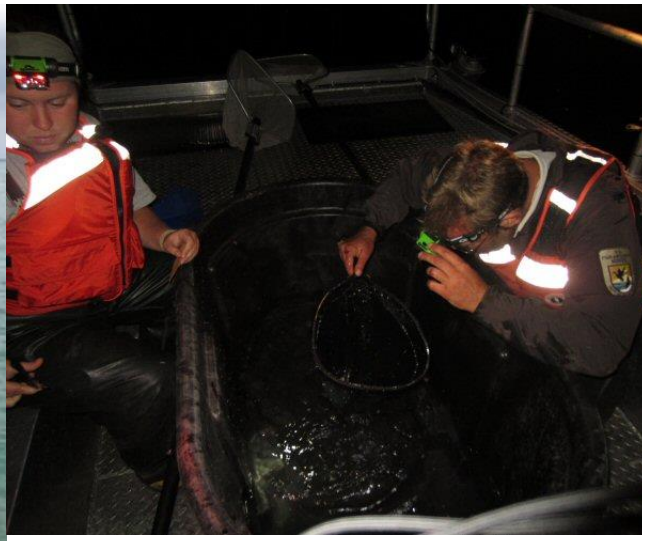
U.S. Fish and Wildlife Service

Early Detection and Monitoring of Non-Native Fishes in Lake Huron, 2013-2015



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*Writing Team (in alphabetical order; * = contact for further information):*

Anjanette Bowen*, Alpena Fish and Wildlife Conservation Office, Alpena, MI

Brandon Harris, Alpena Fish and Wildlife Conservation Office, Waterford, MI

Stephen R. Hensler*, Alpena Fish and Wildlife Conservation Office, Waterford, MI

Janine Lajavic, Alpena Fish and Wildlife Conservation Office, Waterford, MI

Jessica Loughner, Alpena Fish and Wildlife Conservation Office, Waterford, MI

Matthew McLean, Alpena Fish and Wildlife Conservation Office, Alpena, MI

On the cover:
(Left photo): The bottom trawl is lifted at a sampling location in Potagannissing Bay on the St. Marys River in July, 2015. (Right photo): The nighttime electrofishing catch is counted at a sampling location on Munuscong Bay in August, 2015.

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EXECUTIVE SUMMARY

The Laurentian Great Lakes have encountered numerous aquatic non-native and invasive species introductions since Europeans settled in North America (Mills et al. 1994). The impact of aquatic invasive species (AIS) on the Great Lakes has been widely documented by the scientific community (Leung et al. 2002; Mills et al. 1993). Despite increasing regulations aimed at reducing the likelihood of the introduction and spread of AIS into the Great Lakes, there remains a need to monitor for and detect new species before they become established. This is especially true given the costs and difficulty of attempting to control or eradicate a non-native species once it has become established within the system (Trebitz et al. 2009). If a non-native species is detected prior to becoming well established, rapid response decisions can be made in an effort to eradicate or control the species from further spread. Furthermore, continuous monitoring also allows resource managers to look at historical data and assess the impact of future invasions (Trebitz et al. 2009).

This report summarizes the 2013-2015 efforts for early detection of non-native fishes in Lake Huron as implemented by the U.S. Fish and Wildlife Service (USFWS), Alpena Fish and Wildlife Conservation Office and partner agencies. The lower St. Marys River was selected as a priority location for sampling due to the high likelihood of new non-native species introductions according to species-risk and vector-risk analyses (USFWS 2014b). Sampling was conducted each year during 2013-2015 in an effort to detect non-native juvenile and adult fish. Sites within the lower St. Marys River were stratified by suitable gear type according to sampling depth and randomly selected from all sites meeting each depth criteria (USFWS 2014c). Gear used to target juvenile and adult fish included: bottom trawling, nighttime electrofishing and paired fyke nets.

Our monitoring efforts during 2013-2015 captured: a total 23,401 fish representing 56 species in the lower St. Marys River. Each gear type was able to catch a number of unique species that no other gear type captured. Fyke nets captured nine unique species, nighttime electrofishing captured eight unique species, and bottom trawling captured three unique species. Many existing invasive species found in the St. Marys River and Lake Huron were captured during our sampling (e.g., Alewife *Alosa pseudoharengus*, Rainbow Smelt *Osmerus mordax*, Round Goby *Neogobius melanostomus*, Threespine Stickleback *Gasterosteus aculeatus*, and White Perch *Morone americana*), along with several naturalized sportfish that are non-native to the Great Lakes (e.g., Chinook Salmon *Oncorhynchus tshawytscha* and Coho Salmon *Oncorhynchus kisutch*) yet no previously undocumented non-native species were detected in Lake Huron during this study.

According to rarefaction analysis, the current species detection efficiency is approximately 75% of the estimated species assemblage in the lower St. Marys River. For the sampling regime to be most effective, species detection efficiency must be high (e.g., 95%) enough to detect rare species present at low abundances, which is synonymous with non-native species at first introduction (Hoffman et al. 2011). While no new non-native species were detected in 2013- 2015 in the lower St. Marys River, it is critical that this work continues in 2016. This early detection monitoring program is an essential part of non-native and invasive species management for Lake Huron.

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INTRODUCTION

Establishment of aquatic non-native species in the Great Lakes has caused major ecological and economic impacts (Mills et al. 1993; Vanderploeg et al. 2002). Non-native species have entered the Great Lakes through a variety of vectors including ballast water from shipping vessels, canals, aquarium releases, bait release, and intentional stocking by management agencies (Mills et al. 1994). The Great Lakes currently contain 182 identified nonindigenous aquatic species (Ricciardi 2006), 88 of which are present in Lake Huron (Great Lakes Aquatic Nonindigenous Species Information System, GLANSIS 2015).

The impacts of historical non-native introductions in Lake Huron are evident in many forms. Sea Lamprey *Petromyzon marinus* presumably entered Lake Huron in the 1930s (Smith and Tibbles 1980). Ecological and economic impacts from the lamprey invasion have been well documented as losses in commercial and recreational fishing income, as well as costs associated with control measures (Smith and Tibbles 1980; Jones 2007). Zebra Mussels *Dreissena polymorpha* and Quagga Mussels *D. bugensis* have altered trophic dynamics by concentrating energy resources into benthos, oligotrophication, competing for resources with native bivalves, and by promoting conditions favorable to harmful algal blooms (Vanderploeg et al. 2002). The introduction of Rainbow Smelt has caused declines of recruitment in native planktivores such as Lake Whitefish *Coregonus clupeaformis* and Cisco *Coregonus artedi* (Evans and Loftus 1987), and the subsequent spread of Alewife has been linked to reproductive failure in Lake Trout *Salvelinus namaycush* and Atlantic Salmon *Salmo salar* (Fisher et al. 1996).

The Great Lakes are currently facing threats from new invaders whose presence have been documented but are not yet abundant, and other species that are not present but pose a high risk of invasion. Grass Carp *Ctenopharyngodon idella* have been captured at isolated locations within and near Lake Huron but are not known to be abundant (Mandrak and Cudmore 2005). Natural reproduction of Grass Carp has recently been documented within the Lake Erie watershed (Chapman et al. 2013), and Lake Huron remains at risk from this species. Grass Carp feed on submerged aquatic macrophytes and may threaten coastal wetlands which are important spawning and rearing habitats for many species (Chapman et al. 2013). Species with similar reproductive strategies, Silver Carp *Hypophthalmichthys molitrix* and Bighead Carp *H. nobilis*, have rapidly expanded in the Mississippi and Illinois Rivers and are moving closer toward Lake Michigan (Chick and Pegg 2001). Bigheaded carps *Hypophthalmichthys* spp. are large, planktivorous fish that have been reported to dominate fish assemblages (represent as much as 97% of total fish biomass in portions of the Mississippi River basin; MICRA 2002) and alter the structure and species composition of native plankton communities (Laws and Weisburd 1990; Vörös et al. 1997; Stone et al. 2000). Furthermore, many additional species are predicted to be of high risk of entering the Great Lakes through ballast water, the aquarium trade, and other vectors outside of immediately connected waterways (Kolar and Lodge 2002, GLANSIS Watchlist). Minimizing additional introductions of non-native species to the Great Lakes has become increasingly important given their significant impacts to this ecosystem.

Multiple agencies within the Great Lakes basin are working together to prevent or reduce the spread of non-native species. The 2012 amendment of the Great Lakes Water Quality Agreement (1987) committed the U.S. and Canada to cooperate on multiple Great Lakes issues including invasive species issues.

The Great Lakes Restoration Initiative (GLRI) is another effort focused on the Great Lakes that was created to fund efforts for its protection and restoration (GLRI 2014). Under GLRI, several federal agencies have coordinated efforts to focus on issues which threaten the Great Lakes. Among these priorities is the control and prevention of invasive species.

Preventing the transfer of a new species to an ecosystem is ultimately the most effective tool to keep non-native species from becoming invasive. When complete prevention is not possible the next most effective option is monitoring for the arrival of new species and controlling their spread before populations become widespread (USEPA 2008; Trebitz et al. 2009). The U.S. Fish and Wildlife Service developed a strategic framework for the early detection of non-native fishes and select benthic macroinvertebrates in the Great Lakes (USFWS 2014d). Fish and Wildlife Conservation Offices (FWCOs) throughout the Great Lakes lead and coordinate this program. This report describes the efforts devoted to the early detection of non-native fishes in Lake Huron from 2013 to 2015.

STUDY AREA

One priority Lake Huron location was chosen as a result of vector risk analysis for species at risk to become introduced into the Great Lakes. Study areas, sampling gears, and sampling targets were identified in the Lake Huron Implementation Plan for the Early Detection of Non-Native Fishes (USFWS 2014b).

One study area, the lower St. Marys River, was sampled from 2013-2015. This location was evaluated with a suite of other locations across Lake Huron and Lake Erie, and was identified as high risk for introduction of non-native species (Figure 1).

Lower St. Marys River, Michigan/Ontario- The St. Marys River is 120 km in length and forms the connecting channel between Lakes Superior and Huron. It is an international boundary between the U.S. state of Michigan and the Canadian province of Ontario. The river is an integral shipping link between Lake Superior and Lakes Huron, Michigan, Erie, Ontario and the St. Lawrence Seaway. A number of locks (MacArtheur, Poe, Davis and Sabin Locks) were built on the upper river at the rapids to allow ship passage. Historically the river and the St. Marys Rapids were important to aboriginal peoples and early settlers, as a meeting place and as a source of fish and wildlife for subsistence and trade. The river continues to be an important resource for recreational anglers, subsistence fishermen, recreational boaters, and tourism. A variety of natural features exist within the St. Mary River including islands (e.g., Sugar Island, Neebish Island, and St. Joseph Island), lakes (e.g., Lake Nicolet, Lake George, and Munuscong Lake), bays (e.g., Waiska Bay, Potagannissing Bay, Raber Bay, and Worsley Bay), and channels (e.g., North Channel, Munuscong Channel, and St. Joseph Channel). The river also consists of a variety of habitats and structures, both man-made and natural. Man-made habitats and structures include the locks, water diversion canals, seawalls, and dredged channels for shipping. Natural habitats include wetlands, aquatic vegetation beds, and sand or cobble substrates. Pollution along the river led to impaired water quality, sediment, and biota; and the St. Marys River was designated an Area of Concern (AOC) as part of the Great Lakes Water Quality Agreement of 1987. The study area encompasses U.S. and Canadian waters of the river from the compensating works at Sault

Ste. Marie downstream to Lake Huron at De Tour Village and to the North Channel at the connection with the St. Joseph Channel. The study area will be hereafter referenced as the lower St. Marys River. The lower St. Marys River is managed as part of Lake Huron by the Great Lakes Fishery Commission.

METHODS

Individual sampling sites within survey areas were selected using the *Create Random Points* function in ArcGIS 10.1/10.2 constrained by location specific polygon shape files. Due to lack of available bathymetric data for many of the areas to be sampled (shallow, nearshore, outside of dredged areas), shape files were modified for estimated depth ranges specific to gear type. Gear utilization was based on recommendations from Trebitz et al. (2009) and USFWS (2014c). When a randomly selected point was unable to be sampled (e.g., inadequate depth, inaccessibility), an alternate site was selected from a list of previously allocated randomized alternate locations.

All fish were identified to species level. When a fish could not be identified in the field, it was either preserved in 95% ethanol or frozen and brought back for identification in the lab. Starting in 2014, tissue samples were taken on select fish whose identification was questionable, usually in addition to preserving the whole specimen for lab identification. Tissue samples were taken by clipping a small portion of a fin and either preserving it in an individual 2 mL vial with 95% ethanol or placing it in a scale envelope and dried. Tissue samples are pending genetic barcoding analysis by the U.S. Environmental Protection Agency (USEPA) National Exposure Research Laboratory in Cincinnati, Ohio. All species of fish, other than Round Gobies, were released unharmed, and Round Gobies were euthanized in accordance with state regulations and the terms of scientific collection permits. Water quality data was collected at each site and included surface temperature (°C), dissolved oxygen (mg/l), dissolved oxygen staturation (%), turbidity (NTU), pH, and specific conductivity (mS/cm).

Fish Sampling

Paired fyke net units with 4.69 mm (3/16” delta) stretch mesh netting were designed by attaching two 0.91 m x 1.22 m fyke nets to a 15 m x 0.91 m lead. Individual nets consisted of two rectangular frames 0.91 m x 1.22 m, followed by four circular rings 0.91 m in diameter. Fyke net units were set parallel to the shoreline or in “weed pockets” in water depths of 1.0-2.0 m. Nets were set during the day, remaining in the water overnight for a period of 12-24 hours.

Electrofishing was conducted from a boat during night hours, in water depths of 1-3 m. A pulsed DC current 60 Hz electrical unit was used with sufficient power to induce taxis in fish. Electrofishing power is dependent upon water conductivity and level of boat-hull oxidation. Electrofishing near a predetermined randomly selected waypoint occurred within an area of 0.25 km^2 or along the shoreline, for a total electrofishing time of 600 s per sampling location.

Benthic trawling was conducted using a Marinovich design trawl with a 4.9 m head rope, 3.8 cm stretch mesh body, and a 3.125 mm stretch mesh cod end. Trawl tows were performed at depths greater than 2 m, along contours at a speed of ~4 km/h, and for 5 minutes in duration.

Data Analysis

Species Accumulation Curves

Species accumulation curves were used to facilitate comparisons of the rate of species detection among gear types and gear types combined. Curves were generated in R (version 3.2.1) using the number of sampling events and the species abundance data from 2013-2015, and represent the mean of 10,000 random permutations. The species accumulation curve rises steeply at first as common species are detected over the course of a low number of sampling events, and then the curve rises more slowly as species low in abundance are detected more rarely. Ultimately the curve approaches an asymptote when few or no new species are detected following a number of sampling events.

Rarefaction

Rarefaction analysis was used to estimate species richness and sampling efficiency (efficiency at which species are detected) for individual gear types and for all gear types combined. Sample-based rarefaction and extrapolation were conducted using EstimateS (Colwell 2013, version 9.1.0) software and species abundance data (randomized pooling of data) from 2013-2015 for 10,000 sample extrapolations. Estimated species richness is the asymptote of the extrapolated rarefaction curve. The effort required to detect 95% of species present was calculated by multiplying the estimated number of species by 0.95. The resulting number of species corresponded to a number of samples (i.e., effort required for 95% detection) on the rarefaction curve by which we determined how many samples are needed to detect 95% of the species. Sampling efficacy was calculated as the actual number of species collected (observed species richness) by the estimated species richness (asymptote of the rarefaction curve).

RESULTS

During monitoring efforts conducted from 2013-2015, surveillance crews collected a total of 23,401 fish representing 56 species. Results for each sampling year follows.

2013

A total of 12,654 fish representing 38 species were collected (Table 1, Figure 2). No new non-native species were identified; however a number of existing invasive species were collected including Alewife, Round Goby, Threespine Sticklekback and Rainbow Smelt.

A total of 11,396 fish representing 31species were collected using fyke nets. The most abundant speices captured were unknown Cyprinids (46% of total catch), Spottail Shiners *Notropis hudsonius* (21% of total catch) and Bluntnose Minnows *Pimephales notatus* (16% of total catch). A total of 708 fish representing 19 species were collected using electrofishing. The most abundant species encountered were Emerald Shiners *Notropis atherinoides* (46% of total catch), Logperch *Percina caprodes* (17% of total catch) and Spottail Shiners (13% of total catch). A total of 550 fish representing 18 species were collected using the bottom trawl. The most abundant species were Mimic Shiner *Notropis volucellus* (81% of total catch), Yellow Perch *Perca flavescens* (2% of total catch) and Spottail Shiner (2% of total catch).

2014
A total of 3,163 fish were collected representing 43 species (Table 2, Figure 3). No new non-native species were identified; however a number of existing invasive species were collected including Round Goby, Threespine Sticklekback and Rainbow Smelt.

A total of 2,312 fish representing 27 species were collected using fyke nets. The most abundant species encountered were Sand Shiners *Notropis stramineus* (45% of total catch), Spottail Shiners (21% of total catch) and Bluntnose Minnows (10% of total catch). A total of 495 fish representing 28 species were collected using electrofishing. The most abundant species were Yellow Perch (20% of total catch), Pumpkinseed *Lepomis gibbosus* (14% of total catch) and Emerald Shiner (14% of total catch). A total of 356 fish representing 12 species were collected with the bottom trawl. The most abundant species encountered were Trout-perch *Percopsis omiscomaycus* (47% of total catch), Spottail Shiner (20% of total catch) and Rainbow Smelt (19% of total catch).

2015
A total of 7,584 fish were collected representing 42 species (Table 3, Figure 4). No new non-native species were identified; however a number of existing invasive species were collected including Round Goby, Threespine Sticklekback, Common Carp *Cyprinus carpio*, White Perch and Rainbow Smelt.

A total of 4,561 fish representing 30 species were collected using fyke nets. The most abundant species were Yellow Perch (35% of total catch), Mimic Shiners (18% of total catch) and Rainbow Smelt (16% of total catch). A total of 314 fish representing 25 species were collected using electrofishing. The most abundant species encountered were Spottail Shiners (23% of total catch), Emerald Shiners (19% of total catch) and Bluntnose Minnows (11% of total catch). A total of 2,709 fish representing 18 species were collected using the bottom trawl. The most abundant species were Rainbow Smelt (34% of total catch), Yellow Perch (23% of total catch) and Mimic Shiners (22% of total catch).

Species Accumulation Curves and Rarefaction
The efficacy for juvenile and adult fish sampling gears combined and for single gears was generated for the lower St. Marys River (Table 4, Figure 5). An estimated 73 species are present as a result of 2013-2015 data analysis; while 56 species were captured using all gears (Table 4, Figure 5). To reach 95% detection of all species present (70 species), 420 samples will be required (Table 4). Sampling efficacy was 75%. Bottom trawling had the highest single gear sampling efficacy at 88%, and electrofishing was the lowest at 72% sampling efficacy.

DISCUSSION

The 2015 field season was the third year of sampling for the early detection of non-native species in the Lake Huron system. The St. Marys River was selected as the only early detection sampling area in Lake Huron using a vector based risk analysis originally developed for Lake Erie (USFWS 2014a). A large number of juvenile and adult fish species (both native and non-native)

were collected with an assortment of gears during 2013-2015. No new, undocumented, non-native species were captured.

Targeting juvenile and adult fish can be challenging due to fish behavior, refined habitat requirements, and gear avoidance. Non-native species at low abundance can be difficult to detect as juveniles or adults using traditional sampling gear. To account for this, multiple gear types were used to target juveniles and adults. Nearly 76% of species were detected using all sampling techniques. However, the detection efficiency was below the designated 95%threshold required to detect rare species (i.e., non-native species at first introduction; Hoffman et al. 2011). Because unique species continue to be captured, rarefaction analysis indicated a considerable increase in sampling effort, upwards of an additional six years at the current sampling regime, would be required to detect species at low abundances in the lower St. Marys River. The lower St. Marys River consists of diverse habitat and covers a large area such that it is not surprising that unique species continue to be collected during sampling efforts.

Bottom trawling had the highest efficacy among gear types but yielded the fewest unique species. Unique species were collected using all techniques, indicating value in continuing to sample using a diversity of gears. This finding reinforces previous research suggesting a single sampling gear approach only provides a partial representation of the juvenile and adult fish assemblage (Murphy and Willis 1996), and multi-gear approaches are required to adequately characterize fish communities (e.g., Jackson and Harvey 1997; Eggleton et al. 2010; Ruetz et al. 2007).

Designing a long-term monitoring program is challenging due to the need to balance detection efficiency with available resources (Trebitz et al. 2009). These challenges become exacerbated when considering early detection monitoring for newly introduced non-native species because of the exorbitant amounts of effort and high survey efficiency (≥95% species detection) required. It is therefore beneficial to use results from previous sampling as a guide to adapt future survey design and improve overall sampling efficiency and effectiveness. For example, in Duluth-Superior Harbor, Lake Superior, Hoffman et al. (2011) used a re-sampling approach and found that using a targeted sampling design (i.e., resampled areas with high species richness) resulted in greater species richness and detected non-native species with a significantly higher probability than a spatially balanced random design (also see Trebitz et al. 2009). Although the effort required to detect rare (i.e., non-natives at first introduction) species remained large. Non-Metric Multi-Dimensional Scaling analysis could also be used to determine whether gear types are capturing complementary or redundant species assemblage data (cf. Ruetz et al. 2007; Frances et al. 2014). For example, if two gear types capture redundant assemblages then the least efficient gear (according to the ability to catch unique species) could be eliminated, focusing additional effort towards the most efficient gear types, and thereby increase survey effort and theoretically sampling efficiency.

The early detection and monitoring program for non-native species will continue in the lower St. Marys River during 2016. Monitoring data from efforts in 2016 will increase the collective sampling efficiency (2013-2016) toward the 95% of species detection threshold. Survey design will be critically re-evaluated following the 2016 field season. All available options for

increasing sampling efficiency to provide the most comprehensive early detection and monitoring program for non-native species will be considered.

Based on our estimated ability to detect rare or new non-native fishes in the Lake Huron system, there is potential to improve detection probability by having others assist with data collection. Existing sampling occurs by other state, provincial, tribal and federal agencies on a regular basis in Lake Huron, and opportunistic, grant-funded research sampling is conducted by academic and non-profit researchers. Creating and disseminating resources to allow for identification of non-native fishes by others collecting specimens is crucial if data from additional projects are to be legitimately incorporated into our early detection analyses. Misidentification of non-native fishes could easily occur if priority species are not being searched for. This is particularly true for species of high risk to be introduced to the Great Lakes that look similar to fishes already present in the system (e.g., European Perch *Perca fluviatilis* vs. Yellow Perch; Zander *Sander lucioperca* vs. Walleye *Sander vitreus*; Caspian Shad *Clupeonella caspia* vs. Alewife; Monkey Goby *Neogobius fluviatilis* vs. Round Goby).

In addition to traditional scientific sampling, there is great potential for well-organized public participation in scientific research, or "citizen science," to help increase the amount of effort allocated to identifying non-native species. Citizen science has been particularly useful in large-scale, long-term research and management efforts where traditional funding and other resources would be difficult to attain or maintain (Latimore and Steen 2014; Wydeven et al. 2004). Studies to detect non-native and rare species are among the primary scientific focus areas where citizen science has proven plausible and impactful (Dickinson et al. 2012; Hochachka et al. 2012). For example, over the past five years, 67% of the non-native species reported to the USGS Nonindigenous Aquatic Species Database have been identified by citizens (USGS 2016a; USGS 2016b). In the Great Lakes, anglers assisted with collection of the Round Goby when it was first detected in the St. Clair River in Michigan (Jude et al. 1992). During 2013, the non-native Mummichog *Fundulus heteroclitus* was discovered early enough by amateur science enthusiasts in a small Michigan tributary in the Lake Erie watershed that the Michigan Department of Natural Resources was able to eradicate the species from the creek before it became invasive (Braunscheidel 2015). Data produced by amateur scientists have been met with some skepticism, but they have also proven useful from a research and management perspective. Tobin et al. (2014) found in an assessment of successful arthropod eradication programs that eradication success was 'greater when passive means of detection, such as through private citizen reporting pest presence, [was] used rather than pre-emptively searching sites considered to be at high risk of species arrival, which was least likely to be associated with eradication success.' Tobin et al. (2014) also noted that 'every known *Anoplophora glabripennis* (Motschulsky) infestation in the USA was discovered by private citizens.' This suggests detection is critical for eradication success and that targeted and increased vigilance beyond traditional monitoring program efforts would improve detection and, possibly, the probability of eradication.

Clearly, assistance from other professional scientists and an organized network of citizen scientists could help acquire data for and improve the USFWS early detection monitoring program. Bolstering the vigilance needed to rapidly detect non-native species presence in the Great Lakes is critical. So far, we have established a solid baseline to help predict what resources may be necessary to achieve early detection of non-native fishes in Lake Huron. The

USFWS early detection monitoring program will continue to evolve and improve to make the best use of agency assets and partnerships for protection of the biological integrity of Lake Huron and other Great Lakes ecosystems.

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TABLES

TABLE 1. Catch summary for species captured during juvenile and adult fish sampling* in the lower St. Marys River, 2013.

		Electrofishing (Night)		Paired Fyke Net		Bottom Trawl	
Scientific Name	Common Name	Number collected	CPUE (fish/hr)	Number collected	CPUE (fish/hr)	Number collected	Total
Alosa pseudoharengus	Alewife ^	8	3.478			6	14
Ameiurus melas	Black Bullhead			8	0.024		8
Lepomis macrochirus	Bluegill			42	0.125		42
Pimephales notatus	Bluntnose Minnow	24	10.435	1,805	5.364	3	1,832
Culaea inconstans	Brook Stickleback			4	0.012	7	11
Ameiurus nebulosus	Brown Bullhead			5	0.015		5
Catostomid (unknown)	Catostomid (unknown)			2	0.006		2
Cyprinid (unknown)	Cyprinid (unknown)			5,276	15.679	1	5,277
Notropis atherinoides	Emerald Shiner	328	142.609	32	0.095		360
Notropis buchanani	Ghost Shiner			3	0.009		3
Notemigonus crysoleucas	Golden Shiner			1	0.003		1
Moxostoma valenciennesi	Greater Redhorse	2	0.870				2
Etheostoma nigrum	Johnny Darter	5	2.174	48	0.143	11	64
Couesius plumbeus	Lake Chub	2	0.870				2
Micropterus salmoides	Largemouth Bass			7	0.021	5	12
Percina caprodes	Logperch	118	51.304	26	0.077	7	151
Rhinichthys cataractae	Longnose Dace	1	0.435				1
Notropis volucellus	Mimic Shiner	2	0.870	555	1.649	446	1,003
Cottus bairdii	Mottled Sculpin	3	1.304	1	0.003		4
Pungitius pungitius	Ninespine Stickleback					1	1
Esox lucius	Northern Pike	1	0.435				1
Pomoxis (unknown spp.)	Pomoxis (unknown spp.)			2	0.006		2
Lepomis gibbosus	Pumpkinseed			27	0.080	4	31
Osmerus mordax	Rainbow Smelt ^	17	7.391	3	0.009	5	25
Ambloplites rupestris	Rock Bass	39	16.957	114	0.339	4	157
Neogobius melanostomus	Round Goby ^			16	0.048	9	25

TABLE 1 continued.

		Electrofishing (Night)		Paired Fyke Net		Bottom Trawl	
Scientific Name	Common Name	Number collected	CPUE (fish/hr)	Number collected	CPUE (fish/hr)	Number collected	Total
Notropis stramineus	Sand Shiner			404	1.201		404
Moxostoma macrolepidotum	Shorthead Redhorse			1	0.003		1
Micropterus dolomieu	Smallmouth Bass	31	13.478	264	0.785		295
Notropis hudsonius	Spottail Shiner	89	38.696	2,356	7.001	12	2,457
Gasterosteus aculeatus	Threespine Stickleback ^			1	0.003	11	12
Percopsis omiscomaycus	Trout-perch	24	10.435	5	0.015	5	34
Unknown	Unknown			81	0.241		81
Sander vitreus	Walleye	2	0.870			1	3
Morone chrysops	White Bass			1	0.003		1
Morone americana	White Perch			9	0.027		9
Catostomus commersonii	White Sucker	11	4.783	50	0.149		61
Perca flavescens	Yellow Perch	1	0.435	247	0.734	12	260
Total		708		11,397		550	12,654

* Sampling effort for electrofishing was 2.3 hours, paired fyke nets was 336.5 hours, and bottom trawls was 1.2 hours.
^ Not native to the St. Marys River or Lake Huron.
^^ Naturalized sportfish not native to the Great Lakes.

TABLE 2. Catch summary for species captured during juvenile and adult fish sampling* in the lower St. Marys River, 2014.

		Electrofishing (Night)		Paired Fyke Net		Bottom Trawl	
Scientific Name	Common Name	Number collected	CPUE (fish/hr)	Number collected	CPUE (fish/hr)	Number collected	Total
Ameiurus melas	Black Bullhead			4	0.012		4
Pomoxis nigromaculatus	Black Crappie	3	1.875				3
Lepomis macrochirus	Bluegill			1	0.003		1
Pimephales notatus	Bluntnose Minnow	24	15.000	233	0.699		257
Amia calva	Bowfin	1	0.625				1
Culaea inconstans	Brook Stickleback					12	12
Ameiurus nebulosus	Brown Bullhead	1	0.625				1
Oncorhynchus tshawytscha	Chinook Salmon ^^	2	1.250				2
Oncorhynchus kisutch	Coho Salmon ^^	1	0.625	1	0.003		2
Luxilus cornutus	Common Shiner	3	1.875				3
Notropis atherinoides	Emerald Shiner	70	43.750	21	0.063		91
Aplodinotus grunniens	Freshwater Drum	1	0.625				1
Notropis buchanani	Ghost Shiner			1	0.003		1
Moxostoma erythrurum	Golden Redhorse	8	5.000				8
Moxostoma valenciennesi	Greater Redhorse			1	0.003		1
Etheostoma exile	Iowa Darter			1	0.003		1
Etheostoma nigrum	Johnny Darter	2	1.250	11	0.033	8	21
Micropterus salmoides	Largemouth Bass	38	23.750				38
Percina caprodes	Logperch	35	21.875			3	38
Rhinichthys cataractae	Longnose Dace	1	0.625				1
Notropis volucellus	Mimic Shiner	24	15.000	93	0.279		117
Cottus bairdii	Mottled Sculpin	1	0.625	4	0.012		5
Pungitius pungitius	Ninespine Stickleback					4	4
Esox lucius	Northern Pike	3	1.875	1	0.003		4
Lepomis gibbosus	Pumpkinseed	71	44.375	6	0.018		77
Etheostoma caeruleum	Rainbow Darter					1	1
Osmerus mordax	Rainbow Smelt ^	3	1.875			67	70
Ambloplites rupestris	Rock Bass	37	23.125	118	0.354		155
Neogobius melanostomus	Round Goby ^			8	0.024		8

TABLE 2 continued.

Scientific Name	Common Name	Electrofishing (Night) Number collected	Electrofishing (Night) CPUE (fish/hr)	Paired Fyke Net Number collected	Paired Fyke Net CPUE (fish/hr)	Bottom Trawl Number collected	Total
Prosopium cylindraceum	Round Whitefish	1	0.625				1
Notropis stramineus	Sand Shiner			1,034	3.104		1,034
Moxostoma macrolepidotum	Shorthead Redhorse	4	2.500	1	0.003		5
Cottus cognatus	Slimy Sculpin			1	0.003	8	9
Micropterus dolomieu	Smallmouth Bass	12	7.500	130	0.390		142
Notropis hudsonius	Spottail Shiner	18	11.250	487	1.462	72	577
Minytrema melanops	Spotted Sucker	9	5.625				9
Gasterosteus aculeatus	Threespine Stickleback ^			6	0.018	7	13
Percopsis omiscomaycus	Trout-perch	15	9.375	8	0.024	167	190
Unknown	Unknown			117	0.351		117
Sander vitreus	Walleye			3	0.009		3
Catostomus commersonii	White Sucker	6	3.750	4	0.012	4	14
Ameiurus natalis	Yellow Bullhead			2	0.006		2
Perca flavescens	Yellow Perch	101	63.125	15	0.045	3	119
Total		495		2,312		356	3,163

* Sampling effort for electrofishing was 1.6 hours, paired fyke nets was 333.1 hours, and bottom trawls was 1.2 hours.
^ Not native to the St. Marys River or Lake Huron.
^^ Naturalized sportfish not native to the Great Lakes.

TABLE 3. Catch summary for species captured during juvenile and adult fish sampling* in the lower St. Marys River, 2015.

		Electrofishing (Night)		Paired Fyke Net		Bottom Trawl	
Scientific Name	Common Name	Number collected	CPUE (fish/hr)	Number collected	CPUE (fish/hr)	Number collected	Total
Ameiurus melas	Black Bullhead			1	0.003		1
Pomoxis nigromaculatus	Black Crappie			320	0.999		320
Lepomis macrochirus	Bluegill			11	0.034		11
Pimephales notatus	Bluntnose Minnow	36	20.000	237	0.740	148	421
Amia calva	Bowfin			1	0.003		1
Culaea inconstans	Brook Stickleback			1	0.003	28	29
Ameiurus nebulosus	Brown Bullhead	1	0.556				1
Lota lota	Burbot			1	0.003		1
Ictalurus punctatus	Channel Catfish			1	0.003		1
Oncorhynchus kisutch	Coho Salmon ^^					1	1
Cyprinus carpio	Common Carp ^	1	0.556				1
Luxilus cornutus	Common Shiner	8	4.444				8
Notropis atherinoides	Emerald Shiner	60	33.333				60
Aplodinotus grunniens	Freshwater Drum	2	1.111				2
Dorosoma cepedianum	Gizzard Shad			2	0.006		2
Etheostoma nigrum	Johnny Darter	5	2.778	30	0.094	112	147
Coregonus clupeiformis	Lake Whitefish					5	5
Micropterus salmoides	Largemouth Bass	1	0.556	4	0.012		5
Percina caprodes	Logperch	21	11.667	21	0.066	17	59
Rhinichthys cataractae	Longnose Dace	3	1.667				3
Notropis volucellus	Mimic Shiner			829	2.588	588	1,417
Cottus bairdii	Mottled Sculpin	6	3.333	22	0.069	30	58
Pungitius pungitius	Ninespine Stickleback			1	0.003	30	31
Esox lucius	Northern Pike	1	0.556	1	0.003		2
Lepomis gibbosus	Pumpkinseed	2	1.111	9	0.028		11
Osmerus mordax	Rainbow Smelt ^	13	7.222	732	2.285	910	1,655
Ambloplites rupestris	Rock Bass	8	4.444	46	0.144		54
Neogobius melanostomus	Round Goby ^	1	0.556	3	0.009	55	59
Prosopium cylindraceum	Round Whitefish					1	1

TABLE 3 continued.

		Electrofishing (Night)		Paired Fyke Net		Bottom Trawl	
Scientific Name	Common Name	Number collected	CPUE (fish/hr)	Number collected	CPUE (fish/hr)	Number collected	Total
Notropis stramineus	Sand Shiner			217	0.677		217
Moxostoma macrolepidotum	Shorthead Redhorse	3	1.667				3
Moxostoma anisurum	Silver Redhorse	1	0.556				1
Cottus cognatus	Slimy Sculpin			1	0.003	8	9
Micropterus dolomieu	Smallmouth Bass	6	3.333	40	0.125		46
Notropis hudsonius	Spottail Shiner	71	39.444	216	0.674	77	364
Gasterosteus aculeatus	Threespine Stickleback ^					4	4
Percopsis omiscomaycus	Trout-perch	17	9.444	37	0.116	71	125
Sander vitreus	Walleye	4	2.222	1	0.003		5
Morone chrysops	White Bass			8	0.025		8
Morone americana	White Perch ^	1	0.556	50	0.156		51
Catostomus commersonii	White Sucker	13	7.222	111	0.347	7	131
Perca flavescens	Yellow Perch	29	16.111	1,607	5.017	617	2,253
Total		314		4,561		2,709	7,584

* Sampling effort for electrofishing was 1.8 hours, paired fyke nets was 320.3 hours, and bottom trawls was 1.2 hours.
^ Not native to the St. Marys River or Lake Huron.
^^ Naturalized sportfish not native to the Great Lakes.

TABLE 4. Sampling techniques, estimated species richness predicted by rarefaction analysis in estimateS, 95% of estimated species richness, number of unique species captured, estimated number of samples required to reach 95% detection level, and efficiency for gears types from the lower St. Marys River during 2013-2015.

Sample Type	Observed Species Richness	Unique Species	Estimated Species Richness	95% of Species Richness	Estimated Samples to Reach 95%	Estimated Sampling Efficacy (%)
All techniques	56	-	73.86	70.17	420	75.8
Fyke net	43	11	56.77	53.93	121	75.7
Boat electrofishing	39	9	53.69	51.01	116	72.6
Bottom trawl	26	2	29.52	28.04	69	88.1

FIGURES

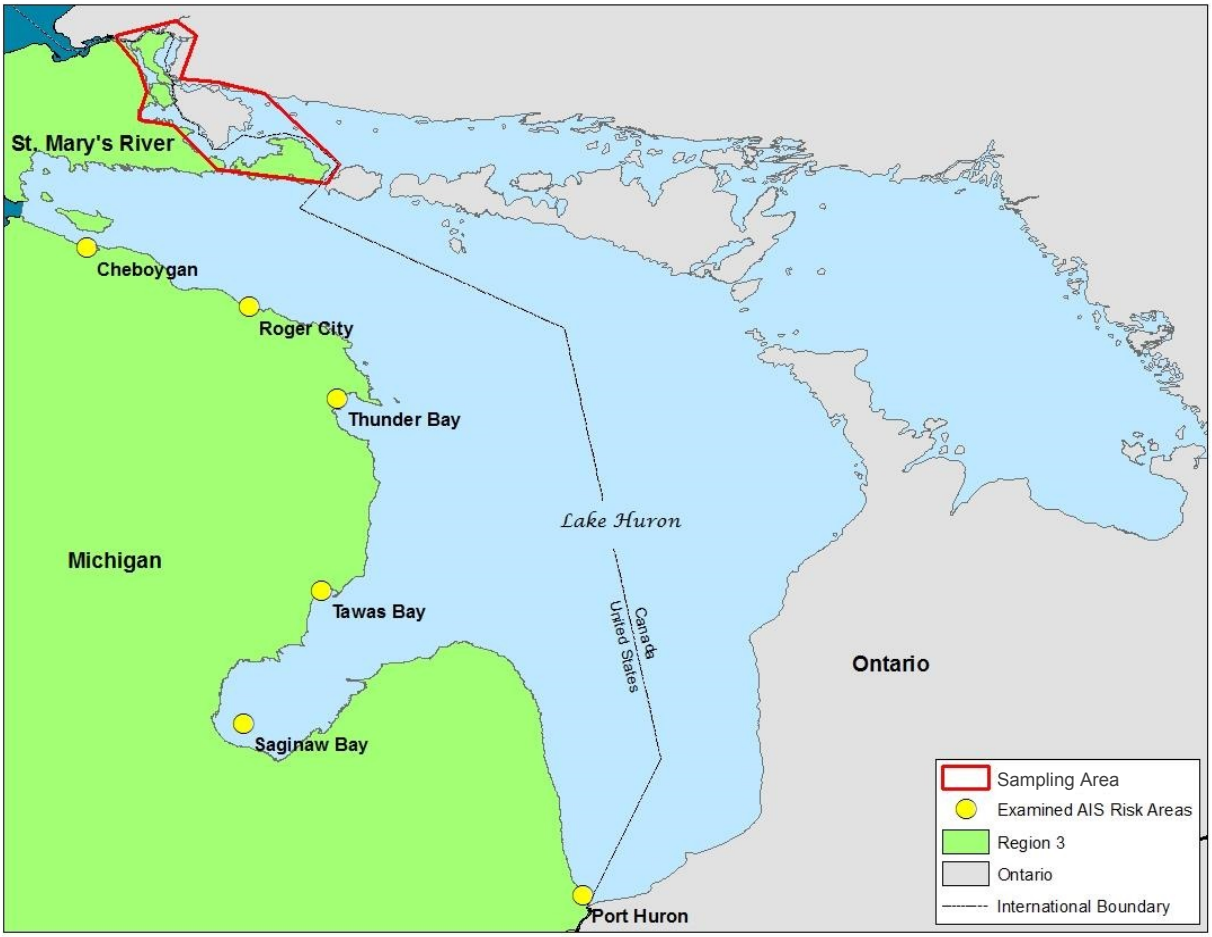

FIGURE 1. The Lake Huron Basin showing risk areas and location sampled during 2013-2015.

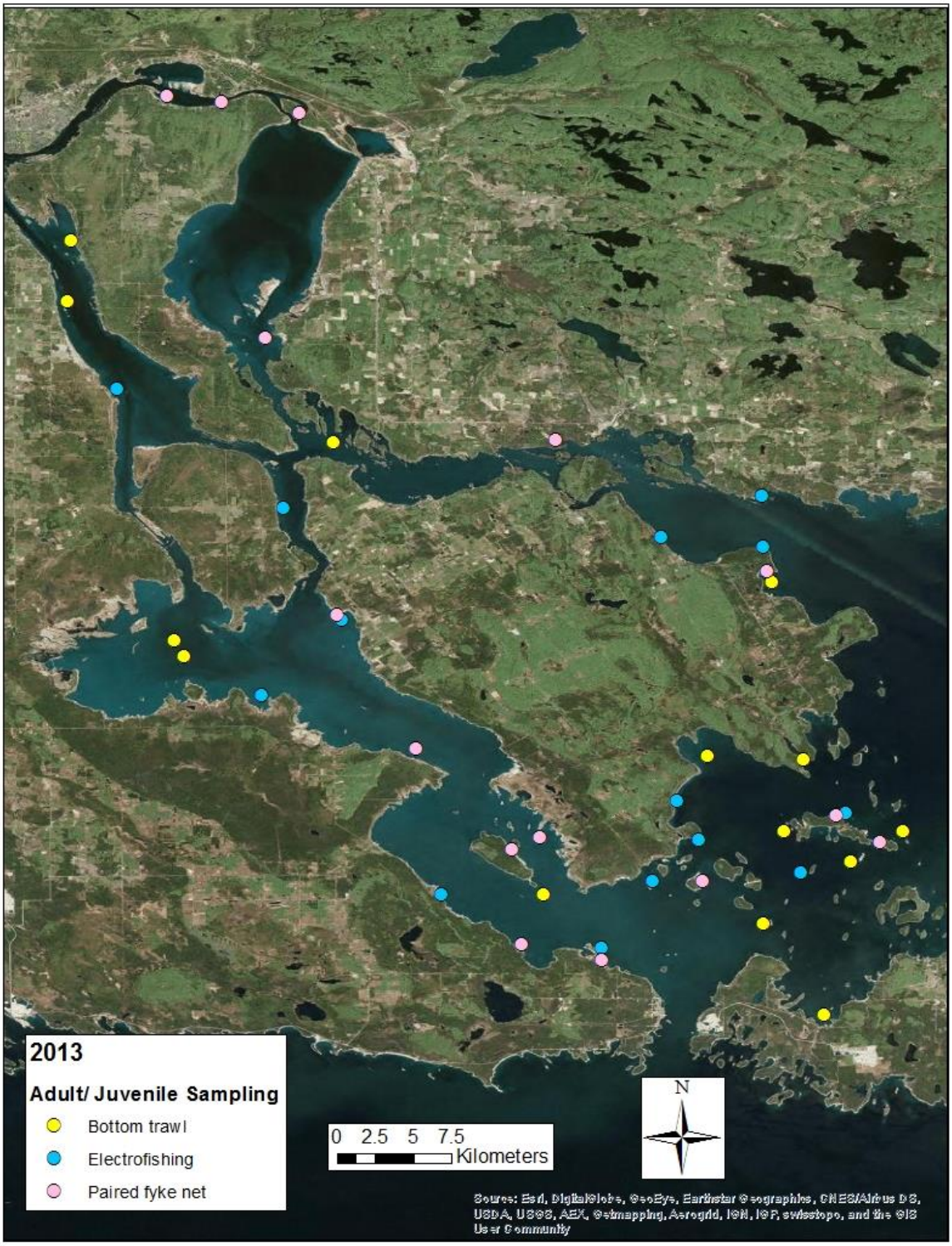

FIGURE 2. The lower St. Marys River showing locations sampled during 2013.

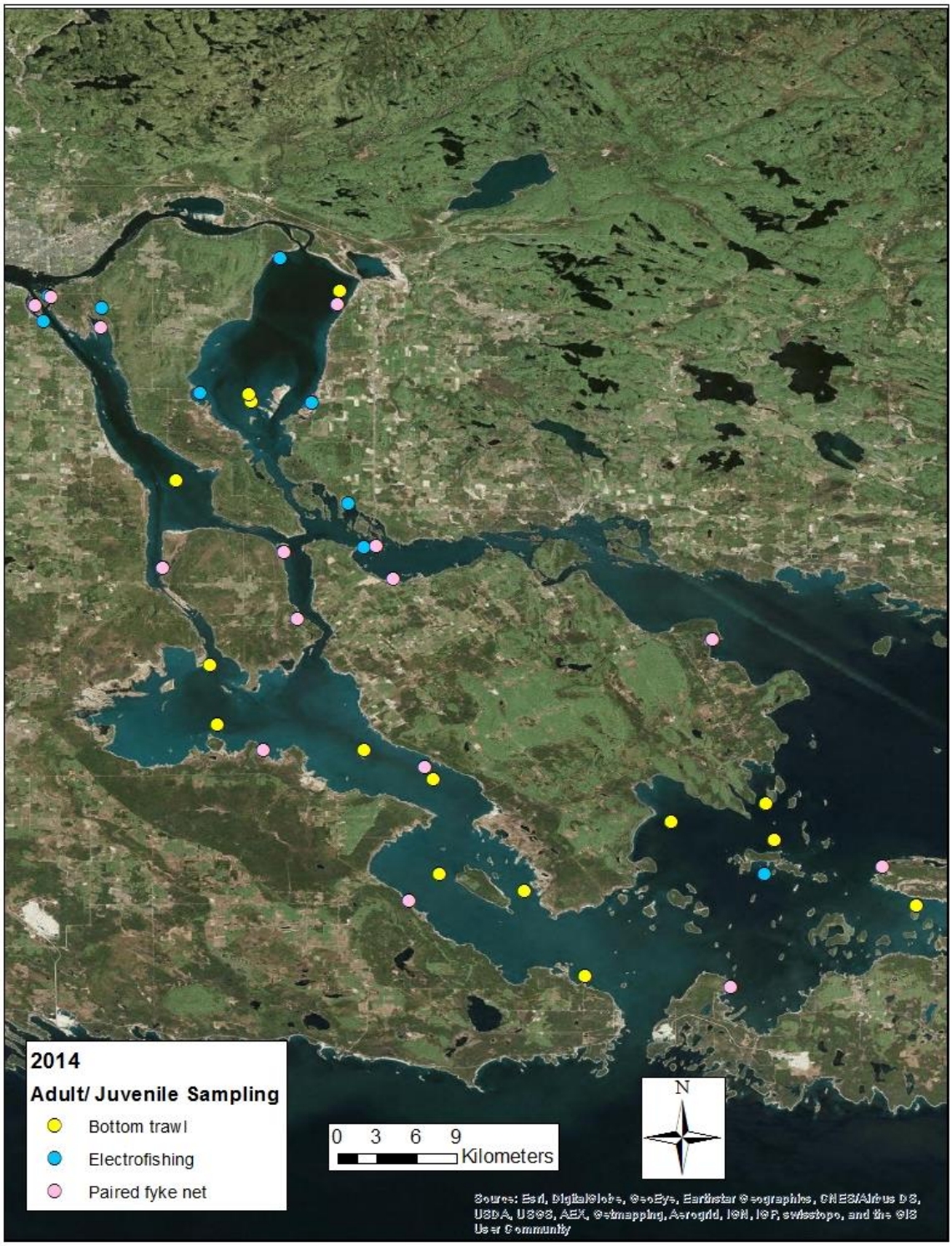

FIGURE 3. The lower St. Marys River showing locations sampled during 2014.

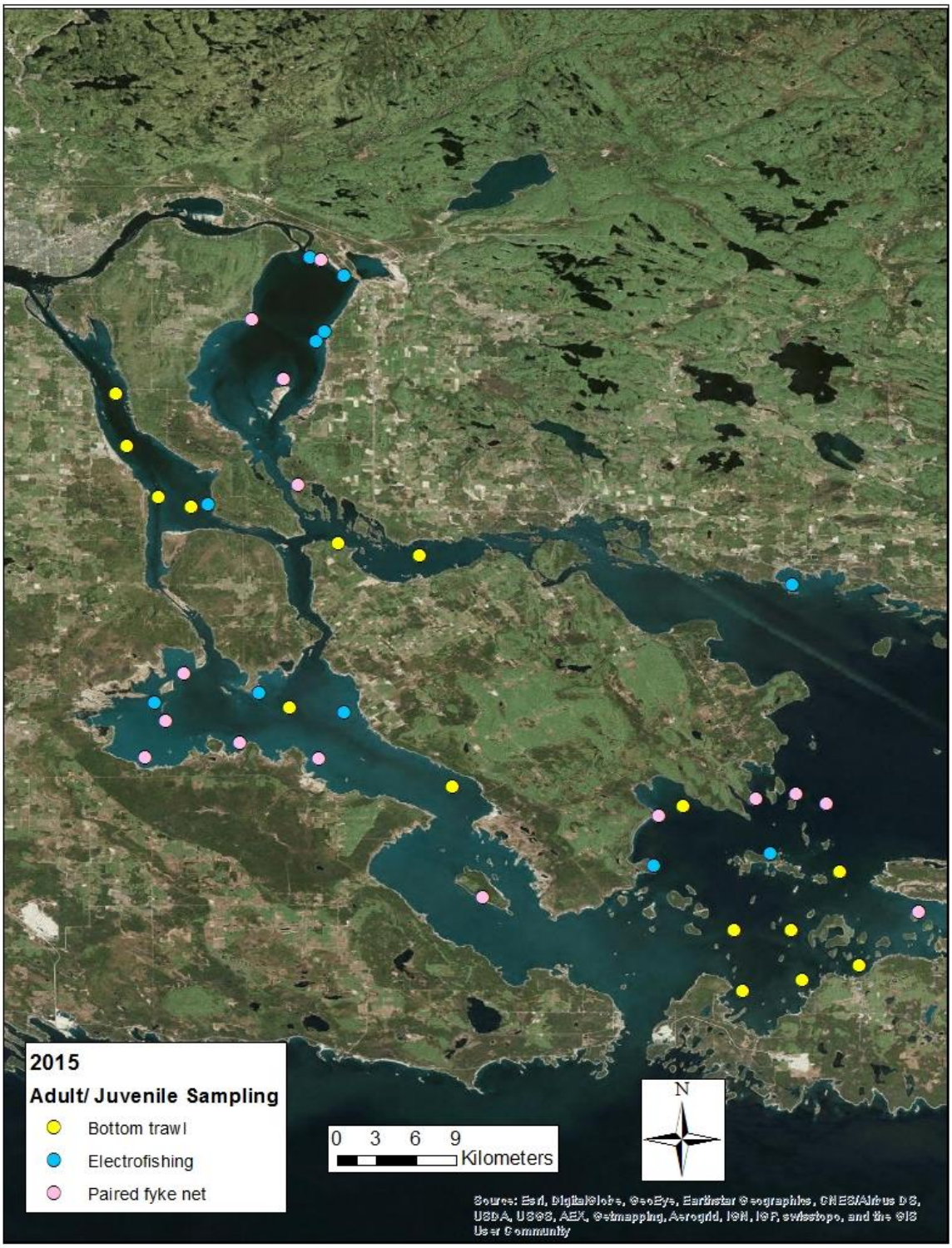

FIGURE 4. The lower St. Marys River showing locations sampled during 2015.

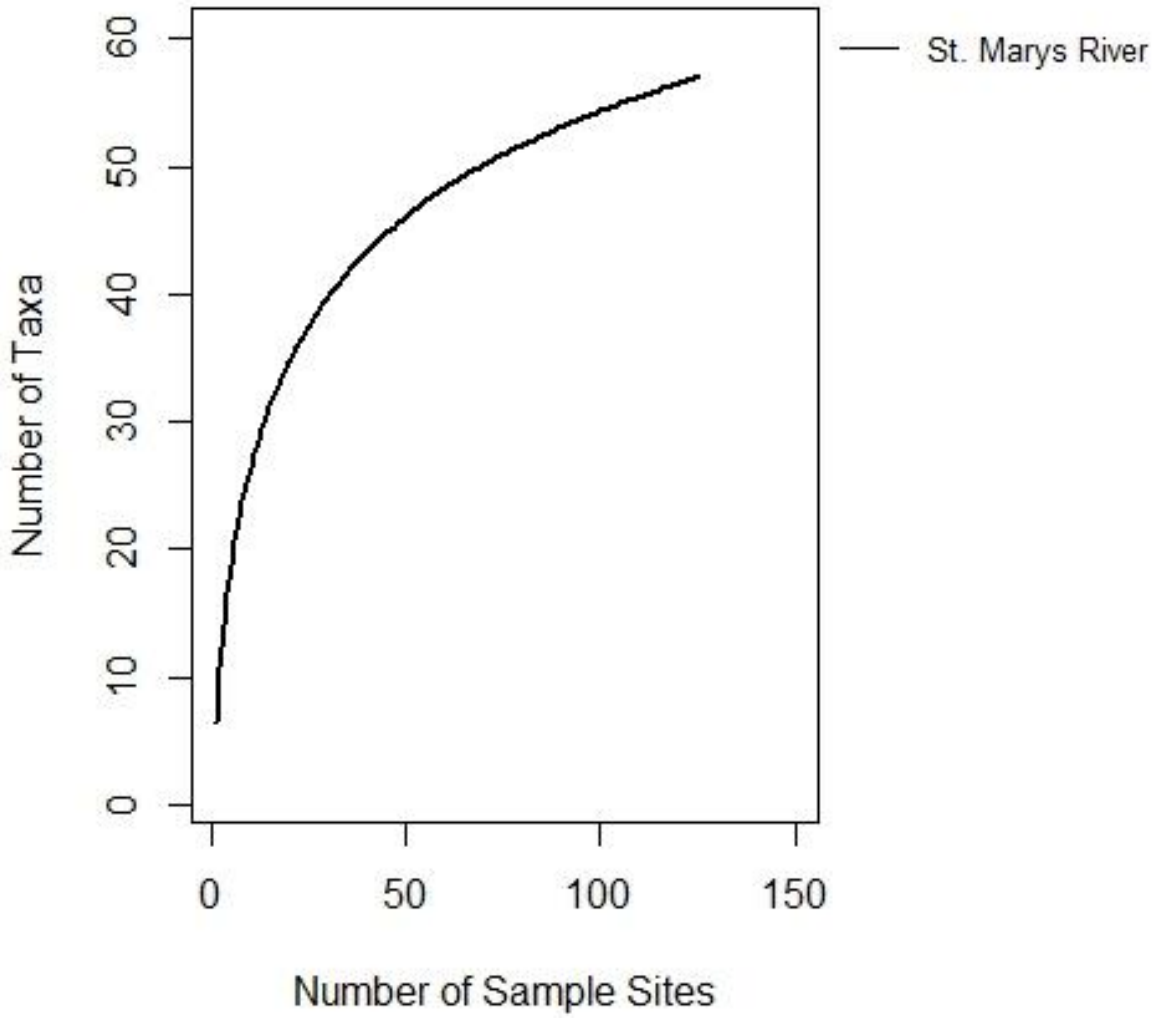

FIGURE 5. Species accumulation curve for the lower St. Marys River from 2013-2015, all gears combined.

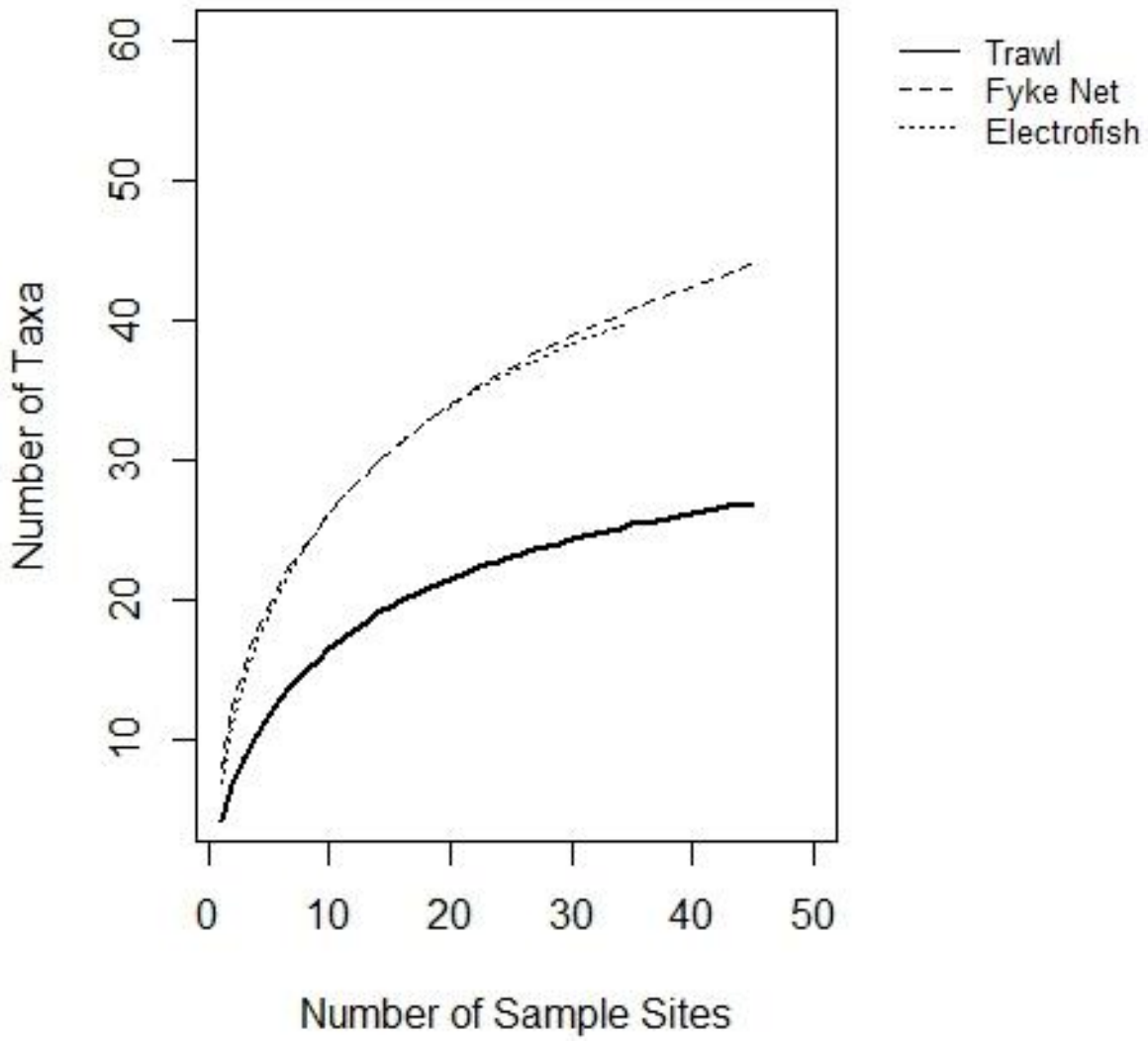

FIGURE 6. Species accumulation curve for sampling gears fished in the lower St. Marys River, 2013-2015.