



Keeyask Generation Project Aquatic Effects Monitoring Plan

Adult Lake Sturgeon Movement Monitoring Report AEMP-2019-01



KEEYASK GENERATION PROJECT

AQUATIC EFFECTS MONITORING PLAN

REPORT #AEMP-2019-01

ADULT LAKE STURGEON MOVEMENT MONITORING IN THE NELSON RIVER BETWEEN CLARK LAKE AND THE LIMESTONE GENERATING STATION, OCTOBER 2017 TO OCTOBER 2018: YEAR 5 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 instream structures map below). 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. This opening was closed in spring 2018, and the area was dewatered. The spillway was commissioned in August 2018. The South Dam Cofferdam was completed in fall 2018, blocking the channel and forcing the entire flow of the river through the spillway.

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 (less than 800 millimetres [mm] in length);
- 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 movements of Lake Sturgeon over Birthday and Gull rapids were monitored prior to 2011, but because different methods were used from 2011 and onward, the results of the two monitoring periods are not directly comparable. While pre-2011 studies did not record detailed fish movement patterns between Clark Lake and Stephens Lake, the data indicated that the majority of Lake Sturgeon continued to live in the area where they had been tagged and did not swim across rapids into different parts of the river. When fish occasionally crossed either Birthday or Gull rapids, they did so in the summer or fall, which suggests that these movements were not a necessary part of spring egg-laying behaviour. No fish moved downstream over the Kettle GS.

This report provides the results of adult sturgeon movement monitoring conducted from October 2017 to October 2018. This monitoring was initiated in June 2011 when 59 adult Lake Sturgeon were tagged with acoustic transmitters with a 10-year battery life. Therefore, movements of these fish were monitored for approximately three years before any changes to the river occurred, and four years and three months since the start of construction.



Adult Lake Sturgeon.

Why is the study being done?

Monitoring during construction is being done to answer three questions:

Is construction affecting the area that adult 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 adult 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 adult 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 sturgeon are moving up or down through Gull Rapids, how far they travel up or downstream away from the site, whether they are leaving the Keeyask area completely and when they are making these movements. The distance they travel is monitored as far upstream as the inlet to Clark Lake and downstream as far as the Limestone Reservoir.

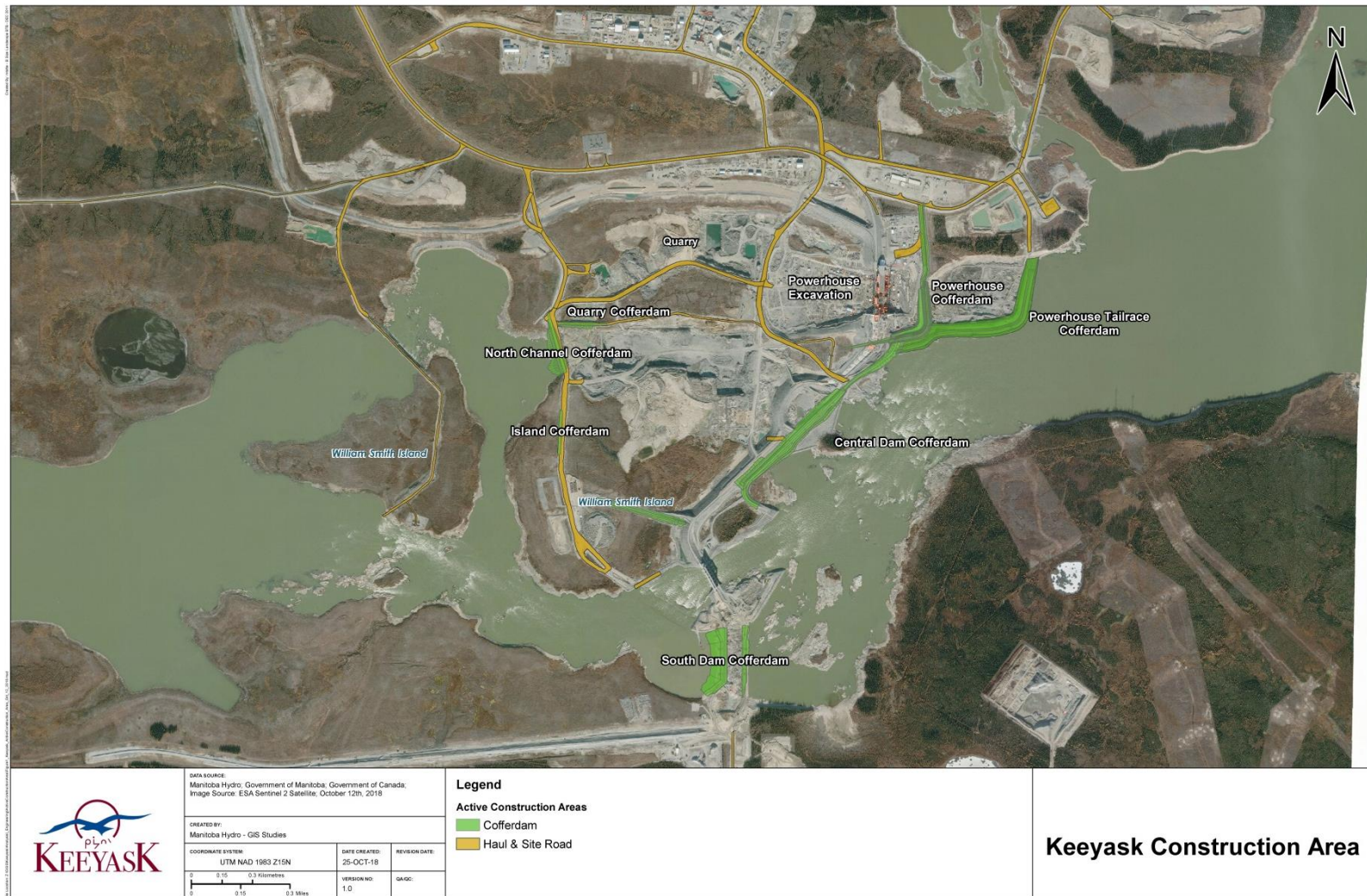
What was done?

The movements of adult sturgeon were tracked using acoustic telemetry. This is a technique in which a tag is surgically implanted inside a fish. Each tag sends out 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 transmitter that sends out a unique ping, which can be detected up to 1 kilometer (km) from a receiver. By looking at the detections that were recorded by different receivers, the movement of each fish can be tracked.

Sixty adult Lake Sturgeon were tagged in 2011 and 2012, 30 upstream and 30 downstream of Gull Rapids. The transmitters are powered by batteries with a 10-year life-span. By the end of 2013, some fish were considered missing so 11 more tags were applied in 2014 (four upstream of Gull Rapids and seven in Stephens Lake) to return the number of tagged fish to the original sample size. One additional tag was applied in spring 2018 to a female sturgeon used for broodstock (eggs) in a stocking program. This tag was applied to track her survival after egg collection.

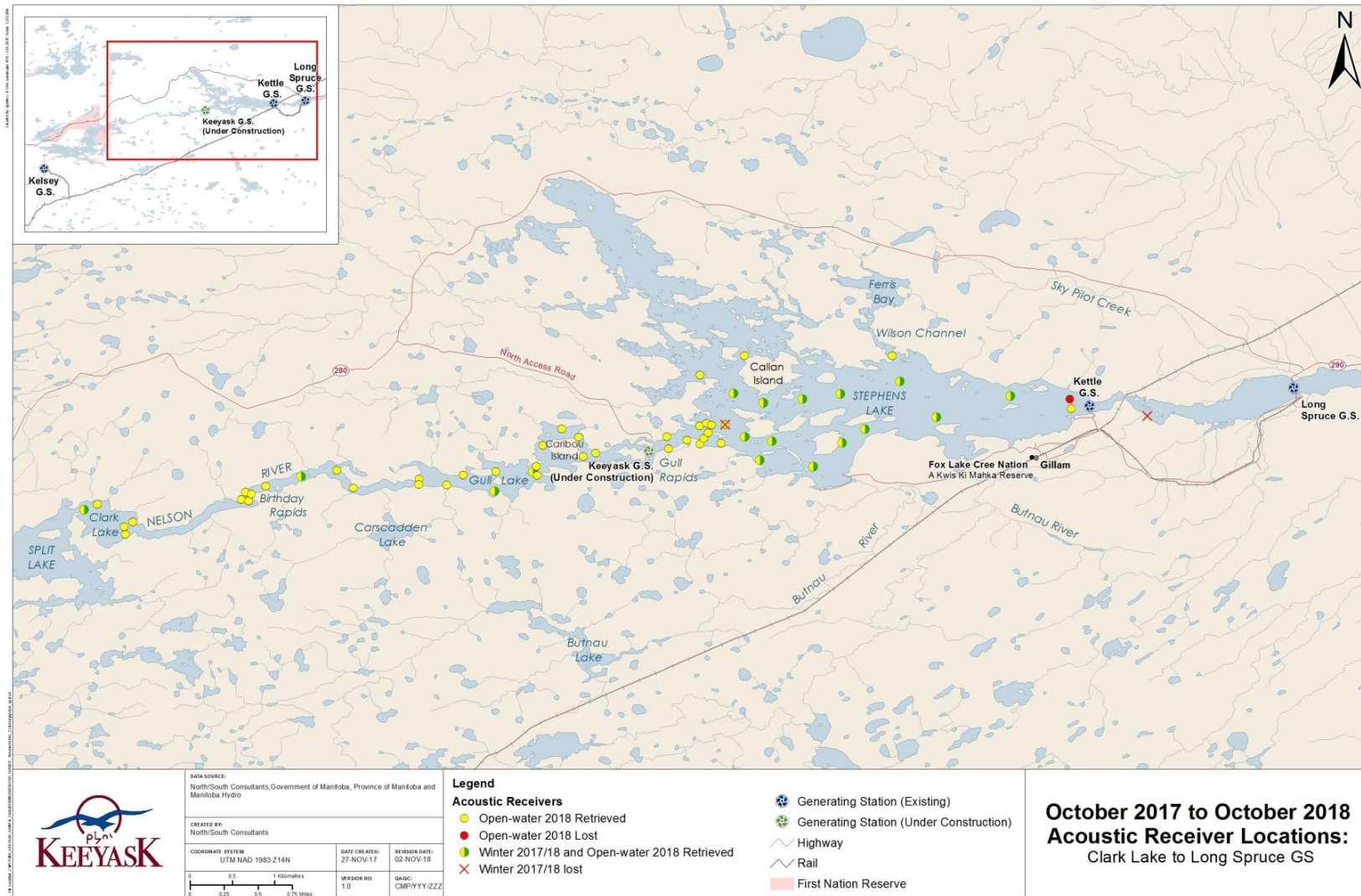


Adult Lake Sturgeon being held in a tank prior to surgery (left). Acoustic tag being implanted in an adult Lake Sturgeon (middle). Adult Lake Sturgeon released into the river after acoustic surgery (right).



Satellite Imagery - October 12th, 2018

Map illustrating instream structures at the Keeyask Generating Station site, October 2018.



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

What was found?

Sturgeon are unique fish in Manitoba because they can live for a long time (100 or more years), become adults when they are 20 to 25 years old, and only spawn every 2 to 5 years. This means that where an individual sturgeon moves may change between years depending on how old it is, whether it is spawning, and what its individual habits are. Sturgeon spawn in spring in the fast-flowing water of large rapids, and spend the rest of the open-water season feeding in areas of rivers or lakes. During the winter, they move to areas where they are protected from ice and fast water.

During this study, movements of the tagged fish were monitored year-round including the winter when the river is covered with ice. Monitoring movements in winter is challenging because the ice conditions can damage or move the receivers. For this reason, receivers are left in only a few locations over the winter, making it less likely that sturgeon will be detected.

After seven-and-a-half years of monitoring, the sturgeon that were tagged in Gull Lake continue to be divided into three groups: those that usually live in Gull Lake (sometimes these fish leave for short periods of time then return); those that usually stay in the channel of the Nelson River between Birthday Rapids and Gull Lake; and those that usually stay in Clark Lake.

Adult Lake Sturgeon tagged in Stephens Lake tend to stay in the main river channel, specifically the part of Stephens Lake where the river channel was flooded when the Kettle GS was built. Fish tagged in Stephens Lake continue to be split into two groups: those that remain in upper Stephens Lake within about 14 km of Gull Rapids; and those that periodically move downstream into lower Stephens Lake (as far as 40 km downstream of Gull Rapids).

No adult Lake Sturgeon moved upstream or downstream over Gull Rapids in 2018. In each previous year of the study, at least one sturgeon has moved through Gull Rapids. Six fish moved upstream (one in 2011, four in 2012, one in 2013, and all prior to 2014 when construction began) and six moved downstream (two in 2014 prior to construction, one in 2015, two in 2016, and one in 2017). This is different than juvenile Lake Sturgeon, which have not been recorded moving over Gull Rapids. No adults have moved upstream through Gull Rapids since construction started, but four have moved downstream. In August 2018, the river channel was completely blocked off and the Keeyask GS spillway was opened for the first time. Because of this, fish are no longer able to move upstream through Gull Rapids.

Since 2011, three sturgeon have moved downstream out of Stephens Lake into the Long Spruce Reservoir after passing through the Kettle GS (one through a turbine, while the other two either moved over the spillway or went through a turbine). Two of these fish moved past the Long Spruce GS in 2016. No receivers could be set downstream of the Kettle or Long Spruce GSs in 2018 due to low water levels, so it is unknown whether or not any fish moved downstream in 2018.

The single female sturgeon used for broodstock (eggs) for the stocking program in 2018 was located for the entire open-water season after release, indicating that she survived.

What does it mean?

So far, monitoring has shown that each sturgeon has a place where it likes to live. At times each fish may move to a different habitat, particularly if it is spawning. So far we have seen that sturgeon usually do not move great distances and that most prefer to live in similar locations year after year. Construction at Gull Rapids does not appear to have affected the movements of sturgeon upstream or downstream of the site to date. Many sturgeon use habitat immediately downstream of the construction site in Stephens Lake. They do not seem to be disturbed by construction activity.

The number of sturgeon moving upstream past Clark Lake or downstream past the Kettle GS does not seem to have increased during construction. However, no sturgeon have been recorded moving upstream over Gull Rapids since construction began.

What will be done next?

The tags that were implanted in 2011 will last until 2021. Following the movements of individual fish over such a long time will give us a better idea of what kinds of habitats these fish need to use over many years and whether construction of the GS is changing their movement patterns.

ACKNOWLEDGEMENTS

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1.0 INTRODUCTION

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

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

One of the main objectives associated with radio and acoustic telemetry studies conducted prior to 2011 (*i.e.*, in support of the Keeyask Generation Project EIS) was detecting upstream and downstream movements of fish over rapids in the study area (Birthday Rapids and Gull Rapids). Pre-Project movement data revealed that the majority of Lake Sturgeon did not move upstream or downstream over rapids into adjacent study reaches; instead, they remained within the reach where they had been tagged. Those few fish that moved over one or more sets of rapids did so in the summer or fall, suggesting that these movements were not associated with a life history event such as spawning. Movement data collected from telemetry studies conducted prior to 2011 are not directly comparable to those described herein given that receiver coverage has improved considerably; the pre-Project acoustic receiver array was comprised of 20 receivers, while the array used after 2011 consists of as many as 60 receivers. Also, radio telemetry has not been used since 2004.

This report provides one year of results (October 2017 to October 2018) from the multi-year adult Lake Sturgeon movement monitoring program described in the AEMP. The report also discusses what has been learned since adult Lake Sturgeon movement monitoring began in 2011. In 2011, 59 fish (measuring > 796 mm fork length) were tagged with acoustic transmitters with a 10-year battery lifespan. Thirty-one fish were captured and tagged upstream of Gull Rapids, and 28 fish were captured and tagged downstream of Gull Rapids. An additional fish was tagged in Stephens Lake in 2013 to replace a tag returned by a local resource user. By 2013, 11 tags were either missing or lost. To compensate for this loss, additional tags were implanted in 2014 to restore the sample size to 59 fish. Results from all studies dating back to 2011 are presented in Hrenchuk and McDougall (2012); Hrenchuk and Barth (2013); Hrenchuk *et al.* (2014); Hrenchuk and Barth (2015); Hrenchuk and Barth (2016); and Hrenchuk and Barth (2017); and Hrenchuk *et al.* (2018).

Adult Lake Sturgeon movement monitoring during the construction phase is being conducted between Clark Lake and the upper portion of the Limestone Reservoir (Map 1) to determine if disturbances associated with construction alter habitat use and coarse-scale movement patterns upstream and downstream of the Project (Map 2). Results assist in identifying:

- The use of key habitats (*i.e.*, spawning, 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 construction effects such as stranding during dewatering, releases of suspended sediment); 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 adult movement monitoring during the construction phase are as follows:

- 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 adult Lake Sturgeon increase during construction?

2.0 STUDY SETTING

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

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

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

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

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

Just below Gull Rapids, the Nelson River enters Stephens Lake (Map 4). 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. In August 2018, flow was further constricted when the spillway was commissioned (see Section 2.1).

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 (Maps 1 and 5).

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 (SWCD), which extends into the south channel of Gull Rapids, was completed in 2015. The rock placement for the inner and outer groins of the Tailrace Cofferdam (TRCD) started in late 2016 and the impervious fill placement was completed in fall 2017. An opening was created to allow fish to move freely over the winter of 2017–2018. The opening was closed in spring 2018 and dewatering of the TRCD occurred in July, at which time a fish salvage was completed. In preparation for commissioning of the spillway, the SWCD was watered-up on both sides of the structure in June 2018. Removal of the SWCD started in early July and continued into August. The spillway was commissioned between August 3 and 7, 2018. Closing the south channel with the upstream South Dam Cofferdam (SDCD) commenced at the beginning of August and river closure was achieved on August 16. This closure and the work that continued to seal the cofferdam forced the entire river flow through the spillway. The downstream SDCD was completed in September and the area between the two cofferdams was dewatered, allowing for fish salvage to be completed by late September 2018. Work continued on the upstream SDCD until it was complete in late fall 2018.

2.2 FLOWS AND WATER LEVELS

From October 2017 to October 2018, Split Lake outflow ranged from about 2,800–4,000 m³/s. Flow typically fell in the range of about 3,000–3,500 m³/s, which is near the historical annual median flow of approximately 3,300 m³/s. Flow was generally higher during the 2017–2018 winter period, gradually declining from about 3,800 m³/s at the end of February 2018 to about 2,800 m³/s by the beginning of May. From early May 2018 to the beginning of July, flow gradually increased to about 3,500 m³/s and remained at that level to the end of July. The flow subsequently declined to about 2,800 m³/s by the end of September. Water levels varied in conjunction with the flows, ranging from about 153.4–155.2 m ASL on Gull Lake.

3.0 METHODS

3.1 ACOUSTIC TELEMETRY

Acoustic telemetry involves tracking movements of fish surgically implanted with internal acoustic transmitters (tags). Each transmitter emits a unique signal, recognizable by stationary receivers. When tagged fish come into range (generally within 500 m to 1 km, depending on conditions), the transmitter code number, as well as the date and time, are stored in the receiver. Initially, the receiver array was designed to monitor adult Lake Sturgeon; however, the same array is also used to monitor juvenile Lake Sturgeon (Lacho and Hrenchuk 2019a), Walleye (Hrenchuk and Lacho 2019), and Lake Whitefish (Lacho and Hrenchuk 2019b).

3.1.1 ACOUSTIC TRANSMITTER APPLICATION

Acoustic transmitters (VEMCO V16-4x, estimated 3,650-day battery life) were first applied to 59 fish in 2011 and 2012: 31 upstream and 28 downstream of Gull Rapids (Table 1). A single transmitter was reapplied to a fish in Stephens Lake in 2013 after being returned by a local resource user. At the beginning of the 2014 open-water period, it was suspected that 11 fish had either shed their tags, suffered mortality, or were captured by local resource users. In order to return the number of tagged fish to the original sample size, additional acoustic transmitters were applied to adult Lake Sturgeon upstream of Gull Rapids ($n = 4$) and in Stephens Lake ($n = 7$) in June 2014 (Hrenchuk and Barth 2015) (Table 1).

One additional fish was tagged with an acoustic transmitter (VEMCO V13-1x, estimated 1,735-day battery life) upstream of Gull Rapids (rkm -26.0) on June 6, 2018 (Table 2). This fish was a female used as broodstock for the Project's stocking program (details can be found in Klassen *et al.* 2019). The acoustic transmitter was applied to monitor survival post egg collection.

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. As noted below, these receivers could not be set in 2018 due to low water conditions.

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 2017/2018

The stationary acoustic receiver array for the winter 2017/2018 (October 17, 2017, to April 30, 2018) period consisted of 20 receivers. Four were set upstream of Gull Rapids, 15 throughout Stephens Lake, and one in the Long Spruce Reservoir (Maps 3, 4, and 5). The winter 2017/2018 array did not differ from that used in winter 2016/2017; however, due to low water levels, the receiver in the Long Spruce Reservoir could not be retrieved at the end of the 2017/2018 winter period.

3.1.2.2 OPEN-WATER 2018

An array of 56 receivers was used during the 2018 open-water period (defined as May 1 to October 10, 2018). Twenty-seven were set upstream of Gull Rapids and 29 were set in Stephens Lake (Maps 6 and 7).

The 2018 open-water array differed slightly from arrays used in previous years. One receiver (#108002) was set in a new location upstream of Gull Rapids, closer to construction, at rkm -4.8 (Map 6). In Stephens Lake, one receiver set during open-water 2017 (rkm 23.5) was not reset due to its proximity to an additional receiver (#114241 at rkm 24.7; Map 7).

Due to low water levels, receivers could not be set in the Long Spruce or Limestone reservoirs during the 2018 open-water period. Several attempts were made to access the sites throughout the open-water period, but a boat could not be safely launched in either area. Receivers will be set in both locations during open-water 2019 provided conditions are suitable.

Receiver “gates” were established in several key areas selected based on river morphology (channel restrictions) and characteristics of habitat (areas with low velocity adjacent to the main flow of the river). Receiver “gates” consisted of two or more acoustic receivers set parallel to flow to provide complete (or nearly complete) signal coverage of a river cross-section. Areas

between the “gates” were referred to as river zones. Receiver gates provide confidence that movements past key points are being detected, which allows for extrapolation of coarse-scale positions (*i.e.*, which zone) during periods when fish remain undetected. When analyzing data, fish detected within a zone that subsequently go undetected for a period of time without passing through a gate, are assumed to be within the zone they were last detected.

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

Water temperature within the Nelson River mainstem was recorded with a HOBO Water Temperature Pro data logger from October 17, 2017, to October 10, 2018. Lake Sturgeon generally spawn in the spring when water temperature ranges from 8–13°C (KHLP 2014). Thus, data collected during this time was considered as “spawning period”.

On October 10, 2018, the majority of receivers were removed and a subset ($n = 19$) were redeployed to monitor movements during winter 2018/2019.

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. The proportion of time that all fish spent within each river zone was calculated and plotted.

3.1.3.1 MAXIMUM LIKELIHOOD APPROACH

A maximum likelihood approach was used to compare pre- and post-construction movements, both between river zones and through Gull Rapids, Kettle GS, and Long Spruce GS. This method is broadly applicable and simple to apply. Maximum likelihood provides estimators that are intuitive and have straightforward statistical properties. The main benefit is that once a maximum-likelihood estimator is derived, the general theory of maximum-likelihood estimation provides standard errors, statistical tests, and other results useful for statistical inference.

A standard binomial coefficient was used to assess the probability of movement estimators.

$$f(y|N, p) = \binom{N}{n} p^y (1 - p)^{(N-y)}$$

Where:

$$\binom{N}{n} = \frac{N!}{n! (N - n)!}$$

A simple example is the chance of observing 5 heads in 20 coin tosses, if $p = 0.50$, would be:

$$f(5|20, 0.5) = \binom{20}{5} 0.5^5 (1 - 0.5)^{(20-5)} = 0.0148$$

For any observed set of results, the binomial coefficient is constant so we can ignore it when evaluating p . The values of p were evaluated using the maximum likelihood approach given the observed data for the following:

- Movement or no movement between zones;
- Upstream movement from zone to zone;
- Downstream movement from zone to zone; and
- Movement past barriers.

4.0 RESULTS

Section 4.1 provides a summary of movements observed for all fish tagged since inception of the study in June 2011 to the end of the 2017 open-water period (October 16, 2017). Numbers of fish tagged upstream of Gull Rapids and in Stephens Lake, by year, are provided in Table 1. Tables 2 and 3 provide acoustic tag and biological information associated with each tagged fish. Table 4 summarizes the proportional distribution of tagged fish upstream and downstream of the construction site (2013–2018). Table 5 summarizes all movements through Gull Rapids by fish tagged during the current (2011–2018) and previous (2001–2004) telemetry studies. Figure 3 provides water temperatures measured in the Nelson River mainstem from October 17, 2017, to October 10, 2018. Figures 4 to 14 illustrate movement range and proportional distribution of tagged fish both upstream and downstream of the construction site by season. Appendix A1 provides furthest upstream and downstream detection summaries for each tagged fish (2011–2018) while Appendices A2 and A3 provide movement summaries, by river kilometer, for each tagged sturgeon since the study began in June 2011.

4.1 2011–2017 RESULTS SUMMARY

4.1.1 UPSTREAM OF GULL RAPIDS

Thirty-one fish were tagged upstream of Gull Rapids in 2011 and 2012 and four additional transmitters were applied in June 2014 (Table 1). Since being applied, several tags have gone missing:

- #16042 was tagged at the outlet of Clark Lake on June 5, 2011. It was detected regularly within Clark Lake until August 8, 2014 and has not been detected since (Appendix A2-4).
- #16045 has not been detected since August 18, 2011. It moved downstream immediately after being tagged in Gull Lake on June 10, 2011, and displayed few upstream movements (Appendix A2-5).
- #16057 was tagged in Gull Lake on June 16, 2011. It remained in this area until June 17, 2014, when it moved upstream through Birthday Rapids into Clark Lake and has not been detected since (Appendix A2-11).
- #16064 was tagged downstream of Birthday Rapids on June 12, 2011 (Appendix A2-18). It moved downstream into Gull Lake, where it was detected until June 21, 2012. It was next detected briefly in Gull Lake on two days in June and July, 2016. It is likely that this fish largely remains outside of the detection range of the receiver array.
- #16077 moved downstream immediately after tagging on June 10, 2011. It was last detected on June 21, 2011, (Appendix A2-31).

- #32177 was tagged in Gull Lake on June 18, 2014. It remained in Gull Lake and was last detected here on June 14, 2015 (Appendix A2-35).

These six missing fish are not discussed in the remainder of this report. One fish (#16067) previously considered missing (Hrenchuk *et al.* 2018) was detected and is discussed in Section 4.1.1.

Prior to winter 2017/2018, six fish had moved upstream from Stephens Lake into Gull Lake, two of which returned to Stephens Lake during the 2014 open-water period:

- #16025 was tagged in Stephens Lake on June 16, 2012, and moved upstream through Gull Rapids on August 22, 2012. This fish subsequently moved back downstream into Stephens Lake, where it was first located on June 18, 2014 (Appendix A3-7).
- #16029 was tagged in Stephens Lake on June 21, 2011, and moved upstream through Gull Rapids between July 29 and August 2, 2011 (Appendix A3-10).
- #16033 was tagged in Stephens Lake on June 18, 2011, and moved upstream through Gull Rapids on July 28, 2012. However, shortly after it was captured by a local resource user and the tag was returned and reapplied to another fish in Stephens Lake in 2013.
- #16037 was tagged in Stephens Lake on June 8, 2011, and moved upstream through Gull Rapids between September 3 and 6, 2013. It then moved downstream and was detected in Stephens Lake on July 1, 2014 (Appendix A3-17).
- #16038 was tagged in Stephens Lake on June 12, 2011, and moved upstream through Gull Rapids on September 13, 2012 (Appendix A3-18).
- #16046 was tagged in Stephens Lake on June 11, 2011, and moved upstream through Gull Rapids between June 27 and July 4, 2012. This fish was detected in Gull Lake until 2013, but has not been located since (Appendix A3-23).
 - This fish is now considered missing and is not discussed in the remainder of the report.

Four fish have moved downstream through Gull Rapids into Stephens Lake:

- #16048 was tagged in Gull Lake on June 7, 2011. It moved downstream through Gull Rapids on June 28, 2015 (Appendix A2-6).
- #16060 was tagged in Gull Lake on June 21, 2011. It was detected exclusively within Gull Lake (rkm -14.8 to -9.5) between 2011 and 2016. It moved downstream through Gull Rapids and was detected in Stephens Lake on July 2, 2016 (Appendix A2-14).
- #16076 was tagged in Gull Lake on June 6, 2011. It moved downstream through Gull Rapids between June 6 and 9, 2017 (Appendix A2-30).
- #32174 was tagged in Gull Lake on June 18, 2014. It moved downstream through Gull Rapids and was detected in Stephens Lake on August 6, 2016 (Appendix A2-32).

In summary, 35 adult Lake Sturgeon were tagged upstream of Gull Rapids between 2011 and 2014. Six fish are considered missing, six moved upstream from Stephens Lake (one of which is considered missing), six fish moved downstream into Stephens Lake, and one was harvested. Therefore, a total of 27 tagged sturgeon were available to be detected upstream of Gull Rapids during winter 2017/2018.

One additional fish (#54799) was tagged upstream of Gull Rapids on June 6, 2018, in order to assess the survival of a female used during broodstock collection. Therefore, a total of 28 tagged sturgeon were available to be detected upstream of Gull Rapids during open-water 2018.

4.1.2 STEPHENS LAKE

Twenty-eight fish were originally tagged downstream of Gull Rapids in 2011 and 2012. Additional tags were applied in 2013 ($n = 1$) and 2014 ($n = 7$) (Table 1). Five tags are considered missing due to a lack of detections:

- #16018 moved downstream immediately after being tagged on June 13, 2012. It was last detected on July 2, 2012, immediately upstream of Kettle GS (Appendix A3-1).
- #16024 moved downstream immediately after being tagged on June 13, 2012. It was last detected in Stephens Lake on June 25, 2012 (Appendix A3-6).
- #16044 moved downstream immediately after being tagged on June 9, 2011. It was last detected in Stephens Lake on September 17, 2012 (Appendix A3-22).
- #16047 moved downstream immediately after being tagged on June 26, 2011. It was last detected in Stephens Lake on June 28, 2011 (Appendix A3-24).
- #32170 was tagged immediately downstream of Gull Rapids on June 11, 2014. It was regularly detected moving throughout Stephens Lake until October 30, 2016 (Appendix A3-32).
 - This fish was captured twice during adult Lake Sturgeon population monitoring conducted from May 27 to June 30, 2018 (rkm 1.2 and 1.3 on June 4 and 8, respectively). Capture details can be found in Holm and Hrenchuk 2019. Due to its proximity to a receiver but lack of detections since 2016, it is likely that the tag has malfunctioned.

These five fish are not discussed in the remainder of the report.

Three fish are known to have moved downstream out of Stephens Lake through the Kettle GS into the Long Spruce Reservoir:

- #16021 was tagged in Stephens Lake on September 28, 2011, and moved downstream through the Kettle GS on September 16, 2012. As the Kettle GS spillway was open on this day, it is unknown whether the Lake Sturgeon moved through the spillway or passed

through a turbine. It was last detected in the Long Spruce Reservoir on September 18, 2012 (Appendix A3-4).

- #16025 was tagged in Stephens Lake on June 15, 2012. It moved upstream into Gull Lake in 2012 but returned to Stephens Lake in 2014 (Section 4.1.1). This fish subsequently moved downstream through Kettle GS between June and July, 2014. The Kettle GS spillway was open during June and July 2014, so it is not possible to determine if the fish moved through either the turbines or spillway. It was last detected in the Long Spruce Reservoir on July 14, 2014 (Appendix A3-7).
- #16034 was tagged in Stephens Lake on June 18, 2011, and moved downstream through the Kettle GS between October 9, 2012, and June 10, 2013. This fish must have passed downstream through one of the Kettle GS turbines as the spillway was closed between October 2012 and June 2013. It was detected in the Long Spruce Reservoir in open-water 2015 (Appendix A3-15).

Six fish have moved upstream out of Stephens Lake into Gull Lake (as discussed in Section 4.1.1); however, one of these fish (#16033) was captured by a local resource user and the tag was reapplied to a fish in Stephens Lake (#16033b). Two (#16025 and #16037) returned to Stephens Lake in 2014; however, #16025 moved downstream through the Kettle GS into the Long Spruce Reservoir (discussed above). An additional four fish (#16048, #16060, #16076, and #32174) initially tagged in Gull Lake moved downstream through Gull Rapids into Stephens Lake (Section 4.1.1).

In summary, 35 adult Lake Sturgeon were tagged in Stephens Lake between 2011 and 2014. Five are considered missing, three moved downstream through Kettle GS, three moved upstream into Gull Lake and did not return to Stephens Lake, and four moved downstream from Gull Lake. Therefore, 28 fish were available to be detected in Stephens Lake during winter 2017/2018.

4.2 WINTER 2017/2018

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, -12.4, and -10.3 (Figure 1). All four of the acoustic receivers were retrieved (Map 3). Fifteen of the 27 fish (56%) were located a total of 195,140 times (range: 144–25,715 detections per individual) (Appendix A1-1). Fish were detected on 14 to 188 days of the 196 day winter period (7–96% of the time) for an average of 84 days, or for 43% of the study period (standard deviation [StDev] = 33.8 days). Detections were logged only by receivers located at rkm -12.4 (n = 14,003) and -10.3 (n = 181,137)

(Figures 4 and 5; Appendix A1-1). No fish were located by the receiver at the inlet of Clark Lake (rkm -48.2) or downstream of Birthday Rapids (rkm -29.4) (Figure 5; Map 3).

Individual Lake Sturgeon movements are summarized graphically in Appendix 2.

4.2.2 STEPHENS LAKE

Fifteen receivers were deployed in Stephens Lake during the 2017/2018 winter period, between rkms 5.2 and 36.1 (Figure 1). Fourteen of the 15 acoustic receivers were retrieved; the receiver at rkm 5.8 (#122774) could not be located and was likely moved by ice (Map 4).

Twenty-five of the 28 fish (89%) were located during the winter period a total of 820,312 times (range: 281–65,428 detections per individual) (Appendix A1-2). On average, fish were detected for 146 days of the 196 day winter period (74%) (range: 5–196 days). The farthest upstream detections occurred at rkm 5.2 (by 20 fish; 80%), while the farthest downstream occurred at rkm 16.8 (by four fish; 16%) (Appendix A1-2). The average movement range was 5.7 rkm (range 2.7–8.9 rkm) (Figure 6; Appendix A1-2).

4.2.2.1 MOVEMENTS

The majority of detections were logged by receivers located in the southern portion of Stephens Lake between rkm 5.3 and 10.3 ($n = 720,280$; 88%; Figure 7). Movements were as follows:

- Fifteen (#16022, #16027, #16028, #16030, #16035, #16040, #16041, #16048, #16049, #16053, #16060, #16076, #32171, #32172, and #32173) were detected exclusively in the upstream portion of Stephens Lake, moving no further downstream than rkm 10.3.
- Five (#16019, #16020, #16032, #16052, and #32169) moved as far downstream as rkm 13.9.
- Four (#16031, #16043, #16050, and #32167) moved farther downstream, as far as rkm 16.8.
- A single fish (#32168) moved into the northern portion of Stephens Lake and was located at receiver #114227 (rkm 6.5; $n = 17,749$) and #122862 (rkm 8.4; $n = 16$) between February 26 and April 30, 2018 (Map 4).

Individual Lake Sturgeon movements are summarized graphically in Appendix 3.

4.2.3 LONG SPRUCE RESERVOIR

Due to low water levels preventing safe access to the Long Spruce Reservoir in 2018, it was not possible to retrieve the receiver deployed at rkm 47.5 (Map 5). Therefore, there were no data collected from this area during winter 2017/2018 and open-water 2018.

4.3 OPEN-WATER 2018

4.3.1 ACOUSTIC RECEIVER RETRIEVAL

All stationary acoustic receivers deployed upstream of Gull Rapids ($n = 27$) during the 2018 open-water period were successfully retrieved (Map 6). For the first time in 2018, a receiver was successfully deployed and retrieved closer to Keeyask construction at rkm -4.8 (#108002; Map 6). One of the 29 receivers deployed in Stephens Lake (#102966) at rkm 40.8 went missing part way through the study period (Map 7). No data were retrieved from this receiver after July 26, 2018; therefore, the “gate” at the downstream end of Stephens Lake was no longer effective after this date. Due to low water levels, no receivers were set or retrieved in the Long Spruce or Limestone reservoirs.

4.3.2 UPSTREAM OF GULL RAPIDS

Twenty-eight adult Lake Sturgeon were available to be detected upstream of Gull Rapids during the 2018 open-water period (Section 4.1.1). All 28 of these were detected between 544 and 61,208 times for 18–141 days of the 163 day open-water period (11–87% of the time; Appendix A1-3). The average total movement range was 13.9 rkm (StDev = 8.6 rkm; range: 0.0–38.3 rkm) (Figure 8; Appendix A1-3). The farthest upstream detections occurred at rkm -48.2 (by four fish; 14%), while the farthest downstream occurred at rkm -4.8 (by 15 fish; 54%) (Figure 8; Appendix A1-3). One fish (#16067) previously considered missing was detected (discussed in Section 4.1.1). No fish moved downstream through Gull Rapids.

Two fish (#16061 and #32175) were captured during adult Lake Sturgeon population monitoring conducted from May 24 to July 1, 2018. Capture details can be found in Holm and Hrenchuk (2019).

4.3.2.1 PROPORTIONAL DISTRIBUTION

As in previous years, individual Lake Sturgeon used Zones 4 (upper basin of Gull Lake) and 5 (lower basin of Gull Lake) most often, spending a total of 50% (StDev = 38%; range: 0–99%) and 29% (StDev = 35%; range: 0–100%) of the study period in these areas, respectively (Table 4; Figures 9 and 10). Zones 1 (Clark Lake), 2 (river reach from Clark Lake to Birthday Rapids), and 3 (river reach from Birthday Rapids to Gull Lake) were used less frequently:

- Zone 1 at 7% (StDev = 26%; range: 0–100%);
- Zone 2 at 0.1% (StDev = 0.5%; range: 0–3%); and
- Zone 3 at 14% (StDev = 32%; range: 0–100%) of the study period.

4.3.2.2 MOVEMENT PATTERNS

During the 2018 open-water period, the majority of detections were logged in Gull Lake downstream of rkm -10.2 ($n = 282,415$; 69%). An additional 15% percent of detections were logged by a single receiver set in the riverine area between Birthday Rapids and Gull Lake at rkm -26.5 ($n = 61,504$) (Figure 11).

As described in previous reports, individual Lake Sturgeon in this study area exhibit habitual movement patterns. In 2018, 26 of the 28 detected fish continued to display the same general pattern of movement observed in previous years:

- Sixteen remained exclusively within Gull Lake, making multiple upstream and downstream movements, as far upstream as rkm -19.5 and as far downstream as rkm -4.8.
 - Three (#16059, #16061, and #16073) made distinct upstream movements to a small set of rapids at rkm -19.5 during the spawning period (May 28 to June 10, 2018; Figure 3).
- Five were located within Gull Lake for the majority of the study period, but made brief upstream movements during the spawning period:
 - Two (#16038 and #16068) moved upstream as far as -26.5 and two (#16062 and #16072) moved as far upstream as rkm -29.4. No rapids are present at either location.
 - One (#16056) moved upstream to Birthday Rapids (rkm -33.8). This fish has made the same movement every year since the study began in 2011.
- Two (#16026 and #16069) remained within the riverine area between Birthday Rapids and Gull Lake (rkm -33.8 to -26.5).
- Two (#16058 and #16074) were detected exclusively within Clark Lake (rkm -48.2 to -44.3). Both fish were tagged downstream of Birthday Rapids, but have been detected exclusively within Clark Lake since 2015 (#16074) and 2016 (#16058).
- One (#16054) has displayed two different patterns of movement:
 - From 2011 to 2014, this fish was detected exclusively within Gull Lake, moving between rkm -19.5 and -7.5.
 - From 2015 to 2018, it moved back and forth from Clark Lake to the riverine area downstream of Birthday Rapids. It appears to alternate its overwintering location, moving upstream past Clark Lake one year (*i.e.*, winter 2015/2016 and 2017/2018), and returning to the riverine area downstream of Birthday Rapids the next (*i.e.*, winter 2016/2017 and likely 2018/2019).

The remaining two fish displayed movements that differed from movements exhibited during previous years:

- #16067 was tagged on June 19, 2011 in Gull Lake (rkm -9.9). It moved upstream through Birthday Rapids during open-water 2012, after which it was presumed missing due to a lack of detections.
 - It was relocated on May 31, 2018 at the inlet of Clark Lake (rkm -48.2). It moved downstream and was detected in the riverine area between Birthday Rapids and Gull Lake (rkm -33.8 to -26.5) from June 9 to August 6. It then continued to move downstream into Gull Lake, where it remained until the end of the study period.
- #54799 was tagged in June, 2018 (at rkm -26.0) in order to assess survival after being used for broodstock. This fish moved downstream into lower Gull Lake (rkm -4.8) within five days of tagging, and remained here until June 29. It then moved upstream and was detected between rkm -10.2 and -9.9 for the remainder of the study period.
 - These movements correspond to what is normal for a recently tagged fish.

Individual Lake Sturgeon movements are summarized graphically in Appendix A2.

4.3.3 STEPHENS LAKE

Twenty-eight adult Lake Sturgeon were available to be detected in Stephens Lake during the 2018 open-water period (Section 4.1.2). All 28 of these fish were detected between 1,751 and 36,522 times over 18–145 days of the 163 day study period (11–89% of the time; Appendix A1-4). Mean movement range was 18.5 rkm (StDev = 7.9 rkm; range: 8.2–39.7 rkm) (Figure 12; Appendix A1-4). The farthest upstream detections occurred immediately downstream of Gull Rapids at rkm 1.2 (by all 28 fish; 100%), while the farthest downstream detections occurred near the Kettle GS at rkm 40.9 and 40.8 (by 2 fish; 7%) (Figure 12; Appendix A1-4). No fish moved upstream through Gull Rapids during the 2018 open-water period prior to Keeyask spillway commissioning.

Seven fish (#16020, #16022, #16033b, #16035, #16041, #16043, and #16049) were captured during adult Lake Sturgeon population monitoring conducted from May 27 to June 30, 2018. Capture details can be found in Holm and Hrenchuk (2019).

4.3.3.1 PROPORTIONAL DISTRIBUTION

As during open-water 2016 and 2017, Lake Sturgeon used Zone 7 slightly more frequently than Zone 6, spending 53% (StDev = 22%; range: 3–99%), and 47% (StDev = 22%; range: 1–97%) of the time in each zone, respectively (Table 4; Figures 9 and 13). However, as in previous open-water periods, utilization of the zones changed over time. A greater proportion of fish were detected close to Gull Rapids during the beginning and middle of the study period than at the end (Figure 9).

- Zone 6 was used an average of:
 - 80% of the time (StDev = 9%; range: 57–93%) between June 6 and 13, 2018;

- 40% (StDev = 8%; range: 21–61%) between June 14 and July 17;
- 59% (StDev = 9%; range: 32–79%) between July 18 and September 5; and
- 28% (StDev = 7%; range: 18–54%) between September 6 and October 10.

4.3.3.2 MOVEMENT PATTERNS

As in 2017, the majority of detections ($n = 510,366$; 94%) were logged by receivers located in the southern portion of Stephens Lake between rkm 1.2 and 13.9 during the 2018 open-water period (Figure 14).

Two general movement patterns were displayed:

- Five (#16033b, #16053, #16060, #32172, and #32173) remained in the upstream portion of Stephens Lake, moving only as far downstream as rkm 13.9.
- The remaining 23 fish moved further downstream into Stephens Lake:
 - Seventeen made regular upstream and downstream movements, moving as far downstream as rkm 18.6.
 - Four moved further downstream into lower Stephens Lake (#16019 to rkm 21.6, #16048 and #16076 to rkm 24.7, and #16020 to rkm 36.1), after which they returned upstream.
 - Two were detected immediately upstream of Kettle GS after being captured during adult Lake Sturgeon population monitoring conducted during spring, 2018 (Holm and Hrenchuk 2019).
 - #16035 was captured in a gill net on June 2, 2018, at rkm 1.2. It was detected moving downstream on this date and was last located at rkm 40.8 on June 8.
 - It is likely that this fish moved downstream through the Kettle GS. This may be confirmed during monitoring conducted in 2019 if it is detected at a receiver set downstream of the GS.
 - #16049 was captured on May 29, 2018, at rkm 2.0, and was located at rkm 40.9 on June 18. It then returned upstream and was located moving between rkm 1.2 and 16.8 for the remainder of the open-water period.
 - Both fish may have moved downstream due to stress caused by handling during capture.

Individual Lake Sturgeon movements are summarized graphically in Appendix 3.

4.3.4 LONG SPRUCE RESERVOIR

One adult Lake Sturgeon (#16025) was last detected in the Long Spruce Reservoir on July 14, 2014 (Appendix A3-7). Due to low water levels, no receivers could be set during open-water 2018. Provided conditions are suitable, receivers will be set in this area in open-water 2019 to monitor potential fish passage.

4.3.5 LIMESTONE RESERVOIR

Two adult Lake Sturgeon were last detected in the Limestone Reservoir, one (#16021) in 2017 and one (#16034) in 2016 (Appendices A3-4 and A3-15). Due to low water levels, no receivers could be set during open-water 2018. Provided conditions are suitable, receivers will be set in this area in open-water 2019 to monitor potential fish passage.

4.4 ADULT LAKE STURGEON DISTRIBUTION

Proportional distributions of fish detected consistently since 2013 ($n = 41$) were compared, and the likelihood of fish movements between zones both before and after construction were calculated (Figures 15, 16, and 17). The overall likelihood of a movement (either upstream or downstream) between zones was 12.2% prior to construction and 14.6% after construction (Figure 15). The likelihood of a fish moving upstream from one zone to another was 43.4% prior to the onset of construction, and 42.8% after (Figure 16). The likelihood of a fish moving downstream from one zone to another was 56.6% before construction and 57.1% after (Figure 17).

4.5 MOVEMENTS THROUGH BARRIERS

Since the inception of the study in 2011, 12 movements through Gull Rapids have occurred: six upstream, and six downstream (Table 5).

- Four (#16029, #16033, #16038, and #16046) tagged in Stephens Lake moved upstream and remained upstream in Gull Lake.
- Four (#16048, #16060, 16076, and #32174) tagged in Gull Lake moved downstream into Stephens Lake and remained in Stephens Lake.
- Two (#16025 and #16037) tagged in Stephens Lake moved upstream into Gull Lake and then returned to Stephens Lake.

Additionally, three (#16021, #16025, and #16034) moved downstream through the Kettle GS. Two of these (#16021 and #16034) have since moved downstream through the Long Spruce GS.

Four downstream movements through Gull Rapids (#16060, #16048, #16076, and #32174) have occurred following the start of Keeyask GS construction. Upstream movements through Gull Rapids have not been observed since 2013.

The likelihood of a fish moving through Gull Rapids, Kettle GS, or the Long Spruce GS was calculated both pre- and post-construction. Prior to construction, there was a 2.1% chance that a fish would move past the rapids or a generating station and a 1.0% chance after the onset of construction (Figure 18).

5.0 DISCUSSION

Adult Lake Sturgeon movement monitoring was initiated in 2011 to describe adult Lake Sturgeon movement during the pre-construction (2011–2013) and construction phases (beginning July 2014) of the Keeyask Project and to determine if disturbances associated with construction would alter habitat use and coarse-scale movement patterns upstream and downstream of the Project. As discussed 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. The discussion below highlights movement patterns that have been observed and discusses the key questions (presented in the AEMP) with respect to potential impacts of construction on Lake Sturgeon and their movements.

5.1 EVALUATION OF METHODOLOGY

Acoustic telemetry continues to be an effective method for monitoring movements and habitat utilization patterns of adult Lake Sturgeon in the study area. During the 2018 open-water period, all of the tagged fish remaining in the area were located. Fish tagged upstream of the Keeyask GS construction site were detected, on average, for 63% of the 162 day open-water study period (22–61% in previous years). Additionally, one fish that was previously thought to be missing (not detected since 2012) was relocated. Fish tagged in Stephens Lake tend to be detected more often, and on average were located for 67% of the 2018 open-water period (34–73% in previous years).

One additional fish was tagged upstream of Gull Rapids in June, 2018, in order to assess the survival of female Lake Sturgeon used during broodstock collection. This fish moved downstream after release, but was detected in Gull Lake for the entire open-water period. These movements are not unusual for a recently tagged fish and indicate that this fish survived post-spawn take.

The quantity of data collected during winter is lower compared to the open-water period given that fewer receivers are used (only four upstream of Gull Rapids and 15 in Stephens Lake). Despite this, 56% of fish tagged upstream of Gull Rapids and 89% of fish tagged in Stephens Lake were detected for an average of 43 and 74% of the winter 2017/2018 period, respectively.

One additional receiver was added to the receiver array during the open-water 2018 period. A receiver was deployed at rkm -4.8 (upstream of Gull Rapids) in order to monitor movements more proximate to the Keeyask GS construction site. During open-water 2018, 15 fish (54%) were detected between 2 and 61,208 times at this receiver. It will continue to be deployed as part of the upstream receiver array.

5.2 KEY QUESTIONS

The key questions described in the AEMP for adult movement monitoring during construction were:

Will disturbances associated with construction alter coarse-scale movements upstream and/or downstream of the construction site?

Adult Lake Sturgeon movement patterns have changed little since the study began in 2011. Fish tend to display habitual movements, with a few fish making movements each year that do not fit into their previous patterns. Upstream of Gull Rapids, fish continue to remain in distinct portions of the study area: a) Clark Lake; b) the riverine portion of the Nelson River between Birthday Rapids and Gull Lake; and c) Gull Lake. Within Stephens Lake, Lake Sturgeon tend to remain in the main river channel, specifically the part of Stephens Lake where the river channel was flooded when the Kettle GS was built. Some fish tend to remain in the upper portion of Stephens Lake, while others utilize both the upper and lower portions.

Based on the maximum likelihood analysis comparing data from the pre-construction and post-construction periods, the frequency of Lake Sturgeon movement between zones has not changed since construction began. The likelihood that an adult Lake Sturgeon would move upstream or downstream from one zone to another was similar (2.4% difference), and generally low, during both time periods. If a movement was made between zones, the likelihood of an upstream movement or a downstream movement was very similar (0.5% difference) between the two time periods.

Are sturgeon using habitat in the immediate vicinity of the construction site?

Lake Sturgeon continued to use the area immediately upstream and downstream of the Keeyask GS construction site in 2018. Upstream, fish spent an average of 29% of the study period in lower Gull Lake, and 15 of 28 fish (54%) were located by the receiver closest to Gull Rapids (rkm -4.8), with one fish remaining here for the majority of the study period. In Stephens Lake, fish spent an average of 53% of the study period within 5.0 rkm of Gull Rapids. All 28 fish detected in 2018 were located by the receiver closest to the construction site (rkm 1.2). The amount of time adult Lake Sturgeon have spent in the area surrounding the Keeyask construction site has changed little since receiver gates were put in place in 2013.

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

No adult Lake Sturgeon moved downstream through Gull Rapids in 2018. Since the study began in 2011, six fish have moved downstream through Gull Rapids: two before construction began in 2014, and four after. Six fish have moved upstream through Gull Rapids, all prior to construction. Based on maximum likelihood estimates, the chance of an adult Lake Sturgeon

moving out of the area upstream of Gull Rapids or out of Stephens Lake was marginally lower during construction (1.0%) than prior to construction (2.1%).

The Keeyask GS spillway was commissioned in August, 2018, after which upstream movement were no longer possible. Future monitoring will determine if this impacts the rate of downstream movement.

6.0 SUMMARY AND CONCLUSIONS

- Acoustic telemetry continues to be an effective method for monitoring adult Lake Sturgeon movement. Monitoring during the 2017/2018 winter period was conducted with an array of 20 receivers and positions were obtained from 40 of the 55 (73%) Lake Sturgeon available to be detected. During the 2018 open-water period, 56 receivers were deployed and positions were obtained from all of the 56 fish available to be detected.
- The key questions, as described in the AEMP, for adult Lake Sturgeon movement monitoring during construction of the Keeyask GS were as follows:
 - *Will disturbances associated with construction alter coarse-scale movements upstream and/or downstream of the construction site?*

Quantitatively and qualitatively, there have been no changes in adult Lake Sturgeon movement patterns since the onset of Keeyask GS construction.
 - *Are adult sturgeon using habitat in the immediate vicinity of the construction site?*

During the 2018 open-water period, fish continued to use the areas both immediately upstream and immediately downstream of Gull Rapids.
 - *Will the frequency of long-distance movements (and subsequent downstream emigration/entrainment) by adult Lake Sturgeon increase during construction and operation of the Project?*

Since the inception of study in 2011, twelve movements through Gull Rapids have occurred: six upstream and six downstream. All upstream movements occurred during the pre-construction phase (one in 2011, four in 2012, and one in 2013). The Keeyask GS spillway was commissioned in August, 2018, after which upstream movements were no longer possible. Downstream movements occurred both during the pre-construction (2014; n = 2) and construction phase (n = 4). Data collected during the pre-construction phase (2011–June 2014) suggested that the probability of moving through a barrier (either Gull Rapids or the Kettle GS) was 2.1%. Data collected after the onset of construction (July 2014–October 2018), suggested that the probability was slightly lower (1.0%).

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TABLES

Table 1: Number of acoustic transmitters applied, missing tags, immigrants and emigrants, and harvested adult Lake Sturgeon upstream of Gull Rapids and in Stephens Lake, indicating the number of fish remaining in the area at the end of each study period between June 2011 and October 2018.

Year	Upstream of Gull Rapids						Stephens Lake						
	Tags Applied	Missing Tags	From Stephens Lake ¹	To Stephens Lake ²	Harvest	# Active Tags	Tags Applied	Missing Tags	From U/S of Gull Rapids ³	To U/S of Gull Rapids ⁴	To D/S Kettle GS ⁵	Harvest	# Active Tags
2011	30	-	1	-	-	31	19	-	-	1	-	-	18
2012	1	-	4	-	1	35	9	-	-	4	2	-	21
2013	0	-	1	-	-	36	1	-	-	1	-	-	21
2014	4	6	-	2	-	32	7	4	2	-	1	-	25
2015	0	6	-	1	-	31	0	4	1	-	-	-	26
2016	0	5	-	2	-	30	0	4	2	-	-	-	28
2017	0	5	-	1	-	29	0	4	1	-	-	-	29
2018	1	6	-	-	-	28	0	5	-	-	-	-	28

1. Immigration from Stephens Lake.
2. Emigration to Stephens Lake.
3. Immigration from upstream of Gull Rapids.
4. Emigration to upstream of Gull Rapids.
5. Emigration to downstream of the Kettle GS.

Table 2: Tagging and biological information associated with adult Lake Sturgeon implanted with acoustic transmitters upstream of Gull Rapids between 2011 and 2018.

Tag ID	Date Tagged	Floy Tag	Fork Length	Total Length	Weight	Sex
16026	19-Jun-12	100450	955	1070	7711	-
16036	5-Jun-11	74400	1313	1414	20185	-
16039	5-Jun-11	48596	1425	1530	27216	F
16042	5-Jun-11	74399	956	1060	8165	M
16045	10-Jun-11	77516	1379	1533	21773	M
16048	7-Jun-11	94396	967	1103	9299	-
16051	10-Jun-11	74394	1386	1510	24494	-
16054	6-Jun-11	74398	816	915	5023	-
16055	6-Jun-11	74396	872	974	6350	M
16056	10-Jun-11	77515	1020	1120	9526	M
16057	16-Jun-11	77509	900	1024	7711	-
16058	9-Jun-11	82631	867	953	6124	-
16059	16-Jun-11	64718	1260	1385	16783	F
16060	21-Jun-11	80188	1060	1170	10433	-
16061	21-Jun-11	77503	1305	1443	14515	-
16062	12-Jun-11	77510	1176	1284	12247	-
16063	11-Jun-11	77514	1124	1229	10660	M
16064	12-Jun-11	80370	1066	1148	9072	M
16065	12-Jun-11	77511	958	1058	7484	-
16066	20-Jun-11	77507	1310	1405	25855	F
16067	19-Jun-11	50826	1090	1210	11340	-
16068	19-Jun-11	80368	1140	1254	11794	-
16069	17-Jun-11	48909	1400	1570	32659	-
16070	16-Jun-11	77508	1072	1195	10886	M
16071	16-Jun-11	76484	1026	1133	7711	M
16072	21-Jun-11	77506	850	967	6350	-
16073	12-Jun-11	77512	1169	1284	15422	M
16074	13-Jun-11	94030	915	1016	6804	M
16075	10-Jun-11	50888	1610	1700	43092	F
16076	16-Jun-11	50808	1260	1375	19958	-
16077	10-Jun-11	80265	1143	1245	12247	M
32174	18-Jun-14	94117	1172	1296	17690	-
32175	18-Jun-14	105480	843	951	4082	-
32176	18-Jun-14	50853	1236	1370	22226	-
32177	18-Jun-14	105479	886	1001	5443	-
54799	6-Jun-18	111765	1431	1475	21319	F

Table 3: Tagging and biological information associated with adult Lake Sturgeon implanted with acoustic transmitters in Stephens Lake between 2011 and 2018.

Tag ID	Date Tagged	Floy Tag	Fork Length	Total Length	Weight	Sex
16018	06/13/12	93923	1024	1145	8618	M
16019	06/13/12	93922	850	951	6577	-
16020	06/08/12	55557	992	1100	-	M
16021	09/28/11	91705	880	977	6804	-
16022	06/13/12	81628	810	900	5443	M
16024	06/13/12	74416	960	1081	8391	-
16025	06/15/12	80374	1120	2350	10433	M
16027	06/13/12	93921	894	991	6804	M
16028	06/13/12	93924	884	976	5216	M
16029	06/21/11	56202	1208	1316	16556	F
16030	06/12/11	56152	1004	1103	7711	-
16031	06/13/12	92925	906	1011	6804	-
16032	06/11/11	46892	1064	1159	11340	M
16033	06/18/11	74419	881	974	5443	-
16033b	09/16/13	103230	755	842	-	-
16034	06/18/11	74418	796	904	4082	-
16035	09/26/11	69868	941	1040	8165	-
16037	06/08/11	-	826	911	-	-
16038	06/12/11	74415	1116	1239	11793	-
16040	06/09/11	74411	1006	1105	8391	M
16041	06/26/11	74421	903	1001	7257	-
16043	06/10/11	88788	790	885	4536	-
16044	06/09/11	56208	1161	1296	14969	M
16046	06/11/11	74413	1085	1209	9979	M
16047	06/26/11	88789	920	1020	6577	-
16049	09/24/11	91174	1070	1182	10886	-
16050	06/13/11	74415	922	1041	6577	-
16052	09/26/11	69865	1190	1337	16329	-
16053	09/26/11	69867	919	1021	8618	-
32167	06/11/14	-	910	1015	4990	-
32168	06/11/14	94234	884	980	4990	-
32169	06/13/14	-	810	908	4082	-
32170	06/11/14	46844	1095	2000	9525	M
32171	06/13/14	-	880	976	4536	M
32172	06/13/14	86136	904	1050	5897	-
32173	06/13/14	-	842	936	4082	-

Table 4: Average proportion of time spent in each river zone by adult Lake Sturgeon tagged upstream of Gull Rapids and in Stephens Lake during a portion of the 2013 (June 4 to October 15), 2014 (June 4 to October 3), 2015 (June 4 to October 11), 2016 (June 4 to October 19), 2017 (June 7 to October 16), and 2018 (June 6 to October 10) open-water periods.

Study Year	Upstream of Gull Rapids					Stephens Lake	
	1	2	3	4	5	6	7
2013	6.4	0.1	12.4	72.5	8.6	45.0	55.0
2014	9.0	0.1	10.8	52.3	27.7	38.2	61.8
2015	4.7	0.1	9.9	43.6	41.7	55.6	44.9
2016	7.3	0.1	12.1	56.5	24.1	41.8	59.2
2017	5.3	0.0	10.7	62.6	21.4	47.6	52.9
2018	7.1	0.1	14.4	49.6	28.7	47.4	53.3

Table 5: Number of Lake Sturgeon tagged with acoustic and radio tags that moved upstream or downstream through Gull Rapids during studies conducted in 2001–2004 and 2011–2018.

Life Stage	Year ¹	# Tagged Fish		# Fish Detected		Downstream Movements			Upstream Movements			Total # Movements	% Tagged Fish Moved	% Detected Fish Moved
		U/S ²	D/S ³	U/S	D/S	#	% of total	% of detected	#	% of total	% of detected			
Adult⁴	2001	21	11	21	11	1	4.8	4.8	0	0.0	0.0	1	3.1	3.1
	2002	19	12	19	10	0	0.0	0.0	3	25.0	30.0	3	9.7	10.3
	2003	21	9	20	4	1	4.8	5.0	0	0.0	0.0	1	3.3	4.2
	2004	19	9	16	4	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
	2011	30	19	28	19	0	0.0	0.0	1	5.3	5.3	1	2.0	2.1
	2012	32	27	30	27	0	0.0	0.0	4	14.8	14.8	4	6.8	7.0
	2013	35	22	28	19	0	0.0	0.0	1	4.5	5.3	1	1.8	2.1
	2014	34	24	33	24	2	5.9	6.1	0	0.0	0.0	2	3.4	3.5
	2015	32	25	28	25	1	3.1	3.6	0	0.0	0.0	1	1.8	1.9
	2016	32	26	29	26	2	6.3	6.9	0	0.0	0.0	2	3.4	3.6
	2017	30	28	26	27	1	3.3	3.8	0	0.0	0.0	1	1.7	1.9
Juvenile⁵	2018	28	28	28	28	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
	2013	20	20	18	20	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
	2014	20	20	20	19	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
	2015	20	20	19	19	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
	2016	20	20	19	19	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
	2017	20	18	18	13	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
	2018	20	19	20	14	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0

1. Includes data from the current study (2011–2016), a study conducted between 2001 and 2004 (Barth and Mochnacz 2004; Barth 2005; Barth and Murray 2005; Barth and Ambrose 2006), and the juvenile Lake Sturgeon acoustic telemetry study initiated in Gull and Stephens Lake in 2013 (Hrenchuk and Barth 2014; Lacho *et al.* 2015, Lacho and Hrenchuk 2016; Lacho and Hrenchuk 2017; Lacho *et al.* 2018; Lacho and Hrenchuk 2019a).

2. Upstream of Gull Rapids (between Clark Lake and Gull Rapids).

3. Downstream of Gull Rapids (in Stephens Lake between Gull Rapids and the Kettle GS).

4. Refers to fish greater than 800 mm fork length.

5. Refers to fish less than 800 mm fork length.

FIGURES

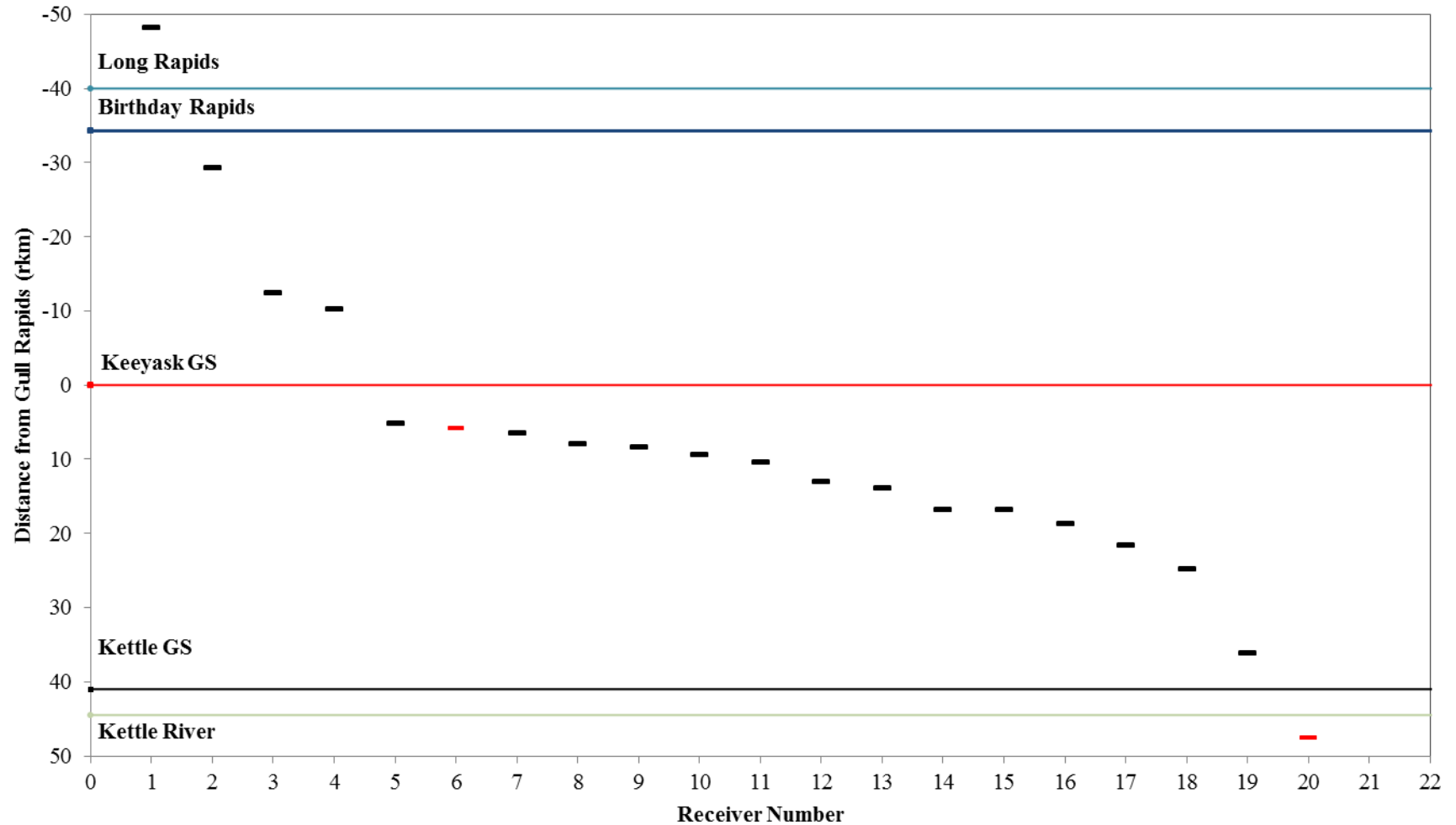


Figure 1: Locations of stationary acoustic receivers (dashes) in relation to the base of Gull Rapids (rkm 0) and other major landmarks (lines) in the Nelson River between Clark Lake and the Limestone GS between October, 2017 and June, 2018. A red dash indicates a receiver that was lost.

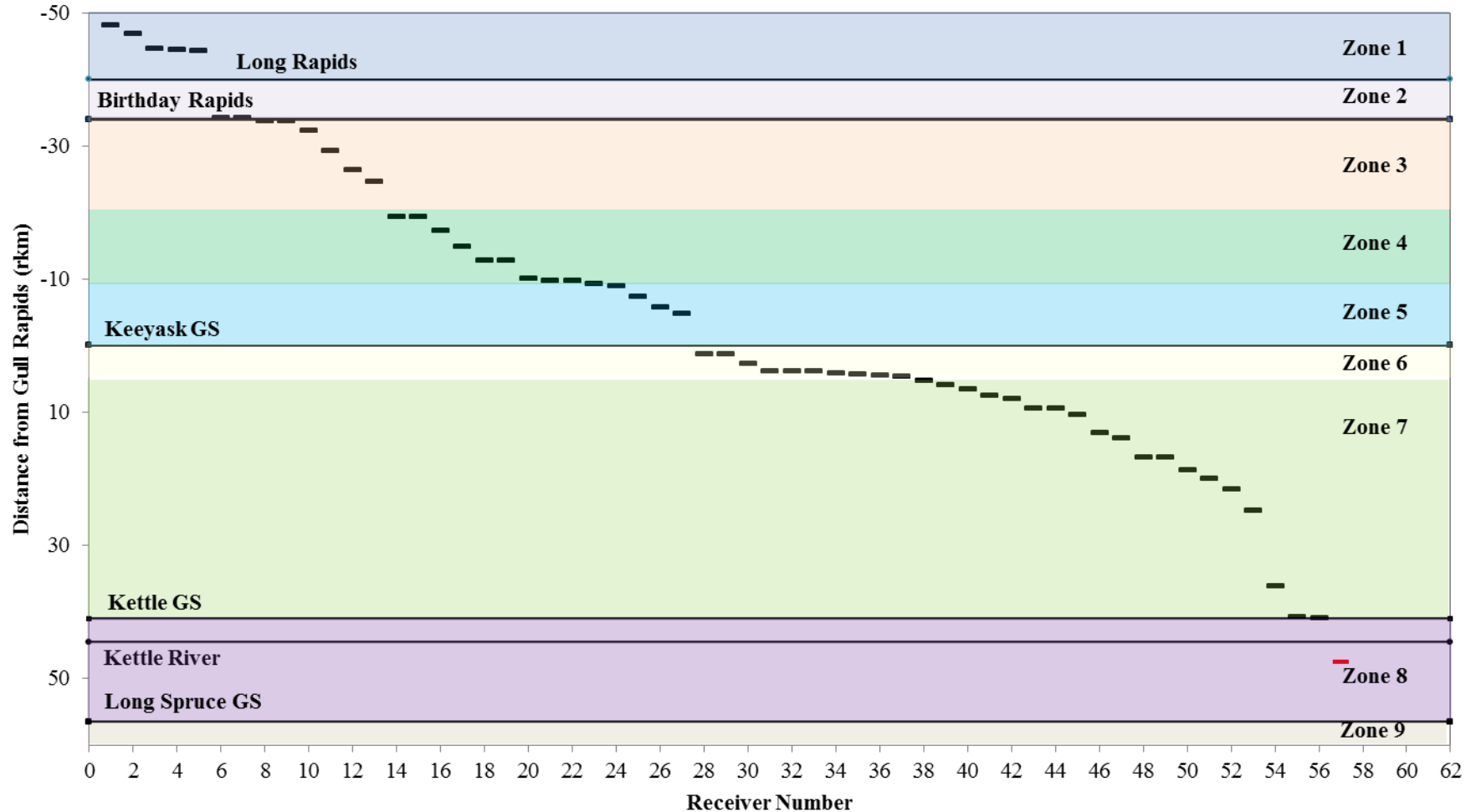


Figure 2: Locations of stationary acoustic receivers (dashes) in relation to the base of Gull Rapids (rkm 0) and other major landmarks (lines) in the Nelson River between Clark Lake and the Limestone GS between June and October, 2018. River zones upstream and downstream of Gull Rapids are indicated by shading. A red dash indicates a receiver was lost.

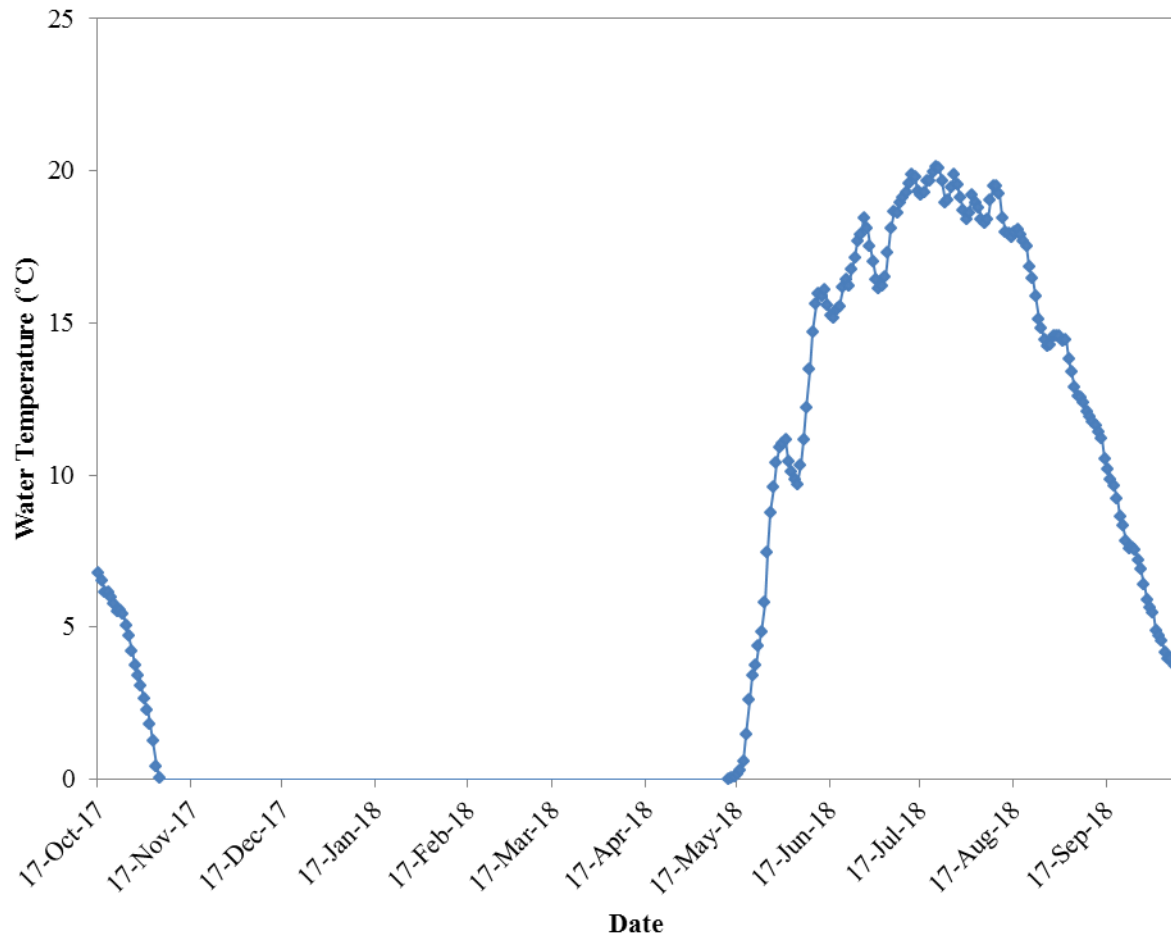


Figure 3: Water temperature in the Nelson River mainstem from October 17, 2017, to October 9, 2018.

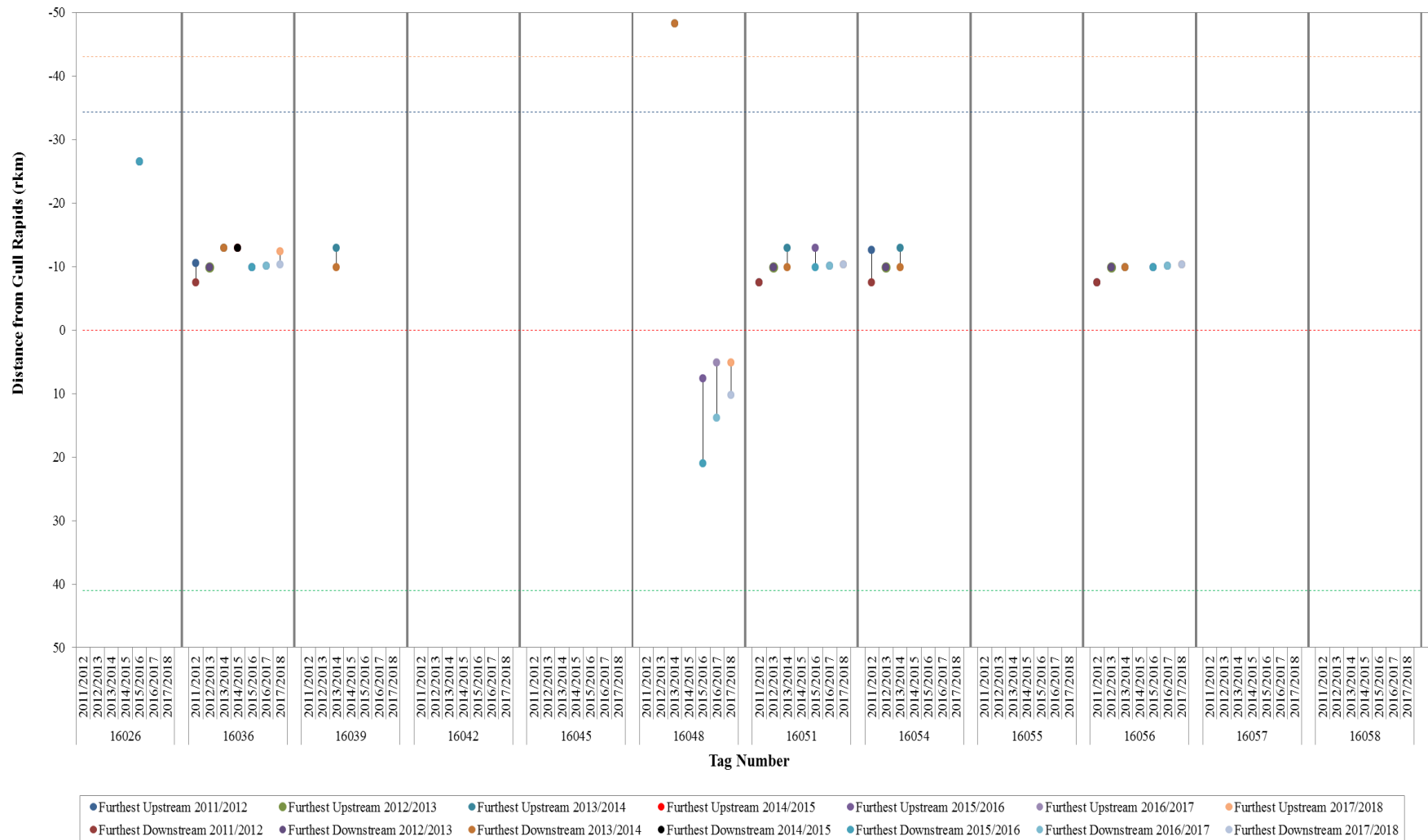


Figure 4: Detection ranges for individual adult Lake Sturgeon tagged with acoustic transmitters upstream of Gull Rapids during the winter period (2011–2018). Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS).

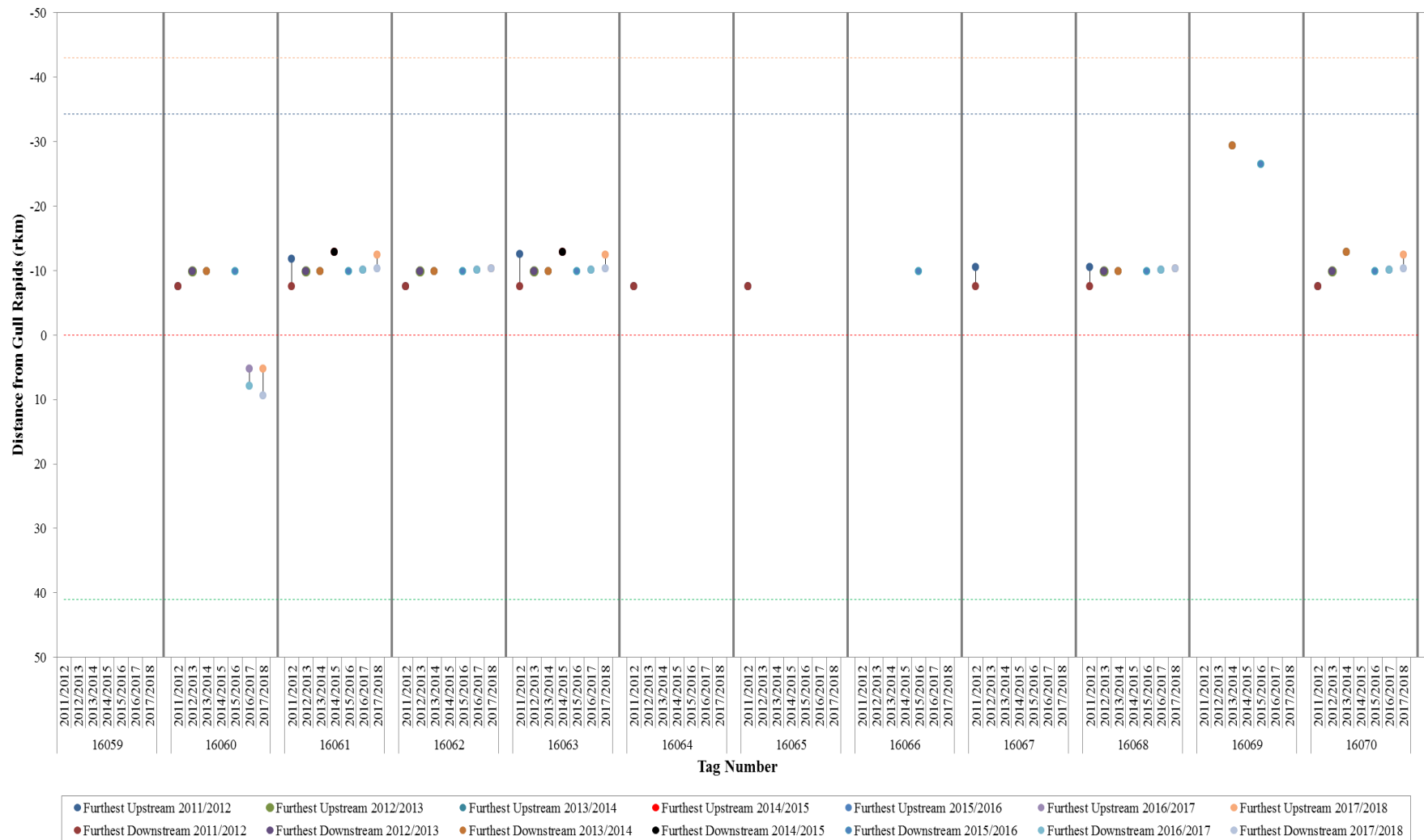


Figure 4: Detection ranges for individual adult Lake Sturgeon tagged with acoustic transmitters upstream of Gull Rapids during the winter period (2011–2018). Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS) (continued).

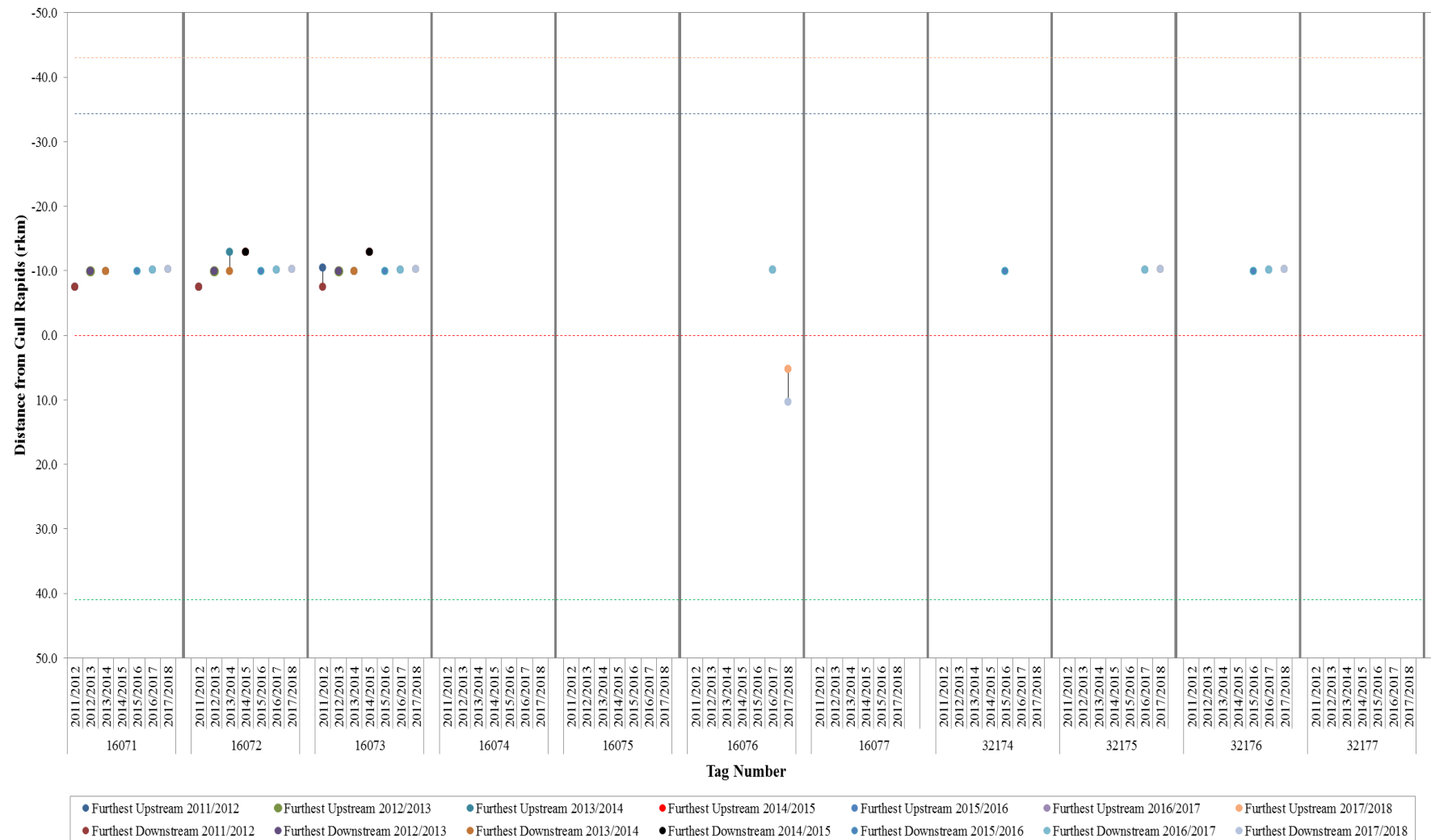


Figure 4: Detection ranges for individual adult Lake Sturgeon tagged with acoustic transmitters upstream of Gull Rapids during the winter period (2011–2018). Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS) (continued).

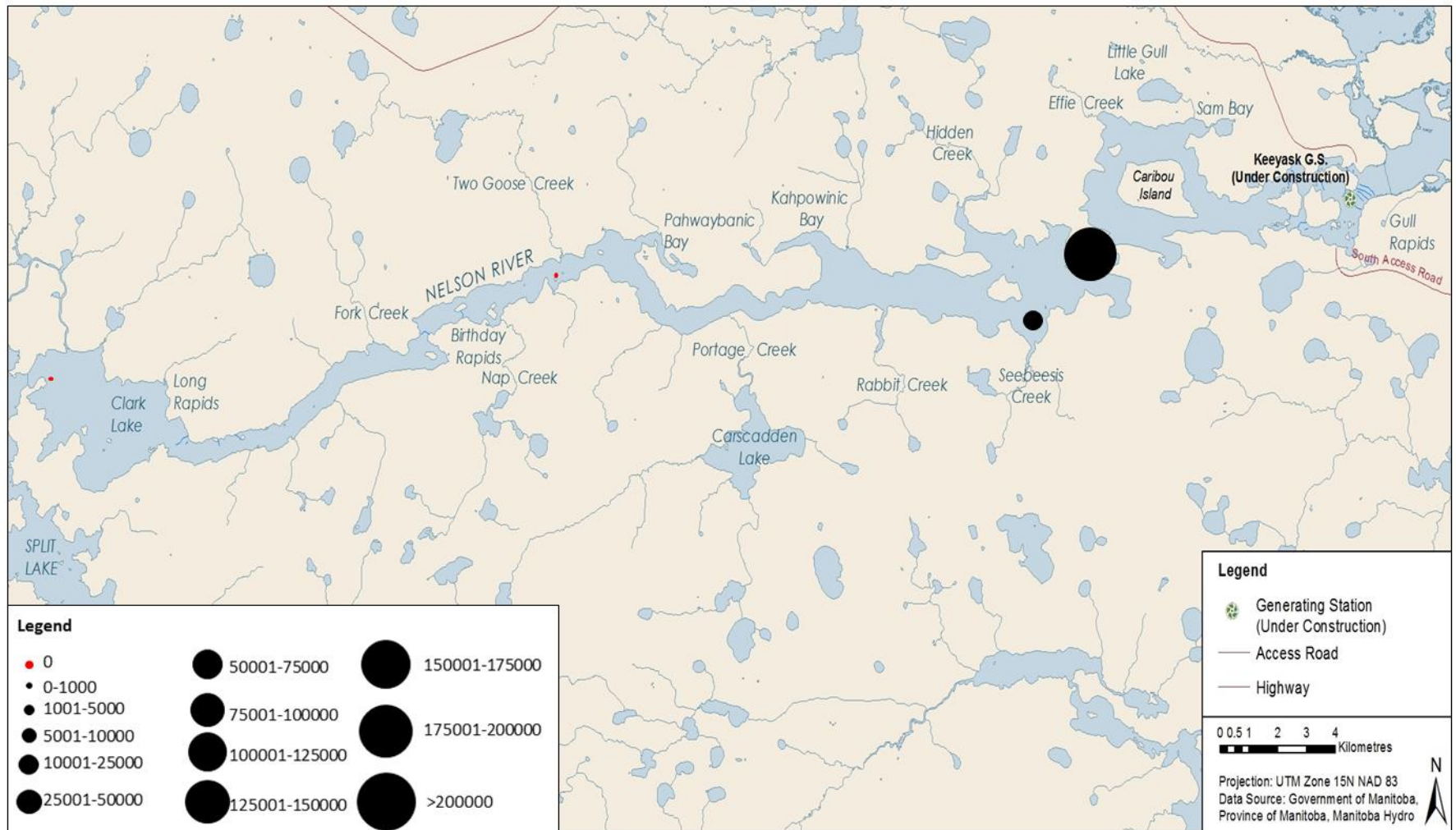


Figure 5: Relative number of detections at each acoustic receiver set between Clark Lake and Gull Rapids during winter 2017/2018 (October 17, 2017, to April 30, 2018). Number of detections indicated by size of bubble (defined in legend). Receivers with no detections indicated with red dot.

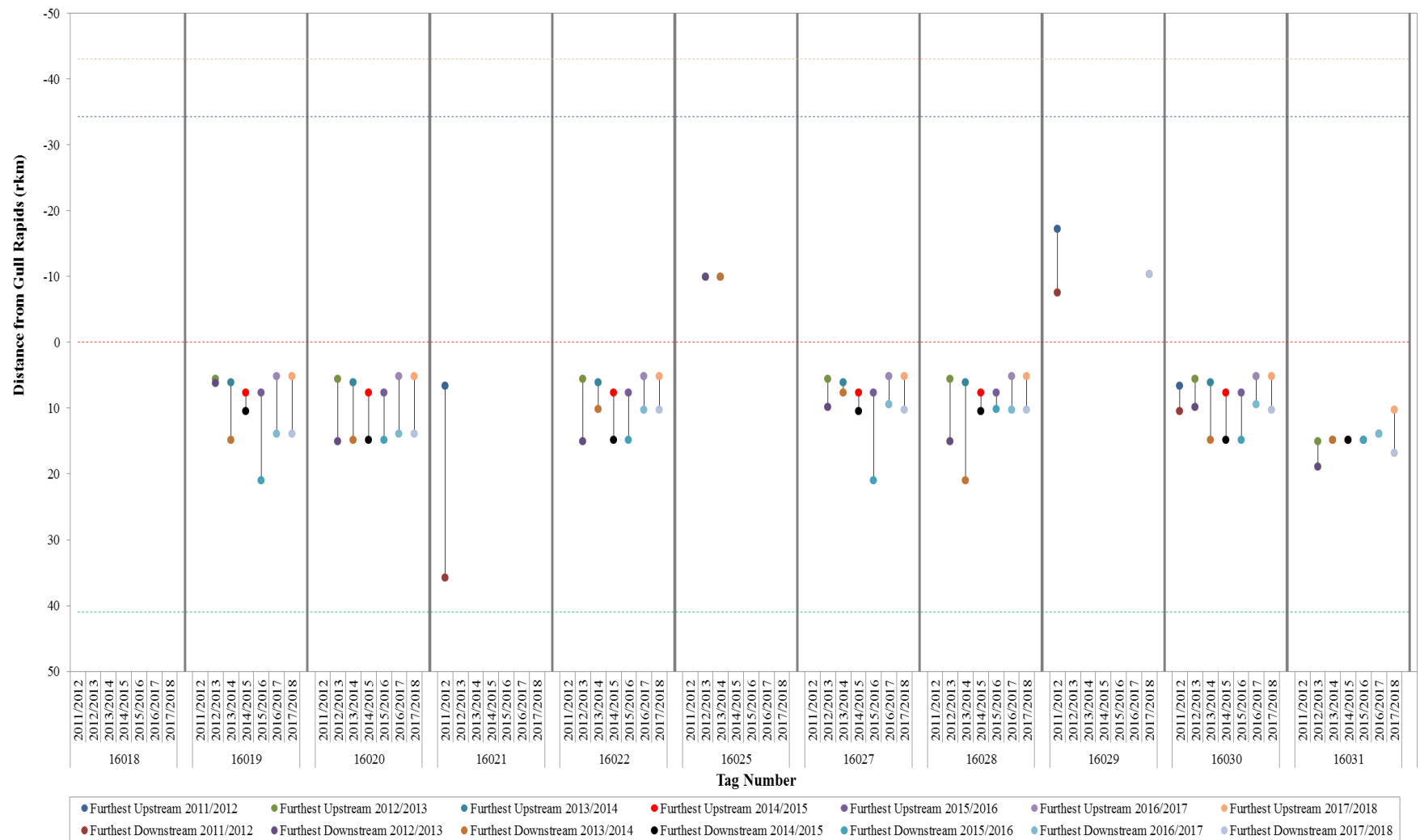


Figure 6: Detection ranges for individual adult Lake Sturgeon tagged with acoustic transmitters in Stephens Lake during the winter period (2011–2018). Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS).

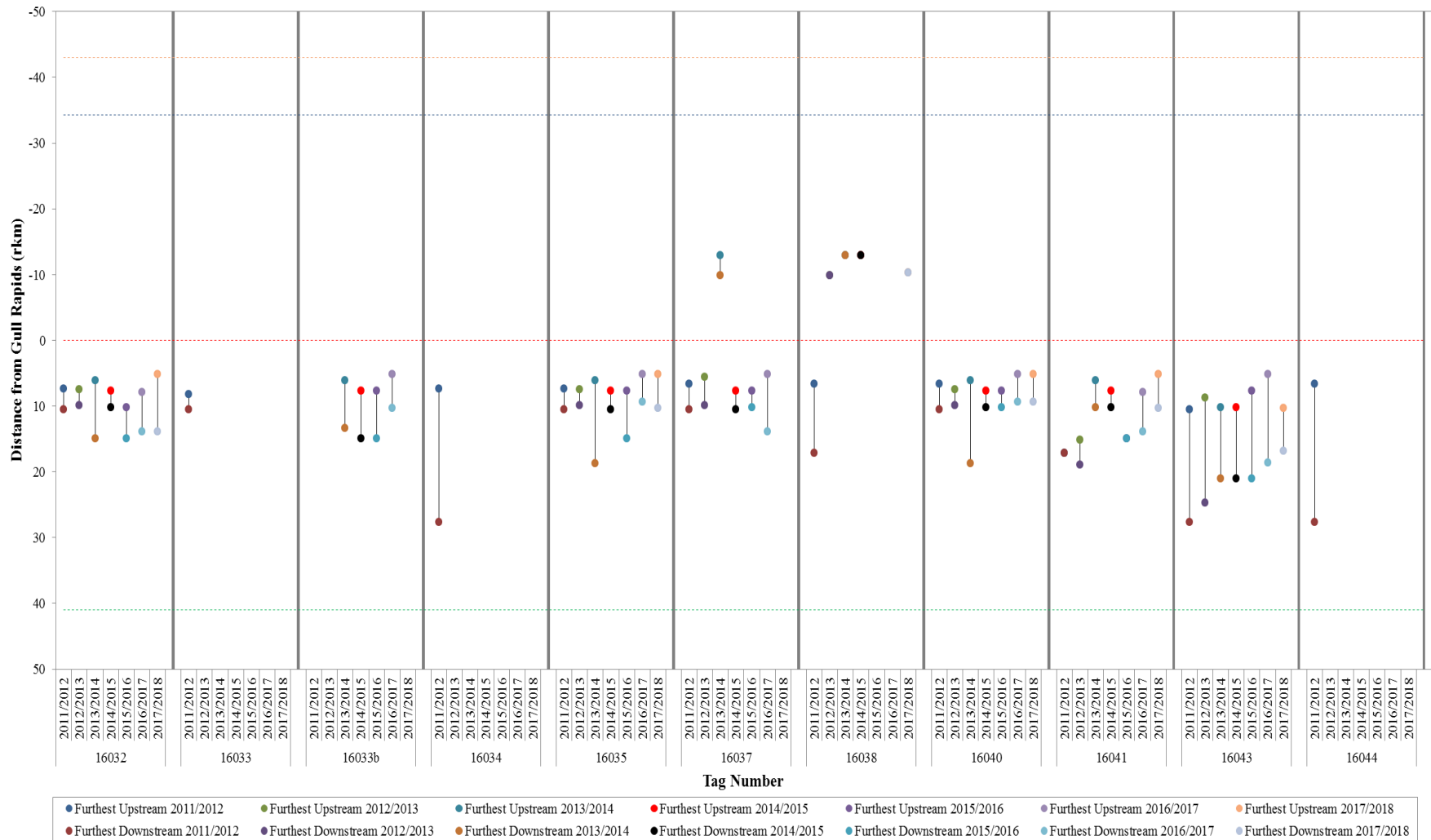


Figure 6: Detection ranges for individual adult Lake Sturgeon tagged with acoustic transmitters in Stephens Lake during the winter period (2011–2018). Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS) (continued).

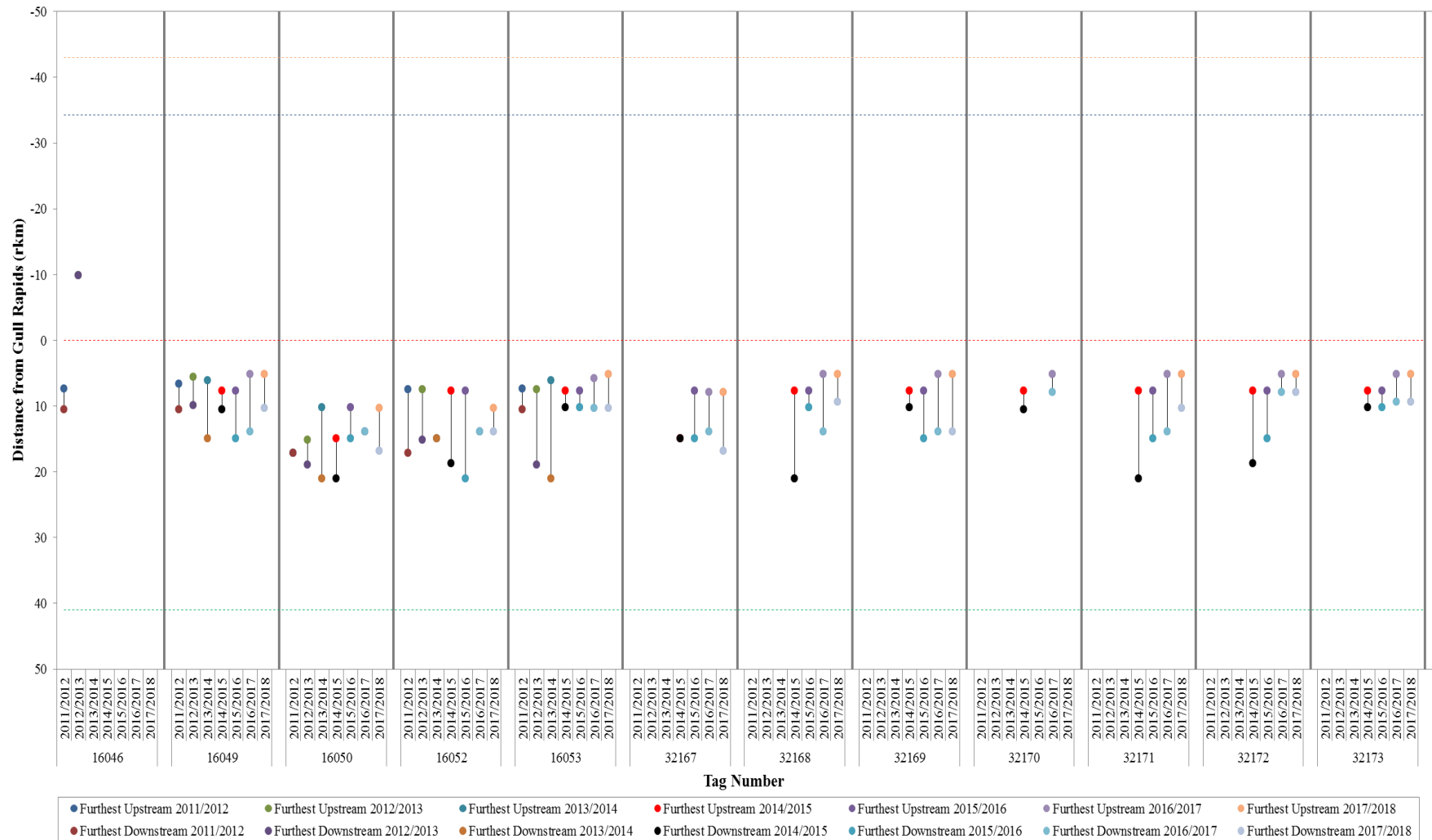


Figure 6: Detection ranges for individual adult Lake Sturgeon tagged with acoustic transmitters in Stephens Lake during the winter period (2011–2018). Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS) (continued).

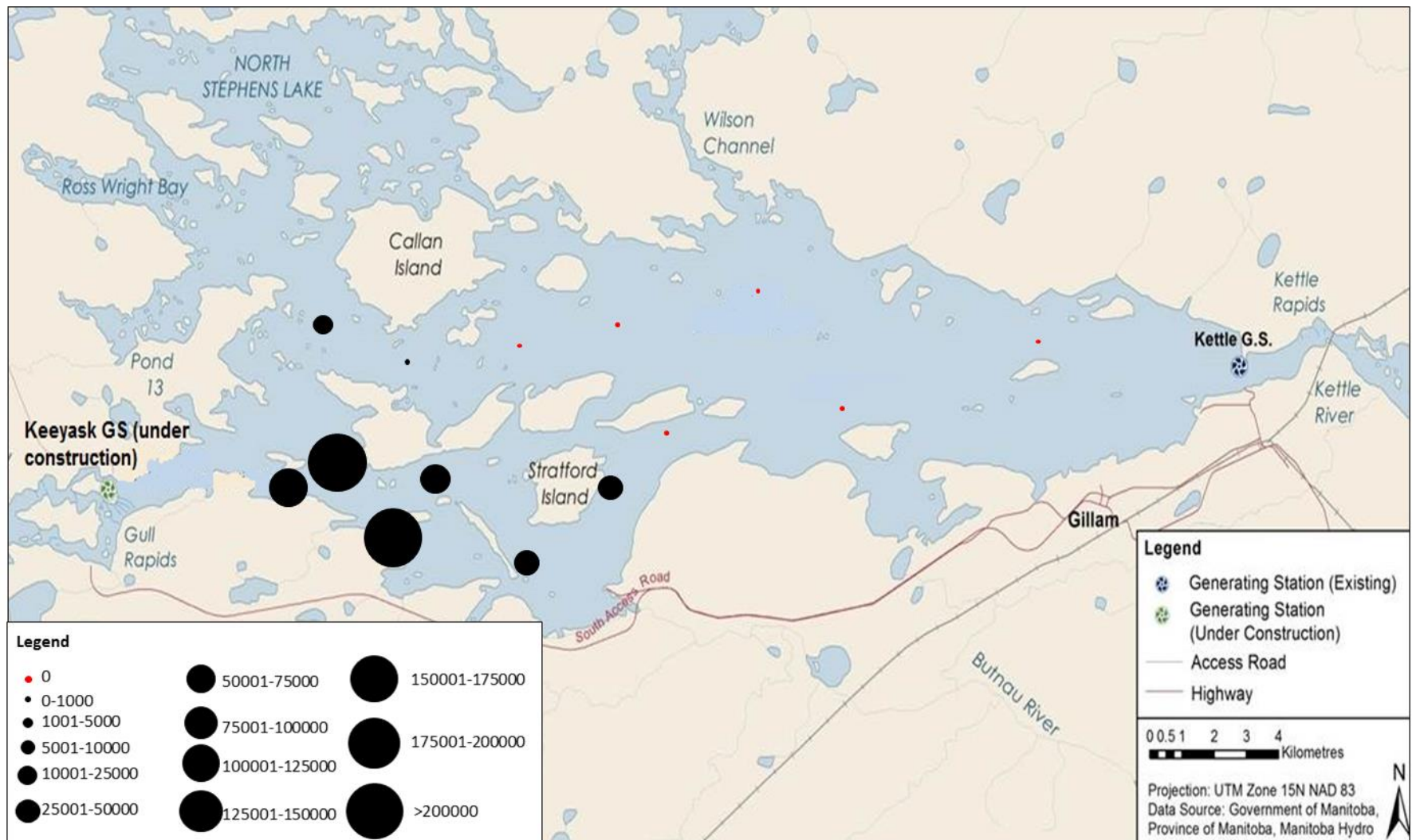


Figure 7: Relative number of detections at each acoustic receiver set in Stephens Lake during winter 2017/2018 (October 17, 2017, to April 30, 2018). Number of detections indicated by size of bubble (defined in legend). Receivers with no detections indicated with red dot.

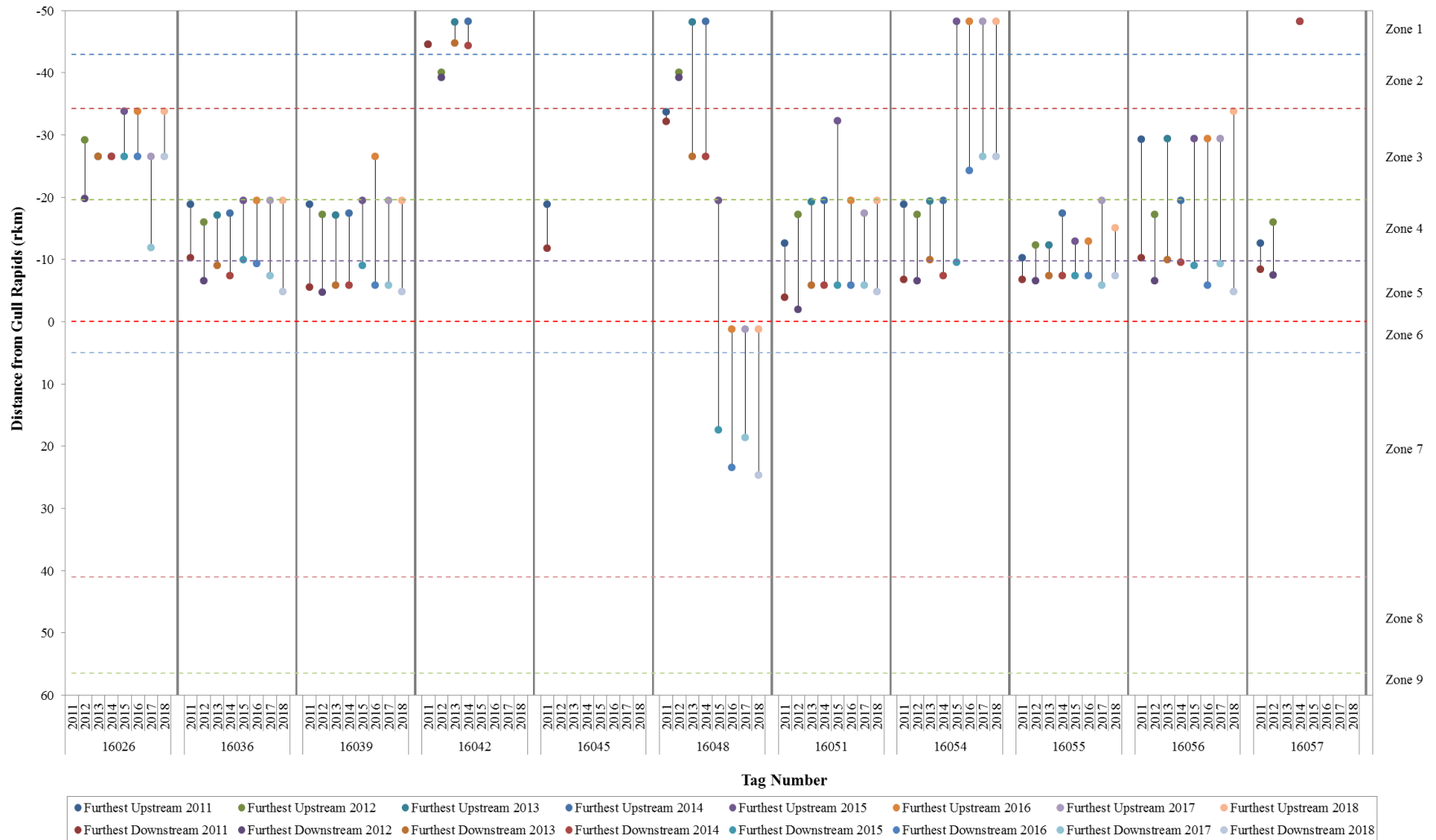


Figure 8: Detection ranges for individual adult Lake Sturgeon tagged with acoustic transmitters upstream of Gull Rapids during the open-water period (2011–2018). Horizontal dotted lines demarcate zones.

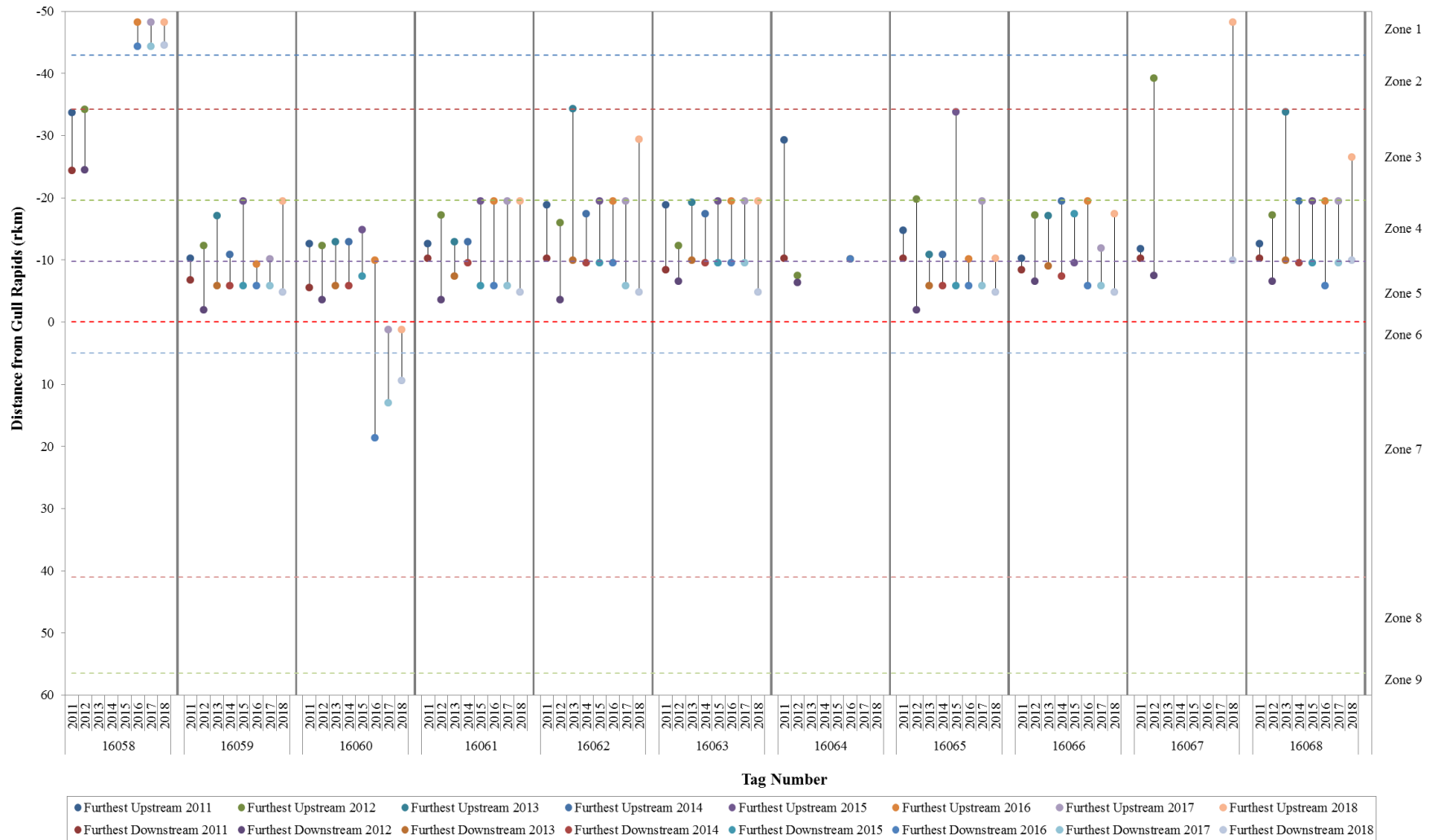


Figure 8: Detection ranges for individual adult Lake Sturgeon tagged with acoustic transmitters upstream of Gull Rapids during the open-water period (2011–2018). Horizontal dotted lines demarcate zones (continued).

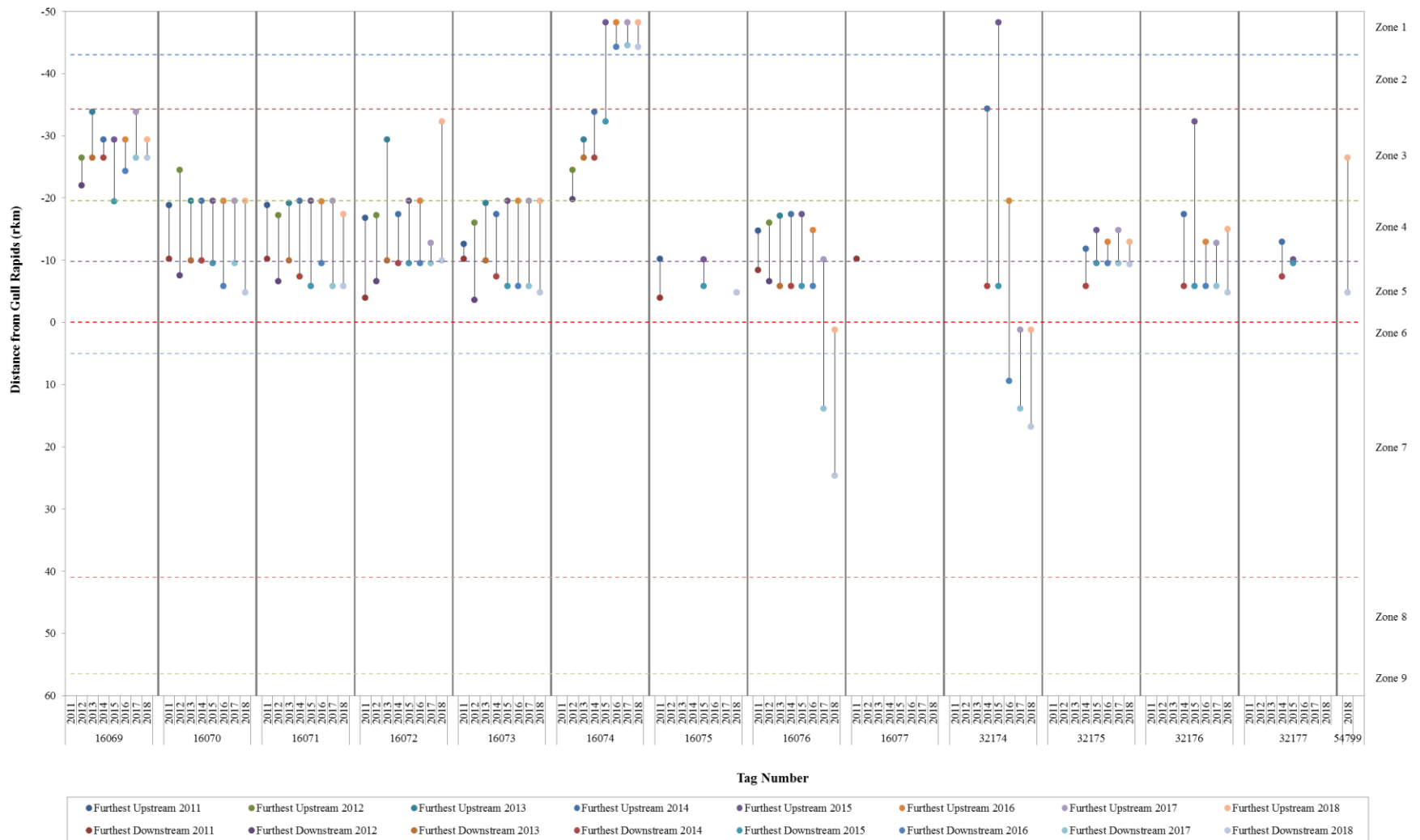


Figure 8: Detection ranges for individual adult Lake Sturgeon tagged with acoustic transmitters upstream of Gull Rapids during the open-water period (2011–2018). Horizontal dotted lines demarcate zones (continued).

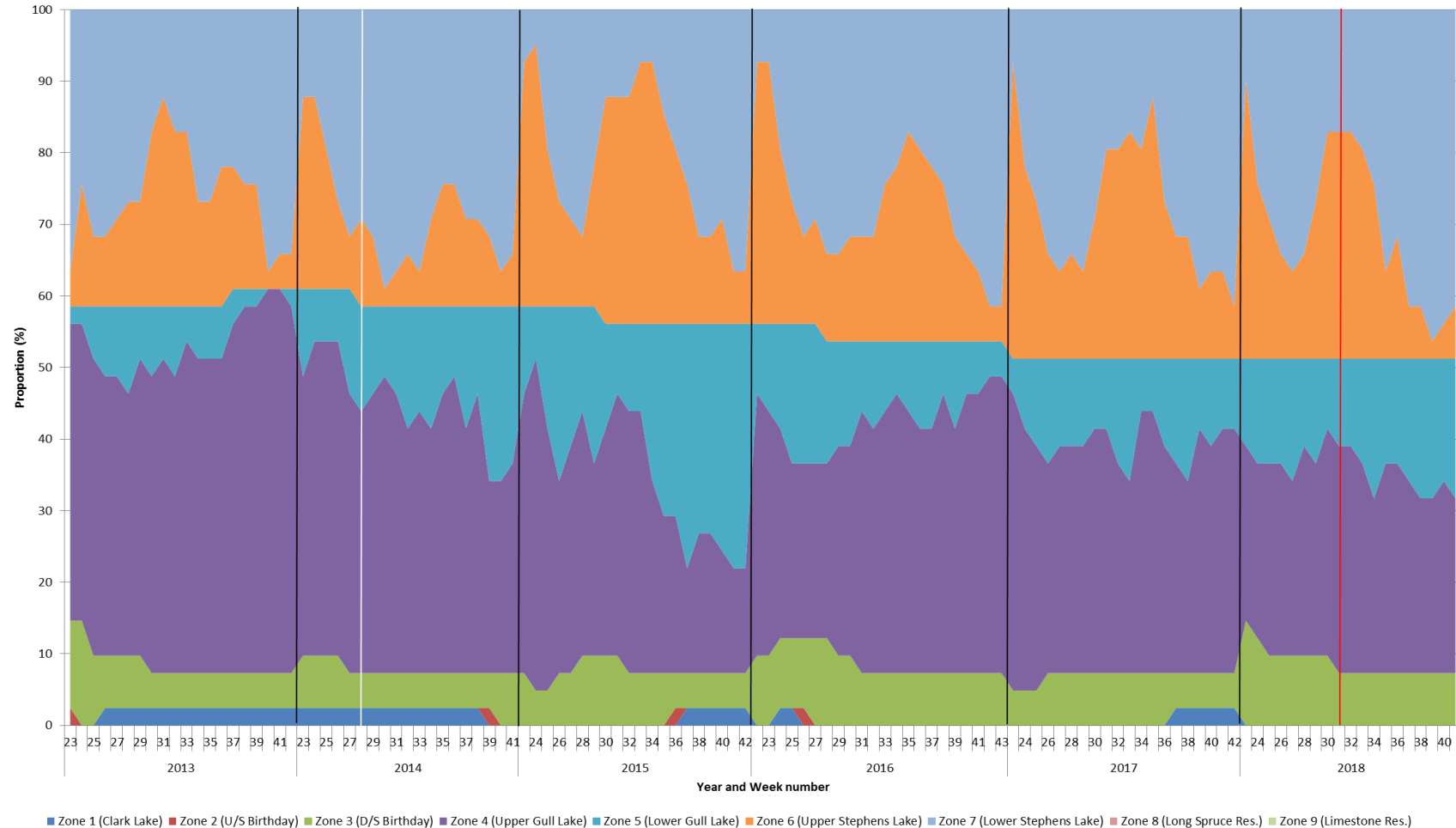


Figure 9: Proportional distribution by zone, for 43 adult Lake Sturgeon tagged with acoustic transmitters in the Keeyask GS Area during a portion of the 2013 (June 4 to October 15), 2014 (June 4 to October 3), 2015 (June 4 to October 11), 2016 (June 4 to October 19), 2017 (June 7 to October 16), and 2018 (June 6 to October 10) open-water periods. Only fish located in all five study years were included. Black lines indicate study years. White line indicates start of Keeyask construction. Red line indicates start of Keeyask spillway commissioning.

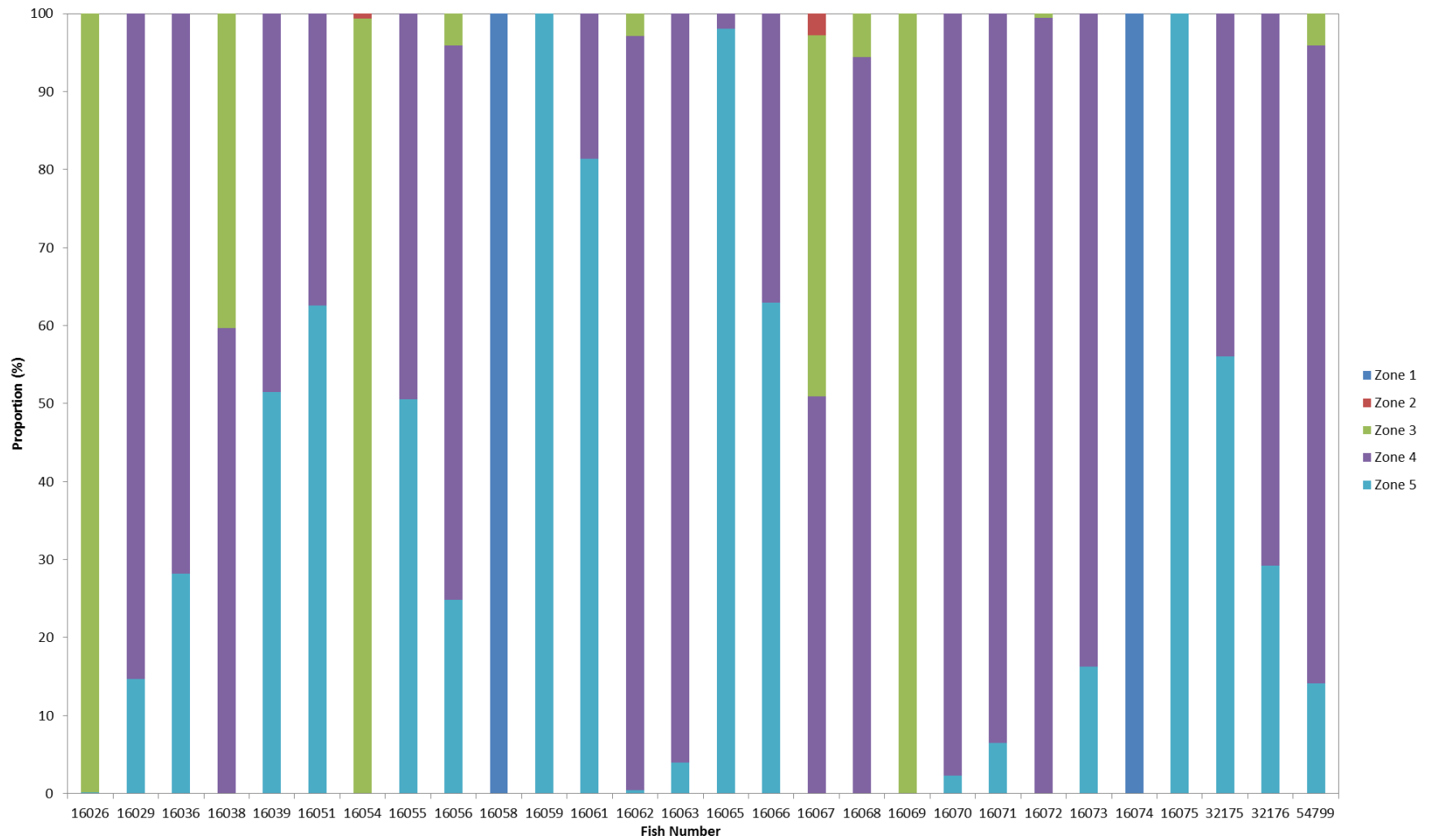


Figure 10: Proportional distributions by zone, for individual adult Lake Sturgeon tagged with acoustic transmitters upstream of Keeyask GS during a portion of the 2018 open-water period (June 6 to October 10).

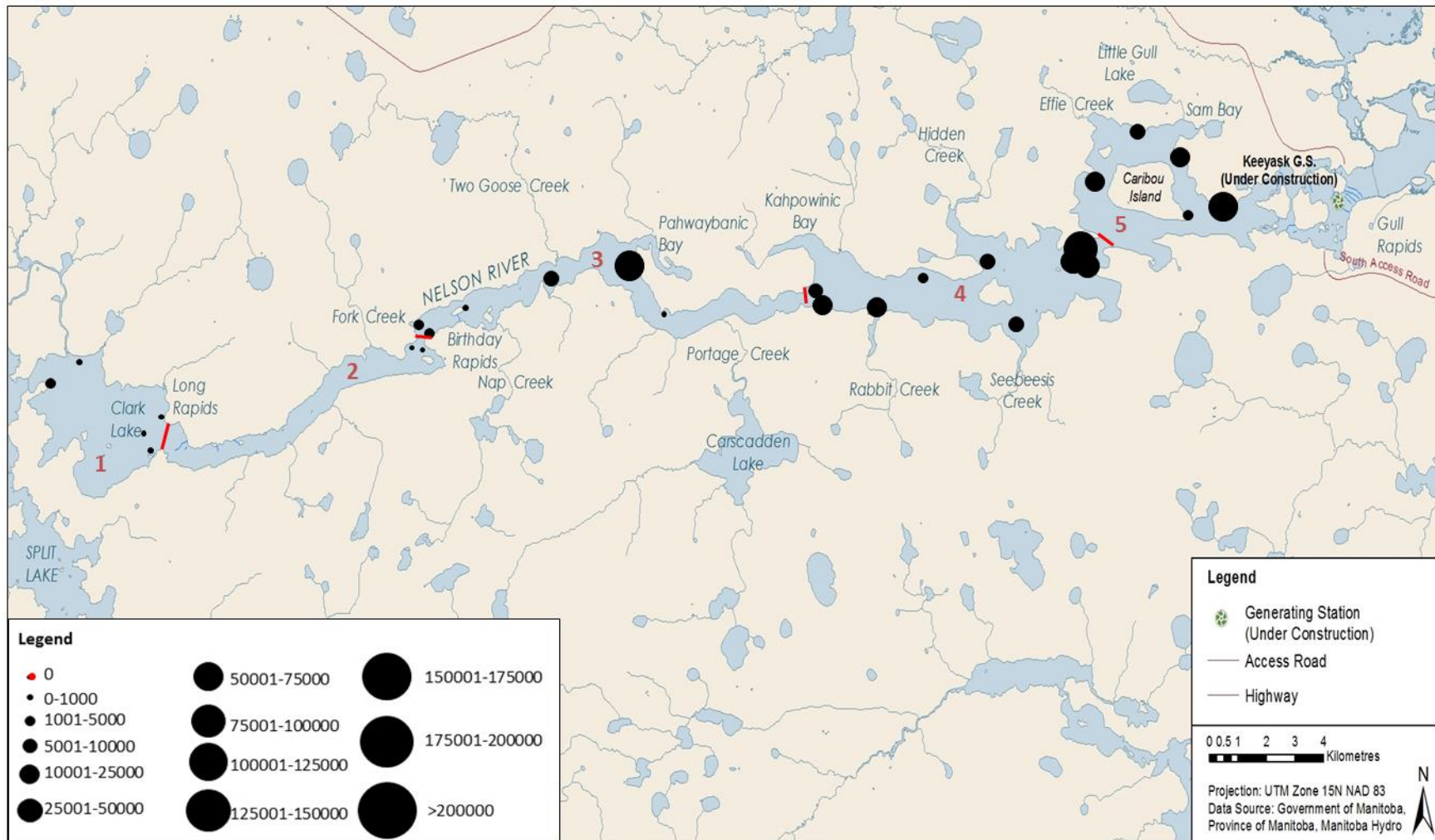


Figure 11: Relative number of detections at each acoustic receiver set in the Nelson River between Clark Lake and Gull Rapids during the 2018 open-water period (May 1 to October 10). Number of detections indicated by size of circle (defined in legend). Receivers with no detections indicated with red dot. The river is divided into five "zones" based on placement of receiver "gates."

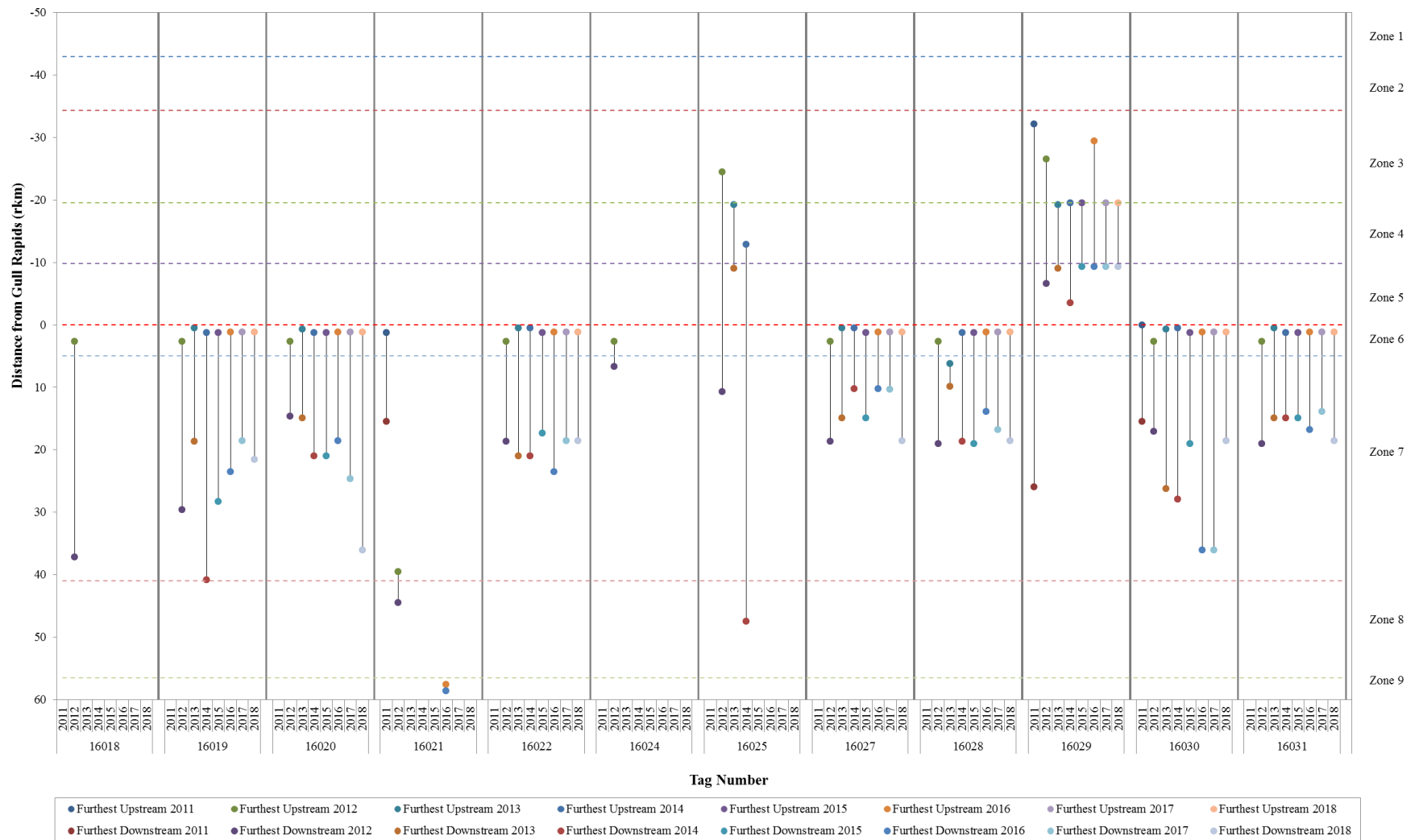


Figure 12: Detection ranges for individual adult Lake Sturgeon tagged with acoustic transmitters in Stephens Lake during the open-water period (2011–2018). Horizontal dotted lines demarcate zones.

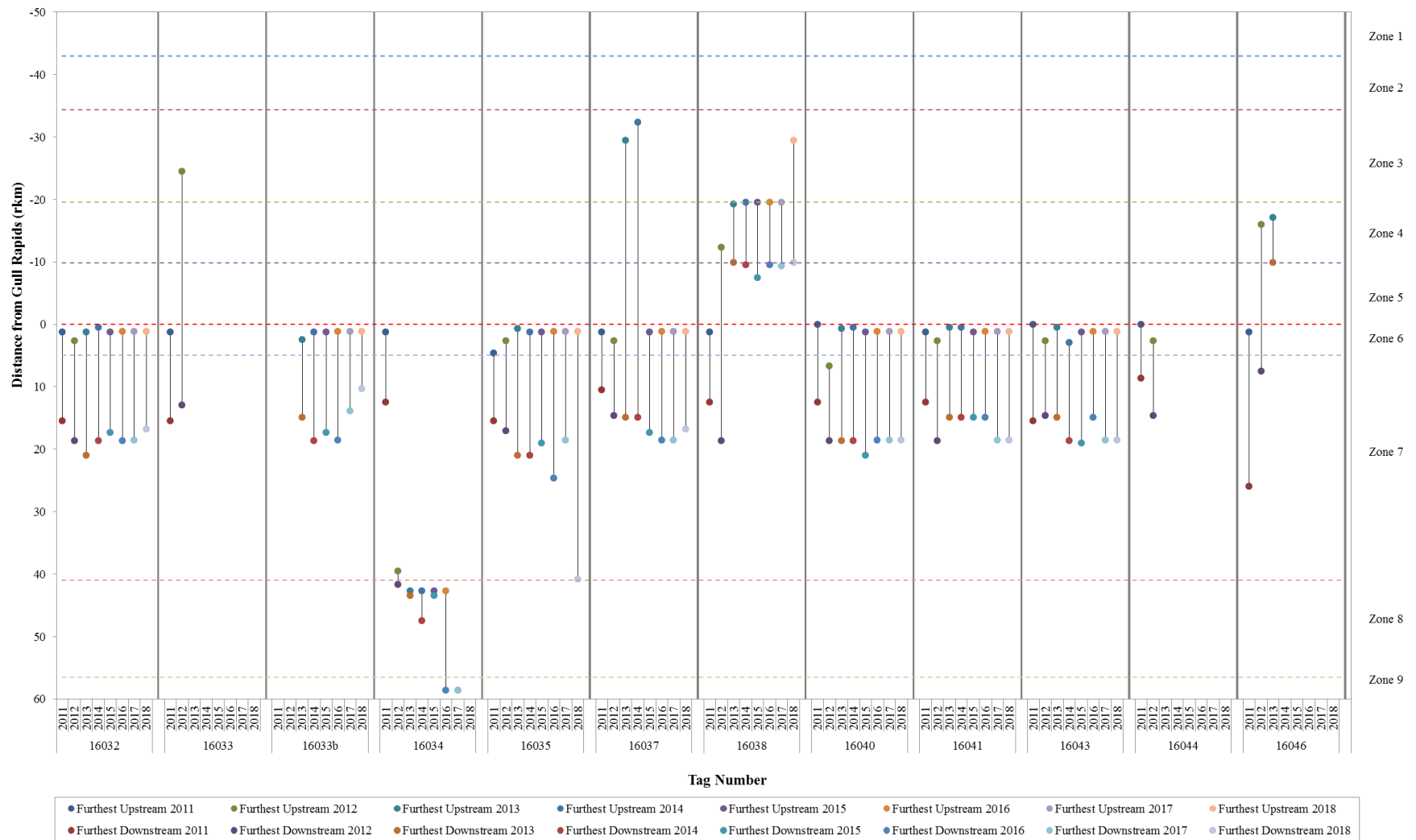


Figure 12: Detection ranges for individual adult Lake Sturgeon tagged with acoustic transmitters in Stephens Lake during the open-water period (2011–2018). Horizontal dotted lines demarcate zones (continued).

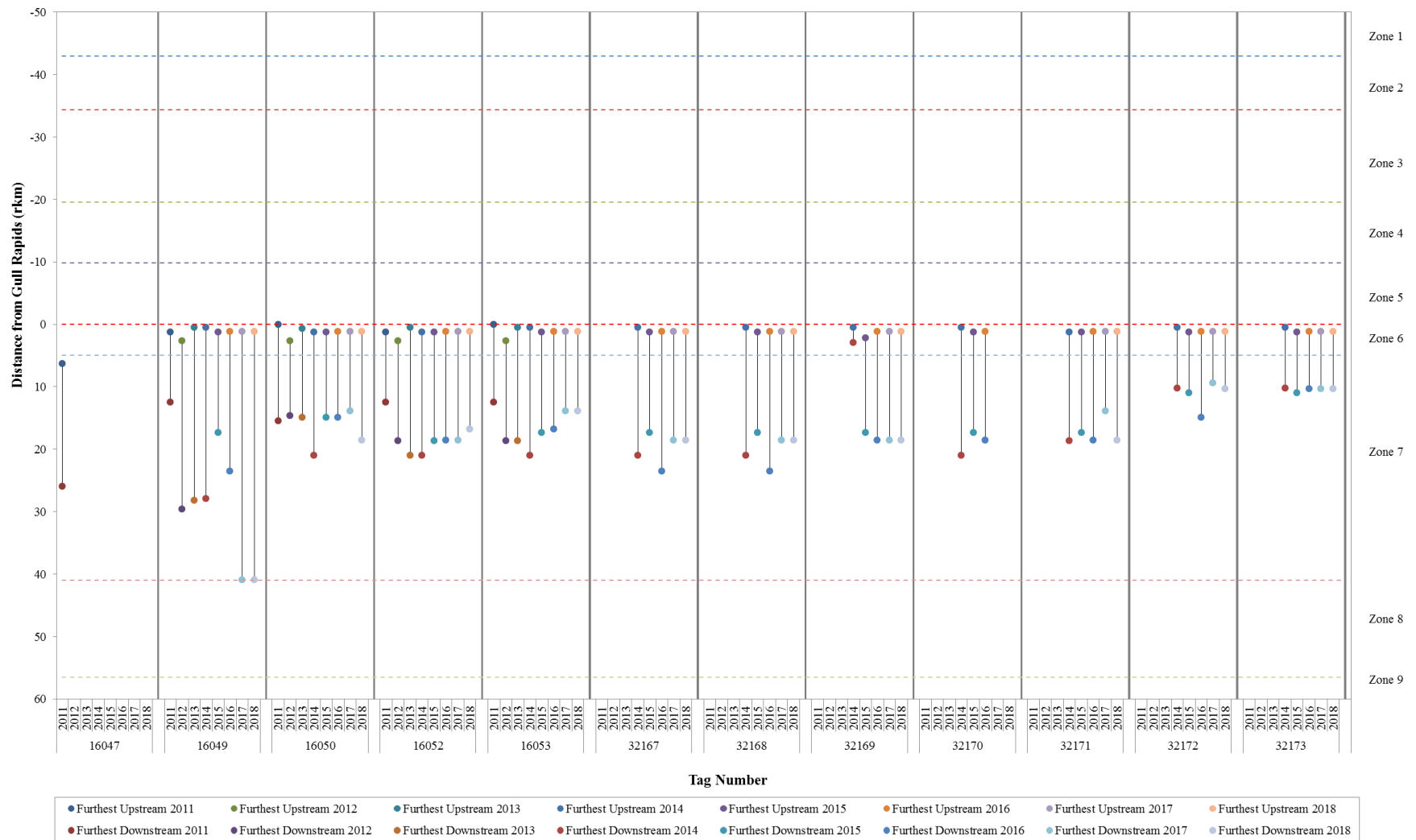


Figure 12: Detection ranges for individual adult Lake Sturgeon tagged with acoustic transmitters in Stephens Lake during the open-water period (2011–2018). Horizontal dotted lines demarcate zones (continued).

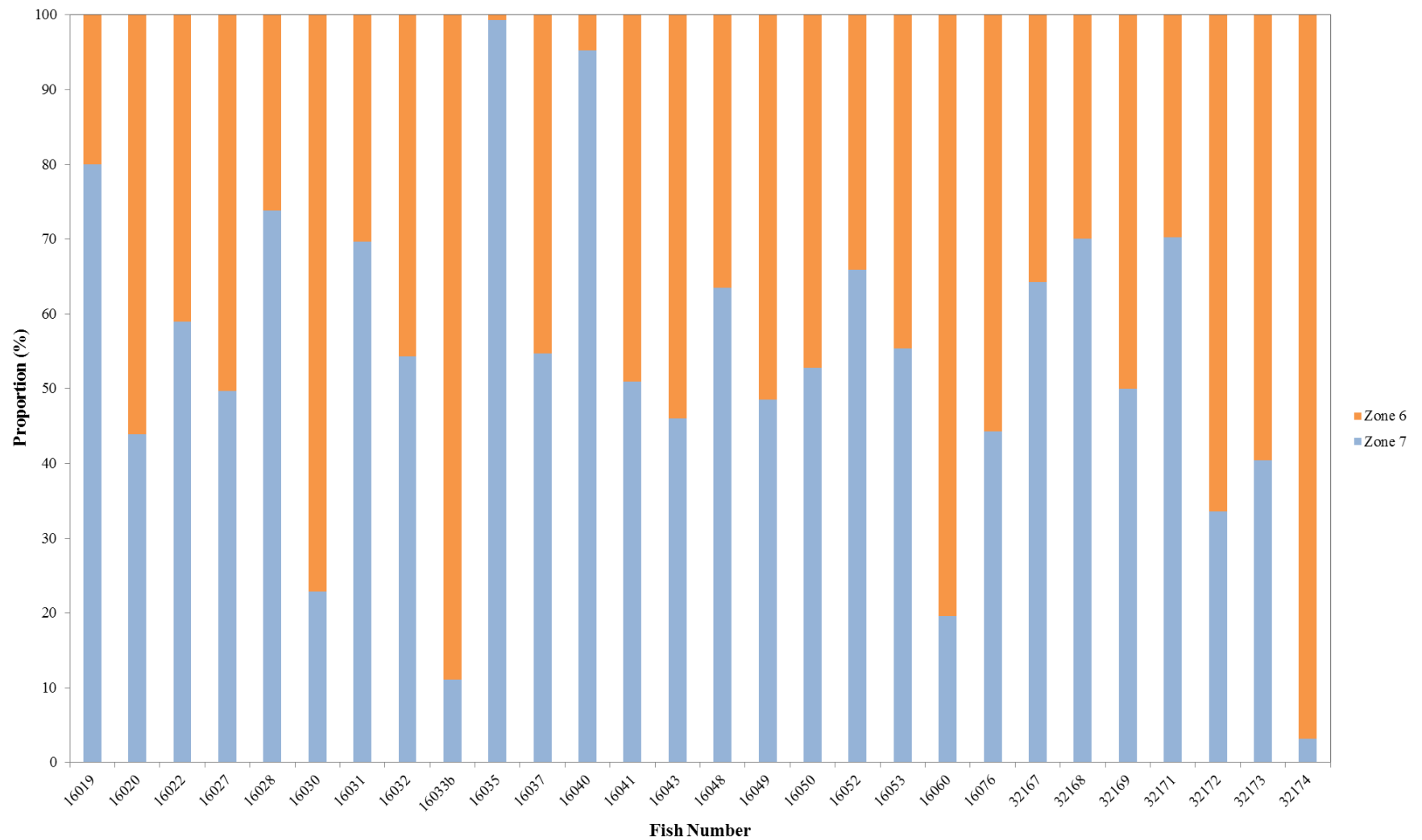


Figure 13: Proportional distributions by zone, for individual adult Lake Sturgeon tagged with acoustic transmitters in Stephens Lake during a portion of the 2018 open-water period (June 6 to October 10).

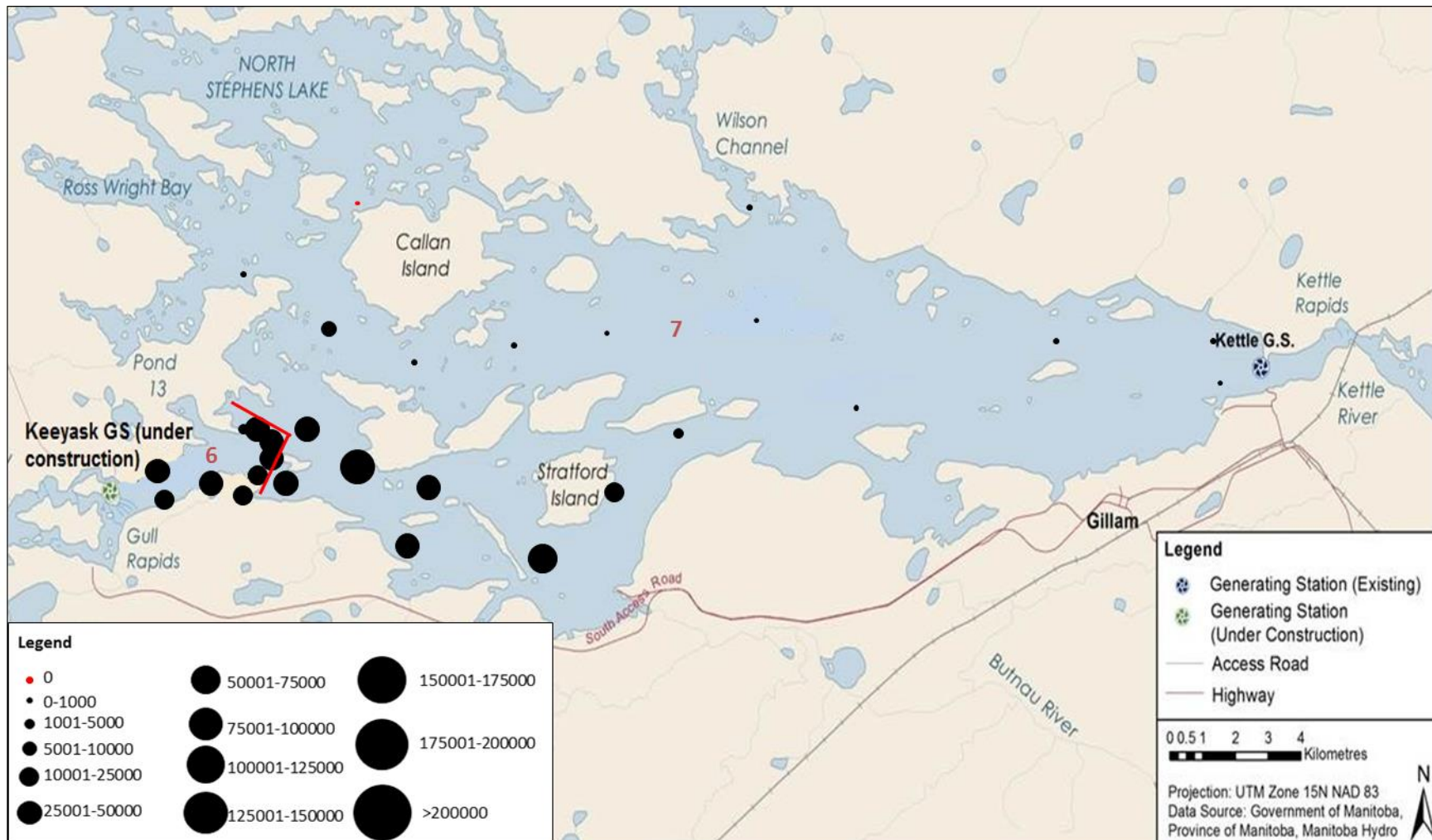


Figure 14: Relative number of detections at each acoustic receiver set in Stephens Lake during the 2018 open-water period (May 1 to October 10). Number of detections indicated by size of circle (defined in legend). Receivers with no detections indicated with red dot. The river is divided into two "zones" based on placement of receiver "gates."

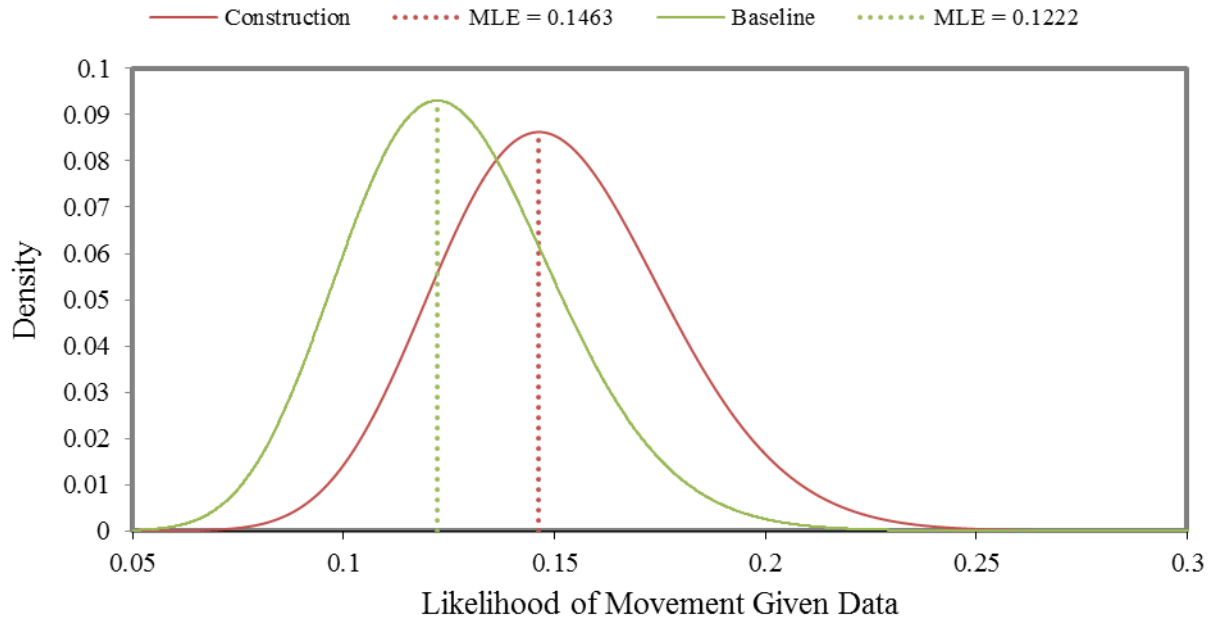


Figure 15: Likelihood of an adult Lake Sturgeon moving between river zones (either upstream or downstream) both before and after the onset of Keeyask construction.

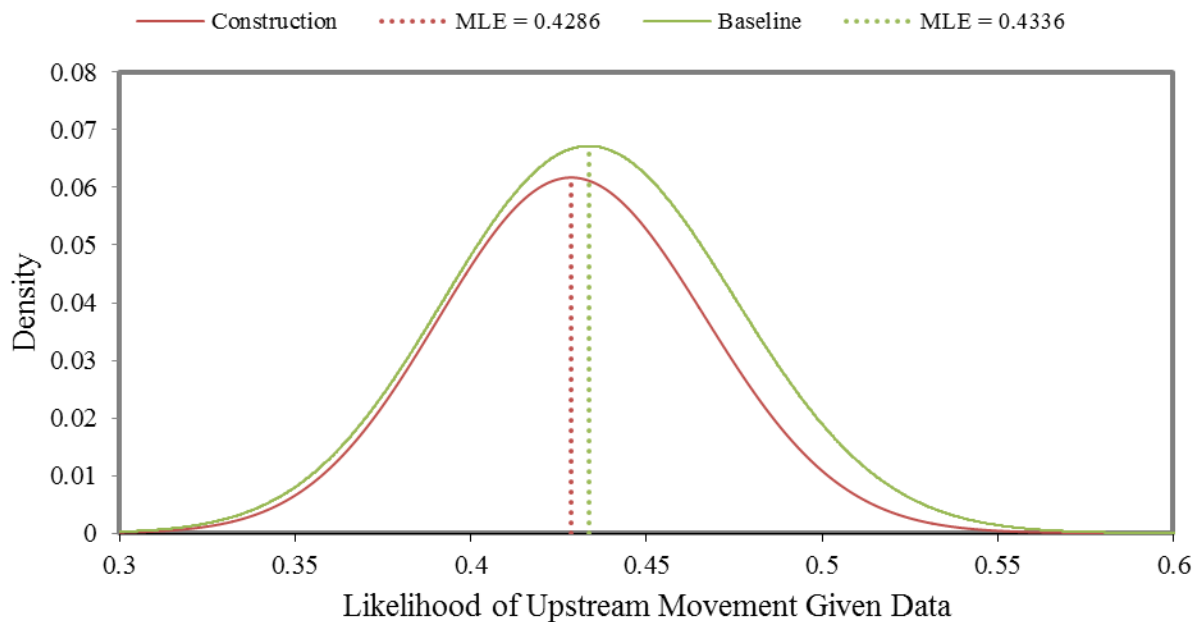


Figure 16: Likelihood that, if an adult Lake Sturgeon moves between river zones, the movement will be upstream both before and after the onset of Keeyask construction.

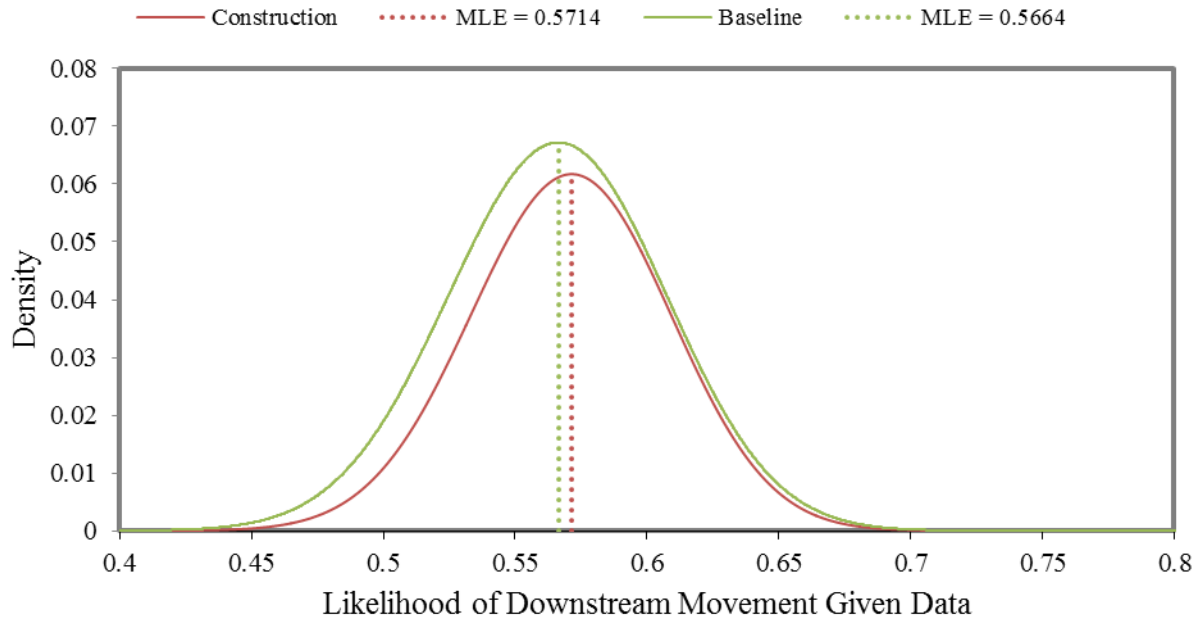


Figure 17: Likelihood that, if an adult Lake Sturgeon moves between river zones, the movement will be downstream both before and after the onset of Keeyask construction.

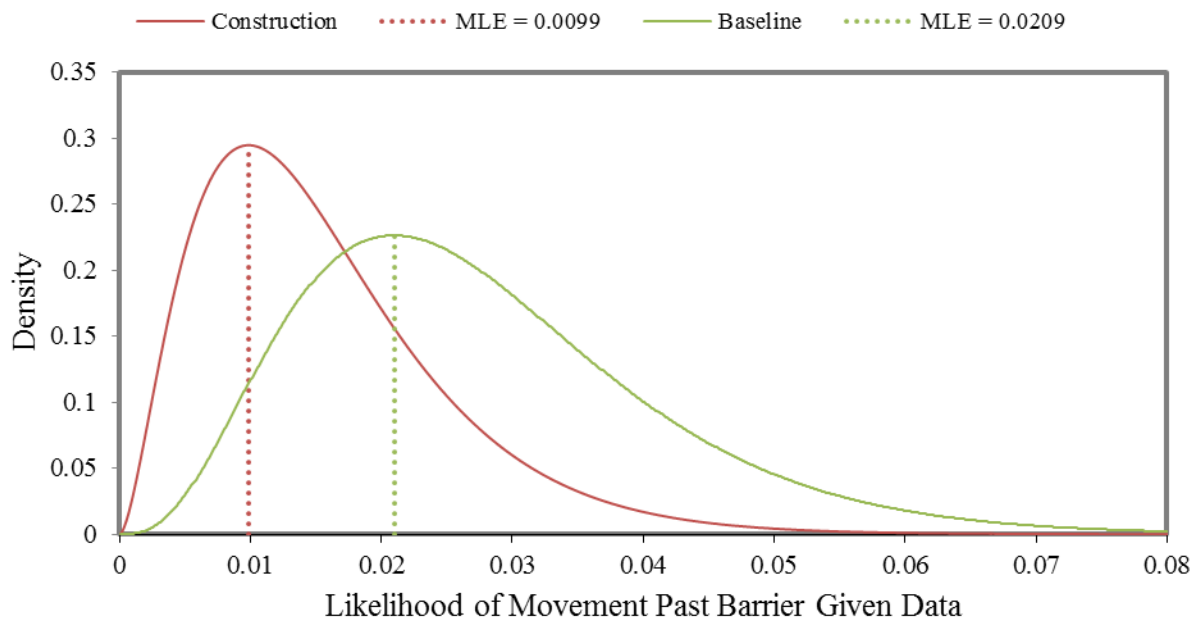
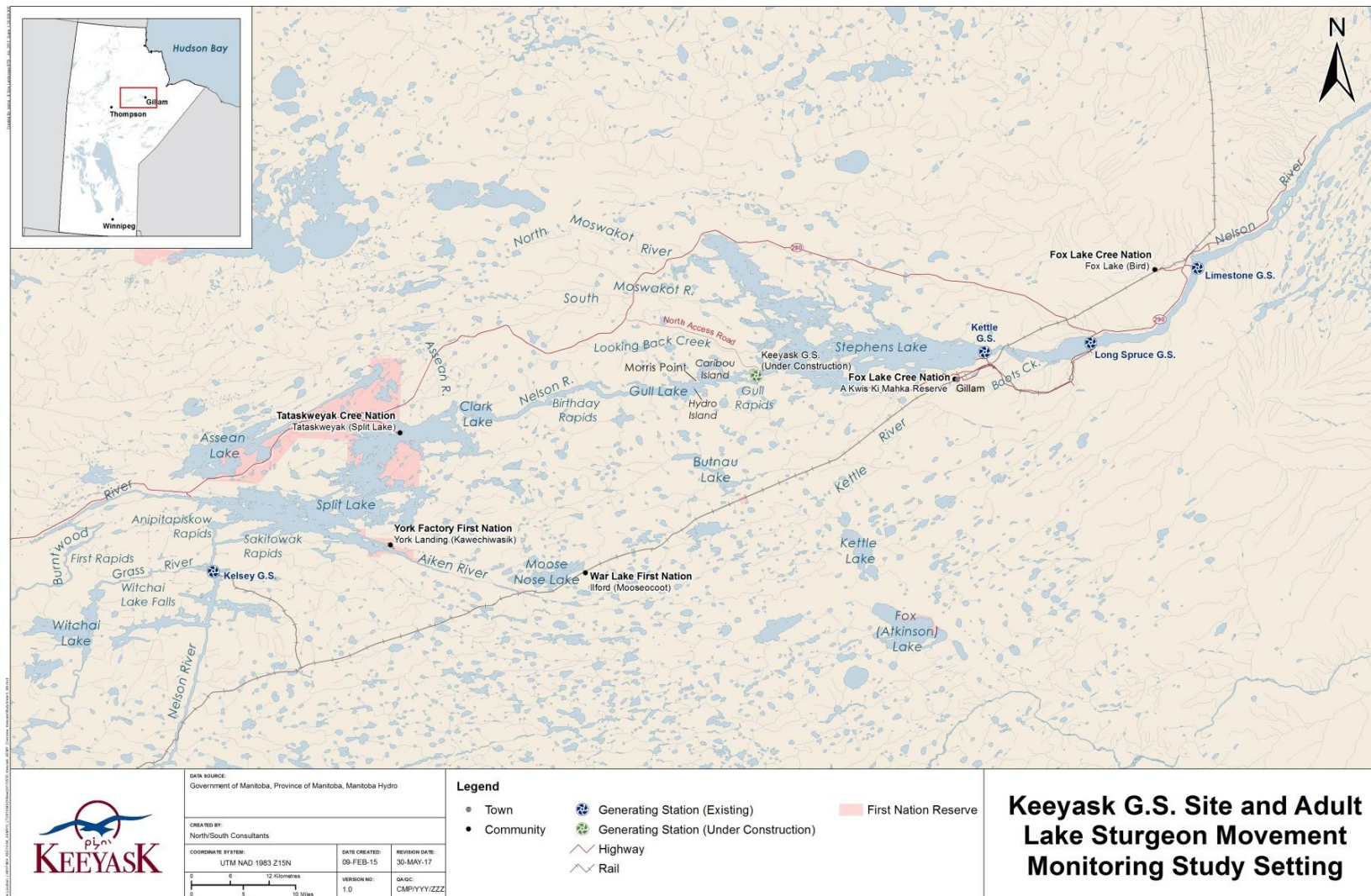
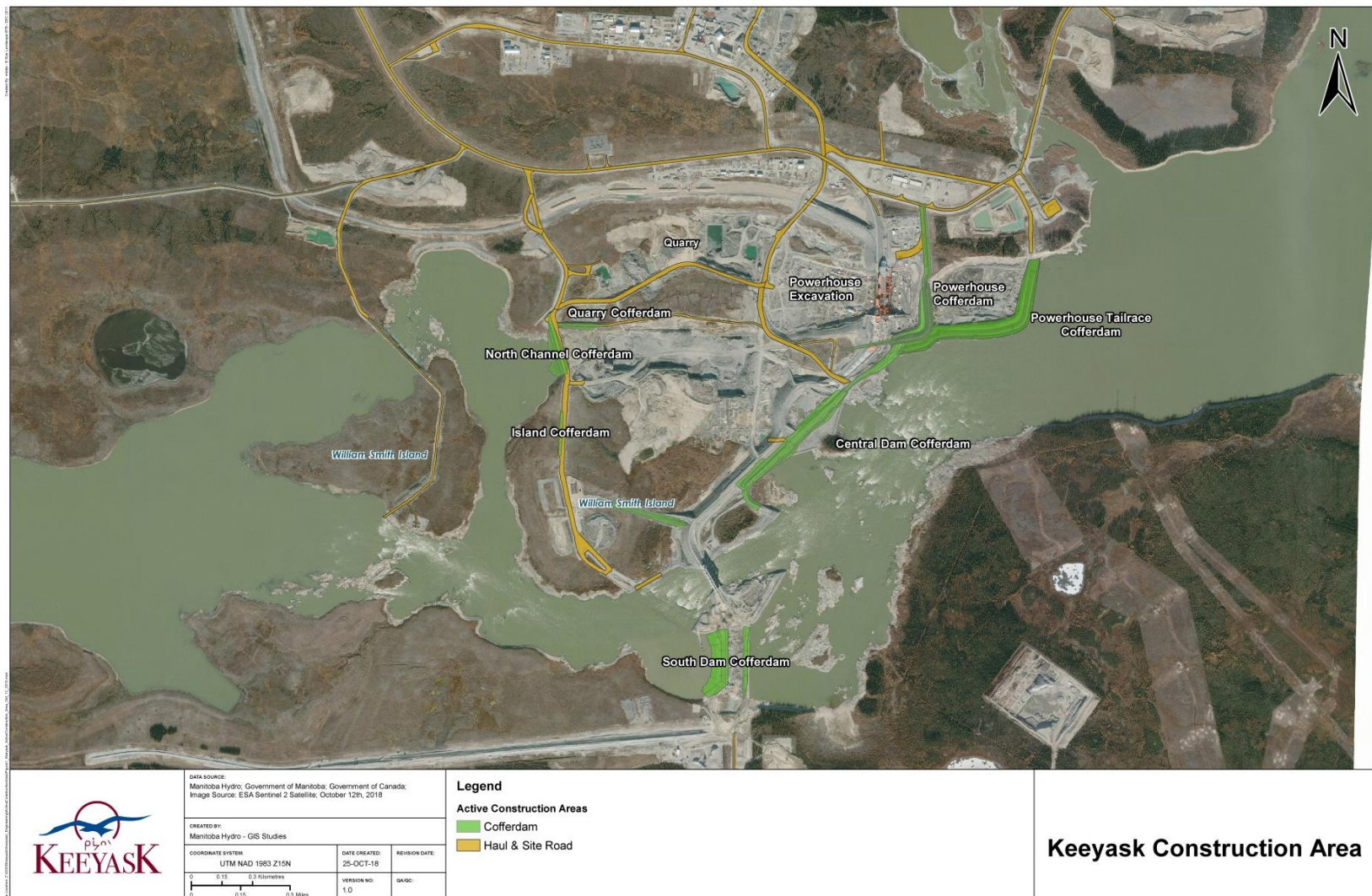


Figure 18: Likelihood of an adult Lake Sturgeon moving past a barrier (either Gull Rapids, Kettle GS, or Long Spruce GS) before and after the onset of Keeyask construction.

MAPS

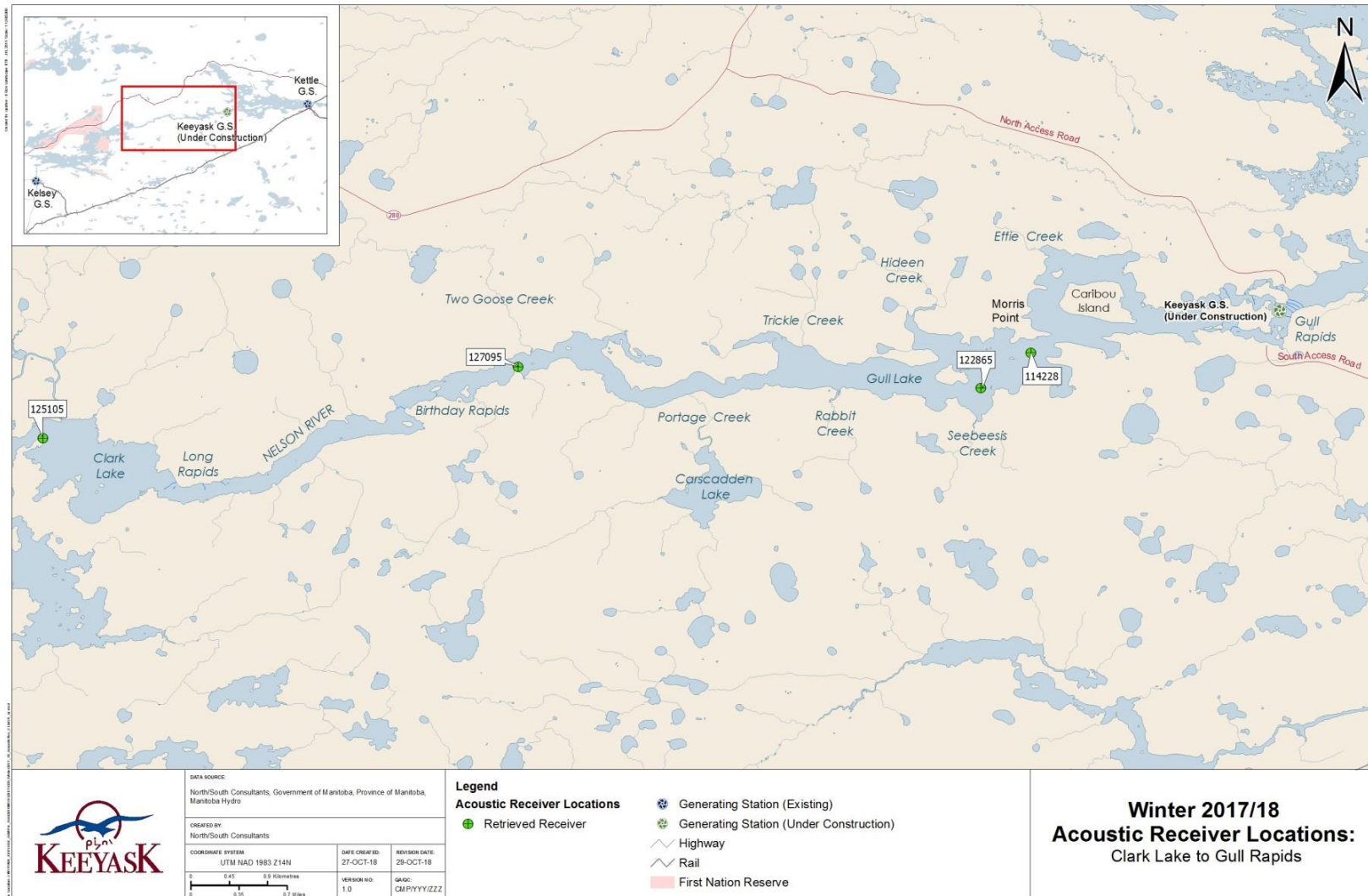


Map 1: Map of the Nelson River showing the site of the Keeyask Generating Station and the adult Lake Sturgeon movement monitoring study setting.

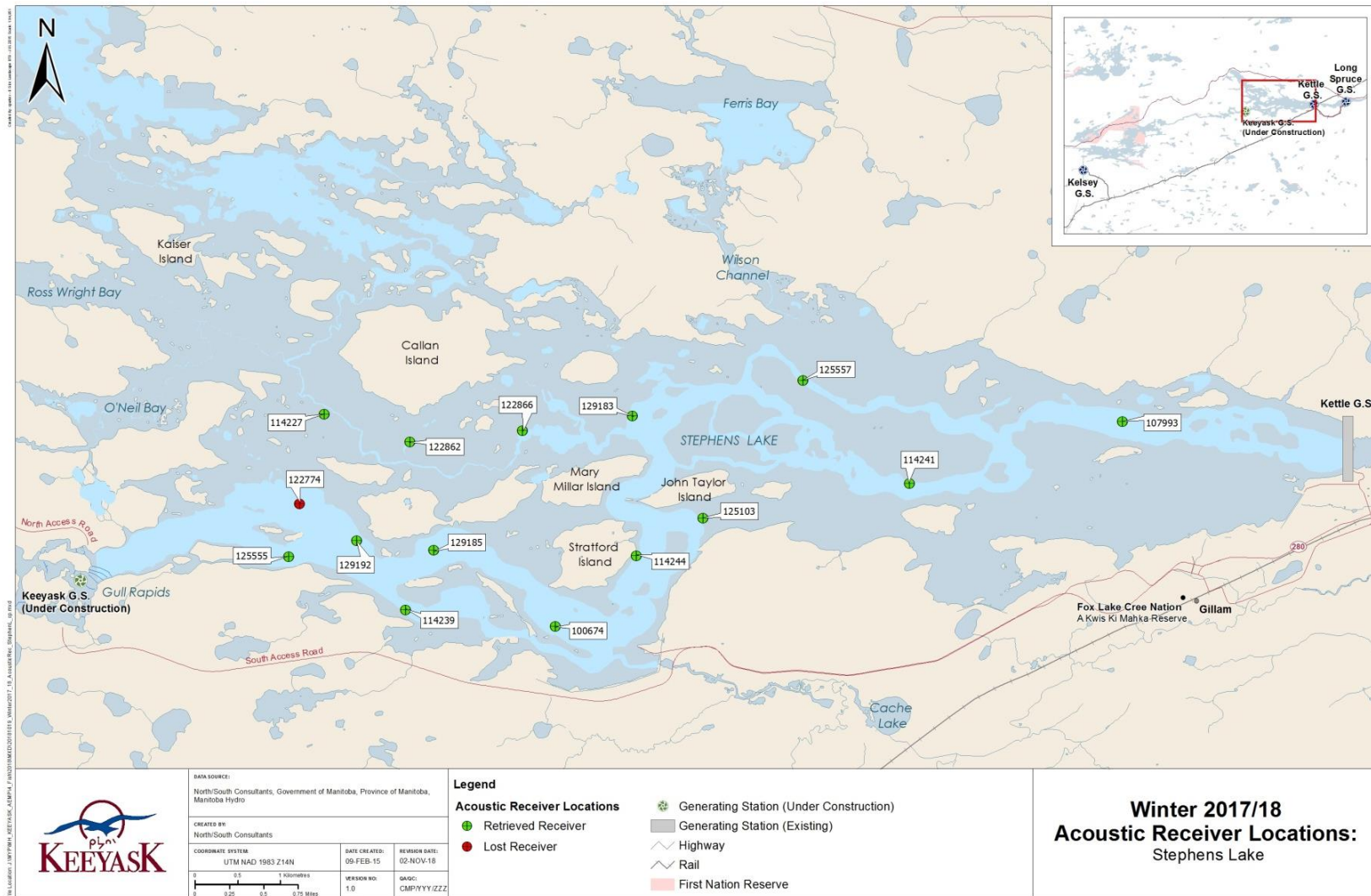


Satellite Imagery - October 12th, 2018

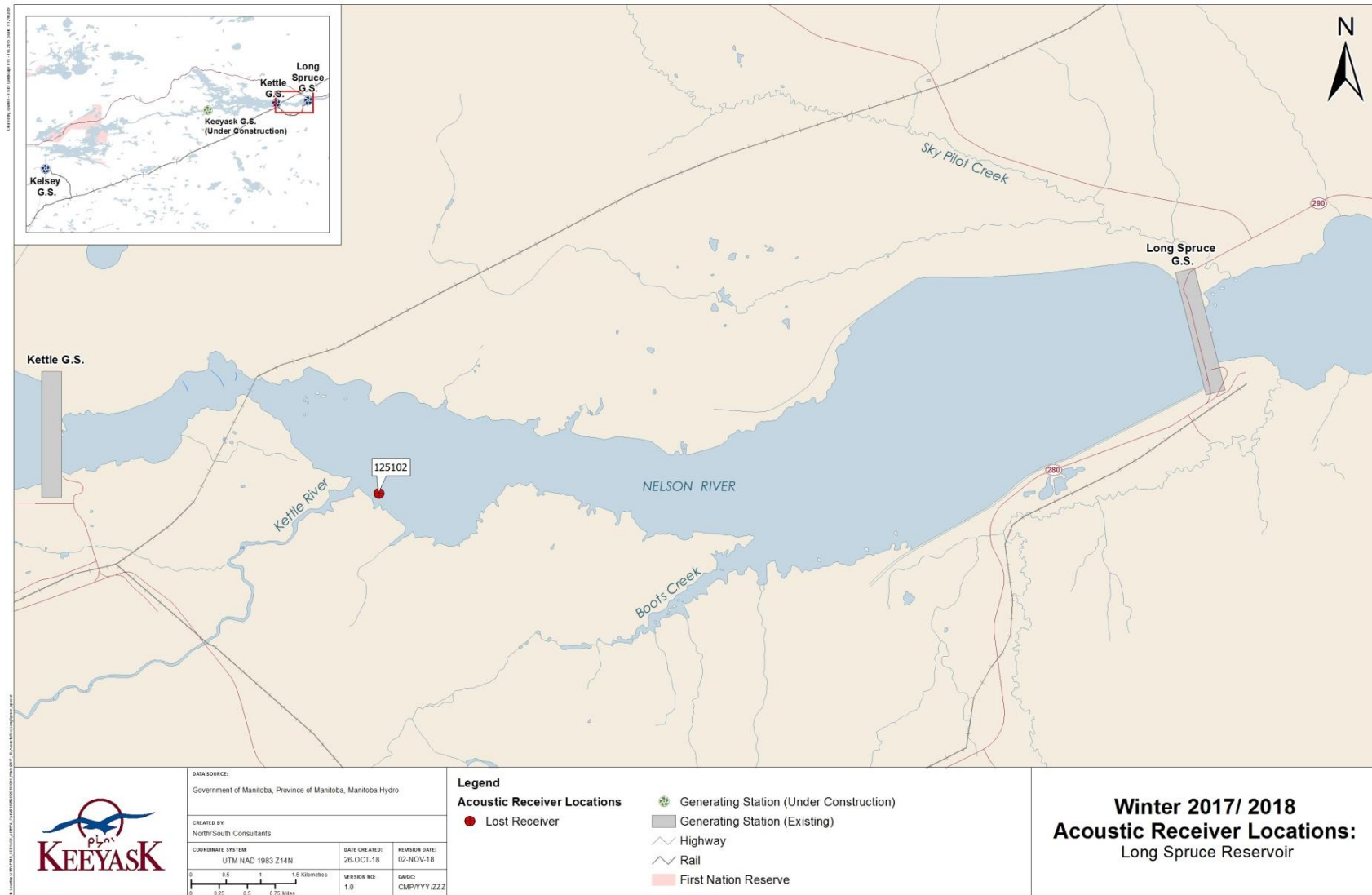
Map 2: Map of instream structures at the Keeyask Generating Station site, October 2018.



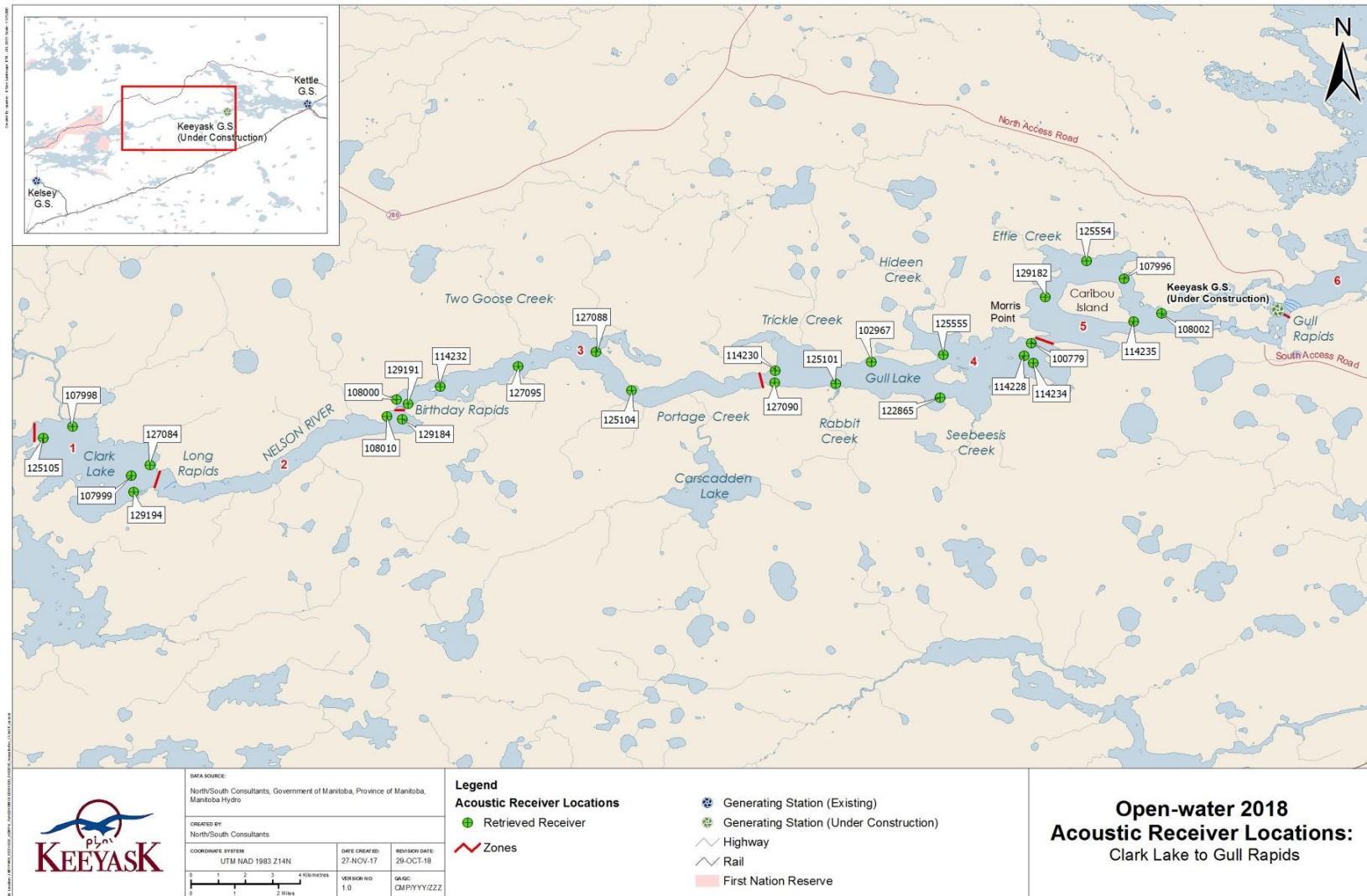
Map 3: Locations of stationary receivers set in the Nelson River from Clark Lake to Gull Rapids between October 2017 and June 2018.



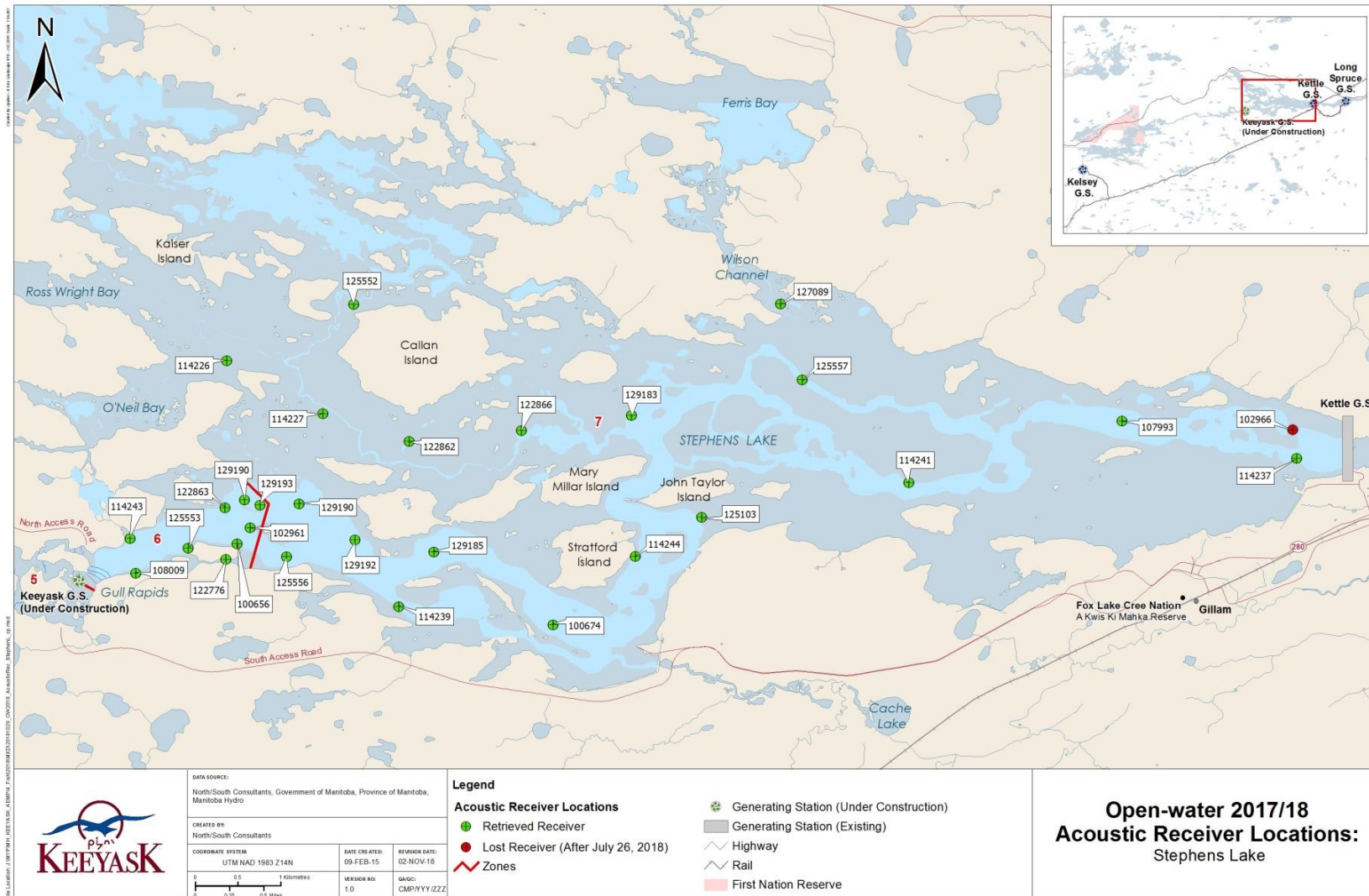
Map 4: Locations of stationary receivers set in Stephens Lake from Gull Rapids to Kettle GS between October 2017 and June 2018. The former (pre-impoundment) river channel is shown in light blue.



Map 5: Location of the stationary receiver set in the Long Spruce Reservoir between October 2017 and June 2018.



Map 6: Locations of stationary receivers set in the Nelson River from Clark Lake to Gull Rapids between June and October 2018. 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 2018. The river is divided into two "zones" based on placement of receiver "gates." The pre-impoundment river channel is shown in light blue.

APPENDICES

APPENDIX 1:

DETECTION SUMMARIES FOR LAKE STURGEON TAGGED AND MONITORED BETWEEN 2011 AND 2018

Table A1-1:	Detection summary for each of 35 Lake Sturgeon tagged and monitored upstream of Keeyask GS during the winter 2011/2012 (October 20, 2011 to April 30, 2012), 2012/2013 (October 16, 2012 to April 30, 2013), 2013/2014 (October 16, 2013 to April 30, 2014), 2014/2015 (October 13, 2014 to April 30, 2015), 2015/2016 (October 12, 2015 to April 30, 2016), 2016/2017 (October 20, 2015 to April 30, 2017), and 2017/2018 (October 17, 2017 to April 30, 2018) periods.....	69
Table A1-2:	Detection summary for each of 36 Lake Sturgeon tagged and monitored in Stephens Lake during the winter 2011/2012 (October 20, 2011 to April 30, 2012), 2012/2013 (October 16, 2012 to April 30, 2013), 2013/2014 (October 16, 2013 to April 30, 2014), 2014/2015 (October 13, 2014 to April 30, 2015), 2015/2016 (October 12, 2015 to April 30, 2016), 2016/2017 (October 20, 2015 to April 30, 2017), and 2017/2018 (October 17, 2017 to April 30, 2018) periods.....	70
Table A1-3:	Detection summary for each of 36 Lake Sturgeon tagged and monitored upstream of Keeyask GS during the open-water 2011 (June 1 to October 20), 2012 (May 1 to October 16), 2013 (May 1 to October 16), 2014 (May 1 to October 13), 2015 (May 1 to October 11), 2016 (May 1 to October 19), 2017 (May 1 to October 16), and 2018 (May 1 to October 10) periods.....	71
Table A1-4:	Detection summary for each of 36 Lake Sturgeon tagged and monitored in Stephens Lake during the open-water 2011 (June 1 to October 20), 2012 (May 1 to October 16), 2013 (May 1 to October 16), 2014 (May 1 to October 13), 2015 (May 1 to October 11), 2016 (May 1 to October 19), 2017 (May 1 to October 16), and 2018 (May 1 to October 10) periods.....	72

Table A1-1: Detection summary for each of 35 Lake Sturgeon tagged and monitored upstream of Keeyask GS during the winter 2011/2012 (October 20, 2011 to April 30, 2012), 2012/2013 (October 16, 2012 to April 30, 2013), 2013/2014 (October 16, 2013 to April 30, 2014), 2014/2015 (October 13, 2014 to April 30, 2015), 2015/2016 (October 12, 2015 to April 30, 2016), 2016/2017 (October 20, 2015 to April 30, 2017), and 2017/2018 (October 17, 2017 to April 30, 2018) periods. Tag id highlighted yellow = lost tags. Tag id highlighted purple = moved downstream through Gull Rapids.

Tag ID	2011/2012			2012/2013			2013/2014			2014/2015			2015/2016			2016/2017			2017/2018				
	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	U/S (rkm)	D/S (rkm)	Range (rkm)
16026	0	-	-	0	-	-	0	-	-	0	-	-	811	3	0.0	0	-	-	0	-	-	-	-
16036	2537	118	3.0	43	12	0.0	2326	52	0.0	362	16	0.0	4663	44	0.0	19532	105	0.0	716	32	-12.4	-10.3	2.1
16039	0	-	-	0	-	-	502	10	3.0	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16042	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16045	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16048	0	-	-	0	-	-	2932	66	0.0	0	-	-	11672	60	13.3	28566	172	8.7	43161	190	5.2	10.3	5.1
16051	2475	51	0.0	7088	93	0.0	14618	92	3.0	0	-	0	13958	92	3.0	8873	101	0.0	18985	112	-10.3	-10.3	0.0
16054	2772	40	5.1	4027	66	0.0	10807	83	3.0	0	-	0	0	-	-	0	-	-	0	-	-	-	-
16055	0	-	-	0	-	-	0	-	-	0	-	0.0	0	-	-	0	-	-	0	-	-	-	-
16056	8711	176	0.0	1893	63	0.0	13493	87	0.0	0	-	0.0	12493	70	0.0	6661	102	0.0	16905	103	-10.3	-10.3	0.0
16057	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16058	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16059	0	-	-	0	-	-	0	-	-	0	-	0.0	0	-	-	0	-	-	0	-	-	-	-
16060	11406	138	0.0	4354	75	0.0	25171	137	0.0	0	-	0.0	12623	76	0.0	8361	82	2.7	281	5	5.2	9.4	4.2
16061	13225	94	4.3	1157	71	0.0	18018	115	0.0	140	11	0.0	16584	98	0.0	911	26	0.0	2403	34	-12.4	-10.3	2.1
16062	5943	148	0.0	2495	48	0.0	9079	120	0.0	0	-	0.0	12485	88	0.0	12753	107	0.0	17968	107	-10.3	-10.3	0.0
16063	7905	134	5.1	3650	60	0.0	6098	84	0.0	739	10	0.0	17893	101	0.0	14630	106	0.0	12976	80	-12.4	-10.3	2.1
16064	6717	139	0.0	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16065	3485	129	0.0	0	-	-	0	-	-	0	-	0.0	0	-	-	0	-	-	0	-	-	-	-
16066	0	-	-	0	-	-	0	-	-	0	-	0.0	12928	84	0.0	0	-	-	0	-	-	-	-
16067	4542	149	3.0	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16068	272	15	3.0	5623	73	0.0	22744	129	0.0	0	-	0.0	32671	142	0.0	17400	106	0.0	20418	116	-10.3	-10.3	0.0
16069	0	-	-	0	-	-	678	4	0.0	0	-	-	20	2	0.0	0	-	-	0	-	-	-	-
16070	12833	184	0.0	2	1	0.0	33086	118	0.0	0	-	-	2	1	0.0	23	6	0.0	144	14	-12.4	-10.3	2.1
16071	7247	122	0.0	2351	38	0.0	11439	95	0.0	0	-	0.0	21854	118	0.0	7883	102	0.0	18505	100	-10.3	-10.3	0.0
16072	11220	174	0.0	11687	96	0.0	27653	142	3.0	958	5	0.0	10157	74	0.0	17250	108	0.0	22681	115	-10.3	-10.3	0.0
16073	2647	51	3.0	3284	66	0.0	1213	18	0.0	800	6	3.4	761	17	0.0	170	15	0.0	1629	83	-10.3	-10.3	0.0
16074	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16075	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16076	0	-	-	0	-	-	0	-	-	0	-	0.0	0	-	-	11940	102	0	51871	187	5.2	10.3	5.1
16077	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
32174	-	-	-	-	-	-	-	-	-	0	-	0.0	988	36	0.0	0	-	-	0	-	-	-	-
32175	-	-	-	-	-	-	-	-	-	0	-	-	0	-	-	6228	75	0	7739	101	-10.3	-10.3	0.0
32176	-	-	-	-	-	-	-	-	-	0	-	0.0	13046	87	0.0	13507	103	0.0	25715	118	-10.3	-10.3	0.0
32177	-	-	-	-	-	-	-	-	-	0	-	0.0	0	-	-	0	-	-	0	-	-	-	-

Table A1-2: Detection summary for each of 36 Lake Sturgeon tagged and monitored in Stephens Lake during the winter 2011/2012 (October 20, 2011 to April 30, 2012), 2012/2013 (October 16, 2012 to April 30, 2013), 2013/2014 (October 16, 2013 to April 30, 2014), 2014/2015 (October 13, 2014 to April 30, 2015), 2015/2016 (October 12, 2015 to April 30, 2016), 2016/2017 (October 20, 2015 to April 30, 2017), and 2017/2018 (October 17, 2017 to April 30, 2018) periods. Tag id highlighted green = moved upstream over Gull Rapids and harvested. Tag id highlighted blue = moved upstream over Gull Rapids. Tag id highlighted yellow = lost tags. Tag id highlighted red = moved downstream through Kettle GS. Tag id highlighted purple = moved downstream through Gull Rapids. Tag id highlighted orange = moved downstream through Long Spruce GS.

Tag ID	2011/2012			2012/2013			2013/2014			2014/2015			2015/2016			2016/2017			2017/2018				
	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	U/S (rkm)	D/S (rkm)	Range (rkm)
16018	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16019	0	-	-	887	39	0.6	2959	33	8.8	8761	79	2.8	14035	107	13.3	34307	144	8.7	49386	193	5.2	13.9	8.7
16020	0	-	-	3625	25	9.5	24335	102	8.8	6183	36	7.2	36598	188	7.2	40522	181	8.7	43215	188	5.2	13.9	8.7
16021	16475	79	29.2	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16022	0	-	-	1227	15	9.5	7508	83	4.1	10649	55	7.2	45870	197	7.2	21329	149	5.1	32696	193	5.2	10.3	5.1
16024	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16025	0	-	-	1974	47	0.0	20670	114	0.0	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16027	0	-	-	3398	70	4.3	2111	24	1.6	23369	120	2.8	50070	189	13.3	17718	175	4.2	32484	177	5.2	10.3	5.1
16028	0	-	-	733	7	9.5	2123	8	14.9	21803	84	2.8	59177	199	2.5	5377	104	5.1	52456	184	5.2	10.3	5.1
16029	1937	39	9.7	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	16781	85	-10.3	-10.3	0.0
16030	12583	70	3.9	13733	89	4.3	2887	63	8.8	8872	97	7.2	24440	160	7.2	29177	156	4.2	49491	192	5.2	10.3	5.1
16031	0	-	-	7414	26	3.8	45513	147	0.0	36654	117	0.0	58954	198	0.0	537	26	0.0	40104	140	10.3	16.8	6.5
16032	48676	67	3.1	2284	23	2.4	3780	48	8.8	4759	53	2.5	36289	190	4.7	39506	164	6.0	2367	21	5.2	13.9	8.7
16033	125	3	2.3	-	-	-	-	-	-	-	-	-	0	-	-	0	-	-	0	-	-	-	-
16033b	-	-	-	-	-	-	15689	104	7.3	3243	42	7.2	34665	149	7.2	17885	68	5.1	0	-	-	-	-
16034	39927	61	20.2	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16035	7225	84	3.1	22099	113	2.4	29174	179	12.6	14317	83	2.8	60418	202	7.2	26922	190	4.2	43778	194	5.2	10.3	5.1
16037	36948	77	3.9	991	18	4.3	24601	133	3.0	10762	61	2.8	4277	21	2.5	1551	17	8.7	0	-	-	-	-
16038	14187	69	10.5	9	2	0.0	106	8	0.0	4	2	0.0	0	-	-	0	-	-	11575	61	-10.3	-10.3	0.0
16040	18814	85	3.9	23113	104	2.4	4436	21	12.6	5033	26	2.5	29413	189	2.5	39264	189	4.2	38059	189	5.2	9.4	4.2
16041	135	11	0.0	4328	25	3.8	16656	153	4.1	16912	74	2.5	30740	174	0.0	22473	119	6.0	48061	196	5.2	10.3	5.1
16043	6989	49	17.1	10520	95	16.0	16074	114	10.8	36372	188	10.8	17192	188	13.3	10142	166	13.4	18030	176	10.3	16.8	6.5
16044	9036	57	21.0	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16046	6972	85	3.1	248	25	0.0	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16047	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16049	20859	75	3.9	32364	157	4.3	24241	140	8.8	9993	101	2.8	18078	144	7.2	31523	176	8.7	16474	90	5.2	10.3	5.1
16050	345	3	0.0	18070	65	3.8	2920	50	10.8	8473	55	6.1	44567	169	4.7	23677	172	0.0	14296	93	10.3	16.8	6.5
16052	143	4	9.6	6505	78	7.6	34688	173	0.0	18189	165	11.0	49267	186	13.3	13313	124	0.0	4096	69	10.3	13.9	3.6
16053	2960	31	3.1	776	10	11.4	2209	20	14.9	7018	46	2.5	68422	200	2.5	26653	140	4.5	49211	184	5.2	10.3	5.1
32167	-	-	-	-	-	-	-	-	-	293	14	0.0	37839	187	7.2	30174	143	6.0	38220	144	7.9	16.8	8.9
32168	-	-	-	-	-	-	-	-	-	19931	142	13.3	47809	189	2.5	24622	74	8.7	22658	121	5.2	9.4	4.2
32169	-	-	-	-	-	-	-	-	-	444	6	2.5	51598	201	7.2	4141	22	8.7	42584	165	5.2	13.9	8.7
32170	-	-	-	-	-	-	-	-	-	3328	69	2.8	0	-	-	47	2	2.7	0	-	-	-	-
32171	-	-	-	-	-	-	-	-	-	3275	24	13.3	53443	182	7.2	30627	156	5.1	65428	196	5.2	10.3	5.1
32172	-	-	-	-	-	-	-	-	-	8293	37	11.0	1455	13	7.2	9761	68	2.7	17548	93	5.2	7.9	2.7
32173	-	-	-	-	-	-	-	-	-	3843	49	2.5	45871	157	2.5	46475	145	4.2	4357	69	5.2	9.4	4.2

Table A1-3: Detection summary for each of 36 Lake Sturgeon tagged and monitored upstream of Keeyask GS during the open-water 2011 (June 1 to October 20), 2012 (May 1 to October 16), 2013 (May 1 to October 16), 2014 (May 1 to October 13), 2015 (May 1 to October 11), 2016 (May 1 to October 19), 2017 (May 1 to October 16), and 2018 (May 1 to October 10) periods. Tag id highlighted yellow = lost tags. Tag id highlighted purple = moved downstream through Gull Rapids.

Tag ID	2011			2012			2013			2014			2015			2016			2017			2018				
	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	U/S (rkm)	D/S (rkm)	Range (rkm)
16026	-	-	-	23195	83	9.4	12588	83	0.0	13090	103	0.0	29896	103	7.3	28343	128	7.3	18137	119	14.6	29052	129	-33.8	-26.5	7.3
16036	2152	32	8.6	6980	86	9.4	5328	82	8.1	12362	112	10.0	20379	132	9.6	16678	140	10.2	11145	102	12.1	9722	90	-19.5	-4.8	14.7
16039	2260	42	13.3	5250	66	12.5	16487	107	11.3	12670	120	11.6	18372	119	10.5	15797	120	13.7	17882	110	13.7	23403	134	-19.5	-4.8	14.7
16042	1914	54	0.0	576	11	0.8	2626	30	3.4	6660	54	3.9	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16045	786	13	7.0	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16048	383	6	1.6	1773	37	0.8	10796	119	21.6	7527	93	21.7	20784	116	36.9	14738	108	22.3	15301	109	17.4	22386	128	1.2	24.7	23.5
16051	1935	76	8.7	5804	105	15.3	8015	115	13.4	10404	57	13.7	10706	126	26.5	8157	96	13.7	8451	85	11.6	15291	135	-19.5	-4.8	14.7
16054	2697	49	12.0	4278	101	10.6	11062	105	9.5	7102	93	12.1	17220	90	38.7	9099	114	23.9	5602	33	21.7	14850	85	-48.2	-26.5	21.7
16055	1140	9	3.4	1384	27	5.7	8271	89	4.9	7657	86	10.0	5005	104	5.5	12401	92	5.5	8824	108	13.7	9709	88	-15	-7.4	7.6
16056	234	12	19.1	4665	87	10.6	12862	96	19.5	17163	115	10.0	18319	113	20.4	29142	135	23.6	16839	88	20.1	14370	110	-33.8	-4.8	29.0
16057	475	25	4.2	524	29	8.5	0	-	-	2	1	0.0	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16058	549	16	9.3	1071	4	9.7	0	-	-	0	-	-	0	-	-	418	13	3.9	1169	38	3.9	544	18	-48.2	-44.5	3.7
16059	599	5	3.4	1696	32	10.4	13935	78	11.3	10991	57	5.1	4708	85	13.7	7570	59	3.5	6223	64	4.3	2903	91	-19.5	-4.8	14.7
16060	1759	43	7.1	4065	95	8.7	16366	124	7.1	13228	108	7.1	19911	115	7.4	8653	73	28.5	18575	115	11.8	12355	55	1.2	9.4	8.2
16061	711	37	2.4	4444	108	13.6	11503	114	5.5	7437	95	3.4	13771	111	13.7	15840	120	13.7	8642	79	13.7	11533	87	-19.5	-4.8	14.7
16062	142	14	8.6	5624	86	12.4	16854	109	24.4	18336	129	7.9	19949	120	10.0	26029	145	10.0	18277	117	13.7	18684	137	-29.4	-4.8	24.6
16063	2617	59	10.4	9474	105	5.7	21588	126	9.3	23121	127	7.9	24981	137	10.0	28915	163	10.0	24788	121	10.0	14228	115	-19.5	-4.8	14.7
16064	1910	27	19.1	573	26	1.2	0	-	-	0	-	-	0	-	-	5	2	0.0	0	-	-	0	-	-	-	-
16065	931	36	4.5	6192	109	17.9	2581	38	5.1	3101	38	5.1	14349	104	28.0	7730	73	4.3	3061	62	13.7	4711	71	-10.2	-4.8	5.4
16066	772	39	1.8	4615	105	10.6	2322	36	8.1	8898	73	12.1	1884	20	7.9	6940	104	13.7	10910	94	6.1	10160	115	-17.4	-4.8	12.6
16067	1640	34	1.6	2516	39	31.7	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	19167	114	-48.2	-9.9	38.3
16068	1046	27	2.4	5882	105	10.6	10402	111	23.9	13158	121	10.0	16490	123	10.0	20273	135	13.7	13842	118	10.0	12545	121	-26.5	-9.9	16.6
16069	0	-	-	17495	85	4.5	13288	100	7.3	14172	66	2.9	8287	80	10.0	24559	122	5.1	18718	92	7.3	19345	102	-29.4	-26.5	2.9
16070	1080	40	8.6	14691	106	17.0	7943	89	9.6	9967	83	9.6	12593	101	10.0	4083	80	13.7	3202	80	10.0	4014	78	-19.5	-4.8	14.7
16071	1403	43	8.6	9124	89	10.6	11285	130	9.3	17413	102	12.1	39272	131	13.7	37521	151	9.9	31215	124	13.7	21205	139	-17.4	-5.8	11.6
16072	2839	58	12.9	4031	91	10.6	16638	129	19.5	19306	112	7.9	15866	127	10.0	6608	129	10.0	16299	127	3.3	10676	115	-32.3	-9.9	22.4
16073	1025	35	2.4	4432	102	12.4	6885	94	9.3	13884	127	10.0	4500	73	13.7	25145	151	13.7	10316	113	13.7	14231	124	-19.5	-4.8	14.7
16074	0	-	-	13006	67	4.7	11803	78	2.9	3105	23	7.3	655	13	15.9	2889	25	3.9	2957	24	3.7	3174	20	-48.2	-44.3	3.9
16075	462	10	6.3	0	-	-	0	-	-	0	-	-	865	35	4.3	0	-	-	0	-	-	61208	134	-4.8	-4.8	0.0
16076	1040	35	6.3	2225	56	9.4	9270	81	11.3	9075	84	11.6	12474	79	11.6	27013	118	9.0	16851	94	24.0	21817	127	1.2	24.7	23.5
16077	282	5	0.0	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
32174	-	-	-	-	-	-	-	-	-	9705	98	28.5	20042	118	42.4	15062	82	28.9	11336	60	12.7	1751	18	1.2	16.8	15.6
32175	-	-	-	-	-	-	-	-	-	9186	90	6.0	22601	114	5.3	48213	134	3.4	32547	133	5.3	11208	84	-12.9	-9.3	3.6
32176	-	-	-	-	-	-	-	-	-	22630	106	11.6	15054	109	26.5	23822	111	7.1	32410	125	7.0	23353	141	-15	-4.8	10.2
32177	-	-	-	-	-	-	-	-	-	20678	109	5.5	265	15	0.6	0	-	-	0	-	-	0	-	-	-	-
54799	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	16229	111	-26.5	-4.8	21.7

Table A1-4: Detection summary for each of 36 Lake Sturgeon tagged and monitored in Stephens Lake during the open-water 2011 (June 1 to October 20), 2012 (May 1 to October 16), 2013 (May 1 to October 16), 2014 (May 1 to October 13), 2015 (May 1 to October 11), 2016 (May 1 to October 19), 2017 (May 1 to October 16), and 2018 (May 1 to October 10) periods. Tag id highlighted green = moved upstream over Gull Rapids and harvested. Tag id highlighted blue = moved upstream over Gull Rapids. Tag id highlighted yellow = lost tags. Tag id highlighted red = moved downstream through Kettle GS. Tag id highlighted purple = moved downstream through Gull Rapids. Tag id highlighted orange = moved downstream through Long Spruce GS.

Tag ID	2011			2012			2013			2014			2015			2016			2017			2018				
	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	U/S (rkm)	D/S (rkm)	Range (rkm)
16018	-	-	-	341	5	34.5	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16019	-	-	-	9272	70	26.9	15039	116	18.2	13297	76	39.5	20832	129	27.0	17331	117	22.3	18192	117	17.4	19589	99	1.2	21.6	20.4
16020	-	-	-	7450	101	11.9	13664	99	14.2	8592	111	19.7	25808	137	19.7	29291	155	17.4	19304	150	23.5	13674	104	1.2	36.1	34.9
16021	2770	21	14.2	4530	30	5.0	0	-	-	0	-	-	0	-	-	1331	18	1.0	0	-	-	0	-	-	-	-
16022	-	-	-	9845	100	16.0	7248	71	20.5	10957	101	20.5	18858	127	16.1	12608	124	22.3	13393	120	17.4	19908	126	1.2	18.6	17.4
16024	-	-	-	398	9	4.0	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16025	-	-	-	2316	67	35.2	9668	119	10.2	1572	23	60.4	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16027	-	-	-	8249	87	16.0	15717	109	14.4	10960	72	9.7	14083	114	13.6	22348	148	9.0	22812	125	9.1	14092	119	1.2	18.6	17.4
16028	-	-	-	9063	92	16.3	98	8	3.7	6174	58	17.4	16344	108	17.7	19657	109	12.7	29657	142	15.6	22350	126	1.2	18.6	17.4
16029	3801	62	58.1	6087	102	19.9	4940	83	10.2	13325	102	16.0	8716	94	10.2	5821	101	20.1	12873	85	10.2	4030	80	-19.5	-9.3	10.2
16030	7733	86	15.5	6414	86	14.4	13494	86	25.5	16498	104	27.4	15935	94	17.7	10843	118	34.9	16302	127	34.9	18034	120	1.2	18.6	17.4
16031	-	-	-	12814	104	16.3	10315	106	14.4	12775	99	13.6	17780	125	13.6	18745	141	15.6	14795	131	12.7	19537	128	1.2	18.6	17.4
16032	5801	56	14.2	13833	120	16.0	17055	115	19.7	16765	118	18.2	11985	106	16.1	18322	116	17.5	29122	157	17.4	23612	107	1.2	16.8	15.6
16033	5144	44	14.2	3001	43	37.5	0	-	-	-	-	-	-	-	-	0	-	-	0	-	-	0	-	-	-	-
16033b	-	-	-	-	-	-	3505	30	12.4	13578	101	17.4	28621	127	16.1	21058	118	17.4	27766	127	12.7	20613	108	1.2	10.3	9.1
16034	15378	75	11.2	15394	61	2.2	38582	117	0.8	25117	99	4.8	30925	119	0.8	10170	70	15.9	13	2	0.0					0.0
16035	1547	12	10.9	8767	91	14.4	19324	116	20.3	16298	121	19.7	23142	119	17.7	19523	133	23.5	27311	149	17.4	6244	35	1.2	40.8	39.6
16037	8375	50	7.4	13685	108	11.9	21481	125	44.3	13636	91	47.2	17230	113	16.1	13411	89	17.4	15203	109	17.4	19431	114	1.2	16.8	15.6
16038	5777	45	11.2	3402	87	31.0	7973	124	9.3	3975	76	10.0	10827	75	12.1	15190	103	10.0	13109	131	10.2	12193	97	-29.4	-9.9	19.5
16040	9602	70	12.5	8598	109	12.0	21959	128	18.0	4833	62	18.2	15041	122	19.7	15740	117	17.4	12642	92	17.4	16018	114	1.2	18.6	17.4
16041	15169	88	11.2	9437	81	40.7	8915	81	14.4	13556	111	14.4	15807	101	16.1	14398	113	13.7	20805	136	17.4	19091	126	1.2	18.6	17.4
16043	20429	92	15.5	13049	98	11.9	12476	115	14.4	13303	118	15.8	20525	131	17.7	22234	122	13.7	18103	135	17.4	13235	102	1.2	18.6	17.4
16044	1582	36	8.7	3932	53	11.9	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16046	8350	72	24.7	199	68	23.5	360	10	7.2	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16047	131	2	19.7	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16049	1919	12	11.2	11705	102	26.9	24320	123	27.7	11319	83	27.4	20752	132	16.1	16056	127	22.3	22073	140	39.7	23304	115	1.2	40.9	39.7
16050	6519	57	15.5	7755	85	11.9	14411	88	14.2	7019	69	19.7	13783	98	13.6	17742	93	13.7	18778	72	12.7	12123	103	1.2	18.6	17.4
16052	1920	17	11.2	4785	80	16.0	9791	65	20.5	8323	68	19.7	10937	96	17.4	13008	113	17.4	19047	127	17.4	14140	110	1.2	16.8	15.6
16053	2740	18	12.5	13416	114	16.0	17049	126	18.2	13586	95	20.5	26058	130	16.1	29704	139	15.6	27363	150	12.7	29144	145	1.2	13.9	12.7
32167	-	-	-	-	-	-	-	-	-	10421	91	20.5	33420	126	16.1	26260	130	22.3	27586	142	17.4	24579	138	1.2	18.6	17.4
32168	-	-	-	-	-	-	-	-	-	18169	100	20.5	34961	140	16.1	27764	134	22.3	35684	132	17.4	26784	129	1.2	18.6	17.4
32169	-	-	-	-	-	-	-	-	-	614	20	2.4	24873	131	15.2	26025	131	17.4	24410	124	17.4	16832	100	1.2	18.6	17.4
32170	-	-	-	-	-	-	-	-	-	5151	77	20.5	17310	127	16.1	13320	103	17.4	0	-	-	0	-	-	-	-
32171	-	-	-	-	-	-	-	-	-	36691	103	17.4	22567	111	16.1	27226	134	17.4	26214	120	12.7	34797	129	1.2	18.6	17.4
32172	-	-	-	-	-	-	-	-	-	19105	86	9.7	17221	108	9.7	19907	110	13.7	23914	93	8.2	18285	92	1.2	10.3	9.1
32173	-	-	-	-	-	-	-	-	-	24278	103	9.7	28920	117	9.7	26056	107	9.1	32014	127	9.1	36522	119	1.2	10.3	9.1

APPENDIX 2:

LOCATION SUMMARY FOR INDIVIDUAL ACOUSTIC TAGGED ADULT LAKE STURGEON, UPSTREAM OF GULL RAPIDS, JUNE 2011 TO OCTOBER 2018

Figure A2-1:	Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16026) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018.	76
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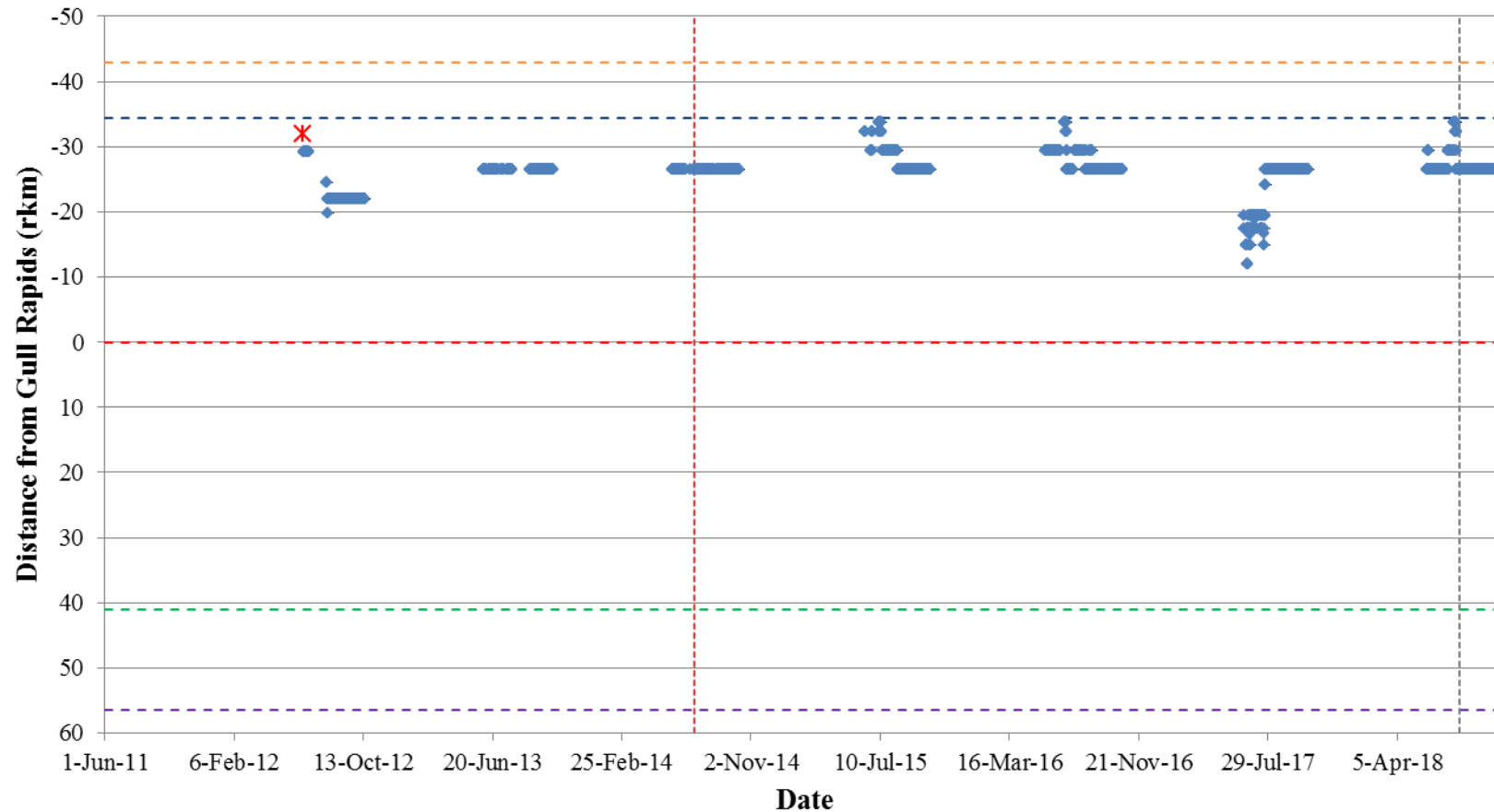


Figure A2-1: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16026) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

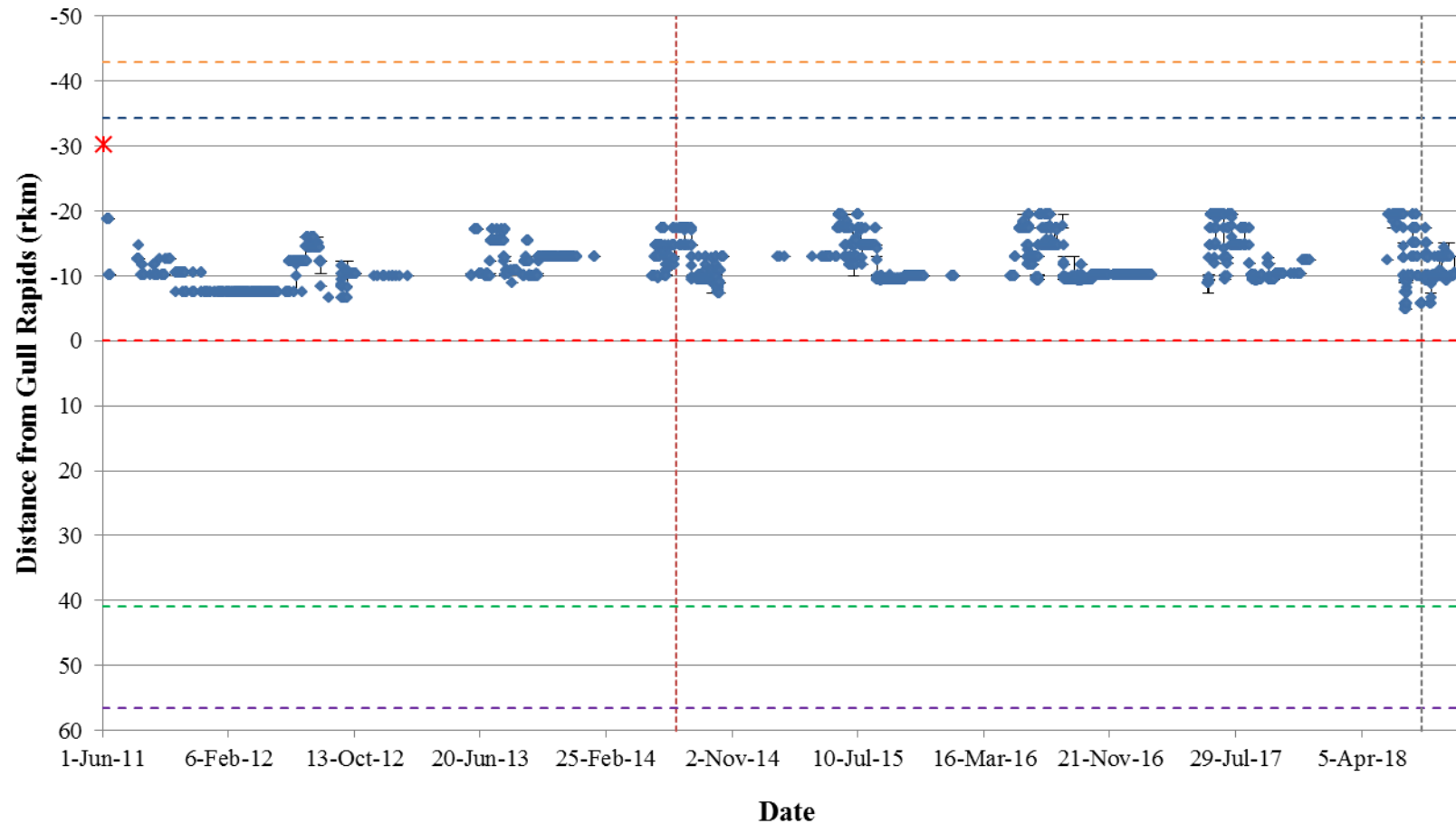


Figure A2-2: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16036) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

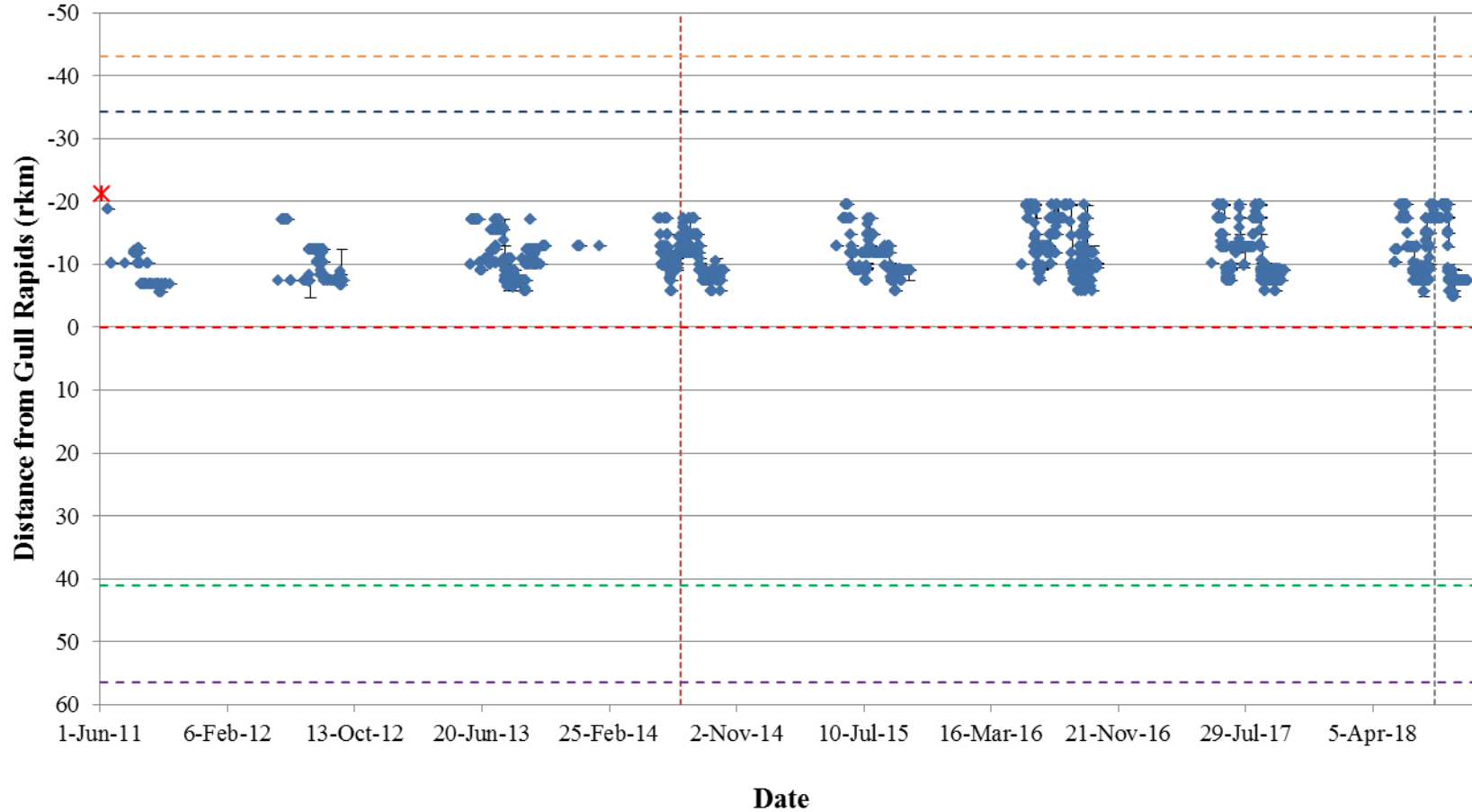


Figure A2-3: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16039) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

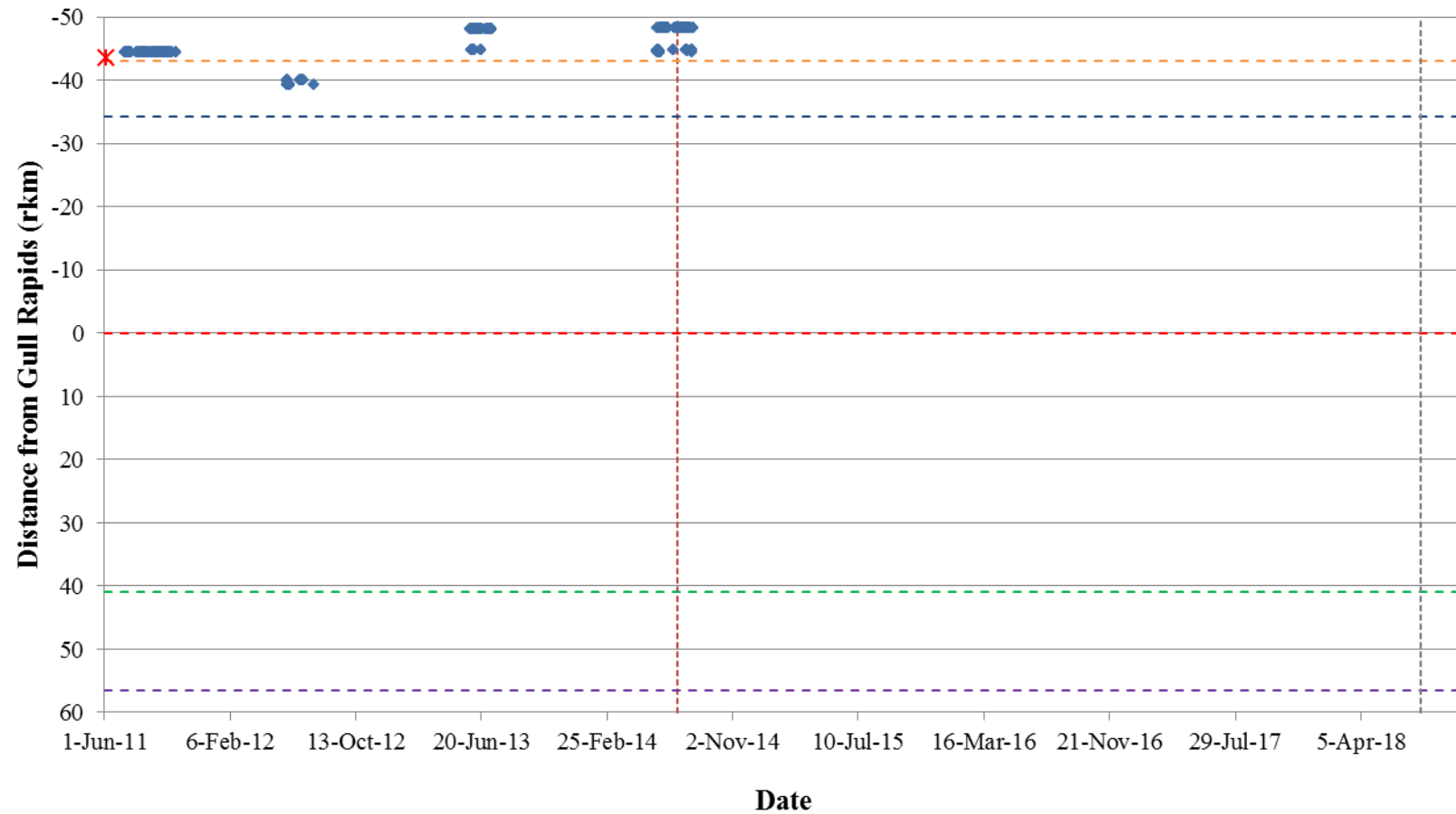


Figure A2-4: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16042) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

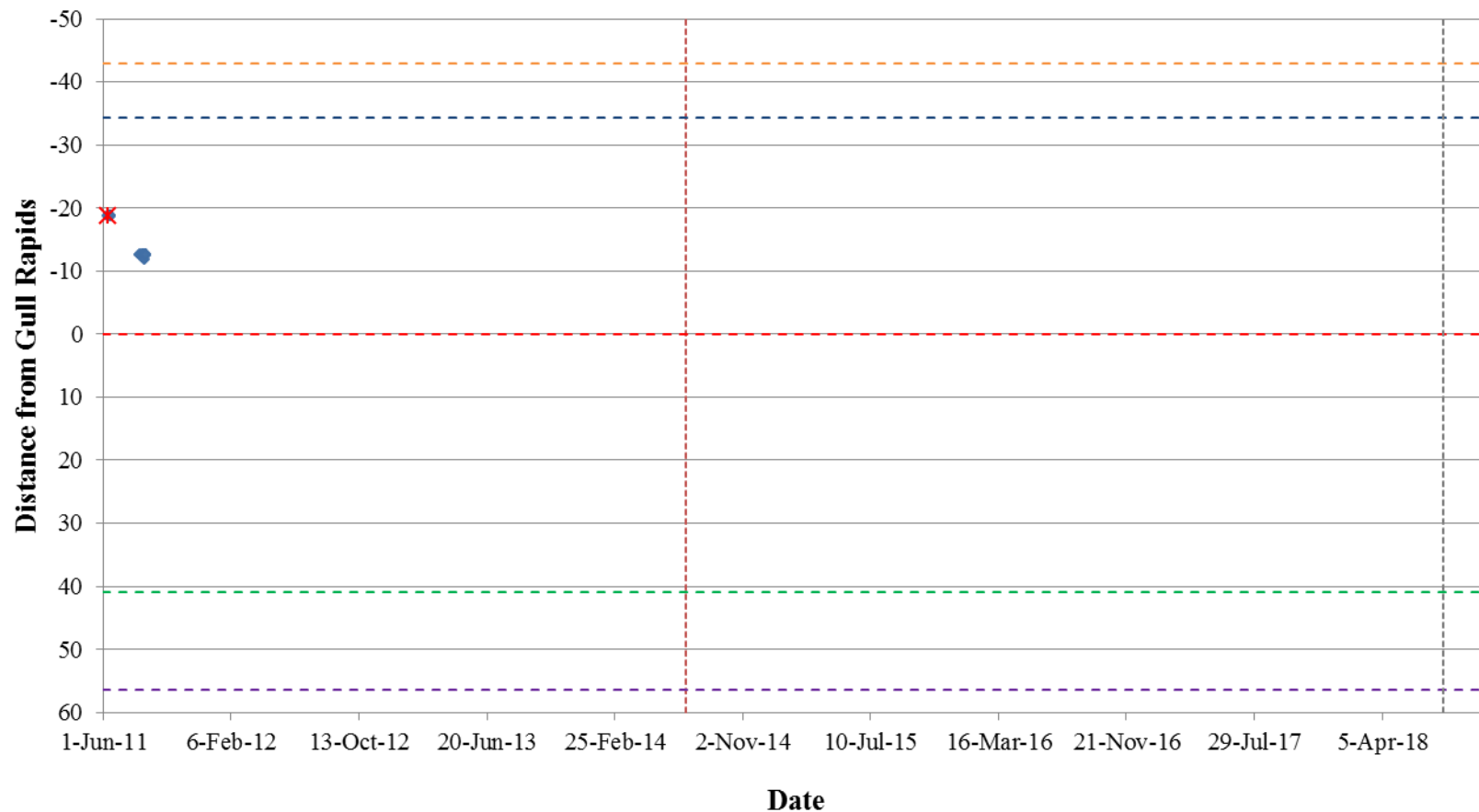


Figure A2-5: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16045) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

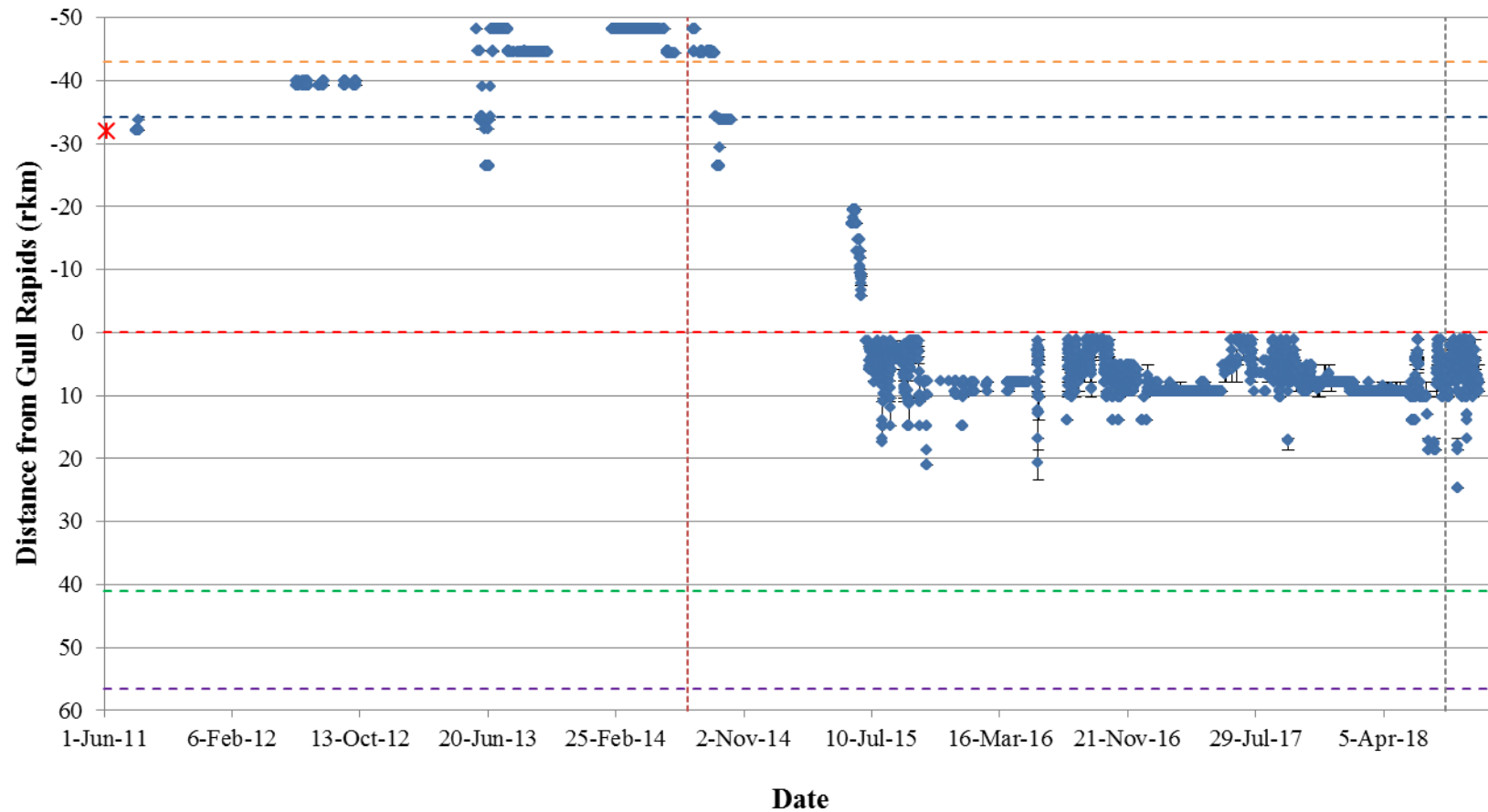


Figure A2-6: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16048) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

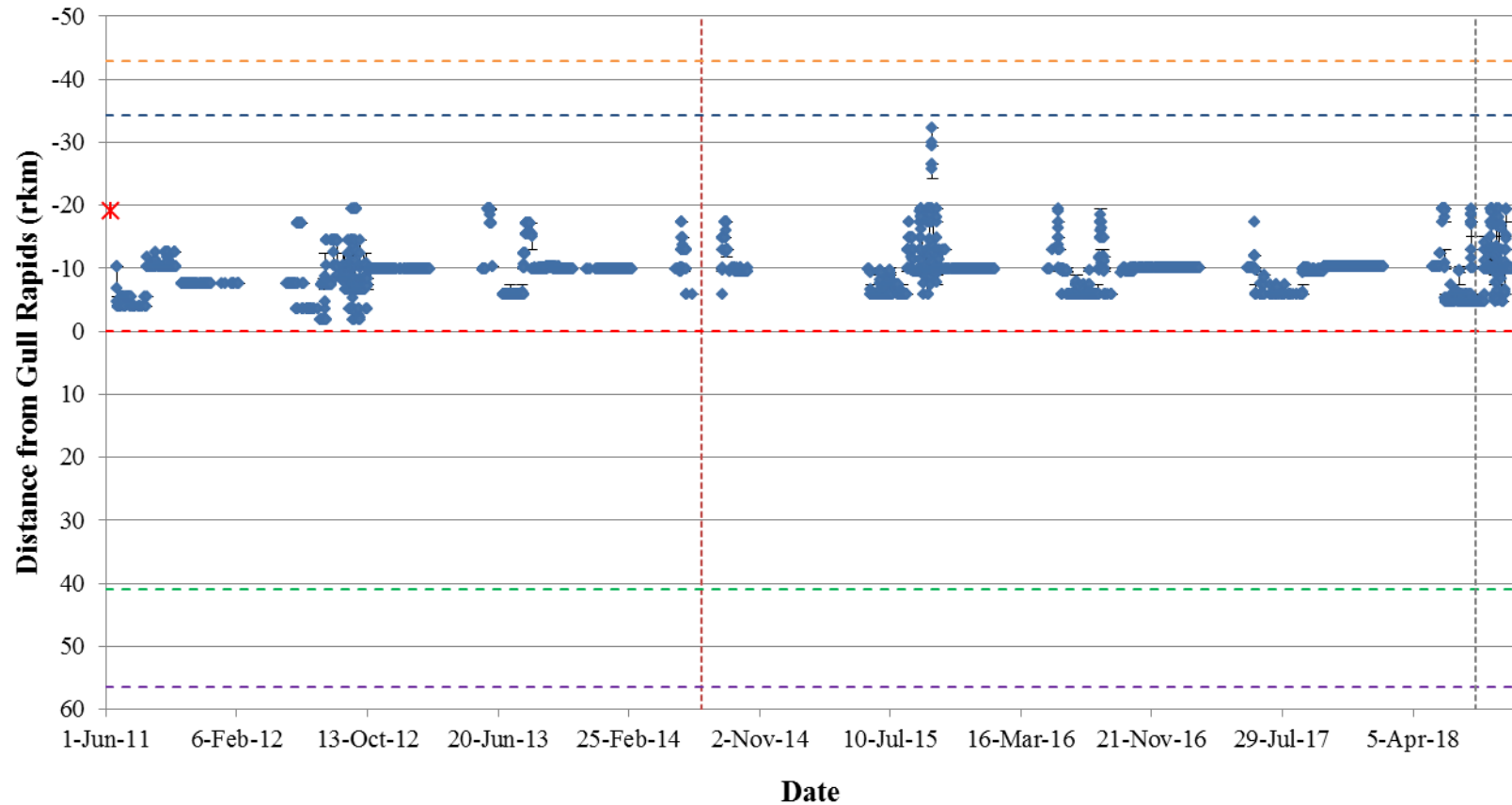


Figure A2-7: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16051) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

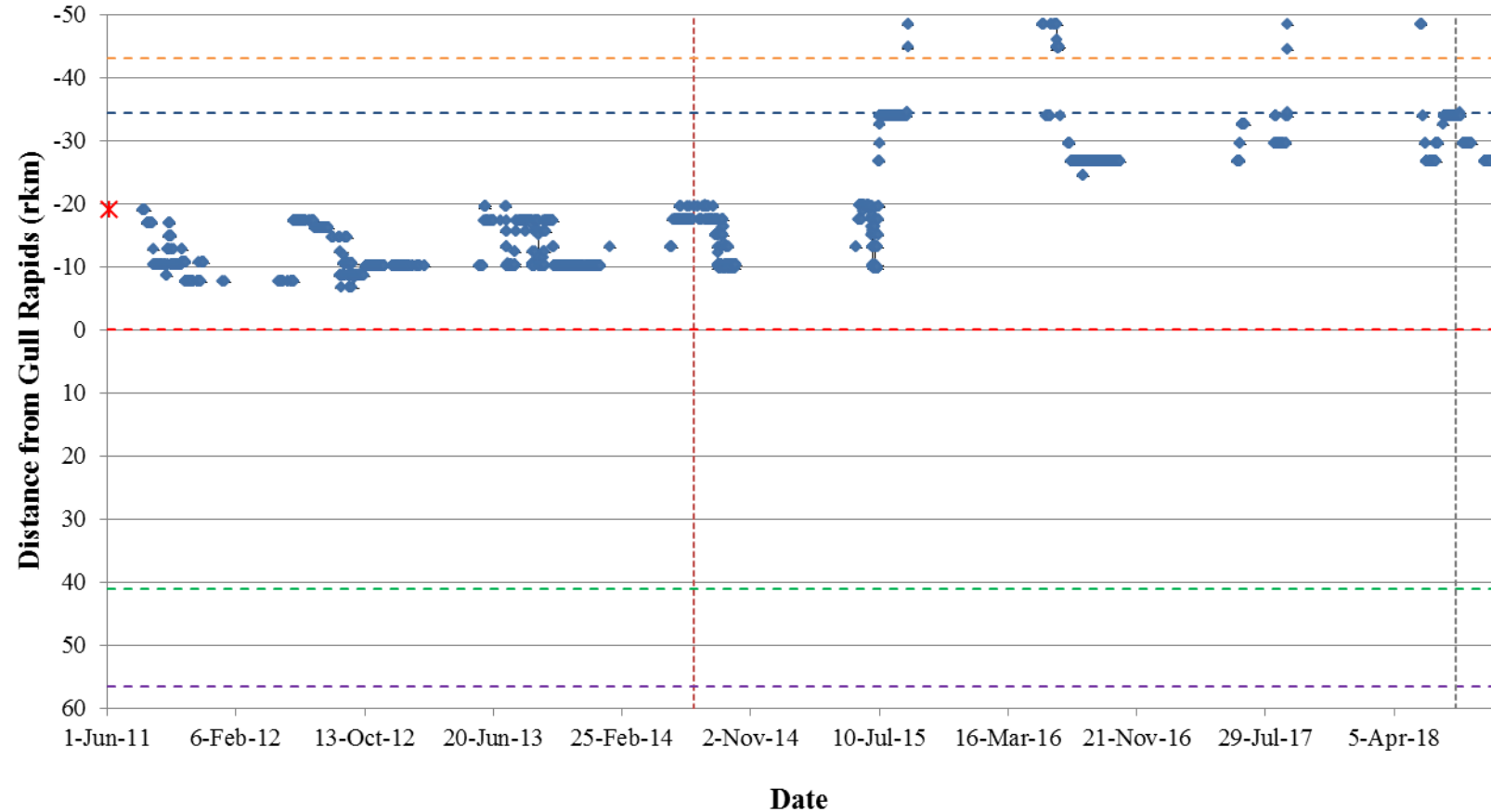


Figure A2-8: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16054) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

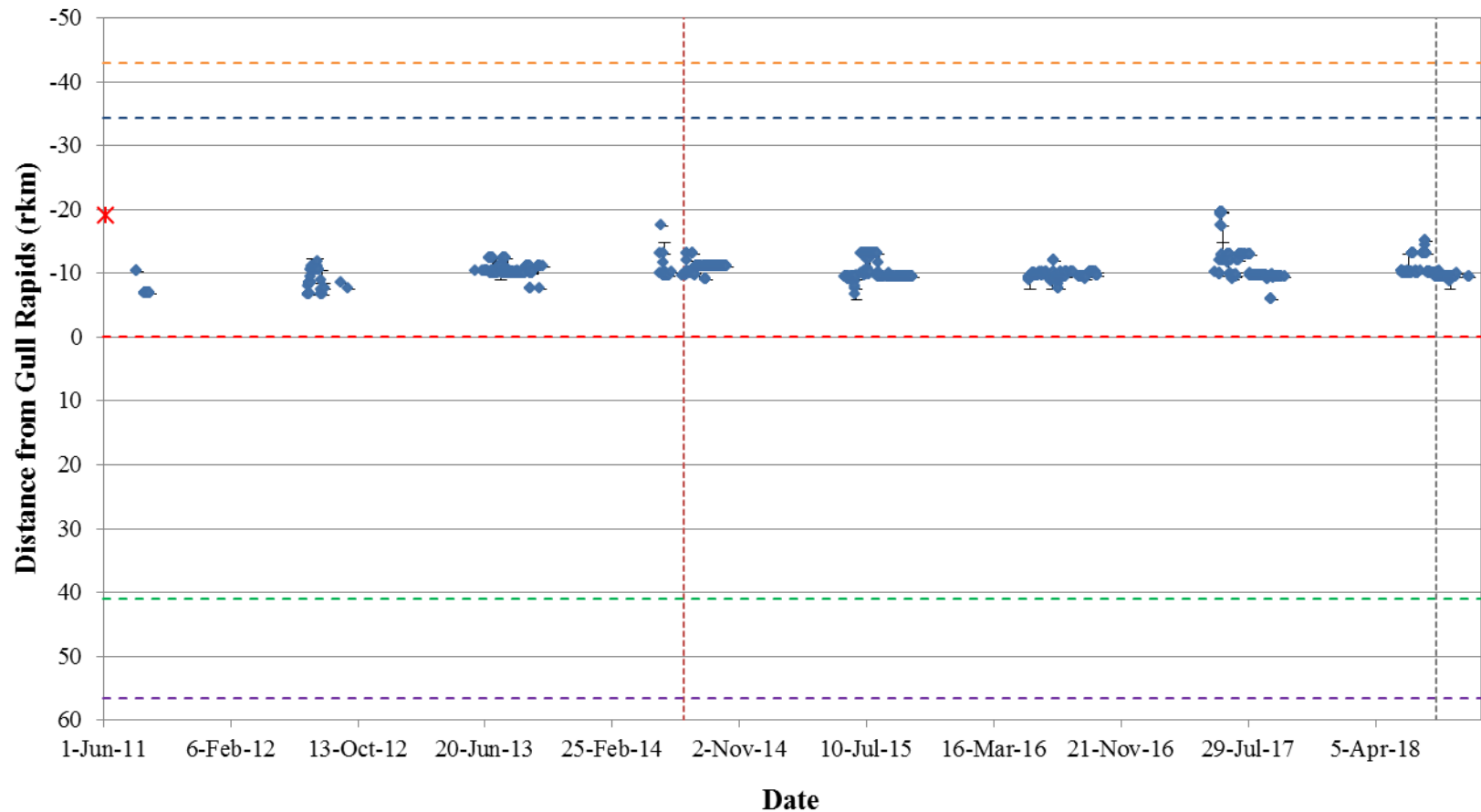


Figure A2-9: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16055) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

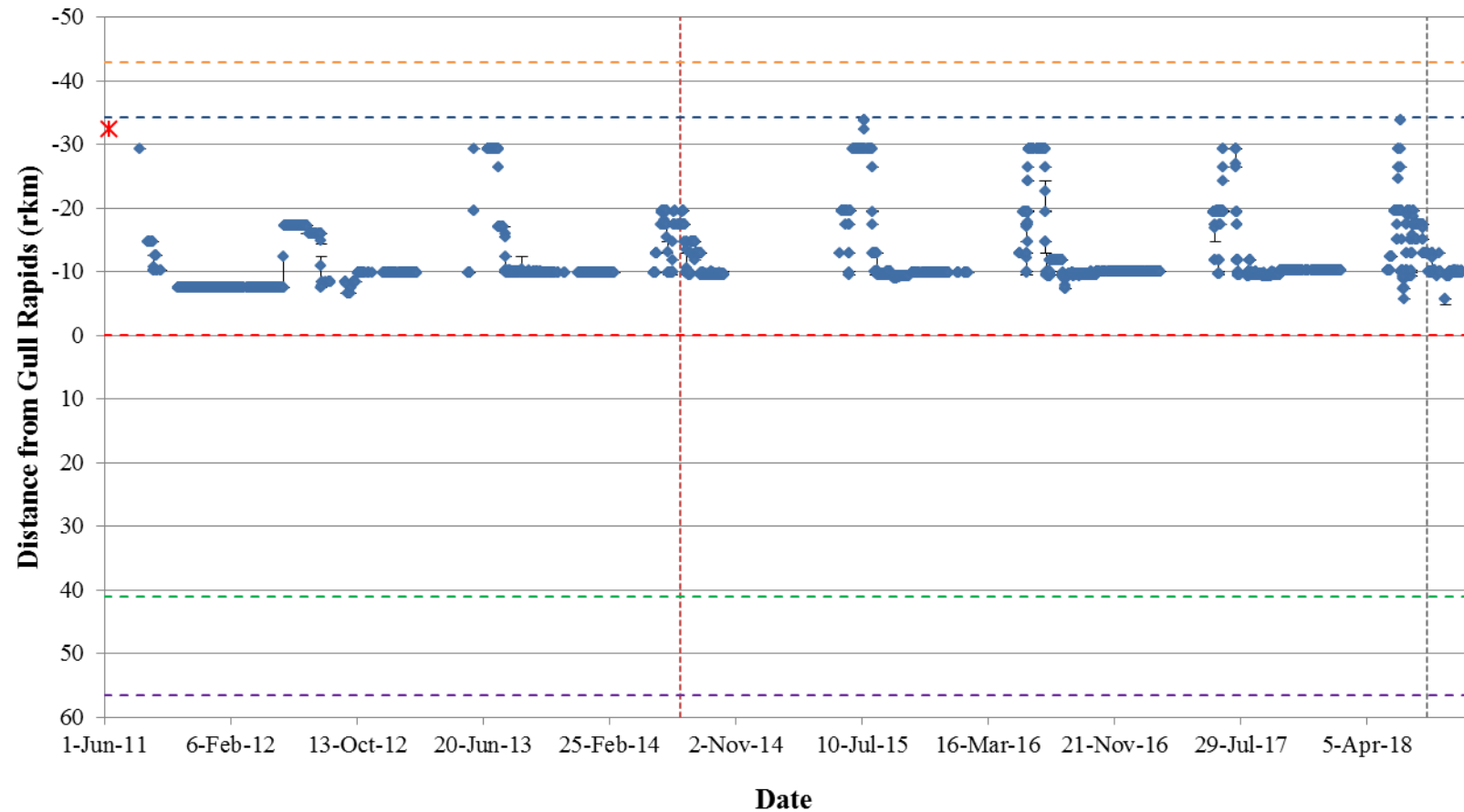


Figure A2-10: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16056) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

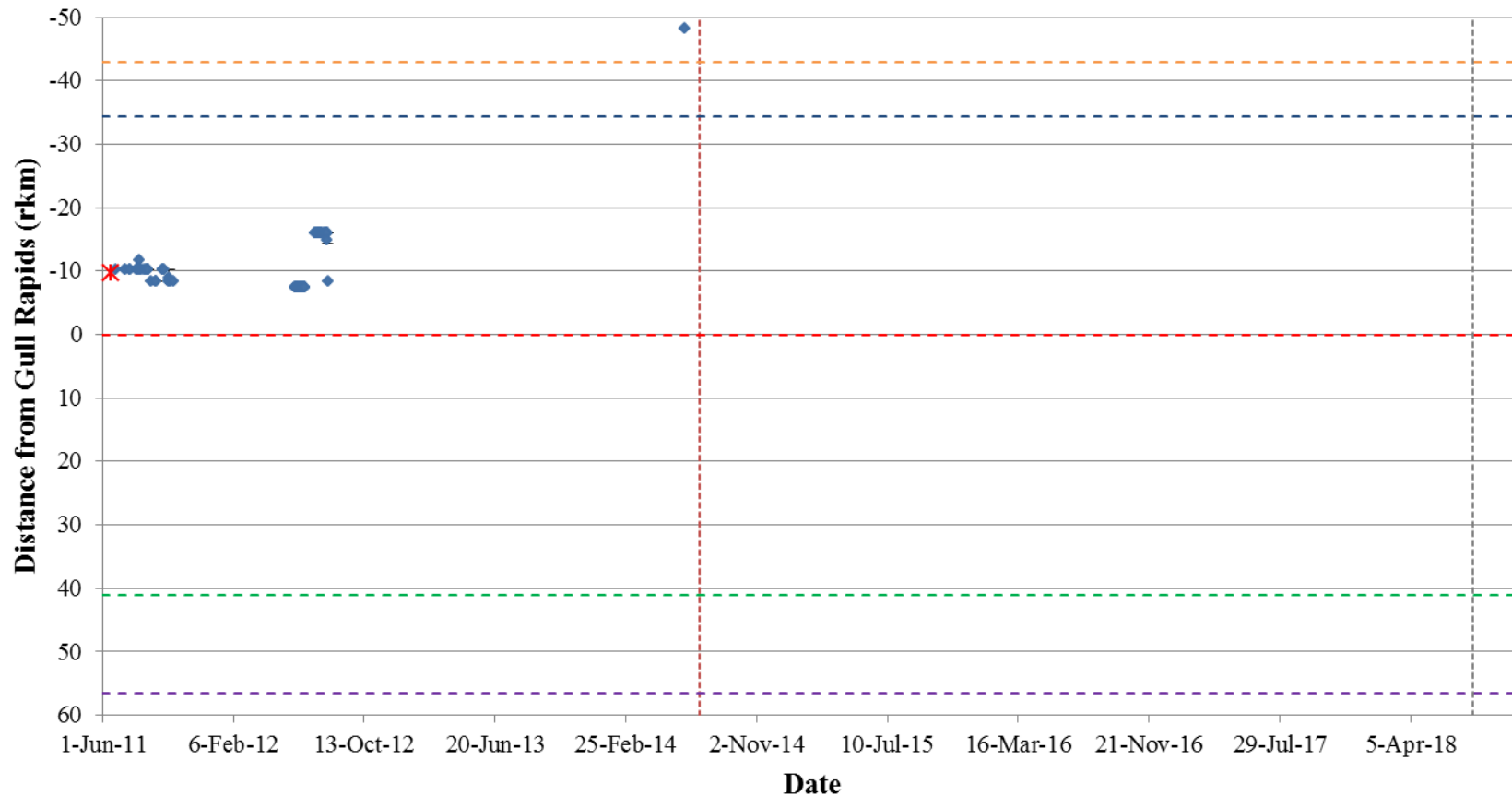


Figure A2-11: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16057) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

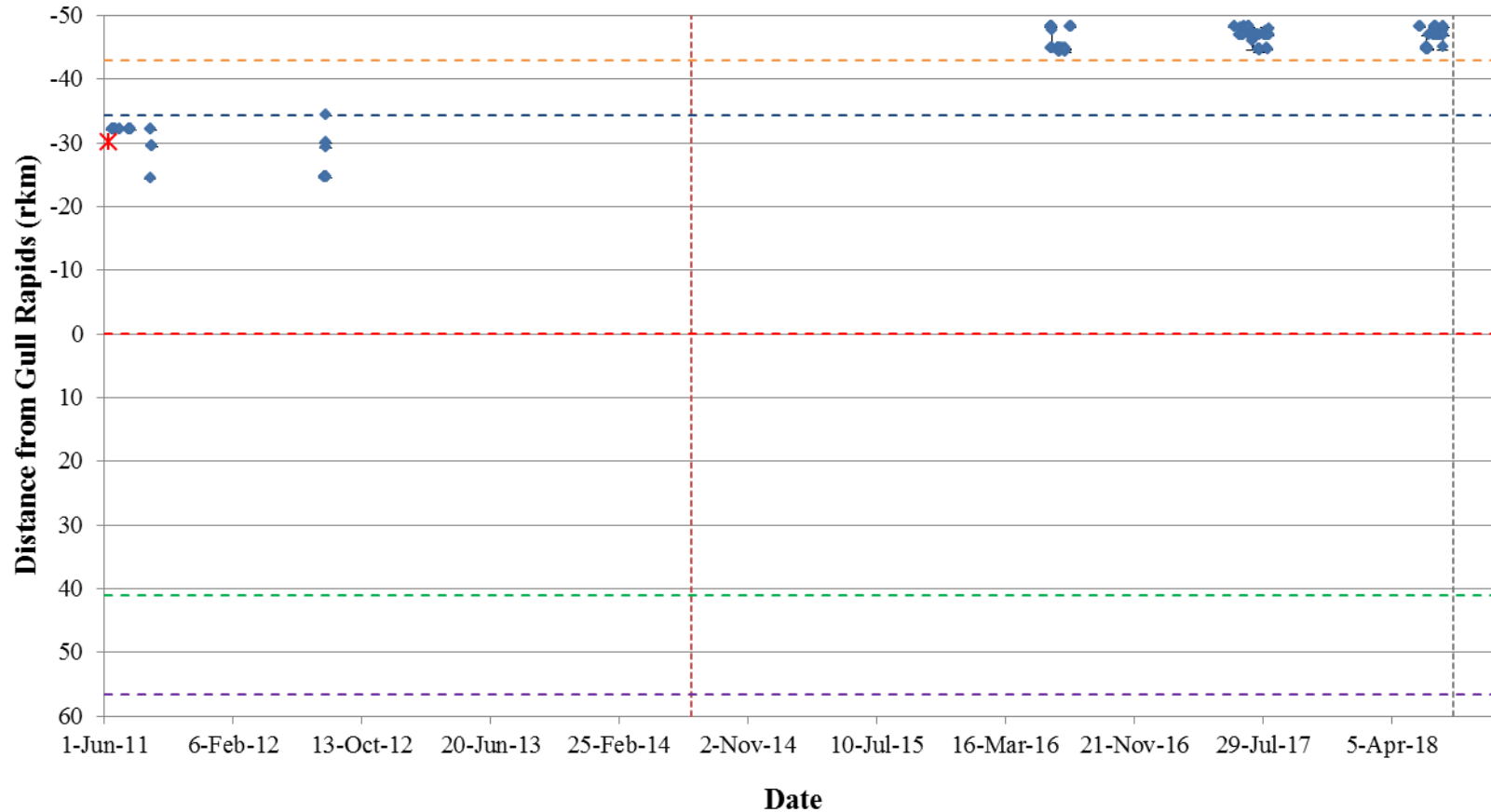


Figure A2-12: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16058) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

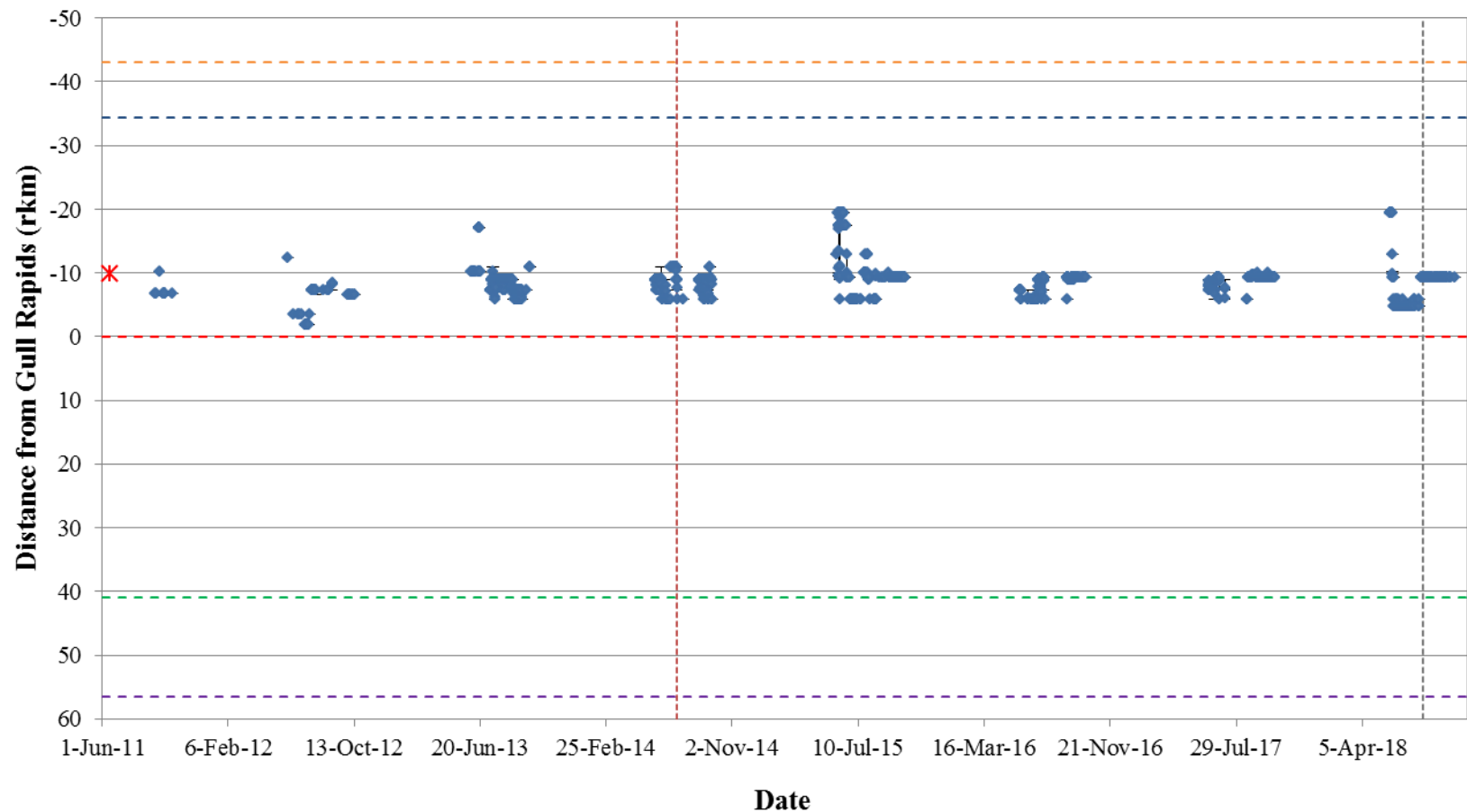


Figure A2-13: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16059) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

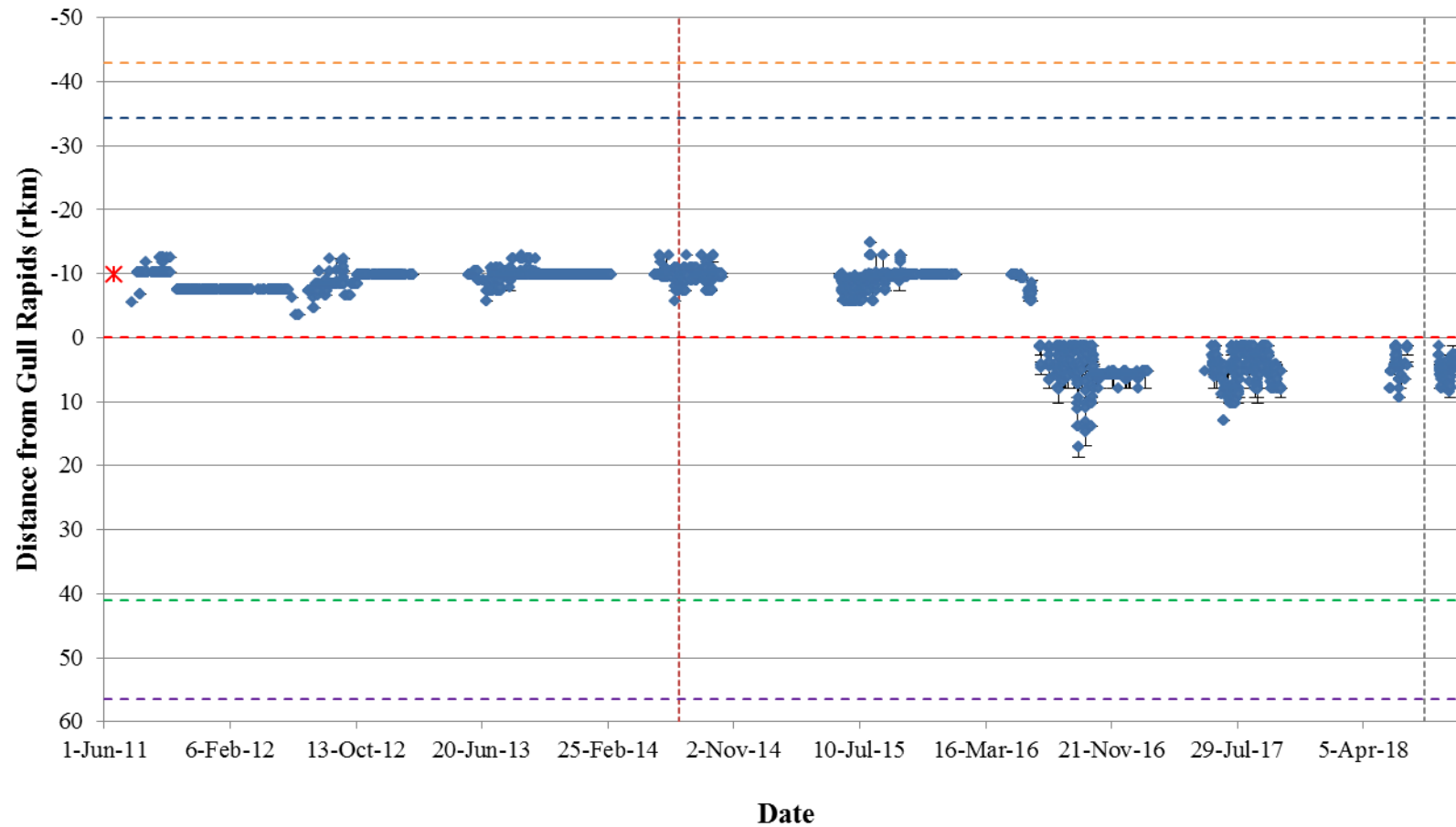


Figure A2-14: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16060) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

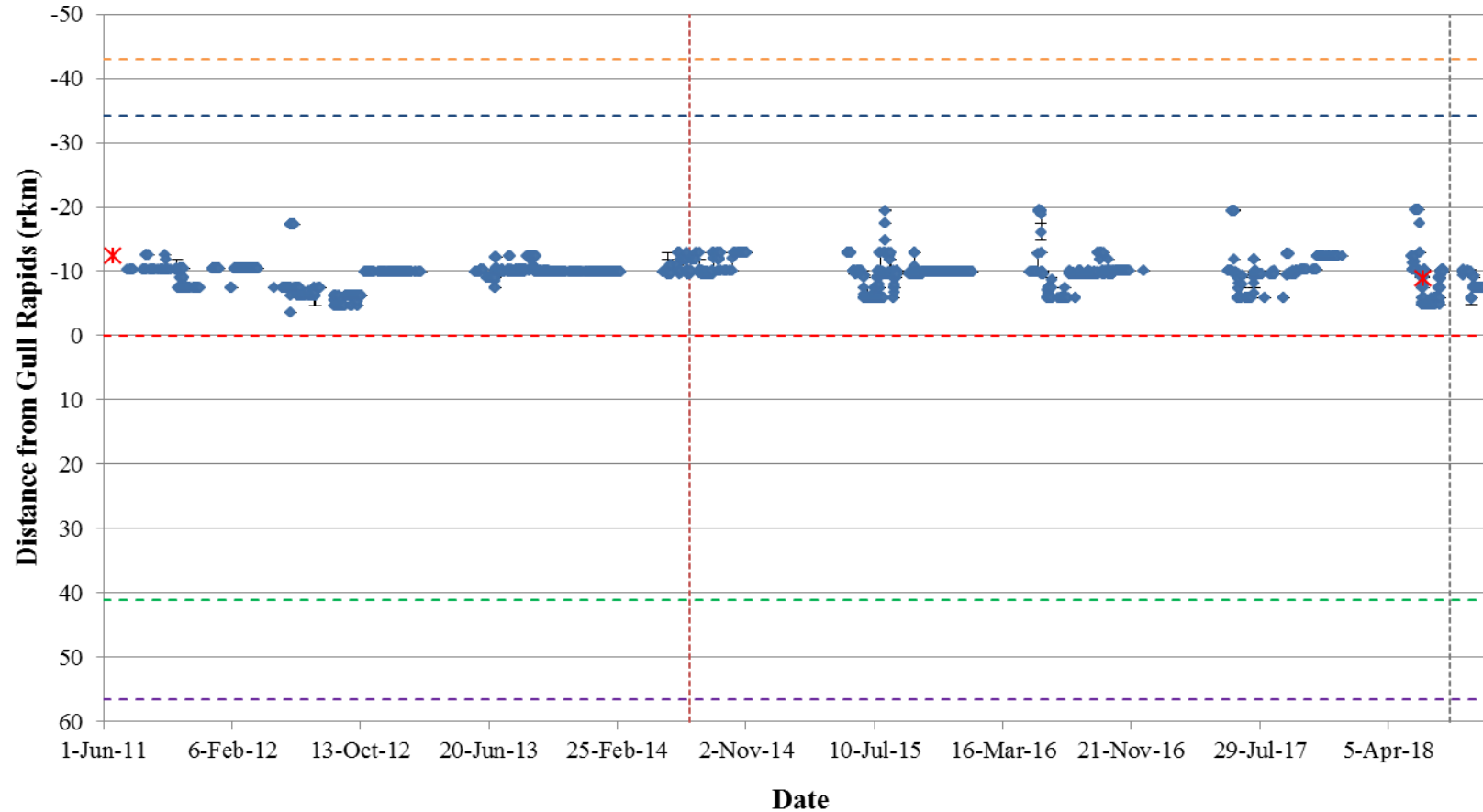


Figure A2-15: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16061) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging and recaptures are indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

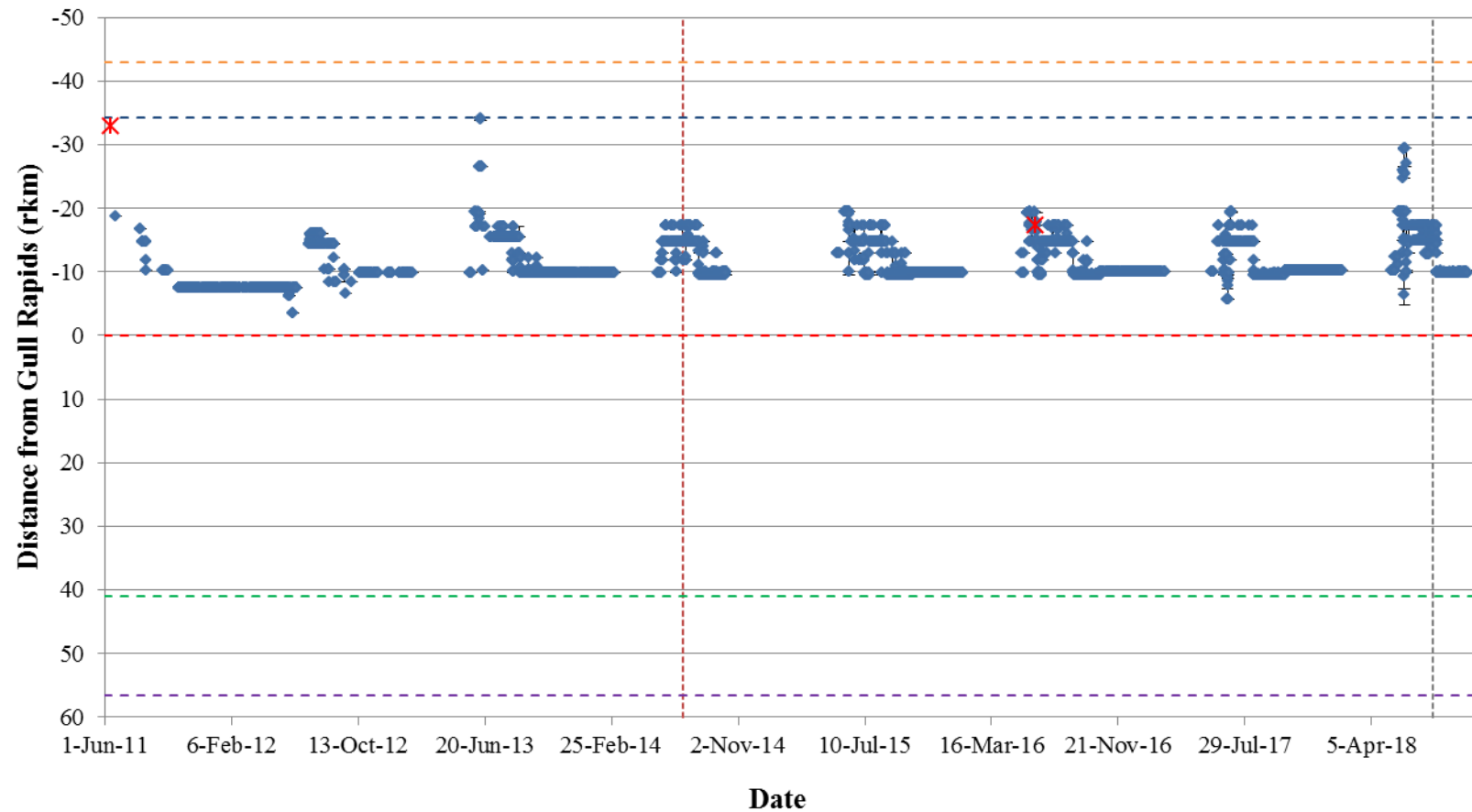


Figure A2-16: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16062) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging and recaptures are indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

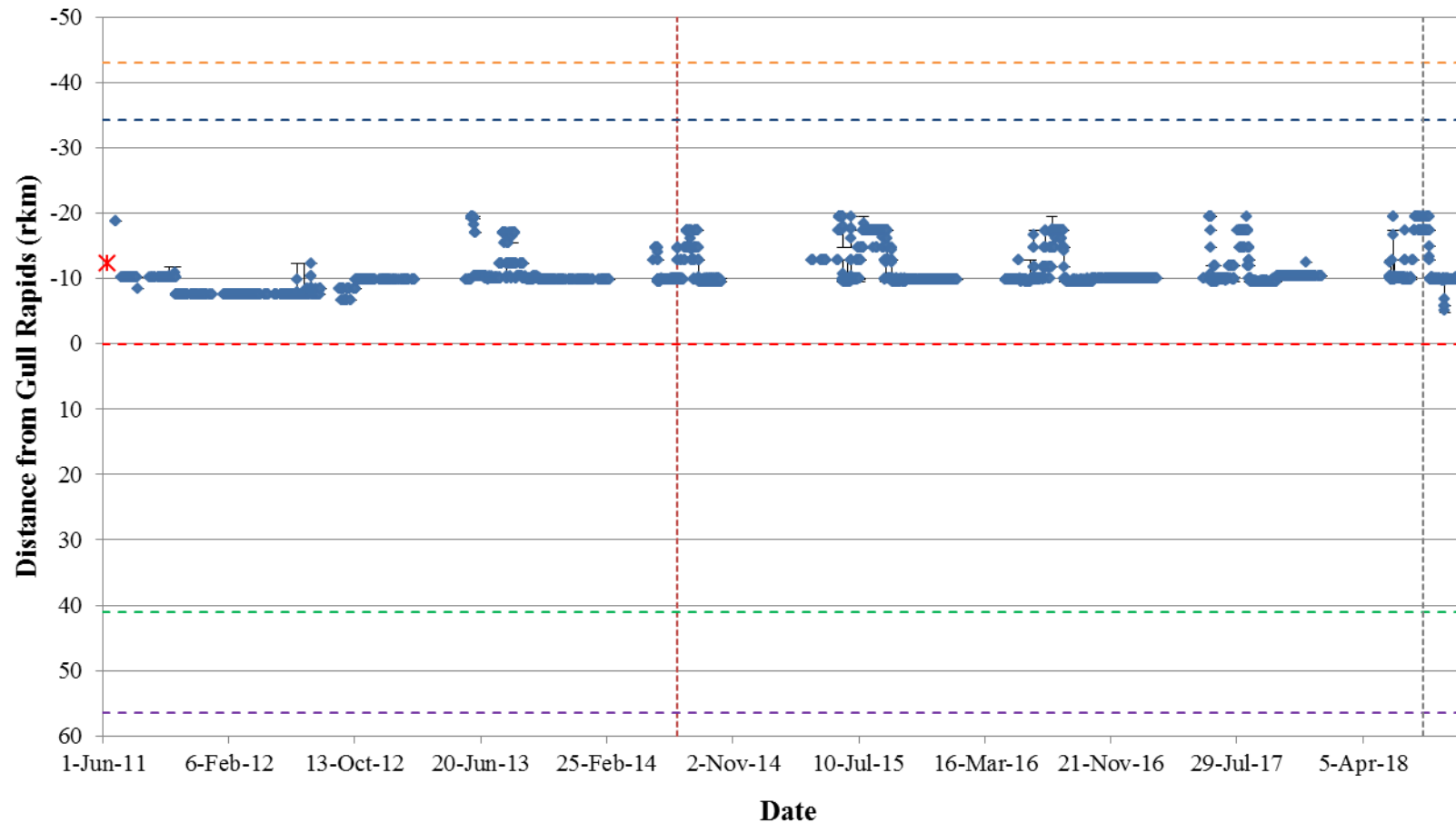


Figure A2-17: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16063) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

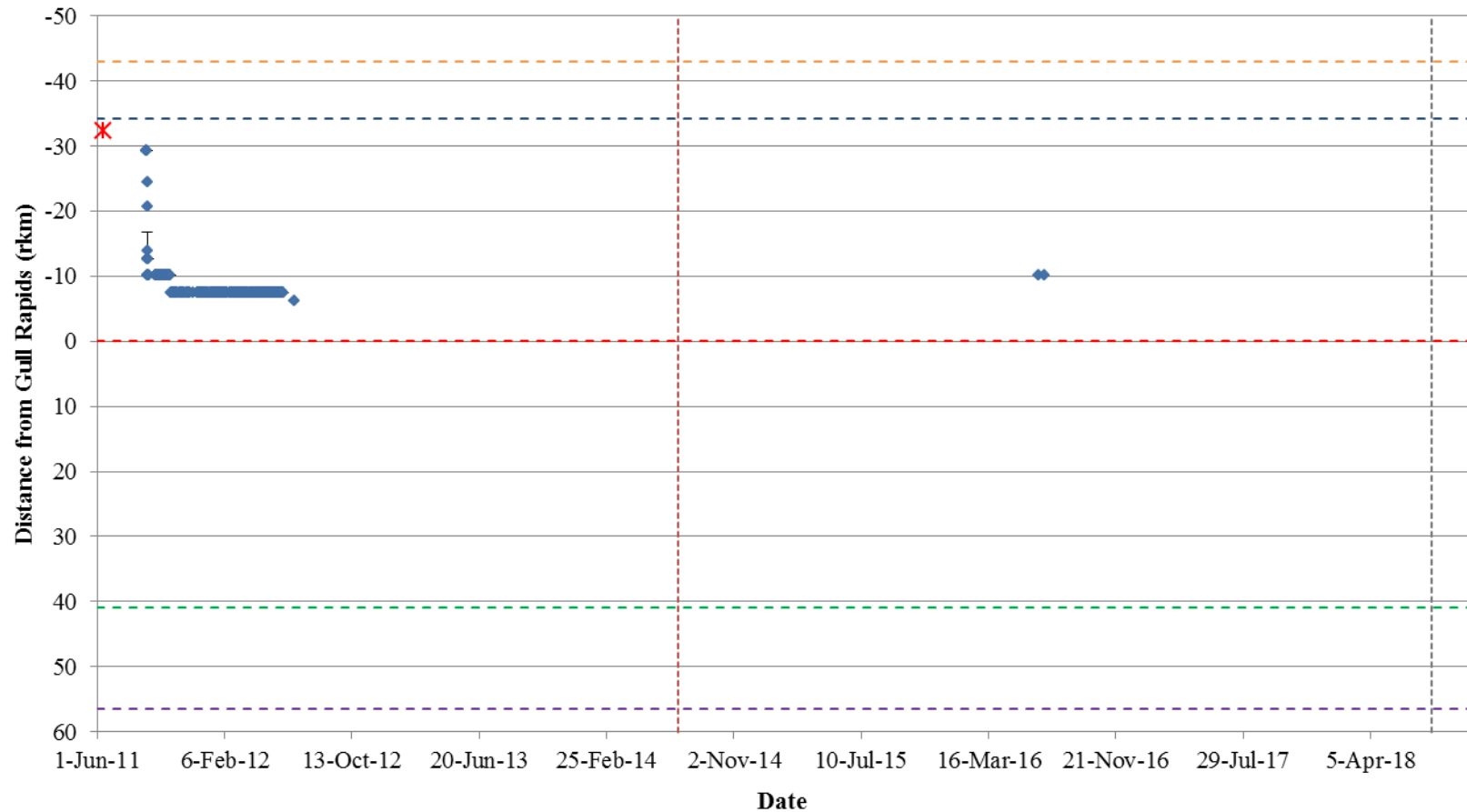


Figure A2-18: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16064) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

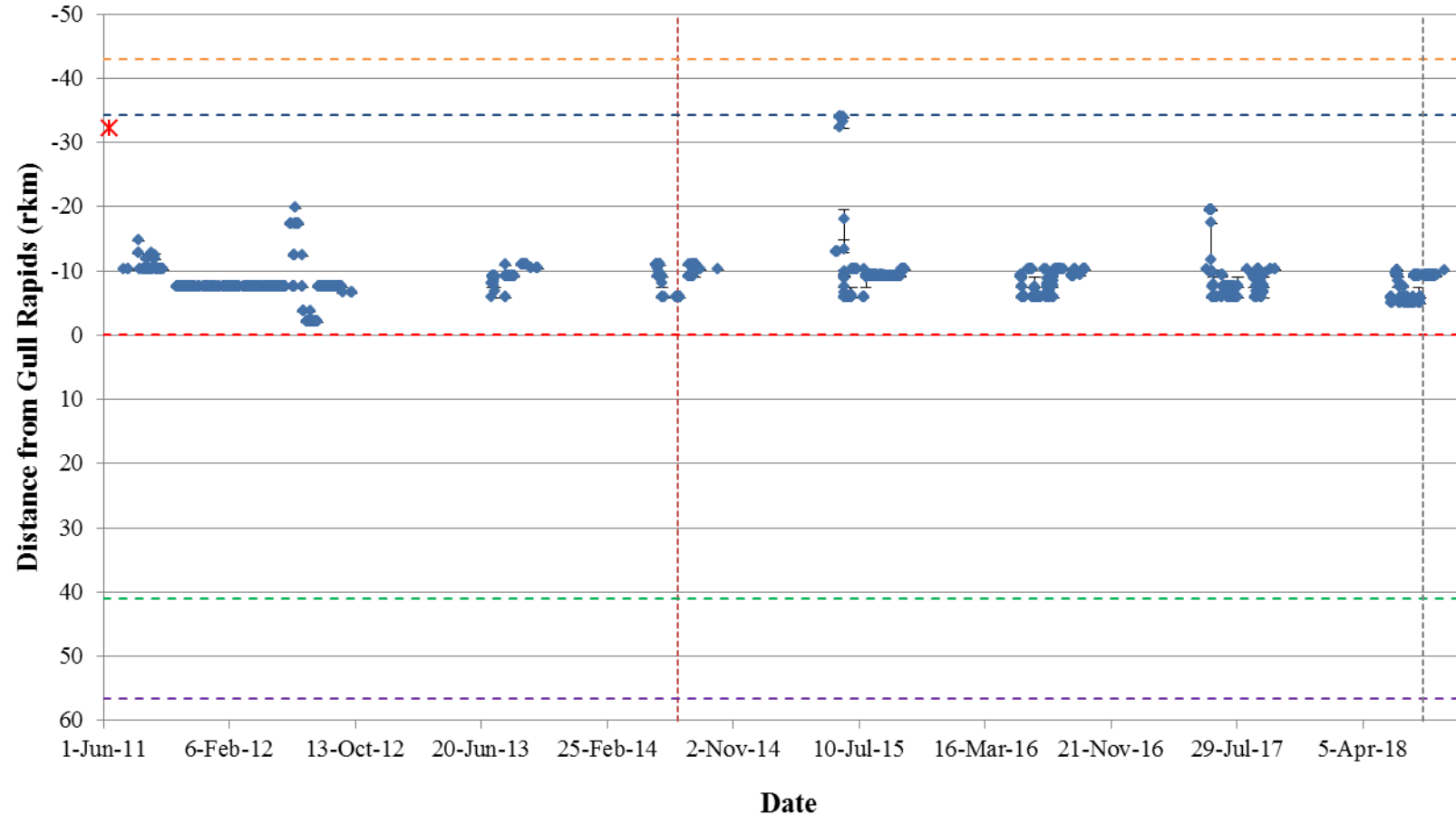


Figure A2-19: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16065) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

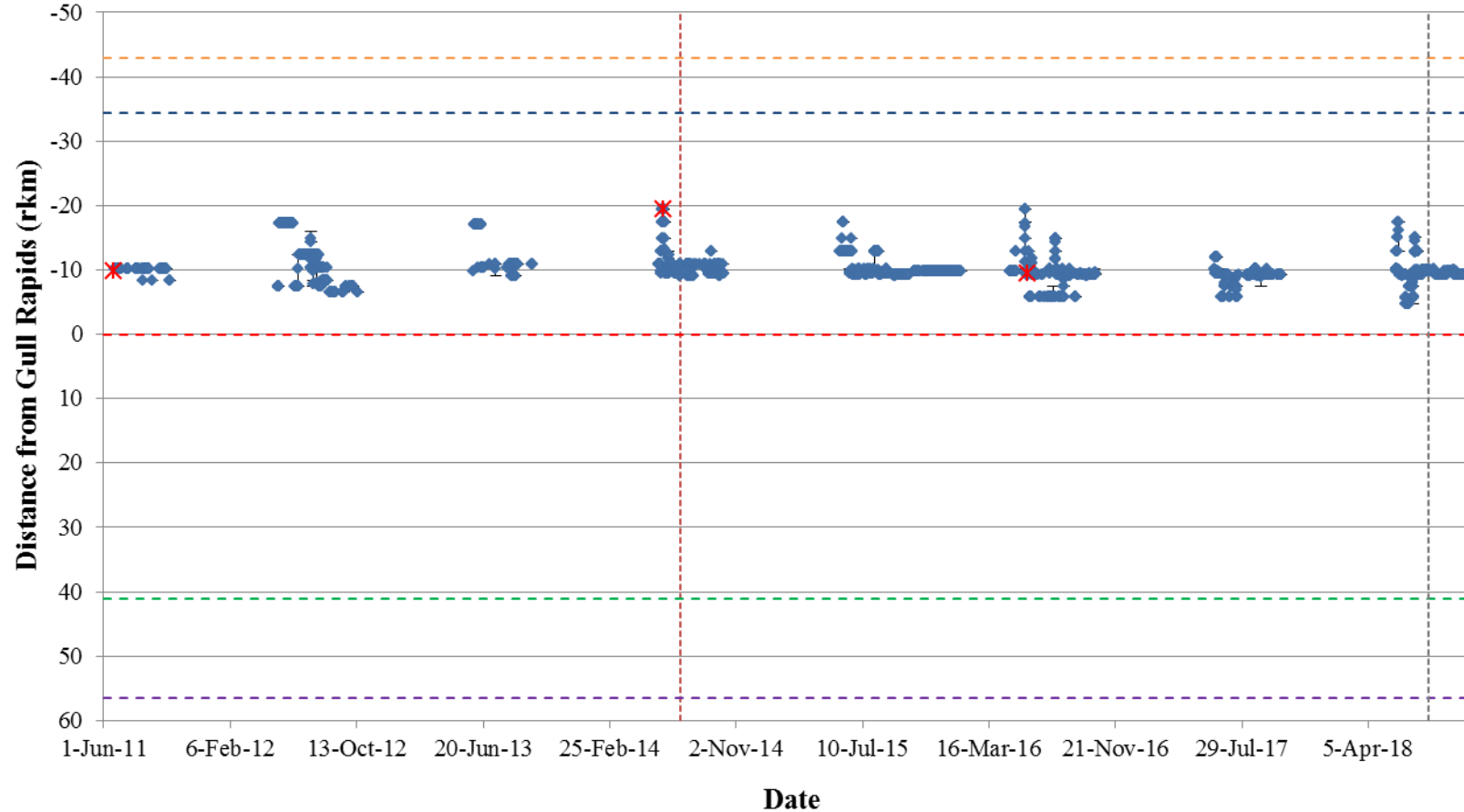


Figure A2-20: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16066) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging and recaptures are indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

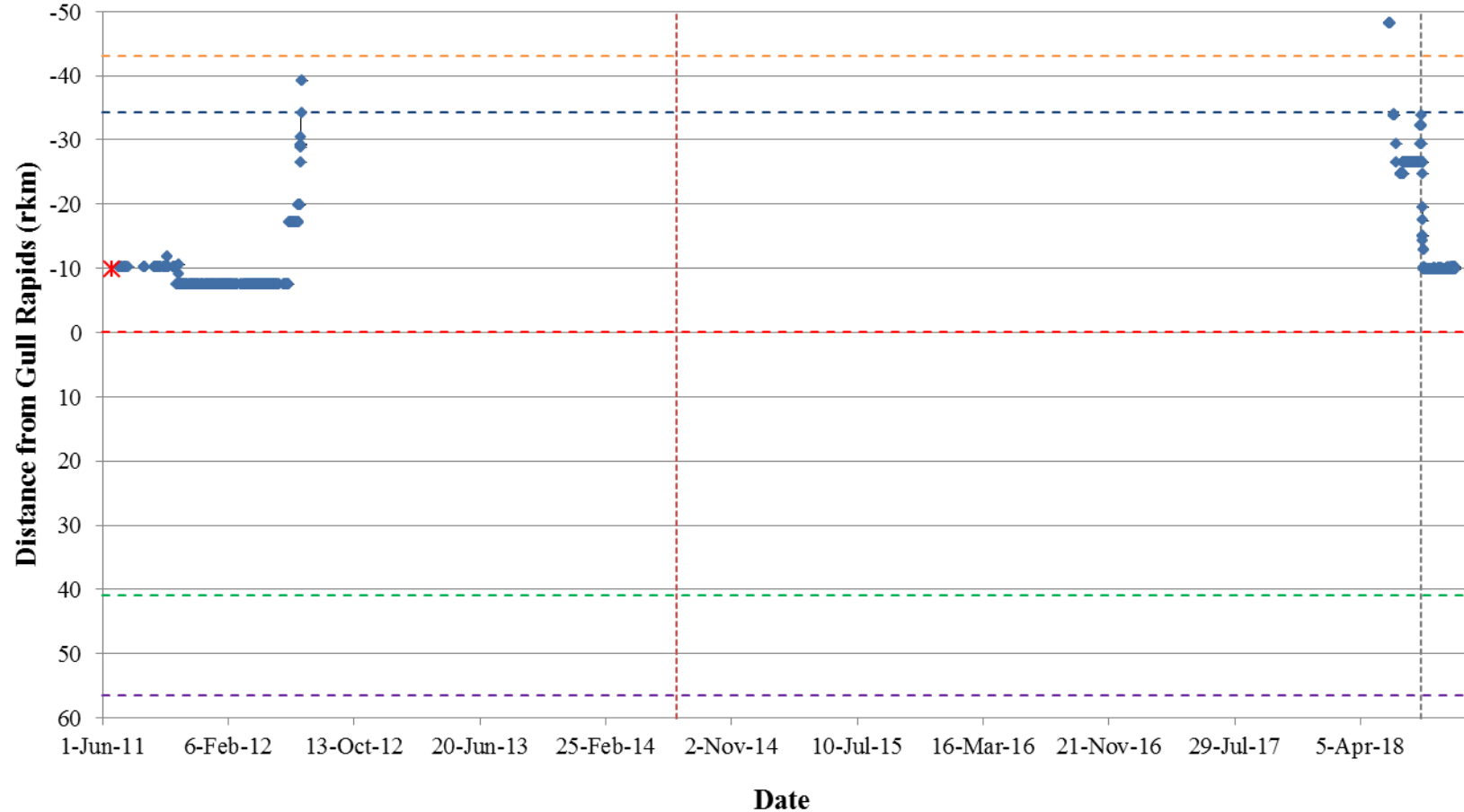


Figure A2-21: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16067) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

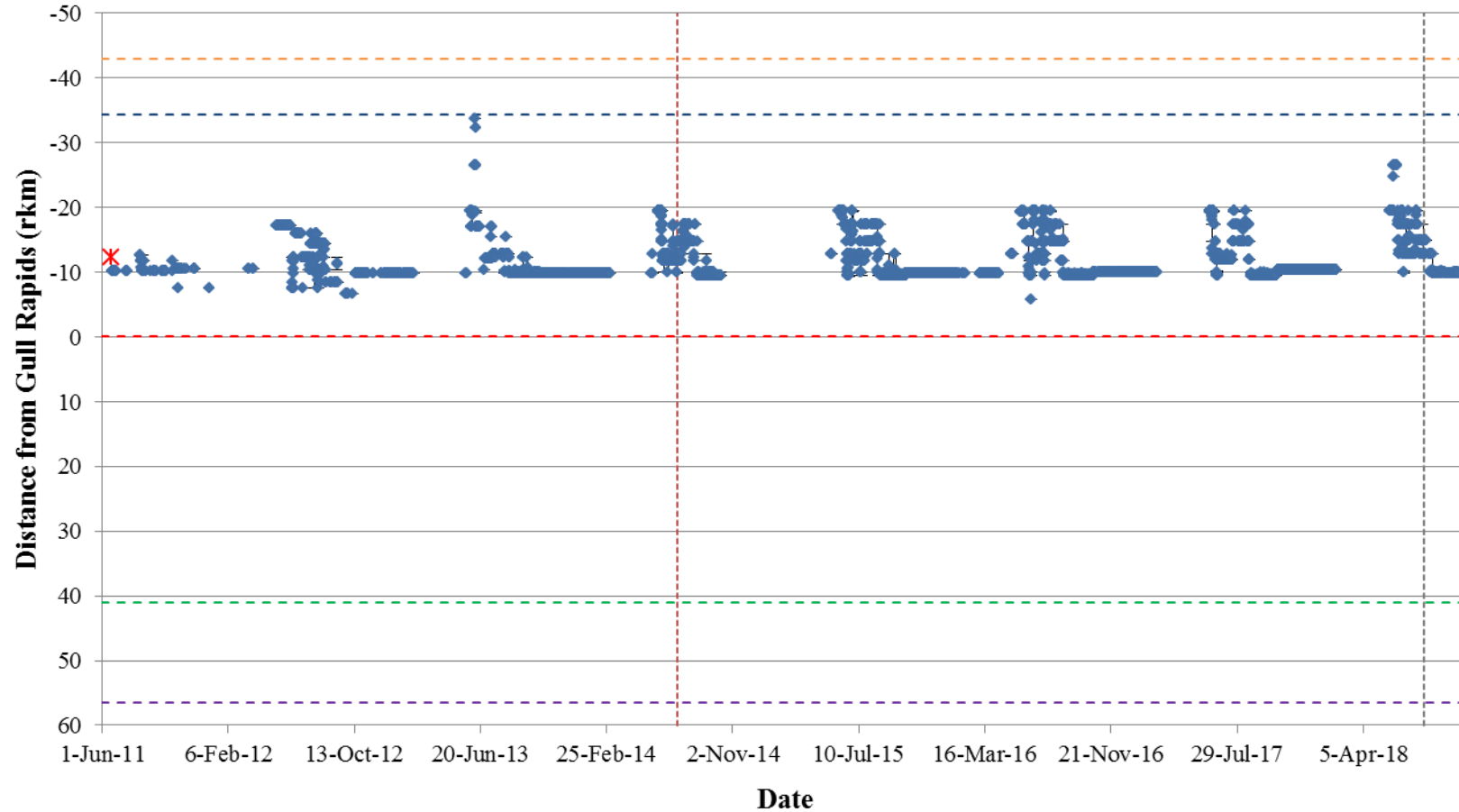


Figure A2-22: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16068) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

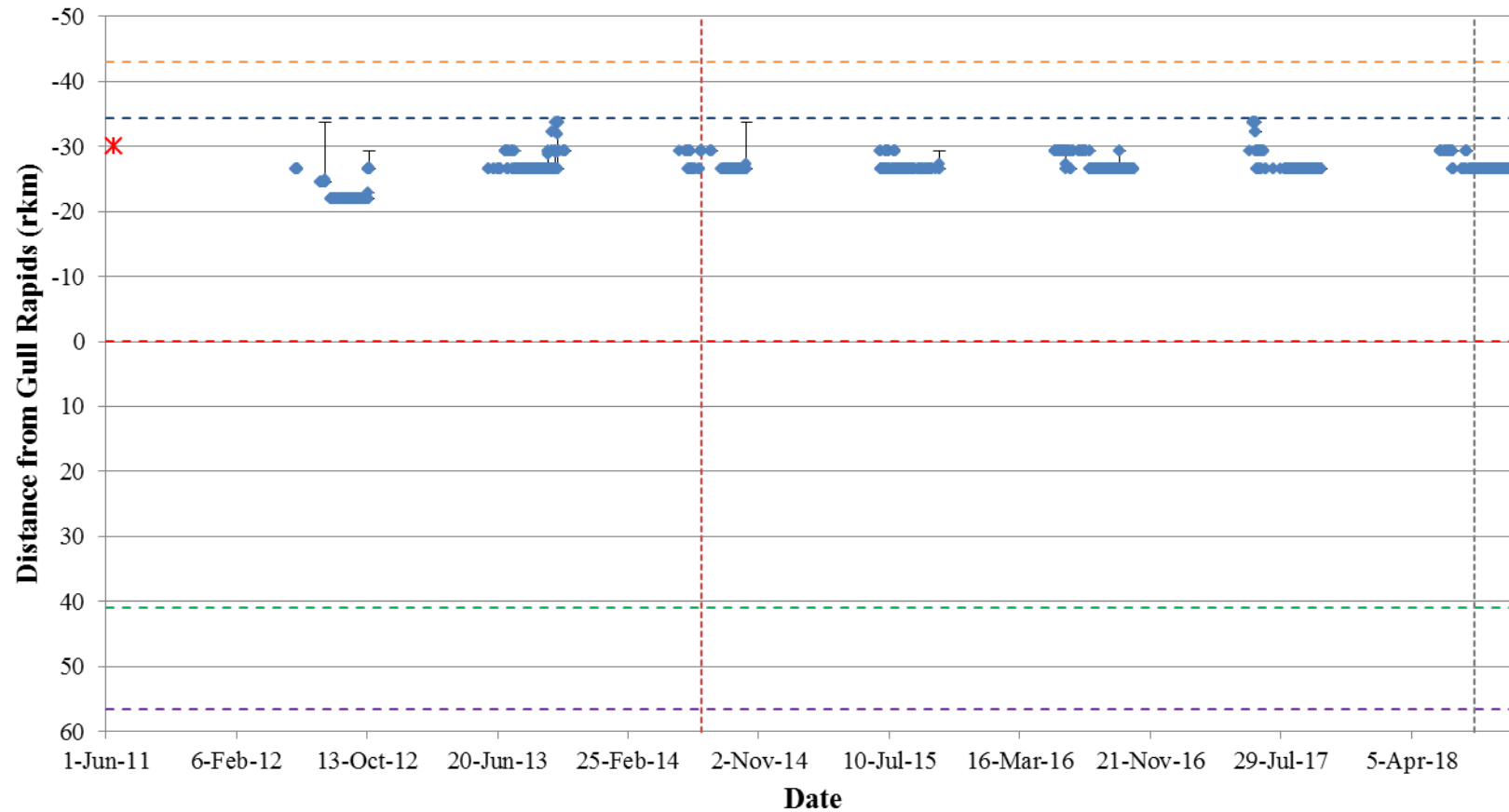


Figure A2-23: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16069) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

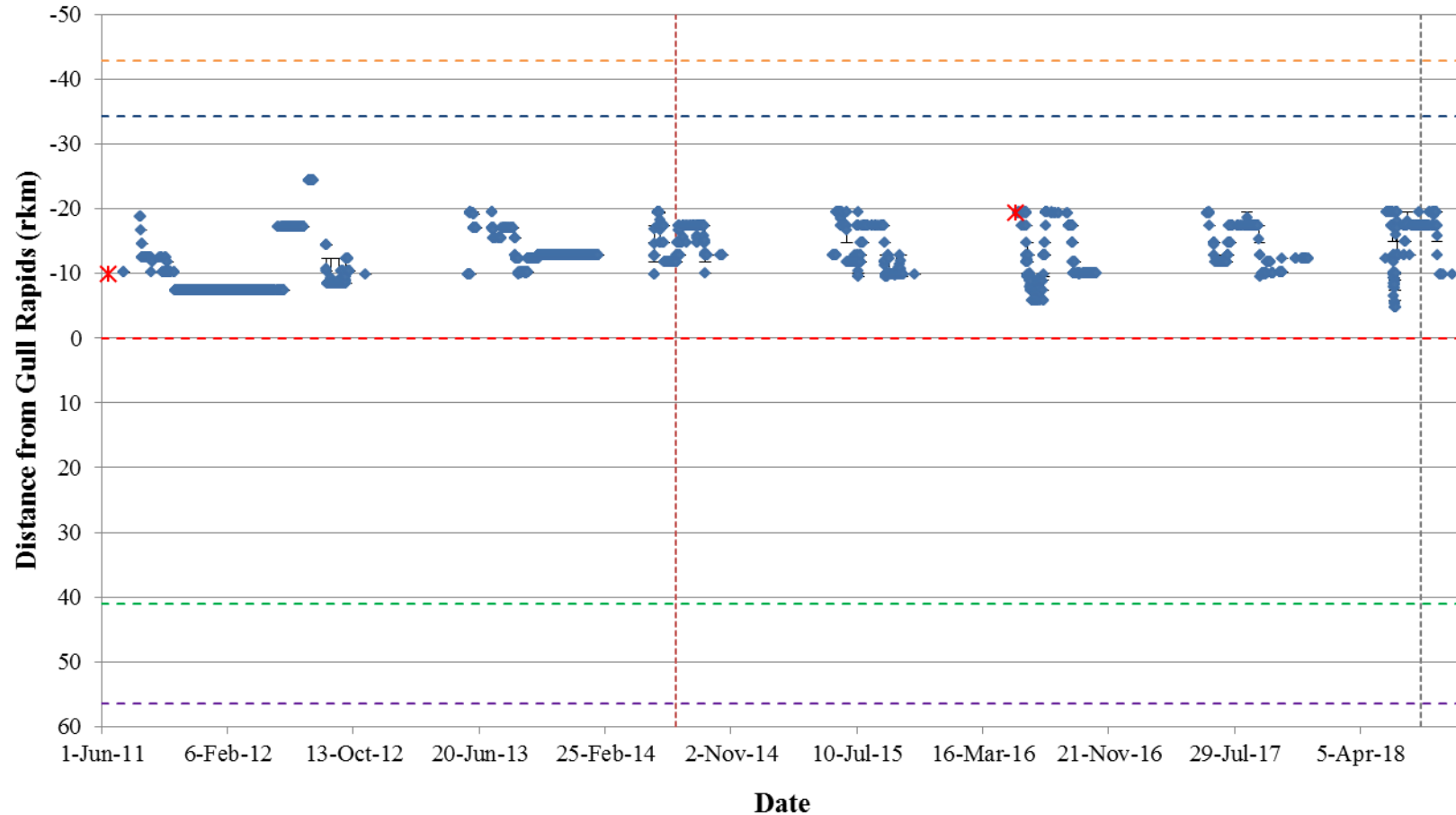


Figure A2-24: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16070) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging and recaptures are indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

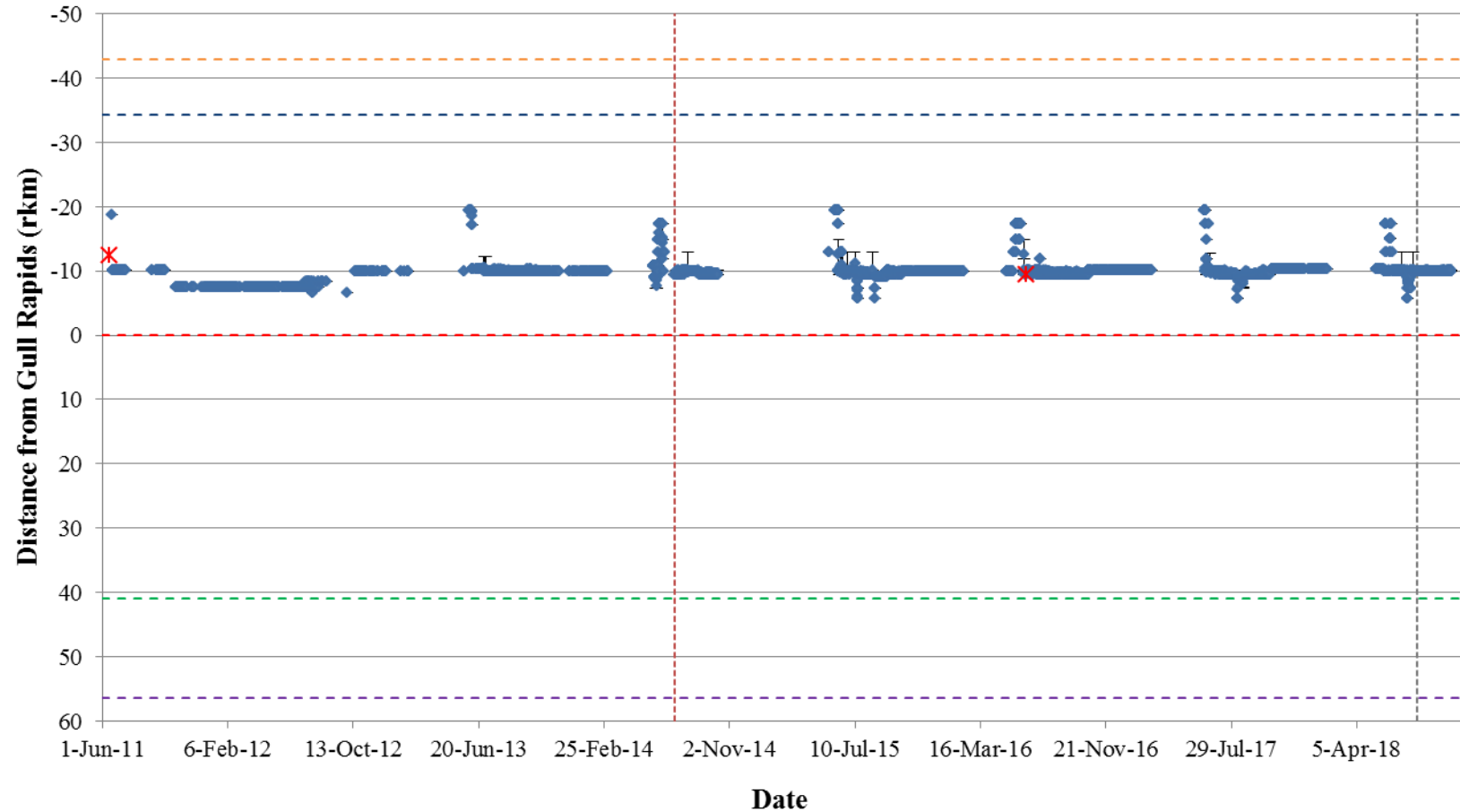


Figure A2-25: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16071) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging and recaptures are indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

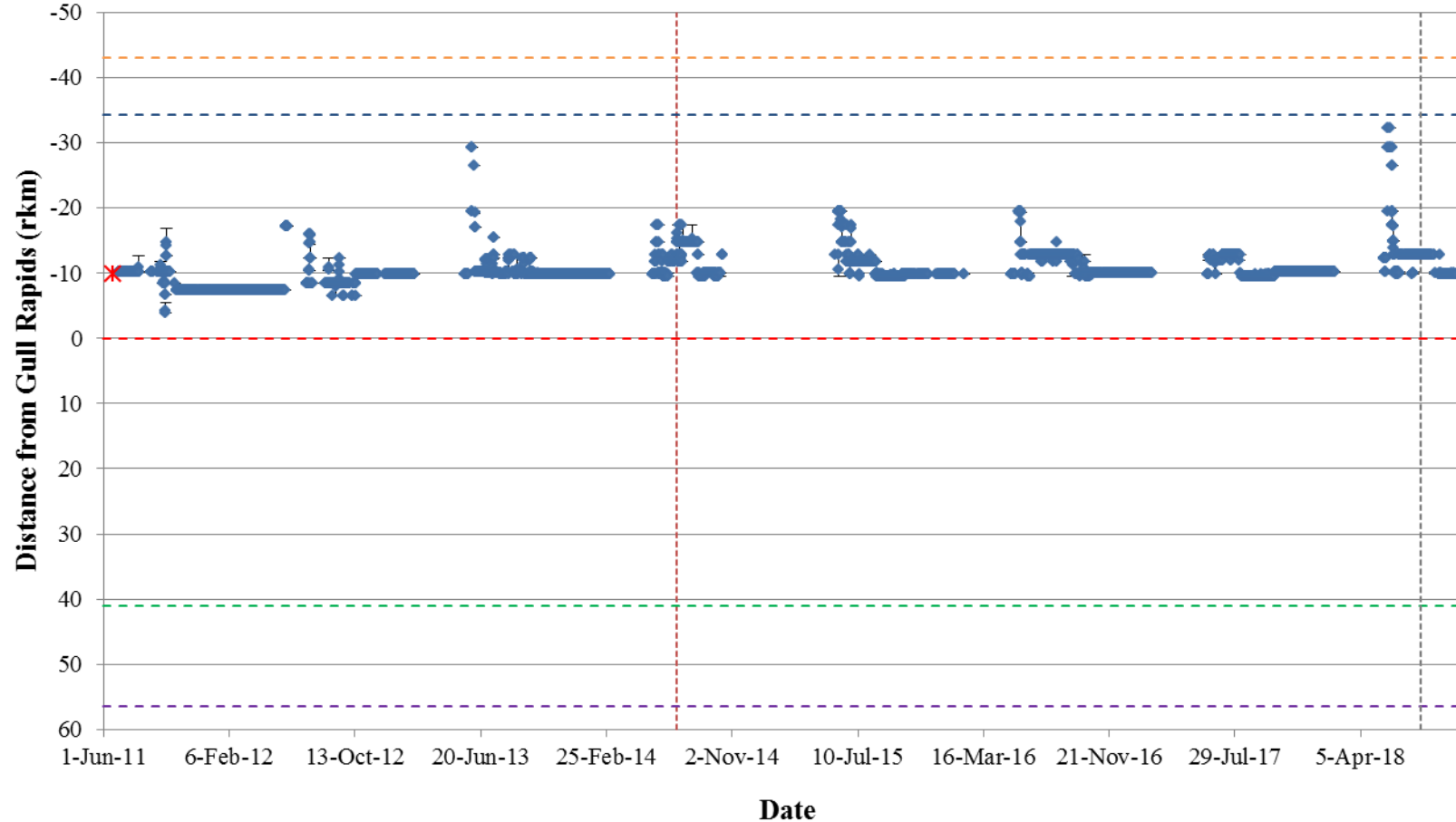


Figure A2-26: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16072) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

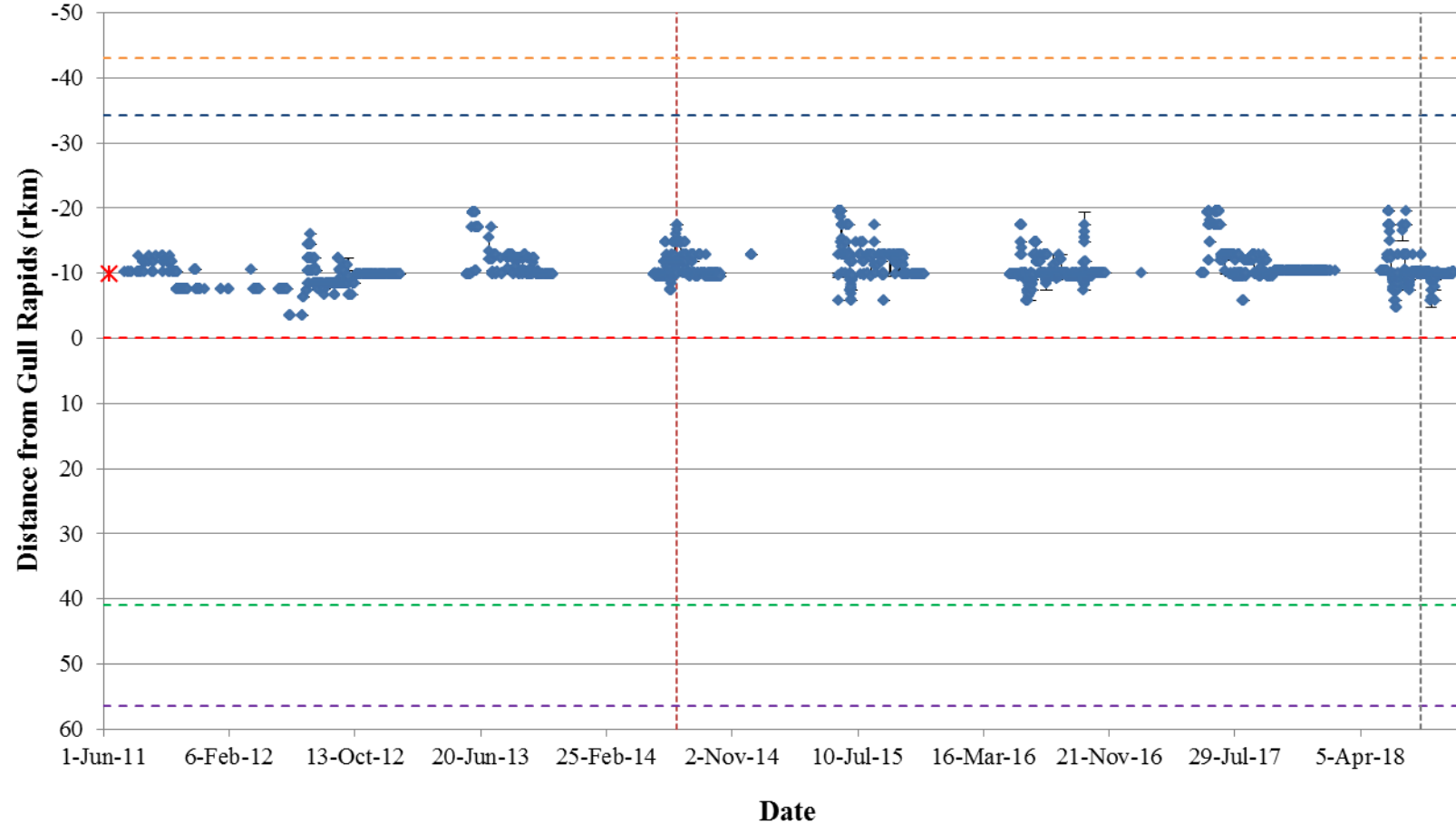


Figure A2-27: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16073) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

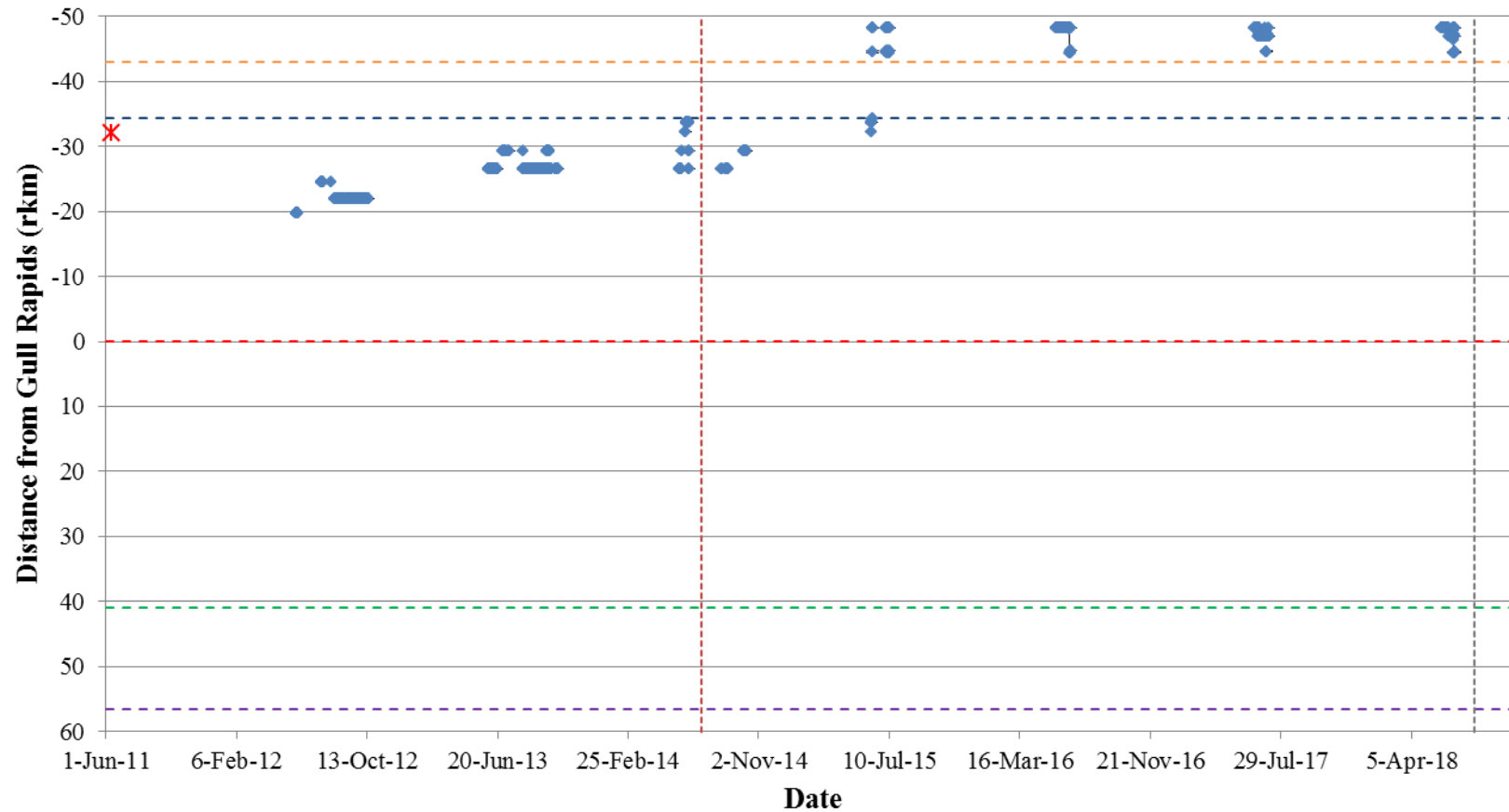


Figure A2-28: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16074) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

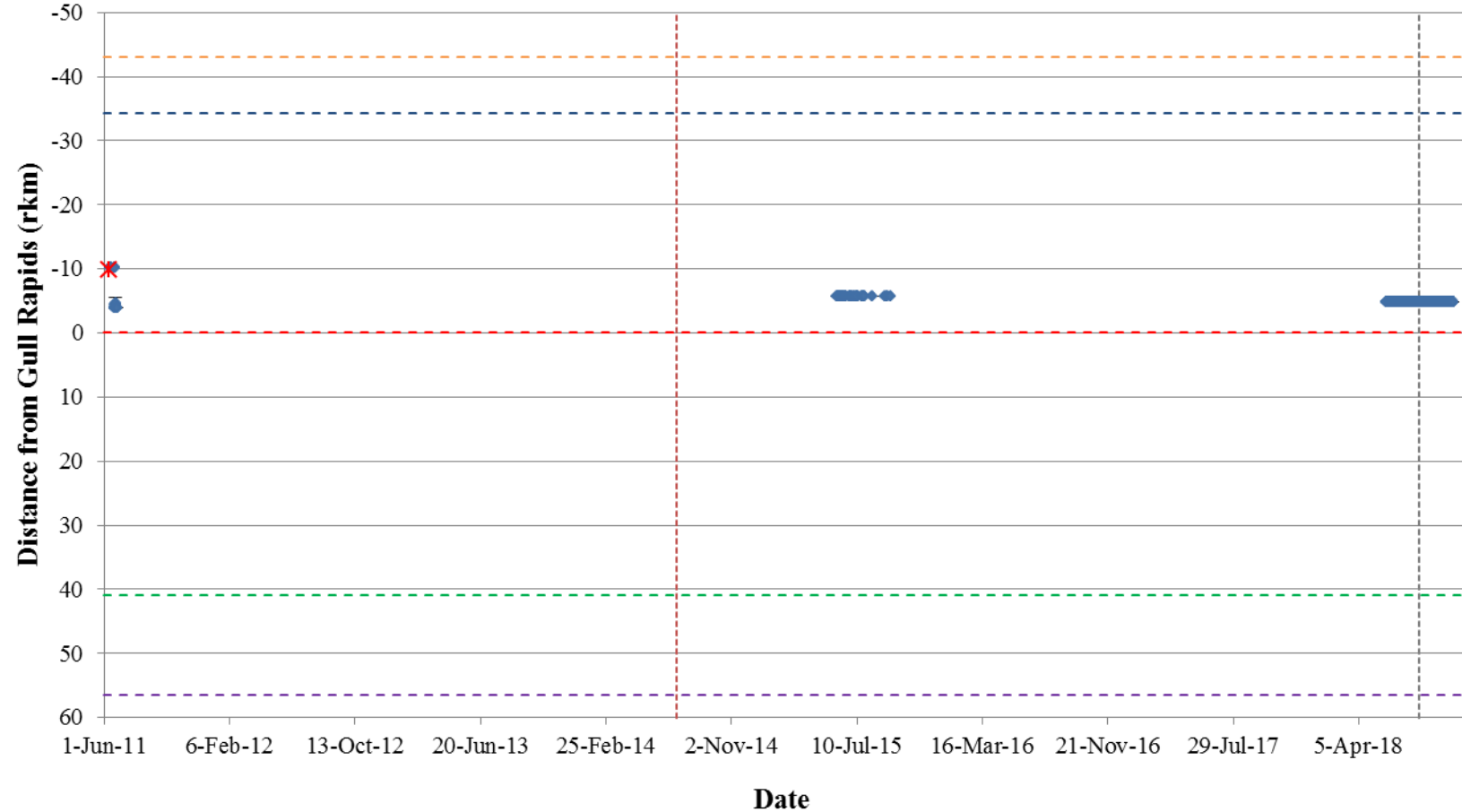


Figure A2-29: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16075) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

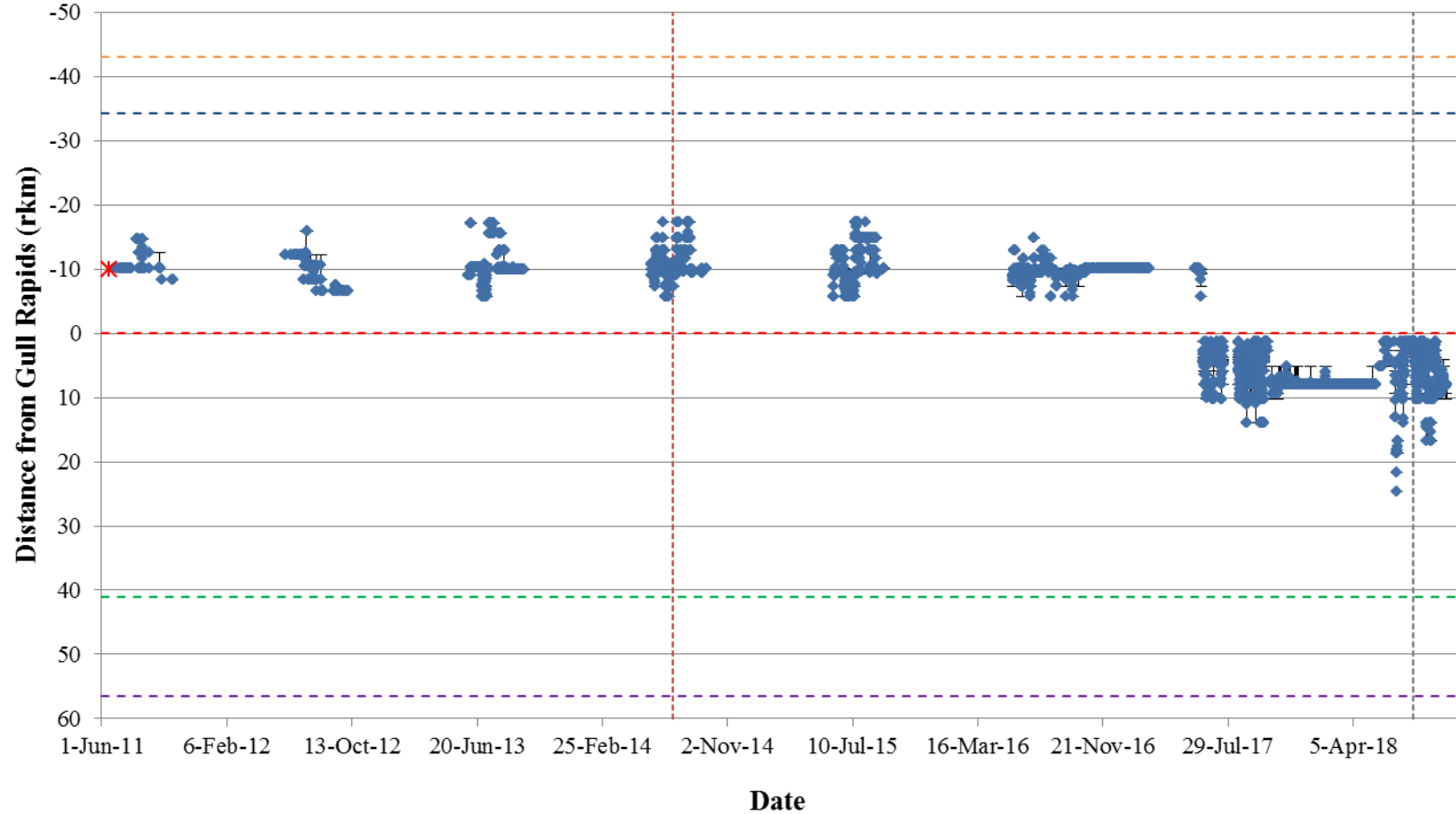


Figure A2-30: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16076) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

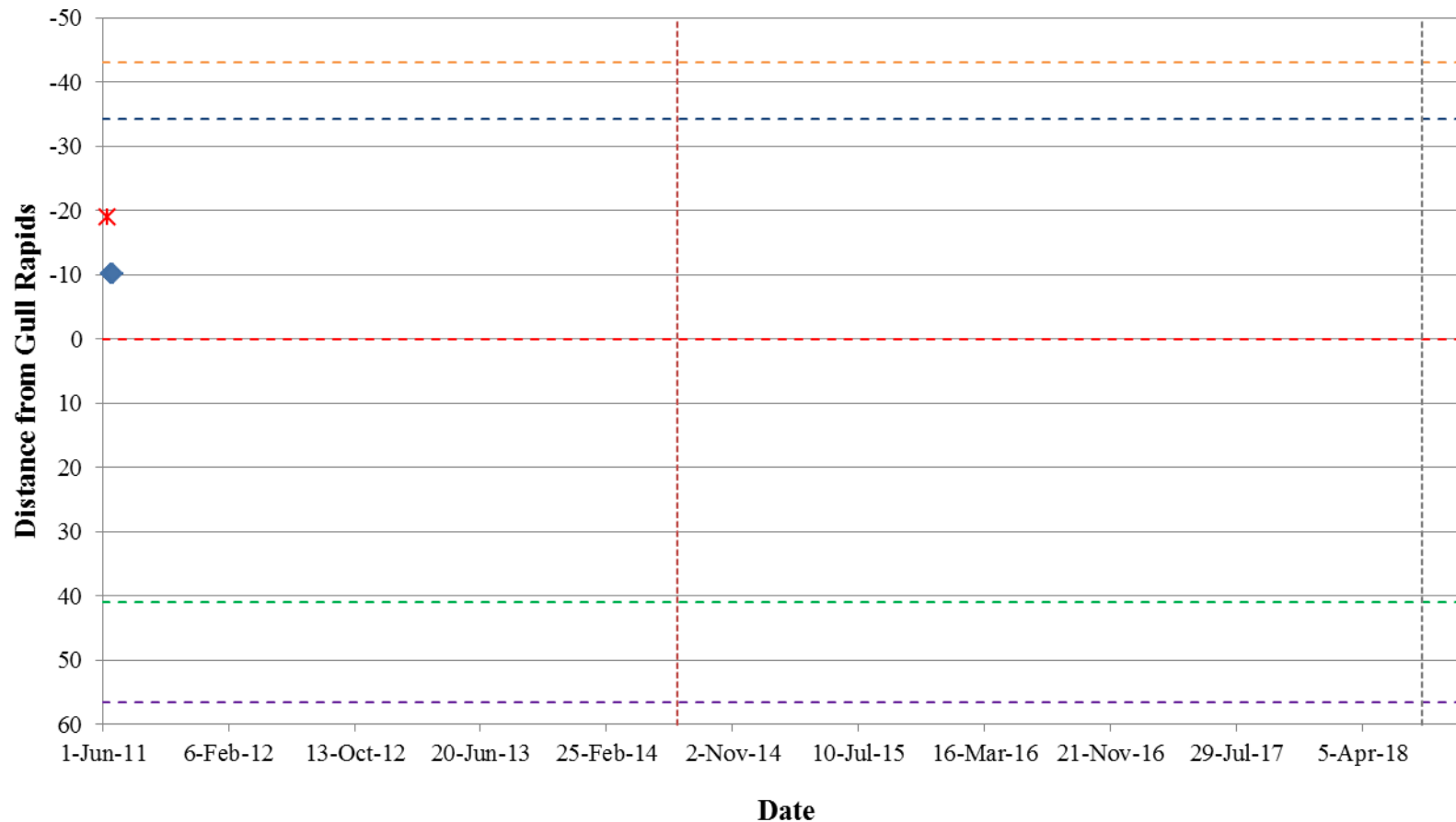


Figure A2-31: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16077) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

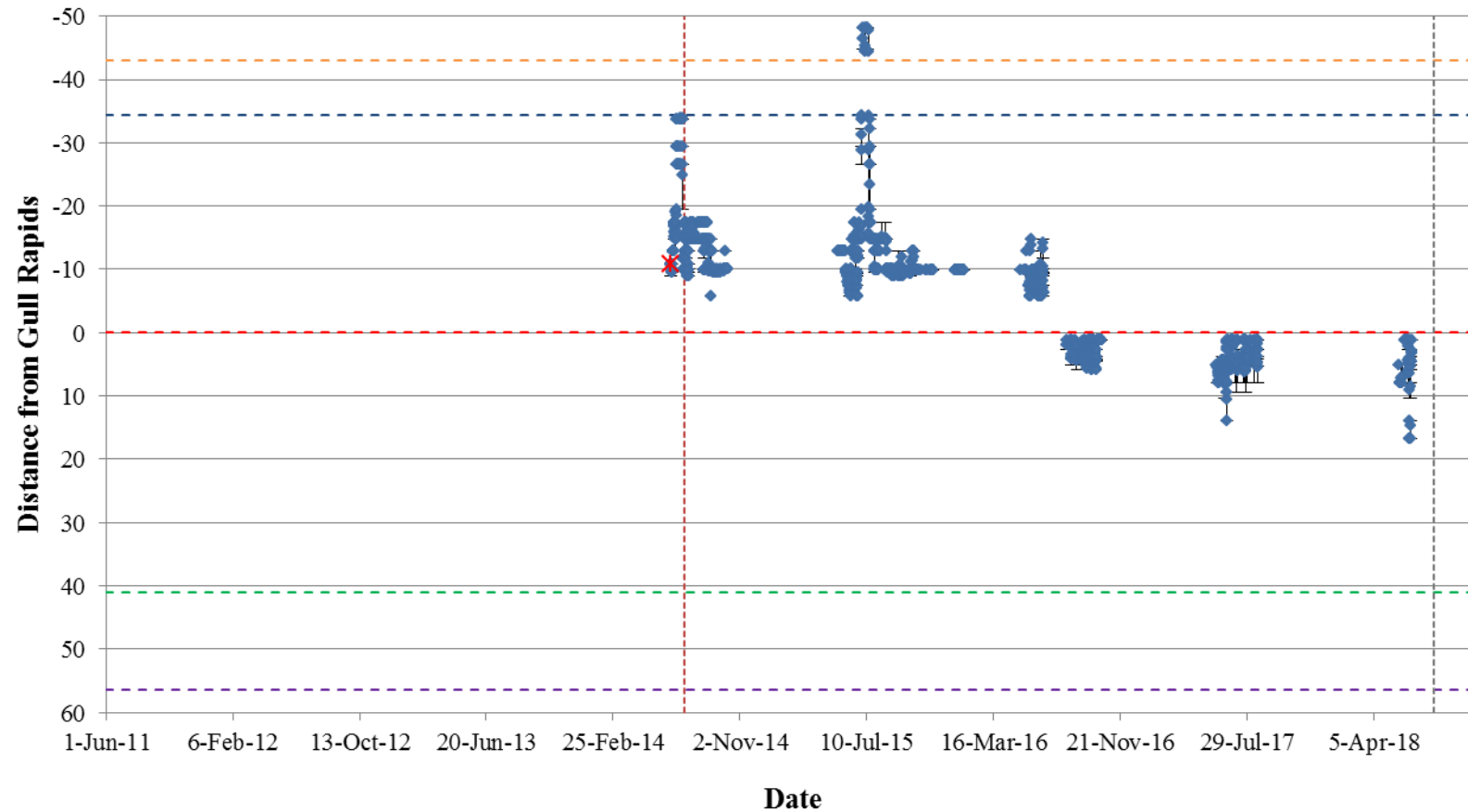


Figure A2-32: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32174) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

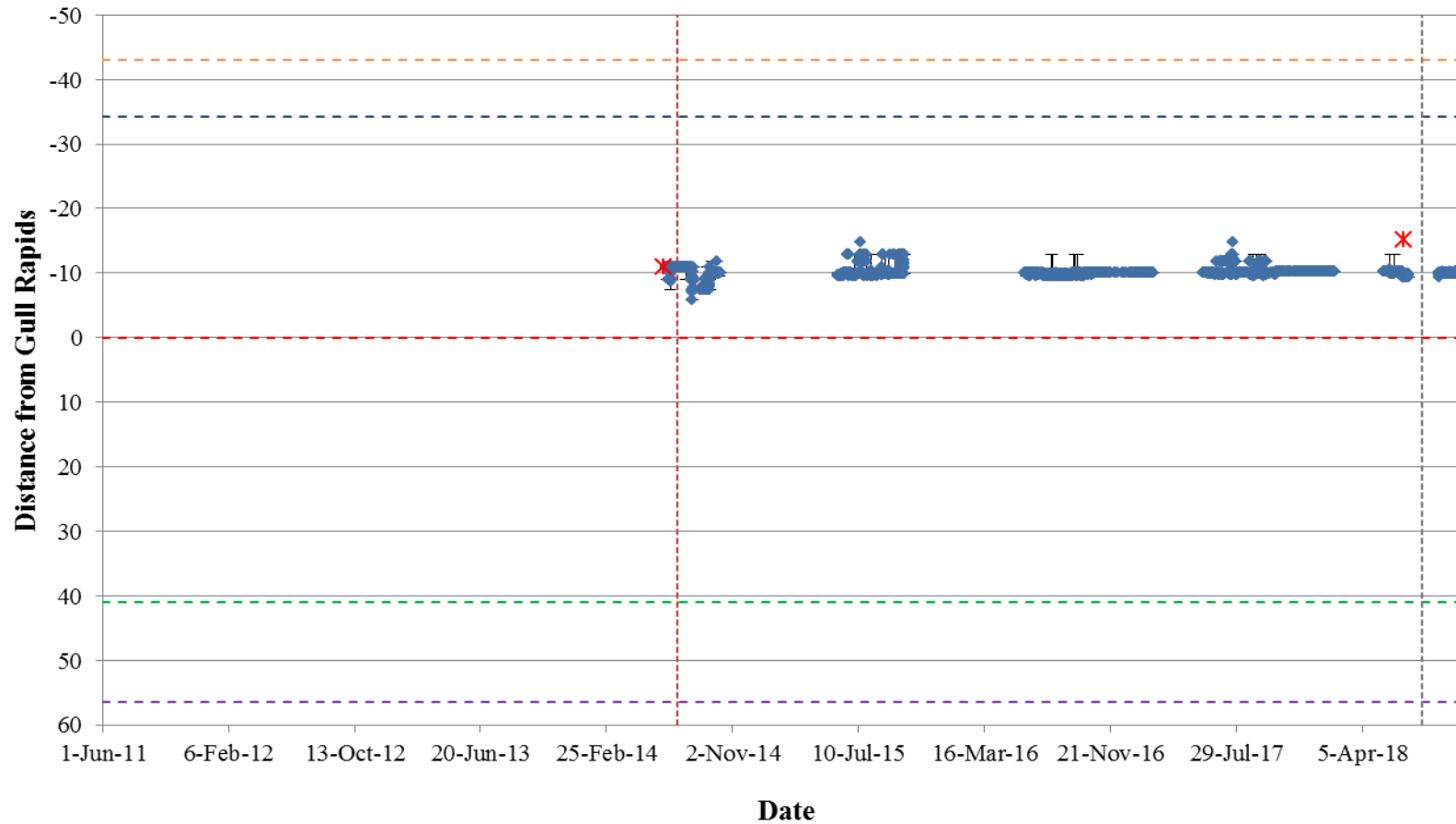


Figure A2-33: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32175) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging and recaptures are indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

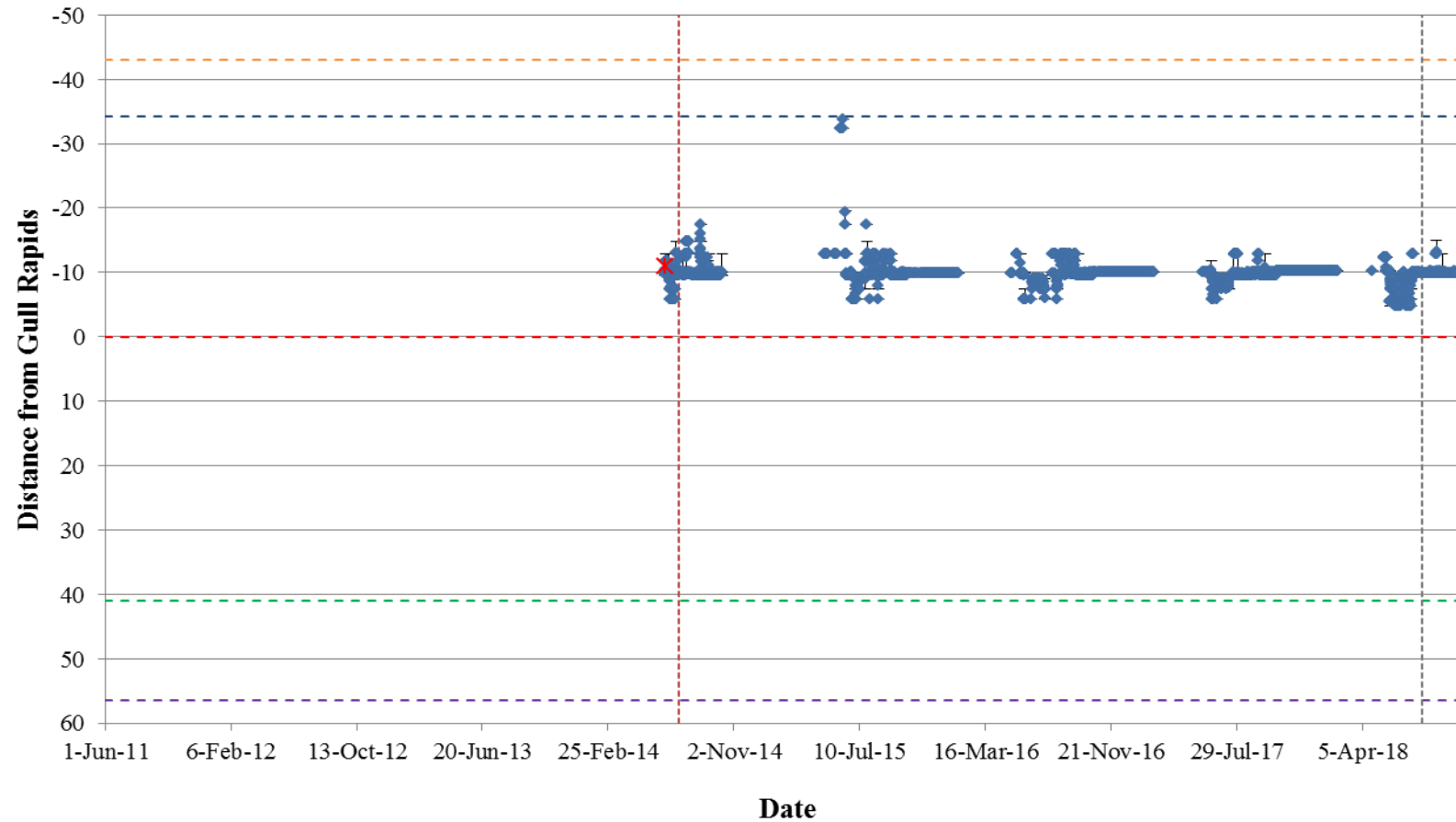


Figure A2-34: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32176) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

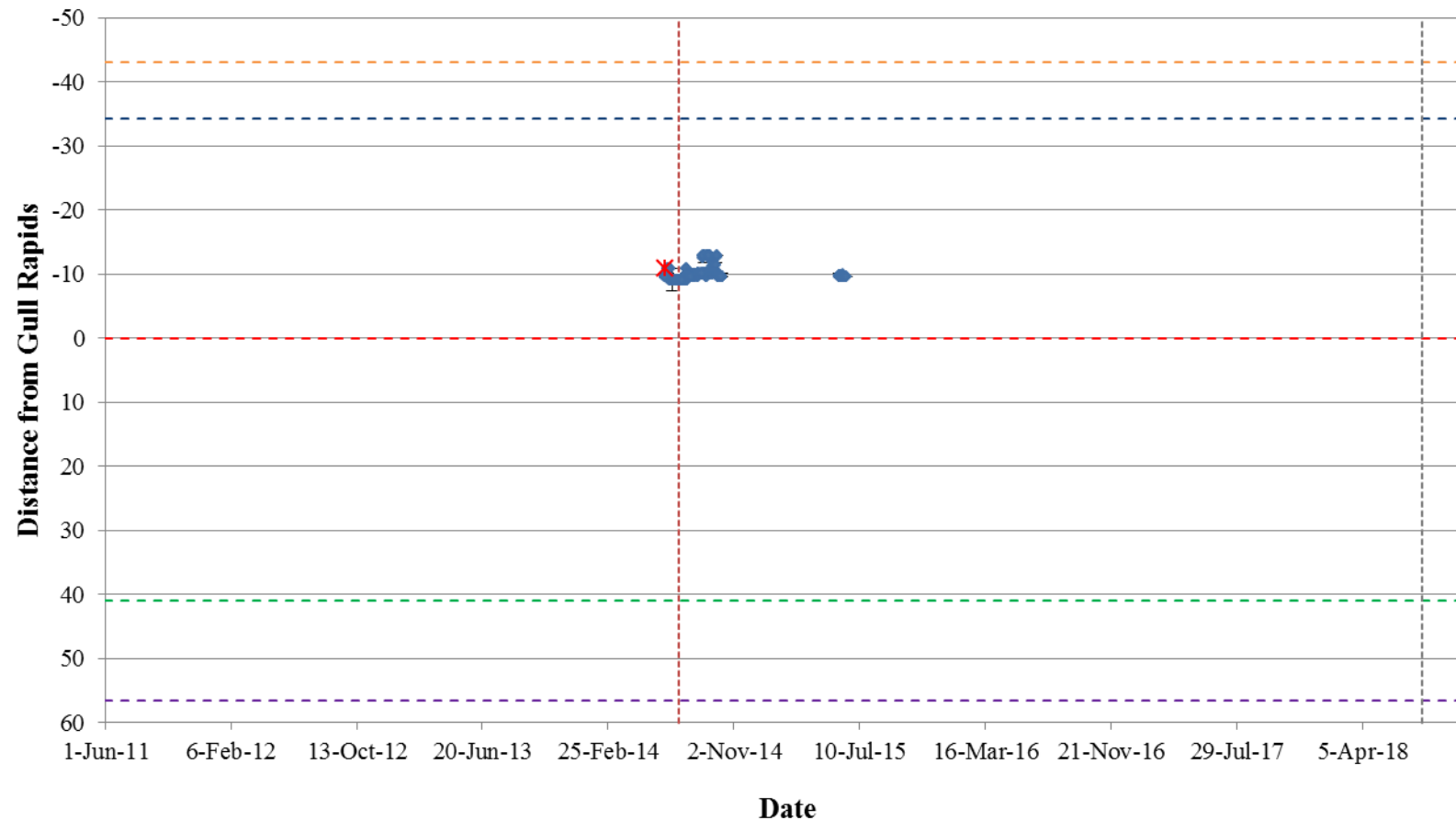


Figure A2-35: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32177) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

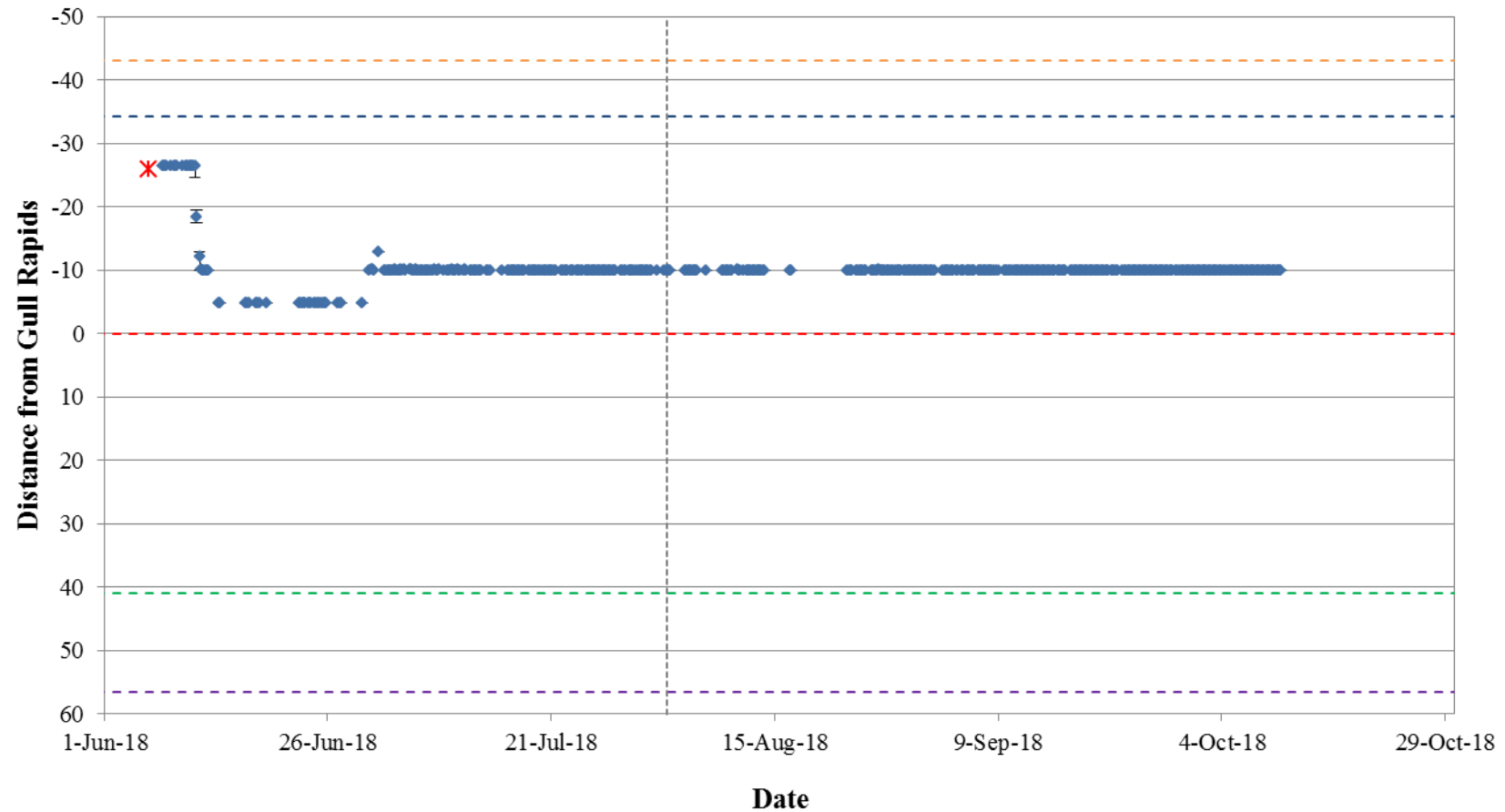


Figure A2-36: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #54799) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2018 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

APPENDIX 3:

LOCATION SUMMARY FOR INDIVIDUAL ACOUSTIC TAGGED ADULT LAKE STURGEON, STEPHENS LAKE, JUNE 2011 TO OCTOBER 2018

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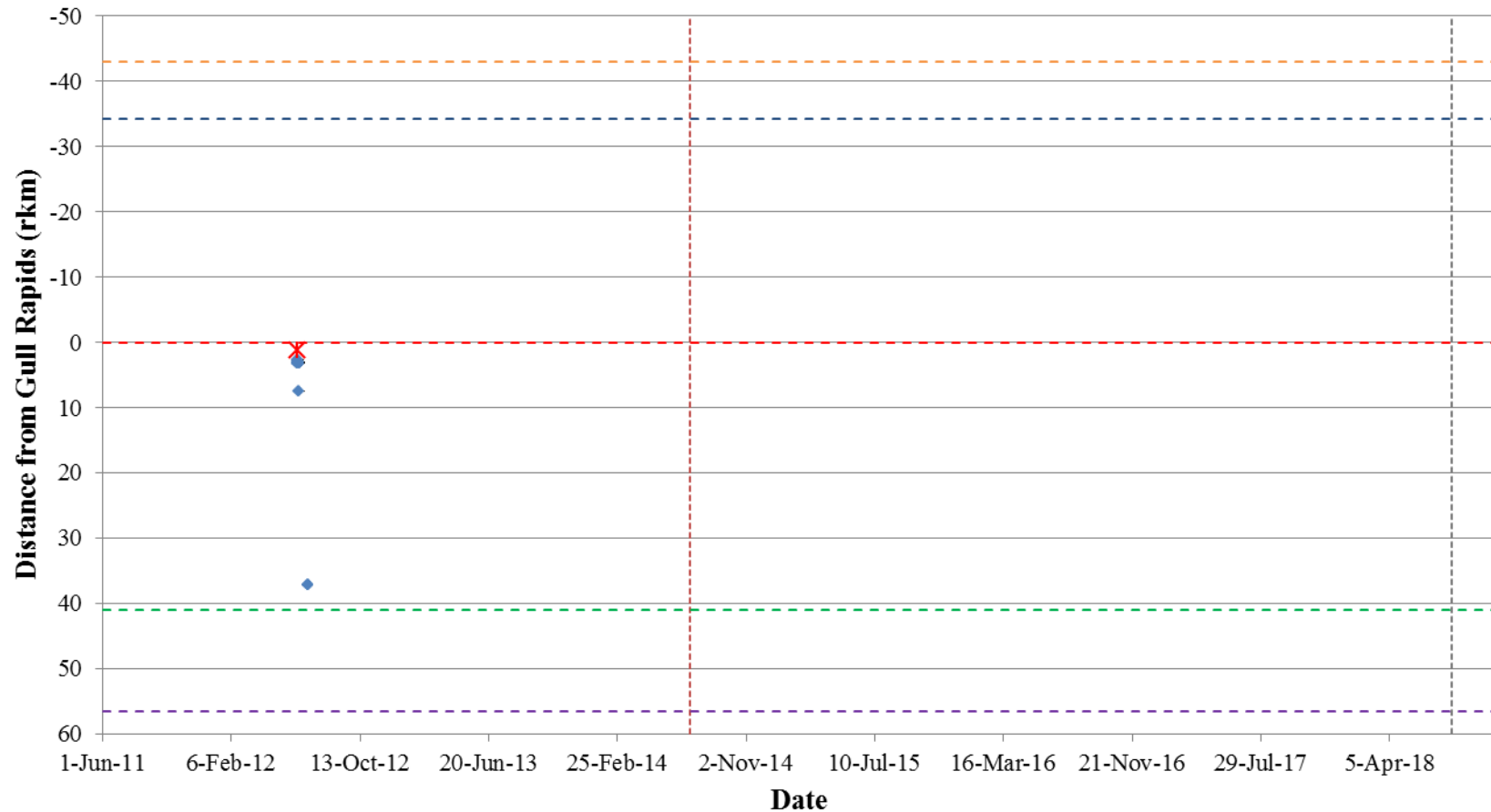


Figure A3-1: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16018) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

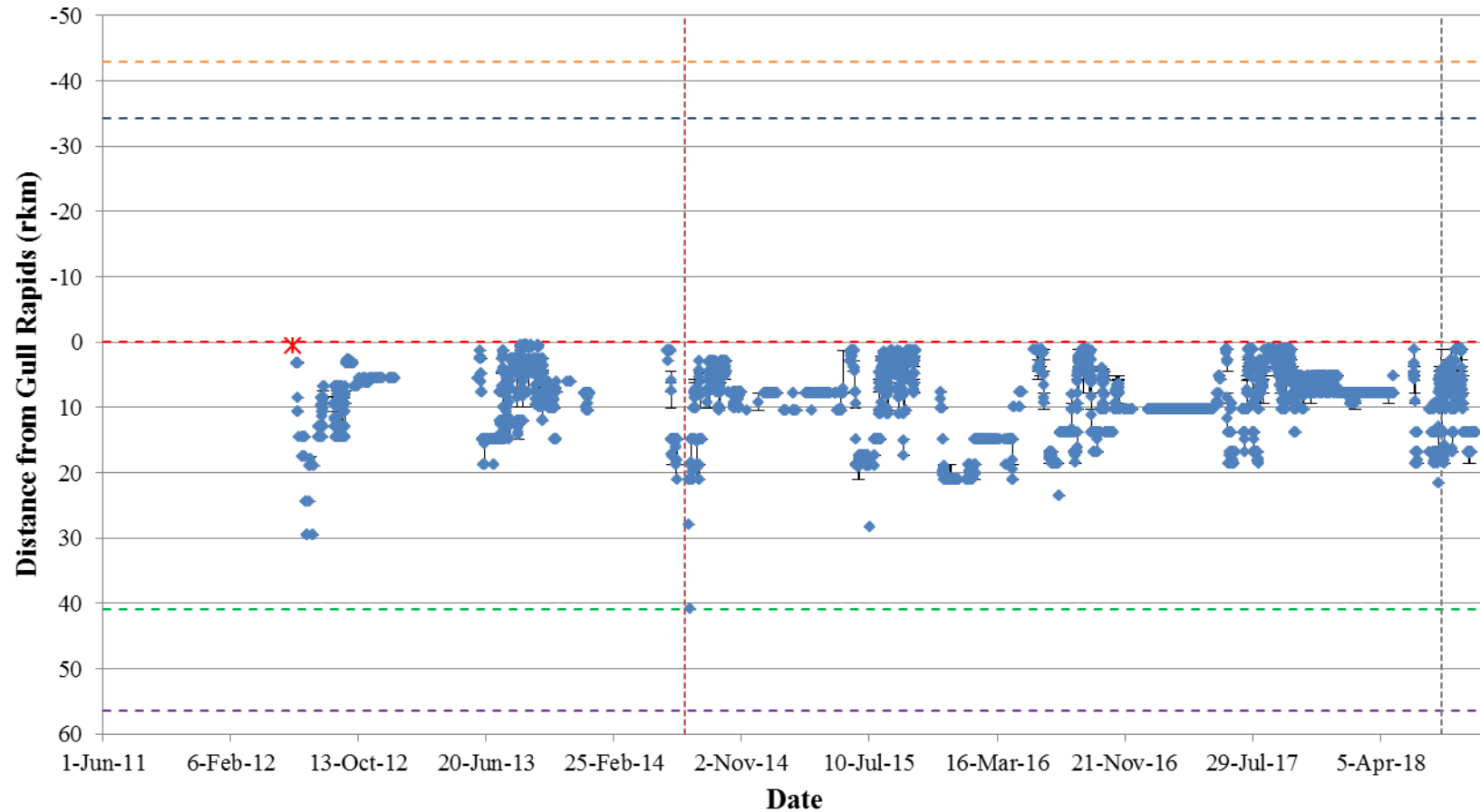


Figure A3-2: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16019) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

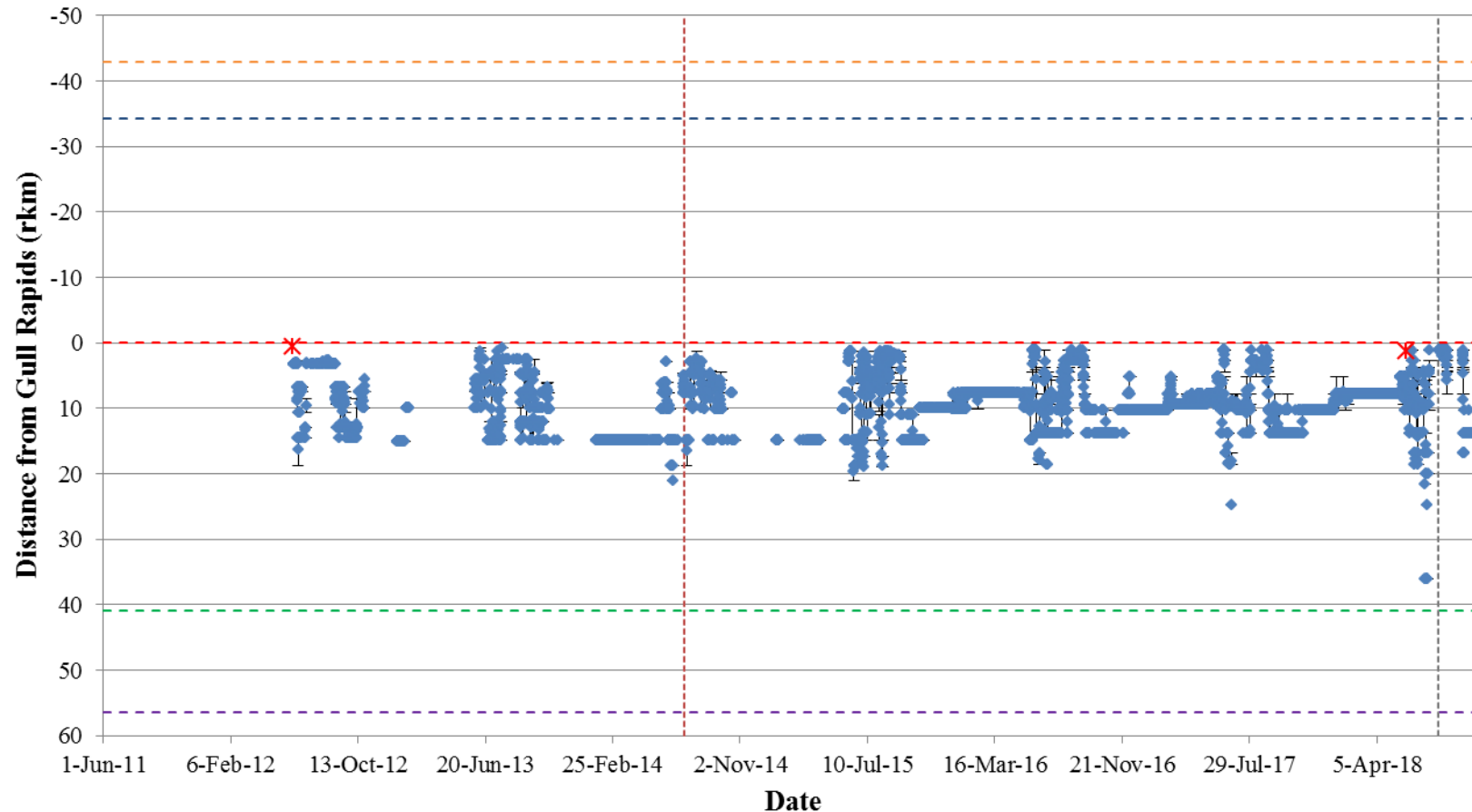


Figure A3-3: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16020) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging and recaptures are indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

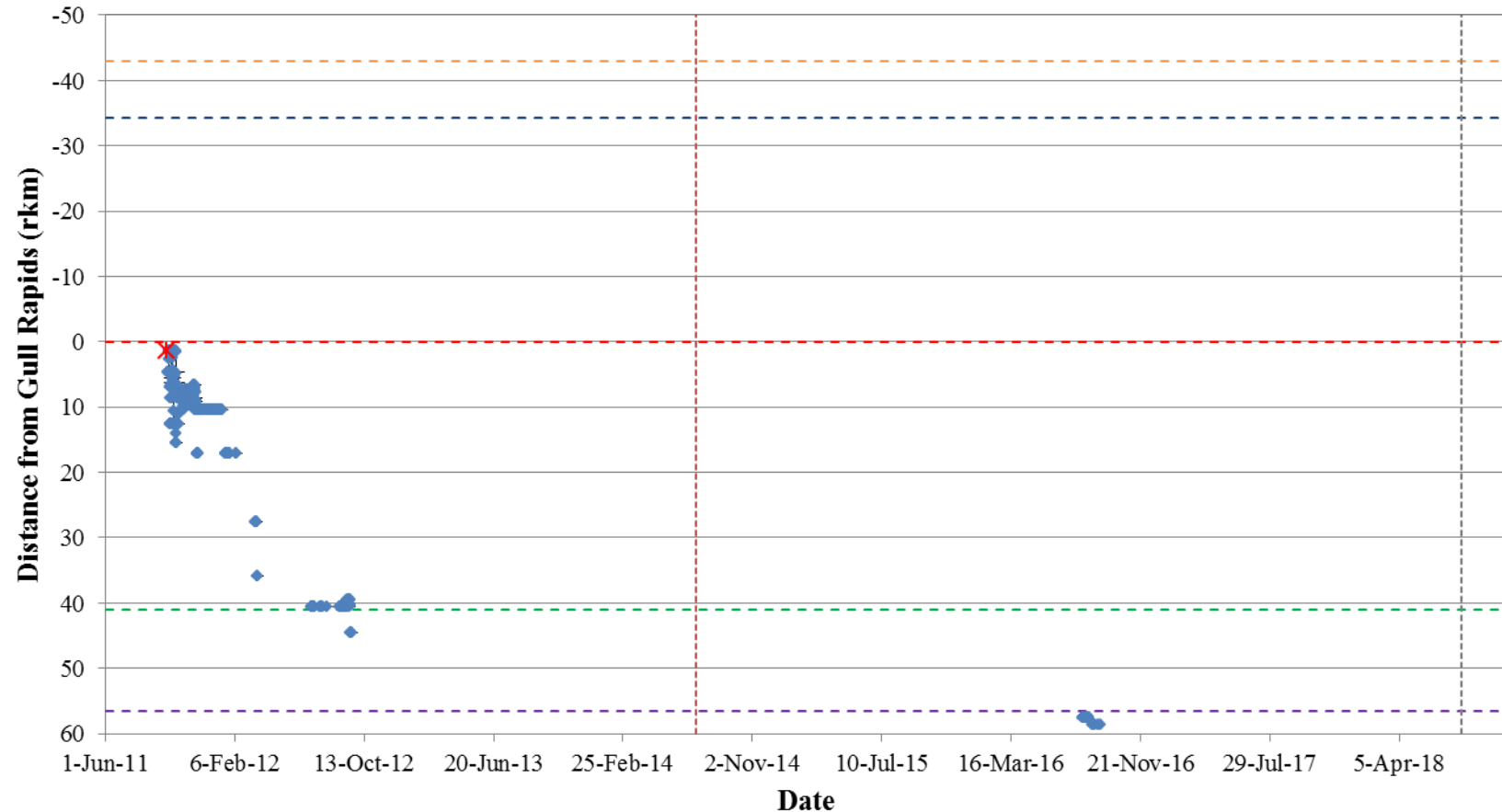


Figure A3-4: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16021) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

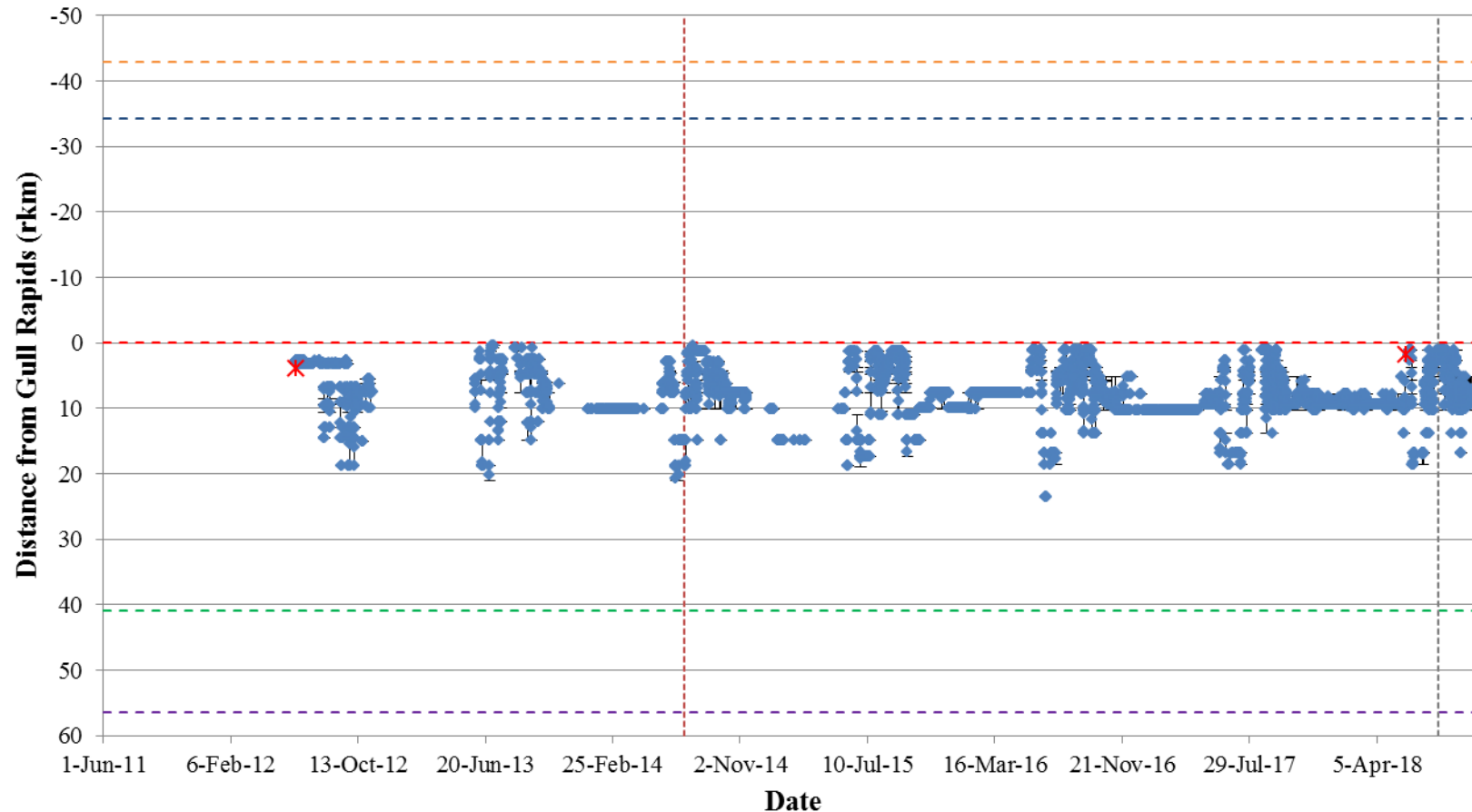


Figure A3-5: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16022) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging and recaptures are indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

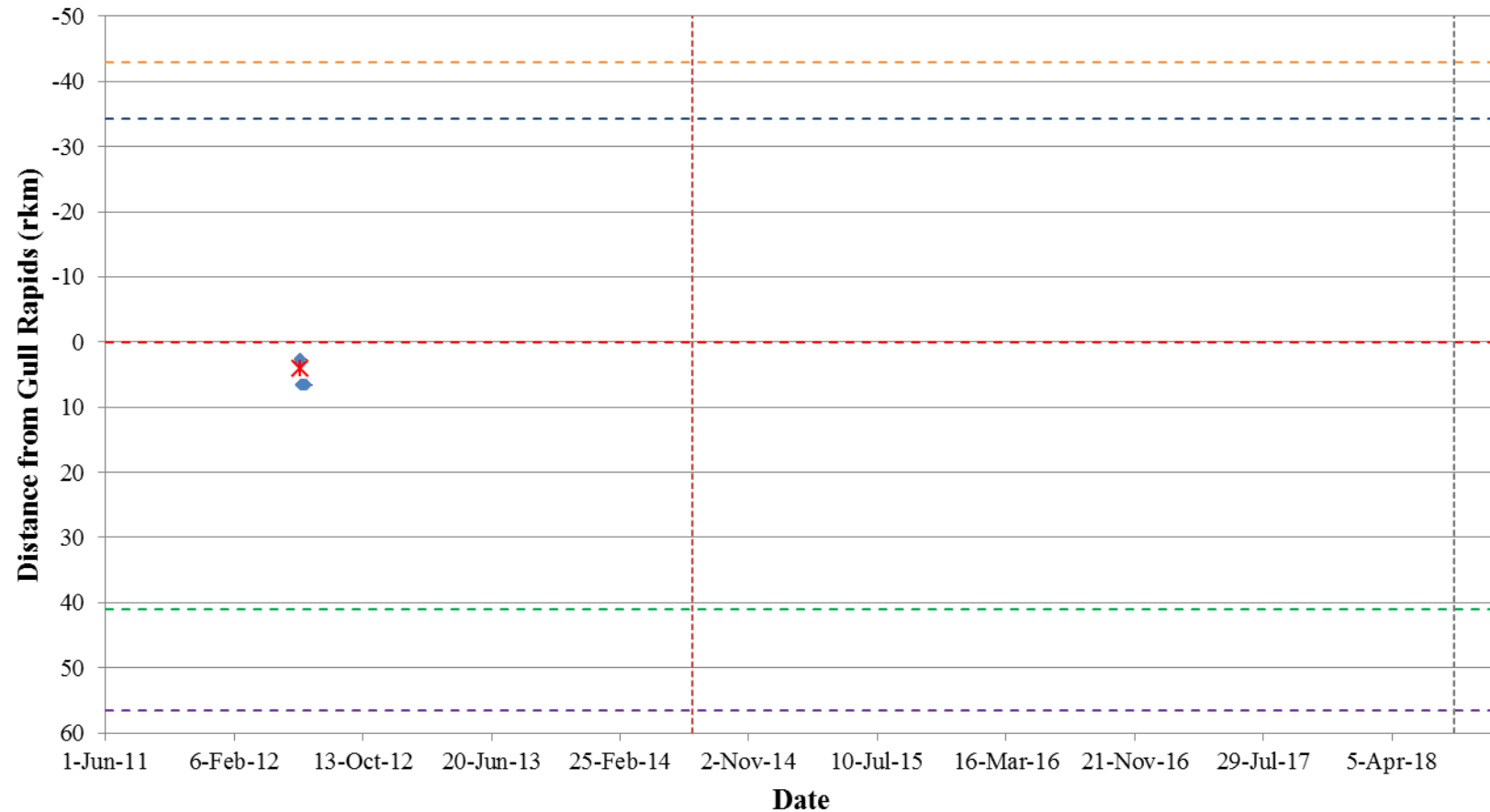


Figure A3-6: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16024) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

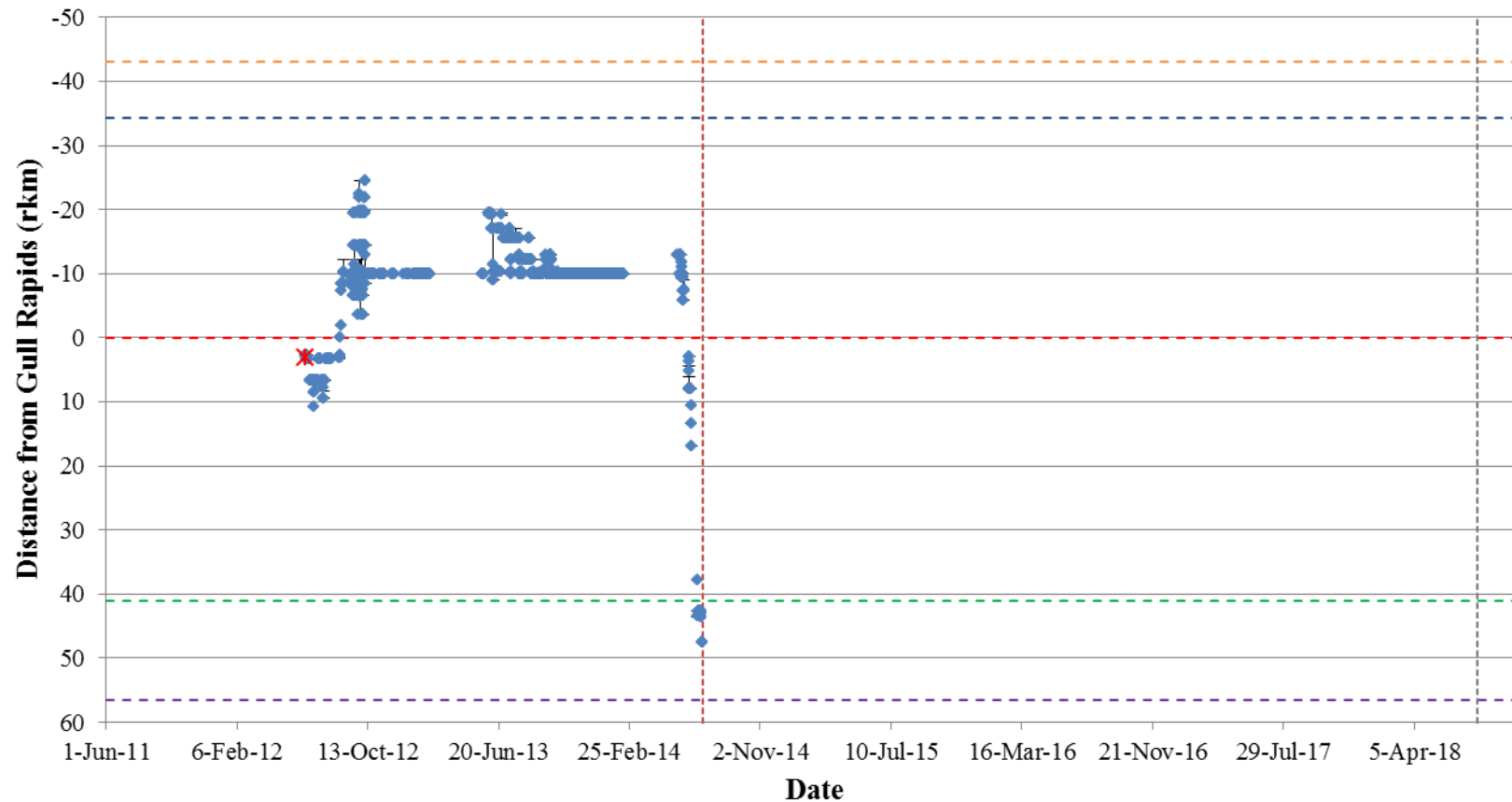


Figure A3-7: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16025) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

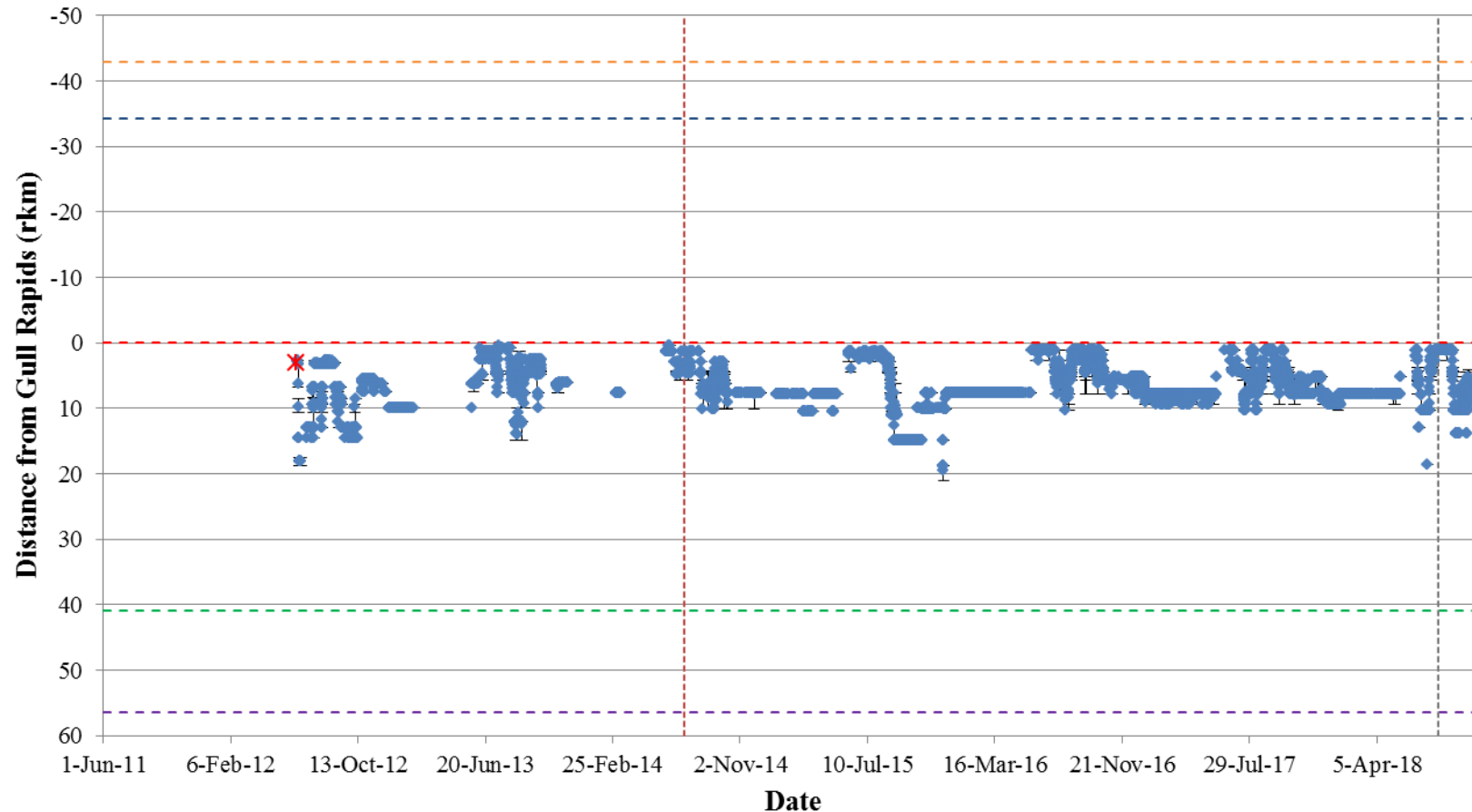


Figure A3-8: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16027) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

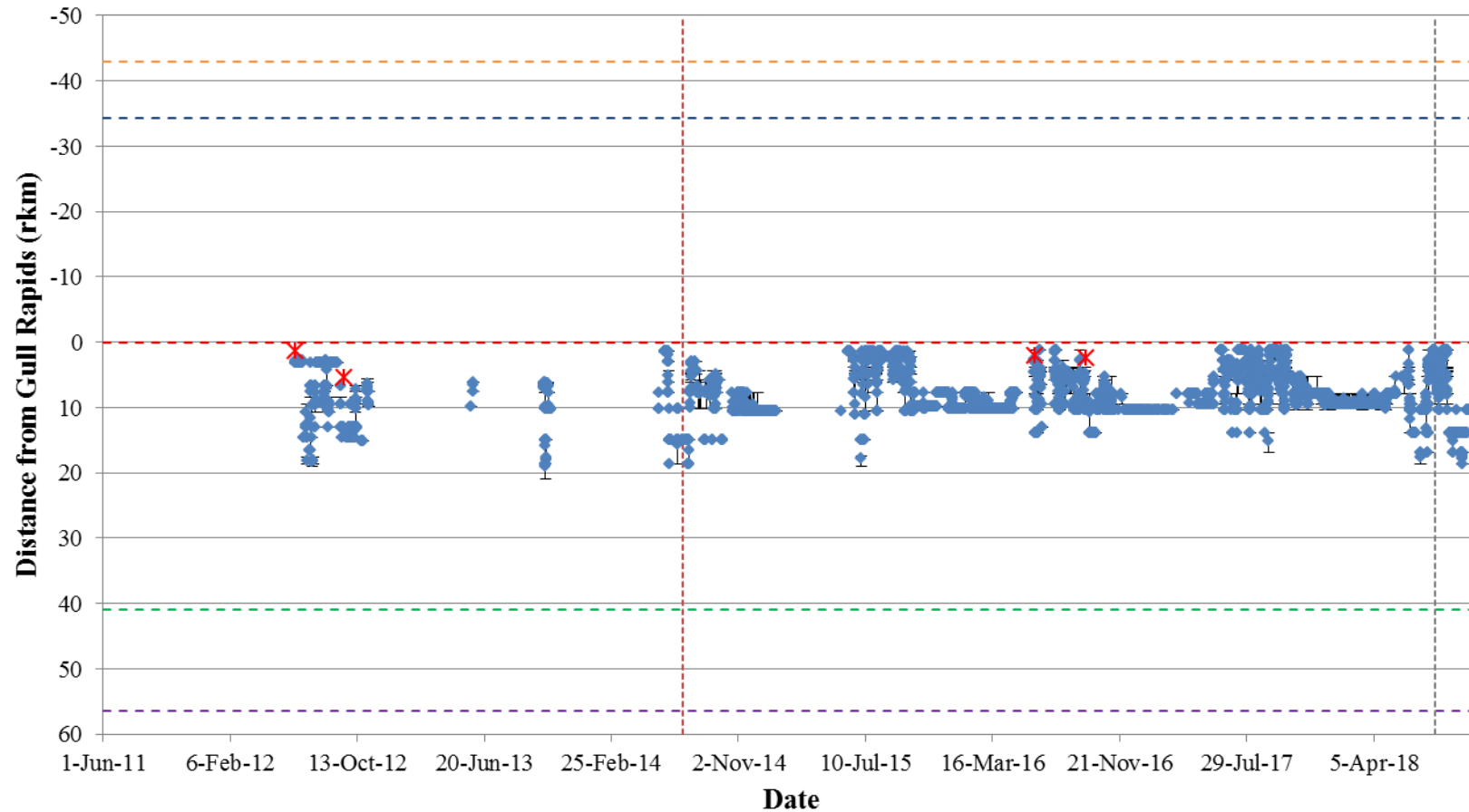


Figure A3-9: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16028) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging and recaptures are indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

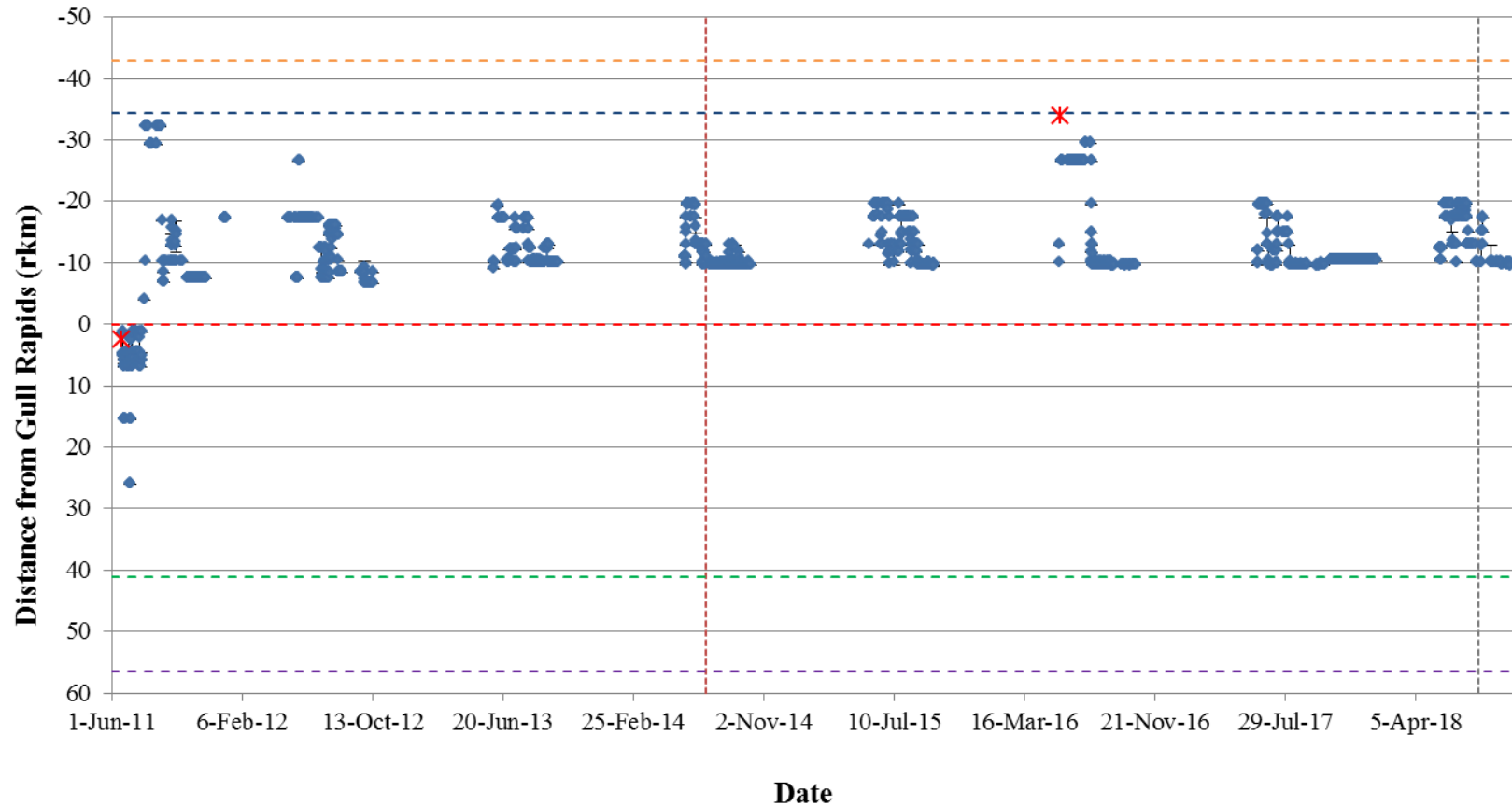


Figure A3-10: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16029) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging and recaptures are indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

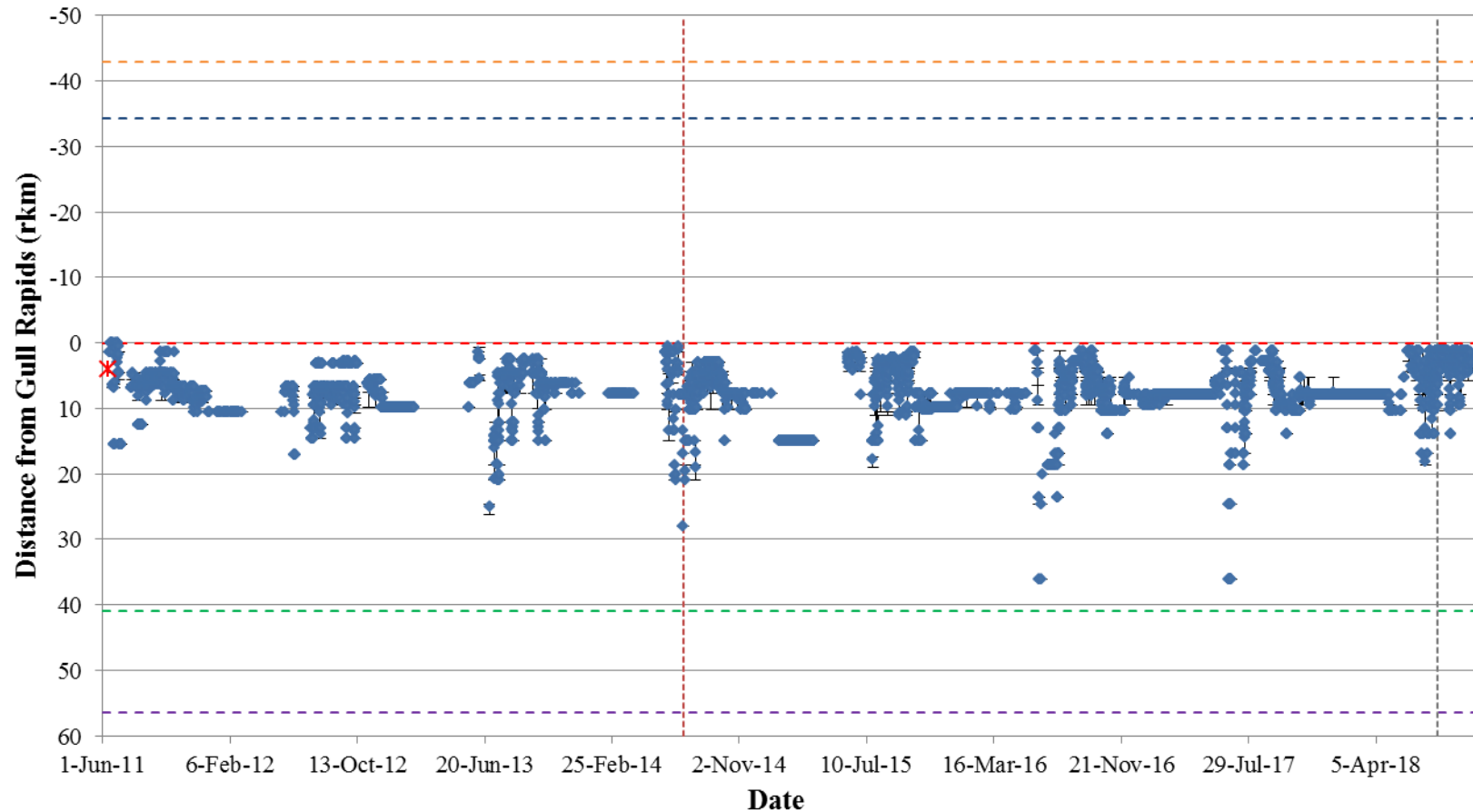


Figure A3-11: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16030) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

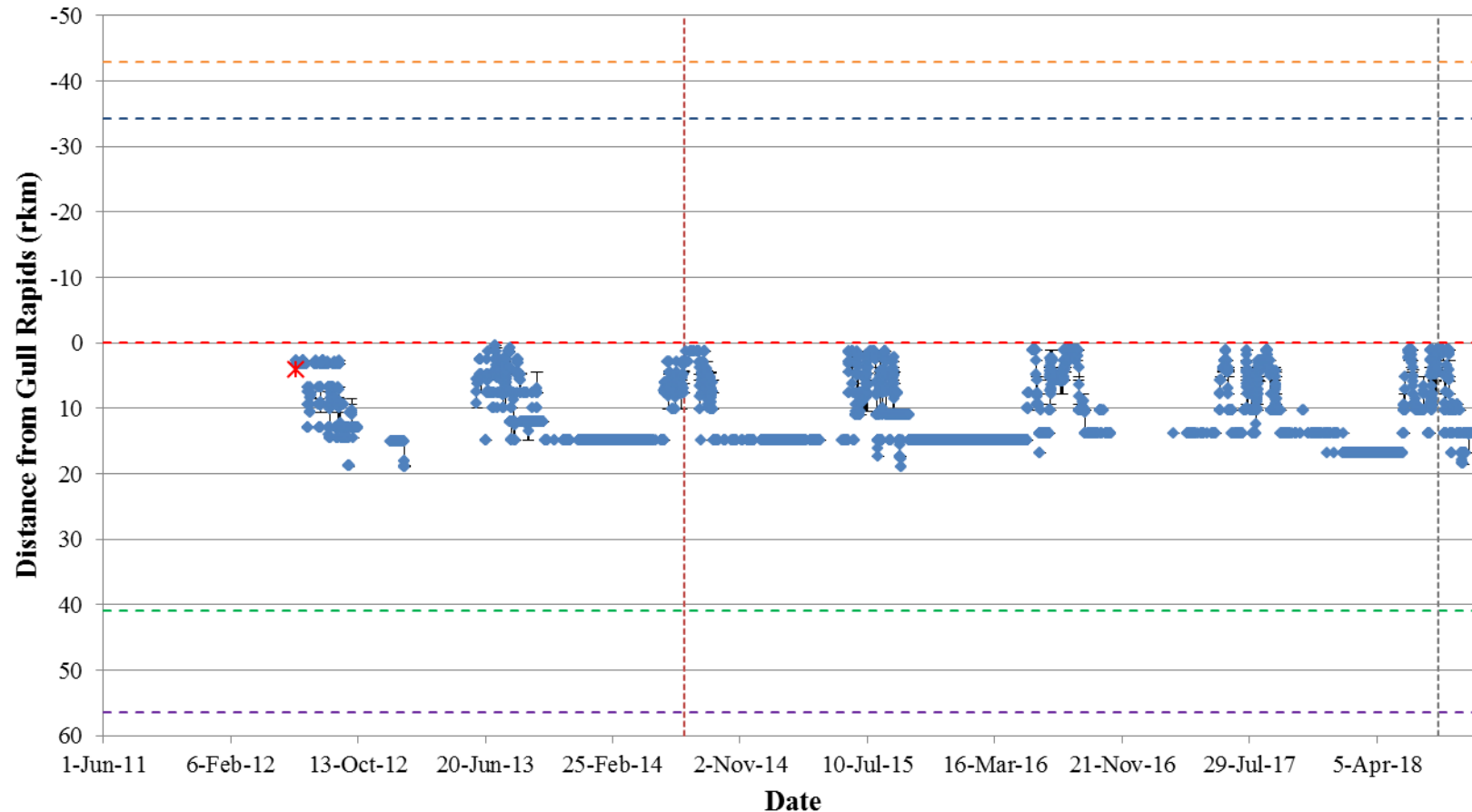


Figure A3-12: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16031) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

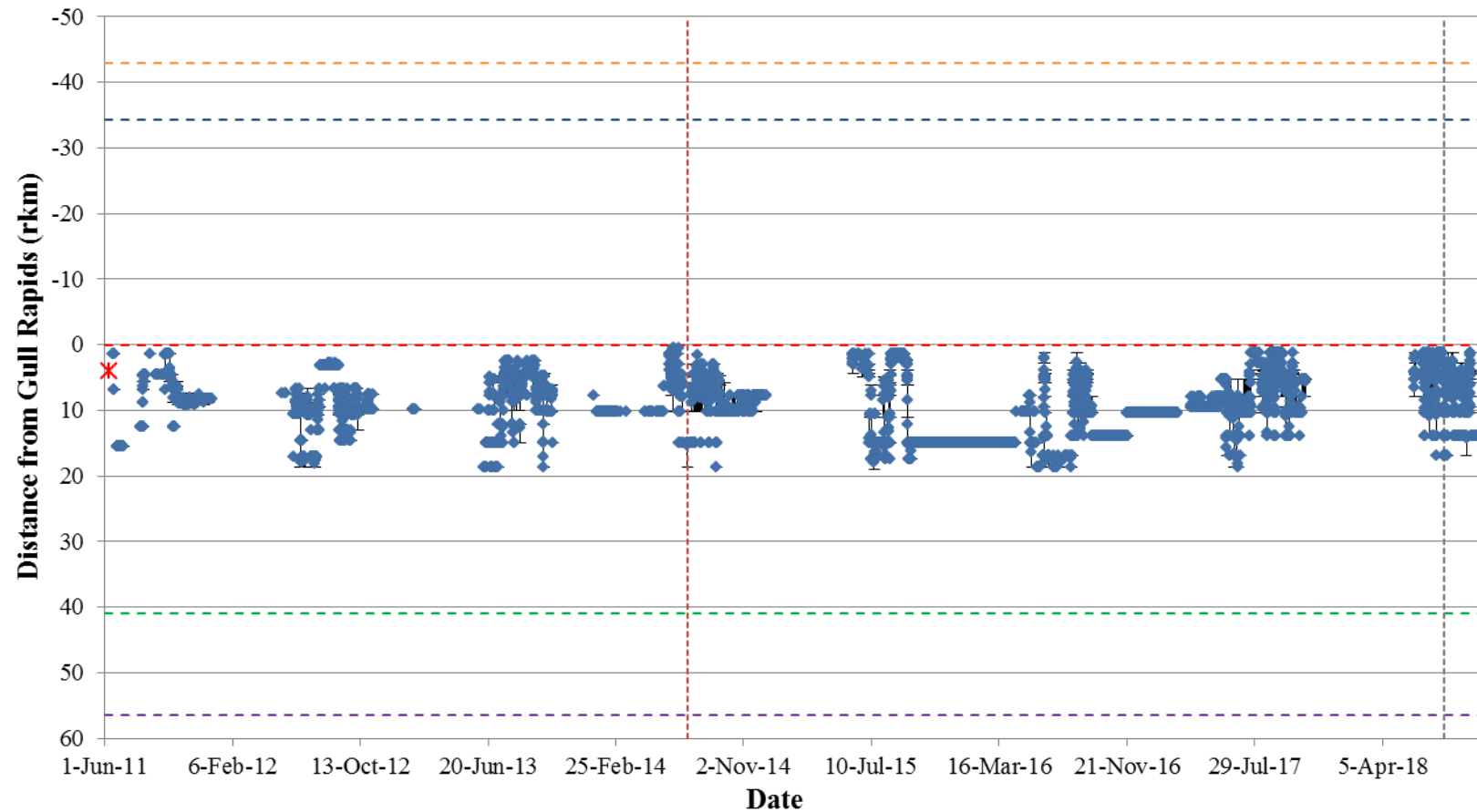


Figure A3-13: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16032) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

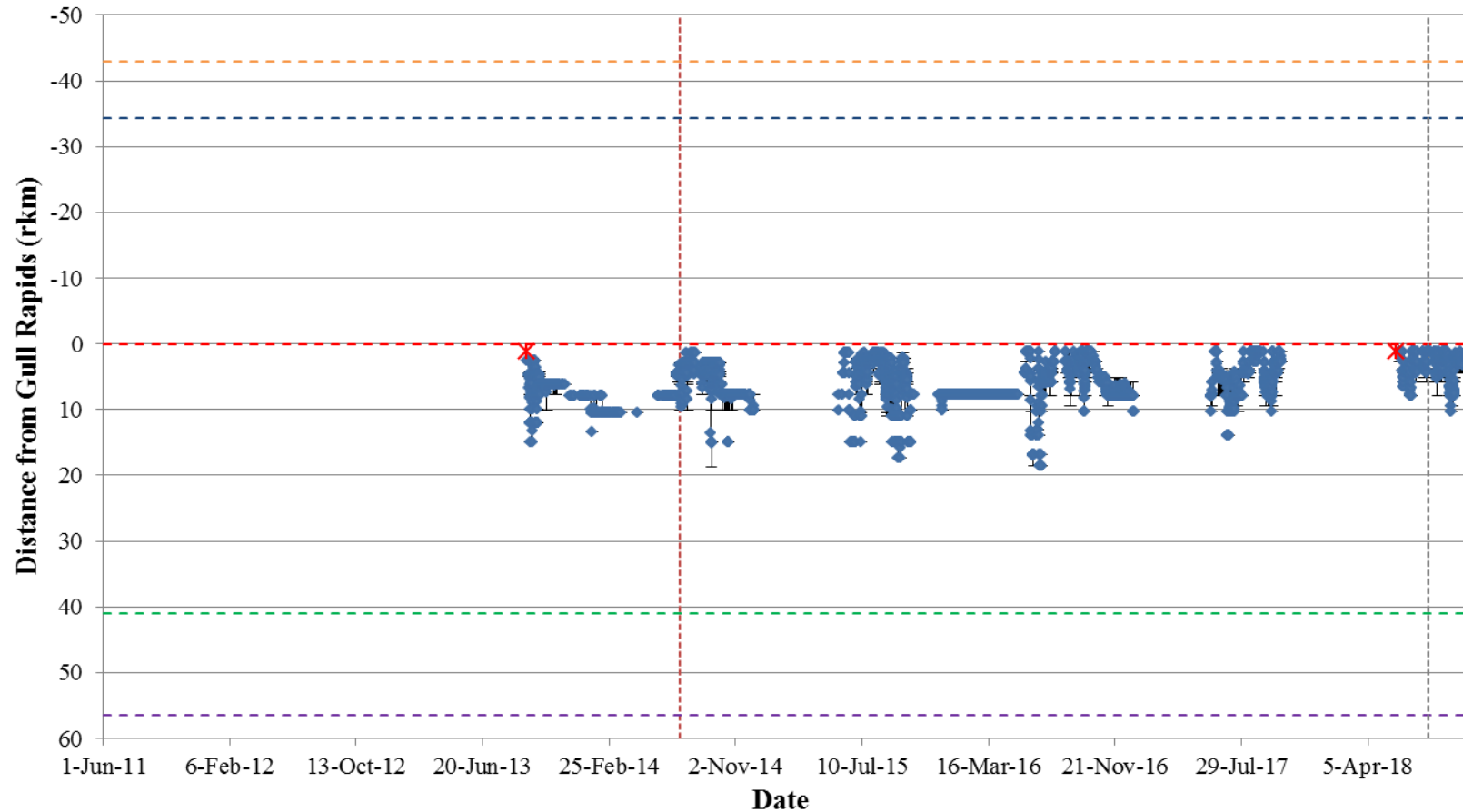


Figure A3-14: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16033b) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging and recapture is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

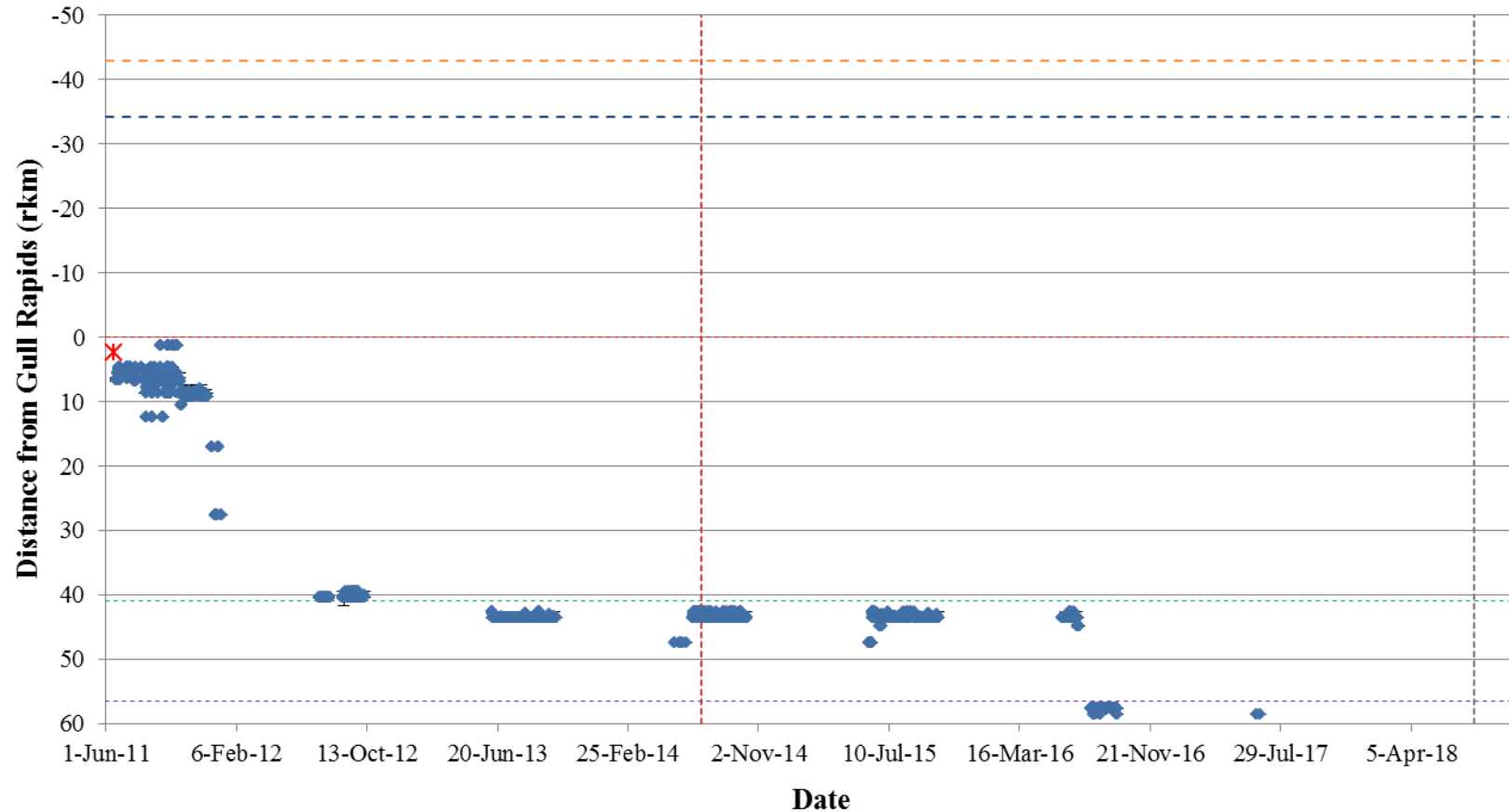


Figure A3-15: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16034) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

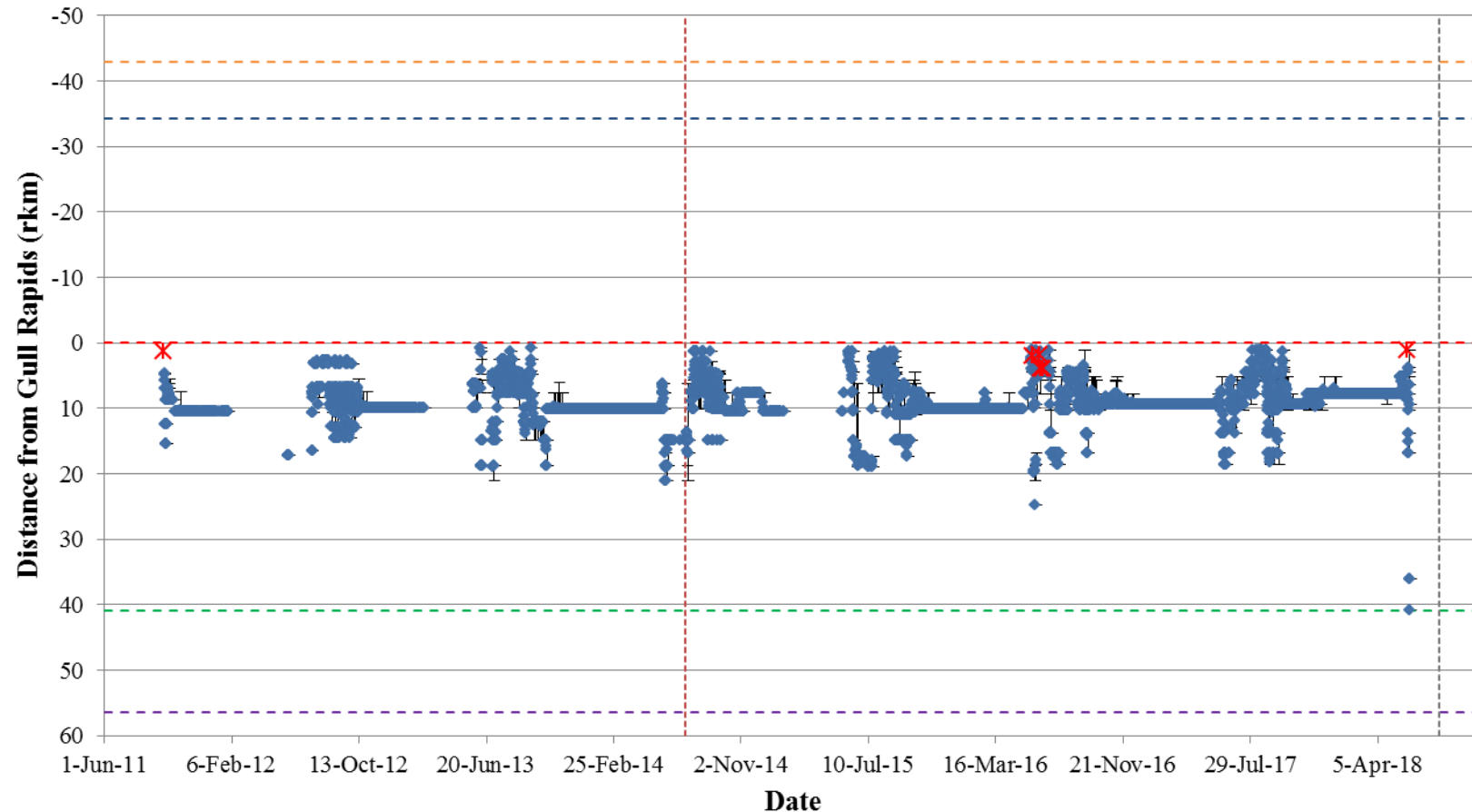


Figure A3-16: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16035) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging and recaptures are indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

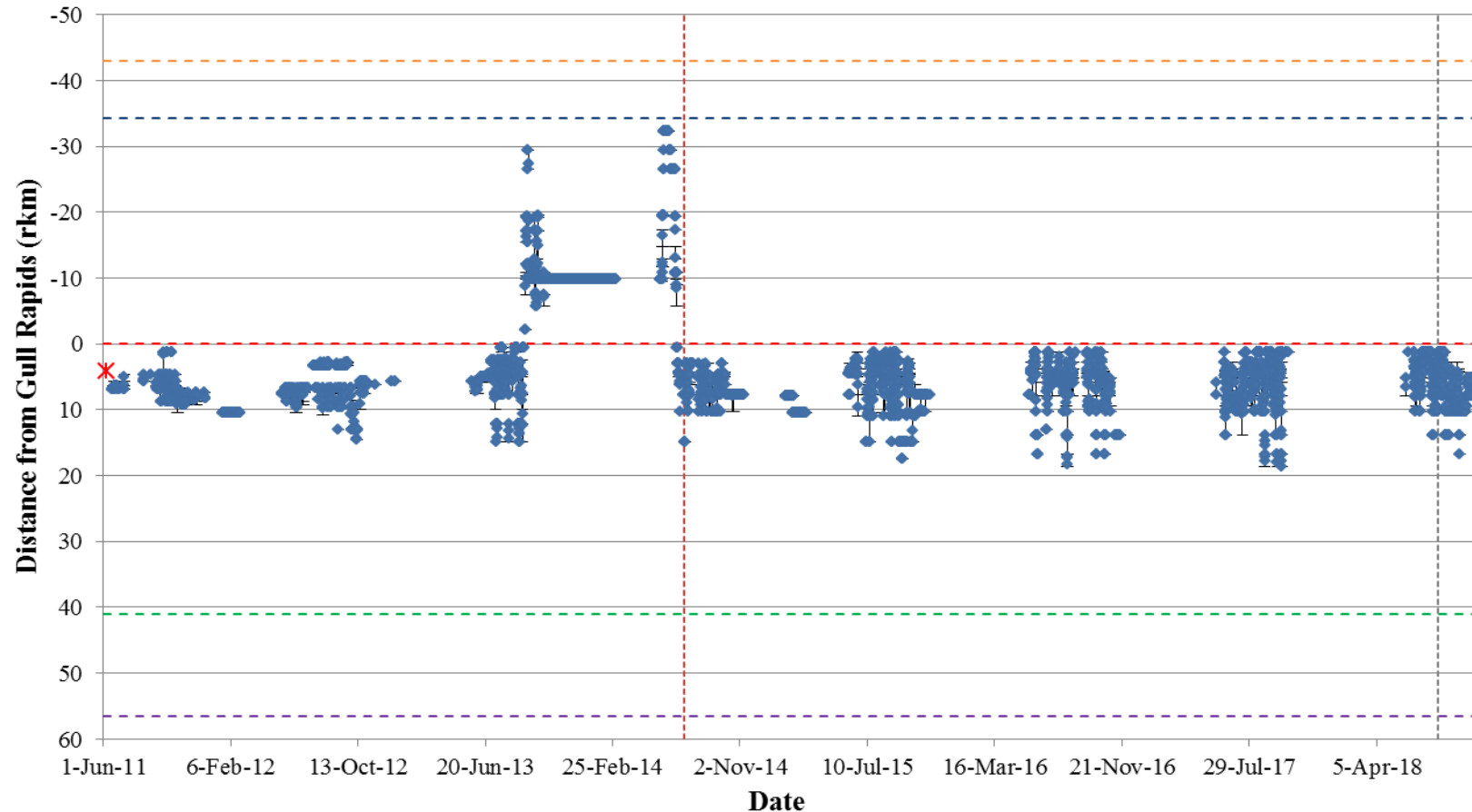


Figure A3-17: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16037) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

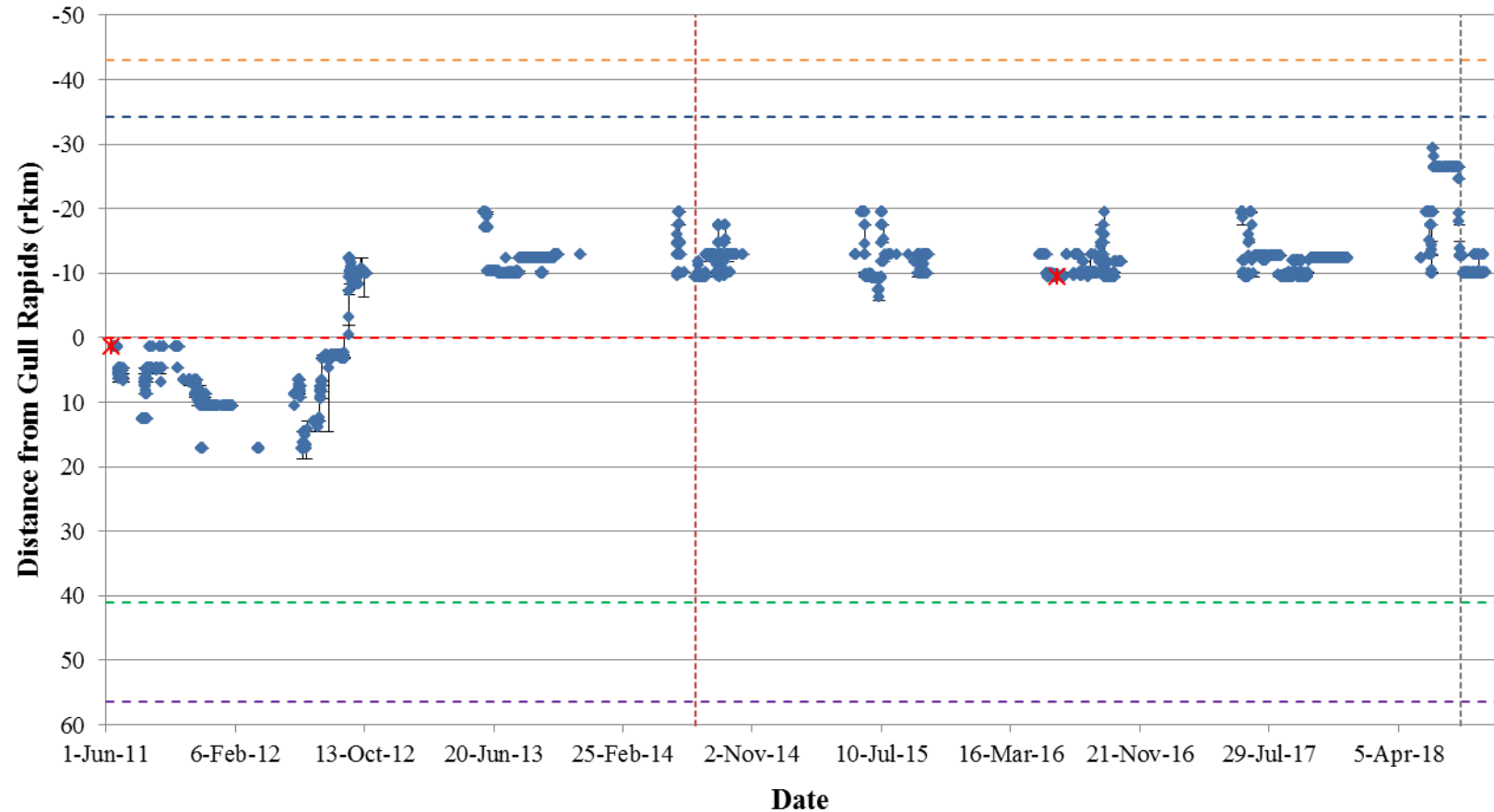


Figure A3-18: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16038) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging and recaptures are indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

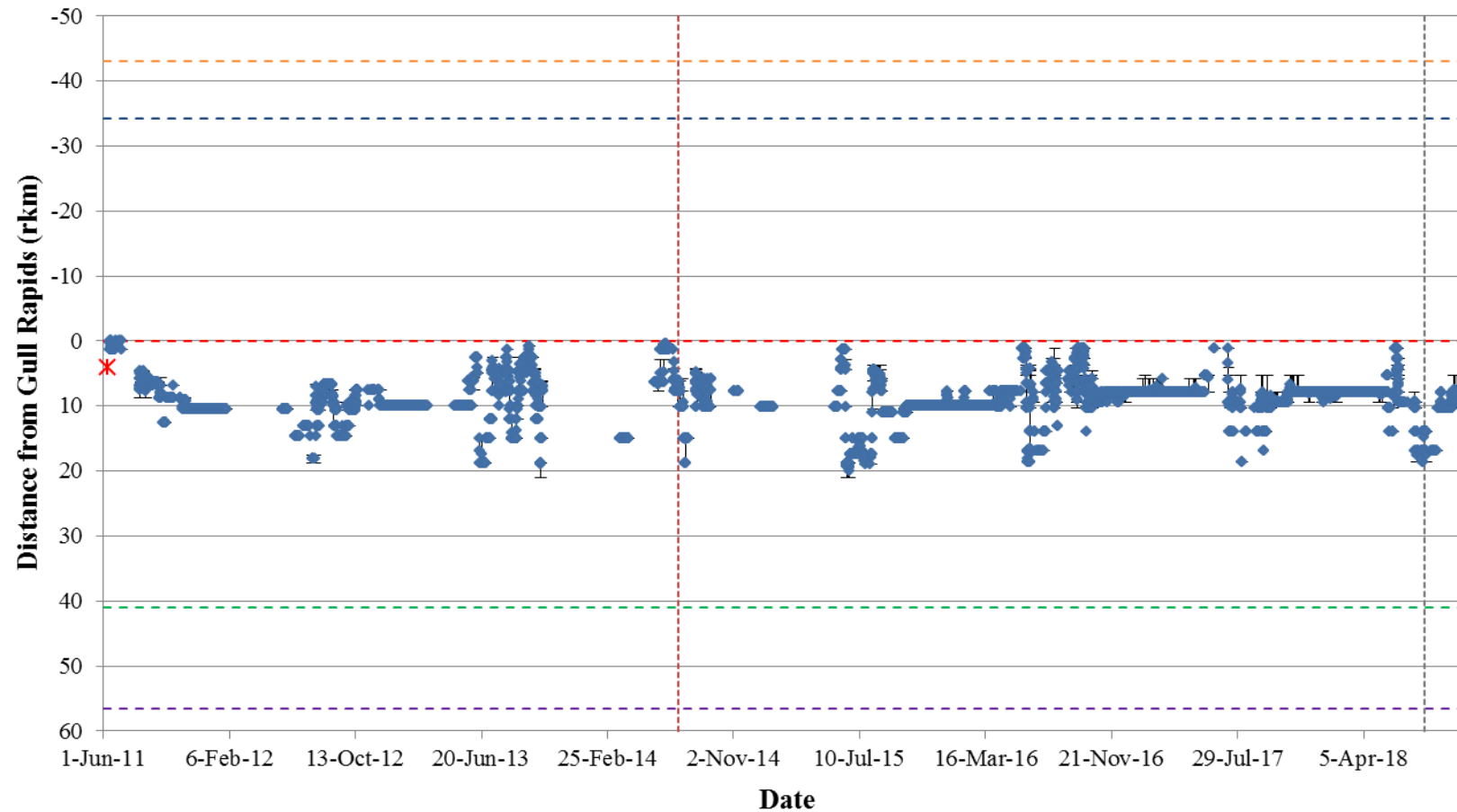


Figure A3-19: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16040) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

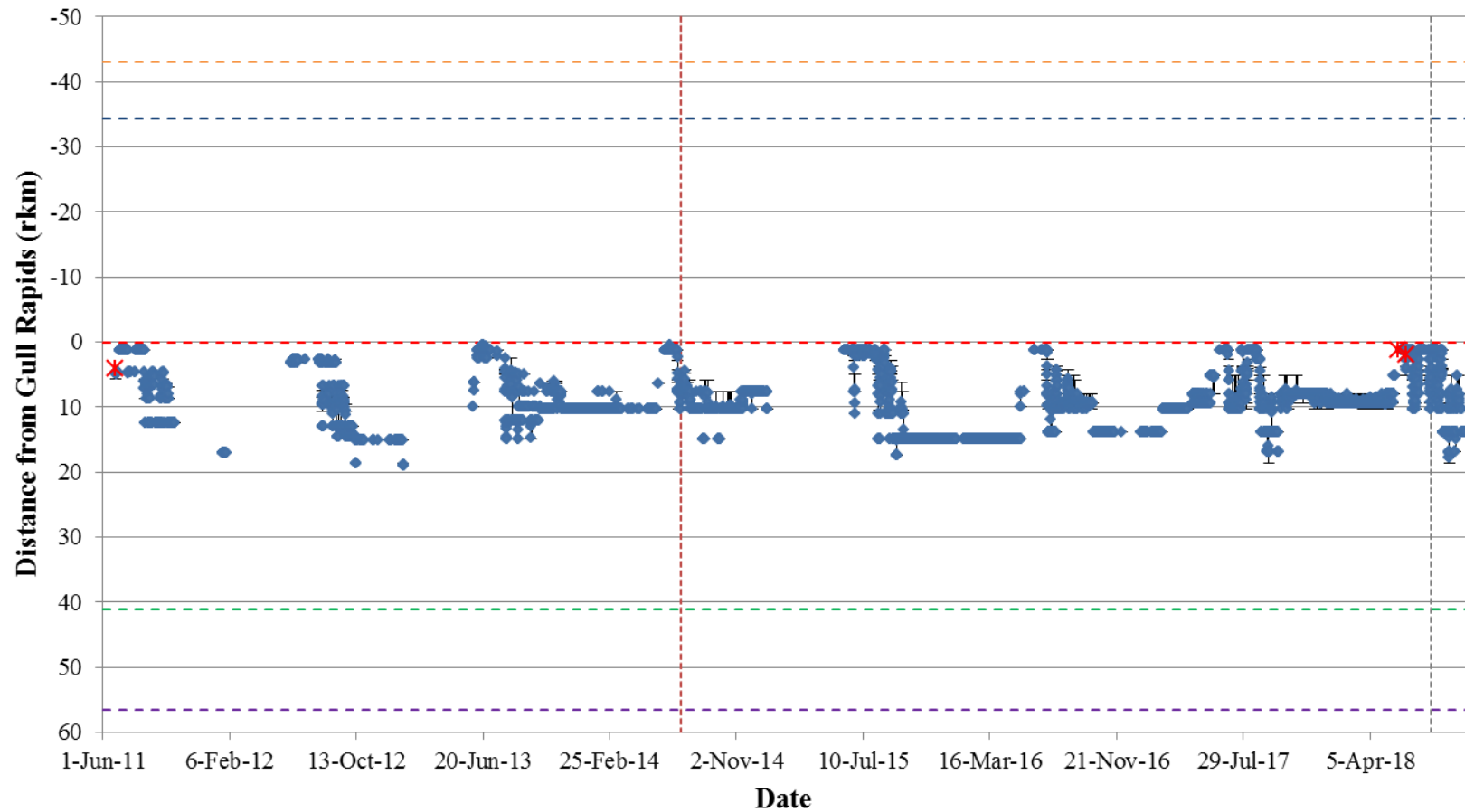


Figure A3-20: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16041) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging and recaptures are indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

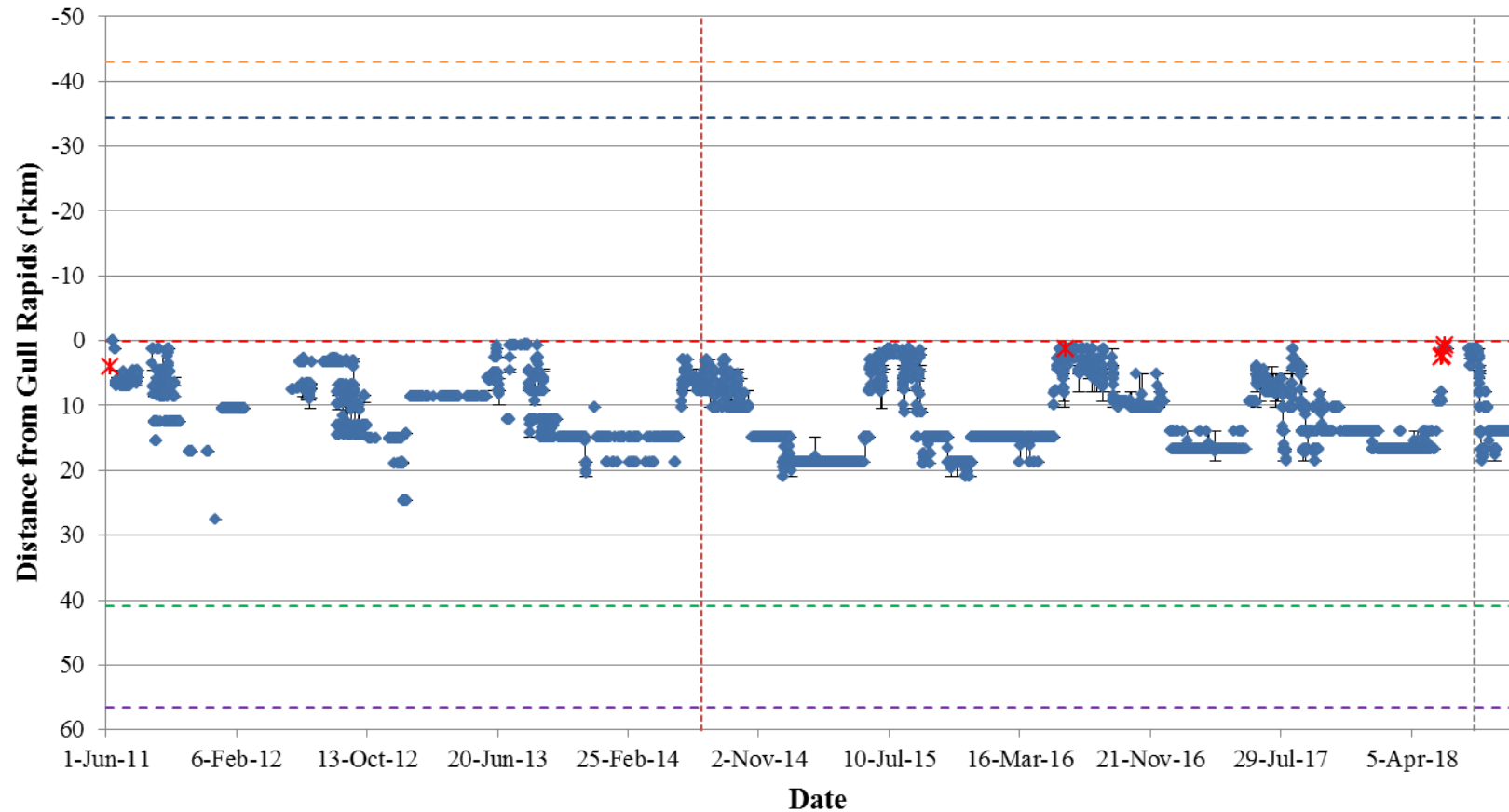


Figure A3-21: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16043) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging and recaptures are indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

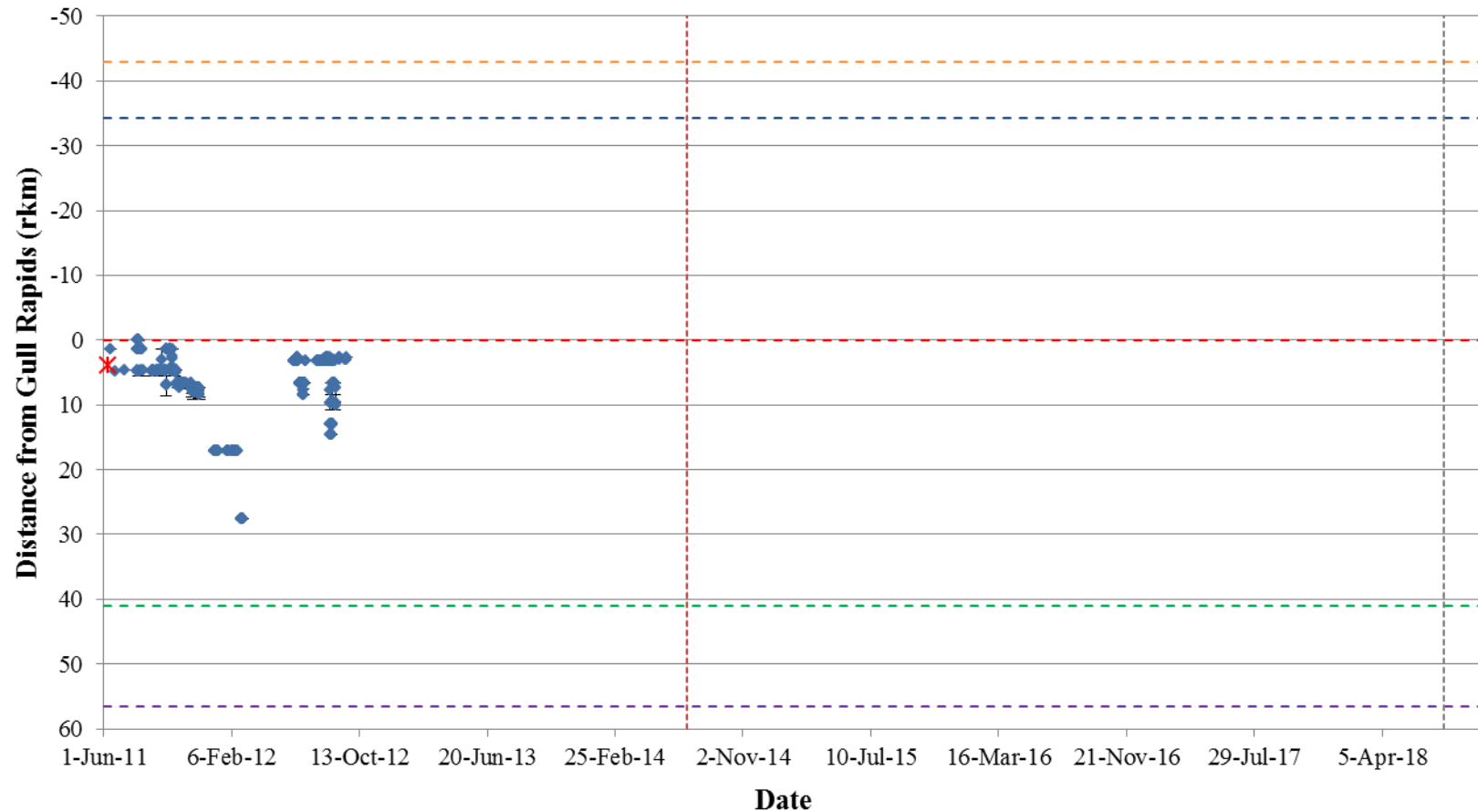


Figure A3-22: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16044) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

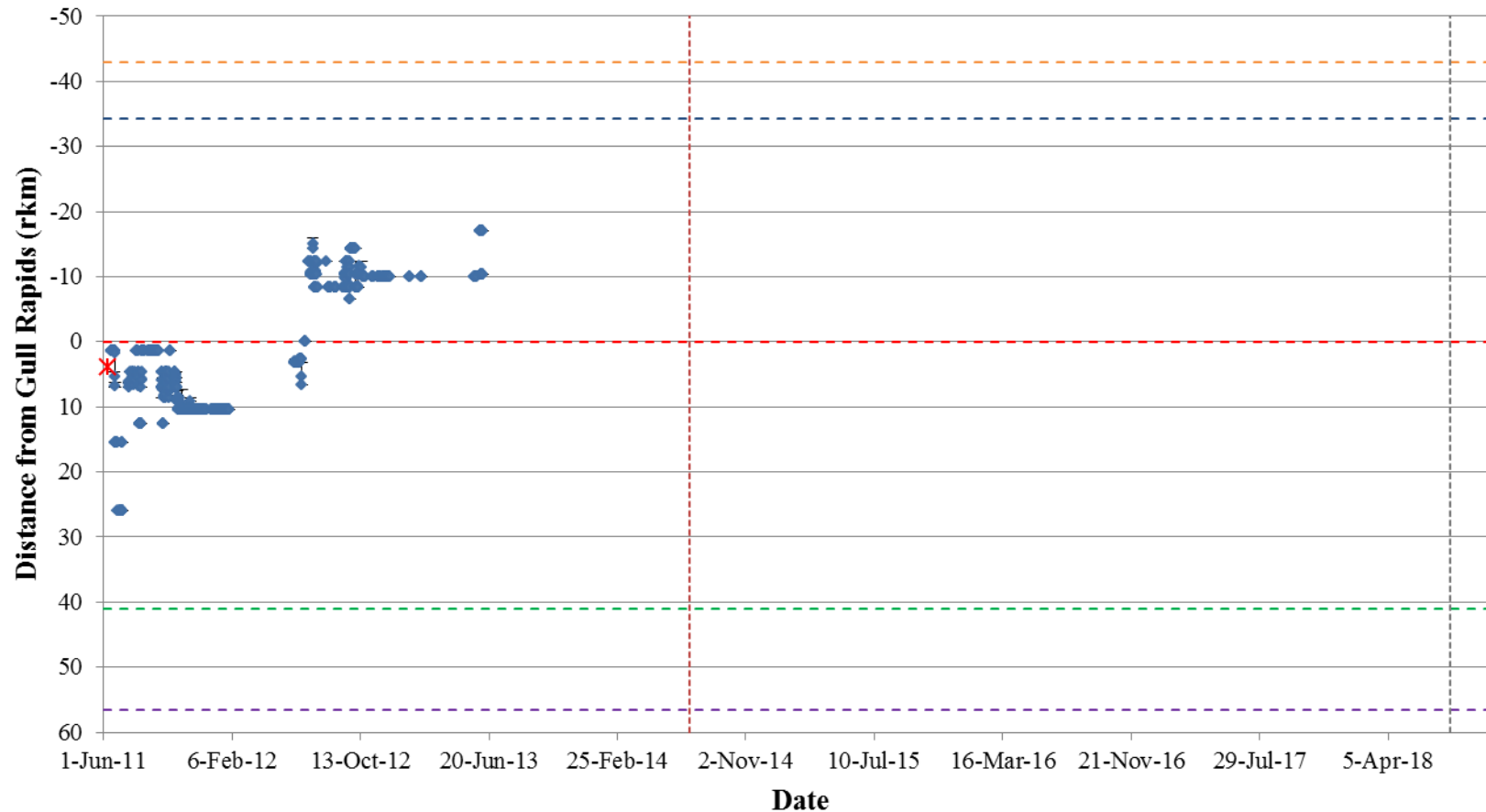


Figure A3-23: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16046) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

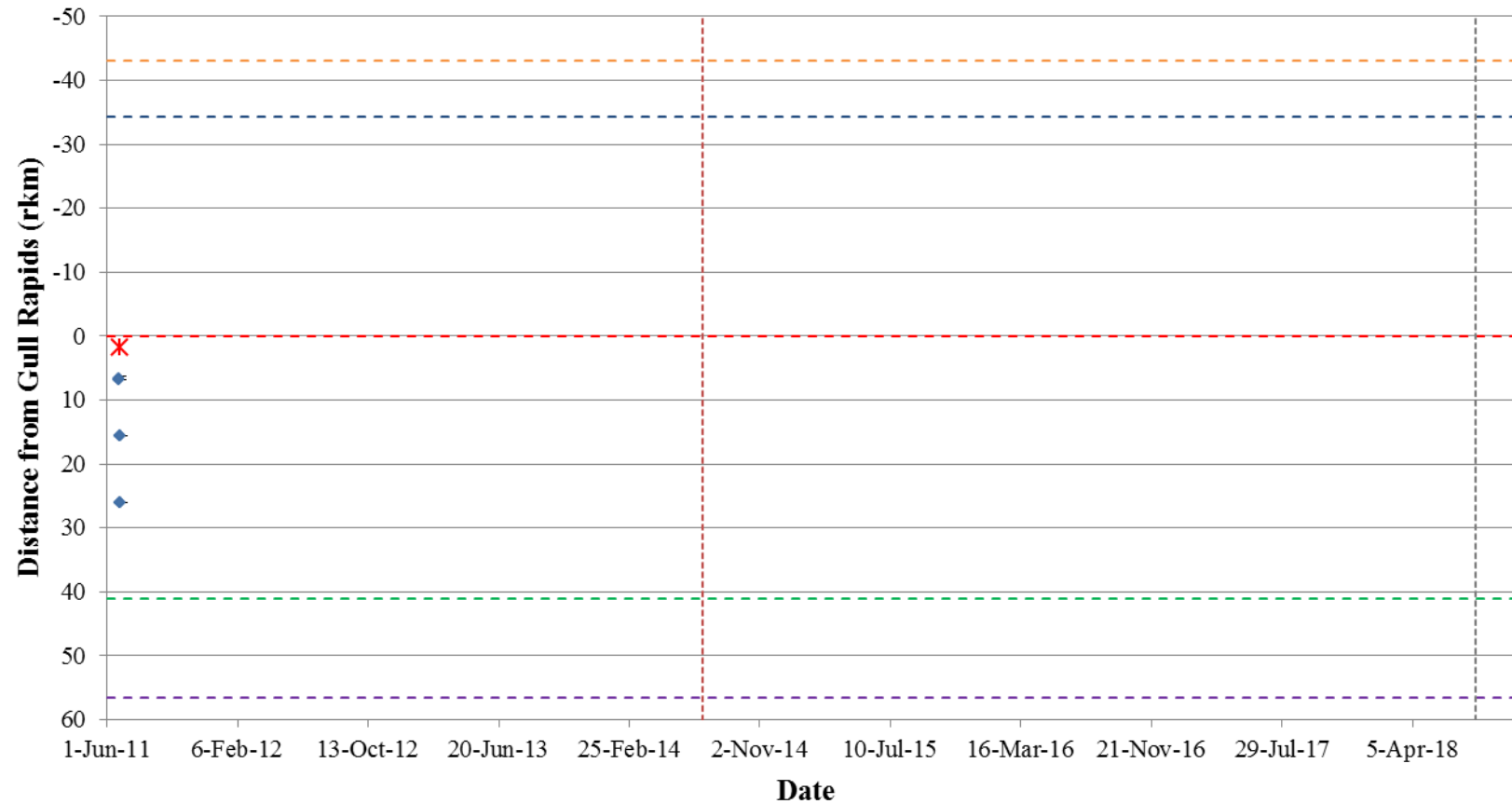


Figure A3-24: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16047) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

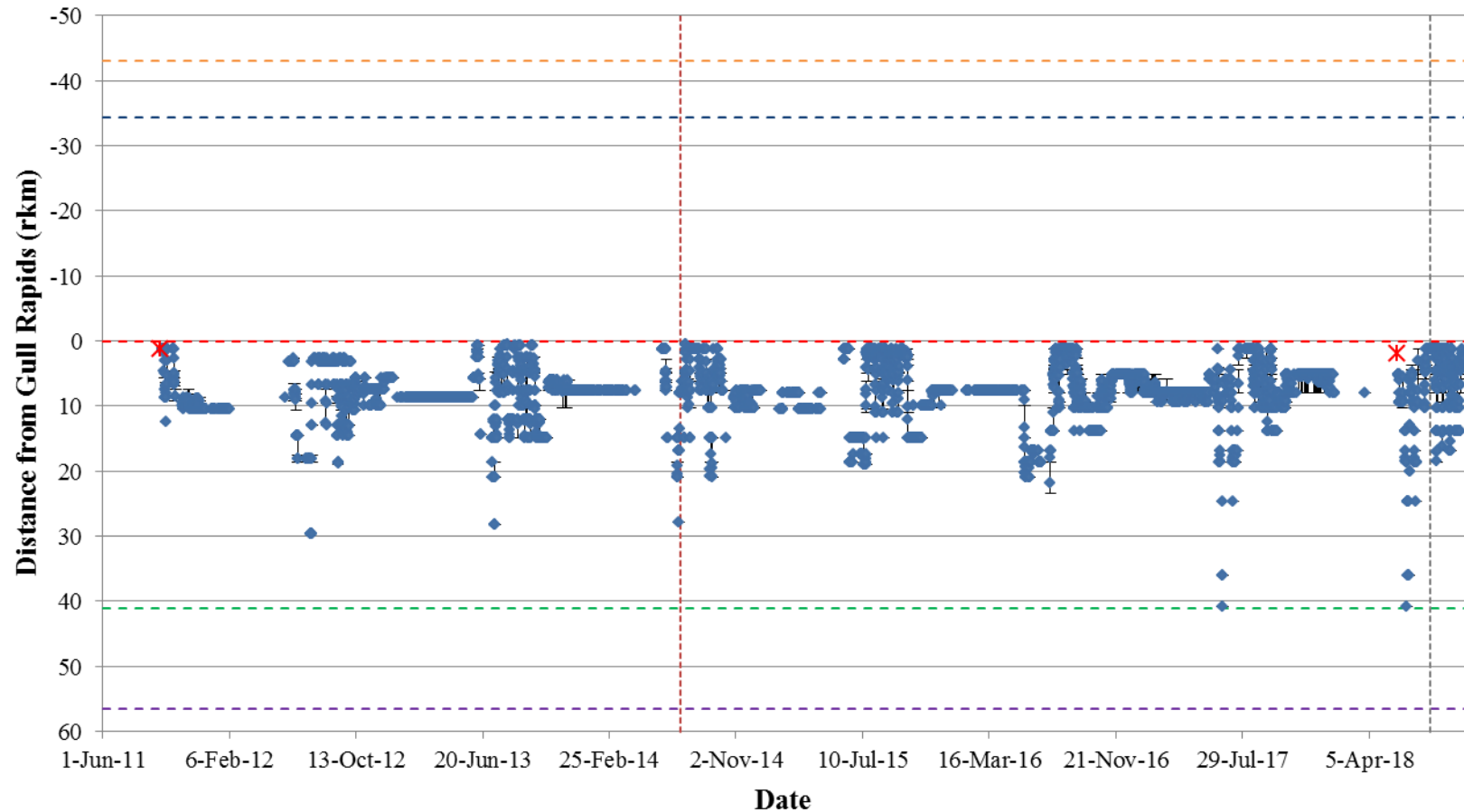


Figure A3-25: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16049) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging and recaptures are indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

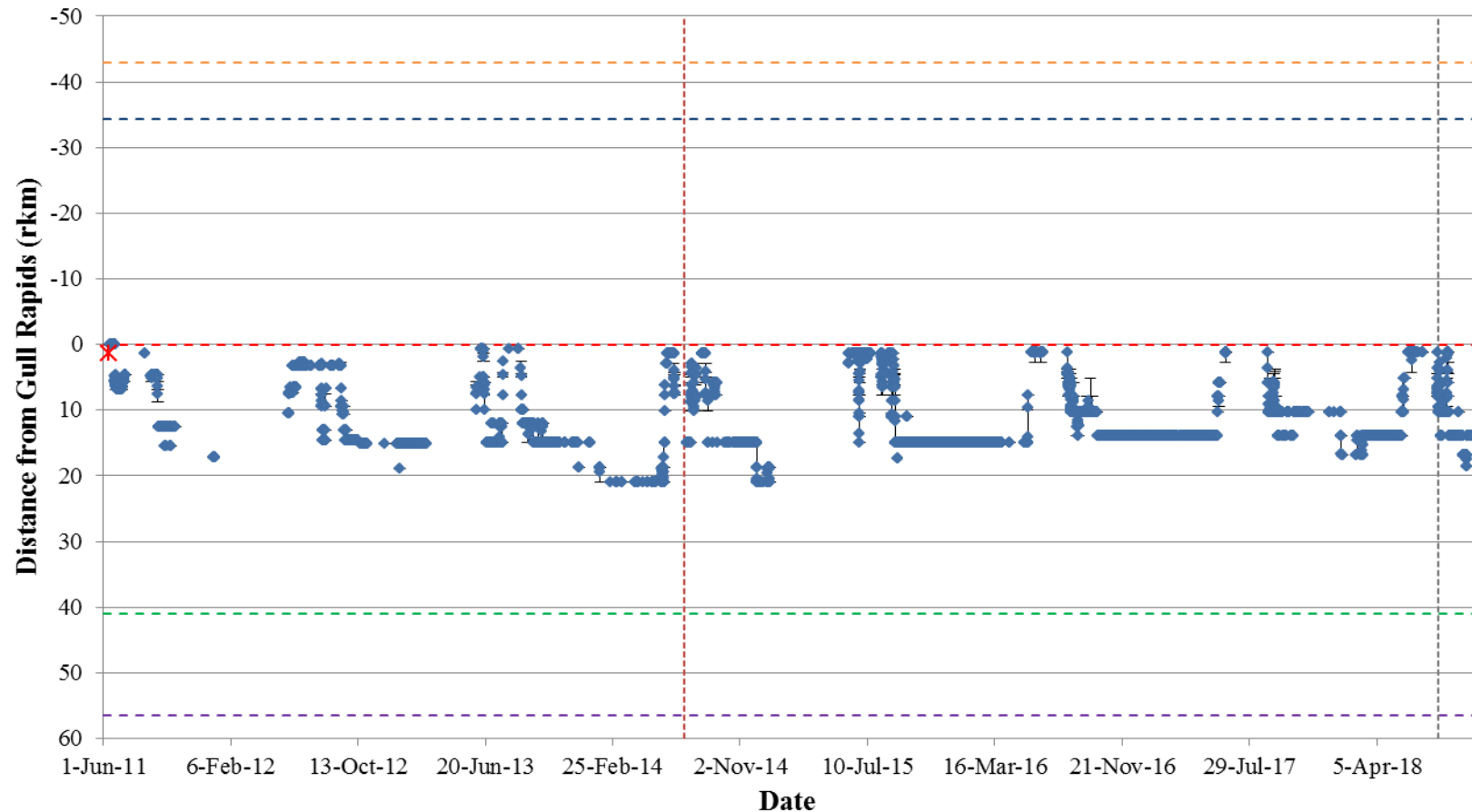


Figure A3-26: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16050) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

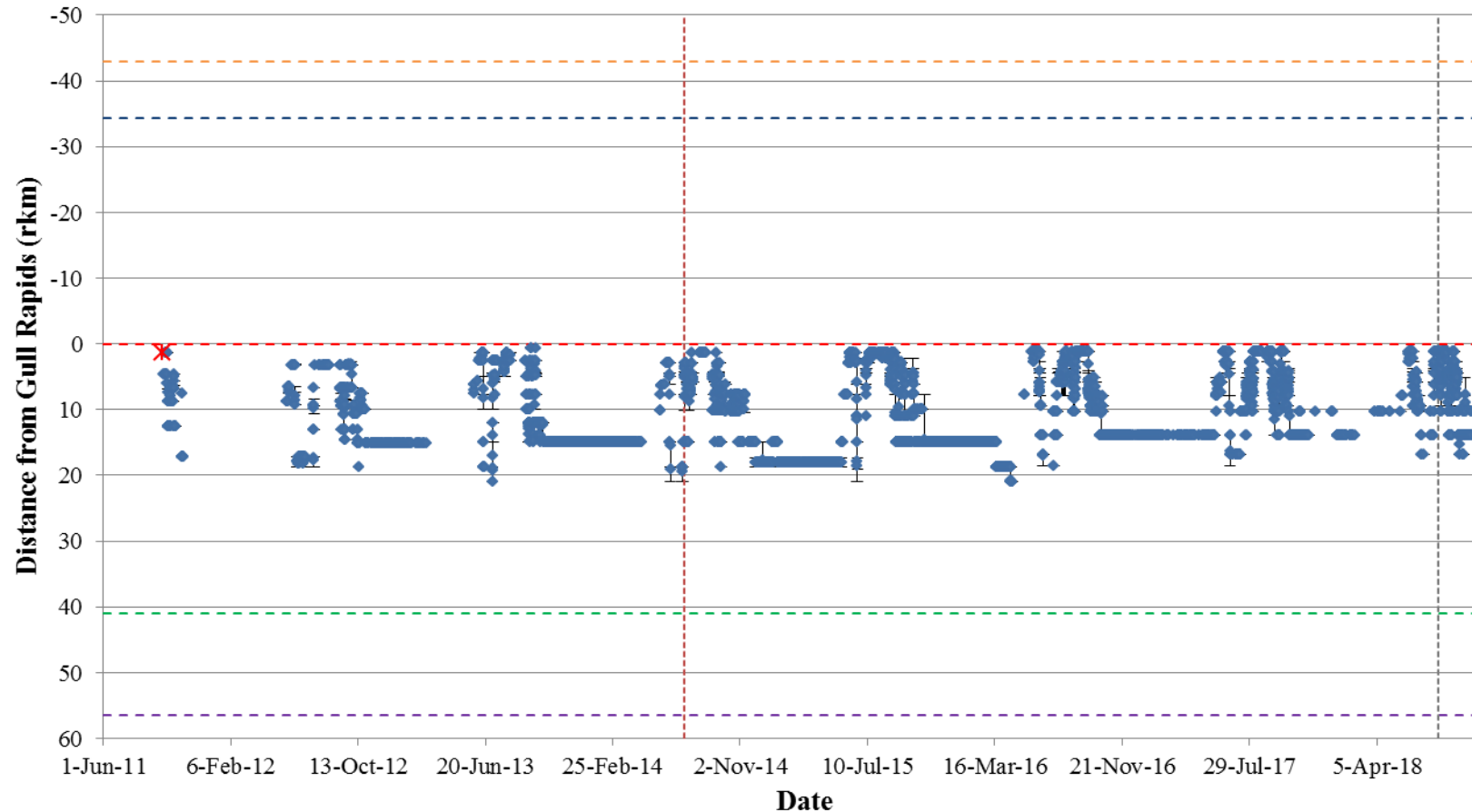


Figure A3-27: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16052) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

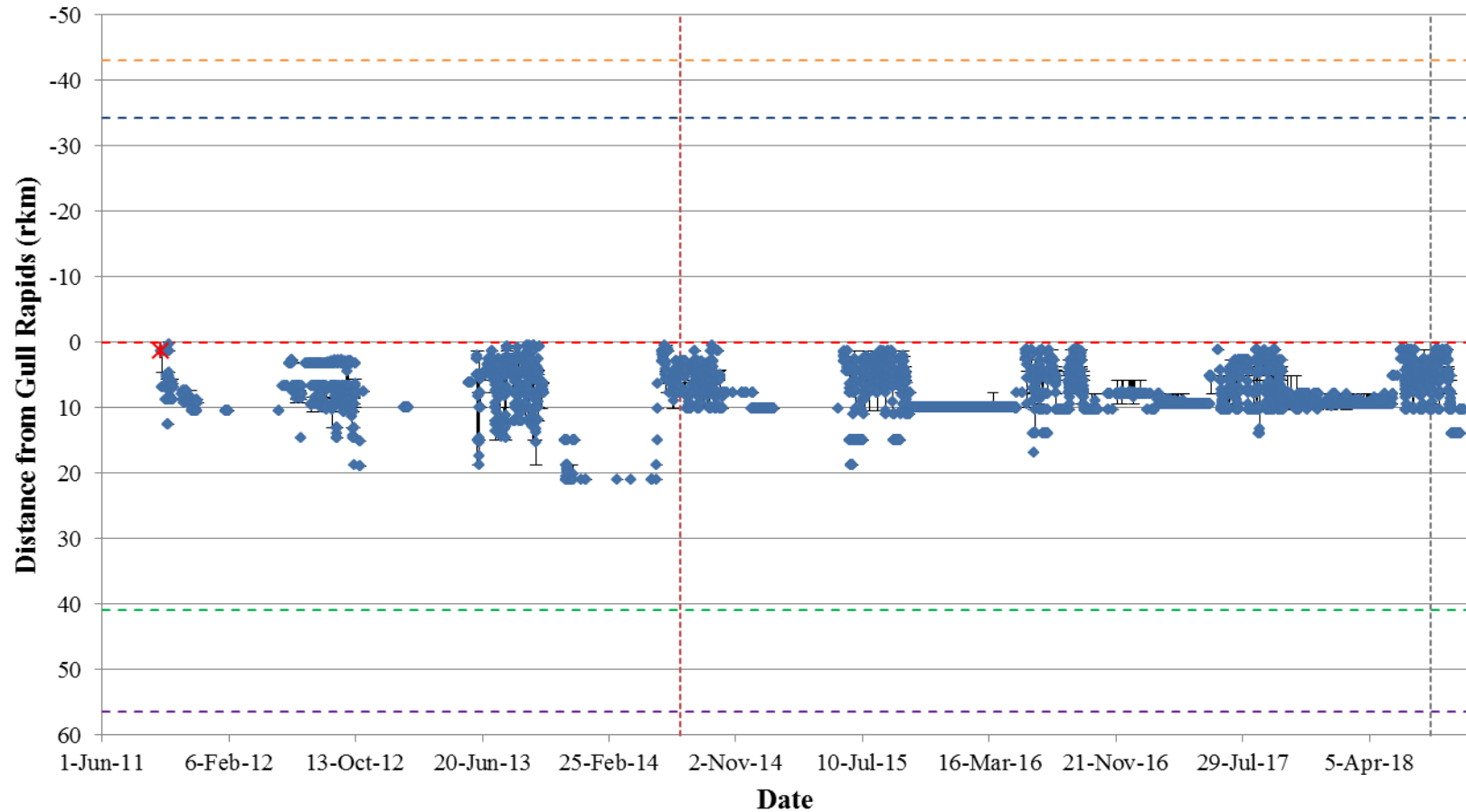


Figure A3-28: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16053) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

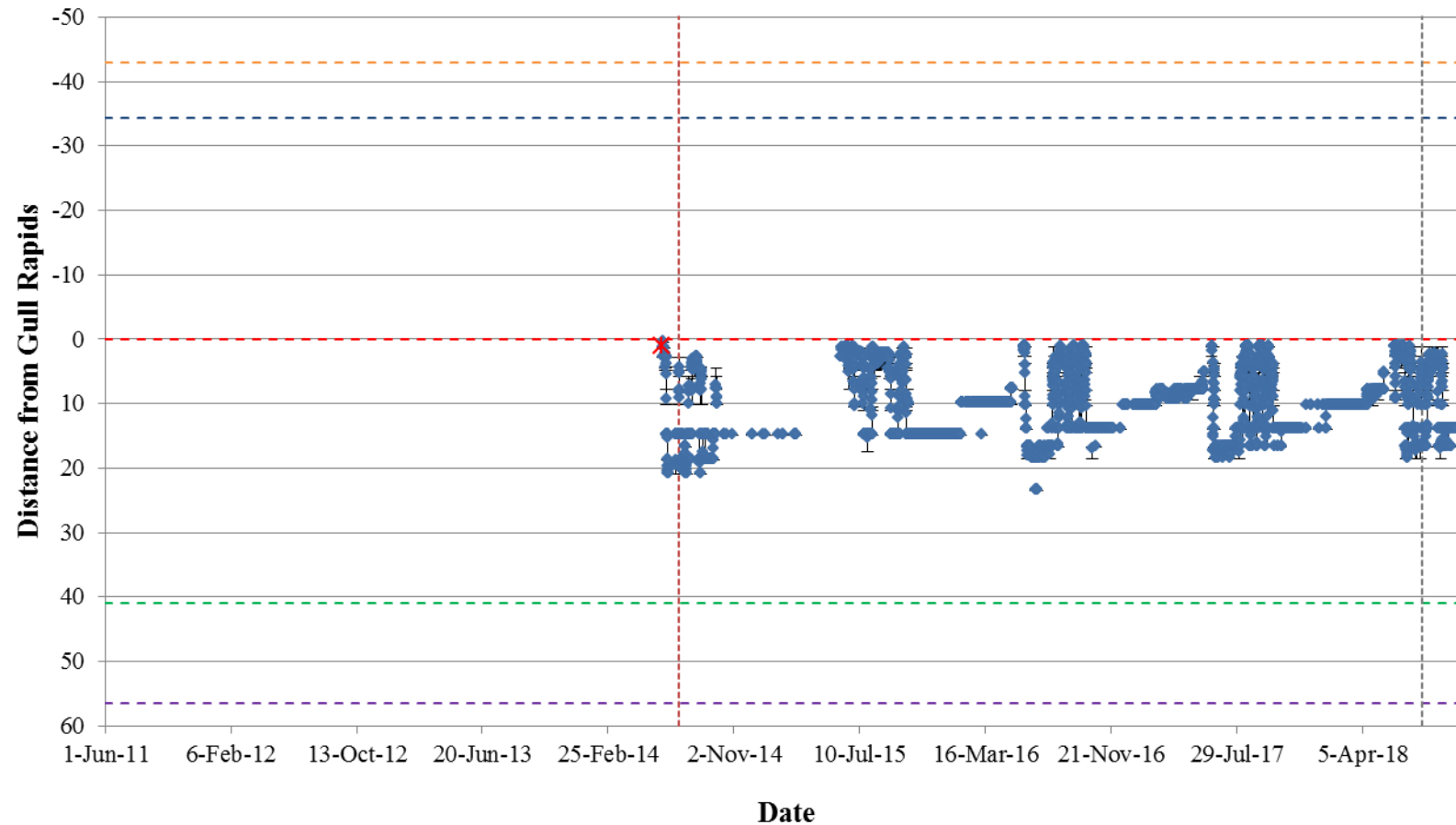


Figure A3-29: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32167) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

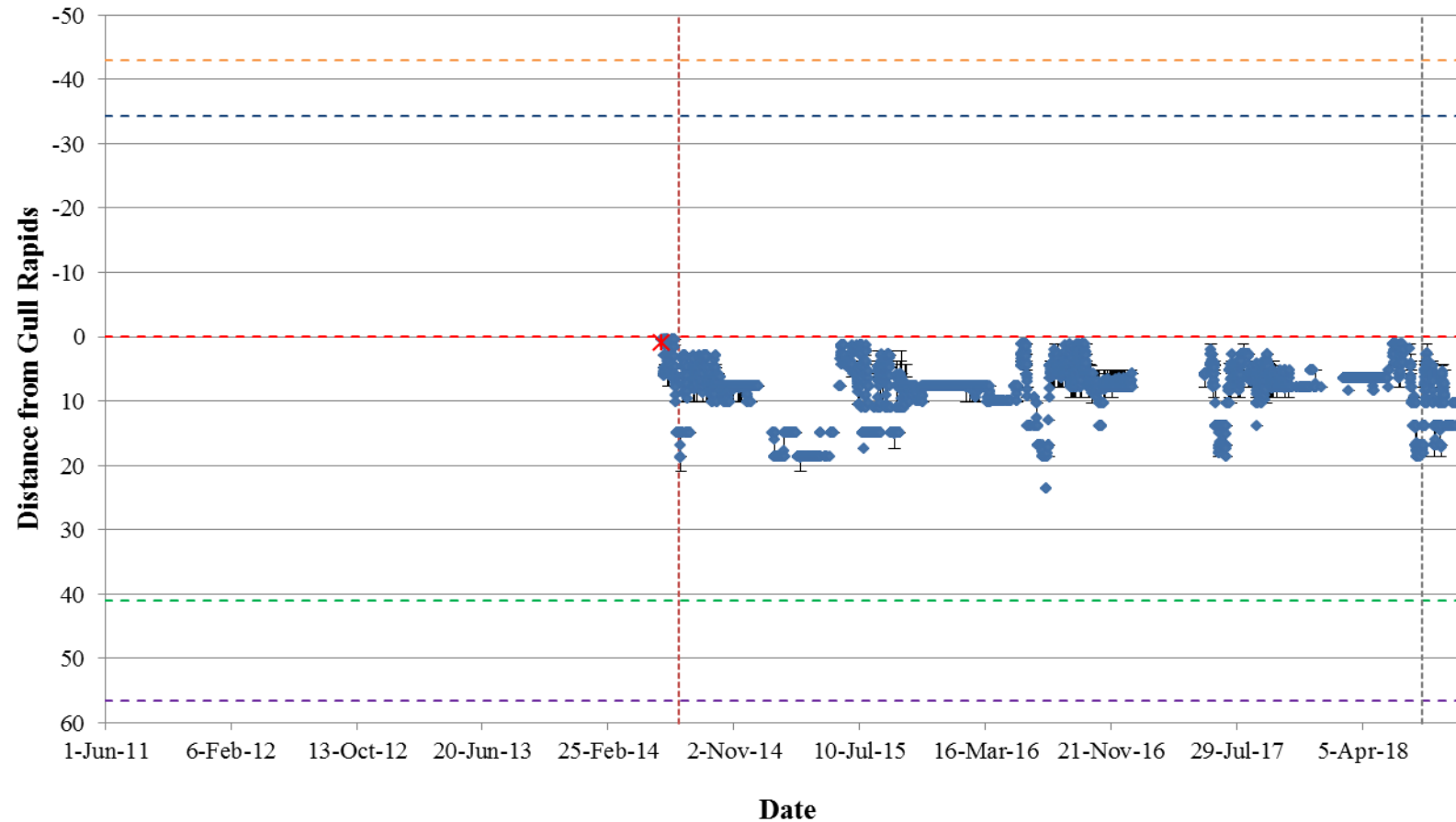


Figure A3-30: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32168) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

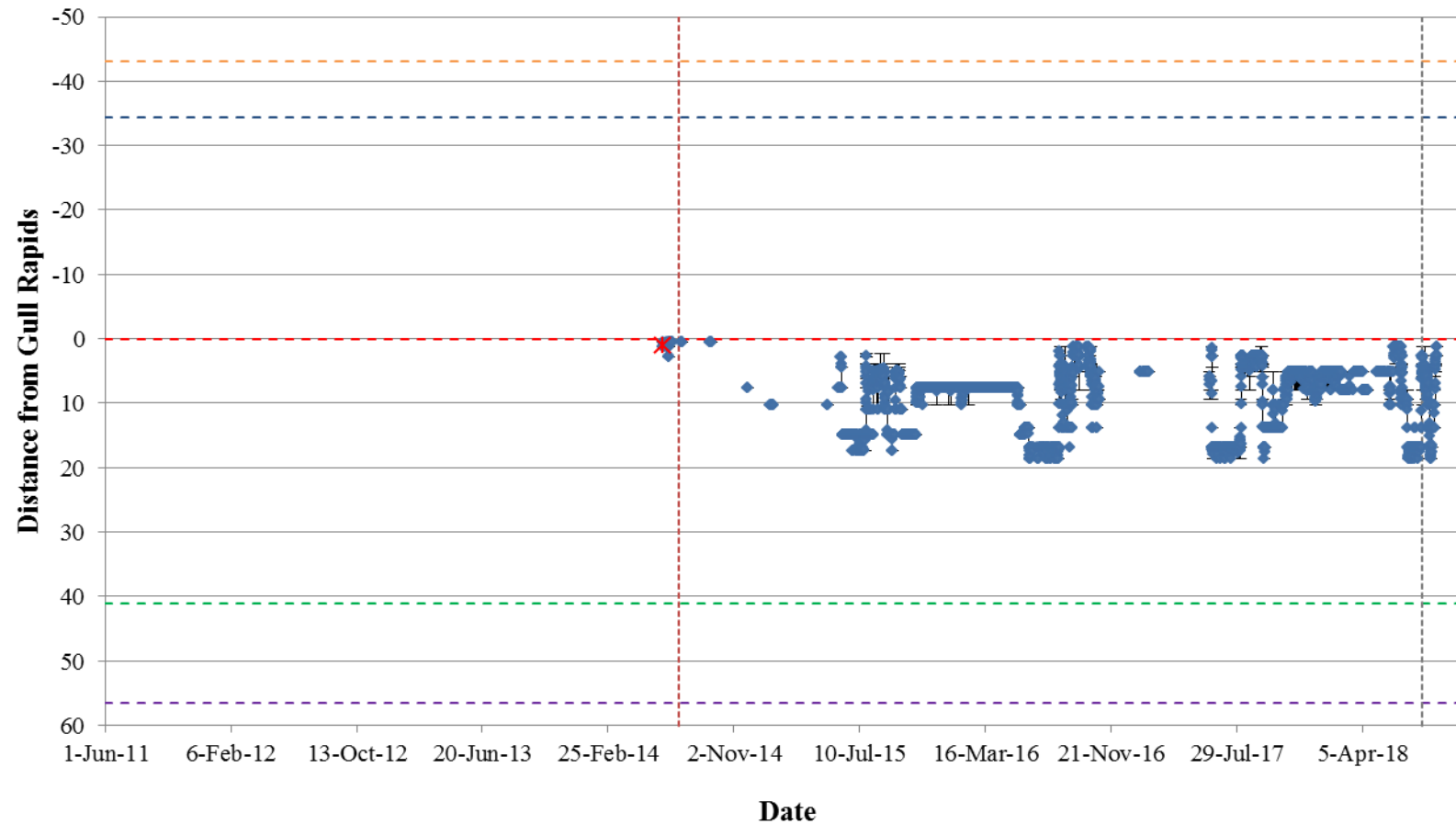


Figure A3-31: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32169) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

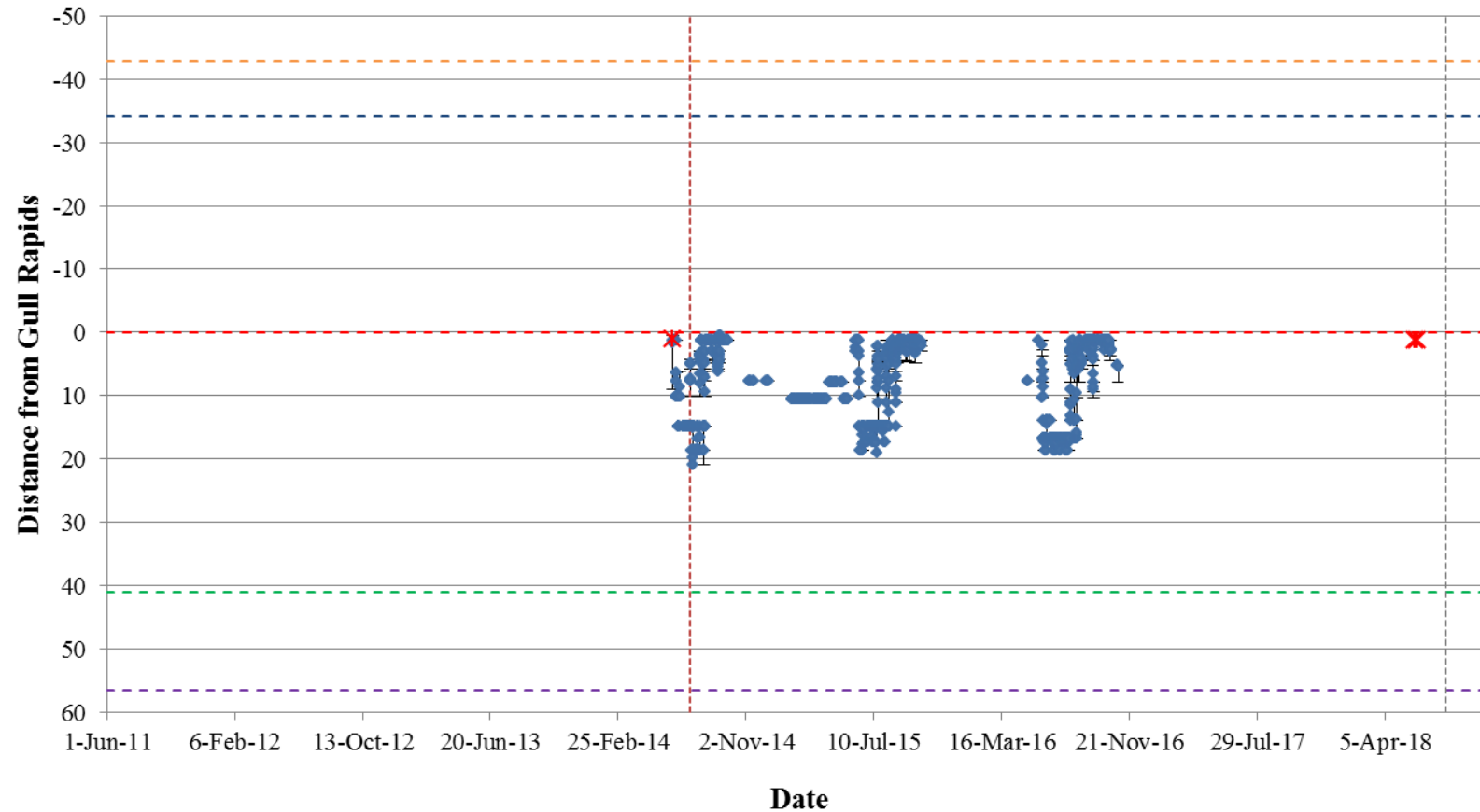


Figure A3-32: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32170) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging and recaptures are indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

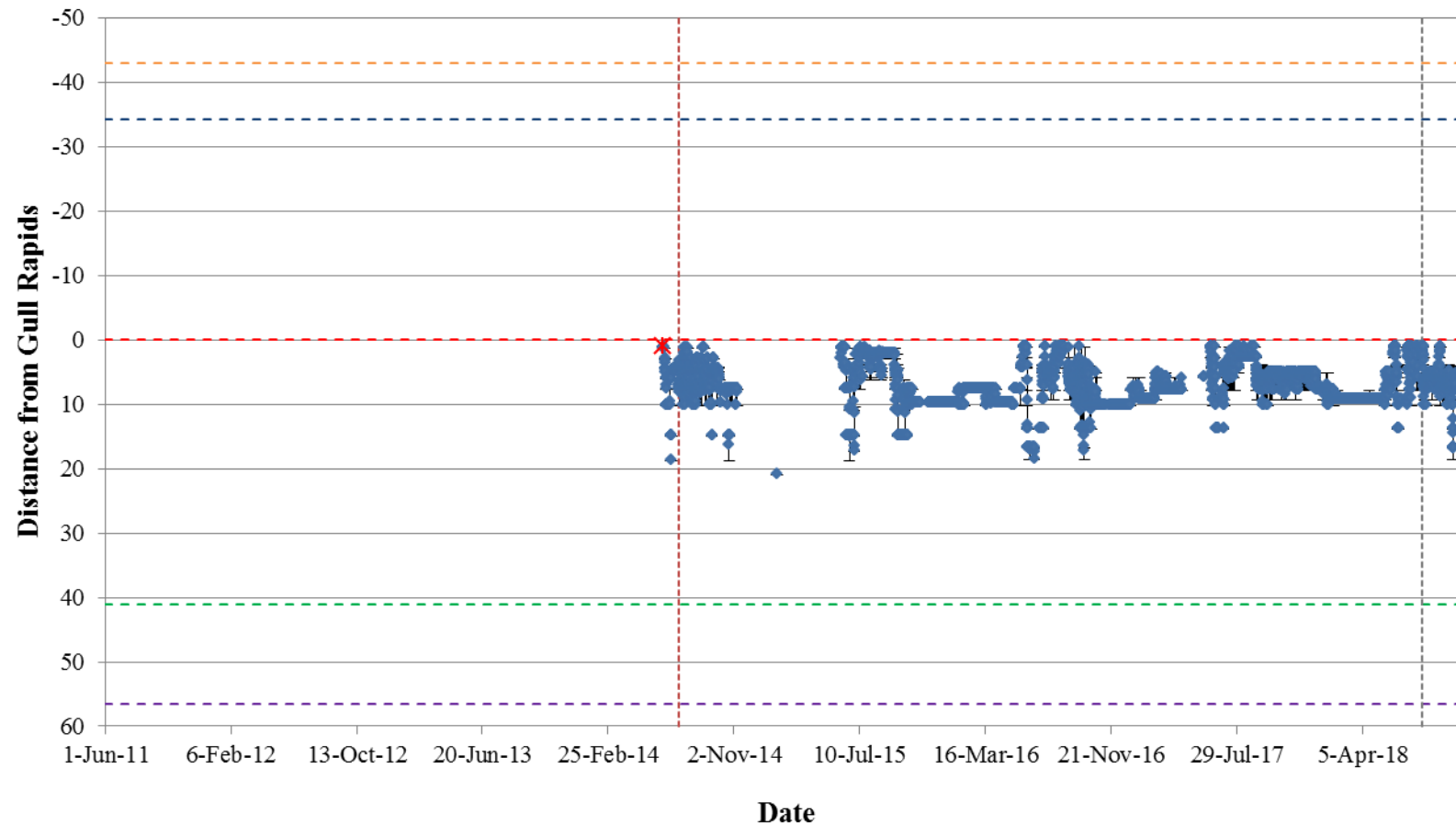


Figure A3-33: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32171) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

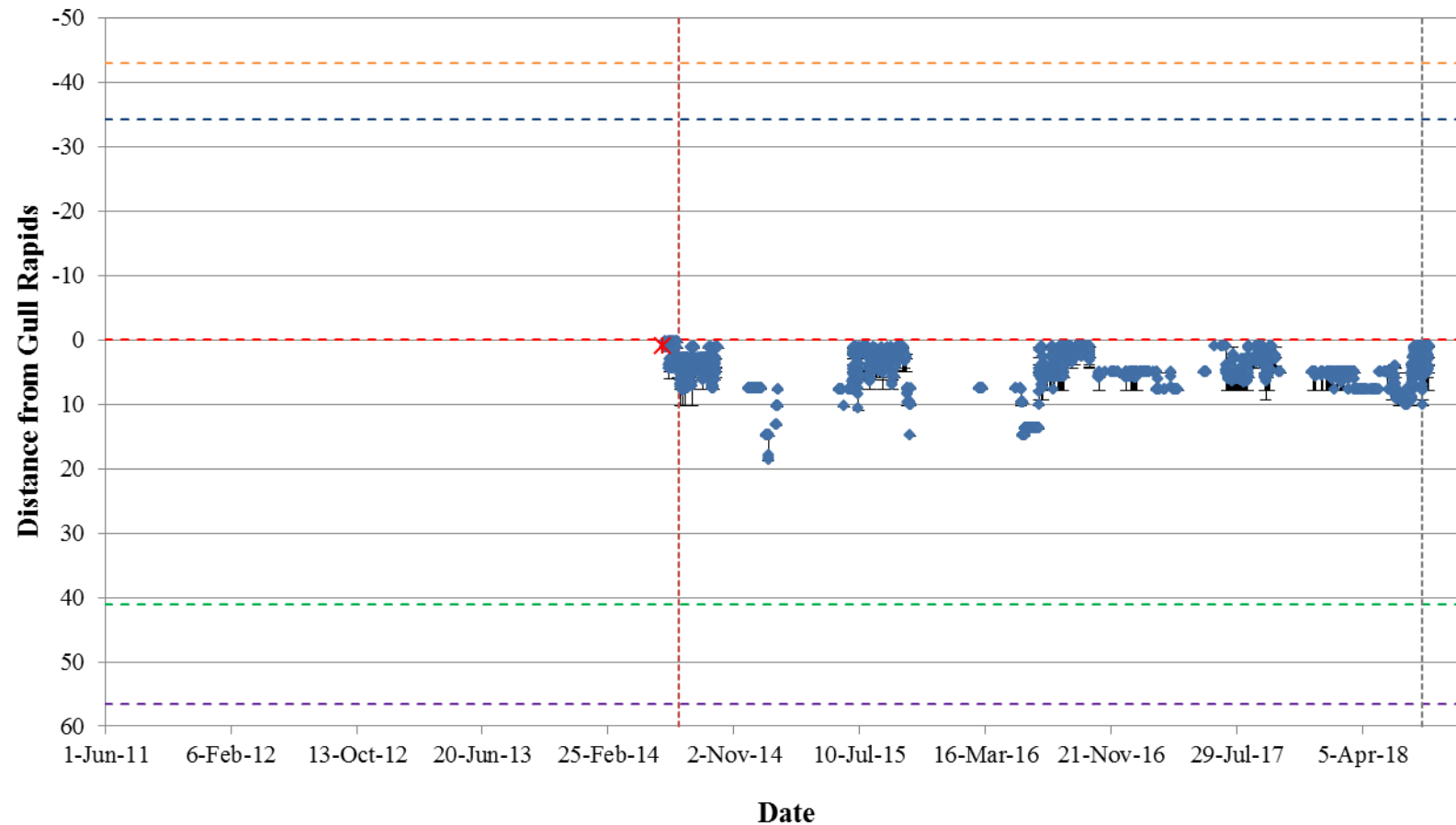


Figure A3-34: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32172) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

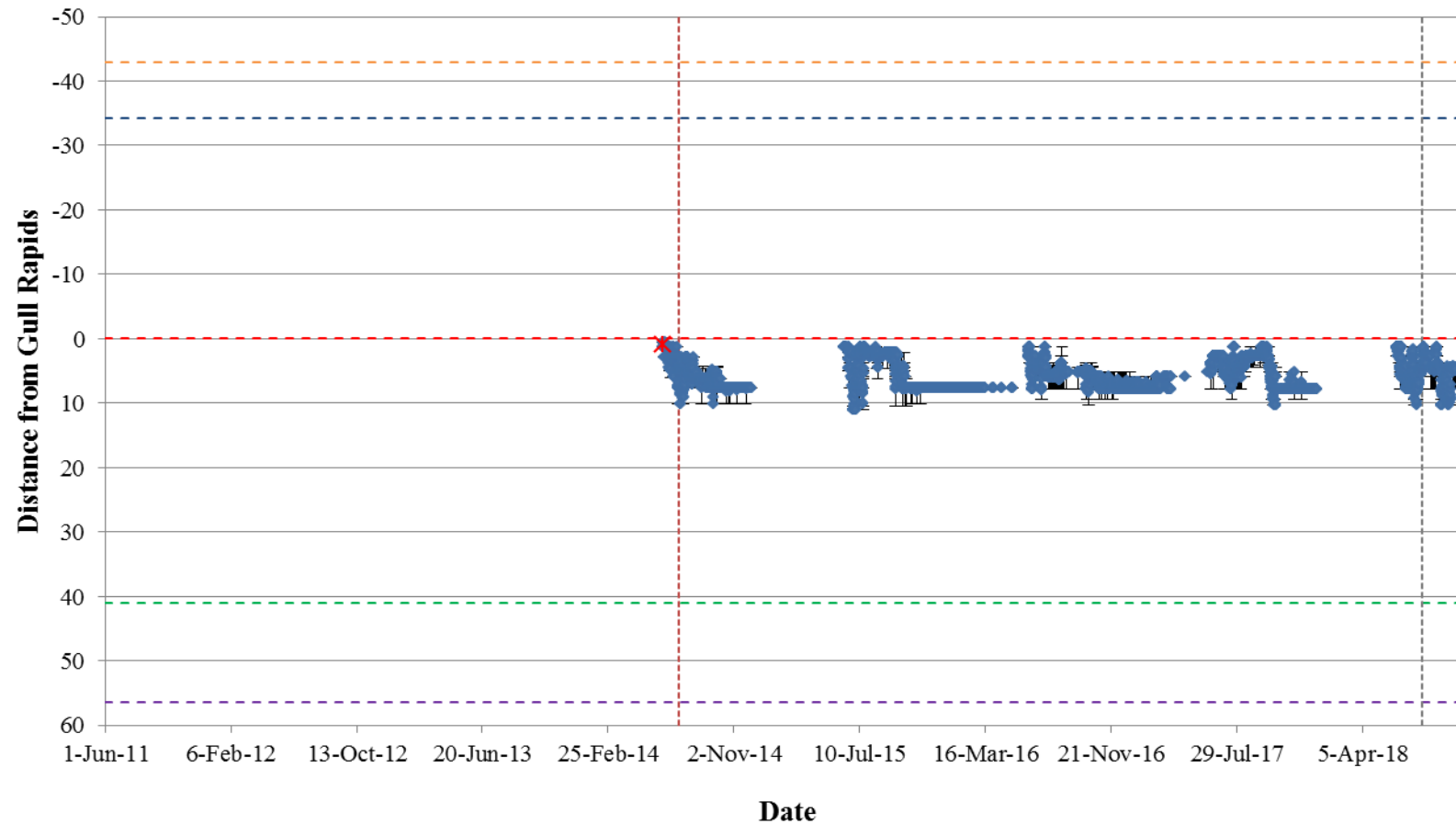


Figure A3-35: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32173) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 10, 2018. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted red line. Beginning of Keeyask spillway commissioning is indicated with a vertical dotted grey line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).