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Seasonal Distribution and Movement of Lake Sturgeon in the Black Sturgeon River and Black Bay, Lake Superior

Upper Great Lakes Management Unit –
Lake Superior, Technical Report

AUTHOR

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EXECUTIVE SUMMARY

From 2003 to 2009 the seasonal migrations of ten sturgeon radio tagged in the Black Sturgeon River (downstream of the Camp 43 dam) were examined using shoreline based data loggers, manual tracking and two flights with an Astar helicopter. This study has shown that lake sturgeon from the Black Sturgeon River population (i) over-winter in Black Bay (ii) migrate into the Black Sturgeon River in the spring and early summer (iii) migrate upstream as far as the Camp 43 dam (iv) inhabit the river during the spring, summer and early fall; and (v) migrated from Black Bay into the Black Sturgeon River for up to 7 consecutive years which is inconsistent with spawning behaviour. This study demonstrates that tributary habitats likely provide opportunities for feeding or better thermal regimes in addition to spawning.

TABLE OF CONTENTS

List of Tables	i
List of Figures	i
List of Appendices	i
Introduction	1
Materials and Methods	3
Radio telemetry	3
Tracking (data loggers)	4
Tracking (manual)	5
Aerial survey 1	5
Aerial survey 2	5
Water temperature	6
Results	6
Telemetry	6
Movements	6
Fall winter	6
Spring summer.....	7
Discussion	8
References	10

LIST OF TABLES

Table		Pg.
1	Tracking method and location of data loggers from 2003 to 2009.	18
2	Tagging information for 10 lake sturgeon.	18
3	Years during which radio tagged lake sturgeon were detected in the Black Sturgeon River.	19

LIST OF FIGURES

Figure		Pg.
1	The Black Sturgeon River from Black Bay, Lake Superior to the Camp 43 dam.	13
2	Location of present (Camp 43) and historical dams along the Black Sturgeon River.	14
3	Flight path (dotted line) during the September 29, 2003 aerial survey.	15
4	Flight path (dotted line) during the April 19, 2004 aerial survey and location of three radio tagged sturgeon in Black Bay.	16
5	Location of tagging site, rapids (yellow circles) and radio telemetry data loggers along the Black Sturgeon River.	17

LIST OF APPENDICES

App.		Pg.
1	The seasonal movements of individual radio tagged sturgeon into and out the Black Sturgeon River in 2004.	19
2	The seasonal movements of individual radio tagged sturgeon into and out the Black Sturgeon River in 2005.	22
3	The seasonal movements of individual radio tagged sturgeon into and out the Black Sturgeon River in 2006.	22
4	The seasonal movements of individual radio tagged sturgeon into and out the Black Sturgeon River in 2007.	24

5	The seasonal movements of individual radio tagged sturgeon into and out the Black Sturgeon River in 2008.	25
6	The seasonal movements of individual radio tagged sturgeon into and out the Black Sturgeon River in 2009.	26
7	The seasonal movements of radio tagged lake sturgeon between Black Bay and the Black Sturgeon River from 2003 to 2009.	26
8	The period of immigration into the Black Sturgeon River and emigration into Black Bay as related to total river flows ($\text{m}^3 \cdot \text{s}^{-1}$).	29

INTRODUCTION

Lake Superior stocks of lake sturgeon (*Acipenser fulvescens*) declined in the late 18th century and into the early part of the 19th century (Ono et al. 1983). Three factors have been cited as reasons for the decline: physical impacts on spawning and nursery habitat, barriers to migration and over-fishing (Ferreri and Taylor 1999). Historic and current information indicate that at least 21 Lake Superior tributaries once supported lake sturgeon populations (Harkness and Dymond 1961; Slade and Auer 1997; Holey et al. 2000). To address this decline, the Lake Superior Technical Committee of the Great Lakes Fishery Commission produced a Lake Sturgeon Rehabilitation Plan for Lake Superior (Auer 2003). The goal for lake sturgeon rehabilitation is to maintain, enhance and rehabilitate self-sustaining populations where the species historically occurred basin-wide. The plan lists nine Lake Superior tributaries currently known to support self-sustaining lake sturgeon populations including the Black Sturgeon River.

The Black Sturgeon River is Lake Superior's seventh largest tributary, draining a watershed of approximately 2,980 km² before emptying into the north end of Black Bay (Figure 1). The river is approximately 100 km in length, has a mean annual discharge of 19 m³·s⁻¹ and originates at the outlet of Black Sturgeon Lake (Swainson 2001). Since 1960, however only 17 river kilometres (rkms) of the river has been accessible to Lake Superior's migratory fish species due to the construction of the Camp 43 dam (Figure 2). The lower 4 rkms of river is an example of a wave-dominated delta. The straight river channel is relatively deep (max 4.9 m) and was created as a result of predominant north-easterly waves moving the river's sediment uniformly along each shore of Black Bay (Sakamoto 2002) (Figure 3). Upstream from this the river is slow moving, has an average depth of 4.0 m and consists mainly of sand, silt and organic substrates. The first three sets of rapids are in close proximity to each other and commence approximately 8 rkms upstream from Lake Superior. Additional rapids are located just upstream of the Trans-Canada Highway and downstream of the

Camp 43 dam (Figure 3). Apart from these areas the river is deep and meandering with steep eroding banks.

Black Bay's surface area is approximately 60,000 ha of which 30% (18,000 ha) is less than 5 m deep and 50% (29,000 ha) is from 5 – 15 m in depth. Mean and maximum water depths are 8.3 m and 64.5 m respectively. The north end of the Bay is shallow while deeper water is largely restricted to a narrow channel in the southern two thirds of the bay. Substrates along the north-western shoreline of Black Bay are predominantly silts and clays with a minor component of sand (Biberhofer 2003).

The Black Sturgeon River watershed was utilized extensively for log drives from 1937 to 1965. Dams were constructed at various lake outflows to manipulate water levels. These lake outflows include: Eskwanonwatin Lake (the Camp 1 Dam was destroyed in a 1999 forest fire and partially removed), Black Sturgeon Lake (Split Rapids Dam - was completely removed in the 1980's), Shillabeer Lake, Sturge Lake, Little Sturge Lake, Leckie Lake, Fog Lake, and Muskrat Lake (Figure 2).

The Camp 43 dam (also known as the Twin Rapids dam) is the only remaining dam on the system and was constructed in 1959-60 approximately 16.3 km upstream from Lake Superior (Sakamoto 2002) (Figures 2).

This study was designed to examine the seasonal distribution and movement patterns of lake sturgeon inhabiting the Black Sturgeon River (downstream of Camp 43 dam) with access to Lake Superior.

MATERIALS AND METHODS

Radio Telemetry

Radio telemetry equipment manufactured by Advanced Telemetry Systems (ATS) was used in this study¹. Transmitters consisted of five 85 g tags (model F1855) with an expected battery life of 1095 d and five 25 g tags (model F1850) with a life of 475 d. Individual transmitters were identified by unique frequencies and operated within the 150.000 to 151.999 MHz band. Each transmitter had a 30 cm trailing whip antenna.

To capture sturgeon for tag implantation, multifilament gill nets in lengths of 45 and 73 m (50 and 80 yds) and mesh sizes of 254 mm (10") and 305 mm (12") were set overnight from June 23 to 25 and on August 27 in a pool that is 325 m downstream of the Camp 43 dam (approximately 16 km from the confluence with Lake Superior) (Figure 3). Mean daily river flows during the two netting periods were 17.4 and 29.9 m³·s⁻¹ respectively. Gear depth ranged from 2.3 m to 3.4 m.

All sturgeon were sampled for length (fork, total), weight, girth and were tagged with a five digit, white floy tag applied along the left hand side of the dorsal fin. Some of the captured fish were selected for transmitter placement such that internal tag weight would not exceed 2% of the fish's body weight. The surgical procedure for implanting radio transmitters was adapted from Martin et al. (1995) and Ross M. (1982) with the following modifications. A solution of 1.2 ml clove oil to 10.8 ml ethanol was used as an anesthetic. Fish were transferred to a cattle trough containing 60 l of water and 36 ml of the clove oil/ethanol solution to initially sedate each fish and to irrigate the fish's gills during surgery. A portable operating table, consisting of a foam-lined, v-shaped trough, was used to hold individual sturgeon during transmitter placement. A surgical scalpel was used to make a 5 cm incision just off midline, half way between the pectoral and pelvic fins, for insertion of the transmitter. An exit incision for the trailing whip antenna

¹ (Reference to trademark names does not imply endorsement by the Ontario government)

was created approximately 2 cm caudal to the main incision by inserting a hollow biopsy needle (#11 Jamshidi bone marrow biopsy/aspiration needle) into the abdominal cavity until the cutting end was visible in the main incision. The antenna was threaded into hollow needle until it exited the body and the tag was gently inserted into the abdominal cavity. The main incision was closed with four individual sutures using Ethicon absorbable nylon thread and cutting needles. Radio tagged fish were allowed to recover in a flow-through trough situated in the river before being released at the capture site.

Tracking

Data Loggers

Shoreline based data loggers (model R4500) were used to track the movements of radio tagged sturgeon as they migrated into and out of the Black Sturgeon River. These systems consisted of a switch box, two directional antennas, a 12-volt deep cycle marine battery and a solar panel. The two antenna system was used to interpret the direction of fish movement as one antenna was facing upstream and the other was facing downstream. A data logger operated at the mouth of the Black Sturgeon River (logger 1) from 2003 to 2009 and additional loggers were installed in 2006 at the “landing” (logger 2 - 7.6 rkm from the mouth), “railway” (logger 3 - 12.3 rkm from the mouth) and the Camp 43 dam (logger 5 - 16.3 rkm from the mouth) (Figure 3 and Table 1). In 2007 the logger that was at the railway crossing in 2006, was moved to the highway (logger 4 -14 rkm from the mouth), where it operated until 2009 (Figure 3). To verify daily logger function, a reference transmitter was placed in the river at each location and its frequency was recorded (by the logger) every six hours. From 2003 to 2005 loggers were installed in the spring and removed in the fall. In 2006 the loggers were installed in the spring and allowed to run continuously until October of 2009 when all systems were removed.

Manual

During the open water season, sturgeon movements between the Camp 43 dam and Black Bay were also monitored using a portable receiver (R2100) and a hand held yagi antenna (manual tracking). The lower 9 kms of the river were surveyed by boat. The remainder of the river was monitored on foot at a number of road accessible sections, namely the Camp 43 dam, Highway 11/17 bridge, the railway bridge and the washout pool approximately 8.2 rkms from Lake Superior. Manual tracking took place on land and by boat in 2003, 2004, 2006 and 2007 but did not occur in 2005, 2008 and 2009 (Table 1).

Aerial Survey 1

Aerial surveys were carried out on September 29 and 30, 2003 via helicopter (Astar). Tracking was carried out from the sea lamprey barrier on the Wolf River to Lake Superior; from the mouth of the Black Sturgeon River to the Camp 43 dam; from the mouth of the Black Sturgeon River east around Delaney and Scimming Islands; from Ham point up the eastern shore of Black Bay over to Shesheeb Bay; from Brodeur Island, around Edward Island across Black Bay and end north of Green Island (Figure 4).

Aerial Survey 2

Another flight was carried out on April 19, 2004. The flight commenced at the mouth of the Black Sturgeon River where the reference transmitter was detected to ensure the tracking equipment was operational. We proceeded 16 km upstream to the Camp 43 dam and then turned back downstream to the mouth. We then flew along to the east shore to Ham Point, turned around along the same tracking route and proceeded to the western shore until Dorion was reached. Two more passes from Dorion to Ham point were flown as well as an additional pass back upstream to the dam (Figure 5). Black Bay was frozen over with ice.

Water Temperature

Water temperature was recorded hourly at the highway 11/17 bridge using a Vemco Minilog -T data logger. The logger was located on the east side of the river in 0.5 m of water.

RESULTS

Telemetry

Ten radio transmitters were implanted into lake sturgeon ranging in total length from 82.9 -110.5 cm (Table 2). The 25 g transmitters (n=5) were applied on June 23 and August 28. The 85 g transmitters (n=5) were applied from June 24 to 26. Complete tracking records were obtained for eight fish that migrated into the Black Sturgeon River on consecutive years that ranged from 3 to 7 (Table 3). Partial records were obtained for two fish (150.474 and 150.146) that migrated out of the Black Sturgeon River in late September 2003 (Table 3). Frequency 150.474 was located in Black Bay during the aerial survey in 2004 (Figure 5). By the end of 2006 the battery life of the 25 gram tags had expired. Data was collected from the 85 gram tags up to the end of October 2009.

Movements

Fall and winter

Radio tagged lake sturgeon utilize Lake Superior (Black Bay) as an over wintering site. After being radio tagged in the vicinity of the Camp 43 dam in June and August of 2003, the data logger at the mouth recorded all ten radio tagged sturgeon migrating out of the river from August 30 to October 11, 2003 (Appendix 1). Two of these fish were located near the dam during the aerial survey on September 29, 2003. During the late winter aerial survey on April 19, 2004 no fish were located in the Black Sturgeon River between the dam and the mouth but three were located in the northern portion of Black Bay. One fish was near the mouth of Coldwater Creek (150.184), one was near the mouth of the Wolf River (150.474) and the other was east of the Black Sturgeon River mouth (150.325) (Figure 5). The late summer / early fall out migrations that were

documented in 2003 are presumed to be typical (i.e. not due to stress from internal tag placement) as similar behaviour was noted throughout the study for every fish that spent the summer in the river. The only exception was frequency 150.123 that was not recorded moving downstream from its last recorded position at the Camp 43 dam in 2006 (Appendix 3). This may be due to the battery life ending while the fish was at this location or the fish being removed from the river. Out migrations from the river to Black Bay ranged from July 26 to November 11 and tended to occur during periods of receding river flows (Appendix 7). The mean daily flow on the date that fish out-migrated from 2004 to 2008 was $18 \text{ m}^3 \cdot \text{s}^{-1}$.

Spring and summer

From 2003 to 2009, radio tagged lake sturgeon that over-wintered in Black Bay migrated into the Black Sturgeon River from April 17 to July 7 and most spent the duration of the summer in the river (Appendix 1 to 7). During their upstream migrations, lake sturgeon moved past the stationary loggers at the mouth and boat launch relatively quickly, with most being recorded for less than 12 hrs. In some instances fish moved past these loggers too quickly to be detected. The mean daily flow on the date that fish migrated into the river (2004 to 2008) was $56 \text{ m}^3 \cdot \text{s}^{-1}$ (Appendix 7). River water temperature during these upstream movements ranged from 3.5 to 18.1°C. In 2006, when movements were monitored with four loggers (mouth, launch, railway and dam) it took from 1 to 2 d for sturgeon to move 12.4 kms upstream from the mouth to the railway logger. From 2007 to 2009, when movements were monitored with four loggers (mouth, launch, highway and dam) it took from 5 to 40 d for sturgeon to move 16.3 kms upstream from the mouth to the camp 43 logger.

The Camp 43 dam was the furthest point of upstream migration documented by manual and stationary tracking methods (Appendix 1 to 7). Over the course of this study all size ranges of radio tagged fish (83 – 111 cm) were detected at this site. The dam data logger detected sturgeon in the spring, summer and fall with

the earliest detection on May 26, 2007 and the latest on October 29, 2007 (Appendix 4). Fish were at this site in consecutive years (i.e. 150.245) and extended periods of residency at this location were common. The number of consecutive days the stationary logger recorded sturgeon in the vicinity of the Camp 43 dam ranged from 3 to 73 d during water temperatures that ranged from 7.2 to 23.9°C. Using manual tracking gear, we determined that sturgeon being detected by the logger were often located in a large pool approximately 325 m downstream of the dam or in the pool approximately 80 m downstream of the dam. During manual tracking at the dam, visual observations of non radio tagged sturgeon in the bedrock “pools” and directly below the face of the dam was also documented.

From 2007 to 2009, two lake sturgeon (150.245 and 150.325) were detected by the stationary logger at the highway, for extended periods (Appendix 4 to 7). Fish 150.245 was at the highway from July 1 to 16, 2007 during mean daily water temperature of 19.2°C and from May 15 to 31, 2008 during mean daily water temperature of 9.7°C. In 2009 this fish was at the highway from June 24 to August 11. Fish 150.325 was at the highway from May 28 to July 12, 2008 during mean daily water temperature of 12.3°C. The number of consecutive days that fish were recorded at this location ranged from 5 to 20 d during water temperatures that ranged from 7 to 20.9°C. In one instance, a fish migrated upstream from Black Bay and remained at the highway for an extended period (150.325 in 2008) while in other instances fish migrated to the dam and dropped back downstream to the highway (i.e. 150.245 in 2007) for an extended period.

DISCUSSION

Fish migrate to optimize feeding, avoid unfavourable conditions and (or) to optimize reproductive success (Auer 1996). Although sex and age information were not collected during this study, we speculate from the total length data (82.9 – 110.5 cm) that our radio tagged fish may have been immature fish. In the Bad

River WI, mature males averaged 120 cm total length while females averaged 148 cm (Slade and Auer 1997). According to the growth equation established for sturgeon in the Kaministiquia River ($\text{Age} = 5.3969(L) + 23.123$) a 100 cm sturgeon is approximately 14 years old (Stephenson 1988). Given the late age of first maturity reported by Scott and Crossman (1973) (20 years for males and 25 years for females) and Mosindy and Rusak (1991) (16.8 years for males and 25.8 years for females) it appears that the migrations into the Black Sturgeon River, for the most part were likely not for spawning. Lake sturgeons are intermittent spawners, are known to ascend rivers to access spawning habitat and do so on an infrequent basis according to gonad maturity (Mosindy and Rusak 1991) (Priegel and Wirth 1977). In this study, lake sturgeon migrated from Lake Superior into the Black Sturgeon River for up to 7 consecutive years (150.245) which is inconsistent with spawning behaviour. This suggests the sturgeon in this study were taking advantage of some other opportunity (such as feeding) available in the riverine environment. Auer (1996) states that lake sturgeon may utilize several different habitat types over the course of their life and that juvenile habits are least understood. It is possible that the movements from Black Bay to the Black Sturgeon River are indicative of a riverine phase to their life cycle. The small size of the fish and the fact that many were in the river after the typical spawning period also suggests they migrated to this location for reasons other than spawning.

The extended periods of residency in the vicinity of rkm 14 (highway 11/17) may indicate a preference for the habitat at this location. Sturgeon were often located upstream of the highway where a 225m stretch of rapids empties into a large pool. In 2007, after migrating to the camp 43 dam, fish 150.245 moved downstream to the pool and remained there from July 1 to 16. It was also at this location from May 15 to 30, 2008 when water temperatures ranged from 7 – 13.3°C and throughout the summer of 2009 when water temperatures ranged from 17.3 to 20.9°C.

The habitat in the vicinity of the Camp 43 may also be important to lake sturgeon. This is evidenced by the extended periods of residency noted throughout the entire open water season and the fact that sturgeon have been captured at this site during previous index netting assessments carried out from 2002 – 2004 (Friday 2004a). This site may be suitable for spawning since there are rapids downstream of the dam and a large pool exists further downstream that may offer refuge while mature fish are staging prior to spawning. Harkness and Dymond (1961) also chronicle accounts of sturgeon “congregating in a pool or hole after reaching the vicinity of the spawning site and remaining there until certain temperature and perhaps other conditions are suitable”. Spawning sturgeons are also known to congregate in the plunge pool at the base of Kakabeka Falls prior to spawning (Friday 2004b).

The seasonal migrations between Black Bay and the Black Sturgeon River documented in this study demonstrate the importance of tributary habitat to lake sturgeon during the entire open water season. Although the use of tributaries for spawning has been well documented (Slade and Rose 1994; Auer 1995; Friday 2004) it is apparent that riverine environments also provide other opportunities, (such as feeding) that are important to sturgeon.

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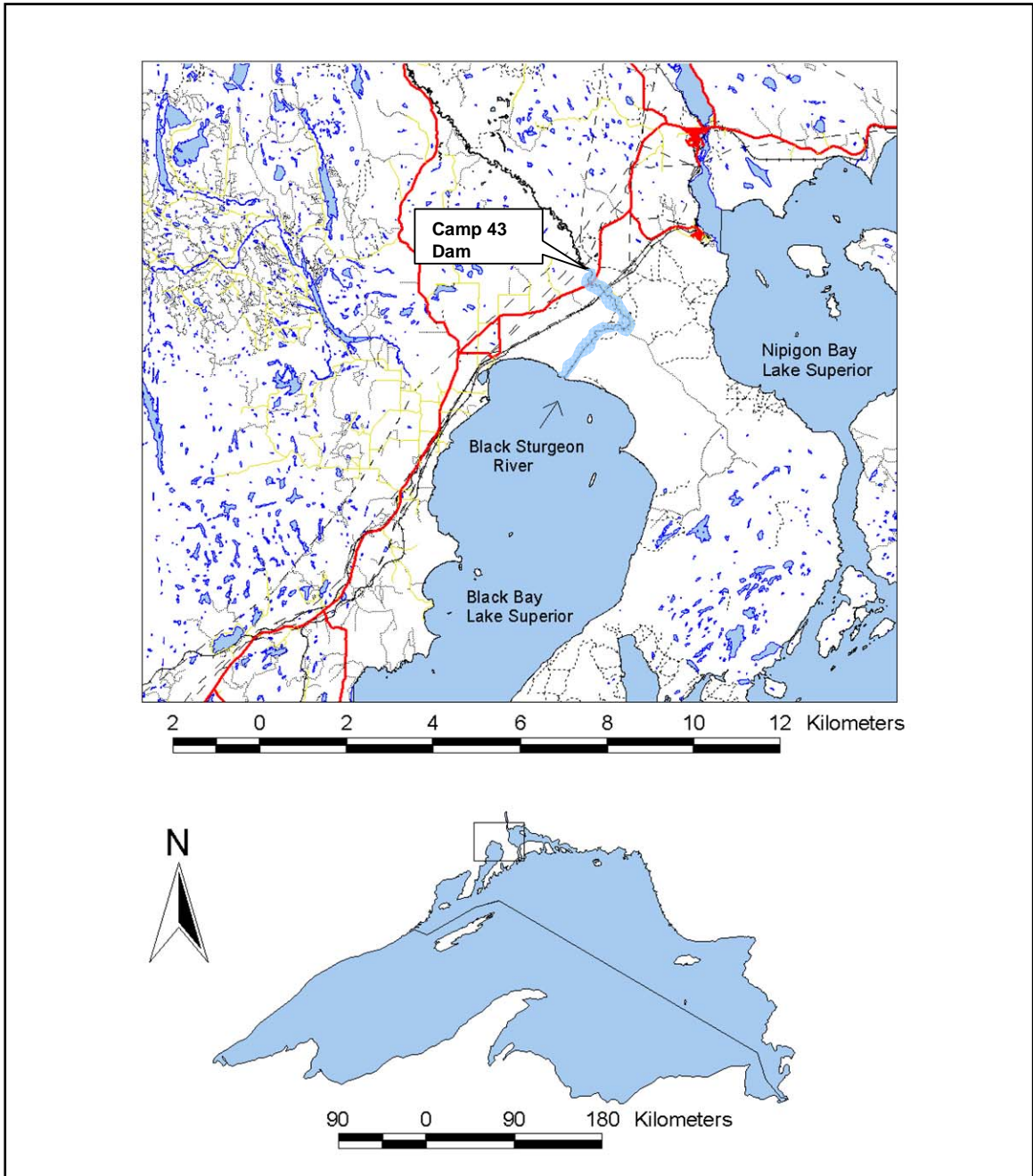


Figure 1. The Black Sturgeon River and Black Bay study area with respect to Lake Superior.

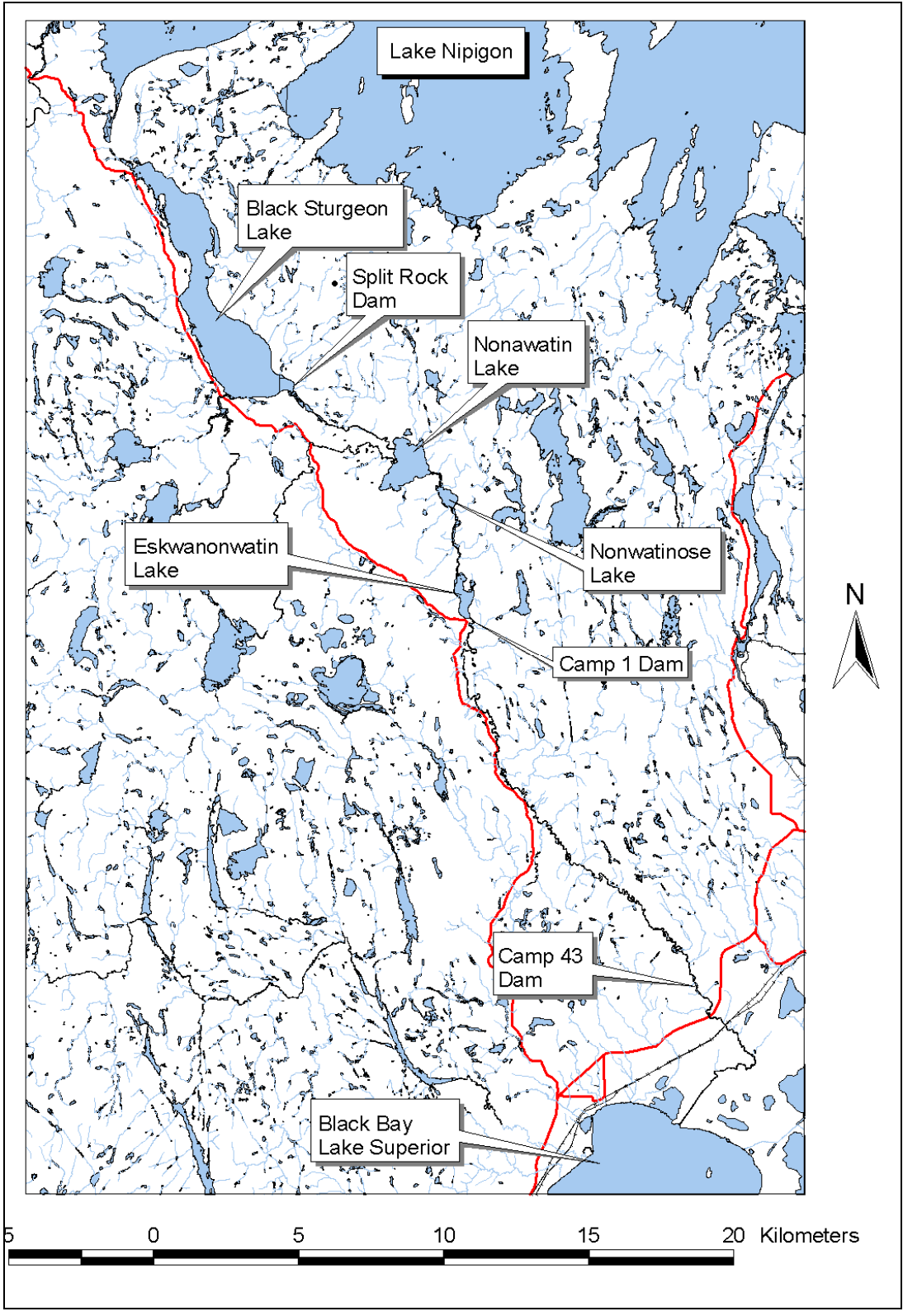


Figure 2. Location of present (Camp 43) and historical dams along the Black Sturgeon River.

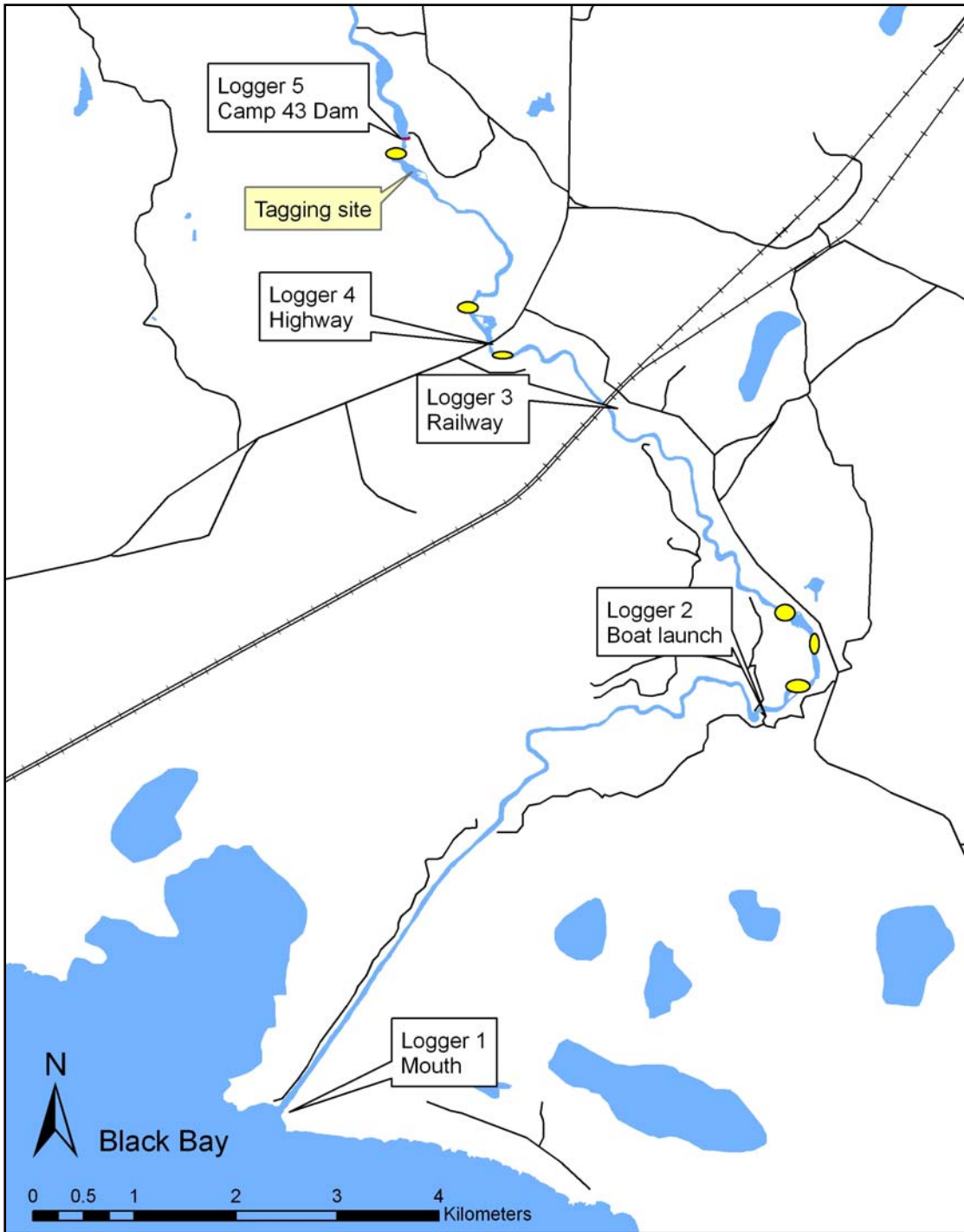


Figure 3. Location of tagging site, rapids (yellow circles) and radio telemetry data loggers along the Black Sturgeon River.

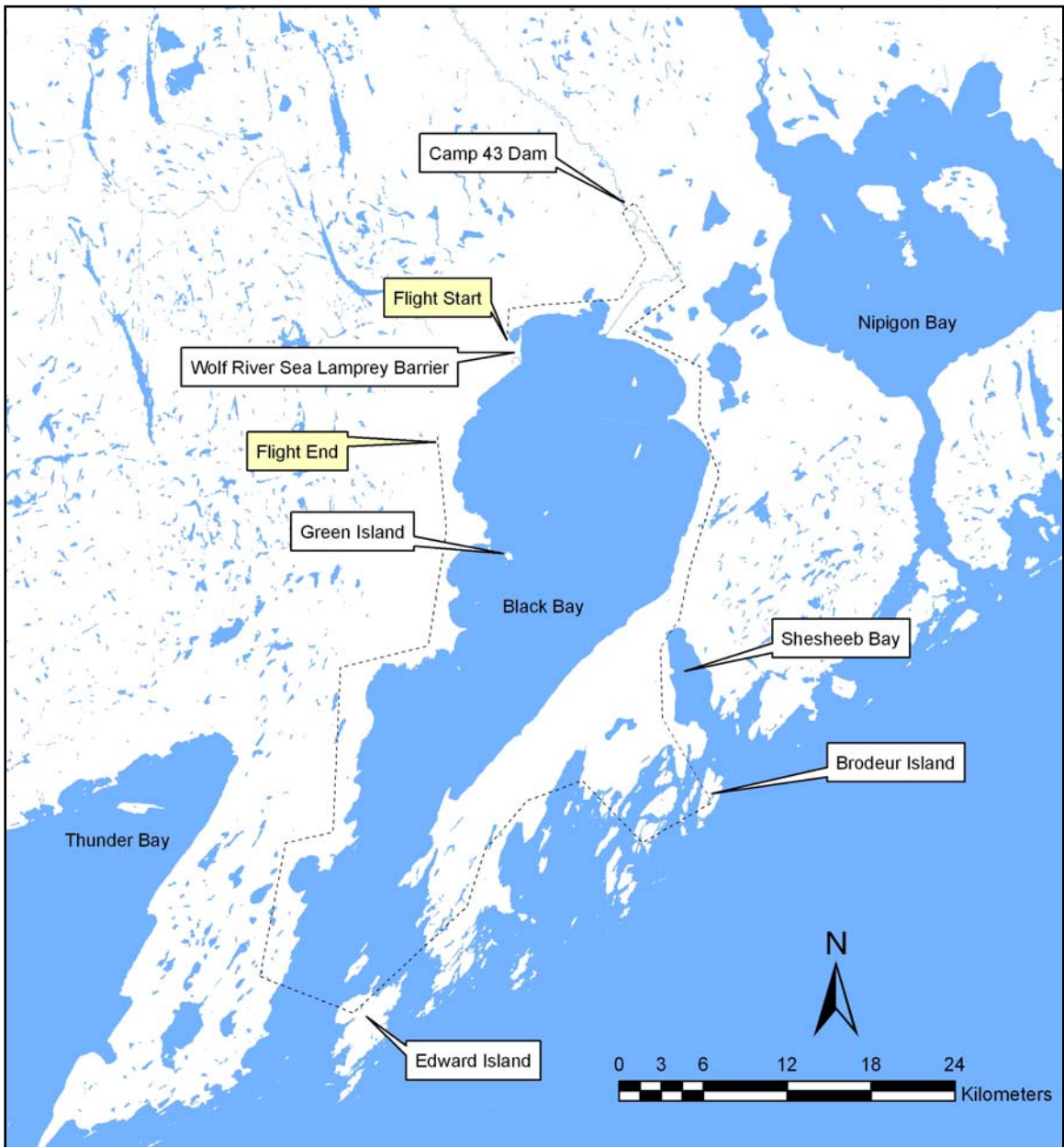


Figure 4. Flight path (dotted line) during the September 29, 2003 aerial survey.

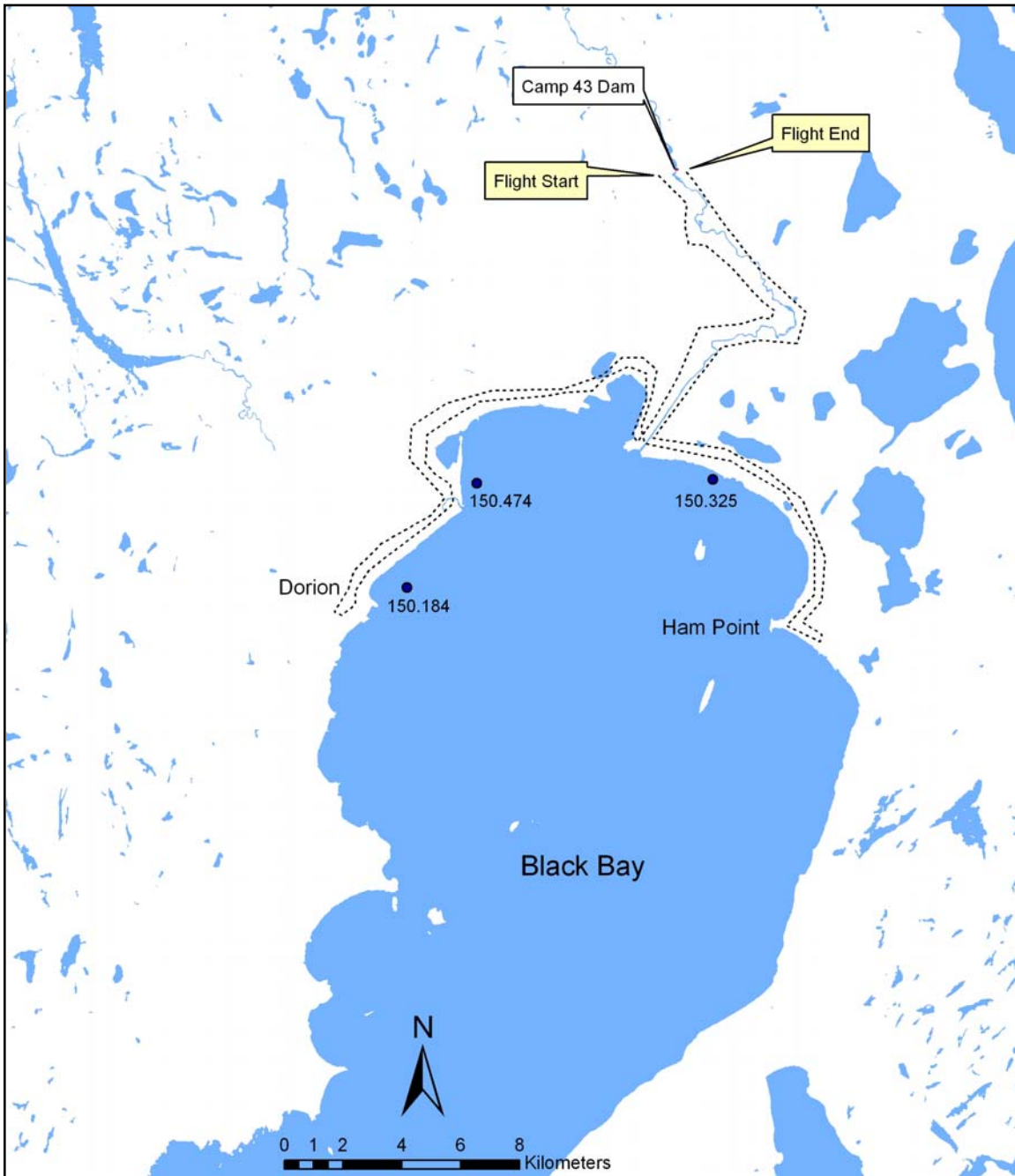


Figure 5. Flight path (dotted line) during the April 19, 2004 aerial survey and location of three radio tagged sturgeon in Black Bay.

Table 1. Tracking method and location of data loggers from 2003 to 2009.

Tracking Method	2003	2004	2005
Logger	Mouth	Mouth	Mouth
Operating time	July 7 – Oct 29	Apr 6 – Oct 5	Apr 15 – Oct 10
Land based (manual)	yes	yes	no

Tracking Method	2006	2007	2008	2009
Logger	Mouth Launch Railway Dam	Mouth Launch Highway Dam	Mouth Launch Highway Dam	Mouth Launch Highway Dam
Operating time	Apr 10 – Oct 18	Apr 2 –	continuous	Removed Oct 22 - 23
Land based (manual)	yes	yes	no	no

Table 2. Tagging information for 10 lake sturgeon.

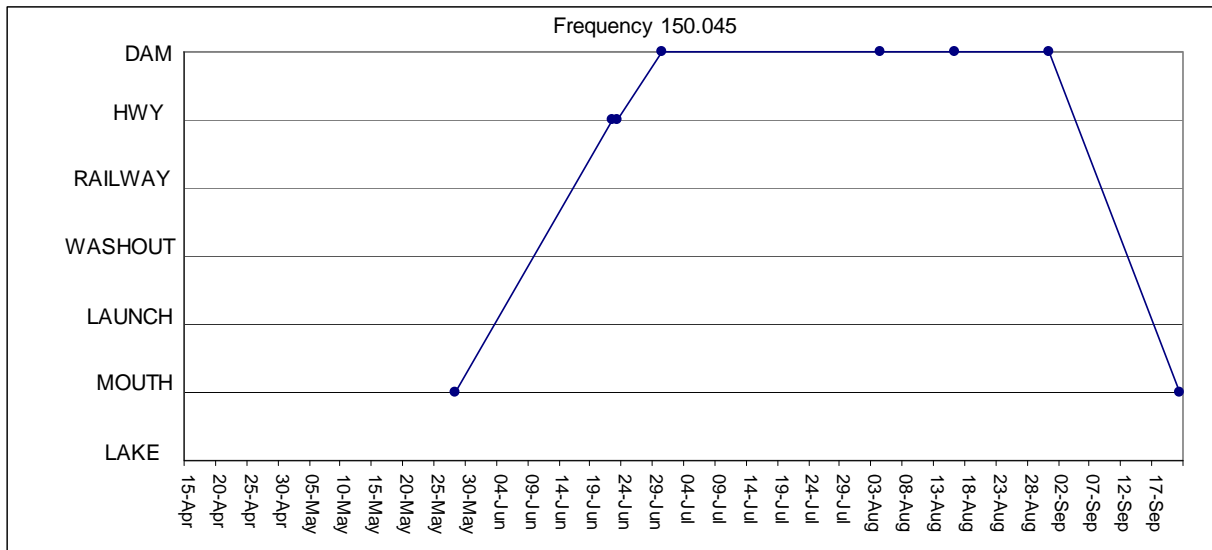
Frequency (MHz)	Tag weight (g)	Tag life (yrs)	Tlen (cm)	Rwt (kg)	Tag date
150.045	25	1.3	82.9	3	24-Jun-03
150.224	85	3	104.7	6.6	24-Jun-03
150.245	85	3	91.5	7.4	25-Jun-03
150.384	85	3	97.5	8.2	25-Jun-03
150.325	85	3	106.7	9.7	26-Jun-03
150.474	85	3	102.8	8.5	26-Jun-03
150.084	25	1.3	102.9	6.9	28-Aug-03
150.123	25	1.3	105	7.5	28-Aug-03
150.146	25	1.3	100.5	5.8	28-Aug-03
150.184	25	1.3	110.5	8.5	28-Aug-03

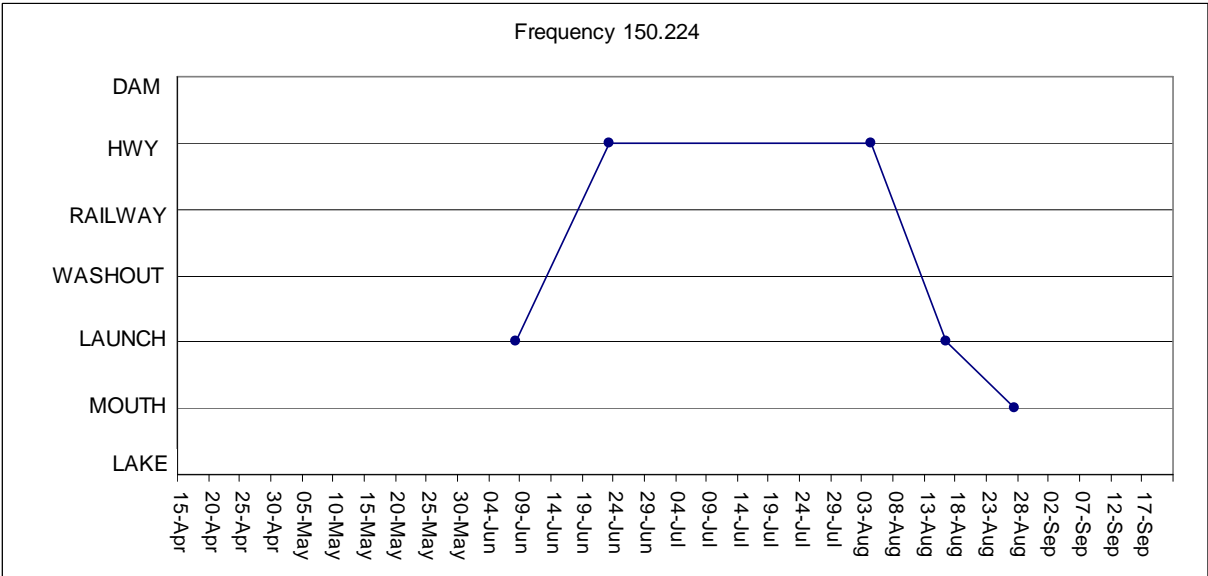
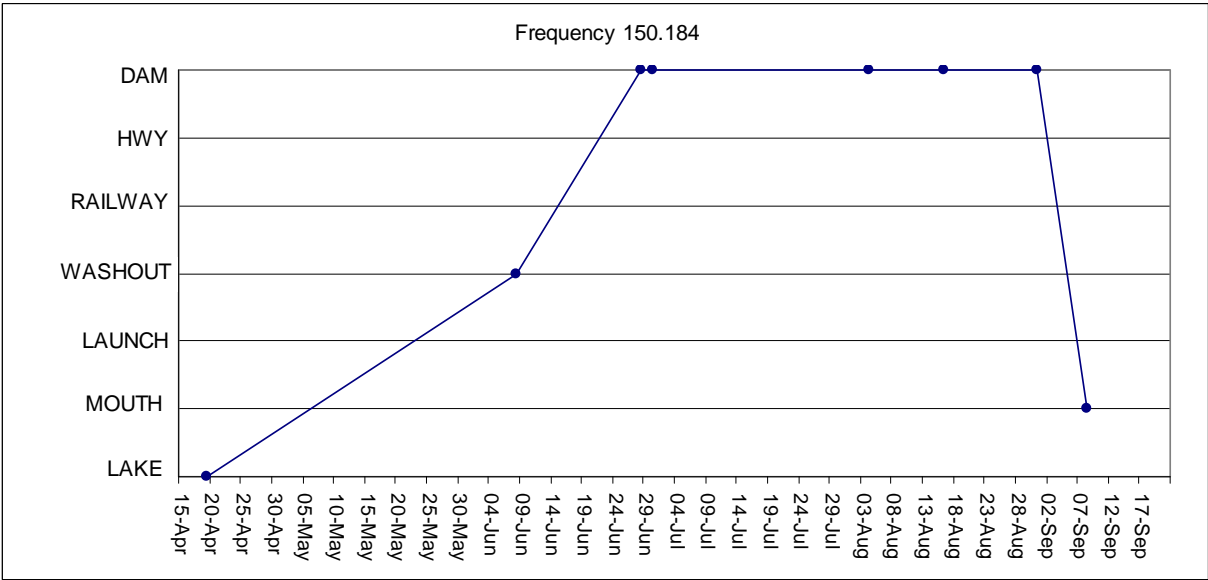
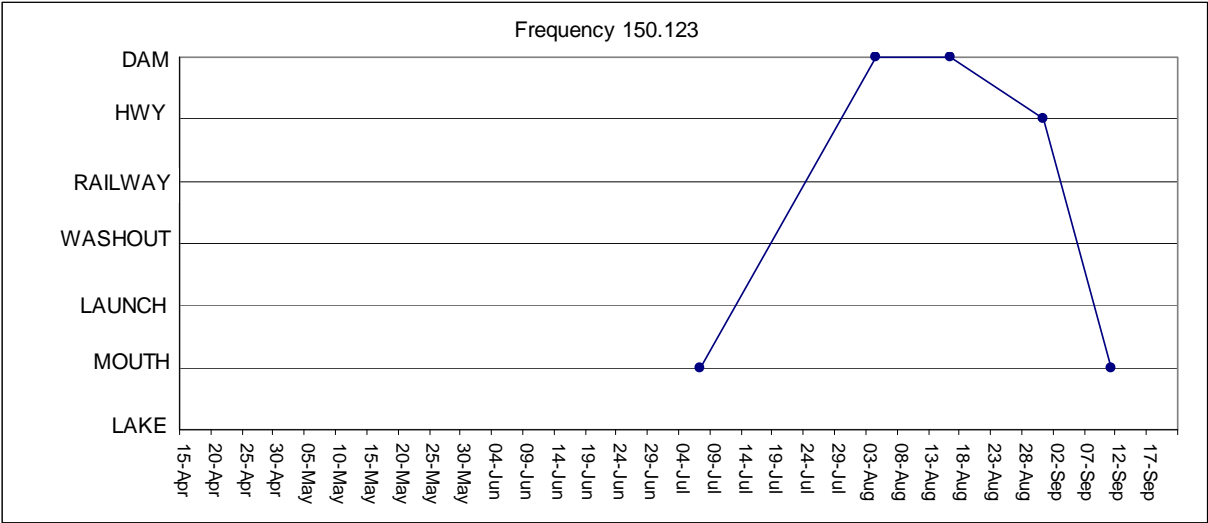
Table 3. Years during which radio tagged lake sturgeon were detected in the Black Sturgeon River (indicated with an x).

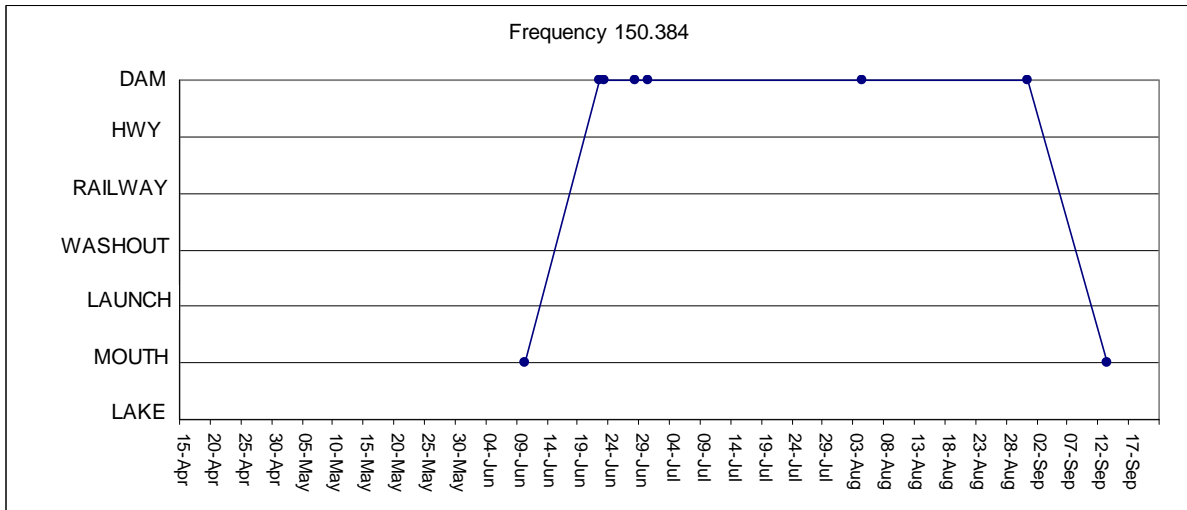
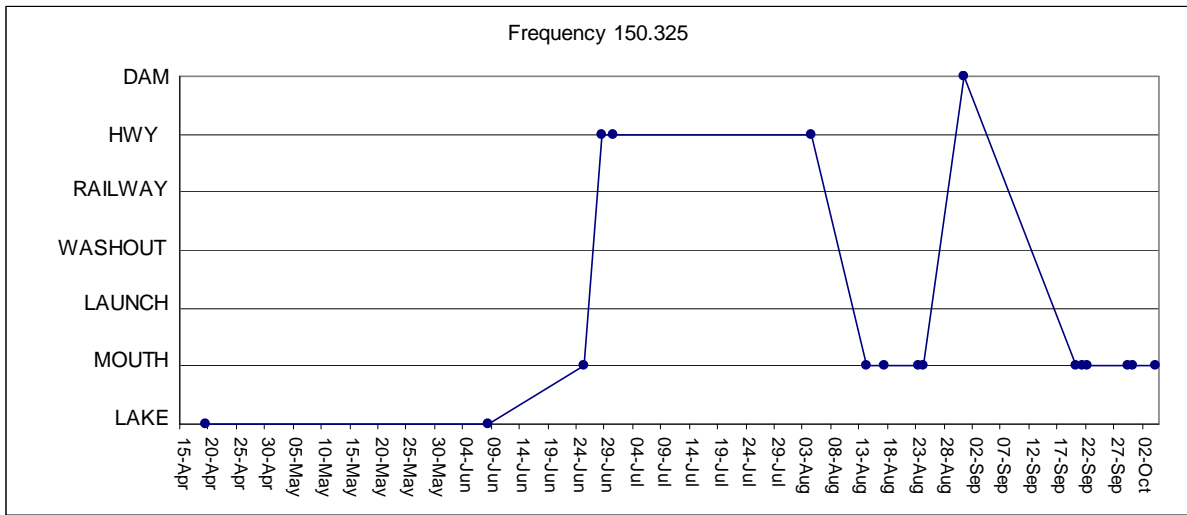
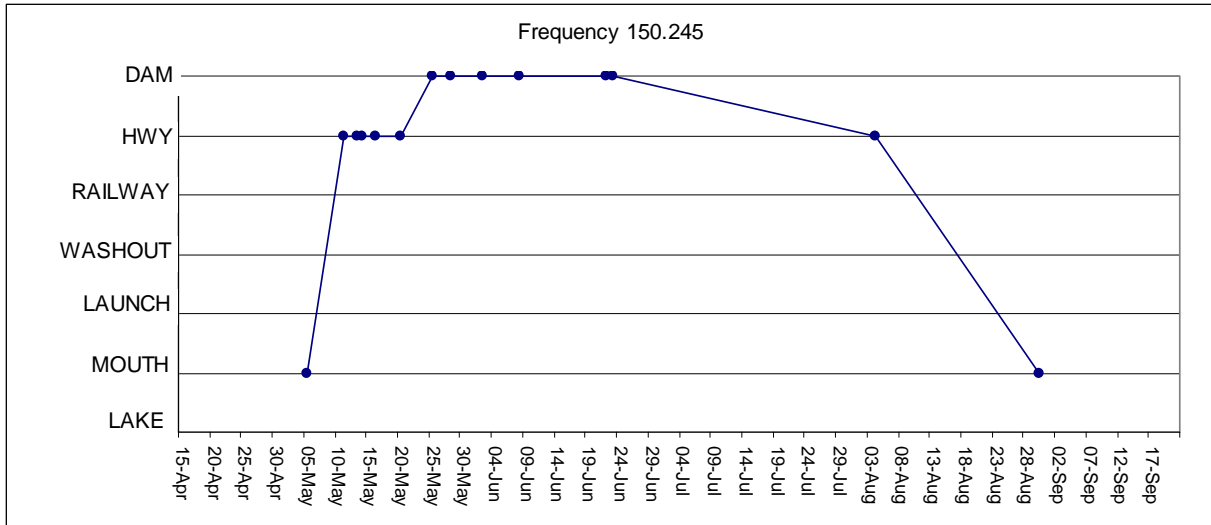
Tag size (g)	Frequency	2003	2004	2005	2006	2007	2008	2009
25	150.045	x	x	x	x			
25	150.084	x	x	x	x			
25	150.123	x	x	x	x			
25	150.146	x						
25	150.184	x	x	x	x			
85	150.224	x	x	x				x
85	150.245	x	x	x	x	x	x	x
85	150.325	x	x	x	x	x	x	
85	150.384	x	x	x				
85	150.474	x						

APPENDIX 1

The seasonal movements of individual radio tagged sturgeon (by MHz) into and out the Black Sturgeon River in 2004. Data points represent locations made by land tracking and detections made by the data logger at the mouth of the River.

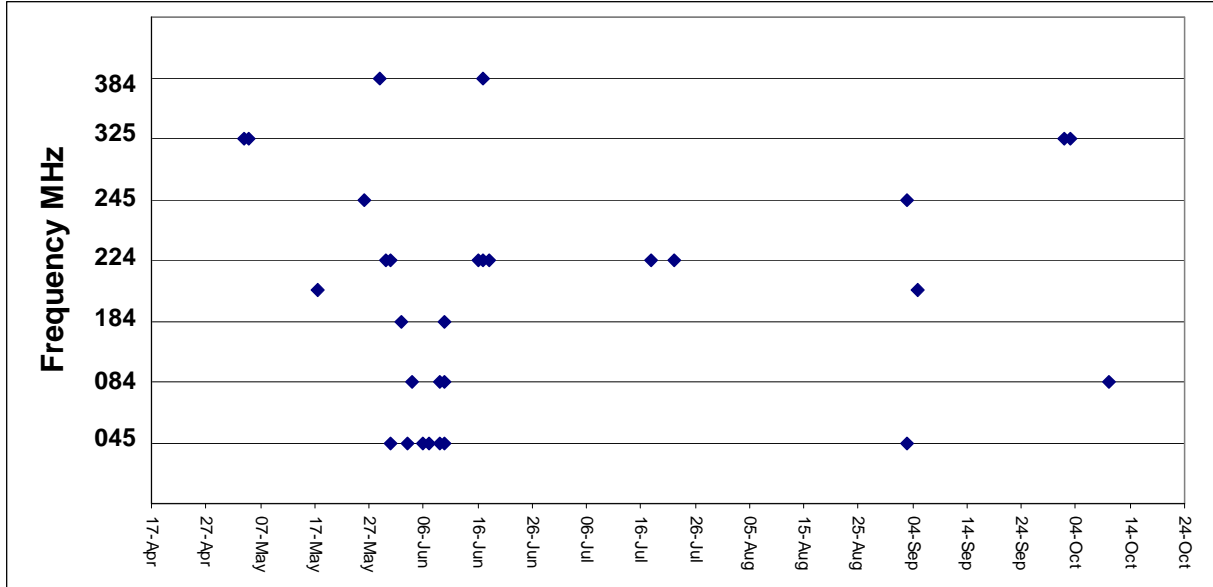






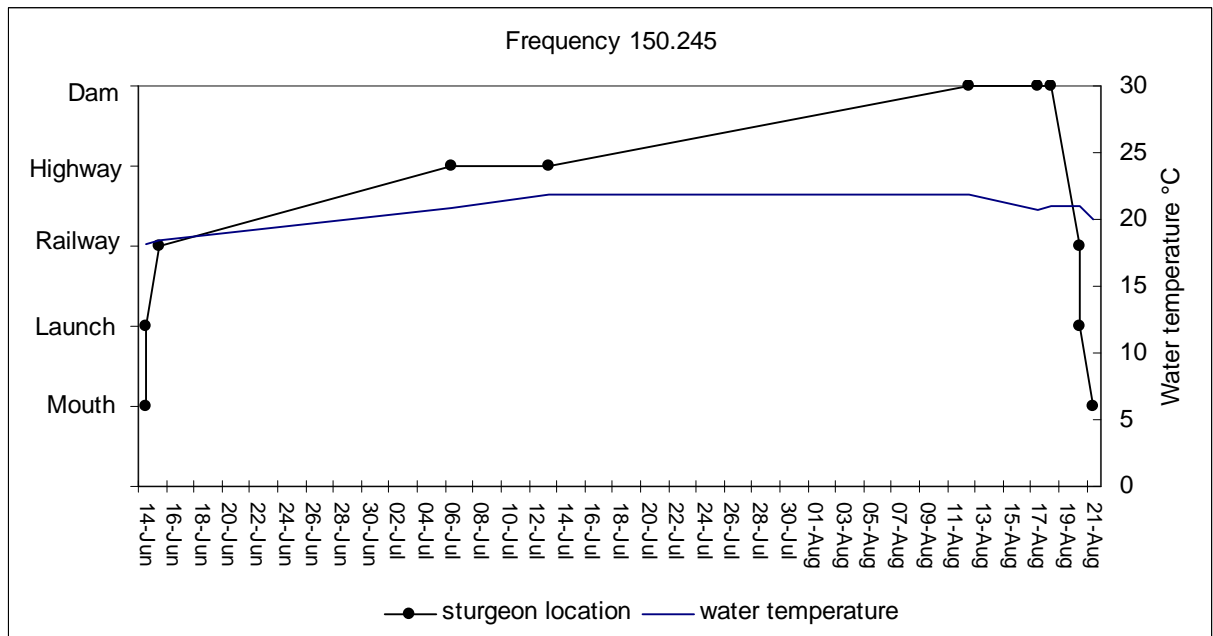
APPENDIX 2

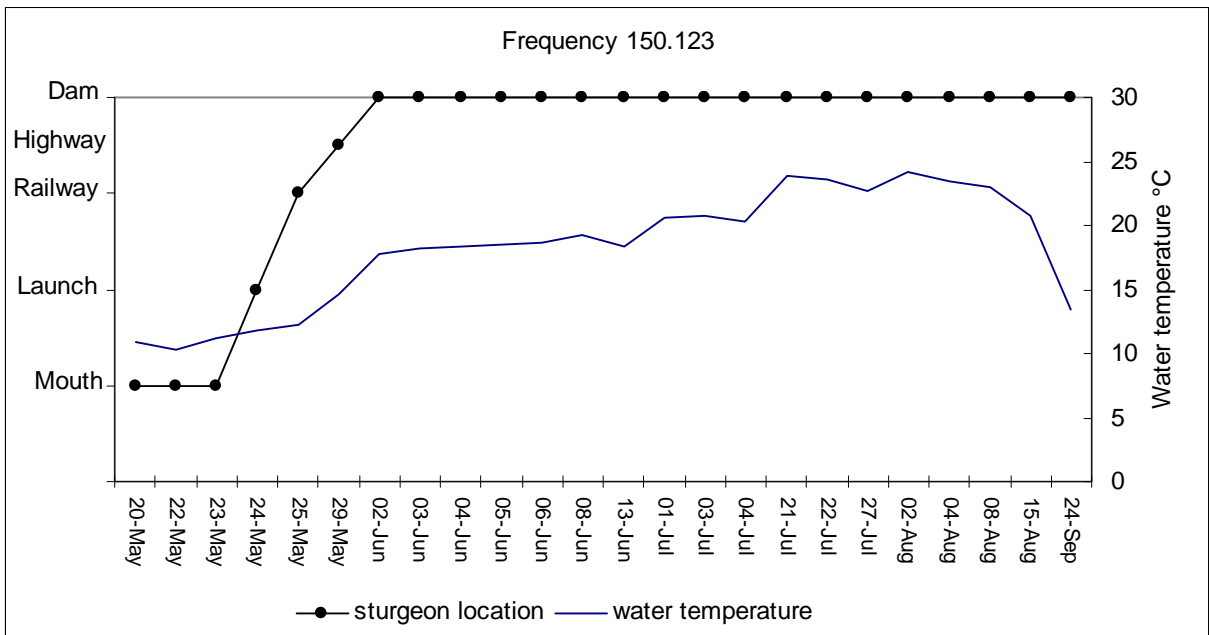
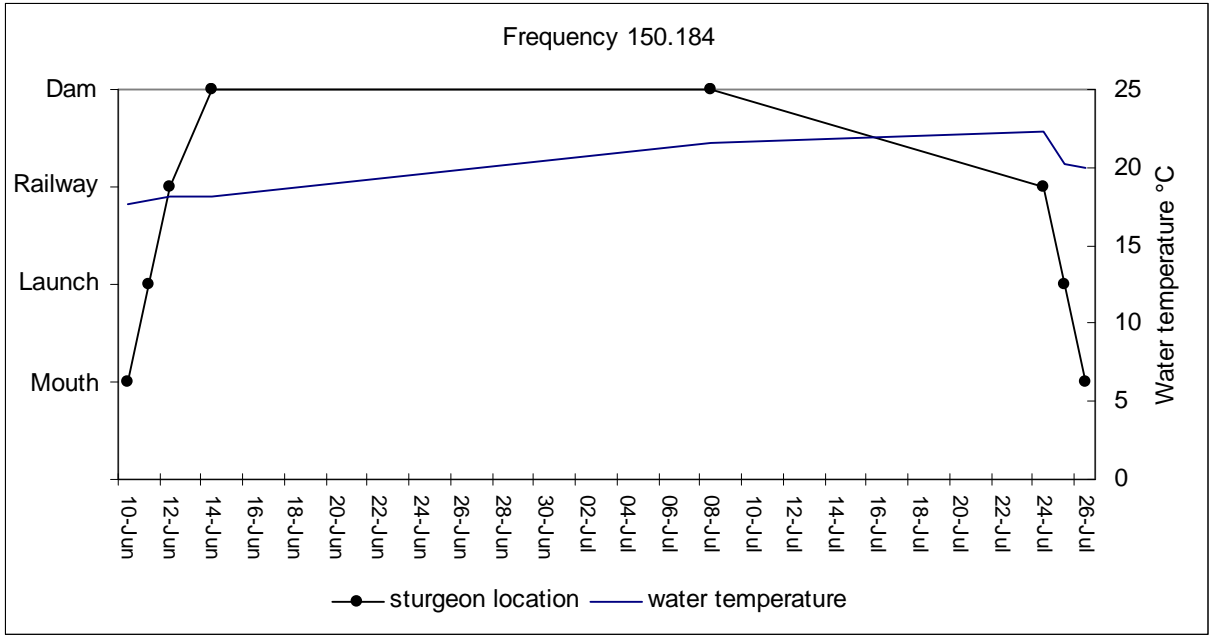
The seasonal movements of individual radio tagged sturgeon (by MHz) into and out the Black Sturgeon River in 2005. Data points represent detections made by the data logger located at the mouth. No land tracking was carried out in 2005.



APPENDIX 3

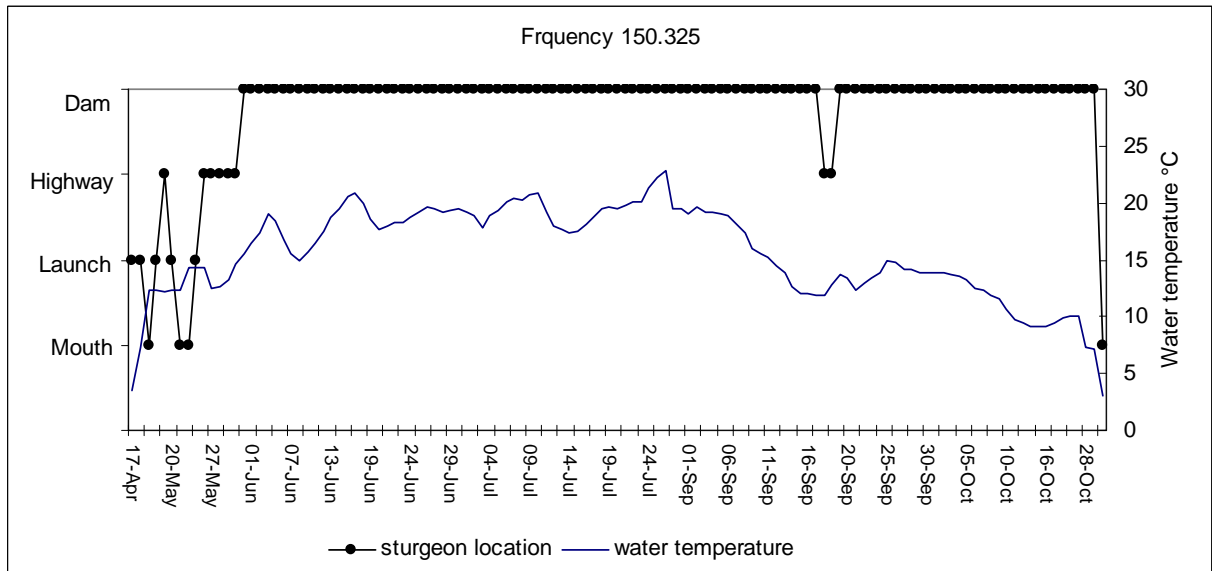
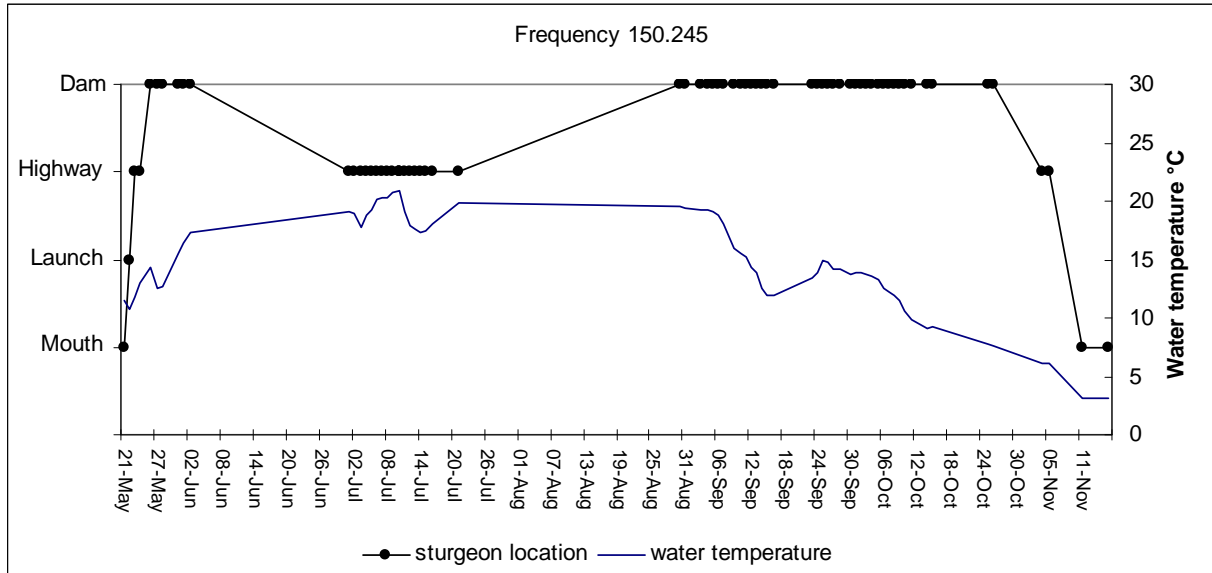
The seasonal movements of individual radio tagged sturgeons (by MHz) into and out the Black Sturgeon River in 2006. Data points represent locations made by land tracking at the highway and detections made by data loggers located at the mouth, launch, railway and Camp 43 dam.





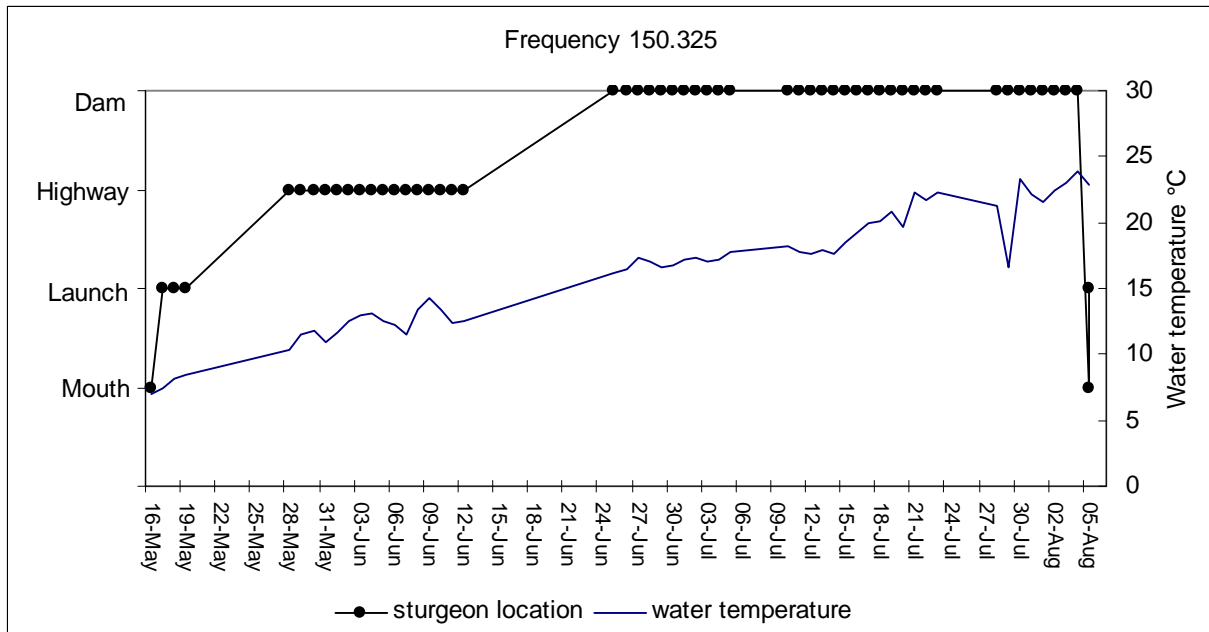
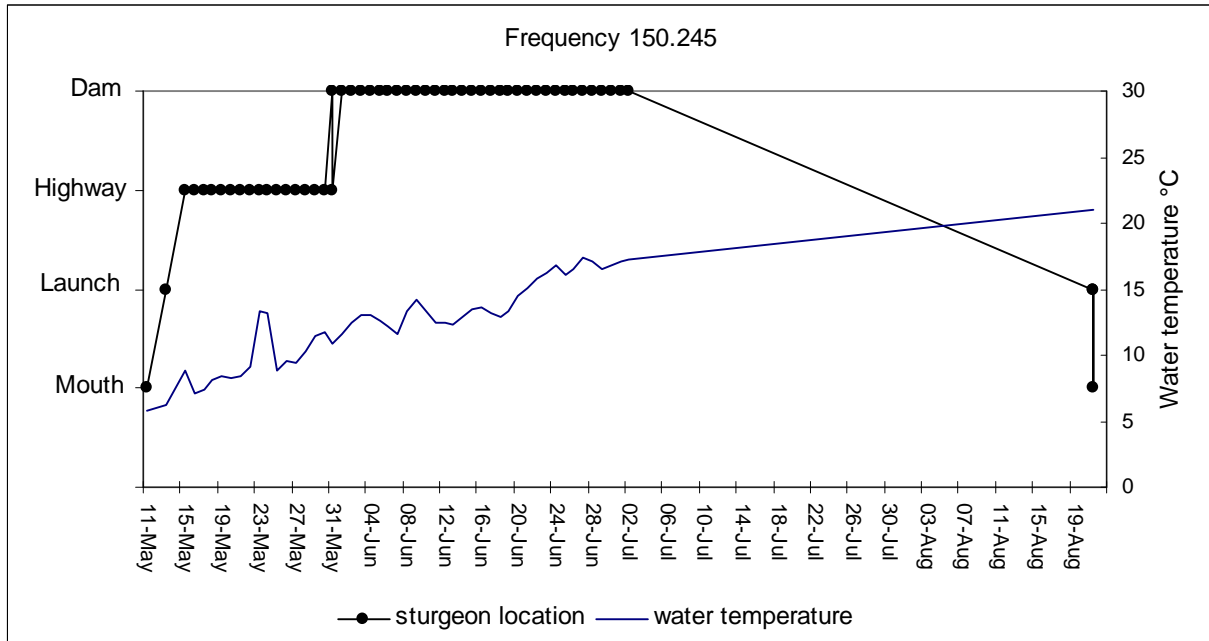
APPENDIX 4

The seasonal movements of individual radio tagged sturgeons (by MHz) into and out the Black Sturgeon River in 2007. Data points represent locations made by data loggers located at the mouth, launch, highway and Camp 43 dam. The mean daily water temperature on each date that a location was made has been included.



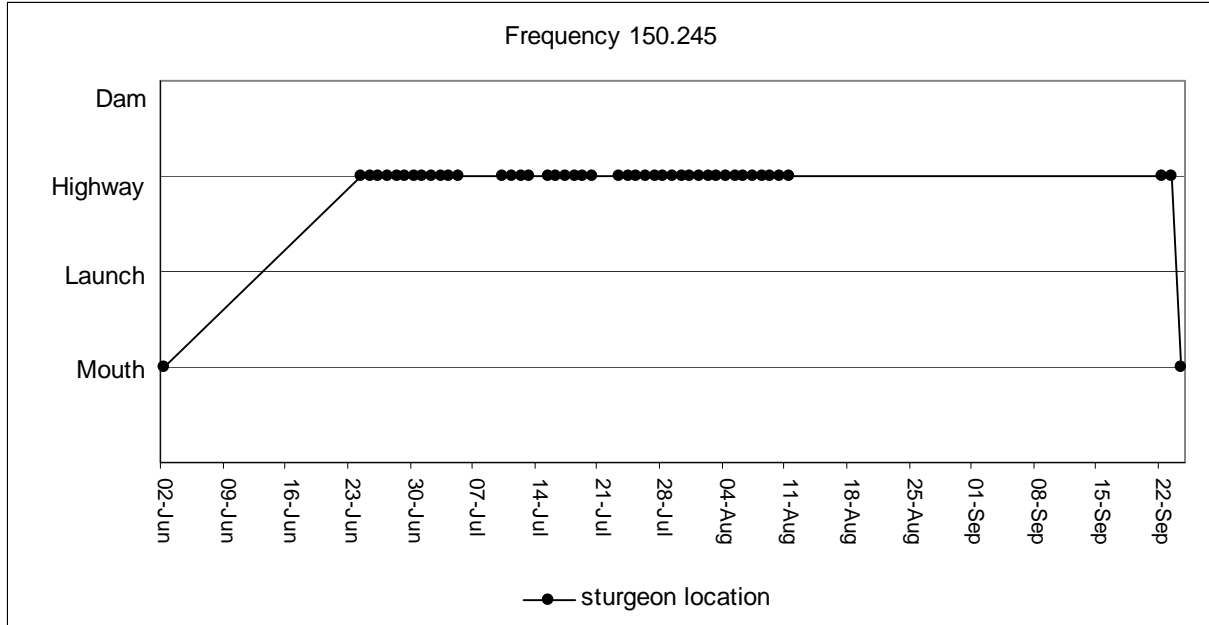
APPENDIX 5

The seasonal movements of individual radio tagged sturgeons (by MHz) into and out the Black Sturgeon River in 2008. Sturgeon data points represent detections made by data loggers located at the mouth, launch, highway and Camp 43 dam. The mean daily water temperature of each date that a location was made has been included.



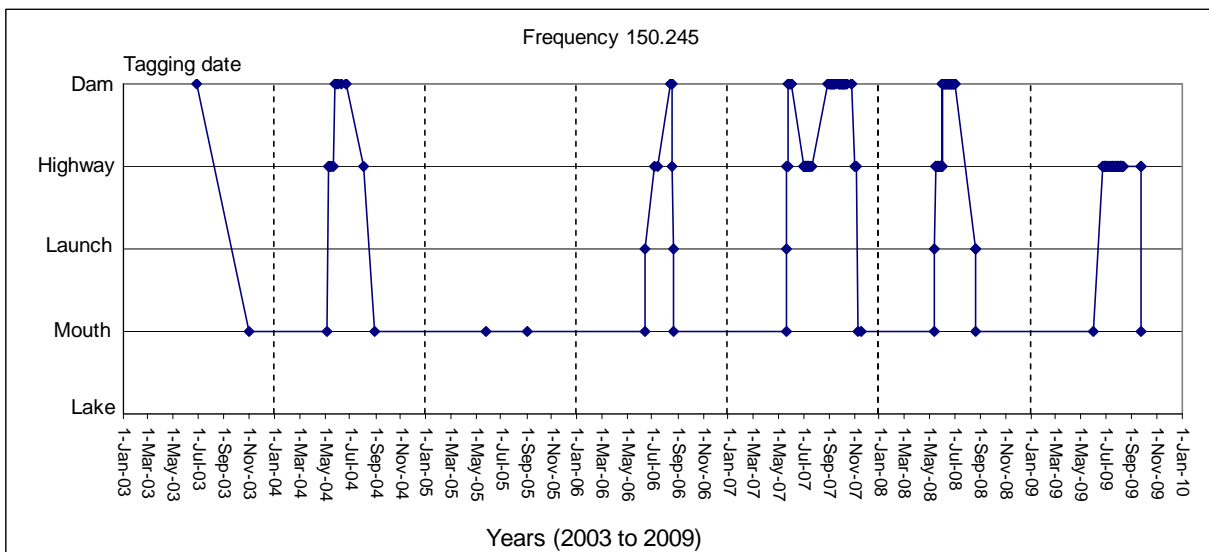
APPENDIX 6

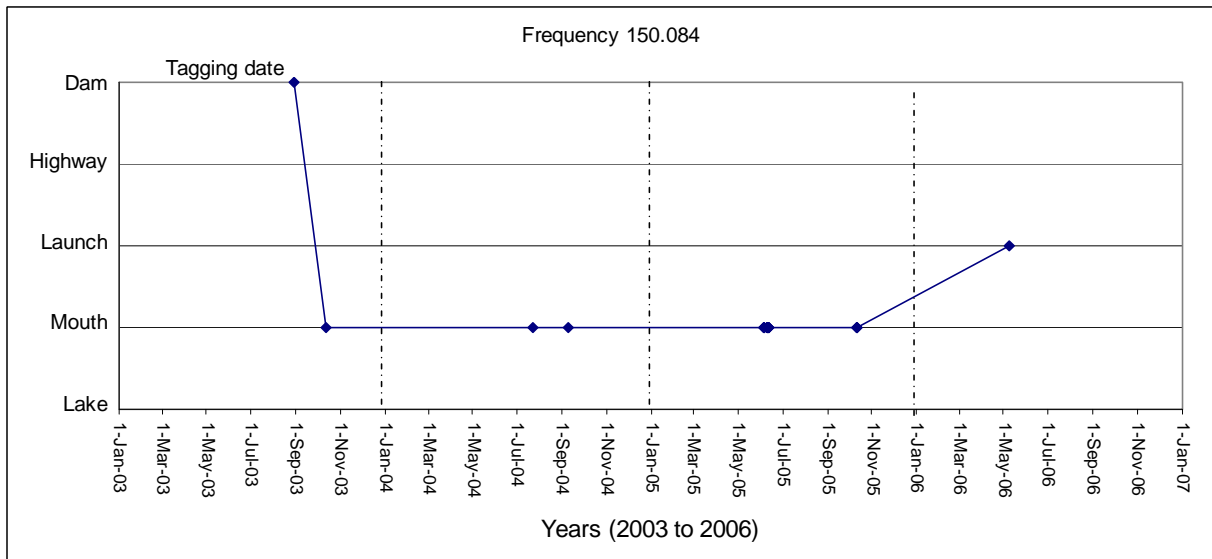
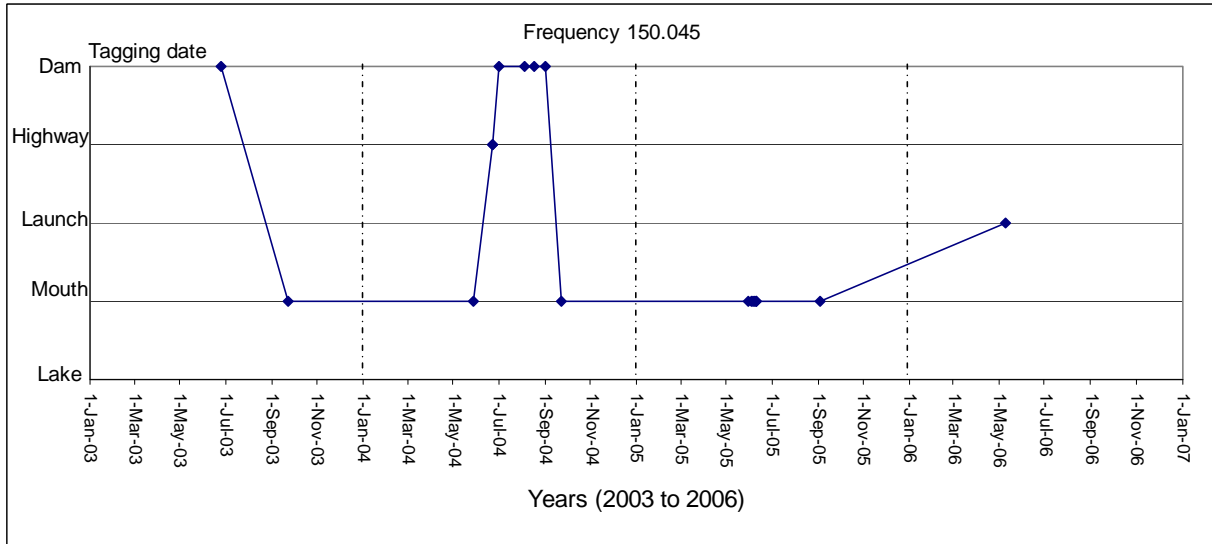
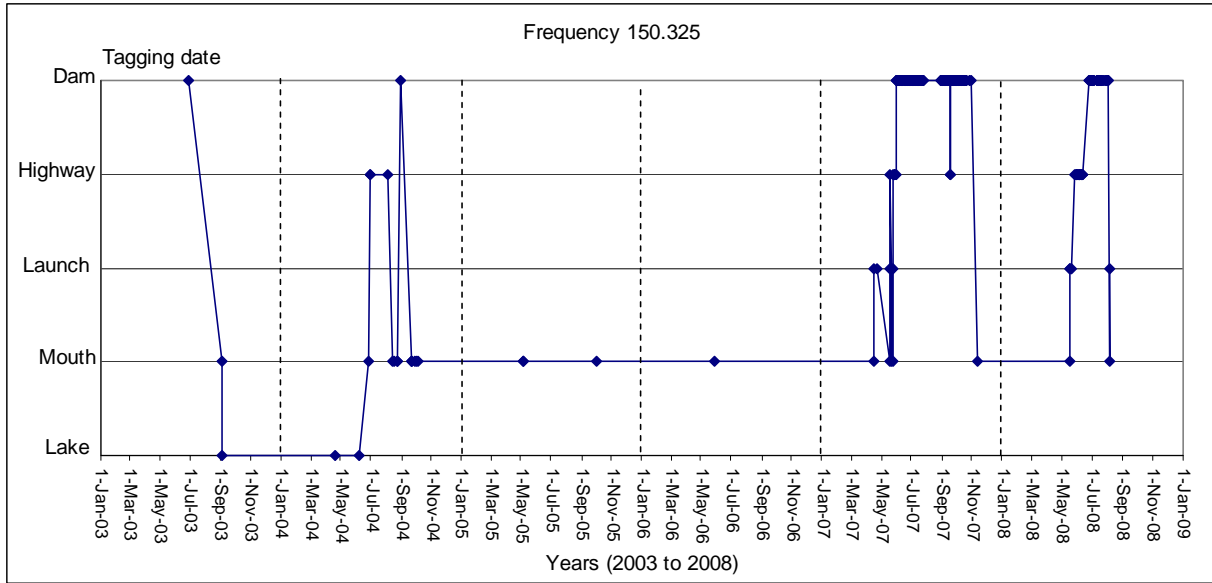
The seasonal movements of individual radio tagged sturgeons (by MHz) into and out the Black Sturgeon River in 2009. Sturgeon data points represent detections made by data loggers located at the mouth, launch, highway and Camp 43 dam.

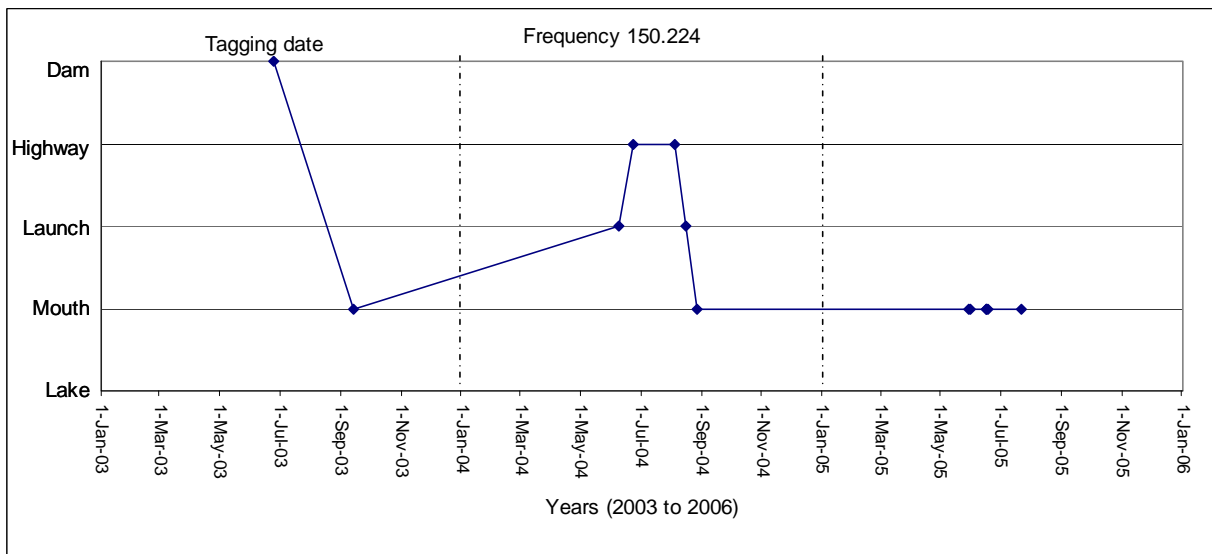
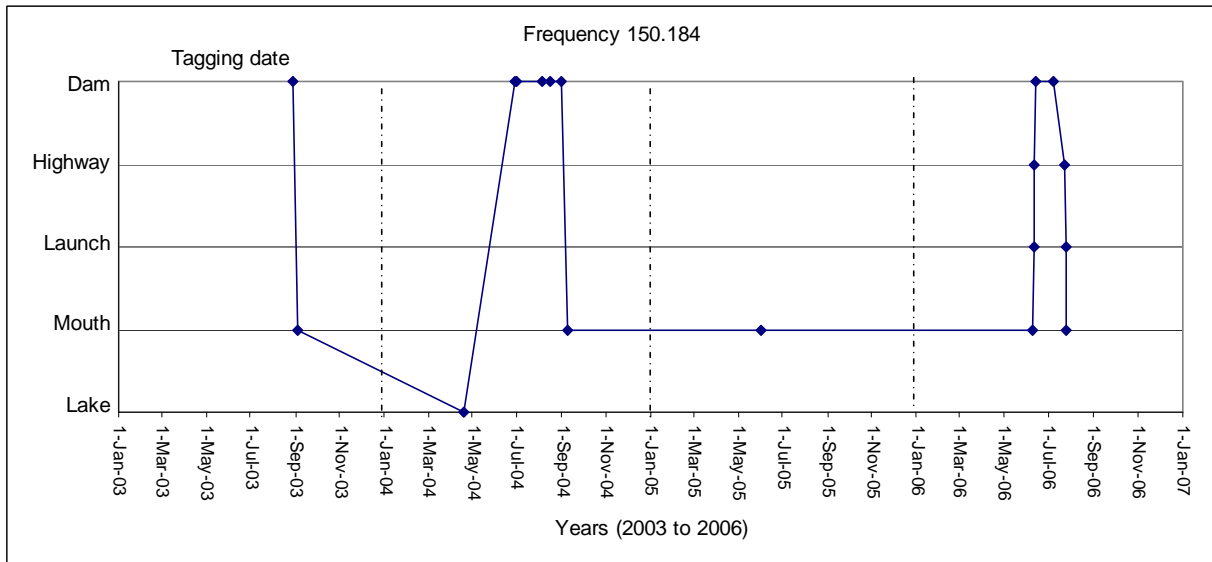
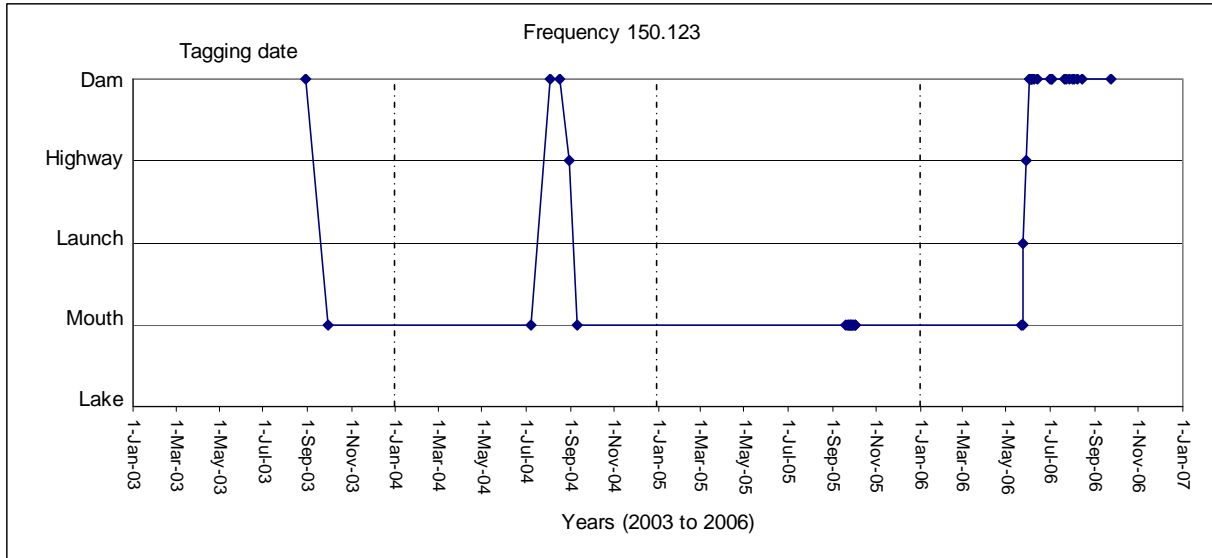


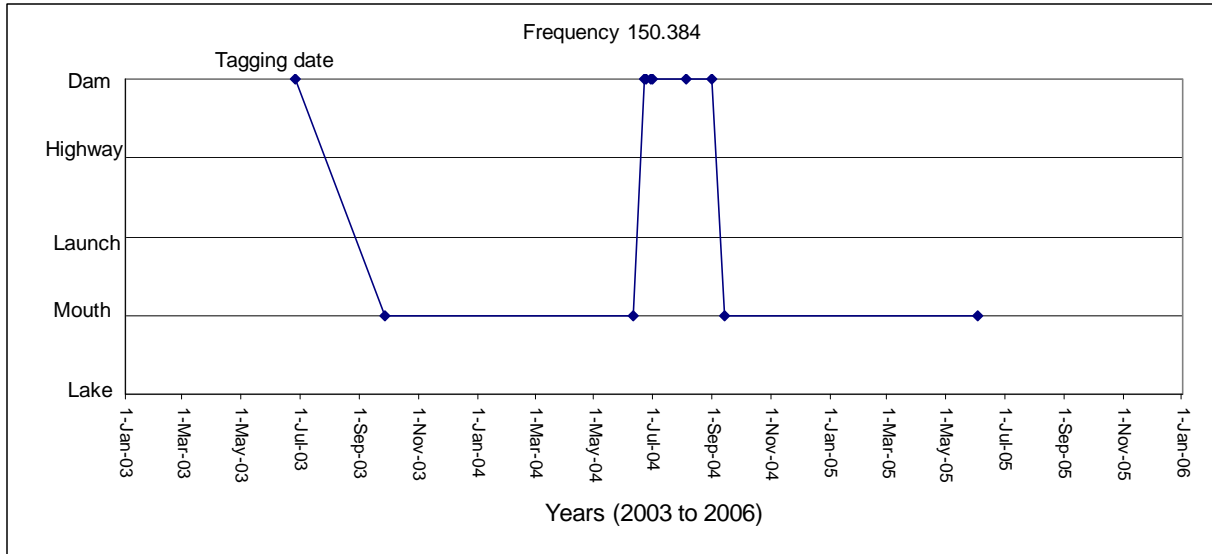
APPENDIX 7

The seasonal movements of radio tagged lake sturgeon between Black Bay and the Black Sturgeon River from 2003 to 2009.









APPENDIX 8

The period of immigration into the Black Sturgeon River and emigration into Black Bay as related to total river flows ($m^3 \cdot s^{-1}$). Each paired colour denotes a single fish.

