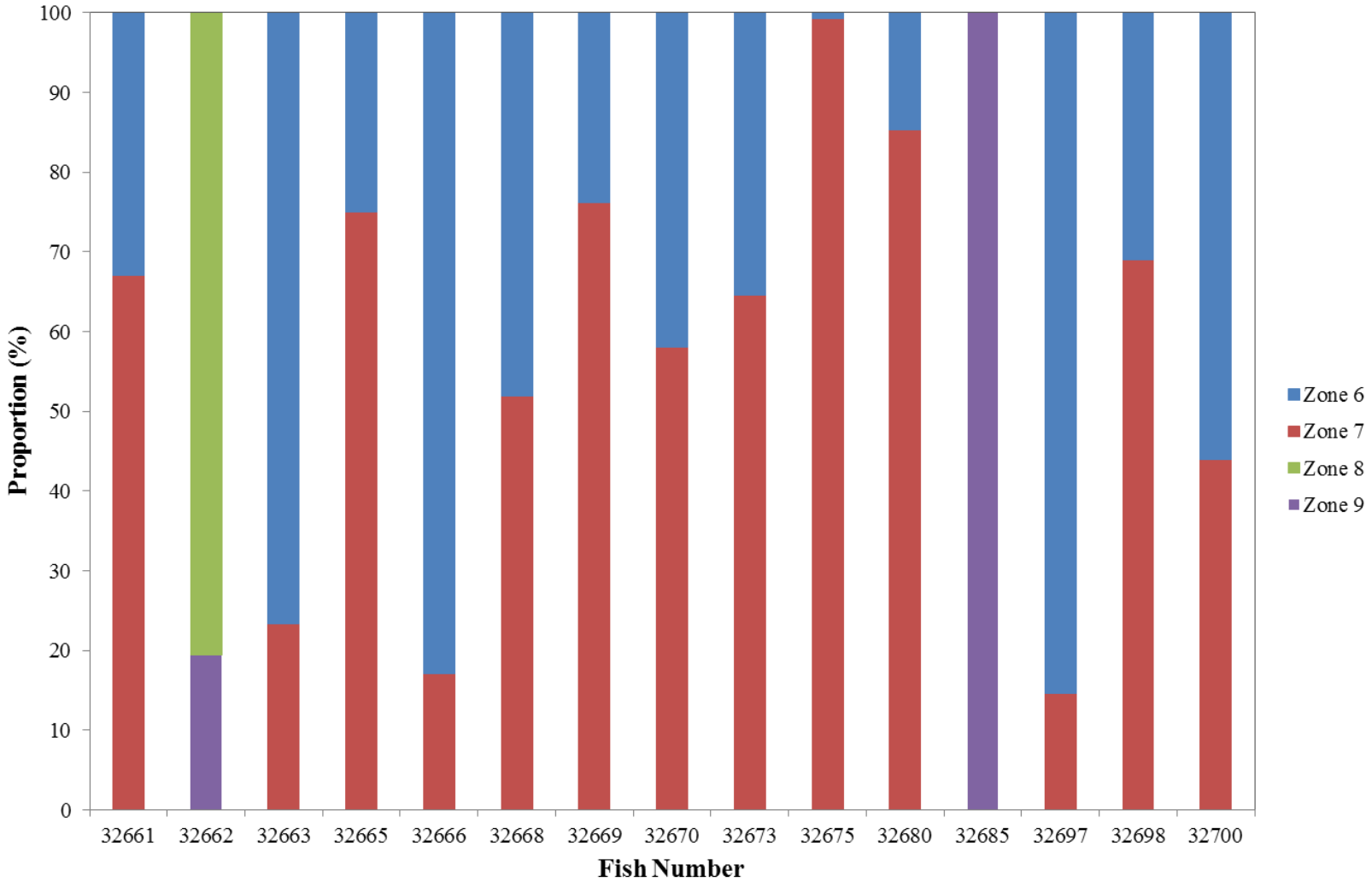


Figure 13: Proportional distributions by zone for individual juvenile Lake Sturgeon downstream of Gull Rapids during a portion of the 2017 open-water period (June 7 to October 16).

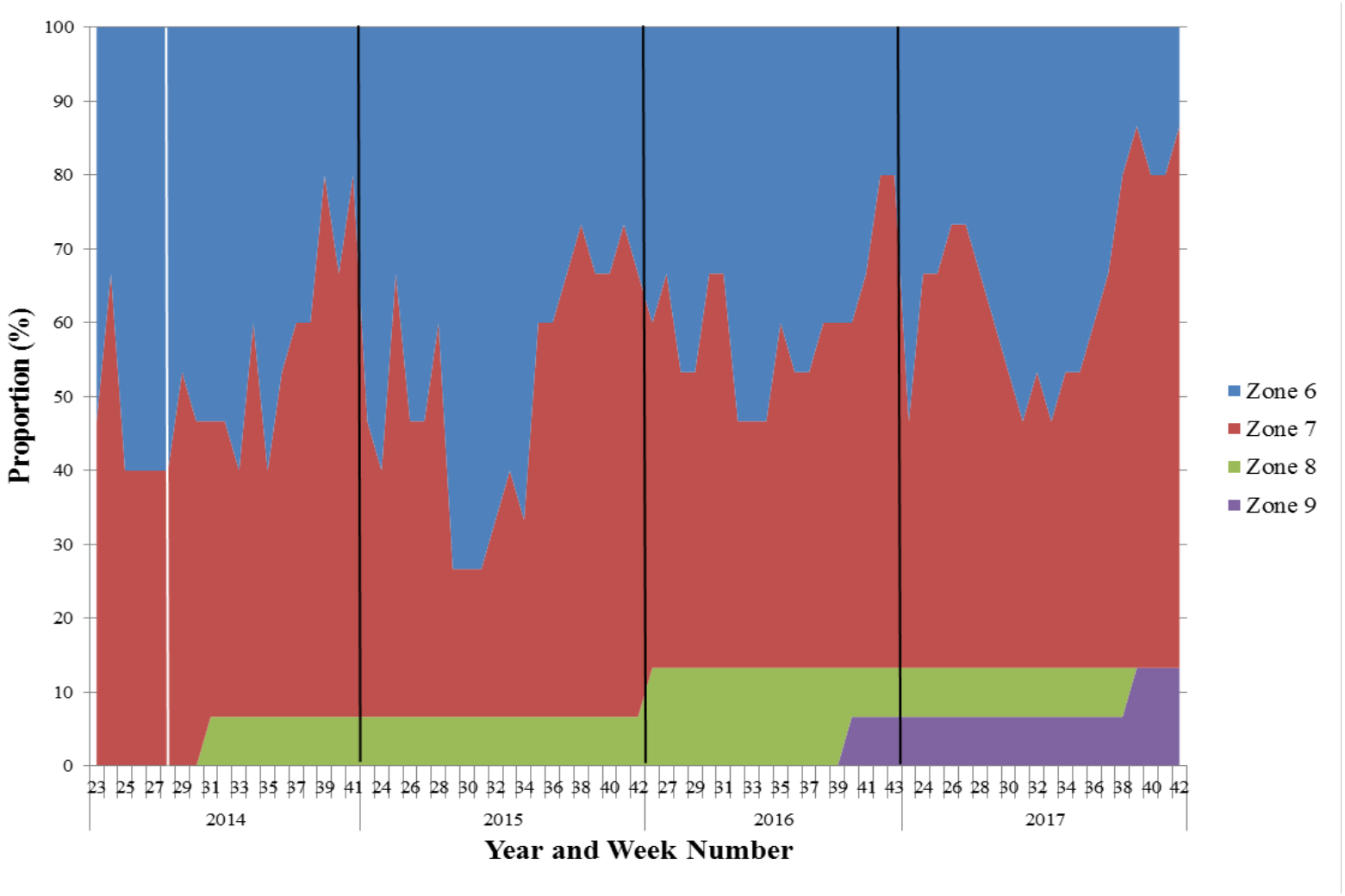
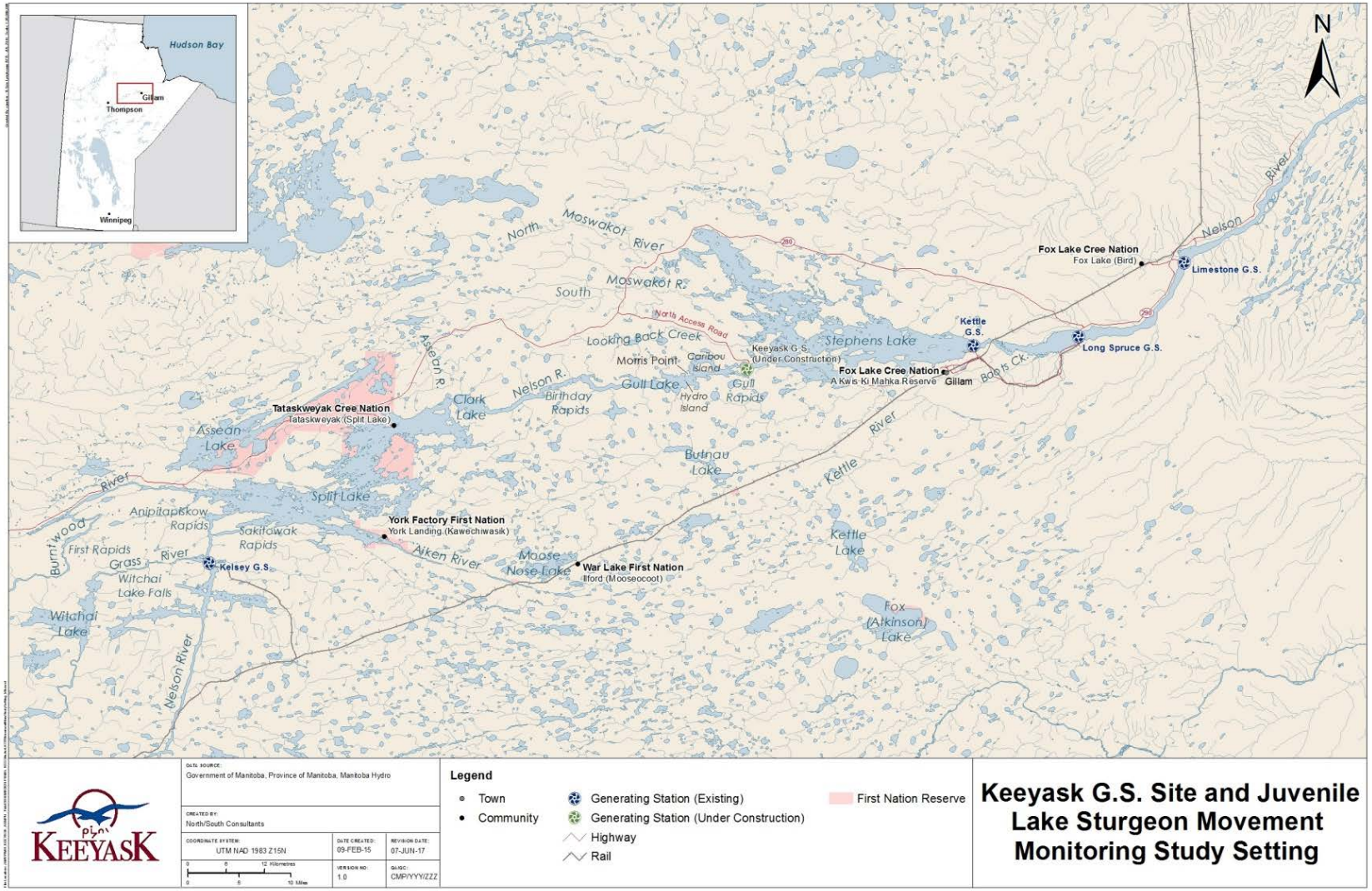


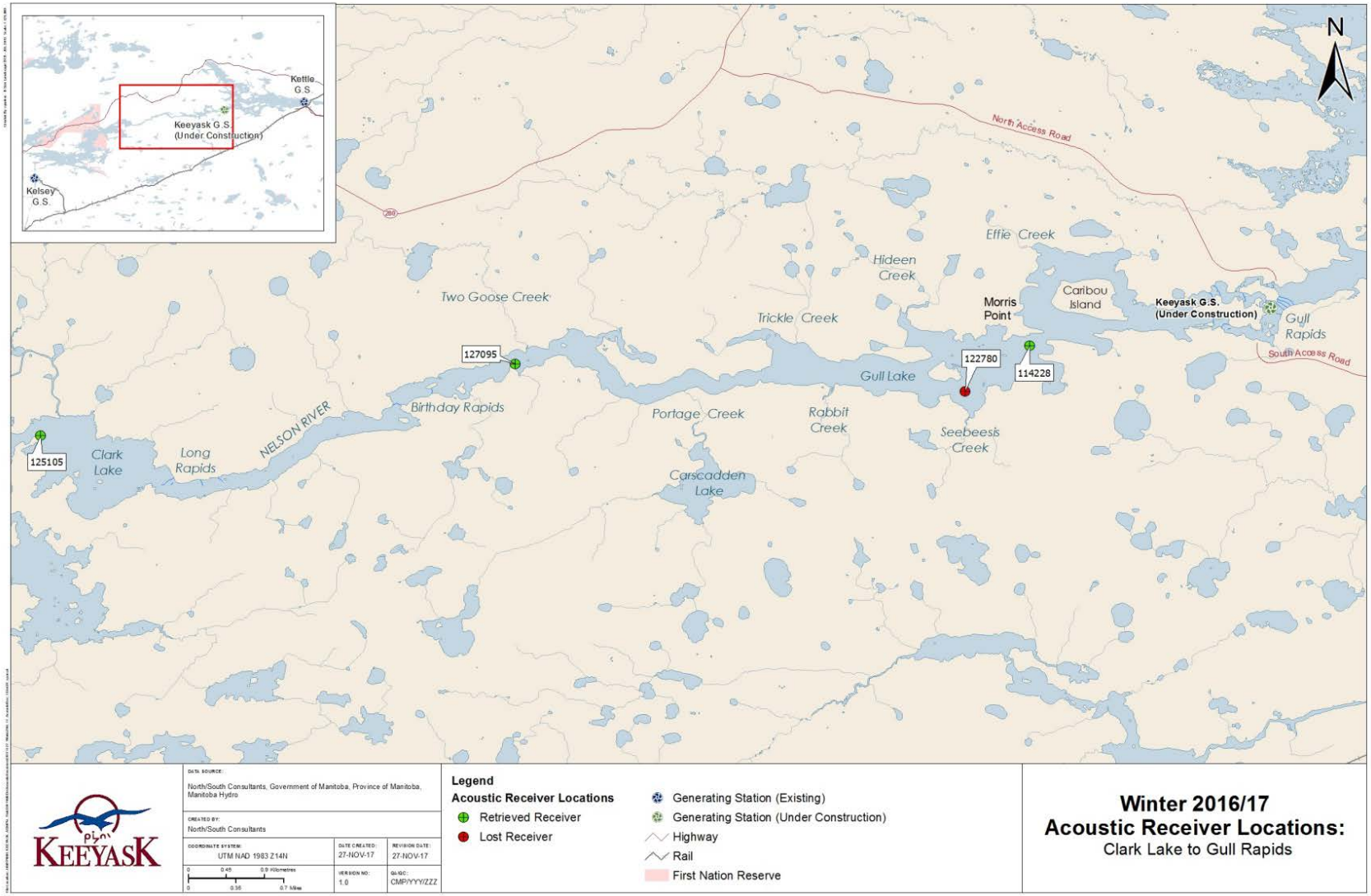
Figure 14: Proportional distribution by zone per week for juvenile Lake Sturgeon downstream of Gull Rapids during portions of the 2014 (June 4 to October 10), 2015 (June 4 to October 11), 2016 (June 25 to October 19), and 2017 (June 7 to October 16) open-water periods. Black vertical lines demarcate years. White vertical line indicates start of construction of Keeyask GS.

MAPS

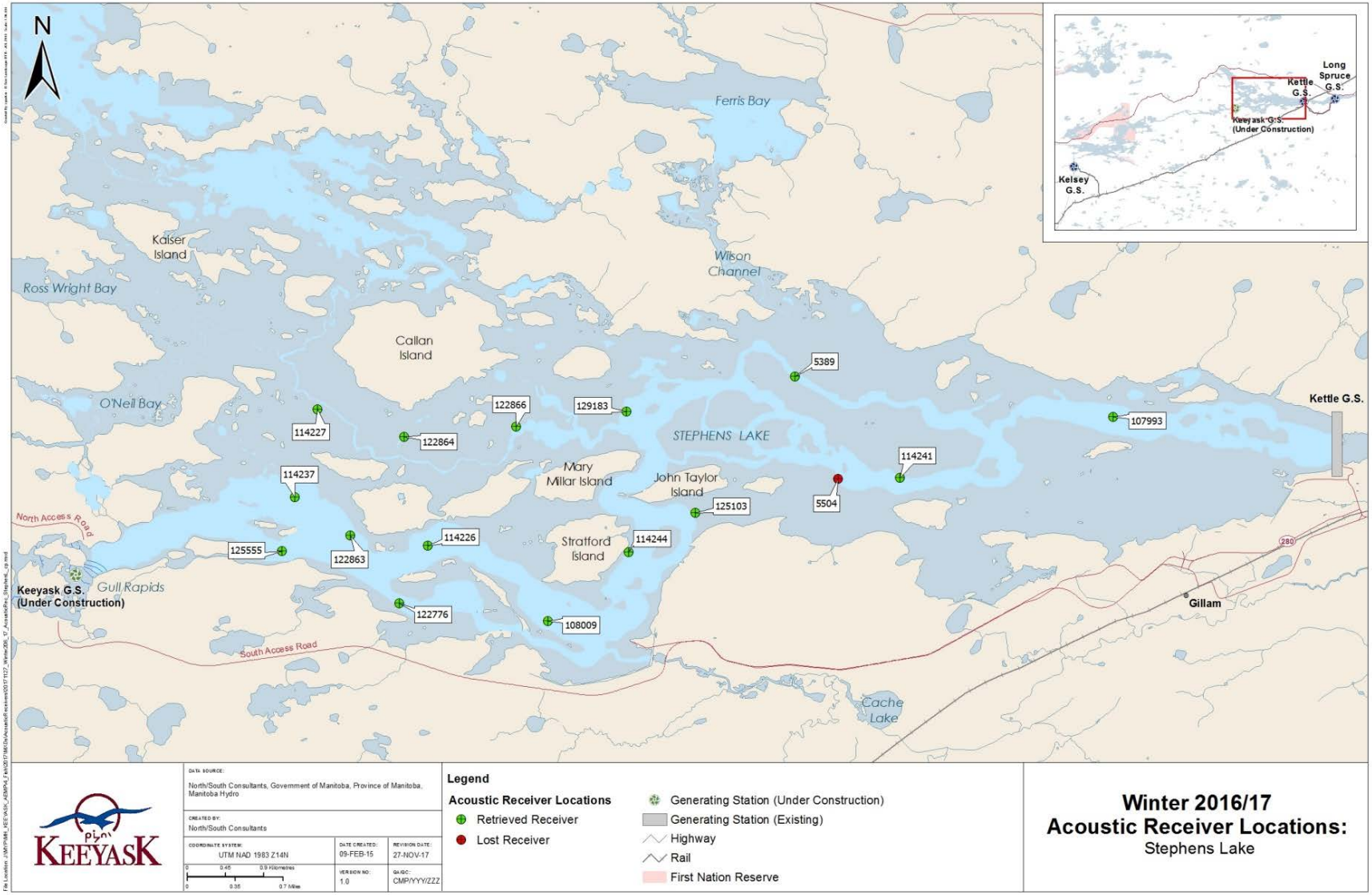


Map 1: Map of the Nelson River showing the site of the Keeyask Generating Station and the juvenile Lake Sturgeon movement monitoring study setting.

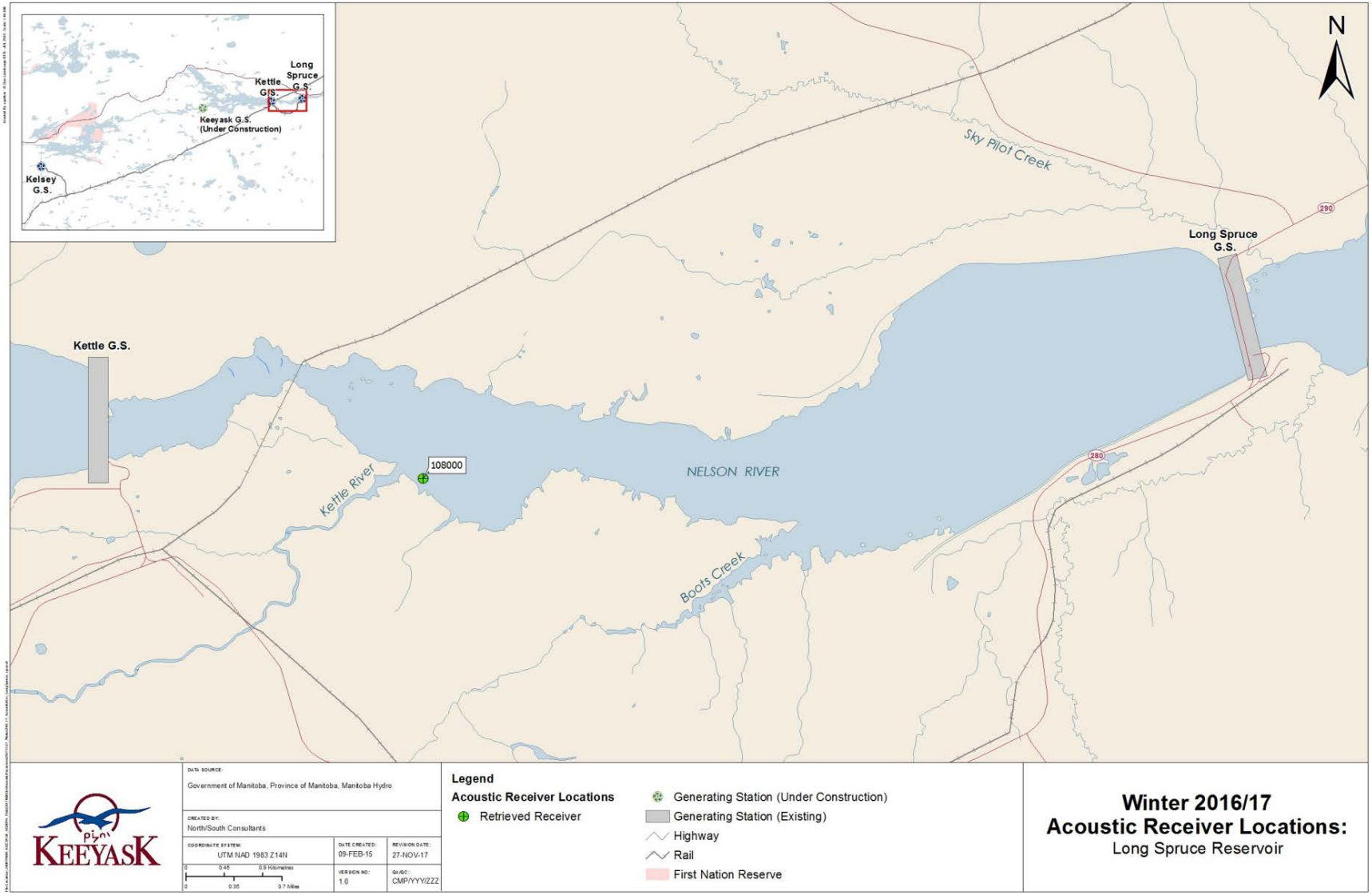
Map 2: Map of instream structures at the Keeyask Generating Station site, September 2017.



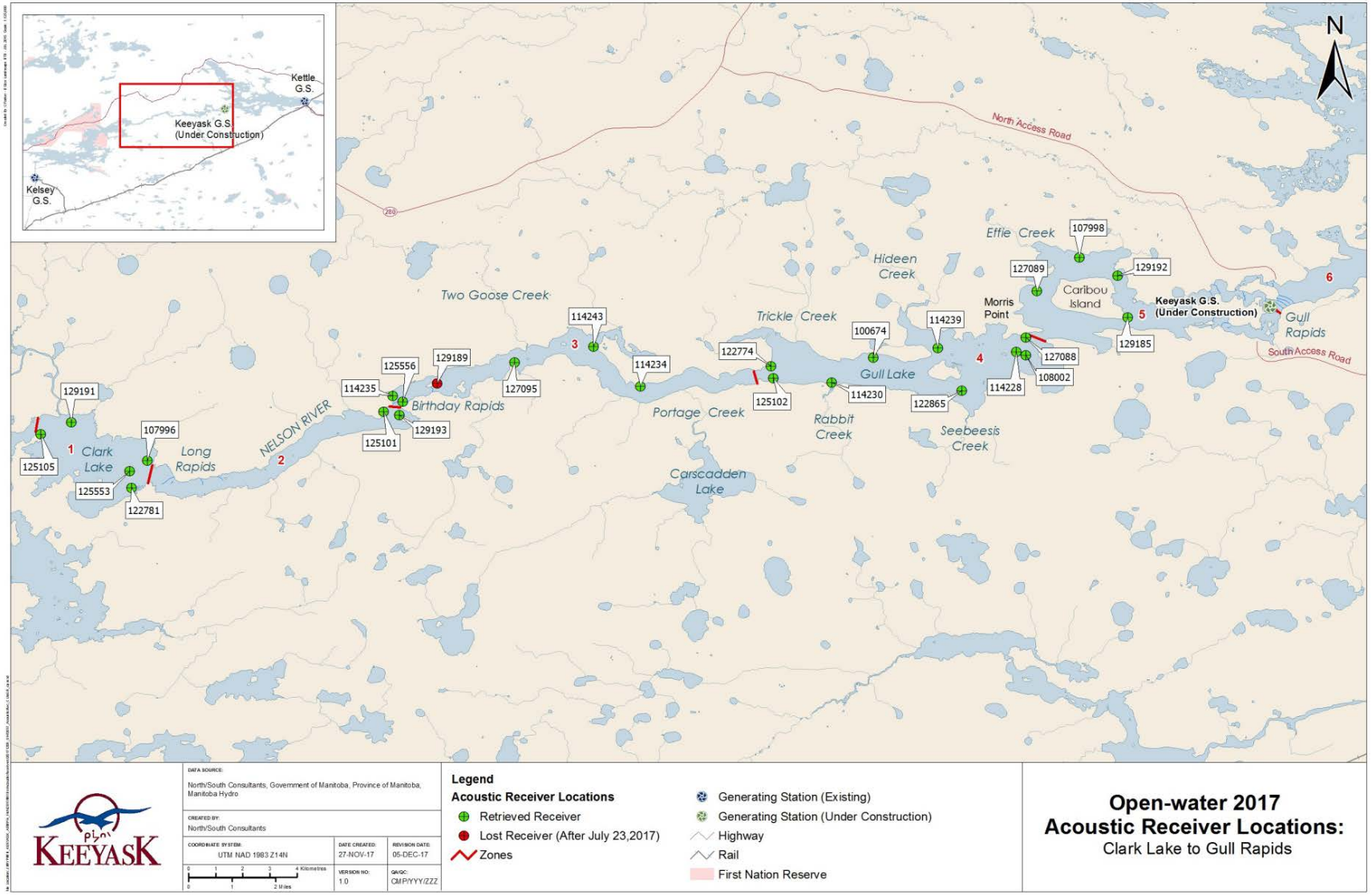
Map 3: Locations of stationary receivers set in the Nelson River from Clark Lake to Gull Rapids between October 2016 and June 2017.



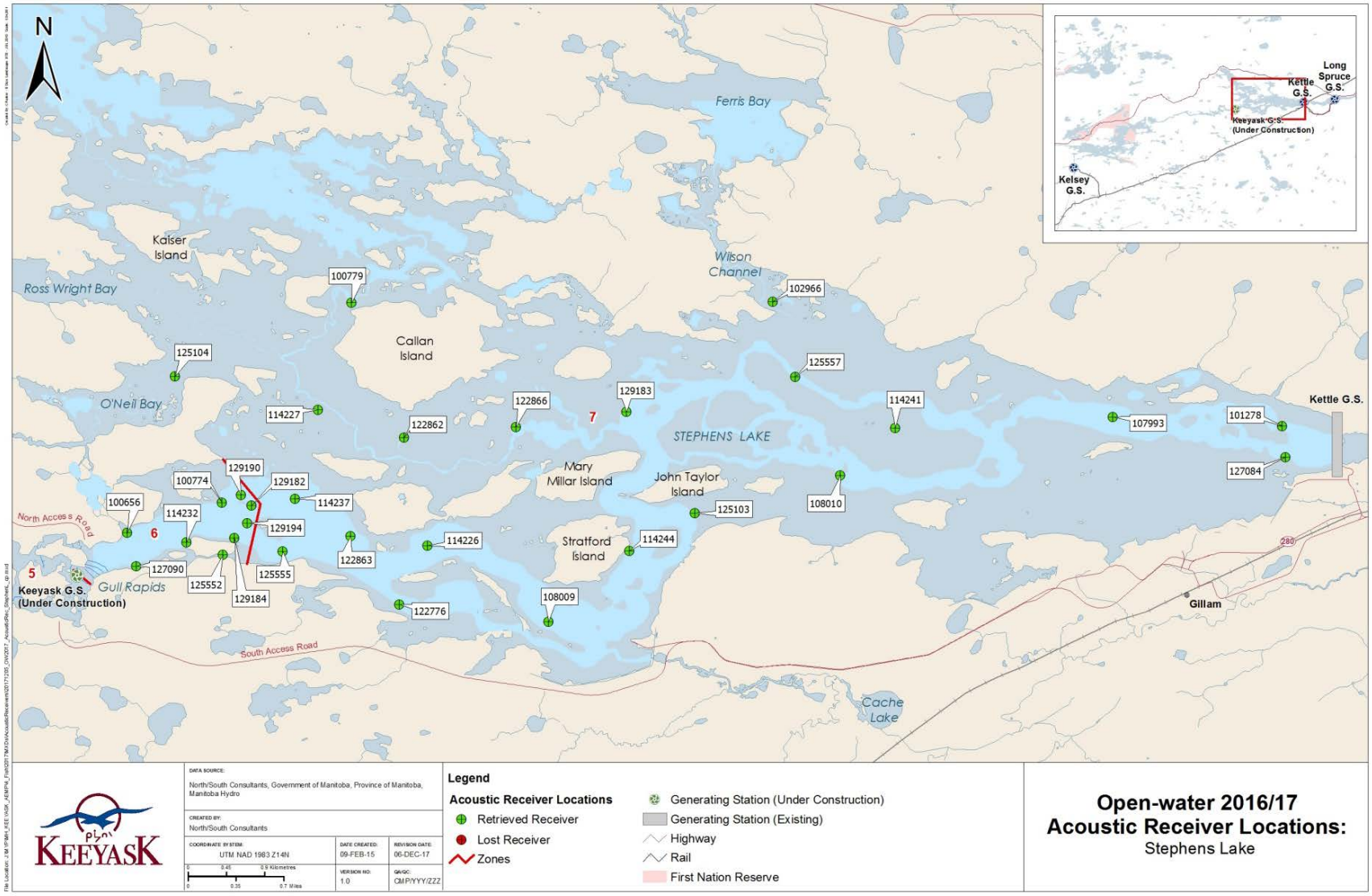
Map 4: Locations of stationary receivers set in Stephens Lake from Gull Rapids to Kettle GS between October 2016 and June 2017. The former (pre-impoundment) river channel is shown in light blue.



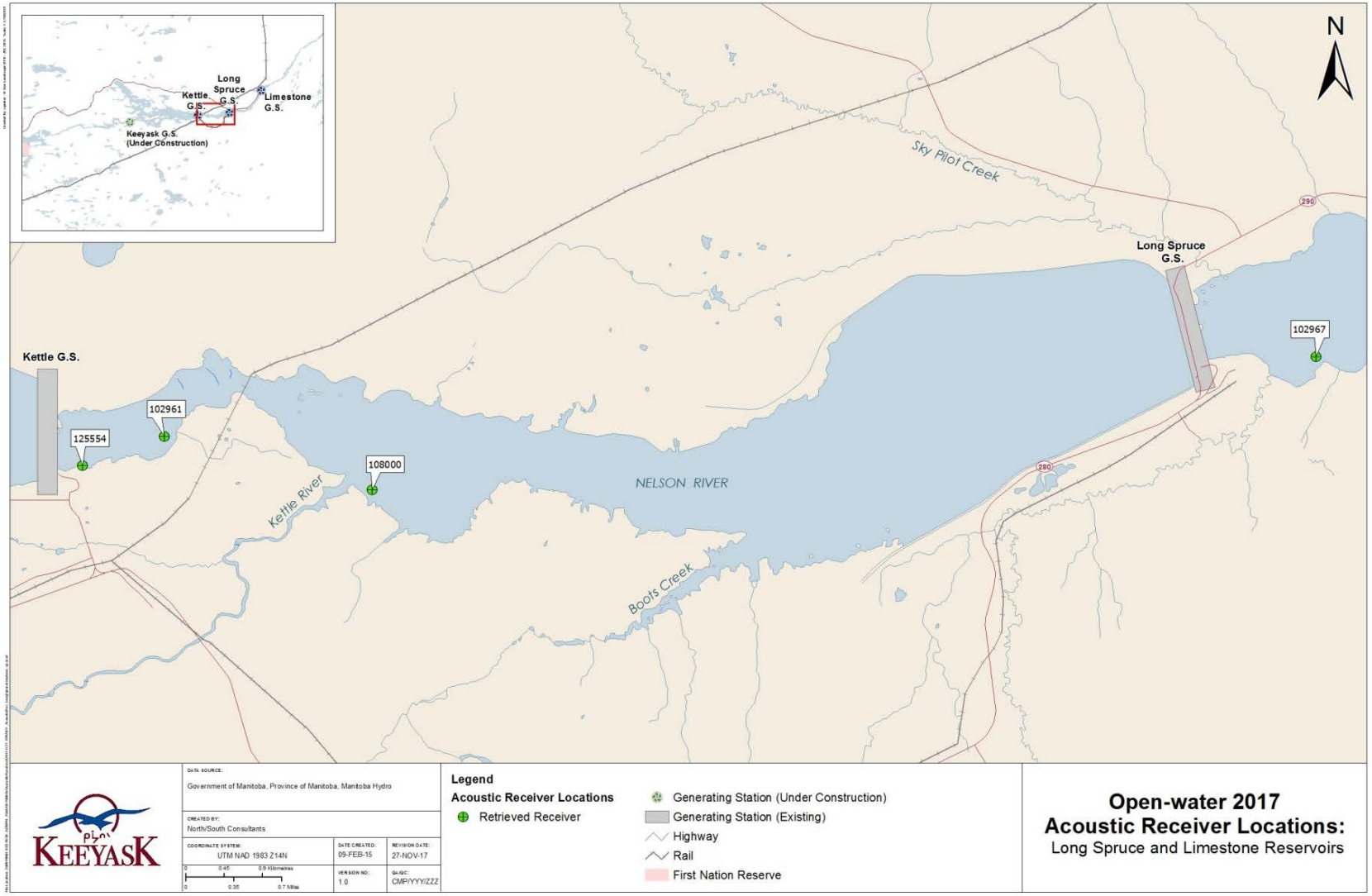
Map 5: Location of the stationary receiver set in the Long Spruce reservoir between October 2016 and June 2017.



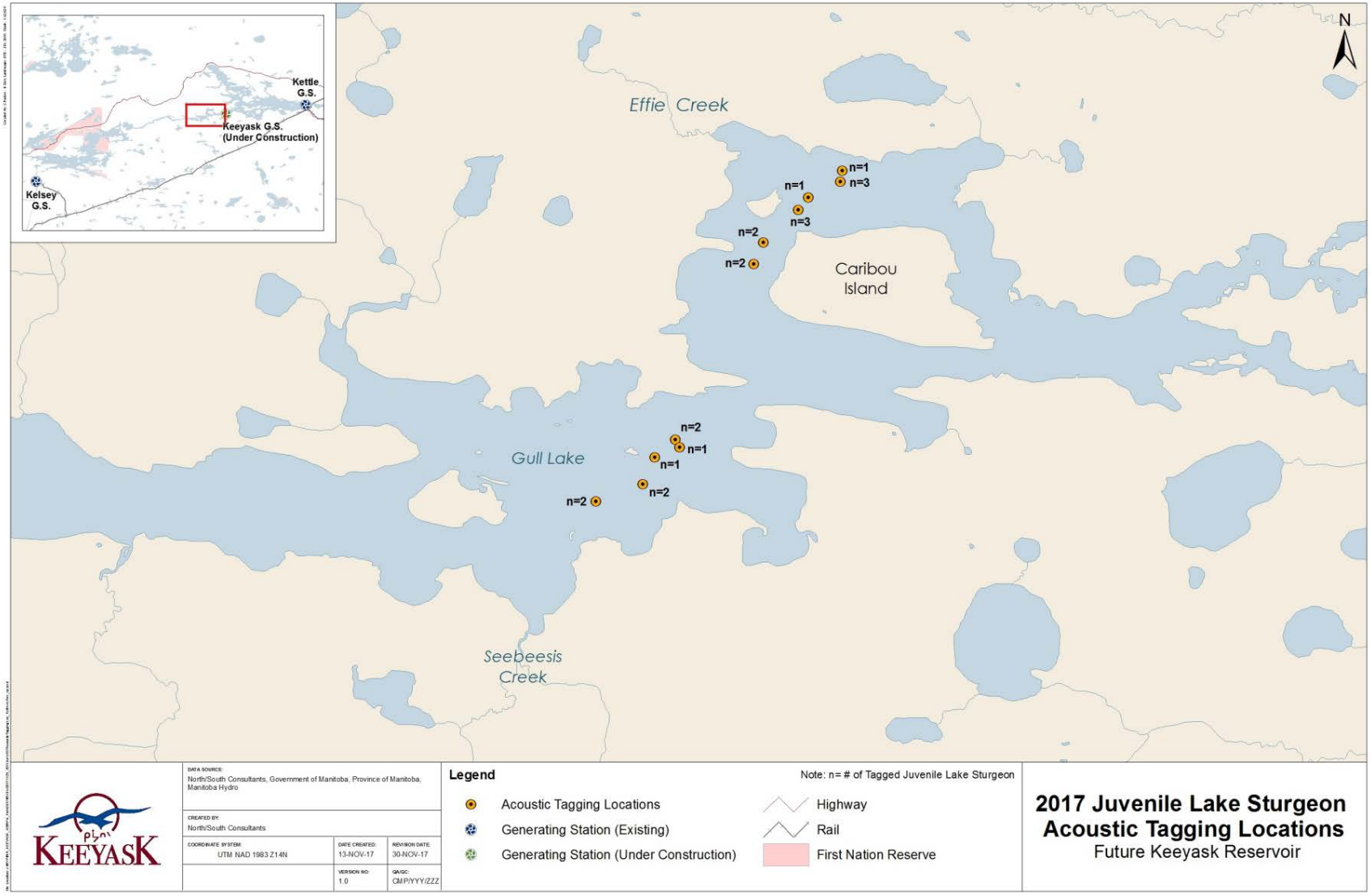
Map 6: Locations of stationary receivers set in the Nelson River from Clark Lake to Gull Rapids between June and October 2017. The river is divided into five "zones" based on placement of receiver "gates."



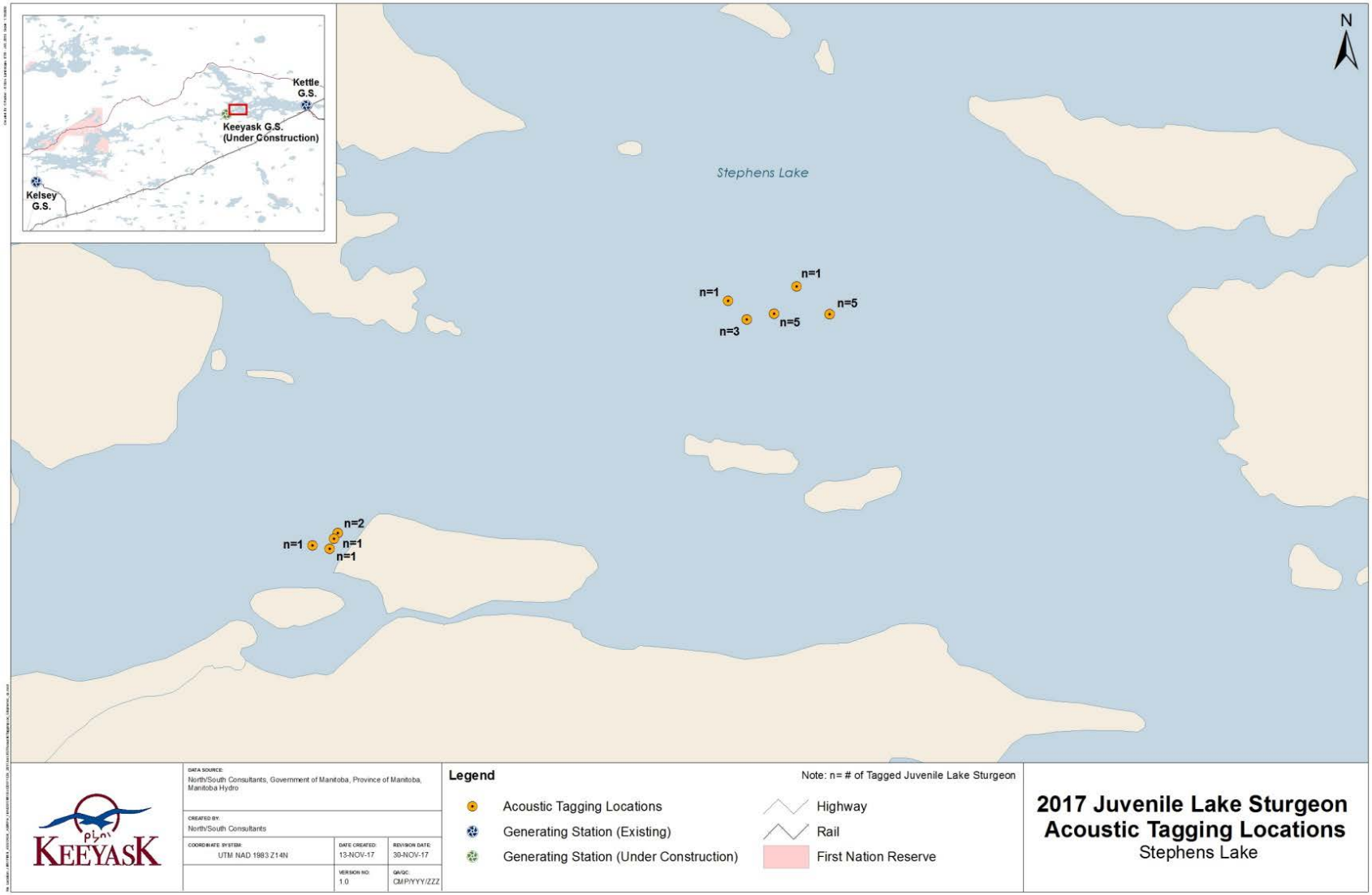
Map 7: **Locations of stationary receivers set in Stephens Lake between June and October 2017. The river is divided into two "zones" based on placement of receiver "gates." The pre-impoundment river channel is shown in light blue.**



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.



Map 9: Locations of juvenile Lake Sturgeon acoustic transmitter application upstream of Gull Rapids, September 2017.



Map 10: Locations of juvenile Lake Sturgeon acoustic transmitter application in Stephens Lake, September 2017.

APPENDICES

APPENDIX 1:
LOCATION SUMMARY FOR INDIVIDUAL ACOUSTIC TAGGED JUVENILE LAKE STURGEON UPSTREAM OF GULL RAPIDS, AUGUST 2013 TO OCTOBER 2017

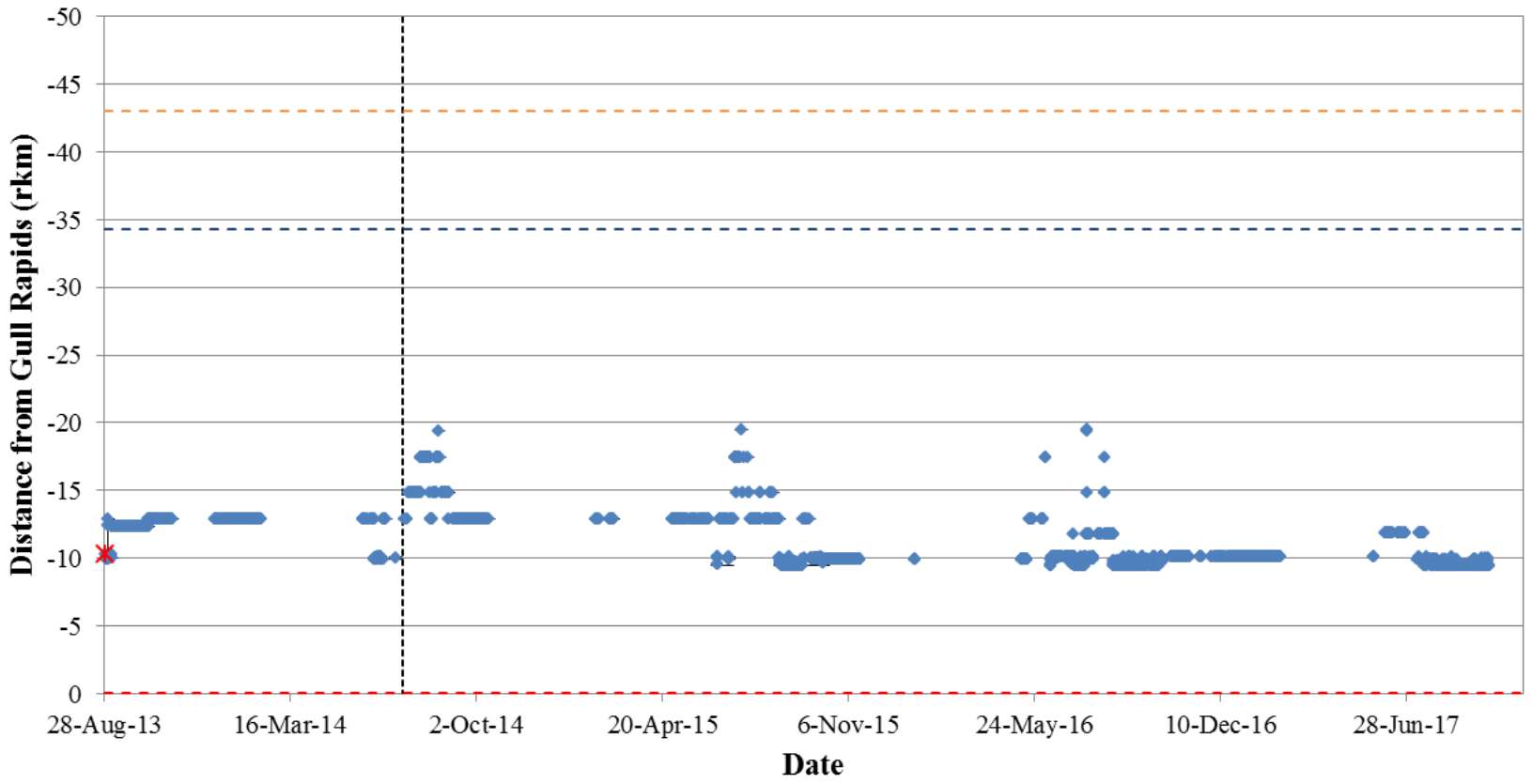


Figure A1-1: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32671) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 16 October, 2017. Date and location of tagging is indicated by red X. Error bars are shown in solid black. Black vertical dashed line represents start date of construction of the Keeyask GS. Horizontal dashed lines indicate the positions of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

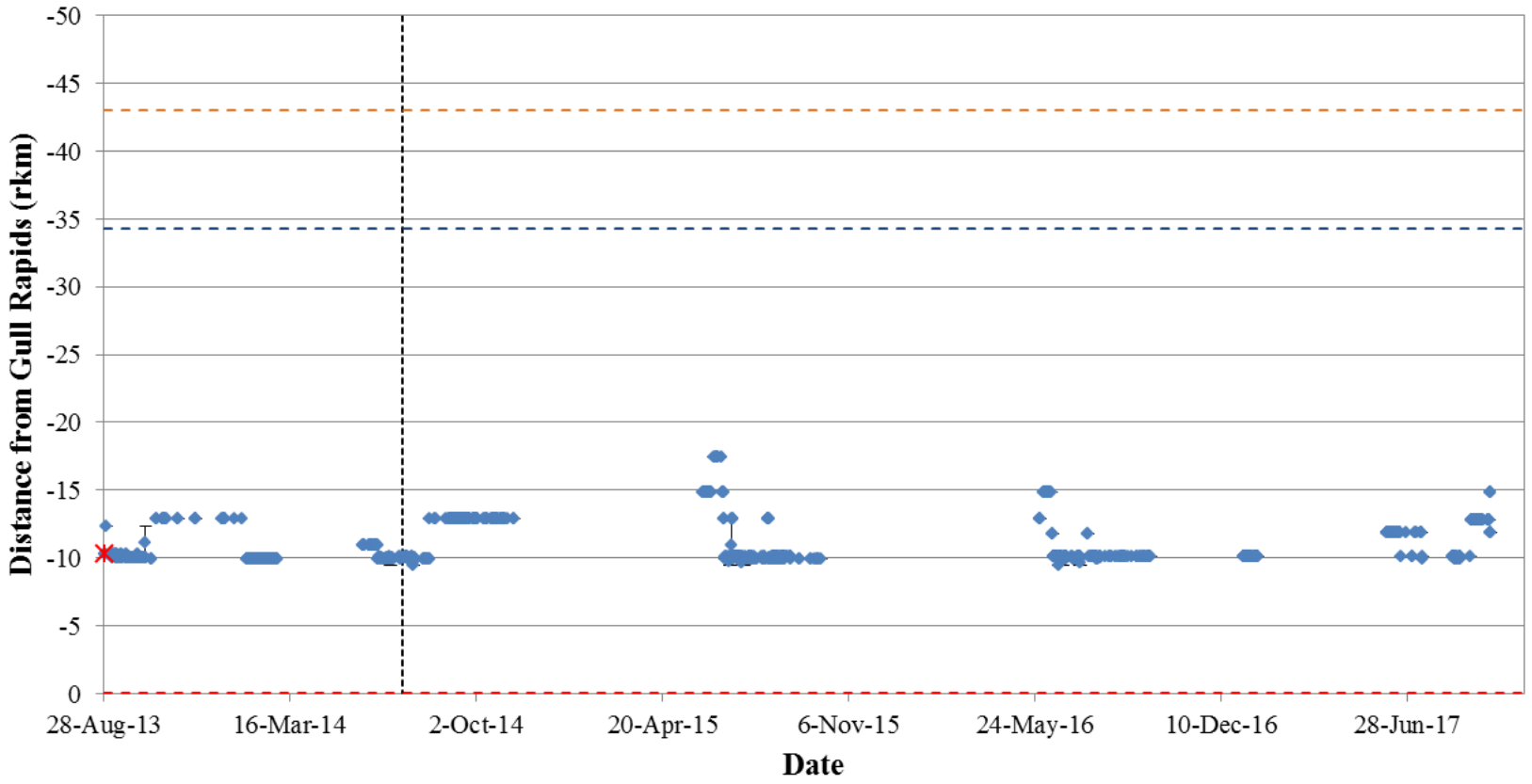


Figure A1-2: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32672) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 16 October, 2017. Date and location of tagging is indicated by red X. Error bars are shown in solid black. Black vertical dashed line represents start date of construction of the Keeyask GS. Horizontal dashed lines indicate the positions of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

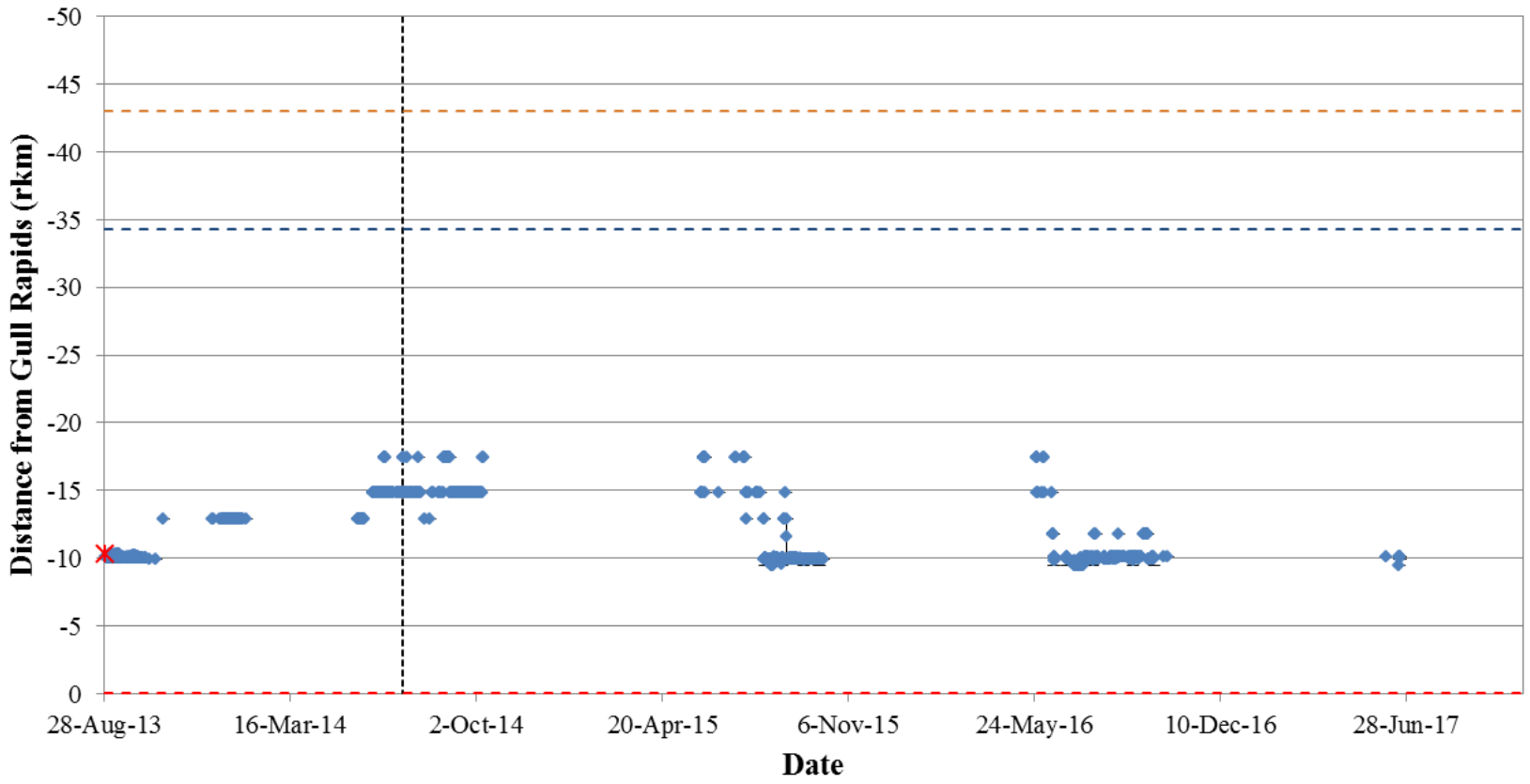


Figure A1-3: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32676) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 16 October, 2017. Date and location of tagging is indicated by red X. Error bars are shown in solid black. Black vertical dashed line represents start date of construction of the Keeyask GS. Horizontal dashed lines indicate the positions of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

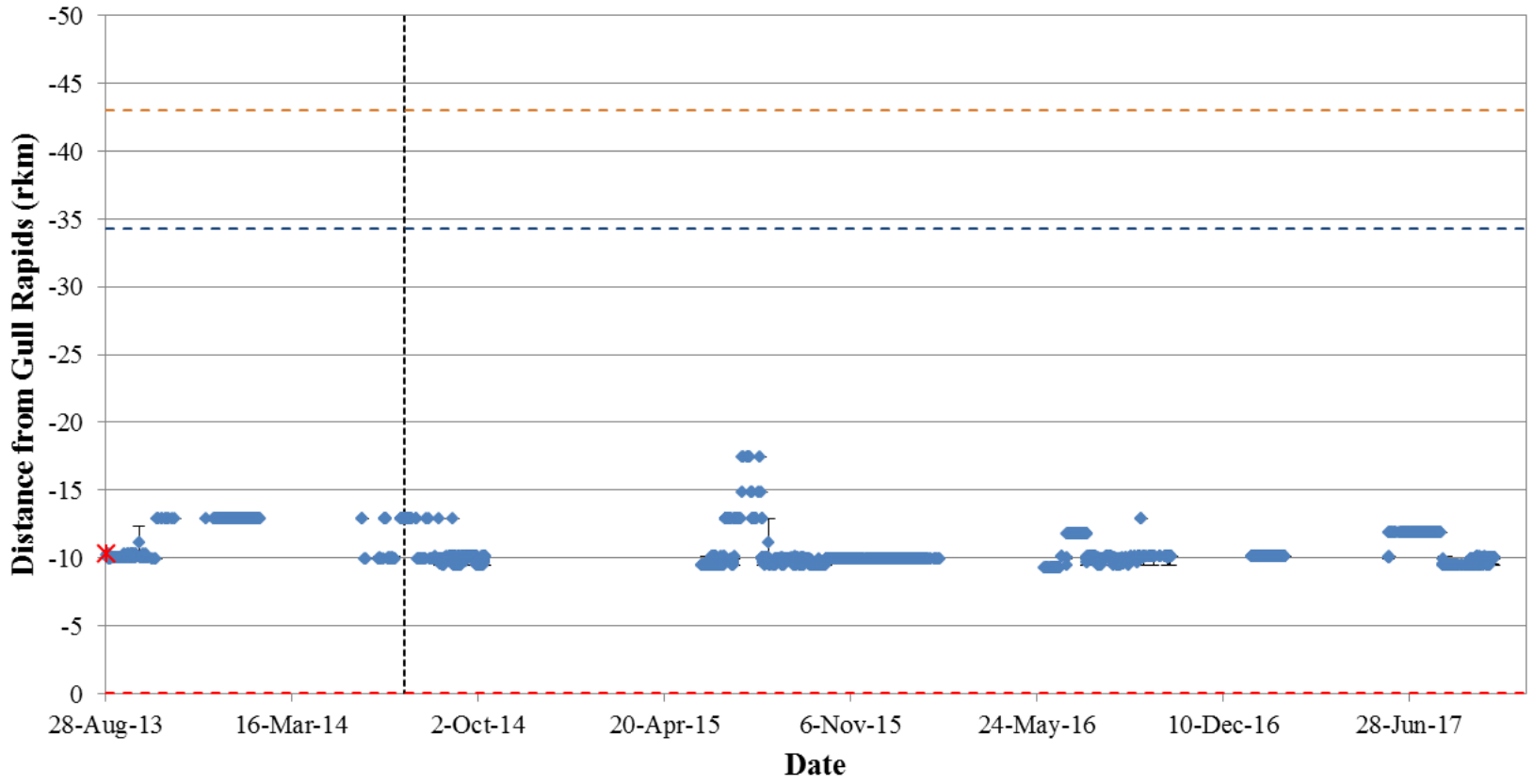


Figure A1-4: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32677) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 16 October, 2017. Date and location of tagging is indicated by red X. Error bars are shown in solid black. Black vertical dashed line represents start date of construction of the Keeyask GS. Horizontal dashed lines indicate the positions of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

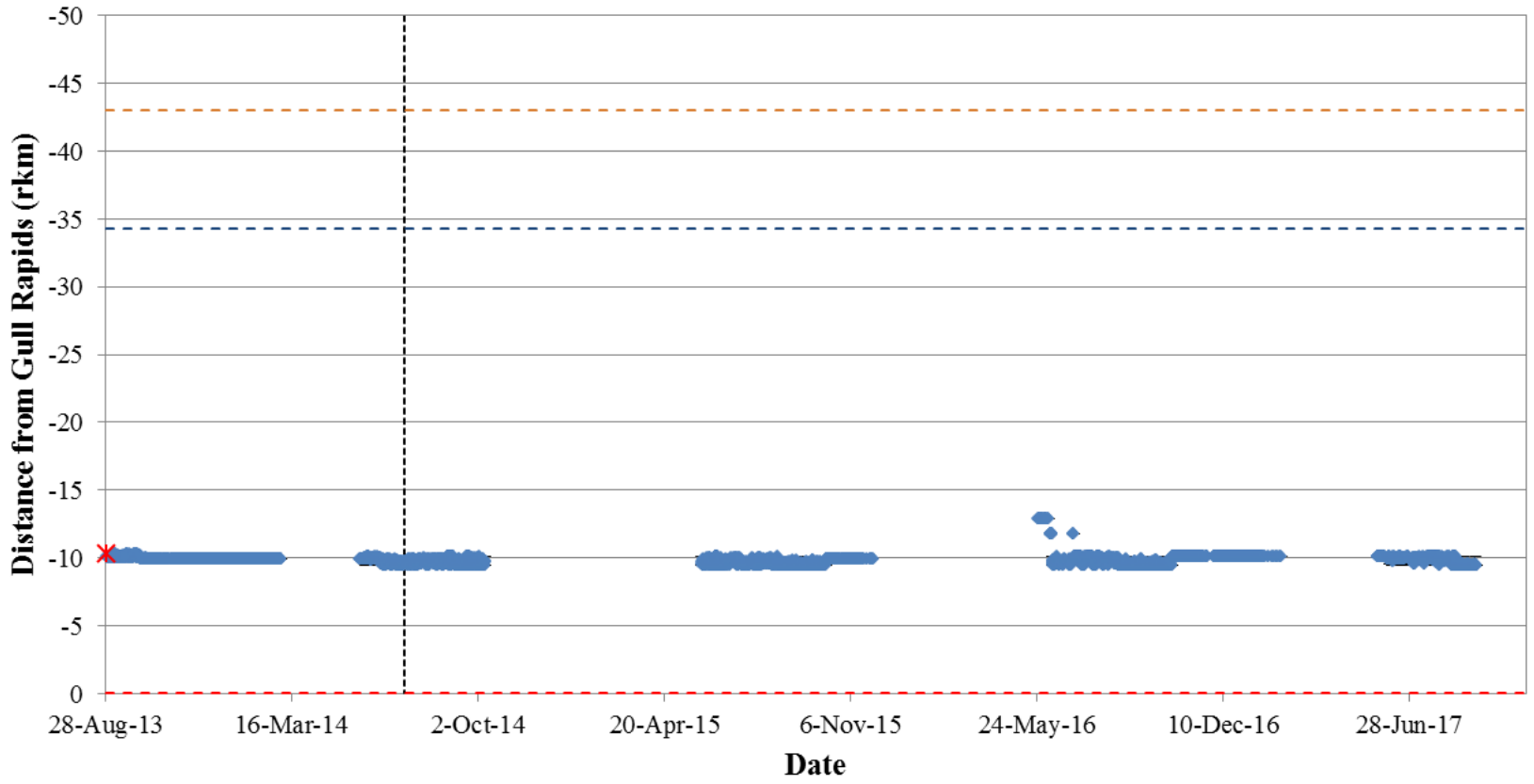


Figure A1-5: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32678) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 16 October, 2017. Date and location of tagging is indicated by red X. Error bars are shown in solid black. Black vertical dashed line represents start date of construction of the Keeyask GS. Horizontal dashed lines indicate the positions of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

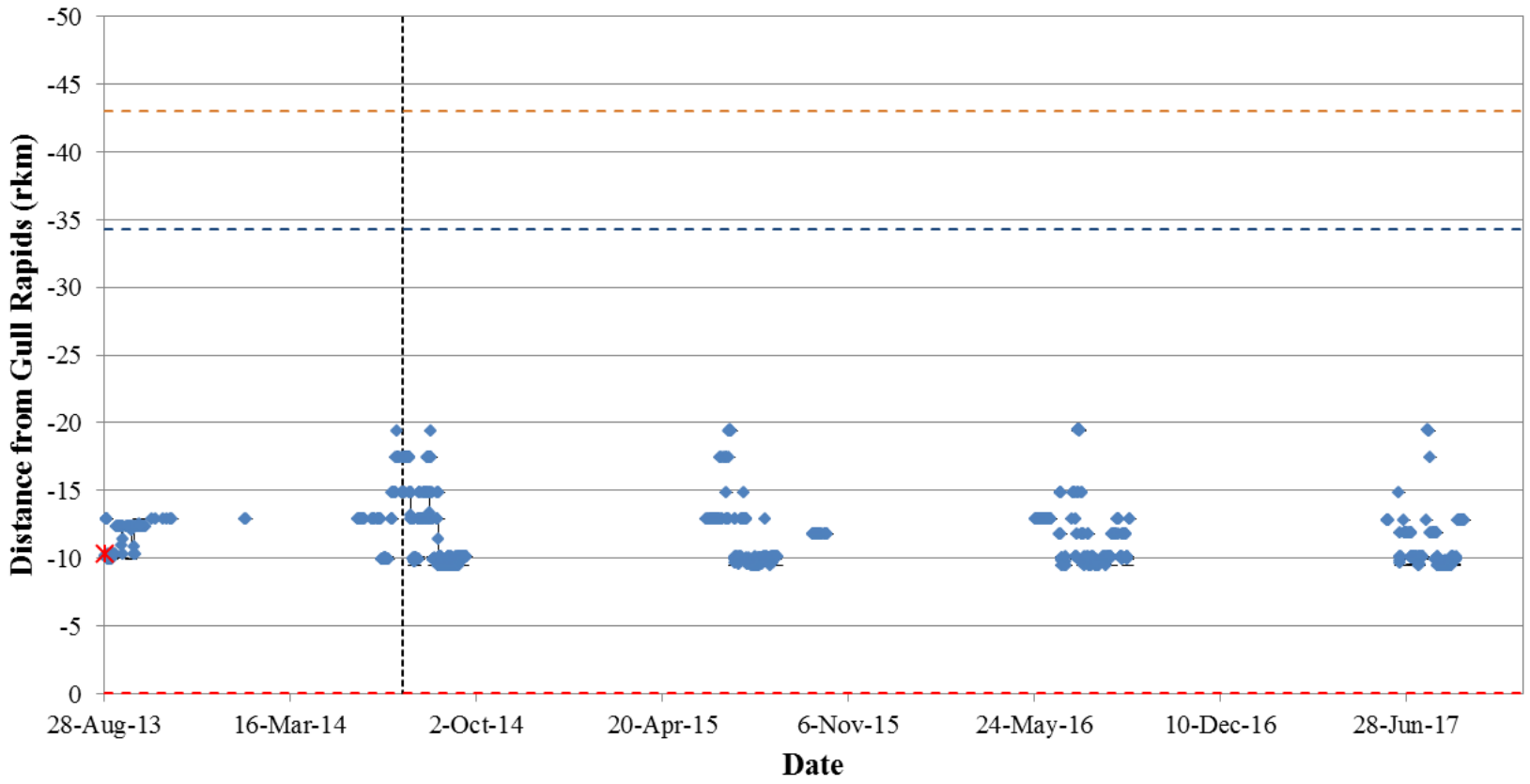


Figure A1-6: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32679) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 16 October, 2017. Date and location of tagging is indicated by red X. Error bars are shown in solid black. Black vertical dashed line represents start date of construction of the Keeyask GS. Horizontal dashed lines indicate the positions of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

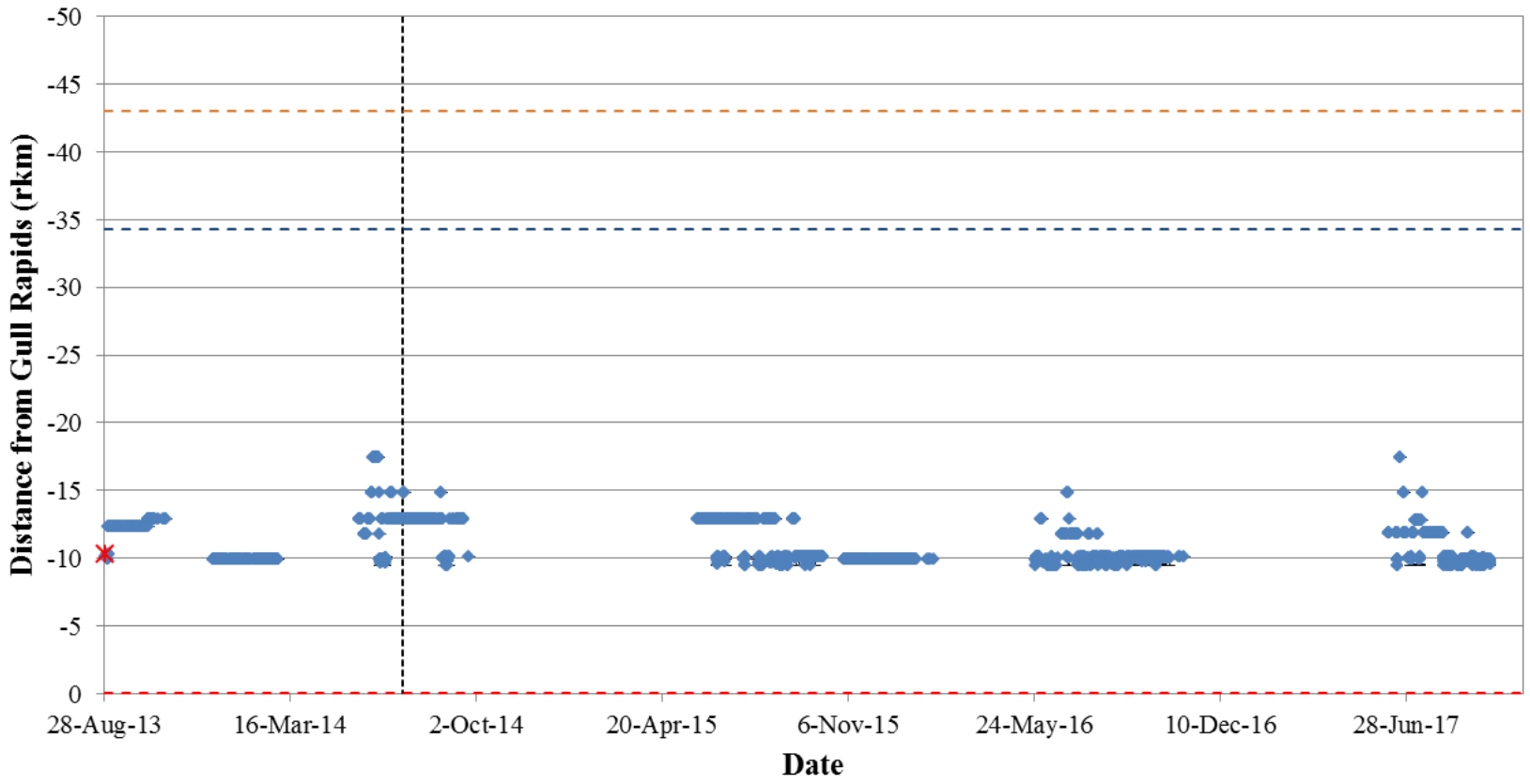


Figure A1-7: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32681) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 16 October, 2017. Date and location of tagging is indicated by red X. Error bars are shown in solid black. Black vertical dashed line represents start date of construction of the Keeyask GS. Horizontal dashed lines indicate the positions of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

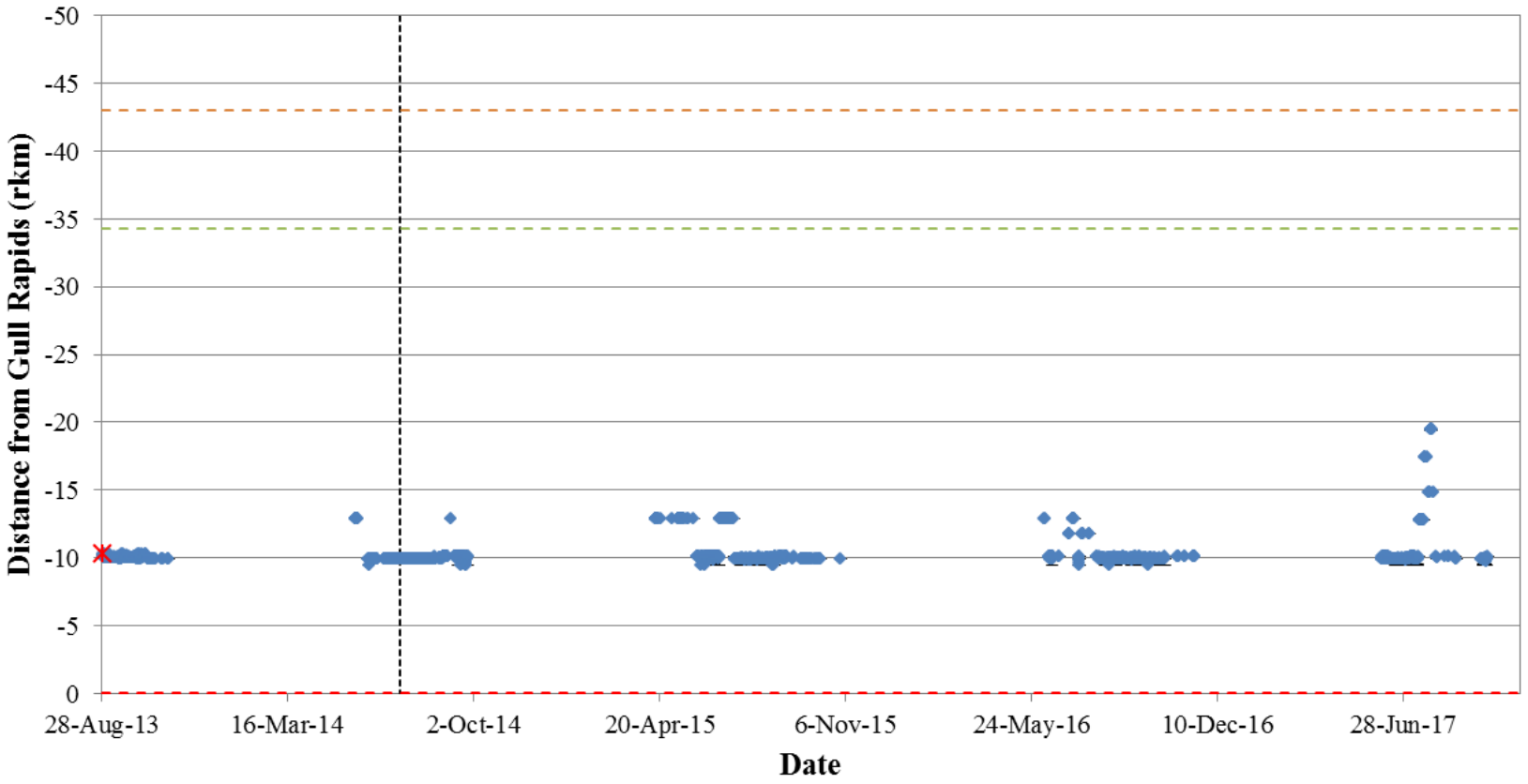


Figure A1-8: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32682) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 16 October, 2017. Date and location of tagging is indicated by red X. Error bars are shown in solid black. Black vertical dashed line represents start date of construction of the Keeyask GS. Horizontal dashed lines indicate the positions of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

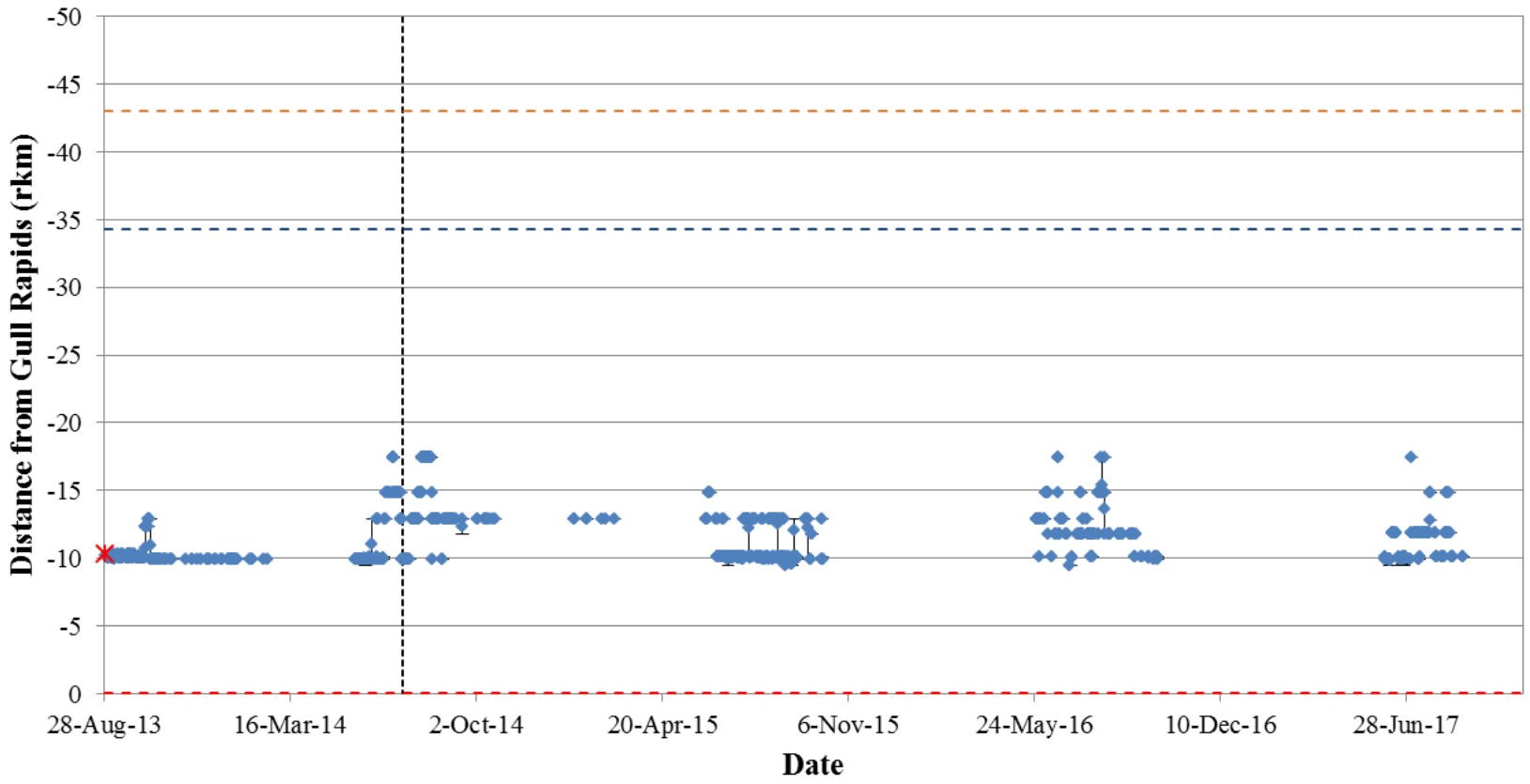


Figure A1-9: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32683) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 16 October, 2017. Date and location of tagging is indicated by red X. Error bars are shown in solid black. Black vertical dashed line represents start date of construction of the Keeyask GS. Horizontal dashed lines indicate the positions of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

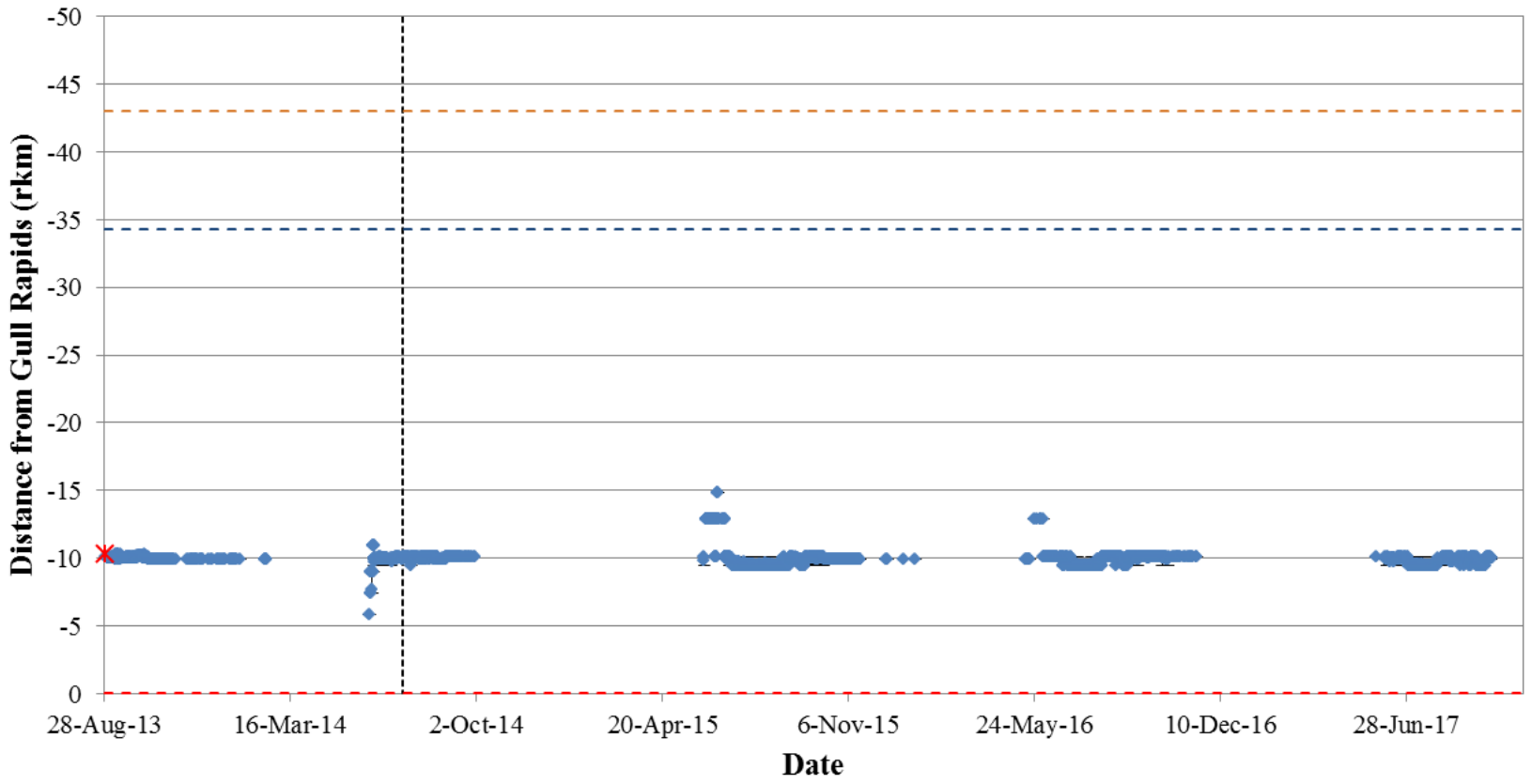


Figure A1-10: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32684) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 16 October, 2017. Date and location of tagging is indicated by red X. Error bars are shown in solid black. Black vertical dashed line represents start date of construction of the Keeyask GS. Horizontal dashed lines indicate the positions of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

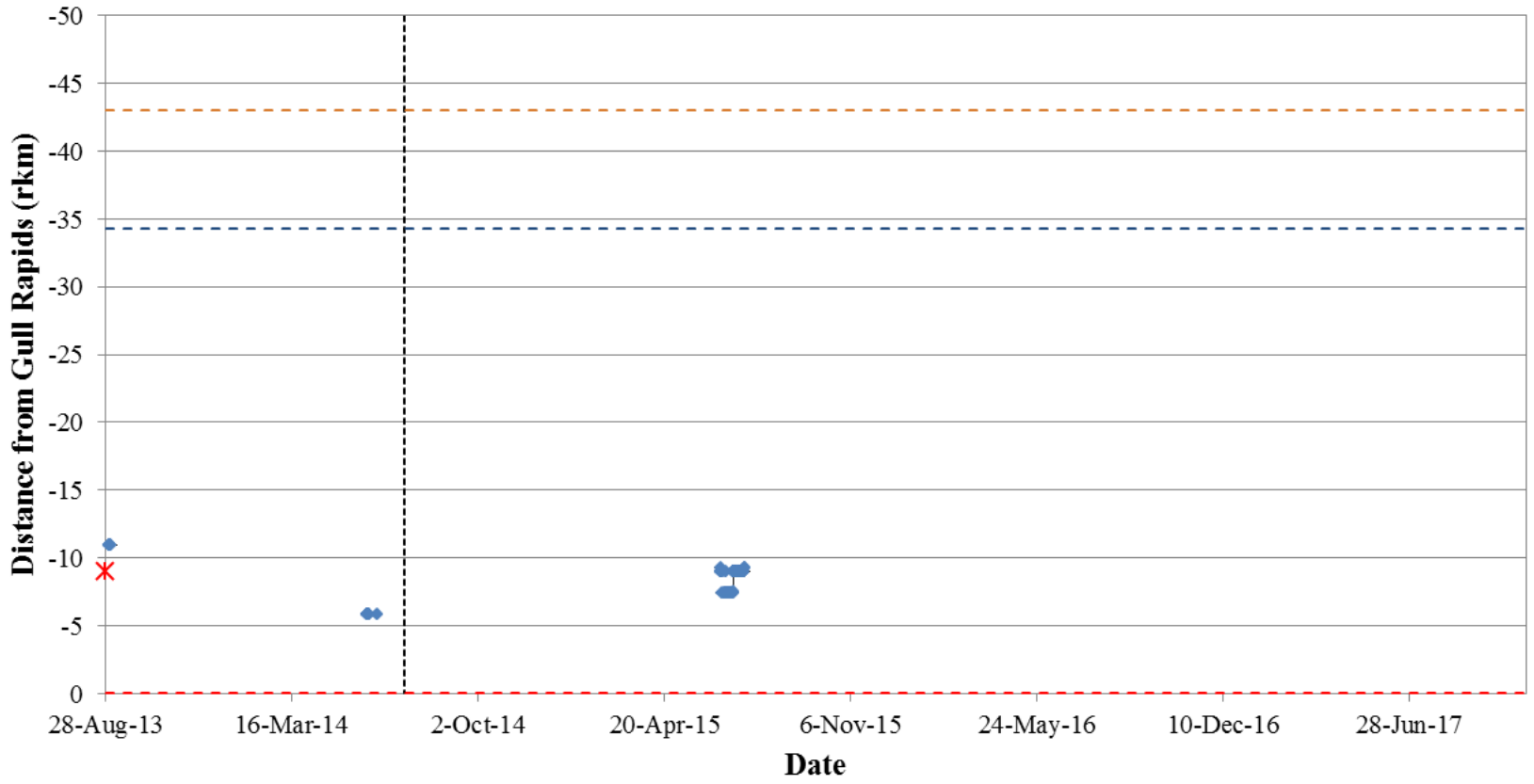


Figure A1-11: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32686) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 16 October, 2017. Date and location of tagging is indicated by red X. Error bars are shown in solid black. Black vertical dashed line represents start date of construction of the Keeyask GS. Horizontal dashed lines indicate the positions of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

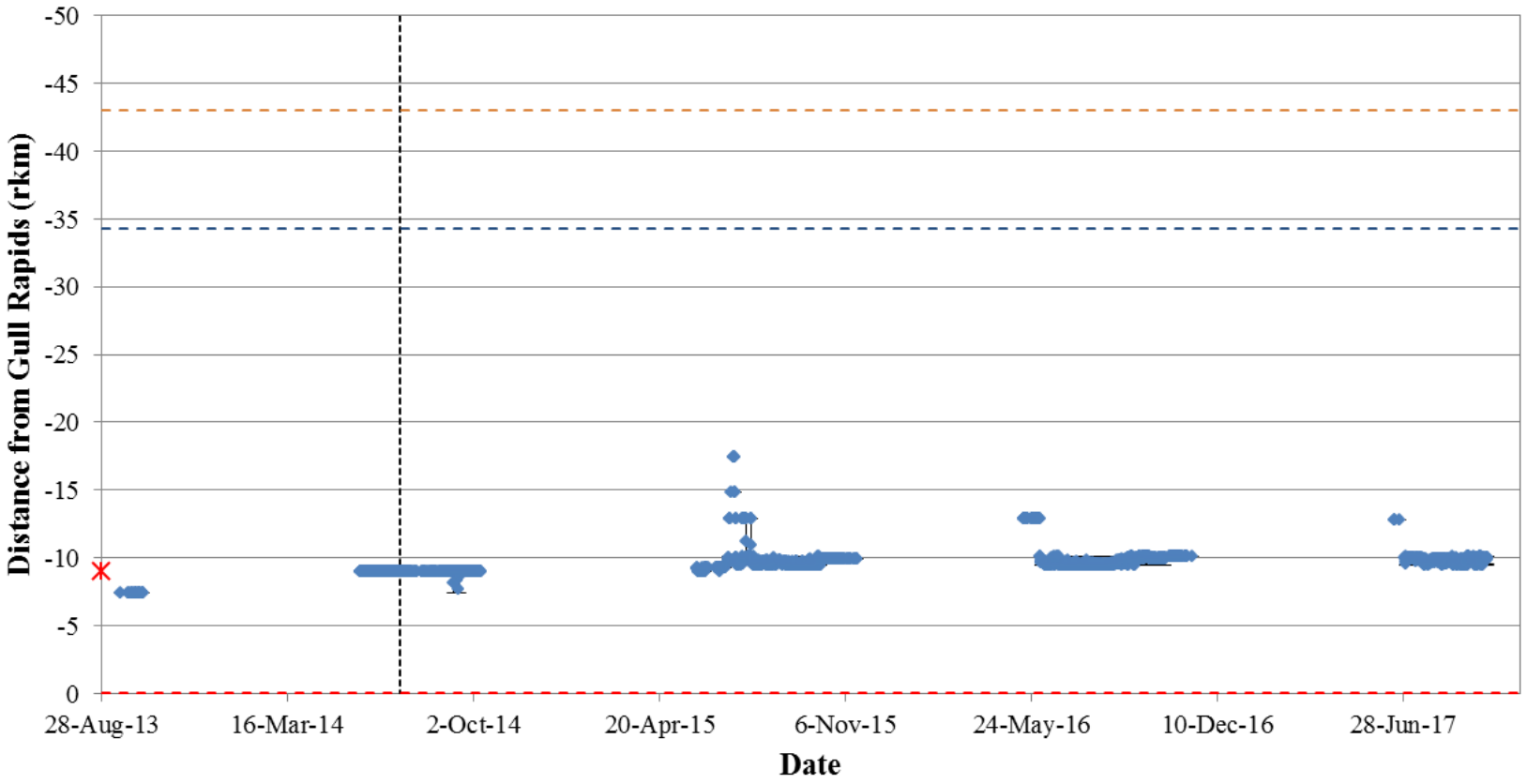


Figure A1-12: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32687) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 16 October, 2017. Date and location of tagging is indicated by red X. Error bars are shown in solid black. Black vertical dashed line represents start date of construction of the Keeyask GS. Horizontal dashed lines indicate the positions of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

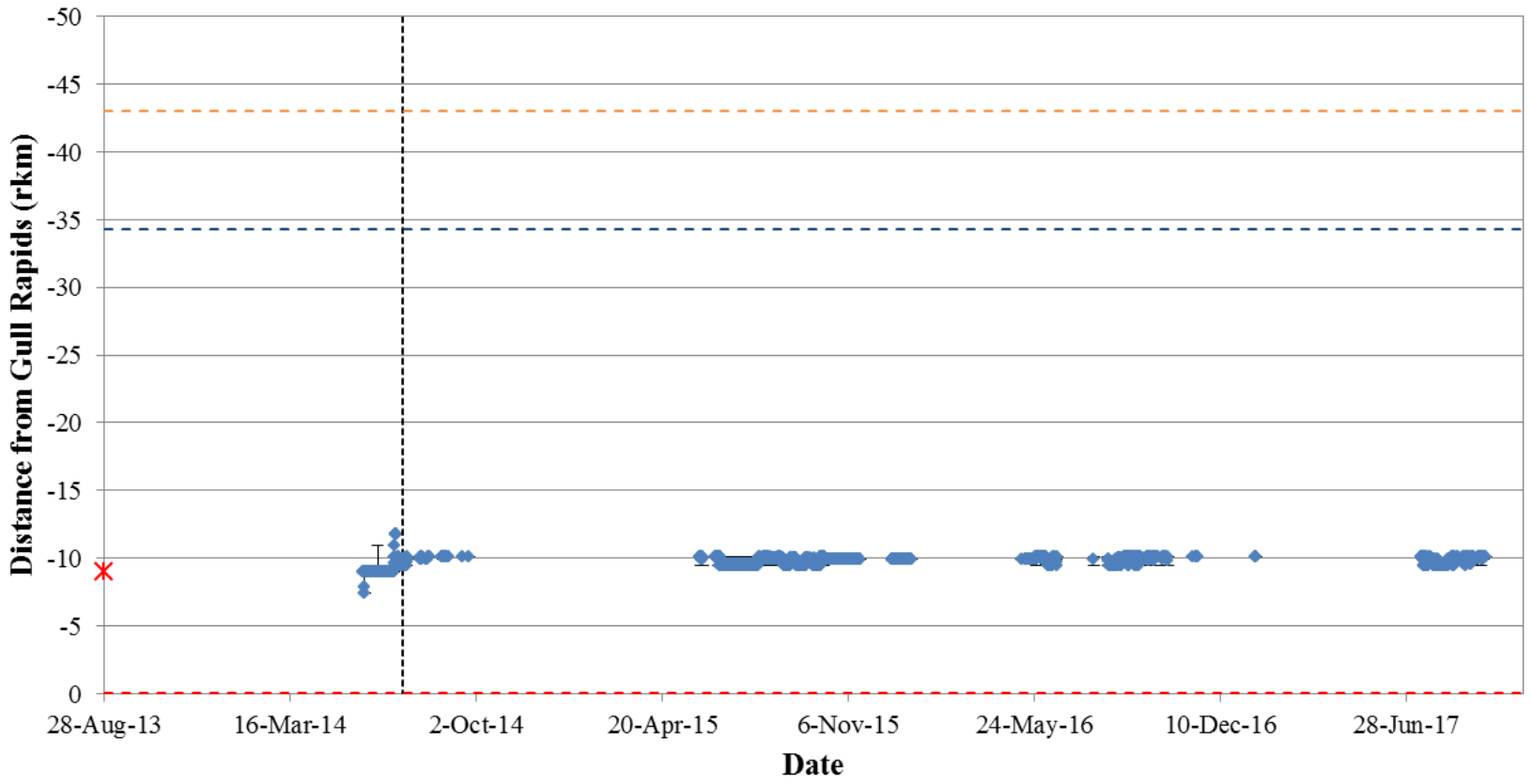


Figure A1-13: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32688) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 16 October, 2017. Date and location of tagging is indicated by red X. Error bars are shown in solid black. Black vertical dashed line represents start date of construction of the Keeyask GS. Horizontal dashed lines indicate the positions of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

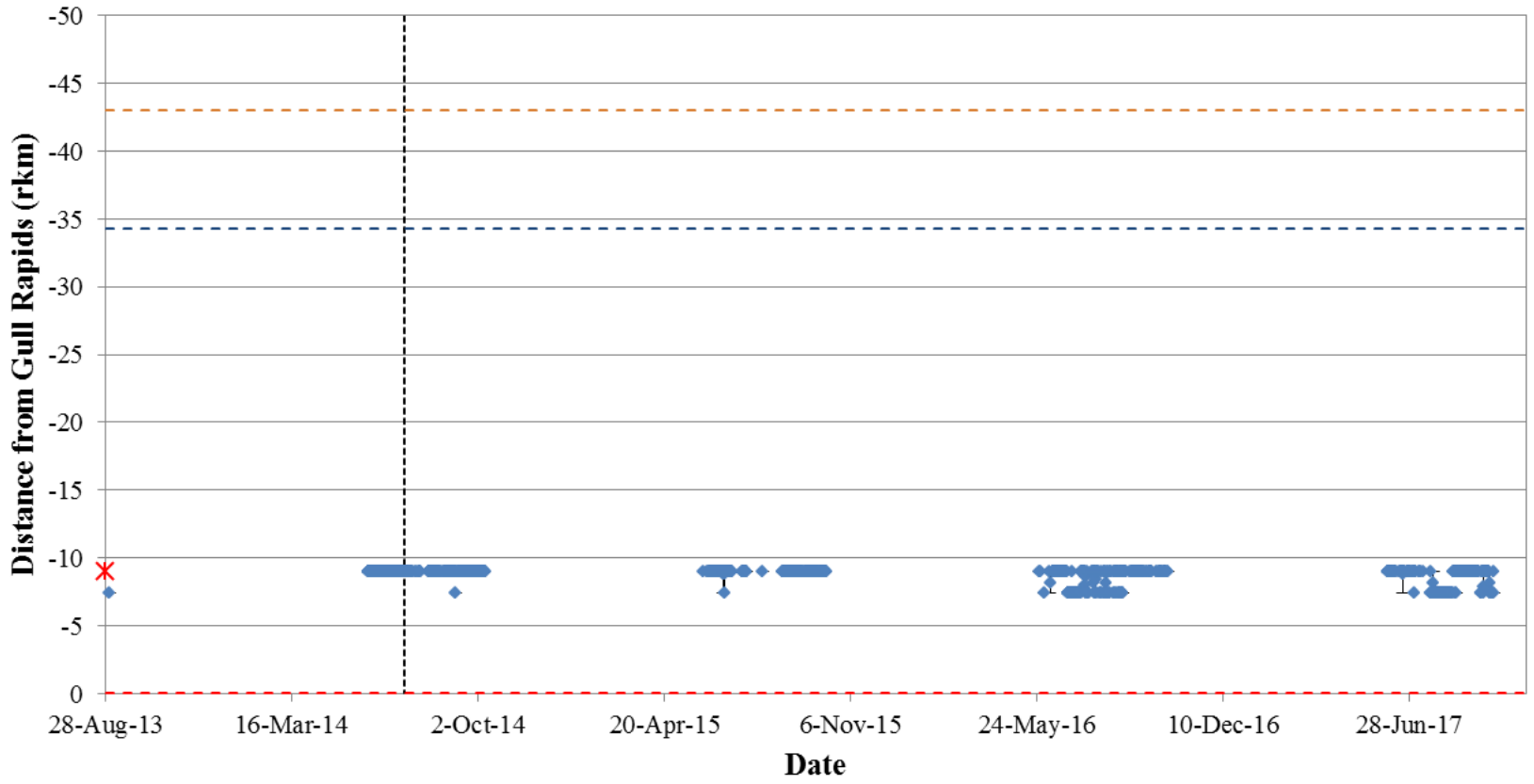


Figure A1-14: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32689) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 16 October, 2017. Date and location of tagging is indicated by red X. Error bars are shown in solid black. Black vertical dashed line represents start date of construction of the Keeyask GS. Horizontal dashed lines indicate the positions of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

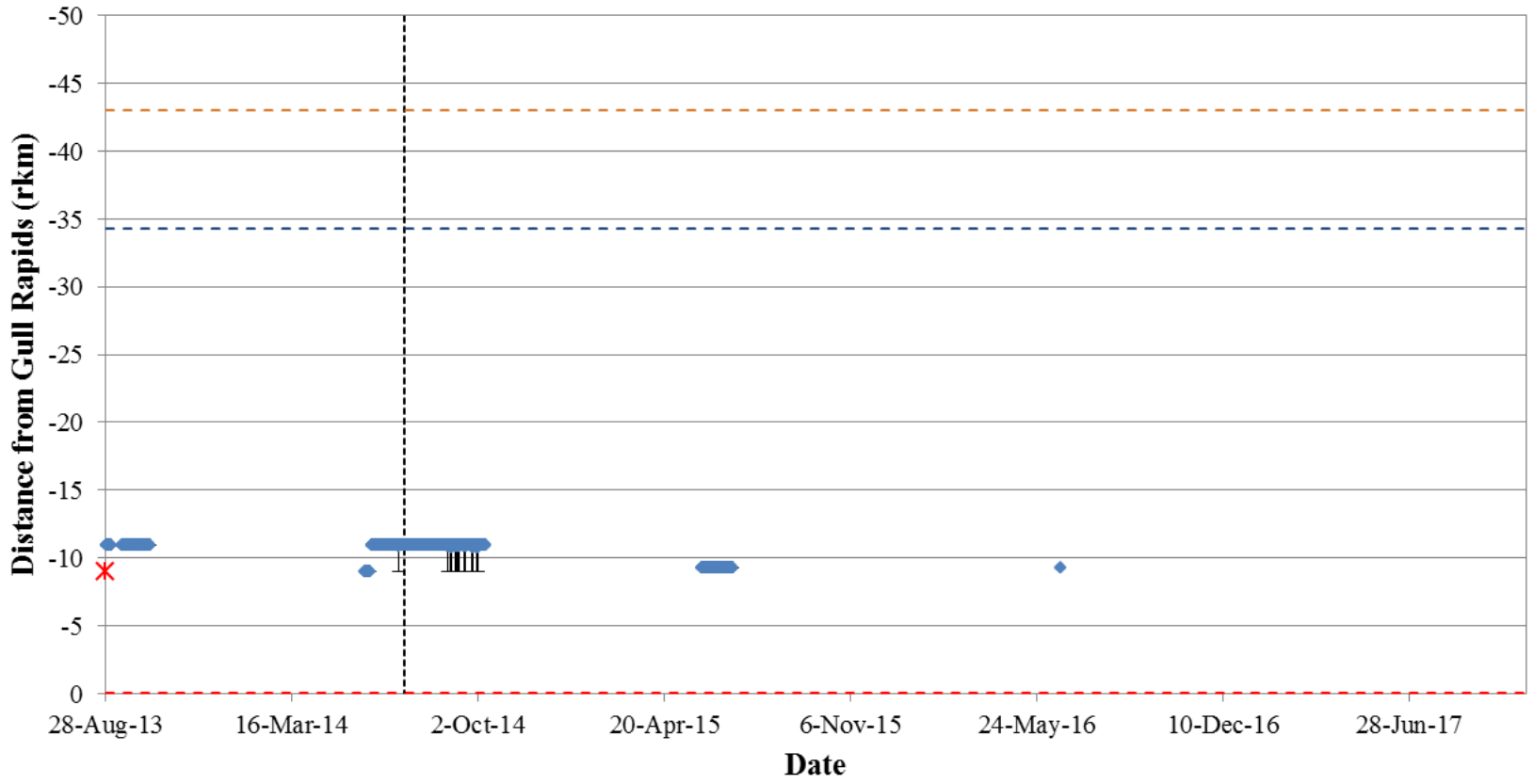


Figure A1-15: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32690) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 16 October, 2017. Date and location of tagging is indicated by red X. Error bars are shown in solid black. Black vertical dashed line represents start date of construction of the Keeyask GS. Horizontal dashed lines indicate the positions of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

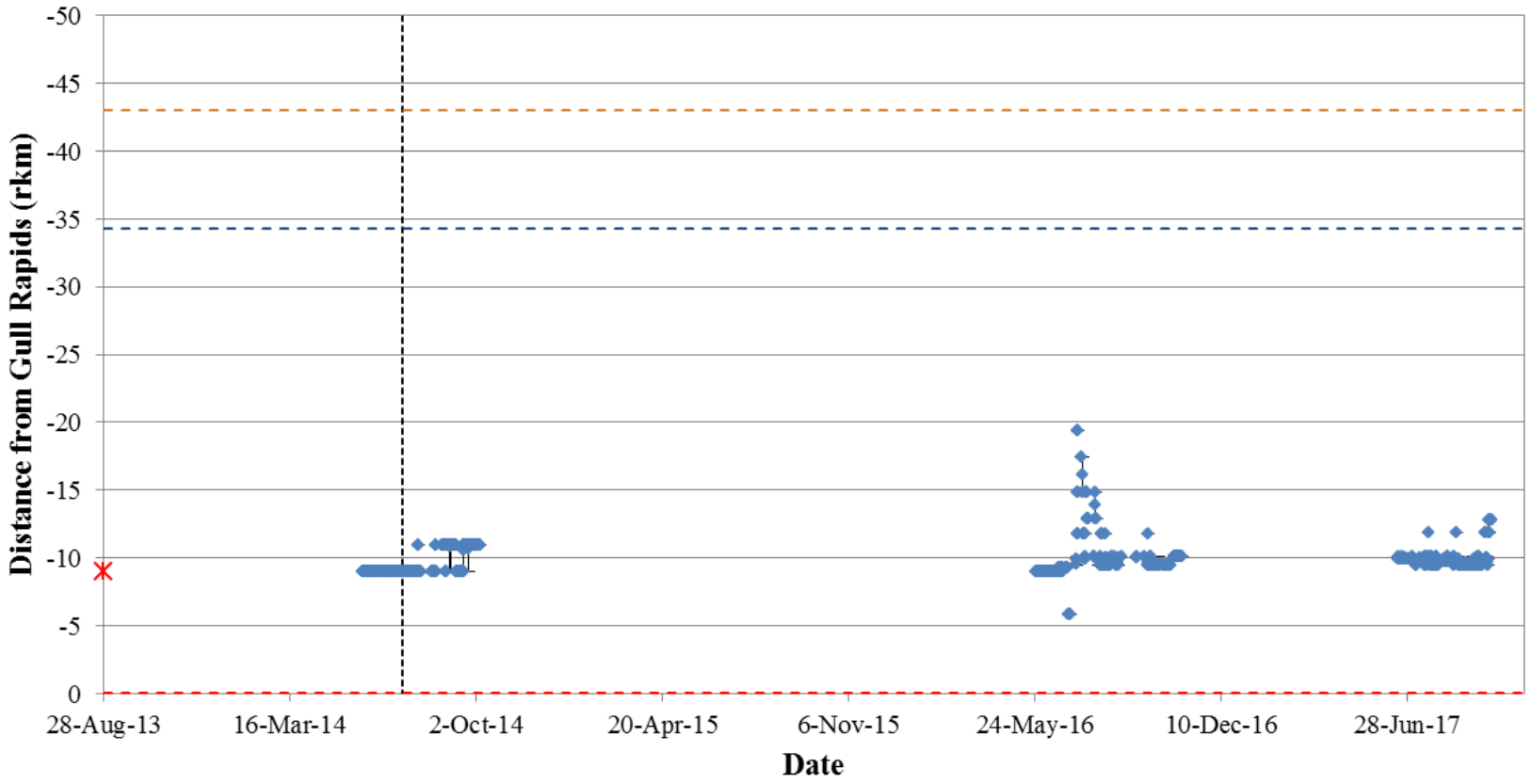


Figure A1-16: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32691) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 16 October, 2017. Date and location of tagging is indicated by red X. Error bars are shown in solid black. Black vertical dashed line represents start date of construction of the Keeyask GS. Horizontal dashed lines indicate the positions of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

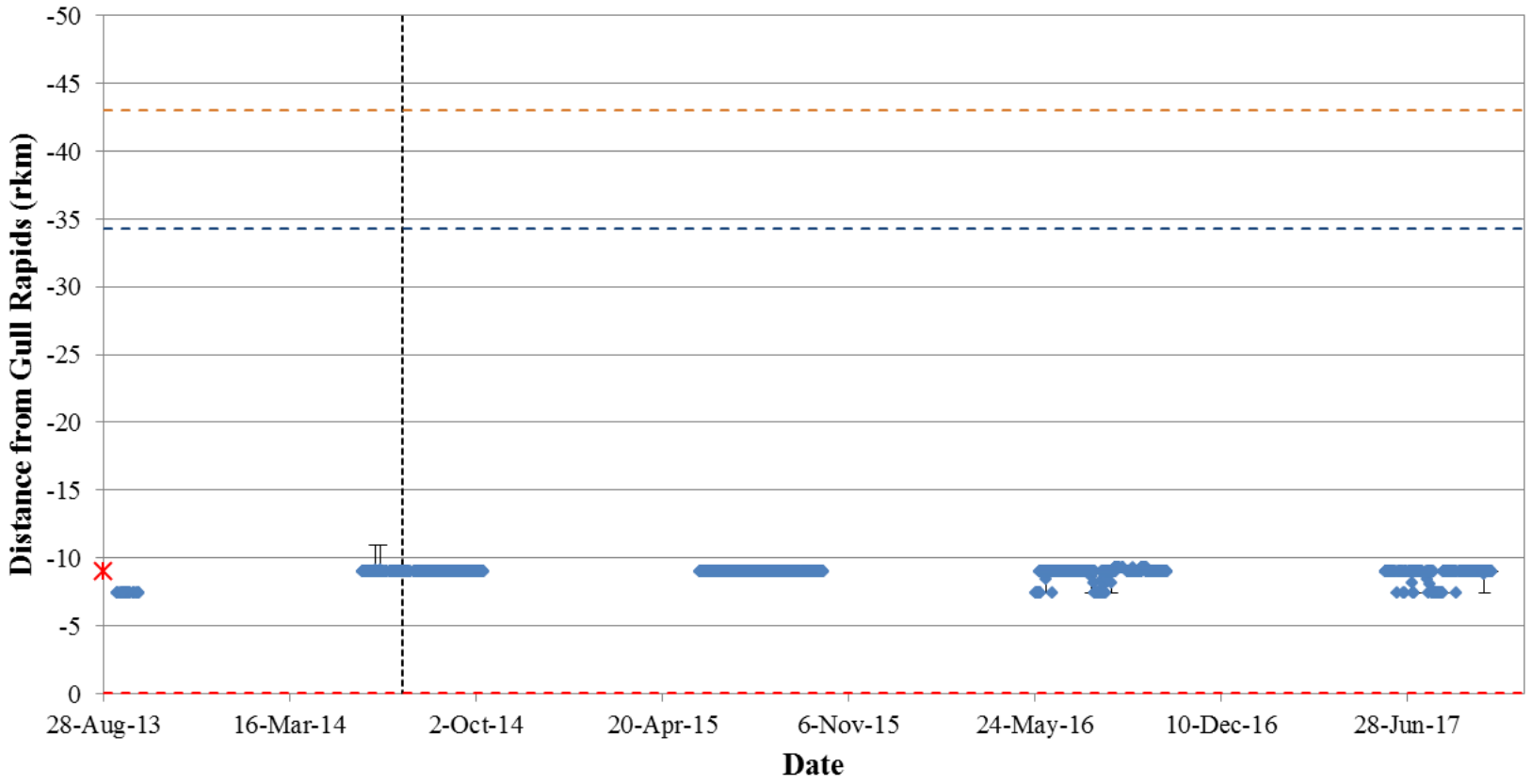


Figure A1-17: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32692) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 16 October, 2017. Date and location of tagging is indicated by red X. Error bars are shown in solid black. Black vertical dashed line represents start date of construction of the Keeyask GS. Horizontal dashed lines indicate the positions of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

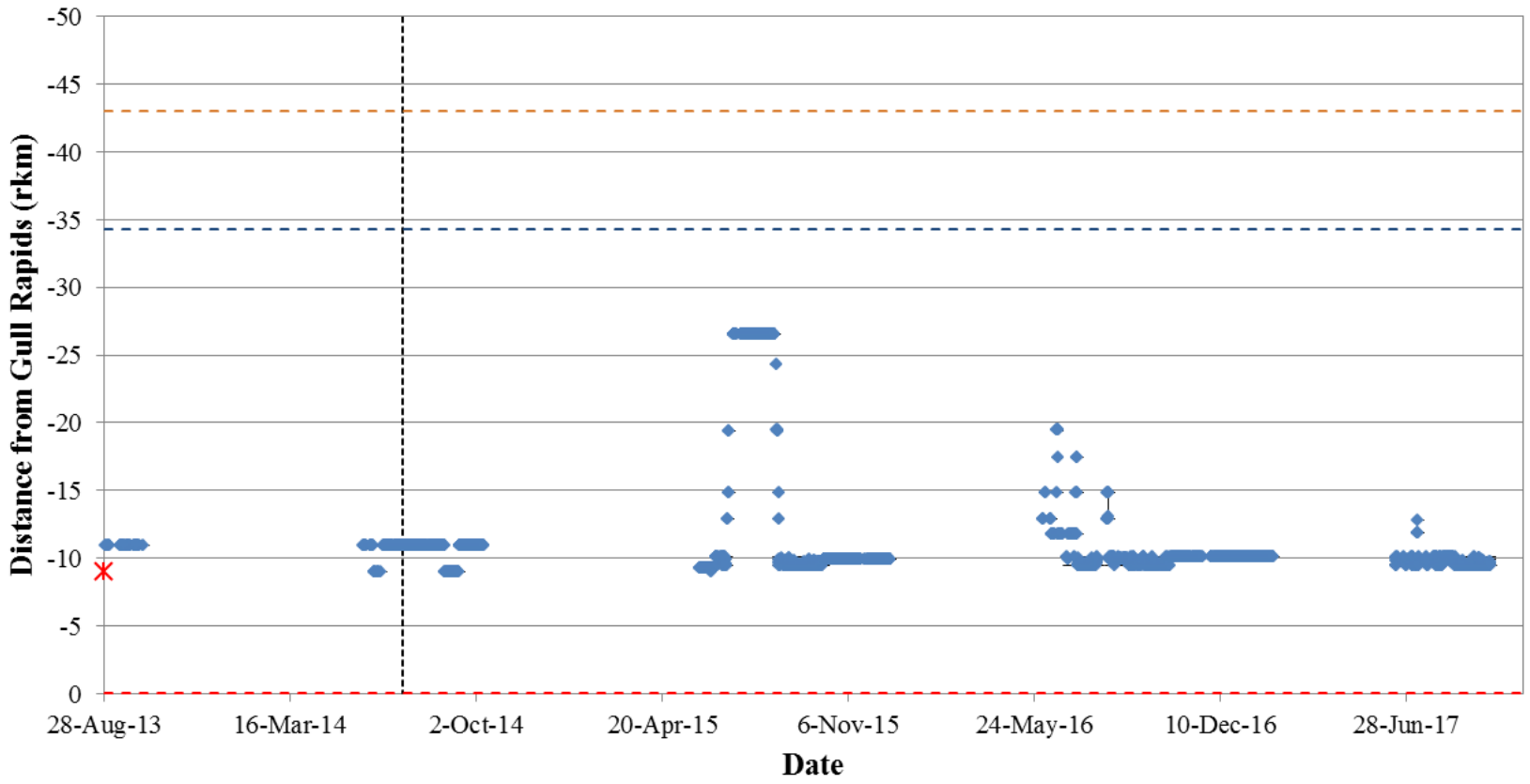


Figure A1-18: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32693) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 16 October, 2017. Date and location of tagging is indicated by red X. Error bars are shown in solid black. Black vertical dashed line represents start date of construction of the Keeyask GS. Horizontal dashed lines indicate the positions of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

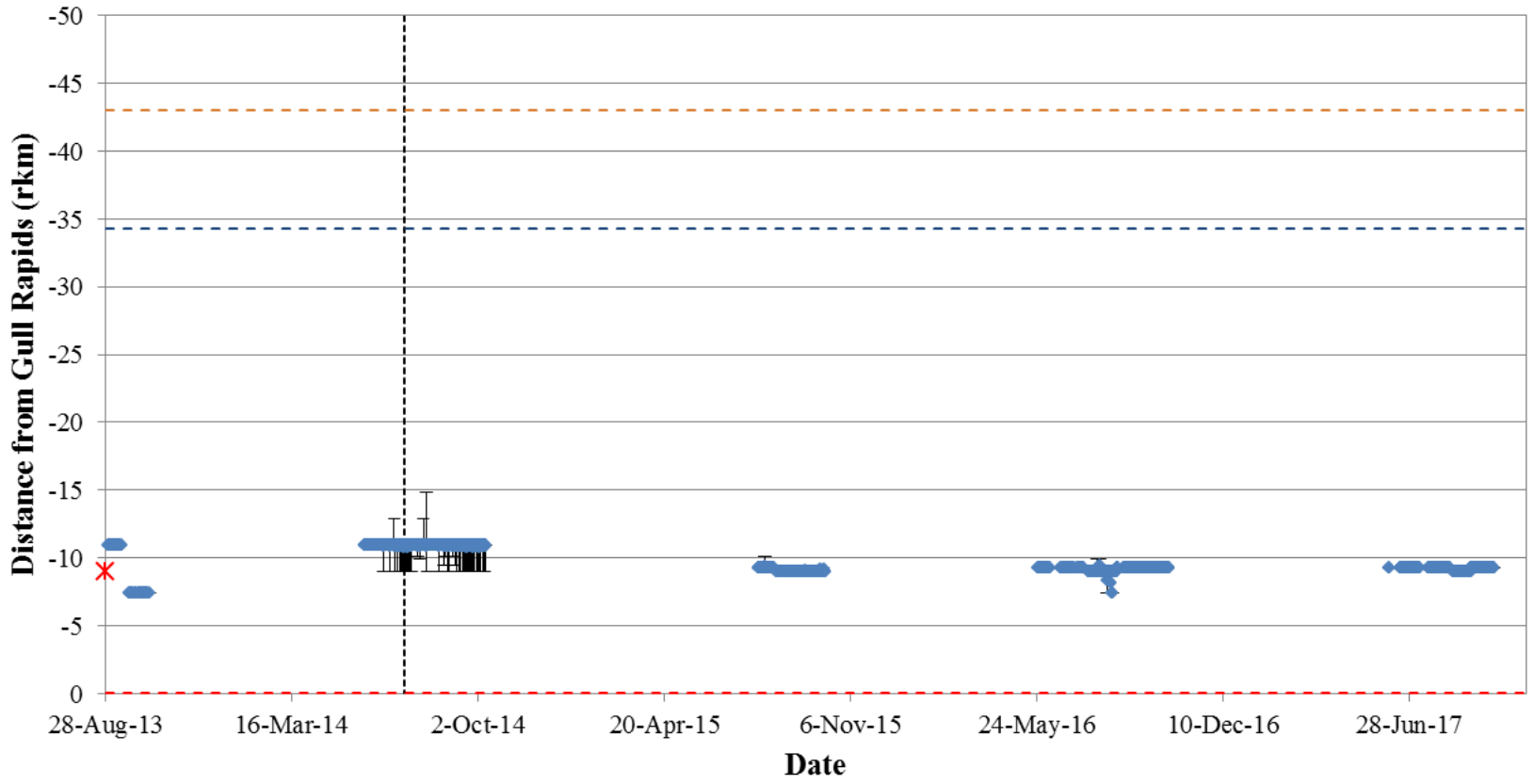


Figure A1-19: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32694) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 16 October, 2017. Date and location of tagging is indicated by red X. Error bars are shown in solid black. Black vertical dashed line represents start date of construction of the Keeyask GS. Horizontal dashed lines indicate the positions of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

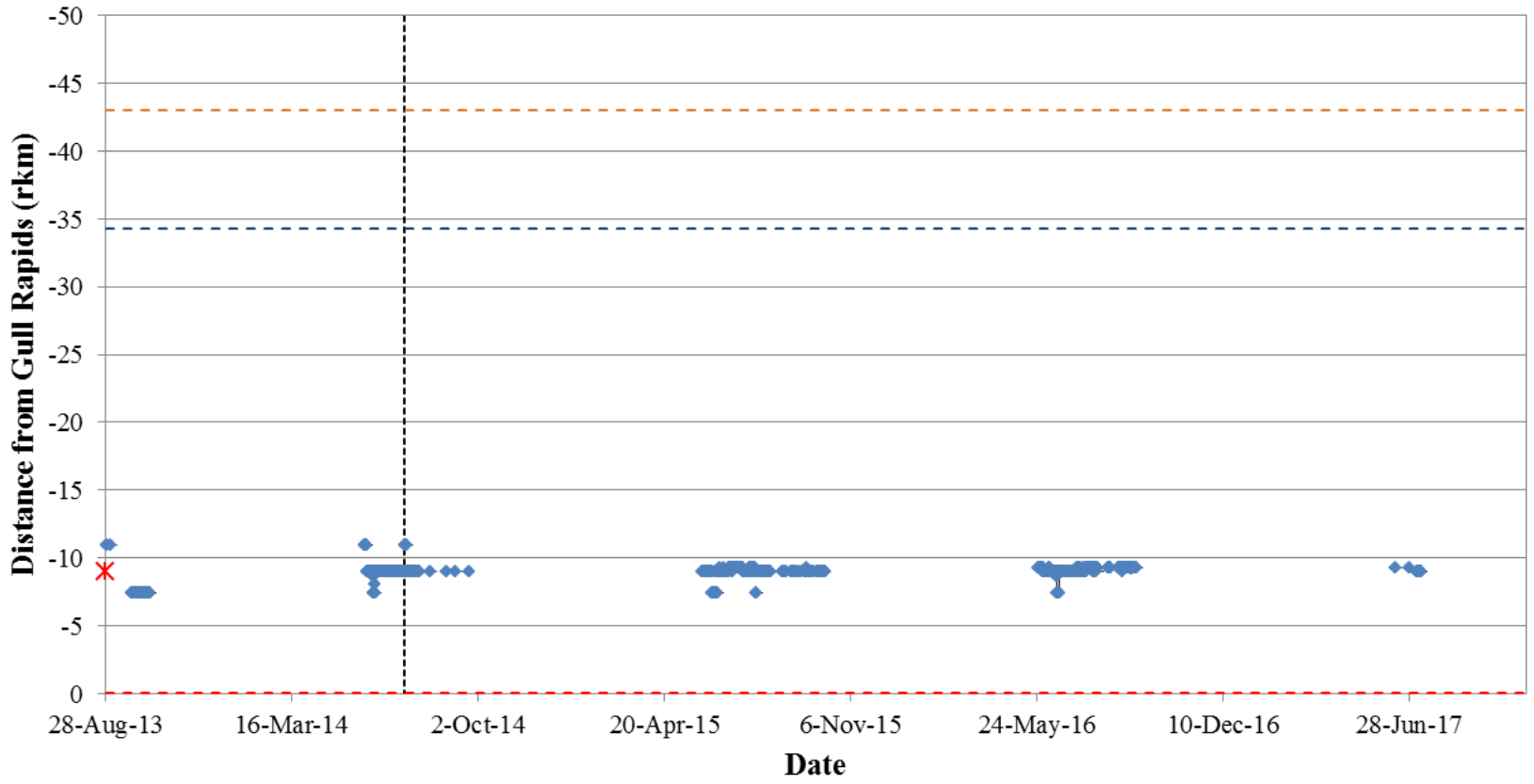


Figure A1-20: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32695) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 16 October, 2017. Date and location of tagging is indicated by red X. Error bars are shown in solid black. Black vertical dashed line represents start date of construction of the Keeyask GS. Horizontal dashed lines indicate the positions of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

APPENDIX 2:
LOCATION SUMMARY FOR INDIVIDUAL ACOUSTIC TAGGED JUVENILE LAKE STURGEON DOWNSTREAM OF GULL RAPIDS, AUGUST 2013 TO OCTOBER 2017

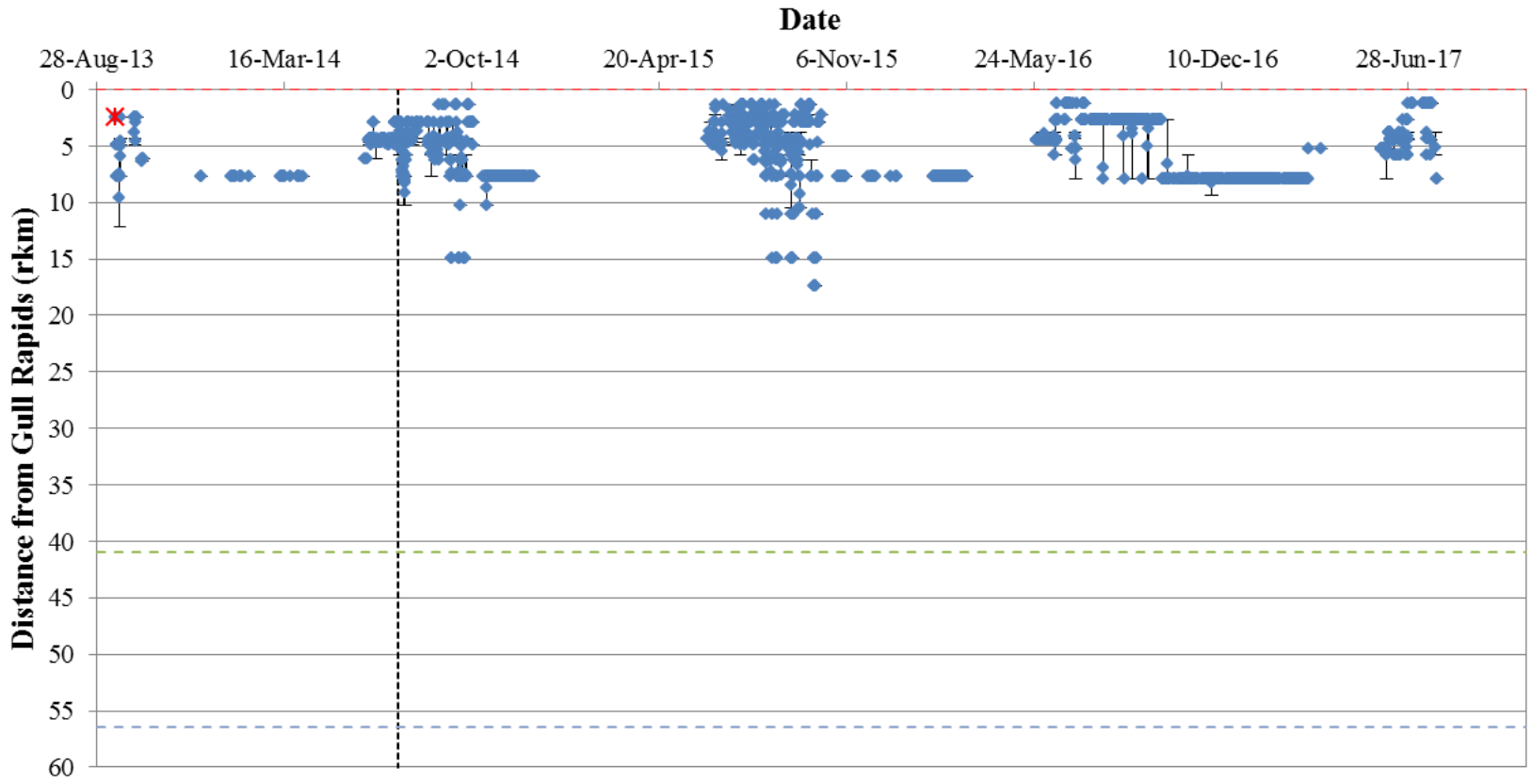


Figure A2-1: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32661) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 16 October, 2017. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black vertical dashed line represents start date of construction of the Keeyask GS. Horizontal dashed lines indicate the positions of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (blue).

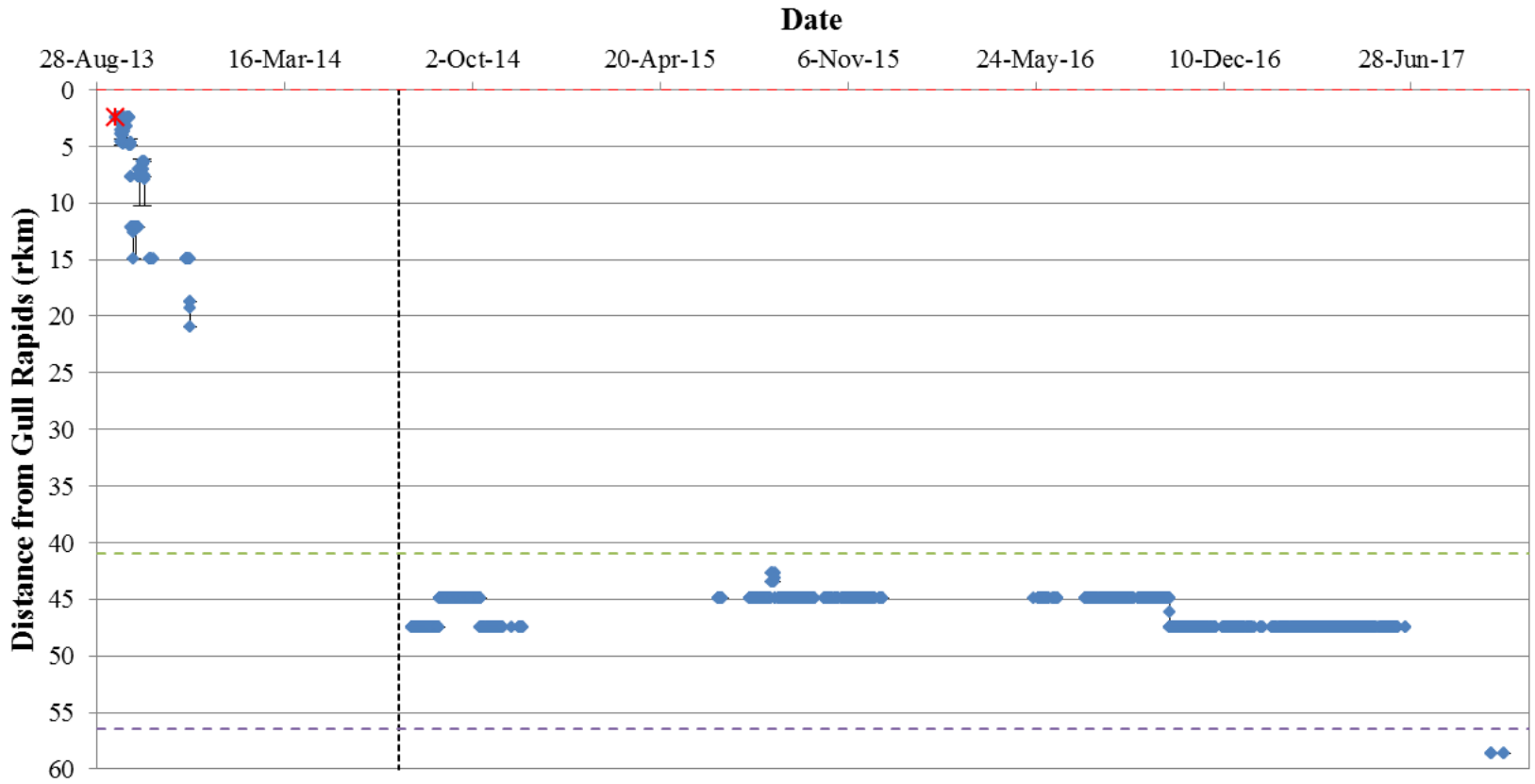


Figure A2-2: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32662) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 16 October, 2017. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black vertical dashed line represents start date of construction of the Keeyask GS. Horizontal dashed lines indicate the positions of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple).

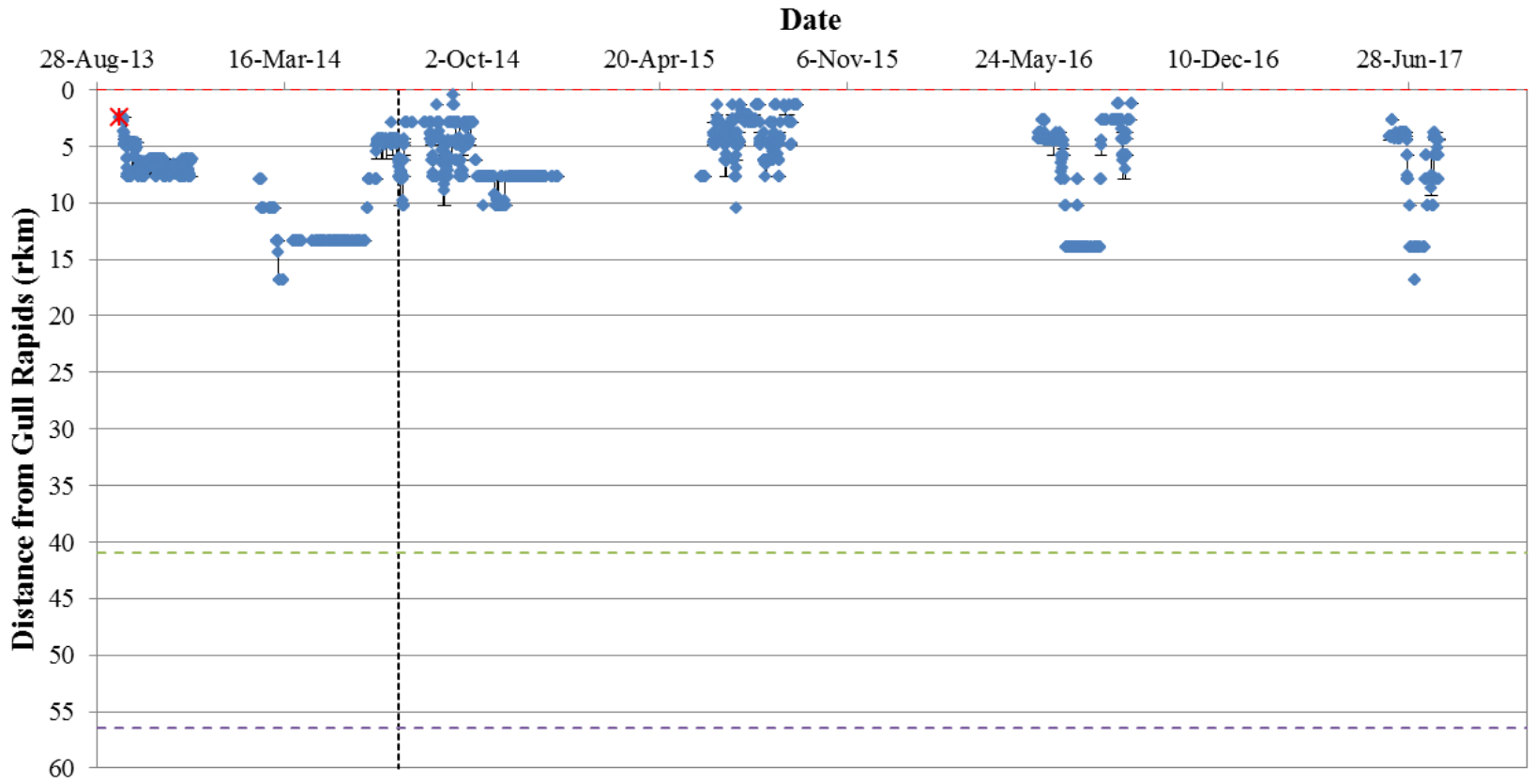


Figure A2-3: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32663) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 16 October, 2017. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black vertical dashed line represents start date of construction of the Keeyask GS. Horizontal dashed lines indicate the positions of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple).

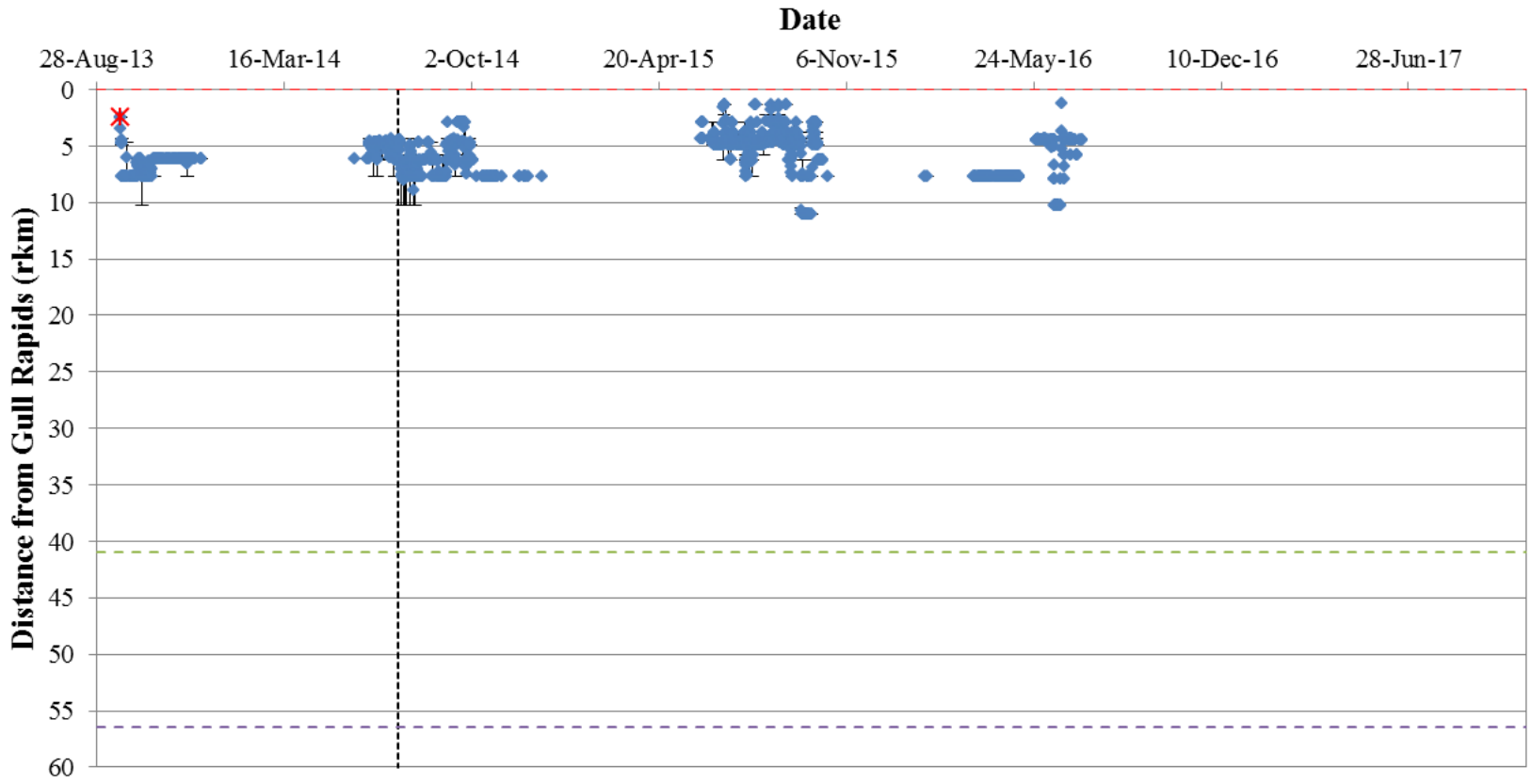


Figure A2-4: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32664) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 16 October, 2017. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black vertical dashed line represents start date of construction of the Keeyask GS. Horizontal dashed lines indicate the positions of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple).

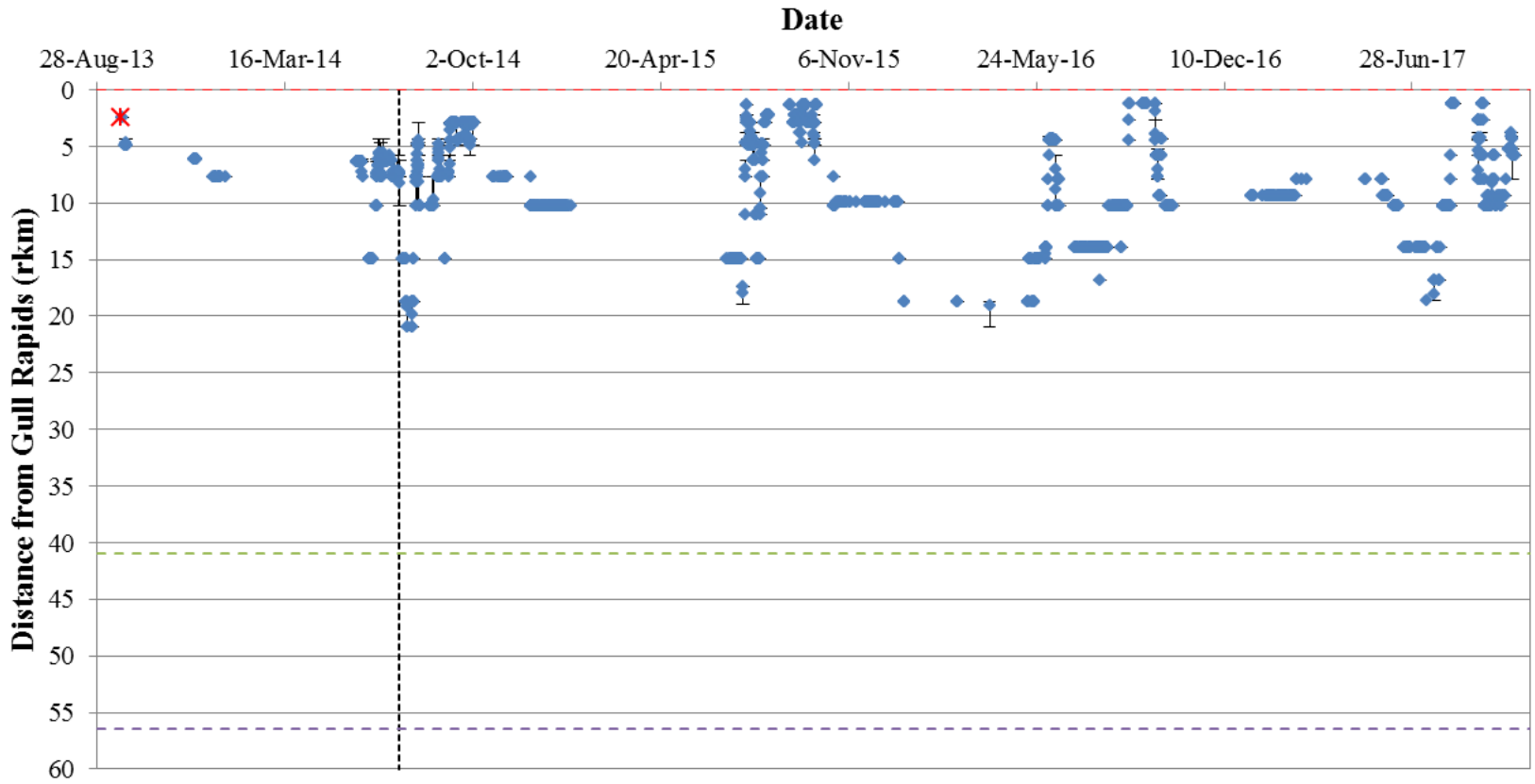


Figure A2-5: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32665) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 16 October, 2017. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black vertical dashed line represents start date of construction of the Keeyask GS. Horizontal dashed lines indicate the positions of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple).

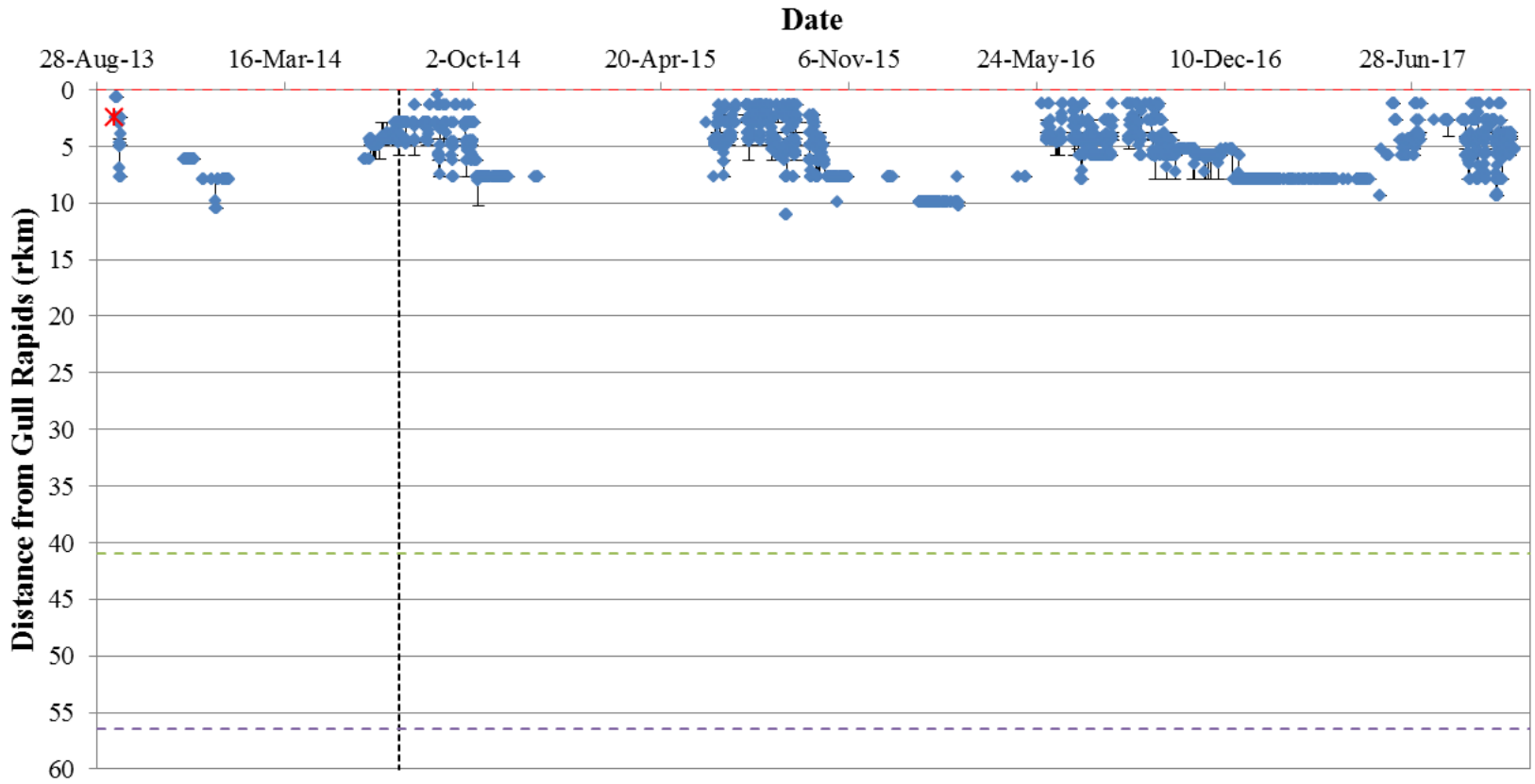


Figure A2-6: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32666) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 16 October, 2017. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black vertical dashed line represents start date of construction of the Keeyask GS. Horizontal dashed lines indicate the positions of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple).

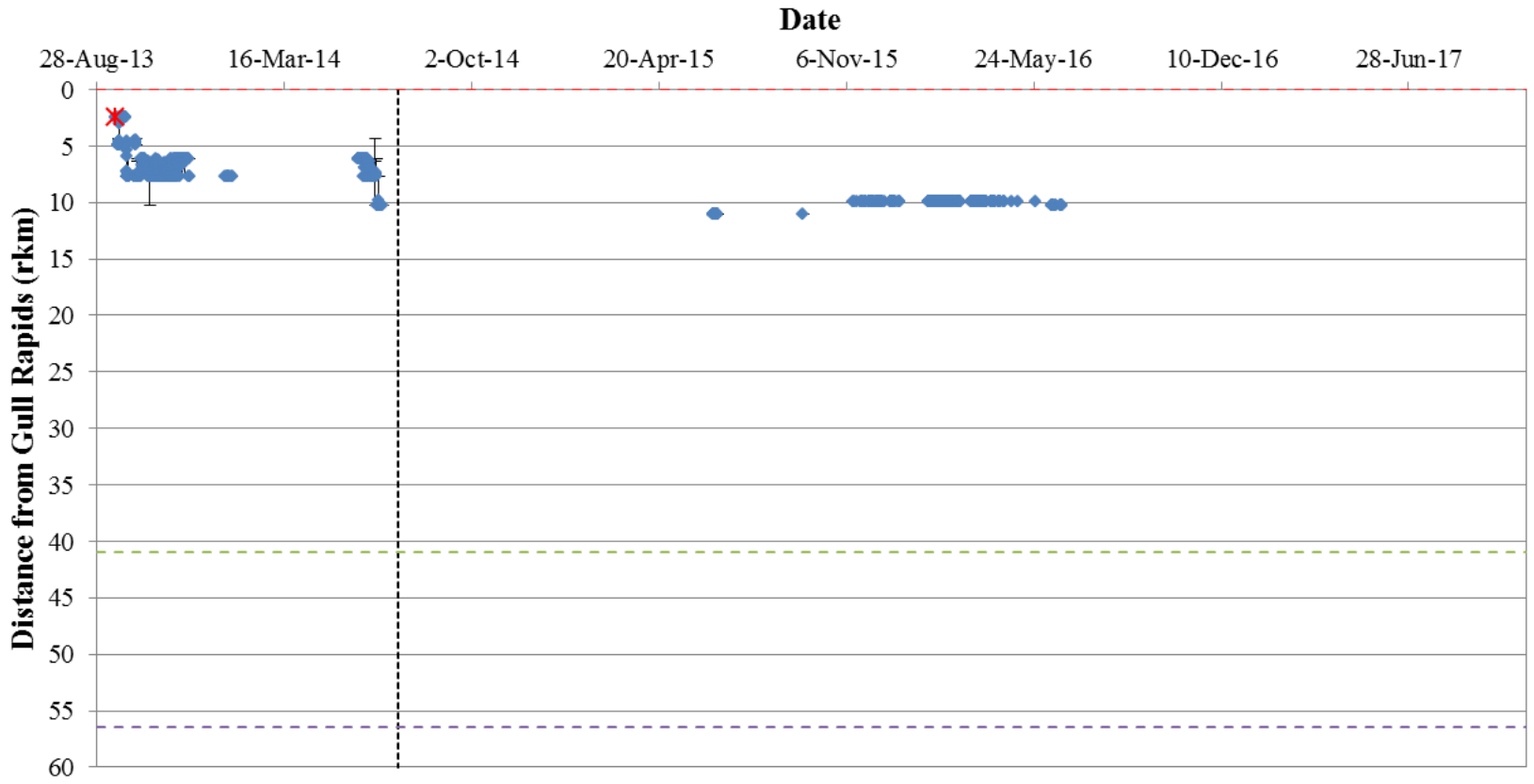


Figure A2-7: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32667) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 16 October, 2017. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black vertical dashed line represents start date of construction of the Keeyask GS. Horizontal dashed lines indicate the positions of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple).

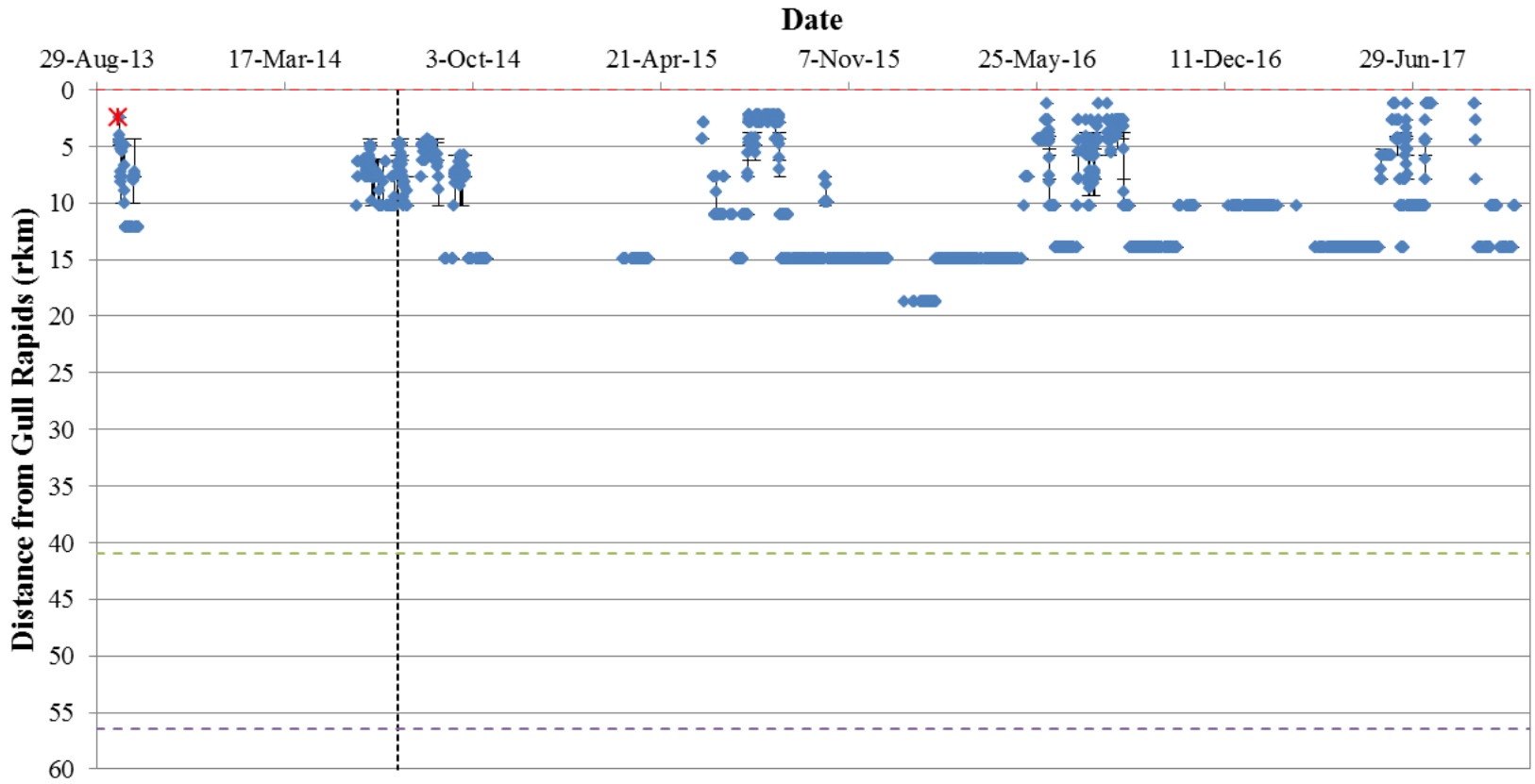


Figure A2-8: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32668) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 16 October, 2017. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black vertical dashed line represents start date of construction of the Keeyask GS. Horizontal dashed lines indicate the positions of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple).

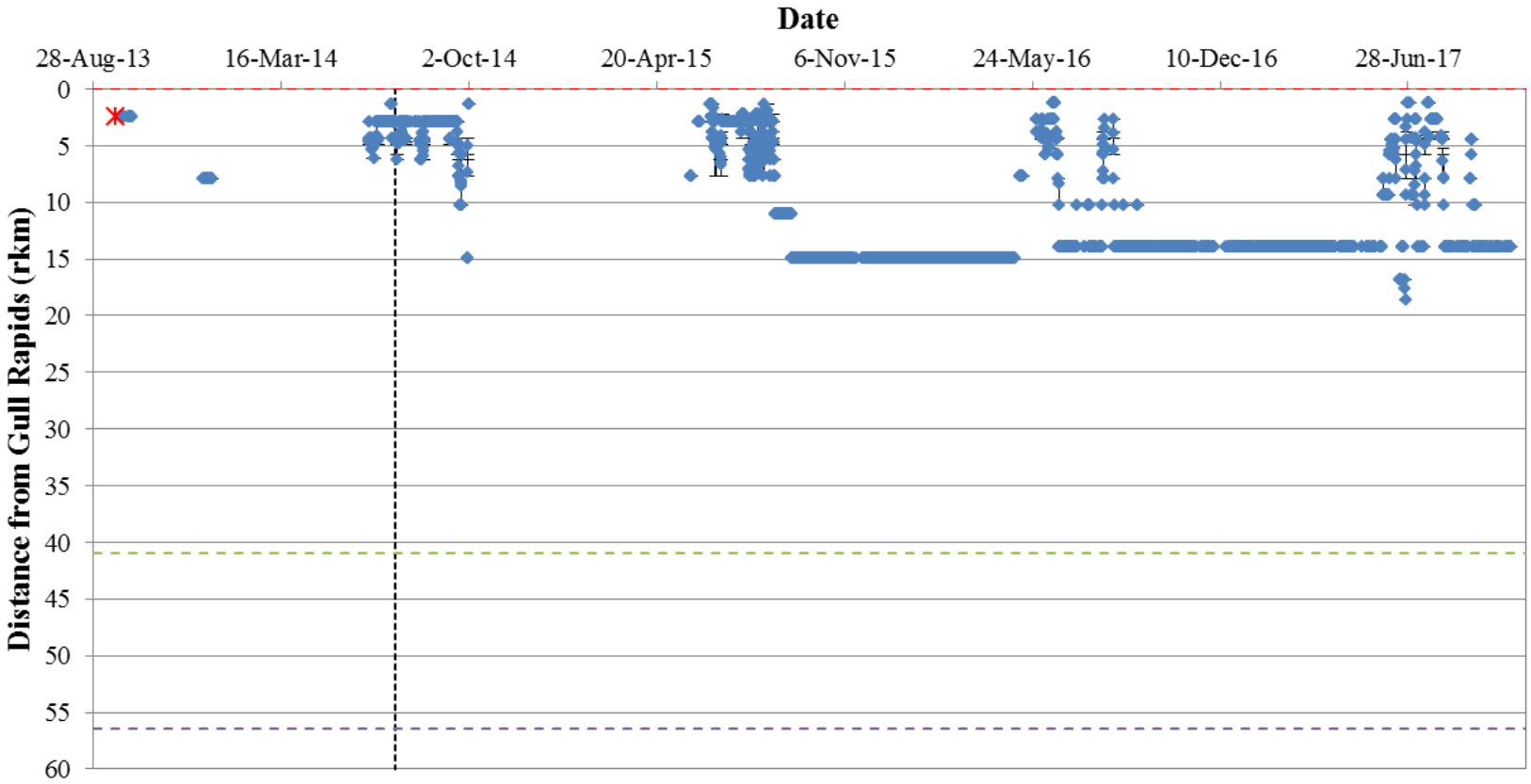


Figure A2-9: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32669) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 16 October, 2017. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black vertical dashed line represents start date of construction of the Keeyask GS. Horizontal dashed lines indicate the positions of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple).

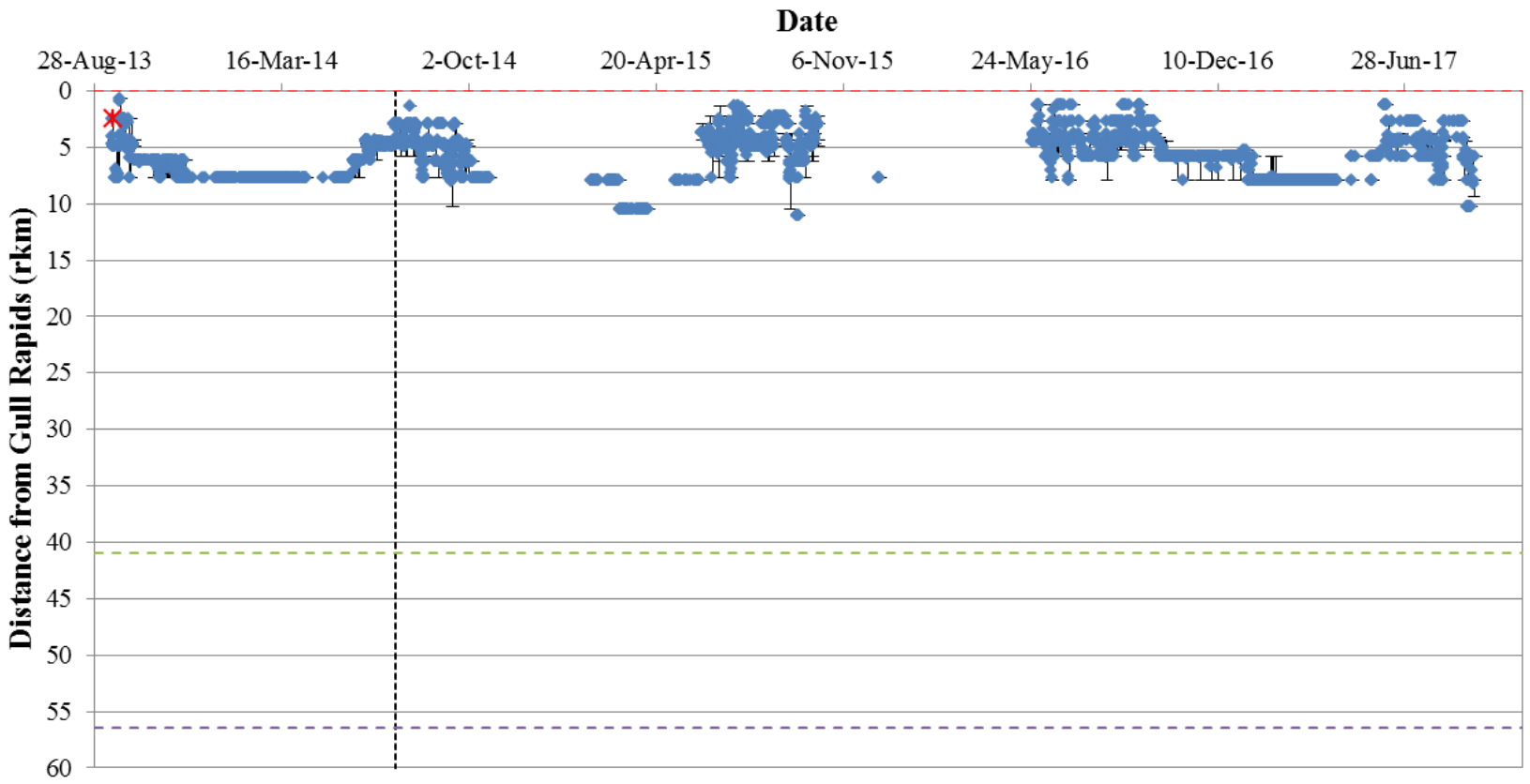


Figure A2-10: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32670) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 16 October, 2017. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black vertical dashed line represents start date of construction of the Keeyask GS. Horizontal dashed lines indicate the positions of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple).

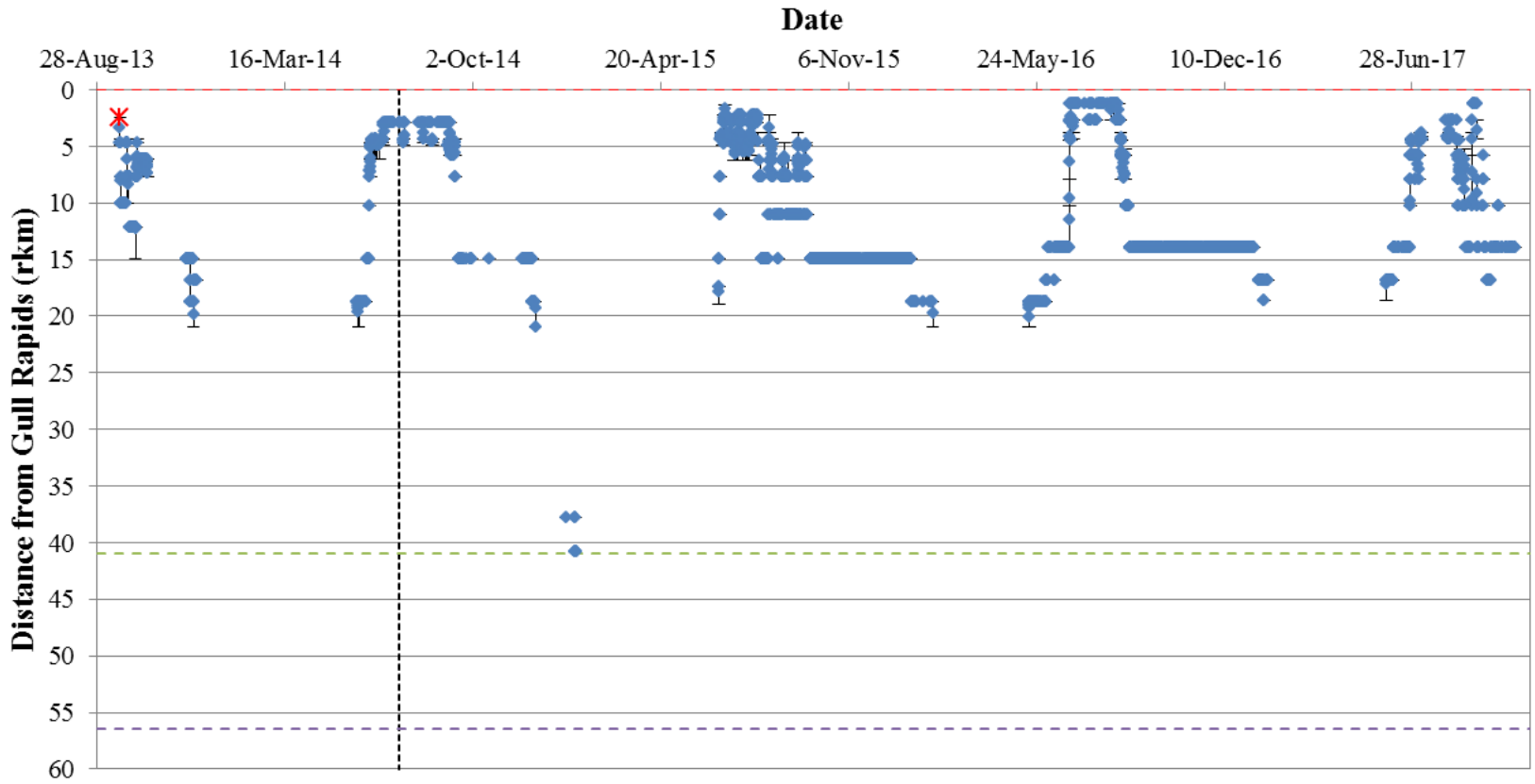


Figure A2-11: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32673) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 16 October, 2016. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black vertical dashed line represents start date of construction of the Keeyask GS. Horizontal dashed lines indicate the positions of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple).

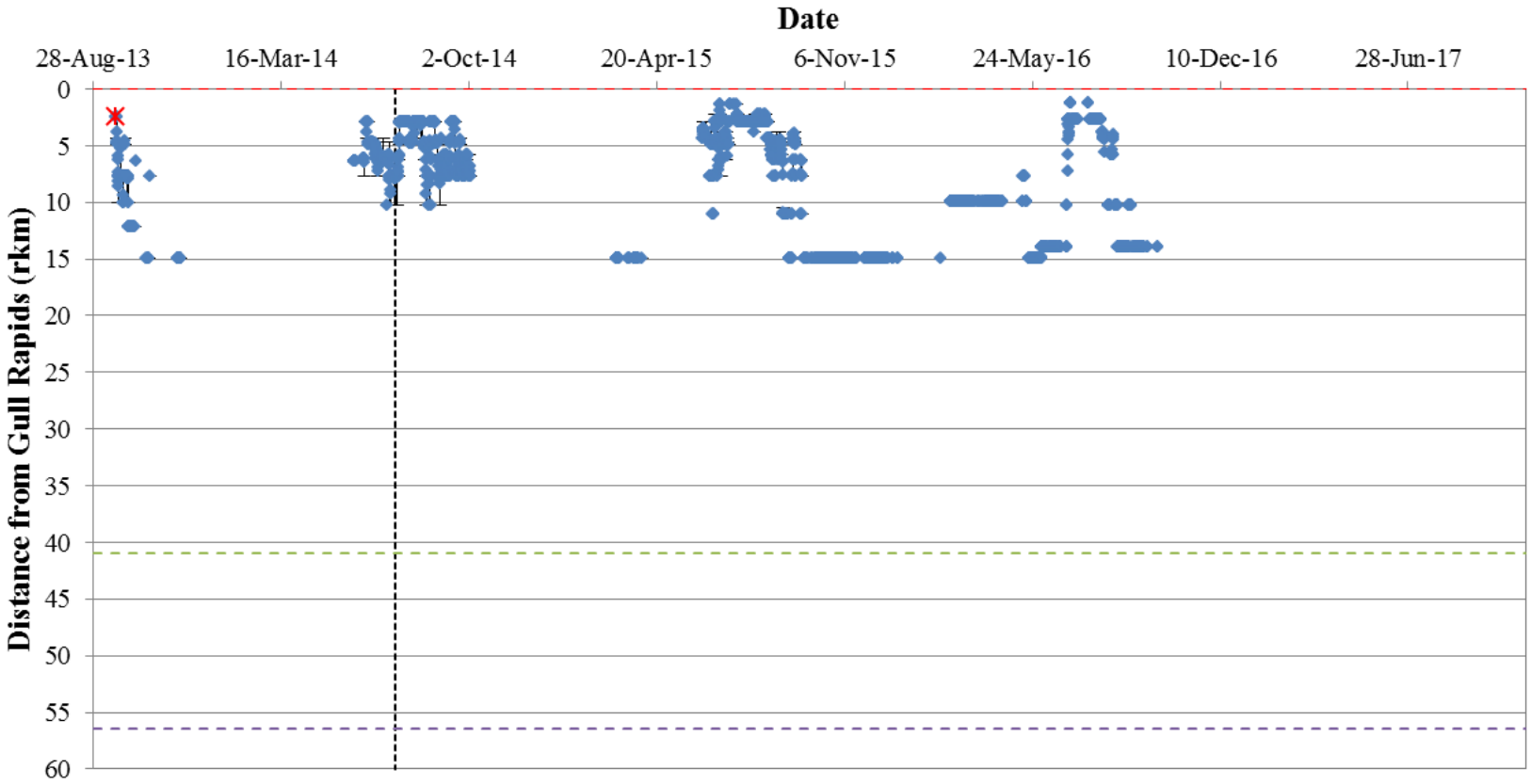


Figure A2-12: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32674) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 16 October, 2017. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black vertical dashed line represents start date of construction of the Keeyask GS. Horizontal dashed lines indicate the positions of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple).

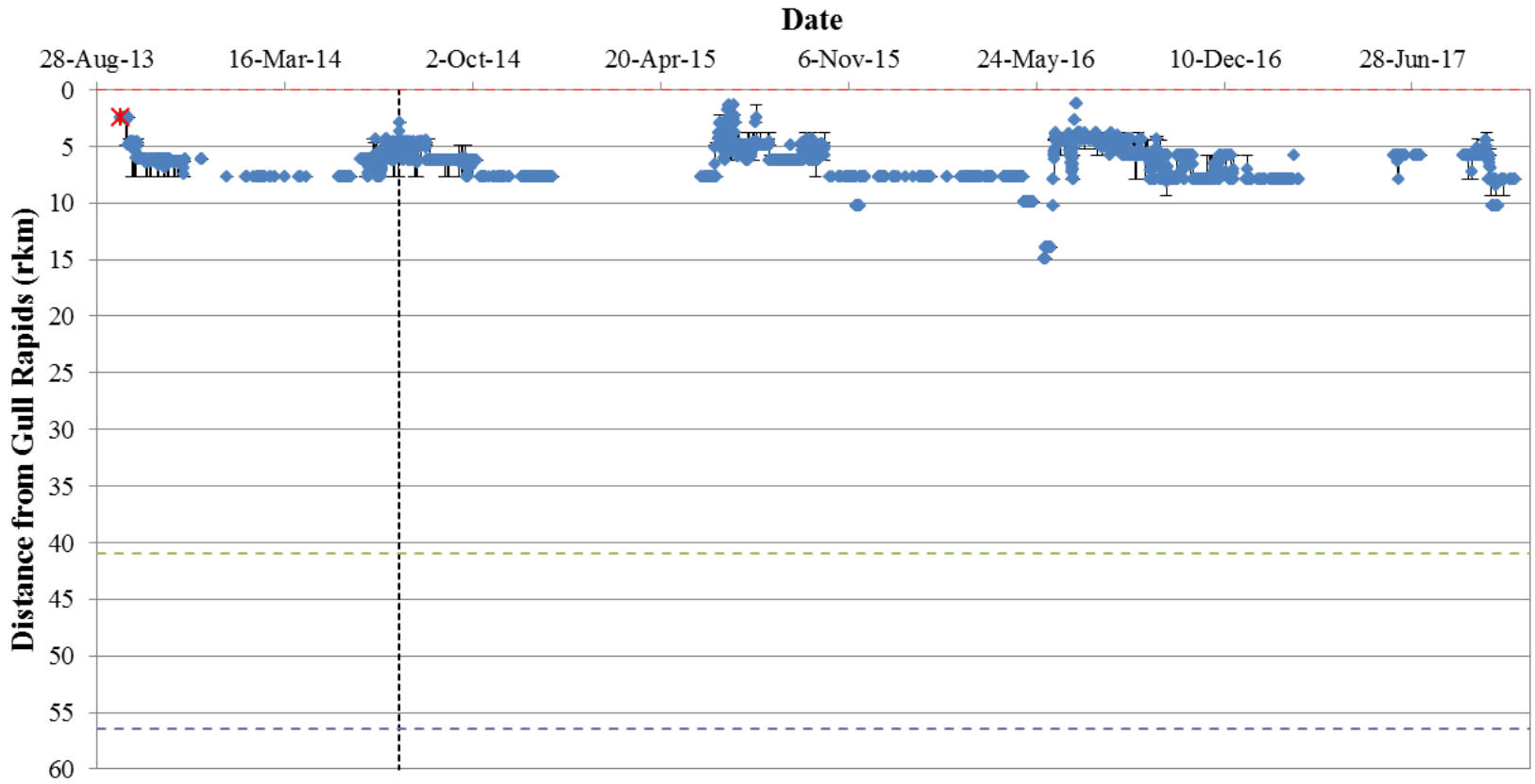


Figure A2-13: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32675) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 16 October, 2017. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black vertical dashed line represents start date of construction of the Keeyask GS. Horizontal dashed lines indicate the positions of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple).

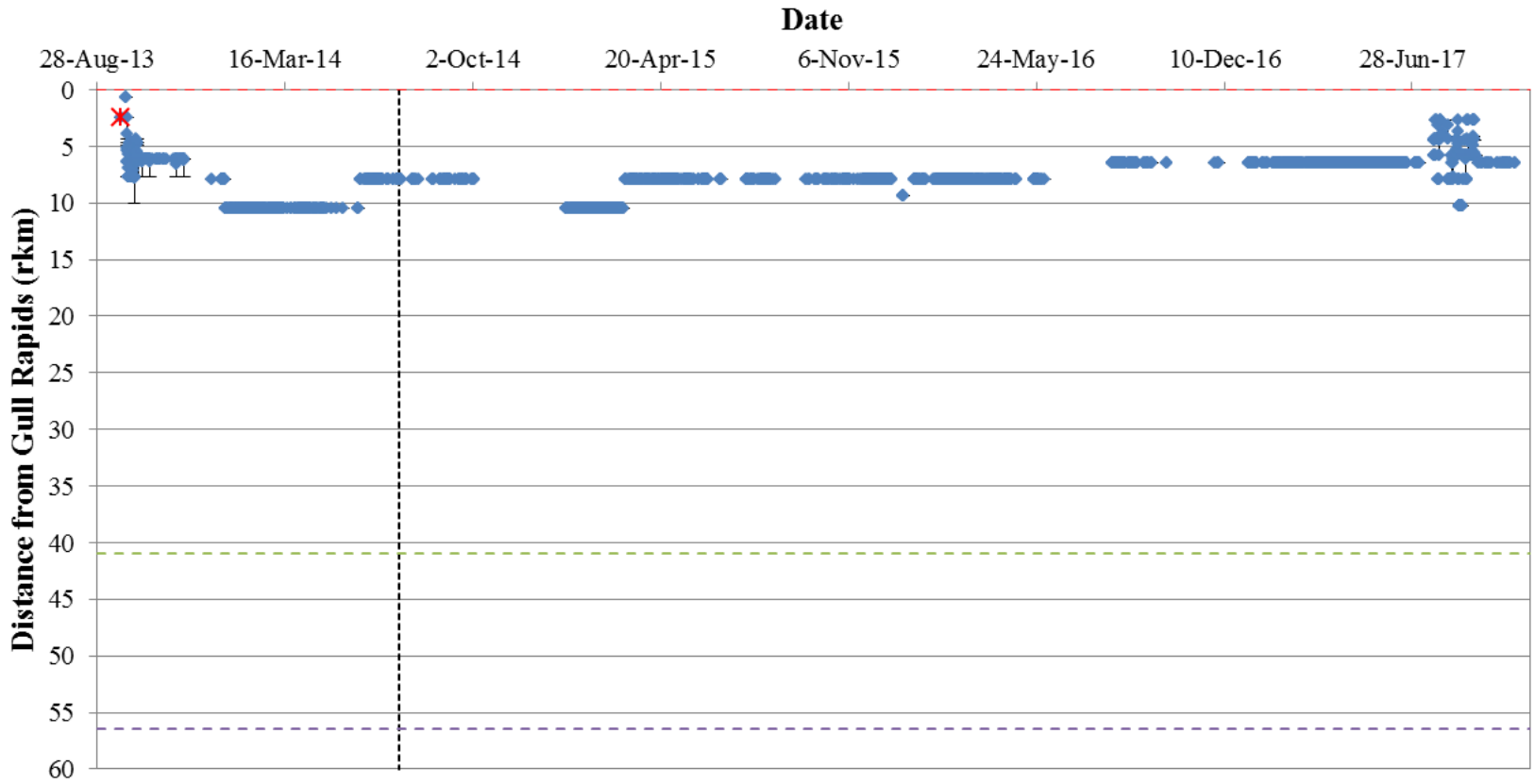


Figure A2-14: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32680) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 16 October, 2017. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black vertical dashed line represents start date of construction of the Keeyask GS. Horizontal dashed lines indicate the positions of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple).

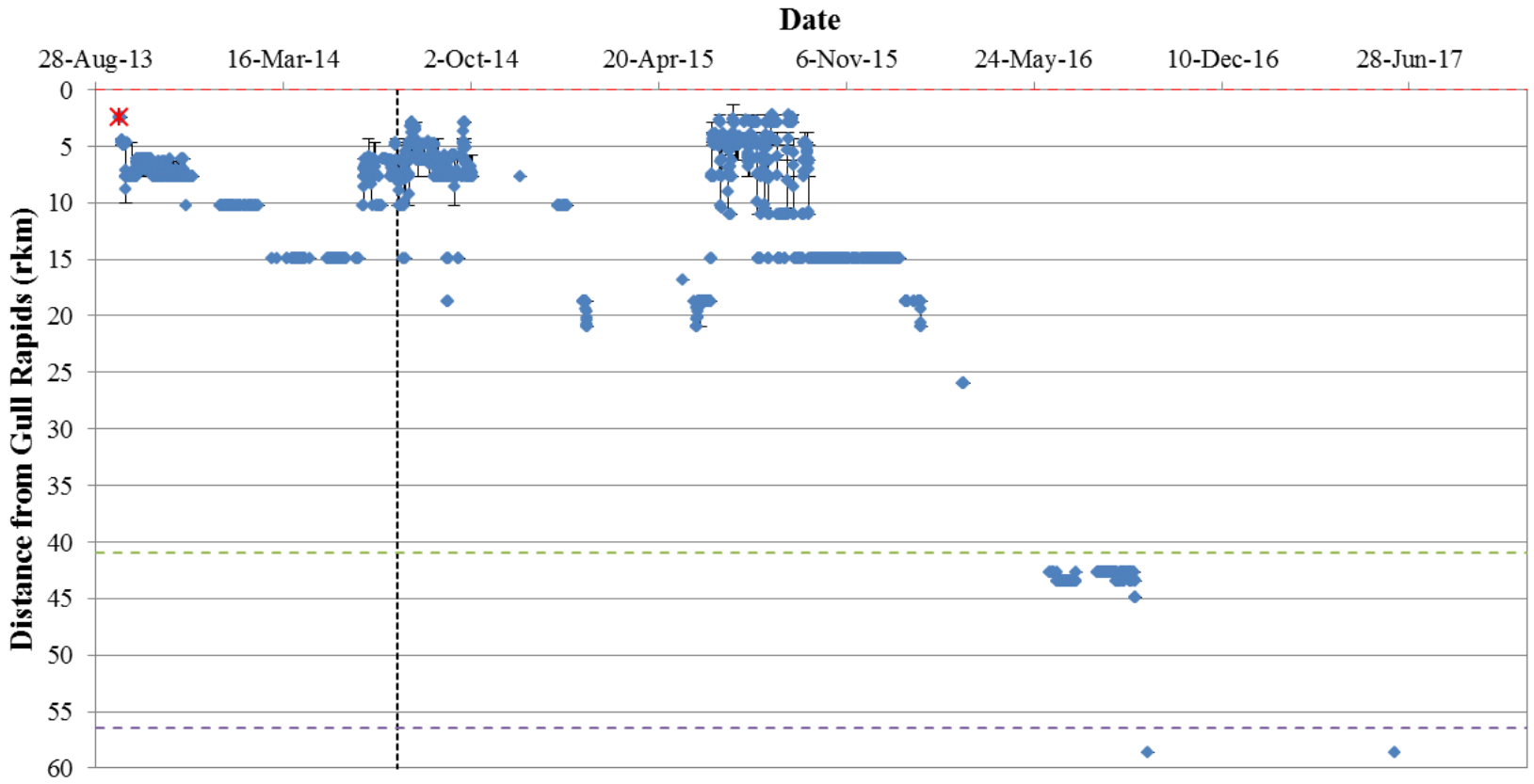


Figure A2-15: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32685) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 16 October, 2017. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black vertical dashed line represents start date of construction of the Keeyask GS. Horizontal dashed lines indicate the positions of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple).

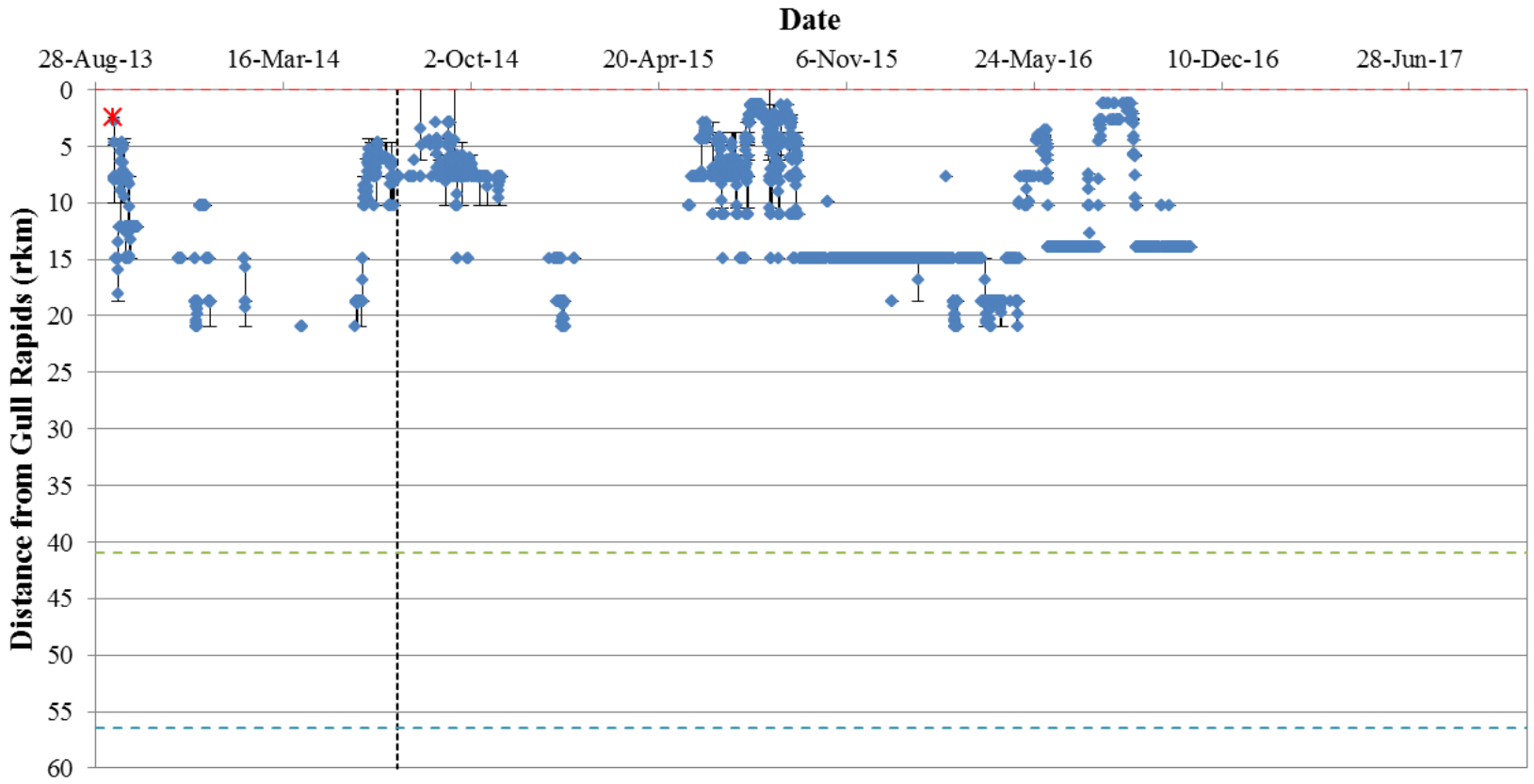


Figure A2-16: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32696) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 16 October, 2017. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black vertical dashed line represents start date of construction of the Keeyask GS. Horizontal dashed lines indicate the positions of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple).

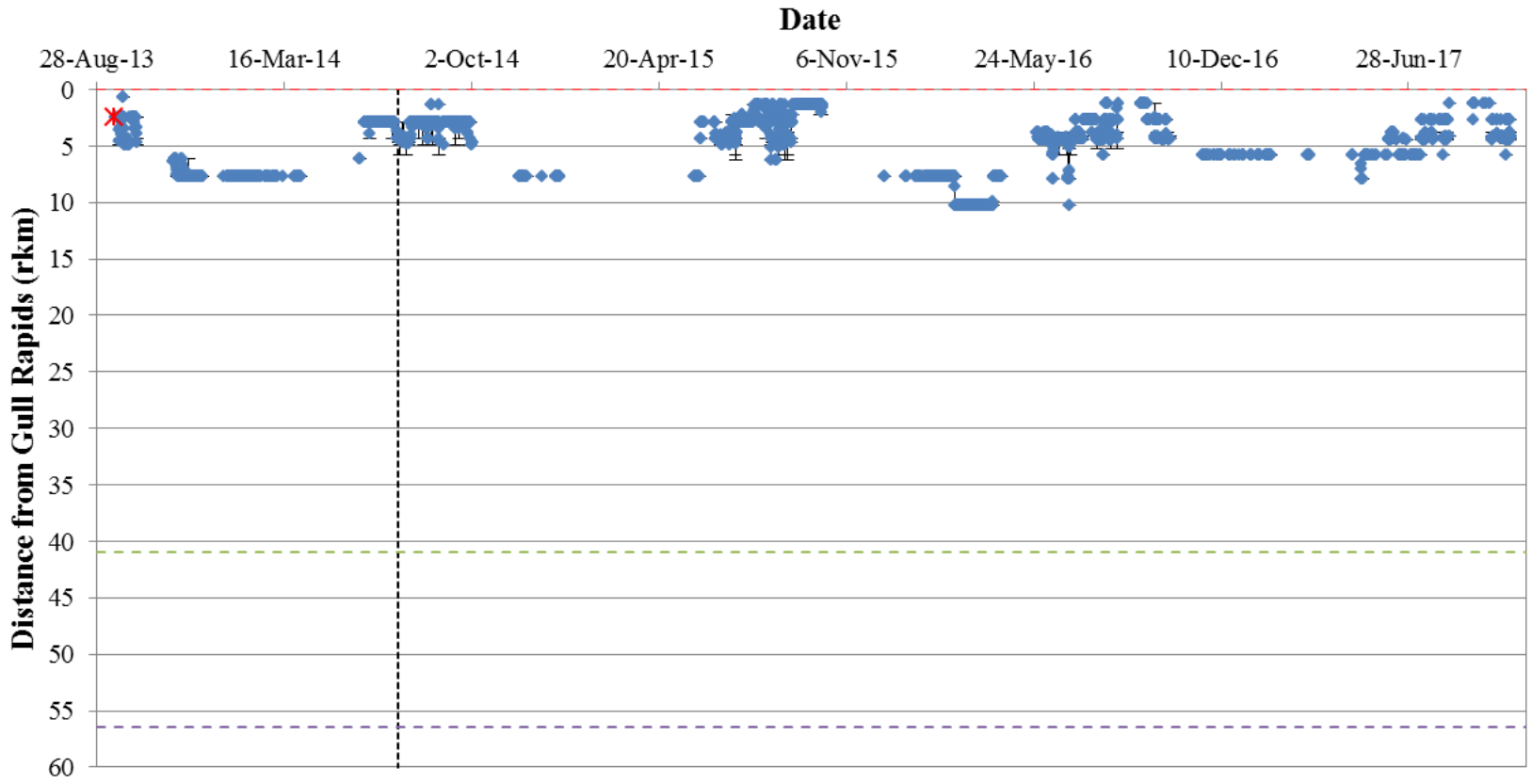


Figure A2-17: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32697) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 16 October, 2017. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black vertical dashed line represents start date of construction of the Keeyask GS. Horizontal dashed lines indicate the positions of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple).

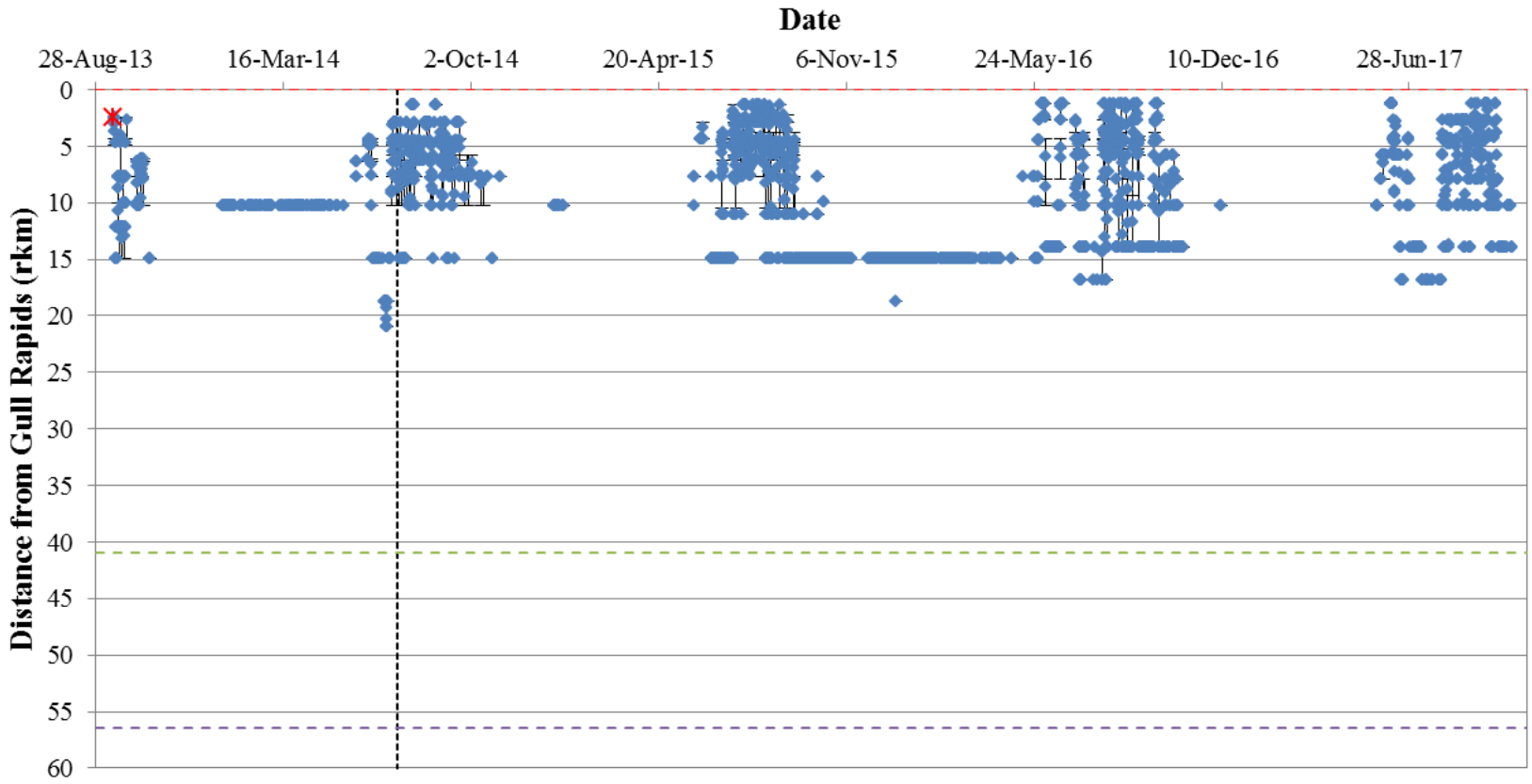


Figure A2-18: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32698) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 16 October, 2017. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black vertical dashed line represents start date of construction of the Keeyask GS. Horizontal dashed lines indicate the positions of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple).

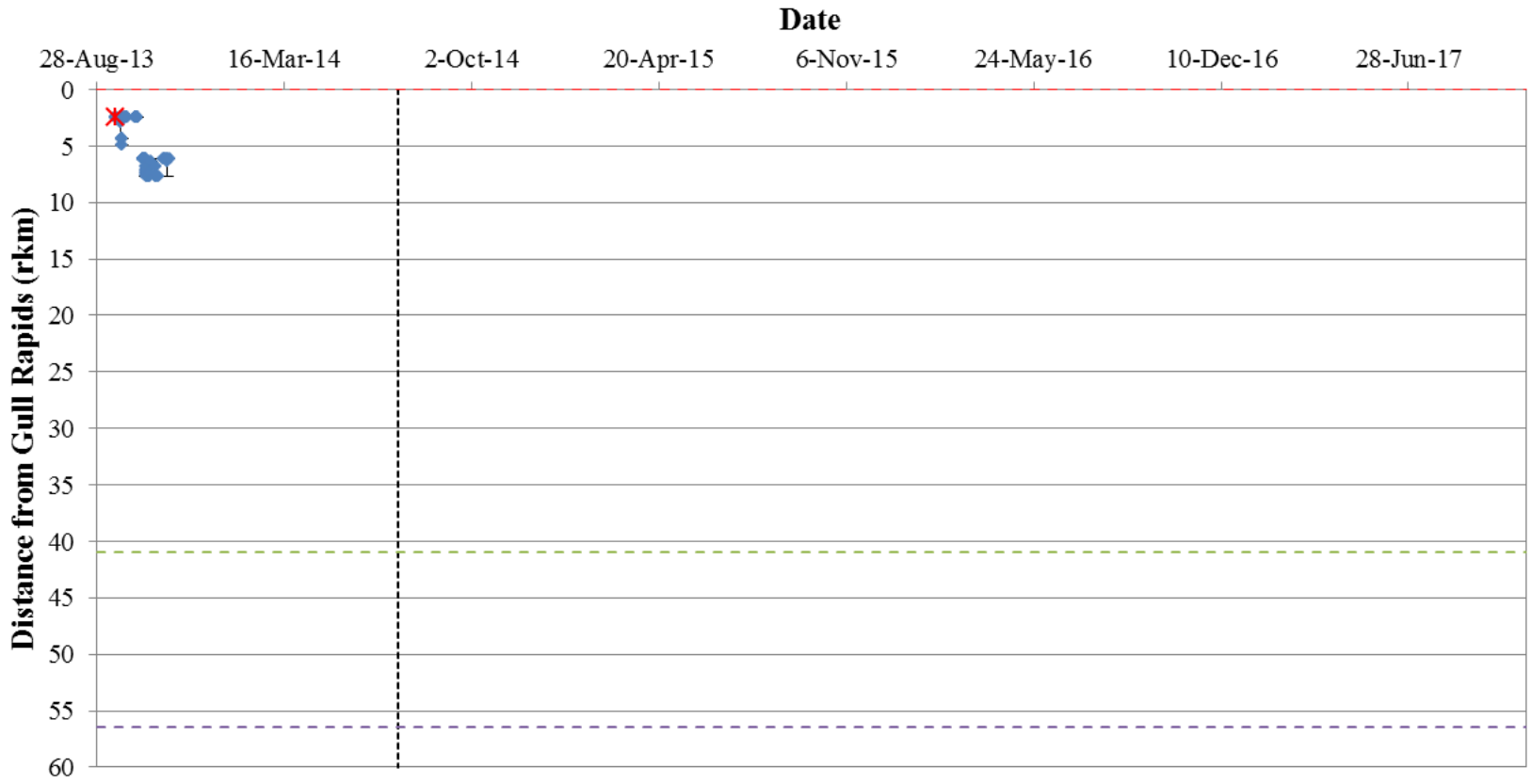


Figure A2-19: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32699) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 16 October, 2017. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black vertical dashed line represents start date of construction of the Keeyask GS. Horizontal dashed lines indicate the positions of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple).

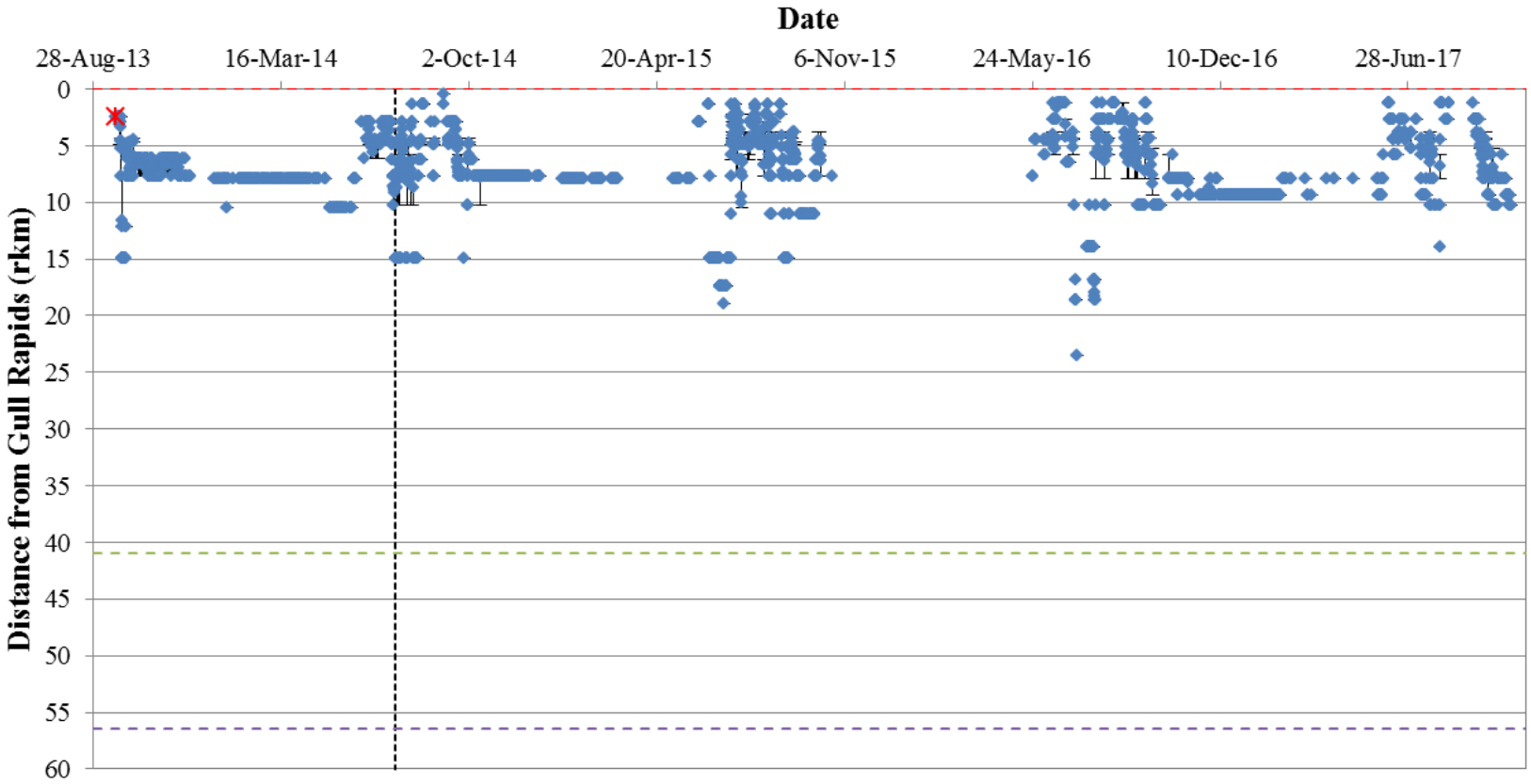


Figure A2-20: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32700) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 16 October, 2017. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black vertical dashed line represents start date of construction of the Keeyask GS. Horizontal dashed lines indicate the positions of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple).

APPENDIX 3:
LOCATION SUMMARY FOR INDIVIDUAL ACOUSTIC TAGGED JUVENILE LAKE STURGEON UPSTREAM OF GULL RAPIDS, SEPTEMBER TO OCTOBER 2017

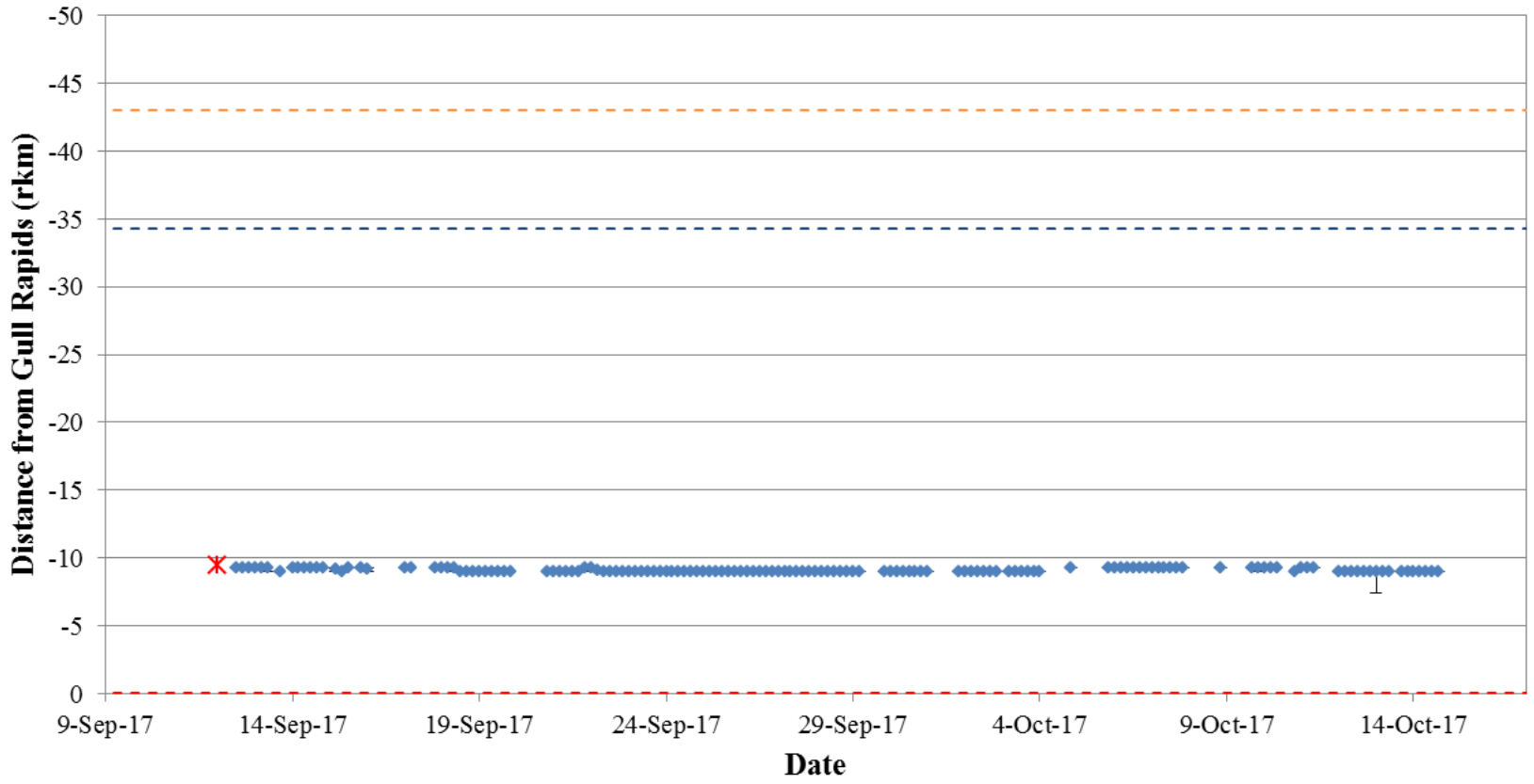


Figure A3-1: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31683) in Gull Lake in relation to Gull Rapids (rkm 0), from 9 September to 16 October, 2017. Date and location of tagging is indicated by red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

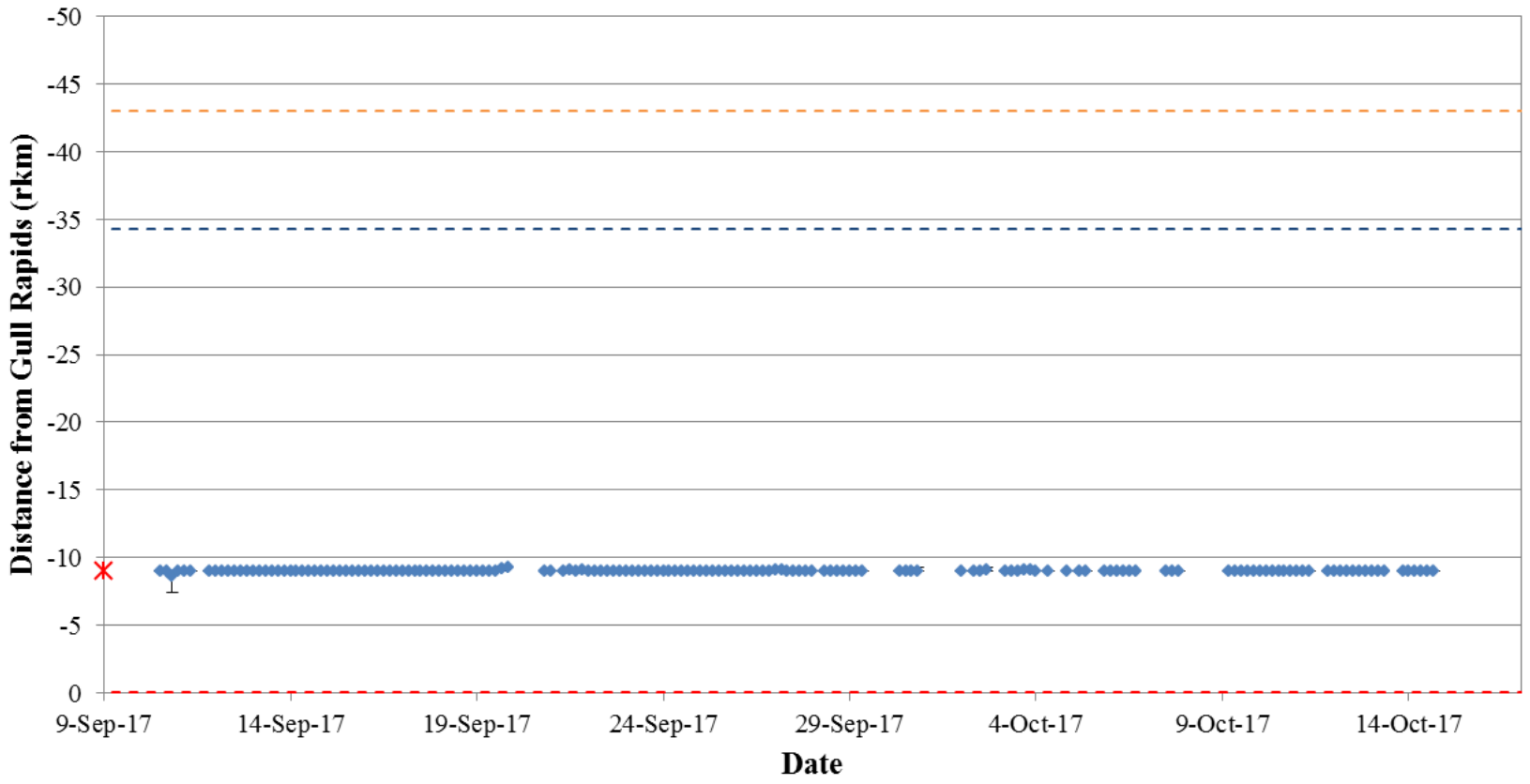


Figure A3-2: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31684) in Gull Lake in relation to Gull Rapids (rkm 0), from 9 September to 16 October, 2017. Date and location of tagging is indicated by red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

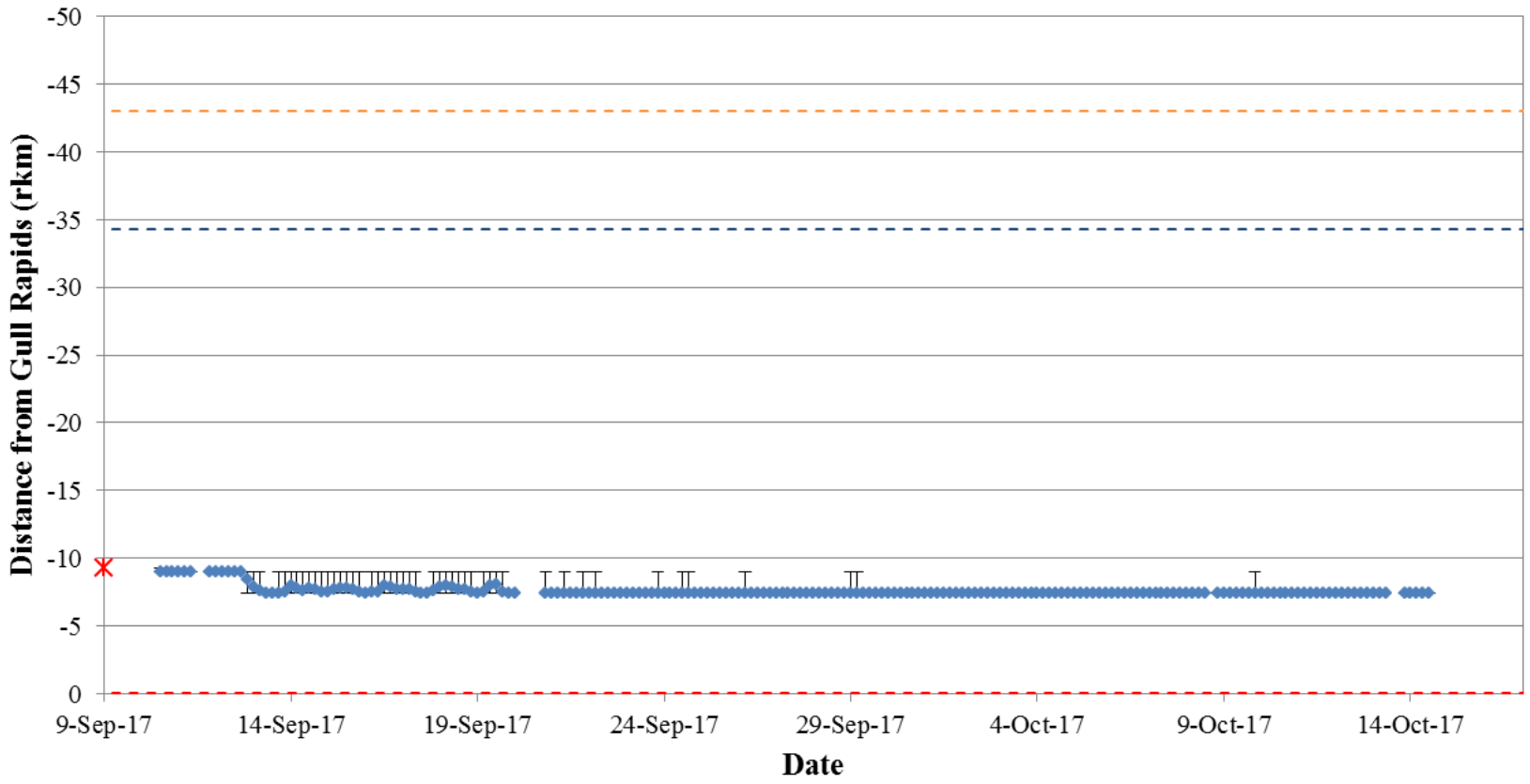


Figure A3-3: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31685) in Gull Lake in relation to Gull Rapids (rkm 0), from 9 September to 16 October, 2017. Date and location of tagging is indicated by red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

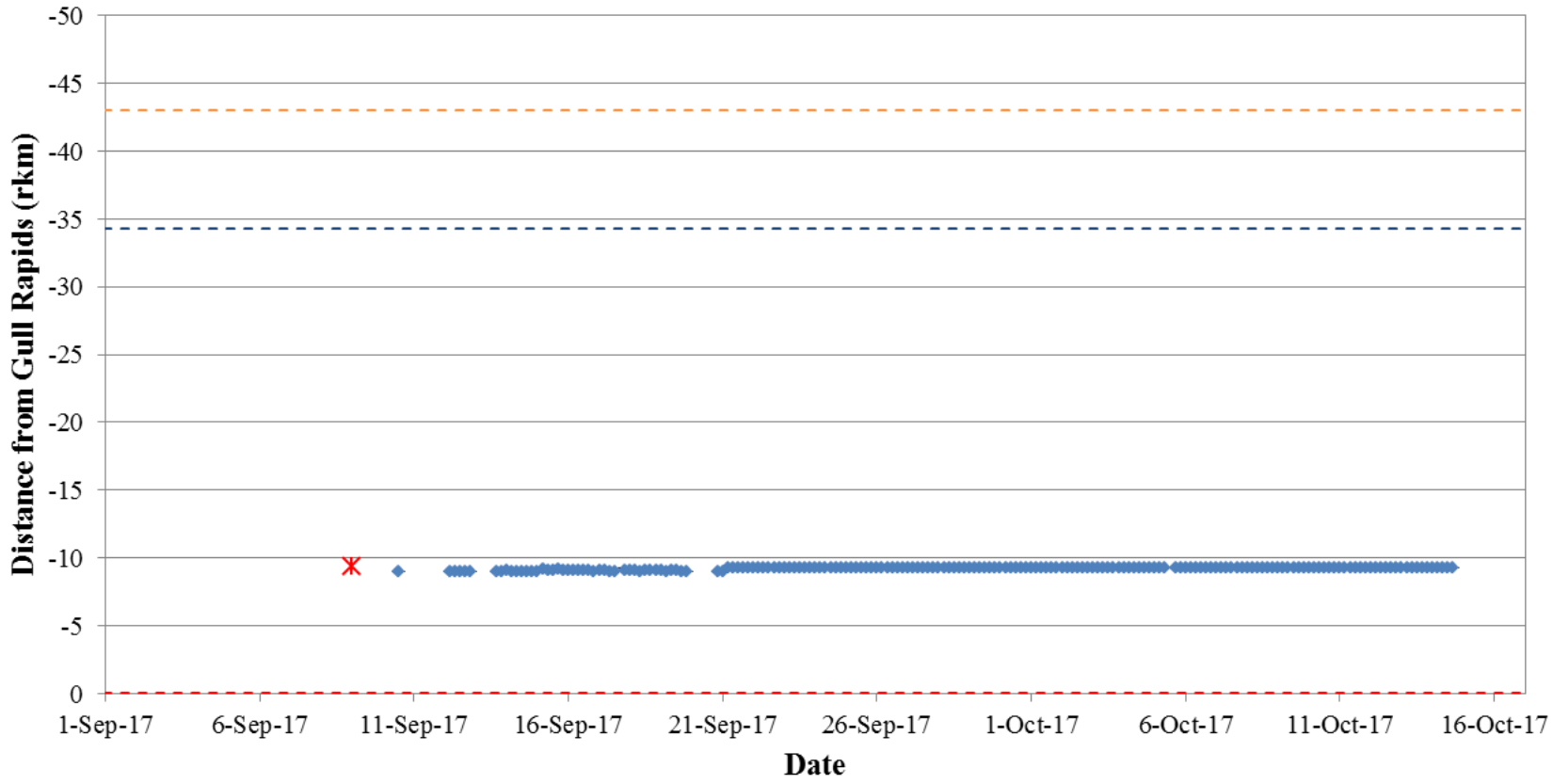


Figure A3-4: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31686) in Gull Lake in relation to Gull Rapids (rkm 0), from 9 September to 16 October, 2017. Date and location of tagging is indicated by red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

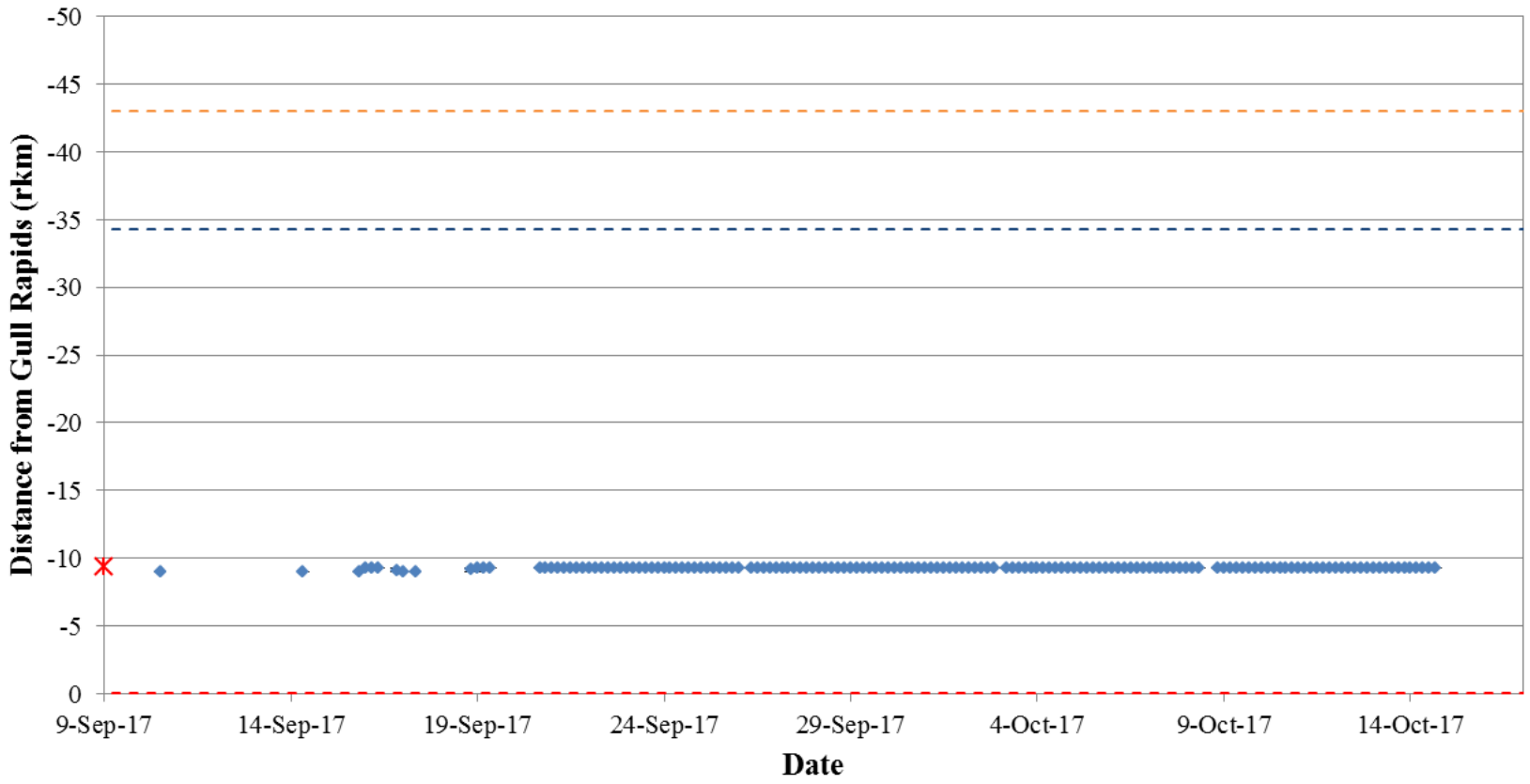


Figure A3-5: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31687) in Gull Lake in relation to Gull Rapids (rkm 0), from 9 September to 16 October, 2017. Date and location of tagging is indicated by red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

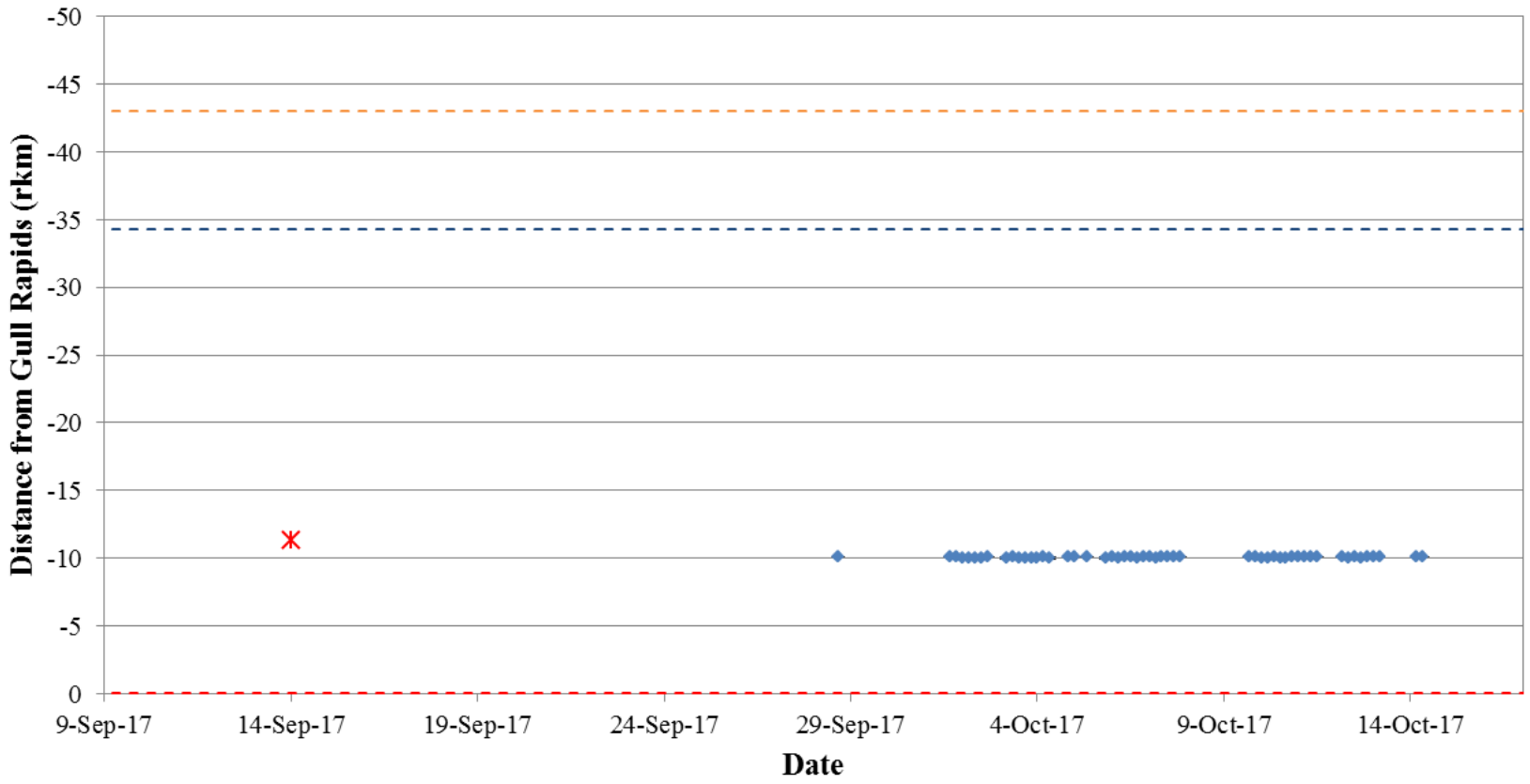


Figure A3-6: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31768) in Gull Lake in relation to Gull Rapids (rkm 0), from 9 September to 16 October, 2017. Date and location of tagging is indicated by red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

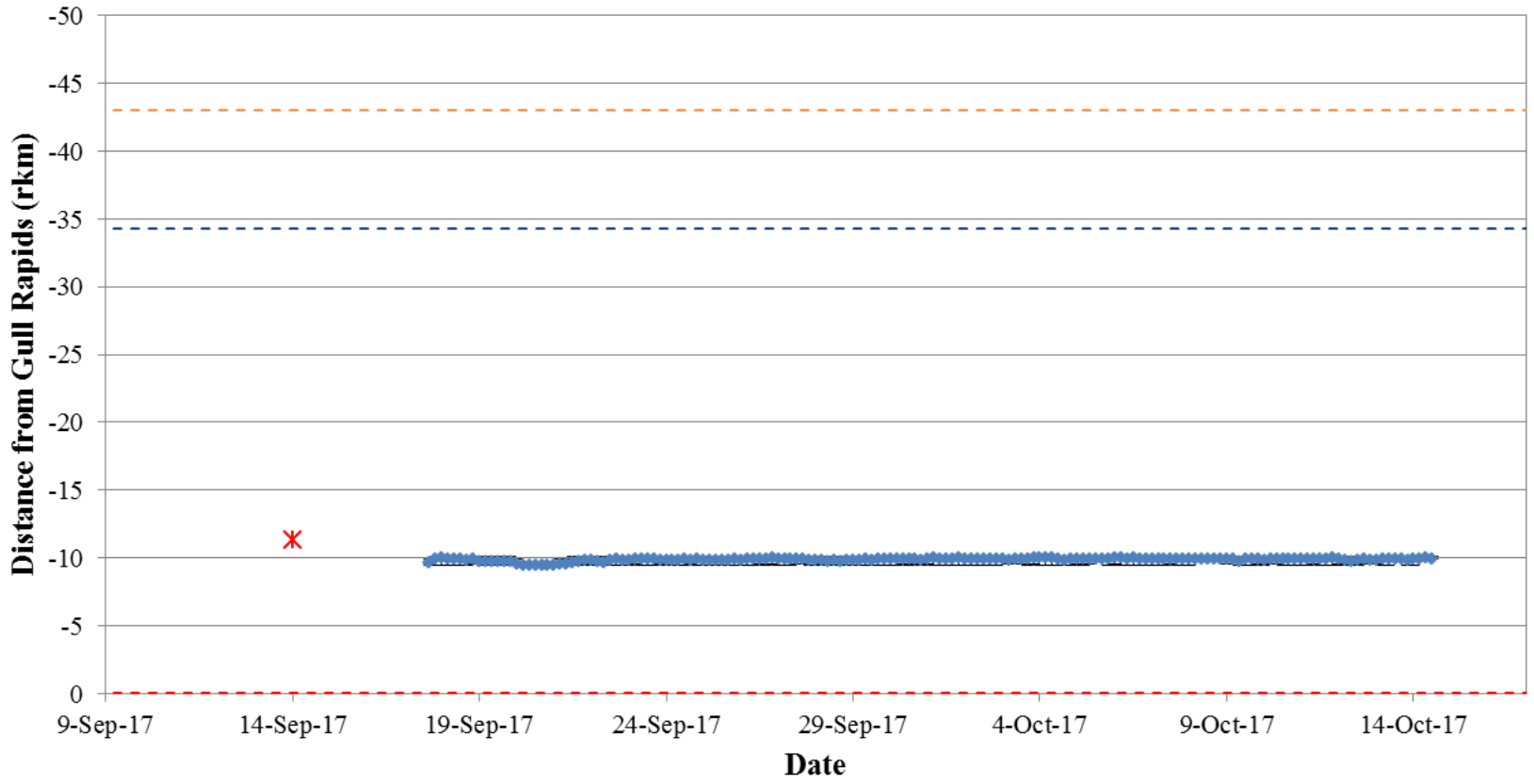


Figure A3-7: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31769) in Gull Lake in relation to Gull Rapids (rkm 0), from 9 September to 16 October, 2017. Date and location of tagging is indicated by red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

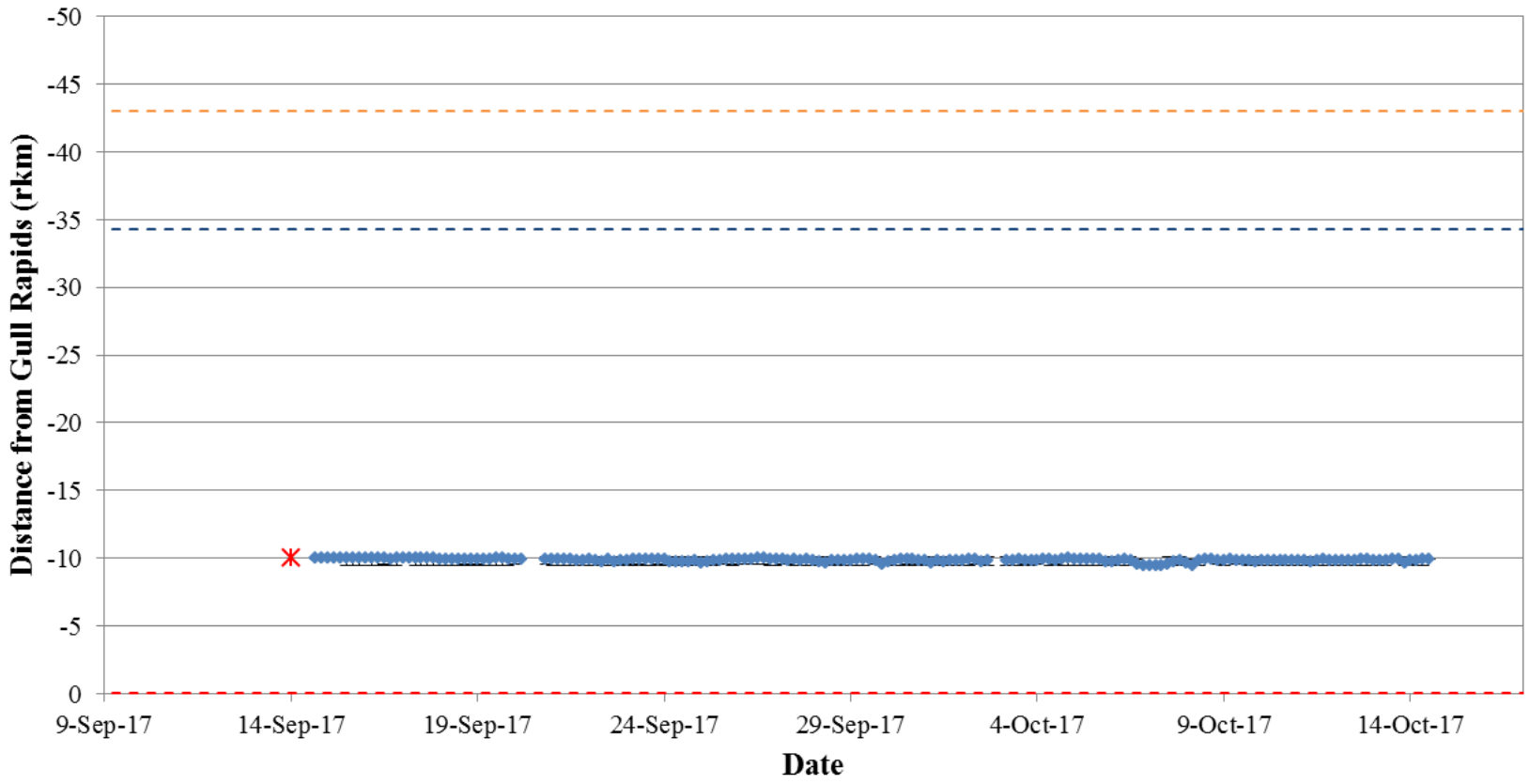


Figure A3-8: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31770) in Gull Lake in relation to Gull Rapids (rkm 0), from 9 September to 16 October, 2017. Date and location of tagging is indicated by red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

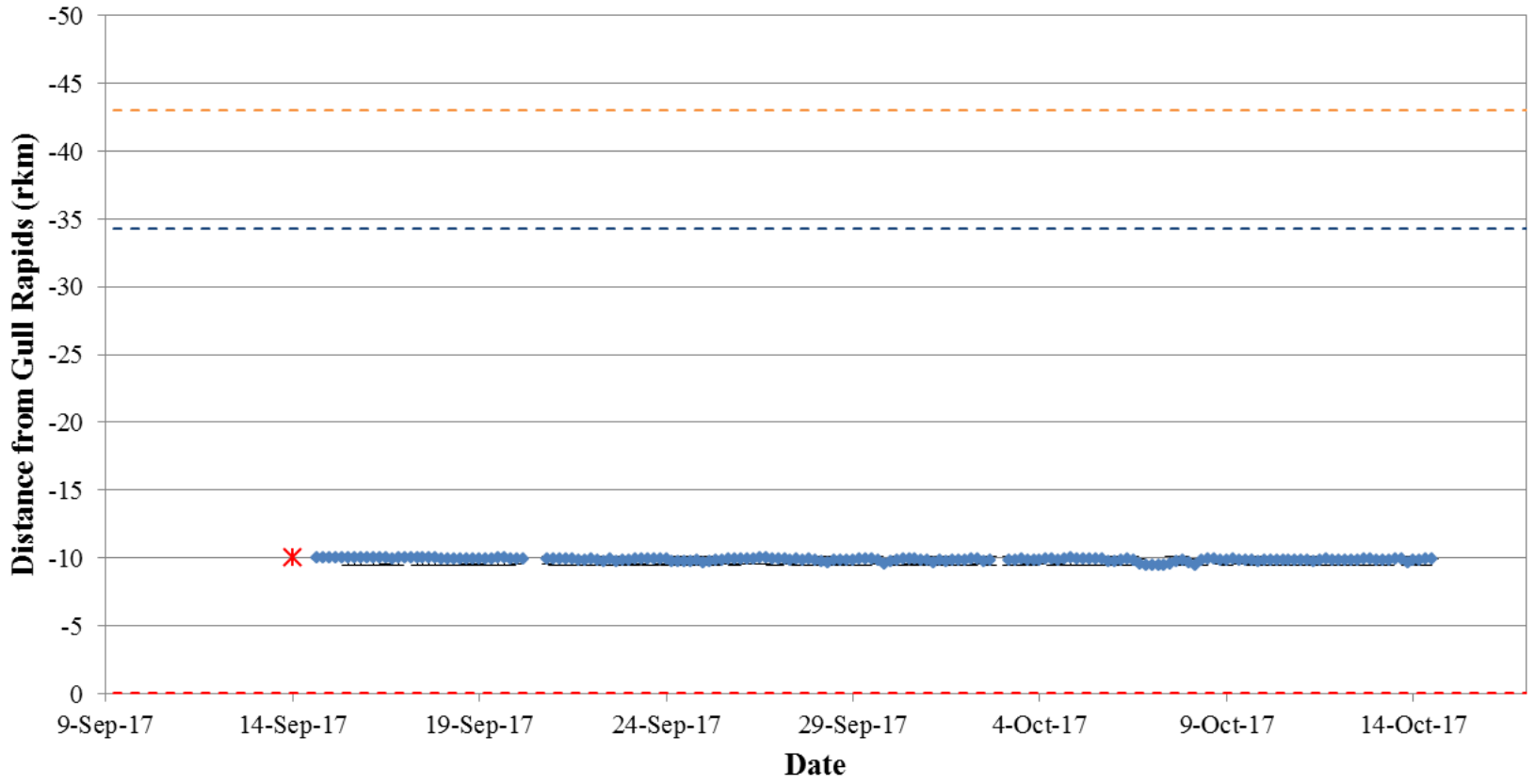


Figure A3-9: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31771) in Gull Lake in relation to Gull Rapids (rkm 0), from 9 September to 16 October, 2017. Date and location of tagging is indicated by red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

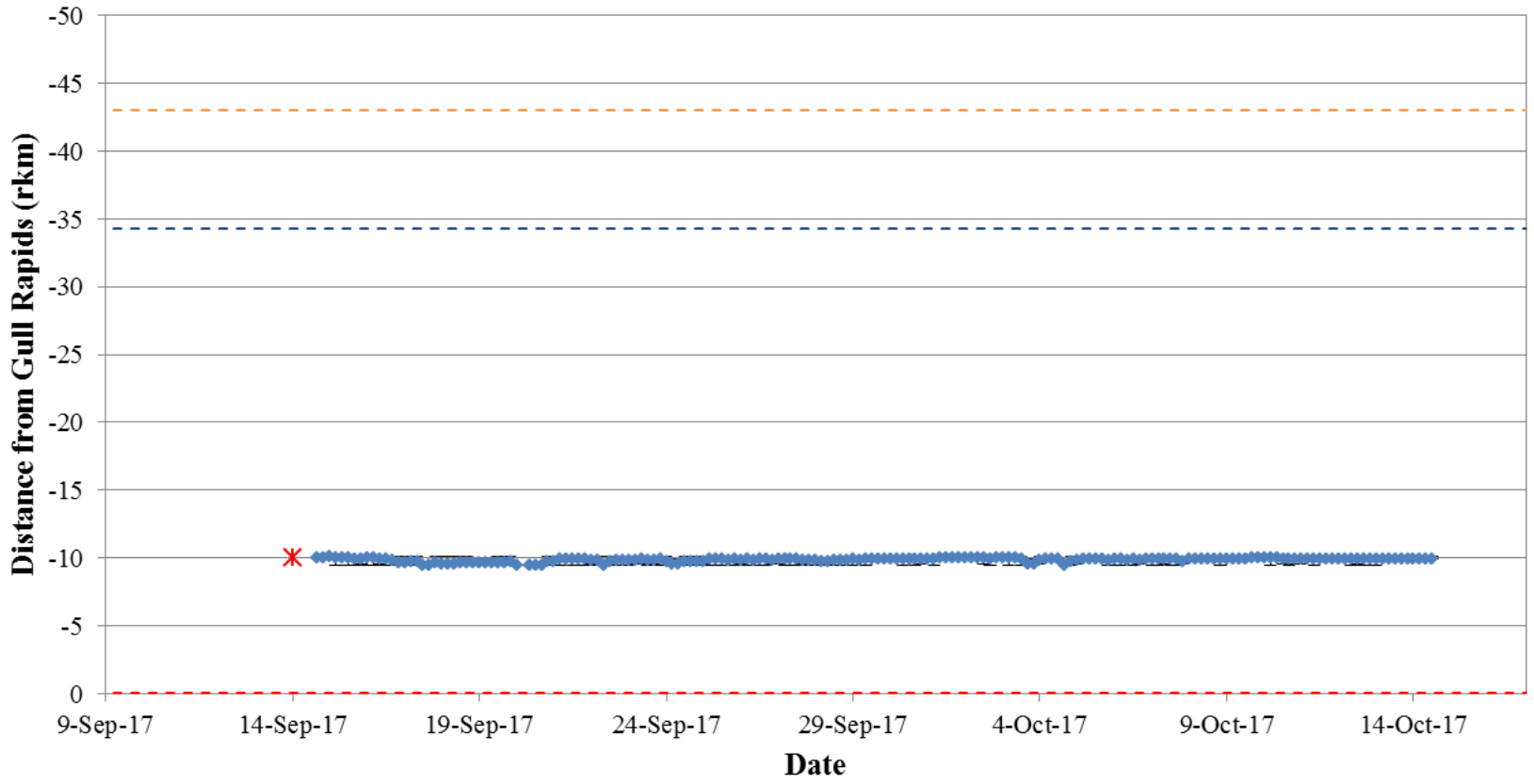


Figure A3-10: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31772) in Gull Lake in relation to Gull Rapids (rkm 0), from 9 September to 16 October, 2017. Date and location of tagging is indicated by red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

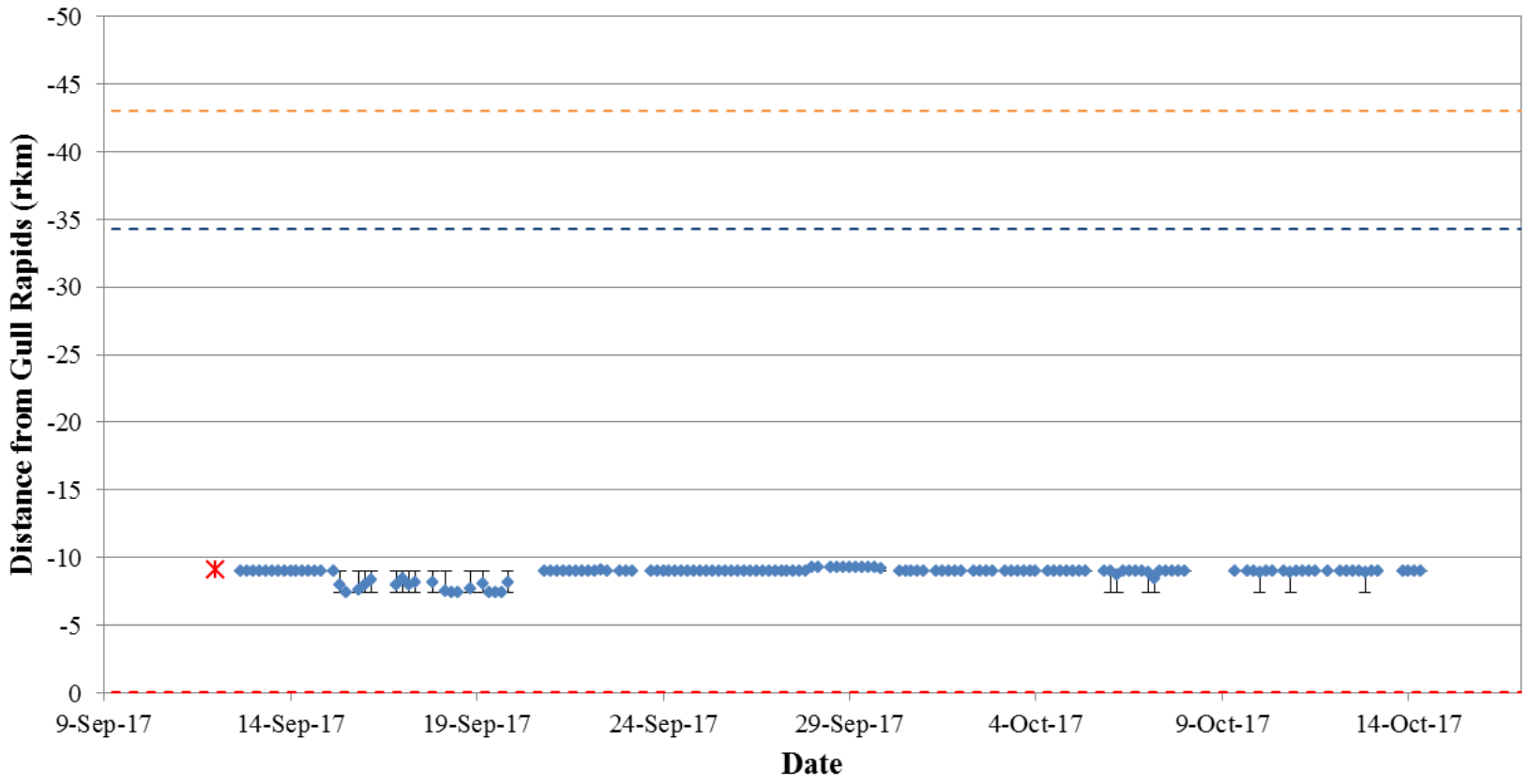


Figure A3-11: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31773) in Gull Lake in relation to Gull Rapids (rkm 0), from 9 September to 16 October, 2017. Date and location of tagging is indicated by red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

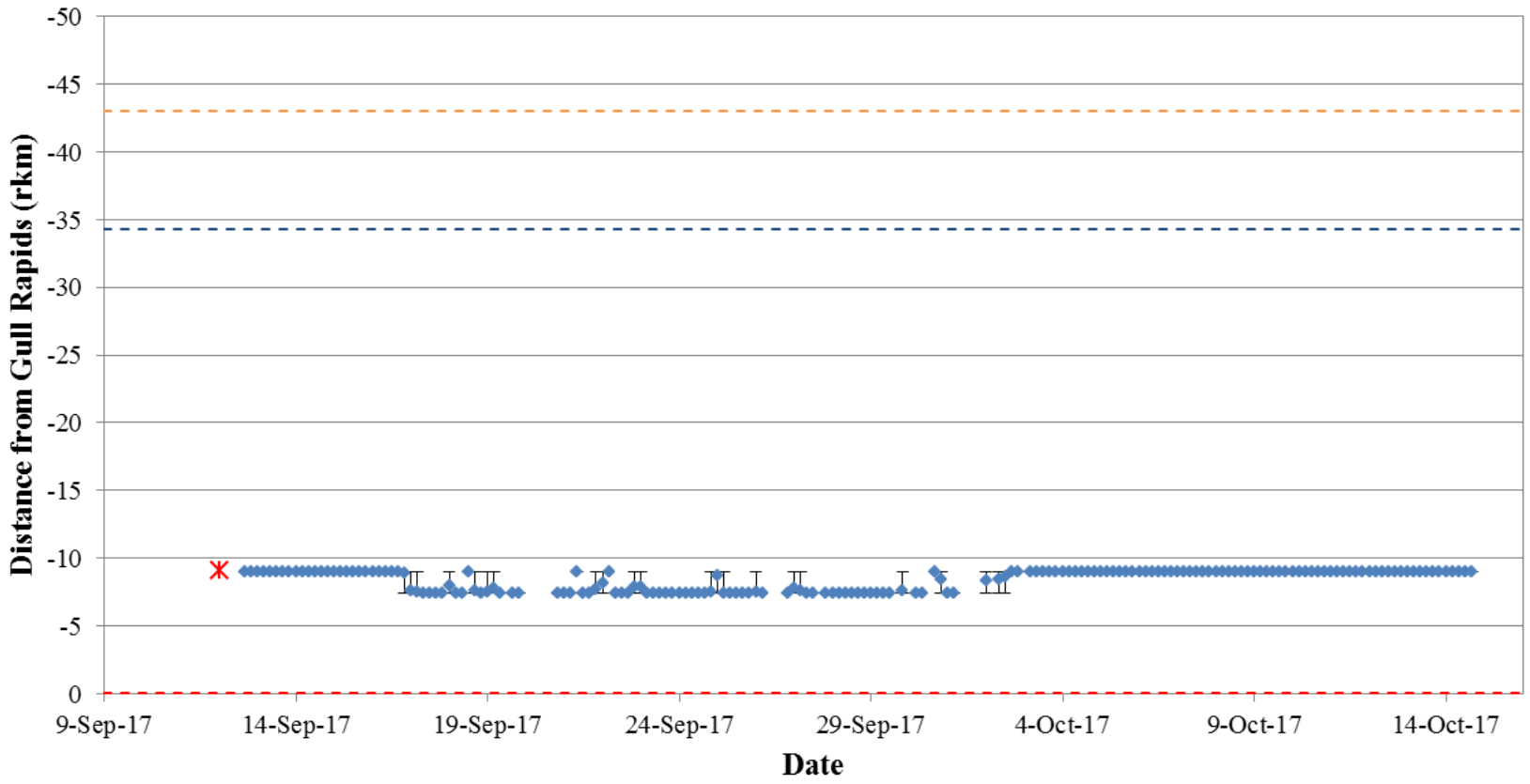


Figure A3-12: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31774) in Gull Lake in relation to Gull Rapids (rkm 0), from 9 September to 16 October, 2017. Date and location of tagging is indicated by red X. Horizontal dashed lines indicate the positions of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

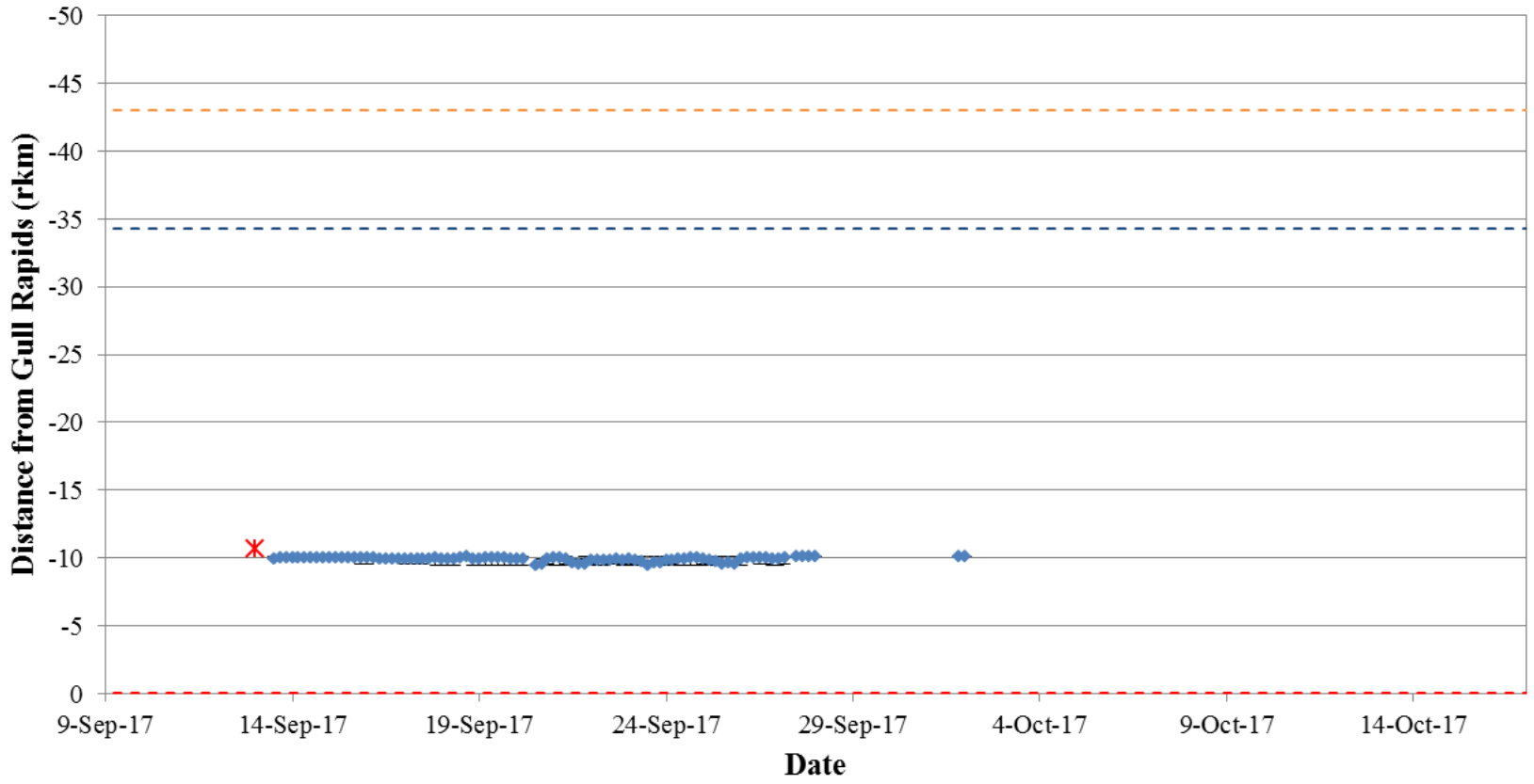


Figure A3-13: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31775) in Gull Lake in relation to Gull Rapids (rkm 0), from 9 September to 16 October, 2017. Date and location of tagging is indicated by red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

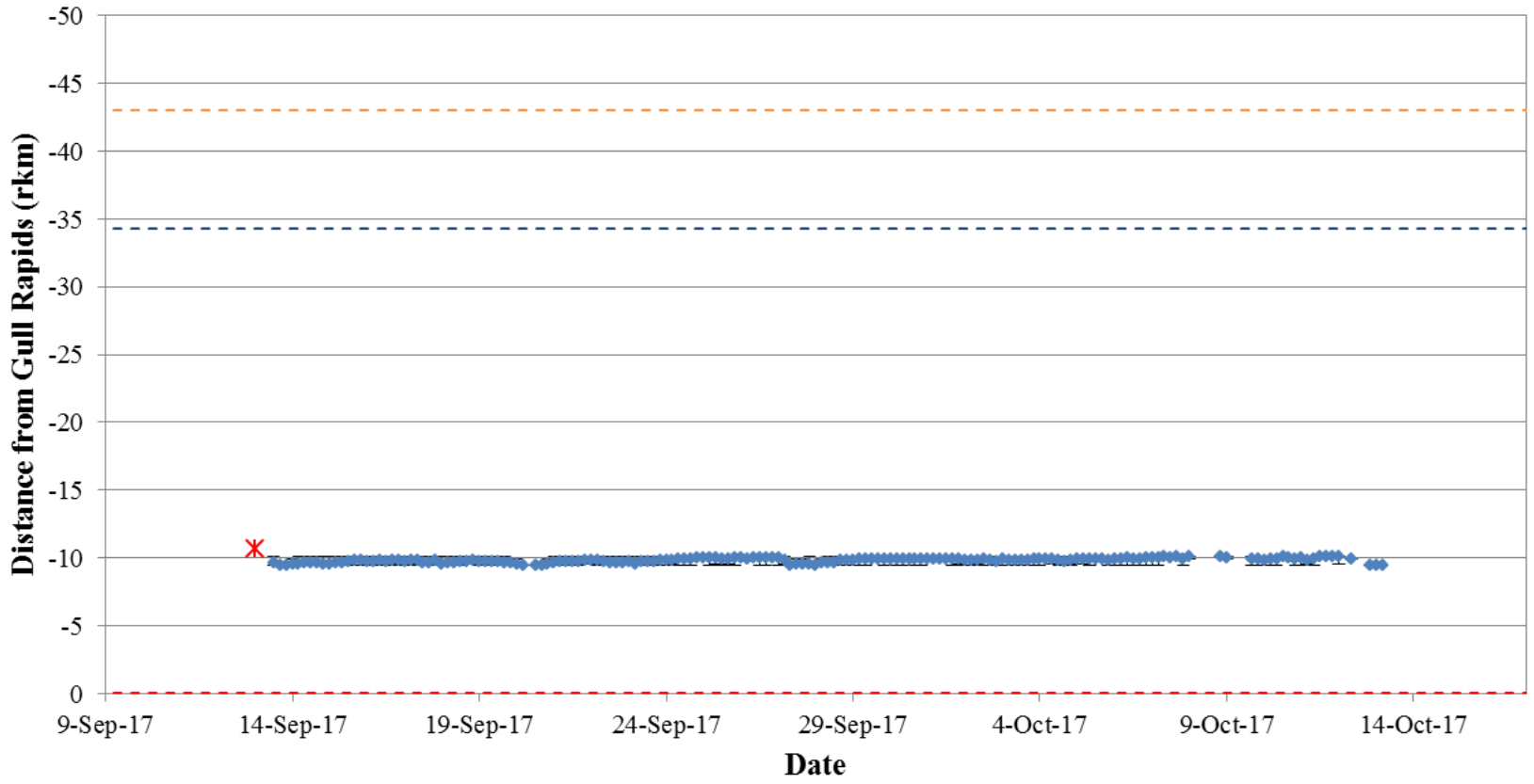


Figure A3-14: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31776) in Gull Lake in relation to Gull Rapids (rkm 0), from 9 September to 16 October, 2017. Date and location of tagging is indicated by red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

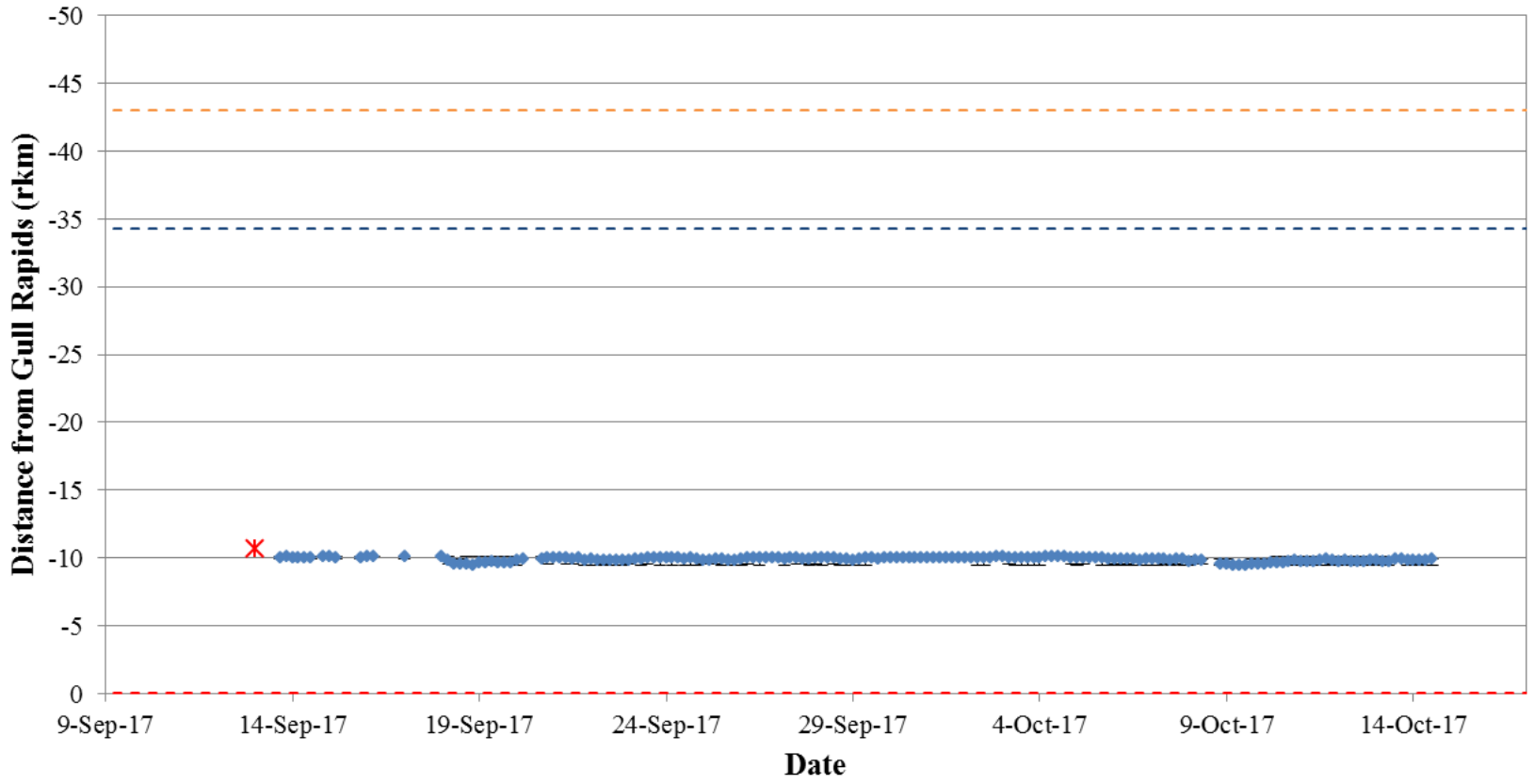


Figure A3-15: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31777) in Gull Lake in relation to Gull Rapids (rkm 0), from 9 September to 16 October, 2017. Date and location of tagging is indicated by red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

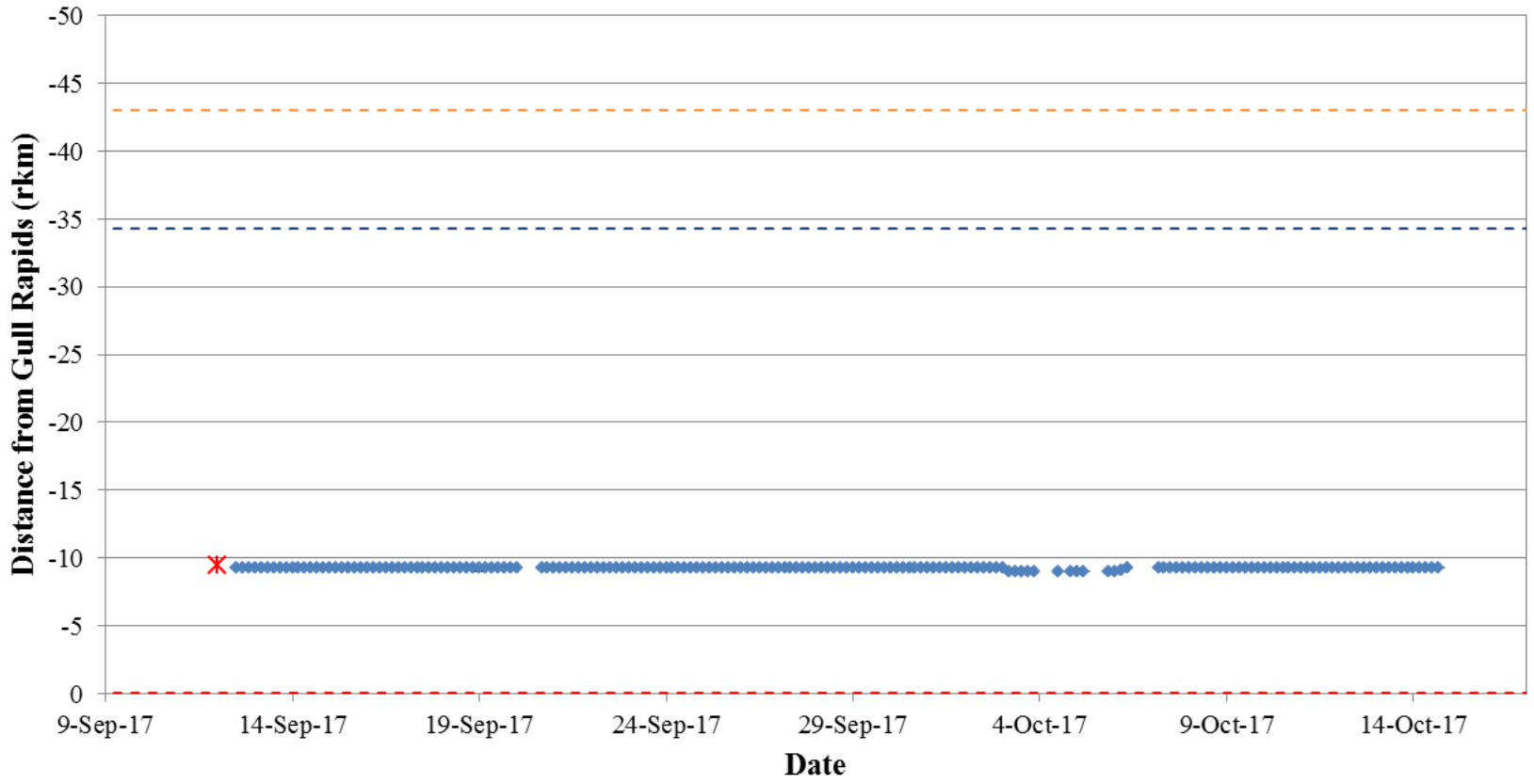


Figure A3-16: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31778) in Gull Lake in relation to Gull Rapids (rkm 0), from 9 September to 16 October, 2017. Date and location of tagging is indicated by red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

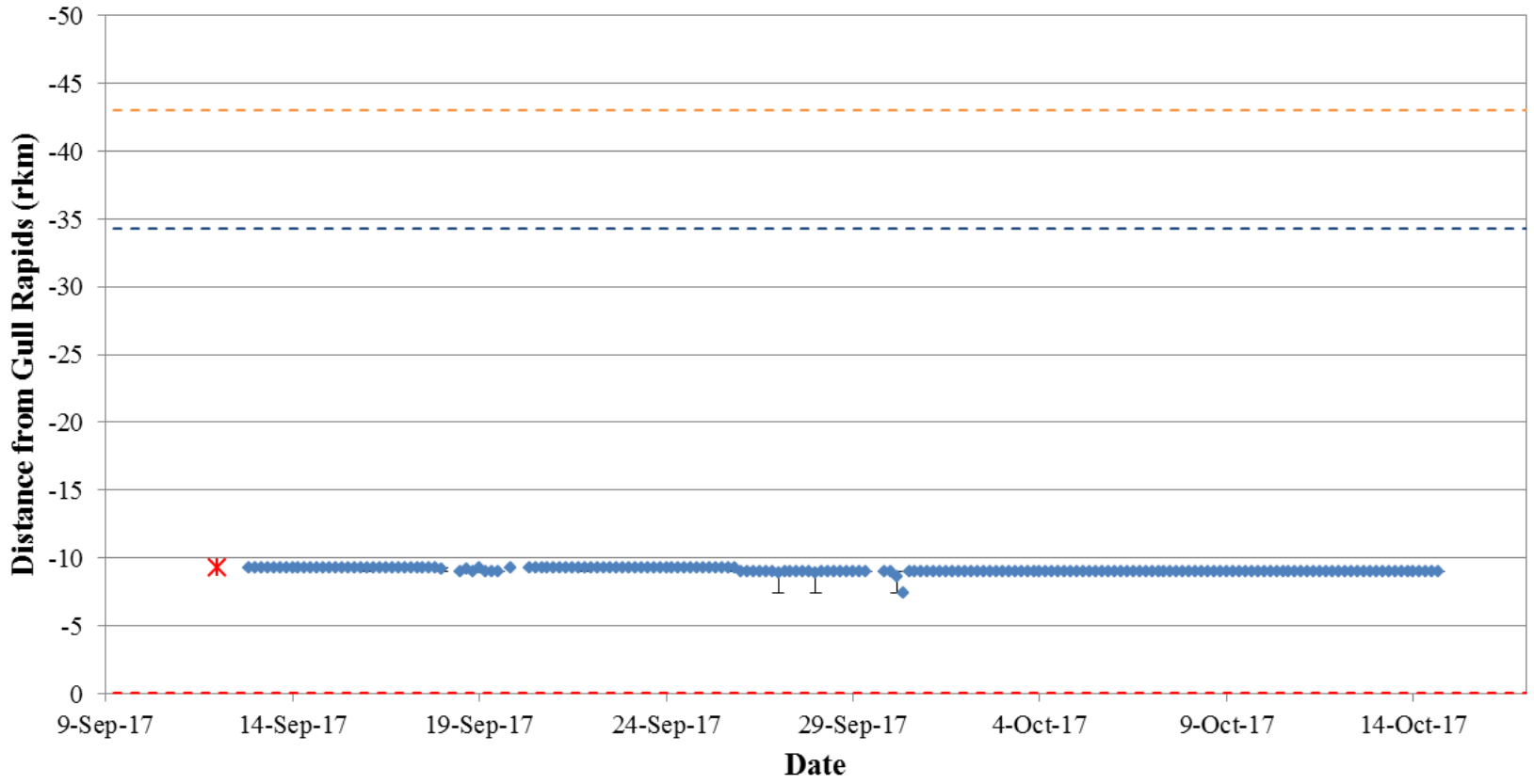


Figure A3-17: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31779) in Gull Lake in relation to Gull Rapids (rkm 0), from 9 September to 16 October, 2017. Date and location of tagging is indicated by red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

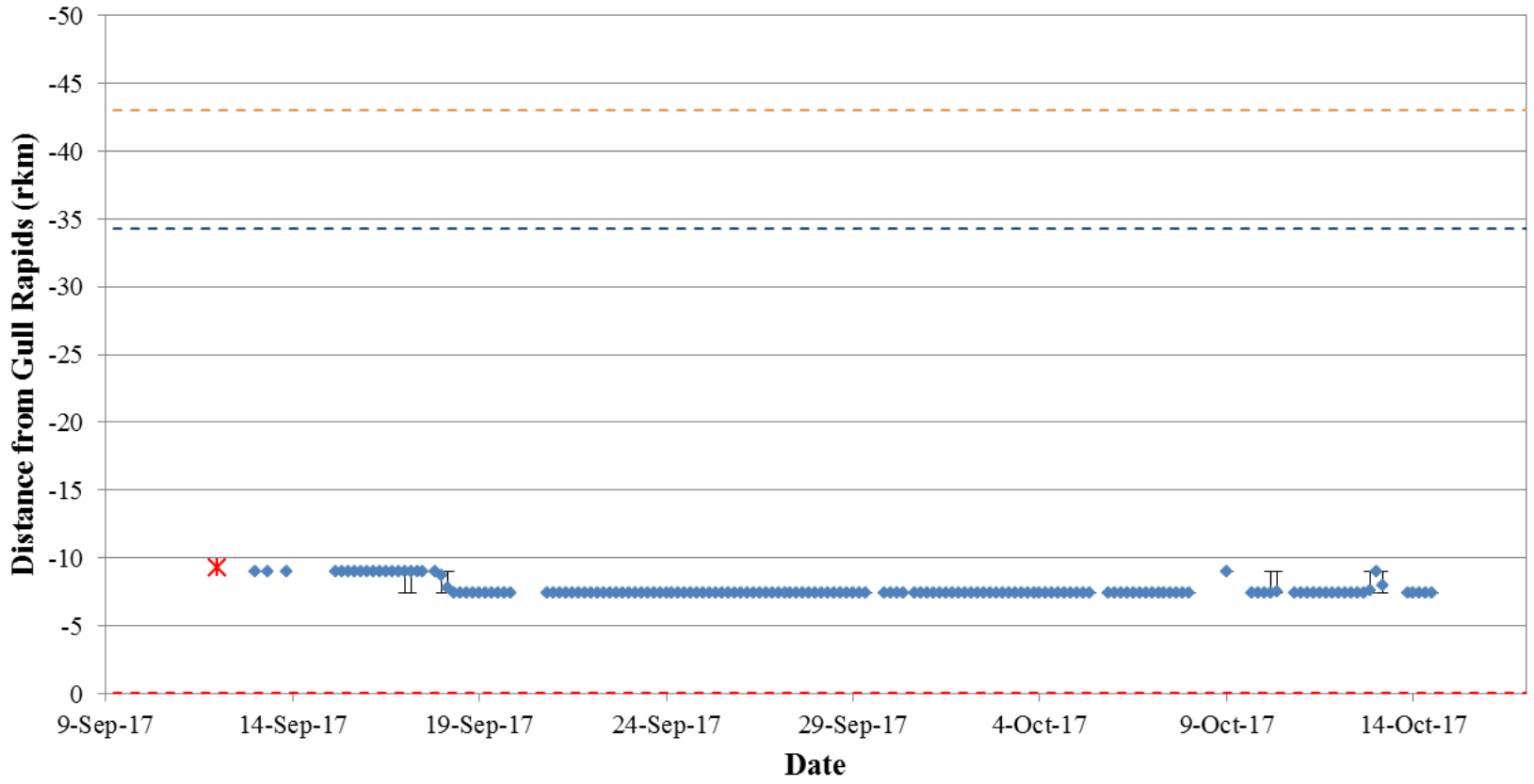


Figure A3-18: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31780) in Gull Lake in relation to Gull Rapids (rkm 0), from 9 September to 16 October, 2017. Date and location of tagging is indicated by red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

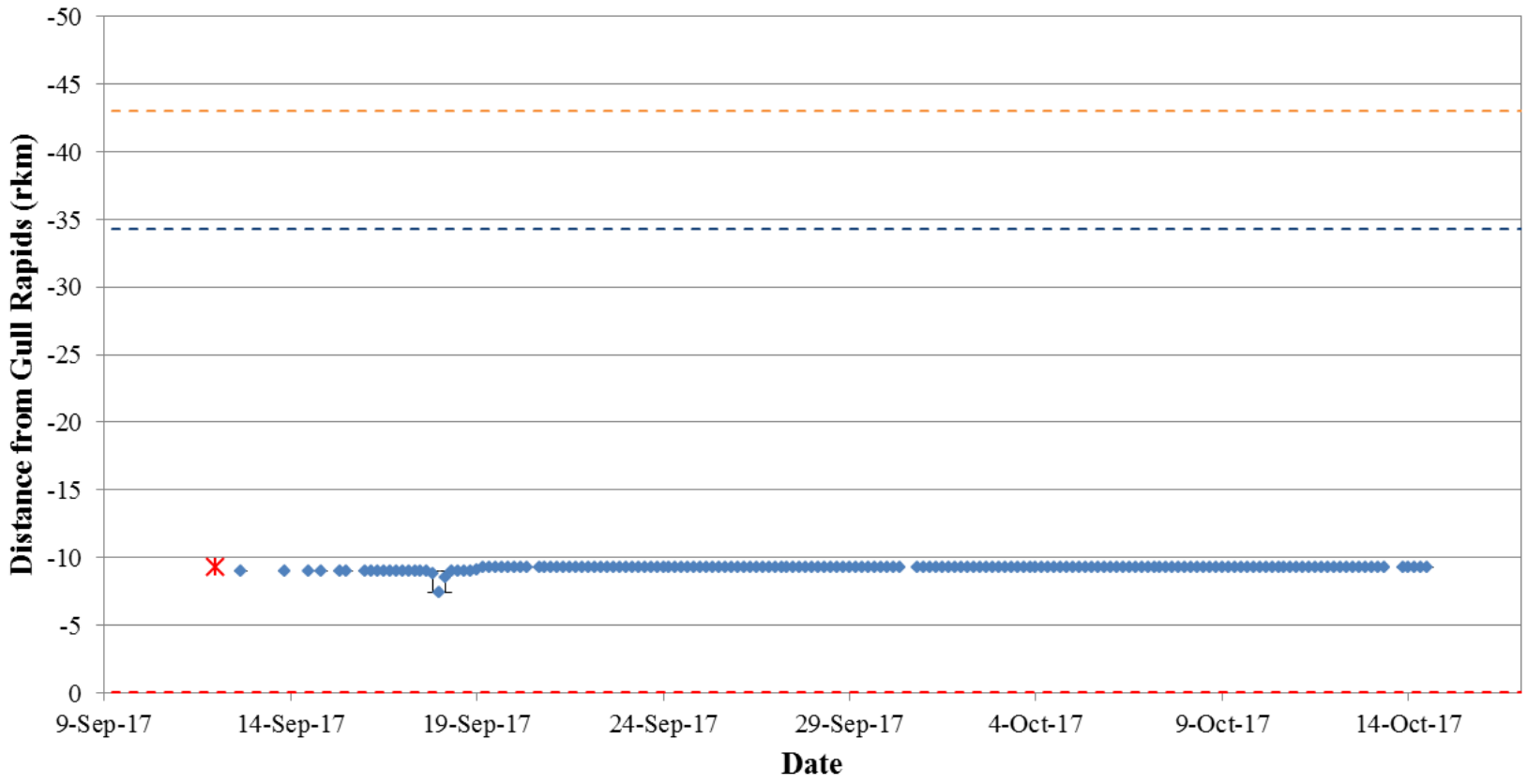


Figure A3-19: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31781) in Gull Lake in relation to Gull Rapids (rkm 0), from 9 September to 16 October, 2017. Date and location of tagging is indicated by red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

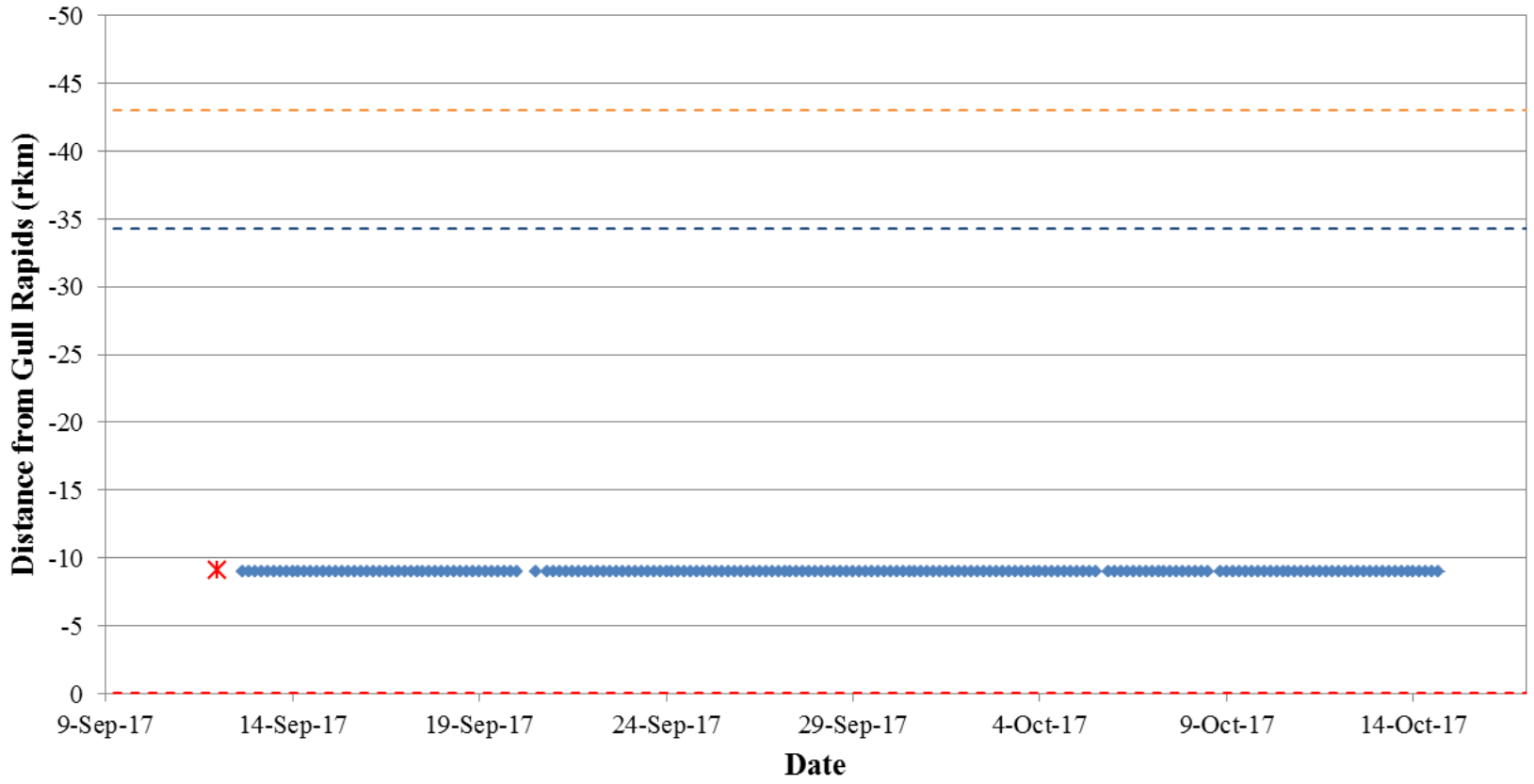


Figure A3-20: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31782) in Gull Lake in relation to Gull Rapids (rkm 0), from 9 September to 16 October, 2017. Date and location of tagging is indicated by red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Gull Rapids (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).

APPENDIX 4:
LOCATION SUMMARY FOR INDIVIDUAL ACOUSTIC TAGGED JUVENILE LAKE STURGEON DOWNSTREAM OF GULL RAPIDS, SEPTEMBER TO OCTOBER 2017

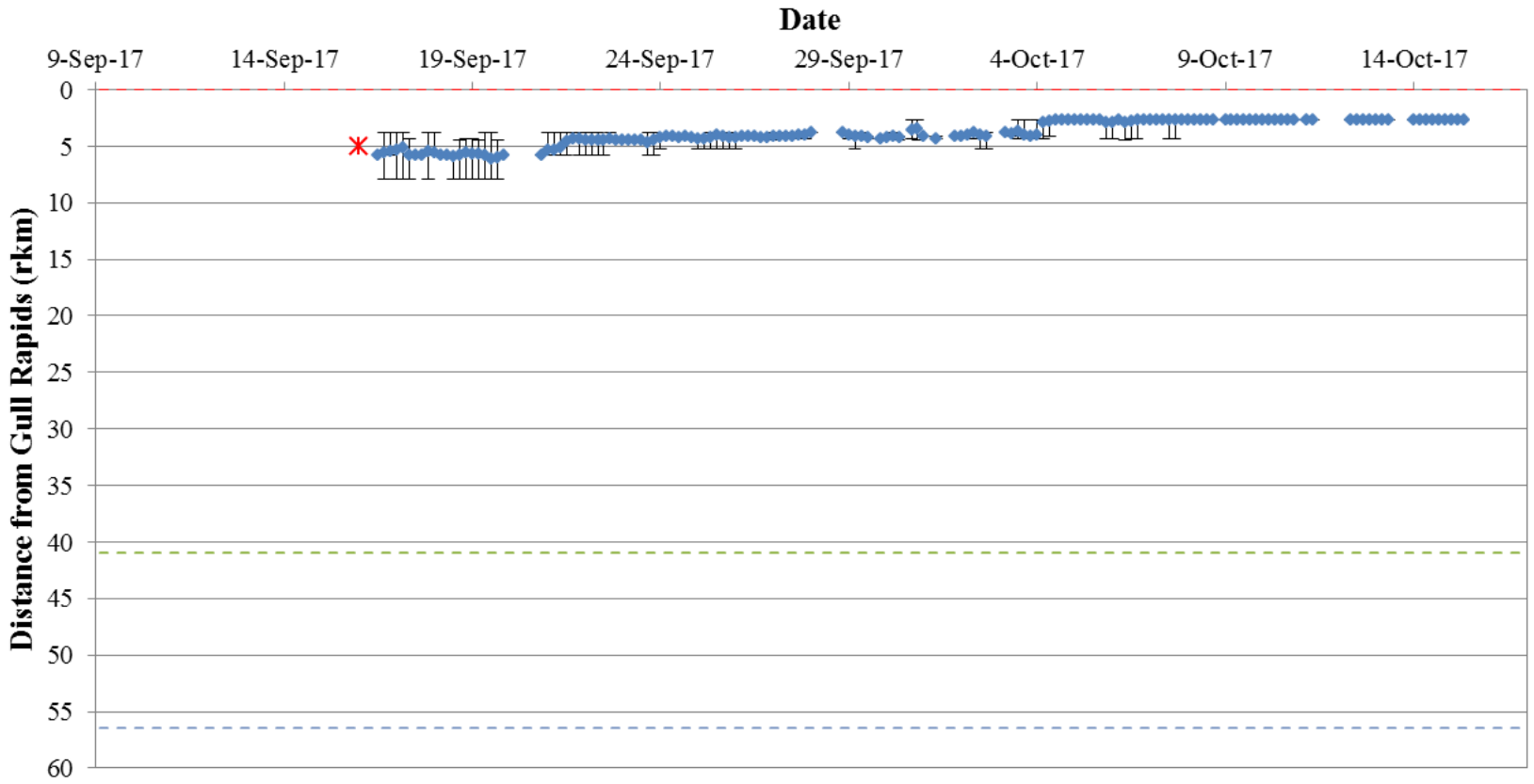


Figure A4-1: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31668) in Stephens Lake in relation to Gull Rapids (rkm 0), 9 September to 16 October, 2017. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (blue).

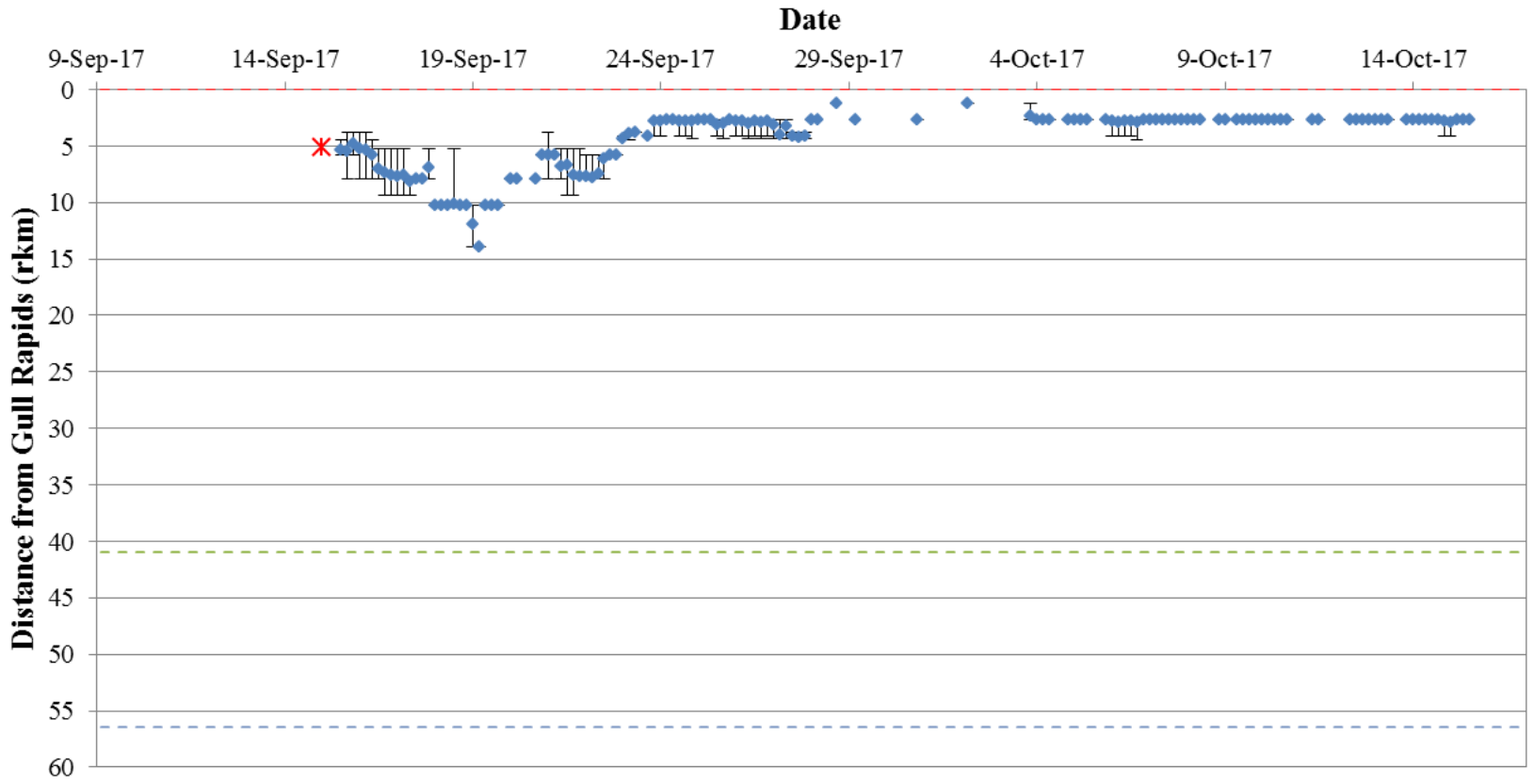


Figure A4-2: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31689) in Stephens Lake in relation to Gull Rapids (rkm 0), from 9 September to 16 October, 2017. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple).

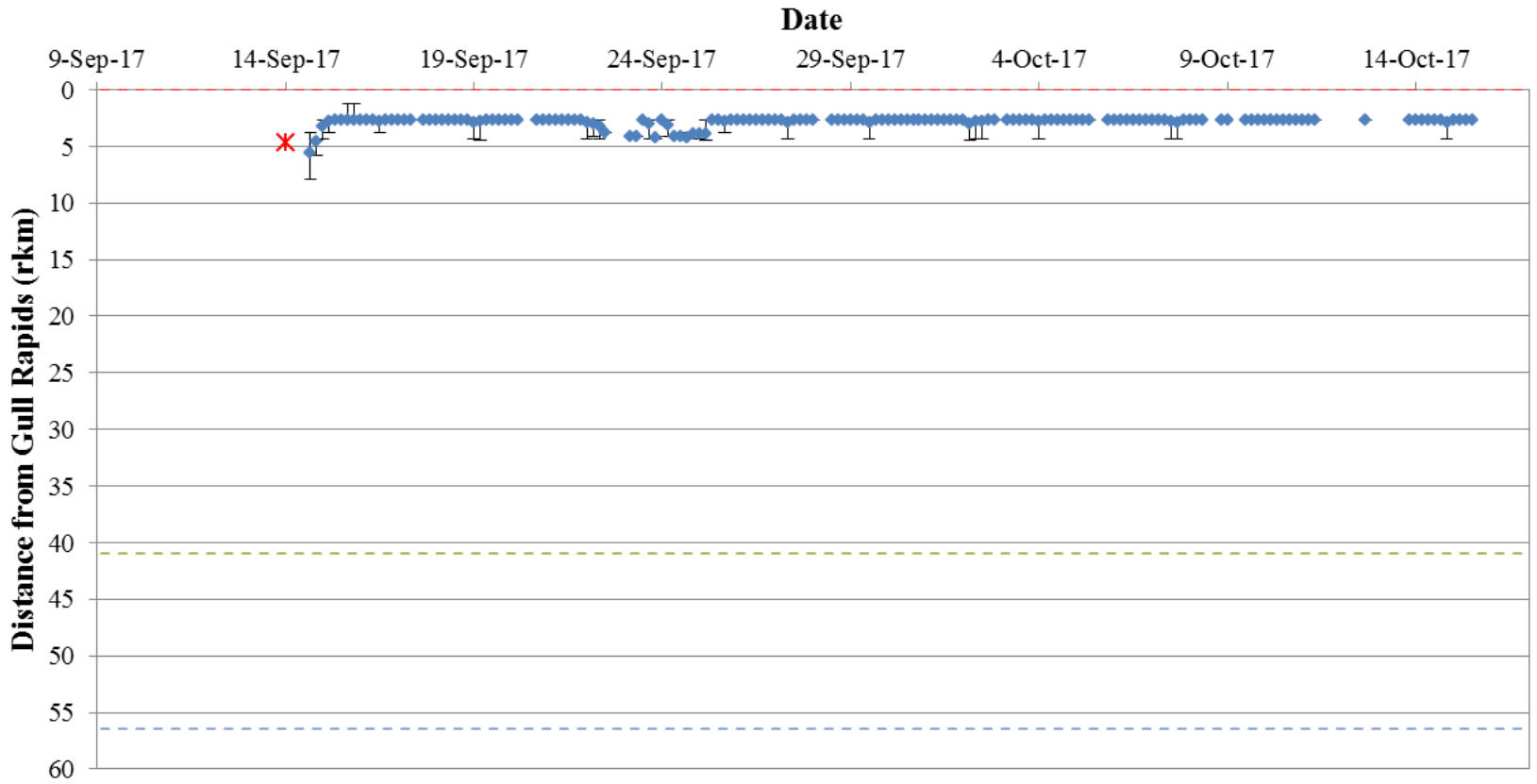


Figure A4-3: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31690) in Stephens Lake in relation to Gull Rapids (rkm 0), from 9 September to 16 October, 2017. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple).

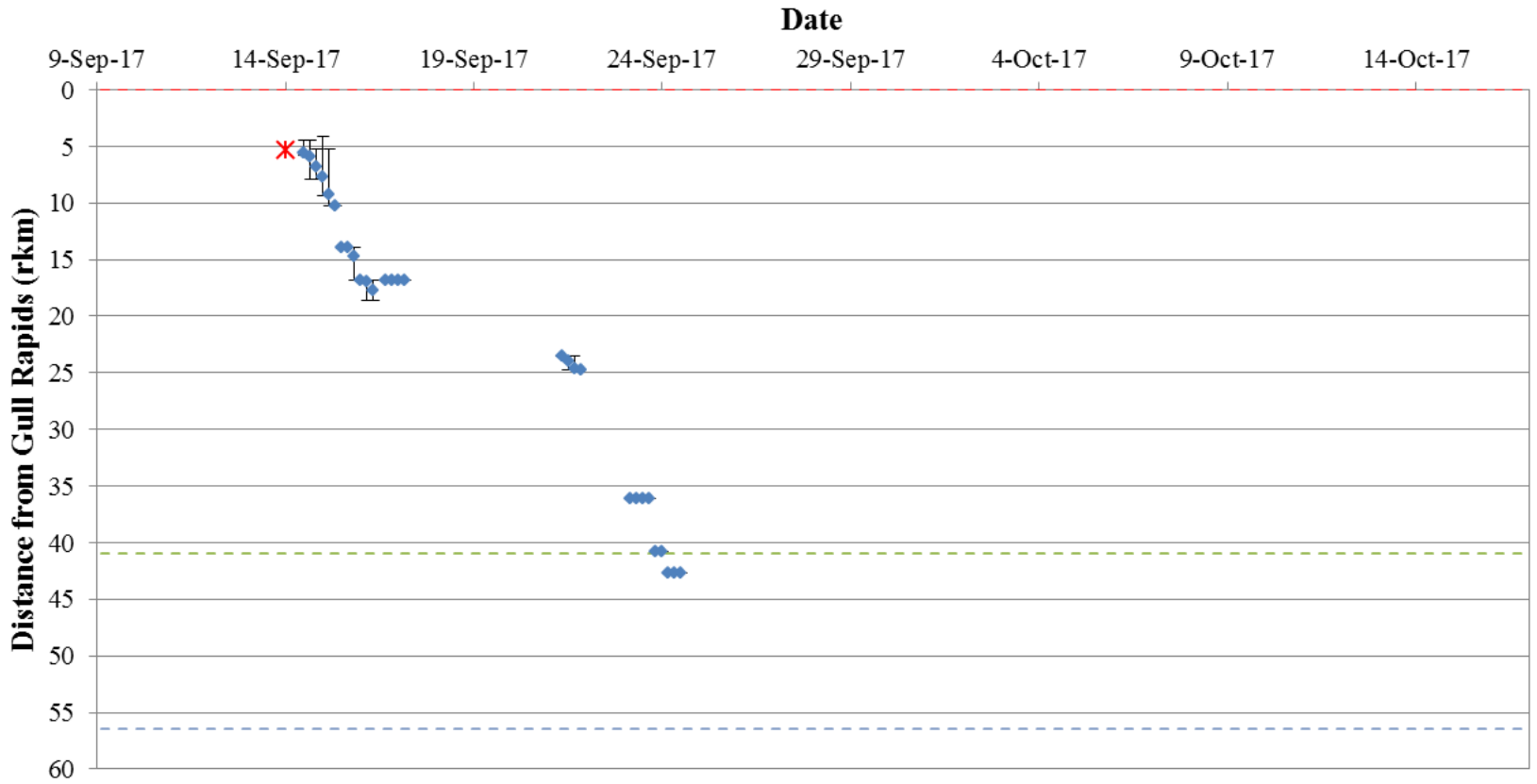


Figure A4-4: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31691) in Stephens Lake in relation to Gull Rapids (rkm 0), from 9 September to 16 October, 2017. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple).

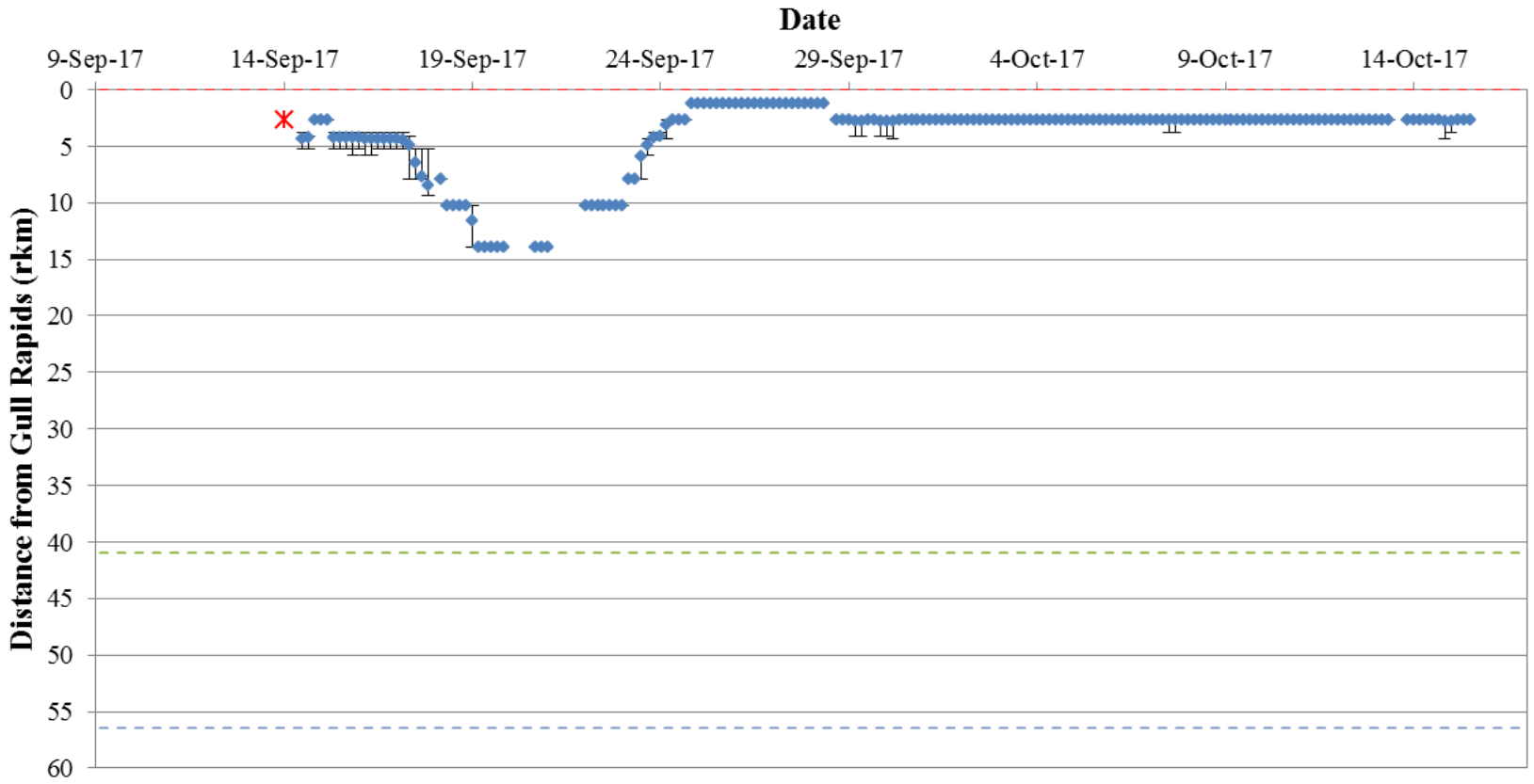


Figure A4-5: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31692) in Stephens Lake in relation to Gull Rapids (rkm 0), from 9 September to 16 October, 2017. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple).

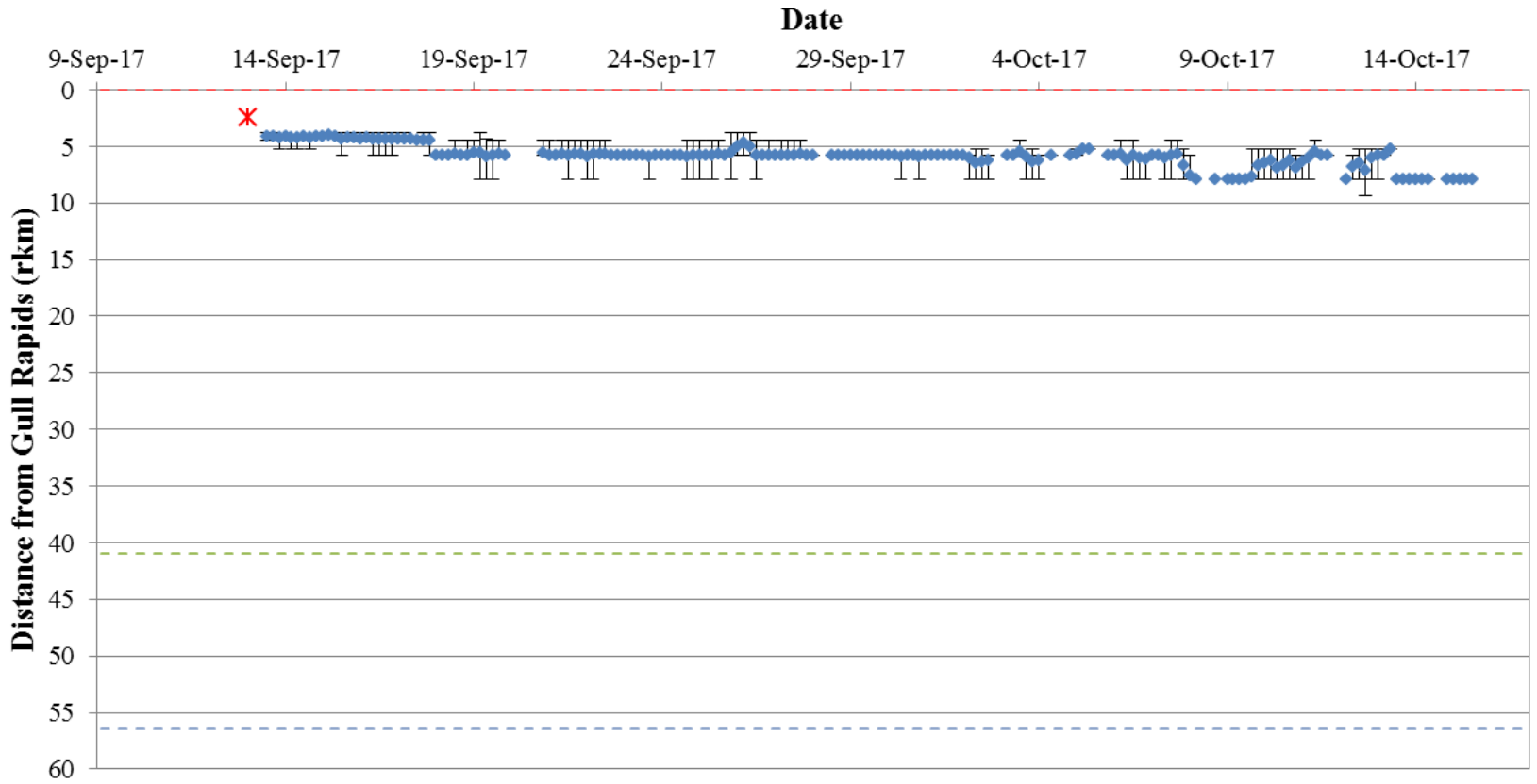


Figure A4-6: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31693) in Stephens Lake in relation to Gull Rapids (rkm 0), from 9 September to 16 October, 2017. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple).

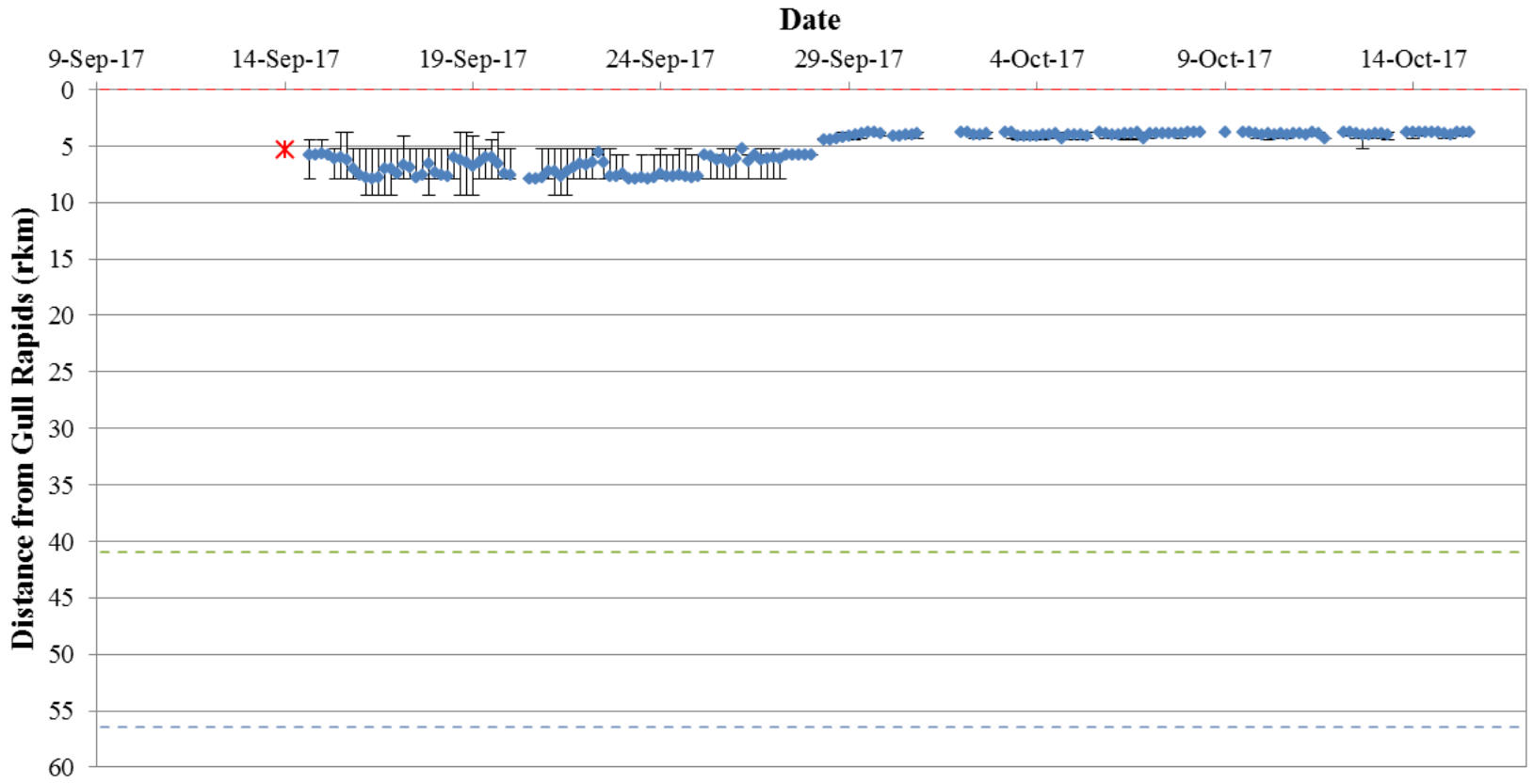


Figure A4-7: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31694) in Stephens Lake in relation to Gull Rapids (rkm 0), from 9 September to 16 October, 2017. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple).

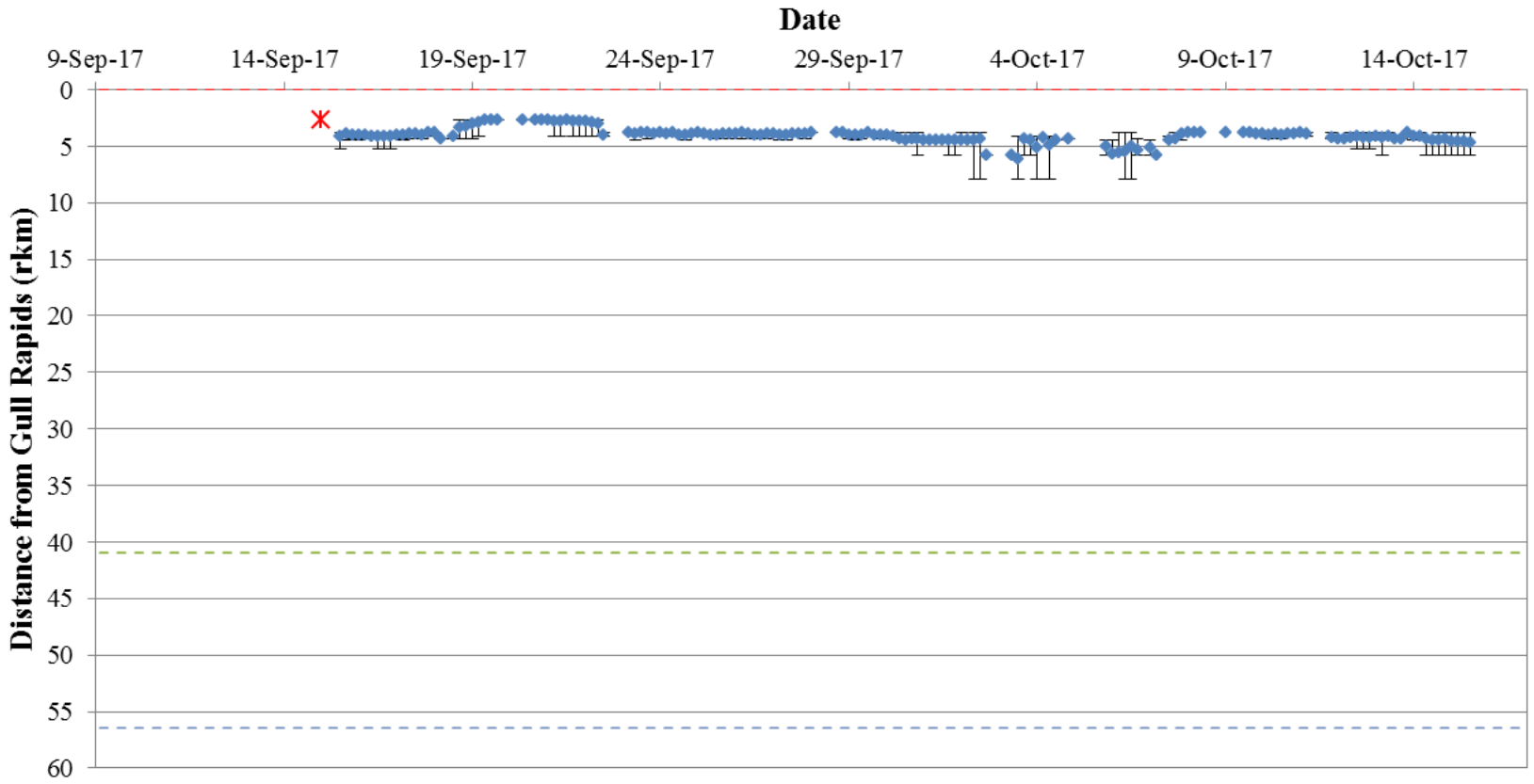


Figure A4-8: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31695) in Stephens Lake in relation to Gull Rapids (rkm 0), from 9 September to 16 October, 2017. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple).

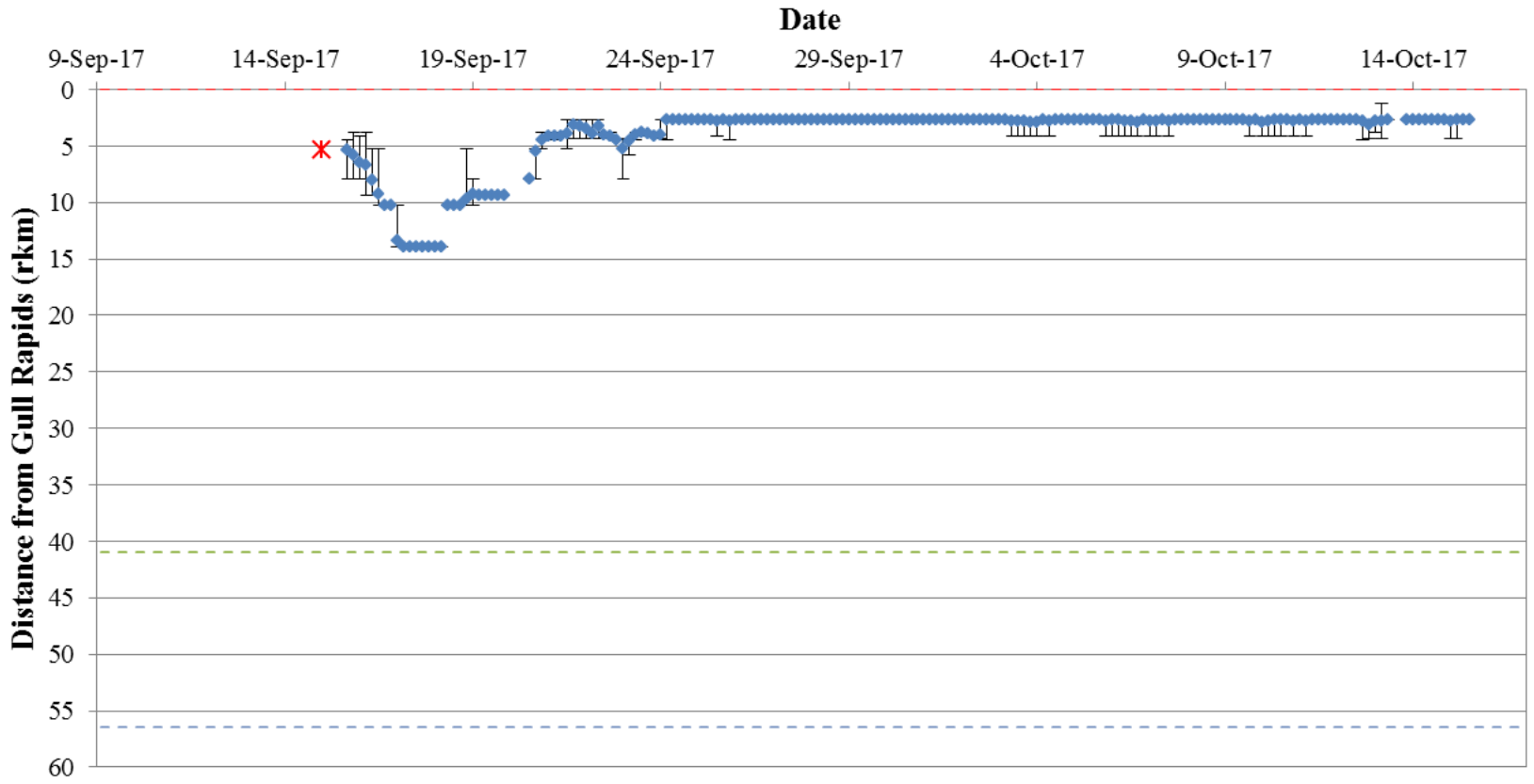


Figure A4-9: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31696) in Stephens Lake in relation to Gull Rapids (rkm 0), from 9 September to 16 October, 2017. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple).

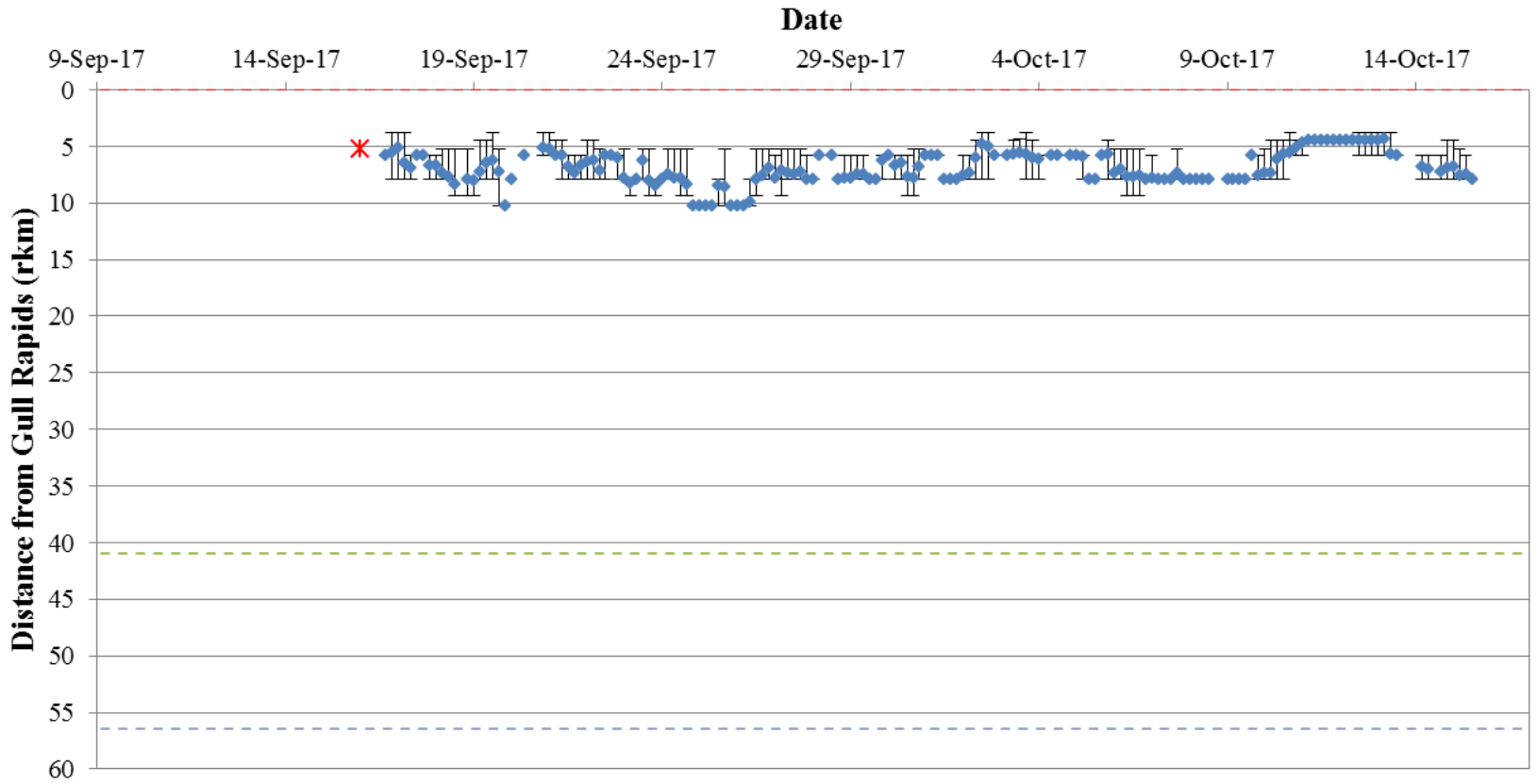


Figure A4-10: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31697) in Stephens Lake in relation to Gull Rapids (rkm 0), from 9 September to 16 October, 2017. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple).

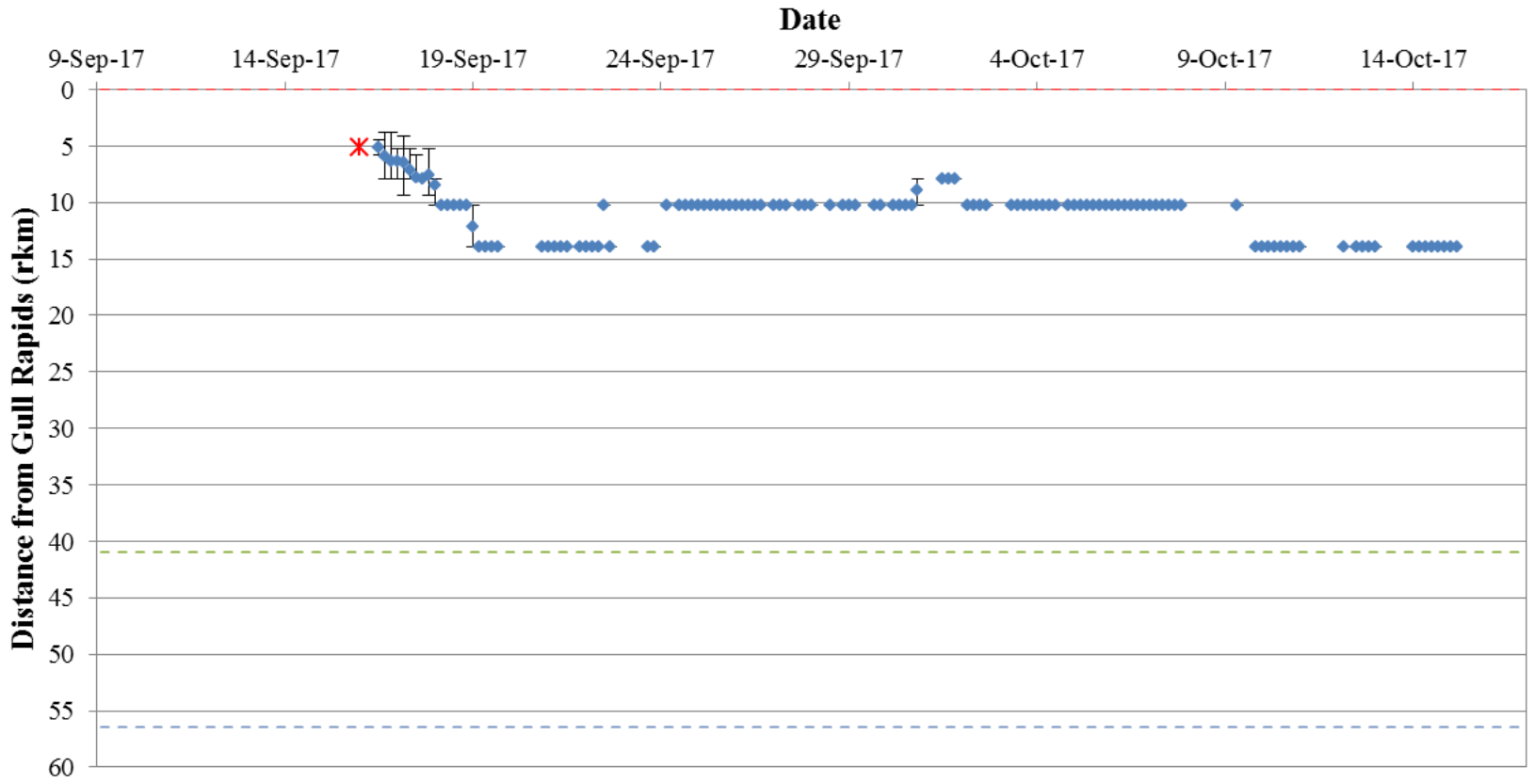


Figure A4-11: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31758) in Stephens Lake in relation to Gull Rapids (rkm 0), from 9 September to 16 October, 2016. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple).

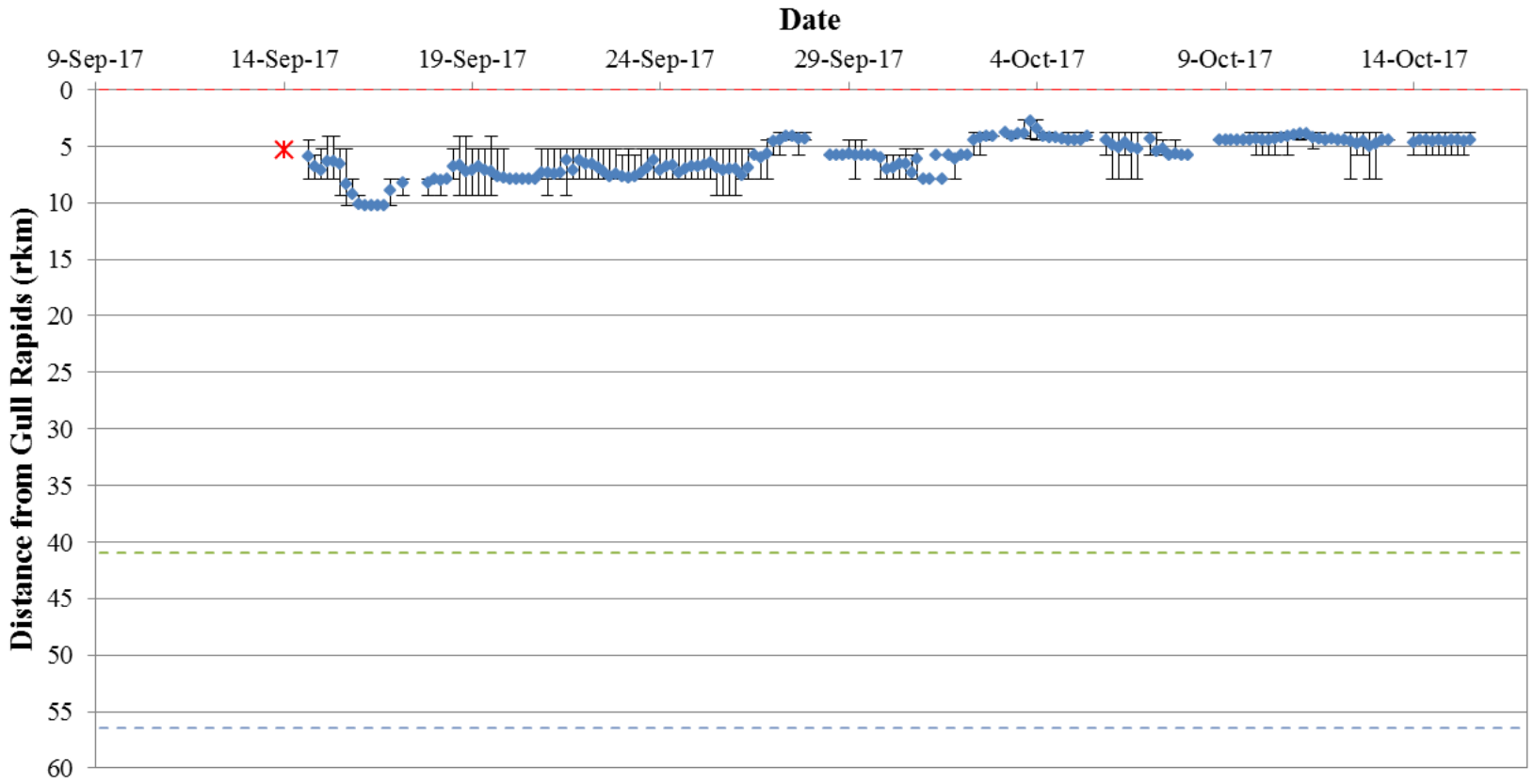


Figure A4-12: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31759) in Stephens Lake in relation to Gull Rapids (rkm 0), from 9 September to 16 October, 2017. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple).

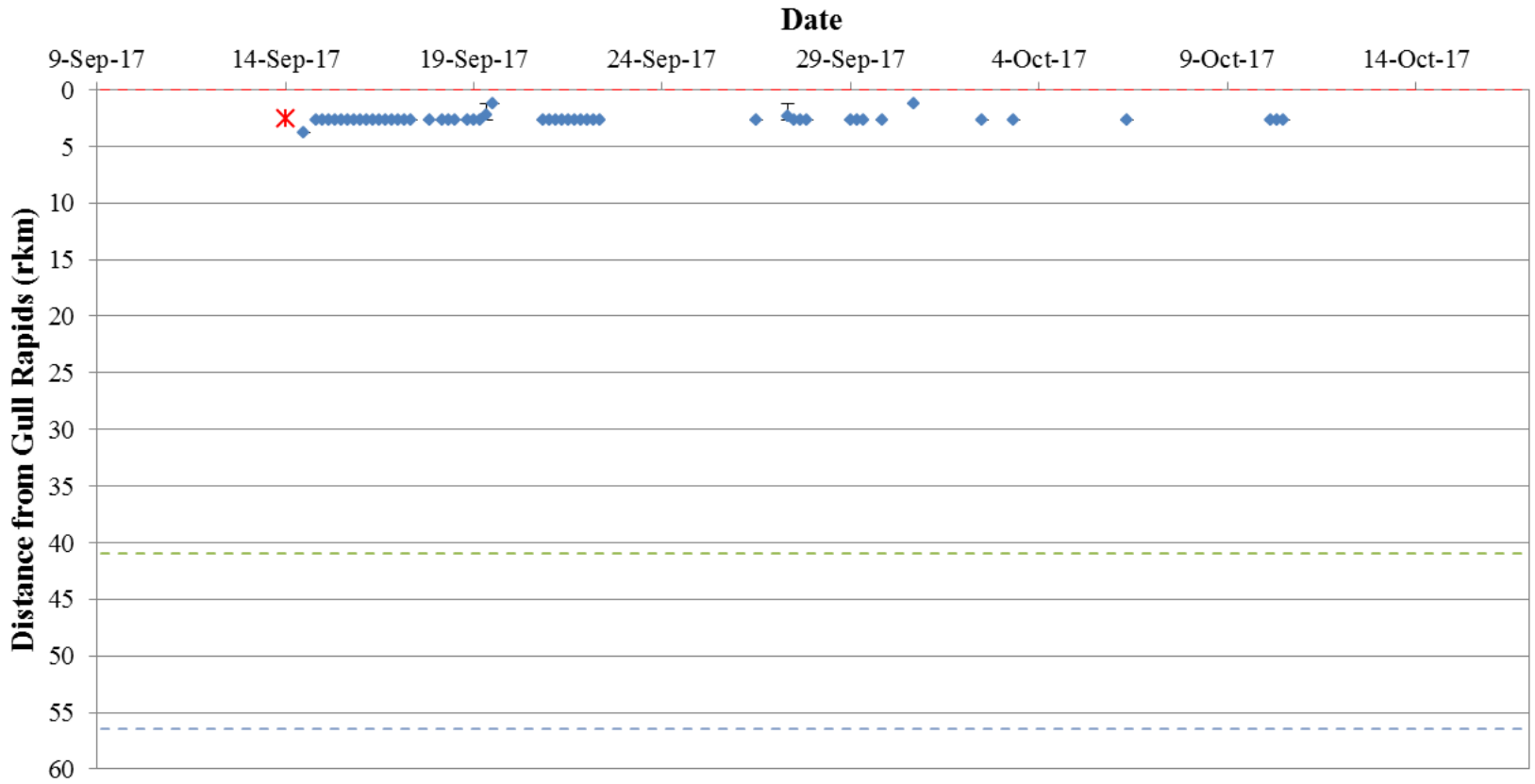


Figure A4-13: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31760) in Stephens Lake in relation to Gull Rapids (rkm 0), from 9 September to 16 October, 2017. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple).

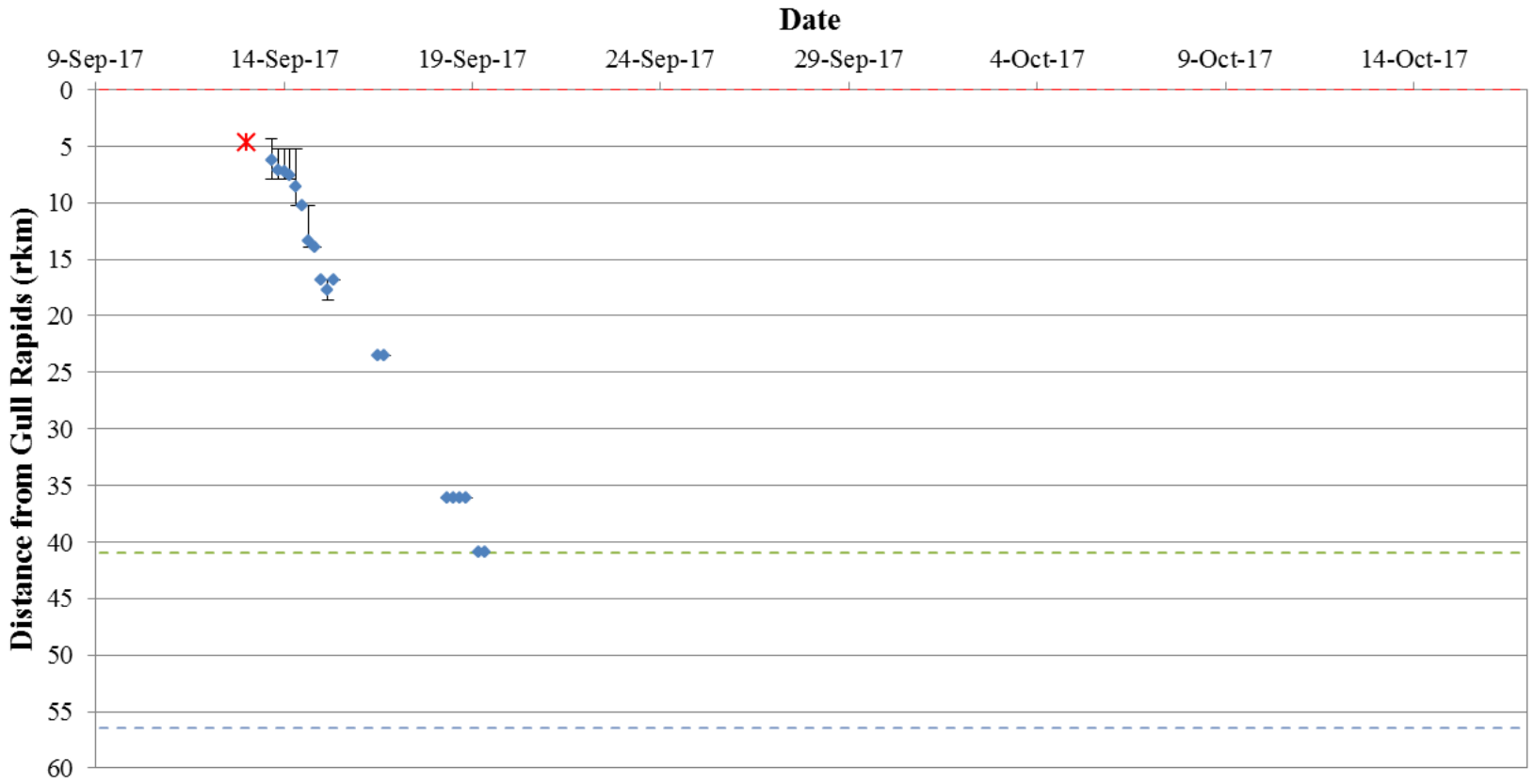


Figure A4-14: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31761) in Stephens Lake in relation to Gull Rapids (rkm 0), from 13 September to 16 October, 2017. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple).

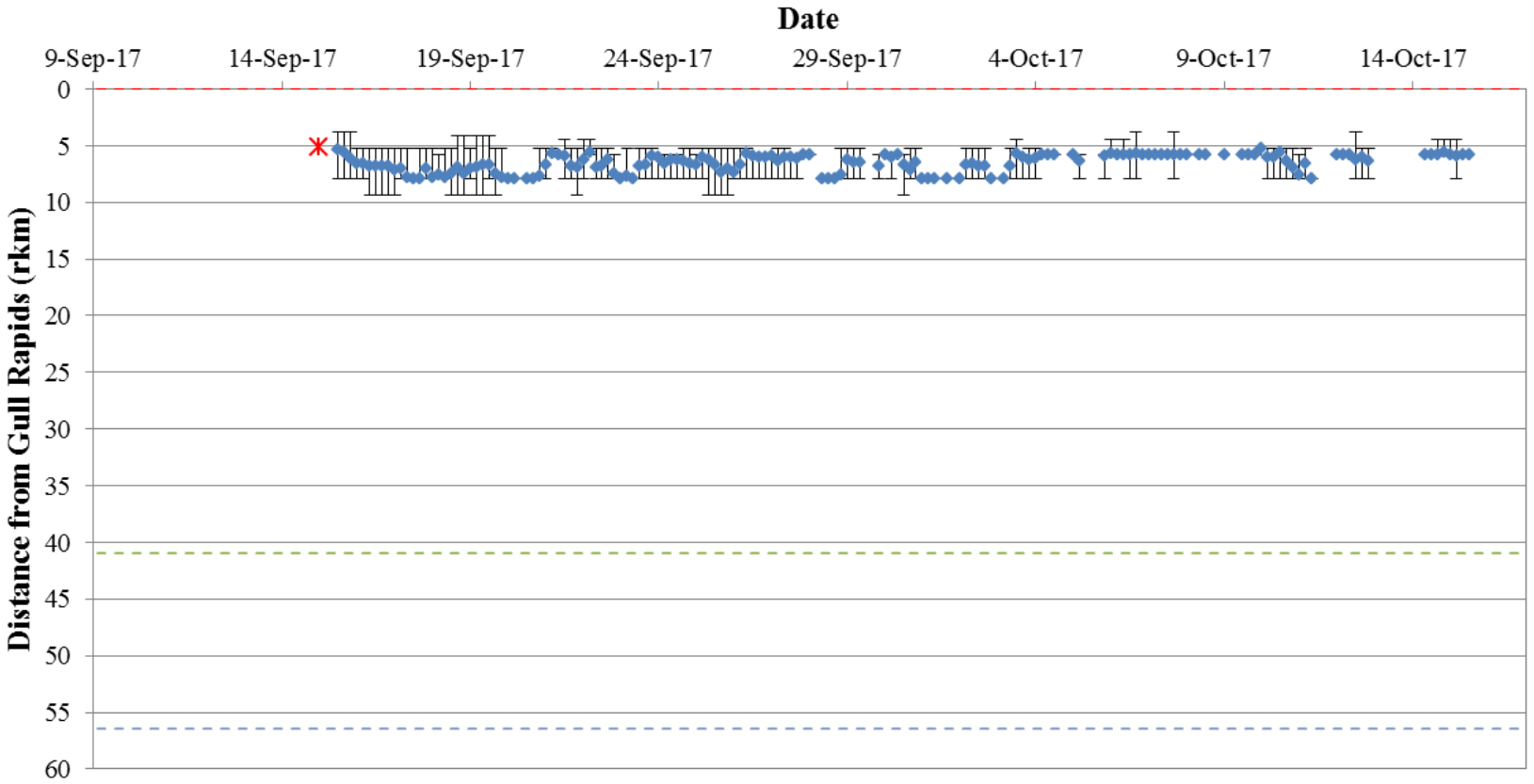


Figure A4-15: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31762) in Stephens Lake in relation to Gull Rapids (rkm 0), from 9 September to 16 October, 2017. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple).

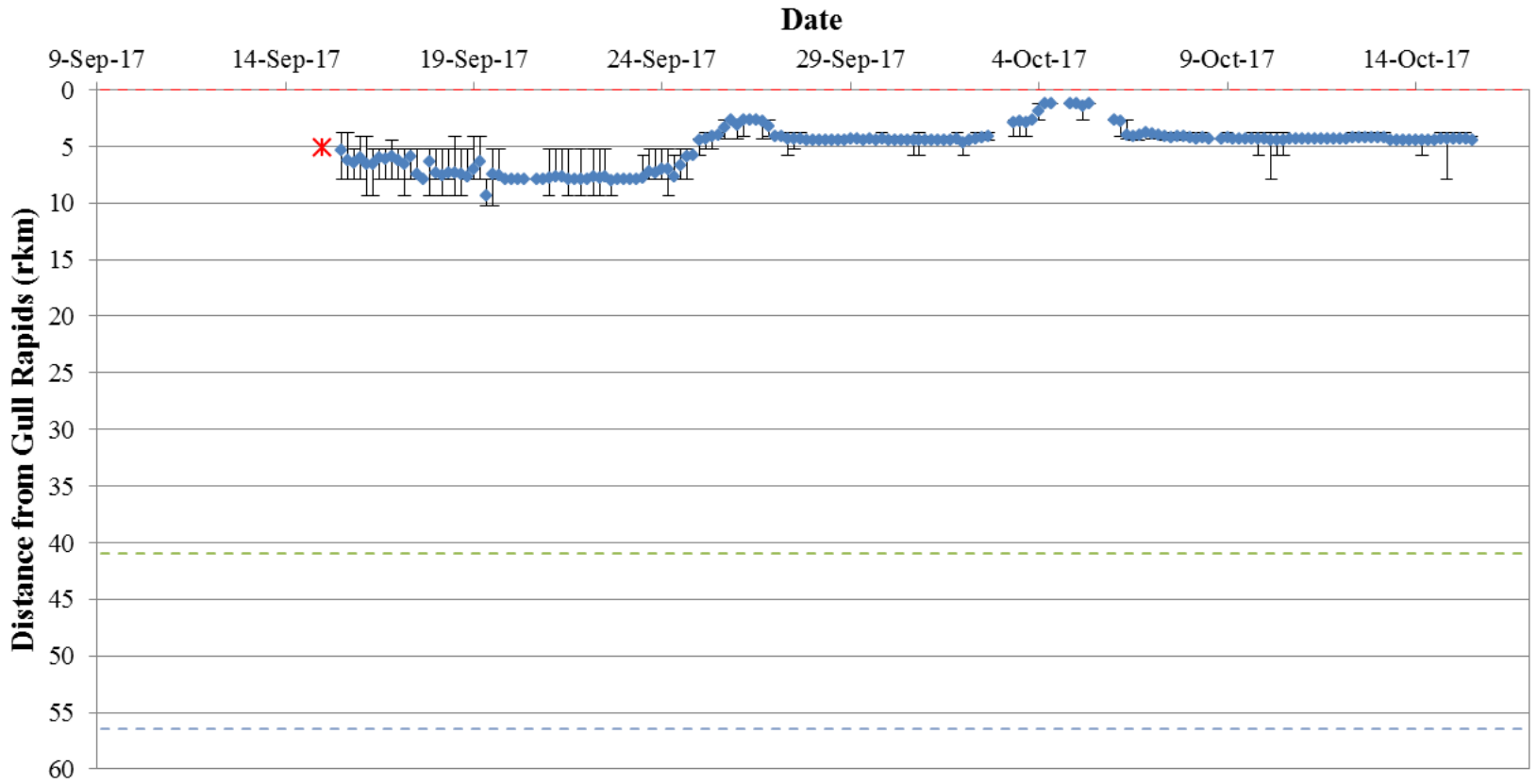


Figure A4-16: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31763) in Stephens Lake in relation to Gull Rapids (rkm 0), from 9 September to 16 October, 2017. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple).

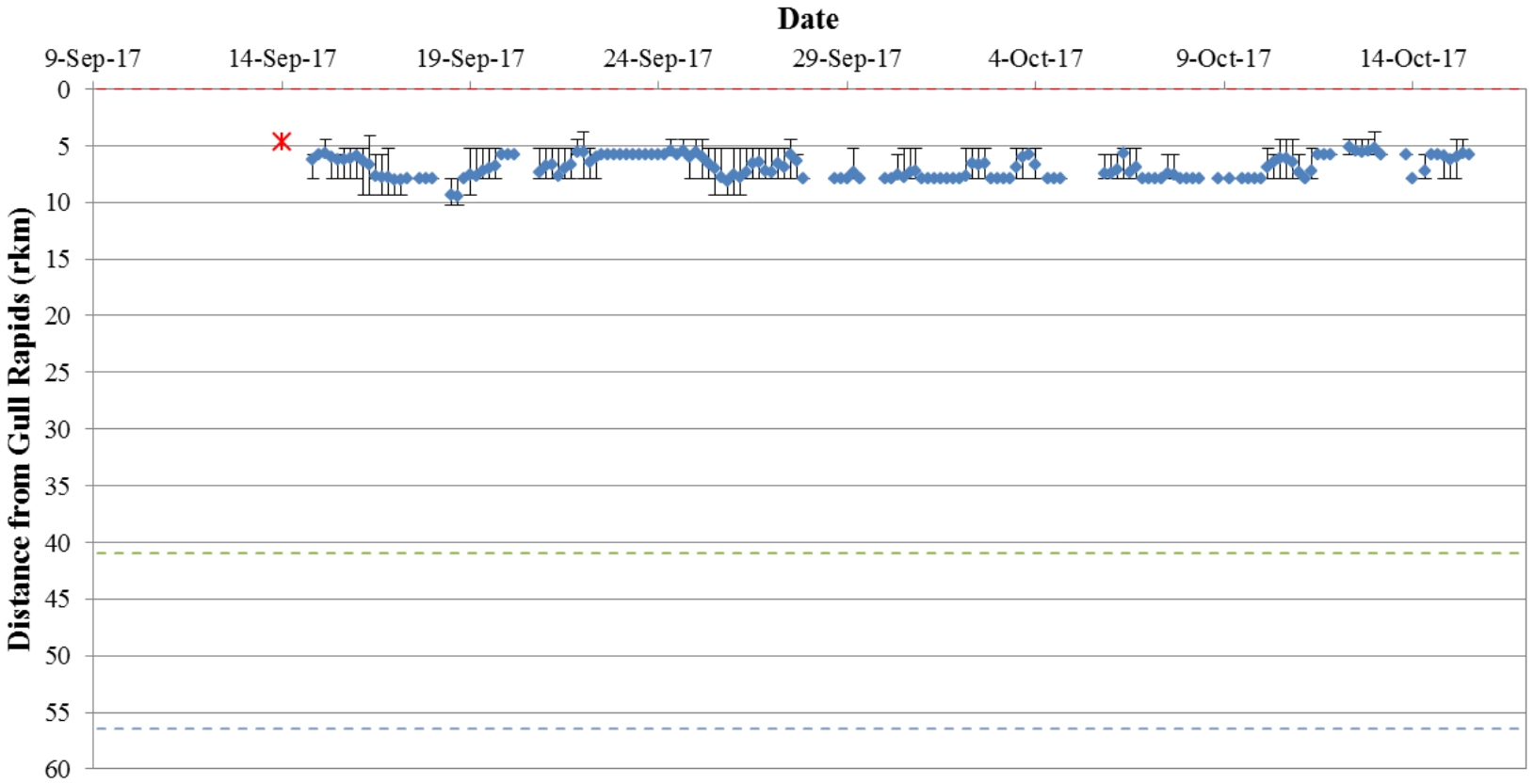


Figure A4-17: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31764) in Stephens Lake in relation to Gull Rapids (rkm 0), from 9 September to 16 October, 2017. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple).

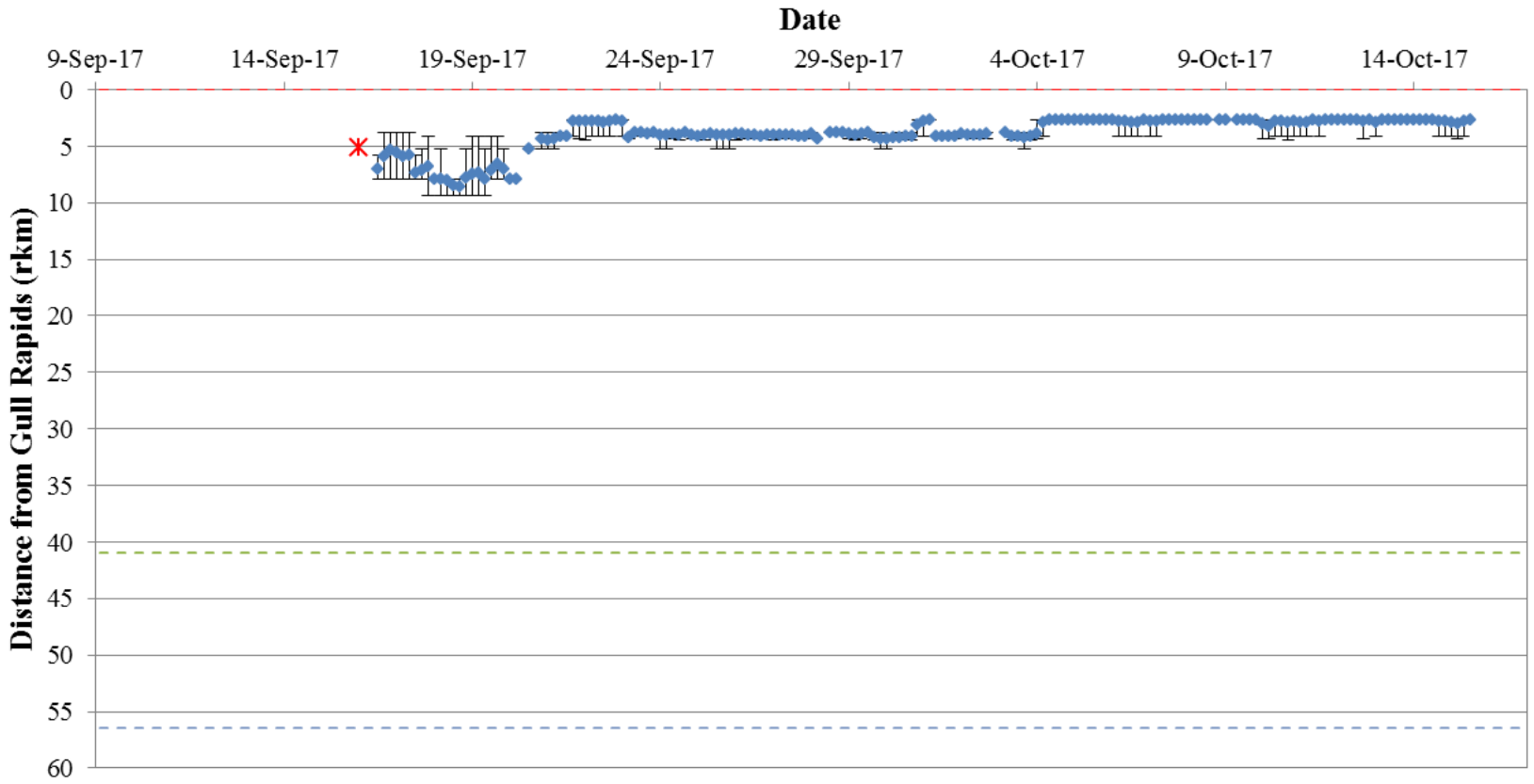


Figure A4-18: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31765) in Stephens Lake in relation to Gull Rapids (rkm 0), from 9 September to 16 October, 2017. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple).

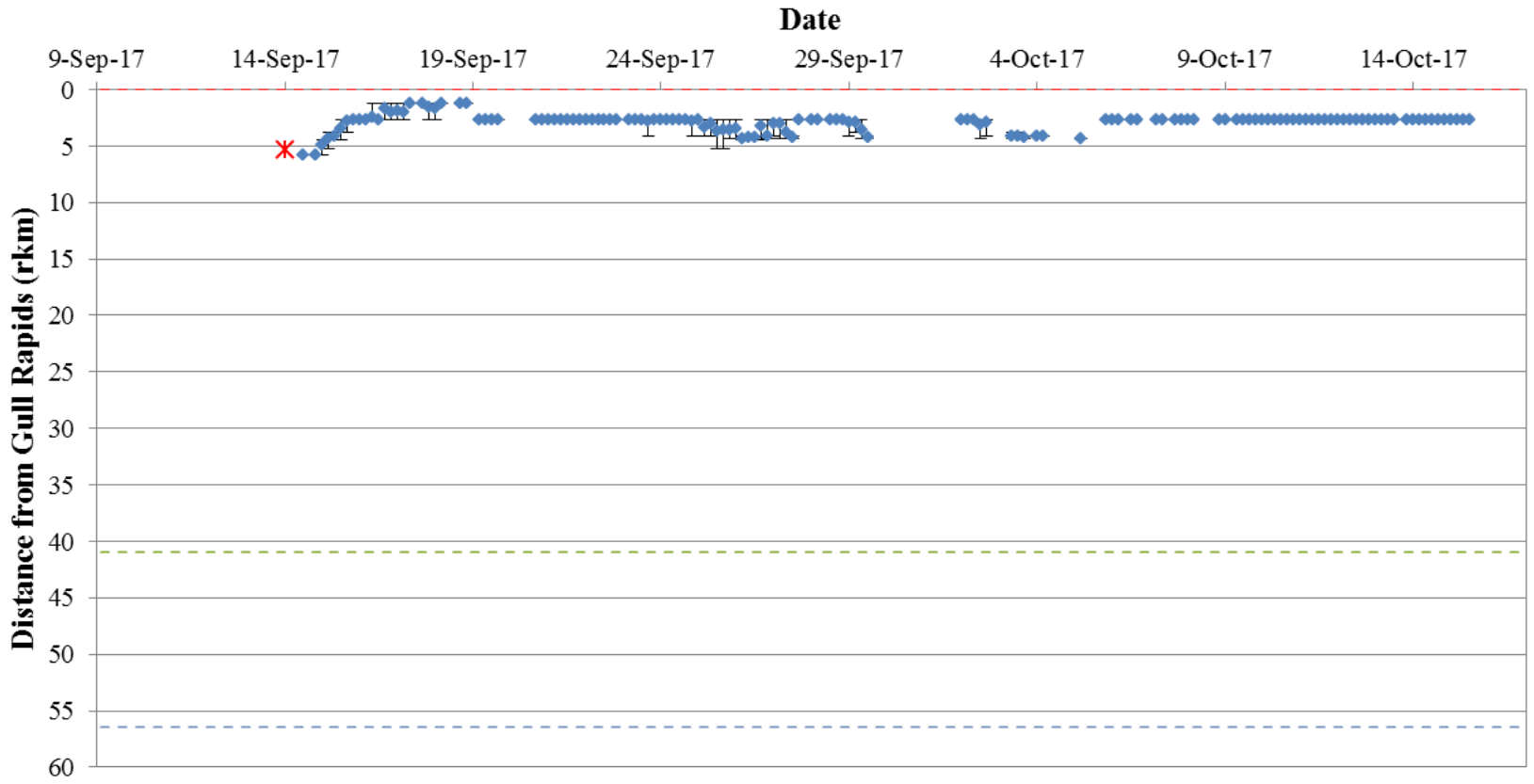


Figure A4-19 Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31766) in Stephens Lake in relation to Gull Rapids (rkm 0), from 9 September to 16 October, 2017. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple).

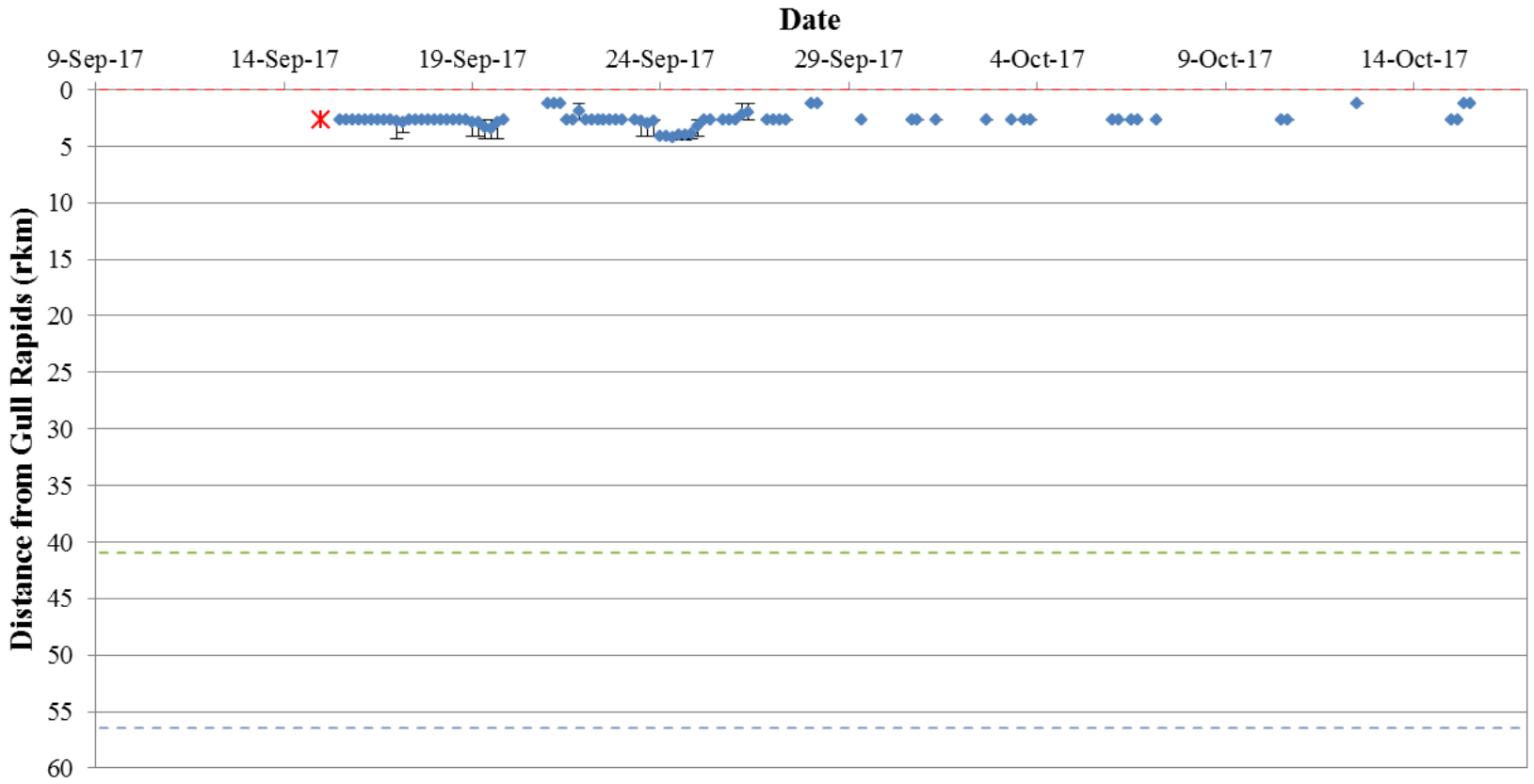


Figure A4-20: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31767) in Stephens Lake in relation to Gull Rapids (rkm 0), from 9 September to 16 October, 2017.Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Gull Rapids (red), Kettle GS (green), and Long Spruce GS (purple).