Final Report for Evaluation of Juvenile Lake Sturgeon (MI)
National Fish and Wildlife Foundation Project no. 2003-0117-004

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Introduction

Lake sturgeon *Acipenser fulvescens* were once widely distributed in rivers and lakes throughout North America. Their historic range included drainage basins of the Mississippi, Hudson Bay and the Great Lakes (MacKay 1963; Scott and Crossman 1973). Although lake sturgeon are found primarily in freshwater, some populations are found in the lower St Lawrence River, Hudson Bay, and James Bay (Harkness and Dymond 1961). Within the last century, lake sturgeon populations have been dramatically reduced or extirpated from much of their native range (Harkness and Dymond 1961; Brousseau 1987). In the 1800s and early 1900s, habitat decline, excessive harvesting, and intentional reduction were determined to be the primary causes for their decline (Harkness and Dymond 1961; Brousseau and Goodrich 1989). In 1885 the combined commercial catch of lake sturgeon in Lakes St. Clair and Erie peaked at about 2.27 million kg per year, then declined to near zero and has remained there since about 1910 (Tody 1974). To help reduce continued decline of the species, state governments in the United States and provincial governments in Canada have listed lake sturgeon as a protected species (Brousseau 1987; Johnson 1987). Lake sturgeon are protected in seven of the eight Great Lakes border states and are listed as a state threatened species in Michigan (Auer 1999).

Within the Great Lakes basin, tributary access continues to be one of the leading factors preventing lake sturgeon recovery. The construction of impassible barriers such as dams continues to disrupt life history requirements of lake sturgeon during various stages of development. The St. Clair River remains one of the few locations in the Great Lakes that provides lake sturgeon free migration and appears to have most of the basic habitat parameters necessary for lake sturgeon survival, although our understanding of those parameters is incomplete.

Recent research has focused on lake sturgeon spawning behavior, movement patterns of adults migrating to and from spawning locations, habitats needed pre- and post-spawning, and larval distribution (Auer 1999, Hay-Chmielewski 1987, Kempinger 1988, Mckinley et al. 1998 Nichols et al. 2003). Only a few recent studies have described young-of-the-year (YOY) and juvenile lake sturgeon (between 75 mm and 1 m TL) populations in both impeded systems (Kempinger 1996, Thuemler 1988) and unimpeded systems (Holtgren and Auer 2004). In shallower river systems lake sturgeon utilized a variety of substrates including clay, silt, sand, and gravel (Holtgren and Auer 2004, Chiasson et al. 1997, Harkness and Dymond 1961, Kempinger 1996). In large river systems like the St. Clair River juvenile lake sturgeon habitat requirements is not understood, this may be partially due to the difficulty in finding and capturing sturgeon in these environments.

The objectives of this study were 1) identify locations where juvenile lake sturgeon could be consistently captured within their natal system, implant them with ultra-sonic transmitters then track their movements, and 2) describe their range of movement within the St. Clair River, and quantify the types of habitats used. Information gathered would provide essential data required to guide future habitat protection, enhancement, and restoration activities, as well as lake sturgeon recovery plans in this and other Great Lakes locations. This demonstration effort would be a crucial first step in determining the present and potential contribution of St. Clair River lake sturgeon to adjacent populations in Lakes Huron, St. Clair and Erie. Additionally, this effort would assist in the recovery of lake sturgeon from "Threatened" status within the state of Michigan.

Study Site

The study area encompassed a small portion of Southern Lake Huron and the St. Clair River (Figure 1). The St. Clair River system is unique to the Great Lakes region both physically and biologically. Water leaving Lake Huron travels 64 km in a southerly direction to Lake St. Clair, before the river enters Lake St. Clair it passes through the largest natural delta system in the Great Lakes (Edsall et al. 1988). The upper reaches of the river are dominated by heavy industry on both sides of the border. In the southern reaches urbanization is prevalent on the U.S. side while wetlands and some agriculture dominate the Canadian side. River velocities at the surface reach 4 m/sec with an average discharge rate of 5,121 m^3/s (Edsall et al. 1988). Once reaching the delta, flow is diverted between four main channels. Navigation-related dredging in the St. Clair system began as early as 1873 and continues to the present, with a minimum depth of 8.3 meters maintained in the shipping lane. Once ships reach the delta region of the river large freighter traffic travels only on the South Channel and the St. Clair Cutoff. Within the river there are natural deep holes >24 m while in other areas deposition of sand has created extensive submerged bars resulting in river depths that are < 1 m deep (Edsall et al. 1988).

Methods

In September and October 2003 18 gillnets (mesh size 60 mm stretch x 1 m high x 37 m long) were deployed in an attempt to identify location where juvenile lake sturgeon were residing and to capture them for implantation (Figure 2). No lake sturgeon were captured during 2003 in part due to the amount of detached drifting vegetation that would clog the gillnets making them ineffective at fishing after periods of four hours or less.

Juvenile lake sturgeon used in this study came from both Southern Lake Huron and the St. Clair River. Fish from Southern Lake Huron were captured in commercial trap nets during the last two weeks of June 2004. The nets were deployed in six meters of water within 10 km of the headwaters of the St. Clair River. Fish were transported to indoor fish raceways located at Purdy Fisheries Ltd. in Point Edward, ON and held until they were implanted with ultrasonic transmitters.

Setlines were used to collect lake sturgeon from the North Channel of the St. Clair River using methods similar to those described by Thomas and Haas (1999). Each setline contained 25 stainless steel hooks alternating between small (2/0) and large (9/0) sizes. During the spring sampling period (1 June – 17 June, 2004) eight setlines per day were fished while during the summer sampling period (17 August – 1 September, 2004) four setlines per day were fished. Setlines were generally set in the morning and retrieved the following day for periods ranging from 18 to 26 hours. Frozen round goby (*Neogobius melanostomus*) was used as bait. At the beginning of each week new bait was used for the first set, for the remainder of the week only empty hooks or hooks with tattered bait were rebaited. Temperature, water depth and GPS coordinates were collected at each setline location.

When lake sturgeon were captured they were hoisted aboard with the aid of a large landing net. Fish captured in the spring were held in a holding container receiving a continuous supply of river water until the entire setline was retrieved. During the summer sampling period a smaller vessel was used therefore each fish was worked up as it was retrieved. The biological information collected included: total length (TL mm), fork length (FL mm), weight (kg), girth (mm), sex, location of lamprey wounds or scars if present, and if the fish had been previously marked. Fish not having previous tags were either marked with an external Floy tag or a Monel tag, both are placed at the posterior end at the base of the dorsal fin. In addition, passive integrated transponder (PIT) tags were injected in an area located dorsally between the end of the cranium and the first dorsal scute. The leading edge of the left pectoral fin was removed for age determination (Roussow 1957; Rossiter et al. 1995) and genetic analysis.

Ultrasonic transmitters were implanted in lake sturgeon using similar procedures described in Summerfelt and Smith (1990). The fish were anesthetized in a plastic bucket containing approximately 15 liters of river water then adding small amounts of MS-222 until the fish became docile. The fish was then removed placed on flat surface with their heads covered with wet cloth to reduce stress. A small incision approximately 2 cm long was made in the abdominal cavity. Ultrasonic transmitters were inserted directly into the body. We used Sonotronics model IBT-96-1 (23 mm length x 8 mm OD) and IBT-96-2 (28 mm length x 9.5 mm OD) transmitters, weight in water of each transmitter was 1.5 g and 2.5 g respectively with each having a audible hydroacoustics range of 500+ m. The fish were sutured with dissolvable nylon thread material. Fish were placed in a holding pen for 24 hours submerged to three meters. This provided an opportunity for post-operation assessment and allowed fish captured in deep water to equilibrate with lower pressures found near the surface. Lake sturgeon captured by Purdy Fisheries and held at Point Edward were implanted at that facility. Those fish were held in the raceway overnight then transported by cooler to the North Channel and released.

Lake sturgeon were tracked by boat using an ultrasonic receiver (Sonotronics Model USR-96) and a hand held directional hydrophone (Sonotronics Model DH-4). Typical distance traveled between listening stations was approximately 250 m. Most fish could be detected from 500m. Using this method, all areas of the St. Clair River could be searched with relatively low likelihood that fish were in the area but not detected. When fish were located some distance from the boat they were advanced upon until the transmitter signal exhibited equal strength in all directions. The amount of error locating fish due to hydrophone limitations was estimated to be $\pm$ 5 m. Fish locations and listening locations were recorded using a Global Positioning System (GPS). When a fish was located, water depth and temperature were also recorded.

After movement patterns were established a second attempt was made to collect lake sturgeon using gillnets. Using the active locations from the implanted juvenile lake sturgeon, gillnets (n = 29) were re-deployed in the North Channel of the St. Clair River from 27 July – 5 August, 2005

(Figure 3). Again, no lake sturgeon were captured however, other non-target species of fish were captured.

Habitat information was collected using a combination of underwater video and deck mounted GPS equipment. Habitat images were geo-referenced and converted into map layers using GIS Mapping Software. Map layers were also made of setline, gillnet, trap net and lake sturgeon locations. Substrate images were filmed midday, under ambient light conditions, during periods of low turbidity. A high-resolution underwater, video camera (Fuhrman Diversified Inc., Seabrook, TX) housed within a protective aluminum tube was used. Three external fins on the housing enabled control of direction and angle of the camera. The camera was attached by a coaxial cable to a video monitor/recorder located on the boat. Substrate images were recorded as the boat drifted downriver, with camera depth being maintained 5m from the bottom.

Locations of the North Channel that were video surveyed were areas frequented by implanted lake sturgeon. A total of three locations were surveyed with a combined river distance of approximately eight km (Figure 4). Transect length ranged from 0.3 to 0.9 km long and were located approximately 100 m apart. The number of transects required to cover a given segment of the river ranged between 3 and 5. Fixed locations were recorded along the entire length of each Video segment along with depth. River bottom substrates were identified and classified from the video recordings and then plotted using ArcView Geographic Information Software (GIS) (ESRI, Inc., Redlands, California). Comparison of sturgeon locations with substrate images helped define juvenile lake sturgeon habitats.

Results

A total of 113 setlines were used in the spring and summer sampling periods in 2004 to capture 159 lake sturgeon. Total hook hours for the spring was 47,030 and resulted in the capture of 106 lake sturgeon. For summer total hook hours was 16,100 and resulted in the capture of 53 lake sturgeon. Lake sturgeon captured ranged in sizes from 374 – 1750 mm and were between 2 and 38 years old. Only five lake sturgeon captured on the spring setlines were less than 766 mm and all were implanted with ultrasonic transmitters the remaining three implanted fish came from Southern Lake Huron (Figure 5). Summer setline surveys resulted in the capture of ten new juveniles (< 766 mm) that had not been previously implanted or tagged with an external tag (Figure 6).

A total of eight lake sturgeon were implanted with ultrasonic transmitters and followed for the duration of the battery life. Biological and information on each transmitter is listed in Table 1. All fish were released at various locations in the North Channel (Figure 7). The three fish that were initially captured in Southern Lake Huron were released at Pt. Aux Chenes (fish 75155), 9 km downriver from Pt. Aux Chenes (fish 75144), and 12 km downriver from Pt. Aux Chenes (fish 74444). Fish 75155 was lost or there was potentially a problem with the transmitters and was not relocated (Figure 8). Fish 75444 was the smallest fish and was released the greatest distance from Pt. Aux Chenes. It was only located on two occasions first on June 6 shortly after initial release and 51 days later on July 27 (Figure 9). Fish 75144 was located on numerous occasions providing information for 64 days Figure 10). Both fish 75444 and 75144 migrated upriver until reaching Pt. Aux Chenes then remained within close proximity to the deep waters of that area of the river.

Fish 75555 was captured approximately 11 km downriver from Pt. Aux Chenes and was released 2 km upriver from Pt. Aux Chenes (Figure 11). Within three days following initial release was located within 1.5 km of its original capture location. The fish remained within a limited segment of the North Channel adjacent to deep water. Fish 75166 was also captured approximately 11 km downriver from Pt. Aux Chenes. However, that fish remained within the deep water area of Pt. Aux Chenes (Figure 12). Fish 75666 was captured and released at Pt. Aux Chenes then tracked for 53 days (Figure 13). Over a period of 10 days the fish migrated downriver then continued to move between a series of two deep sections of the river. Two fish (75357 and 75777) were captured, released and remained within the deep water area of Pt. Aux Chenes (Figures 14 and 15 respectively). Fish 75357 was tracked for a period of 58 days while fish 75777 was tracked for 19 days before contact was lost. Depths where juvenile lake sturgeon were captured during spring and summer setline sampling and depths at locations frequented by sturgeon after implantation was between 5 and 25 m deep with over 95 % of the fish being located between 10 and 24 meters (Figure 16).

Batteries in the small transmitters were designed to last for a period of 30 days and last for a period of 45 days in the larger transmitters. Our results varied from 1 to 64 days with an average of 47 days for those transmitters that did not fail. During events when a fish could not be located the entire river system form the headwaters area through each major channel of the delta was searched. At least once a week all major channels of the delta were searched. The longest period between search events was five days.

A total of 218 minutes of substrate images were recorded on videotape in North Channel of the St. Clair River. Analysis of the recordings revealed substrates composed of sand, imbedded coarse gravel (< 8 cm in diameter), compacted clay, and large mounds of zebra mussels (*Dreissena polymorpha*). Some of the most notable features found in the North Channel are the series of deep naturally occurring holes ranging from 18 to 24 m deep and 1 to 3 km in length. Bottom substrates can best be described in a general sense where areas between deep holes were composed primarily of underwater sand dunes that are in a constant state of flux. Within those sand areas were the occasional woody debris piles or areas where the sand was gone and the compacted clay bottom was exposed. Within deep areas the substrate was composed of imbedded coarse gravel. At the very tail downstream end of deep holes there were large piles of zebra mussels and shells of dead zebra mussels. Deep holes were associated with constricted areas and major changes in the direction of the river, these areas also tended to be locations with the highest current velocities. We identified seven distinct deep holes in the North Channel where we were tracking the implanted fish.

Discussion

Several features of the North Channel of the St. Clair River are likely responsible for the high density of both juvenile and adult lake sturgeon. First, there are only two known lake sturgeon spawning areas located in the St. Clair River. The first spawning location was identified by researchers in 1996 and is located approximately 2 km from where the Middle Channel splits form the North Channel (Manny and Kennedy 2002, Nichols et al 2002, Thomas and Haas 2004). The second spawning location was identified from research funded by NFWF in 2002 and 2004 and is located up at the headwaters of the St. Clair River (Boase unpublished data). In fact, those two locations are only two of three locations known in Michigan waters of Lakes Huron and Erie where lake sturgeon have spawning habitat (Manny and Kennedy 2002). Site fidelity is an important intrinsic characteristic that lake sturgeon exhibit and helps explain why many sturgeon remain in this area of the Great Lakes. Lake sturgeon considered a poto-anadromous species meaning they move within freshwater environments but generally migrate from lake environments to river environments to spawn. During those spawning events and in the vicinity of those spawning locations researchers capture not only spawning ready adults but also non-spawning adults and juveniles as well (Thomas and Haas 2004). There also is recent evidence that many lake sturgeon remain in the St. Clair River year round, it seem plausible that all of the growth and maintenance requirements of the fish are met while living in the river (James Boase 2003).

A second factor that may be responsible for the high density of lake sturgeon in the North Channel can be partially explained by the early life history of the species. Although the largest spawning habitat is located almost 60 km upriver at the headwaters of the St. Clair River, following a three to four week development period post-spawning, the fry begin a period where they drift within the water column (Nichols et al. 2002). It is possible that most fish end up down in the delta region or end up drifting out into Lake St. Clair. The youngest lake sturgeon captured were ages two and older, no young-of-the-year (YOY) or one year olds were captured during setline or gillnet sampling. We hypothesize that YOY sturgeon migrate out into the lake as water temperatures begin to decrees during fall which would be consistent with the findings of Holtgren and Auer (2004). Other potential explanations include YOY fish are in the river but were located in habitats not sampled, or were in the same habitats as the older cohorts but were not susceptible to the gear.

Based on information derived from movement patterns of the implanted fish and from the setline surveys juvenile lake sturgeon are selecting habitats in the deepest portions of the North Channel. Most of the fish were found over either sand substrates adjacent to deep areas or in the deep areas which were composed primarily of imbedded coarse gravel. Sand areas appeared to be constantly changing and it is unclear what type or amounts of forage would be available in those habitats. Coarse gravel substrates located in the deep areas would probably provide abundant forage or would be locations in the river where drifting materials in the water column settle out and collect. Although no benthic samples were collect during this study previous studies have demonstrated that the highest densities of benthic organisms are found in softer substrates found in lower current velocity areas such as near shore shallow areas (Edsal et al. 1988). No lake sturgeon were found in shallow water.

The proximity of zebra mussels to locations where the fish were found may be providing a continuous supply of food for lake sturgeon using habitats in the adjacent sand and gravel substrates. However, no diets were sampled during this study. To address that question diet information would need to be collected form fish as they were captured. Fish collected using setlines would not provide that information because of the amount of time they are hooked on a setline and the amount of digestion taking place. Some forage may be available form material drifting in the water column. Deep water areas have lower velocities near the bottom relative to the areas before and after and tended to have some settling of organic matter associated with the deepest sections.

Relative to other locations around the Great Lakes the St. Clair River and Lake St. Clair have a high abundance of lake sturgeon. Our capture success of both adult and juvenile lake sturgeon during the spring and summer of 2004 and the movement patterns of the implanted fish support this. The Michigan Department of Natural Resources has been intensively collecting information about lake sturgeon since 1996 and estimate population in Lake St. Clair and the North Channel of the St. Clair River to be approximately 45, 000 fish. Adults are probably using the North Channel because of the spawning habitat. With the juveniles it is not fully understood why they are so prevalent in the North Channel. Deep water areas are also found in other channels of the delta and we presume that sand and zebra mussel substrates are also found in those locations. One difference between the North Channel and the South Channel is the fact that large freighters continually disturb areas within the navigation channel of the South Channel.

The importance of North Channel as a nursery area for juvenile lake sturgeon cannot be overemphasized. Lake sturgeon abundance in this area of the Great Lakes is likely due to the fact that two major spawning areas are located in this river system. Because no other spawning areas have been found in Michigan waters of Lakes Huron or Erie, fisheries managers need to recognize the importance of these areas. This river is especially vulnerable to the affects of major industries that are located on the river and to the demands of the urban development taking place in the surrounding metropolitan area. Lake sturgeon with origins in the St. Clair River may be serving as source populations in other locations of the Great Lakes so protecting this system is vital.

Implications for Rehabilitation of Lake Sturgeon

At the outset of this project one of the primary goals was to find juvenile lake sturgeon on a consistent basis. Because we are dealing with remnant populations of lake sturgeon in the Great Lakes and so little was understood about the habitats where juvenile lake sturgeon reside, finding those habitats was key to the success of this project. This project demonstrated that juvenile lake sturgeon are fairly abundant in the North Channel of the St. Clair River and can be found in some of the deepest waters in the system. Being able to collect juvenile lake sturgeon consistently such as we demonstrated in this project provides an important tool for fisheries managers allowing them to forecast population trends into the future. The fact that lake juvenile lake sturgeon were only captured in the North Channel of the St. Clair River possibly indicates the lack of suitable nursery habitat. Critical to the rehabilitation of lake sturgeon in this region of the Great Lakes is the maintenance and protection of habitats like those found in the North Channel.

The second primary goal of this project was to characterize the habitat used as nursery areas. We found that deepwater areas are an important requirement of juvenile lake sturgeon residing in the North Channel. Because information about the importance of nursery areas and early life history requirements of lake sturgeon is lacking, further research should be considered. Funding by the National Fish and Wildlife Foundation made it possible to achieve the objectives proposed and with the completion of this project added new knowledge about lake sturgeon in the Great Lakes.

Future Research

In the summer of 2006, working with researchers from USGS and Michigan Department of Natural Resources we plan to map the entire North Channel quantifying the available habitats. Graduate students from the University of Michigan will be conducting similar telemetry research in other channels of the St. Clair Delta. The goal of that research is to determine if similar habitats are being utilized by juvenile lake sturgeon in those channels. To date no information is available about the period of time when lake sturgeon swim up from the spawning reef until they are captured as two year olds. Although different sampling techniques have been tried to try and locate where lake sturgeon that age reside and many areas of both the river and lake system have been searched, no fish that size have been captured. Continued research is critical if our rehabilitation efforts are to be successful.

Acknowledgements

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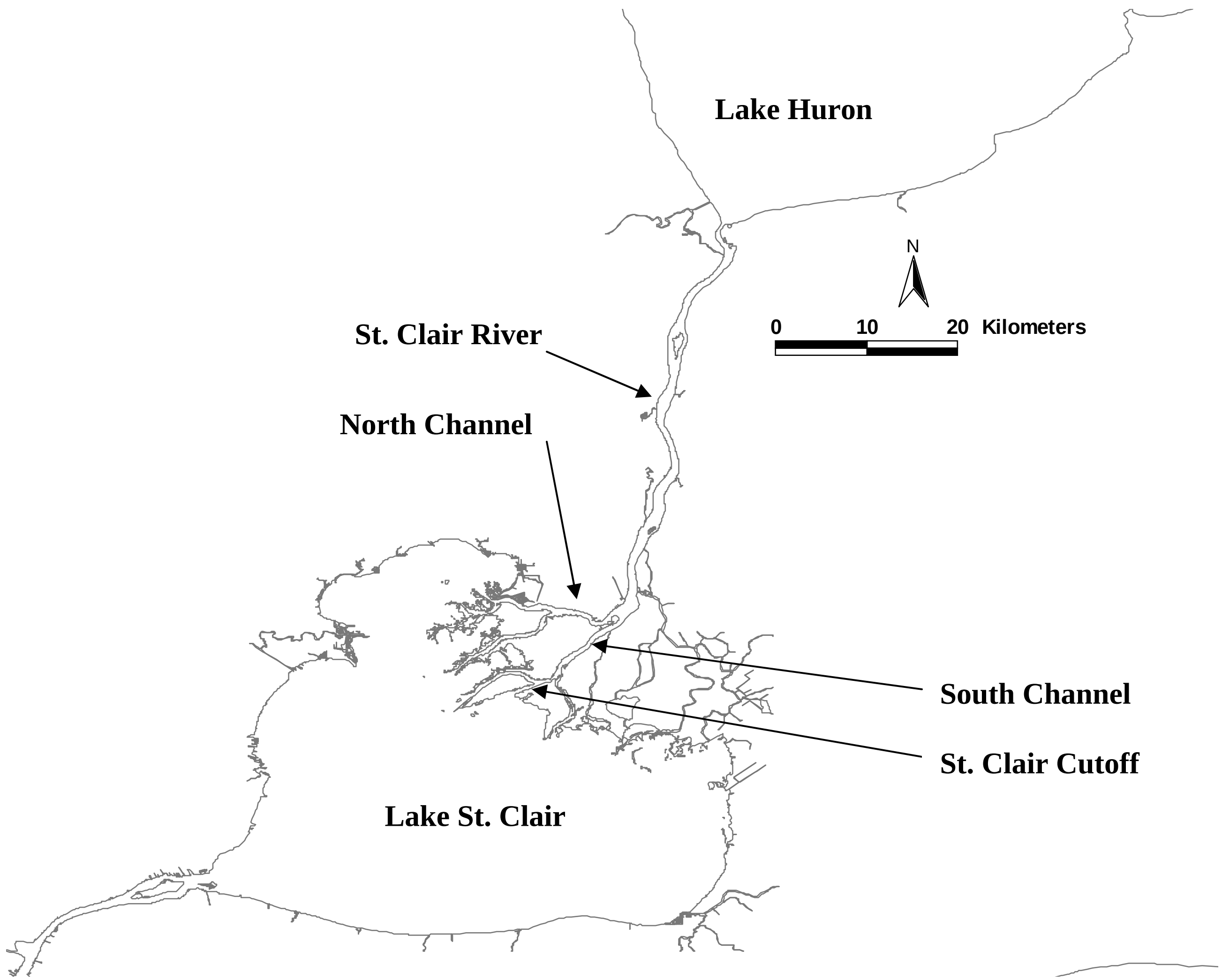

Figure 1. Study area during 2003 – 2004 included Southern Lake Huron through the St. Clair Delta. Shipping traffic that reaches the delta region travels on the South Channel and the St. Clair Cutoff.

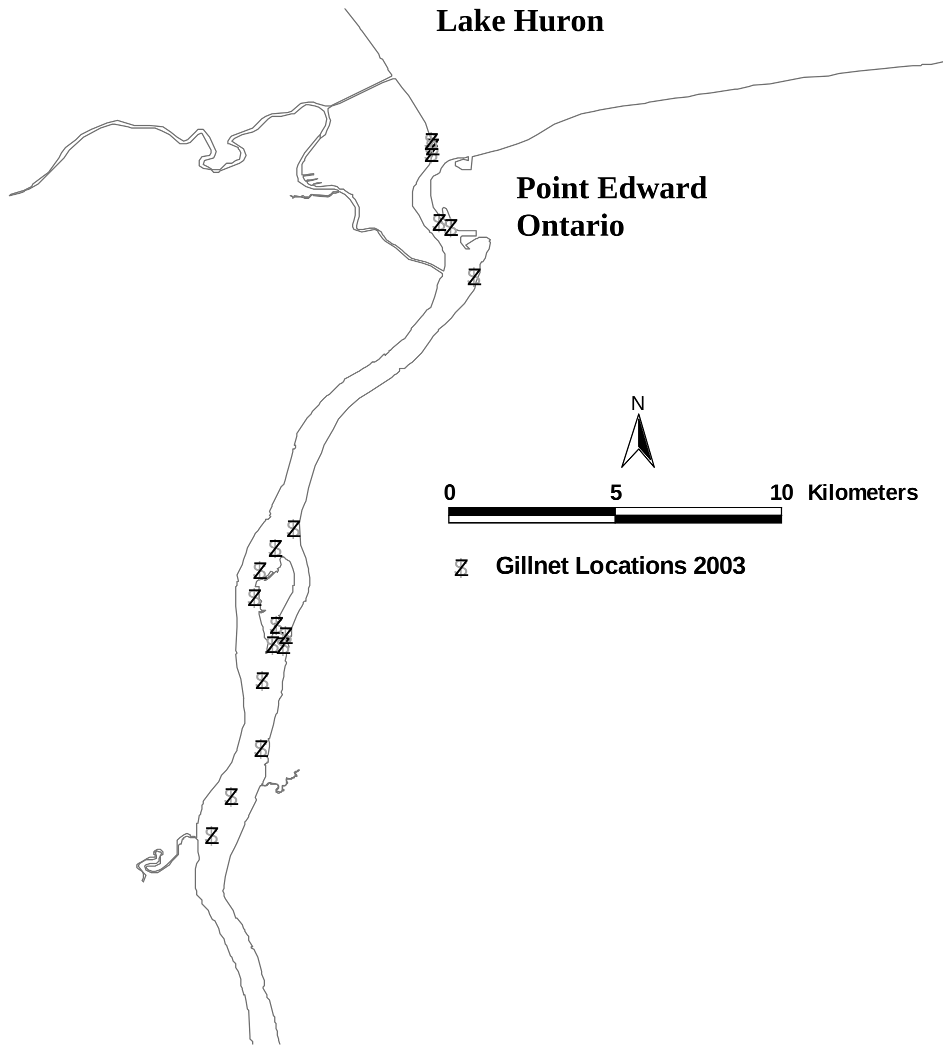

Figure 2. Gillnet locations (n = 18) from September 19 – October 1, 2003 in the Upper St. Clair River.

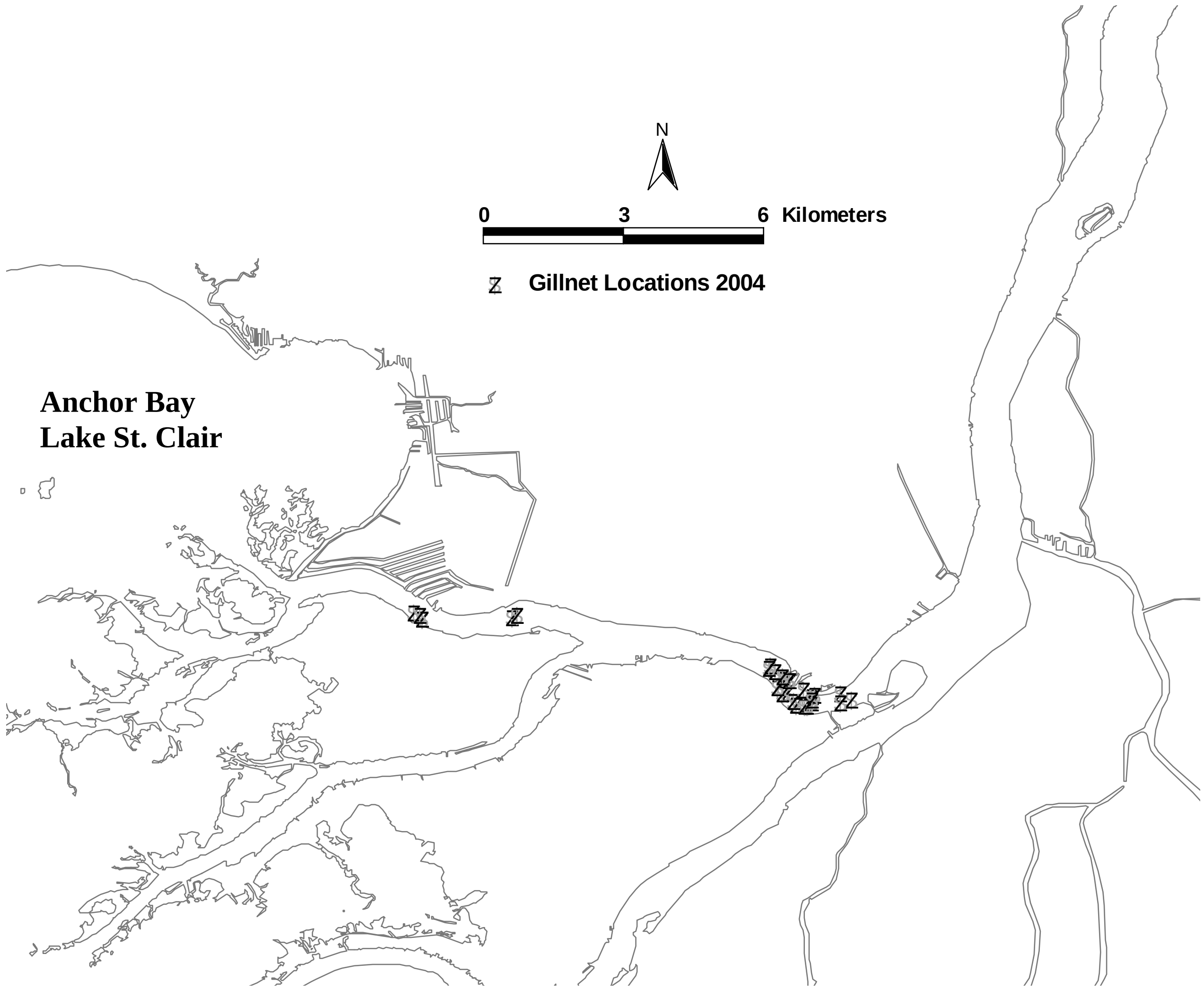

Figure 3. Gillnet locations (n = 29) in the North Channel of the St. Clair River from 27 July – 5 August, 2005.

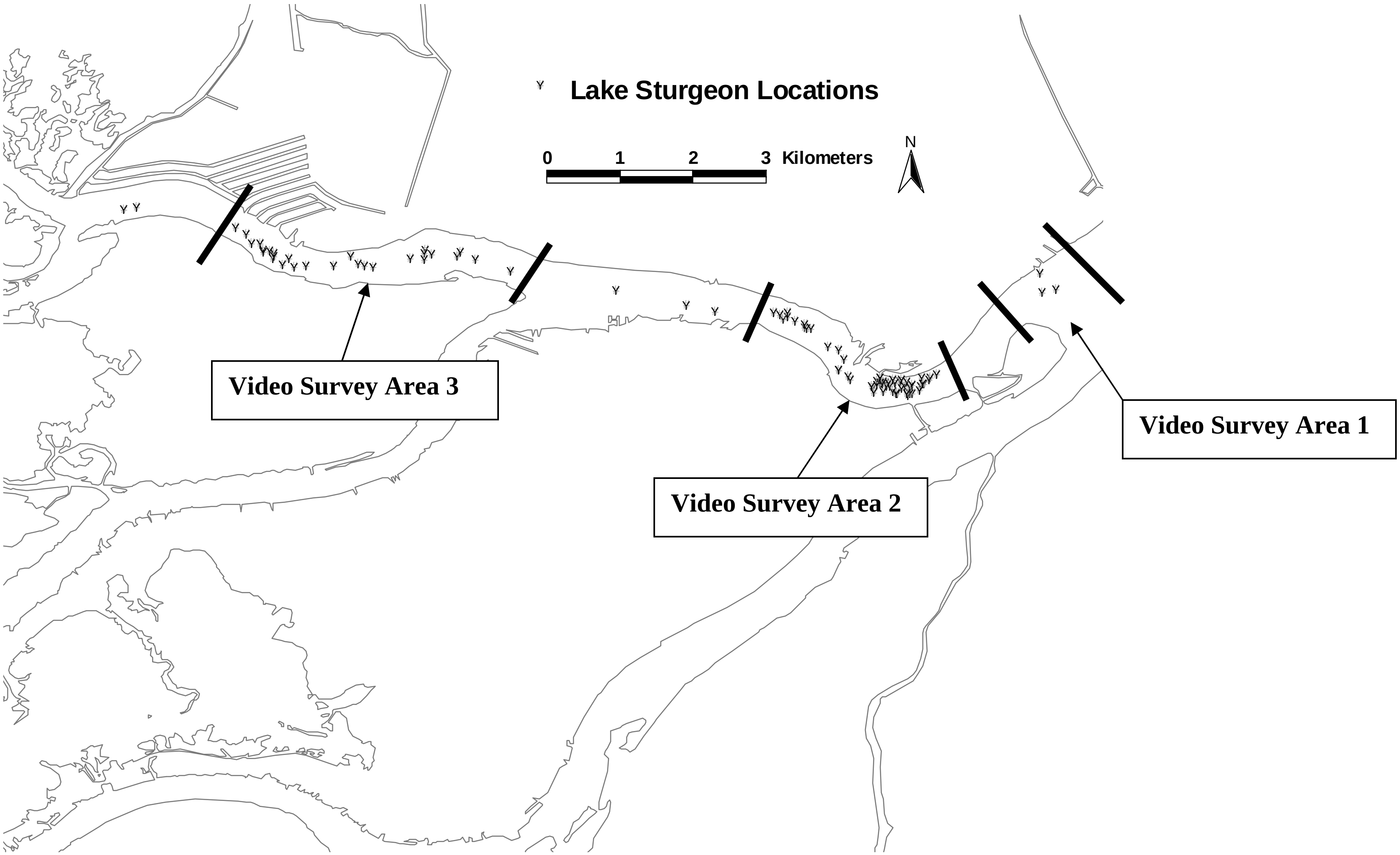

Figure 4. Locations in the North Channel of the St. Clair River where underwater video recordings were collected to determine substrate composition and habitats used by implanted juvenile lake sturgeon.

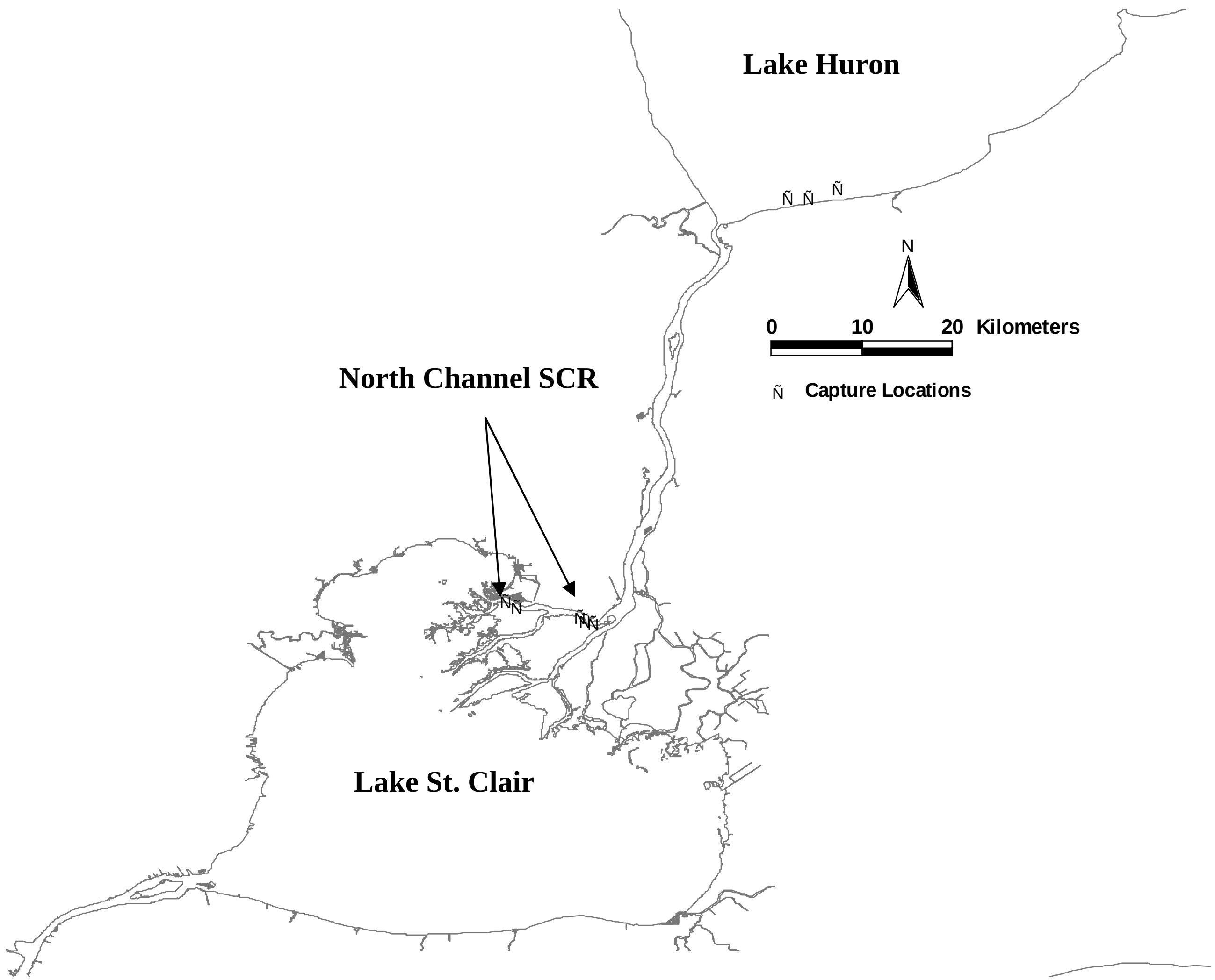

Figure 5. Capture locations of three lake sturgeon from Southern Lake Huron (captured in commercial trap nets) and five from the North Channel of the St. Clair River (captured on setlines) used for telemetry study.

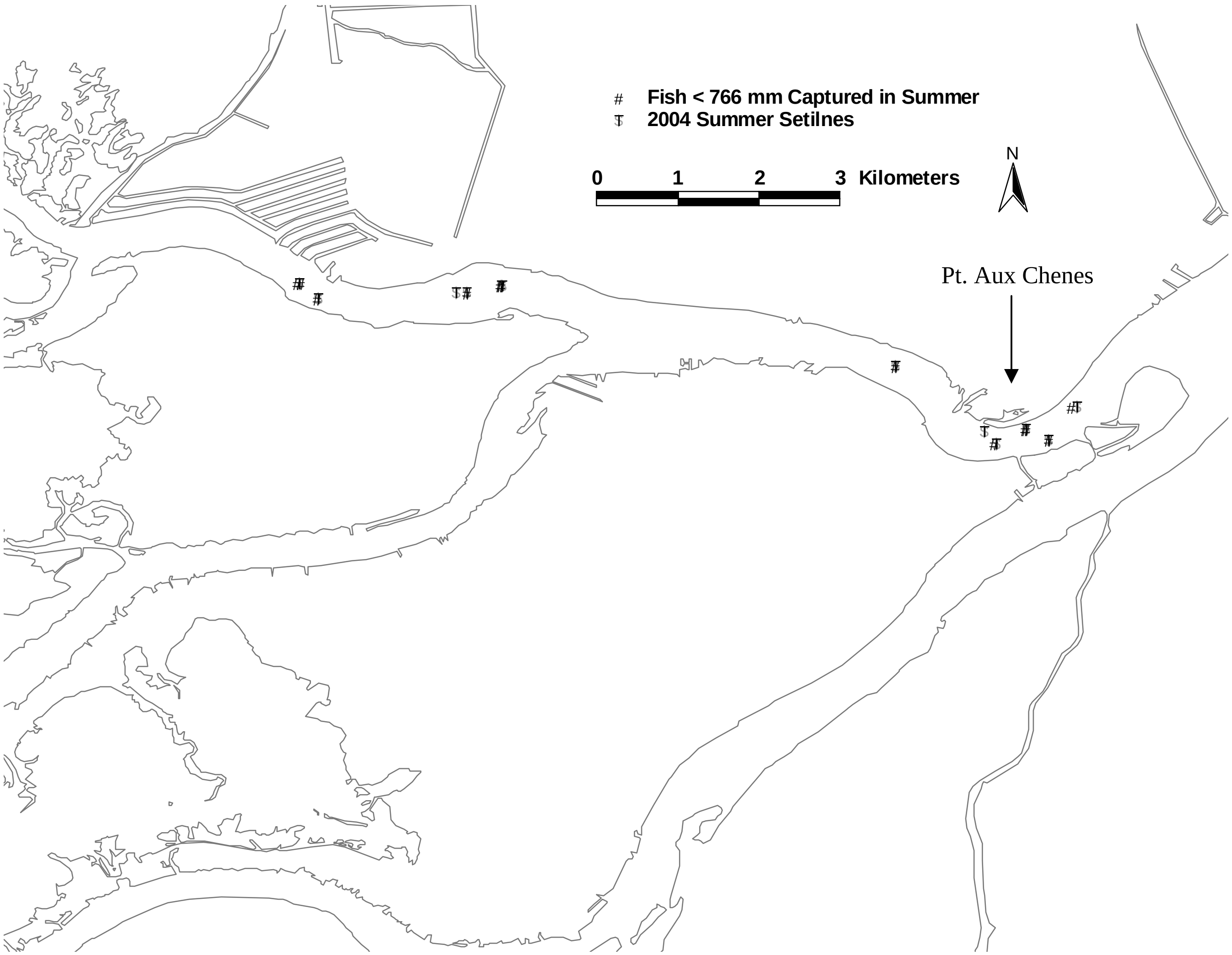

Figure 6. Locations of summer setlines in 2004 and fish captured less than 766 mm.

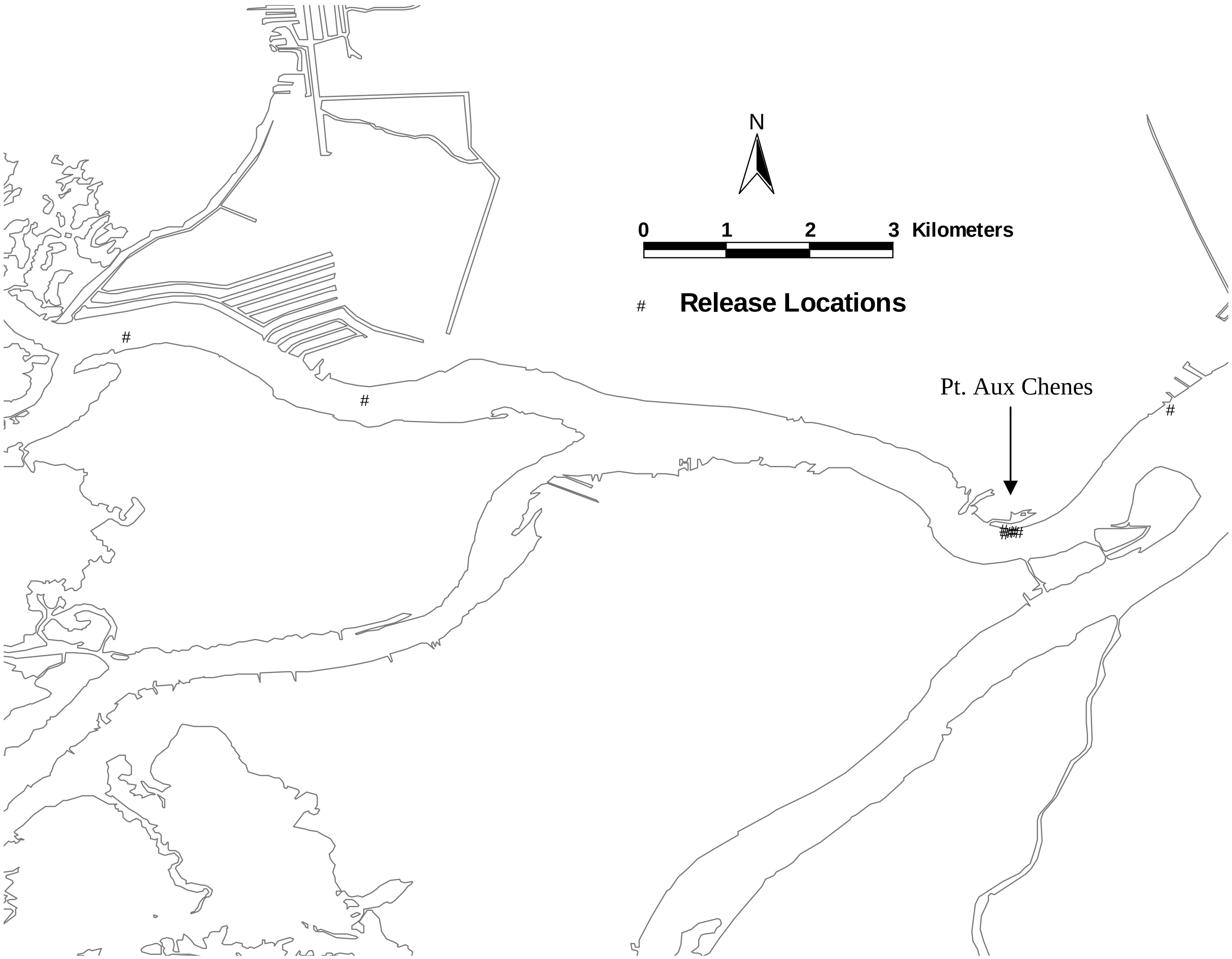

Figure 7. Release locations of eight juvenile (< 766 mm) lake sturgeon implanted with ultrasonic transmitters.

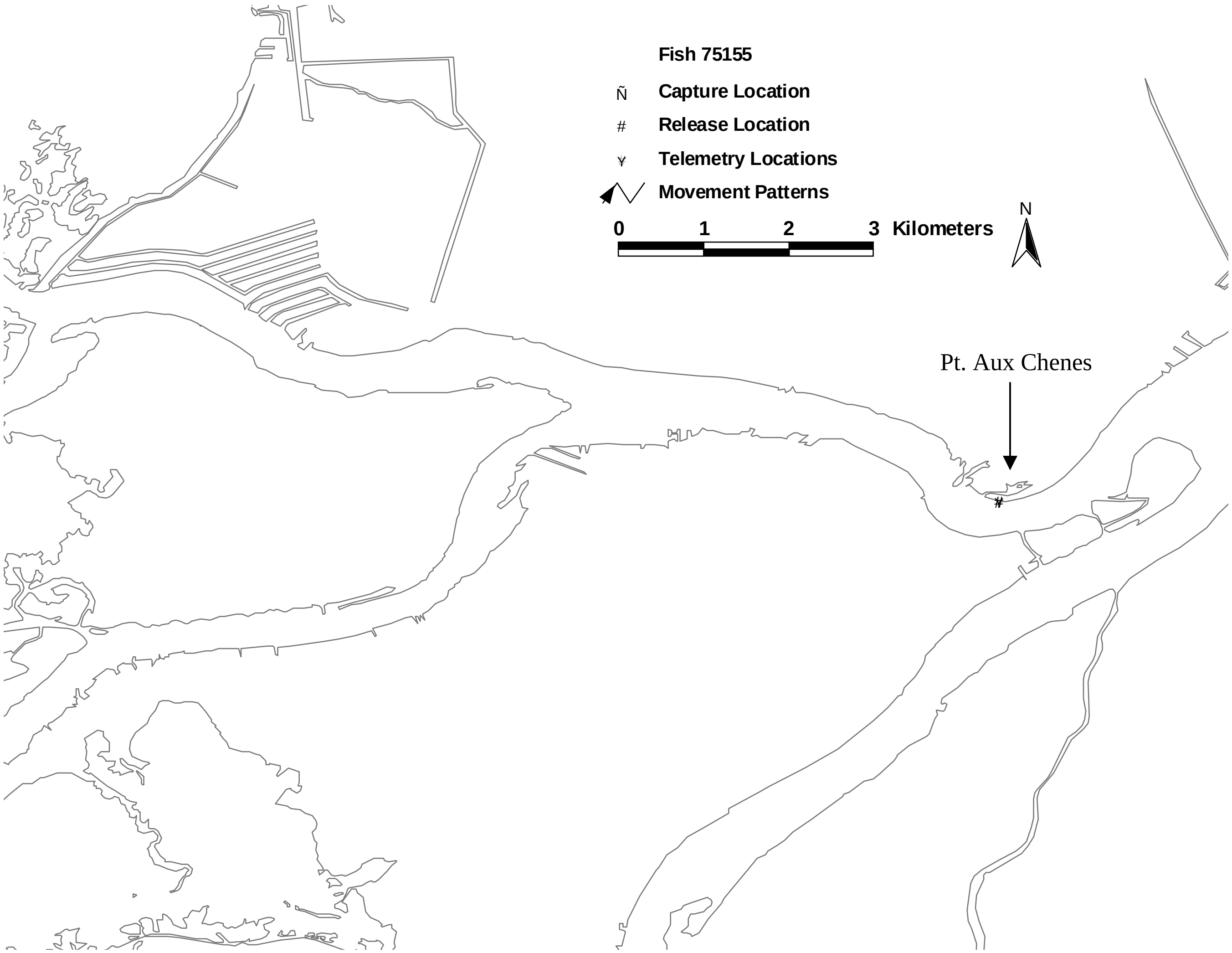

Figure 8. Location of fish 75155 at time of release no subsequent locations were identified.

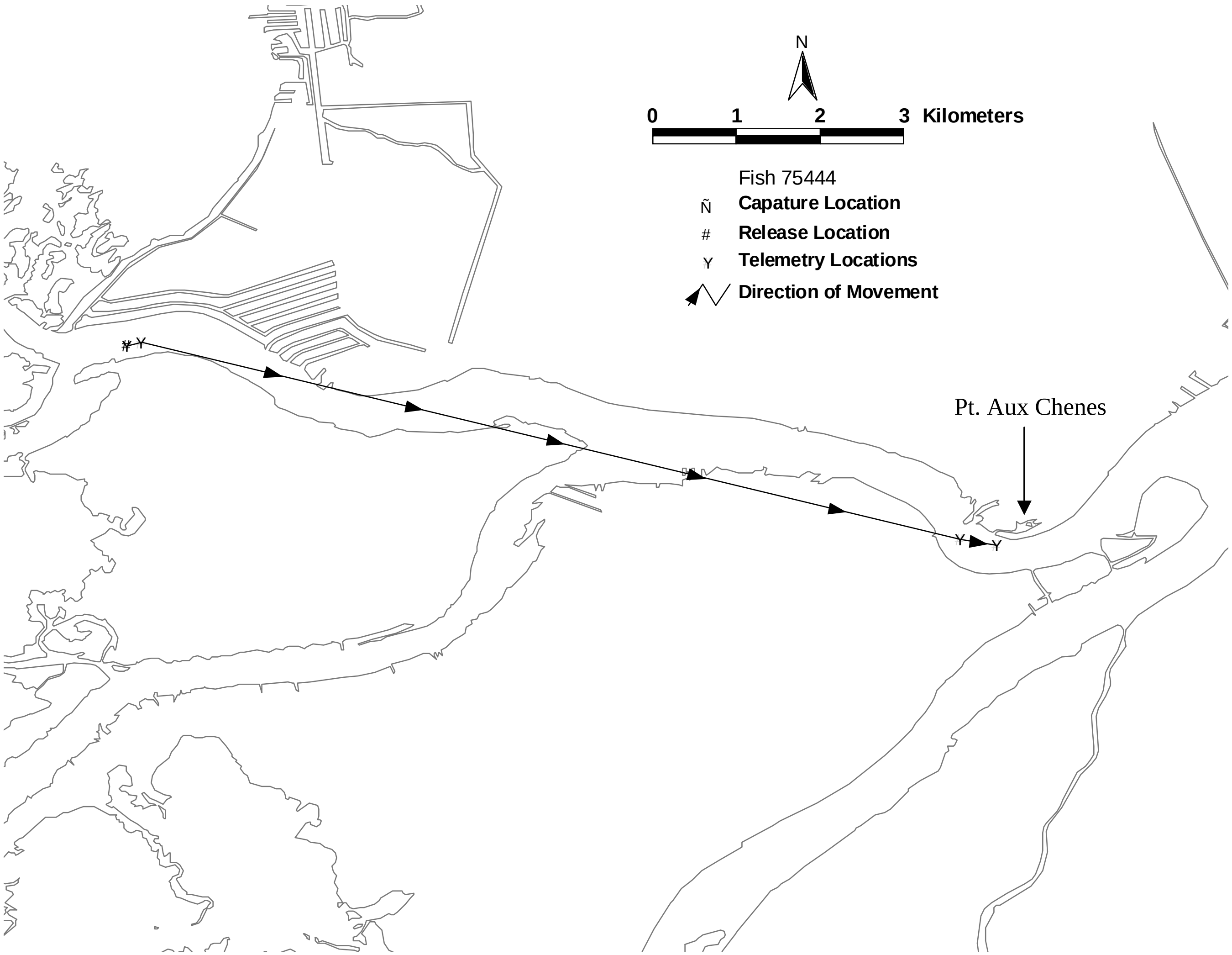

Figure 9. Movement patterns of fish 75444 following initial release on 6 June, date last located 27 July.

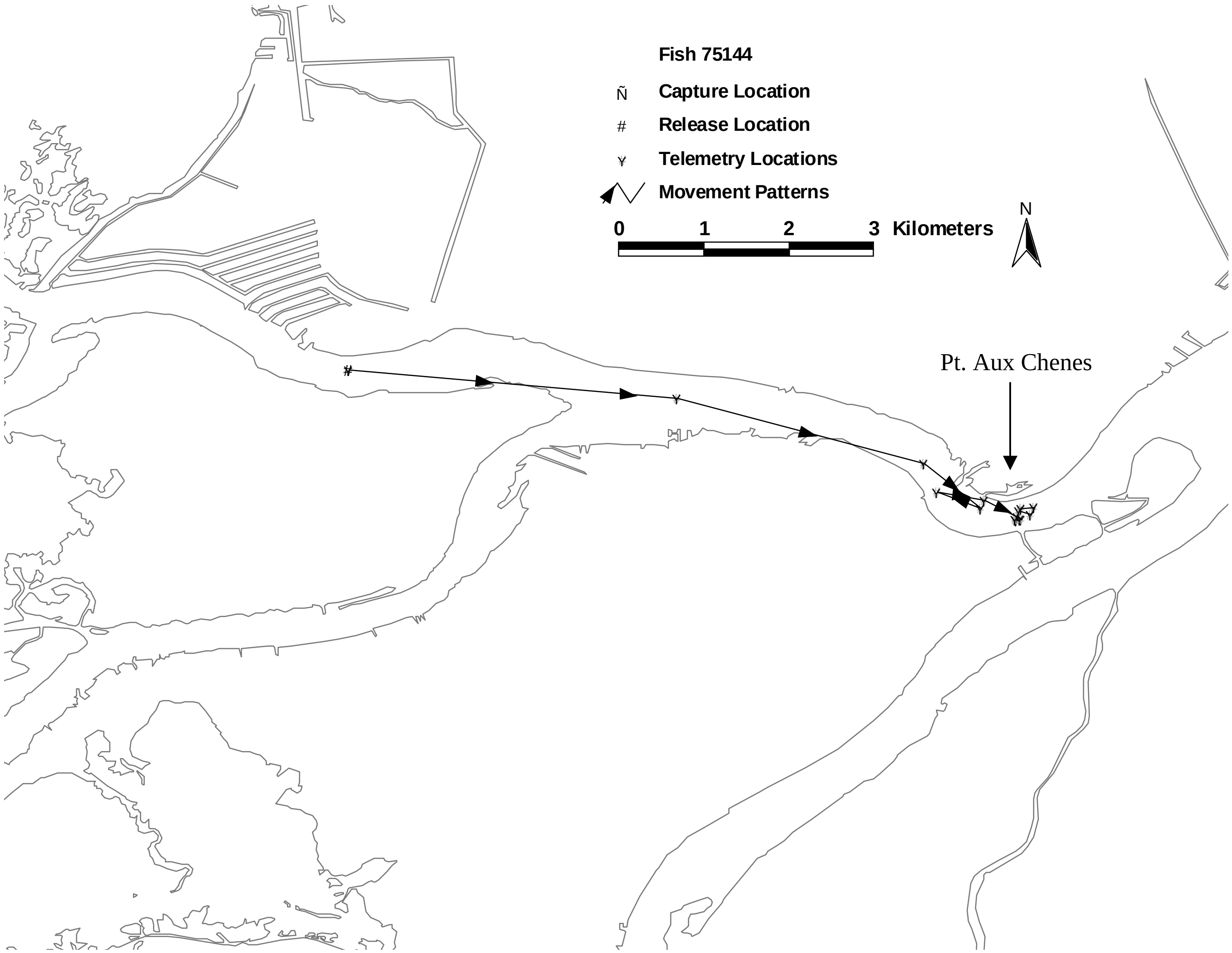

Figure 10. Movement patterns of fish 75144 following initial release on 16 June, date last located 19 August.

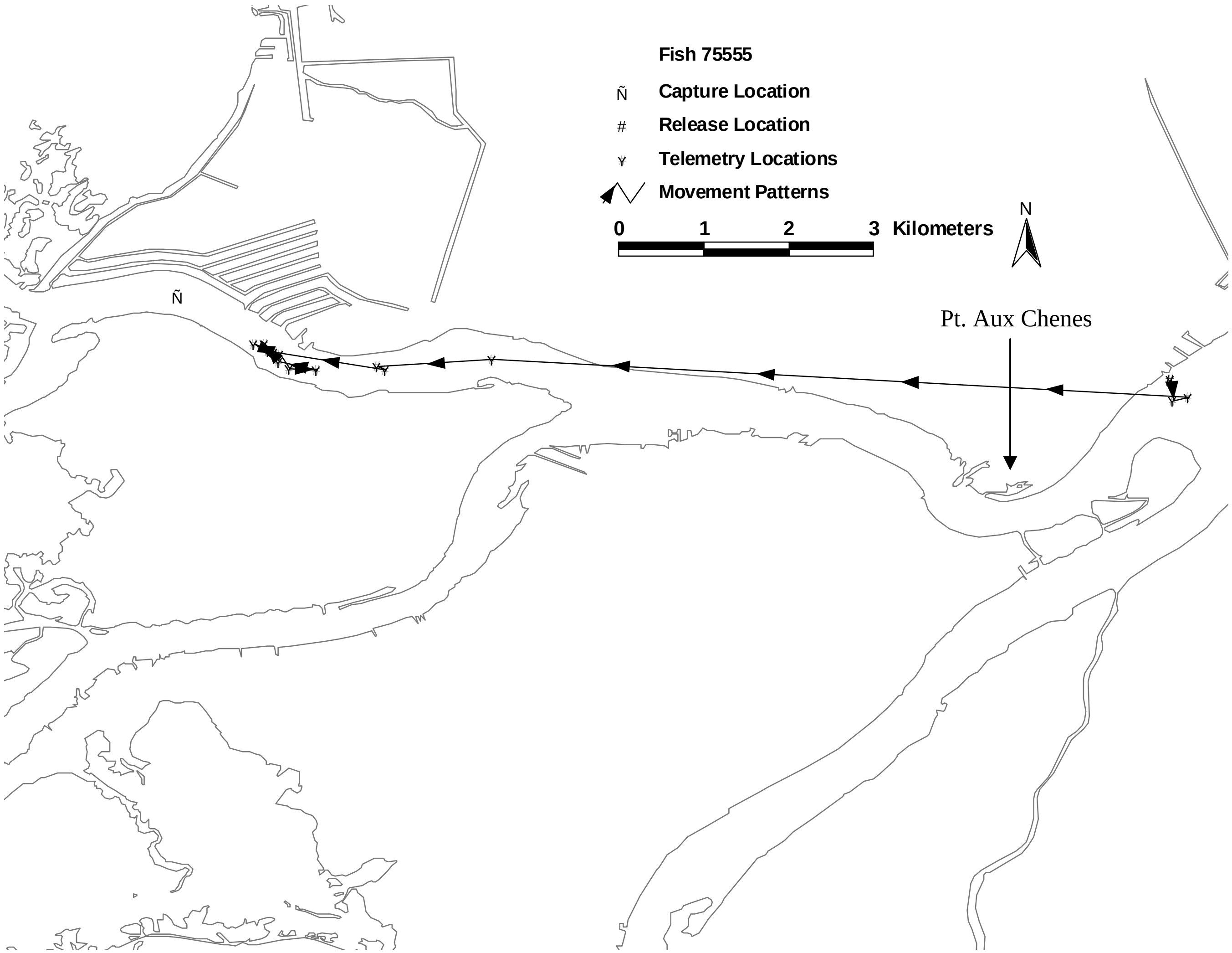

Figure 11. Movement patterns of fish 75555 following initial release on 18 June, date last located 6 August.

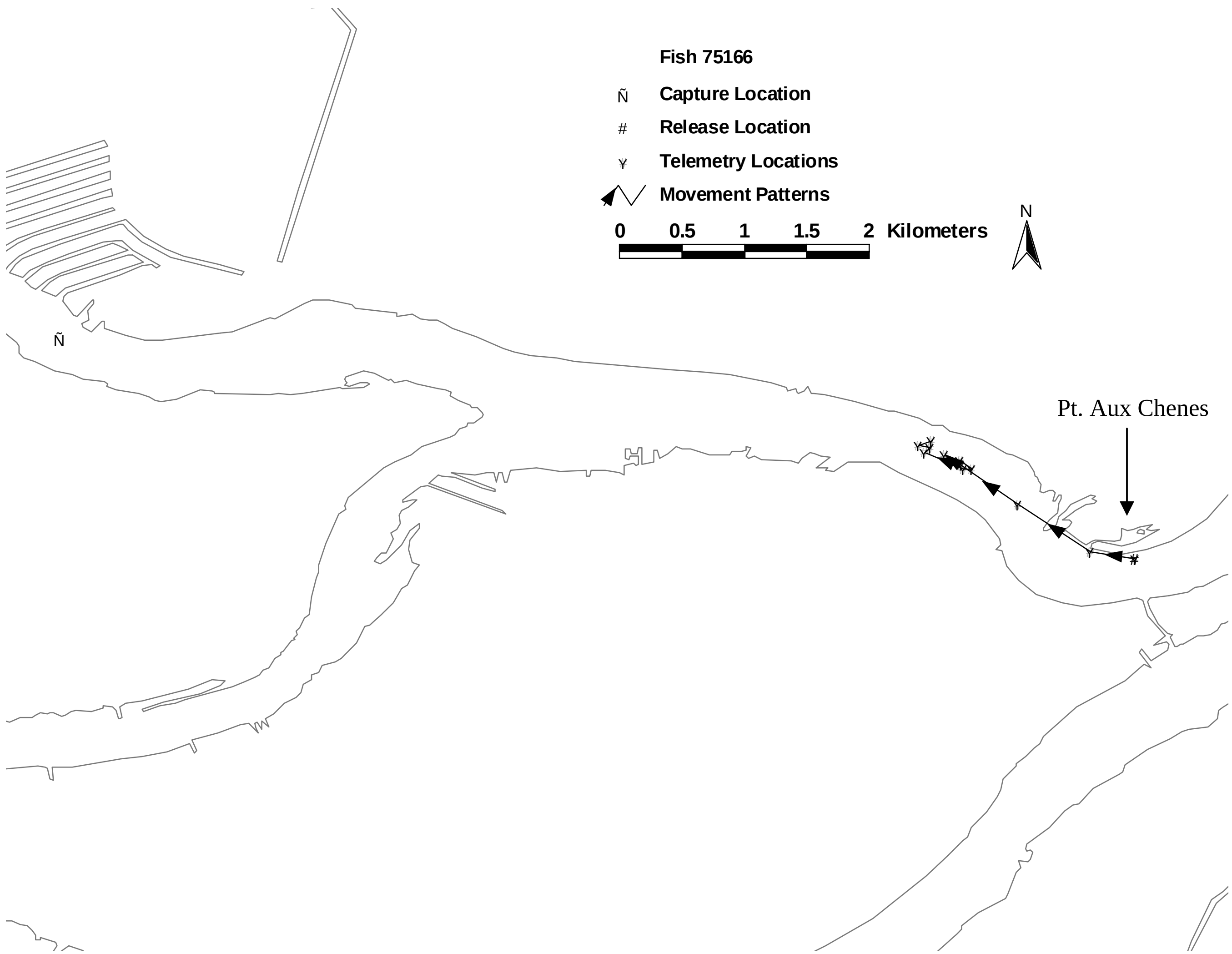

Figure 12. Movement patterns of fish 75166 following initial release on 16 June, date last located 22 July.

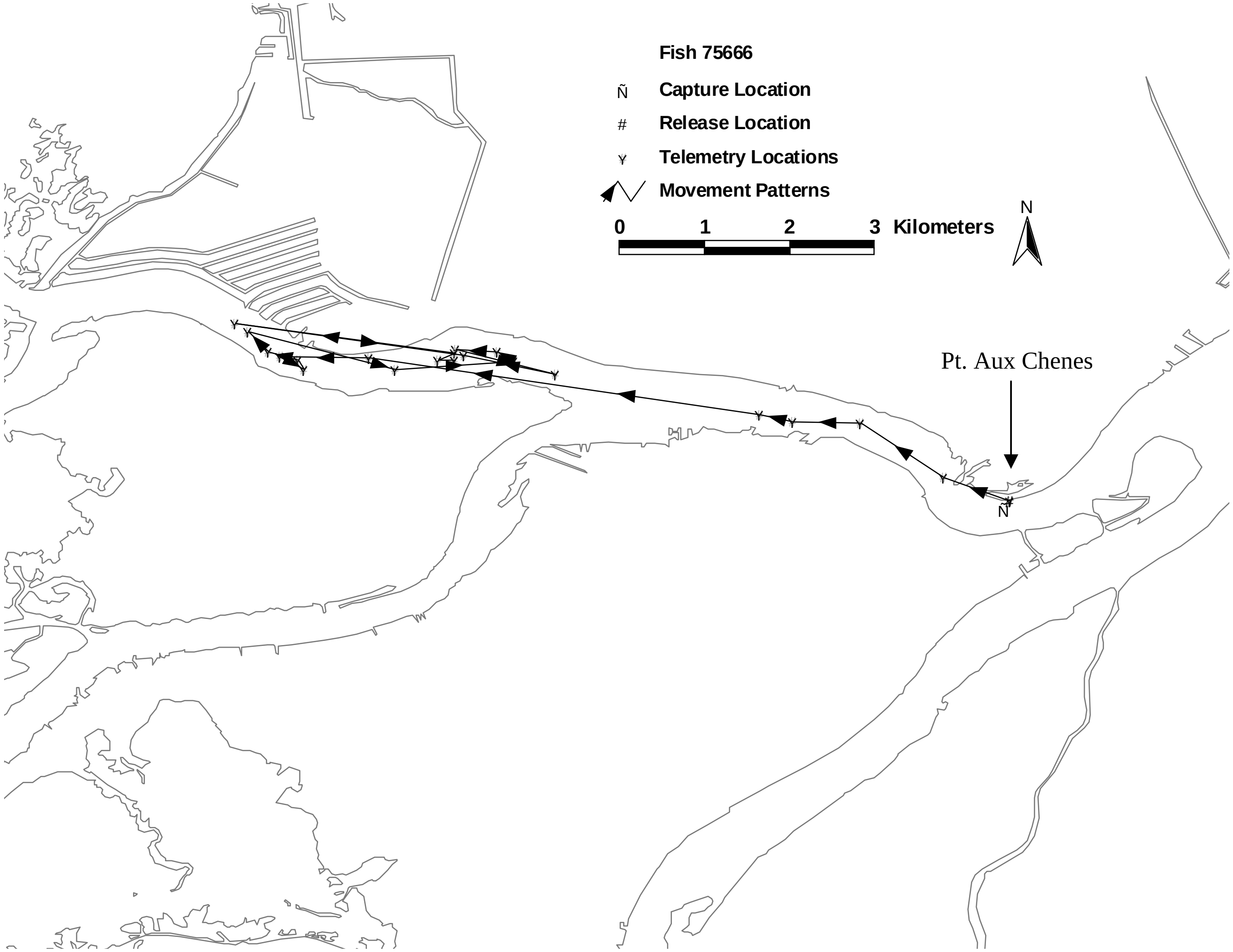

Figure 13. Movement patterns of fish 75666 following initial release on 4 June, date last located 27 July.

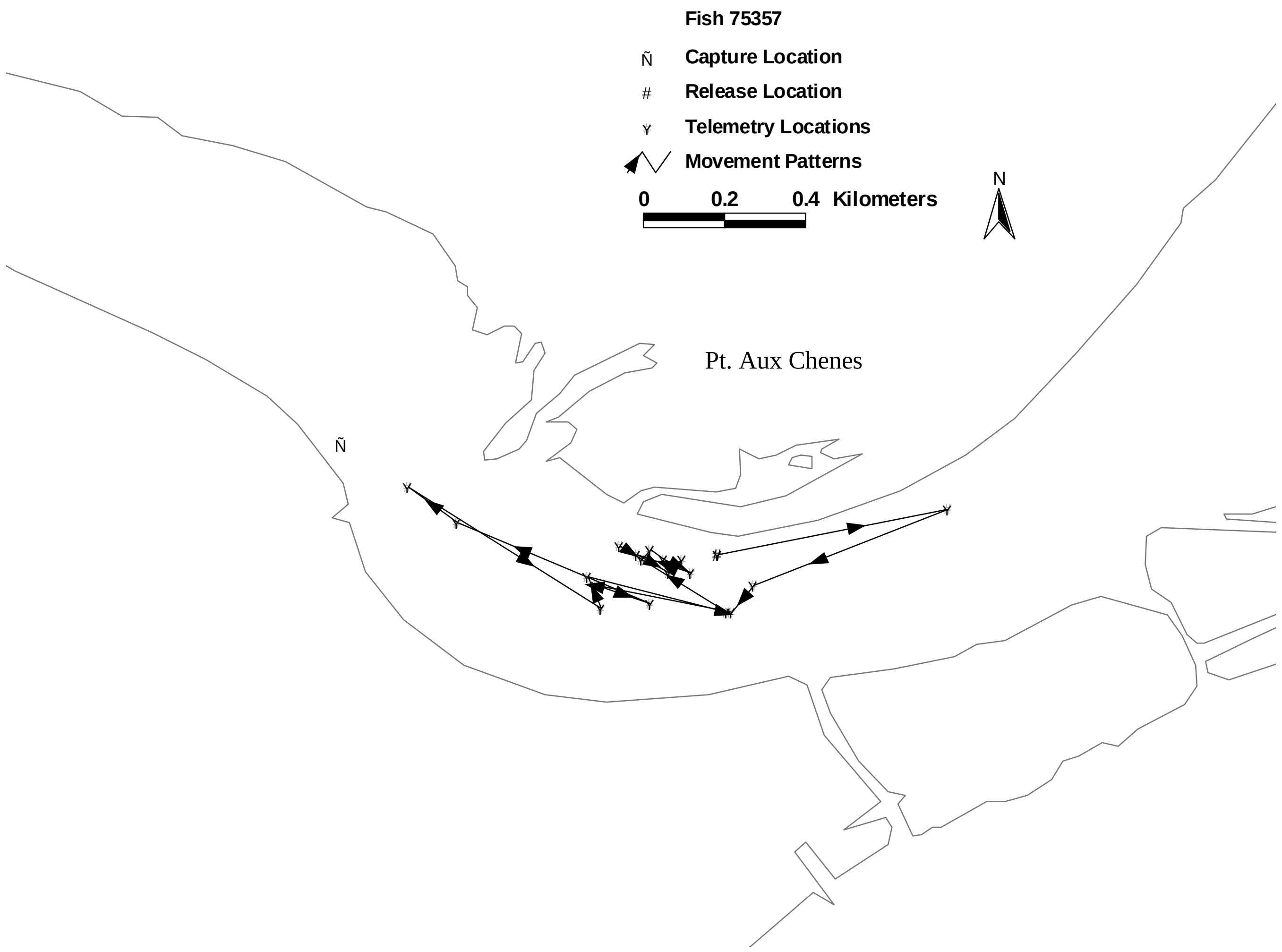

Figure 14. Movement patterns of fish 75357 following initial release on 9 June, date last located 6 August.

Figure 15. Movement patterns of fish 75777 following initial release on 11 June, date last located 30 June.

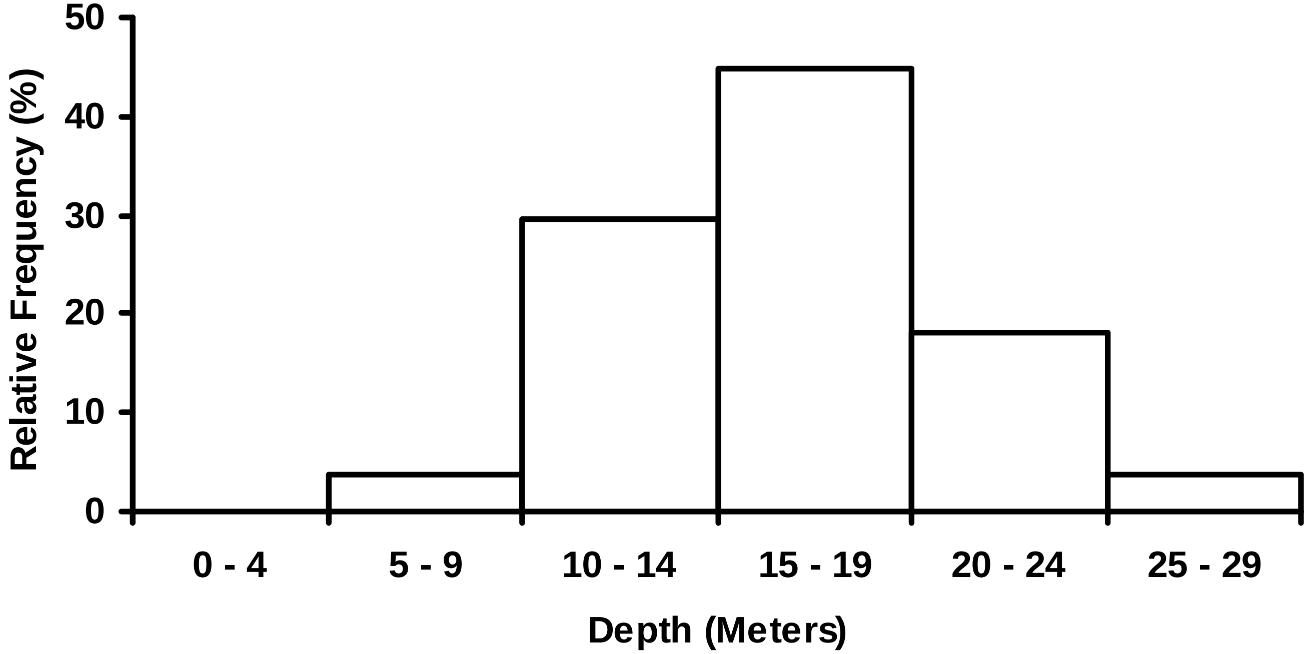

Figure 16. Water depths measured at locations where lake sturgeon were captured on setlines (N = 18) and locations frequented by ultrasonic-tagged fish (N = 88) in 2004 in the North Channel of the St. Clair River.

Table 1. Biological and logistical information of juvenile lake sturgeon implanted with ultrasonic transmitters that were released in the North Channel of the St. Clair River.

Capture Location	Total Length (mm)	Girth (mm)	Weight (kg)	Age	Year Class	Sonic Tag Number	Tag Size	Tag Duration (Days)	Implant Date	Date Last Located
L. Huron	604	245	0.67	4	2000	75144	Large	64	15/06/04	19/08/04
L. Huron	590	220	0.67	3	2001	75155	Large	1	15/06/04	15/06/04
N. Channel	620	229	1.00	4	2000	75166	Large	36	15/06/04	22/08/04
N. Channel	660	249	1.80	4	2000	75357	Large	59	08/06/04	06/08/04
L. Huron	374	158	0.23	2	2002	75444	Small	51	05/06/04	27/08/04
N. Channel	632	249	1.60	4	2000	75555	Large	49	17/06/04	06/08/04
N. Channel	665	274	1.50	4	2000	75666	Large	53	03/06/04	27/08/04
N. Channel	765	325	2.90	5	1999	75777	Large	19	10/06/04	30/06/04