Keeyask Generation Project

Aquatic Effects Monitoring Plan

Juvenile Lake Sturgeon Movement Monitoring Report

AEMP-2015-02

Manitoba Hydro

KEEYASK

Manitoba Conservation and Water Stewardship Client File 5550.00
Manitoba Environment Act Licence No. 3107

2014 - 2015

KEEYASK GENERATION PROJECT

AQUATIC EFFECTS MONITORING REPORT

Report #AEMP–2015–02

Juvenile Lake Sturgeon Movement Monitoring in the Nelson River between Clark Lake and the Long Spruce generating station, October 2013 to October 2014: Year 1 Construction

Prepared for

Manitoba Hydro

By

C.D. Lacho, C.L. Hrenchuk, and C.C. Barth

June 2015

North/South Consultants Inc.
Aquatic Environment Specialists

83 Scurfield Blvd.
Winnipeg, Manitoba, R3Y 1G4
Website: www.nscons.ca

Tel.: (204) 284-3366
Fax: (204) 477-4173
E-mail: nscons@nscons.ca

This report should be referenced as:

Lacho, C.D., C.L. Hrenchuk and C.C. Barth. 2015. Juvenile Lake Sturgeon movement monitoring in the Nelson River between Clark Lake and the Long Spruce Generating Station, October 2013 to October 2014: Year 1 Construction. Keeyask Generation Project Aquatic Effects Monitoring Report #AEMP-2015-02. A report prepared for Manitoba Hydro by North/South Consultants Inc., June 2015, 92 pp.

SUMMARY

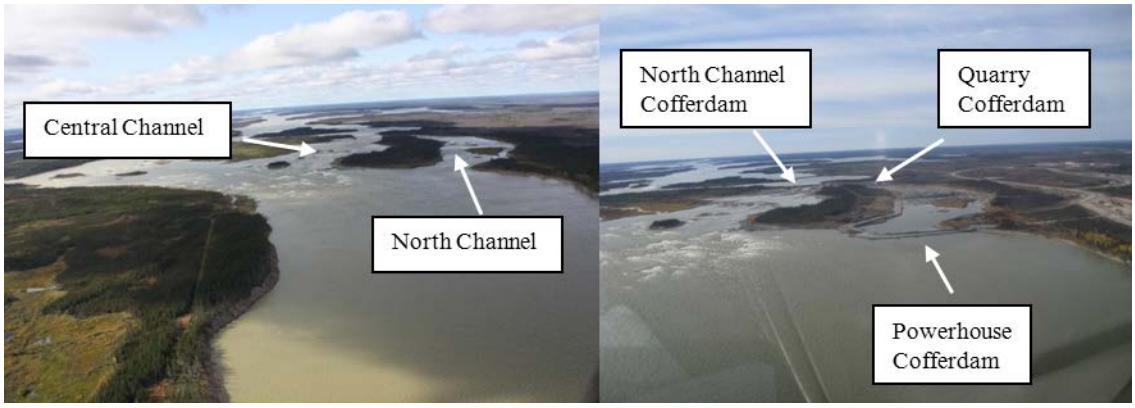
BACKGROUND

Construction of the Keeyask Generating Station (GS) at Gull Rapids began in July 2014. Before the government issued a licence to construct the generating station, the Keeyask Hydropower Limited Partnership (KHLP) was required to prepare a plan to monitor the effects of the generating station on the aquatic environment. Monitoring results will help the KHLP, government regulators, members of local First Nation communities, and the general public understand how construction and operation of the generating station will affect the environment, and whether or not more needs to be done to reduce harmful effects.

Lake Sturgeon are one of the key species to monitor because they are important to local people, their population is currently stressed and the generating station will alter or destroy important habitat. The plan to monitor sturgeon includes several different types of studies:

- Measurement of the number of adults;
- Measurement of the number and growth of juveniles (in particular fish up to ten years of age);
- Recording of spawning (egg-laying); and
- Studies of movement to record use of different kinds of habitat and longer migrations.

This report provides results of juvenile sturgeon movement monitoring conducted from October 2013 to October 2014. Juvenile sturgeon movement monitoring was initiated in late August 2013, approximately 10.5 months prior to the start of construction of the Keeyask GS on 14 July, 2014. This report includes eight months of movement monitoring prior to changes to the river (pre-construction), and approximately three months of monitoring following the start of construction. From mid-July to October 2014, flow in the north and central channels of Gull Rapids was blocked by the construction of cofferdams, which are temporary dams that create dry conditions where the powerhouse and permanent dams will be built.



Gull Rapids before (left) and after (right) construction of cofferdams blocked the north and central channels.

WHY IS THE STUDY BEING DONE?

The study is being done to look at two questions:

Do sturgeon move away from the construction area and, if so, how far? This is important because if sturgeon are in the river right where a cofferdam is being built, they could be harmed by higher than normal concentrations of mud in the water or trapped inside an area that will be drained. On the other hand, if they move very far away, they may permanently leave this sturgeon population.

Do sturgeon move up and down over Gull Rapids to reach habitat that they need to complete their life cycle? This is important because, after the permanent dam is built, sturgeon will no longer be able to go up over Gull Rapids unless a special fish passage structure, that will allow them to get over the dam, is built that makes this movement possible. Movement studies will help regulators and the KHLP decide if sturgeon living in Stephens Lake must be able to move upstream past the generating station to Gull Lake for the sturgeon population to survive. Sturgeon moving downstream after the GS is built would need to go over either the spillway or through the powerhouse and by the turbines (see photo), both of which may injure or kill them. Movement studies are also important to help decide if too many sturgeon will be injured or killed moving downstream and if additional ways to reduce effects to sturgeon are needed.

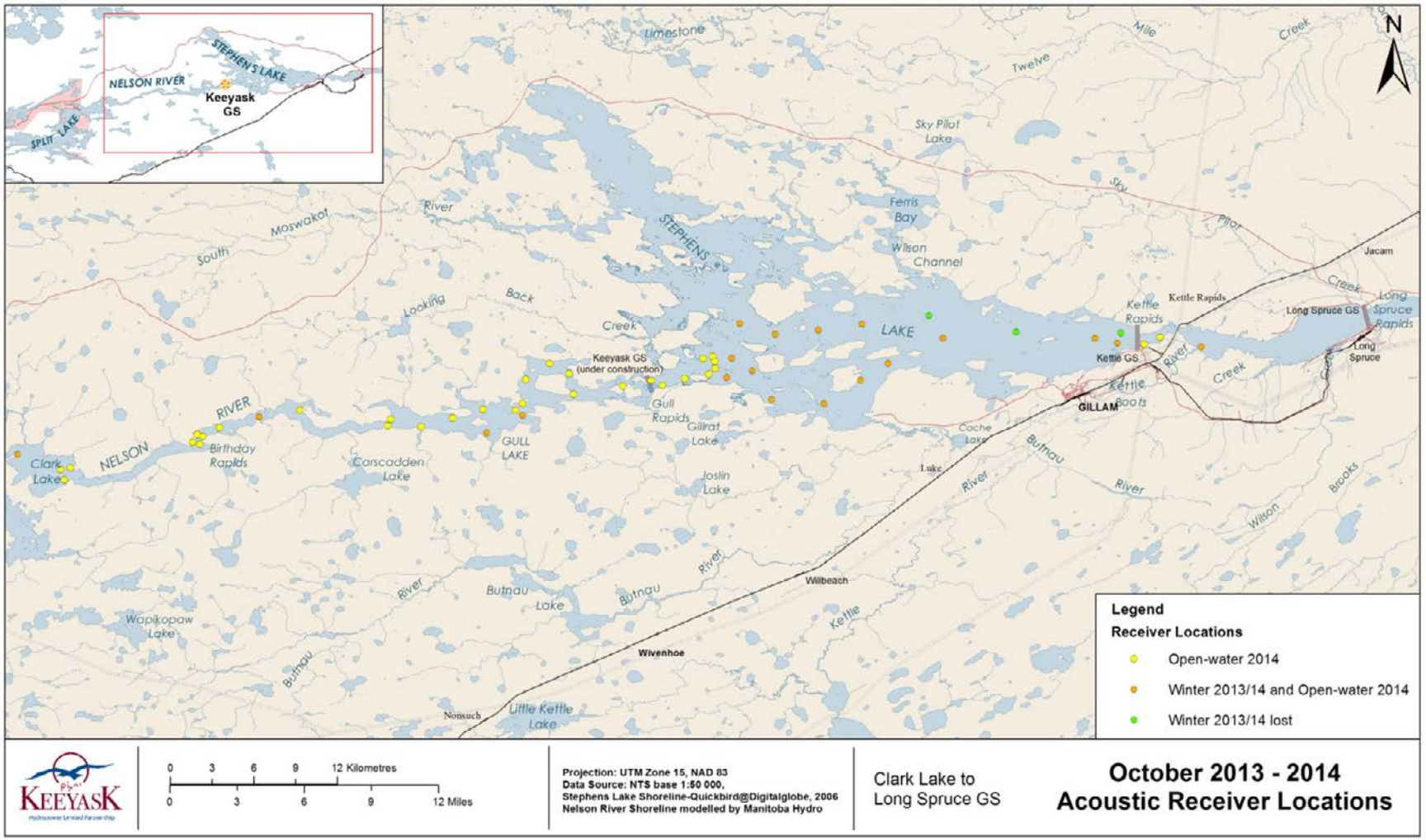
Generating station showing the powerhouse and spillway Water passing through the powerhouse turns turbines (example turbine on right).

WHAT WAS DONE?

The movements of juvenile sturgeon were tracked using acoustic telemetry. This is a technique in which an acoustic tag (also known as a transmitter) is surgically implanted inside a fish (see photo below). The tag emits a sound signal (called a “ping”) that is picked up by receivers placed along the Nelson River between Clark Lake and Gull Rapids, and in Stephens Lake (see map on next page). Each fish is given a tag that transmits a unique ping which can be detected up to 1 km away from a receiver. By looking at the pings that were recorded by different receivers, the movement of each fish can be tracked. The tags are powered by batteries and are expected to last for about four years.

During fall 2013, 20 tags were applied to juvenile sturgeon in Gull Lake and 20 were applied to juveniles in Stephens Lake. These tags will be monitored for four years, until fall 2017. In 2017, more juvenile lake sturgeon will receive tags.

Surgery on juvenile Lake Sturgeon to implant acoustic tag.



Map showing 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 they lived in Gull Lake or Stephens Lake, and the season. The sturgeon that were tagged in Gull Lake in 2013 stayed in Gull Lake. The sturgeon that were tagged in Stephens Lake mostly stayed in Stephens Lake, except for one fish that moved through the Kettle GS, into the Long Spruce Reservoir.

Juvenile Lake Sturgeon

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

One fish that was tagged in Stephens Lake moved downstream through the Kettle GS into the Long Spruce GS Reservoir. It is not known exactly when it travelled through the Kettle dam, but this fish was detected swimming upstream against the current after it went through the dam. This means that it must have survived passage through the Kettle GS.

None of the sturgeon moved from Gull Lake to Stephens Lake over Gull Rapids. This is different from adult Lake Sturgeon, which have been detected moving both upstream and downstream over the rapids. The fast current of the rapids probably blocks the smaller juveniles from moving upstream from Stephens Lake to Gull Lake; however they should be able to move downstream relatively easily if they wanted to. Although a few of the juvenile sturgeon were detected going near Gull Rapids, none of the fish spent very much time there.

Stephens Lake

Monitoring movements in winter is very challenging because of ice conditions. Ice has damaged receivers set at the bottom in 17 m deep channels. For this reason, receivers are left in only a few locations, making it less likely that sturgeon will be detected. However, in both Stephens and Gull lakes, sturgeon have been detected in deeper areas with little current and many seem to move very little. During the summer, sturgeon moved farther distances than they did during the winter in both Stephens and Gull lakes.

Gull Rapids

WHAT DOES IT MEAN?

For the most part, this study has shown that juvenile sturgeon tended to stay in the area in which they were tagged. The exception is the one fish that moved through the Kettle GS into the Long Spruce Reservoir. It is not known why this fish moved so much farther than the other fish.

None of the fish moved over Gull Rapids, and they did not spend much time in the area where the Keeyask GS is being built. Right now, it seems that juvenile sturgeon do not use the area around the construction site very much. Since this study started in late August 2013, it is necessary to study the movements of juveniles for a longer period of time. It will then be possible to see if the fish move around more or continue to stay in the same places. It will also be possible to see if the movements of the sturgeon change as construction continues.

The information collected so far does not give a clear answer about whether or not an upstream fish passage structure will be needed, or whether many sturgeon will move downstream past the GS after it is built. So far we have seen that juvenile sturgeon usually do not move great distances and that they live in similar locations year after year. How far sturgeon move may also depend on the habitat that they have – they may move further when there is a long stretch of deep river channel. For this reason, the movements of sturgeon after the GS is built and Gull Lake has become part of a deep reservoir may change.

WHAT WILL BE DONE NEXT?

The tags that were implanted in 2013 will last until 2017. Tracking individual fish over several years will give us a better idea of what kinds of habitats these fish need to use over many years. It will also be possible to see if the behaviour of the fish is changing as the construction of the Keeyask GS continues. This information will help government regulators and the KHLP decide if fish passage structures or additional fish mitigation measures are needed after the generating station is built. The tracking will also let us continue to know whether fish may be exposed to harm at the construction site.

ACKNOWLEDGEMENTS

We would like to thank Manitoba Hydro for the opportunity and resources to conduct this study. Kelvin Kitchekeesik, Tyler Kitchekeesik, Saul Mayham, and Leonard Kirkness of Tataskweyak Cree Nation, and Ryan West of Fox Lake Cree Nation are thanked for their assistance in conducting the field work.

The collection of biological samples described in this report was authorized by Manitoba Conservation and Water Stewardship, Fisheries Branch, under terms of the Scientific Collection Permit # 18-14.

NORTH/SOUTH CONSULTANTS INC. STUDY TEAM

Data Collection

James Aiken

Duncan Burnett

Claire Hrenchuk

Christine Lacho

Data Analysis, Report Preparation, and Report Review

Cameron Barth

Elena Fishkin

Claire Hrenchuk

Christine Lacho

Friederike Schneider-Vieira

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1.0 INTRODUCTION

Construction of the Keeyask Generation Project (the Project), a 695 megawatt hydroelectric generating station and associated facilities, began in July 2014. The Project is located at Gull Rapids on the lower Nelson River in northern Manitoba where Gull Lake flows into Stephens Lake, 35 km upstream of the existing Kettle Generating Station (Figure 1).

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

The study area included in the sturgeon components of the AEMP is the reach of the Nelson River from the Kelsey GS to the Kettle GS, as well as waterbodies immediately adjacent to the Nelson River (Figure 1).

The Lake Sturgeon component includes four monitoring activities:

- Adult population monitoring;
- Juvenile population monitoring;
- Spawn monitoring; and
- Movement monitoring.

This report provides results of a juvenile Lake Sturgeon movement monitoring study, conducted from October 2013 to October 2014. Results of this study from its inception in August 2013 to October 2013 are provided in a previous report (Hrenchuk and Barth 2014). Lake Sturgeon are classified as juveniles if they are between one and ten years of age. In Gull and Stephens lakes, this age corresponds to sturgeon with fork lengths smaller than 800 mm (Henderson et al. 2014). Movement monitoring during the construction phase is being conducted to determine if disturbances associated with construction alter habitat use and coarse-scale movement patterns upstream and/or downstream of the Project. Results will assist in identifying the use of key habitats (*i.e.*, rearing, and foraging) during construction, the potential vulnerability of sturgeon to activities at the construction site (*i.e.,* if sturgeon use the area in the immediate vicinity of the construction site they may be vulnerable to stranding during dewatering), and the potential for increased emigration or avoidance of the construction site due to disturbance (*i.e.,* blasting, suspended sediment inputs, etc.). Movement data collected during the construction period, in conjunction with baseline data collected prior to construction, will also contribute to the

assessment of the need for: (i) upstream fish passage; and (ii) additional mitigation measures to address effects to fish moving downstream after the GS is completed.

The key questions for juvenile movement monitoring during construction are as follows:

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

The juvenile movement study was initiated in late August 2013, when 40 fish (measuring between 450 and 668 mm fork length) were tagged with acoustic transmitters with a four-year battery lifespan. Twenty fish captured upstream of Gull Rapids and 20 fish captured downstream of Gull Rapids were tagged.

Construction of the Keeyask GS began in mid-July 2014, and altered flows in the north and central channels of Gull Rapids, diverting them into the south channel. Between 22 July and 4 August 2014, flow in the north channel was cut off by construction of the Quarry Cofferdam. Movements of tagged sturgeon in the vicinity of construction activities were monitored by a receiver placed at the base of the north channel of Gull Rapids. As construction continued, flow in the central channel of Gull Rapids was gradually cut off (construction of the North Channel Cofferdam began on 10 September and dewatering continued to the end of October, 2014). The Powerhouse Cofferdam was constructed at the base of the north channel of Gull Rapids, and dewatered the remainder of the north channel between 2 and 26 October, 2014. During this time, the receiver at the base of the north channel was removed. Blasting occurred in quarries situated in the north channel intermittently from July through October 2014.

2.0 THE KEEYASK STUDY SETTING

The study area encompasses an approximately 95 km long reach of the Nelson River from Clark Lake to the upstream end of the Long Spruce GS forebay. This section of river offers a diversity of physical habitat conditions, including a variety of substrate types, and variable water depths (ranging from 0 to 30 m) and velocities.

Clark Lake is located immediately downstream of Split Lake, and approximately 42 km upstream of Gull Rapids (Figure 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 (figures 1 and 2). The drop in elevation from the upstream to downstream side of Birthday Rapids is approximately 2 m. The 14 km reach of the Nelson River between Birthday Rapids and Gull Lake is characterized as a large somewhat uniform channel with medium to high water velocities. There are a few large bays with reduced water velocity and a number of small tributaries that drain into the Nelson River.

Gull Lake is a section of the Nelson River where the river widens, with moderate to low water velocity. Gull Lake is herein defined as the reach of the Nelson River beginning approximately 17 km upstream of Gull Rapids and 14 km downstream of Birthday Rapids, where the river widens to the north into a bay around a large point of land (figures 1 and 2), 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.

Gull Rapids is located approximately 3 km downstream of Caribou Island on the Nelson River (figures 1 and 2). Two large islands and several small islands occur within the rapids, prior to the river narrowing. The rapids are approximately 2 km in length, and the river elevation drops approximately 11 m along its 2 km length.

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 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. 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 (Figure 1). Kettle GS is located approximately 40 km downstream of Gull Rapids.

Long Spruce Forebay 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 Forebay, with both tributaries entering the Forebay on the south shore (Figure 1).

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.

3.1.1 ACOUSTIC TRANSMITTER APPLICATION

Acoustic transmitters (Vemco V13-1x, estimated 1480 day battery life) were applied to 40 fish in 2013; 20 upstream and 20 downstream of Gull Rapids (Tables 1 and 2). Tagged Lake Sturgeon had fork lengths ranging from 450 to 668 mm, which corresponds to fish less than ten years of age, based on size and known length at age for fish in Gull and Stephens lakes (Henderson et al. 2014).

3.1.2 ACOUSTIC RECEIVERS AND DEPLOYMENT

During the open-water season, 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 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 pass by.

The retrieval of receivers deployed during winter has proven challenging and several were lost in 2011/2012 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 at depths > 10 m, the number of possible receiver locations during winter, especially in Gull Lake, is limited.

3.1.2.1 WINTER 2013/2014

Twenty-two stationary acoustic receivers (VEMCO model VR2 and VR2W, Shad Bay, Nova Scotia) were placed between Clark Lake and the Long Spruce GS during the winter 2013/2014 period (16 October, 2013, to 30 April, 2014; figures 2, 3, and 4). Four were set upstream of Gull Rapids, 16 throughout Stephens Lake, and one in the Long Spruce Reservoir (Figure 4). Two additional receivers were deployed at new sites in 2013/2014, one in Gull Lake (#122862; river kilometre [rkm] -12.9), and one in Stephens Lake (#114233; rkm 32).

3.1.2.2 OPEN-WATER 2014

An array of 50 receivers was used during the 2014 open-water period (open-water period defined as 1 May to 12 October, 2014). Twenty-four were set between Clark Lake and Gull Rapids, one in Gull Rapids proper, and 22 in Stephens Lake. Three additional receivers were placed in the Long Spruce Reservoir. No receivers were set at new deployment locations (figures 5, 6, and 7).

Receiver "gates" were deployed in several key areas: four between Clark Lake and Gull Rapids (44, 34, 19, and 10 rkms upstream of Gull Rapids), and two in Stephens Lake (4.5 and 40 rkms downstream of Gull Rapids) (figures 5 and 6). Receiver "gates" consisted of two or more acoustic receivers set parallel to flow to provide complete signal coverage[1] of a river cross-section. Areas between the "gates" were referred to as river zones. The area upstream of Gull Rapids was divided into five zones (Figure 5), while Stephens Lake was divided into two zones (Figure 6). Gate locations were consistent with the 2013 open-water study period, and divided the river into the same zones. On 12 October 2014, the majority of receivers were removed and a subset (n = 22) were redeployed to monitor movements during winter 2014/2015.

3.1.3 DATA ANALYSIS

To filter out false relocations, a Lake Sturgeon was required to be detected at least two times within a 30 minute interval at a given stationary receiver for the detections to be deemed valid. Single detections were filtered and not used in the analyses.

Movements were analysed in terms of rkm, 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 Forebay) was considered positive (+), while the area located upstream (*i.e.,* Gull and Clark lakes) was considered negative (-) (Figure 8). The average rkm distance from Gull Rapids was calculated over a 4-hour interval and plotted versus time for each fish. Total relocation ranges were calculated by subtracting the furthest downstream detection location from the location of the furthest upstream detection. Proportion of time all fish spent within each river zone was calculated and plotted.

[1] Coverage refers to relocation coverage, in that all tagged fish passing through receivers are detected.

4.0 RESULTS

Tables 1 to 6 provide detection summaries, acoustic tag and biological information associated with each tagged fish. Figures 1 to 18 provide maps of release locations, movement range, and proportional distribution of tagged fish both upstream and downstream of the construction site by season. Appendices 1 and 2 provide movement summaries, by rkm, for each tagged sturgeon since the study began in late August/September 2013.

4.1 WINTER 2013/2014

4.1.1 UPSTREAM OF GULL RAPIDS

All four acoustic receivers deployed in the Nelson River between Clark Lake and Gull Rapids during winter 2013/2014 were retrieved (Figure 2). Ten of the twenty juvenile Lake Sturgeon tagged in Gull Lake in 2013 were detected during winter 2013/2014. A total of 52,435 detections were logged by two receivers in Gull Lake, located at rkms -9.9 and -12.9. The number of detections per fish ranged from 31 to 17,388 (Table 3). The two receivers located at rkm -29.4 and at rkm -48.2 in Clark Lake did not detect any tagged juveniles. Fish were detected at receivers for an average of 53.4 days of the 196 day winter period (StDev = 36.7 days). The number of days detected ranged from seven to 135 (Table 3).

- Five fish were only detected by a single receiver:
  - Two fish (#32671 and #32679) at rkm -12.9, and
  - Three fish (#32678, #32682, and #32684) at rkm -9.9.
- The remaining five fish were detected by both receivers (Figure 11).

There were no detections logged by any receiver upstream of Gull Rapids between 4 March and 1 May, 2014. Individual fish movements are summarized in Appendix 1.

4.1.2 DOWNSTREAM OF GULL RAPIDS

Thirteen of the 16 receivers deployed in Stephens Lake during winter were retrieved; the three receivers located at rkms 26.0, 32.0, and 40.8 could not be retrieved due to the buildup of large woody debris around the receiver (Figure 3). The single receiver set in the Long Spruce reservoir was retrieved (Figure 4). A total of 106,913 detections were logged by 19 fish, ranging from 243 – 27,731 detections per individual (Table 5). Fish were detected between eight and 141 days of the 196 day winter period (with a mean of 54.6 days (27.9% of days); StDev = 43.7 days) (Table 5). The mean detection range was 5.5 rkm (StDev = 4.7 rkm; range 0.0 – 14.9 rkm) (Table 5, Figure 12).

Two distinct patterns of movement were evident:

- Twelve of the nineteen fish remained in the upper end of Stephens Lake (at, or upstream of rkm 10.5) (Section 4.1.2.1).
- The remaining seven moved within both the upstream and downstream (downstream of rkm 10.5) portions of Stephens Lake (Section 4.1.2.2).

4.1.2.1 UPPER STEPHENS LAKE

Twelve juvenile Lake Sturgeon remained in the upper reaches of Stephens Lake throughout the winter.

- Seven (#32661, #32664, #32665, #32675, #32697, #32699, and #32670) were only detected between rkm 6.1 and rkm 7.7 (Table 5; appendices A2-1, A2-4, A2-5, A2-10 A2-13, A2-17, and A2-19).
    - One (#32699) of these was last detected on 15 November, 2013 at rkm 6.1 and then was not detected again during the study (Appendix A2-19).
- Fish (#32667) had a slightly larger range, being detected between rkm 6.1 and rkm 10.2 (Table 5; Figure 12; Appendix A2-7).
- Four fish (#32666, #32669, #32680, and #32700) were relocated in the northern portion of Stephens Lake in the former channel of the Moosenose River (appendices A2-6, A2-9, A2-14, and A2-20).
    - #32669 was only detected from 22 December, 2013 to 1 January, 2014 at rkm 7.9. (Appendix A2-9).
    - The other three fish were detected in the upper reaches of Stephens Lake between rkm 6.1 – 7.7 in late November to early December before moving to the northern portion of the lake.

4.1.2.2 DETECTIONS THROUGHOUT STEPHENS LAKE

Seven juvenile Lake Sturgeon moved between upper (rkm 6.1 - 10.5) and lower (rkm 10.5 – 21.0) Stephens Lake (Table 5).

- Two (#32662 and #32674) were only detected during the early part of the winter :
    - #32662 was last detected on 5 December, 2013 at rkm 21.0. (Appendix A2-2)
    - #32674 was detected at rkm 14.9 on 29 November, 2013 (Appendix A2-12).
- Two were relocated within the former channel of the Moosenose River:
    - Fish #32663 was detected continuously between rkm 6.1 and 7.7 from 16 October, 2013 until 7 December, 2013. It then was detected in the northern portion of Stephens Lake, on 17 February, 2014, where it was sporadically detected until end of the winter period (Appendix A2-3).

- Lake Sturgeon #32673 was detected between rkm 6.1 and 7.7 from 16 to 21 October, 2013. It was next detected in the lower Stephens Lake at rkm 14.9 starting on 1 December, 2013. It then moved into the northern portion of Stephens Lake (rkm 16.8) on 12 December, 2014, where it remained for three days. It was not detected again until the open-water period (Appendix A2-11).

- Three (#32685, #32696, and #32698) were relocated in the southern portion of the lake over the course of the winter:
  - Two were detected between rkm 6.1 and 14.9.
    - #32685 moved progressively downstream as the winter progressed (Appendix A2-15).
    - #32698 was relocated at rkm 14.9 in late October and then at rkm 10.2 from mid-January 2014 until the open water 2014 season (Appendix A2-18).
  - #32696 was detected sporadically (23 days) between rkm 10.2 and 21.0 from 24 November, 2013 to 2 March, 2014 (Appendix A2-16).

4.2 OPEN-WATER 2014

4.2.1 UPSTREAM OF GULL RAPIDS

All 24 acoustic receivers deployed upstream of the Keeyask construction site were retrieved at the end of the open-water period (Figure 5). All twenty juvenile Lake Sturgeon tagged upstream of Gull Rapids in 2013 were relocated during the 2014 open-water season, including two (#32688 and #32691) that had not been relocated since they were tagged on 28 August, 2013 (Table 4). The fish were detected 140 – 38,932 times and on average were relocated for 99.1 days of the 165 day open-water season (range: 3 – 135 days or 1.8 – 81.8%). Fish had a mean movement range of 4.1 rkm (StDev = 2.9 rkm; range: 0 – 10.0 rkm) (Table 4).

All relocations occurred in Gull Lake in zones 4 and 5, the two zones closest to Gull Rapids (Figures 5 and 15). None of the tagged fish were detected further upstream than rkm -19.5 (Figure 13). Juvenile Lake Sturgeon spent proportionally more time in Zone 4 (mean = 63.4%; StDev = 43.1%; range: 0.0 – 100.0%) than Zone 5, the closest zone to Gull Rapids (mean = 36.6%; StDev = 43.1%, range: 0.0 – 100.0%) (Figure 15).

- One fish (#32676; Appendix A1-3) was detected exclusively in Zone 4 during the study period while three individuals (#32686, #32687, and #32689; appendices A1-11, A1-12, A1-14) were detected exclusively in Zone 5 (Figure 16).
  - #32686 was only detected 140 times between 4 and 15 June, 2014 at rkm -5.8, after not being detected since August 2013 (Table 4). It was then undetected for the remainder of the study period (Appendix A1-11).

- The remaining 16 fish displayed some degree of movement between zones 4 and 5:
  - Four (#32671, #32679, #32681, and #32683) made several upstream and downstream movements between rkms -9.5 and -19.5 (appendices A1-1, A1-6, A1-7, and A1-9).
  - Four (#32678, #32690, #32691, and #32693) exhibited a movement range of less than 2 rkm (Table 4; appendices A1-5, A1-15, A1-16, and A1-18).
  - Eight (#32672, #32677, #32682, #32684, #32688, #32692, #32694, and #32695; Table 4) had movement ranges between 3.4 and 5.8 rkm. Most of these fish were detected at a single receiver for an extended period of time, with occasional short-term movements to other locations (appendices A1-2, A1-4, A1-8, A1-10, A1-13, A1-17, A1-19, and A1-20).

4.2.2 DOWNSTREAM OF GULL RAPIDS

All 22 receivers from Stephens Lake (Figure 6) and all three receivers from the Long Spruce Reservoir (Figure 7) were successfully retrieved. The receiver (#122775) set within Gull Rapids was lost (Figure 6). Nineteen of 20 fish tagged in Stephens Lake in 2013 were detected between 1,238 and 25,924 times, over 26 to 135 days of the 196 day study period (average = 90.7 days; StDev = 35.0 days) (Table 6). The one sturgeon that was not relocated during the open-water season (#32699) was last detected on 15 November, 2013 at rkm 6.1. Relocated fish had a mean movement range of 11.1 rkm (StDev = 5.4 rkm; range: 2.6 – 19.7 rkm). On average, sturgeon spent more time in Zone 2, the zone further away from Gull Rapids (57.9%; StDev = 32.4%; range: 4.2 – 100%) than in Zone 1 (42.1%; StDev = 32.4%; range: 0 – 95.8%) (figures 6 and 18). In general, the relative amount of time spent in Zone 1 increased as summer progressed, then decreased after mid-August (Figure 17).

Three patterns of movement were identified:

- One fish moved downstream through the Kettle GS into the Long Spruce Reservoir (Section 4.2.2.1.)
- Two fish remained in the lower portion (Zone 2) of Stephens Lake (Section 4.2.2.2.) and
- Sixteen fish were regularly detected throughout Stephens Lake (Section 4.2.2.3.).

4.2.2.1 LONG SPRUCE RESERVOIR

One juvenile Lake Sturgeon (#32662) was detected downstream of Kettle GS in the Long Spruce Reservoir on 29 July, 2014, after not being detected since the previous December (Appendix A2-2). The date that this fish moved through the Kettle GS is unknown. This individual was detected at rkm 47.5 at the mouth of the Kettle River from 29 July to 27 August, 2014 and then moved upstream to rkm 44.9 where it was detected from 27 August to 10 October, 2014 (Appendix A2-2).

4.2.2.2 LOWER STEPHENS LAKE

Two individuals (#32667 and #32680) were only relocated in Zone 2 (Figure 18):

- #32667 moved downstream from rkm 6.1 to 10.2 during June 2014 and was not detected for the remainder of the study period (Appendix A2-7).
- #32680 was relocated only in the former channel of the Moosenose River. It was sporadically detected at rkms 7.9 and 10.5 between 5 May and 3 October, 2014 (Appendix A2-14).

4.2.2.3 REGULAR DETECTIONS THROUGHOUT STEPHENS LAKE

The remaining 16 sturgeon were relocated throughout Stephens Lake:

- Two (#32663 and #32700) were detected in the former Moosenose River channel (appendices A2-3 and A2-20).
    - o #32663 was detected in this area from 1 May to 22 June, 2014 (rkm 7.9 – 13.4).
    - o #32700 was relocated here from 1 May to 3 June, 2014 (rkm 7.9 – 10.5).
- Fourteen fish made upstream and downstream movements throughout Stephens Lake.
    - o Three (#32663, #32666, and #32700) were detected as far upstream as the base of Gull Rapids (north channel), at rkm 0.5.
        - #32663 was detected briefly (approximately 30 minutes) at this location on 12 September, 2014 before moving back downstream into Stephens Lake (Appendix A2-3).
        - #32666 was only detected at rkm 0.5 on 8 August, 2014 and moved back downstream the same day (Appendix A2-6).
        - #32700 was detected at rkm 0.5 on 5 September, 2014. It was then relocated four days later at rkm 2.9 (Appendix A2-20).
    - o Four fish (#32665, #32673, #32696, and #32698) moved as far downstream as rkm 21.0 (appendices A2-5, A2-11, A2-16, and A2-18).

5.0 DISCUSSION

This multi-year movement monitoring study was initiated in 2013 to assess the response of juvenile Lake Sturgeon to construction and operation of the Keeyask GS. More specifically, the study aims to determine potential effects associated with construction and operation that may include increased emigration from the population (through either an avoidance response to disturbances such as noise and blasting at the construction site; or as a response to altered water levels and flows associated with impoundment), increased mortality at the GS structure through either entrainment or impingement, and loss of ability to move to critical habitats needed to complete their lifecycle. The transmitters applied in 2013 will last until 2017. Once these transmitters expire, the study will be replicated (using transmitters with a 4-year battery life), extending the study through to 2021. The discussion below highlights movement patterns that have been observed since the study began and discusses the key questions (presented in the AEMP) with respect to potential impacts of construction on Lake Sturgeon and their movements.

The use of acoustic telemetry to monitor movements of juvenile Lake Sturgeon has been very effective despite the many difficulties associated with using this methodology in this study area (*i.e.,* as discussed in Hrenchuk and Barth 2013 and Hrenchuk and Barth 2014b; few suitable receiver locations during the winter months, large areas in particular in Stephens Lake where fish could be beyond the range of the receivers). There are several reasons why acoustic telemetry has worked so well for juvenile sturgeon. First, juvenile Lake Sturgeon have a low natural mortality rate and are generally not harvested. Therefore, data analyses are not confounded by the sudden disappearance of transmitters. Secondly, many behavioural traits, including a strong preference for deep water habitat, restricted movement patterns (*i.e.,* avoid moving through river constrictions or rapids), and small home range sizes, improve the ability of receivers to locate fish (*i.e.,* they are not occupying shallow water habitat where they can move past receivers undetected or undertaking extensive movements beyond the receiver array) and increase the amount of data collected for each fish (*i.e.,* many fish remain within the detection range of a receiver for extended periods) (Barth et al. 2009, Barth et al. 2011, McDougall and Pisiak 2012, McDougall et al. 2013a). For example, during the open-water period of 2014, 30 of the 40 tagged fish were detected for more than 50% of the days monitored, while ten were detected for over 70% of the days monitored. Conversely, some of the juveniles were not relocated for extended periods, however, as these results suggest, fish will remain in a small area for an extended period, and therefore, although not being detected, the approximate location of these fish in zones between sets of receivers can be ascertained with confidence.

After approximately one and a half years of monitoring, fish captured and tagged in Gull Lake were found to have moved over a limited spatial extent (average range of movement is 4.3 rkm). No fish moved upstream of rkm -19.5 (upstream extent of Gull Lake). Fish have been detected as far downstream as rkm -5.8. It is unknown if fish are moving closer to Gull Rapids, since there were no receivers deployed further downstream in Gull Lake; however, it is known that none have passed downstream over Gull Rapids. The greatest range of movement observed

was 10.0 rkm and only four of the 20 fish exhibited a range of movement greater than 5.8 rkm. Other studies on juvenile Lake Sturgeon movement and home range size have also found that they move over a limited spatial extent and occupy a small home range (Holtgren and Auer 2004; Smith and King 2005; Barth et al. 2011; Trested et al. 2011, McDougall et al. 2013a, McDougall et al. 2013b, McDougall et al. 2013c). In the Winnipeg River, juvenile Lake Sturgeon rarely move between constrictions in the river or small rapids, despite there being no obvious barrier to movement (Barth et al. 2011, McDougall et al. 2013c). Similarly, juvenile fish tagged in Gull Lake have not moved either downstream through Gull Rapids or upstream through the river constriction at the upstream end of Gull Lake.

Juveniles tagged in Stephens Lake had a greater range of movement (average = 12.9 rkm) relative to those tagged in Gull Lake. This pattern is consistent with observations of the same fish during the 2013 open-water season (Hrenchuk and Barth 2014), as well as previous acoustic telemetry studies in the area (McDougall et al. 2013b, McDougall et al. 2013c). The differences observed in movement between juvenile sturgeon occupying Gull and Stephens lakes is likely due to the availability and continuity of deep water habitat in Stephens Lake (McDougall et al. 2013b, McDougall et al 2013c).

One juvenile Lake Sturgeon (total length = 554 mm at the time it was tagged in 2013) moved downstream into the Long Spruce Reservoir through the Kettle GS during the summer of 2014. This fish moved upstream after it was initially relocated in the reservoir indicating that it had survived passage. Since this sturgeon was not detected between December 2013 (Stephens Lake) and August 2014 (Long Spruce Reservoir), it is not known at what time of year it moved through the GS.

Construction of the Keeyask GS began in July 2014, with the building of cofferdams in the north and central channels of Gull Rapids from July to October. The key questions, as described in the AEMP, for juvenile movement monitoring during construction are as follows:

- Are juvenile Lake Sturgeon using habitat in the immediate vicinity of the construction site?
- Will the frequency of long-distance movements (and subsequent downstream emigration/ entrainment) by sub-adult Lake Sturgeon increase during construction and operation of the project?
- Will disturbances associated with construction of the Keeyask GS alter coarse-scale movement upstream or downstream of the GS?

Results of this study suggests that only two of the 20 fish tagged in Gull Lake moved within 5.8 rkm of the upstream end of Gull Rapids. Therefore, disturbances associated with construction are expected to be minimal for juvenile sturgeon in this area. It is expected that effects of GS construction on juvenile sturgeon upstream of the GS may not occur until the reservoir is fully impounded. In Stephens Lake, the impacts of construction on juvenile sturgeon could be more immediate. Results suggest that three of 20 fish were detected by the receiver at the base of the north channel of Gull Rapids in 2014, while four were detected by the receiver nearest to the rapids in 2013. Further, eight of 20 spent more than 50% of their time during the open water season in Zone 1, near to Gull Rapids. Because they inhabit the area close to the

construction site, it is possible that the fish could be directly impacted by construction-related effects including increased total suspended sediment levels, blasting or noise associated with construction machinery, or changes in flow or dewatering of Gull Rapids.

As previously discussed, one juvenile Lake Sturgeon moved downstream through the Kettle GS. It is unknown if this movement was related to the construction at Keeyask but given that it was relocated in the Long Spruce forebay on July 29 (after not being detected since December 2013, and that construction had begun only 14 days earlier), it is unlikely that this fish was located near Gull Rapids at the time construction began and moved downstream through Stephens Lake undetected. Therefore, it is unlikely that construction influenced the movement of this fish.

Given that only three months of movement data have been collected since construction at Keeyask began, an assessment of the impacts of construction on sturgeon habitat use and movement of juvenile sturgeon is premature. Qualitatively, there was not an obvious change in Lake Sturgeon movement, the frequency of long-distance movements, or the use of habitat immediately downstream of Gull Rapids. Given that the juvenile movement monitoring has been very successful, any changes to juvenile habitat use or movement should be readily identified. This study will continue until August 2017, at which point this study will be repeated, with an additional 20 tags being applied to juvenile Lake Sturgeon on either side of Gull Rapids. Going forward, this will provide movement information for juvenile sturgeon until 2021.

6.0 REFERENCES

Barth, C.C., W.G Anderson, L.M. Henderson, and S.J. Peake. 2011. Home range size and seasonal movement of juvenile Lake Sturgeon in a large river in the Hudson Bay Drainage Basin. Transactions of the American Fisheries Society 140: 1629-1641.

Barth, C.C., S.J. Peake, P.J. Allen, and W.G. Anderson. 2009. Habitat utilization of juvenile Lake Sturgeon, *Acipenser fulvescens*, in a large Canadian river. Journal of Applied Ichthyology 25: 18-26.

Holtgren, J.M. and N.A. Auer. 2004. Movement and habitat of juvenile Lake Sturgeon (*Acipenser fulvescens*) in the Sturgeon River-Portage Lake system. Michigan Journal of Ecology 19: 419-429.

Henderson, L.M., C.C. Barth, and P.A. Nelson. 2014. Results of Juvenile Lake Sturgeon population monitoring, Fall 2014. A report prepared for Manitoba Hydro by North/South Consultants Inc.

Hrenchuk, C.L., and C.C. Barth. 2013. Results of adult Lake Sturgeon movement monitoring in the Nelson River between Clark Lake and the Long Spruce Generating Station, October 2011 to October 2012. Viii + 137 pp.

Hrenchuk, C.L. and C.C. Barth. 2014. Results of juvenile Lake Sturgeon movement monitoring in the Nelson River between Clark Lake and the Long Spruce Generating Station, August to October, 2013. A report prepared for Manitoba Hydro by North/South Consultants Inc. ix + 75 pp.

Hrenchuk, C.L. and C.C. Barth. 2015. Adult Lake Sturgeon movement monitoring in the Nelson River between Clark Lake and the Long Spruce Generating Station, October 2013 to October 2014: Year 1 Construction. Keeyask Generation Project Aquatic Effects Monitoring Report #AEMP-2015-01. A report prepared for Manitoba Hydro by North/South Consultants Inc., June 2015, 143 pp.

Manitoba Hydro Public Affairs. December 1999. Long Spruce Generating Station. Brochure.

McDougall, C.A. and D.J. Pisiak. 2012. Results of a Lake Sturgeon inventory conducted in the Sea Falls to Sugar Falls reach of the Nelson River – Fall, 2012. A Lake Sturgeon Stewardship and Enhancement Program report prepared for Manitoba Hydro by North/South Consultants Inc., Winnipeg, Manitoba. ix + 46 pp.

McDougall, C.A., P.J. Blanchfield, S.J. Peake and W.G. Anderson. 2013a. Movement patterns and size-class influence entrainment susceptibility of Lake Sturgeon in a small hydroelectric reservoir. Transactions of the American Fisheries Society 142: 1508-1521.

McDougall, C.A., C.L. Hrenchuk, and C.C. Barth. 2013b. Results of juvenile Lake Sturgeon movement and habitat utilization studies in Stephens Lake – 2011. A report prepared for Manitoba Hydro by North/South Consultants Inc. ix + 92 pp.

McDougall, C.A., C.L. Hrenchuk, and C.C. Barth. 2013c. Results of juvenile Lake Sturgeon movement in Stephens Lake – October 2011 to October 2012. A report prepared for Manitoba Hydro by North/South Consultants Inc. viii + 47 pp.

Smith, K.M. and D. King. 2005. Movement and habitat use of yearling and juvenile Lake Sturgeon in Black Lake, Michigan. Transactions of the American Fisheries Society 134: 1159-1172.

Trested, D.G., Chan, M.D., Bridges, W.C., and J.J. Isely. 2011. Seasonal movement and mesohabitat usage of adult and juvenile Lake Sturgeon in the Grasse River, New York. Transactions of the American Fisheries Society 140: 1006-1014.

TABLES

Table 1: Acoustic tag and biological data for the 20 juvenile Lake Sturgeon tagged in Gull Lake in 2013.

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

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

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

Table 3: Detection summary for each of 20 juvenile Lake Sturgeon tagged and monitored upstream of Gull Rapids during the 2013/2014 (16 October, 2013 – 30 April, 2014) winter period. Refer to Table 1 for tagging and biological data.

Tag ID	# of Coarse-Scale Detections	Furthest Upstream (rkm)	Furthest Downstream (rkm)	Total Detection Range (rkm)	# of Days Detected	% Days Detected
32671	9727	-12.9	-12.9	0.0	69	35.0
32672	3696	-12.9	-9.9	3.0	48	24.4
32676	2528	-12.9	-9.9	3.0	29	14.7
32677	4785	-12.9	-9.9	3.0	59	29.9
32678	17388	-9.9	-9.9	0.0	135	68.5
32679	31	-12.9	-12.9	0.0	7	3.6
32681	8205	-12.9	-9.9	3.0	76	38.6
32682	270	-9.9	-9.9	0.0	12	6.1
32683	2864	-12.9	-9.9	3.0	42	21.3
32684	2941	-9.9	-9.9	0.0	57	28.9
32686	-	-	-	-	0	0.0
32687	-	-	-	-	0	0.0
32688	-	-	-	-	0	0.0
32689	-	-	-	-	0	0.0
32690	-	-	-	-	0	0.0
32691	-	-	-	-	0	0.0
32692	-	-	-	-	0	0.0
32693	-	-	-	-	0	0.0
32694	-	-	-	-	0	0.0
32695	-	-	-	-	0	0.0

Table 4: Detection summary for each of 20 juvenile Lake Sturgeon tagged and monitored upstream of Gull Rapids during the 2013 (28 August – 15 October, 2013) and 2014 (1 May, 2014 – 12 October, 2014) open-water seasons. Refer to Table 1 for tagging and biological data.

Tag ID	2013						2014					
	# of Detections	Furthest Upstream (rkm)	Furthest Downstream (rkm)	Total detection range (rkm)	# of Days Detected	% Days Detected	# of Detections	Furthest Upstream (rkm)	Furthest Downstream (rkm)	Total detection range (rkm)	# of Days Detected	% Days Detected
32671	8302	-12.9	-9.9	3.0	46	95.8	9056	-19.4	-9.5	9.9	98	59.4
32672	676	-12.3	-9.9	2.4	35	72.9	7601	-12.9	-9.5	3.4	88	53.3
32676	5460	-10.3	-9.9	0.4	39	81.3	5176	-17.4	-12.9	4.5	100	60.6
32677	1648	-12.3	-9.9	2.4	40	83.3	8866	-12.9	-9.5	3.4	96	58.2
32678	4925	-10.3	-9.9	0.4	46	95.8	22368	-10.1	-9.5	0.6	135	81.8
32679	637	-12.9	-9.9	3.0	35	72.9	9726	-19.5	-9.5	10.0	100	60.6
32681	834	-12.9	-9.9	3.0	38	79.2	12817	-17.4	-9.5	7.9	100	60.6
32682	4736	-10.3	-9.9	0.4	44	91.7	15245	-12.9	-9.5	3.4	98	59.4
32683	258	-12.3	-9.9	2.4	40	83.3	4684	-17.4	-9.5	7.9	98	59.4
32684	16091	-10.3	-9.9	0.4	46	95.8	14878	-10.8	-5.8	5.0	102	61.8
32686	131	-10.9	-10.9	0.0	2	4.1	140	-5.8	-5.8	0.0	3	1.8
32687	70	-7.4	-7.4	0.0	16	32.7	14680	-9.0	-7.4	1.6	120	72.7
32688	-	-	-	-	0	0.0	9142	-11.8	-7.4	4.4	63	38.2
32689	2	-7.4	-7.4	0.0	1	2.0	9835	-9.0	-7.4	1.6	112	67.9
32690	12027	-10.9	-10.9	0.0	35	71.4	34865	-10.9	-9.0	1.9	129	78.2
32691	-	-	-	-	0	0.0	23712	-10.9	-9.0	1.9	110	66.7
32692	126	-7.4	-7.4	0.0	17	34.7	16704	-10.9	-7.4	3.5	122	73.9
32693	777	-10.9	-10.9	0.0	24	49.0	26300	-10.9	-9.0	1.9	117	70.9
32694	2582	-10.9	-7.4	3.5	30	61.2	38932	-14.8	-9.0	5.8	130	78.8
32695	1203	-10.9	-7.4	3.5	22	44.9	6974	-10.9	-7.4	3.5	61	37.0

Table 5: Detection summary for each of 20 juvenile Lake Sturgeon tagged and monitored in Stephens Lake during the 2013/2014 (16 October, 2013 – 30 April, 2014) winter period. Refer to Table 2 for tagging and biological data

Tag ID	# of Detections	Furthest Upstream (rkm)	Furthest Downstream (rkm)	Total detection range (rkm)	# of Days Detected	% Days Detected
32661	567	6.1	7.7	1.6	19	9.6
32662	484	6.1	21.0	14.9	10	5.1
32663	10755	6.1	16.8	10.7	87	44.2
32664	3531	6.1	7.7	1.6	52	26.4
32665	272	6.1	7.7	1.6	10	5.1
32666	1242	6.1	10.5	4.4	27	13.7
32667	4980	6.1	10.2	4.1	54	27.4
32668	0	-	-	-	0	0.0
32669	1089	7.9	7.9	0.0	10	5.1
32670	27731	6.1	7.7	1.6	141	71.6
32673	1548	6.1	21.0	14.9	17	8.6
32674	243	7.7	14.9	7.2	8	4.1
32675	6497	6.1	7.7	1.6	66	33.5
32680	11457	6.1	10.5	4.4	115	58.4
32685	8417	6.1	14.9	8.8	101	51.3
32696	2027	10.2	21.0	10.8	23	11.7
32697	10294	6.1	7.7	1.6	87	44.2
32698	2153	6.1	14.9	8.8	71	36.0
32699	877	6.1	7.7	1.6	17	8.6
32700	12749	6.1	10.5	4.4	122	61.9

Table 6. Detection summary for each of 20 juvenile Lake Sturgeon tagged and monitored in Stephens Lake during the 2013 (28 August – 15 October, 2013) and 2014 (1 May – 12 October, 2014) open-water seasons. Refer to Table 2 for tagging and biological data.

Tag ID	2013						2014					
	# of Detections	Furthest Upstream (rkm)	Furthest Downstream (rkm)	Total detection range (rkm)	# of Days Detected	% Days Detected	# of Detections	Furthest Upstream (rkm)	Furthest Downstream (rkm)	Total detection range (rkm)	# of Days Detected	% Days Detected
32661	644	2.5	12.1	9.6	11	37.9	12372	1.3	14.9	13.6	92	55.8
32662	4164	2.5	14.9	12.4	26	89.7	11682	44.9	47.5	2.6	74	44.8
32663	2690	2.5	7.7	5.2	25	100.0	10771	0.5	13.4	12.9	121	73.3
32664	1890	2.5	10.2	7.7	15	62.5	14347	2.9	10.2	7.3	111	67.3
32665	360	2.5	4.9	2.4	4	17.4	7433	2.9	21.0	18.1	85	51.5
32666	396	0.7	10.0	9.3	7	23.3	9527	0.5	10.2	9.7	81	49.1
32667	3633	2.5	7.7	5.2	21	72.4	4660	4.4	10.2	5.8	26	15.8
32668	2768	2.5	12.1	9.6	21	84.0	8076	4.3	14.9	10.6	79	47.9
32669	75	2.5	4.9	2.4	7	28.0	12559	1.3	14.9	13.6	93	56.4
32670	4289	0.7	7.7	7.0	23	79.3	25924	1.3	10.2	8.9	135	81.8
32673	2191	2.5	14.9	12.4	25	100.0	11506	2.9	21.0	18.1	83	50.3
32674	2468	2.5	12.1	9.6	22	88.0	13328	2.9	10.2	7.3	111	67.3
32675	2933	2.5	7.7	5.2	22	91.7	19778	2.9	10.2	7.3	134	81.2
32680	1579	0.7	10.0	9.3	18	75.0	1238	7.9	10.5	2.6	59	35.8
32685	2034	2.5	10.0	7.5	21	87.5	18830	2.9	18.7	15.8	130	78.8
32696	3803	2.5	18.7	16.2	25	83.3	9650	2.9	21.0	18.1	81	49.1
32697	1623	0.7	4.9	4.2	21	70.0	9822	1.3	6.1	4.8	108	65.5
32698	2082	2.5	14.9	12.4	18	60.0	9414	1.3	21.0	19.7	99	60.0
32699	556	2.5	6.3	3.8	11	37.9	0	-	-	-	0	0.0
32700	2830	2.5	14.9	12.4	21	84.0	14196	0.5	14.9	14.4	112	67.9

FIGURES

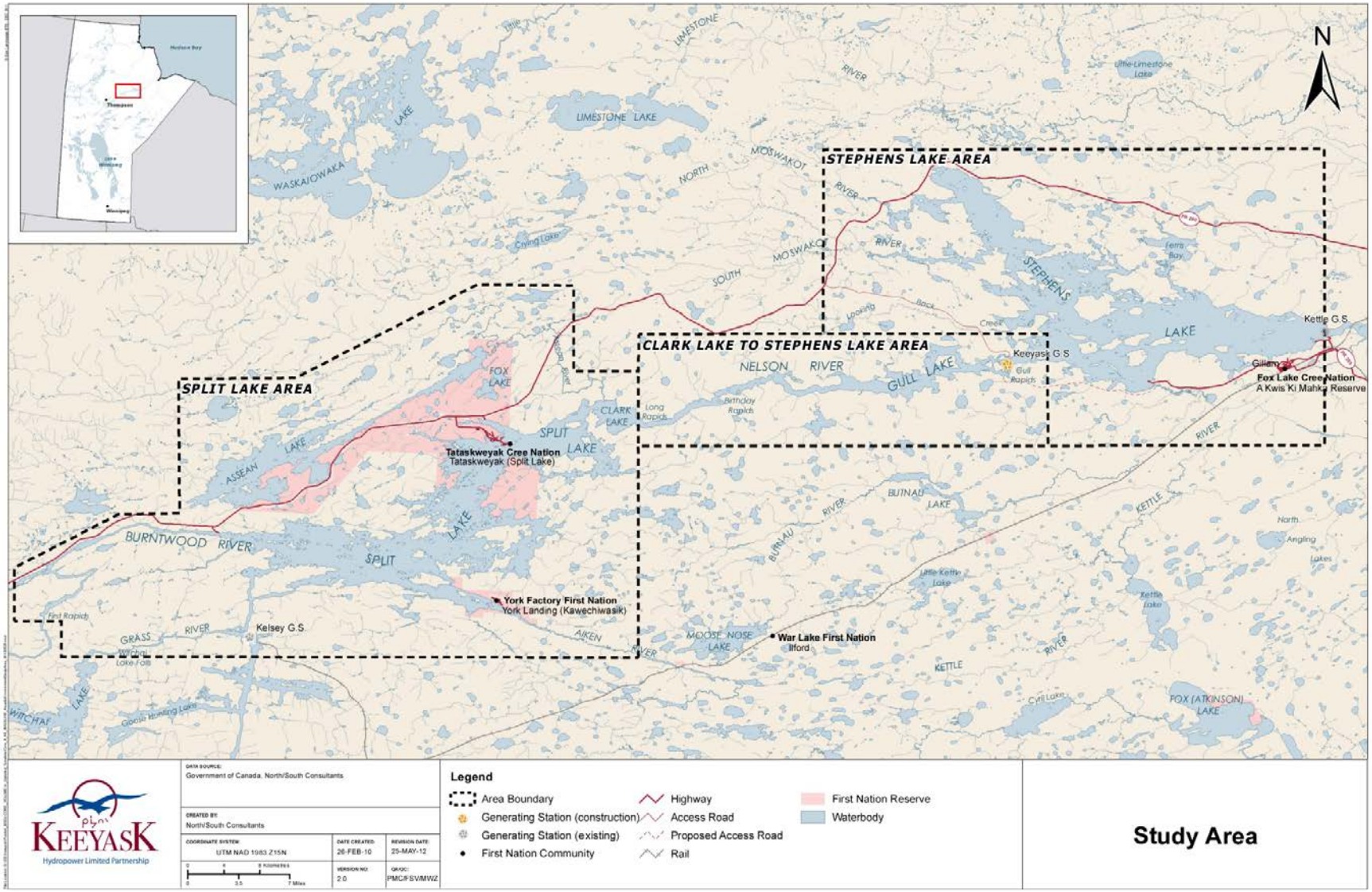


Figure 1: Map of the Nelson River showing the site of the Keeyask GS

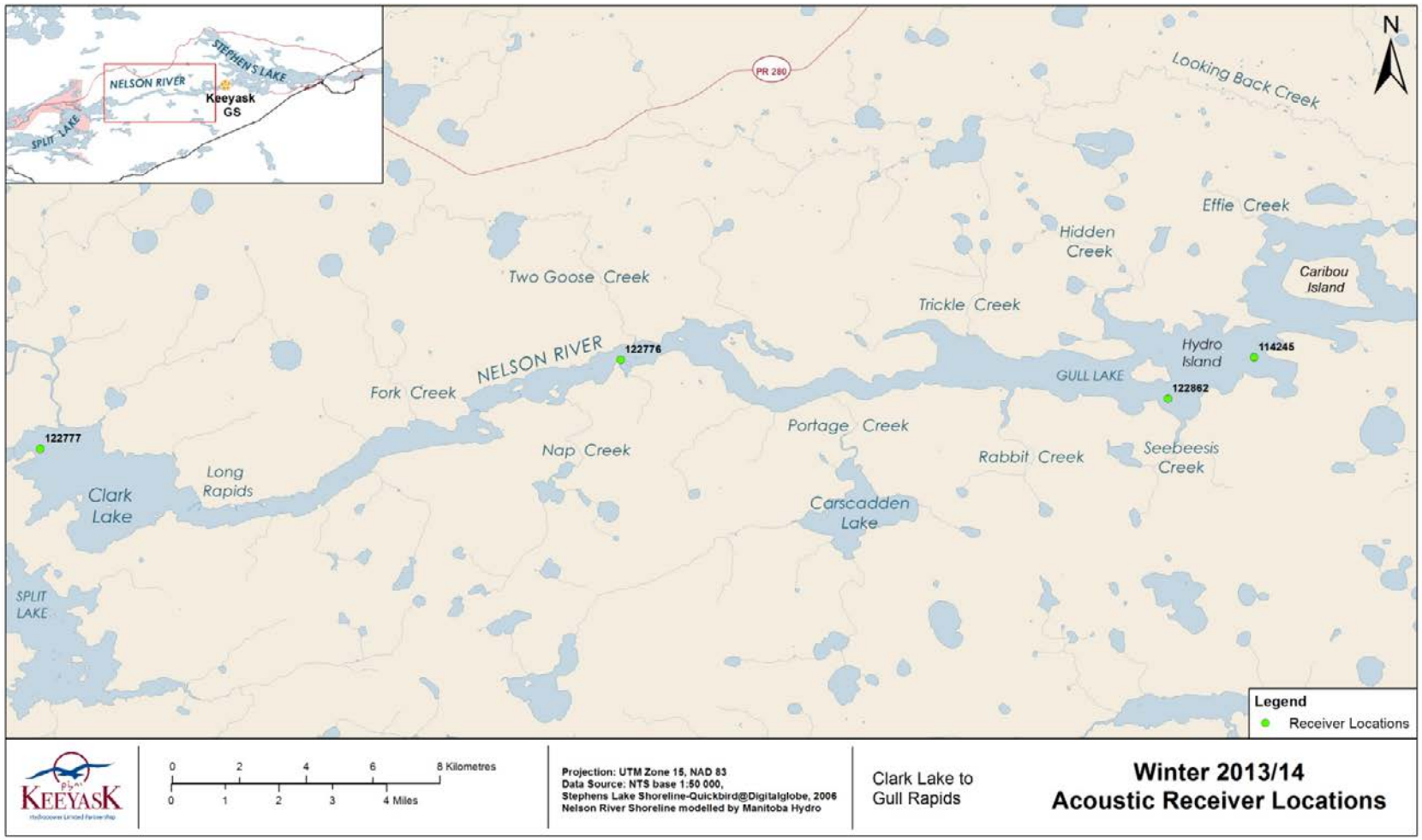


Figure 2: Locations of stationary receivers set in the Nelson River from Clark Lake to Gull Rapids between October, 2013 and June, 2014.

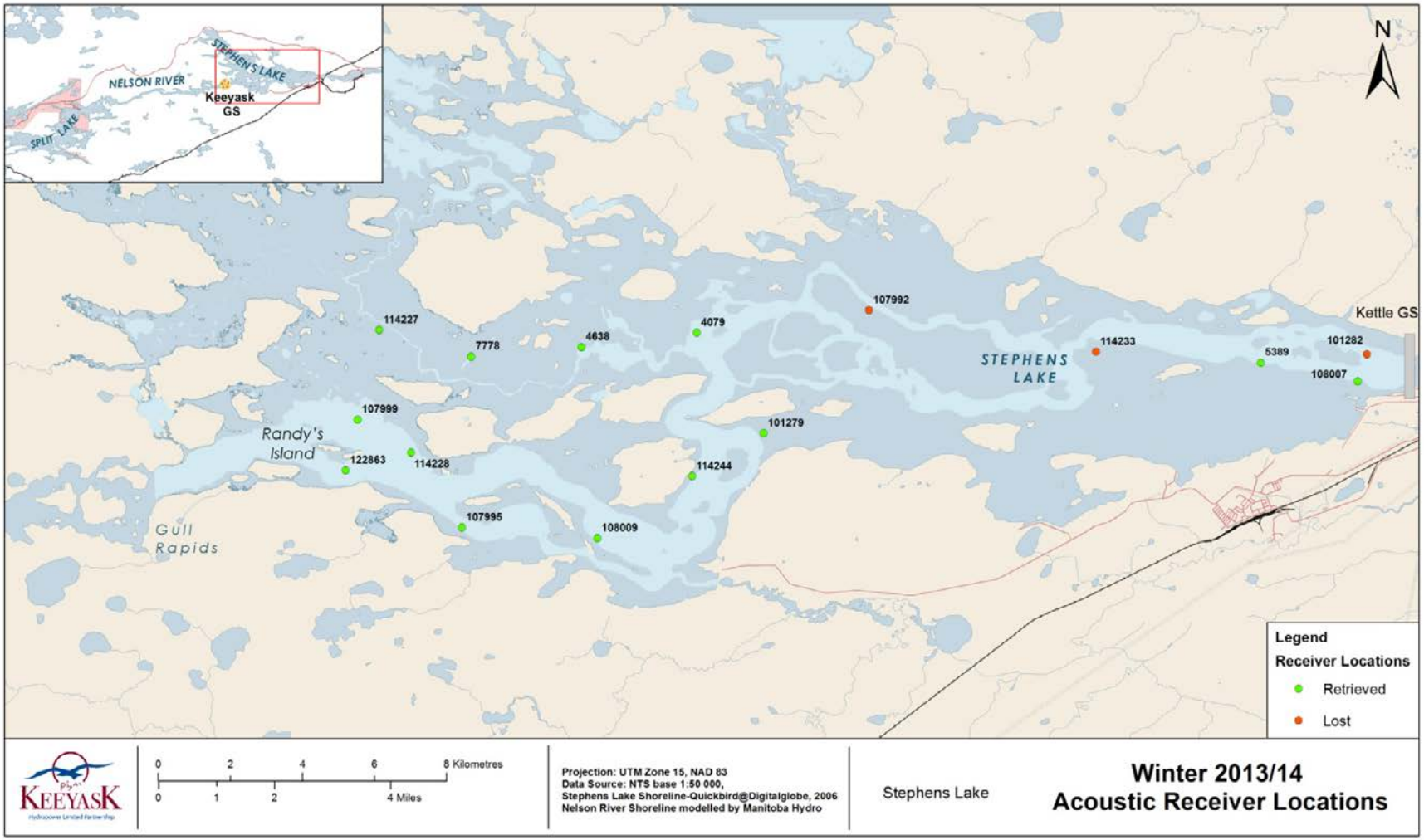


Figure 3: Locations of stationary receivers set in Stephens Lake from Gull Rapids to Kettle GS between October, 2013 and June, 2014. The former (pre-impoundment) river channel is shown in light blue.

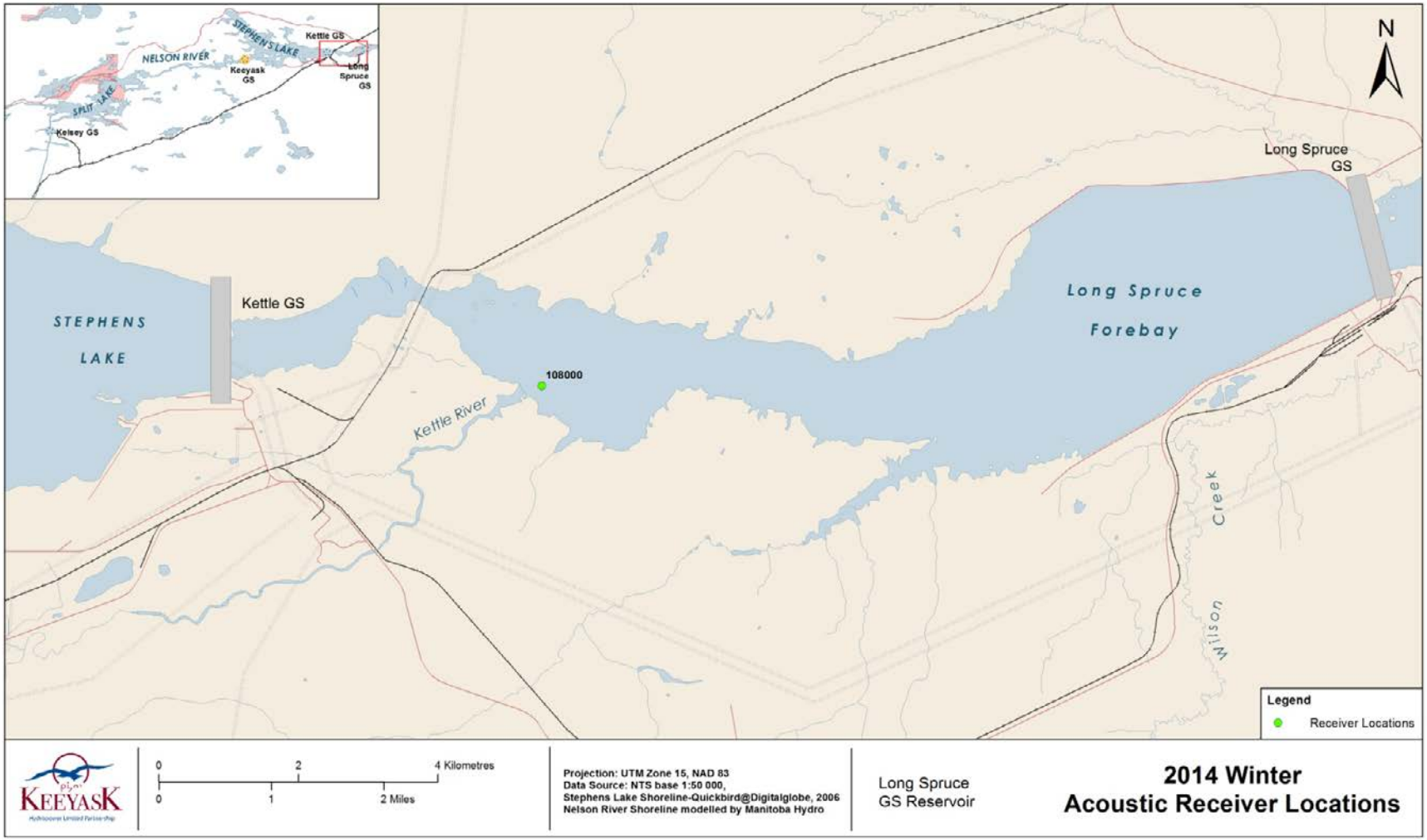


Figure 4: Location of the stationary receiver set in the Long Spruce Forebay between October, 2013 and June, 2014

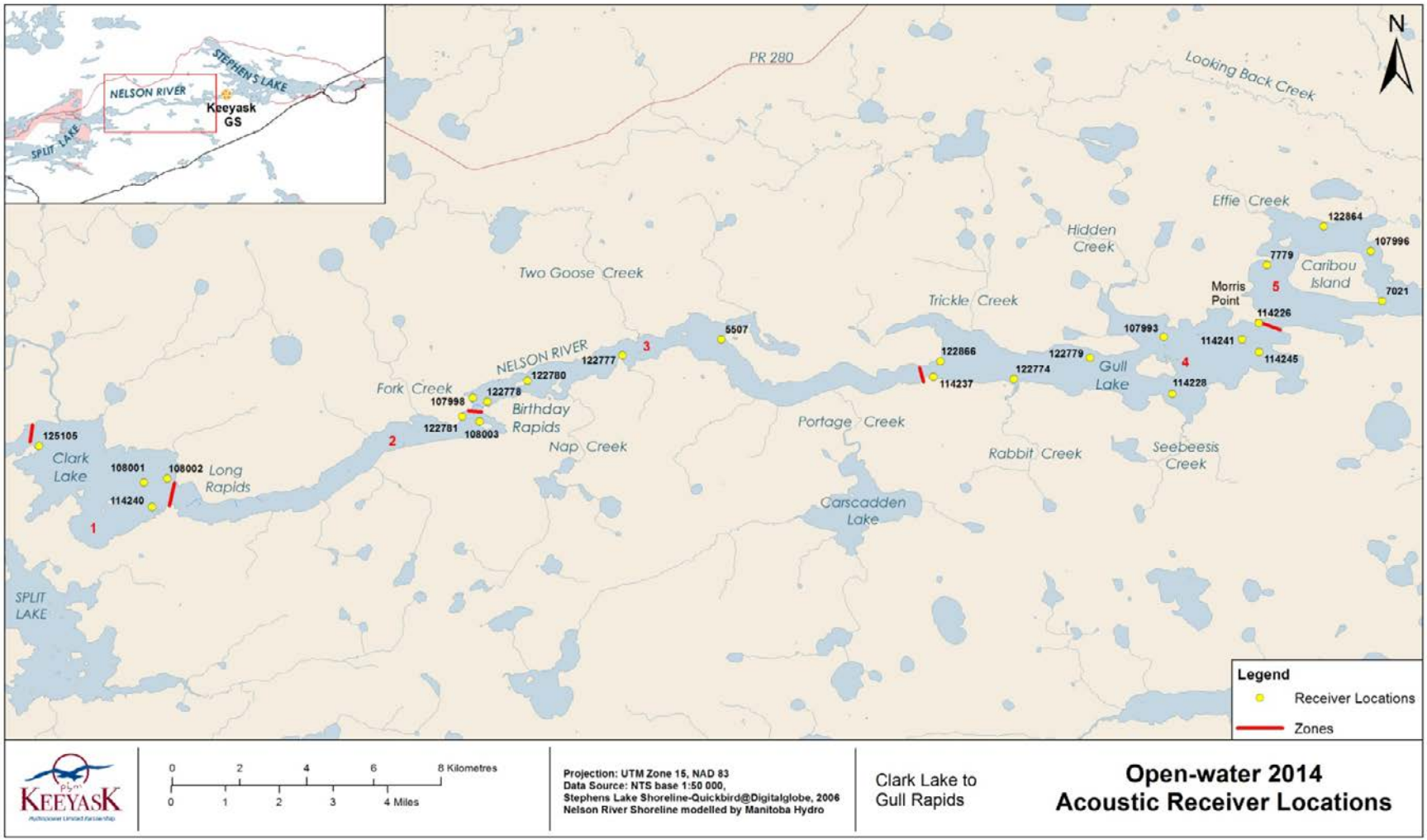


Figure 5: Locations of stationary receivers set in the Nelson River from Clark Lake to Gull Rapids between June and October, 2014. The river is divided into five "zones" based on placement of receiver "gates"

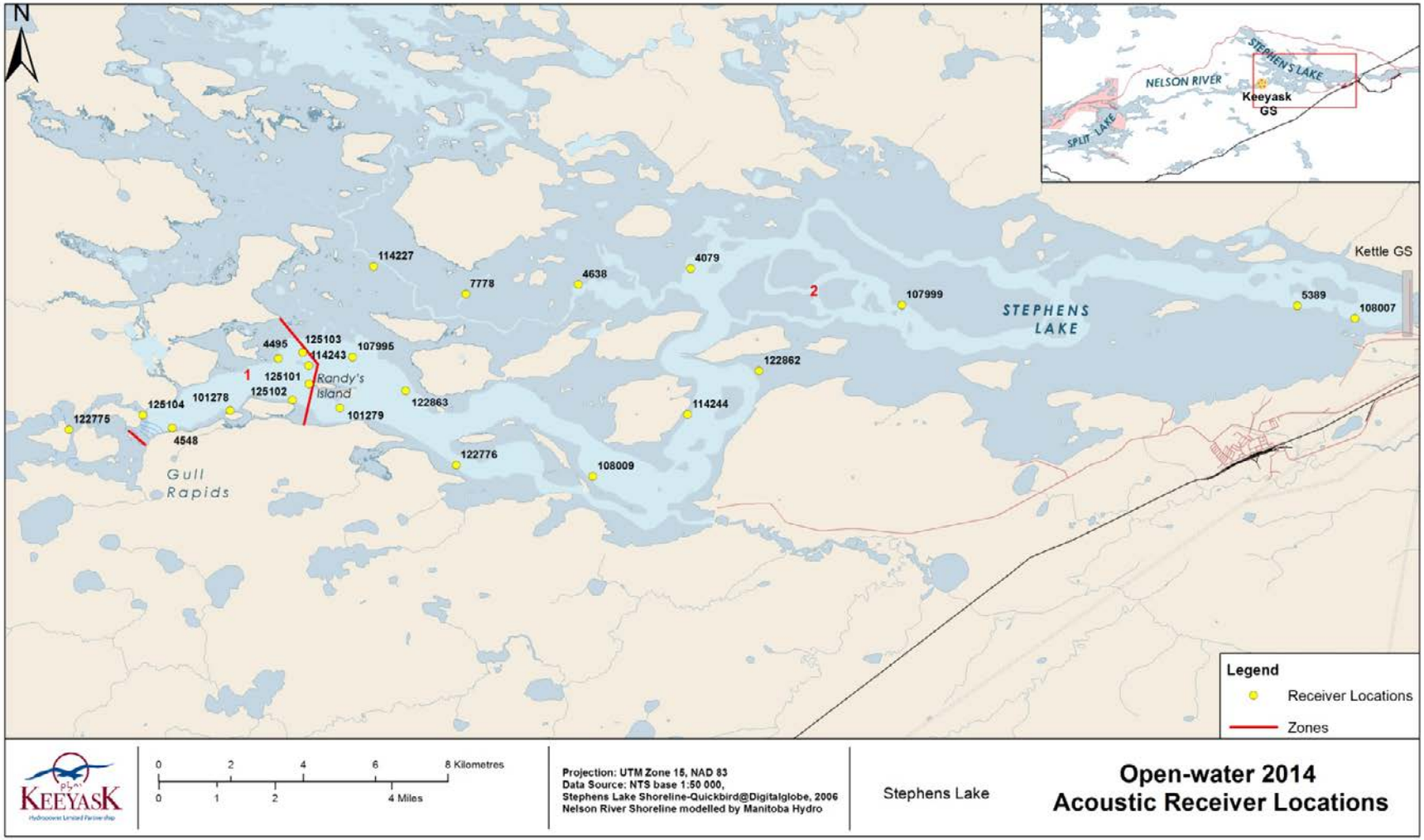


Figure 6: Locations of stationary receivers set in Stephens Lake between June and October, 2014. The river is divided into two "zones" based on placement of receiver "gates." The pre-impoundment river channel is shown in light blue

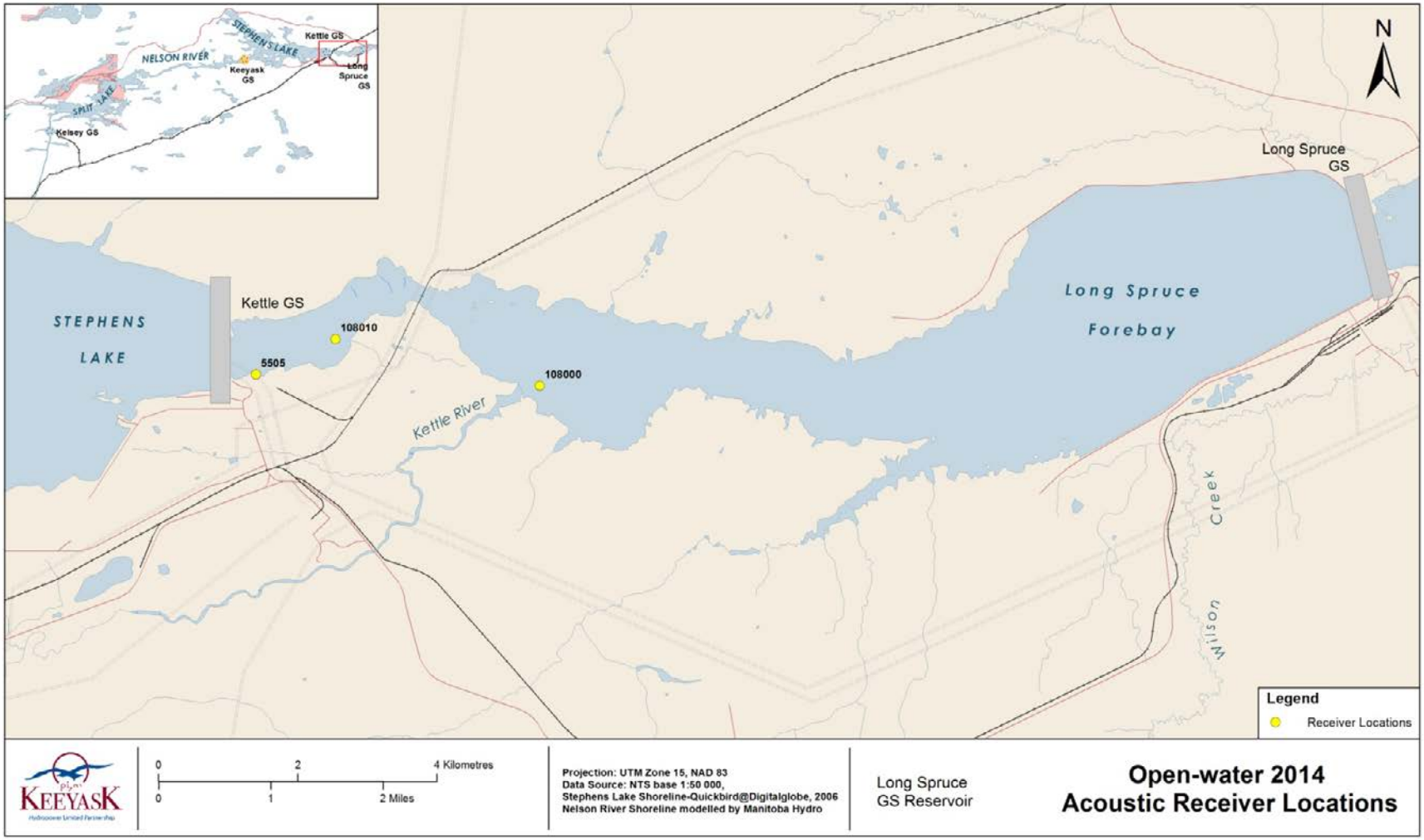


Figure 7: Locations of stationary receivers set in the Long Spruce Forebay between June and October, 2014.

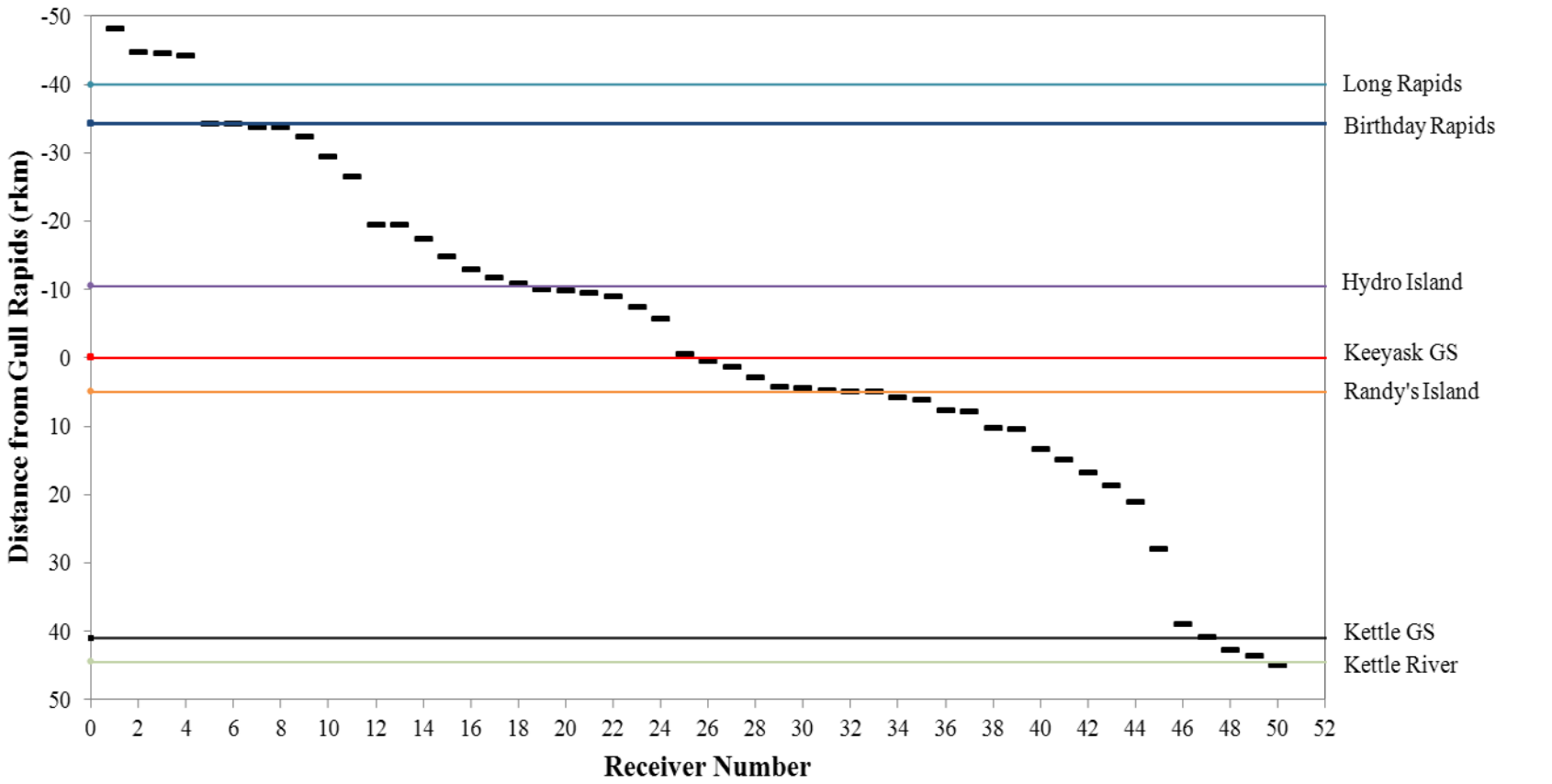


Figure 8: Locations of stationary acoustic receivers in relation to the base of Gull Rapids (rkm 0) and other major landmarks in the Nelson River between Clark Lake and the Long Spruce GS between June and October, 2014.

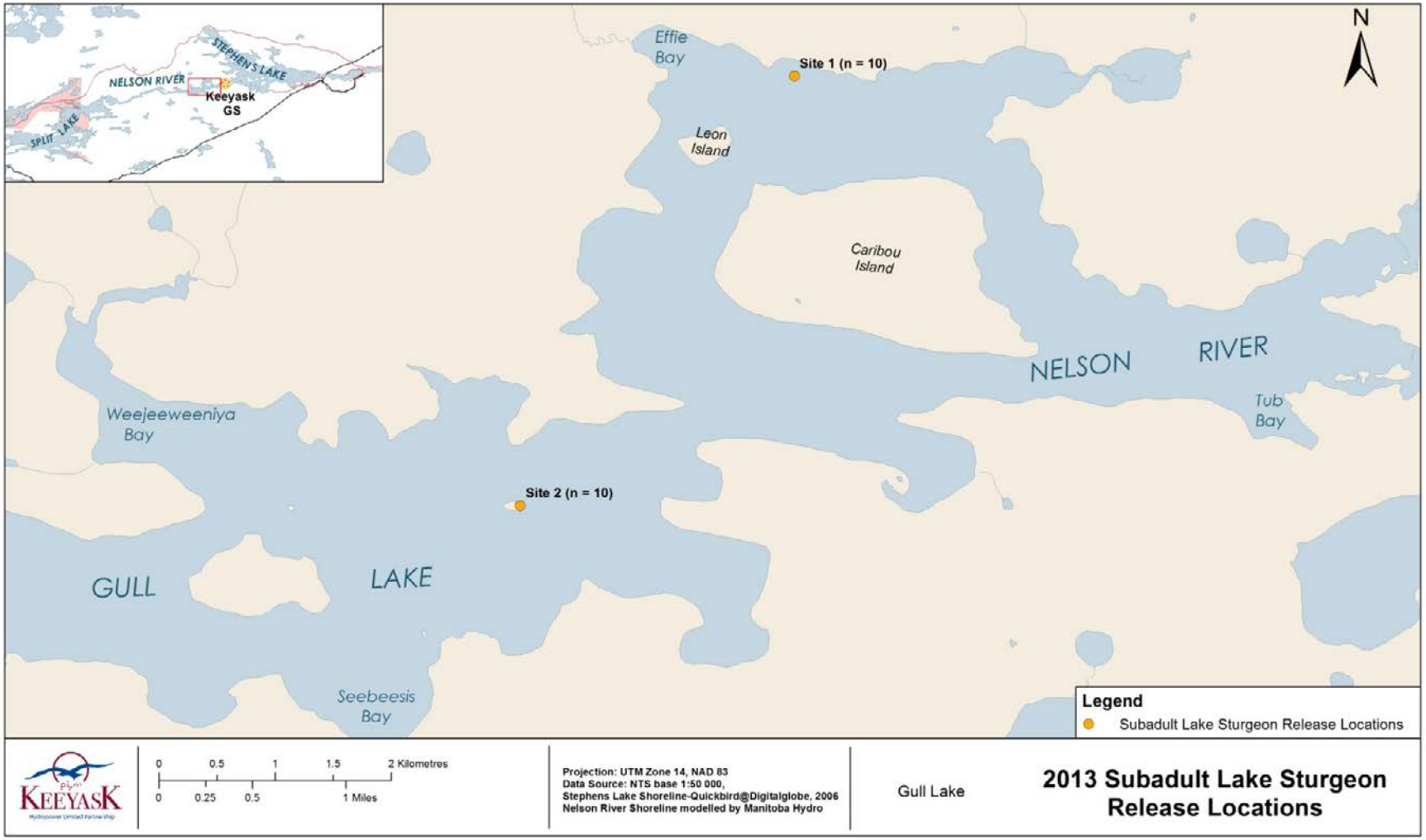


Figure 9: Release locations for juvenile Lake Sturgeon tagged in Gull Lake on 28 and 29 June, 2013.

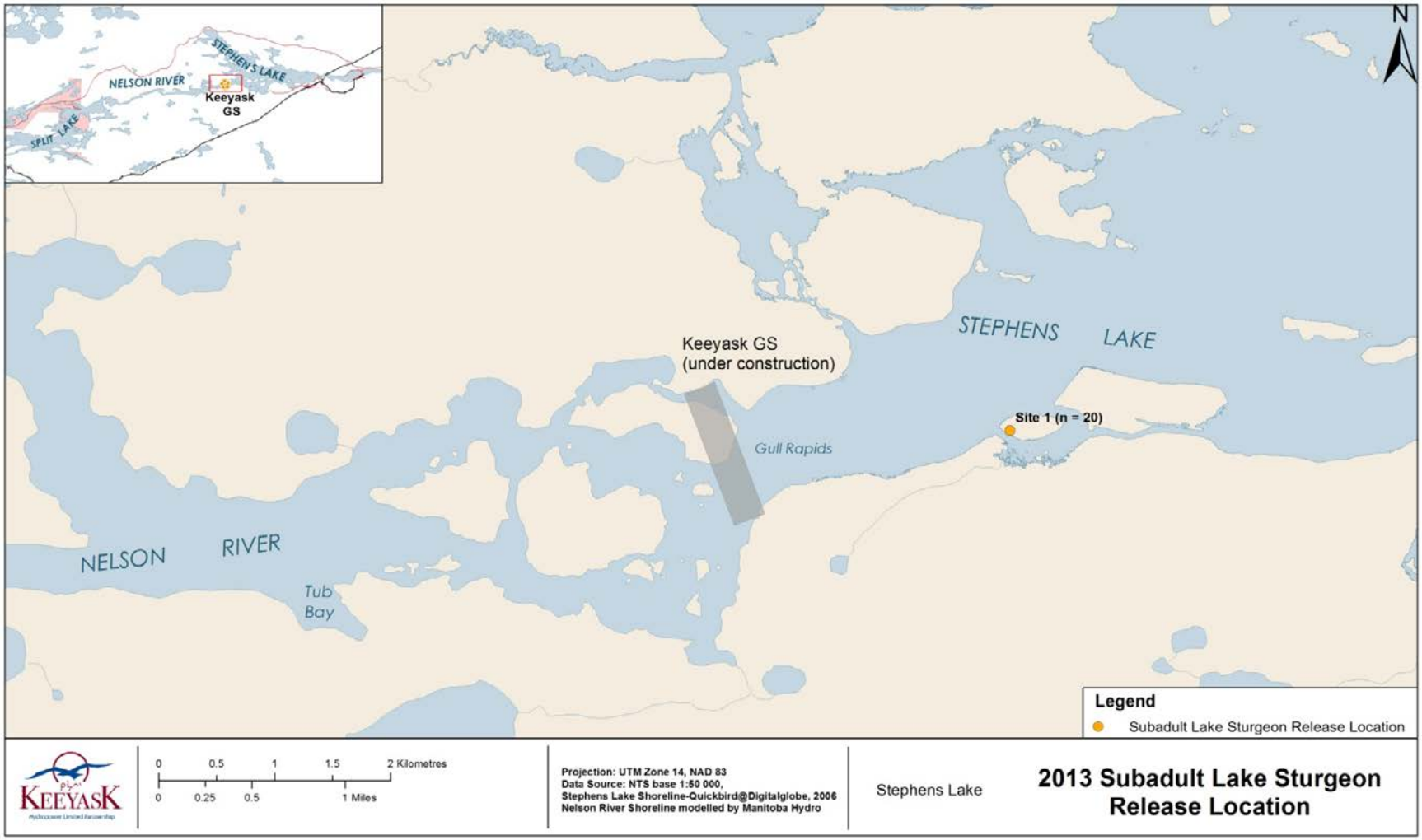


Figure 10: Release locations for juvenile Lake Sturgeon tagged in Stephens Lake between 16 and 23 September, 2013.

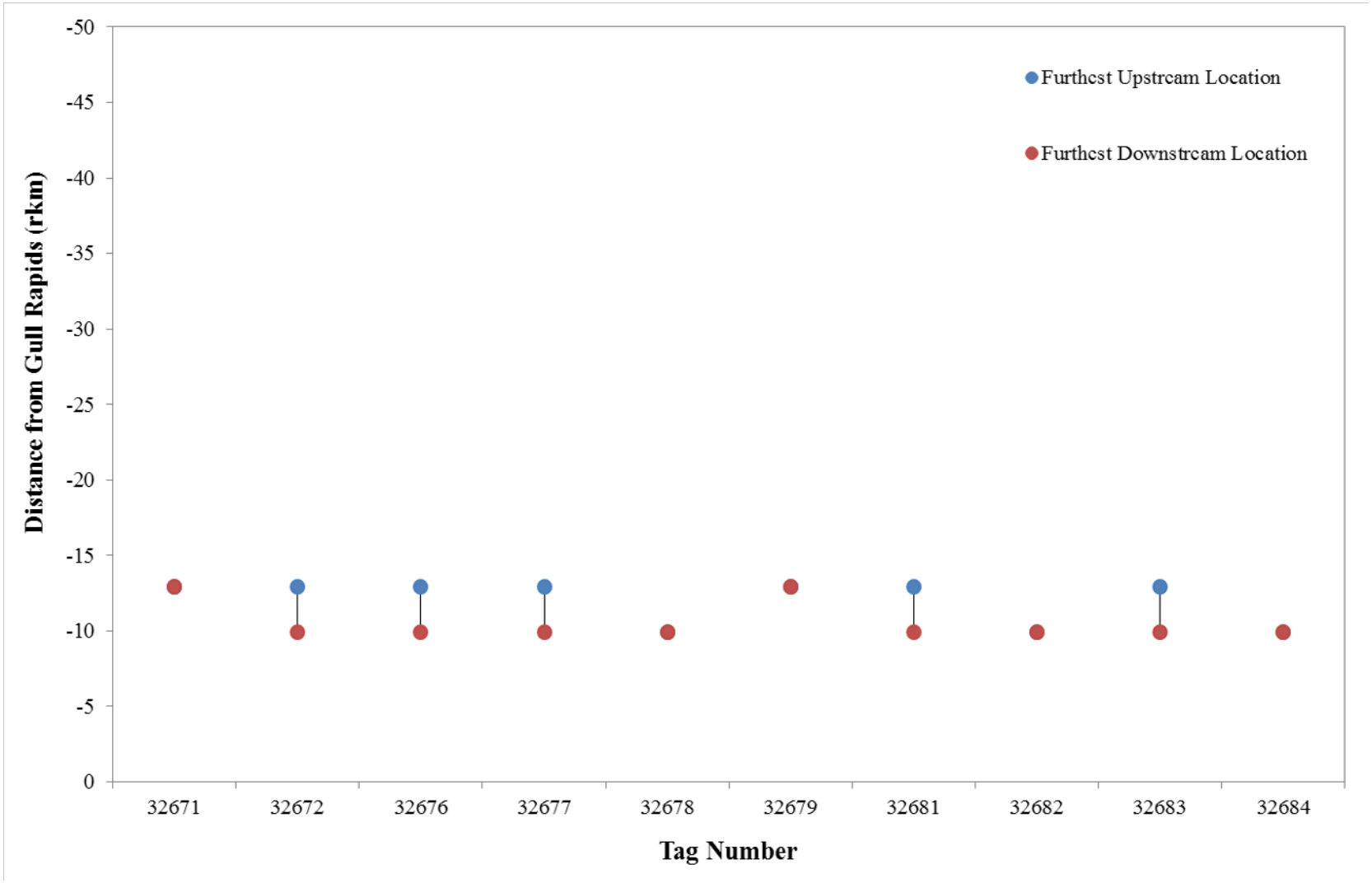


Figure 11: Detection ranges for the ten acoustic tagged juvenile Lake Sturgeon detected between Clark Lake and Gull Rapids during the winter 2013/2014 period (16 October, 2013 to 30 April, 2014).

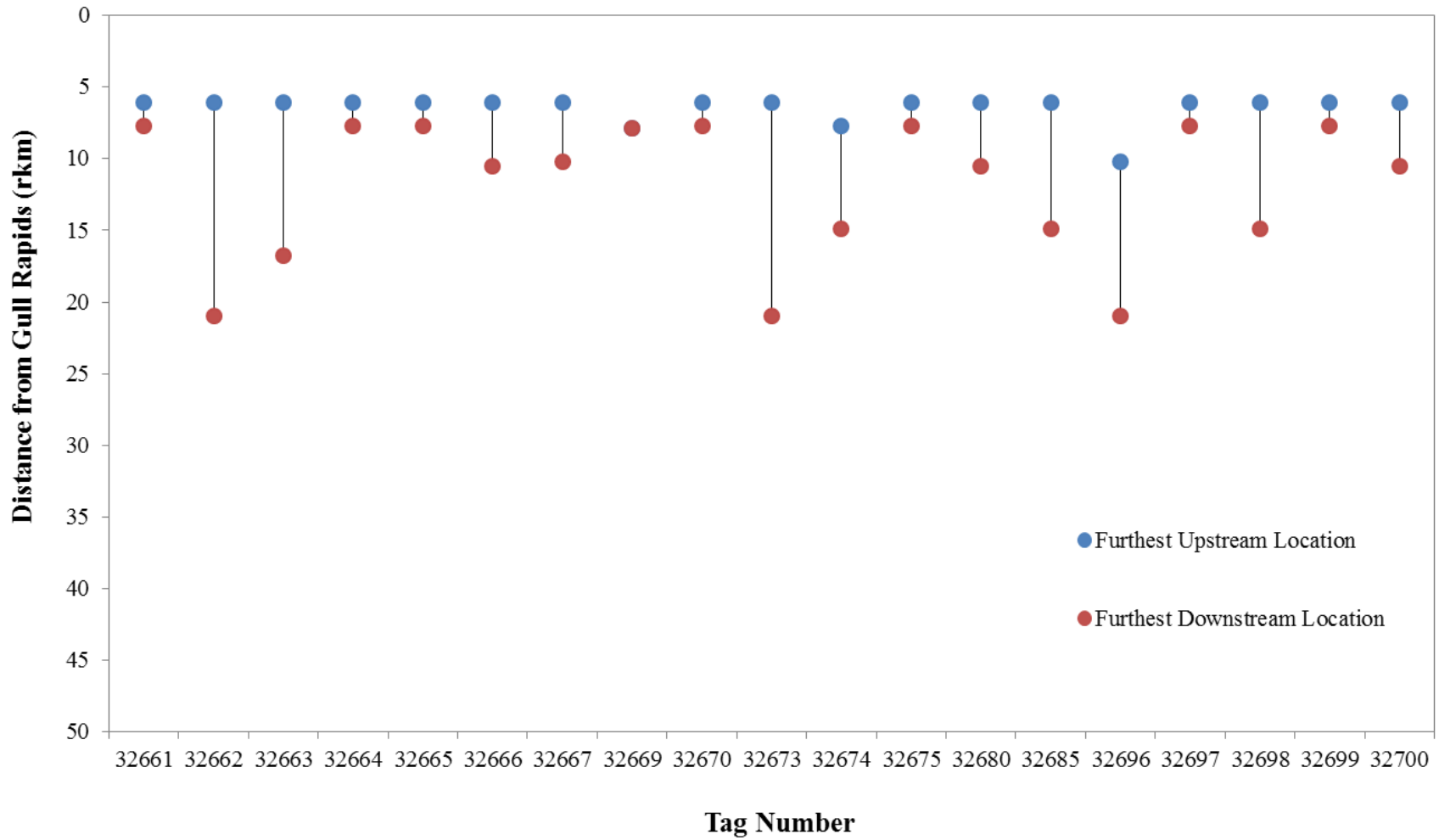


Figure 12: Detection ranges for the 19 acoustic tagged juvenile Lake Sturgeon detected in Stephens Lake during the winter 2013/2014 period (16 October, 2013 to 30 April, 2014).

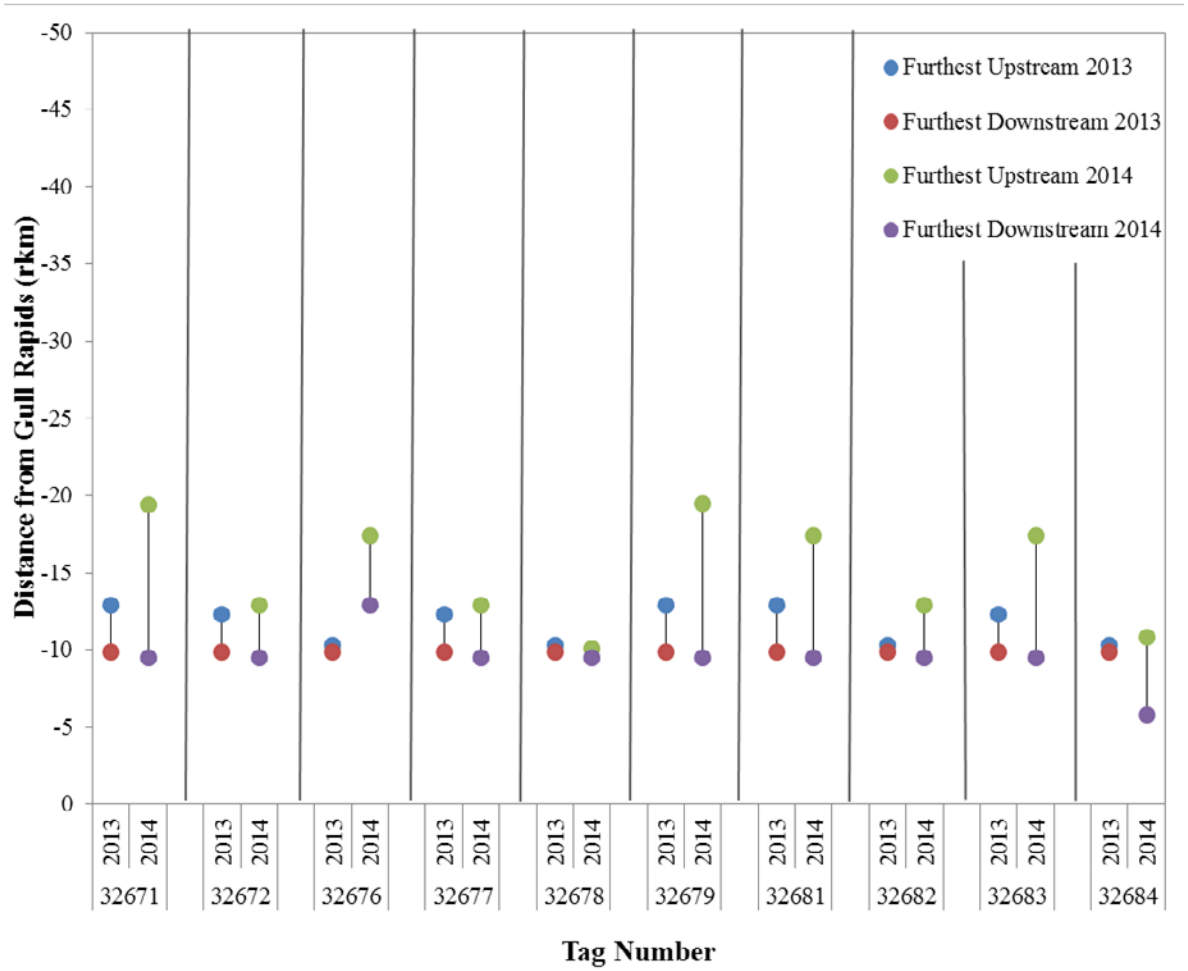


Figure 13: Detection ranges for acoustic tagged juvenile Lake Sturgeon in Gull Lake during the open-water periods of 2013 and 2014.

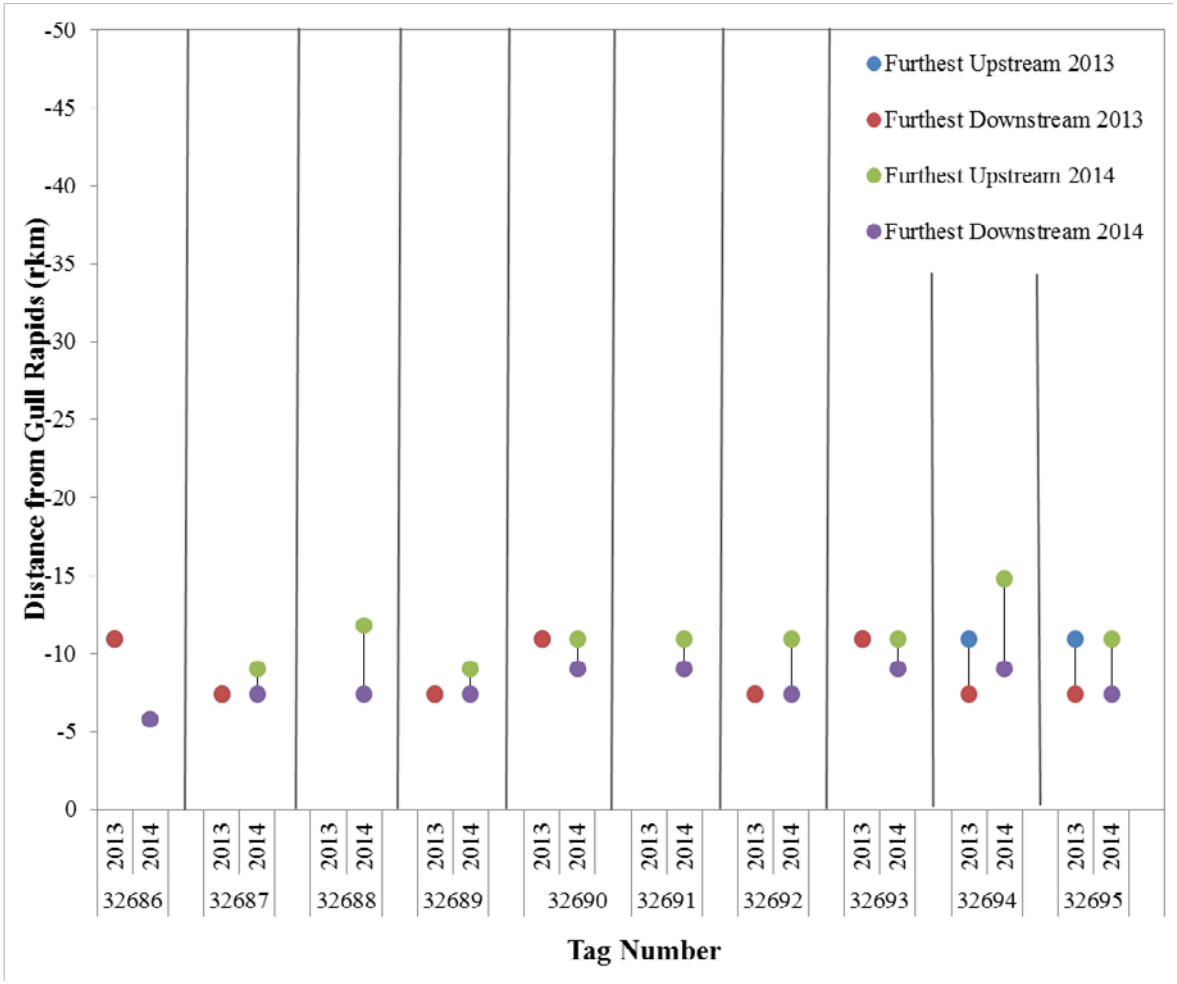


Figure 13: Continued

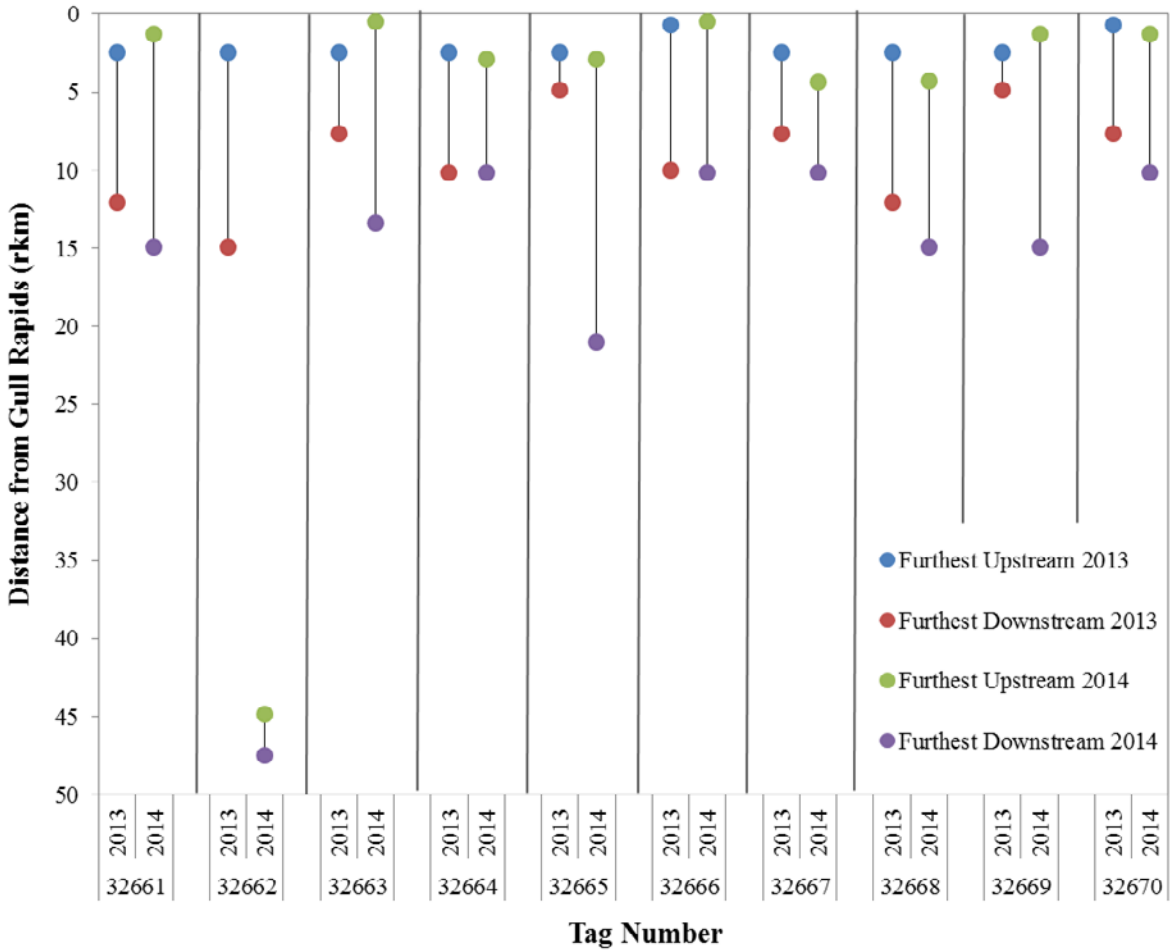


Figure 14: Detection ranges for acoustic tagged juvenile Lake Sturgeon in Stephens Lake during the open-water periods of 2013 and 2014. An "X" indicates that a fish was not detected during a season.

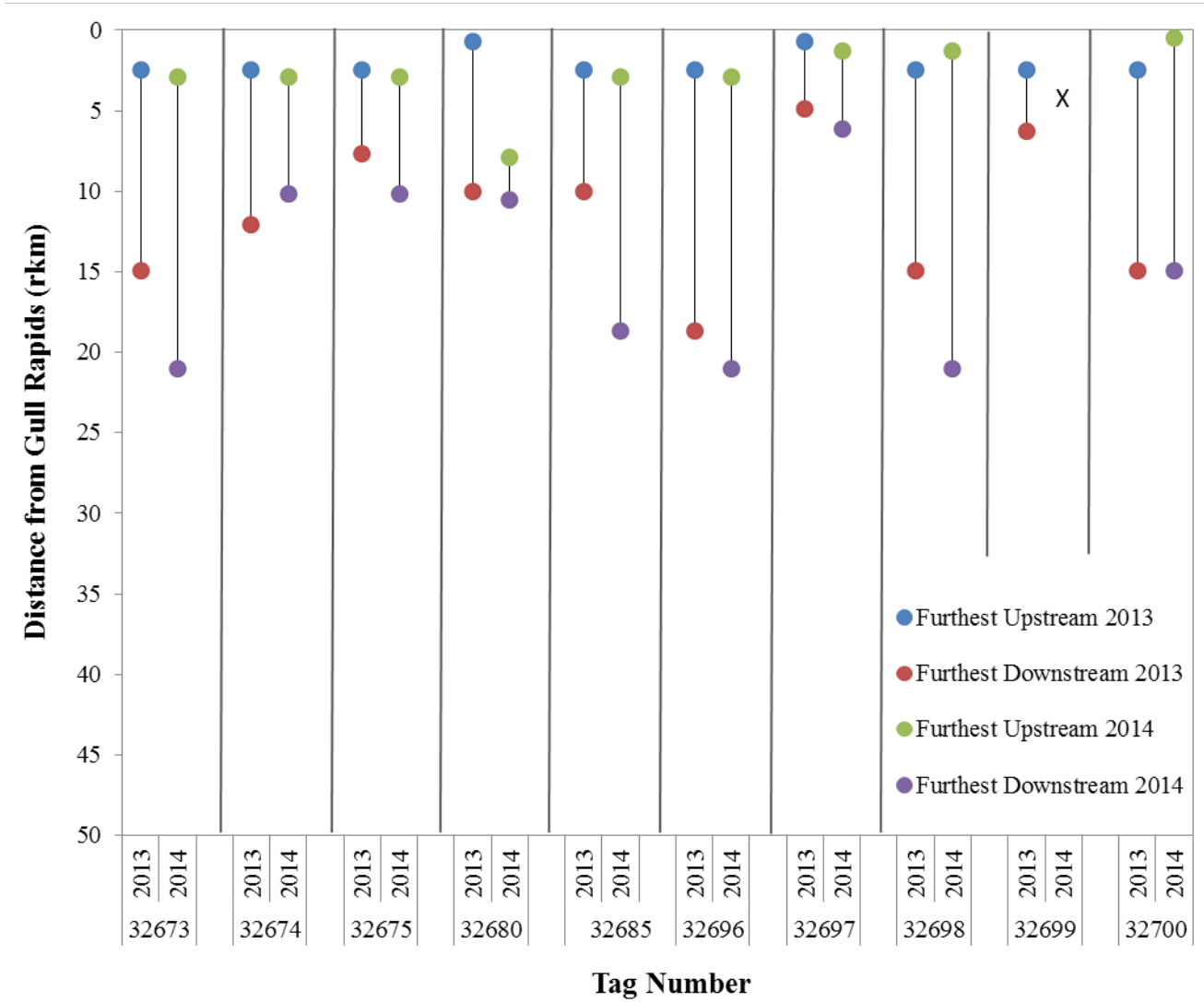


Figure 14: Continued.

Figure 15: Proportional distribution by zone for juvenile Lake Sturgeon tagged with acoustic transmitters in the Nelson Rive (CL - GR) during a portion of the 2014 open-water period (4 June to 3 October, 2014). Black dashed line represents start date of construction of Keeyask GS on 15 July, 2014.

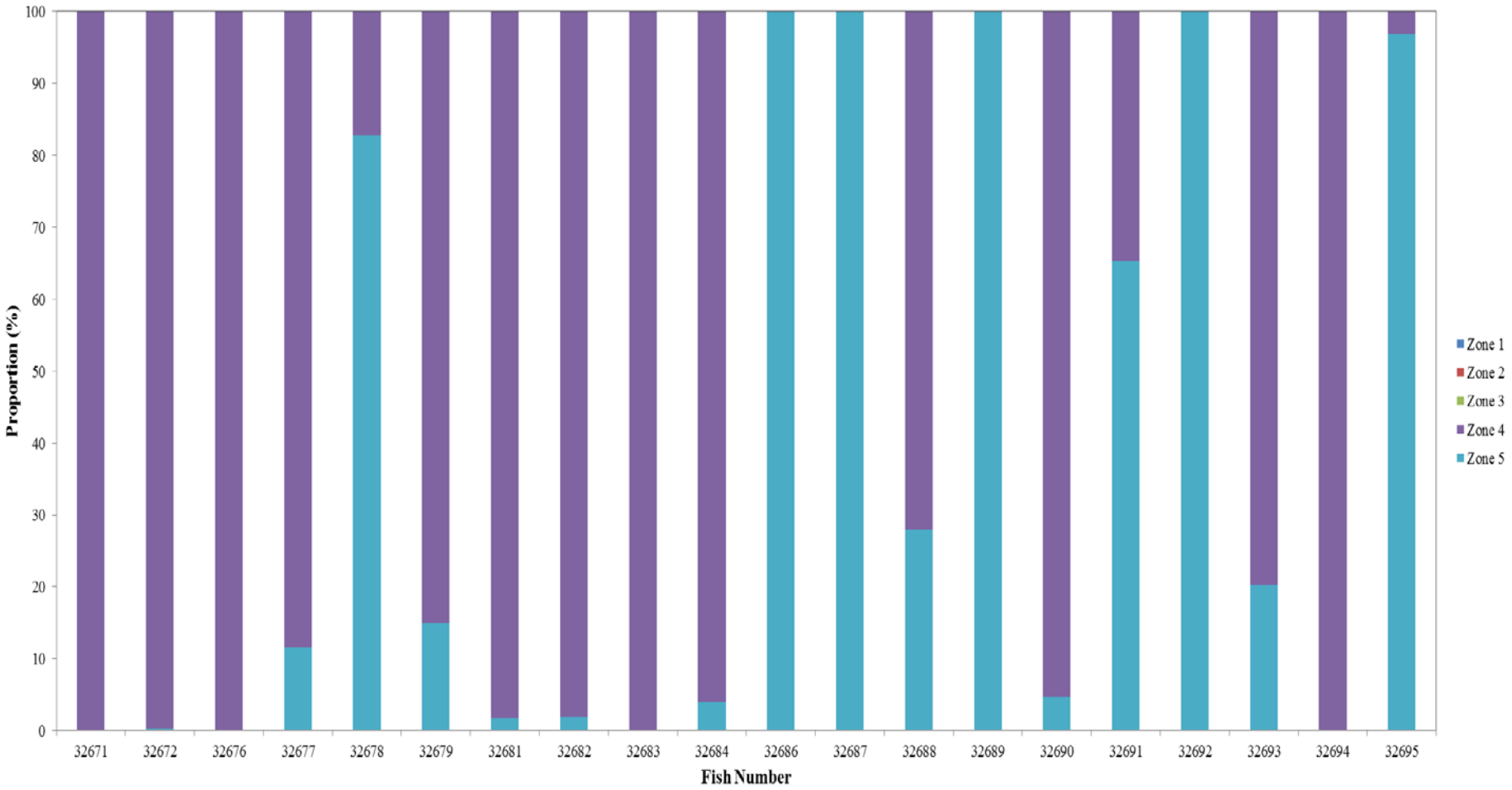


Figure 16: Proportional distributions by zone, for individual juvenile Lake Sturgeon tagged with acoustic transmitters in the Nelson River (CL – GR) during the 2014 open-water period (1 May to 12 October, 2014).

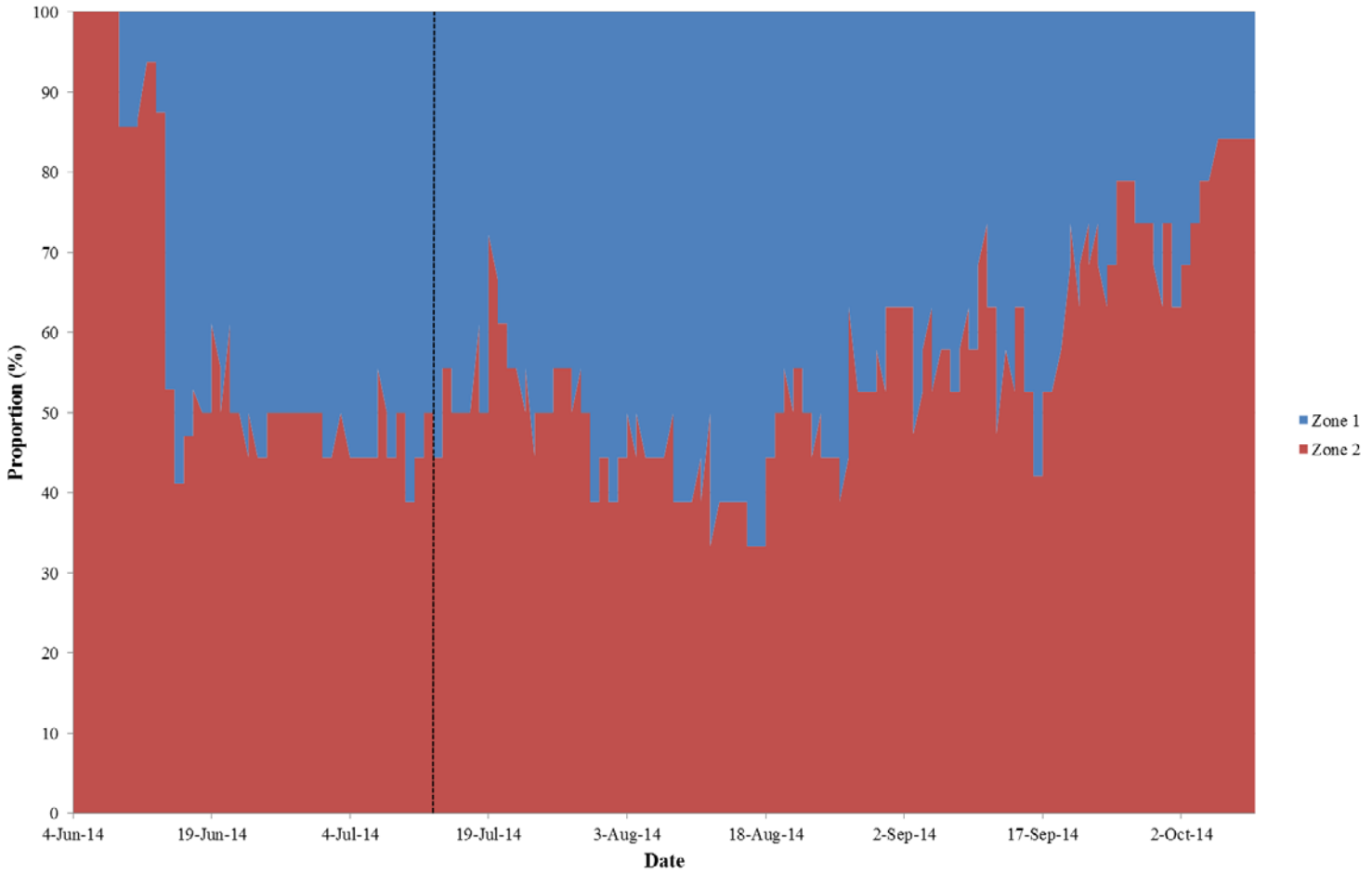


Figure 17: Proportional distribution, by zone, for juvenile Lake Sturgeon tagged with acoustic transmitters in Stephens Lake during a portion of the 2014 open-water period (4 June to 3 October, 2014). Black dashed line represents start date of construction of Keeyask GS on 15 July, 2014.

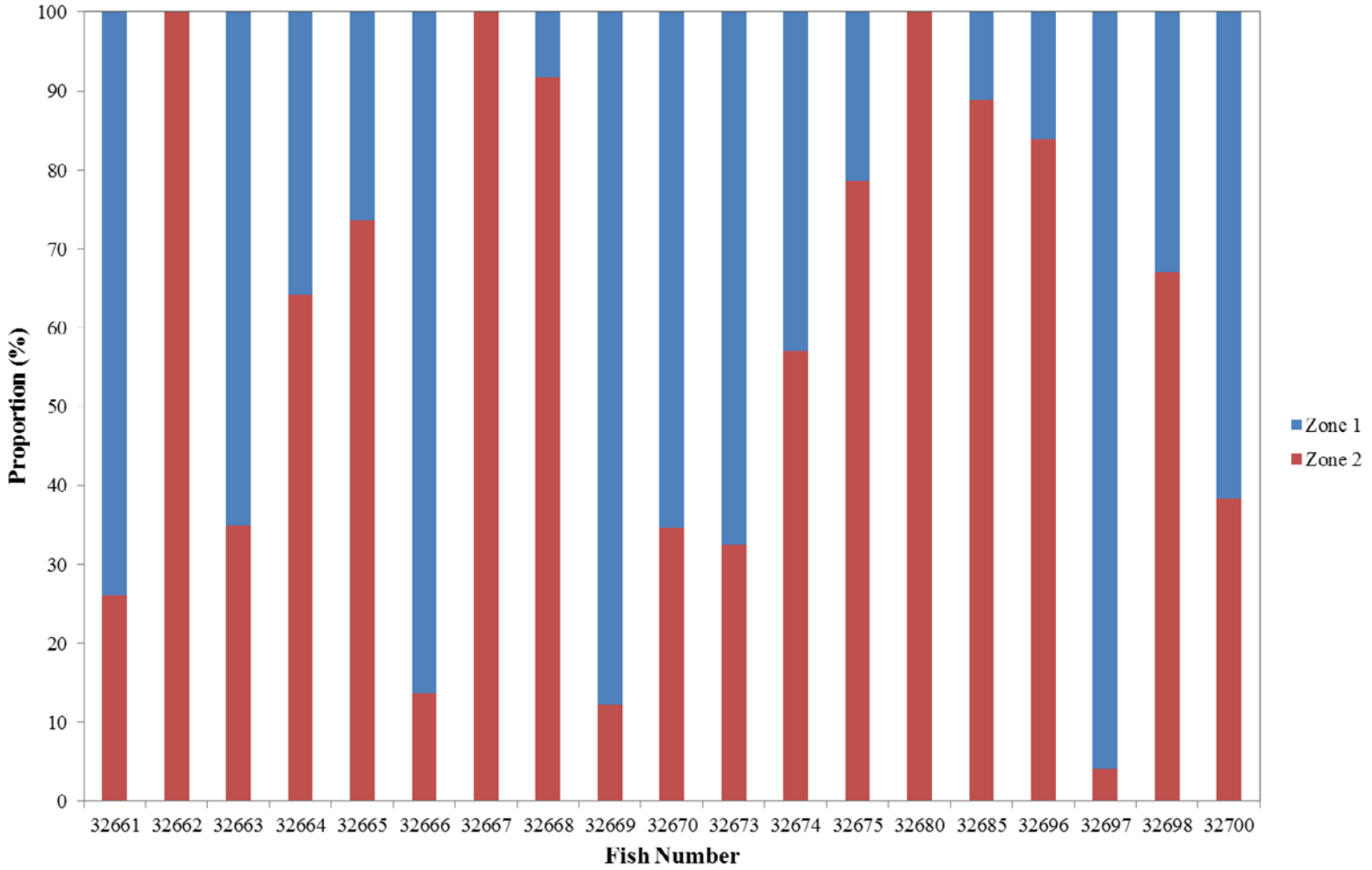


Figure 18: Proportional distributions, by zone, for individual juvenile Lake Sturgeon tagged with acoustic transmitters in Stephens Lake during a portion of the 2014 open-water period (4 June to 3 October, 2014).

APPENDICES

APPENDIX 1:
LOCATION SUMMARY FOR INDIVIDUAL ACOUSTIC TAGGED JUVENILE LAKE STURGEON UPSTREAM OF GULL RAPIDS, SEPTEMBER 2013 TO OCTOBER 2014.

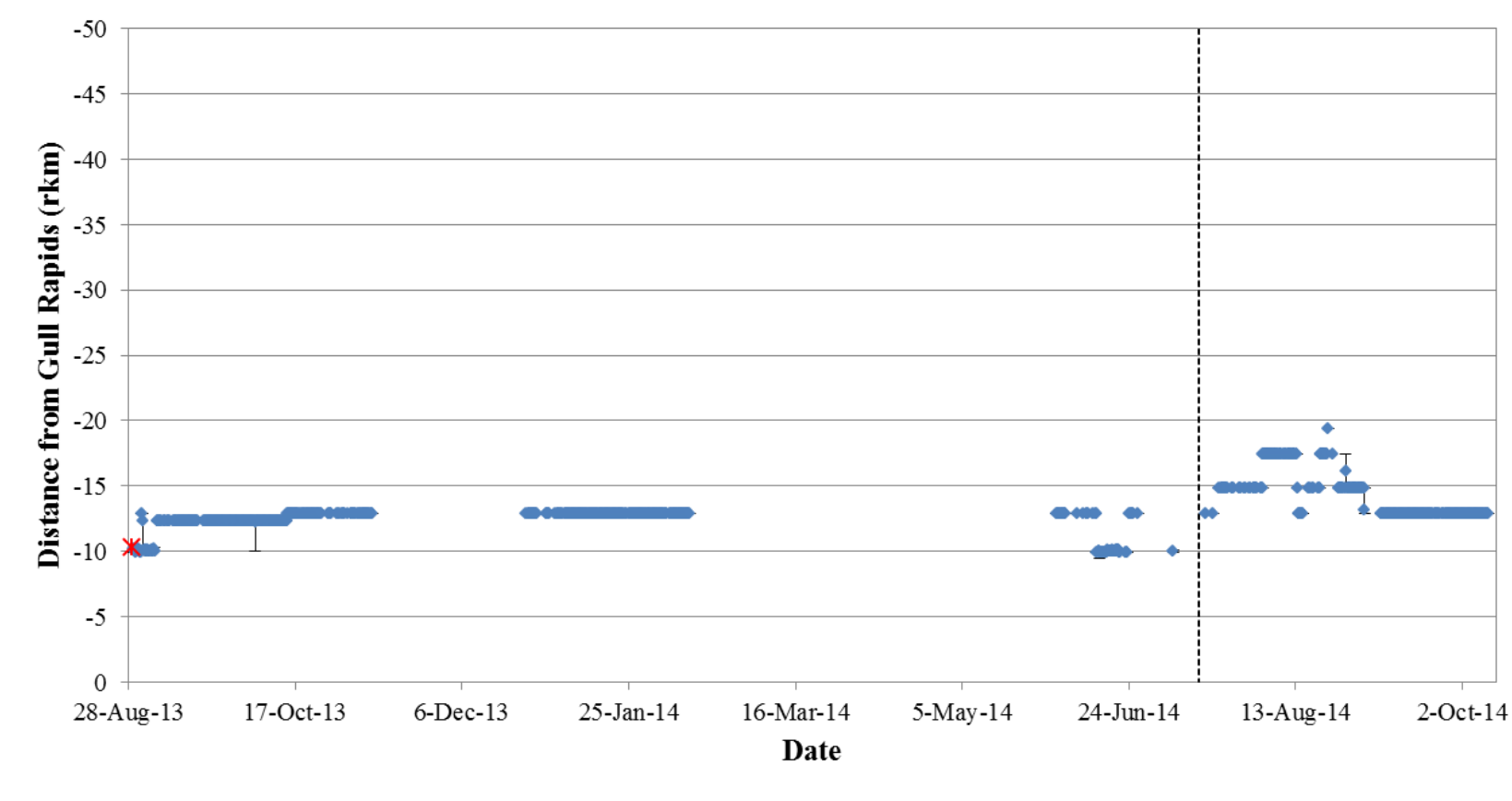


Figure A1- 1: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32671) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 12 October, 2014. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

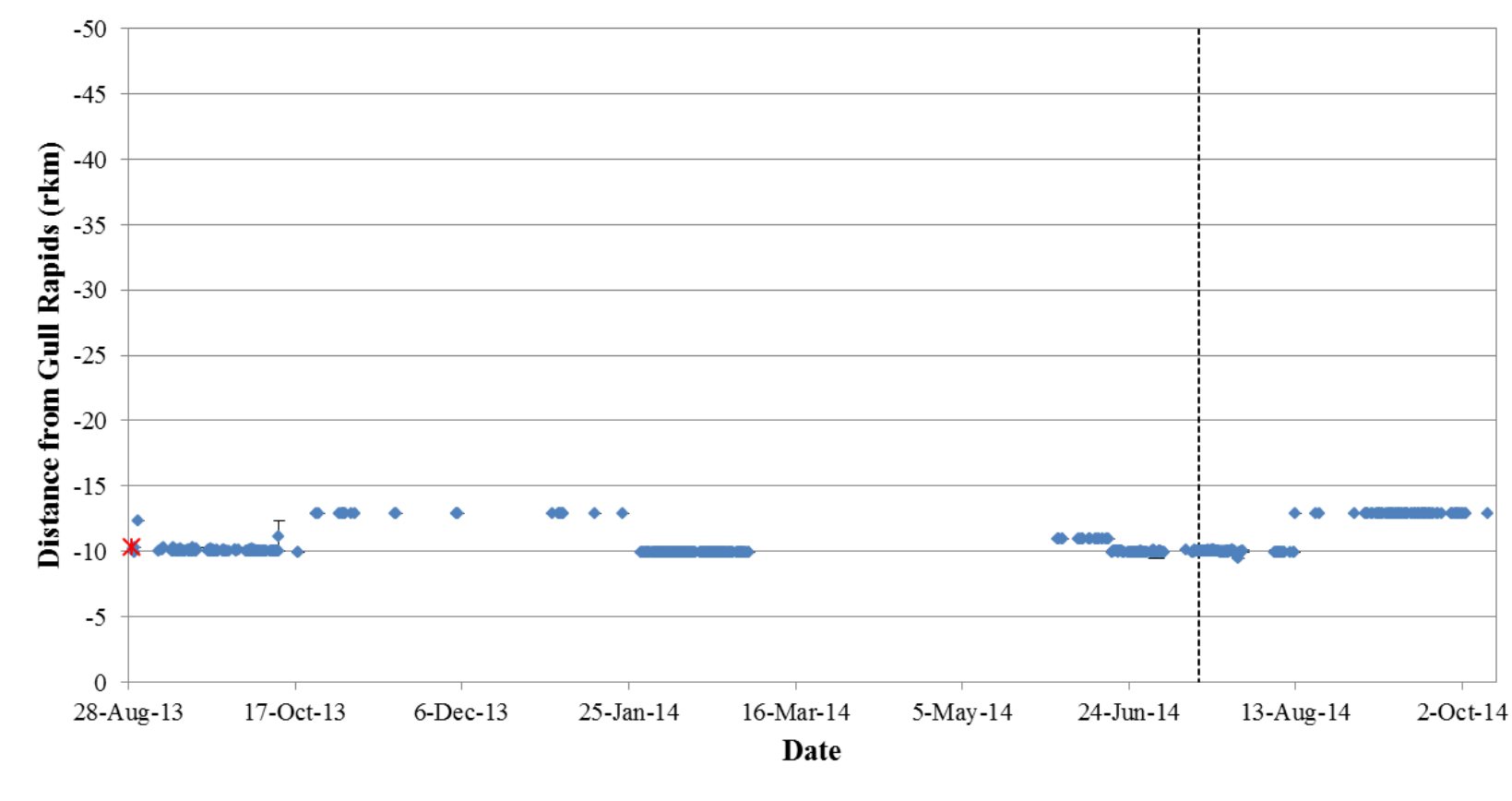


Figure A1- 2: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32672) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 12 October, 2014. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

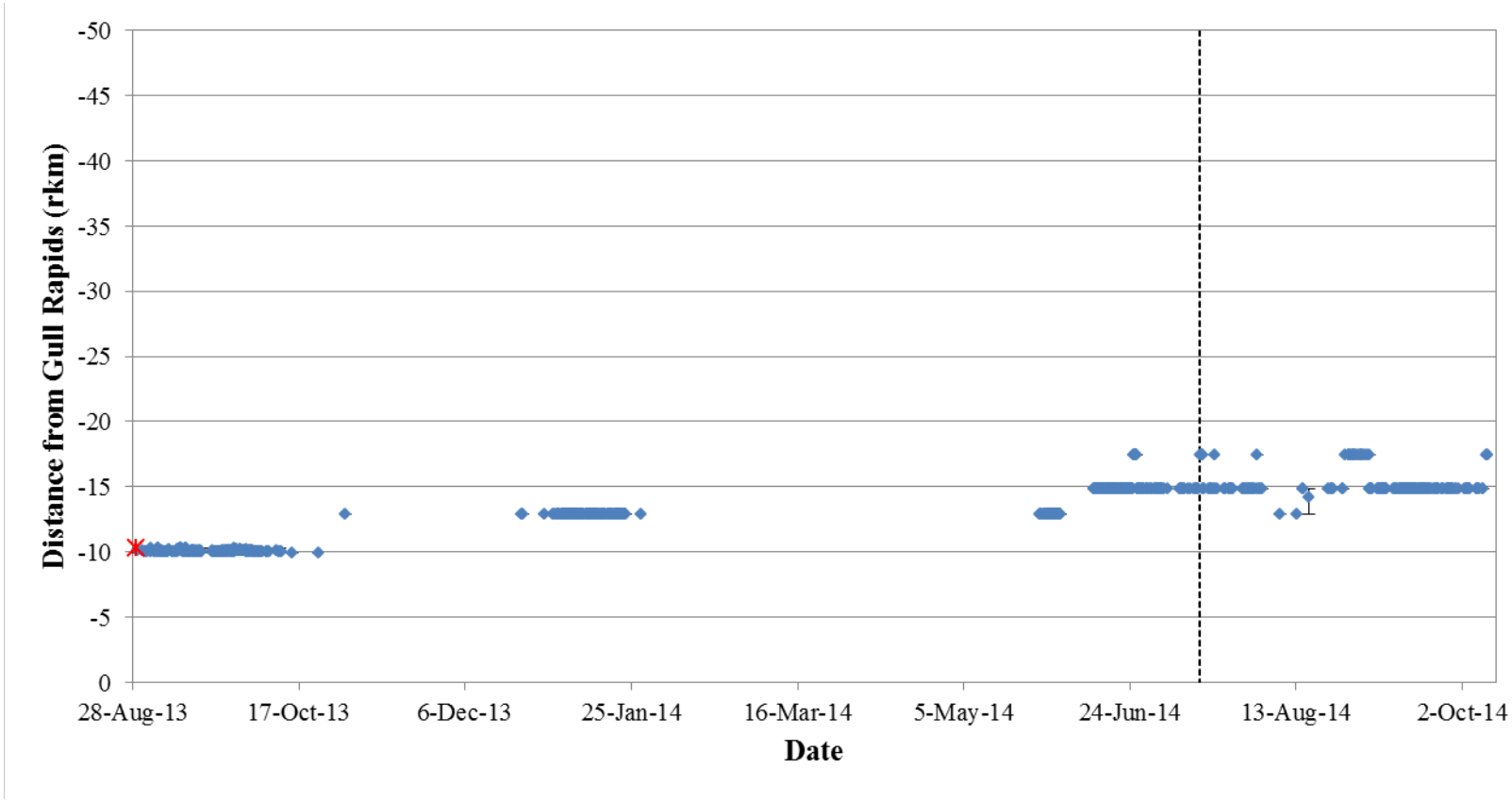


Figure A1- 3: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32676) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 12 October, 2014. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

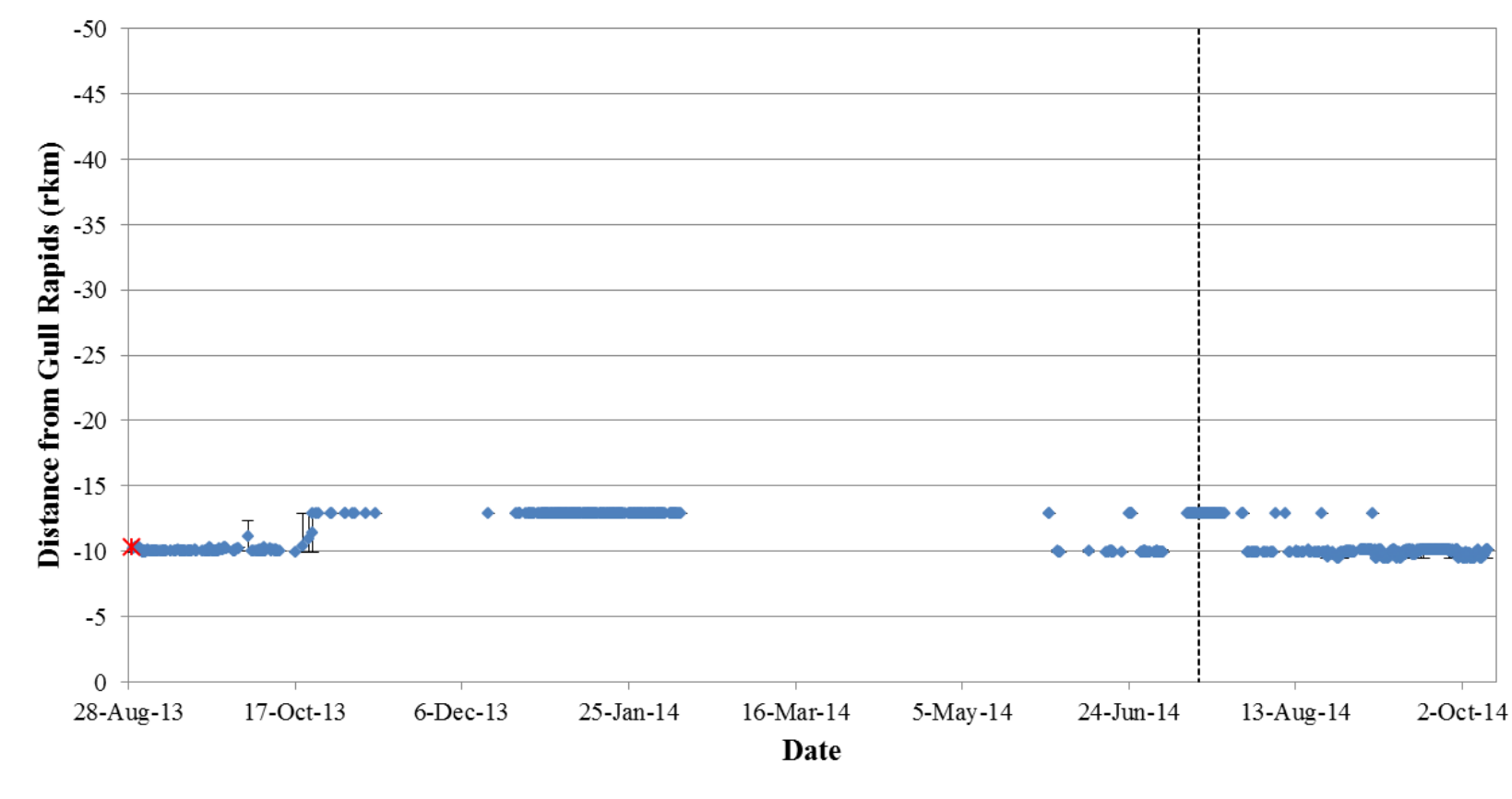


Figure A1- 4: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32677) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 12 October, 2014. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

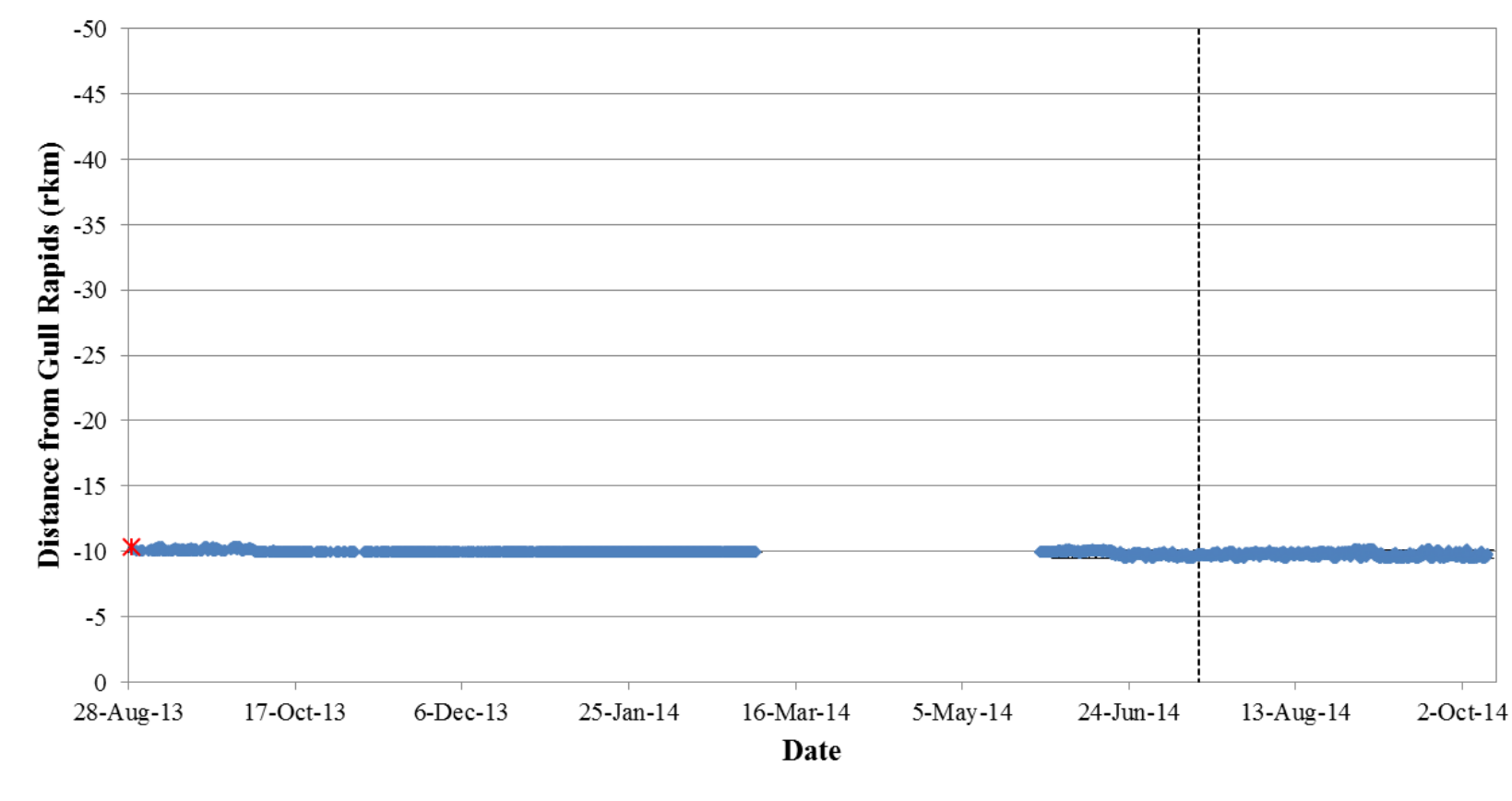


Figure A1- 5: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32678) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 12 October, 2014. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

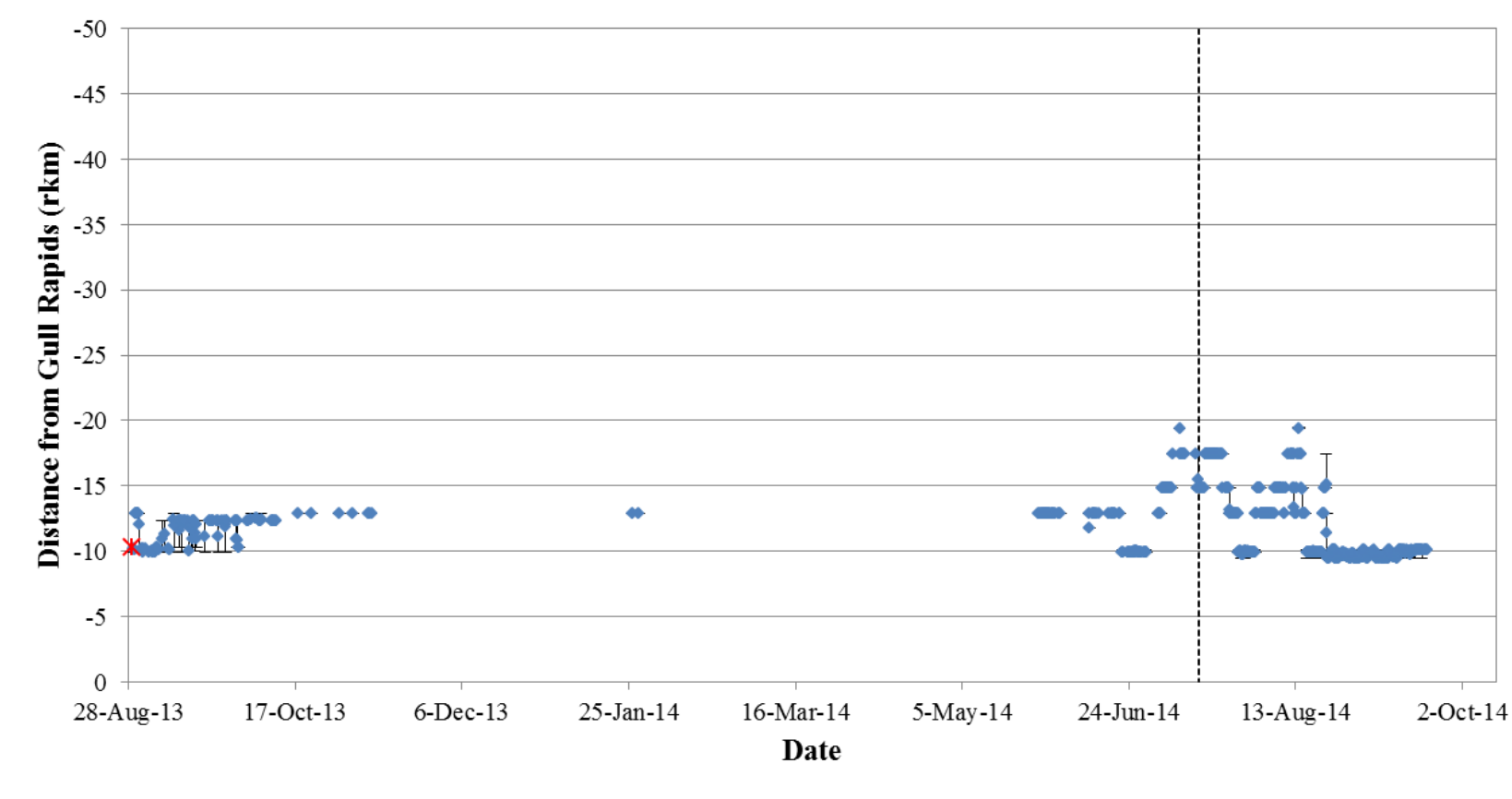


Figure A1- 6: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32679) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 12 October, 2014. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

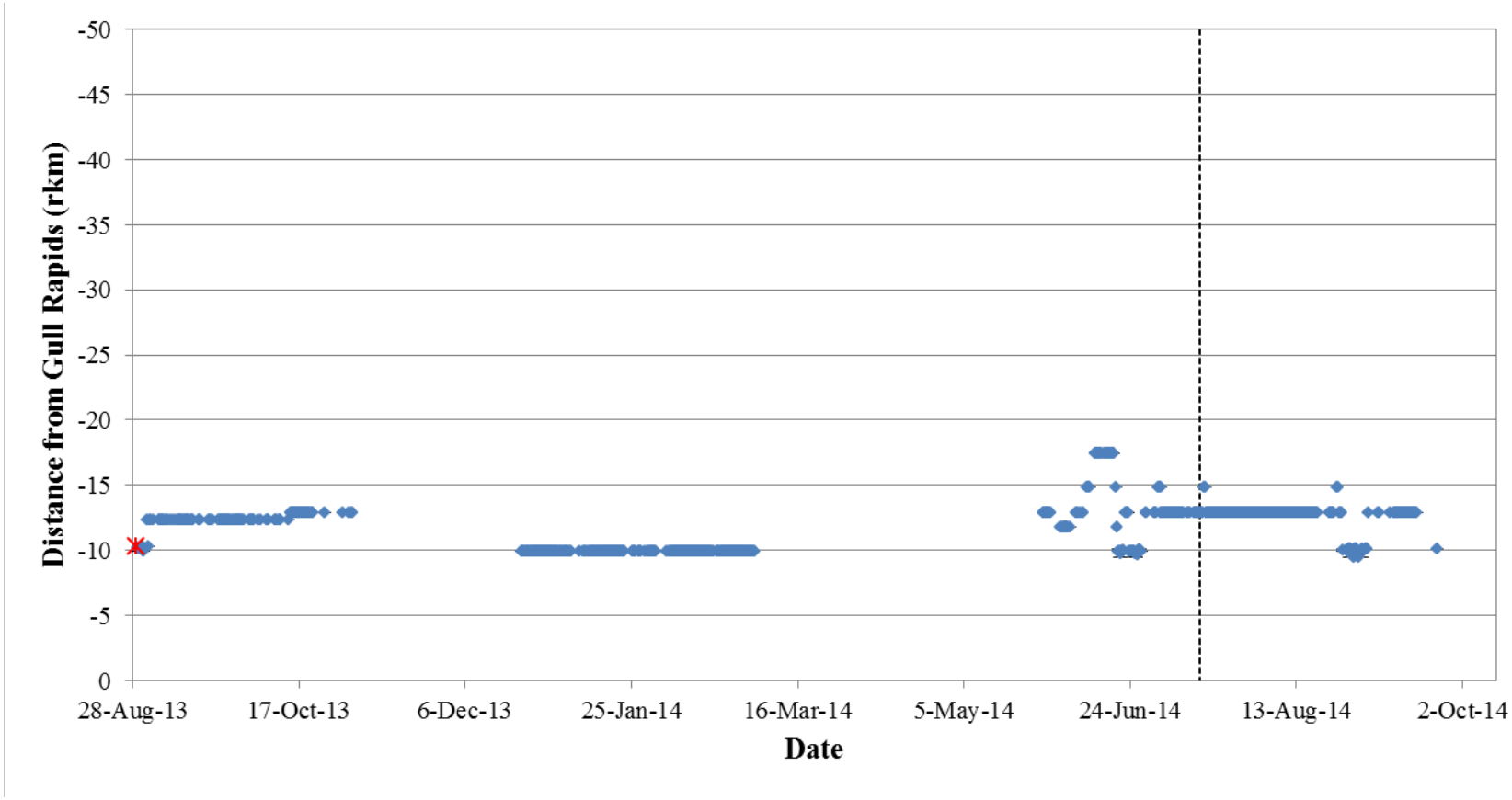


Figure A1- 7: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32681) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 12 October, 2014. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

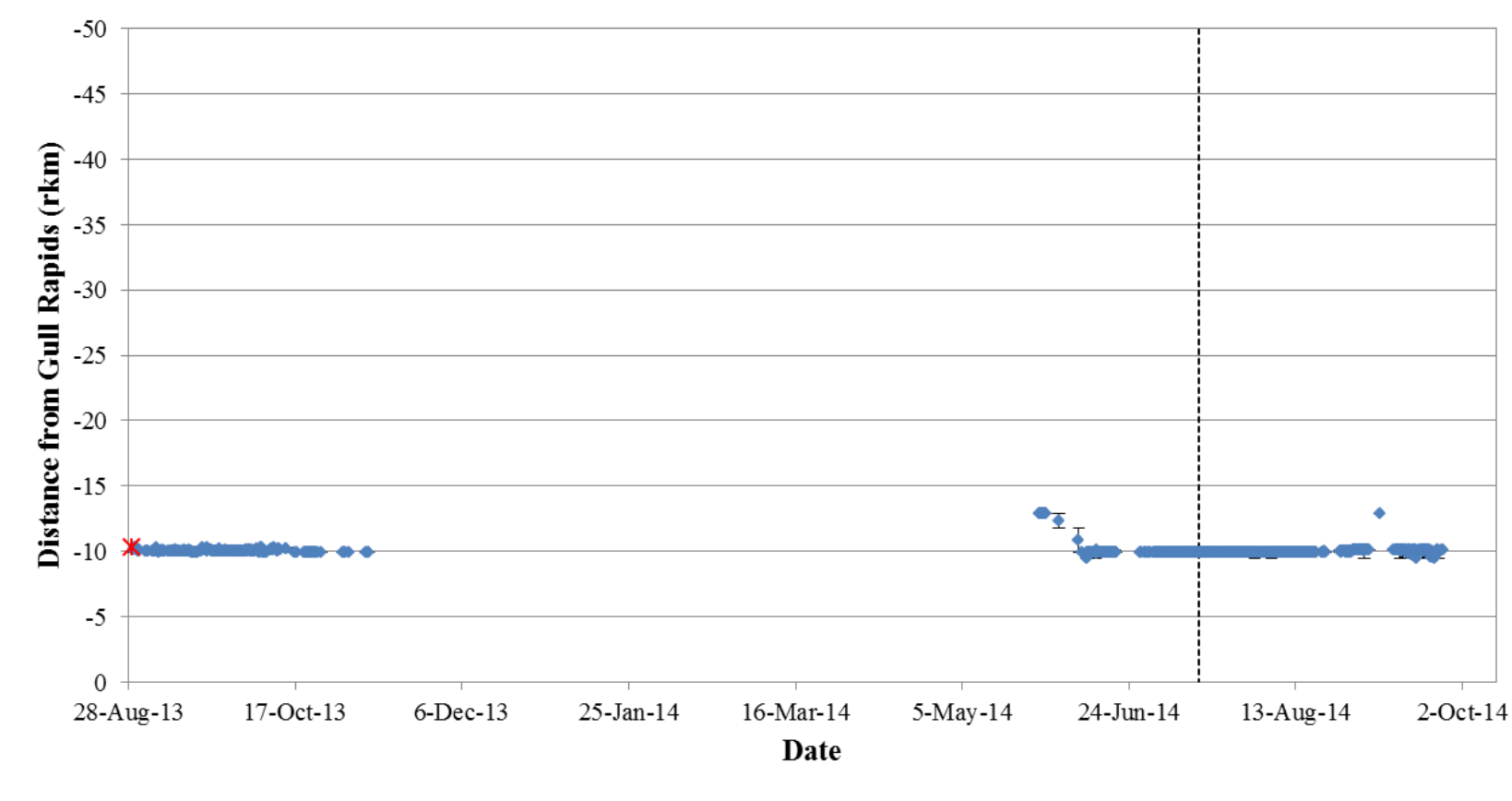


Figure A1- 8: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32682) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 12 October, 2014. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

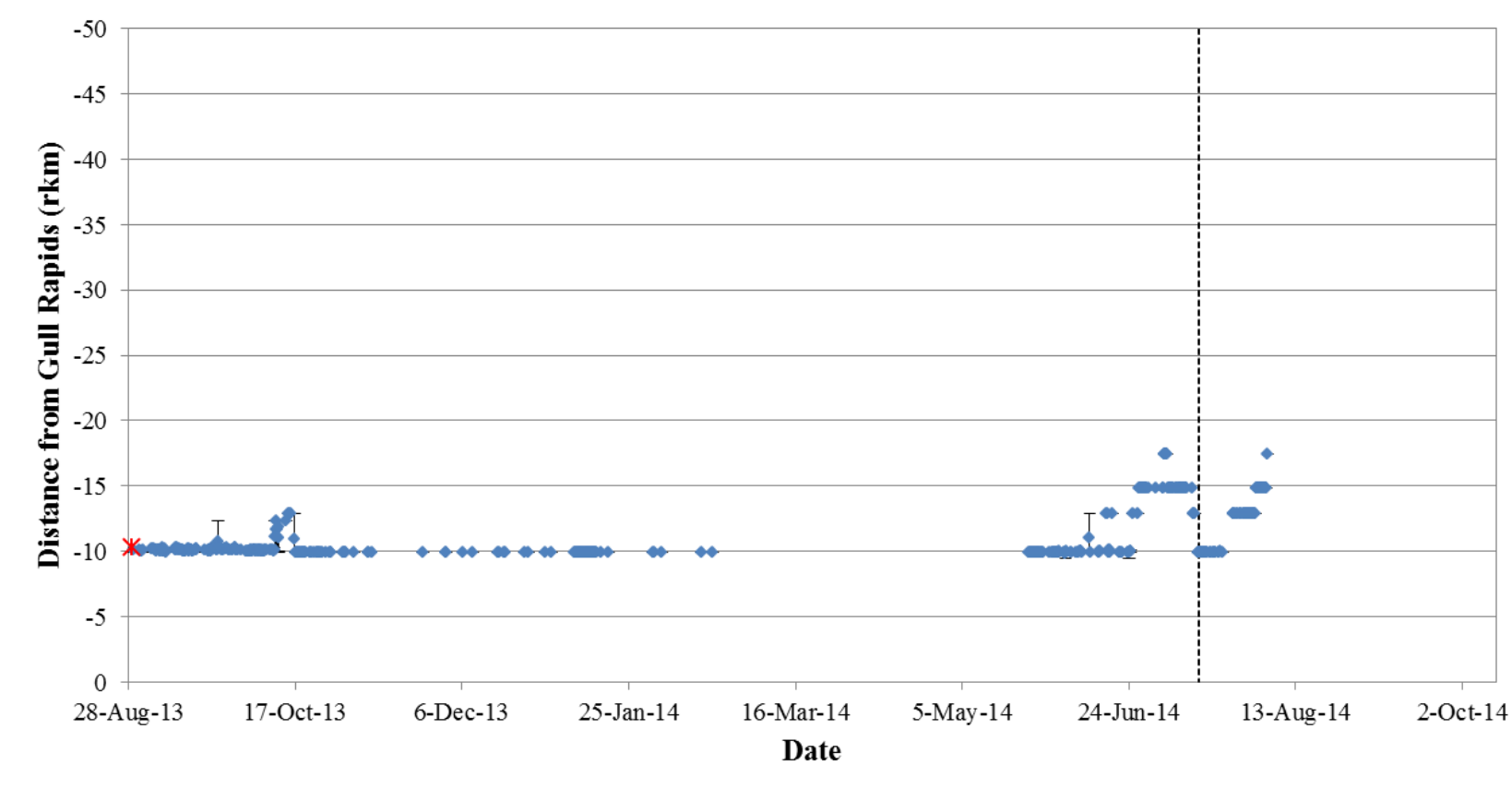


Figure A1- 9: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32683) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 12 October, 2014. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

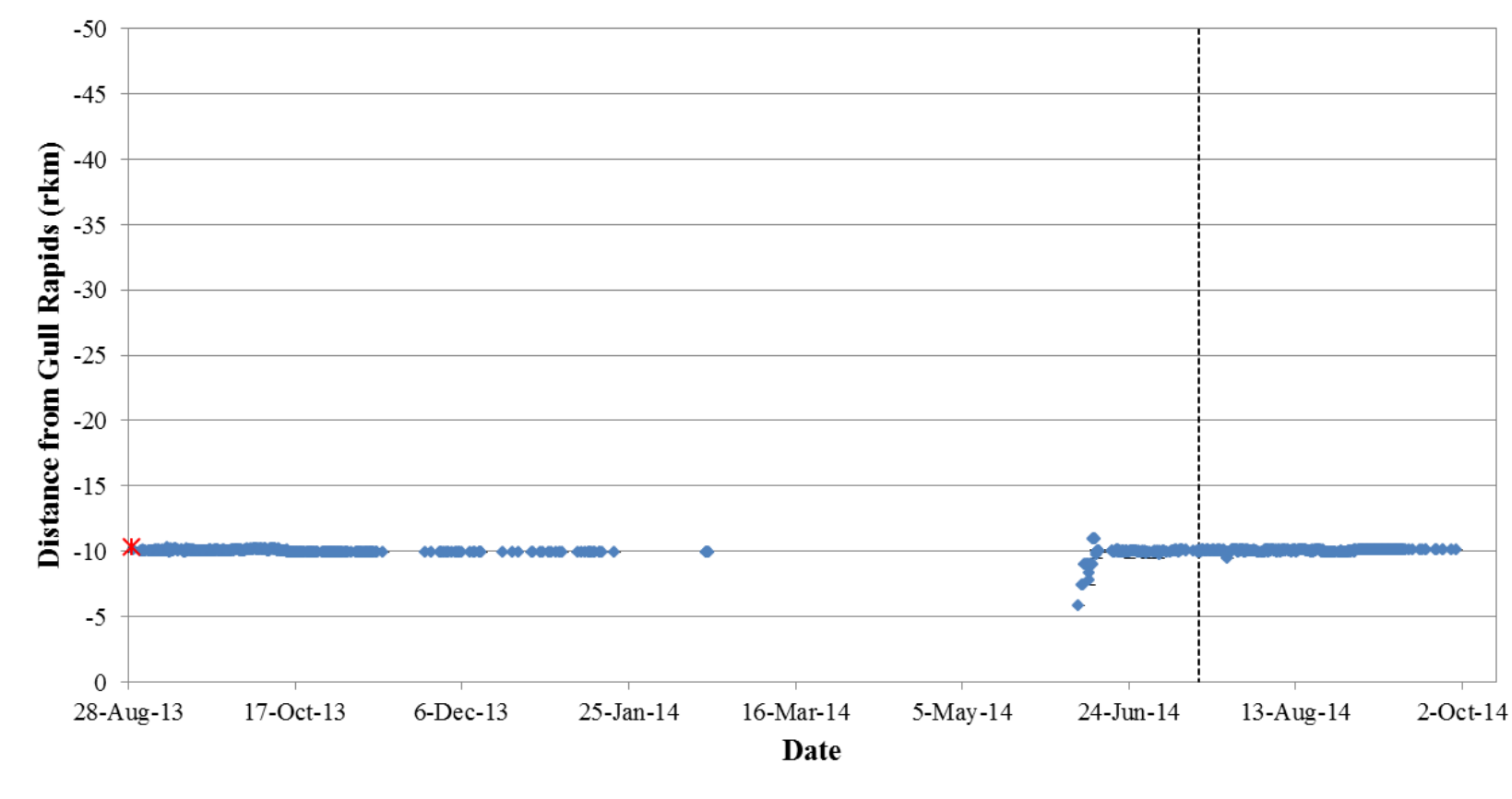


Figure A1- 10: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32684) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 12 October, 2014. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

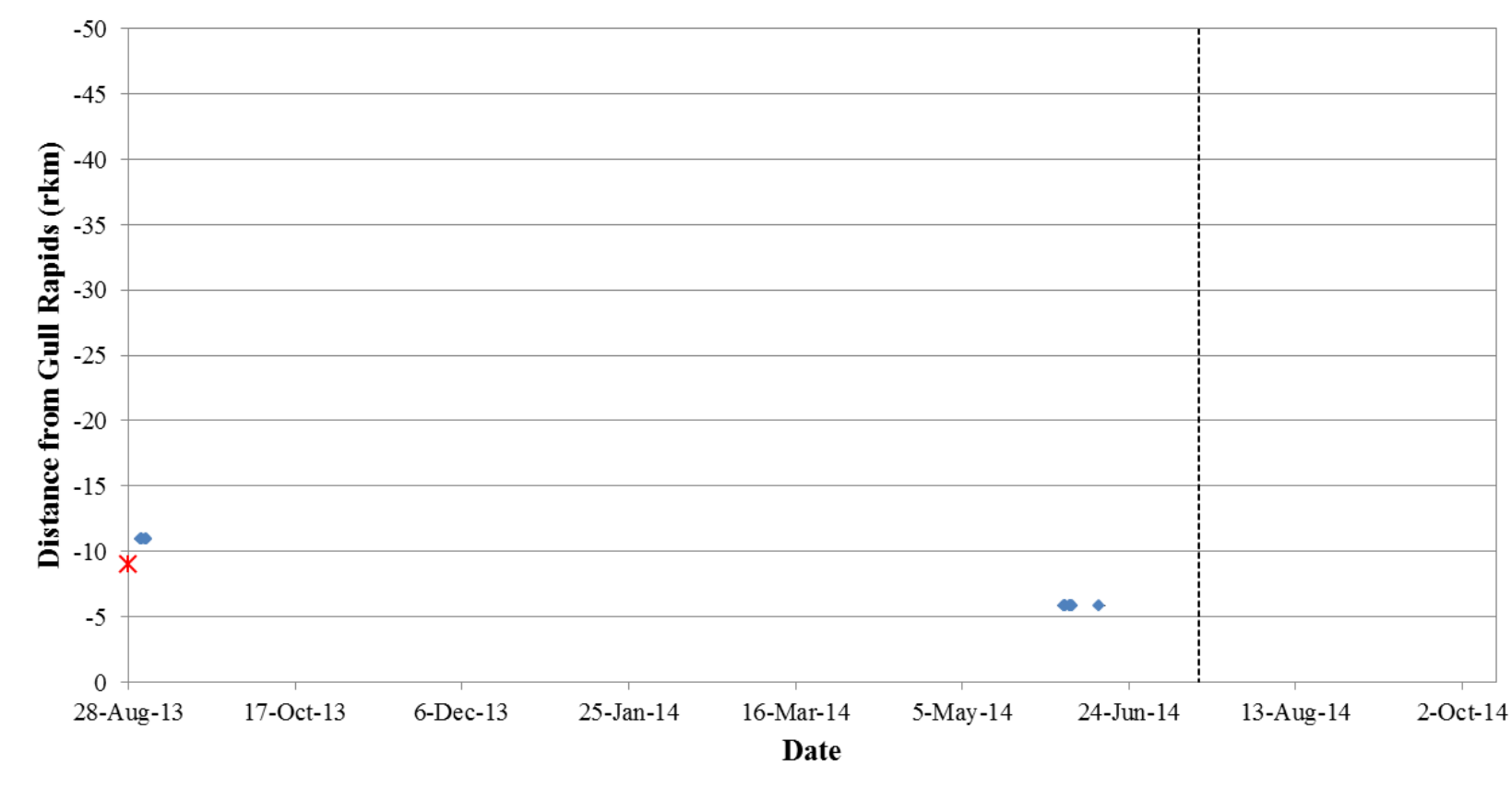


Figure A1- 11: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32686) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 12 October, 2014. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

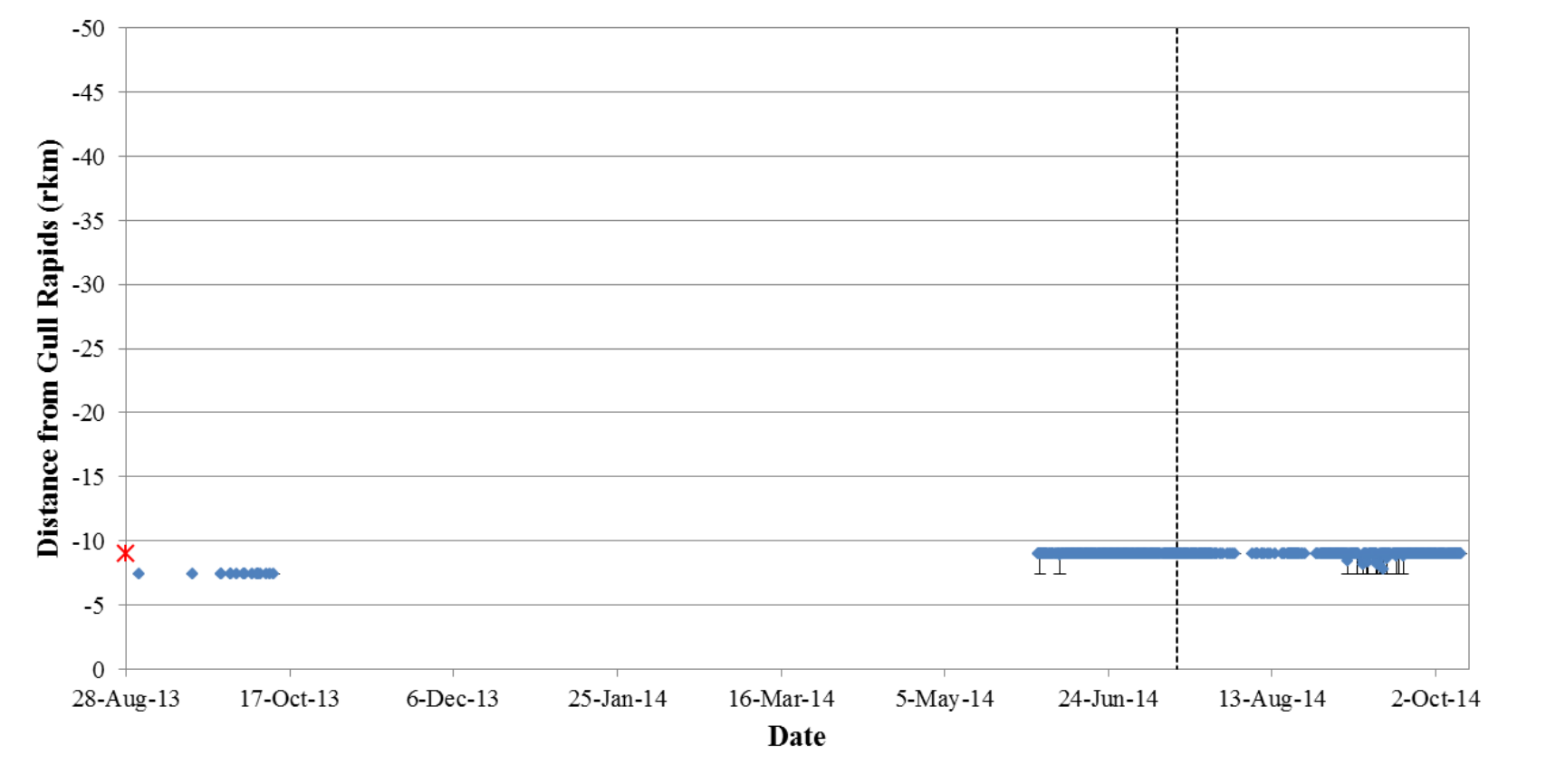


Figure A1- 12: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32687) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 12 October, 2014. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

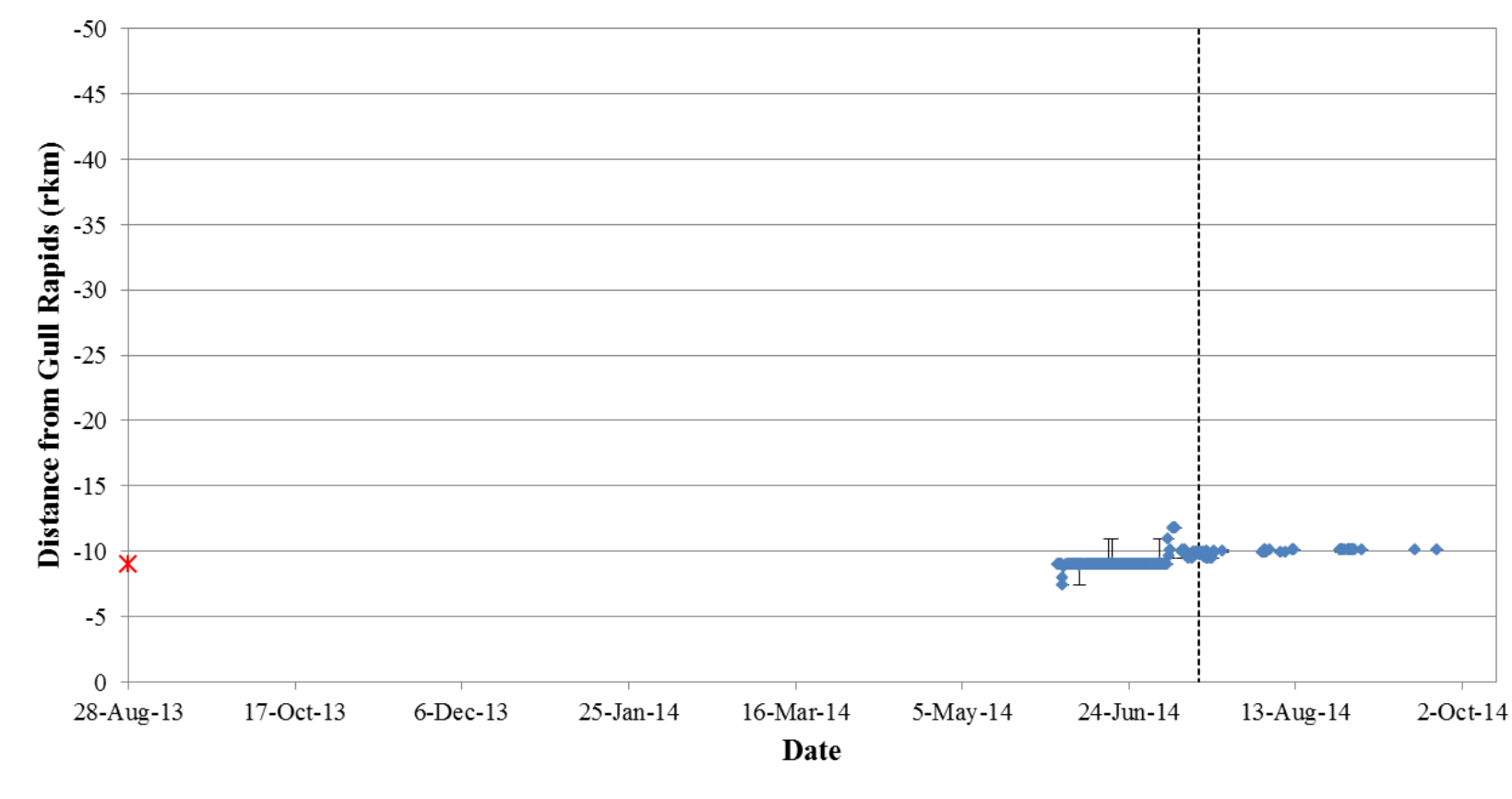


Figure A1- 13: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32688) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 12 October, 2014. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

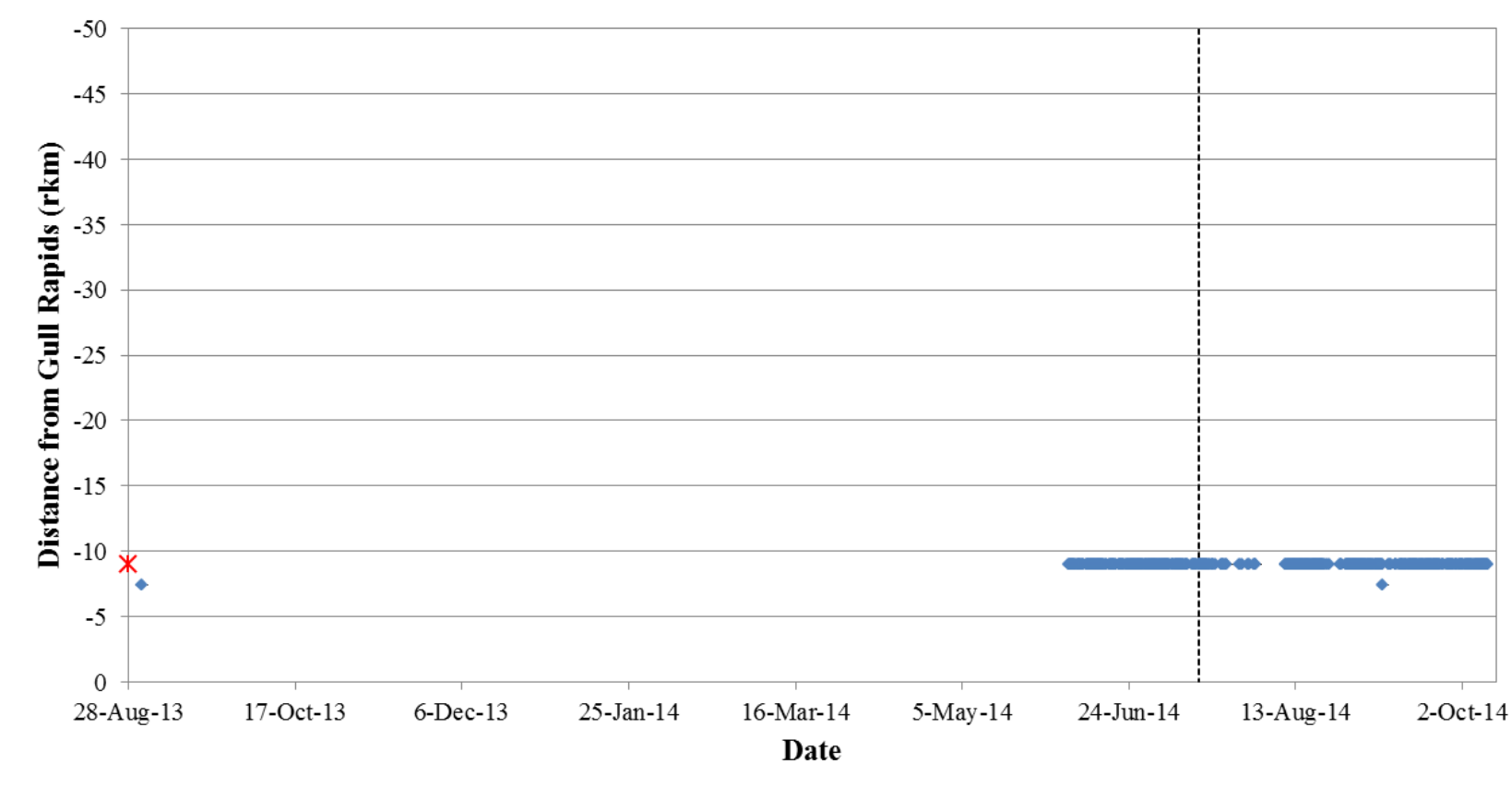


Figure A1- 14: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32689) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 12 October, 2014. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

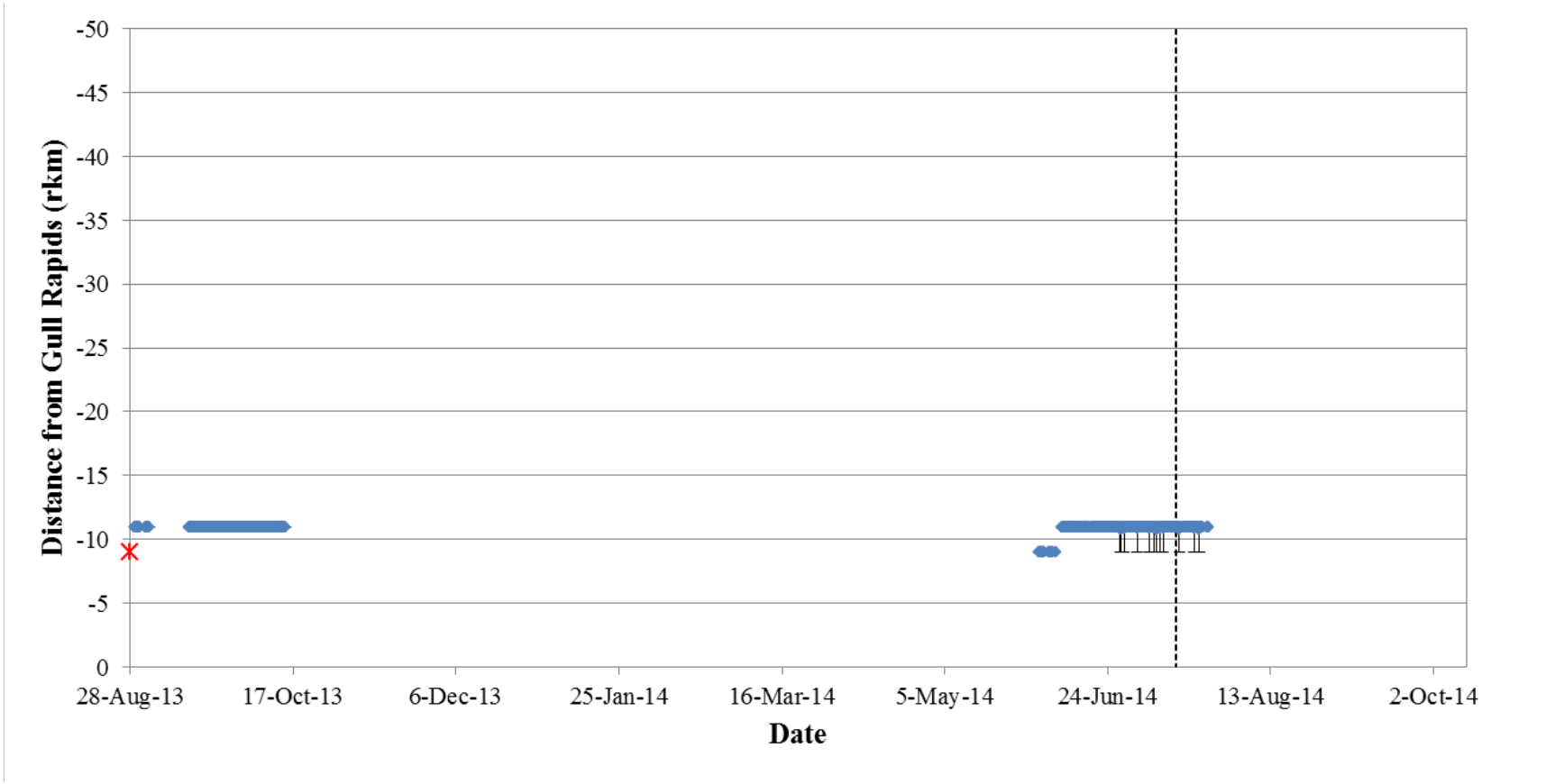


Figure A1- 15: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32690) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 12 October, 2014. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

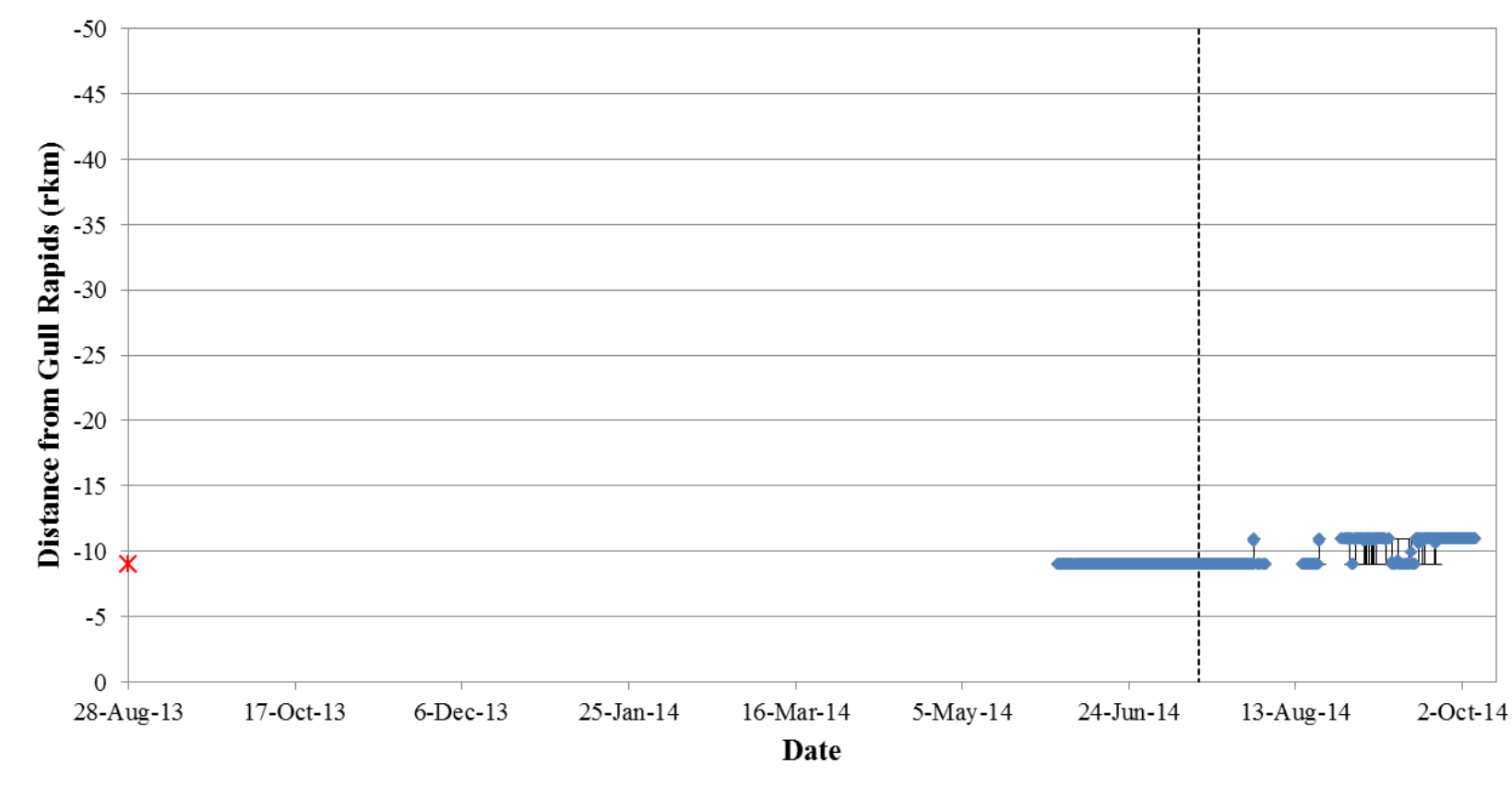


Figure A1- 16: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32691) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 12 October, 2014. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

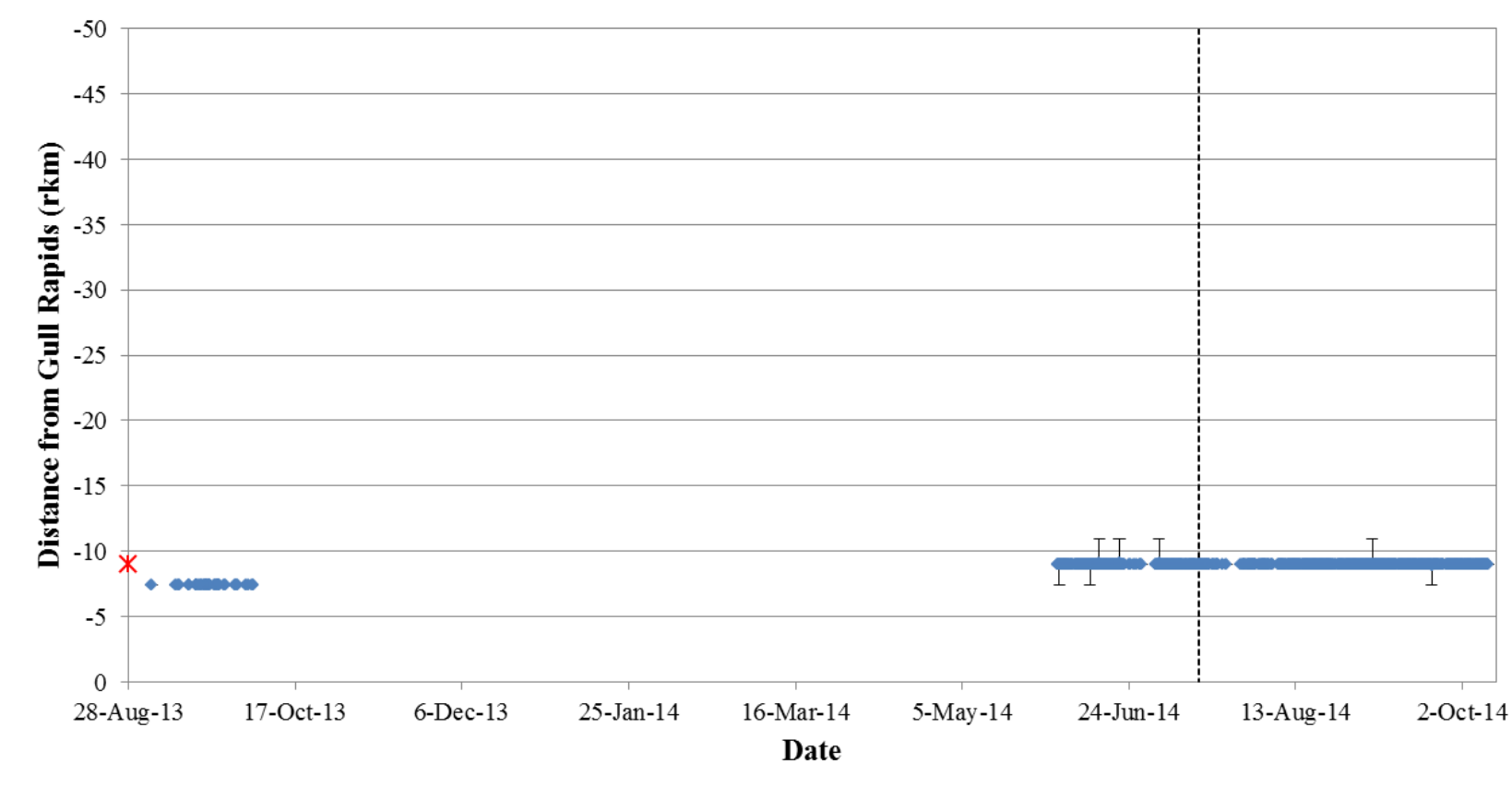


Figure A1- 17: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32692) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 12 October, 2014. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

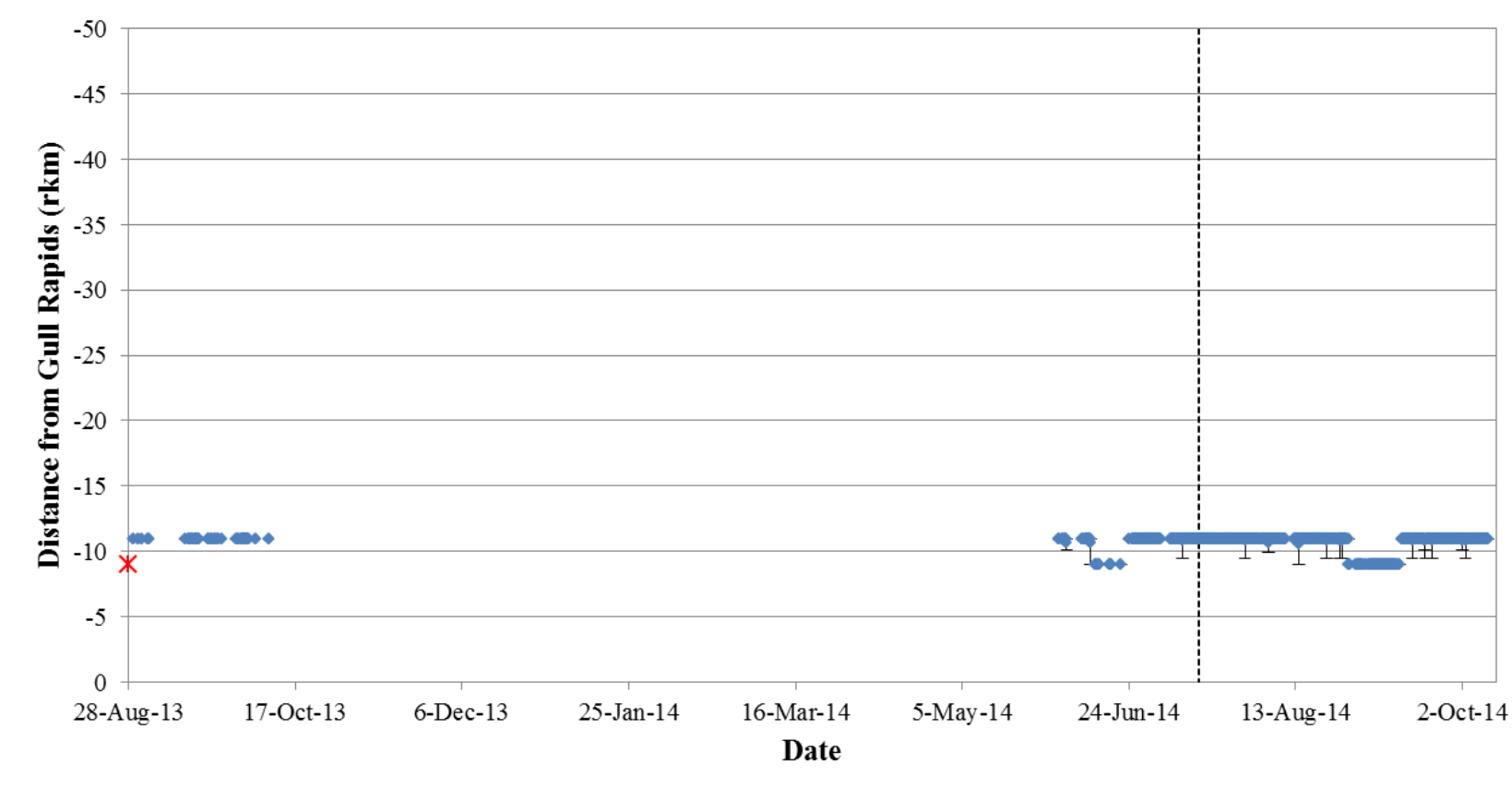


Figure A1- 17: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32693) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 12 October, 2014. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

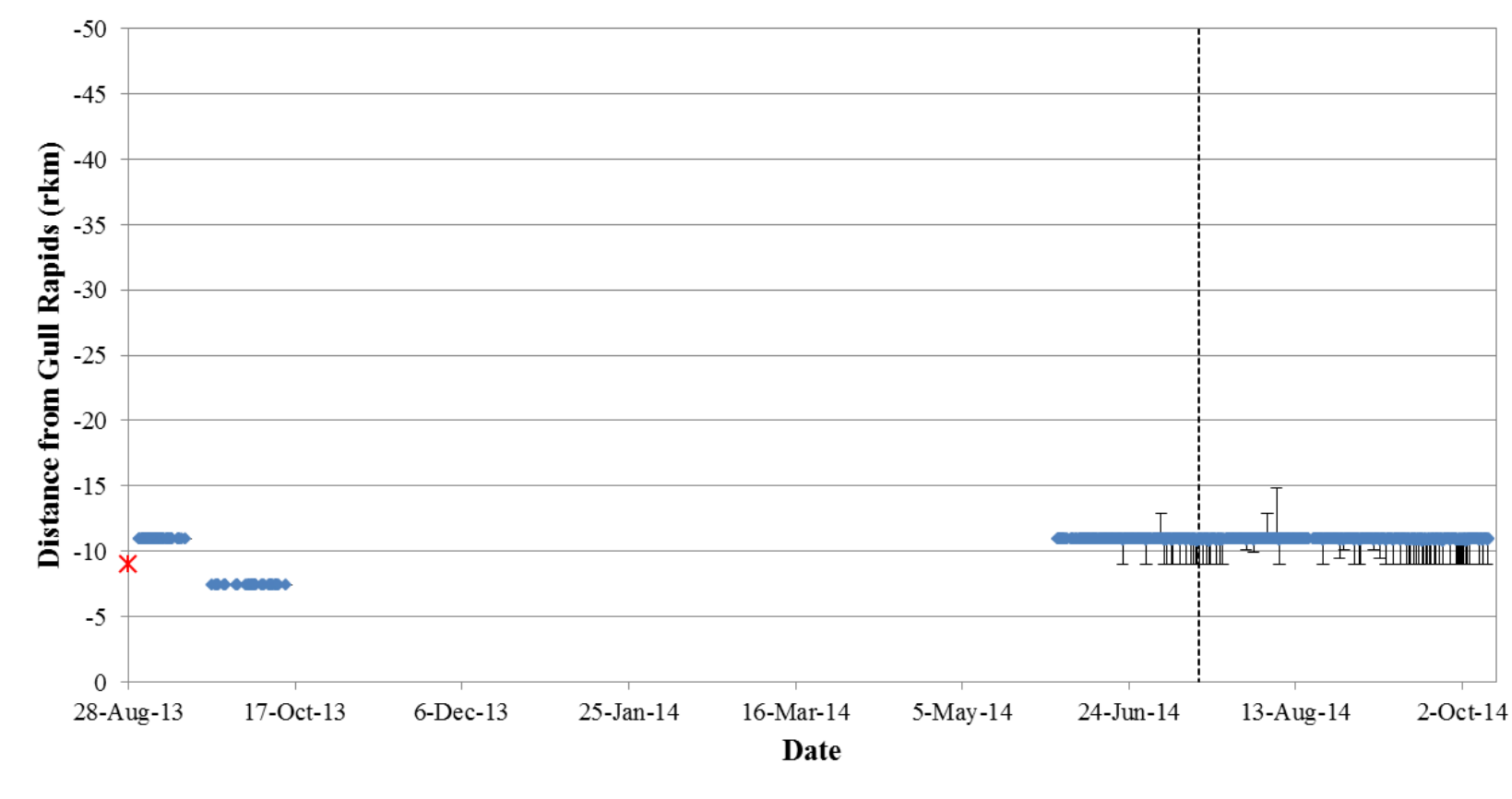


Figure A1- 18: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32694) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 12 October, 2014. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

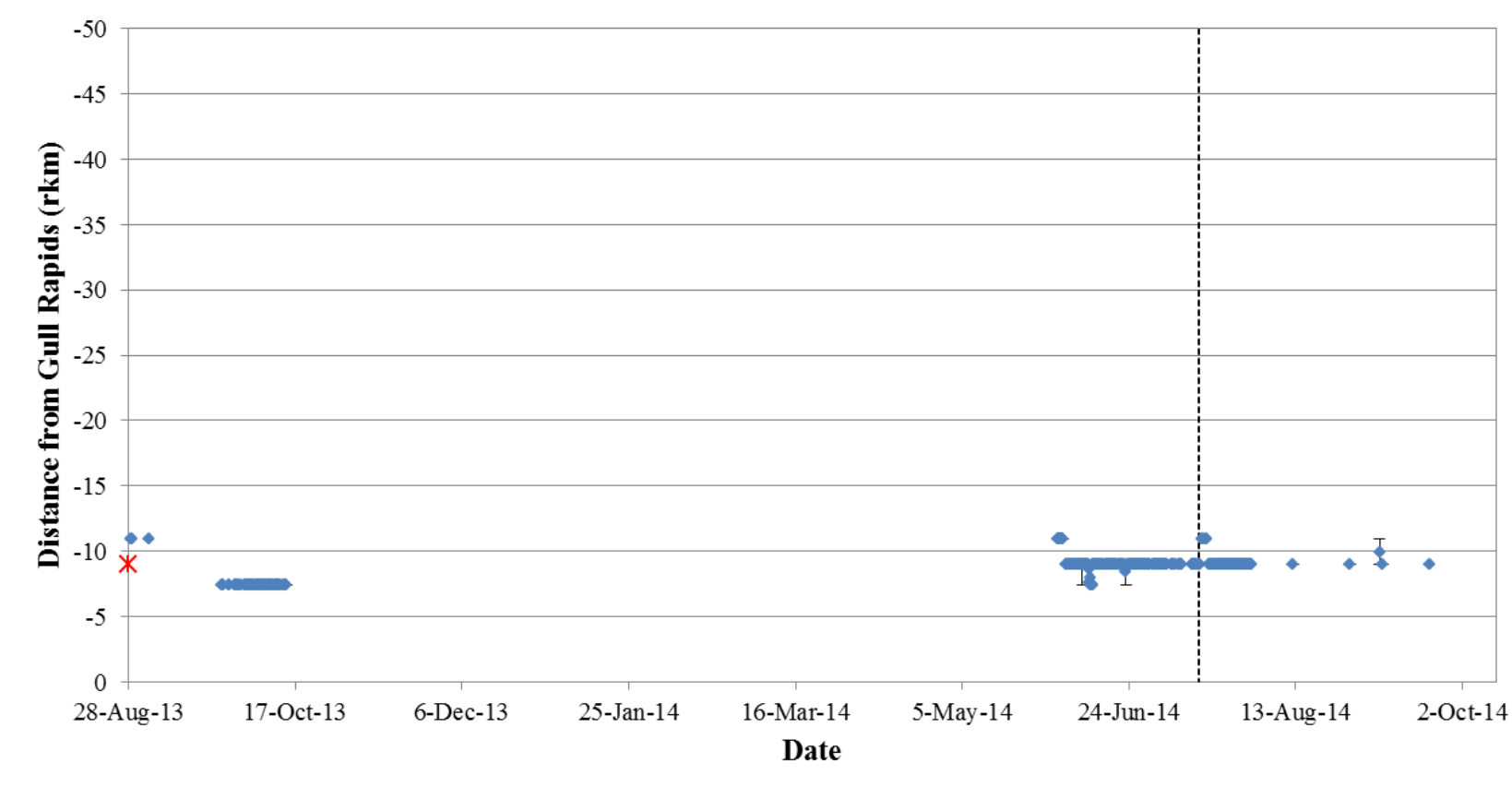


Figure A1- 20: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32695) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 12 October, 2014. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

APPENDIX 2:
LOCATION SUMMARY FOR INDIVIDUAL ACOUSTIC TAGGED JUVENILE LAKE STURGEON DOWNSTREAM OF GULL RAPIDS, SEPTEMBER 2013 TO OCTOBER 2014

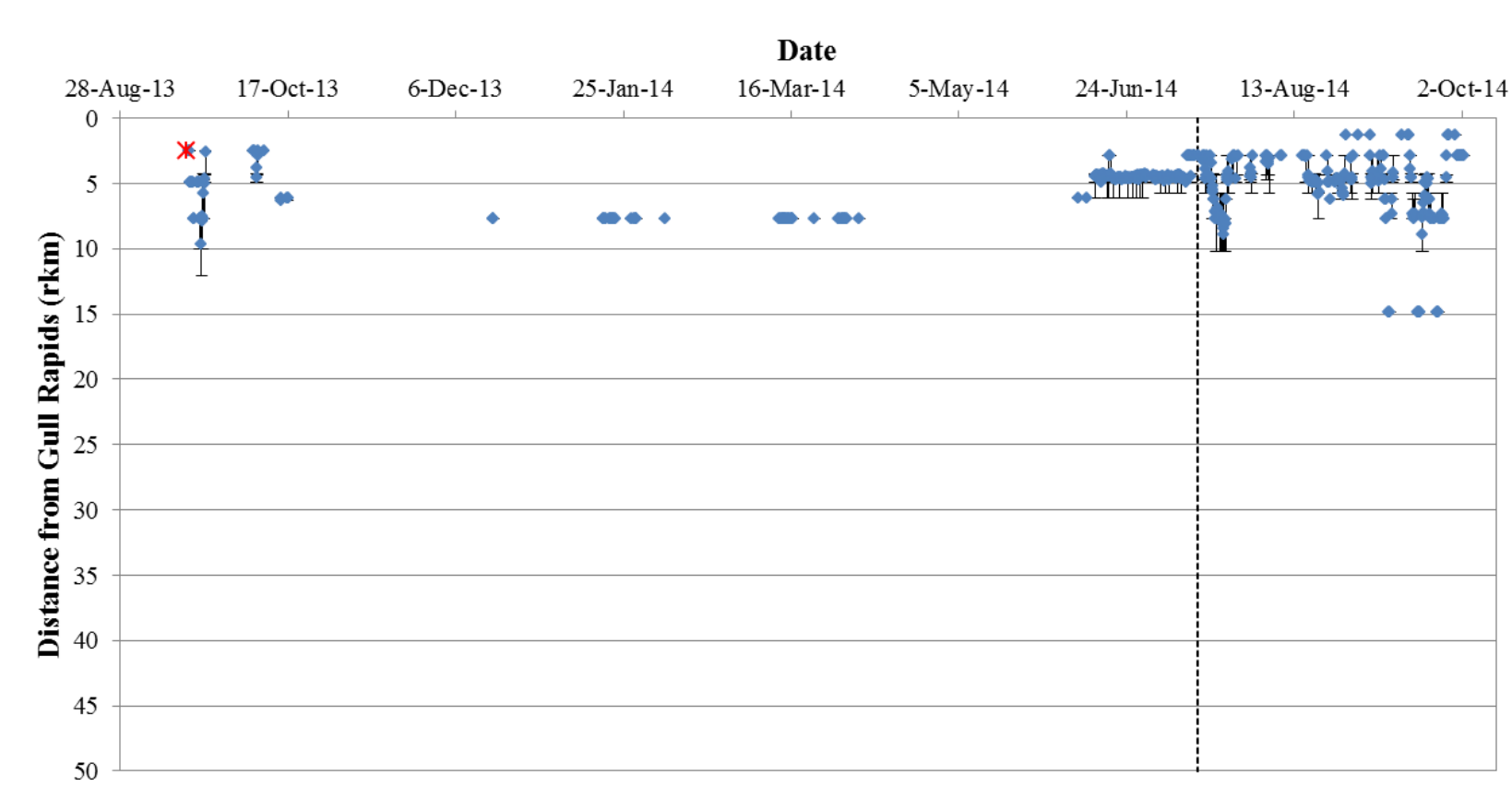


Figure A2- 1: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32661) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 12 October, 2014. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

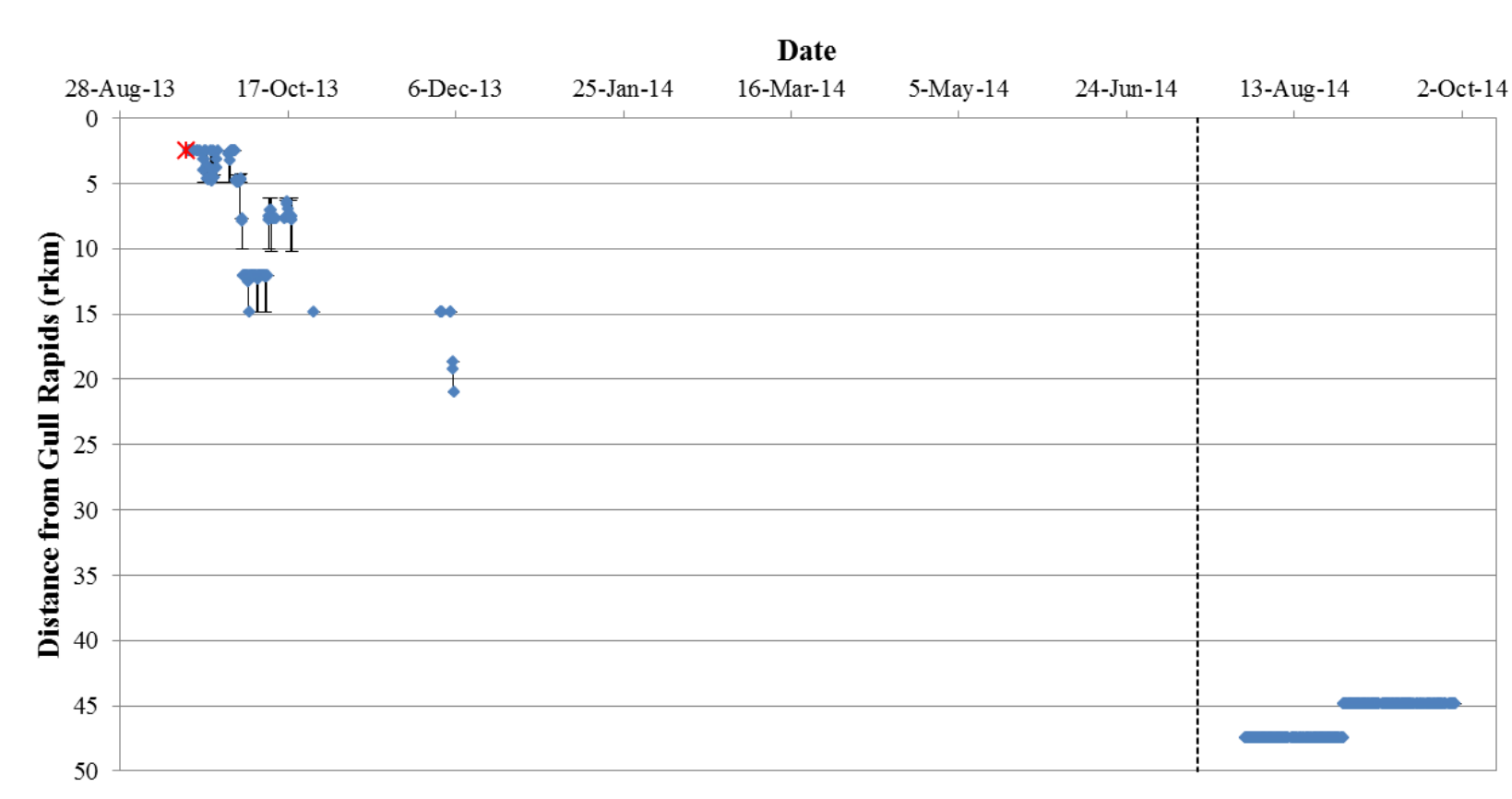


Figure A2- 2: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32662) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 12 October, 2014. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

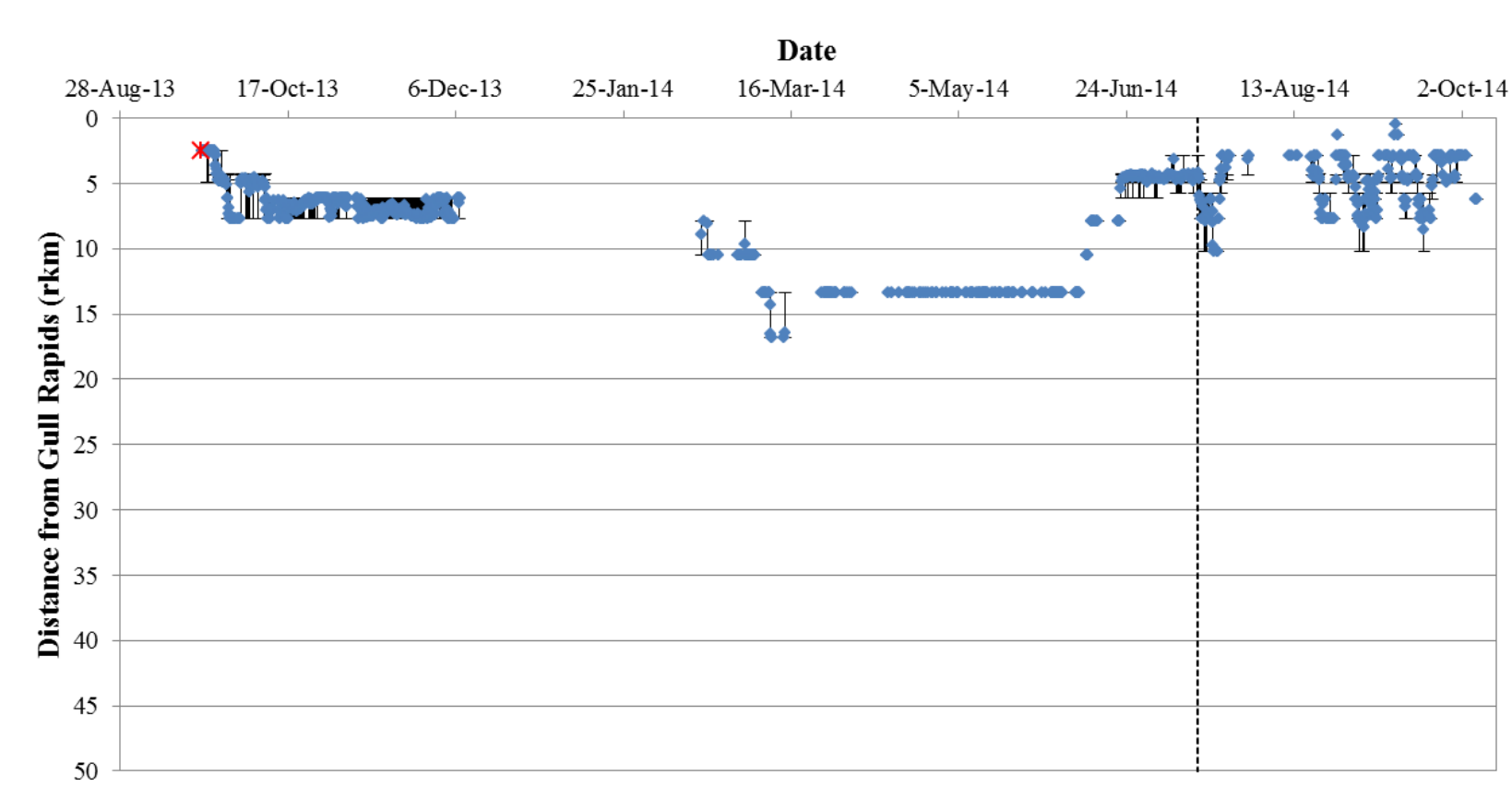


Figure A2- 3: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32663) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 12 October, 2014. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

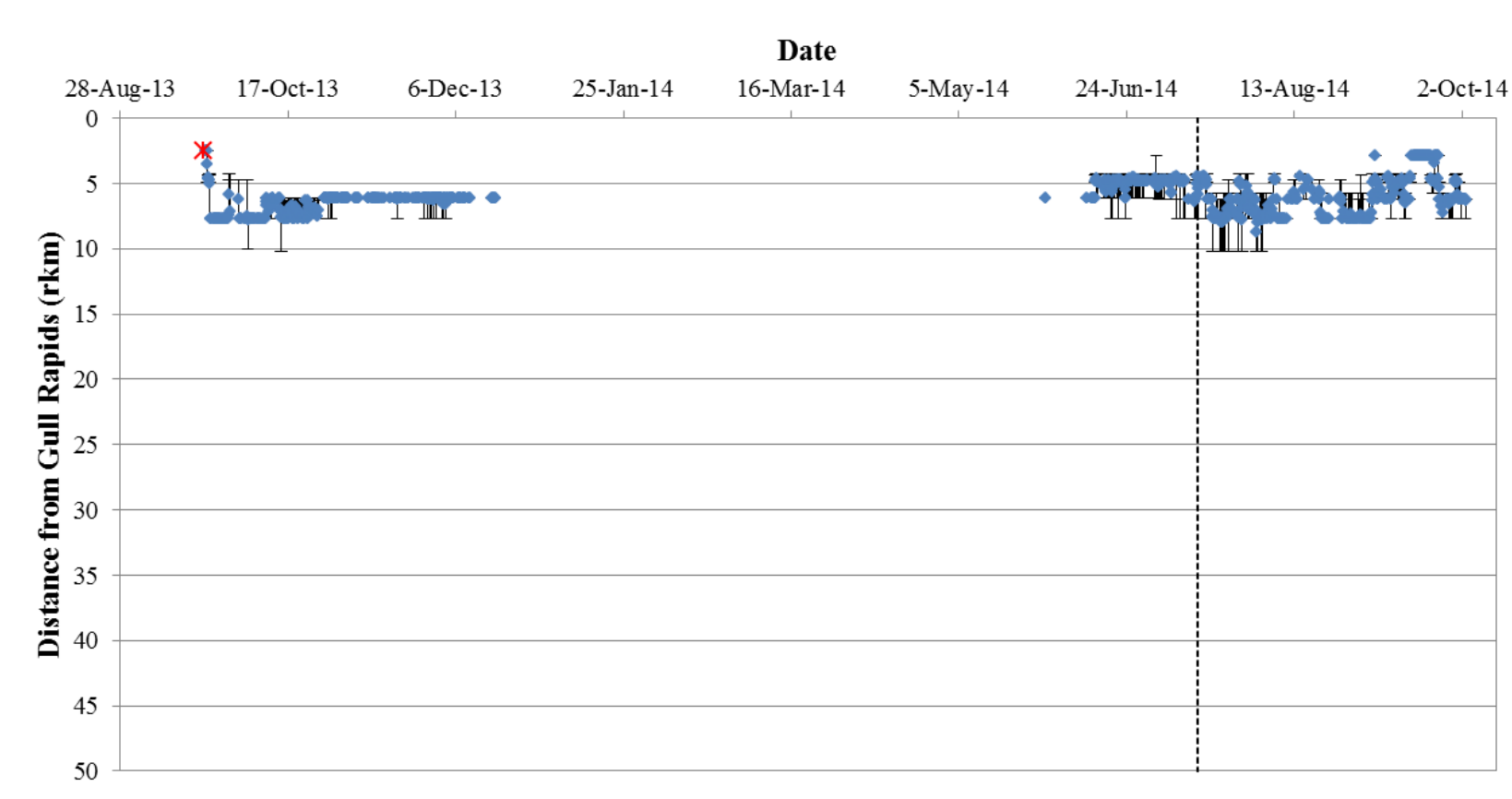


Figure A2- 4: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32664) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 12 October, 2014. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

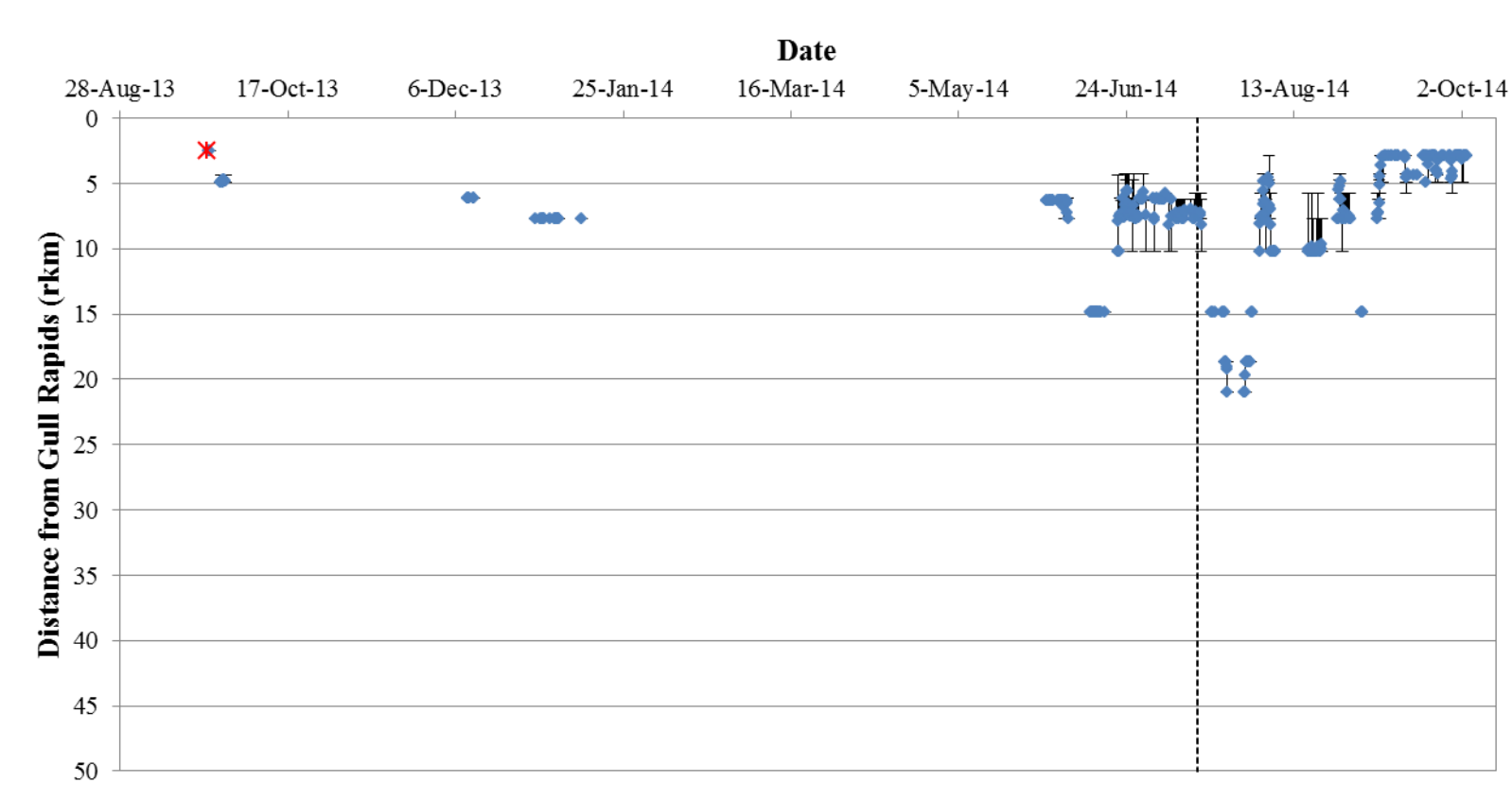


Figure A2- 5: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32665) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 12 October, 2014. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

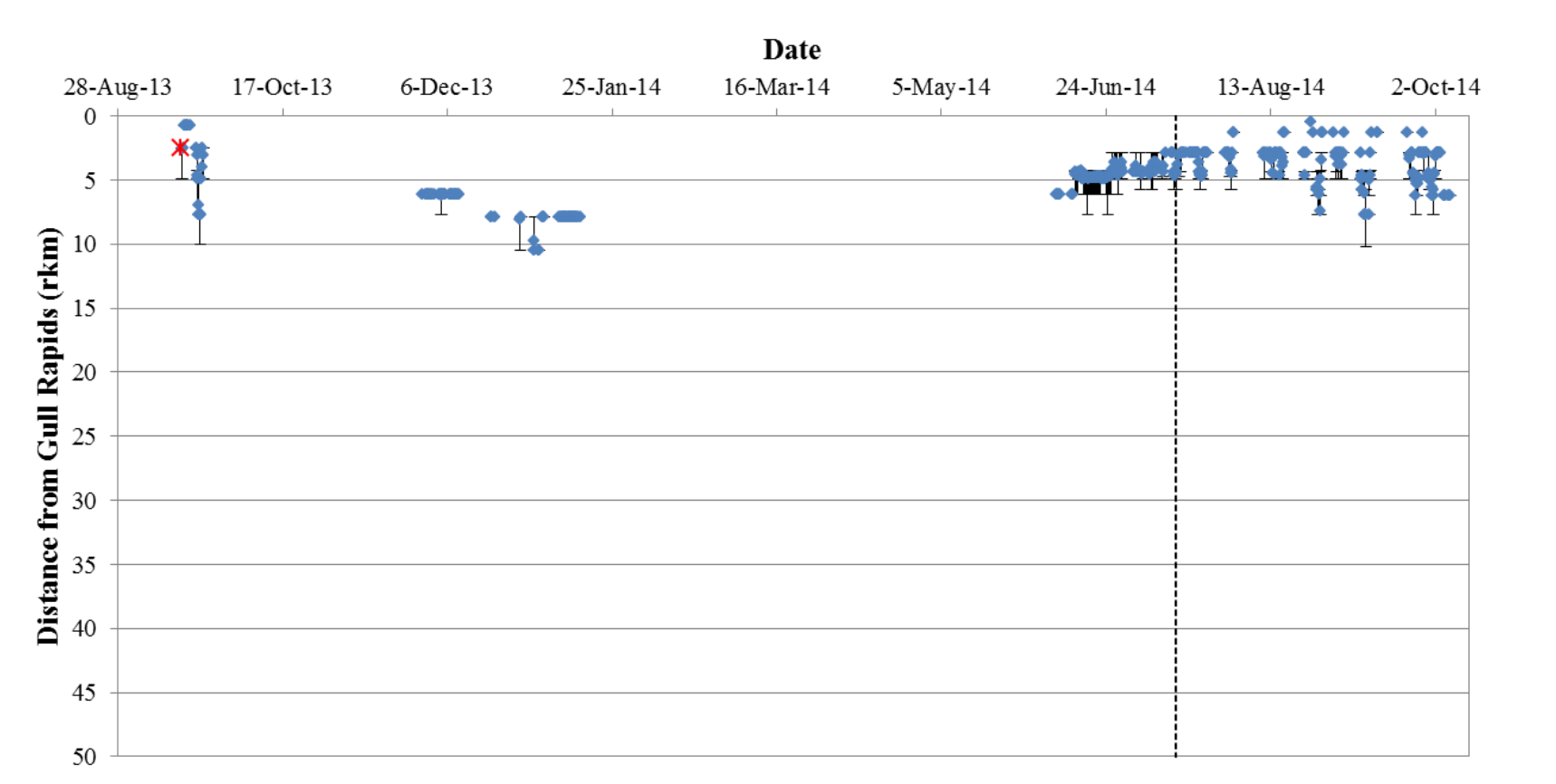


Figure A2- 6: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32666) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 12 October, 2014. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

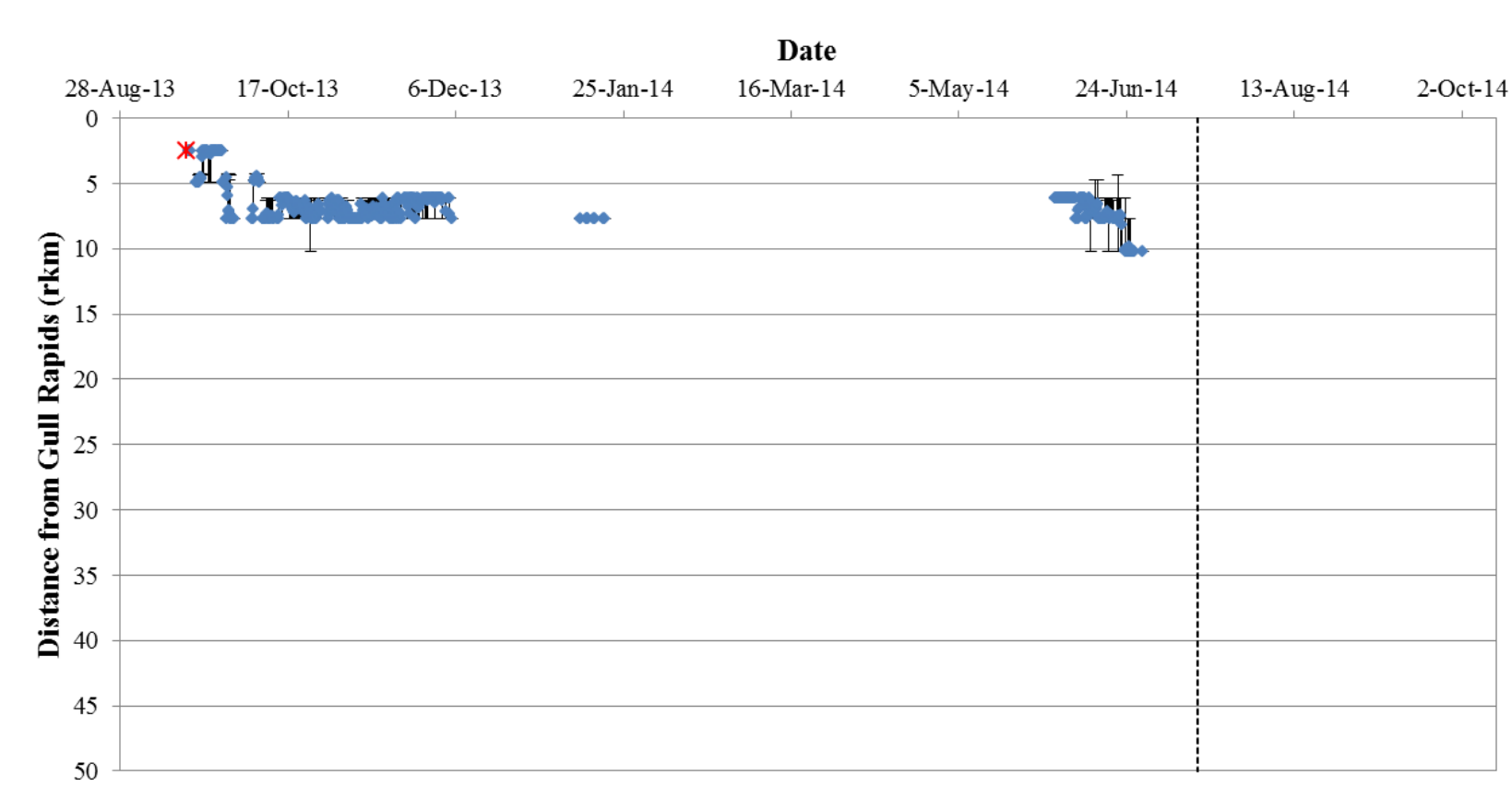


Figure A2- 7: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32667) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 12 October, 2014. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

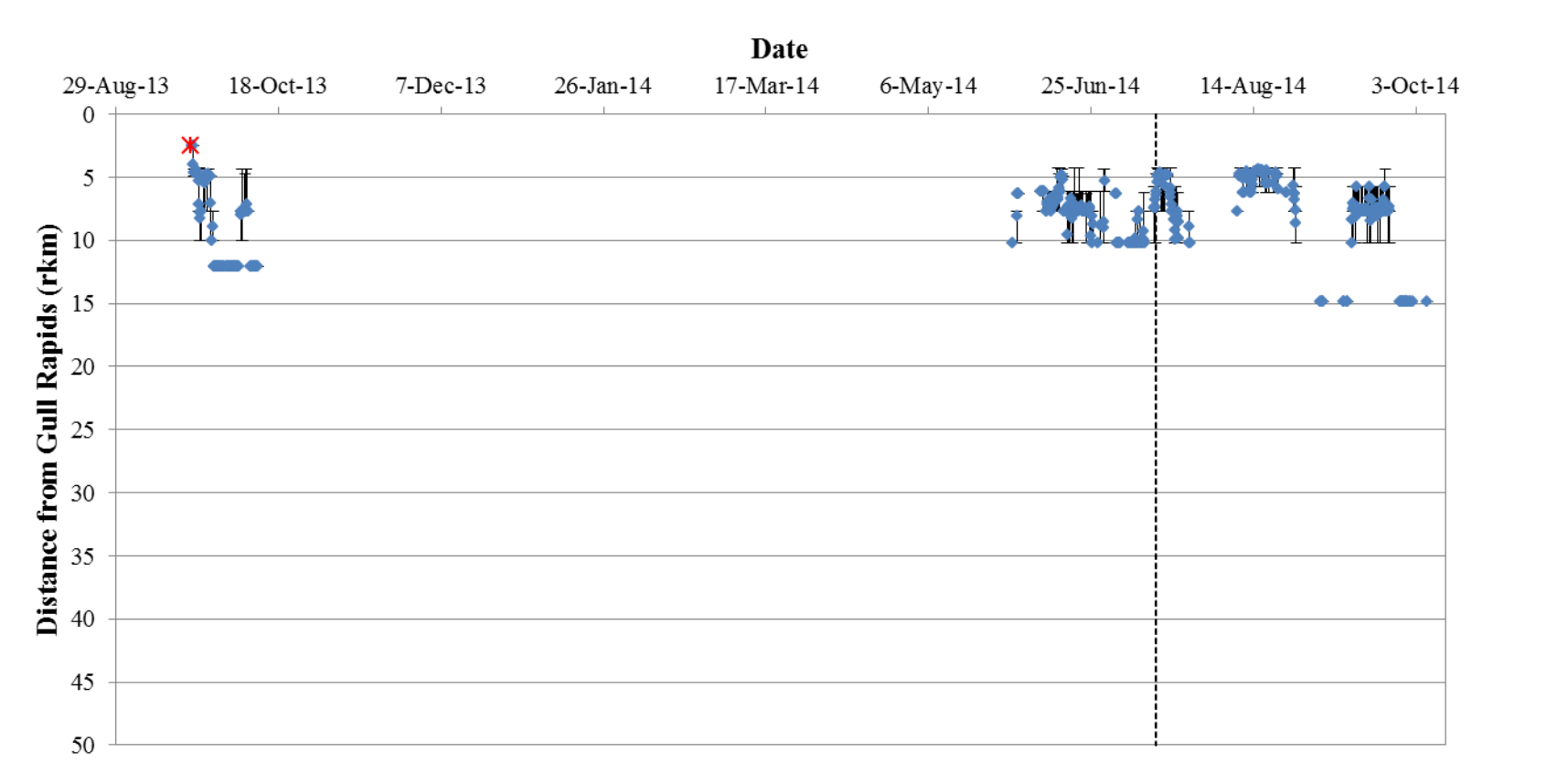


Figure A2- 8: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32668) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 12 October, 2014. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

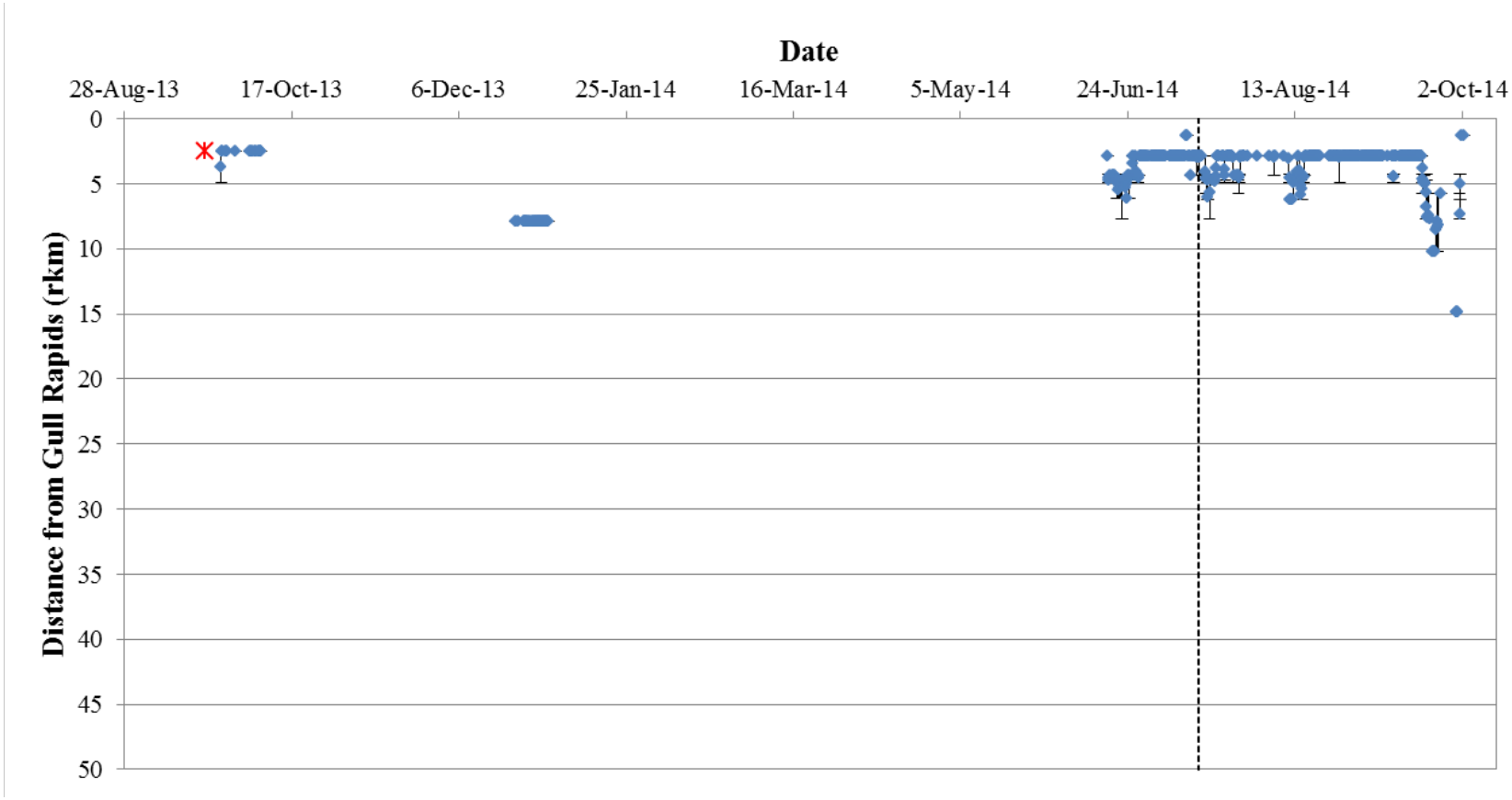


Figure A2- 9: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32669) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 12 October, 2014. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

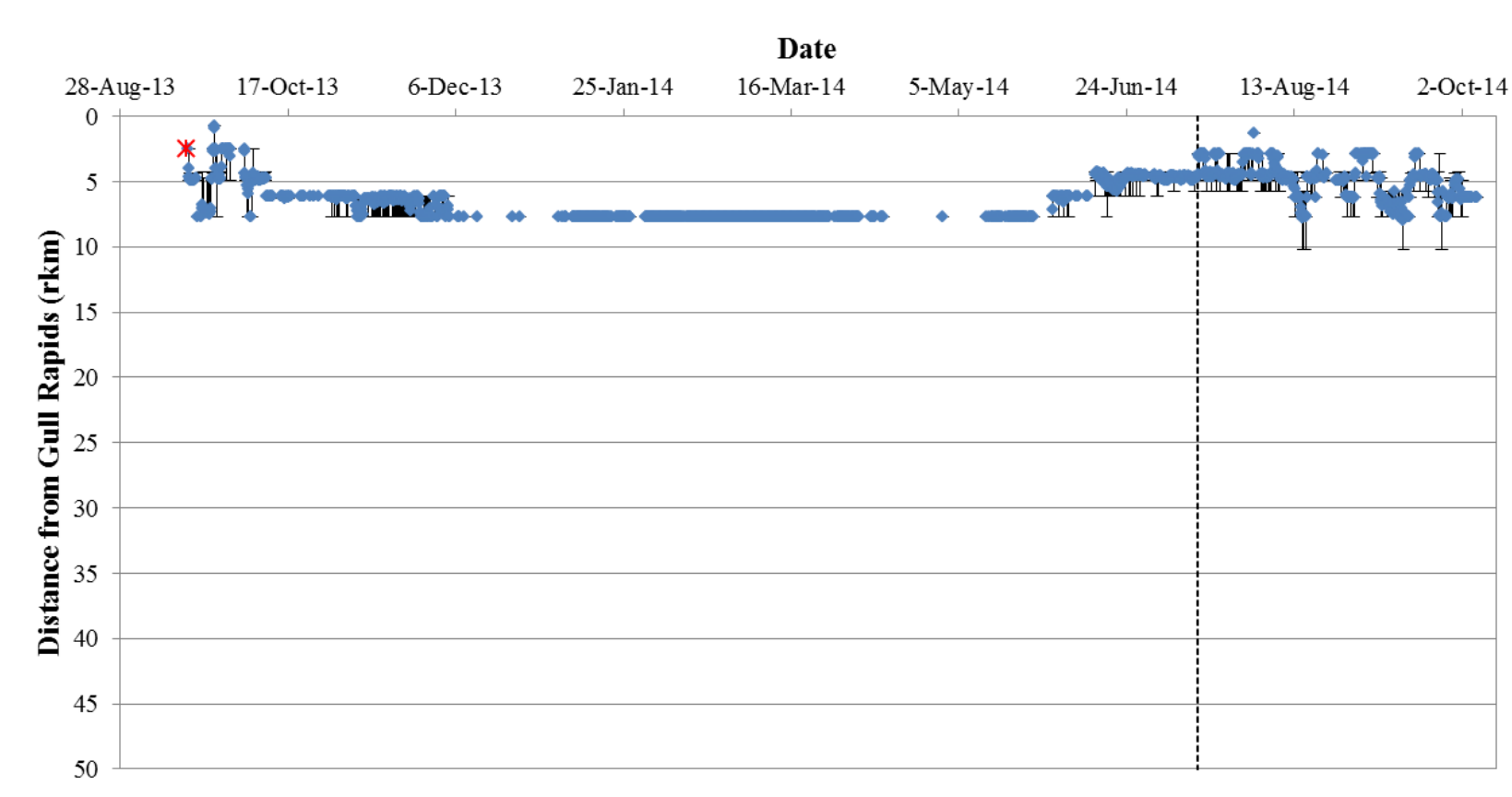


Figure A2- 10: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32670) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 12 October, 2014. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

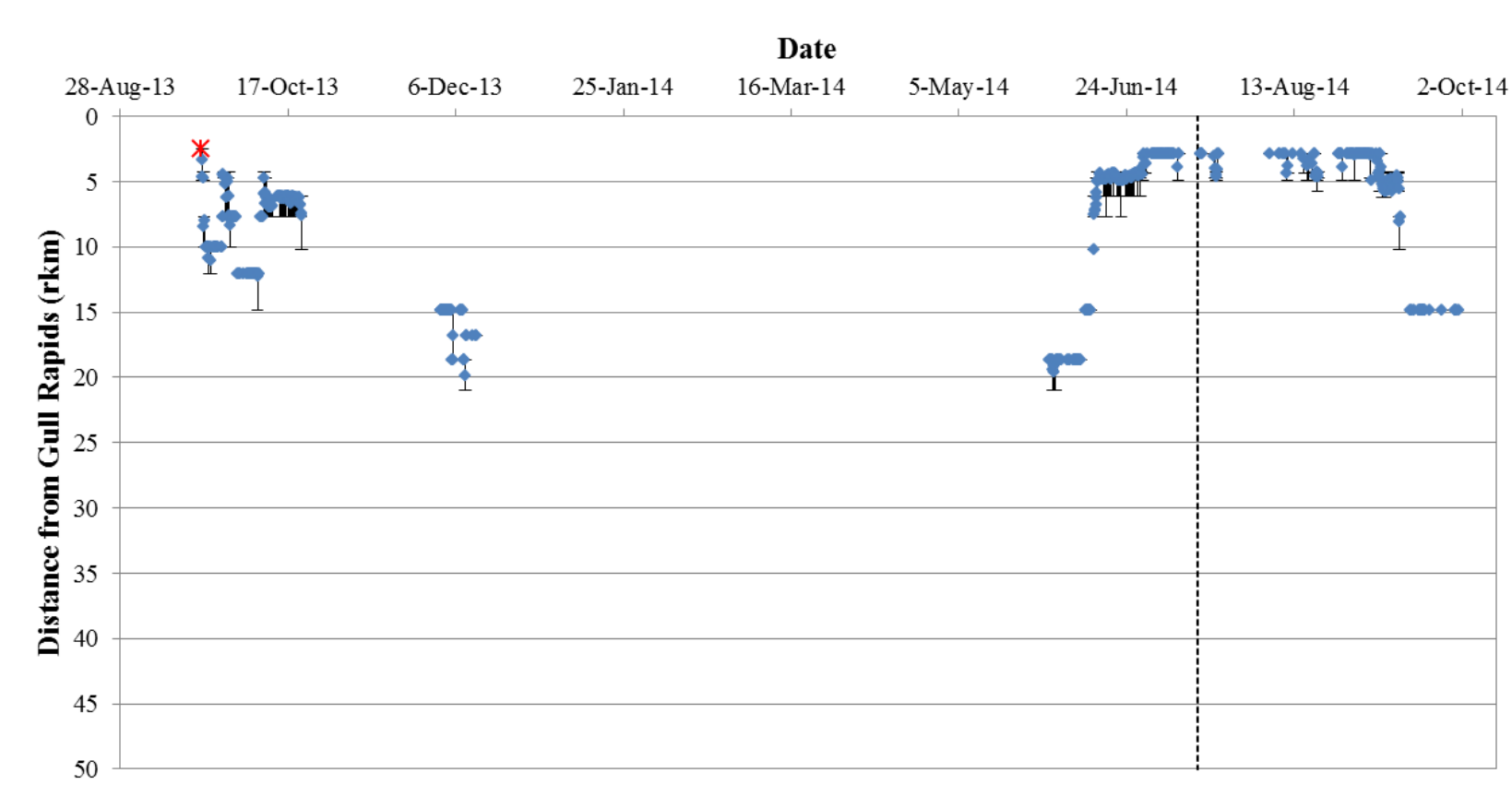


Figure A2- 11: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32673) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 12 October, 2014. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

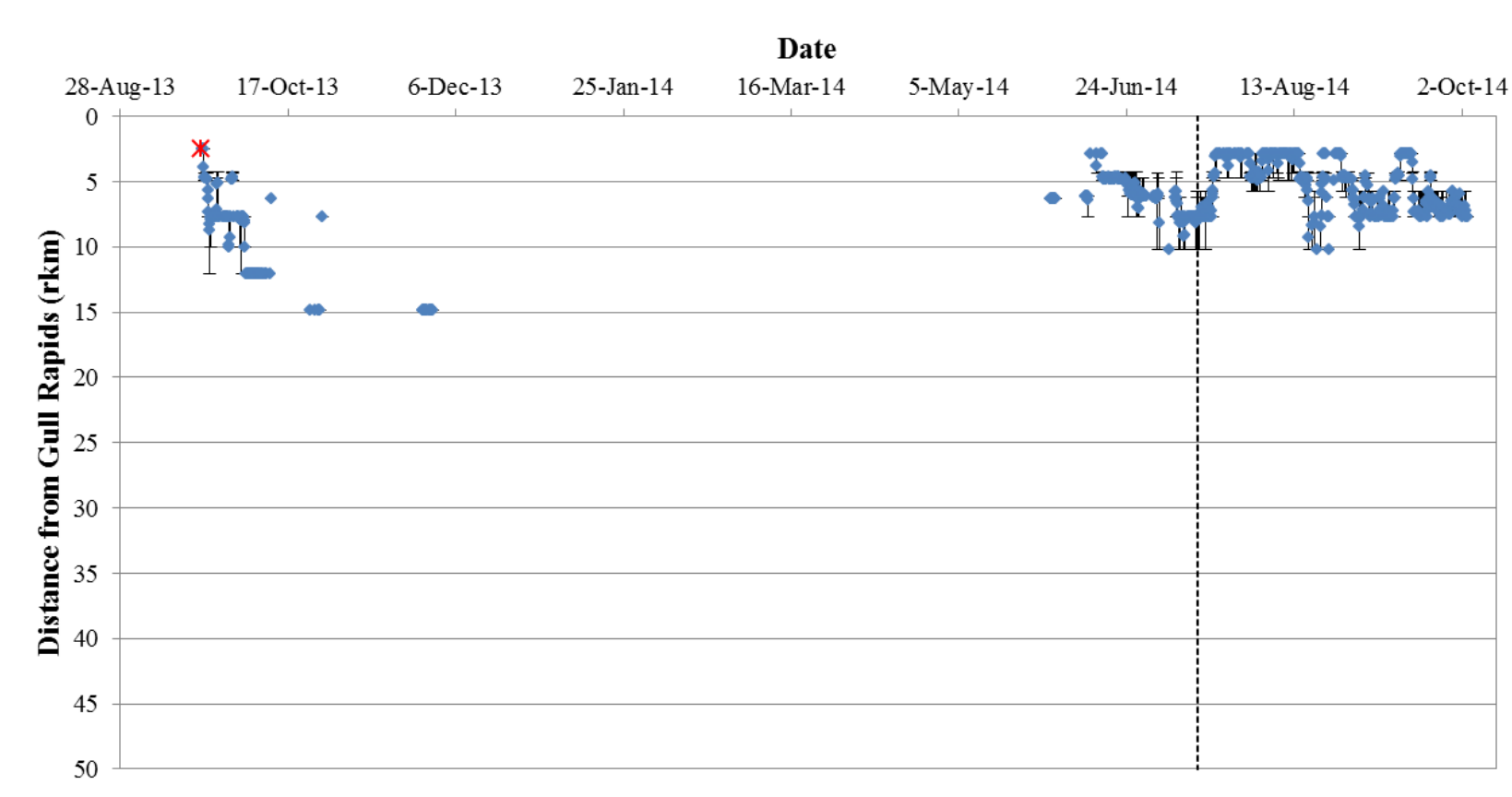


Figure A2- 12: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32674) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 12 October, 2014. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

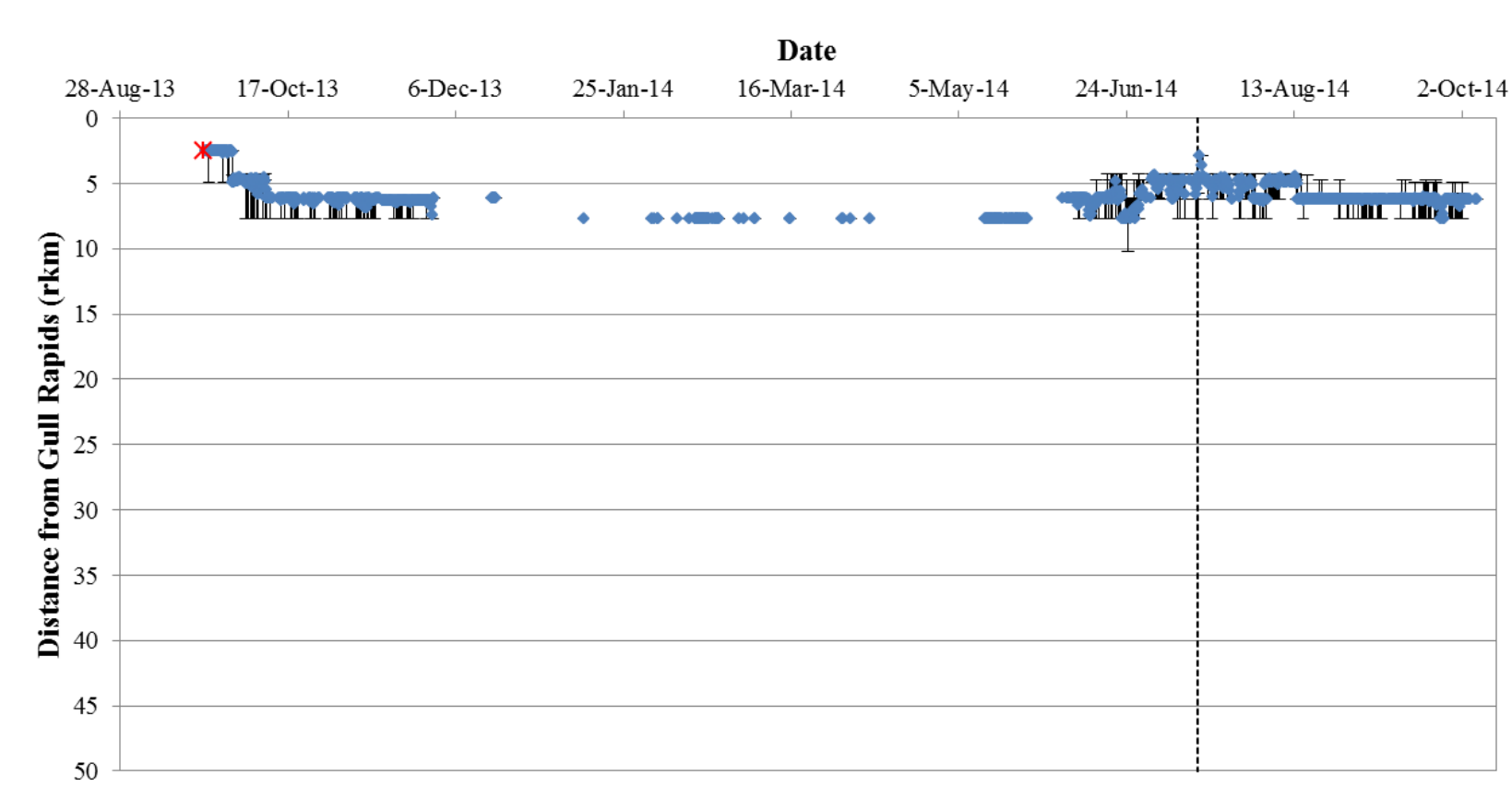


Figure A2- 13: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32675) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 12 October, 2014. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

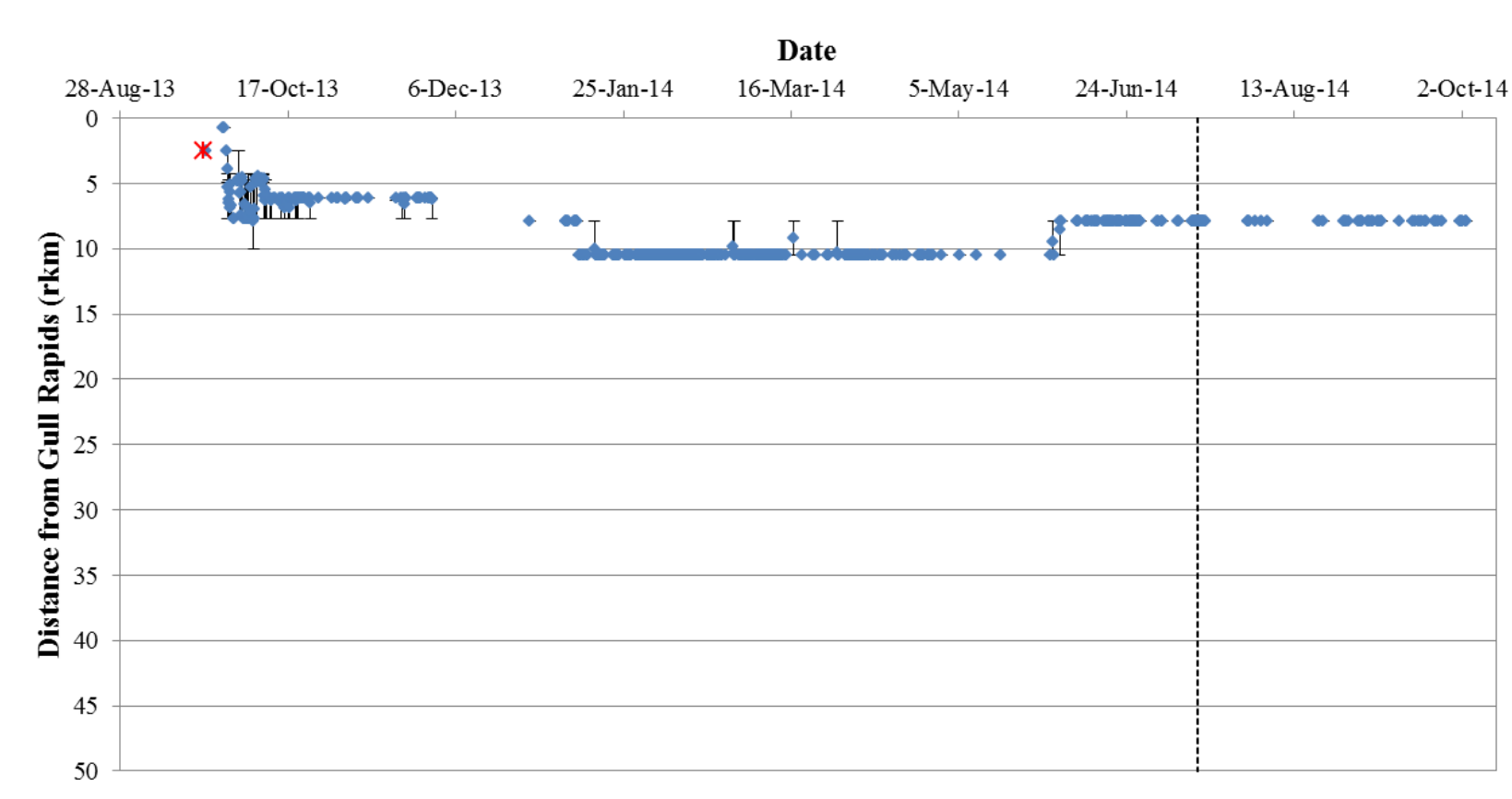


Figure A2- 14: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32680) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 12 October, 2014. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

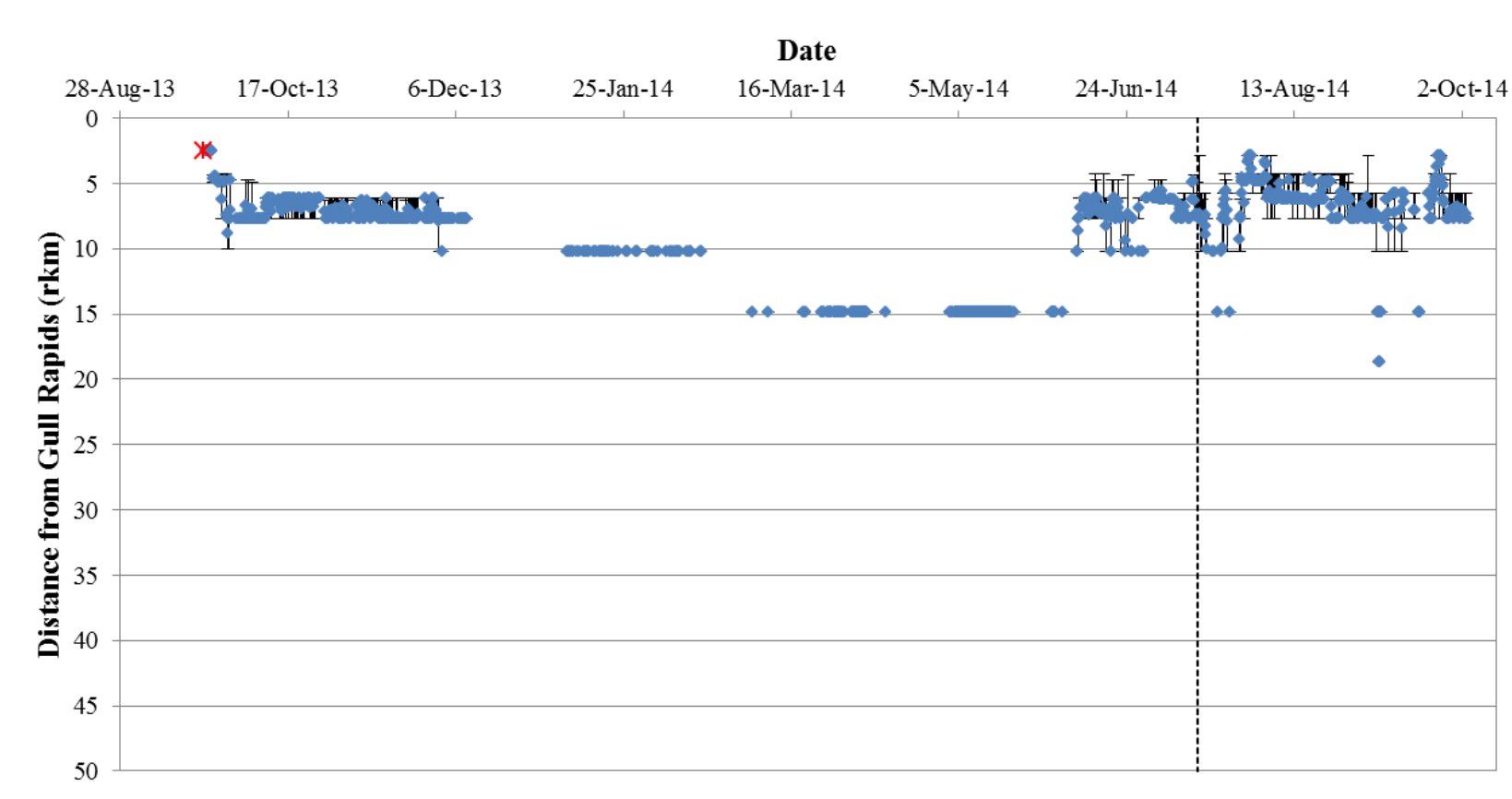


Figure A2- 15: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32685) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 12 October, 2014. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

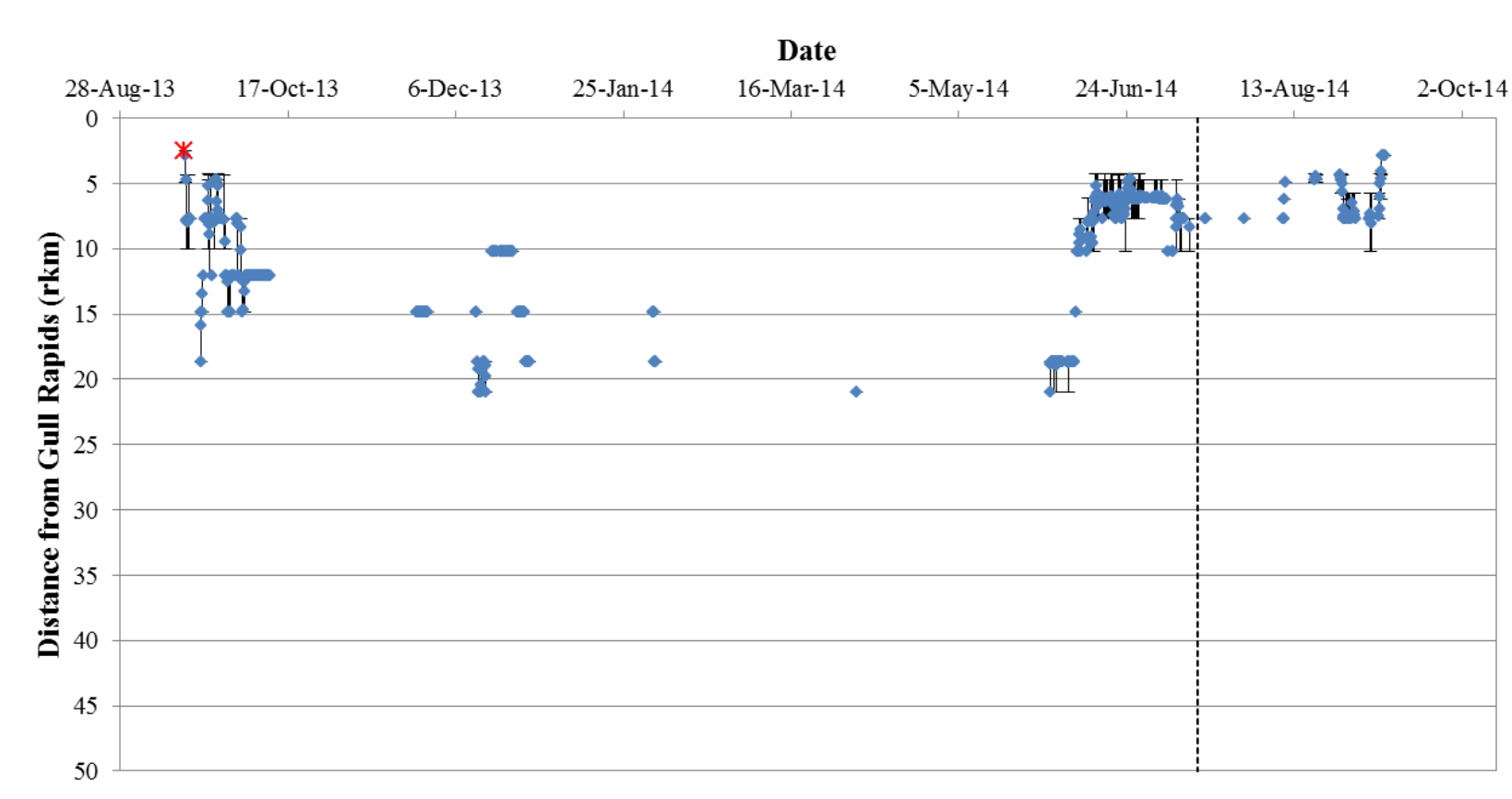


Figure A2- 16: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32696) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 12 October, 2014. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

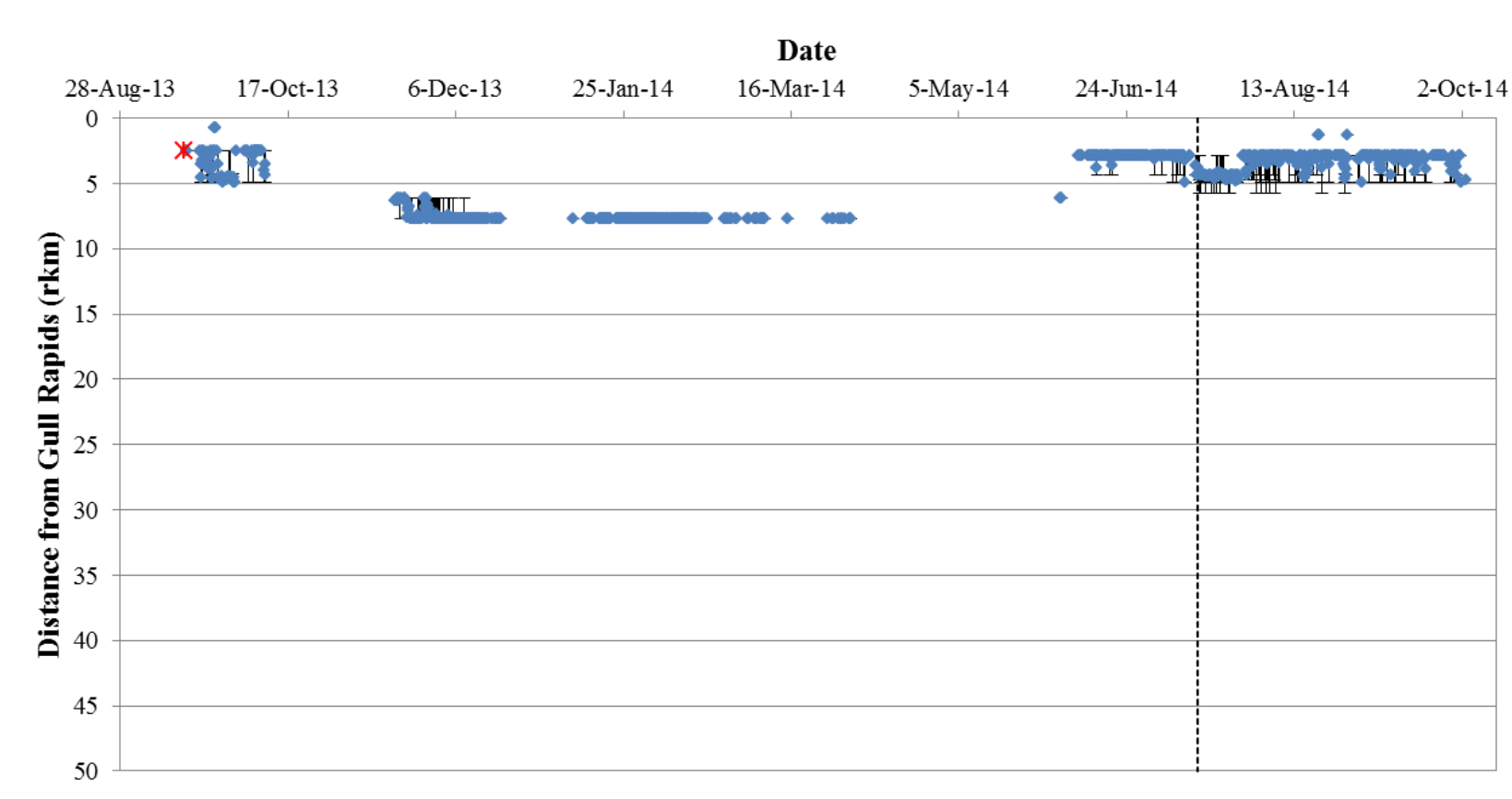


Figure A2- 17: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32697) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 12 October, 2014. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

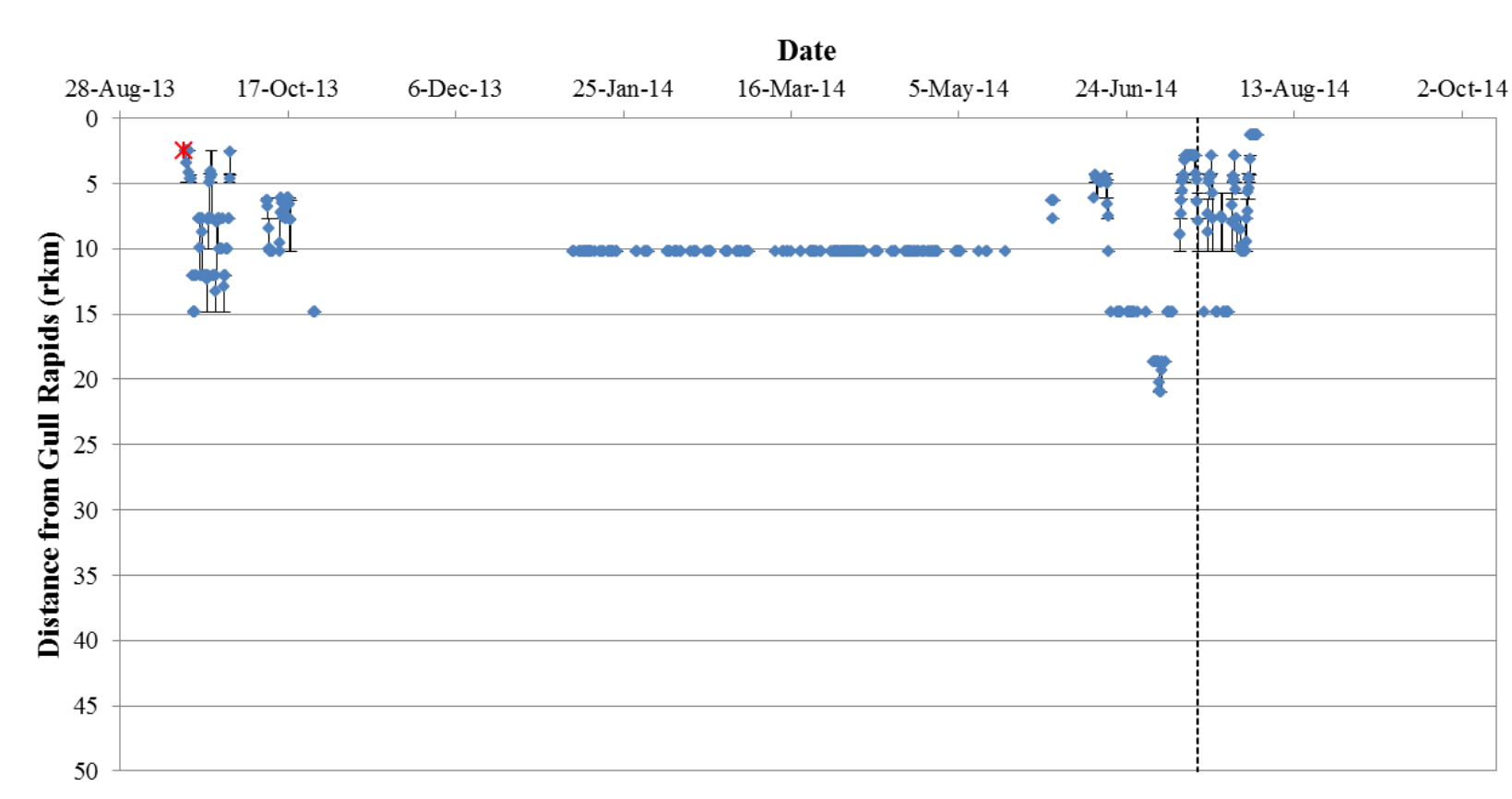


Figure A2- 18: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32698) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 12 October, 2014. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

Figure A2- 19: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32699) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 12 October, 2014. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

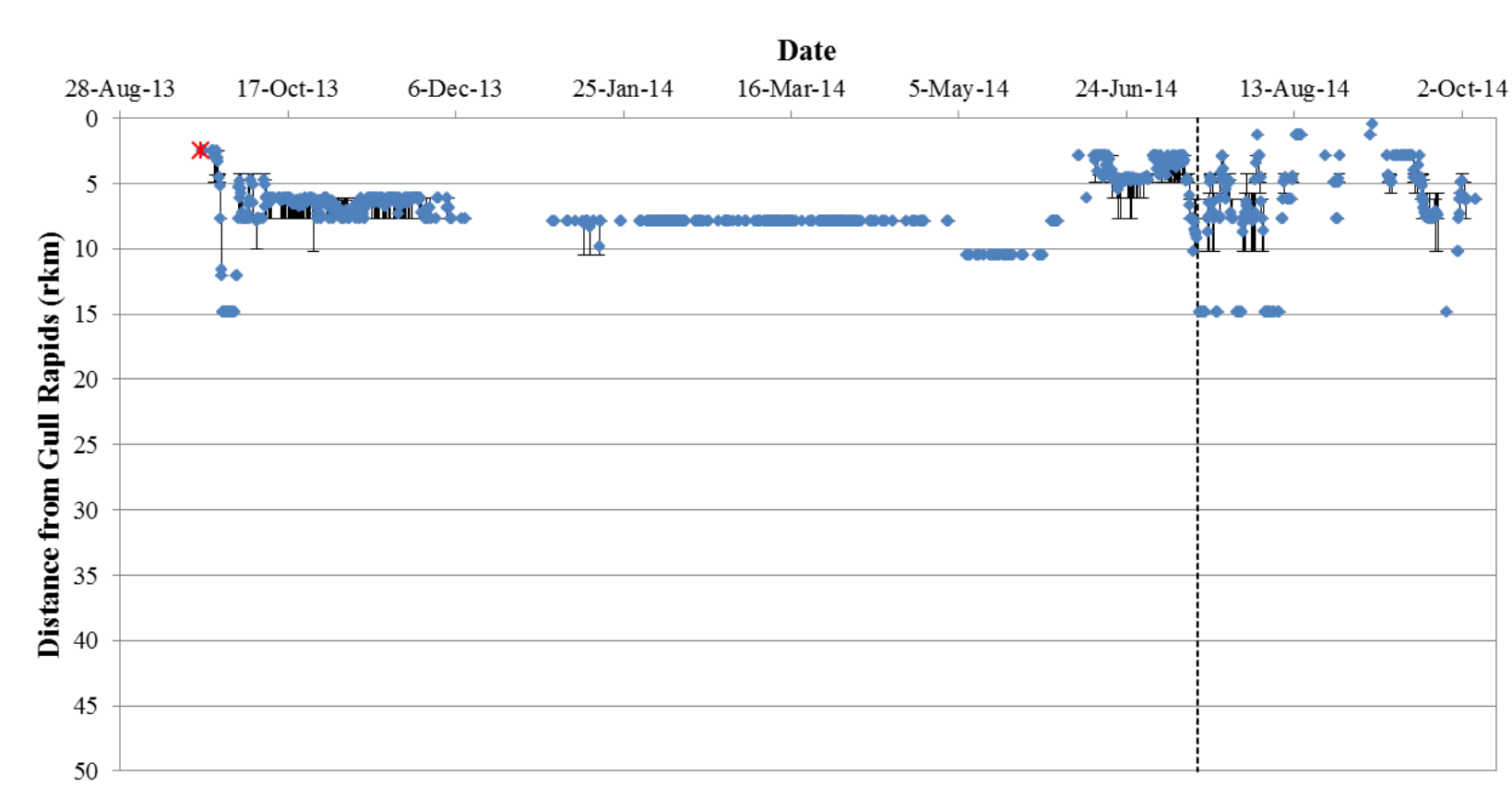


Figure A2- 20: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32700) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 12 October, 2014. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.