



## Keeyask Generation Project Aquatic Effects Monitoring Plan

# Juvenile Lake Sturgeon Movement Monitoring Report

AEMP-2022-02



# **KEEYASK GENERATION PROJECT**

## **AQUATIC EFFECTS MONITORING PLAN**

REPORT #AEMP-2022-02

### **JUVENILE LAKE STURGEON MOVEMENT MONITORING IN THE NELSON RIVER BETWEEN CLARK LAKE AND THE LIMESTONE GENERATING STATION, SEPTEMBER 2020 TO OCTOBER 2021: YEAR 8 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 and instream work was completed in 2020. The reservoir was impounded with water levels being raised to full supply level between August 31 and September 5, 2020. Commissioning of the powerhouse turbines was initiated after impoundment and five of seven units were in-service by fall 2021. During commissioning and as units came into service, substantial flows continued through the spillway until the summer of 2021 when more flow was going through the powerhouse than spillway. By mid-September the spillway was closed and barely used in the fall.

Lake Sturgeon was identified as one of the key species for monitoring. They were chosen because they are culturally important to partner First Nations, local sturgeon 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.

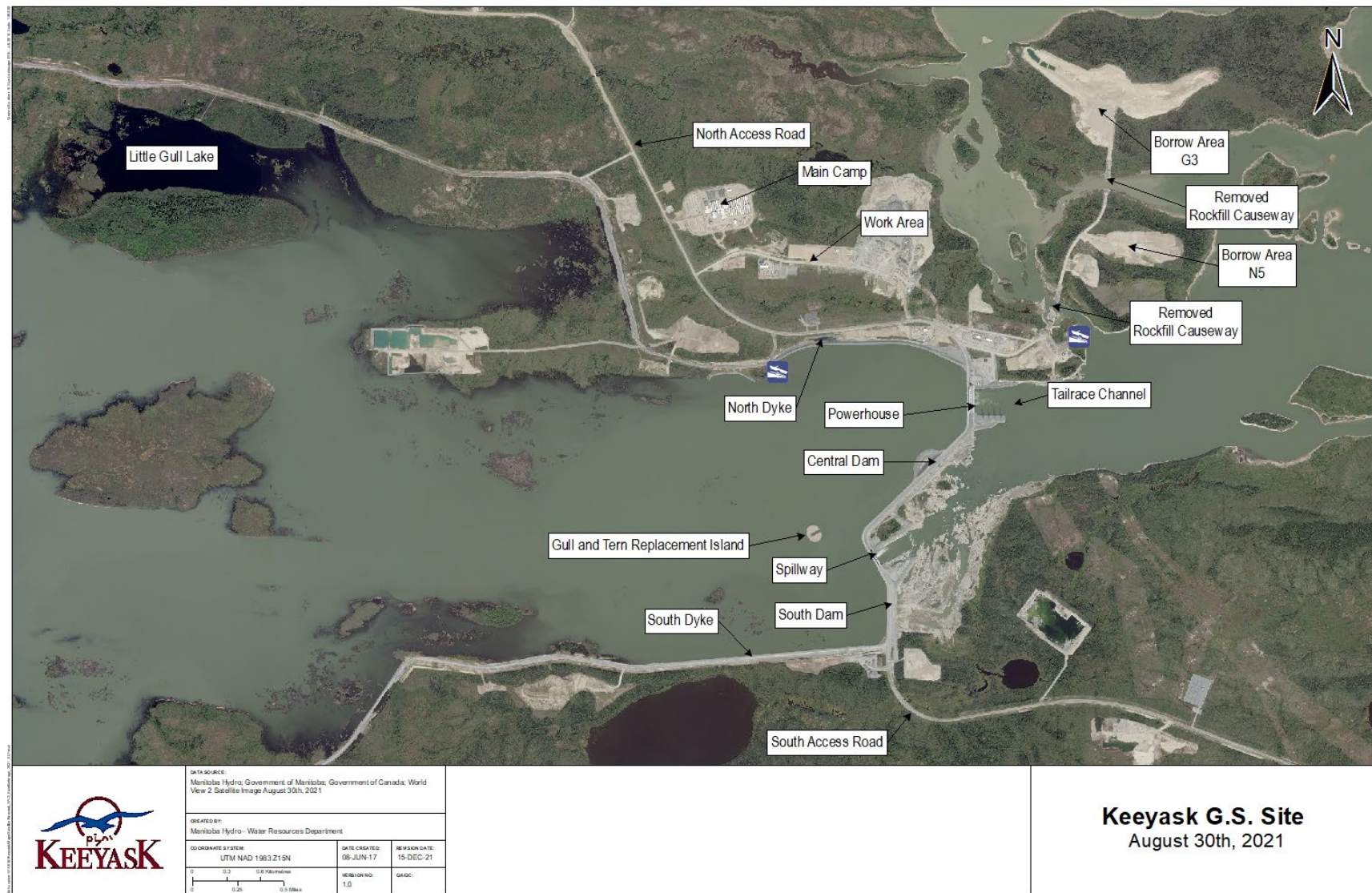
Movements of juvenile Lake Sturgeon in Stephens Lake were monitored with acoustic transmitters in 2011 and 2012, but because different methods are being used for the current study, the results of the two programs cannot be directly compared. Results of the 2011/2012 study showed that young Lake Sturgeon in Stephens Lake preferred to live in the deep water during the spring, summer and fall, but moved into nearby, shallower habitat outside the old river channel in winter. Also, it was unusual for juvenile Lake Sturgeon to travel large distances; instead they generally stayed in the upstream portion of the lake where water flows decreased downstream of Gull Rapids. No tagged juveniles moved upstream through Gull Rapids or downstream through the Kettle GS.

Monitoring juvenile sturgeon movement using the methodology described in the AEMP began in August 2013. Therefore, movements of juvenile Lake Sturgeon have been monitored for 10.5



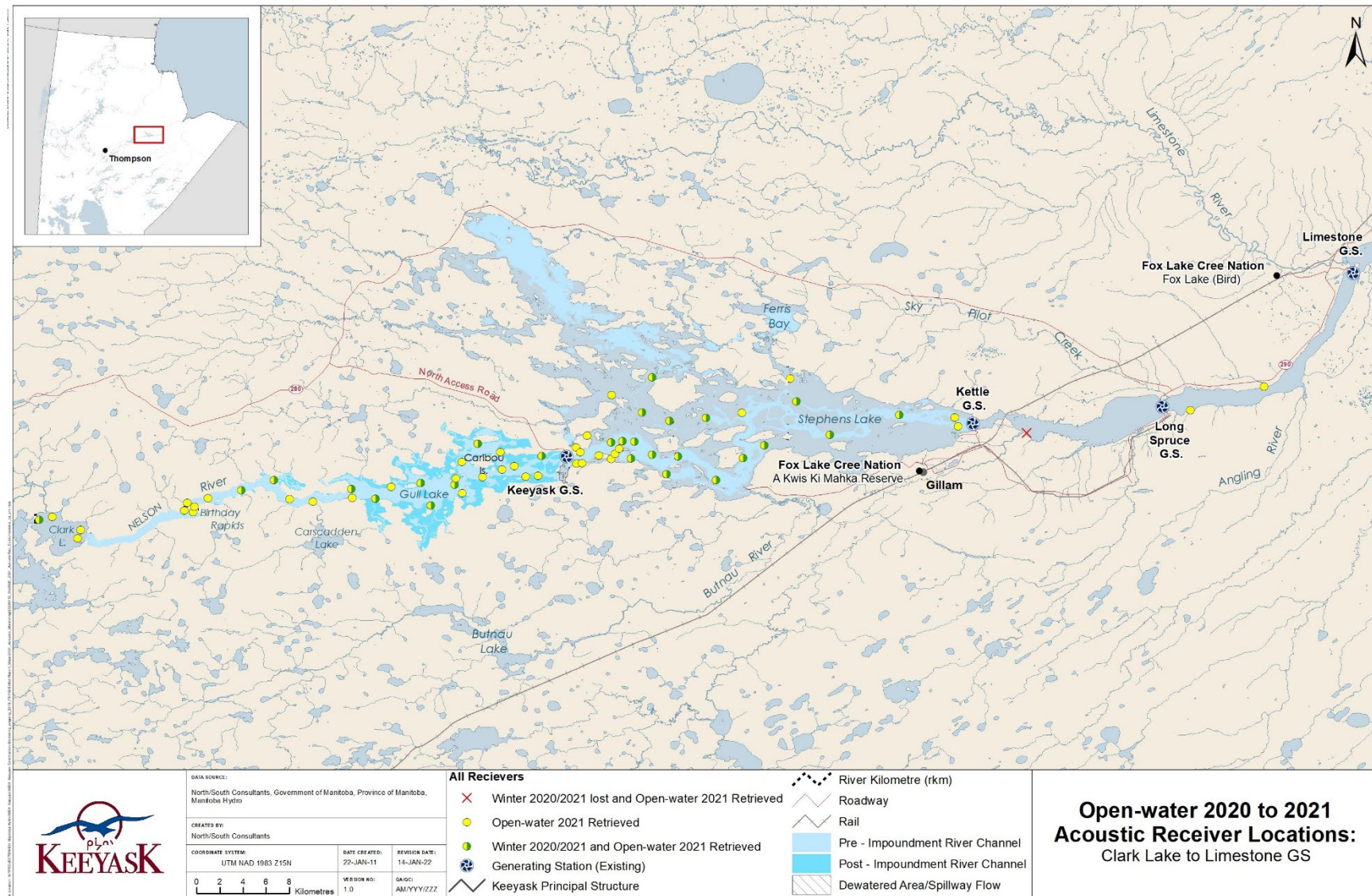
months before changes to the river (pre-construction), approximately six years and two months of construction, and just over one year after impoundment (September 5, 2020 to October 10, 2021). The original 40 acoustic tags applied in 2013 reached the end of their battery lives in 2017; therefore, 40 juvenile Lake Sturgeon were implanted with acoustic tags in September 2017, and subsequently in September 2021, to continue the study.

This report provides results of juvenile sturgeon movement monitoring conducted from September 2020 to October 2021.



Map illustrating instream structures at the Keeyask Generating Station site after reservoir flooding, August 2021.





**Map showing the study area (pre-flooding shoreline). 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.**



**Why is the study being done?**

Monitoring during the end of construction of the GS during the first year after the reservoir was flooded is being done to answer five questions:

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

Monitoring sturgeon movement shows what areas of the river the sturgeon are using relative to the construction site and if these areas change during and after construction of the Keeyask GS.

*Are there juvenile Lake Sturgeon close to the construction site?*

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

*How many juvenile Lake Sturgeon are moving through and/or away from the Keeyask GS during construction and how far are they going?*

Movement studies tell us how many juvenile sturgeon are moving down through the Keeyask GS, 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.

*Are fish moving downstream through the GS and are these fish surviving passage?*

Now that the reservoir is flooded, fish may react to changes in habitat by leaving the area. If they move downstream through the GS (powerhouse or spillway), they cannot move back, and may be injured or killed during passage. This could decrease the number of fish living upstream of the GS.

*Did juvenile Lake Sturgeon change where they live after the reservoir was flooded?*

Flooding of Gull Lake has caused changes to available habitat in the area. This may cause juvenile Lake Sturgeon to move away or to use different areas of the river. Monitoring over the next nine years will tell us if they have change where they live.

**What was done?**

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

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

tags with a 4-year battery life. During fall 2021, an additional 40 tags were applied to juvenile Lake Sturgeon, 20 upstream and 20 downstream of the Keeyask GS.



**Surgery on a juvenile Lake Sturgeon (left and middle) to implant an acoustic tag (right).**

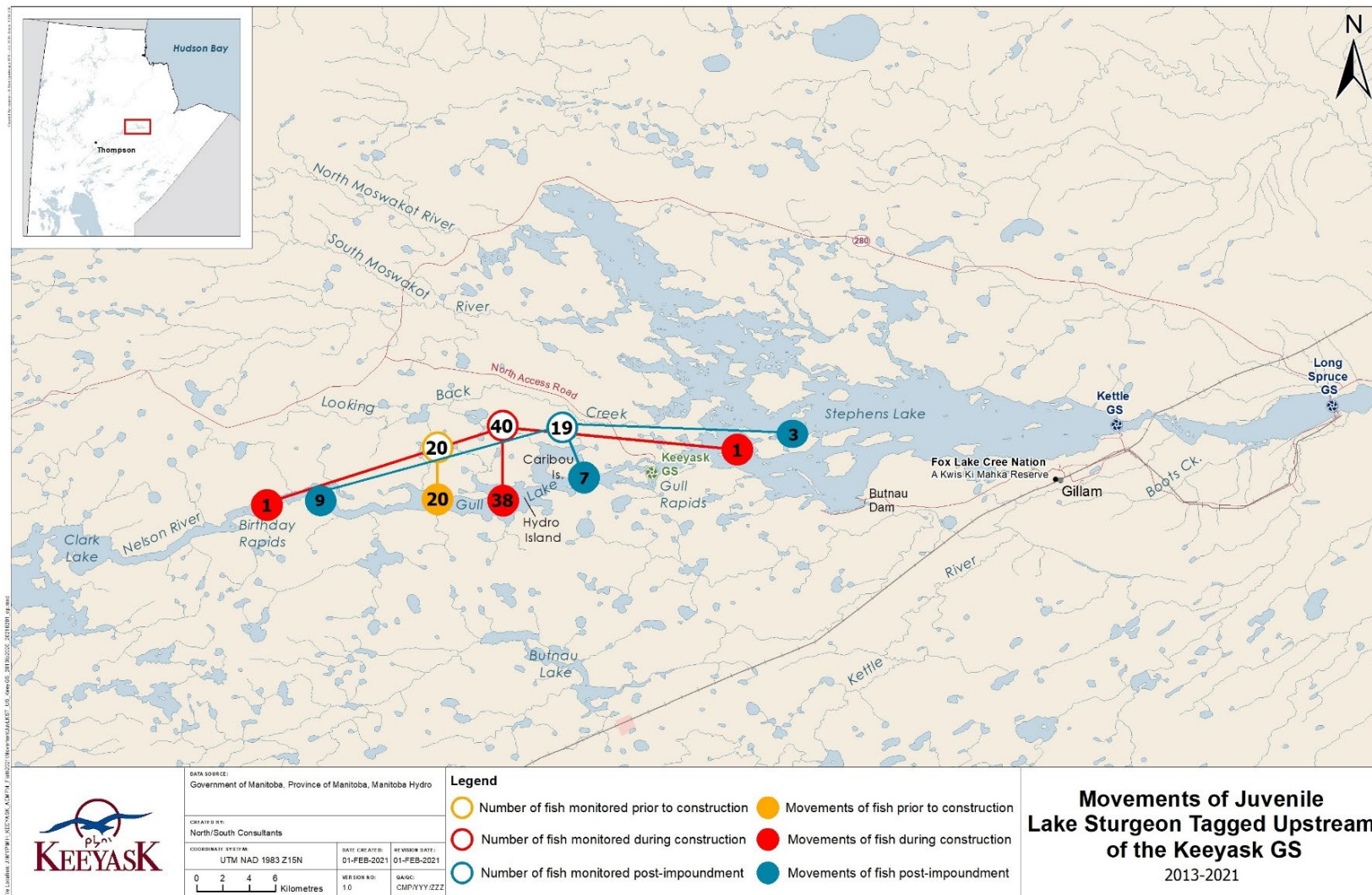
### What was found?

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. Because the reservoir was flooded in 2020, more suitable areas for receivers were available (deep areas with low flow) and additional receivers were set in winter 2020/2021.

Before and during construction, juvenile Lake Sturgeon upstream of the Keeyask GS did not move very far and most lived in small areas within Gull Lake. Immediately after impoundment in fall 2020 and during winter 2020/2021, juvenile Lake Sturgeon did not change their movement patterns. However, beginning in June 2021, juvenile Lake Sturgeon began to move longer distances and occupy different areas of Gull Lake. Of the 19 fish with transmitters, seven showed similar movement patterns to previous years, nine moved longer distances and moved farther upstream relative to previous years, and three moved downstream through the Keeyask GS.

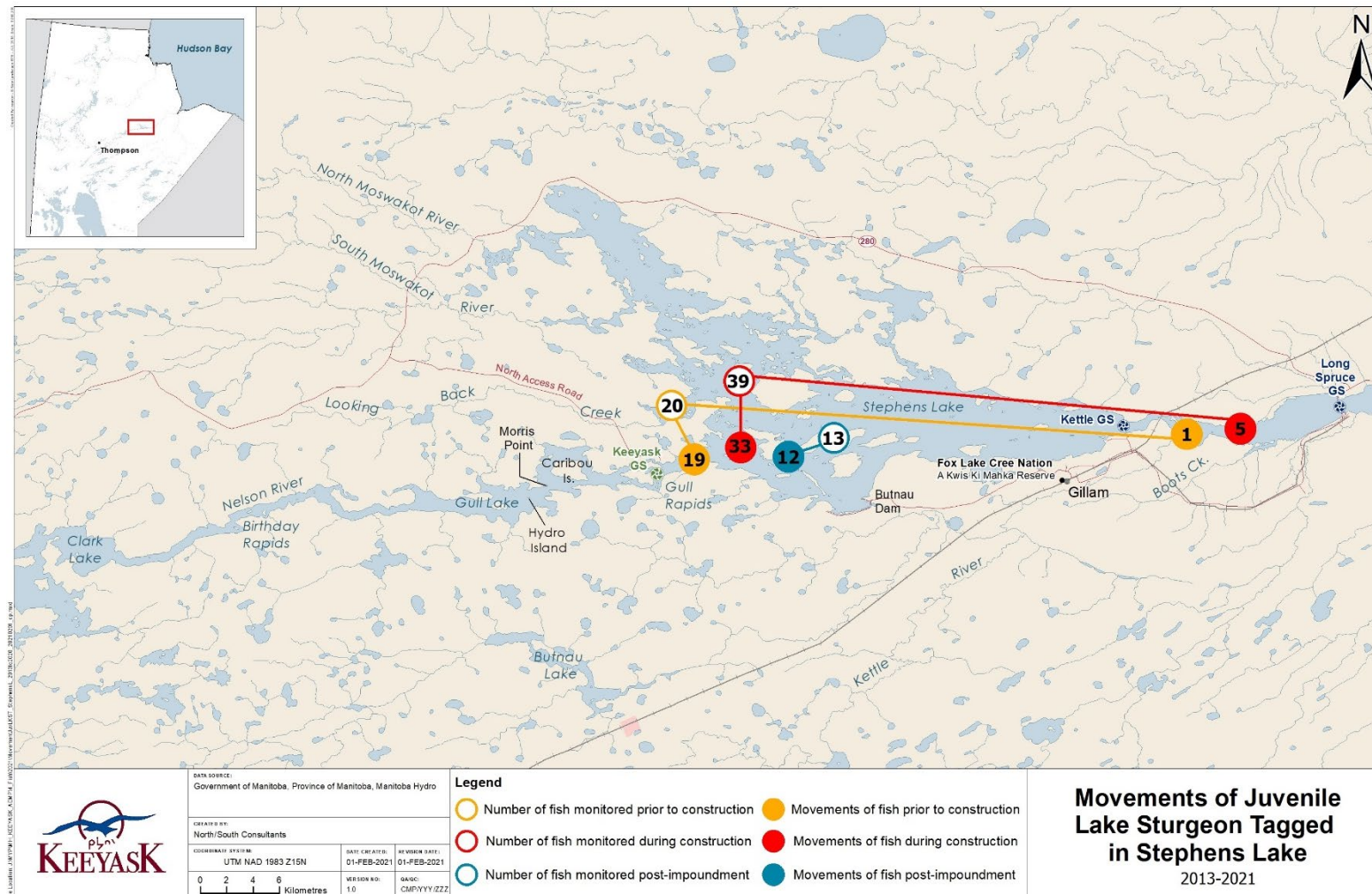
The three fish that moved downstream through the GS represents an increase from previous years. Between 2013 and 2020, only one fish moved downstream. All movements through Gull Rapids/the Keeyask GS are shown in the maps below. All three fish moved downstream between June and July. After moving past the Keeyask GS, all three fish moved upstream and downstream in Stephens Lake, showing that they survived passage.

In Stephens Lake, juvenile Lake Sturgeon continued to show the same general movements as in previous years but spent slightly more time farther from the GS. Fish 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.



**Map showing how many juvenile Lake Sturgeon moved upstream out of Gull Lake, stayed in Gull Lake, and moved into Stephens Lake before construction (yellow), during construction (red) and after reservoir impoundment (blue). Movements of fish due to tagging stress or mortality were not included. Numbers of fish monitored (hollow circles) represent the number of fish tagged while the number of fish movements (solid circles) represent the number of fish detected.**





**Map showing how many juvenile Lake Sturgeon moved upstream through Gull Rapids, stayed in Stephens Lake, and moved downstream through the Kettle GS before construction (yellow), during construction (red) and after reservoir impoundment (blue). Movements due to tagging stress and mortality were not included. Numbers of fish monitored (hollow circles) represent the number of fish tagged while the number of fish movements (solid circles) represent the number of fish detected.**

**What does it mean?**

Before the Keeyask GS reservoir was flooded, monitoring upstream of the Keeyask GS showed that each sturgeon tended to stay in the same areas year after year, moving little. Data collected immediately after impoundment and during the winter showed that these movements didn't change. Data collected during the first open-water period after the reservoir was flooded suggests that movements of juvenile sturgeon appear to have changed. During the open-water season following reservoir impoundment, most fish moved more frequently and moved over longer distances than they had in previous years. Some stayed in the reservoir, while others moved downstream through the GS.

Movement monitoring from 2013–2021 suggests that construction of the Keeyask GS has not affected movement patterns or habitat use of juvenile Lake Sturgeon in Stephens Lake. Lake Sturgeon continue to mostly use the southern portion of the Lake, within 10 rkm of the GS.

**What will be done next?**

The original tags applied to juvenile Lake Sturgeon in 2013 are now expired and cannot be tracked by the receivers. Open-water 2021 was the last year that tags applied in 2017 were active. Therefore, an additional 40 fish were tagged in late 2021, 20 upstream and 20 downstream of the GS. Following the movements of individual fish over a long time will give us a better idea of what kinds of habitats these fish need to use over many years and if fish continue to change their movements in the Keeyask reservoir.

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The collection of biological samples described in this report was authorized by Manitoba Conservation and Water Stewardship, Fisheries Branch, under terms of the Scientific Collection Permit #08-2021.



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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 licencing process for the Project, an Aquatic Effects Monitoring Plan (AEMP) was developed detailing the monitoring activities of various components of the aquatic environment including the focus of this report, juvenile Lake Sturgeon movement, for the construction and operation phases of the Project.

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

The Keeyask AEMP juvenile Lake Sturgeon movement monitoring program was initiated in August 2013 when 40 juvenile Lake Sturgeon were tagged with acoustic transmitters with a four-year battery life, 20 in Gull Lake and 20 in Stephens Lake (Map 1). In Gull and Stephens lakes, Lake Sturgeon are classified as juveniles if they have a fork length measuring less than 800 mm (Henderson *et al.* 2015). The original 40 transmitters were set to expire in August 2017. Therefore, to continue the study (after the batteries expired in the original 40 transmitters), an additional 40 transmitters were applied to juvenile Lake Sturgeon in September 2017, again with 20 applied in both Gull and Stephens lakes. As these were set to expire an additional 40 transmitters were applied in September 2021. The original 40 transmitters are now expired and no longer being tracked.

The overall aim of this monitoring study is to describe juvenile Lake Sturgeon movement during the pre-construction (2013–July 2014), construction (July 2014–September 2020) and post-impoundment (September 2020–ongoing) phases of the Project and to determine if disturbances associated with construction alter habitat use and coarse-scale movement patterns upstream and downstream of the Project (Map 2). Results have assisted in identifying the use of key habitats (*i.e.*, rearing and foraging) during construction, the potential vulnerability of sturgeon to activities at the construction site (*i.e.*, if sturgeon use the area in the immediate vicinity of the construction site, they may be vulnerable to stranding during dewatering), and the potential for increased emigration or avoidance of the construction site due to disturbance (*i.e.*, blasting, suspended sediment inputs, *etc.*).

Impoundment of the Keeyask reservoir was completed on September 5, 2020. Sampling in the Keeyask reservoir in 2021 represented the first year of sampling under operating conditions (water levels and flows). Monitoring in Stephens Lake, however, represented a transition between construction and operation as a considerable portion of the flow was still being passed through the spillway in spring and early summer when only a few units were in-service. Later in the summer and early fall as additional units became operational all the entire flow of the river was going through the powerhouse. Due to Keeyask reservoir impoundment, several key questions identified in the AEMP that have not been previously discussed are addressed below.

- Will disturbances associated with construction alter coarse-scale movements upstream and/or downstream of the construction site?
- Are sturgeon using habitat in the immediate vicinity of the construction site?
- Will the frequency of long-distance movements (and subsequent downstream emigration/entrainment) by Lake Sturgeon increase during construction and operation of the Project?
- Are fish moving downstream past the GS and, if so, is there an indication that they have survived passage?
- Will there be a change in the proportional distribution of adult Lake Sturgeon following reservoir creation (*i.e.*, will there be a population level shift in distribution patterns following reservoir creation)?

This report provides results from September 2020 to October 2021, which is the sixth winter and seventh open-water period of monitoring conducted since construction of the Keeyask GS began in July 2014, and the first full year of monitoring following reservoir impoundment.



## 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. Clark Lake is located immediately downstream of Split Lake, and approximately 42 km upstream of the Keeyask GS (formerly 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. The area between Clark Lake and the Keeyask GS is considered the Keeyask reservoir.

Birthday Rapids is located approximately 10 km downstream of Clark Lake and 30 km upstream of Gull Rapids/the Keeyask GS (Maps 1 and 2) and marks the upstream end of major water level changes as a result of impoundment by the Keeyask GS. The drop in elevation from the upstream to downstream side of Birthday Rapids was approximately 2 m prior to impoundment but is now a nearly level, albeit fast-flowing section of river. The 14 km reach of the Nelson River between Birthday Rapids and Gull Lake was characterized as a large and somewhat uniform channel with medium to high water velocities and a few large bays. This area is now within the Keeyask reservoir, though flooding was limited to mainly shoreline areas.

Prior to impoundment, Gull Lake was a widening of the Nelson River, with moderate to low water velocity beginning approximately 20 km upstream of Gull Rapids/the Keeyask GS. Water levels on Gull Lake increased by several metres following impoundment and flooding along the shoreline and small tributaries entering this reach was extensive. Although this area is now a portion of the Keeyask reservoir, it is referred to herein as Gull Lake.

Just below the Keeyask GS, the Nelson River enters Stephens Lake. Stephens Lake was formed in 1971 by construction of the Kettle GS. Construction of the Keeyask GS has altered the flow distribution immediately downstream of the station.

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 3). 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 the Keeyask GS.

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 6).

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 FLOWS, WATER LEVELS, AND KEEYASK OPERATIONS

From October 2020 to mid-June 2021 the calculated Split Lake outflow varied about the median flow of about 3,300 m<sup>3</sup>/s, ranging between about 3,000 m<sup>3</sup>/s and 3,900 m<sup>3</sup>/s. From mid-June to mid-August, the flows steadily decreased from about 3,700 m<sup>3</sup>/s to about 2,000 m<sup>3</sup>/s, which is approximately the 5th percentile low flow. Low flow conditions persisted from summer into winter, with flows dropping to a low of about 1,800 m<sup>3</sup>/s at the end of November 2021. These are the lowest flows that have occurred during Keeyask construction. It is not since 2005 that flows this low have occurred on the Nelson River.

Water levels on Gull Lake have been held steady between about 158.8-159 m since reservoir impoundment in September 2020. Upstream of Gull Lake at gauges below and above Birthday Rapids the levels were about 0.5 m and 2 m higher than on Gull Lake, a smaller difference than would have occurred prior to the project. Upstream levels increased about 3-4 m at these sites in winter due to ice effects as in previous years. Due to low flows in summer 2021 the water surface was relatively flat from Gull Lake to the gauge just upstream of Birthday Rapids, with a difference of only about 0.8-0.9 m between the two.

Keeyask is transitioning from a construction project to an operating station (Map 2). In 2021, the work at site has been focused on bringing units into service. By the end of April 2021, prior to the start of aquatic monitoring, Unit 1 and Unit 2 were in service. Throughout the open water period more units were being tested and brought into service one at a time. As units came into service, the distribution of flow between the spillway and powerhouse has gradually shifted, as summarized below. By the end of October 2021 five units were fully in service.

Discharges from the spillway and powerhouse are not measured but have been estimated based on performance design curves. For reference it is noted that the design discharge capacity of the powerhouse is 4,000 m<sup>3</sup>/s, giving each turbine unit a discharge capacity of approximately 570 m<sup>3</sup>/s.

Table below outlines Keeyask GS operation, including powerhouse and spillway flows, in 2021.

Dates	Powerhouse Units	Spillway Gate Operation	Powerhouse	Spillway	Keeyask Total
			Discharge (m <sup>3</sup> /s)		
End Apr. - end June 2021	Unit 2 online; Unit 3 testing	Gates 1, 2, 3, 5, 7 in use until mid-June. Gates 1, 3, 5, 7 primarily mid- to end-June.	Steady at about 1,100 varying down to 600 on a few intermittent days and up to 1,650 during two weeks of Unit 3 testing.	Generally, 2,200-2,800 except during U3 testing it varied from about 1,400-2,400	Generally, 3,400-3,900 except during Unit 3 testing it varied from 2,600-3,600.
End June – mid Sept. 2021	Unit 3 online; Unit 5 testing	Generally, Gates 1,3, 5, 7 until mid-July. Gates 3, 5, 7 until end of July. Various gates used in Aug. Gates 1 and 7 used in Sept. until closure of all gates on Sept. 11.	About 1,650, but reduced to 1,100 for two weeks with a unit shut down and varying up to 2,100 during two weeks of Unit 5 testing.	From end of June to mid-Aug. Nelson R inflow declined from about 3,600 to about 1,800-2,200 and has remained steady around 2,000-2,200 since then – corresponding spillway discharge gradually declined from about 2,400 to 0 by mid-Sept. when Unit 5 came into service, although daily variations of +/- 200-400 or more in a few instances occurred during this time.	Total Keeyask discharge declined from about 3,600 to an average of about 2,000-2,200 corresponding to the decrease in Nelson R inflow, and daily variation of about +/- 200-400 depending on spillway and powerhouse operations.
Mid-Sept. – end Oct. 2021	Unit 5 online; Unit 4 testing; Unit 4 online Oct. 25	Various gates used very sporadically. First reopening on Sept. 28.	Average discharge about 2,000-2,200 with typical daily variation from 1,600-2,200 and a maximum variation between 1,000-2,800 depending on unit operations and Unit 4 testing.	No spillway flow except for a few intermittent days of up to 1,000.	Same as powerhouse.

## 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 the detection range of a receiver (generally within 500 m to 1 km, depending on conditions), the transmitter code number, as well as the date and time, are stored in the receiver.

#### 3.1.1 ACOUSTIC TRANSMITTER APPLICATION

Acoustic transmitters (Vemco V13-1x, estimated 1,480-day battery life) were first applied to 40 juvenile Lake Sturgeon (fork lengths: 450–668 mm) in August and September 2013; 20 upstream and 20 downstream of Gull Rapids (now the Keeyask GS) (Hrenchuk and Barth 2014). These transmitters expired during the fall of 2017. To continue juvenile Lake Sturgeon movement monitoring with a similar sample size, 40 tags (estimated 1,737-day battery life) were applied to juveniles in September 2017; 20 upstream and 20 downstream of the Keeyask GS (Tables 1 and 2). Sturgeon tagged in September 2017 had fork lengths ranging from 360 to 578 mm (Lacho *et al.* 2018). As these tags are nearing the end of their expected battery life, an additional 40 tags were applied to juveniles in September 2021; 20 upstream and 20 downstream of the Keeyask GS (Tables 1 and 2). Sturgeon tagged in September 2021 had fork lengths ranging from 390 to 563 mm. A detailed description of acoustic transmitter application can be found in Hrenchuk and McDougall (2012).

#### 3.1.2 ACOUSTIC RECEIVERS

Since 2013, stationary acoustic receivers (VEMCO model VR2W) have been used to continuously monitor tagged juvenile Lake Sturgeon in the Nelson River between Clark Lake and the Long Spruce GS. In spring 2016, the receiver array was extended to the upper Limestone reservoir, with the placement of two receivers downstream of the Long Spruce GS. The intent of adding these receivers was to determine whether fish that had moved into the Long Spruce reservoir had continued to move downstream.

During the six 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, likely 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 is limited, especially in areas upstream of the Keeyask GS.

### **3.1.2.1 WINTER 2020/2021**

The stationary acoustic receiver array for the winter 2020/2021 (September 24, 2020, to April 30, 2021) period consisted of 28 receivers. Although additional receivers were not set until May, the end of the winter period is defined as April 30 to provide consistency between years. Ten were set upstream of the Keeyask GS, 17 throughout Stephens Lake, and one in the Long Spruce forebay (Maps 3, 4, and 5). Forebay impoundment in fall 2020 allowed for additional receivers to be set in the reservoir, due to the increase in deep off-current areas. An additional five receivers were set including one in the riverine portion of the reservoir between Birthday Rapids and Gull Lake (#114230; rkm -26.4), one at the inlet of Gull Lake (#122779; rkm -19.5), one at the mouth of the flooded backbay at Rabbit Creek (#114226; rkm -17.4), one north of Caribou Island (#129182; rkm -7.9), and one immediately upstream of the powerhouse (#127100; rkm -2.2) (Map 2). One additional receiver was set in Stephens Lake, closer to the GS (#125557; rkm 3.9).

### **3.1.2.2 OPEN-WATER 2021**

An array of 64 acoustic receivers was used during the 2021 open-water period (defined as May 1 to October 10, 2021). Although additional receivers were not set until later in May, the start of the open-water period is defined as May 1 to provide consistency between years. Thirty-one were set both upstream of the Keeyask GS and in Stephens Lake (Maps 5 and 6). The 2021 open-water array differed slightly from the array used in 2020. Three additional receivers were set upstream of the GS: one in the reservoir upstream of Gull Lake (#114235; rkm -22.6), one south of Caribou Island (#114232; rkm -7.7), and one upstream of the Keeyask GS spillway (#129192; rkm -2.5) (Map 5).

Water levels downstream of the Keeyask GS in spring and summer 2021 were lower than in previous years, preventing access to the receiver set downstream of the Kettle GS. Several attempts were made to access the site throughout the open-water period. A boat was successfully launched downstream of the Kettle GS in October 2021, however, the single receiver set during winter 2020/2021 could not be retrieved. Despite this, two receivers were set downstream of the Long Spruce GS for the duration of the 2021 open-water period (Map 7).

Similar to previous years, receiver “gates” were established in several key areas selected by river morphology (channel restrictions) and habitat characteristics (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 in which they were last detected.

Four gates were established between Clark Lake and the Keeyask GS (44.0, 34.0, 19.0, and 10.0 rkms upstream of the GS), and two were established in Stephens Lake (4.5 and 40.0 rkms downstream of the GS) (Maps 5 and 6). The location of the “gates” has remained consistent since 2013.

To describe fish movements for reporting purposes, the study area was divided into nine different zones. The area upstream of the Keeyask GS was divided into five zones (Map 5; Zones 1–5), while Stephens Lake was divided into two zones (Map 6; Zones 6 and 7). The Long Spruce reservoir is referred to as Zone 8 and the Limestone reservoir as Zone 9.

Water temperature within the Nelson River mainstem was recorded with a HOBO Water Temperature Pro data logger from September 24, 2020, to October 3, 2021.

By October 11, 2021, the majority of receivers were removed, and a subset ( $n = 27$ ) were redeployed to monitor movements during winter 2021/2022.

### 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 the Keeyask GS representing a distance of 0 rkm. The area located downstream of the Keeyask GS (*i.e.*, Stephens Lake and the Long Spruce reservoir) were given positive (+) distance values from the GS, 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 the GS 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 during each 4-hour interval was plotted and presented as a percentage of the study period. For example, a fish that spent 44% of the time between May 1 and May 31 within Zone 4 means that the fish was detected within Zone 4 for 44% of the 186 4-hour intervals between May 1 and May 31.

Rapid downstream movements observed within two weeks of tagging were classified as caused by tagging mortality or stress. If the fish made a rapid downstream movement within two weeks of tagging followed by upstream and downstream movements, it was classified as tagging stress. If a fish made a rapid downstream movement within two weeks of tagging and was not detected again or did not display upstream movements, it was classified as a tagging mortality. If a fish was not detected for more than one year, it was classified as missing.

## 4.0 RESULTS

Section 4.1 provides a summary of movements observed between tagging in September 2017 and the end of the 2020 open-water period (September 23, 2020), Sections 4.2 and 4.3 detail results from winter 2020/21 and open-water 2021, respectively, and Section 4.4 outlines initial movement results for Lake Sturgeon tagged in September 2021, near the end of the open-water period. Biological information for fish tagged upstream of the Keeyask GS and in Stephens Lake in 2017 are provided in tables 1 and 2. Tables 3 to 11 provide proportional distributions and detection summaries associated with each tagged fish. Figures 1 and 2 show acoustic receiver locations during the study period. Figures 3 to 12 summarize movement range and proportional distribution of tagged fish both upstream and downstream of the construction site by season. Figures 13 and 14 summarize long-distance movements by study period since the study began in 2013. Maps 3 to 6 provide maps of receiver locations. Appendices 1 and 2 provide movement summaries for the juvenile Lake Sturgeon tagged in September 2017 and 2021.

### 4.1 2017-2020 RESULTS SUMMARY

#### 4.1.1 UPSTREAM OF THE KEEYASK GS

Twenty juvenile Lake Sturgeon were tagged in Gull Lake in September 2017 (Table 1). A single juvenile sturgeon moved downstream through the Keeyask GS spillway.

- #31778 was tagged in Gull Lake on September 12, 2017. It was first detected in Stephens Lake on June 25, 2019, and displayed upstream and downstream movements in the lake, indicating it survived passage (Appendix A1-16).

Therefore, there were 19 juvenile Lake Sturgeon available to be detected upstream of the Keeyask GS at the beginning of the winter 2020/2021 season.

#### 4.1.2 STEPHENS LAKE

Twenty juvenile Lake Sturgeon were tagged in Stephens Lake in September 2017 (Table 2). Since that time, six fish moved downstream out of Stephens Lake through the Kettle GS into the Long Spruce reservoir:

- #31689 was last detected in lower Stephens Lake on January 8, 2018 after moving steadily downstream from the upper portion of the lake starting on December 28, 2017. It was first detected in the Long Spruce reservoir on June 18, 2018 (Appendix A2-2).



- #31690 was last detected in Stephens Lake on December 4, 2017 after moving steadily downstream starting on November 26, 2017. It was first detected in the Long Spruce reservoir on June 12, 2018 (Appendix A2-3)
- #31691 moved downstream past the Kettle GS nine days after being tagged in September, 2017. It was first detected in the Long Spruce reservoir on September 24, 2017 (Appendix A2-4).
- #31692 was last detected in Stephens Lake on February 22, 2019 and was first detected in the Long Spruce reservoir on May 26, 2019 (Appendix A2-5).
- #31764 was last detected in Stephens Lake on November 28, 2017 at rkm 24.7. It was first detected in the Long Spruce reservoir on November 30, 2017 (Appendix A2-17).
- #31762 was last detected in Stephens Lake on January 25, 2020 and was detected in the Long Spruce reservoir on August 14, 2020 (Appendix A2-15).

An additional two fish are missing (*i.e.*, have not been detected for more than a year). It is possible that these fish moved downstream through the Kettle GS.

- #31693 was last detected in lower Stephens Lake on November 30, 2017 (Appendix A2-6).
- #31761 moved steadily downstream immediately after tagging in upper Stephens Lake on September 13, 2017. It was last detected on September 19, 2017, immediately upstream of the Kettle GS (Appendix A2-14).

Therefore, accounting for the six fish that moved downstream out of Stephens Lake, the two missing fish, and the one fish that moved downstream through the Keeyask GS, 13 juveniles were available to be detected in Stephens Lake at the beginning of winter 2020/2021.

## 4.2 WINTER 2020/2021

### 4.2.1 UPSTREAM OF THE KEEYASK GS

All ten receivers deployed between Clark Lake and the Keeyask GS during the 2020/2021 winter period were retrieved (Figure 1). Fifteen of the 19 juvenile Lake Sturgeon (79%) were located a total of 300,362 times (range: 10–46,997 detections per individual) (Appendix A1-1). Fish were detected on 3 to 216 days of the 219-day winter period (1–99% of the time) for an average of 142 days, or for 65% of the study period (standard deviation [StDev] = 73 days). The farthest upstream detections occurred at rkm -17.4 (by one fish; 7%), while the farthest downstream occurred at rkm -7.9 (by six fish; 40%) (Appendix A1-1). The average movement range was 2.1 rkm (range 0.0–7.3 rkm) (Figure 3; Appendix A1-1).

The majority of detections were logged by receivers located in the lower portion of the reservoir, north of Caribou Island at rkm -7.9 (n = 141,402; 47%; Figure 4). A large number of detections

were also logged in the middle basin of Gull Lake between rkm -12.4 and -10.1 (n = 142,868; 51%). Movements were as follows:

- Nine fish (60% of all fish detected) remained within the upper Gull Lake portion of the reservoir, moving no farther upstream than rkm -17.4 and no farther downstream than rkm -10.1.
- Four (27%) remained within the lower Gull Lake portion of the reservoir and were detected exclusively at rkm -7.9.
- Two (13%) moved between both areas and were detected as far upstream as rkm -12.9 and as far downstream as rkm -7.9.

#### 4.2.2 STEPHENS LAKE

All of the 17 receivers deployed in Stephens Lake during the 2020/2021 winter period were retrieved. Eleven of the 13 juvenile Lake Sturgeon (85%) were located a total of 336,784 times (range: 3,657–66,054 detections per individual) (Appendix A1-1). Fish were detected on 48 to 219 days of the 219-day winter period (22–100% of the time) for an average of 142 days, or for 65% of the study period (standard deviation [StDev] = 60 days). The farthest upstream detections occurred at rkm 3.9 (by eight fish; 73%), while the farthest downstream occurred at rkm 13.4 (by two fish; 18%). The average movement range was 3.6 rkm (StDev = 2.6 rkm; range = 0.0–9.5 rkm) (Table 6; Figure 5).

The majority of detections were logged in the southern portion of Stephens Lake at rkms 3.9 (n = 70,725; 21%) and 10.2 (n = 107,186; 32%) (Figure 6). No fish were detected farther downstream than rkm 13.4 or in the northern portion of Stephens Lake (Figure 6). Movements were as follows:

- Eight fish (53%) remained exclusively in upper Stephens Lake, moving no farther downstream than rkm 10.2.
- Two (13%) moved between upper and lower Stephens Lake and were detected as far upstream as rkm 1.2 and as far downstream as rkm 13.4.
- One (7%) was detected exclusively at rkm 13.4.

Individual movement graphs can be found in Appendix 2.

## 4.3 OPEN-WATER 2021

### 4.3.1 ACOUSTIC RECEIVER RETRIEVAL

All stationary acoustic receivers deployed upstream of the Keeyask GS (n = 31), in Stephens Lake (n = 31), and the Limestone reservoir (n = 2) during the 2021 open-water period were successfully retrieved (Maps 5 and 6).

### 4.3.2 KEEYASK RESERVOIR

All 19 juvenile Lake Sturgeon available for detection upstream of the Keeyask GS were located during the 2021 open-water period (Table 7, Figure 7). These fish were detected between five and 33,172 times on two to 158 days (1–98%) of the 162-day open-water period (average = 107 days [66%], StDev = 41 days) (Table 7). Average total movement range was 19.0 rkm (StDev = 9.2 rkm; range: 0.0–33.8 rkm; Table 4; Figure 7). Two fish (11%) were detected as far upstream as Birthday Rapids (rkms -33.9 and -32.2). Not including three fish that moved downstream through the Keeyask GS (discussed further in Section 4.3.2.2), two (11%) were detected at the receiver closest to the Keeyask GS spillway (rkm -2.5) and three (16%) were detected by the receivers closest to the powerhouse (rkm -2.2). The majority of detections were logged in the lower portion of the reservoir between rkm -10.1 and -3.8 (n = 220,962, 81.6%), with the majority logged at rkm -7.9 (n = 60,835, 22%) (Figure 8).

A single fish (#31782) was captured during juvenile Lake Sturgeon population monitoring conducted from September 14–23, 2021. Capture details can be found in Burnett and Hrenchuk (2022).

#### 4.3.2.1 PROPORTIONAL DISTRIBUTION

Not including the three Lake Sturgeon that moved downstream into Stephens Lake, individual juvenile fish spent more time in the lower basin of the reservoir (Zone 5) than in previous years. Fish spent an average of 61% of the study period in Zone 5 (lower basin of Gull Lake) and 39% in Zone 4 (upper basin of Gull Lake) (Table 3). The remaining time (0.7%) was spent in Zone 3.

#### 4.3.2.2 MOVEMENT PATTERNS

Seven fish remained within the Gull Lake portion of the reservoir for the entire open-water period.

- Two (#31769 and #31776) were exclusively detected in the lower basin of Gull Lake (Zone 5).
  - #31769 was detected for two days between rkm -9.9 to -10.3. It had previously not been detected since 2018.

- Five (#31771, #31774, #31777, #31781, and #31782) moved between the upper and lower basins of Gull Lake (zones 4 and 5).

Nine fish moved as far upstream as Zone 3 (the riverine area of the reservoir between Birthday Rapids and Gull Lake). Since studies began in 2014, only a single tagged fish had moved briefly into this area (in 2016).

- Two (#31768 and #31773) moved as far upstream as Birthday Rapids (rkm -32.2 and -33.9).
- Two (#31772 and #31775) moved as far upstream as rkm -29.3.
- One (#31686) moved as far upstream as rkm -26.2.
- Four (#31683, #31684, #31779, and #31770) moved as far upstream as rkm -24.2.

Three fish moved downstream through the Keeyask GS into Stephens Lake.

- #31685 was detected in the reservoir at rkm -7.7 until July 5. It moved downstream and was last detected in the reservoir at rkm -3.8 on July 16.
  - It was first detected in Stephens Lake on July 21 at rkm 0.8 and moved as far downstream as rkm 10.2.
- #31687 was detected between rkm -15.0 and -10.1 until June 16. It moved downstream and was last detected within the reservoir on July 5 at rkm -3.8.
  - It was first detected in Stephens Lake on August 19 and moved between rkms 0.8 and 18.8.
- #31780 was detected within the reservoir between rkm -10.1 and -7.7 until July 20. It then moved downstream and was last detected in the reservoir at rkm -2.5 on July 29.
  - It was first detected in Stephens Lake on August 5 and moved as far downstream as rkm 13.4.

### 4.3.3 STEPHENS LAKE

Twelve of 13 (92%) juvenile Lake Sturgeon were located during the 2021 open-water period. They were detected between nine and 36,691 times over one to 155 days (1–96%) of the 162-day study period (average = 122 days [75%]; StDev = 41 days) (Table 8). The average total movement range was 12.1 rkm (StDev = 5.8 rkm; range: 0.0–24.1 rkm; Table 4; Figure 10). Four fish were detected as far upstream as rkm 0.8, immediately downstream of the Keeyask GS spillway, while one fish was detected in lower Stephens Lake rkm 24.9. Nearly all detections were recorded in the southern portion of Stephens Lake with 226,689 (71%) detections within 7.8 rkm of the Keeyask GS, and 316,003 (99%) within 13.4 rkm (Figure 11).

The single fish that moved downstream through the Keeyask GS in 2019 (#31778) was not detected. It was last located at rkm 9.4 on July 6, 2019 (Appendix A1-16).

One fish (#31685) was captured during juvenile Lake Sturgeon population monitoring conducted from September 14–23, 2021. Capture details can be found in Burnett and Hrenchuk (2022).

#### **4.3.3.1 PROPORTIONAL DISTRIBUTION**

Juvenile Lake Sturgeon spent more time in the zone farther from the GS in 2021 than in 2020. In 2021, fish spent an average of 30% of the study period in Zone 6 (closer to the GS) and 70% in Zone 7 (farther from the GS) (Table 3).

#### **4.3.3.2 MOVEMENT PATTERNS**

Of the 12 fish located during the open-water period, one (#31688) was detected exclusively in Zone 6 (rkm 1.2) but was only detected on a single day.

The remaining 11 fish made regular movements between Zones 6 and 7.

- Seven (#31695, #31696, #31697, #31758, #31760, #31763 and #31766) moved as far downstream as rkm 13.4.
- Three (#31694, #31765, and #31767) moved as far downstream as rkm 18.8.
- One (#31759) moved briefly into lower Stephens Lake and was detected at rkm 24.9. It was located here over two days in July, after which it returned upstream and remained in upper Stephens Lake for the remainder of the open-water period.

#### **4.3.4 LONG SPRUCE RESERVOIR**

Due to low water levels that prevented boat access downstream of the Kettle GS throughout the majority of the open-water period, no acoustic receivers were set in the Long Spruce reservoir. A single fish (#31689) was detected within the Limestone reservoir. It was last detected in the Long Spruce reservoir in 2019.

### **4.4 FISH TAGGED IN 2021**

Acoustic transmitters were applied to 40 juvenile Lake Sturgeon in September 2021 to enable continuation of the study, as tags applied in 2017 are set to expire. Tags were applied during the fall juvenile sturgeon population monitoring program conducted in Stephens Lake and the Keeyask reservoir (Burnett and Hrenchuk 2022). Tagging information for these juveniles can be found in Tables 1 and 2. As less than one month of data was collected after these fish were tagged, no analyses were performed. Observed movements are briefly discussed and supplementary movement graphs are provided in Appendices 1 and 2.



#### **4.4.1 KEEYASK RESERVOIR**

Acoustic tags were applied to 20 juvenile Lake Sturgeon between September 18 and 20, 2021. All sturgeon were detected after tag application, ranging from four to 20 days (20-91% of the days available for detection; Table 10). Lake sturgeon moved between 0.0 and 7.9 rkm from their tagging locations. Although one fish was located upstream of the Keeyask GS powerhouse, no fish moved downstream through the GS.

#### **4.4.2 STEPHENS LAKE**

Acoustic tags were applied to 20 juvenile Lake Sturgeon between September 16 and 17, 2021. All sturgeon were detected after tag application, for 11 to 21 days (46-91% of the days available for detection; Table 11). Two fish (#48294 and #48300) moved as far downstream as rkm 32 in lower Stephens Lake. The remaining fish moved between 0.5 and 15.5 rkm from their tagging locations.

## 5.0 DISCUSSION

Juvenile Lake Sturgeon movement monitoring was initiated in 2013 to describe movements during the pre-construction (2013), construction/commissioning (2014–2021), and operation phases of the Keeyask Project. The intent of the study was to determine if habitat changes associated with construction and operation of the GS would alter habitat use and coarse-scale movement patterns. 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 and impoundment on Lake Sturgeon and their movements

### 5.1 EVALUATION OF METHODOLOGY

The movement patterns and habitat use of juvenile Lake Sturgeon make them an ideal species to study using acoustic telemetry. Since the study was initiated in 2013, the proportion of tagged fish detected, and the number of detections associated with each tagged fish during the open-water period, has remained consistently high both upstream and downstream of the construction site. Fish tagged upstream of the Keeyask GS were detected, on average, on 66% of the days during the 2021 open-water study period (43–66% in previous years). Fish tagged in Stephens Lake tend to be detected more often, and on average were located for 75% of the days during the 2021 open-water period (46–78% in previous years). Impoundment of the reservoir did not appear to have a notable effect on the distribution of the sturgeon in the main channel, as they were still detected by receivers.

Prior to reservoir impoundment in 2020, tracking during the winter period was limited by ice conditions which prevented use of a large receiver array, and only four receivers were set upstream of the Keeyask GS. However, forebay impoundment in fall 2020 increased suitable locations for receiver deployment, allowing for an additional six receivers to be set in the reservoir (i.e., due to the increase in deep off-current areas). During the 2020/2021 winter period, 79% of tagged Lake Sturgeon were detected for an average of 142 days (65% of the study period). This represents an increase from previous years when the average number of detection days were lower (for example, 37% of fish tagged were detected for 35% of the winter 2019/2020 period). In Stephens Lake, receiver coverage has been more extensive since studies began and 85% fish were detected for 65% of the 2020/2021 winter period.

### 5.2 KEY QUESTIONS

Impoundment of the Keeyask reservoir was completed on September 5, 2020 and sampling in the Keeyask reservoir in 2021 represented the first year that the reservoir was at full supply level. Monitoring in Stephens Lake, however, represented a transition between construction and operation as a considerable portion of the flow was still being passed through the spillway in

spring and early summer when only a few units were in-service. Later in the summer and early fall as additional units became operational all the entire flow of the river was going through the powerhouse. Due to Keeyask reservoir impoundment, several key questions identified in the AEMP that have not been previously discussed are addressed below.

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

Instream construction activities related to the Keeyask GS concluded prior to open-water 2021. Juvenile Lake Sturgeon movement patterns changed little during the construction period. Upstream of Gull Rapids/the Keeyask GS, fish tended to move little, remaining within distinct portions of Gull Lake. Fish have been most frequently located near the boundary of Gull Lake that separates the middle and lower basins (Zones 4 and 5) as well as the areas north and west of Caribou Island. Lake Sturgeon in Stephens Lake have tended to move longer distances on average than those upstream of the GS, but still display small movement ranges relative to the amount of deep-water habitat available. Fish spent the greatest amount of time in the southern portion of Stephens Lake within 7.8 rkm of the Keeyask GS. Overall, there were no obvious changes in movement patterns of juvenile Lake Sturgeon upstream and downstream of the GS during the construction period. As construction is now complete, this question is no longer relevant and will not be discussed going forward.

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

As instream construction activities related to the Keeyask GS concluded prior to open-water 2021, this question is no longer relevant. During the construction period, tagged juvenile Lake Sturgeon upstream of the Keeyask GS spent little time near the construction site. In contrast Juvenile Lake Sturgeon in Stephens Lake frequently detected near the construction site. These patterns did not change over the course of the construction period. As construction is now complete, this question is no longer relevant and will not be discussed going forward.

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

Prior to impoundment, the majority of juvenile Lake Sturgeon remained in distinct areas of Gull Lake, and movement ranges were small. Average movement ranges during the open-water period ranged from 2.6 rkm (in 2019) to 5.2 rkm (in 2016). A single sturgeon briefly moved upstream out of Gull Lake (in 2016) and returned within the same year, and a single Lake Sturgeon moved downstream through the Keeyask GS spillway (in 2019). These movements did not change during the nine months following impoundment. However, the frequency of long-distance movements appears to have increased during the first open-water period following reservoir impoundment, starting in June. Nine fish (47% of all detected fish) moved upstream out of Gull Lake to the riverine portion of the reservoir downstream of Birthday Rapids and the average total movement range increased to 19.0 rkm. Further, three fish (16% of all detected) moved downstream through the Keeyask GS into Stephens Lake.

It is unclear why the movement patterns of juvenile Lake Sturgeon in the Keeyask reservoir changed (specifically the increase in long distance movements) in the middle of the open-water period (i.e., in June 2021) nine months after reservoir impoundment. Based on the date of last detection in the reservoir and the first detections in Stephens Lake, one fish moved downstream through the GS in July, and two moved downstream between July and August. The timing of these movements is similar to those seen in adult Lake Sturgeon: 13 acoustically tagged fish moved downstream in open-water 2021, six in June or July, one in August, and six between June and September (Hrenchuk and Small 2022). A similar increase in downstream movements out of the reservoir was observed from Floy-tag recaptures during the fall juvenile Lake Sturgeon population monitoring study (Burnett and Hrenchuk 2022). Eleven fish tagged upstream of the GS were captured within Stephens Lake in fall 2021. This represents an increase, as only seven fish floy-tagged upstream had been captured in Stephens Lake previously (2009–2020).

In contrast, juvenile sturgeon tagged in Stephens Lake did not display the same increase in long-distance movements. Juveniles in Stephens Lake tend to move longer distances on average than upstream of the GS prior to impoundment. Since 2014, average movement ranges during the open-water period have ranged from 9.3 rkm (in 2020) to 12.1 rkm (in 2021).

It is possible that the large emigration of Lake Sturgeon observed in 2021 was a singular event as fish adjusted to the new reservoir habitat. Continued monitoring will determine if fish continue to move downstream out of the reservoir and if the fish that moved downstream in 2021 remain in Stephens Lake.

*Are fish moving downstream past the GS and, if so, is there an indication that they have survived passage?*

Three juvenile Lake Sturgeon moved downstream past the GS in open-water 2021. All three fish displayed both upstream and downstream movements within Stephens Lake, indicating they survived passage. It is unclear whether they moved through the spillway or powerhouse.

*Will there be a change in the proportional distribution of juvenile Lake Sturgeon following reservoir creation (i.e., will there be a population level shift in distribution patterns following reservoir creation)?*

During the first full open-water period after reservoir impoundment, Lake Sturgeon tagged upstream of the GS tended to spend more time in the lower portion of the reservoir (Zone 5) than in previous years. During the construction period (2014–2020), fish spent 45–78% of each open-water study period in Zone 4 and 22–55% of each open-water period in Zone 5 (the upper and lower basins of Gull Lake). In 2021, the fish that remained upstream of the GS spent 39% of the time in Zone 4 and 61% of the time in Zone 5.

In Stephens Lake, fish tended to spend a greater proportion of the open-water period farther downstream from the GS than in previous years. During the construction period, fish spent 49–59% of the time in the zone farther from Gull Rapids/the Keeyask GS (Zone 7). In contrast, fish spent 70% of the open water period in this area in 2021.

## 6.0 SUMMARY AND CONCLUSIONS

- Juveniles (n=40) implanted with acoustic transmitters in 2017 have now been tracked for four years. The original 40 transmitters implanted in 2013 are no longer active. An additional 40 acoustic transmitters were applied in 2021 split equally between the reservoir and Stephens Lake.
- Acoustic telemetry continues to be an effective method for monitoring juvenile Lake Sturgeon movement and habitat use. In the Keeyask Study Area, movement monitoring is generally more effective during the open-water period relative to the winter period. However, forebay impoundment in fall 2020 allowed for an additional six receivers to be set in the reservoir. Juvenile Lake Sturgeon were detected for 66% of the 2021 open-water period and 65% of the 2020/2021 winter period upstream of the GS and 75% of the open-water period and 65% of the winter period in Stephens Lake.
- The key questions, as described in the AEMP, for juvenile Lake Sturgeon movement monitoring during construction and commissioning of the Keeyask GS were as follows:
  - *Will disturbances associated with construction of the Keeyask GS alter coarse-scale movement upstream or downstream of the GS?*

Instream construction activities related to the Keeyask GS concluded prior to open-water 2021. Juvenile Lake Sturgeon movement patterns changed little during the construction period. Upstream of Gull Rapids/the Keeyask GS, fish tended to move little, remaining within distinct portions of Gull Lake. Lake Sturgeon in Stephens Lake have tended to move longer distances on average than those upstream of the GS, but still display small movement ranges relative to the amount of deep-water habitat available. Overall, there were no obvious changes in movement patterns of juvenile Lake Sturgeon upstream and downstream of the GS during the construction period. As construction is now complete, this question is no longer relevant and will not be discussed going forward.

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

During the construction period, tagged juvenile Lake Sturgeon upstream of the Keeyask GS spent little time near the construction site. In contrast Juvenile Lake Sturgeon in Stephens Lake frequently detected near the construction site. These patterns did not change over the course of the construction period. As construction is now complete, this question is no longer relevant and will not be discussed going forward.

- *Will the frequency of long-distance movements by juvenile Lake Sturgeon increase during construction and operation of the Project?*



The number of long-distance downstream movements through the Keeyask GS increased in 2021. Nine fish (47% of all detected fish) moved upstream out of Gull Lake to the riverine portion of the reservoir downstream of Birthday Rapids (one fish had previously displayed this movement). The average total movement range increased from a range of 2.6–5.2 rkm to 19.0 rkm. Further, three fish (16% of all detected) moved downstream through the Keeyask GS into Stephens Lake. Prior to 2021, a single juvenile Lake Sturgeon moved downstream through Gull Rapids/the Keeyask GS since studies began in 2013. All three fish moved downstream between July and August.

No long-distance movements out of Stephens Lake were observed in 2021.

- *Are fish moving downstream past the GS and, if so, is there an indication that they have survived passage?*

Three juvenile Lake Sturgeon moved downstream past the GS in open-water 2021. All three fish displayed both upstream and downstream movements within Stephens Lake, indicating they survived passage. It is unclear if these fish moved through the powerhouse or spillway.

- *Will there be a statistically significant change in the proportional distribution of juvenile Lake Sturgeon following reservoir creation (i.e., will there be a population level shift in distribution patterns following reservoir creation)?*

During the first full open-water period after reservoir impoundment, Lake Sturgeon tagged upstream of the GS tended to spend more time in the lower portion of the reservoir (Zone 5) than in previous years. In Stephens Lake, fish tended to spend a greater proportion of the open-water period farther downstream from the GS than in previous years.

- An additional 40 tags were applied in open water 2021, which will allow these fish to be tracked until 2025. An array of acoustic receivers was deployed at the end of the open-water period in 2021 to continue monitoring movements.

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## **TABLES**

**Table 1: Acoustic-tag and biological information for each juvenile Lake Sturgeon tagged with an acoustic transmitter in the Nelson River upstream of the Keeyask GS, from fall 2017 and 2021.**

Tag ID	Floy tag #	Date Tagged	Expiry Date	Fork Length (mm)	Total Length (mm)	Weight (g)
31683	106469	12-Sep-17	15-Jun-22	505	579	800
31684	106464	09-Sep-17	12-Jun-22	432	501	600
31685	106460	09-Sep-17	12-Jun-22	410	460	550
31686	106456	09-Sep-17	12-Jun-22	504	584	1100
31687	106454	09-Sep-17	12-Jun-22	545	624	1200
31768	109632	14-Sep-17	17-Jun-22	459	532	700
31769	109633	14-Sep-17	17-Jun-22	462	516	600
31770	109636	14-Sep-17	17-Jun-22	442	511	650
31771	109637	14-Sep-17	17-Jun-22	470	541	600
31772	111031	15-Sep-17	18-Jun-22	518	598	1100
31773	109564	12-Sep-17	15-Jun-22	545	616	1000
31774	109565	12-Sep-17	15-Jun-22	481	559	800
31775	109570	13-Sep-17	16-Jun-22	459	519	600
31776	109571	13-Sep-17	16-Jun-22	410	479	400
31777	109626	13-Sep-17	16-Jun-22	578	662	1350
31778	106475	12-Sep-17	15-Jun-22	435	504	800
31779	109552	12-Sep-17	15-Jun-22	490	549	800
31780	109553	12-Sep-17	15-Jun-22	448	494	650
31781	109554	12-Sep-17	15-Jun-22	468	544	850
31782	109563	12-Sep-17	15-Jun-22	448	506	600
48280	121193	19-Sep-21	18-Sep-25	413	471	450
48281	121192	19-Sep-21	18-Sep-25	414	466	500
48286	121284	20-Sep-21	19-Sep-25	510	592	700
48287	121285	20-Sep-21	19-Sep-25	419	481	475
48292	121287	20-Sep-21	19-Sep-25	440	510	550
48293	121286	20-Sep-21	19-Sep-25	449	510	575
48297	121238	18-Sep-21	17-Sep-25	436	485	475
48298	121292	20-Sep-21	19-Sep-25	489	555	900
48299	121294	20-Sep-21	19-Sep-25	474	540	750
48302	121191	19-Sep-21	18-Sep-25	492	551	775
48303	121183	19-Sep-21	18-Sep-25	450	509	500
48304	121298	20-Sep-21	19-Sep-25	466	521	600
48305	121296	20-Sep-21	19-Sep-25	449	505	600
48308	121232	18-Sep-21	17-Sep-25	471	539	650
48309	121239	18-Sep-21	17-Sep-25	467	525	550
48310	121188	19-Sep-21	18-Sep-25	489	545	675
48311	121178	19-Sep-21	18-Sep-25	446	506	500
48315	121231	18-Sep-21	17-Sep-25	497	578	675
48316	121179	19-Sep-21	18-Sep-25	470	529	600
48317	121189	19-Sep-21	18-Sep-25	445	499	600



**Table 2: Acoustic-tag and biological information for each juvenile Lake Sturgeon tagged with an acoustic transmitter in Stephens Lake, fall 2017 and 2021.**

Tag ID	Floy tag #	Date Tagged	Expiry Date	Fork Length (mm)	Total Length (mm)	Weight (g)
31688	110782	16-Sep-17	19-Jun-22	436	498	625
31689	112905	15-Sep-17	18-Jun-22	445	515	625
31690	112914	14-Sep-17	17-Jun-22	433	480	525
31691	112917	14-Sep-17	17-Jun-22	487	554	750
31692	112921	14-Sep-17	17-Jun-22	453	529	400
31693	111065	13-Sep-17	16-Jun-22	494	553	900
31694	112919	14-Sep-17	17-Jun-22	390	445	375
31695	112909	15-Sep-17	18-Jun-22	455	521	650
31696	112901	15-Sep-17	18-Jun-22	440	496	700
31697	110795	16-Sep-17	19-Jun-22	433	500	600
31758	110787	16-Sep-17	19-Jun-22	375	429	425
31759	112915	14-Sep-17	17-Jun-22	445	508	575
31760	112924	14-Sep-17	17-Jun-22	363	398	280
31761	111075	13-Sep-17	16-Jun-22	435	507	500
31762	112903	15-Sep-17	18-Jun-22	434	487	525
31763	112904	15-Sep-17	18-Jun-22	457	520	725
31764	112913	14-Sep-17	17-Jun-22	440	503	500
31765	110788	16-Sep-17	19-Jun-22	505	569	950
31766	112918	14-Sep-17	17-Jun-22	360	400	300
31782	110552	15-Sep-17	18-Jun-22	455	505	675
48276	121392	17-Sep-21	16-Sep-25	525	610	1000
48277	121394	17-Sep-21	16-Sep-25	414	484	450
48278	121398	17-Sep-21	16-Sep-25	465	529	750
48279	121327	17-Sep-21	16-Sep-25	390	446	475
48282	121391	17-Sep-21	16-Sep-25	440	505	750
48283	121395	17-Sep-21	16-Sep-25	405	465	400
48284	121397	17-Sep-21	16-Sep-25	420	486	525
48285	121328	17-Sep-21	16-Sep-25	438	504	525
48288	120054	17-Sep-21	16-Sep-25	416	475	475
48289	118812	17-Sep-21	16-Sep-25	517	592	1000
48290	121399	17-Sep-21	16-Sep-25	456	509	625
48291	121396	17-Sep-21	16-Sep-25	427	485	525
48294	121333	16-Sep-21	15-Sep-25	457	513	525
48295	121331	16-Sep-21	15-Sep-25	496	561	875
48296	117678	16-Sep-21	15-Sep-25	504	577	900
48300	121334	16-Sep-21	15-Sep-25	458	520	720
48301	117682	16-Sep-21	15-Sep-25	431	596	540
48306	121330	16-Sep-21	15-Sep-25	530	617	950
48307	113277	16-Sep-21	15-Sep-25	563	632	1125
48312	121329	16-Sep-21	15-Sep-25	394	456	400

**Table 3: Proportion of time spent in each river zone by juvenile Lake Sturgeon implanted with acoustic transmitters upstream of Gull Rapids (now the Keeyask GS) and in Stephens Lake during a portion of the 2014 (June 4 to October 10), 2015 (June 4 to October 11), 2016 (June 4 to October 19), 2017 (June 7 to October 16), 2018 (June 6 to October 10), 2019 (June 2 to October 7), 2020 (July 3 to September 23), and 2021 (June 13 to October 10) open-water periods.**

Year Tagged	Study Year	Upstream of Gull Rapids/Keeyask GS <sup>1</sup>					Stephens Lake	
		1	2	3	4	5	6	7
2013	2014	0.0	0.0	0.0	63.4	36.6	42.1	57.9
	2015	0.0	0.0	1.9	44.6	53.4	51.0	49.0
	2016	0.0	0.0	0.0	73.2	26.8	46.7	53.2
	2017	0.0	0.0	0.0	77.8	22.2	42.7	57.3
2017	2018	0.0	0.0	0.0	48.8	51.2	46.6	53.4
	2019	0.0	0.0	0.0	44.8	55.2	40.7	59.3
	2020	0.0	0.0	0.0	44.7	55.3	46.5	53.5
	2021	0.0	0.0	0.7	38.5	60.7	30.4	69.6

1. Beginning in 2019, Gull Rapids is referred to as the Keeyask GS, and since impoundment in 2020, the area is referred to as the Keeyask reservoir.

**Table 4: Movement range (km) of juvenile Lake Sturgeon implanted with acoustic transmitters, including standard deviation (StDev), minimum (Min), and maximum (Max) distance upstream of Gull Rapids (now the Keeyask GS) and in Stephens Lake during the 2014–2021 open-water periods.**

Year Tagged	Study Year	Upstream of Gull Rapids/Keeyask GS <sup>1</sup>					Stephens Lake				
		n <sup>2</sup>	Avg	StDev	Min	Max	n	Avg	StDev	Min	Max
<b>2013</b>	2014	20	4.1	2.9	0.0	10	18	11.1	5.4	2.6	19.7
	2015	19	5.1	4.5	0.3	17.5	18	11.2	5.9	0.0	19.7
	2016	19	5.2	3.9	0.0	13.7	17	11.6	6.6	0.0	22.3
	2017	18	3.4	3.3	0.3	10.0	13	11.7	4.4	6.5	17.4
<b>2017</b>	2018	20	4.1	3.5	0.3	12.1	14	12.0	5.7	1.2	23.5
	2019	16	2.6	2.4	0.0	8.1	13	9.6	4.1	0.0	15.9
	2020	17	4.1	2.9	0.4	11.2	12	9.3	4.1	0.0	17.6
	2021	19	19.0	9.2	0.0	33.8	12	12.1	5.8	0.0	24.1

1. Beginning in 2019, Gull Rapids is referred to as the Keeyask GS.
2. Number of fish detected.

**Table 5: Number of detections (n), number of days detected, farthest upstream (U/S) and downstream (D/S) river kilometer (rkm) detection sites, and detection range for each of 20 juvenile Lake Sturgeon implanted with acoustic transmitters and monitored upstream of the Keeyask GS during the 2017/2018 (October 17, 2017 to April 30, 2018), 2018/2019 (October 11, 2018 to April 30, 2019), 2019/2020 (October 8, 2019 to April 30, 2020), and 2020/2021 (September 24, 2020 to April 30, 2021) winter periods. Tag ID highlighted purple = moved downstream through Keeyask GS.**

Tag ID	Date tagged	2017/2018					2018/2019					2019/2020					2020/2021				
		n	# Days	Farthest U/S (rkm)	Farthest D/S (rkm)	Range (rkm)	n	# Days	Farthest U/S (rkm)	Farthest D/S (rkm)	Range (rkm)	n	# Days	Farthest U/S (rkm)	Farthest D/S (rkm)	Range (rkm)	n	# Days	Farthest U/S (rkm)	Farthest D/S (rkm)	Range (rkm)
31683	12-Sep-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1021	94	-7.9	-7.9	0.0
31684	9-Sep-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31685	9-Sep-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31686	9-Sep-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6162	43	-12.9	-7.9	5.0
31687	9-Sep-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10789	128	-17.4	-10.1	7.3
31768	14-Sep-17	5506	35	-12.4	-10.3	2.1	2	1	-12.4	-12.4	0.0	4882	35	-10.3	-10.3	0.0	39654	201	-12.4	-7.9	4.5
31769	14-Sep-17	37229	117	-10.3	-10.3	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31770	14-Sep-17	7414	54	-12.4	-10.3	2.1	17898	76	-12.4	-12.4	0.0	-	-	-	-	-	18725	206	-12.9	-12.4	0.5
31771	14-Sep-17	14272	61	-12.4	-10.3	2.1	33	12	-12.4	-12.4	0.0	3357	38	-10.3	-10.3	0.0	247	12	-12.4	-10.1	2.3
31772	15-Sep-17	34442	111	-10.3	-10.3	0.0	-	-	-	-	-	42031	149	-10.3	-10.3	0.0	36405	156	-12.9	-10.1	2.8
31773	12-Sep-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5095	154	-12.4	-10.1	2.3
31774	12-Sep-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	3	-10.1	-10.1	0.0
31775	13-Sep-17	1045	29	-12.4	-12.4	0.0	17883	97	-12.4	-12.4	0.0	74	10	-10.3	-10.3	0.0	23015	199	-12.4	-10.1	2.3
31776	13-Sep-17	108	22	-12.4	-10.3	2.1	-	-	-	-	-	20667	104	-10.3	-10.3	0.0	46555	213	-7.9	-7.9	0.0
31777	13-Sep-17	30754	98	-10.3	-10.3	0.0	-	-	-	-	-	4336	53	-10.3	-10.3	0.0	14328	151	-12.4	-10.1	2.3
31778	12-Sep-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31779	12-Sep-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	45391	216	-7.9	-7.9	0.0
31780	12-Sep-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	46997	212	-7.9	-7.9	0.0
31781	12-Sep-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31782	12-Sep-17	-	-	-	-	-	-	-	-	-	-	17203	114	-10.3	-10.3	0.0	5968	147	-12.9	-10.1	2.8

**Table 1: Number of detections (n), number of days detected, farthest upstream (U/S) and downstream (D/S) river kilometer (rkm) detection sites, and detection range for each of 20 juvenile Lake Sturgeon implanted with acoustic transmitters and monitored in Stephens Lake during the 2017/2018 (October 17, 2017 to April 30, 2018), 2018/2019 (October 11, 2018 to April 30, 2019), 2019/2020 (October 8, 2019 to April 30, 2020), and 2020/2021 (September 24, 2020 to April 30, 2021) winter periods. Tag ID highlighted yellow = lost tags. Tag ID highlighted red = moved downstream through Kettle GS.**

Tag ID	Date tagged	2017/2018					2018/2019					2019/2020					2020/2021				
		n	# Days	Farthest U/S (rkm)	Farthest D/S (rkm)	Range (rkm)	n	# Days	Farthest U/S (rkm)	Farthest D/S (rkm)	Range (rkm)	n	# Days	Farthest U/S (rkm)	Farthest D/S (rkm)	Range (rkm)	n	# Days	Farthest U/S (rkm)	Farthest D/S (rkm)	Range (rkm)
31688	16-Sep-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31689	15-Sep-17	1301	12	6.5	21.6	15.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31690	14-Sep-17	1303	6	6.5	24.7	18.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31691	14-Sep-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31692	14-Sep-17	9	3	7.9	7.9	0.0	1338	29	5.8	36.1	30.3	-	-	-	-	-	-	-	-	-	-
31693	13-Sep-17	1726	30	5.2	24.7	19.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31694	14-Sep-17	-	-	-	-	-	51477	165	5.2	10.3	5.1	5278	82	5.2	7.9	2.7	39657	164	7.8	10.2	2.4
31695	15-Sep-17	7	2	7.9	7.9	0.0	5887	78	5.8	8.4	2.6	29347	163	5.2	10.3	5.1	18559	80	3.9	5.9	2.0
31696	15-Sep-17	25955	133	5.2	7.9	2.7	-	-	-	-	-	33261	130	5.2	9.4	4.2	17029	72	3.9	5.9	2.0
31697	16-Sep-17	65106	187	5.2	9.4	4.2	9831	99	5.8	13	7.2	1248	29	5.8	5.8	0.0	66054	219	3.9	7.8	3.9
31758	16-Sep-17	35901	171	13.9	13.9	0.0	1260	40	10.6	13.9	3.3	62576	189	7.9	13.9	6.0	63903	205	3.9	13.4	9.5
31759	14-Sep-17	7747	100	5.2	10.3	5.1	16397	130	5.2	7.9	2.7	26340	190	5.2	7.9	2.7	19791	106	3.9	7.8	3.9
31760	14-Sep-17	-	-	-	-	-	101	8	16.8	16.8	0.0	5791	91	5.2	10.3	5.1	26595	198	3.9	10.2	6.3
31761	13-Sep-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31762	15-Sep-17	3135	70	5.2	16.8	11.6	29754	140	5.2	10.3	5.1	9616	59	5.2	36.1	30.9	-	-	-	-	-
31763	15-Sep-17	2604	24	5.2	5.2	0.0	32	2	5.2	5.2	0.0	-	-	-	-	-	16798	114	3.9	4.9	1.0
31764	14-Sep-17	3526	32	5.2	24.7	19.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31765	16-Sep-17	-	-	-	-	-	53	5	5.8	5.8	0.0	71	10	5.2	5.8	0.6	29008	185	3.9	7.8	3.9
31766	14-Sep-17	22	1	5.2	5.2	0.0	15271	88	5.2	13.9	8.7	35373	131	5.2	13.9	8.7	3657	48	13.4	13.4	0.0
31767	15-Sep-17	-	-	-	-	-	-	-	-	-	-	479	28	5.2	5.8	0.6	35733	175	5.4	10.2	4.8



**Table 2: Number of detections (n), number of days detected, farthest upstream (U/S) and downstream (D/S) river kilometer (rkm) detection sites, and detection range for each of 20 juvenile Lake Sturgeon tagged and monitored upstream of Keeyask GS during the open-water 2017 (May 1 to October 16), 2018 (May 1 to October 10), 2019 (May 1 to October 7), 2020 (1 May to September 23), and 2021 (1 May to October 10) periods. Tag id highlighted purple = moved downstream through Gull Rapids/the Keeyask GS.**

Tag ID	Date tagged	2017			2018			2019			2020			2021				
		n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Farthest U/S (rkm)	Farthest D/S (rkm)	Range (rkm)
31683	12-Sep-17	4718	33	1.9	31943	133	0.3	40792	136	0.3	11757	79	2.7	22634	137	-24.2	-3.8	20.4
31684	9-Sep-17	5706	34	1.9	36007	109	5.1	28126	125	0.3	540	5	2.1	8079	106	-24.2	-3.8	20.4
31685	9-Sep-17	12846	35	1.9	4022	38	0.9	-	-	-	-	-	-	22618	102	-7.7	10.2	17.9
31686	9-Sep-17	9918	34	0.3	40702	107	0.9	38228	128	0.0	4237	63	1.0	5698	97	-26.4	-3.8	22.6
31687	9-Sep-17	9880	32	0.3	10221	49	3.5	-	-	-	3429	47	8.7	13063	71	-15.0	18.8	33.8
31768	14-Sep-17	1050	14	0.2	27068	130	7.5	31550	120	7.5	14996	70	7.5	7543	122	-32.2	-3.8	28.4
31769	14-Sep-17	18816	28	0.6	16493	34	0.4	-	-	-	-	-	-	5	2	-7.7	-7.7	0.0
31770	14-Sep-17	17899	31	0.6	5455	87	7.5	4929	58	3.0	1566	56	5.1	8734	109	-24.2	-2.5	21.7
31771	14-Sep-17	13740	31	0.6	78420	141	0.4	36862	115	2.6	13940	69	2.6	7339	90	-19.5	-3.8	15.7
31772	15-Sep-17	9198	30	0.6	78858	137	5.1	67609	140	2.6	48333	87	0.4	30382	131	-29.3	-3.8	25.5
31773	12-Sep-17	5954	32	1.9	24849	108	12.1	16674	114	1.9	12206	74	11.2	33172	121	-33.9	-2.2	31.7
31774	12-Sep-17	8289	33	1.6	42167	134	1.9	22305	106	1.9	4290	34	2.1	23830	126	-12.4	-3.8	8.6
31775	13-Sep-17	8804	17	0.6	2681	27	7.5	2859	62	5.1	12963	97	3.0	12035	92	-29.3	-2.2	27.1
31776	13-Sep-17	14995	31	0.6	49473	131	5.1	29508	105	8.1	19917	79	2.7	23080	149	-8.9	-6.2	2.7
31777	13-Sep-17	18412	31	0.6	29917	98	3.0	39441	131	0.9	13228	53	7.1	25968	143	-19.5	-3.8	15.7
31778	12-Sep-17	12574	33	0.3	42749	119	10.0	566	3	18.4	-	-	-	-	-	-	-	-
31779	12-Sep-17	11059	33	1.9	47302	133	1.9	47534	135	0.3	18722	77	2.7	23433	158	-24.2	-3.8	20.4
31780	12-Sep-17	5304	30	1.6	33306	132	1.9	38052	137	1.9	11764	77	2.7	15513	135	-10.1	13.4	23.5
31781	12-Sep-17	10304	33	1.9	173	13	1.0	5945	43	0.3	3483	46	5.1	1383	17	-9.9	-2.2	7.7
31782	12-Sep-17	13002	33	0.3	42404	119	5.5	44580	126	2.6	15995	78	3.0	14188	121	-19.4	-2.5	16.9

**Table 3: Number of detections (n), number of days detected, farthest upstream (U/S) and downstream (D/S) river kilometer (rkm) detection sites, and detection range for each of 20 juvenile Lake Sturgeon tagged and monitored in Stephens Lake during the open-water 2017 (May 1 to October 16), 2018 (May 1 to October 10), 2019 (May 1 to October 7), 2020 (May 1 to September 23), and 2021 (May 1 to October 10) periods. Tag ID highlighted yellow = lost tags. Tag ID highlighted red = moved downstream through Kettle GS.**

Tag ID	Date tagged	2017			2018			2019			2020			2021				
		n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Farthest U/S (rkm)	Farthest D/S (rkm)	Range (rkm)
31688	28-May-16	30	1	5.2	27068	74	1.5	27193	117	0.0	23635	81	0.0	9	1	1.2	1.2	0.0
31689	28-May-16	30	1	12.7	-	-	-	-	-	-	-	-	-	121	3	65.3	65.3	0.0
31690	27-May-16	32	1	6.7	-	-	-	-	-	-	4524	33	0.0	-	-	-	-	-
31691	27-May-16	7	0	38.6	-	-	-	-	-	-	709	23	0.0	-	-	-	-	-
31692	28-May-16	32	1	12.7	17702	100	17.4	-	-	-	22	8	0.0	-	-	-	-	-
31693	28-May-16	33	1	5.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31694	28-May-16	32	1	5.6	13155	81	15.9	15913	124	12.2	1688	33	8.7	11768	125	4.6	18.8	14.2
31695	28-May-16	31	1	5.2	47506	123	6.7	52297	140	6.7	11028	77	9.5	21009	115	1.2	13.4	12.2
31696	28-May-16	31	1	12.7	43099	154	9.1	43128	127	9.1	11844	114	9.1	36691	125	0.8	13.4	12.6
31697	28-May-16	30	1	6.5	97400	153	9.1	22941	130	10.3	15485	98	12.2	27834	143	1.0	10.2	9.2
31758	30-May-16	28	1	10.1	18719	141	12.7	30068	119	11.2	13830	101	9.1	22387	153	3.9	13.4	9.5
31759	30-May-16	32	1	7.6	37102	126	17.4	29872	137	11.2	17055	116	17.6	17005	107	0.8	24.9	24.1
31760	30-May-16	17	1	2.6	25510	119	17.4	17664	117	14.7	13837	115	7.6	31426	147	2.7	13.4	10.7
31761	30-May-16	6	0	36.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31762	29-May-16	30	1	5.6	39066	154	10.1	50261	142	6.4	15989	40	1.3	-	-	-	-	-
31763	31-May-16	31	1	9.1	25869	130	9.1	32315	131	9.1	7019	90	6.0	20453	139	0.8	10.2	9.4
31764	31-May-16	32	1	6.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31765	31-May-16	30	1	6.7	35362	125	9.1	26941	101	9.1	11978	79	9.1	29700	155	0.8	18.8	18.0
31766	30-May-16	31	1	4.6	16440	104	23.5	13002	104	15.9	14695	105	12.2	12619	126	2.7	13.4	10.7
31767	30-May-16	24	1	3.2	30261	123	9.1	22366	124	12.7	3782	53	10.7	11098	125	3.9	18.8	14.9

**Table 9: Number and proportion of tagged juvenile Lake Sturgeon that have moved downstream through Gull Rapids (now the Keeyask GS) and the Kettle GS each year since studies began in 2013. The total number of movements, the proportion of movements suspected to have occurred due to tagging stress or mortality (*i.e.*, within two weeks of tagging), and the adjusted number of movements (*i.e.*, total movements minus movements due to stress) are provided. Grey highlighting indicates movements that occurred prior to the onset of construction.**

Year	Gull Rapids/Keeyask GS									Kettle GS								
	Total Movements <sup>1</sup>			Tagging Stress/Mortality <sup>2</sup>			Adjusted Movements <sup>3</sup>			Total Movements			Tagging Stress/mortality			Adjusted Movements		
	Total Fish	Total Move	% <sup>3</sup>	# Fish Tagged	Total Move	% <sup>4</sup>	Total Fish	Total Move	%	Total Fish <sup>6</sup>	Total Move	%	# Fish Tagged	Total Move	%	Total Fish	Total Move	%
2013	20	0	0	20	0	0	20	0	0	20	0	0	20	0	0	20	0	0
2014	19	0	0	0	-	-	19	0	0	19	1	5	0	-	-	19	1	5
2015	19	0	0	0	-	-	19	0	0	18	0	0	0	-	-	18	0	0
2016	19	0	0	0	-	-	19	0	0	18	1	6	0	-	-	18	1	6
2017	19	0	0	20	0	0	19	0	0	37	4	11	20	1	5	37	3	8
2018	20	0	0	0	-	-	20	0	0	15	0	0	0	-	-	15	0	0
2019	20	1	5	0	-	-	20	1	5	15	1	7	0	-	-	15	1	2
2020	19	0	0	0	-	-	19	0	0	13	1	8	0	-	-	13	1	8
2021	19	3	16	20	0	0	19	3	16	13	0	0	20	0	-	13	0	0

1. Includes all downstream movements, including those that are interpreted to have occurred due to tagging stress and mortality.
2. Includes only juvenile Lake Sturgeon that moved downstream within two weeks of tagging. These movements are likely caused by tagging stress or mortality
3. Does not include fish interpreted to have moved downstream due to tagging stress or mortality.
4. Proportion is calculated as a percentage of the total number of fish available for detection in the current year.
5. Proportion is calculated as a percentage of those tagged in the current year.
6. Includes all fish tagged in Stephens Lake as well as those that moved downstream from Gull Lake.

**Table 10: Number of detections (n), number of days detected, farthest upstream (U/S) and downstream (D/S) river kilometer (rkm) detection sites, and detection range for each of 20 juvenile Lake Sturgeon tagged and monitored upstream of Keeyask GS during the 2021 (1 May to October 10) open-water period.**

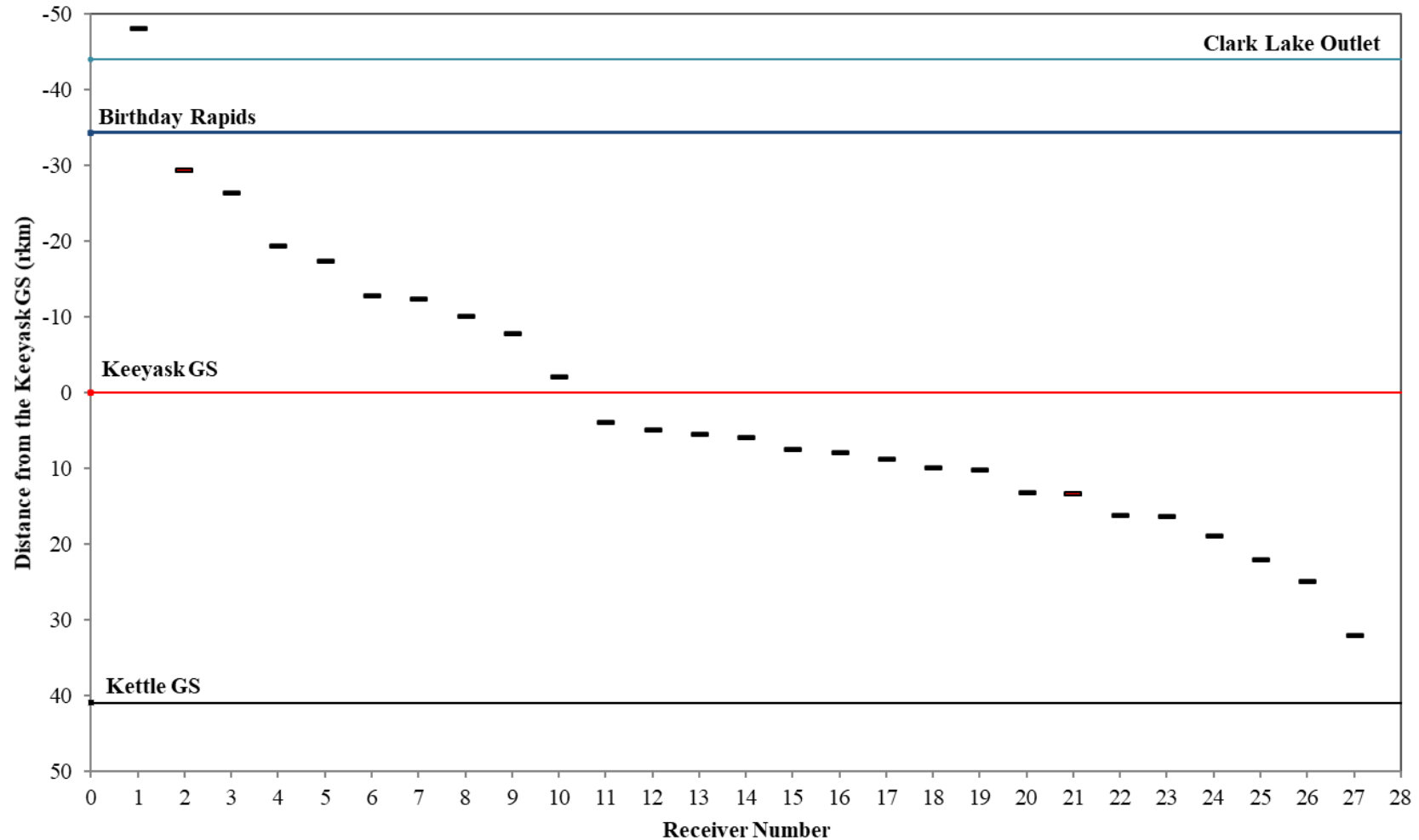
Tag ID	Date Tagged	# Potential Detection Days	n	# Days	U/S (rkm)	D/S (rkm)	Range (rkm)
48280	19-Sep-21	21	3023	14	-10.1	-9.9	0.2
48281	19-Sep-21	21	2842	17	-15.0	-7.7	7.3
48286	20-Sep-21	20	3521	13	-15.0	-9.9	5.1
48287	20-Sep-21	20	2797	13	-17.4	-12.5	4.9
48292	20-Sep-21	20	110	4	-17.4	-15.0	2.4
48293	20-Sep-21	20	1158	16	-15.0	-9.9	5.1
48297	18-Sep-21	22	2685	19	-8.9	-6.2	2.7
48298	20-Sep-21	20	3519	17	-5.8	-3.8	2.0
48299	20-Sep-21	20	2228	18	-8.9	-3.8	5.1
48302	19-Sep-21	21	100	9	-9.9	-7.7	2.2
48303	19-Sep-21	21	460	9	-26.4	-24.2	2.2
48304	20-Sep-21	20	5283	18	-5.8	-3.8	2.0
48305	20-Sep-21	20	2087	17	-6.2	-3.8	2.4
48308	18-Sep-21	22	1455	14	-8.9	-7.9	1
48309	18-Sep-21	22	486	13	-10.1	-7.7	2.4
48310	19-Sep-21	21	314	11	-24.2	-24.2	0.0
48311	19-Sep-21	21	257	12	-24.2	-24.2	0.0
48315	18-Sep-21	22	2281	20	-10.1	-2.2	7.9
48316	19-Sep-21	21	560	13	-24.2	-24.2	0.0
48317	19-Sep-21	21	123	7	-24.2	-24.2	0.0

**Table 11: Number of detections (n), number of days detected, farthest upstream (U/S) and downstream (D/S) river kilometer (rkm) detection sites, and detection range for each of 20 juvenile Lake Sturgeon tagged and monitored in Stephens Lake during the 2021 (1 May to October 10) open-water period.**

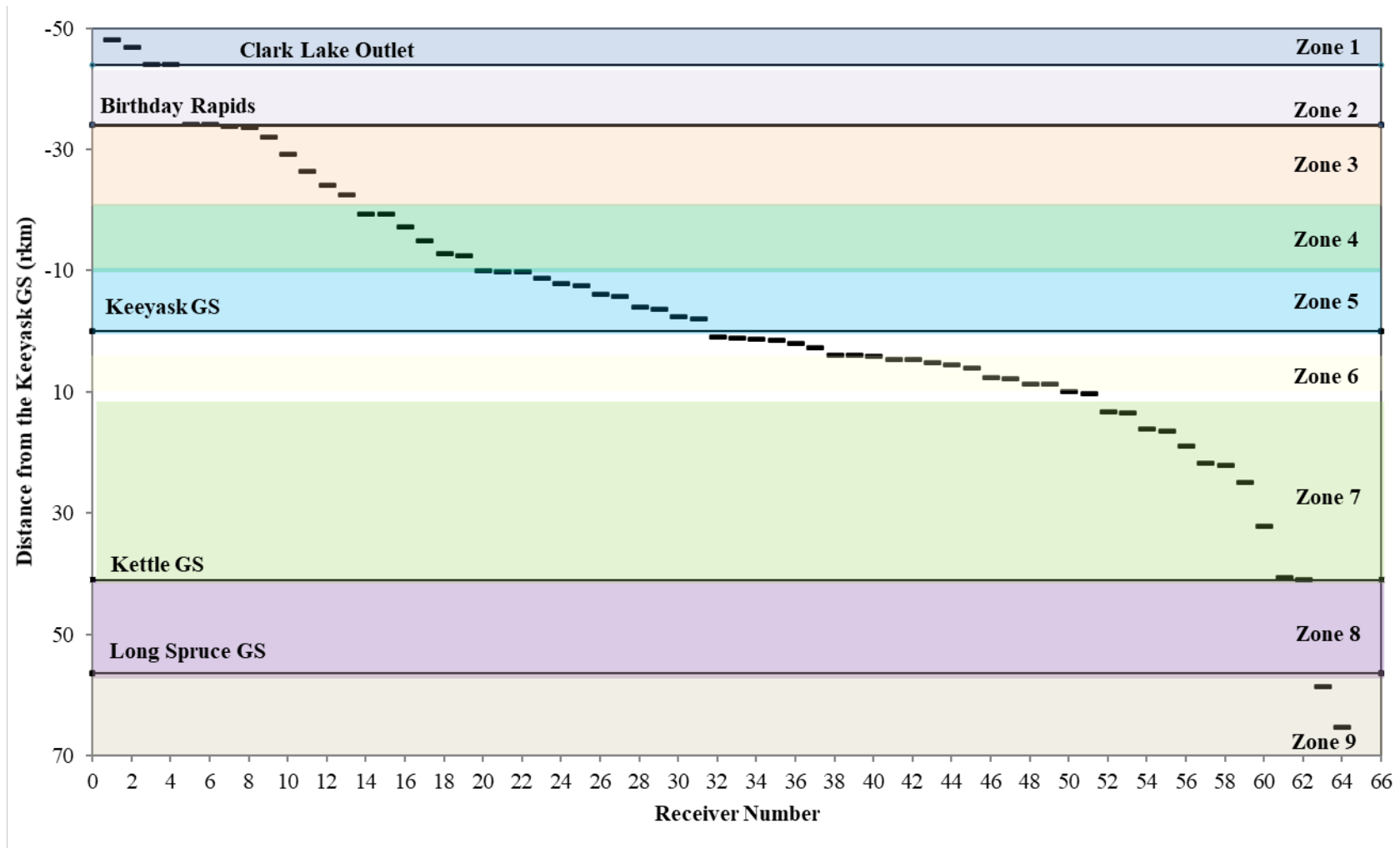
Tag ID	Date Tagged	# Potential Detection Days	n	# Detection Days	U/S (rkm)	D/S (rkm)	Range (rkm)
48276	17-Sep-21	23	267	15	1.3	3.8	2.5
48277	17-Sep-21	23	1013	21	0.8	1.3	0.5
48278	17-Sep-21	23	6553	15	3.9	10.2	6.3
48279	17-Sep-21	23	1701	14	3.9	18.8	14.9
48282	17-Sep-21	23	6244	16	3.8	10.2	6.4
48283	17-Sep-21	23	5464	15	1.3	7.8	6.5
48284	17-Sep-21	23	2685	15	4.1	8.7	4.6
48285	17-Sep-21	23	1568	19	1.2	4.6	3.4
48288	17-Sep-21	23	719	19	0.8	2.7	1.9
48289	17-Sep-21	23	3715	15	3.9	13.4	9.5
48290	17-Sep-21	23	2641	15	3.9	13.4	9.5
48291	17-Sep-21	23	3269	16	1.2	10.2	9.0
48294	16-Sep-21	24	4304	14	3.8	32	28.2
48295	16-Sep-21	24	4148	14	1	8.7	7.7
48296	16-Sep-21	24	4470	17	0.8	10.2	9.4
48300	16-Sep-21	24	1834	11	1.3	32	30.7
48301	16-Sep-21	24	2714	15	0.8	16.3	15.5
48306	16-Sep-21	24	3716	16	0.8	8.7	7.9
48307	16-Sep-21	24	4019	18	0.8	18.8	18.0
48312	16-Sep-21	24	5851	20	0.8	8.7	7.9

## FIGURES

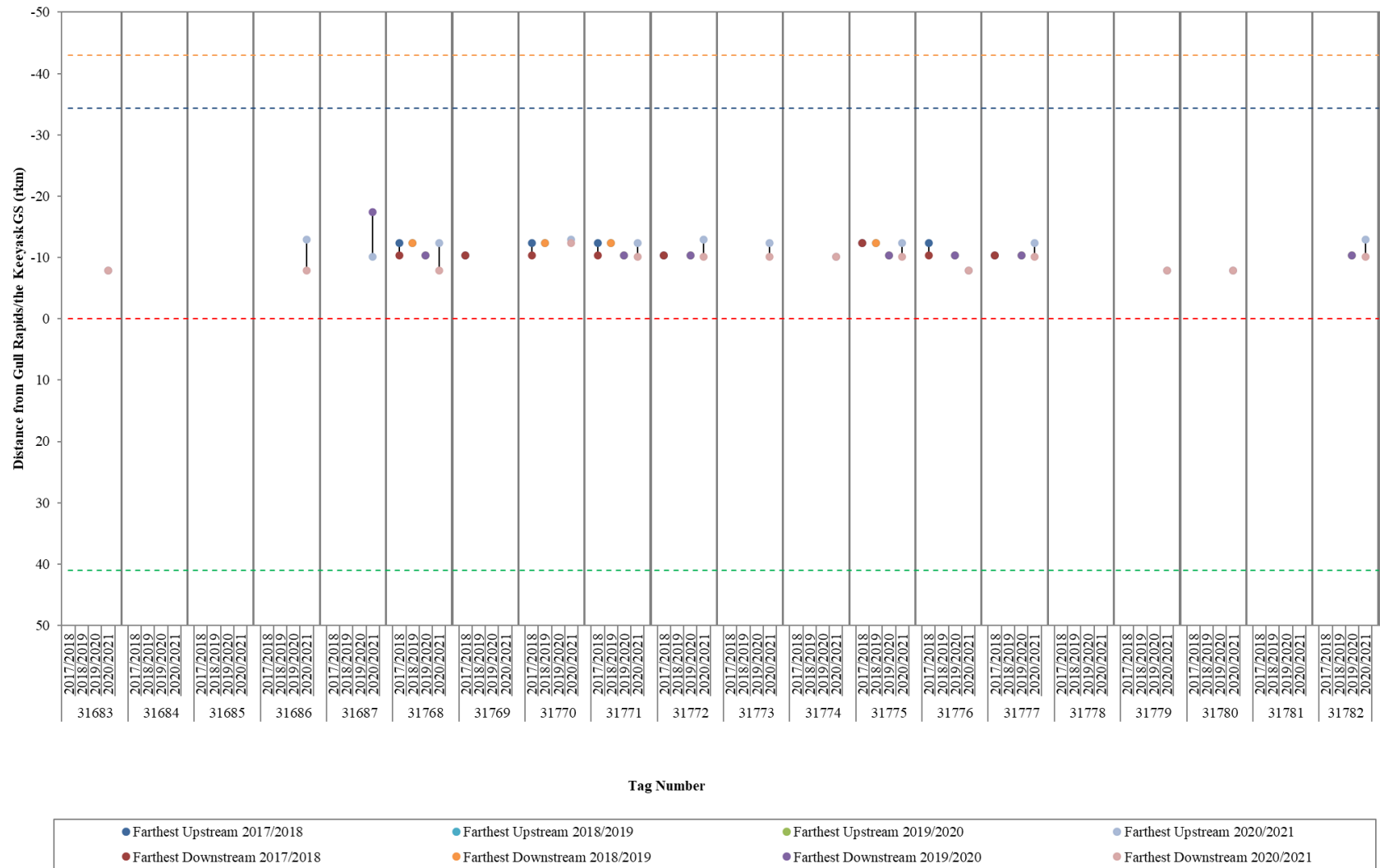




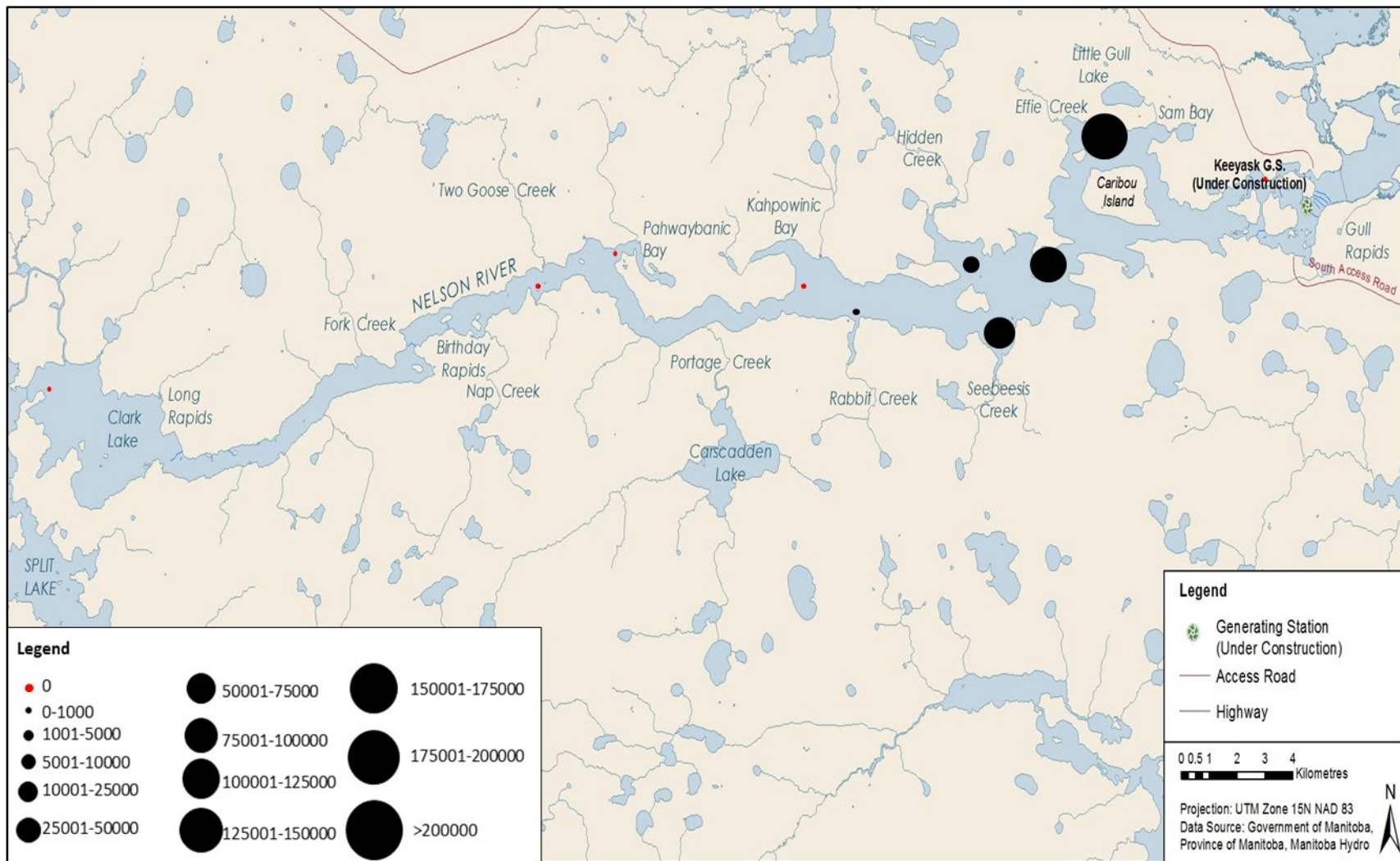
**Figure 1:** Locations of stationary acoustic receivers (dashes) in relation to the base of the Keeyask GS (rkm 0) and other major landmarks (lines) in the Nelson River between Clark Lake and the Kettle GS between October 2019 and May 2021.



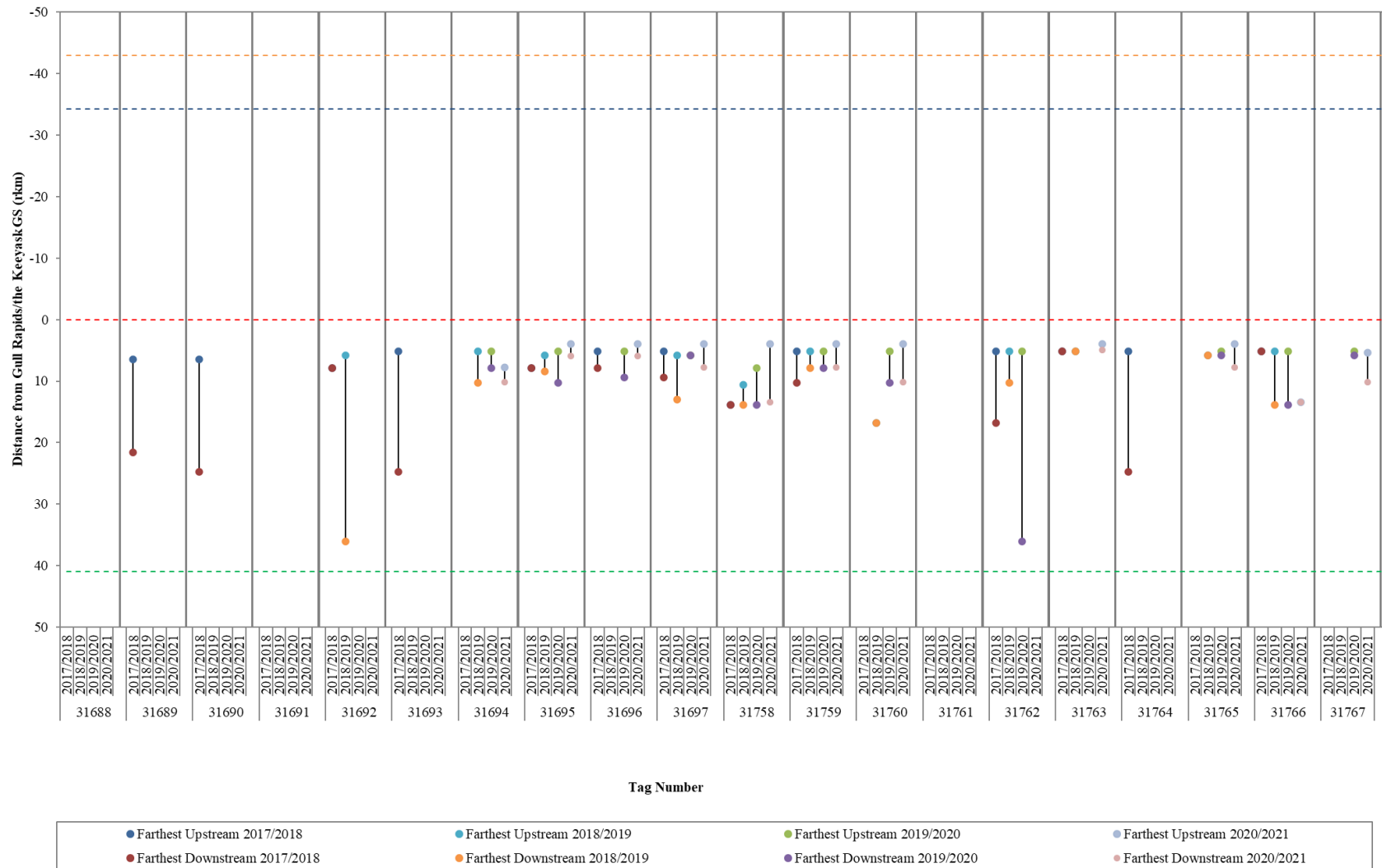
**Figure 2:** Locations of stationary acoustic receivers (dashes) in relation to the base of the Keeyask GS (rkm 0) and other major landmarks (lines) in the Nelson River between Clark Lake (Zone 1) and the Limestone GS (Zone 9) between May and October 2021. River zones are indicated by different colours.



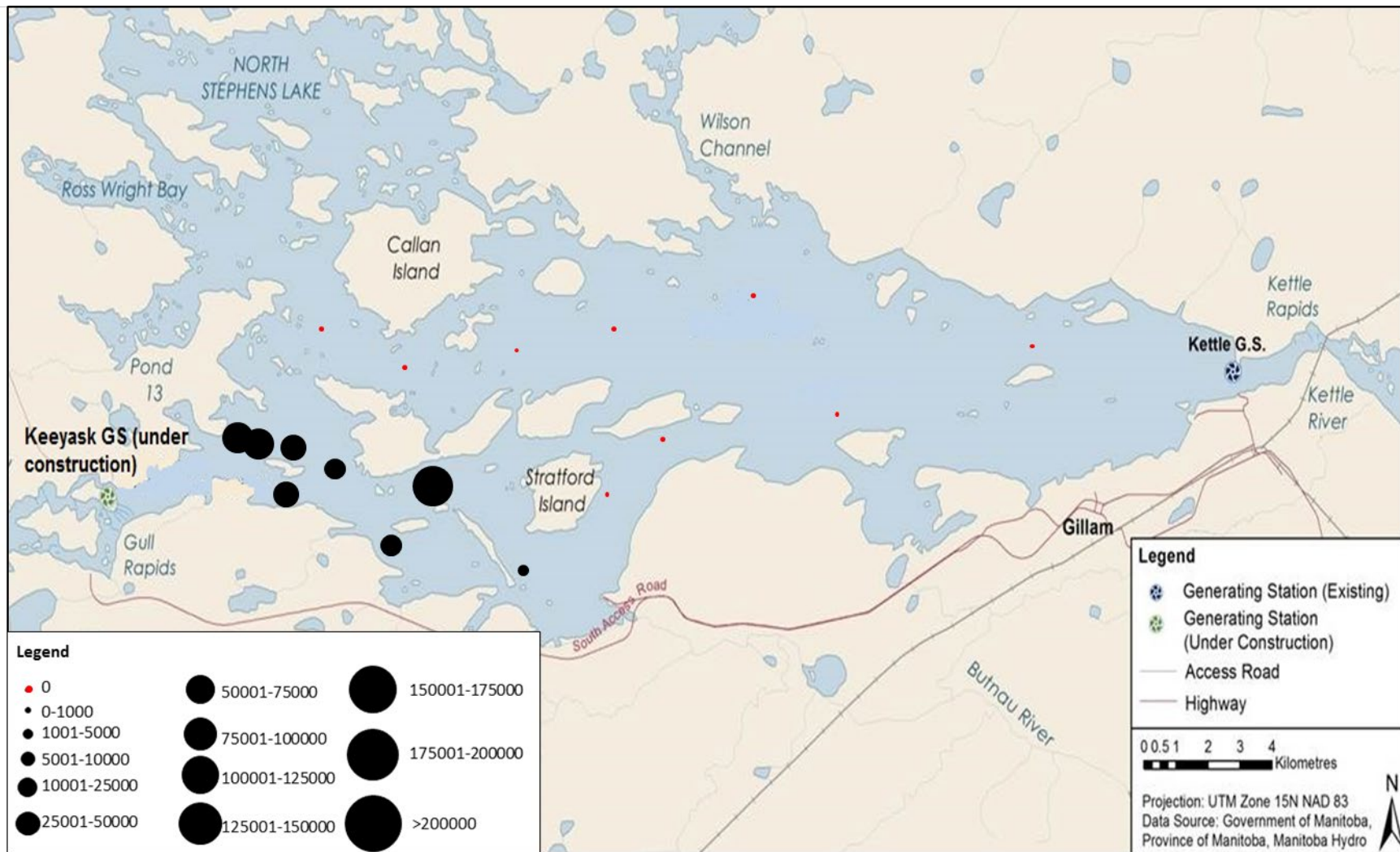
**Figure 3: Detection ranges for acoustic tagged juvenile Lake Sturgeon detected between Clark Lake and the Keeyask GS during the winter period (2017–2021). Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = the Keeyask GS; green = Kettle GS).**



**Figure 4:** Relative number of detections at each acoustic receiver set between Clark Lake and the Keeyask GS during winter 2020/2021 (September 24, 2020 to April 30, 2021). Number of detections indicated by size of bubble (defined in legend). Receivers with no detections indicated with red dot.

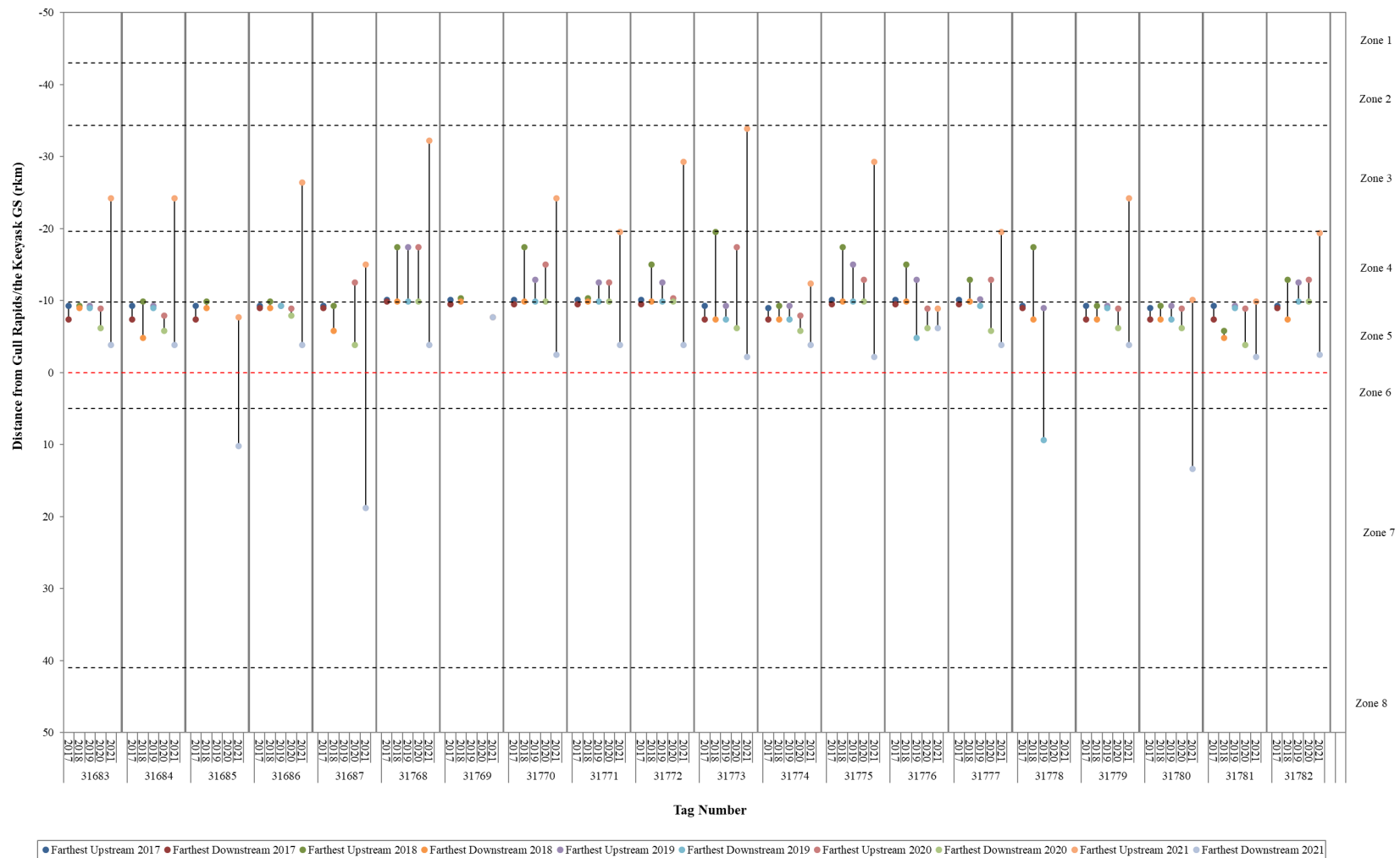


**Figure 5: Detection ranges for acoustic tagged juvenile Lake Sturgeon detected in Stephens Lake during the winter period (2017–2021). Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = the Keeyask GS; green = Kettle GS).**

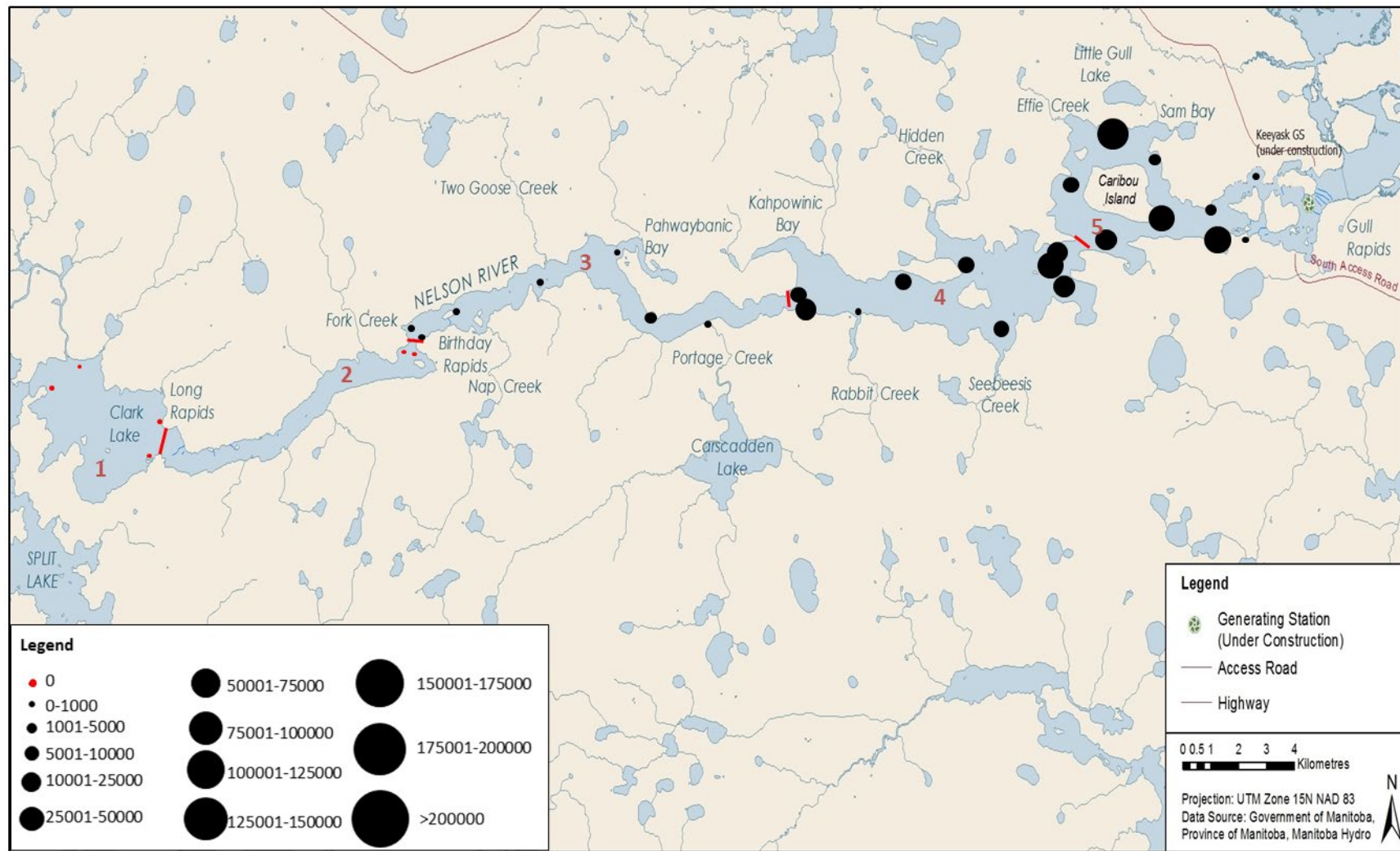


**Figure 6:** Relative number of detections at each acoustic receiver set in Stephens Lake during winter 2020/2021 (September 24, 2020 to April 30, 2021). Number of detections indicated by size of bubble (defined in legend). Receivers with no detections indicated with red dot.

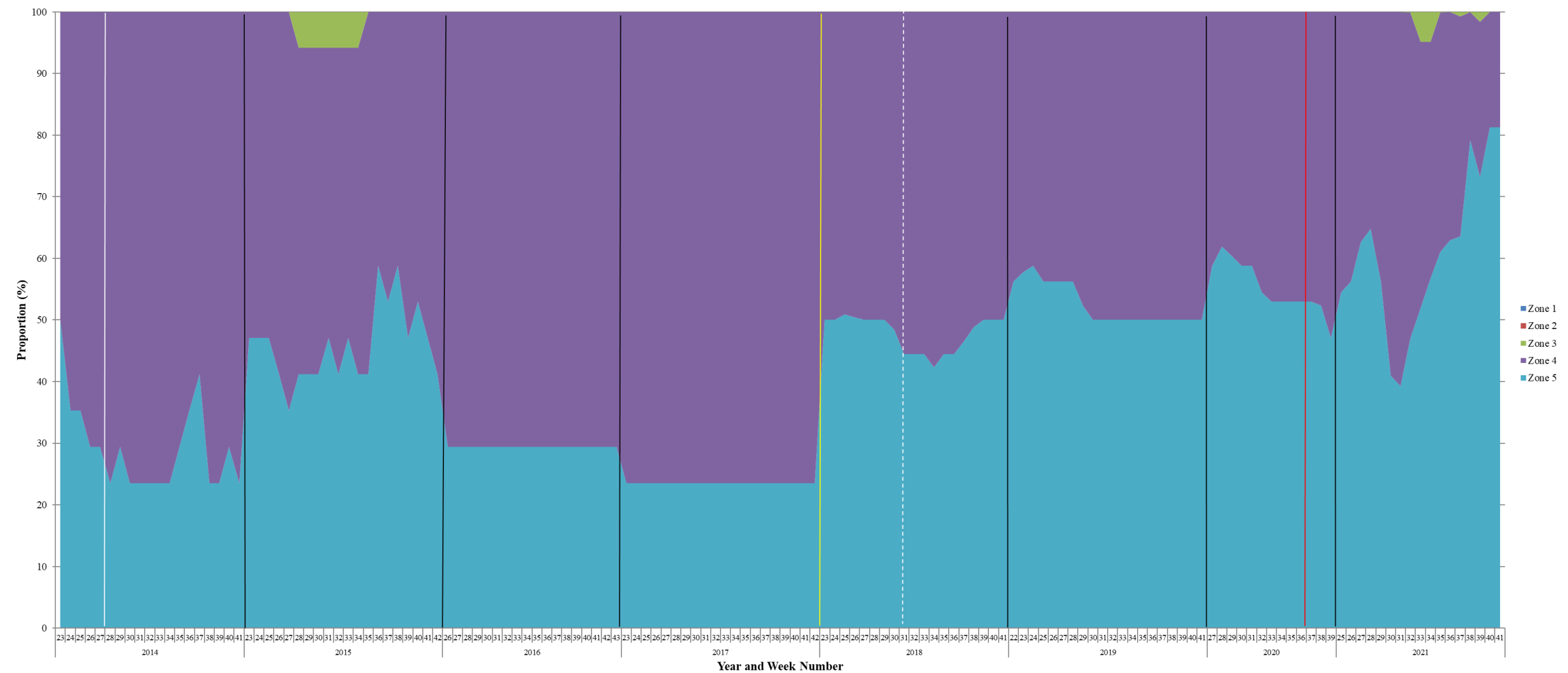




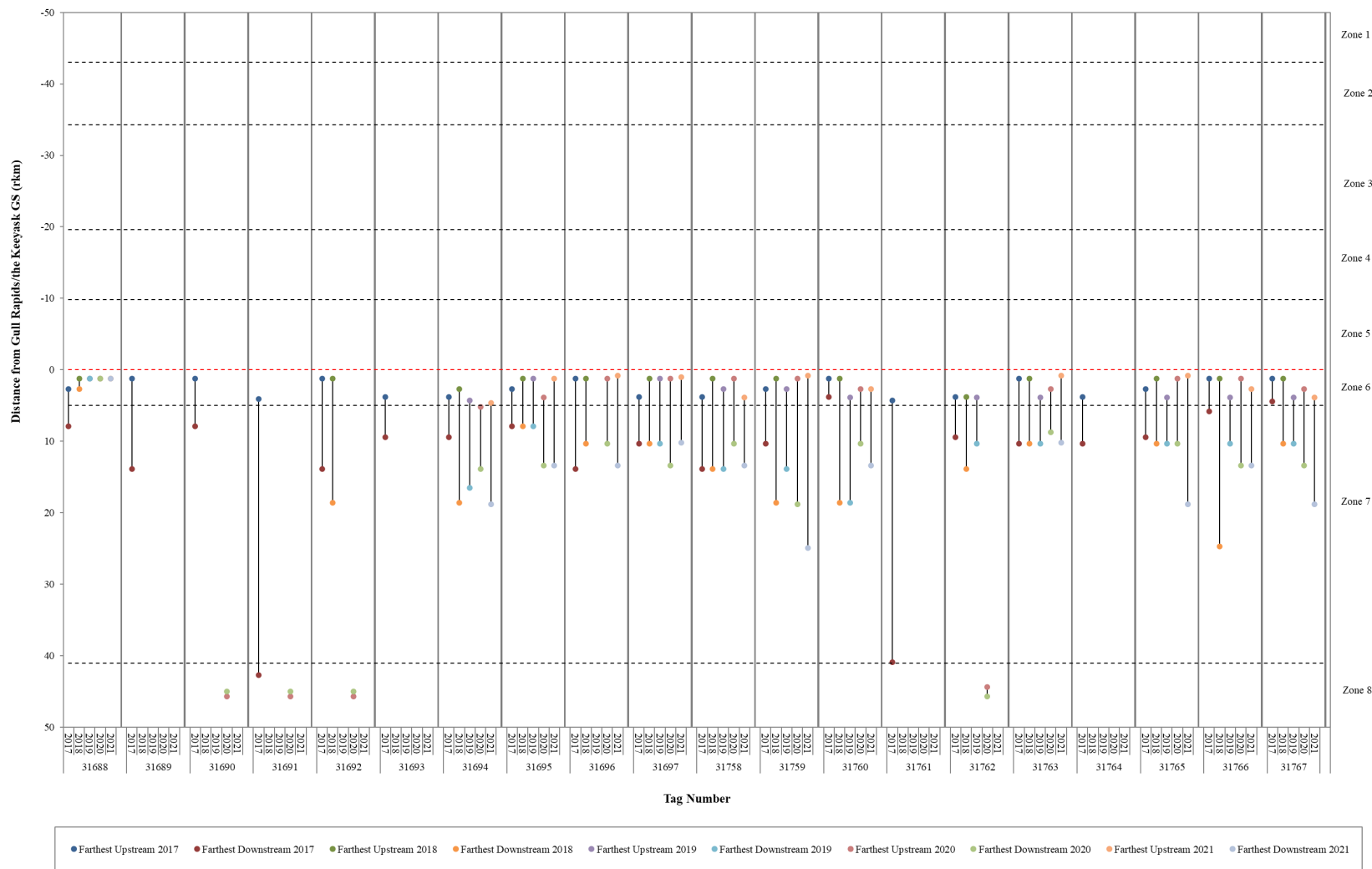
**Figure 7: Detection ranges for individual juvenile Lake Sturgeon tagged with acoustic transmitters upstream of Gull Rapids/the Keyyask GS during the open-water period (2017–2021). Horizontal dotted lines demarcate zones with the red line representing the Keyyask GS.**



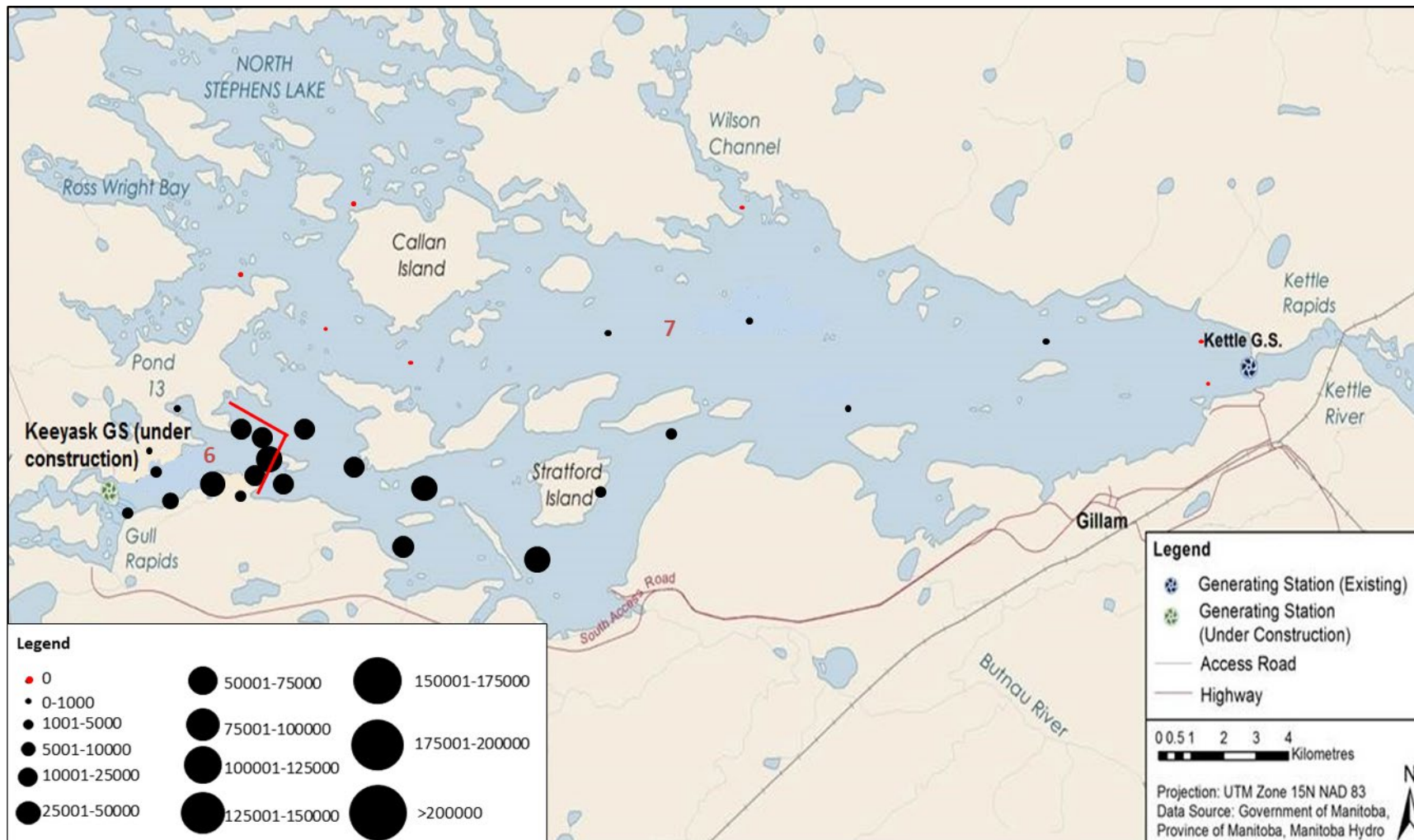
**Figure 8:** Relative number of detections at each acoustic receiver set in the Nelson River between Clark Lake and the Keeyask GS during the 2021 open-water period (May 1 to October 10). Number of detections indicated by size of bubble (defined in legend). Receivers with no detections indicated with red dot. The river is divided into five "zones" based on placement of receiver "gates."



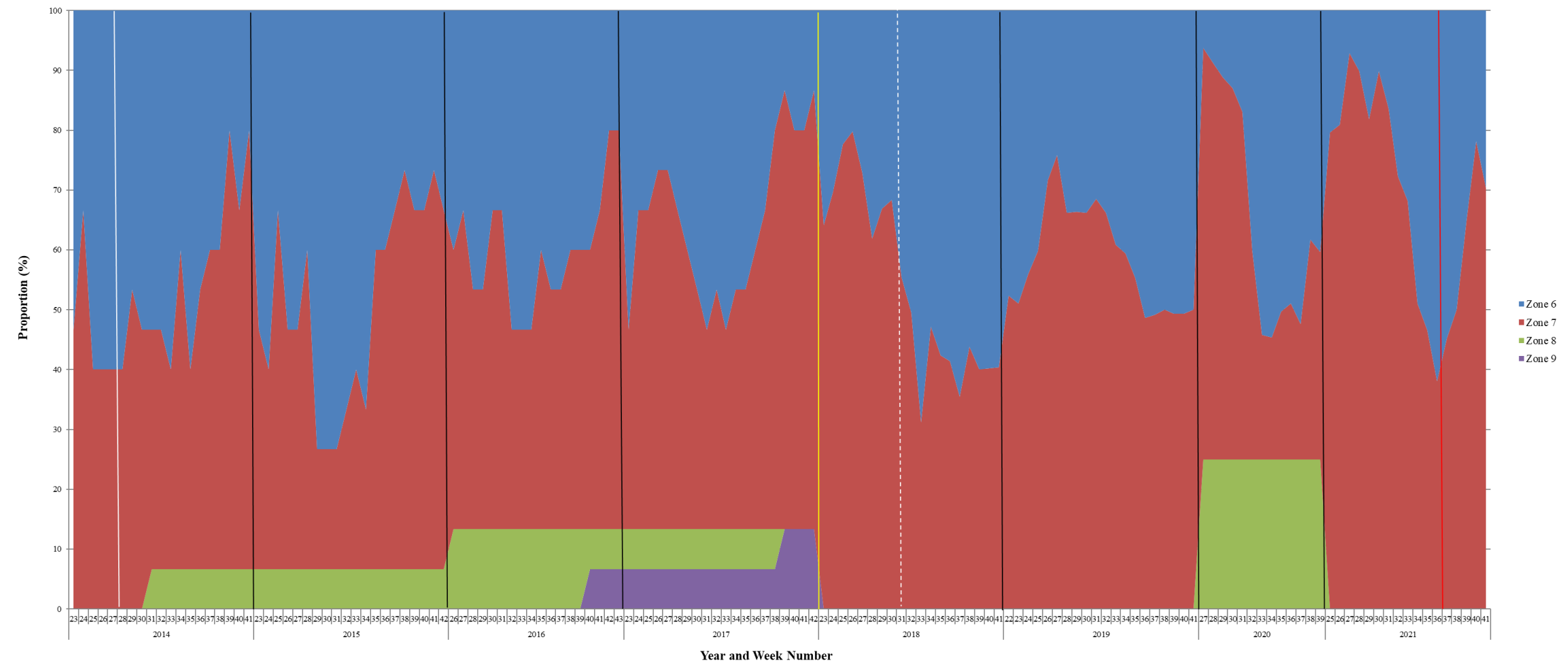
**Figure 9:** Proportional distribution by zone per week for juvenile Lake Sturgeon between Clark Lake and Gull Rapids/the Keeyask GS during a portion of the open-water periods of 2014 (June 4 to October 10), 2015 (June 4 to October 11), 2016 (June 25 to October 19), 2017 (June 7 to October 16), 2018 (June 6 to October 10), 2019 (June 2 to October 7), 2020 (July 3 to September 23), and 2021 (June 13 to October 10). White solid line indicates start of construction while white dashed line indicates start of spillway operation and red solid line indicates completion of reservoir impoundment. Yellow solid line indicates when tags expired, and new fish were tagged.



**Figure 10: Detection ranges for acoustic tagged juvenile Lake Sturgeon in Stephens Lake during the open-water periods of 2017–2021. Horizontal dotted lines demarcate zones with the red line representing the Keeyask GS.**

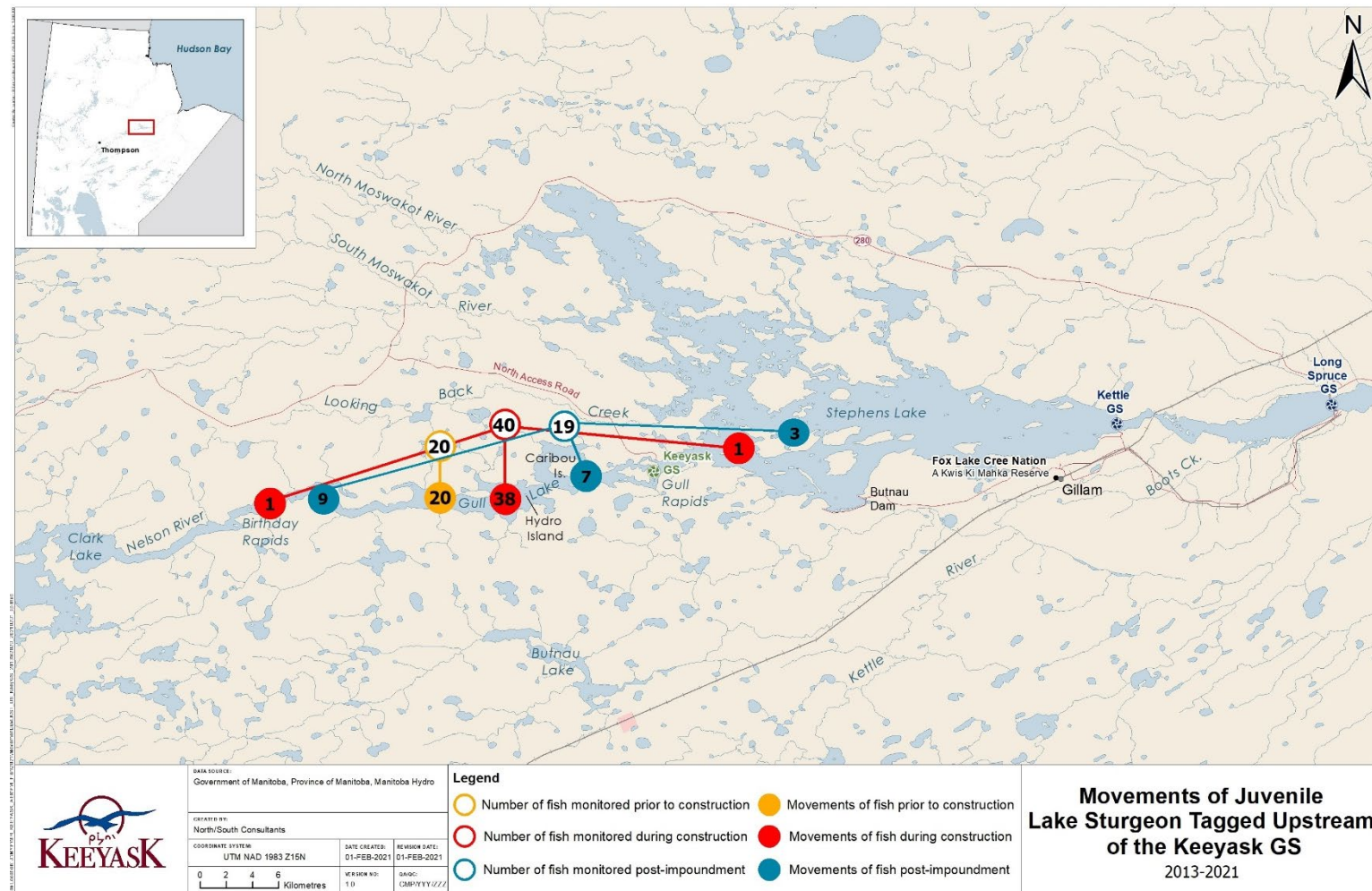


**Figure 11:** Relative number of detections at each acoustic receiver set in Steptens Lake during the 2021 open-water period (May 1 to October 10). Number of detections indicated by size of bubble (defined in legend). Receivers with no detections indicated with red dot.

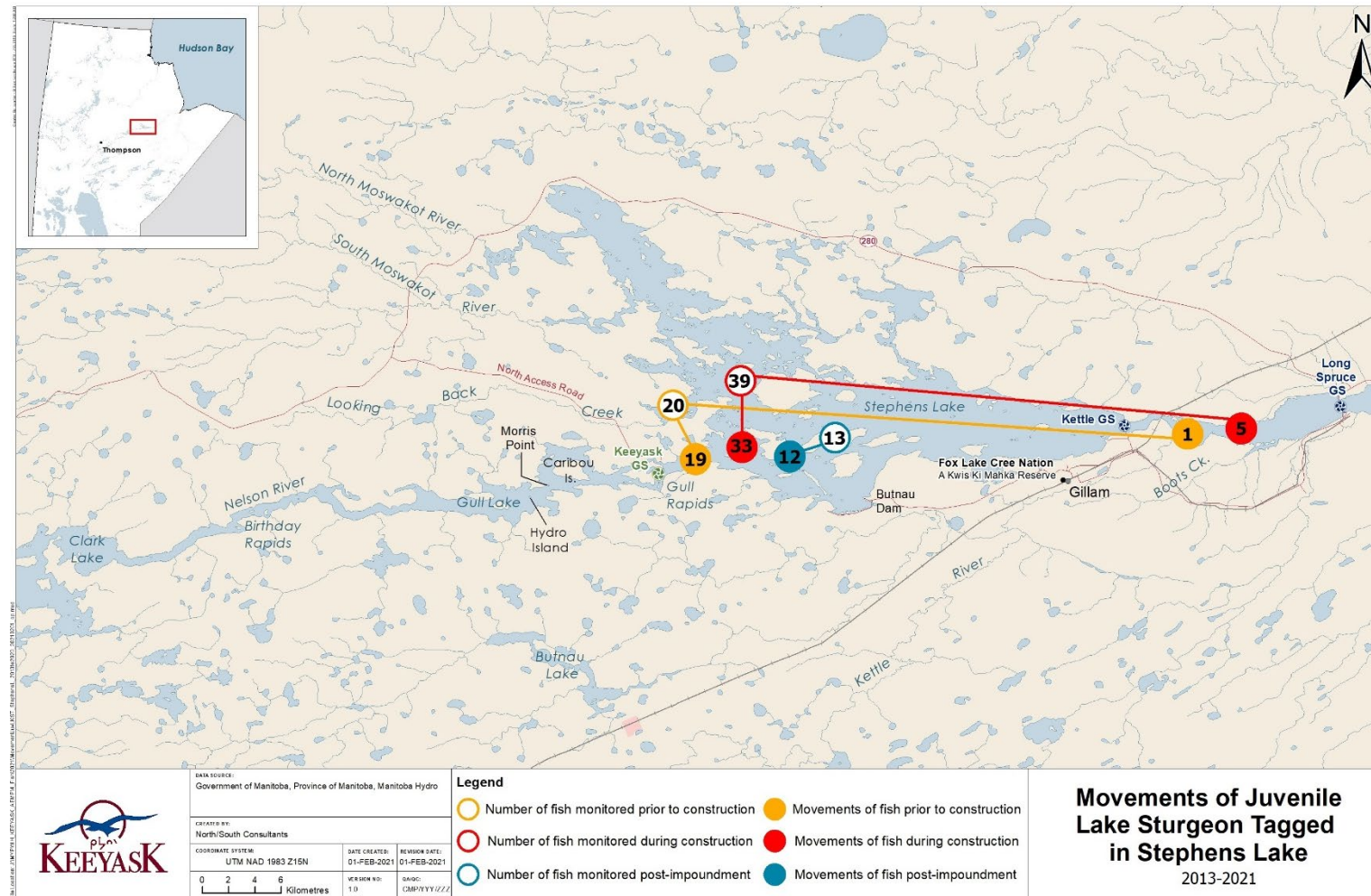


**Figure 12: Proportional distribution by zone per week for juvenile Lake Sturgeon downstream of Gull Rapids/the Keeyask GS during a portion of the open-water periods of 2014 (June 4 to October 10), 2015 (June 4 to October 11), 2016 (June 25 to October 19), 2017 (June 7 to October 16), 2018 (June 6 to October 10), 2019 (June 2 to October 7), 2020 (July 3 to September 23), and 2021 (June 13 to October 10). White solid line indicates start of construction while white dashed line indicates start of spillway operation and red solid line indicates completion of reservoir impoundment. Yellow solid line indicates when tags expired, and new fish were tagged.**





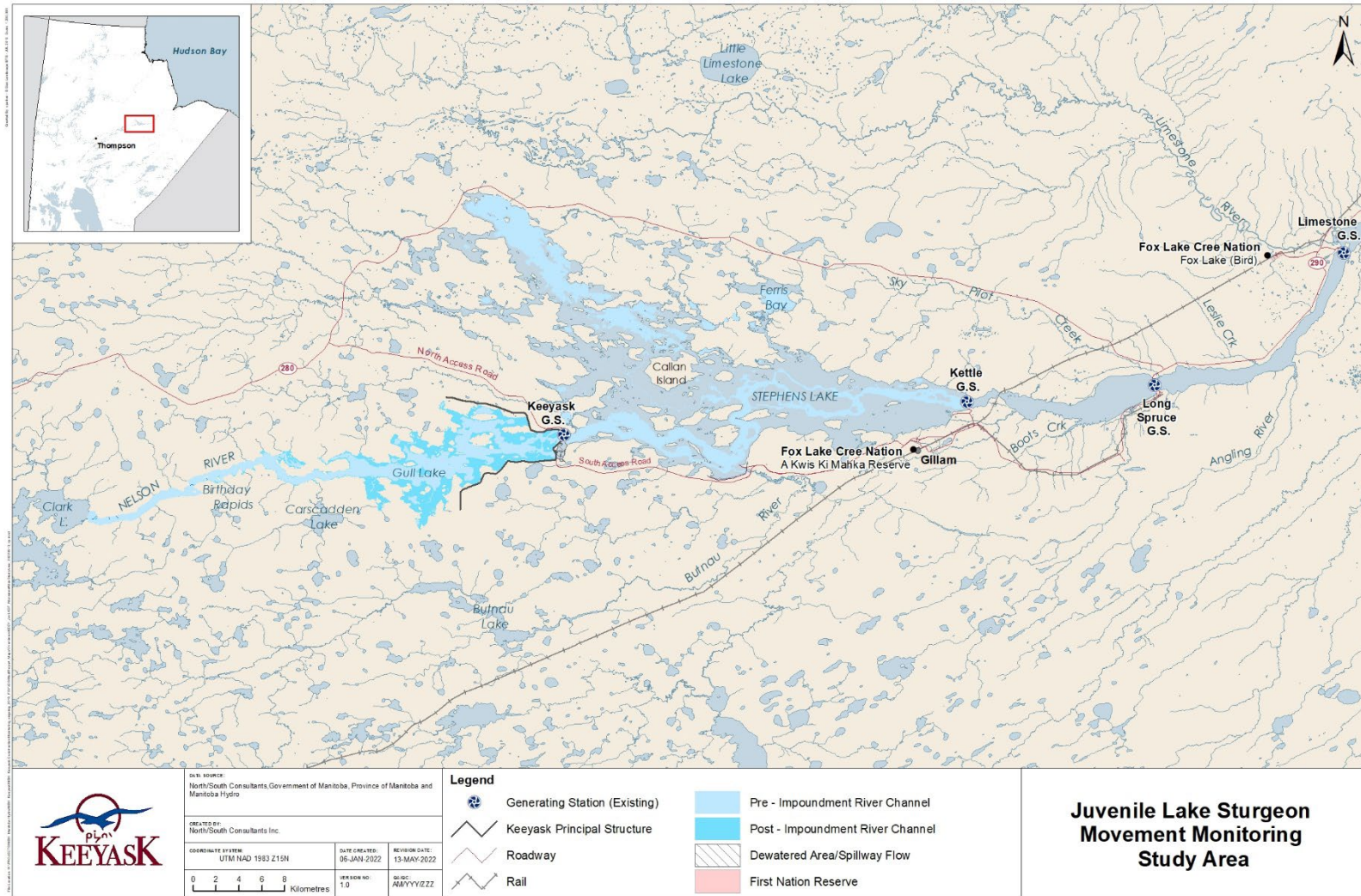
**Figure 13:** Map showing how many juvenile Lake Sturgeon moved upstream out of Gull Lake, stayed in Gull Lake, moved into Stephens Lake, and moved downstream through the Kettle GS before construction (yellow), during construction (red) and after reservoir impoundment (blue). Movements of fish due to mortality were not included. Numbers of fish monitored (hollow circles) represent the number of fish tagged while the number of fish movements (solid circles) represent the number of fish detected.



**Figure 14:** Map showing how many juvenile Lake Sturgeon stayed in Stephens Lake and moved downstream through the Kettle GS during before construction (yellow), during construction (red), and after reservoir impoundment (blue). Movements of fish due to tagging stress or mortality were not included. Numbers of fish monitored (hollow circles) represent the number of fish tagged while the number of fish movements (solid circles) represent the number of fish detected.

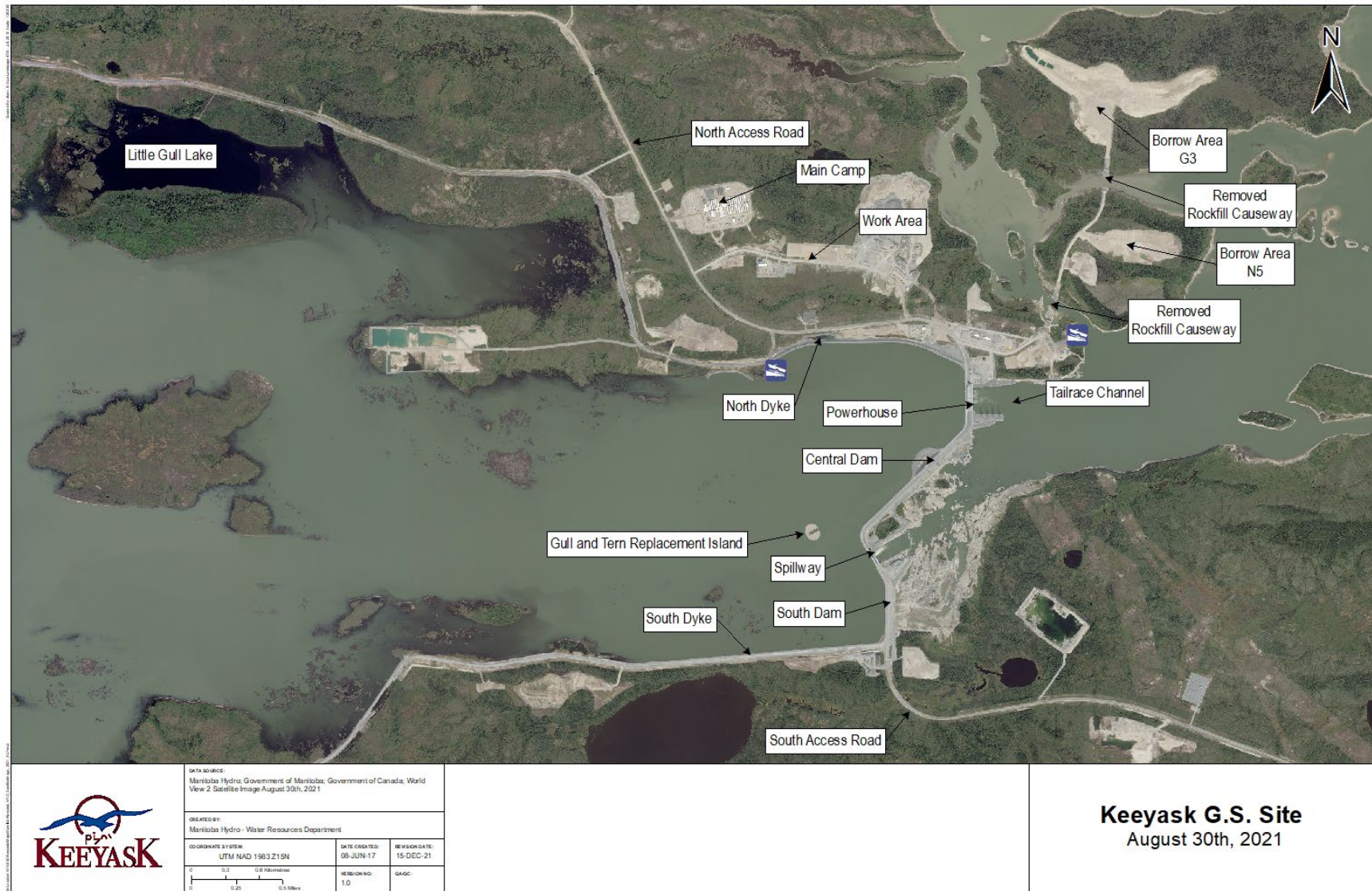
## MAPS



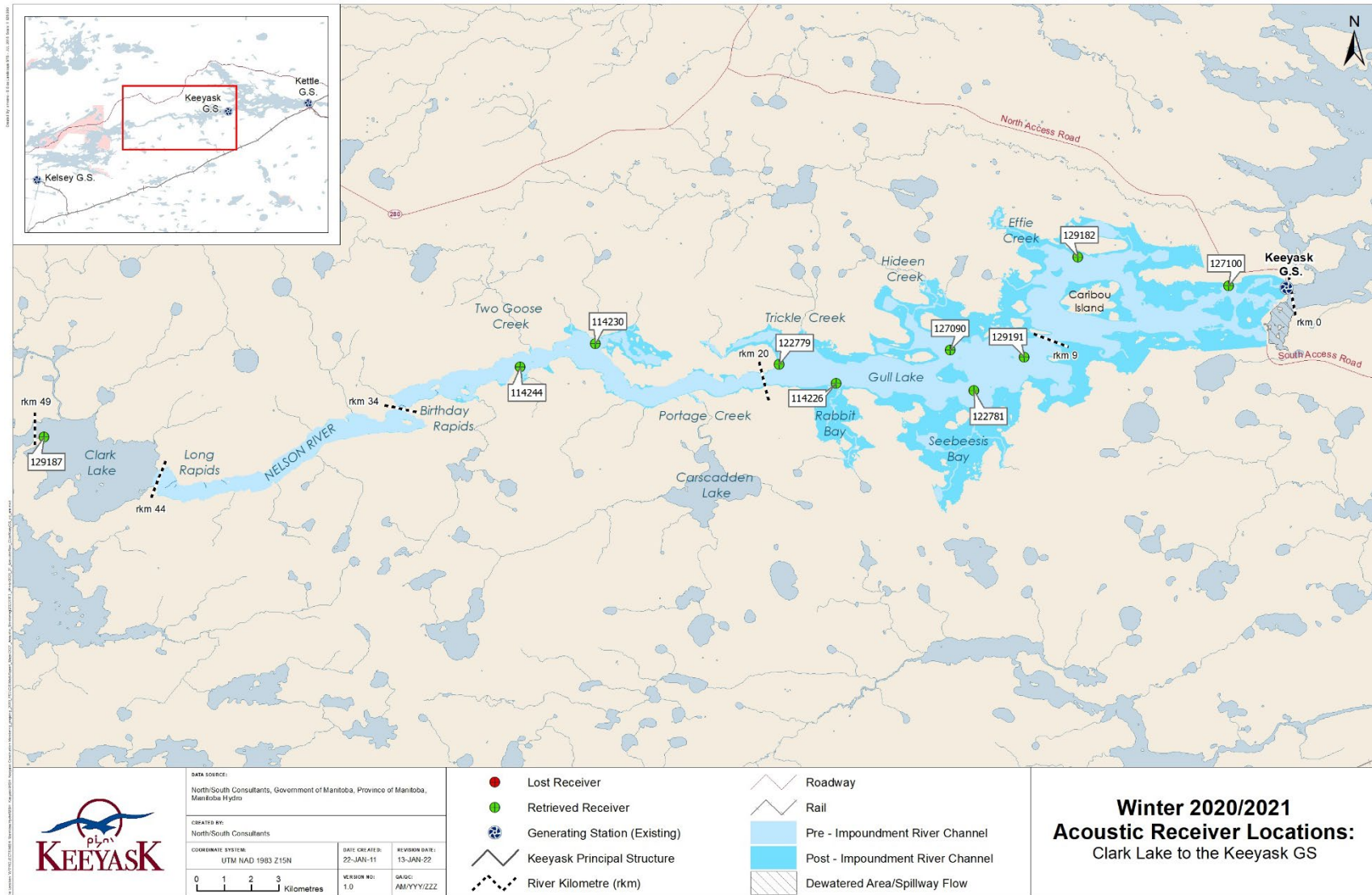


**Map 1: Map of the Nelson River showing the site of the Keeyask Generating Station and the juvenile Lake Sturgeon movement monitoring study setting.**





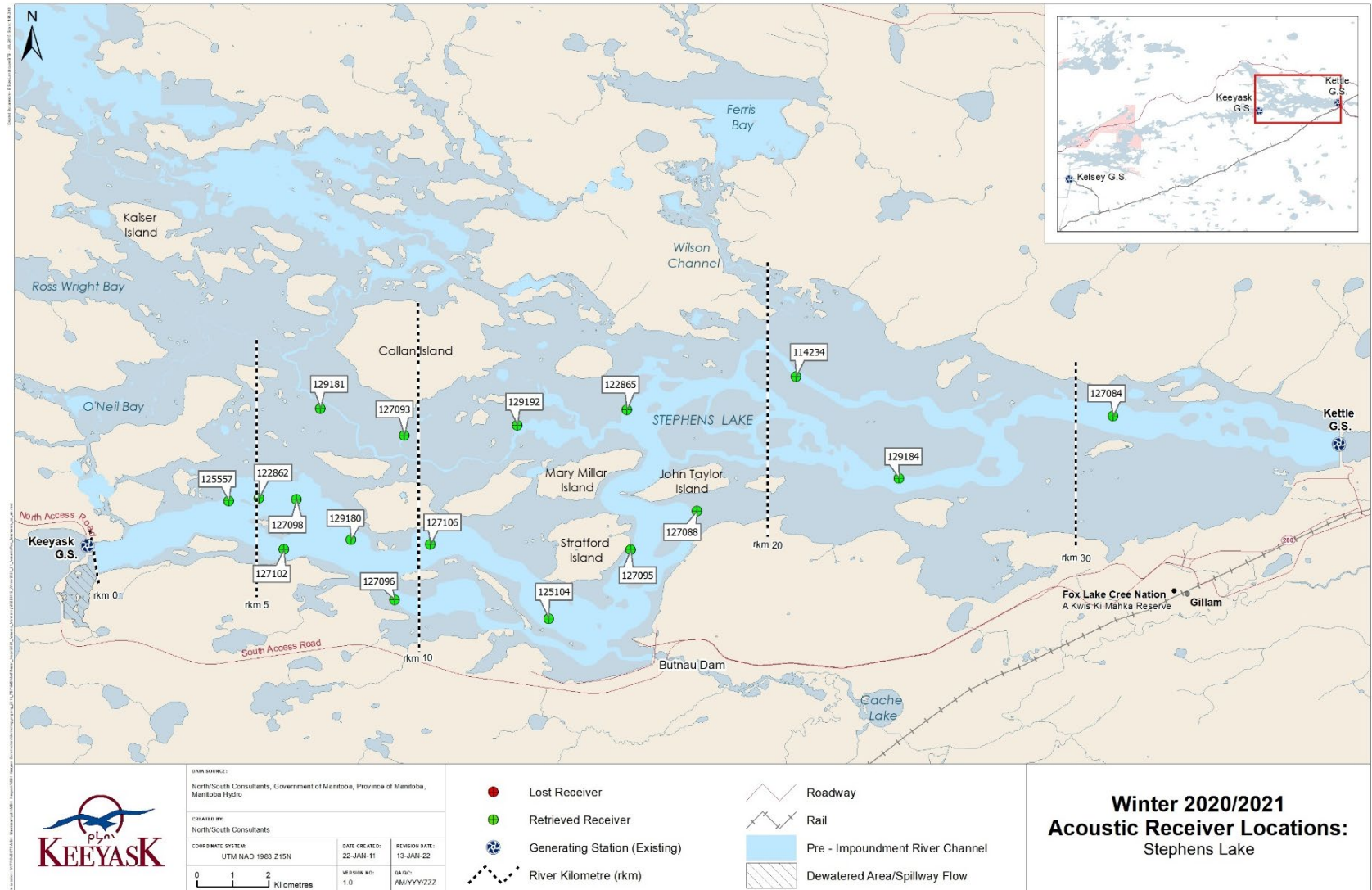
**Map 2: Map illustrating instream structures at the Keeyask Generating Station site after reservoir flooding, August 2021.**



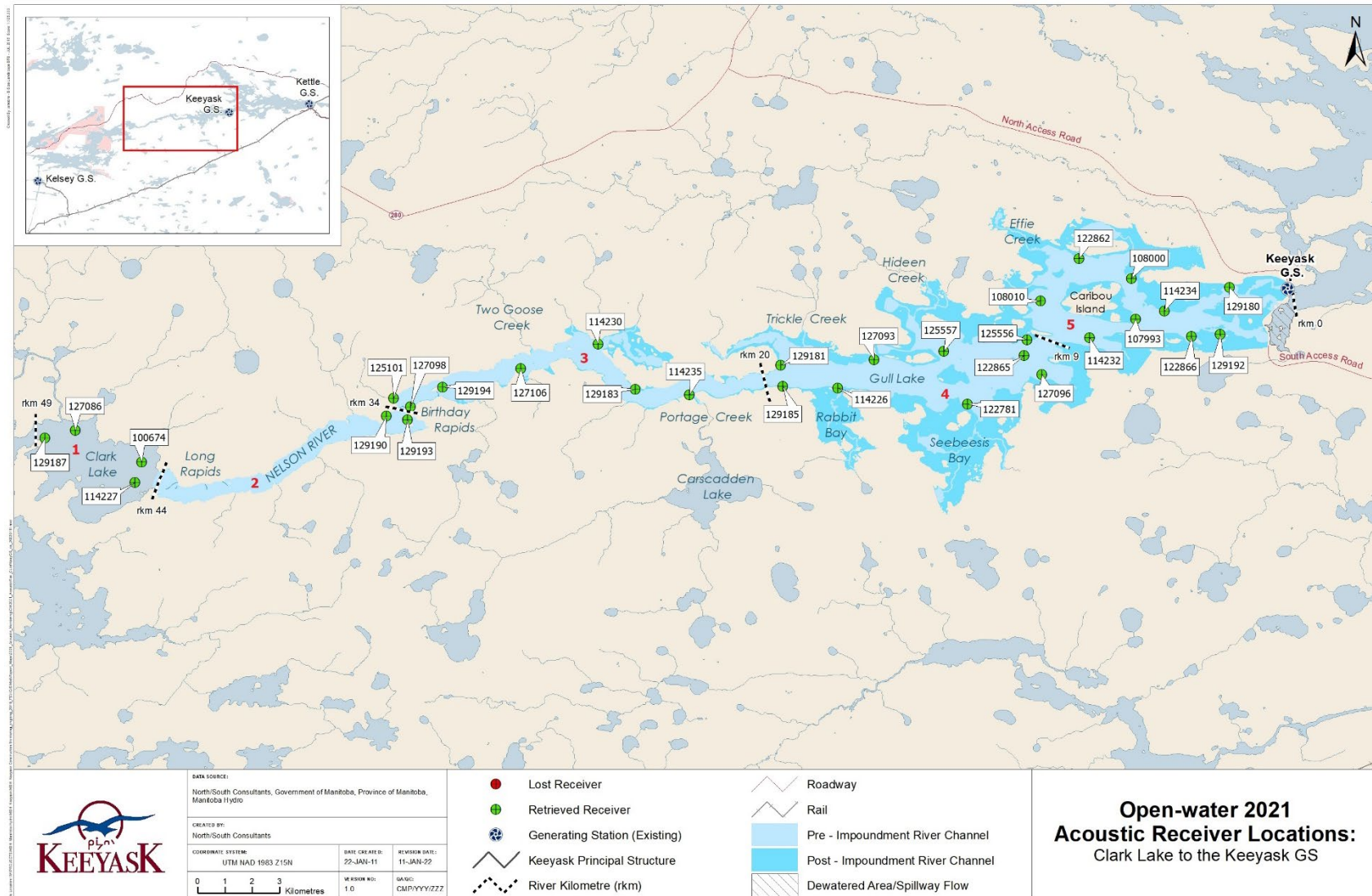
**Map 3: Locations of stationary receivers set in the Nelson River from Clark Lake to the Keeyask GS between September 2020 and May 2021. River kilometer (rkm) distances are indicated with a dotted line. The former (pre-**



impoundment) river channel is shown in light blue.

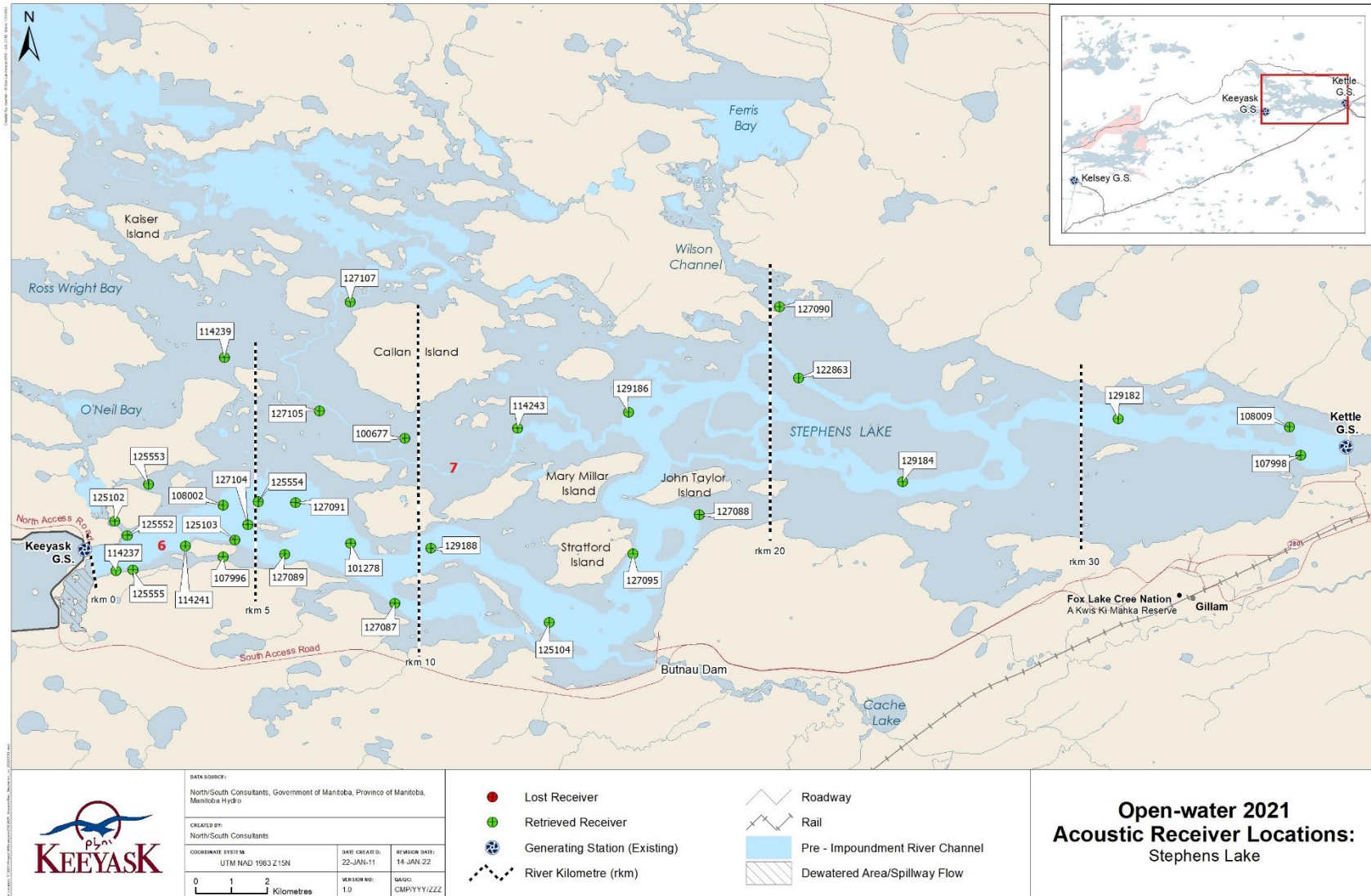


**Map 4: Locations of stationary receivers set in Stephens Lake from the Keeyask GS to Kettle GS between September 2020 to May 2021. River kilometer (rkm) distances are indicated with a dotted line. The former (pre-impoundment) river channel is shown in light blue.**

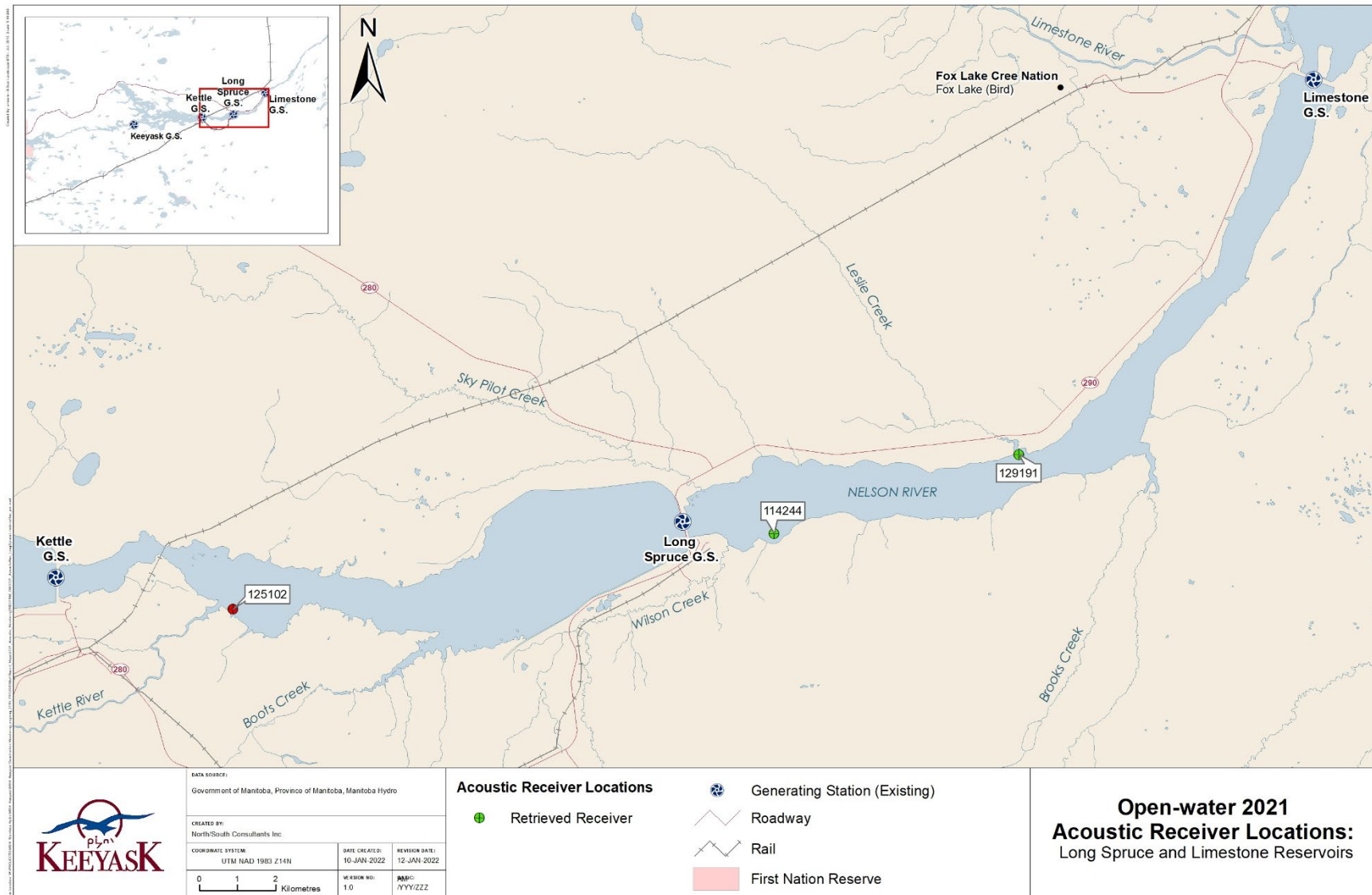




**Map 5: Locations of stationary receivers set in the Nelson River from Clark Lake to the Keeyask GS between June and October 2021. The river is divided into five "zones" based on placement of receiver "gates." River kilometer (rkm) distances at zone divisions are indicated in red.**



**Map 6:**        **Locations of stationary receivers set in Stephens Lake between June and October 2021. The river is divided into two "zones" based on placement of receiver "gates." The pre-impoundment river channel is shown in light blue. River kilometer (rkm) distances are indicated with a dotted red line.**



**Map 7: Locations of stationary receivers set between the Kettle and Limestone Generating Stations, June to October 2021.**

# APPENDICES



# APPENDIX 1:

## LOCATION SUMMARY FOR INDIVIDUAL ACOUSTIC TAGGED JUVENILE LAKE STURGEON UPSTREAM OF THE KEEYASK GS, SEPTEMBER 2017 TO OCTOBER 2021

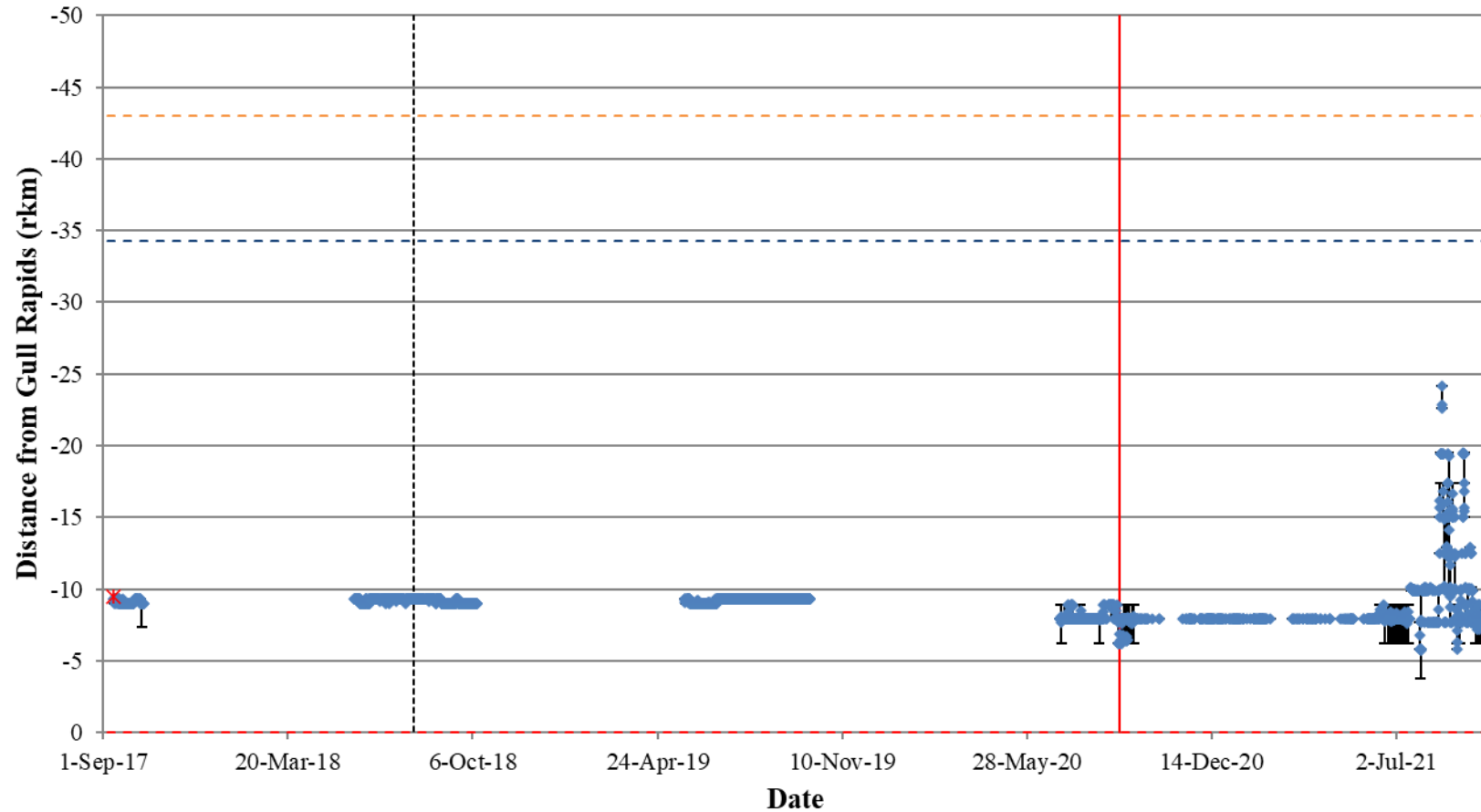
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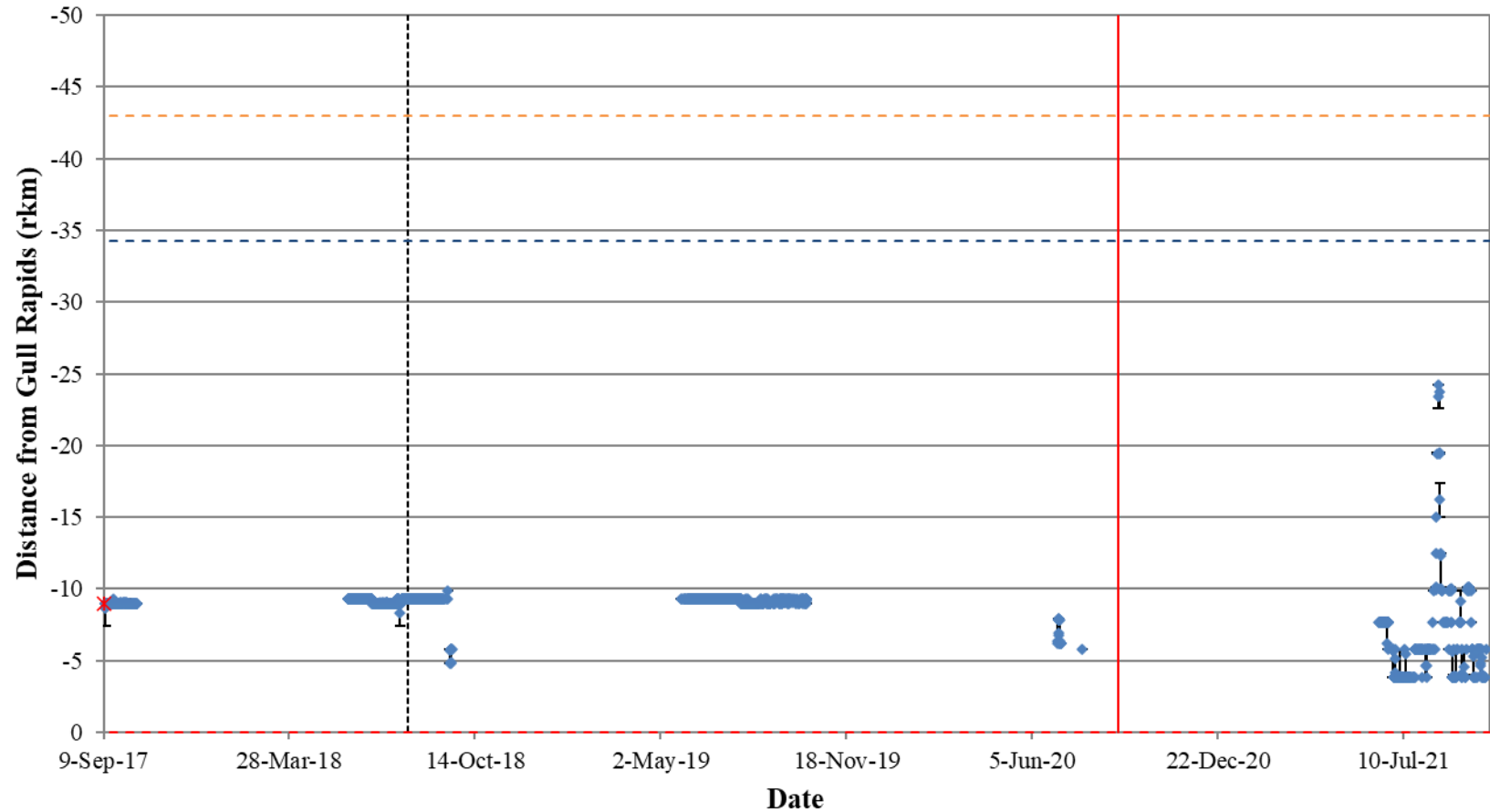
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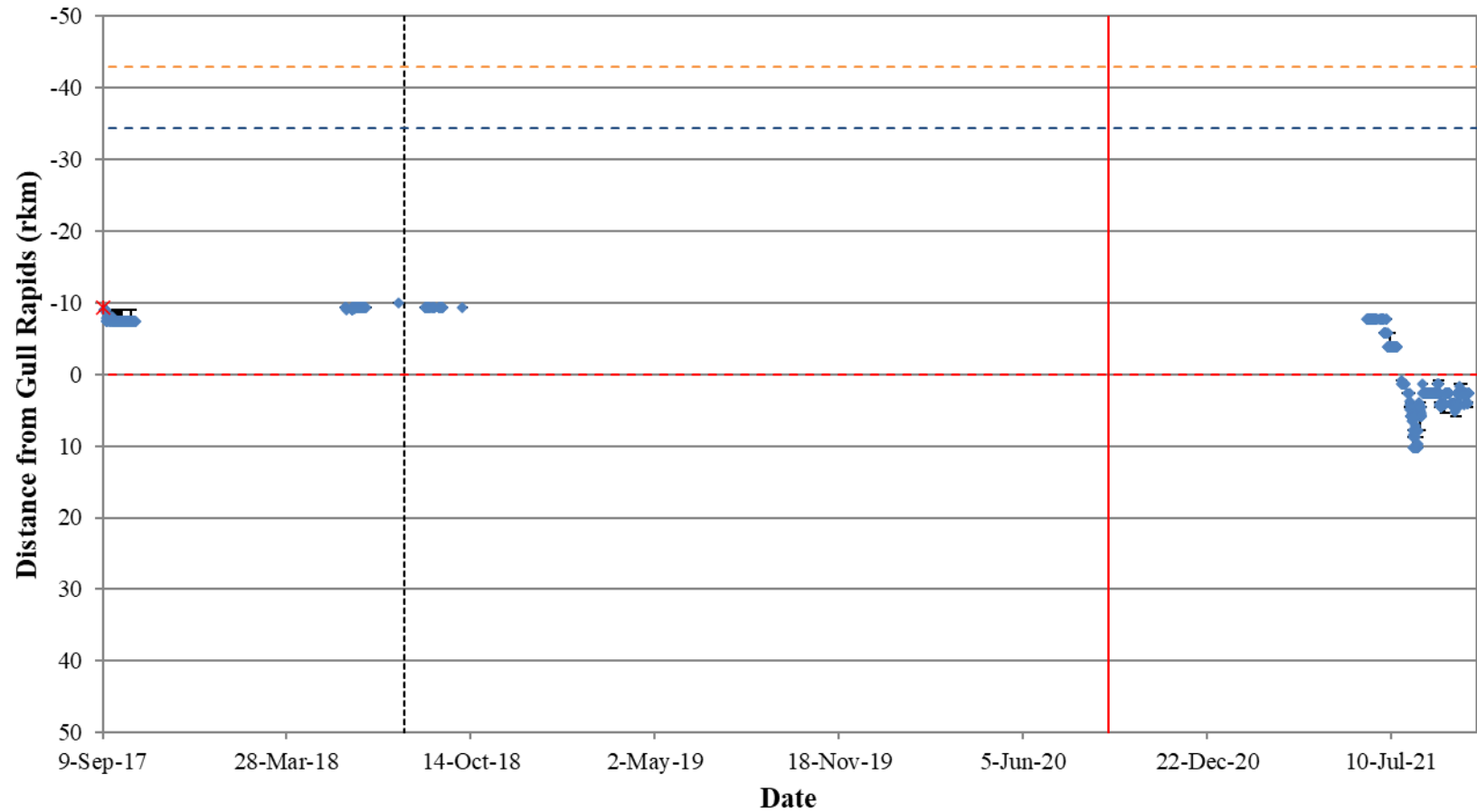


**Figure A1-1: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31683) in Gull Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to October 10, 2021. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange). Dashed black vertical line indicates start of spillway operation (Aug 3, 2018). Solid red vertical line indicates completion of reservoir impoundment (September 5, 2020).**

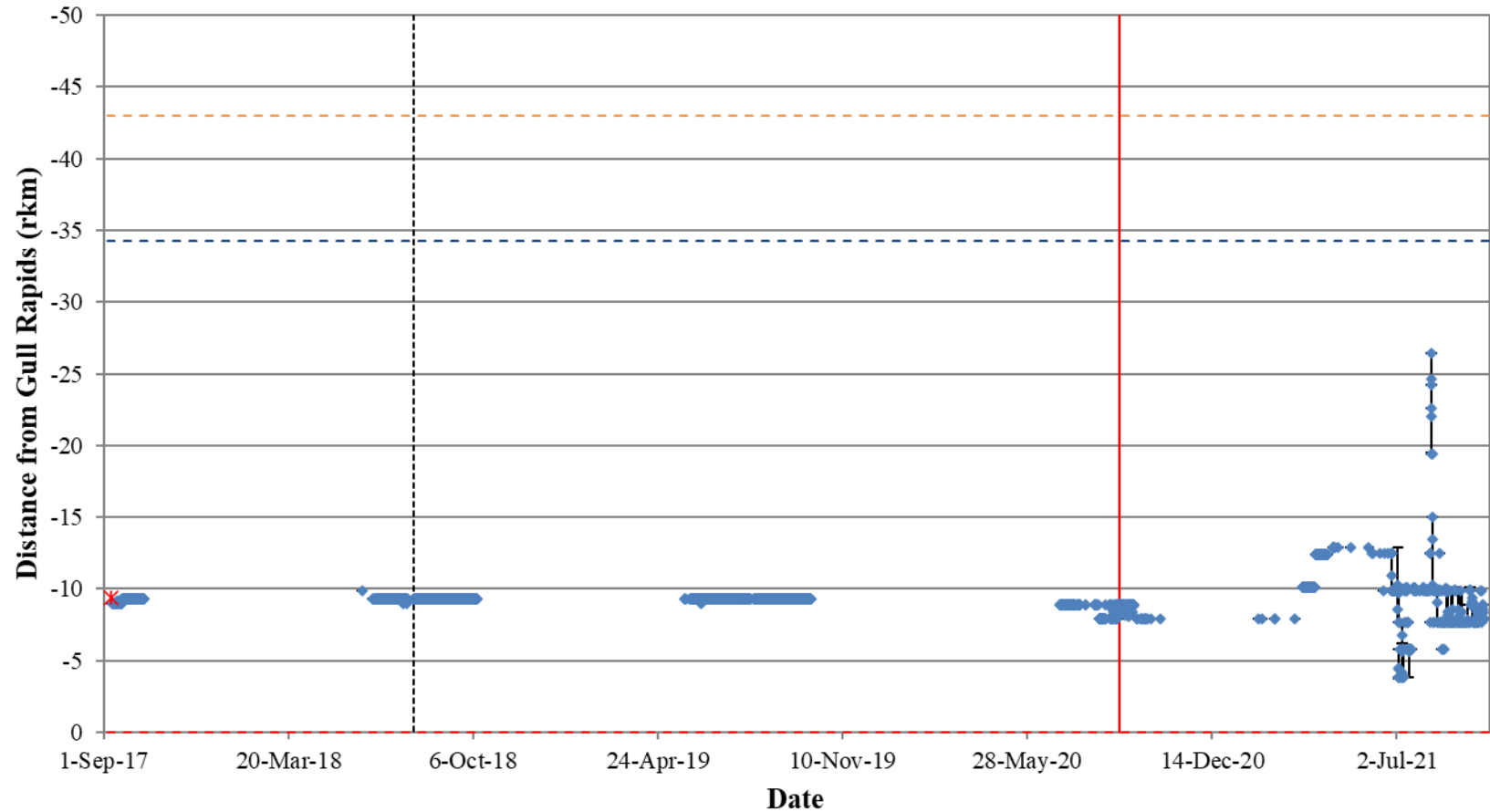


**Figure A1-2: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31684) in Gull Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to October 10, 2021. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange). Dashed black vertical line indicates start of spillway operation (Aug 3, 2018). Solid red vertical line indicates completion of reservoir impoundment (September 5, 2020).**

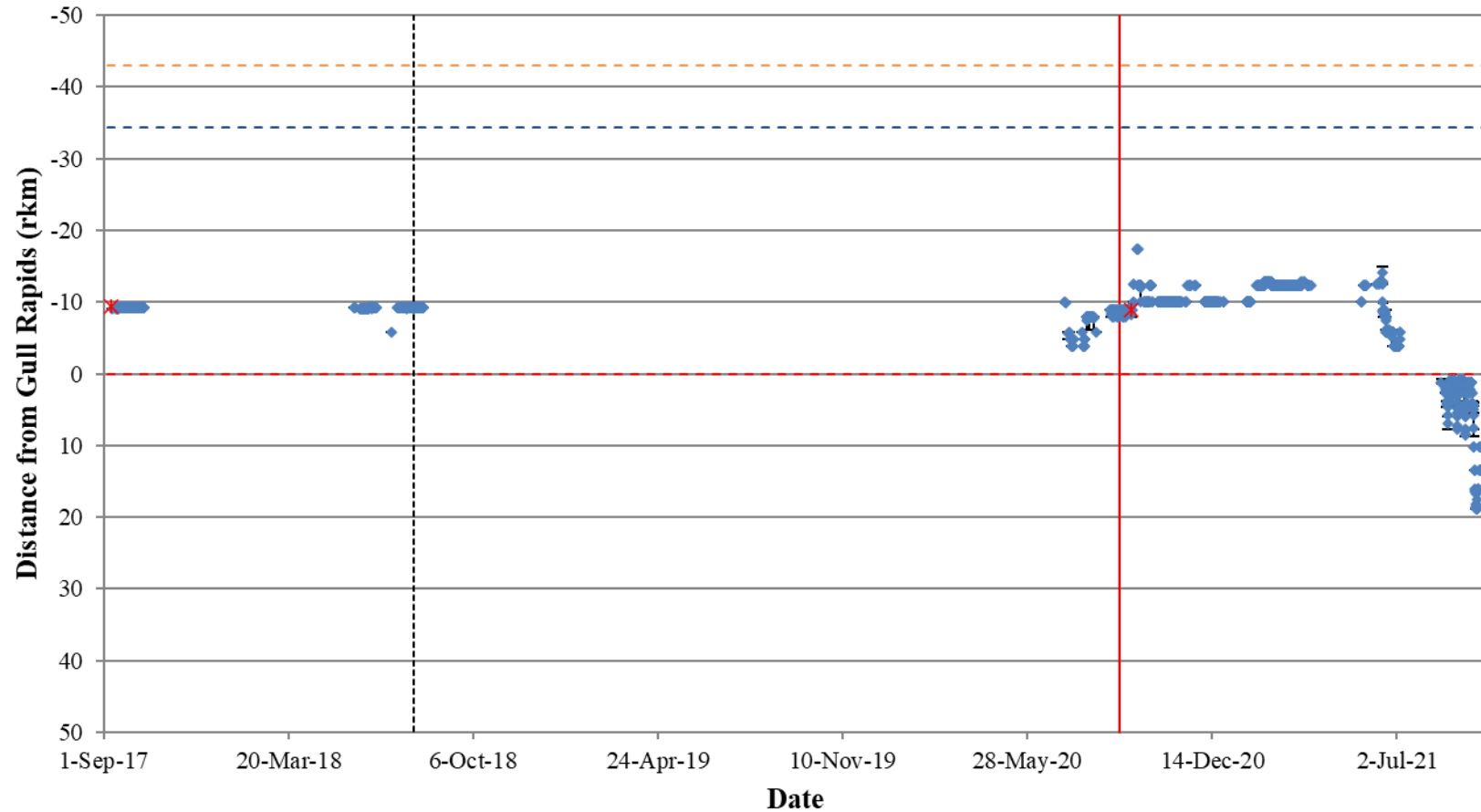




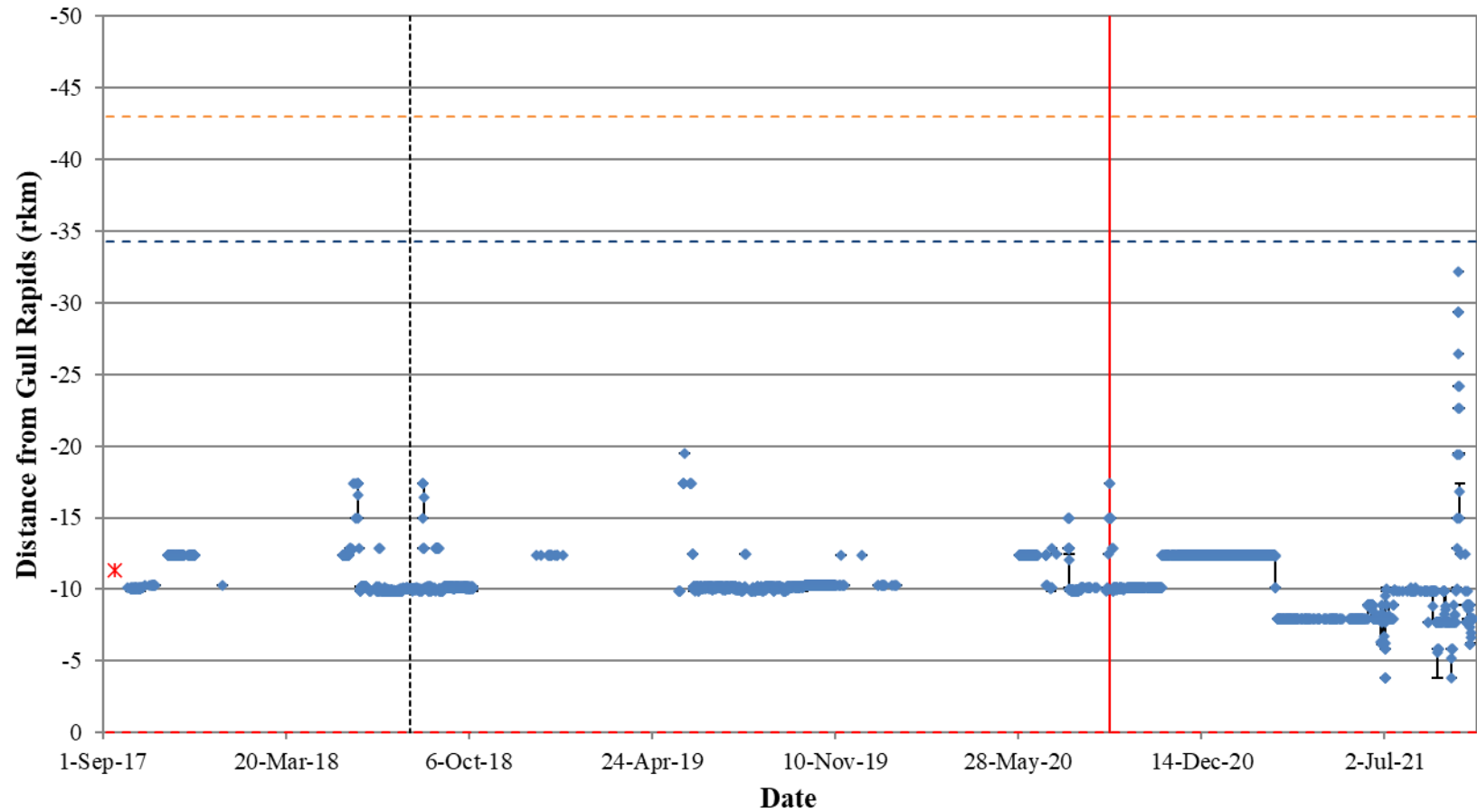
**Figure A1-3: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31685) in Gull Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to October 10, 2021. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange). Dashed black vertical line indicates start of spillway operation (Aug 3, 2018). Solid red vertical line indicates completion of reservoir impoundment (September 5, 2020).**



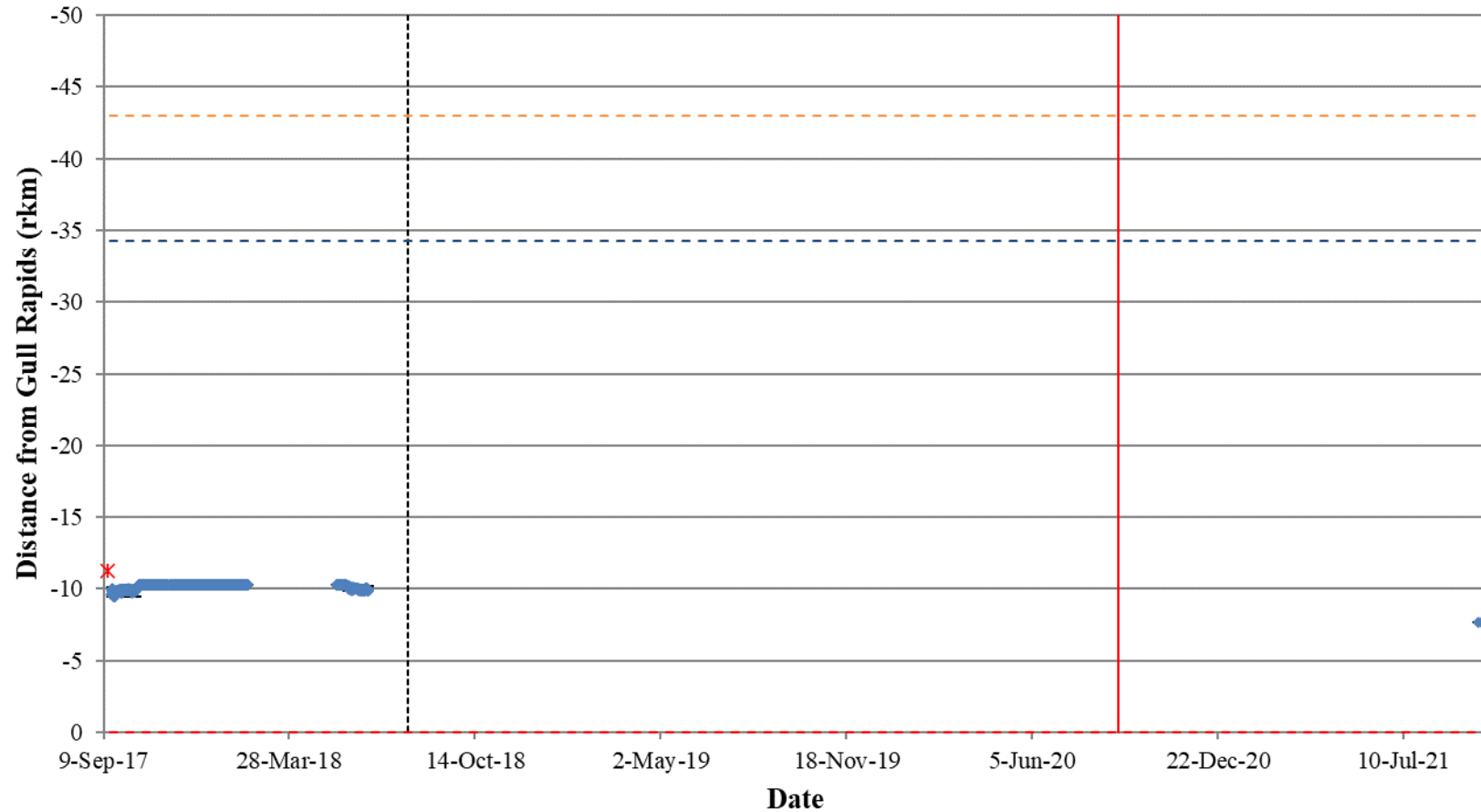
**Figure A1-4: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31686) in Gull Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to October 10, 2021. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange). Dashed black vertical line indicates start of spillway operation (Aug 3, 2018). Solid red vertical line indicates completion of reservoir impoundment (September 5, 2020).**



**Figure A1-5: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31687) in Gull Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to October 10, 2021. Date and location of tagging and subsequent recapture are indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange). Dashed black vertical line indicates start of spillway operation (Aug 3, 2018). Solid red vertical line indicates completion of reservoir impoundment (September 5, 2020).**

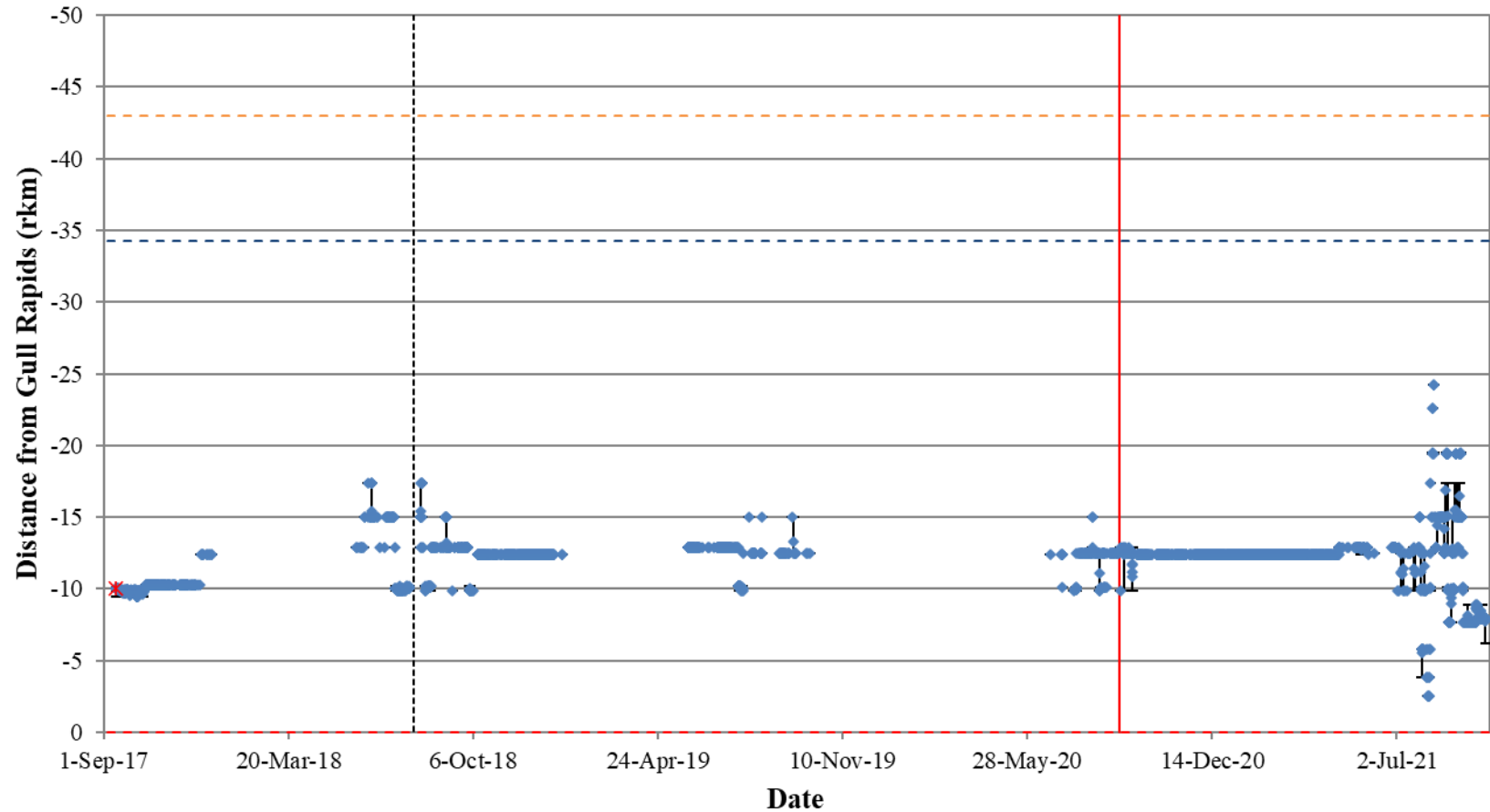


**Figure A1-6: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31768) in Gull Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to October 10, 2021. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange). Dashed black vertical line indicates start of spillway operation (Aug 3, 2018). Solid red vertical line indicates completion of reservoir impoundment (September 5, 2020).**

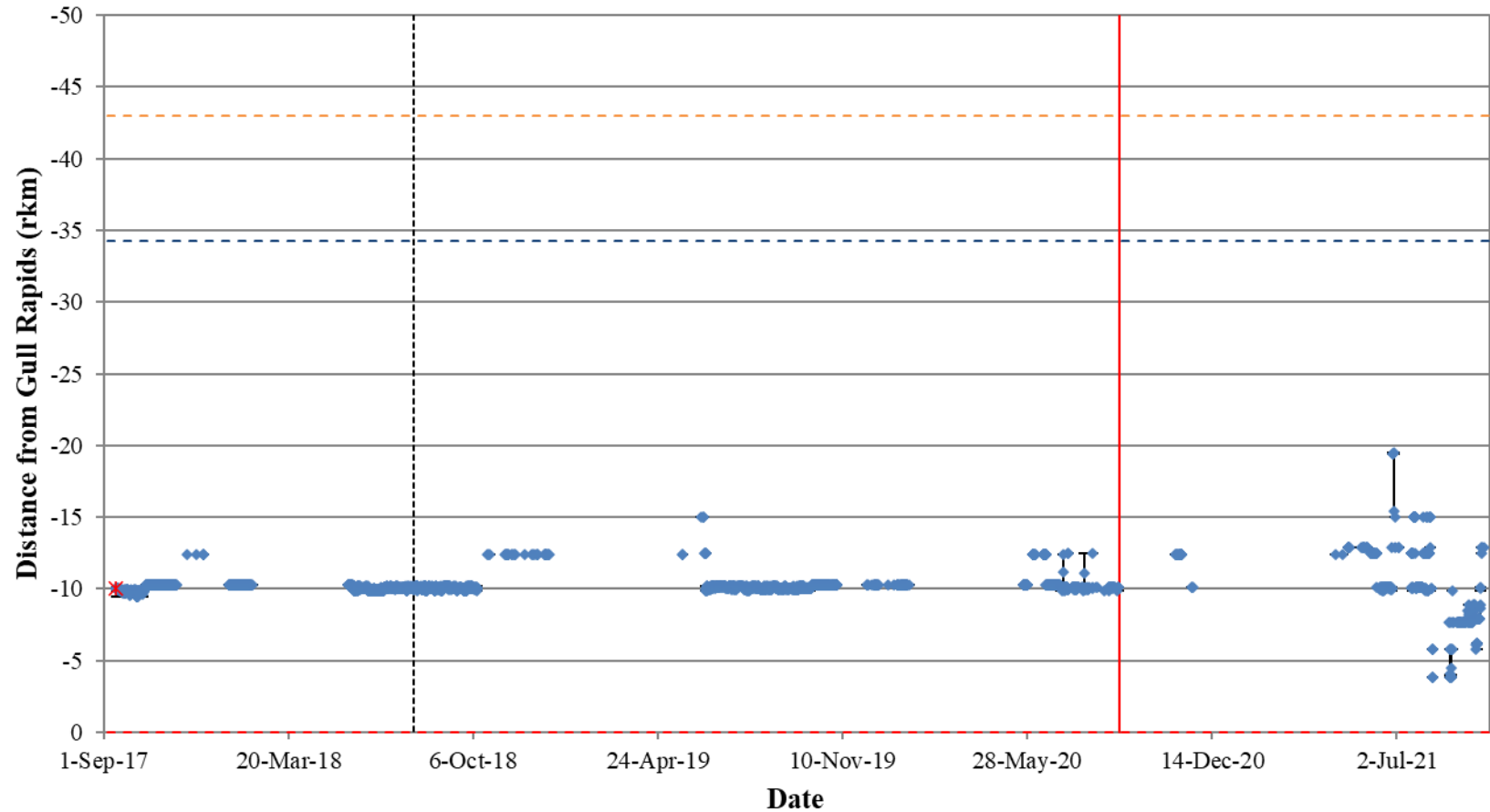


**Figure A1-7: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31769) in Gull Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to October 10, 2021. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange). Dashed black vertical line indicates start of spillway operation (Aug 3, 2018). Solid red vertical line indicates completion of reservoir impoundment (September 5, 2020).**

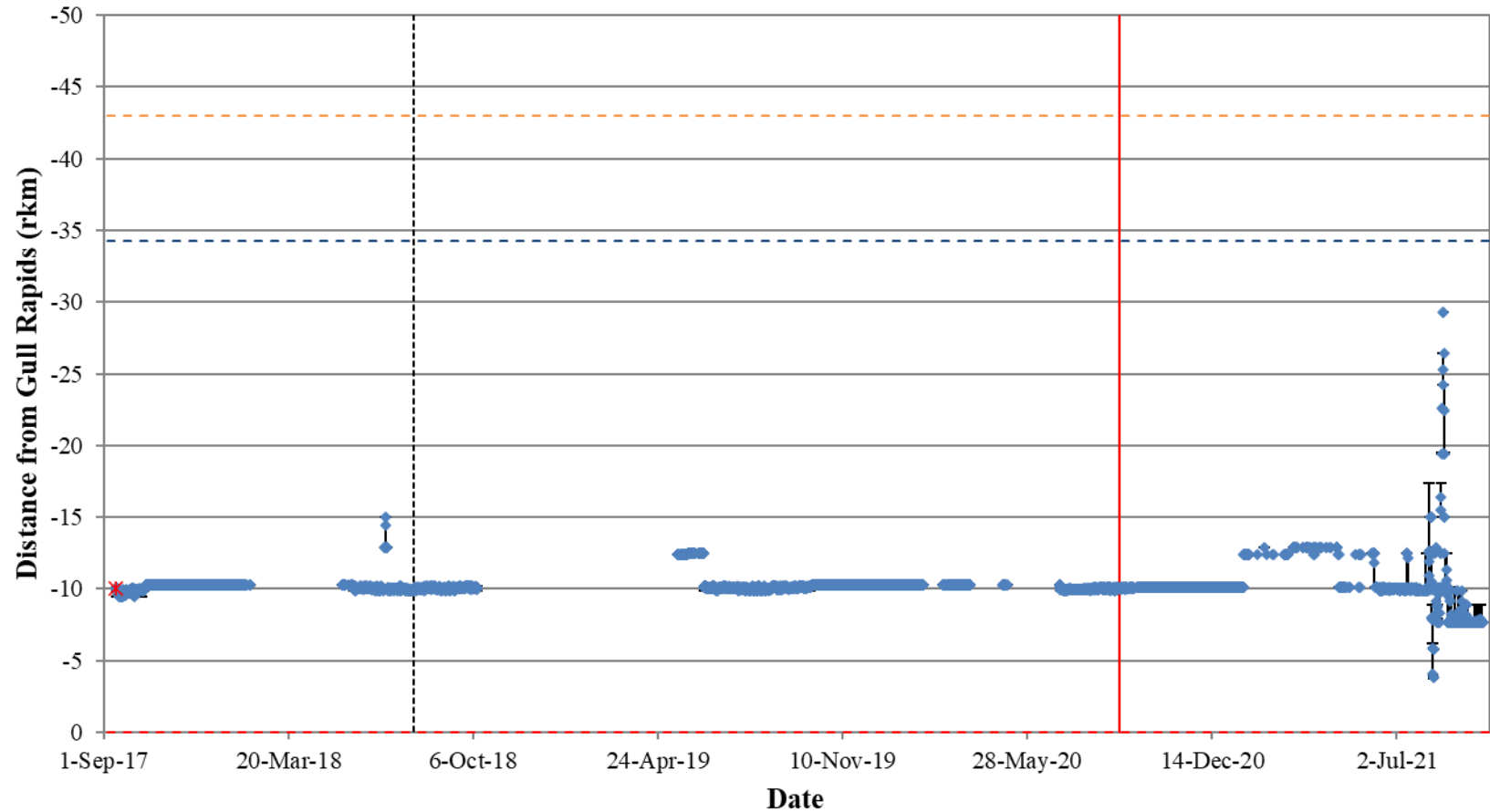




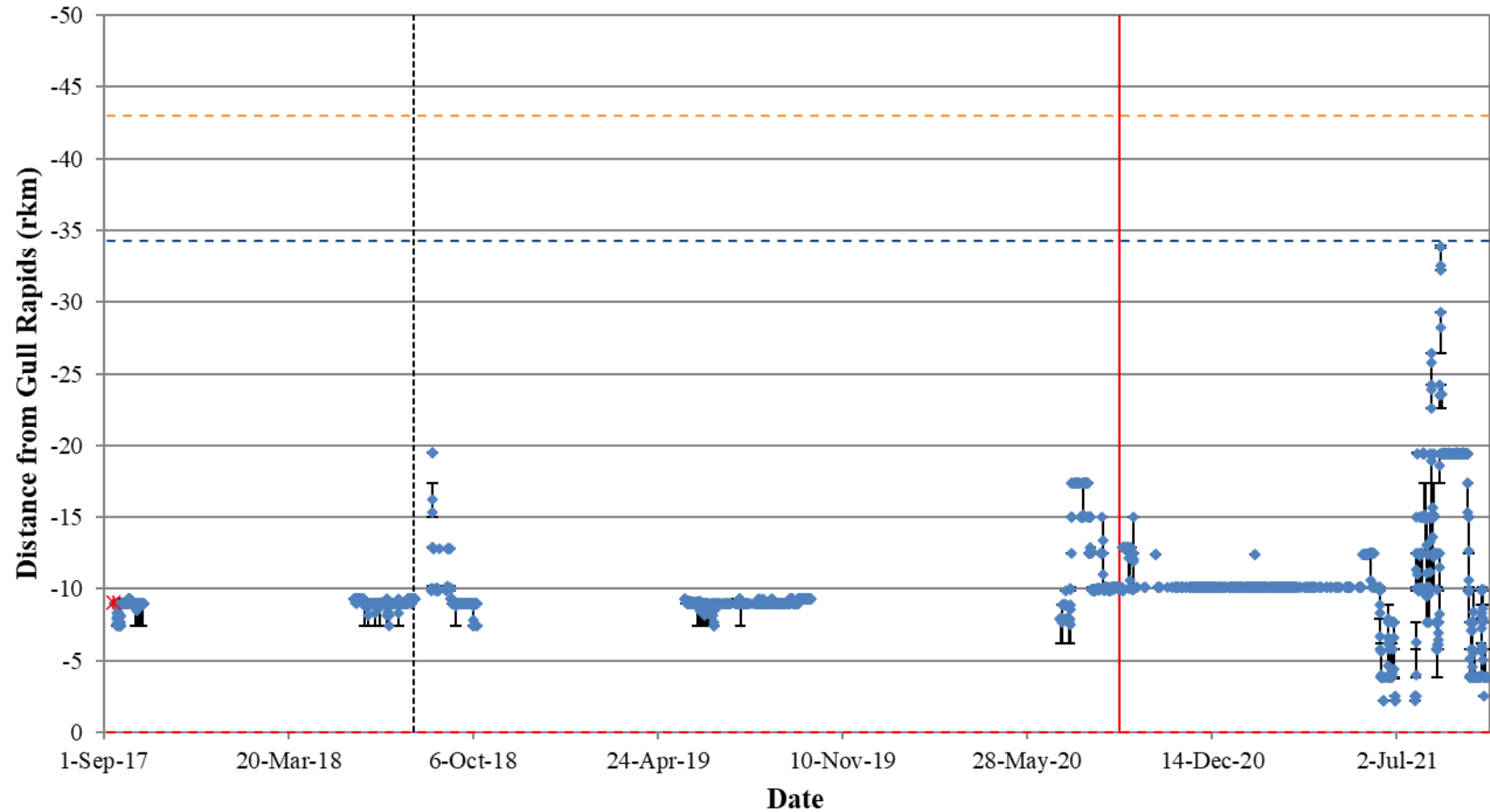
**Figure A1-8: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31770) in Gull Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to October 10, 2021. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange). Dashed black vertical line indicates start of spillway operation (Aug 3, 2018). Solid red vertical line indicates completion of reservoir impoundment (September 5, 2020).**



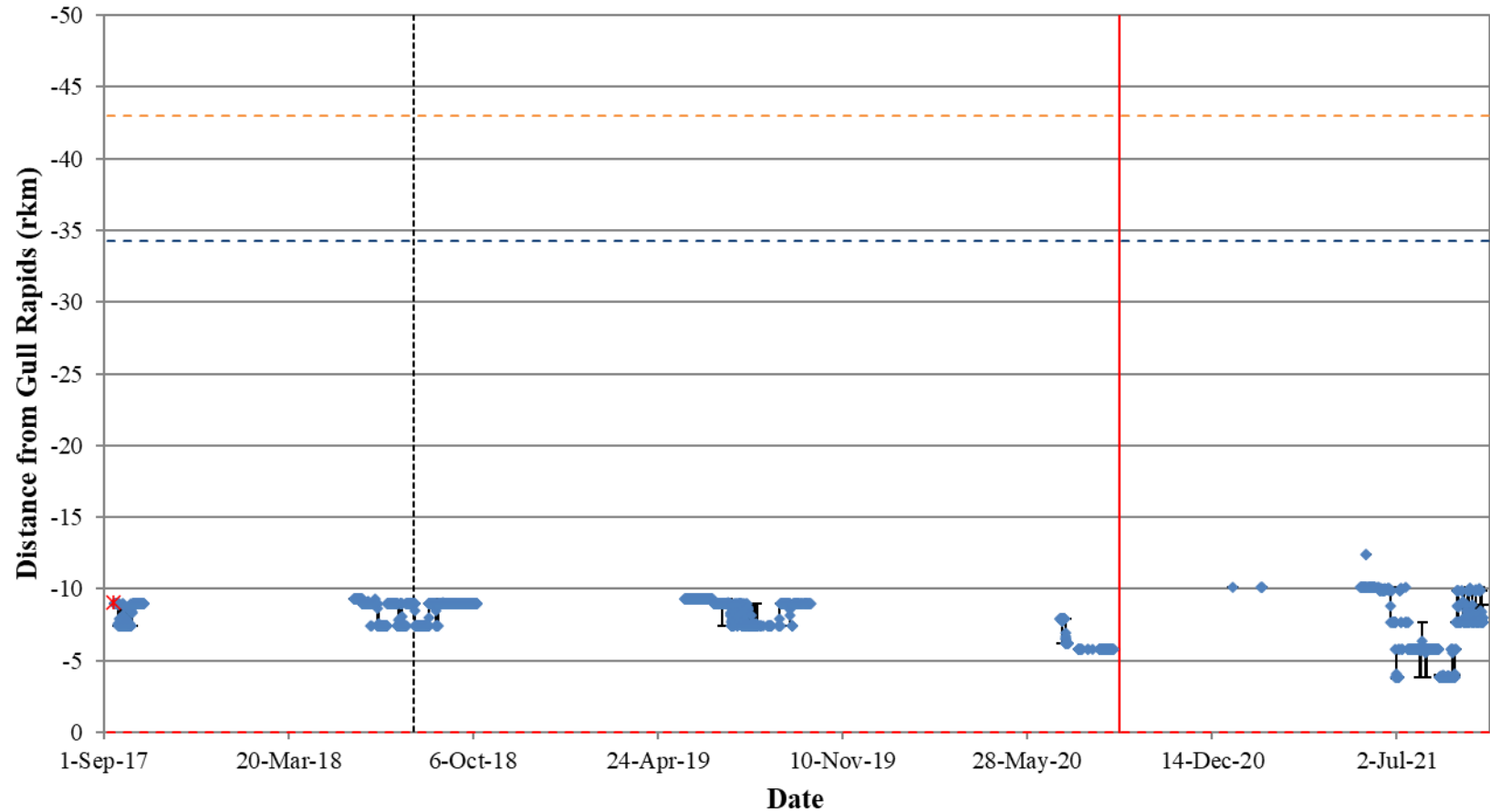
**Figure A1-9: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31771) in Gull Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to October 10, 2021. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange). Dashed black vertical line indicates start of spillway operation (Aug 3, 2018). Solid red vertical line indicates completion of reservoir impoundment (September 5, 2020).**



**Figure A1-10: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31772) in Gull Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to October 10, 2021. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange). Dashed black vertical line indicates start of spillway operation (Aug 3, 2018). Solid red vertical line indicates completion of reservoir impoundment (September 5, 2020).**

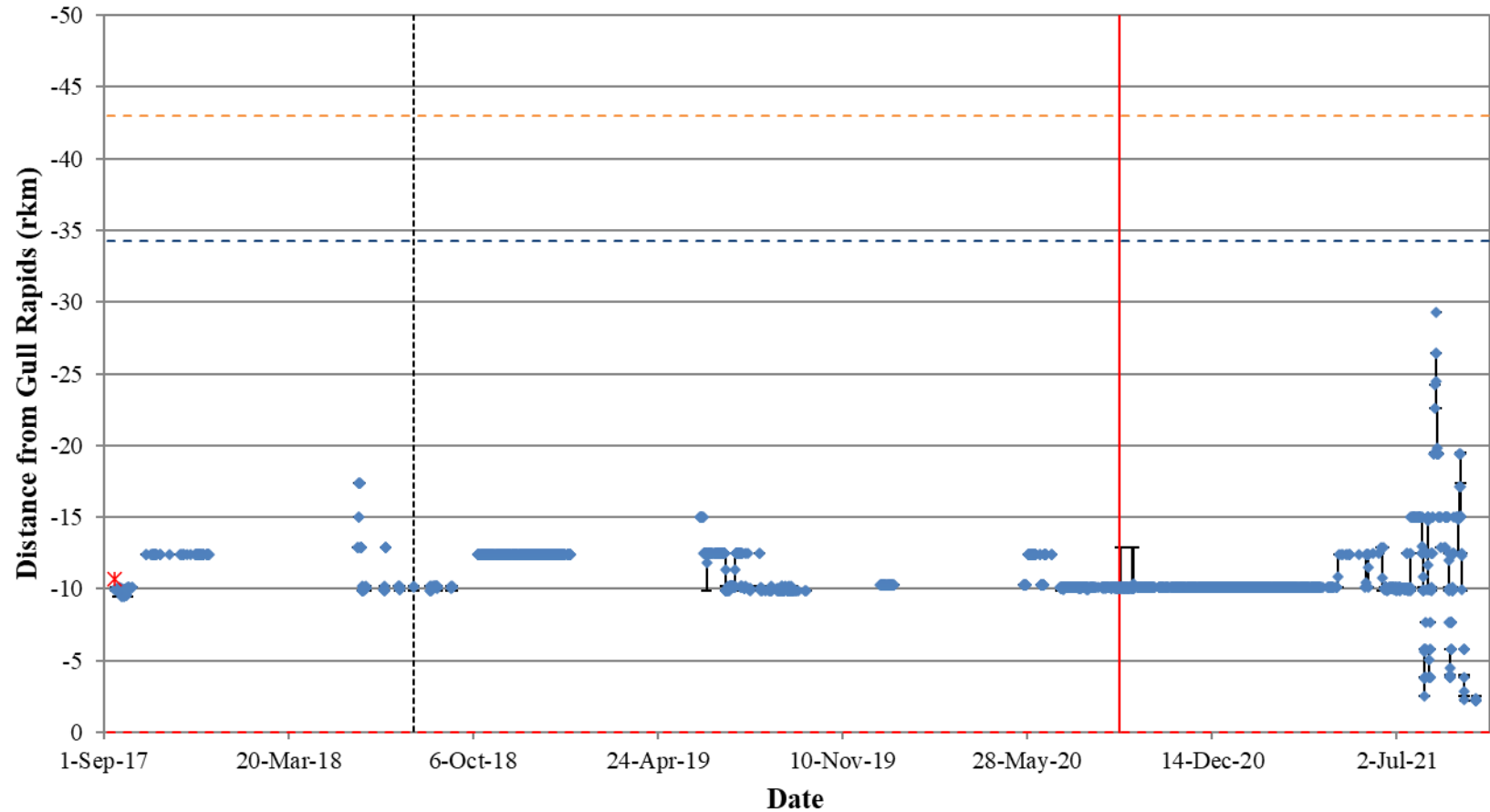


**Figure A1-11: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31773) in Gull Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to October 10, 2021. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange). Dashed black vertical line indicates start of spillway operation (Aug 3, 2018). Solid red vertical line indicates completion of reservoir impoundment (September 5, 2020).**

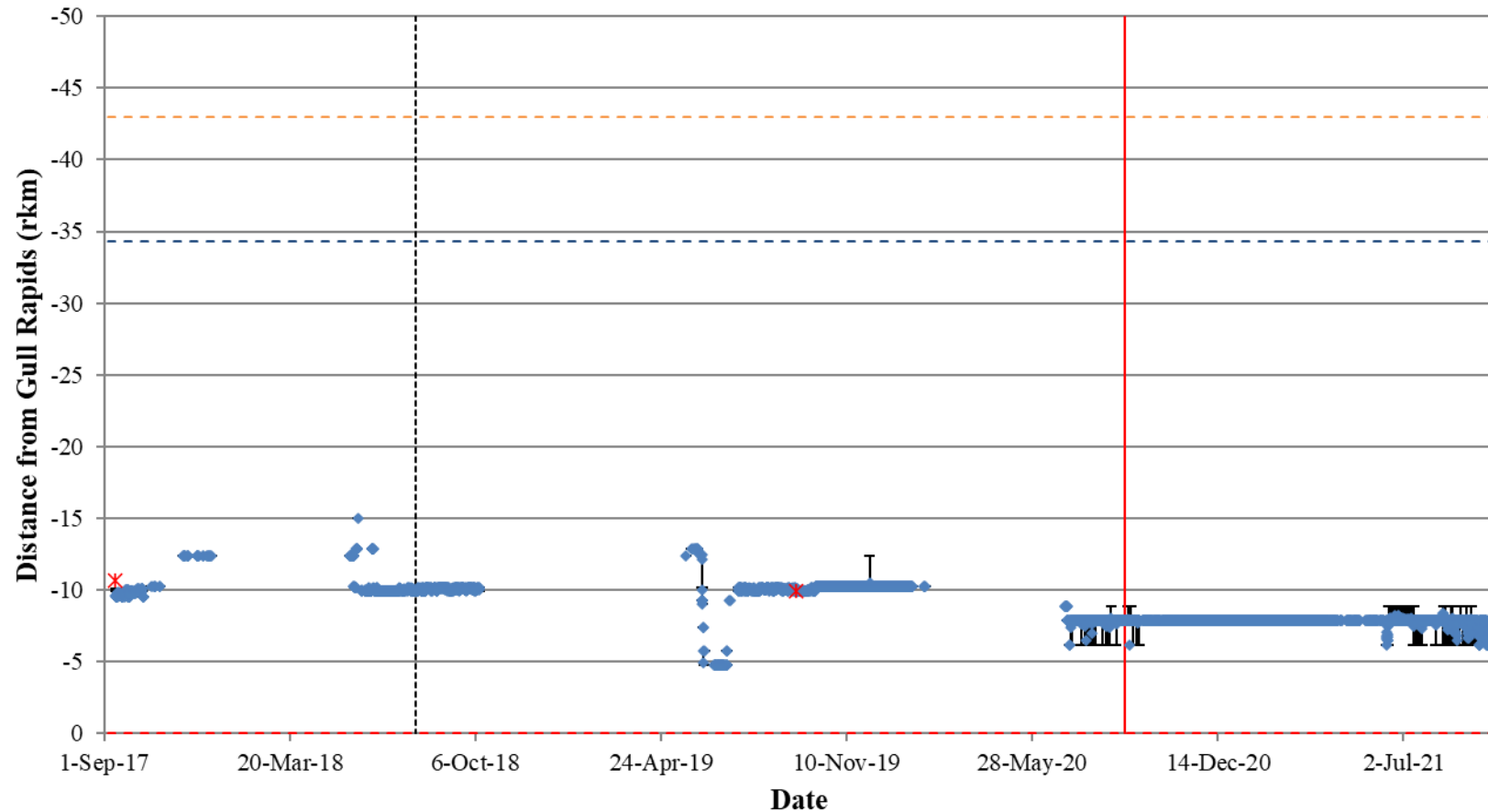


**Figure A1-12: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31774) in Gull Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to October 10, 2021. Date and location of tagging is indicated by a red X. Horizontal dashed lines indicate the positions of Keeyask GS (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange). Dashed black vertical line indicates start of spillway operation (Aug 3, 2018). Solid red vertical line indicates completion of reservoir impoundment (September 5, 2020).**

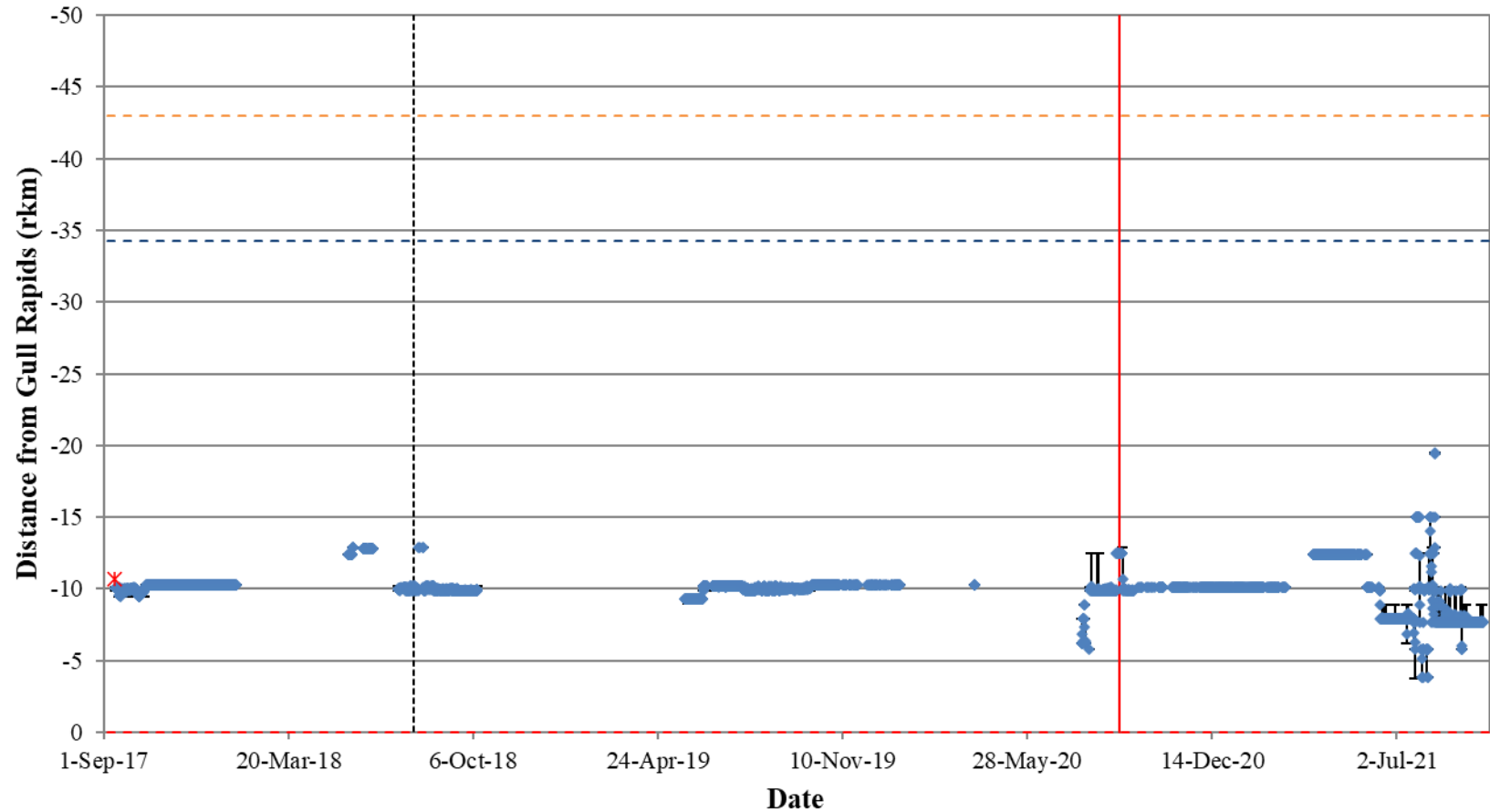




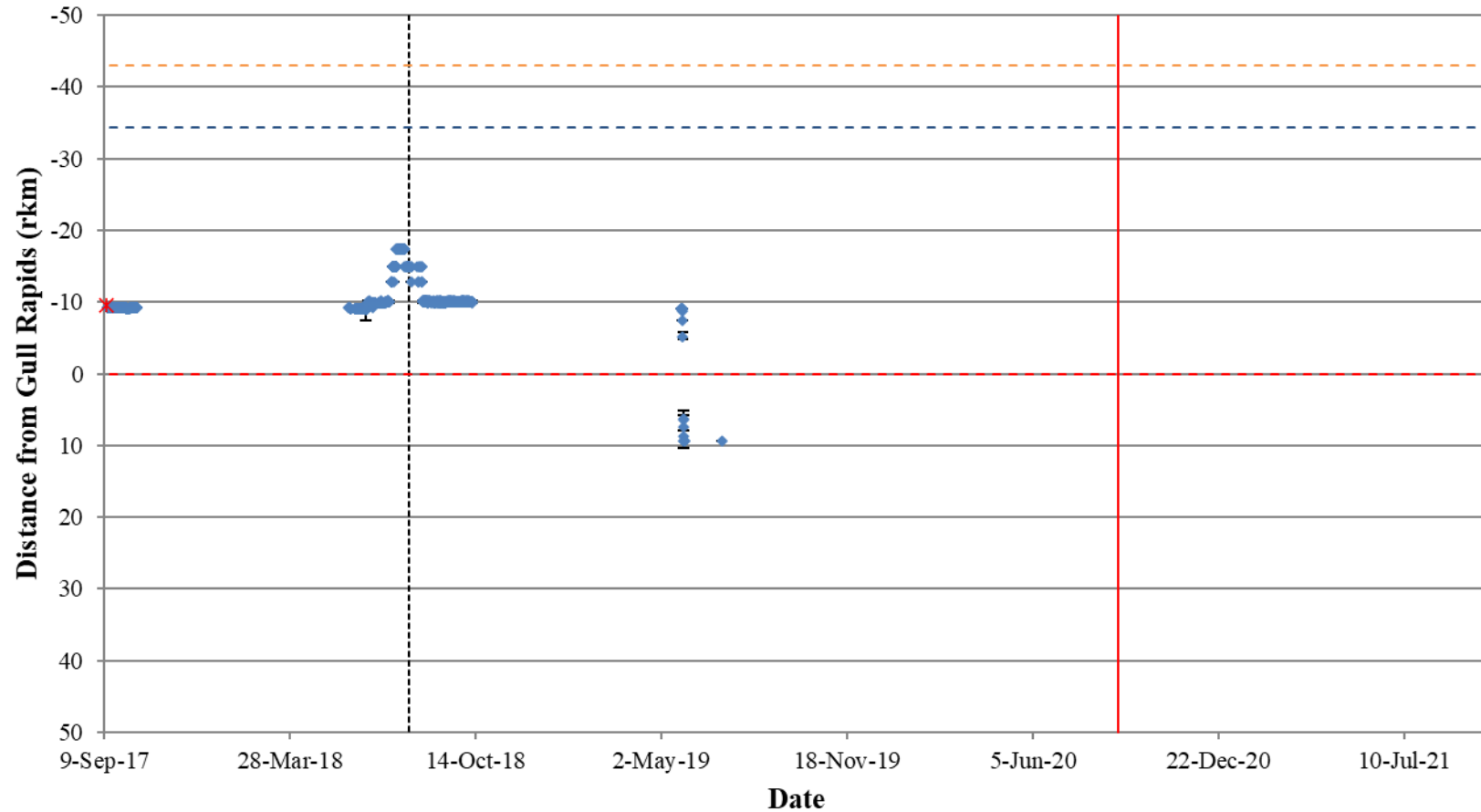
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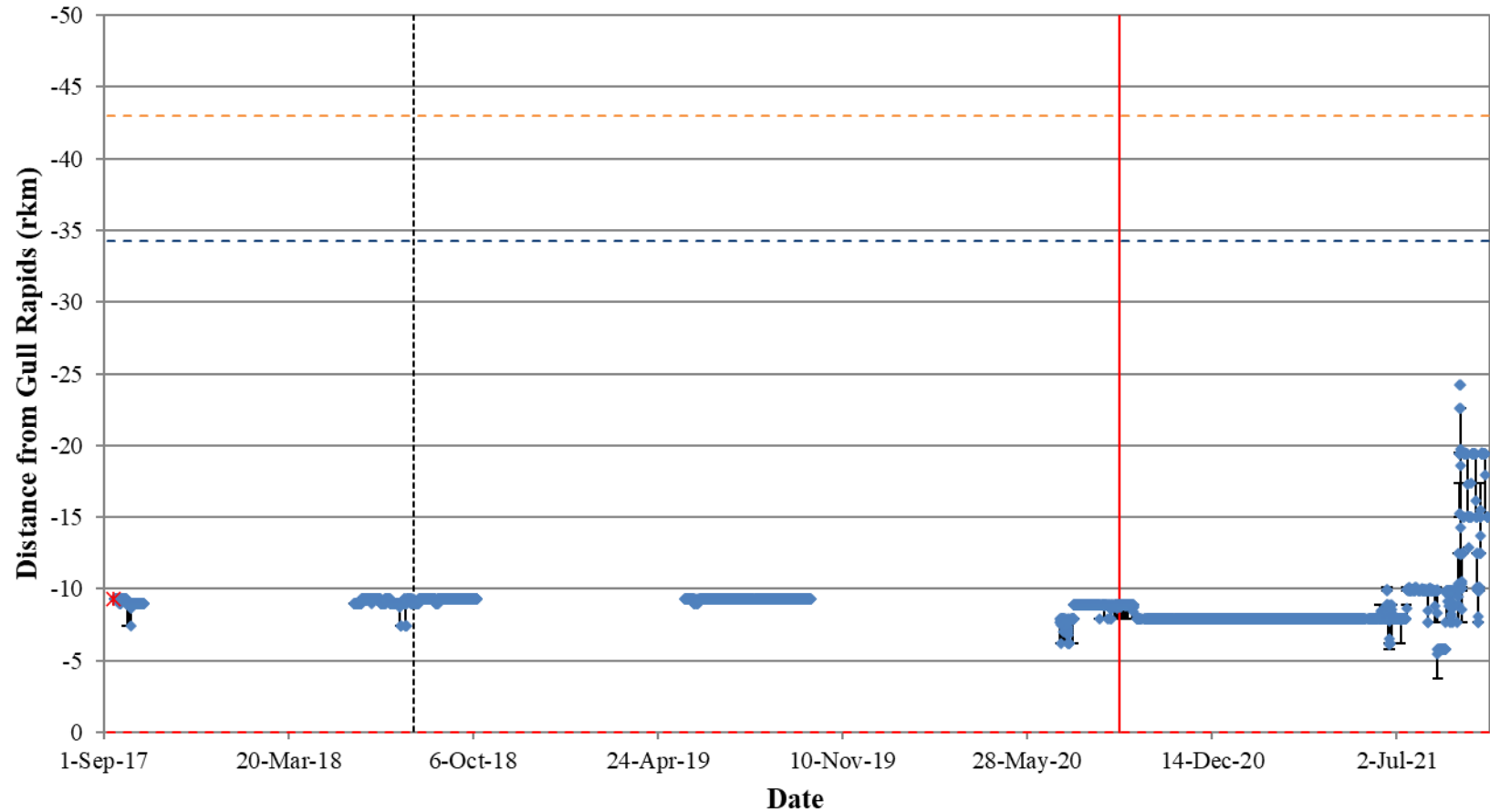
**Figure A1-14: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31776) in Gull Lake in relation to the Keyyask GS (rkm 0), from September 9, 2017 to October 10, 2021. Date and location of tagging and subsequent recapture are indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keyyask GS (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange). Dashed black vertical line indicates start of spillway operation (Aug 3, 2018). Solid red vertical line indicates completion of reservoir impoundment (September 5, 2020).**



**Figure A1-15: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31777) in Gull Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to October 10, 2021. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange). Dashed black vertical line indicates start of spillway operation (Aug 3, 2018). Solid red vertical line indicates completion of reservoir impoundment (September 5, 2020).**

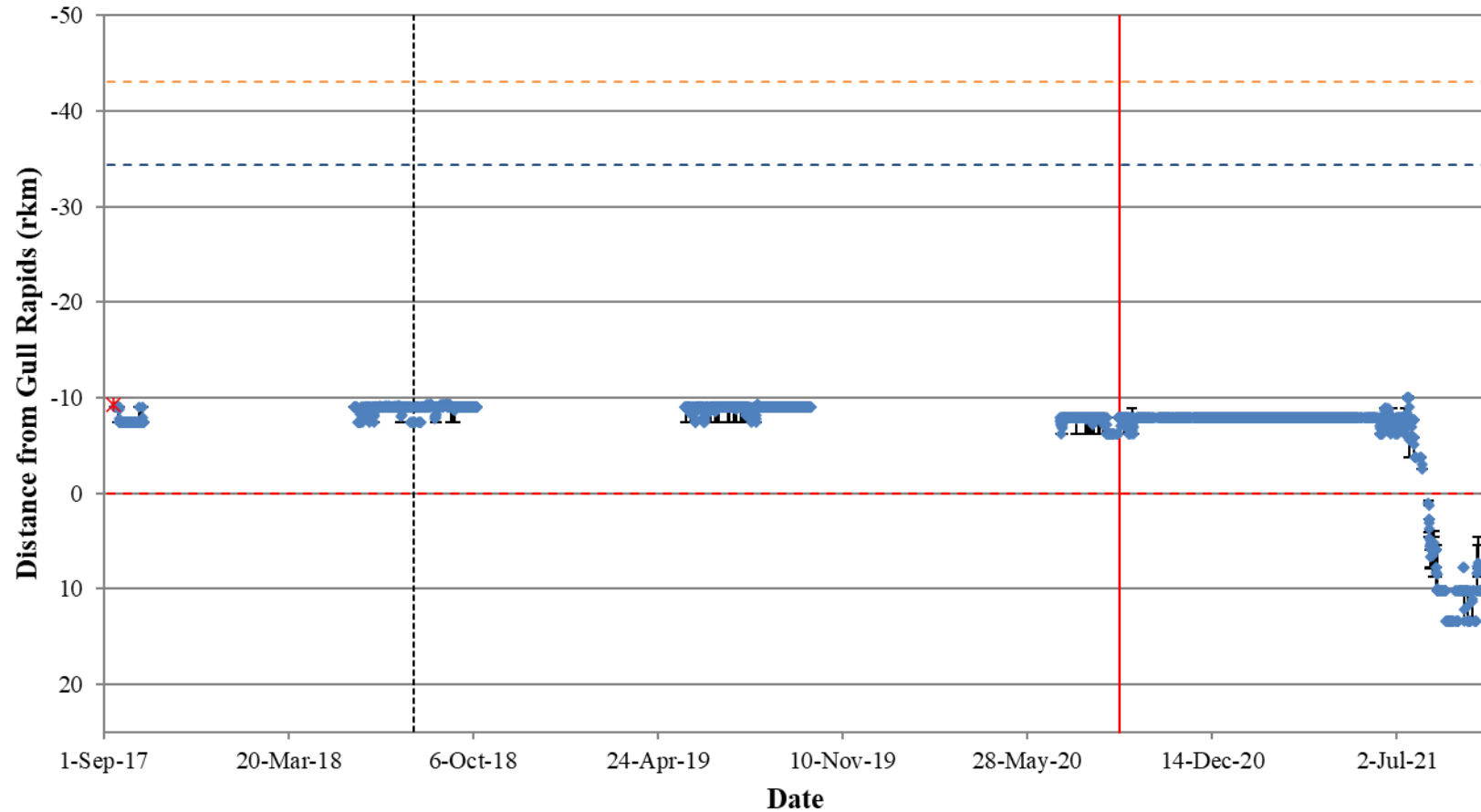


**Figure A1-16: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31778) in Gull Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to October 10, 2021. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange). Dashed black vertical line indicates start of spillway operation (Aug 3, 2018). Solid red vertical line indicates completion of reservoir impoundment (September 5, 2020).**

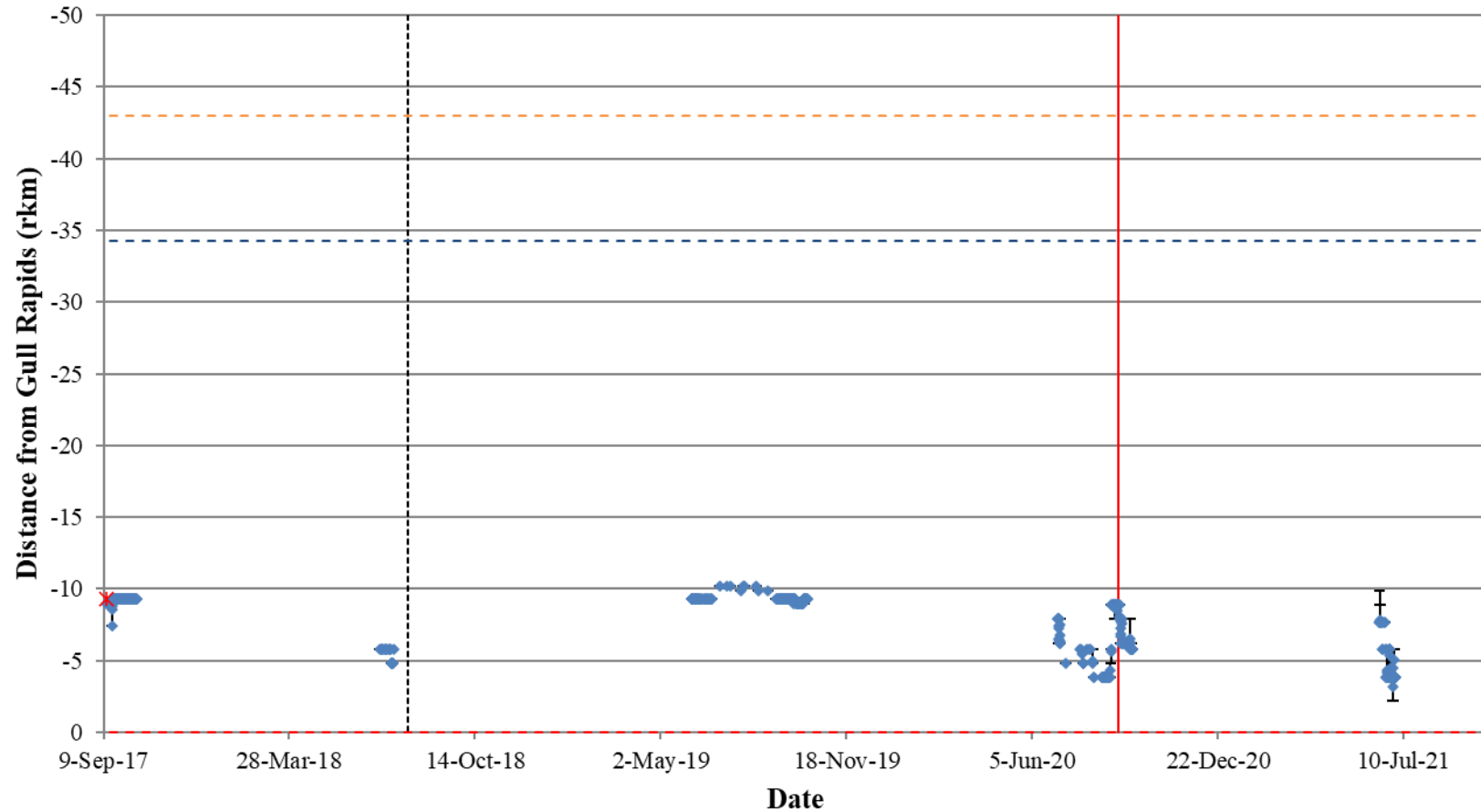


**Figure A1-17: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31779) in Gull Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to October 10, 2021. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange). Dashed black vertical line indicates start of spillway operation (Aug 3, 2018). Solid red vertical line indicates completion of reservoir impoundment (September 5, 2020).**

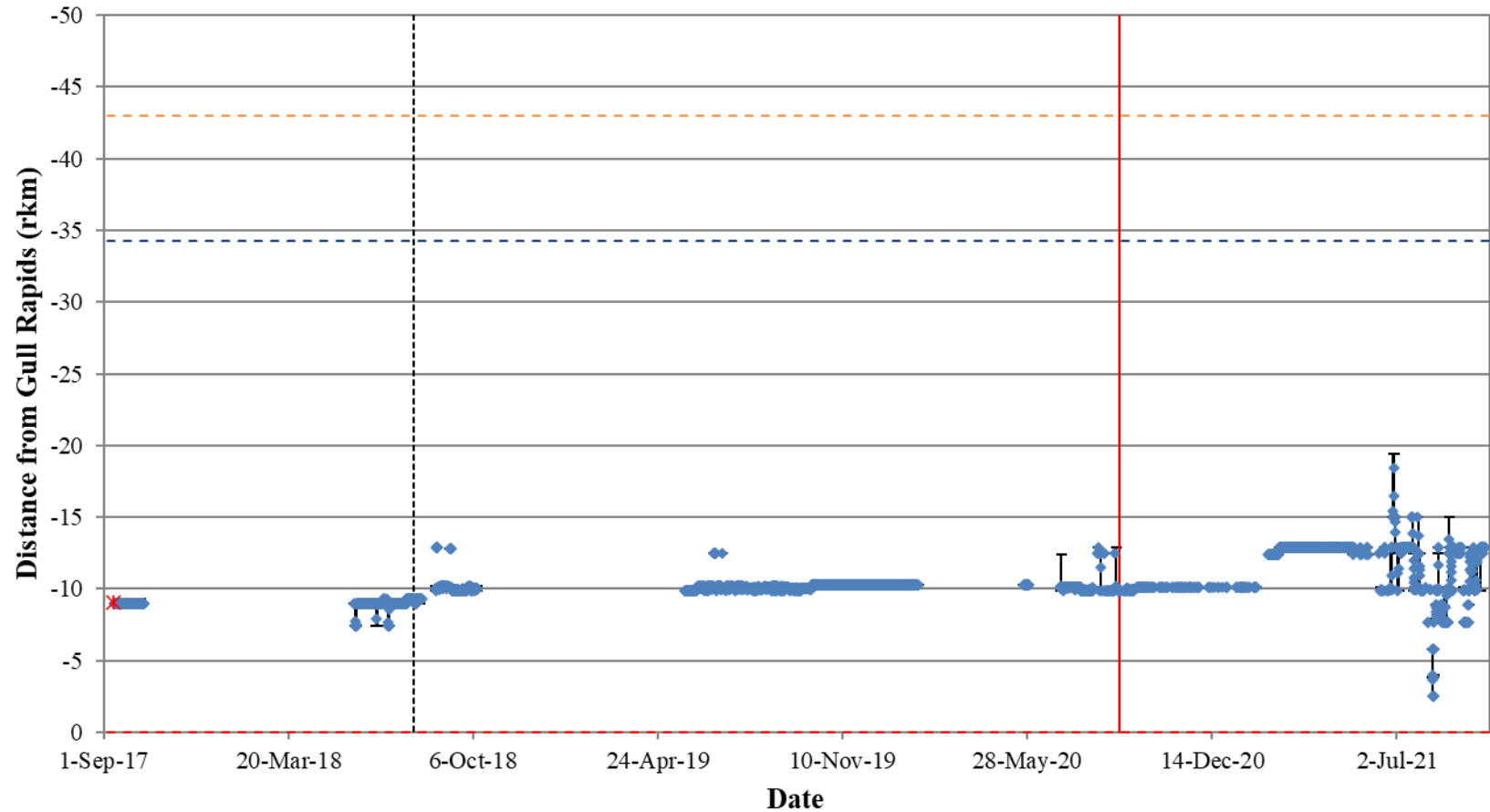




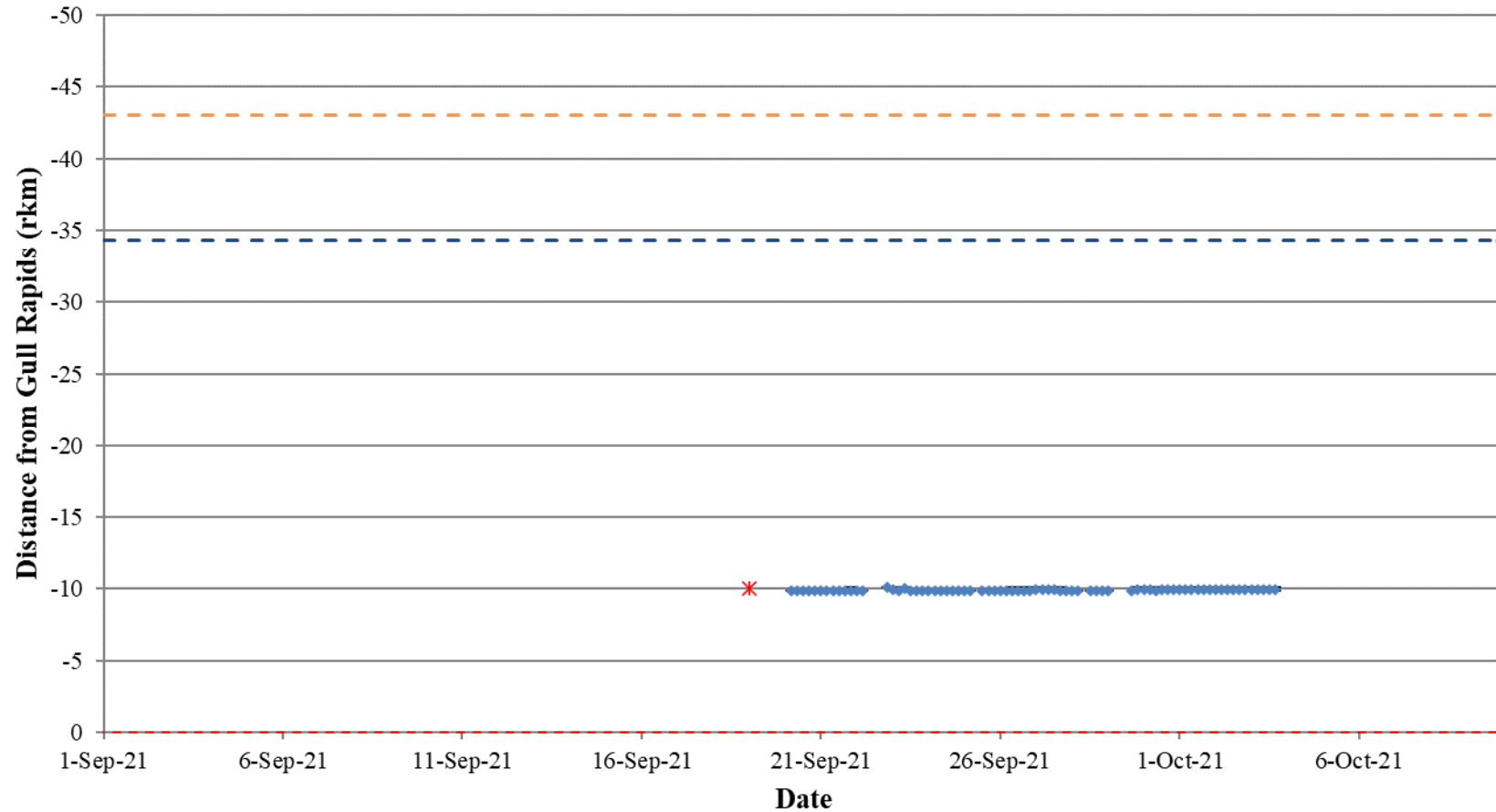
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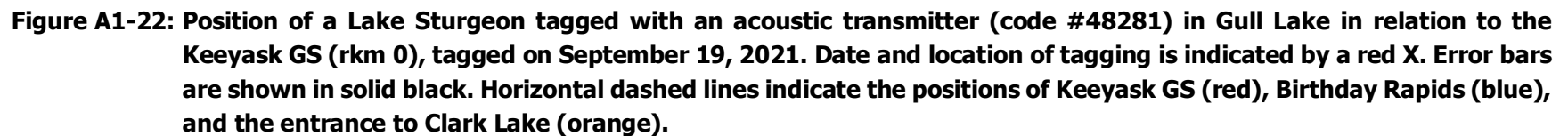
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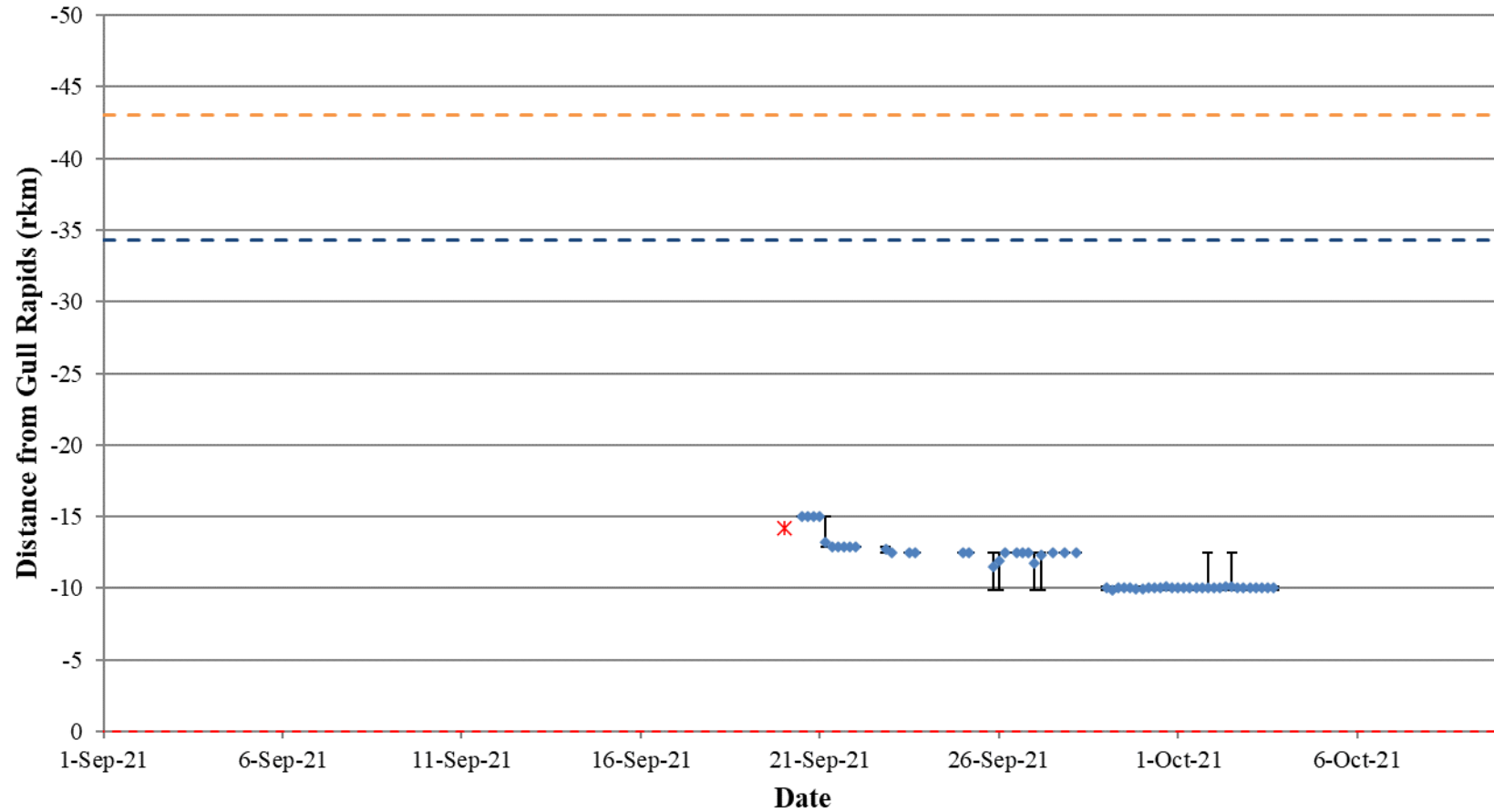
**Figure A1-20: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31782) in Gull Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to October 10, 2021. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange). Dashed black vertical line indicates start of spillway operation (Aug 3, 2018). Solid red vertical line indicates completion of reservoir impoundment (September 5, 2020).**



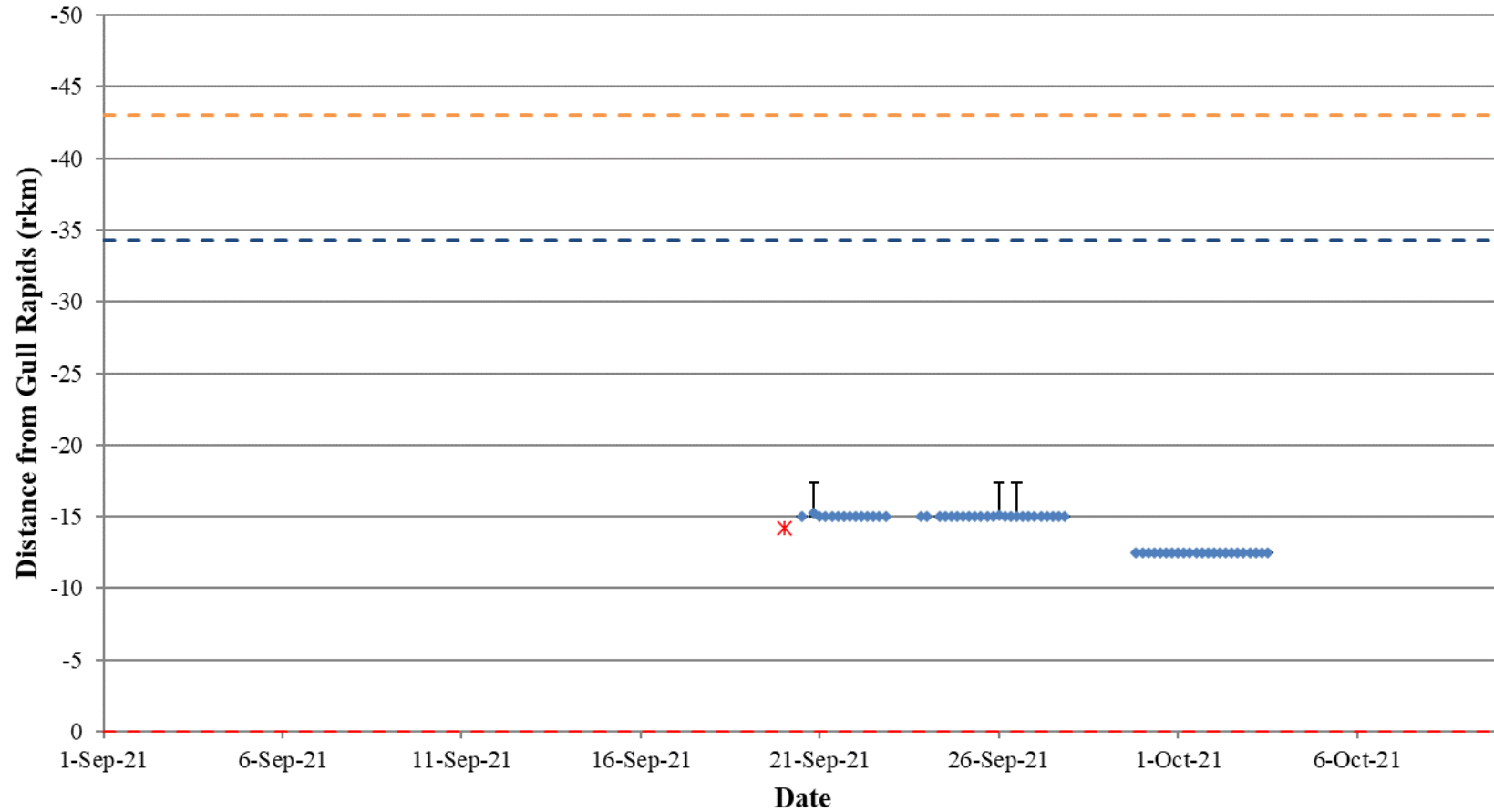
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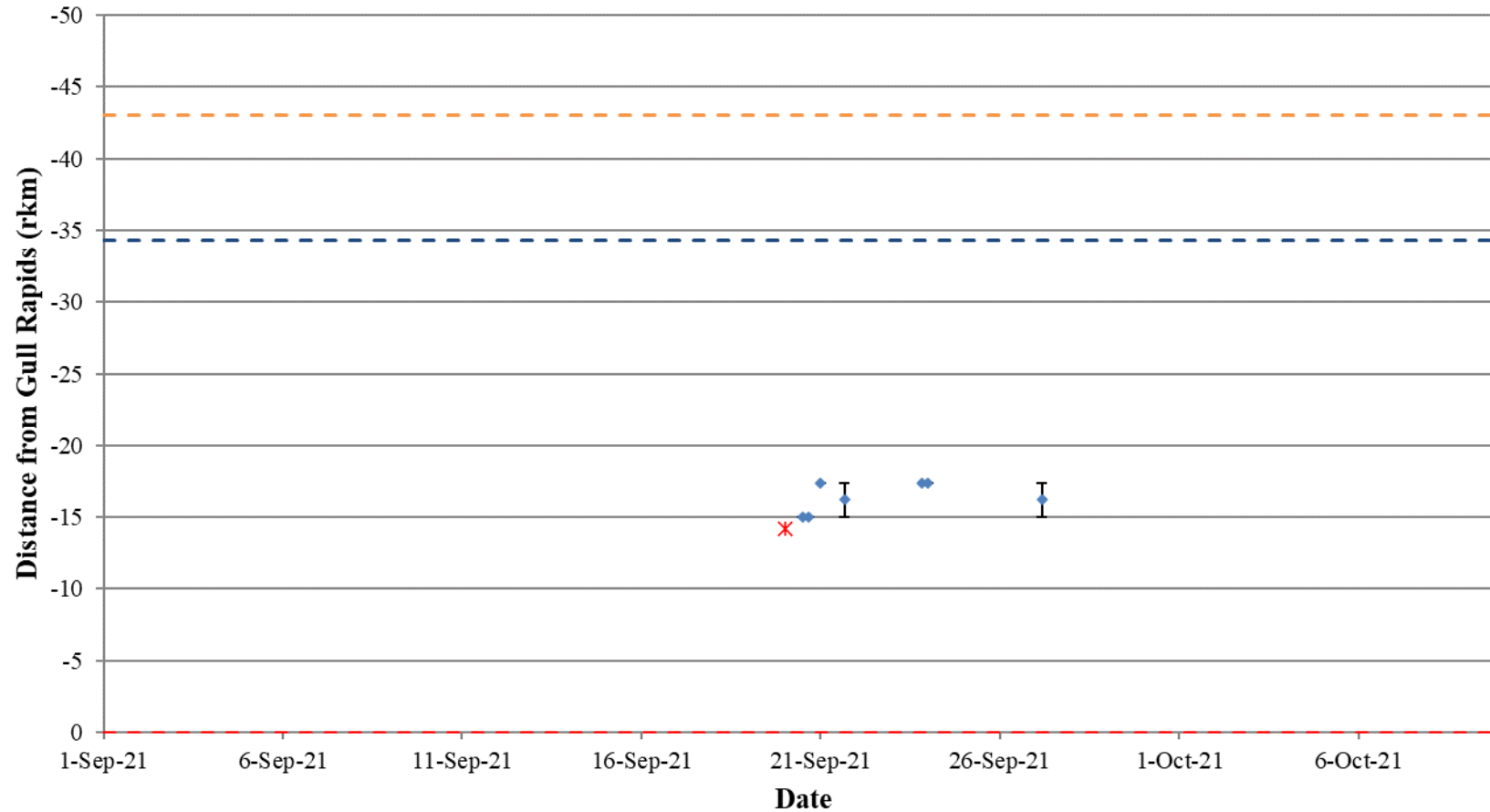




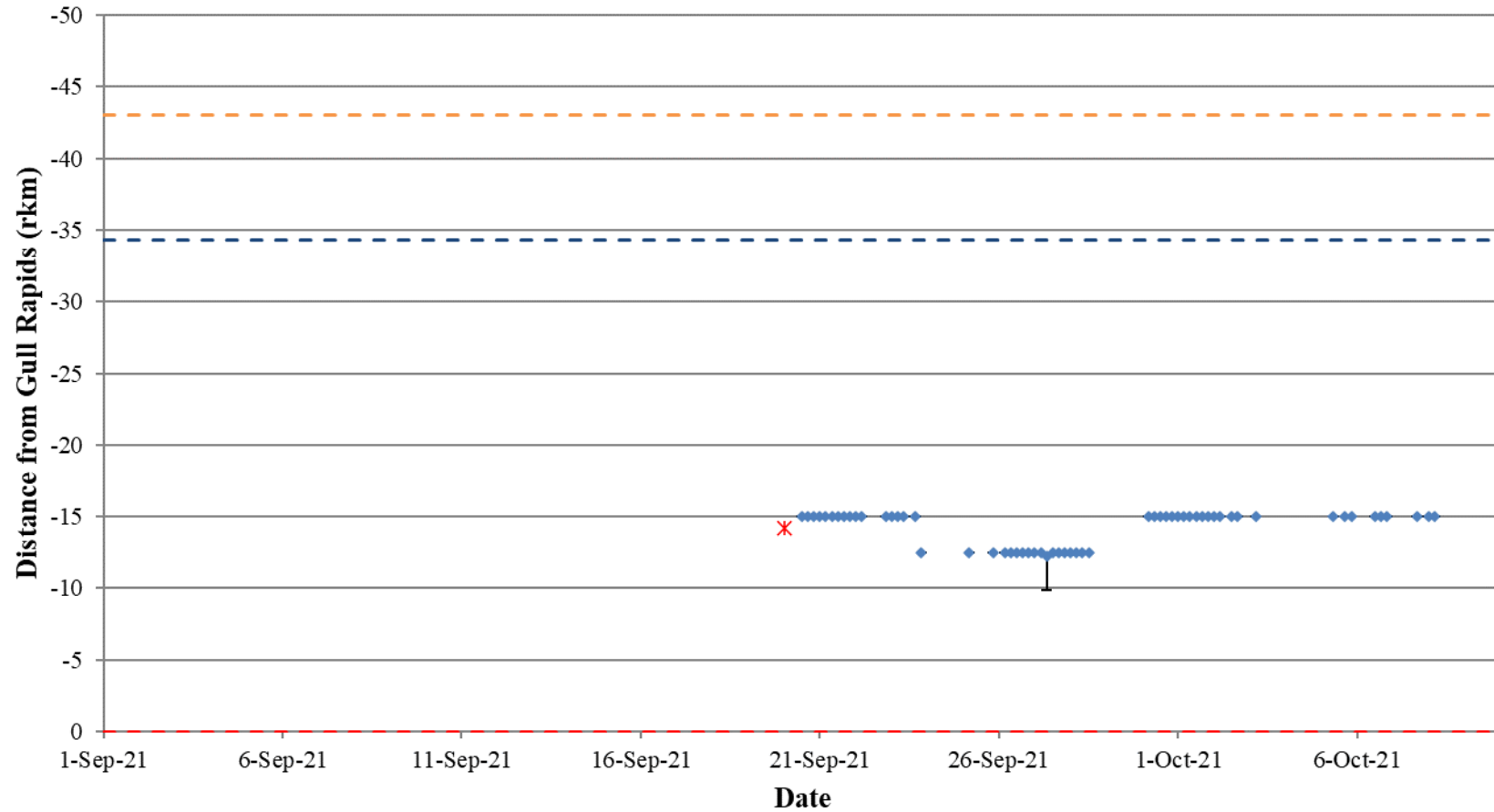
**Figure A1-23: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #48286) in Gull Lake in relation to the Keeyask GS (rkm 0), tagged on September 20, 2021. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).**



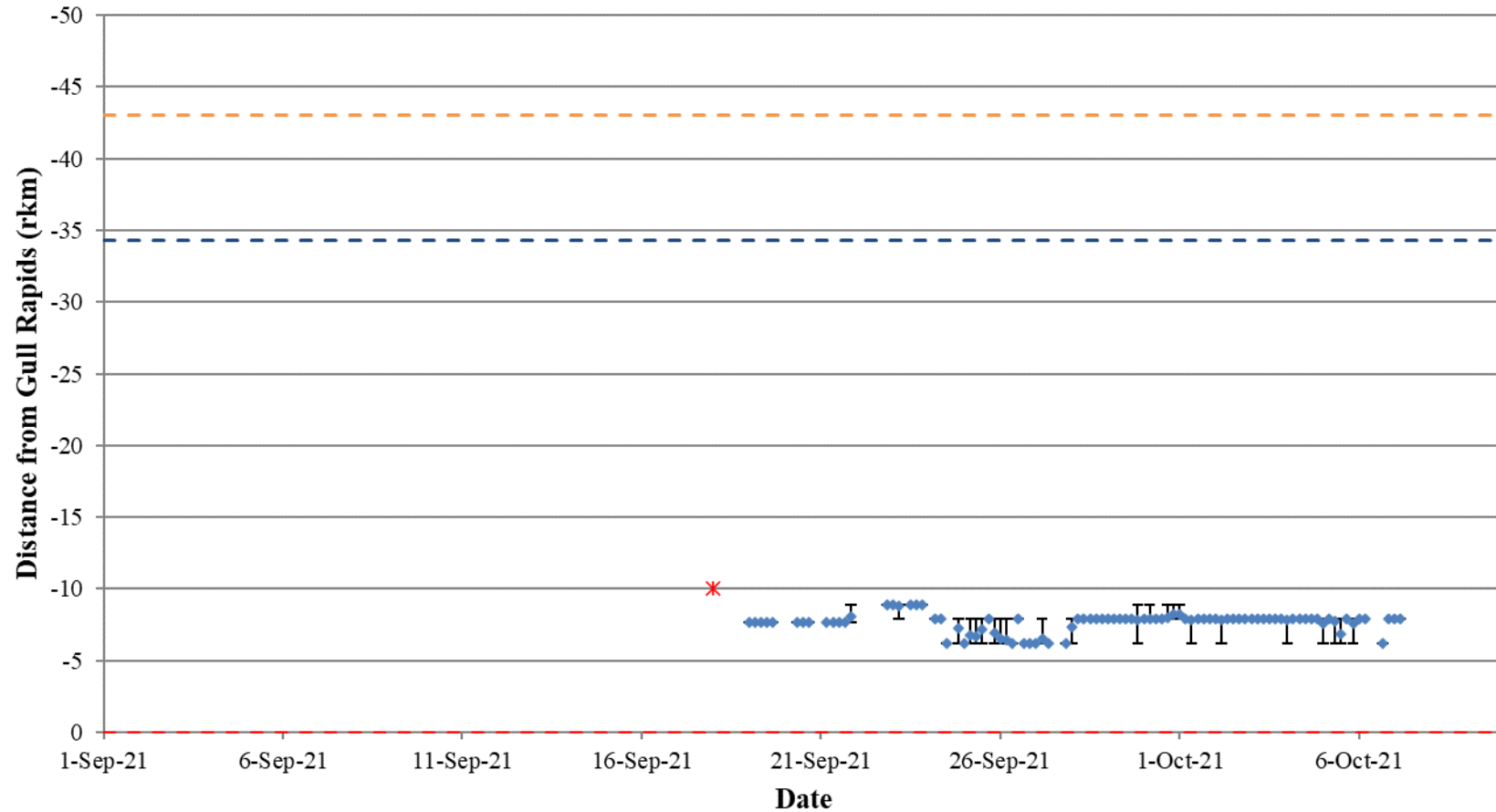
**Figure A1-24: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #48287) in Gull Lake in relation to the Keeyask GS (rkm 0), tagged on September 20, 2021. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).**



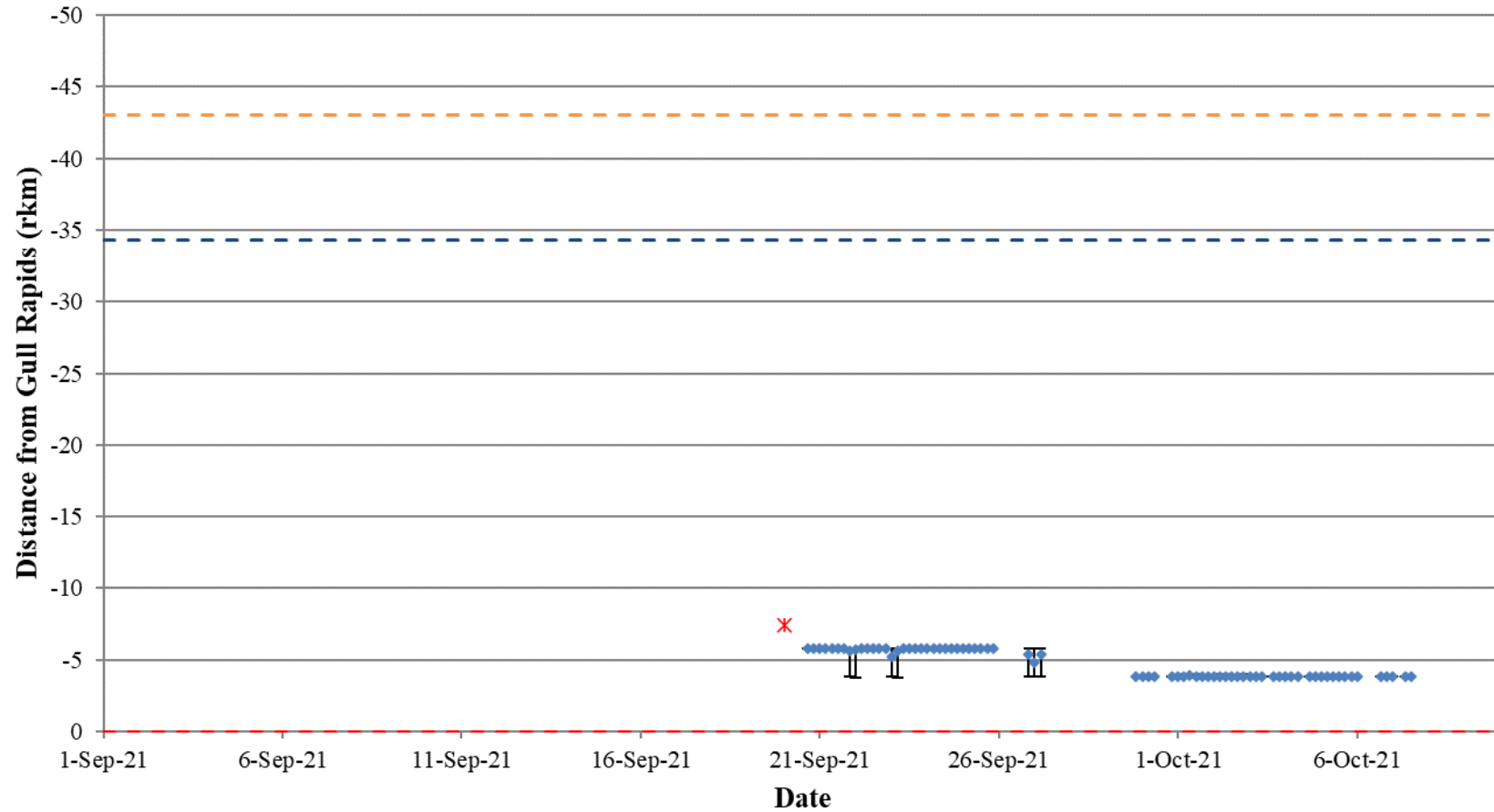
**Figure A1-25: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #48292) in Gull Lake in relation to the Keeyask GS (rkm 0), tagged on September 20, 2021. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).**



**Figure A1-26: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #48293) in Gull Lake in relation to the Keeyask GS (rkm 0), tagged on September 20, 2021. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).**

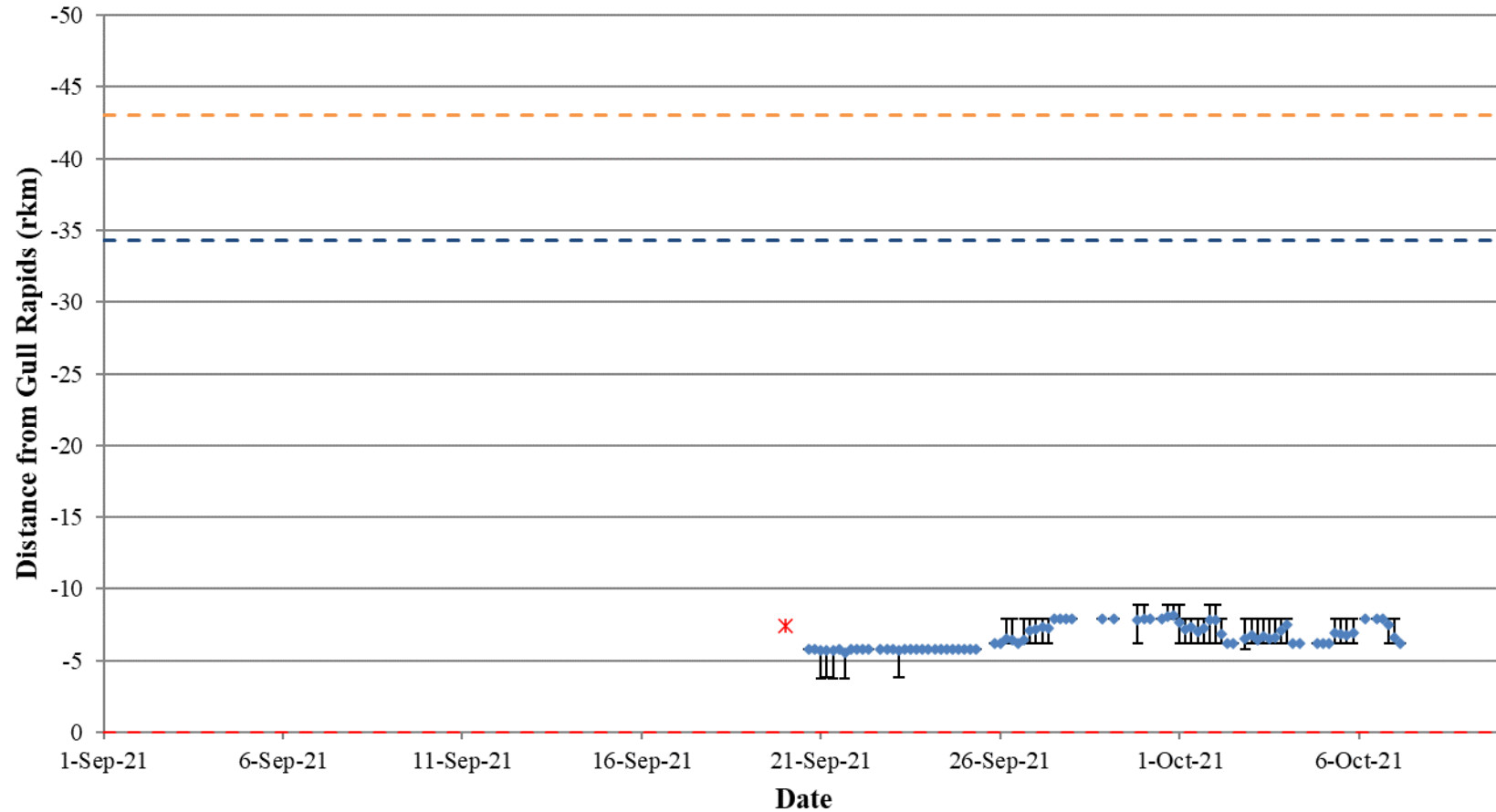


**Figure A1-27: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #48297) in Gull Lake in relation to the Keeyask GS (rkm 0), tagged on September 18, 2021. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).**

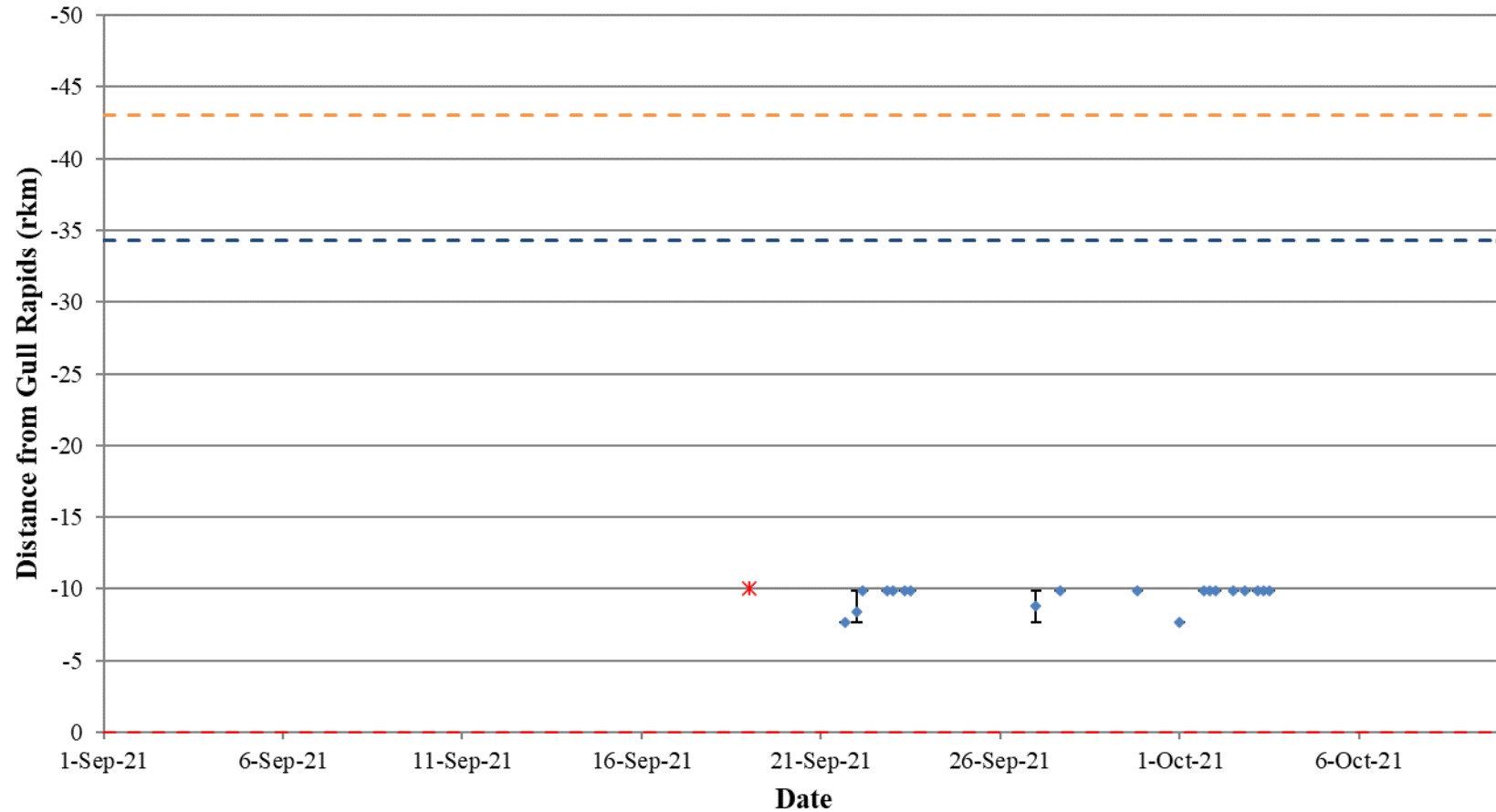


**Figure A1-28: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #48298) in Gull Lake in relation to the Keeyask GS (rkm 0), tagged on September 20, 2021. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).**

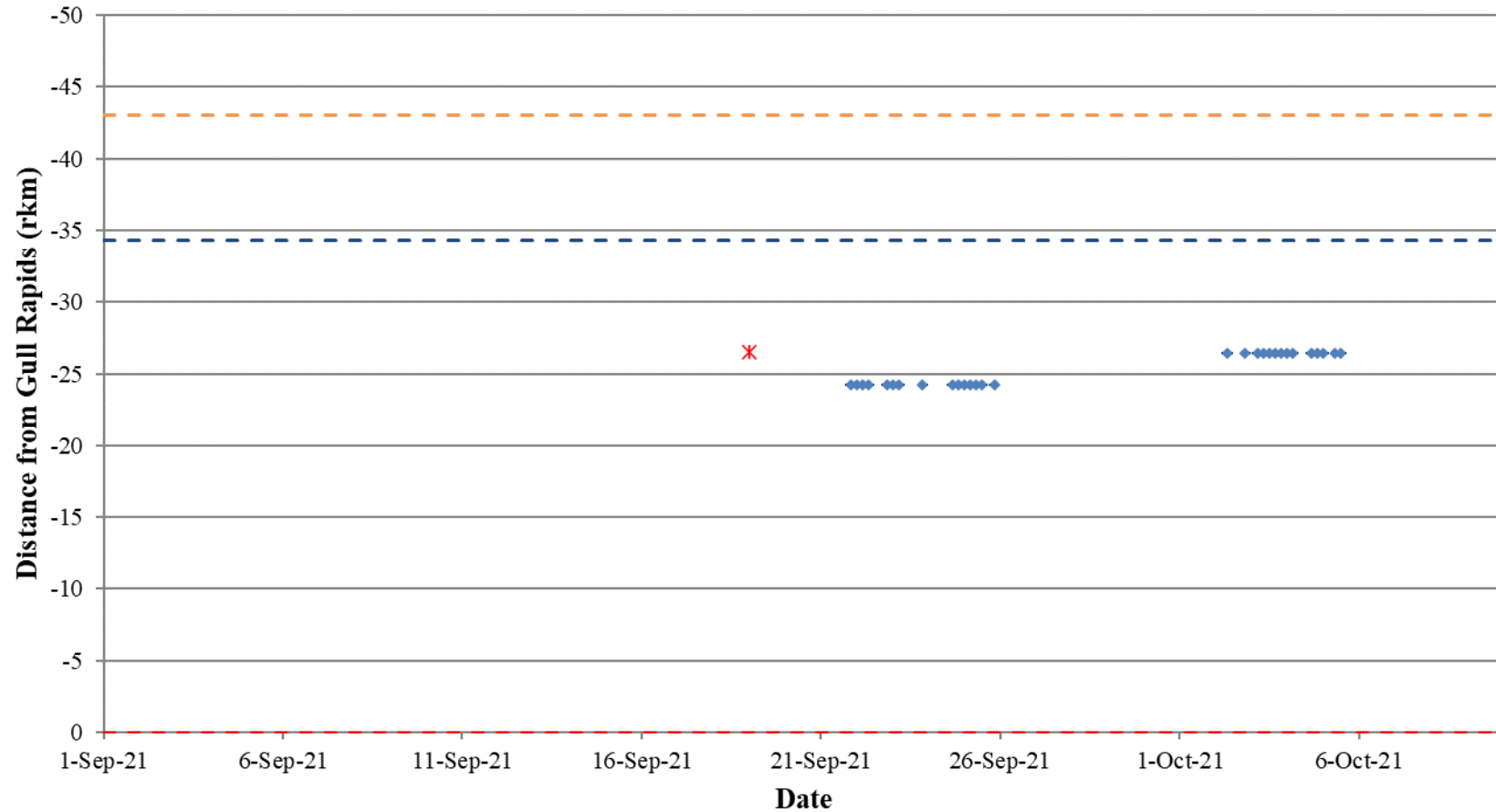




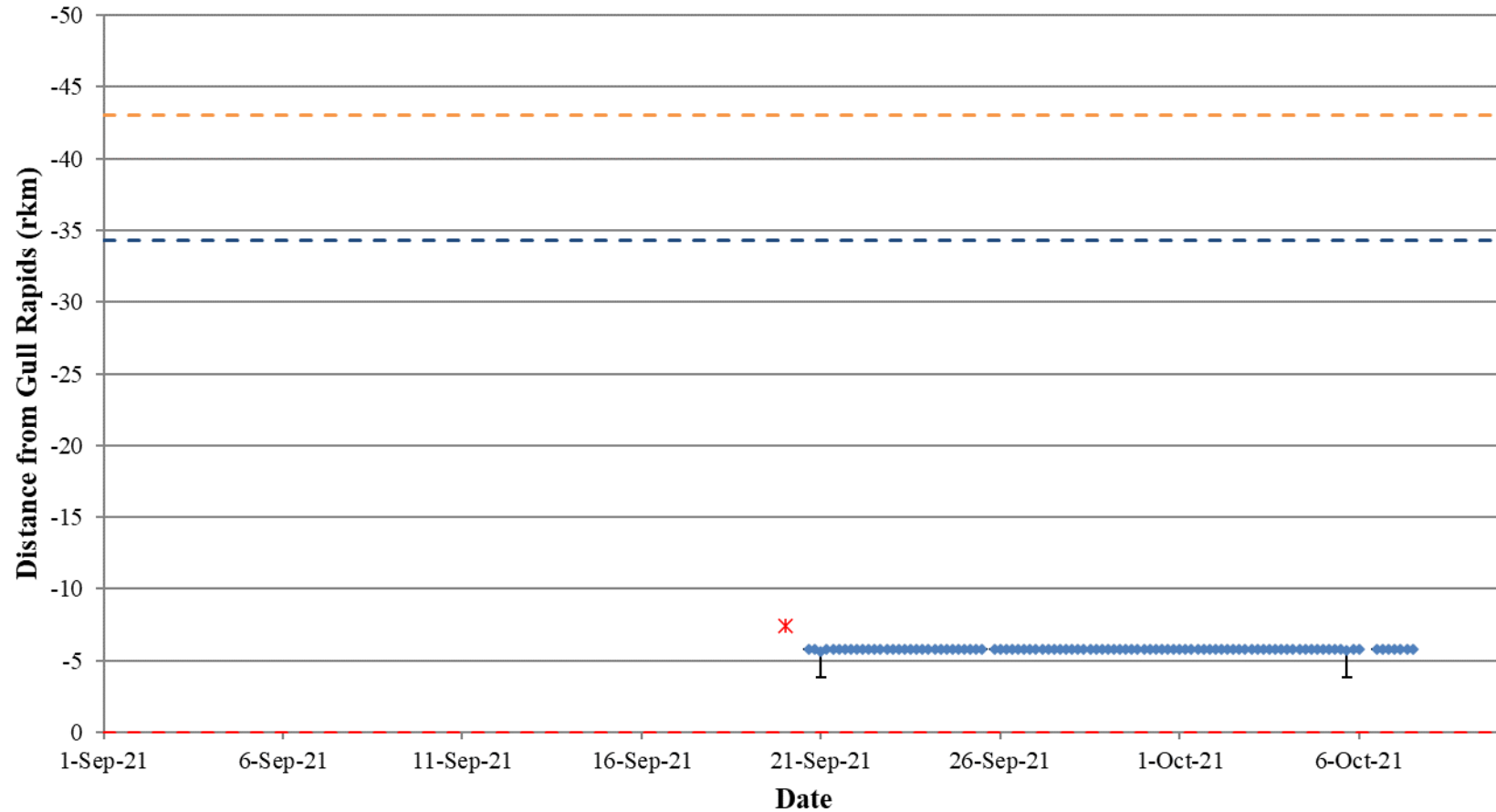
**Figure A1-29: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #48299) in Gull Lake in relation to the Keeyask GS (rkm 0), tagged on September 20, 2021. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).**



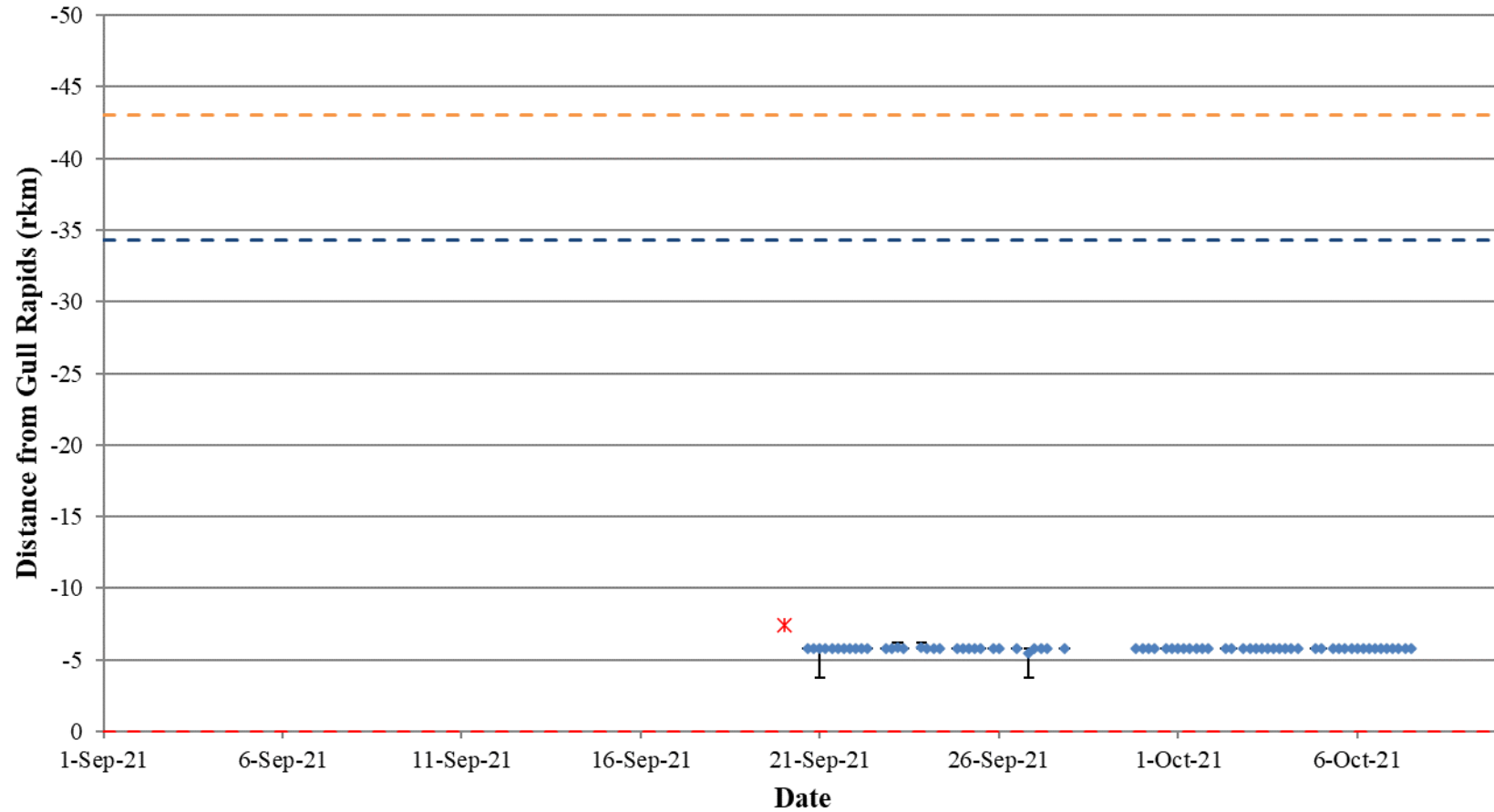
**Figure A1-30: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #48302) in Gull Lake in relation to the Keeyask GS (rkm 0), tagged on September 19, 2021. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).**



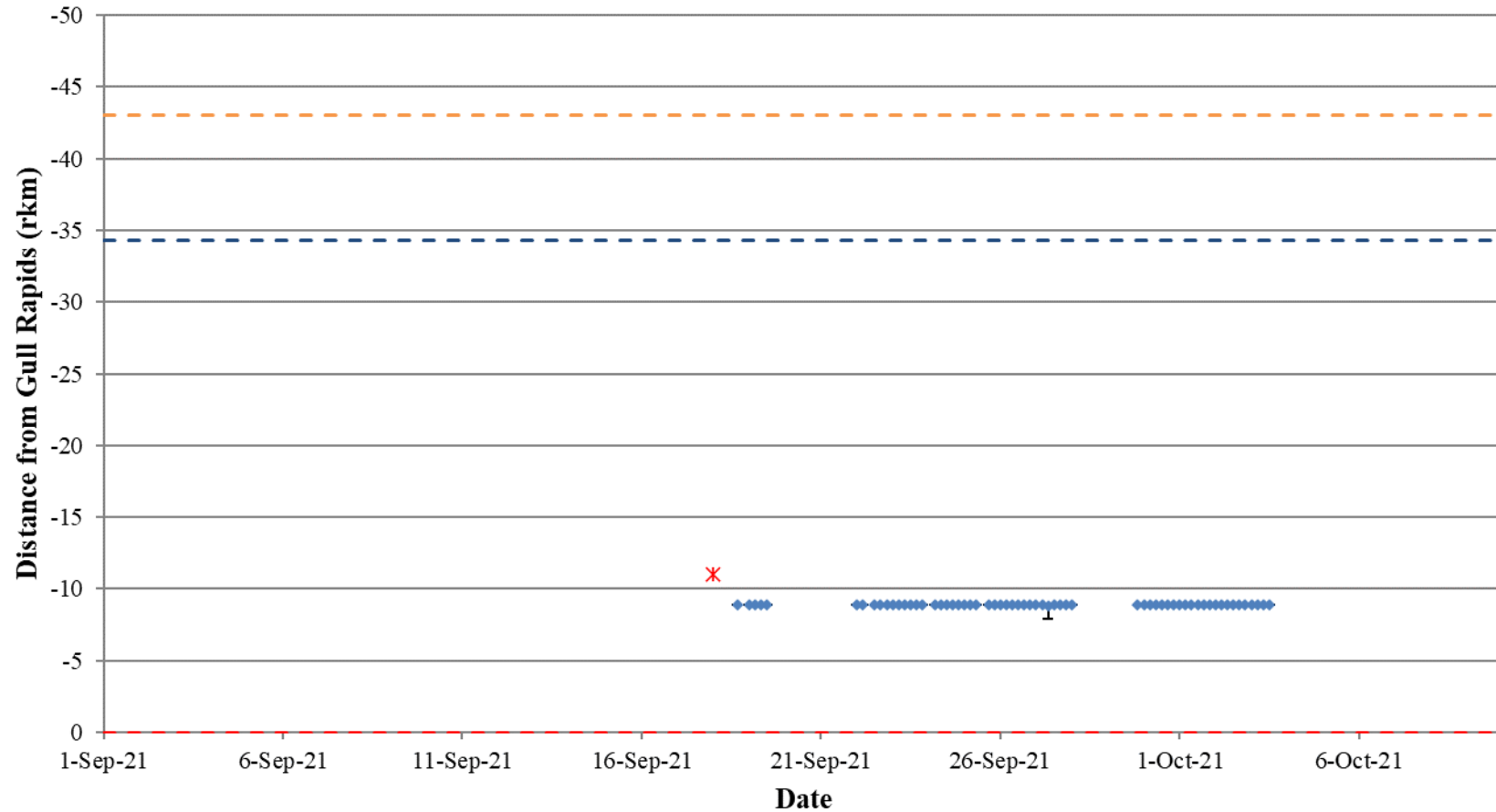
**Figure A1-31: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #48303) in Gull Lake in relation to the Keeyask GS (rkm 0), tagged on September 19, 2021. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).**



**Figure A1-32: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #48304) in Gull Lake in relation to the Keeyask GS (rkm 0), tagged on September 20, 2021. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).**

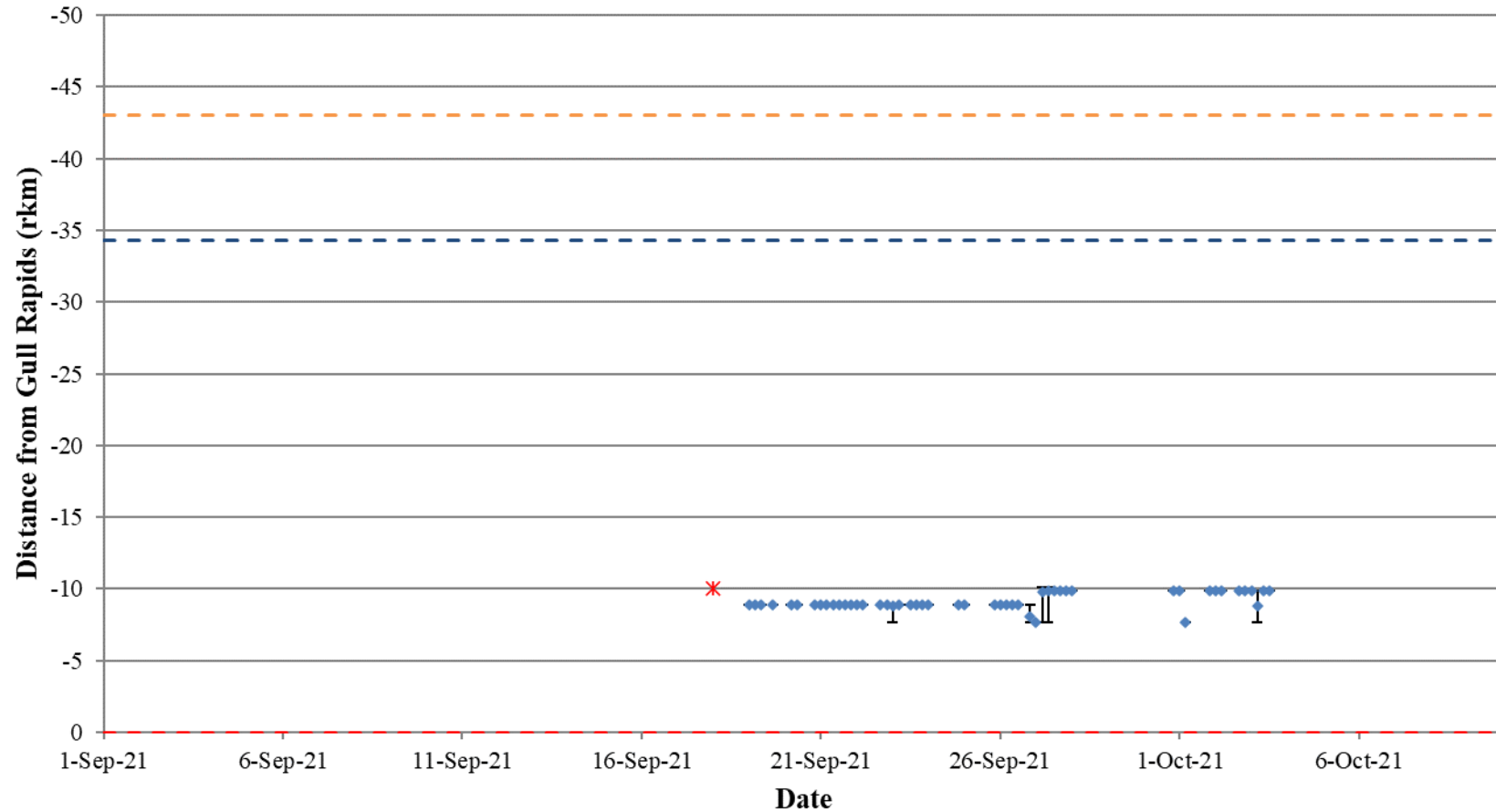


**Figure A1-33: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #48305) in Gull Lake in relation to the Keeyask GS (rkm 0), tagged on September 20, 2021. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).**

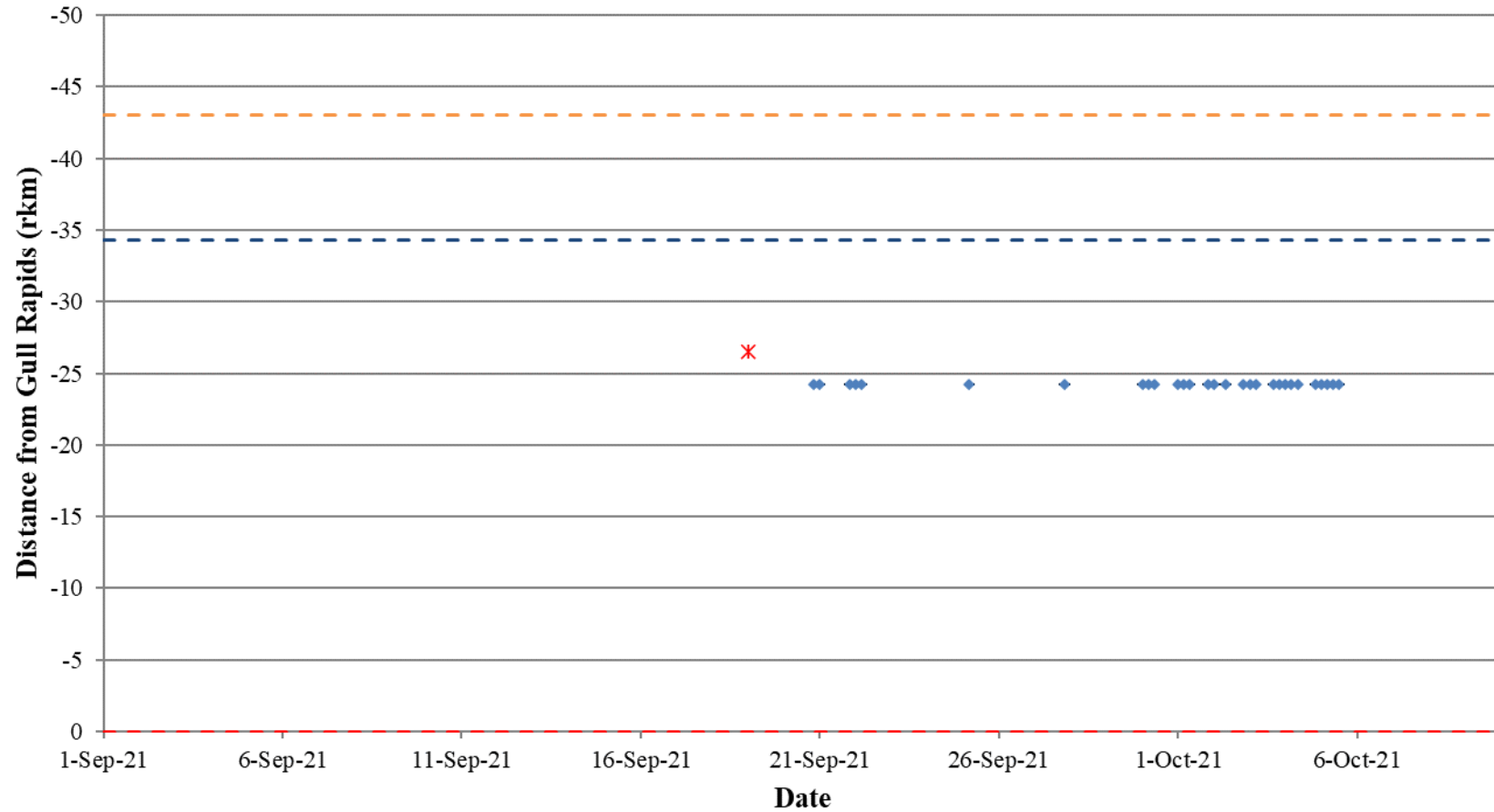


**Figure A1-34: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #48308) in Gull Lake in relation to the Keeyask GS (rkm 0), tagged on September 18, 2021. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).**

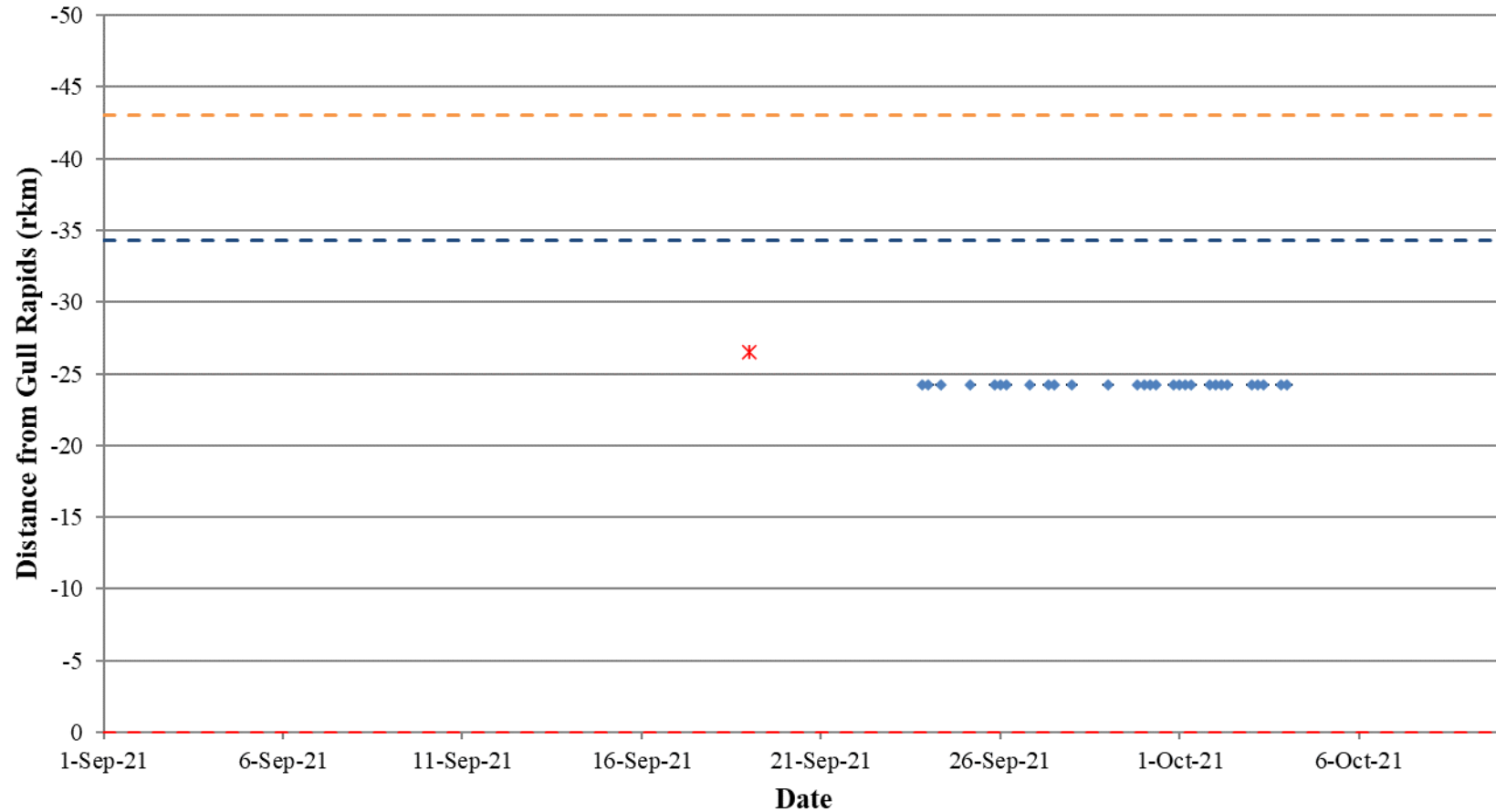




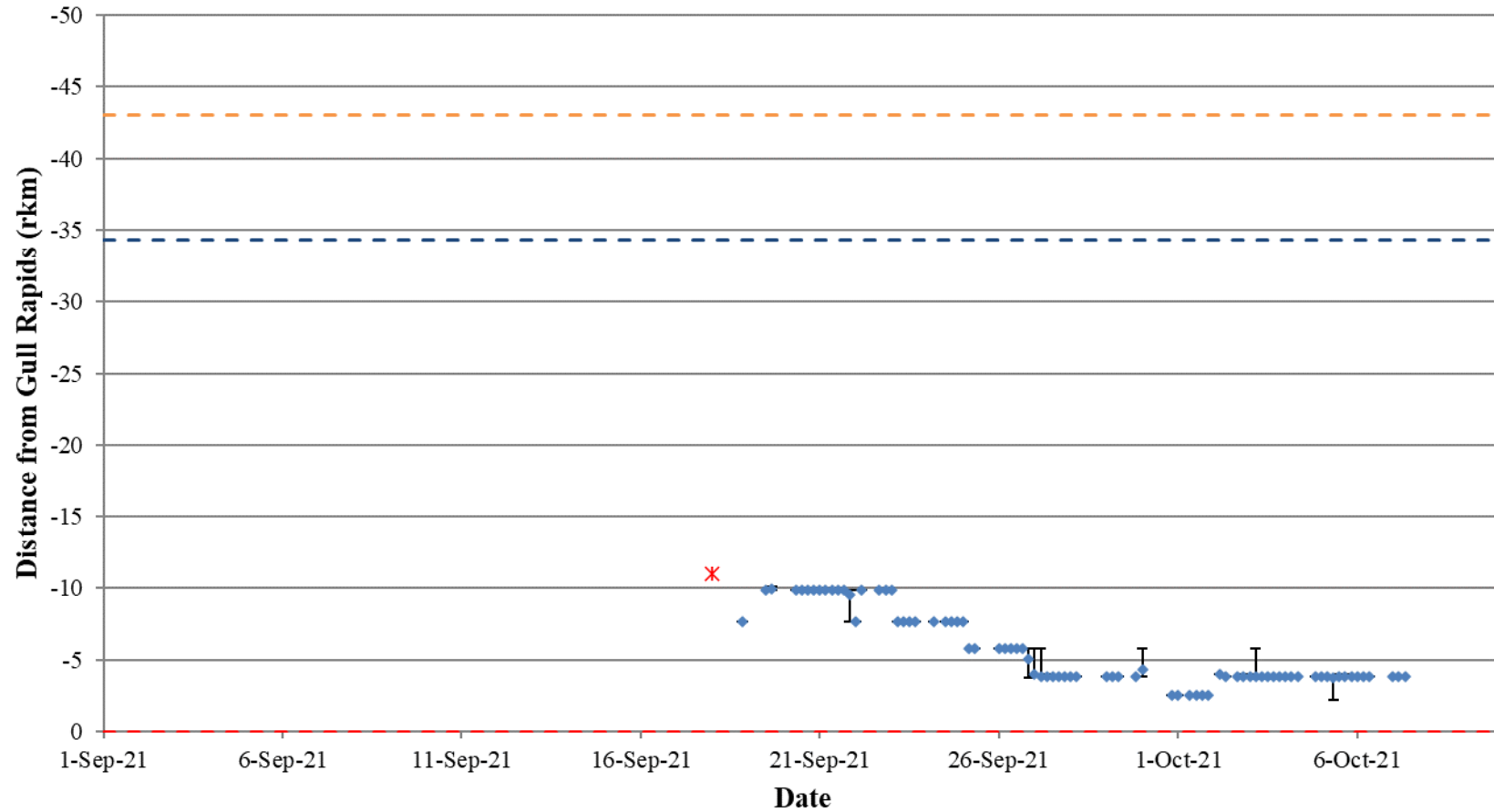
**Figure A1-35: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #48309) in Gull Lake in relation to the Keeyask GS (rkm 0), tagged on September 18, 2021. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).**



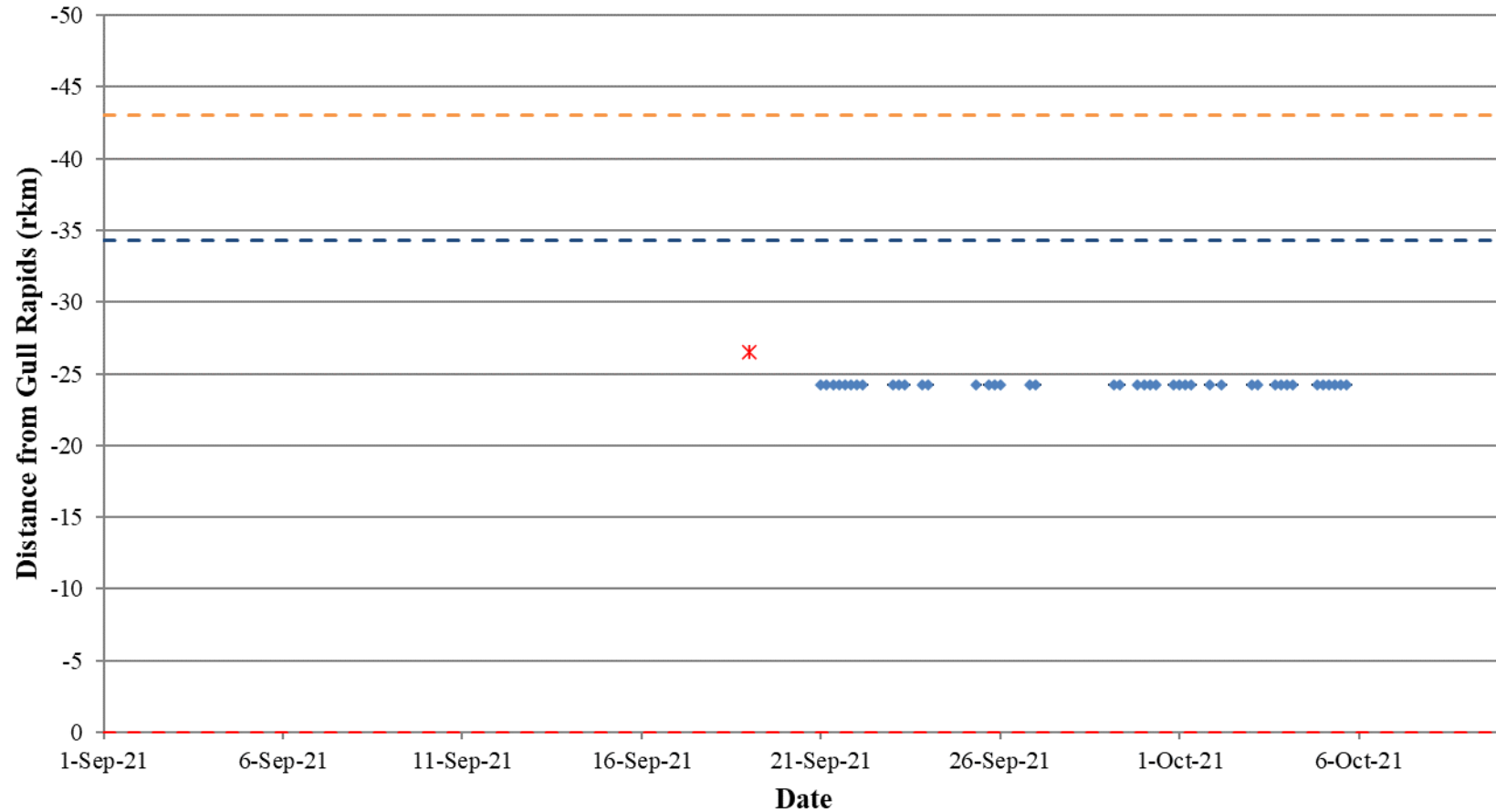
**Figure A1-36: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #48310) in Gull Lake in relation to the Keeyask GS (rkm 0), tagged on September 19, 2021. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).**



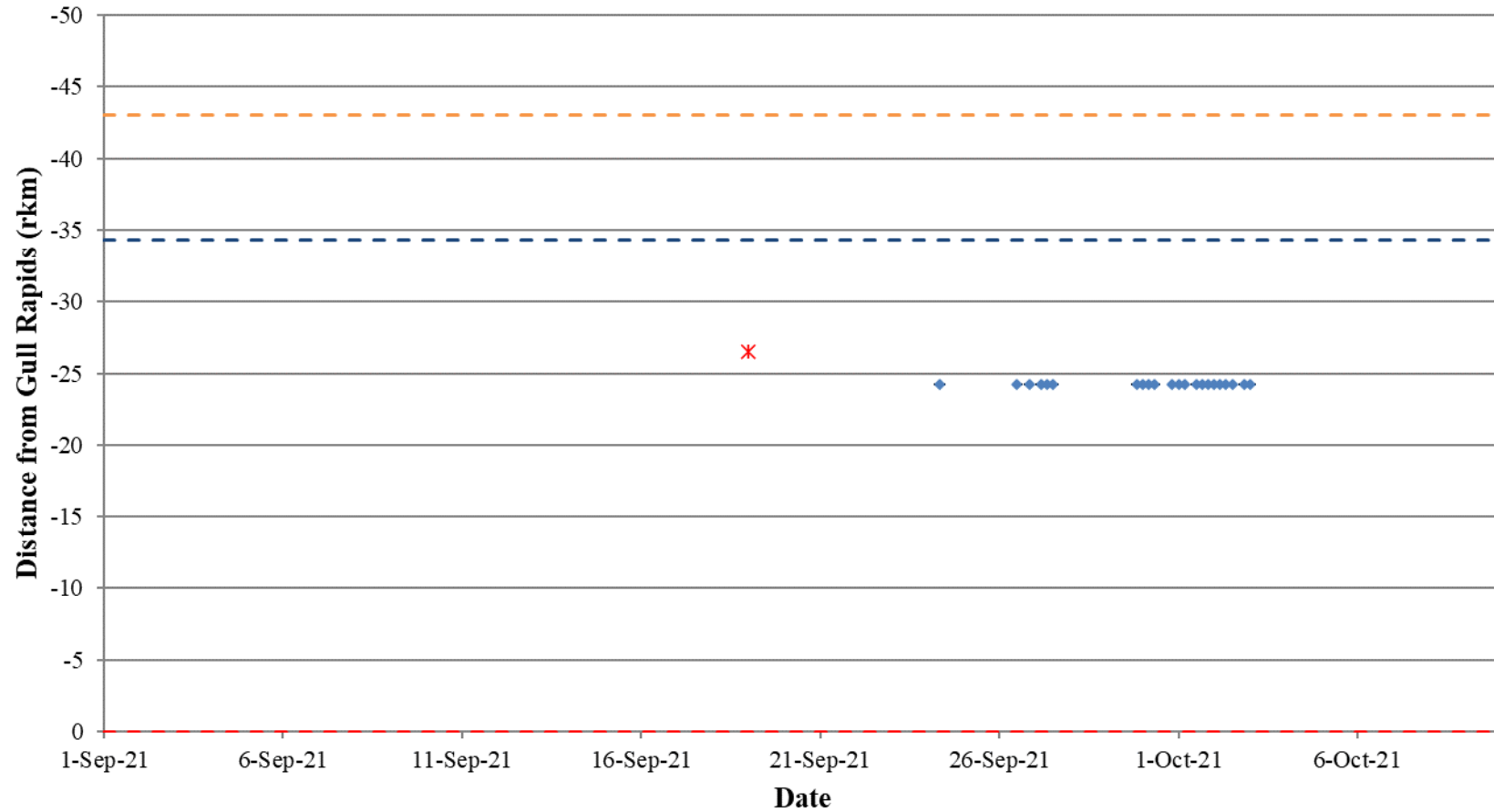
**Figure A1-37: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #48311) in Gull Lake in relation to the Keeyask GS (rkm 0), tagged on September 19, 2021. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).**



**Figure A1-38: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #48315) in Gull Lake in relation to the Keeyask GS (rkm 0), tagged on September 18, 2021. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).**



**Figure A1-39: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #48316) in Gull Lake in relation to the Keeyask GS (rkm 0), tagged on September 19, 2021. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).**



**Figure A1-40: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #48317) in Gull Lake in relation to the Keeyask GS (rkm 0), tagged on September 19, 2021. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Birthday Rapids (blue), and the entrance to Clark Lake (orange).**

## **APPENDIX 2:**

# **LOCATION SUMMARY FOR INDIVIDUAL ACOUSTIC TAGGED JUVENILE LAKE STURGEON DOWNSTREAM OF THE KEEYASK GS, SEPTEMBER 2017 TO OCTOBER 2021**

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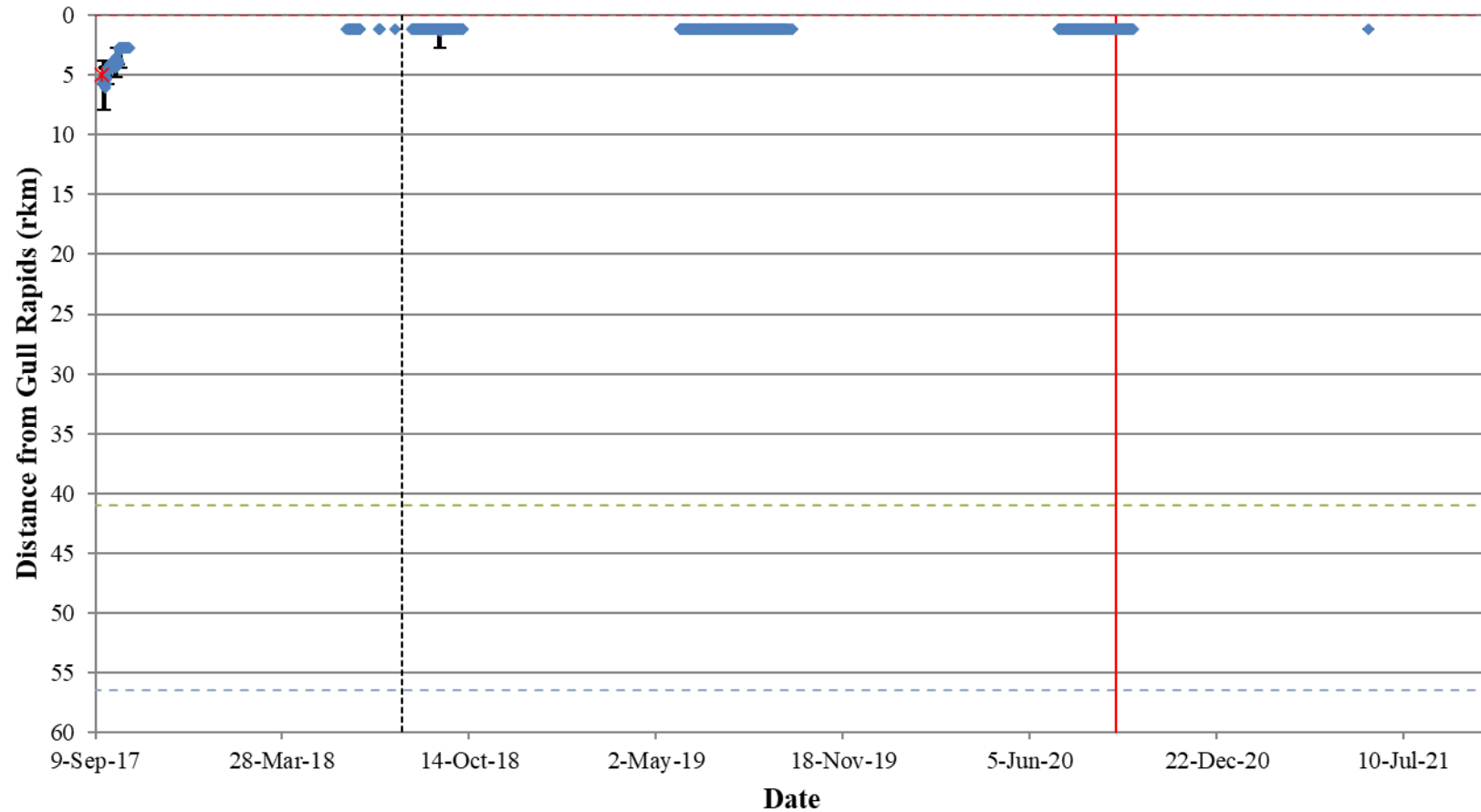
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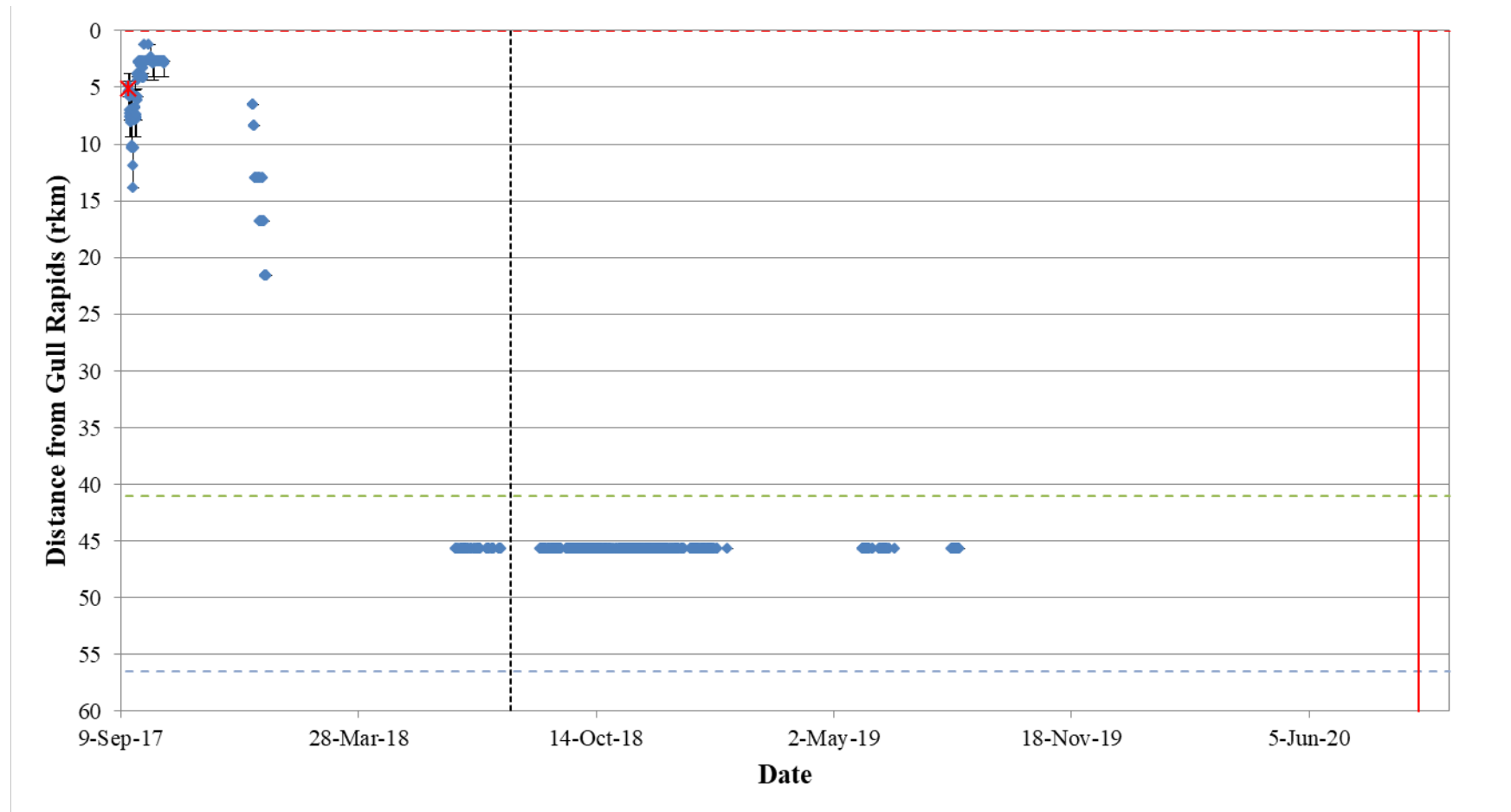
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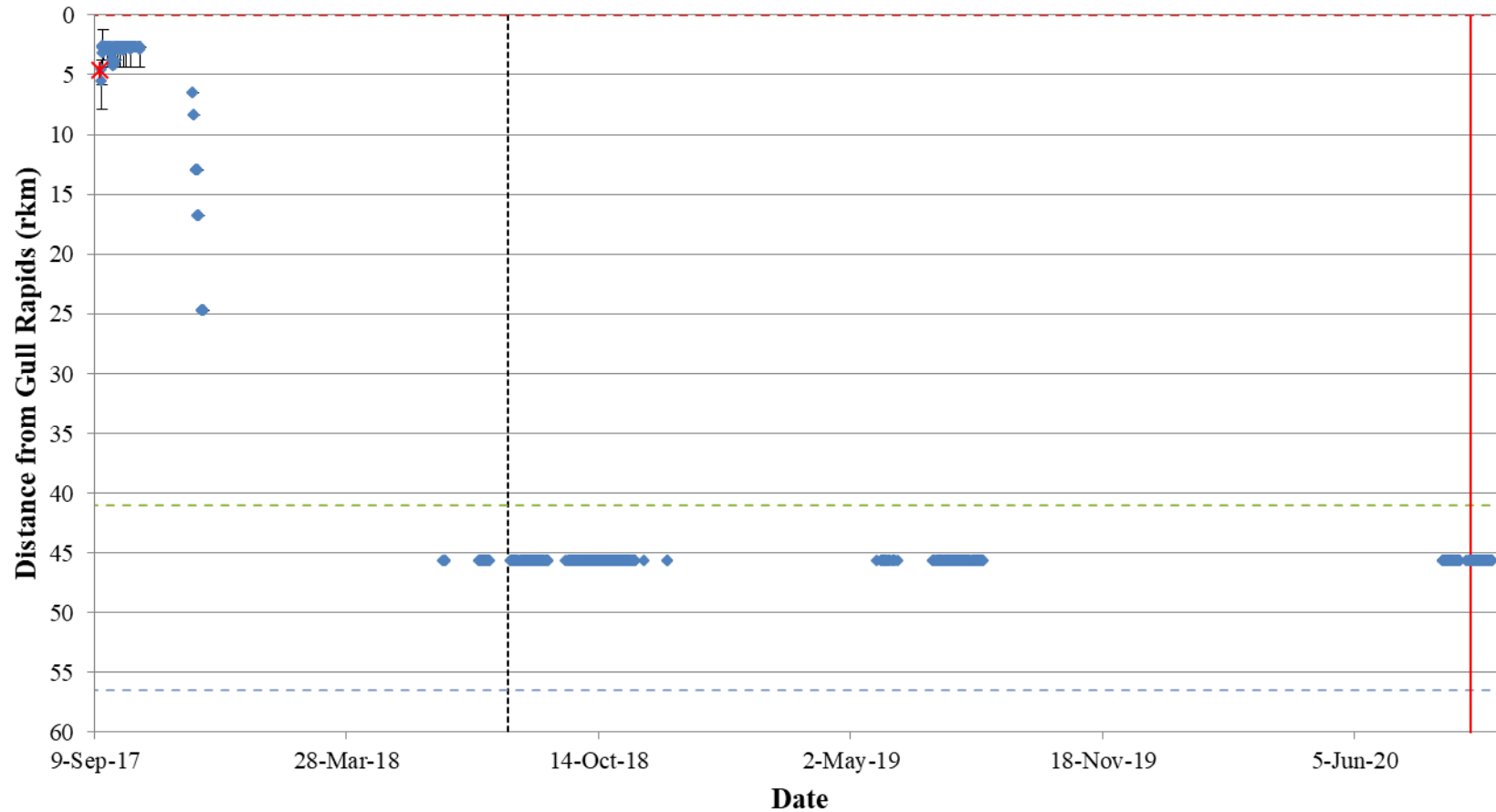
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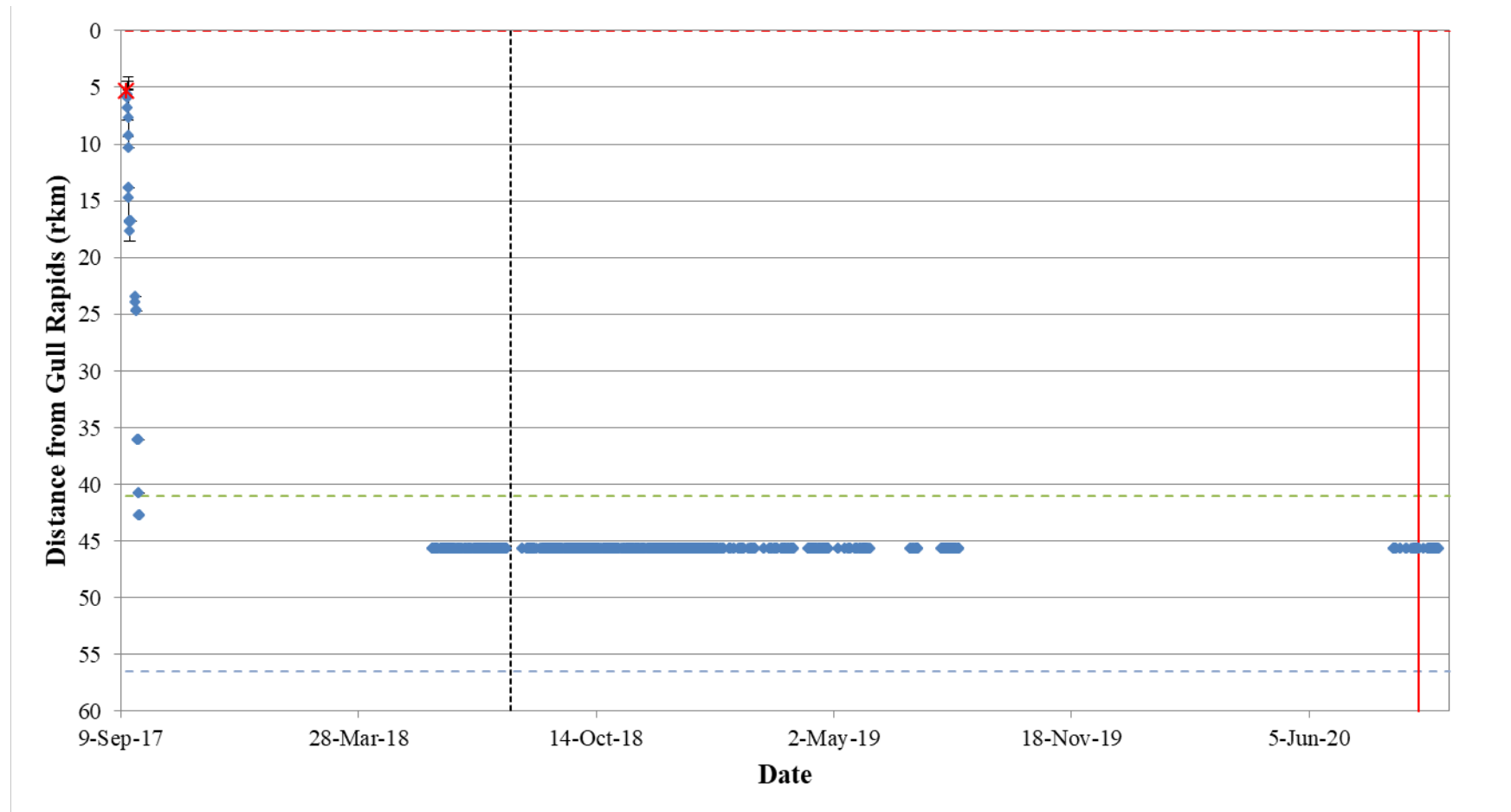
**Figure A2-1: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31688) in Stephens Lake in relation to the Keeyask GS (rkm 0), September 9, 2017 to October 10, 2021. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Kettle GS (green), and Long Spruce GS (blue). Dashed black vertical line indicates start of spillway operation (Aug 3, 2018). Solid red vertical line indicates completion of reservoir impoundment (September 5, 2020).**



**Figure A2-2: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31689) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to October 10, 2021. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Kettle GS (green), and Long Spruce GS (purple). Dashed black vertical line indicates start of spillway operation (Aug 3, 2018). Solid red vertical line indicates completion of reservoir impoundment (September 5, 2020).**

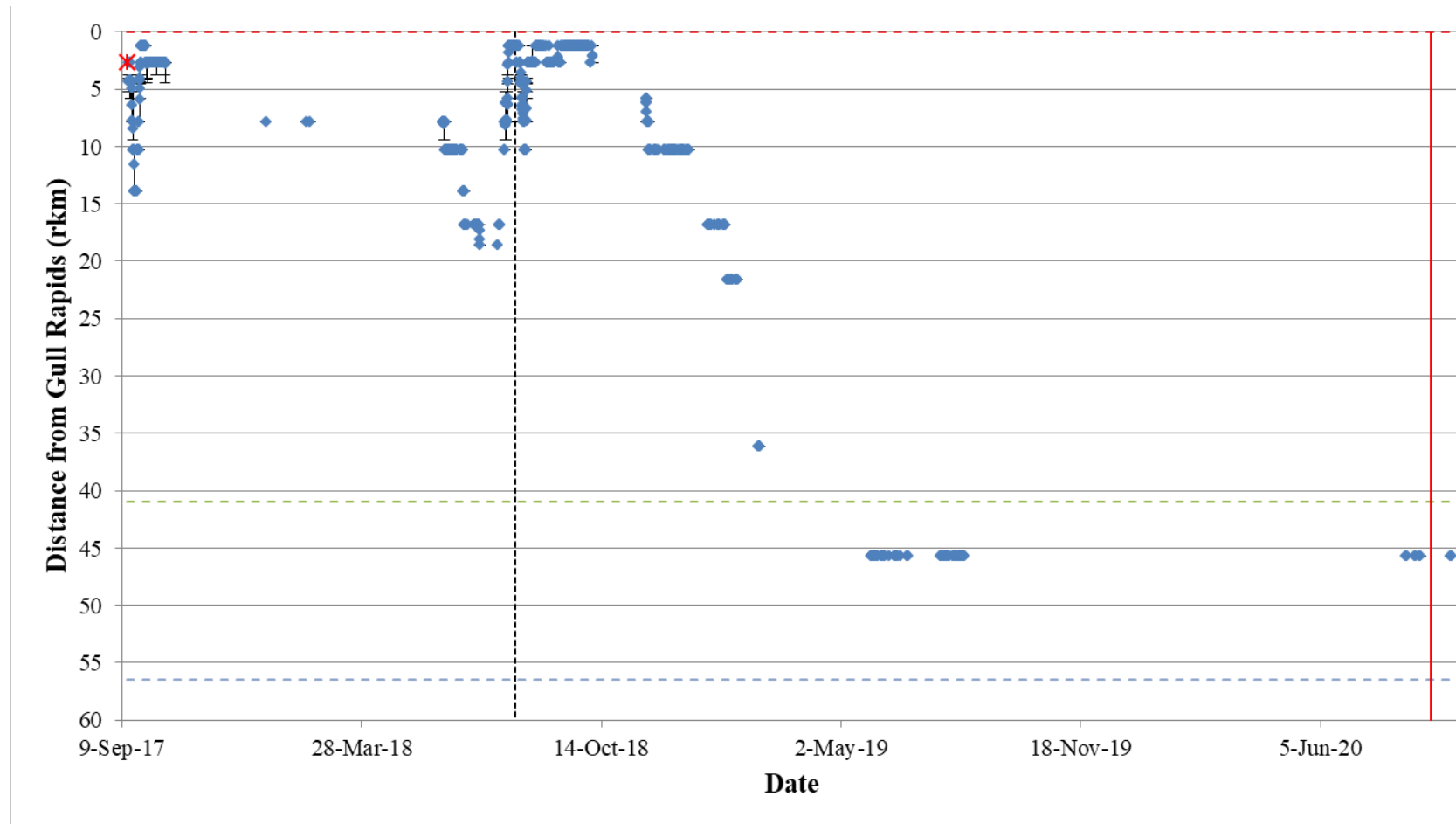


**Figure A2-3: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31690) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to October 10, 2021. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Kettle GS (green), and Long Spruce GS (purple). Dashed black vertical line indicates start of spillway operation (Aug 3, 2018). Solid red vertical line indicates completion of reservoir impoundment (September 5, 2020).**

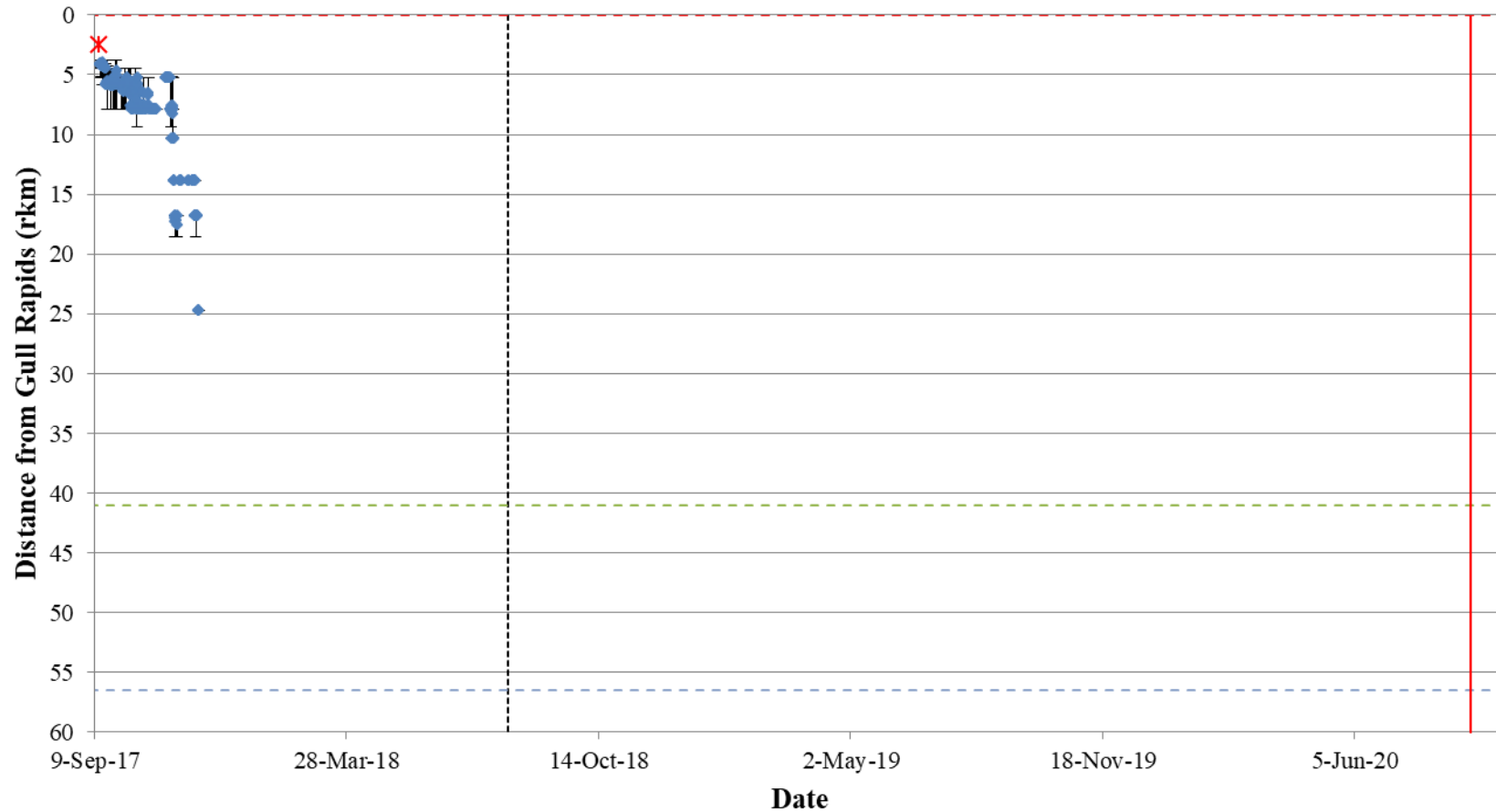


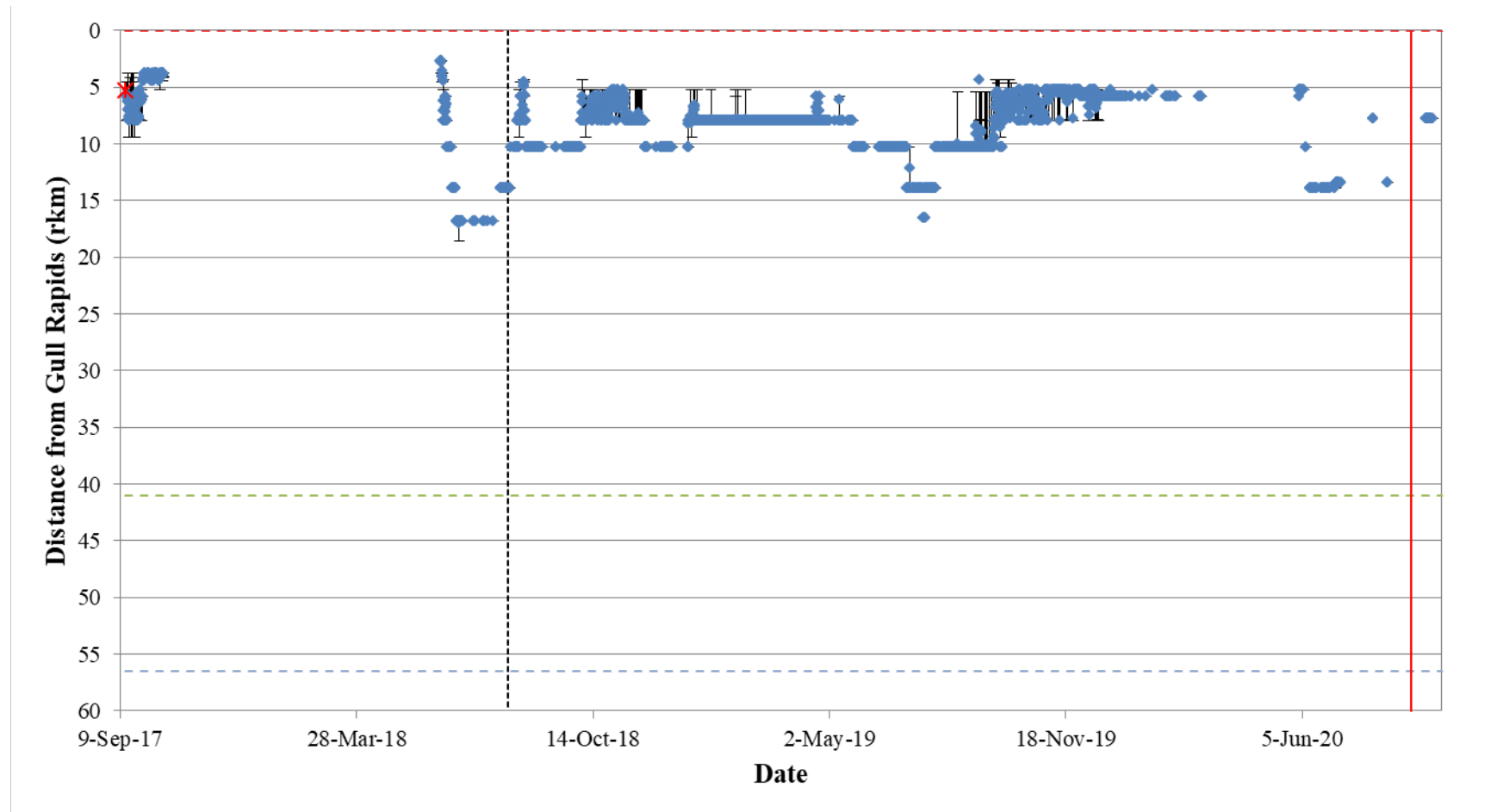
**Figure A2-4: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31691) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to October 10, 2021. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Kettle GS (green), and Long Spruce GS (purple). Dashed black vertical line indicates start of spillway operation (Aug 3, 2018). Solid red vertical line indicates completion of reservoir impoundment (September 5, 2020).**



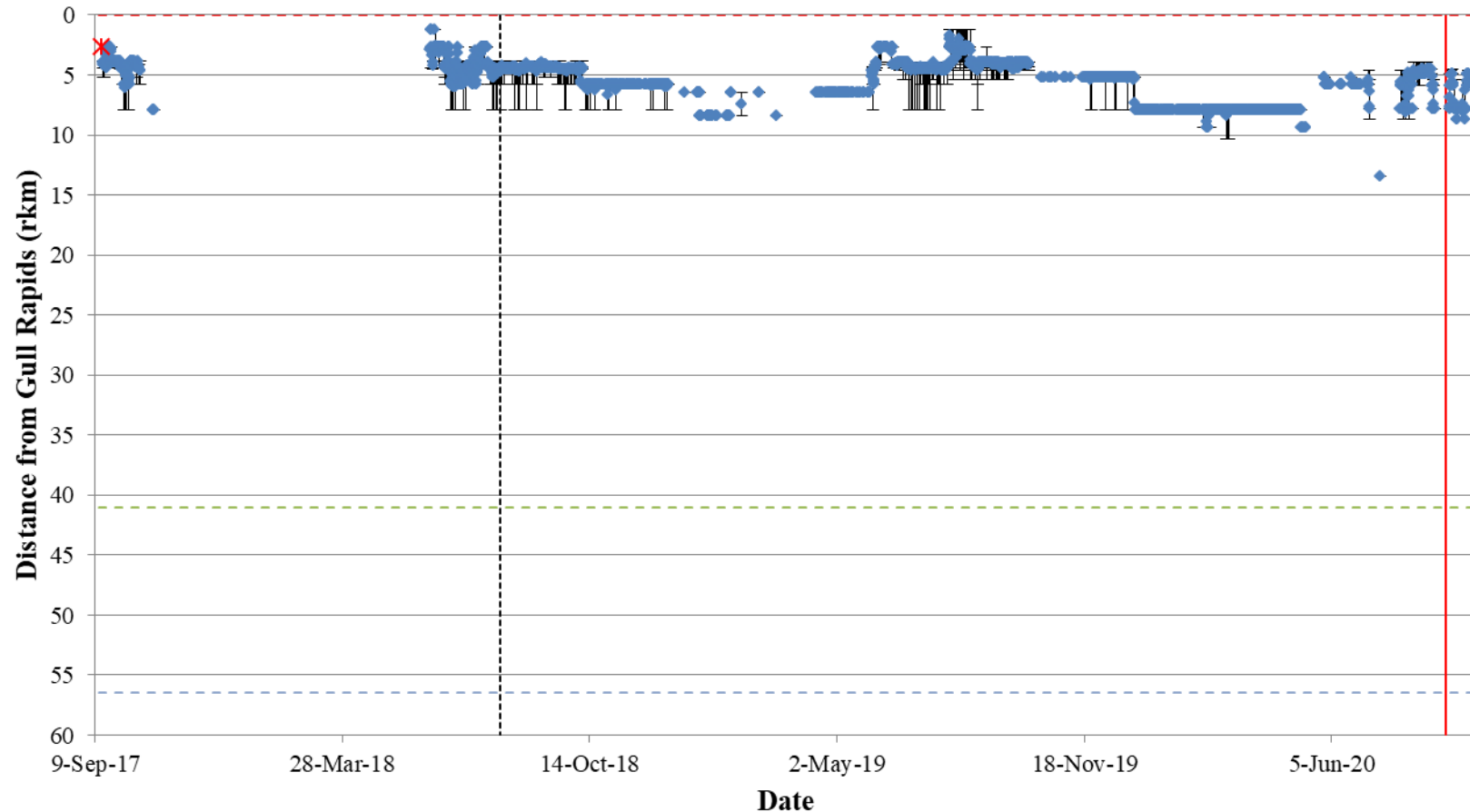


**Figure A2-5: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31692) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to October 10, 2021. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Kettle GS (green), and Long Spruce GS (purple). Dashed black vertical line indicates start of spillway operation (Aug 3, 2018). Solid red vertical line indicates completion of reservoir impoundment (September 5, 2020).**

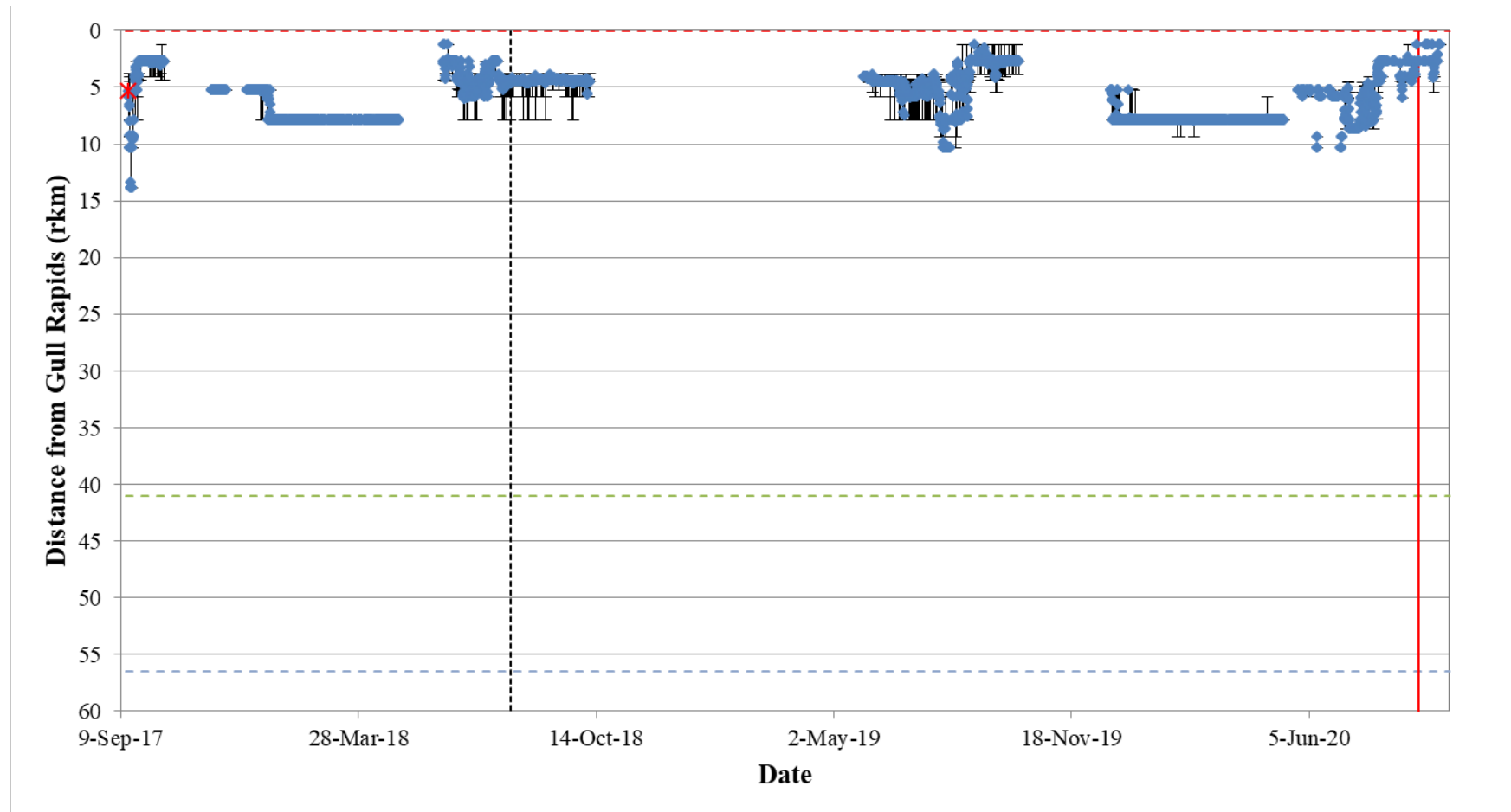




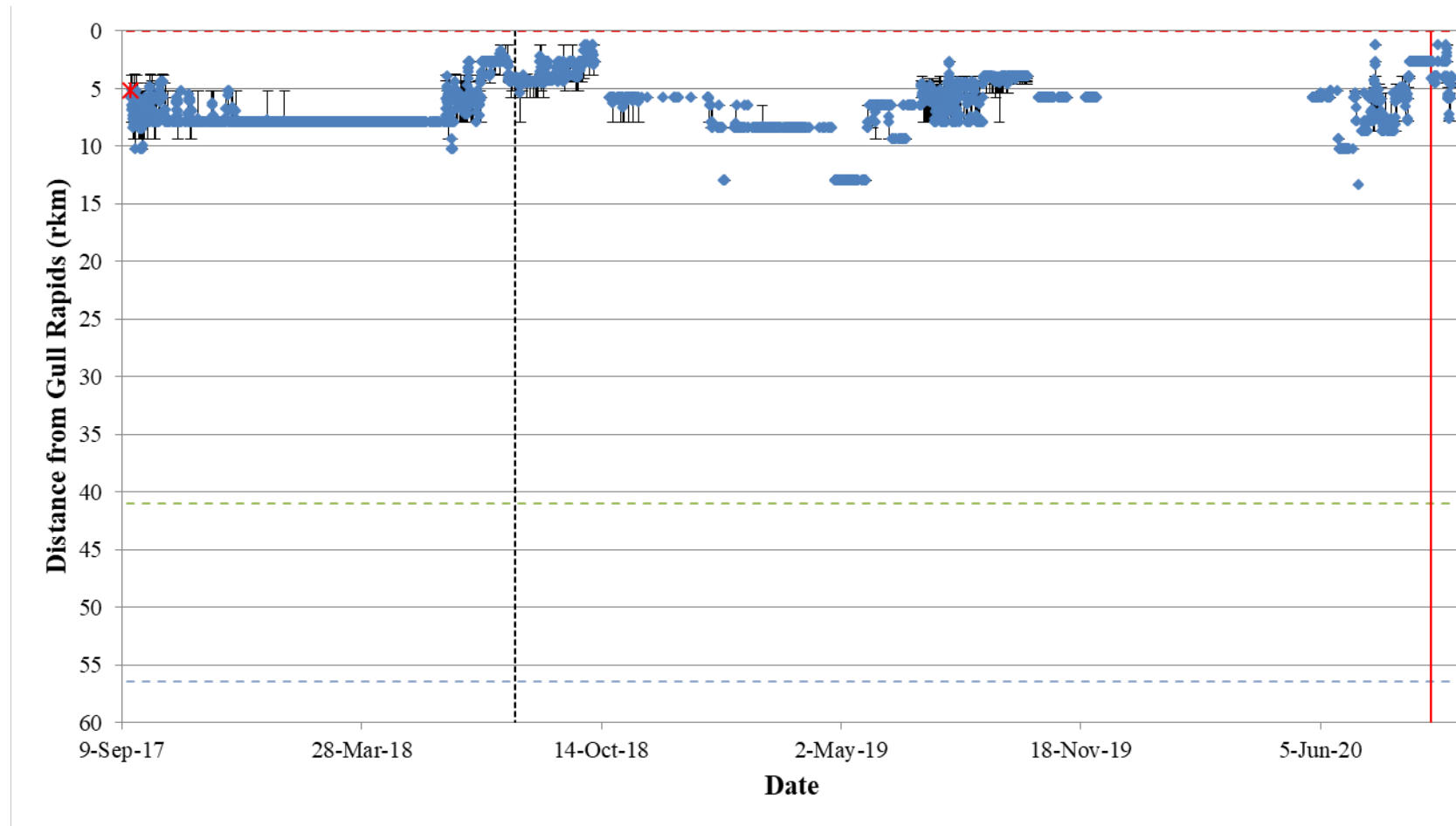
**Figure A2-7: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31694) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to October 10, 2021. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Kettle GS (green), and Long Spruce GS (purple). Dashed black vertical line indicates start of spillway operation (Aug 3, 2018). Solid red vertical line indicates completion of reservoir impoundment (September 5, 2020).**



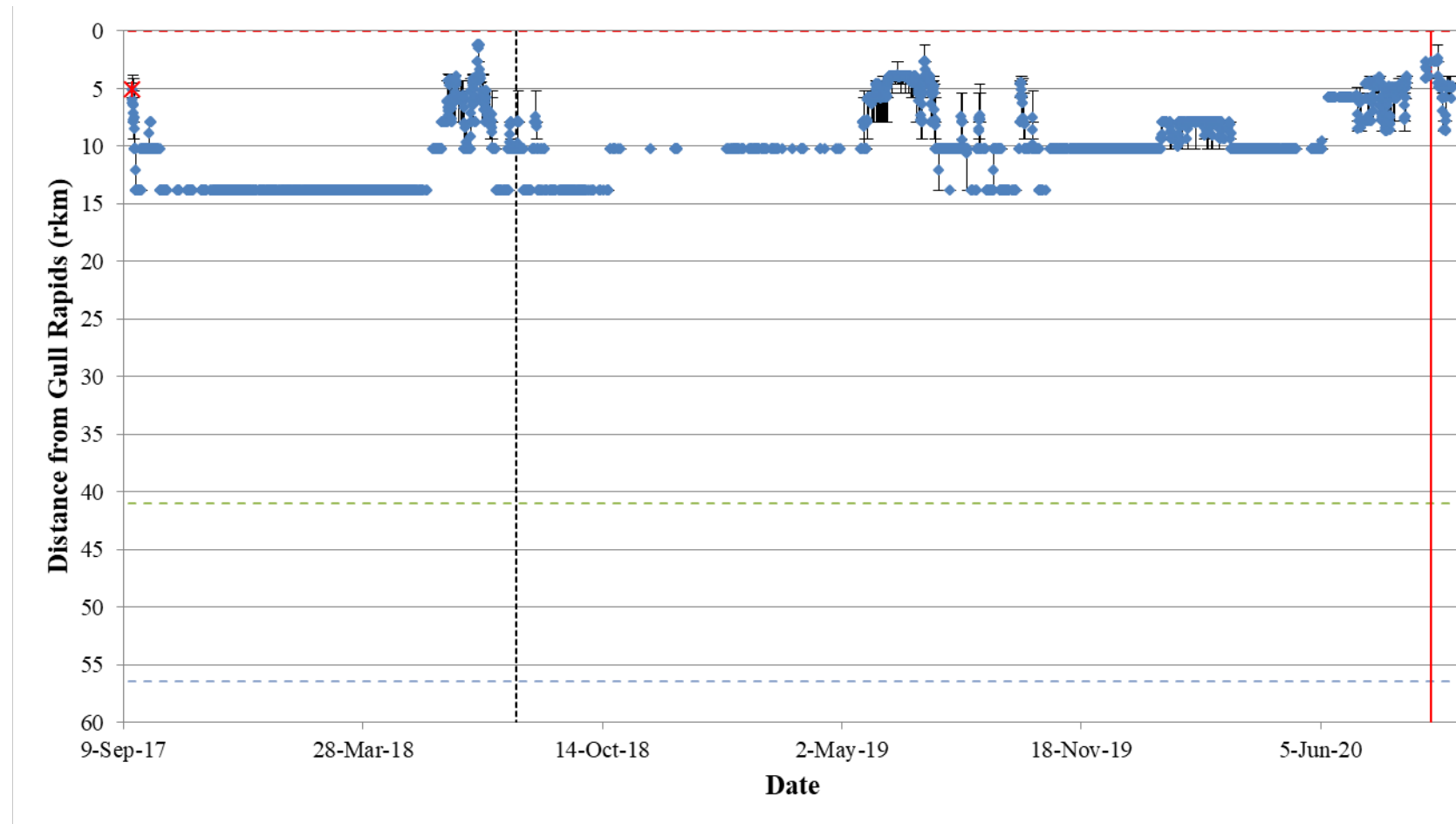
**Figure A2-8: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31695) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to October 10, 2021. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Kettle GS (green), and Long Spruce GS (purple). Dashed black vertical line indicates start of spillway operation (Aug 3, 2018). Solid red vertical line indicates completion of reservoir impoundment (September 5, 2020).**



**Figure A2-9: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31696) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to October 10, 2021. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Kettle GS (green), and Long Spruce GS (purple). Dashed black vertical line indicates start of spillway operation (Aug 3, 2018). Solid red vertical line indicates completion of reservoir impoundment (September 5, 2020).**

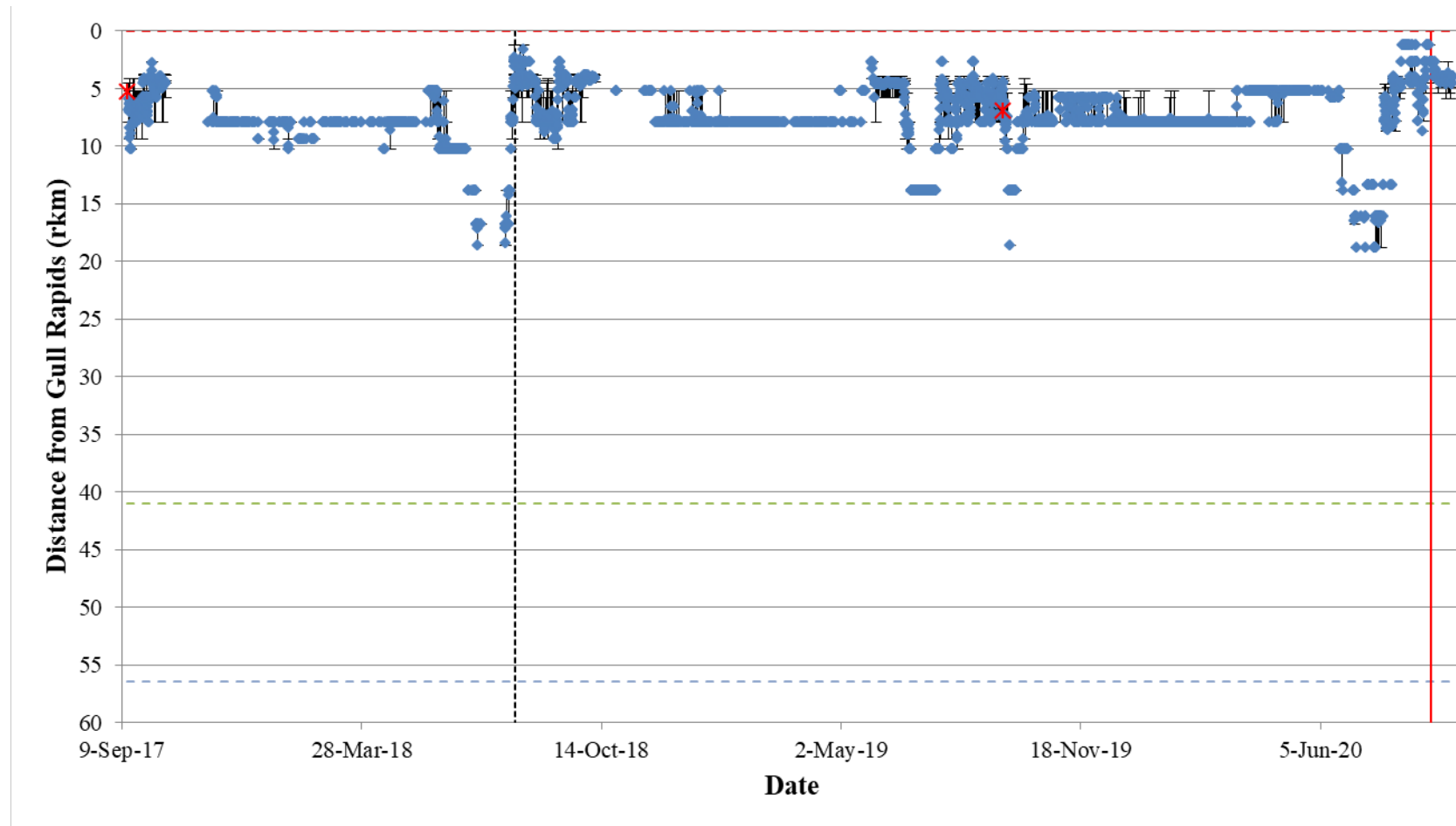


**Figure A2-10: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31697) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to October 10, 2021. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Kettle GS (green), and Long Spruce GS (purple). Dashed black vertical line indicates start of spillway operation (Aug 3, 2018). Solid red vertical line indicates completion of reservoir impoundment (September 5, 2020).**

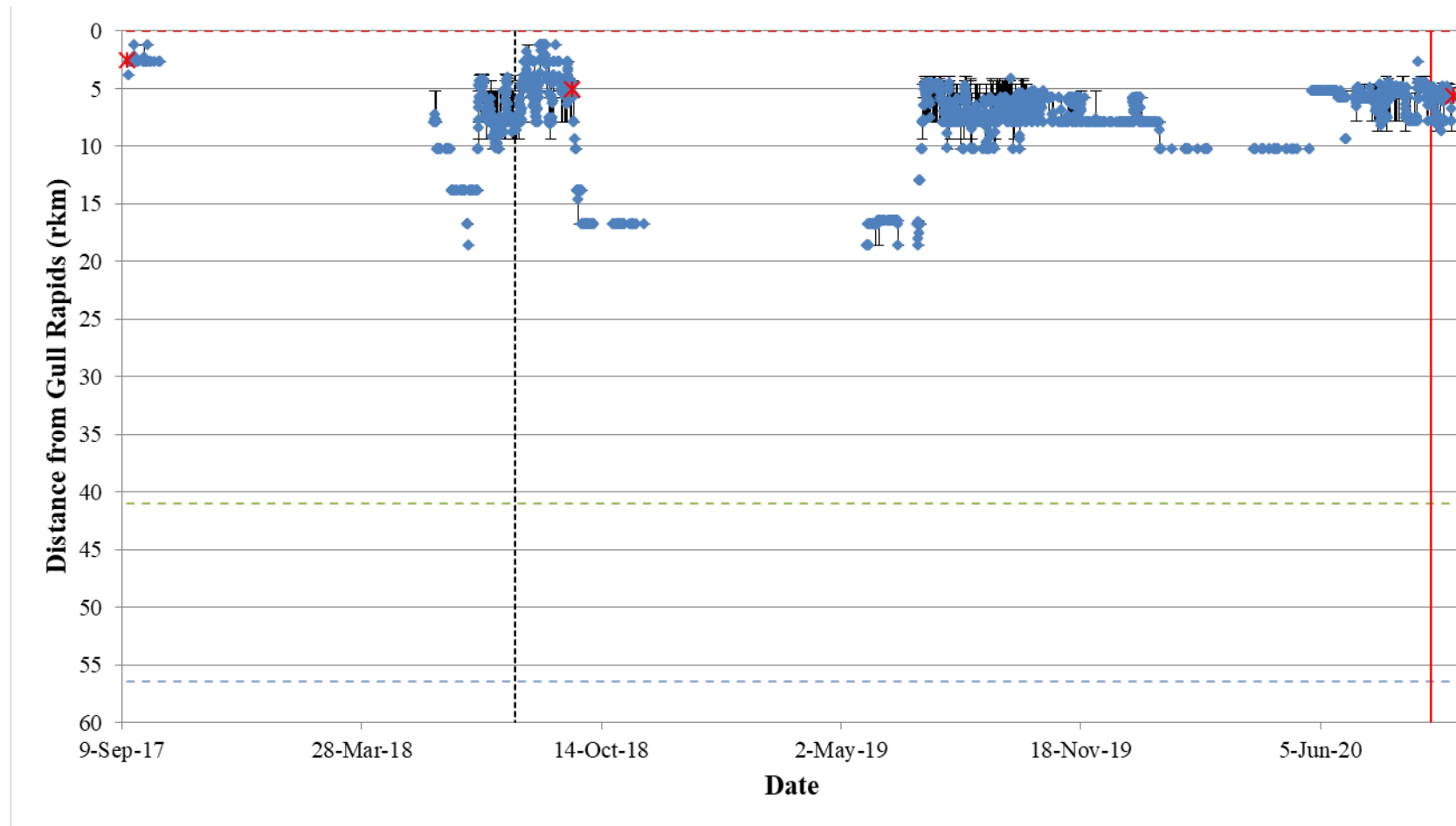


**Figure A2-11: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31758) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to October 10, 2021. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Kettle GS (green), and Long Spruce GS (purple). Dashed black vertical line indicates start of spillway operation (Aug 3, 2018). Solid red vertical line indicates completion of reservoir impoundment (September 5, 2020).**

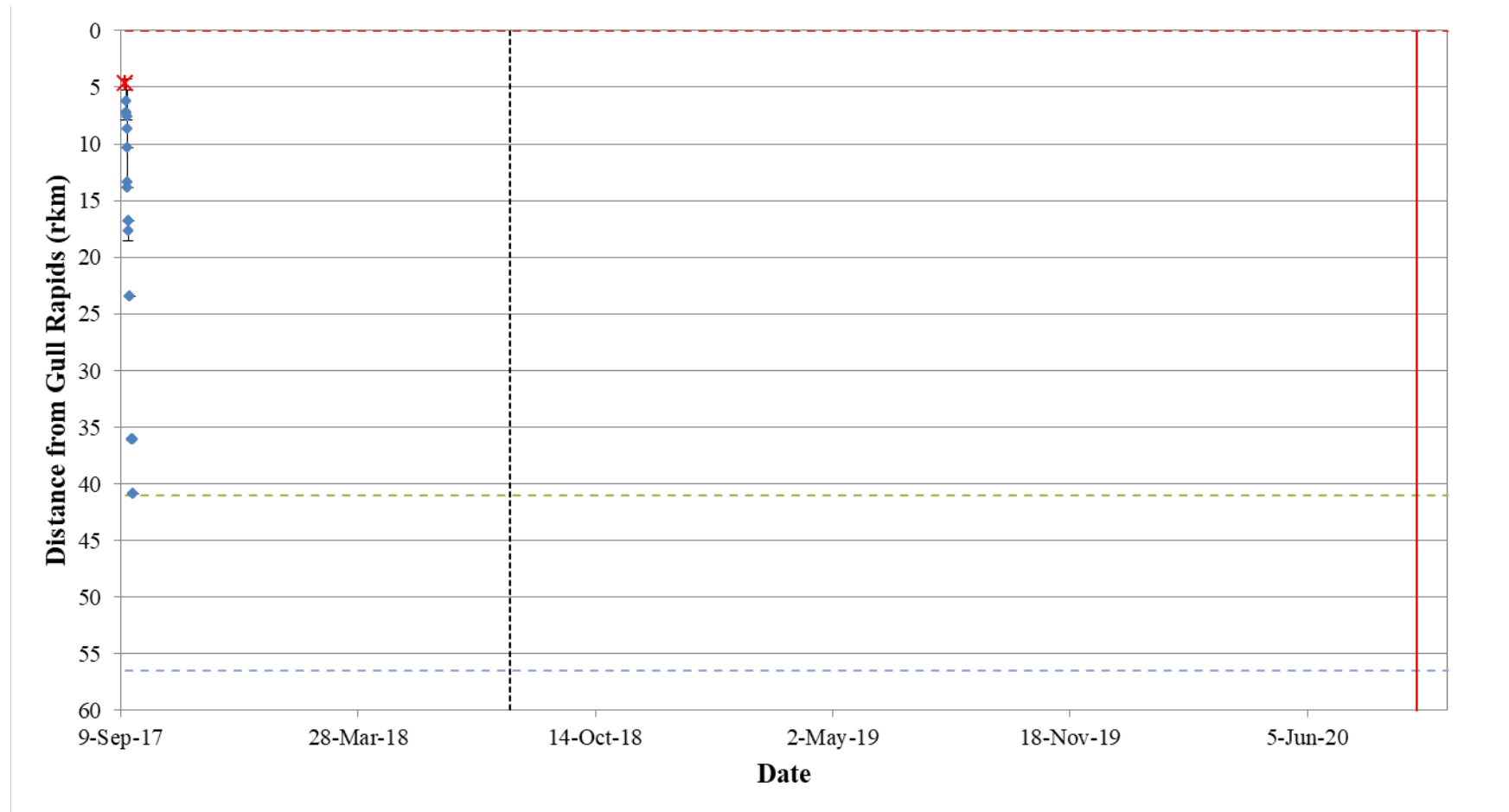




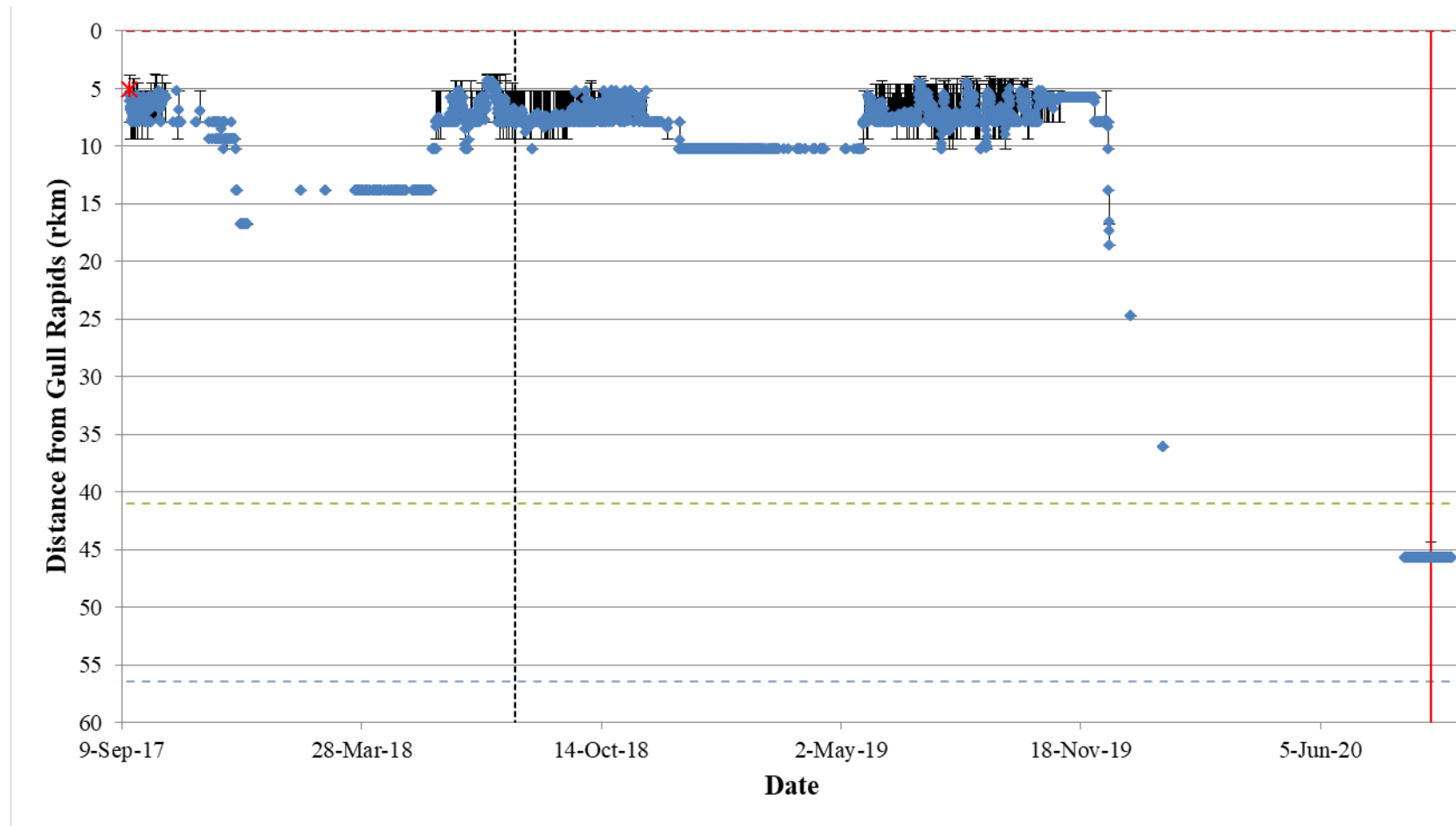
**Figure A2-12: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31759) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to October 10, 2021. Date and location of tagging and recapture is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Kettle GS (green), and Long Spruce GS (purple). Dashed black vertical line indicates start of spillway operation (Aug 3, 2018). Solid red vertical line indicates completion of reservoir impoundment (September 5, 2020).**



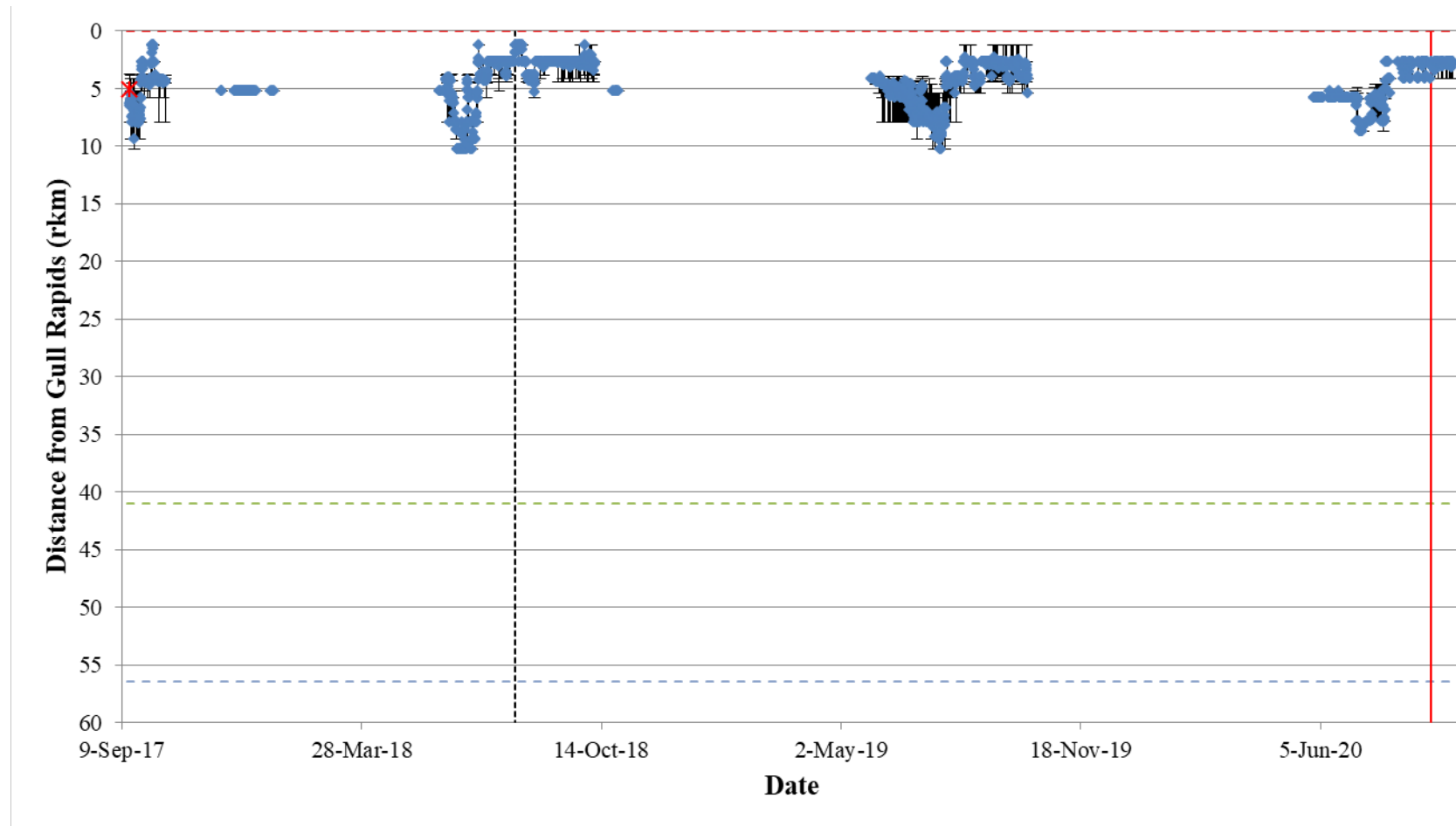
**Figure A2-13: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31760) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to October 10, 2021. Date and location of tagging and subsequent recaptures are indicated by a red star. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Kettle GS (green), and Long Spruce GS (purple). Dashed black vertical line indicates start of spillway operation (Aug 3, 2018). Solid red vertical line indicates completion of reservoir impoundment (September 5, 2020).**



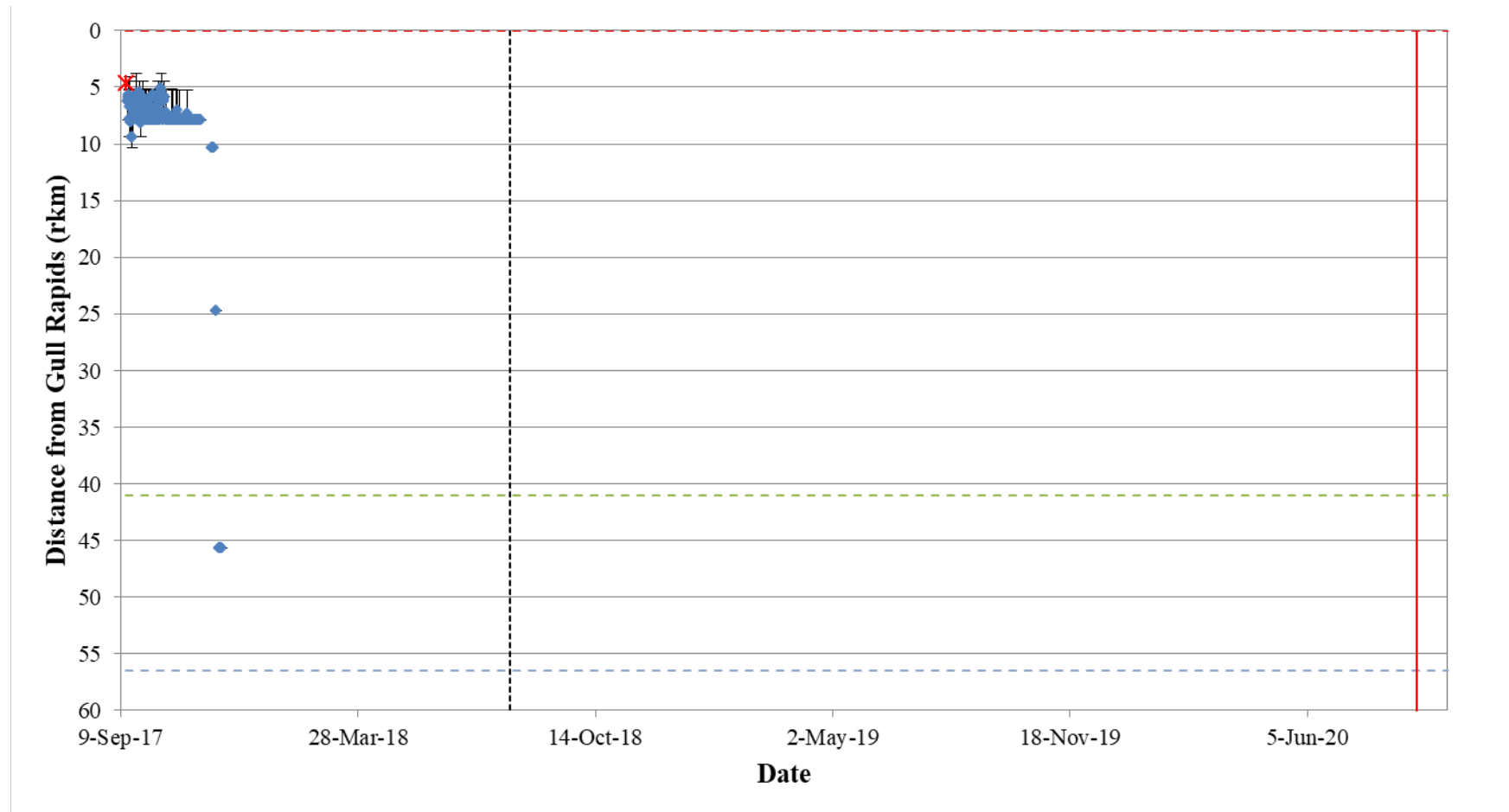
**Figure A2-14: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31761) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to October 10, 2021. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Kettle GS (green), and Long Spruce GS (purple). Dashed black vertical line indicates start of spillway operation (Aug 3, 2018). Solid red vertical line indicates completion of reservoir impoundment (September 5, 2020).**



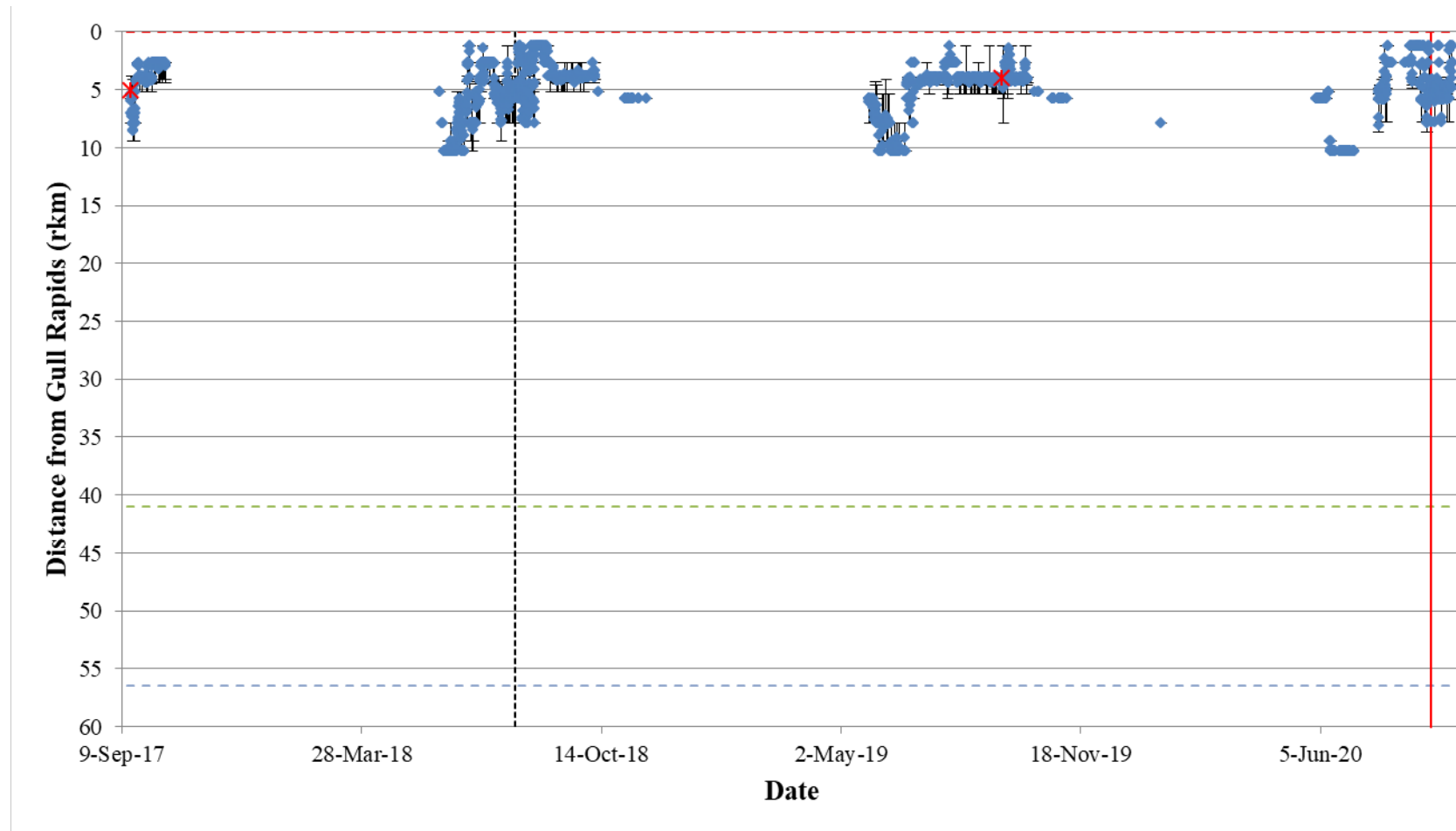
**Figure A2-15: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31762) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to October 10, 2021. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Kettle GS (green), and Long Spruce GS (purple). Dashed black vertical line indicates start of spillway operation (Aug 3, 2018). Solid red vertical line indicates completion of reservoir impoundment (September 5, 2020).**



**Figure A2-16: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31763) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to October 10, 2021. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Kettle GS (green), and Long Spruce GS (purple). Dashed black vertical line indicates start of spillway operation (Aug 3, 2018). Solid red vertical line indicates completion of reservoir impoundment (September 5, 2020).**

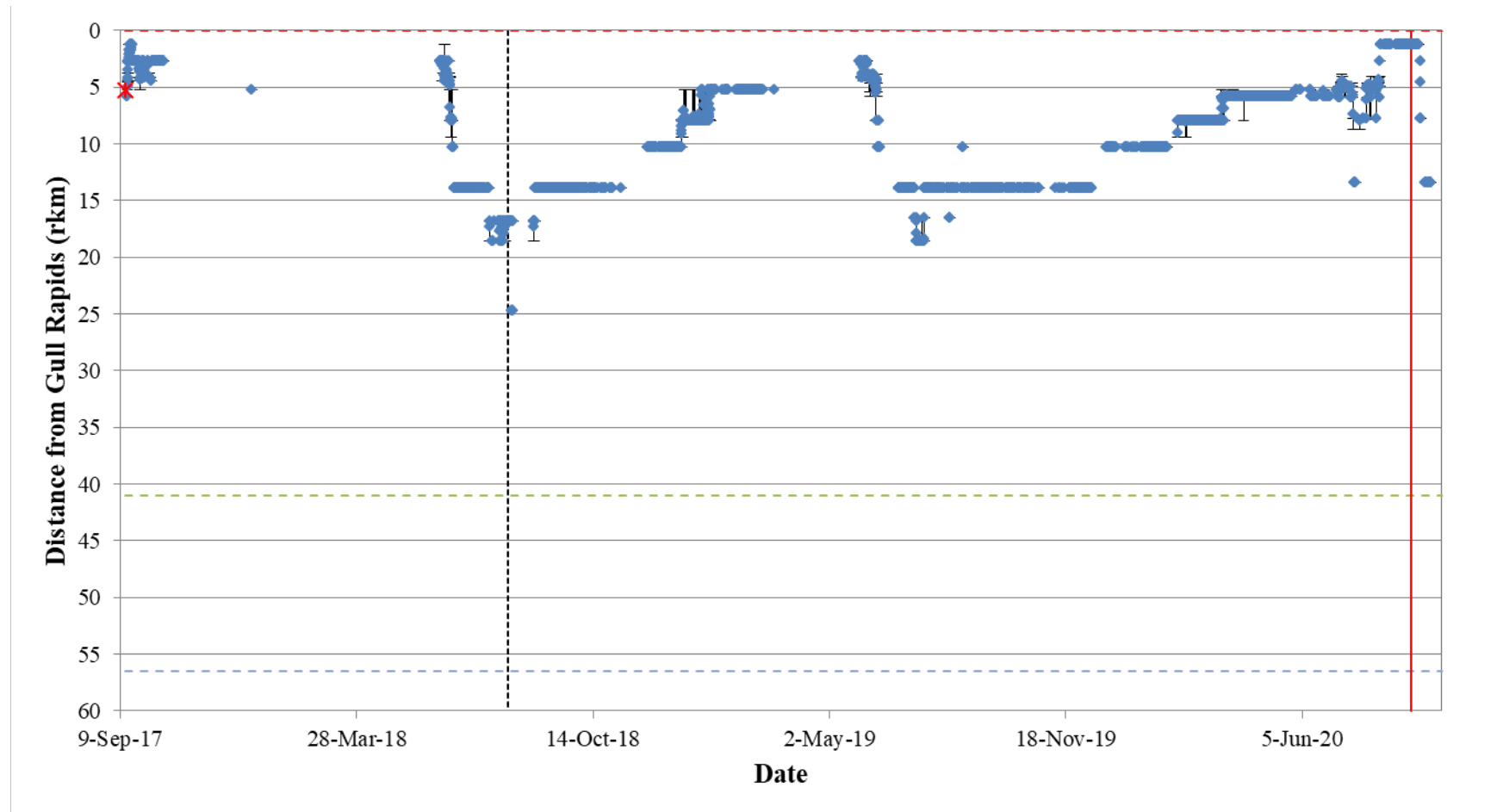


**Figure A2-17: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31764) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to October 10, 2021. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Kettle GS (green), and Long Spruce GS (purple). Dashed black vertical line indicates start of spillway operation (Aug 3, 2018). Solid red vertical line indicates completion of reservoir impoundment (September 5, 2020).**

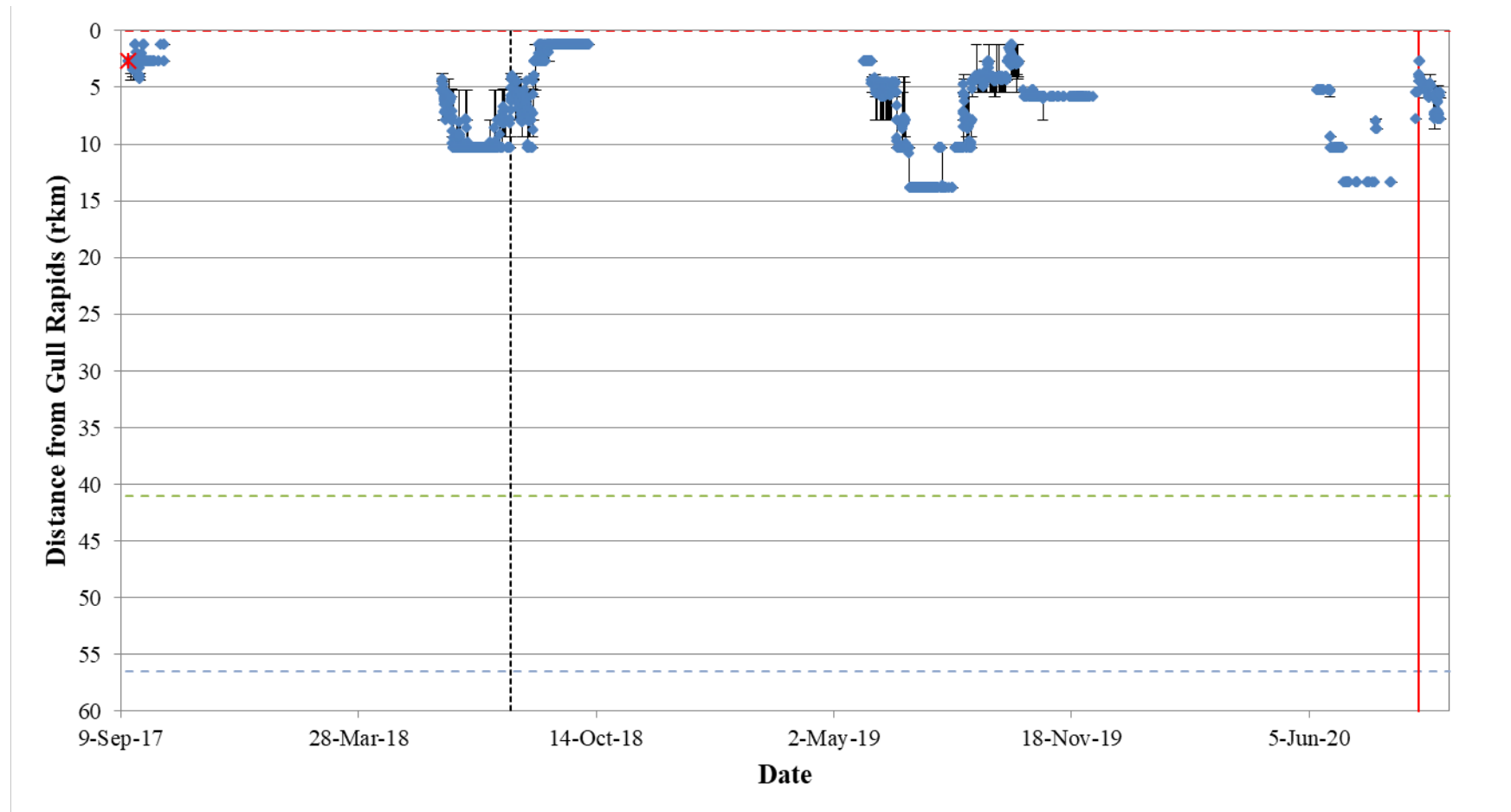


**Figure A2-18: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31765) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to October 10, 2021. Date and location of tagging and recapture is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Kettle GS (green), and Long Spruce GS (purple). Dashed black vertical line indicates start of spillway operation (Aug 3, 2018). Solid red vertical line indicates completion of reservoir impoundment (September 5, 2020).**

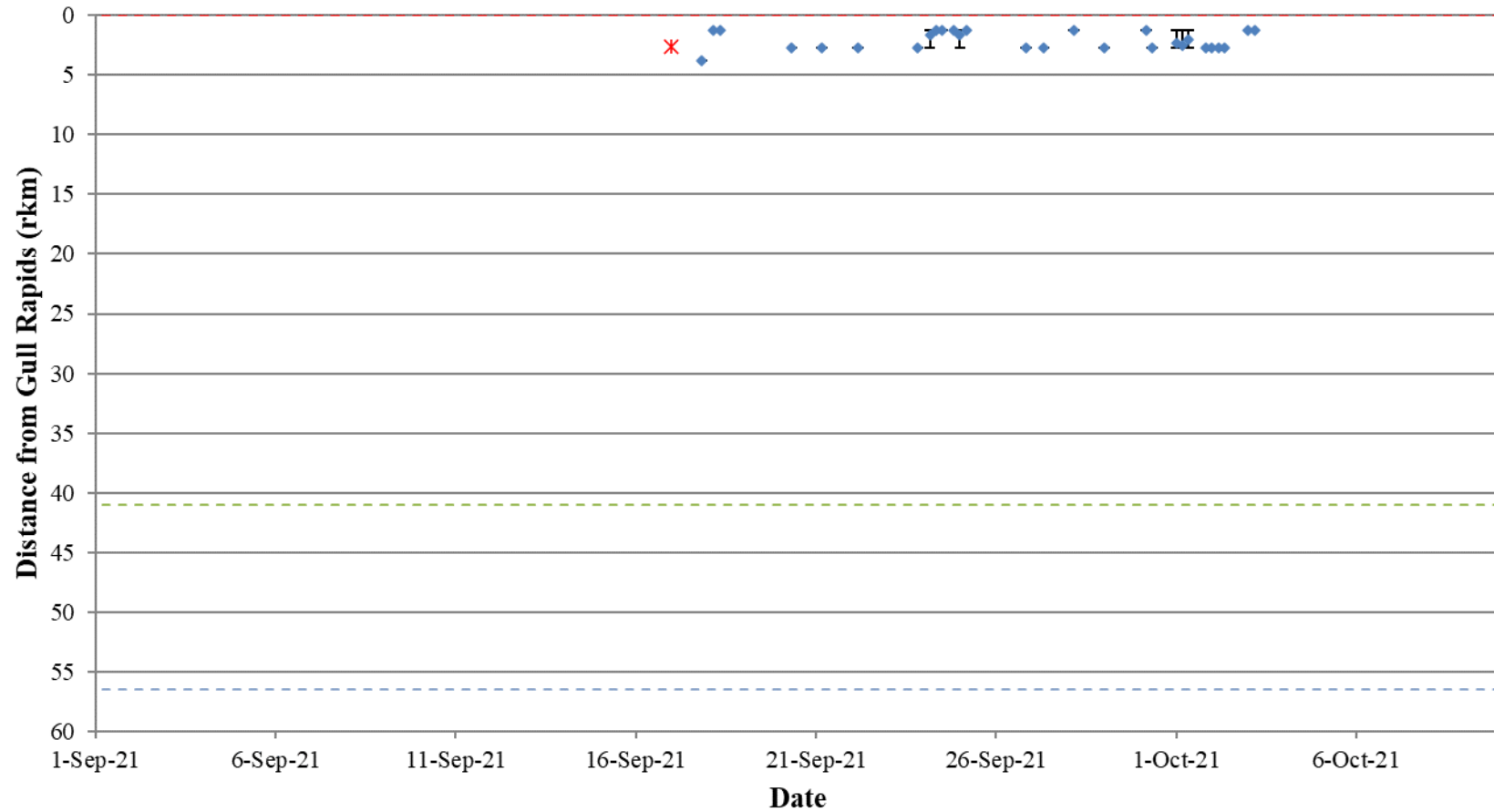




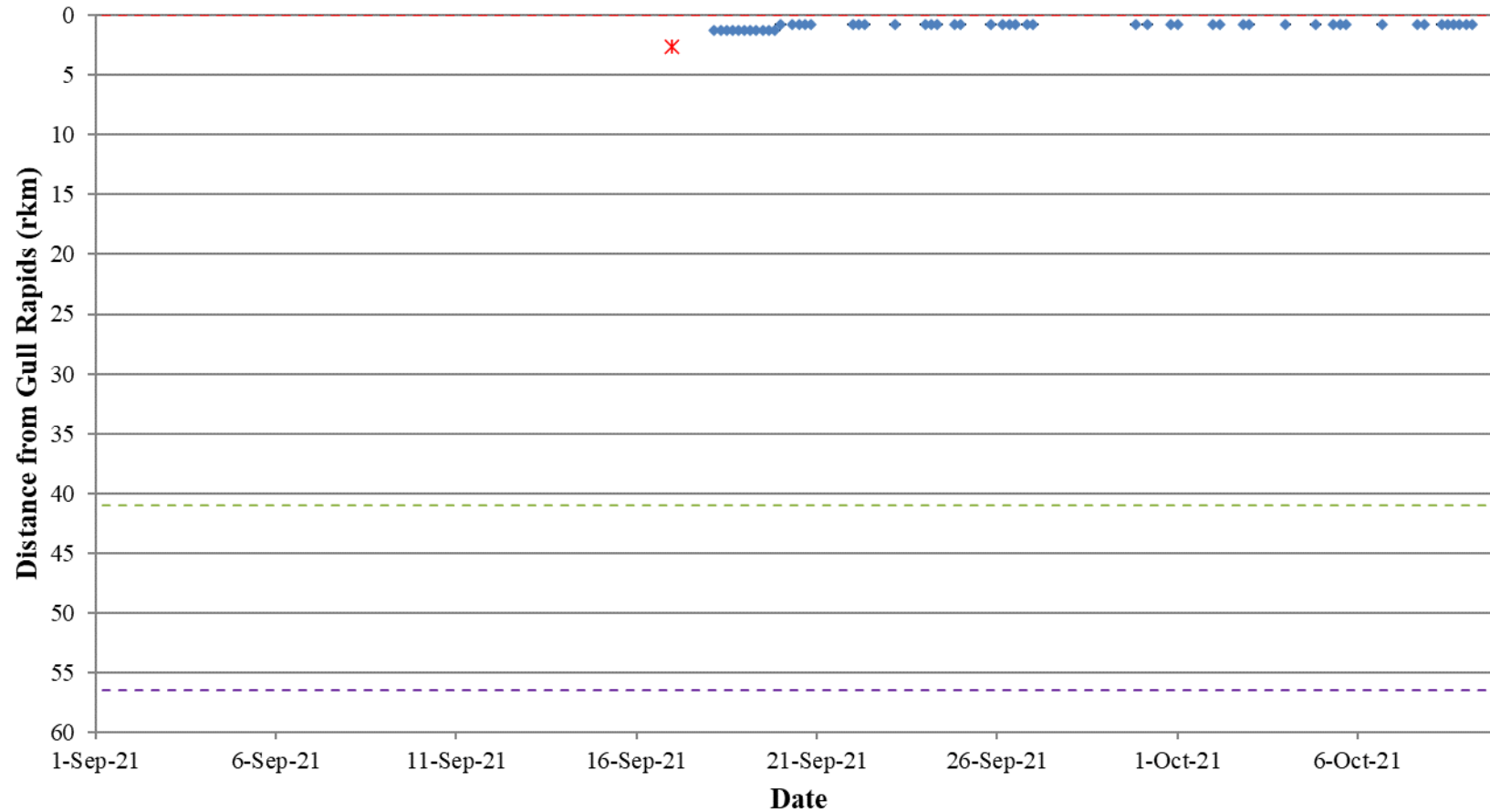
**Figure A2-19** Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31766) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to October 10, 2021. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Kettle GS (green), and Long Spruce GS (purple). Dashed black vertical line indicates start of spillway operation (Aug 3, 2018). Solid red vertical line indicates completion of reservoir impoundment (September 5, 2020).



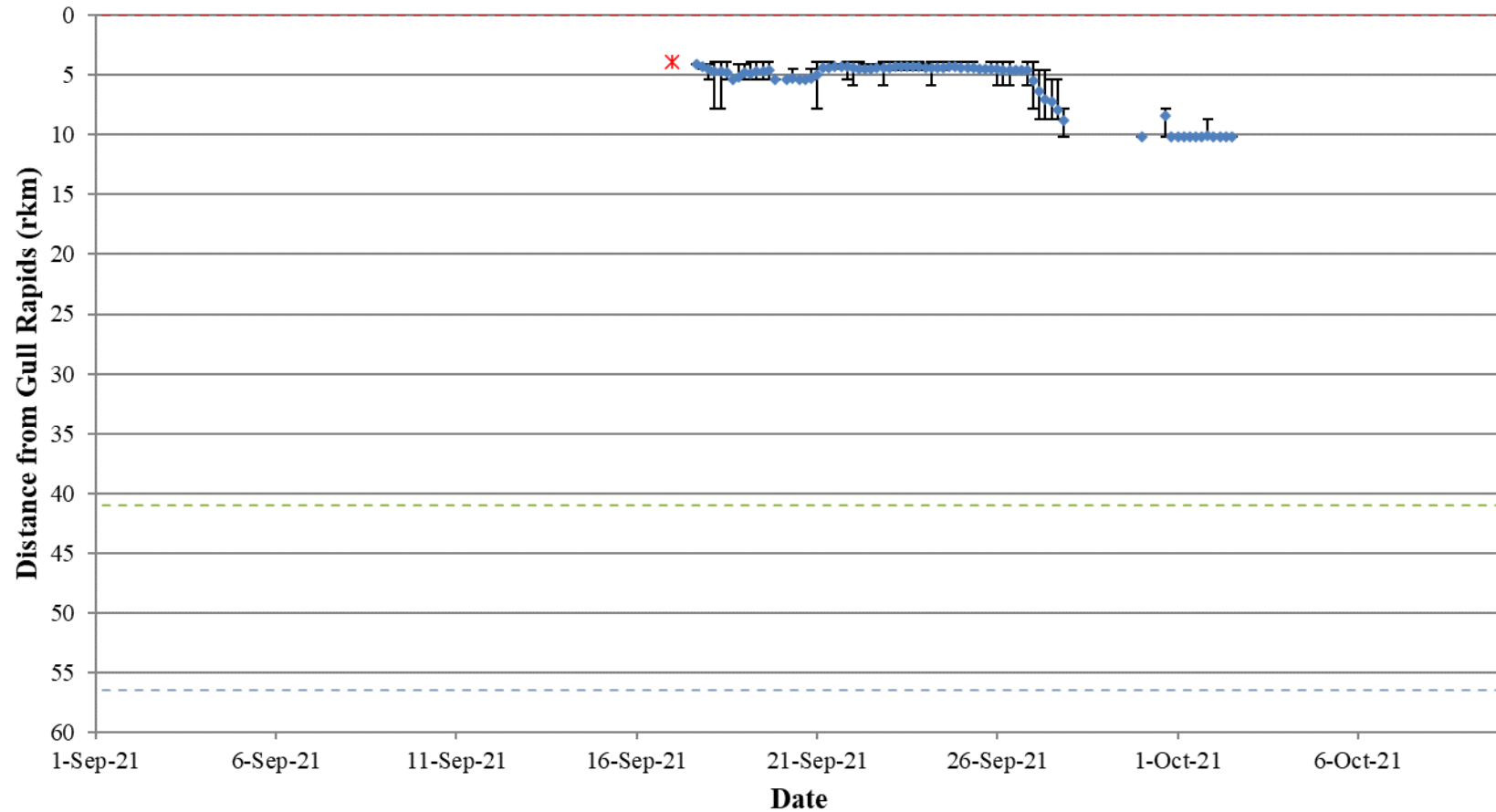
**Figure A2-20: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31767) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to October 10, 2021. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Kettle GS (green), and Long Spruce GS (purple). Dashed black vertical line indicates start of spillway operation (Aug 3, 2018). Solid red vertical line indicates completion of reservoir impoundment (September 5, 2020).**



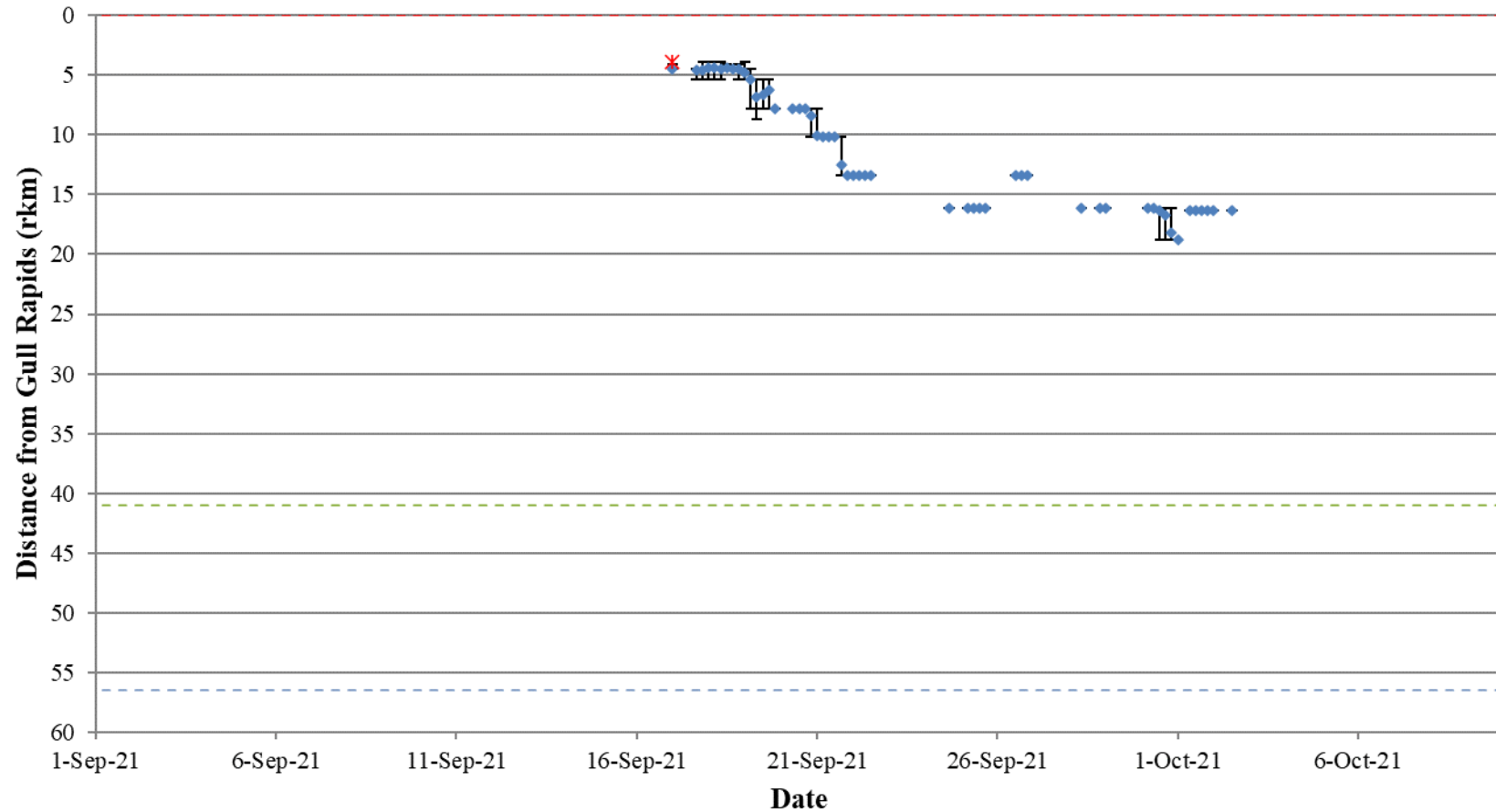
**Figure A2-21: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #48276) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 17, 2021. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Kettle GS (green), and Long Spruce GS (purple).**



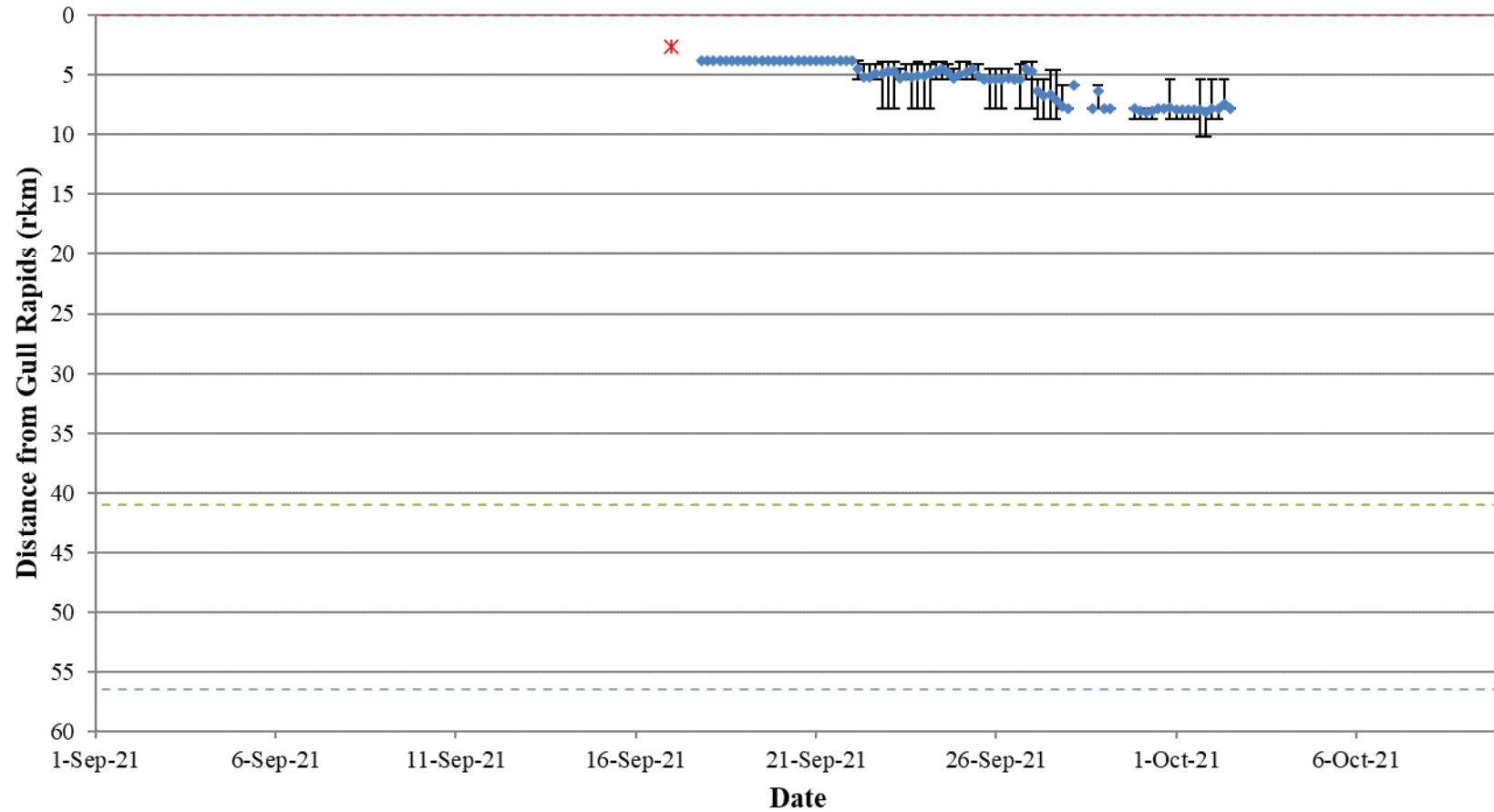
**Figure A2-22: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #48277) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 17, 2021. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Kettle GS (green), and Long Spruce GS (purple).**



**Figure A2-23: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #48278) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 17, 2021. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Kettle GS (green), and Long Spruce GS (purple).**

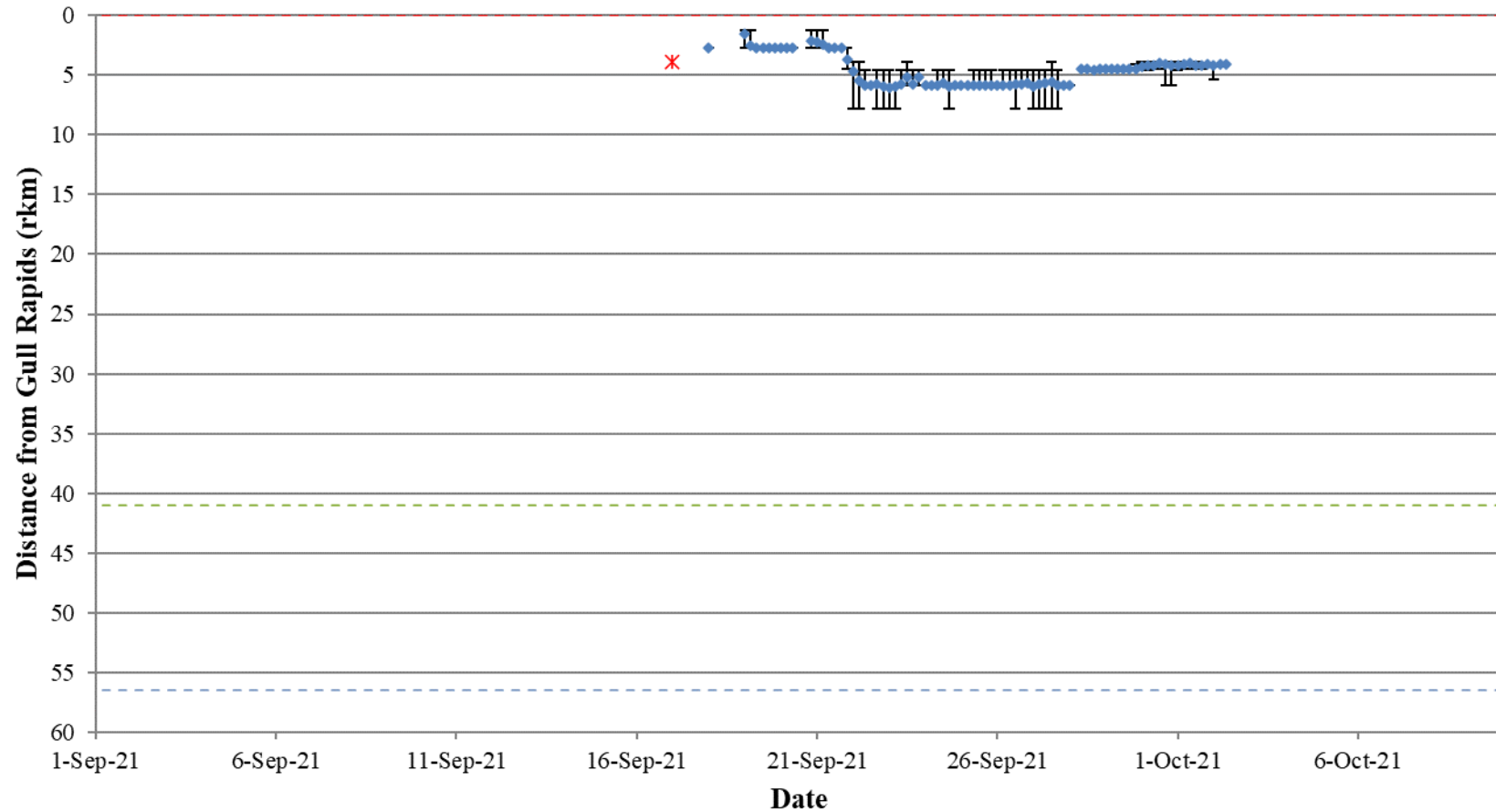


**Figure A2-24: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #48279) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 17, 2021. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Kettle GS (green), and Long Spruce GS (purple).**

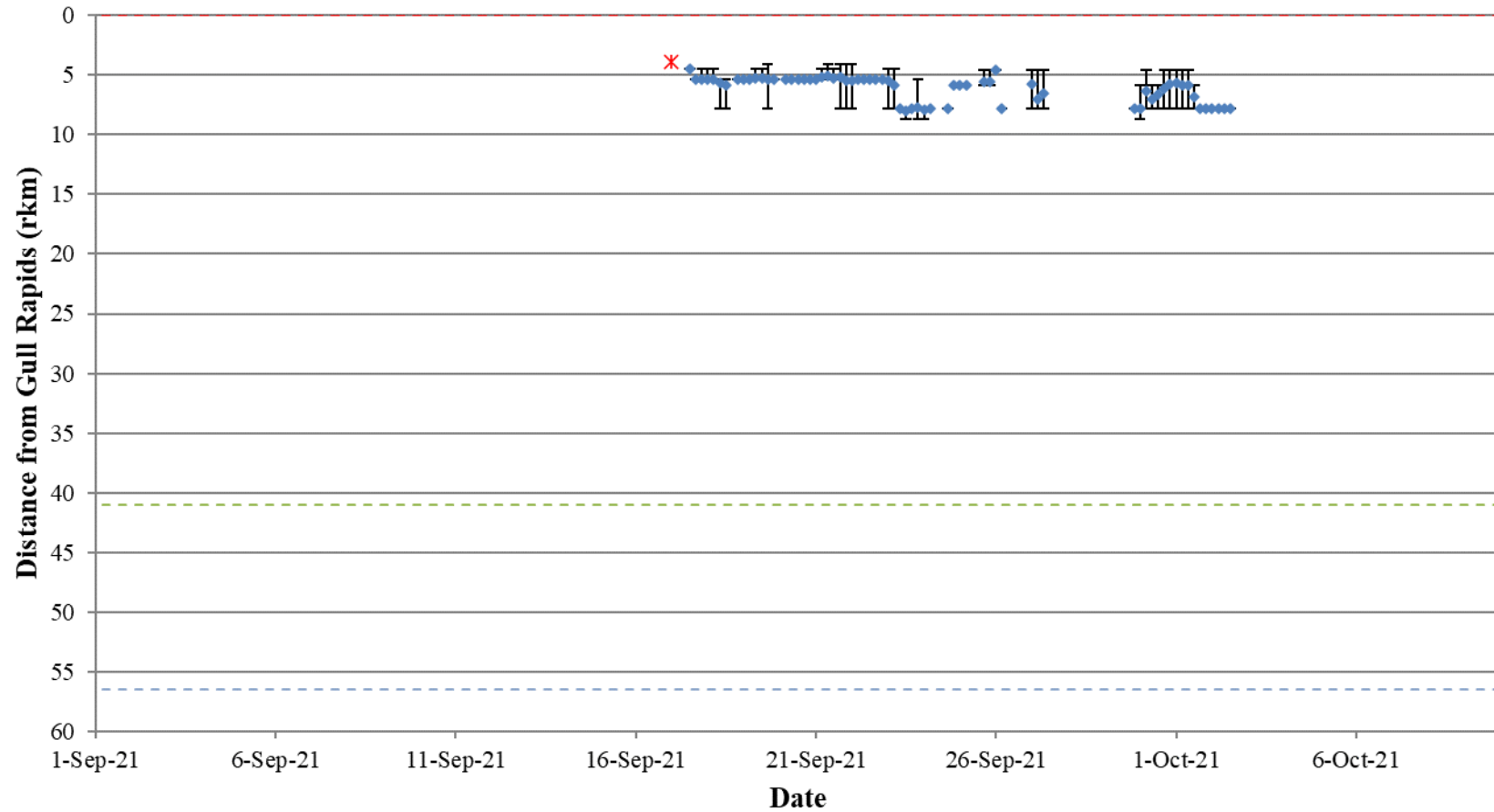


**Figure A2-25: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #48282) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 17, 2021. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Kettle GS (green), and Long Spruce GS (purple).**

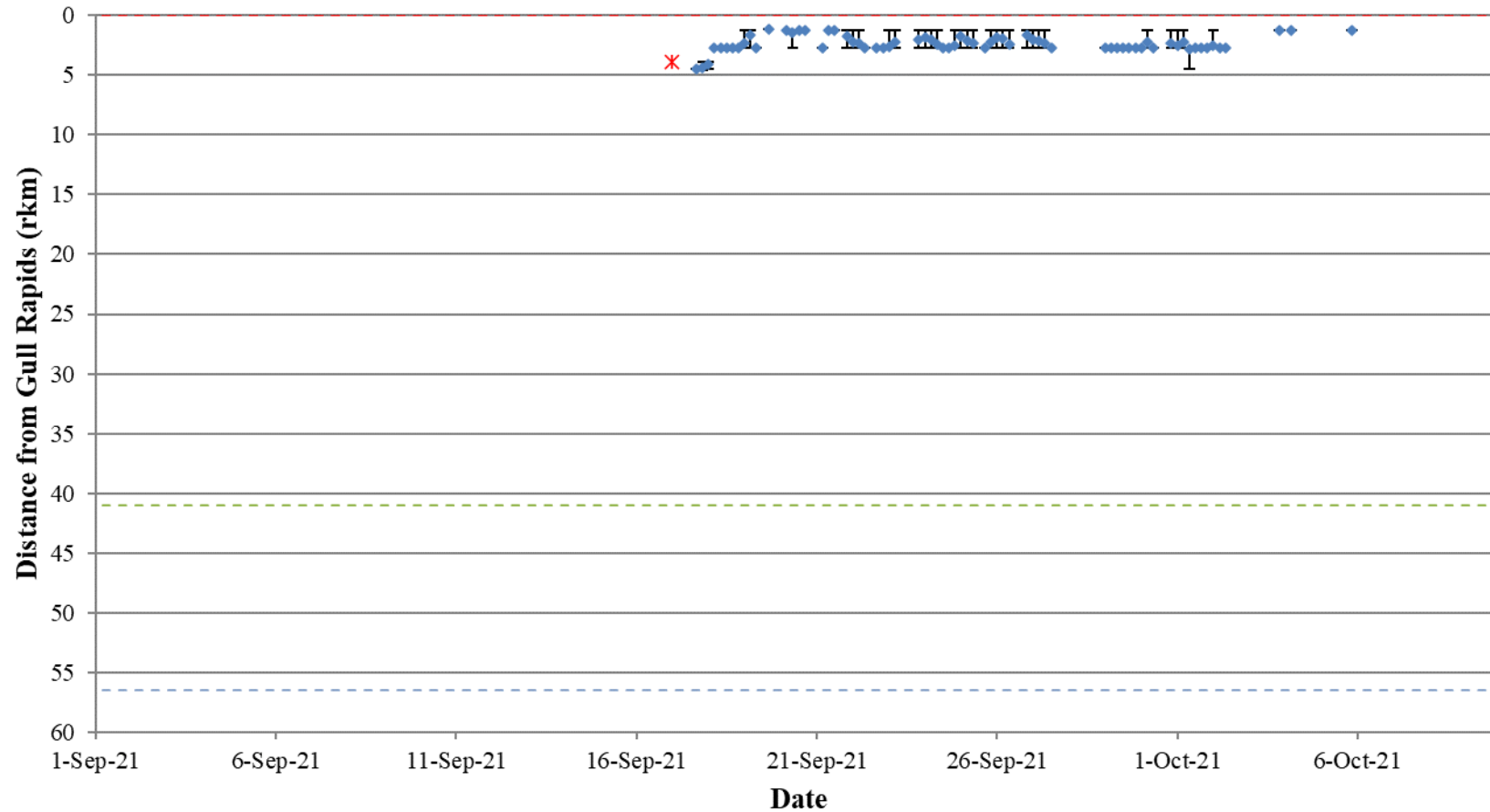




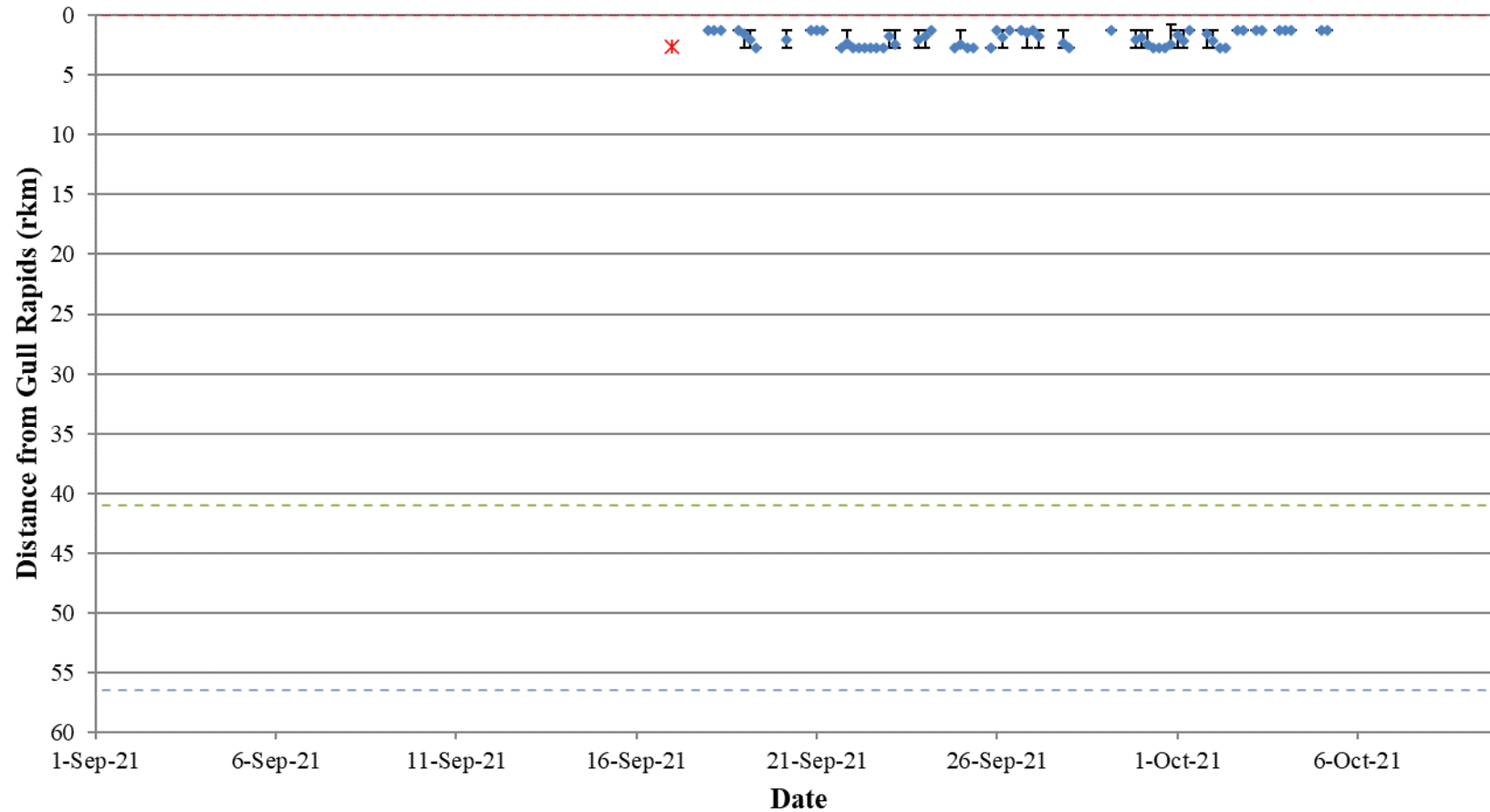
**Figure A2-26: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #48283) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 17, 2021. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Kettle GS (green), and Long Spruce GS (purple).**



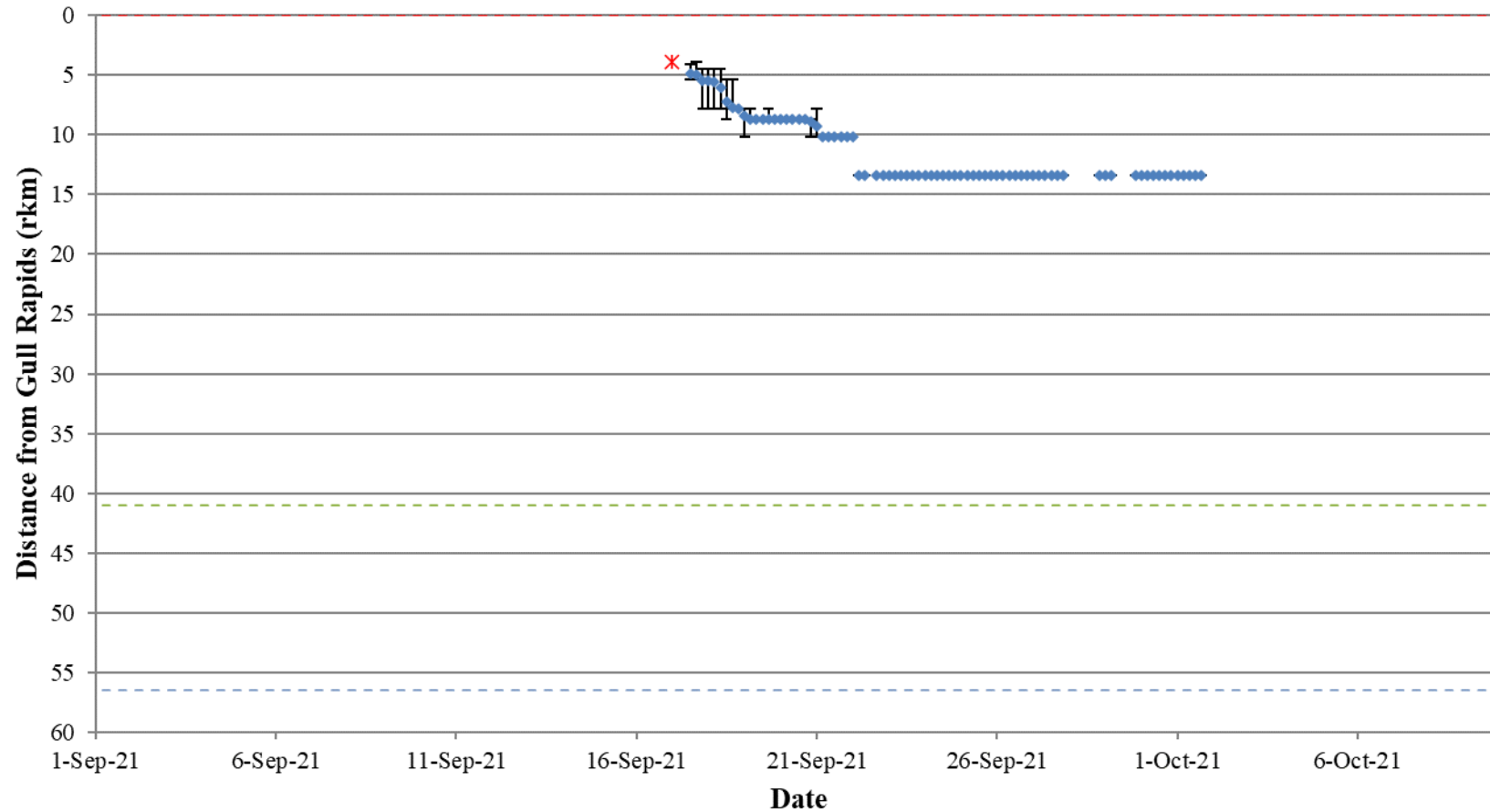
**Figure A2-27: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #48284) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 17, 2021. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Kettle GS (green), and Long Spruce GS (purple).**



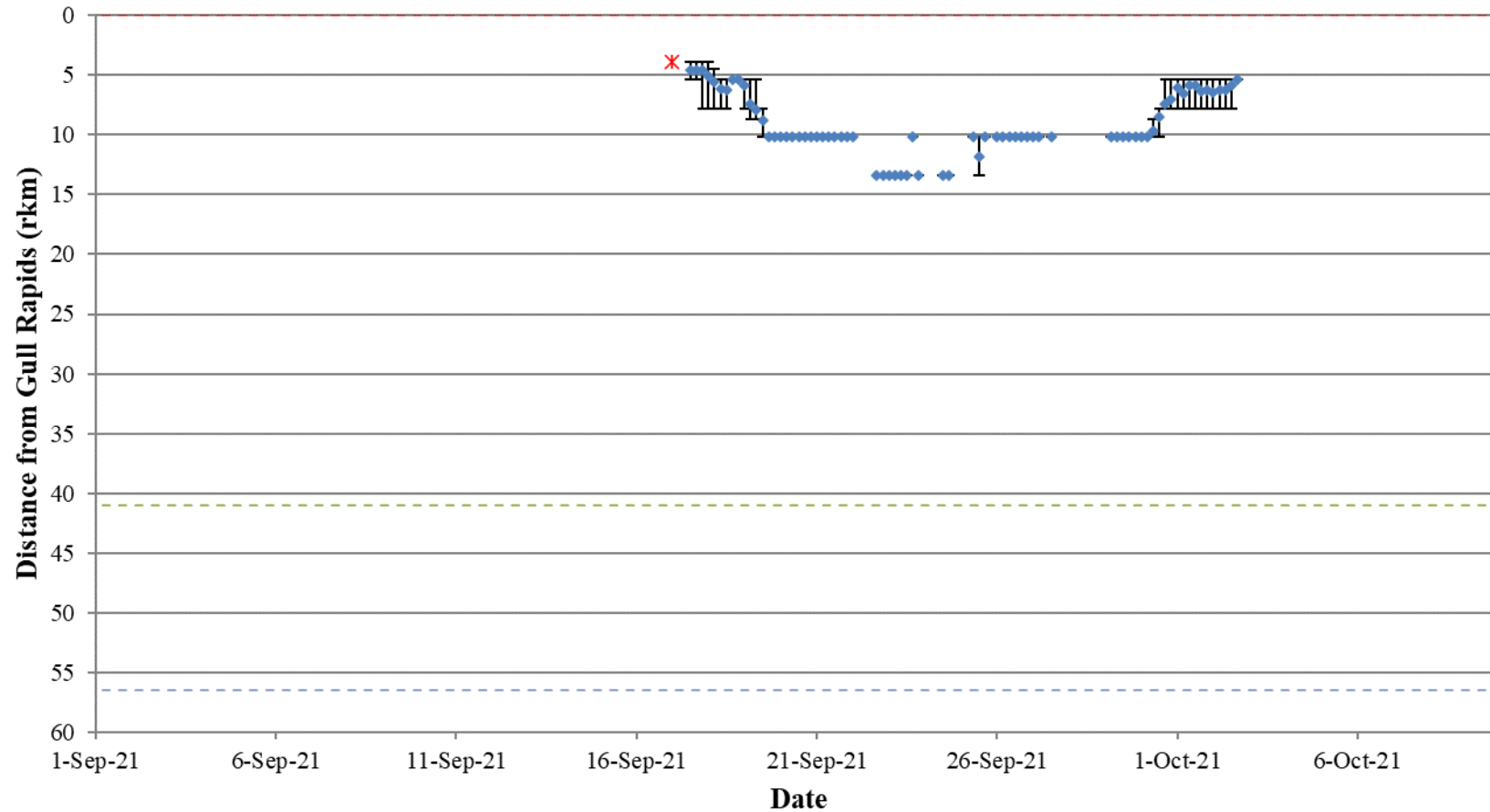
**Figure A2-28: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #48285) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 17, 2021. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Kettle GS (green), and Long Spruce GS (purple).**



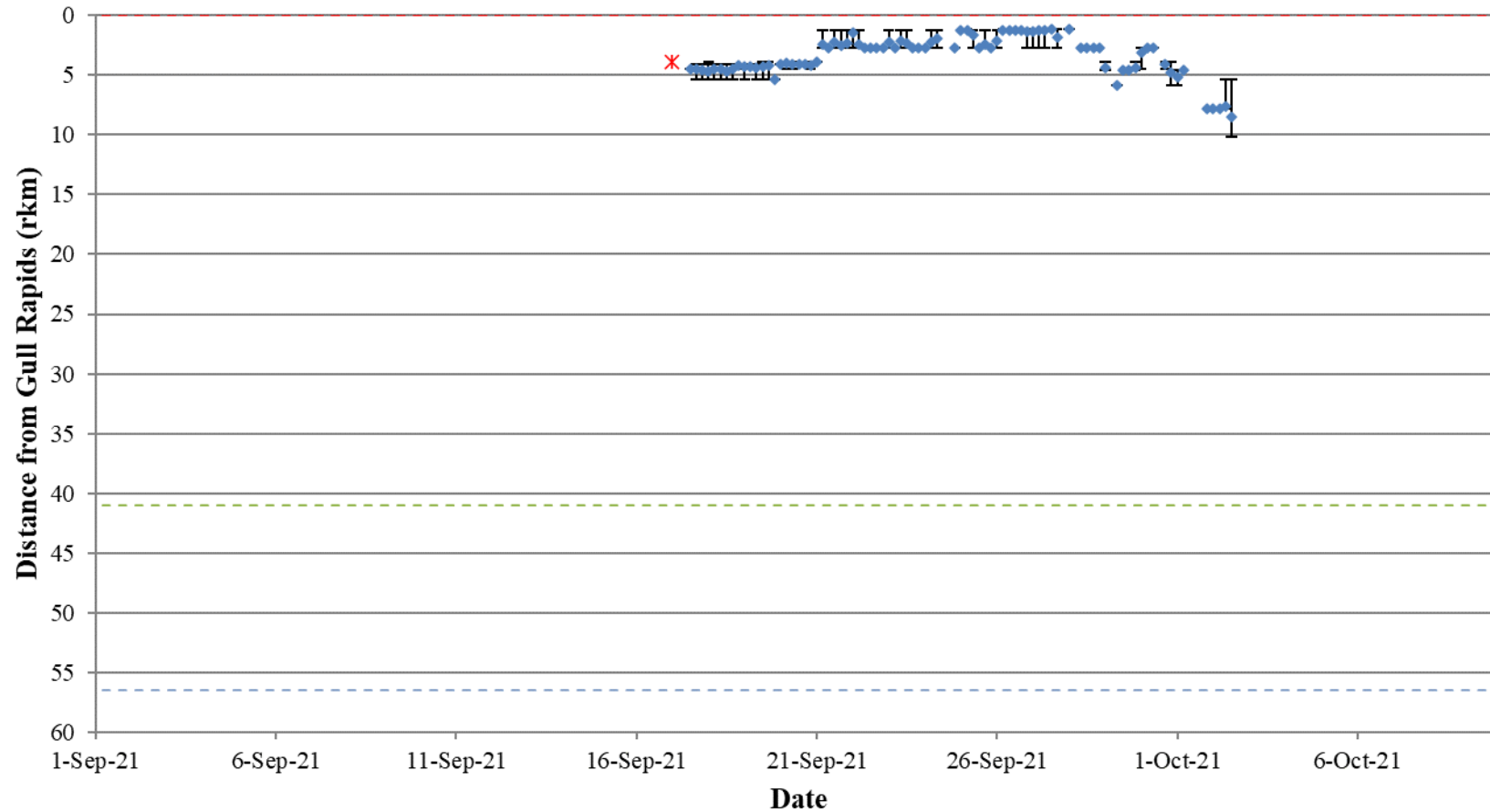
**Figure A2-29: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #48288) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 17, 2021. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Kettle GS (green), and Long Spruce GS (purple).**



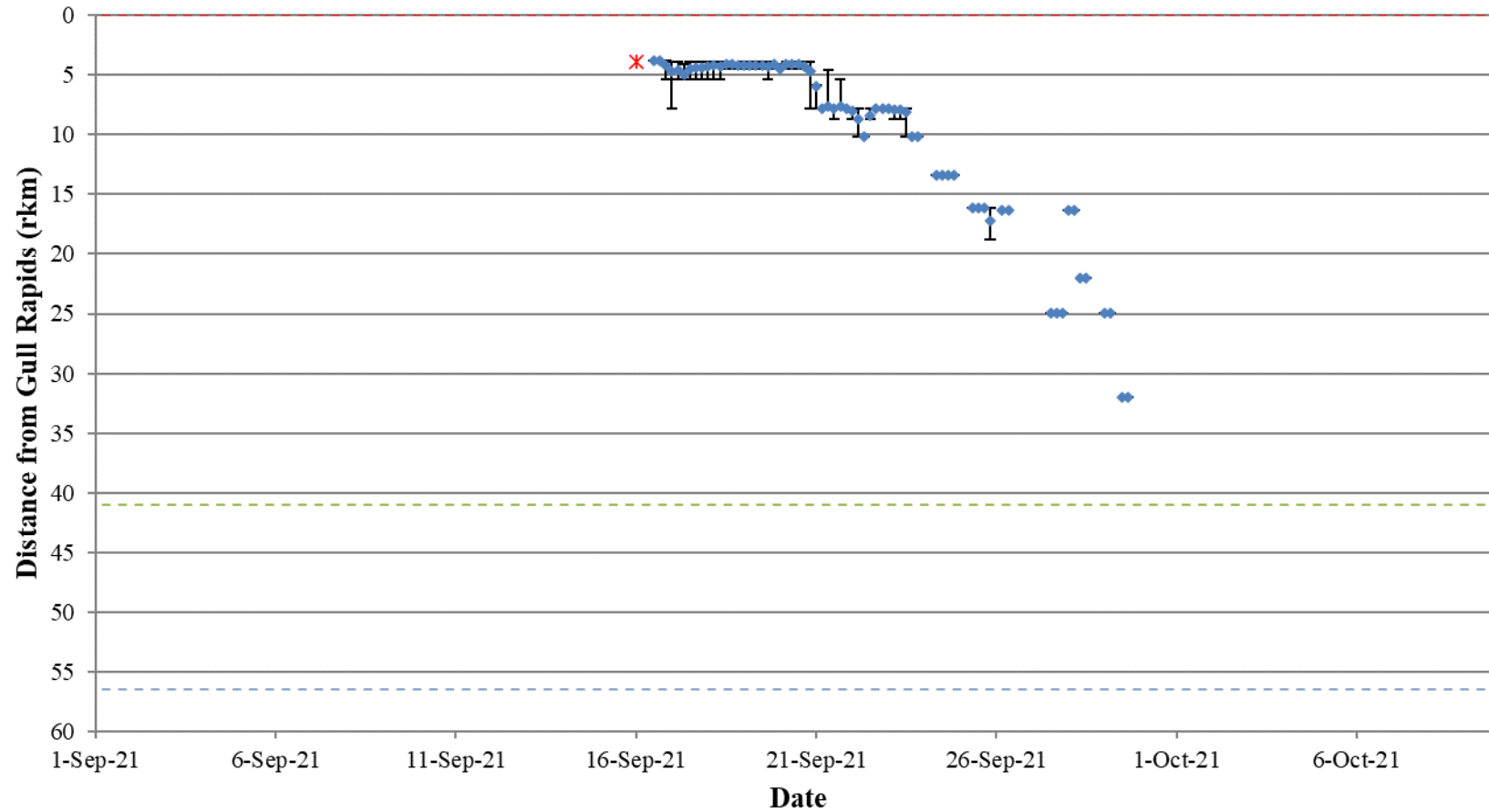
**Figure A2-30: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #48289) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 17, 2021. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Kettle GS (green), and Long Spruce GS (purple).**



**Figure A2-31: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #48290) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 17, 2021. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Kettle GS (green), and Long Spruce GS (purple).**

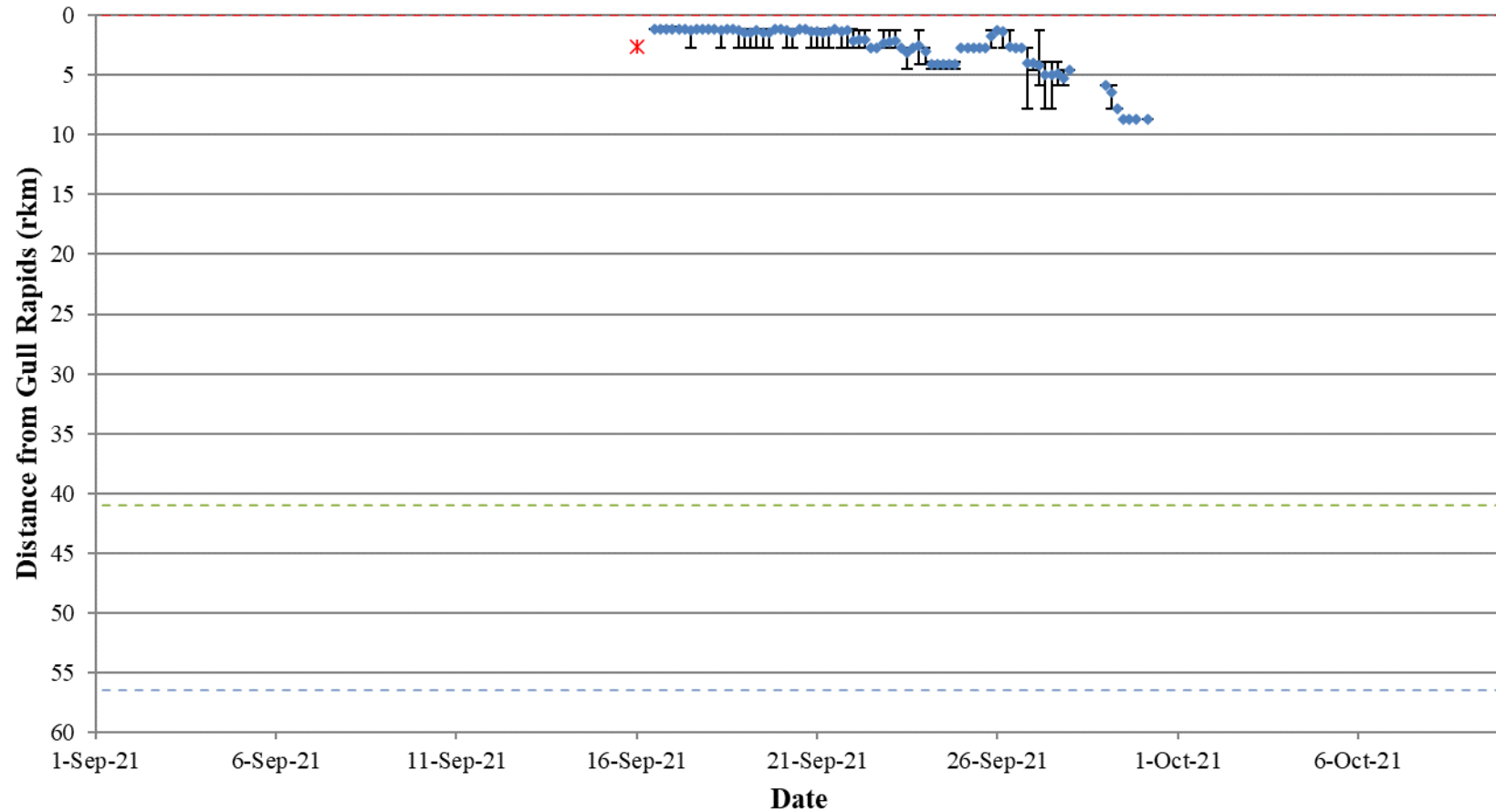


**Figure A2-32: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #48291) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 17, 2021. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Kettle GS (green), and Long Spruce GS (purple).**

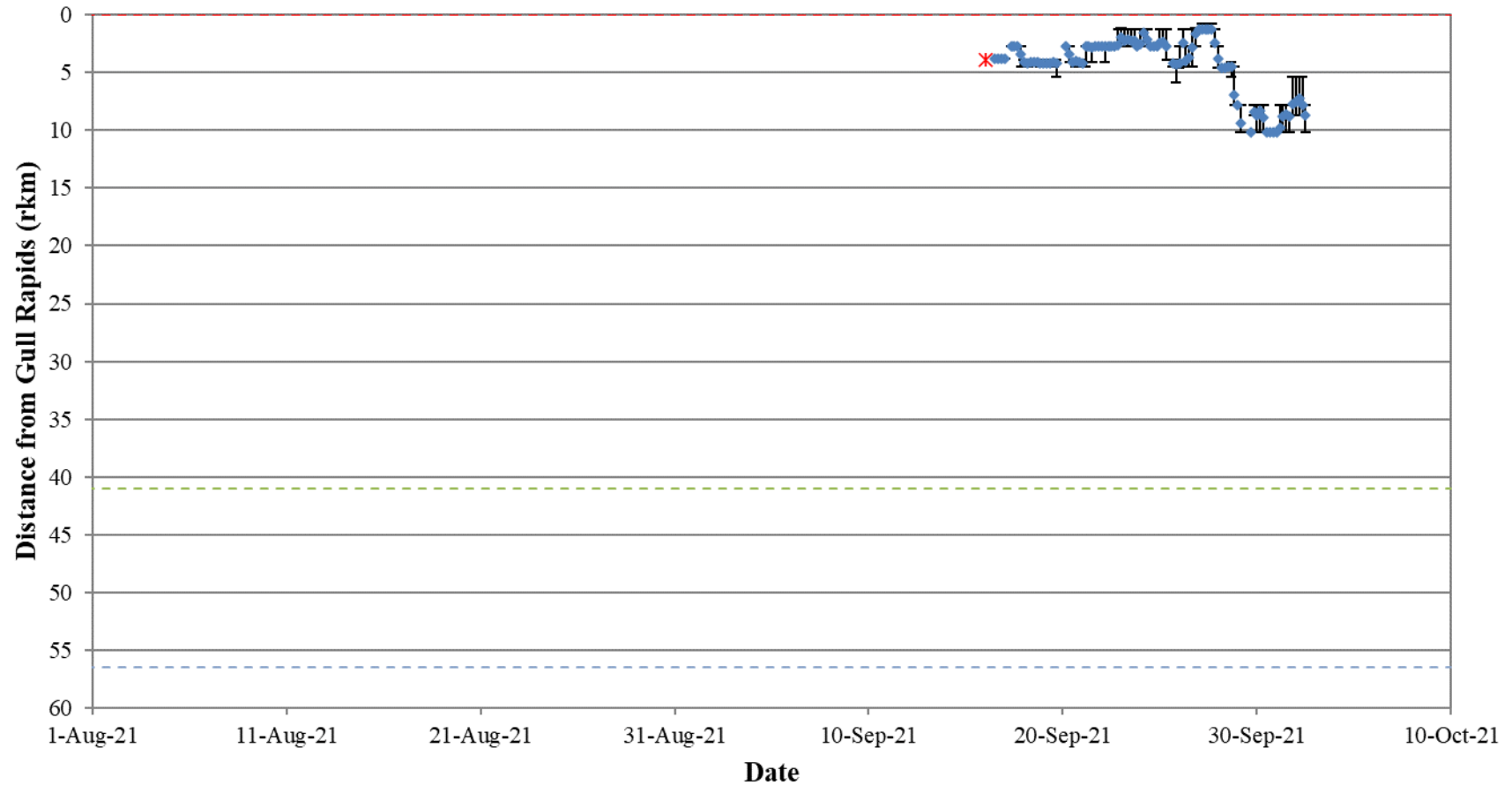


**Figure A2-33: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #48294) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 16, 2021. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Kettle GS (green), and Long Spruce GS (purple).**

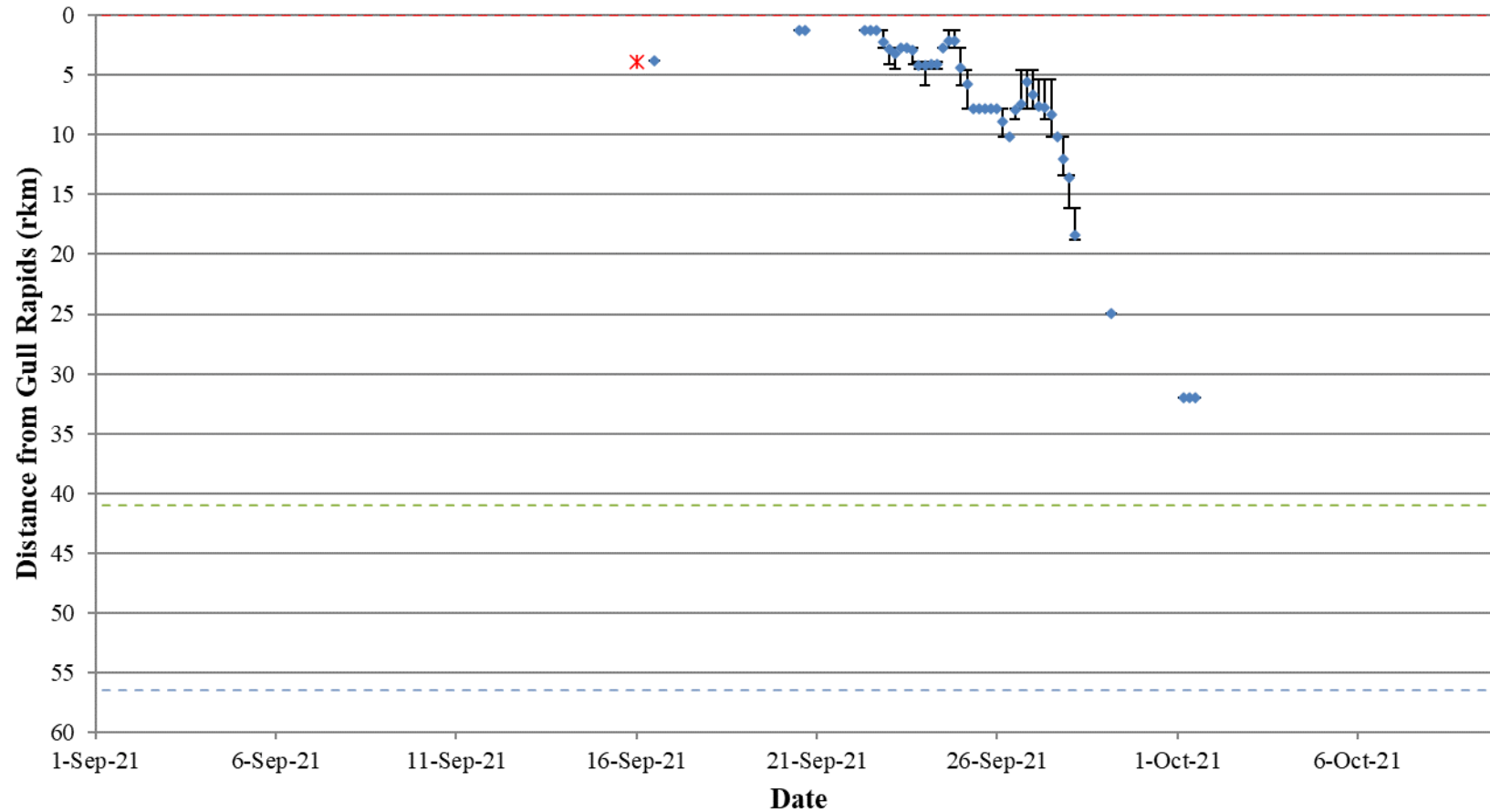




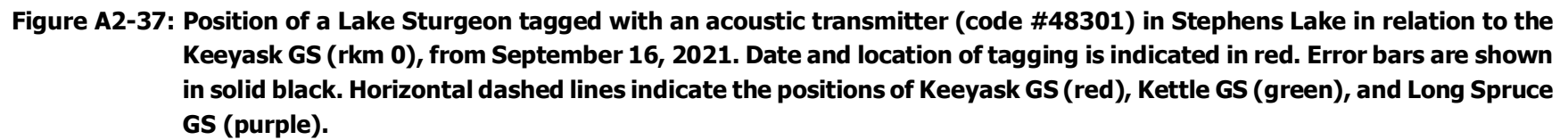
**Figure A2-34: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #48295) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 16, 2021. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Kettle GS (green), and Long Spruce GS (purple).**

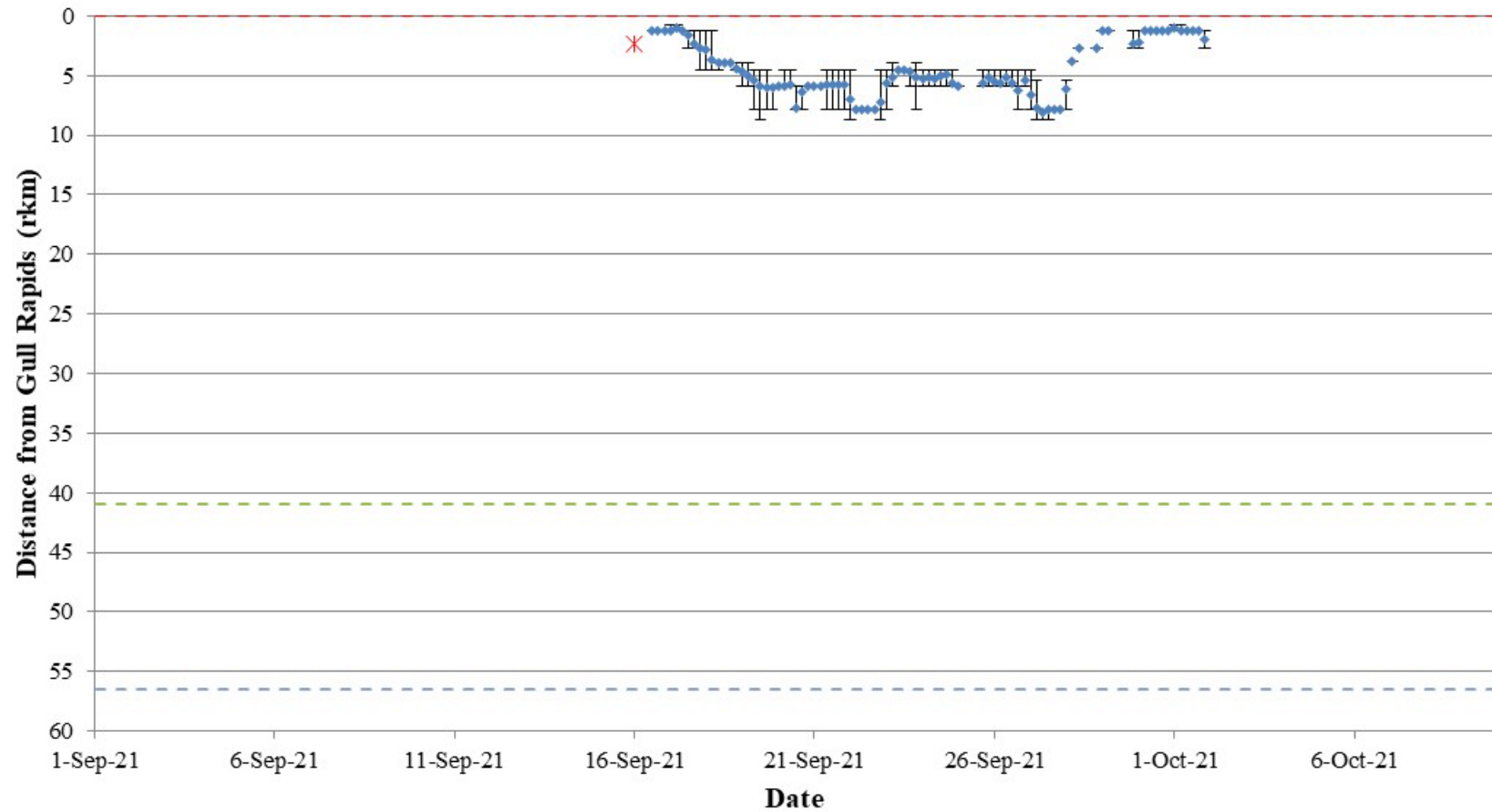


**Figure A2-35: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #48296) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 16, 2021. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Kettle GS (green), and Long Spruce GS (purple).**

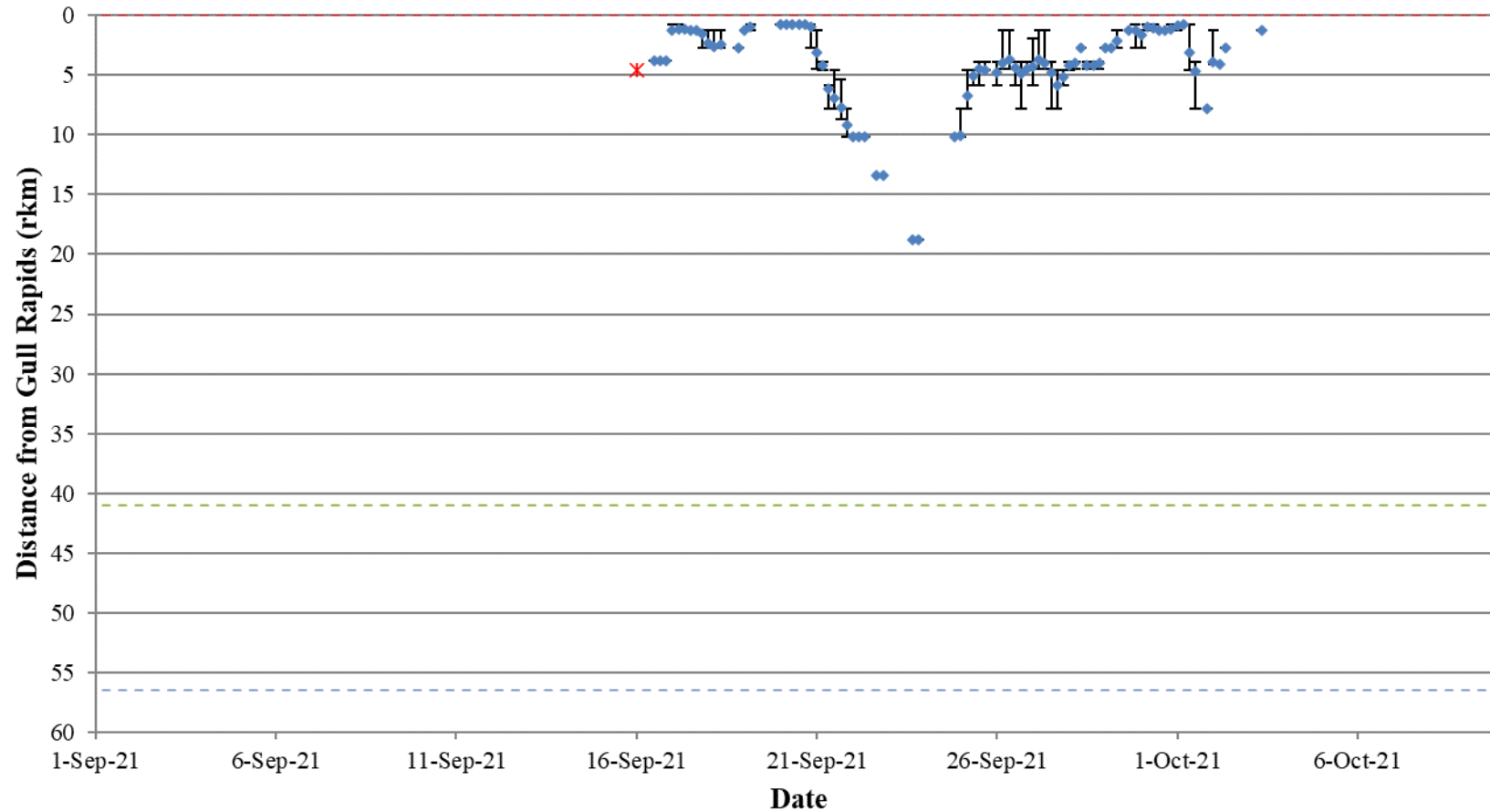


**Figure A2-36: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #48300) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 16, 2021. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Kettle GS (green), and Long Spruce GS (purple).**

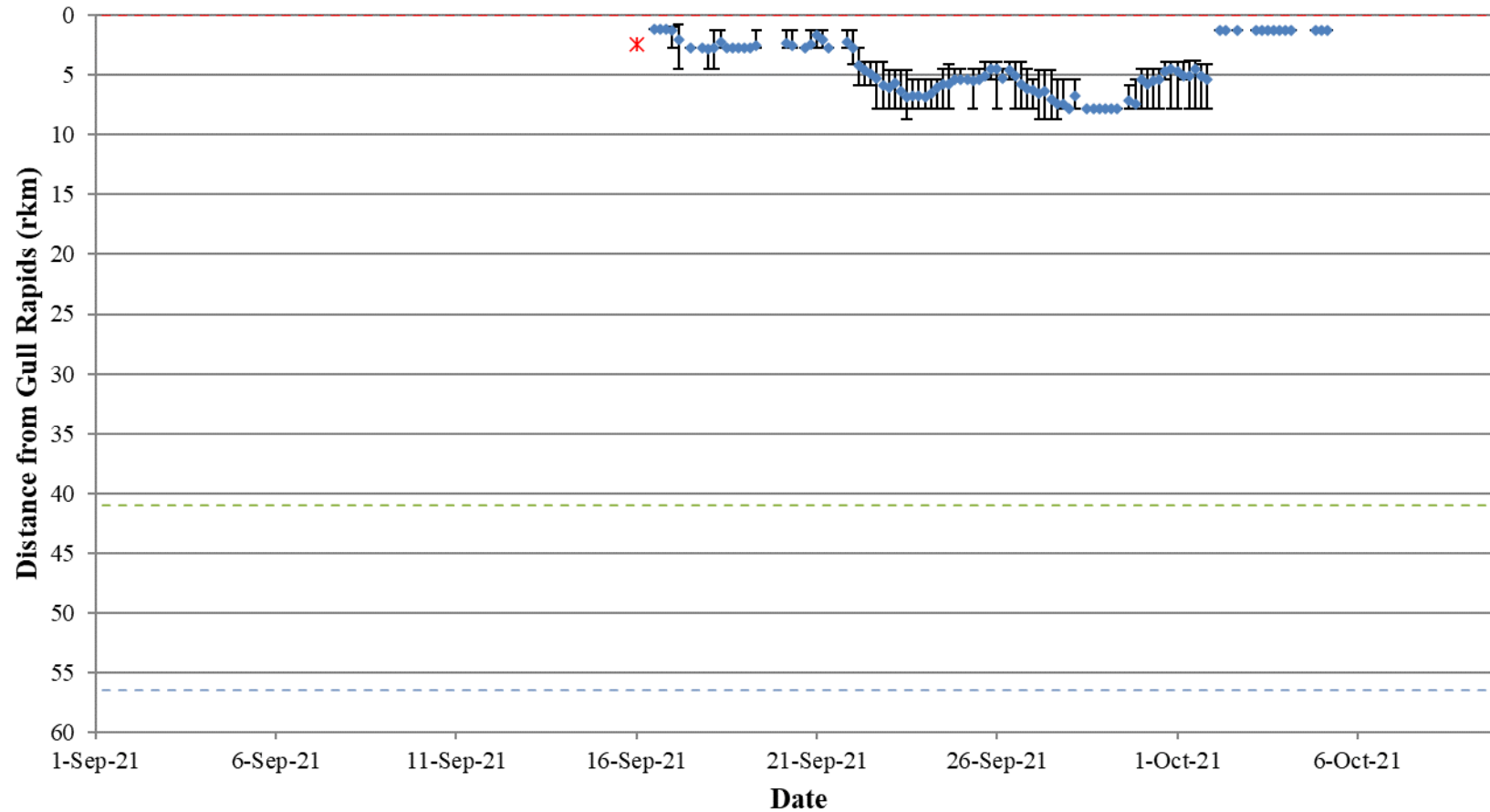




**Figure A2-38: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #48306) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 16, 2021. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Kettle GS (green), and Long Spruce GS (purple).**



**Figure A2-39: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #48307) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 16, 2021. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Kettle GS (green), and Long Spruce GS (purple).**



**Figure A2-40: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #48312) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 16, 2021. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate the positions of Keeyask GS (red), Kettle GS (green), and Long Spruce GS (purple).**