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Population status and demographics of lake sturgeon (*Acipenser fulvescens*) in the St. Marys River, from 2000 to 2007

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ABSTRACT

The St. Marys River, the sole outflow of Lake Superior, was historically inhabited by lake sturgeon (*Acipenser fulvescens*); until recently it was unclear whether a population was still present in the river. From 2000 to 2007, the population status of subadult and adult lake sturgeon in the St. Marys River was characterized. Setlines were deployed at multiple water depths (2–20 m) for 3400 setline nights. Biological measurements including total length and weight were recorded and each individual was affixed with unique identification tags before being released. A total of 192 unique lake sturgeon were captured with a recapture rate of 16%. The population size of lake sturgeon in the St. Marys River was estimated to be near 500 individuals. Fish captured exhibited a mean weight of 13 kg (range 2–37 kg) and a mean total length of 125 cm (range 80–175 cm). The mean age of lake sturgeon captured was 20 years (range 7–59 years) and 36 age classes were represented. Lamprey wounds were observed on 23% ($N=53$) of sturgeon and nearly 19% ($N=44$) of lake sturgeon had visible external parasites classified as *Argulus* spp. This study suggests that a recovering lake sturgeon population exists in the St. Marys River, however, it remains unclear as to whether this is a self-sustaining population reproducing in the river. Additional information is needed on metapopulation dynamics, habitat use, and younger age classes to assess recruitment success and population status.

Introduction

Historically, lake sturgeon (*Acipenser fulvescens*) was an abundant species throughout the Great Lakes basin. Populations declined precipitously beginning in the late 1880s because of aggressive commercial harvest, habitat degradation (e.g., shoreline development, logging practices), and construction of dams which prevented access to spawning habitat (Harkness and Dymond, 1961; Rochard et al., 1990). The initial view of sturgeon as a nuisance fish resulted in commercial fishers discarding carcasses ashore. As the market value of lake sturgeon was realized, commercial harvest ensued (Tody, 1974). The largest commercial catches of lake sturgeon in the Great Lakes occurred in the 1880s when an average of 8.6 million pounds was harvested per year, but by the turn of the century lake sturgeon catches had dropped drastically and the Lake Erie population for example declined by over 80% (USFWS, 2008). In addition to overharvest, deforestation and the construction of hydroelectric facilities have degraded the quality and accessibility of spawning habitat used by lake sturgeon (Harkness and Dymond, 1961; Auer, 1996a). These factors coupled with unique life history attributes, including late maturity and individual variation in reproduction periodicity make natural recovery of depleted populations a long and difficult process.

Currently, lake sturgeon is considered threatened in 20 states and 7 provinces within their native range (Knights et al., 2002). Out of 107 Great Lakes locations where lake sturgeon populations once existed, 59 (55%) are recorded as "small" and 45 (42%) are listed as "extirpated" (Holey et al., 2000). Strategic fisheries rehabilitation goals have been proposed to assist in the recovery of lake sturgeon throughout the Great Lakes. Recently, The Nature Conservancy listed lake sturgeon as a "conservation target" in the St. Marys River (Harris et al., 2009), which further emphasizes the need for local as well as regional rehabilitation efforts.

Within the Great Lakes many studies have focused on lake sturgeon to understand their unique life history characteristics in efforts to rehabilitate threatened populations (Harkness and Dymond, 1961; Thomas and Haas, 1999; Fortin et al., 1996; Auer, 1996a,b, 1999a). Despite increased efforts, sturgeon status in many areas of the Great Lakes, including major connecting channels such as the St. Marys River, still remains relatively unknown (Hay-Chmielewski and

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Whelan, 1997; Holey et al., 2000, but see Thomas and Haas, 1999). Since 1975, the Michigan Department of Natural Resources has conducted gill net surveys throughout the St. Marys River to determine trends in the fish community composition at least once every decade (Fielder and Waybrant, 1998). This information has indicated that a sturgeon population exists in the St. Marys River; however, captures were limited and declined from 1975 to 1995 (CPUE = capture per 305 m of gill net per net night: 1975 = 0.99, 1979 = 0.03, 1987 = 0.09, 1995 = 0.00) (Fielder and Waybrant, 1998).

The St. Marys River, the sole outflow of Lake Superior, is an important ecological corridor between Lake Superior and Lake Huron. The river and its biota have been impacted by many anthropogenic activities including shipping, sediment contamination, and shoreline development (see Ripley et al., 2011). Understanding the current status of lake sturgeon in the St. Marys River is an essential first step in protecting and recovering sturgeon populations in this area. Also, because lake sturgeon are considered an indicator of ecosystem health and a conservation target for the ecosystem, knowledge gained about the lake sturgeon population will enhance efforts towards conservation of the entire St. Marys River ecosystem. The objective of this study was to characterize the current lake sturgeon population in the upper reaches of the St. Marys River.

Study area

The St. Marys River connects Lake Superior and Lake Huron through a 112-km waterway. The "rapids" area of the St. Marys River historically was the only hydrological connection between the lakes, but compensating gates and locks now obstruct river passage and the rapids contribute less than 50%, and sometimes less than 10% of the total discharge (Bray, 1996). The river also possesses many large tributaries, including the Garden River, Charlotte River, and Munuscong River, which provide important spawning and nursery habitat for many St. Marys River fishes.

During the past century the St. Marys River has been a site of extensive industrialization (see Ripley et al., 2011). The steel and shipping industry, paper processing mills, sewage treatment plants and tanneries have operated on the river and have contributed to the designation of this location as an international Area of Concern (USEPA, 1988). These developments have contributed to the degradation of natural channel morphology, flow regimes, habitat and water quality. Additionally, transoceanic vessels in the Great Lakes have impacted the St. Marys through the introduction of non-native species and re-suspension of sediment (Gleason et al., 1979; Poe and Edsall, 1982; Mills et al., 1993).

Despite vast degradation, the St. Marys River has been listed as "high" in regards to the suitability of maintaining a self-sustaining population of lake sturgeon (Hay-Chmielewski and Whelan, 1997). High habitat heterogeneity offers refuge from environmental disturbance and may be important wintering and feeding habitat (Auer, 1999b). The "rapids" area and some tributaries entering the St. Marys River, including the Garden River, may provide sufficient spawning habitat (e.g., large-cobble substrate, swift current) as characterized in other systems (e.g., LaHaye et al., 1992; Auer, 1996a,b; Chiotti et al., 2008). Reports from local fishermen and Sea Lamprey Control suggest that sturgeon may be spawning in the Garden River and in the main river near Neebish Island. However, natural reproduction by lake sturgeon in the St. Marys River has yet to be documented in the scientific literature.

The study site assessed from 2000 to 2007 for lake sturgeon included international waters from the North Channel of Sugar Island to East Neebish Island (Fig. 1). During this study, several attempts were made by Lake Superior State University's Aquatic Research Laboratory (LSSU) to sample lake sturgeon in the shipping channel west of Sugar Island, however, no sturgeon were captured in the shipping channel. Our remaining efforts were focused outside of the shipping channel because previous efforts did not capture sturgeon and freighter traffic in the shipping channel made it logistically difficult to set and retrieve setlines.

Methods

From 2000 to 2007, lake sturgeon were captured in the St. Marys River by LSSU from early spring to late summer using baited setlines 100 m in length, containing 25 snews each (7/0 saltwater hooks) (Thomas and Haas, 1999). Setlines were deployed for 24 to 48 h intervals at water depths of 2 to 16 m, and baited with a variety of baits. Baits used included lake whitefish (*Coregonus clupeaformis*), lake trout (*Salvelinus namaycush*), northern cisco (*Coregonus artedi*), sucker (*Catostomus* spp.), brown trout (*Salmo trutta*), northern pike (*Esox lucius*), yellow perch (*Perca flavescens*), chicken livers, earthworms, rainbow smelt (*Osmerus mordax*) and pickled squid.

Setlines were haphazardly placed throughout the study area in the St. Marys River to assess the distribution of lake sturgeon. This approach was used since little information existed on lake sturgeon locations in the St. Marys River. Setlines that did not catch fish for one week were pulled and set at other haphazardly selected locations. Latitude and longitude of all sites were recorded using a portable GPS and imported into ArcGIS (ESRI® ArcMAP(tm)™ 9.3).

All sturgeon captured were measured for total length (TL), fork length (FL), weight, and girth. Lake sturgeon were classified as subadults if length at capture was <100 cm or age at capture was <15 years (Auer, 2003). An anterior pectoral fin ray sample was removed for age estimation. For unique identification, lake sturgeon were tagged with alphanumeric passive integrated transponder (PIT) tags inserted under the third dorsal scute and Floy (T-anchor bar) tags inserted posterior to the dorsal fin. Before release, captured lake sturgeon were inspected for any observable abnormalities including lamprey scars and external parasites. In 2006 and 2007, 18 adult lake sturgeon were implanted with sonic transponders with a 4-year battery life (Gerig et al., 2011).

Individual yearly capture histories of sub-adult and adult lake sturgeon collected from 2000 to 2007 were used to estimate the population size of lake sturgeon in the St. Marys River. The adult and sub-adult lake sturgeon population estimate was calculated using a POPAN Jolly–Seber model within Program Mark version 5.1 (Crosbie and Manly, 1985; White and Burnham, 1999). Because our sampling took place primarily in the upper St. Marys River and because lake sturgeon emigration and immigration between lakes Huron and Superior and the tributaries are unknown, we considered this an open, mixed population (Fig. 1). In addition to an absolute abundance estimate, the POPAN formulation provides estimates of apparent survival (Φ_i), recapture probability (p_i), and probability of entrance into the population (b_i). In the current study the probability of entrance is defined as a measure of recruitment to the gear and immigration into the study area. In order to evaluate the equal recapture probability and survival assumptions associated with Jolly–Seber methods, lake sturgeon were classified as either subadult or adult based on length and age at capture. Lake sturgeon were classified as subadults if length at capture was <100 cm or age at capture was <15 years (Auer, 2003). The recapture probability and survival assumptions between subadults and adults and between sampling occasions were then tested for goodness of fit using program RELEASE within program MARK (Burnham et al., 1987). The constant study area, instantaneous sampling, tag identification, and tag loss assumptions associated with Jolly–Seber population estimates were not evaluated, but nothing in our sampling design would suggest violation of these assumptions.

Akaike's information criterion corrected for sample size (AIC_c) was used to select the most parsimonious model explaining the survival, recapture probability, and probability of entrance parameters (Anderson and Burnham, 2002). Because the analysis of the survival