Keeyask Generation Project

Aquatic Effects Monitoring Plan

Adult Lake Sturgeon Movement Monitoring Report

AEMP-2016-04

KEEYASK

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

2015 - 2016

KEEYASK GENERATION PROJECT

AQUATIC EFFECTS MONITORING REPORT

Report #AEMP–2016-04

ADULT 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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June 2016

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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.

This report provides the results of adult sturgeon movement monitoring conducted from October 2014 to October 2015. The study was initiated in June 2011 when 59 adult Lake Sturgeon were tagged with acoustic transmitters with a 10-year battery life. Movements of these fish were monitored for three years before any changes to the river occurred, and for approximately one year and three months since the start of construction.

DATA SOURCE:
Orthophoto: Manitoba Hydro - June 21, 2015

CREATED BY:
North/South Consultants

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z15N	26-FEB-10	30-MAY-16
0 0.15 0.3 Kilometres / 0 0.15 0.3 Miles	VERSION NO: 2.0	QA/QC: PMC/FSV/MWZ

KEEYASK

Construction Site

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

Why is the monitoring being done?

Monitoring is being done to answer two questions:

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

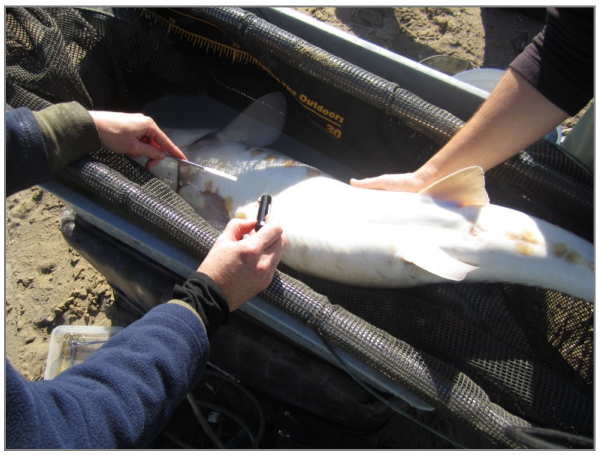
If sturgeon stay close to the construction area, they could be harmed by high amounts of mud in the water, or they could be trapped inside an area that will be drained. On the other hand, if they move far away, they may permanently leave the local population.

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

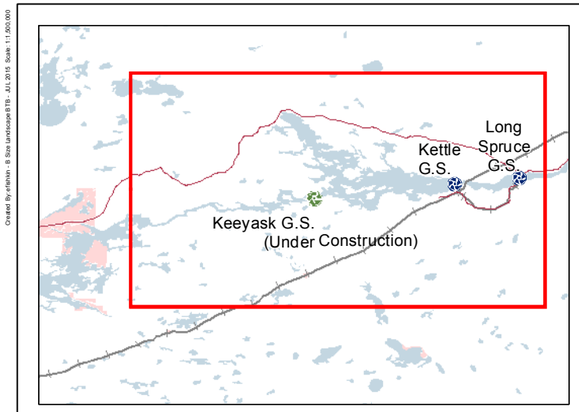
Movement studies tell us how many adult Lake Sturgeon are moving through Gull Rapids (upstream and downstream) between Gull and Stephens lakes, and when the fish are making these movements. Recording where fish move during construction tells us how close the fish are to construction activities, which is important because fish moving past the construction site may be harmed. Also, if adult Lake Sturgeon can't reach spawning sites because their movements are blocked by the GS, then it would harm their overall population. This study will be used along with other monitoring to help determine whether or not Lake Sturgeon need to cross Gull Rapids to spawn.

What was done?

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



An acoustic tag is implanted into a sturgeon through an incision.



N

Sky Pilot Lake
Sky Pilot
Ferris Bay
Wilson Channel
STEPHENS LAKE
River
Moswakot
South
North Access Road
280
Back
Looking
Creek
Kettle Rapids
Kettle G.S.
Long Spruce Rapids
Long Spruce G.S.
290
Creek
Fox Lake Cree Nation
A Kwis Ki Mahka Reserve
Gillam
Boots
Creek
Morris Point
Keeyask G.S. (Under Construction)
Gull Rapids
Gillrat Lake
GULL LAKE
RIVER
Clark Lake
NELSON
Birthday Rapids
Carscadden Lake
Cache Lake
Butnau
River
Joslin Lake
River
River
SPLIT LAKE
River
Butnau
Lake
Butnau
River
North
River
Wapikopaw Lake
Butnau
Kettle
Angling
Angling
Lakes
North
Little Kettle Lake
Kettle Lake

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	08-JUN-16
0 0.45 0.9 Kilometres 0 0.35 0.7 Miles	VERSION NO: 1.0	QA/QC: CMP/YYY/ZZZ

Legend

Receiver Locations
- Winter 2014/2015
- Winter 2014/2015 lost
- Open-water 2015
- Winter 2014/2015 and Open-water 2015
- Winter 2014/2015 and Open-water 2015 lost

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

2015 Acoustic Receivers
Clark Lake to Long Spruce G.S.

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

What was found?

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

Sturgeon are unique fish in Manitoba because they can live for a long time (100 or more years), become adults when they are 20 to 25 years old, and only spawn every 3 to 5 years. This means that where an individual sturgeon moves may change between years depending on how old it is, whether it is spawning, and what its individual habits are. Sturgeon spawn in spring in the fast-flowing water of large rapids, and spend the rest of the ice free season feeding in areas of rivers or lakes. During the winter, they move to areas where they are protected from ice and fast water.

Adult sturgeon caught in rapids (left). Sturgeon spawning in rapids (right).

Movements of the tagged fish have been monitored during winter when the river is covered with ice and during the spring, summer and fall. Monitoring movements in winter is challenging because the ice conditions can damage the receivers. For this reason, receivers are left in only a few locations over the winter, making it less likely that sturgeon will be detected.

After four-and-a-half years of monitoring, the sturgeon that were tagged in Gull Lake were divided into three groups: those that usually live in Gull Lake (18 fish), those that usually stayed in the channel of the Nelson River between Clark Lake and Gull Lake (5 fish), and those that were usually found in Gull Lake but left for short periods of time (2 fish). During 2015, three fish moved to different areas than other years. Two moved upstream into Clark Lake and one moved downstream into Stephens Lake.

Monitoring sturgeon over the years has indicated that fish tagged in Stephens Lake tend to stay in the main river channel, specifically the part of Stephens Lake where the river channel was flooded when the Kettle GS was built. After 2014, movements of adult sturgeon tagged in Stephens Lake were divided into two groups: those that remained within 15 km of Gull Rapids; and those that moved further downstream (as far as 21 km downstream of Gull Rapids). In addition, between 2011 and 2013, six adult sturgeon tagged in Stephens Lake moved upstream through Gull Rapids. This type of upstream movement was not observed in 2014 or 2015.

In each year of the study, at least one sturgeon has moved through Gull Rapids. Six fish moved upstream through Gull Rapids (one in 2011, four in 2012, one in 2013, and none in 2014 and 2015) and three moved downstream (two in 2014 and one in 2015). This is different than juvenile Lake Sturgeon, which do not move over Gull Rapids.

What does it mean?

So far, monitoring has shown that each sturgeon has a place where it likes to live. At times each fish may move to a different habitat, particularly if it is spawning. It is not known why some sturgeon move through Gull Rapids. So far we have seen that sturgeon usually do not move great distances and that most prefer to live in similar locations year after year. Habitat may affect how far sturgeon move. For example, sturgeon may move further when they are living in a long stretch of deep river channel. For this reason, the movements of sturgeon may change after the GS is built and Gull Lake becomes part of a deep reservoir.

What will be done next?

The tags that were implanted in 2011 will last to the end of construction in 2021. Following the movements of individual fish over such a long time will give us a better idea of what kinds of habitats these fish need to use over many years. It will also show us when they are spawning and when they are resting (growing).

ACKNOWLEDGEMENTS

We would like to thank Manitoba Hydro for the opportunity and resources to conduct this study.

The following members of Tataskweyak Cree Nation (TCN), Fox Lake Cree Nation (FLCN), and War Lake First Nation (WLFN) are thanked for their local expertise and assistance in conducting the field work: Saul Mayham and Michael John Garson of TCN; Jimmy Lockhart of FLCN; and Tim Flett of WLFN.

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 Gillam (Map 1). Construction of the Project began in July 2014.

The *Keeyask Generation Project: Response to EIS Guidelines*, completed in June 2012, provides a summary of predicted effects and planned mitigation for the Project. Technical supporting information for the aquatic environment, including a description of the environmental setting, effects and mitigation, and a summary of proposed monitoring and follow-up programs is provided in the *Keeyask Generation Project Environmental Impact Statement: Aquatic Environment Supporting Volume* (AE SV). As part of the licensing process for the Project, an Aquatic Effects Monitoring Plan (AEMP) was developed detailing the monitoring activities of various components of the aquatic environment including the focus of this report, fish community, specifically adult 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 report provides one-year of results (October 2014 to October 2015) of a multi-year adult Lake Sturgeon movement monitoring program. It also discusses what we have learned since monitoring movement of adult Lake Sturgeon started in 2011. In 2011, 59 fish (measuring > 755 mm fork length) were tagged with acoustic transmitters with a ten-year battery lifespan. Thirty-one fish were captured and tagged upstream of Gull Rapids, and 28 fish were captured and tagged downstream of Gull Rapids. An additional fish was tagged in Stephens Lake in 2013 to replace a tag returned by a local resource user. By 2013, 11 tags were either missing or lost. To compensate for this loss, additional tags were implanted in 2014 to restore the sample size to 59 fish. Data collected prior to the start of construction (from June 2011 to mid-July 2014) are reported in Hrenchuk and McDougall 2012; Hrenchuk and Barth 2013; and Hrenchuk *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.,* spawning, rearing, and foraging) during construction;

- the potential vulnerability of sturgeon to activities at the construction site (*i.e.,* if sturgeon use the area in the immediate vicinity of the construction site they may be vulnerable to stranding during dewatering); and
- the potential for increased emigration or avoidance of the construction site due to disturbance (*i.e.*, blasting, suspended sediment inputs, *etc.*).

The key questions for adult movement monitoring during 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 adult Lake Sturgeon increase during construction?

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. 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 (Map 4).

Gull Rapids is located approximately 3 km downstream of Caribou Island on the Nelson River (Map 1). 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. A summary of 2014/2015 construction activities at Gull Rapids is provided in Section 2.1.

Just below Gull Rapids, the Nelson River enters Stephens Lake. Stephens Lake was formed in 1971 by construction of the Kettle GS. Between Gull Rapids and Stephens Lake there is an approximately 6 km long reach of the Nelson River that, although affected by water regulation at the Kettle GS, remains riverine habitat with moderate velocity. Construction 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 further 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 (VEMCO V16-4x, estimated 3650 day battery life) were first applied to 59 fish in 2011 and 2012; 31 upstream, and 28 downstream of Gull Rapids (Table 1). By the end of the 2013 open-water period, it was suspected that 11 fish had either shed their tags, suffered mortality, or were captured by local resource users (tags have not been returned to NSC). In order to return the number of tagged fish to the original sample size, additional acoustic transmitters were applied to adult Lake Sturgeon upstream of the GS (n = 4) and in Stephens Lake (n = 7) in June 2014 (described in Hrenchuk and Barth 2015) (Table 1).

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 adult Lake Sturgeon between Clark Lake and the Keeyask GS construction site, Stephens Lake, and the Long Spruce Forebay.

In 2014 and 2015, receivers have been deployed at the same sites as those established during pre-construction monitoring (2011–2013). 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 were placed between Clark Lake and the Long Spruce GS during the winter 2014/2015 period (October 13, 2014 to April 30, 2015). Four were set upstream of Gull Rapids, 15 throughout Stephens Lake, and one in the Long Spruce Forebay (maps 4, 5, and 6). All receiver sites were previously used in winter 2013/2014.

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 provided in Section 4.0 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 (May 1 to October 11, 2015). Twenty-five were set between Clark Lake and Gull Rapids, 27 in Stephens Lake, and four in the Long Spruce Reservoir (maps 7, 8, and 9). A single receiver (#114243; rkm -24.3) was set upstream of the Keeyask GS construction site that had not been set during previous study years (Map 7). Five receivers set in Stephens Lake were not set in open-water 2014, but were set in 2015 to increase detection coverage: #4548 at rkm 3.6; 122863 at rkm 7.7; #5389 at rkm 21.6; 122778 at rkm 28.3; and #114240 at rkm 40.9 (Map 8). Additionally, a receiver previously set 0.5 rkm downstream of the Keeyask GS construction site was moved further downstream to rkm 2.2.

Receiver “gates” were deployed in several key areas: four between Clark Lake and Gull Rapids (44.0, 34.0, 19.0, and 10.0 rkms upstream of Gull Rapids), and two in Stephens Lake (4.5 and 40.0 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). The location of the “gates” has remained consistent since first set in 2012. On October 11, 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 distance, with the base of Gull Rapids representing a distance of 0 rkm. The area located downstream of Gull Rapids (*i.e.,* Stephens Lake and the Long Spruce 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 detection 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.

3.1.3.1 MAXIMUM LIKELIHOOD APPROACH

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

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

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

Where:

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

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

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

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

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

4.0 RESULTS

Tables 1 through 3 provide acoustic tagging and biological information associated with each tagged fish. Table 4 summarizes all movements through Gull Rapids by fish tagged during current (2011-2015) and previous (2001-2004) telemetry studies. Figures 3 to 9 provide movement range, and proportional distribution of tagged fish both upstream and downstream of the construction site by season. Appendix A1 provides detection summaries, while appendices A2 and A3 provide movement summaries, by rkm, for each tagged sturgeon since the study began in June 2011.

4.1 2011-2014 RESULTS SUMMARY

4.1.1 UPSTREAM OF GULL RAPIDS

Thirty-one fish were tagged upstream of Gull Rapids in 2011 and 2012 (Table 1), but, since that time, several tags have gone missing:

- #16045 has not been detected since August 18, 2011. It moved downstream immediately after tagging and displayed few upstream movements (Appendix A2-5).
- #16058 was tagged downstream of Birthday Rapids (rkm -30.2) in 2011. It was last detected in the riverine section of the Nelson River near Birthday Rapids on August 5, 2012 (Appendix A2-12).
- #16064 was regularly detected in Gull Lake from the date it was tagged (June 12, 2011) until June 21, 2012 (Appendix A2-18) and has not been detected since that time.
- #16067 was tagged in Gull Lake on June 19, 2011. It remained in this area until May 27, 2012, when it moved upstream through Birthday Rapids into Clark Lake. It was last detected in Clark Lake on June 29, 2012. This fish may have continued to move upstream past the receiver array (Appendix A2-21).
- #16075 moved downstream immediately after tagging on June 10, 2011. It was last detected on June 27, 2011 (Appendix A2-29).
- #16077 moved downstream immediately after tagging on 10 June, 2011. It was last detected on June 21, 2011, (Appendix A2-31).

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

Four additional transmitters were applied to fish upstream of Gull Rapids in June, 2014 (appendices A2-32, A2-33, A2-34, and A2-35).

Prior to winter 2014/2015, six fish moved upstream from Stephens Lake into Gull Lake, two of which returned to Stephens Lake in open-water 2014:

- #16025 was tagged in Stephens Lake on June 16, 2012, and moved upstream through Gull Rapids on August 22, 2012. This fish subsequently moved back downstream into Stephens Lake, where it was first located on June 18, 2014 (Appendix A3-7).
- #16029 was tagged in Stephens Lake on June 21, 2011, and moved upstream through Gull Rapids between July 29 and August 2, 2011. This fish remained in Gull Lake and continued to be detected here in 2015 (Appendix A3-10).
- #16033 was tagged in Stephens Lake on June 18, 2011, and moved upstream through Gull Rapids on July 28, 2012. However, shortly after, it was captured by a local resource user and the tag was returned and reapplied to another fish in Stephens Lake in 2013.
- #16037 was tagged in Stephens Lake on June 8, 2011, and moved upstream through Gull Rapids between September 3 and 6, 2013. It then moved downstream and was detected in Stephens Lake on July 1, 2014 (Appendix A3-17).
- #16038 was tagged in Stephens Lake on June 12, 2011, and moved upstream through Gull Rapids on September 12, 2013. This fish remained in Gull Lake and continued to be detected here in 2015 (Appendix A3-18).
- #16046 was tagged in Stephens Lake on June 11, 2011, and moved upstream through Gull Rapids between June 27 and July 4, 2012. This fish was detected in Gull Lake until 2013, but has not been located since (Appendix A3-23).

Therefore, accounting for the 31 fish originally tagged, the six missing fish (highlighted in yellow in Appendix A1-1), the four additional tags added in 2014, and the three fish that moved upstream from Stephens Lake (subtracting the one that was confirmed harvested [highlighted green in Appendix A1-1], and the two that returned to Stephens Lake in 2014), a total of 32 sturgeon were available to be detected upstream of Gull Rapids during winter 2014/2015.

4.1.2 STEPHENS LAKE

Twenty-eight fish were originally tagged downstream of Gull Rapids in 2011 and 2012 (Table 3). Four fish are considered missing due to a lack of detections:

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

- #16047 moved downstream immediately after being tagged on June 26, 2011. It was last detected in Stephens Lake on June 28, 2011 (Appendix A3-24).

Three fish have moved downstream through the Kettle GS into the Long Spruce Reservoir:

- #16021 was tagged in Stephens Lake on September 28, 2011, and moved downstream through the Kettle GS on September 16, 2012. It was last detected in the Long Spruce Reservoir on September 18, 2012 (Appendix A3-4).
- #16025 was tagged in Stephens Lake on in 2012. It moved upstream into Gull Lake in 2012 but returned to Stephens Lake in 2014 (Section 4.1.1). This fish subsequently moved downstream through Kettle GS between June and July, 2014. It was last detected in the Long Spruce Reservoir on July 14, 2014 (Appendix A3-7).
- #16034 was tagged in Stephens Lake on June 18, 2011, and moved downstream through the Kettle GS between October 9, 2012, and June 10, 2013. It was detected in the Long Spruce Reservoir in open-water 2015 (Appendix A3-15).

A single fish (#32169) was suspected missing at the end of the 2014 open-water study period (Hrenchuk and Barth 2015). It was last located in the area where the Powerhouse Cofferdam was constructed in mid-September, 2014. This fish was detected further downstream in Stephens Lake in 2015 (Section 4.2.2.1).

Six fish have moved upstream into Gull Lake (as discussed in Section 4.1.1.), however, one of these fish (#16033) was captured by a local resource user and the tag was reapplied to a fish in Stephens Lake. Two of these fish (#16025 and #16037) returned to Stephens Lake in 2014, however, #16025 moved downstream through the Kettle GS into the Long Spruce Reservoir (discussed above).

Additional acoustic tags were applied to seven fish in Stephens Lake within 2 rkm of Gull Rapids in June, 2014 (Table 3).

Originally, 28 fish were tagged in Stephens Lake. Four are considered missing, three moved downstream through Kettle GS, three moved upstream into Gull Lake and did not return to Stephens Lake, and seven were tagged in 2014. Therefore 25 fish were available to be detected in Stephens Lake during winter 2014/2015.

4.2 WINTER 2014/2015 MOVEMENTS

4.2.1 UPSTREAM OF GULL RAPIDS

Only two of the four receivers deployed upstream of Gull Rapids (rkm -48.2 and rkm -12.9) during winter 2014/2015 were retrieved (Map 4). The remaining two receivers (located at rkm -9.9 and -29.4) could not be located, and were likely moved by ice. Only six (#16036, #16038, #16061, #16063, #16071, and #16072) of the possible 32 fish were detected. All detections

(n = 2,863) were logged by a single receiver deployed in Gull Lake (rkm -12.9) (Figure 3; Map 4; Appendix A1-1). Fish were located over two to 16 days of the 200 day winter period (1 to 8% of the time). Individual Lake Sturgeon movements are summarized graphically in Appendix 2. Movement monitoring during winter continues to be challenging in Gull Lake, largely due to the limited number of sites available to deploy receivers. The loss of two of the four receivers deployed upstream of the Keeyask construction area in 2015 greatly limited the detection frequency of adults in this area.

From January 14–21, 2015, 16 of 32 (50%) adult Lake Sturgeon were detected during the tracking event conducted at two potential ice blasting locations in Gull Lake (specifically the downstream end of zone 4 rkm -9.9 and the upstream end of zone 5 rkm -6.9) (see Appendix 4). These data suggest that the downstream end of Gull Lake (rkm -9.9 to -6.9) provides important overwintering habitat for adults in this study area. Three of these fish had not previously been detected during winter. When combined with data from the receiver retrieved from rkm -12.9, data suggest that adult Lake Sturgeon rarely move during winter. Only three of the fish located by the receiver at rkm -12.9 were located at rkm -9.5.

4.2.2 STEPHENS LAKE

Ten of the 15 receivers deployed in Stephens Lake during winter were retrieved. Three receivers located at rkms 26.0, 32.0, and 40.8 could not be retrieved due to the buildup of large woody debris during the winter. The two receivers closest to Gull Rapids (rkms 6.1 and 6.3) could not be located and were likely moved by ice (Map 5).

Twenty-three of the 25 fish were located, logging a total of 290,769 detections (range: 293–36,654 detections per individual) (Appendix A1-2). Fish were detected on 6 to 188 days of the 200 day winter period (3–94% of the time). Nineteen fish (83%) were located as far upstream as rkm 7.7, while four (16%) were located as far downstream as rkm 21.0 (Appendix A1-2). The average overall movement range was 5.2 rkm (range: 0.0–13.3 rkm) (Figure 4; Appendix A1-2).

4.2.2.1 MOVEMENT PATTERNS

Fish displayed two general patterns of movement, illustrated in Map 10:

- Seven (#16019, #16027, #16037, #16040, #16049, #32169, and #32170) were detected exclusively within the upstream portion of Stephens Lake, moving no further downstream than rkm 10.5 (Appendix A1-2).
    - Four of these (#16037, #16040, #32169, and #32170) were detected sporadically (between 6 and 69 days).
    - Three (#16019, #16027, and #16049) were detected for 79 to 120 days from October, 2014, to April, 2015. All three fish moved between rkm 7.7 and 10.5 (Appendix A1-2).

- Sixteen fish were detected further downstream than rkm 10.5 (Appendix A1-2).
    - Eight (#16020, #16022, #16030, #16032, #16033b, #16041, #16053, and #32173) moved between rkm 7.7 and 14.9.
    - Two (#16031 and #32167) were only detected at rkm 14.9.
    - The remaining six (#16043, #16050, #16052, #32168, #32171, and #32172) moved further downstream within Stephens Lake, as far downstream as rkm 21.0.

Individual Lake Sturgeon movements are summarized graphically in Appendix 3.

4.2.3 LONG SPRUCE RESERVOIR

The single receiver set in the Long Spruce Reservoir was retrieved (Map 6). However, none of the three Lake Sturgeon (#16021, #16025, and #16034) last detected in this area were located during winter 2014/2015 (appendices A3-4, A3-7, and A3-15).

4.3 OPEN-WATER 2015 MOVEMENTS

4.3.1 ACOUSTIC RECEIVER RETRIEVAL

All stationary acoustic receivers were successfully retrieved upstream of the GS construction site (25), and the Long Spruce Reservoir (4) at the end of the open-water study period (maps 7 and 9). Two of the 27 receivers deployed in Stephens Lake (#122778 rkm 28.3, and #108003 rkm 39.9) were caught on submerged trees and could not be retrieved during the last download on October 11, 2015 (Map 8).

4.3.2 UPSTREAM OF GULL RAPIDS

Thirty-two fish were available to be detected upstream of Gull Rapids during the 2015 open-water period (Section 4.1.1). Twenty-eight of these fish were detected between 265 and 39,272 times for 13–137 days of the 164 day open-water period (8–84% of the time; Appendix A1-3). The average total movement range was 15.0 rkm (StDev = 10.8 rkm; range: 0.6–38.7 rkm) (Figure 5; Appendix A1-3). Three fish (11%) were located as far upstream as the inlet of Clark Lake (rkm -48.2), while ten (36%) were located as far downstream in Gull Lake as rkm -5.8 (Figure 5; Appendix A1-3). A single fish (#16048) moved downstream through Gull Rapids into Stephens Lake, and was detected as far downstream as rkm 17.4 (a total movement range of 36.9 rkm) (Figure 5; Appendix A1-3).

Two fish, last located in open-water 2014, were not detected in the 2015 open-water period. Both fish #16042 and #16057 were last located at the inlet of Clark Lake (rkm -48.2) in 2014, in

August and June, respectively (appendices A2-4 and A2-11). It is possible that these fish moved upstream past the array into Split Lake.

One fish that was not detected in 2014 was located during the 2015 open-water period. Fish #16075 was tagged on June 10, 2011 in Gull Lake. It was only detected for 10 days post-tagging, and was last detected on June 27, 2011 (Appendix 2-29). It was detected again at the downstream end of Gull Lake (rkm -5.8) on May 30, 2015. It is likely that this fish moves little and has remained outside of the receiver array for the last several years.

4.3.2.1 PROPORTIONAL DISTRIBUTION

Individual Lake Sturgeon used zones 4 (central basin of Gull Lake) and 5 (lower basin of Gull Lake) most often, spending a total of 44% (StDev = 29%; range: 0–97%) and 42% (StDev = 29%; range: 0–100%) of the study period in these areas, respectively (Figures 6 and 7). Zones 1 (Clark Lake), 2 (river reach Clark Lake to Birthday Rapids), and 3 (river reach Birthday Rapids to Gull Lake) were used less frequently: Zone 1 (5%) (StDev = 19%; range: 0–97%), Zone 2 (0.1%) (StDev = 0.4%; range: 0–2%), and Zone 3 (10%) (StDev = 27%; range: 0–97%) (Figures 6 and 7).

4.3.2.2 MOVEMENT PATTERNS

As described in previous reports, individual Lake Sturgeon in this study area exhibit habitual movements. Distinct movement patterns have emerged from this long-term data set and based on these patterns, fish were split into three groups: i) those that remain in Clark Lake.; ii) those that remain within the riverine area between Clark Lake and Gull Lake; and iii) those that remain in Gull Lake (Hrenchuk and Barth 2015).

In 2015, 25 fish continued to display the same general patterns of movement as in previous years, illustrated in Map 11:

- Twenty-three remained in Gull Lake for the majority of the open-water period:
    - Eighteen were detected exclusively within Gull Lake:
        - Four (#16055, #16066, #16075, and #32177) remained within lower Gull Lake, moving between rkm -12.9 and -5.8.
        - The remaining 14 fish made multiple upstream and downstream movements within Gull Lake, moving as far upstream as rkm -19.5 and as far downstream as rkm -5.8.
    - Five were located within Gull Lake for the majority of the study period, but made brief upstream movements, after which they returned to Gull Lake:
        - Four (#16051, #16056, #16065, and #32176) moved upstream to the base of Birthday Rapids (rkm -32.3).

    - #16065 and #32176 were located at Birthday Rapids during the spawning period (from June 1 to 8, 2015) when water temperature ranged from 8 to 11˚C.
    - #16051 moved to the base of Birthday Rapids on Sept 28, 2015, while #16056 was located there from June 22 to July 31, 2015.
  - One (#32174) moved upstream as far as the inlet to Clark Lake (rkm -48.2). It was located in Gull Lake (rkm -17.4 to -5.8) from May 14 to June 30, 2015. It moved upstream to Clark Lake on July 1 and back downstream to Gull Lake on July 17, 2015 (Appendix A2-32).
- Two (#16026 and #16069) remained within the riverine area between Clark Lake and Gull Lake and have been located exclusively within this river reach since the study began in 2011.

The remaining three fish displayed non-habitual movements:

- One was previously located exclusively in the riverine area between Clark Lake and Gull Lake:
    - #16074 was detected within Clark Lake at the beginning of the 2015 open-water period, moved downstream to Birthday Rapids between June 4 and 7, 2015, and returned to Clark Lake. It was last located at the upstream end of Clark Lake on July 10, 2015 (Appendix A2-28).
      - This fish was located at Birthday Rapids during the spawning period when water temperature ranged from 10 to 12˚C.
- One was previously located exclusively in Clark Lake:
    - #16048 moved downstream through Gull Rapids into Stephens Lake. This fish moved between Birthday Rapids (rkm -32.3) and the upstream end of Clark Lake (rkm -48.2) between 2011 and 2014. It was detected at the upstream end of Gull Lake (rkm -19.5) at the beginning of the 2015 open-water period. It then moved downstream and was detected in Stephens Lake on June 28, 2015. It moved between rkm 1.3 and 14.9 for the remainder of the study period (Appendix A2-6).
      - By June 28, water temperature in Stephens Lake measured 18˚C, which is too warm for spawning. Therefore, this fish likely did not move downstream to spawn at Gull Rapids.
      - This fish represents the third downstream movement observed through Gull Rapids since the inception of this study in 2011 (discussed further in Section 4.5). A summary of all observed movement through Gull Rapids by adult Lake Sturgeon tagged with radio or acoustic tags since 2001 is provided in Table 4.

- One was previously located exclusively in Gull Lake:
    - #16054 remained in Gull Lake (between rkm -19.5 and -6.6) until July 9, 2015, when it moved immediately upstream of Birthday Rapids (rkm -33.8). It remained here until September 3, 2015, after which it continued upstream and was last detected at the inlet to Clark Lake (rkm -44.8) on September 4, 2015 (Appendix A2-8).

Individual Lake Sturgeon movements are summarized graphically in Appendix 2.

4.3.3 STEPHENS LAKE

All 25 fish available to be detected in Stephens Lake during the 2015 open-water period (Section 4.1.2) were detected between 10,937 and 34,961 times over 94–140 days of the 164 day study period (57–85% of the time; Appendix A1-4). Mean movement range was 16.3 rkm (StDev = 3.3 rkm; range: 9.7–27.0 rkm) (Figure 8; Appendix A1-4). Twenty-four fish were detected as far upstream as rkm 1.3, while a single fish was detected as far downstream as rkm 28.3 (Figure 8; Appendix A1-4). No fish moved upstream through Gull Rapids.

4.3.3.1 PROPORTIONAL DISTRIBUTION

Unlike previous years, Lake Sturgeon used Zone 6 (referred to as Zone 1 in previous reports) more frequently than Zone 7 (referred to as Zone 2 in previous reports), spending 56% (StDev = 20%; range: 4–100%), and 45% (StDev = 20%; range: 0–96%) of the time in each zone, respectively (Figures 6 and 9). However, utilization of the zones changed over time. A greater proportion of fish were detected close to Gull Rapids during the beginning and middle of the study period than at the end (Figures 6 and 9).

- Zone 6 was used an average of 89% of the time (StDev = 5%; range: 77–96%) between June 4 and 11, 2015;
- 51% (StDev = 12%; range: 27–73%) between June 12 and August 1, 2015;
- 75% (StDev = 7%; range: 54–88%) between August 2 and 25, 2015; and
- 43% (StDev = 17%; range: 19–81%) between August 26 and October 11, 2015.

4.3.3.2 MOVEMENT PATTERNS

Two general movement patterns were displayed during the 2015 open-water period, illustrated in Map 12:

- Six fish (#16027, #16031, #16041, #16050, #32172, and #32173) remained in the upstream portion of Stephens Lake, moving only as far downstream as rkm 14.9. All six of these fish displayed the same movement pattern during open-water 2014 (Appendix 3).
- The remaining 19 fish moved further downstream into Stephens Lake:

- Thirteen made regular upstream and downstream movements, moving as far downstream as rkm 17.4.
- Four fish (#16028, #16030, #16035, and #16043) moved as far downstream as rkm 19.0.
- #16019 was located between rkm 19.0 and 28.3 from June 18 to July 20, 2015 (Appendix A3-2).
- A single fish (#16020) was located as far downstream as rkm 21.0 on June 13, 2015 (Appendix A3-3).

No fish moved as far downstream as the Kettle GS in 2015. In fact, no fish were detected within 20 rkm of the station.

Individual Lake Sturgeon movements are summarized graphically in Appendix 3.

4.3.4 LONG SPRUCE RESERVOIR

One of the three (Section 4.1.2) fish last detected in the Long Spruce Reservoir was located in the open-water period. Lake Sturgeon #16034 was detected by the three receivers closest to Kettle GS (Map 9). As in 2014, this fish remained at rkm 47.5 from June 2 to 6, 2015. It was then detected at the two upstream acoustic receivers, logging 30,767 detections between June 7 and October 11, 2015 (appendices A1-4 and A3-15).

4.4 ADULT LAKE STURGEON DISTRIBUTION

Proportional distributions of fish detected consistently since 2012 (n = 45) were compared, and the likelihood of fish movements between zones both before and after construction were calculated (Figures 10, 11, and 12). The overall likelihood of a movement (either upstream or downstream) between zones was 12.2% prior to construction and 15.2% after construction (Figure 10). The likelihood of a fish moving upstream from one zone to another was 43.4% prior to the onset of construction, and 44.7% after (Figure 11). The likelihood of a fish moving downstream from one zone to another was 56.6% before construction and 55.8% after (Figure 12).

4.5 LONG DISTANCE MOVEMENTS

Since the inception of the study in 2011, nine movements through Gull Rapids have occurred: six upstream, and three downstream (Table 4).

- Four fish (#16029, #16033, #16038, and #16046) tagged in Stephens Lake made a single upstream movement.

- One fish (#16048) tagged in Gull Lake made a single downstream movement.
- Two fish (#16025 and #16037) tagged in Stephens Lake moved upstream into Gull Lake and returned to Stephens Lake.

Additionally, three fish (#16021, #16025, and #16034) have moved downstream through the Kettle GS.

A single movement through Gull Rapids (#16048) occurred following the start of Keeyask GS construction.

The likelihood of a fish moving through a barrier (either Gull Rapids or Kettle GS) was calculated both pre- and post-construction. Prior to construction, there was a 2.1% chance that a fish would move through a barrier, and a 0.9% chance after the onset of construction (Figure 13).

5.0 DISCUSSION

This movement study was initiated in 2011 with the long-term objective of assessing impacts of construction and operation of the Keeyask GS on adult 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. Movements of individual fish were monitored for approximately three years prior to the start of construction in July 2014. Results included in this report represent the first winter and full open-water season since construction of the Keeyask GS began. The discussion below highlights movement patterns that have been observed and discusses the key questions (presented in the AEMP) with respect to potential impacts of construction on Lake Sturgeon and their movements.

5.1 EVALUATION OF METHODOLOGY

Acoustic telemetry continues to be an effective method for monitoring movements and habitat utilization patterns of adult Lake Sturgeon in the Keeyask study area. Although the quality of winter data has been negatively affected by sparse receiver coverage, particularly in Gull Lake, this has not compromised data quality given that Lake Sturgeon tend to move relatively little during winter. During the open-water season, when most coarse-scale movements seem to occur, the robust array of stationary receivers has enabled good spatial coverage resulting in a high quality dataset. Tagged adults rarely move past receivers without being detected and therefore, the approximate location of a tagged fish at any given point in time can be inferred with confidence. The “sudden disappearance” of tagged fish presents a challenge for data analyses, as it is unknown if the fish suffered natural mortality, harvest, tag loss or tag failure. However, from the standpoint of examining the response of adult Lake Sturgeon to construction, impoundment and operation of the Keeyask GS, this long-term data set should be more than adequate to inform conclusions, and will be unique in terms of monitoring impacts of hydroelectric development on adult Lake Sturgeon behaviour.

5.2 KEY QUESTIONS

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

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

Qualitatively, there has been no change in adult Lake Sturgeon movement patterns since the onset of Keeyask GS construction. Upstream of the Keeyask GS, fish tend to be habitual in their movement patterns with individuals remaining in distinct portions of the study area: i) Clark

Lake; ii) the riverine portion of the Nelson River between Clark Lake and Gull Lake; and iii) Gull Lake. Although some fish move between these areas, these movements tend to be short-lived and are likely related to spawning (*e.g.* fish that remain in Gull Lake but move to Birthday Rapids in the spring). In 2015, three of 28 (11%) fish located upstream of the Keeyask GS displayed movement patterns that did not conform to their habitual pattern (*i.e.*, different than movements observed in previous years): one that was previously located in Clark Lake moved downstream through Gull Rapids, one previously in Gull Lake moved to Clark Lake, and one previously in the riverine section between Clark Lake and Gull Lake moved upstream through Clark Lake. As mentioned Hrenchuk and Barth (2015), a few adult Lake Sturgeon each year seem to make movements that do not fit into either pattern, however long-term observation may lead to new movement patterns being revealed.

In Stephens Lake, all fish detected in 2015 displayed the same general movement patterns as observed in 2014. Since 2014, movement patterns have been split into two general groups: i) those that remain within upper Stephens Lake; and ii) those that move between upper and lower Stephens Lake. Between 2011 and 2013, six tagged sturgeon moved upstream through Gull Rapids into Gull Lake. For two consecutive open-water periods (2014 and 2015) there have been no Lake Sturgeon that have moved upstream through Gull Rapids.

It might be expected that fish would utilize the riverine reach downstream of Gull Rapids less frequently during construction, however, fish tended to use the zones immediately upstream and downstream from Gull Rapids more in 2015 than in previous years. On average adult Lake Sturgeon used the area immediately upstream of Gull Rapids (the lower basin of Gull Lake) 9% of the time in 2013, 28% in 2014, and 42% in 2015. Similarly, fish used the area immediately downstream of Gull Rapids (the upper portion of Stephens Lake) 45% of the time in 2013, 38% in 2014, and 56% in 2015. Based on the maximum likelihood analysis, the frequency of Lake Sturgeon movement between zones has not changed since the beginning of construction. The likelihood that an adult Lake Sturgeon would move upstream or downstream from one zone to another was similar (<1.5% difference) between both time periods.

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

In September, 2015, two ice booms were put in place upstream of Gull Rapids on each of the south and east side of Caribou Island. Caribou Island was also cleared of trees and burned in October, 2015 as part of the Reservoir Clearing Plan. Despite these activities, fish continued to use the surrounding areas. In open-water 2015, four fish remained exclusively in lower Gull Lake (in the area around Caribou island), and 10 fish (36%) were located at the receiver closest to Gull Rapids (rkm -5.8).

Lake Sturgeon tagged in Stephens Lake continued to use habitat immediately downstream of Gull Rapids post-construction. In total, 24 of the 25 detected fish (96%) moved as far upstream as rkm 1.3 (the receiver closest to the rapids). Fish continued to move upstream during the spring, and further downstream in fall, a trend that has been observed in other years. Although it is difficult to distinguish between spawning movements and foraging movements, sturgeon

continue to move upstream to the same area during the spawning period as they did pre-construction.

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

Understanding the frequency of adult Lake Sturgeon movement through Gull Rapids has been the impetus for several initiatives aimed at studying Lake Sturgeon movement since 2001 (Barth and Mochnacz 2004; Barth 2005; Barth and Murray 2005; Barth and Ambrose 2006; Hrenchuk and McDougall 2012; Hrenchuk and Barth 2013; Hrenchuk and Barth 2014). Based on these data, a pre-construction downstream dispersal rate of adult Lake Sturgeon was estimated at ~2% (Hrenchuk and Barth 2015). The Population Viability Assessment model for the Lake Sturgeon population upstream of Gull Rapids with the Keeyask GS in place estimated a downstream dispersal rate through the GS of 4.5% at all life stages, however, given data from the current study, this estimate may be high. Since construction began, a single Lake Sturgeon has moved downstream through Gull Rapids. Based on maximum likelihood estimates the likelihood that an adult Lake Sturgeon would move through a barrier was lower during construction (0.8%) than prior to construction (2%). However, given that this comparison includes four years of baseline data and a single year of construction data, additional monitoring data will be used to refine this estimate.

6.0 SUMMARY AND CONCLUSIONS

- Acoustic telemetry continues to be an effective method for monitoring adult Lake Sturgeon in the Keeyask study area. In the 2015 open-water period, 53 of the 57 (93%) tagged fish were detected. Monitoring during winter continues to be difficult, largely due to the limited number of sites available to deploy receivers.
- The key questions, as described in the AEMP, for adult Lake Sturgeon movement monitoring during construction of the Keeyask GS are as follows:
    - *Will disturbances associated with construction alter coarse-scale movements upstream and/or downstream of the construction site?*

      Qualitatively, there have been no changes in adult Lake Sturgeon movement patterns since the onset of Keeyask GS construction. Upstream of the Keeyask GS, fish tend to be habitual in their movement patterns with individuals remaining in distinct portions of the study area: i) Clark Lake; ii) the riverine portion of the Nelson River between Clark Lake and Gull Lake; and iii) Gull Lake. In Stephens Lake, fish tend to either remain within upper Stephens Lake, or move between upper and lower Stephens Lake.
    - *Are adult sturgeon using habitat in the immediate vicinity of the construction site?*

      Fish continued to use the areas both immediately upstream and immediately downstream of Gull Rapids in open-water 2015. Fish tended to use these areas more in 2015 than in previous years.
    - *Will the frequency of long-distance movements (and subsequent downstream emigration/entrainment) by adult Lake Sturgeon increase during construction and operation of the Project?*

      Since the inception of study in 2011, nine movements through Gull Rapids have occurred: six upstream, and three downstream. All upstream movements occurred between 2011 and 2013, while all downstream movements occurred between 2014 and 2015. A single fish moved downstream since construction began. Prior to construction, there was a 2.1% chance that a fish would move through a barrier (either Gull Rapids or Kettle GS), and a 0.9% chance after the onset of construction.

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TABLES

Table 1: Number of acoustic transmitters applied to adult Lake Sturgeon in the Keeyask study area (upstream of Gull Rapids (GR) and in Stephens Lake) between June 2011 and October 2015.

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

Table 2: Tagging and biological information associated with Lake Sturgeon implanted with acoustic transmitters upstream of Gull Rapids between 2011 and 2015.

Tag ID	Date Tagged	Tag Life (days)	Fork Length (mm)	Total Length (mm)	Weight (g)	Sex
16026	19-Jun-12	3650	955	1070	7711	-
16036	05-Jun-11	3650	1313	1414	20185	-
16039	05-Jun-11	3650	1425	1530	27216	F
16042	05-Jun-11	3650	956	1060	8165	M
16045	10-Jun-11	3650	1379	1533	21773	M
16048	07-Jun-11	3650	967	1103	9299	-
16051	10-Jun-11	3650	1386	1510	24494	-
16054	06-Jun-11	3650	816	915	5023	-
16055	06-Jun-11	3650	872	974	6350	M
16056	10-Jun-11	3650	1020	1120	9526	M
16057	16-Jun-11	3650	900	1024	7711	-
16058	09-Jun-11	3650	867	953	6124	-
16059	16-Jun-11	3650	1260	1385	16783	F
16060	21-Jun-11	3650	1060	1170	10433	-
16061	21-Jun-11	3650	805	901	3175	-
16062	12-Jun-11	3650	1176	1284	12247	-
16063	11-Jun-11	3650	1124	1229	10660	M
16064	12-Jun-11	3650	1066	1148	9072	M
16065	12-Jun-11	3650	958	1058	7484	-
16066	20-Jun-11	3650	1310	1405	25855	F
16067	19-Jun-11	3650	1090	1210	11340	-
16068	19-Jun-11	3650	1140	1254	11794	-
16069	17-Jun-11	3650	1400	1570	32659	-
16070	16-Jun-11	3650	1072	1195	10886	M
16071	16-Jun-11	3650	1026	1133	7711	M
16072	21-Jun-11	3650	850	967	6350	-
16073	12-Jun-11	3650	1169	1284	15422	M
16074	13-Jun-11	3650	915	1016	6804	M
16075	10-Jun-11	3650	1610	1700	43092	F
16076	16-Jun-11	3650	1260	1375	19958	-
16077	10-Jun-11	3650	1143	1245	12247	M
32174	18-Jun-14	3650	1172	1296	17690	-
32175	18-Jun-14	3650	843	951	4082	-
32176	18-Jun-14	3650	1236	1370	22226	-
32177	18-Jun-14	3650	886	1001	5443	-

Table 3: Tagging and biological information for Lake Sturgeon implanted with acoustic transmitters in Stephens Lake between 2011 and 2015.

Tag ID	Date Tagged	Tag Life (days)	Fork Length (mm)	Total Length (mm)	Weight (g)	Sex
16018	13-Jun-12	3650	850	951	6577	M
16019	13-Jun-12	3650	894	991	6804	-
16020	08-Jun-12	3650	992	1100	-	M
16021	28-Sep-11	3650	880	977	6804	-
16022	13-Jun-12	3650	884	976	5216	M
16024	13-Jun-12	3650	906	1011	6804	-
16025	16-Jun-12	3650	1176	2956	14969	M
16027	15-Jun-12	3650	1120	2350	10433	M
16028	13-Jun-12	3650	1024	1145	8618	M
16029	21-Jun-11	3650	1208	1316	16556	F
16030	12-Jun-11	3650	1004	1103	7711	-
16031	13-Jun-12	3650	810	900	5443	-
16032	11-Jun-11	3650	1064	1159	11340	M
16033	18-Jun-11	3650	881	974	5443	-
16033b	16-Sep-13	3650	755	842	-	-
16034	18-Jun-11	3650	796	904	4082	-
16035	26-Sep-11	3650	941	1040	8165	-
16037	08-Jun-11	3650	826	911	-	-
16038	12-Jun-11	3650	1116	1239	11793	-
16040	09-Jun-11	3650	1006	1105	8391	M
16041	26-Jun-11	3650	903	1001	7257	-
16043	10-Jun-11	3650	790	885	4536	-
16044	09-Jun-11	3650	1161	1296	14969	M
16046	11-Jun-11	3650	1085	1209	9979	M
16047	26-Jun-11	3650	920	1020	6577	-
16049	24-Sep-11	3650	1070	1182	10886	-
16050	13-Jun-11	3650	922	1041	6577	-
16052	26-Sep-11	3650	1190	1337	16329	-
16053	26-Sep-11	3650	919	1021	8218	-
32167	11-Jun-14	3650	910	1015	4990	-
32168	11-Jun-14	3650	884	980	4990	-
32169	13-Jun-14	3650	810	908	4082	-
32170	11-Jun-14	3650	1095	2000	9526	M
32171	13-Jun-14	3650	880	976	4536	M
32172	13-Jun-14	3650	904	1050	5897	-
32173	13-Jun-14	3650	842	936	4082	-

Table 4: Number of Lake Sturgeon tagged with acoustic and radio tags that moved upstream or downstream through Gull Rapids during studies conducted in the Keeyask Study Ares in 2001-2004 and 2011-2015.

Life Stage	Year [1]	# Tagged Fish		# Fish Detected		Downstream Movements			Upstream Movements			Total #	% Tagged Fish Moved	% Detected Fish Moved
		U/S [2]	D/S [3]	U/S	D/S	#	% of total	% of detected	#	% of total	% of detected			
Adult [4]	2001	21	11	21	11	1	4.8	4.8	0	0	0	1	3.1	3.1
	2002	19	12	19	10	0	0	0	3	25	30	3	9.7	10.3
	2003	21	9	20	4	1	4.8	5	0	0	0	1	3.3	4.2
	2004	19	9	16	4	0	0	0	0	0	0	0	0	0
	2011	30	19	28	19	0	0	0	1	5.3	5.3	1	2	2.1
	2012	32	27	30	27	0	0	0	4	14.8	14.8	4	6.8	7
	2013	35	22	28	19	0	0	0	1	4.5	5.3	1	1.8	2.1
	2014	34	24	33	24	2	5.9	6.1	0	0	0	2	3.4	3.5
	2015	32	25	28	25	1	3.1	3.6	0	0	0	1	1.8	1.9
Juvenile [5]	2013	20	20	18	20	0	0	0	0	0	0	0	0	0
	2014	20	20	20	19	0	0	0	0	0	0	0	0	0
	2015	20	20	19	19	0	0	0	0	0	0	0	0	0

1. Includes data from the current study (2011–2015), a study conducted between 2001 and 2004 (Barth and Mochnacz 2004; Barth 2005; Barth and Murray 2005; Barth and Ambrose 2006), and the juvenile Lake Sturgeon acoustic telemetry study initiated in Gull and Stephens Lake in 2013 (Hrenchuk and Barth 2014; Lacho *et al.* 2015, Lacho *et al.* 2016).
2. Upstream of Gull Rapids (between Clark Lake and Gull Rapids)
3. Downstream of Gull Rapids (in Stephens Lake between Gull Rapids and the Kettle GS)
4. Refers to fish > 834 mm FL.
5. Refers to fish < 834 mm FL.

FIGURES

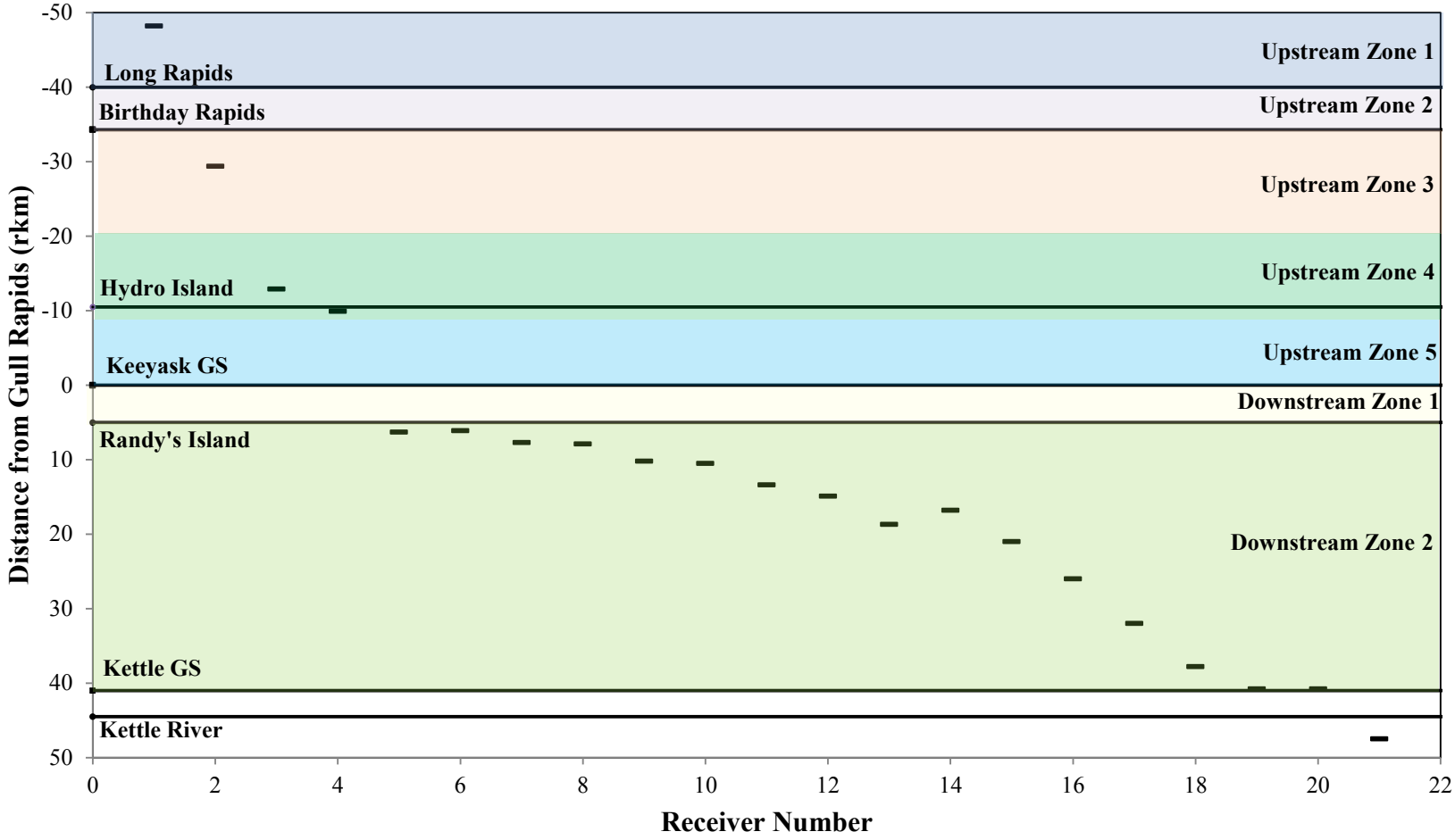


Figure 1: **Locations of stationary acoustic receivers (dashes) in relation to the base of Gull Rapids (rkm 0) and other major landmarks (lines) in the Nelson River between Clark Lake and the Long Spruce GS between October, 2014 and June, 2015. River zones upstream and downstream of Gull Rapids are indicated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

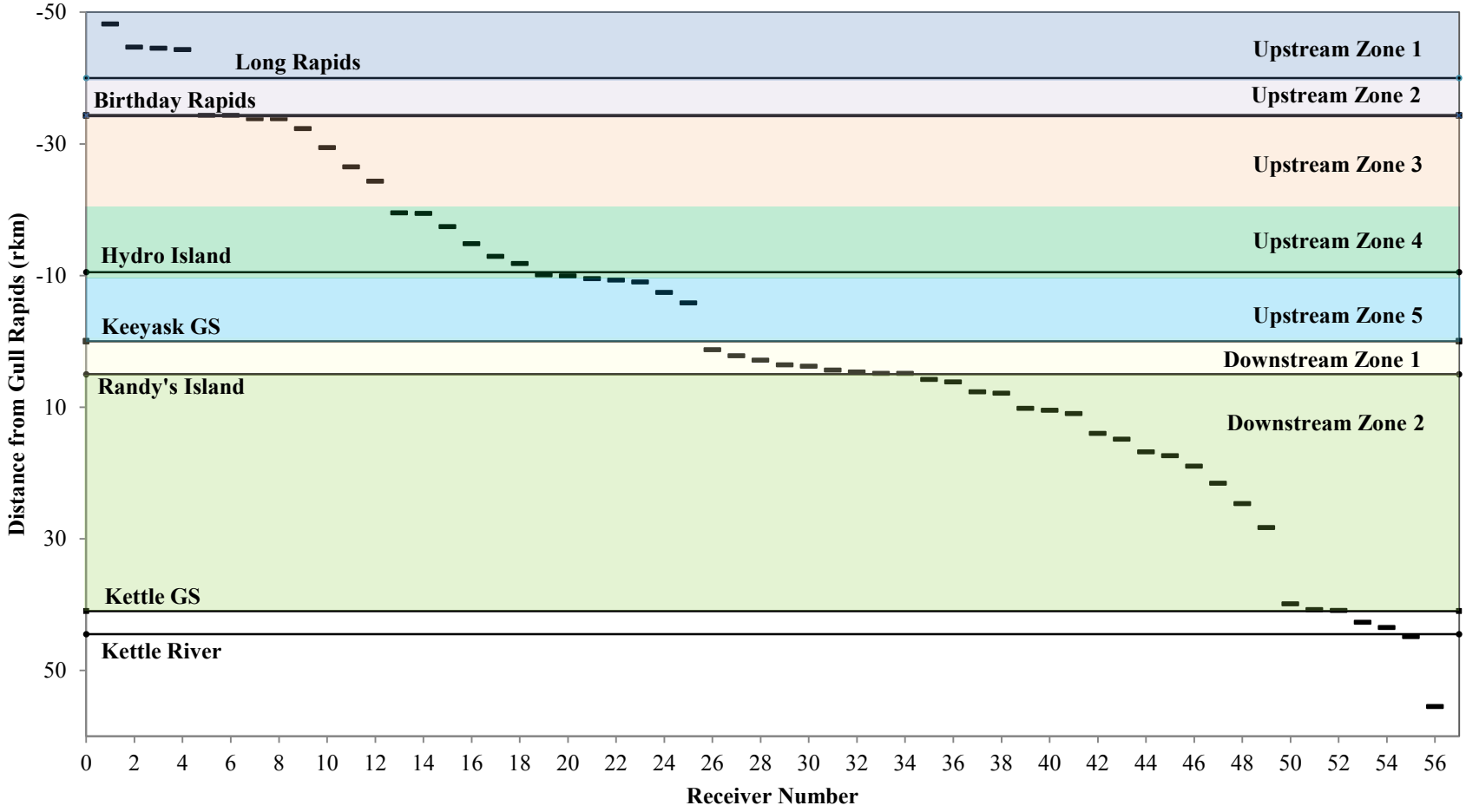


Figure 2: **Locations of stationary acoustic receivers (dashes) in relation to the base of Gull Rapids (rkm 0) and other major landmarks (lines) in the Nelson River between Clark Lake and the Long Spruce GS between June and October, 2015. River zones upstream and downstream of Gull Rapids are indicated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

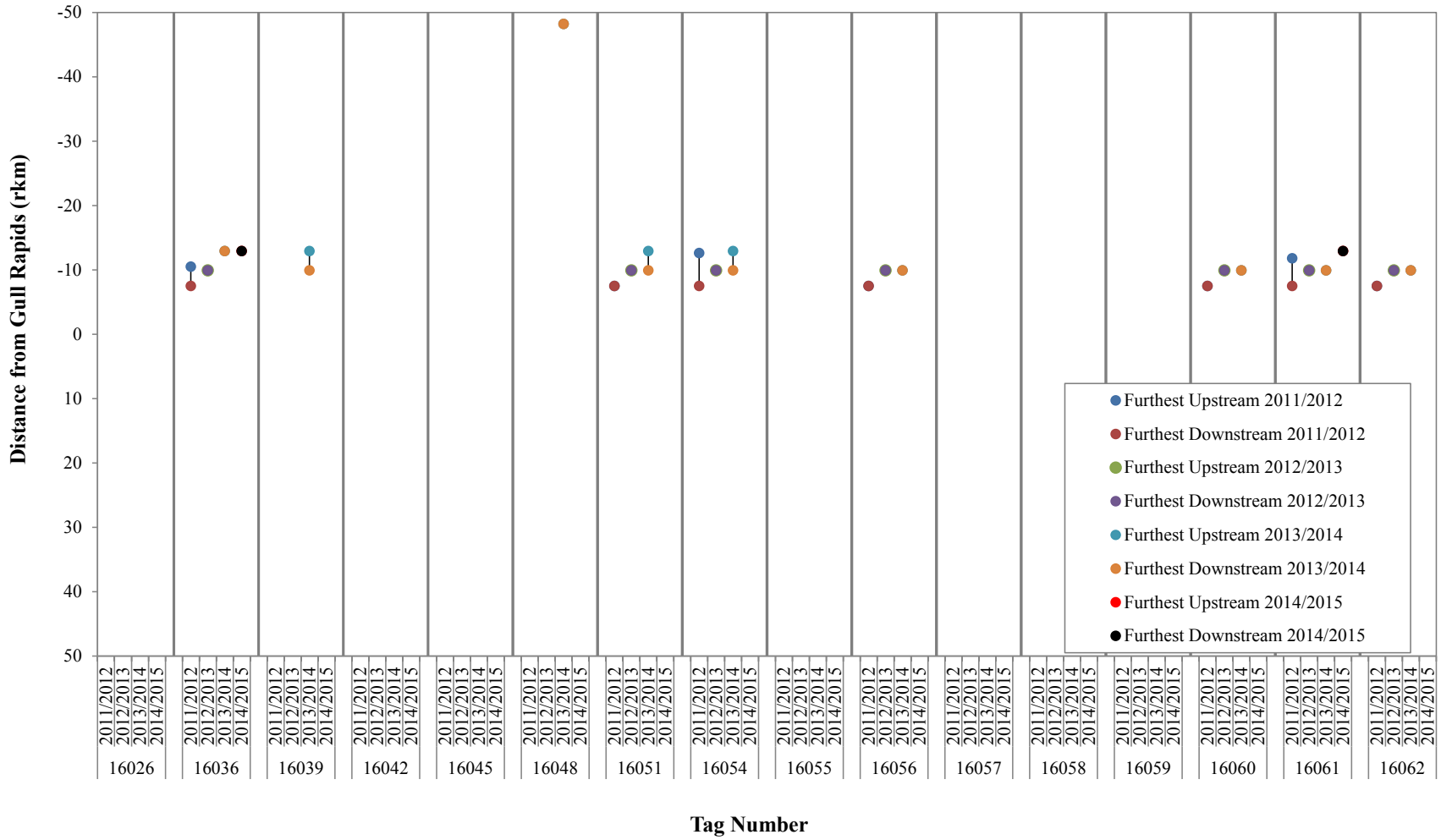


Figure 3: Detection ranges for individual adult Lake Sturgeon tagged with acoustic transmitters upstream of Gull Rapids during the winter 2012–2015.

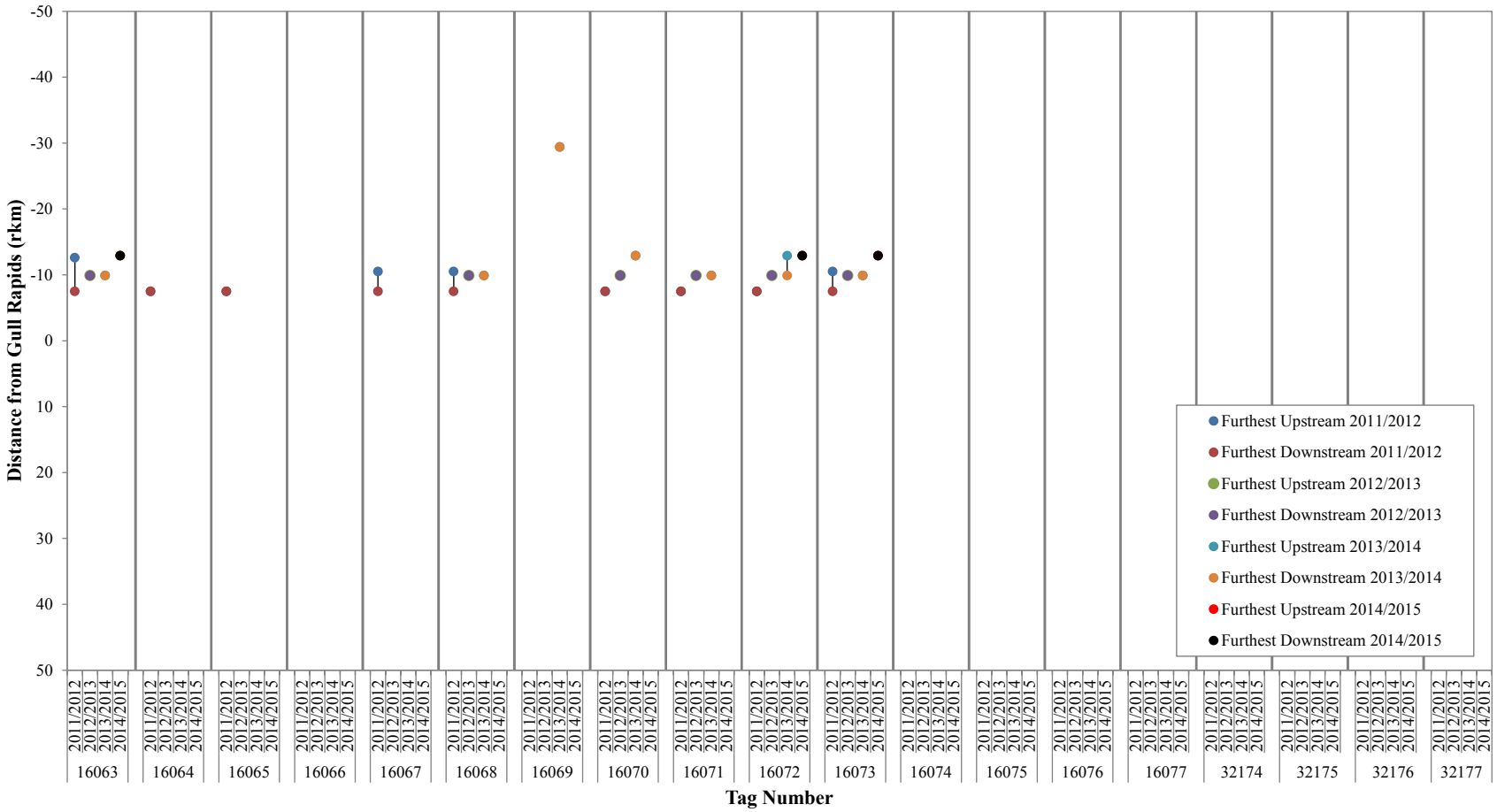


Figure 3: Detection ranges for individual adult Lake Sturgeon tagged with acoustic transmitters upstream of Gull Rapids during the winter 2012–2015 (continued).

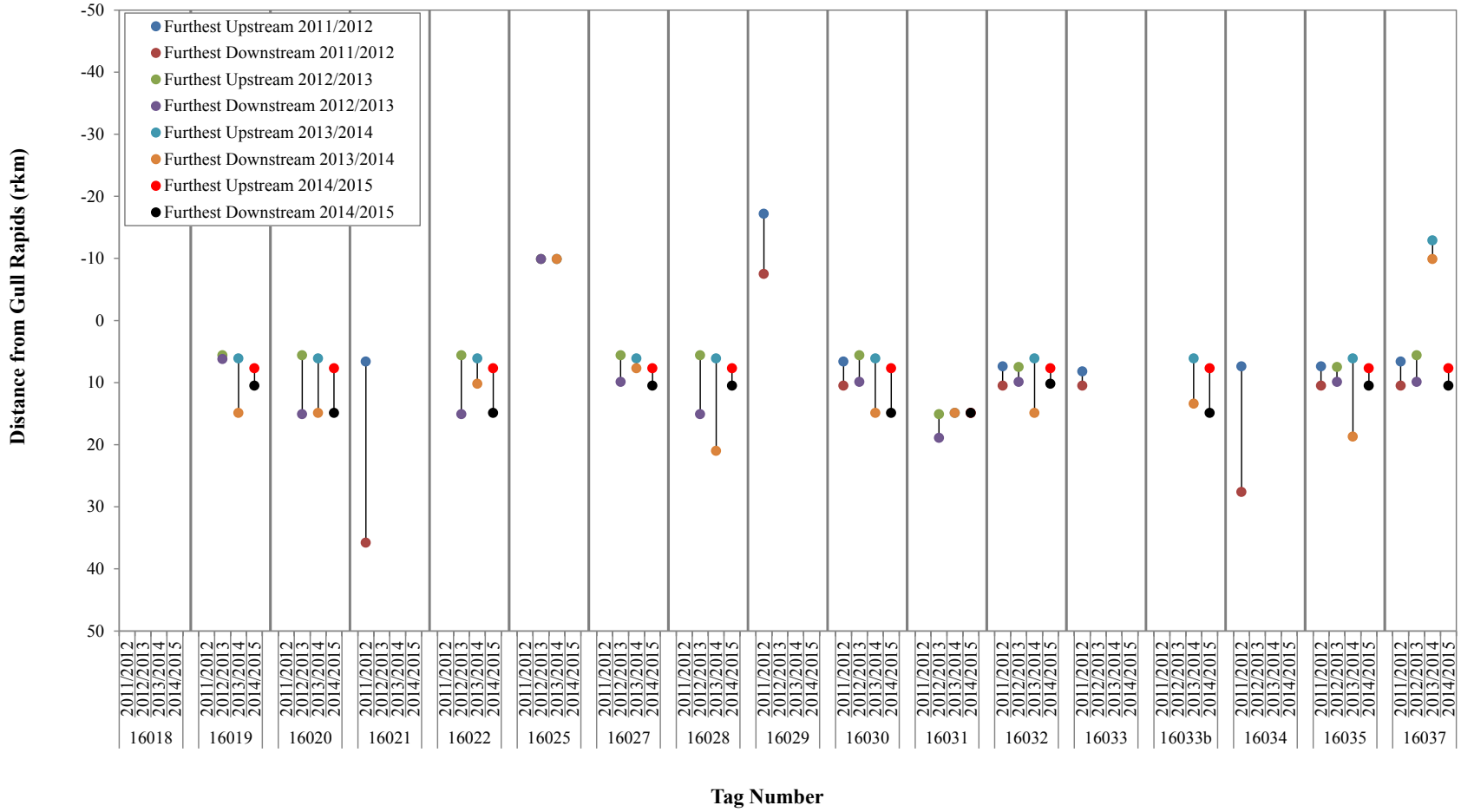


Figure 4: Detection ranges for individual adult Lake Sturgeon tagged with acoustic transmitters in Stephens Lake during the winter 2012–2015.

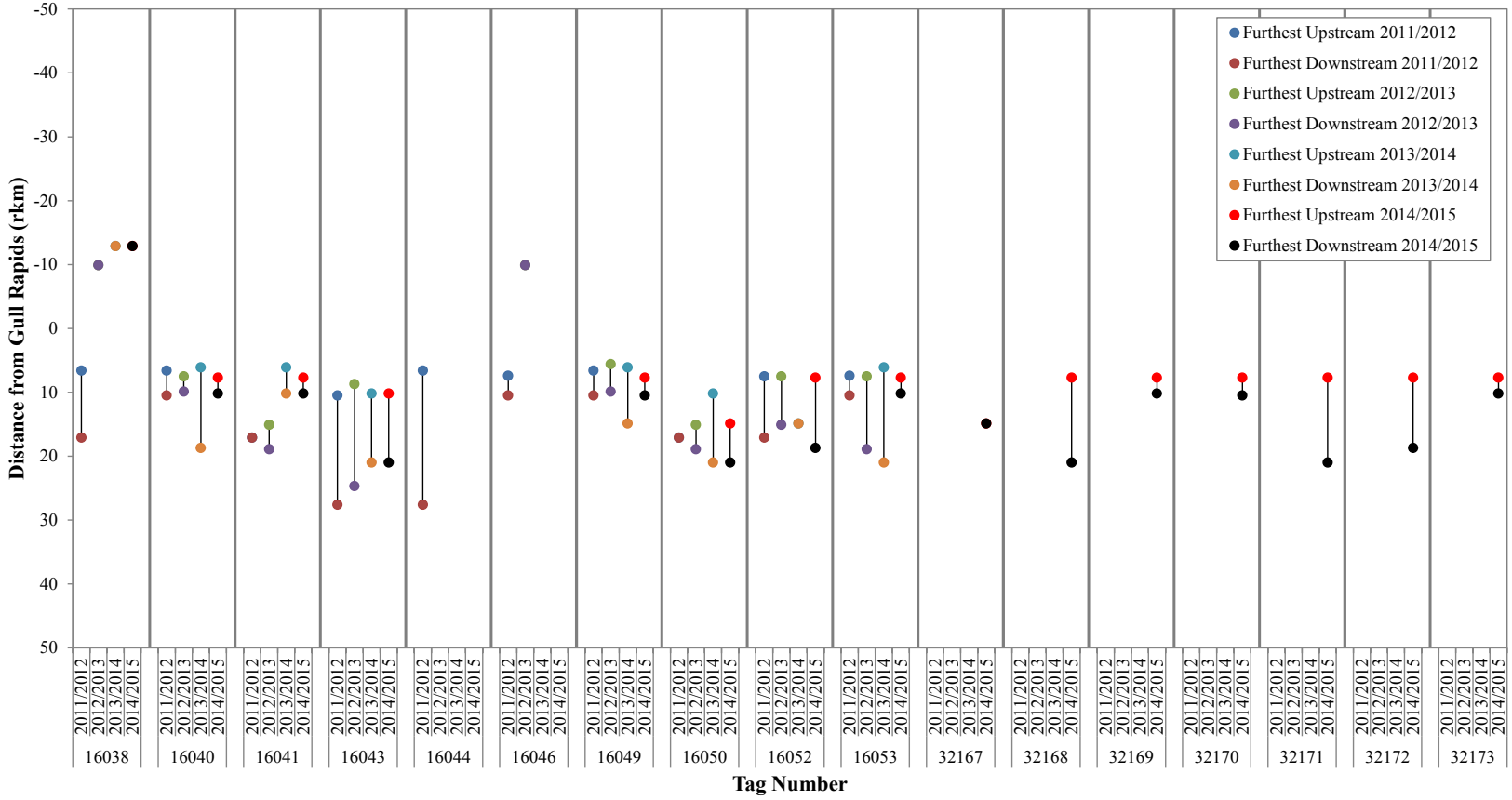


Figure 4: Detection ranges for individual adult Lake Sturgeon tagged with acoustic transmitters in Stephens Lake during the winter 2012–2015 (continued).

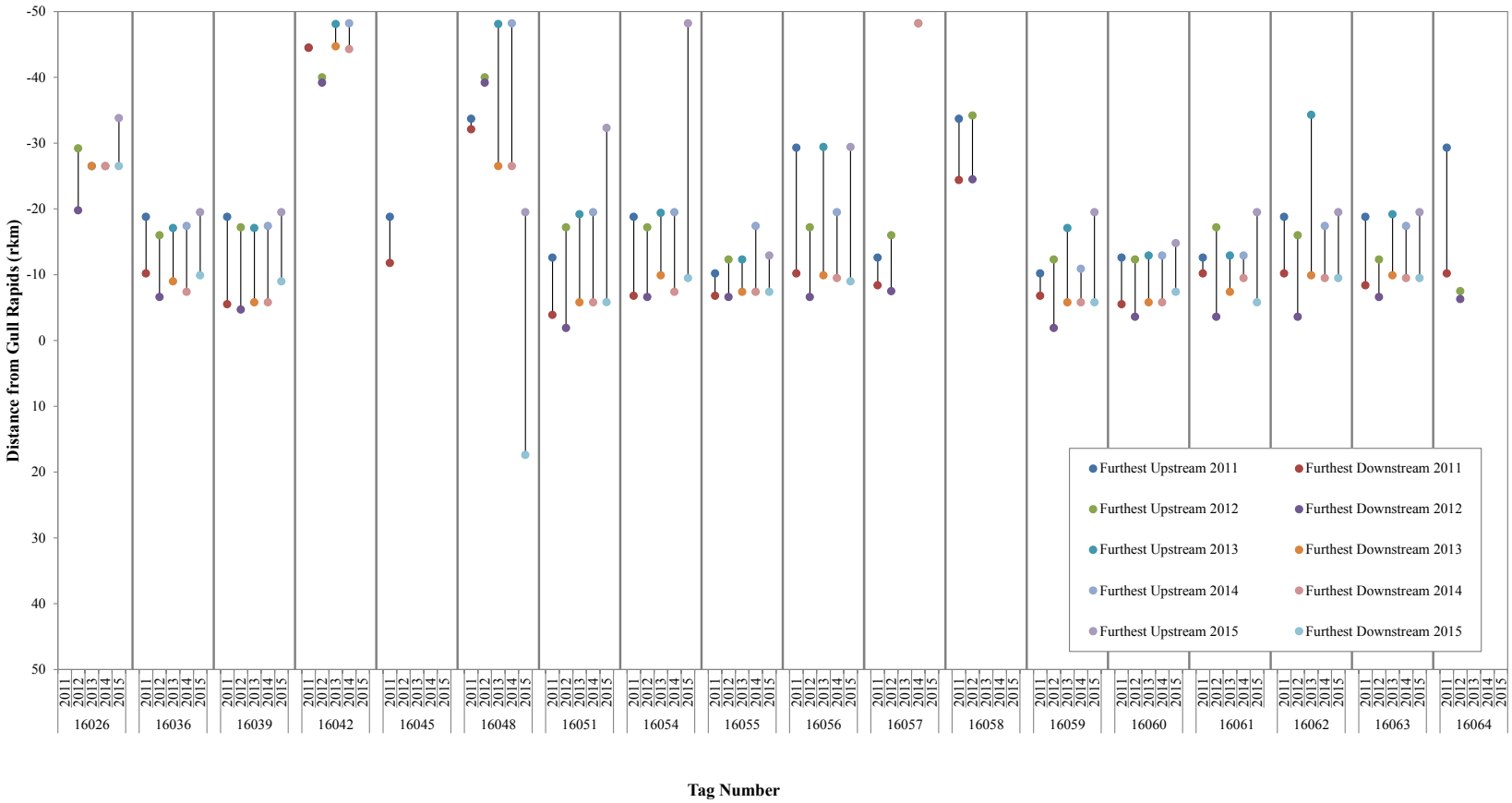


Figure 5: Detection ranges for individual adult Lake Sturgeon tagged with acoustic transmitters upstream of Gull Rapids during the 2015 open-water period (1 May, 2015 to 11 October, 2015).

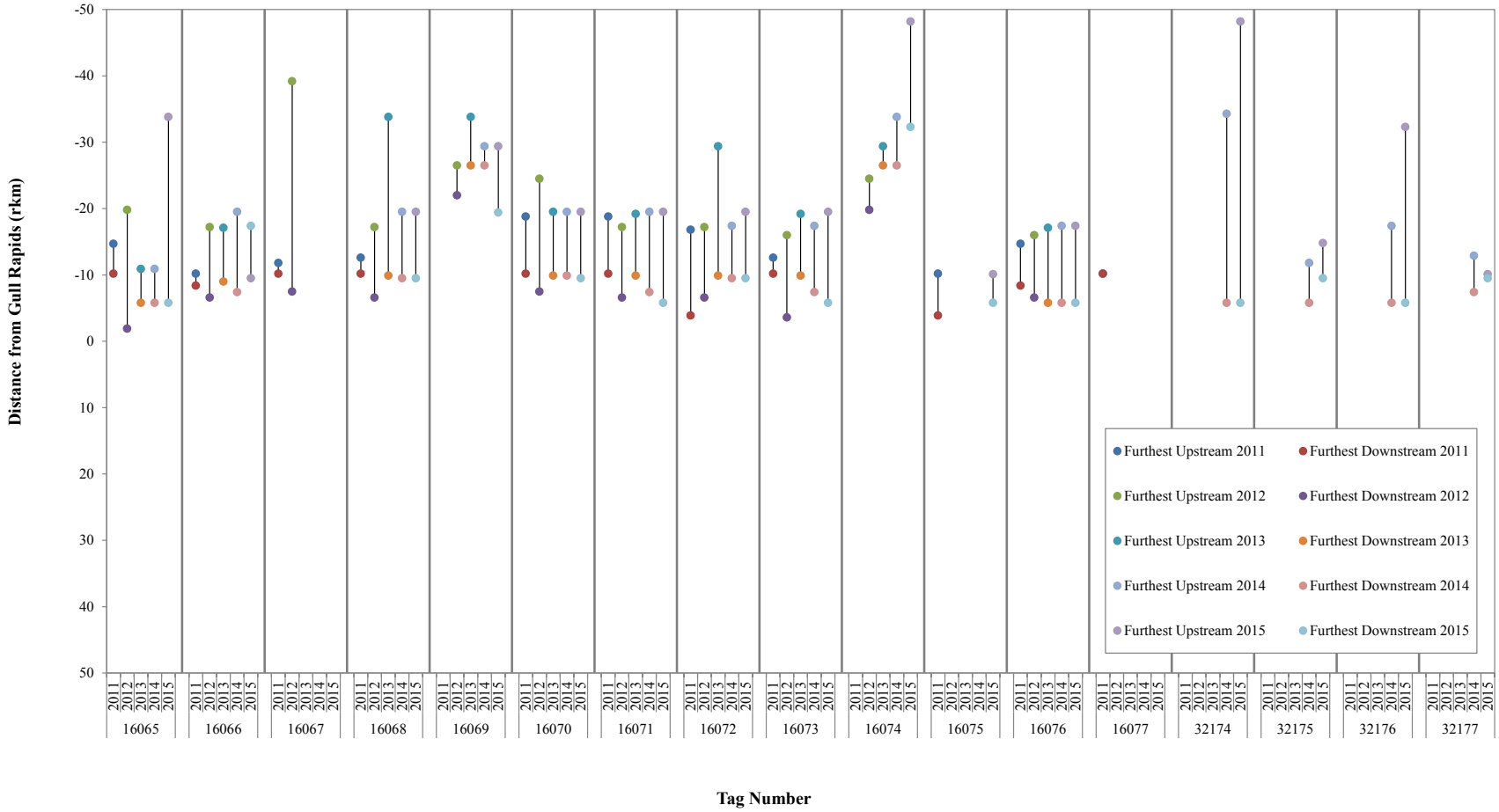


Figure 5: Detection ranges for individual adult Lake Sturgeon tagged with acoustic transmitters upstream of Gull Rapids during the 2015 open-water period (1 May, 2015 to 11 October, 2015) (continued).

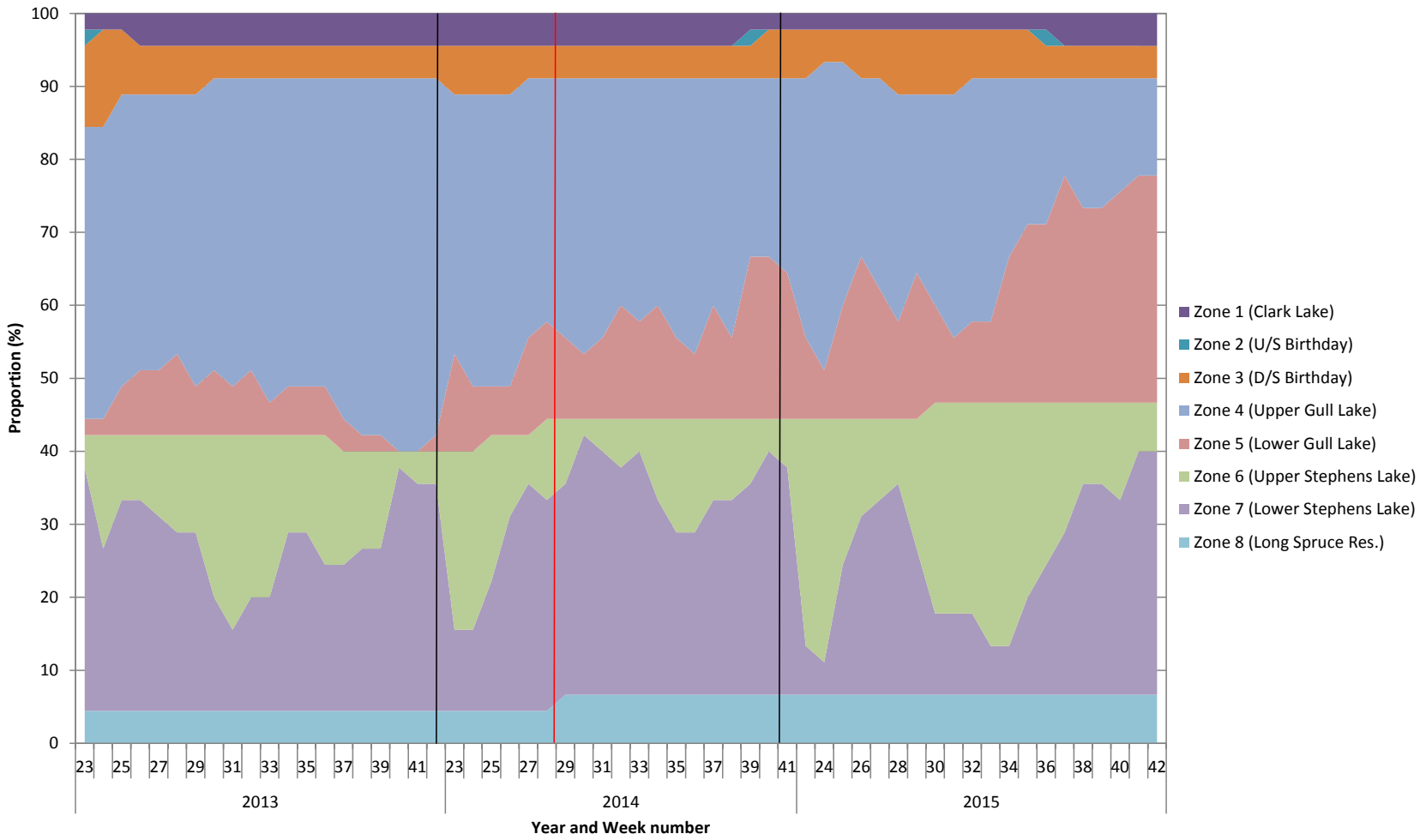


Figure 6: **Proportional distribution by zone, for 45 adult Lake Sturgeon tagged with acoustic transmitters in the Keeyask GS Area during a portion of the 2013 (4 June to 15 October, 2013), 2014 (4 June to 3 October, 2014), and 2015 (4 June to 11 October, 2015) open-water periods. Only fish located in all three study years were included. Black lines indicate study years. Red line indicates start of Keeyask construction.**

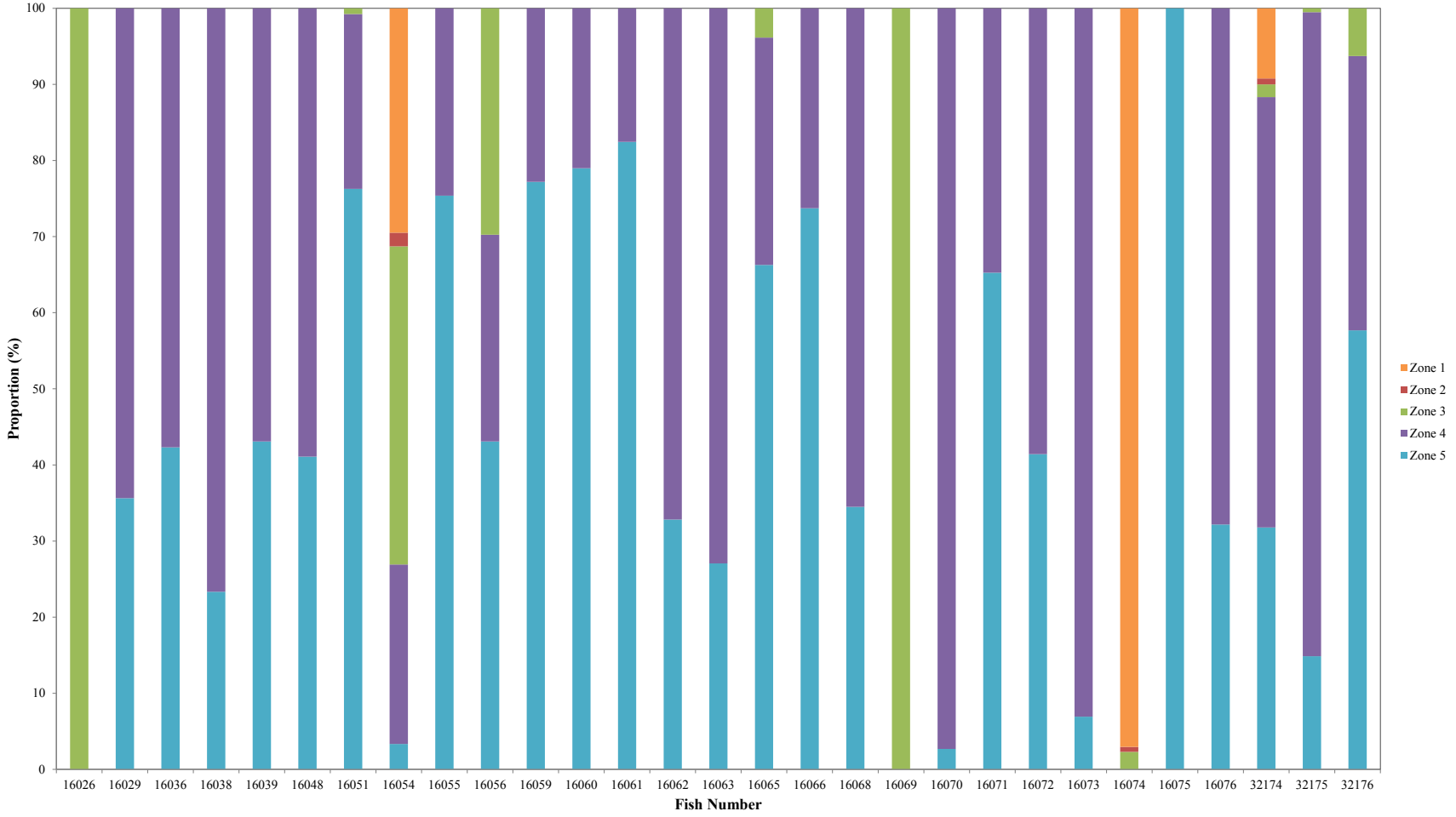


Figure 7: Proportional distributions by zone, for individual adult Lake Sturgeon tagged with acoustic transmitters upstream of Keeyask GS during a portion of the 2015 open-water period (4 June to 11 October, 2015).

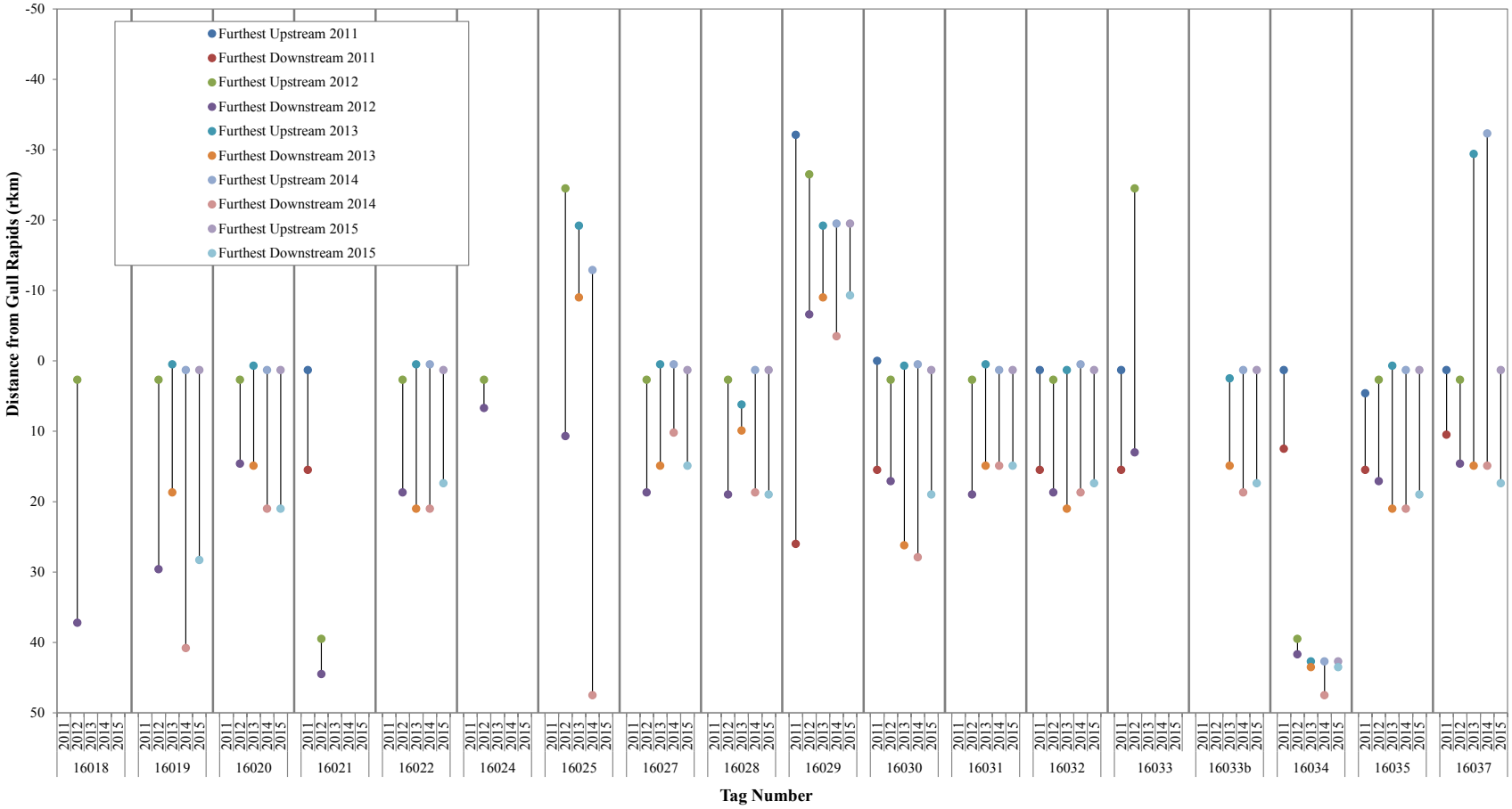


Figure 8: Detection ranges for individual adult Lake Sturgeon tagged with acoustic transmitters in Stephens Lake during the open-water period (2011–2015).

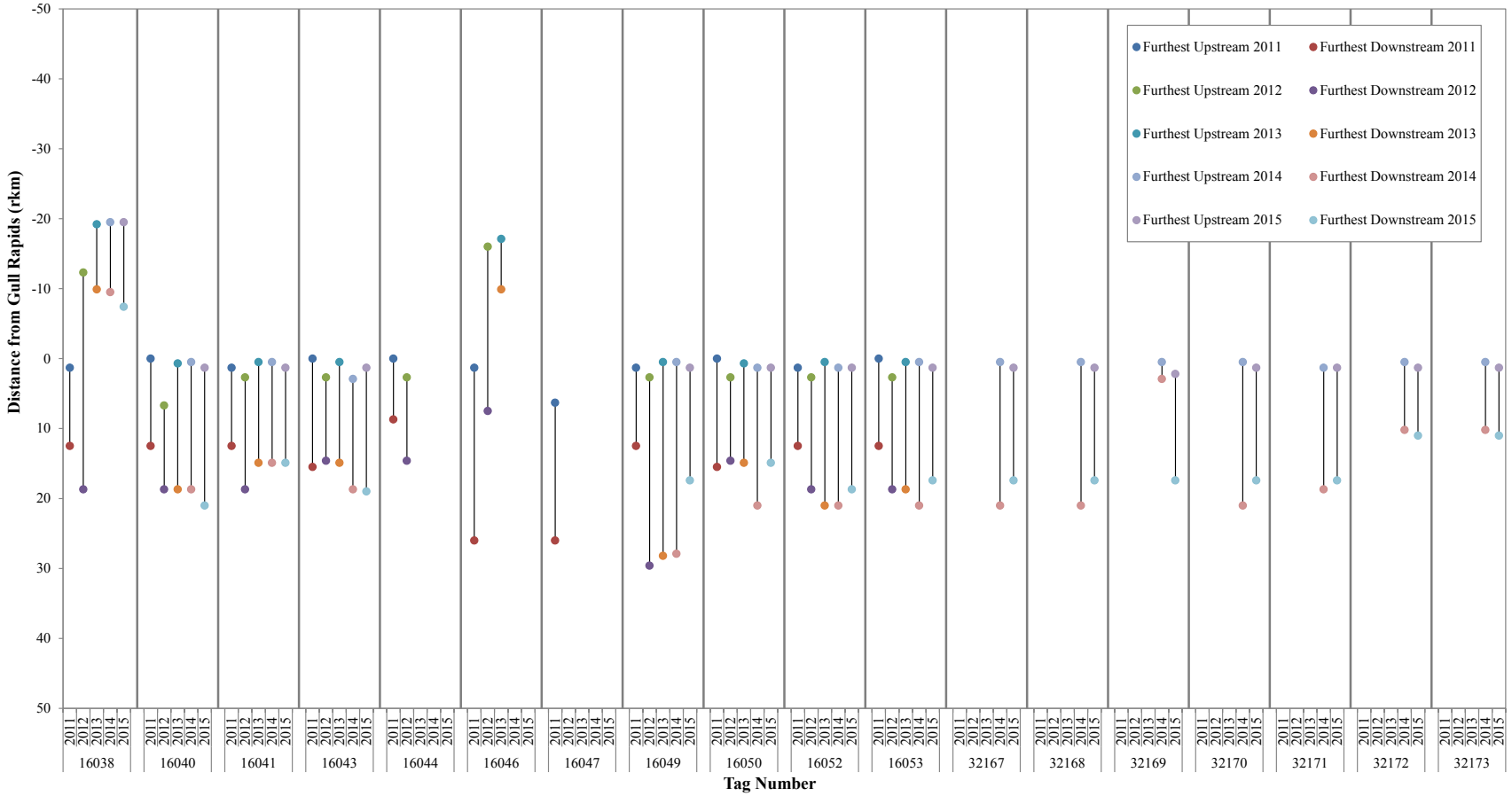


Figure 8: Detection ranges for individual adult Lake Sturgeon tagged with acoustic transmitters in Stephens Lake during the open-water period (2011–2015) (continued).

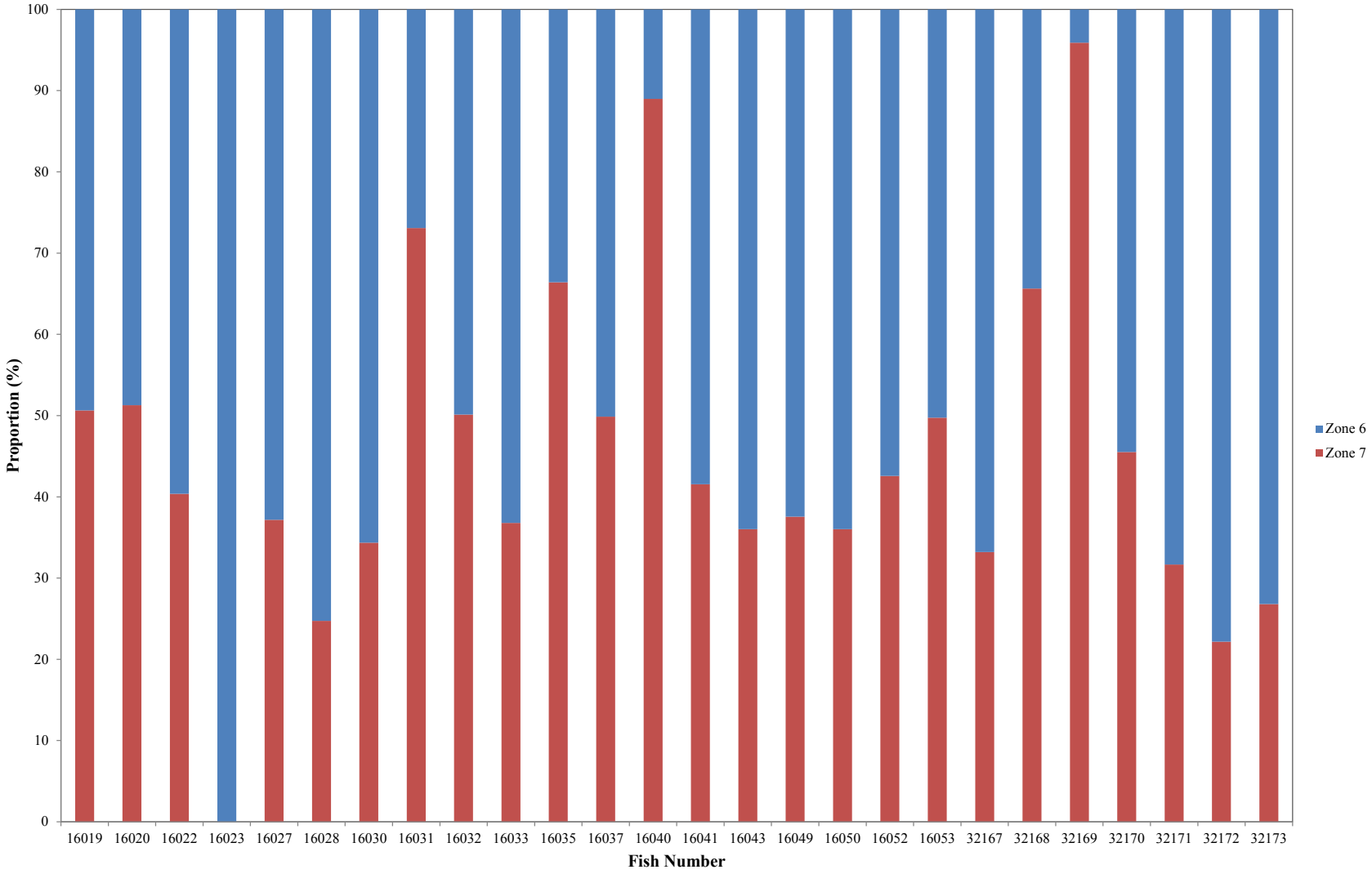


Figure 9: Proportional distributions by zone, for individual adult Lake Sturgeon tagged with acoustic transmitters in Stephens Lake during a portion of the 2015 open-water period (4 June to 11 October, 2015).

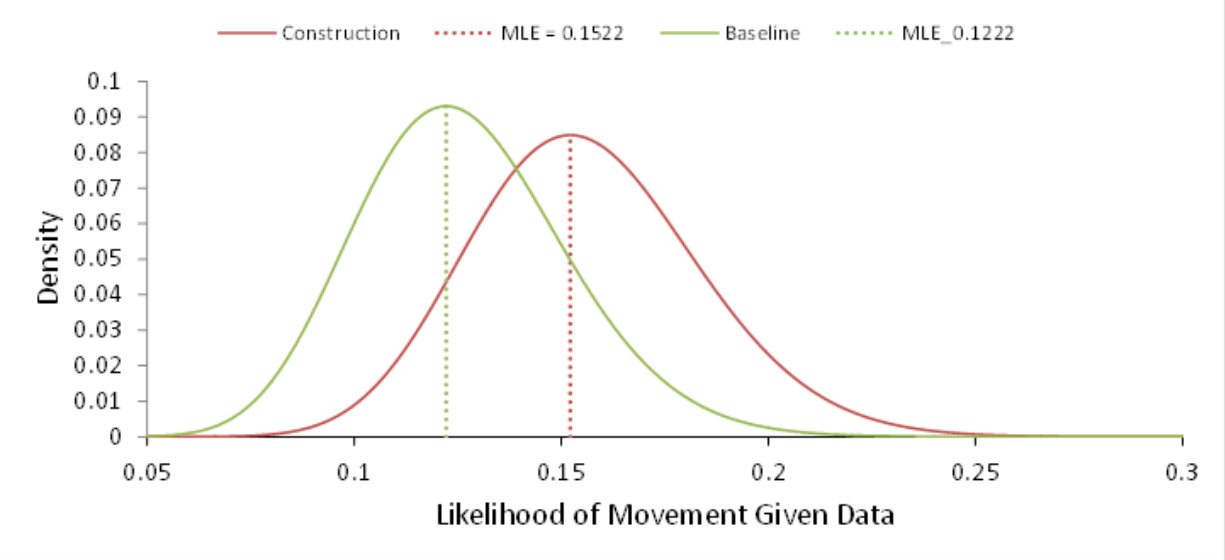


Figure 10: Likelihood of an adult Lake Sturgeon moving between river zones (either upstream or downstream) both before and after the onset of Keeyask construction.

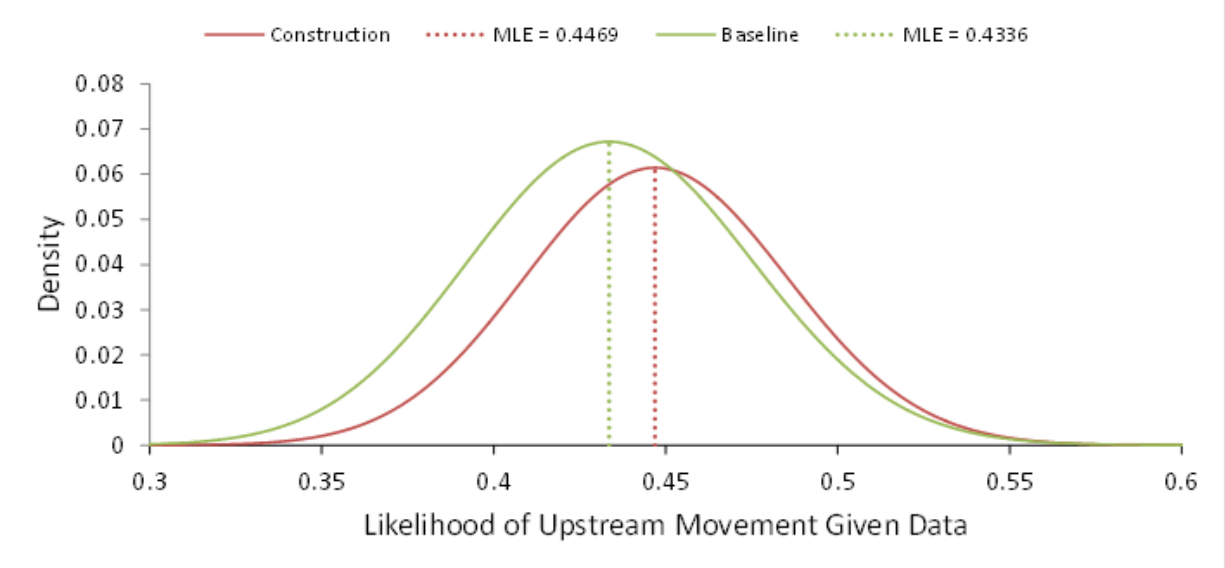


Figure 11: Likelihood of an adult Lake Sturgeon moving upstream from one river zone to another both before and after the onset of Keeyask construction.

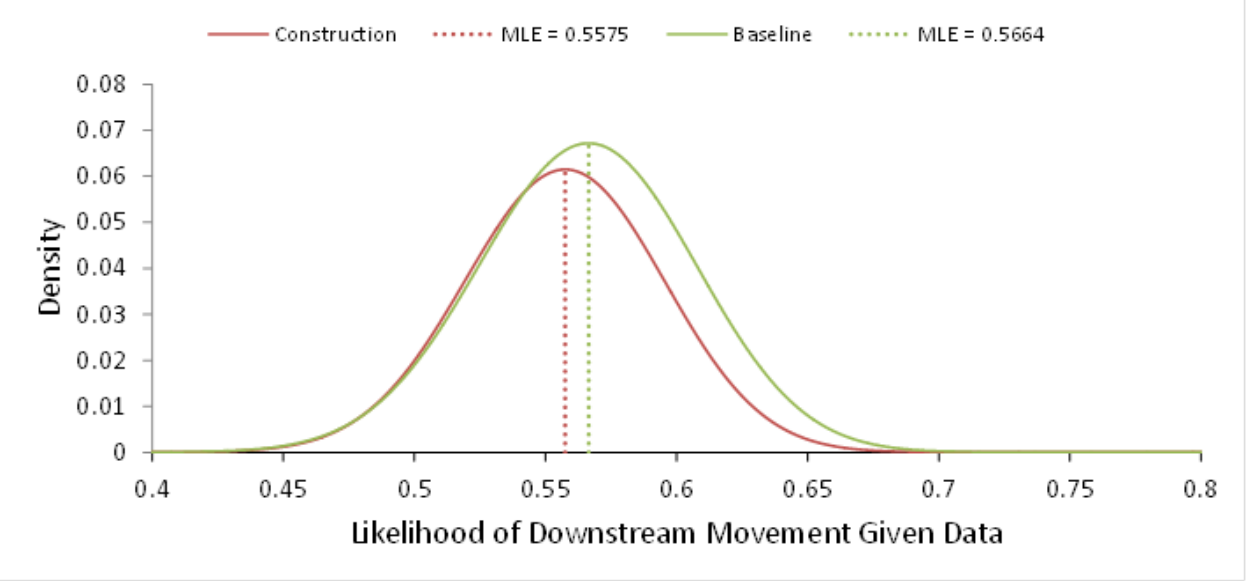


Figure 12: Likelihood of an adult Lake Sturgeon moving downstream from one river zone to another both before and after the onset of Keeyask construction.

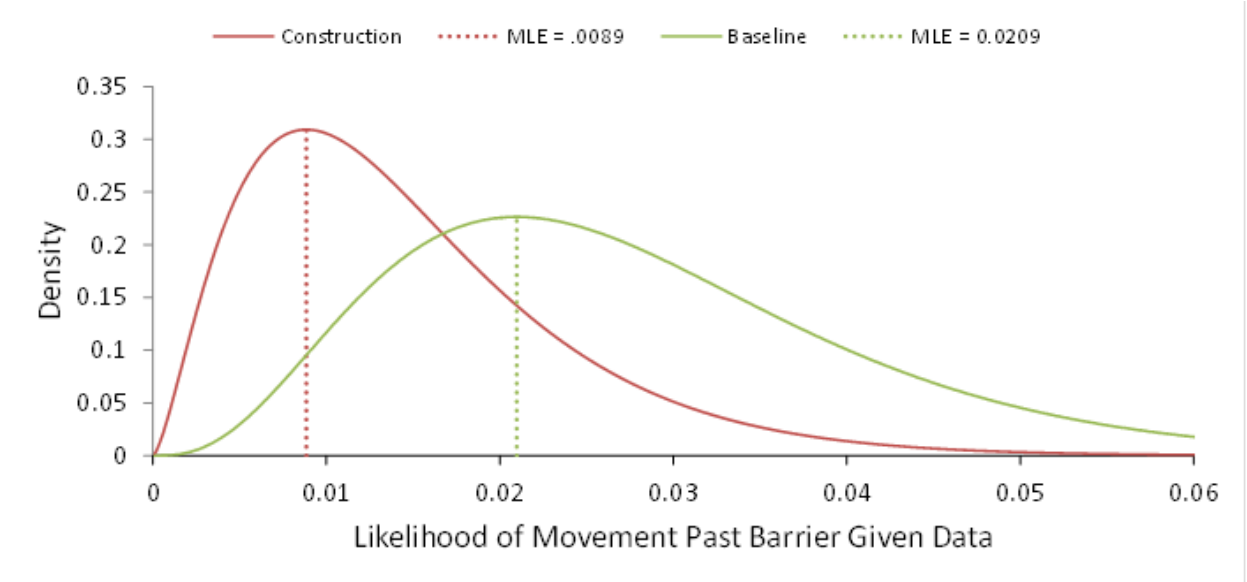


Figure 13: Likelihood of an adult Lake Sturgeon moving past a barrier (either Gull Rapids or Kettle GS) before and after the onset of Keeyask construction.

MAPS

KEEYASK

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

CREATED BY:
North/South Consultants

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z15N	09-FEB-15	02-JUN-16
0 6 12 Kilometres / 0 5 10 Miles	VERSION NO: 1.0	QA/QC: CMP/YYY/ZZZ

Legend

- Town
- Community
- Generating Station (Existing)
- Generating Station (Under Construction)
- Generating Station (Potential)
- Highway
- Rail
- First Nation Reserve

Keeyask Study Area

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

DATA SOURCE:
Orthophoto: Manitoba Hydro - June 21, 2015

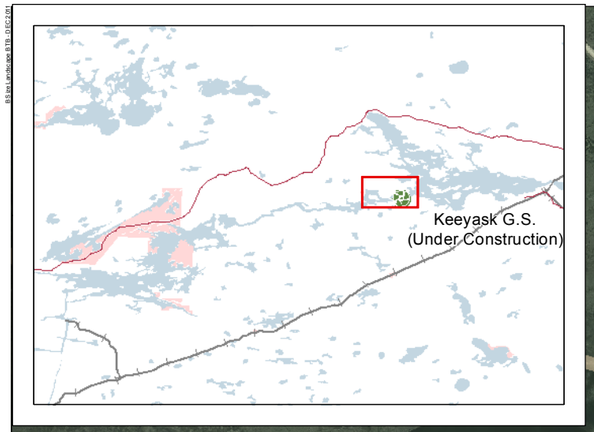
CREATED BY:
North/South Consultants

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z15N	26-FEB-10	30-MAY-16
0 0.15 0.3 Kilometres / 0 0.15 0.3 Miles	VERSION NO: 2.0	QA/QC: PMC/FSV/MWZ

KEEYASK

Construction Site

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



KEEYASK

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

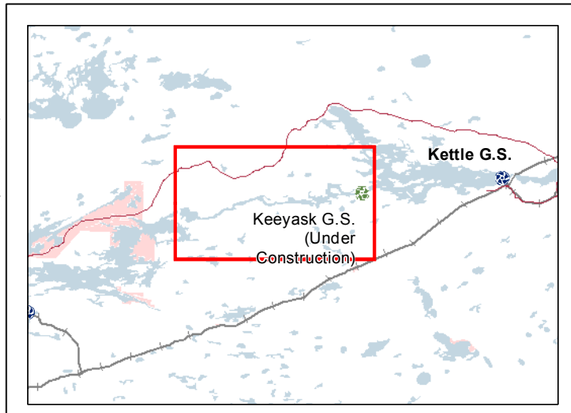
COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z15N	22-MAY-15	06-JAN-16
0 0.4 0.8 Kilometres 0 0.3 0.6 Miles	VERSION NO: 1.0	QA/QC:

Legend

- Ice Boom
- Infrastructure

Keeyask G.S.
Ice Boom Locations

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



Ross Wright Bay

North Access Road

Looking Back Creek

280

Effie Creek

Pond 13

Hidden Creek

Two Goose Creek

Trickle Creek

Caribou Island

Morris Point

Keeyask G.S.
(Under Construction)

Gull Rapids

South Access Road

NELSON RIVER

122777

114245

114228

Fork Creek

125105

Clark Lake

Long Rapids

Birthday Rapids

Nap Creek

Portage Creek

Rabbit Creek

Seebeesis Creek

Carscadden Lake

SPLIT LAKE

N

KEEYASK

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

0 0.45 0.9 Kilometres
0 0.35 0.7 Miles

VERSION NO:
1.0

QA/QC:
CMP/YYY/ZZZ

Legend

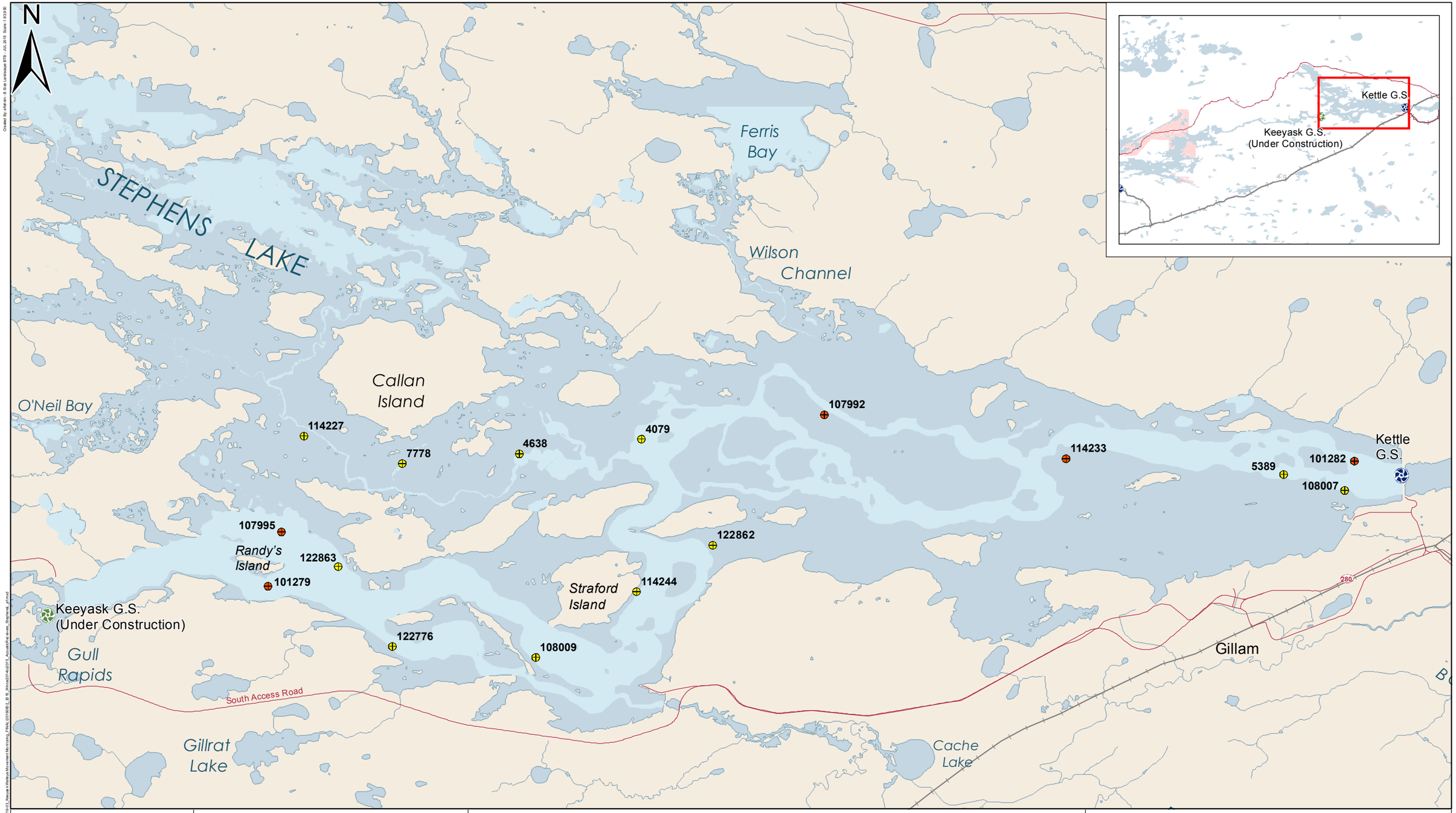
Receiver Locations

- Lost
- Retrieved
- Generating Station (Existing)
- Generating Station (Under Construction)

Highway
Rail
First Nation Reserve

Winter 2014/2015
Acoustic Receiver Locations
Clark Lake to Gull Rapids

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

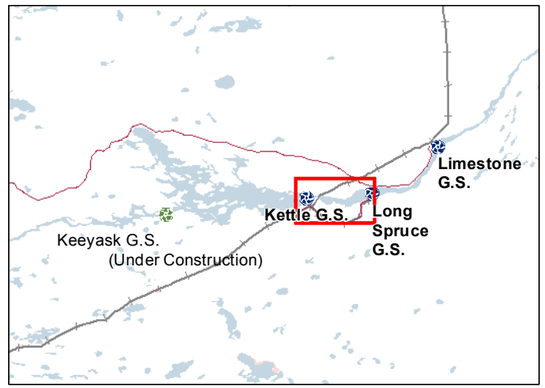
Legend

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:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	09-FEB-15	03-JUN-16
0 0.45 0.9 Kilometres / 0 0.35 0.7 Miles	VERSION NO: 1.0	QA/QC: CMP/YYY/ZZZ

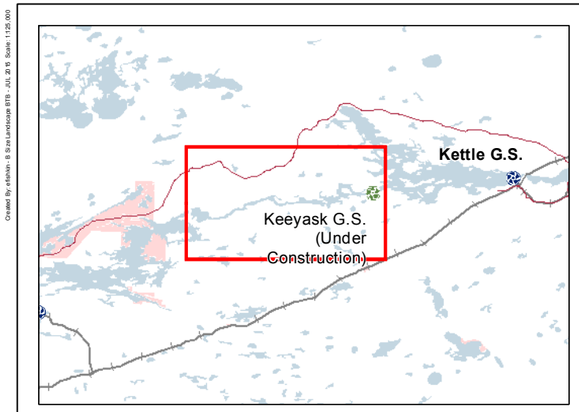
Legend

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

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.



Ross Wright Bay

North Access Road

Looking Back Creek

280

Effie Creek

125552

114237

Pond 13

Hidden Creek

107993

Caribou Island

Morris Point

7779

5

Keeyask G.S.
(Under Construction)

Gull Rapids

South Access Road

Two Goose Creek

Trickle Creek

5507

122780

125553

114228

4495

127089

108002

101278

127075

3

127071

127095

NELSON RIVER

125557

Fork Creek

125555

122781

125556

108010

114243

Portage Creek

4

2

Birthday Rapids

Nap Creek

Rabbit Creek

Seebeesis Creek

125105

Clark Lake

7021

107998

5505

1

Long Rapids

Carscadden Lake

SPLIT LAKE

N

Legend

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

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

CREATED BY:
North/South Consultants

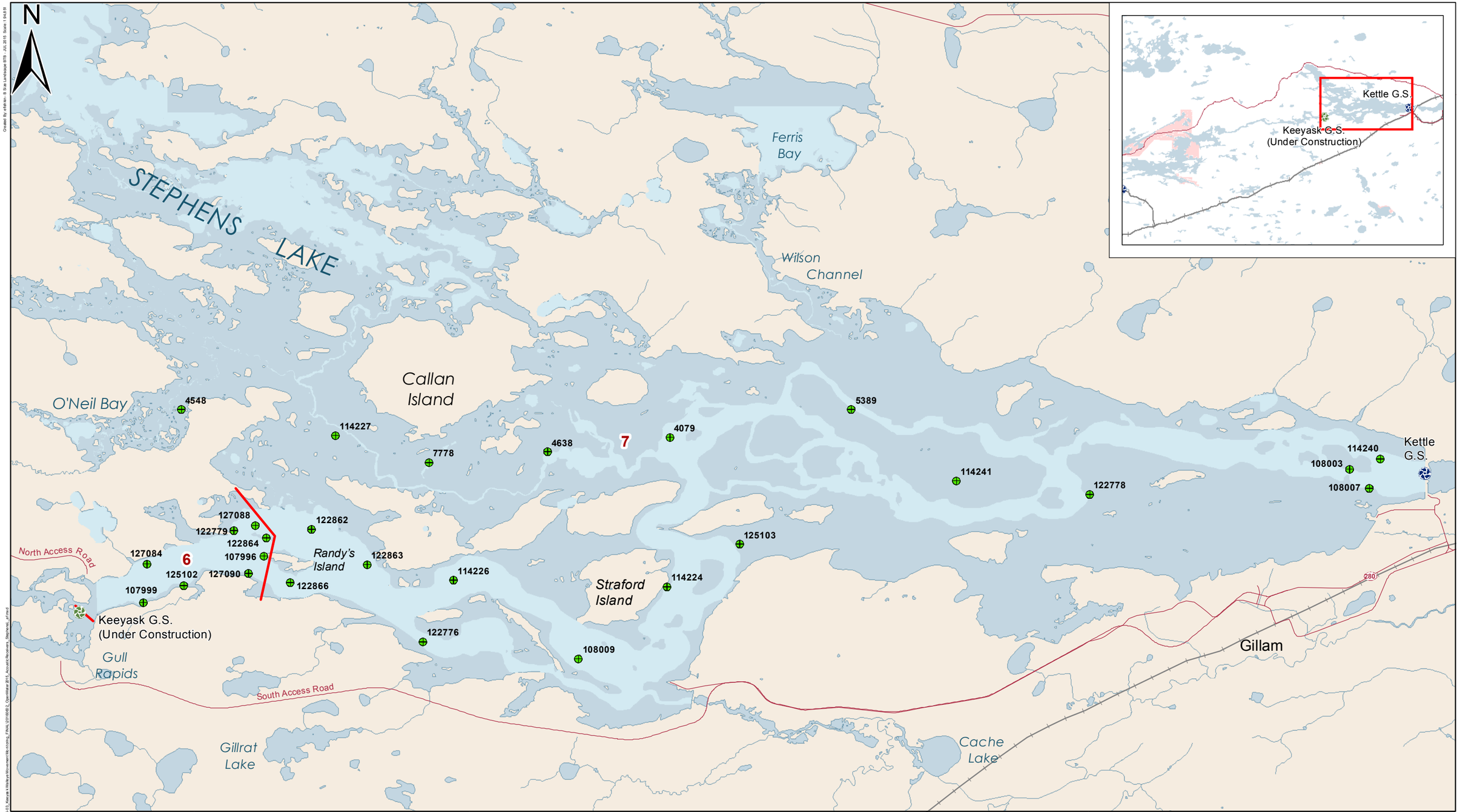
COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	09-FEB-15	06-JUN-16
0 0.45 0.9 Kilometres 0 0.35 0.7 Miles	VERSION NO: 1.0	QA/QC: CMP/YYY/ZZZ

KEEYASK

Open-water 2015 Acoustic Receiver Locations

Clark Lake to Gull Rapids

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".



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

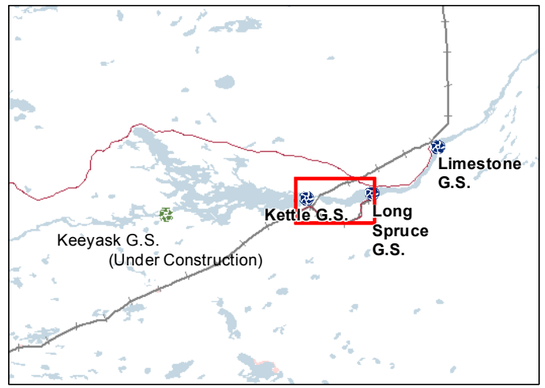
Legend

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

Open-water 2015 Acoustic Receiver Locations

Stephens Lake

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.



N

STEPHENS LAKE

125101

122774

108000

Kettle River

Long Spruce Forebay

125104

Wilson Creek

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	03-JUN-16
0 0.45 0.9 Kilometres 0 0.35 0.7 Miles	VERSION NO: 1.0	QA/QC: CMP/YYY/ZZZ

Legend

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

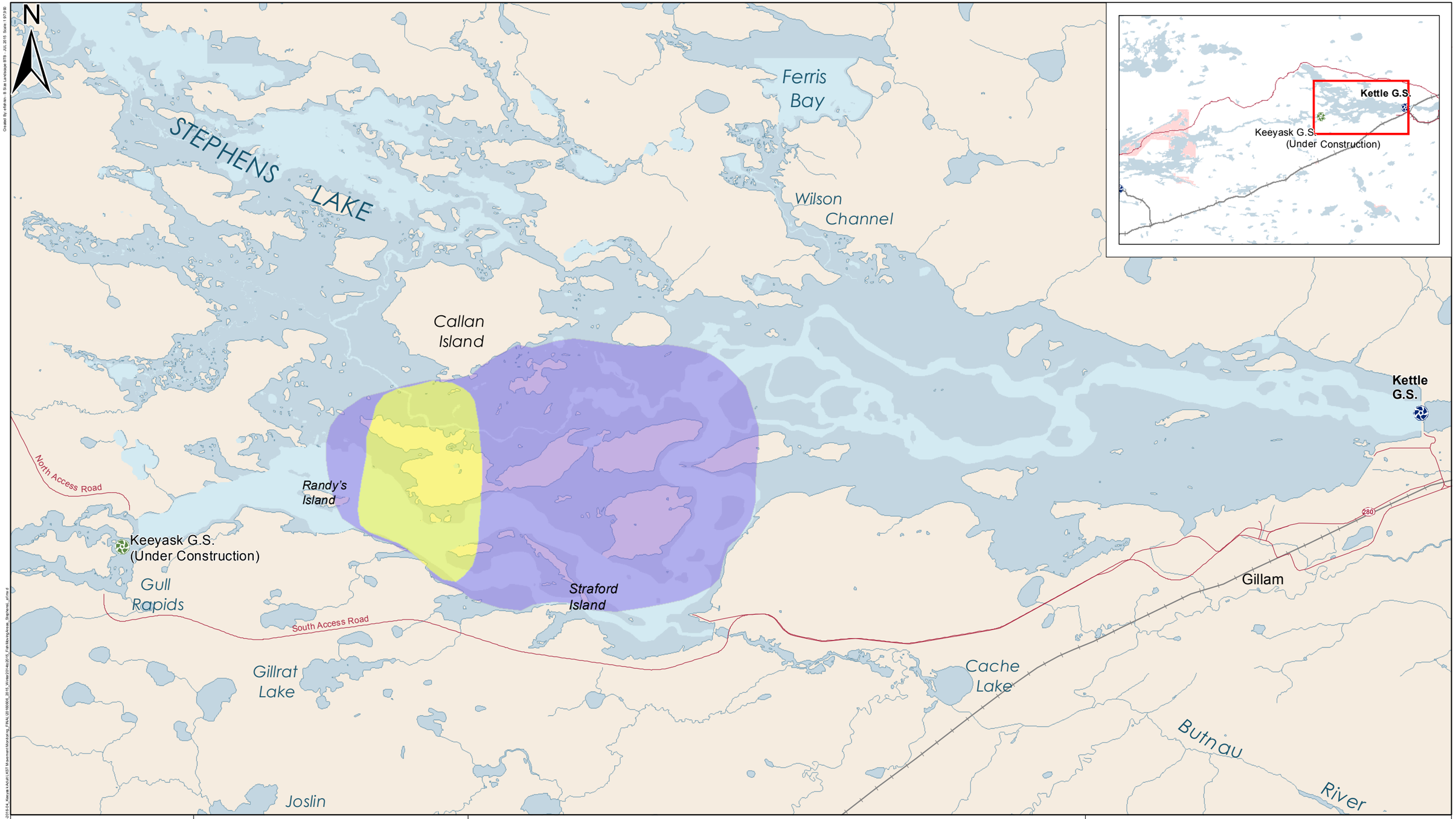
Open-water 2015 Acoustic Receiver Locations

Long Spruce G.S. Reservoir

File Location: J:\MYP\MYP_KEEYASK_ADMP\4_Fish\2016\GIS\Keeyask EMP-2016-03_Keeyask Whitefish Movement Mapping_FINAL\2015\MXD_2016-03_OpenWaterRecievers_2015_LongSpruceGS_all.mxd

Created By: ehinton - B Size Landscape 8.5"x11" - JUL 2015 Scale 1:1,000,000

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



KEEYASK

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	06-JUN-16
0 0.4 0.8 Kilometres 0 0.35 0.7 Miles	VERSION NO: 1.0	QA/QC: CMP/YYY/ZZZ

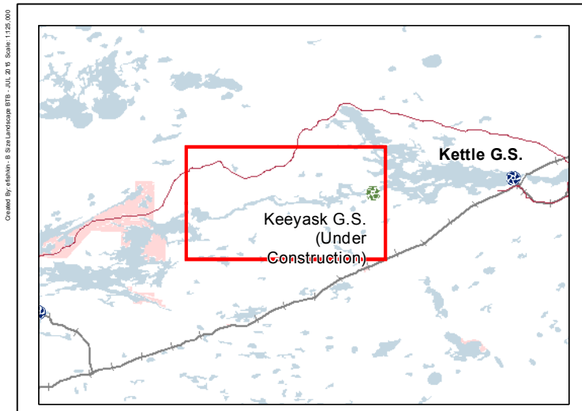
Legend

Fish Movement Areas
- Upper Stephens Lake (n=7)
- Upper and lower Stephens Lake (n=16)

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

Winter 2014/2015 Fish Moving Areas
Stephens Lake

Map 10: Illustration of movement patterns for 23 fish located in Stephens Lake during the winter 2014/2015 period (13 October, 2014 to 30 April, 2015).



Ross Wright Bay

North Access Road

Looking Back Creek

280

Effie Creek

Pond 13

Hidden Creek

Two Goose Creek

Caribou Island

Morris Point

Trickle Creek

Keeyask G.S.
(Under Construction)

Gull Rapids

South Access Road

NELSON RIVER

Fork Creek

Portage Creek

Clark Lake

Long Rapids

Birthday Rapids

Nap Creek

Rabbit Creek

Seebeesis Creek

Carscadden Lake

SPLIT LAKE

N

KEEYASK

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	06-JUN-16
0 0.4 0.8 Kilometres 0 0.35 0.7 Miles	VERSION NO: 1.0	QA/QC: CMP/YYY/ZZZ

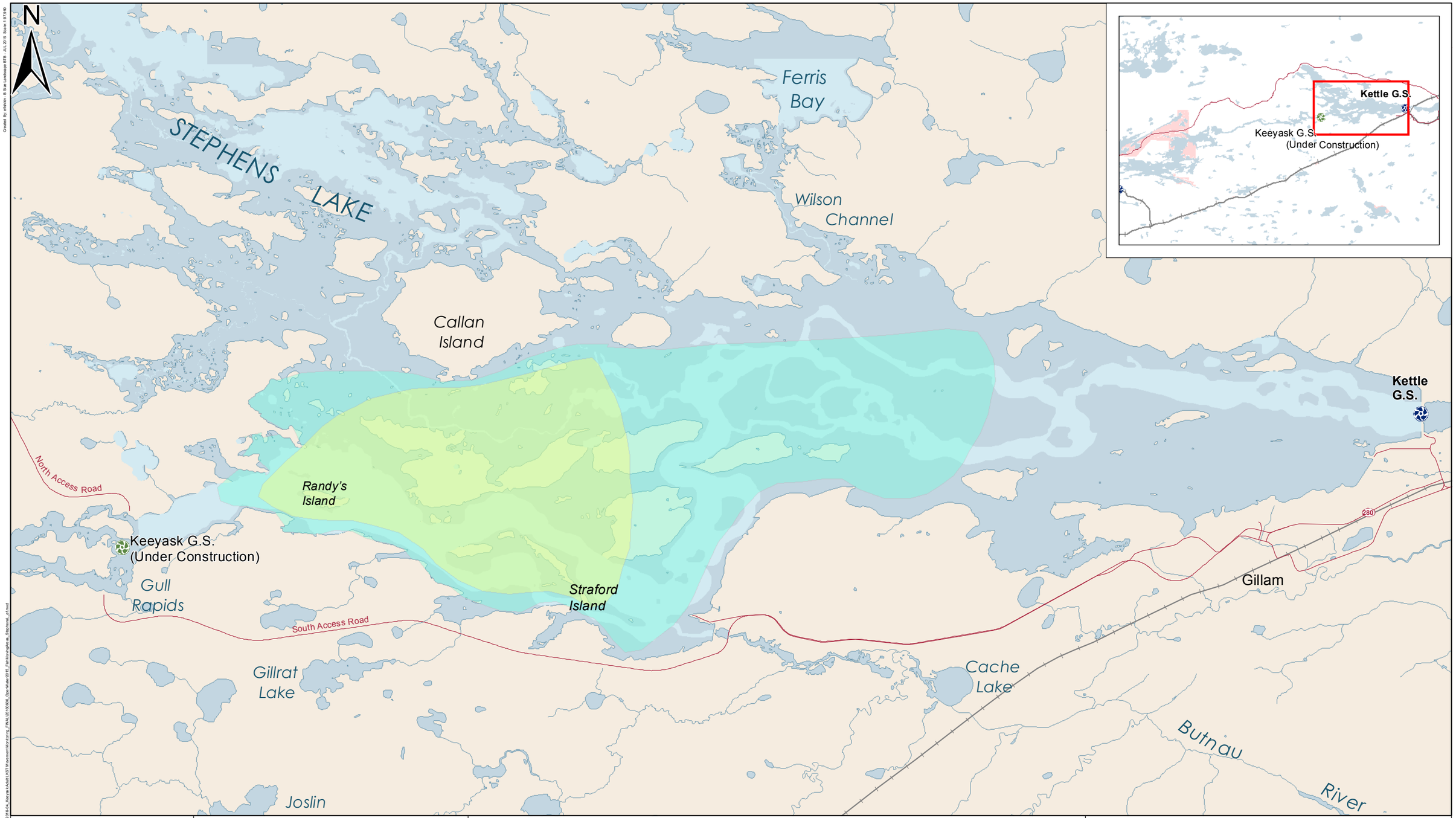
Legend

- Clark Lake to Gull Lake (n=2)
- Gull Lake (n=18)
- Gull Lake with brief upstream movements (n=5)
- Generating Station (Existing)
- Generating Station (Under Construction)
- Highway
- Rail
- First Nation Reserve

Open-water 2015 Fish Moving Areas

Clark Lake to Gull Rapids

Map 11: Illustration of movement patterns for 25 fish located upstream of Keeyask GS during the 2015 open-water period (1 May to 11 October, 2015). Three additional fish did not display a consistent movement pattern.



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	06-JUN-16
0 0.4 0.8 Kilometres 0 0.35 0.7 Miles	VERSION NO: 1.0	QA/QC: CMP/YYY/ZZZ

Legend

Fish Movement Areas (n=6)
- Upper Stephens Lake (n=6)
- Upper and Lower Stephens Lake (n=19)

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

Open-water 2015 Fish Moving Areas
Stephens Lake

Map 12: Illustration of movement patterns for 25 fish located in Stephens Lake during the 2015 open-water period (1 May to 11 October, 2015).

APPENDICES

APPENDIX 1:
DETECTION SUMMARIES FOR LAKE STURGEON TAGGED AND MONITORED IN THE KEEYASK STUDY AREA BETWEEN 2011 AND 2015

Table A1-1. Detection summary for each of 35 Lake Sturgeon tagged and monitored upstream of Keeyask GS during the winter 2011/2012 (20 October, 2011 to 30 April, 2012), 2012/2013 (16 October, 2012 to 30 April, 2013), 2013/2014 (16 October, 2013 to 30 April, 2014), and 2014/2015 (13 October, 2014 to 30 April, 2015) periods. Tag id highlighted yellow = lost tags.

Tag ID	2011/2012					2012/2013					2013/2014					2014/2015				
	n	# Days	U/S (rkm)	D/S (rkm)	Range (rkm)	n	# Days	U/S (rkm)	D/S (rkm)	Range (rkm)	n	# Days	U/S (rkm)	D/S (rkm)	Range (rkm)	n	# Days	U/S (rkm)	D/S (rkm)	Range (rkm)
16026	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
16036	2537	118	-10.5	-7.5	3.0	43	12	-9.9	-9.9	0.0	2326	52	-12.9	-12.9	0.0	362	16	-12.9	-12.9	0.0
16039	0	-	-	-	-	0	-	-	-	-	502	10	-12.9	-9.9	3.0	0	-	-	-	-
16042	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
16045	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
16048	0	-	-	-	-	0	-	-	-	-	2932	66	-48.2	-48.2	0.0	0	-	-	-	-
16051	2475	51	-7.5	-7.5	0.0	7088	93	-9.9	-9.9	0.0	14618	92	-12.9	-9.9	3.0	0	-	-	-	-
16054	2772	40	-12.6	-7.5	5.1	4027	66	-9.9	-9.9	0.0	10807	83	-12.9	-9.9	3.0	0	-	-	-	-
16055	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
16056	8711	176	-7.5	-7.5	0.0	1893	63	-9.9	-9.9	0.0	13493	87	-9.9	-9.9	0.0	0	-	-	-	-
16057	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
16058	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
16059	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
16060	11406	138	-7.5	-7.5	0.0	4354	75	-9.9	-9.9	0.0	25171	137	-9.9	-9.9	0.0	0	-	-	-	-
16061	13225	94	-11.8	-7.5	4.3	1157	71	-9.9	-9.9	0.0	18018	115	-9.9	-9.9	0.0	140	11	-12.9	-12.9	0.0
16062	5943	148	-7.5	-7.5	0.0	2495	48	-9.9	-9.9	0.0	9079	120	-9.9	-9.9	0.0	0	-	-	-	-
16063	7905	134	-12.6	-7.5	5.1	3650	60	-9.9	-9.9	0.0	6098	84	-9.9	-9.9	0.0	739	10	-12.9	-12.9	0.0
16064	6717	139	-7.5	-7.5	0.0	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
16065	3485	129	-7.5	-7.5	0.0	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
16066	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
16067	4542	149	-10.5	-7.5	3.0	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
16068	272	15	-10.5	-7.5	3.0	5623	73	-9.9	-9.9	0.0	22744	129	-9.9	-9.9	0.0	0	-	-	-	-
16069	0	-	-	-	-	0	-	-	-	-	678	4	-29.4	-29.4	0.0	0	-	-	-	-
16070	12833	184	-7.5	-7.5	0.0	2	1	-9.9	-9.9	0.0	33086	118	-12.9	-12.9	0.0	0	-	-	-	-
16071	7247	122	-7.5	-7.5	0.0	2351	38	-9.9	-9.9	0.0	11439	95	-9.9	-9.9	0.0	0	-	-	-	-
16072	11220	174	-7.5	-7.5	0.0	11687	96	-9.9	-9.9	0.0	27653	142	-12.9	-9.9	3.0	958	5	-12.9	-12.9	0.0
16073	2647	51	-10.5	-7.5	3.0	3284	66	-9.9	-9.9	0.0	1213	18	-9.9	-9.9	0.0	800	6	-12.9	-12.9	0.0
16074	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
16075	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
16076	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
16077	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
32174	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-
32175	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-
32176	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-
32177	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-

Table A1-2. Detection summary for each of 36 Lake Sturgeon tagged and monitored in Stephens Lake during the winter 2011/2012 (20 October, 2011 to 30 April, 2012), 2012/2013 (16 October, 2012 to 30 April, 2013), 2013/2014 (16 October, 2013 to 30 April, 2014), and 2014/2015 (13 October, 2014 to 30 April, 2015) periods. Tag id highlighted green = moved upstream over Gull Rapids and harvested. Tag id highlighted blue = moved upstream over Gull Rapids. Tag id highlighted yellow = lost tags. Tag id highlighted red = moved downstream through Kettle GS. Tag id highlighted purple = moved downstream through Gull Rapids.

Tag ID	2011/2012					2012/2013					2013/2014					2014/2015				
	n	# Days	U/S (rkm)	D/S (rkm)	Range (rkm)	n	# Days	U/S (rkm)	D/S (rkm)	Range (rkm)	n	# Days	U/S (rkm)	D/S (rkm)	Range (rkm)	n	# Days	U/S (rkm)	D/S (rkm)	Range (rkm)
16018	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
16019	0	-	-	-	-	887	39	5.6	6.2	0.6	2959	33	6.1	14.9	8.8	8761	79	7.7	10.5	2.8
16020	0	-	-	-	-	3625	25	5.6	15.1	9.5	24335	102	6.1	14.9	8.8	6183	36	7.7	14.9	7.2
16021	16475	79	6.6	35.8	29.2	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
16022	0	-	-	-	-	1227	15	5.6	15.1	9.5	7508	83	6.1	10.2	4.1	10649	55	7.7	14.9	7.2
16024	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
16025	0	-	-	-	-	1974	47	-9.9	-9.9	0.0	20670	114	-9.9	-9.9	0.0	0	-	-	-	-
16027	0	-	-	-	-	3398	70	5.6	9.9	4.3	2111	24	6.1	7.7	1.6	23369	120	7.7	10.5	2.8
16028	0	-	-	-	-	733	7	5.6	15.1	9.5	2123	8	6.1	21.0	14.9	21803	84	7.7	10.5	2.8
16029	1937	39	-17.2	-7.5	9.7	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
16030	12583	70	6.6	10.5	3.9	13733	89	5.6	9.9	4.3	2887	63	6.1	14.9	8.8	8872	97	7.7	14.9	7.2
16031	0	-	-	-	-	7414	26	15.1	18.9	3.8	45513	147	14.9	14.9	0.0	36654	117	14.9	14.9	0.0
16032	48676	67	7.4	10.5	3.1	2284	23	7.5	9.9	2.4	3780	48	6.1	14.9	8.8	4759	53	7.7	10.2	2.5
16033	125	3	8.2	10.5	2.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16033b	-	-	-	-	-	-	-	-	-	-	15689	104	6.1	13.4	7.3	3243	42	7.7	14.9	7.2
16034	39927	61	7.4	27.6	20.2	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
16035	7225	84	7.4	10.5	3.1	22099	113	7.5	9.9	2.4	29174	179	6.1	18.7	12.6	14317	83	7.7	10.5	2.8
16037	36948	77	6.6	10.5	3.9	991	18	5.6	9.9	4.3	24601	133	-12.9	-9.9	3.0	10762	61	7.7	10.5	2.8
16038	14187	69	6.6	17.1	10.5	9	2	-9.9	-9.9	0.0	106	8	-12.9	-12.9	0.0	4	2	-12.9	-12.9	0.0
16040	18814	85	6.6	10.5	3.9	23113	104	7.5	9.9	2.4	4436	21	6.1	18.7	12.6	5033	26	7.7	10.2	2.5
16041	135	11	17.1	17.1	0.0	4328	25	15.1	18.9	3.8	16656	153	6.1	10.2	4.1	16912	74	7.7	10.2	2.5
16043	6989	49	10.5	27.6	17.1	10520	95	8.7	24.7	16.0	16074	114	10.2	21.0	10.8	36372	188	10.2	21.0	10.8
16044	9036	57	6.6	27.6	21.0	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
16046	6972	85	7.4	10.5	3.1	248	25	-9.9	-9.9	0.0	0	-	-	-	-	0	-	-	-	-
16047	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-
16049	20859	75	6.6	10.5	3.9	32364	157	5.6	9.9	4.3	24241	140	6.1	14.9	8.8	9993	101	7.7	10.5	2.8
16050	345	3	17.1	17.1	0.0	18070	65	15.1	18.9	3.8	2920	50	10.2	21.0	10.8	8473	55	14.9	21.0	6.1
16052	143	4	7.5	17.1	9.6	6505	78	7.5	15.1	7.6	34688	173	14.9	14.9	0.0	18189	165	7.7	18.7	11.0
16053	2960	31	7.4	10.5	3.1	776	10	7.5	18.9	11.4	2209	20	6.1	21.0	14.9	7018	46	7.7	10.2	2.5
32167	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	293	14	14.9	14.9	0.0
32168	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19931	142	7.7	21.0	13.3
32169	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	444	6	7.7	10.2	2.5
32170	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3328	69	7.7	10.5	2.8
32171	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3275	24	7.7	21.0	13.3
32172	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8293	37	7.7	18.7	11.0
32173	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3843	49	7.7	10.2	2.5

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

Tag ID	2011			2012			2013			2014			2015				
	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	U/S (rkm)	D/S (rkm)	Range (rkm)
16026	-	-	-	23195	83	9.4	12588	83	0.0	13090	103	0.0	29896	103	-33.8	-26.5	7.3
16036	2152	32	8.6	6980	86	9.4	5328	82	8.1	12362	112	10.0	20379	132	-19.5	-9.9	9.6
16039	2260	42	13.3	5250	66	12.5	16487	107	11.3	12670	120	11.6	18372	119	-19.5	-9.0	10.5
16042	1914	54	0.0	576	11	0.8	2626	30	3.4	6660	54	3.9	0	-	-	-	-
16045	786	13	7.0	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16048	383	6	1.6	1773	37	0.8	10796	119	21.6	7527	93	21.7	20784	116	-19.5	17.4	36.9
16051	1935	76	8.7	5804	105	15.3	8015	115	13.4	10404	57	13.7	10706	126	-32.3	-5.8	26.5
16054	2697	49	12.0	4278	101	10.6	11062	105	9.5	7102	93	12.1	17220	90	-48.2	-9.5	38.7
16055	1140	9	3.4	1384	27	5.7	8271	89	4.9	7657	86	10.0	5005	104	-12.9	-7.4	5.5
16056	234	12	19.1	4665	87	10.6	12862	96	19.5	17163	115	10.0	18319	113	-29.4	-9.0	20.4
16057	475	25	4.2	524	29	8.5	0	-	-	2	1	0.0	0	-	-	-	-
16058	549	16	9.3	1071	4	9.7	0	-	-	0	-	-	0	-	-	-	-
16059	599	5	3.4	1696	32	10.4	13935	78	11.3	10991	57	5.1	4708	85	-19.5	-5.8	13.7
16060	1759	43	7.1	4065	95	8.7	16366	124	7.1	13228	108	7.1	19911	115	-14.8	-7.4	7.4
16061	711	37	2.4	4444	108	13.6	11503	114	5.5	7437	95	3.4	13771	111	-19.5	-5.8	13.7
16062	142	14	8.6	5624	86	12.4	16854	109	24.4	18336	129	7.9	19949	120	-19.5	-9.5	10.0
16063	2617	59	10.4	9474	105	5.7	21588	126	9.3	23121	127	7.9	24981	137	-19.5	-9.5	10.0
16064	1910	27	19.1	573	26	1.2	0		-	0		-	0	-	-	-	-
16065	931	36	4.5	6192	109	17.9	2581	38	5.1	3101	38	5.1	14349	104	-33.8	-5.8	28.0
16066	772	39	1.8	4615	105	10.6	2322	36	8.1	8898	73	12.1	1884	20	-9.5	-17.4	-7.9
16067	1640	34	1.6	2516	39	31.7	0		-	0		-	0	-	-	-	-
16068	1046	27	2.4	5882	105	10.6	10402	111	23.9	13158	121	10.0	16490	123	-19.5	-9.5	10.0
16069	0	-	-	17495	85	4.5	13288	100	7.3	14172	66	2.9	8287	80	-29.4	-19.4	10.0
16070	1080	40	8.6	14691	106	17.0	7943	89	9.6	9967	83	9.6	12593	101	-19.5	-9.5	10.0
16071	1403	43	8.6	9124	89	10.6	11285	130	9.3	17413	102	12.1	39272	131	-19.5	-5.8	13.7
16072	2839	58	12.9	4031	91	10.6	16638	129	19.5	19306	112	7.9	15866	127	-19.5	-9.5	10.0
16073	1025	35	2.4	4432	102	12.4	6885	94	9.3	13884	127	10.0	4500	73	-19.5	-5.8	13.7
16074	0	-	-	13006	67	4.7	11803	78	2.9	3105	23	7.3	655	13	-48.2	-32.3	15.9
16075	462	10	6.3	0	-	-	0	-	-	0	-	-	865	35	-10.1	-5.8	4.3
16076	1040	35	6.3	2225	56	9.4	9270	81	11.3	9075	84	11.6	12474	79	-17.4	-5.8	11.6
16077	282	5	0.0	0	-	-	0	-	-	0	-	-	0	-	-	-	-
32174	-	-	-	-	-	-	-	-	-	9705	98	28.5	20042	118	-48.2	-5.8	42.4
32175	-	-	-	-	-	-	-	-	-	9186	90	6.0	22601	114	-14.8	-9.5	5.3
32176	-	-	-	-	-	-	-	-	-	22630	106	11.6	15054	109	-32.3	-5.8	26.5
32177	-	-	-	-	-	-	-	-	-	20678	109	5.5	265	15	-10.1	-9.5	0.6

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

Tag ID	2011			2012			2013			2014			2015				
	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	Range (rkm)	n	# Days	U/S (rkm)	D/S (rkm)	Range (rkm)
16018	-	-	-	341	5	34.5	0	-	-	0	-	-	0	-	-	-	-
16019	-	-	-	9272	70	26.9	15039	116	18.2	13297	76	39.5	20832	129	1.3	28.3	27.0
16020	-	-	-	7450	101	11.9	13664	99	14.2	8592	111	19.7	25808	137	1.3	21.0	19.7
16021	2770	21	14.2	4530	30	5.0	0	-	-	0	-	-	0	-	-	-	-
16022	-	-	-	9845	100	16.0	7248	71	20.5	10957	101	20.5	18858	127	1.3	17.4	16.1
16024	-	-	-	398	9	4.0	0	-	-	0	-	-	0	-	-	-	-
16025	-	-	-	2316	67	35.2	9668	119	10.2	1572	23	60.4	0	-	-	-	-
16027	-	-	-	8249	87	16.0	15717	109	14.4	10960	72	9.7	14083	114	1.3	14.9	13.6
16028	-	-	-	9063	92	16.3	98	8	3.7	6174	58	17.4	16344	108	1.3	19.0	17.7
16029	3801	62	58.1	6087	102	19.9	4940	83	10.2	13325	102	16.0	8716	94	-19.5	-9.3	10.2
16030	7733	86	15.5	6414	86	14.4	13494	86	25.5	16498	104	27.4	15935	94	1.3	19.0	17.7
16031	-	-	-	12814	104	16.3	10315	106	14.4	12775	99	13.6	17780	125	1.3	14.9	13.6
16032	5801	56	14.2	13833	120	16.0	17055	115	19.7	16765	118	18.2	11985	106	1.3	17.4	16.1
16033	5144	44	14.2	3001	43	37.5	0	-	-	-	-	-	-	-	-	-	-
16033b	-	-	-	-	-	-	3505	30	12.4	13578	101	17.4	28621	127	1.3	17.4	16.1
16034	15378	75	11.2	15394	61	2.2	38582	117	0.8	25117	99	4.8	30925	119	42.7	43.5	0.8
16035	1547	12	10.9	8767	91	14.4	19324	116	20.3	16298	121	19.7	23142	119	1.3	19.0	17.7
16037	8375	50	7.4	13685	108	11.9	21481	125	44.3	13636	91	47.2	17230	113	1.3	17.4	16.1
16038	5777	45	11.2	3402	87	31.0	7973	124	9.3	3975	76	10.0	10827	75	-19.5	-7.4	12.1
16040	9602	70	12.5	8598	109	12.0	21959	128	18.0	4833	62	18.2	15041	122	1.3	21.0	19.7
16041	15169	88	11.2	9437	81	40.7	8915	81	14.4	13556	111	14.4	15807	101	1.3	17.4	16.1
16043	20429	92	15.5	13049	98	11.9	12476	115	14.4	13303	118	15.8	20525	131	1.3	19.0	17.7
16044	1582	36	8.7	3932	53	11.9	0	-	-	0	-	-	0	-	-	-	-
16046	8350	72	24.7	199	68	23.5	360	10	7.2	0	-	-	0	-	-	-	-
16047	131	2	19.7	0	-	-	0	-	-	0	-	-	0	-	-	-	-
16049	1919	12	11.2	11705	102	26.9	24320	123	27.7	11319	83	27.4	20752	132	1.3	17.4	16.1
16050	6519	57	15.5	7755	85	11.9	14411	88	14.2	7019	69	19.7	13783	98	1.3	14.9	13.6
16052	1920	17	11.2	4785	80	16.0	9791	65	20.5	8323	68	19.7	10937	96	1.3	18.7	17.4
16053	2740	18	12.5	13416	114	16.0	17049	126	18.2	13586	95	20.5	26058	130	1.3	17.4	16.1
32167	-	-	-	-	-	-	-	-	-	10421	91	20.5	33420	126	1.3	17.4	16.1
32168	-	-	-	-	-	-	-	-	-	18169	100	20.5	34961	140	1.3	17.4	16.1
32169	-	-	-	-	-	-	-	-	-	614	20	2.4	24873	131	2.2	17.4	15.2
32170	-	-	-	-	-	-	-	-	-	5151	77	20.5	17310	127	1.3	17.4	16.1
32171	-	-	-	-	-	-	-	-	-	36691	103	17.4	22567	111	1.3	17.4	16.1
32172	-	-	-	-	-	-	-	-	-	19105	86	9.7	17221	108	1.3	11.0	9.7
32173	-	-	-	-	-	-	-	-	-	24278	103	9.7	28920	117	1.3	11.0	9.7

APPENDIX 2:
LOCATION SUMMARY FOR INDIVIDUAL ACOUSTIC TAGGED ADULT LAKE STURGEON, UPSTREAM OF GULL RAPIDS, JUNE 2011 TO OCTOBER 2015

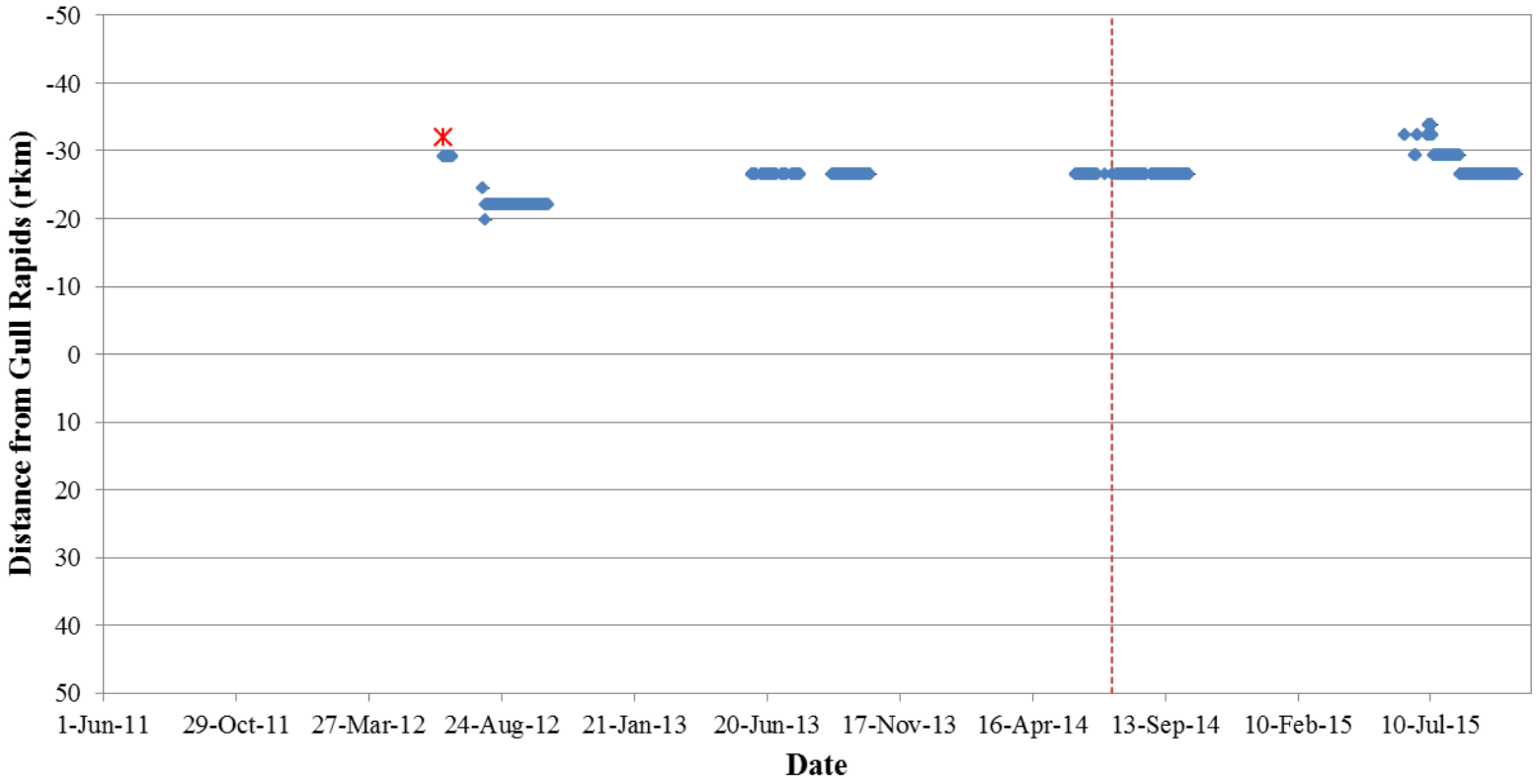


Figure A2-1: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16026) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

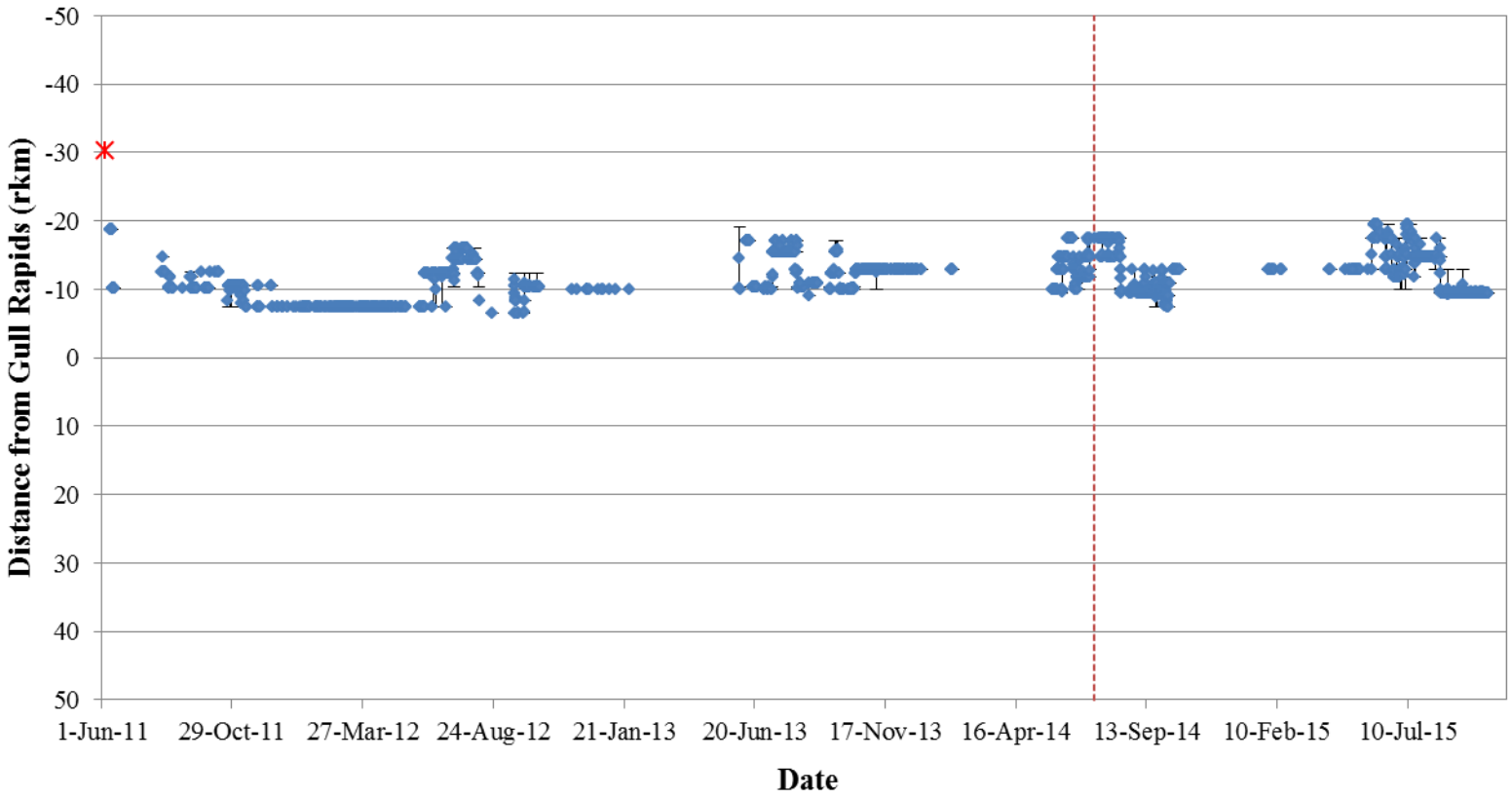


Figure A2-2: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16036) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

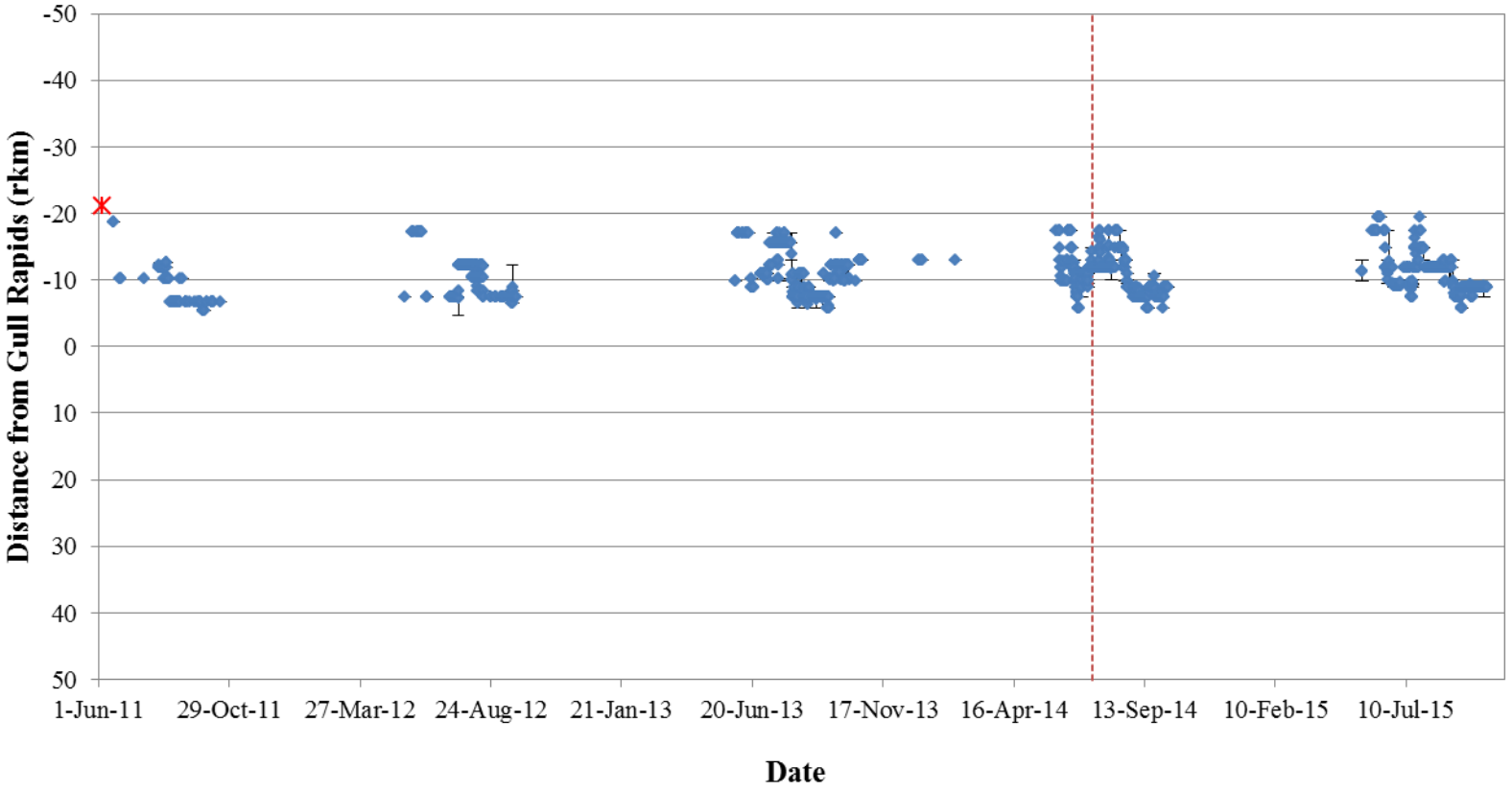


Figure A2-3: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16039) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

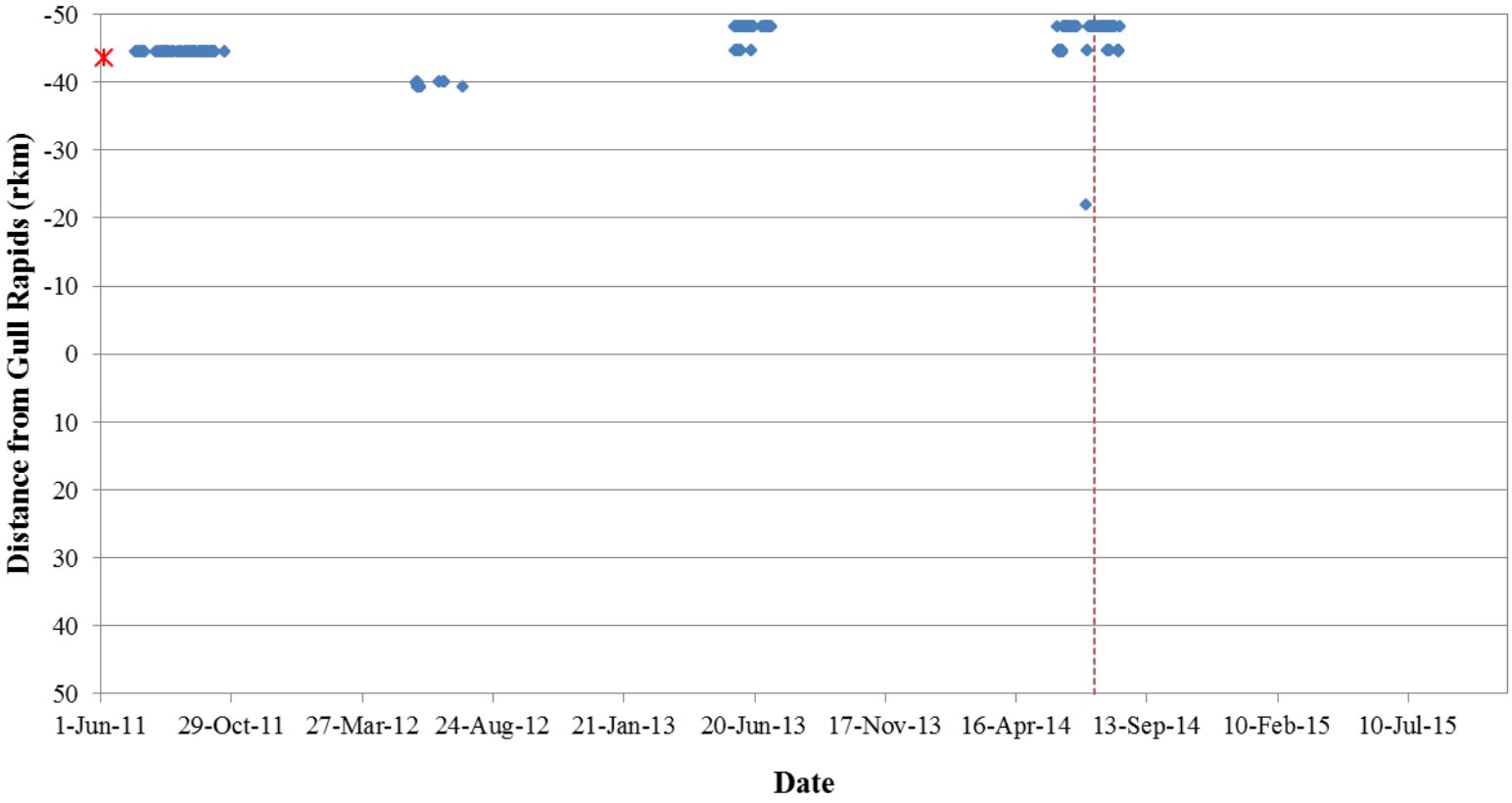


Figure A2-4: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16042) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

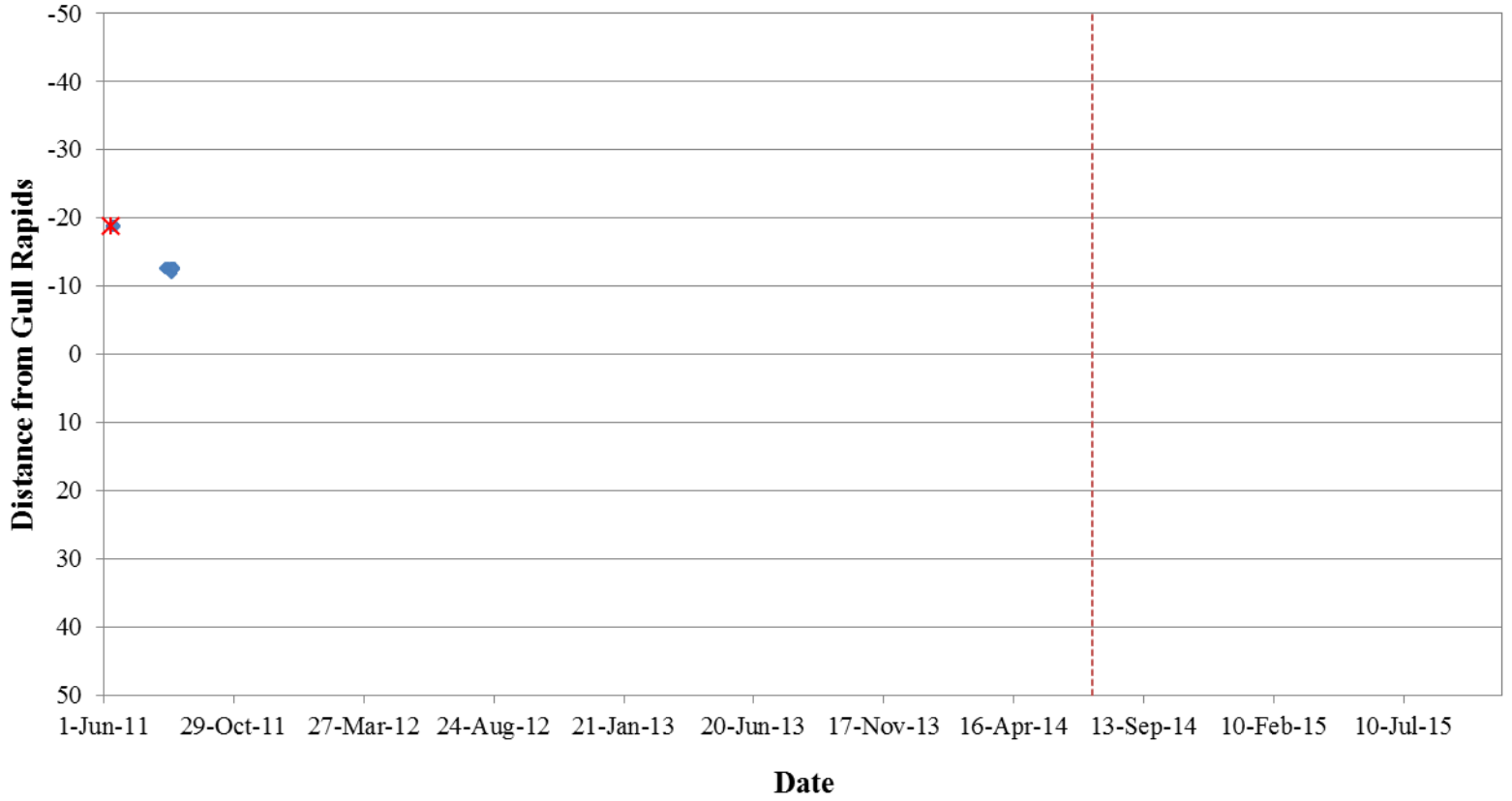


Figure A2-5: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16045) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

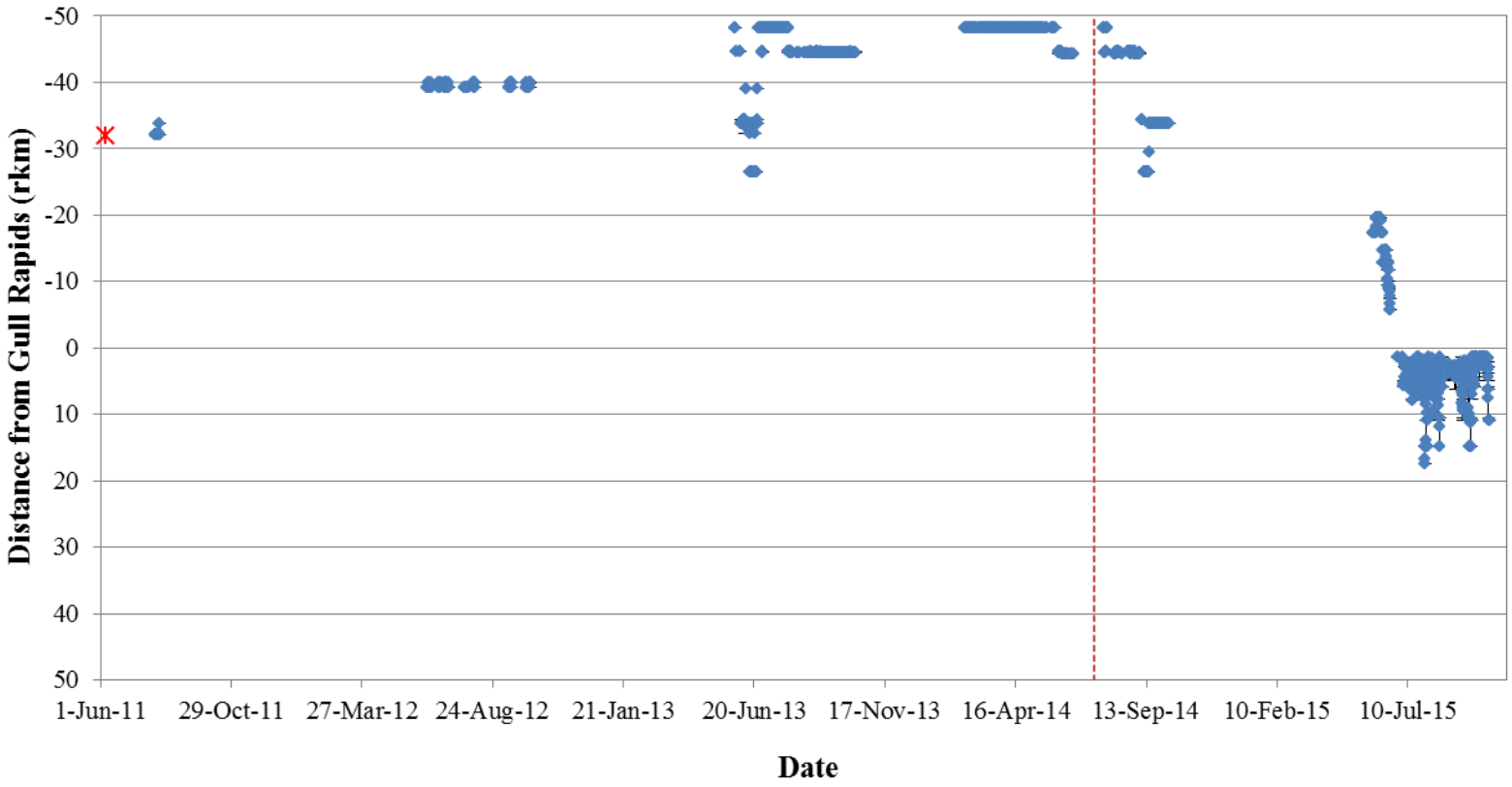


Figure A2-6: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16048) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

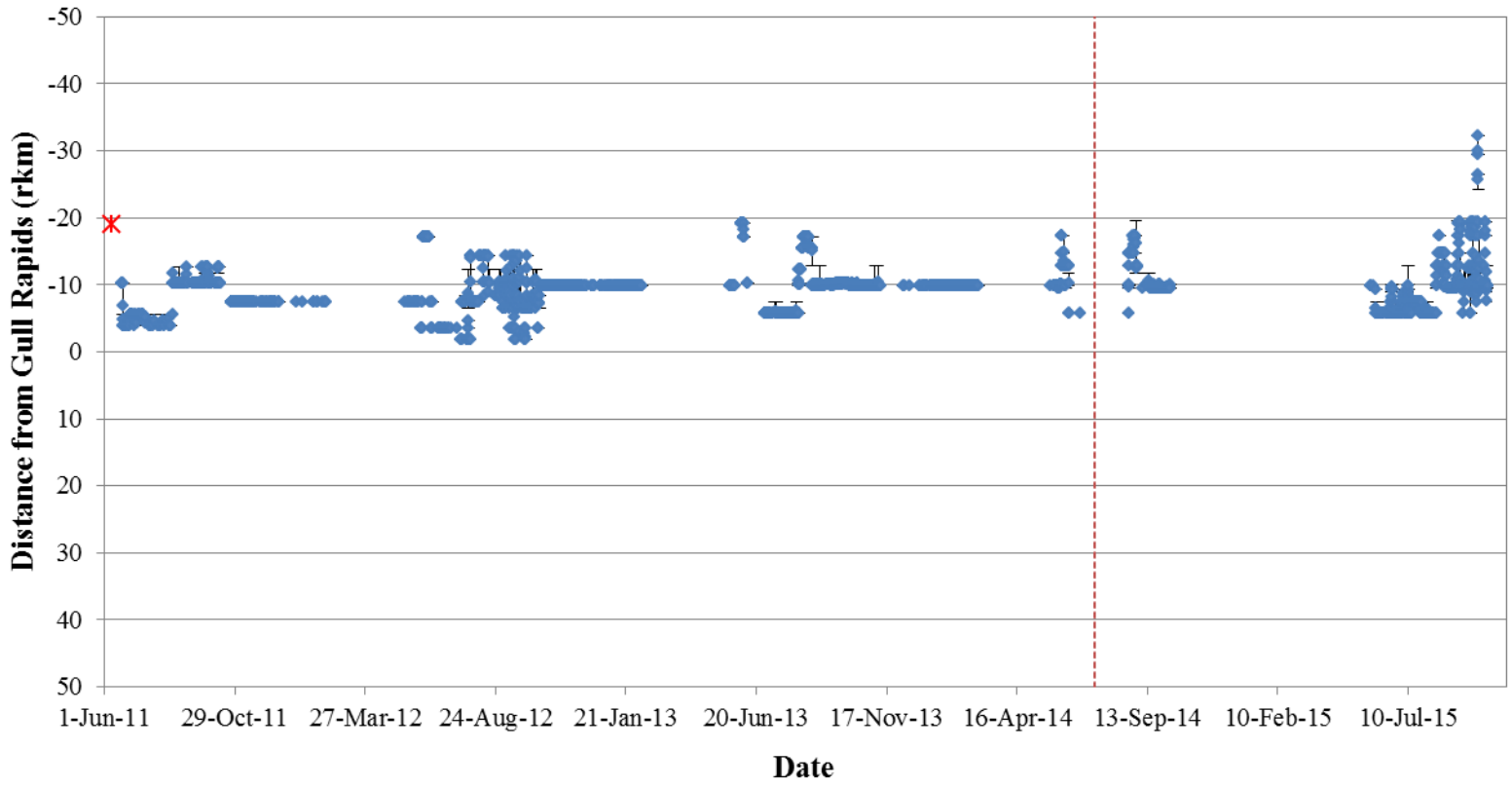


Figure A2-7: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16051) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

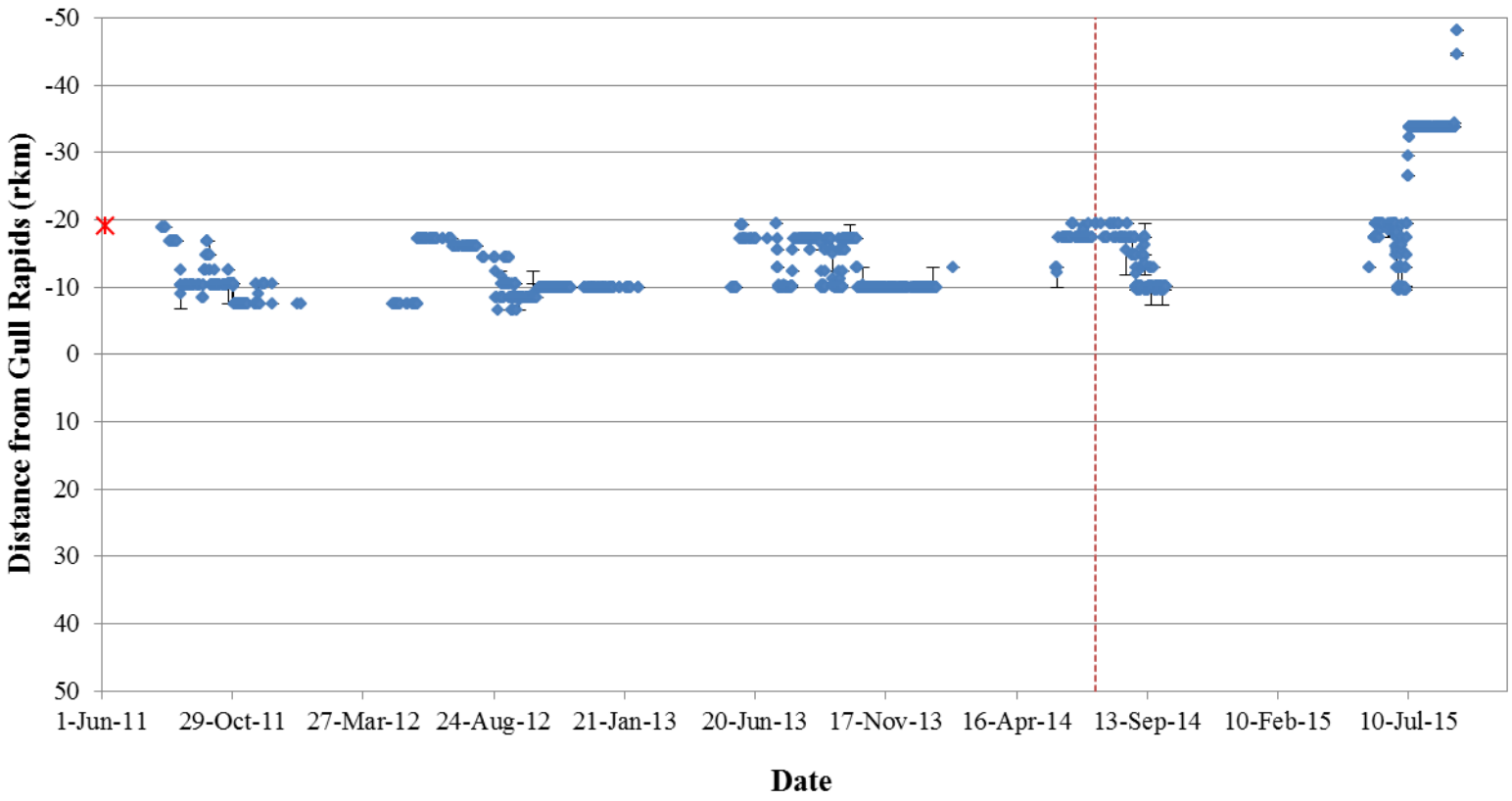


Figure A2-8: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16054) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

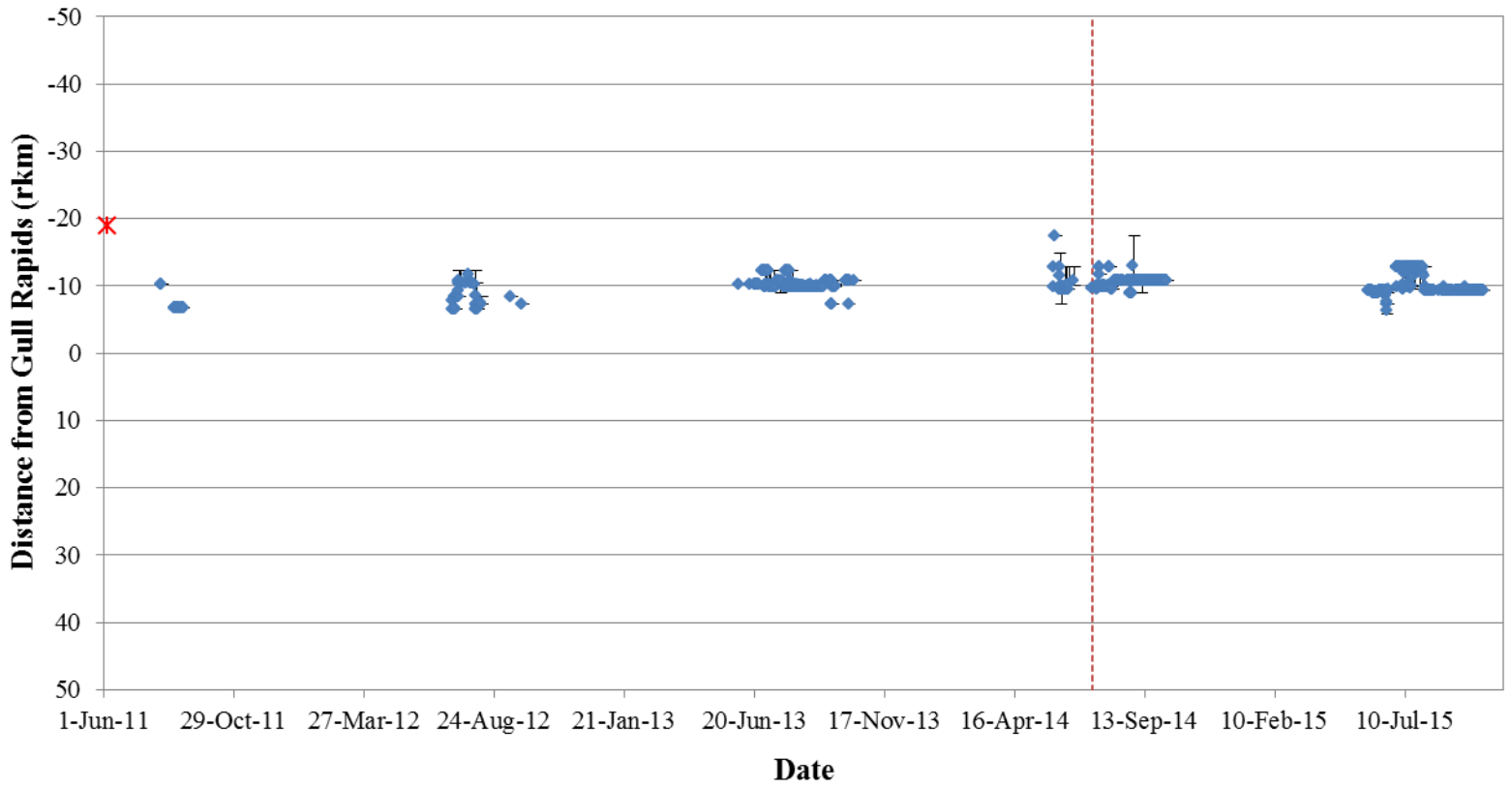


Figure A2-9: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16055) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

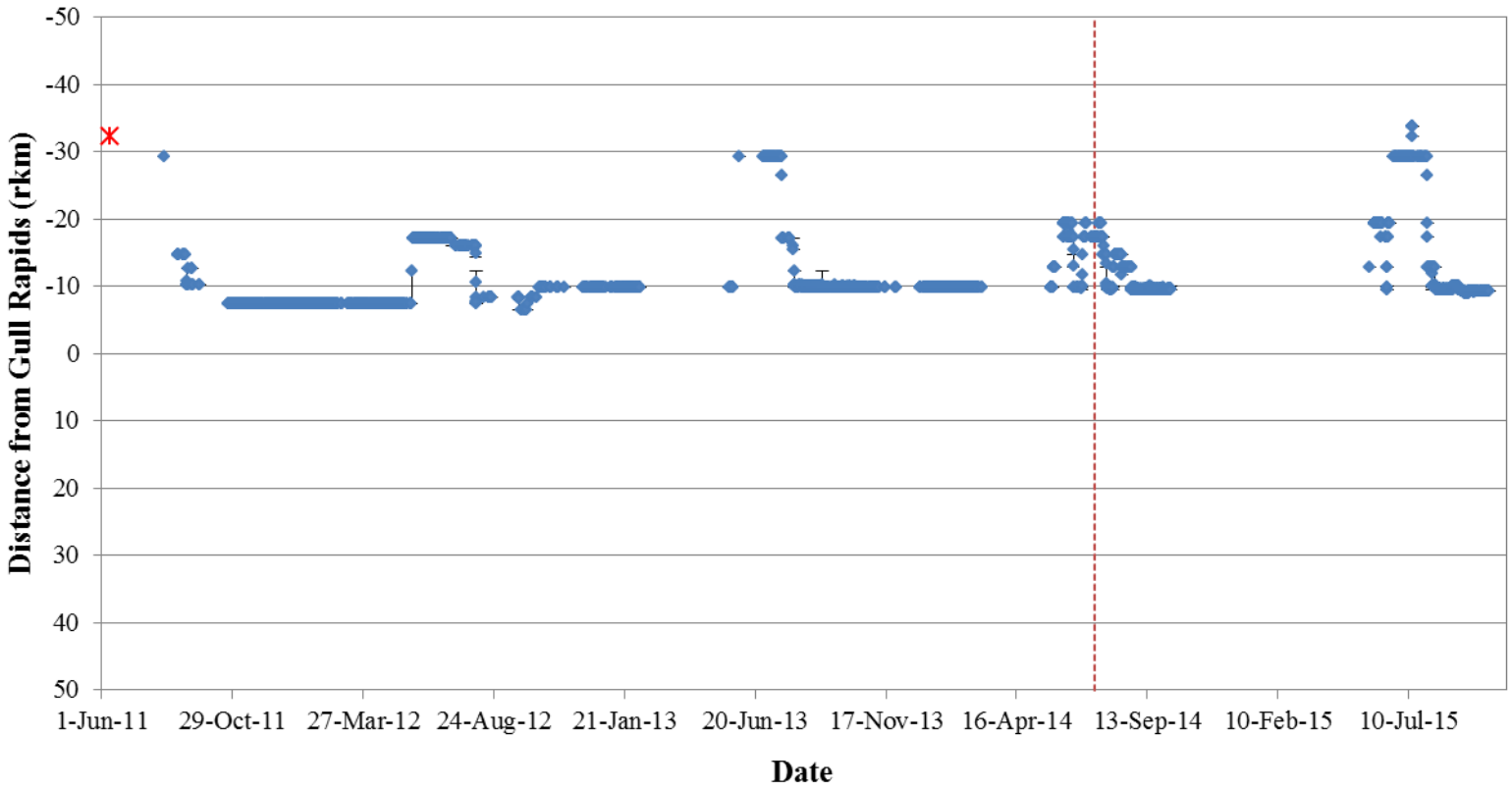


Figure A2-10: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16056) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

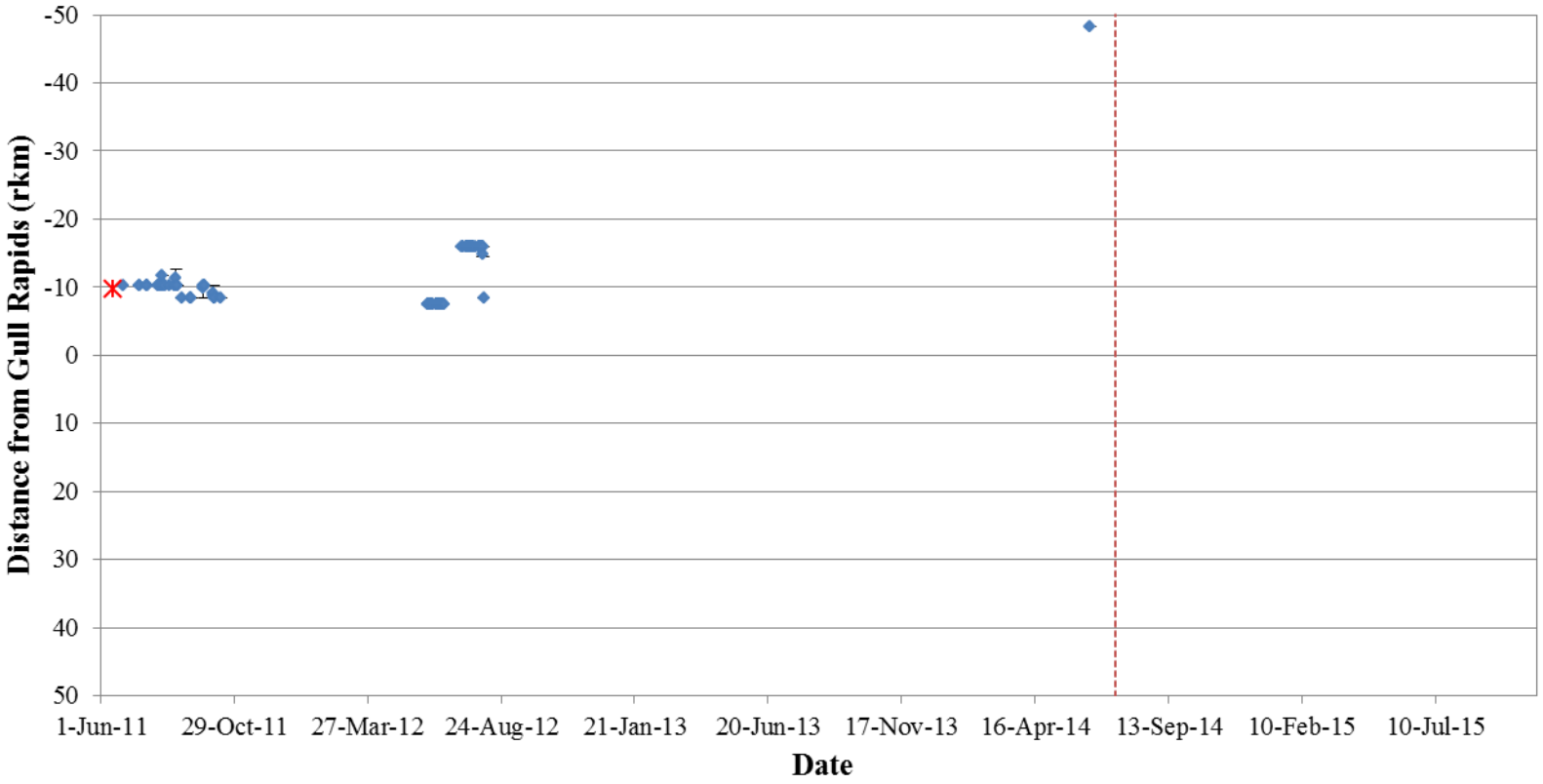


Figure A2-11: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16057) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

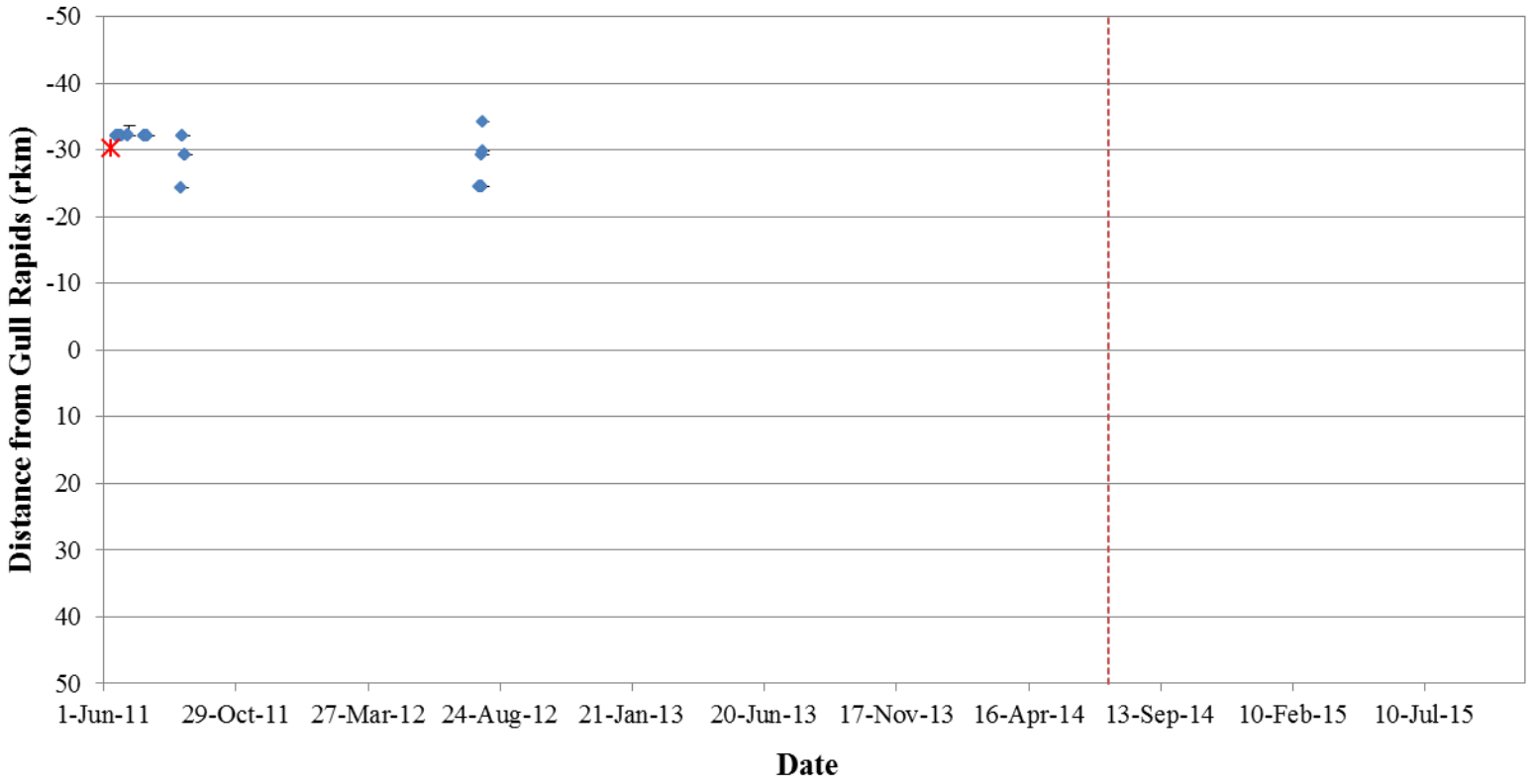


Figure A2-12: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16058) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

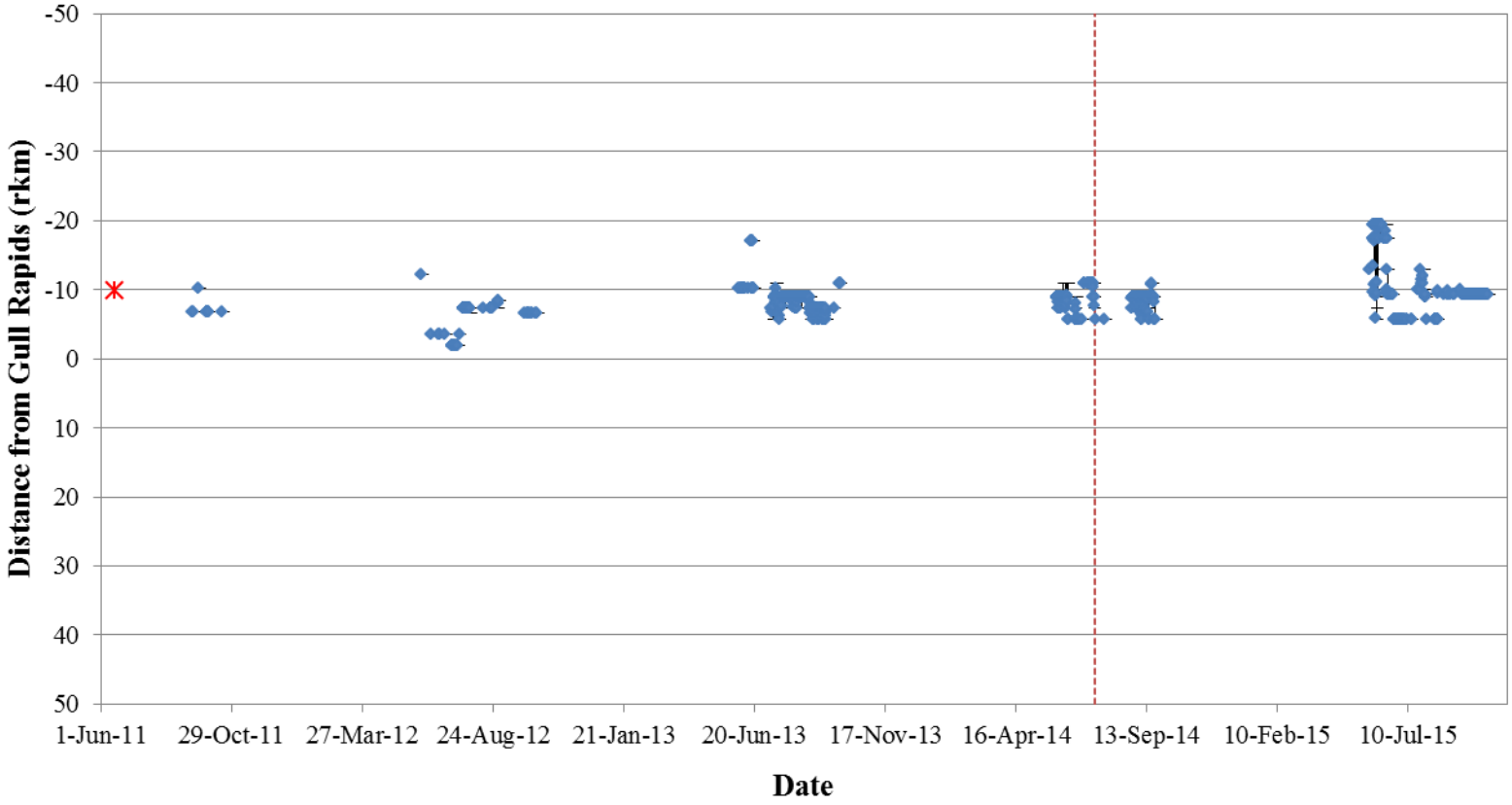


Figure A2-13: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16059) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

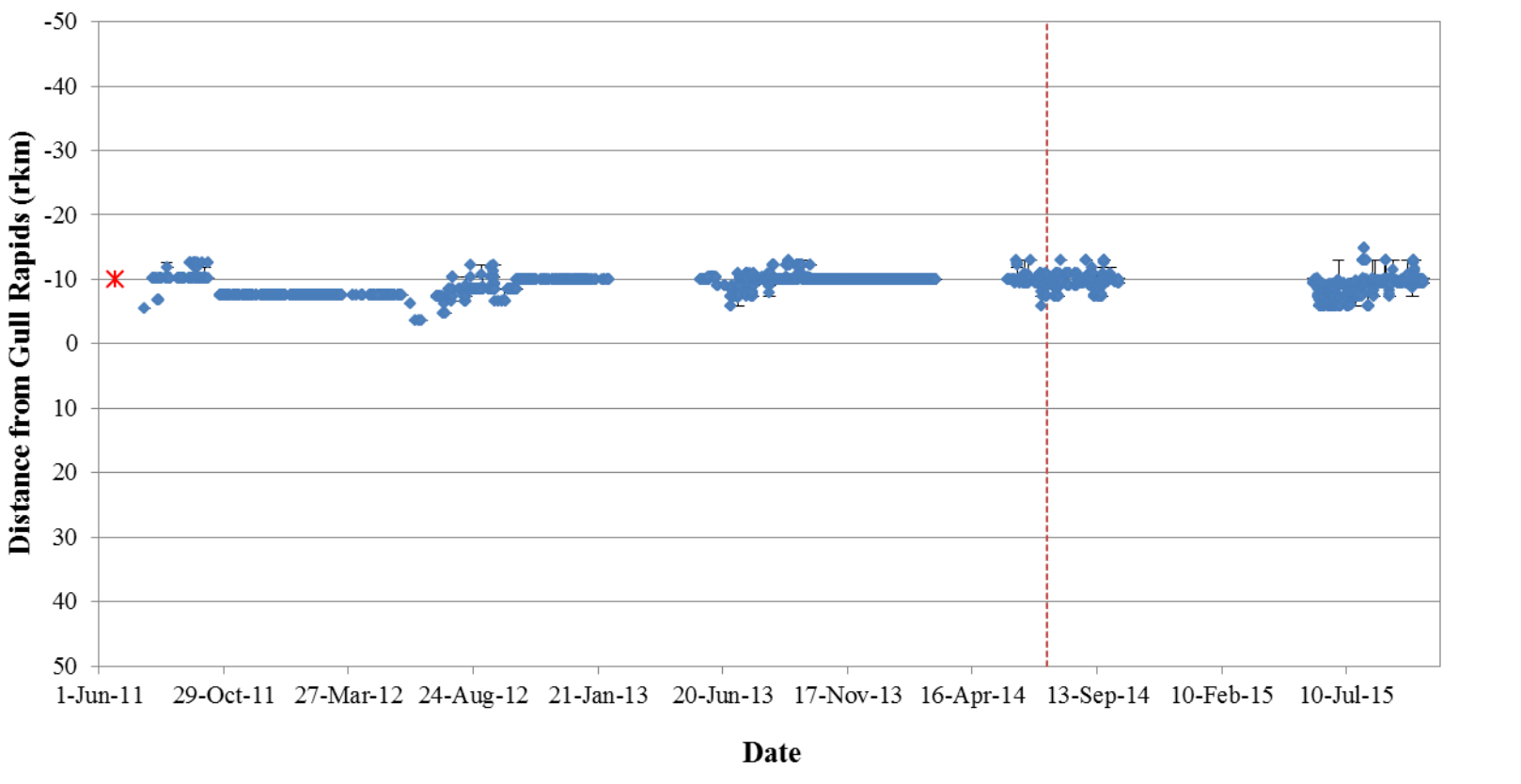


Figure A2-14: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16060) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

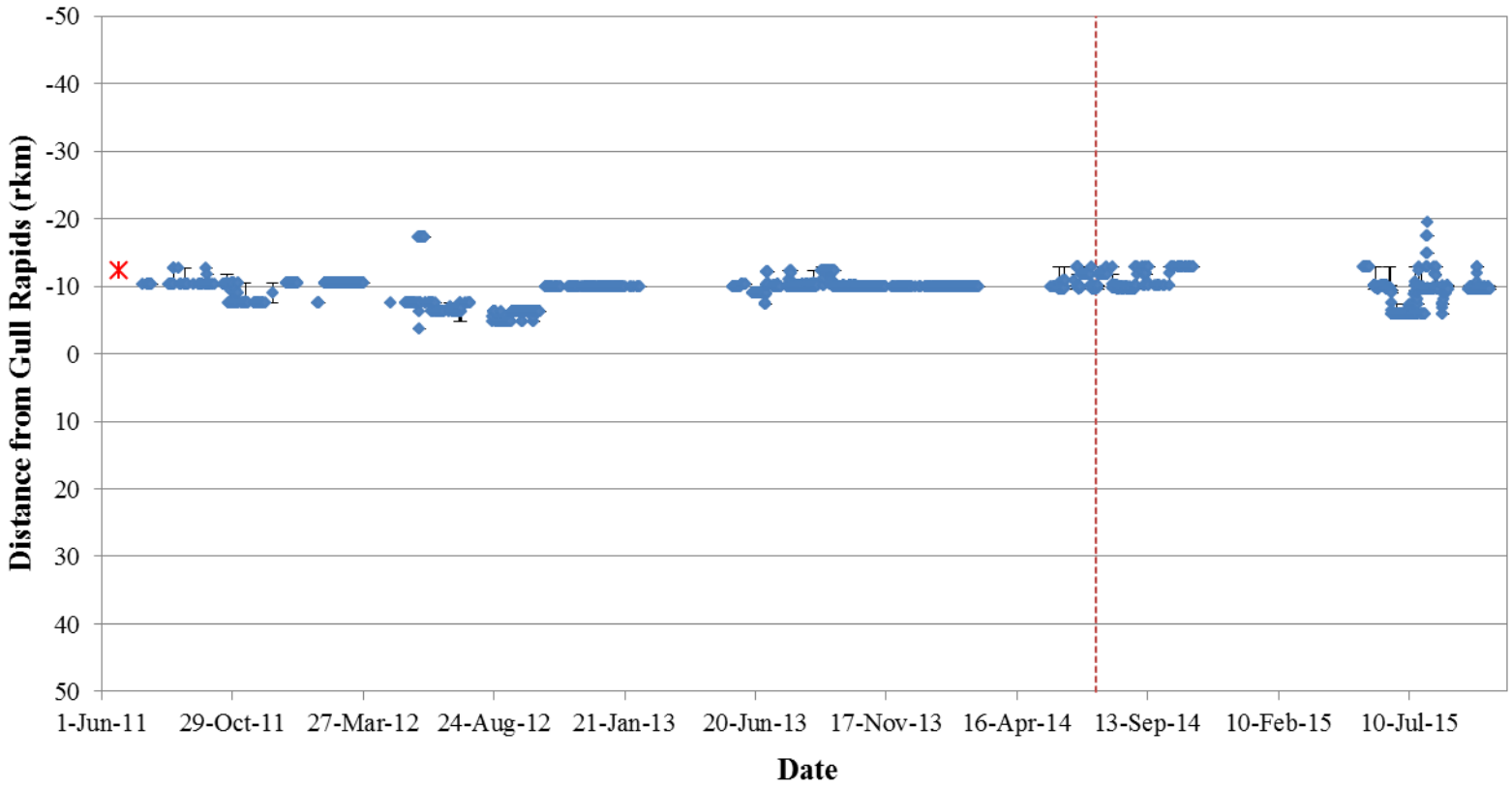


Figure A2-15: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16061) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

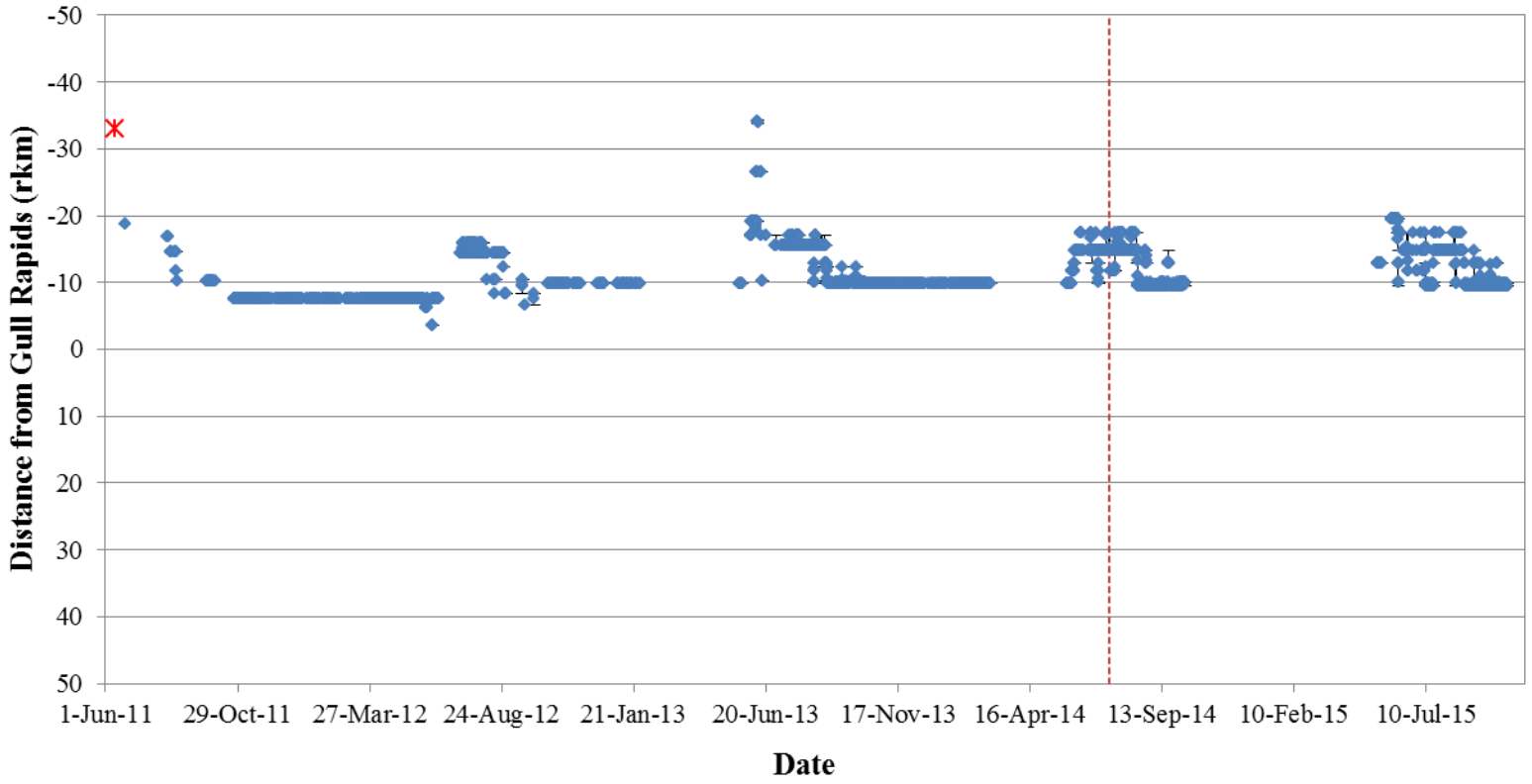


Figure A2-16: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16062) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

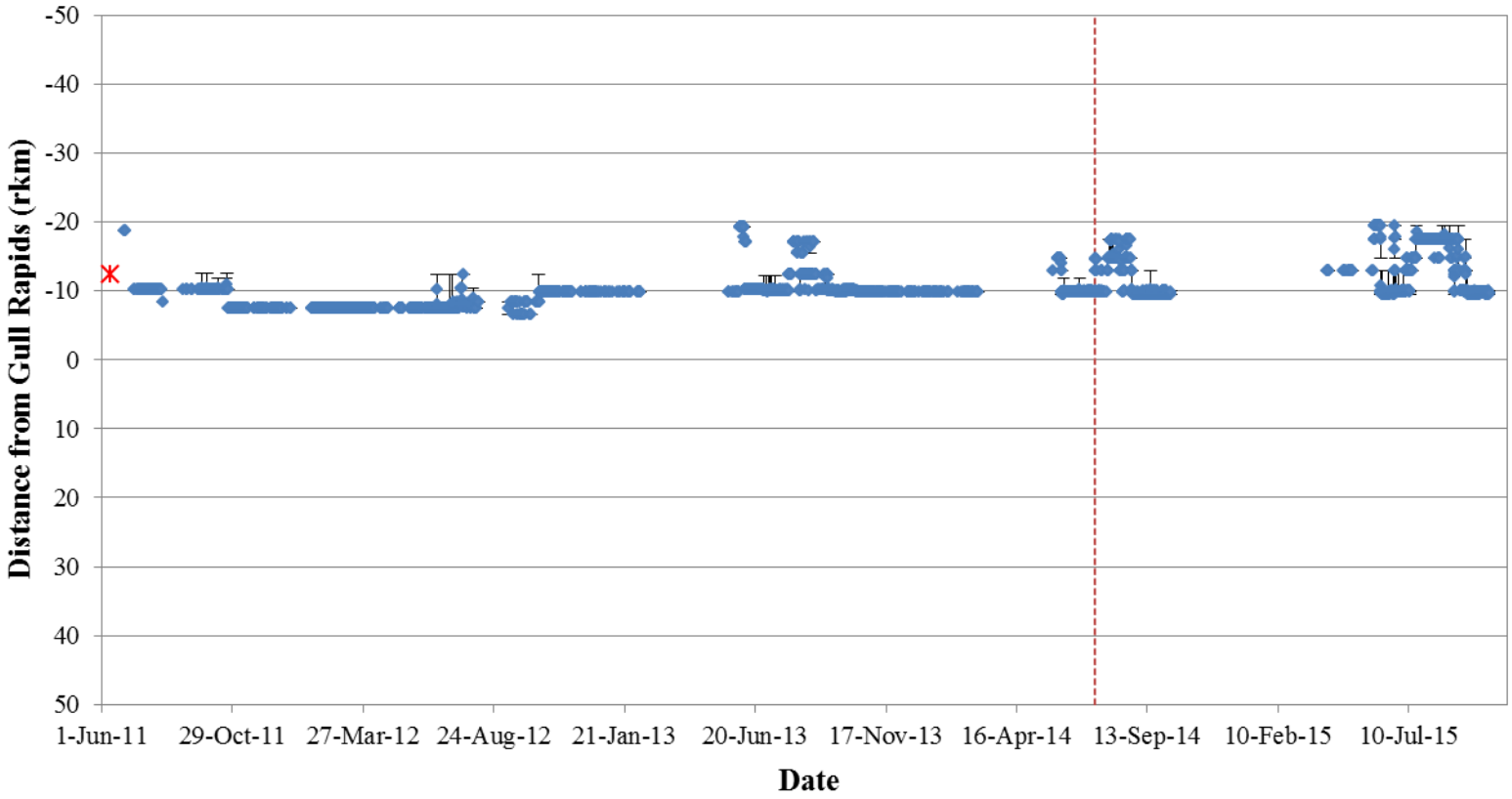


Figure A2-17: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16063) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

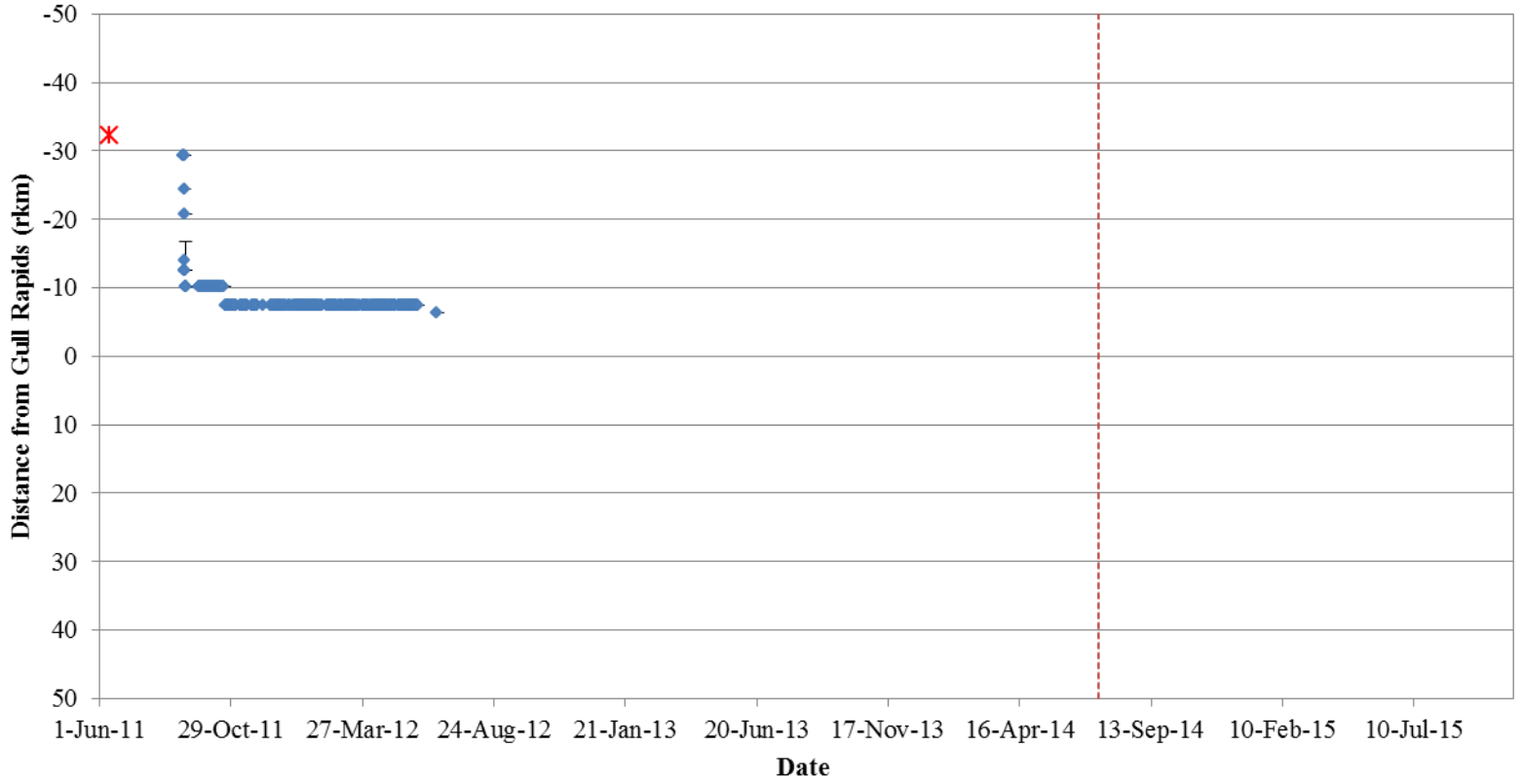


Figure A2-18: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16064) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

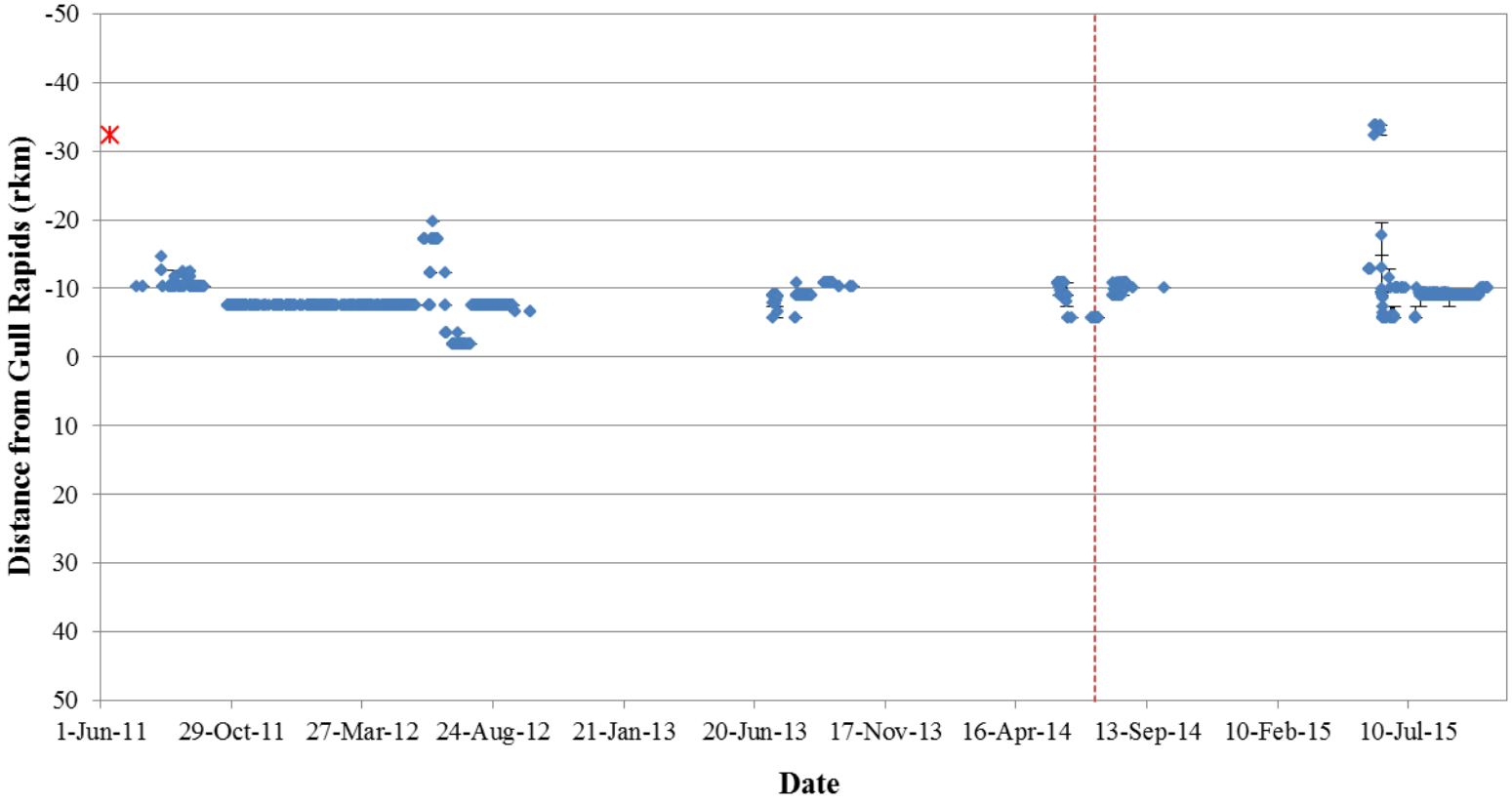


Figure A2-19: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16065) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

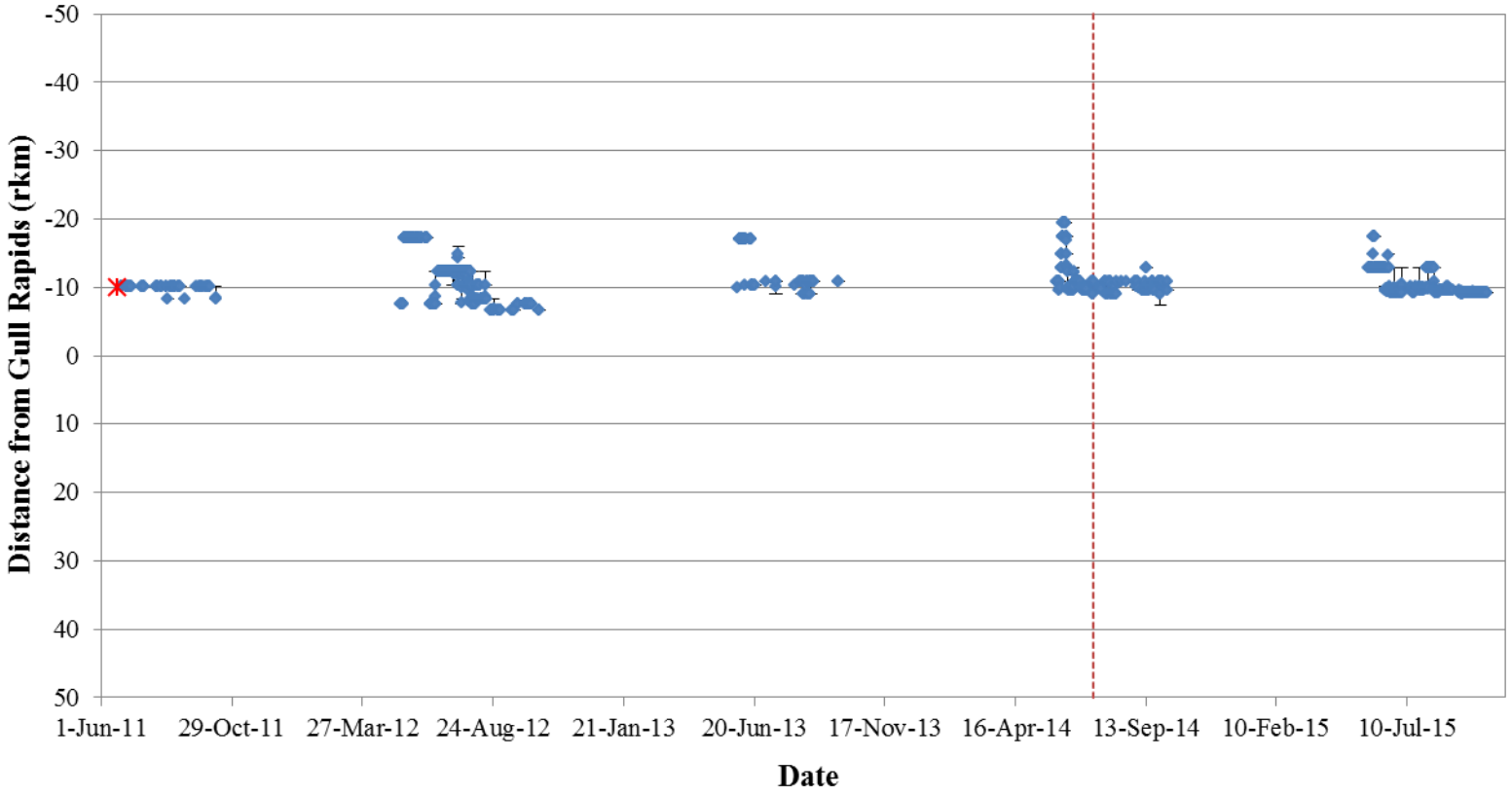


Figure A2-20: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16066) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

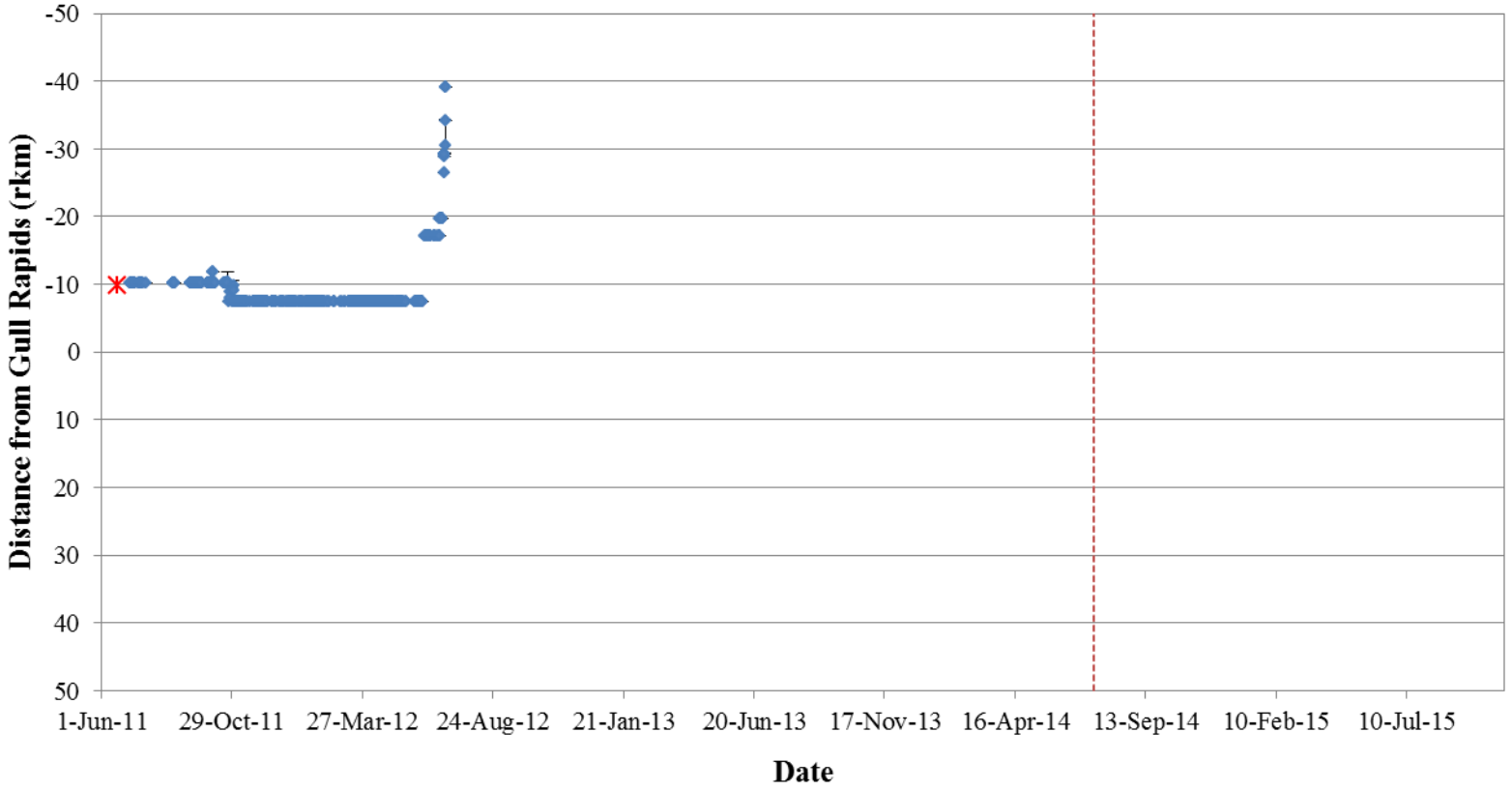


Figure A2-21: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16067) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

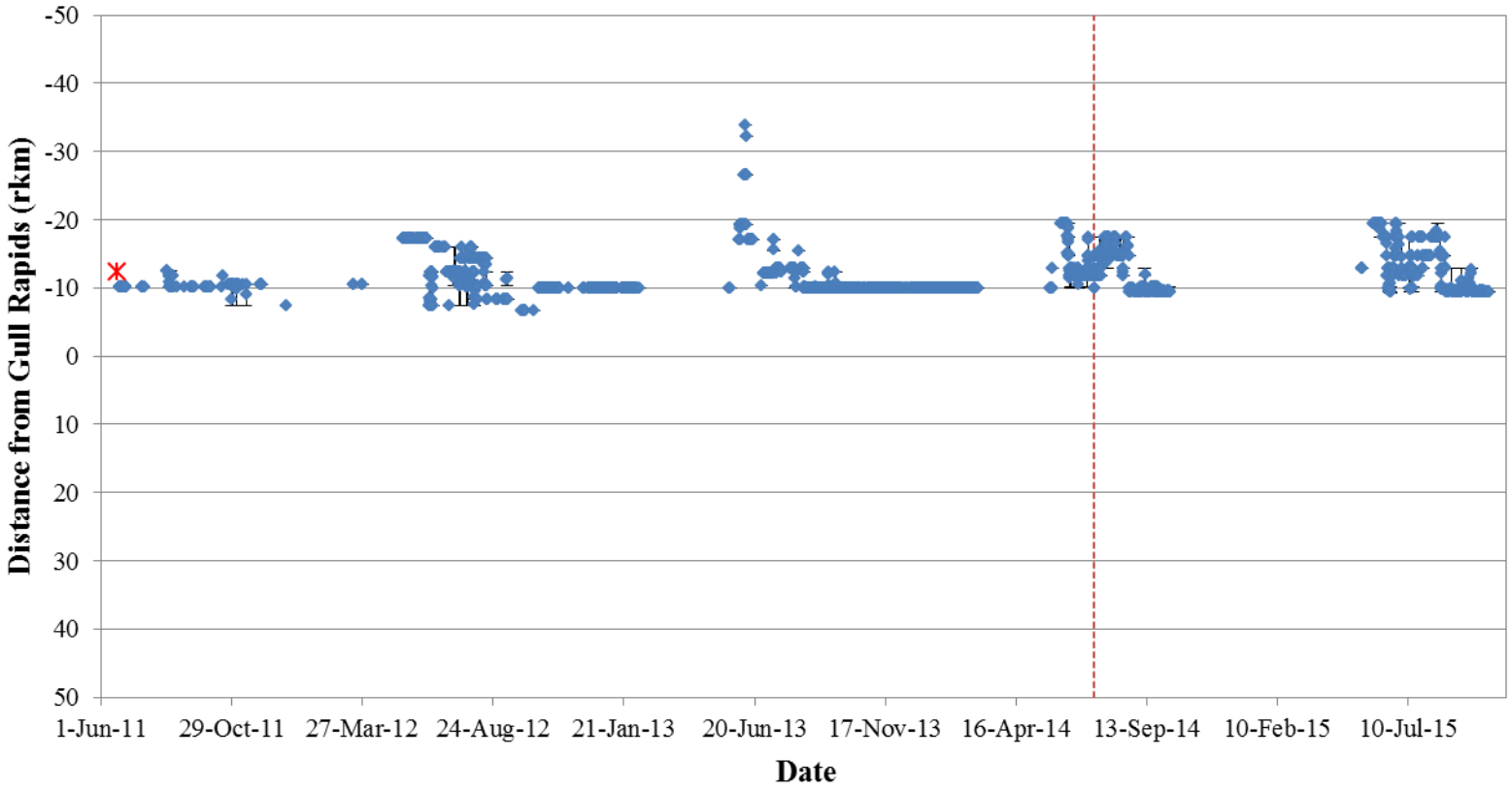


Figure A2-22: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16068) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

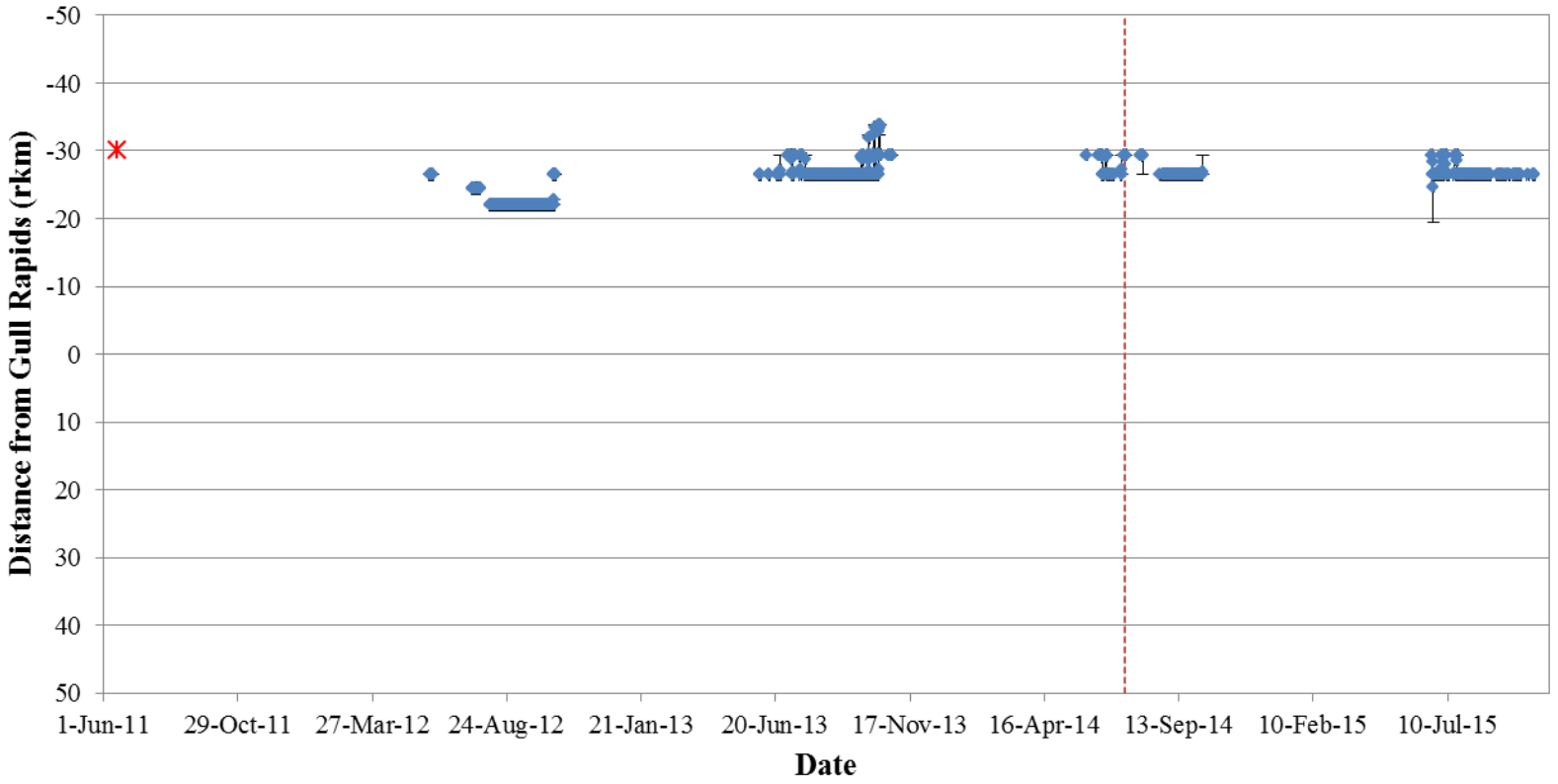


Figure A2-23: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16069) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

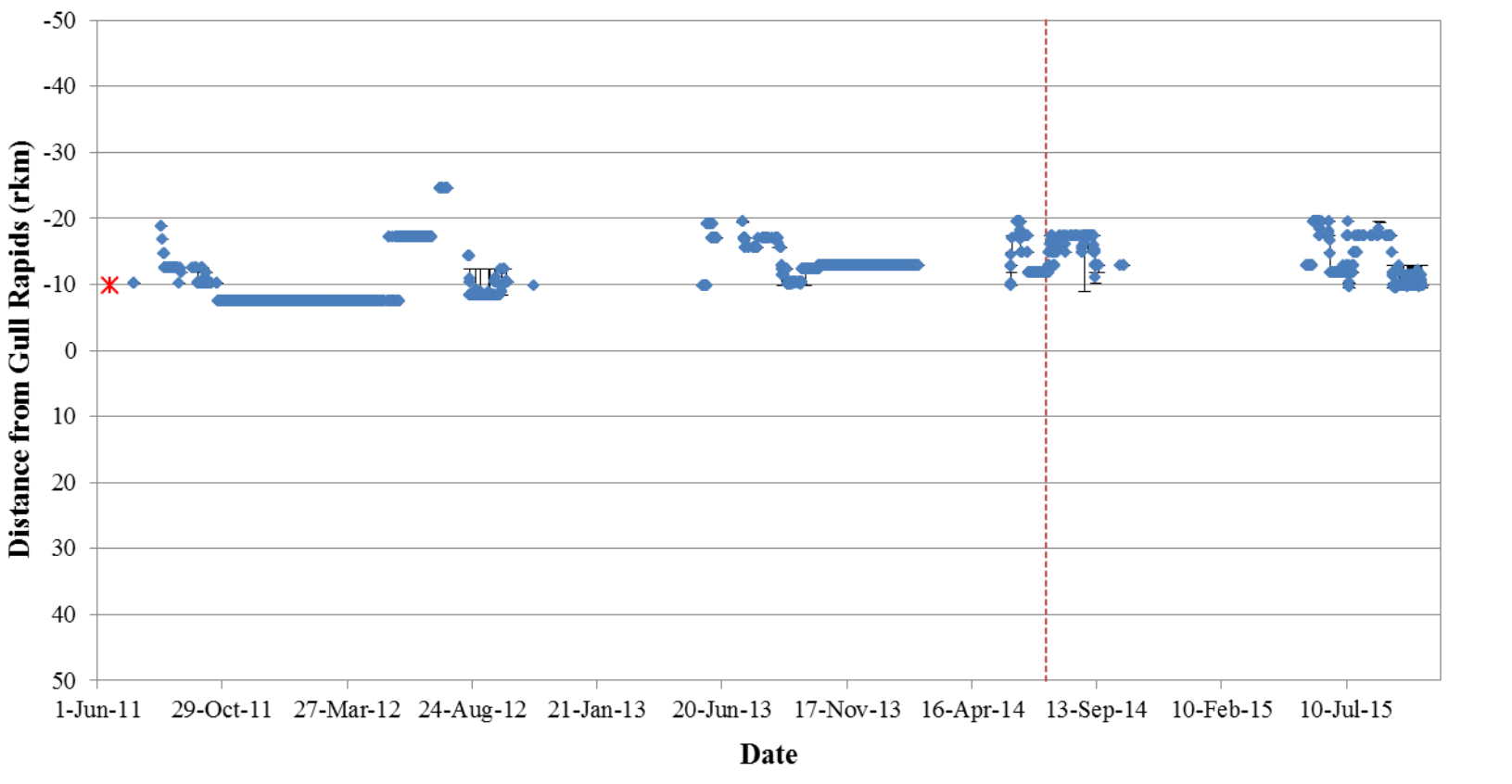


Figure A2-24: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16070) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

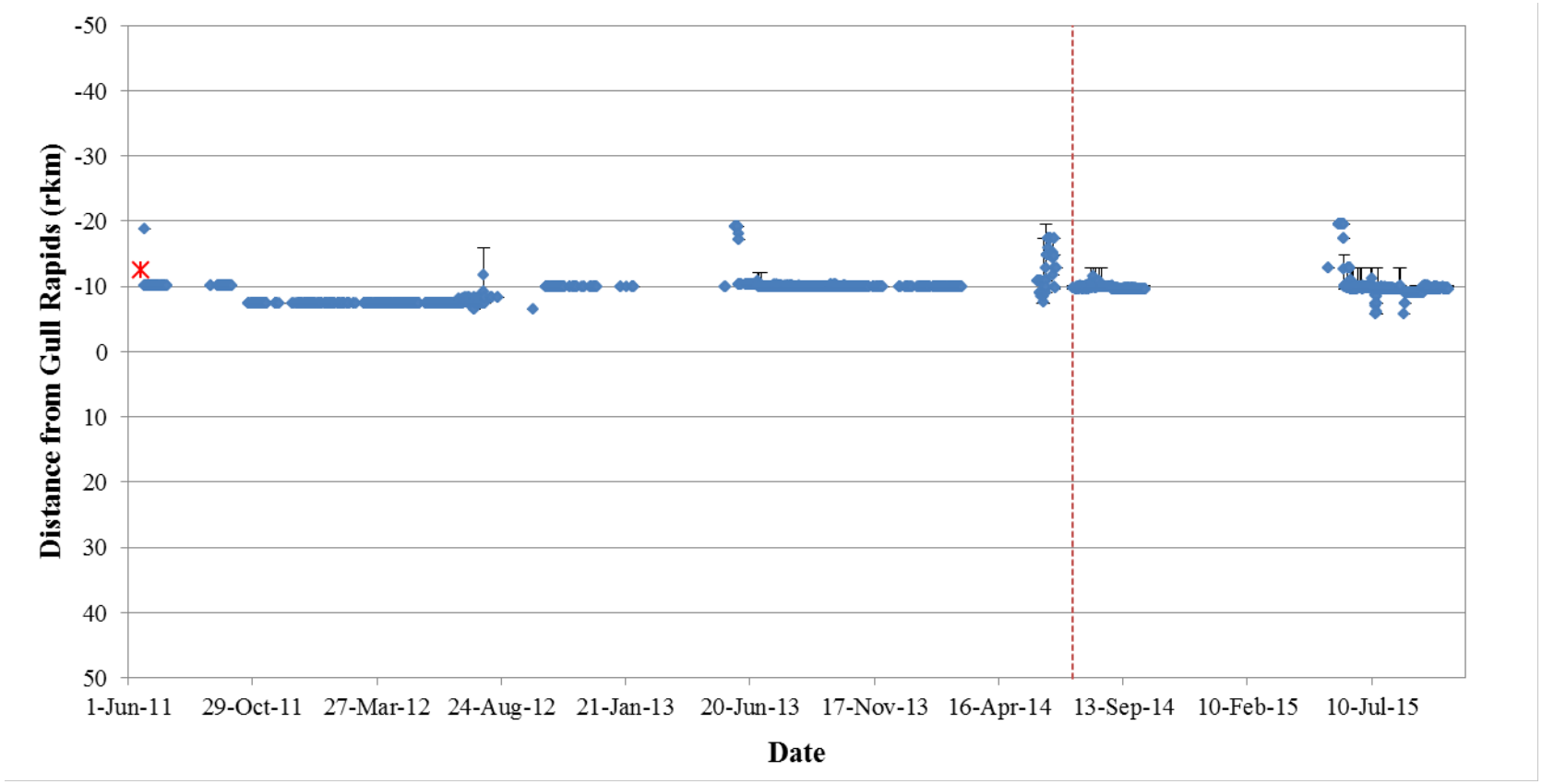


Figure A2-25: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16071) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

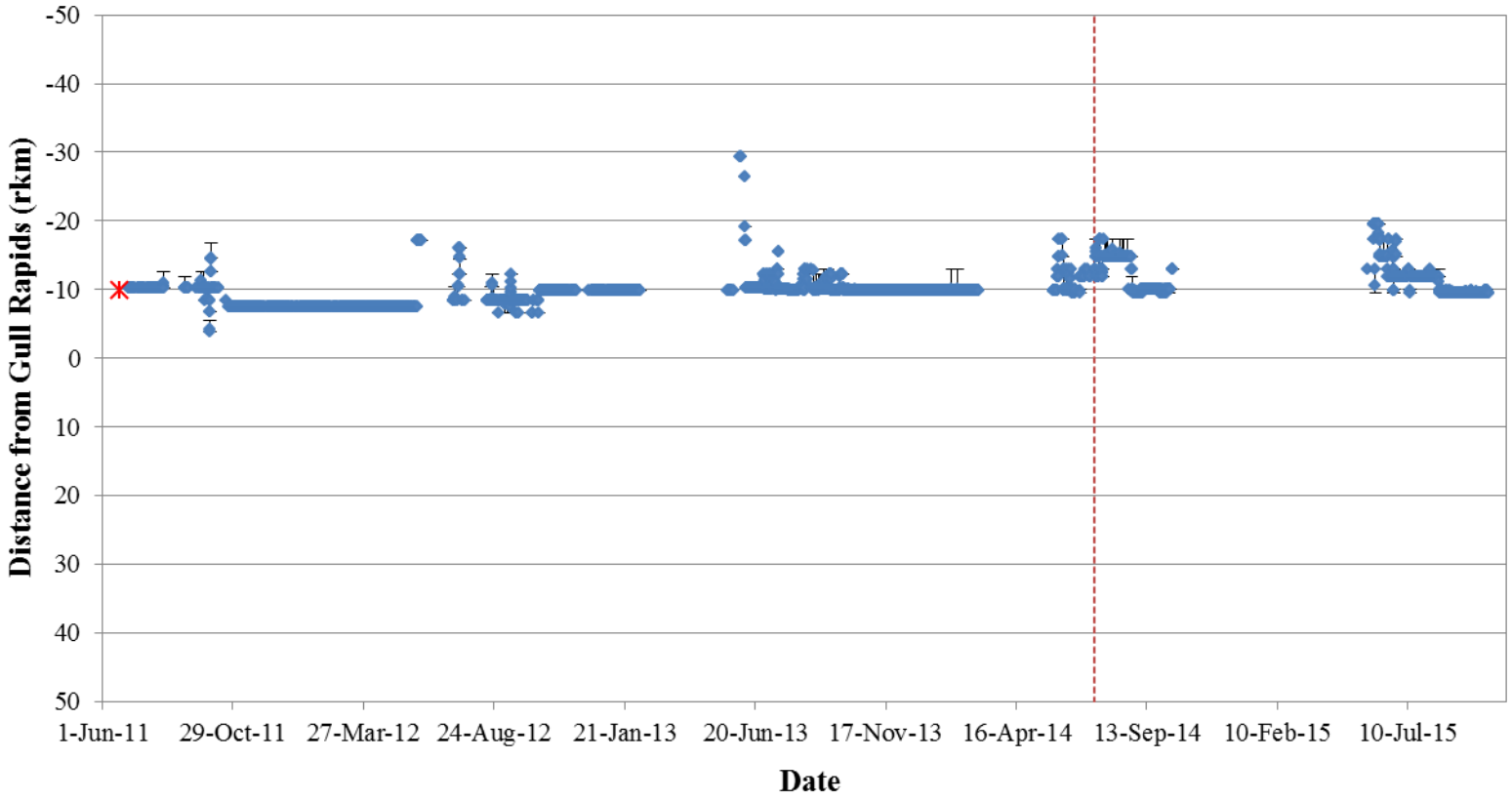


Figure A2-26: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16072) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

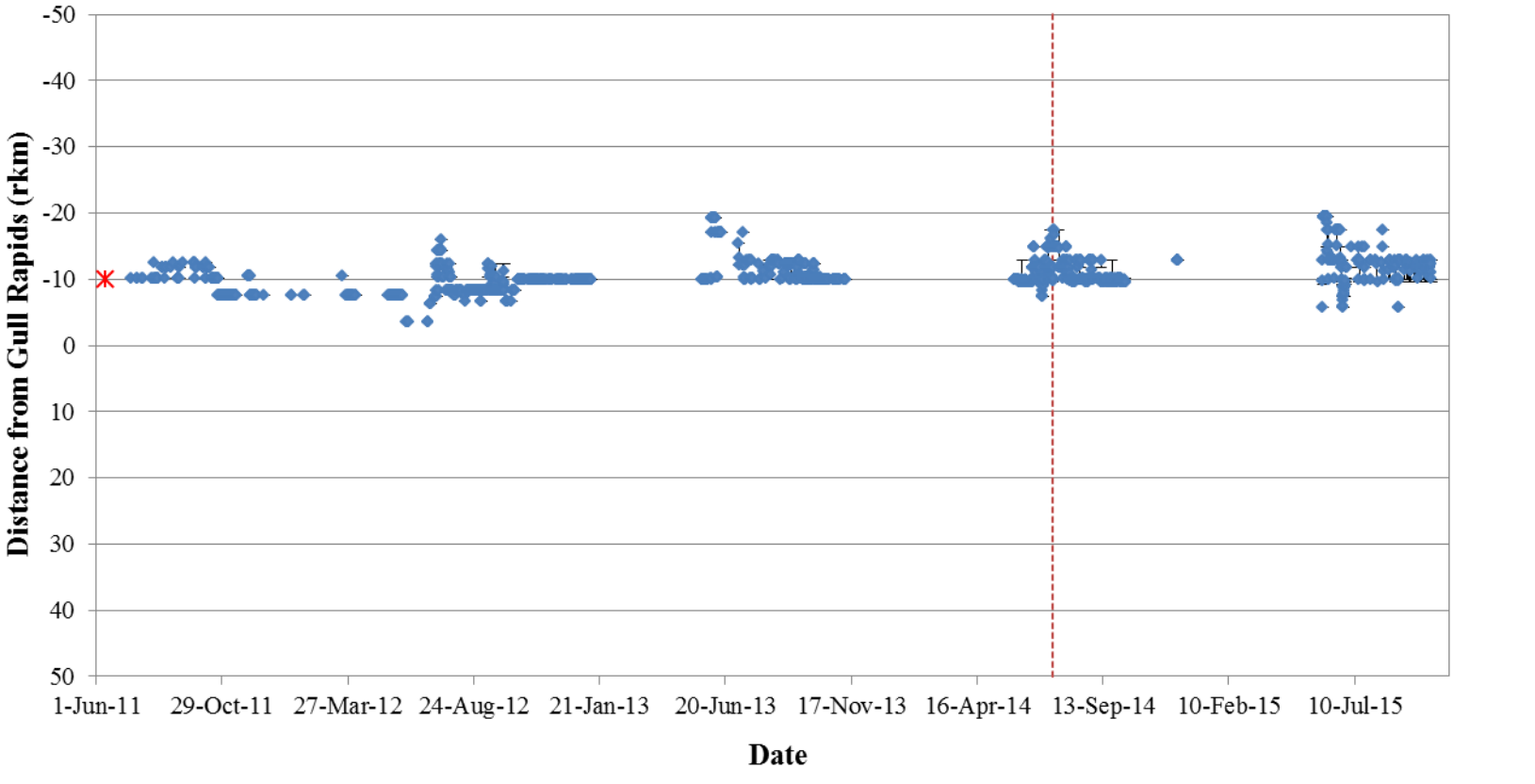


Figure A2-27: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16073) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

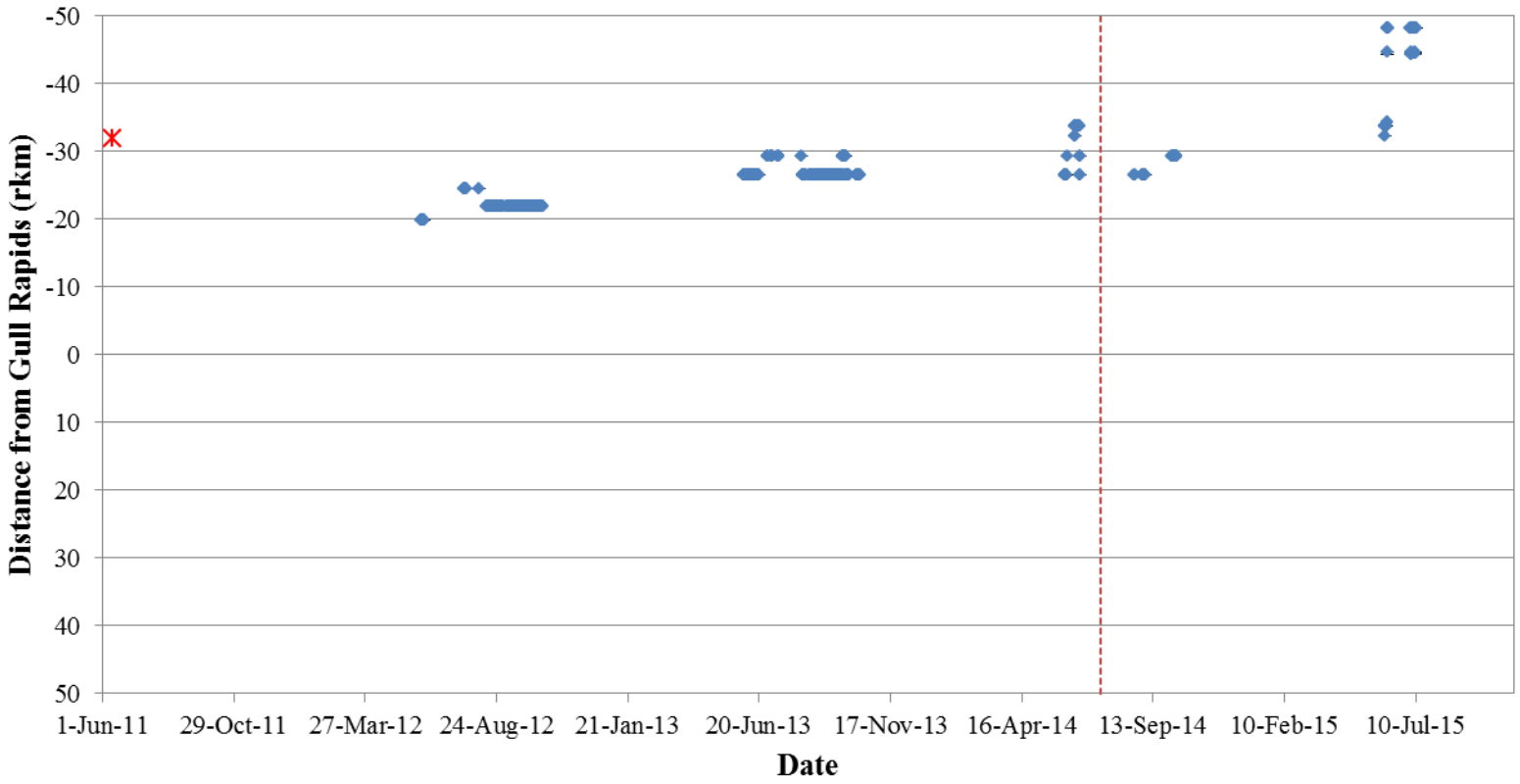


Figure A2-28: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16074) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

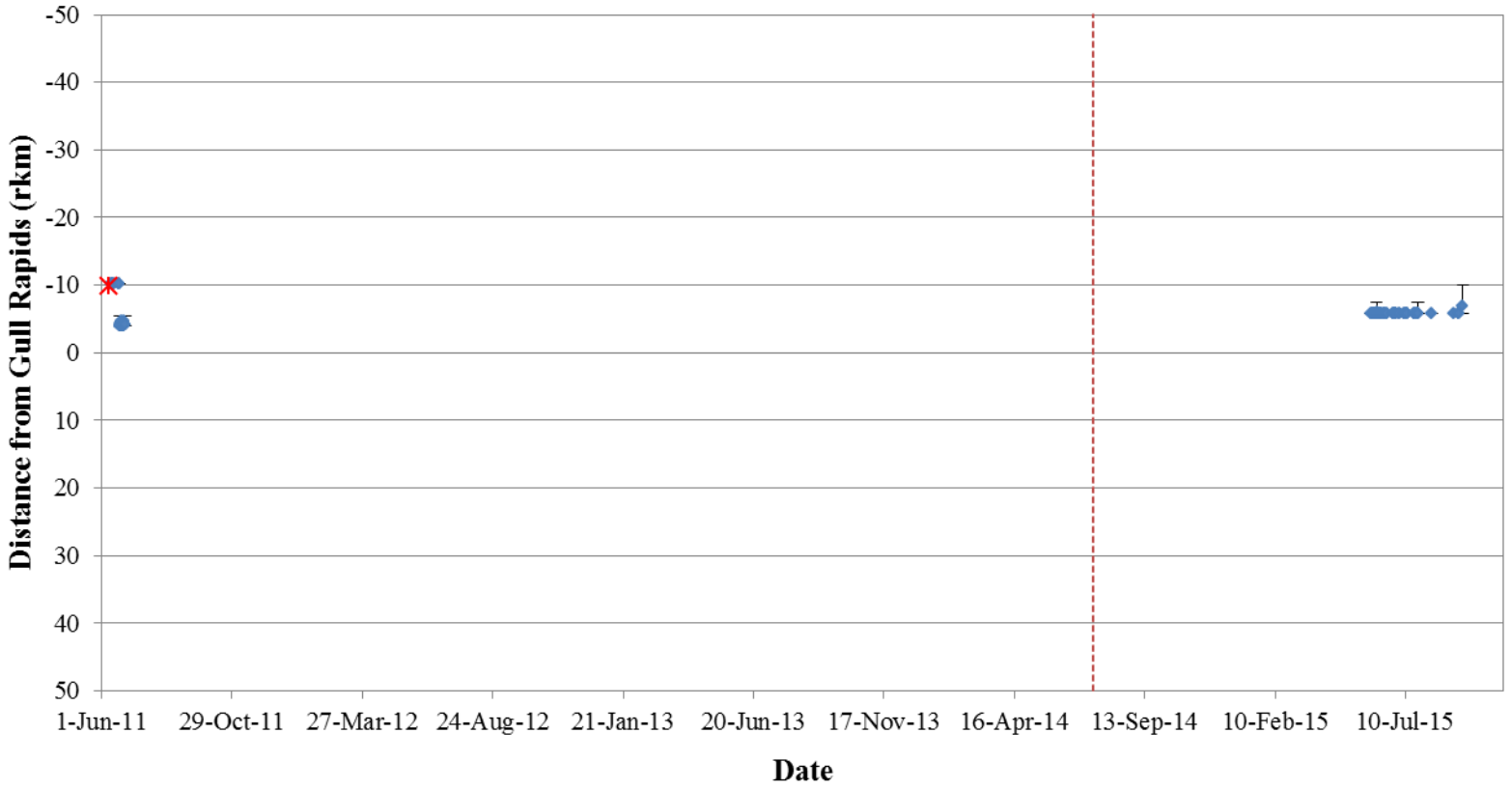


Figure A2-29: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16075) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

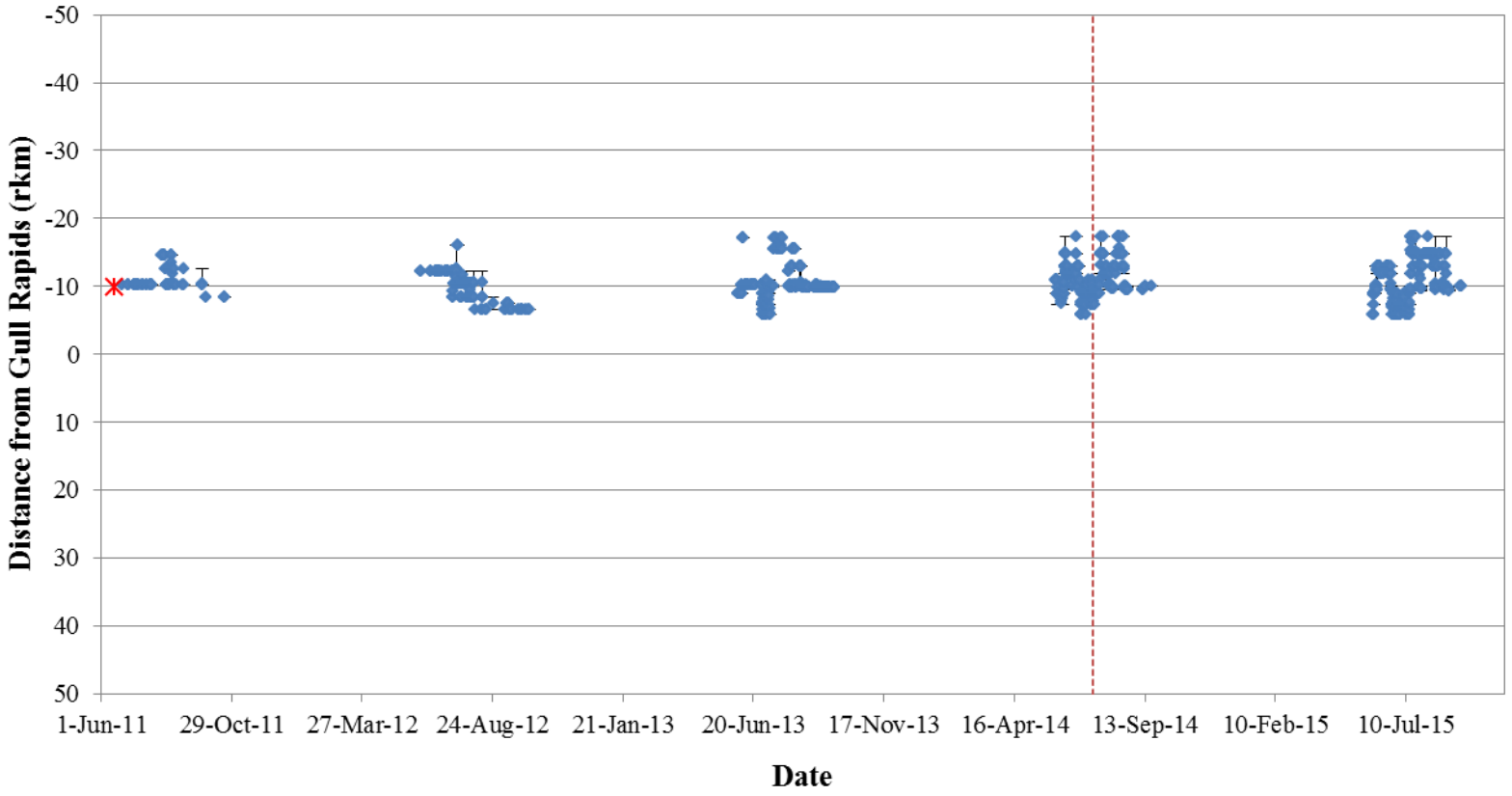


Figure A2-30: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16076) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

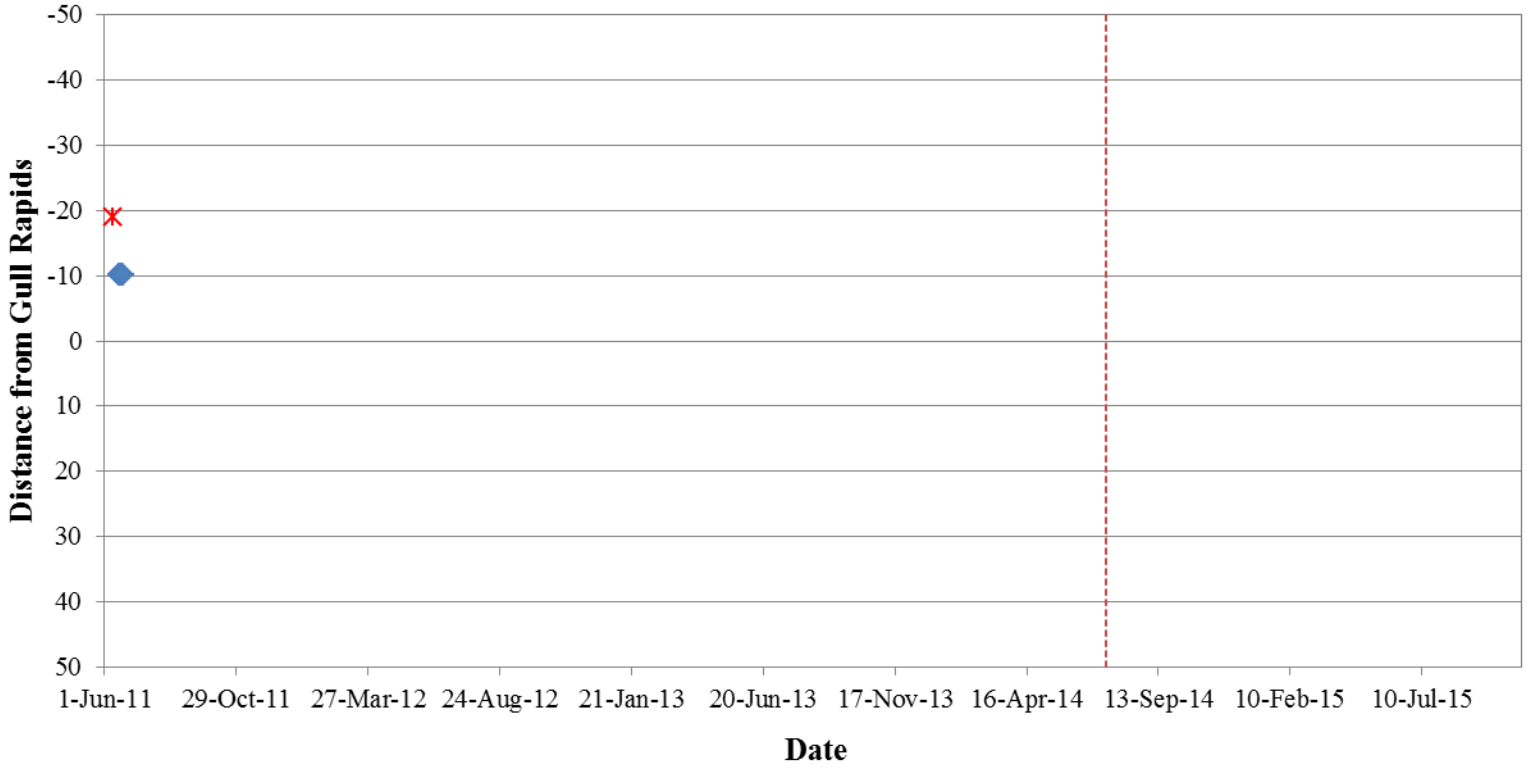


Figure A2-31: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16077) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

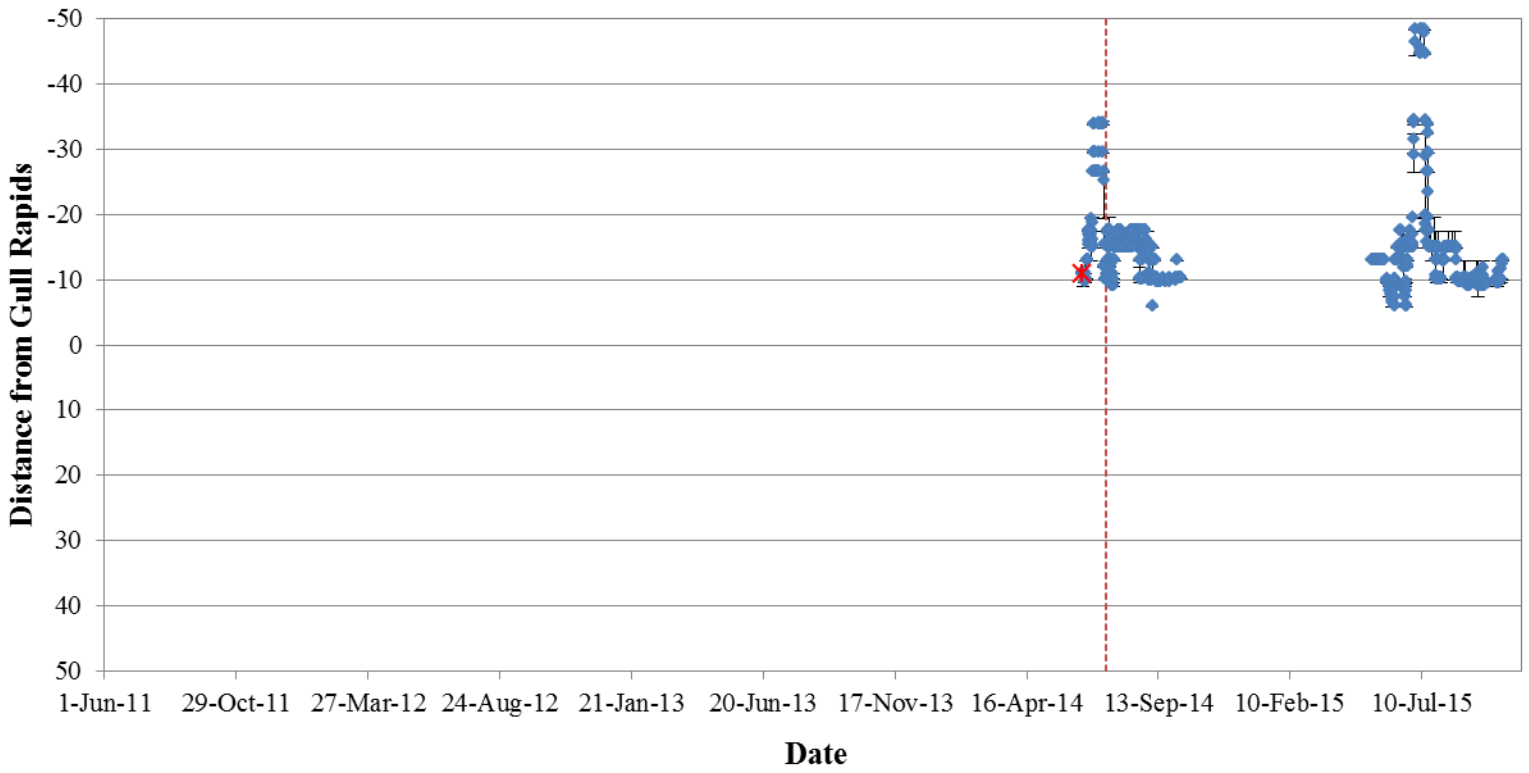


Figure A2-32: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32174) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 12 October, 2014. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

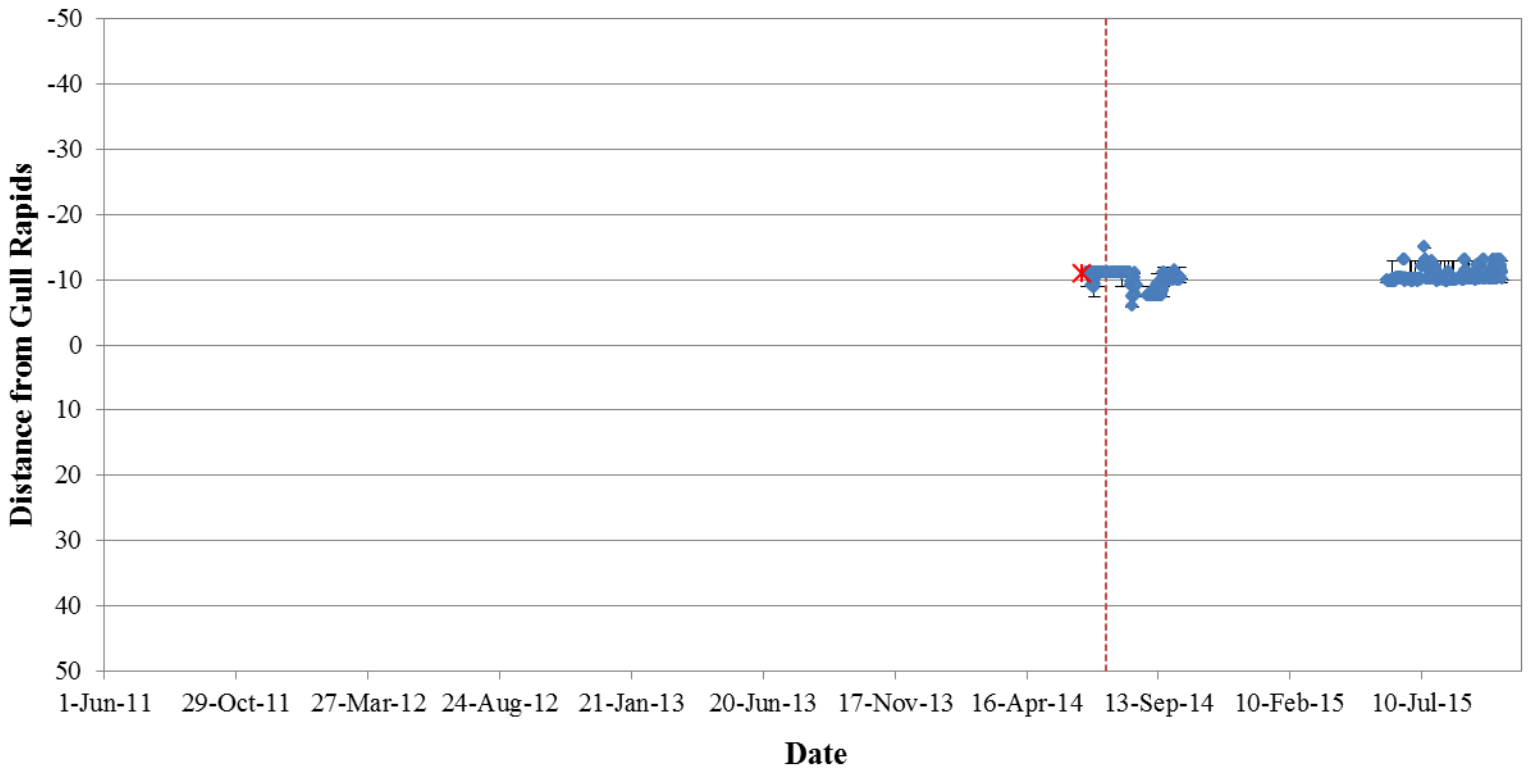


Figure A2-33: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32175) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

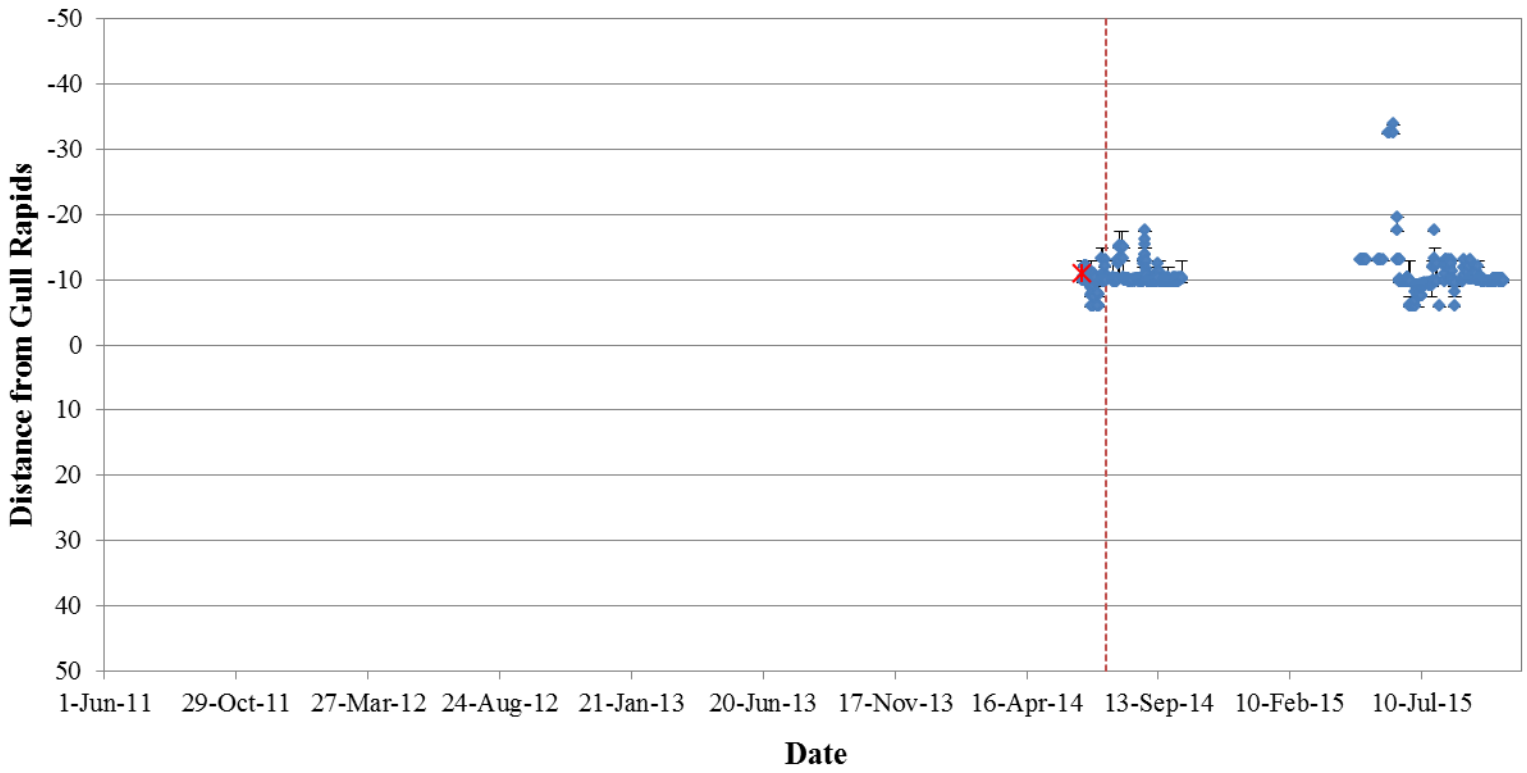


Figure A2-34: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32176) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

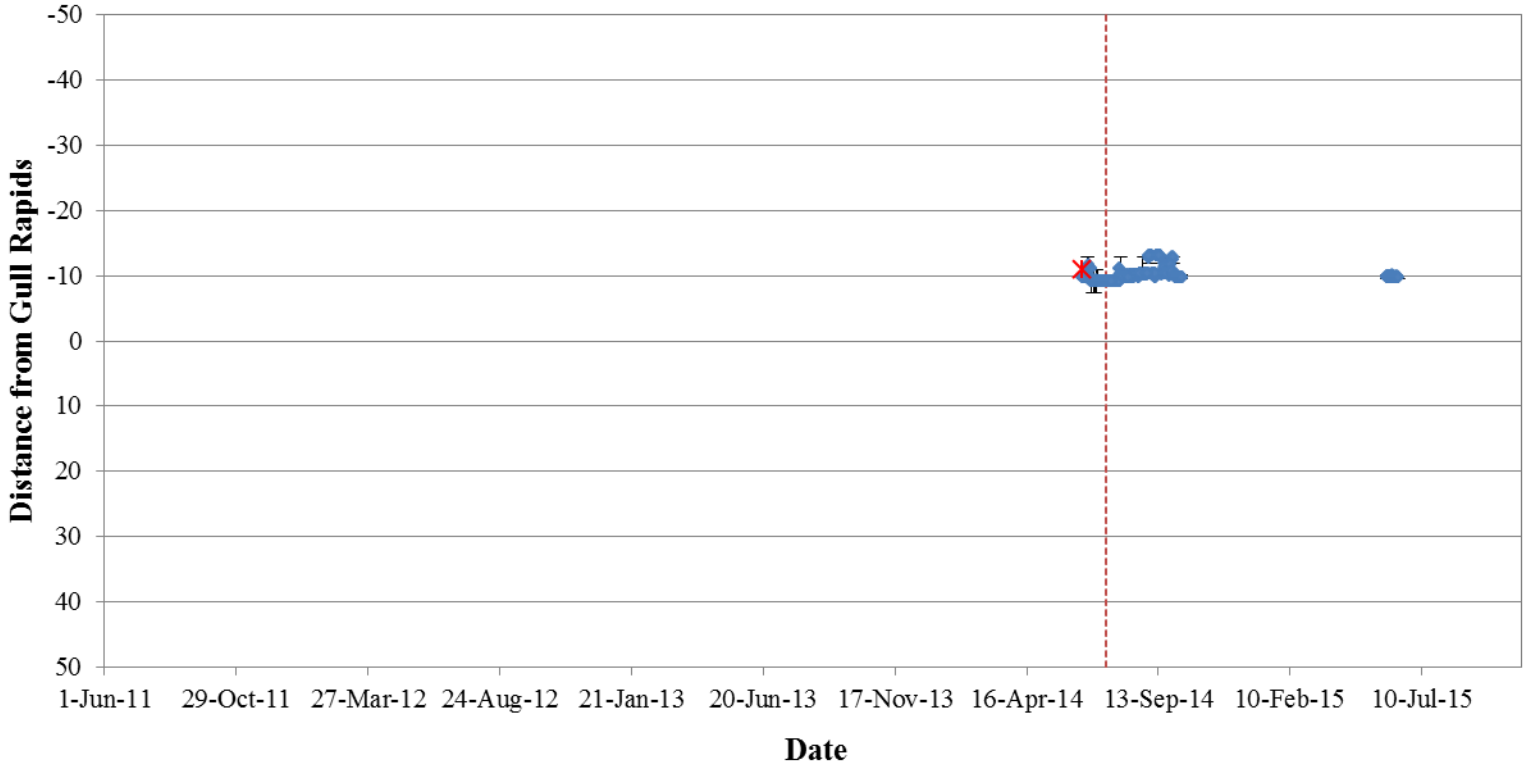


Figure A2-35: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32177) in the Nelson River between Clark Lake and Gull Rapids in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

APPENDIX 3:
LOCATION SUMMARY FOR INDIVIDUAL ACOUSTIC TAGGED ADULT LAKE STURGEON DOWNSTREAM OF GULL RAPIDS, JUNE 2011 TO OCTOBER 2015

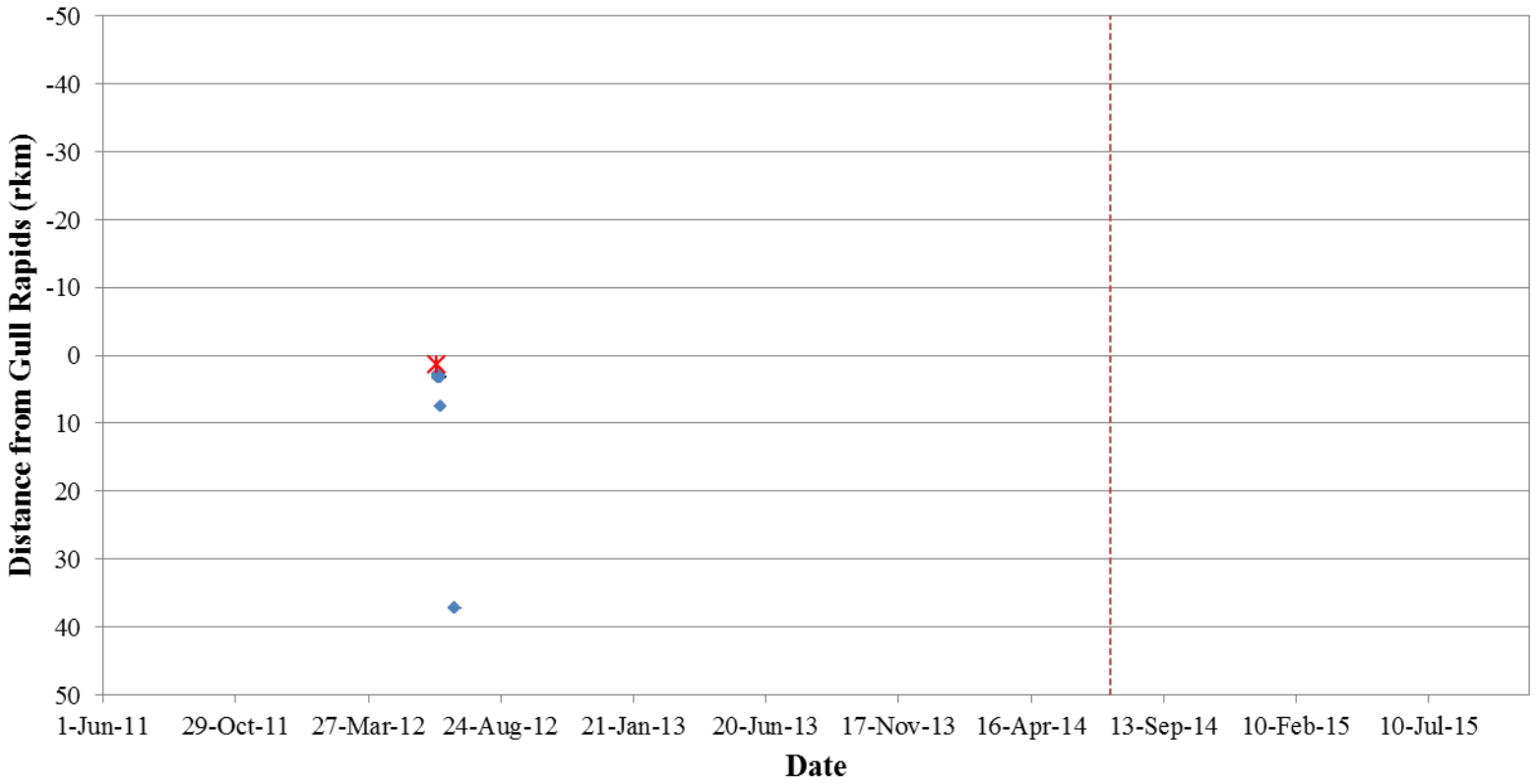


Figure A3-1: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16018) in Stephens Lake in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

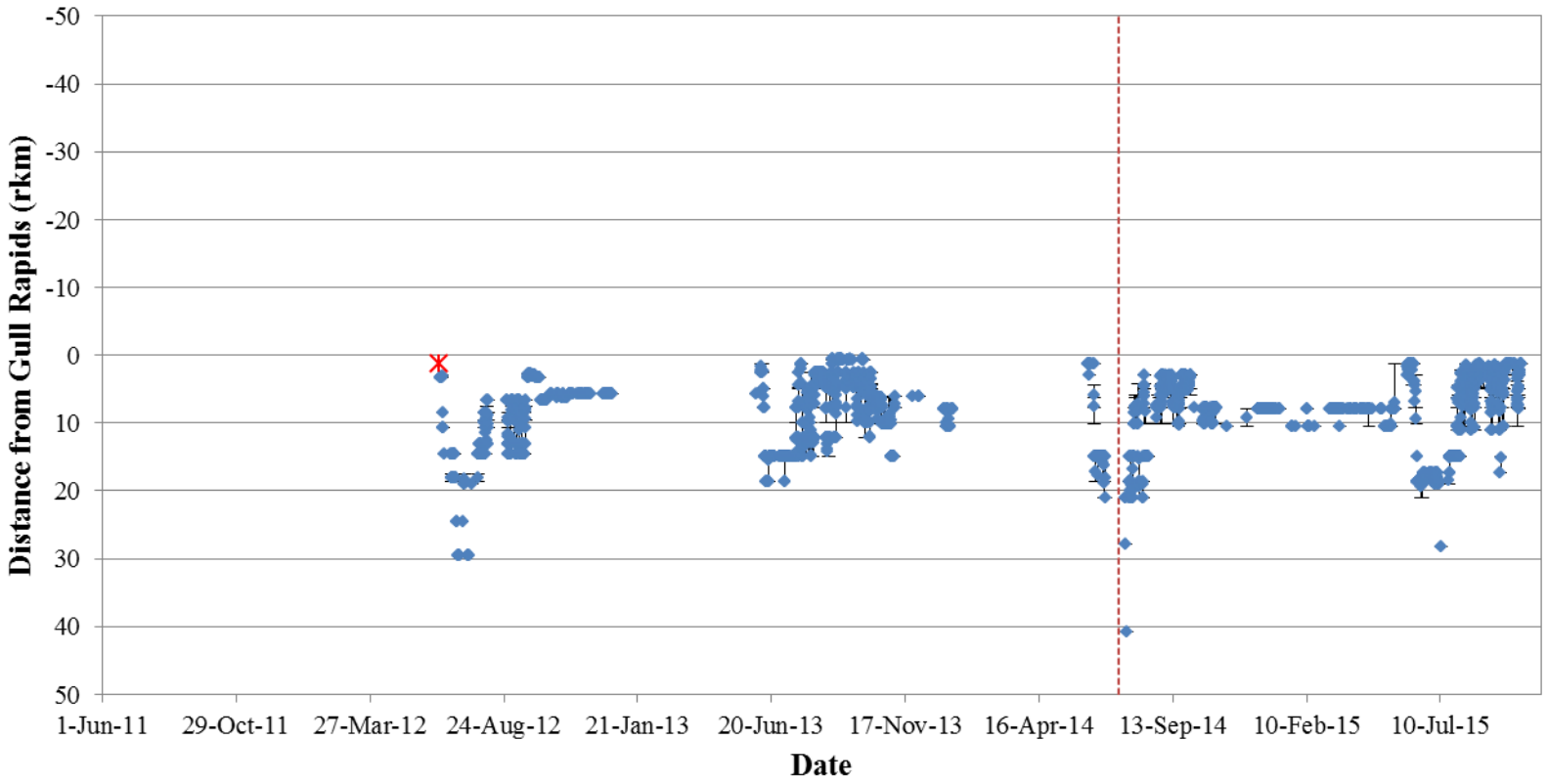


Figure A3-2: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16019) in Stephens Lake in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

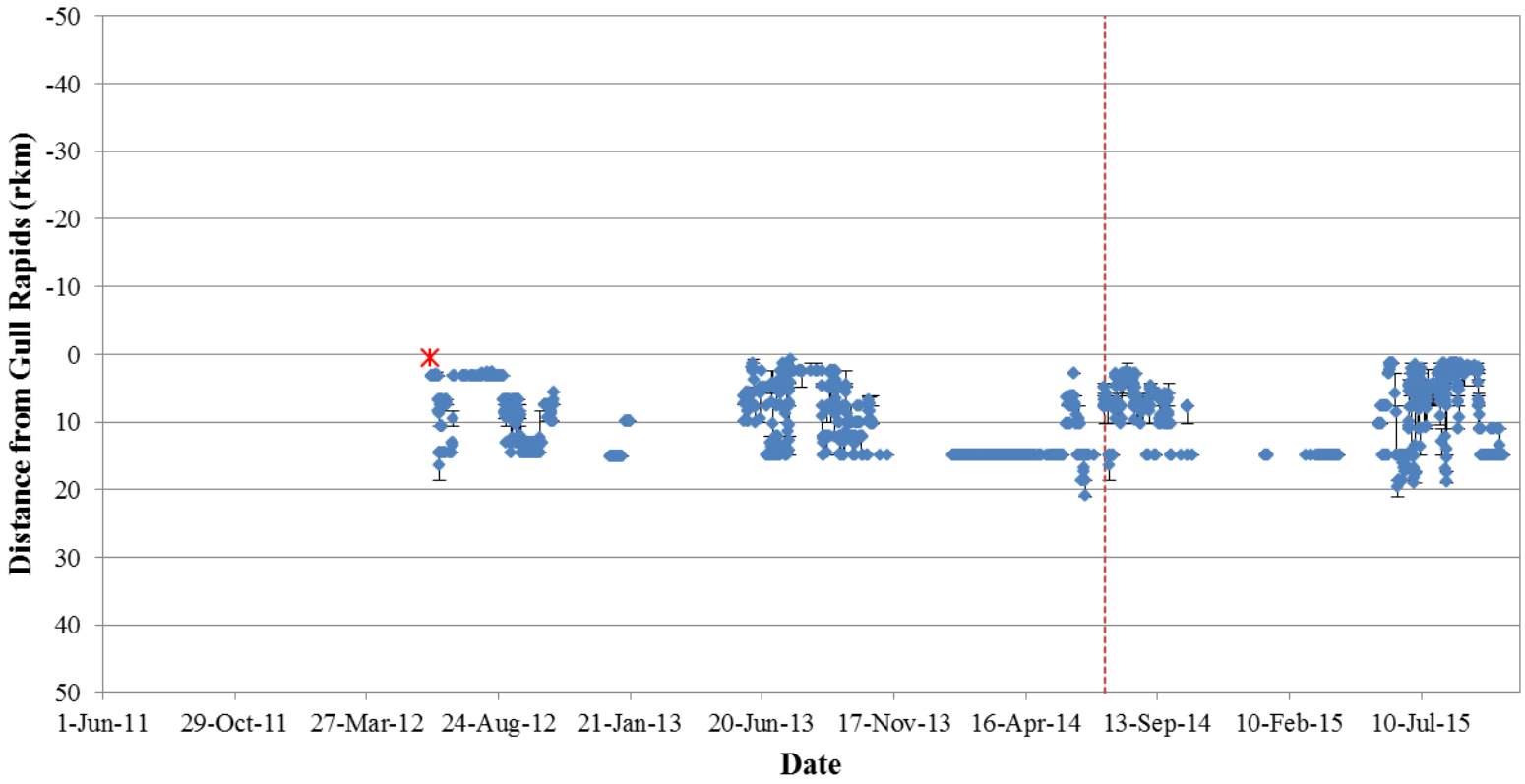


Figure A3-3: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16020) in Stephens Lake in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

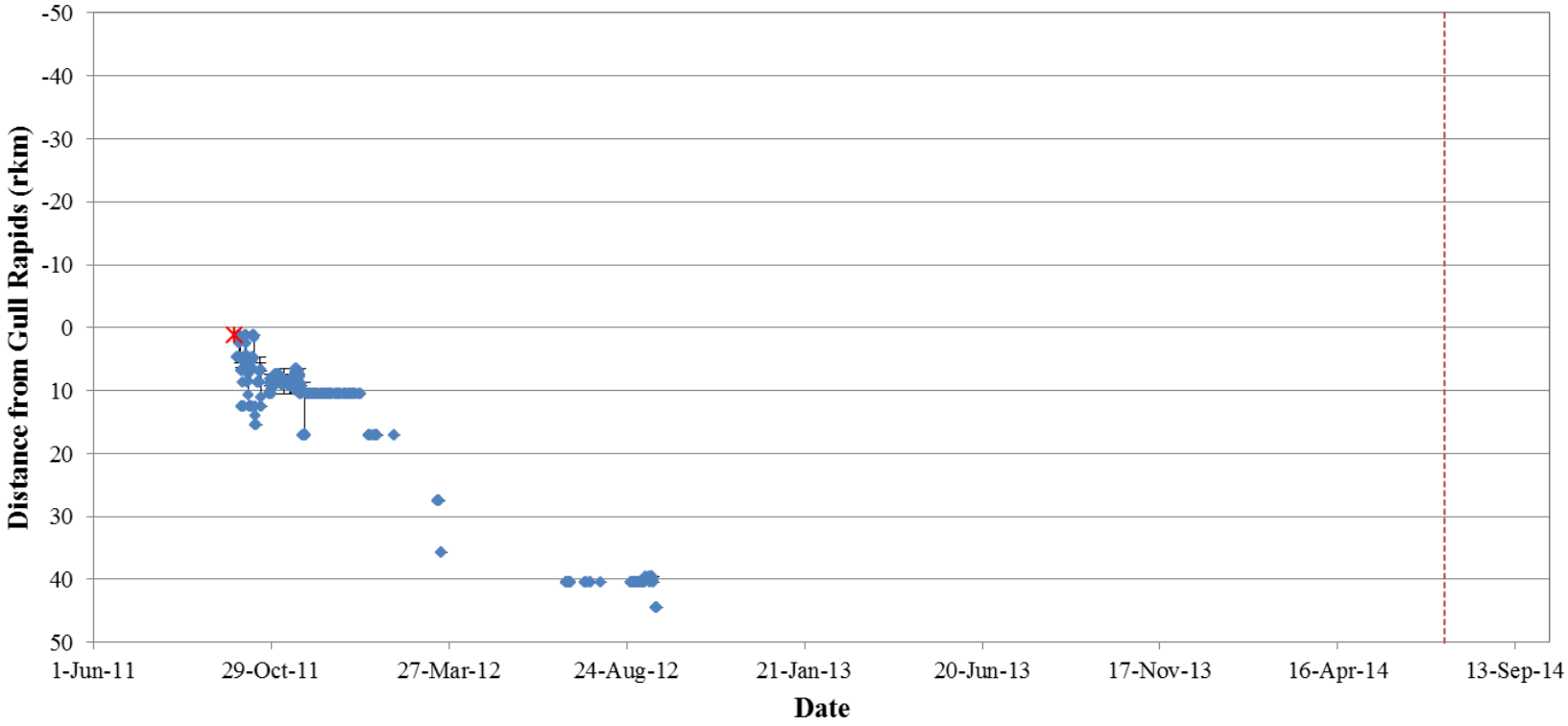


Figure A3-4: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16021) in Stephens Lake in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

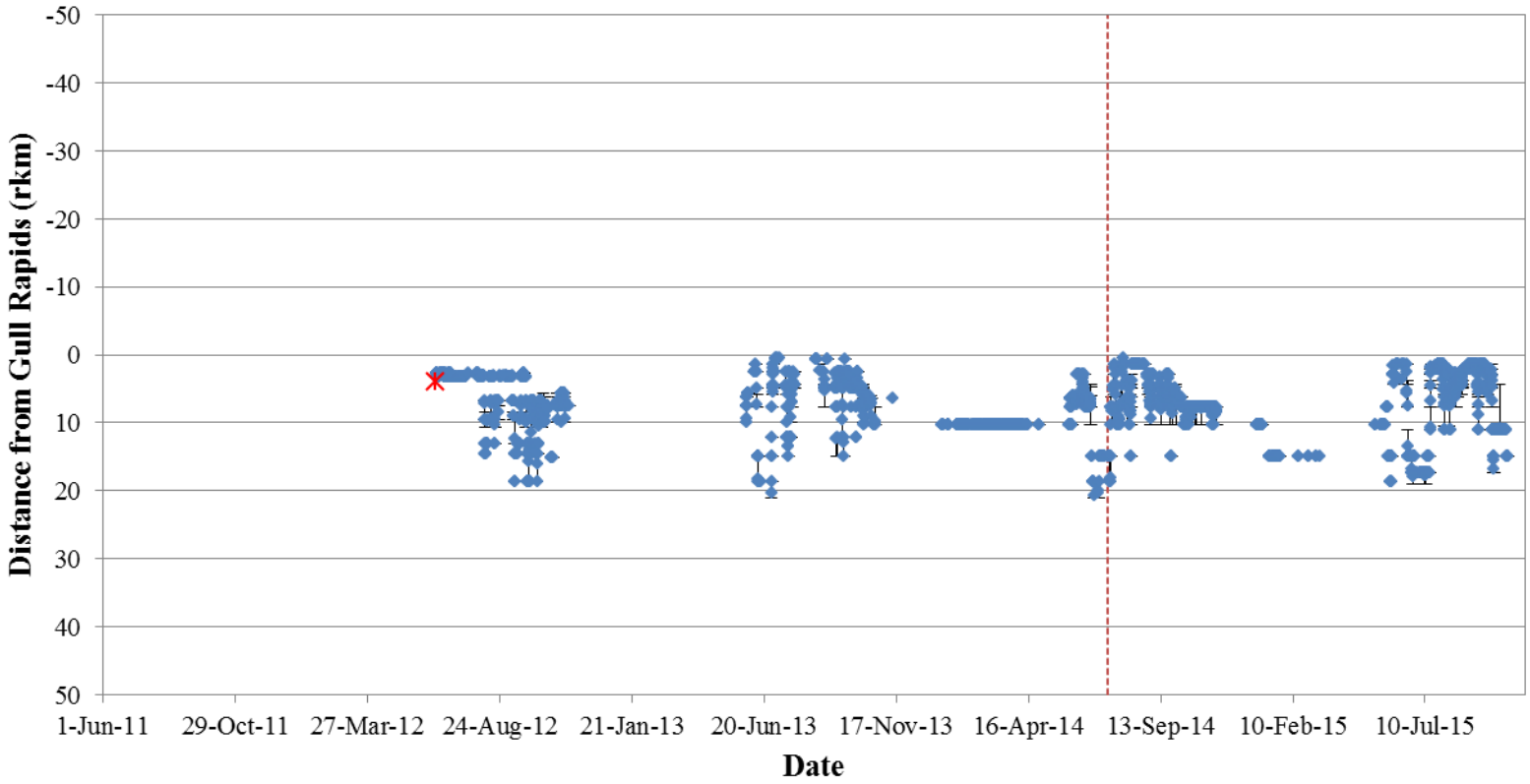


Figure A3-5: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16022) in Stephens Lake in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

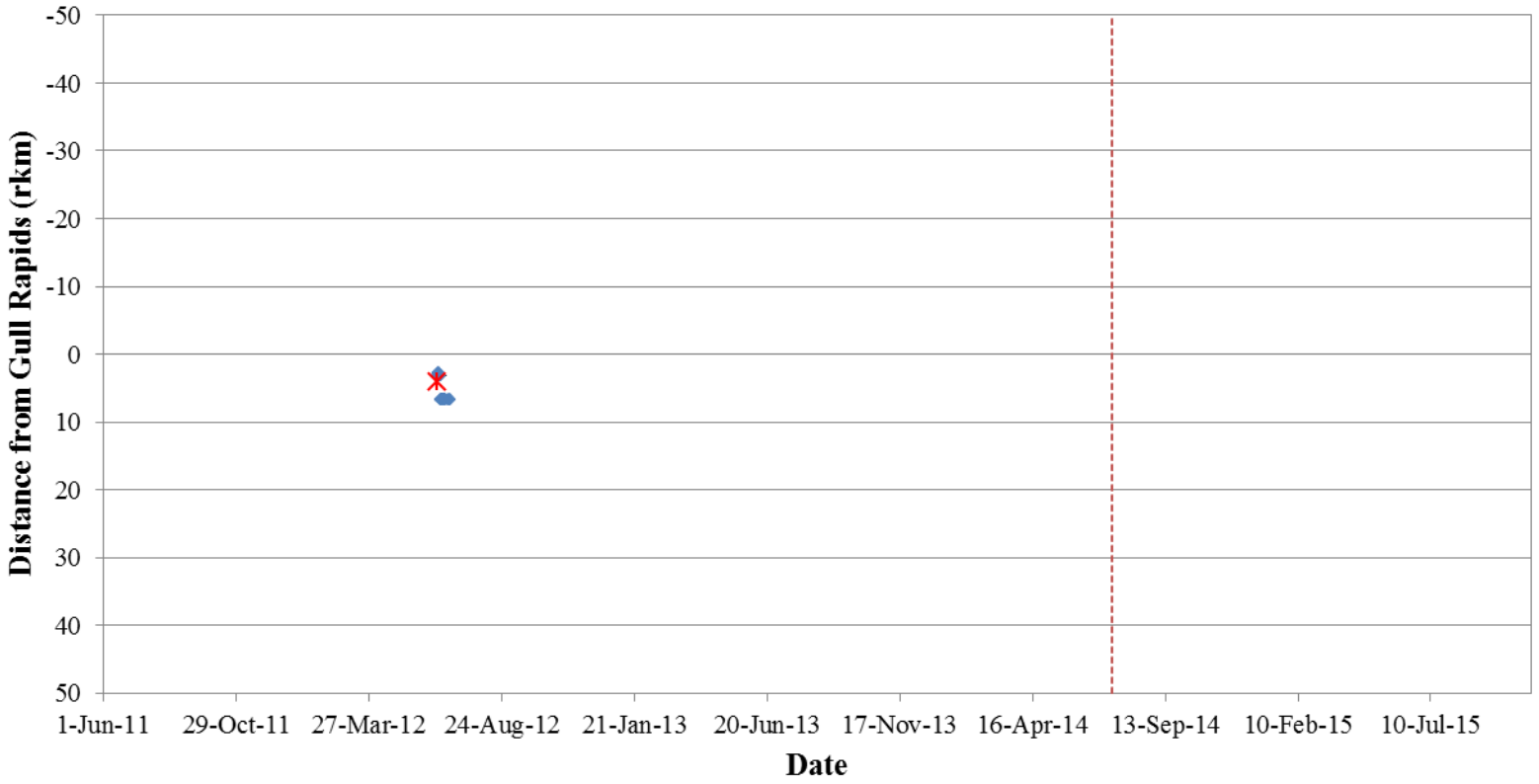


Figure A3-6: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16024) in Stephens Lake in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

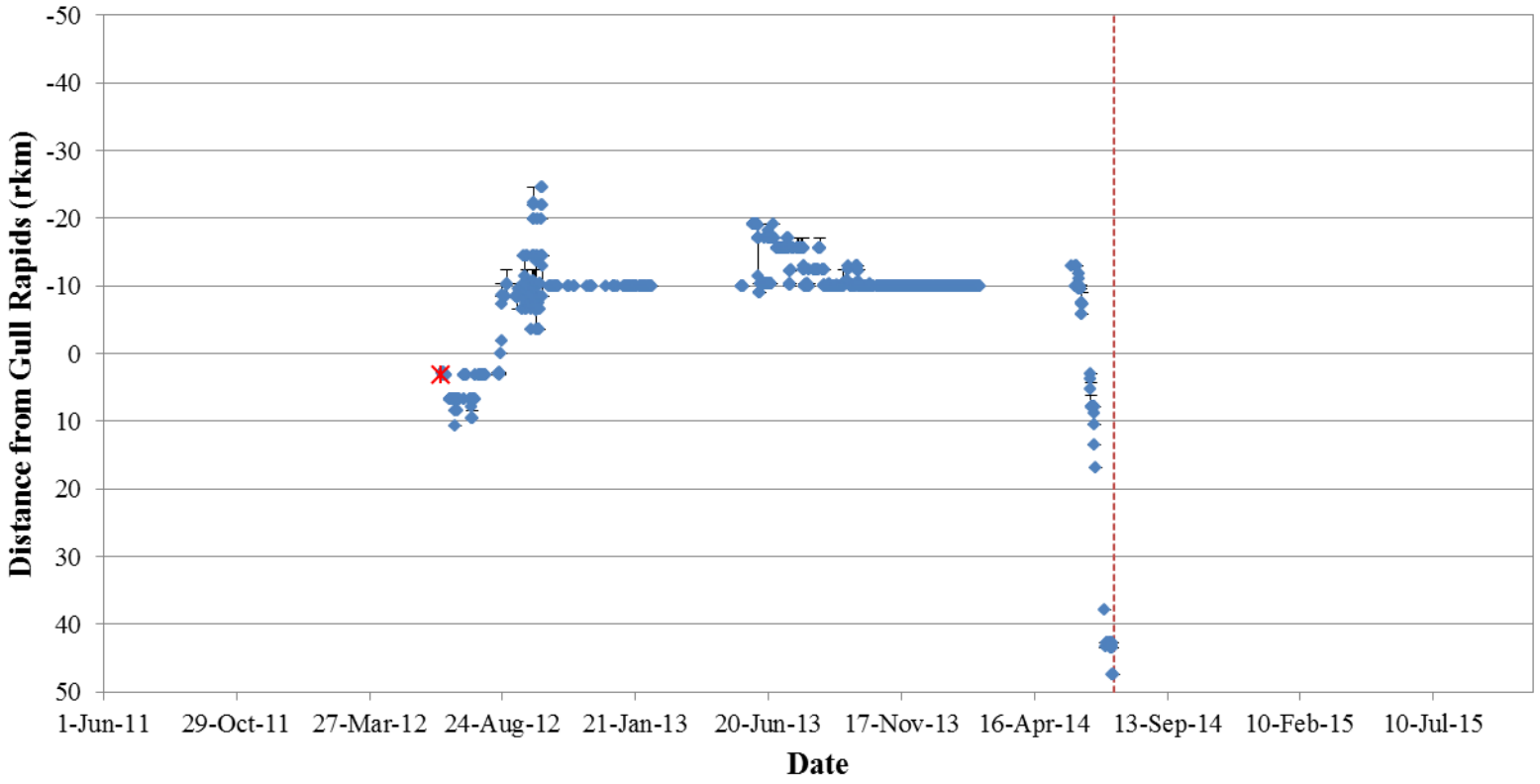


Figure A3-7: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16025) in Stephens Lake in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

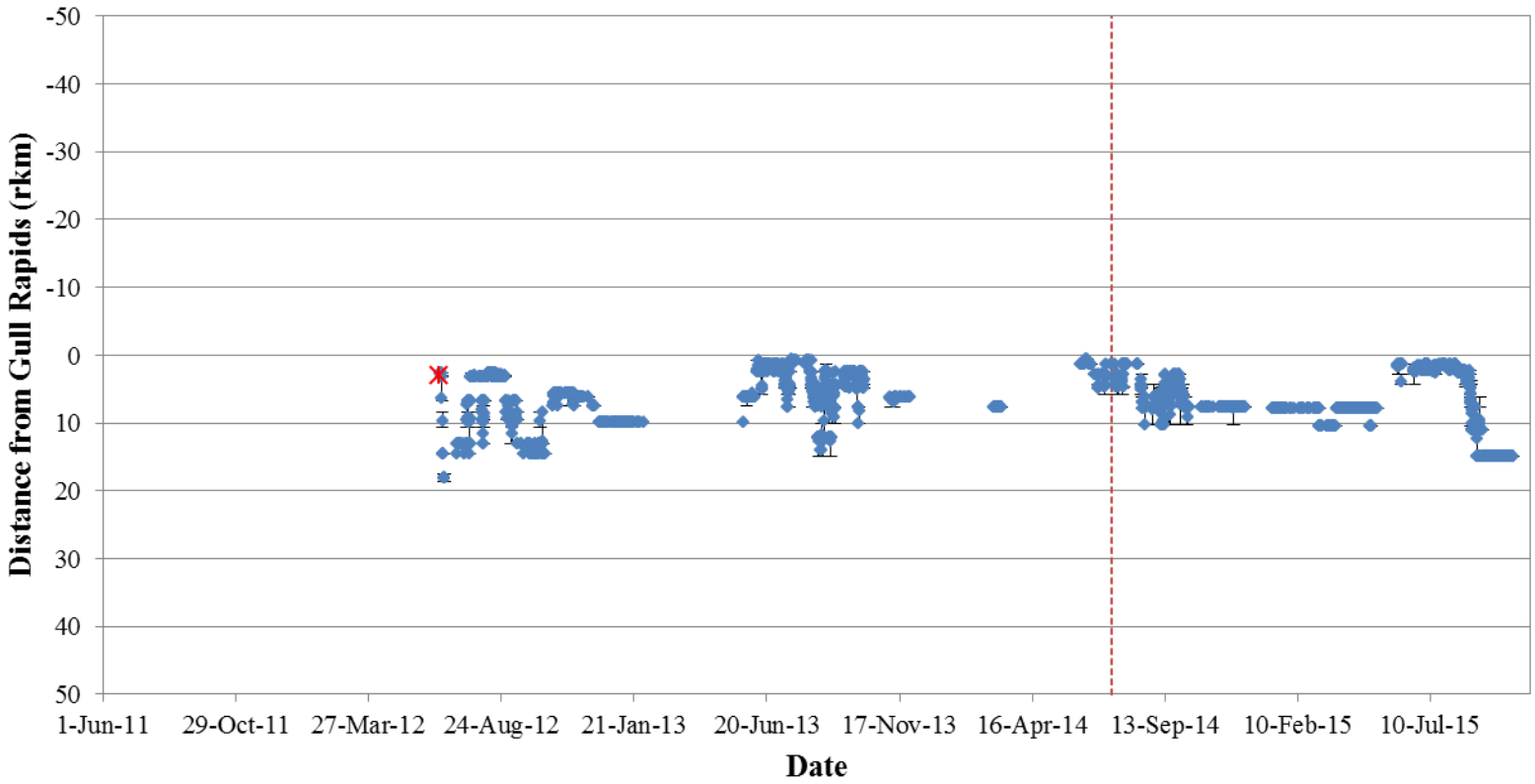


Figure A3-8: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16027) in Stephens Lake in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

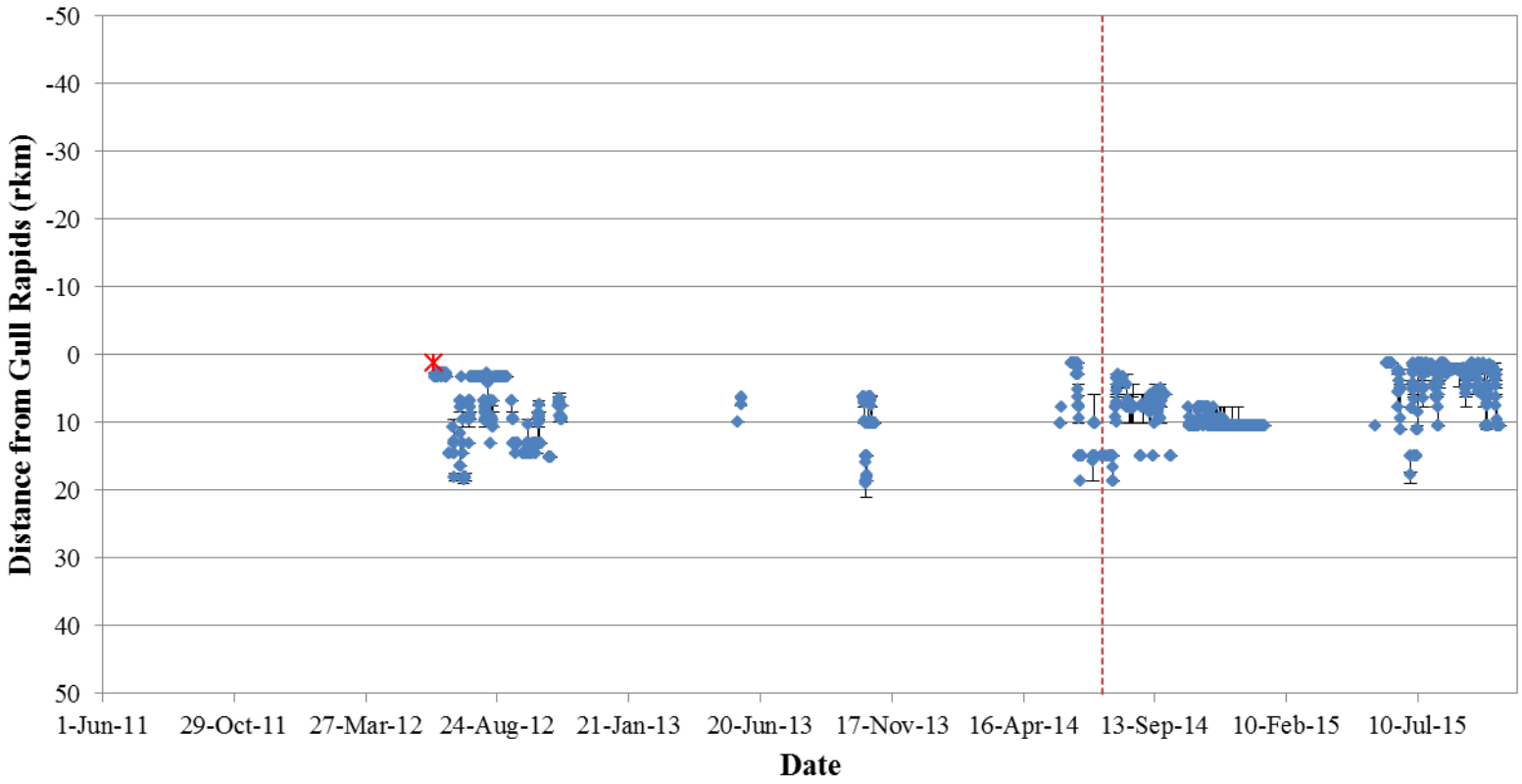


Figure A3-9: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16028) in Stephens Lake in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

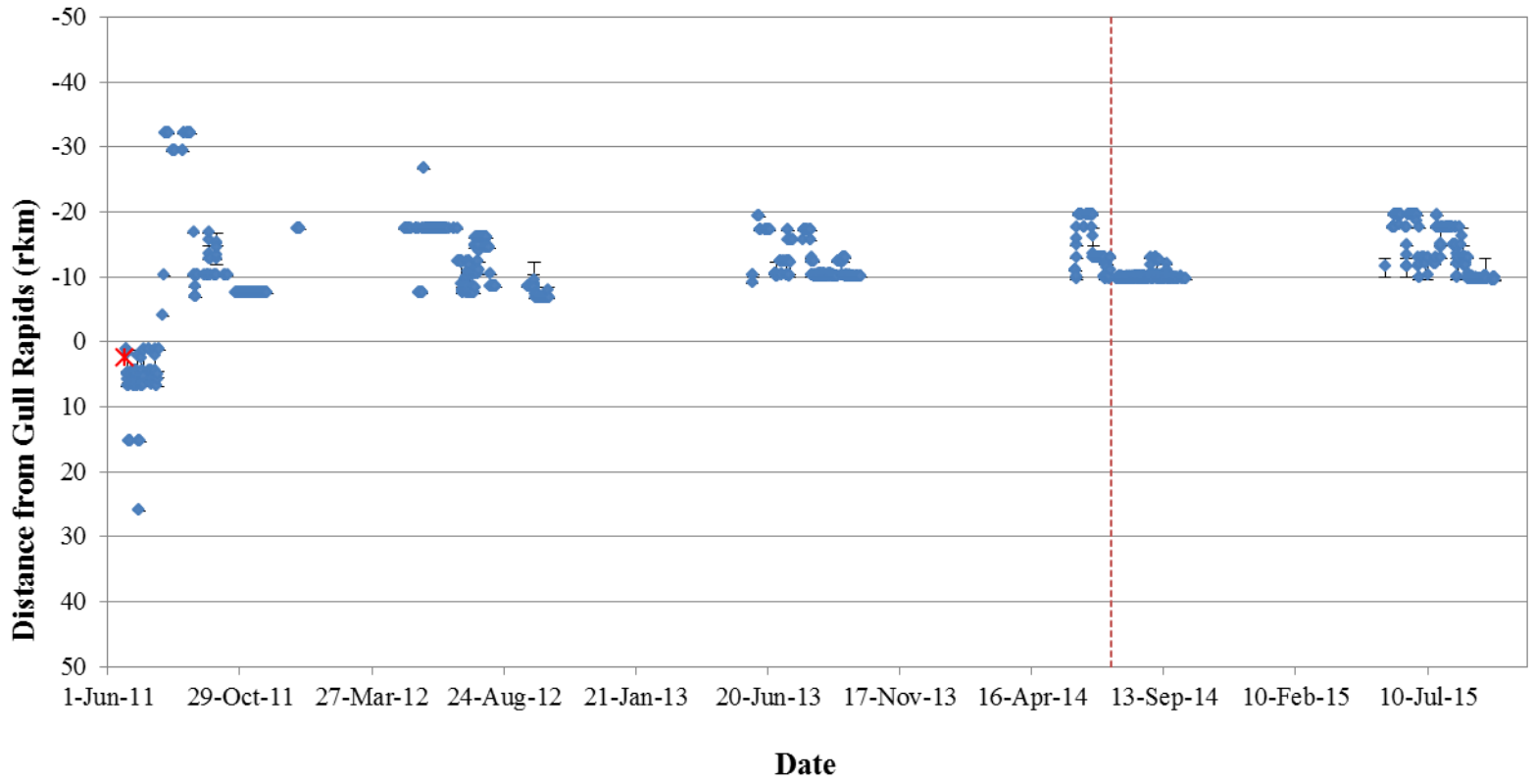


Figure A3-10: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16029) in Stephens Lake in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

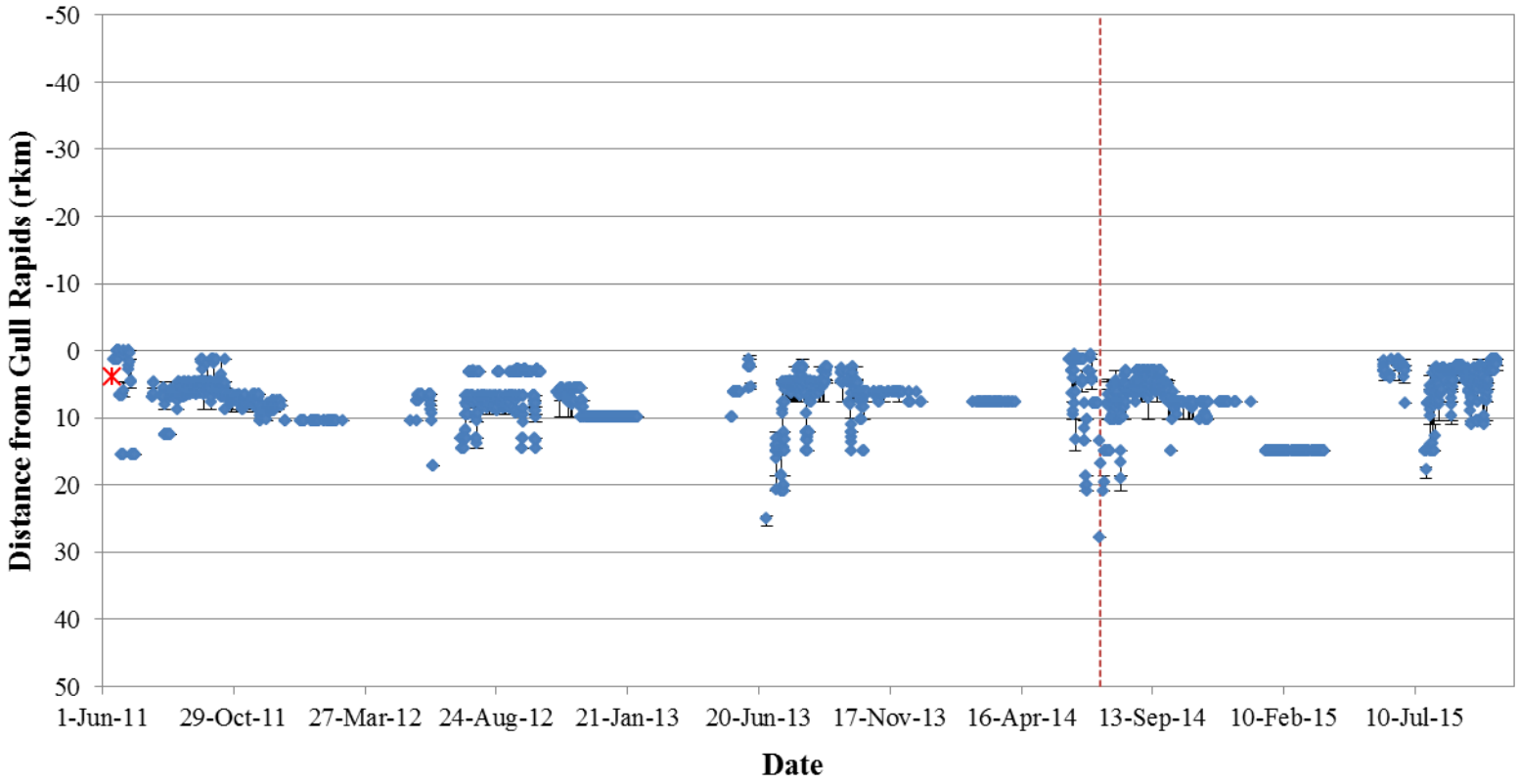


Figure A3-11: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16030) in Stephens Lake in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

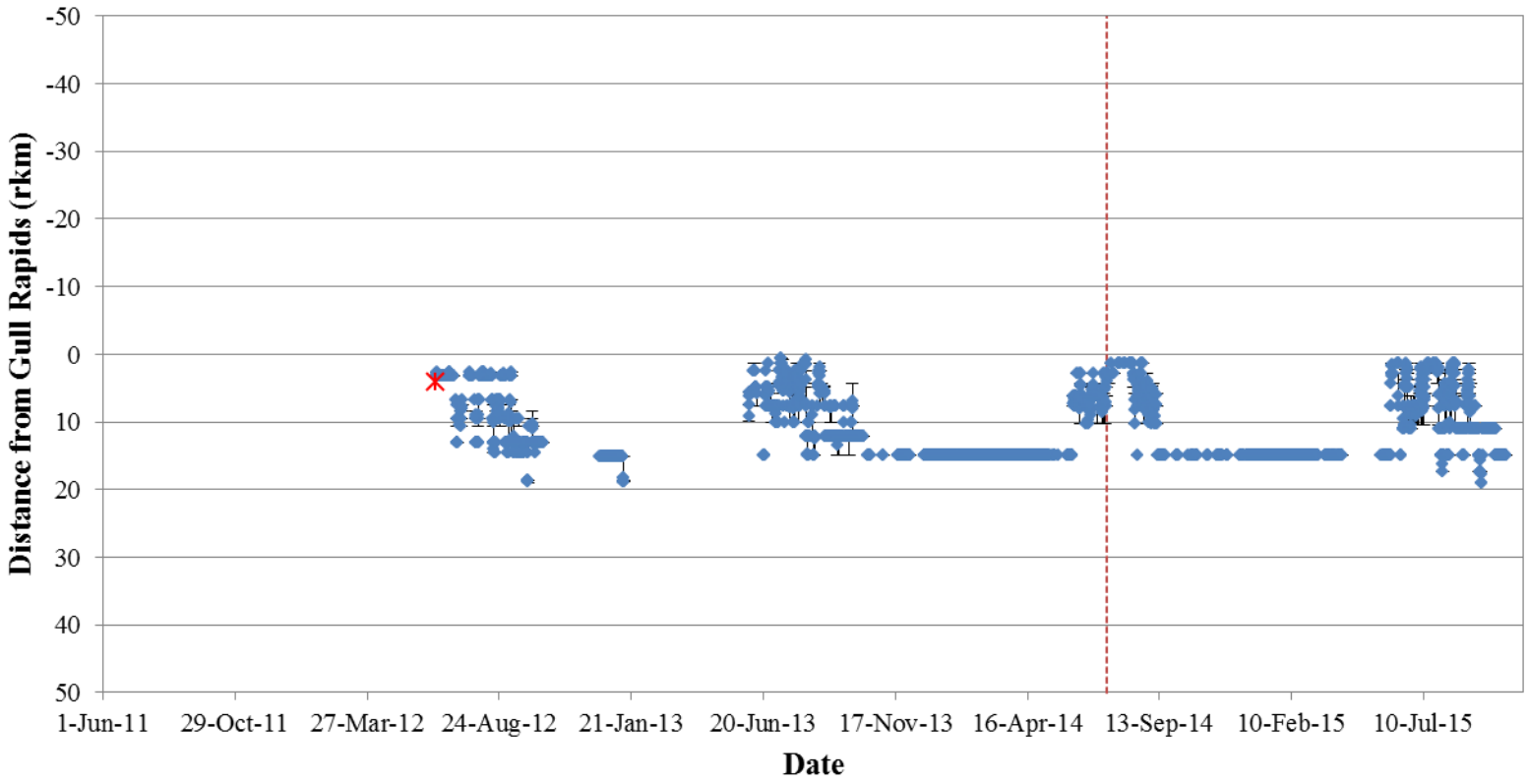


Figure A3-12: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16031) in Stephens Lake in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

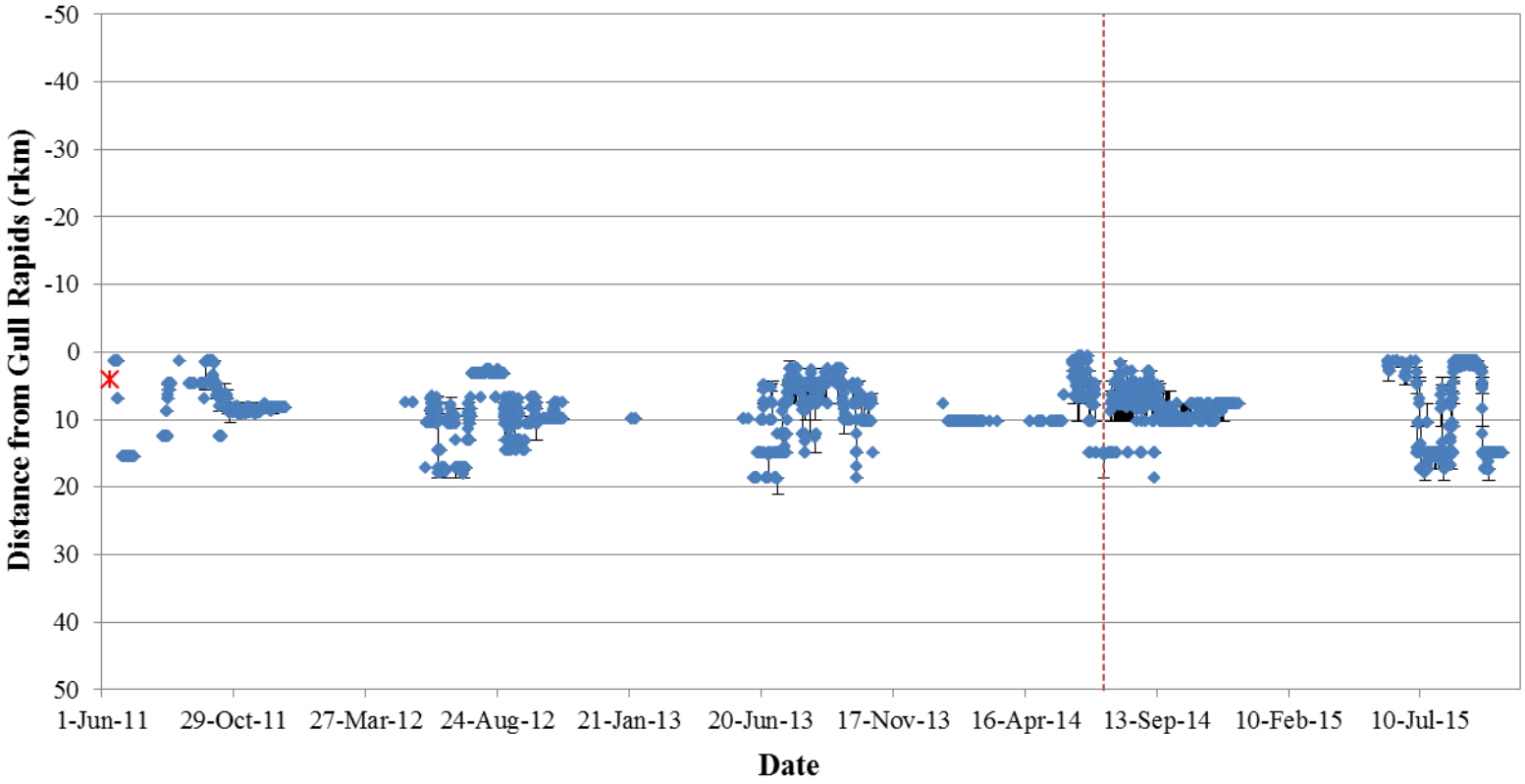


Figure A3-13: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16032) in Stephens Lake in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

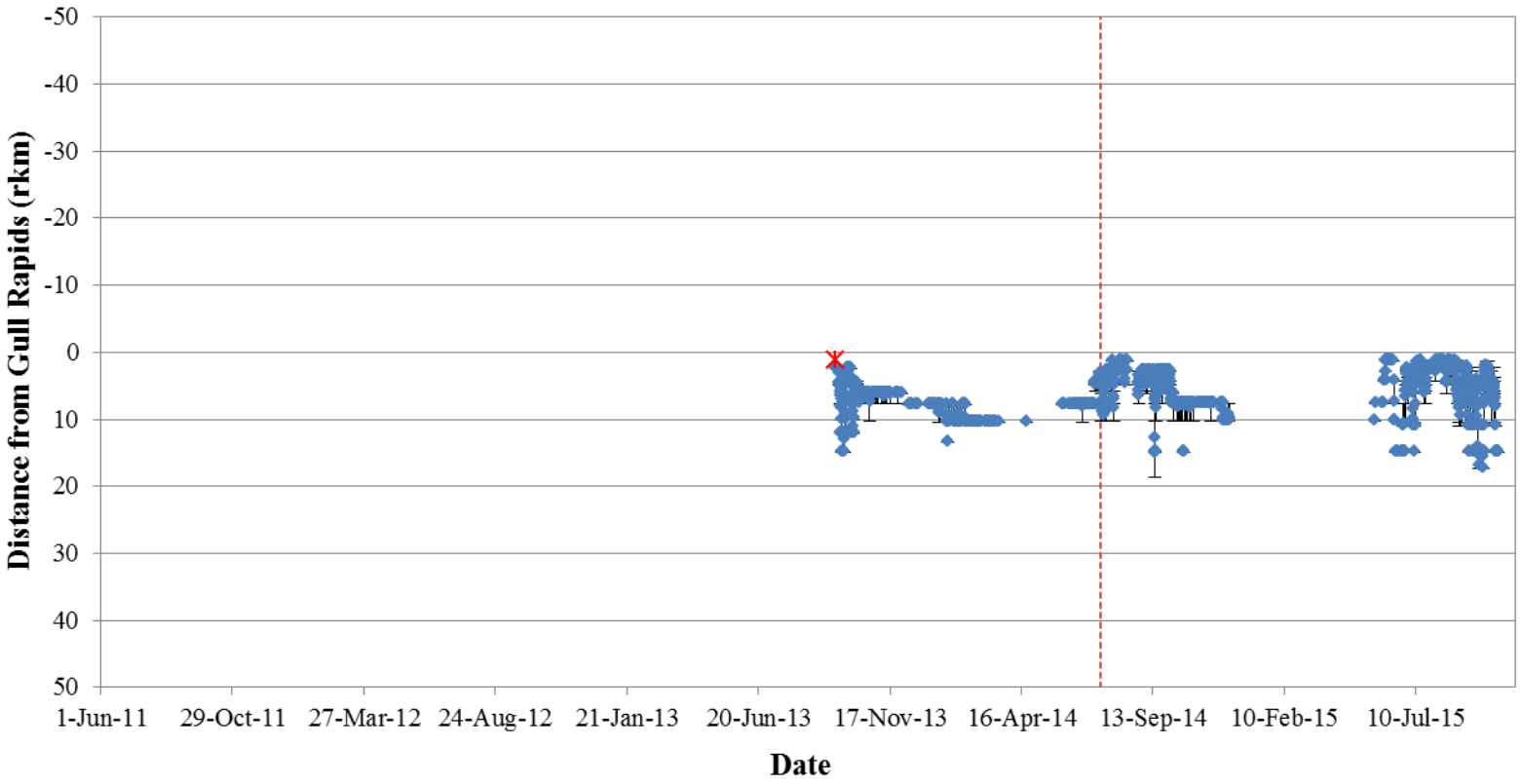


Figure A3-14: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16033b) in Stephens Lake in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

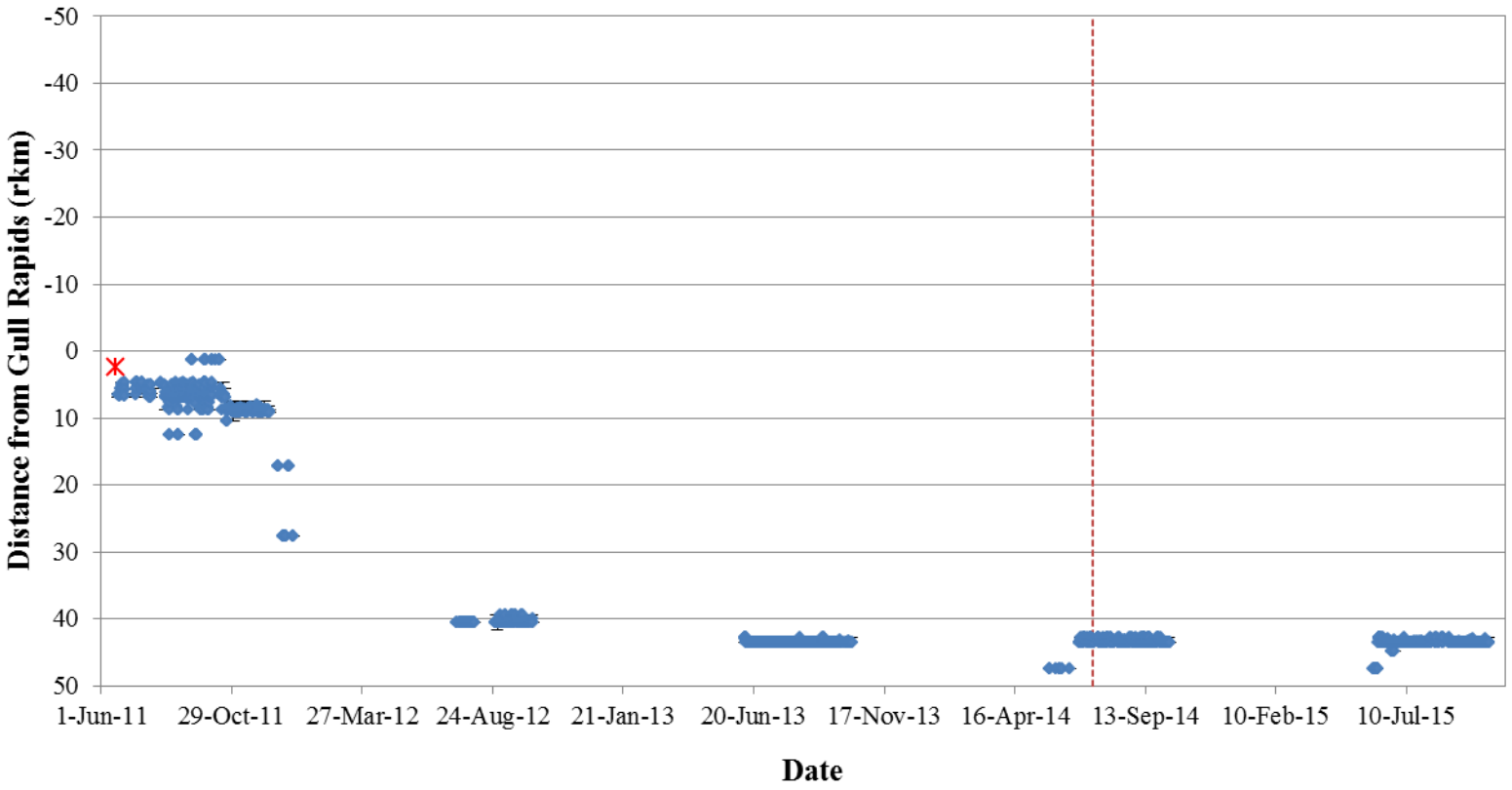


Figure A3-15: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16034) in Stephens Lake in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

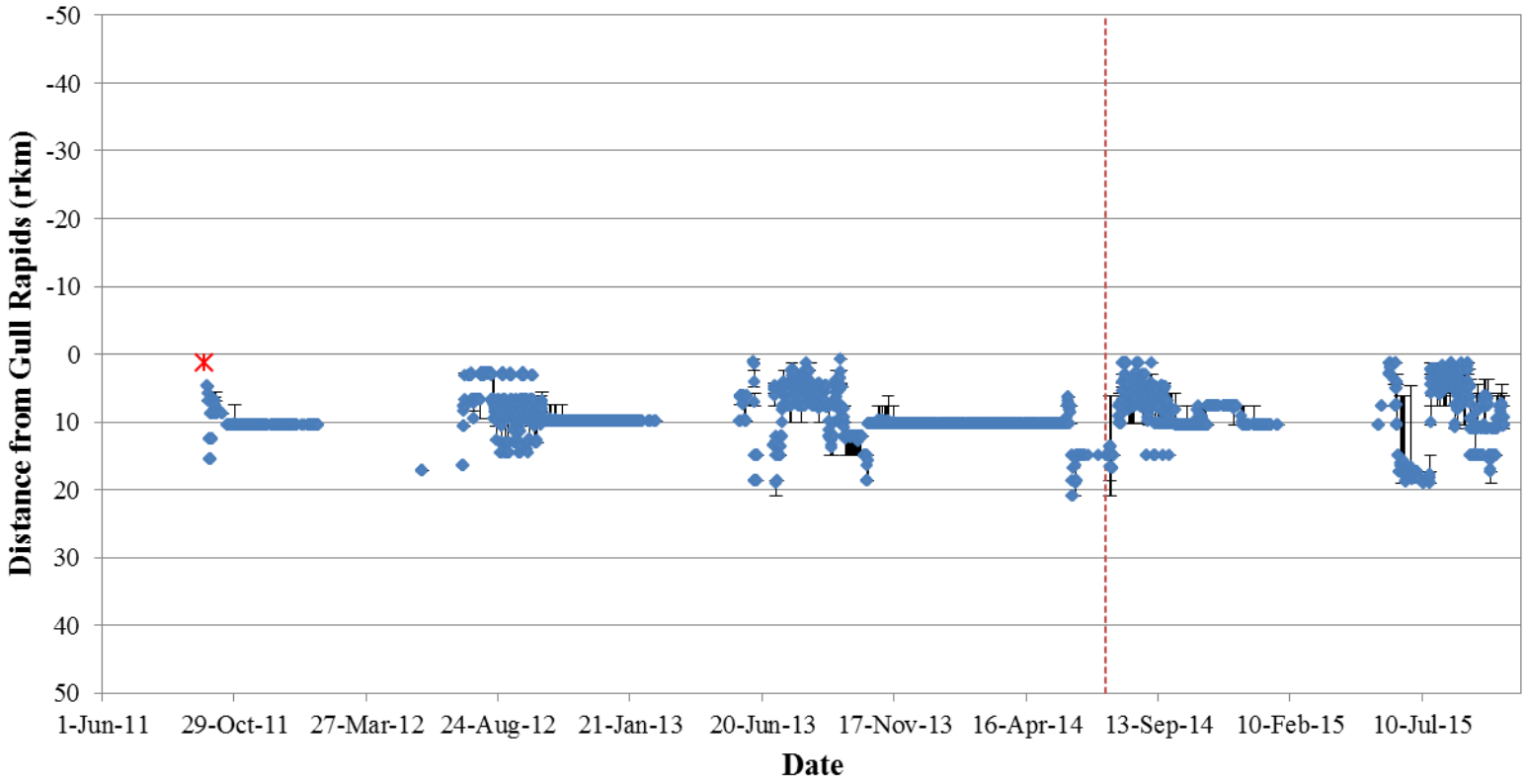


Figure A3-16: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16035) in Stephens Lake in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

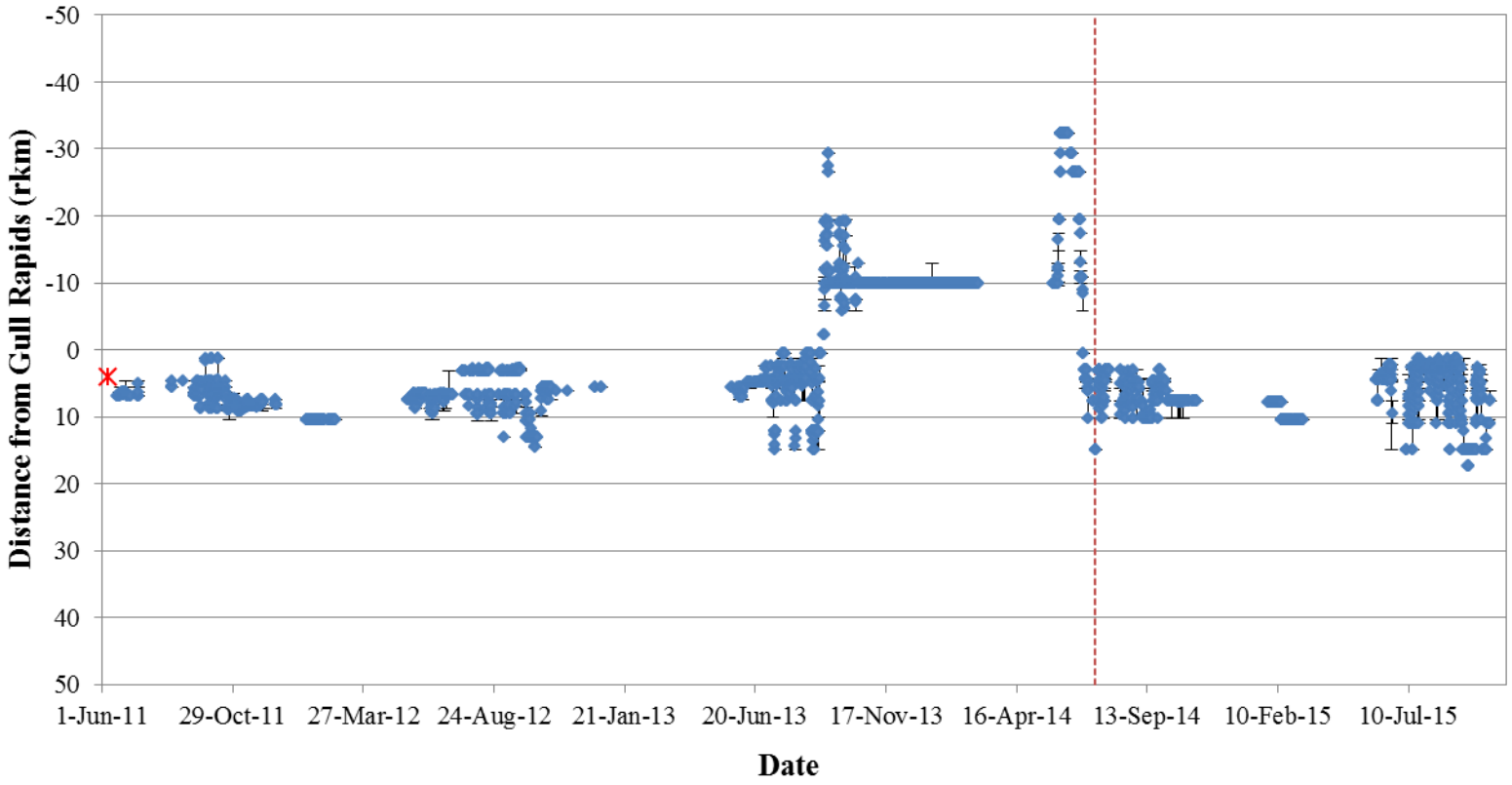


Figure A3-17: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16037) in Stephens Lake in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

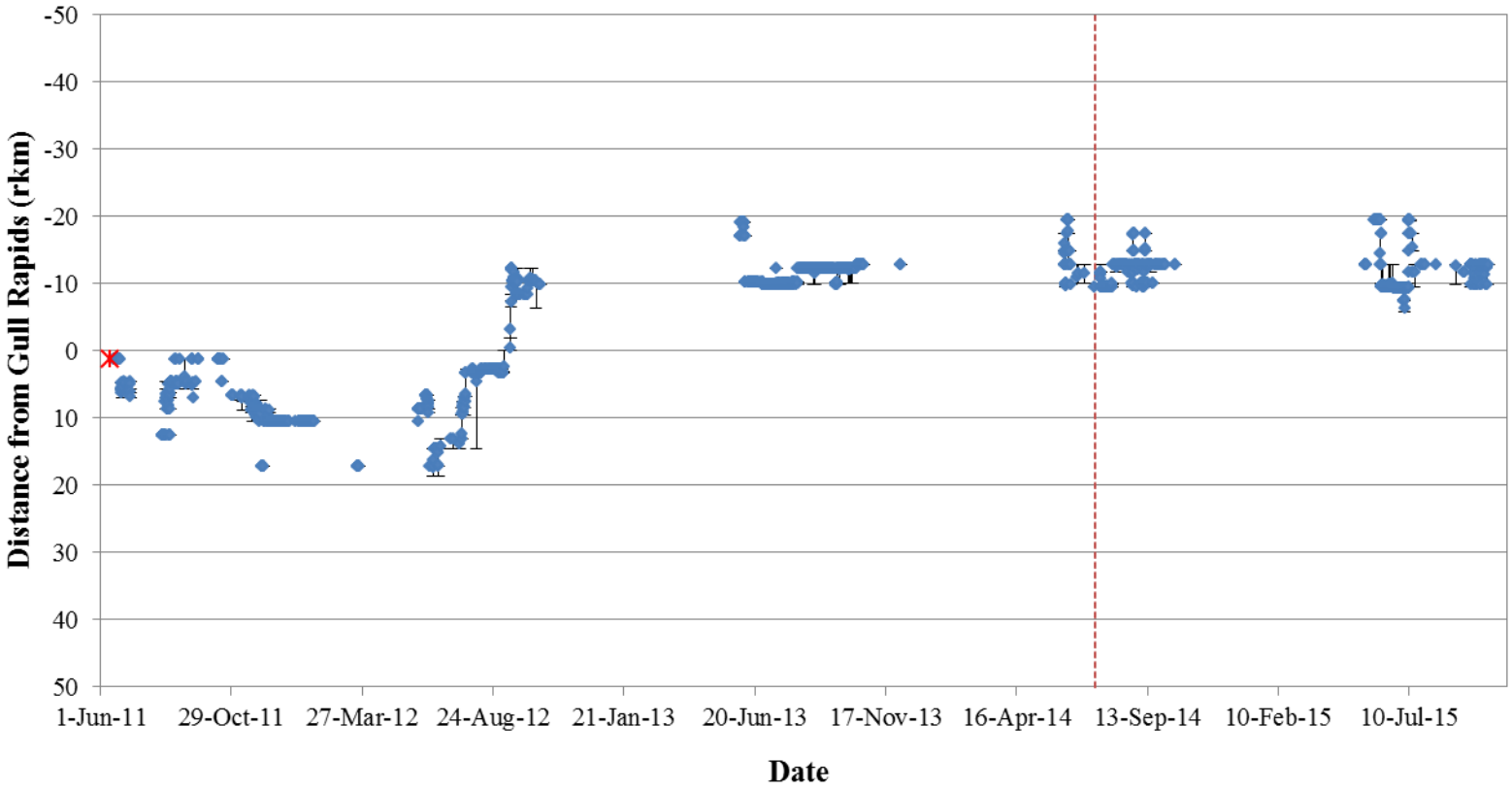


Figure A3-18: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16038) in Stephens Lake in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

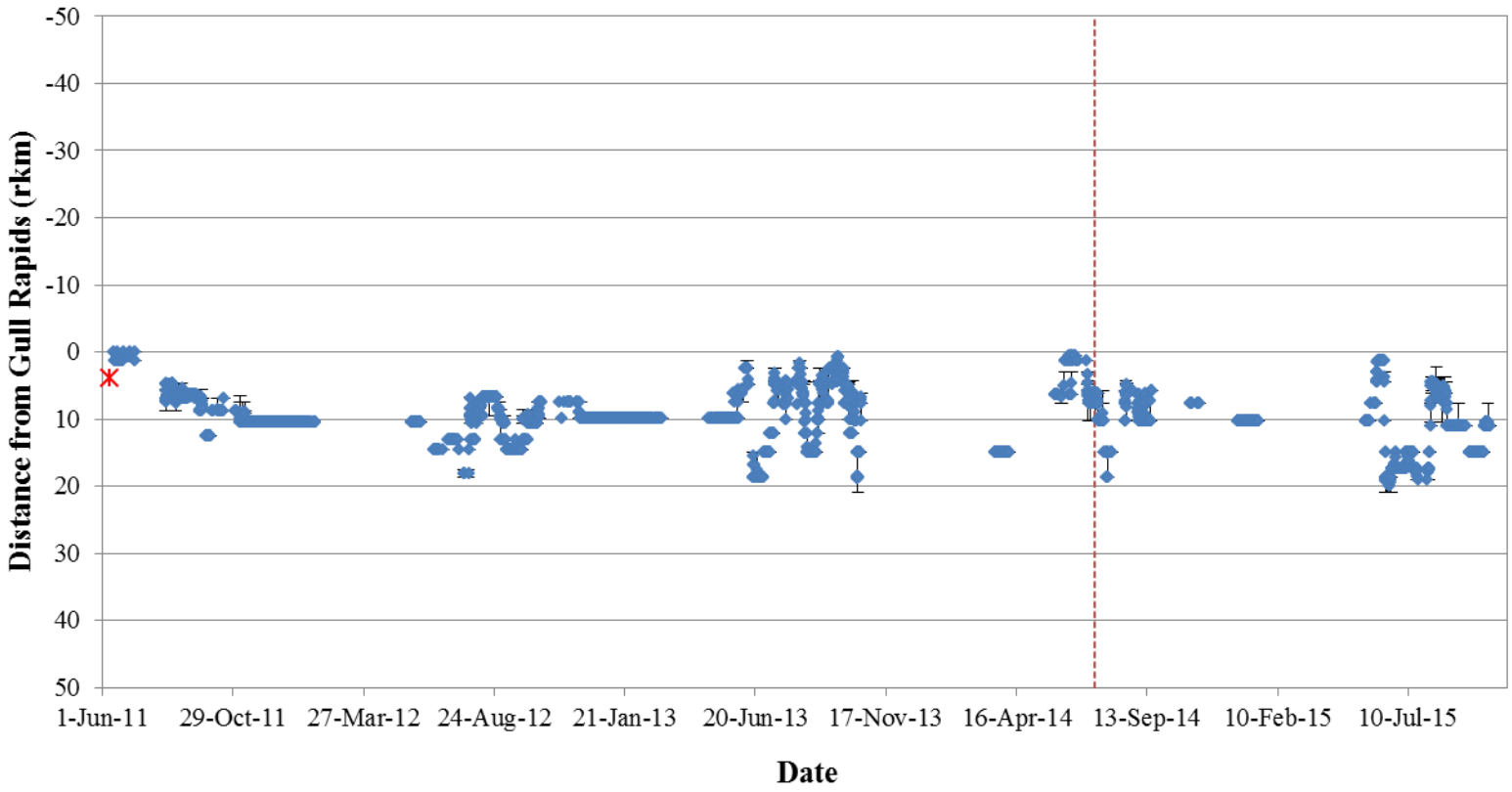


Figure A3-19: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16040) in Stephens Lake in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

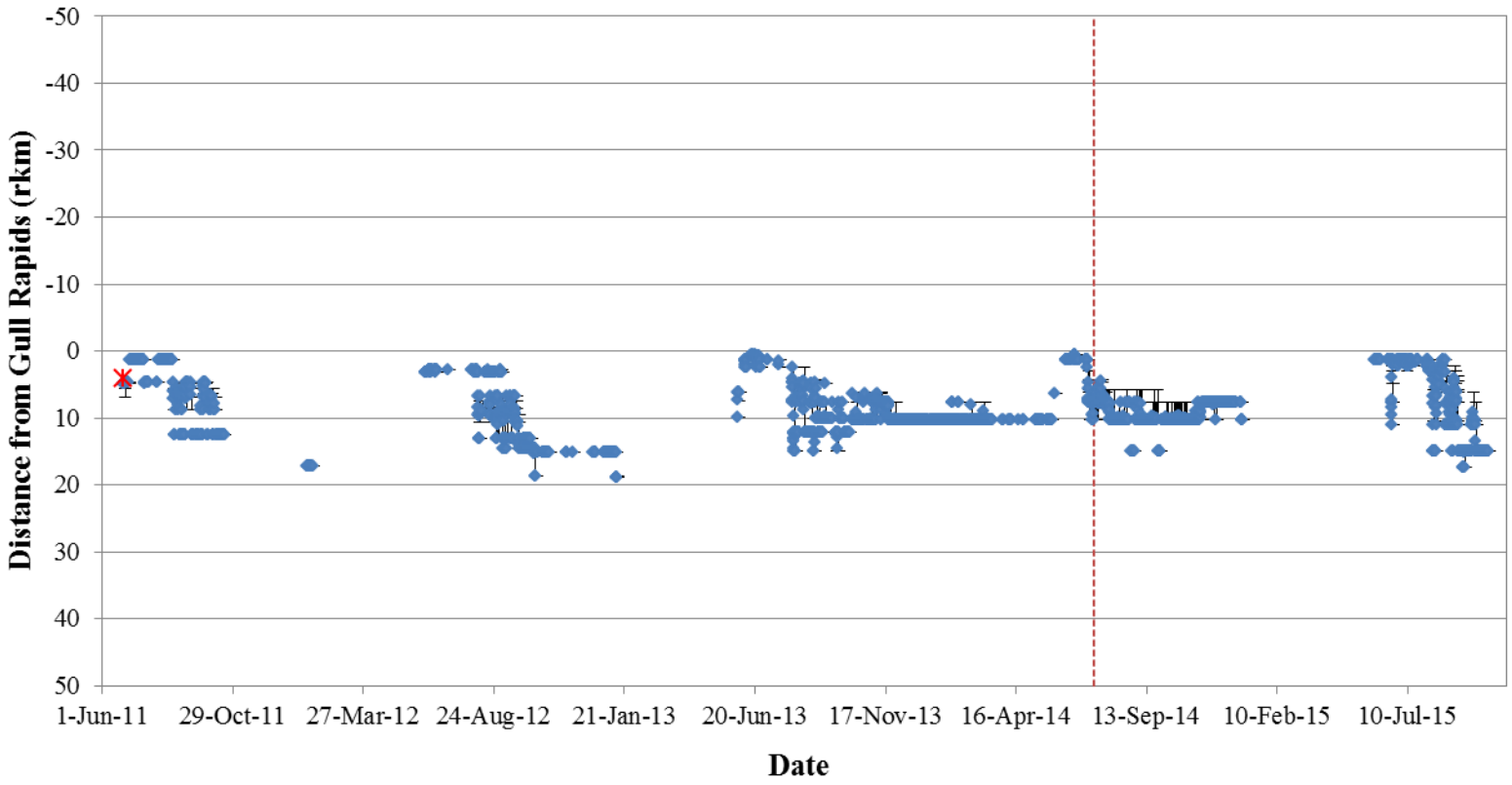


Figure A3-20: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16041) in Stephens Lake in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

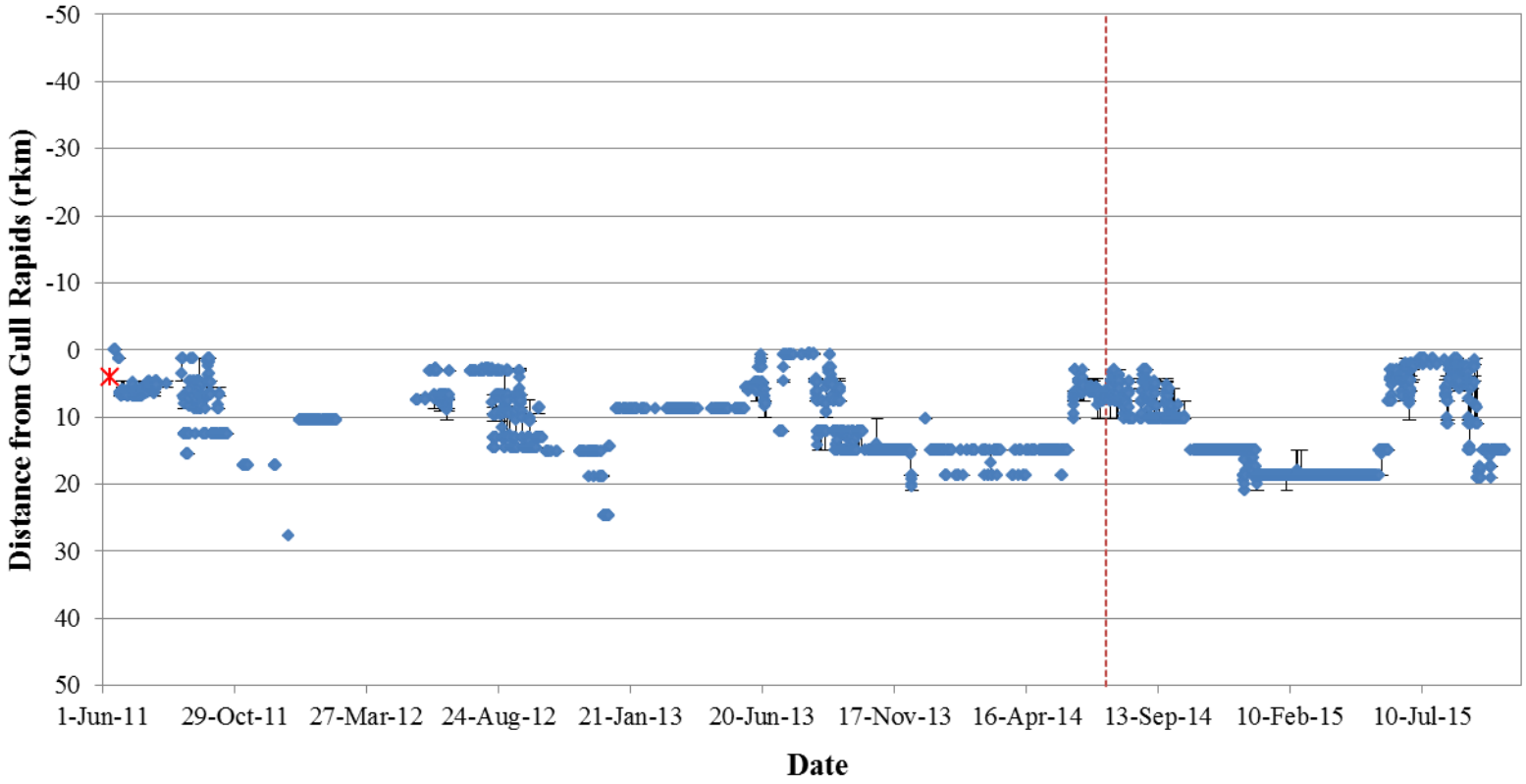


Figure A3-21: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16043) in Stephens Lake in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

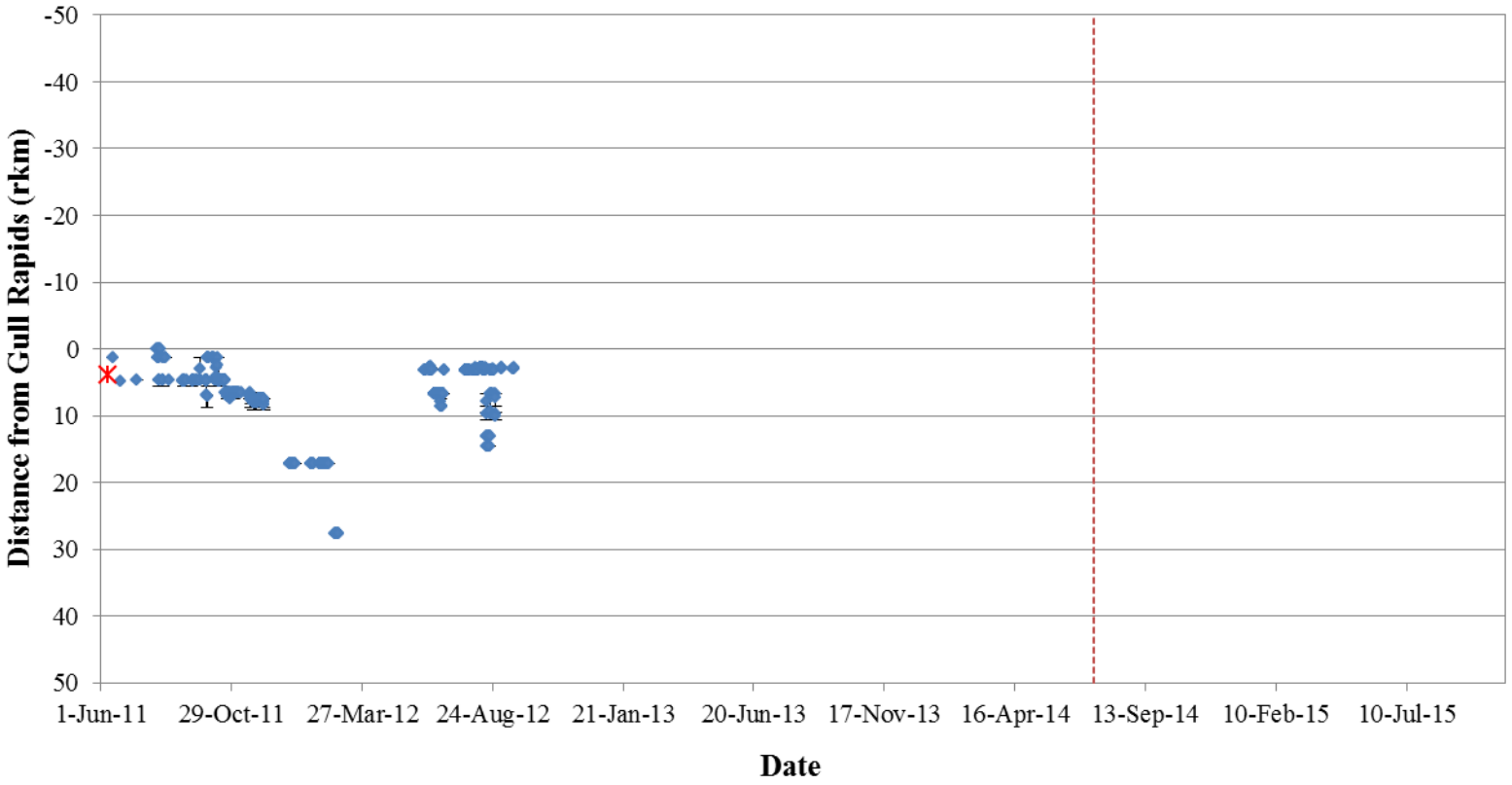


Figure A3-22: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16044) in Stephens Lake in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

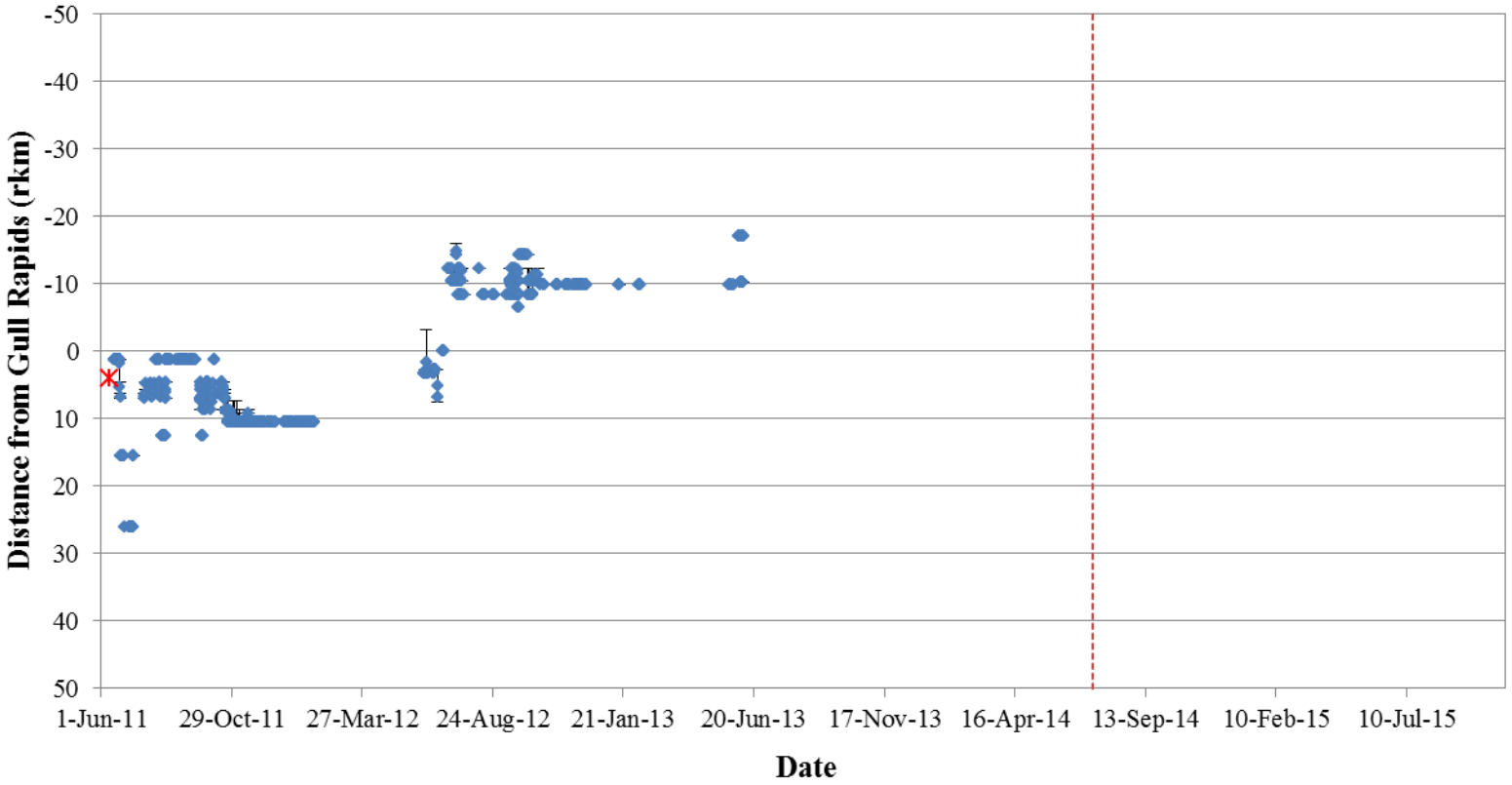


Figure A3-23: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16046) in Stephens Lake in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

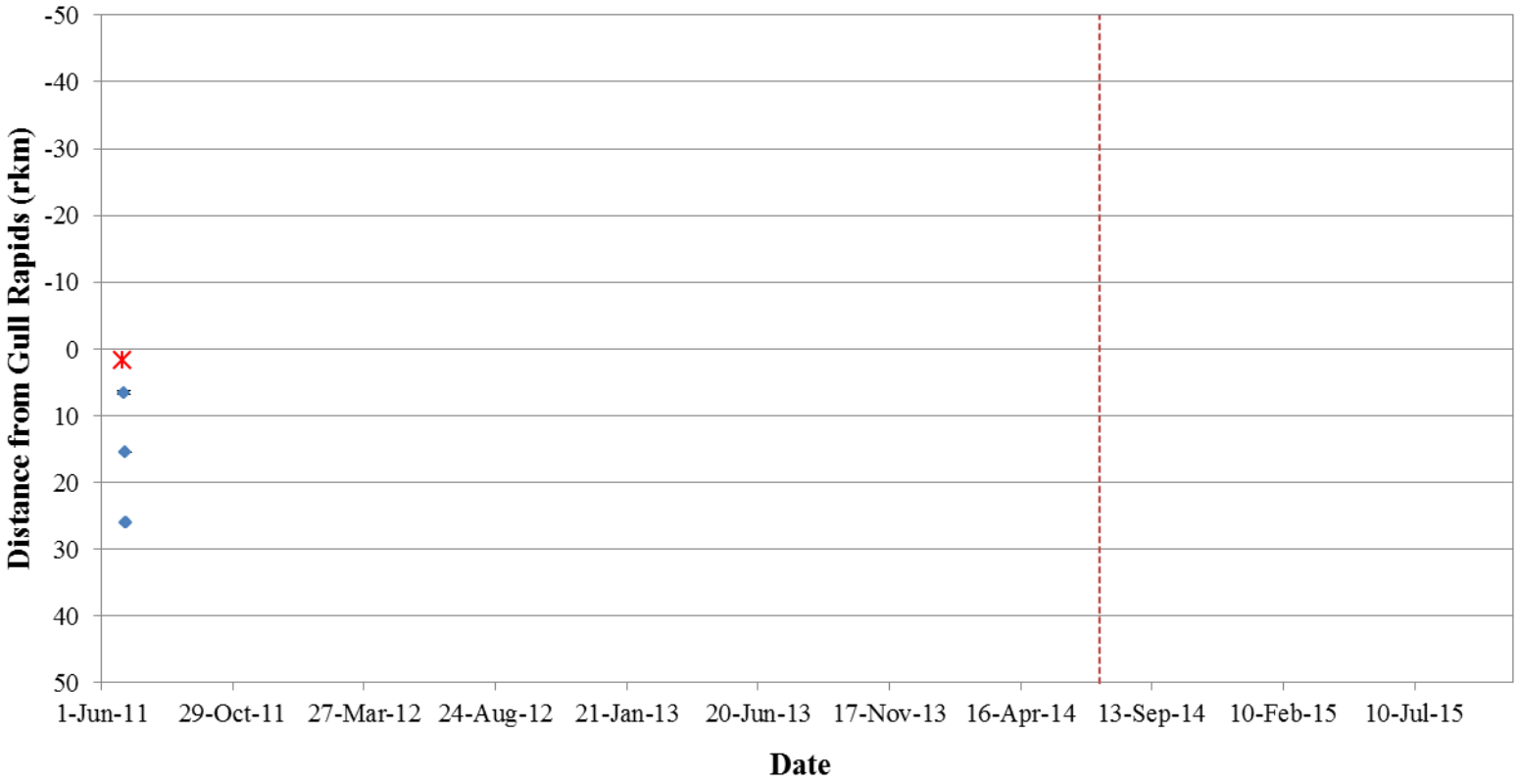


Figure A3-24: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16047) in Stephens Lake in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

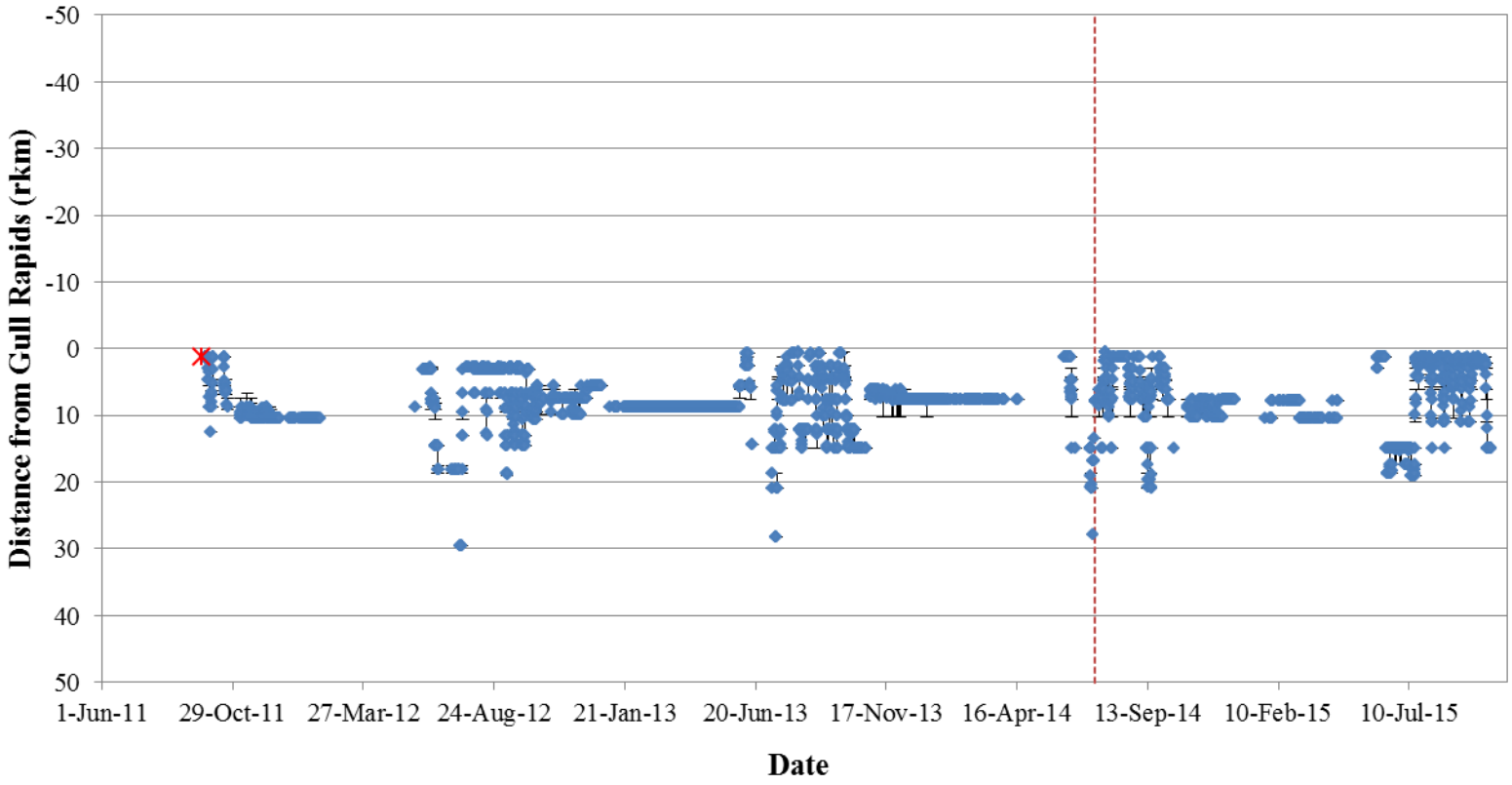


Figure A3-25: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16049) in Stephens Lake in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

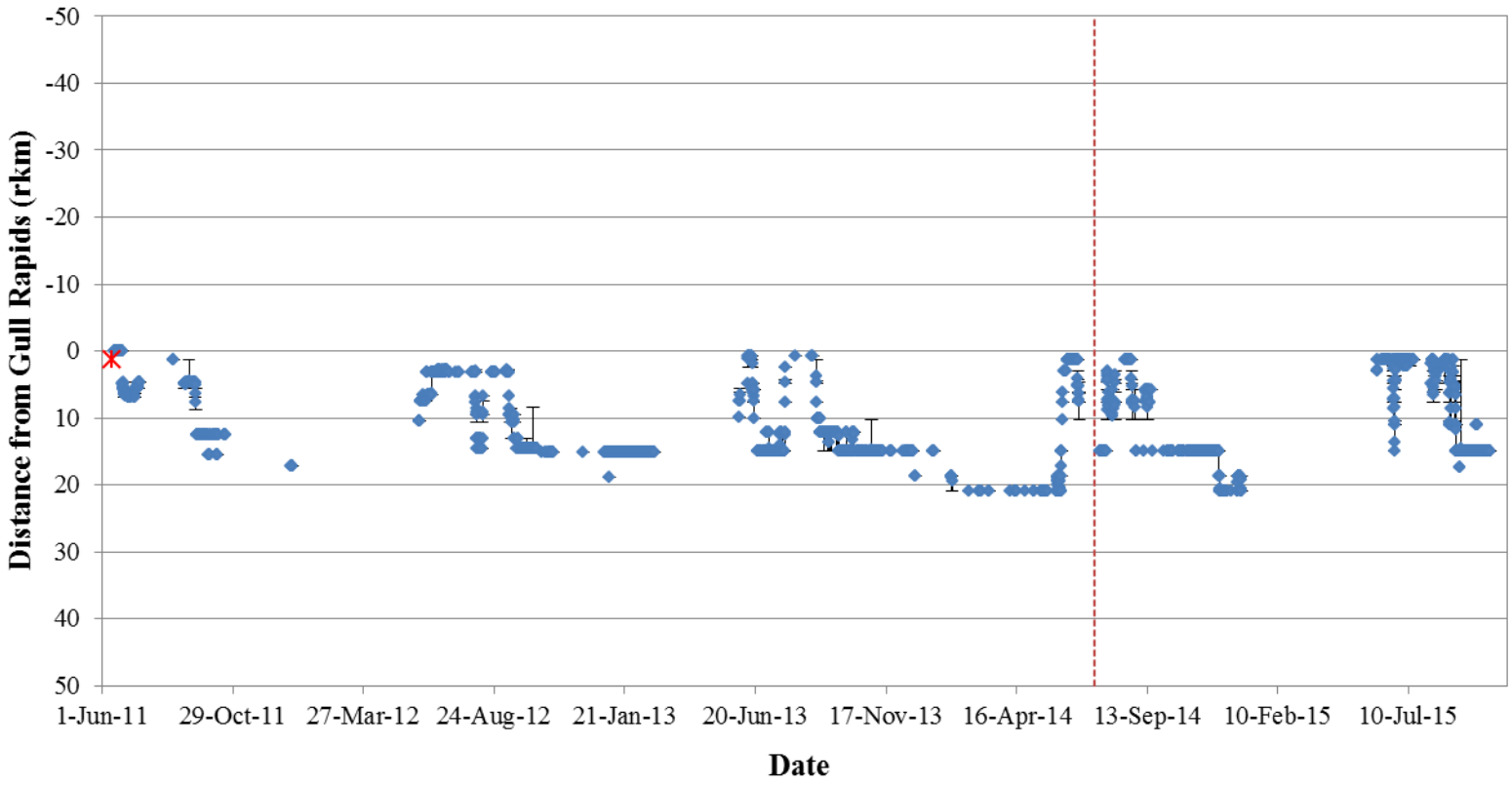


Figure A3-26: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16050) in Stephens Lake in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

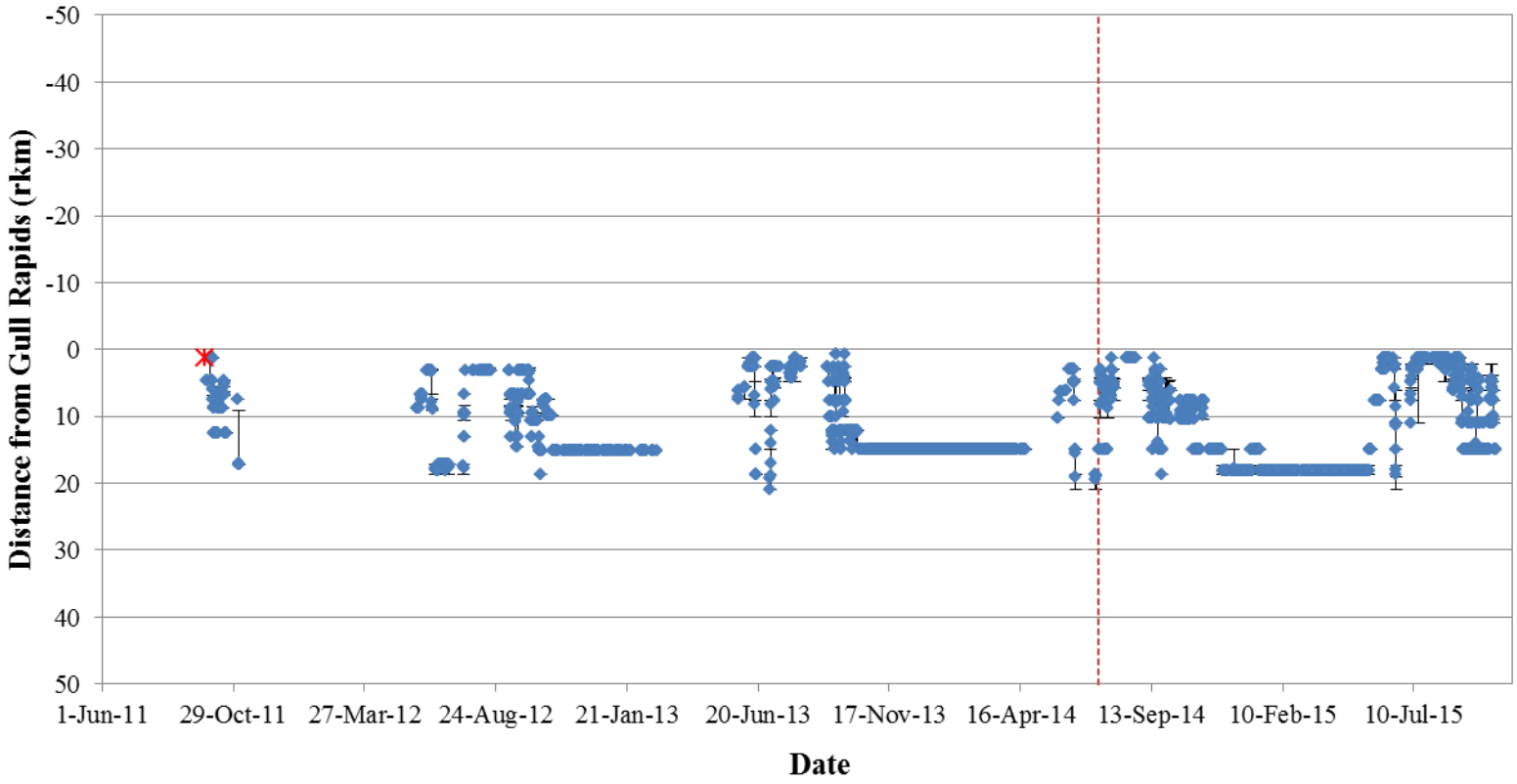


Figure A3-27: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16052) in Stephens Lake in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

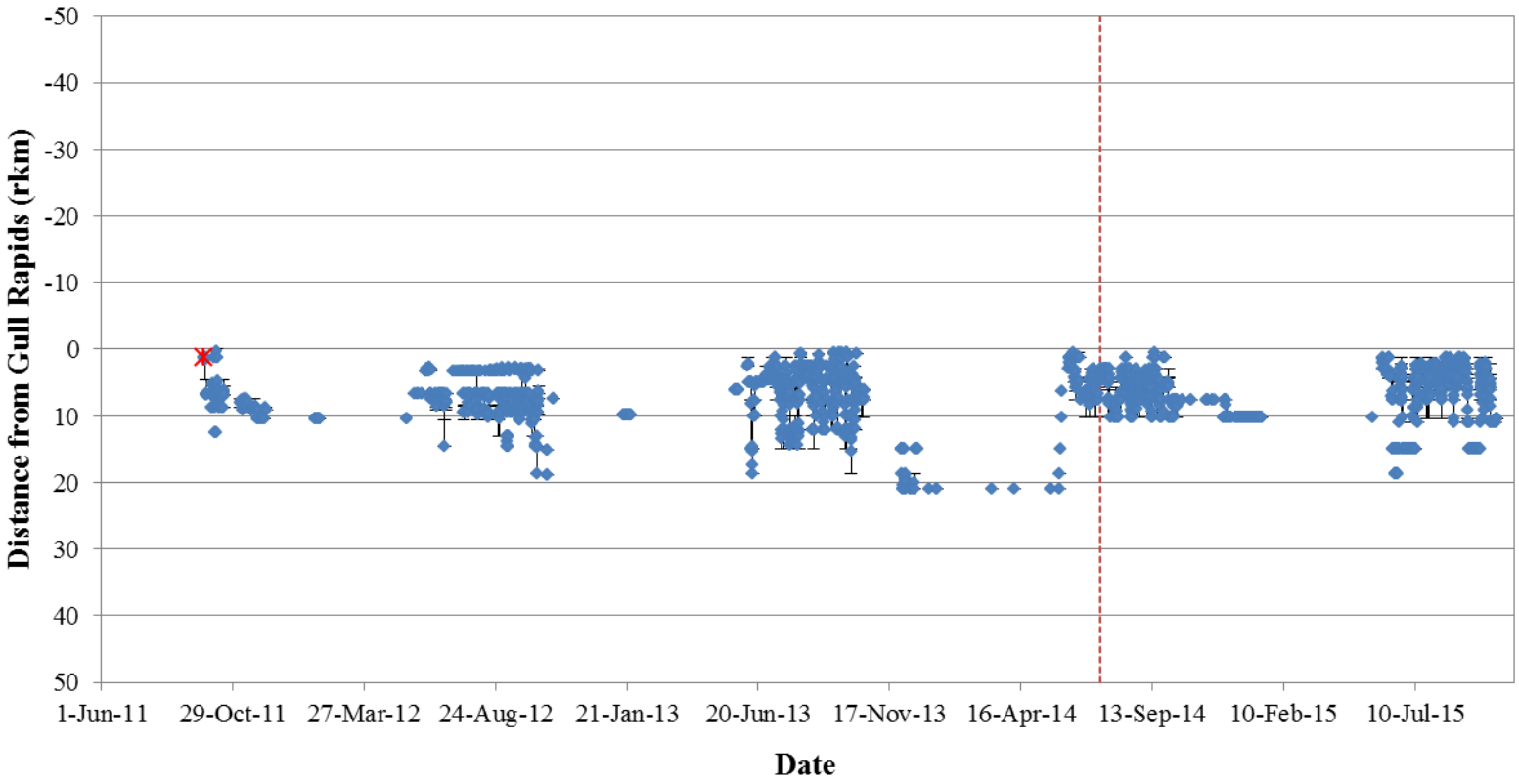


Figure A3-28: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #16053) in Stephens Lake in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

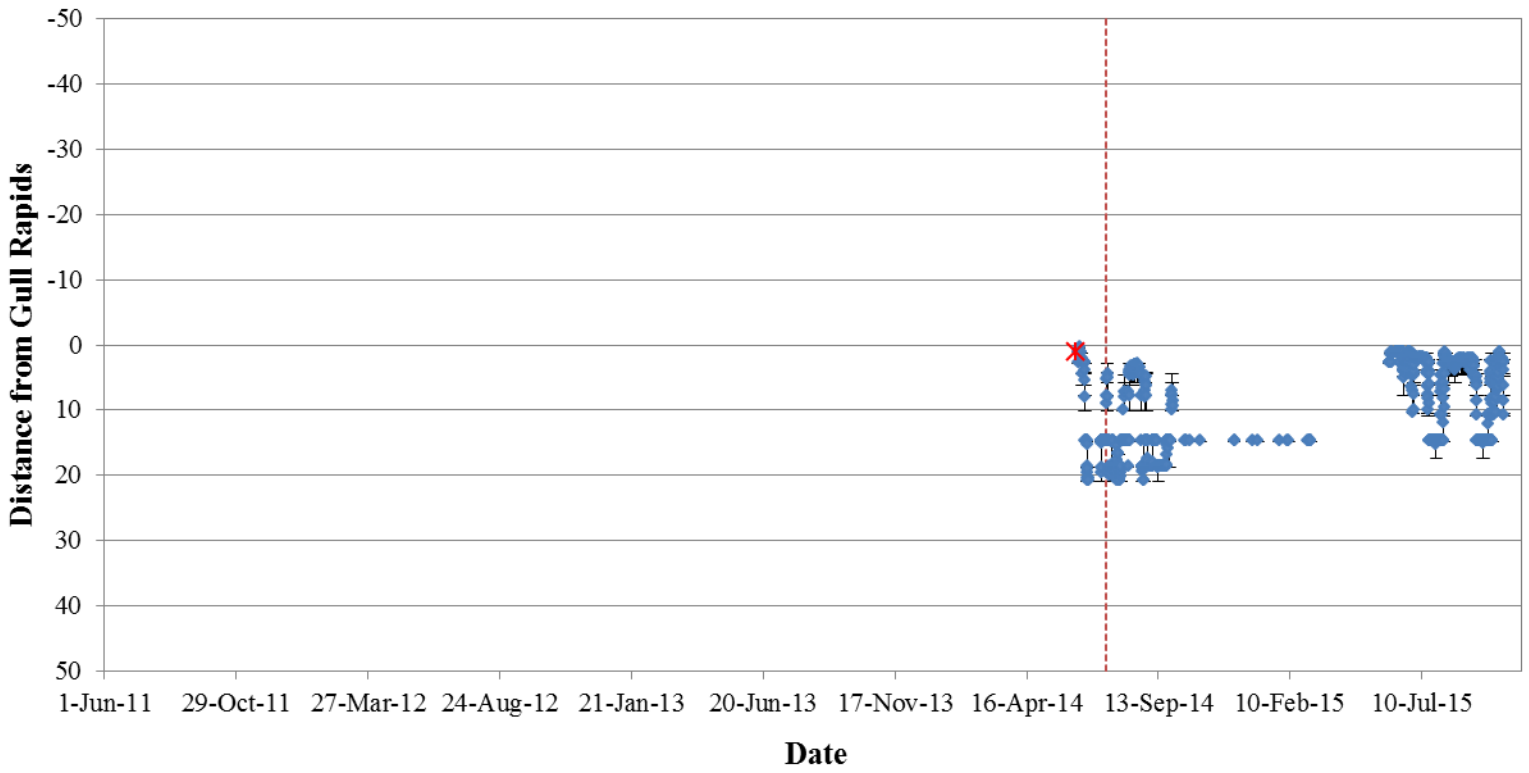


Figure A3-29: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32167) in Stephens Lake in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

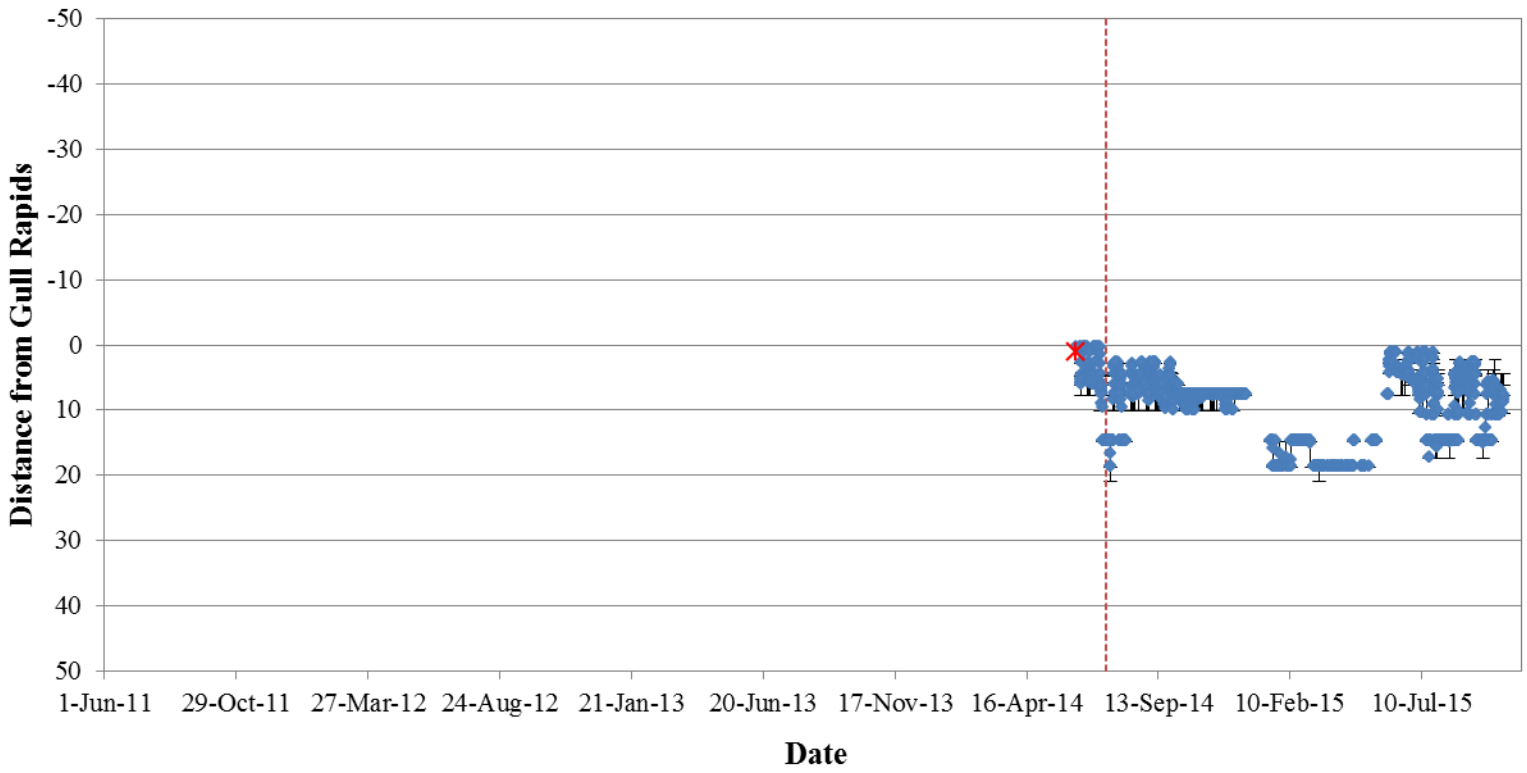


Figure A3-30: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32168) in Stephens Lake in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

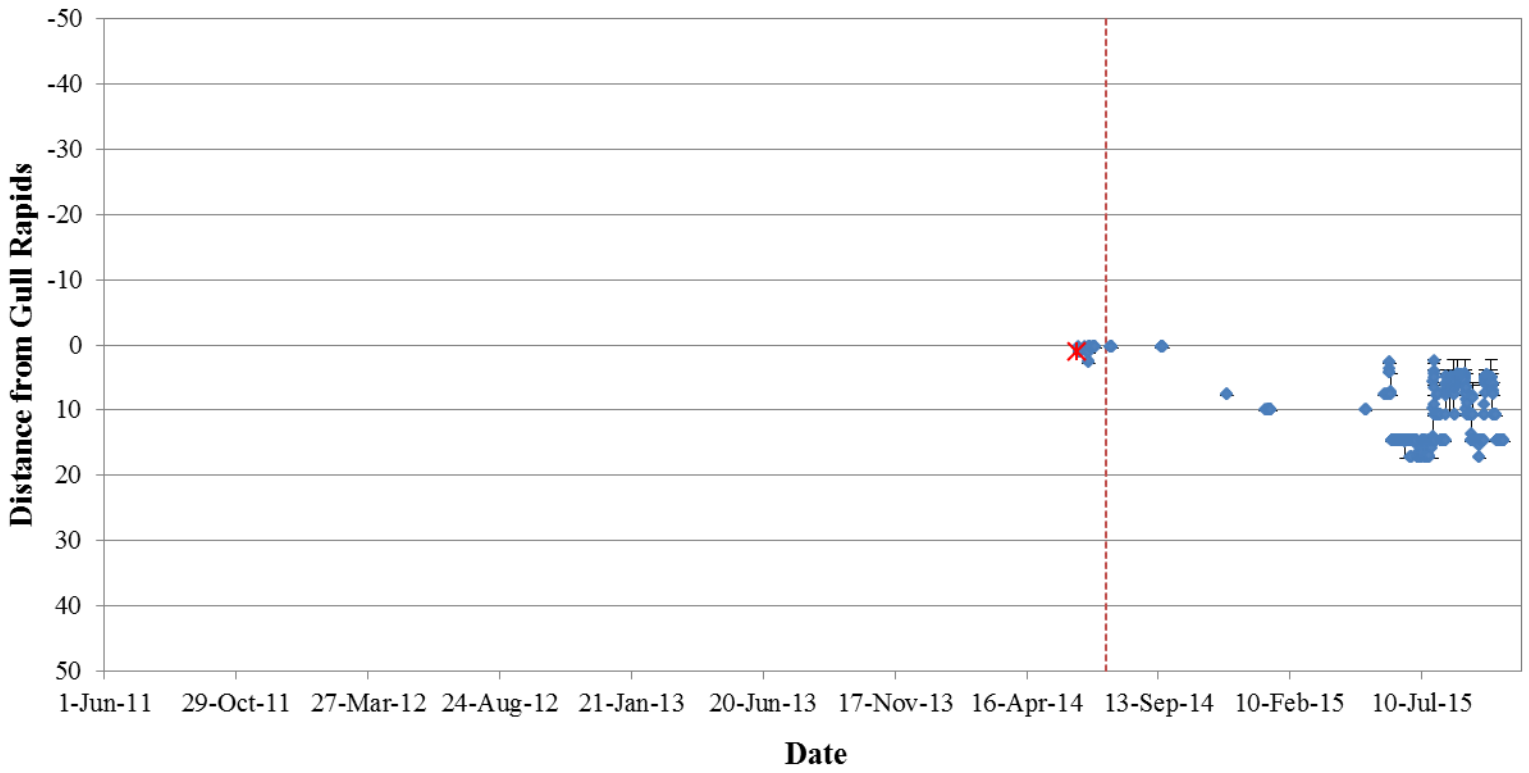


Figure A3-31: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32169) in Stephens Lake in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

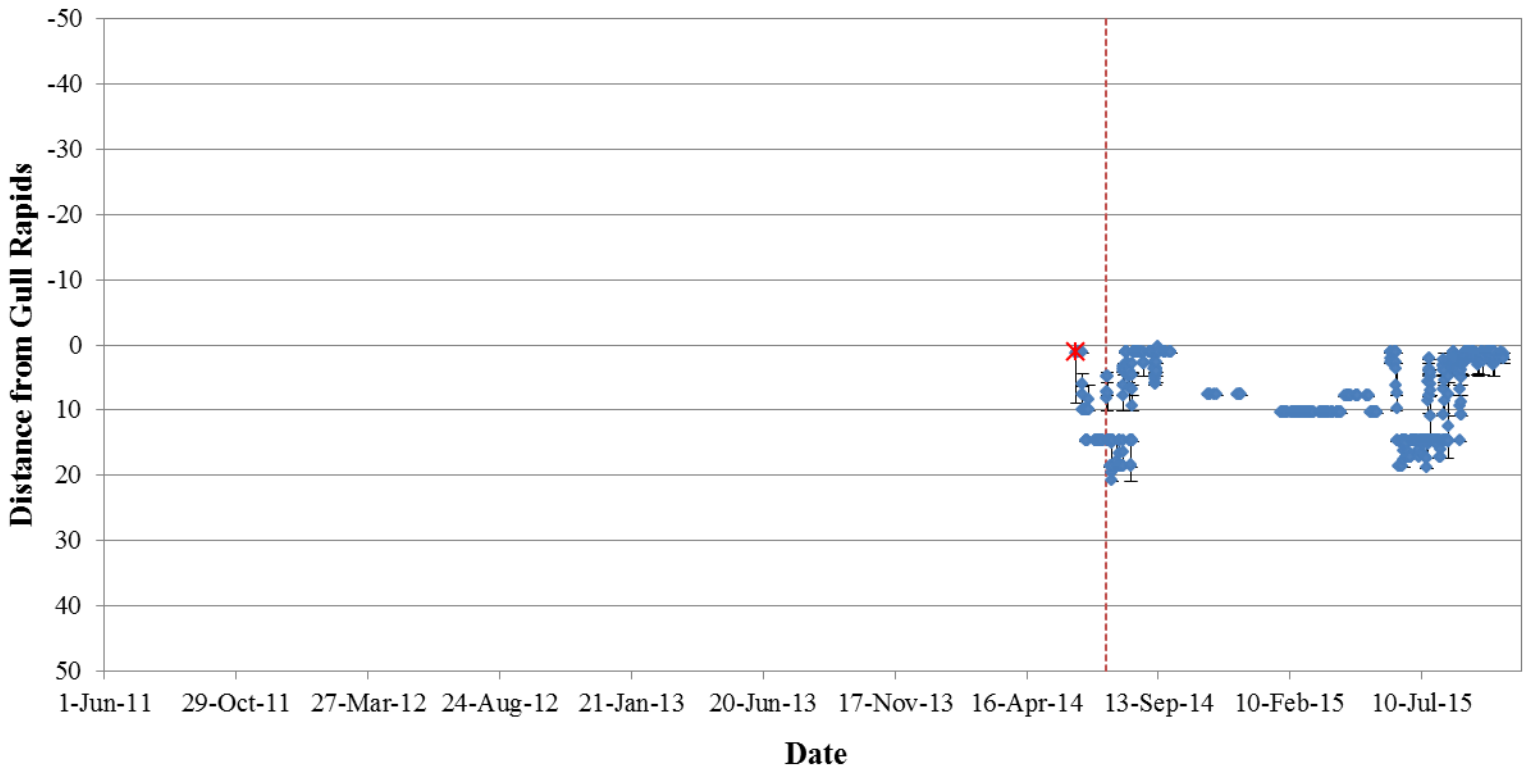


Figure A3-32: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32170) in Stephens Lake in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

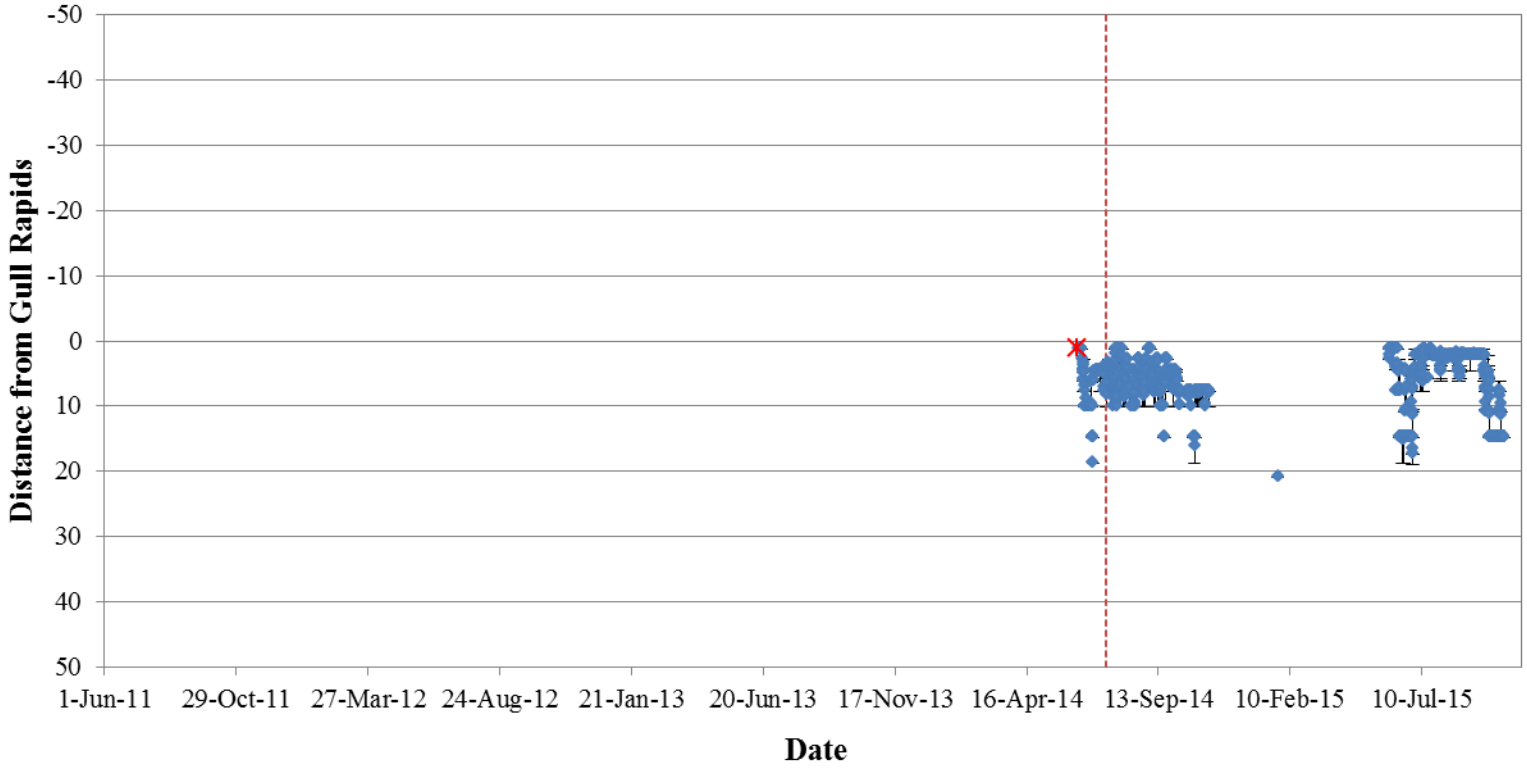


Figure A3-33: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32171) in Stephens Lake in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

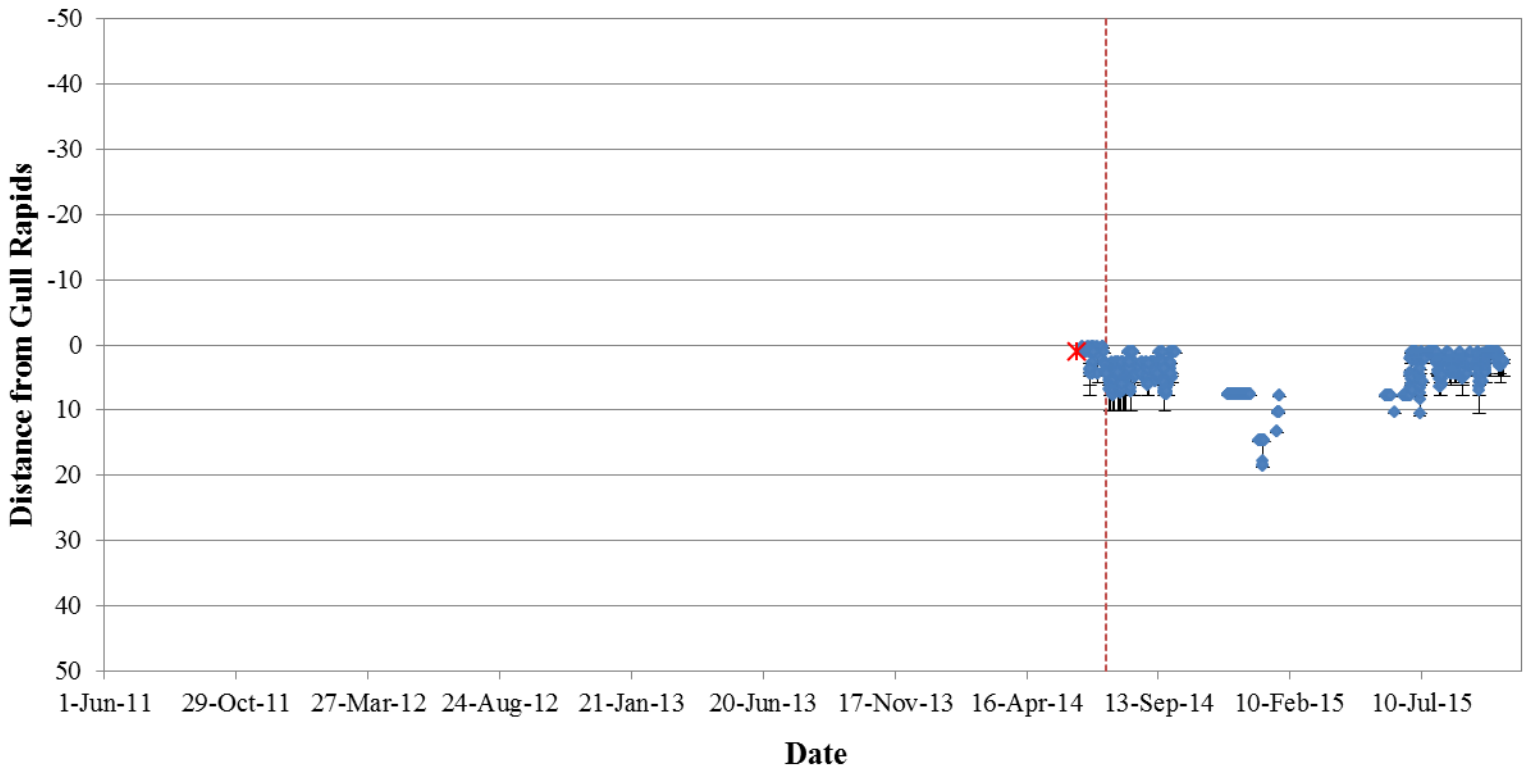


Figure A3-34: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32172) in Stephens Lake in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

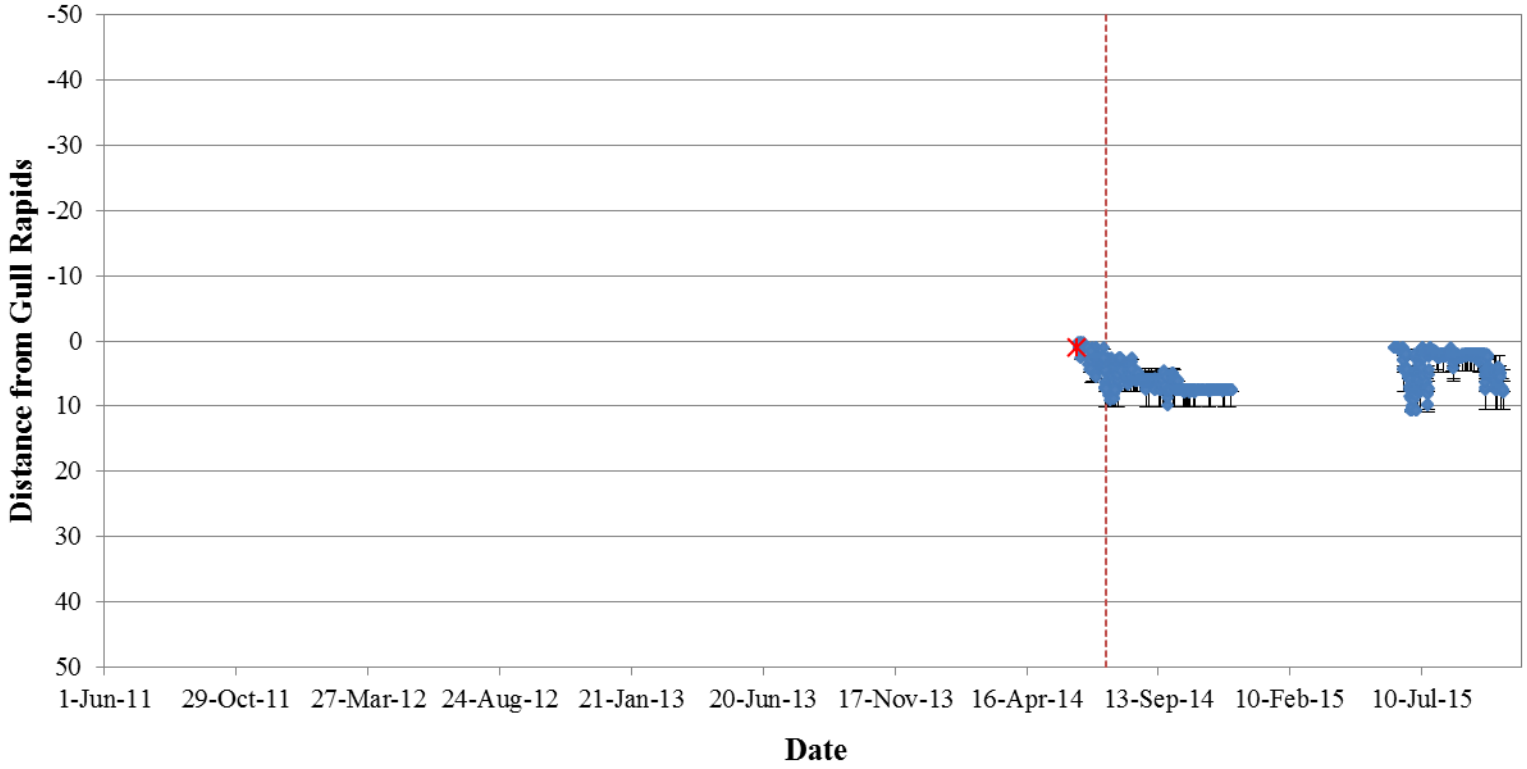


Figure A3-35: Position of a Lake Sturgeon tagged with an acoustic transmitter (code #32173) in Stephens Lake in relation to Gull Rapids (rkm 0), from 1 June, 2011 to 11 October, 2015. Date and location of tagging is indicated by a star. Beginning of Keeyask construction is indicated with a dotted line.

APPENDIX 4: SUMMARY OF SUPPLEMENTARY ACOUSTIC TRACKING: 14–21 JANUARY, 2015

Additional monitoring was conducted as part of a separate study from January 14 to 21, 2015 to assess the abundance of tagged fish in the vicinity of two potential ice blasting locations in Gull Lake, described in the 2014-15 Environmental Protection Plan report (Manitoba Hydro 2015). Holes were drilled through the ice upstream of Gull Rapids to monitor fish movements. Five additional stationary VR2W receivers were deployed between Hydro Island and the downstream end of Caribou Island (between rkm -9.5 and -5.8) (Appendix A1-1). In addition, a portable acoustic receiver (Vemco model VR100) with an omni-directional or directional hydrophone was used to manually track fish near the upstream end of Caribou Island. The hydrophone was lowered below the ice for an approximate 5-minute period (or longer if multiple fish were detected). Manual tracking was conducted at a total of nine sites.

A total of 27 fish were located, including 19 adult Lake Sturgeon, five juvenile Lake Sturgeon, two Walleye, and one Lake Whitefish.

Adult Lake Sturgeon

Nineteen fish were located, 16 of which were not detected at the stationary receiver permanently deployed at rkm -12.9 (Appendix A1-1).

- Ten (#16051, #16054, #16060, #16063, #16068, #16071, #16072, #16073, #16074, #32177) were detected only at the stationary receiver deployed at rkm -9.5, in the upper basin of Gull Lake.
- Three fish (#16055, #16066, and #16076) have not previously detected in winter, but were located south of Caribou Island between rkms -9.3 and -6.9.
- The remaining five fish (#16029, #16056, #16059, #16062, and #16065) moved between rkms -9.9 and -6.9.

Juvenile Lake Sturgeon

Five juvenile Lake Sturgeon (#32677, #32678, #32682, #32686, and #32690) were detected by receivers. While #32682 was also detected at the receiver at rkm -12.9 during the winter, the rest of the fish were not detected by any other receivers during the winter period.

- #32677 was detected at a stationary receiver deployed at rkm -9.5 between January 18 and 21.
- #32678 was detected during manual tracking on January 14, 2015 at rkm -7.6 and during manual tracking on January 15 at rkms -6.9 and -7.0. It was also detected at a stationary receiver at rkm -9.5 between January 19 and 21.
- #32682 was detected at the stationary receiver at rkm -9.5 between January 19 and 21.
- #32686 was detected during manual tracking on January 16, 2015 at rkm -7.1, and at stationary receivers at rkms -7.0, -7.6, -8.5 and -9.3 between January 18 and 21.

- #32690 was detected at stationary receivers at rkms -7.0, -7.6, -8.5 and -9.3 between January 18 and 21.

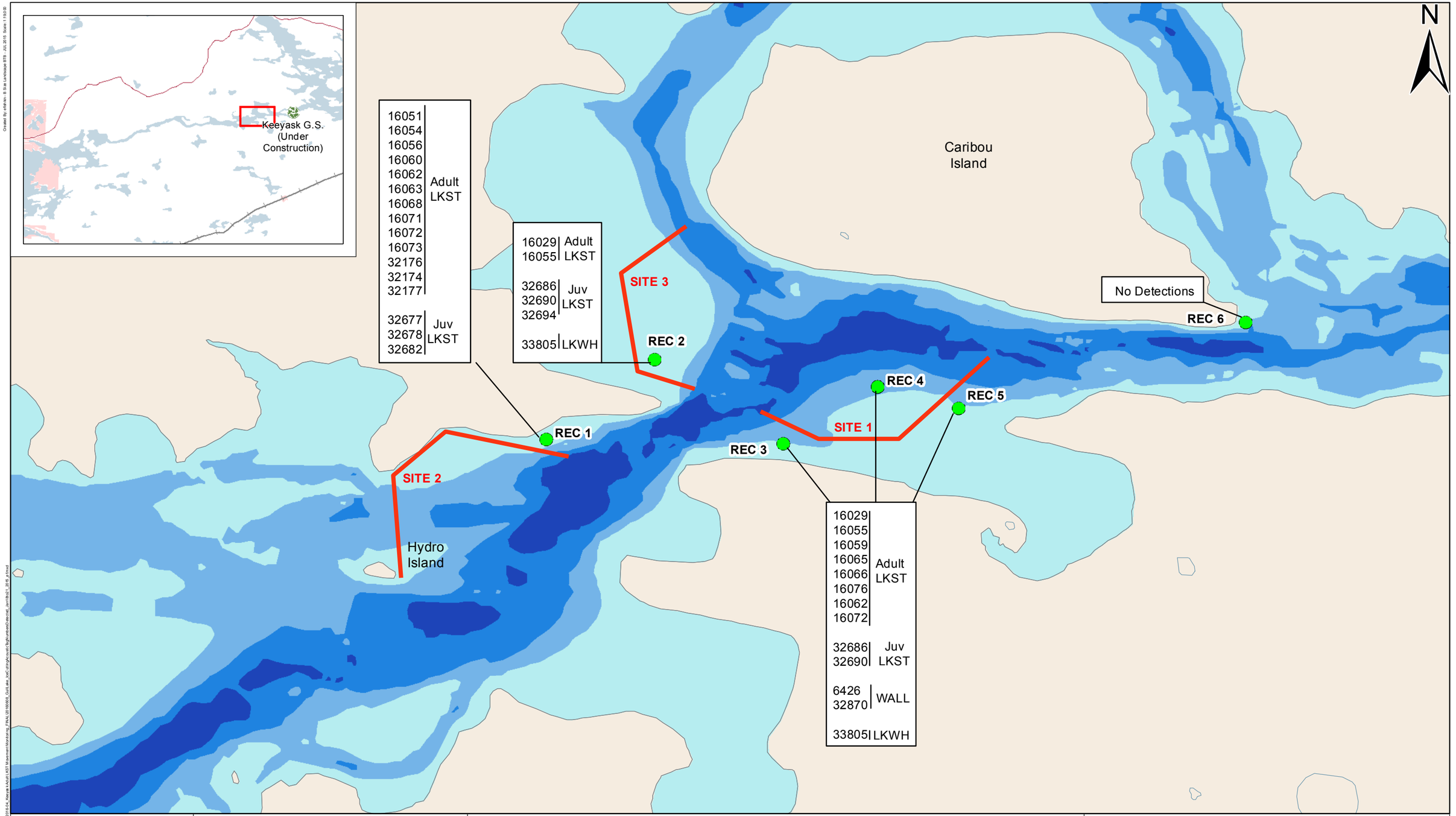
Walleye

Two Walleye (#6424, #6426, and #32870) were detected in January 2015 upstream of Gull Rapids using a manual hydrophone placed through the ice.

- Walleye #32870 has not been detected since it was tagged in June, 2013, and was thought to be a tagging mortality. It was located at a stationary receiver deployed at rkm -7.6, and during manual tracking.
- #6426 was located between rkms -7.6 and -7.5.

Lake Whitefish

One Lake Whitefish (#33805) was located at rkm -7.5 (near the upstream end of Caribou Island) for six detection days between January 15 and 21, 2015.



DATA SOURCE:
Government of Manitoba, Province of Manitoba, Manitoba Hydro
Note: Shows 95th percentile inflow

CREATED BY:
North/South Consultants

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	09-FEB-15	08-JUN-16
0 0.45 0.9 Kilometres / 0 0.35 0.7 Miles	VERSION NO: 1.0	QA/QC: CMP/YYY/ZZZ

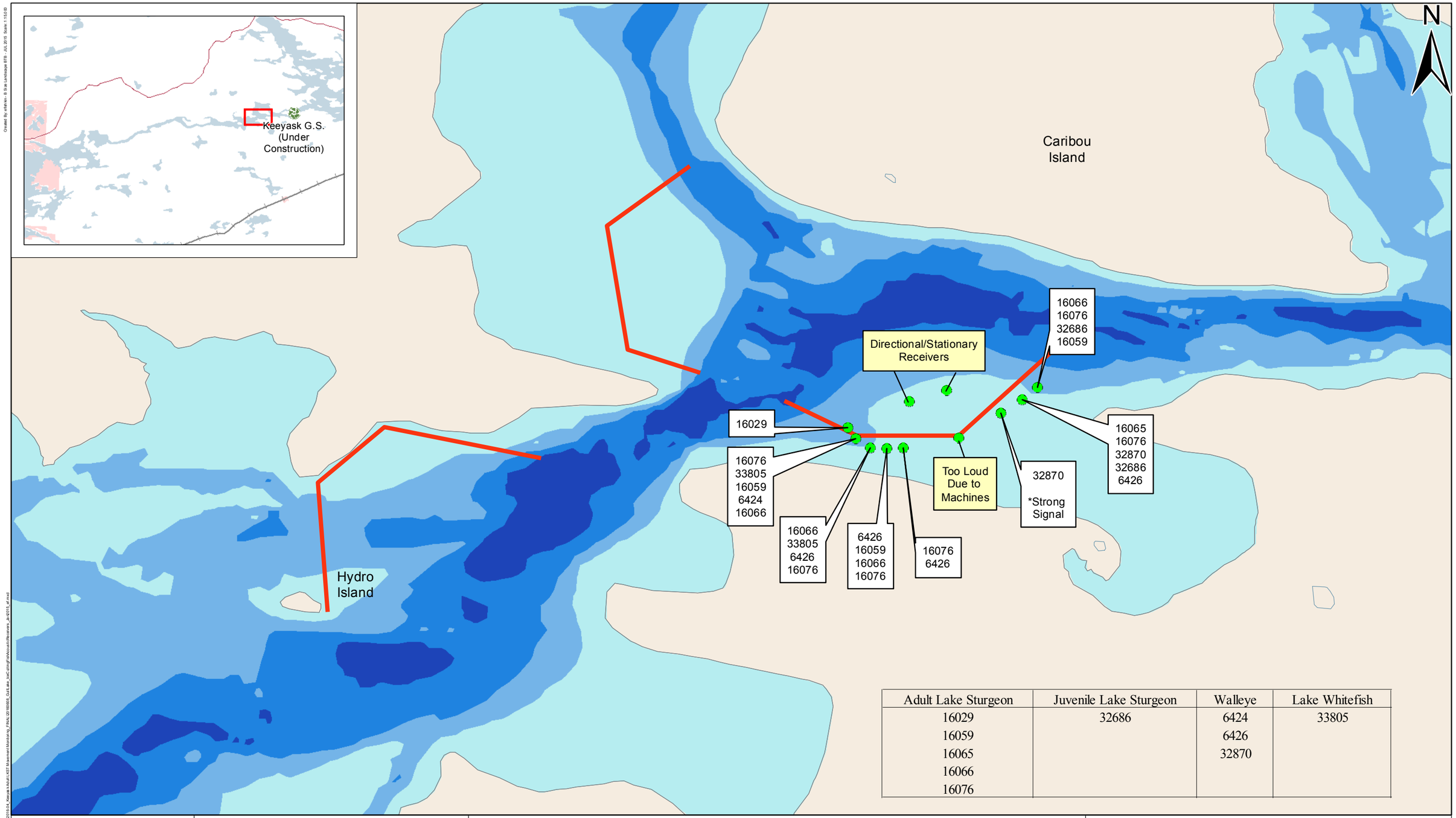
Legend

Depth (metres)
- 0 - 4
- 4 - 8
- 8 - 12
- 12 - 18
- 18 - 23

- Approximate Ice Cutting Location
- Generating Station (Existing)
- Generating Station (Under Construction)
- Highway
- Rail
- First Nation Reserve

Gull Lake Ice Cutting
Acoustic Tag Numbers Detected
January 18-21, 2015

Map A4-1: Fish detected at stationary receivers set in Gull Lake from January 18-21, 2015.



Adult Lake Sturgeon	Juvenile Lake Sturgeon	Walleye	Lake Whitefish
16029	32686	6424	33805
16059		6426	
16065		32870	
16066			
16076			

KEEYASK

DATA SOURCE:
Government of Manitoba, Province of Manitoba, Manitoba Hydro
Note: Shows 95th percentile inflow

CREATED BY:
North/South Consultants

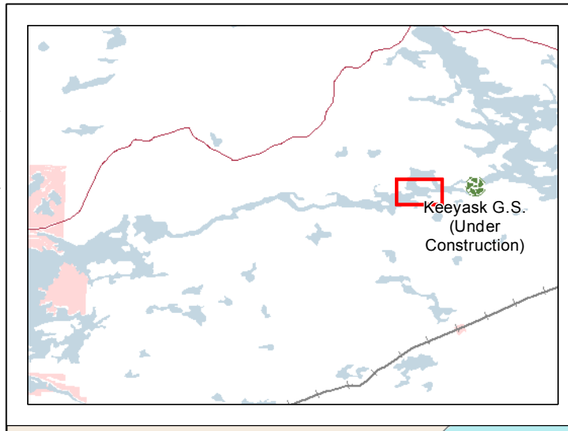
COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	09-FEB-15	08-JUN-16
0 0.45 0.9 Kilometres / 0 0.35 0.7 Miles	VERSION NO: 1.0	QA/QC: CMP/YYY/ZZZ

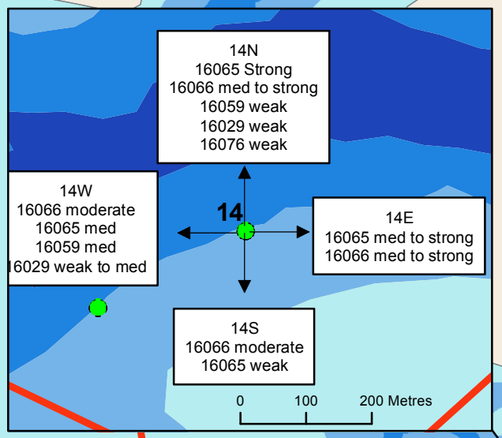
Legend
Depth (metres)
- 0 - 4
- 4 - 8
- 8 - 12
- 12 - 18
- 18 - 23

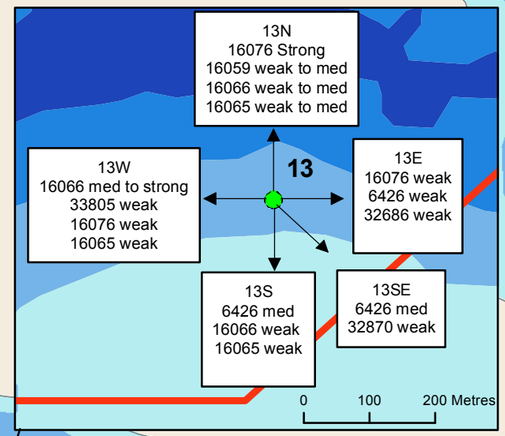
- Approximate Ice Cutting Location
- Generating Station (Existing)
- Generating Station (Under Construction)
- Highway
- Rail
- First Nation Reserve

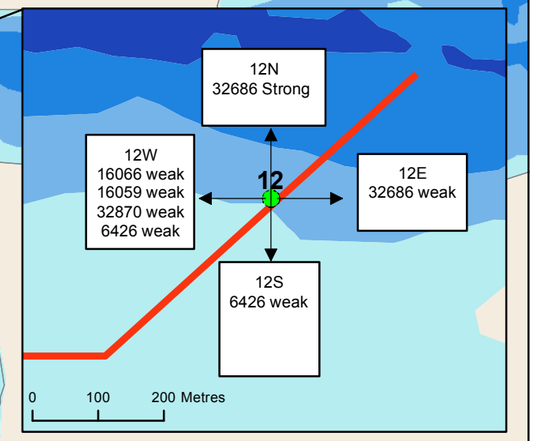
Gull Lake Ice Cutting Fish Acoustic Locations
January 2015

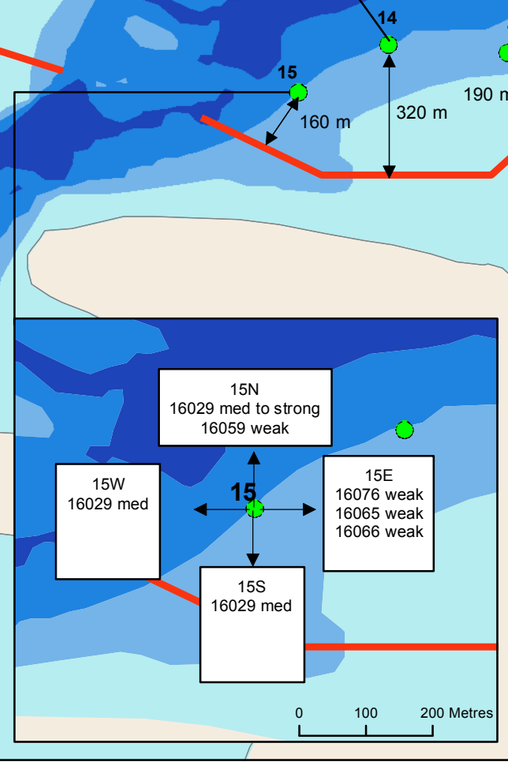
Map A4-2: Fish located during manual tracking conducted on January 15, 2015.











Adult Lake Sturgeon	Juvenile Lake Sturgeon	Walleye	Lake Whitefish
16029	32686	6424	33805
16059		6426	
16065		32870	
16066			
16076			

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DATA SOURCE:
Government of Manitoba, Province of Manitoba, Manitoba Hydro
Note: Shows 95th percentile inflow

CREATED BY:
North/South Consultants

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z14N	09-FEB-15	08-JUN-16
0 0.45 0.9 Kilometres / 0 0.35 0.7 Miles	VERSION NO: 1.0	QA/QC: CMP/YYY/ZZZ

Legend
Depth (metres)
- 0 - 4
- 4 - 8
- 8 - 12
- 12 - 18
- 18 - 23

- Approximate Ice Cutting Location
- Generating Station (Existing)
- Generating Station (Under Construction)
- Highway
- Rail
- First Nation Reserve

Gull Lake Ice Cutting Acoustic Fish Detections
January 16, 2015

Map A4-3: Fish located during directional manual tracking conducted on January 16, 2015.

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