Keeyask Generation Project
Aquatic Effects Monitoring Plan

Juvenile Lake Sturgeon Movement Monitoring Report

AEMP-2016-05

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KEEYASK GENERATION PROJECT

AQUATIC EFFECTS MONITORING REPORT

Report #AEMP–2016–05

JUVENILE LAKE STURGEON MOVEMENT MONITORING IN THE NELSON RIVER BETWEEN CLARK LAKE AND THE LONG SPRUCE GENERATING STATION, OCTOBER 2014 TO OCTOBER 2015: YEAR 2 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. During August and September, the flow in the north and central channels of Gull Rapids was blocked off and all the flow was diverted to the south channel. Cofferdams were constructed in the north and central channels and these channels were dewatered by fall (see construction site map below). The combination of high natural flows in the Nelson River and diversion of flow resulted in water levels on Gull Lake increasing about 1.3 m at the water level monitoring site at Caribou Island. The rise in water levels resulted in flooding along the shoreline and in low-lying areas. During the winter, a cofferdam was constructed extending into the south channel. During the spring of 2015, flows in the Nelson River decreased and water level on Gull Lake went down to pre-construction high water levels.

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 up to ten years old (less than 800mm);
- 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.

Monitoring of juvenile sturgeon movement began in August 2013. A Lake Sturgeon is considered to be a juvenile if it is over one year, but less than 10 years old (less than 800 mm long). This report provides results of juvenile sturgeon movement monitoring conducted from October 2014 to October 2015. The movements of juvenile Lake Sturgeon were monitored for 10.5 months prior to changes to the river (pre-construction), and have now been monitored for approximately one year and three months following the start of construction.

KEEYASK

DATA SOURCE: Orthophoto: Manitoba Hydro - June 21, 2015			
CREATED BY: North/South Consultants			
COORDINATE SYSTEM: UTM NAD 1983 Z15N		DATE CREATED: 26-FEB-10	REVISION DATE: 30-MAY-16
0 0.15 0.3 Kilometres / 0 0.15 0.3 Miles		VERSION NO: 2.0	QA/QC: PMC/FSV/MWZ

Construction Site

Map of instream structures at the Keeyask Generating Station site, June 2015.

Why is the Monitoring being done?

The monitoring is being done to answer two questions:

Do juvenile sturgeon move away from the construction area and, if so, how far?

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 the local population.

Do sturgeon move up and down over Gull Rapids to reach habitat that they need to complete their life cycle?

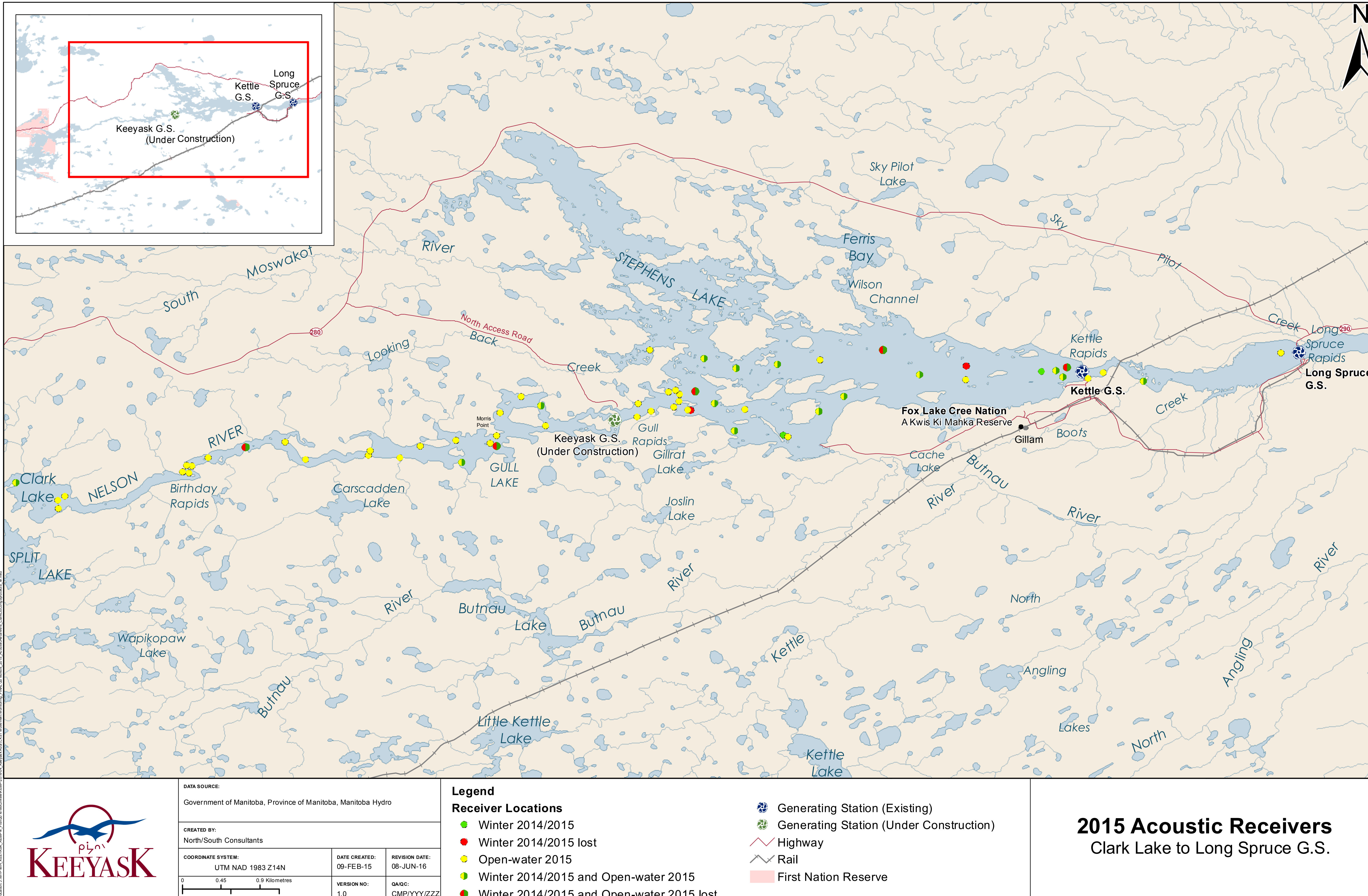
Movement studies tell us how many juvenile Lake Sturgeon are moving through Gull Rapids (upstream and downstream) between Gull and Stephens lakes, and when the fish are making these movements. Recording where fish move during construction tells us how close the fish are to construction activities, which is important because fish moving past the construction site may be harmed. Lake Sturgeon movement monitoring will also be used along with other monitoring conducted to determine if areas exist on both sides of the dam that are suitable for all ages of fish to exist.

What was done?

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

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

Surgery on juvenile Lake Sturgeon to implant acoustic tag.



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 and whether they lived in Gull Lake or Stephens Lake. The sturgeon that were tagged in Gull Lake in 2013 stayed in Gull Lake. The sturgeon that were tagged in Stephens Lake stayed in Stephens Lake, except for one that moved downstream through the Kettle GS into the Long Spruce Reservoir in 2014. This fish was detected moving around in the Long Spruce Reservoir.

Juvenile Lake Sturgeon

Juvenile sturgeon in Stephens Lake moved farther 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 concentrate in these areas.

None of the tagged juvenile sturgeon moved from Gull Lake to Stephens Lake or Stephens Lake to Gull Lake through Gull Rapids. This is different from adult Lake Sturgeon, as a few have been detected moving both upstream and downstream over the rapids. The fast current of the rapids likely blocks the smaller juveniles from moving upstream from Stephens Lake to Gull Lake, but they should be able to move downstream 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.

Monitoring movements in winter is very challenging because of ice conditions. Ice has damaged receivers set in channels as deep as 17 m. For this reason, receivers are left in only a few locations, making it less likely that sturgeon will be detected. However, during winter in both Stephens and Gull lakes, juvenile sturgeon have been detected in deeper areas with little current, and most appear to move very little. Juvenile sturgeon were only detected at one receiver in Gull Lake during the winter, but at many receivers in Stephens Lake during this time. During the summer, juvenile sturgeon moved farther distances than they did during the winter. Juvenile sturgeon tended to move downstream in Stephens Lake in the late summer, which may be because ice builds up below Gull Rapids in the winter and the sturgeon choose to avoid the ice.

What does it mean?

For the most part, monitoring has shown that juvenile sturgeon tend to stay in the area in which they were tagged. None have moved upstream or downstream through Gull Rapids since monitoring began in August 2013. No fish moved downstream through the Kettle GS during the current monitoring year. Right now, it appears that juvenile sturgeon do not use the area around the construction site very much. The movement of juvenile sturgeon will continue to be monitored as construction of the Keeyask GS progresses. It will then be possible to see if the fish move around more or continue to stay in the same places.

Information collected so far shows 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. For example, they may move farther when they have access to a long stretch of deep river channel. For this reason, the movements of sturgeon may change after the GS is built, when Gull Lake becomes part of a deep reservoir.

What will be done next?

The acoustical tags that were implanted in 2013 will last until 2017. Tracking individual fish over several years will provide more information about 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 and the fish age and grow.

ACKNOWLEDGEMENTS

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The collection of biological samples described in this report was authorized by Manitoba Conservation and Water Stewardship, Fisheries Branch, under terms of the Scientific Collection Permit #17-15.

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1.0 INTRODUCTION

The Keeyask Generation Project (the Project) is a 695-megawatt (MW) hydroelectric generating station at Gull (Keeyask) Rapids on the lower Nelson River in northern Manitoba. The Project is approximately 725 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 Gilliam (Map 1). Construction of the Project began in July 2014.

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

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 (Map 1). This study area for juvenile Lake Sturgeon movement monitoring extends farther downstream into the Long Spruce Reservoir given the potential for fish to be entrained at the Kettle GS.

This report provides one-year of results (October 2014 to October 2015) of a multi-year juvenile Lake Sturgeon movement monitoring study that was initiated in August 2013. Results build on those provided in two previous reports (Hrenchuk and Barth 2014; Lacho *et al*. 2015).

Lake Sturgeon in the Keeyask study area 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 a fork length that is less 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*.).

The key questions for juvenile movement monitoring during construction include:

- 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?

From August 2013 to October 2014, monitoring of movement patterns of juvenile Lake Sturgeon demonstrated that juveniles in Stephens Lake had greater movement ranges than those in Gull Lake. Fish in Gull Lake stayed in the lake and did not make upstream movements into more riverine habitat. Fish in Stephens Lake had a wider extent of movement relative to Gull Lake, and one moved downstream through the Kettle GS into the Long Spruce Reservoir between December 2013 and July 2014.

This report discusses juvenile Lake Sturgeon movement from October 2014 to October 2015, representing the first winter and full open-water season of monitoring since construction commenced.

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 downstream 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. Water velocities were classified as low (0.2–0.5 m/s), moderate (0.5–1.5 m/s), or high (>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 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 (maps 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 (maps 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. Gull Rapids is the site of the Keeyask Generation Project. A summary of 2014/2015 construction activities 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 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.

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 (Map 1).

2.1 2014/2015 CONSTRUCTION SUMMARY

Construction of the Keeyask GS began in mid-July 2014 with the construction of the Quarry Cofferdam in the north channel of Gull Rapids. In August, the North Channel Rock Groin and North Channel Cofferdam were constructed to diverted flow from the north and central channels of Gull Rapids to the south channel. The north and central channels were gradually dewatered by late fall 2014. The Stage 1 Powerhouse Cofferdam was constructed in the fall to permit excavation of the powerhouse. Construction of the Central Dam Cofferdam rock groins began the fall of 2014 and was completed the summer of 2015. During the winter of 2014/15 high flows in the Nelson River and partial failure of the ice boom resulted in high water levels in Gull Rapids which required some cofferdams to be raised. The North Channel Rock Groin was extended into the south channel of Gull Rapids during the winter 2014/15 to raise the water level on Gull Lake to promote the formation of a stable ice cover. The groin extension was partially removed in 2015. Construction of the spillway cofferdam, which extends into the south channel of Gull Rapids, began in early winter 2015 and was completed by late summer. Dewatering of the spillway cofferdam occurred in summer/fall 2015. The configuration of cofferdams as of mid-summer 2015 is shown on Map 2.

During July and August 2015, additional ice booms were installed in Gull Lake so that a stable ice cover would develop upstream of the construction site (as noted above, the previous ice boom had partially failed during the winter of 2014/2015). Map 3 illustrates the location of the new ice booms, which are held in place by anchors drilled into the bedrock below the river bottom.

Due to high flows in the Nelson River (almost a 1:20 year flow event) and the construction of the North Channel Rock Groin, water levels in Gull Lake rose to between 155 m ASL and 156 m ASL during late summer 2014. This resulted in water levels above the existing environment 95th percentile water level for open-water (154.2 m ASL) until the following spring (Manitoba Hydro 2015). Open water levels on Gull Lake in the existing environment were as high as 155 m and surpassed 156 m during winter on occasion. The amount of land inundated during the 2014-2015 period is not known, but based on estimates of flooded areas expected in the later stages of construction (as presented in the Environmental Impact Statement), this area likely included the nearshore areas of much of Gull Lake and some localized areas in and around Gull Rapids, as well as low-lying areas that extended farther inland. Water levels during the open-water season of 2015 declined due to lower discharge in the Nelson River. Water levels on Gull Lake ranged from 154 m ASL to 155 m ASL in 2015, and inundated areas were likely confined to localized sections of low-lying areas around Gull Lake.

Blasting at quarries within the north channel cofferdam has been on-going throughout the construction period, with blasts occurring every one to two weeks.

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 (model #Vemco V13-1x, estimated 1480 day battery life) were applied to 40 fish in August and September 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 length at age relationships for fish in Gull and Stephens lakes (Henderson *et al*. 2014).

3.1.2 ACOUSTIC RECEIVERS AND DEPLOYMENT

Stationary acoustic receivers (VEMCO model VR2 and VR2W, Shad Bay, Nova Scotia) were used to continuously monitor tagged juvenile Lake Sturgeon between Clark Lake and the Keeyask GS construction site, Stephens Lake, and the Long Spruce Forebay.

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 passed by the river cross-section.

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 at depths > 10 m, the number of possible receiver locations during winter, especially in Gull Lake, is limited.

3.1.2.1 WINTER 2014/2015

Twenty 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 2014/2015 period (13 October, 2014 to 30 April, 2015; maps 4, 5, and 6). Four were set upstream of Gull Rapids, 15 throughout Stephens Lake, and one in the Long Spruce Reservoir.

From January 14 to 21, acoustic tracking was conducted to assess the abundance of tagged fish in the vicinity of two potential ice blasting locations in Gull Lake (Manitoba Hydro 2015). Additional movement information acquired during this tracking event are discussed in Section 5.0 and a full summary of results are provided in Hrenchuk and Barth (2016).

3.1.2.2 OPEN-WATER 2015

An array of 56 receivers was used during the 2015 open-water period (open-water period defined as 1 May to 11 October, 2015). Along with the receivers left in the water overwinter, 21 additional receivers were set between Clark Lake and Gull Rapids, 17 additional were set in Stephens Lake, and three additional receivers were set in the Long Spruce Reservoir (maps 7, 8, and 9).

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) (maps 7 and 8). Receiver “gates” consisted of two or more acoustic receivers set parallel to flow to provide complete signal coverage 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 (Map 7), while Stephens Lake was divided into two zones (Map 8). Gate locations were consistent with the 2014 open-water study period, and divided the river into the same zones. On 11 October 2015, the majority of receivers were removed and a subset (n = 21) were redeployed to monitor movements during winter 2015/2016.

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 a different behaviour or movement pattern for monitored fish.

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) 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 relocation ranges were calculated by subtracting the farthest downstream detection location from the location of the farthest upstream detection. Proportion of time all fish spent within each river zone was calculated and plotted.

4.0 RESULTS

Tables 1 to 6 provide detection summaries, acoustic tag and biological information associated with each tagged fish. Figures 1 to 10 and maps 4 to 9 provide maps of receiver 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 2013.

4.1 WINTER 2014/2015

4.1.1 UPSTREAM OF GULL RAPIDS

Two of the four acoustic receivers deployed in the Nelson River between Clark Lake and Gull Rapids during winter 2014/2015 were retrieved (Map 4). The acoustic receivers deployed at rkm -29.4 and rkm -9.9 could not be located and were likely moved by ice during the winter. Four of the 20 juvenile Lake Sturgeon tagged in Gull Lake in 2013 were detected during winter 2014/2015. All four were detected only by the receiver at rkm -12.9, with a total of 2,783 detections logged (Table 3; Figure 3). The number of detections per fish ranged from 42 to 2,479 (Table 3). The receiver located at rkm -48.2 in Clark Lake did not detect any tagged juveniles. Fish were detected for an average of 15 days of the 200 day winter period (StDev = 17.1 days). The number of days fish were detected ranged from six to 44 (Table 3). Individual fish movements are summarized in Appendix 1.

4.1.2 DOWNSTREAM OF GULL RAPIDS

Ten of the 15 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 each receiver, while the two receivers at rkms 6.1 and 6.3 could not be located (Map 5). The single receiver set in the Long Spruce Reservoir was retrieved (Map 6). A total of 53,294 detections were logged by 17 fish, ranging from 93–11,466 detections per individual (Table 5). Fish were detected between 14 and 97 days of the 200 day winter period (mean: 37.2 days; StDev = 25.9 days) (Table 5). The mean detection range was 4.7 rkm (StDev = 6.9 rkm; range 0.0–25.9 rkm) (Table 5, Figure 4).

Four patterns of movement were evident:

- Ten of the seventeen fish remained in the upper end of Stephens Lake (at, or upstream of rkm 10.5) (Section 4.1.2.1).
- Three fish moved within both the upstream and downstream (downstream of rkm 10.5) portions of Stephens Lake (Section 4.1.2.2).

- Three fish were only detected in the downstream portion of Stephens Lake (Section 4.1.2.3)
- One sturgeon was detected in the Long Spruce Reservoir (Section 4.1.2.4)

4.1.2.1 UPPER STEPHENS LAKE

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

- Two fish (#32664 and #32675) were detected at rkm 7.7 (Table 5; appendices A2-4, A2-13).
- Six fish (#32661, #32663, #32665, #32666, #32697 and #32700) were detected between rkm 7.7 and rkm 10.2 (Table 5; Figure 4; appendices A2-1, A2-3, A2-5, A2-6, A2-17, and A2-20).
- Two fish (#32670 and #32680) were located in the northern portion of Stephens Lake in the former channel of the Moosenose River (appendices A2-10 and A2-14).

4.1.2.2 MOVEMENTS THROUGHOUT STEPHENS LAKE

Three juvenile Lake Sturgeon moved between upper (rkm 7.7–10.5) and lower (rkm 10.5–21.0) Stephens Lake during the winter period (Table 5).

- Two (#32685 and #32696) were detected between rkm 7.7 and 21.0 (Appendix A2-15; Appendix A2-16).
- One (#32698) was detected between rkm 7.7 and rkm 14.9. It was detected at rkm 7.7 and 10.2 on October 15, 2014 and then moved downstream to rkm 14.9 on October 24, 2015. It was then detected sporadically at rkm 7.7 and 10.2 until January 8, 2015, after which it was not detected until open-water season (Appendix A2-18).

4.1.2.3 LOWER STEPHENS LAKE

Three juvenile Lake Sturgeon were located exclusively in lower Stephens Lake (rkm 14.9–40.8) over the winter (Table 5).

- Two fish (#32668 and #32674) were detected at rkm 14.9 (Appendix A2-8; Appendix A2-12).
- One fish (#32673) was detected at rkm 14.9 between October 19 and December 4, 2015, then moved progressively downstream until it was detected at rkm 40.8 on December 19, 2015. It was not detected again until the open water season (Appendix A2-11).

4.1.2.4 LONG SPRUCE RESERVOIR

The juvenile Lake Sturgeon (#32662) that moved through the Kettle GS between December 2013 and July 2014 was detected at the single receiver at rkm 47.5 in the Long Spruce Reservoir during winter 2014/2015. This sturgeon was only detected between October 16 and

November 24, 2014 and was not detected again until the open-water season of 2015 (Table 5, Appendix A2-2).

4.2 OPEN-WATER 2015

4.2.1 UPSTREAM OF GULL RAPIDS

All 25 acoustic receivers deployed upstream of the Keeyask construction site were retrieved at the end of the open-water period (Map 7).

Nineteen of the twenty juvenile Lake Sturgeon tagged upstream of Gull Rapids in 2013 were located during the 2015 open-water season (Table 4). The one sturgeon that was not detected, #32691, was last detected on May 10, 2014 at rkm -10.9 (Appendix A1-16). The located fish were detected between 3,808–41,794 times over 26 to 134 days of the 164 day study period (average = 99.7 days; StDev = 32.4 days) (Table 4).

Fish had a mean movement range of 5.1 rkm (StDev = 4.5 rkm; range: 0.3–17.5 rkm) (Table 4; Figure 5). Juvenile Lake Sturgeon were detected in the three closest zones to Gull Rapids (zones 3, 4, and 5; figures 7 and 8). Proportionally, juvenile Lake Sturgeon spent the most time in Zone 5, the closest zone to Gull Rapids (mean = 53.4%; StDev = 42.1%; range: 0.4–100.0%),followed by Zone 4 (mean = 44.6%; StDev = 42.7%, range: 0.0–99.6%), and Zone 3 (mean = 1.9%, StDev = 8.4%, range: 0.0–36.7%). No juvenile Lake Sturgeon were detected at the receiver closest to Gull Rapids at rkm -5.8 (Map 7).

A single Lake Sturgeon (#32693) moved as far upstream as Zone 3. This fish was detected in the three closest zones to Gull Rapids during the open-water period (Figure 8, Appendix A2-17). This fish was detected in Zone 1 at rkm -9.0 and -9.3 from 30 May to 14 June, 2015. After this, it began to move upstream and spend time in the transition zone between Zones 1 and 2 (rkm -9.5 and rkm -10.1) between June 16 and June 28, 2015. Between June 29 and 30, the fish was detected in Zone 2 between rkm -12.9 to -19.5. It was then detected in Zone 3, at rkm -26.5 from July 5 to August 18, 2015. It was detected in Zone 3 for one more day, August 20, 2015, before steadily moving downstream back to near the border of zones 1 and 2 by August 23, 2015 (Appendix A2-17).

The rest of the Lake Sturgeon tagged in Gull Lake were only detected in zones 4 and 5, the two zones closest to Gull Rapids (figures 7 and 8). None of these fish were detected farther upstream than rkm -19.5 (Figure 5). Six fish (#32686; #32689, #32690, #32692, #32694, and #32695) (appendices A1-11, A1-14, A1-15, A1-17, A1-19, and A1-20) were detected exclusively in Zone 5 during the study period. (Figure 8).

The remaining 12 fish displayed some degree of movement between zones 4 and 5:

- Two fish (#32678 and #32688) were detected near the boundary of Zone 4 and Zone 5 and were repeatedly detected at receivers at rkm -9.5 (Zone 5), rkm -9.9 and -10.1 (Zone 4) throughout the open-water season (appendices A2-5 and A2-13).
- Ten fish (#32671, #32672, #32676, #32677, #32679, #32681, #32682, #32683, #32684, and #32687) moved farther upstream into Zone 4 and had movement ranges between 3.4 and 10.0 rkm (Table 4; appendices A1-1, A1-2, A1-3, A1-4, A1-6, A1-7, A1-8, A1-9, A1-10, and A1-12).

4.2.2 DOWNSTREAM OF GULL RAPIDS

Twenty-five receivers from Stephens Lake (Map 8) and all four receivers from the Long Spruce Reservoir (Map 8) were successfully retrieved throughout the open-water season. Two receivers in Stephens Lake (#122778 at rkm 28.3 and #108003 at rkm 39.9) were downloaded during the open-water season, however during the last download on October 11, 2015, they were caught on submerged trees and could not be retrieved (Map 8).

Nineteen of the 20 fish tagged in Stephens Lake were detected between 259 and 20,054 times over 7 to 135 days of the 164 day study period (average = 99.6 days; StDev = 32.2 days) (Table 6). The one sturgeon that was not located during the open-water season (#32699) was last detected on November 15, 2013 at rkm 6.1 (Appendix A2-19). Located fish had a mean movement range of 11.2 rkm (StDev = 5.9 rkm; range: 0.0–19.7 rkm; Figure 6). On average, sturgeon spent almost the same amount of time in both zones in Stephens Lake, with slightly more time spent In Zone 6, closest to Gull Rapids (mean = 51.0%; StDev = 30.1%; range: 0.0–97.5%) than in Zone 7 (mean = 49.0%; StDev = 30.1%; range: 2.5–100%) (figures 9 and 10). In general, the relative amount of time spent in Zone 6 increased as summer progressed, then decreased after mid-August (Figure 10).

Three patterns of movement were identified:

- One fish was detected in the Long Spruce Reservoir (Section 4.2.2.1.);
- Two fish remained in the lower portion (Zone 7) 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

The juvenile Lake Sturgeon (#32662) that moved through the Kettle GS in 2014 was detected in the Long Spruce Reservoir during the open water season of 2015 (Table 6, Appendix A2-2). This individual was detected at rkm 44.9 between June 20 and August 15, 2015. It was then detected upstream at rkm 42.7 and 43.5 between August 18 and 20, before being detected again at rkm 44.9 between August 20 and 10 October 10, 2015 (Appendix A2-2).

4.2.2.2 LOWER STEPHENS LAKE

Two juvenile Lake Sturgeon (#32667 and #32680) were located in Zone 7 (Map 8):

- #32667 was detected periodically at rkm 11 between June 16 and September 20, 2015 (Appendix A2-7).
- #32680 was located in the former channel of the Moosenose River. It was sporadically detected at rkm 7.9 between May 1 and October 4, 2015 (Appendix A2-14).

4.2.2.3 MOVEMENTS THROUGHOUT STEPHENS LAKE

The remaining 16 sturgeon were located throughout Stephens Lake.

- Three (#32696, #32698, and #32700) were detected at receiver #114227 and #7778 (in the area corresponding to the former Moosenose River channel) (Map 8). All three fish were detected in this area in May and then were exclusively located in the southern portion of the lake for the remainder of the open water season:
    - #32696 was detected at rkm 10.2 on May 22 and 23 (Appendix A2-16).
    - #32698 was detected at rkm 10.2 on May 27 (Appendix A2-18).
    - #32700 was located at km 7.9 between May 7 and 26 (Appendix A2-20).
- Fifteen of the sixteen fish were detected for at least one day at the closest receiver to Gull Rapids at rkm 1.3 during the open-water season:
    - #32673 was only detected at this location on June 27 (Appendix A2-11).
    - The rest of the fish were detected at this receiver sporadically during the open-water season
        - Three (#32669, #32699, and #32700) were detected at this receiver several times between June and August (appendices A2-9, A2-19, and A2-20).
        - Five (#32661, #32663, #32664, #32666, and #32670) were detected at this receiver between mid-June and September (appendices A2-1, A2-3, A2-4, A2-6, and A2-10).
        - #32674 was located between June 26 and July (Appendix A2-12).
        - #32696 was detected between July and September (Appendix A2-16).
        - Two (#32674 and #32685) were located only during the month of July (appendices A2-12 and A2-15).
        - Two (#32665 and #32697) were located between July and October (appendices A2-5 and A2-17).
- Only one fish (#32685) was detected as far downstream as rkm 21.0 (Table 5; Appendix A2-15).

5.0 DISCUSSION

This movement study was initiated in 2013 with the long-term objective of assessing the impacts of construction and operation of the Keeyask GS on juvenile Lake Sturgeon movement. As predicted 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.

Juvenile Lake Sturgeon were tagged in late summer of 2013, and construction of the Keeyask GS began in July 2014. Data included in this report represent the first winter and full open-water season of data collection since construction of the Keeyask GS commenced. The transmitters currently being monitored have an approximate four-year lifespan and will therefore last until 2017. In 2017, the study will be repeated, meaning a similar number of juvenile Lake Sturgeon will be tagged and their movements will be monitored until 2021. The discussion below highlights movement patterns observed since the study was initiated and discusses key questions from the AEMP with respect to potential impacts of construction on the movements of juvenile Lake Sturgeon.

5.1 EVALUATION OF METHODOLOGY

Acoustic telemetry continues to be an effective method for monitoring juvenile Lake Sturgeon in the study area during the open-water period. Thirty-eight of the 40 juvenile Lake Sturgeon implanted with transmitters in 2013 were detected during the open-water season of 2015. Twenty-eight of the 40 tagged fish were detected for more than 50% of the days monitored (compared to 31 of 40 in 2014), while ten were detected for over 70% of the days monitored (compared to ten in 2014) (Lacho *et al*. 2015). As noted in previous reports (Hrenchuk and Barth 2013a, Hrenchuk and Barth 2014b, and Lacho *et al*. 2015), there are difficulties associated with using acoustic telemetry in the study area during the winter. In Gull Lake it is difficult to keep receivers safe from moving ice as there are a limited number of deployment sites of sufficient depth. For example, in 2015, the loss of two of the four receivers deployed during the winter months limited data collection, and only four of the 20 fish tagged in this area were detected.

Additional monitoring with stationary receivers and a portable receiver during ice-blasting was conducted in January 2015 near Caribou Island (described in Hrenchuk and Barth 2016). During this monitoring, four additional juvenile Lake Sturgeon were detected that had not been previously located during the winter, indicating that juvenile Lake Sturgeon were overwintering in this area (Hrenchuk and Barth 2016).

In Stephens Lake, although five receivers were lost during the winter, the greater availability of deep water meant that more receivers could be deployed. Seventeen of the 20 fish tagged in Stephens Lake were detected during the winter months, however, many fish were detected only sporadically (*i.e.,* average of 18.6% of days).

5.2 KEY QUESTIONS

The key questions, as described in the AEMP, for juvenile movement monitoring during construction of the Keeyask GS are as follows:

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

No juvenile Lake Sturgeon moved downstream through the Kettle GS in 2015. The fish that passed through the station between December 2013 and July 2014 (Lacho *et al*. 2015) was detected in the Long Spruce Reservoir during both the winter and open-water seasons. No juvenile Lake Sturgeon were detected at any of the receivers immediately upstream of the Kettle GS in 2015. The farthest downstream detection of a juvenile sturgeon in Stephens Lake occurred at the receiver at rkm 21, by a fish that was later detected upstream at rkm 1.3.

Upstream of the construction site, juvenile Lake Sturgeon did not appear to avoid the construction area. Although one individual moved upstream out of Gull Lake into more riverine habitat, it did move back downstream into the zone closest to Gull Rapids.

To date, no juvenile Lake Sturgeon have moved permanently out of Gull Lake, either upstream or downstream.

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

Results from the past two years indicate that the area immediately upstream of Gull Rapids is not heavily used by juvenile Lake Sturgeon. In 2015, none of the fish tagged in Gull Lake were detected by the receiver closest to the rapids, at 5.8 rkm upstream. In addition, only four of the tagged fish moved within 7.4 rkm of the rapids. Similarly, in 2014, only two juvenile Lake Sturgeon were detected within 5.8 rkm of the rapids (Lacho *et al*. 2015). Because they are not inhabiting the area directly upstream of the rapids, it is unlikely they are being impacted directly by construction activities.

The majority of the juvenile Lake Sturgeon tagged in Stephens Lake were detected within 1.3 rkm of Gull Rapids during the open-water period of 2015, indicating that there is valuable juvenile habitat in this area. Therefore, fish in Stephens Lake may be susceptible to potential construction-related effects, such as increased sedimentation, changes in flow, and disturbances associated with blasting or construction equipment.

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

Qualitatively, juvenile Lake Sturgeon movement patterns have not changed since the study began. In Gull Lake, juvenile Lake Sturgeon have inhabited the same general areas since being tagged prior to the start of construction. The detection range of the open-water season of 2014 and 2015 were very similar; average of 4.1 rkm in 2014, and 5.1 rkm in 2015. Except for one fish in 2015, which moved upstream out of Gull Lake and then returned, all fish tagged in Gull Lake in 2013 have remained in the lake since the beginning of the study.

Movement patterns in Stephens Lake have also been consistent since the study commenced. The detection range in 2014 (11.1 rkm) is almost identical to that of 2015 (11.2 rkm). In both 2014 and 2015, juvenile Lake Sturgeon in Stephens Lake spent proportionally more time upstream closer to Gull Rapids in the middle of the summer and then moved downstream later in the open-water season. This might be attributed to the build-up of ice at the base of Gull Rapids during winter, which causes fish to move downstream away from the moving ice, which is known to move at depth (*i.e.,* receiver deployed at 17 m in 2013 was damaged by moving ice). As was observed in 2013 (Hrenchuk and Barth 2014) and 2014 (Lacho *et al*. 2015), juveniles moved greater distances in Stephens Lake (average = 11.2 rkm) than in Gull Lake. As noted in previous reports (McDougall *et al*. 2013b, McDougall *et al* 2013c), the greater movement range is likely due to the greater amount and continuity of deep water habitat available to juvenile Lake Sturgeon in Stephens Lake compared with Gull Lake.

Consistent with previous years' results and findings of other studies, juvenile Lake Sturgeon moved over a limited spatial extent. The finding that juvenile Lake Sturgeon utilize a small home range is consistent with other studies (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). Recapture of marked fish during juvenile Lake Sturgeon targeted gillnetting conducted during fall in the Keeyask study area also confirmed the limited movement of these fish in this study area. For example, in 2014 almost all recaptured juveniles in the Burntwood River, Gull Lake and Stephens Lake moved less than 7 km from their original tagging location (Henderson *et al*. 2015), while in 2015 almost all recaptures moved less than 5 km (Burnett *et al*. 2016). The only exceptions to this limited movement range have been hatchery-raised juvenile Lake Sturgeon. One hatchery raised juvenile was recaptured in Gull Lake, 97 rkm downstream from its release site in the Burntwood River in 2014 (Henderson *et al*. 2014), while another was recaptured in Gull Lake, 92 rkm downstream in 2015 (Burnett *et al*. 2016).

6.0 SUMMARY AND CONCLUSIONS

- Acoustic monitoring continues to be an effective method for monitoring juvenile Lake Sturgeon in the study area during the open-water period, as 38 of the 40 sturgeon tagged in 2013 were detected during the open-water period of 2015. Monitoring during winter is difficult and several receivers have been lost, however, the data that has been collected thus far is valuable for identifying overwintering areas and winter movements.
- The key questions, as described in the AEMP, for juvenile Lake Sturgeon movement monitoring during construction of the Keeyask GS are as follows:
  - *Will the frequency of long-distance movements by juvenile Lake Sturgeon increase during construction and operation of the project?*

    For the duration of this monitoring, juvenile Lake Sturgeon have not made long-range movements out of the study area prior to or after the start of construction. Only one Lake Sturgeon tagged in Gull Lake has moved upstream out of Gull Lake into more riverine habitat since the study began, and this fish returned downstream to Gull Lake. Although one juvenile Lake Sturgeon did move downstream through the Kettle GS in 2014, it is unlikely this movement was related to construction at the Keeyask GS site, and no sturgeon has moved though Kettle since then. There have been no upstream or downstream movements of juvenile Lake Sturgeon through Gull Rapids since monitoring began.
  - *Are juvenile Lake Sturgeon using habitat in the immediate vicinity of the construction site?*

    *S*imilar to results in 2014, juvenile Lake Sturgeon tagged in Gull Lake are not using habitat directly upstream of Gull Rapids and are therefore less likely to be affected directly by construction-related activities such as blasting. In contrast, the majority of juveniles tagged in Stephens Lake did spend time near the base of Gull Rapids and may be more directly impacted by construction activities at the Keeyask site.
  - *Will disturbances associated with construction of the Keeyask GS alter coarse-scale movement upstream or downstream of the GS?*

    Qualitatively, there has been no observed change in the movement patterns of juvenile Lake Sturgeon since the study began. Juvenile Lake Sturgeon have remained in the same areas and move over relatively limited home ranges during the period of monitoring that has occurred during construction when compared to the monitoring period prior to construction. The distance moved is greater in Stephens Lake than in Gull Lake, likely due to the greater availability of deep water.

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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) and 2014/2015 (13 October – 30 April, 2015) winter periods. Refer to Table 1 for tagging and biological data.

Tag ID	2013/2014						2014/2015					
	# of Detections	Farthest Upstream (rkm)	Farthest Downstream (rkm)	Total detection range (rkm)	# of Days Detected	% Days Detected	# of Detections	Farthest Upstream (rkm)	Farthest Downstream (rkm)	Total detection range (rkm)	# of Days Detected	% Days Detected
32671	9727	-12.9	-12.9	0.0	69	35.0	2479	-12.9	-12.9	0.0	44.0	22.0
32672	3696	-12.9	-9.9	3.0	48	24.4	126	-12.9	-12.9	0.0	15.0	7.5
32676	2528	-12.9	-9.9	3.0	29	14.7	-	-	-	-	0.0	0
32677	4785	-12.9	-9.9	3.0	59	29.9	-	-	-	-	0.0	0
32678	17388	-9.9	-9.9	0.0	135	68.5	-	-	-	-	0.0	0
32679	31	-12.9	-12.9	0.0	7	3.6	-	-	-	-	0.0	0
32681	8205	-12.9	-9.9	3.0	76	38.6	-	-	-	-	0.0	0
32682	270	-9.9	-9.9	0.0	12	6.1	136	-12.9	-12.9	0.0	6.0	3.0
32683	2864	-12.9	-9.9	3.0	42	21.3	42	-12.9	-12.9	0.0	10.0	5.0
32684	2941	-9.9	-9.9	0.0	57	28.9	-	-	-	-	0.0	0
32686	-	-	-	-	0	0.0	-	-	-	-	0.0	0
32687	-	-	-	-	0	0.0	-	-	-	-	0.0	0
32688	-	-	-	-	0	0.0	-	-	-	-	0.0	0
32689	-	-	-	-	0	0.0	-	-	-	-	0.0	0
32690	-	-	-	-	0	0.0	-	-	-	-	0.0	0
32691	-	-	-	-	0	0.0	-	-	-	-	0.0	0
32692	-	-	-	-	0	0.0	-	-	-	-	0.0	0
32693	-	-	-	-	0	0.0	-	-	-	-	0.0	0
32694	-	-	-	-	0	0.0	-	-	-	-	0.0	0
32695	-	-	-	-	0	0.0	-	-	-	-	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), 2014 (1 May, 2014 – 12 October, 2014), and 2015 (1 May, 2015 – 11 October, 2015) open-water seasons. Refer to Table 1 for tagging and biological data.

Tag ID	2013						2014						2015					
	# of Detections	Farthest Upstream (rkm)	Farthest Downstream (rkm)	Total range (rkm)	# of Days Detected	% Days Detected	# of Detections	Farthest Upstream (rkm)	Farthest Downstream (rkm)	Total range (rkm)	# of Days Detected	% Days Detected	# of Detections	Farthest Upstream (rkm)	Farthest Downstream (rkm)	Total 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	12115	-19.5	-9.5	10.0	126	76.8
32672	676	-12.3	-9.9	2.4	35	72.9	7601	-12.9	-9.5	3.4	88	53.3	8996	-17.4	-9.5	7.9	86	52.4
32676	5460	-10.3	-9.9	0.4	39	81.3	5176	-17.4	-12.9	4.5	100	60.6	10299	-17.4	-9.5	7.9	79	48.2
32677	1648	-12.3	-9.9	2.4	40	83.3	8866	-12.9	-9.5	3.4	96	58.2	16278	-17.4	-9.5	7.9	120	73.2
32678	4925	-10.3	-9.9	0.4	46	95.8	22368	-10.1	-9.5	0.6	135	81.8	41794	-10.1	-9.5	0.6	134	81.7
32679	637	-12.9	-9.9	3.0	35	72.9	9726	-19.5	-9.5	10.0	100	60.6	12607	-19.5	-9.5	10.0	82	50.0
32681	834	-12.9	-9.9	3.0	38	79.2	12817	-17.4	-9.5	7.9	100	60.6	12201	-12.9	-9.5	3.4	125	76.2
32682	4736	-10.3	-9.9	0.4	44	91.7	15245	-12.9	-9.5	3.4	98	59.4	11238	-12.9	-9.5	3.4	128	78.0
32683	258	-12.3	-9.9	2.4	40	83.3	4684	-17.4	-9.5	7.9	98	59.4	7347	-14.8	-9.5	5.3	97	59.1
32684	16091	-10.3	-9.9	0.4	46	95.8	14878	-10.8	-5.8	5.0	102	61.8	28581	-14.8	-9.5	5.3	125	76.2
32686	131	-10.9	-10.9	0.0	2	4.1	140	-5.8	-5.8	0.0	3	1.8	4028	-9.3	-7.4	1.9	26	15.9
32687	70	-7.4	-7.4	0.0	16	32.7	14680	-9.0	-7.4	1.6	120	72.7	27075	-17.4	-9.0	8.4	121	73.8
32688	-	-	-	-	0	0.0	9142	-11.8	-7.4	4.4	63	38.2	31073	-10.1	-9.5	0.6	120	73.2
32689	2	-7.4	-7.4	0.0	1	2.0	9835	-9.0	-7.4	1.6	112	67.9	9662	-9.0	-7.4	1.6	78	47.6
32690	12027	-10.9	-10.9	0.0	35	71.4	34865	-10.9	-9.0	1.9	129	78.2	3884	-9.3	-9.0	0.3	34	20.7
32691	-	-	-	-	0	0.0	23712	-10.9	-9.0	1.9	110	66.7	-	-	-	-	0	0.0
32692	126	-7.4	-7.4	0.0	17	34.7	16704	-10.9	-7.4	3.5	122	73.9	17810	-9.3	-7.4	1.9	131	79.9
32693	777	-10.9	-10.9	0.0	24	49.0	26300	-10.9	-9.0	1.9	117	70.9	20360	-26.5	-9.0	17.5	120	73.2
32694	2582	-10.9	-7.4	3.5	30	61.2	38932	-14.8	-9.0	5.8	130	78.8	3808	-10.1	-9.0	1.1	67	40.9
32695	1203	-10.9	-7.4	3.5	22	44.9	6974	-10.9	-7.4	3.5	61	37.0	9706	-9.3	-7.4	1.9	95	57.9

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) and 2014/2015 (13 October, 2014 – 30 April, 2015) winter period. Refer to Table 2 for tagging and biological data.

Tag ID	2013/2014						2014/2015					
	# of Detections	Farthest Upstream (rkm)	Farthest Downstream (rkm)	Total detection range (rkm)	# of Days Detected	% Days Detected	# of Detections	Farthest Upstream (rkm)	Farthest Downstream (rkm)	Total detection range (rkm)	# of Days Detected	% Days Detected
32661	567	6.1	7.7	1.6	19	9.6	4883	7.7	10.2	2.5	46	23.0
32662	484	6.1	21.0	14.9	10	5.1	1422	47.5	47.5	0.0	24	12.0
32663	10755	6.1	16.8	10.7	87	44.2	8428	7.7	10.2	2.5	63	31.5
32664	3531	6.1	7.7	1.6	52	26.4	93	7.7	7.7	0.0	19	9.5
32665	272	6.1	7.7	1.6	10	5.1	1276	7.7	10.2	2.5	48	24.0
32666	1242	6.1	10.5	4.4	27	13.7	2860	7.7	10.2	2.5	26	13.0
32667	4980	6.1	10.2	4.1	54	27.4	-	-	-	-	0	0.0
32668	-	-	-	-	0	0.0	963	14.9	14.9	0.0	25	12.5
32669	1089	7.9	7.9	0.0	10	5.1	-	-	-	-	0	0.0
32670	27731	6.1	7.7	1.6	141	71.6	2770	7.7	10.5	2.8	54	27.0
32673	1548	6.1	21.0	14.9	17	8.6	1404	14.9	40.8	25.9	19	9.5
32674	243	7.7	14.9	7.2	8	4.1	399	14.9	14.9	0.0	14	7.0
32675	6497	6.1	7.7	1.6	66	33.5	4218	7.7	7.7	0.0	43	21.5
32680	11457	6.1	10.5	4.4	115	58.4	8863	7.9	10.5	2.6	97	48.5
32685	8417	6.1	14.9	8.8	101	51.3	1319	7.7	21.0	13.3	16	8.0
32696	2027	10.2	21.0	10.8	23	11.7	2284	7.7	21.0	13.3	23	11.5
32697	10294	6.1	7.7	1.6	87	44.2	371	7.7	10.2	2.5	14	7.0
32698	2153	6.1	14.9	8.8	71	36.0	275	7.7	14.9	7.2	14	7.0
32699	877	6.1	7.7	1.6	17	8.6	-	-	-	-	0	0.0
32700	12749	6.1	10.5	4.4	122	61.9	11466	7.7	10.2	2.5	88	44.0

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), 2014 (1 May – 12 October, 2014), and 2015 (1 May – 11 October, 2015) open-water seasons. Refer to Table 2 for tagging and biological data.

Tag ID	2013						2014						2015					
	# of Detections	Farthest Upstream (rkm)	Farthest Downstream (rkm)	Total detection range (rkm)	# of Days Detected	% Days Detected	# of Detections	Farthest Upstream (rkm)	Farthest Downstream (rkm)	Total detection range (rkm)	# of Days Detected	% Days Detected	# of Detections	Farthest Upstream (rkm)	Farthest 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	6280	1.3	17.4	16.1	107	65.2
32662	4164	2.5	14.9	12.4	26	89.7	11682	44.9	47.5	2.6	74	44.8	8910	42.7	44.9	2.2	71	43.3
32663	2690	2.5	7.7	5.2	25	100.0	10771	0.5	13.4	12.9	121	73.3	3745	1.3	10.5	9.2	82	50.0
32664	1890	2.5	10.2	7.7	15	62.5	14347	2.9	10.2	7.3	111	67.3	17796	1.3	11.0	9.7	115	70.1
32665	360	2.5	4.9	2.4	4	17.4	7433	2.9	21.0	18.1	85	51.5	4196	1.3	19.0	17.7	61	37.2
32666	396	0.7	10.0	9.3	7	23.3	9527	0.5	10.2	9.7	81	49.1	7921	1.3	11.0	9.7	85	51.8
32667	3633	2.5	7.7	5.2	21	72.4	4660	4.4	10.2	5.8	26	15.8	259	11.0	11.0	0.0	7	4.3
32668	2768	2.5	12.1	9.6	21	84.0	8076	4.3	14.9	10.6	79	47.9	8016	2.2	14.9	12.7	94	57.3
32669	75	2.5	4.9	2.4	7	28.0	12559	1.3	14.9	13.6	93	56.4	19628	1.3	14.9	13.6	117	71.3
32670	4289	0.7	7.7	7.0	23	79.3	25924	1.3	10.2	8.9	135	81.8	18930	1.3	11.0	9.7	131	79.9
32673	2191	2.5	14.9	12.4	25	100.0	11506	2.9	21.0	18.1	83	50.3	11254	1.3	19.0	17.7	105	64.0
32674	2468	2.5	12.1	9.6	22	88.0	13328	2.9	10.2	7.3	111	67.3	10650	1.3	14.9	13.6	105	64.0
32675	2933	2.5	7.7	5.2	22	91.7	19778	2.9	10.2	7.3	134	81.2	16380	1.3	7.7	6.4	126	76.8
32680	1579	0.7	10.0	9.3	18	75.0	1238	7.9	10.5	2.6	59	35.8	2273	7.9	7.9	0.0	62	37.8
32685	2034	2.5	10.0	7.5	21	87.5	18830	2.9	18.7	15.8	130	78.8	20054	1.3	21.0	19.7	135	82.3
32696	3803	2.5	18.7	16.2	25	83.3	9650	2.9	21.0	18.1	81	49.1	11864	1.3	14.9	13.6	133	81.1
32697	1623	0.7	4.9	4.2	21	70.0	9822	1.3	6.1	4.8	108	65.5	14190	1.3	11.0	9.7	120	73.2
32698	2082	2.5	14.9	12.4	18	60.0	9414	1.3	21.0	19.7	99	60.0	14110	1.3	14.9	13.6	116	70.7
32699	556	2.5	6.3	3.8	11	37.9	0	-	-	-	0	0.0	-	-	-	-	0	0.0
32700	2830	2.5	14.9	12.4	21	84.0	14196	0.5	14.9	14.4	112	67.9	11478	1.3	19.0	17.7	120	73.2

FIGURES

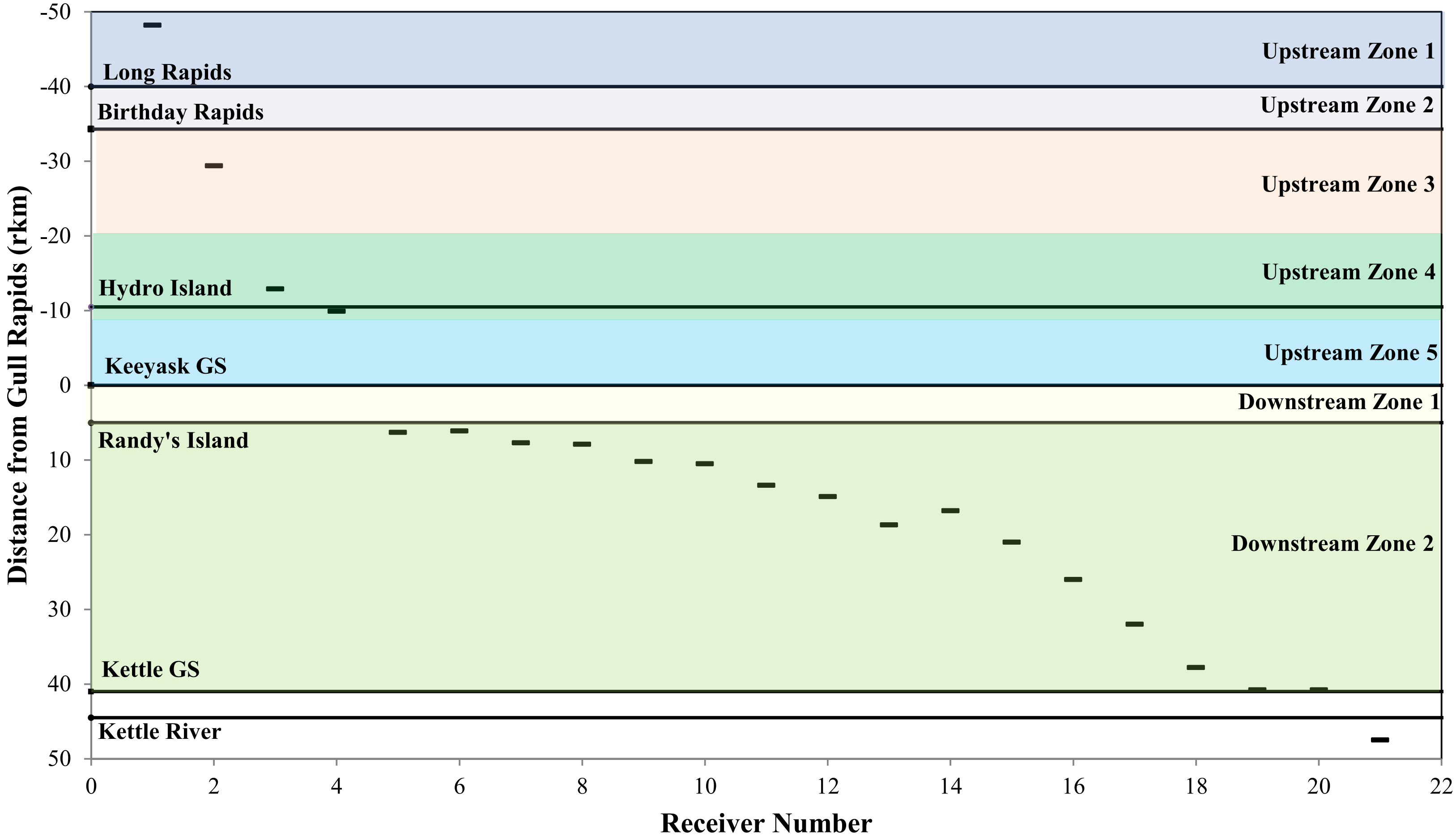


Figure 1: **Locations of stationary acoustic receivers (dashes) in relation to the base of Gull Rapids (rkm 0) and other major landmarks (lines) in the Nelson River between Clark Lake and the Long Spruce GS between October, 2014 and June, 2015. River zones upstream and downstream of Gull Rapids are indicated by shading.**

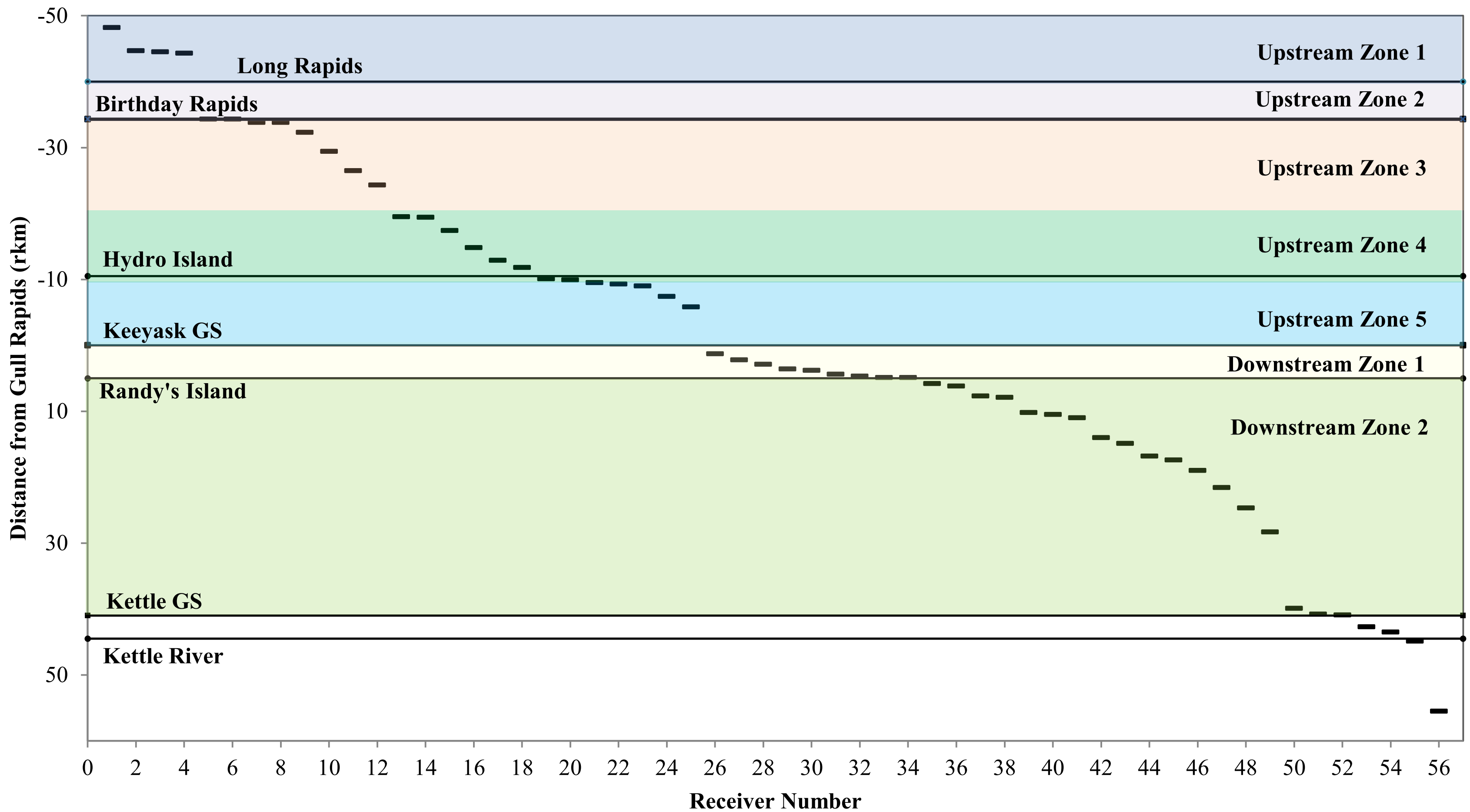


Figure 2: **Locations of stationary acoustic receivers (dashes) in relation to the base of Gull Rapids (rkm 0) and other major landmarks (lines) in the Nelson River between Clark Lake and the Long Spruce GS between June and October, 2015. River zones upstream and downstream of Gull Rapids are indicated by shading.**

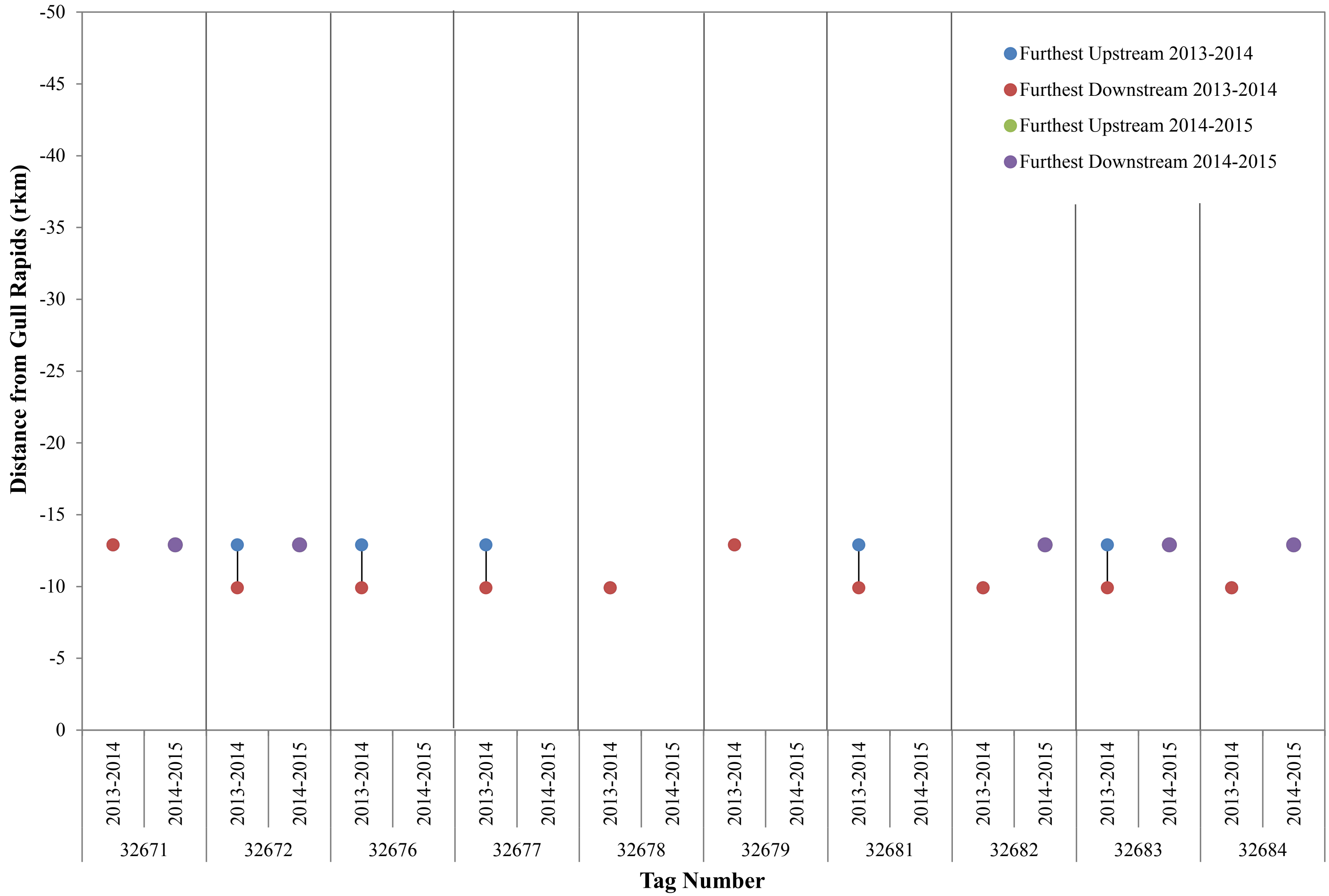


Figure 3: **Detection ranges for acoustic tagged juvenile Lake Sturgeon detected between Clark Lake and Gull Rapids during the winter 2013/2014 and 2014/2015 periods.**

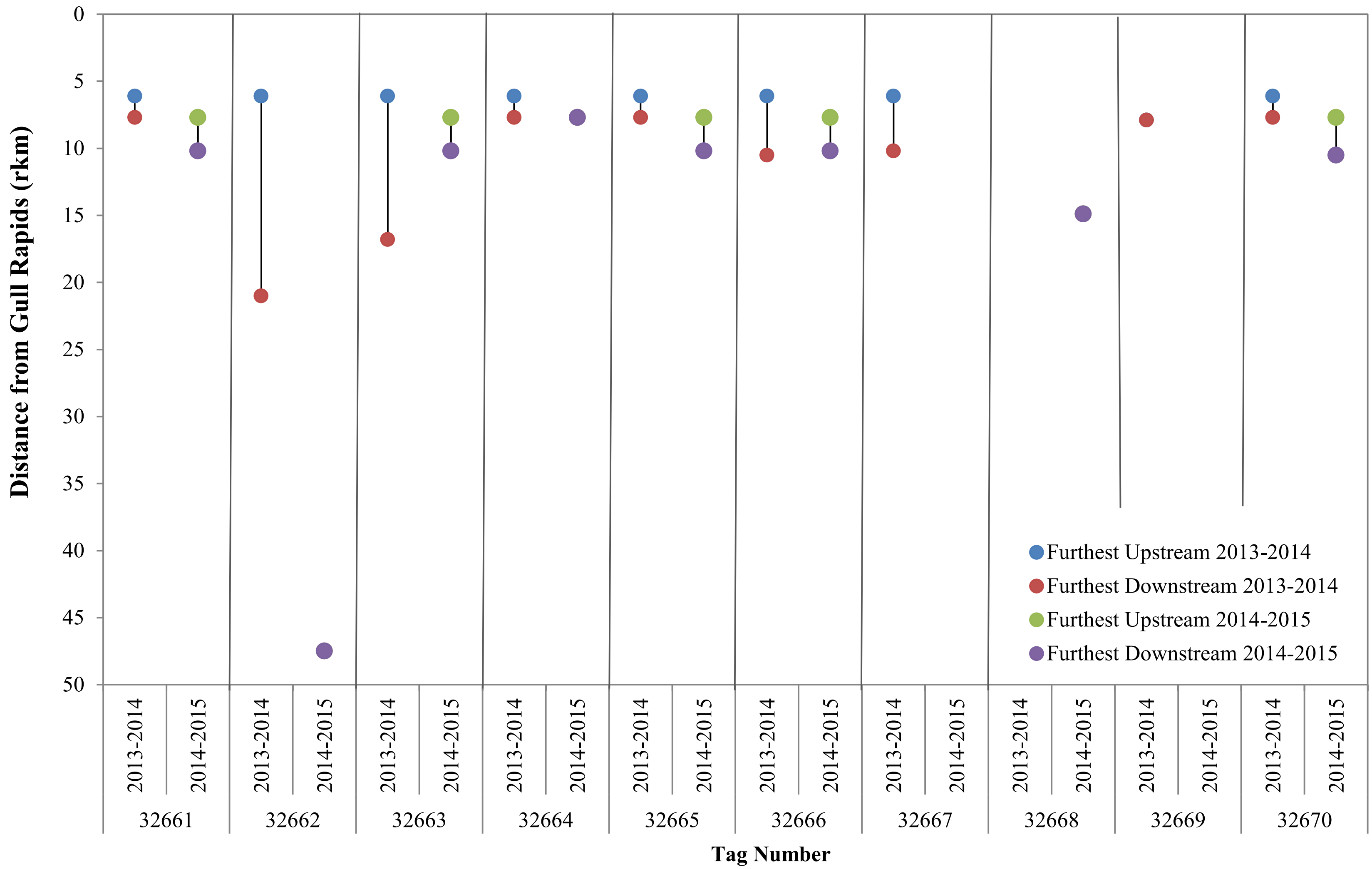


Figure 4: Detection ranges for acoustic tagged juvenile Lake Sturgeon detected downstream of Gull Rapids during the winter 2013/2014 and 2014/2015 periods.

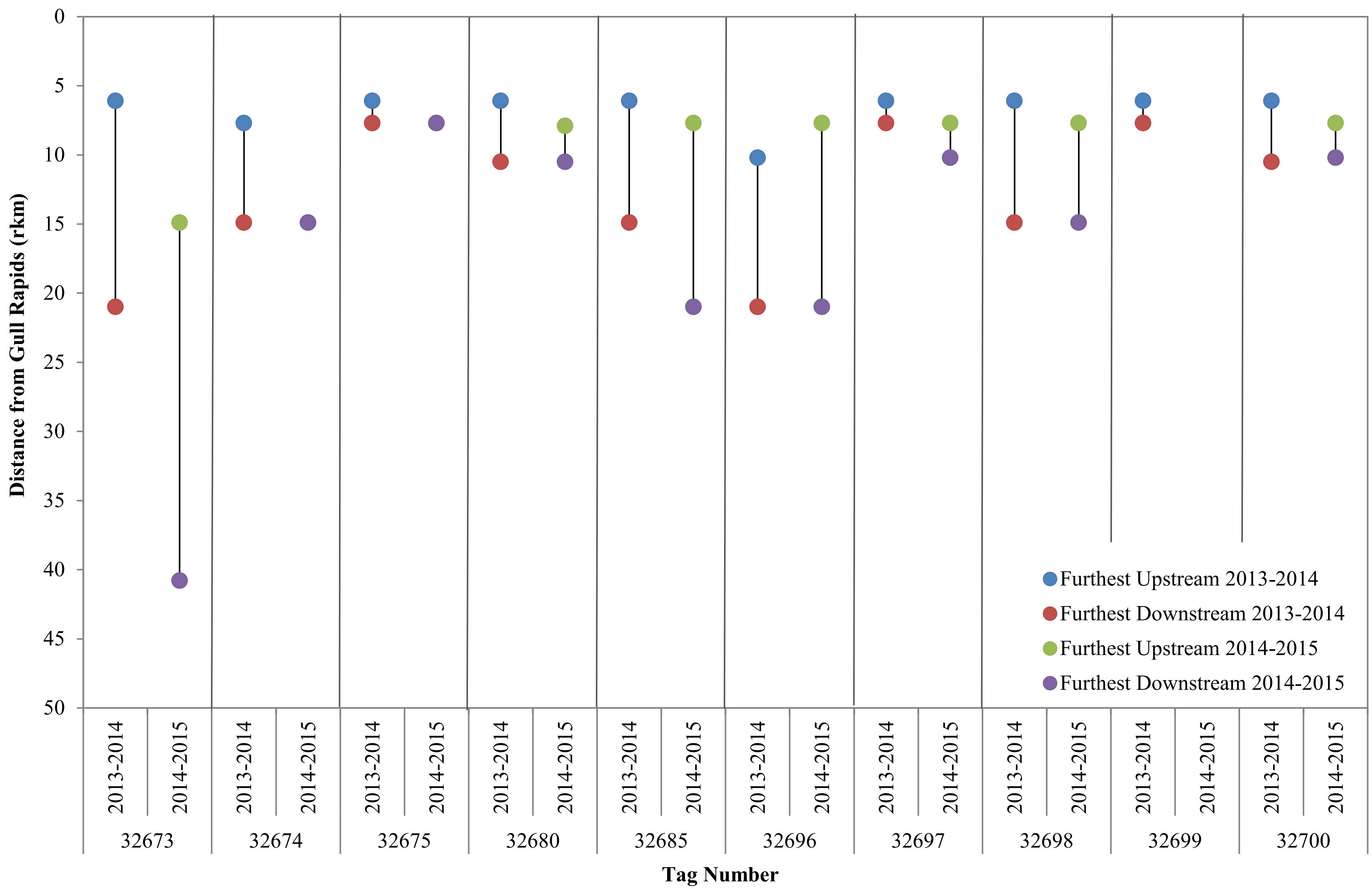


Figure 4: **Detection ranges for acoustic tagged juvenile Lake Sturgeon detected downstream of Gull Rapids during the winter 2013/2014 and 2014/2015 periods (continued).**

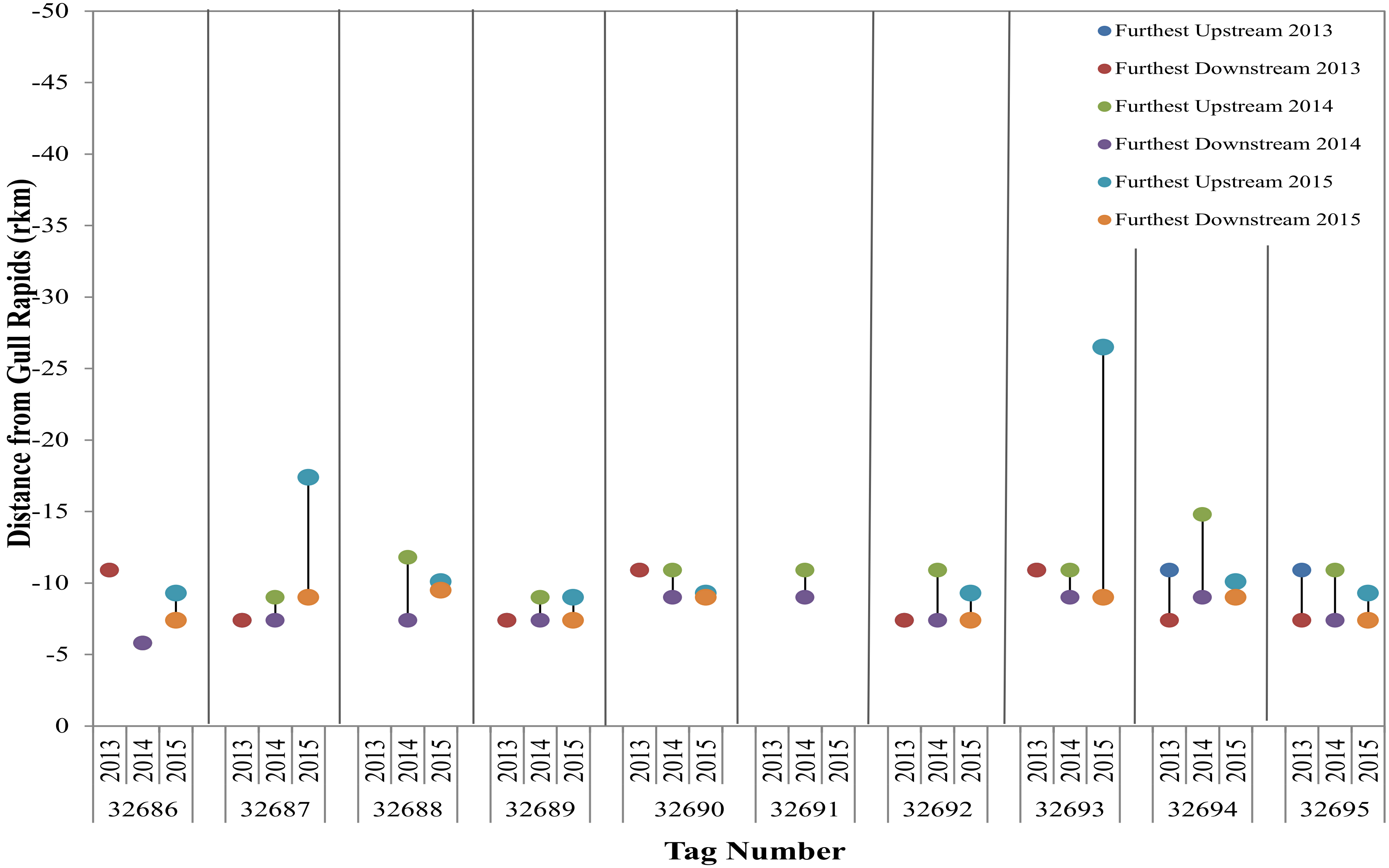


Figure 5: **Detection ranges for acoustic tagged juvenile Lake Sturgeon between Clark Lake and Gull Rapids during the open water periods of 2013-2015.**

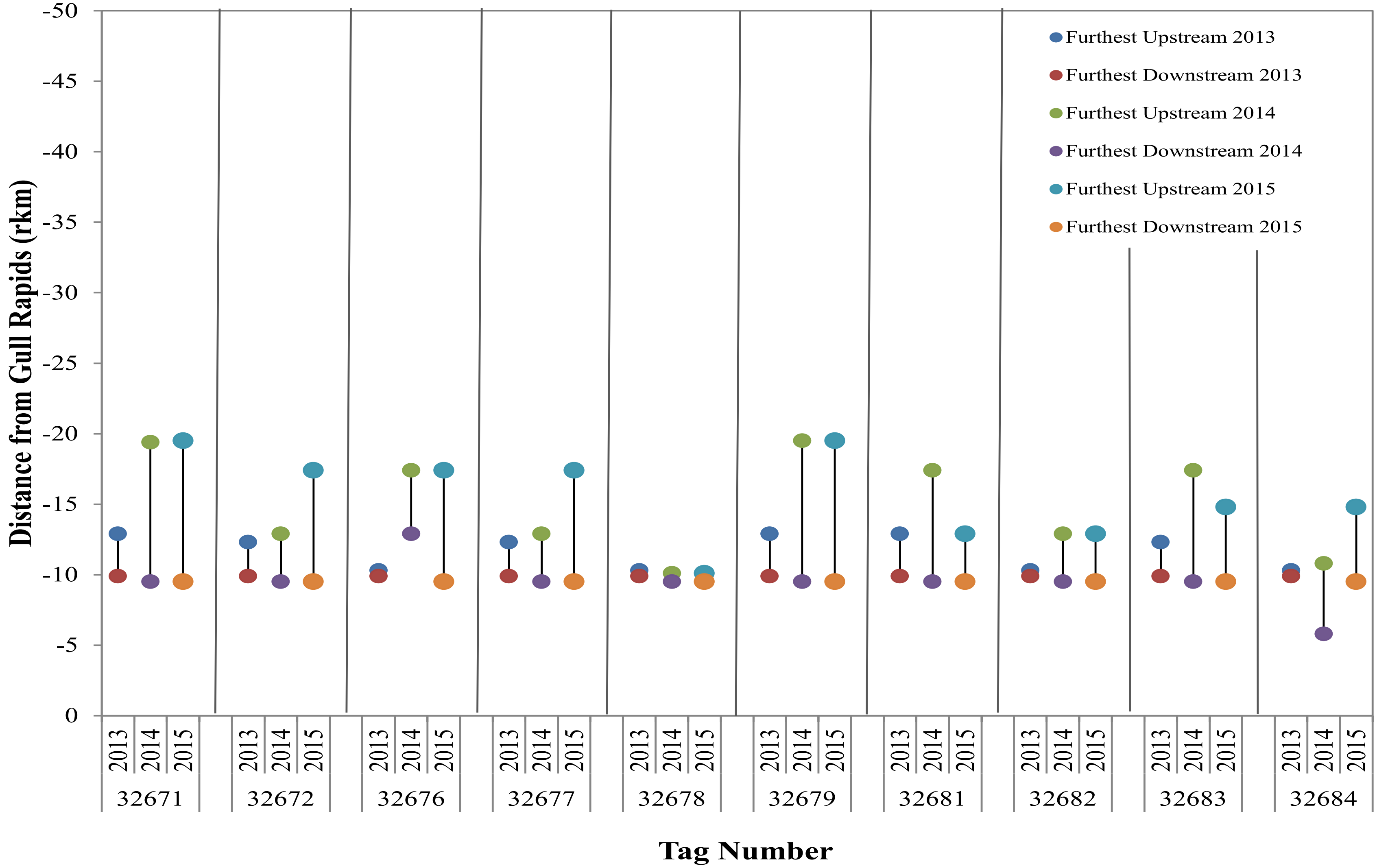


Figure 5: Detection ranges for acoustic tagged juvenile Lake Sturgeon between Clark Lake and Gull Rapids during the open water periods of 2013-2015 (continued).

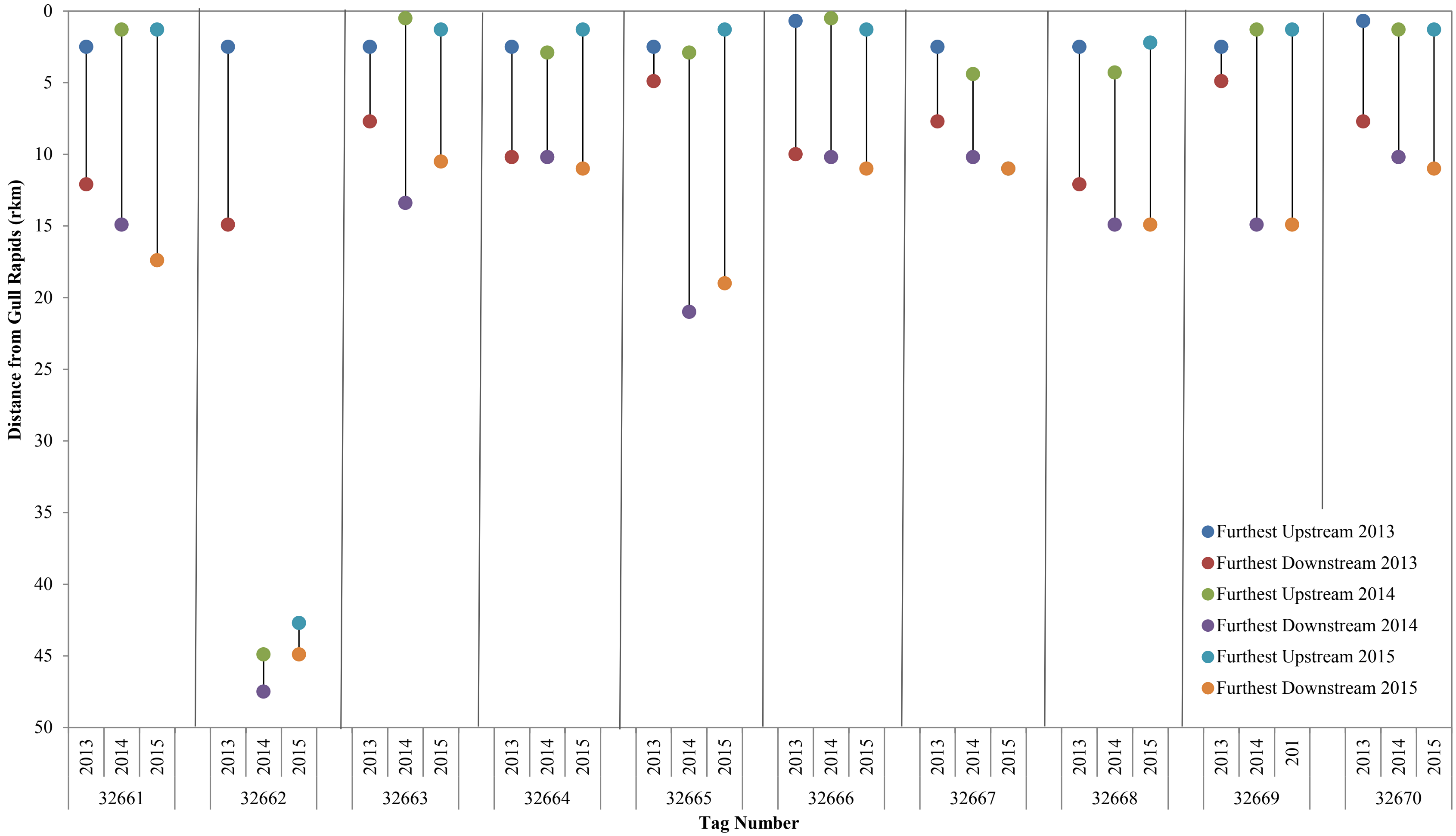


Figure 6: Detection ranges for acoustic tagged juvenile Lake Sturgeon downstream of Gull Rapids during the open-water periods of 2013-2015.

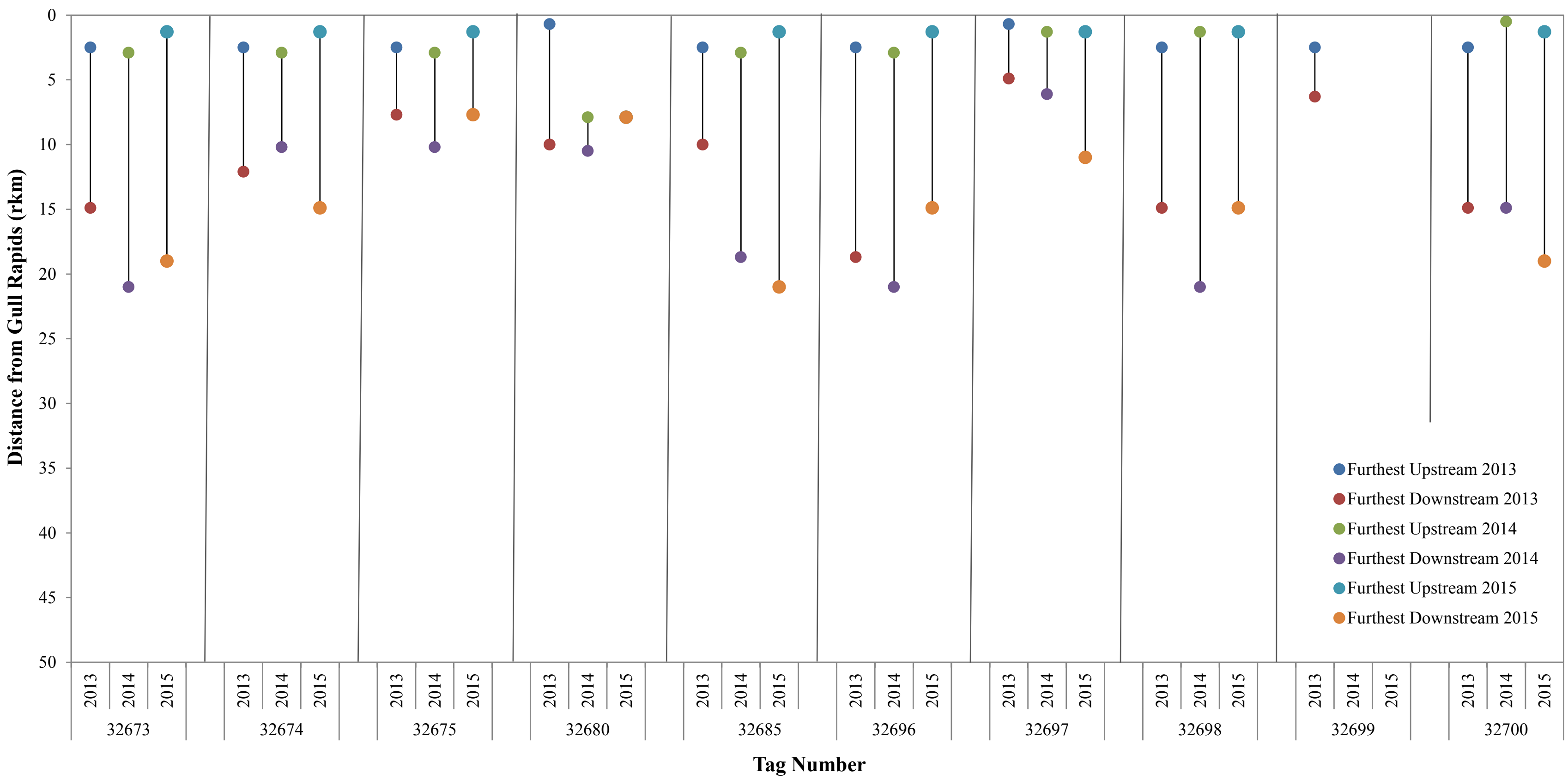


Figure 6: Detection ranges for acoustic tagged juvenile Lake Sturgeon downstream of Gull Rapids during the open-water periods of 2013-2015 (continued).

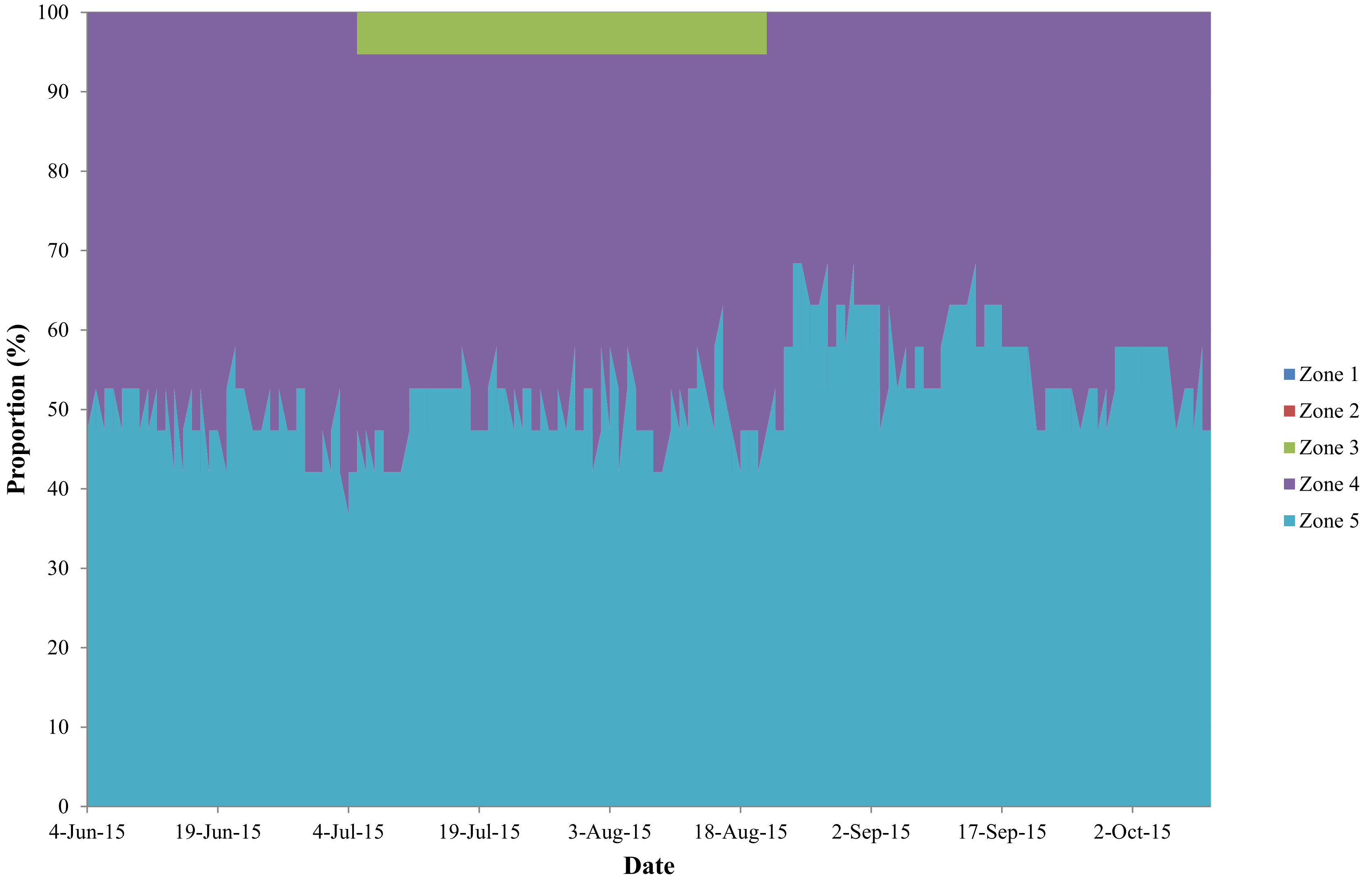


Figure 7: Proportional distribution by zone for juvenile Lake Sturgeon between Clark Lake and Gull Rapids during a portion of the 2015 open-water period (4 June to 11 October, 2015).

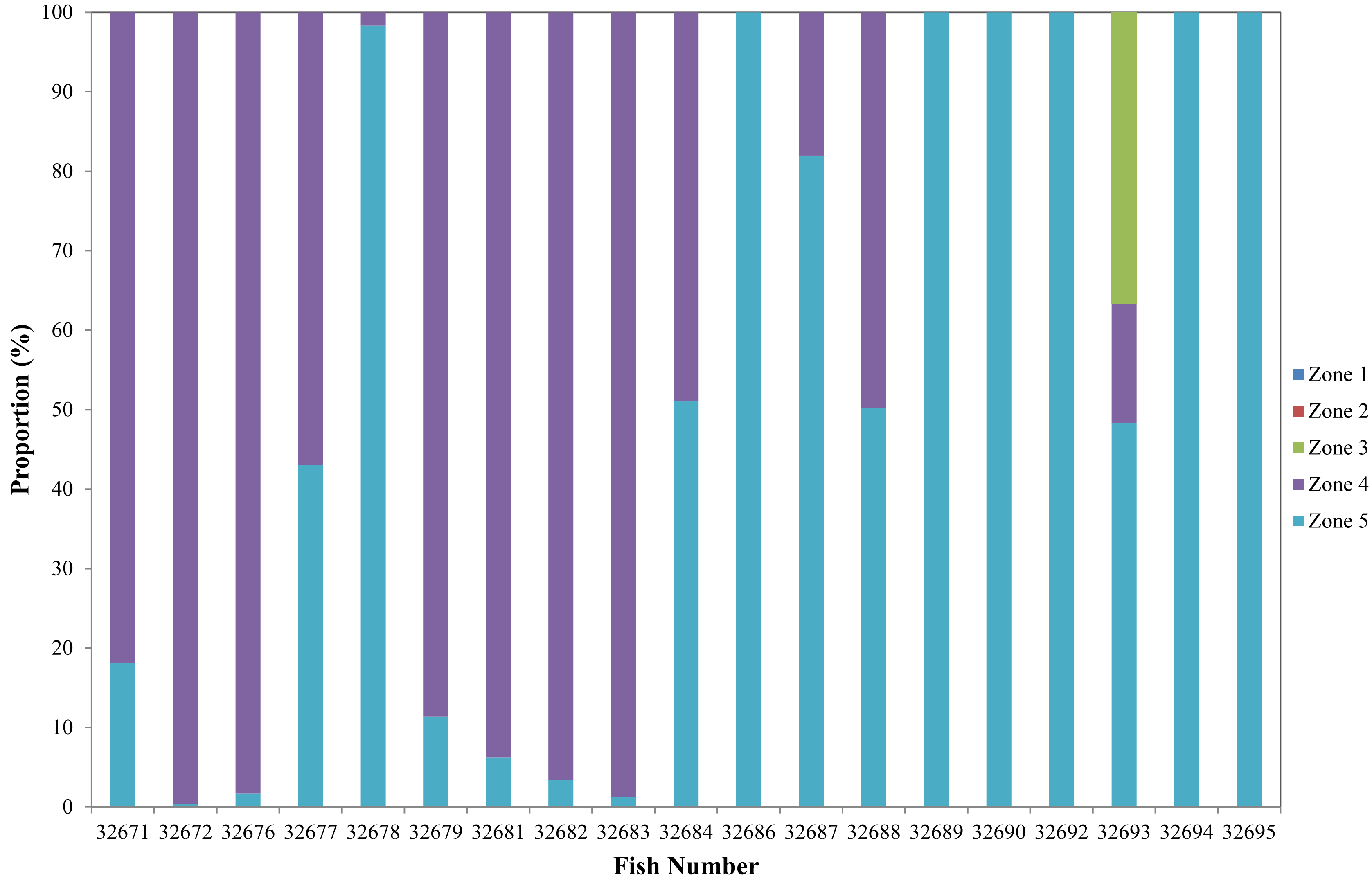


Figure 8: Proportional distributions by zone for individual juvenile Lake Sturgeon between Clark Lake and Gull Rapids during a portion of the 2015 open-water period (4 June to 11 October, 2015).

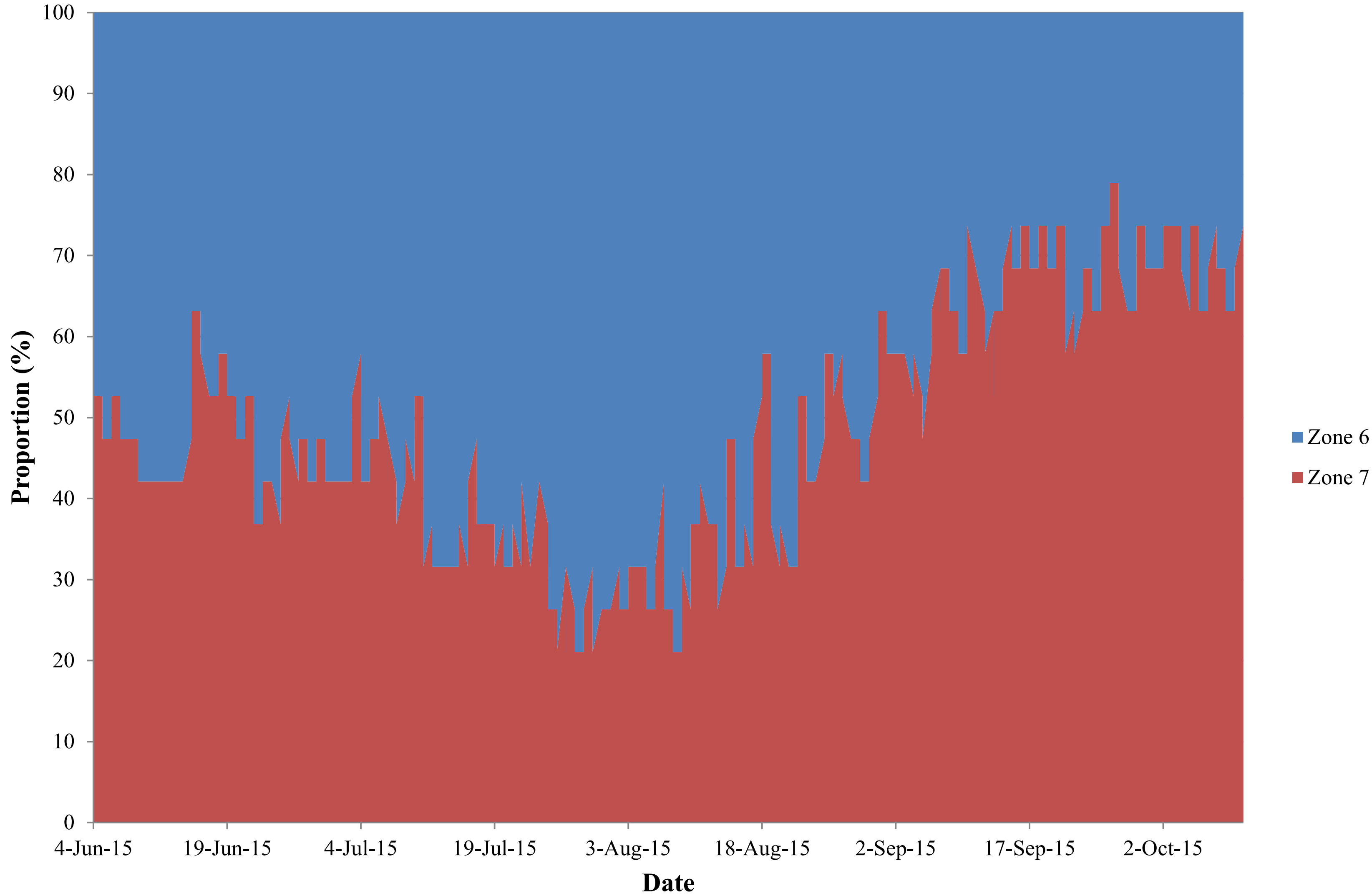


Figure 9: Proportional distribution, by zone, for juvenile Lake Sturgeon downstream of Gull Rapids during a portion of the 2015 open-water period (4 June to 11 October, 2015).

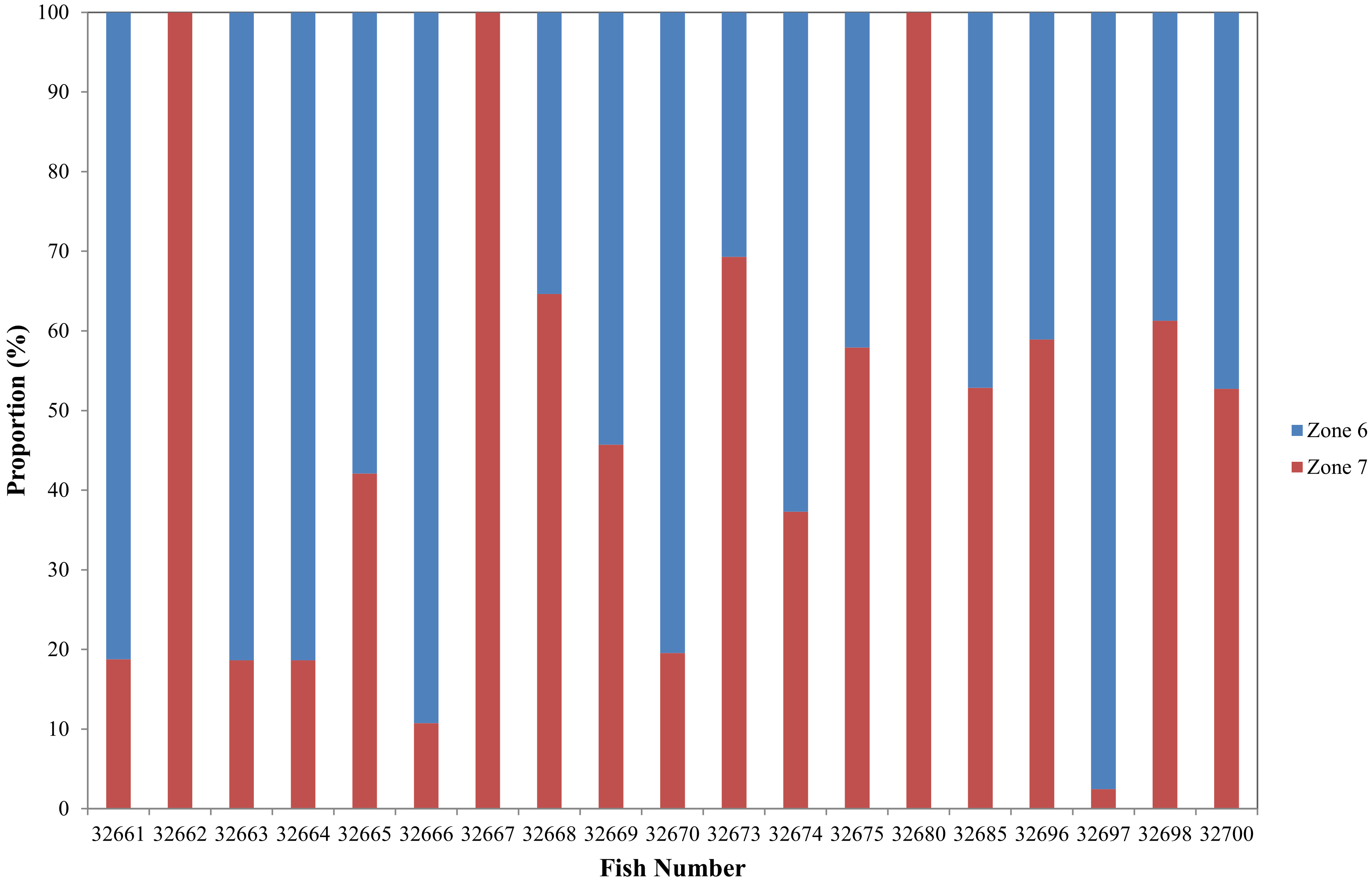
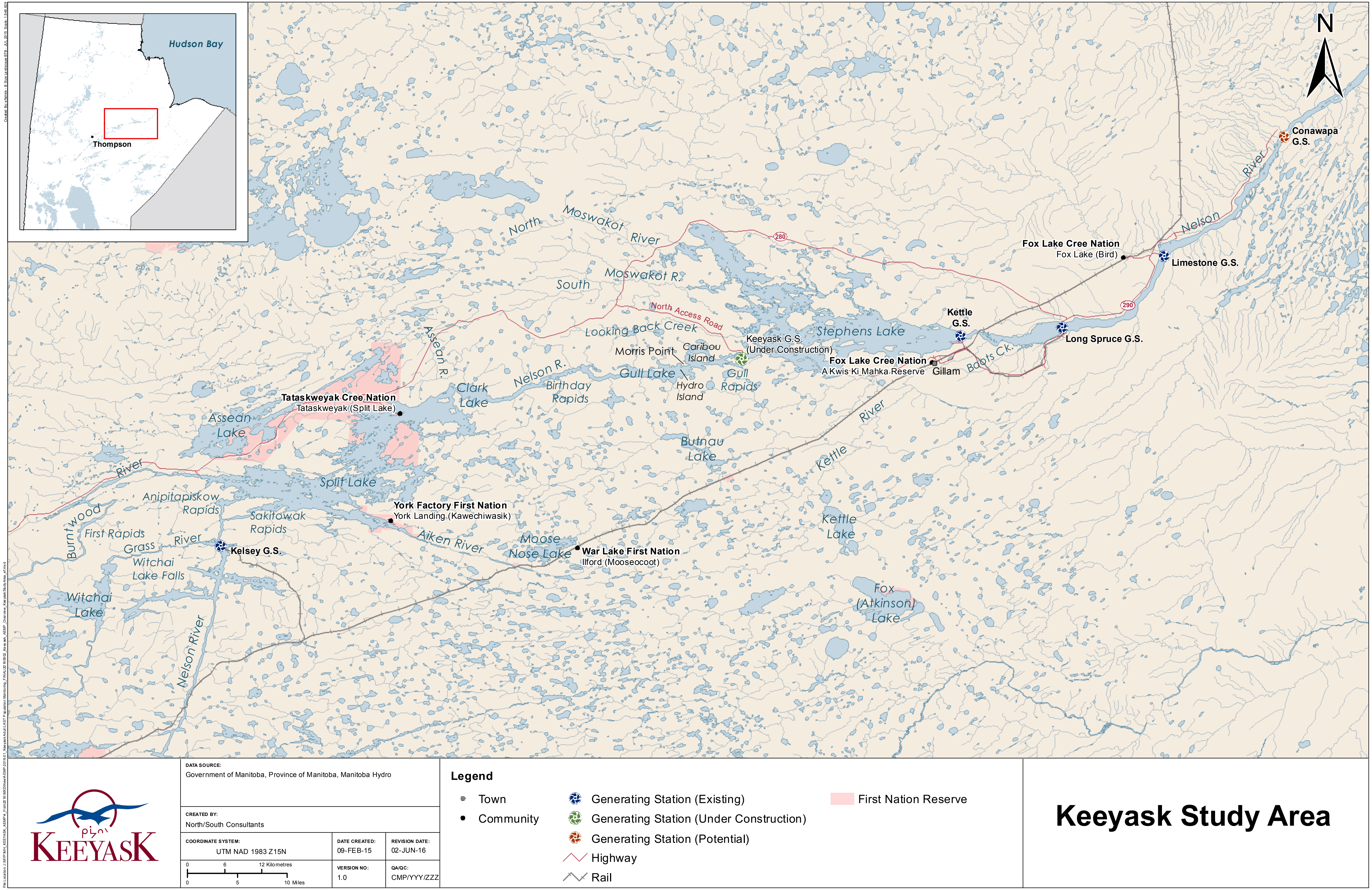


Figure 10: Proportional distributions by zone for individual juvenile Lake Sturgeon downstream of Gull Rapids during a portion of the 2015 open-water period (4 June to 11 October, 2015).

MAPS



Map 1: Map of the Nelson River showing the site of the Keeyask Generating Station.

DATA SOURCE: Orthophoto: Manitoba Hydro - June 21, 2015			
CREATED BY: North/South Consultants			
COORDINATE SYSTEM: UTM NAD 1983 Z15N		DATE CREATED: 26-FEB-10	REVISION DATE: 30-MAY-16
0 0.15 0.3 Kilometres 0 0.15 0.3 Miles		VERSION NO: 2.0	QA/QC: PMC/FSV/MWZ

Construction Site

Map 2: **Map of instream structures at the Keeyask Generating Station site, June 2015.**

DATA SOURCE:
Manitoba Hydro; Government of Manitoba; Government of Canada:
Imagery - 2010 Keeyask 10cm and 1999 Gull 1m (Black an White)

CREATED BY:
Manitoba Hydro - GIS Studies

COORDINATE SYSTEM: UTM NAD 1983 Z15N

DATE CREATED: 22-MAY-15

REVISION DATE: 06-JAN-16

VERSION NO: 1.0

QA/QC:

0 0.4 0.8 Kilometres

0 0.3 0.6 Miles

Legend

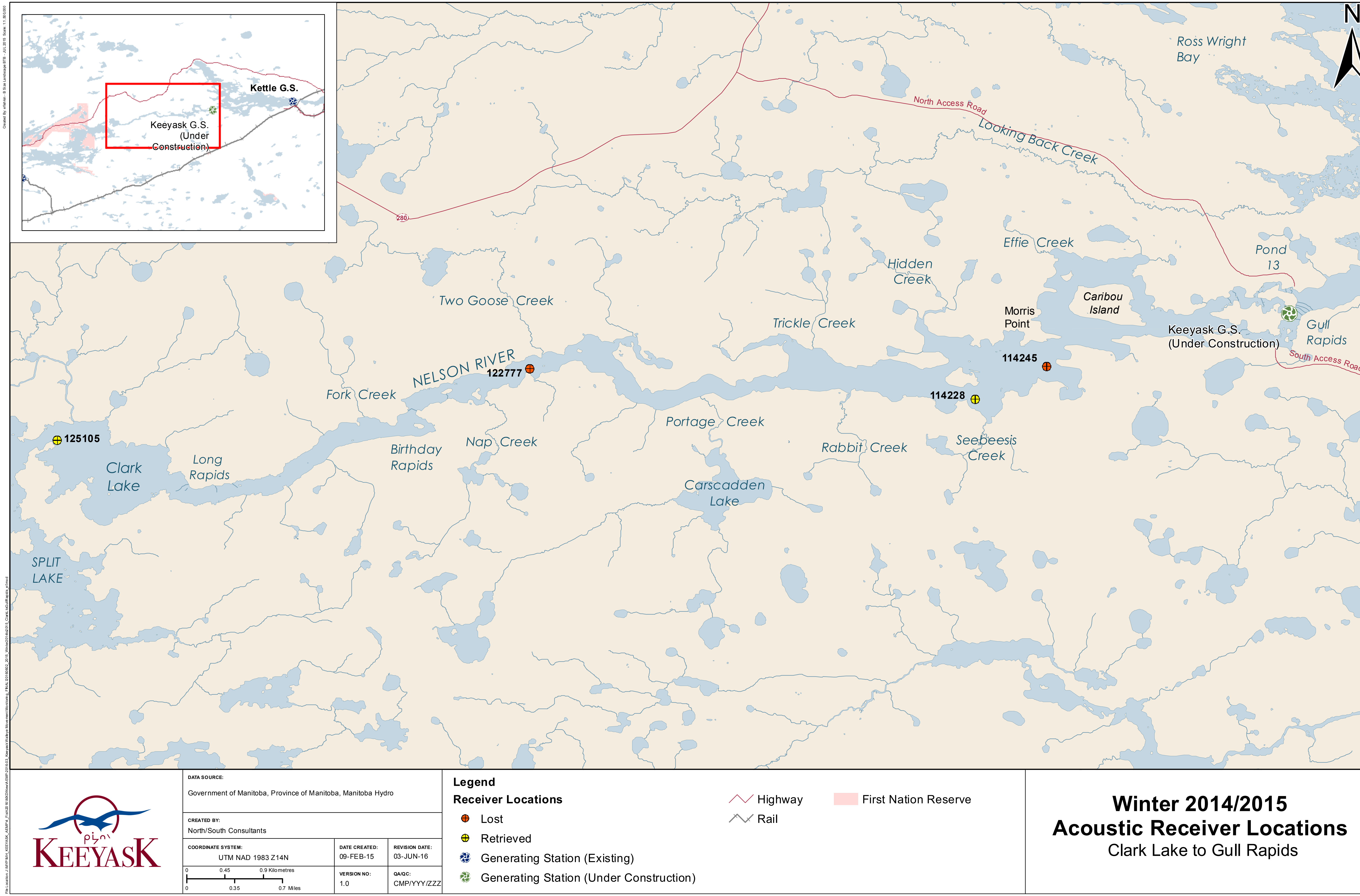
Ice Boom

Infrastructure

KEEYASK

Keeyask G.S. Ice Boom Locations

Map 3: Locations where ice booms were installed, July to August 2015.



Map 4: **Locations of stationary receivers set in the Nelson River from Clark Lake to Gull Rapids between October 2014 and June 2015.**

DATA SOURCE:
Government of Manitoba, Province of Manitoba, Manitoba Hydro

CREATED BY:
North/South Consultants

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	09-FEB-15	09-JUN-16
0 0.45 0.9 Kilometres / 0 0.35 0.7 Miles	VERSION NO: 1.0	QA/QC: CMP/YYY/ZZZ

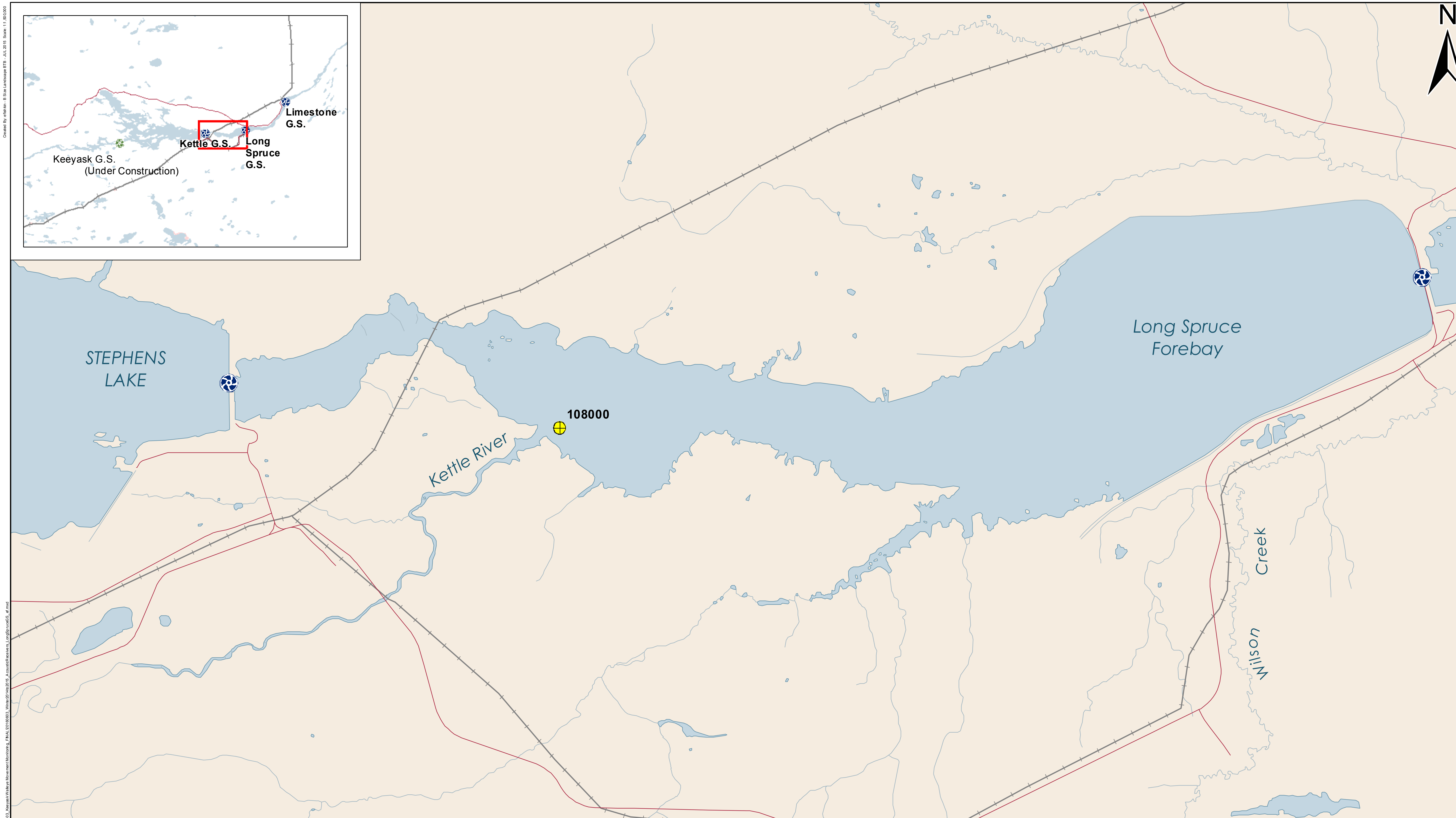
KEEYASK

Legend

Receiver Locations
- Lost
- Retrieved
- Generating Station (Existing)
- Generating Station (Under Construction)
- Highway
- Rail
- First Nation Reserve

Winter 2014/2015
Acoustic Receiver Locations
Stephens Lake

Map 5: Locations of stationary receivers set in Stephens Lake from Gull Rapids to Kettle GS between October 2014 and June 2015. The former (pre-impoundment) river channel is shown in light blue.



DATA SOURCE:
Government of Manitoba, Province of Manitoba, Manitoba Hydro

CREATED BY:
North/South Consultants

COORDINATE SYSTEM: UTM NAD 1983 Z14N

DATE CREATED: 09-FEB-15

REVISION DATE: 03-JUN-16

VERSION NO: 1.0

QA/QC: CMP/YYY/ZZZ

0 0.45 0.9 Kilometres

0 0.35 0.7 Miles

Legend

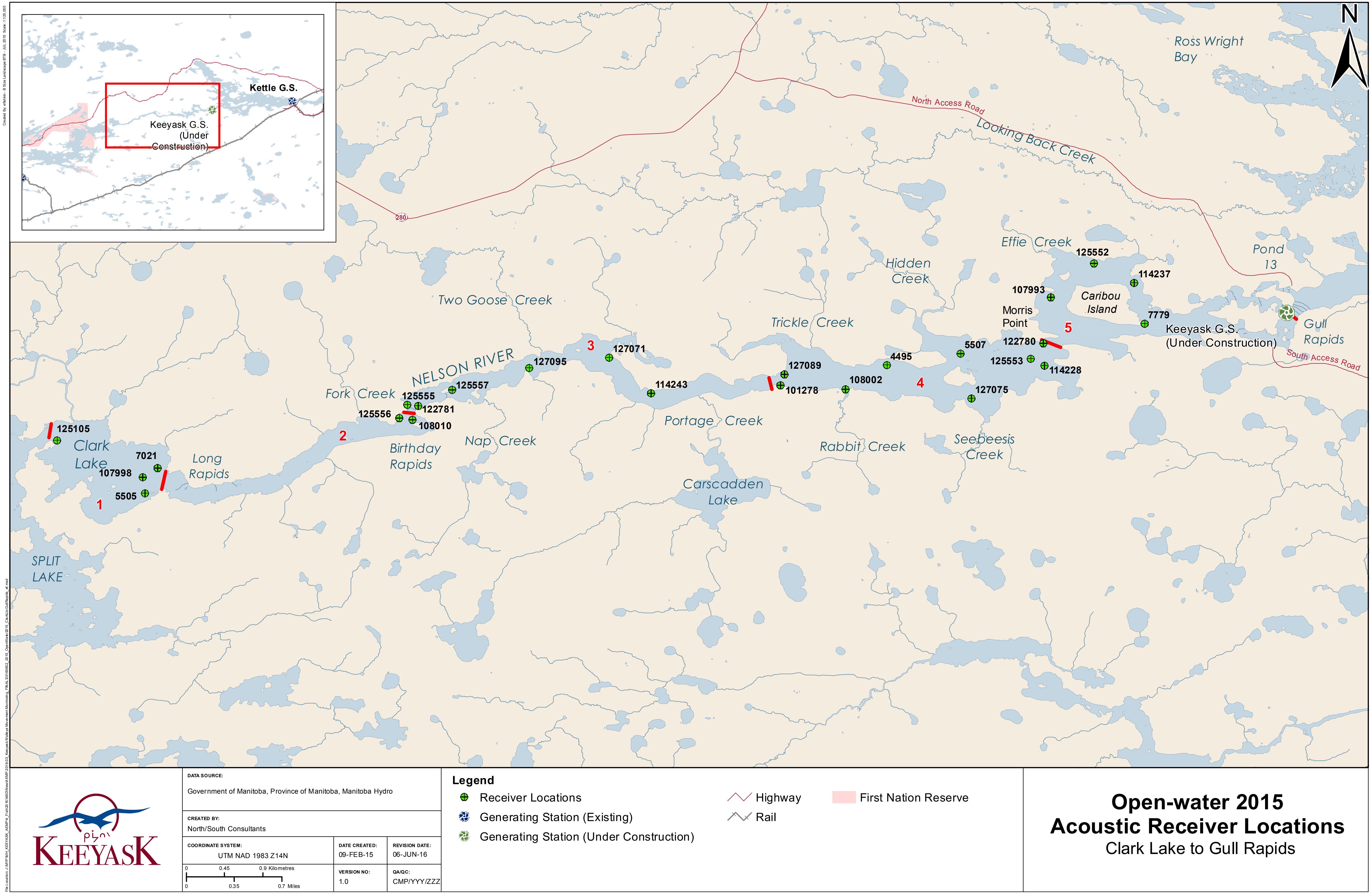
- Receiver Locations
- Generating Station (Existing)
- Generating Station (Under Construction)
- Highway
- Rail
- First Nation Reserve

KEEYASK

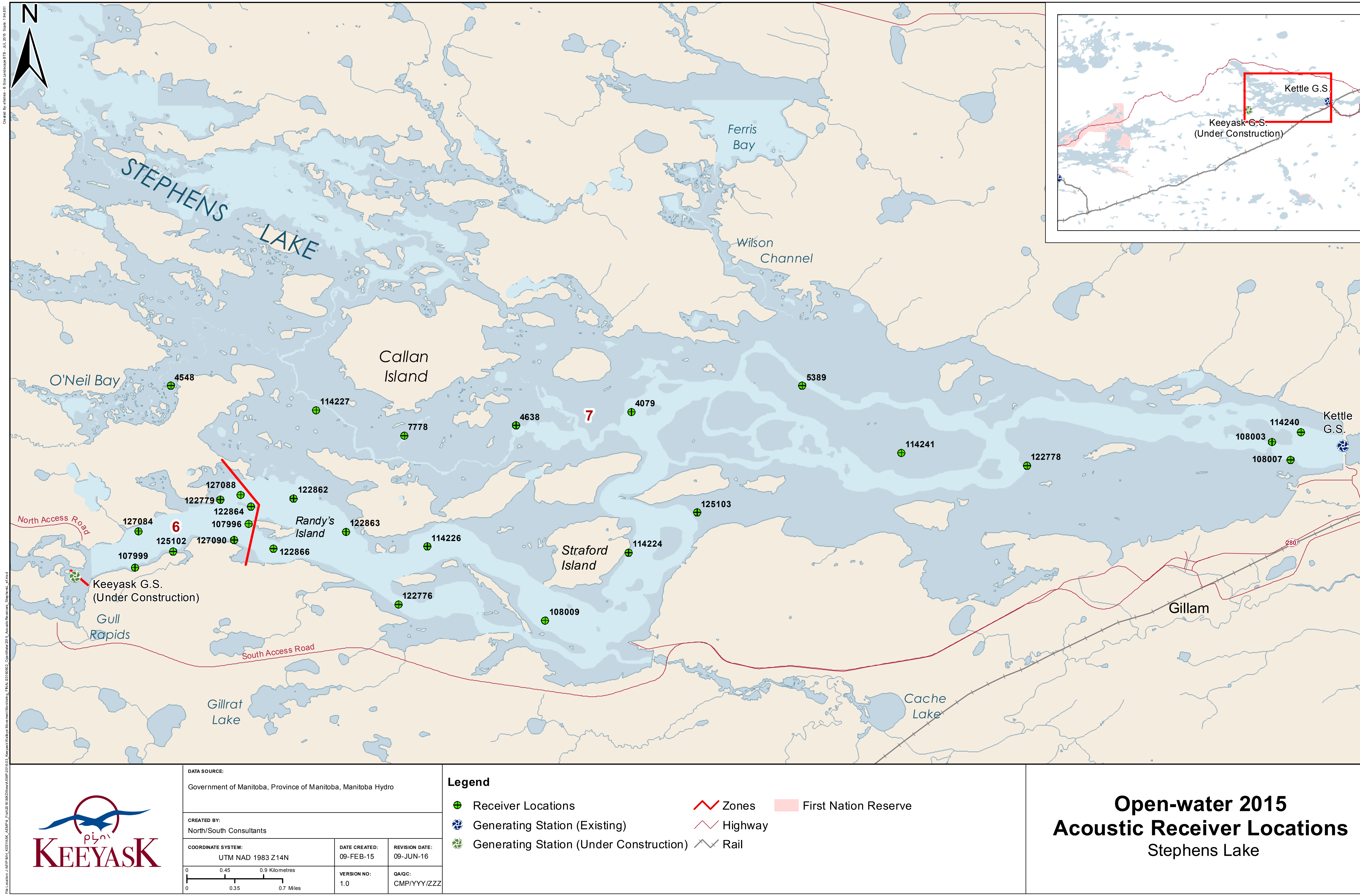
Winter 2014/2015 Acoustic Receiver Locations

Long Spruce G.S. Reservoir

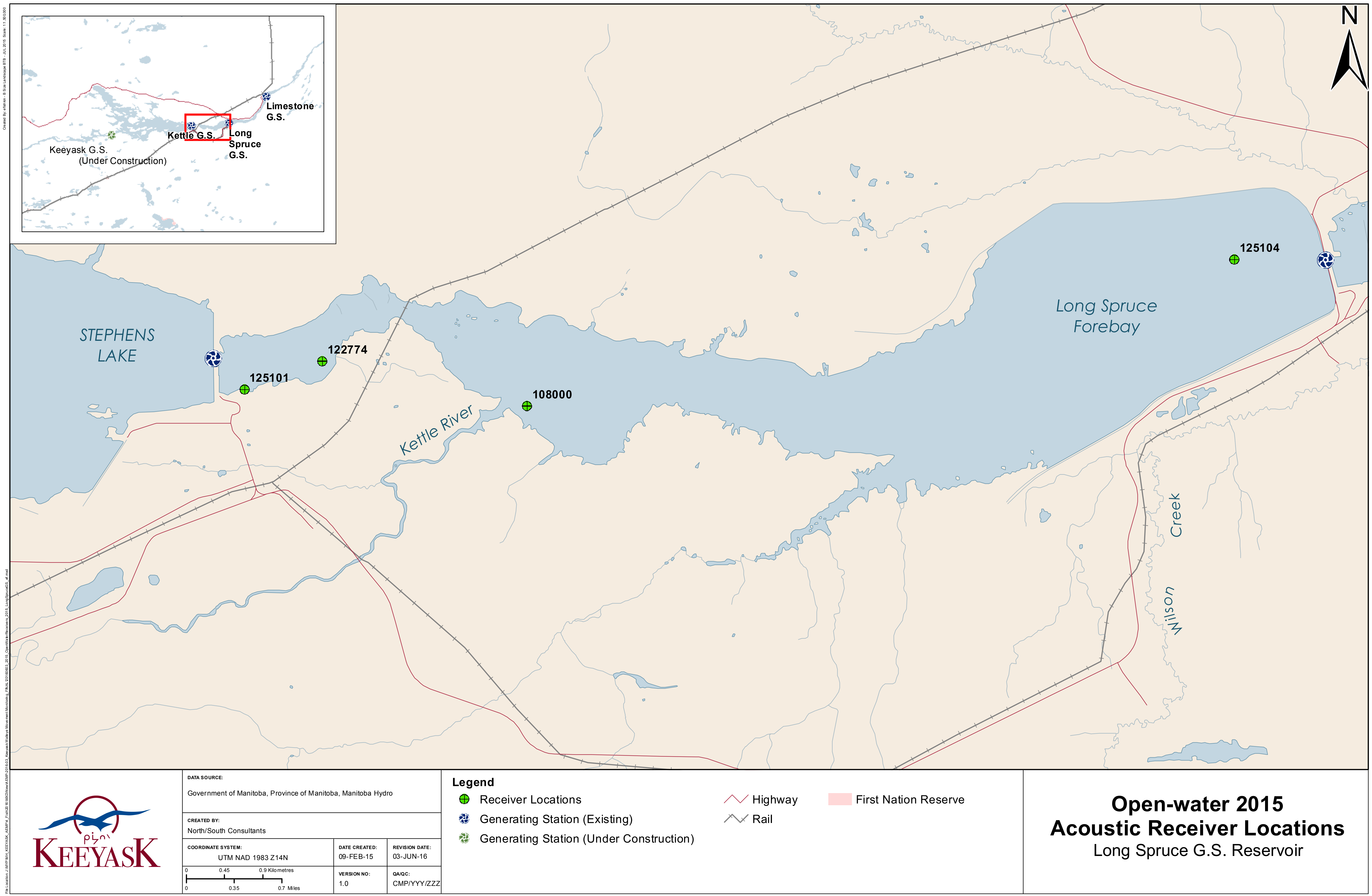
Map 6: Locations of stationary receviers set in the Long Spruce Forebay between October 2014 and June 2015.



Map 7: Locations of stationary receivers set in the Nelson River from Clark Lake to Gull Rapids between June and October 2015. The river is divided into five "zones" based on placement of receiver "gates".



Map 8: **Locations of stationary receivers set in Stephens Lake from Gull Rapids to Kettle GS between June and October 2015. The river is divided into two "zones" based on placement of receiver "gates". The pre-impoundment river channel is shown in light blue.**



Map 9: **Locations of stationary receivers set in the Long Spruce Forebay between June and October 2015.**

APPENDICES

APPENDIX 1: LOCATION SUMMARY FOR INDIVIDUAL ACOUSTIC TAGGED JUVENILE LAKE STURGEON UPSTREAM OF GULL RAPIDS, AUGUST 2013 TO OCTOBER 2015

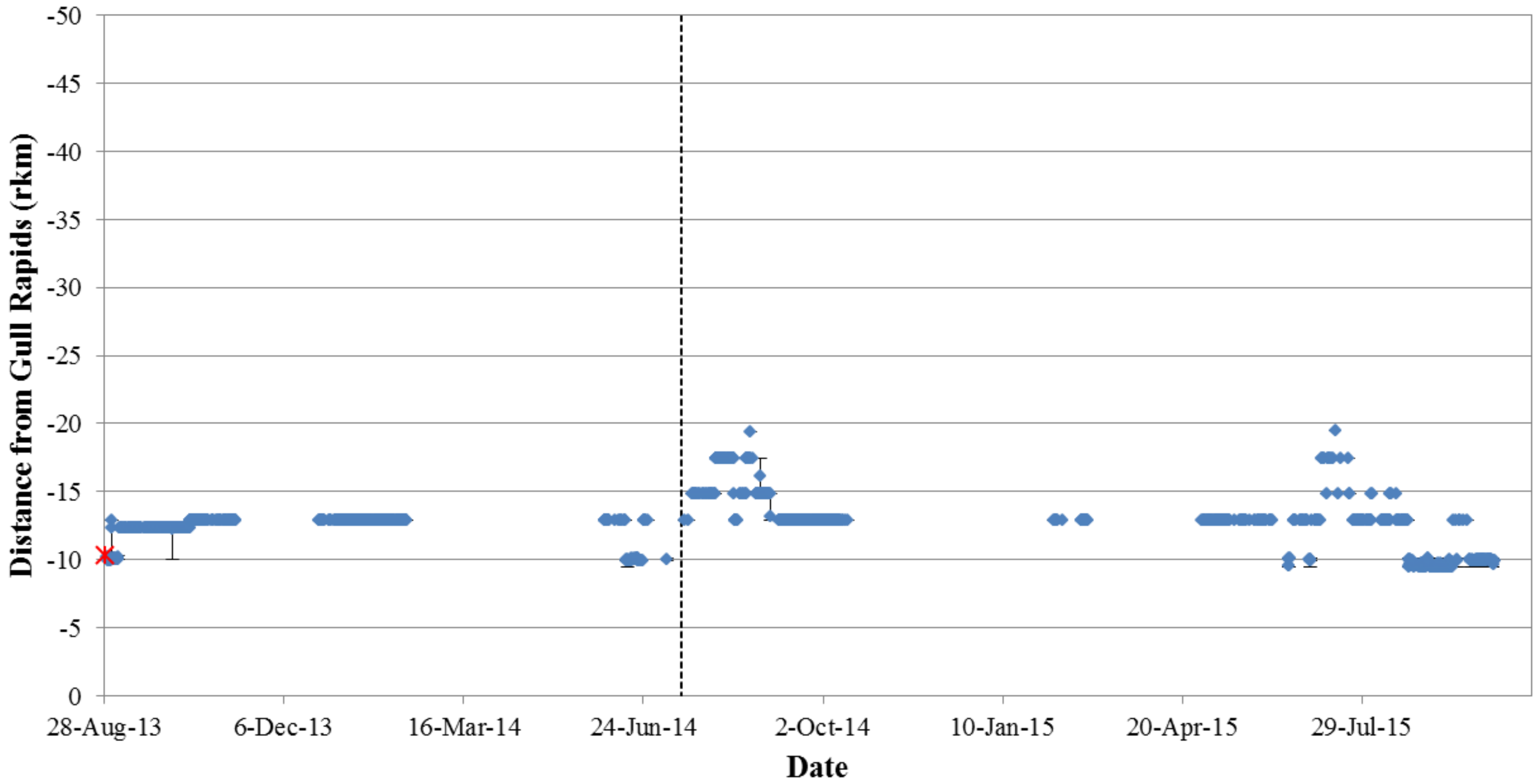


Figure A1-1: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32671) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 11 October, 2015. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

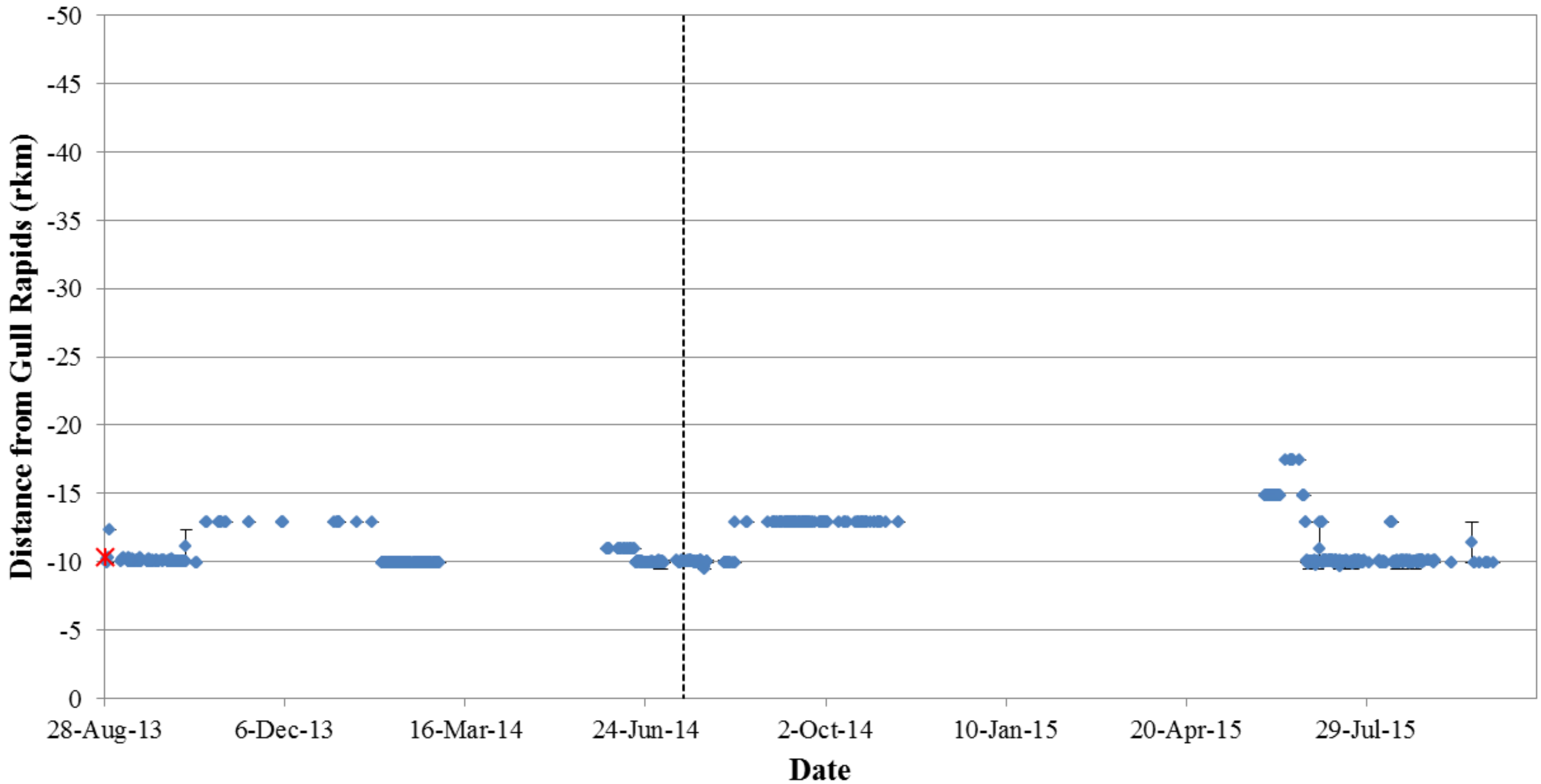


Figure A1-2: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32672) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 11 October, 2015. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

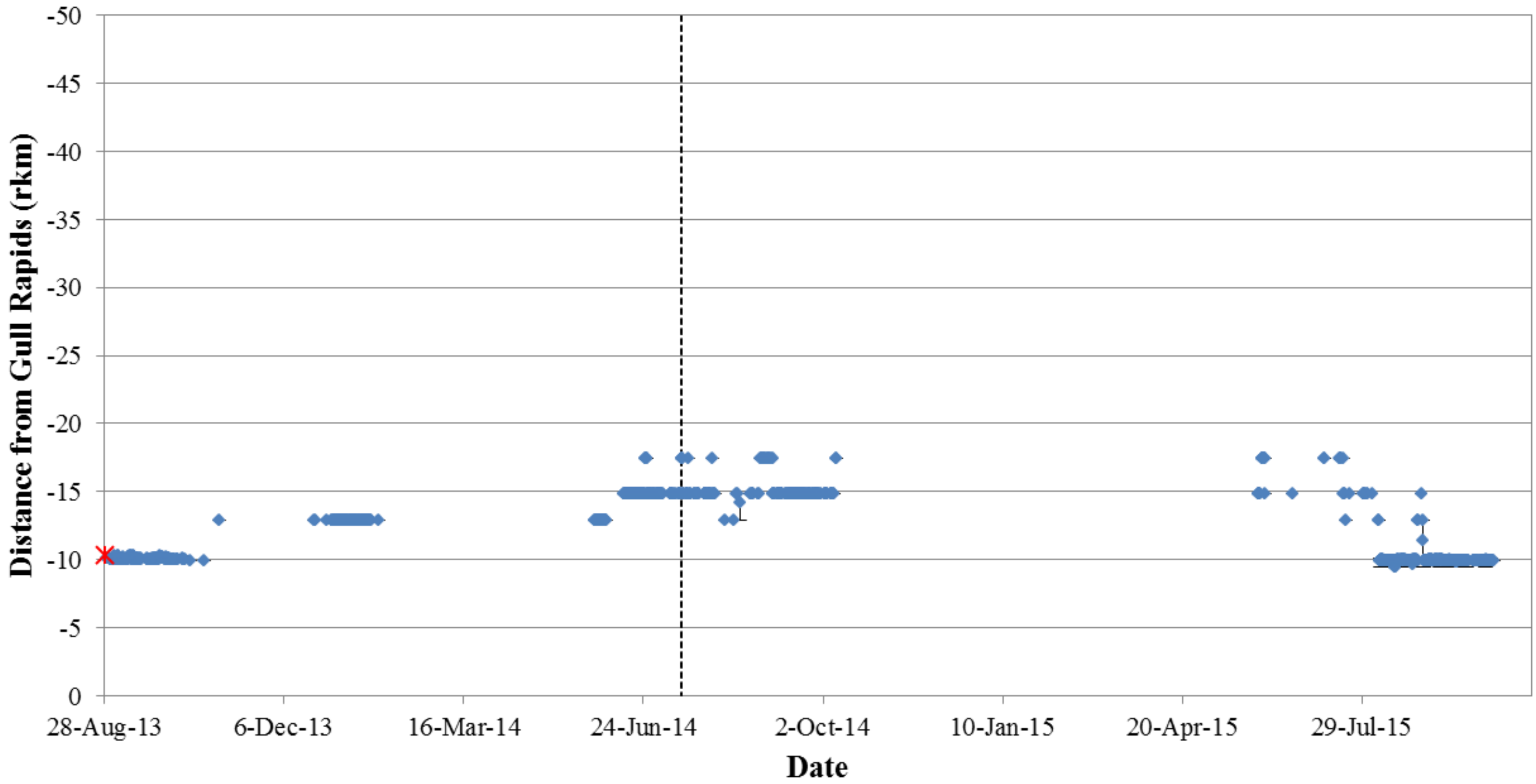


Figure A1-3: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32676) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 11 October, 2015. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

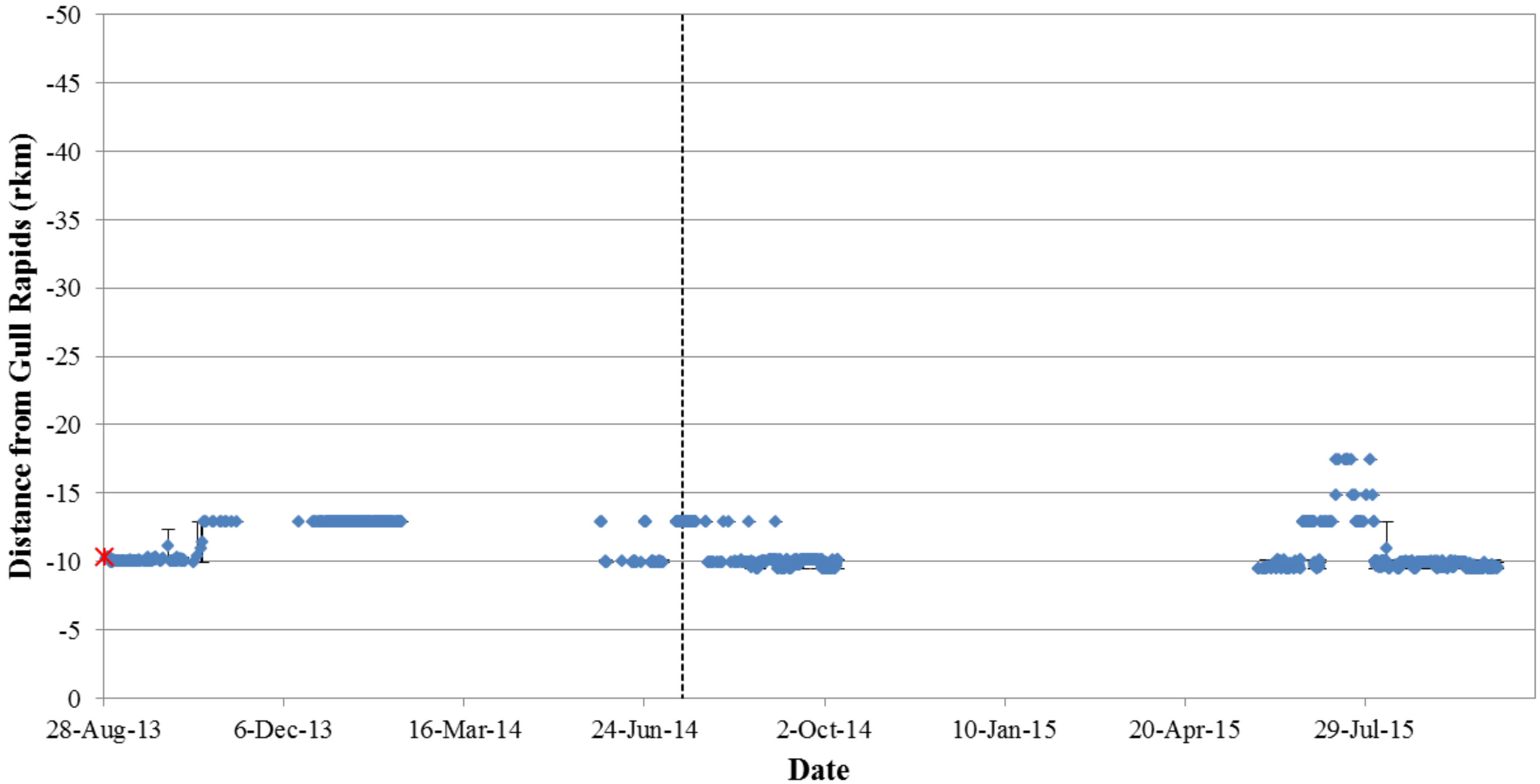


Figure A1-4: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32677) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 11 October, 2015. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

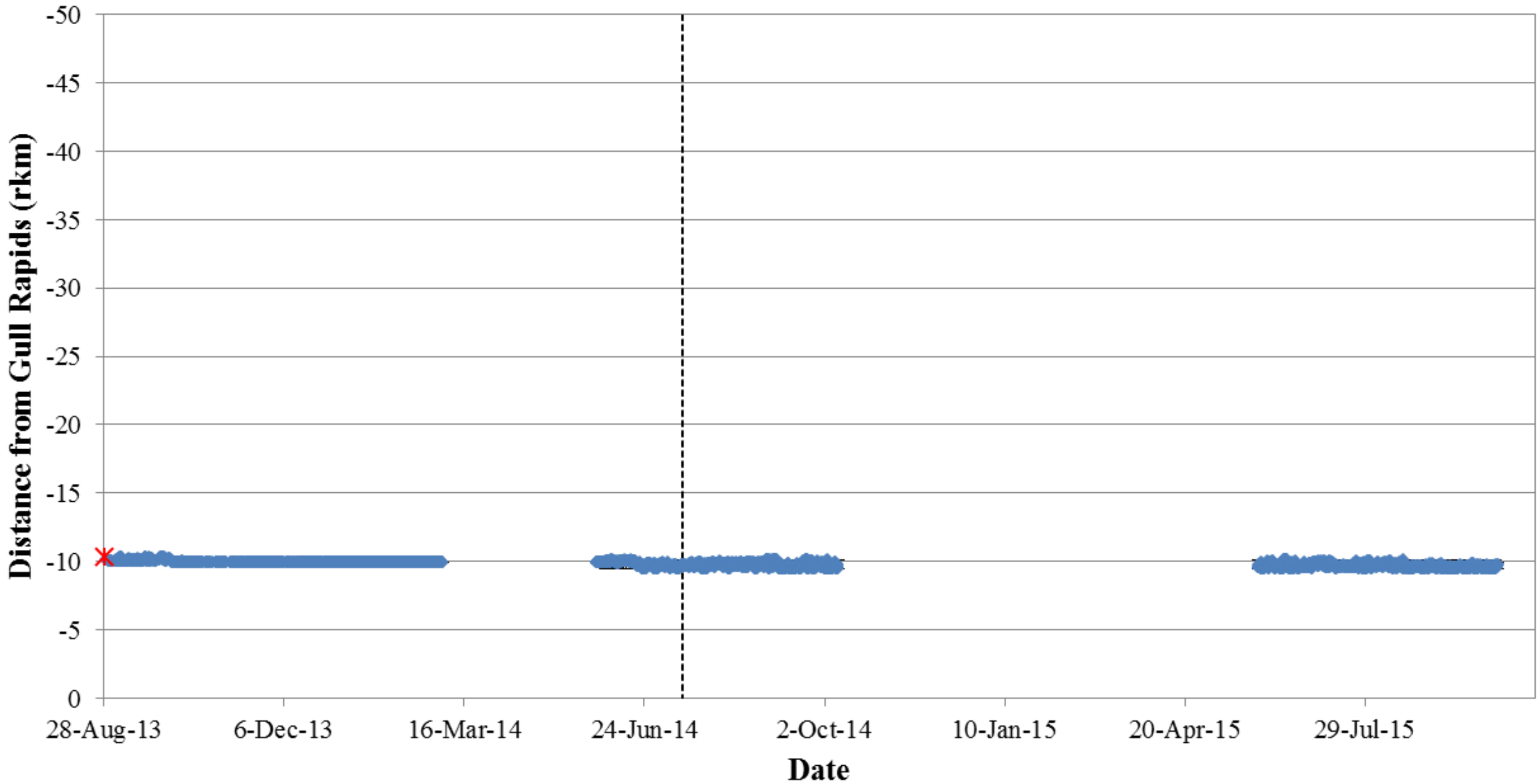


Figure A1-5: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32678) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 11 October, 2015. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

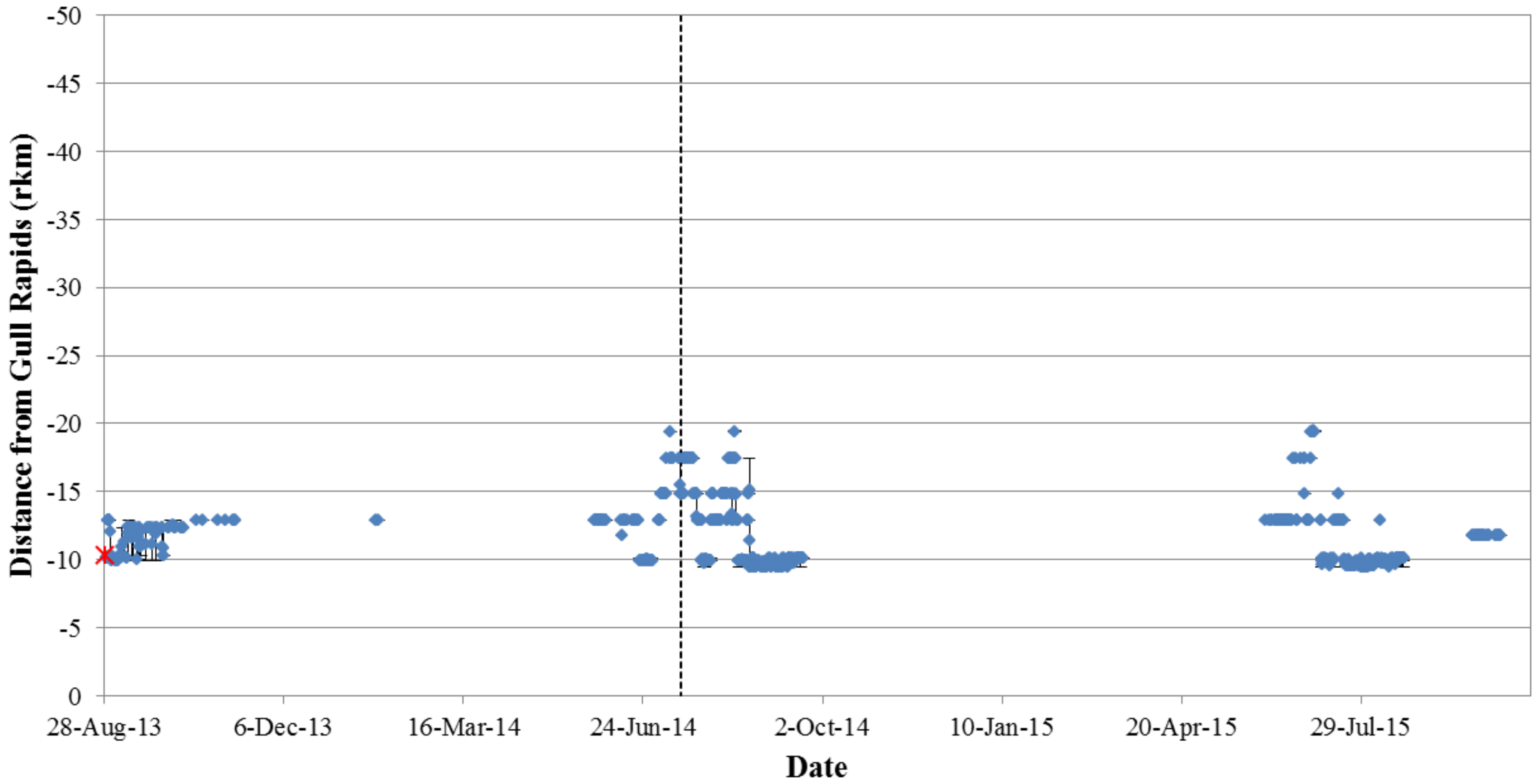


Figure A1-6: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32679) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 11 October, 2015. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

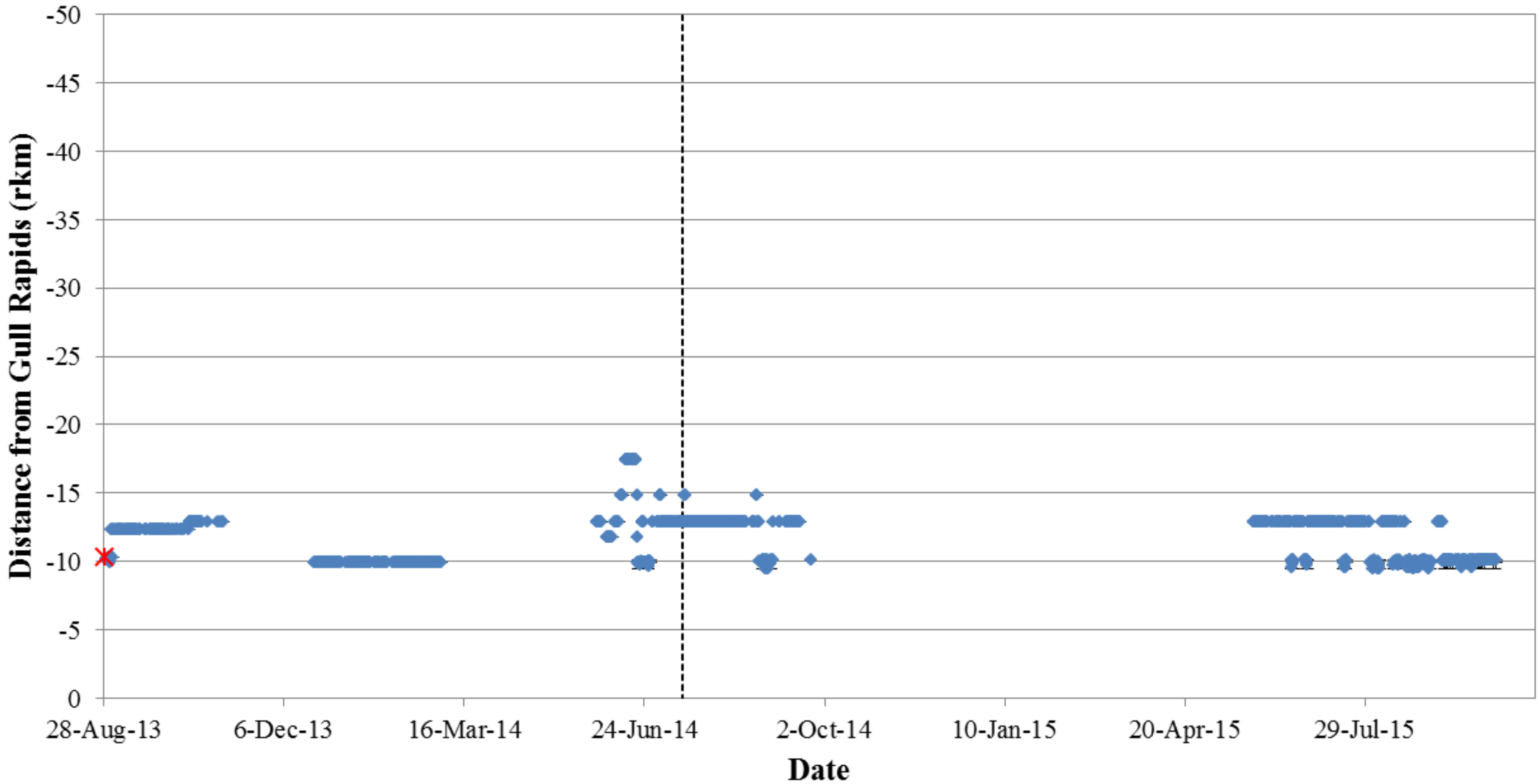


Figure A1-7: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32681) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 11 October, 2015. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

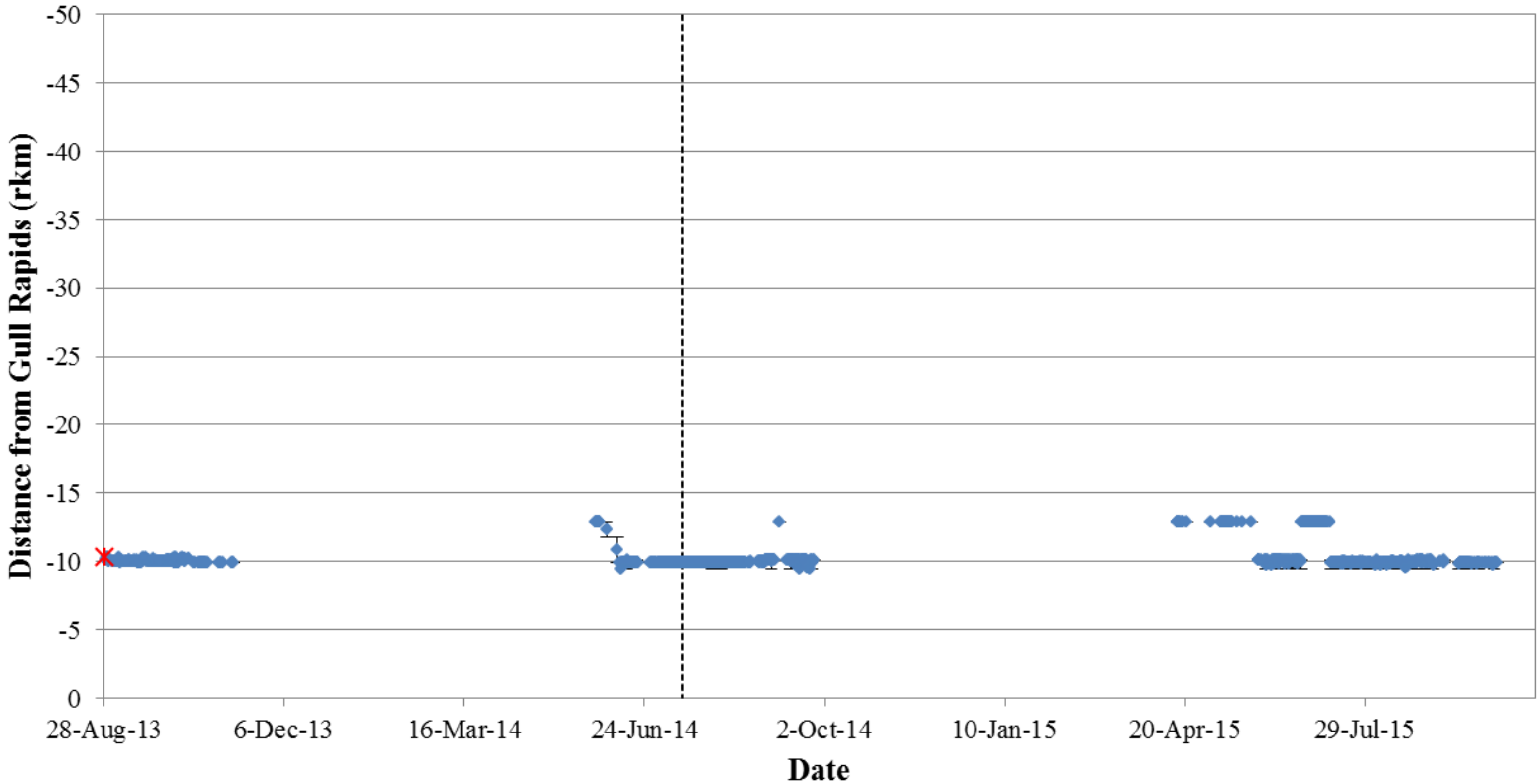


Figure A1-8: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32682) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 11 October, 2015. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

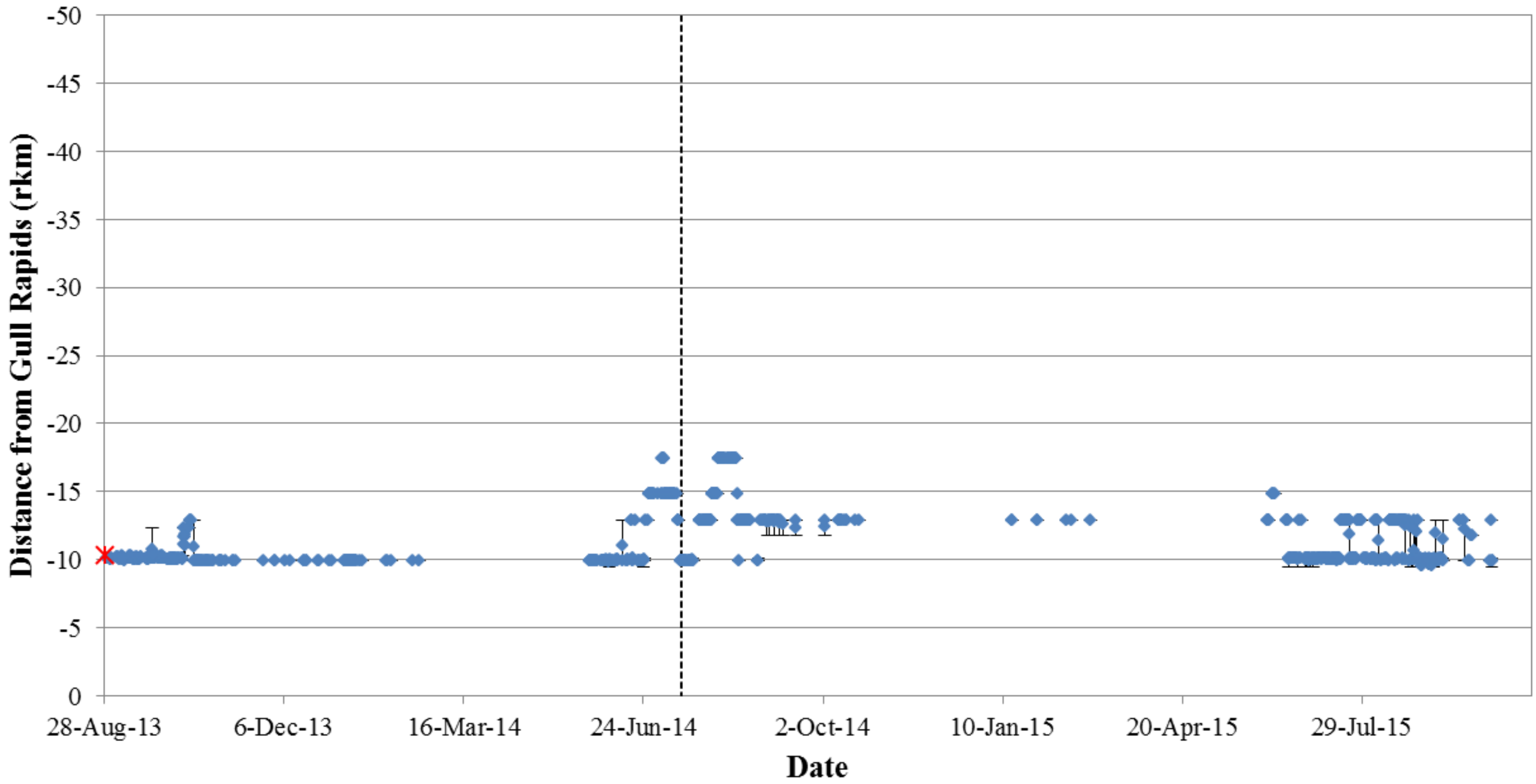


Figure A1-9: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32683) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 11 October, 2015. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

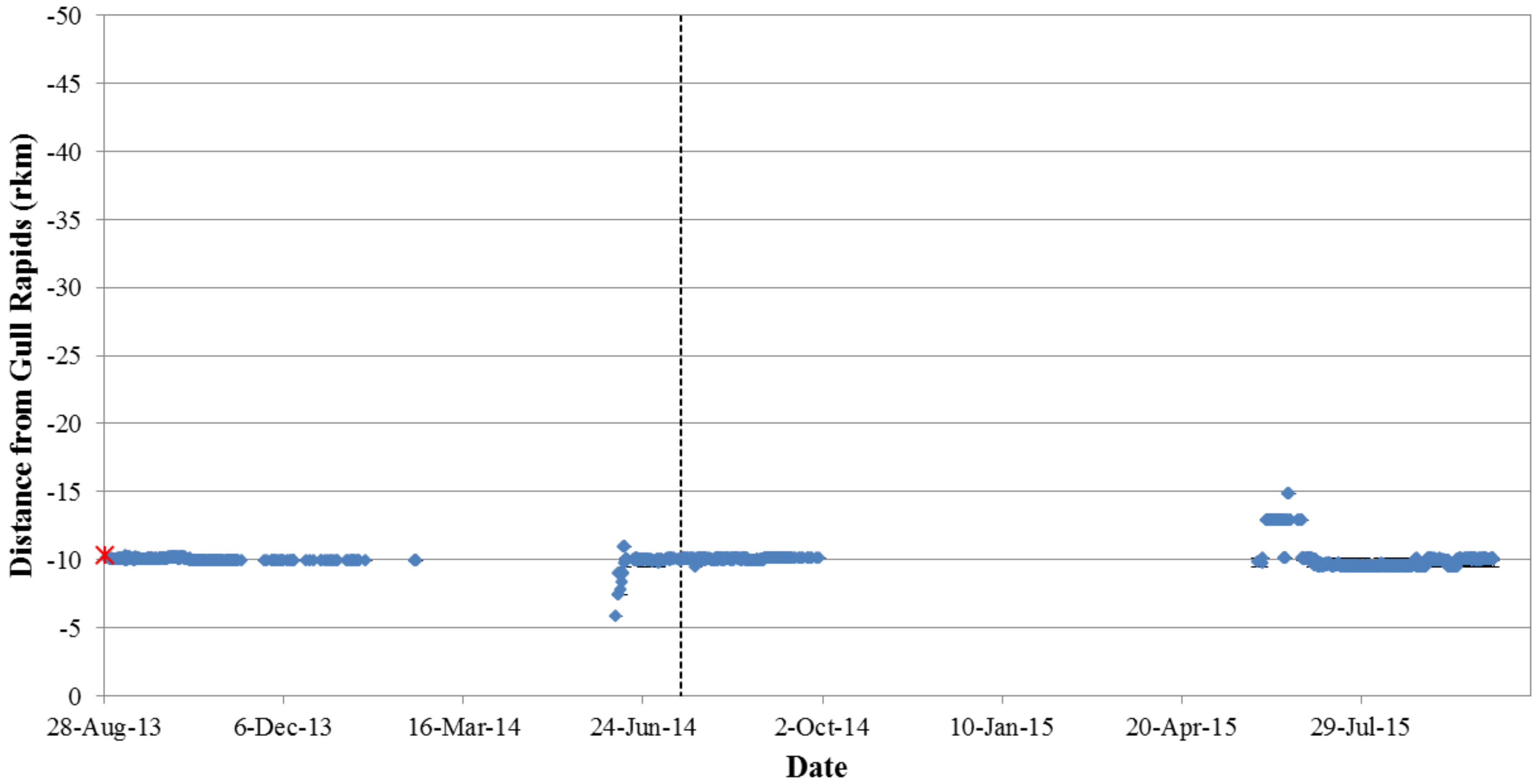


Figure A1-10: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32684) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 11 October, 2015. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

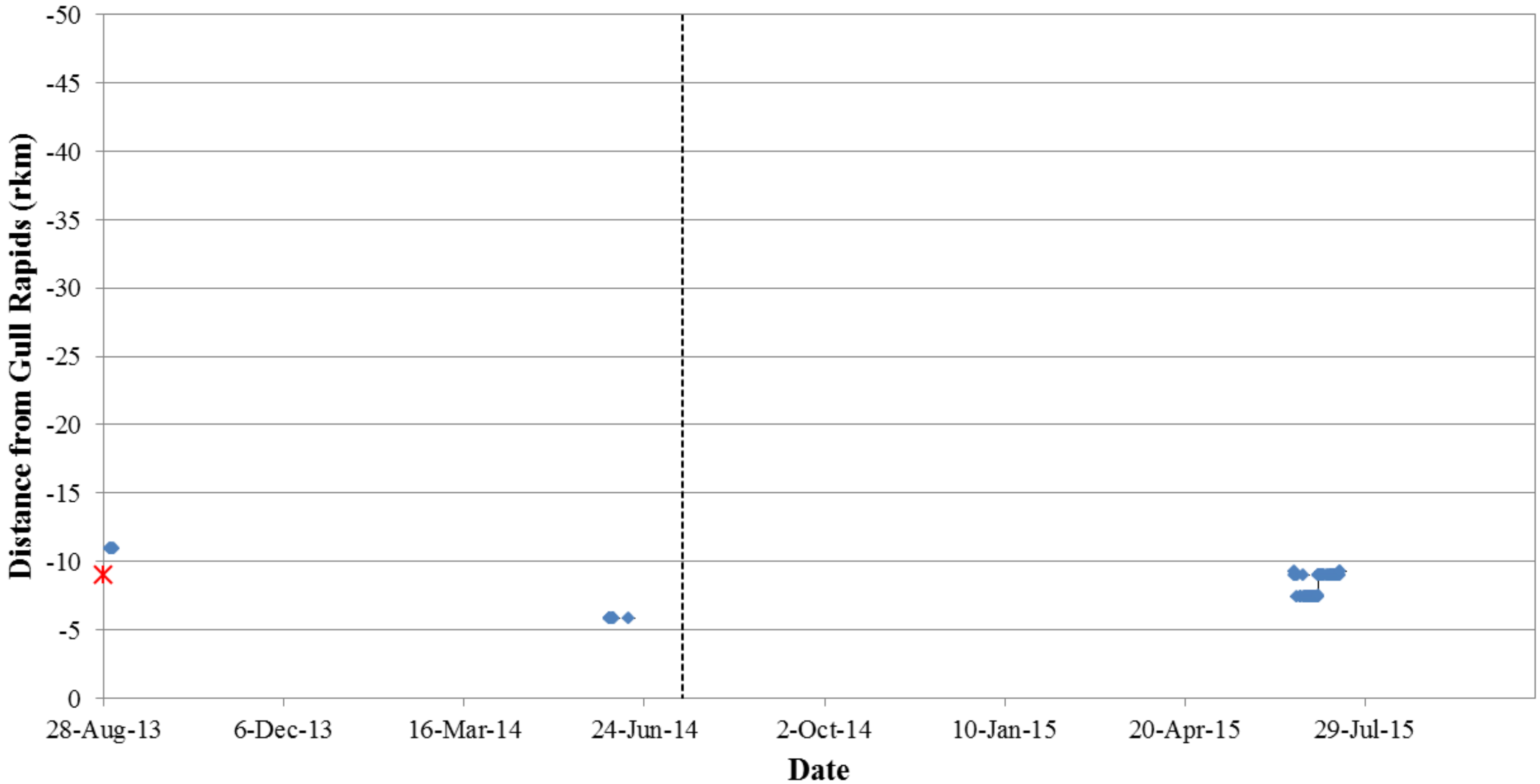


Figure A1-11: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32686) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 11 October, 2015. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

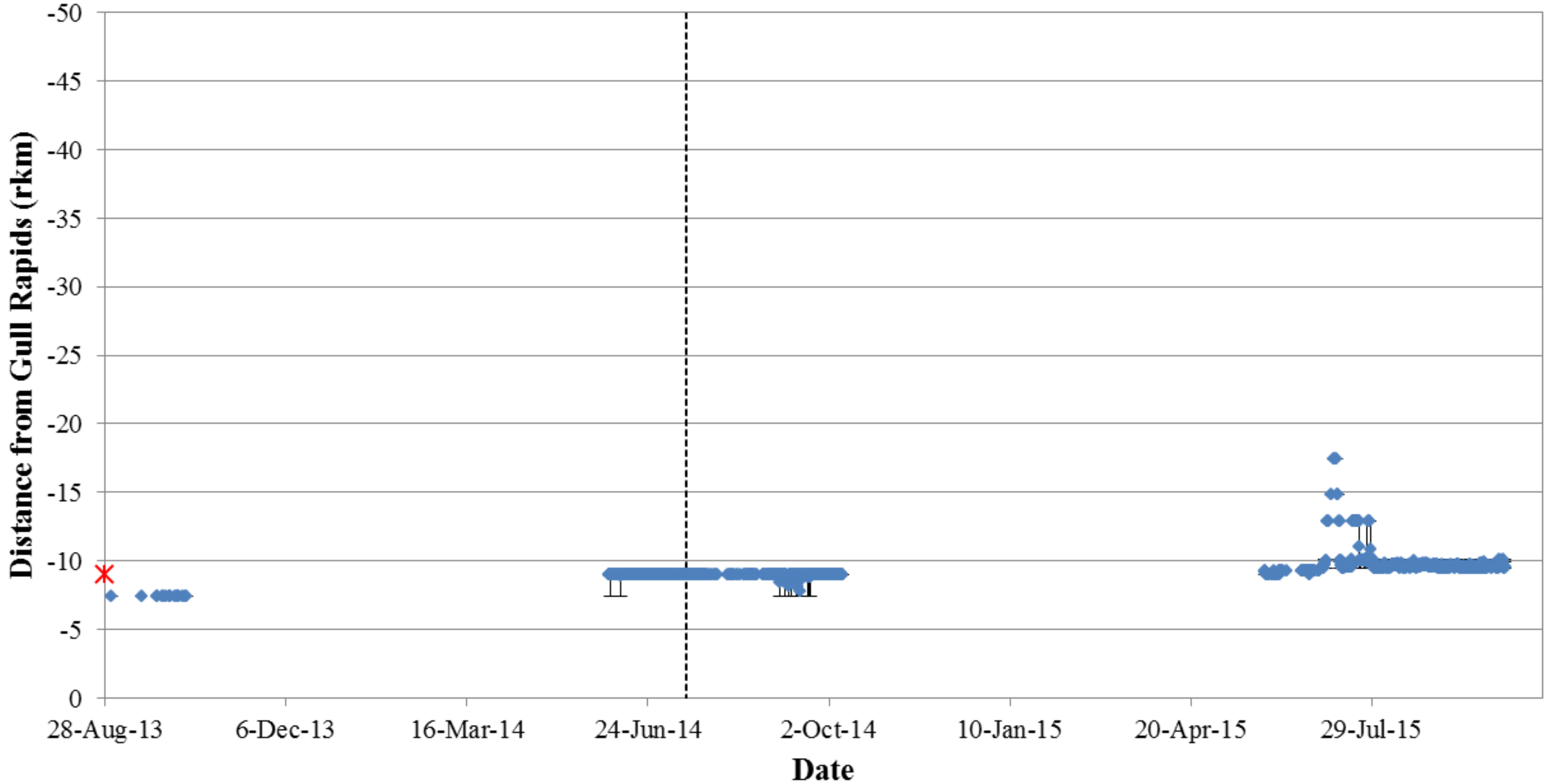


Figure A1-12: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32687) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 11 October, 2015. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

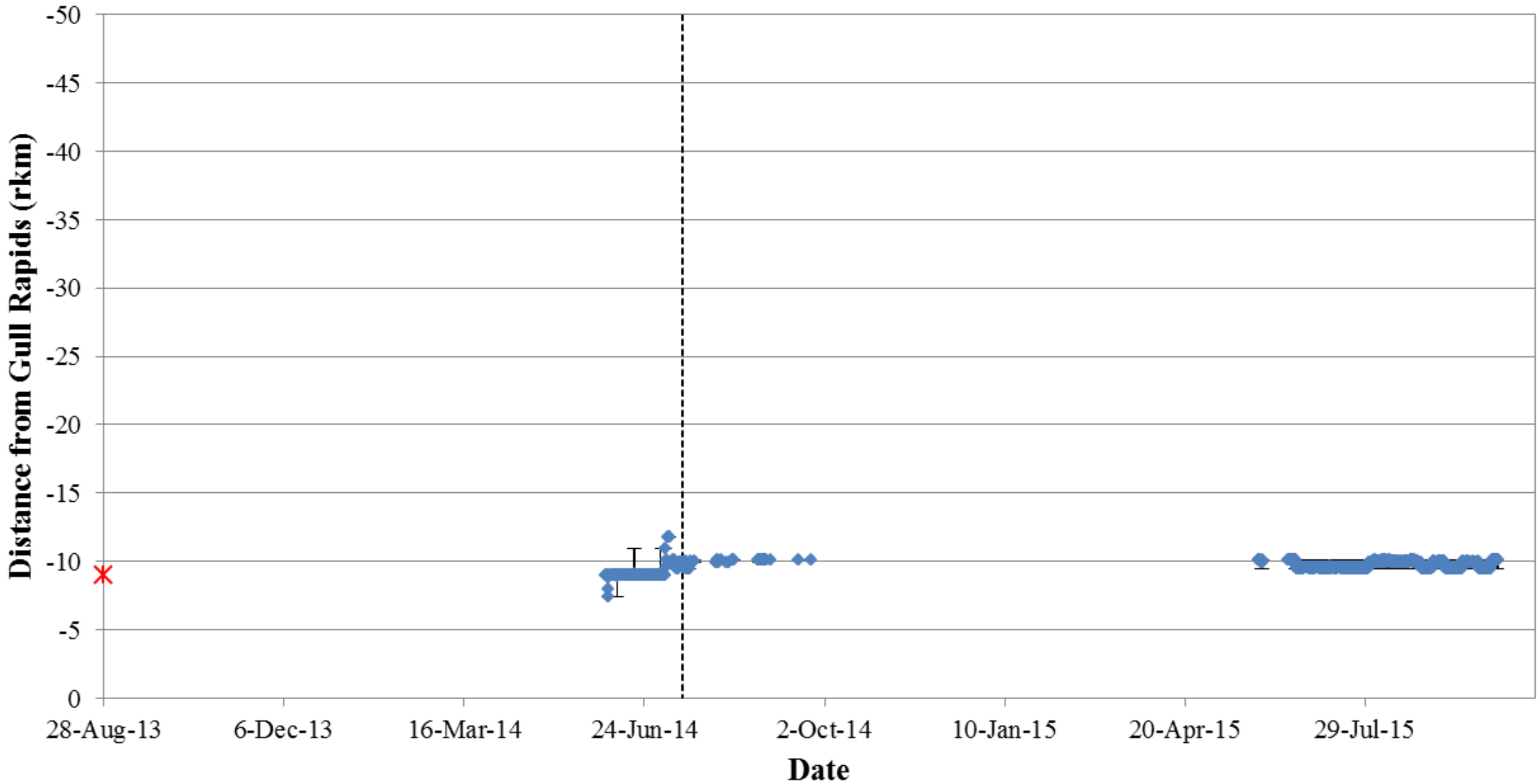


Figure A1-13: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32688) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 11 October, 2014. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

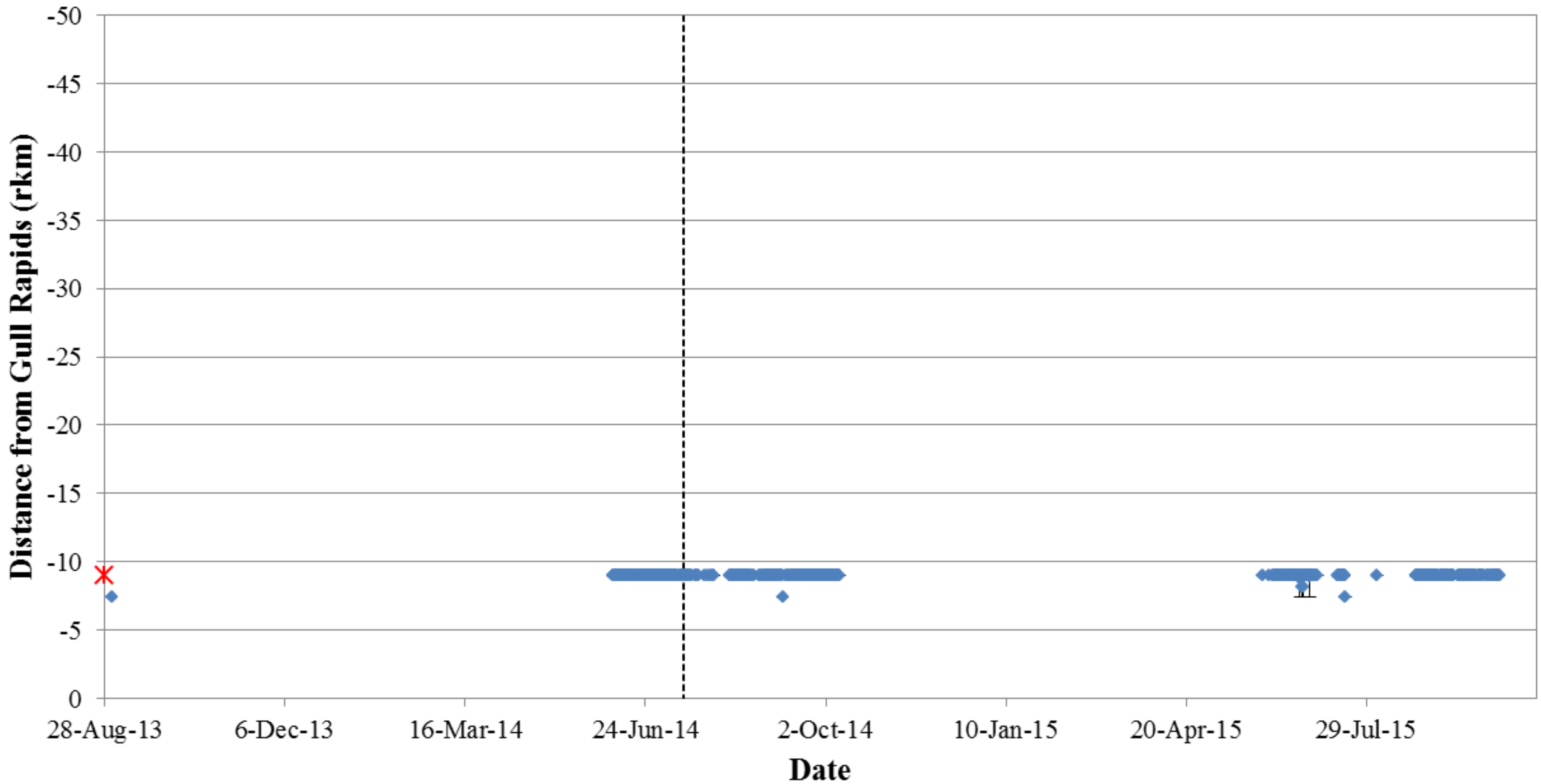


Figure A1-14: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32689) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 11 October, 2015. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

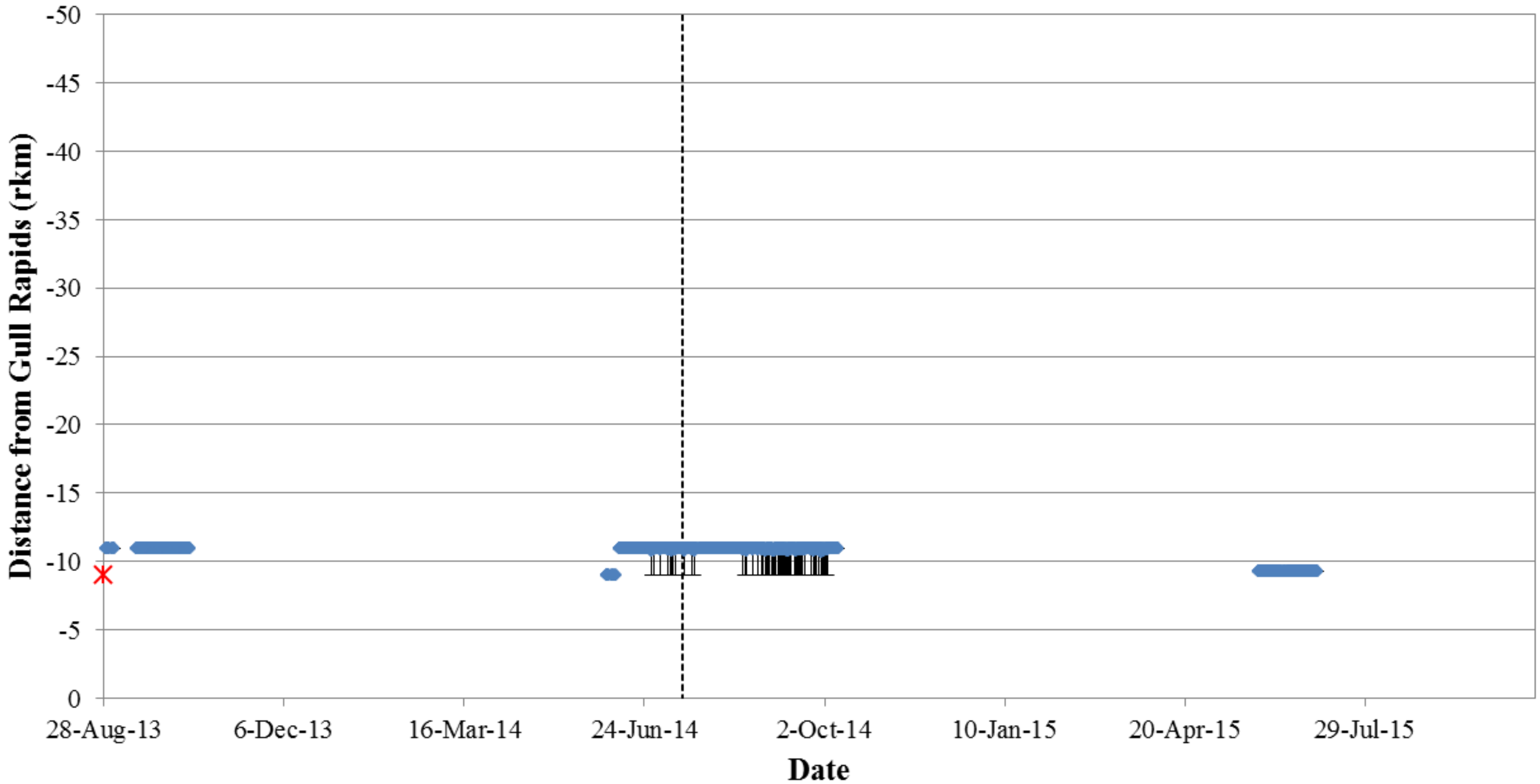


Figure A1-15: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32690) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 11 October, 2015. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

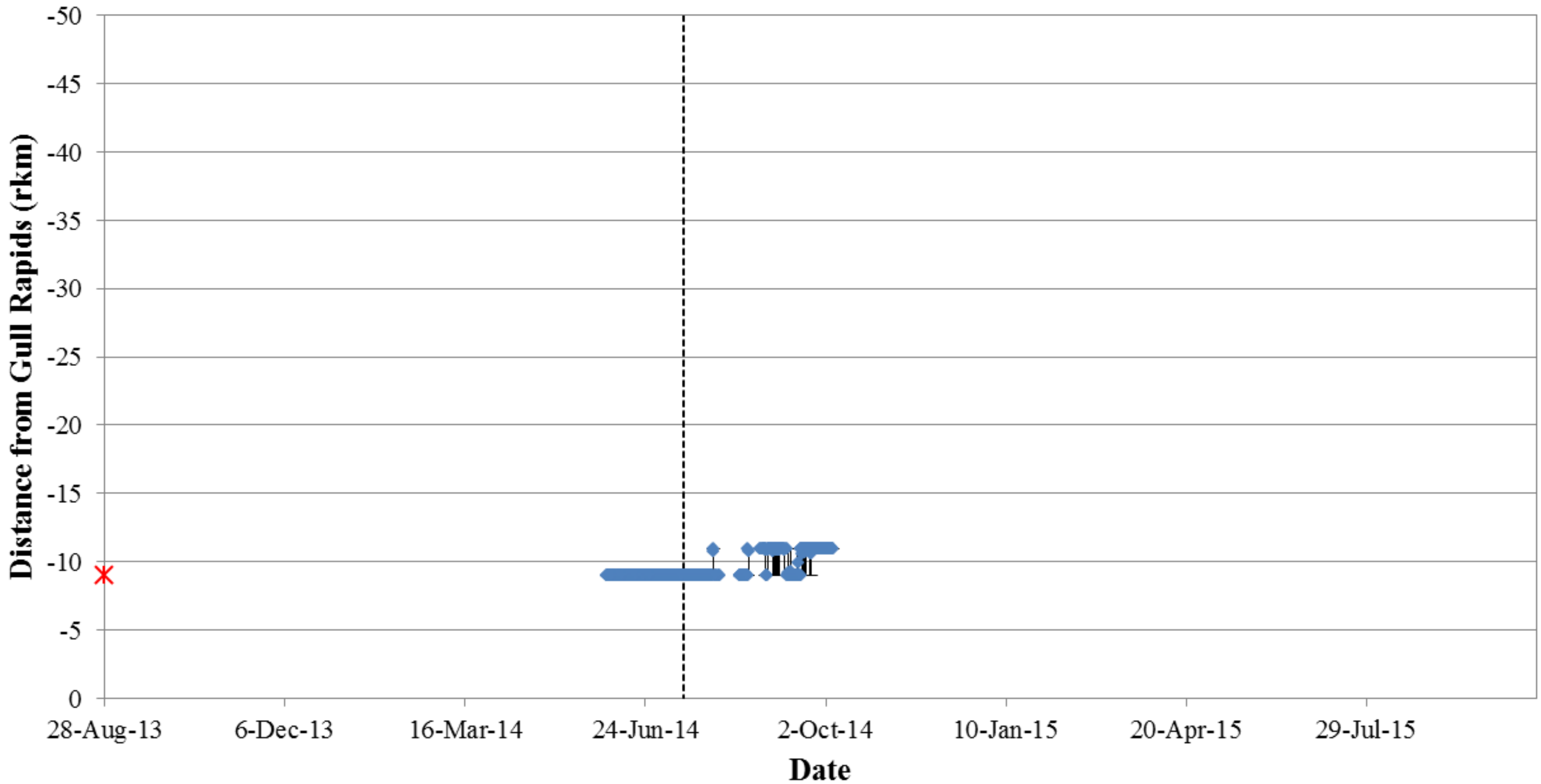


Figure A1-16: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32691) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 11 October, 2015. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

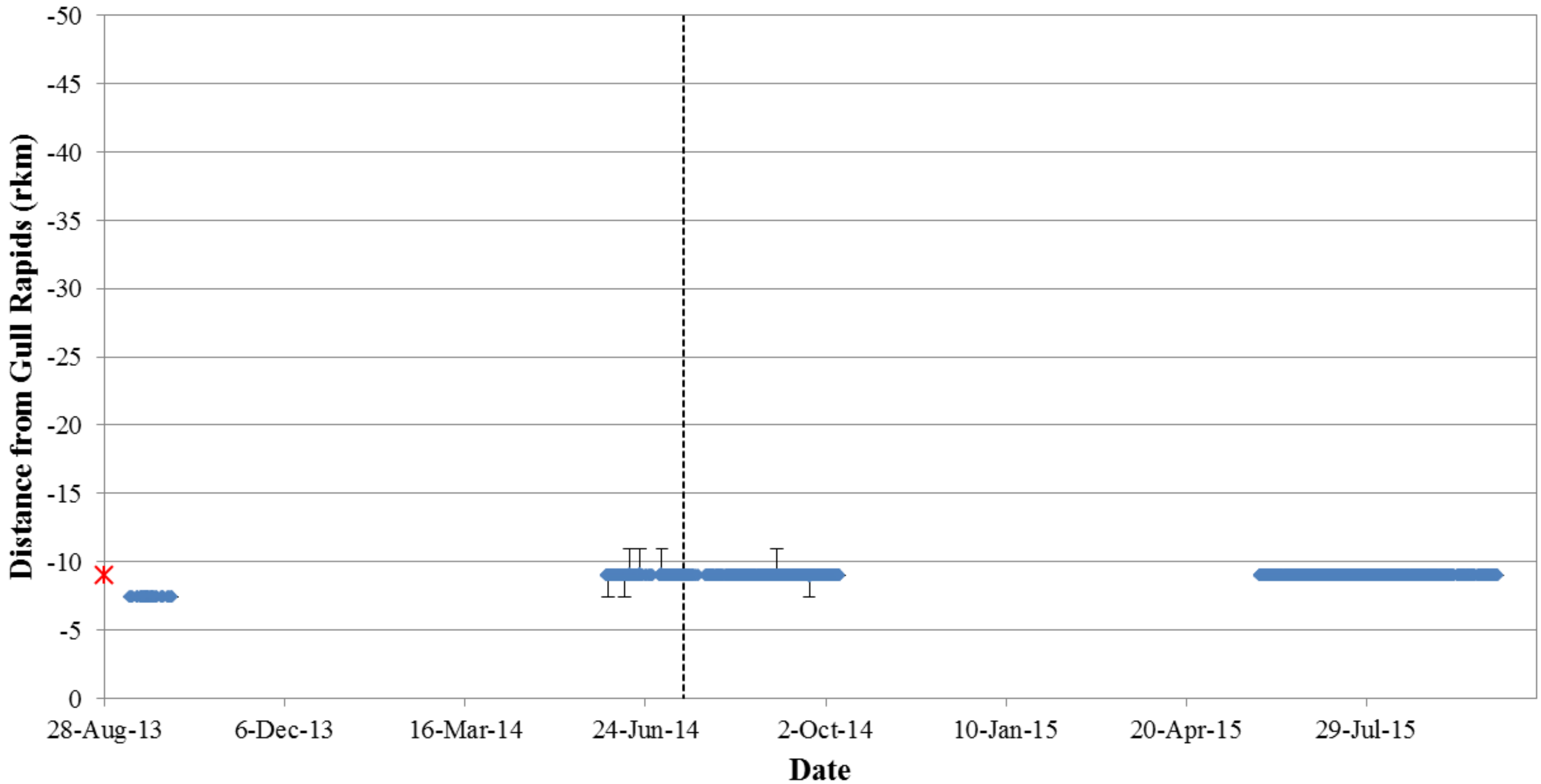


Figure A1-17: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32692) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 11 October, 2015. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

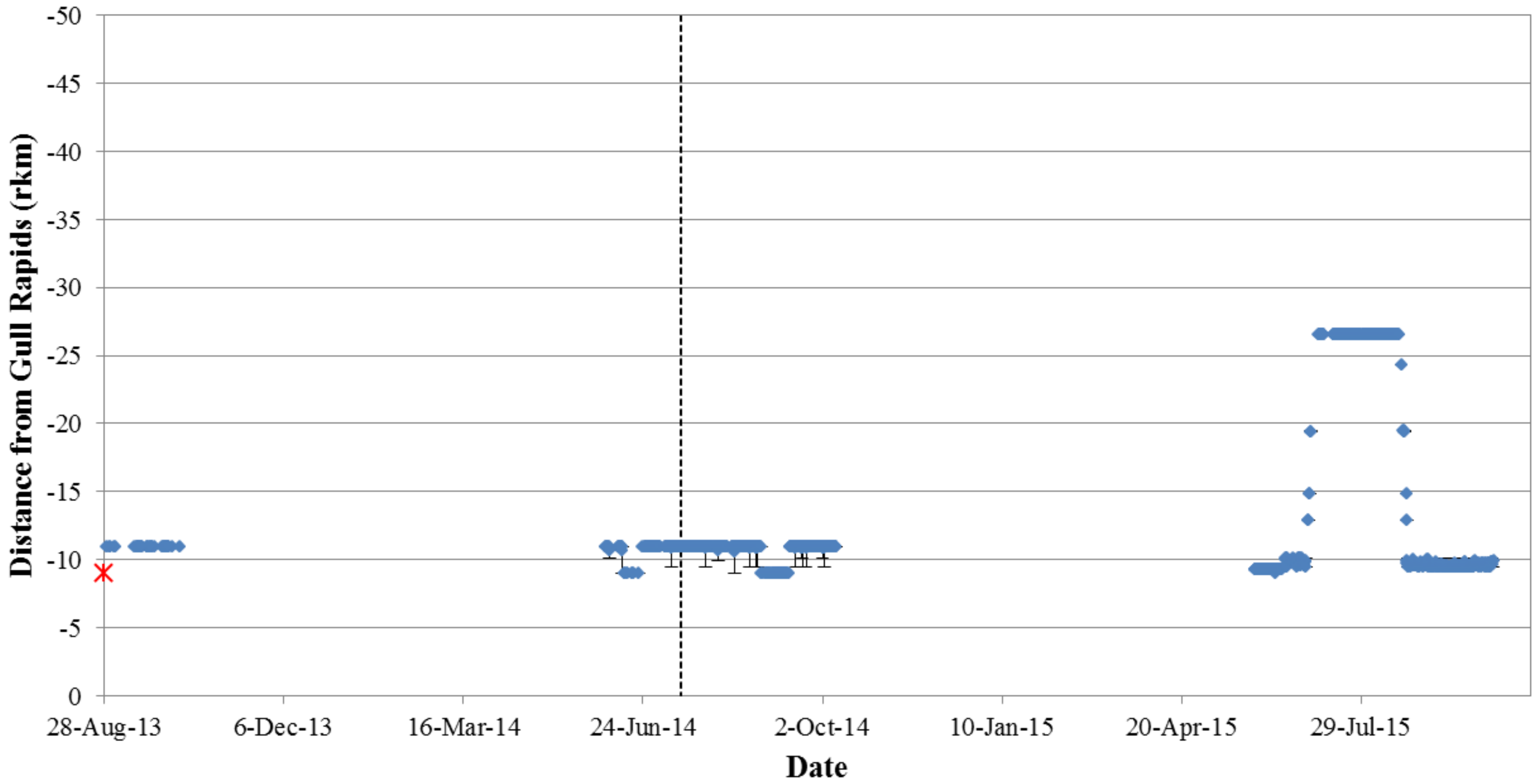


Figure A1-18: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32693) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 11 October, 2015. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

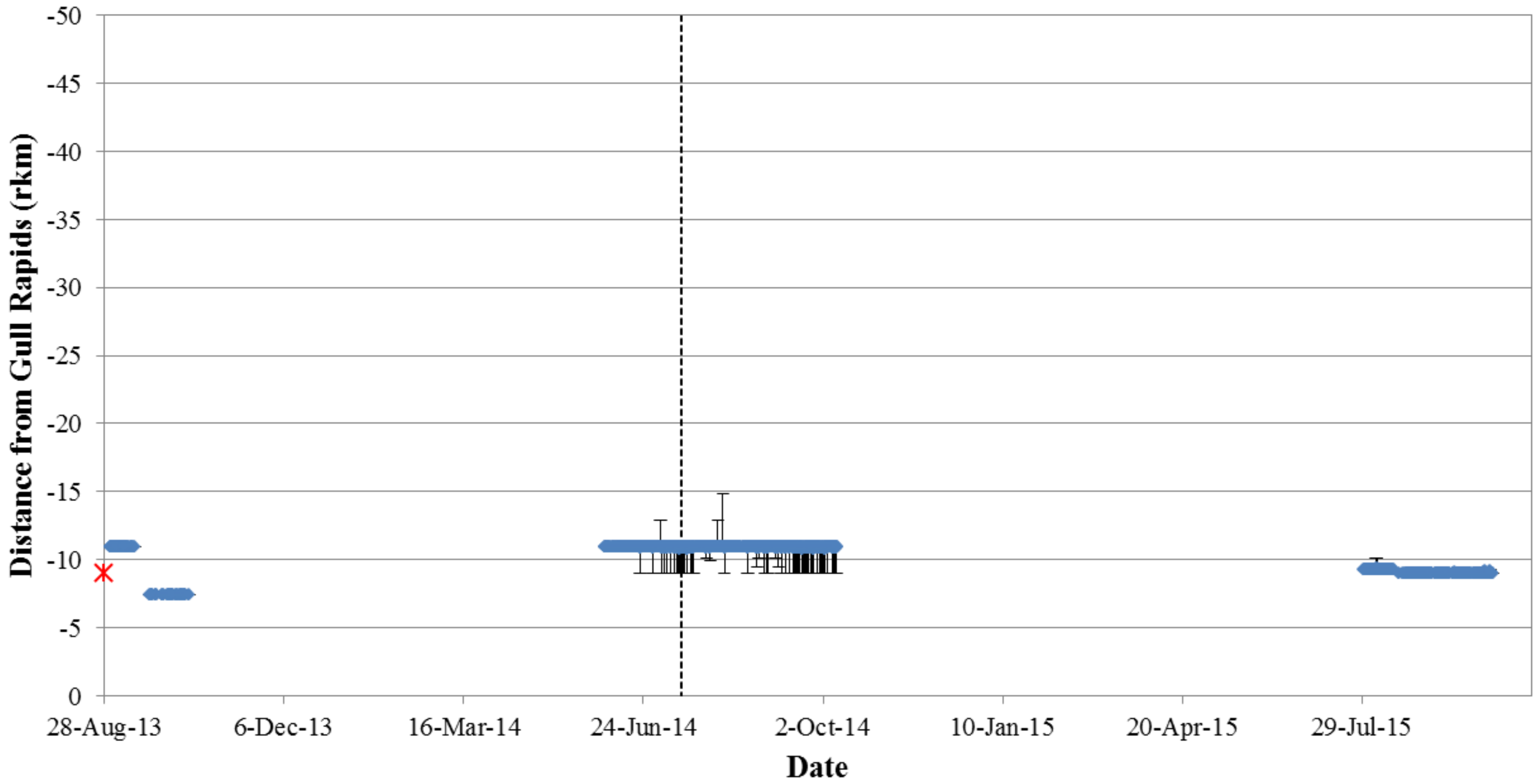


Figure A1-19: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32694) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 11 October, 2015. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

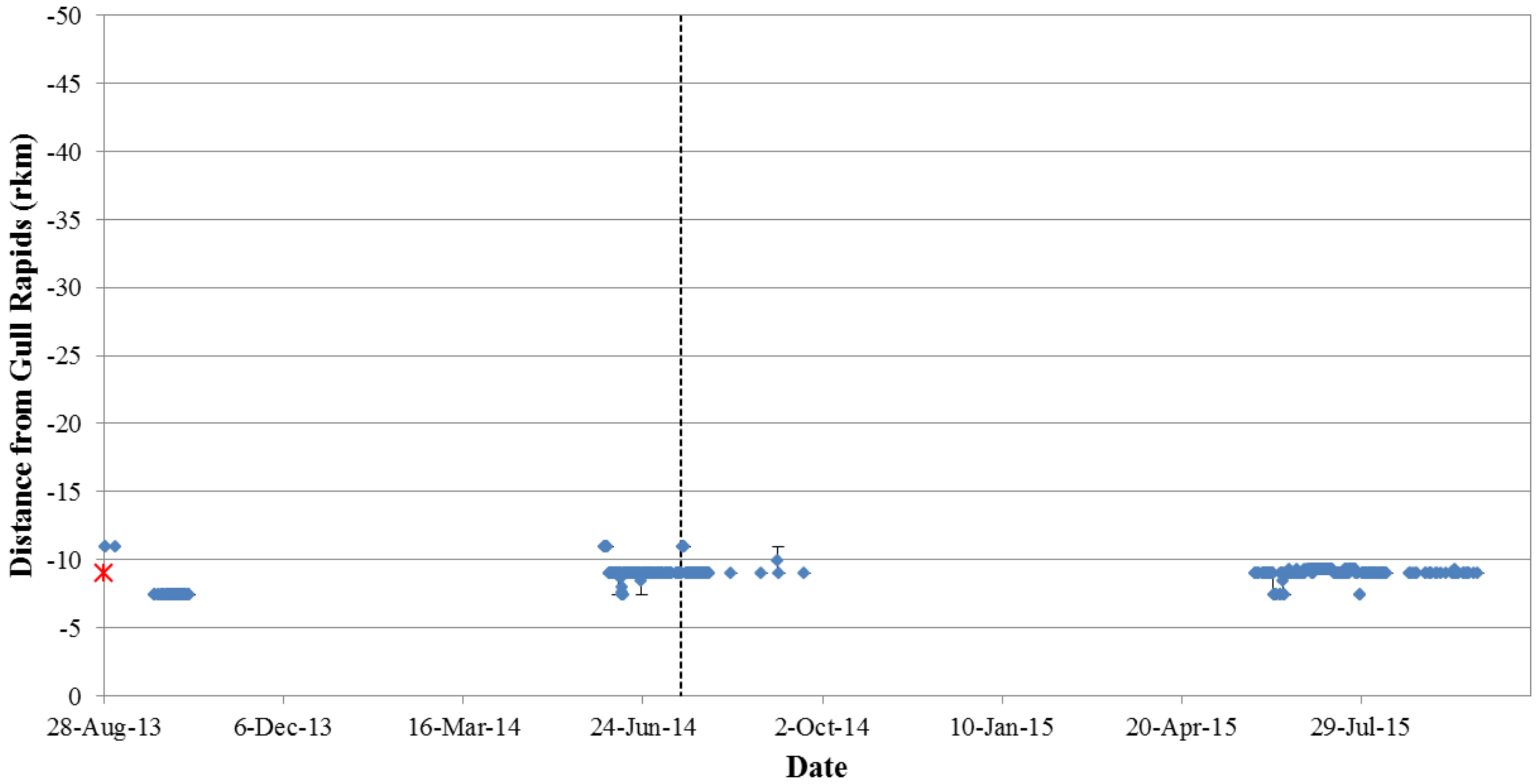


Figure A1-20: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32695) in Gull Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 11 October, 2015. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

APPENDIX 2:
LOCATION SUMMARY FOR INDIVIDUAL ACOUSTIC TAGGED JUVENILE LAKE STURGEON DOWNSTREAM OF GULL RAPIDS, AUGUST 2013 TO OCTOBER 2015

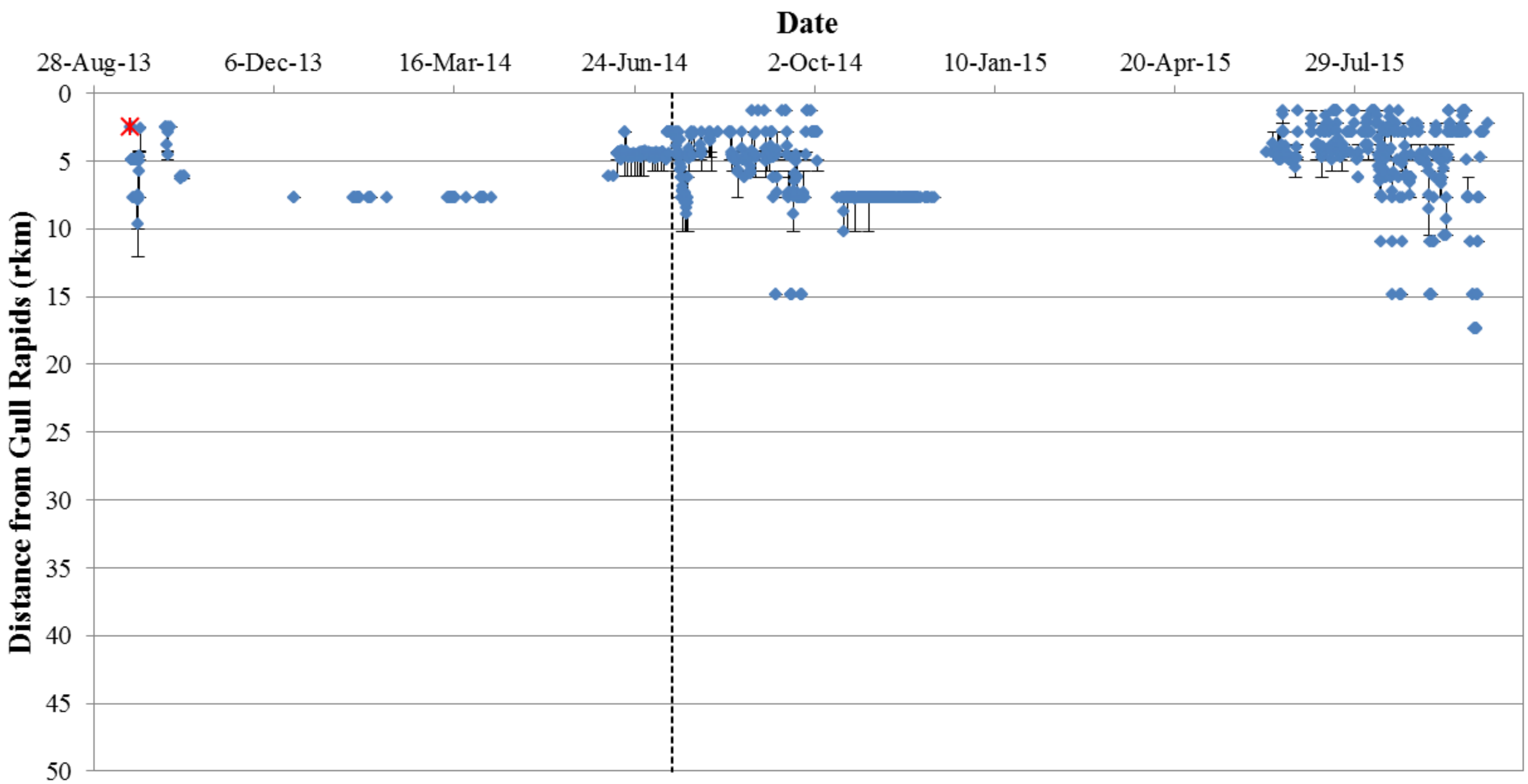


Figure A2-1: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32661) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 11 October, 2015. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

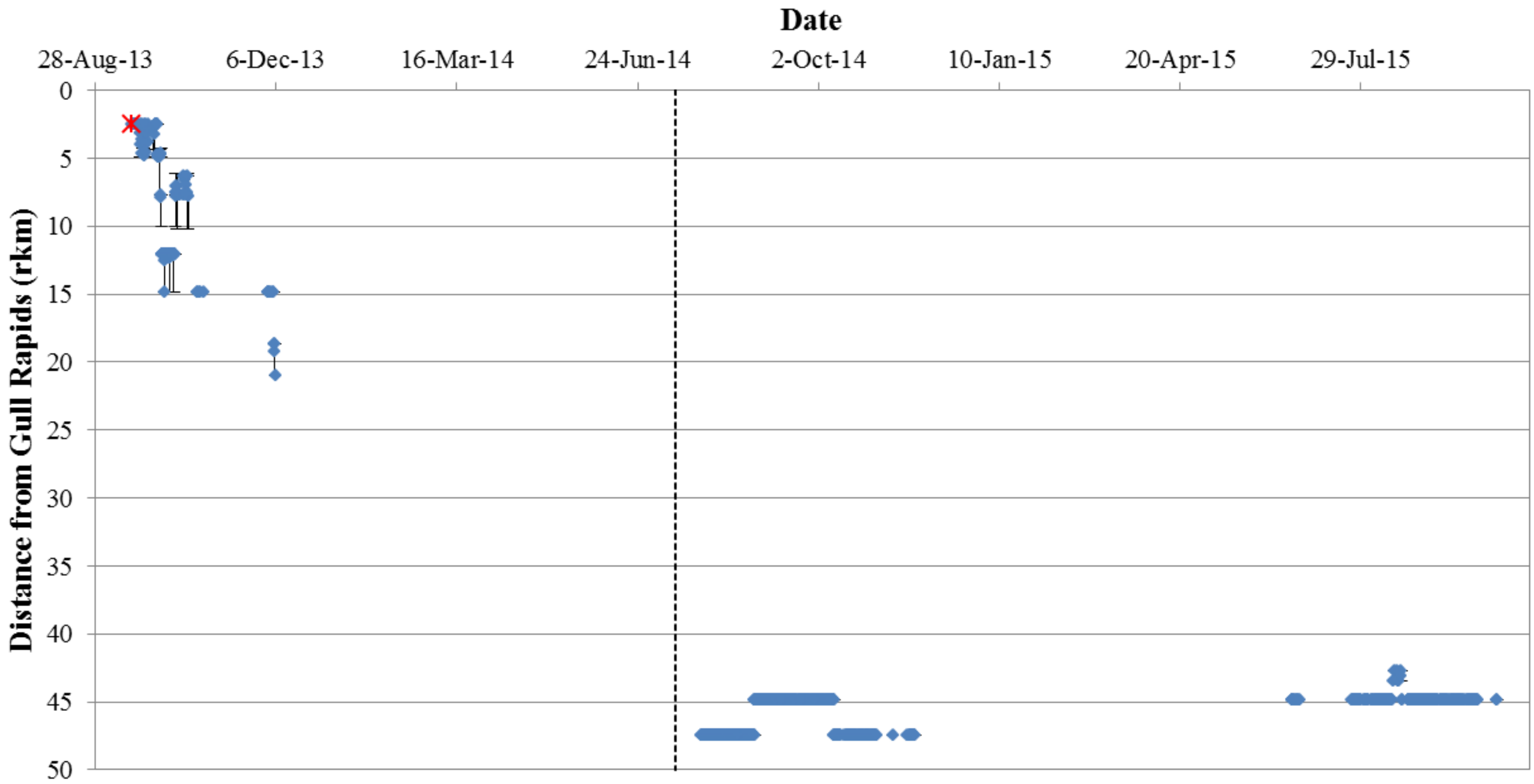


Figure A2-2: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32662) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 11 October, 2015. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

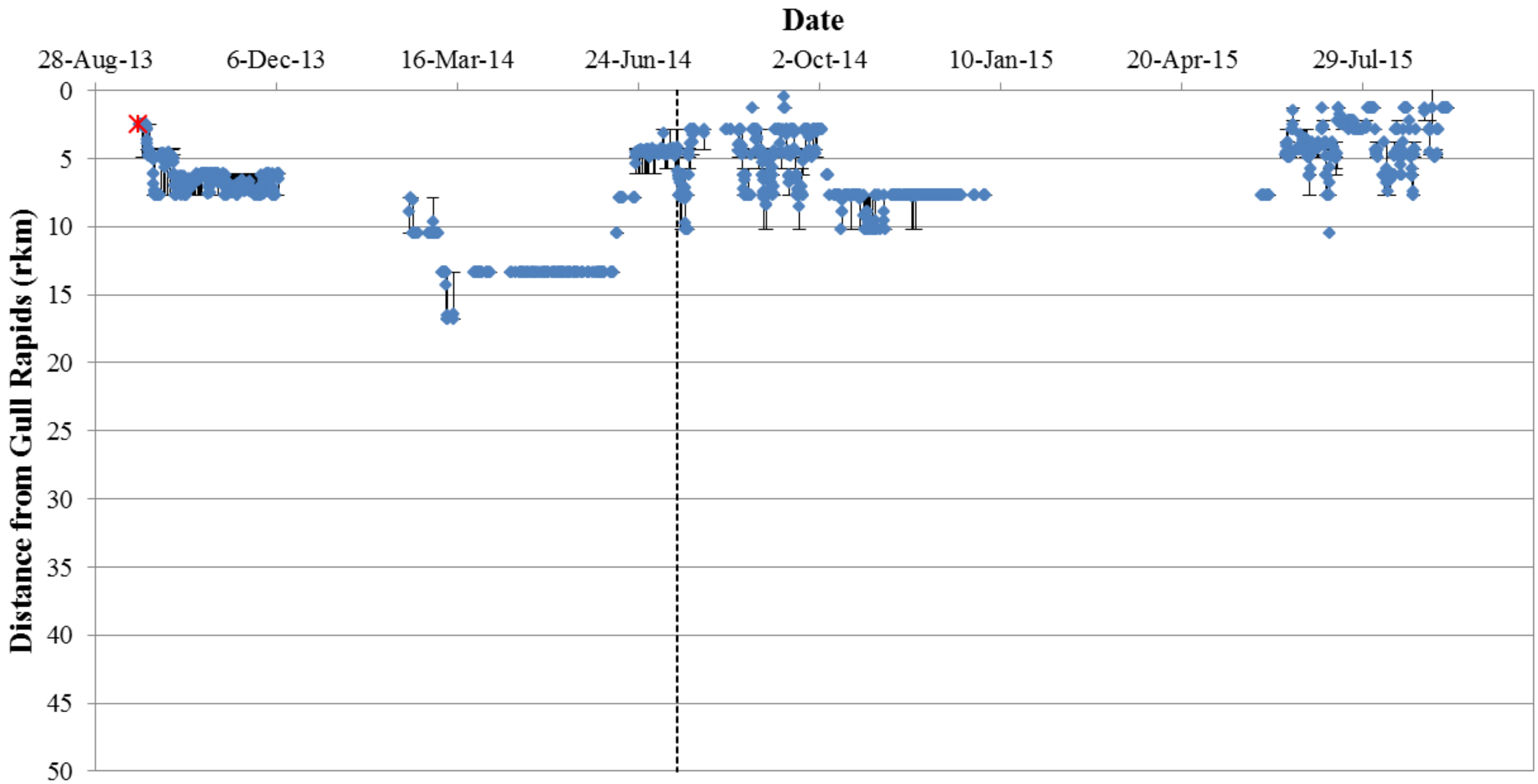


Figure A2-3: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32663) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 11 October, 2015. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

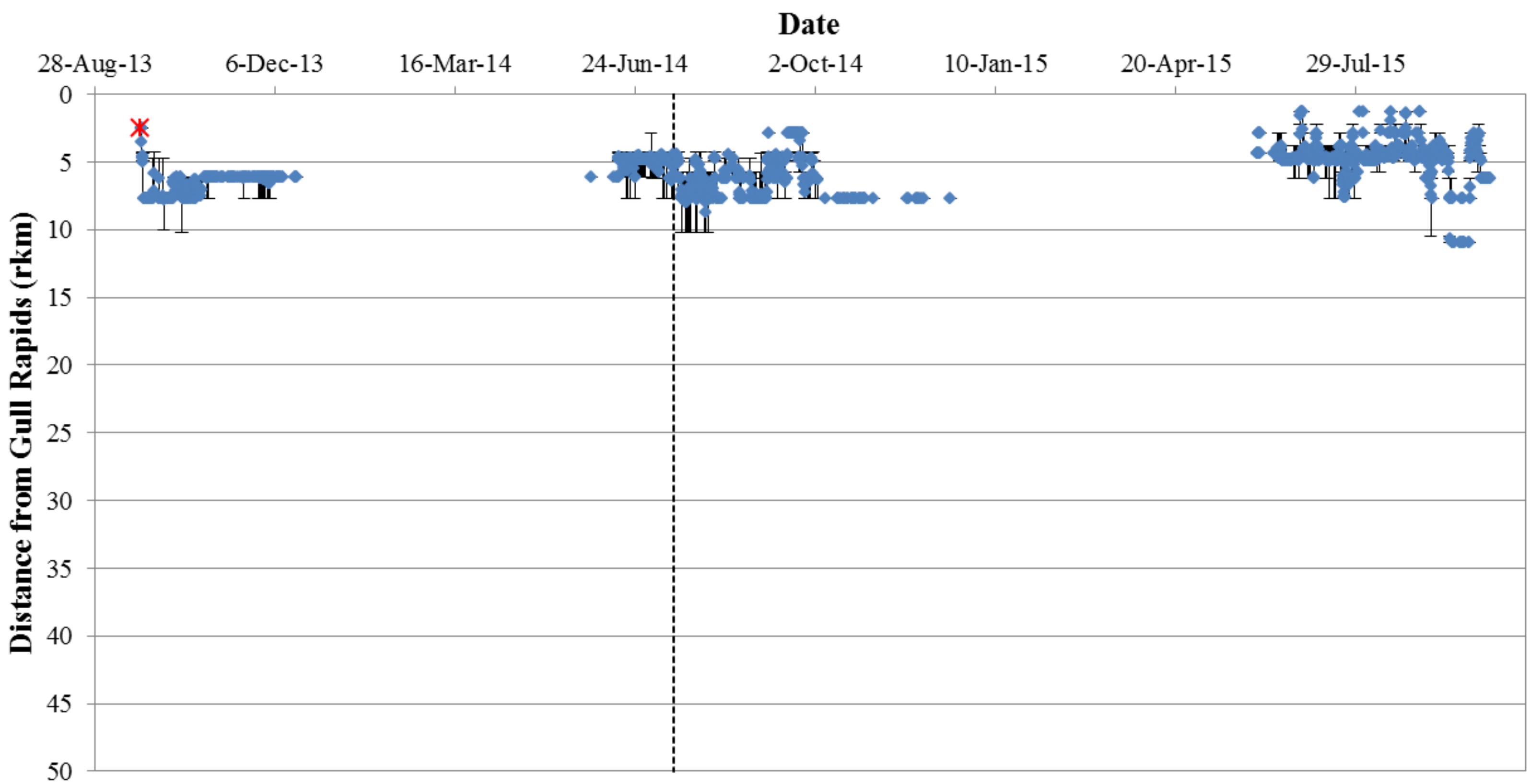


Figure A2-4: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32664) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 11 October, 2015. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

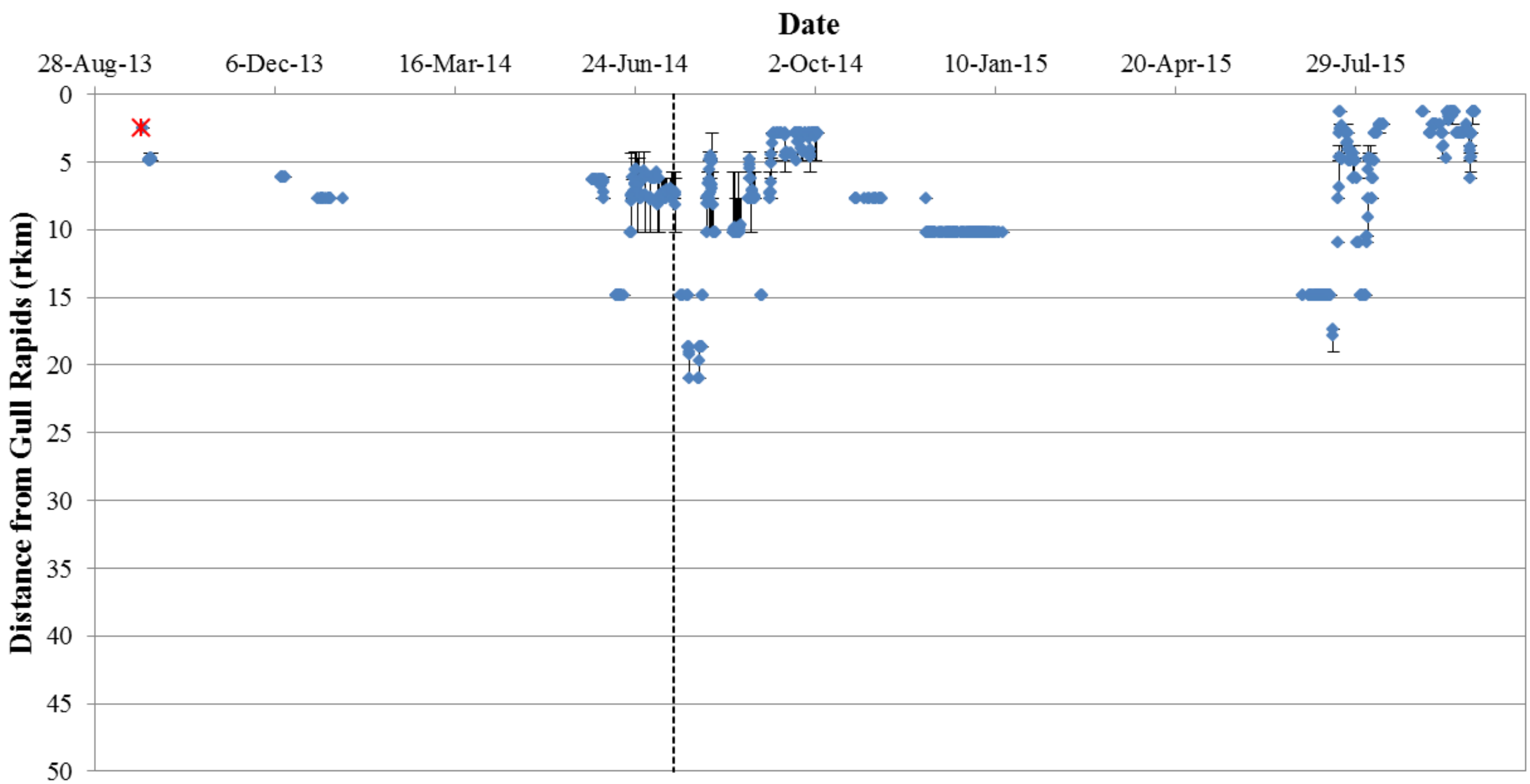


Figure A2-5: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32665) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 11 October, 2015. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

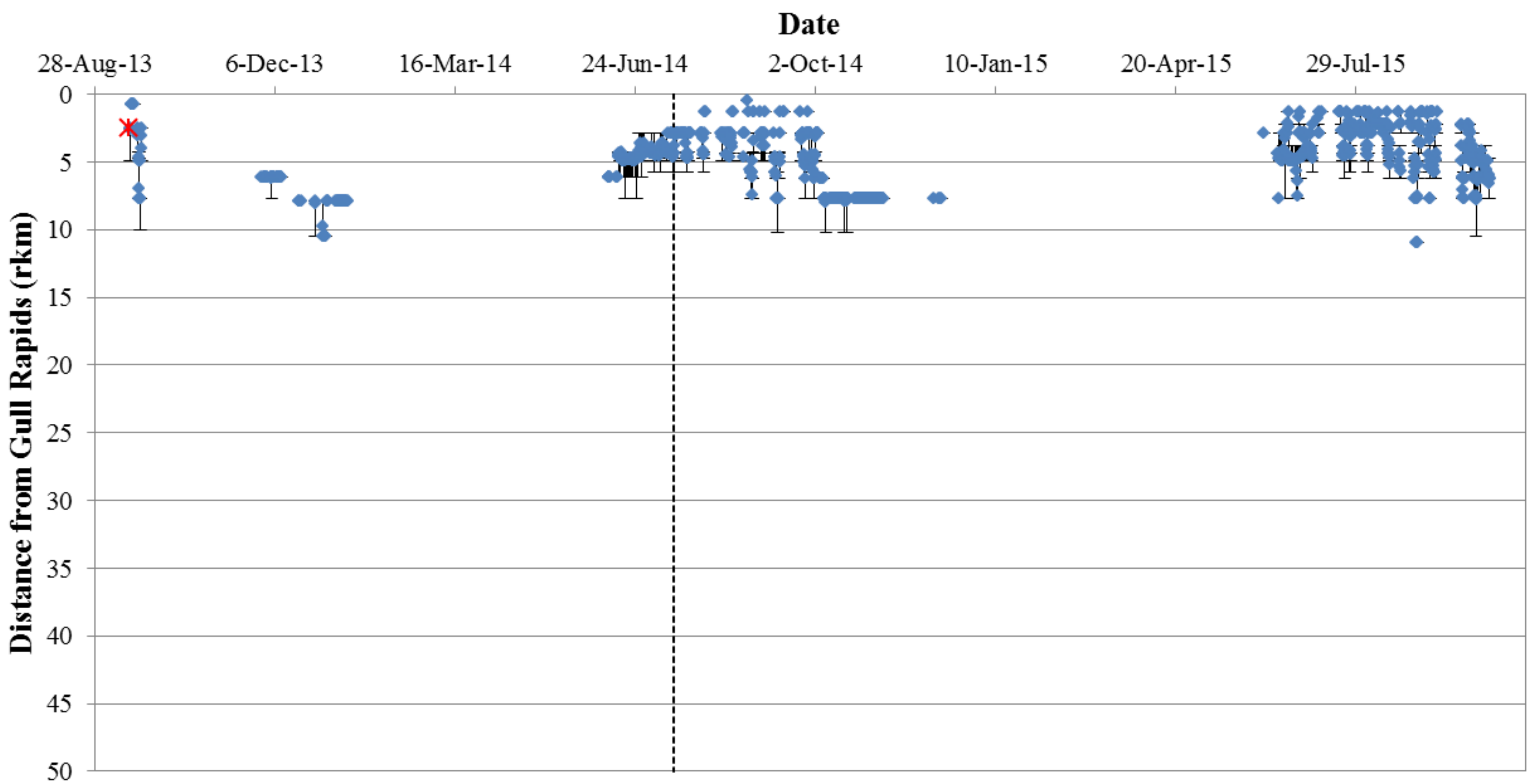


Figure A2-6: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32666) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 11 October, 2015. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

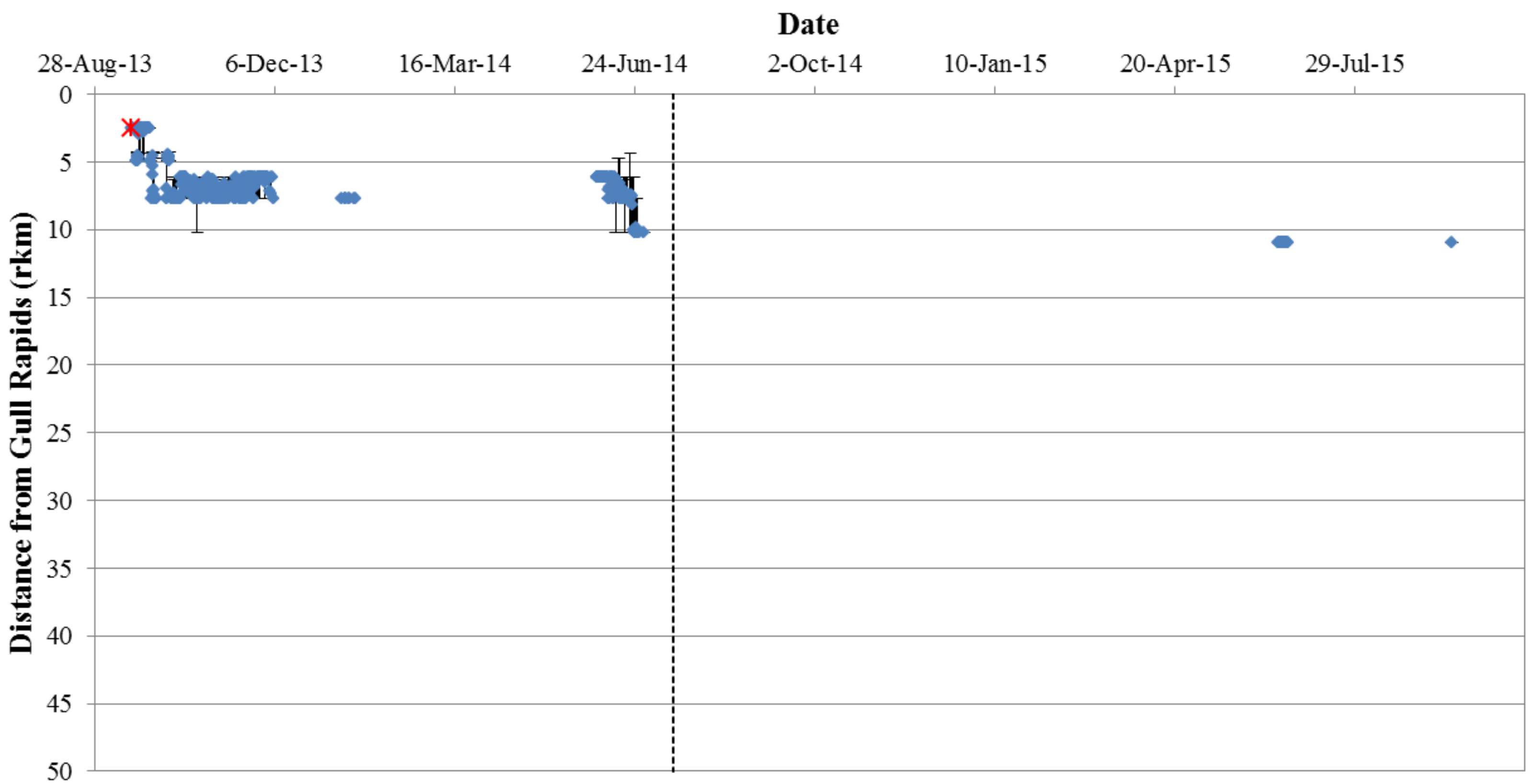


Figure A2-7: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32667) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 11 October, 2015. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

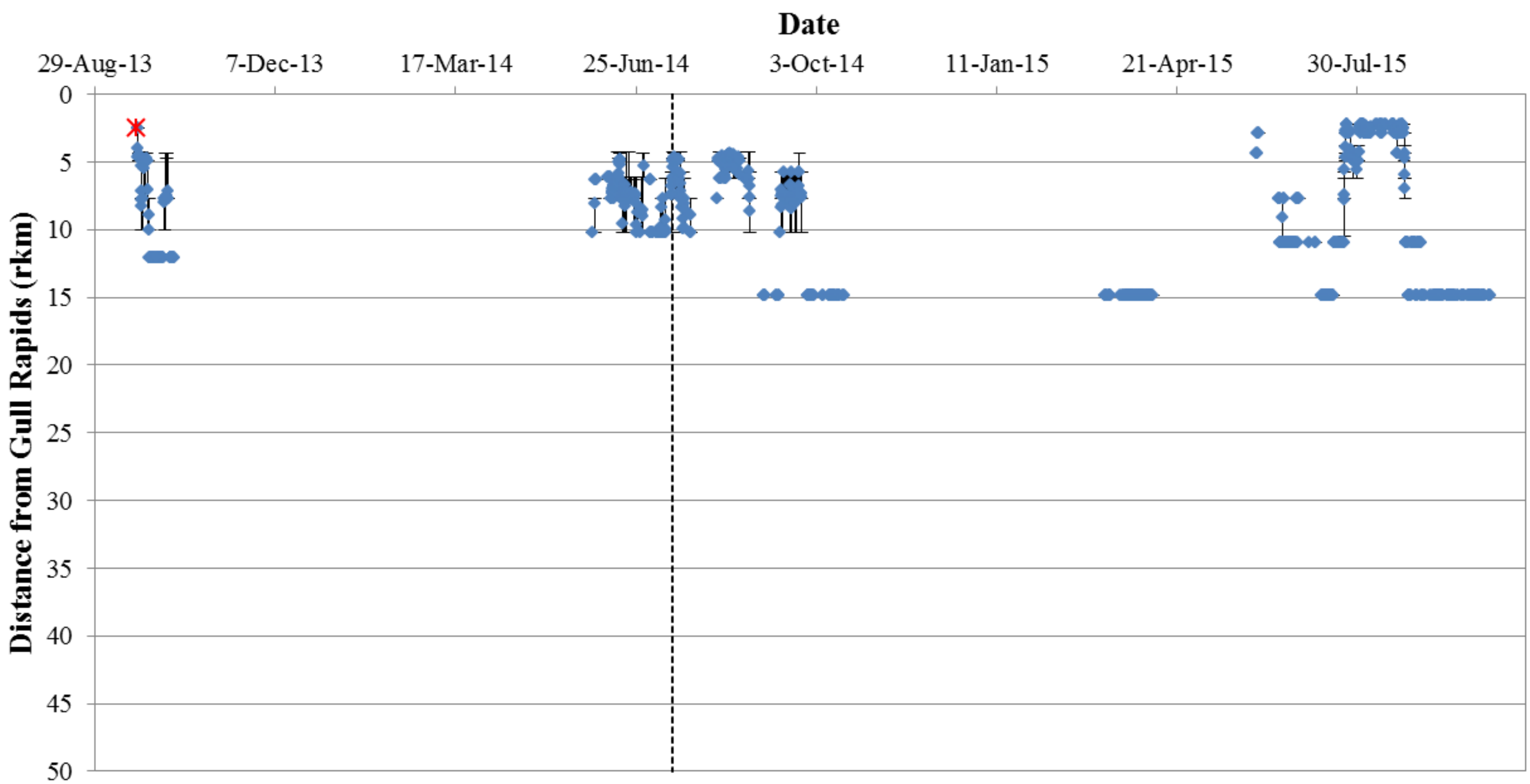


Figure A2-8: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32668) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 11 October, 2015. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

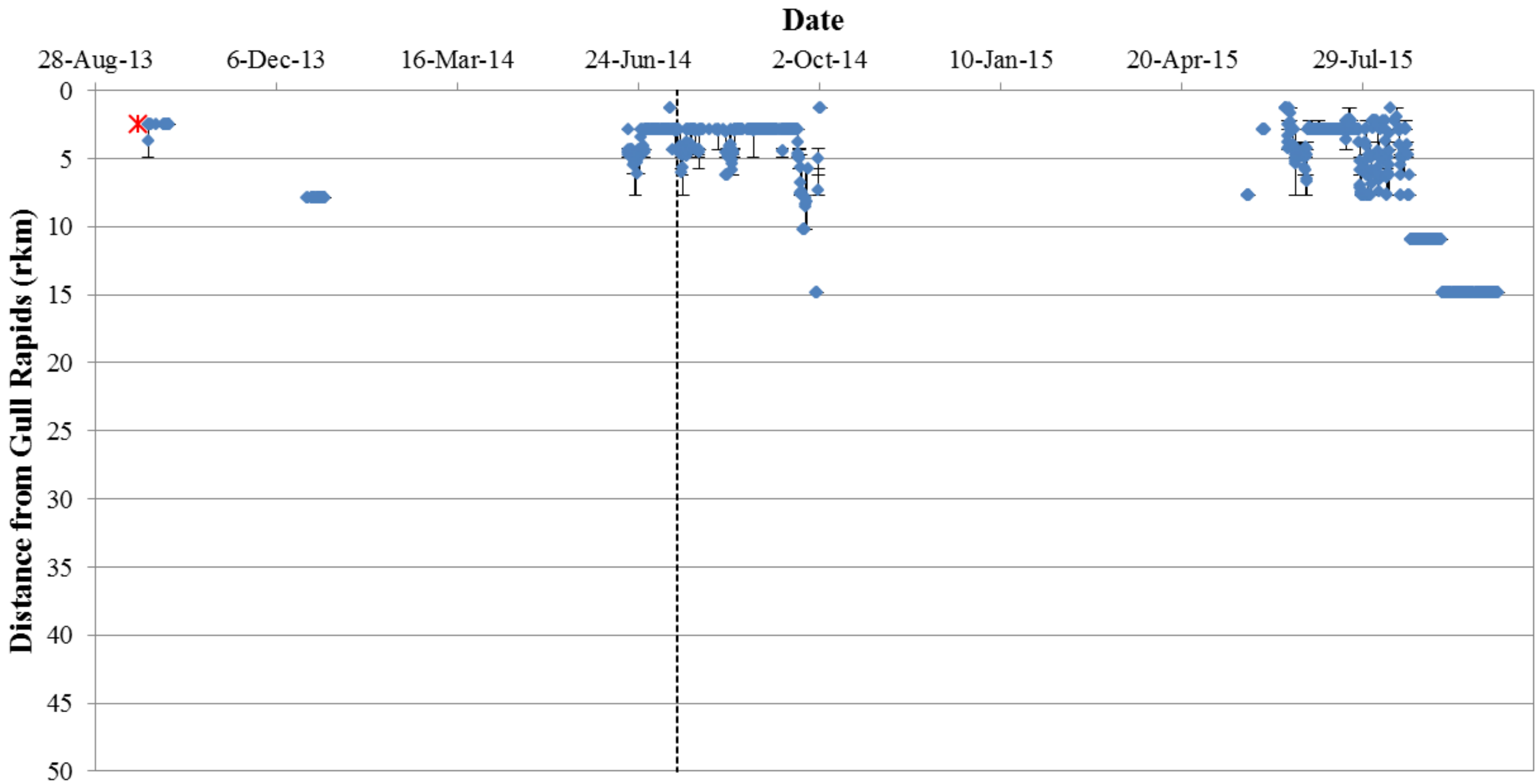


Figure A2-9: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32669) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 11 October, 2015. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

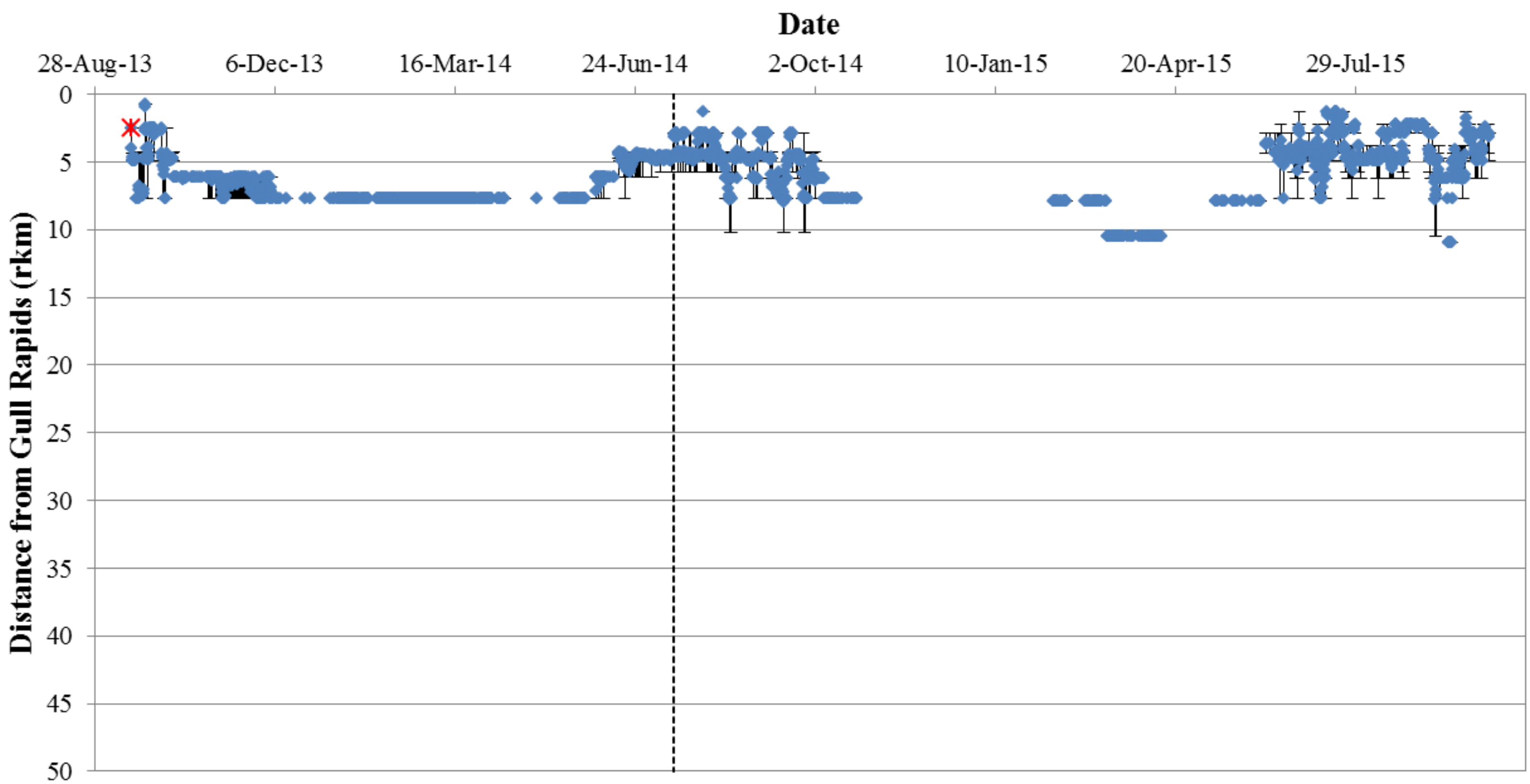


Figure A2-10: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32670) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 11 October, 2015. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

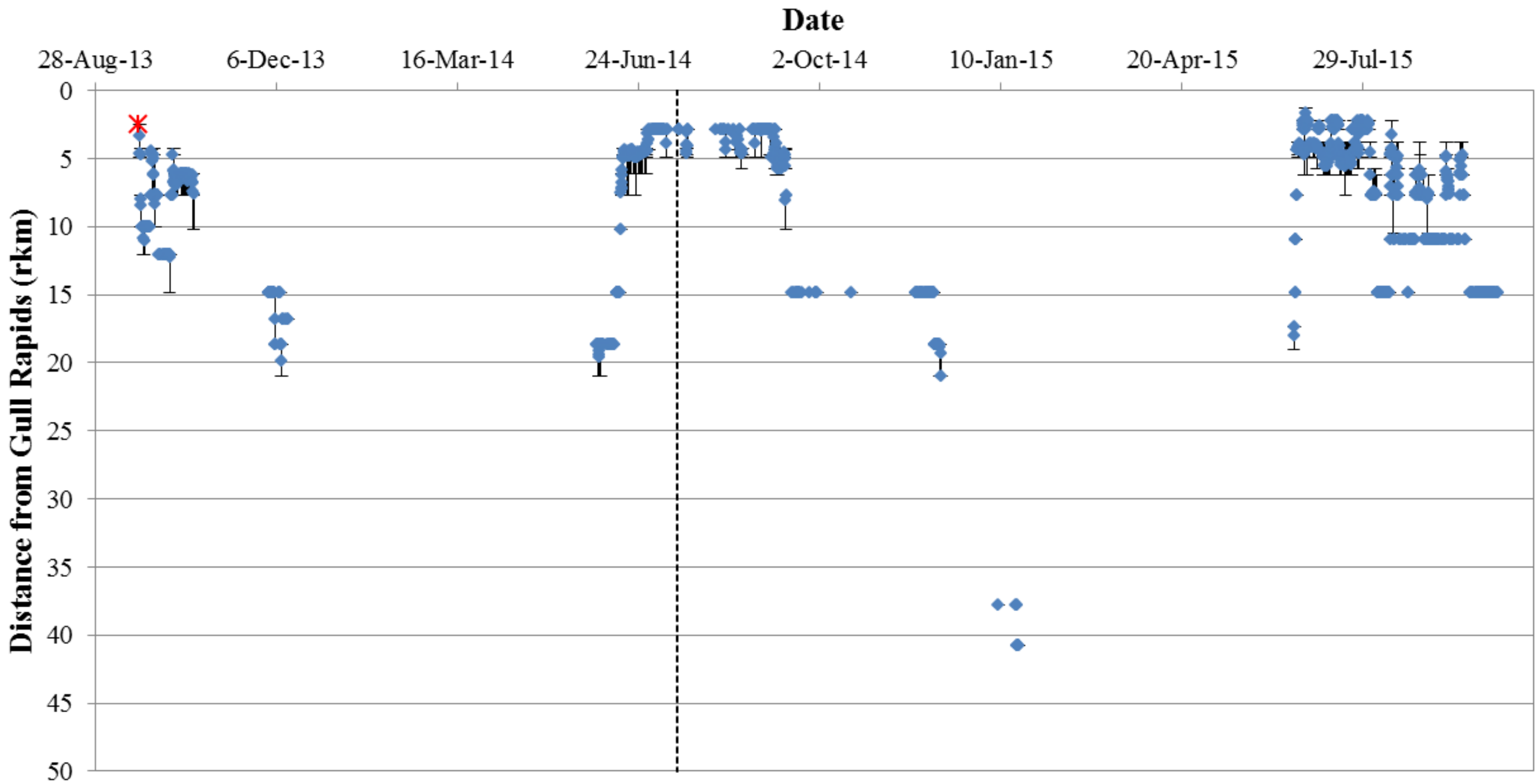


Figure A2-11: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32673) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 11 October, 2015. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

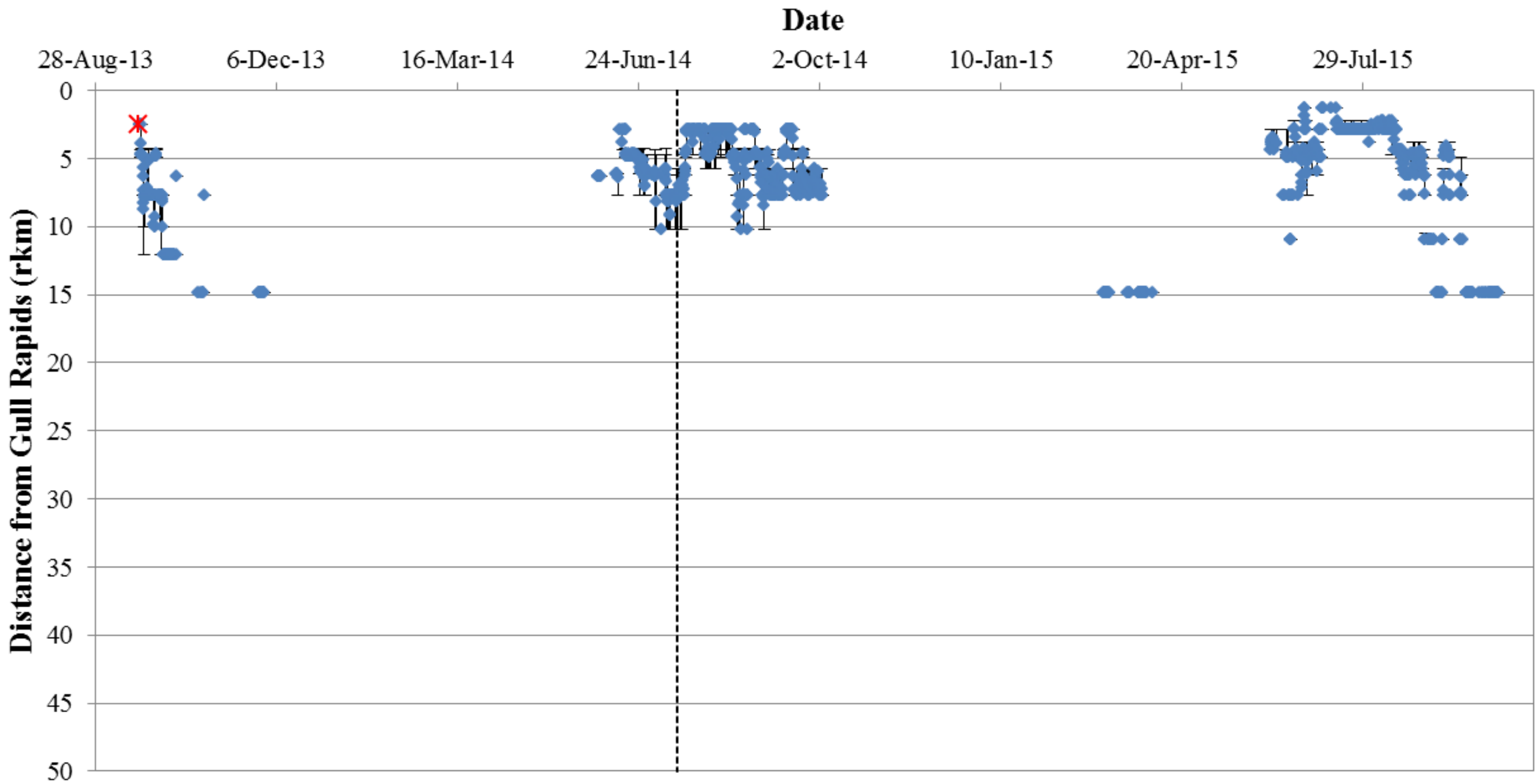


Figure A2-12: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32674) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 11 October, 2015. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

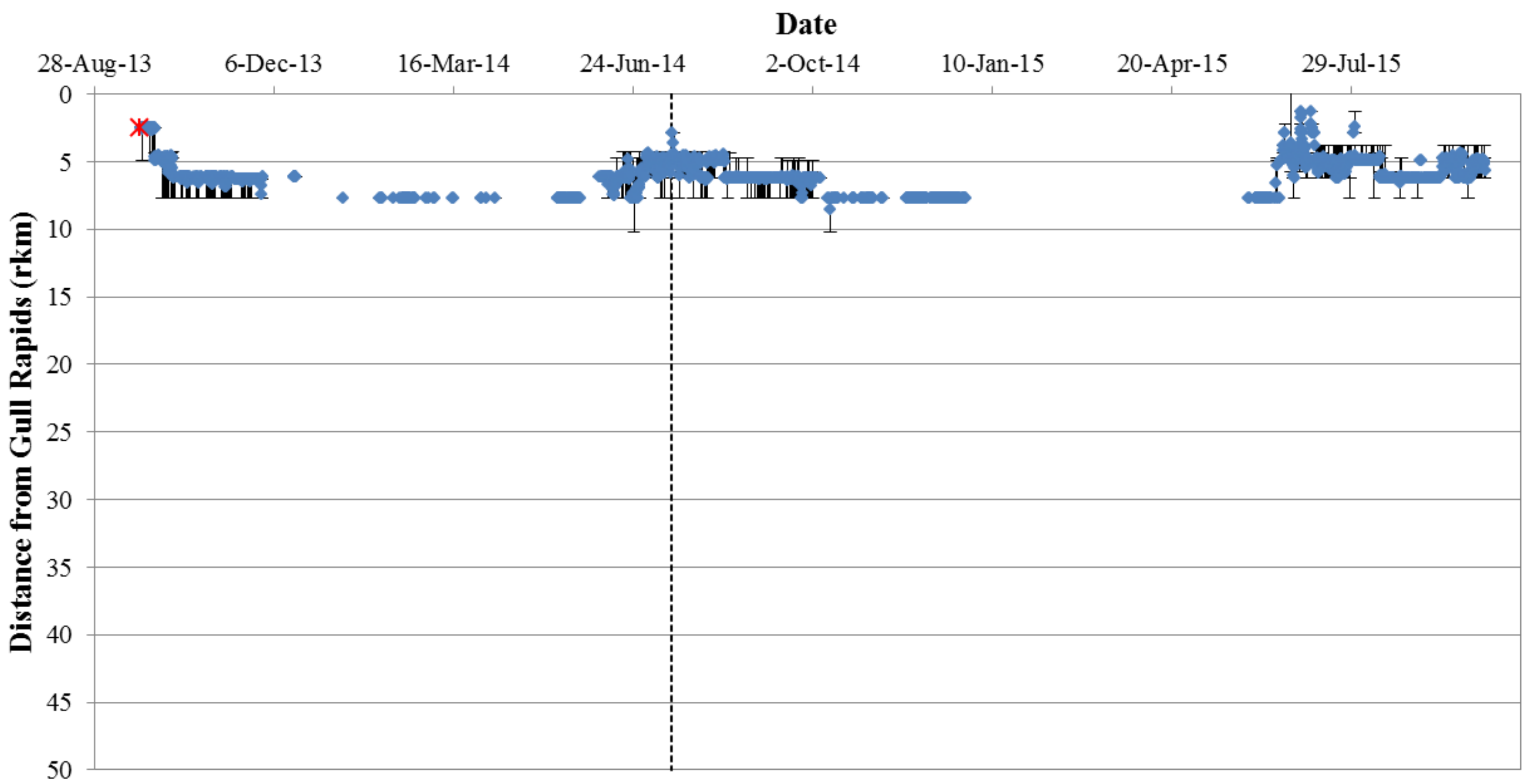


Figure A2-13: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32675) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 11 October, 2015. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

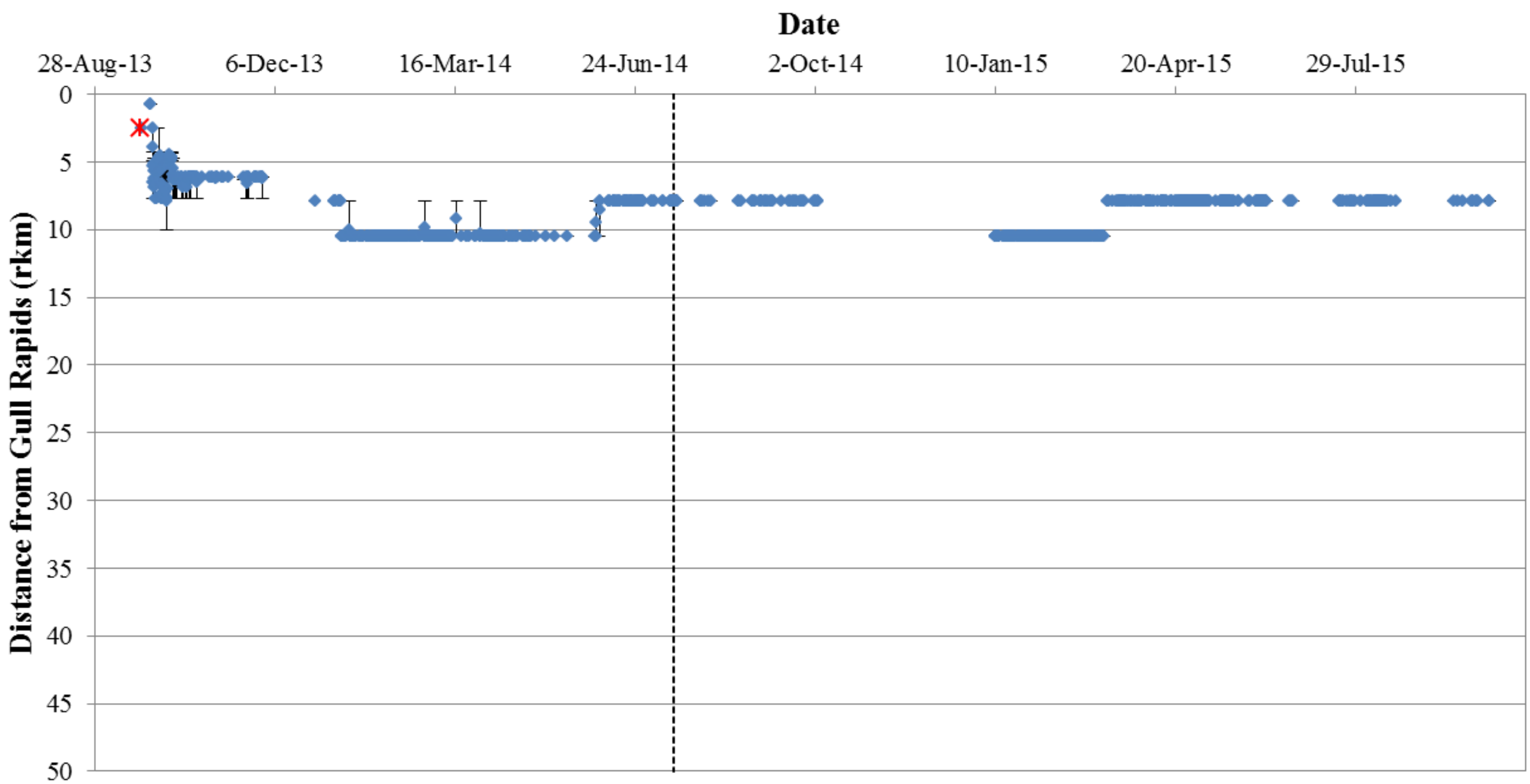


Figure A2-14: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32680) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 11 October, 2015. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

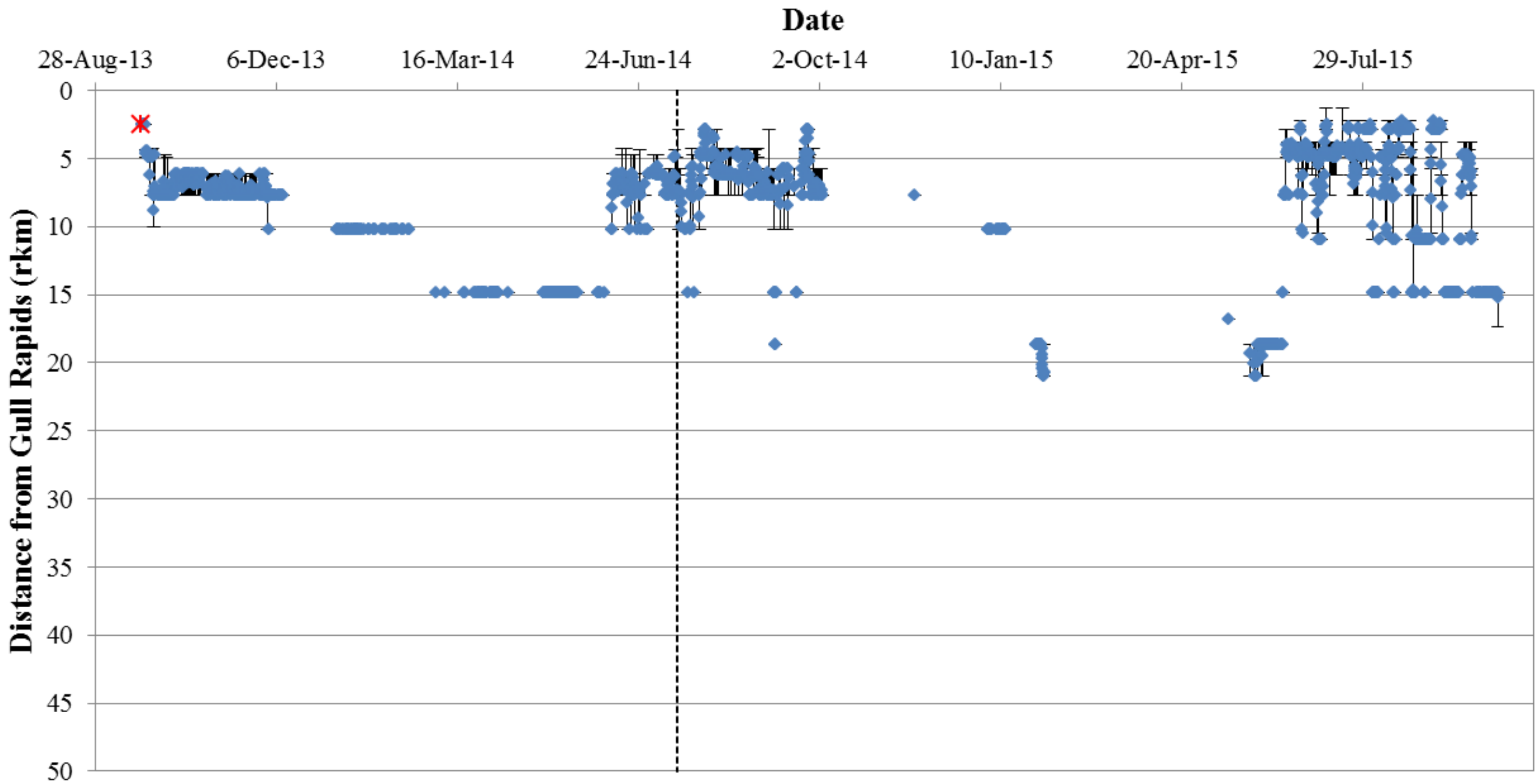


Figure A2-15: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32685) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 11 October, 2015. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

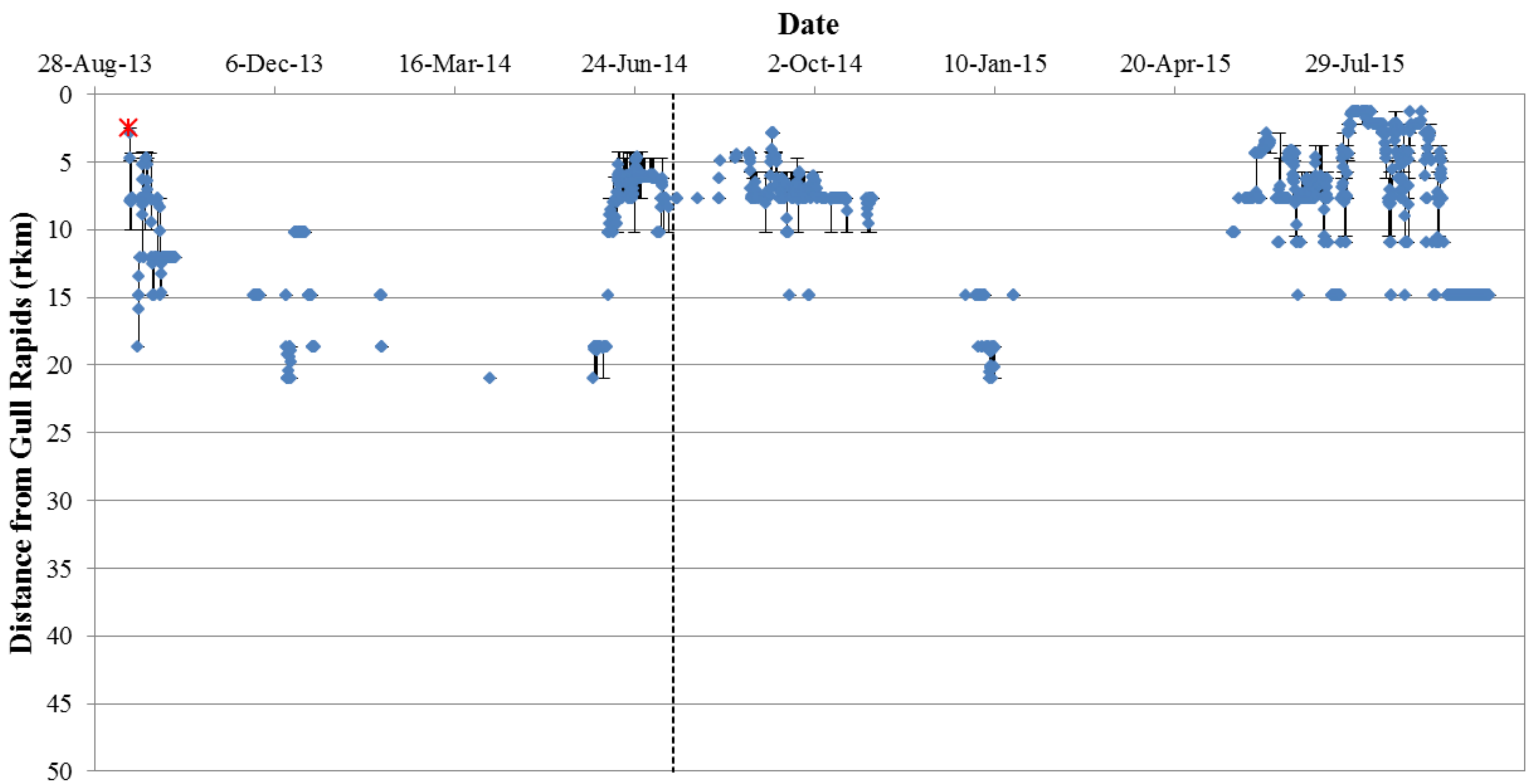


Figure A2-16: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32696) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 11 October, 2015. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

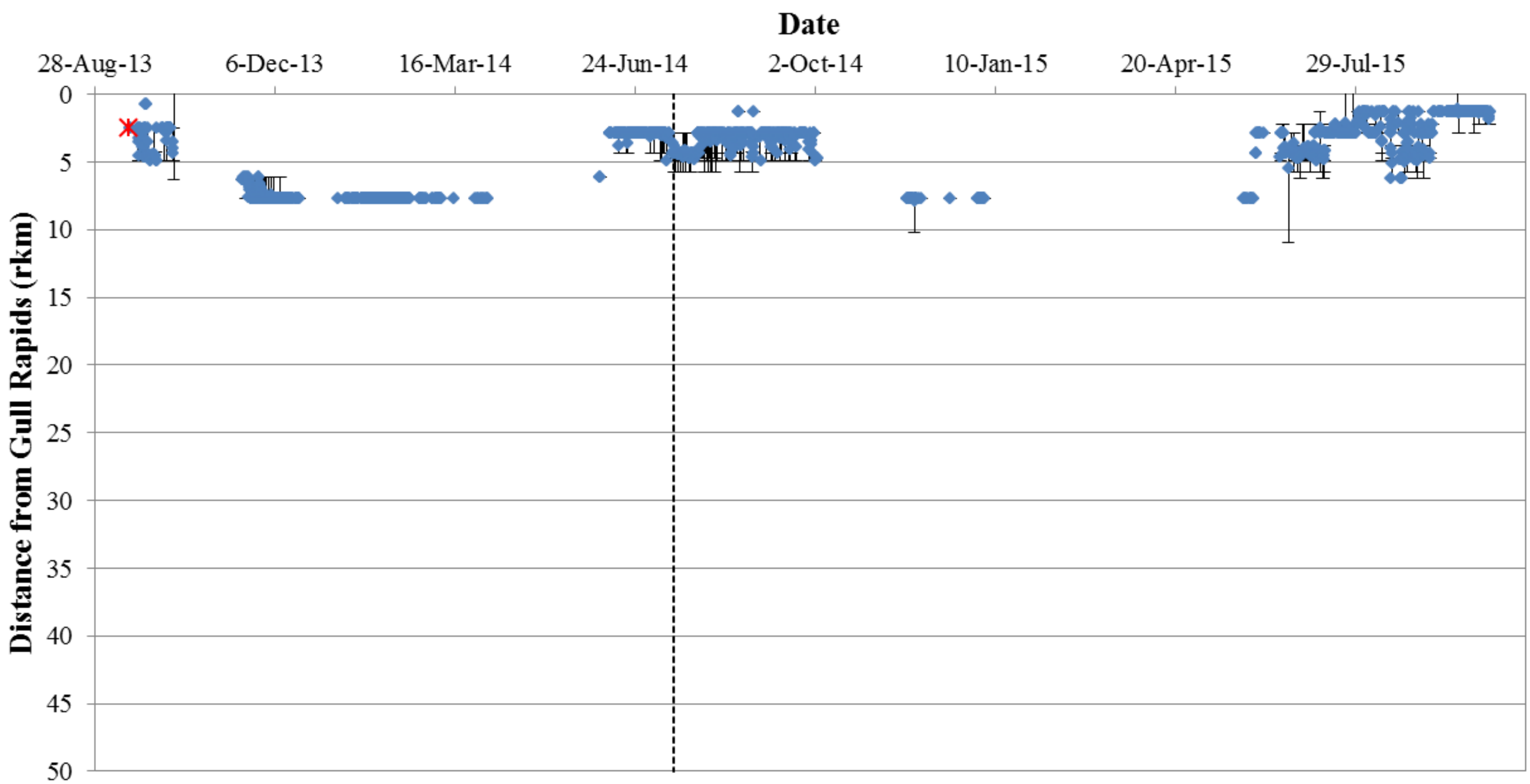


Figure A2-17: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32697) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 11 October, 2015. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

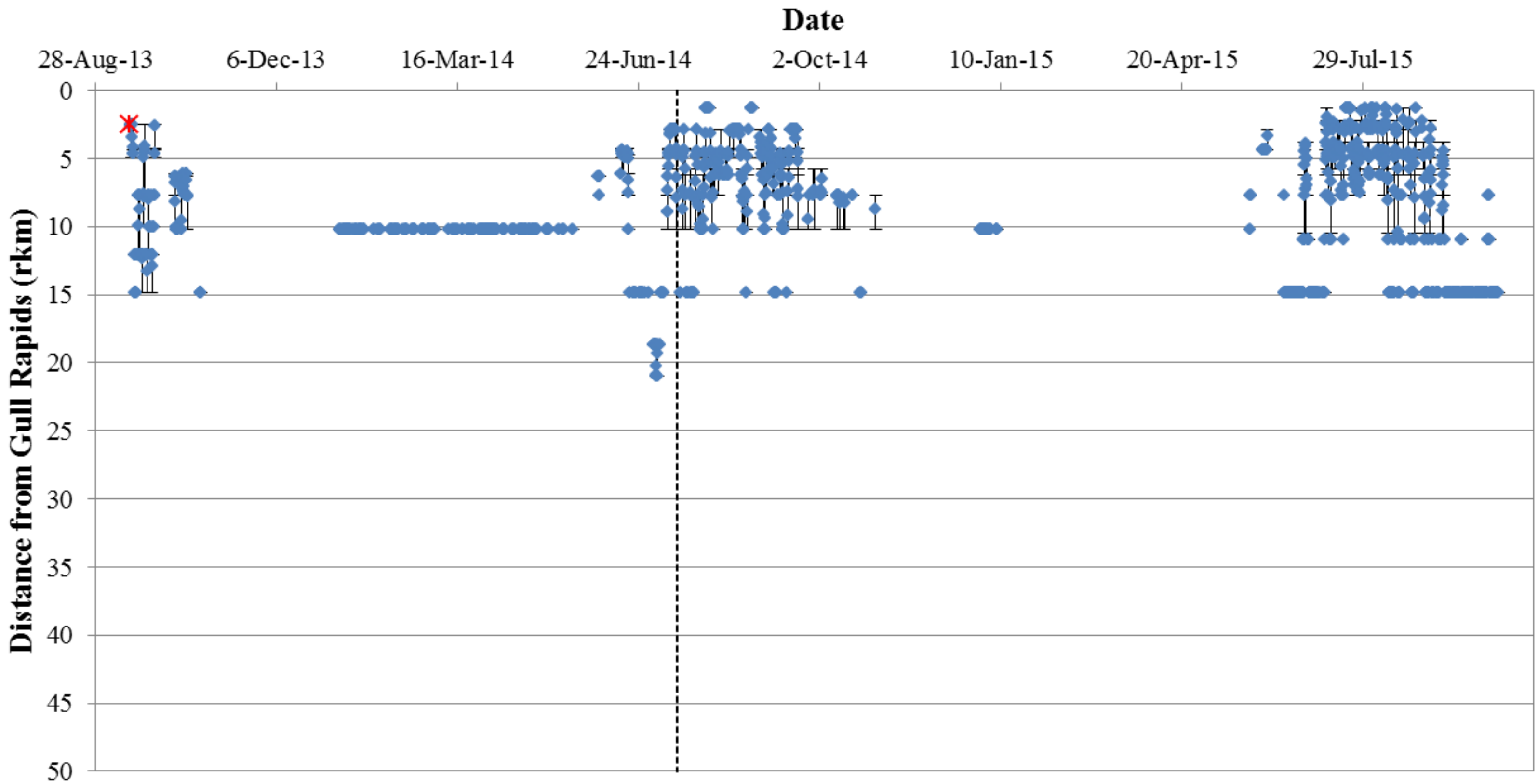


Figure A2-18: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32698) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 11 October, 2015. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

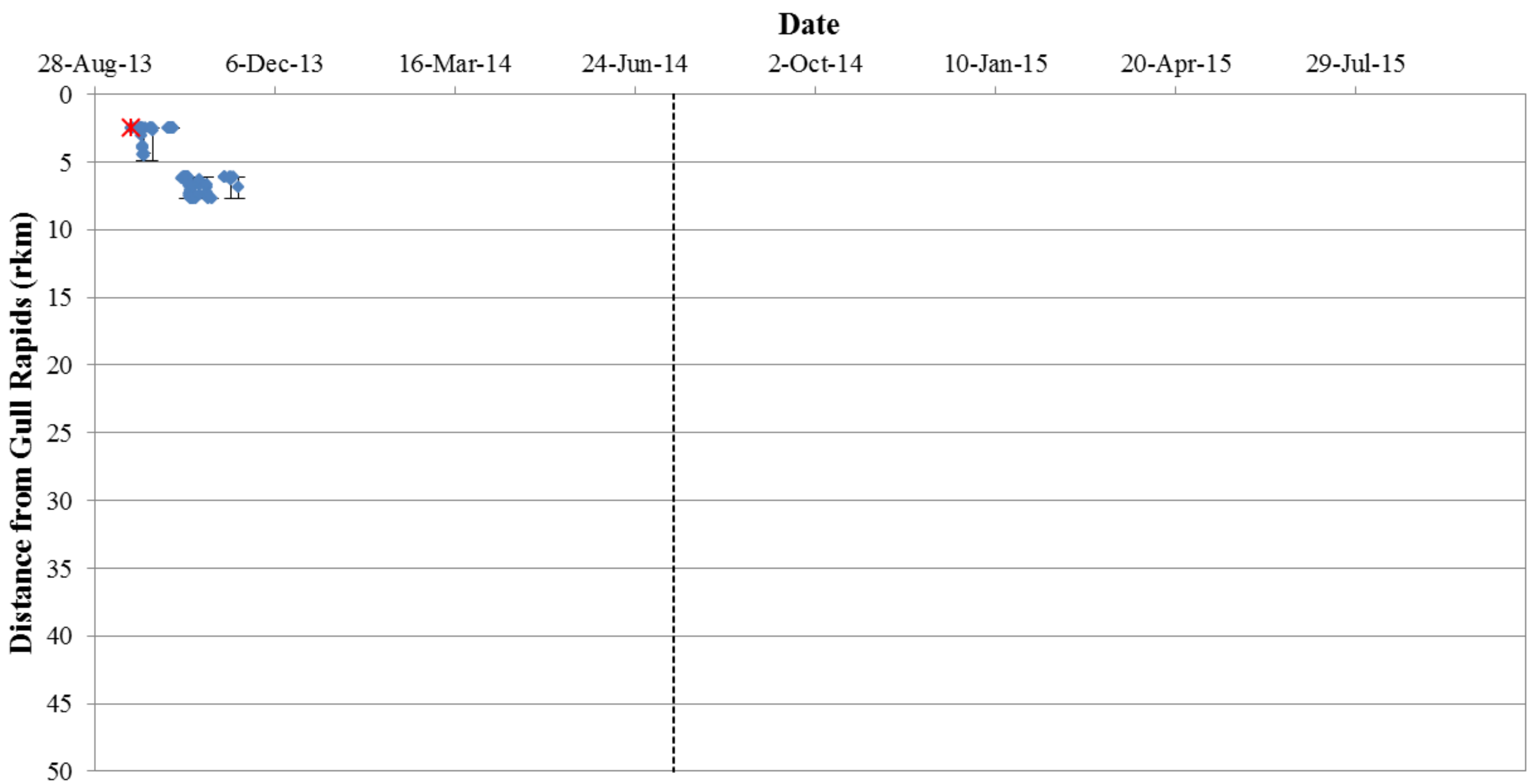


Figure A2-19: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32699) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 11 October, 2015. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

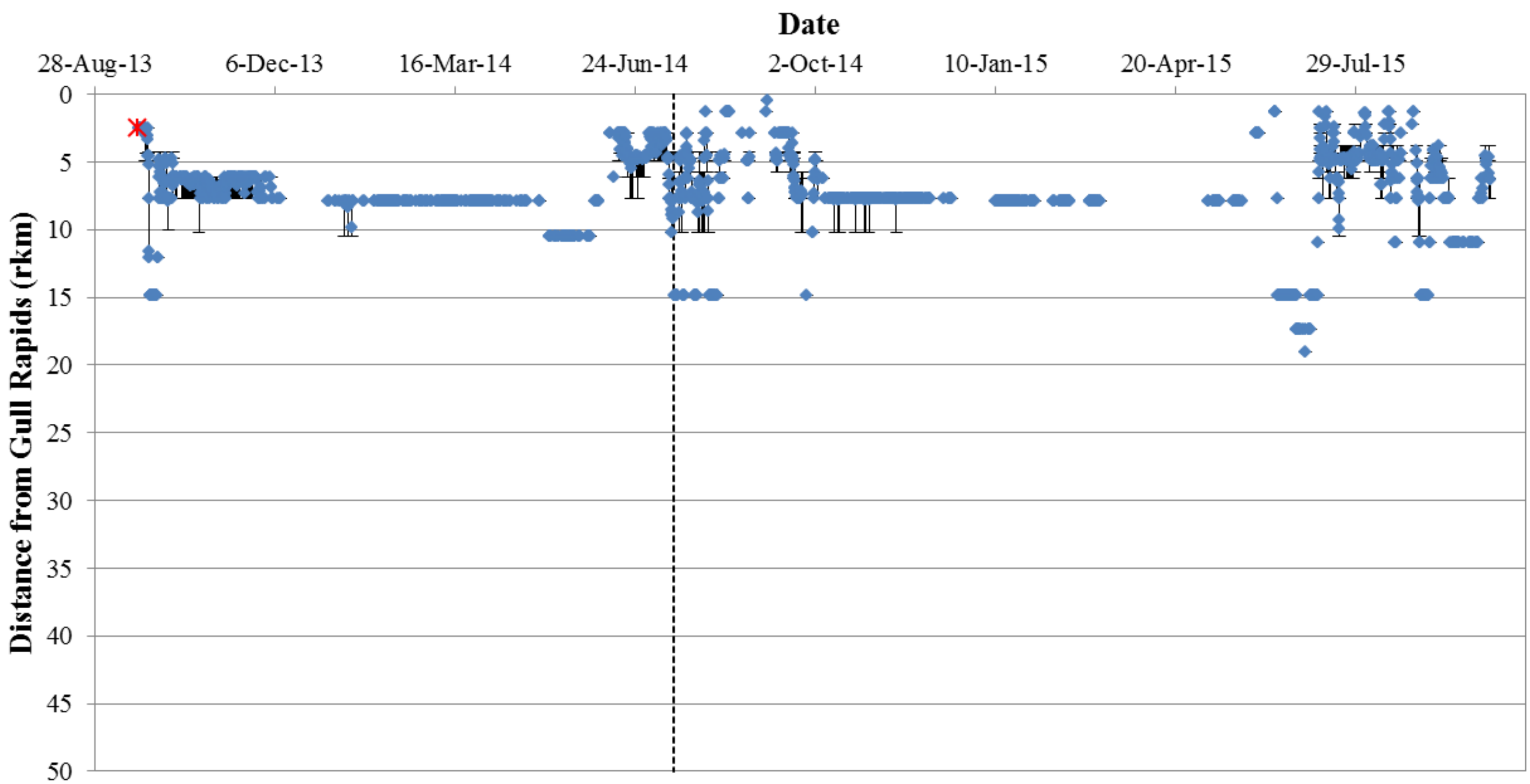


Figure A2-20: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32700) in Stephens Lake in relation to Gull Rapids (rkm 0), from 28 August, 2013 to 11 October, 2015. Date and location of tagging is indicated in red. Error bars are shown in solid black. Black dashed line represents start date of construction of the Keeyask GS.

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