Keeyask Generation Project

Aquatic Effects Monitoring Plan

Juvenile Lake Sturgeon Movement Monitoring Report

AEMP-2021-02

KEEYASK

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KEEYASK GENERATION PROJECT

AQUATIC EFFECTS MONITORING PLAN

REPORT #AEMP-2021-02

JUVENILE LAKE STURGEON MOVEMENT MONITORING IN THE NELSON RIVER BETWEEN CLARK LAKE AND THE LIMESTONE GENERATING STATION, OCTOBER 2019 TO SEPTEMBER 2020: YEAR 7 CONSTRUCTION

Prepared for

Manitoba Hydro

By

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SUMMARY

Background

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

Construction of the Keeyask GS began in mid-July 2014 with the construction of cofferdams in the north and central channels of Gull Rapids. These cofferdams resulted in the dewatering of the north and central channels and the diversion of all flow to the south channel. Construction of the Spillway Cofferdam (SWCD), which extends into the south channel of Gull Rapids, was completed in 2015. The rock placement for the inner and outer groins of the Tailrace Cofferdam (TRCD) started in late 2016 and the impervious fill placement was completed in fall 2017. The spillway was commissioned between August 3 and 7, 2018. Closing the south channel with the upstream South Dam Cofferdam (SDCD) commenced at the beginning of August and river closure was achieved on August 16. This closure and the work that continued to seal the cofferdam forced the entire river flow through the spillway. In 2020 water-up of the areas kept dry by cofferdams for construction occurred between the end of February and mid-April. The cofferdams upstream of Keeyask and North Channel Rock Groin were removed and/or lowered throughout the water-up process. Excavation of the TRCD occurred from mid-April to May 14 and then resumed on July 16 and was completed in October. Impoundment of the Keeyask reservoir took place between August 31 and September 5, 2020. Commissioning of the first generator unit started on August 31, 2020 and was still underway at the end of 2020.

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:

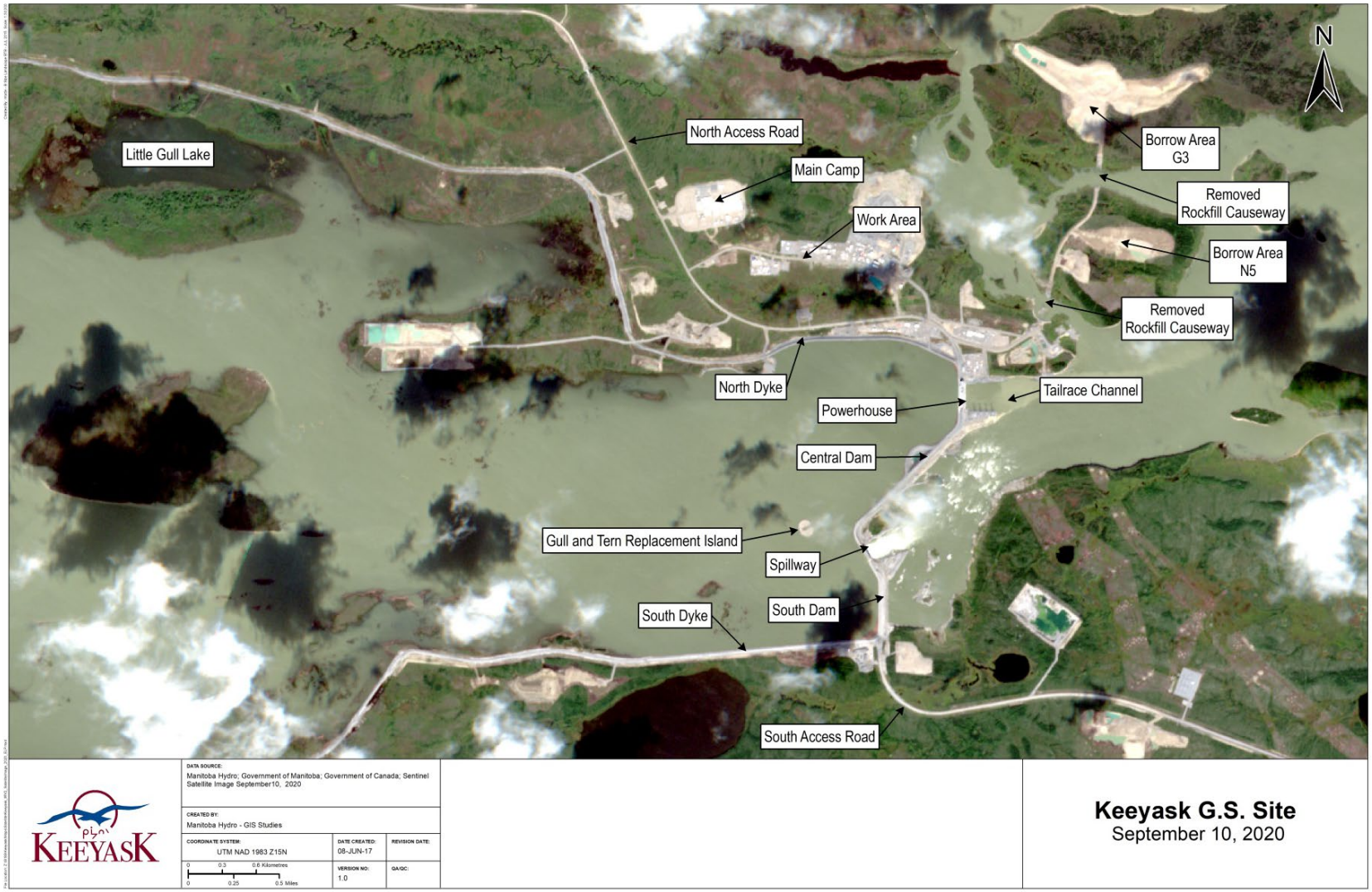
- Estimating the number of adults;
- Estimating the number and growth of juveniles (less than 800 millimetres [mm] in length);
- Identifying spawning locations and numbers of spawning fish; and
- Recording seasonal habitat use and long-distance movements (*i.e.*, over GS's or rapids) through movement 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 19 days after Keeyask reservoir impoundment to full supply level (GS commissioning). 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 to continue the study.

This report provides results of juvenile sturgeon movement monitoring conducted from October 2019 to September 2020.



Map illustrating instream structures at the Keeyask Generating Station site after reservoir flooding, September 2020.

Why is the study being done?

Monitoring during construction is being done to answer three questions:

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

Monitoring sturgeon movement shows what areas of the river the sturgeon are using 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.

In 2020, monitoring was conducted for the first 19 days after the reservoir was flooded on September 5. This means an additional AEMP key question can begin to be addressed.

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

Flooding of Gull Lake will cause 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 data collected from the first 19 days after the reservoir was created are presented in this report.

What was done?

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

During fall 2013, 20 tags were applied to juvenile sturgeon in Gull Lake and 20 were applied to juveniles in Stephens Lake. Since these tags 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.

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

What was found?

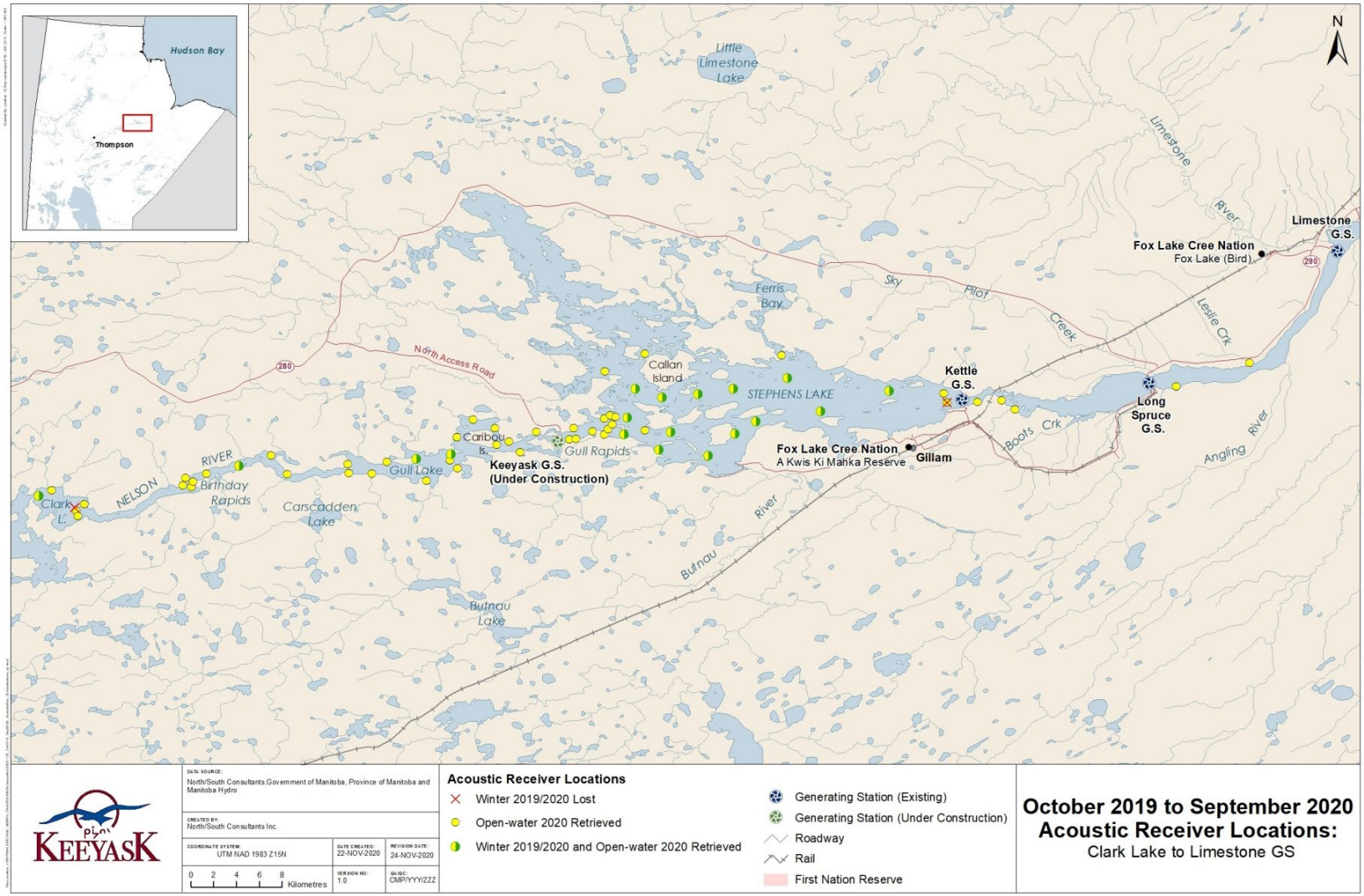
Overall, most juvenile sturgeon do not move very far. Sturgeon in Stephens Lake move farther than those in Gull Lake. This is probably because juvenile sturgeon prefer deep-water habitat, and there is more of it in Stephens Lake than in Gull Lake. Juveniles in Gull Lake like to stay in the few deep-water sites in the lake and do not make many movements away from these sites. In Stephens Lake, there is more deep-water habitat and juveniles spend most of their time in the upper portion of Stephens Lake within 13 km of the Keeyask GS.

In previous years, juvenile Lake Sturgeon have tended to stay in the area where they were tagged. For fish tagged in 2013, only one fish made a movement upstream out of Gull Lake but returned in the same year. No other movements out of Gull Lake were recorded since 2013 until 2019 when one fish tagged in Gull Lake moved downstream through the Keeyask GS spillway. This fish continued to move in Stephens Lake, showing that it survived the downstream movement. All movements of tagged sturgeon out of Gull Lake are shown in the map below.

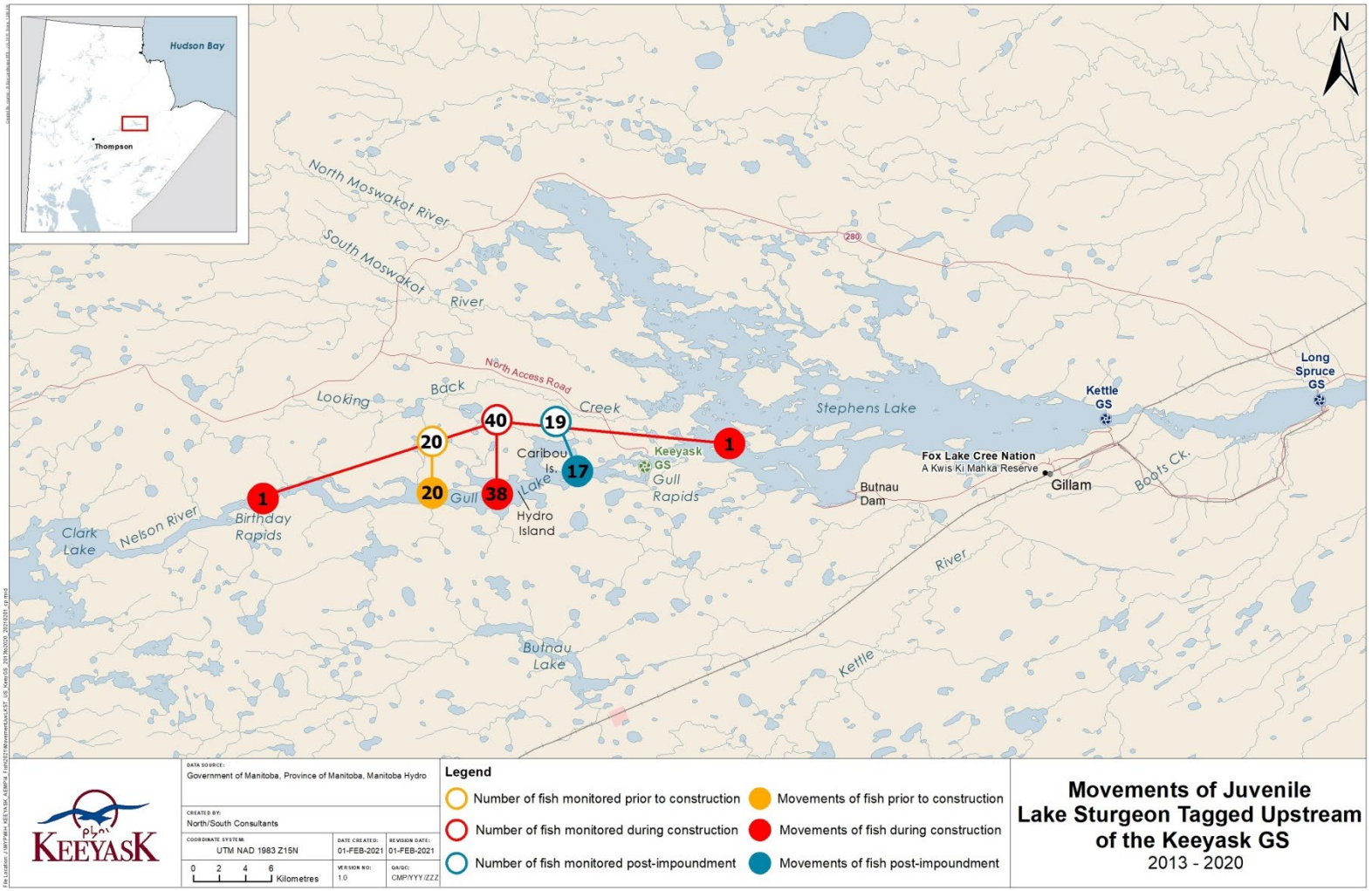
In Stephens Lake, seven fish are known to have moved downstream past the Kettle GS since the start of the study: two fish tagged in 2013 (one before construction and one after construction), and five fish tagged in 2017. All movements of tagged sturgeon out of Stephens Lake are shown in the map below.

At Keeyask, the river was completely blocked off and the spillway was commissioned during August of 2018, meaning upstream movement out of Stephens Lake is no longer possible. This is not likely to affect juvenile sturgeon movements, as no juvenile has ever been recorded moving upstream over Gull Rapids. Juvenile sturgeon in Gull Lake do not spend much time in the area near the construction site, but the ones in Stephens Lake do spend time right below the site.

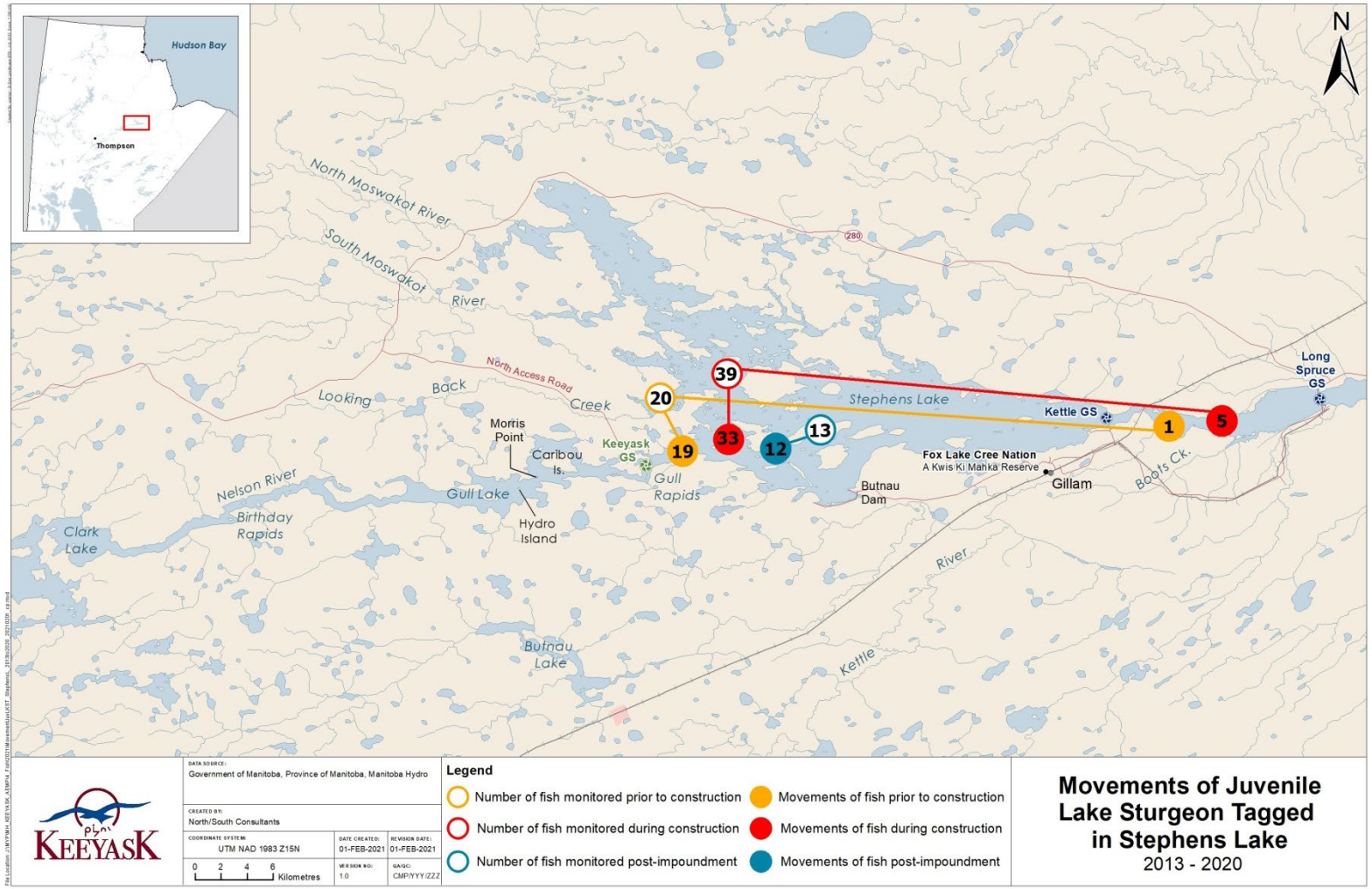
Flooding of the Keeyask GS reservoir to the full supply level was completed during six days ending on September 5, 2020. Monitoring was conducted for 19 days after this date. No fish tagged in Gull Lake moved upstream or downstream out of the reservoir during or following reservoir impoundment.



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.



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?

For the most part, monitoring has shown that juvenile sturgeon tend to stay in the same areas year after year, and these areas have not changed since construction started in 2014. A single fish tagged in Gull Lake moved downstream through the Keeyask GS in 2019, while seven fish tagged in Stephens Lake have moved downstream through the Kettle GS. The movement of juvenile sturgeon will continue to be monitored to address the key questions in the AEMP.

How far sturgeon move may also depend on the habitat that is available. For example, they may move farther when they have access to a long stretch of deep river channel. For this reason, the movements of sturgeon may change after the GS is built and Gull Lake becomes part of a deep reservoir.

What will be done next?

The original tags applied to juvenile Lake Sturgeon in 2013 are now expired and cannot be tracked by the receivers. The 40 new tags applied in 2017 will allow the movements of juvenile Lake Sturgeon to be tracked until 2021. Additional tags will be applied in 2021. Tracking a new group of fish will provide more information about what kinds of habitats juvenile Lake Sturgeon use over many years, and whether construction and operation of the GS is changing their movement patterns.

ACKNOWLEDGEMENTS

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Grant Connell and Leslie Flett of Tataskweyak Cree Nation are thanked for their local expertise and assistance in conducting the field work.

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 #10-20.

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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. The original 40 transmitters are now expired and are no longer being tracked in the study area.

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

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

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

Reservoir impoundment occurred over six days ending on September 5. Monitoring was conducted for 19 days after impoundment, which made it possible to begin to address another key question:

- 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)?

This report provides results from October 2019 to September 2020, which is the fifth winter and sixth open-water period of monitoring conducted since construction of the Keeyask GS began in July 2014. This report includes data collected during the first 19 days (September 5 to September 23, 2020) after impoundment of the Keeyask reservoir.

2.0 STUDY SETTING

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

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

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

Gull Lake is a section of the Nelson River where the river widens, with moderate to low water velocity. Gull Lake is herein defined as the reach of the Nelson River beginning approximately 19.5 km upstream of the Keeyask GS and 14 km downstream of Birthday Rapids, where the river widens to the north into a bay around a large point of land (Maps 1 and 3), and extending to the downstream end of Caribou Island, approximately 3 km upstream of the Keeyask GS. Gull Lake has three distinct basins, the first extending from the upstream end of the lake downstream approximately 6 km to a large island; the second extending from the large island to Morris Point (a constriction in the river immediately upstream of Caribou Island); and the third extending from Morris Point to the downstream end of Caribou Island (Map 3).

In fall 2020, Gull Lake was impounded by the Keeyask GS and became part of the Keeyask reservoir, which will operate at a full supply level (FSL) of 159 m above sea level (ASL) on a permanent basis. The Keeyask reservoir is comprised of the mainstem of the original Nelson River from the outlet of Clark Lake as far as the Keeyask GS, plus 45 km^2 of adjacent, flooded terrestrial area. Reservoir impoundment formed relatively shallow bays due to flooding of terrestrial areas, which generally have low water velocities and limited mixing with the mainstem flow. Over time the total area of the reservoir will increase as the terrestrial (peat) areas erode.

Gull Rapids, now the site of the Keeyask GS, was located approximately 3 km downstream of Caribou Island on the Nelson River (Map 1). Prior to construction, the rapids were approximately 2 km in length, and the river elevation dropped approximately 11 m along the 2

km length. Two large islands and several small islands occurred within the rapids, prior to the river narrowing; these features are within the Project footprint and have now been either dewatered, incorporated into the GS or were flooded after impoundment (Map 2). A summary of construction activities is provided in Section 2.1.

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

Construction of the Keeyask GS began in mid-July 2014 with the construction of cofferdams in the north and central channels of Gull Rapids. These cofferdams resulted in the dewatering of the north and central channels and the diversion of all flow to the south channel. Construction of the Spillway Cofferdam (SWCD), which extends into the south channel of Gull Rapids, was completed in 2015. The rock placement for the inner and outer groins of the Tailrace Cofferdam (TRCD) started in late 2016 and the impervious fill placement was completed in fall 2017. The spillway was commissioned between August 3 and 7, 2018. Closing the south channel with the upstream South Dam Cofferdam (SDCD) commenced at the beginning of August and river closure was achieved on August 16. This closure and the work that continued to seal the cofferdam forced the entire river flow through the spillway. In 2020 water-up of the areas kept dry by cofferdams for construction occurred between the end of February and mid-April. The cofferdams upstream of Keeyask and the North Channel Rock Groin were removed and/or lowered throughout the water-up process. Excavation of the TRCD occurred from mid-April to May 14 and then resumed on July 16 and was completed in October. Impoundment of the Keeyask reservoir took place between August 31 and September 5, 2020. Commissioning of the first generator unit started on August 31, 2020 and was still underway at the end of 2020.

2.2 FLOWS AND WATER LEVELS

From October 2019 to October 2020 the calculated Split Lake outflow ranged between 2,600 m³/s in October 2019 and 5,900 m³/s in May 2020. Flows increased from about 2,600 m³/s in October 2019 to about 4,000 m³/s in December 2019 and remained fairly steady between 4,000–4,400 m³/s until the end of April 2020. In summer the flows were high and ranged between 5,000–6,000 m³/s from May through August before dropping in September through October until it reached 3,500 m³/s, slightly above the existing environment average flow.

Water levels on Gull Lake generally varied with flow and ice conditions between October 2019 and February 2020. Levels on Gull Lake rose from a low of about 153.5 m to 156 m from October to December and remained near that level until February while upstream levels varied with flow and ice conditions. From February to April, water-up activities at the construction site caused Gull Lake levels to rise about 0.3 m. After water-up, the spillway gates were used to keep levels relatively steady between about 156.3–156.8 m until the end of August prior to impoundment. The Keeyask reservoir was impounded to its operating level (158 to 159 m) from August 31 to September 5. During this period, Gull Lake was raised about 2 m to a maximum level of 158.9 m, 0.1 m below the full supply level. Upstream of Gull Lake the water level increase diminished with distance, with increases of about 0.8 m and 0.2 m immediately below and above Birthday Rapids while no increases occurred at the water level gauges immediately below and on Clark Lake. Gull Lake has since been held near 158.8 m while upstream levels vary with flow. With impoundment the Keeyask reservoir has entered its operating condition. Water levels on Gull Lake and upstream areas within the project's open water hydraulic zone of influence, which extends to about 3 km below Clark Lake, will now be permanently elevated relative to pre-project conditions.

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. Initially, the receiver array was designed to monitor adult Lake Sturgeon (Hrenchuk 2021a); however, the same array is also used to monitor juvenile Lake Sturgeon (the focus of this report), Walleye (Hrenchuk 2021b), and Lake Whitefish (Hrenchuk 2021c).

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).

3.1.2 ACOUSTIC RECEIVERS

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

During the 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 Gull Lake.

3.1.2.1 WINTER 2019/2020

The stationary acoustic receiver array for the winter 2019/2020 (October 8, 2019, to April 30, 2020) period consisted of 21 receivers. Five were set upstream of the Keeyask GS and 16 throughout Stephens Lake (Maps 3 and 4). Low water levels prevented boat access to the river section between Kettle GS and Long Spruce GS, and therefore, an acoustic receiver could not be set downstream of the Kettle GS during winter 2019/2020. The 2019/2020 winter array differed slightly from the array used in 2018/2019. An additional receiver (#107999) was set near the outlet of Clark Lake at rkm -45.0 (Map 3). One receiver (#122776) was set immediately upstream of the Kettle GS, at rkm 40.0 (Map 4).

3.1.2.2 OPEN-WATER 2020

An array of 64 acoustic receivers was used during the 2020 open-water period (defined as May 1 to September 23, 2020). Twenty-nine were set upstream of the Keeyask GS and 30 were set in Stephens Lake (Maps 5 and 6). The 2020 open-water array differed slightly from the array used in 2019. Two additional receivers were set upstream of the GS, one close to the spillway (#127091 at rkm -3.8) and one close to the powerhouse (#127100 at rkm -2.2) (Map 6).

Water levels were higher in 2020 than in previous sampling years, and receivers were set in the Long Spruce (n = 3) and Limestone (n = 2) reservoirs (Map 7). A single receiver deployed in the Long Spruce reservoir prior to winter 2017/2018 was retrieved. The battery was no longer active, but data was recorded from October 13, 2017, to August 15, 2019.

Due to complications associated with conducting field work during the COVID-19 pandemic, the open-water receiver array was deployed later than in previous years. The open-water array was completely deployed by July 3, 2020, whereas in previous years, the array was deployed in late May or early June.

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.

Between August 31 and September 5, 2020, the Keeyask GS reservoir was impounded to full-supply level. Prior to impoundment, all acoustic receivers set within the reservoir (*i.e.*, between Birthday Rapids and the Keeyask GS) were sunk as is done prior to the winter study period. This was done to minimize the potential for losing receivers due to increased water levels and potential debris. All receivers were retrieved prior to the end of the open-water period.

By September 23, 2020, the majority of receivers were removed and a subset (n = 26) were redeployed to monitor movements during winter 2020/2021.

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. It 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 2019 open-water period (October 7, 2019), and Sections 4.2 and 4.3 detail results from winter 2019/20 and open-water 2020, respectively. 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 8 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 14 summarize movement range and proportional distribution of tagged fish both upstream and downstream of the construction site by season. 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.

4.1 2017-2019 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 2019/2020 season.

4.1.2 STEPHENS LAKE

Twenty juvenile Lake Sturgeon were tagged in Stephens Lake in September 2017 (Table 2). Since that time, five 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).

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 five fish that moved downstream out of Stephens Lake, the two missing fish, and the one fish that moved downstream through the Keeyask GS, 14 juveniles were available to be detected in Stephens Lake at the beginning of winter 2019/2020.

An additional fish moved downstream through the Kettle GS during winter 2019/2020.

- #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).

Therefore, 13 juvenile Lake Sturgeon were available to be detected in Stephens Lake during open-water 2020.

4.2 WINTER 2019/2020

4.2.1 UPSTREAM OF THE KEEYASK GS

The 2019/2020 winter receiver array consisted of five receivers deployed in the Nelson River between Clark Lake and the Keeyask GS at rkms -48.2, -45.0, -29.4, -12.4, and -10.3 (Figure 1). Four of the five acoustic receivers were retrieved; the receiver near the outlet of Clark Lake (rkm -45.0) could not be located (Map 3).

Seven of the 19 juvenile Lake Sturgeon (37%) were detected, for a total of 92,550 detections (range: 74–42,031 detections per individual; Table 5). Juvenile sturgeon were only detected at the receiver set in Gull Lake at rkm -10.3 (figures 3 and 4). Fish were detected for an average of 72 days, or for 35% of the 206 day, winter period (standard deviation [StDev] = 51 days; range: 10–149 days; Table 5).

Individual movement graphs can be found in Appendix 1.

4.2.2 STEPHENS LAKE

Fifteen of the 16 receivers deployed in Stephens Lake during the 2019/2020 winter period were retrieved. The receiver located immediately upstream of the Kettle GS (at rkm 40.0) was lost.

Eleven of the 14 juveniles (79%) were located during the winter period, for a total of 209,380 detections (range: 71–62,576 detections per individual; Table 6). Fish were detected for an average of 100 days, or for 49% of the 206 day winter period (StDev = 65 days; range: 10–190 days). The mean detection range was 6.1 rkm (StDev = 8.7 rkm; range = 0.0–30.9 rkm) (Table 6; Figure 5).

As in previous years, the majority of detections were logged in the southern portion of Stephens Lake at rkms 7.9 (n = 93,503; 45%) and 10.3 (n = 62,428; 30%) (Figure 6). No fish were detected in the northern portion of Stephens Lake (Figure 6).

One fish moved downstream through the Kettle GS.

- #31762 was last detected in Stephens Lake on January 25, 2020 and was detected in the Long Spruce reservoir on August 14, 2020 (Appendix A2-2).
    - This represents the sixth known movement of juvenile Lake Sturgeon through the Kettle GS since tagging in 2017. All six movements likely occurred during winter.
    - This fish continued to be detected in the Long Spruce reservoir during open-water 2020 and likely survived passage (section 4.3.4).

The ten remaining fish displayed patterns of movement similar to previous years:

- Eight fish remained exclusively in upper Stephens Lake, moving no farther downstream than rkm 10.3.
- The remaining two fish moved between upper and lower Stephens Lake, and were detected as far upstream as rkm 1.2 and as far downstream as rkm 13.9.

Individual movement graphs can be found in Appendix 2.

4.3 OPEN-WATER 2020

4.3.1 ACOUSTIC RECEIVER RETRIEVAL

All stationary acoustic receivers deployed upstream of the Keeyask GS (n = 29), in Stephens Lake (n = 30), and the Long Spruce (n = 3) and Limestone (n = 2) reservoirs during the 2020 open-water period were successfully retrieved (Maps 5 and 6).

4.3.2 UPSTREAM OF THE KEEYASK GS

Seventeen of the 19 juvenile Lake Sturgeon (89%) available for detection upstream of the Keeyask GS were detected during the 2020 open-water period (Table 7, Figure 7). These fish were detected between 540 and 48,333 times on 5 to 97 days (3–66%) of the 146 day open-water period (average = 64 days [44%], StDev = 22 days) (Table 7). Average total movement range was 4.1 rkm (StDev = 2.9 rkm; range: 0.4–11.2 rkm; Table 4; Figure 7). Fish were only detected in the two zones closest to the Keeyask GS (Zones 4 and 5); no fish were detected farther upstream than the upper basin of Gull Lake (rkm -17.4) or at the receiver located closest to the powerhouse (rkm -2.2) (Table 7; Map 5). Two fish (#31687 and #31781) were detected at the receiver closest to the Keeyask GS spillway (rkm -3.8). No fish moved downstream through the Keeyask GS. As in previous years, the majority of detections (n = 120,457; 59%) occurred at the receiver gate located between upper and lower Gull Lake (rkms -10.3 and -9.9) (Figure 8).

Of the two fish that were not detected:

- #31685 was tagged on September 9, 2017 in upper Gull Lake. It was detected exclusively in lower Gull Lake until October 5, 2018 (Appendix A1-3).
- #31769 was tagged on September 14, 2017 in upper Gull Lake. It was last detected in upper Gull Lake on June 21, 2018 (Appendix A1-7).

A single fish (#31687) was captured during juvenile Lake Sturgeon population monitoring conducted from September 15–25, 2020. Capture details can be found in Burnett and Hrenchuk (2021).

4.3.2.1 PROPORTIONAL DISTRIBUTION

Individual juvenile Lake Sturgeon spent a similar proportion of the 2020 open-water period as in 2019. In both years, fish spent slightly less time in the lower basin of Gull Lake (Zone 5; 44.8% in 2019 and 43.7% in 2020) than the upper basin (Zone 4; 55.2% in 2019 and 56.3% in 2020 (Table 3; Figure 9). As in previous study years, the proportion of time spent in each zone remained relatively stable during the open-water season, with time spent in Zone 4 slightly increasing in July (Figure 10).

During the 19 days of monitoring after impoundment on September 5, 2020, juvenile Lake Sturgeon continued to spend a greater proportion of time in the lower basin of Gull Lake than the upper. Juvenile Lake Sturgeon spent 48.5% of the time from September 5 to the end of the study period in Zone 4 and 51.4% of the time in Zone 5. No long distance movements out of the reservoir were observed in the 19 days after reservoir impoundment.

4.3.2.2 MOVEMENT PATTERNS

Six fish were detected exclusively in Zone 4 during the open-water season (Figure 9). All six were detected as far downstream as rkm -9.9:

- Four (#31771, #31772, #31782, and #31775) were only detected between rkm -12.5 and -9.9, while one (#31770) moved as far upstream as rkm -15.0, and one (#31768) as far upstream as rkm -17.4.

Eight fish were only detected in Zone 5 (Figure 9):

- #31686 was only detected at rkm -8.9 and -7.9.
- Four (#31683, #31776, #31779, and #31780) moved between rkm -8.9 and -6.2.
- Two (#31684 and #31774) moved between rkm -7.9 and -5.8.
- #31781 showed the greatest movement range, moving between rkm -8.9 and -3.8, the receiver located closest to the GS spillway.

Three fish were detected in both zones (Figure 9):

- One (#31687) spent the majority of the study period in Zone 5, while two (#31773 and #31777) were located for the majority of the time in Zone 4.

4.3.3 STEPHENS LAKE

Twelve of the 13 juvenile Lake Sturgeon (92%) available for detection in Stephens Lake were located during the 2020 open-water period. These fish were detected between 1,688 and 23,635 times over 33 to 116 days (23–79%) of the 146 day study period (average = 89 days [61%]; StDev = 26 days) (Table 8). The average total movement range was 9.3 rkm (StDev = 4.1 rkm; range: 0.0–17.6 rkm; Table 4; Figure 11). No fish were detected farther upstream than rkm 1.2 or farther downstream than rkm 18.8. The majority of detections were logged in the southern portion of Stephens Lake within 7.8 rkm of the GS (132,808 detections or 91%; Figure 12).

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

One fish (#31760) was captured during juvenile Lake Sturgeon population monitoring conducted from September 15–25, 2020. Capture details can be found in Burnett and Hrenchuk (2021).

4.3.3.1 PROPORTIONAL DISTRIBUTION

As in previous study years, fish spent a similar amount of time in both zones of Stephens Lake. In 2020, fish spent an average of 43% of the study period prior to reservoir impoundment in

Zone 6 (closer to the GS) and 57% in Zone 7 (farther from the GS) (Table 3; Figure 13). Time spent in Zone 6 increased at the end of August, as was seen previous study years (Figure 14).

After reservoir impoundment on September 5, 2020, juvenile Lake Sturgeon continued to use both zones of Stephens Lake, however, spent more time closer to the GS. Juvenile Lake Sturgeon spent 59% of the time between reservoir impoundment and the end of the study period in Zone 6 and 41% of the time in Zone 7.

4.3.3.2 MOVEMENT PATTERNS

Of the 12 fish located during the open-water period, one (#31688) was detected exclusively in Zone 6 (at rkm 1.2), and one (#31694) was detected exclusively in Zone 7 (between rkm 5.2 and 13.9). The remaining 11 fish were detected in both Zones 6 and 7.

A single fish (#31759) was detected within the northern portion of Stephens Lake and was located as far downstream as rkm 18.8. The remaining nine fish were detected exclusively at receivers in the southern portion of the lake:

- Five were detected as far upstream 1.2 rkm downstream of the GS. Three of these (#31696, #31758, and #31765) moved as far downstream as rkm 10.3, and two (#31697 and #31766) to rkm 13.4.
- Three (#31760, #31763, and #31767) were detected as far upstream as rkm 2.7 and as far downstream as rkm 13.4.
- #31695 was detected between rkm 3.9 and 13.4.

4.3.4 LONG SPRUCE RESERVOIR

Due to low water levels that prevented boat access, no acoustic receivers were set or retrieved from the Long Spruce reservoir between October 2017 and August 2020. Water levels were higher in 2020 than in previous sampling years, and receivers were set in the Long Spruce (n = 3) and Limestone (n = 2) reservoirs (Map 7). A single receiver deployed in the Long Spruce reservoir prior to winter 2017/2018 was retrieved. The battery was no longer active, but data was recorded from October 13, 2017, to August 15, 2019.

Prior to retrieval of this receiver, five fish tagged in Stephens Lake were missing and were suspected to have moved downstream through the Kettle GS. Data from this receiver along with three additional set in August 2020 confirmed that six of the 20 fish tagged in Stephens Lake (30%) in 2017 moved downstream into the Long Spruce reservoir (section 4.1.2).

One fish (#31691) moved downstream through the Kettle GS within nine days of tagging. This movement was likely due to tagging stress. Based on the date of last detection in Stephens Lake, it is likely that the remaining five downstream movements occurred during winter independently of tagging stress or mortality:

- Two fish moved downstream in November (#31764) and December (#31690) 2017;
- One (#31689) in January 2018;
- One (#31692) in February 2019; and
- One (#31762) in January 2020.

Four of the six fish (#31690, #31691, #31692, and #31762) continued to be detected in the Long Spruce reservoir at rkm 45.7 during open-water 2020.

5.0 DISCUSSION

Juvenile Lake Sturgeon movement monitoring was initiated in 2013 to describe movements during the pre-construction (2013), construction (2014–August 2020), and post-impoundment/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.

Acoustic transmitters were applied to 40 juvenile Lake Sturgeon in 2013 and 40 in 2017. Acoustic transmitters applied in 2013 expired in 2017, and the transmitters applied in 2017 have a four-year battery life and will expire in 2021. Upstream of the Keeyask GS, juvenile Lake Sturgeon tagged in 2017 generally exhibit similar movement patterns to the original 20 fish tagged in Gull Lake in 2013. Since inception of the study, juveniles have continued to spend the majority of time 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 (Figure 8). Similar to previous years, juveniles did not move upstream or downstream out of Gull Lake in 2020. A single juvenile Lake Sturgeon has moved downstream through the GS over seven years of study (in 2019). Juveniles tagged in Stephens Lake continued to display larger average movement ranges compared to those upstream of the GS, which has been attributed to the greater amount of continuous deep-water habitat available in this area (McDougall *et al* 2013a, b).

The EIS predicted that Lake Sturgeon in Gull Lake may emigrate upstream or downstream from the Keeyask reservoir in response to habitat changes associated with impoundment. Results indicate that in the 19 days after full supply level was reached, no upstream or downstream emigration of juvenile Lake Sturgeon from the Keeyask reservoir was observed and there were no obvious changes in proportional distribution or movement patterns within the newly-formed reservoir.

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. Tracking has always been more effective during the open-water period compared to the winter, as there are limited locations where receivers can be deployed in winter without the risk of being moved or damaged by ice. Fish tagged upstream of the Keeyask GS

were detected, on average, on 44% of the days during the 2020 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 61% of the days during the 2020 open-water period (46–78% in previous years).

Two additional receivers were added to the receiver array upstream of the GS in 2020, one closer to the powerhouse (rkm -2.2) and one closer to the spillway (rkm -3.8). No juvenile Lake Sturgeon were detected by the receiver closest to the powerhouse, while two fish were briefly detected by the receiver close to the spillway. These receivers will continue to be deployed as part of the Keeyask reservoir receiver array.

5.2 KEY QUESTIONS

The AEMP identified key questions for juvenile Lake Sturgeon movement monitoring, two of which are relevant to the construction period. Keeyask reservoir impoundment was completed on September 5 and monitoring was conducted for 19 days after impoundment. An additional key question presented in the AEMP is relevant to this period. Key questions are addressed below.

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

Since movement monitoring began in 2013, juvenile Lake Sturgeon upstream of the Keeyask GS have consistently occupied small home ranges. Only one juvenile Lake Sturgeon (tagged in 2013) moved upstream out of Gull Lake (in 2015); this fish returned downstream in the same year and did not repeat the movement. In May 2019, a single juvenile Lake Sturgeon (tagged in 2017) moved downstream through the Keeyask GS spillway (Figure 15). These are essentially the only long distance movements observed since the study began.

In Stephens Lake, juveniles generally exhibit a similar pattern, displaying small movement ranges relative to the amount of available deep-water habitat; however, the frequency of downstream emigration out of Stephens Lake through the Kettle GS is higher. The number of juvenile Lake Sturgeon that have emigrated from Stephens Lake has varied each year. In 2013 and 2014, (during the 10.5 months prior to the onset of construction), one fish moved downstream through the Kettle GS (Table 9). In the five years of monitoring since the onset of construction, five fish have moved downstream through the Kettle GS independent of tagging stress: three in winter 2017/2018, one in winter 2018/2019, and one in winter 2019/2020 (Figure 16).

Overall, the number of juvenile Lake Sturgeon that have moved downstream through Gull Rapids/the Keeyask GS has remained low. The number of fish entrained through the Kettle GS (independent of tagging stress) is higher; however, the number of downstream movements has

fluctuated annually with no clear increasing or decreasing pattern. It is likely that all downstream movements have occurred during the winter period.

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

Monitoring has consistently shown that juvenile Lake Sturgeon upstream of the Keeyask GS do not spend much time near the construction site. In 2019, detections at the three receivers located nearest to the Keeyask GS (rkm -4.8, -3.8, and -2.2) comprised less than 1% of the total detections, and no fish were detected at the receiver closest to the GS (rkm -2.2). Juveniles (both those tagged in 2013 and 2017) are consistently detected most often near the transition between Zones 4 and 5, as well as at the receivers on the north and east side of Caribou Island (Map 5).

In contrast, juveniles in Stephens Lake have been frequently detected near the construction site. In 2019 and 2020, no juveniles were detected at a receiver placed 0.6 rkm downstream of the Keeyask GS spillway, however, 42% of detected fish were located by a receiver located 1.2 rkm downstream of the Keeyask GS near the tailrace.

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

Movement patterns of juvenile Lake Sturgeon have remained relatively consistent since monitoring started in 2013. Upstream of the Keeyask GS, juveniles are consistently located in the same area year after year. Fish are 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. Average movement ranges during the open-water period have remained similar each year, ranging from 2.6 rkm (in 2019) to 5.2 rkm (in 2016). Juveniles in Stephens Lake tend to move longer distances on average than in Gull Lake, likely due to longer expanses of deep-water habitat. Since 2013, average movement ranges during the open-water period have ranged from 9.3 rkm (in 2020) to 12.0 rkm (in 2018).

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)?

After reservoir impoundment, juvenile Lake Sturgeon tagged upstream of the GS continued to spend a greater proportion of time in the lower basin of Gull Lake than the upper. Prior to impoundment during the 2020 open-water period, juvenile Lake Sturgeon spend 44% of the time in Zone 4 and 56% in Zone 5. After impoundment, juvenile Lake Sturgeon spent 49% of the time in Zone 4 and 51% of the time in Zone 5. No Lake Sturgeon were detected upstream of Zone 4 during open-water 2020, either before or after reservoir impoundment. In the 19 days following impoundment, no long distance movements or changes to movement patterns were observed. These initial observations are based on a very short period of record and further monitoring will identify if fish continue to remain in the same area following impoundment.

In Stephens Lake, after reservoir impoundment, Lake Sturgeon spent more time closer to the GS (59% of the time after impoundment vs. 43% of the time before impoundment). However, this may be due to the timing of impoundment later in the study period. In both 2018 and 2019, the use of Zone 6 increased between the end of August and the end of September (from 33% to 60% in 2018 and 36% to 50% in 2019). In the 19 days following impoundment, no long distance movements or changes to movement patterns were observed.

As discussed previously, movements of Lake Sturgeon were only monitored for 19 days after reservoir impoundment was completed and movements associated with impoundment may be observed during 2020/2021. An array of acoustic receivers was deployed at the end of the open-water period to continue monitoring movements during the first winter following GS commissioning. Continued monitoring will determine if movements change over time during Keeyask GS operation.

6.0 SUMMARY AND CONCLUSIONS

- Juveniles (n=40) implanted with acoustic transmitters in 2017 have now been tracked for three years. The original 40 transmitters implanted in 2013 are no longer active.
- Juvenile Lake Sturgeon continue to be tracked effectively using acoustic telemetry. 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. Tracking has always been more effective during the open-water period compared to the winter, as there are limited locations where receivers can be deployed in winter without the risk of being moved or damaged by ice. Fish were detected for 44% of the 2020 open-water period upstream of the Keeyask GS and 61% in Stephens Lake. This is comparable to previous years.
- 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 the frequency of long-distance movements by juvenile Lake Sturgeon increase during construction and operation of the Project?*

      Overall, the number of juvenile Lake Sturgeon that have moved downstream through Gull Rapids/the Keeyask GS has remained low, with the first and only downstream movement recorded in 2019. The number of fish entrained through the Kettle GS (independent of tagging stress) is higher; however, the number of downstream movements has fluctuated annually with no clear increasing or decreasing pattern. All downstream movements during construction have occurred during the winter period: three in 2017/2018, one in 2018/2019, and one in winter 2019/2020.
    - *Are juvenile Lake Sturgeon using habitat in the immediate vicinity of the construction site?*

      Juvenile Lake Sturgeon upstream of the Keeyask GS have consistently spent little time near the construction site since the beginning of the study. In contrast, juveniles are frequently detected by the receivers immediately downstream of the site in Stephens Lake, making these fish potentially susceptible to construction-related effects. However, no juvenile Lake Sturgeon were detected by the closest receiver placed 0.6 rkm downstream of the Keeyask GS spillway in 2019 or 2020.
    - *Will disturbances associated with construction of the Keeyask GS alter coarse-scale movement upstream or downstream of the GS?*

      Juvenile Lake Sturgeon have exhibited similar movement patterns since the start of the study. Juveniles are consistently detected at the same receivers year after year, both upstream and downstream of the Keeyask GS.

- *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)?*

  Although the proportion of juvenile Lake Sturgeon in the lower portion of the reservoir was higher after GS impoundment, this pattern follows what was seen in previous years, with more fish located in this area in September than earlier in the open-water season. No juvenile Lake Sturgeon emigrated out of the reservoir (either upstream or downstream) after impoundment.

- Movements of juvenile Lake Sturgeon were monitored for 19 days after reservoir impoundment was completed. An array of acoustic receivers were deployed at the end of the open-water period to continue monitoring movements during the first winter of GS operation. Continued monitoring will determine if movements change over time.

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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, fall 2017.

Tag ID	Floy Tag #	Date Tagged	Fork Length (mm)	Total Length (mm)	Weight (g)
31683	106469	12-Sep-17	505	579	800
31684	106464	09-Sep-17	432	501	600
31685	106460	09-Sep-17	410	460	550
31686	106456	09-Sep-17	504	584	1100
31687	106454	09-Sep-17	545	624	1200
31768	109632	14-Sep-17	459	532	700
31769	109633	14-Sep-17	462	516	600
31770	109636	14-Sep-17	442	511	650
31771	109637	14-Sep-17	470	541	600
31772	111031	15-Sep-17	518	598	1100
31773	109564	12-Sep-17	545	616	1000
31774	109565	12-Sep-17	481	559	800
31775	109570	13-Sep-17	459	519	600
31776	109571	13-Sep-17	410	479	400
31777	109626	13-Sep-17	578	662	1350
31778	106475	12-Sep-17	435	504	800
31779	109552	12-Sep-17	490	549	800
31780	109553	12-Sep-17	448	494	650
31781	109554	12-Sep-17	468	544	850
31782	109563	12-Sep-17	448	506	600

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

Tag ID	Floy Tag #	Date Tagged	Fork Length (mm)	Total Length (mm)	Weight (g)
31688	110782	16-Sep-17	436	498	625
31689	112905	15-Sep-17	445	515	625
31690	112914	14-Sep-17	433	480	525
31691	112917	14-Sep-17	487	554	750
31692	112921	14-Sep-17	453	529	400
31693	111065	13-Sep-17	494	553	900
31694	112919	14-Sep-17	390	445	375
31695	112909	15-Sep-17	455	521	650
31696	112901	15-Sep-17	440	496	700
31697	110795	16-Sep-17	433	500	600
31758	110787	16-Sep-17	375	429	425
31759	112915	14-Sep-17	445	508	575
31760	112924	14-Sep-17	363	398	280
31761	111075	13-Sep-17	435	507	500
31762	112903	15-Sep-17	434	487	525
31763	112904	15-Sep-17	457	520	725
31764	112913	14-Sep-17	440	503	500
31765	110788	16-Sep-17	505	569	950
31766	112918	14-Sep-17	360	400	300
31782	110552	15-Sep-17	455	505	675

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), and 2020 (July 3 to September 23) open-water periods.

Year Tagged	Study Year	Upstream of Gull Rapids[1]					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

1. Beginning in 2019, Gull Rapids is referred to as the Keeyask GS.

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 2014–2020 open-water periods.

Year Tagged	Study Year	Upstream of Gull Rapids[1]					Stephens Lake					Long Spruce Forebay				
		n[2]	Avg	StDev	Min	Max	n	Avg	StDev	Min	Max	n	Avg	StDev	Min	Max
2013	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	-	-	-	-	-
2017	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	4	0.3	0.7	0	1.3

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), and 2019/2020 (October 8, 2019 to April 30, 2020) winter periods. Tag id highlighted purple = moved downstream through Keeyask GS.**

Tag ID	Date tagged	2017/2018					2018/2019					2019/2020				
		n	# Days	Furthest U/S (rkm)	Furthest D/S (rkm)	Range (rkm)	n	# Days	Furthest U/S (rkm)	Furthest D/S (rkm)	Range (rkm)	n	# Days	Furthest U/S (rkm)	Furthest D/S (rkm)	Range (rkm)
31683	12-Sep-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31684	9-Sep-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31685	9-Sep-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31686	9-Sep-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31687	9-Sep-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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
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	-	-	-	-	-
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
31772	15-Sep-17	34442	111	-10.3	-10.3	0.0	-	-	-	-	-	42031	149	-10.3	-10.3	0.0
31773	12-Sep-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31774	12-Sep-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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
31776	13-Sep-17	108	22	-12.4	-10.3	2.1	-	-	-	-	-	20667	104	-10.3	-10.3	0.0
31777	13-Sep-17	30754	98	-10.3	-10.3	0.0	-	-	-	-	-	4336	53	-10.3	-10.3	0.0
31778	12-Sep-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31779	12-Sep-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31780	12-Sep-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31781	12-Sep-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31782	12-Sep-17	-	-	-	-	-	-	-	-	-	-	17203	114	-10.3	-10.3	0.0

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), and 2019/2020 (October 8, 2019 to April 30, 2020) 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				
		n	# Days	Furthest U/S (rkm)	Furthest D/S (rkm)	Range (rkm)	n	# Days	Furthest U/S (rkm)	Furthest D/S (rkm)	Range (rkm)	n	# Days	Furthest U/S (rkm)	Furthest 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
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
31696	15-Sep-17	25955	133	5.2	7.9	2.7	-	-	-	-	-	33261	130	5.2	9.4	4.2
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
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
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
31760	14-Sep-17	-	-	-	-	-	101	8	16.8	16.8	0.0	5791	91	5.2	10.3	5.1
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	-	-	-	-	-
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
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
31767	15-Sep-17	-	-	-	-	-	-	-	-	-	-	479	28	5.2	5.8	0.6

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), and 2020 (1 May to September 23) periods. Tag id highlighted purple = moved downstream through Gull Rapids/the Keeyask GS.**

Tag ID	Date tagged	2017					2018					2019					2020				
		n	# Days	U/S (rkm)	D/S (rkm)	Range (rkm)	n	# Days	U/S (rkm)	D/S (rkm)	Range (rkm)	n	# Days	U/S (rkm)	D/S (rkm)	Range (rkm)	n	# Days	U/S (rkm)	D/S (rkm)	Range (rkm)
31683	12-Sep-17	4718	33	-9.3	-7.4	1.9	31943	133	-9.3	-9	0.3	40792	136	-9.3	-9.0	0.3	11757	79	-8.9	-6.2	2.7
31684	9-Sep-17	5706	34	-9.3	-7.4	1.9	36007	109	-9.9	-4.8	5.1	28126	125	-9.3	-9.0	0.3	540	5	-7.9	-5.8	2.1
31685	9-Sep-17	12846	35	-9.3	-7.4	1.9	4022	38	-9.9	-9	0.9	-	-	-	-	-	-	-	-	-	-
31686	9-Sep-17	9918	34	-9.3	-9	0.3	40702	107	-9.9	-9	0.9	38228	128	-9.3	-9.3	0.0	4237	63	-8.9	-7.9	1.0
31687	9-Sep-17	9880	32	-9.3	-9	0.3	10221	49	-9.3	-5.8	3.5	-	-	-	-	-	3429	47	-12.5	-3.8	8.7
31768	14-Sep-17	1050	14	-10.1	-9.9	0.2	27068	130	-17.4	-9.9	7.5	31550	120	-17.4	-9.9	7.5	14996	70	-17.4	-9.9	7.5
31769	14-Sep-17	18816	28	-10.1	-10	0.6	16493	34	-10.3	-9.9	0.4	-	-	-	-	-	-	-	-	-	-
31770	14-Sep-17	17899	31	-10.1	-9.5	0.6	5455	87	-17.4	-9.9	7.5	4929	58	-12.9	-9.9	3.0	1566	56	-15.0	-9.9	5.1
31771	14-Sep-17	13740	31	-10.1	-9.5	0.6	78420	141	-10.3	-9.9	0.4	36862	115	-12.5	-9.9	2.6	13940	69	-12.5	-9.9	2.6
31772	15-Sep-17	9198	30	-10.1	-9.5	0.6	78858	137	-15	-9.9	5.1	67609	140	-12.5	-9.9	2.6	48333	87	-10.3	-9.9	0.4
31773	12-Sep-17	5954	32	-9.3	-7.4	1.9	24849	108	-19.5	-7.4	12.1	16674	114	-9.3	-7.4	1.9	12206	74	-17.4	-6.2	11.2
31774	12-Sep-17	8289	33	-9	-7.4	1.6	42167	134	-9.3	-7.4	1.9	22305	106	-9.3	-7.4	1.9	4290	34	-7.9	-5.8	2.1
31775	13-Sep-17	8804	17	-10.1	-9.5	0.6	2681	27	-17.4	-9.9	7.5	2859	62	-15.0	-9.9	5.1	12963	97	-12.9	-9.9	3.0
31776	13-Sep-17	14995	31	-10.1	-9.5	0.6	49473	131	-15	-9.9	5.1	29508	105	-12.9	-4.8	8.1	19917	79	-8.9	-6.2	2.7
31777	13-Sep-17	18412	31	-10.1	-9.5	0.6	29917	98	-12.9	-9.9	3.0	39441	131	-10.2	-9.3	0.9	13228	53	-12.9	-5.8	7.1
31778	12-Sep-17	12574	33	-9.3	-9	0.3	42749	119	-17.4	-7.4	10.0	566	3	-9.0	9.4	18.4	-	-	-	-	-
31779	12-Sep-17	11059	33	-9.3	-7.4	1.9	47302	133	-9.3	-7.4	1.9	47534	135	-9.3	-9.0	0.3	18722	77	-8.9	-6.2	2.7
31780	12-Sep-17	5304	30	-9	-7.4	1.6	33306	132	-9.3	-7.4	1.9	38052	137	-9.3	-7.4	1.9	11764	77	-8.9	-6.2	2.7
31781	12-Sep-17	10304	33	-9.3	-7.4	1.9	173	13	-5.8	-4.8	1.0	5945	43	-9.3	-9.0	0.3	3483	46	-8.9	-3.8	5.1
31782	12-Sep-17	13002	33	-9.3	-9	0.3	42404	119	-12.9	-7.4	5.5	44580	126	-12.5	-9.9	2.6	15995	78	-12.9	-9.9	3.0

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), and 2020 (May 1 to September 23) periods. Tag id highlighted yellow = lost tags. Tag id highlighted red = moved downstream through Kettle GS.**

Tag ID	Date tagged	2017					2018					2019					2020				
		n	# Days	U/S (rkm)	D/S (rkm)	Range (rkm)	n	# Days	U/S (rkm)	D/S (rkm)	Range (rkm)	n	# Days	U/S (rkm)	D/S (rkm)	Range (rkm)	n	# Days	U/S (rkm)	D/S (rkm)	Range (rkm)
31688	28-May-16	30	1	2.7	7.9	5.2	27068	74	1.2	2.7	1.5	27193	117	1.2	1.2	0.0	23635	81	1.2	1.2	0.0
31689	28-May-16	30	1	1.2	13.9	12.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31690	27-May-16	32	1	1.2	7.9	6.7	-	-	-	-	-	-	-	-	-	-	4524	33	45.7	45.7	0.0
31691	27-May-16	7	0	4.1	42.7	38.6	-	-	-	-	-	-	-	-	-	-	709	23	45.7	45.7	0.0
31692	28-May-16	32	1	1.2	13.9	12.7	17702	100	1.2	18.6	17.4	-	-	-	-	-	22	8	45.7	45.7	0.0
31693	28-May-16	33	1	3.8	9.4	5.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31694	28-May-16	32	1	3.8	9.4	5.6	13155	81	2.7	18.6	15.9	15913	124	4.3	16.5	12.2	1688	33	5.2	13.9	8.7
31695	28-May-16	31	1	2.7	7.9	5.2	47506	123	1.2	7.9	6.7	52297	140	1.2	7.9	6.7	11028	77	3.9	13.4	9.5
31696	28-May-16	31	1	1.2	13.9	12.7	43099	154	1.2	10.3	9.1	43128	127	1.2	10.3	9.1	11844	114	1.2	10.3	9.1
31697	28-May-16	30	1	3.8	10.3	6.5	97400	153	1.2	10.3	9.1	22941	130	2.7	13.0	10.3	15485	98	1.2	13.4	12.2
31758	30-May-16	28	1	3.8	13.9	10.1	18719	141	1.2	13.9	12.7	30068	119	2.7	13.9	11.2	13830	101	1.2	10.3	9.1
31759	30-May-16	32	1	2.7	10.3	7.6	37102	126	1.2	18.6	17.4	29872	137	2.7	13.9	11.2	17055	116	1.2	18.8	17.6
31760	30-May-16	17	1	1.2	3.8	2.6	25510	119	1.2	18.6	17.4	17664	117	3.9	18.6	14.7	13837	115	2.7	10.3	7.6
31761	30-May-16	6	0	4.3	40.9	36.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31762	29-May-16	30	1	3.8	9.4	5.6	39066	154	3.8	13.9	10.1	50261	142	3.9	10.3	6.4	15989	40	44.4	45.7	1.3
31763	31-May-16	31	1	1.2	10.3	9.1	25869	130	1.2	10.3	9.1	32315	131	1.2	10.3	9.1	7019	90	2.7	8.7	6.0
31764	31-May-16	32	1	3.8	10.3	6.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31765	31-May-16	30	1	2.7	9.4	6.7	35362	125	1.2	10.3	9.1	26941	101	1.2	10.3	9.1	11978	79	1.2	10.3	9.1
31766	30-May-16	31	1	1.2	5.8	4.6	16440	104	1.2	24.7	23.5	13002	104	2.7	18.6	15.9	14695	105	1.2	13.4	12.2
31767	30-May-16	24	1	1.2	4.4	3.2	30261	123	1.2	10.3	9.1	22366	124	1.2	13.9	12.7	3782	53	2.7	13.4	10.7

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 interpreted to have occurred outside of tagging stress (*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[1]			Tagging Stress/Mortality[2]			Adjusted Movements[3]			Total Movements			Tagging Stress/mortality			Adjusted Movements		
	Total Fish	Total Move	%[3]	# Fish Tagged	Total Move	%[4]	Total Fish	Total Move	%	Total Fish[6]	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

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.

FIGURES

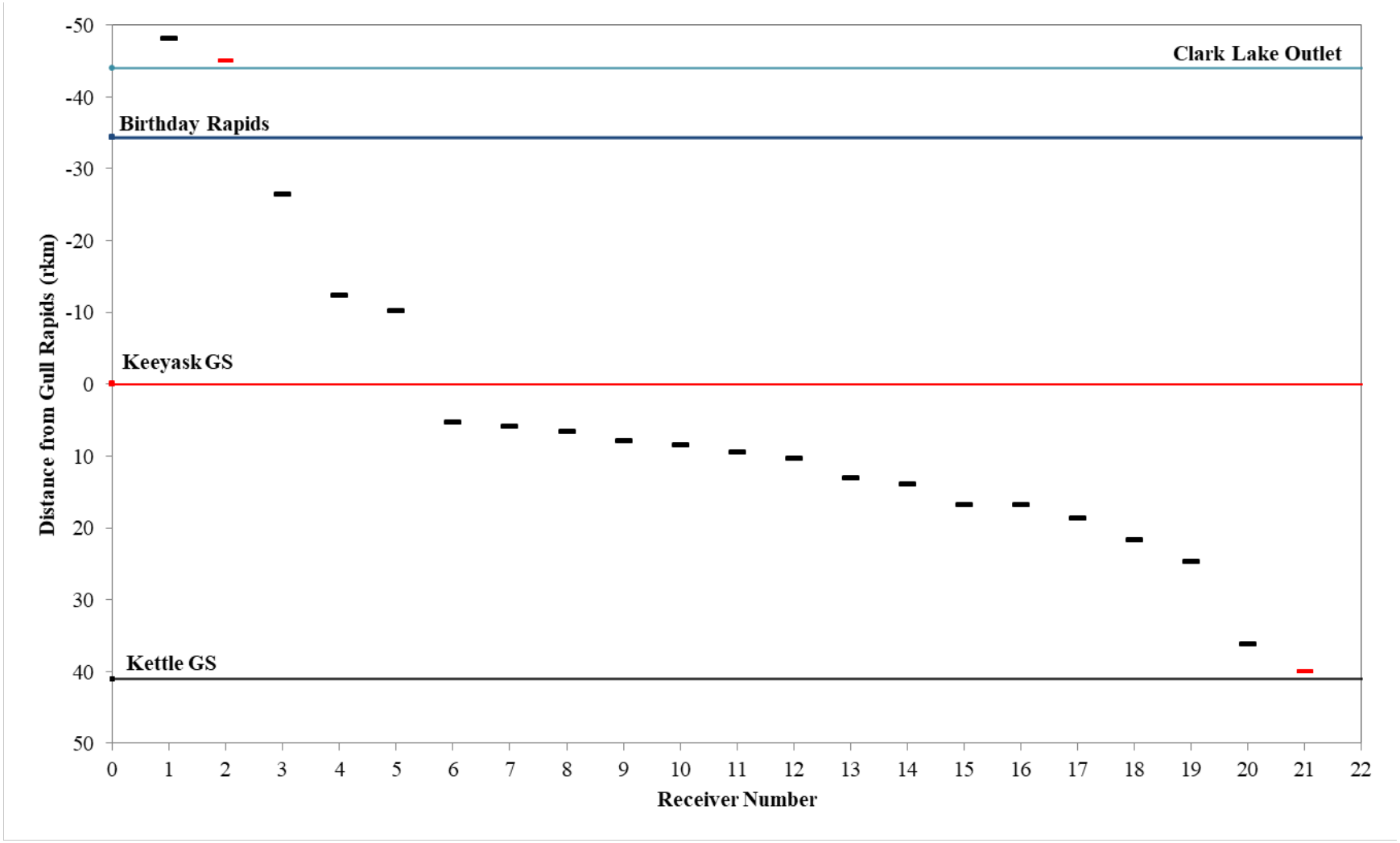


Figure 1: **Locations of stationary acoustic receivers (dashes) in relation to the base of the Keeyask GS (rkm 0) and other major landmarks (lines) in the Nelson River between Clark Lake and the Kettle GS between October 2019 and July 2020. Red dashes indicate lost receivers.**

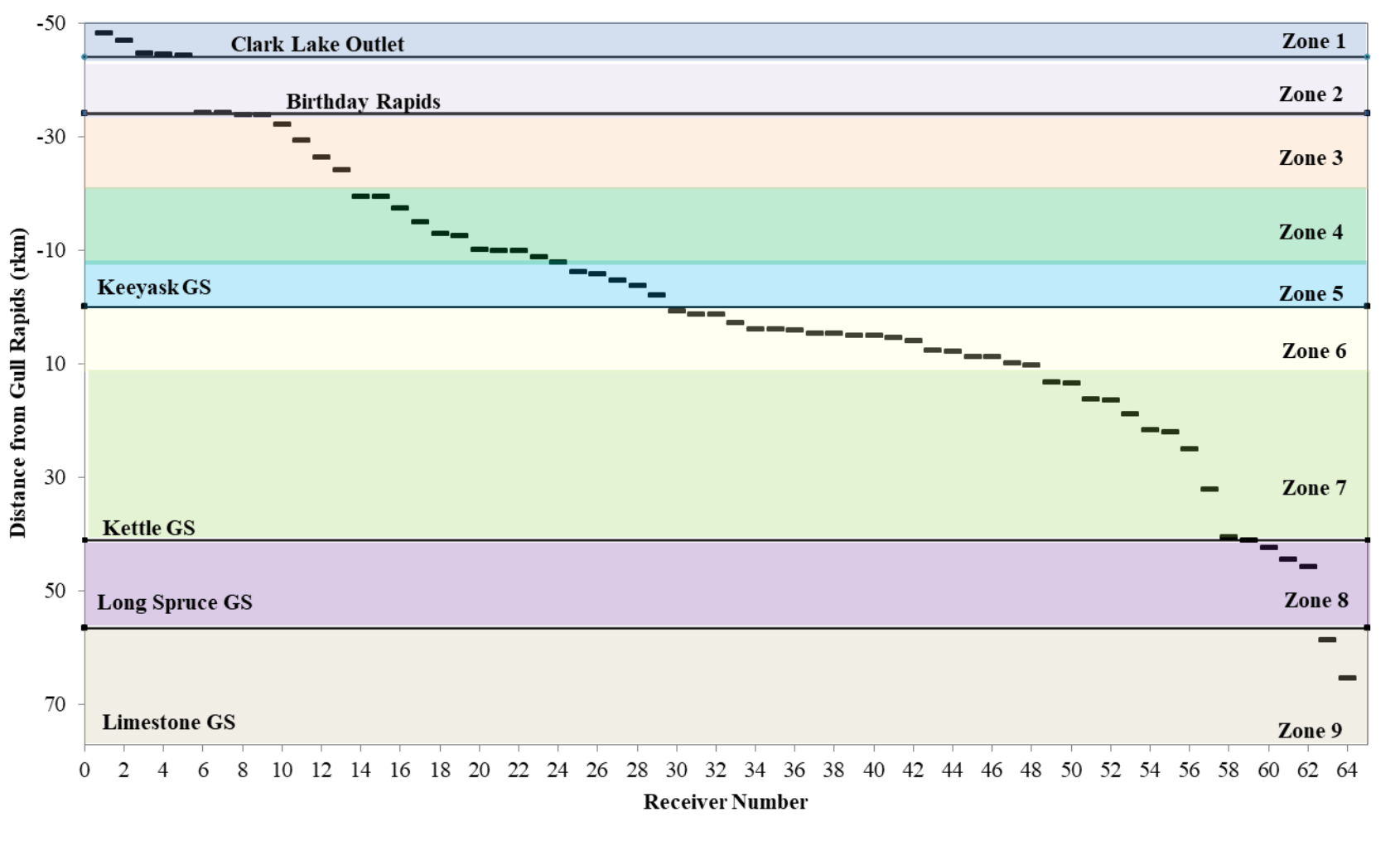


Figure 2: Locations of stationary acoustic receivers (dashes) in relation to the base of the Keeyask GS (rkm 0) and other major landmarks (lines) in the Nelson River between Clark Lake (Zone 1) and the Limestone GS (Zone 9) between July and September 2020. River zones are indicated by different colours.

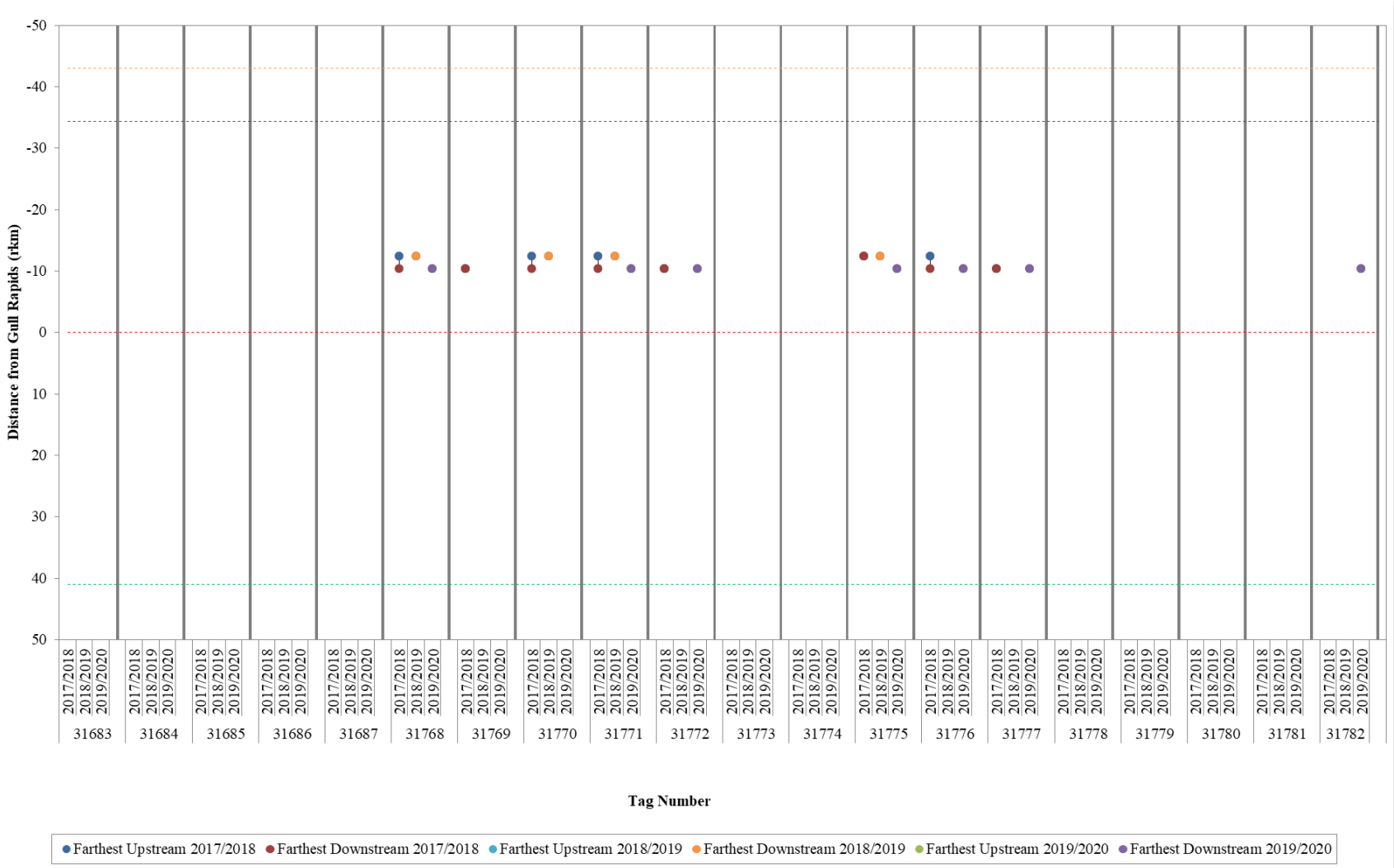


Figure 3: Detection ranges for acoustic tagged juvenile Lake Sturgeon detected between Clark Lake and the Keeyask GS during the winter period (2017–2020). Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = the Keeyask GS; green = Kettle GS).

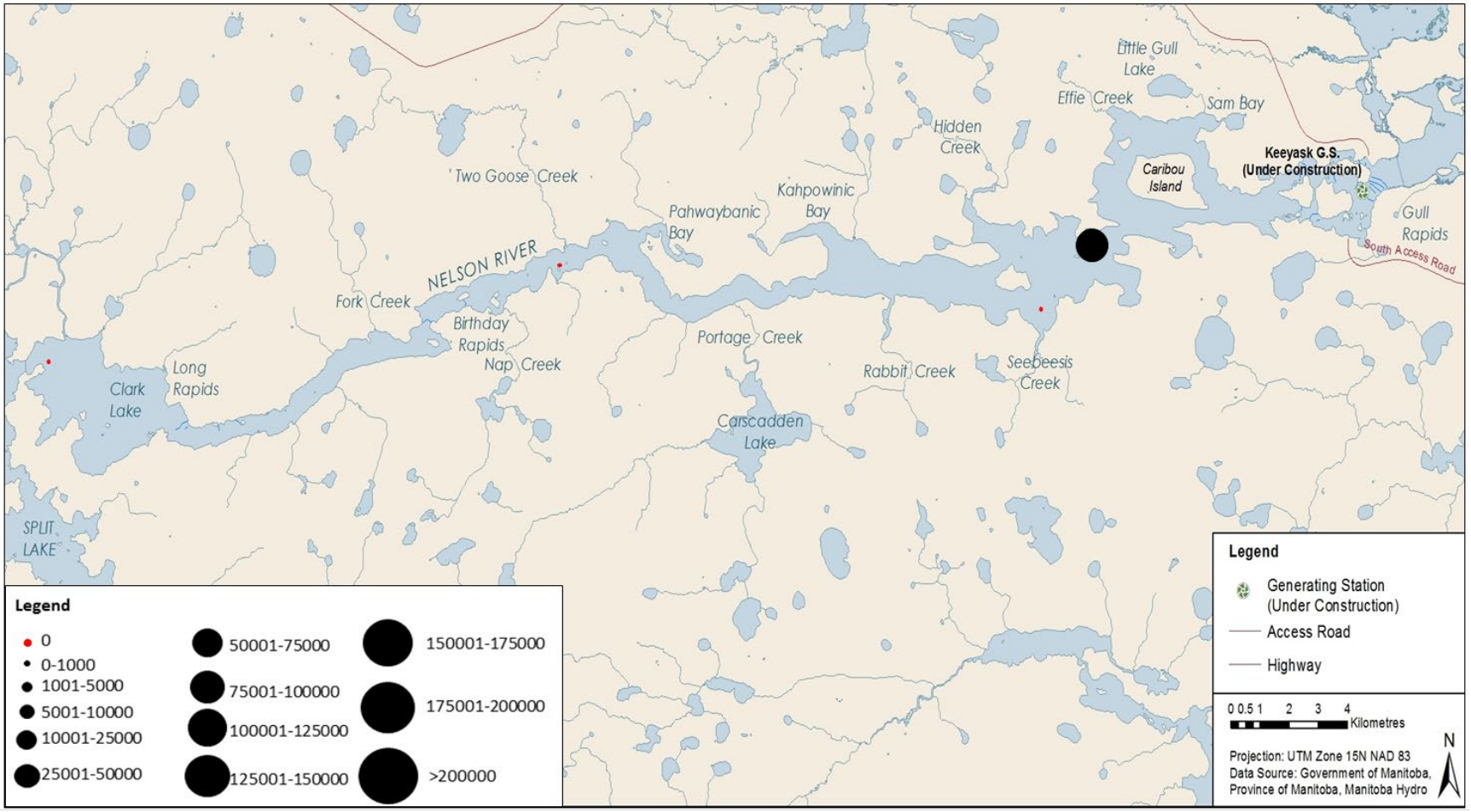


Figure 4: Relative number of detections at each acoustic receiver set between Clark Lake and the Keeyask GS during winter 2019/2020 (October 8, 2019, to April 30, 2020). Number of detections indicated by size of bubble (defined in legend). Receivers with no detections indicated with red dot.

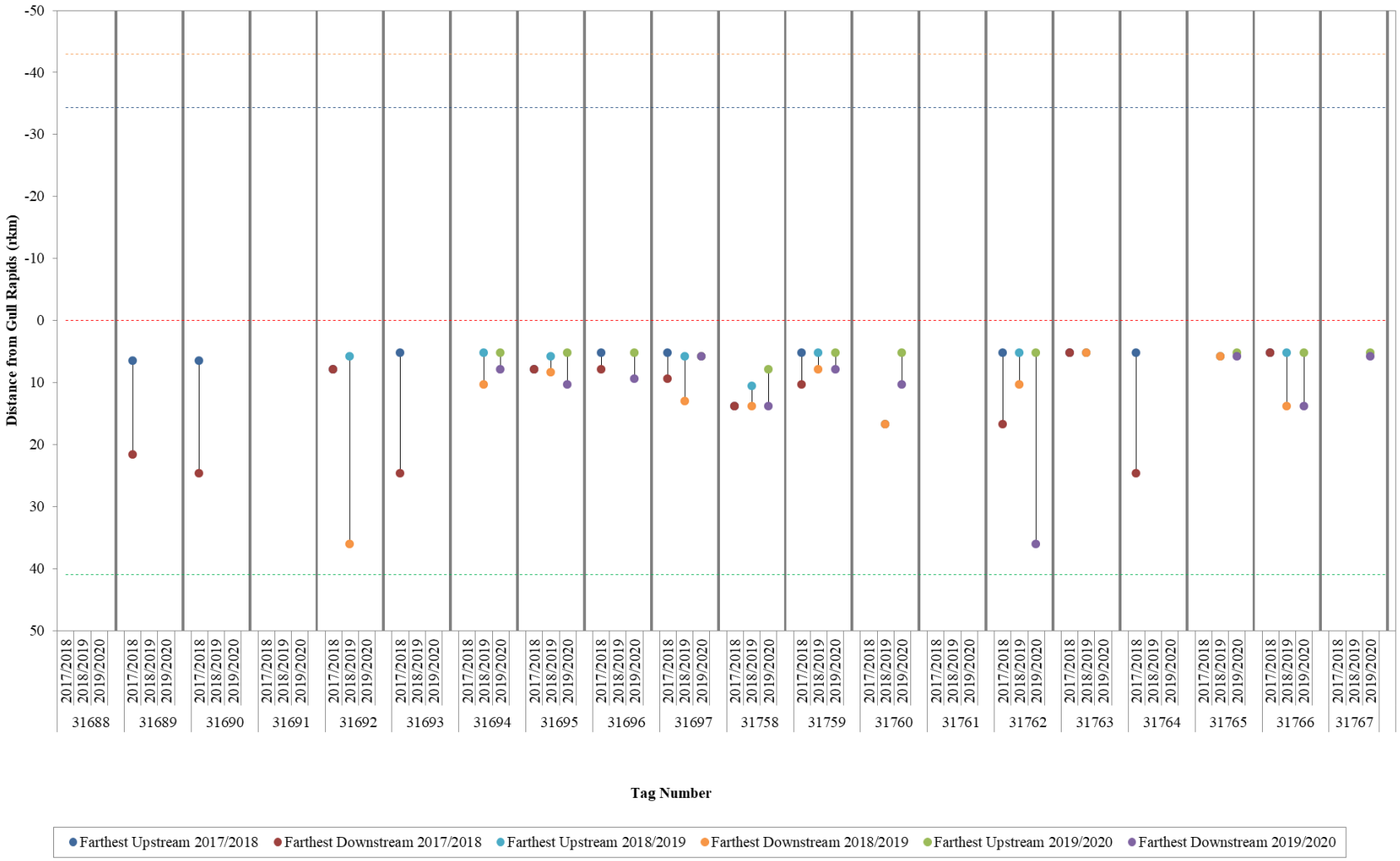


Figure 5: Detection ranges for acoustic tagged juvenile Lake Sturgeon detected in Stephens Lake during the winter period (2017–2020). Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = the Keeyask GS; green = Kettle GS).

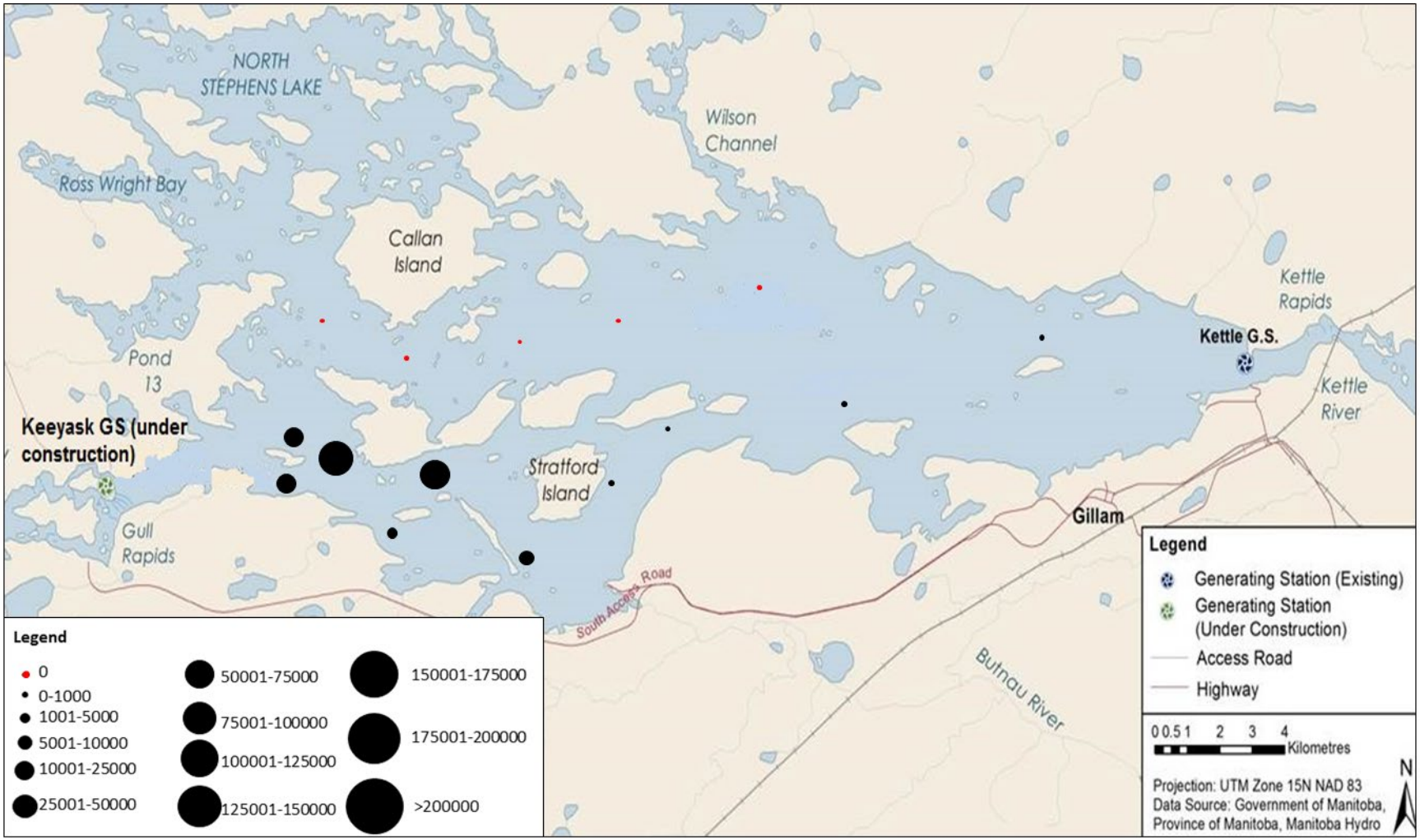


Figure 6: Relative number of detections at each acoustic receiver set in Stephens Lake during winter 2019/2020 (October 8, 2019, to April 30, 2020). Number of detections indicated by size of bubble (defined in legend). Receivers with no detections indicated with red dot.

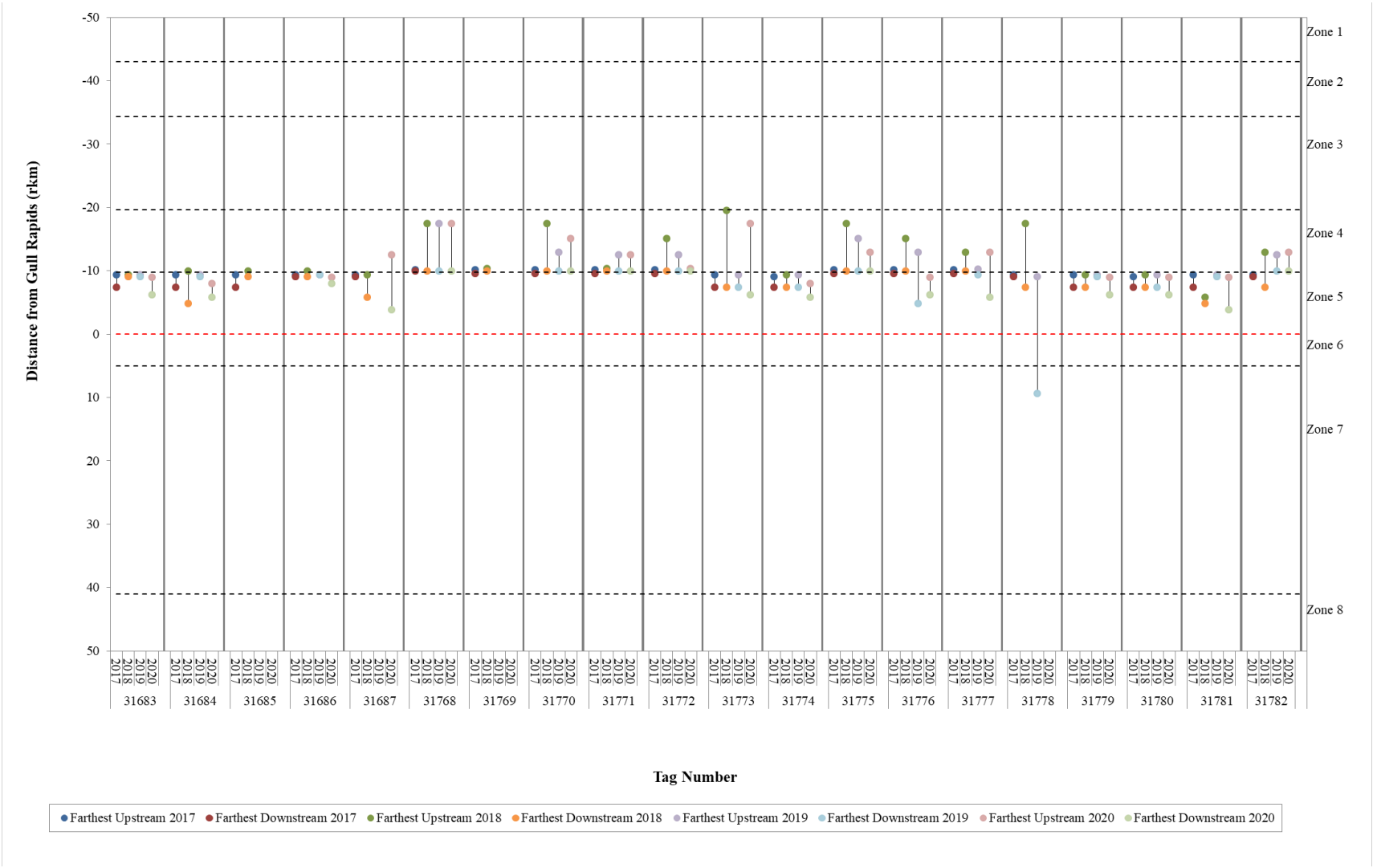


Figure 7: Detection ranges for individual juvenile Lake Sturgeon tagged with acoustic transmitters upstream of Gull Rapids/the Keeyask GS during the open-water period (2017–2020). Horizontal dotted lines demarcate zones with the red line representing the Keeyask GS.

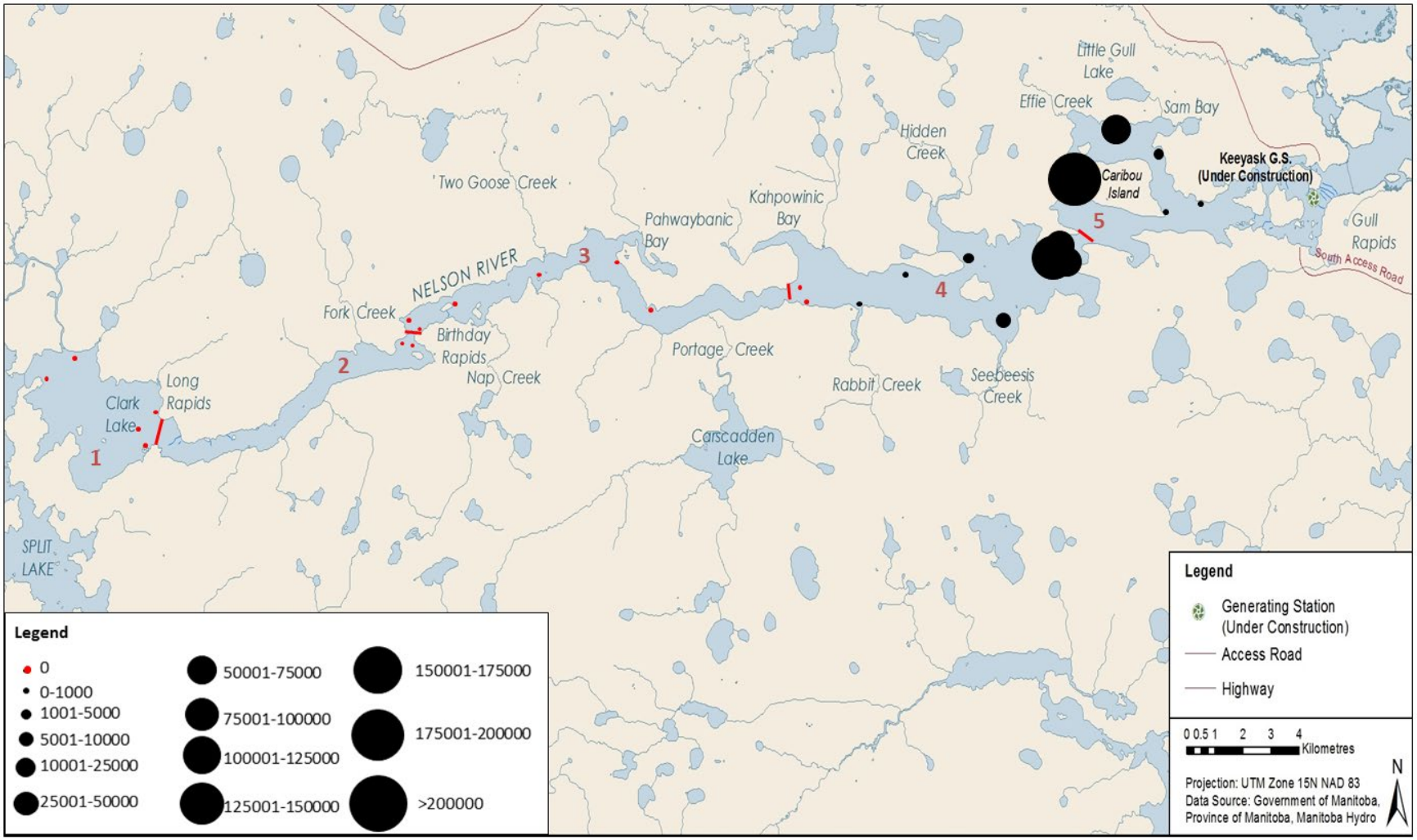


Figure 8: Relative number of detections at each acoustic receiver set in the Nelson River between Clark Lake and the Keeyask GS during the 2020 open-water period (May 1 to September 23). Number of detections indicated by size of bubble (defined in legend). Receivers with no detections indicated with red dot. The river is divided into five "zones" based on placement of receiver "gates."

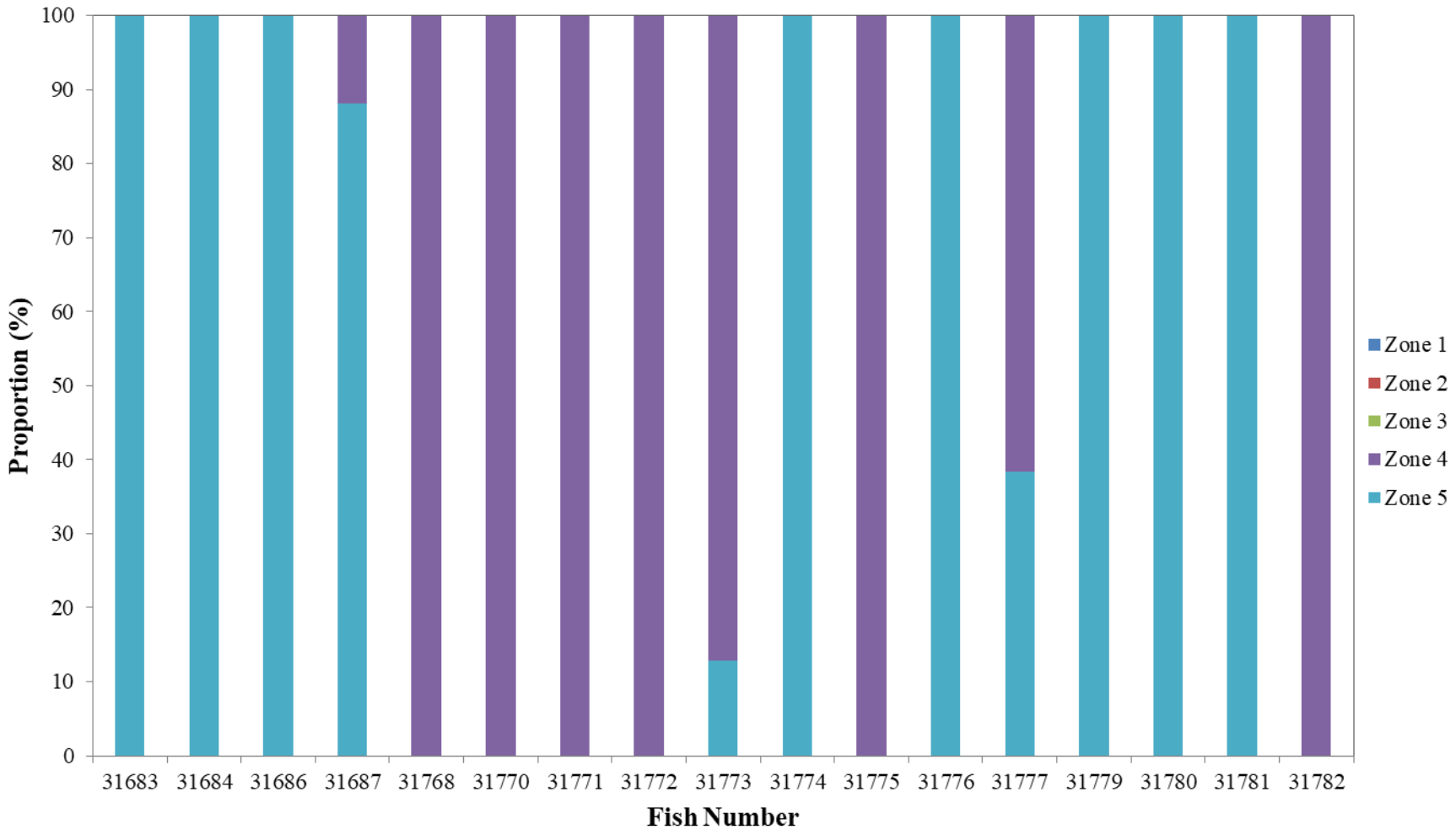


Figure 9: Proportional distributions by zone for individual juvenile Lake Sturgeon between Clark Lake and the Keeyask GS during a portion of the 2020 open-water period (July 3 to September 23). The single fish that moved downstream through the Keeyask GS during open-water 2019 was not included in the analysis.

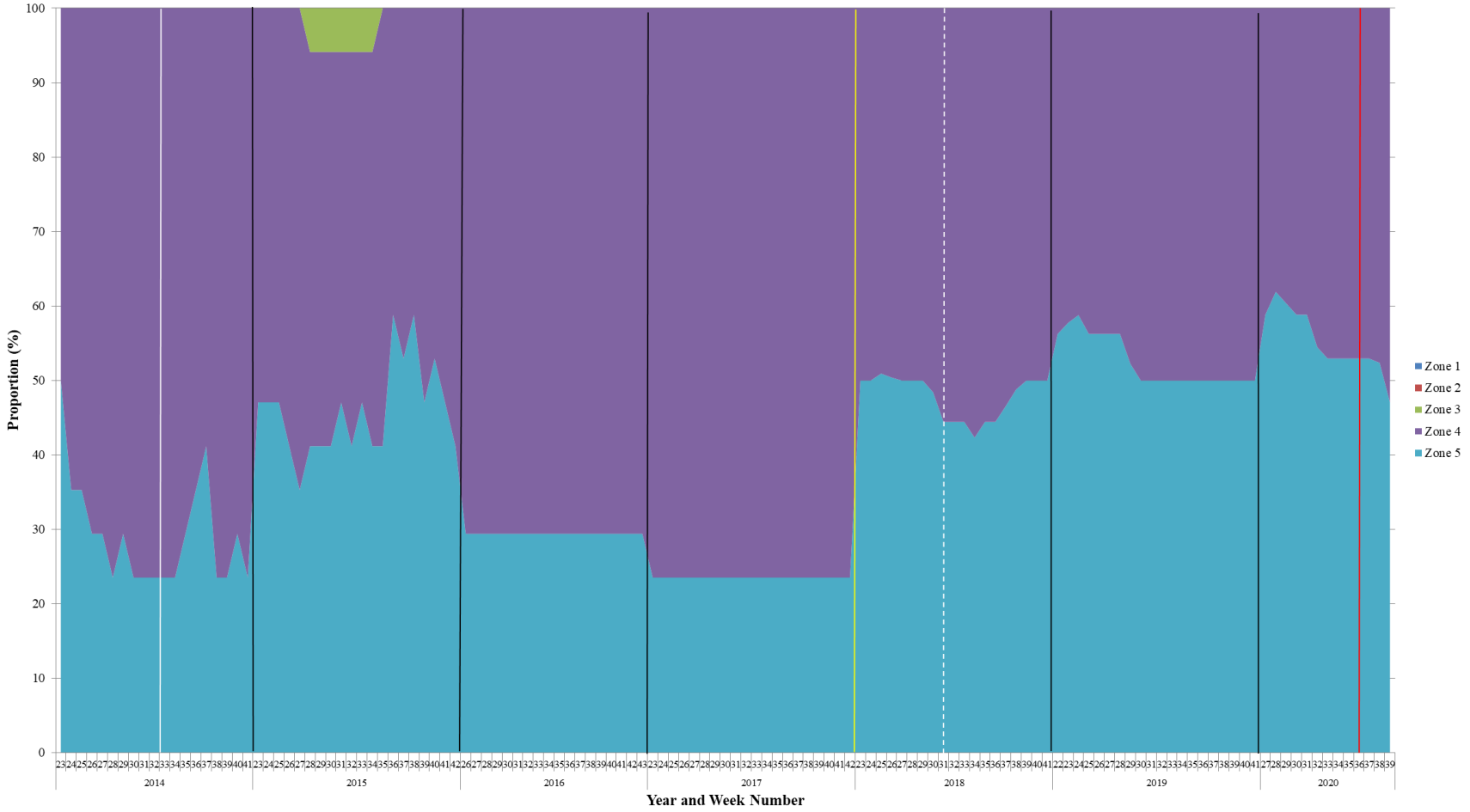


Figure 10: Proportional distribution by zone per week for juvenile Lake Sturgeon between Clark Lake and Gull Rapids/the Keeyask GS during a portion of the open-water periods of 2014 (June 4 to October 10), 2015 (June 4 to October 11), 2016 (June 25 to October 19), 2017 (June 7 to October 16), 2018 (June 6 to October 10), 2019 (June 2 to October 7), and 2020 (July 3 to September 23). 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.

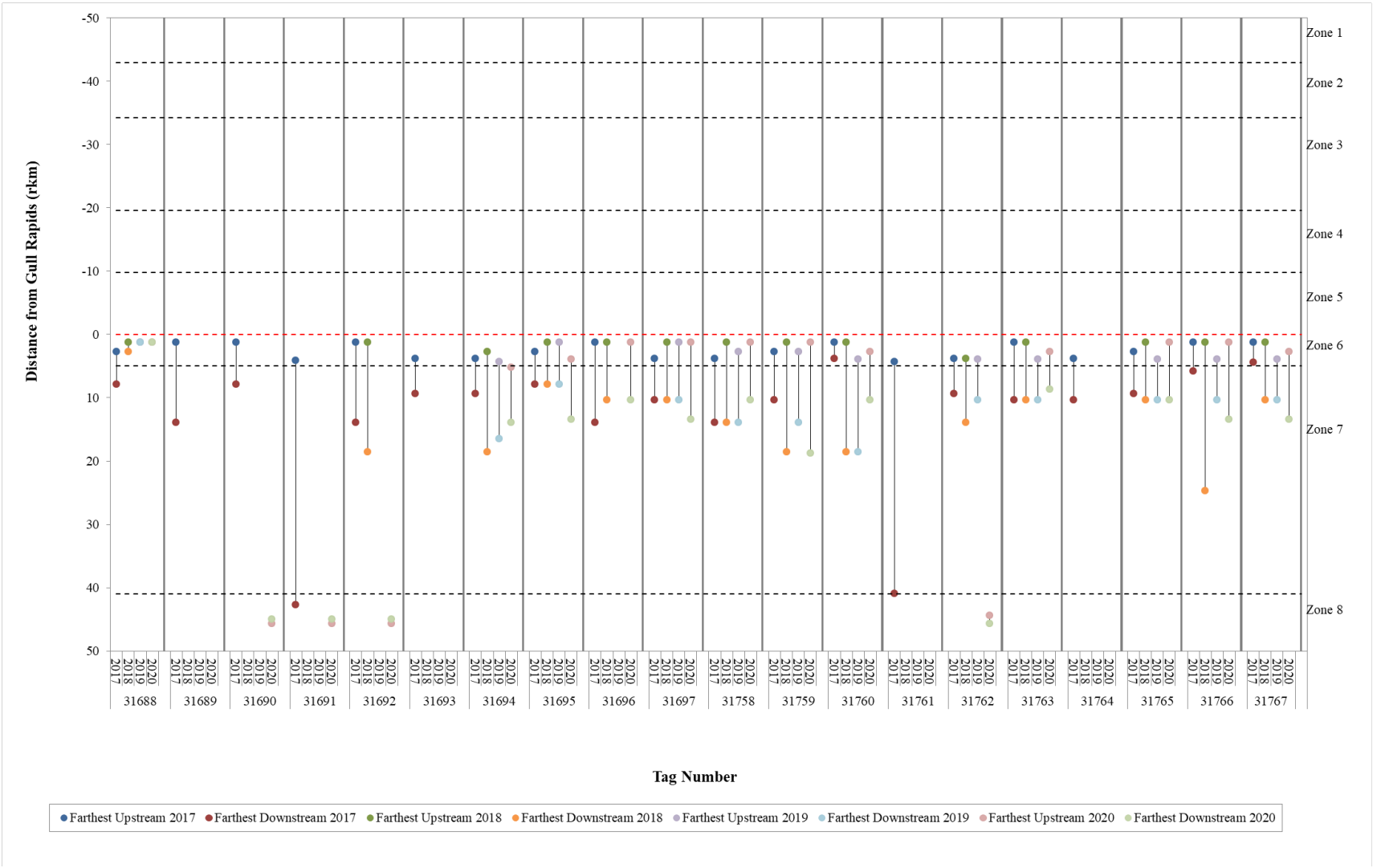


Figure 11: Detection ranges for acoustic tagged juvenile Lake Sturgeon in Stephens Lake during the open-water periods of 2017–2020. Horizontal dotted lines demarcate zones with the red line representing the Keeyask GS.

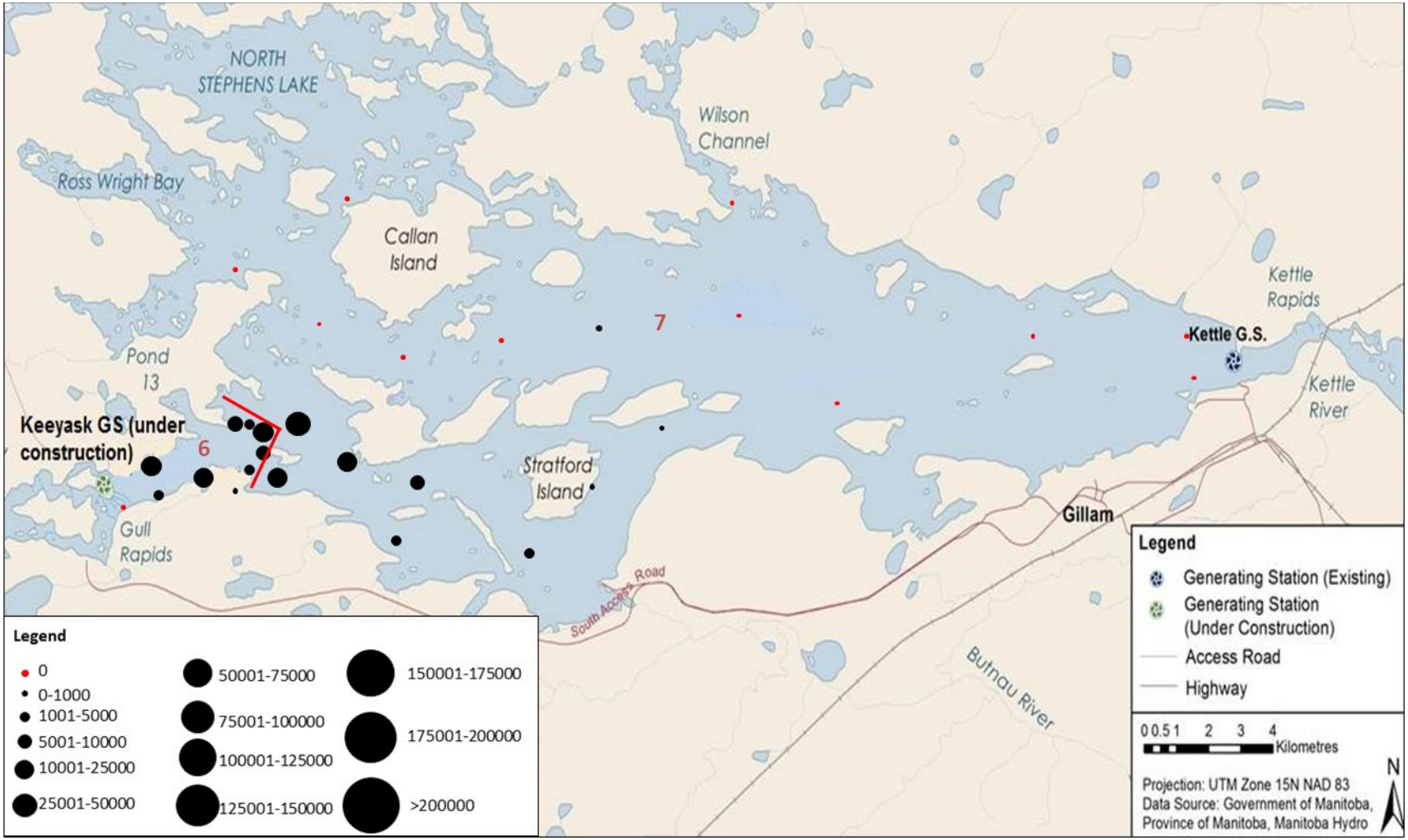


Figure 12: Relative number of detections at each acoustic receiver set in Stephens Lake during the 2020 open-water period (May 1 to September 23). Number of detections indicated by size of bubble (defined in legend). Receivers with no detections indicated with red dot.

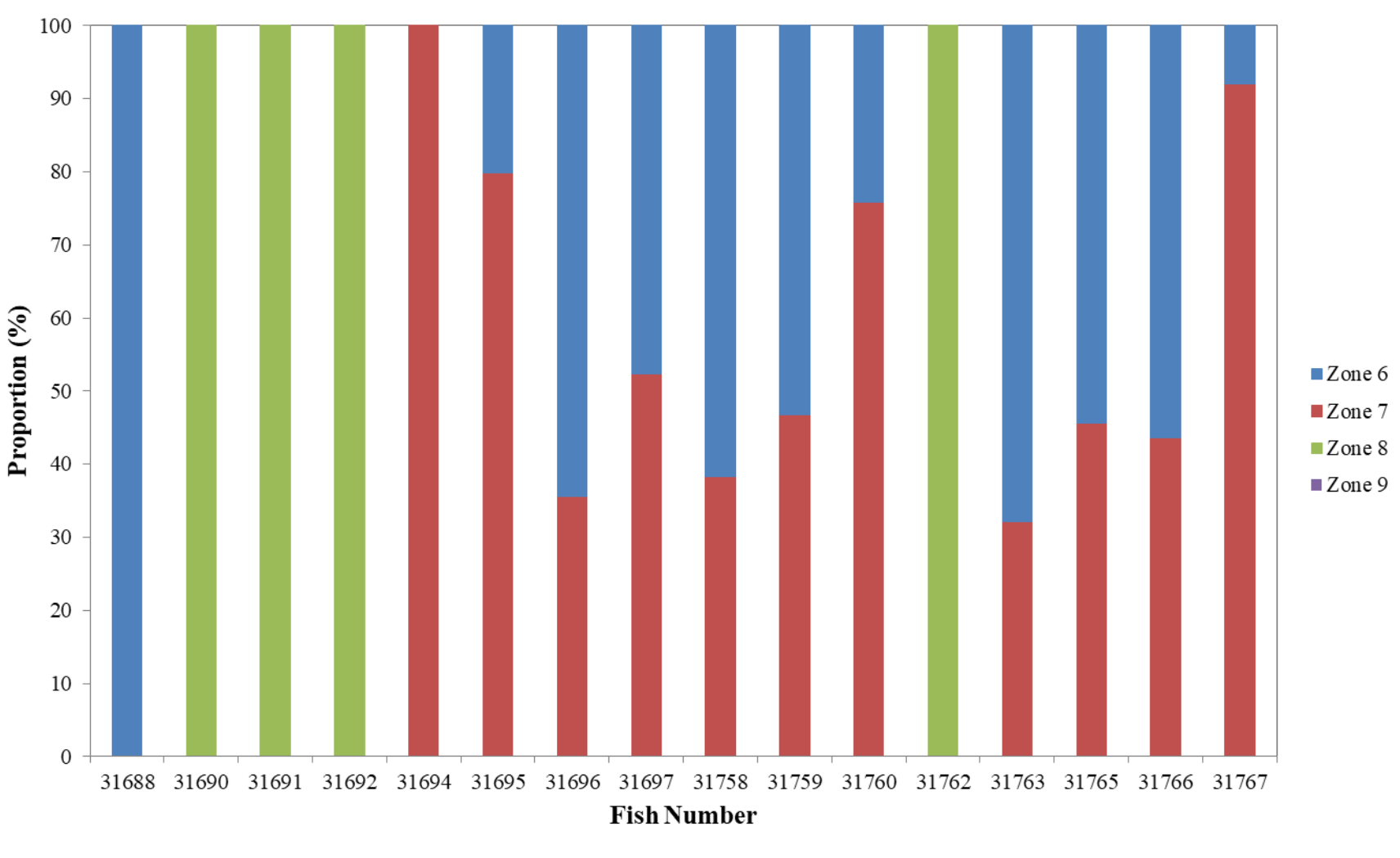


Figure 13: Proportional distributions by zone, for individual juvenile Lake Sturgeon tagged with acoustic transmitters in Stephens Lake during a portion of the 2020 open-water period (July 3 to September 23).

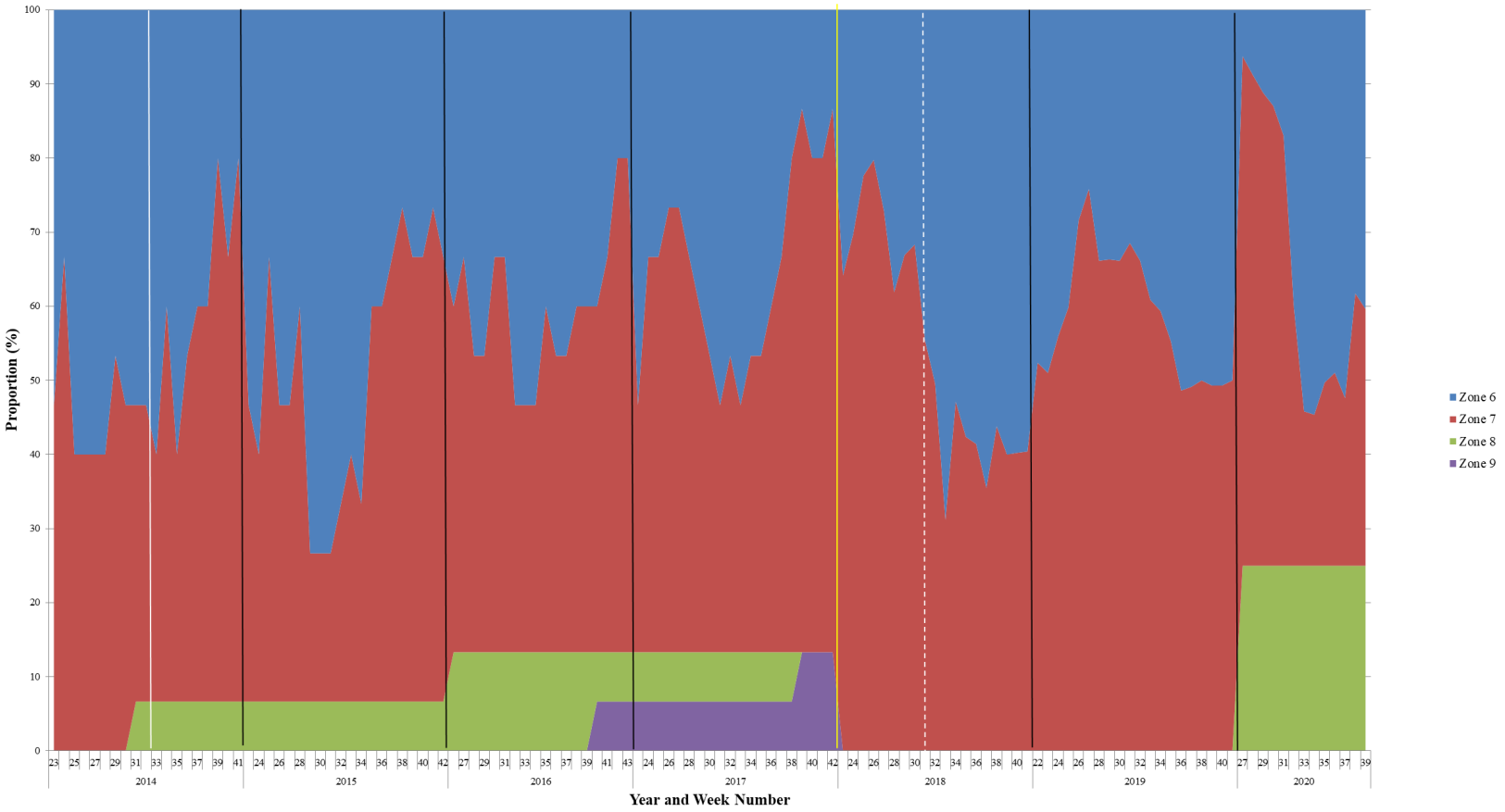


Figure 14: Proportional distribution by zone per week for juvenile Lake Sturgeon downstream of Gull Rapids/the Keeyask GS during a portion of the open-water periods of 2014 (June 4 to October 10), 2015 (June 4 to October 11), 2016 (June 25 to October 19), 2017 (June 7 to October 16), 2018 (June 6 to October 10), 2019 (June 2 to October 7), and 2020 (July 3 to September 23). 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.

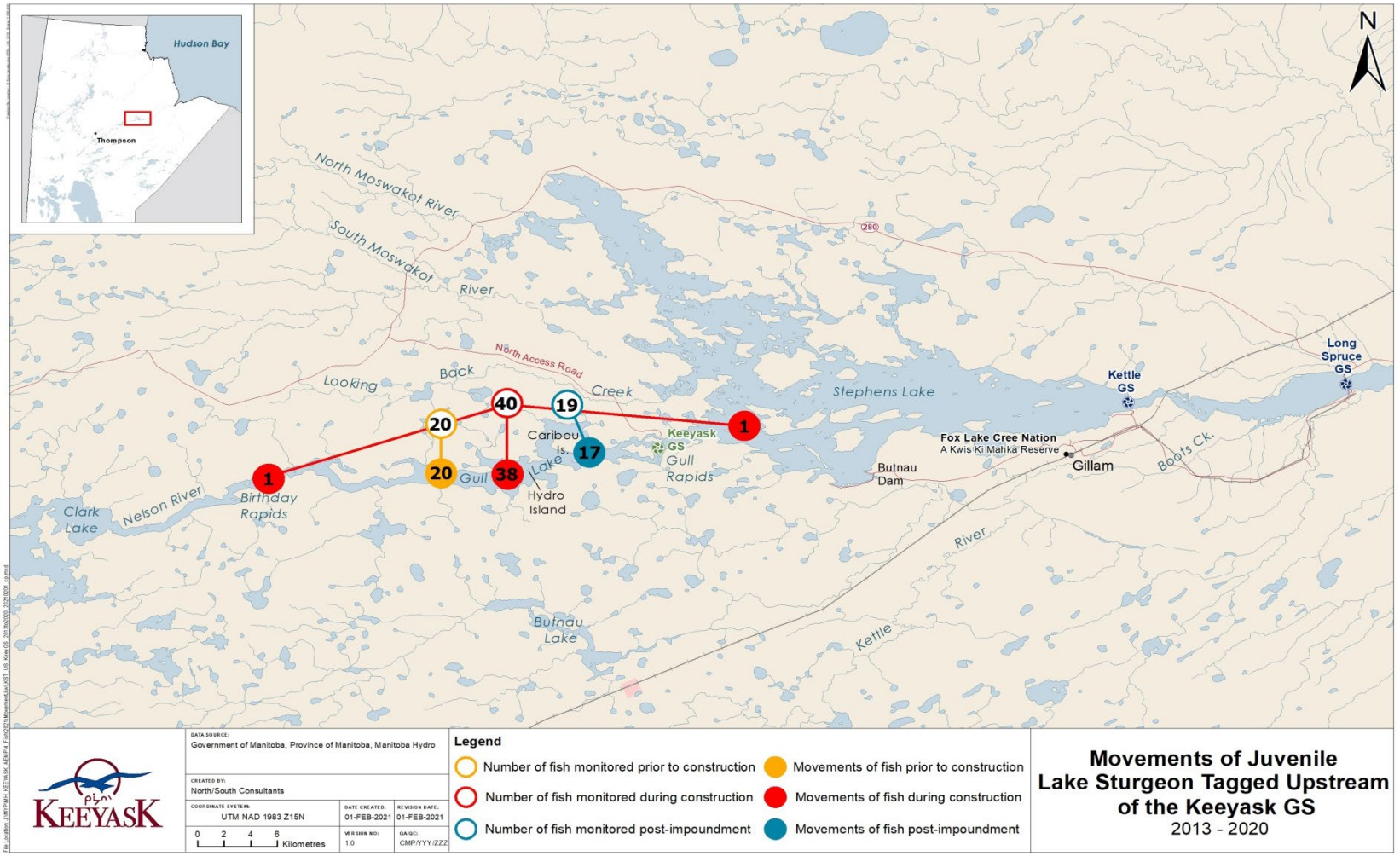


Figure 15: Map showing how many juvenile Lake Sturgeon moved upstream out of Gull Lake, stayed in Gull Lake, moved into Stephens Lake, and moved downstream through the Kettle GS before construction (yellow), during construction (red) and after reservoir impoundment (blue). Movements of fish due to mortality 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.

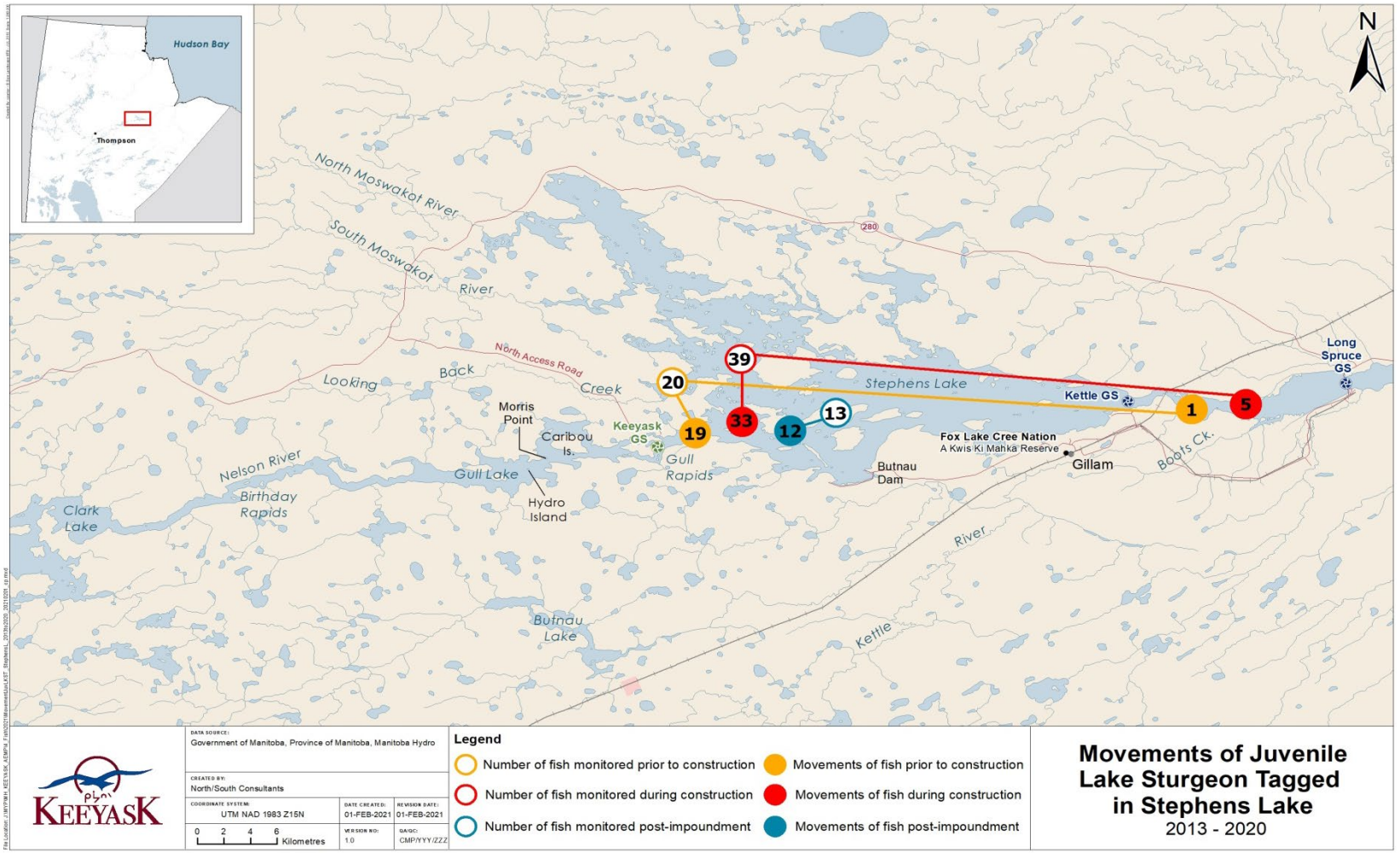
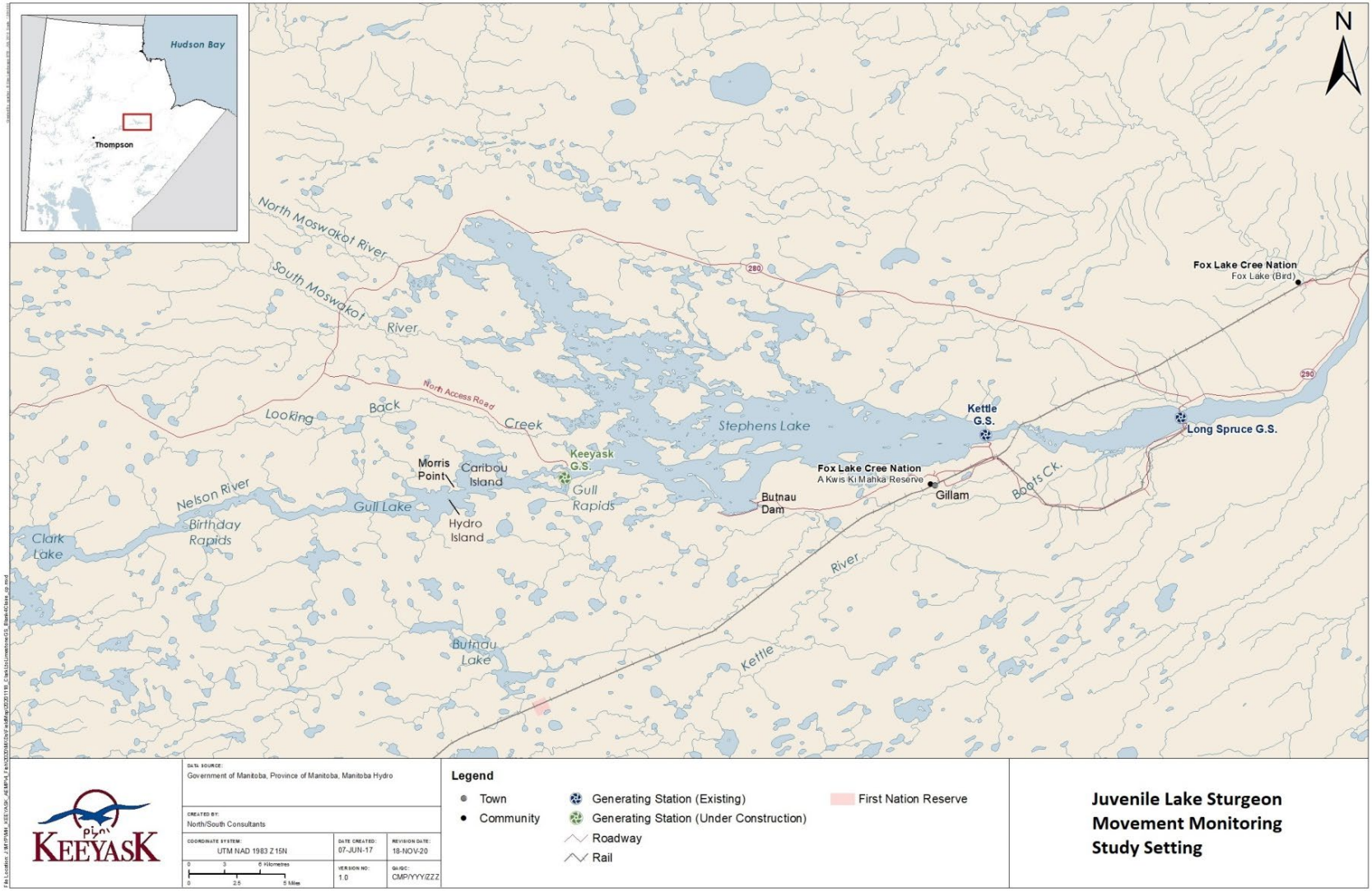
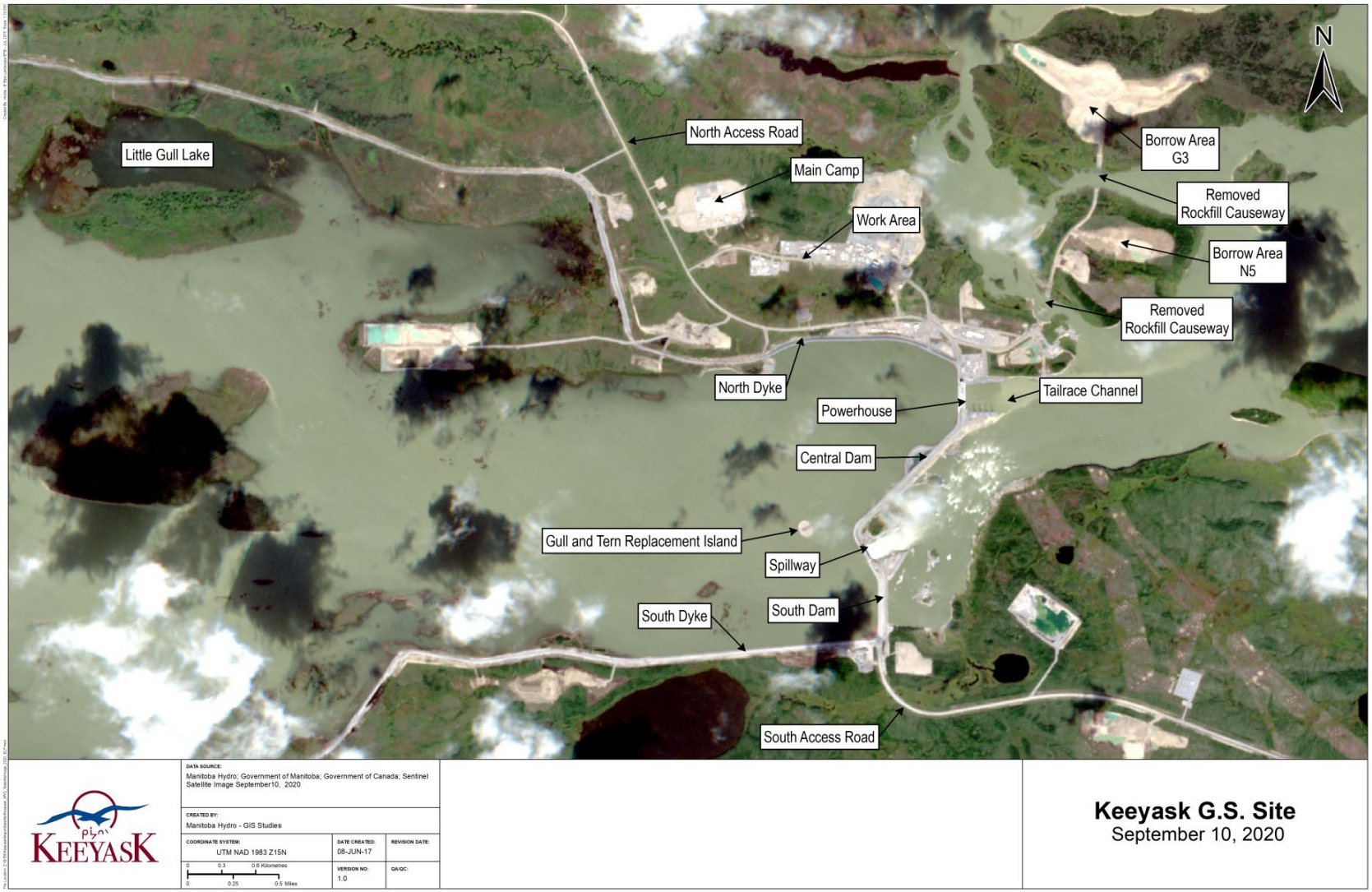


Figure 16: Map showing how many juvenile Lake Sturgeon moved stayed in Stephens Lake and moved downstream through the Kettle GS during before construction (yellow), during construction (red), and after reservoir impoundment (blue). Movements of fish due to tagging stress or mortality were not included. 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.

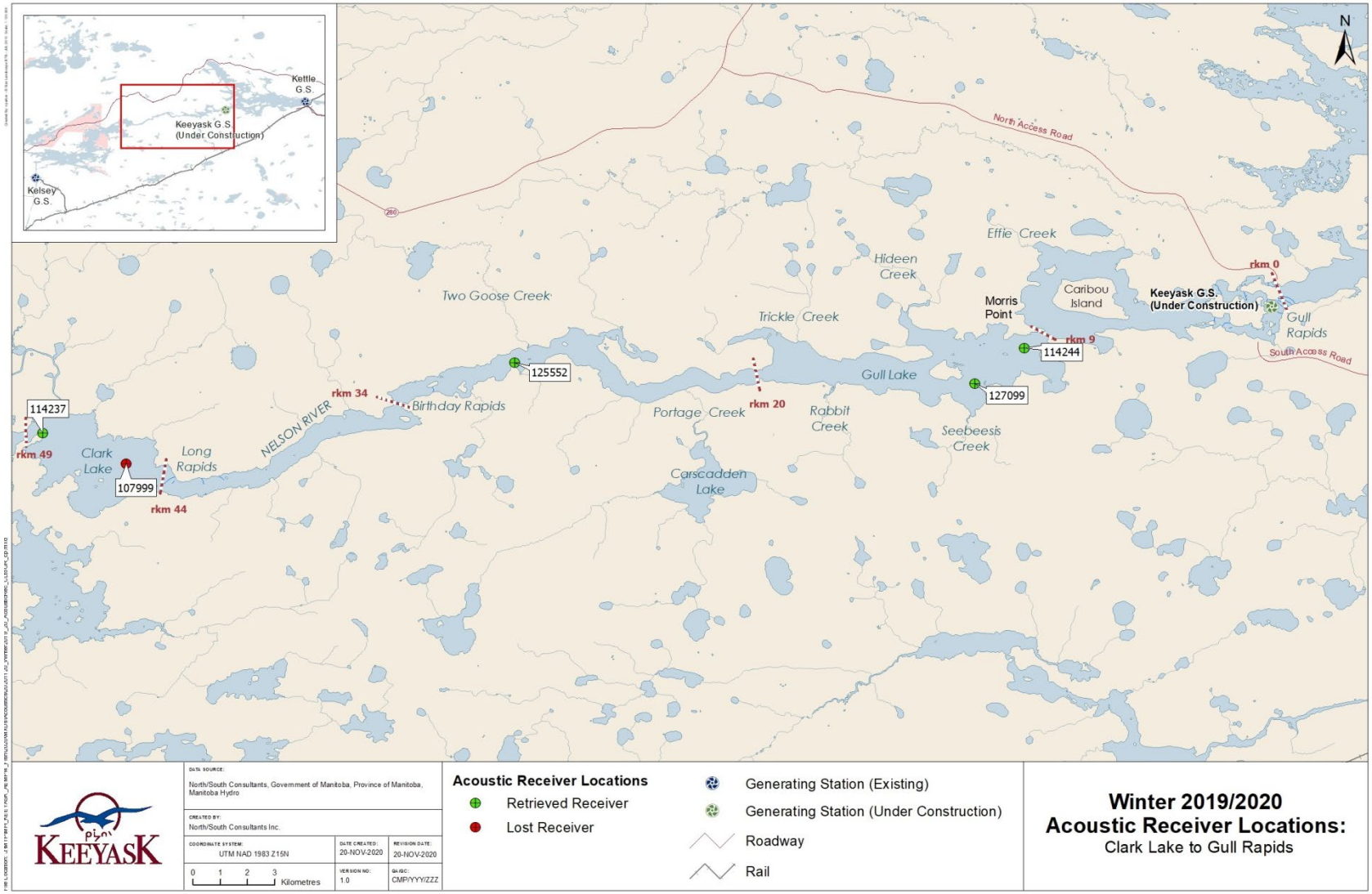
MAPS



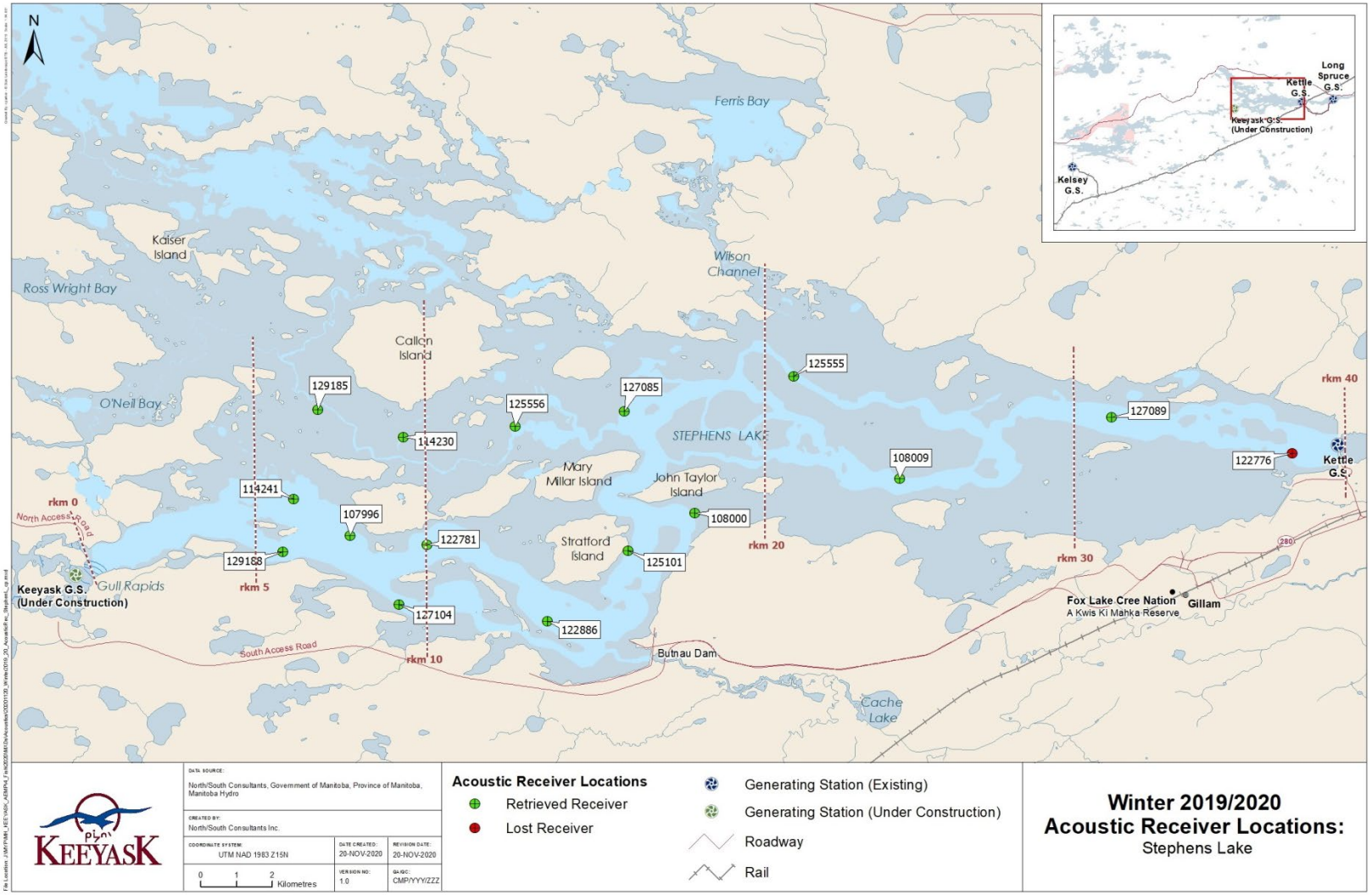
Map 1: Map of the Nelson River showing the site of the Keeyask Generating Station and the juvenile Lake Sturgeon movement monitoring study setting.



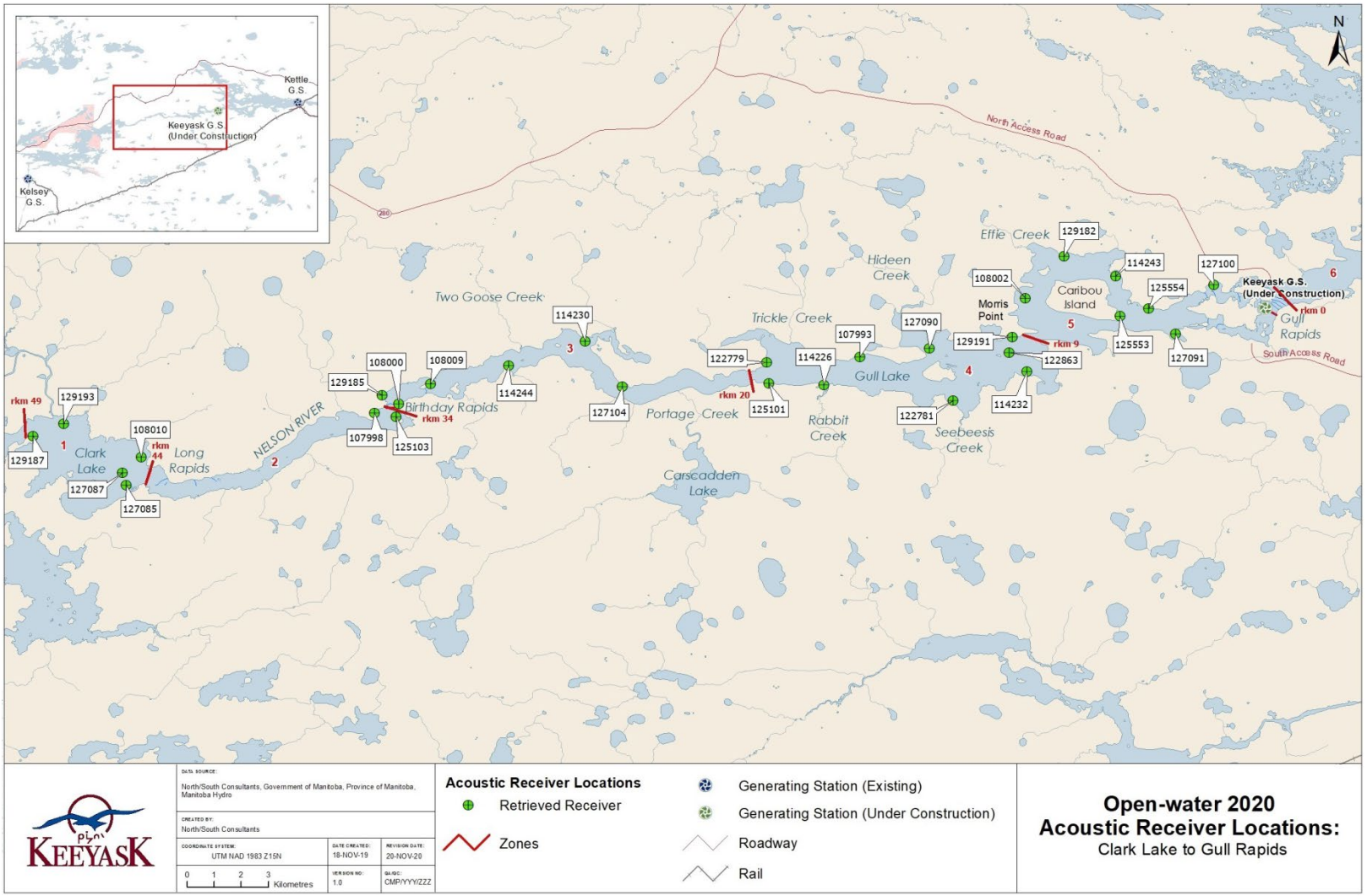
Map 2: Map illustrating instream structures at the Keeyask Generating Station site after reservoir flooding, September 2020.



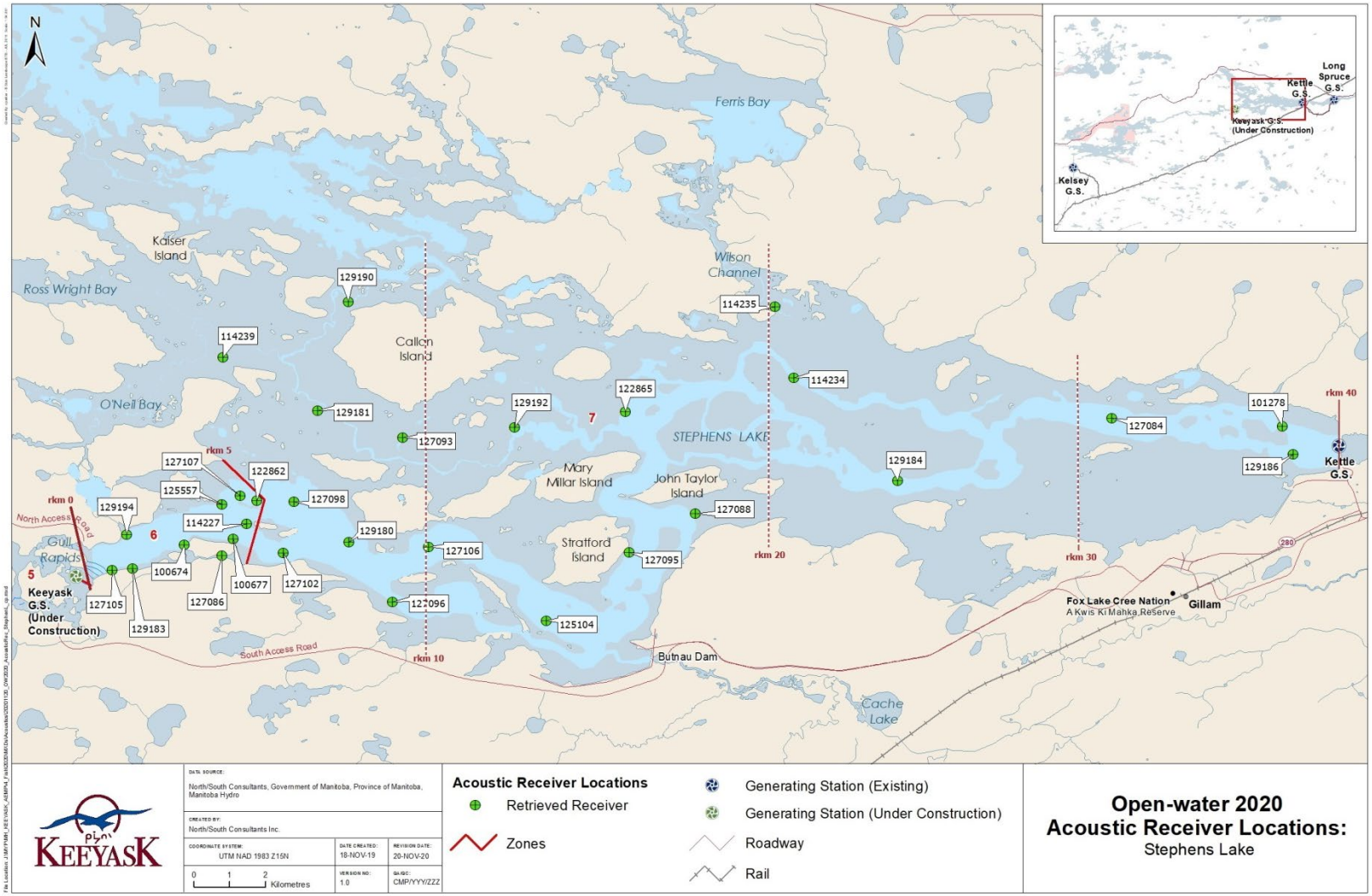
Map 3: **Locations of stationary receivers set in the Nelson River from Clark Lake to the Keeyask GS between October 2019 and July 2020. River kilometer (rkm) distances are indicated with a red dotted line.**



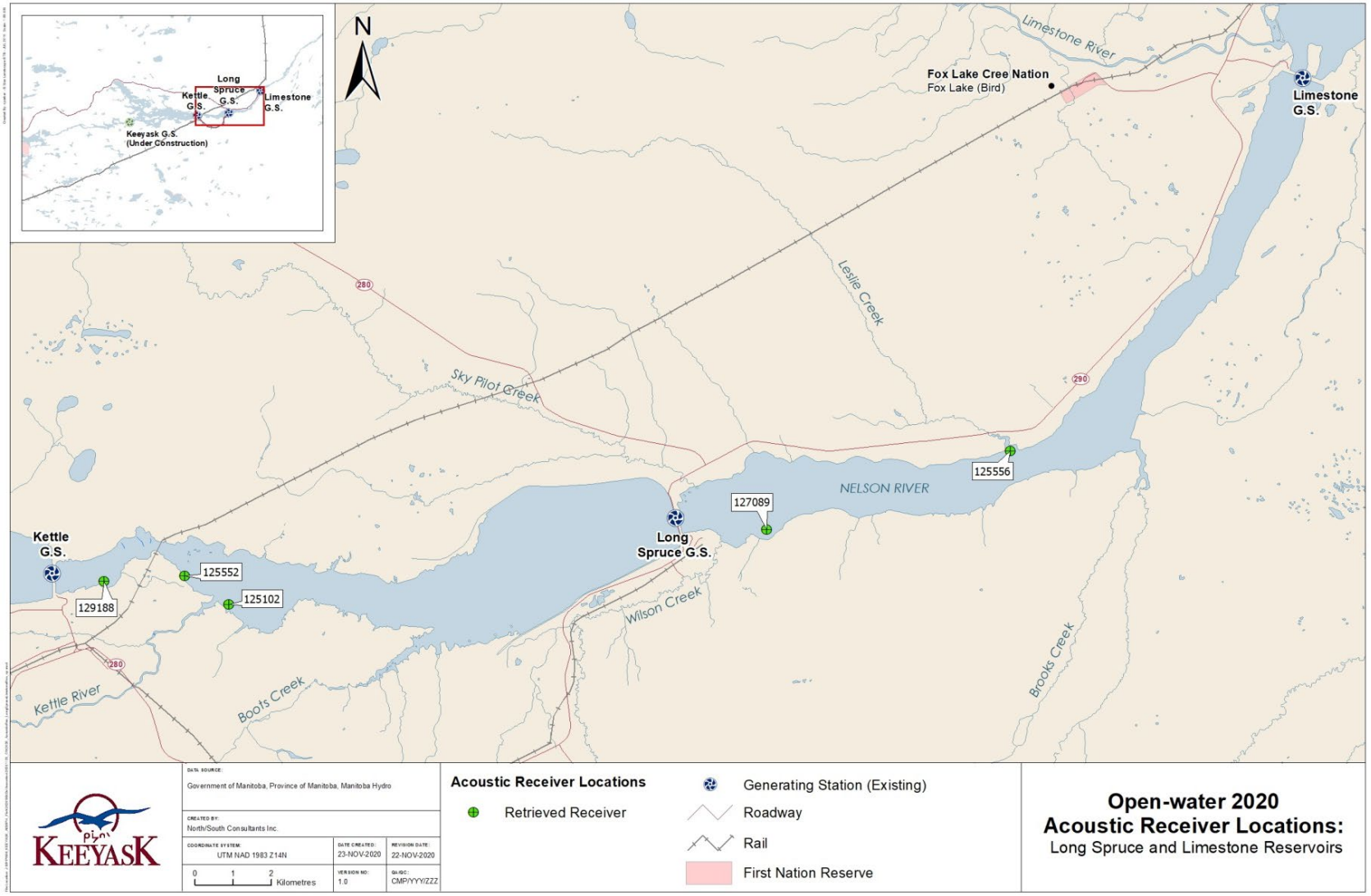
Map 4: Locations of stationary receivers set in Stephens Lake from the Keeyask GS to Kettle GS between October 2019 and July 2020. The former (pre-impoundment) river channel is shown in light blue. River kilometer (rkm) distances are indicated with a dotted red line.



Map 5: Locations of stationary receivers set in the Nelson River from Clark Lake to the Keeyask GS between July and September 2020. 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 July and September 2020. 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, August to September 2020.

APPENDICES

APPENDIX 1:
LOCATION SUMMARY FOR INDIVIDUAL ACOUSTIC TAGGED JUVENILE LAKE STURGEON UPSTREAM OF THE KEEYASK GS, SEPTEMBER 2017 TO OCTOBER 2020

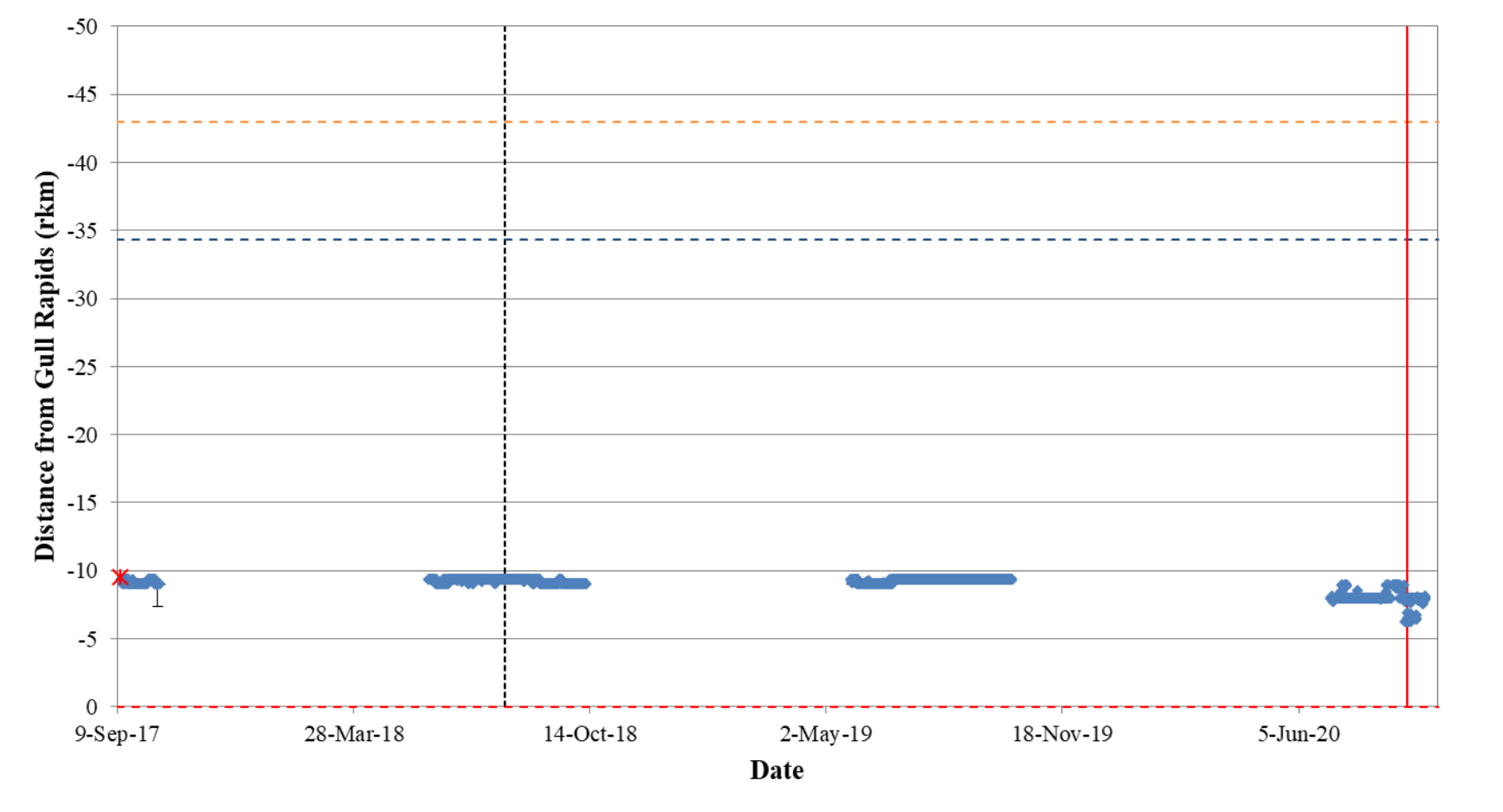


Figure A1-1: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31683) in Gull Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to September 23, 2020. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines 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).

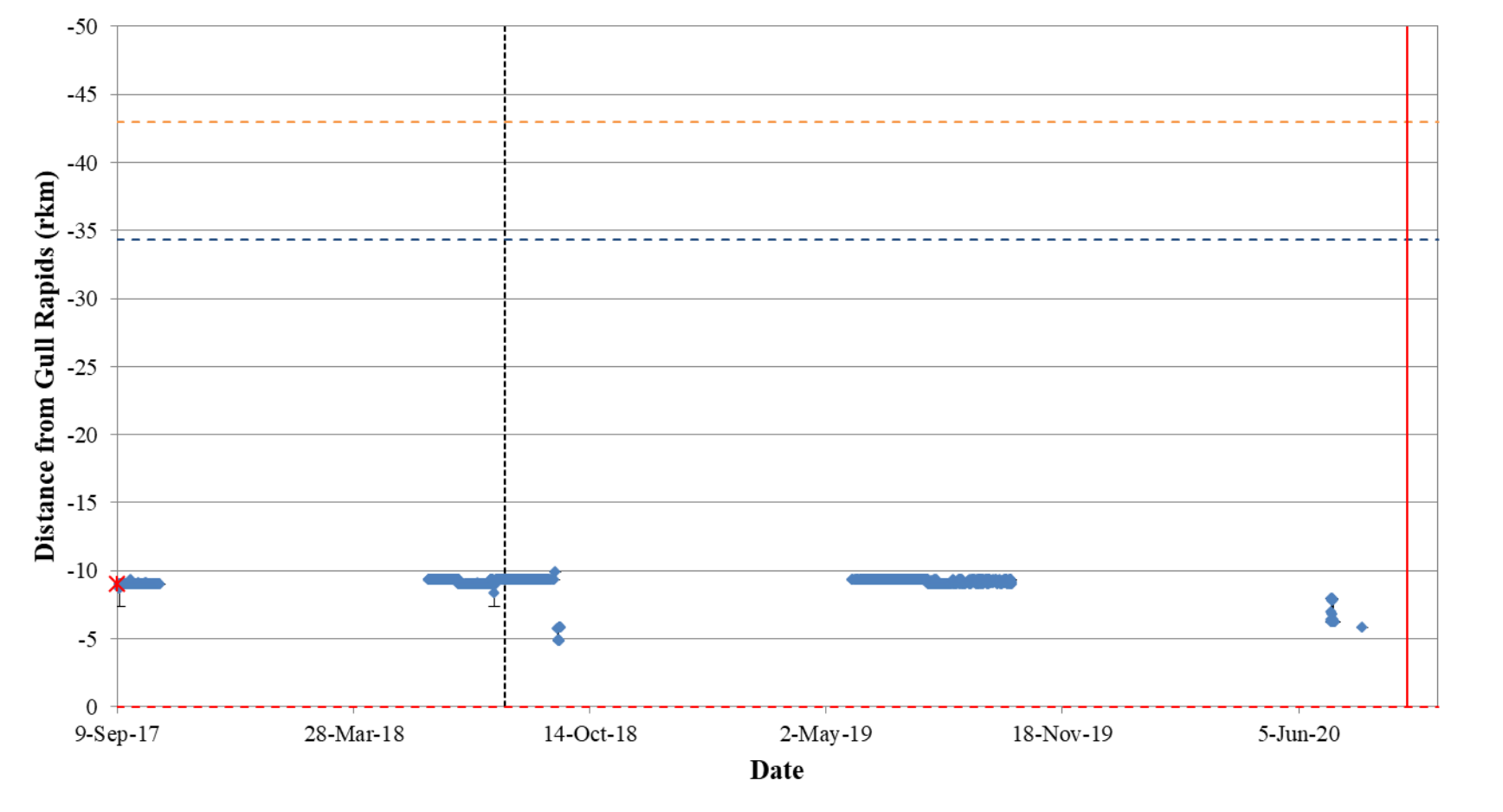


Figure A1-2: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31684) in Gull Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to September 23, 2020. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines 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).

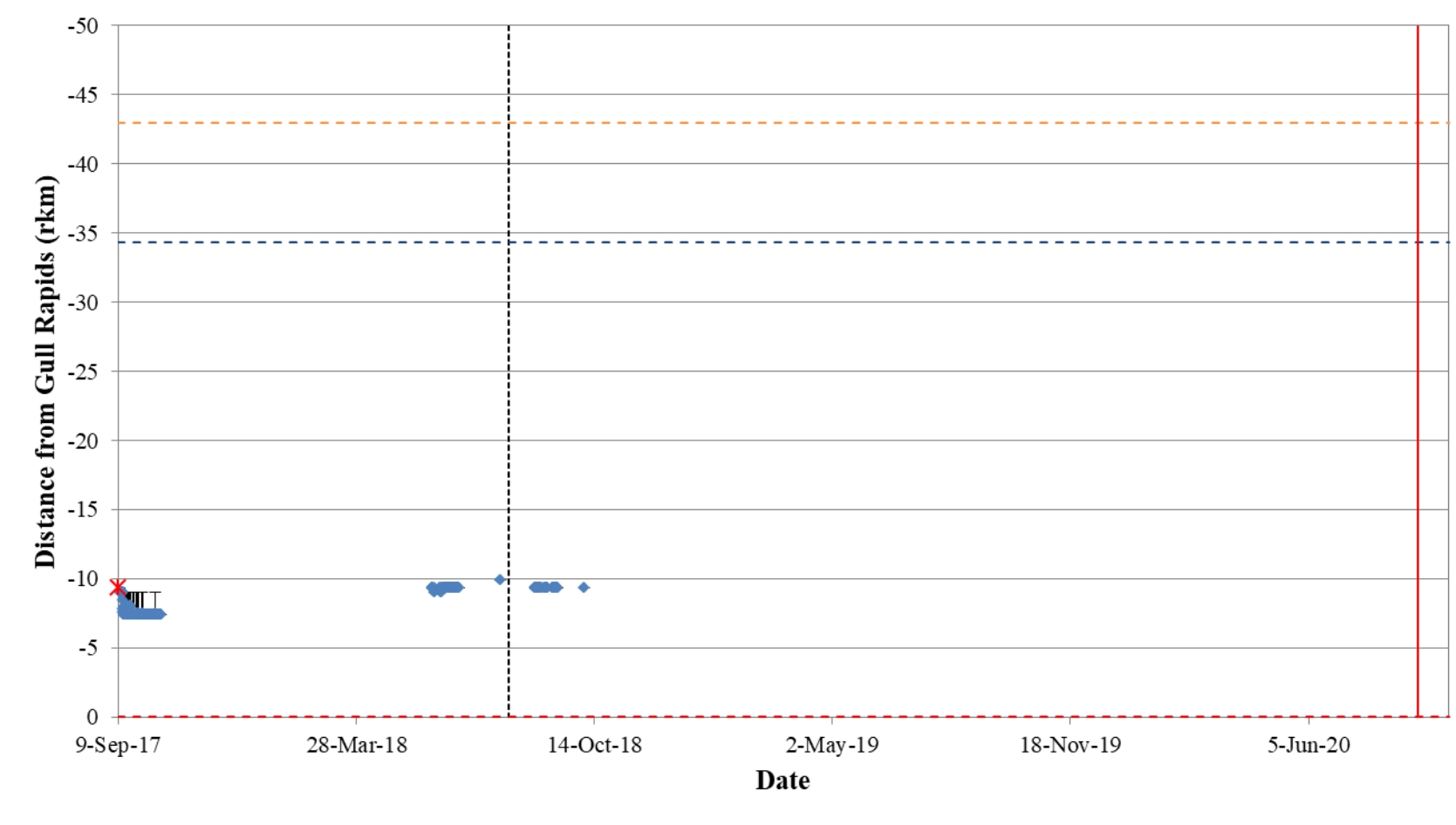


Figure A1-3: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31685) in Gull Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to September 23, 2020. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines 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).

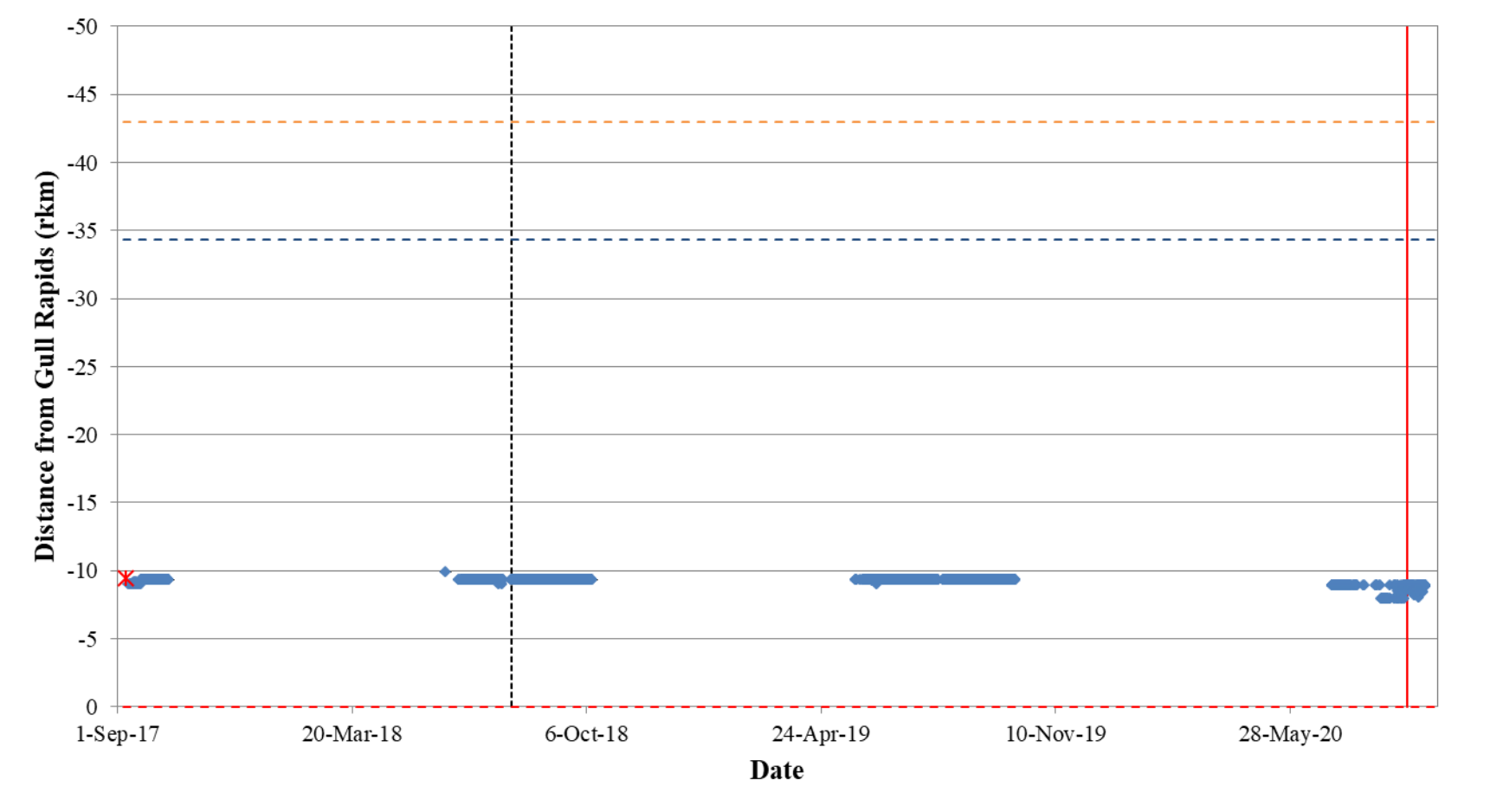


Figure A1-4: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31686) in Gull Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to September 23, 2020. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines 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).

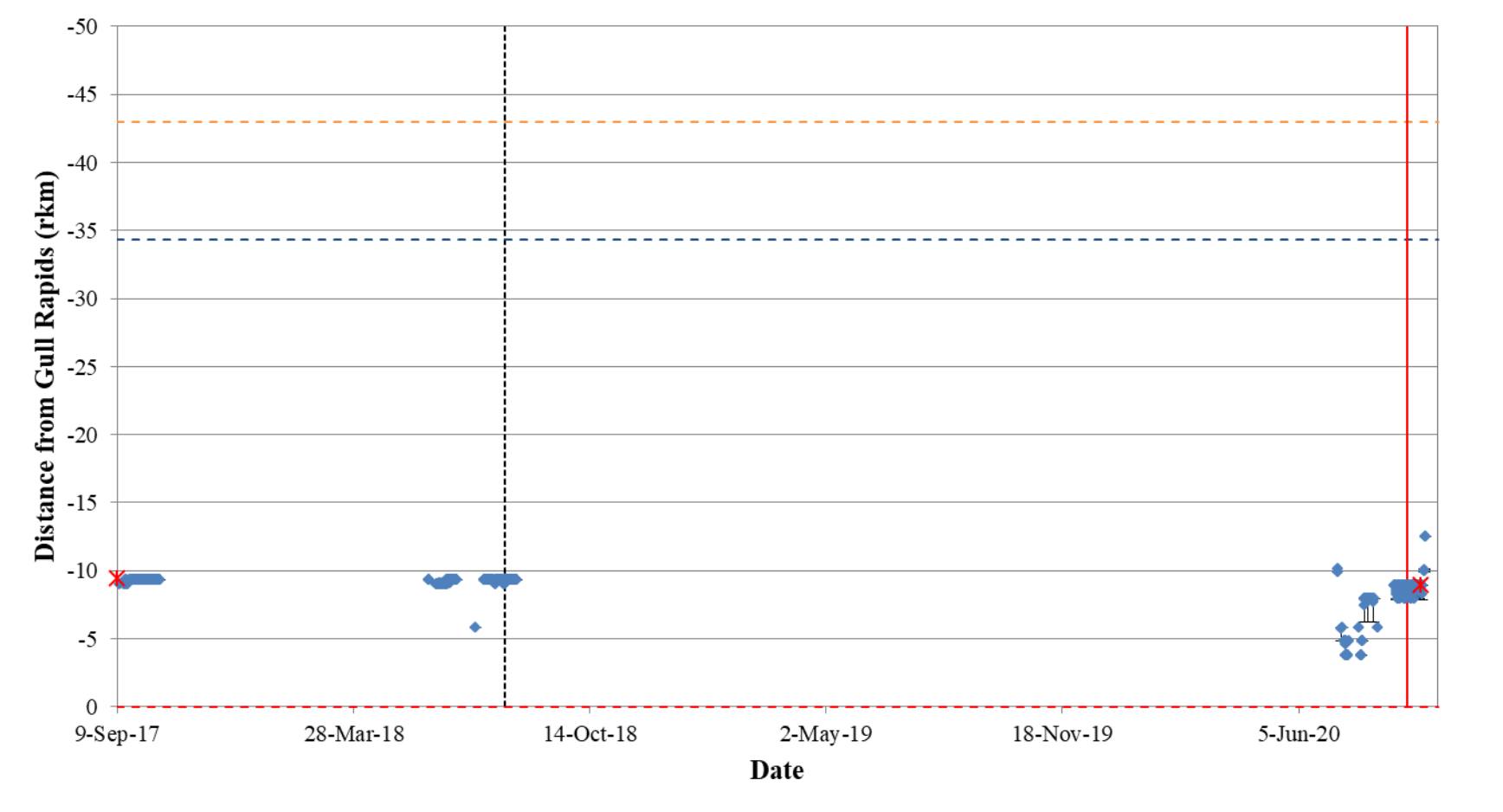


Figure A1-5: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31687) in Gull Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to September 23, 2020. Date and location of tagging and subsequent recapture are indicated by a red X. Error bars are shown in solid black. 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).

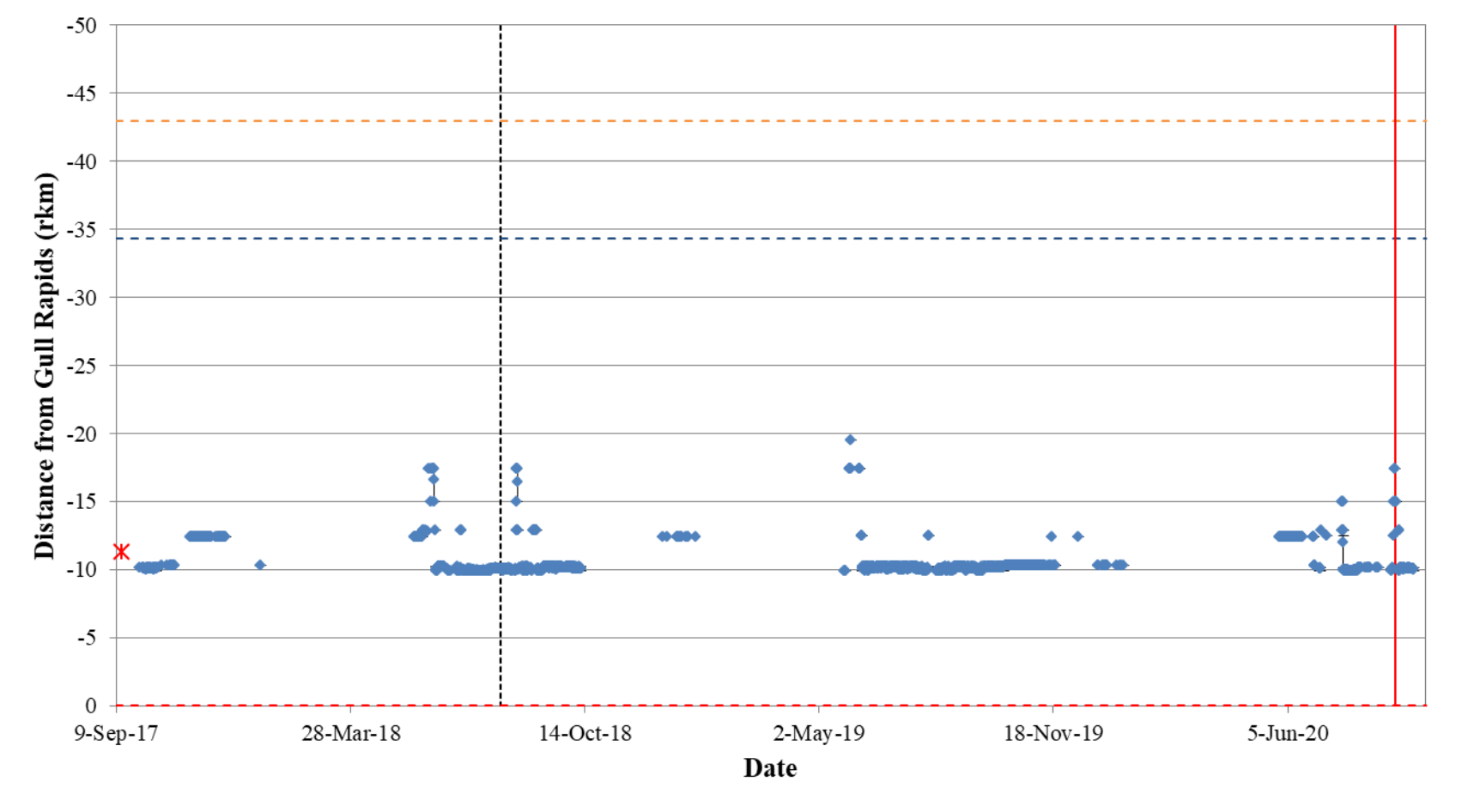


Figure A1-6: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31768) in Gull Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to September 23, 2020. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines 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).

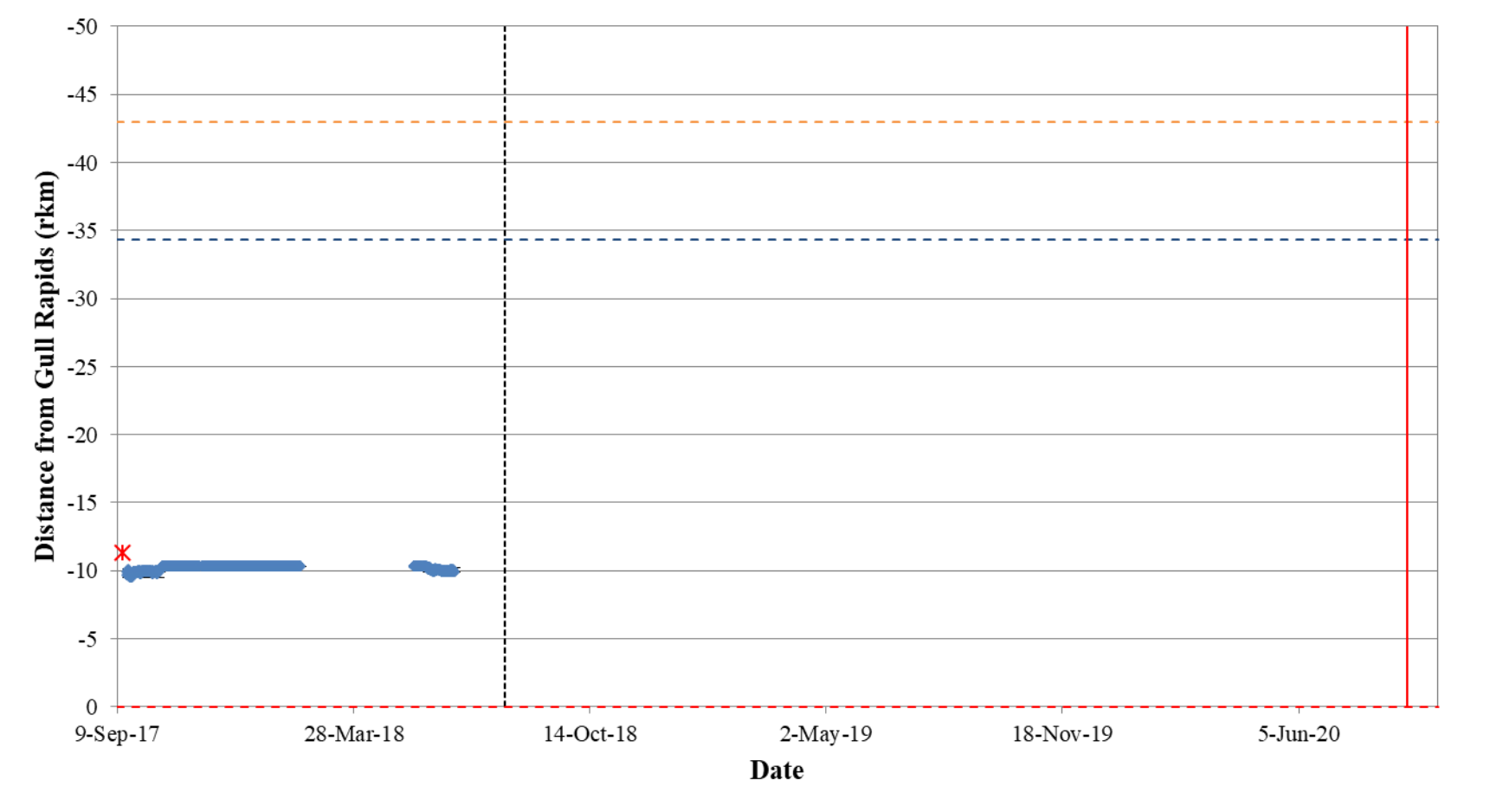


Figure A1-7: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31769) in Gull Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to September 23, 2020. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines 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).

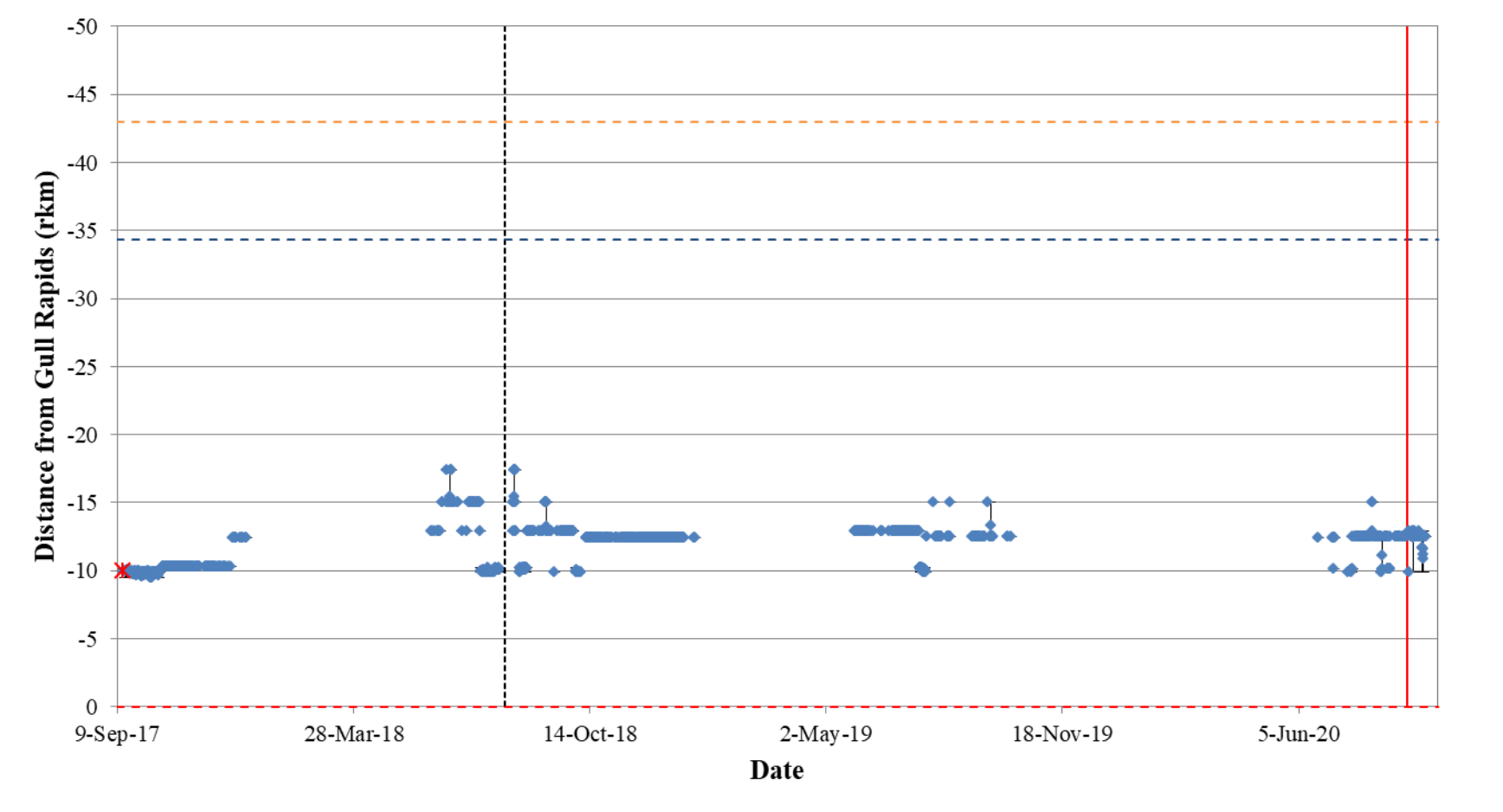


Figure A1-8: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31770) in Gull Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to September 23, 2020. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines 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).

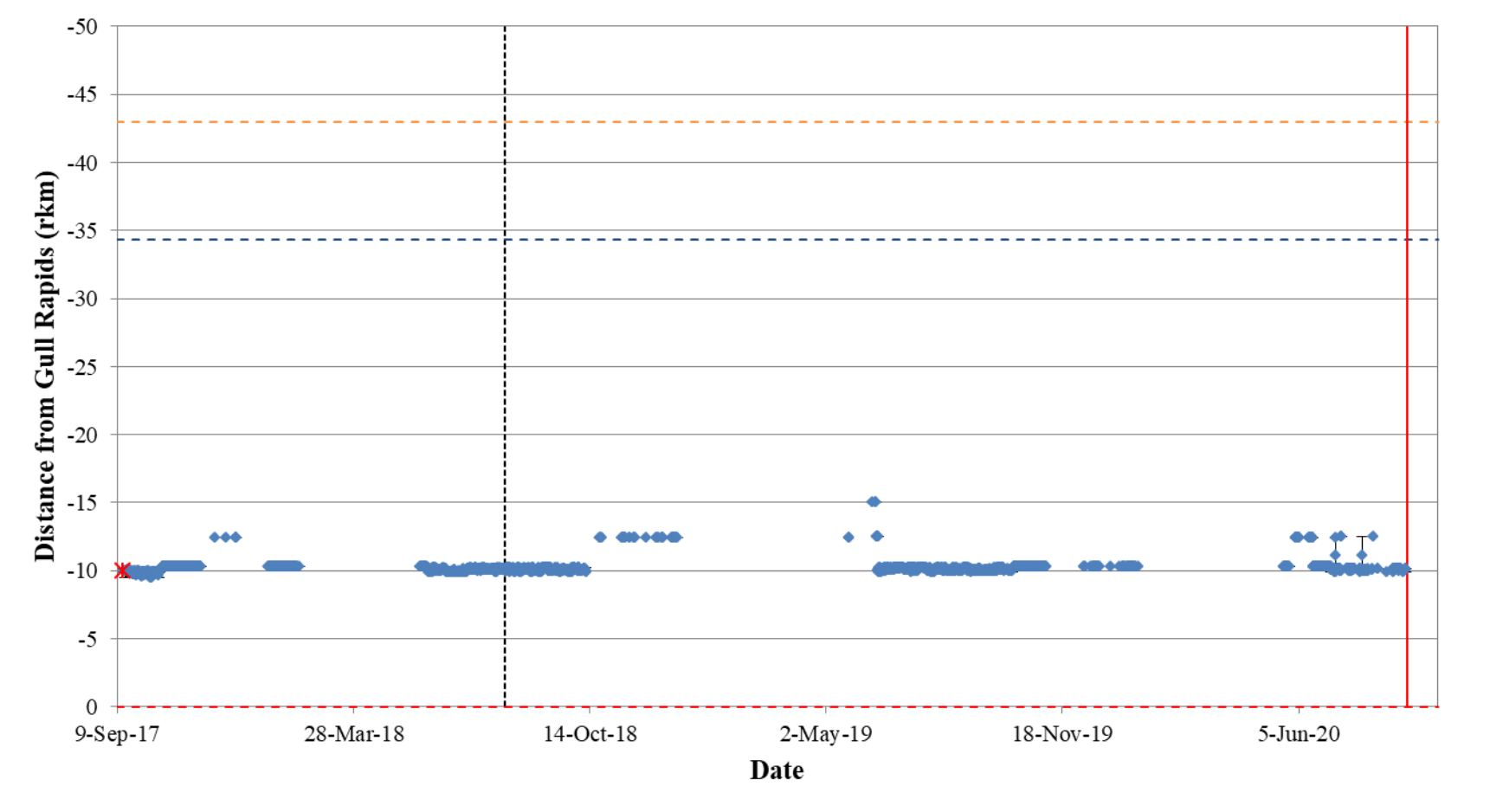


Figure A1-9: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31771) in Gull Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to September 23, 2020. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines 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).

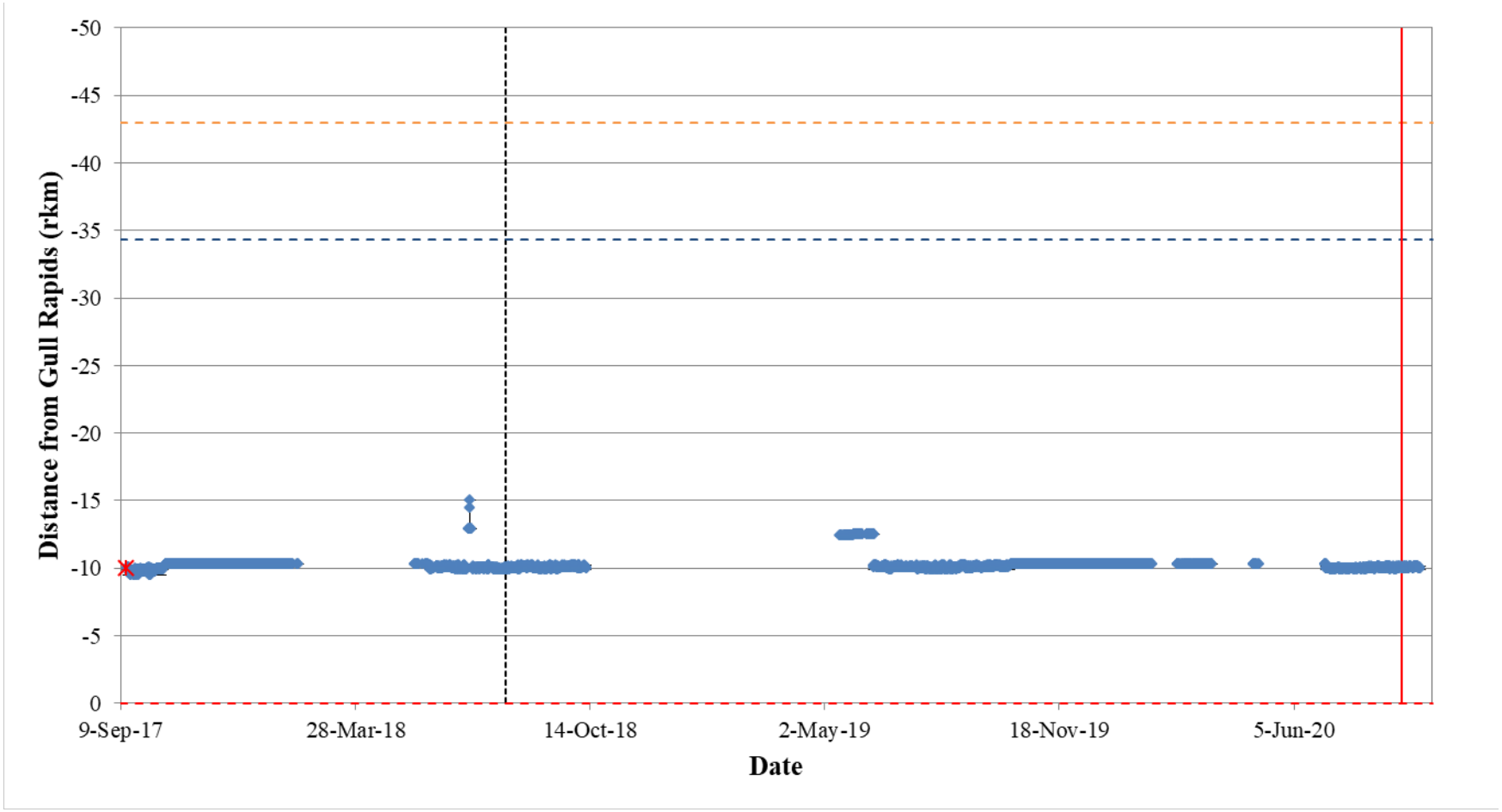


Figure A1-10: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31772) in Gull Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to September 23, 2020. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines 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).

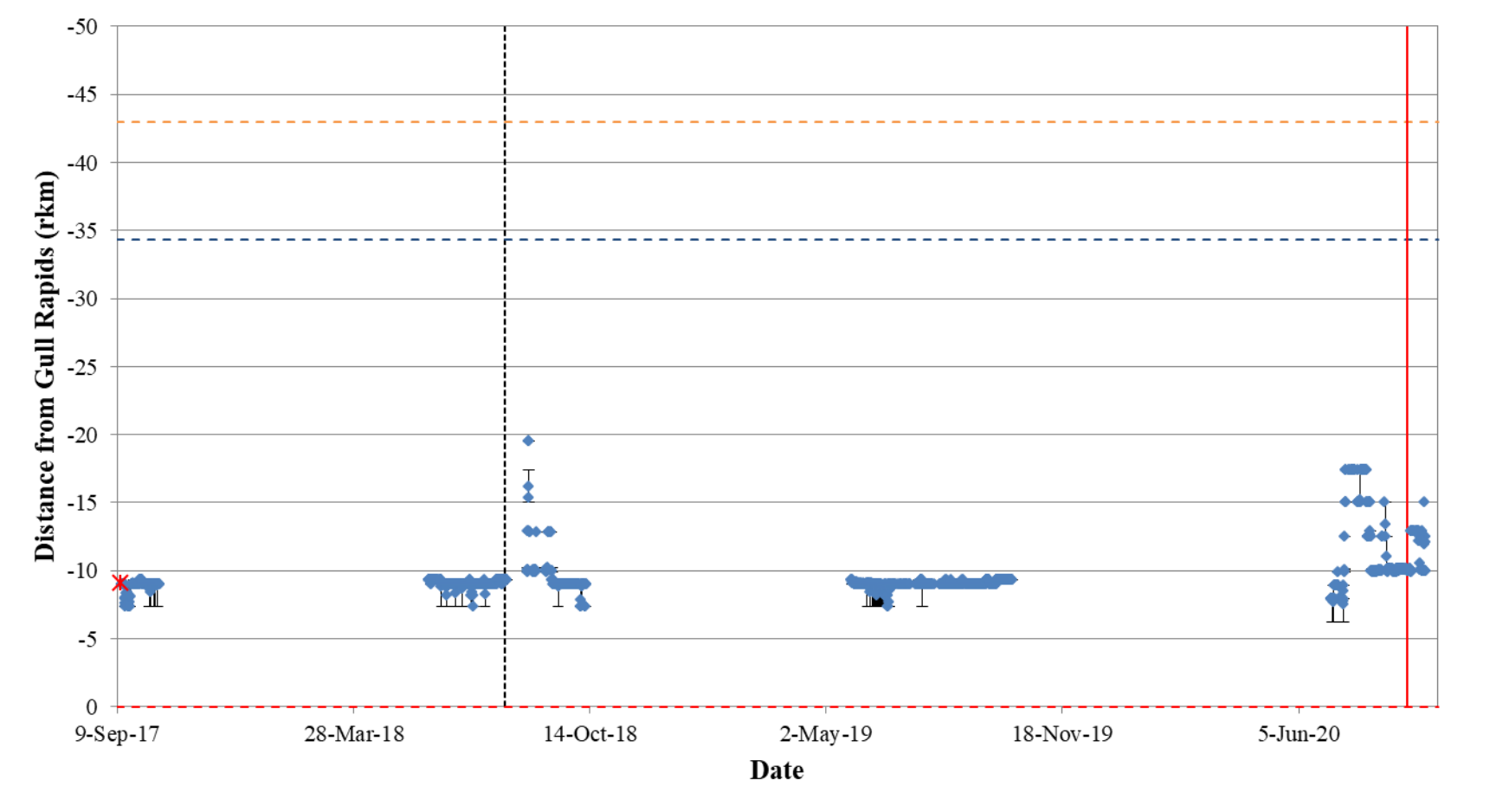


Figure A1-11: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31773) in Gull Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to September 23, 2020. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines 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).

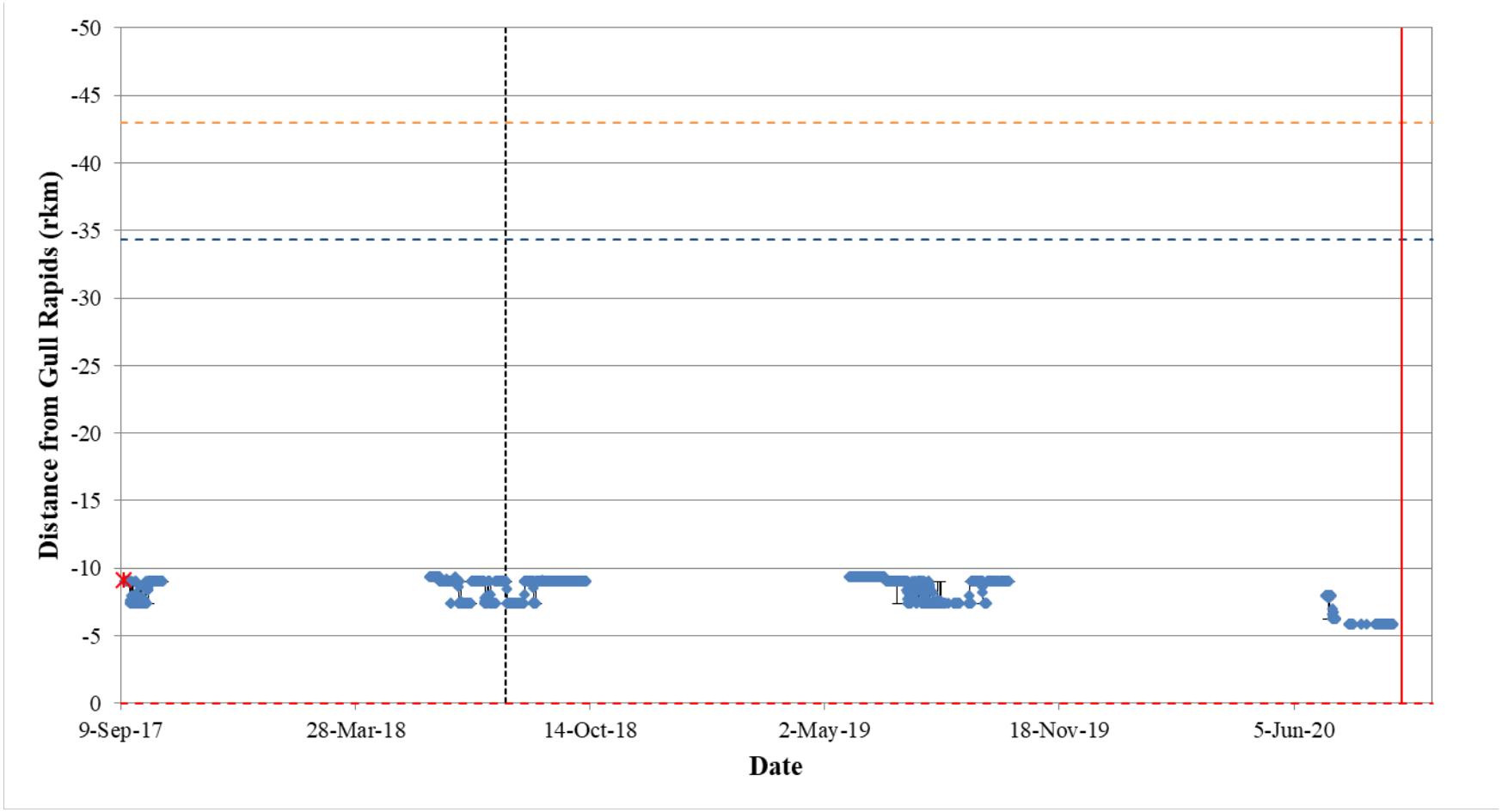


Figure A1-12: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31774) in Gull Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to September 23, 2020. Date and location of tagging is indicated by a red X. Horizontal dashed lines indicate the positions of Keeyask 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).

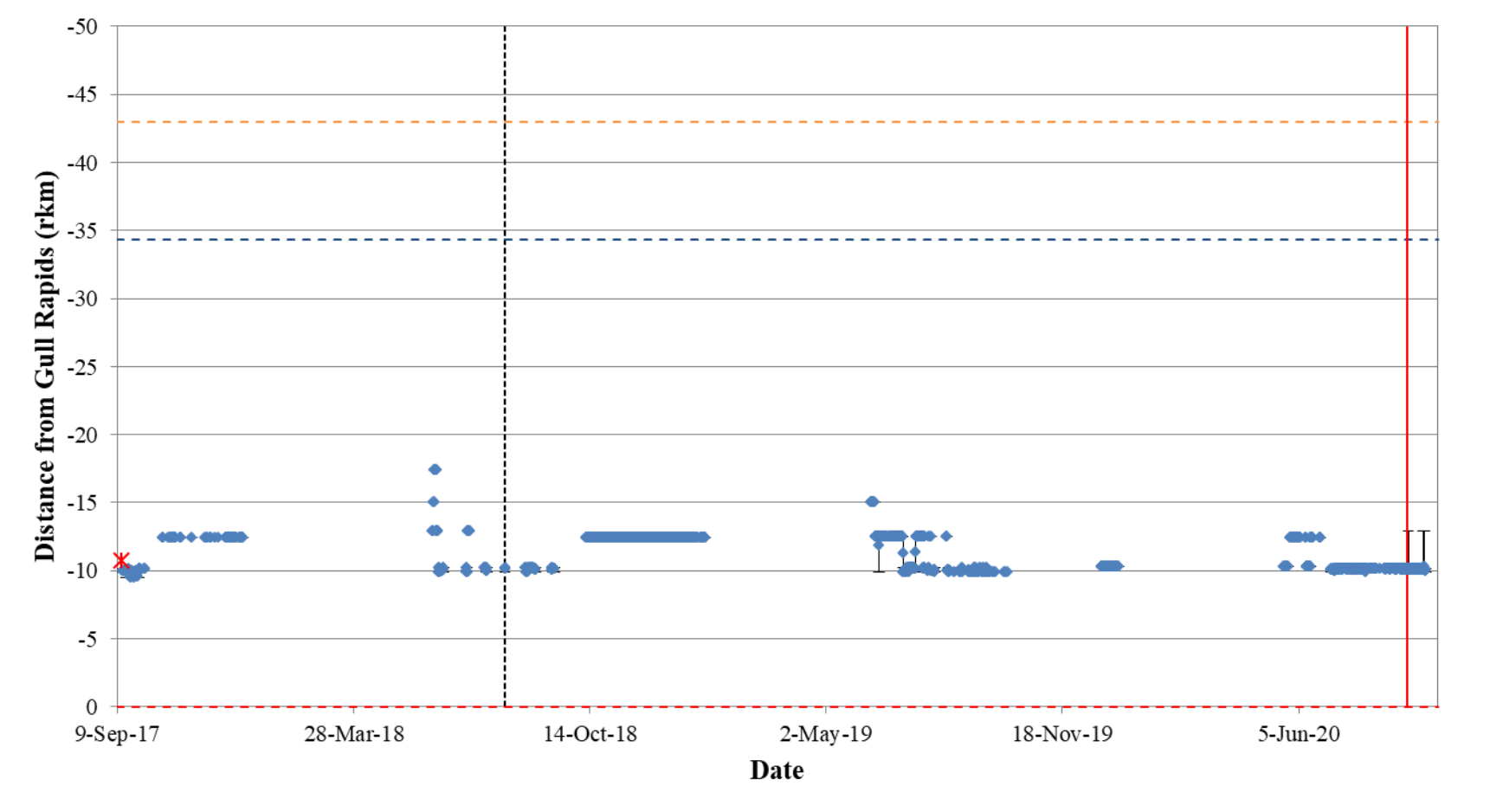


Figure A1-13: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31775) in Gull Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to September 23, 2020. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines 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).

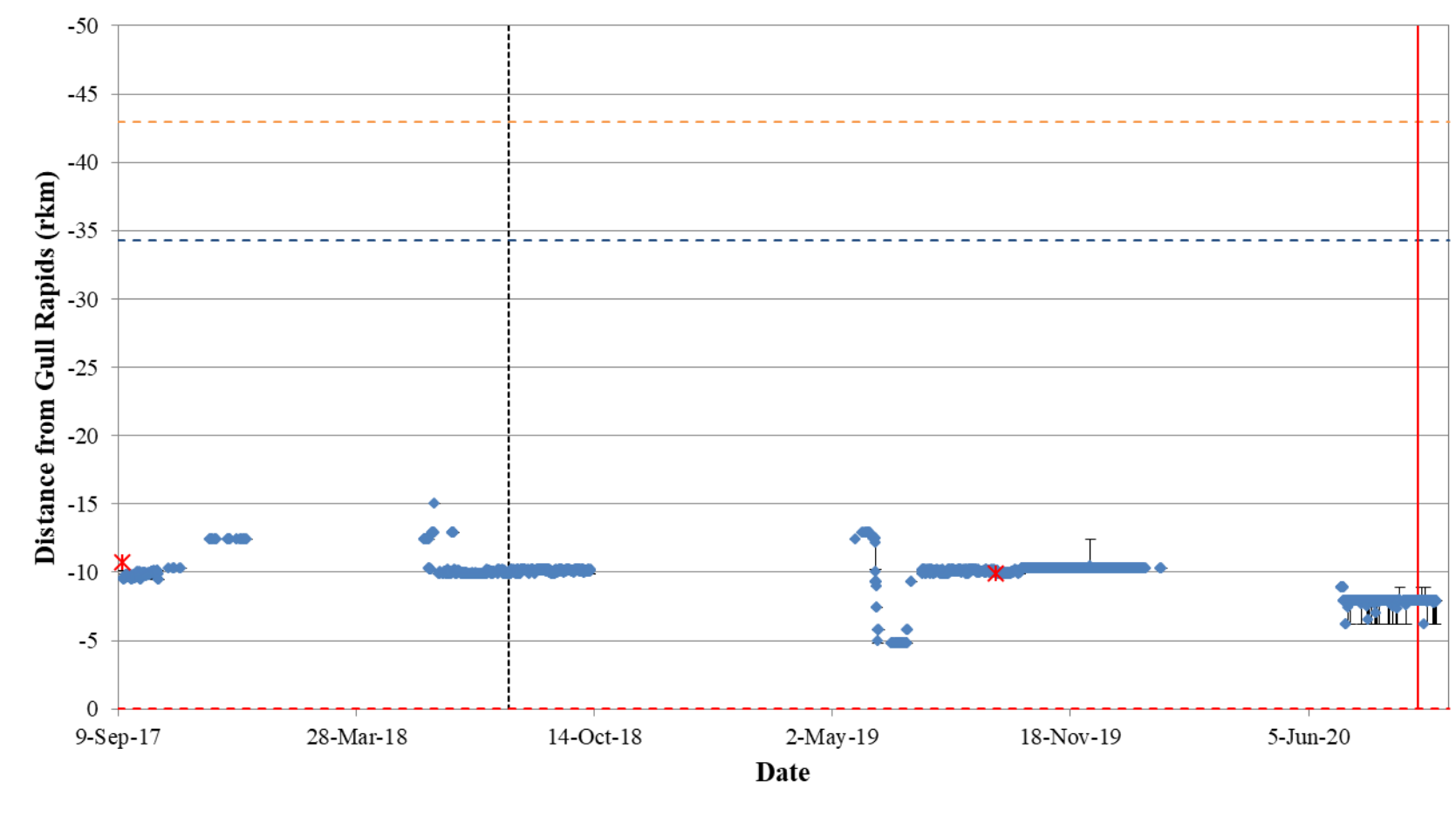


Figure A1-14: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31776) in Gull Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to September 23, 2020. Date and location of tagging and subsequent recapture are indicated by a red X. Error bars are shown in solid black. 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).

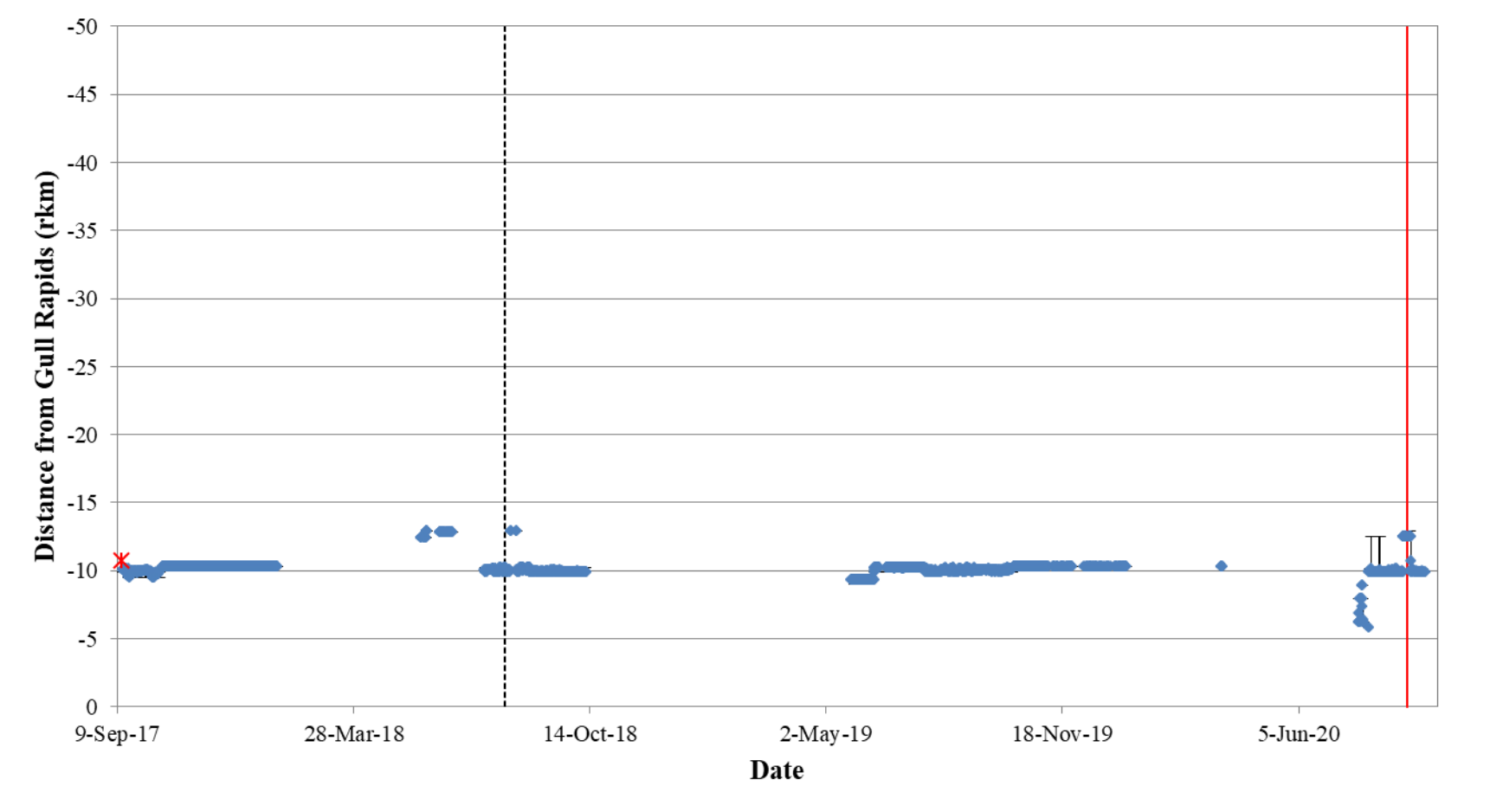


Figure A1-15: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31777) in Gull Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to September 23, 2020. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines 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).

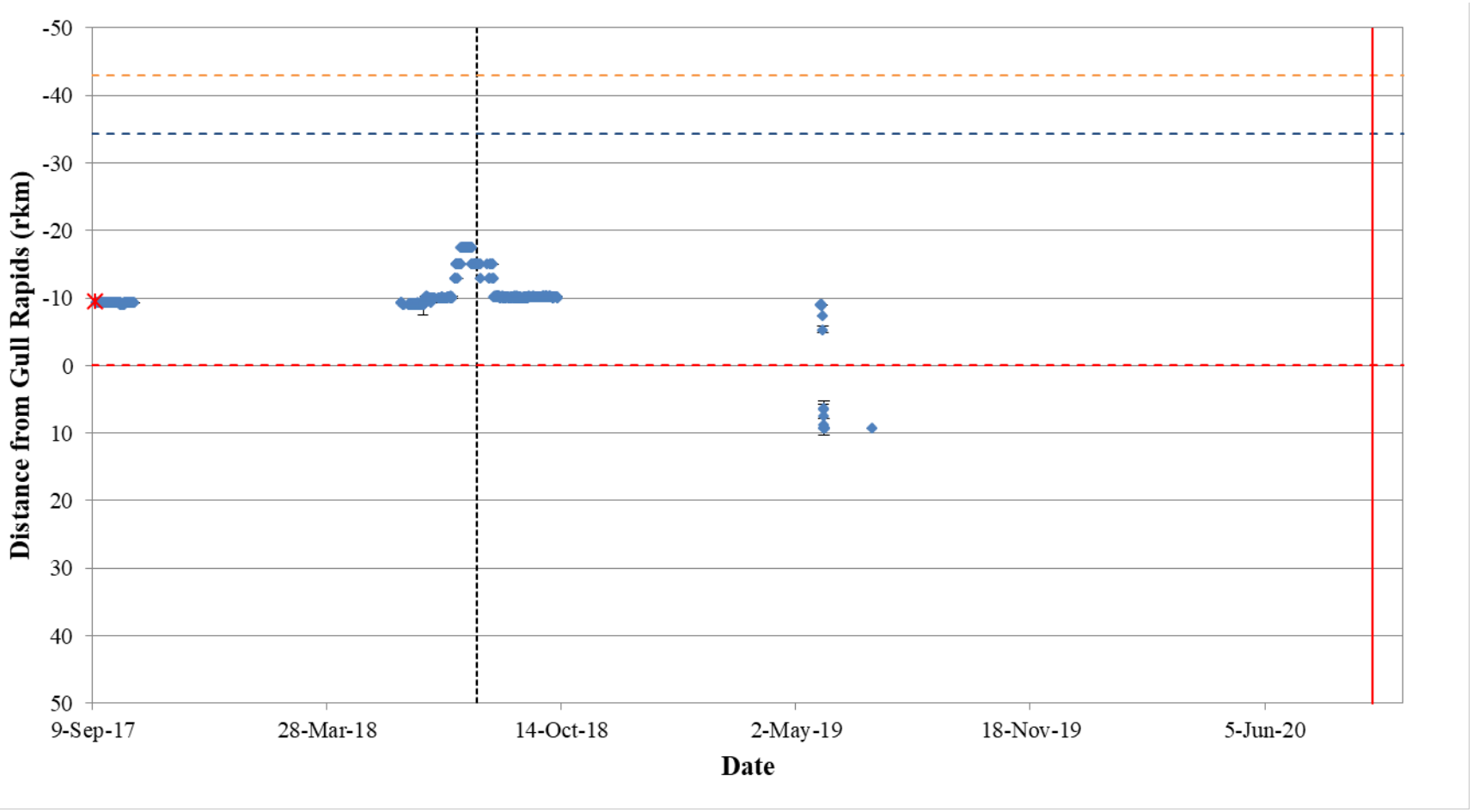


Figure A1-16: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31778) in Gull Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to September 23, 2020. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines 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).

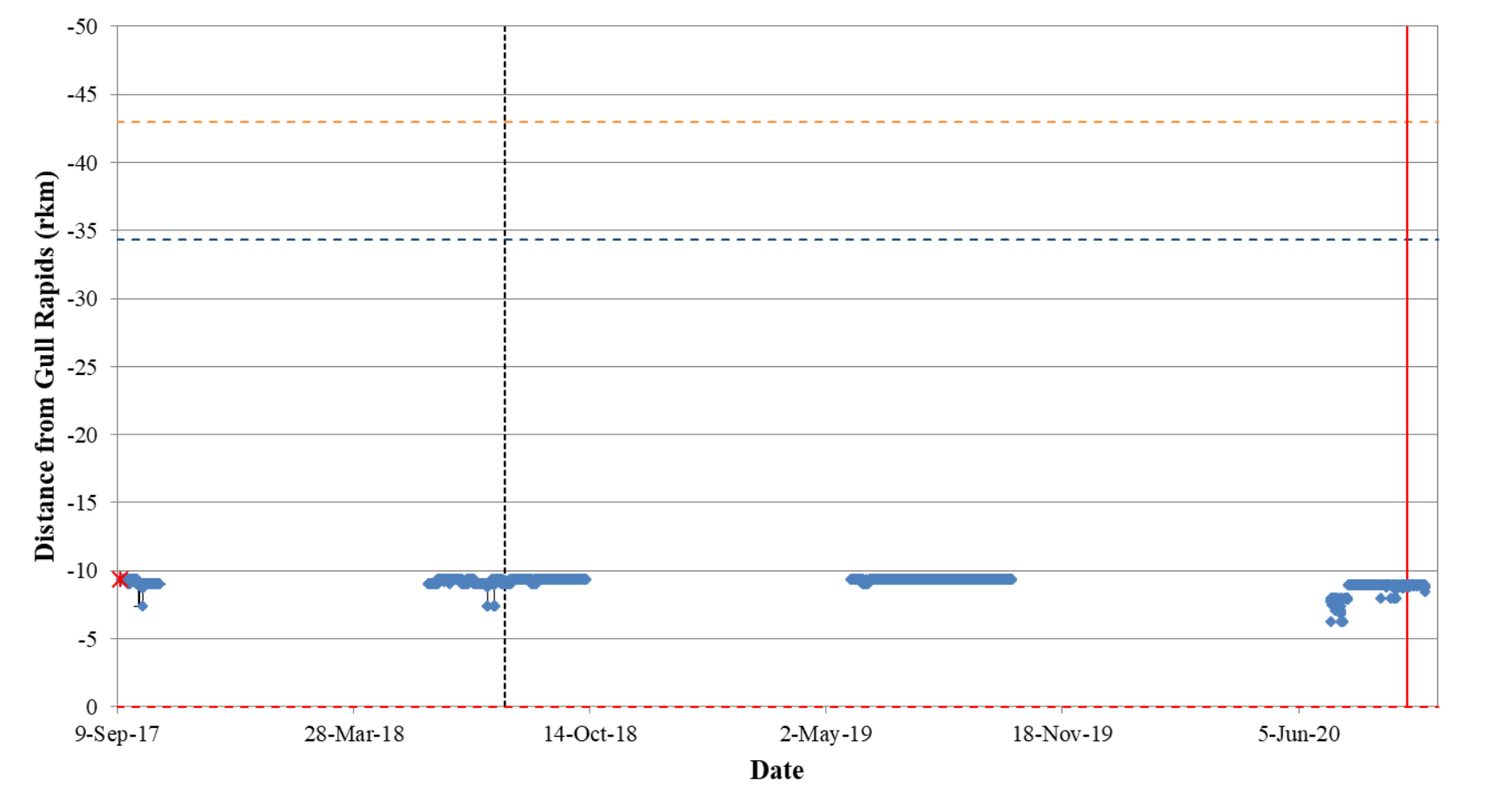


Figure A1-17: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31779) in Gull Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to September 23, 2020. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines 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).

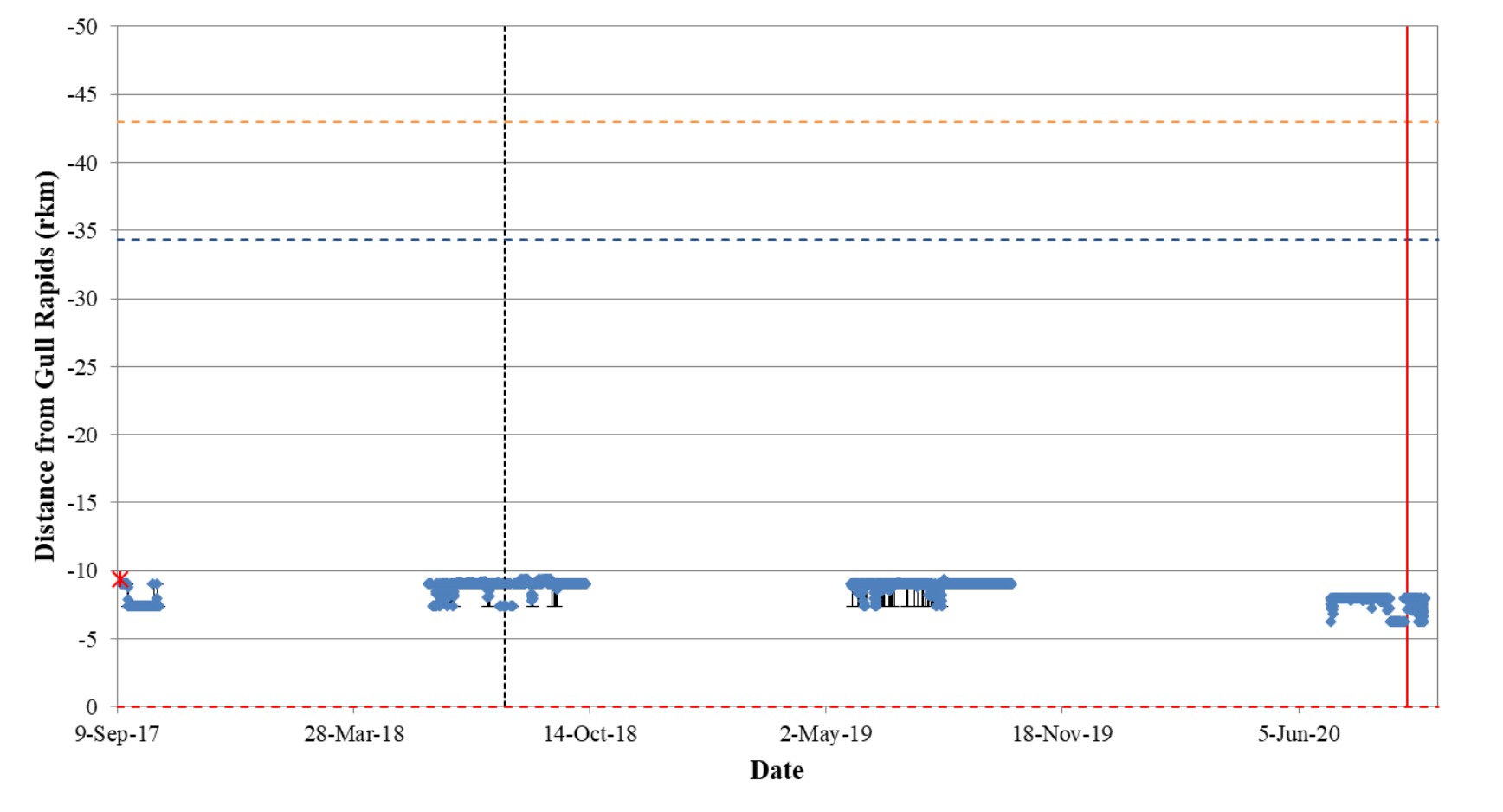


Figure A1-18: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31780) in Gull Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to September 23, 2020. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines 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).

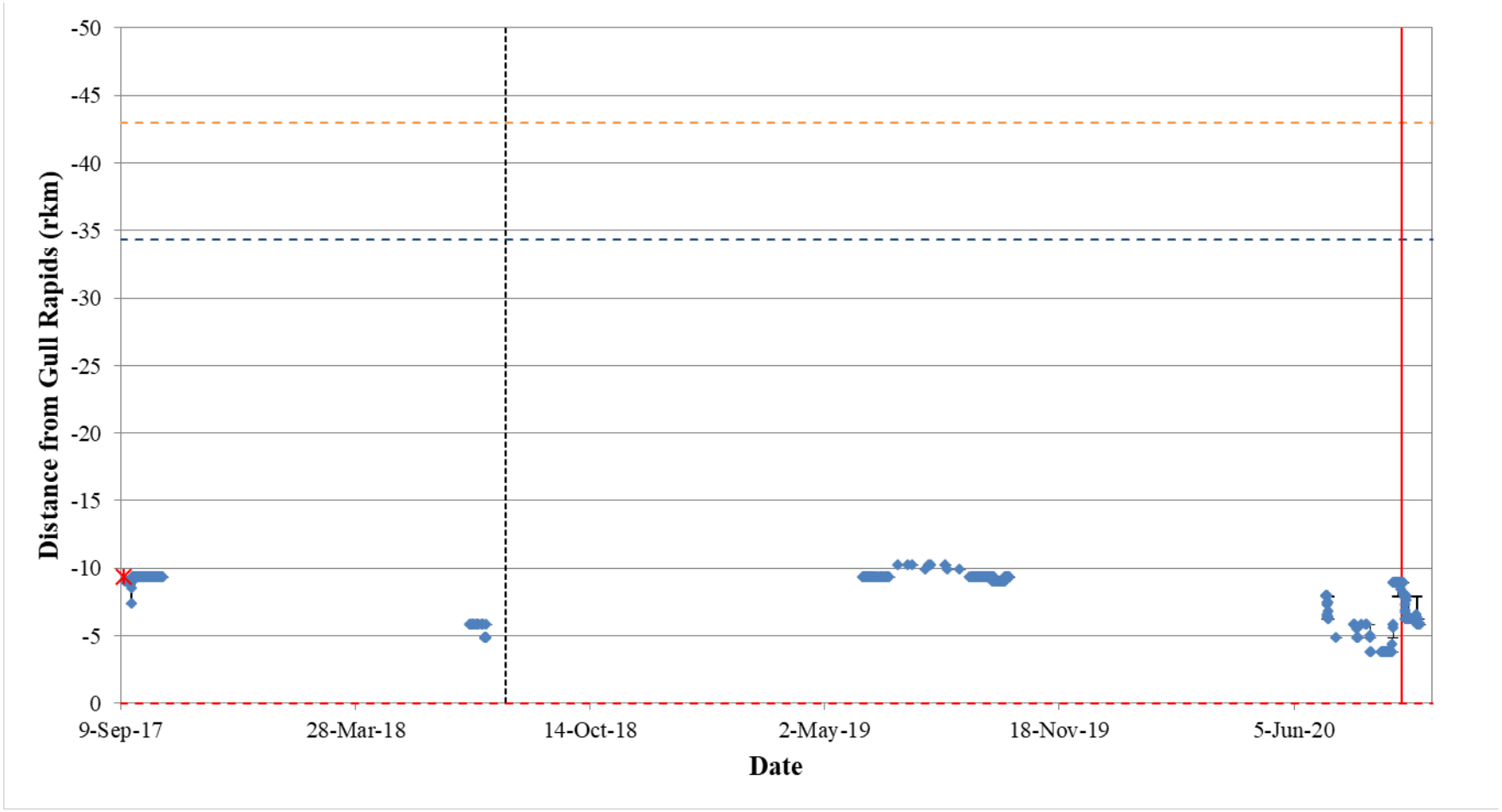


Figure A1-19: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31781) in Gull Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to September 23, 2020. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines 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).

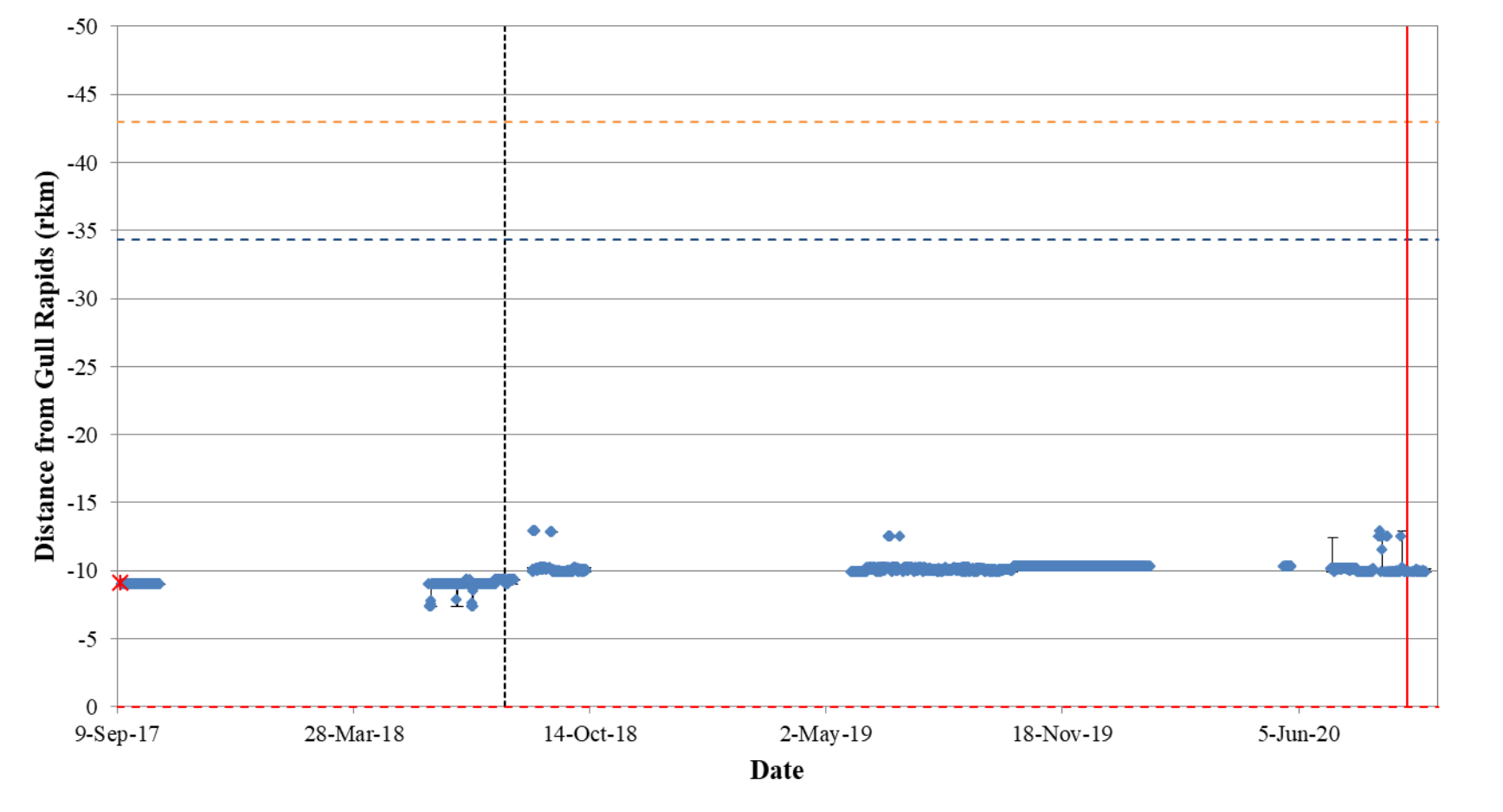


Figure A1-20: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31782) in Gull Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to September 23, 2020. Date and location of tagging is indicated by a red X. Error bars are shown in solid black. Horizontal dashed lines 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).

APPENDIX 2:
LOCATION SUMMARY FOR INDIVIDUAL ACOUSTIC TAGGED JUVENILE LAKE STURGEON DOWNSTREAM OF THE KEEYASK GS, SEPTEMBER 2017 TO OCTOBER 2020

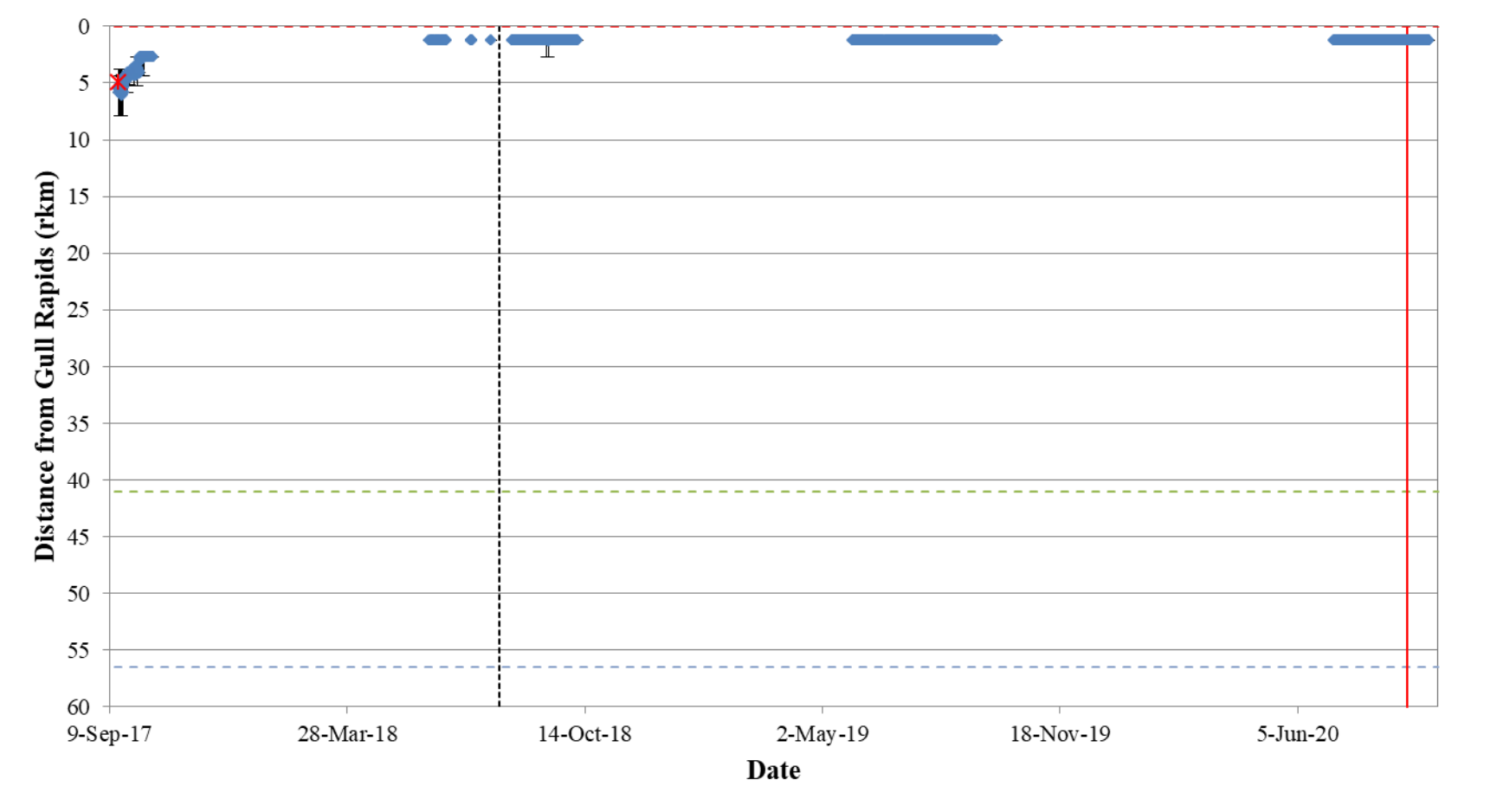


Figure A2-1: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31668) in Stephens Lake in relation to the Keeyask GS (rkm 0), September 9, 2017 to September 23, 2020. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines indicate 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).

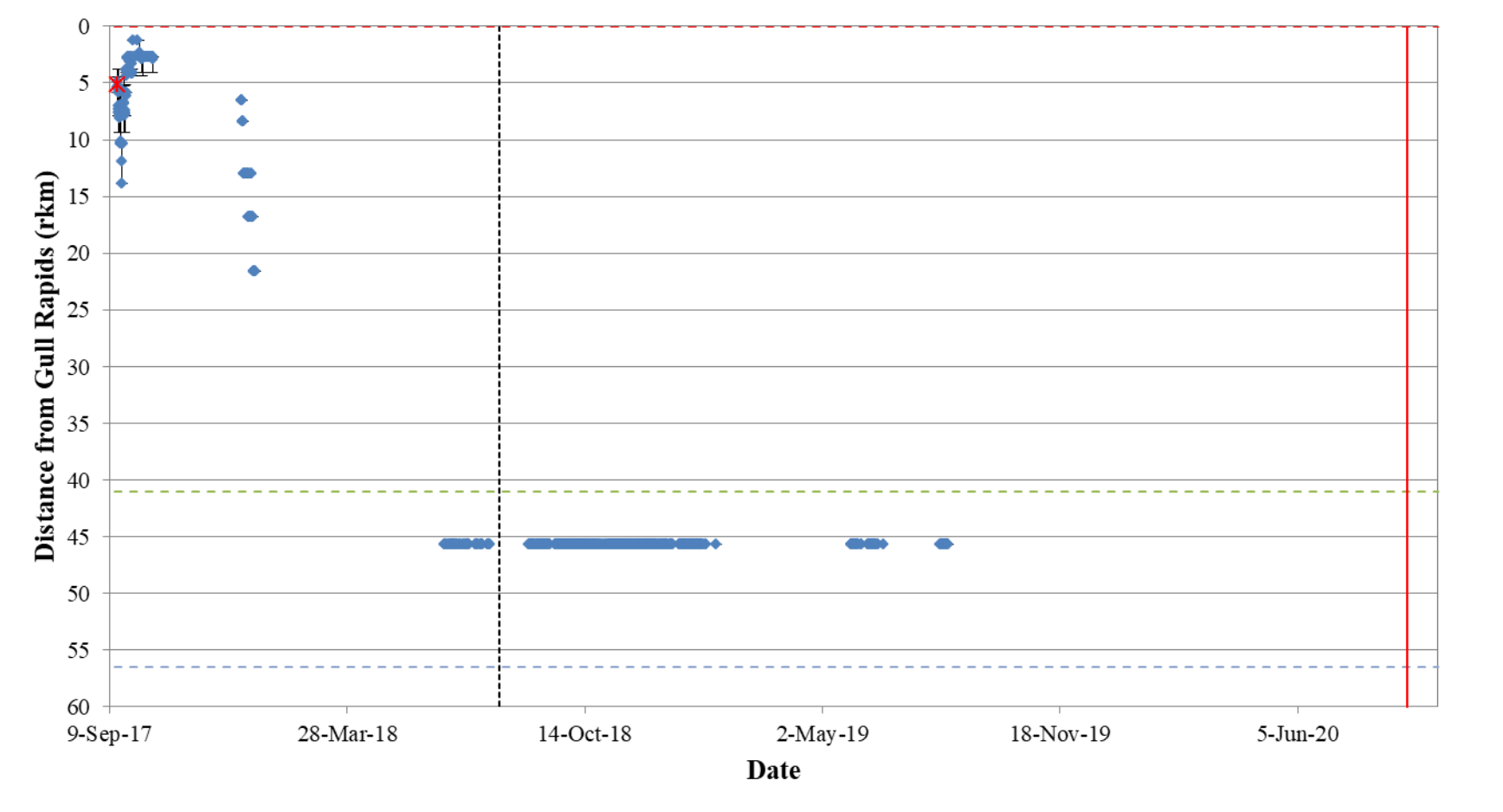


Figure A2-2: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31689) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to September 23, 2020. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines 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).

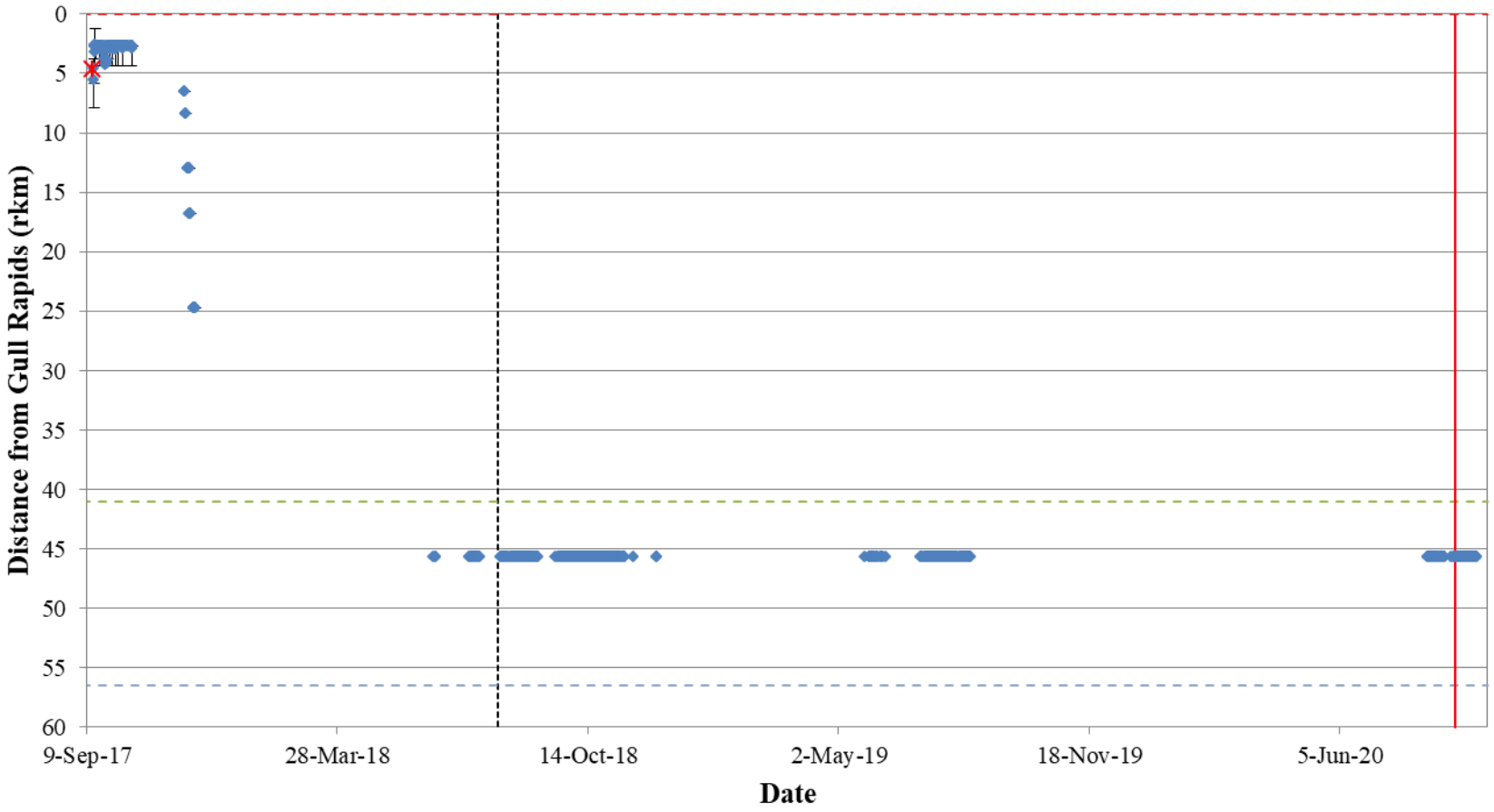


Figure A2-3: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31690) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to September 23, 2020. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines 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).

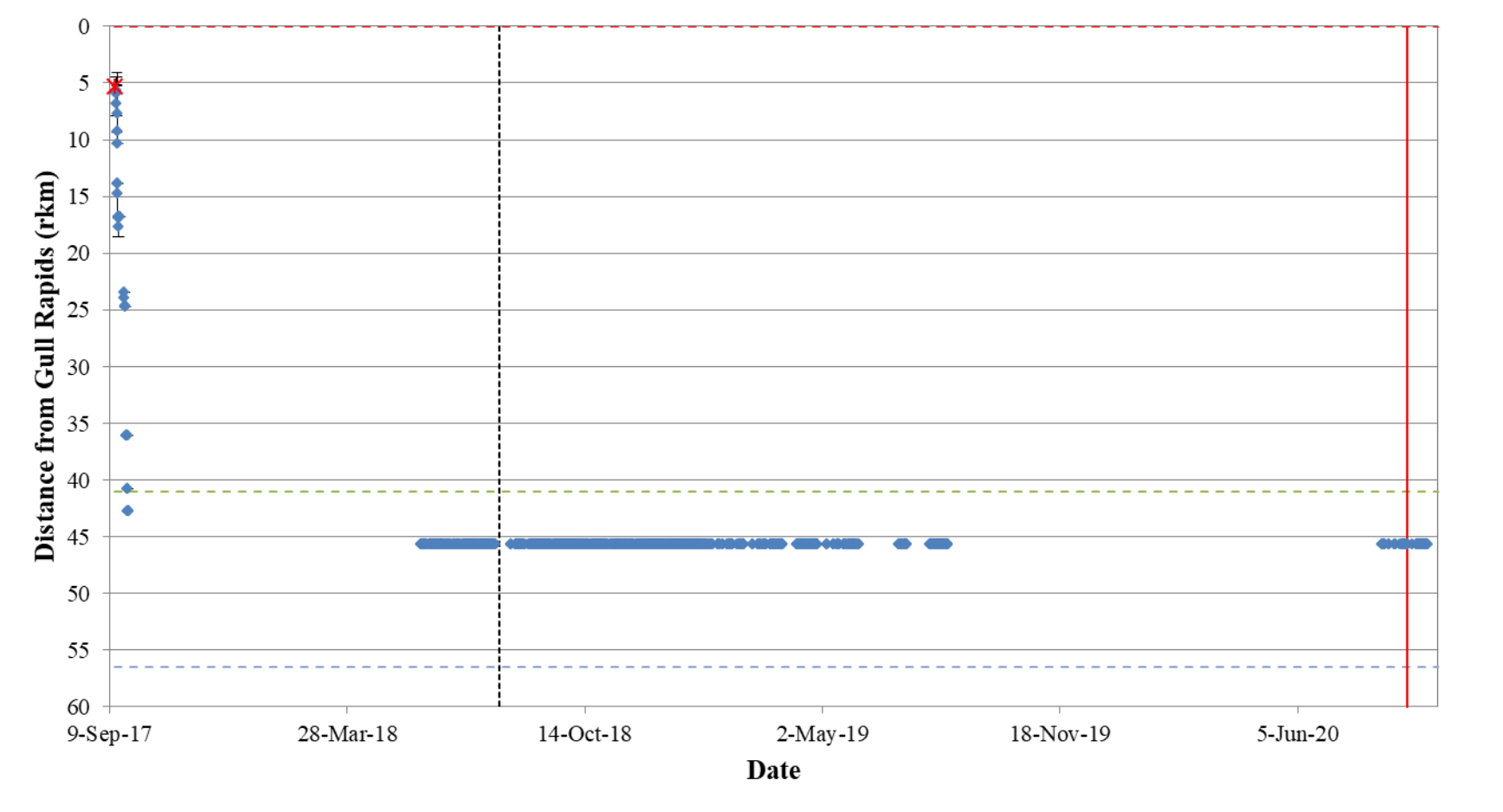


Figure A2-4: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31691) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to September 23, 2020. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines 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).

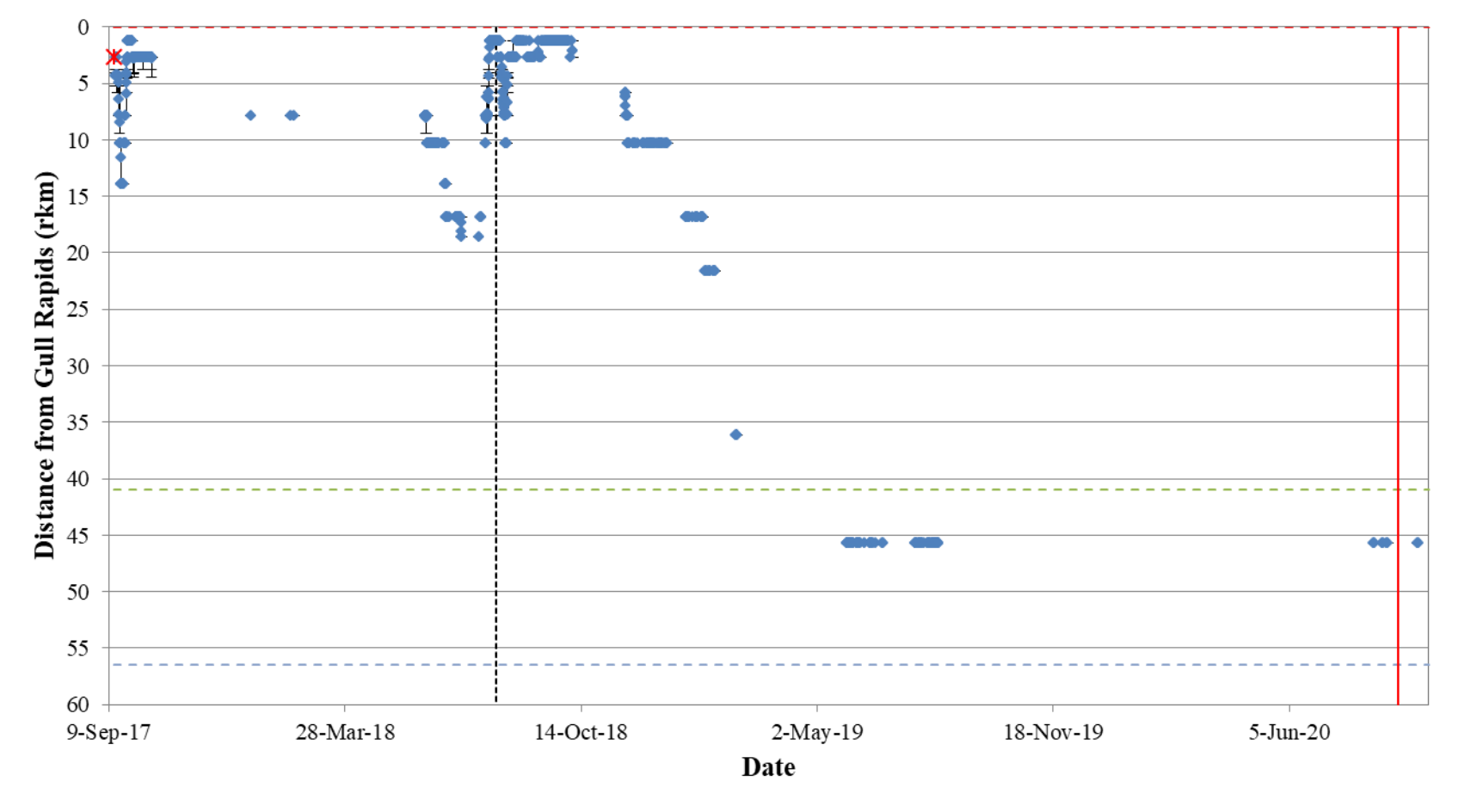


Figure A2-5: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31692) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to September 23, 2020. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines 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).

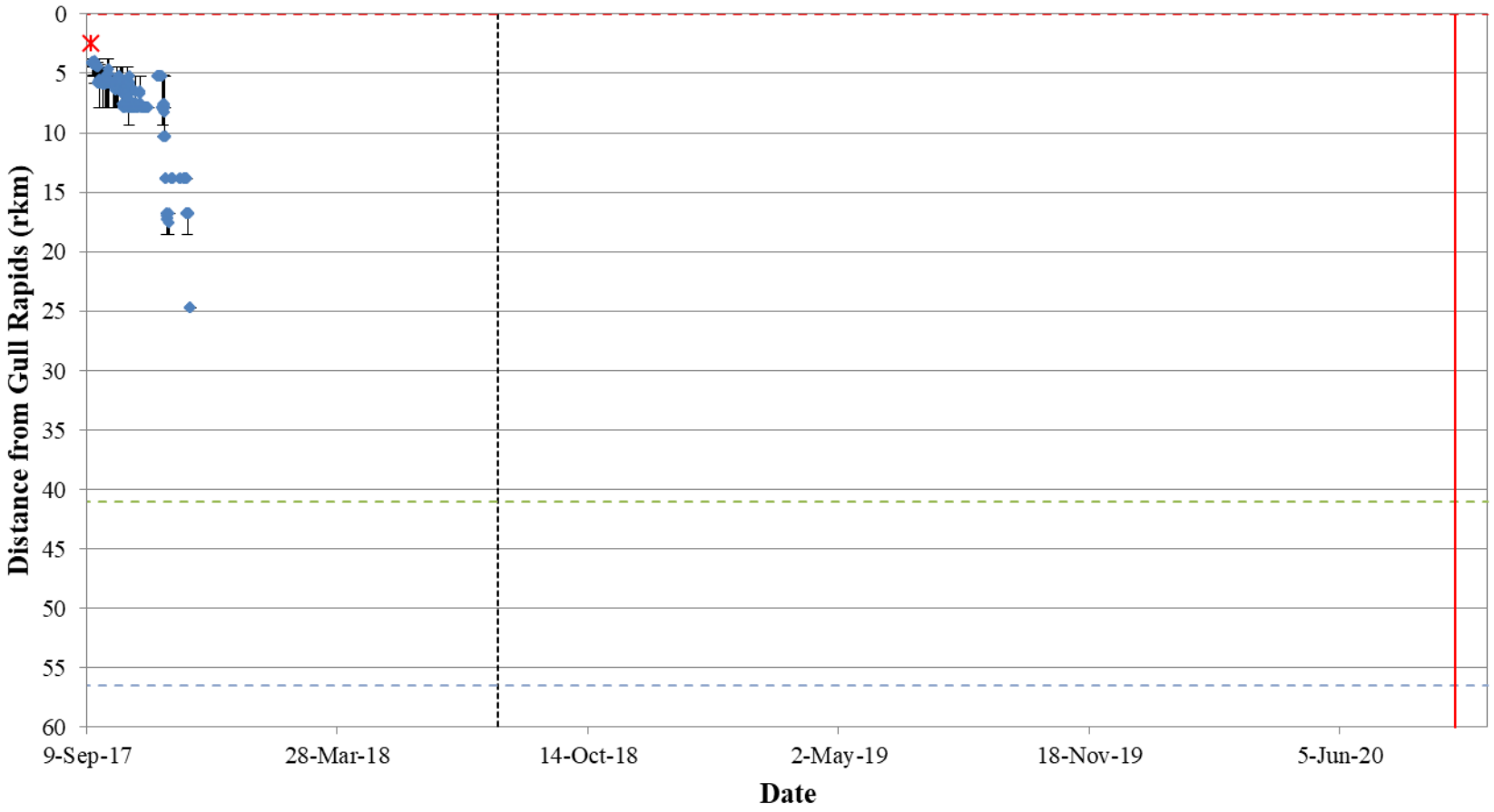


Figure A2-6: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31693) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to September 23, 2020. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines 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).

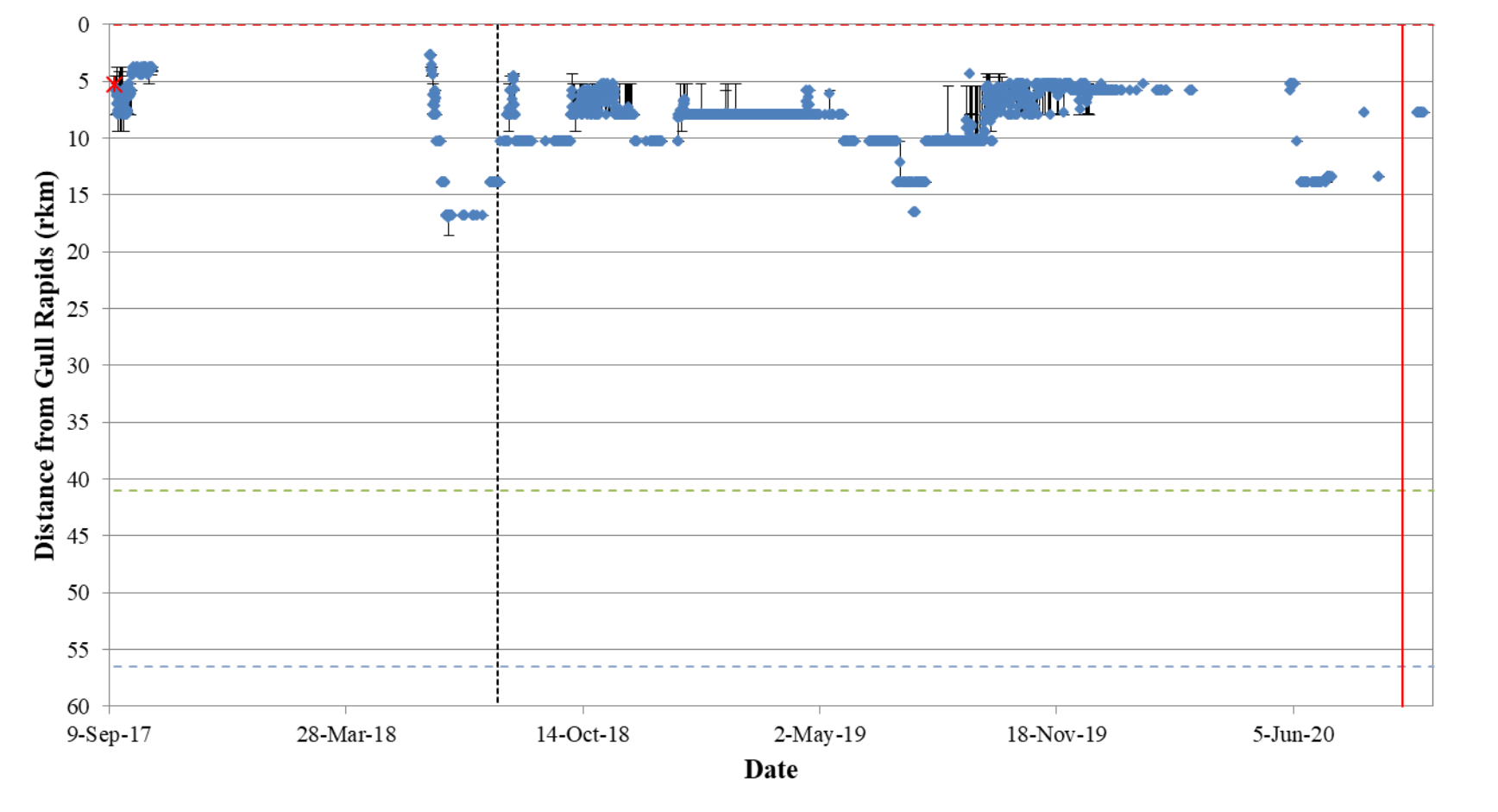


Figure A2-7: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31694) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to September 23, 2020. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines 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).

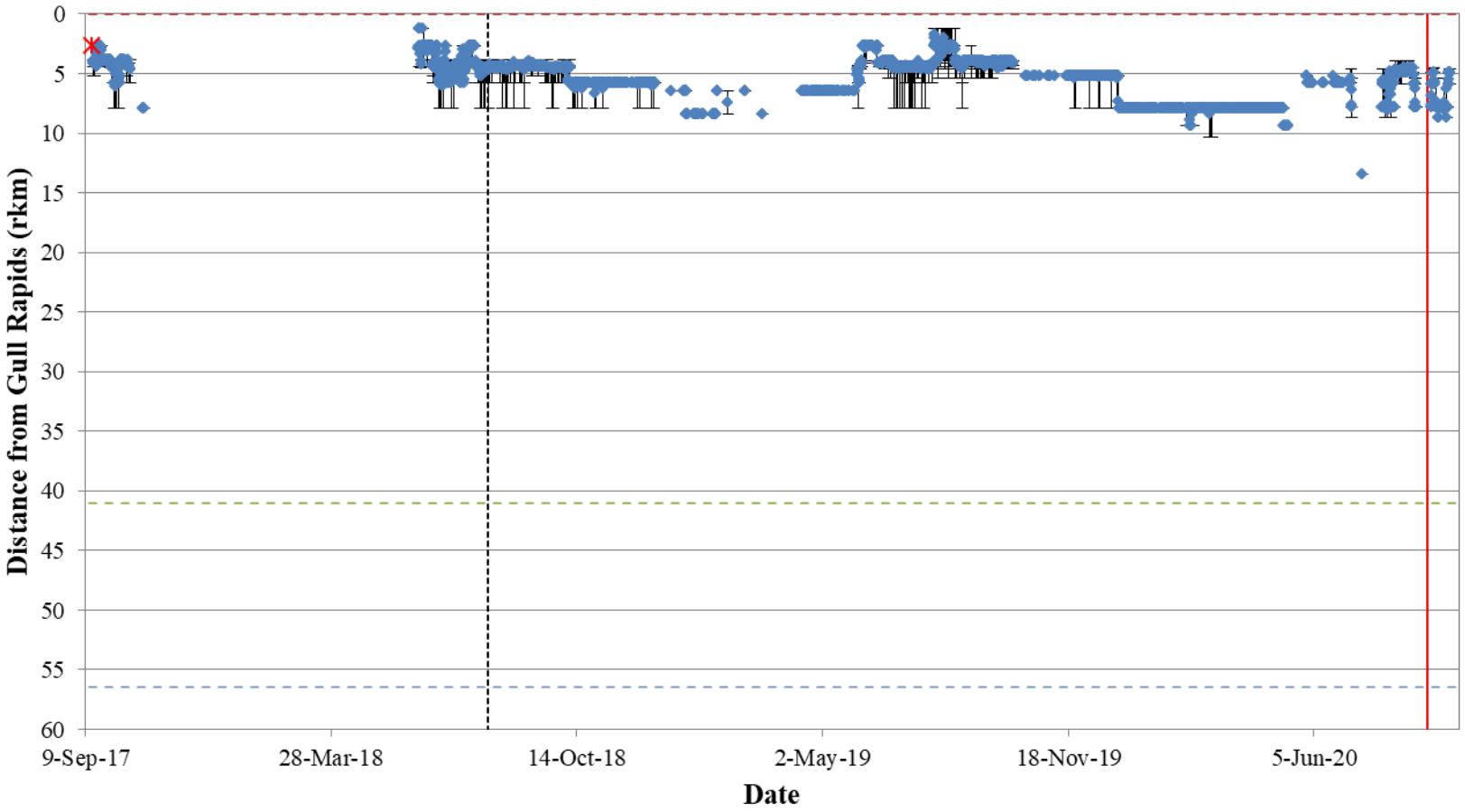


Figure A2-8: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31695) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to September 23, 2020. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines 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).

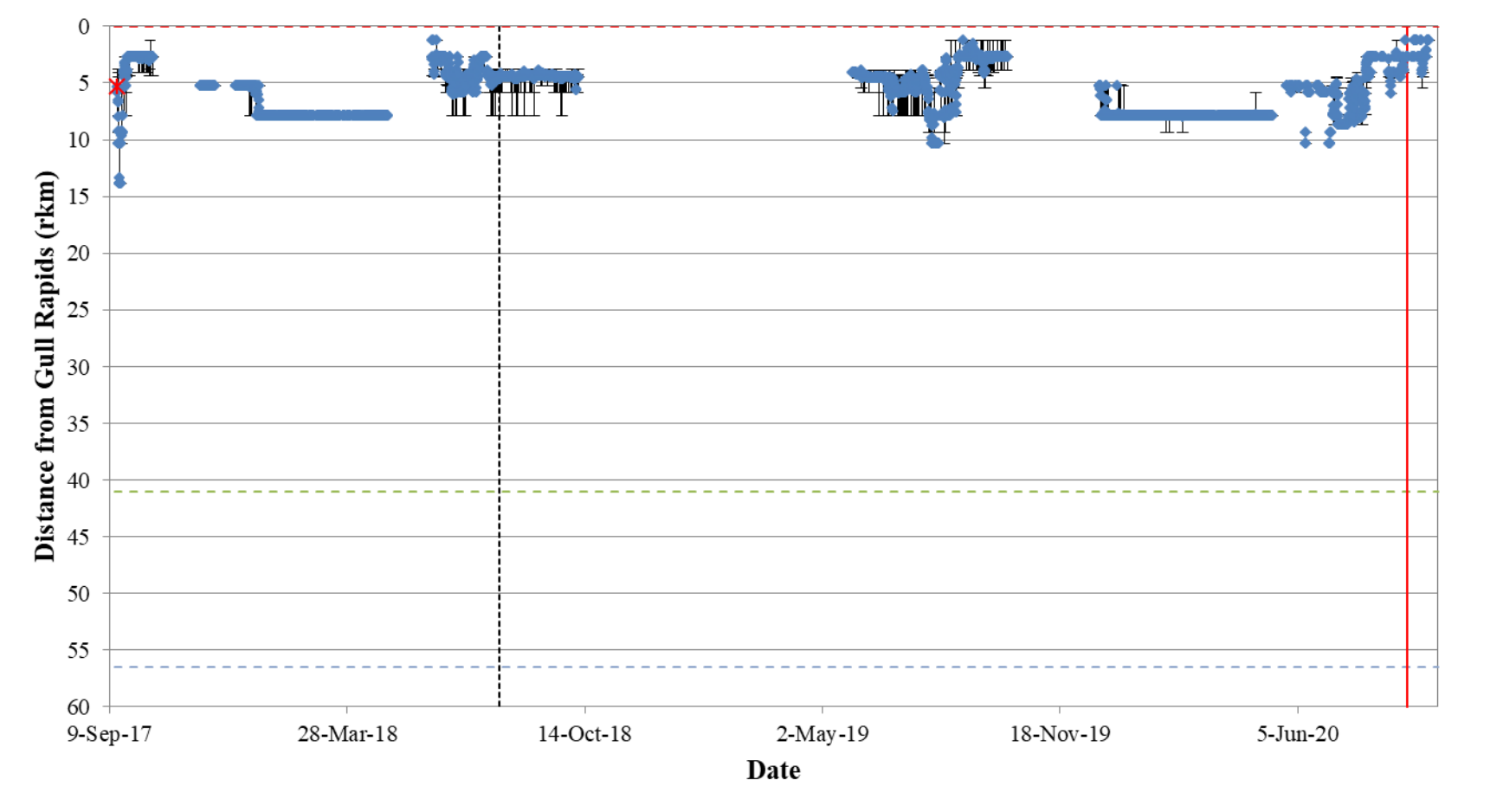


Figure A2-9: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31696) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to September 23, 2020. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines 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).

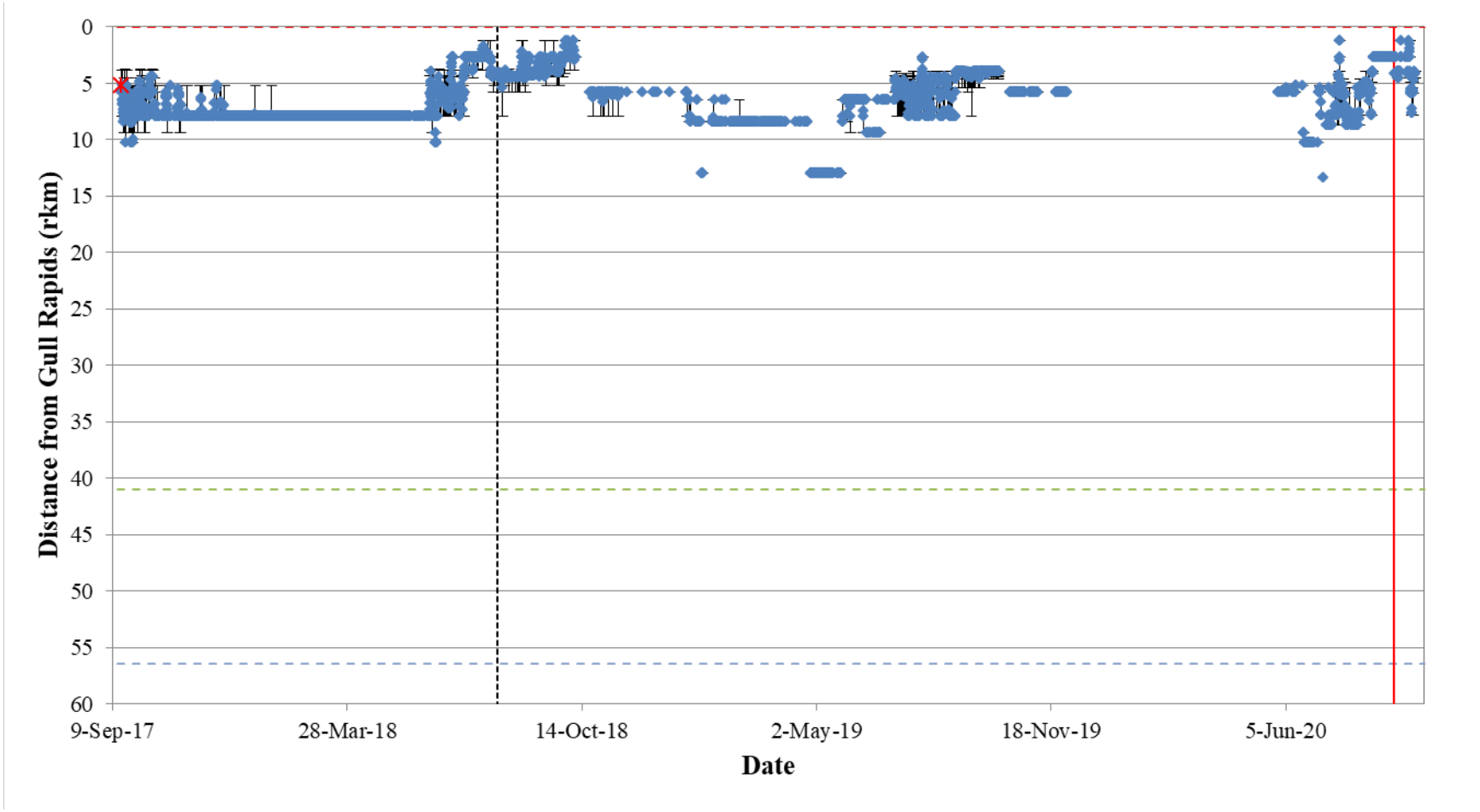


Figure A2-10: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31697) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to September 23, 2020. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines 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).

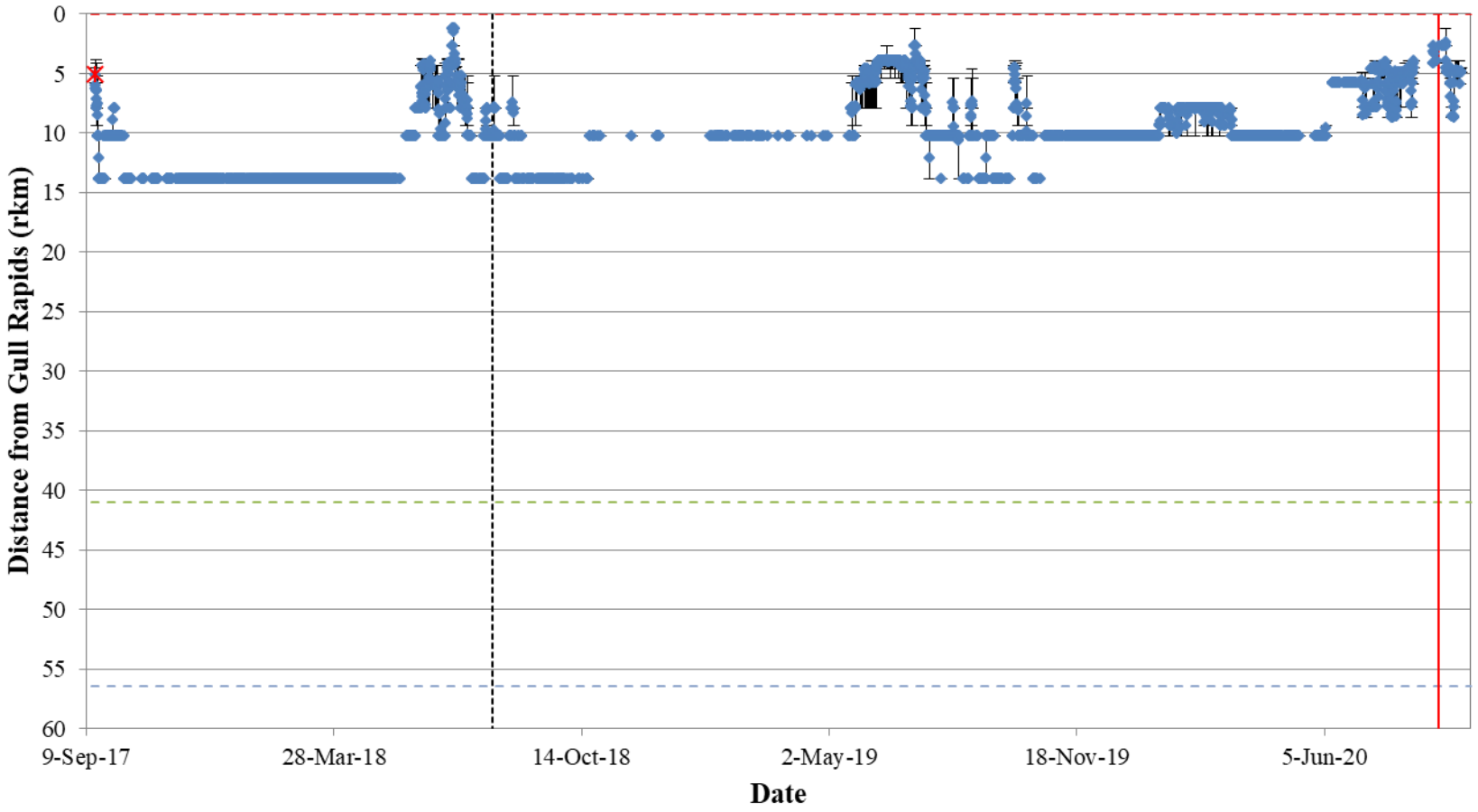


Figure A2-11: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31758) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to September 23, 2020. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines 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).

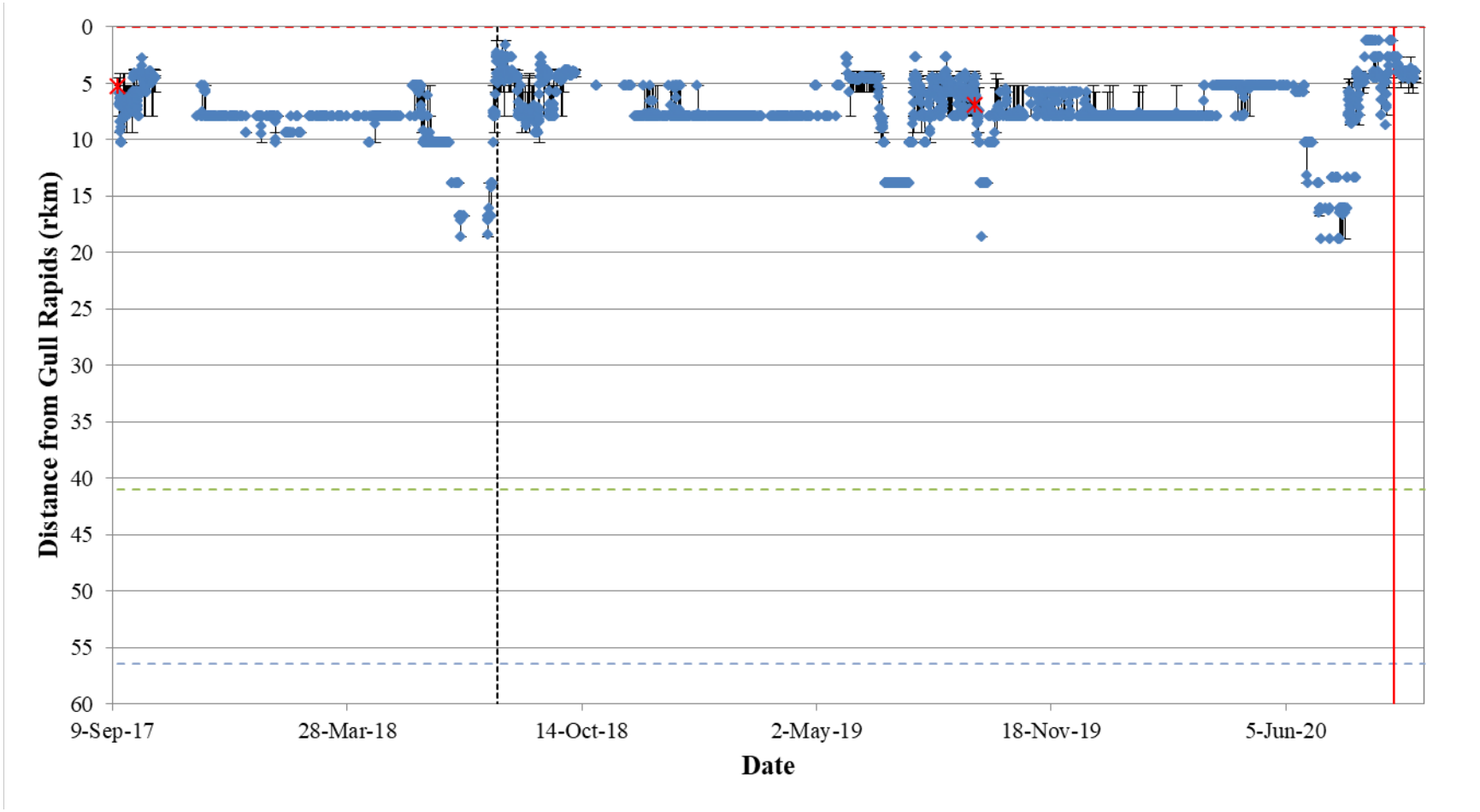


Figure A2-12: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31759) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to September 23, 2020. Date and location of tagging and recapture is indicated in red. Error bars are shown in solid black. Horizontal 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).

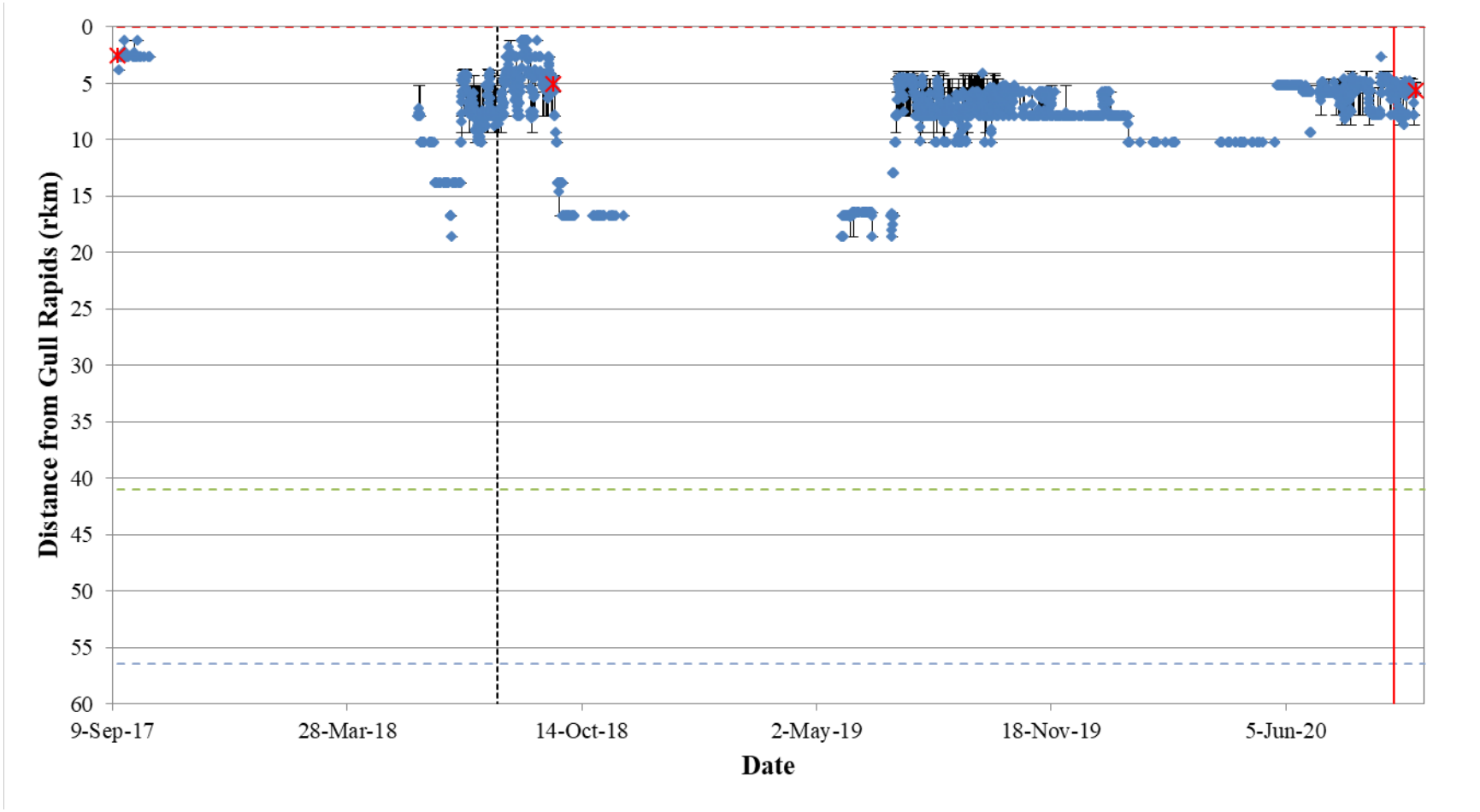


Figure A2-13: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31760) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to September 23, 2020. Date and location of tagging and subsequent recaptures are indicated by a red star. Error bars are shown in 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).

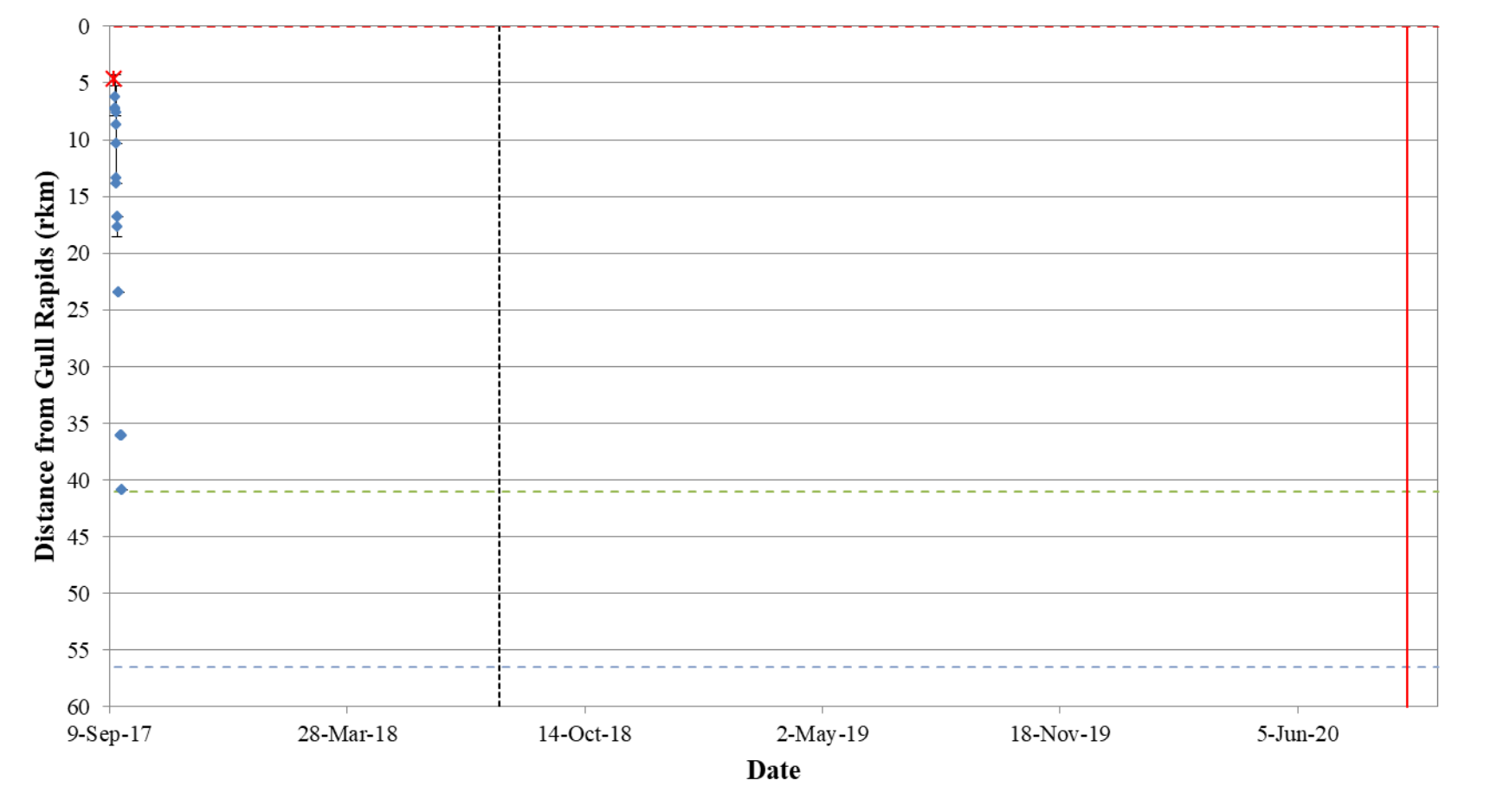


Figure A2-14: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31761) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to September 23, 2020. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines 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).

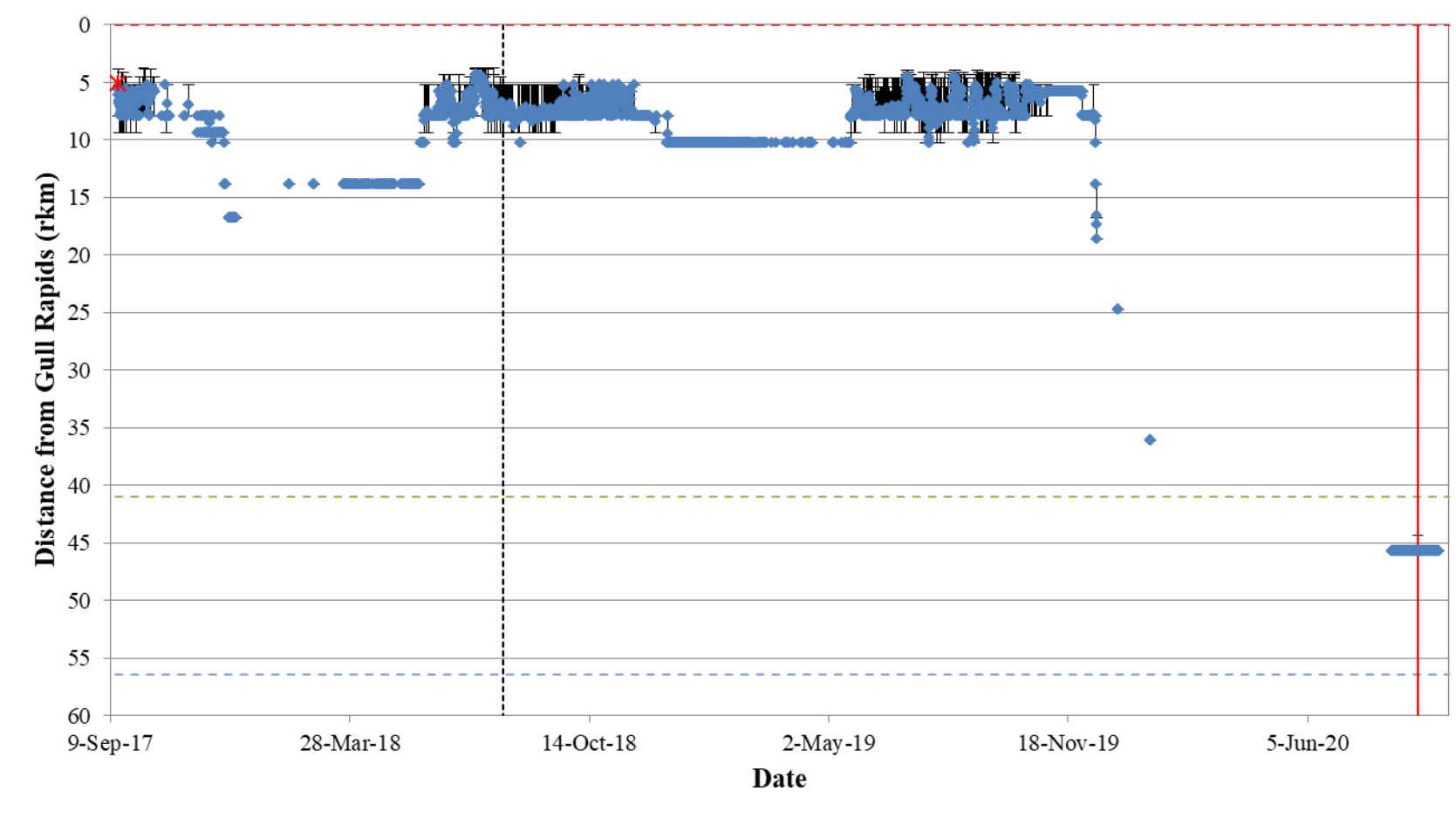


Figure A2-15: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31762) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to September 23, 2020. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines 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).

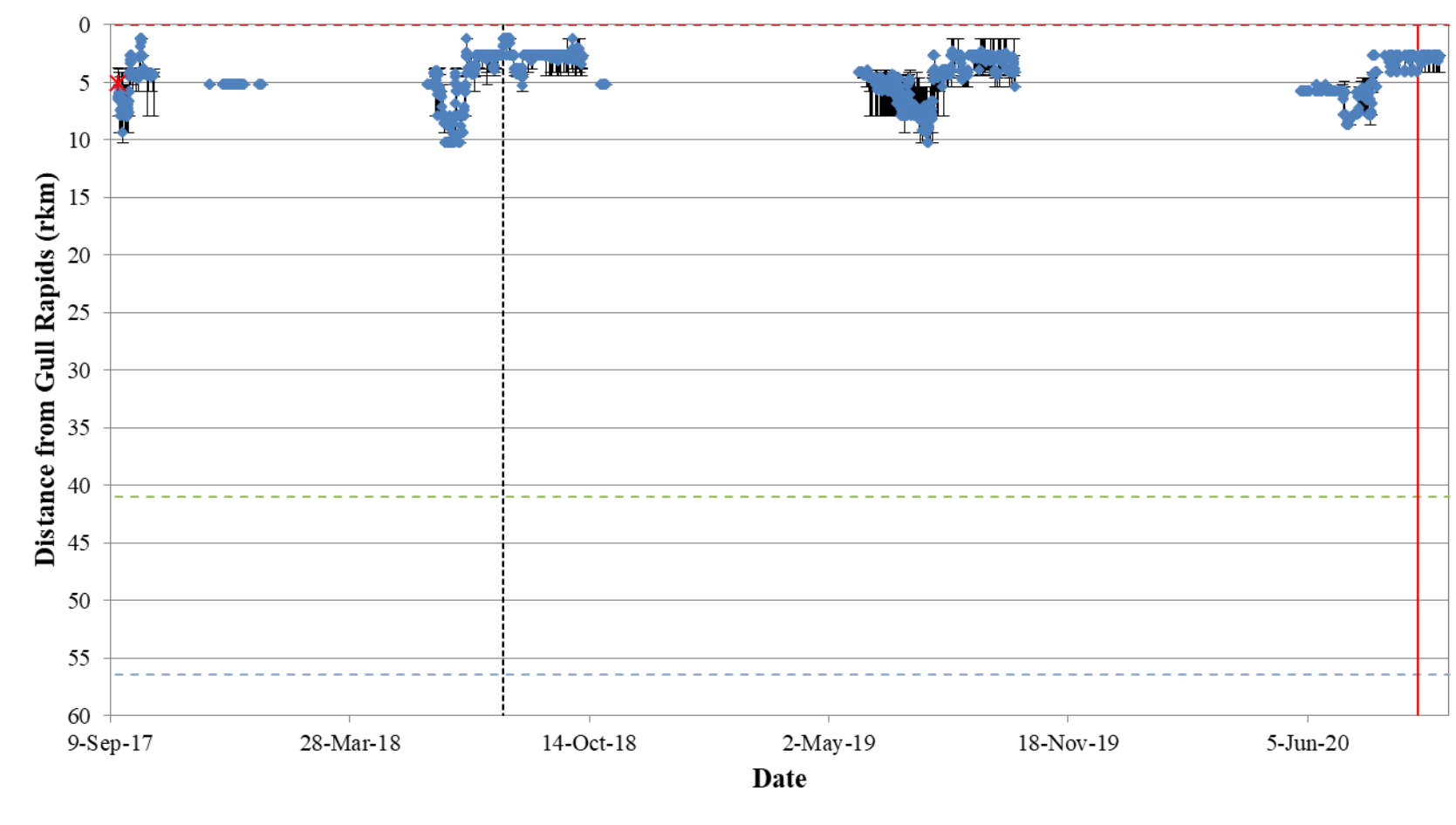


Figure A2-16: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31763) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to September 23, 2020. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines 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).

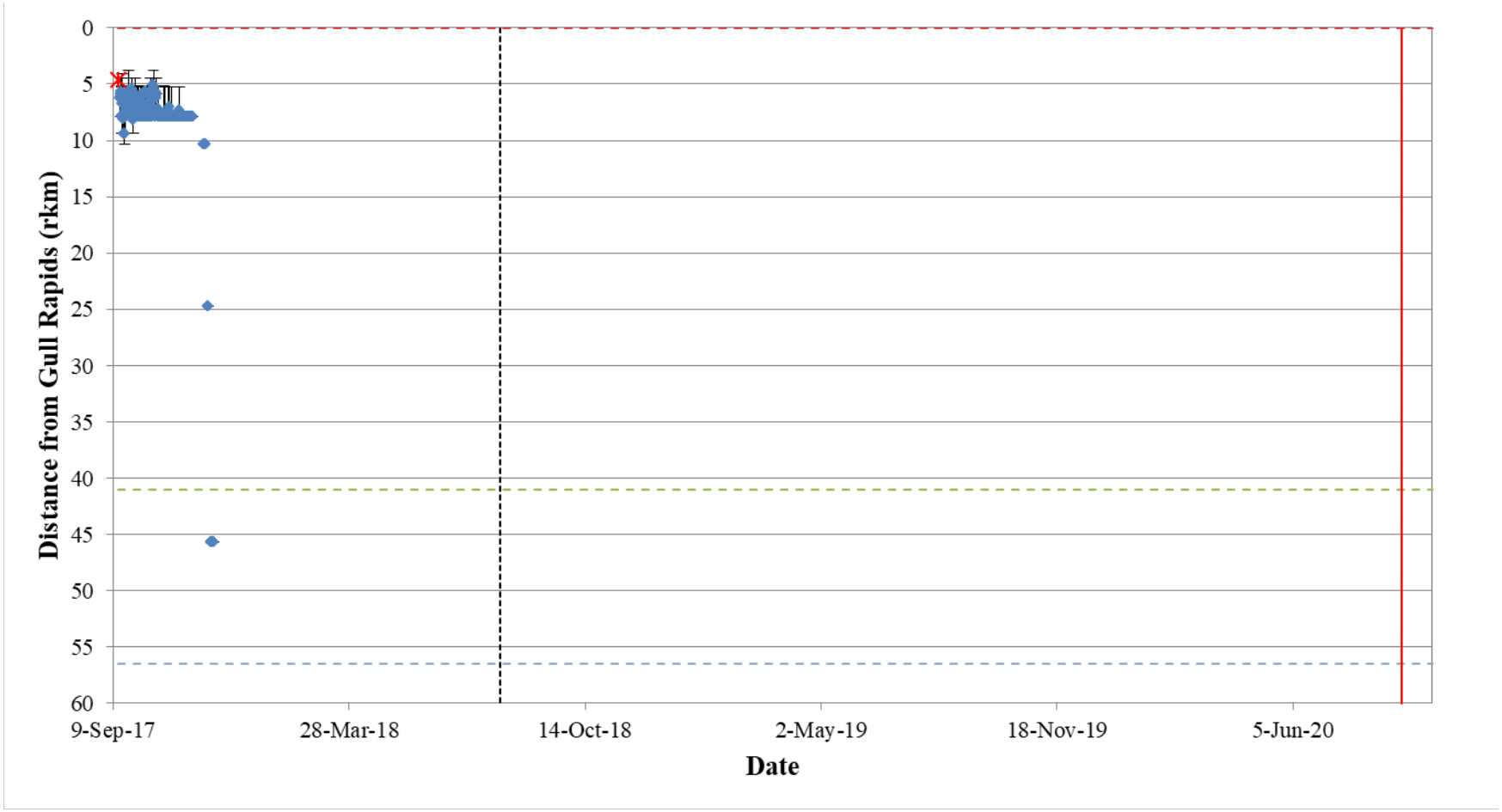


Figure A2-17: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31764) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to September 23, 2020. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines 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).

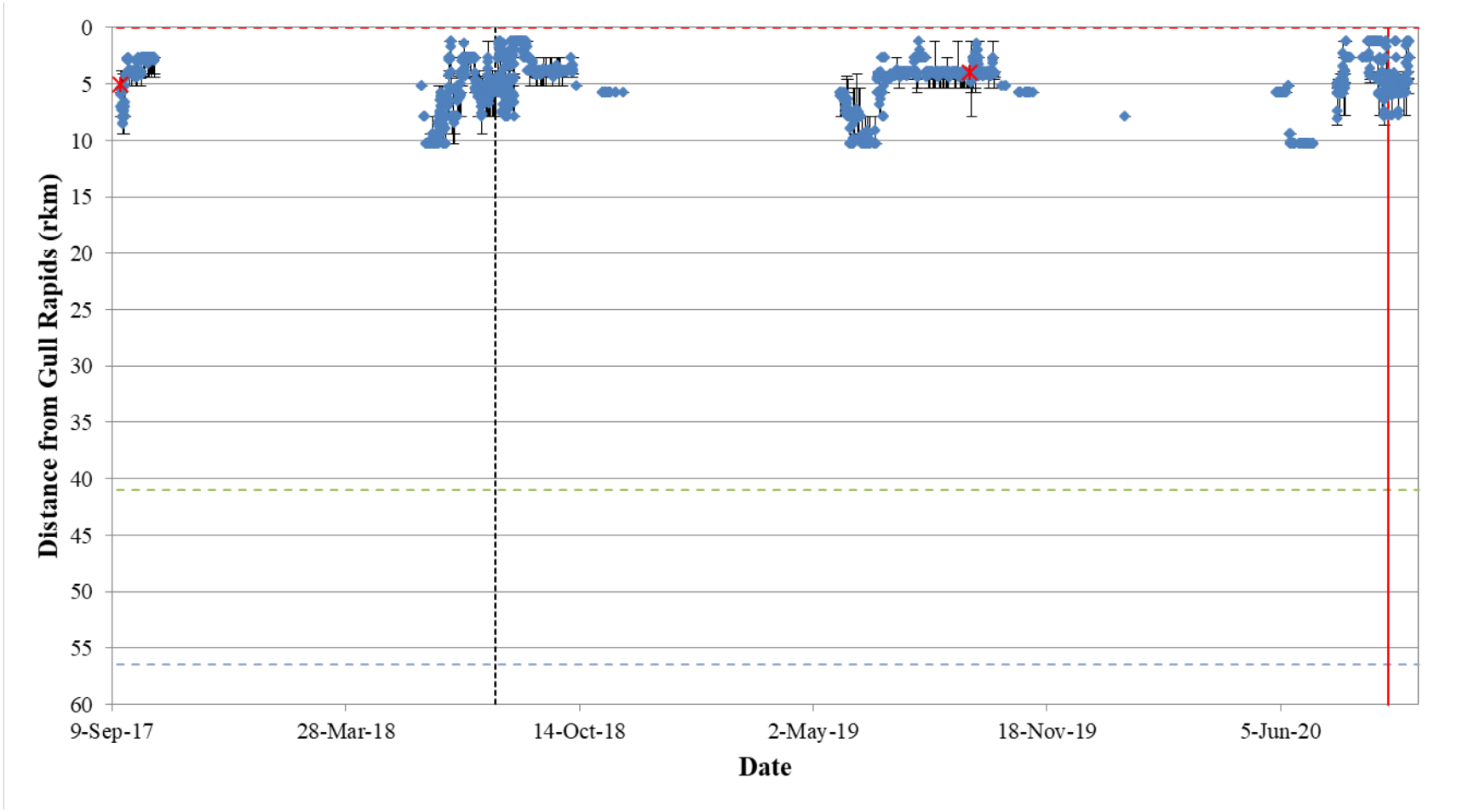


Figure A2-18: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31765) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to September 23, 2020. Date and location of tagging and recapture is indicated in red. Error bars are shown in solid black. Horizontal 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).

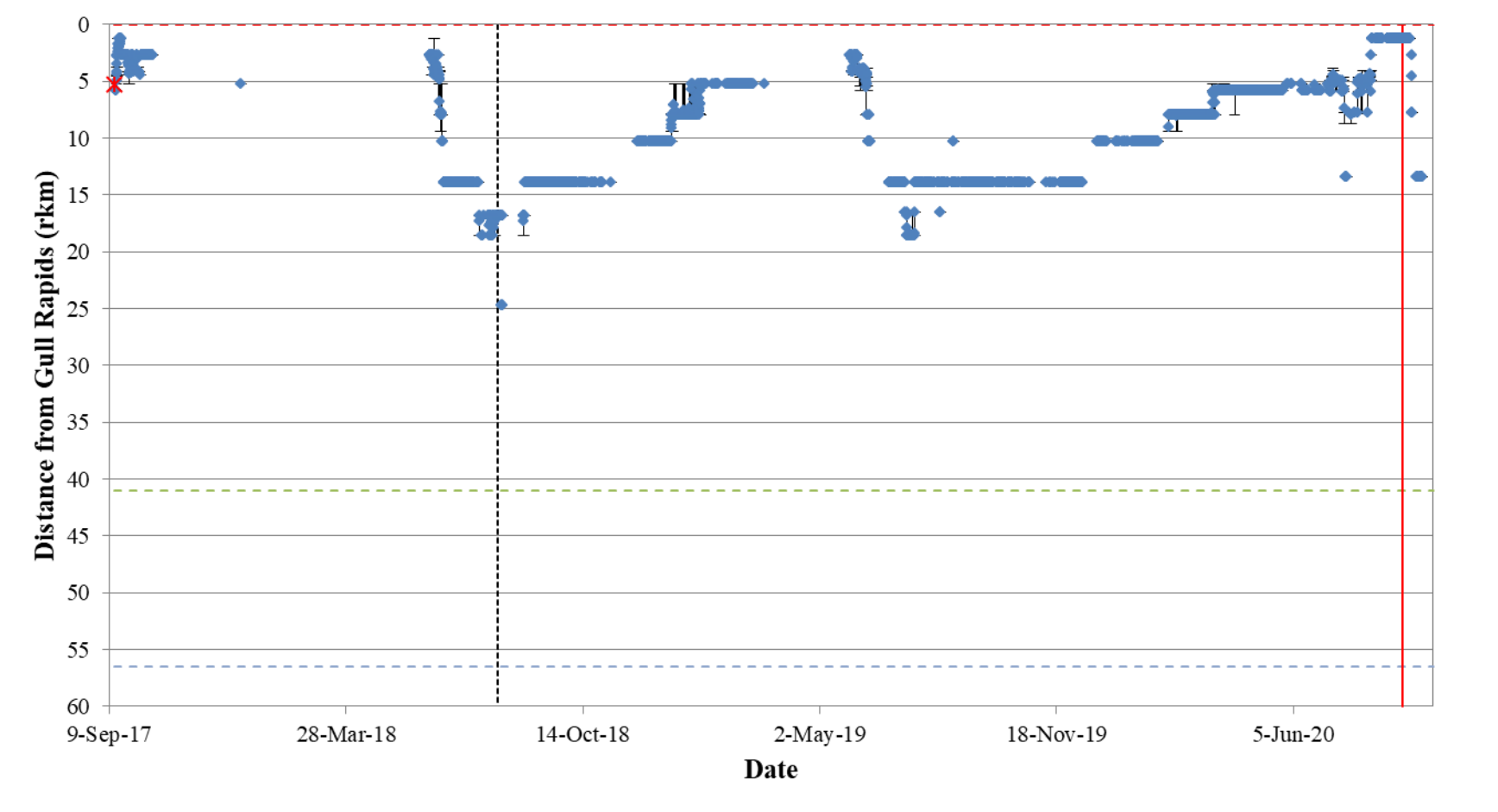


Figure A2-19 Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31766) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to September 23, 2020. Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines 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).

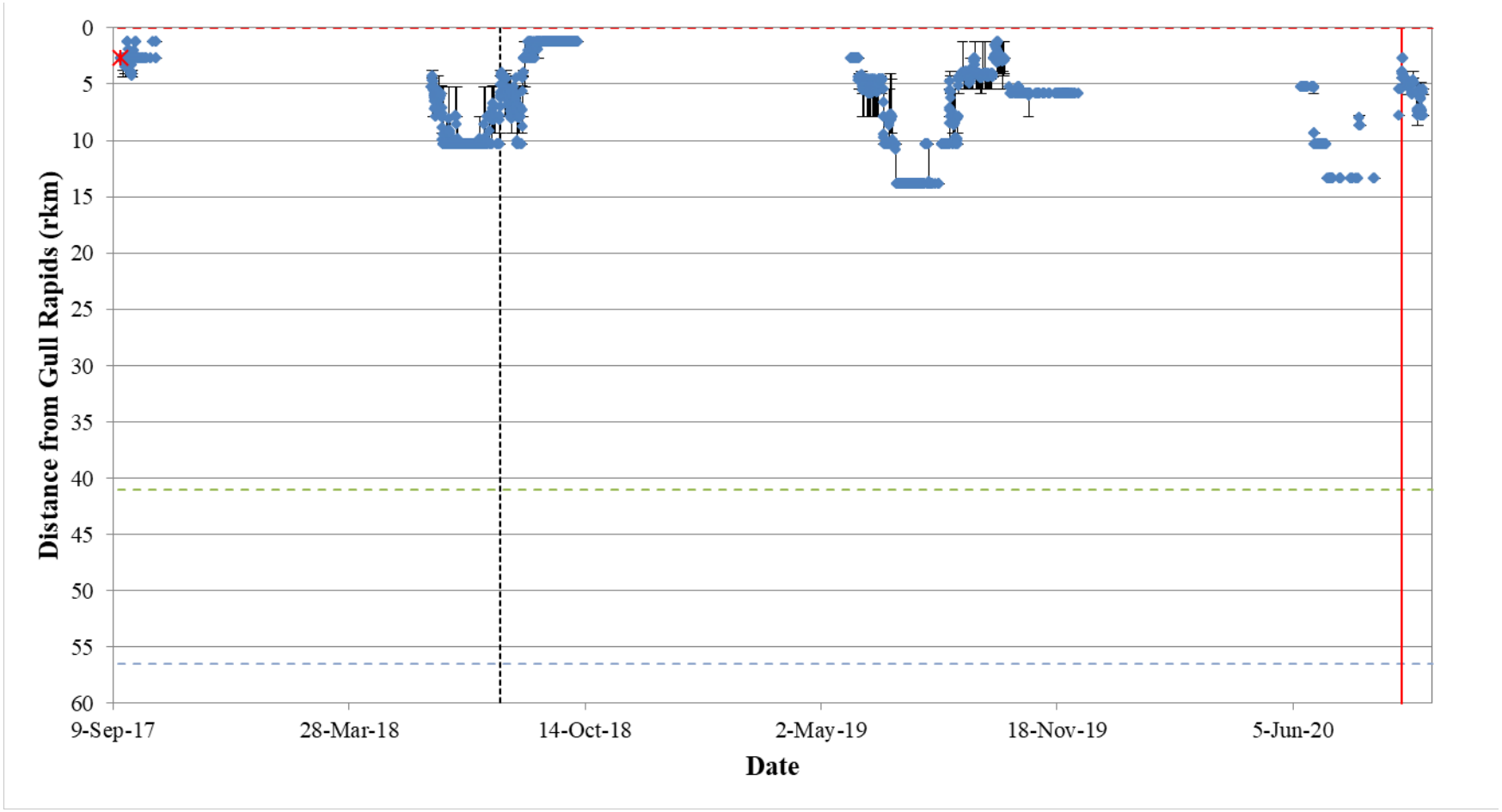


Figure A2-20: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #31767) in Stephens Lake in relation to the Keeyask GS (rkm 0), from September 9, 2017 to September 23, 2020.Date and location of tagging is indicated in red. Error bars are shown in solid black. Horizontal dashed lines 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).