# Lake Sturgeon, *Acipenser fulvescens,* Movements in Rainy Lake, Minnesota and Ontario

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Rainy Lake, Minnesota-Ontario, contains a native population of Lake Sturgeon (*Acipenser fulvescens*) that has gone largely unstudied. The objective of this descriptive study was to summarize generalized Lake Sturgeon movement patterns through the use of biotelemetry. Telemetry data reinforced the high utilization of the Squirrel Falls geographic location by Lake Sturgeon, with 37% of the re-locations occurring in that area. Other spring aggregations occurred in areas associated with Kettle Falls, the Pipestone River, and the Rat River, which could indicate spawning activity. Movement of Lake Sturgeon between the Seine River and the South Arm of Rainy Lake indicates the likelihood of one integrated population on the east end of the South Arm. The lack of re-locations in the Seine River during the months of September and October may have been due to Lake Sturgeon moving into deeper water areas of the Seine River and out of the range of radio telemetry gear or simply moving back into the South Arm. Due to the movements between Minnesota and Ontario, coordination of management efforts among provincial, state, and federal agencies will be important.

Key Words: Lake Sturgeon, *Acipenser fulvescens*, biotelemetry, Rainy Lake, Ontario, Minnesota.

Movement patterns of Lake Sturgeon (*Acipenser fulvescens*) were relatively unstudied through the early 1970s (Scott and Crossman 1973). However, in the past decade, Lake Sturgeon movements have been studied at an increasing rate throughout much of the species' range (Rusak and Mosindy 1997; McKinley et al. 1998; Auer 1999; Borkholder et al. 2002; Knights et al. 2002). Lake Sturgeon have been found to move large distances for purposes such as spawning (Threader and Brosseau 1986; Fortin et al. 1993; Rusak and Mosindy 1997; Auer 1999) while maintaining smaller ranges in other systems (Bassett 1982*). Such movement patterns make Lake Sturgeon management difficult, particularly for multiple agencies dealing with border waters of substantial size.

Rainy Lake, a border water shared by Minnesota and Ontario, contains a Lake Sturgeon population that has gone largely unstudied. Lake Sturgeon in this system have been segregated from upstream Namakan Lake and downstream Lake of the Woods/Rainy River system populations by dams constructed on the outlets of Rainy and Namakan lakes early in the 20th century. The Lake Sturgeon is a Minnesota state-listed species of special concern (Minnesota Department of Natural Resources 2003*), while The Committee on the Status of Endangered Wildlife in Canada considers western populations of Lake Sturgeon to be endangered and the Rainy River-Lake of the Woods populations to be of special concern (Environment Canada 2005*).

Management of the Lake Sturgeon population in Rainy Lake is a cooperative effort among the Ontario Ministry of Natural Resources, the Minnesota Department of Natural Resources, and the United States federal government. Movement of Lake Sturgeon across international borders leads to an increase in importance of appropriate harvest regulations and an understanding of movement patterns and spawning locations. Such information will allow managers to protect areas that are important for Lake Sturgeon spawning.

The objective of this descriptive study was to determine generalized Lake Sturgeon movement patterns in Rainy Lake through the use of biotelemetry. Movement data obtained from tagged Lake Sturgeon were organized using a geographic information system (GIS) and used to help identify seasonal movement patterns and potential spawning locations.

## Study Site

Rainy Lake, located on the Minnesota-Ontario border, consists of three main basins: the North Arm, Redgut Bay, and the South Arm, all of which are part of the Winnipeg-Nelson drainage system in the Lake Winnipeg primary watershed (Figure 1). The North Arm and Redgut Bay are both located entirely in Canada. Rainy Lake has a total surface area of 92 000 ha, a maximum depth of 49.1 m, and a mean depth of 9.9 m. Of the three main lake basins, the South Arm has the greatest surface area at 49 200 ha, with 27 300 ha in Ontario and 21 900 ha in Minnesota. The South Arm is also the deepest basin with a mean depth of 9.9 m and a maximum depth of 49.1 m. The South Arm extends for 56 km along the border of the United States

and Canada. The South Arm of Rainy Lake, along with a 40-km section of the Seine River, was the area of focus for this study.

The watershed associated with Rainy Lake encompasses over 37 500 km$^2$ and can be divided into two sub-basins, including a 19 270-km$^2$ area above the outlet of Namakan Reservoir at Kettle Falls and Squirrel Falls and a 19 320-km$^2$ area below Kettle Falls and Squirrel Falls that drains directly to Rainy Lake. Overflows between Namakan Reservoir and Rainy Lake also occur at Bear Portage and Gold Portage. Below Kettle Falls and Squirrel Falls there are two principal tributaries that enter Rainy Lake, the Turtle River with a mean discharge of 37 m$^3$/sec and the Seine River with a mean discharge of 48 m$^3$/sec. Smaller, ungauged tributaries into the South Arm of Rainy Lake include the Rat and Pipestone rivers, both of which may be used by Lake Sturgeon for spawning. Changes in flow initiated at the headwaters of the watershed take about 21 days to reach the outlet of Rainy Lake under normal flow conditions with the water dropping about 135 m in the 338 km between these two points (International Rainy Lake Board of Control/ International Lake of the Woods Control Board 1984*). Long-term flow records indicate that approximately 8.3 billion m$^3$ of water move through the Rainy Lake watershed annually (Ericson et al. 1976*).

## Methods

Biotelemetry was utilized in the identification and characterization of Lake Sturgeon seasonal movement patterns and likely spawning locations in Rainy Lake. Lake Sturgeon were captured for transmitter implantation in October of 2002 ($n$ = 13), May and June of 2003 ($n$ = 20), and October of 2003 ($n$ = 8) at the mouths of tributaries where they were known to concentrate (tagging locations are noted in Table 1). Large mesh multifilament gill nets with mesh sizes of 103, 114, 127, 152, and 178 mm (bar measure; i.e., distance from knot to adjacent knot) were used to capture fish. Net lengths varied from 30 to 91 m, with all nets having a height of 1.83 m. Most nets were fished for approximately 24 hours, but actual times varied among sampling crews. Captured Lake Sturgeon were measured, weighed, sex was noted if gonads were identifiable during surgery, and a pectoral fin ray section was removed for aging (Adams et al. 2006).

Lotek Wireless combined acoustic/radio transmitters (CART) were surgically implanted into 41 Lake Sturgeon (≥8 kg) throughout the duration of this study. Thus, only a single tag was implanted and used for both radio and acoustic tracking, with the radio portion of the tag allowing tracking of fish in shallow or turbulent habitats, while the ultrasonic portion of the tag was needed for tracking of Lake Sturgeon in deeper habitats (Winter 1996). Surgical implantation procedures followed guidelines set by Hart and Summerfelt (1975). A 5- to 8-cm incision was made on the ventral fish surface approximately 3 cm off the midline and approximately 3 cm from the anterior end of the pelvic girdle. A 0.5-cm exit hole for the whip antenna was started with a scalpel on the midline approximately 3 cm posterior to the incision. A curved, 12-gauge catheter needle was passed through the hole and out through the incision with care taken to not penetrate or cut the viscera. The whip antenna projecting from the CART tag was then threaded though the end of the catheter needle that was protruding through the incision with the antenna being passed out of the peritoneal cavity through the antenna hole. The CART tag was then inserted into the peritoneal cavity with minimal pressure exerted on the internal organs. Fish were placed in a holding pen following implantation, if necessary. When full equilibrium was regained, fish were placed in the water at the site of capture and monitored until they vacated the area. All fish handling and surgery followed guidelines for use of wild fishes established by Nickum et al. (2004).

Lotek CART 16-2 series tags were implanted in 33 Lake Sturgeon with the remaining eight fish receiving CART 16-1 series tags. Lotek CART 16-2 tags were 16 mm × 85 mm with a weight in air of 36 g, while Lotek CART 16-1 tags were 16 mm × 60 mm with a weight in air of 25.3 g. Implanted CART tags did not exceed 2% of the total body weight of any given fish (Gallep and Magnuson 1972; McCleave and Stred 1975; Stasko and Pincock 1977; Moser et al. 1990).

Aerial tracking of Lake Sturgeon occurred at least once per week throughout the spring spawning season and summer months when the airplane was operational. Transects were flown covering the eastern half of the South Arm, with every flight including a 40-km stretch of the Seine River that flows into Rainy Lake. Transects were chosen to maximize area covered with the least amount of flight time. The remaining portion of the South Arm was flown at least once every two flights, time and weather permitting. The North Arm of Rainy Lake was flown once in the summer of 2003 in an attempt to locate a fish that could not be located in the South Arm.

Radio tracking by boat took place on average two to three times per week depending upon weather conditions. Tracking was also dependent on time availability, with partial and full days devoted to boat tracking when possible. Locations highly used by Lake Sturgeon were sampled by boat during May and June because recognition of individual signals was difficult from the airplane.

Distributional patterns of Lake Sturgeon were summarized by month during the spawning period (May and June) and by two-month periods throughout the rest of the summer (July/August and September/October). Movement rates were calculated as the linear distance between successive fixes divided by the number of elapsed days. Lake Sturgeon home ranges were calculated using the Animal Movement extension in

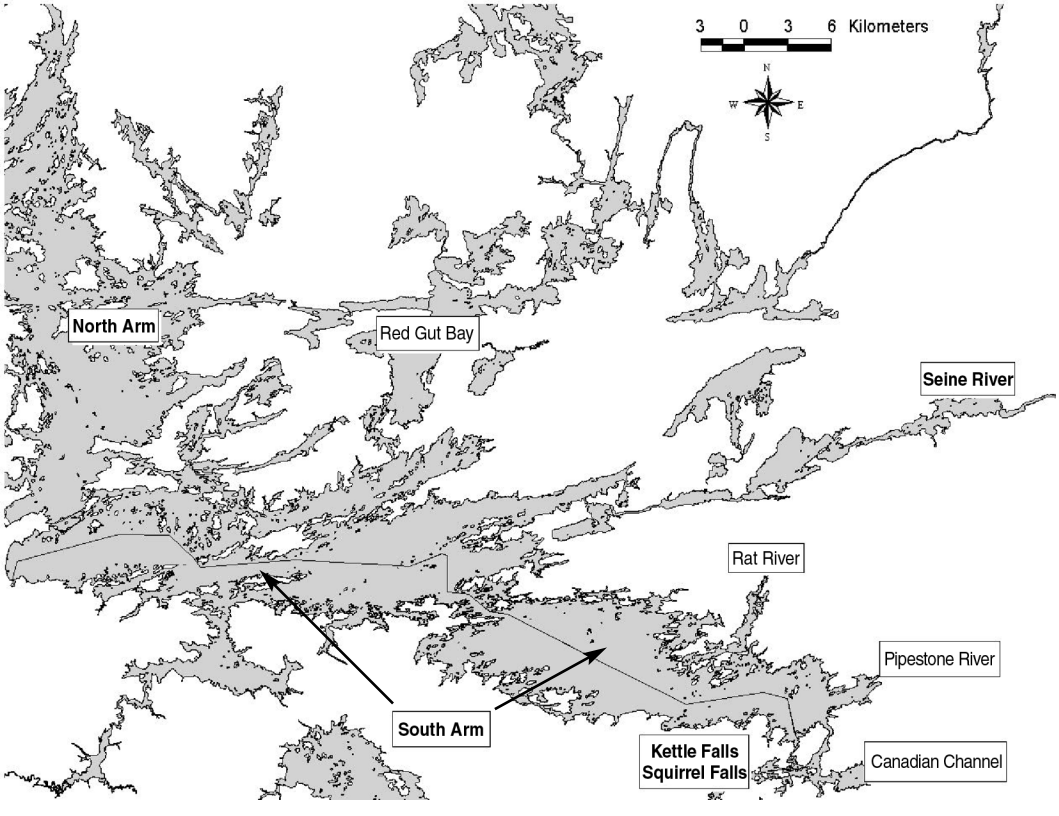


FIGURE 1. Rainy Lake, Minnesota and Ontario. The line across the South Arm indicates the border between Canada and the United States.

ArcView 3.2 (Hooge et al. 1999*), with home ranges estimated by using minimum convex polygons (White and Garrett 1990). Home ranges included only water area; land masses were excluded.

Lake Sturgeon eggs were sampled during 2004 in an attempt to confirm spawning locations. Egg collectors were set weekly from 7 June through 1 July in three areas of high Lake Sturgeon use. Collectors consisted of an 18-m mainline of vinyl-coated wire cable (4.8 × 6.4 mm) with cement blocks (203 × 406 × 102 mm) attached at 3-m intervals and wrapped in furnace filter material. Floats were attached to each end of the mainline and egg collectors were set in shallow water areas of 0.3 to 4.6-m depth. Egg collectors were checked once weekly during the entire time period in which they were deployed. A sample of all egg types present on the collectors was removed and transported back to laboratory facilities to be hatched and the fry subsequently identified.

## Results and Discussion

*Lake Sturgeon tagging and survival*

Forty-one Lake Sturgeon were implanted with CART tags during 2002 and 2003 (Table 1). Individual Lake Sturgeon were re-located between 0 and 36 times. No mortalities were positively identified. However, fish 99, implanted in October of 2003, was not located during the remainder of the study. Fish 30 was not located for 12 months after it was tagged and released, but then was subsequently located 11 times throughout the remainder of the study. Fish 106 was found at the same location, adjacent to the Seine River First Nations village on the Seine River, weekly for 11 weeks. We later learned that fish 106 may have perished in a gill net used in the Seine River First Nations subsistence fishery that had been left on the bottom of the Seine River due to entanglement with the substrate. All other fish were located at least once throughout the study.

Lake Sturgeon implanted with CART tags had a mean fork length of 1217.4 mm (range 951-1505 mm), girth of 502.4 mm (range 372-639 mm), mass of 15.35 kg (range 7.5-30 kg), and age of 25.9 (range 15-55) (Table 1). These ranges were representative of the Lake Sturgeon population in Rainy Lake at the time of this study (Adams et al. 2006).

*Transmitter detection*

Acoustic equipment was tested during the spring of 2003. Tags were lowered at 2-m intervals between

TABLE 1. Fish description, transmitter code, and capture location at time of tagging for Lake Sturgeon implanted with Lotek CART transmitters in Rainy Lake, 2002-2003. Ages were determined from pectoral fin ray sections. NA = not available.

| Code number | Tagging date Month/day/year | Total length (mm) | Fork length (mm) | Girth (mm) | Weight (kg) | Sex* | Age | Tagging location |
|---|---|---|---|---|---|---|---|---|
| 1 | 10/2/02 | NA | 1100 | 444 | 11.5 | FI | 22 | Canadian Channel |
| 2 | 5/21/03 | 1506 | 1433 | 635 | 30 | F | 55 | Brule Narrows |
| 3 | 10/9/02 | NA | 1210 | 556 | 19 | FM | 26 | Stokes Bay |
| 4 | 10/9/02 | NA | 1275 | 615 | 22.5 | FM | 27 | Canadian Channel |
| 5 | 10/9/02 | NA | 994 | 372 | 8 | MM | 15 | Stokes Bay |
| 6 | 10/9/02 | NA | 1050 | 425 | 9.5 | Unk | 19 | Stokes Bay |
| 7 | 10/9/02 | NA | 951 | 395 | 7.5 | MM | 17 | Squirrel Falls |
| 8 | 10/8/02 | NA | 1212 | 485 | 16 | Unk | 28 | Squirrel Falls |
| 9 | 10/8/02 | NA | 1313 | 582 | 20.5 | FM | 32 | Canadian Channel |
| 10 | 10/8/02 | NA | 1386 | 614 | 23.5 | FM | 28 | Canadian Channel |
| 11 | 10/8/02 | NA | 1447 | 639 | 30 | FM | 31 | Stokes Bay |
| 12 | 10/8/02 | NA | 1388 | 585 | 22.5 | FM | 26 | Kettle Falls |
| 13 | 10/8/02 | NA | 1200 | 445 | 13.5 | Unk | 18 | Squirrel Falls |
| 14 | 10/8/02 | NA | 1125 | 407 | 11.5 | Unk | 19 | Squirrel Falls |
| 15 | 5/28/03 | 1372 | 1260 | 495 | 14.5 | Unk | 21 | Kettle Falls |
| 16 | 5/20/03 | 1400 | 1270 | 503 | 16.5 | Unk | NA | Brule Narrows |
| 17 | 5/28/03 | 1404 | 1300 | 520 | 16.75 | MM | 21 | Kettle Falls |
| 18 | 5/28/03 | 1410 | 1285 | 475 | 15 | MM | 35 | Kettle Falls |
| 19 | 6/18/03 | 1270 | 1140 | 410 | 9.5 | M | 32 | Kettle Falls |
| 20 | 5/28/03 | 1200 | 1060 | 415 | 9 | MM | 20 | Kettle Falls |
| 21 | 6/18/03 | 1425 | 1280 | 570 | 20 | FM | 30 | Squirrel Falls |
| 22 | 5/28/03 | 1505 | 1365 | 545 | 1935 | FM | 27 | Kettle Falls |
| 23 | 6/18/03 | 1120 | 1000 | 460 | 11 | Unk | 21 | Kettle Falls |
| 24 | 5/21/03 | 1460 | 1315 | 578 | 20.75 | FM | 22 | Brule Narrows |
| 25 | 5/20/03 | 1379 | 1260 | 525 | 18 | Unk | 26 | Brule Narrows |
| 27 | 5/23/03 | 1640 | 1505 | 585 | 19.25 | FM | 47 | Seine River |
| 30 | 5/29/03 | 1444 | 1291 | 595 | 17.5 | F | 29 | Squirrel Falls |
| 39 | 5/23/03 | 1555 | 1429 | 580 | 22 | FM | 47 | Stokes Bay |
| 43 | 5/29/03 | 1335 | 1205 | 520 | 16.5 | FI | 22 | Stokes Bay |
| 51 | 5/29/03 | 1180 | 1063 | 405 | 8.5 | Unk | 19 | Seine River |
| 56 | 5/23/03 | 1575 | 1443 | 589 | 16 | Unk | 44 | Seine River |
| 63 | 5/23/03 | 1135 | 1025 | 435 | 8 | Unk | 18 | Seine River |
| 69 | 5/28/03 | 1280 | 1140 | 410 | 10 | F | 23 | Rat River Bay Mouth |
| 75 | 10/8/03 | 1449 | 1325 | 568 | 21 | F | NA | Seine River |
| 82 | 10/7/03 | 1400 | 1275 | 486 | 12.5 | Unk | 31 | Brule Narrows |
| 87 | 10/8/03 | 1095 | 997 | 431 | 8 | Unk | 18 | Seine River |
| 93 | 10/8/03 | 1265 | 1134 | 442 | 10.5 | M | 16 | Seine River |
| 99 | 10/8/03 | 1217 | 1094 | 450 | 9.5 | Unk | 16 | Brule Narrows |
| 106 | 10/8/03 | 1288 | 1186 | 461 | 12 | M | 18 | Seine River |
| 111 | 10/8/03 | 1272 | 1138 | 467 | 11.5 | M | 25 | Seine River |
| 119 | 10/8/03 | 1160 | 1045 | 480 | 10.5 | Unk | 19 | Seine River |

*F = female, maturity unknown; FM = female, mature; FI = female, immature; M = male, maturity unknown; MM = male, mature; Unk = sex unknown

2 and 20 m. The highest maximum detectable distance from the boat was 0.95 km when the CART tag was lowered to 6 m. The lowest maximum detectable distance of 0.53 km occurred at a tag depth of 18 m. The mean maximum detectable distance was 0.65 km with a standard error of 0.04. Limitations in the performance of the acoustic portion of the tags led to the discontinuation of acoustic telemetry from the study beginning during July of 2003. No fish locations were recorded with the acoustic equipment despite attempts on 10 dates between 15 May and 15 June 2003. The complexity of the bottom contours of Rainy Lake may have been the reason for the lack of reception of the directional acoustic signal.

Radio telemetry equipment was also tested. The highest maximum detectable distance from the boat was 0.47 km when the CART tag was lowered to 2 m. The lowest maximum detectable distance of 0.017 km occurred at a tag depth of 20 m. The mean maximum detectable distance was 0.21 km with a standard error of 0.05. The maximum detectable distance by airplane with the tag lowered to 8.77 m was 0.55 km with a standard error of 38.5.

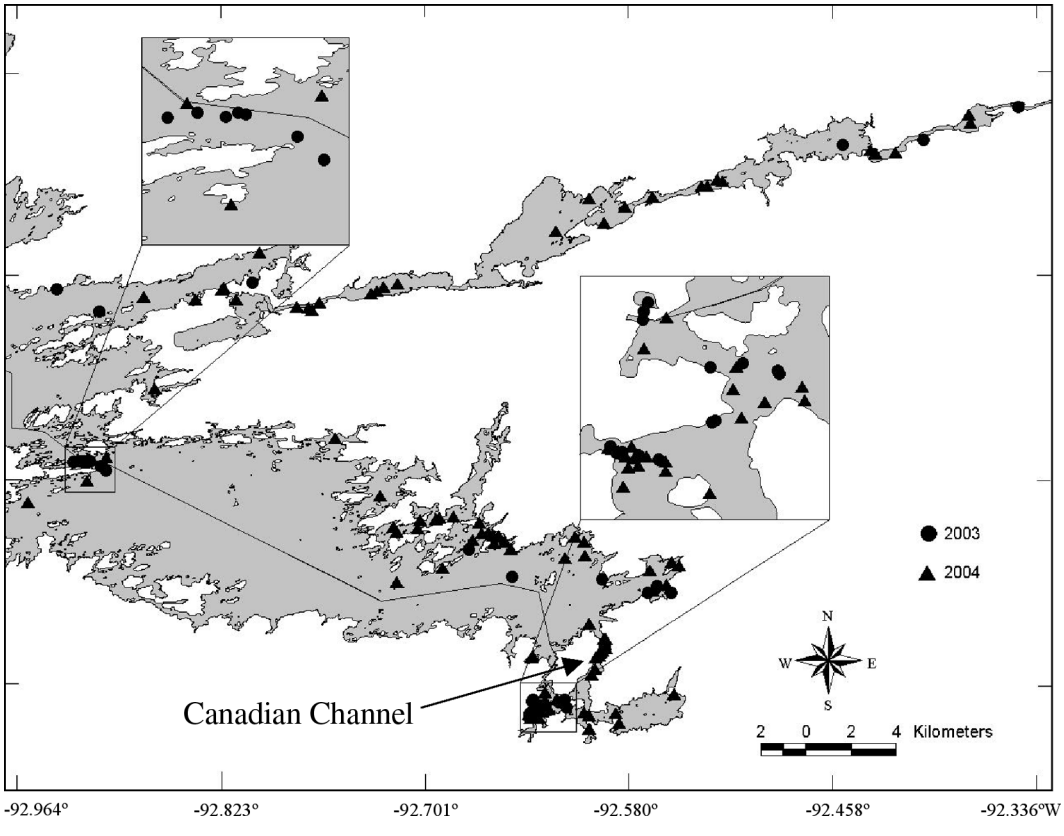


FIGURE 2. Distribution of Lake Sturgeon locations in Rainy Lake during May and June, 2003 and 2004.

*Lake Sturgeon locations*

The 41 implanted Lake Sturgeon were located 587 times throughout the study, with fish being tracked through September 2004. In 2003 Lake Sturgeon were located 285 times and in 2004 Lake Sturgeon were located 302 times.

Lake Sturgeon utilized Squirrel Falls/Kettle Falls and adjacent areas (Canadian Channel, Hale Bay) extensively throughout the study (37% of total locations, including both spawning and non-spawning seasons). A rock shelf below the Squirrel Falls Dam is one of the areas thought to be a spawning site for Lake Sturgeon in Rainy Lake. Egg samplers were placed below the Squirrel Falls Dam, in the Canadian Channel, and below the falls in the Pipestone River in 2004. Lake Sturgeon spawning, verified by hatching eggs and identifying larvae, was confirmed only at the Squirrel Falls Dam and occurred between 14 June and 17 June of 2004. Thus, we cannot exclude the possibility of spawning at other locations, but were able to verify spawning below the Squirrel Falls Dam. Other sites with Lake Sturgeon spawning habitat characteristics as listed by Scott and Crossman (1973) (e.g., 0.6-4.6 m depth, swift current, below falls) include the Kettle Falls Dam, Pipestone River, Rat River, and the Seine River (Crilly Dam and Highway 11 Bridge). Lake Sturgeon were located at all of these sites throughout the study, including the spawning season.

The majority of May locations (89%) for both 2003 (85%) and 2004 (90%) were associated with the current area directly below Kettle Falls, Squirrel Falls, and in the Canadian Channel (Figure 2), which suggests pre-spawning aggregations. Four of the other six May locations were associated with the Brule Narrows, also an area with consistent current.

Fewer Lake Sturgeon were located in the Kettle Falls/Squirrel Falls/Canadian Channel area as June progressed in both years (Adams 2004*). We suspect that Lake Sturgeon gradually left the spawning areas at Kettle Falls and Squirrel Falls, and dispersed primarily to the main basin east of Brule Narrows. During this month, Lake Sturgeon locations in the Seine River were spread throughout Seine Bay and 36 km upriver. The increased number of Seine River locations from 2003 to 2004 was due to the increased number of tagged Lake Sturgeon. Only four fish from the Seine River were tagged for 2003 tracking, while six additional fish were tagged for 2004 tracking.

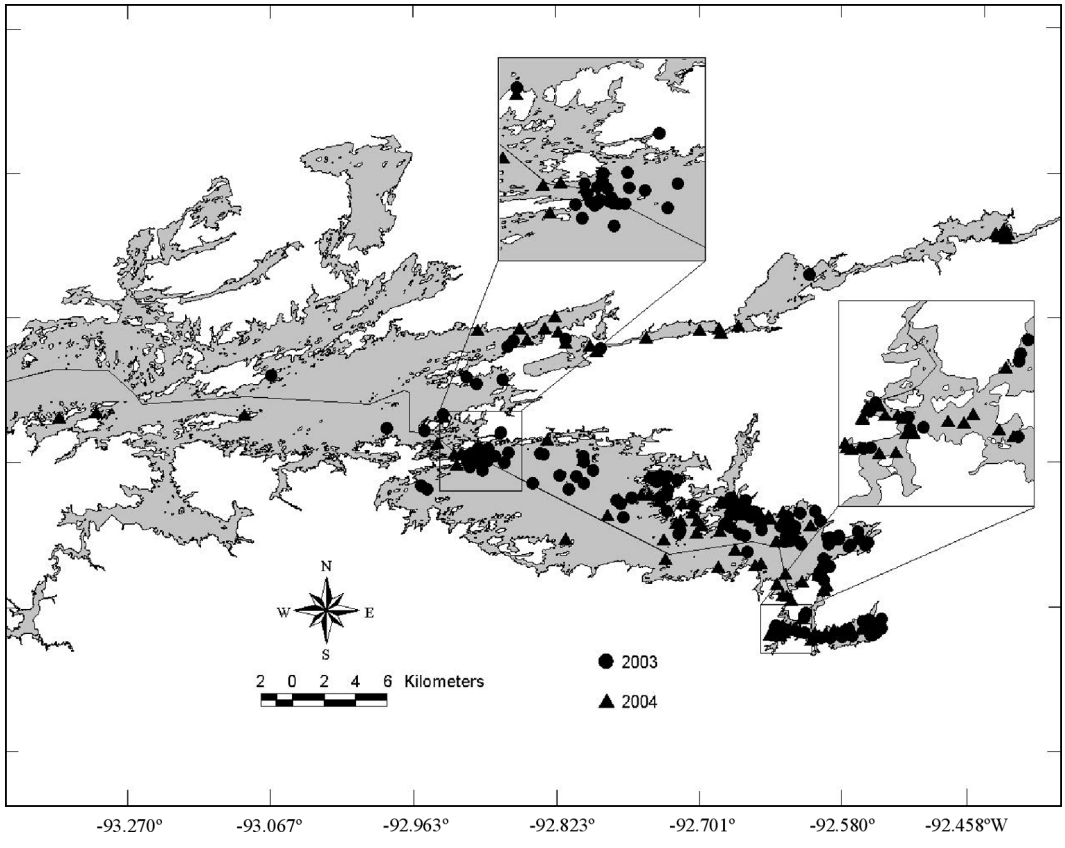


FIGURE 3. Distribution of Lake Sturgeon in Rainy Lake during July and August, 2003 and 2004.

During the July/August period, the majority of Lake Sturgeon were found from the Brule Narrows eastward and in the Seine Bay/Seine River system, with only five locations found west of the Brule Narrows (Figure 3). Some Lake Sturgeon continued to be located in the Kettle Falls/Squirrel Falls area during this period in both years (15 locations and 35 locations, respectively). Locations in the main body of the South Arm were associated with the north shore more than the south shore during this time period (96% in 2003 and 84% in 2004). There are substantial habitat differences between the two areas with the south shore consisting of a sharp drop-off into depths of over 30 m. Conversely, the north shore consists of rock reefs and depths shallower than 15 m. Either the fish were less likely to use the deeper water, or the lack of locations was due to limitations of the telemetry equipment with radio signals detected from depths no greater than 18 m.

September locations were obtained during both 2003 and 2004 with October locations obtained only in 2003. Locations during this time period were distributed throughout the South Arm (Figure 4). Locations in the Seine River were few, with zero in 2003 and two in 2004. Fish 75 was tagged in the Seine River but located in the South Arm during this time period. Lake Sturgeon were located on the south shore of the South Arm for the first time in September. One potential explanation is that Lake Sturgeon were staging at locations in the vicinity of winter habitats. Rusak and Mosindy (1997) found that Lake Sturgeon in the Lake of the Woods/Rainy River system demonstrated consistent preferences for specific areas in the main basin of Lake of the Woods during the winter; these areas were adjacent to the mouth of the Rainy River where the Lake Sturgeon would later spawn in the spring.

*Lake Sturgeon movement rates*

Mean movement rates of Lake Sturgeon were calculated by month for descriptive purposes (Figure 5). Movement rates increased from May to June during 2003 and 2004, with a maximum movement rate of 0.80 km/day in June of 2004 and a minimum movement rate of 0.17 km/day in May of 2003. Movement rates in five of the 10 months exceeded the mean spring

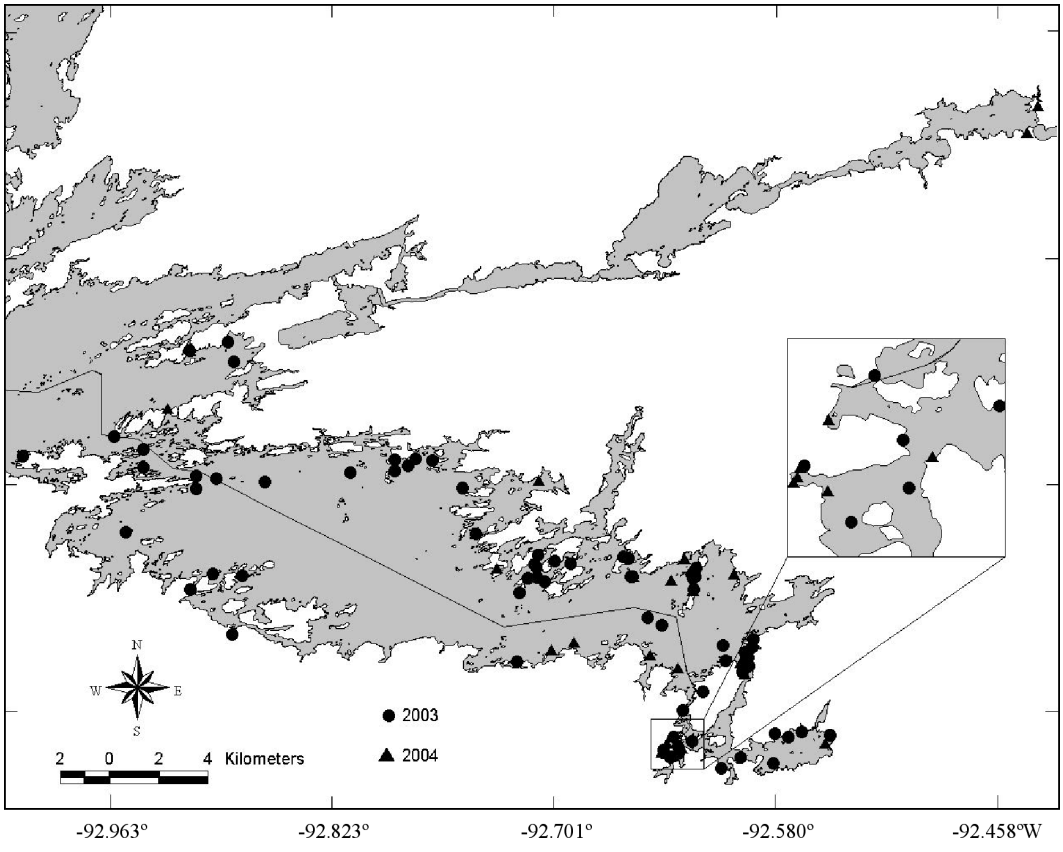


FIGURE 4. Distribution of Lake Sturgeon locations in Rainy Lake during September and October 2003 and September 2004.

movement rate of 0.50 km/day observed by Knights et al. (2002) for Lake Sturgeon in the upper Mississippi River system. Lake Sturgeon in Rainy Lake likely were dispersing into the lake away from spawning sites during the post-spawn period in June. However, movement rate patterns were dissimilar for the same months between years. Further research thus will be needed to ascertain seasonal movement patterns and explanations for those patterns.

Movement of fish between the Seine River and the main body of the South Arm did occur but was minimal throughout the study. Rusak and Mosindy (1997) found that in the Lake of the Woods/Rainy River system, there was a separation in the population based primarily on winter habitat use. "River" fish spawned in the Rainy River and remained there throughout the winter months. "Lake" fish spawned in the Rainy River but moved into the main basin of Lake of the Woods during the winter months. If a similar dichotomy exists in the Rainy Lake/Seine River population, there may be greater movement of Lake Sturgeon between these two areas during the time period in which we did not attempt to locate fish (i.e., late fall and winter). Thus, Lake Sturgeon may move from Rainy Lake into the Seine River during this time period, but further investigation will be needed.

Movement patterns varied for individual Lake Sturgeon in Rainy Lake. Some fish did not exhibit discernable movement patterns, such as fish 21, which was located throughout the east end of the South Arm from Stokes Bay to the Brule Narrows and also in Seine Bay and at the mouth of Seine Bay (Figure 6). Locations in 2003 began in the east and moved west with the last location east of the Brule Narrows. The first locations in 2004 were in the Seine Bay/Seine River area with the remainder of locations further east. One factor contributing to the differential patterns between years may be the spawning interval exhibited by Lake Sturgeon, which ranges between 1 and 3 years for males and 4 and 6 years for females (Magnin 1966).

Telemetry results from Rainy Lake suggest that some Lake Sturgeon remained in the same area for

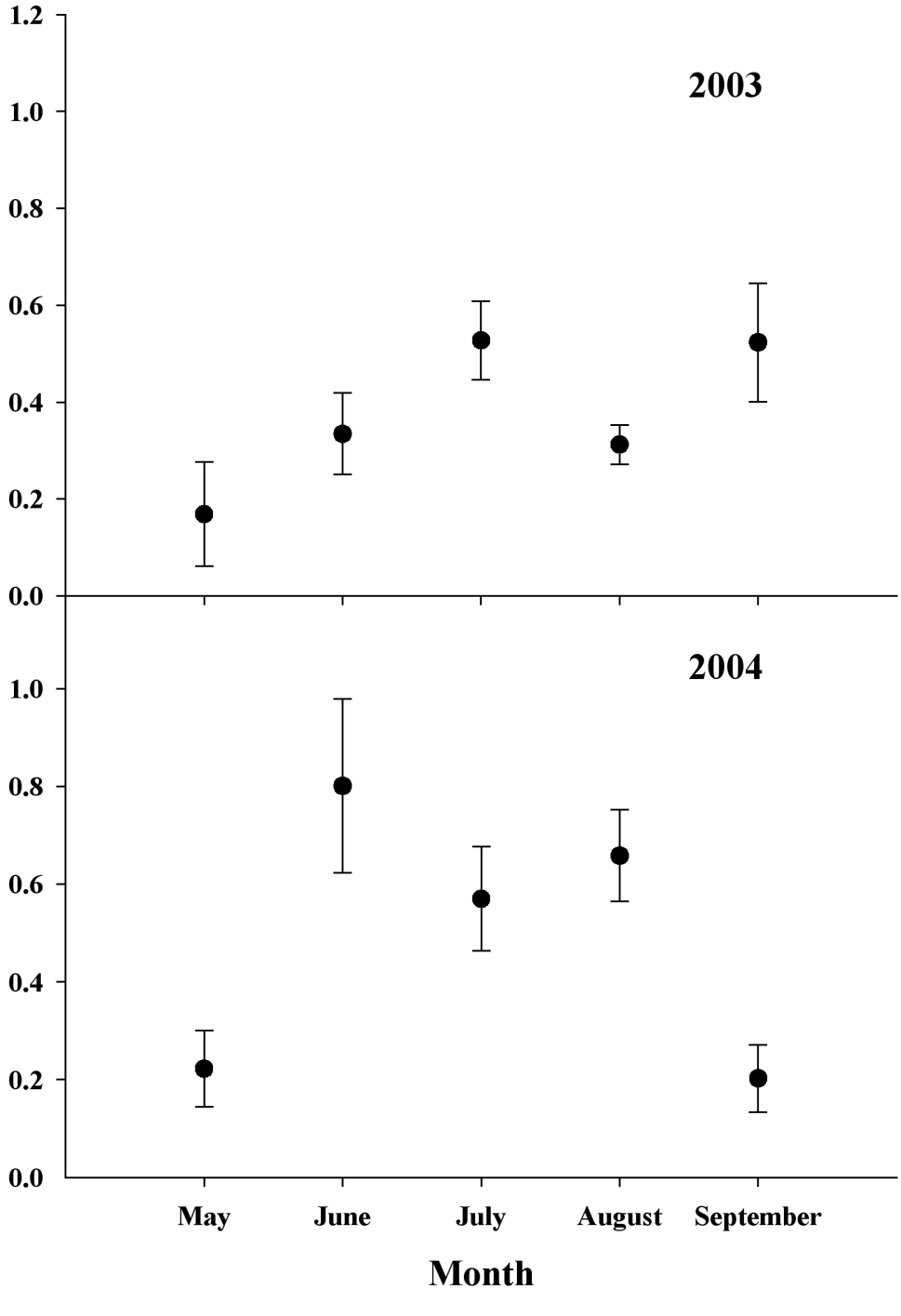


FIGURE 5. Mean monthly movement rate (± standard error) of Lake Sturgeon in Rainy Lake during 2003 and 2004.

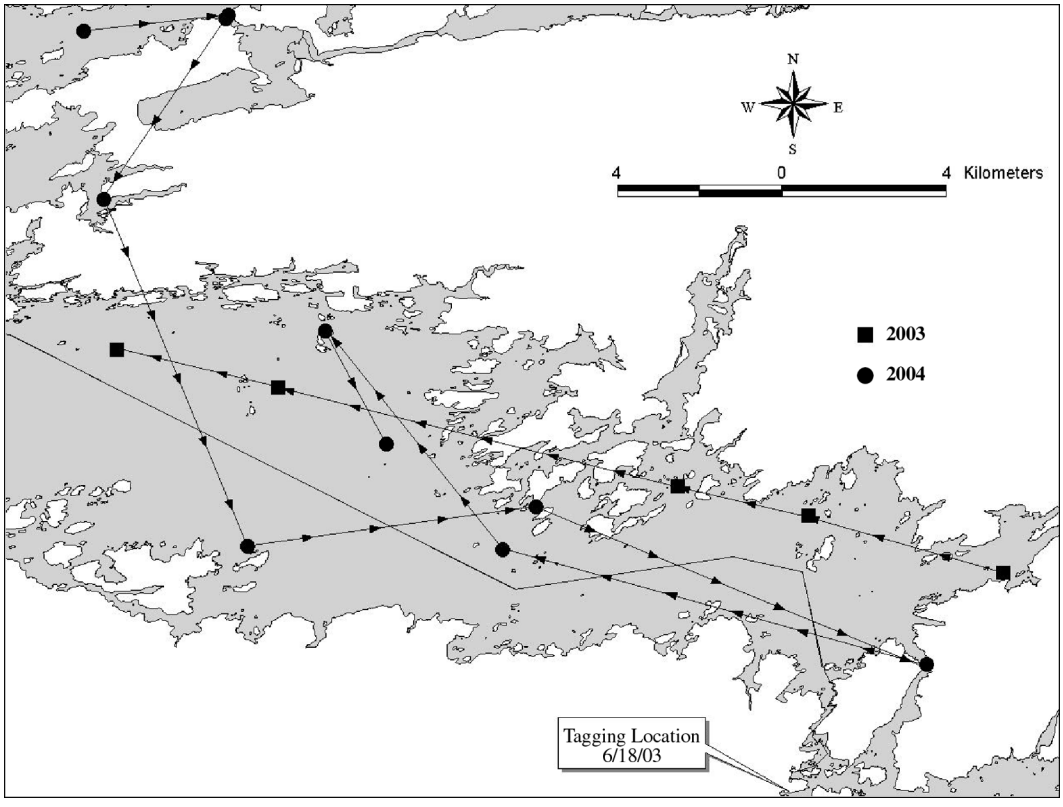


FIGURE 6. Distribution of locations for Lake Sturgeon number 21 in Rainy Lake, 2003 and 2004.

extended periods. For example, fish 15 was tagged at the Squirrel Falls Dam on 28 May 2003 and was next located in the Brule Narrows area (Figure 7). Subsequent locations were all in the area of the Brule Narrows until 26 August 2003. The next locations were in the Squirrel Falls Dam area beginning on 28 September 2003. The fish was then located in the Squirrel Falls Dam area on 18 May 2004 and was not located in the Brule Narrows area until 30 June 2004.

*Lake Sturgeon home ranges*

Home ranges for Lake Sturgeon in Rainy Lake varied substantially, with a maximum home range size of 14 844 ha, a minimum size (excluding fish 106, possible mortality) of 84 ha, and a mean home range size of 4 625 ha (standard error = 642). Lyons and Kempinger (1992*) reported that most Lake Sturgeon in the Lake Winnebago system had consistent movement patterns, while others demonstrated variable movement patterns and apparently did not establish home ranges. They also found that Lake Sturgeon in Lake Winnebago did not remain in any particular location for long periods of time.

## Conclusions

This research should provide biologists from multiple agencies insight into general movement patterns of Lake Sturgeon inhabiting Rainy Lake. Telemetry data indicated high utilization of the Squirrel Falls area, with 37% of total locations occurring at that area. Squirrel Falls was the only site at which spawning was confirmed by collection of Lake Sturgeon eggs, although other aggregations in areas associated with Kettle Falls, the Pipestone River, and the Rat River also could indicate spawning activity. Movement of Lake Sturgeon between the Seine River and the South Arm of Rainy Lake indicates the likelihood of one integrated population on the east end of the South Arm. The lack of locations in the Seine River during the months of September and October might result from Lake Sturgeon moving into deeper water areas of the Seine River and out of the range of telemetry gear or simply moving back into the South Arm. Further research will be needed to determine the winter range of Lake Sturgeon in Rainy Lake. The Lake Sturgeon has historically been a resource of both cultural and economic importance to the Rainy Lake area. Due to

TABLE 2. Home ranges and mean movement rates (SD) by year for Lake Sturgeon in Rainy Lake. Missing values (dots) indicate that a fish was located zero or one times that year and thus movement could not be calculated.

| Fish number | Total locations | Home range (ha) | Mean movement rate 2003 (km/d) | Mean movement rate 2004 (km/d) |
|---|---|---|---|---|
| 1 | 25 | 2164 | 0.320 (0.22) | 0.265 (0.31) |
| 2 | 12 | 7758 | 0.170 (0.14) | 0.564 (0.26) |
| 3 | 17 | 2985 | 0.267 (0.20) | 0.372 (0.33) |
| 4 | 7 | 14844 | 0.619 (0.50) | . |
| 5 | 13 | 3779 | 0.285 (0.33) | 0.510 (0.36) |
| 6 | 15 | 5416 | 0.448 (0.70) | 0.663 (0.72) |
| 7 | 23 | 3558 | 0.289 (0.28) | 1.065 (0.74) |
| 8 | 20 | 7277 | 0.076 (0.05) | 0.554 (1.11) |
| 9 | 11 | 8600 | 0.156 (0.20) | . |
| 10 | 29 | 11894 | 0.808 (0.67) | 0.977 (1.29) |
| 11 | 17 | 10501 | 0.309 (0.23) | 0.382 (0.23) |
| 12 | 12 | 578 | 0.233 (0.25) | 0.261 (0.43) |
| 13 | 31 | 4404 | 0.420 (0.54) | 0.120 (0.23) |
| 14 | 12 | 3806 | 1.121 (1.00) | 0.195 (0.21) |
| 15 | 34 | 7141 | 0.352 (0.42) | 0.714 (0.92) |
| 16 | 19 | 2434 | 0.324 (0.25) | . |
| 17 | 29 | 10245 | 0.565 (0.53) | 0.552 (0.41) |
| 18 | 28 | 3517 | 0.279 (0.28) | 0.513 (0.46) |
| 19 | 14 | 6434 | 0.396 (0.39) | 1.091 (1.74) |
| 20 | 34 | 1859 | 0.299 (0.51) | 0.870 (1.30) |
| 21 | 15 | 10017 | 0.316 (0.11) | 0.817 (0.61) |
| 22 | 26 | 8492 | 0.459 (0.36) | 0.511 (0.38) |
| 23 | 19 | 4095 | 0.684 (0.80) | 0.187 (0.20) |
| 24 | 19 | 9411 | 0.587 (0.94) | 0.236 (0.31) |
| 25 | 7 | 7677 | . | 1.713 (1.56) |
| 27 | 10 | 1921 | 0.324 (0.19) | 0.200 (0.20) |
| 30 | 10 | 1196 | . | 0.527 (0.66) |
| 51 | 18 | 1049 | 0.131 (0.06) | 0.262 (0.38) |
| 56 | 6 | 1499 | . | 0.651 (0.81) |
| 69 | 10 | 2448 | 0.267 (0.36) | 0.960 (1.26) |
| 75 | 14 | 159 | . | 1.160 (2.77) |
| 82 | 6 | 641 | . | 0.213 (0.26) |
| 87 | 5 | 433 | . | 0.397 (0.15) |
| 93 | 8 | 2355 | . | 0.995 (0.97) |
| 106 | 14 | 71 | . | 0.099 (0.04) |
| 111 | 3 | 84 | . | 1.114 (0.35) |
| 119 | 6 | 380 | . | 0.583 (0.90) |

the movements between Minnesota and Ontario, coordination of future management efforts among provincial, state, and federal agencies will be important.

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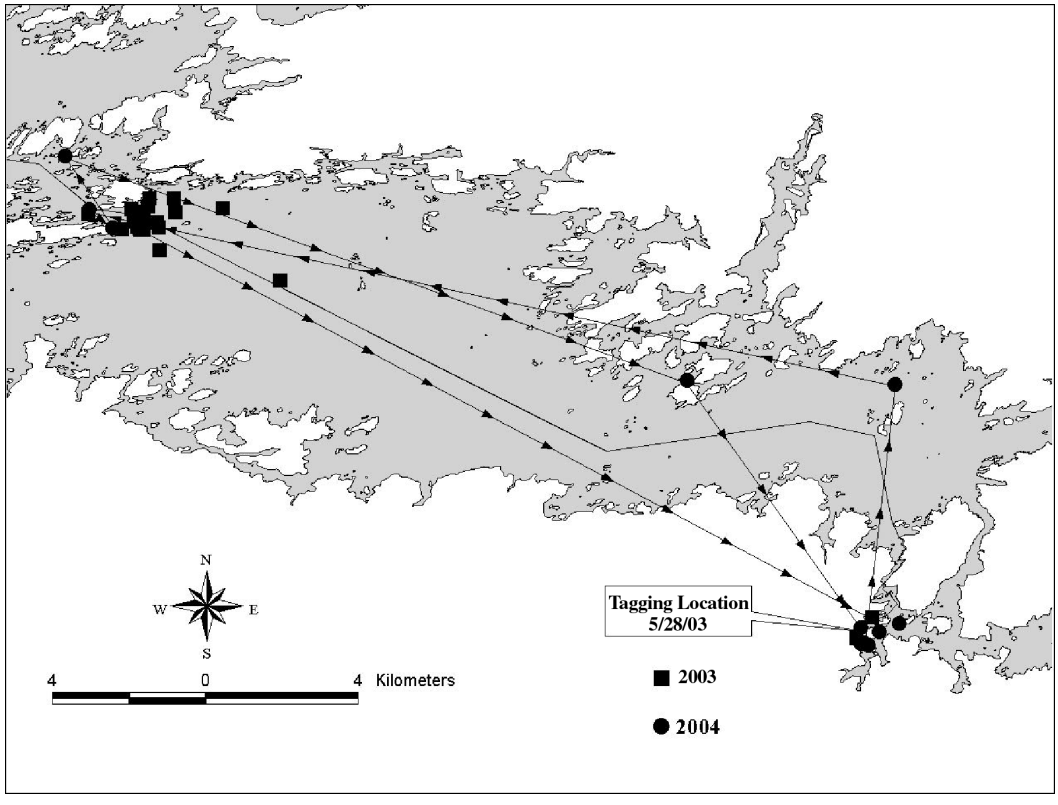


FIGURE 7. Distribution of locations for Lake Sturgeon number 15 in Rainy Lake, 2003 and 2004.

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