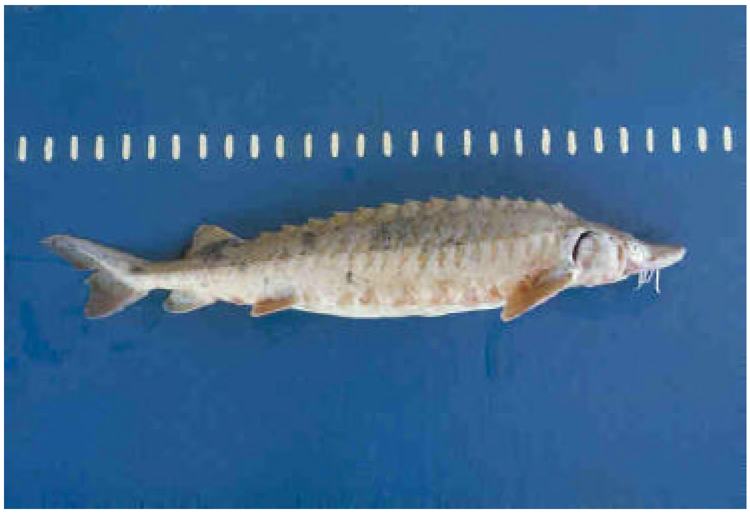
Spawning by Lake Sturgeon (*Acipenser fulvescens*) in the Detroit River



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N. M. Caswell
Department of Biology
Central Michigan University
Mt. Pleasant, Michigan

D. L. Peterson
Warnell School of Forest Resources
University of Georgia
Athens, Georgia

B. A. Manny
G. W. Kennedy
United States Geological Survey
Great Lakes Science Center
Ann Arbor, Michigan

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Summary

Overfishing and habitat destruction in the early 1900s devastated lake sturgeon (*Acipenser fulvescens*) populations in the Great Lakes. Although a comprehensive restoration strategy for this species was recently drafted by the Michigan Department of Natural Resources, a lack of current data on Great Lakes sturgeon stocks has hindered rehabilitation efforts. Historically, the Detroit River supported one of the largest lake sturgeon populations in the Great Lakes; however, little is known about the current population or its habitat use. The main objective of this study was to determine if lake sturgeon spawn in the Detroit River. As part of a larger study, we used baited setlines to capture lake sturgeon in the Detroit River in the spring and summer of 2000 and 2001. In each year of the study ultrasonic transmitters were surgically implanted in 10 adult fish to track their movements, evaluate habitat use, and identify possible spawning sites. Using telemetry and egg mats to verify spawning activity, we located and verified one spawning site in the Detroit River. Spawning was verified by recovering sturgeon eggs deposited on egg collection mats anchored at the site. Telemetry data suggested that several other possible spawning sites also may exist, however we were not able to verify spawning activity at these sites.

Introduction

Lake sturgeon (*Acipenser fulvescens*) in the Detroit River and western Lake Erie have had a colorful, if not tragic, history. Prior to 1860, lake sturgeon were regarded as trash fish (Baker 1980) as their flesh and roe had no commercial value. Lake sturgeon often damaged commercial nets and, consequently, were routinely killed and wasted. By 1860, however, lake sturgeon were valued for both meat and caviar, and commercial harvests increased dramatically (Harkness and Dymond 1961). Overexploitation of sturgeon through the turn of the century quickly decimated lake sturgeon populations. The lake sturgeon harvest in Lake Erie fell by 80%, from over 2.3 million kg in 1895 to less than 0.45 million kg in 1905 (Brousseau 1987). Lake sturgeon populations throughout the Great Lakes have never recovered from decades of overfishing, habitat loss, and pollution prevalent at the end of the 19th century. Today, lake sturgeon populations are estimated to be at less than 1% of their former abundance (Tody 1974), and in Michigan, lake sturgeon are listed as a threatened species (Hay-Chmielewski and Whelan 1997). Harkness and Dymond (1961) and Scott and Crossman (1973) gave detailed descriptions of the morphology and biology of lake sturgeon.

Recently, renewed public interest in lake sturgeon has prompted new conservation and rehabilitation efforts. In 1997, the Michigan Department of Natural Resources (MDNR) drafted the state's first lake sturgeon rehabilitation strategy. Research needs identified by this strategy included the identification of historic and current spawning habitat, and information on seasonal movements and habitat use by lake sturgeon (Hay-Chmielewski and Whelan 1997).

Although there are no published studies of lake sturgeon in the Detroit River, anecdotal information suggests that the Detroit River historically supported a significant lake sturgeon population (Harkness and Dymond 1961). Lake sturgeon eventually became important enough to the economy of the central Great Lakes region that some of the first attempts to artificially propagate the fish took place in the mid-1880s on the Detroit River (Meehan 1909).

Although the extent of lake sturgeon spawning activity in the Detroit River has never been documented, Goodyear *et al.* (1982) reported the presence of seven historic spawning sites. Considering the dramatic habitat changes that have taken place (most of the historic sites have been rendered unsuitable), it is unknown whether lake sturgeon currently spawn in the Detroit River (McClain *et al.* 2000). The primary goal of this study was to aid in the recovery of the lake sturgeon population in the Detroit River by meeting a portion of the research needs identified by the MDNR rehabilitation plan. The specific objective of this project was to determine if lake sturgeon spawn in the Detroit River. By determining the specific locations of active spawning sites within the Detroit River, results of this study may enhance local rehabilitation efforts. Once identified, critical spawning habitat may be characterized, providing additional data to assist other researchers studying lake sturgeon in similar habitats in other systems.

Materials and Methods

Study Area

The Detroit River is located in Wayne County in southeastern Michigan, where it forms the border between Michigan and Ontario, Canada (Fig. 1). The 51-km river is part of the channel connecting lakes Huron and Erie. Mean annual temperatures in the river range from 0.7^{0}C in January to 22.4^{0}C in August, and dissolved oxygen usually averages over 6.0 mg/L (Edwards *et al.* 1989). Flow in the Detroit River, unlike many other large rivers, is relatively constant (Manny *et al.* 1988). Mean water velocity is 0.1 – 1.8 m s^{-1}, and mean discharge is 5300 $m^3 s^{-1}$ [4,400 $m^3 s^{-1}$ – winter, 5,700 $m^3 s^{-1}$ – summer] (Edwards *et al.* 1989). The total fall of the river is about 1 m (Hamdy and Post 1985). The upper Detroit River (north end of Fighting Island to the headwaters at Lake St. Clair) flows in a single channel 700 - 1000 m wide, with a mean depth of 9 to 16 m. The lower portion of the river has a maximum depth of about 10 m and is approximately 4.5 km wide at the mouth (Edwards *et al.* 1989).

The Detroit River is highly developed; the City of Detroit, Michigan occupies the west riverbank, Windsor, Ontario, the east bank. Numerous factories, power plants, wastewater treatment plants, and freight docks occupy its shores, and the area is home to nearly 4.3 million people (Manny *et al.* 1988). Two thirds of the Michigan shoreline has been stabilized with iron or concrete seawalls (Manny 2001). Although the river has been highly modified by development, it is undammed, so its entire length is accessible to migrating lake sturgeon. The river provides a critical passageway for commercial ships moving between the upper and lower Great Lakes, and as such, is home to the busiest ports on the Great Lakes with thousands of commercial vessels traversing its waters annually. The natural flow of the river has been altered by the construction of artificial channels and compensating dikes and the entire corridor has been dredged extensively to create and maintain shipping channels (Derecki 1985).

Goodyear *et al.* (1982) reported the existence of seven historic lake sturgeon spawning sites in the Detroit River. Because of dramatic habitat changes (dredging, changes in flow regime, etc.) and the lack of current knowledge available for lake sturgeon in the Detroit River, the current status of these reputed spawning sites was unclear. McClain and Manny (2000) examined each of the reputed spawning sites, as well as two additional sites reported by sport anglers. They found that only two of the nine sites, located near Grassy Island and Sugar Island, had suitable spawning habitat for lake sturgeon. Lake sturgeon spawning at other locations in the Detroit River has never been documented.

Research Methods

Sampling of lake sturgeon took place from April – October 2000 and March – September 2001. To capture lake sturgeon in the Detroit River, four to eight baited setlines were set for 24 – 48 h in channels measuring 8 to 15 m deep. Each setline consisted of an 83-m main line (0.9 cm diamond braid nylon) with an additional 16-m line of the same material attached at each end (Thomas and Haas 1999). Twenty-five dropper lines were attached to the main line at 3-m intervals. The droppers consisted of a 20.3-cm length of tarred twine, a net snap and swivel at one end, and a 7/0 stainless steel [Eagle Claw O'Shaughnessy 254SS, non-offset, 60 X 26 mm] hook at the other end. Hooks were baited with dead round gobies (*Neogobius melanostomus*) or cut squid. Trap-net anchors with nylon bridles were placed at each end of the setline. Float lines (16 m) and buoys were attached to the bridles on the anchors to mark the location of each setline. Lake sturgeon were retrieved by bringing them to the surface with the setline and landing them with a dip net. Because of the docile nature of lake sturgeon, injuries from the hooks were typically minor.

Total length (cm), fork length (cm), girth (cm), and total weight (kg) were recorded for each lake sturgeon captured and released. Prior to release, each fish was tagged externally with a numbered floy tag inserted into the base of the dorsal fin or a numbered monel cattle ear tag placed at the leading edge of the dorsal fin. Each sturgeon also was tagged internally with a PIT-tag (passive integrated transponder), injected under the fourth dorsal scute. A 2-cm^2 section of the left marginal pectoral fin ray was removed from each lake sturgeon for age determination, using the methods of Wilson (1987).

Ultrasonic transmitters were implanted in adult lake sturgeon in 2000 and 2001. The surgical methods used to implant the transmitters were similar to those described by Fox *et al.* (2000). A 50-mm incision was made with a surgical scalpel on the mid-ventral line about 40 – 60 mm anterior to the insertion of the pelvic fins. Once the peritoneum was cut, gonads were inspected for ripeness, and the transmitter inserted into the body cavity. Oxytetracycline antibiotic was then injected into the body cavity at a dosage of 20 mg/ kg body weight. The incision was closed with monofilament absorbable sutures (4-8 stitches) and sealed with veterinary surgical glue. No anesthetic was used, and the fish's gills were kept moist throughout the procedure. The entire tagging and surgical procedure took less than 20 minutes, and the fish was placed in the water between tagging and surgery. After surgery, the fish was allowed to recover to equilibrium (at least 15 minutes) prior to release. No mortality was observed during any part of the study.

The ultrasonic transmitters (Sonotronics CT-82-2E; 77 x 17 mm; 21 g) operated on frequencies of 70 to 76 kHz. Each transmitter possessed a unique signal code (e.g. 2-3-7, 4-5-6, 14-2) and transmittered lake sturgeon were tracked using an ultrasonic receiver (Sonotronics USR-5W) with a directional hydrophone (Sonotronics DH-4). Starting on 15 April 2001, the entire river was traveled by boat at least once each week to monitor individual movements of transmittered sturgeon. The hydrophone and receiver were used to check for the presence of transmittered fish at 1.6-km intervals during each tracking day. The date, GPS coordinates, depth, and a general description of the location were recorded each time a fish was relocated.

Based on telemetry data from April and May 2001, egg collection mats were set at 2 of 3 suspected spawning locations (Fig. 1). The mats were constructed from square (40 X 40 cm) sections of fibrous furnace filter fastened inside of a steel frame. Five mats were tied together in series to facilitate ease of deployment and retrieval. Egg mats were deployed at Zug Island (ZI) on 5 May 2001, and above the Amherstburg Channel (AC) on 9 May 2001. Water temperatures at this time were 14^0 to 15^0 C. No egg mats were set at a third suspected spawning site located at the northwest corner of Fighting Island (NWFI) because we believed that spawning had already occurred. The egg mats were retrieved after 3 days, and later examined for the presence of lake sturgeon eggs.

At spawning sites where lake sturgeon eggs were recovered, images of bottom substrates were obtained with a high-resolution, underwater video camera (Deep Sea Micro-Sea Cam 1050). Images were recorded on three transects, 0.5-0.9 km in length, at distances of 10 m (within 5 m of where sturgeon eggs were collected), 30 m, and 380 m from shore (mid-channel). The camera, attached by coaxial cable to a 30 x 30 cm monitor on board, was deployed from a boat while drifting downstream. Camera position was maintained continuously < 0.5 m from the river bottom, directly beneath the boat, permitting us to view the bottom substrates on the monitor while recording. Water depth was measured with a boat-mounted depth sounder. Water transparency was measured with a secchi disk while drifting, and current velocity was measured using a Marsh McBirney (Model 201) current meter. Diameters of substrate particles were determined by measuring materials collected at 12 randomly selected locations on the three transects with a ponar grab.

Results

Ten adult fish were transmittered in each year of the study, However, none of the fish captured in 2000 (fish #1-10, sex unknown) were in spawning condition. Data on the size of transmittered lake sturgeon and dates of capture are given in Table 1. In 2001, however, sampling began earlier in the spring, and the first two fish captured were ripe males (fish #11-12). Although these were the only two ripe fish captured during the study, telemetry data from these fish did lead to the discovery of at least one new spawning site near Zug Island in the Detroit River.

Lake sturgeon movements in the Detroit River were primarily confined to the Canadian side of the Detroit River in 2000 and 2001. Most of the transmittered fish stayed in a 10-12-km stretch of water, a "home area" (HA), extending from the north end of Fighting Island, south along the Canadian side of the river to the north end of the Amherstburg Channel. Suspected spawning movements appeared as obvious exceptions to this pattern of activity. Fish #11 and #12 were captured, transmittered, and released on 20 April and 22 April 2001, respectively, in HA of the Detroit River. Fish #11 was relocated on 27 April in the same area. On 2 May 2001, the fish had moved approximately 8 km upriver to the mid-channel at ZI (Table 2). On 4 May 2001, it was relocated again in HA, and on 6 May, again at ZI. Fish #11 was last relocated at AC on 8 May 2001 (approximately 15 km downstream from ZI). In 2001, fish #2 (tagged in 2000) was relocated at the mouth of the Detroit River below its junction with Lake Erie. Following that, the fish moved upstream in mid-April, and followed a movement pattern similar to fish #11. It was relocated in HA on 22 April 2001, at ZI (mid-channel) on 2 May, and back at HA on 4 May. Fish #2 was last relocated on 6 May 2001 approximately 8 km upstream from ZI near Belle Isle. Fish #1 also was relocated at ZI (approximately 10 m offshore) on 4 May 2001, and approximately 2 km upstream from ZI on 6 May.

Fish #12 (captured in HA) also followed a movement pattern similar to fish #11. The fish was relocated on 27 April 2001 approximately 1 km west of AC. It was relocated again on 1 May just below AC, where it stayed until 3 May. On 4 May, fish #12 was relocated in HA. On 5 May it was relocated at AC, where it remained. Fish #11 was also found in this location on 8 May 2001 before it left the river.

Fish #3 and #4 moved into the Detroit River in mid-April 2001, probably from Lake St. Clair, as that was their last know location in 2000. Fish #3 was relocated in HA on 27 April 2001. It then was relocated at NWFI on 2 May, and again on 4 May. On 5 May, it was relocated again in HA where it remained. Fish #4 was relocated approximately 1 km upstream from HA on 19 April 2001. It was relocated again on 27

April at NWFI, on 2 May <1 km west of this site and, again, at NWFI (along with fish #3) on 4, 5, and 6 May. It began moving rapidly upstream on 8 May, apparently migrating out of the Detroit River and into Lake St. Clair.

Egg mats deployed at ZI were placed 10 m from an iron seawall in water 11 m deep. On 8 May the mats were retrieved and we recovered six lake sturgeon eggs that had adhered to the mat material. Water temperatures at this time were 14^{0} C. The mats deployed above the AC were set next to the shipping channel in water 5-6 m deep. Although these mats were also retrieved from a probable spawning site at preferred spawning temperature of 15^{0} C, they contained no lake sturgeon eggs.

Visibility with the underwater camera near the river bottom at ZI was estimated to be < 1 m near shore and 1-2 m at the transect located furthest offshore. Water transparency 10-30 m from shore (Table 3) (2.4-m secchi depth) was lower than that 380 m from shore (2.5-m secchi depth). Current velocity was lower 10-30 m offshore (0.35 m s^{-1}) than 380 m offshore (0.73 m s^{-1}). We classified substrate at ZI using a total of 65 minutes of videotape. Water depth (10-11 m) and estimated differences in bottom elevation (0.3-0.6 m) were the same on all three transects. Substrates 10 m offshore, where sturgeon eggs were collected, consisted of coal-cinders (1-4 cm in diameter), several layers thick, covering an area measuring approximately 50-m by 300-m (15,000 m^2). Within this cinder deposit, we also found scattered deposits of gravel (2-8 cm in diameter), also several layers thick. Substrates 30 m offshore consisted of deposits of gravel and cobble (2-6 cm and 7-20 cm in diameter, respectively) 1-2 layers thick, interspersed with smaller patches of cinders, 1-4 cm in diameter. Substrates 380 m offshore were hard-pan clay overlain by scattered deposits of gravel, cobble, and boulders up to 50 cm in diameter, 1-3 layers thick. Substrates 10-30 m offshore were either clean or partially covered by periphyton and silt. Substrates 380 m offshore were clean and free of sand and silt. Although many areas of the Detroit River contain dense populations of zebra mussels (*Dreissena polymorpha*), no substrates that we examined in the study area were colonized by these molluscs.

Discussion

Transmittered lake sturgeon observed in this study did not normally stay in the area around ZI. The movements of fish #11 between HA and ZI and fish #12 between HA and AC suggest that lake sturgeon in the Detroit River may undertake multiple runs between areas of concentrated sturgeon activity (home areas) and areas with suitable spawning substrate. Although the reproductive condition of fish #4 was unknown in 2001 (tagged 1 year earlier) the multiple movements of fish #4 between HA and NWFI were consistent with this pattern.

Lake sturgeon spawning was confirmed in the near-shore area at ZI, and we believe that spawning also occurred in the adjacent mid-channel area. Of the three transmittered sturgeon that were relocated near ZI, two (fish #1 and #11) were found in the mid-channel during the suspected spawning period. The movements of fish #11, a ripe male, further supported this inference as it was never relocated near shore. Because there was suitable spawning substrate and sturgeon remained in the mid-channel area for protracted periods during known spawning activity, we suspect that the mid-channel habitat may also harbor spawning fish during the spring.

Although we could not confirm the location of other spawning sites, movements of transmittered fish, suggested that spawning also took place at the NWFI (fish #3 and 4) and AC (fish #12) sites in 2001. With the exception of fish #12, all suspected spawning sturgeon were relocated at least once at suspected spawning sites between 2 May and 8 May 2001, the same period of known spawning activity at ZI. After 8 May, no transmittered sturgeon were found at ZI or NWFI. At the AC site, fish #12 remained in the same general area until mid-June, but fish #11 had visited this site by 8 May.

Only 6 lake sturgeon eggs were recovered in the egg mats deployed at the ZI spawning site but many eggs may have been dislodged by shipping traffic before the nets could be retrieved. Because of heavy commercial shipping traffic in the vicinity of ZI, deployment of egg mats was limited to near-shore sites. Despite these precautions, even the mats retrieved from near-shore sites were clogged with silt and clay and two of the mats were severely damaged, presumably by a large ship.

The egg mats recovered from the AC site contained no sturgeon eggs, however, spawning may have concluded by the time these mats were set. The mats were not deployed until 9 May 2001 and all transmittered fish, except fish #12, had left their suspected spawning sites by 8 May.

Spawning habitat near ZI contained both coal cinders and glacial till spread over a relatively large area and thickness. Cinders and till deposits near ZI closely resembled the cinder substrate near Algonac, Michigan and till substrates near Port Huron, Michigan, 50 and 100 km upstream, respectively, in the St. Clair River where lake sturgeon spawning was documented by Nichols et al. (2001) and Manny and Kennedy (this volume). Spawning by lake sturgeon on coal cinder substrates also has been documented in the Wolf River of the Lake Winnebago system (Kempinger 1988). The extent and thickness of deposits of these two substrate types near ZI greatly exceeds that present at any of nine reputed sturgeon spawning sites located elsewhere in the Detroit River (U.S. Geological Survey, Great Lakes Science Center, Ann Arbor, Michigan; unpublished data). Despite its close proximity to intense industrial activity, lower water transparency and current velocity than that at other known spawning sites in the St. Clair River (2.6-6.5 m secchi depth and 0.4 - 1.0 m s -1, respectively; U.S. Geological Survey, Great Lakes Science Center, Ann Arbor, Michigan; unpublished data), the abundant, relatively clean, and suitably sized substrates at the ZI site were the most suitable for spawning lake sturgeon of any substrates known at this time in the Detroit River.

The results of this study must be considered preliminary. Although we successfully documented a previously unknown lake sturgeon spawning site in the Detroit River, further research is needed to determine the extent and distribution of spawning activity in this system. Our telemetry data suggest that the Detroit River is widely used by lake sturgeon from both Lake Erie and Lake St. Clair populations, but genetic data regarding the discreteness of these stocks is lacking. Additional research also should include detailed habitat analysis of known and suspected spawning sites.

Management Implications

The Detroit River has undergone major physical and environmental changes during the last century resulting from development and pollution. Most of the historic spawning habitat available for species such as lake sturgeon has either been altered or completely destroyed. This study confirmed spawning by lake sturgeon in the Detroit River for the first time in several decades. By locating previously unidentified active spawning sites, fisheries managers can try to protect these areas. Additionally, there has been recent interest in creating artificial lake sturgeon spawning habitat in the Detroit River and other systems. This study gives further evidence that lake sturgeon will use man-made substrates for spawning, and will provide fisheries managers with additional data to aid in the construction of new artificial spawning sites.

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Author's address:

Dr. Douglas L. Peterson
Warnell School of Forest Resources
University of Georgia
Athens, Georgia, USA 30602
Tel: (706) 542-2944
E-mail: peterson@smokey.forestry.uga.edu

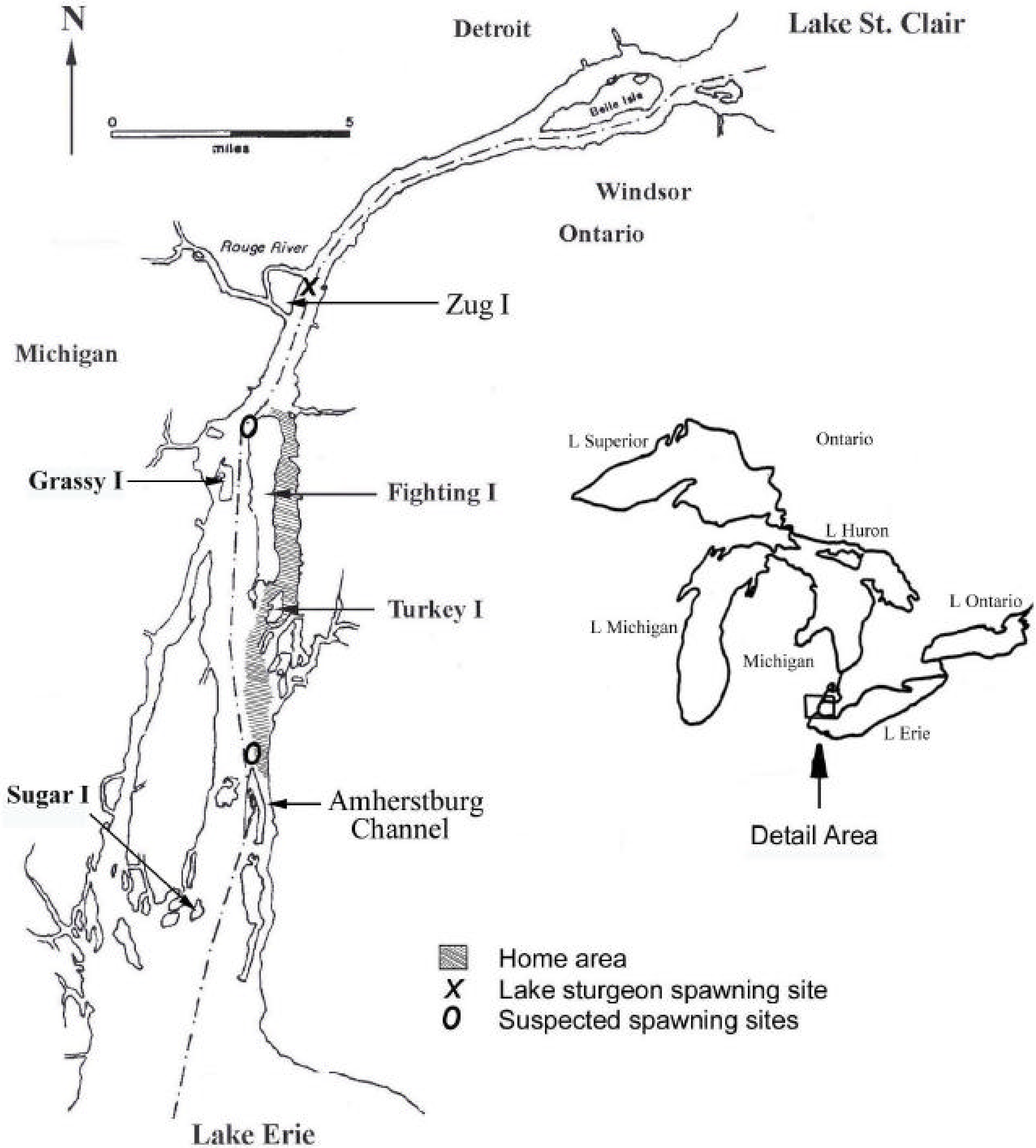
Figure Captions:

Fig. 1. Map showing location of the Detroit River, lake sturgeon home area, confirmed spawning site, and suspected spawning sites

Table 1. Tables showing the sizes, ages, and capture dates of transmittered lake sturgeon.

Table 2. Table showing suspected spawning sites and dates, or approximate residence times, of transmittered sturgeon on those sites.

Table 3. Table showing limnological data collected on three transects at Zug Island site.



N
0
5
miles
Detroit
Lake St. Clair
Belle Isle
Windsor
Ontario
Rouge River
Zug I
Michigan
Grassy I
Fighting I
Turkey I
Amherstburg Channel
Sugar I
Lake Erie
L Superior
Ontario
L Huron
L Ontario
L Michigan
Michigan
L Erie
Detail Area
Home area
X Lake sturgeon spawning site
O Suspected spawning sites

Table 1. Tables showing the sizes, ages, and capture dates of transmittered lake sturgeon

Fish ID #	TL (cm)	Weight (kg)	Age	Capture Date
1	146	21.5	24	04/04/00
2	154.5	38	30	04/11/00
3	150.3	21.5	26	04/12/00
4	153	19	25	05/03/00
5	106	6	-	05/04/00
6	158	29	21	05/12/00
7	131	11	16	05/24/00
8	139	19	17	06/09/00
9	177	38	31	06/09/00
10	165	31	27	06/09/00
11	162	32	27	04/20/01
12	145.5	17.5	21	04/22/01
13	151	25	20	05/24/01
14	148	25	24	05/24/01
15	186	54	38	05/26/01
16	138	17	21	06/07/01
17	152	23.5	19	06/09/01
18	151	24.5	21	06/15/01
19	167	26.5	31	06/19/01
20	162	27	27	06/19/01

Table 2. Table showing suspected spawning sites and dates, or approximate residence times, of transmittered sturgeon on those sites.

Suspected Spawning Site	Fish ID#	Dates on Site
Zug Island (ZI)	1	5-May
	2	2-May
		3-May
	11	2-May
		3-May
		6-May
NW Fighting Island (NWFI)	3	2-May
		4-May
	4	27-Apr
		4-May
		5-May
		6-May
Amherstburg Channel (AC)	11	8-May
	12	1-May
		2-May
		3-May
		05-May - 12-June

Table 3. Table showing limnological data collected on three transects at Zug Island site.

Transect	Distance from shore (m)	Secchi depth (m)	Velocity (ms-1)
1, 2	10, 30	2.4	0.35
3	380	2.5	0.73