



Keeyask Generation Project
Aquatic Effects Monitoring Plan

Adult Lake Sturgeon Movement Monitoring Report
AEMP-2018-03



KEEYASK GENERATION PROJECT

AQUATIC EFFECTS MONITORING PLAN

REPORT #AEMP-2018-03

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

Prepared for

Manitoba Hydro

By

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SUMMARY

Background

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

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

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

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

The movements of Lake Sturgeon over Birthday and Gull rapids were monitored prior to construction, but because different methods are being used for the Aquatic Effect Monitoring Plan (AEMP) data collection, the results of the two programs cannot be compared. While pre-construction studies did not record detailed fish movement patterns between Clark Lake and Stephens Lake, the data indicated that the majority of Lake Sturgeon continued to live in the area where they had been tagged and did not swim across rapids into different parts of the river. When fish occasionally crossed either Birthday or Gull rapids, they did so in the summer or fall, which suggests that these movements were not a necessary part of spring egg-laying behaviour. During the pre-construction study, none of the tagged sturgeon moved downstream past the Kettle GS.

This report provides the results of adult sturgeon movement monitoring conducted from October 2016 to October 2017. The study was initiated in June 2011 when 59 adult Lake Sturgeon were

tagged with acoustic transmitters with a 10-year battery life. Therefore, movements of these fish were monitored for three years before any changes to the river occurred, and for approximately three years and three months since the start of construction.

Why is the study being done?

Monitoring during construction is being done to answer three questions:

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

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

Are there adult Lake Sturgeon close to the construction site?

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

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

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

What was done?

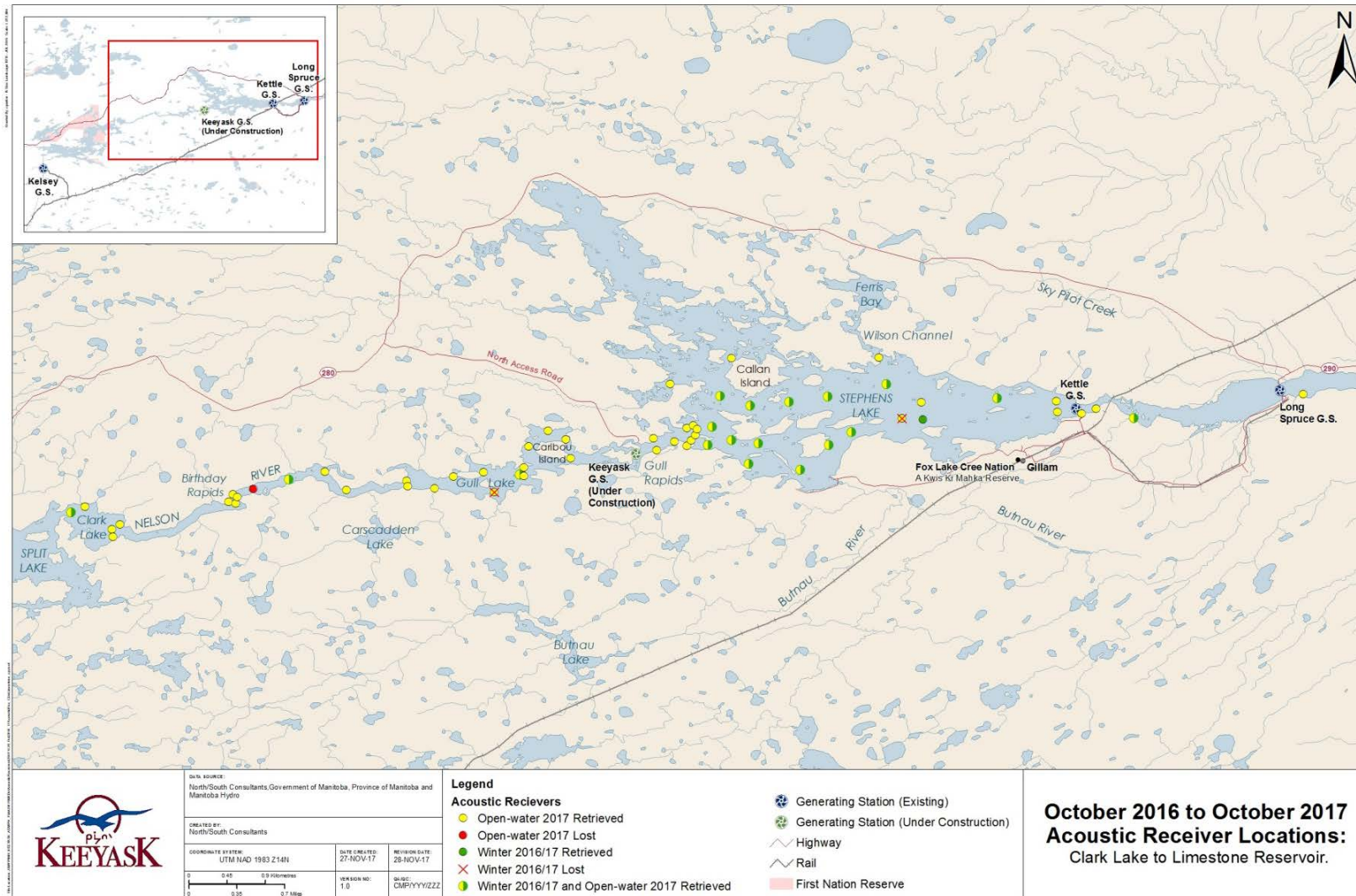
The movements of adult sturgeon were tracked using acoustic telemetry. This is a technique in which a tag is surgically implanted inside a fish. Each tag sends out a sound signal (called a “ping”) that is picked up by receivers placed along the Nelson River between Clark Lake and the Limestone GS (see study area map below). Each fish is given a transmitter that sends out a unique ping, which can be detected up to 1 kilometre (km) from a receiver. By looking at the pings that were recorded by different receivers, the movement of each fish can be tracked. The transmitters are powered by batteries with a 10-year life-span.



Adult Lake Sturgeon.



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



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

What was found?

How far and where sturgeon moved depended on the individual fish, whether it lived in Gull Lake or Stephens Lake, and the season.

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

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

After six-and-a-half years of monitoring, the sturgeon that were tagged in Gull Lake continue to be divided into three groups: those that usually live in Gull Lake (sometimes these fish leave for short periods of time then return), those that usually stay in the channel of the Nelson River between Birthday Rapids and Gull Lake, and those that were usually found in Clark Lake. During 2017, three fish moved to different areas than other years. One was previously found in the river between Birthday Rapids and Gull Lake, and it moved into Gull Lake. Two were previously found only in Gull Lake. One of these fish moved upstream to Clark Lake and the other moved downstream through Gull Rapids into Stephens Lake.

Adult Lake Sturgeon tagged in Stephens Lake tend to stay in the main river channel, specifically the part of Stephens Lake where the river channel was flooded when the Kettle GS was built. About half of the sturgeon have always remained in upper Stephens Lake within about 14 km of Gull Rapids, while the other half have periodically moved into lower Stephens Lake (as far as 40 km downstream of Gull Rapids).

In each year of the study, at least one sturgeon has moved through Gull Rapids. Six fish moved upstream through Gull Rapids (one in 2011, four in 2012, one in 2013, and none between 2014 and 2016) and six moved downstream (two in 2014, one in 2015, two in 2016, and one in 2017). This is different than juvenile Lake Sturgeon, which do not move over Gull Rapids. No adults have moved upstream through Gull Rapids since construction started, but four have moved downstream. Because all of the water has been diverted to a small portion of the rapids, it might be flowing too fast for sturgeon to move upstream.

Since 2011, three sturgeon have moved downstream out of Stephens Lake into the Long Spruce reservoir after passing through the Kettle GS (one through a turbine, while the other two either moved over the spillway or went through a turbine). Two of these fish moved over the Long Spruce GS in 2016. No adult Lake Sturgeon moved through these dams in 2017.

What does it mean?

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

Many sturgeon use habitat immediately downstream of the construction site in Stephens Lake. They do not seem to be disturbed by construction activity.

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

What will be done next?

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

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TABLE OF CONTENTS

1.0	INTRODUCTION	1
2.0	STUDY SETTING.....	3
2.1	CONSTRUCTION SUMMARY.....	4
2.2	FLOWS AND WATER LEVELS	5
3.0	METHODS.....	6
3.1	ACOUSTIC TELEMETRY	6
3.1.1	Acoustic Transmitter Application	6
3.1.2	Acoustic Receivers.....	6
3.1.2.1	Winter 2016/2017	7
3.1.2.2	Open-water 2017	7
3.1.3	Data Analysis	8
3.1.3.1	Maximum Likelihood Approach.....	9
4.0	RESULTS.....	10
4.1	2011–2016 RESULTS SUMMARY	10
4.1.1	Upstream of Gull Rapids	10
4.1.2	Stephens Lake	11
4.2	WINTER 2016/2017	13
4.2.1	Upstream of Gull Rapids	13
4.2.2	Stephens Lake	13
4.2.2.1	Movements.....	13
4.2.3	Long Spruce Reservoir.....	14
4.3	OPEN-WATER 2017	14
4.3.1	Acoustic Receiver Retrieval.....	14
4.3.2	Upstream of Gull Rapids	14
4.3.2.1	Proportional Distribution	15
4.3.2.2	Movement Patterns	15
4.3.3	Stephens Lake	17

4.3.3.1	Proportional Distribution	17
4.3.3.2	Movement Patterns	18
4.3.4	Long Spruce Reservoir	19
4.3.5	Limestone Reservoir	19
4.4	ADULT LAKE STURGEON DISTRIBUTION.....	19
4.5	LONG DISTANCE MOVEMENTS.....	20
5.0	DISCUSSION	21
5.1	EVALUATION OF METHODOLOGY	21
5.2	KEY QUESTIONS.....	21
6.0	SUMMARY AND CONCLUSIONS	23
7.0	LITERATURE CITED	24

LIST OF TABLES

Table 1:	Number of acoustic transmitters applied to adult Lake Sturgeon upstream of Gull Rapids [GR] and in Stephens Lake between June 2011 and October 2017.....	28
Table 2:	Tagging and biological information associated with adult Lake Sturgeon implanted with acoustic transmitters upstream of Gull Rapids between 2011 and 2017.....	29
Table 3:	Tagging and biological information associated with adult Lake Sturgeon implanted with acoustic transmitters in Stephens Lake between 2011 and 2017.....	30
Table 4:	Proportion of time spent in each river zone by adult Lake Sturgeon tagged upstream of Gull Rapids and in Stephens Lake during a portion of the 2013 (June 4 to October 15), 2014 (June 4 to October 3), 2015 (June 4 to October 11), 2016 (June 4 to October 19), and 2017 (June 7 to October 16) open-water periods.	31
Table 5:	Number of Lake Sturgeon tagged with acoustic and radio tags that moved upstream or downstream through Gull Rapids during studies conducted in 2001–2004 and 2011–2017.	32

LIST OF FIGURES

Figure 1:	Locations of stationary acoustic receivers (dashes) in relation to the base of Gull Rapids (rkm 0) and other major landmarks (lines) in the Nelson River between Clark Lake and the Limestone GS between October, 2016 and June, 2017.	34
Figure 2:	Locations of stationary acoustic receivers (dashes) in relation to the base of Gull Rapids (rkm 0) and other major landmarks (lines) in the Nelson River between Clark Lake and the Limestone GS between June and October, 2017.	35
Figure 3:	Water temperature in the Nelson River mainstem from October 16, 2016, to October 14, 2017.	36
Figure 4:	Detection ranges for individual adult Lake Sturgeon tagged with acoustic transmitters upstream of Gull Rapids during the winter period (2011–2017).	37
Figure 5:	Relative number of detections at each acoustic receiver set between Clark Lake and Gull Rapids during winter 2016/2017 (October 20, 2016, to April 30, 2017).	40
Figure 6:	Detection ranges for individual adult Lake Sturgeon tagged with acoustic transmitters in Stephens Lake during the winter period (2011–2017).	41
Figure 7:	Relative number of detections at each acoustic receiver set in Stephens Lake during winter 2016/2017 (October 20, 2016, to April 30, 2017).	44
Figure 8:	Detection ranges for individual adult Lake Sturgeon tagged with acoustic transmitters upstream of Gull Rapids during the open-water period (2011–2017).	45
Figure 9:	Proportional distribution by zone, for 43 adult Lake Sturgeon tagged with acoustic transmitters in the Keeyask GS Area during a portion of the 2013 (June 4 to October 15), 2014 (June 4 to October 3), 2015 (June 4 to October 11), 2016 (June 4 to October 19), and 2017 (June 7 to October 16) open-water periods	48
Figure 10:	Proportional distributions by zone, for individual adult Lake Sturgeon tagged with acoustic transmitters upstream of Keeyask GS during a portion of the 2017 open-water period (June 7 to October 16).	49
Figure 11:	Relative number of detections at each acoustic receiver set in the Nelson River between Clark Lake and Gull Rapids during the 2017 open-water period (May 1 to October 16).	50
Figure 12:	Detection ranges for individual adult Lake Sturgeon tagged with acoustic transmitters in Stephens Lake during the open-water period (2011–2017). Horizontal dotted lines demarcate zones.	51

Figure 13:	Proportional distributions by zone, for individual adult Lake Sturgeon tagged with acoustic transmitters in Stephens Lake during a portion of the 2017 open-water period (June 7 to October 16).....	54
Figure 14:	Relative number of detections at each acoustic receiver set in Stephens Lake during the 2017 open-water period (May 1 to October 16).....	55
Figure 15:	Likelihood of an adult Lake Sturgeon moving between river zones (either upstream or downstream) both before and after the onset of Keeyask construction.	56
Figure 16:	Likelihood that, if an adult Lake Sturgeon moves between river zones, the movement will be upstream both before and after the onset of Keeyask construction.	56
Figure 17:	Likelihood that, if an adult Lake Sturgeon moves between river zones, the movement will be downstream both before and after the onset of Keeyask construction.	57
Figure 18:	Likelihood of an adult Lake Sturgeon moving past a barrier (either Gull Rapids, Kettle GS, or Long Spruce GS) before and after the onset of Keeyask construction.....	57

LIST OF MAPS

Map 1:	Map of the Nelson River showing the site of the Keeyask Generating Station and the adult Lake Sturgeon movement monitoring study setting.	59
Map 2:	Map of instream structures at the Keeyask Generating Station site, 2017.....	60
Map 3:	Locations of stationary receivers set in the Nelson River from Clark Lake to Gull Rapids between October 2016 and June 2017.	61
Map 4:	Locations of stationary receivers set in Stephens Lake from Gull Rapids to Kettle GS between October 2016 and June 2017. The former (pre-impoundment) river channel is shown in light blue.	62
Map 5:	Location of the stationary receiver set in the Long Spruce reservoir between October 2016 and June 2017.	63
Map 6:	Locations of stationary receivers set in the Nelson River from Clark Lake to Gull Rapids between June and October 2017. The river is divided into five "zones" based on placement of receiver "gates."	64
Map 7:	Locations of stationary receivers set in Stephens Lake between June and October 2017.....	65
Map 8:	Locations of stationary receivers set in the Long Spruce reservoir (Zone 8) between June and October 2016, and in the Limestone reservoir (Zone 9) between July and October 2017.....	66

LIST OF APPENDICES

Appendix 1:	Detection Summaries for Lake Sturgeon Tagged and Monitored Between 2011 and 2017	68
Appendix 2:	Location Summary for Individual Acoustic Tagged Adult Lake Sturgeon, Upstream of Gull Rapids, June 2011 to October 2017	73
Appendix 3:	Location Summary for Individual Acoustic Tagged Adult Lake Sturgeon, Stephens Lake, June 2011 to October 2017	111

1.0 INTRODUCTION

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

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

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

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

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

- The use of key habitats (*i.e.*, spawning, rearing, and foraging) during construction;
- The potential vulnerability of sturgeon to activities at the construction site (*i.e.*, if sturgeon use the area in the immediate vicinity of the construction site they may be vulnerable to 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 adult movement monitoring during the construction phase are as follows:

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

2.0 STUDY SETTING

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

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

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

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

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

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

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

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

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

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

2.1 CONSTRUCTION SUMMARY

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

2.2 FLOWS AND WATER LEVELS

From October 2016 to October 2017, Split Lake outflows ranged from about 3,200–6,600 m³/s. Flow exceeded the historical annual median flow of approximately 3,300 m³/s each month except for October 2017 when it dropped to about 3,200 m³/s. From about October 2016 through mid-September 2017, the flow exceeded the historical 75th percentile flow of about 3,780 m³/s, and from about May to mid-August 2017 the flow exceeded the 95th percentile flow of approximately 5,230 m³/s. During the spring melt in May 2017, flow rose to about 6,590 m³/s, which is near the historical maximum flow observed in August 2005. Water levels varied in conjunction with flow, ranging from about 154.9–156.6 m ASL on Gull Lake, with the highest level observed during the near historical maximum flow in May.

3.0 METHODS

3.1 ACOUSTIC TELEMETRY

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

3.1.1 ACOUSTIC TRANSMITTER APPLICATION

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

3.1.2 ACOUSTIC RECEIVERS

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

During the first four years of the construction phase of the project (beginning in July 2014), receivers were deployed at the same sites as those established during the pre-construction phase (2011–2013). During the open-water period, receivers were deployed in calm water with a flat bottom, free of large debris to maximize detection range, and spaced along the main river channel throughout the study area to maximize spatial coverage. In Stephens Lake, receivers were placed at locations within pre-flood river channels, based on the observation that sturgeon tend to stay within river channels, even in flooded environments. At constrictions within the river

channel, a series of receivers were deployed to create “gates” with the intent of recording all fish that passed by the river cross-section (described in section 3.1.2.2).

The retrieval of receivers deployed during winter has proven challenging and several were lost in previous winters that were believed to have been moved by ice (Hrenchuk and Barth 2013). Because it appears that receivers will only remain safe from ice if deployed in calm areas at depths greater than 10 m, the number of possible receiver locations during winter, especially in Gull Lake, is limited.

3.1.2.1 WINTER 2016/2017

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

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

3.1.2.2 OPEN-WATER 2017

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

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

During winter 2016, the Keeyask Fisheries Regulatory Review Committee (KFRRC)¹ suggested that a receiver be placed in close proximity to the upstream side of Gull Rapids to monitor

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

potential fish movements adjacent to the construction site. However, due to high flows and safety concerns during the 2017 open-water period, a suitable location was not found.

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

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

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

3.1.3 DATA ANALYSIS

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

Movements were analysed in terms of rkm distance, with the base of Gull Rapids representing a distance of 0 rkm. The area located downstream of Gull Rapids (*i.e.*, Stephens Lake and the Long Spruce reservoir) were given positive (+) distance values from Gull Rapids, while the area located upstream (*i.e.*, Gull and Clark lakes) were given negative (-) distance values (Figures 1 and 2). The average rkm distance from Gull Rapids was calculated over a 4-hour interval and plotted versus time for each fish. Total detection ranges were calculated by subtracting the furthest downstream detection location from the location of the furthest upstream detection. The proportion of time that all fish spent within each river zone was calculated and plotted.

3.1.3.1 MAXIMUM LIKELIHOOD APPROACH

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

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

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

Where:

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

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

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

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

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

4.0 RESULTS

Section 4.1 provides a summary of movements observed since inception of the study in June 2011 to the end of the 2016 open-water period (October 2016). Numbers of fish tagged upstream of Gull Rapids and in Stephens Lake, by year, are provided in Table 1. Tables 2 and 3 provide acoustic tag and biological information associated with each tagged fish. Table 4 summarizes the proportional distribution of tagged fish upstream and downstream of the construction site. Table 5 summarizes all movements through Gull Rapids by fish tagged during current (2011–2017) and previous (2001–2004) telemetry studies. Figures 4 to 14 illustrate movement range and proportional distribution of tagged fish both upstream and downstream of the construction site by season. Appendix A1 provides detection summaries, while Appendices A2 and A3 provide movement summaries, by river kilometre, for each tagged sturgeon since the study began in June 2011.

4.1 2011–2016 RESULTS SUMMARY

4.1.1 UPSTREAM OF GULL RAPIDS

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

- #16042 was tagged at the outlet of Clark Lake on June 5, 2011. It was detected regularly within Clark Lake until August 8, 2014. This fish may have continued to move upstream past the receiver array (Appendix A2-4).
- #16045 has not been detected since August 18, 2011. It moved downstream immediately after being tagged in Gull Lake on June 10, 2011, and displayed few upstream movements (Appendix A2-5).
- #16057 was tagged in Gull Lake on June 16, 2011. It remained in this area until June 17, 2014, when it moved upstream through Birthday Rapids into Clark Lake. This fish may have continued to move upstream past the receiver array (Appendix A2-11).
- #16067 was tagged in Gull Lake on June 19, 2011. It remained in this area until May 27, 2012, when it moved upstream through Birthday Rapids into Clark Lake. It was last detected in Clark Lake on June 29, 2012. This fish may have continued to move upstream past the receiver array (Appendix A2-21).
- #16077 moved downstream immediately after tagging on June 10, 2011. It was last detected on June 21, 2011, (Appendix A2-31).

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

Prior to winter 2016/2017, six fish had moved upstream from Stephens Lake into Gull Lake, two of which returned to Stephens Lake during the 2014 open-water period:

- #16025 was tagged in Stephens Lake on June 16, 2012, and moved upstream through Gull Rapids on August 22, 2012. This fish subsequently moved back downstream into Stephens Lake, where it was first located on June 18, 2014 (Appendix A3-7).
- #16029 was tagged in Stephens Lake on June 21, 2011, and moved upstream through Gull Rapids between July 29 and August 2, 2011. This fish remained in Gull Lake and continued to be detected here in 2017 (Appendix A3-10).
- #16033 was tagged in Stephens Lake on June 18, 2011, and moved upstream through Gull Rapids on July 28, 2012. However, shortly after it was captured by a local resource user and the tag was returned and reapplied to another fish in Stephens Lake in 2013.
- #16037 was tagged in Stephens Lake on June 8, 2011, and moved upstream through Gull Rapids between September 3 and 6, 2013. It then moved downstream and was detected in Stephens Lake on July 1, 2014 (Appendix A3-17).
- #16038 was tagged in Stephens Lake on June 12, 2011, and moved upstream through Gull Rapids on September 12, 2013. This fish remained in Gull Lake and continued to be detected here in 2017 (Appendix A3-18).
- #16046 was tagged in Stephens Lake on June 11, 2011, and moved upstream through Gull Rapids between June 27 and July 4, 2012. This fish was detected in Gull Lake until 2013, but has not been located since (Appendix A3-23).

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

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

In summary, 35 adult Lake Sturgeon were tagged upstream of Gull Rapids between 2011 and 2014. Five fish are considered missing, six moved upstream from Stephens Lake, five fish moved downstream into Stephens Lake, and one was harvested. Therefore, a total of 30 tagged sturgeon were available to be detected upstream of Gull Rapids during winter 2016/2017.

4.1.2 STEPHENS LAKE

Twenty-eight fish were originally tagged downstream of Gull Rapids in 2011 and 2012 (Table 1). Additional tags were applied to seven fish in June, 2014 (Table 1). Four of these are considered missing due to a lack of detections:

- #16018 moved downstream immediately after being tagged on June 13, 2012. It was last detected on July 2, 2012, immediately upstream of Kettle GS (Appendix A3-1).
- #16024 moved downstream immediately after being tagged on June 13, 2012. It was last detected in Stephens Lake on June 25, 2012 (Appendix A3-6).
- #16044 moved downstream immediately after being tagged on June 9, 2011. It was last detected in Stephens Lake on September 17, 2012 (Appendix A3-22).
- #16047 moved downstream immediately after being tagged on June 26, 2011. It was last detected in Stephens Lake on June 28, 2011 (Appendix A3-24).

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

Three fish moved downstream out of Stephens Lake through the Kettle GS into the Long Spruce reservoir:

- #16021 was tagged in Stephens Lake on September 28, 2011, and moved downstream through the Kettle GS on September 16, 2012. As the Kettle GS spillway was open on this day, it is unknown whether the Lake Sturgeon moved through the spillway or passed through a turbine. It was last detected in the Long Spruce reservoir on September 18, 2012 (Appendix A3-4).
- #16025 was tagged in Stephens Lake on June 15, 2012. It moved upstream into Gull Lake in 2012 but returned to Stephens Lake in 2014 (Section 4.1.1). This fish subsequently moved downstream through Kettle GS between June and July, 2014. The Kettle GS spillway was open during June and July 2014, so it is not possible to determine if the fish moved through either the turbines or spillway. It was last detected in the Long Spruce reservoir on July 14, 2014 (Appendix A3-7).
- #16034 was tagged in Stephens Lake on June 18, 2011, and moved downstream through the Kettle GS between October 9, 2012, and June 10, 2013. This fish must have passed downstream through one of the Kettle GS turbines as the spillway was closed between October 2012 and June 2013. It was detected in the Long Spruce reservoir in open-water 2015 (Appendix A3-15).

Six fish have moved upstream out of Stephens Lake into Gull Lake (as discussed in Section 4.1.1); however, one of these fish (#16033) was captured by a local resource user and the tag was reapplied to a fish in Stephens Lake (#16033b). Two (#16025 and #16037) returned to Stephens Lake in 2014; however, #16025 moved downstream through the Kettle GS into the Long Spruce reservoir (discussed above). An additional three fish (#16048, #16060, and #32174) initially tagged in Gull Lake moved downstream through Gull Rapids into Stephens Lake in 2015 (Section 4.1.1).

In summary, 35 adult Lake Sturgeon were tagged in Stephens Lake between 2011 and 2014. Four are considered missing, three moved downstream through Kettle GS, three moved upstream into Gull Lake and did not return to Stephens Lake, and three moved downstream from Gull Lake in 2015 and 2016. Therefore, 28 fish were available to be detected in Stephens Lake during winter 2016/2017.

4.2 WINTER 2016/2017

4.2.1 UPSTREAM OF GULL RAPIDS

The winter receiver array consisted of four receivers deployed at rkms -48.2, -29.4, -12.9, and -10.1 (Figure 1). Three of these receivers were retrieved; the receiver deployed at rkm -12.9 could not be located and was likely moved by ice (Map 3). Fourteen of the 30 fish (47%) were located a total of 137,761 times (range: 23–19,532 detections per individual) (Appendix A1-1). Fish were detected on 6 to 108 days of the 193 day winter period (3–56% of the time) for an average of 83 days, or for 43% of the study period (standard deviation [StDev] = 37.6 days). Detections were logged only by the receiver located at rkm-10.1 (Figures 4 and 5; Appendix A1-1).

Individual Lake Sturgeon movements are summarized graphically in Appendix 2.

4.2.2 STEPHENS LAKE

Sixteen receivers were deployed in Stephens Lake during the winter 2016/2017 period, between rkms 5.2 and 36.1 (Figure 1). Fifteen of these receivers were retrieved; the receiver deployed at rkm 23.5 was not retrieved due to the buildup of large woody debris that occurred during the winter months (Map 4). Twenty-seven of the 28 fish (96%) were located during the winter period a total of 584,650 times (range: 47–46,475 detections per individual) (Appendix A1-2). On average, fish were detected for 123 days of the 193 day winter period (64%) (range: 2–190 days). The farthest upstream detections occurred at rkm 5.2 (by 20 fish; 74%), while the farthest downstream occurred at rkm 18.6 (by one fish; 4%) (Appendix A1-2). The average movement range was 5.4 rkm (range 0.0–13.4 rkm) (Figure 6; Appendix A1-2).

4.2.2.1 MOVEMENTS

The majority of detections were logged by receivers located in the southern portion of Stephens Lake between rkm 5.2 and 13.9 ($n = 580,436$; 99%; Figure 7). Movements were as follows:

- Eleven (#16022, #16027, #16028, #16030, #16033b, #16035, #16060, #32170, #32171, #32172, and #32173) were detected exclusively in the upstream portion of Stephens Lake, moving no further downstream than rkm 10.3 (Appendix A1-2).
- Nine (#16019, #16020, #16032, #16037, #16041, #16049, #32167, #32168, and #32169) moved further downstream, as far as rkm 13.9.
- Three (#16031, #16050, and #16052) were only detected at rkm 13.9.
- A single fish (#16043) moved as far downstream as rkm 18.6.
- A single fish (#16048) moved into the northern portion of Stephens Lake and was located briefly (39 times) at receiver #114227 (rkm 6.5).

Individual Lake Sturgeon movements are summarized graphically in Appendix 3.

4.2.3 LONG SPRUCE RESERVOIR

The single receiver set in the Long Spruce reservoir was retrieved (Map 5). The single fish last located in this area (#16025) was not detected during winter 2016/2017 (Appendix A3-7).

4.3 OPEN-WATER 2017

4.3.1 ACOUSTIC RECEIVER RETRIEVAL

Stationary acoustic receivers deployed in Stephens Lake (30), in the Long Spruce reservoir (3), and in the Limestone reservoir (1) during the 2017 open-water period were successfully retrieved (Maps 7 and 8). One of the 26 receivers deployed upstream of Gull Rapids (#129189; rkm -32.3) went missing part way through the study period (Map 6). No data were retrieved from this receiver after July 23, 2017.

4.3.2 UPSTREAM OF GULL RAPIDS

Thirty adult Lake Sturgeon were available to be detected upstream of Gull Rapids during the 2017 open-water period (Section 4.1.1). Twenty-six of these were detected between 1,169 and 32,547 times for 24–133 days of the 169 day open-water period (14–79% of the time; Appendix A1-3). The average total movement range was 10.7 rkm (StDev = 4.8 rkm; range: 3.3–21.7 rkm) (Figure 8; Appendix A1-3). The farthest upstream detections occurred at rkm -48.2 (by two fish; 8%), while the furthest downstream occurred at rkm -5.8 (by 11 fish; 42%) (Figure 8; Appendix A1-3). One fish (#16076) moved downstream through Gull Rapids into Stephens Lake. It was

detected as far downstream as rkm 13.9 and had a total overall movement range of 24.0 rkm (Figure 8; Appendix A1-3).

Of the four fish that were not detected:

- Two (#16064 and #16075) have been detected sporadically (1,905 to 2,488 times on 45 to 54 days) since tagging in June 2011 (Appendices A2-18 and A2-29). Both fish #16064 and #16075 were last detected at rkm -10.1 in 2016 and 2015, respectively. It is likely that these fish move little and generally stay outside of the detection range of the receiver array.
- Two were detected regularly after tagging:
 - #16046 was tagged on June 11, 2011 in Stephens Lake. It moved upstream through Gull Rapids between June 27 and July 4, 2012 (described in Section 4.1.1). This fish was detected in Gull Lake until 2013, but has not been located since (Appendix A3-23).
 - #32177 was tagged on June 18, 2014, at rkm -10.9. It was detected regularly (20,678 times on 109 days) in Gull Lake until the end of the 2014 open-water period. It was last located in lower Gull Lake (rkm 9.5) on June 14, 2015.

4.3.2.1 PROPORTIONAL DISTRIBUTION

As in previous years, individual Lake Sturgeon used Zones 4 (upper basin of Gull Lake) and 5 (lower basin of Gull Lake) most often, spending a total of 63% (StDev = 38%; range: 0–100%) and 21% (StDev = 30%; range 0–94%) of the study period in these areas, respectively (Table 4; Figures 10 and 11). Zones 1 (Clark Lake), 2 (river reach from Clark Lake to Birthday Rapids), and 3 (river reach from Birthday Rapids to Gull Lake) were used less frequently:

- Zone 1 at 5% (StDev = 21%; range 0–100%);
- Zone 2 at 0.03% (StDev = 0.2%; range 0–0.8%); and
- Zone 3 at 11% (StDev = 38%; range 0–100%) of the study period.

4.3.2.2 MOVEMENT PATTERNS

During the 2017 open-water period, the majority of detections ($n = 212,384$; 61%) were logged in Gull Lake between rkm -10.1 and -9.5 (Figure 11). During the spawning period (May 31 to June 6, 2017), eight fish (#16038, #16051, #16055, #16061, #16065, #16069, #16071, and #16073) made distinct upstream movements, where one (#16069) moved to Birthday Rapids and seven moved as far upstream as a small set of rapids at rkm -19.5.

As described in previous reports, individual Lake Sturgeon in this study area exhibit habitual movement patterns. In 2017, 23 of the 26 detected fish continued to display the same general pattern of movement displayed in previous years:

- Twenty remained in Gull Lake for the majority of the open-water period:
 - Nineteen were detected exclusively within Gull Lake:
 - Five (#16063, #16068, #16070, #16072, and #32175) remained within upper Gull Lake, moving between rkm -19.5 and -9.5.
 - The remaining 14 made multiple upstream and downstream movements within Gull Lake, moving as far upstream as rkm -19.5 and as far downstream as rkm -5.8.
 - One (#16056) was located within Gull Lake for the majority of the study period, but made a brief upstream movement to the base of Birthday Rapids, after which it returned to Gull Lake.
 - #16056 was located in Gull Lake (rkm -19.5 to -12.9) from June 5 to 24, 2017. It moved upstream to rkm -24.2 on June 25, and remained between rkm -29.4 and -24.2 until July 21, when it moved back downstream to Gull Lake (Appendix A2-10).
 - This fish was located downstream of Birthday Rapids outside of the spawning period when the water temperature ranged between 15 and 18°C (Figure 3).
 - This fish has displayed the same pattern of movement since 2015.
- Two (#16058 and #16074) were detected exclusively within Clark Lake (rkm -48.2 to – 44.3). Both fish were tagged downstream of Birthday Rapids, but have been detected exclusively within Clark Lake in 2015 (#16074) and 2016 (#16058) (Appendices A2-12 and A2-28).
- One (#16069) remained within the riverine area between Birthday Rapids and Gull Lake (rkm -32.3 to -24.2). This fish has been located exclusively within this reach since the study began in 2011 (Appendix A2-23).

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

- #16026 was exclusively detected in the riverine area between Birthday Rapids and Gull Lake from 2011 to 2016. It was detected in upper Gull Lake (rkm -19.5) at the beginning of the 2017 open-water period (June 12) and continued to move downstream. It remained in Gull Lake (rkm -19.5 to -11.9) until July 23 when it moved upstream. It remained within the riverine area between Birthday Rapids and Gull Lake (rkm -26.5) until the end of the study period (Appendix A2-1).
- #16054 remained in Gull Lake from 2011 to July 2015, when it moved upstream into Clark Lake (rkm -48.2). It moved downstream to the riverine area between Clark Lake and Gull Lake (rkm -29.4) in June 2016 where it remained until the end of the 2016 open-water period. It was located at rkm -26.5 on June 5, 2017, and remained downstream of Birthday Rapids (rkm -33.8 to -26.5) until September 9. It then moved

upstream through Birthday Rapids on September 10 and was last detected at the inlet of Clark Lake (rkm -48.2) on September 11 (Appendix A2-8).

- #16076 moved downstream through Gull Rapids into Stephens Lake. This fish was detected exclusively within Gull Lake (rkm -17.4 and -5.8) since it was tagged on June 6, 2011. It was detected within Gull Lake (rkm -10.1 to -5.8) at the beginning of the 2017 open-water period (May 24 to June 6). It was first detected in Stephens Lake on June 9, and moved between rkm 1.2 and 13.9 for the remainder of the study period (Appendix A2-30).
 - By June 9, water temperature in Stephens Lake measured 13°C, which is in the range of potential spawning temperatures. It is possible that this fish moved downstream to spawn.
 - This fish represents the sixth downstream movement observed through Gull Rapids since the inception of this study.
 - Gaps in the detection data for the other five downstream movements precludes the determination of timing and water temperature during movement.

Individual Lake Sturgeon movements are summarized graphically in Appendix A2.

4.3.3 STEPHENS LAKE

Twenty-eight adult Lake Sturgeon were available to be detected in Stephens Lake during the 2017 open-water period (Section 4.1.2). Twenty-seven of these fish were detected between 11,336 and 35,684 times over 60–157 days of the 169 day study period (36–93% of the time; Appendix A1-4). Mean movement range was 16.8 rkm (StDev = 6.9 rkm; range: 8.2–39.7 rkm) (Figure 12; Appendix A1-4). The farthest upstream detections occurred immediately downstream of Gull Rapids at rkm 1.2 (by all 27 fish; 100%), while the farthest downstream detections occurred near the Kettle GS at rkm 40.9 (by 1 fish; 4%) (Figure 12; Appendix A1-4). No fish moved upstream through Gull Rapids or downstream through the Kettle GS during the 2017 open-water period.

One fish (#32170) last located in winter 2016/2017 (October 30) in upper Stephens Lake (rkm 7.9) was not detected during the 2017 open-water period (Appendix A3-32). This fish has been detected regularly since it was tagged on June 11, 2014.

4.3.3.1 PROPORTIONAL DISTRIBUTION

As during open-water 2016, Lake Sturgeon used Zone 7 slightly more frequently than Zone 6, spending 53% (StDev = 18%; range 15–85%), and 48% (StDev = 18%; range 15–85%) of the time in each zone, respectively (Table 4; Figures 9 and 13). However, as in open-water 2015 and 2016, utilization of the zones changed over time. A greater proportion of fish were detected

close to Gull Rapids during the beginning and middle of the study period than at the end (Figure 9).

- Zone 6 was used an average of:
 - 71% of the time (StDev = 14%; range: 48–89%) between June 7 and 14, 2017;
 - 34% (StDev = 8%; range: 19–52%) between June 15 and July 31, 2011;
 - 67% (StDev = 9%; range: 37–85%) between August 1 and September 11, 2017; and
 - 35% (StDev = 9%; range: 19–56%) between September 12 and October 16, 2017.

4.3.3.2 MOVEMENT PATTERNS

During the 2017 open-water period, the majority of detections ($n = 594,188$; 98%) were logged by receivers located in the southern portion of Stephens Lake between rkm 1.2 and 13.9 (Figure 14).

Two general movement patterns were displayed during the 2017 open-water period:

- Eleven remained in the upstream portion of Stephens Lake
 - Ten moved only as far downstream as rkm 13.9.
 - Four (#16027, #16050, #32172, and #32173) displayed the same movement pattern during open-water 2015 and 2016 (Appendices A3-8, A3-26, A3-34, and A3-35).
 - Four (#16031, #16033b, #16053, and #32171) moved as far downstream as rkm 18.6 in open-water 2016 (Appendices A3-12, A3-14, A3-28, and A3-33).
 - Two (#16060 and #32174) moved downstream through Gull Rapids into Stephens Lake in 2016 (Appendices A2-14 and A2-32).
 - One (#16048) remained in the upstream portion of Stephens Lake (rkm 1.2 to 10.3), but made a single movement further downstream to rkm 18.6 (Appendix A2-6).
- The remaining 16 fish moved further downstream into Stephens Lake:
 - Thirteen made regular upstream and downstream movements, moving as far downstream as rkm 18.6.
 - #16020 was detected as far downstream as rkm 24.7 in lower Stephens Lake (Appendix A3-3).
 - #16030 was located as far downstream as rkm 36.1, ~5 rkm upstream of Kettle GS however, this fish did not pass through the station and moved back

upstream, moving between rkm 1.2 and 13.9 for the remainder of the open-water period (Appendix A3-11).

- This fish displayed the same pattern of movement during open-water 2016.
- #16049 was detected as far downstream as rkm 40.9, immediately upstream of Kettle GS. This fish did not pass through the station and returned upstream. It was detected moving between rkm 1.2 and 13.9 for the remainder of the open-water period (Appendix A3-25).

Individual Lake Sturgeon movements are summarized graphically in Appendix 3.

4.3.4 LONG SPRUCE RESERVOIR

The single fish (#16025) last detected in the Long Spruce reservoir (on July 14, 2014) was not located during the 2017 open-water period (Appendix A3-7). It is possible that this fish moved downstream into the Limestone reservoir prior to 2016 when a receiver was placed in the area, was a mortality (e.g., harvested, natural mortality), or has remained in a location where it is not detected.

4.3.5 LIMESTONE RESERVOIR

One of the two Lake Sturgeon last detected in the Limestone reservoir was located during the 2017 open-water period. Lake Sturgeon #16021 was detected 13 times over two days at rkm 58.6. It was last detected on June 19, 2017 (Appendix A3-4).

Lake Sturgeon #16034 was last detected in the Limestone reservoir at rkm 58.6 on September 5, 2016 (Appendix A3-15). It is possible that this fish continued to move downstream, or remained outside of the receiver detection range for the duration of the 2017 open-water period.

4.4 ADULT LAKE STURGEON DISTRIBUTION

Proportional distributions of fish detected consistently since 2013 ($n = 42$) were compared, and the likelihood of fish movements between zones both before and after construction were calculated (Figures 15, 16, and 17). The overall likelihood of a movement (either upstream or downstream) between zones was 12.2% prior to construction and 14.9% after construction (Figure 15). The likelihood of a fish moving upstream from one zone to another was 43.4% prior to the onset of construction, and 43.0% after (Figure 16). The likelihood of a fish moving downstream from one zone to another was 56.6% before construction and 57.0% after (Figure 17).

4.5 LONG DISTANCE MOVEMENTS

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

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

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

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

The likelihood of a fish moving through Gull Rapids, Kettle GS, or the Long Spruce GS was calculated both pre- and post-construction. Prior to construction, there was a 2.1% chance that a fish would move past the rapids or a generating station and a 1.2% chance after the onset of construction (Figure 18).

5.0 DISCUSSION

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

5.1 EVALUATION OF METHODOLOGY

Acoustic telemetry continues to be an effective method for monitoring movements and habitat utilization patterns of adult Lake Sturgeon in the study area. During the 2017 open-water period, 91% of the tagged fish remaining in the area were located. Fish tagged upstream of the Keeyask GS construction site were detected for, on average, 56% of the 169 day open-water study period (22–61% in previous years). Fish tagged in Stephens Lake tend to be detected more often, and on average were located for 73% of the 2017 open-water period (34–72% in previous years).

The quantity of data collected during winter is comparably less relative to the open-water period given that fewer receivers are used (only four upstream of Gull Rapids and 16 in Stephens Lake). Overall, fewer fish were detected during this period than in winter 2015/2016 (47% of available fish in 2016/2017 vs. 53% in 2015/2016), and fewer detections per receiver were logged (38,977 in 2016/2017 and 84,742 in 2015/2016).

One additional receiver was added to the receiver array during the 2017, open-water period; it was deployed at rkm 3.8 in Stephens Lake in a channel between a small island and the southern shore. During open-water 2016, it was suspected that fish were using this channel to move between Zones 6 and 7 and were being missed by the receiver gate. During open-water 2017, 18 fish (67%) were detected between 2 and 1,931 times at this receiver; therefore, the new receiver will continue to be deployed as part of the Stephens Lake receiver gate.

5.2 KEY QUESTIONS

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

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

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

Based on the maximum likelihood analysis comparing data from the pre-construction and post-construction periods, the frequency of Lake Sturgeon movement between zones has not changed since construction began. The likelihood that an adult Lake Sturgeon would move upstream or downstream from one zone to another was similar (2.7% difference), and generally low, during both time periods. If a movement was made between zones, the likelihood of an upstream movement or a downstream movement was very similar (0.4% difference) between the two time periods.

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

Lake Sturgeon continued to use the area immediately upstream and downstream of the Keeyask GS construction site in 2017. Upstream, fish spent an average of 21% of the study period in lower Gull Lake, and 11 of 26 fish (42%) were located by the receiver closest to Gull Rapids (rkm -5.8). In Stephens Lake, fish spent an average of 48% of the study period within 5.0 rkm of Gull Rapids. All 27 fish detected in 2017 were located by the receiver closest to the construction site (rkm 1.2). The amount of time adult Lake Sturgeon have spent in the area surrounding the Keeyask construction site has changed little since receiver gates were put in place in 2013.

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

One adult Lake Sturgeon moved downstream through Gull Rapids in 2017, representing the fourth downstream movement through Gull Rapids since construction began (sixth overall). No upstream movements have been observed since construction began in 2014. It is possible that fish are no longer able to move upstream through the rapids due to the blockage of the north and central channels and constricted flows within the south channel (discussed in Hrenchuk and Barth 2017).

Based on maximum likelihood estimates, the chance of an adult Lake Sturgeon moving out of the area upstream of Gull Rapids or out of Stephens Lake was marginally lower during construction (1.2%) than prior to construction (2.1%).

6.0 SUMMARY AND CONCLUSIONS

- Acoustic telemetry continues to be an effective method for monitoring adult Lake Sturgeon movement. Monitoring during the 2016/2017 winter period was conducted with an array of 20 receivers and positions were obtained from 41 of the 58 (71%) Lake Sturgeon available to be detected. During the 2017 open-water period, 60 receivers were deployed and positions were obtained from 53 of the 58 (91%) fish available to be detected.
- The key questions, as described in the AEMP, for adult Lake Sturgeon movement monitoring during construction of the Keeyask GS were as follows:
 - *Will disturbances associated with construction alter coarse-scale movements upstream and/or downstream of the construction site?*
Quantitatively and qualitatively, there have been no changes in adult Lake Sturgeon movement patterns since the onset of Keeyask GS construction.
 - *Are adult sturgeon using habitat in the immediate vicinity of the construction site?*
During the 2017 open-water period, fish continued to use the areas both immediately upstream and immediately downstream of Gull Rapids.
 - *Will the frequency of long-distance movements (and subsequent downstream emigration/entrainment) by adult Lake Sturgeon increase during construction and operation of the Project?*

Since the inception of study in 2011, twelve movements through Gull Rapids have occurred: six upstream, and six downstream. All upstream movements occurred during the pre-construction phase (one in 2011, four in 2012, and one in 2013). Because flows were routed through the southern channel of Gull Rapids only in 2014, upstream passage may no longer be possible. Downstream movements occurred both during the pre-construction (2014; n = 2) and construction phase (n = 4). Data collected during the pre-construction phase (2011 – June 2014) suggested that the probability of moving through a barrier (either Gull Rapids or the Kettle GS) was 2.1%. Data collected after the onset of construction (July 2014 – October 2016), suggested that the probability was slightly lower (1.2%).

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TABLES

Table 1: Number of acoustic transmitters applied to adult Lake Sturgeon upstream of Gull Rapids [GR] and in Stephens Lake between June 2011 and October 2017.

Year	Upstream GR	Stephens Lake	Total
2011	30	19	49
2012	1	9	10
2013	0	1	1
2014	4	7	11
2015	0	0	0
2016	0	0	0
2017	0	0	0

Table 2: Tagging and biological information associated with adult Lake Sturgeon implanted with acoustic transmitters upstream of Gull Rapids between 2011 and 2017.

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

Table 3: Tagging and biological information associated with adult Lake Sturgeon implanted with acoustic transmitters in Stephens Lake between 2011 and 2017.

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

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

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

Table 5: Number of Lake Sturgeon tagged with acoustic and radio tags that moved upstream or downstream through Gull Rapids during studies conducted in 2001–2004 and 2011–2017.

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

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

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

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

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

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

FIGURES

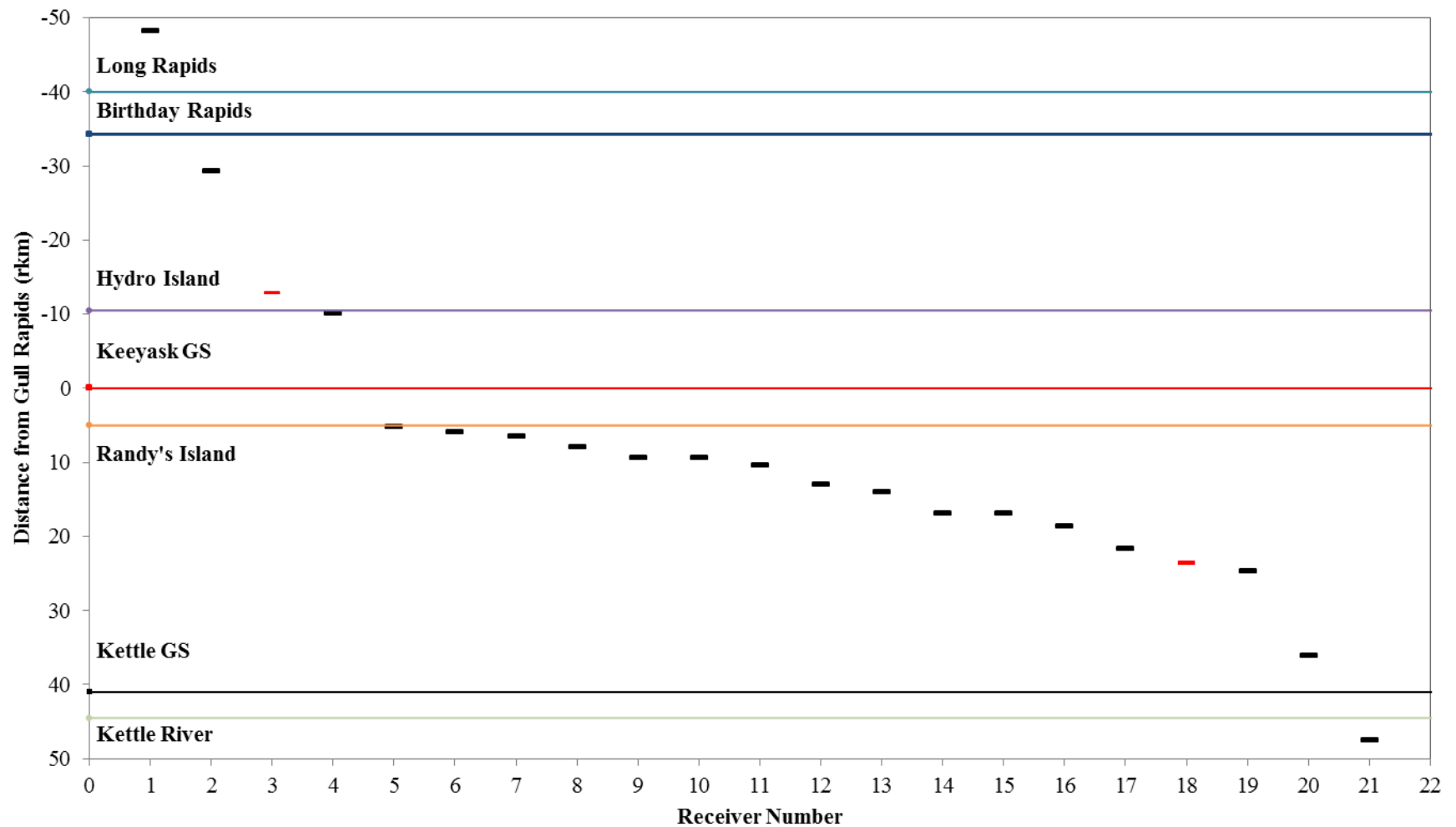


Figure 1: Locations of stationary acoustic receivers (dashes) in relation to the base of Gull Rapids (rkm 0) and other major landmarks (lines) in the Nelson River between Clark Lake and the Limestone GS between October, 2016 and June, 2017. A red dash indicates a receiver that was lost.

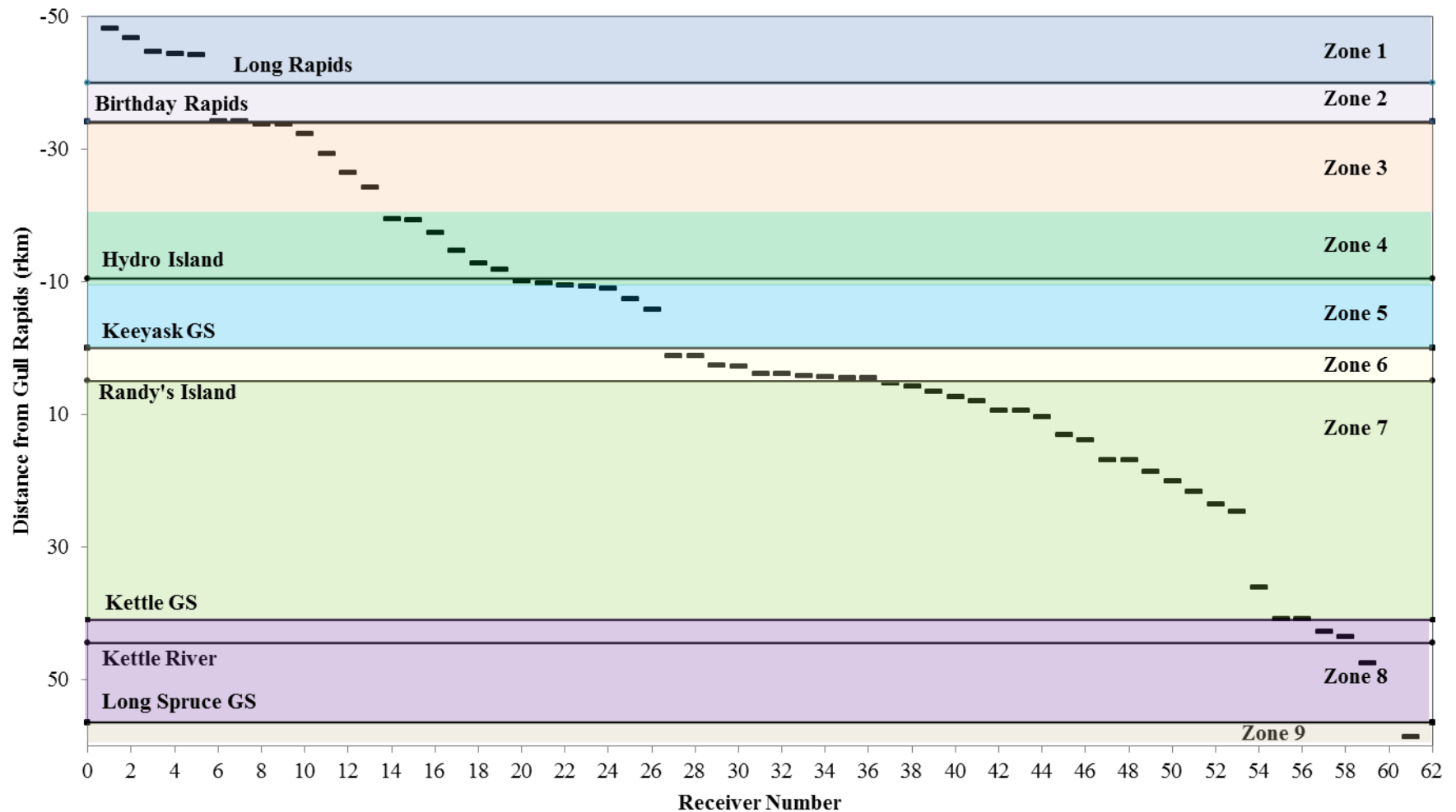


Figure 2: Locations of stationary acoustic receivers (dashes) in relation to the base of Gull Rapids (rkm 0) and other major landmarks (lines) in the Nelson River between Clark Lake and the Limestone GS between June and October, 2017. River zones upstream and downstream of Gull Rapids are indicated by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

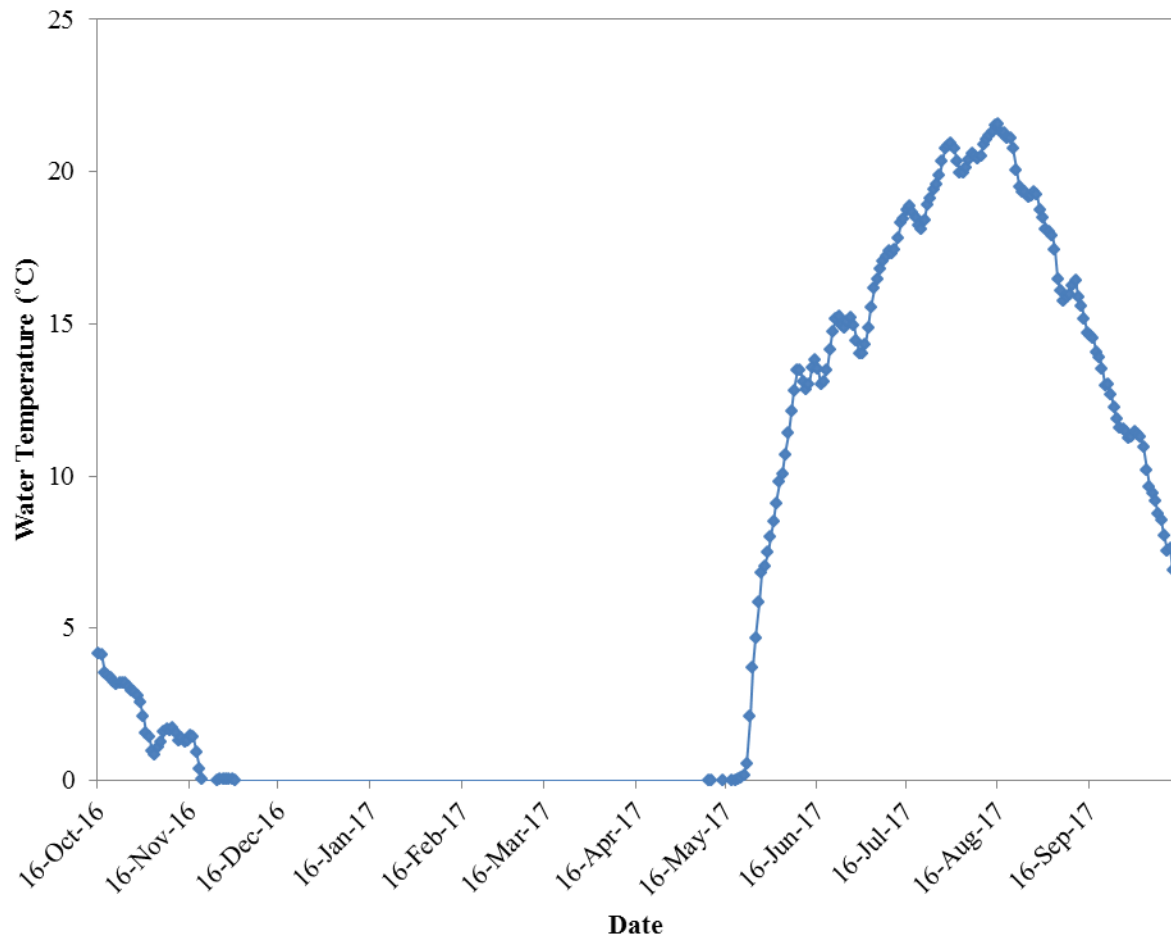


Figure 3: Water temperature in the Nelson River mainstem from October 16, 2016, to October 14, 2017.

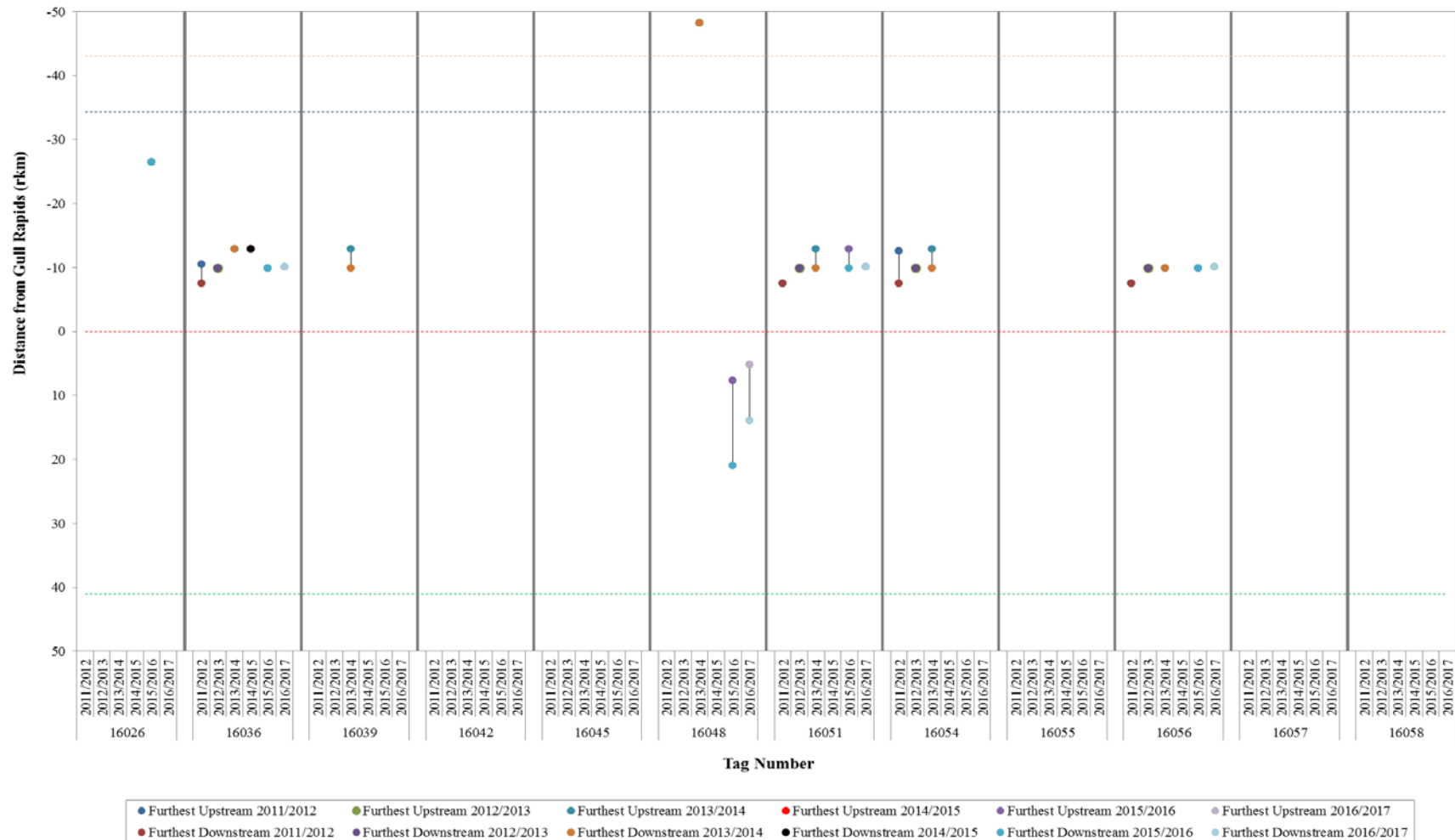


Figure 4: Detection ranges for individual adult Lake Sturgeon tagged with acoustic transmitters upstream of Gull Rapids during the winter period (2011–2017). Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS).

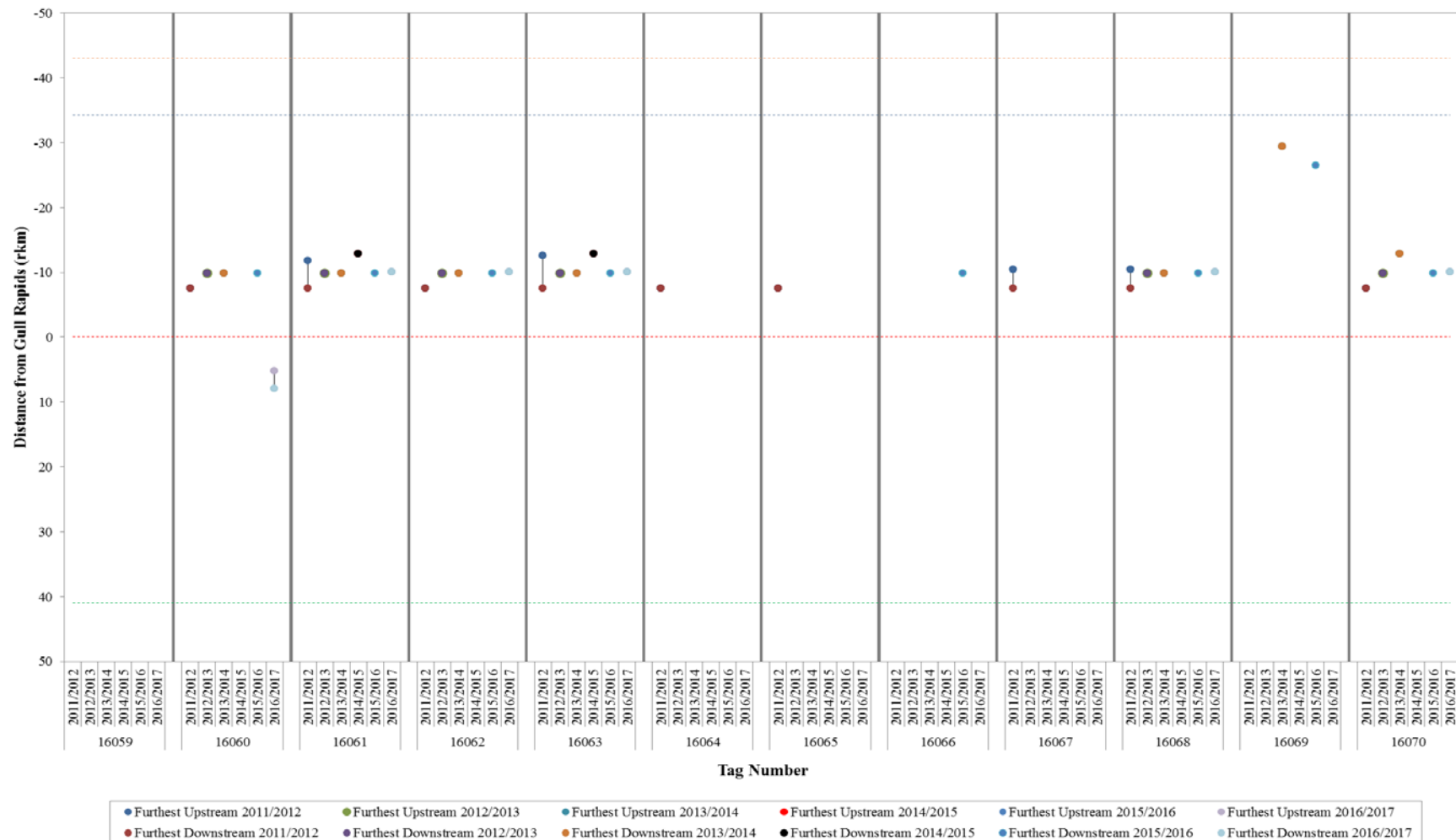


Figure 4: Detection ranges for individual adult Lake Sturgeon tagged with acoustic transmitters upstream of Gull Rapids during the winter period (2011–2017). Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS) (continued).

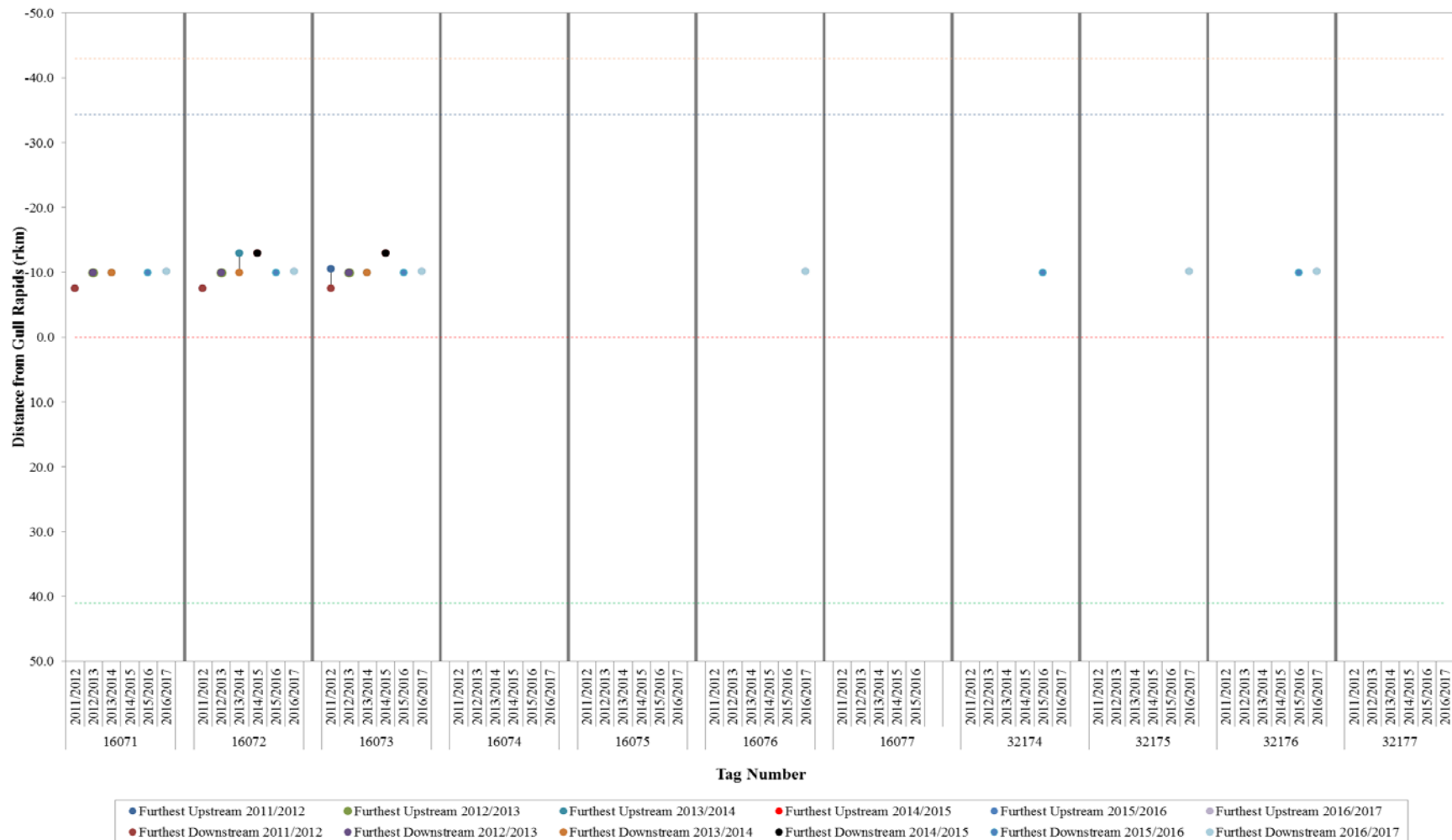


Figure 4: Detection ranges for individual adult Lake Sturgeon tagged with acoustic transmitters upstream of Gull Rapids during the winter period (2011–2017). Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS) (continued).

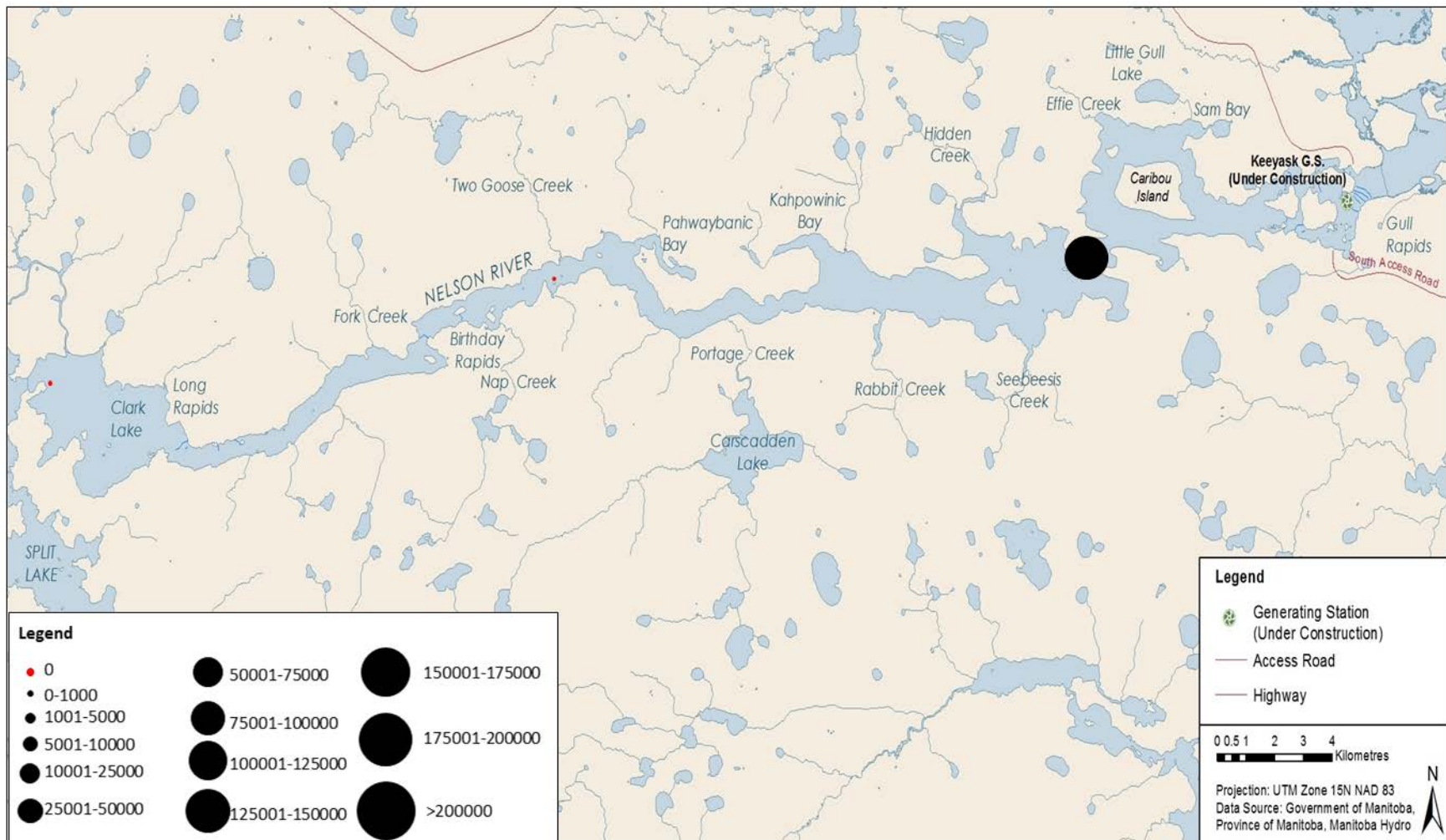


Figure 5: Relative number of detections at each acoustic receiver set between Clark Lake and Gull Rapids during winter 2016/2017 (October 20, 2016, to April 30, 2017). Number of detections indicated by size of bubble (defined in legend). Receivers with no detections indicated with red dot.

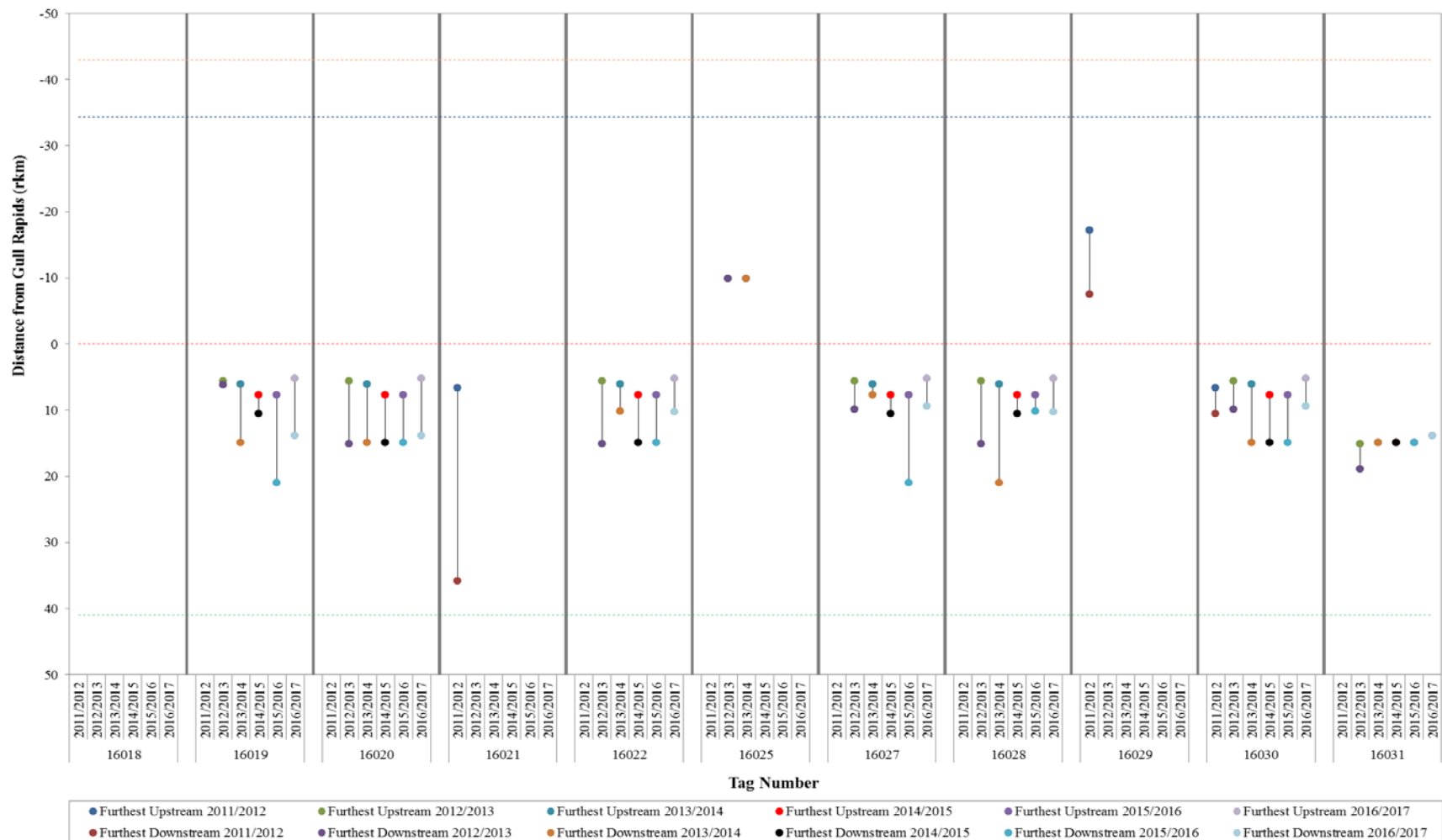


Figure 6: Detection ranges for individual adult Lake Sturgeon tagged with acoustic transmitters in Stephens Lake during the winter period (2011–2017). Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS).

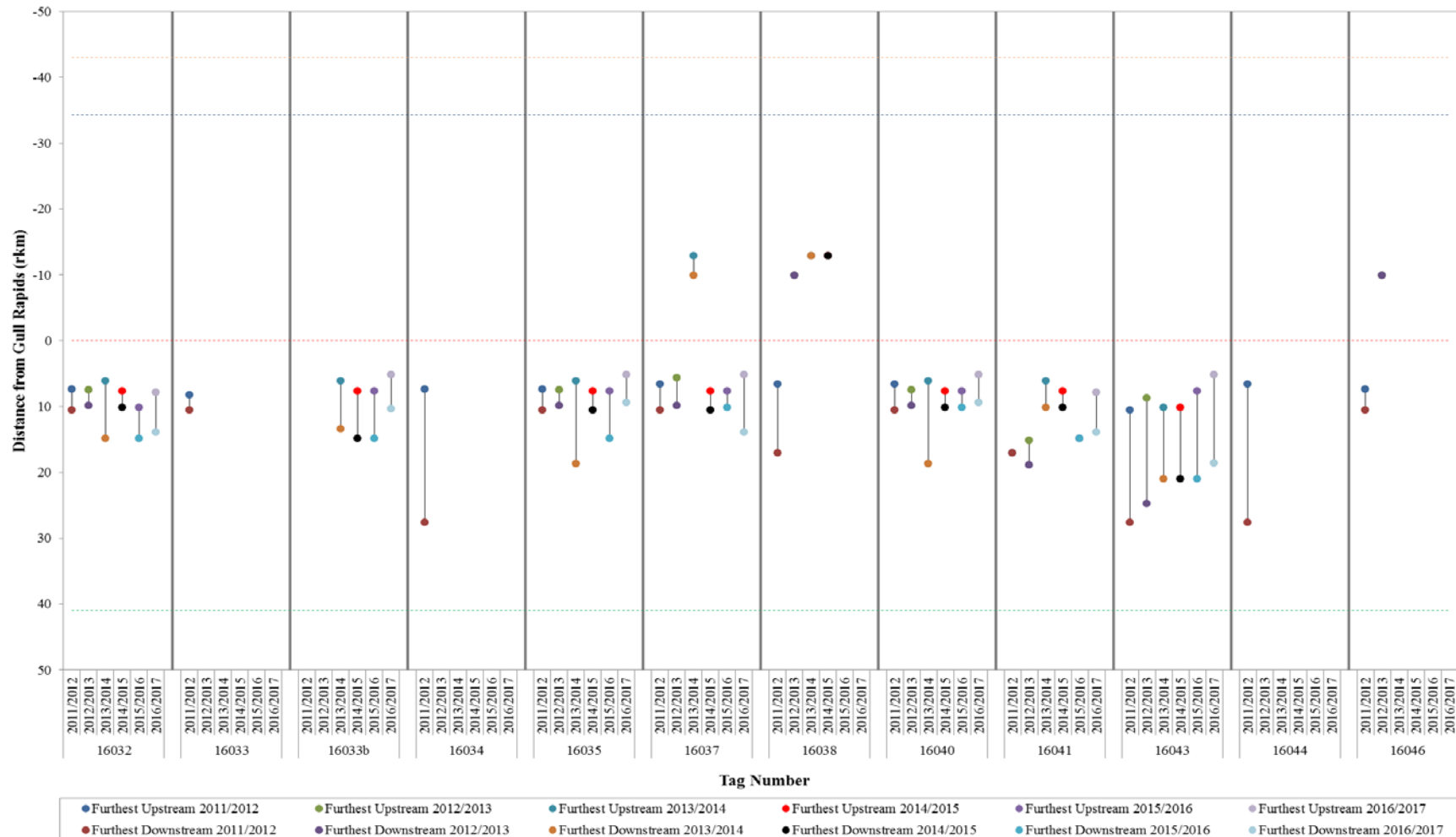


Figure 6: Detection ranges for individual adult Lake Sturgeon tagged with acoustic transmitters in Stephens Lake during the winter period (2011–2017). Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS) (continued).

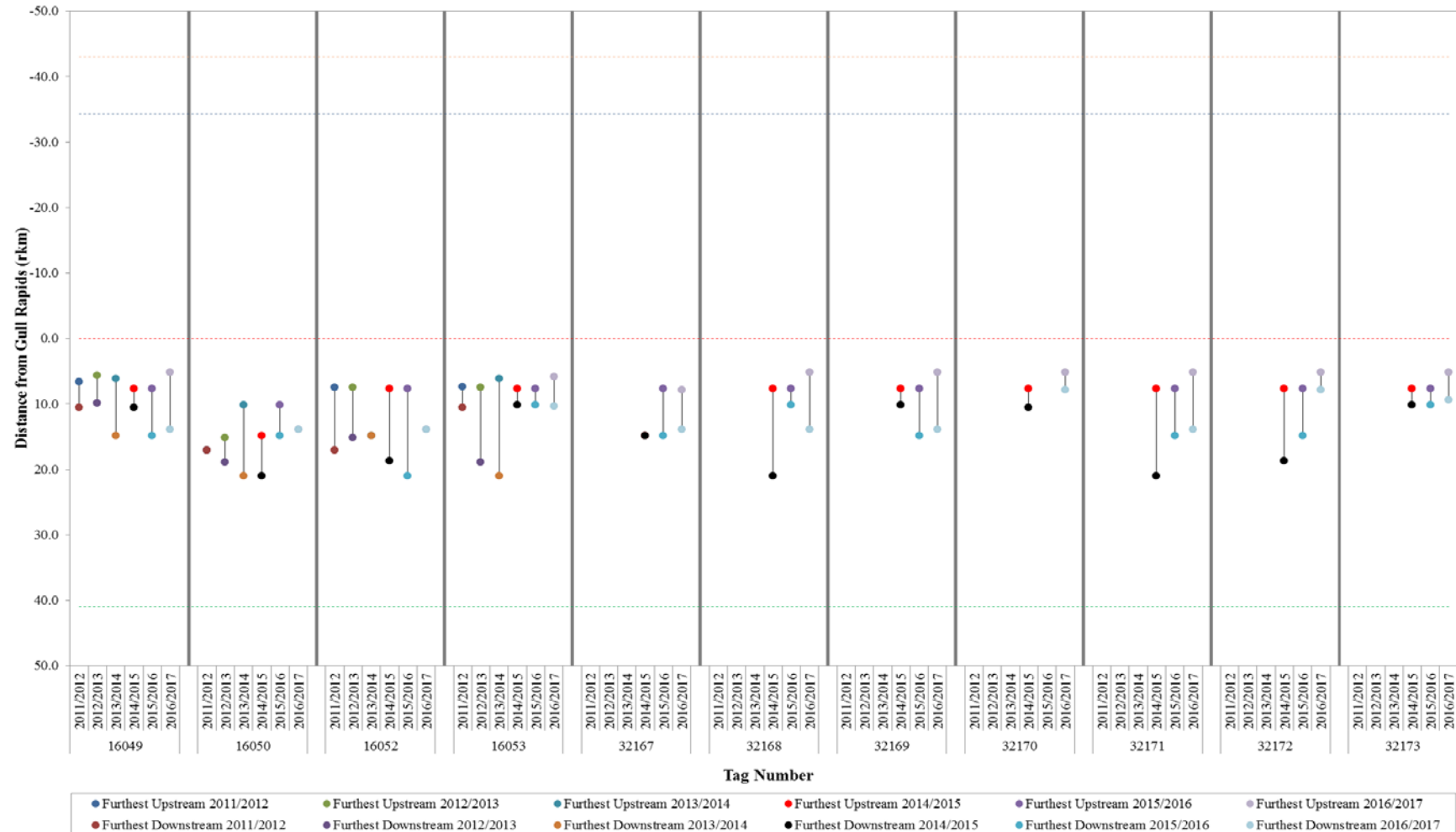


Figure 6: Detection ranges for individual adult Lake Sturgeon tagged with acoustic transmitters in Stephens Lake during the winter period (2011–2017). Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS) (continued).

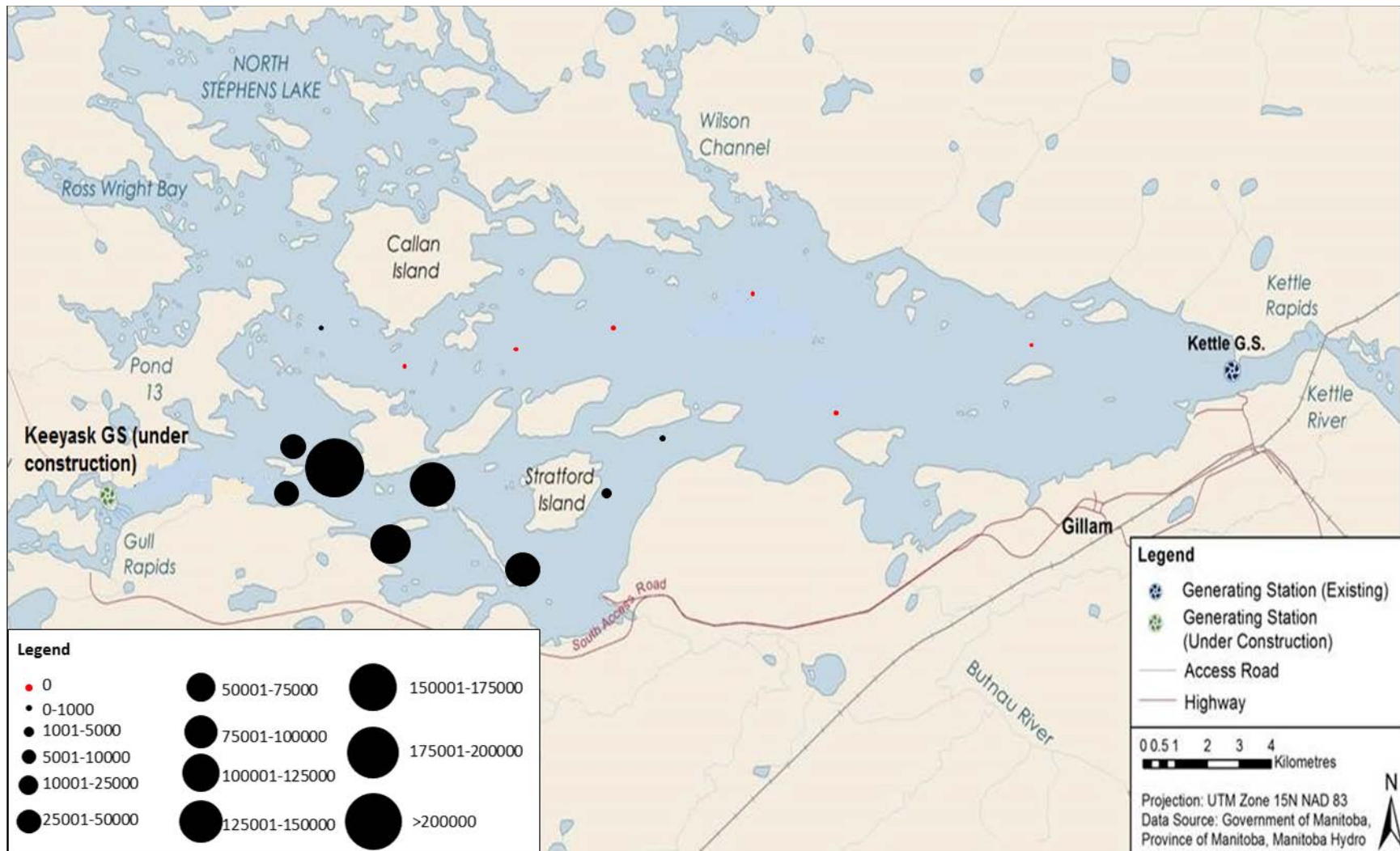


Figure 7: Relative number of detections at each acoustic receiver set in Stephens Lake during winter 2016/2017 (October 20, 2016, to April 30, 2017). Number of detections indicated by size of bubble (defined in legend). Receivers with no detections indicated with red dot.

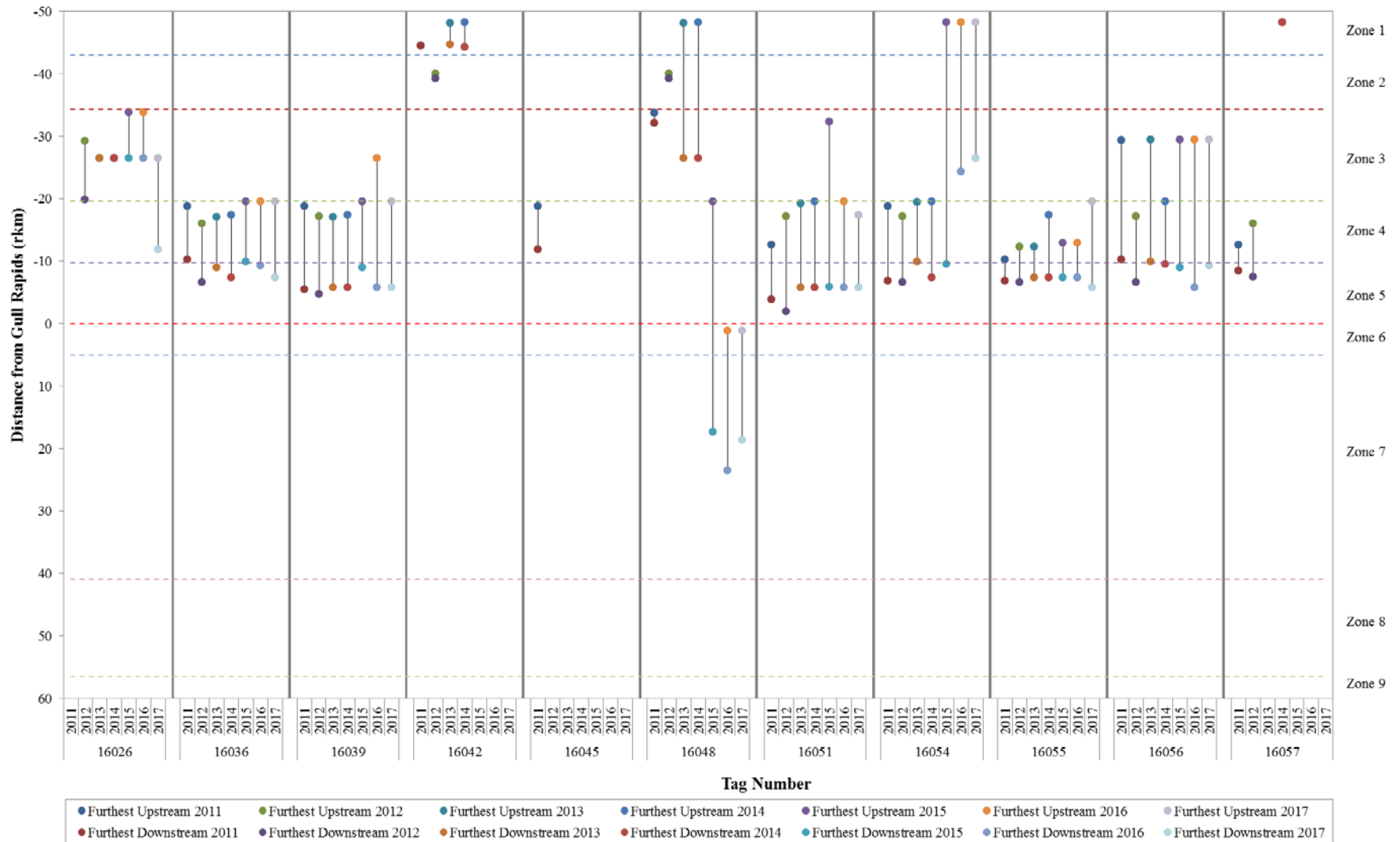


Figure 8: Detection ranges for individual adult Lake Sturgeon tagged with acoustic transmitters upstream of Gull Rapids during the open-water period (2011–2017). Horizontal dotted lines demarcate zones.

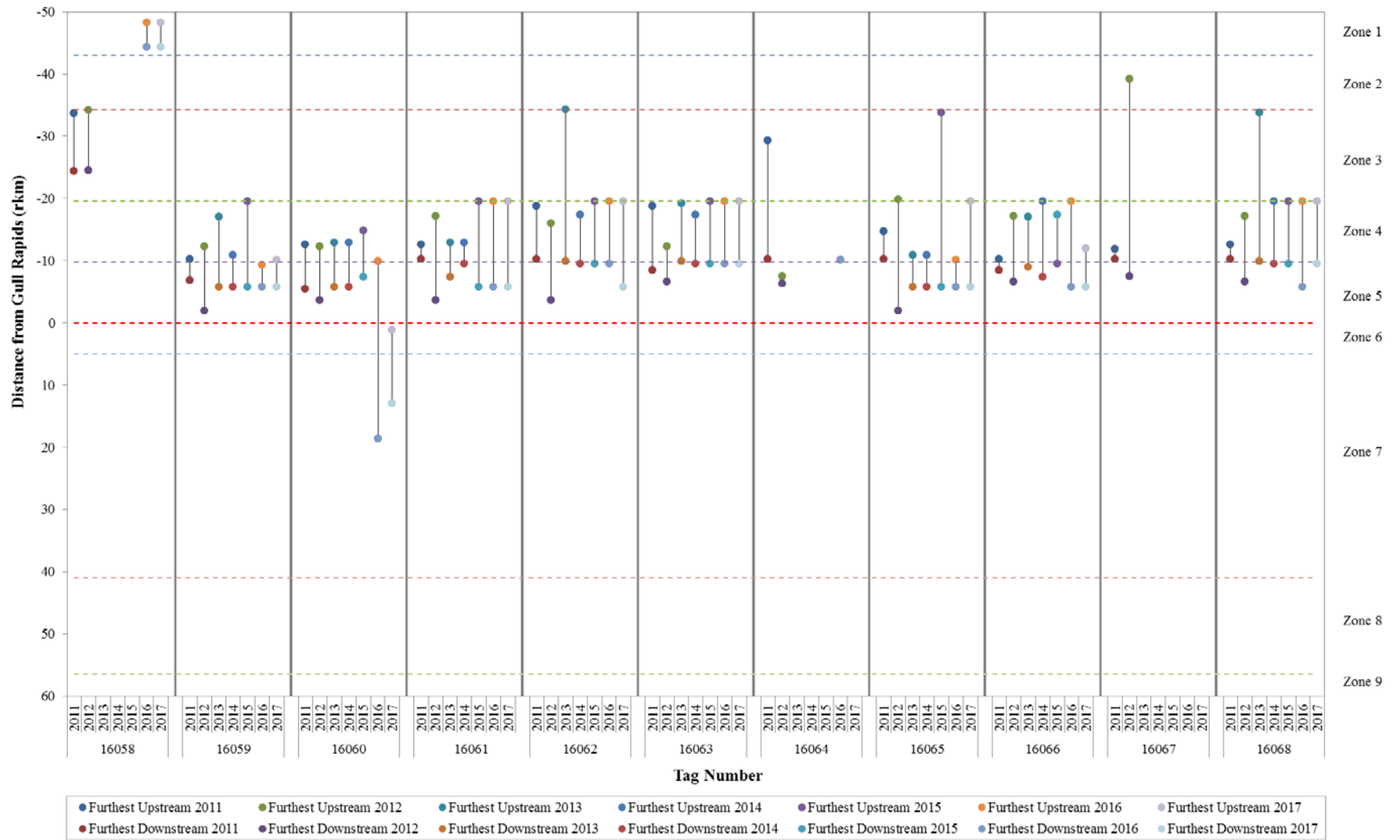


Figure 8: Detection ranges for individual adult Lake Sturgeon tagged with acoustic transmitters upstream of Gull Rapids during the open-water period (2011–2016). Horizontal dotted lines demarcate zones (continued).

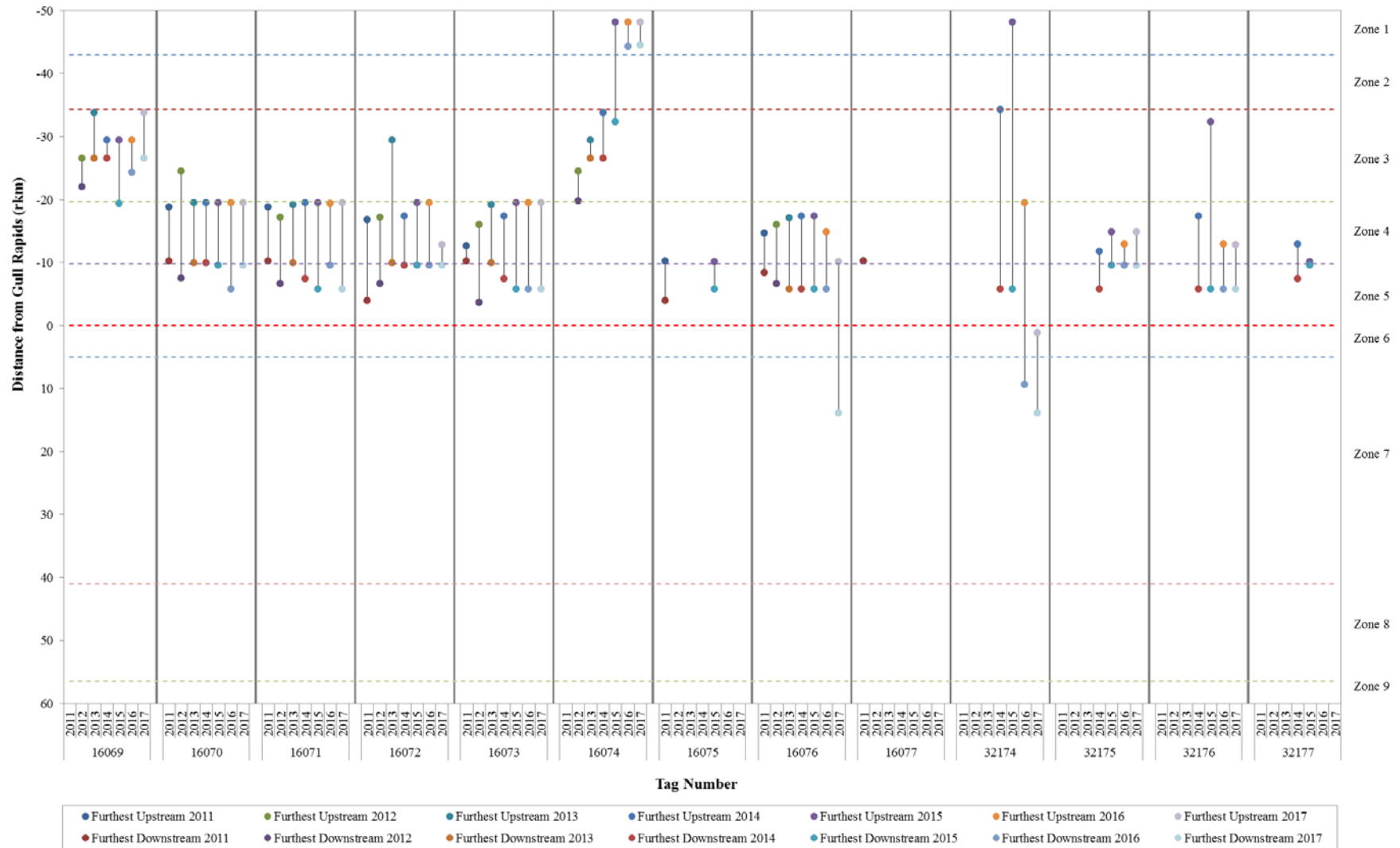


Figure 8: Detection ranges for individual adult Lake Sturgeon tagged with acoustic transmitters upstream of Gull Rapids during the open-water period (2011–2016). Horizontal dotted lines demarcate zones (continued).

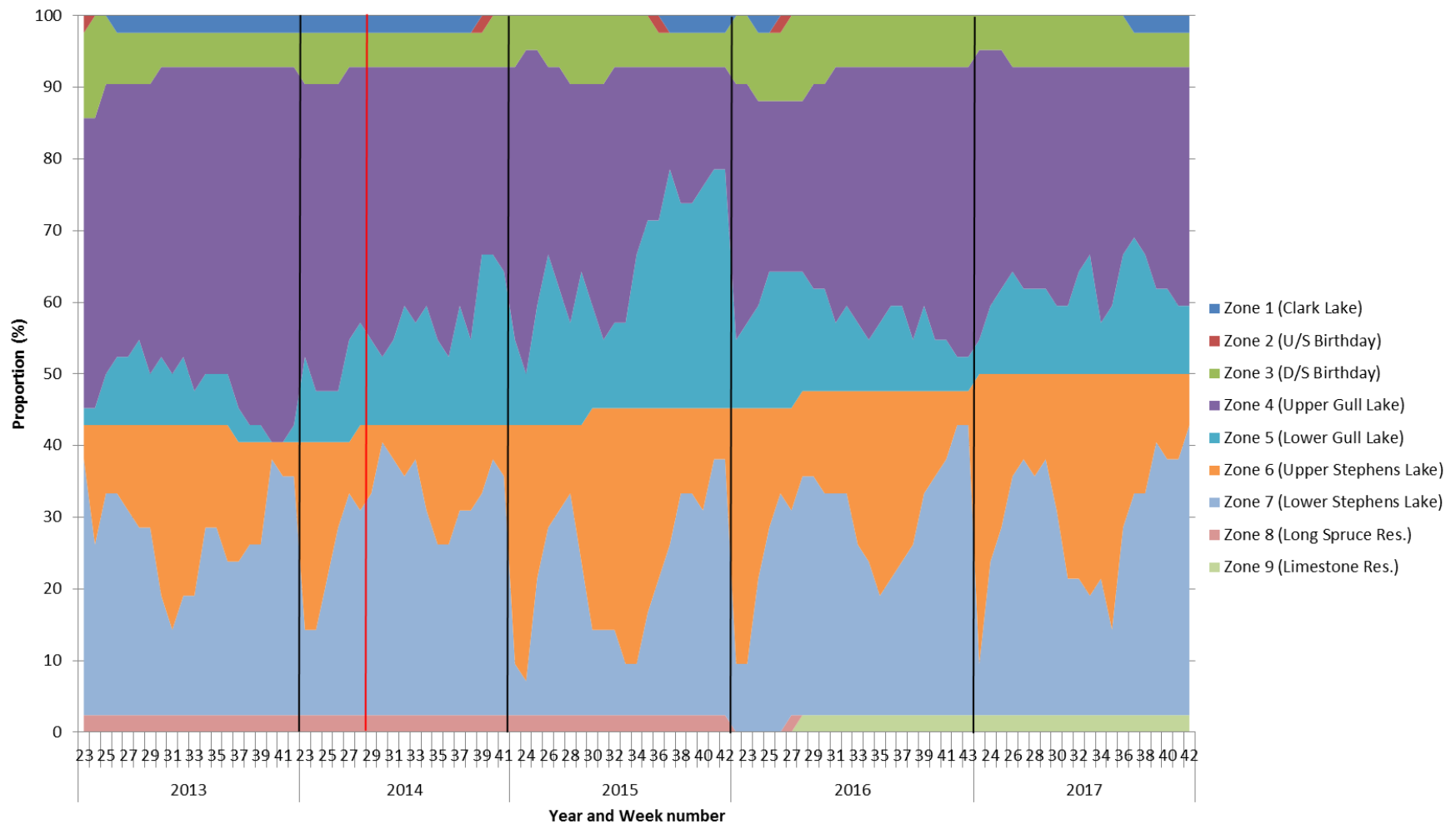


Figure 9: Proportional distribution by zone, for 43 adult Lake Sturgeon tagged with acoustic transmitters in the Keeyask GS Area during a portion of the 2013 (June 4 to October 15), 2014 (June 4 to October 3), 2015 (June 4 to October 11), 2016 (June 4 to October 19), and 2017 (June 7 to October 16) open-water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

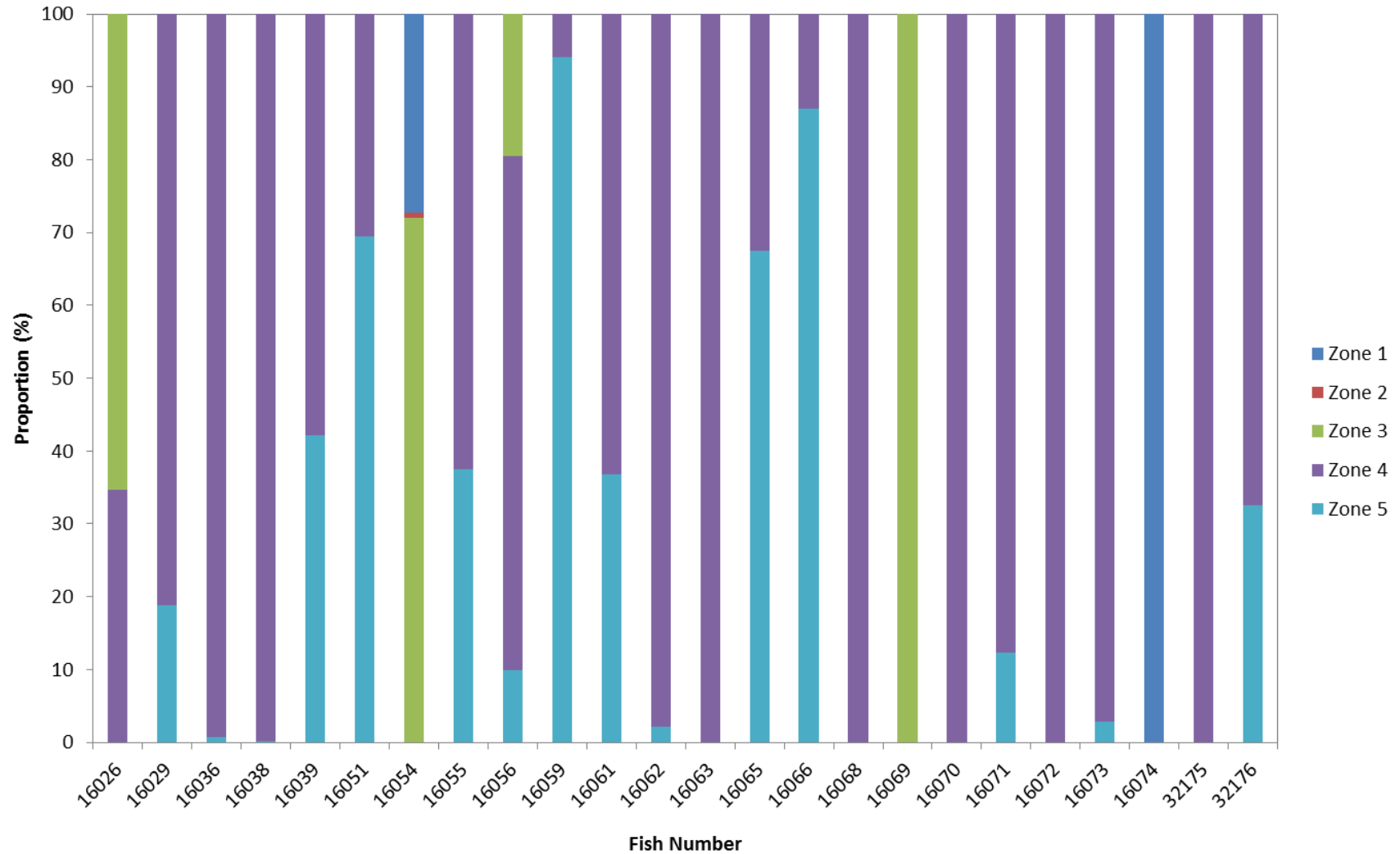


Figure 10: Proportional distributions by zone, for individual adult Lake Sturgeon tagged with acoustic transmitters upstream of Keeyask GS during a portion of the 2017 open-water period (June 7 to October 16).

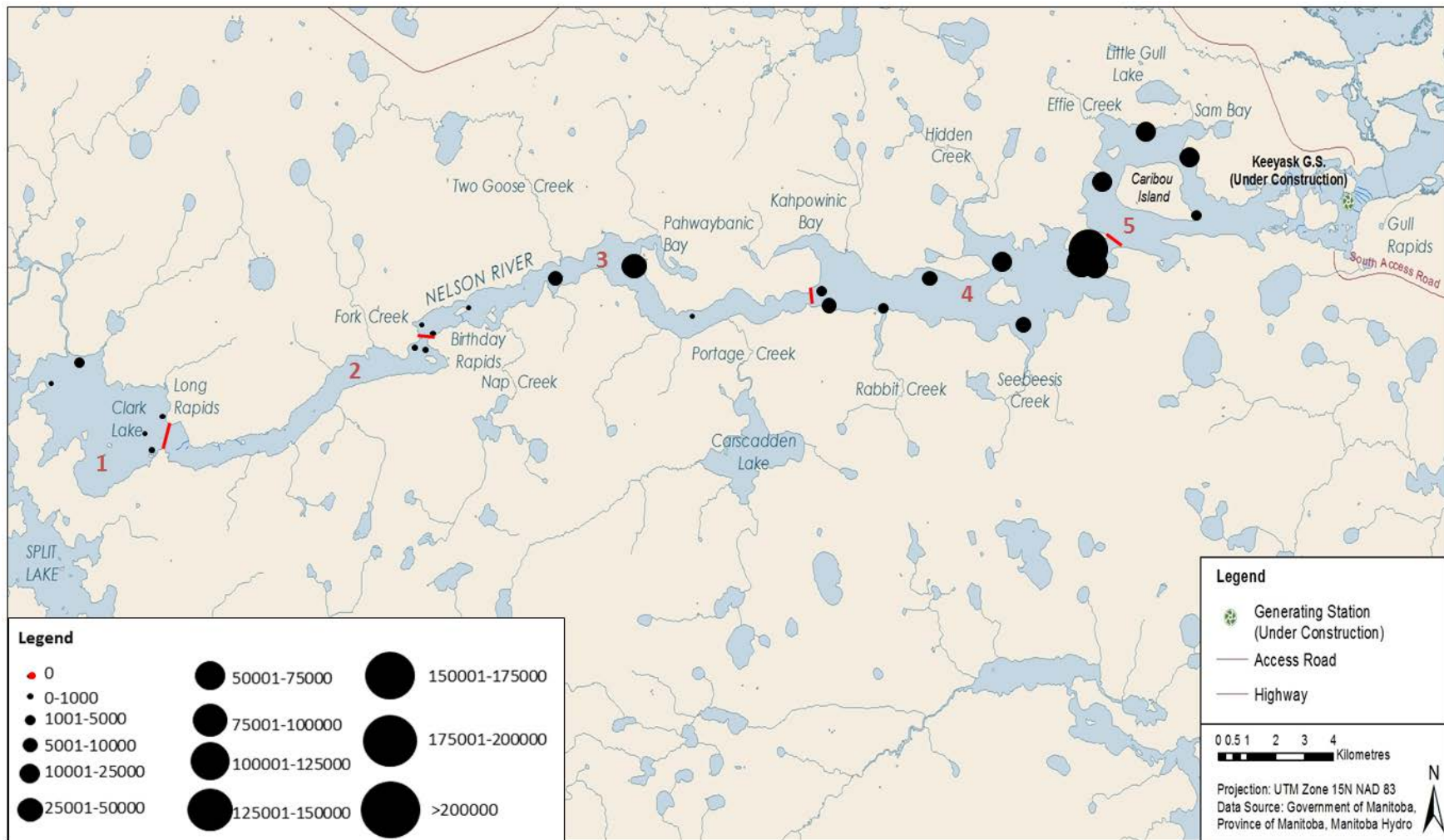


Figure 11: Relative number of detections at each acoustic receiver set in the Nelson River between Clark Lake and Gull Rapids during the 2017 open-water period (May 1 to October 16). Number of detections indicated by size of circle (defined in legend). Receivers with no detections indicated with red dot. The river is divided into five "zones" based on placement of receiver "gates."

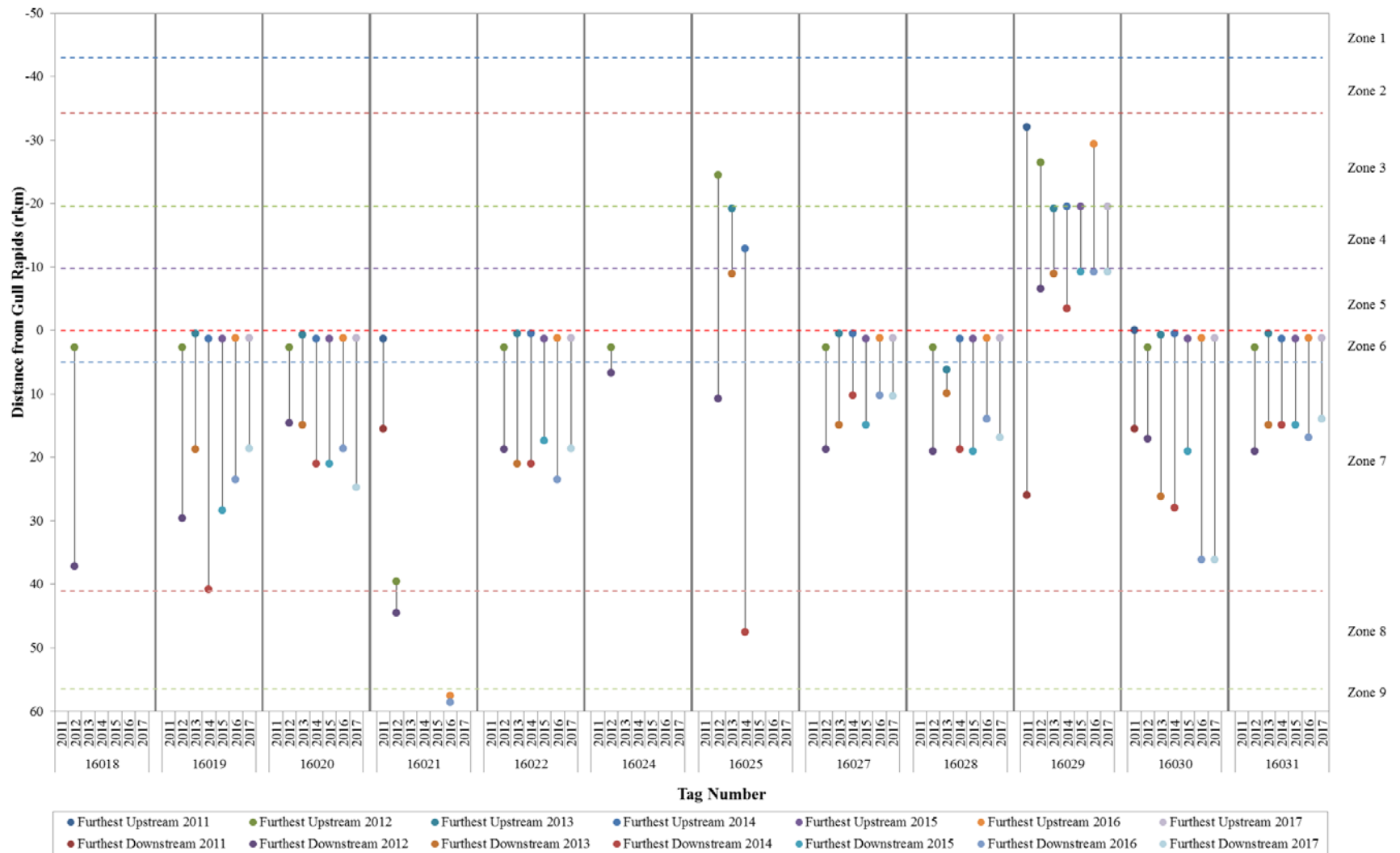


Figure 12: Detection ranges for individual adult Lake Sturgeon tagged with acoustic transmitters in Stephens Lake during the open-water period (2011–2017). Horizontal dotted lines demarcate zones.

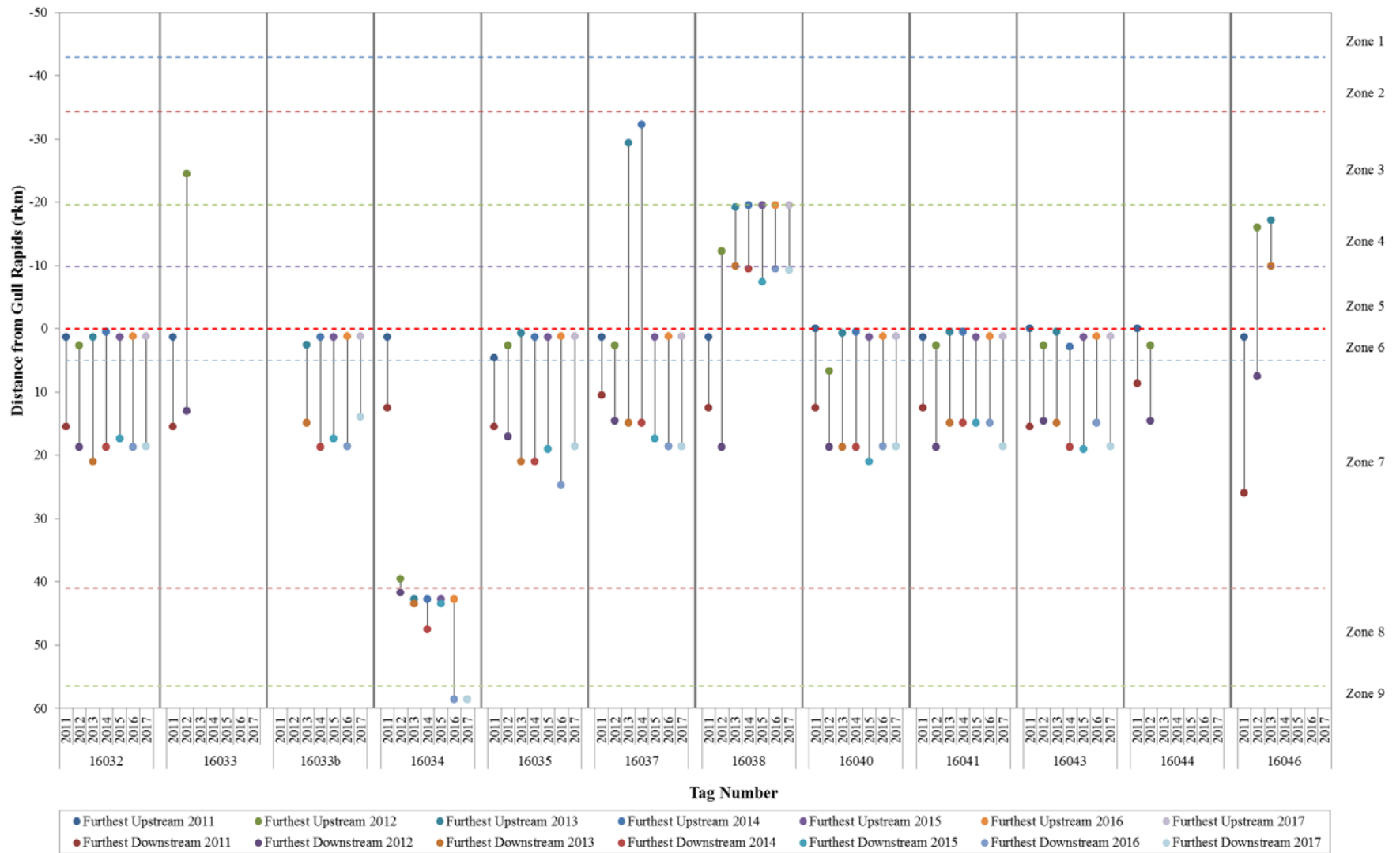


Figure 12: Detection ranges for individual adult Lake Sturgeon tagged with acoustic transmitters in Stephens Lake during the open-water period (2011–2017). Horizontal dotted lines demarcate zones (continued).

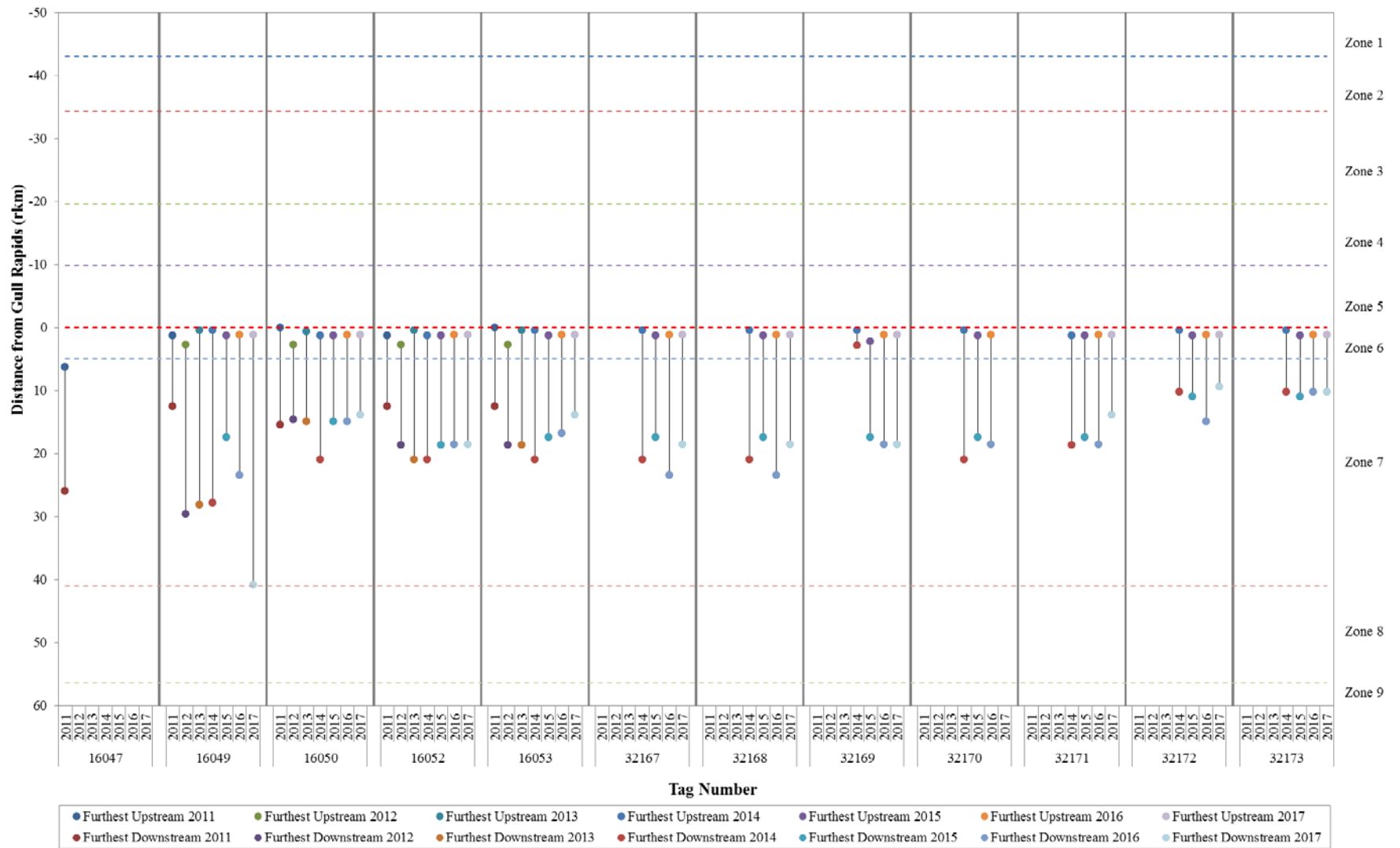


Figure 12: Detection ranges for individual adult Lake Sturgeon tagged with acoustic transmitters in Stephens Lake during the open-water period (2011–2017). Horizontal dotted lines demarcate zones (continued).

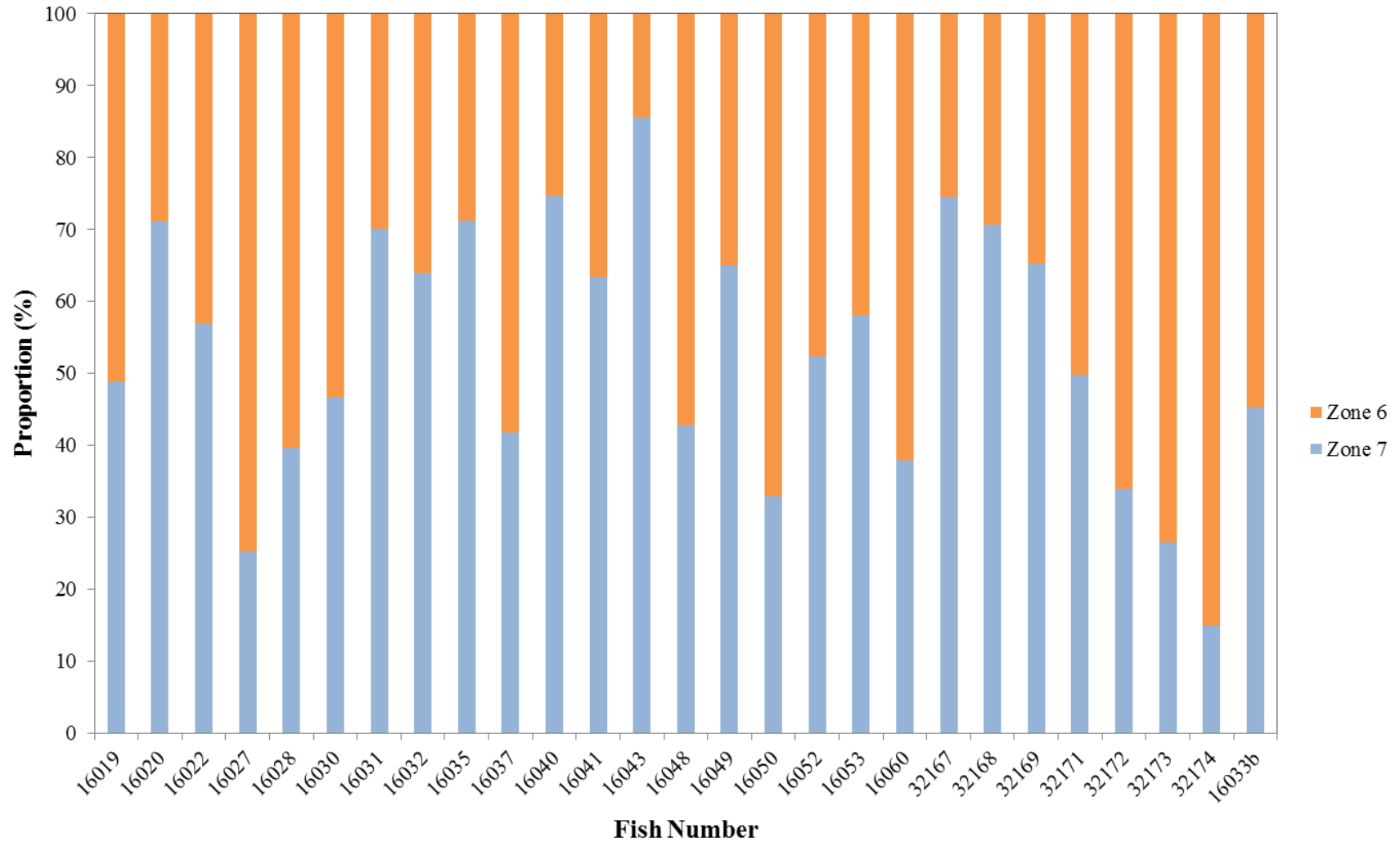


Figure 13: Proportional distributions by zone, for individual adult Lake Sturgeon tagged with acoustic transmitters in Stephens Lake during a portion of the 2017 open-water period (June 7 to October 16).

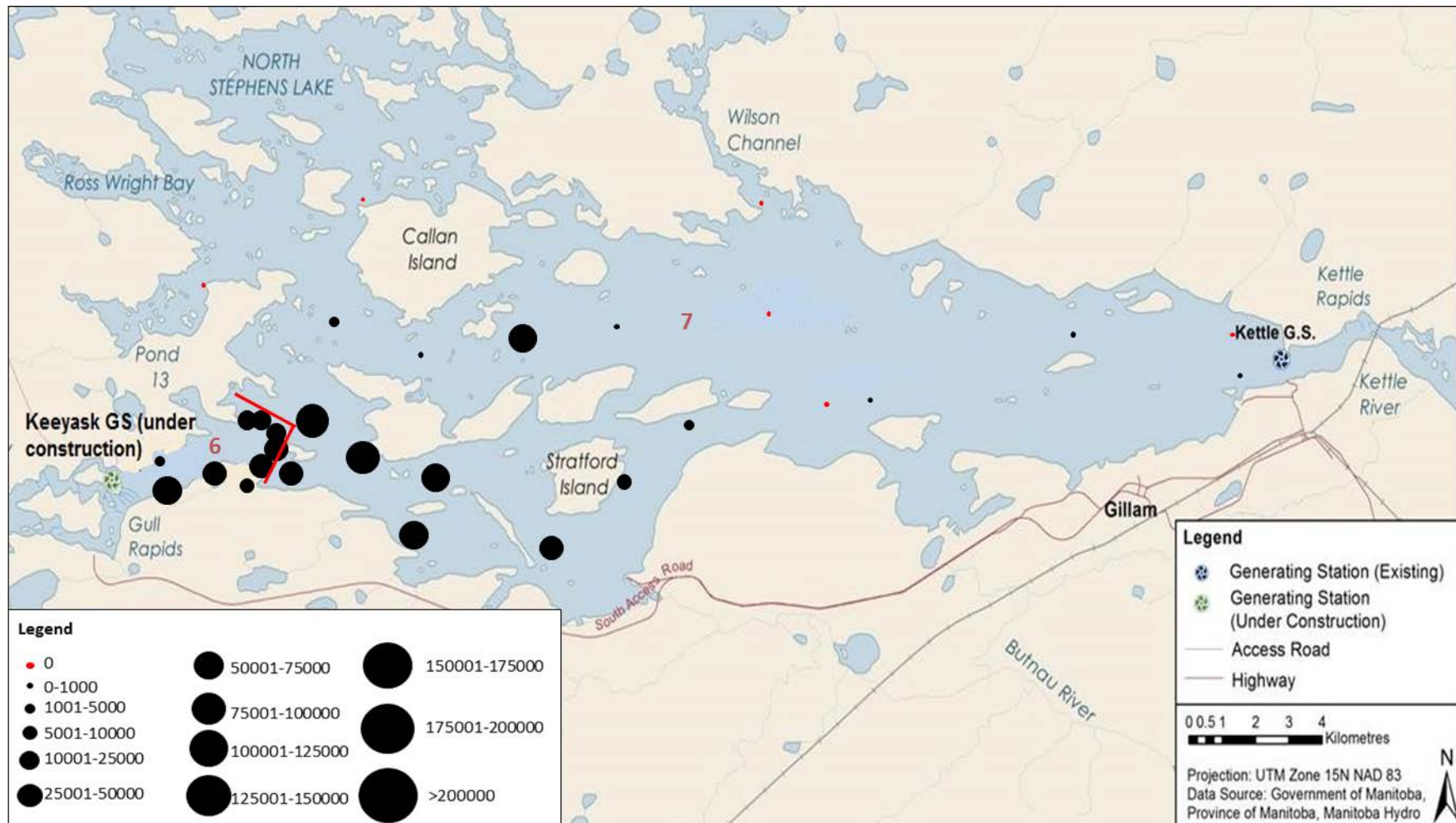


Figure 14: Relative number of detections at each acoustic receiver set in Stephens Lake during the 2017 open-water period (May 1 to October 16). Number of detections indicated by size of circle (defined in legend). Receivers with no detections indicated with red dot. The river is divided into two "zones" based on placement of receiver "gates."

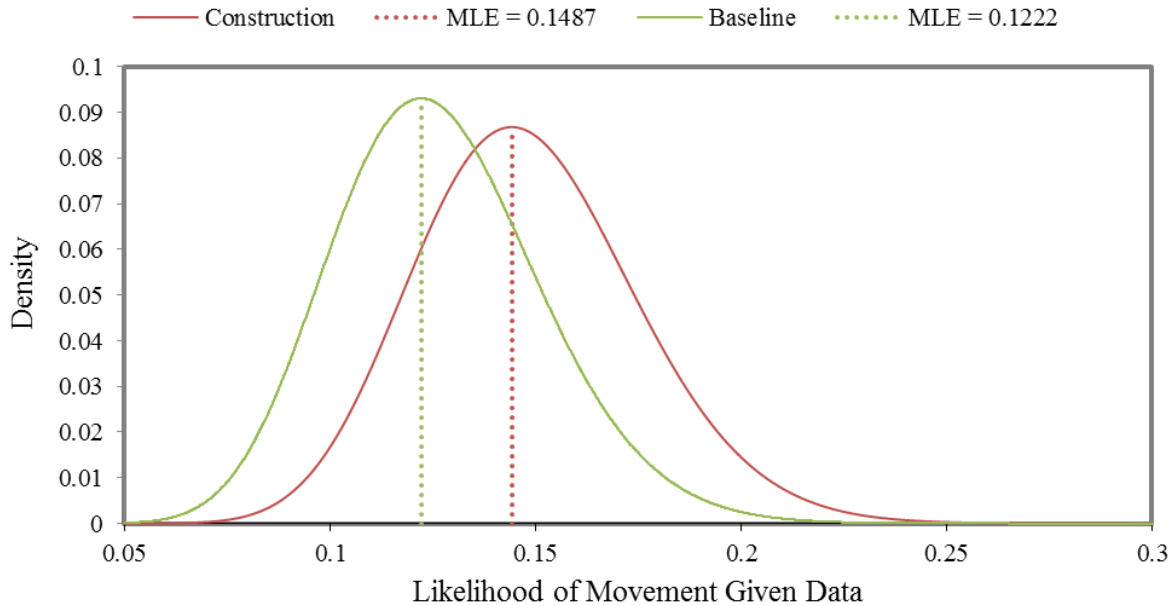


Figure 15: Likelihood of an adult Lake Sturgeon moving between river zones (either upstream or downstream) both before and after the onset of Keeyask construction.

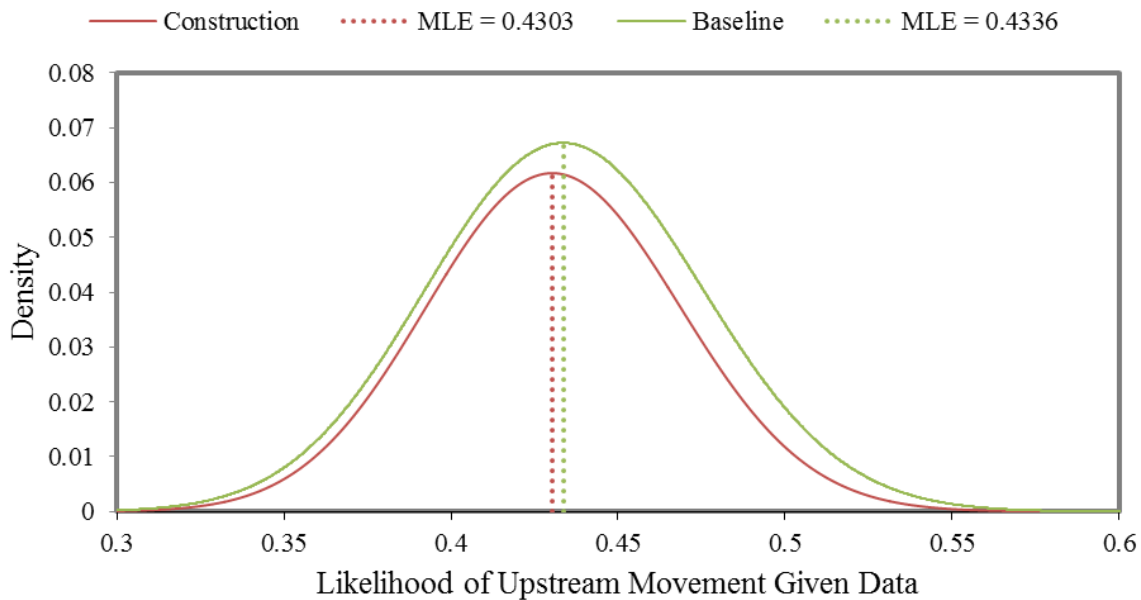


Figure 16: Likelihood that, if an adult Lake Sturgeon moves between river zones, the movement will be upstream both before and after the onset of Keeyask construction.

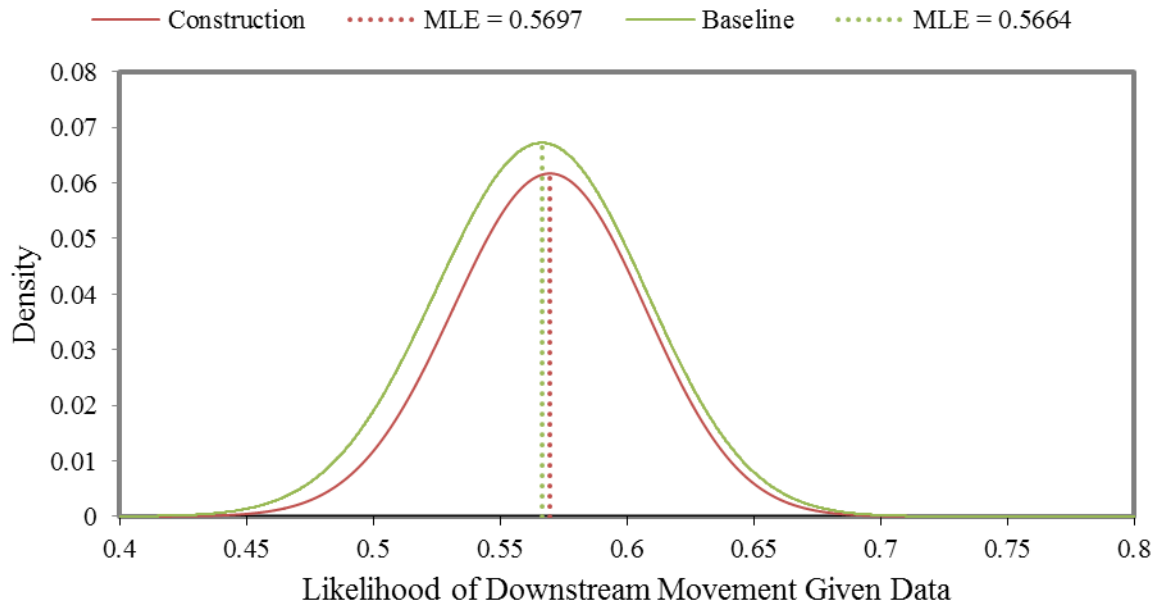


Figure 17: Likelihood that, if an adult Lake Sturgeon moves between river zones, the movement will be downstream both before and after the onset of Keeyask construction.

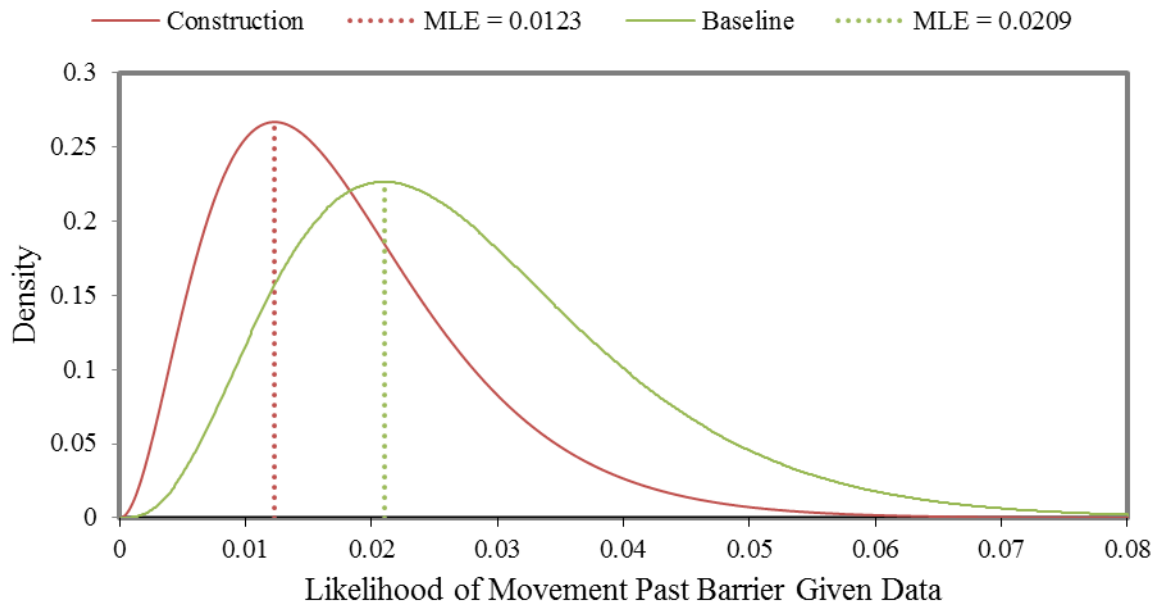
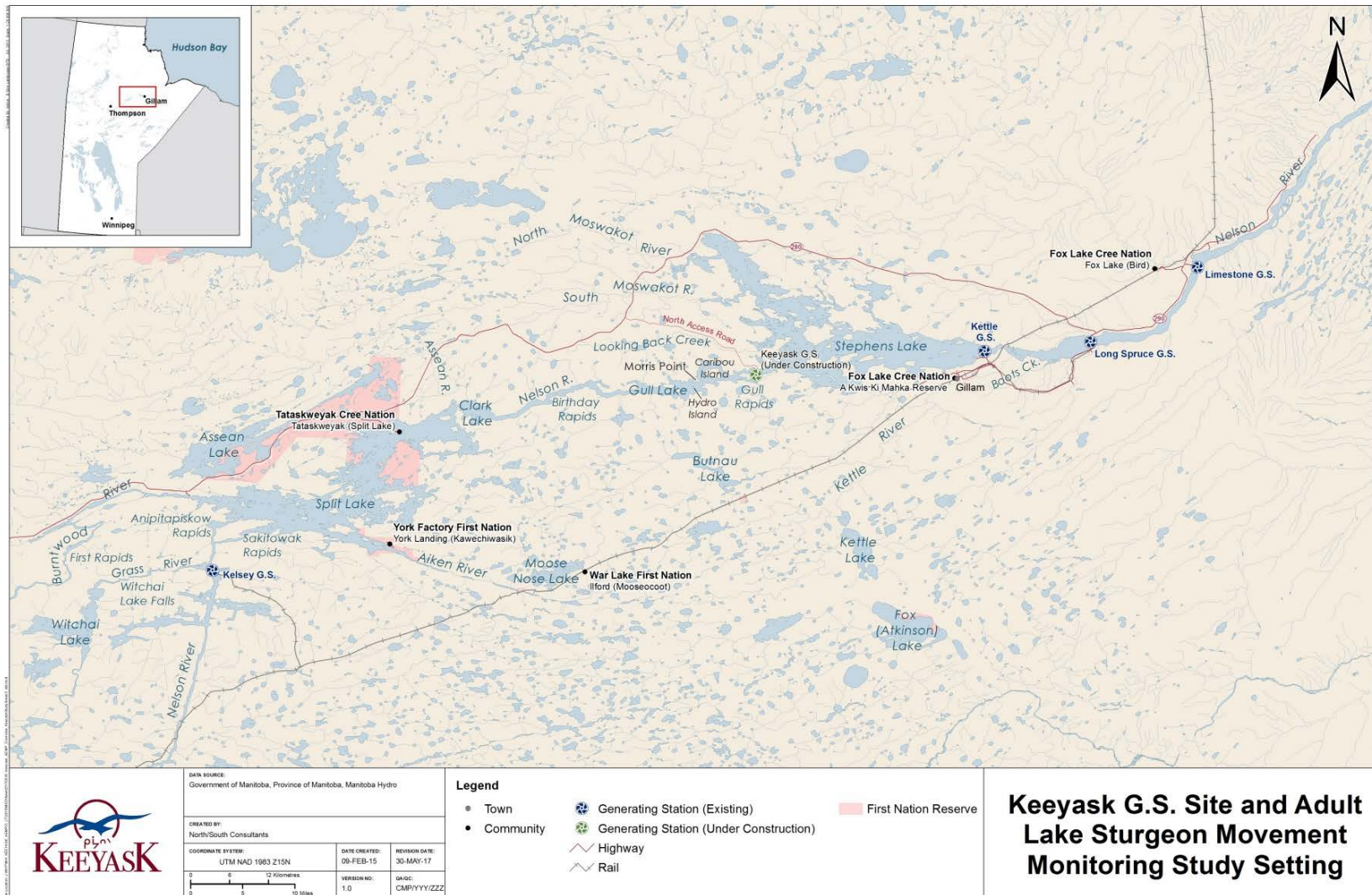


Figure 18: Likelihood of an adult Lake Sturgeon moving past a barrier (either Gull Rapids, Kettle GS, or Long Spruce GS) before and after the onset of Keeyask construction.

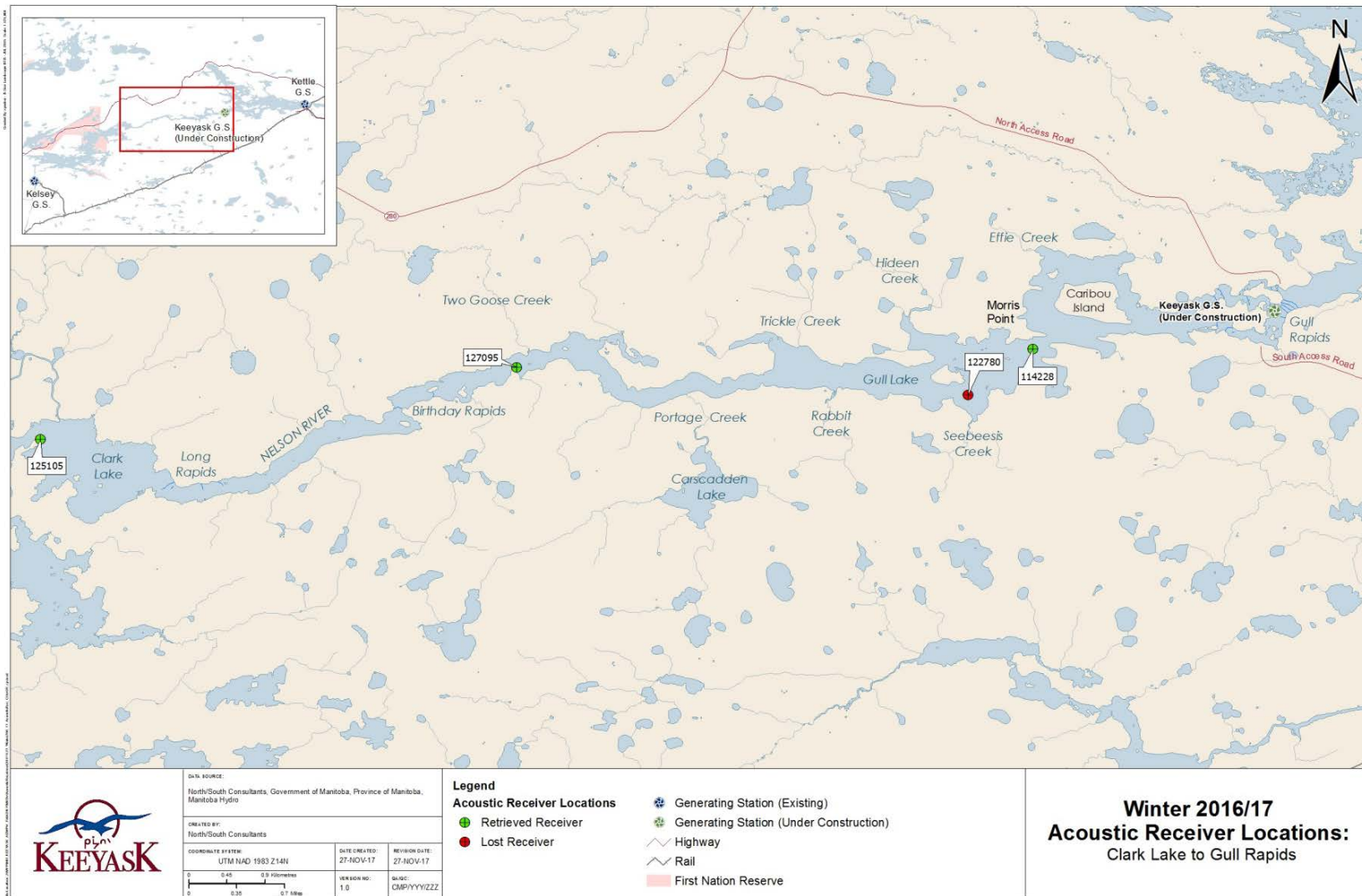
MAPS



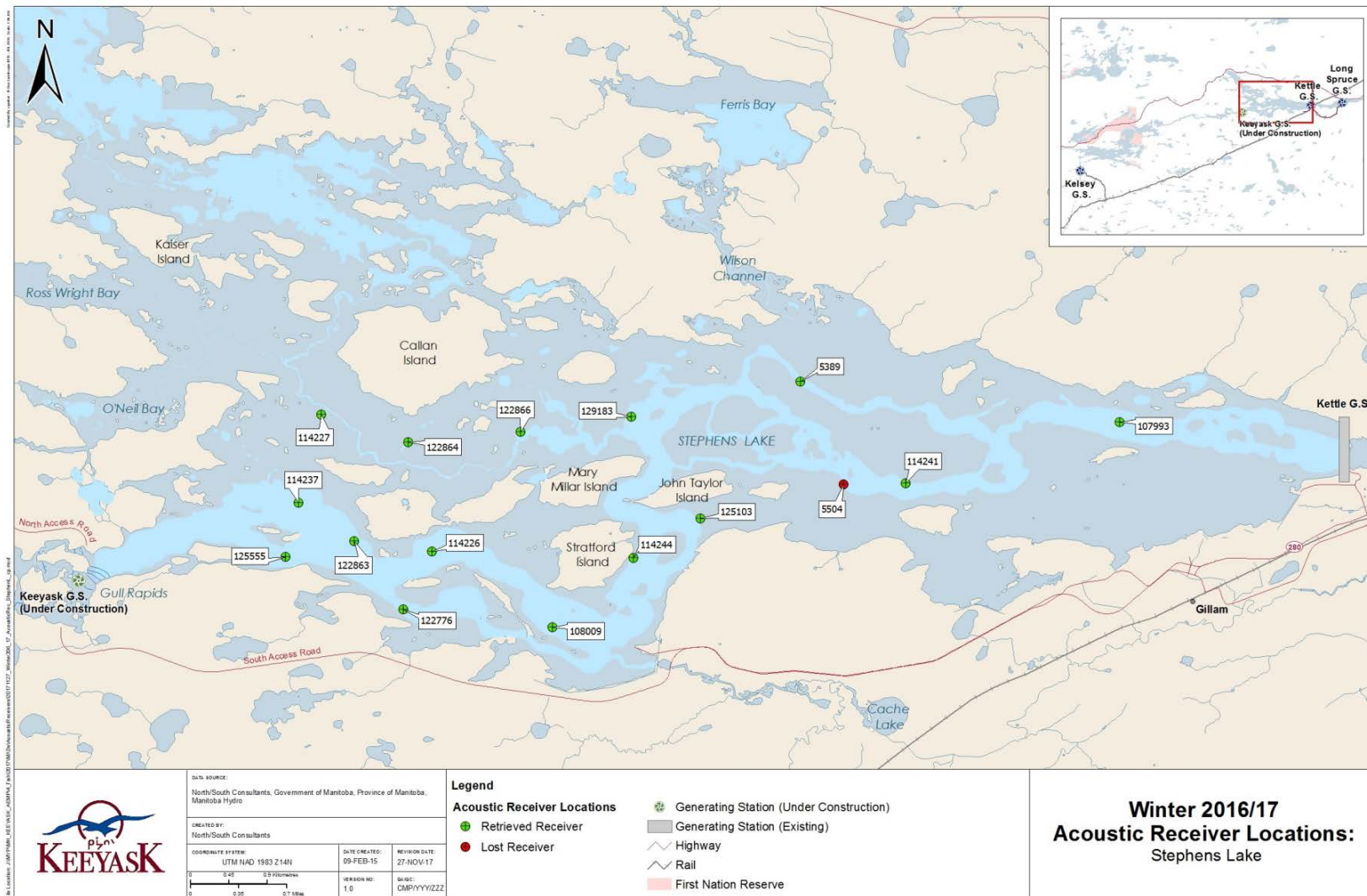
Map 1: Map of the Nelson River showing the site of the Keeyask Generating Station and the adult Lake Sturgeon movement monitoring study setting.



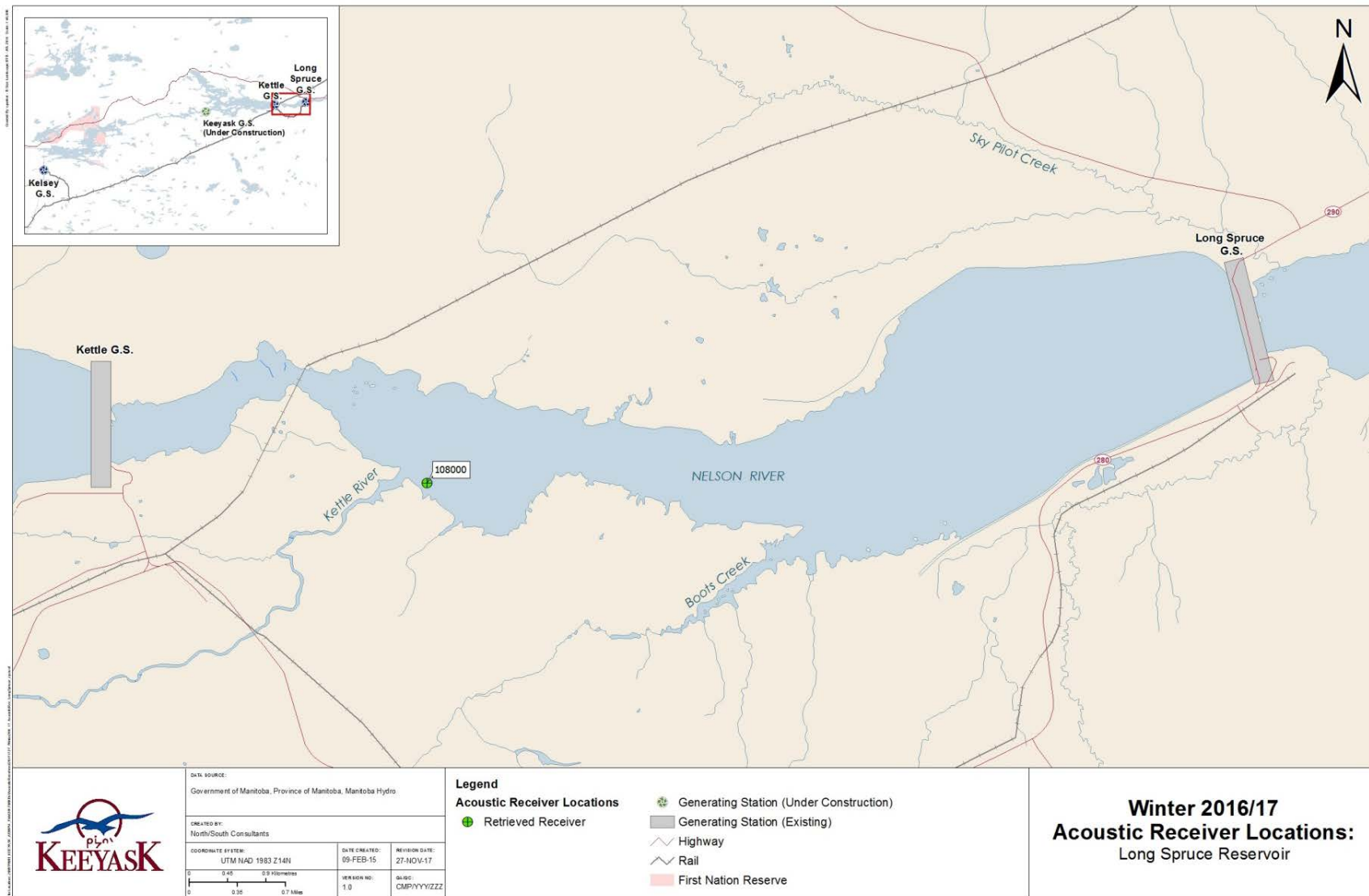
Map 2: Map of instream structures at the Keeyask Generating Station site, 2017.



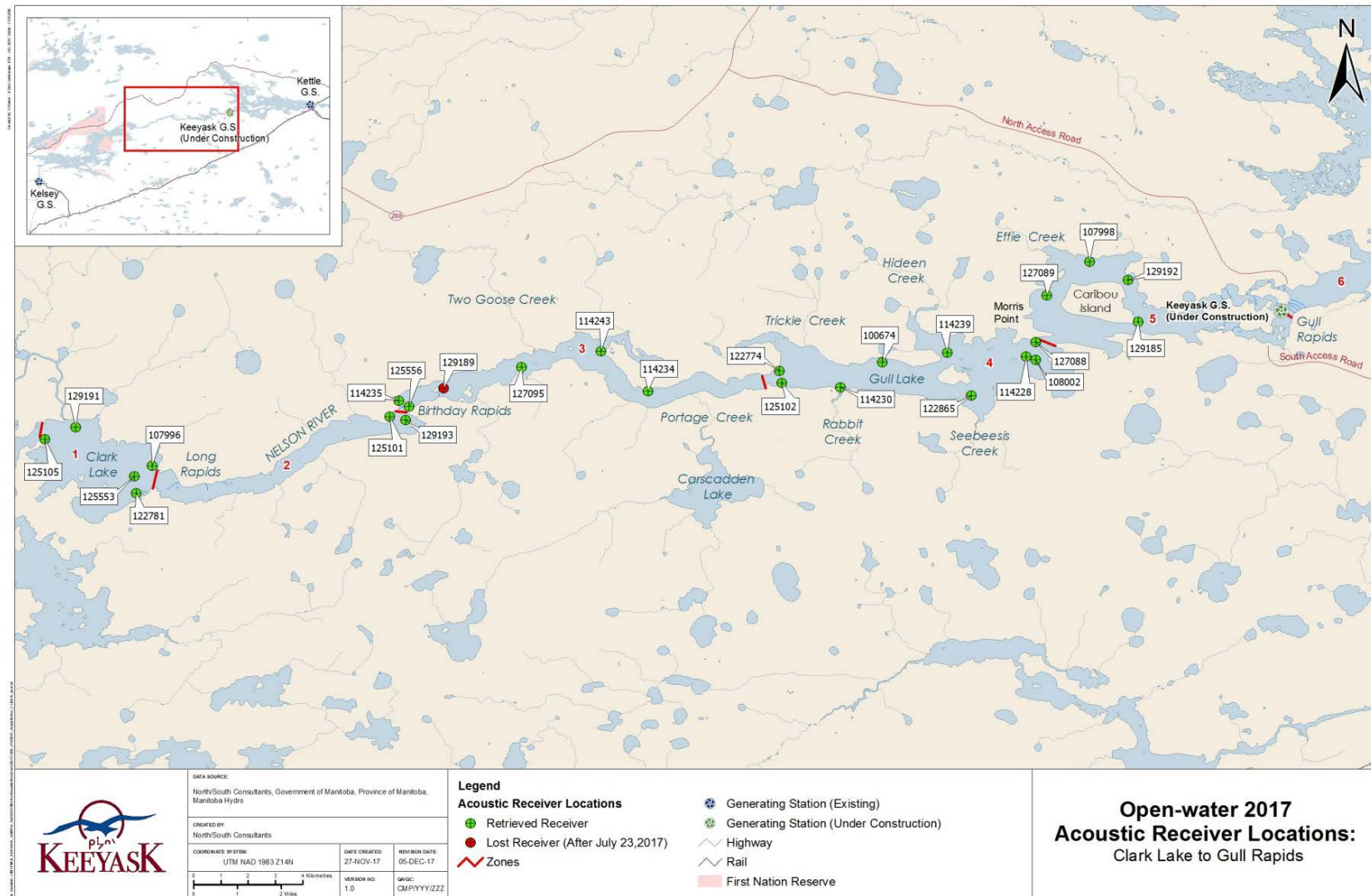
Map 3: Locations of stationary receivers set in the Nelson River from Clark Lake to Gull Rapids between October 2016 and June 2017.



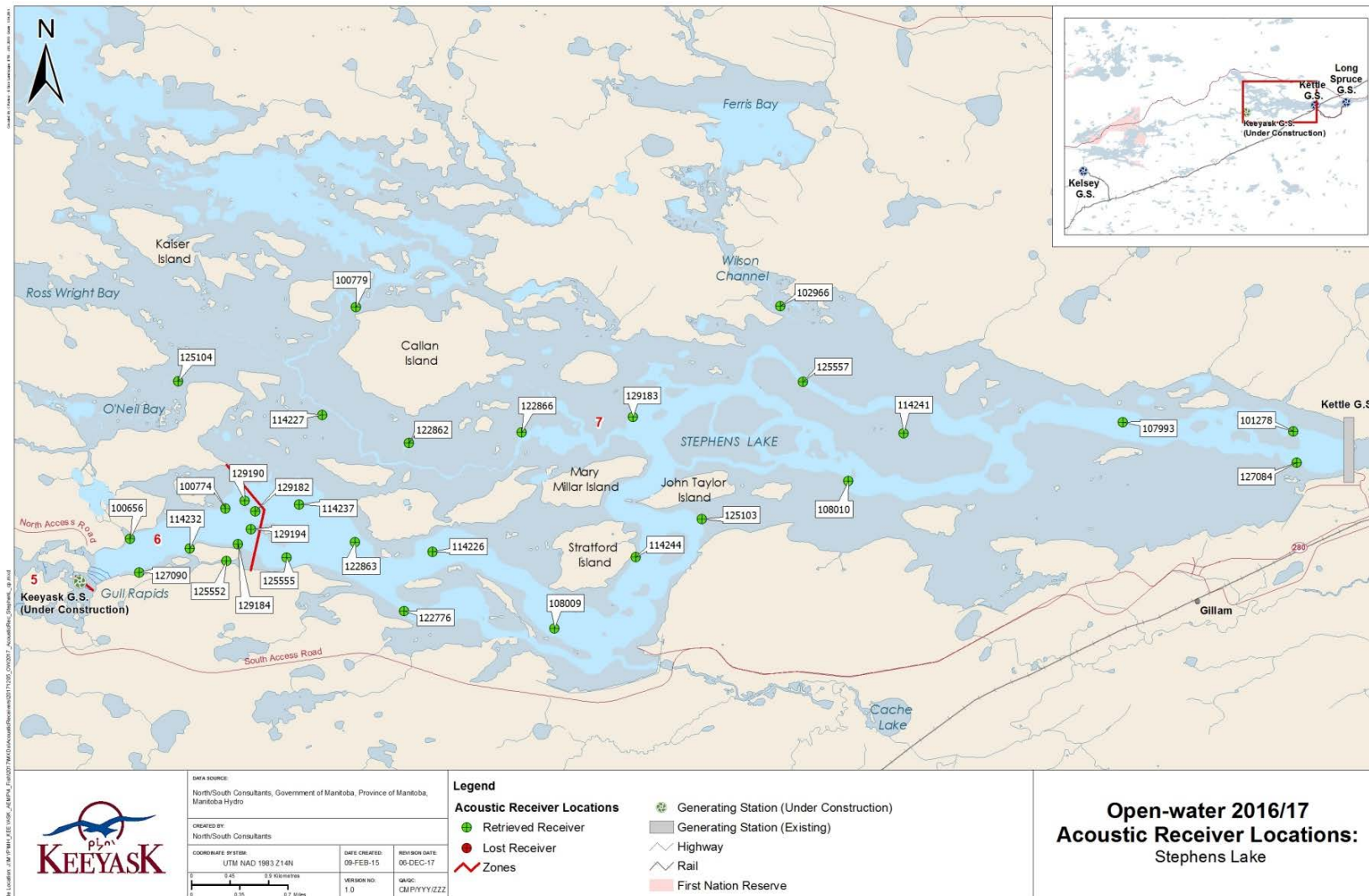
Map 4: Locations of stationary receivers set in Stephens Lake from Gull Rapids to Kettle GS between October 2016 and June 2017. The former (pre-impoundment) river channel is shown in light blue.



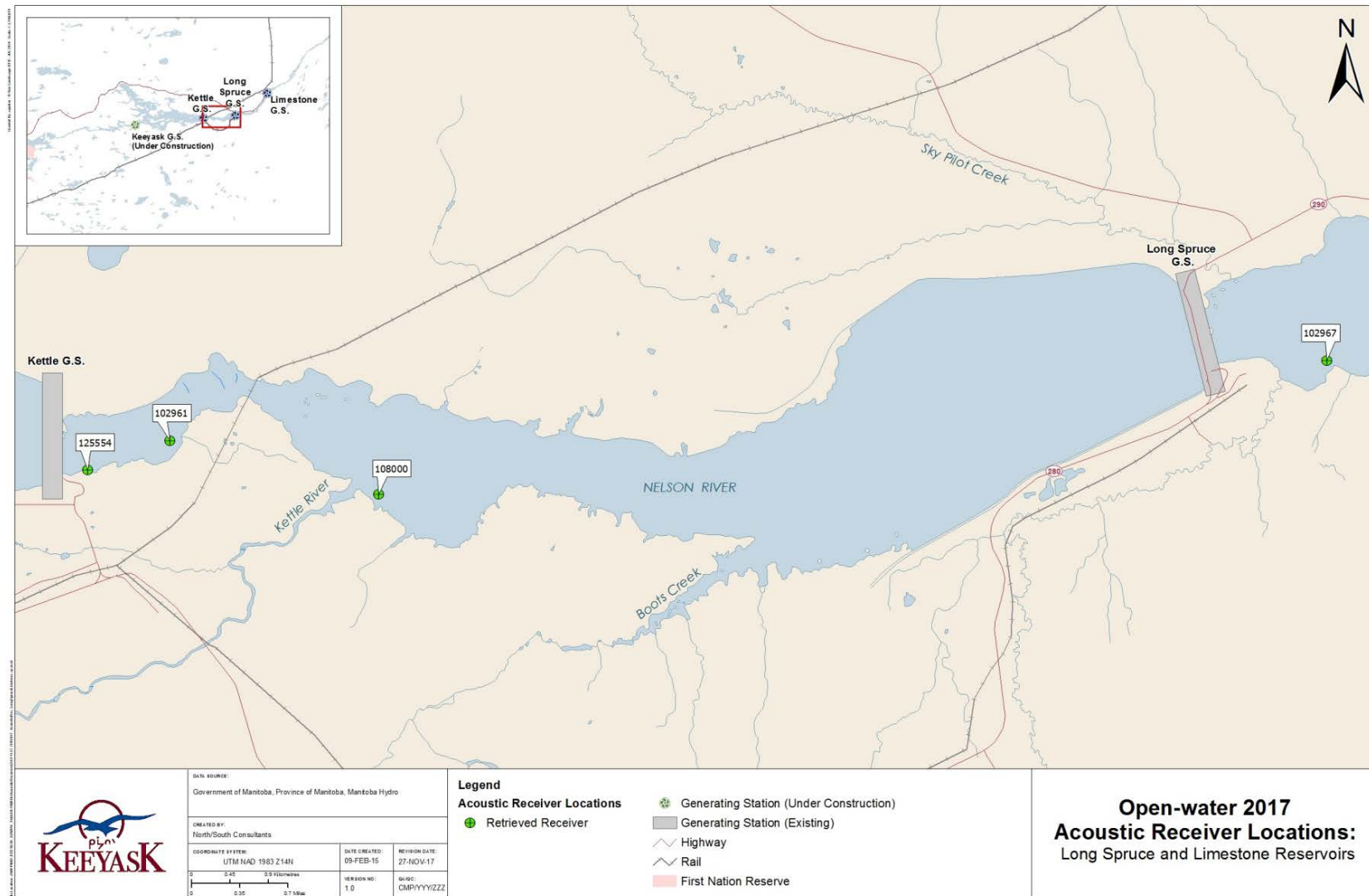
Map 5: Location of the stationary receiver set in the Long Spruce reservoir between October 2016 and June 2017.



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



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



Map 8: Locations of stationary receivers set in the Long Spruce reservoir (Zone 8) between June and October 2016, and in the Limestone reservoir (Zone 9) between July and October 2017.

APPENDICES

APPENDIX 1:

DETECTION SUMMARIES FOR LAKE STURGEON TAGGED AND MONITORED BETWEEN 2011 AND 2017

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

Table A1-1: Detection summary for each of 36 Lake Sturgeon tagged and monitored upstream of Keeyask GS during the winter 2011/2012 (October 20, 2011 to April 30, 2012), 2012/2013 (October 16, 2012 to April 30, 2013), 2013/2014 (October 16, 2013 to April 30, 2014), 2014/2015 (October 13, 2014 to April 30, 2015), 2015/2016 (October 12, 2015 to April 30, 2016), and 2016/2017 (October 20, 2015 to April 30, 2017) periods. Tag id highlighted yellow = lost tags. Tag id highlighted purple = moved downstream through Gull Rapids.

Tag ID	2011/2012			2012/2013			2013/2014			2014/2015			2015/2016			2016/2017				
	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	U/S (rkm)	D/S (rkm)	Range (rkm)
16026	0	-	-	0	-	-	0	-	-	0	-	-	811	3	0.0	0	-	-	-	-
16036	2537	118	3.0	43	12	0.0	2326	52	0.0	362	16	0.0	4663	44	0.0	19532	105	-10.1	-10.1	0.0
16039	0	-	-	0	-	-	502	10	3.0	0	-	-	0	-	-	0	-	-	-	-
16042	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16045	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16048	0	-	-	0	-	-	2932	66	0.0	0	-	-	11672	60	13.3	28566	172	5.2	13.9	8.7
16051	2475	51	0.0	7088	93	0.0	14618	92	3.0	0	-	0	13958	92	3.0	8873	101	-10.1	-10.1	0.0
16054	2772	40	5.1	4027	66	0.0	10807	83	3.0	0	-	0	0	-	-	0	-	-	-	-
16055	0	-	-	0	-	-	0	-	-	0	-	0.0	0	-	-	0	-	-	-	-
16056	8711	176	0.0	1893	63	0.0	13493	87	0.0	0	-	0.0	12493	70	0.0	6661	102	-10.1	-10.1	0.0
16057	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16058	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16059	0	-	-	0	-	-	0	-	-	0	-	0.0	0	-	-	0	-	-	-	-
16060	11406	138	0.0	4354	75	0.0	25171	137	0.0	0	-	0.0	12623	76	0.0	8361	82	5.2	7.9	2.7
16061	13225	94	4.3	1157	71	0.0	18018	115	0.0	140	11	0.0	16584	98	0.0	911	26	-10.1	-10.1	0.0
16062	5943	148	0.0	2495	48	0.0	9079	120	0.0	0	-	0.0	12485	88	0.0	12753	107	-10.1	-10.1	0.0
16063	7905	134	5.1	3650	60	0.0	6098	84	0.0	739	10	0.0	17893	101	0.0	14630	106	-10.1	-10.1	0.0
16064	6717	139	0.0	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16065	3485	129	0.0	0	-	-	0	-	-	0	-	0.0	0	-	-	0	-	-	-	-
16066	0	-	-	0	-	-	0	-	-	0	-	0.0	12928	84	0.0	0	-	-	-	-
16067	4542	149	3.0	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16068	272	15	3.0	5623	73	0.0	22744	129	0.0	0	-	0.0	32671	142	0.0	17400	106	-10.1	-10.1	0.0
16069	0	-	-	0	-	-	678	4	0.0	0	-	-	20	2	0.0					0.0
16070	12833	184	0.0	2	1	0.0	33086	118	0.0	0	-	-	2	1	0.0	23	6	-10.1	-10.1	0.0
16071	7247	122	0.0	2351	38	0.0	11439	95	0.0	0	-	0.0	21854	118	0.0	7883	102	-10.1	-10.1	0.0
16072	11220	174	0.0	11687	96	0.0	27653	142	3.0	958	5	0.0	10157	74	0.0	17250	108	-10.1	-10.1	0.0
16073	2647	51	3.0	3284	66	0.0	1213	18	0.0	800	6	3.4	761	17	0.0	170	15	-10.1	-10.1	0.0
16074	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16075	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16076	0	-	-	0	-	-	0	-	-	0	-	0.0	0	-	-	11940	102	-10.1	-10.1	0.0
16077	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
32174	-	-	-	-	-	-	-	-	-	0	-	0.0	988	36	0.0	0	-	-	-	-
32175	-	-	-	-	-	-	-	-	-	0	-	-	0	-	-	6228	75	-10.1	-10.1	0.0
32176	-	-	-	-	-	-	-	-	-	0	-	0.0	13046	87	0.0	13507	103	-10.1	-10.1	0.0
32177	-	-	-	-	-	-	-	-	-	0	-	0.0	0	-	-	0	-	-	-	-

Table A1-2: Detection summary for each of 35 Lake Sturgeon tagged and monitored in Stephens Lake during the winter 2011/2012 (October 20, 2011 to April 30, 2012), 2012/2013 (October 16, 2012 to April 30, 2013), 2013/2014 (October 16, 2013 to April 30, 2014), 2014/2015 (October 13, 2014 to April 30, 2015), 2015/2016 (October 12, 2015 to April 30, 2016), and 2016/2017 (October 20, 2015 to April 30, 2017) periods. Tag id highlighted green = moved upstream over Gull Rapids and harvested. Tag id highlighted blue = moved upstream over Gull Rapids. Tag id highlighted yellow = lost tags. Tag id highlighted red = moved downstream through Kettle GS. Tag id highlighted purple = moved downstream through Gull Rapids. Tag id highlighted orange = moved downstream through Long Spruce GS.

Tag ID	2011/2012			2012/2013			2013/2014			2014/2015			2015/2016			2016/2017				
	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	U/S (rkm)	D/S (rkm)	Range (rkm)
16018	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16019	0	-	-	887	39	0.6	2959	33	8.8	8761	79	2.8	14035	107	13.3	34307	144	5.2	13.9	8.7
16020	0	-	-	3625	25	9.5	24335	102	8.8	6183	36	7.2	36598	188	7.2	40522	181	5.2	13.9	8.7
16021	16475	79	29.2	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16022	0	-	-	1227	15	9.5	7508	83	4.1	10649	55	7.2	45870	197	7.2	21329	149	5.2	10.3	5.1
16024	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16025	0	-	-	1974	47	0.0	20670	114	0.0	0	-	-	0	-	-	0	-	-	-	-
16027	0	-	-	3398	70	4.3	2111	24	1.6	23369	120	2.8	50070	189	13.3	17718	175	5.2	9.4	4.2
16028	0	-	-	733	7	9.5	2123	8	14.9	21803	84	2.8	59177	199	2.5	5377	104	5.2	10.3	5.1
16029	1937	39	9.7	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16030	12583	70	3.9	13733	89	4.3	2887	63	8.8	8872	97	7.2	24440	160	7.2	29177	156	5.2	9.4	4.2
16031	0	-	-	7414	26	3.8	45513	147	0.0	36654	117	0.0	58954	198	0.0	537	26	13.9	13.9	0.0
16032	48676	67	3.1	2284	23	2.4	3780	48	8.8	4759	53	2.5	36289	190	4.7	39506	164	7.9	13.9	6.0
16033	125	3	2.3	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-
16033b	-	-	-	-	-	-	15689	104	7.3	3243	42	7.2	34665	149	7.2	17885	68	5.2	10.3	5.1
16034	39927	61	20.2	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16035	7225	84	3.1	22099	113	2.4	29174	179	12.6	14317	83	2.8	60418	202	7.2	26922	190	5.2	9.4	4.2
16037	36948	77	3.9	991	18	4.3	24601	133	3.0	10762	61	2.8	4277	21	2.5	1551	17	5.2	13.9	8.7
16038	14187	69	10.5	9	2	0.0	106	8	0.0	4	2	0.0	0	-	-	0	-	-	-	-
16040	18814	85	3.9	23113	104	2.4	4436	21	12.6	5033	26	2.5	29413	189	2.5	39264	189	5.2	9.4	4.2
16041	135	11	0.0	4328	25	3.8	16656	153	4.1	16912	74	2.5	30740	174	0.0	22473	119	7.9	13.9	6.0
16043	6989	49	17.1	10520	95	16.0	16074	114	10.8	36372	188	10.8	17192	188	13.3	10142	166	5.2	18.6	13.4
16044	9036	57	21.0	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16046	6972	85	3.1	248	25	0.0	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16047	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16049	20859	75	3.9	32364	157	4.3	24241	140	8.8	9993	101	2.8	18078	144	7.2	31523	176	5.2	13.9	8.7
16050	345	3	0.0	18070	65	3.8	2920	50	10.8	8473	55	6.1	44567	169	4.7	23677	172	13.9	13.9	0.0
16052	143	4	9.6	6505	78	7.6	34688	173	0.0	18189	165	11.0	49267	186	13.3	13313	124	13.9	13.9	0.0
16053	2960	31	3.1	776	10	11.4	2209	20	14.9	7018	46	2.5	68422	200	2.5	26653	140	5.8	10.3	4.5
32167	-	-	-	-	-	-	-	-	-	293	14	0.0	37839	187	7.2	30174	143	7.9	13.9	6.0
32168	-	-	-	-	-	-	-	-	-	19931	142	13.3	47809	189	2.5	24622	74	5.2	13.9	8.7
32169	-	-	-	-	-	-	-	-	-	444	6	2.5	51598	201	7.2	4141	22	5.2	13.9	8.7
32170	-	-	-	-	-	-	-	-	-	3328	69	2.8	0	-	-	47	2	5.2	7.9	2.7
32171	-	-	-	-	-	-	-	-	-	3275	24	13.3	53443	182	7.2	30627	156	5.2	10.3	5.1
32172	-	-	-	-	-	-	-	-	-	8293	37	11.0	1455	13	7.2	9761	68	5.2	7.9	2.7
32173	-	-	-	-	-	-	-	-	-	3843	49	2.5	45871	157	2.5	46475	145	5.2	9.4	4.2

Table A1-3: Detection summary for each of 35 Lake Sturgeon tagged and monitored upstream of Keeyask GS during the open-water 2011 (June 1 to October 20), 2012 (May 1 to October 16), 2013 (May 1 to October 16), 2014 (May 1 to October 13), 2015 (May 1 to October 11), 2016 (May 1 to October 19), and 2017 (May 1 to October 16) periods. Tag id highlighted yellow = lost tags. Tag id highlighted purple = moved downstream through Gull Rapids.

Tag ID	2011			2012			2013			2014			2015			2016			2017				
	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	U/S (rkm)	D/S (rkm)	Range (rkm)
16026	-	-	-	23195	83	9.4	12588	83	0.0	13090	103	0.0	29896	103	7.3	28343	128	7.3	18137	119	-26.5	-11.9	14.6
16036	2152	32	8.6	6980	86	9.4	5328	82	8.1	12362	112	10.0	20379	132	9.6	16678	140	10.2	11145	102	-19.5	-7.4	12.1
16039	2260	42	13.3	5250	66	12.5	16487	107	11.3	12670	120	11.6	18372	119	10.5	15797	120	13.7	17882	110	-19.5	-5.8	13.7
16042	1914	54	0.0	576	11	0.8	2626	30	3.4	6660	54	3.9	0	-	-	0	-	-	0	-	-	-	-
16045	786	13	7.0	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16048	383	6	1.6	1773	37	0.8	10796	119	21.6	7527	93	21.7	20784	116	36.9	14738	108	22.3	15301	109	1.2	18.6	17.4
16051	1935	76	8.7	5804	105	15.3	8015	115	13.4	10404	57	13.7	10706	126	26.5	8157	96	13.7	8451	85	-17.4	-5.8	11.6
16054	2697	49	12.0	4278	101	10.6	11062	105	9.5	7102	93	12.1	17220	90	38.7	9099	114	23.9	5602	33	-48.2	-26.5	21.7
16055	1140	9	3.4	1384	27	5.7	8271	89	4.9	7657	86	10.0	5005	104	5.5	12401	92	5.5	8824	108	-19.5	-5.8	13.7
16056	234	12	19.1	4665	87	10.6	12862	96	19.5	17163	115	10.0	18319	113	20.4	29142	135	23.6	16839	88	-29.4	-9.3	20.1
16057	475	25	4.2	524	29	8.5	0	-	-	2	1	0.0	0	-	-	0	-	-	0	-	-	-	-
16058	549	16	9.3	1071	4	9.7	0	-	-	0	-	-	0	-	-	418	13	3.9	1169	38	-48.2	-44.3	3.9
16059	599	5	3.4	1696	32	10.4	13935	78	11.3	10991	57	5.1	4708	85	13.7	7570	59	3.5	6223	64	-10.1	-5.8	4.3
16060	1759	43	7.1	4065	95	8.7	16366	124	7.1	13228	108	7.1	19911	115	7.4	8653	73	28.5	18575	115	1.2	13	11.8
16061	711	37	2.4	4444	108	13.6	11503	114	5.5	7437	95	3.4	13771	111	13.7	15840	120	13.7	8642	79	-19.5	-5.8	13.7
16062	142	14	8.6	5624	86	12.4	16854	109	24.4	18336	129	7.9	19949	120	10.0	26029	145	10.0	18277	117	-19.5	-5.8	13.7
16063	2617	59	10.4	9474	105	5.7	21588	126	9.3	23121	127	7.9	24981	137	10.0	28915	163	10.0	24788	121	-19.5	-9.5	10.0
16064	1910	27	19.1	573	26	1.2	0	-	-	0	-	-	0	-	-	5	2	0.0	0	-	-	-	-
16065	931	36	4.5	6192	109	17.9	2581	38	5.1	3101	38	5.1	14349	104	28.0	7730	73	4.3	3061	62	-19.5	-5.8	13.7
16066	772	39	1.8	4615	105	10.6	2322	36	8.1	8898	73	12.1	1884	20	7.9	6940	104	13.7	10910	94	-11.9	-5.8	6.1
16067	1640	34	1.6	2516	39	31.7	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16068	1046	27	2.4	5882	105	10.6	10402	111	23.9	13158	121	10.0	16490	123	10.0	20273	135	13.7	13842	118	-19.5	-9.5	10.0
16069	0	-	-	17495	85	4.5	13288	100	7.3	14172	66	2.9	8287	80	10.0	24559	122	5.1	18718	92	-33.8	-26.5	7.3
16070	1080	40	8.6	14691	106	17.0	7943	89	9.6	9967	83	9.6	12593	101	10.0	4083	80	13.7	3202	80	-19.5	-9.5	10.0
16071	1403	43	8.6	9124	89	10.6	11285	130	9.3	17413	102	12.1	39272	131	13.7	37521	151	9.9	31215	124	-19.5	-5.8	13.7
16072	2839	58	12.9	4031	91	10.6	16638	129	19.5	19306	112	7.9	15866	127	10.0	6608	129	10.0	16299	127	-12.8	-9.5	3.3
16073	1025	35	2.4	4432	102	12.4	6885	94	9.3	13884	127	10.0	4500	73	13.7	25145	151	13.7	10316	113	-19.5	-5.8	13.7
16074	0	-	-	13006	67	4.7	11803	78	2.9	3105	23	7.3	655	13	15.9	2889	25	3.9	2957	24	-48.2	-44.5	3.7
16075	462	10	6.3	0	-	-	0	-	-	0	-	-	865	35	4.3	0	-	-	0	-	-	-	-
16076	1040	35	6.3	2225	56	9.4	9270	81	11.3	9075	84	11.6	12474	79	11.6	27013	118	9.0	16851	94	-10.1	13.9	24.0
16077	282	5	0.0	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
32174	-	-	-	-	-	-	-	-	-	9705	98	28.5	20042	118	42.4	15062	82	28.9	11336	60	1.2	13.9	12.7
32175	-	-	-	-	-	-	-	-	-	9186	90	6.0	22601	114	5.3	48213	134	3.4	32547	133	-14.8	-9.5	5.3
32176	-	-	-	-	-	-	-	-	-	22630	106	11.6	15054	109	26.5	23822	111	7.1	32410	125	-12.8	-5.8	7.0
32177	-	-	-	-	-	-	-	-	-	20678	109	5.5	265	15	0.6	0	-	-	0	-	-	-	-

Table A1-4: Detection summary for each of 35 Lake Sturgeon tagged and monitored in Stephens Lake during the open-water 2011 (June 1 to October 20), 2012 (May 1 to October 16), 2013 (May 1 to October 16), 2014 (May 1 to October 13), 2015 (May 1 to October 11), 2016 (May 1 to October 19), and 2017 (May 1 to October 16) periods. Tag id highlighted green = moved upstream over Gull Rapids and harvested. Tag id highlighted blue = moved upstream over Gull Rapids. Tag id highlighted yellow = lost tags. Tag id highlighted red = moved downstream through Kettle GS. Tag id highlighted purple = moved downstream through Gull Rapids. Tag id highlighted orange = moved downstream through Long Spruce GS.

Tag ID	2011			2012			2013			2014			2015			2016			2017				
	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	U/S (rkm)	D/S (rkm)	Range (rkm)
16018	-	-	-	341	5	34.5	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16019	-	-	-	9272	70	26.9	15039	116	18.2	13297	76	39.5	20832	129	27.0	17331	117	22.3	18192	117	1.2	18.6	17.4
16020	-	-	-	7450	101	11.9	13664	99	14.2	8592	111	19.7	25808	137	19.7	29291	155	17.4	19304	150	1.2	24.7	23.5
16021	2770	21	14.2	4530	30	5.0	0	-	-	0	-	-	0	-	-	1331	18	1.0	0	-	-	-	-
16022	-	-	-	9845	100	16.0	7248	71	20.5	10957	101	20.5	18858	127	16.1	12608	124	22.3	13393	120	1.2	18.6	17.4
16024	-	-	-	398	9	4.0	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16025	-	-	-	2316	67	35.2	9668	119	10.2	1572	23	60.4	0	-	-	0	-	-	0	-	-	-	-
16027	-	-	-	8249	87	16.0	15717	109	14.4	10960	72	9.7	14083	114	13.6	22348	148	9.0	22812	125	1.2	10.3	9.1
16028	-	-	-	9063	92	16.3	98	8	3.7	6174	58	17.4	16344	108	17.7	19657	109	12.7	29657	142	1.2	16.8	15.6
16029	3801	62	58.1	6087	102	19.9	4940	83	10.2	13325	102	16.0	8716	94	10.2	5821	101	20.1	12873	85	-19.5	-9.3	10.2
16030	7733	86	15.5	6414	86	14.4	13494	86	25.5	16498	104	27.4	15935	94	17.7	10843	118	34.9	16302	127	1.2	36.1	34.9
16031	-	-	-	12814	104	16.3	10315	106	14.4	12775	99	13.6	17780	125	13.6	18745	141	15.6	14795	131	1.2	13.9	12.7
16032	5801	56	14.2	13833	120	16.0	17055	115	19.7	16765	118	18.2	11985	106	16.1	18322	116	17.5	29122	157	1.2	18.6	17.4
16033	5144	44	14.2	3001	43	37.5	0	-	-	-	-	-	-	-	-	0	-	-	0	-	-	-	-
16033b	-	-	-	-	-	-	3505	30	12.4	13578	101	17.4	28621	127	16.1	21058	118	17.4	27766	127	1.2	13.9	12.7
16034	15378	75	11.2	15394	61	2.2	38582	117	0.8	25117	99	4.8	30925	119	0.8	10170	70	15.9	13	2	58.6	58.6	0.0
16035	1547	12	10.9	8767	91	14.4	19324	116	20.3	16298	121	19.7	23142	119	17.7	19523	133	23.5	27311	149	1.2	18.6	17.4
16037	8375	50	7.4	13685	108	11.9	21481	125	44.3	13636	91	47.2	17230	113	16.1	13411	89	17.4	15203	109	1.2	18.6	17.4
16038	5777	45	11.2	3402	87	31.0	7973	124	9.3	3975	76	10.0	10827	75	12.1	15190	103	10.0	13109	131	-19.5	-9.3	10.2
16040	9602	70	12.5	8598	109	12.0	21959	128	18.0	4833	62	18.2	15041	122	19.7	15740	117	17.4	12642	92	1.2	18.6	17.4
16041	15169	88	11.2	9437	81	40.7	8915	81	14.4	13556	111	14.4	15807	101	16.1	14398	113	13.7	20805	136	1.2	18.6	17.4
16043	20429	92	15.5	13049	98	11.9	12476	115	14.4	13303	118	15.8	20525	131	17.7	22234	122	13.7	18103	135	1.2	18.6	17.4
16044	1582	36	8.7	3932	53	11.9	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16046	8350	72	24.7	199	68	23.5	360	10	7.2	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16047	131	2	19.7	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16049	1919	12	11.2	11705	102	26.9	24320	123	27.7	11319	83	27.4	20752	132	16.1	16056	127	22.3	22073	140	1.2	40.9	39.7
16050	6519	57	15.5	7755	85	11.9	14411	88	14.2	7019	69	19.7	13783	98	13.6	17742	93	13.7	18778	72	1.2	13.9	12.7
16052	1920	17	11.2	4785	80	16.0	9791	65	20.5	8323	68	19.7	10937	96	17.4	13008	113	17.4	19047	127	1.2	18.6	17.4
16053	2740	18	12.5	13416	114	16.0	17049	126	18.2	13586	95	20.5	26058	130	16.1	29704	139	15.6	27363	150	1.2	13.9	12.7
32167	-	-	-	-	-	-	-	-	-	10421	91	20.5	33420	126	16.1	26260	130	22.3	27586	142	1.2	18.6	17.4
32168	-	-	-	-	-	-	-	-	-	18169	100	20.5	34961	140	16.1	27764	134	22.3	35684	132	1.2	18.6	17.4
32169	-	-	-	-	-	-	-	-	-	614	20	2.4	24873	131	15.2	26025	131	17.4	24410	124	1.2	18.6	17.4
32170	-	-	-	-	-	-	-	-	-	5151	77	20.5	17310	127	16.1	13320	103	17.4	0	-	-	-	-
32171	-	-	-	-	-	-	-	-	-	36691	103	17.4	22567	111	16.1	27226	134	17.4	26214	120	1.2	13.9	12.7
32172	-	-	-	-	-	-	-	-	-	19105	86	9.7	17221	108	9.7	19907	110	13.7	23914	93	1.2	9.4	8.2
32173	-	-	-	-	-	-	-	-	-	24278	103	9.7	28920	117	9.7	26056	107	9.1	32014	127	1.2	10.3	9.1

APPENDIX 2:

LOCATION SUMMARY FOR INDIVIDUAL ACOUSTIC TAGGED ADULT LAKE STURGEON, UPSTREAM OF GULL RAPIDS, JUNE 2011 TO OCTOBER 2017

Figure A2-1:	Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16026) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.....	76
Figure A2-2:	Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16036) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.....	77
Figure A2-3:	Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16039) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.....	78
Figure A2-4:	Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16042) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.....	79
Figure A2-5:	Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16045) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.....	80
Figure A2-6:	Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16048) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.....	81
Figure A2-7:	Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16051) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.....	82
Figure A2-8:	Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16054) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.....	83
Figure A2-9:	Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16055) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.....	84
Figure A2-10:	Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16056) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.....	85

Figure A2-11: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16057) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.....	86
Figure A2-12: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16058) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.....	87
Figure A2-13: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16059) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.....	88
Figure A2-14: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16060) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.....	89
Figure A2-15: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16061) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.....	90
Figure A2-16: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16062) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.....	91
Figure A2-17: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16063) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.....	92
Figure A2-18: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16064) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.....	93
Figure A2-19: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16065) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.....	94
Figure A2-20: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16066) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.....	95
Figure A2-21: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16067) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.....	96
Figure A2-22: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16068) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.....	97
Figure A2-23: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16069) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.....	98

Figure A2-24: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16070) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.....	99
Figure A2-25: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16071) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.....	100
Figure A2-26: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16072) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.....	101
Figure A2-27: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16073) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.....	102
Figure A2-28: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16074) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.....	103
Figure A2-29: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16075) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.....	104
Figure A2-30: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16076) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.....	105
Figure A2-31: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16077) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.....	106
Figure A2-32: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32174) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.....	107
Figure A2-33: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32175) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.....	108
Figure A2-34: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32176) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.....	109
Figure A2-35: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32177) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.....	110

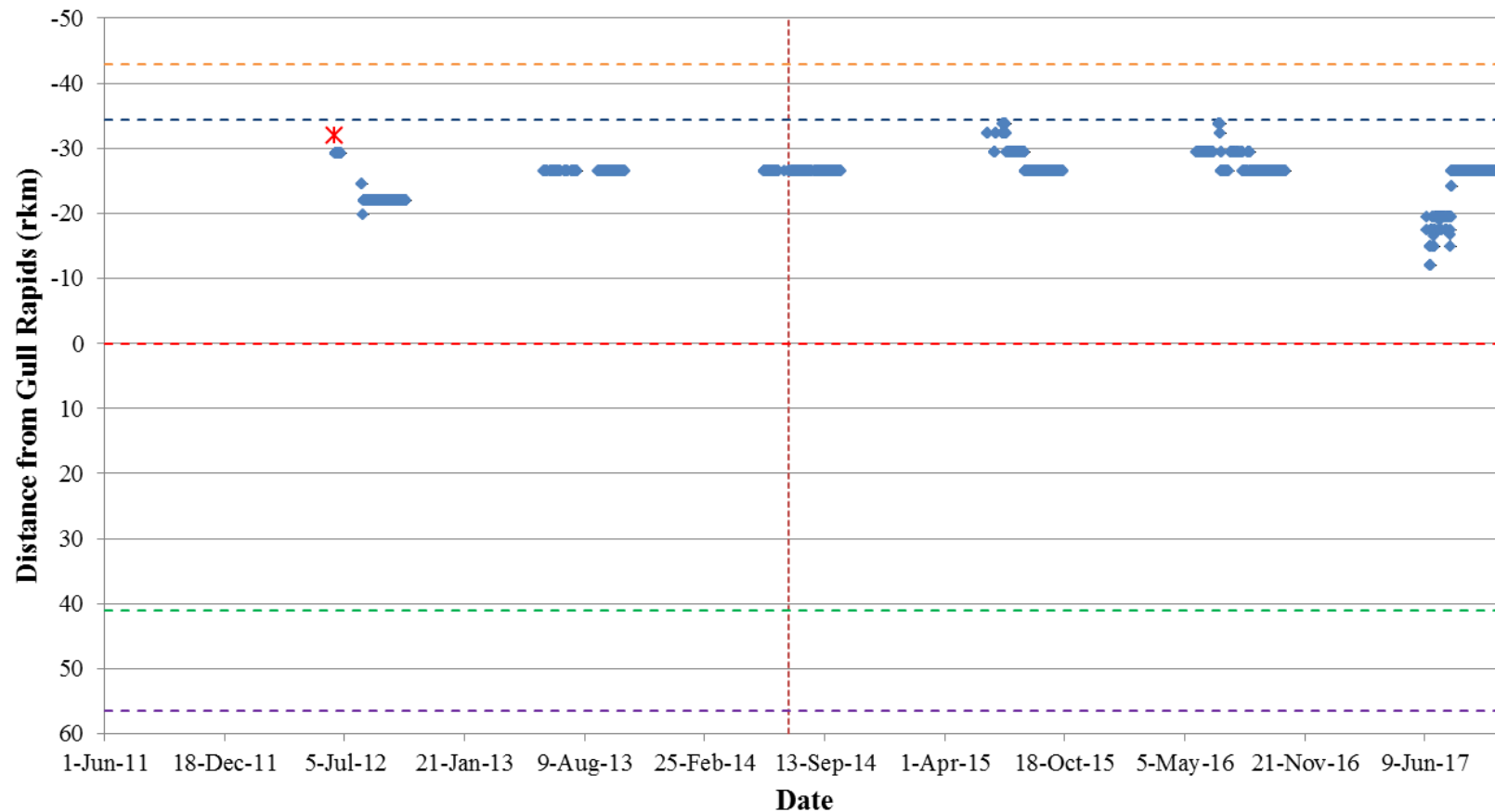


Figure A2-1: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16026) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

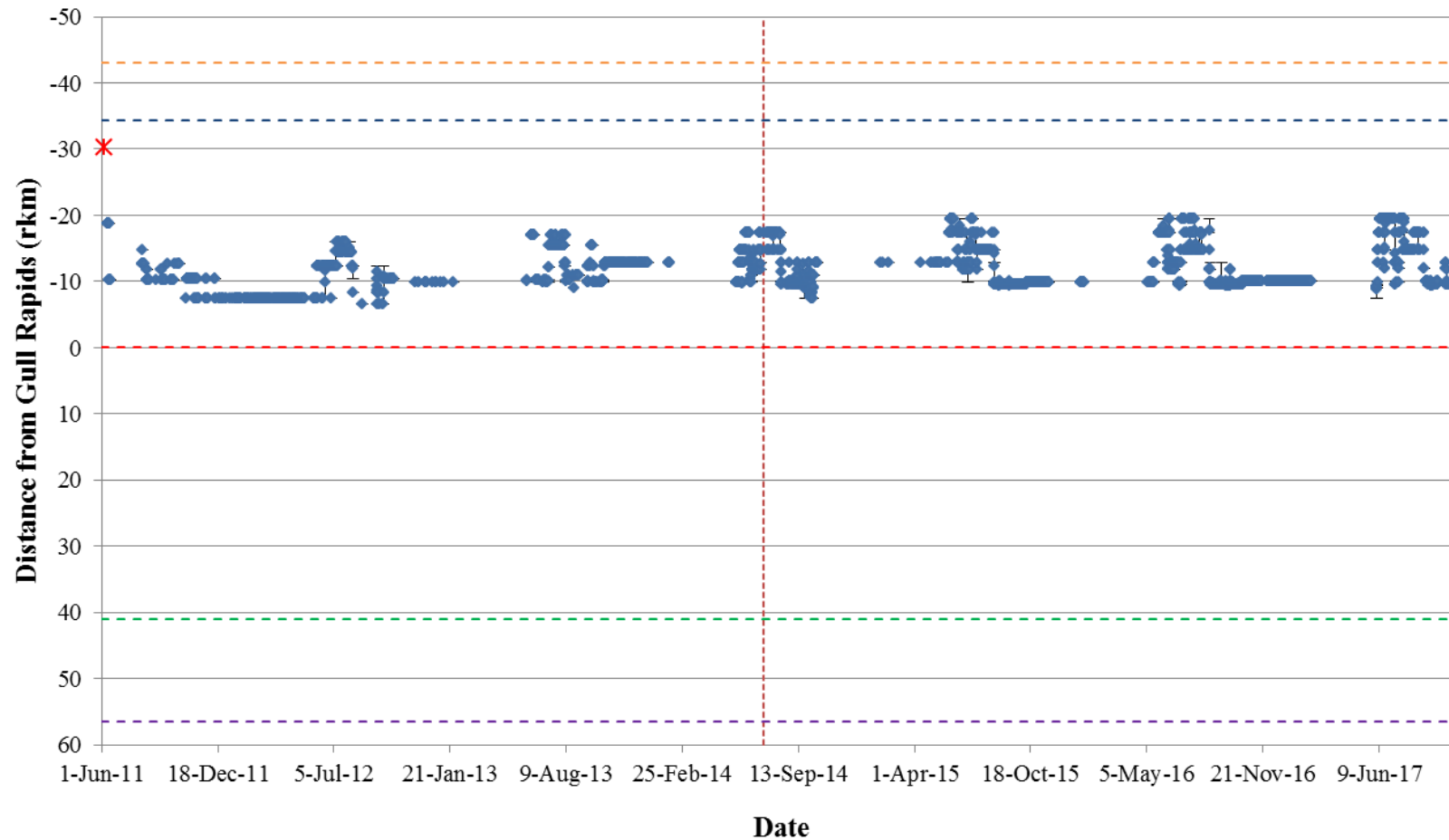


Figure A2-2: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16036) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

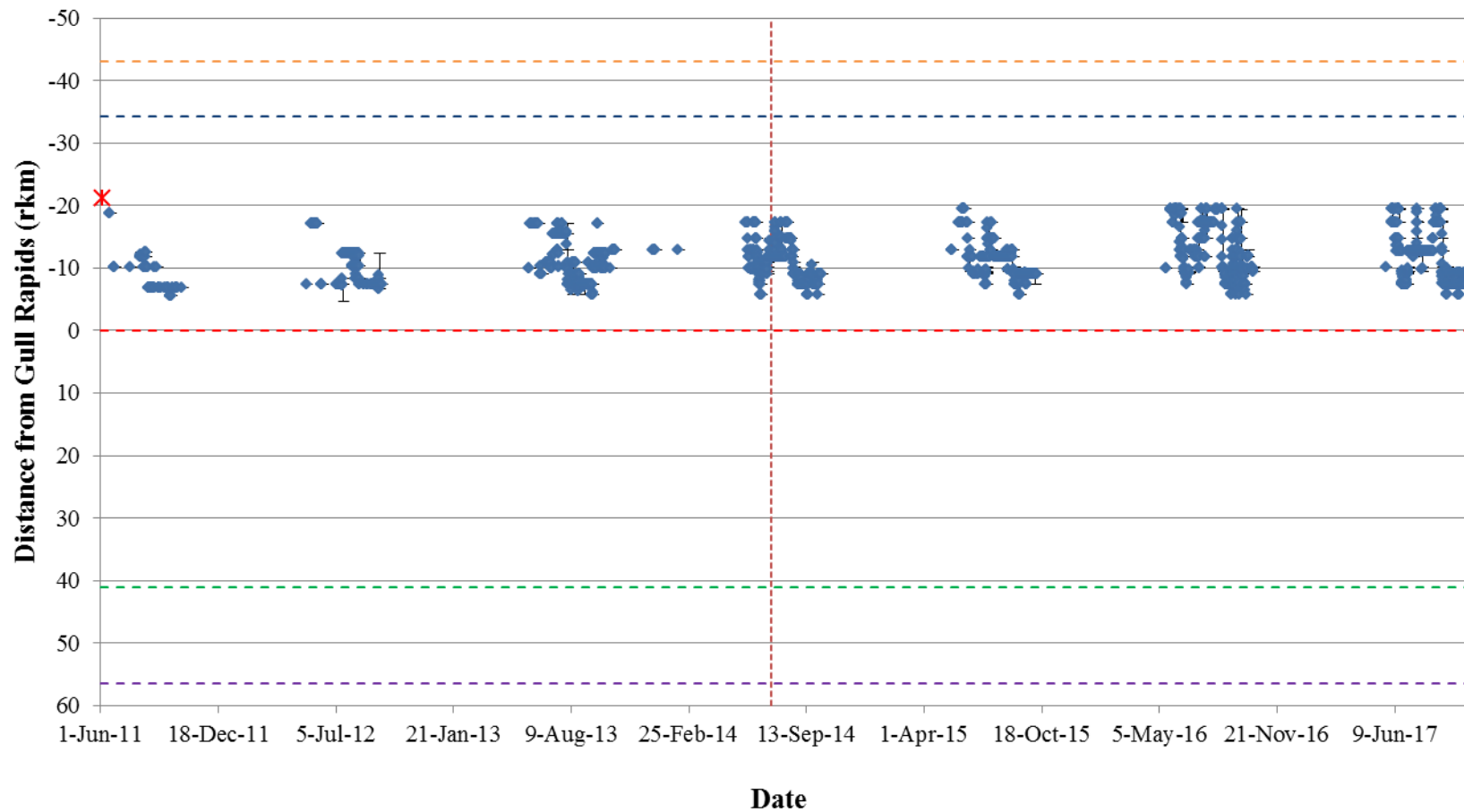


Figure A2-3: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16039) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

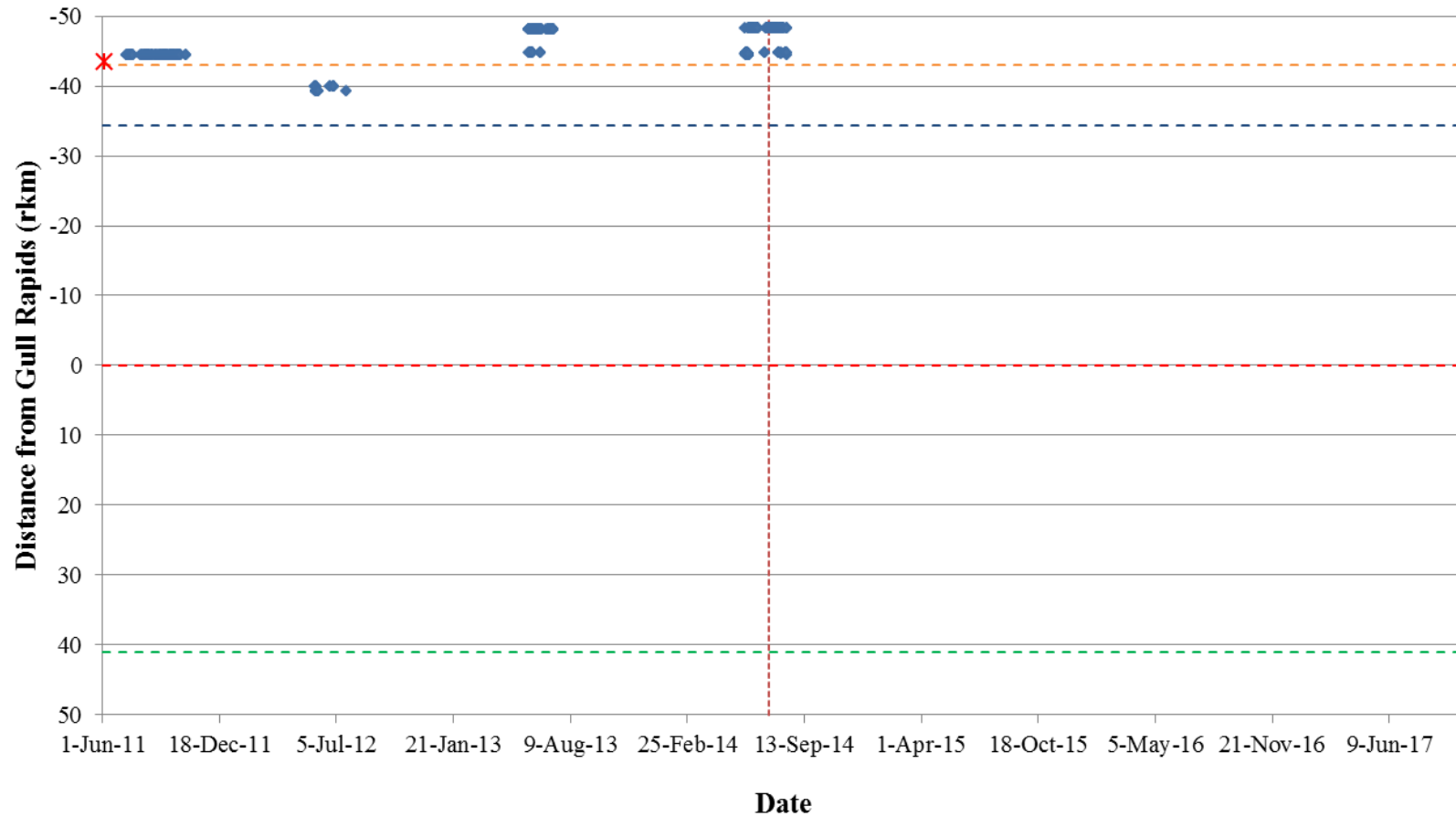


Figure A2-4: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16042) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

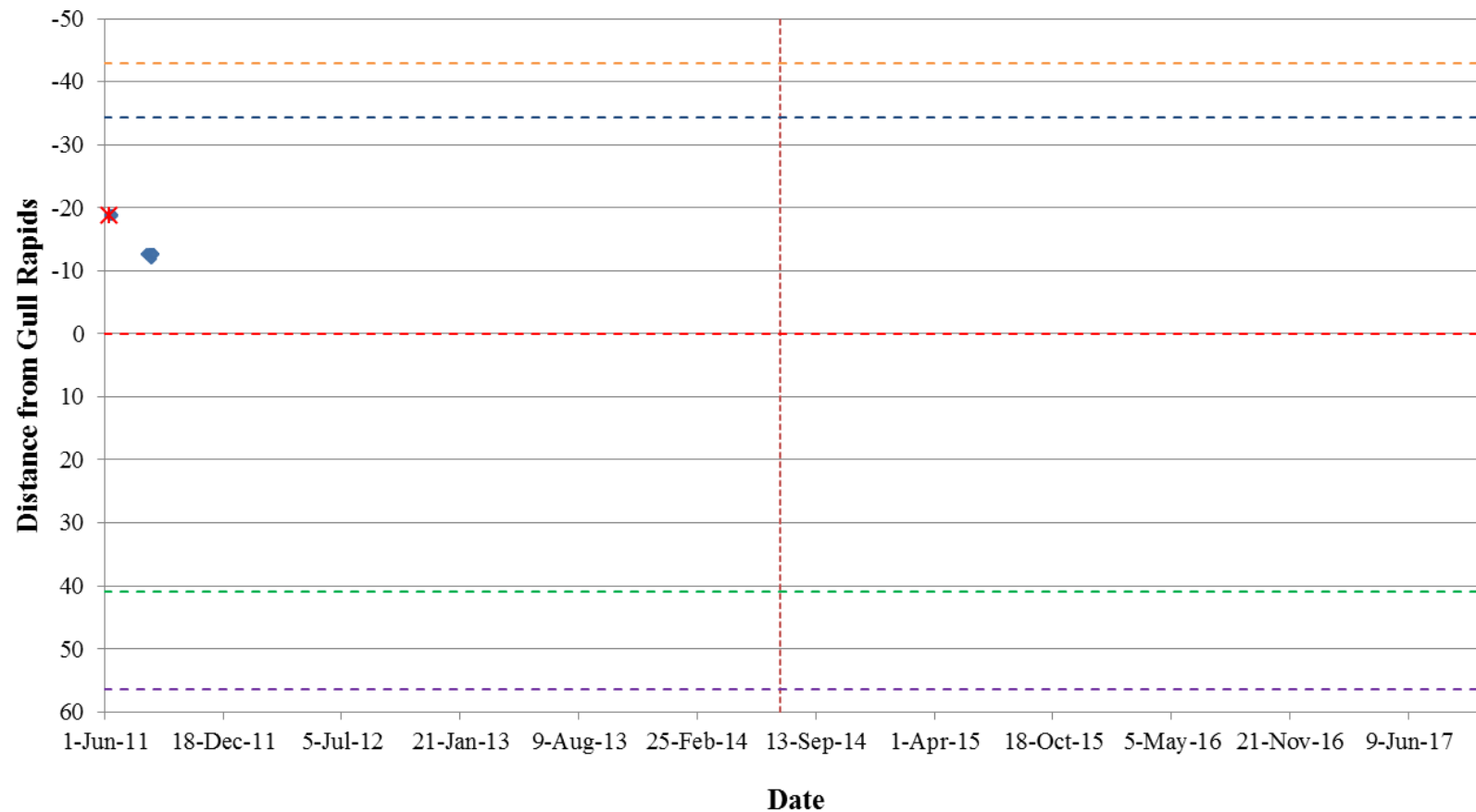


Figure A2-5: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16045) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

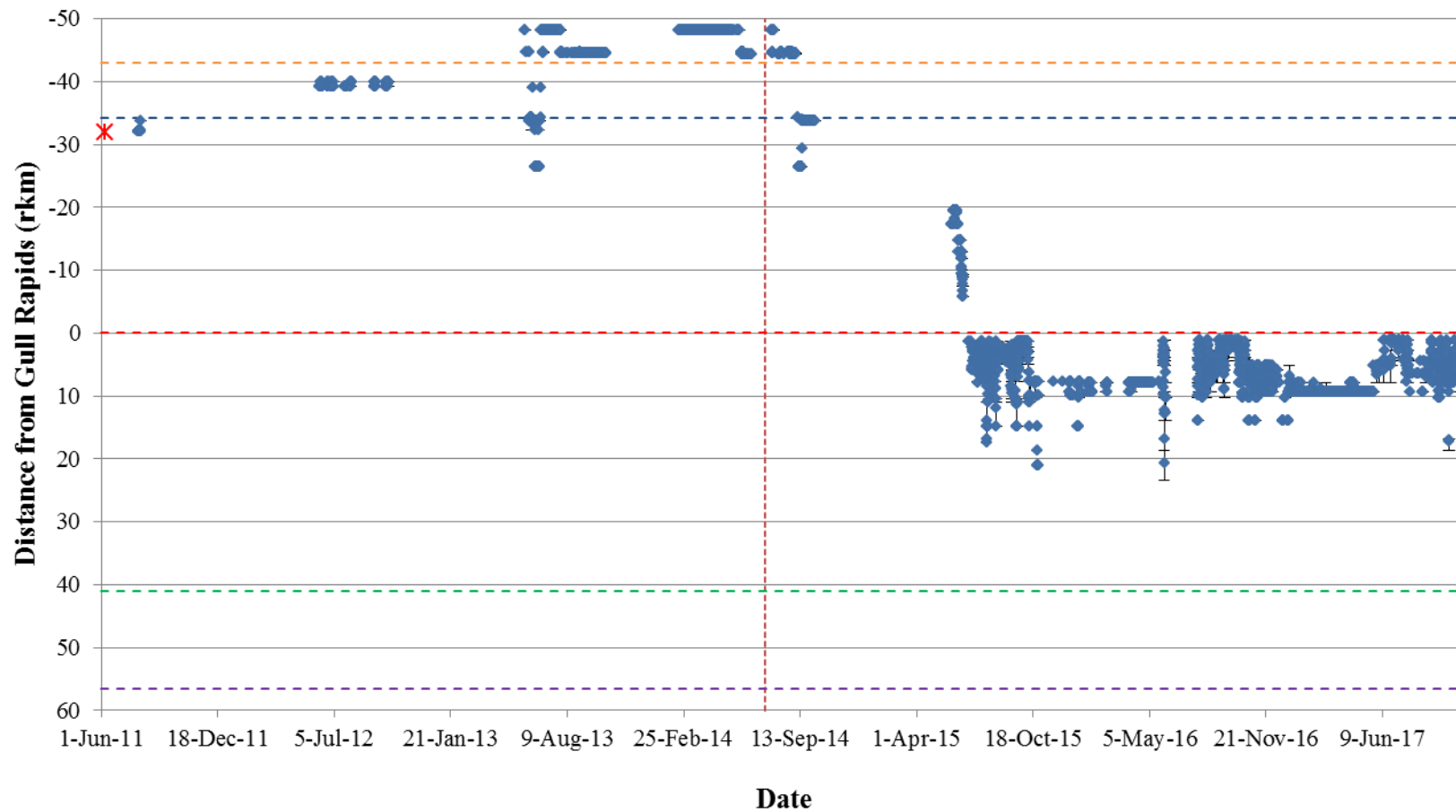


Figure A2-6: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16048) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

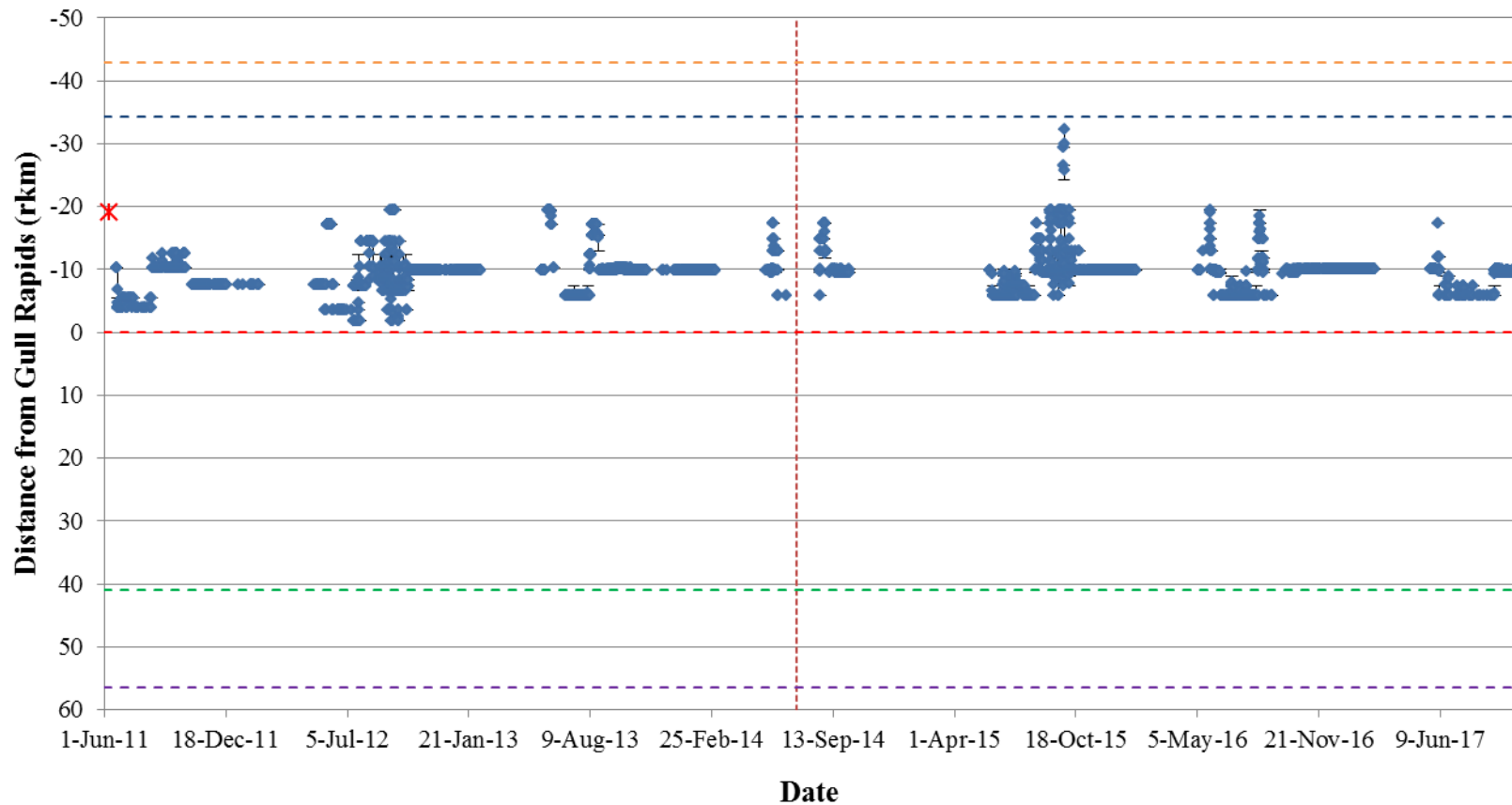


Figure A2-7: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16051) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

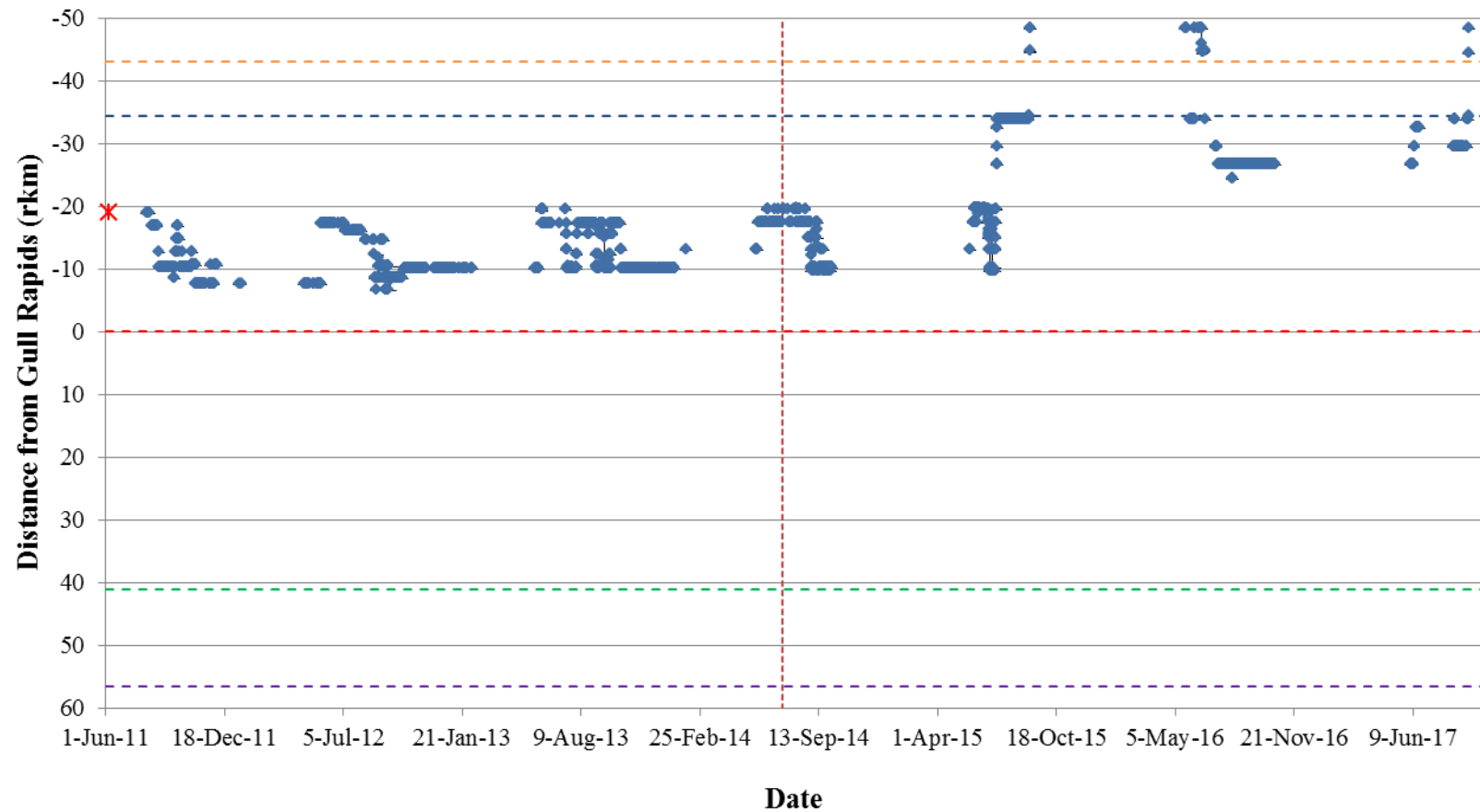


Figure A2-8: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16054) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

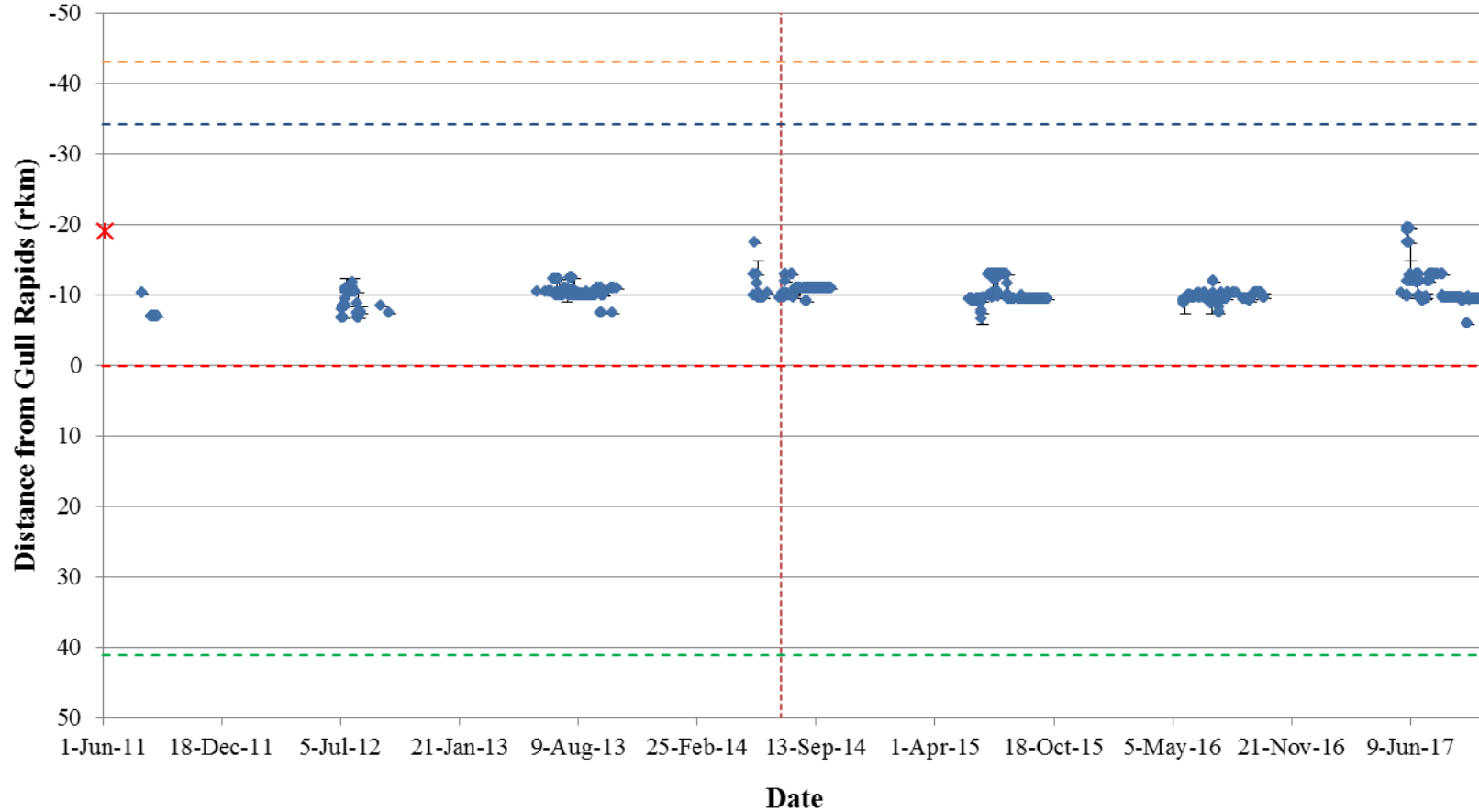


Figure A2-9: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16055) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

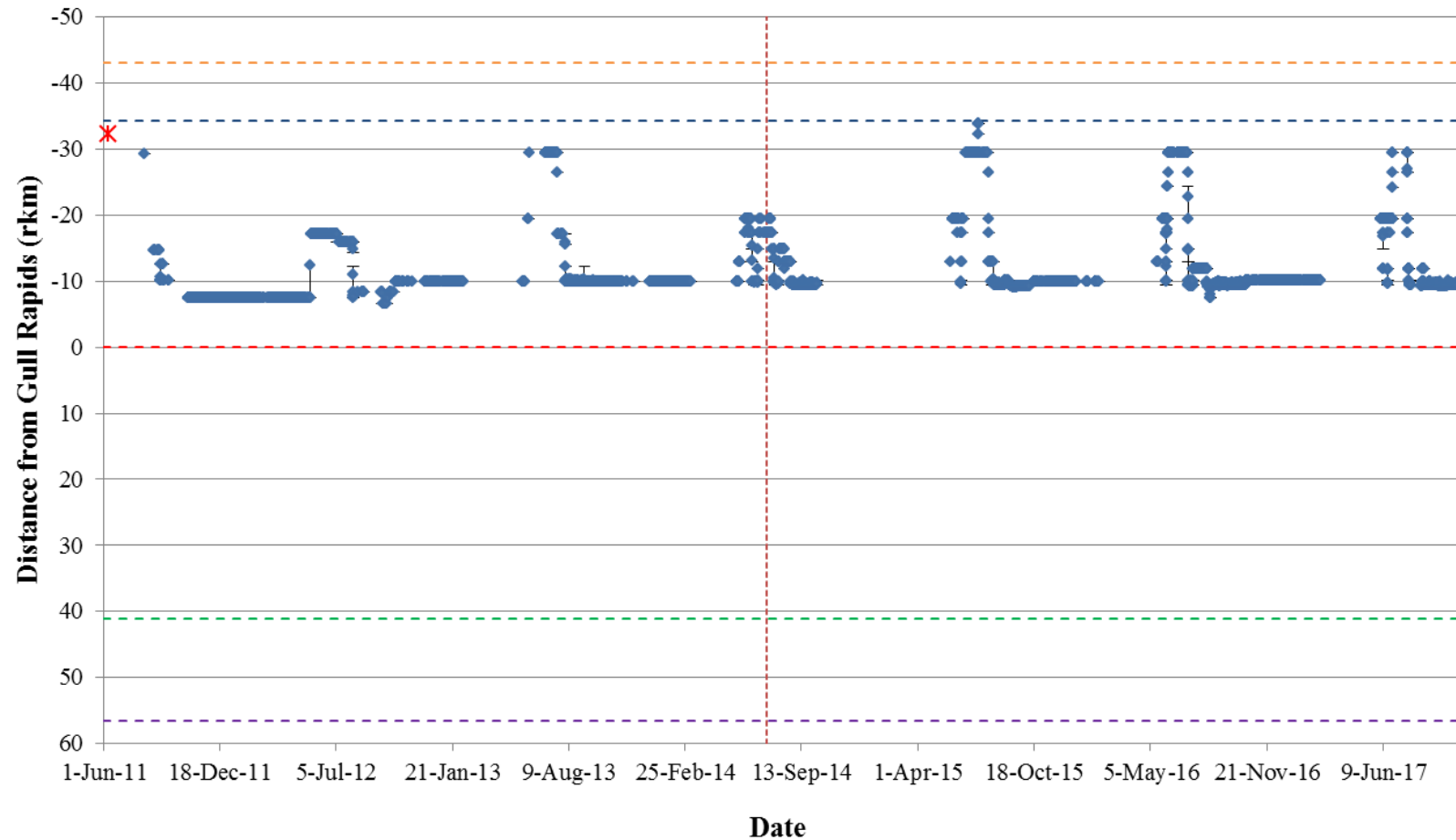


Figure A2-10: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16056) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

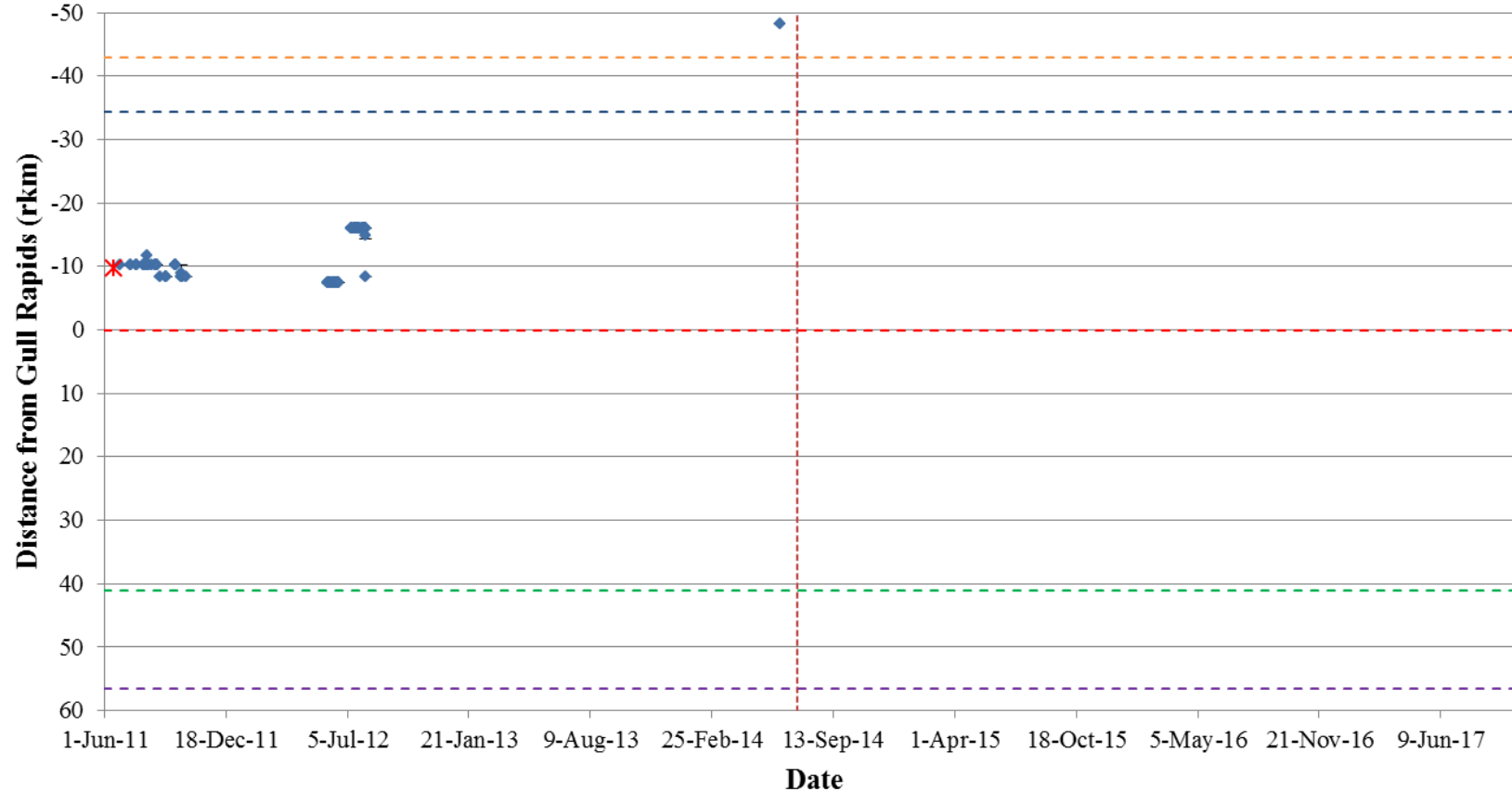


Figure A2-11: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16057) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

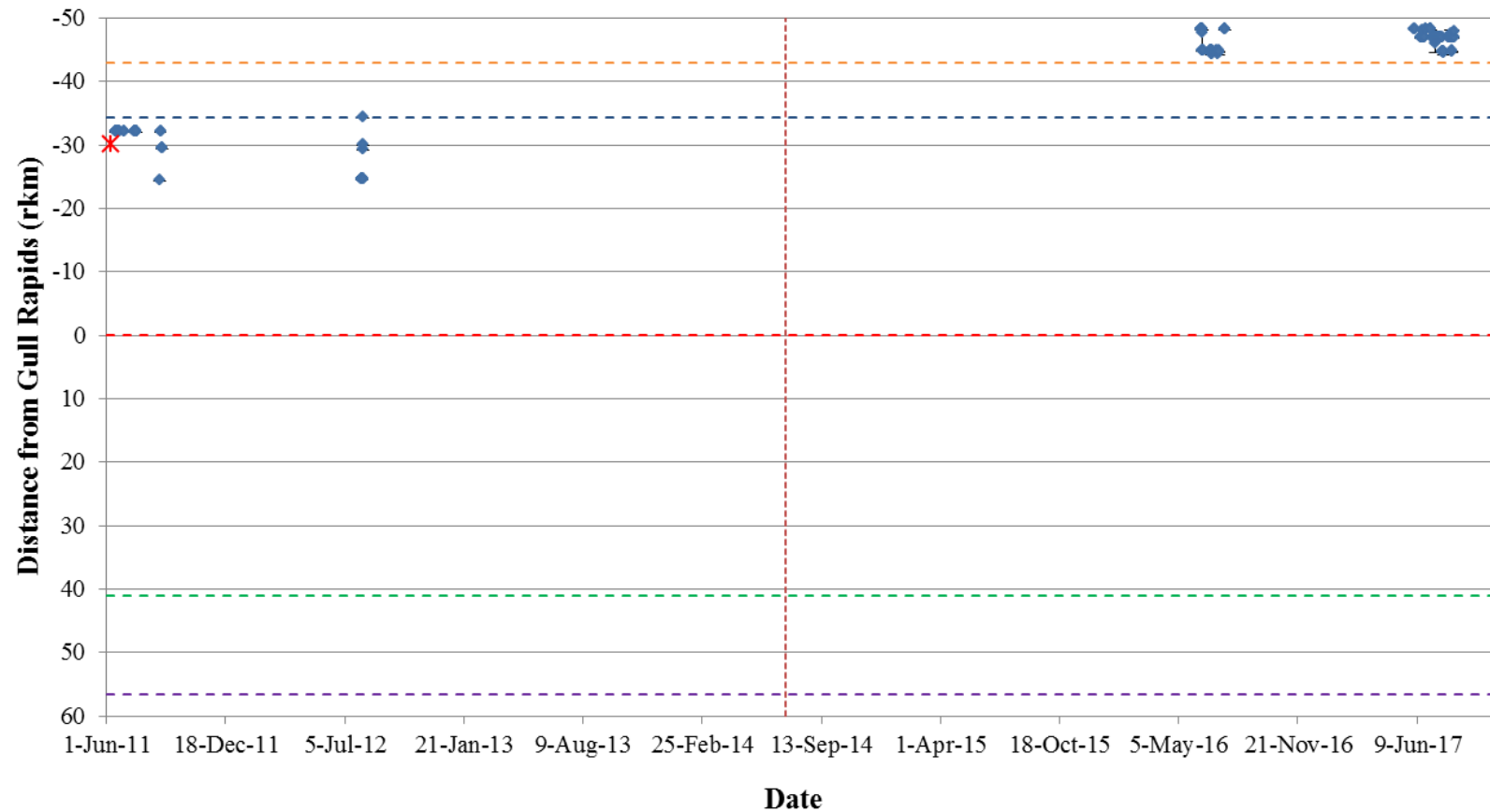


Figure A2-12: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16058) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

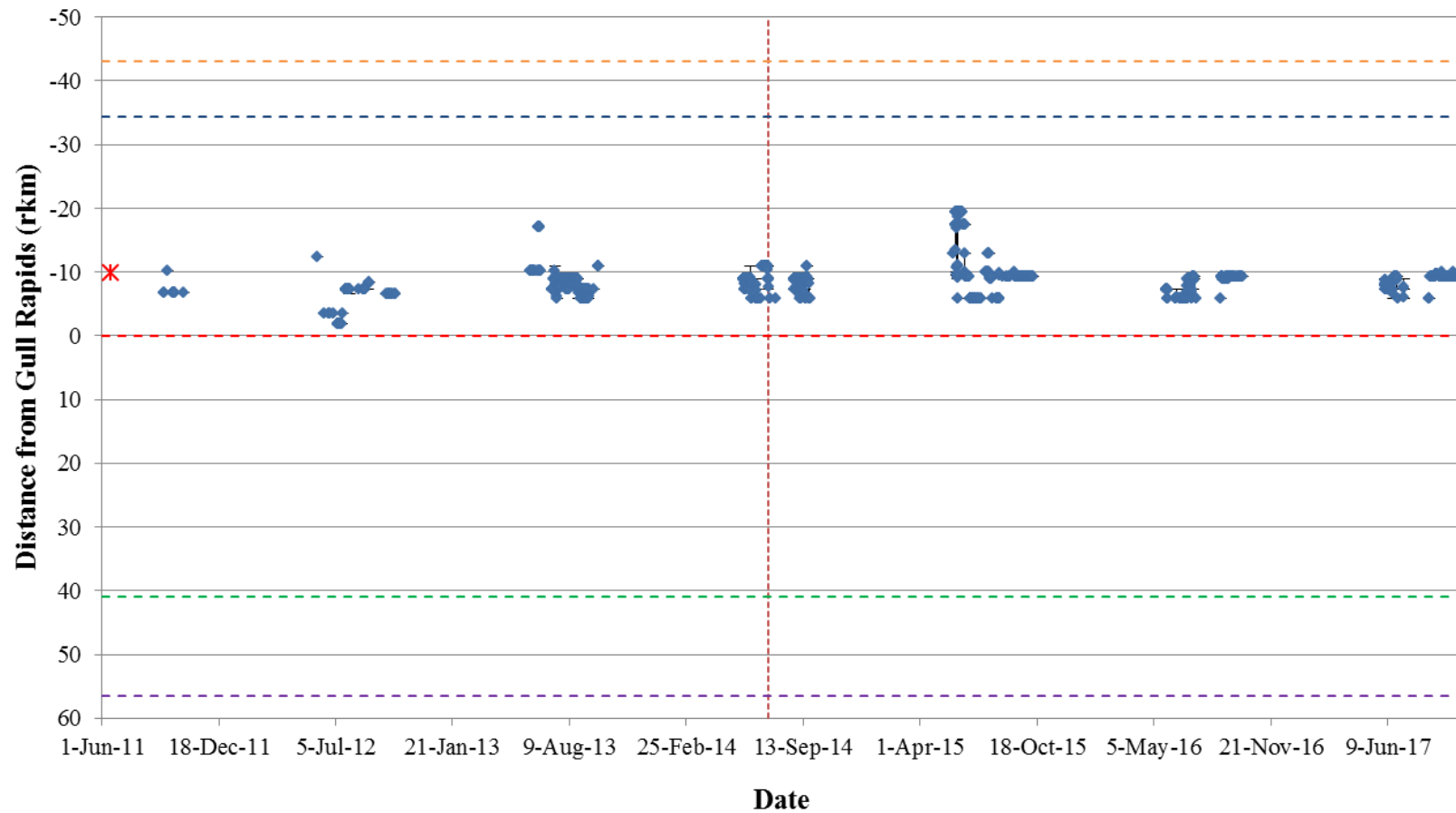


Figure A2-13: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16059) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

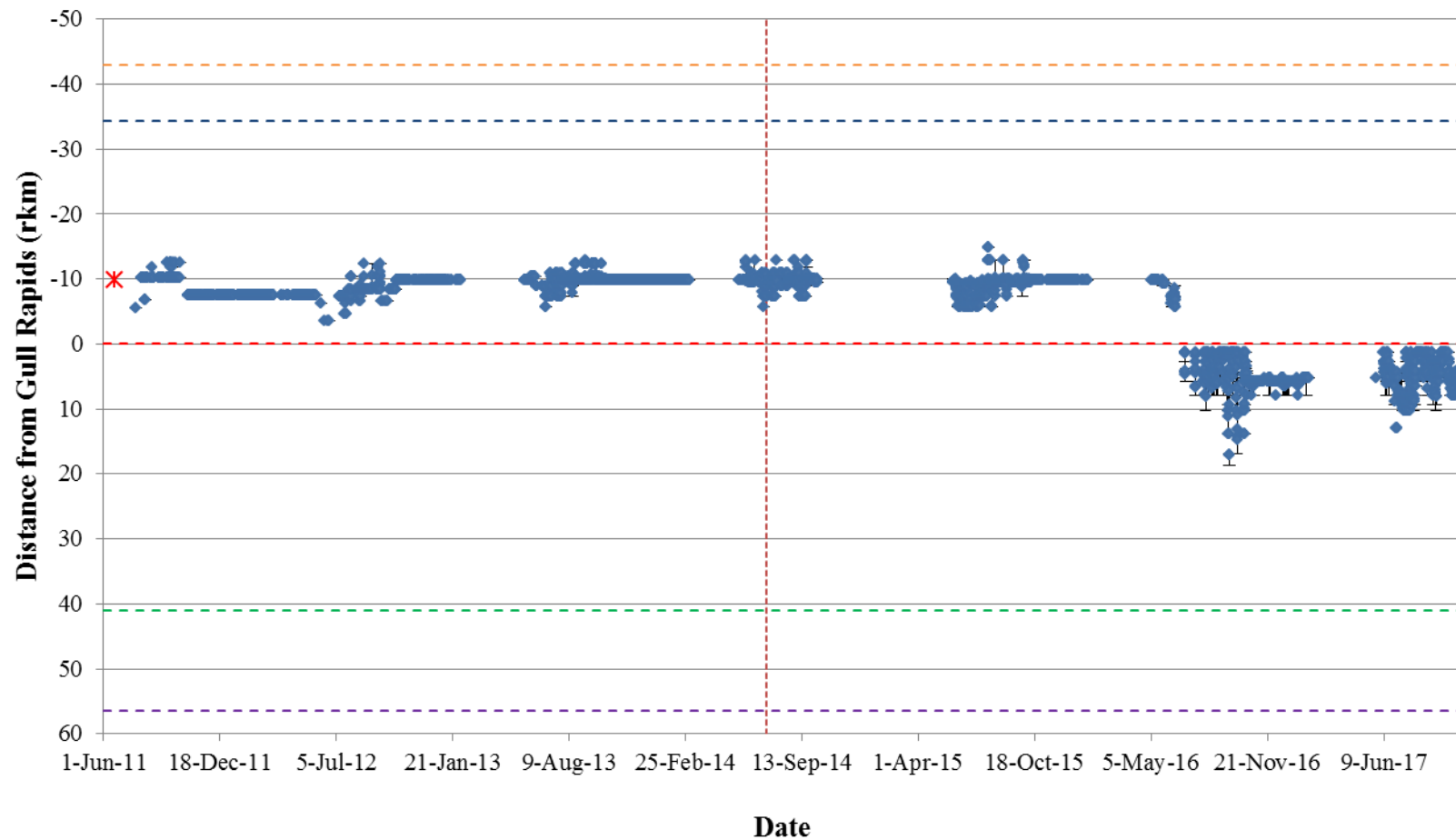


Figure A2-14: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16060) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

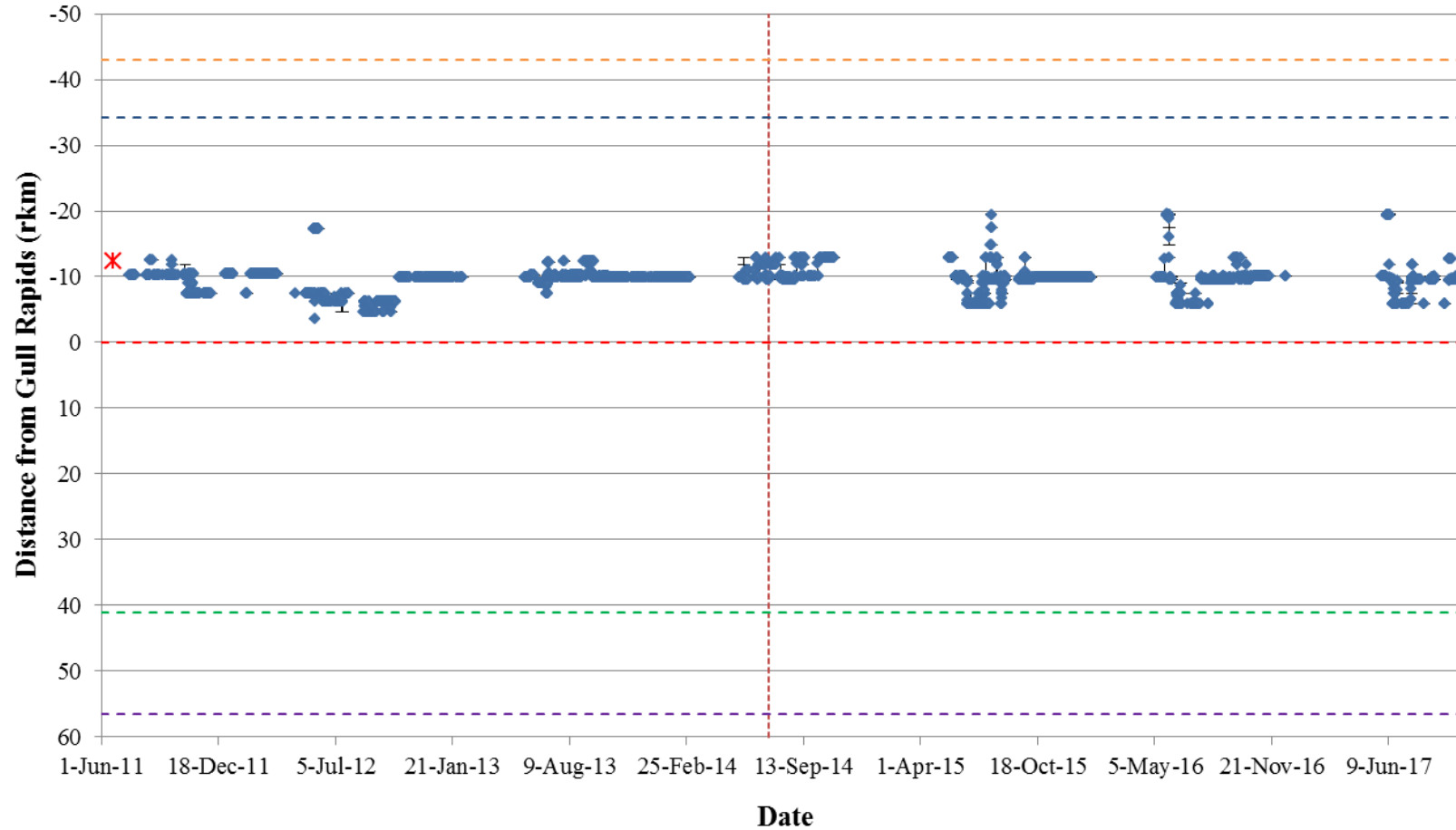


Figure A2-15: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16061) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

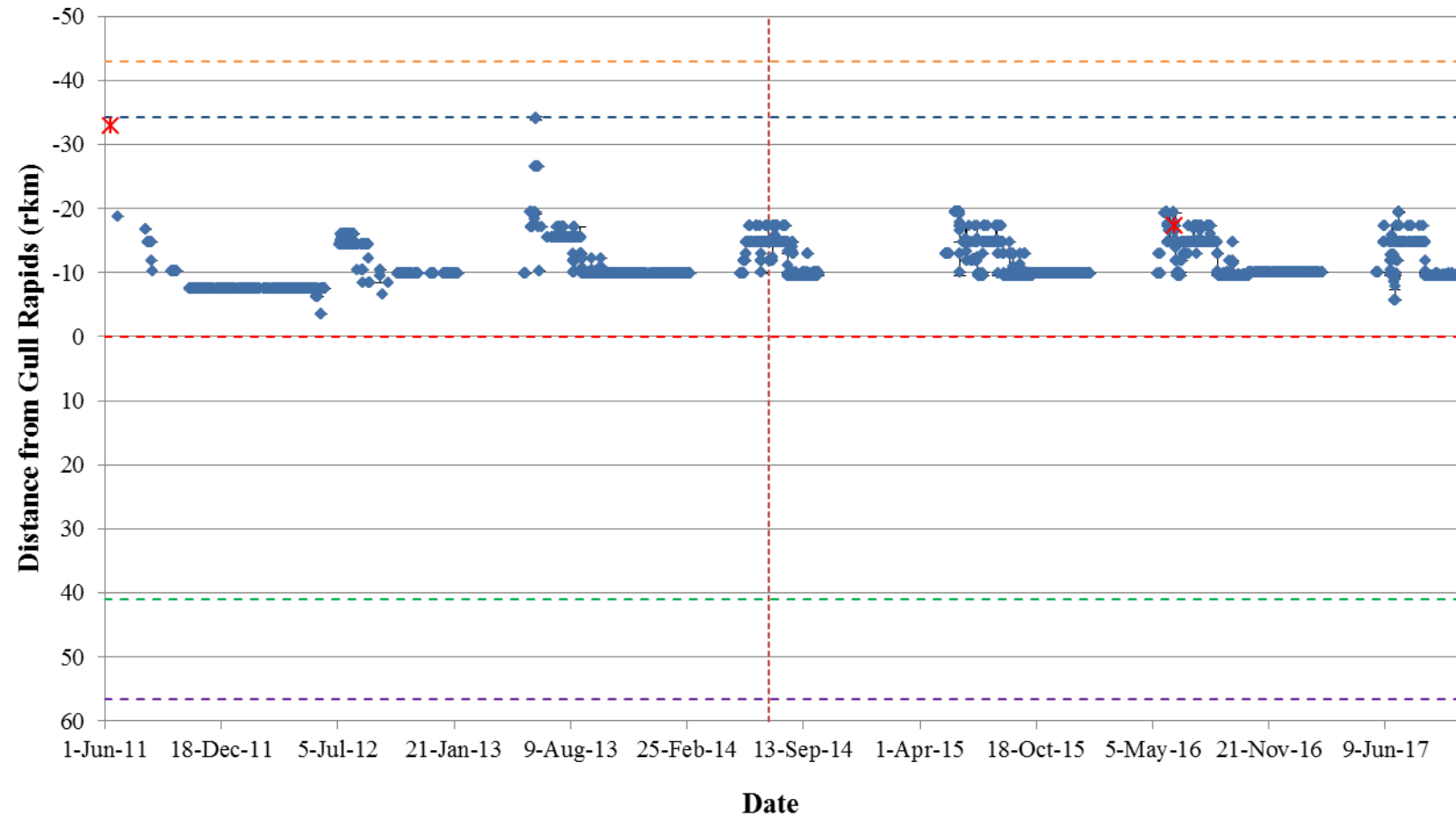


Figure A2-16: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16062) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

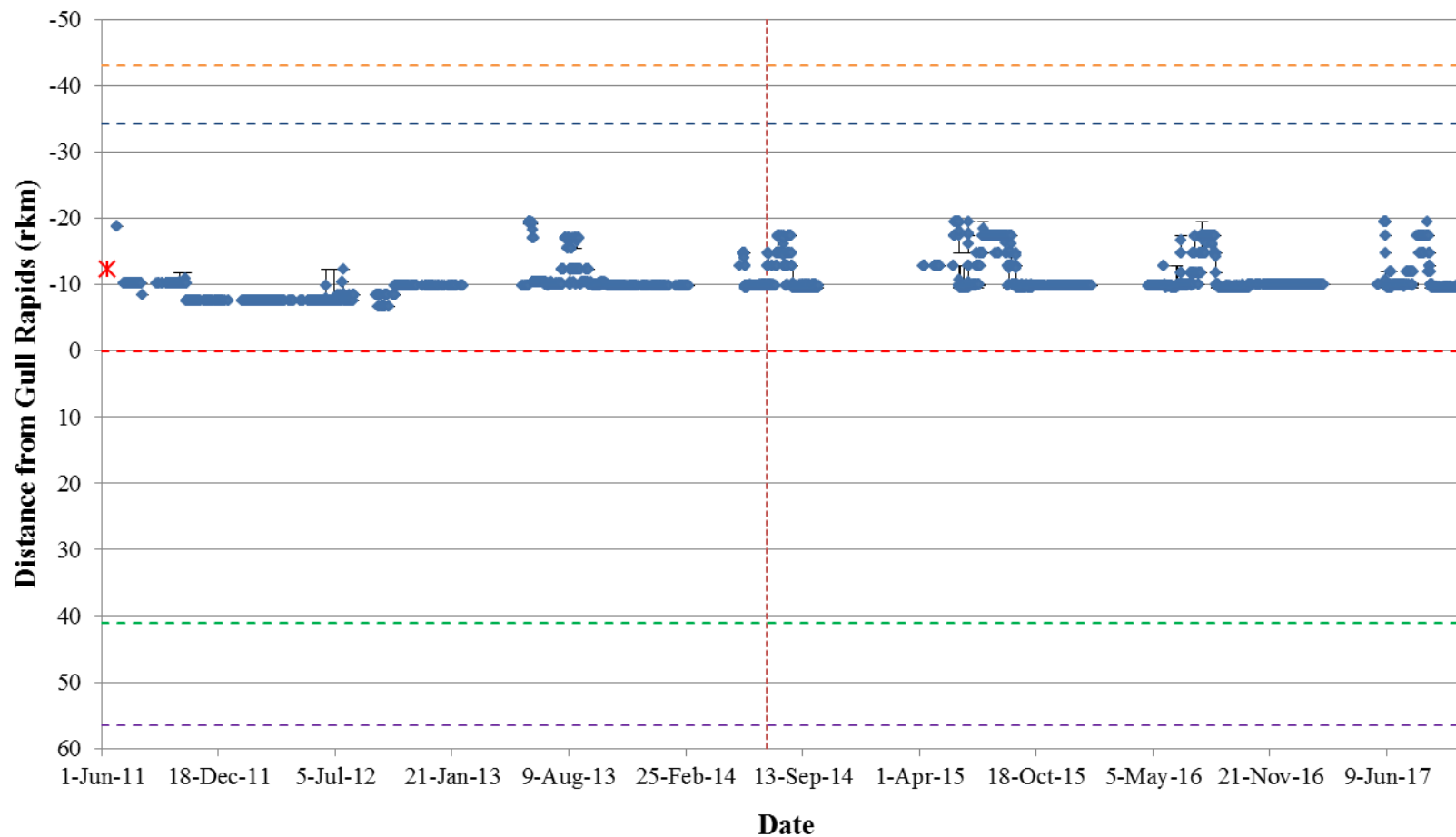


Figure A2-17: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16063) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

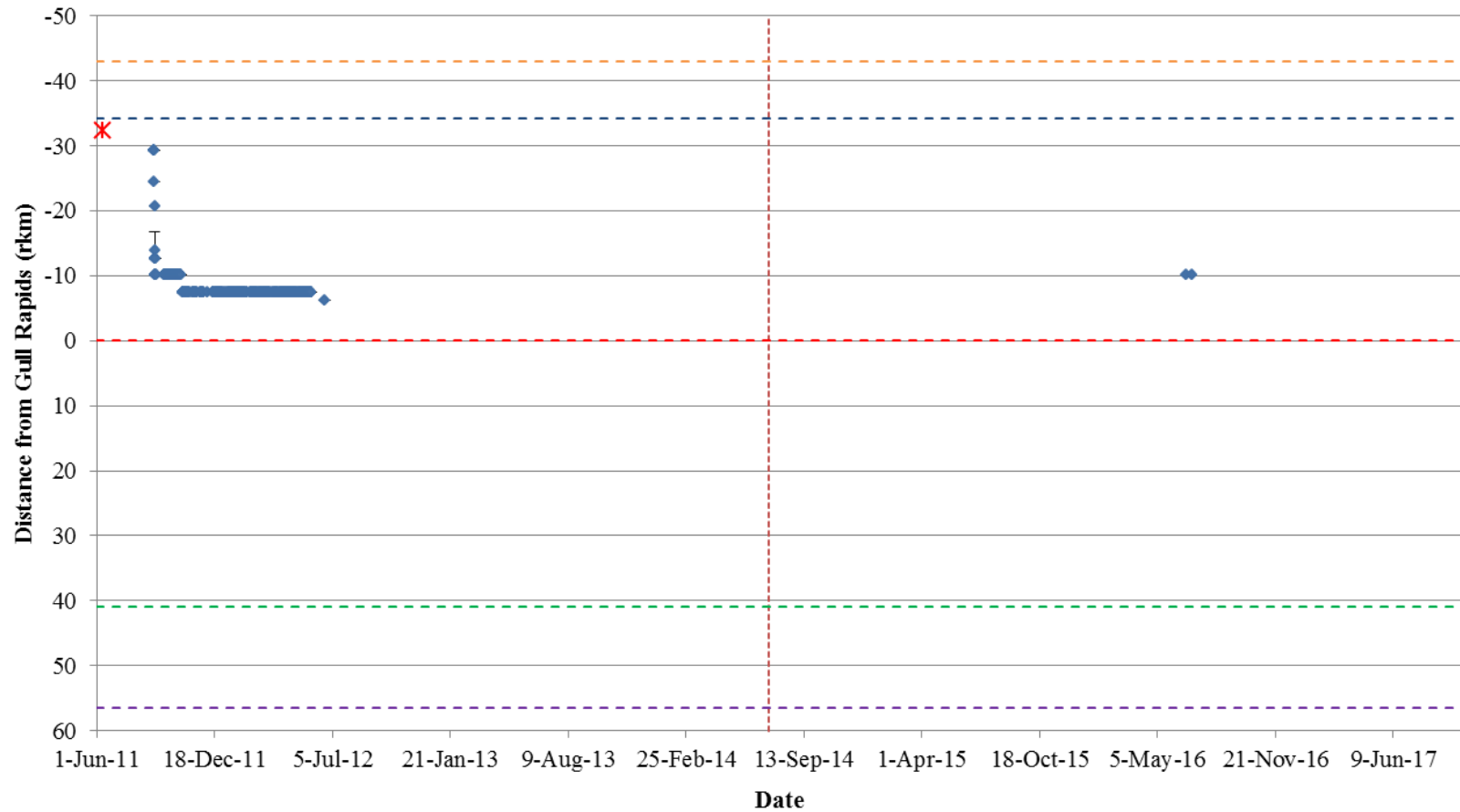


Figure A2-18: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16064) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

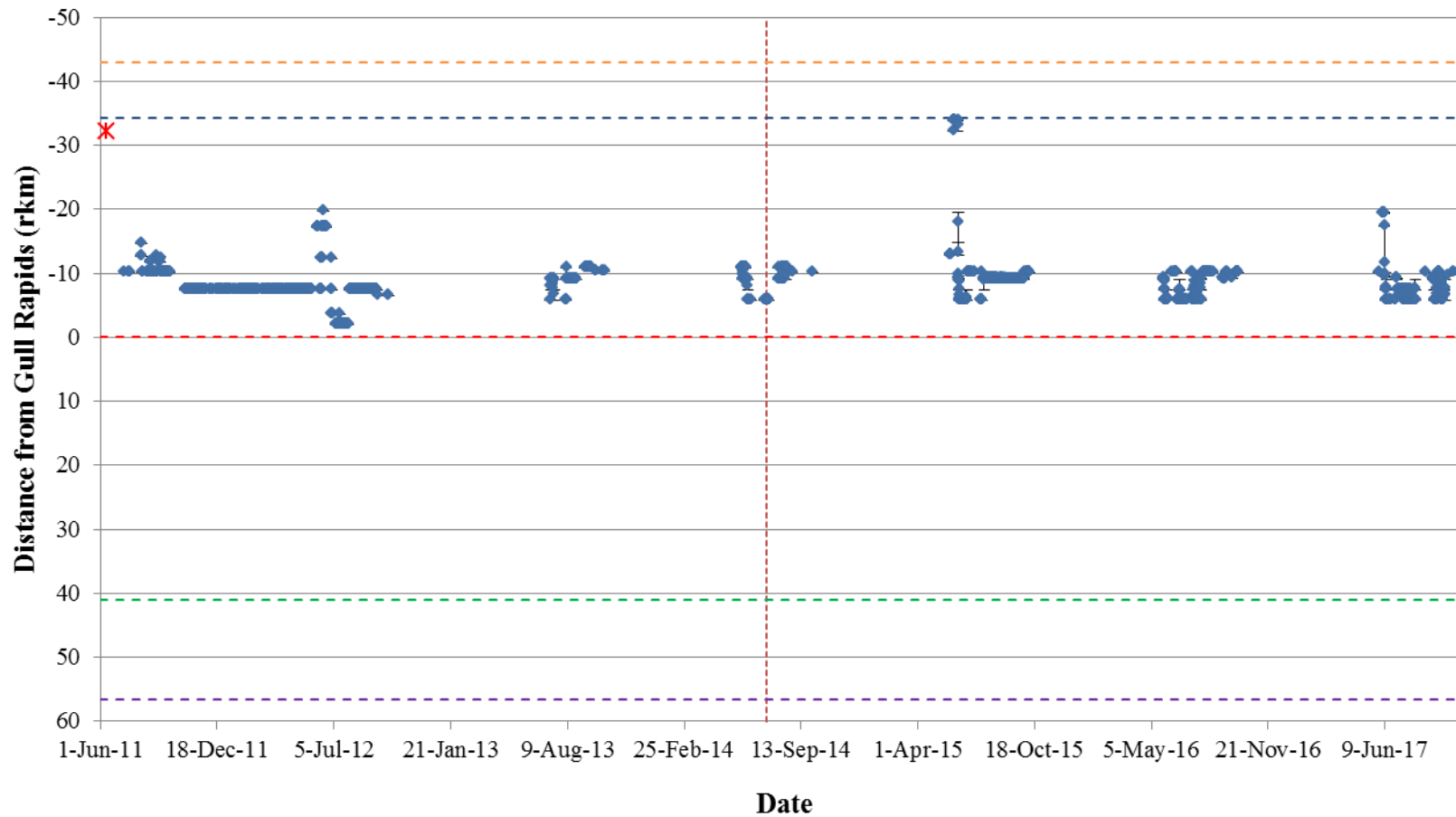


Figure A2-19: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16065) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

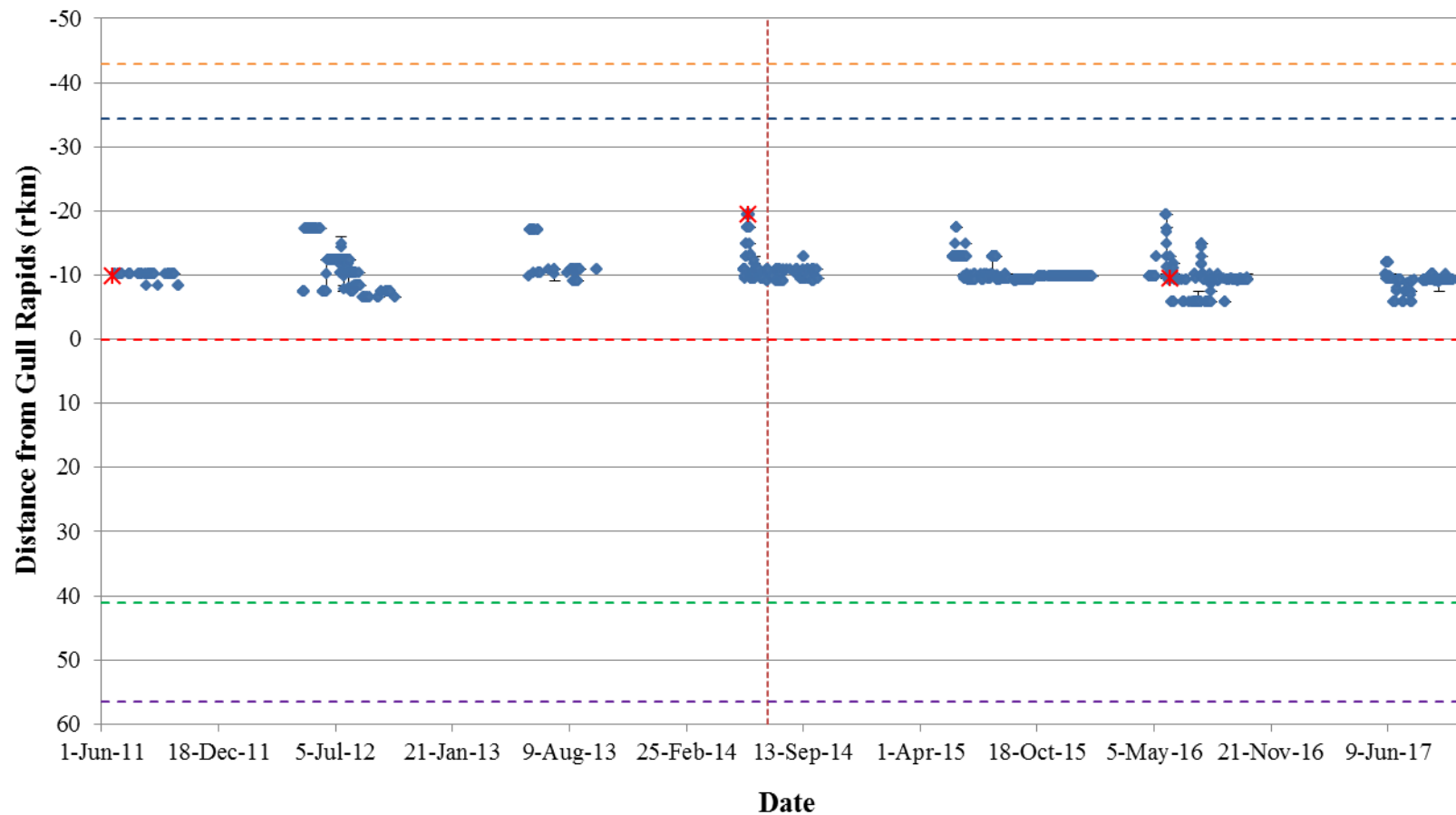


Figure A2-20: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16066) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

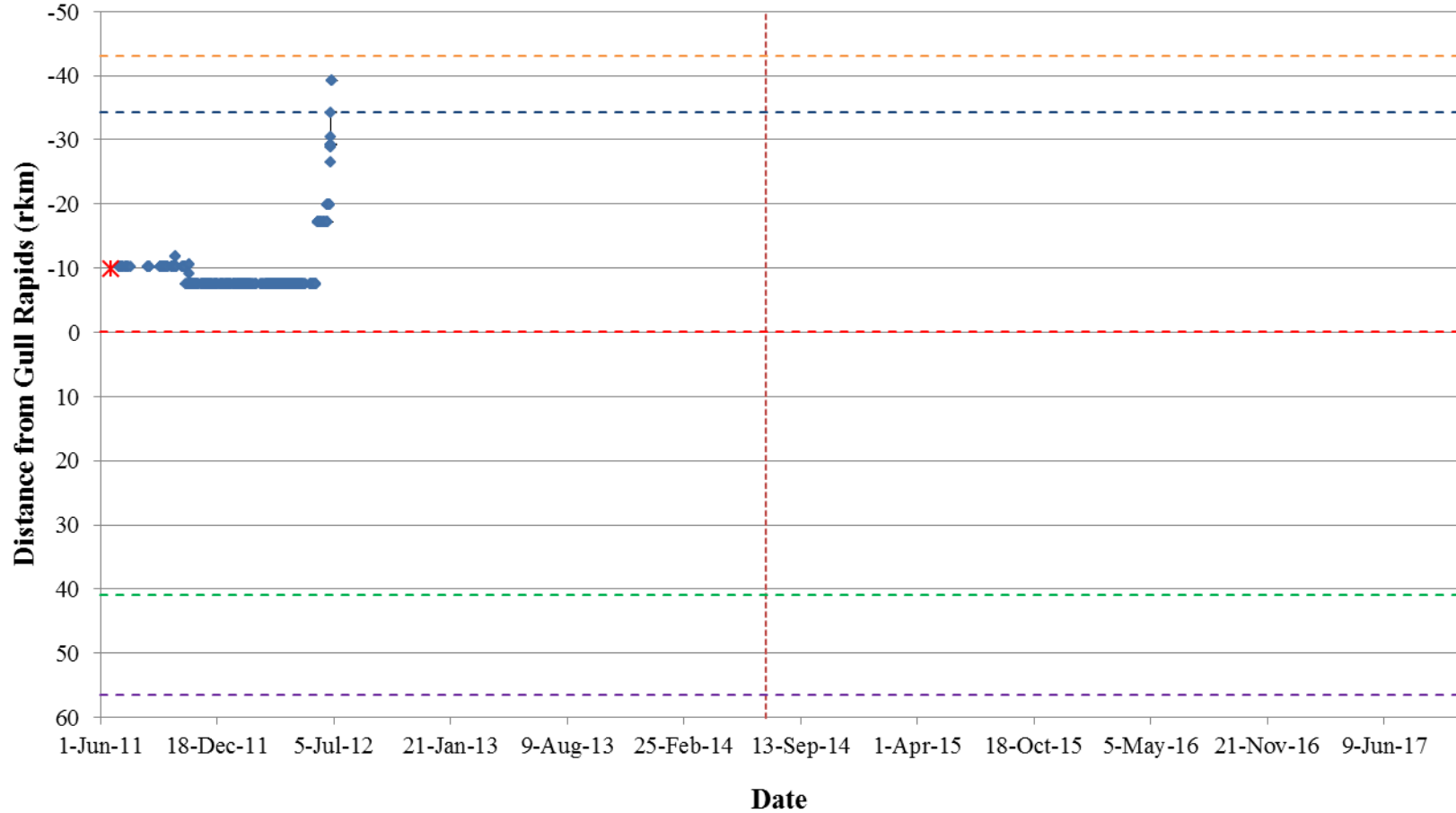


Figure A2-21: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16067) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

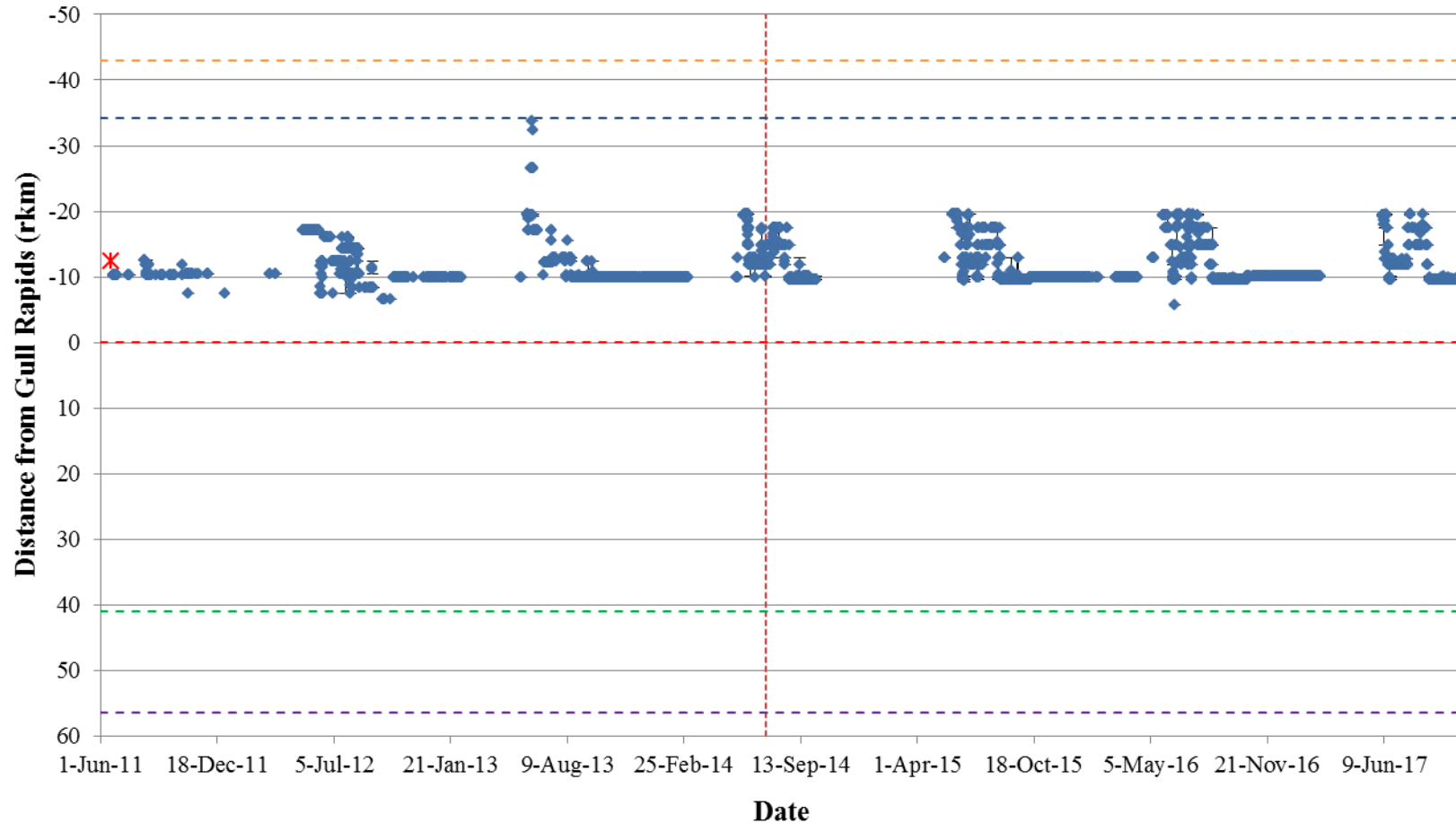


Figure A2-22: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16068) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

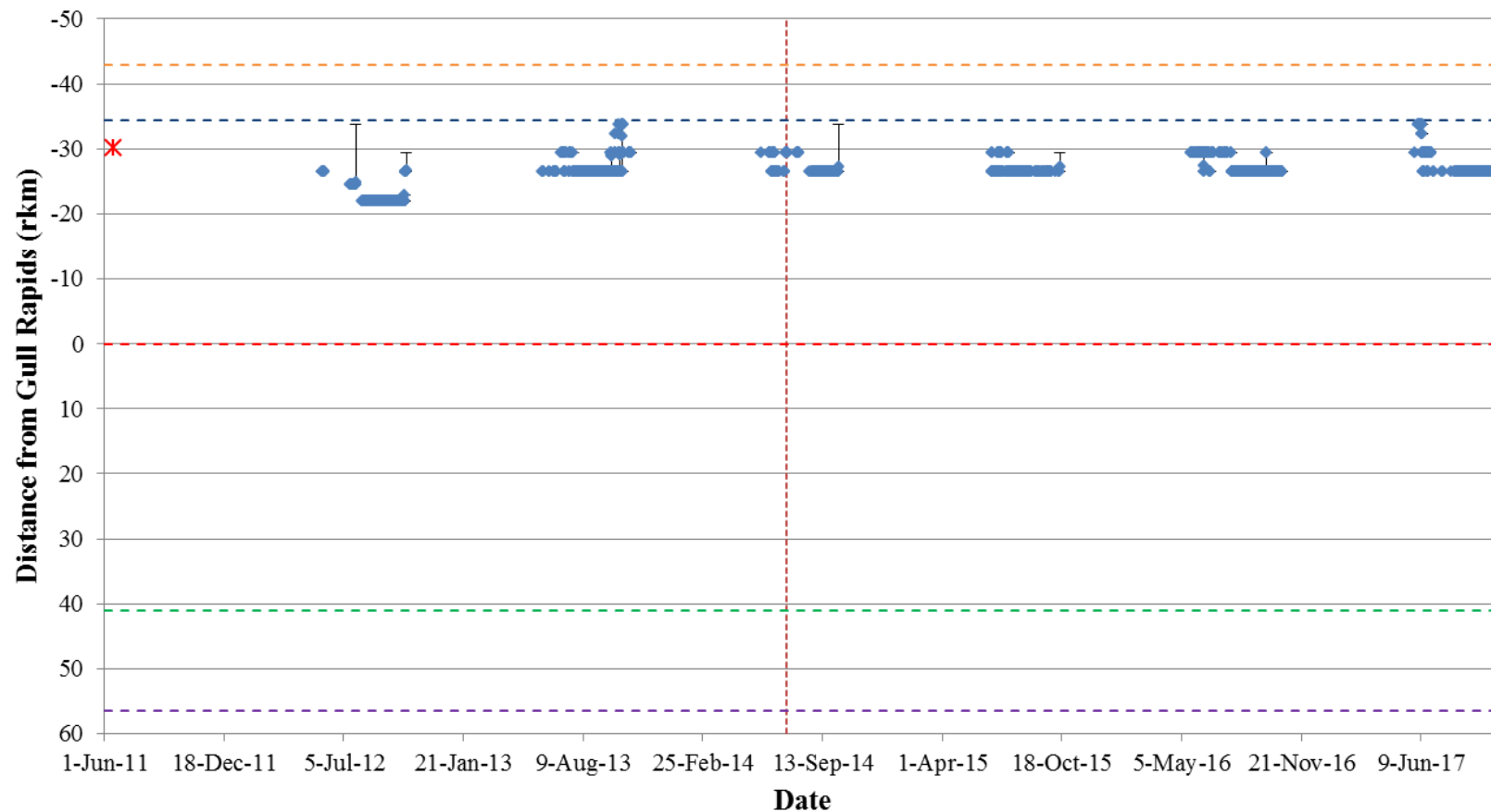


Figure A2-23: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16069) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

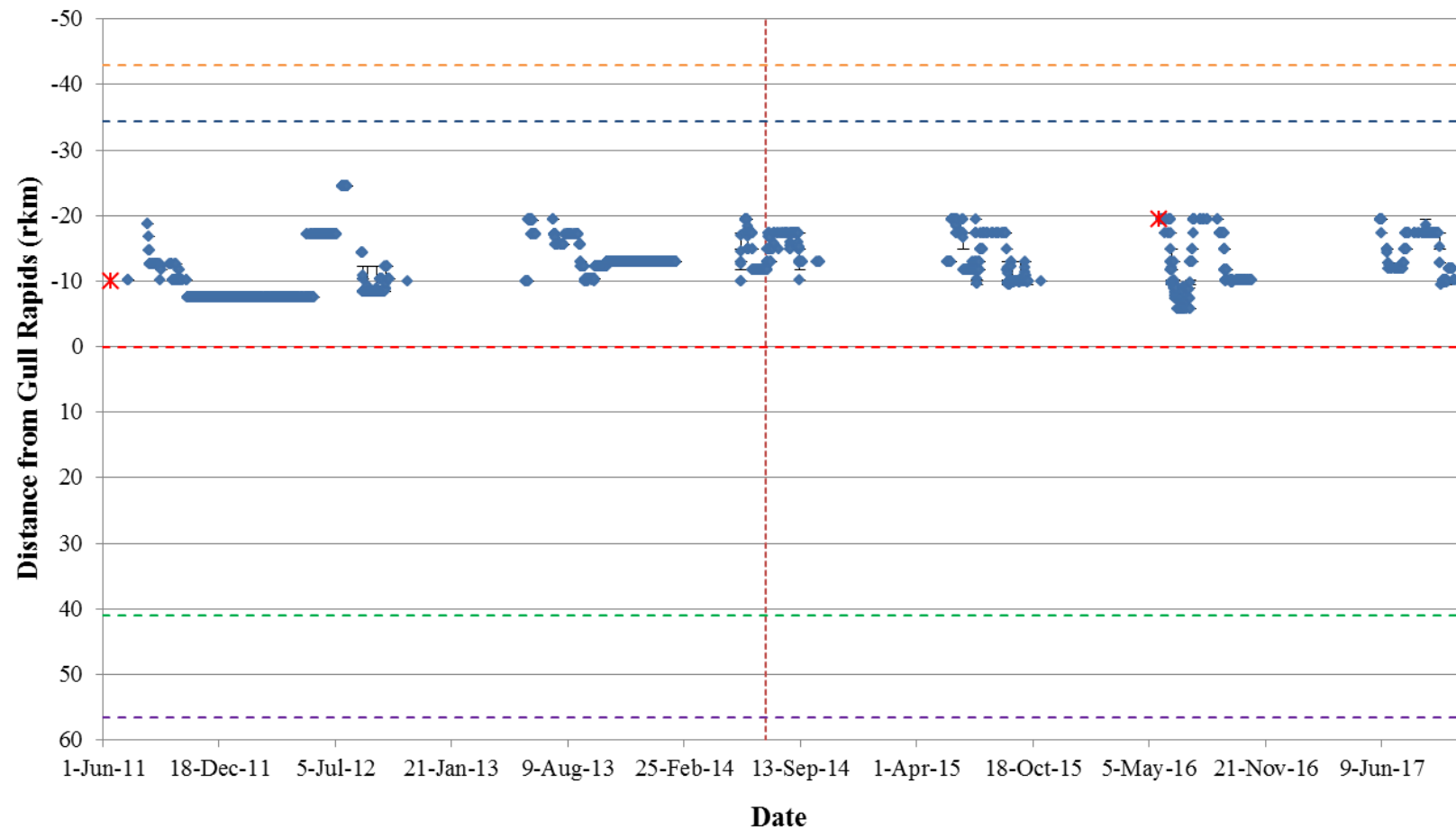


Figure A2-24: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16070) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

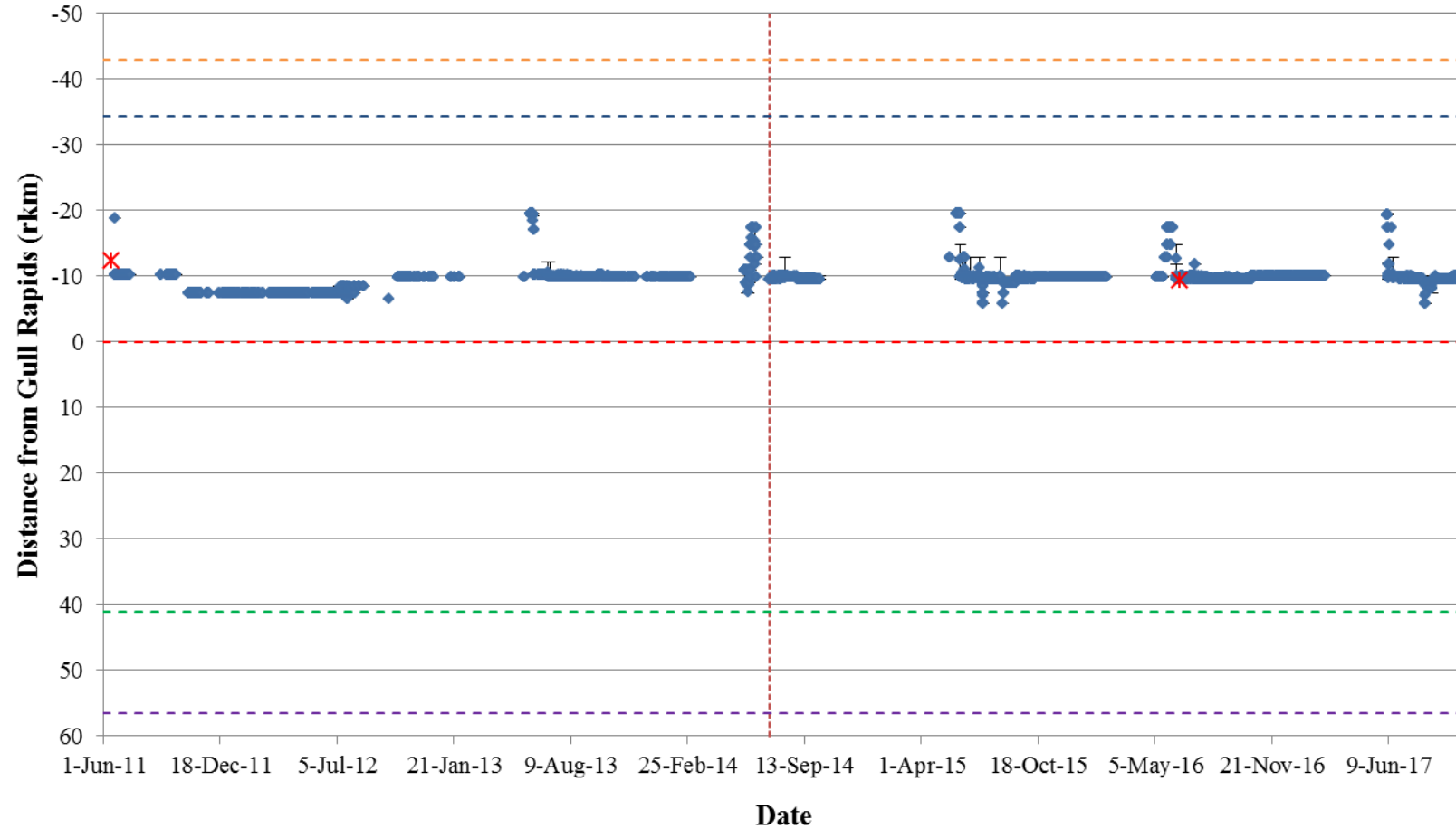


Figure A2-25: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16071) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

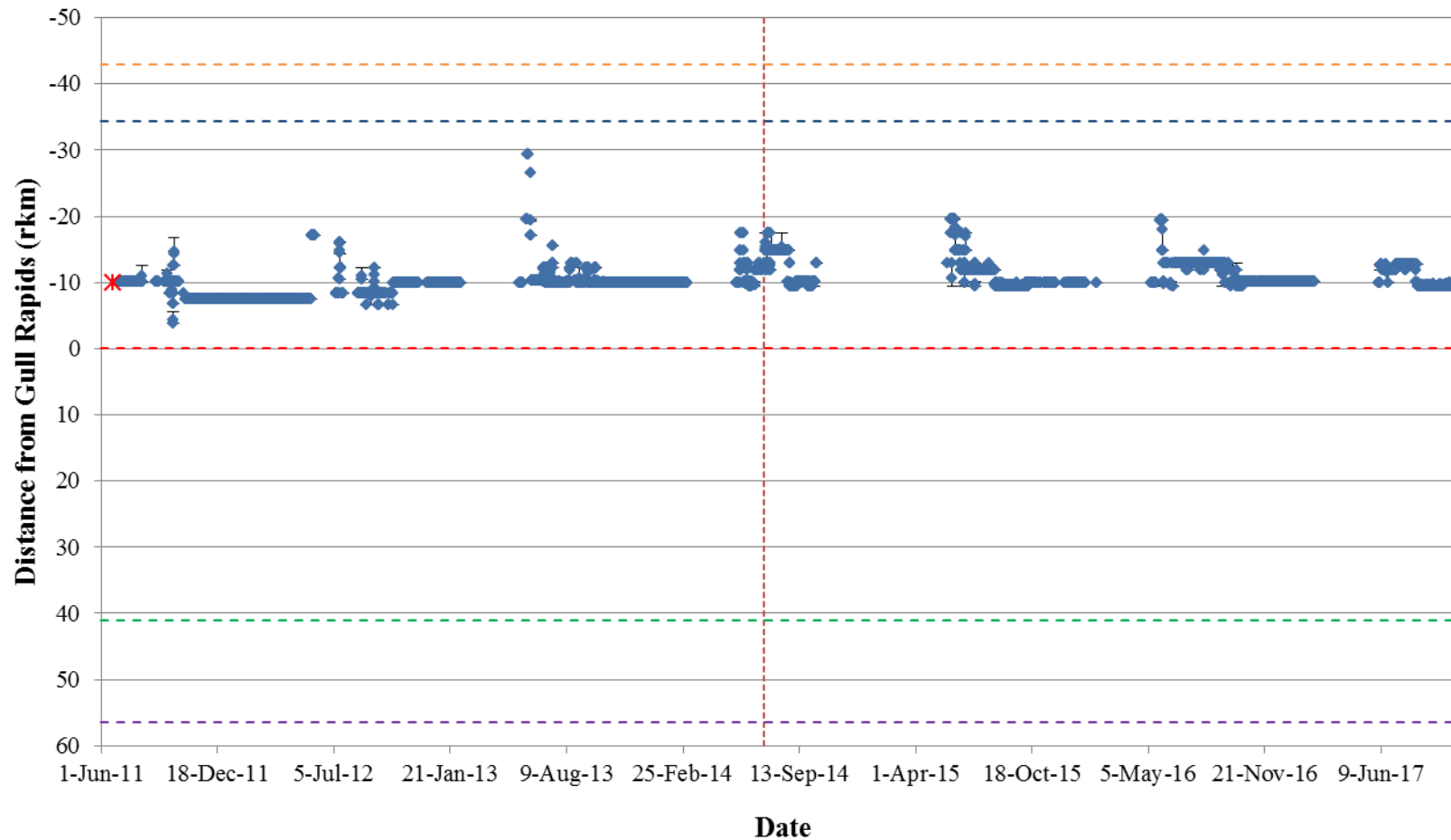


Figure A2-26: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16072) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

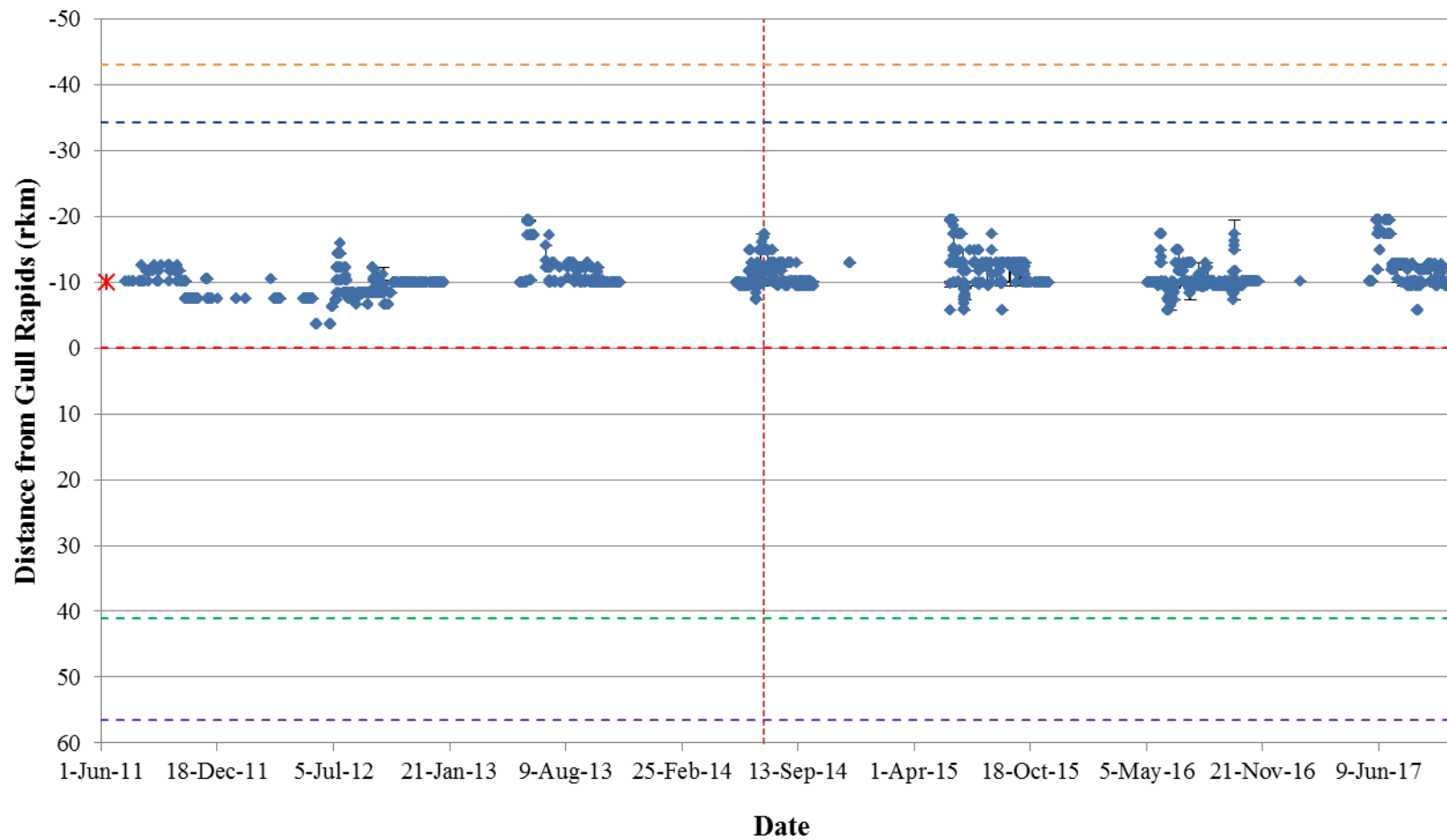


Figure A2-27: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16073) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

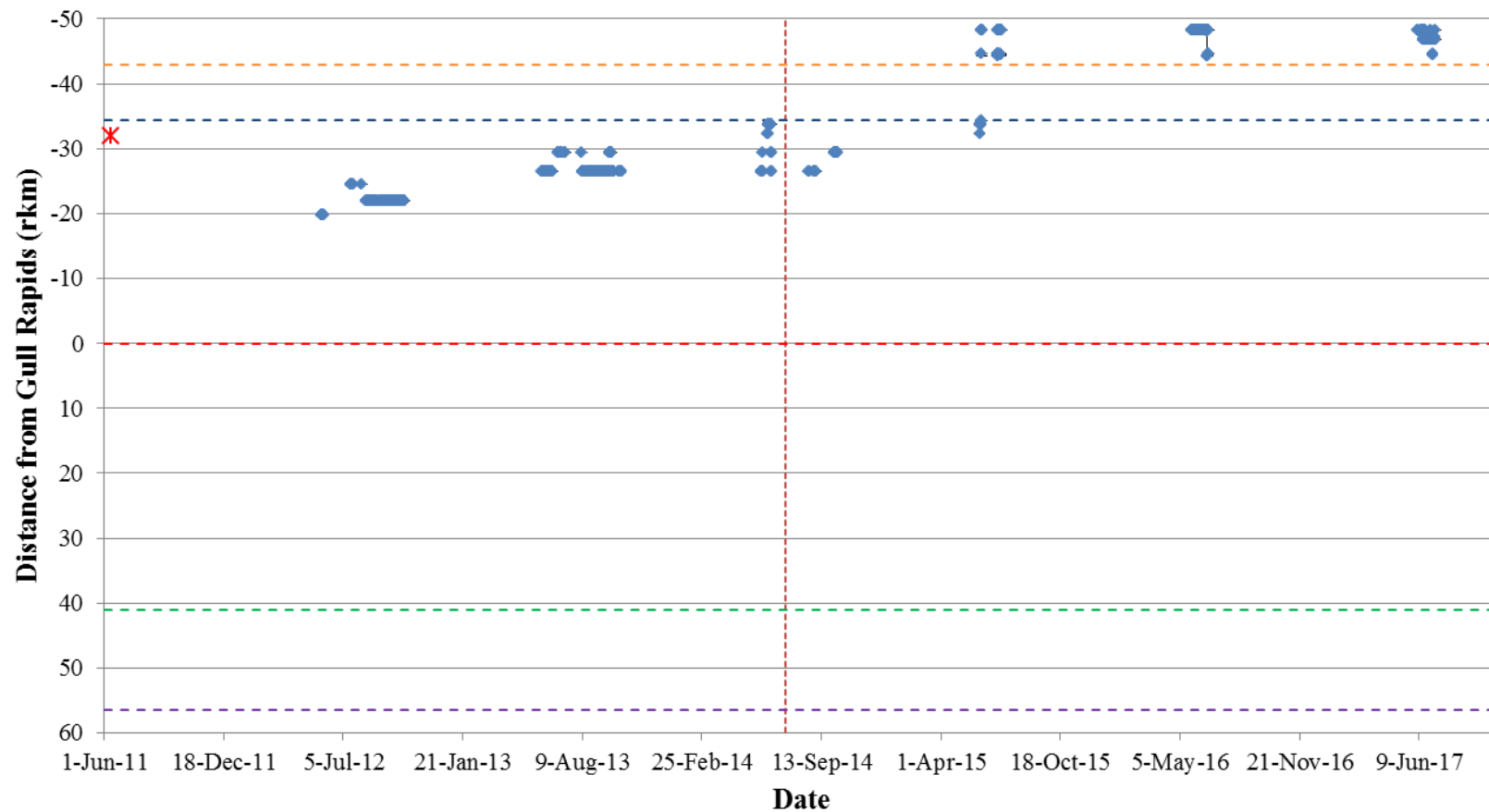


Figure A2-28: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16074) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

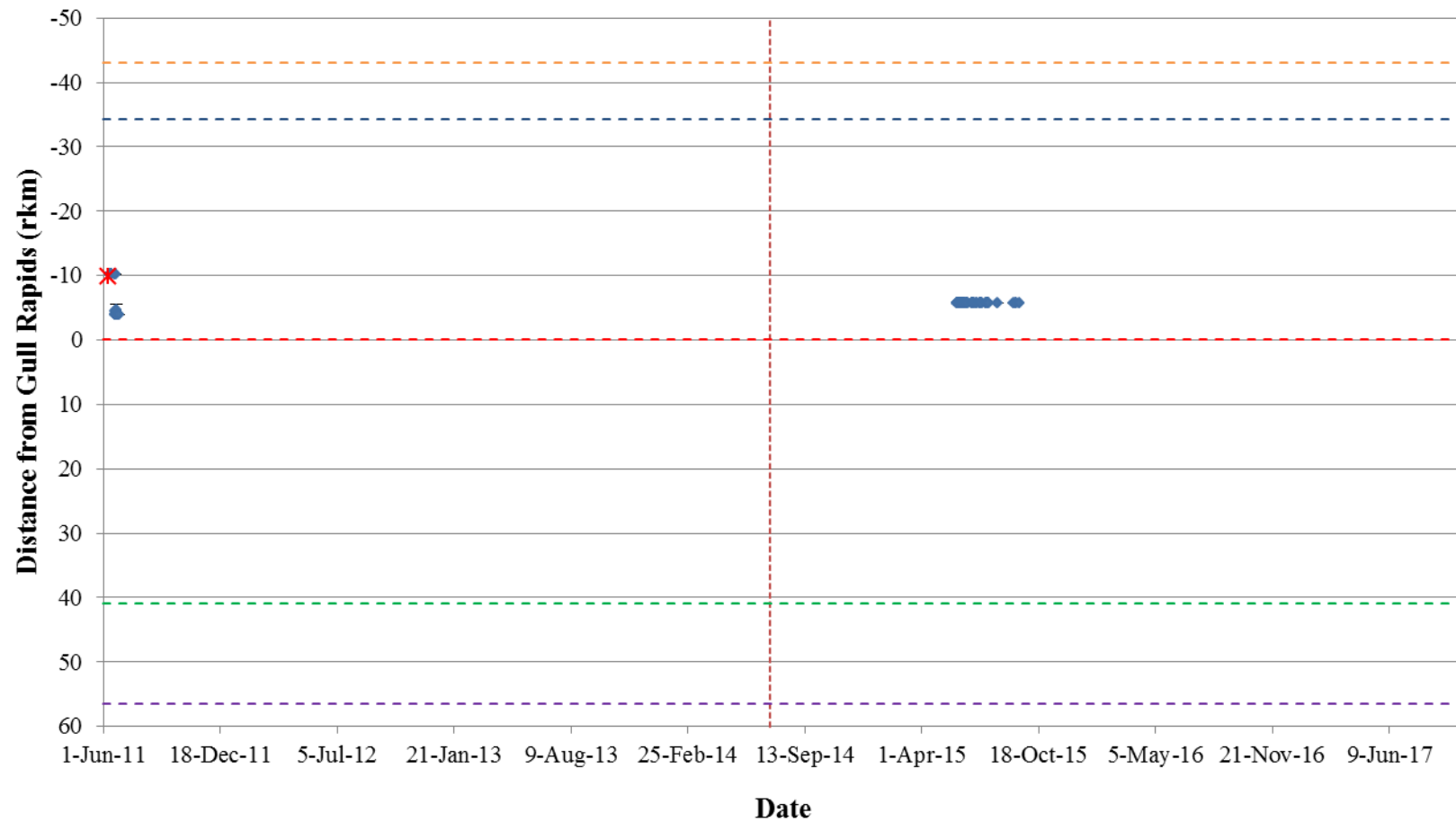


Figure A2-29: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16075) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

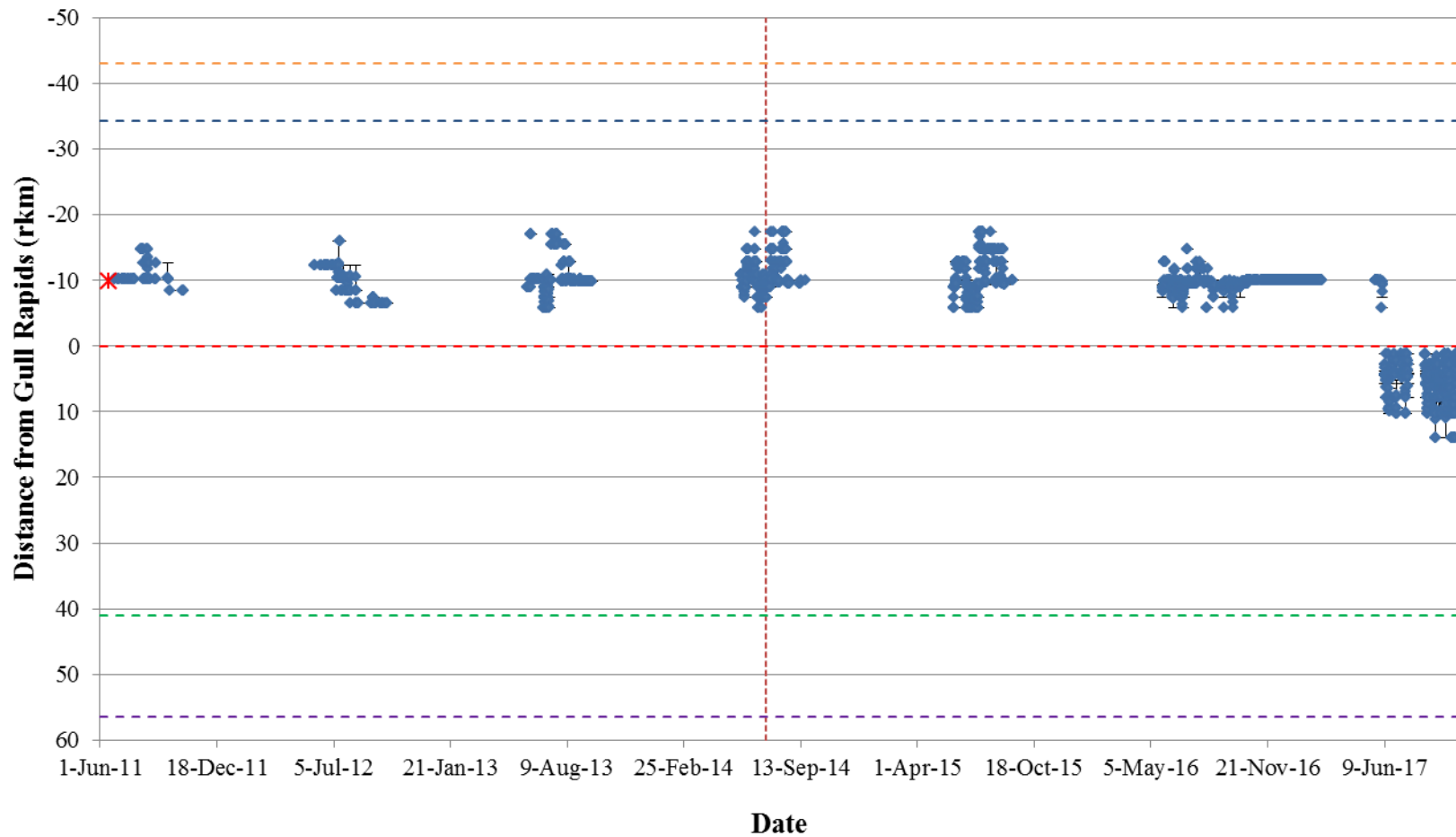


Figure A2-30: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16076) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

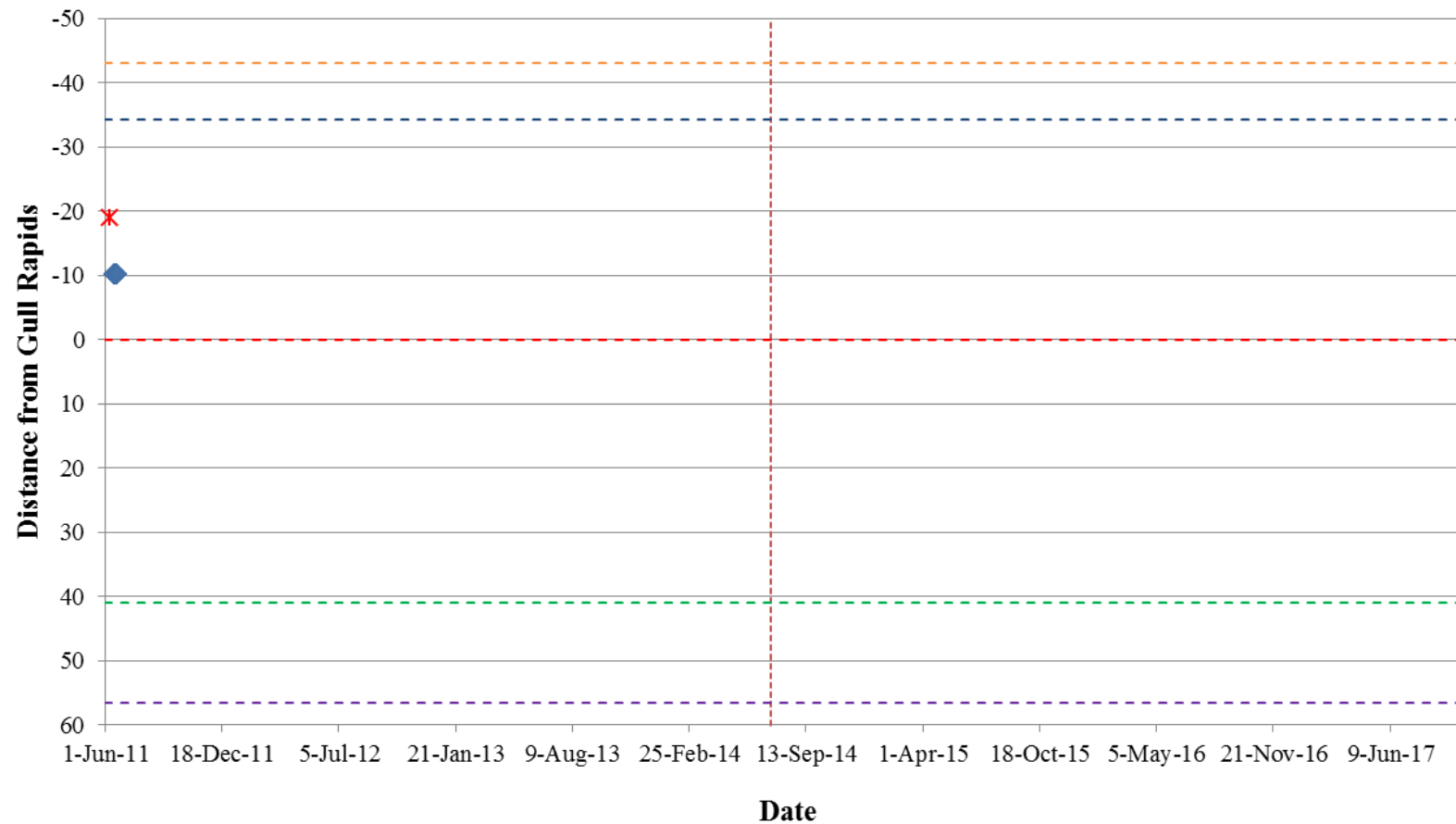


Figure A2-31: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16077) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

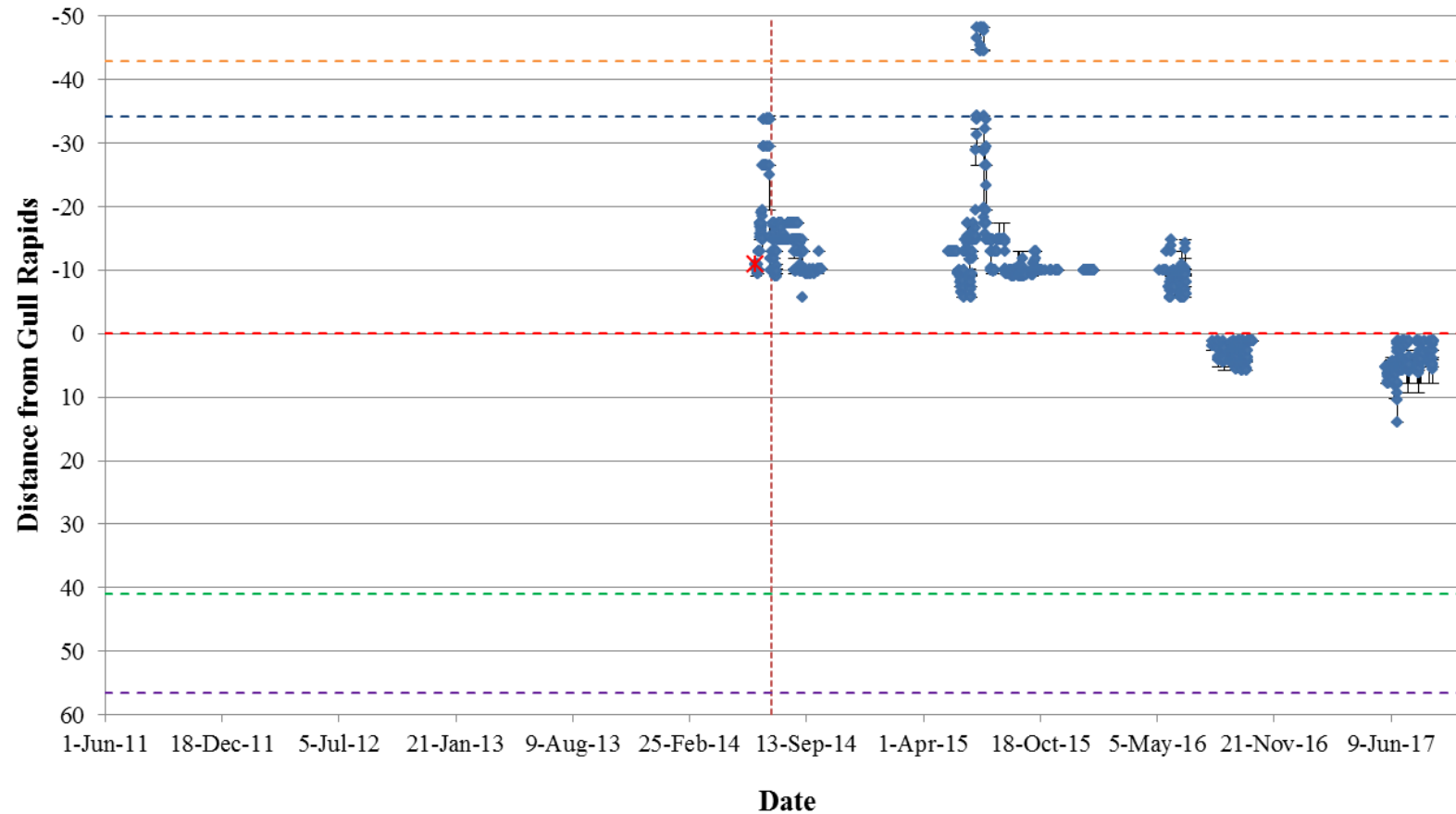


Figure A2-32: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32174) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

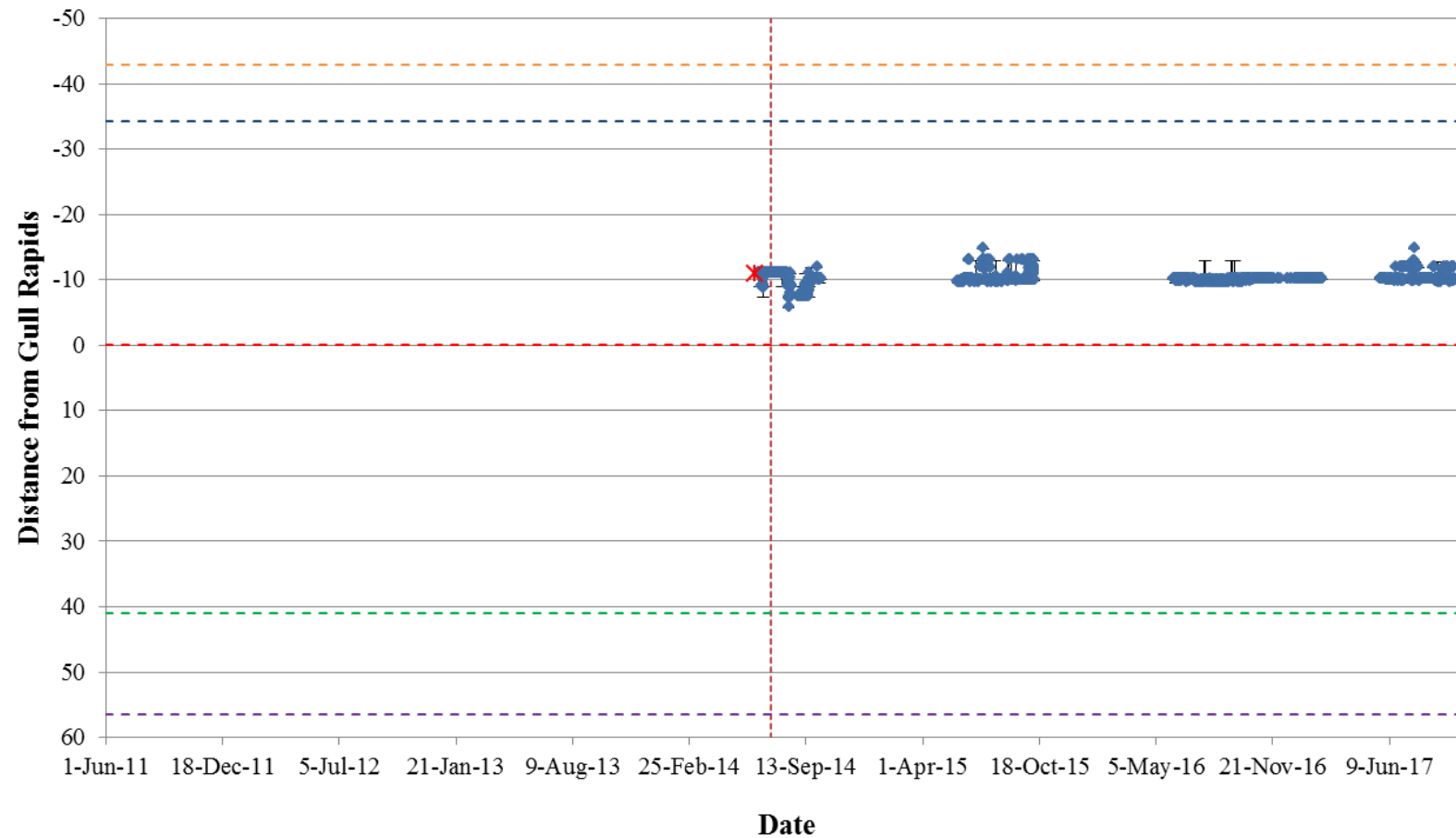


Figure A2-33: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32175) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

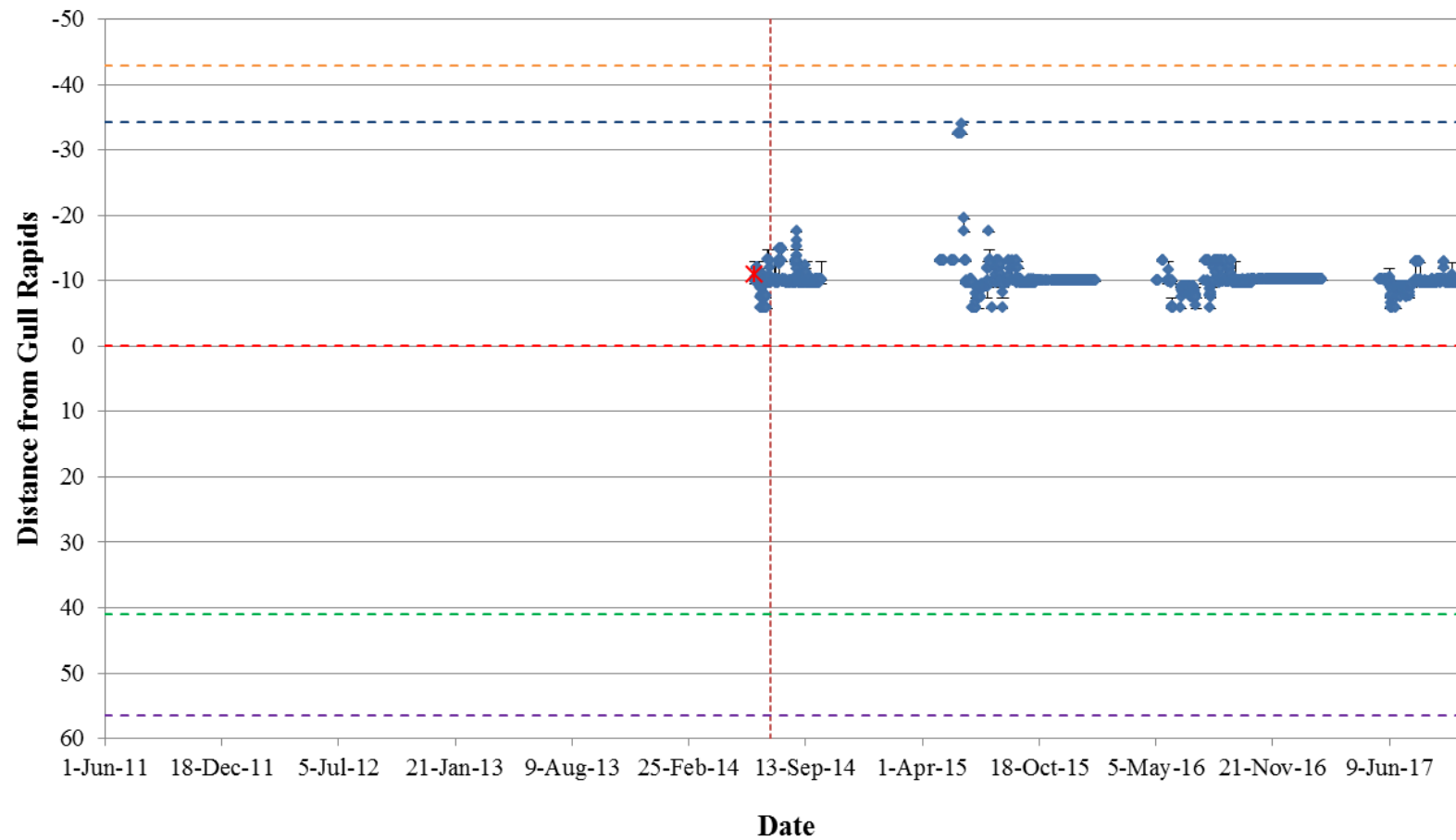
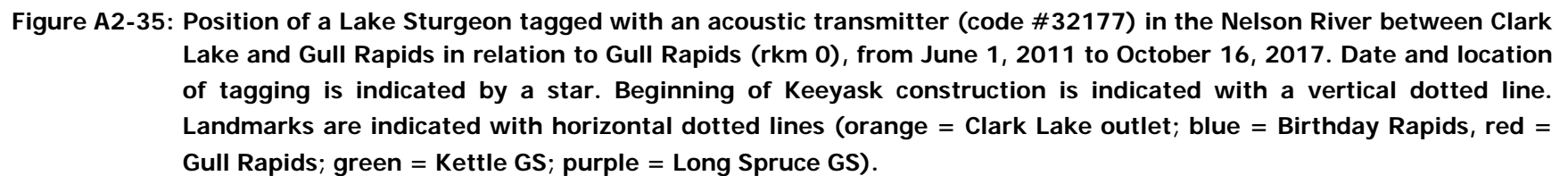


Figure A2-34: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32176) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).



APPENDIX 3:

LOCATION SUMMARY FOR INDIVIDUAL ACOUSTIC TAGGED ADULT LAKE STURGEON, STEPHENS LAKE, JUNE 2011 TO OCTOBER 2017

Figure A3-1: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16018) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.	114
Figure A3-2: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16019) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.	115
Figure A3-3: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16020) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.	116
Figure A3-4: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16021) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.	117
Figure A3-5: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16022) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.	118
Figure A3-6: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16024) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.	119
Figure A3-7: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16025) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.	120
Figure A3-8: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16027) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.	121
Figure A3-9: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16028) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.	122
Figure A3-10: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16029) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.	123

Figure A3-11: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16030) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.	124
Figure A3-12: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16031) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.	125
Figure A3-13: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16032) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.	126
Figure A3-14: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16033b) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.	127
Figure A3-15: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16034) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.	128
Figure A3-16: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16035) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.	129
Figure A3-17: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16037) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.	130
Figure A3-18: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16038) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.	131
Figure A3-19: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16040) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.	132
Figure A3-20: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16041) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.	133
Figure A3-21: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16043) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.	134
Figure A3-22: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16044) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.	135
Figure A3-23: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16046) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.	136

Figure A3-24: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16047) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.	137
Figure A3-25: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16049) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.	138
Figure A3-26: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16050) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.	139
Figure A3-27: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16052) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.	140
Figure A3-28: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16053) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.	141
Figure A3-29: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32167) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.	142
Figure A3-30: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32168) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.	143
Figure A3-31: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32169) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.	144
Figure A3-32: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32170) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.	145
Figure A3-33: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32171) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.	146
Figure A3-34: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32172) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.	147
Figure A3-35: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32173) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017.	148

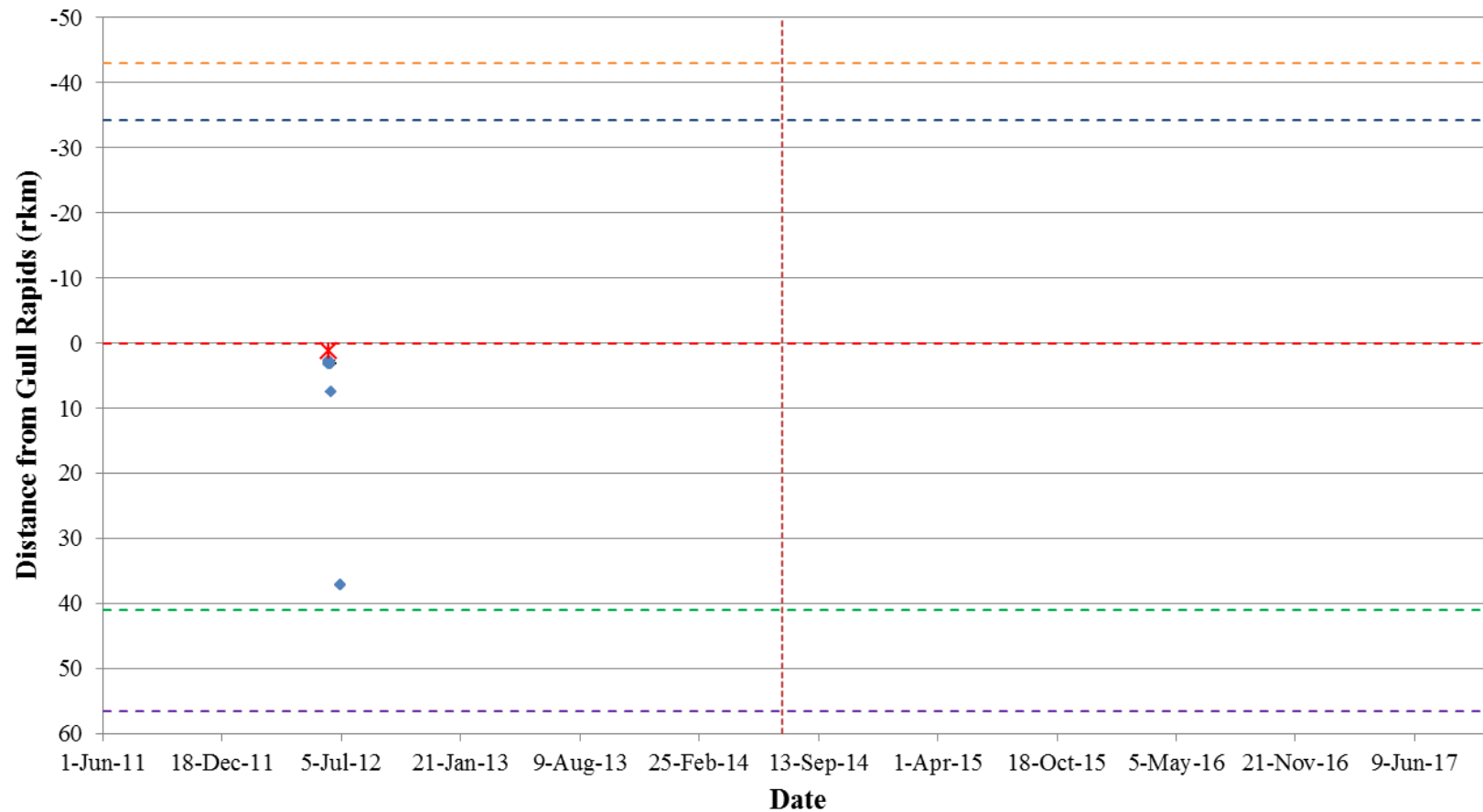


Figure A3-1: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16018) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

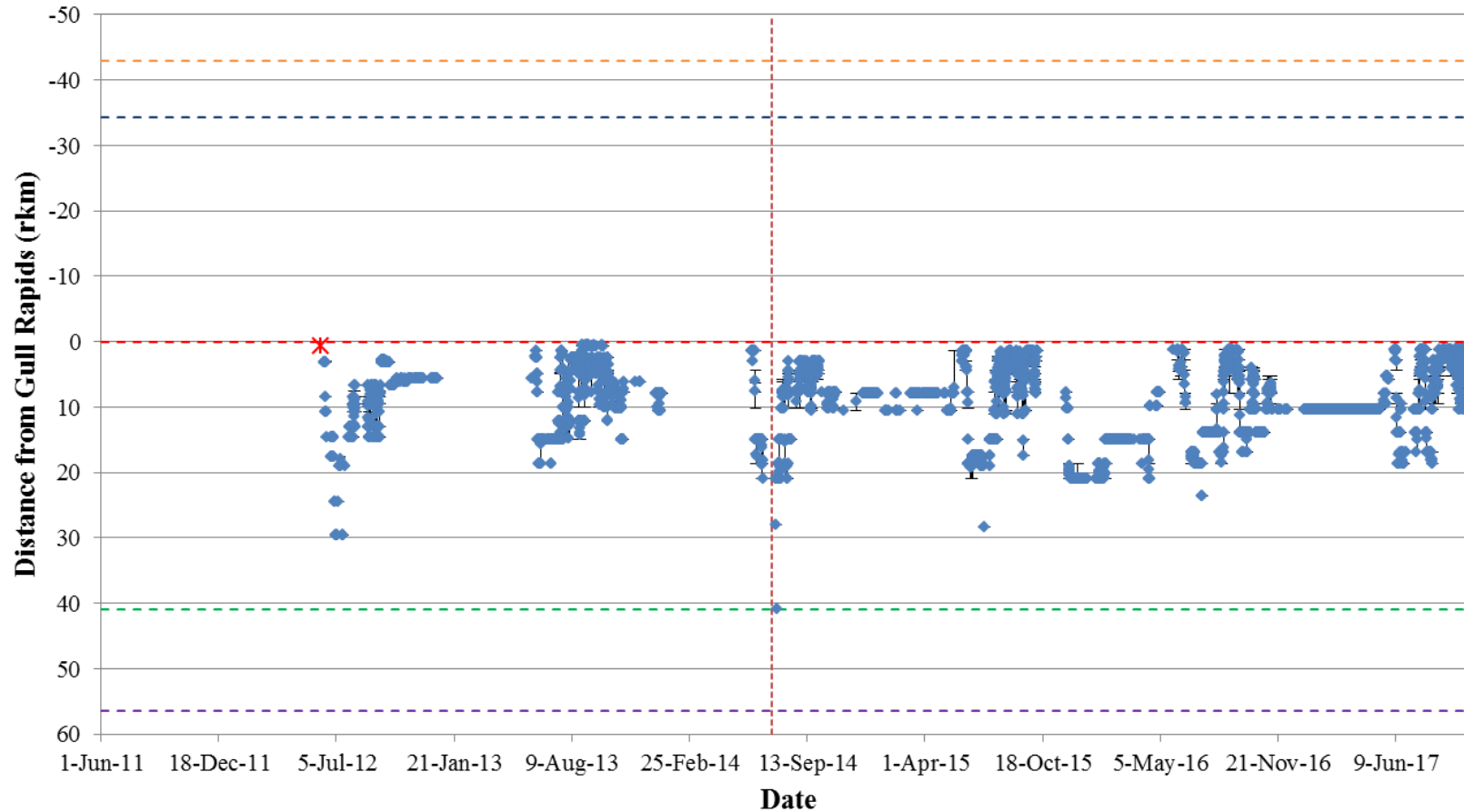


Figure A3-2: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16019) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

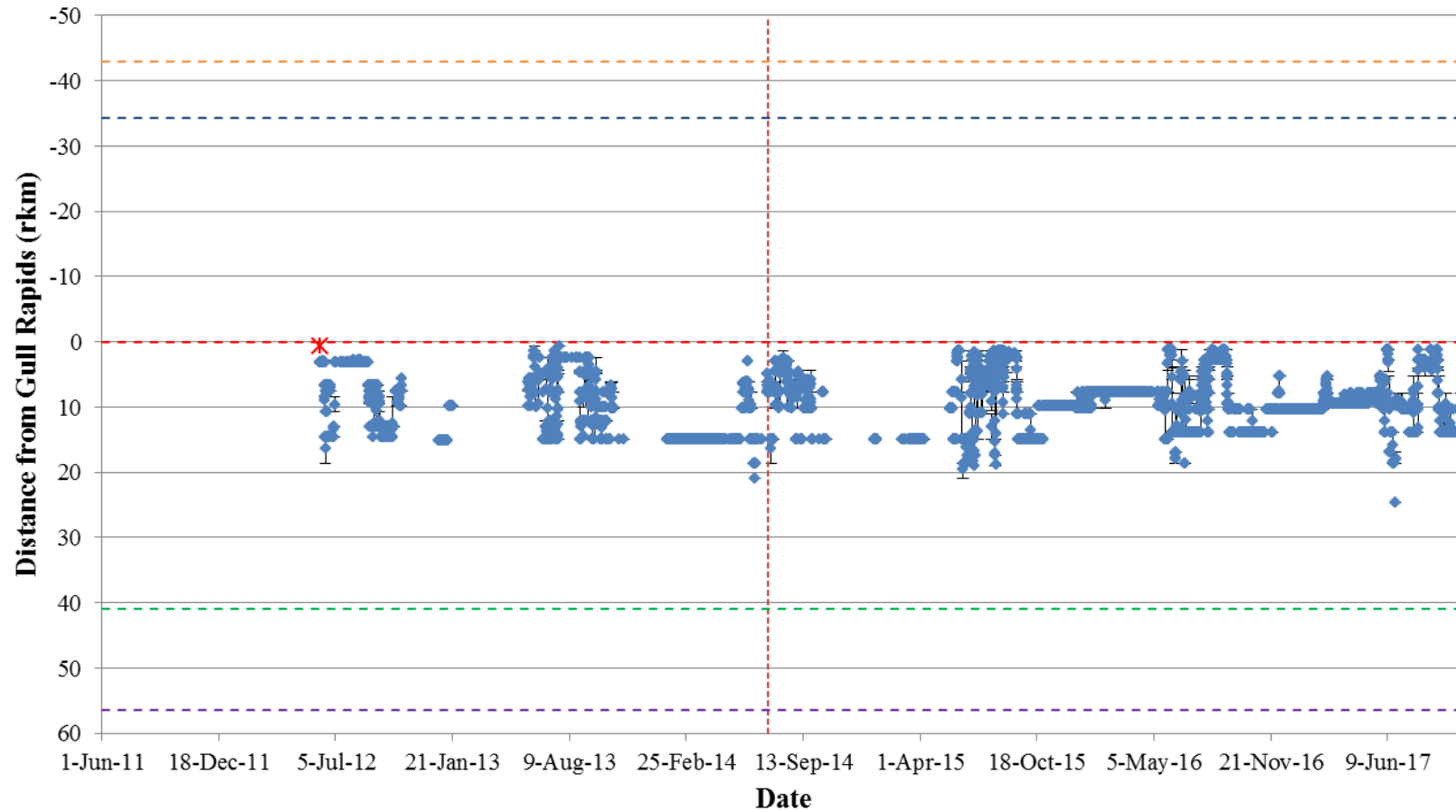


Figure A3-3: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16020) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

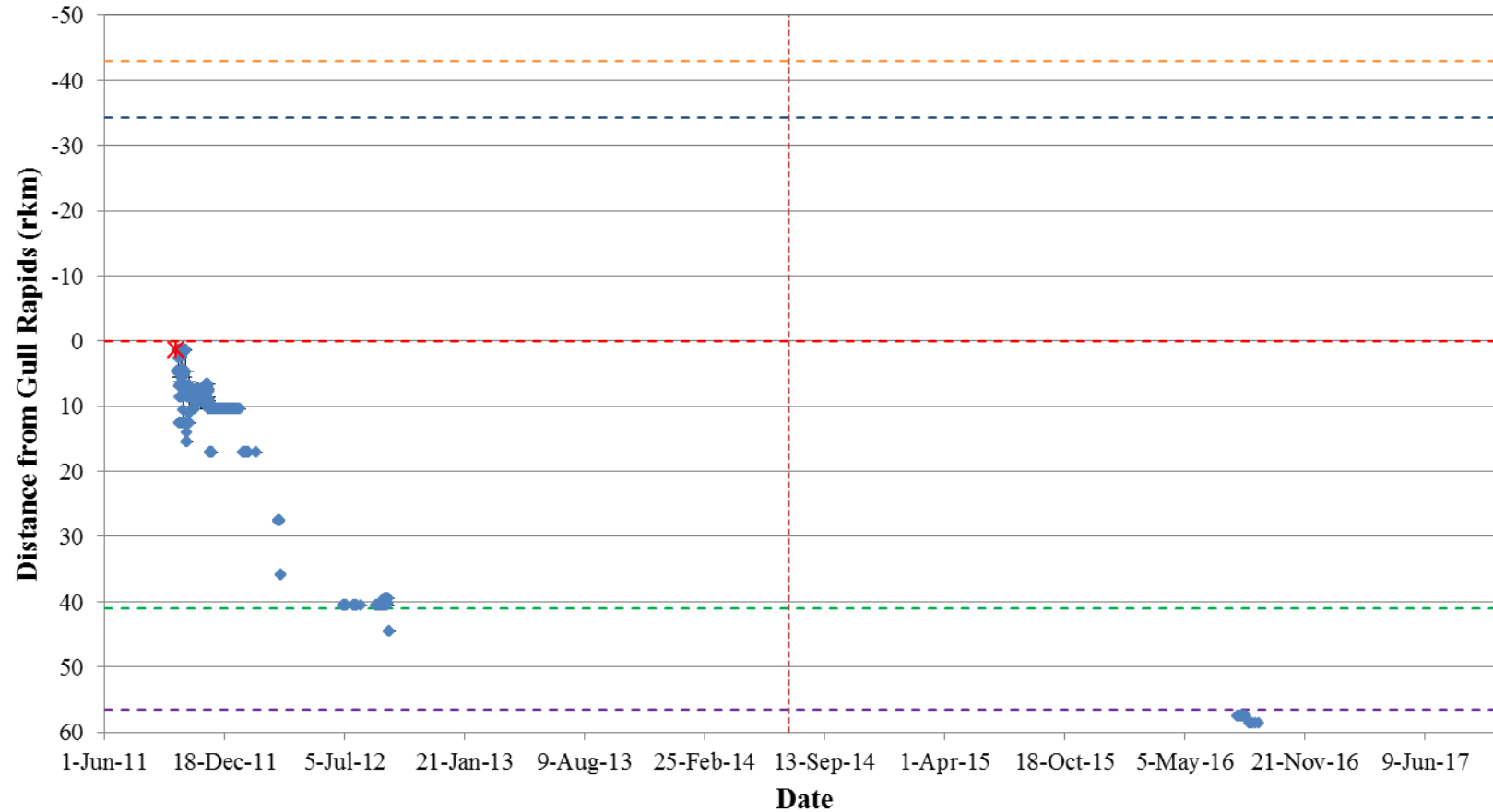


Figure A3-4: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16021) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

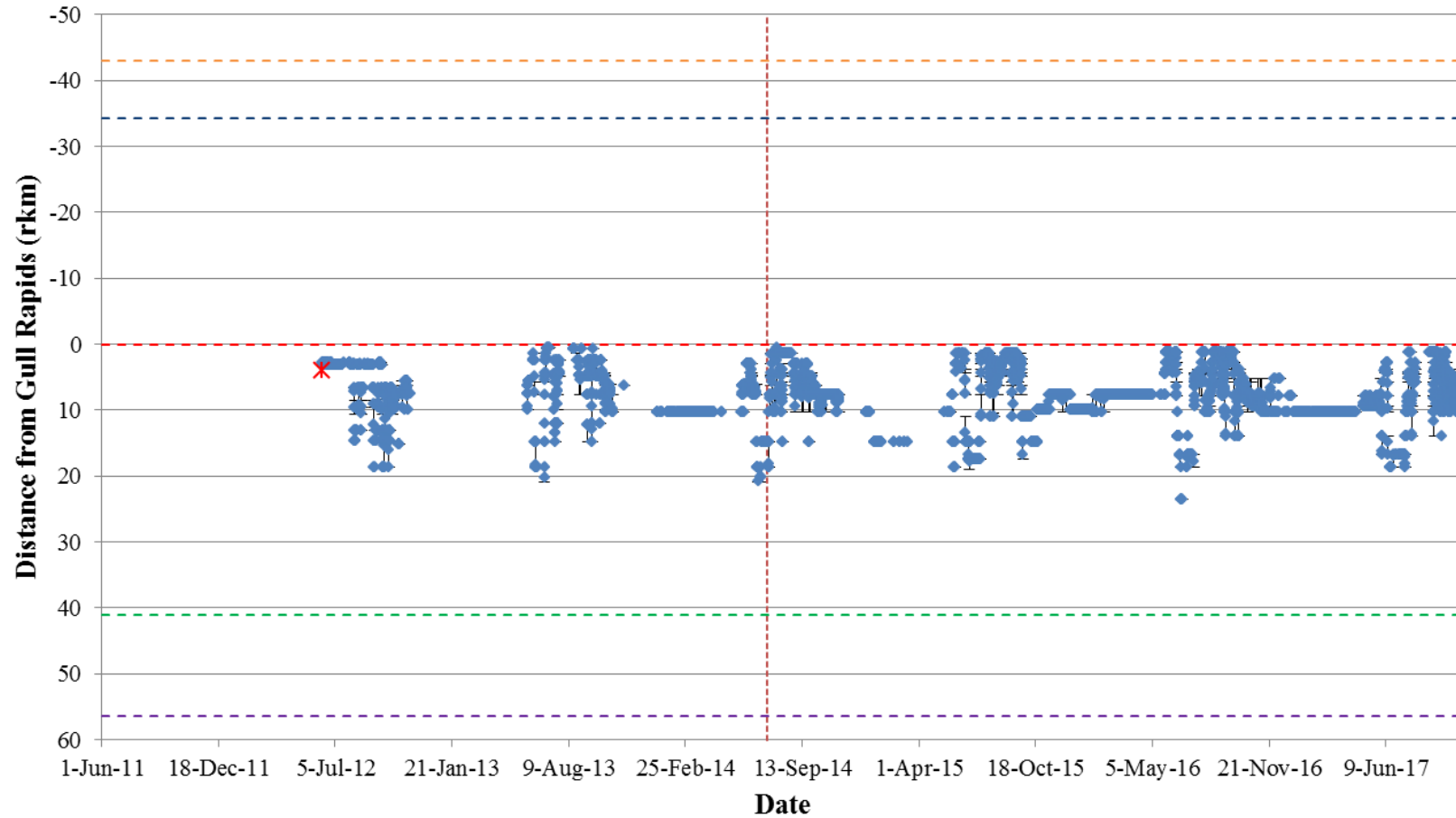


Figure A3-5: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16022) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

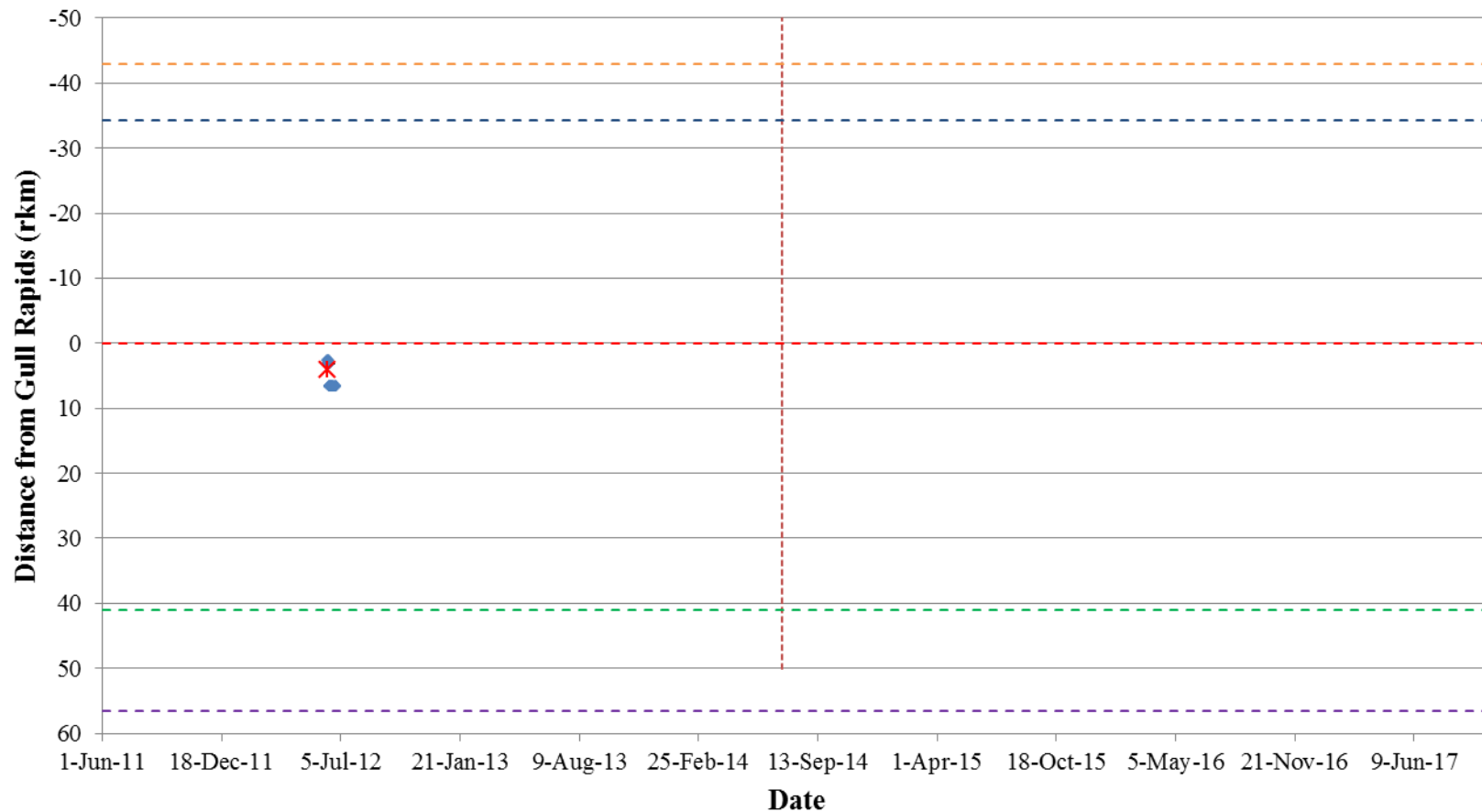


Figure A3-6: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16024) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

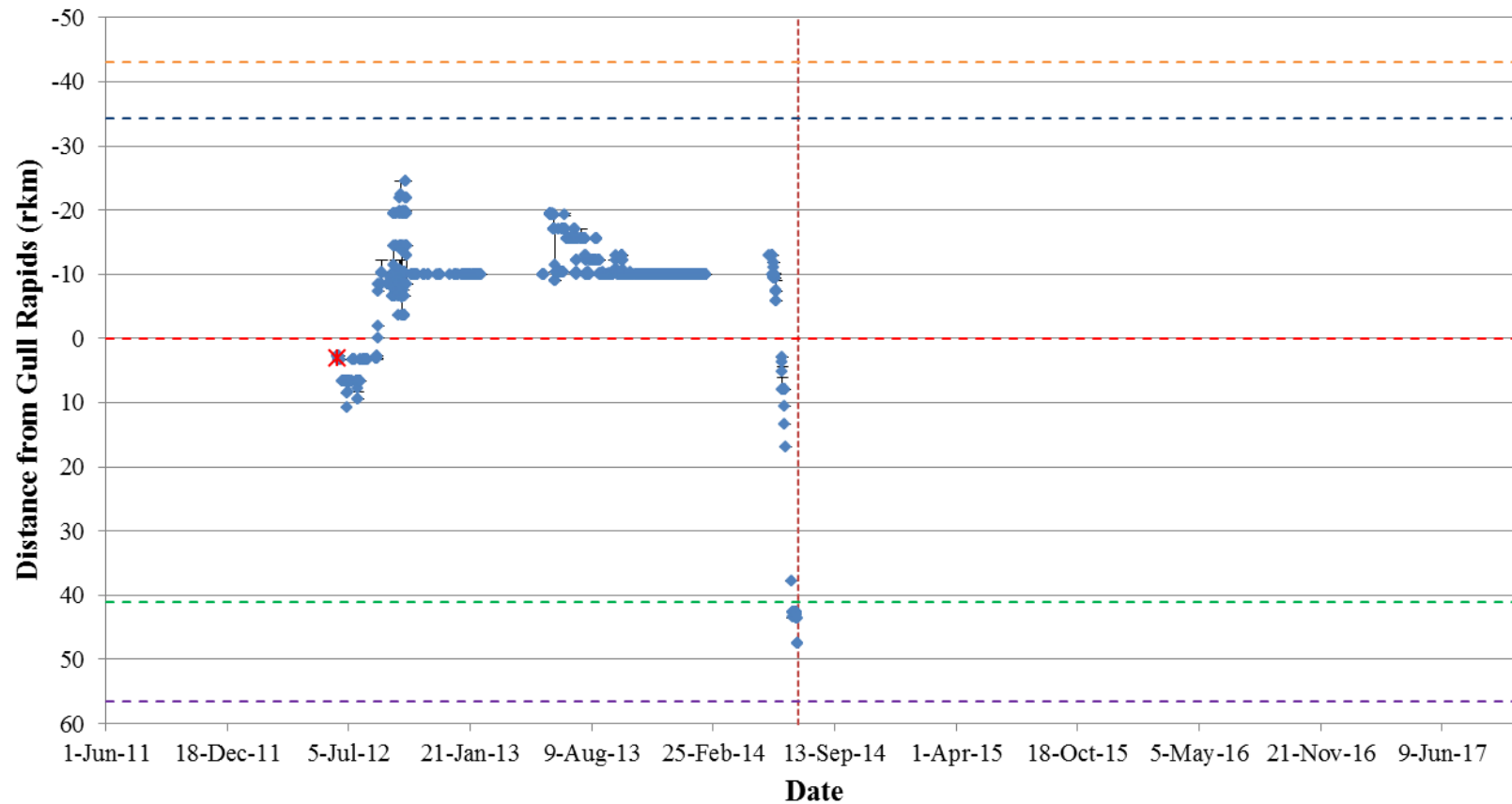


Figure A3-7: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16025) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

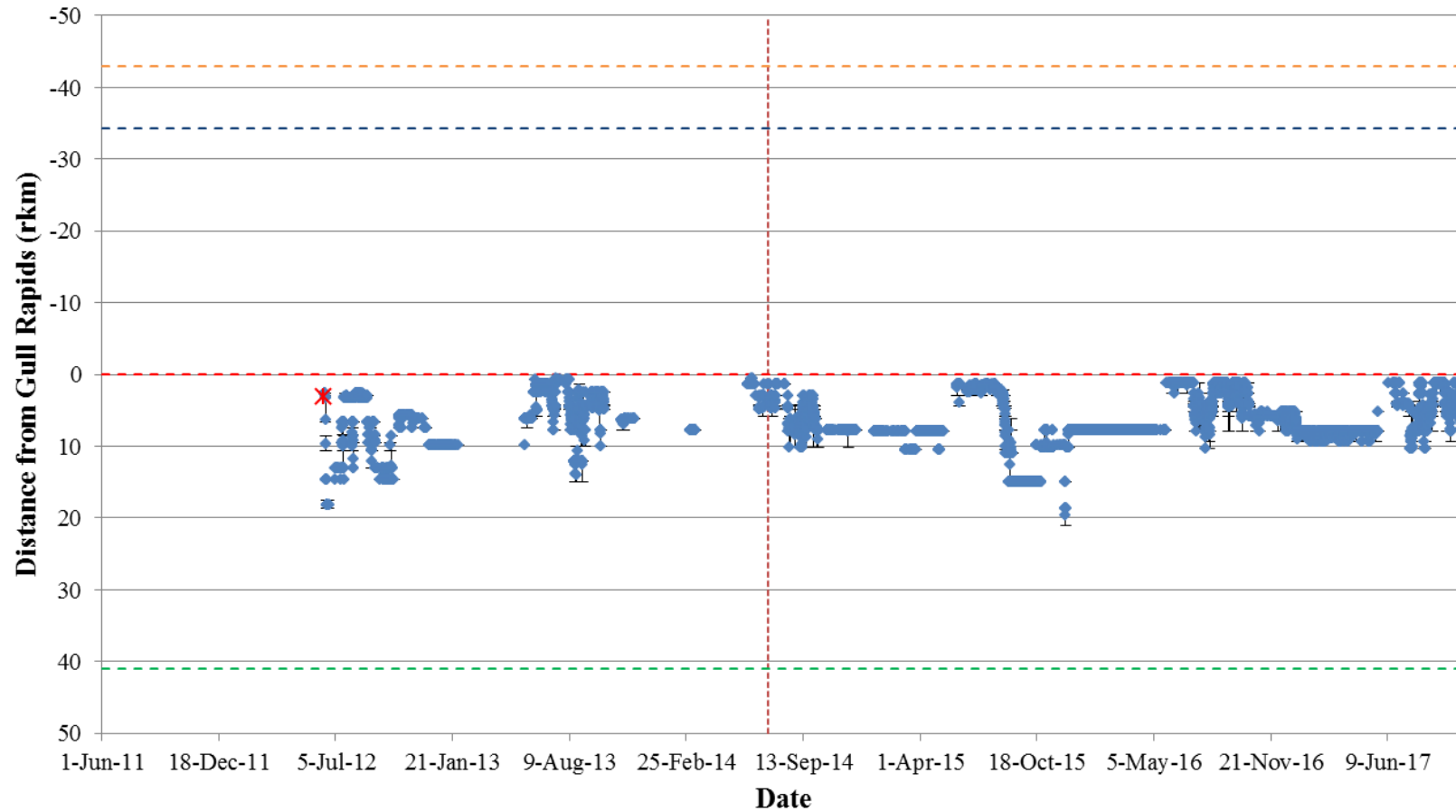


Figure A3-8: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16027) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

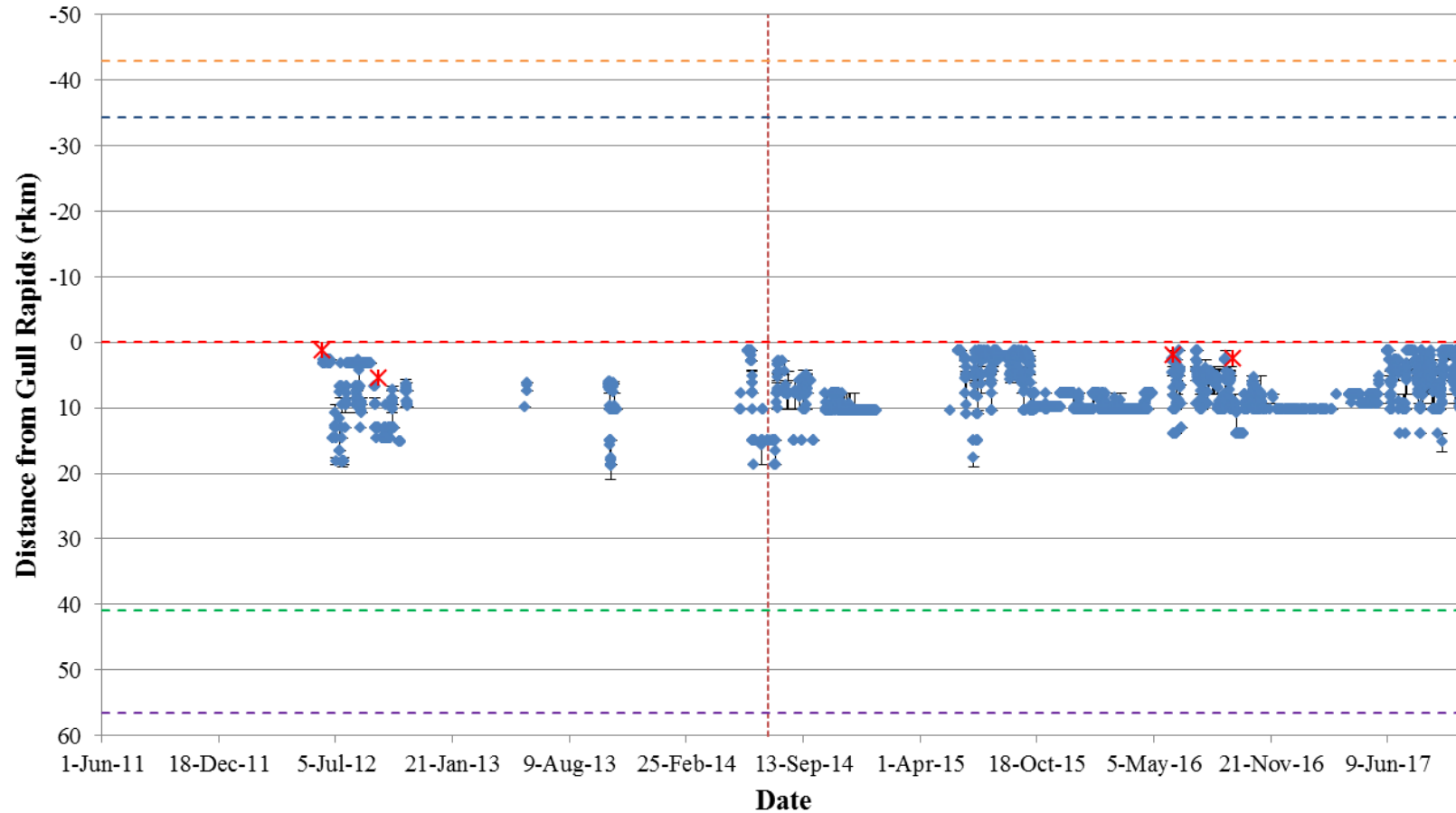


Figure A3-9: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16028) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

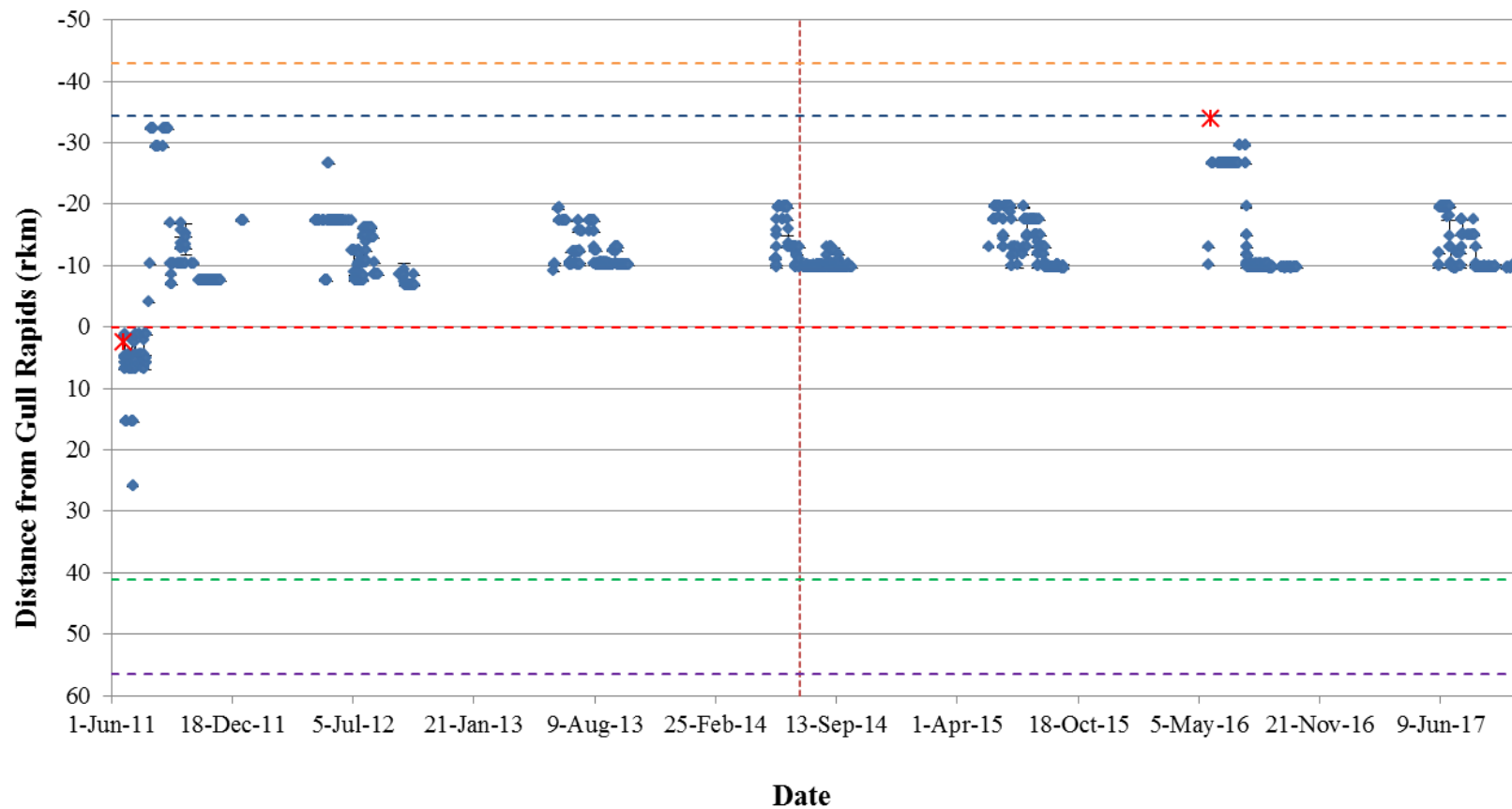


Figure A3-10: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16029) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

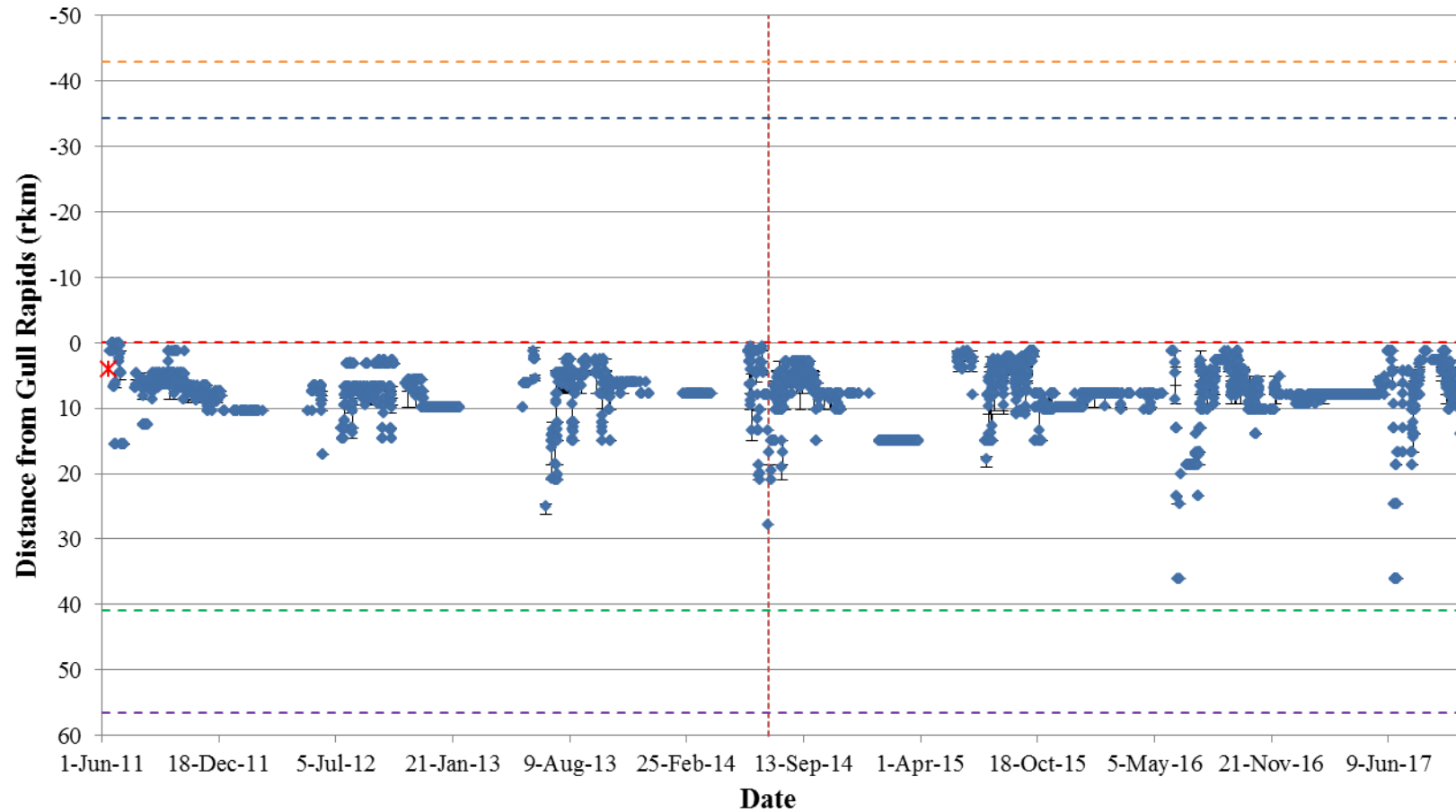


Figure A3-11: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16030) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

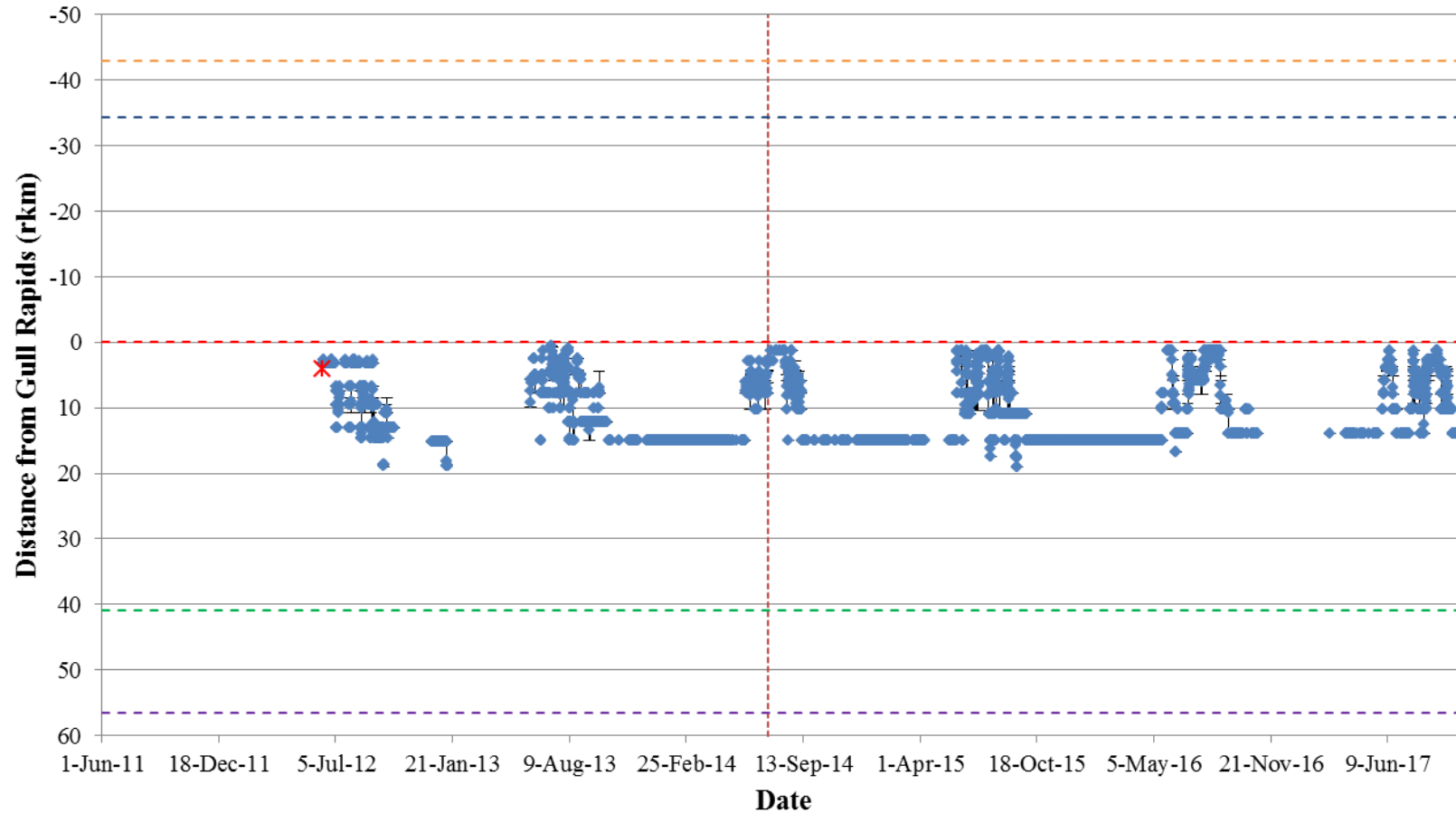


Figure A3-12: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16031) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

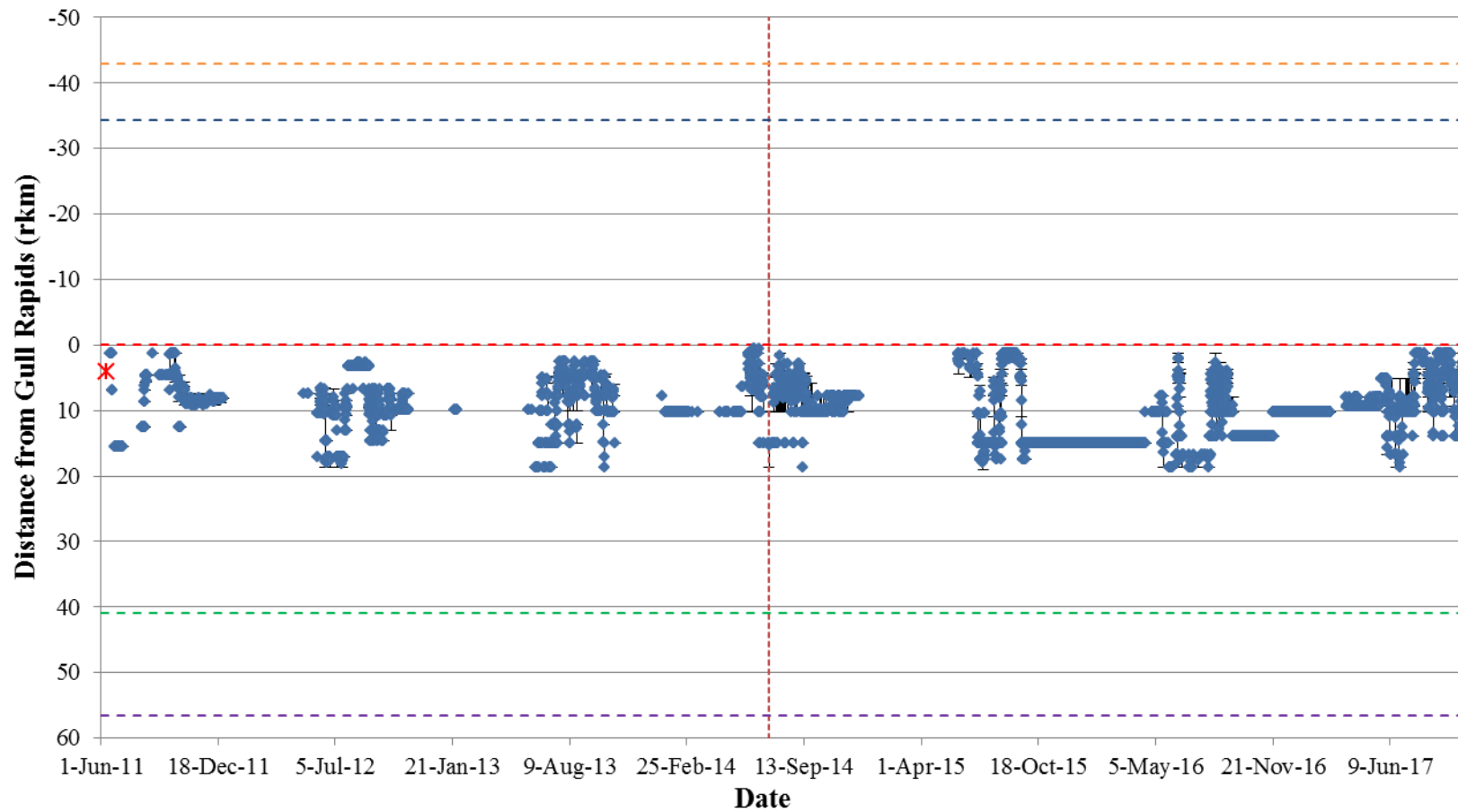


Figure A3-13: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16032) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

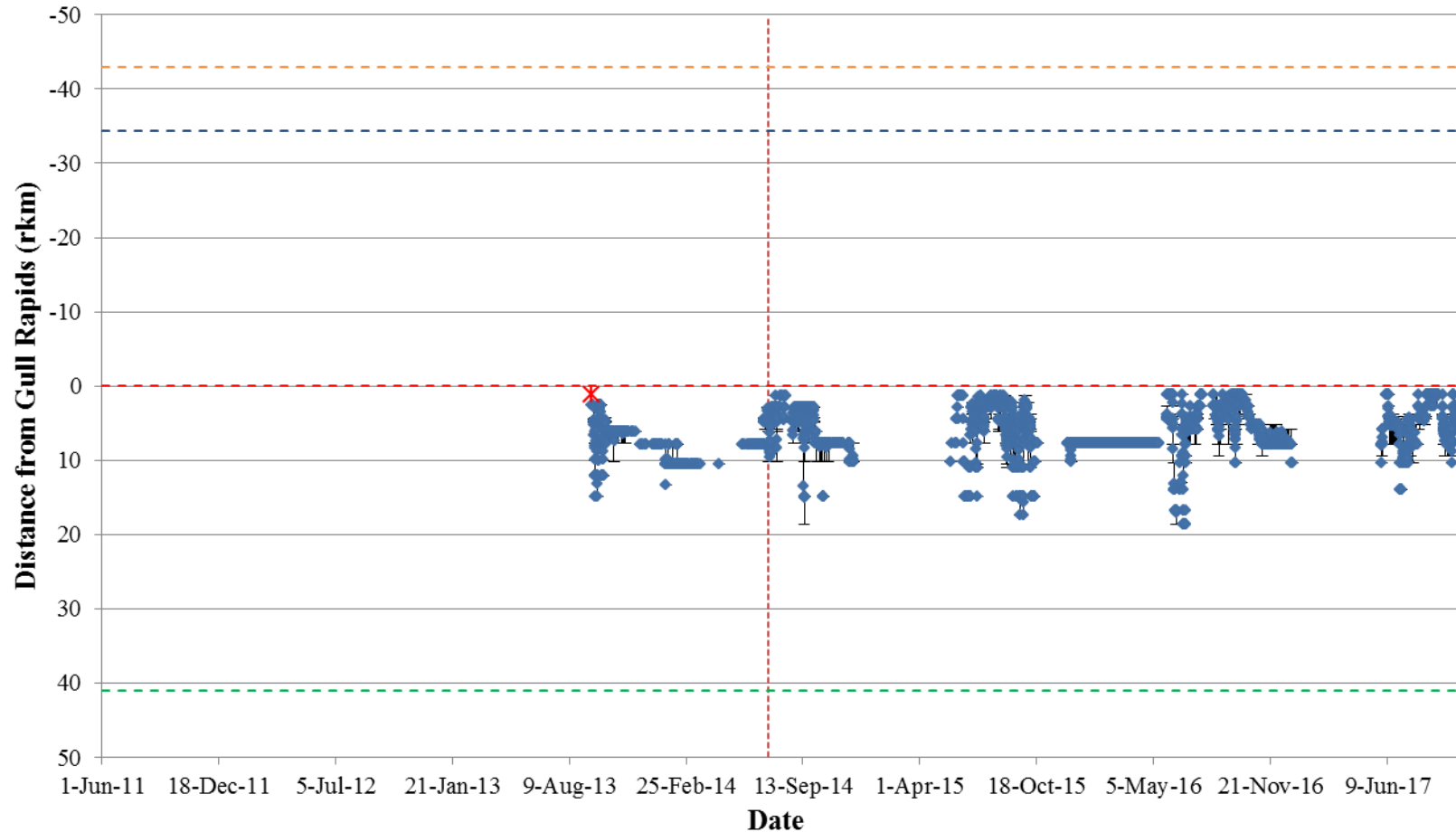


Figure A3-14: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16033b) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

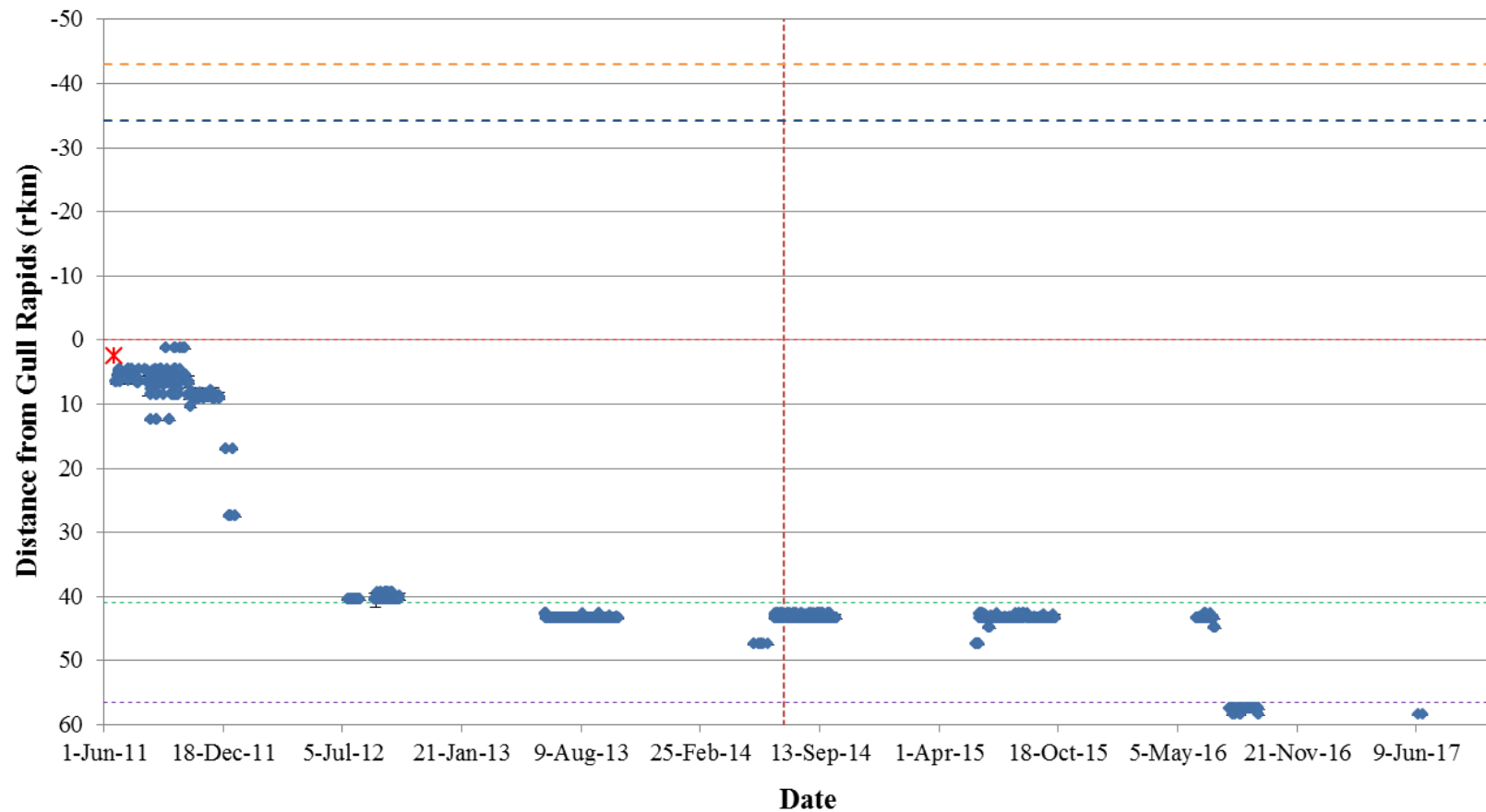


Figure A3-15: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16034) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

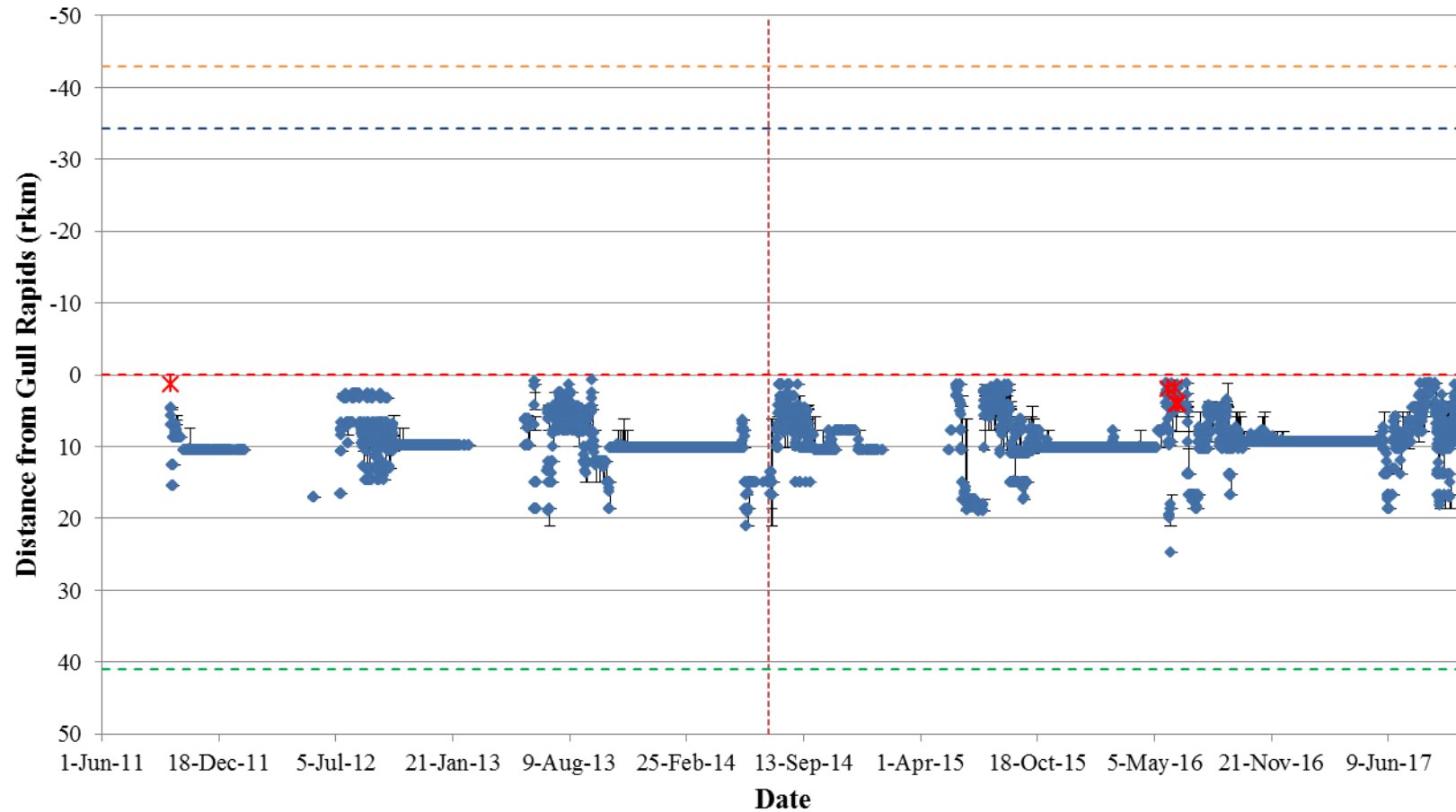


Figure A3-16: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16035) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging and recaptures are indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

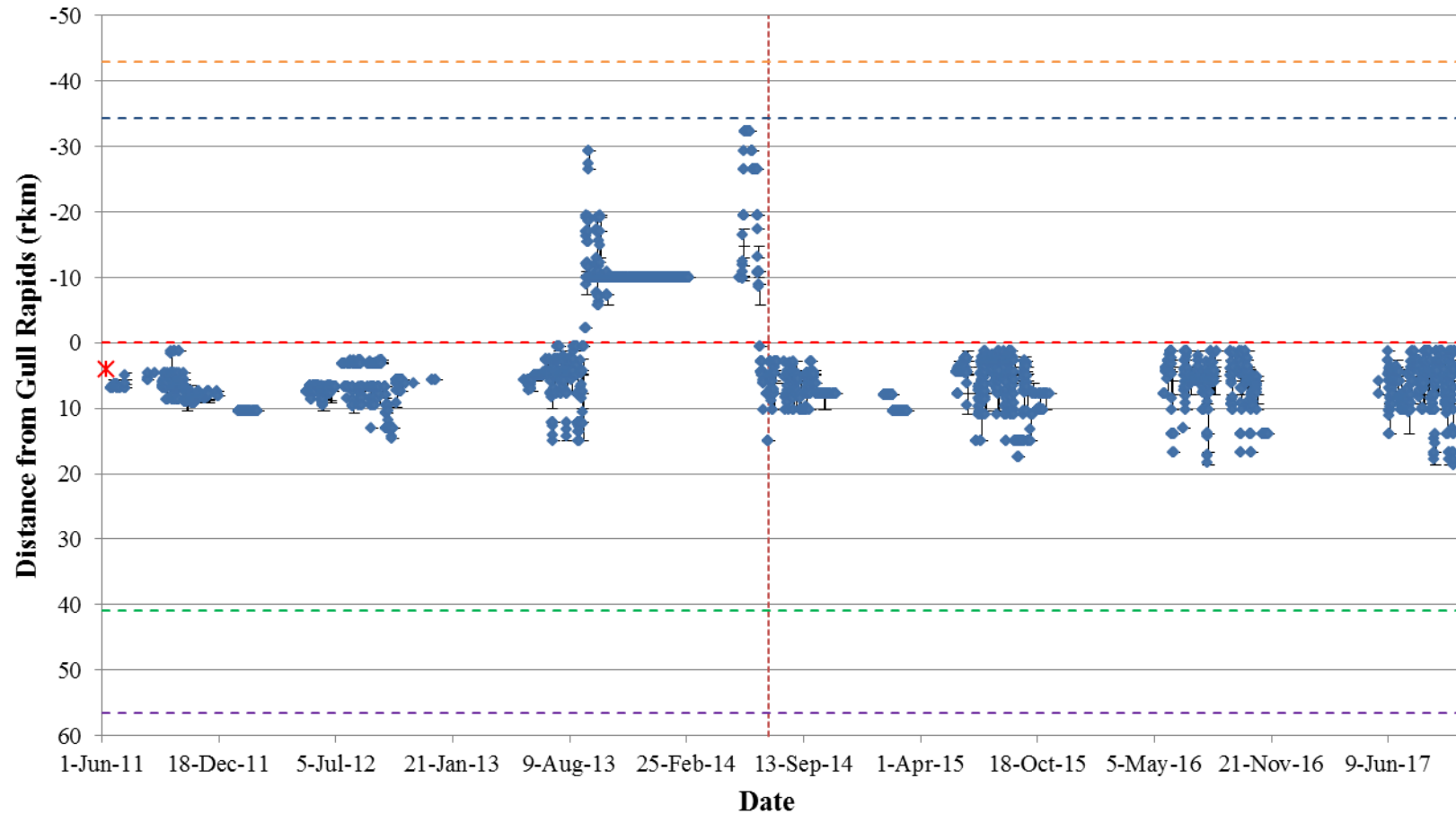


Figure A3-17: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16037) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging and recaptures are indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

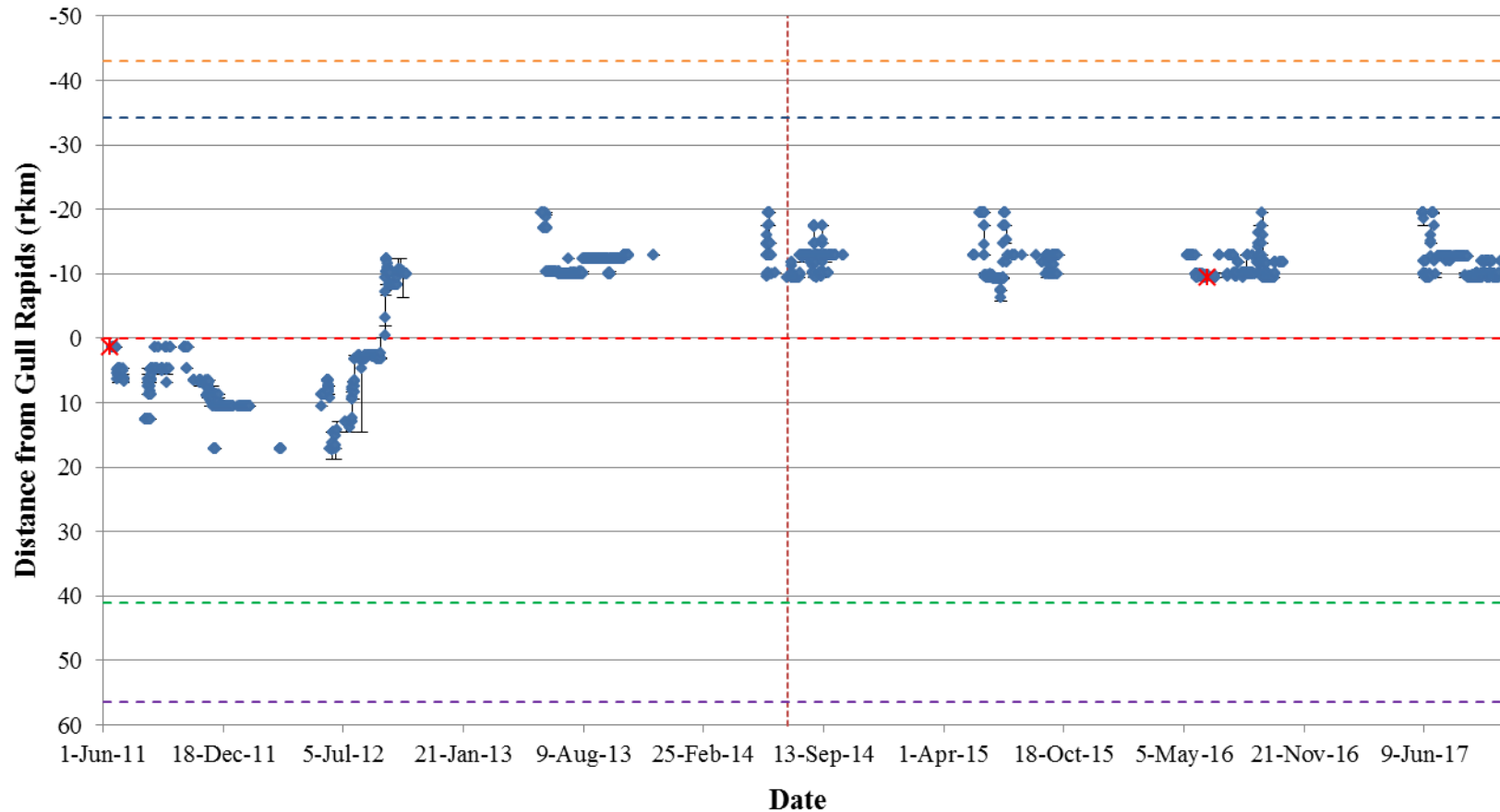


Figure A3-18: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16038) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging and recaptures are indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

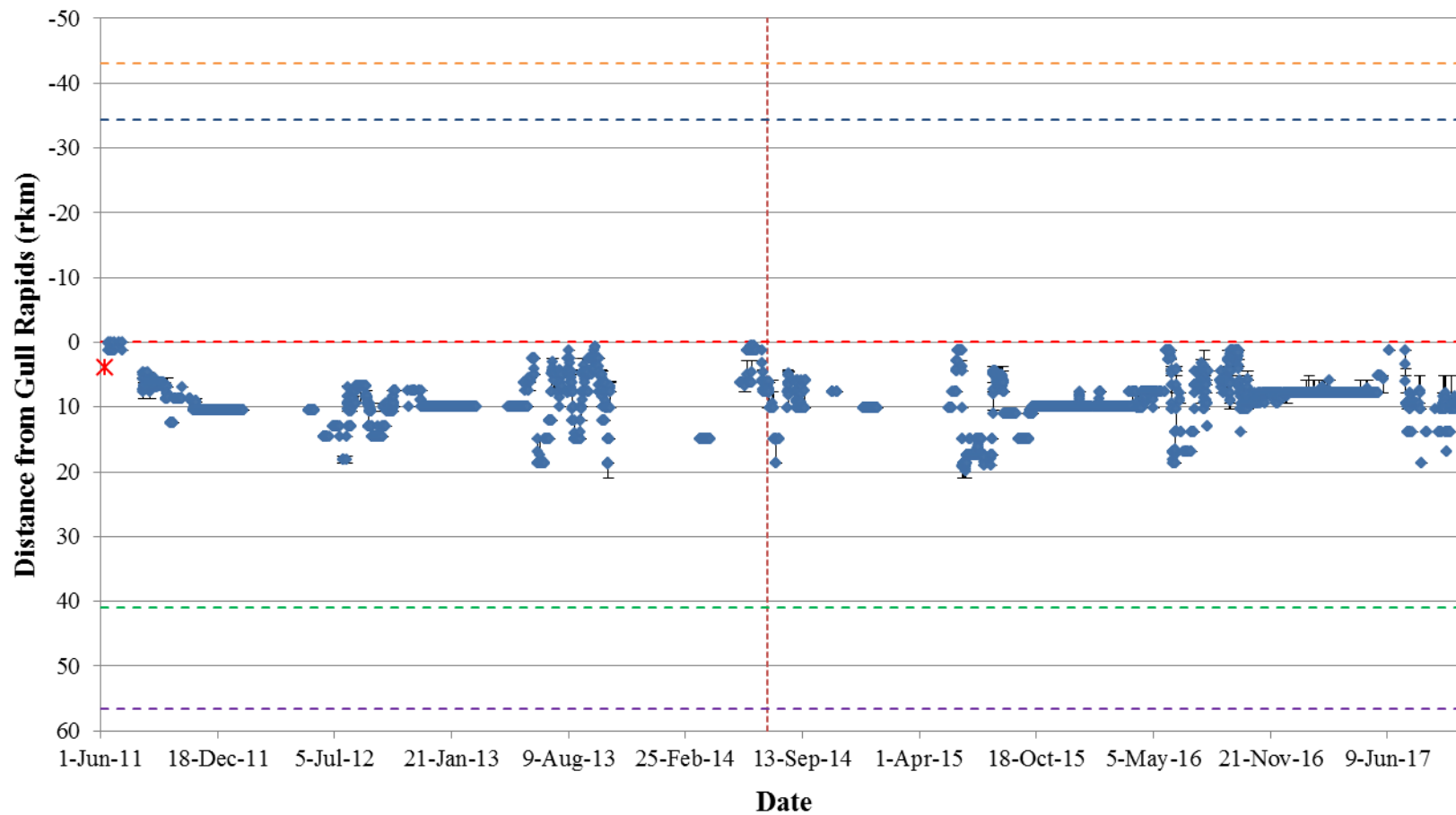


Figure A3-19: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16040) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging and recaptures are indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

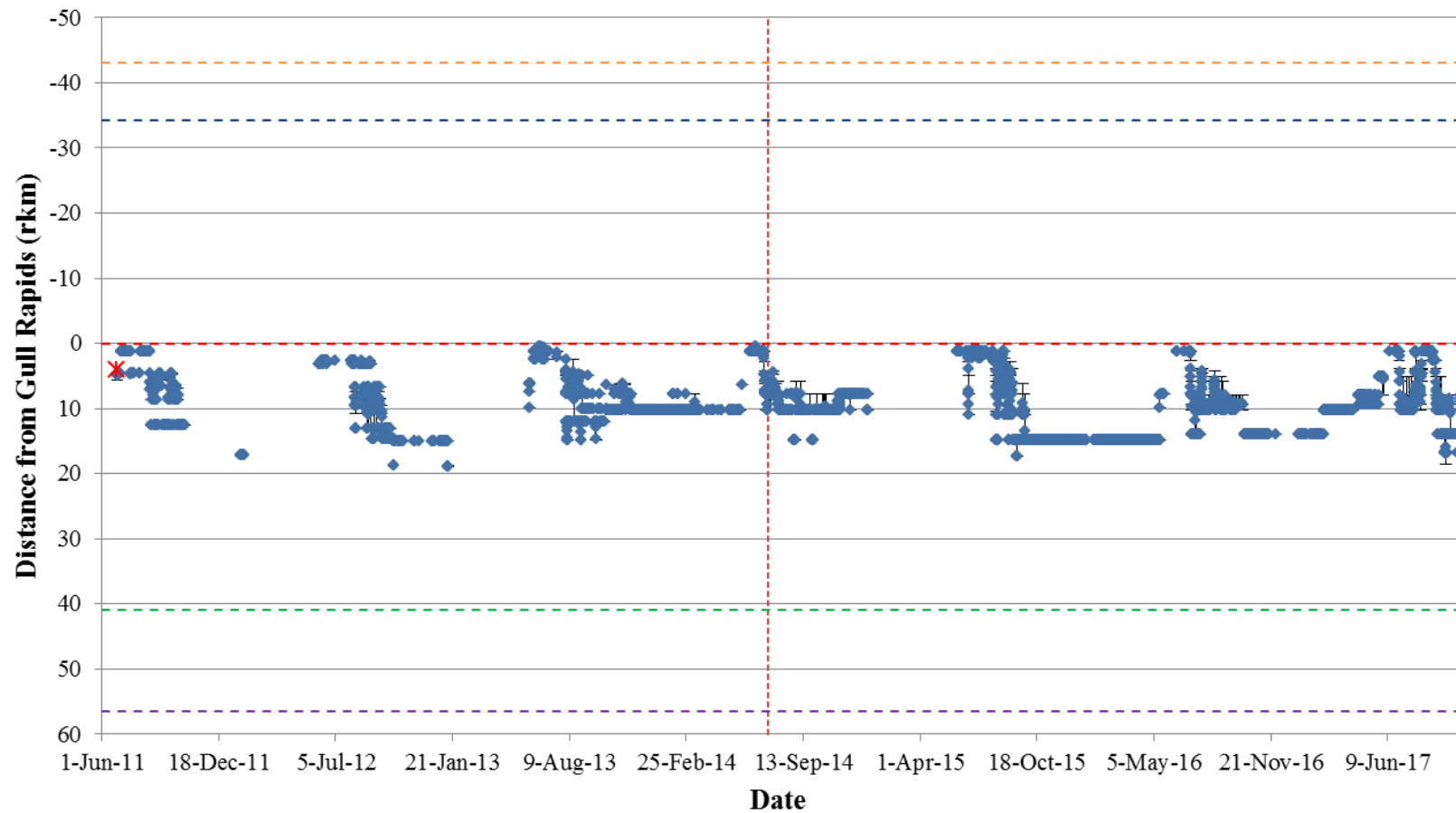


Figure A3-20: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16041) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging and recaptures are indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

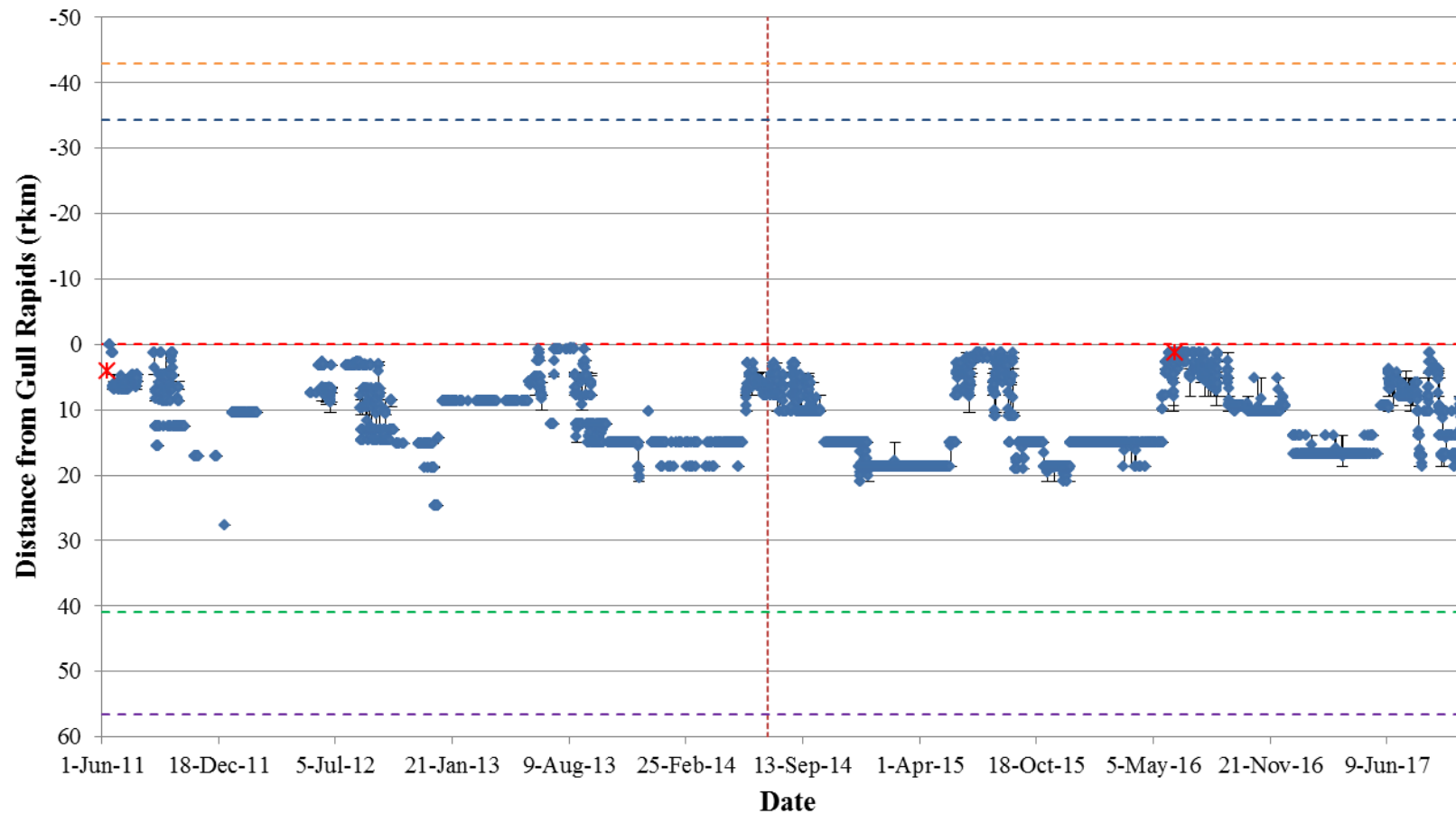


Figure A3-21: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16043) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging and recaptures are indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

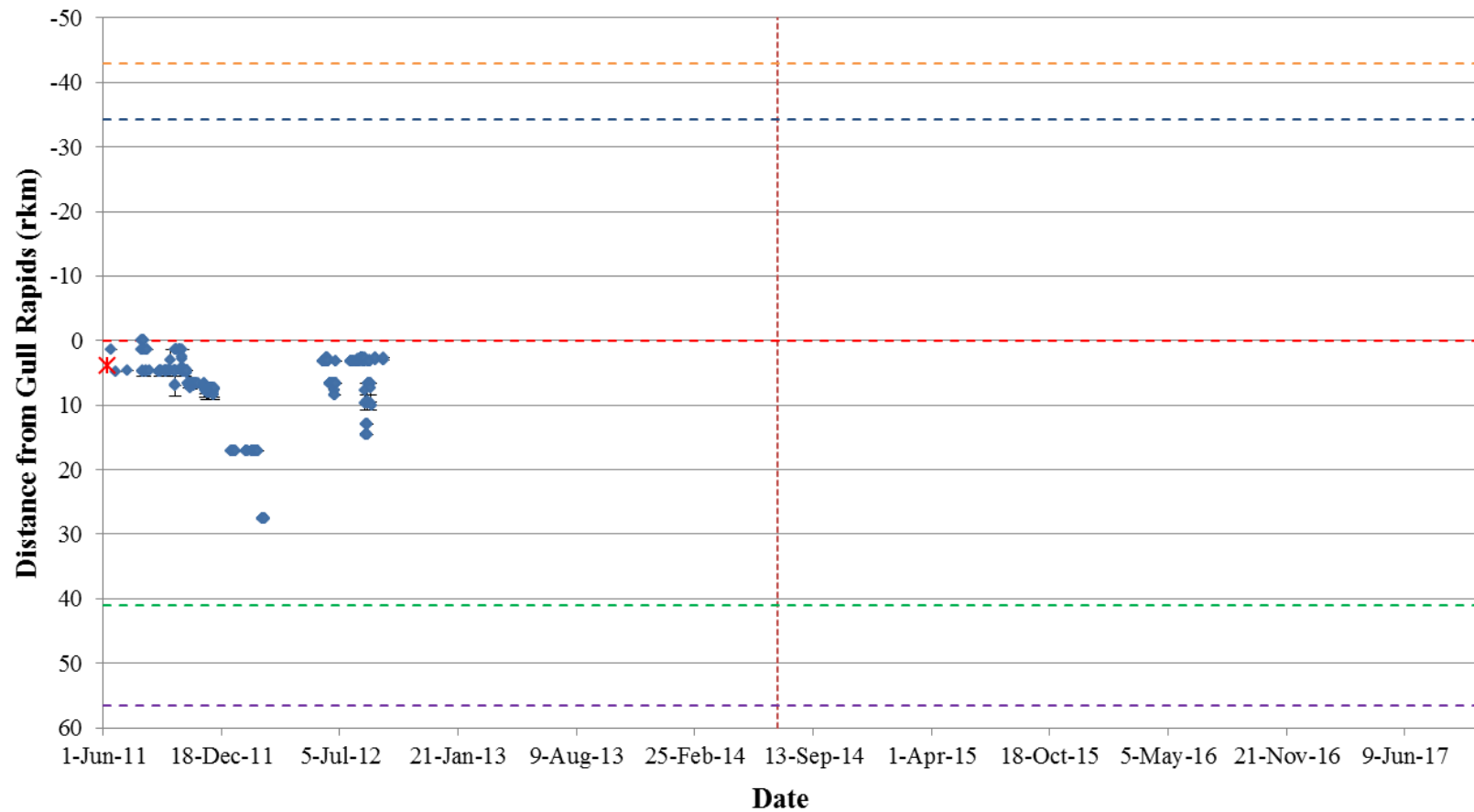


Figure A3-22: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16044) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging and recaptures are indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

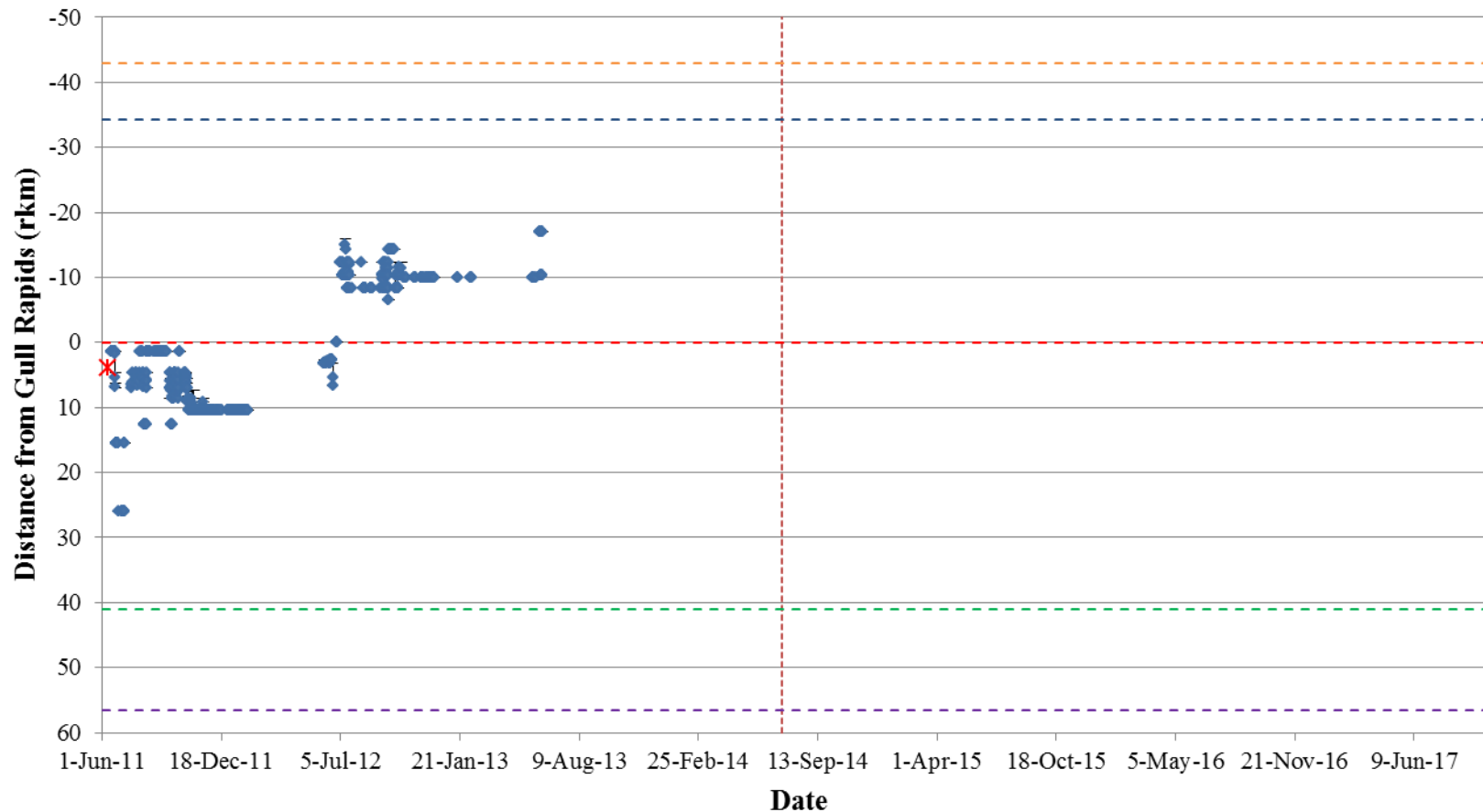


Figure A3-23: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16046) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging and recaptures are indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

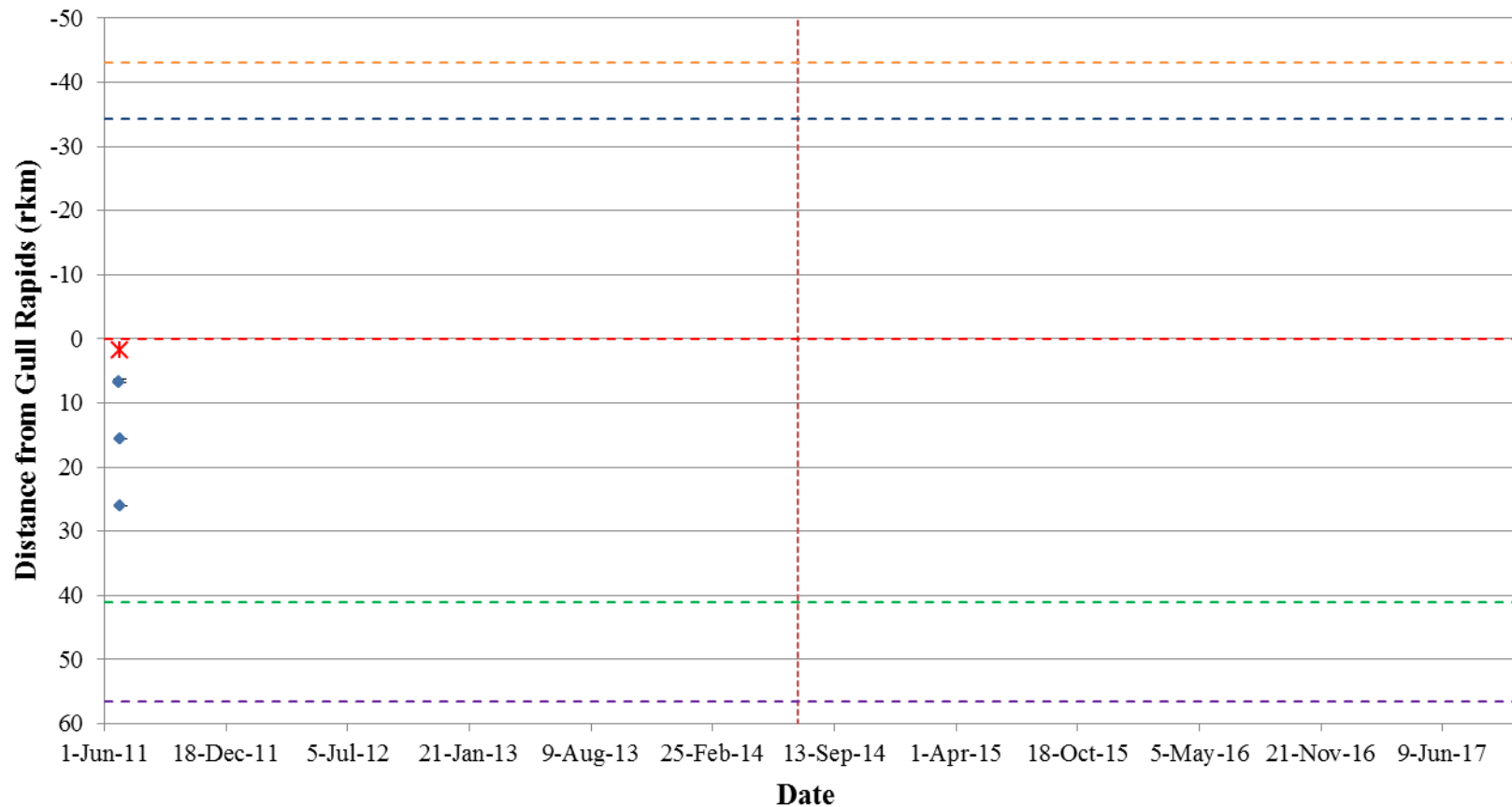


Figure A3-24: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16047) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging and recaptures are indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

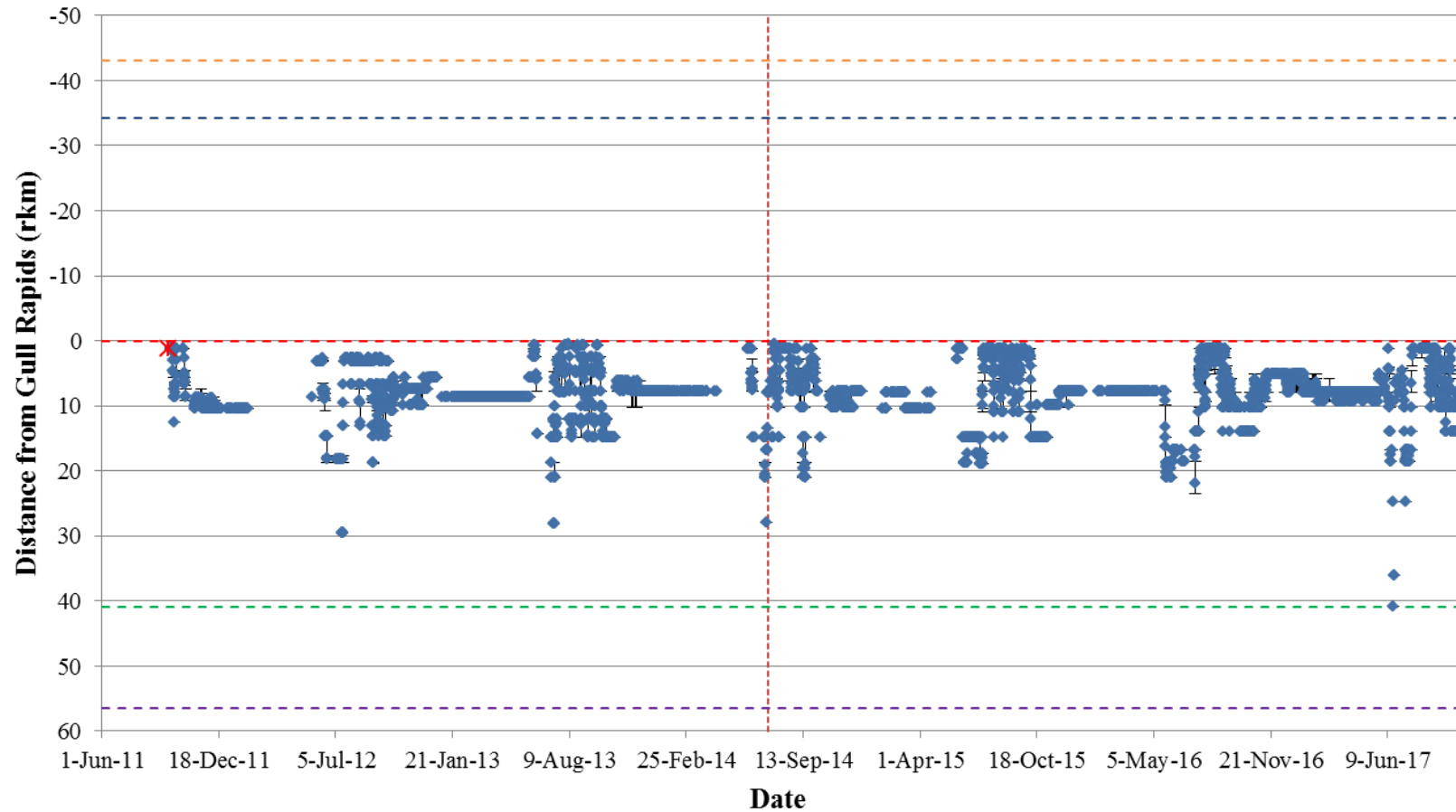


Figure A3-25: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16049) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging and recaptures are indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

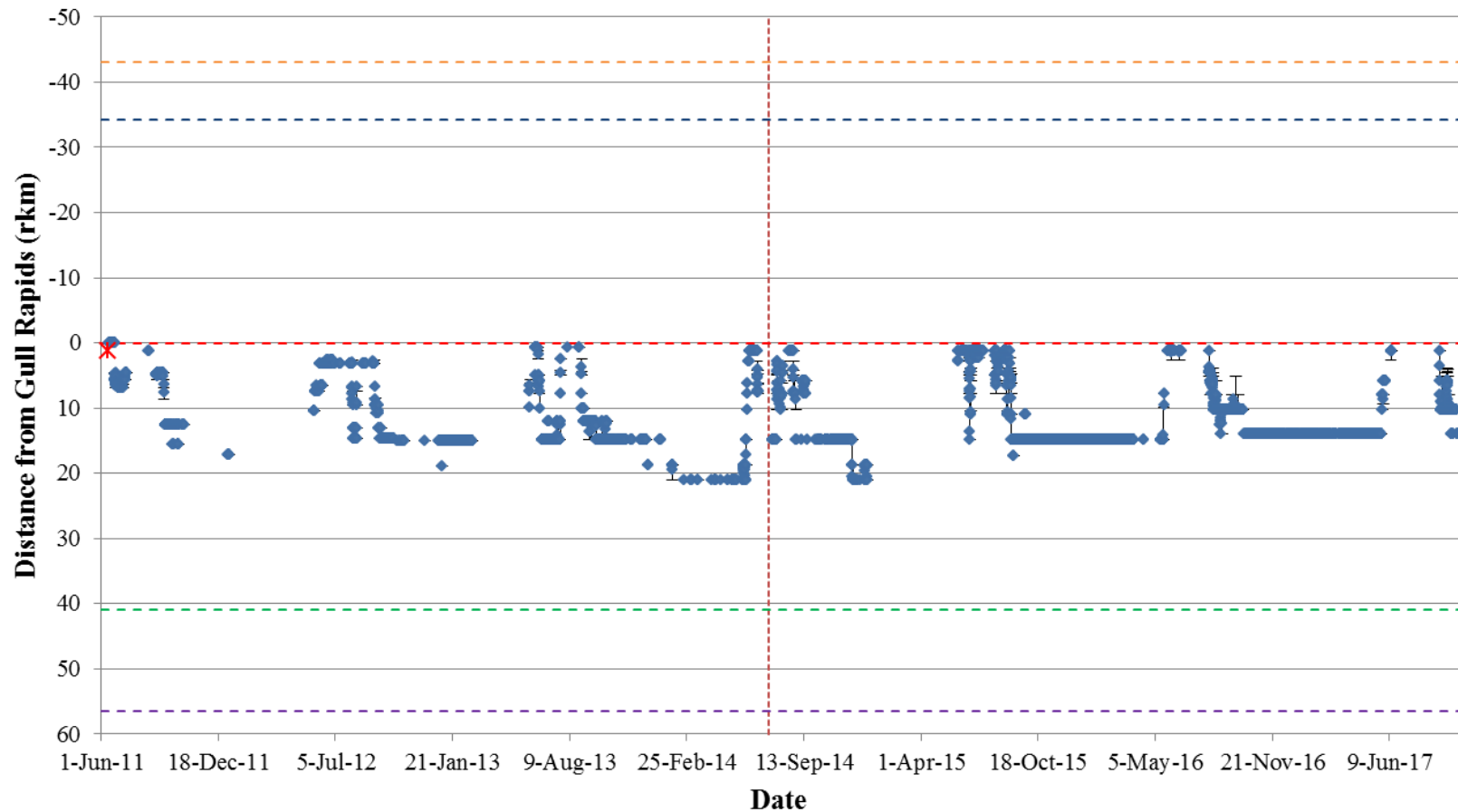


Figure A3-26: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16050) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging and recaptures are indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

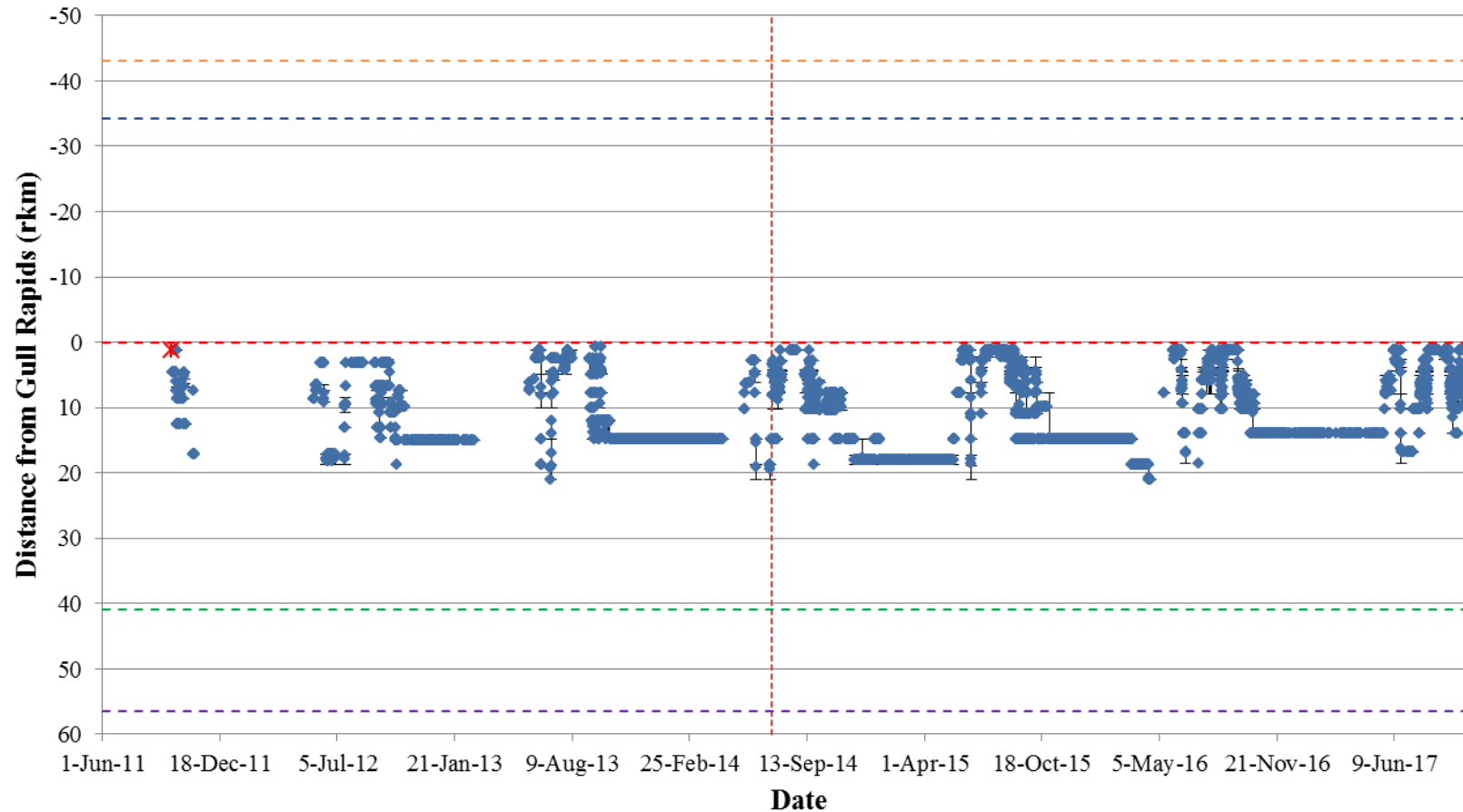


Figure A3-27: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16052) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging and recaptures are indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

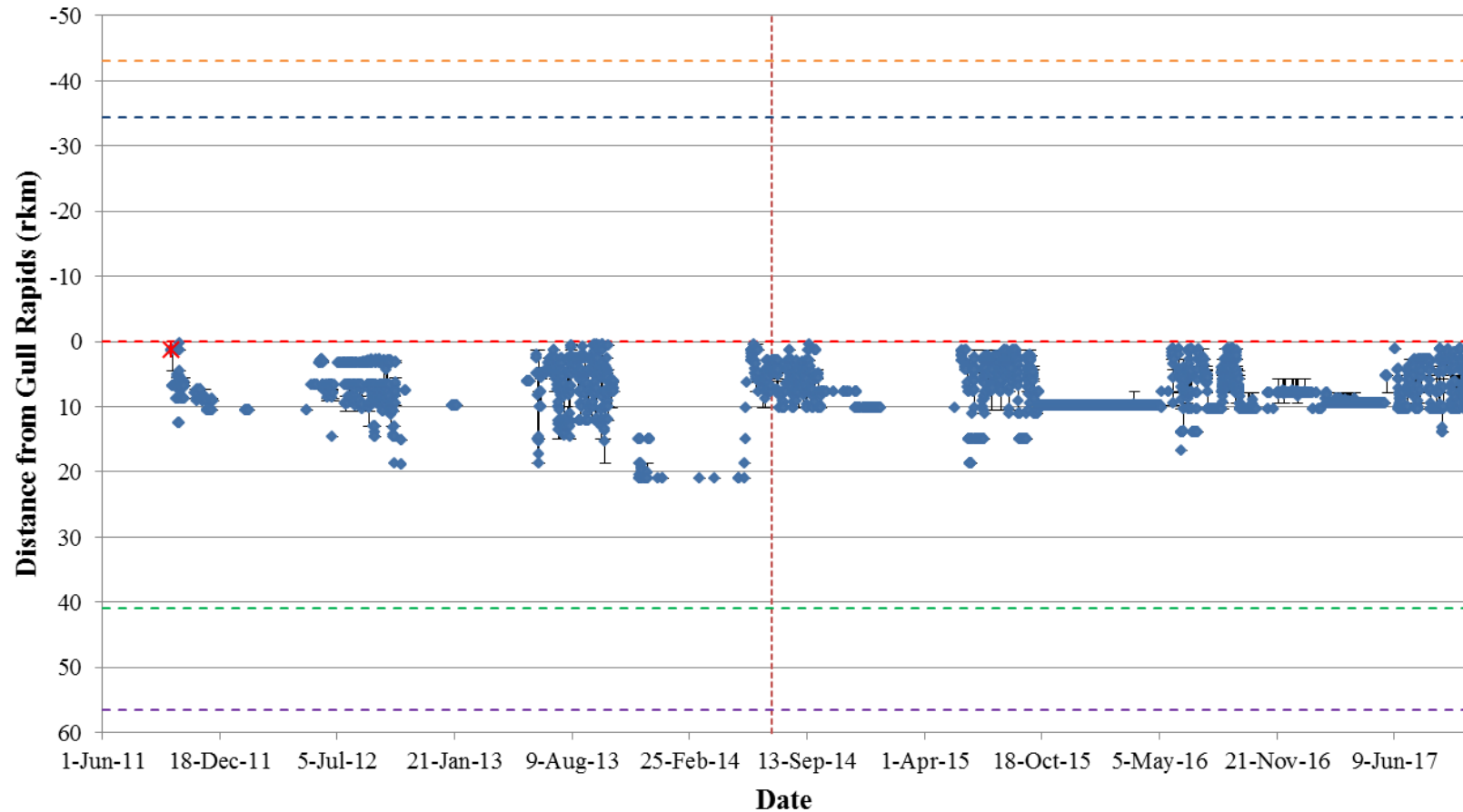


Figure A3-28: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16053) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging and recaptures are indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

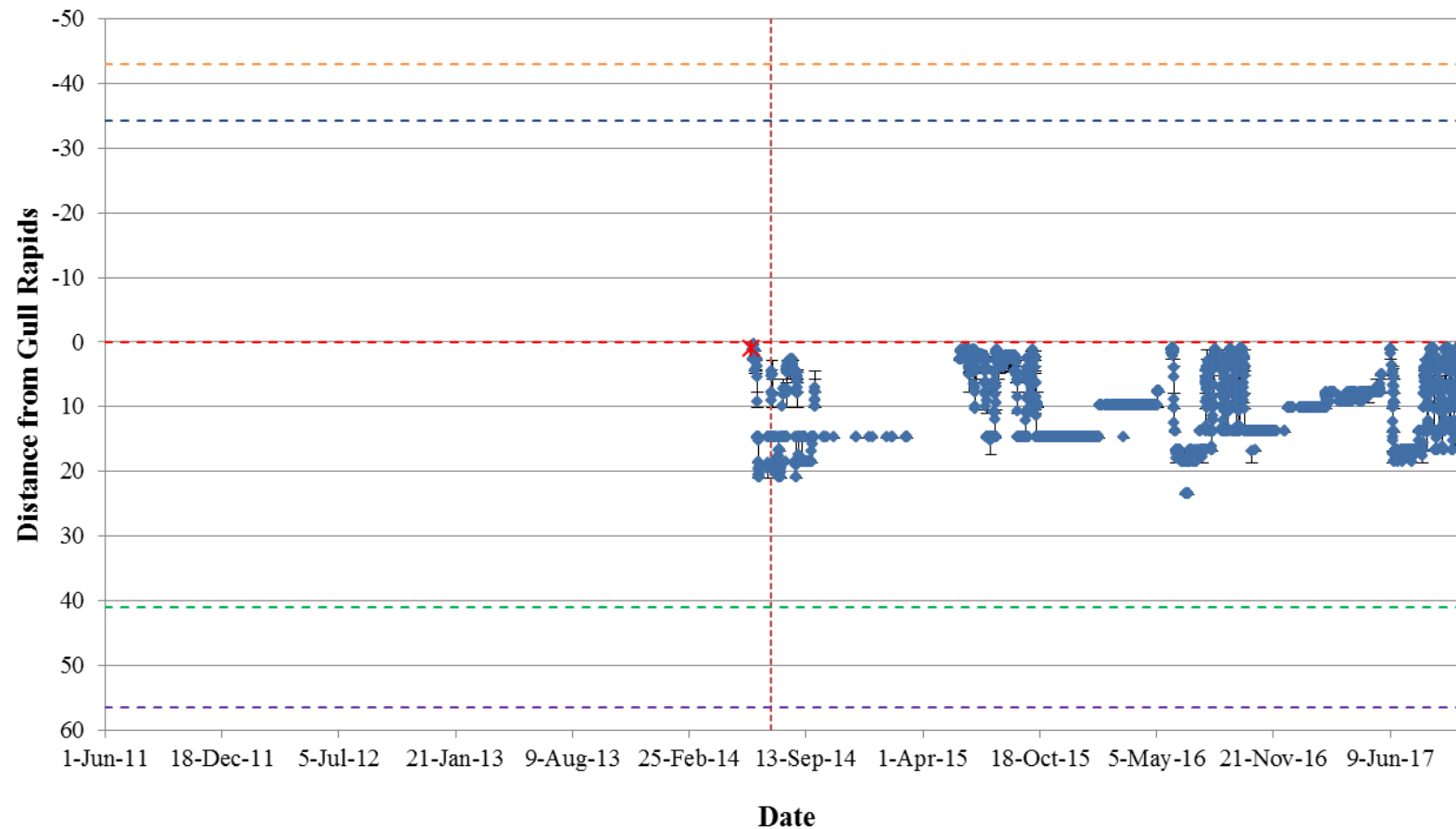


Figure A3-29: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32167) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging and recaptures are indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

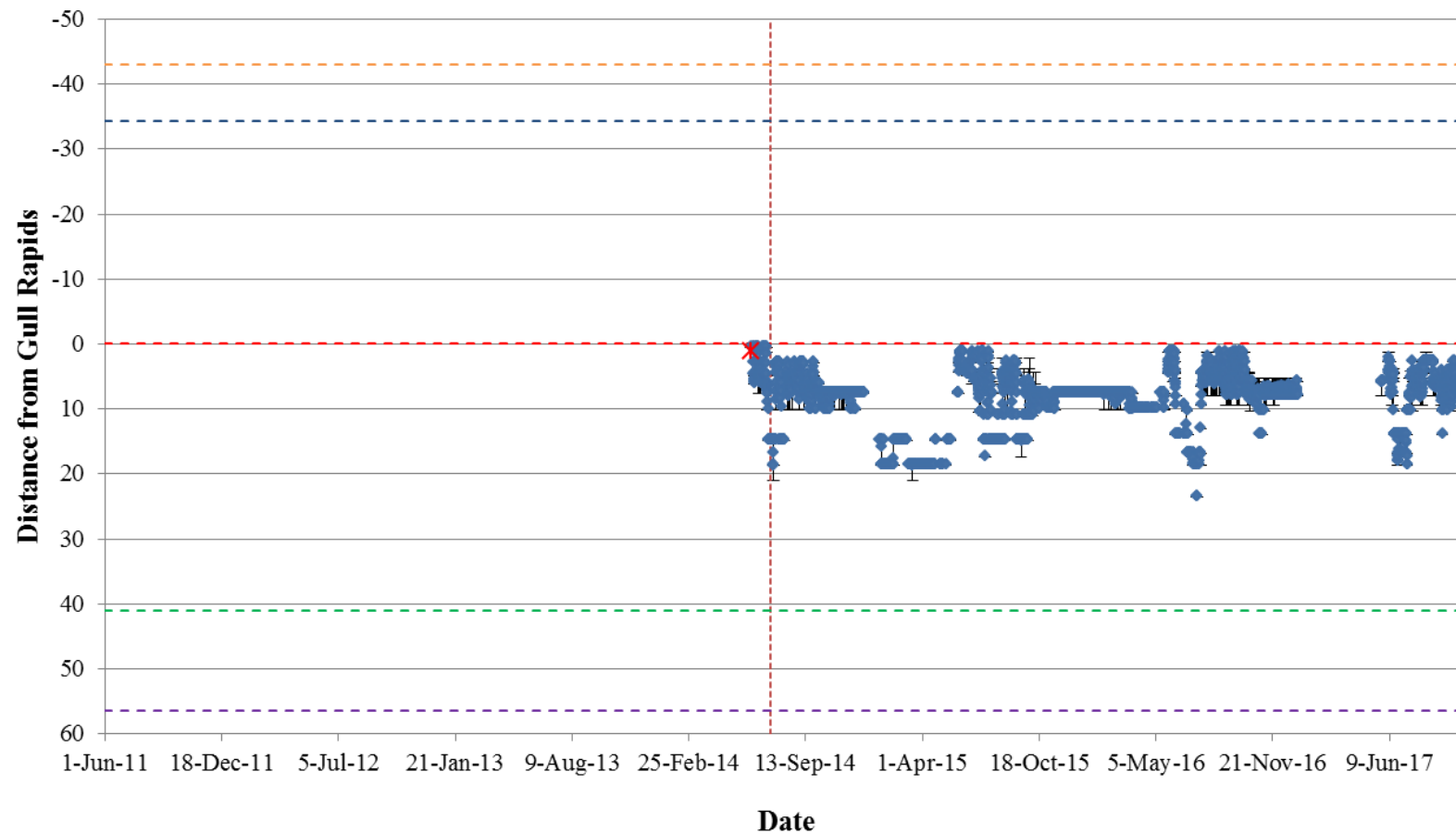


Figure A3-30: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32168) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging and recaptures are indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

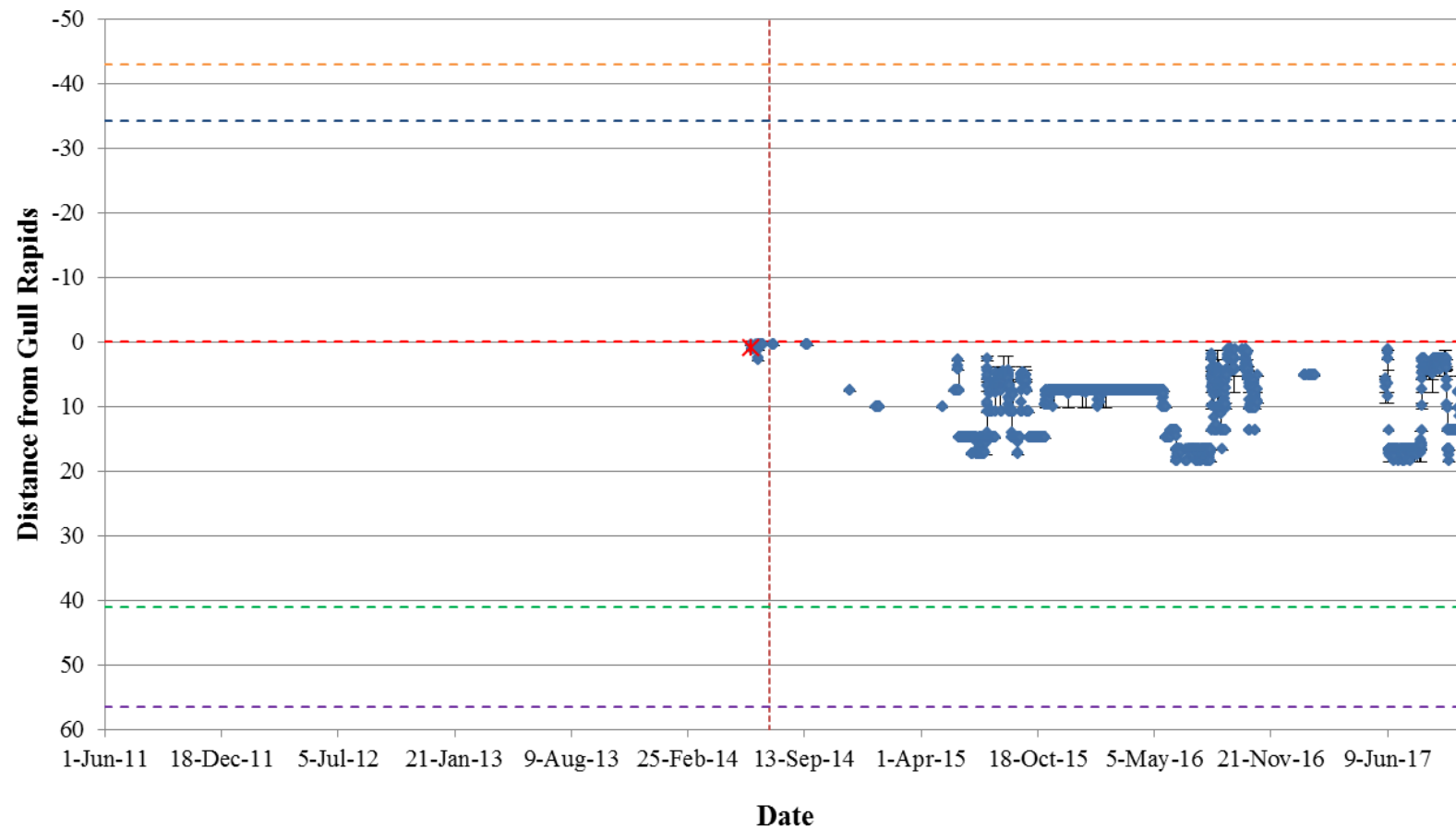


Figure A3-31: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32169) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging and recaptures are indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

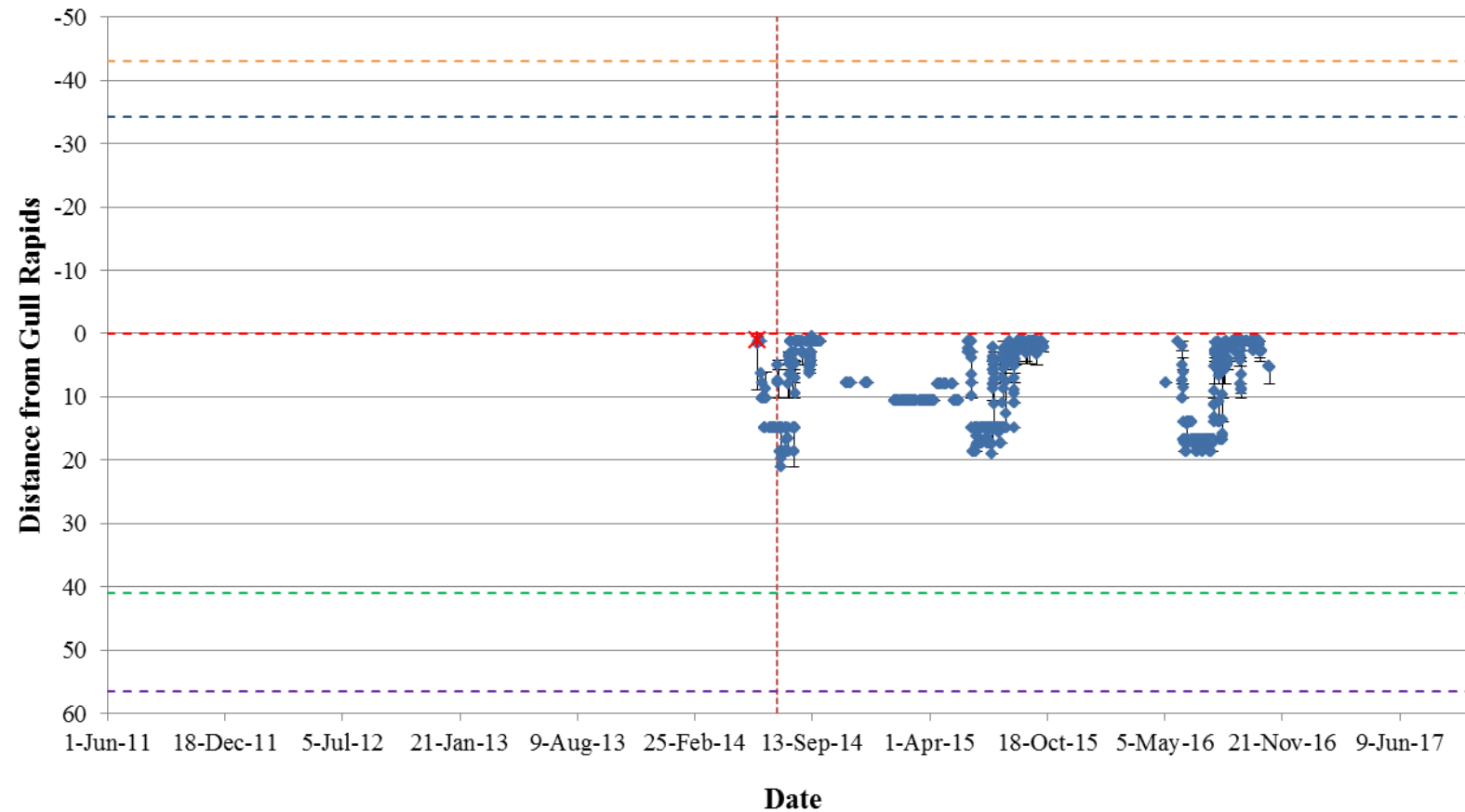


Figure A3-32: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32170) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging and recaptures are indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

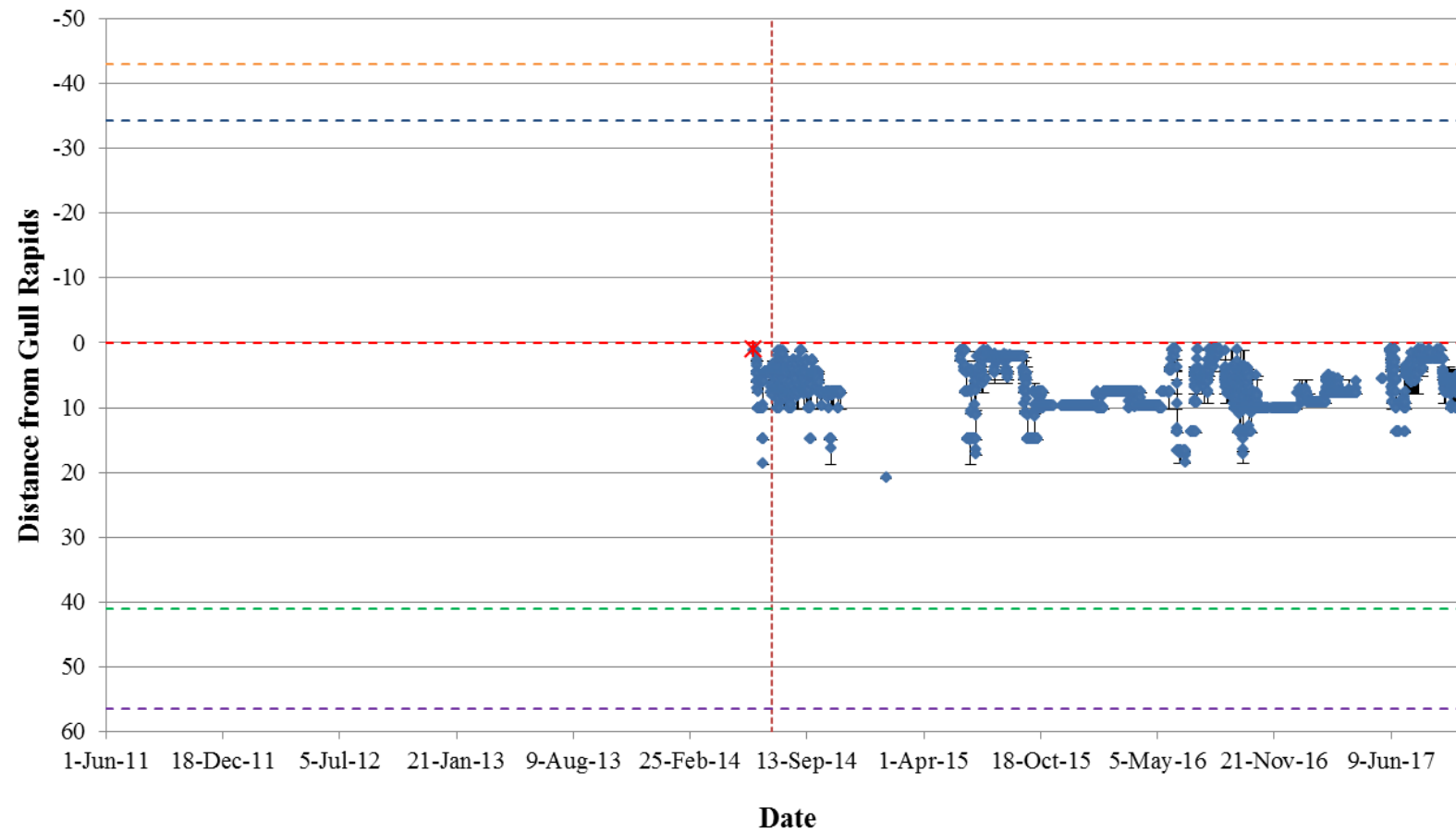


Figure A3-33: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32171) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging and recaptures are indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

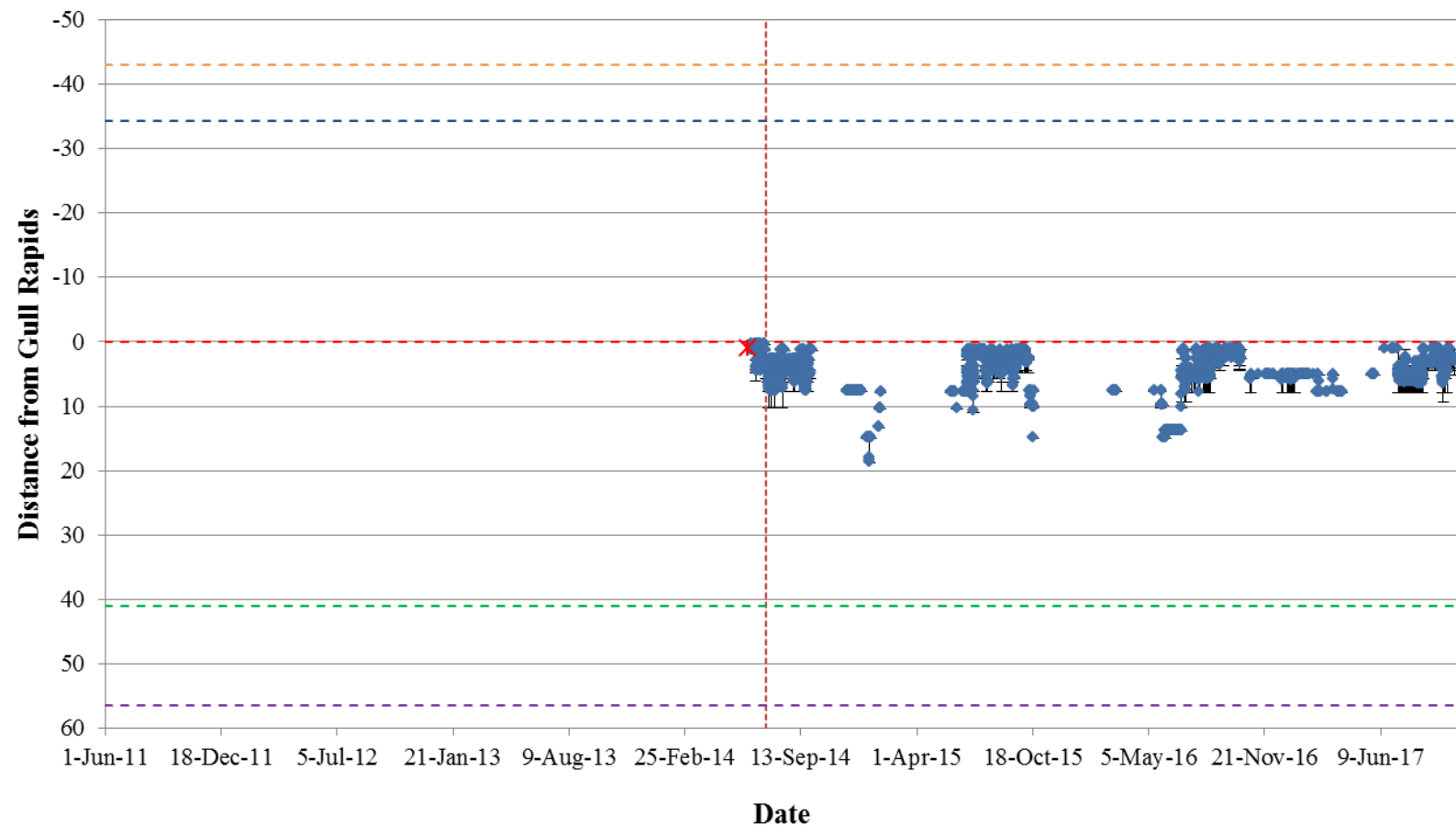


Figure A3-34: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32172) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging and recaptures are indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).

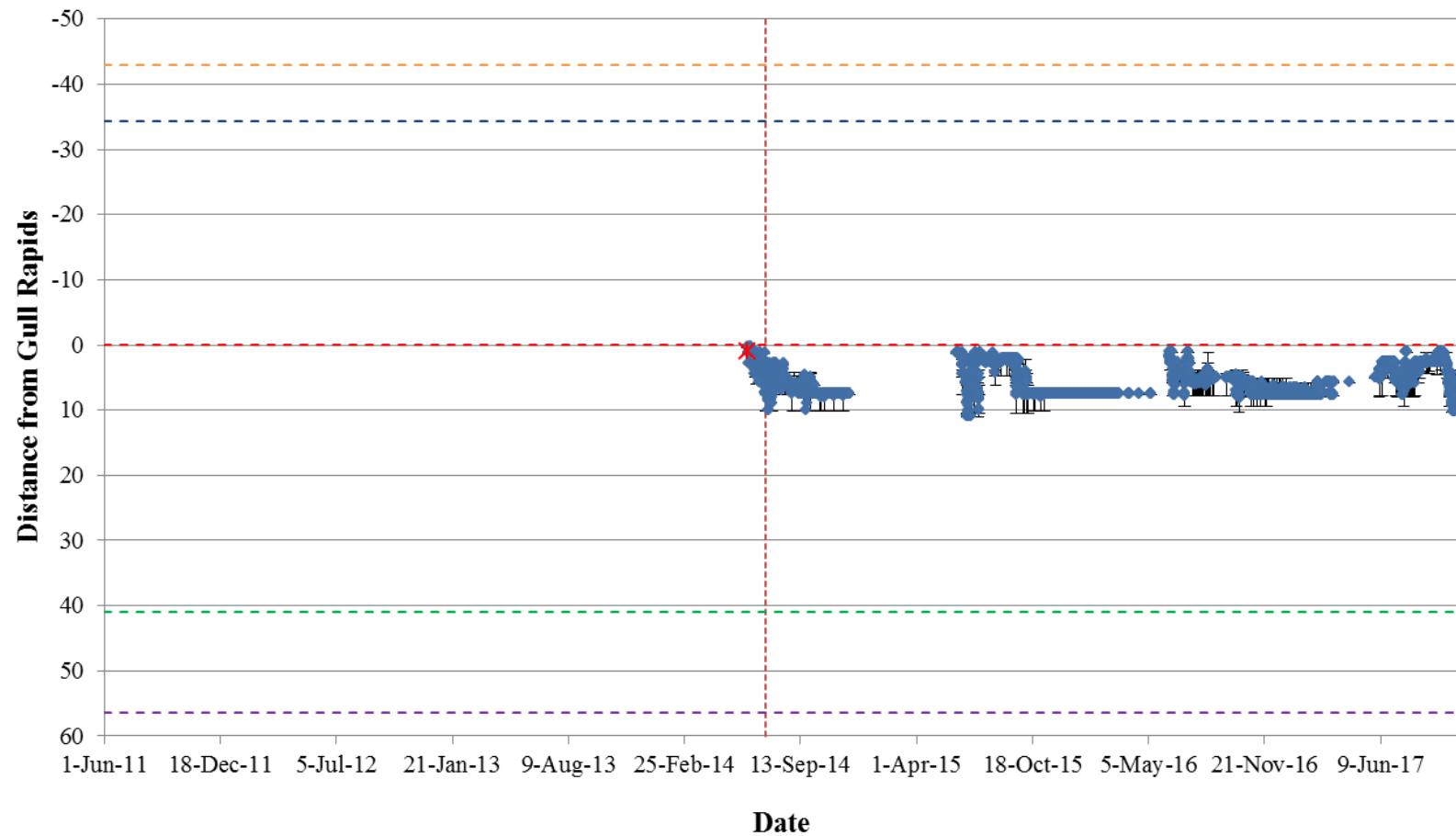


Figure A3-35: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32173) in Stephens Lake in relation to Gull Rapids (rkm 0), from June 1, 2011 to October 16, 2017. Date and location of tagging and recaptures are indicated by a star. Beginning of Keeyask construction is indicated with a vertical dotted line. Landmarks are indicated with horizontal dotted lines (orange = Clark Lake outlet; blue = Birthday Rapids, red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).