Evaluation of Nearshore Fish Assemblages, Habitat, and the Effects of Herbivorous Rudd (*Scardinius erythrophthalmus*): Determining the Efficacy of Fish Habitat Restoration Efforts in the Buffalo Harbor and Niagara River

An Application for Funding Through the Greenway Ecological Fund Standing Committee

By

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Purpose

We seek to acquire information that will promote successful habitat restoration efforts in the Buffalo Harbor and Niagara River. Most of the major habitat improvement projects planned and completed for the upper Niagara River affect nearshore fish assemblages and aquatic vegetation. In addition, the non-native, herbivorous rudd (*Scardinius erythrophthalmus*) may negatively influence habitat restoration outcomes by consuming aquatic vegetation; rudd was the dominant species in spring trap-net surveys during 2007-2008 (Kapuscinski and Wilkinson 2008; Kapuscinski et al. 2009). Many native species, including the economically important muskellunge (*Esox masquinongy*; Menz 1981; Connelly et al. 1997) rely on nearshore habitats for reproduction and first-year growth (Harrison and Hadley 1978; Kapuscinski et al. 2010). All habitat restoration efforts should include a rigorous evaluation (Society for Ecological Restoration International Science & Policy Working Group 2004), which typically requires that data be collected before and after habitats are manipulated. Therefore, we are proposing to conduct (1) surveys of nearshore fish assemblages and aquatic vegetation near restoration sites, (2) a laboratory experiment investigating selection of aquatic plant species by rudd, and (3) a study determining which aquatic vegetation and physical conditions are associated with muskellunge spawning sites. The information acquired from these efforts will help biologists evaluate current nearshore habitats and guide the design of new projects. This work will

continue and expand upon the surveys of nearshore fish assemblages, aquatic habitat, and rudd that were conducted during 2007-2010.

Objectives & Justification

Objective 1: Survey nearshore fish assemblages to monitor reproduction, identify priority areas for protection and habitat improvement, and determine if fish assemblages change in response to habitat restoration efforts.

Achieving this objective will provide young-of-the-year (YOY) muskellunge catch rates at individual nursery sites, continuing an effort begun in 2007. These catch rates serve as relative abundance estimates of YOY muskellunge and allow for site-specific comparisons and examination of trends through time. Data collected during previous efforts were used to identify the prey species that muskellunge depended upon during their first year of growth (e.g. banded killifish *Fundulus diaphanus*, cyprinids, and darters; Kapuscinski et al. *In review*). In the future, these data can be used to determine how habitat restoration efforts affect the relative abundance of muskellunge and important prey species.

Important relations between fish assemblages and local habitat characteristics were determined from data collected during 2008-2009 (Kapuscinski and Farrell *In prep.*). Small-bodied cyprinids, which are important prey for YOY muskellunge, dominated nearshore sites that had measurable flow, abundant aquatic macrophytes, coarse substrates, and little or no macroalgae. Conversely, nearshore sites that lacked flow, had relatively few aquatic macrophytes, fine substrates, and dense beds of macroalgae were dominated by centrarchids and yellow perch (*Perca flavescens*), which are poor prey for YOY muskellunge. Continued annual monitoring will allow us to quantify changes in fish assemblages and physical habitat near restoration sites (e.g. Motor Island, Strawberry Island, etc.); this can serve as an evaluation of these projects and provide guidance for future efforts.

In previous years, we identified four undocumented muskellunge nursery sites (one in 2008 and three in 2009). Densities of YOY muskellunge at these sites ranged from moderate to extremely high. Identification of such sites has provided justification for protection from future disturbances (e.g. at River Lea) and can lead to habitat restoration where necessary.

All fish species are quantified during this seining effort, so important information on species of greatest conservation need in NY State may be collected. For example, we collected a

number of rare species in 2008 and 2009, including blackchin shiner *Notropis heterodon*. Blackchin shiner has a NY Natural Heritage Program rank of S1, meaning typically 5 or fewer occurrences (see http://www.dec.ny.gov/animals/9406.html). Information on these rare species is unlikely to be collected in the absence of this survey.

Objective 2: Examine aquatic plant species selection by rudd.

The non-native rudd was the most abundant fish in trap-net catches from the Buffalo Harbor and upper Niagara River during 2007 when they comprised 38% of the total catch (n = 2,066; Kapuscinski and Wilkinson 2008) and 2008 when they comprised 56% of the total catch (n = 4,821; Kapuscinski et al. 2009). Rudd catches during 2008 were about four times greater than catches for the next most abundant species, brown bullhead (*Ameiurus nebulosus*; n = 1,260). The abundant rudd may contribute to poor water quality and impair aquatic vegetation by consuming plants and excreting biologically available nutrients (Lake et al. 2002; Nurminen et al. 2003). We will determine the effects of rudd on nearshore aquatic habitats in the Buffalo Harbor and upper Niagara River by conducting a series of laboratory experiments to quantify (1) selection for aquatic vegetation species, (2) consumption rates of aquatic vegetation, and (3) nutrient excretion rates. Selection of aquatic plant species by rudd will be determined during 2011, whereas consumption and excretion rates will be quantified during a follow-up study that will be proposed to the Habitat Enhancement and Restoration Fund for 2012-2013. Determining how rudd affect vegetation and water quality will help us understand the ecological interactions between rudd and nearshore fish assemblages and will be critical for designing successful restoration projects.

Objective 3: Identify and quantify vegetation and physical habitat characteristics at muskellunge spawning sites in the Buffalo Harbor and upper Niagara River.

Previous studies have found that spawning muskellunge select for emergent vegetation and newly emerging submerged aquatic vegetation (SAV; Farrell 2001; Nohner 2009). Emergent vegetation and emerging SAV may play important roles for muskellunge egg incubation by (1) elevating eggs above the zone of low dissolved oxygen concentration that occurs at the substrate-water interface in some habitats, and (2) preventing eggs from being displaced to less desirable habitats by river current and wave action. Aquatic vegetation may be especially important for

protecting eggs at higher energy incubating sites (e.g. Buffalo Harbor sites exposed to wave action and Niagara River sites exposed to the main river current). Identifying muskellunge spawning sites and describing associated vegetation and physical habitat at the time of spawning will allow us to assess habitat conditions in this system and provide habitat targets for restoration projects. Additionally, linking spawning habitat characteristics to YOY muskellunge catch data collected during past and proposed seining surveys (Objective 1) may provide insight to the quality of spawning habitat at different sites.

Methods & Expected Results

Objective 1

We will sample fish assemblages at nearshore sites with a fine-mesh bag seine (9.14 m long, 1 mm mesh), using the standardized protocol employed during 2007-2010. Seine hauls will be of equal length (30.5 m) to allow for comparisons of catch rates between sites and among years. Seining will be conducted during 27 July-7 August to be consistent with efforts during previous years. All fish captured will be identified and released, and all northern pike (*Esox lucius*) and muskellunge will be measured for total length (mm). Stomach contents will be flushed out of muskellunge ≥ 80 mm (non-lethal lavage technique, see Farrell 1998) and prey items will be identified and measured for total length when possible. At least 10 sites will be sampled, including two in the Buffalo Harbor and eight in the upper Niagara River (Figures 1-3). Site-specific catch rates of YOY muskellunge will be calculated, and trends will be examined to identify priority areas for protection and habitat improvement (e.g. see Figure 4).

Objective 2

A laboratory experiment will be conducted with rudd to quantify selection of aquatic vegetation species. We will determine if rudd feed selectively by offering equal quantities of different vegetation species to captive rudd and quantifying the loss (by weight) of each over time (e.g. see Lake et al. 2002). Understanding which aquatic plant species are preferred by rudd will help us (1) understand how rudd alter existing aquatic habitat, and (2) guide efforts to restore nearshore aquatic habitats in the Buffalo Harbor, Niagara River, and other locations where rudd are established or might invade (e.g. Long Point Bay, Ontario). For example, native aquatic vegetation that is resistant to rudd herbivory may be planted at restoration sites.

Objective 3

Visual observation (nighttime spotlighting) following the methods of Zorn et al. (1998), Rust et al. (2002), and Nohner (2009) will be used to identify muskellunge spawning sites in the Buffalo Harbor and upper Niagara River. The location of spawning fish will be recorded using a GPS unit so we can return to sites during daylight hours and conduct habitat surveys. Data describing vegetative coverage, species composition, and physical habitat (e.g. water velocity, depth, substrate type, and temperature) will be collected at each identified spawning site. We will also estimate the percent of vegetation covering the substrate and vegetation height at each site. The species composition of the vegetation present will be recorded to determine which species are most abundant at sites during the spawning period. Water depth will be measured at the time of spotlighting and during daytime habitat surveys because water levels may fluctuate substantially on a daily basis. Substrate characteristics at spawning sites will be described following the Udden-Wentworth grain size scale (Udden, 1914; Wentworth, 1922). Temperature data will be collected throughout the spawning period using temperature loggers placed at multiple nearshore sites in the Buffalo Harbor and Niagara River. Data from this study will be used to quantitatively describe muskellunge spawning habitat; these descriptions can be used to develop targets for restoration efforts that seek to improve or create nearshore habitat for spawning muskellunge.

Linkages

Data collected to achieve our project objectives can be used to address several issues identified in the Niagara River Remedial Action Plan (New York State Department of Environmental Conservation 1994) and the Buffalo and Niagara Rivers Habitat Assessment and Conservation Framework (Wooster and Matthies 2008). For example, the index sites identified for monitoring in our Objective 1 are within or adjacent to habitats identified as priorities for protection and restoration in the Niagara River Remedial Action Plan (New York State Department of Environmental Conservation 1994; e.g. Strawberry Island-Motor Island shallows, east river wetland, Buffalo Harbor, and Buckhorn Island wetlands). Our data can be used to characterize aquatic habitat and fish assemblages in these areas, prioritize sites for protection and restoration, and monitor changes through time.

Monitoring non-native species and their affects on native species and habitats was a remedial action recommended in the Niagara River Remedial Action Plan (New York State Department of Environmental Conservation 1994). The data collected to achieve our Objectives 1 and 2 will provide important information on the presence and relative abundance of several non-native fishes, and will determine if rudd may be altering existing native aquatic vegetation via selective feeding. Furthermore, we will continue to document the selection or avoidance of non-native prey by muskellunge. Data collected during 2008-2009 indicated that YOY muskellunge were selectively feeding on round goby (*Neogobius melanostomus*), carp (*Cyprinus carpio*), and goldfish (*Carassius auratus*), but no rudd were recovered from muskellunge stomachs (Kapuscinski et al. *In review*). This finding is of particular interest because round goby were implicated as a reservoir host of viral hemorrhagic septicemia (Eckerlin 2008), which can infect and kill muskellunge (Elsayed et al. 2006; Kipp and Ricciardi 2010).

The Buffalo and Niagara Rivers Habitat Assessment and Conservation Framework (Wooster and Matthies 2008) states that "a new baseline inventory of Niagara River aquatic habitat is needed". While our Objective 1 does not include a strict inventory, the habitat data to be collected (at no less than ten sites) can be used as baseline information; a comprehensive inventory-type survey is planned for these and possibly additional sites in 2012-2013. Ensuring that long-term management programs are in place to protect priority habitats was also identified as a challenge by Wooster and Matthies (2008). The habitat and fish population data collected for Objective 1 will build upon four years of existing data that was collected under a standardized framework. So long as these surveys are continued annually, the data collected can be used for monitoring and managing priority habitat areas.

The Buffalo and Niagara Rivers Habitat Assessment and Conservation Framework (Wooster and Matthies 2008) identifies "better characterization of fish uses of river and lake areas" as an information need. Completing our Objective 1 will advance our knowledge of how habitat factors influence fish assemblage structure in the Buffalo Harbor and Niagara River, and completing our Objective 3 will describe which habitats are required by spawning muskellunge. Collectively, this information can be used to set habitat targets that are most likely to support native fish assemblages, which include rare species such as blackchin shiner and the ecologically and economically important muskellunge.

Deliverables

A project summary presentation will be given to the Greenway Ecological Fund Standing Committee (GEFSC) upon completion. In addition, the following objective-specific deliverables will be produced:

- Objective 1: fish assemblage and habitat data will be entered into a database containing data collected at index sites since 2007; this database will be provided to the New York State Department of Environmental Conservation (NYSDEC). A summary report indicating fish assemblage trends through time (e.g. catch rates of YOY muskellunge) will be produced and provided to the GEFSC and NYSDEC (to be included in their Lake Erie Unit Annual Report at their discretion). Data collected for this objective may also be used for publication in a peer-reviewed scientific journal article.
- Objective 2: the results obtained from completing this objective will be provided to the GEFSC and NYSDEC in the form of a written summary report. In addition, these data will be used for publication in a peer-reviewed scientific journal article. These written documents will include suggestions on which plant species to use or avoid in habitat restoration projects, based on whether species were selected or avoided by rudd.
- Objective 3: the results obtained from completing this objective will be (1) provided to the GEFSC and NYSDEC in the form of a written summary report, (2) written as a chapter in a doctoral dissertation, and (3) used for publication in a peer-reviewed journal article. These written documents will include a map of documented muskellunge spawning areas and a model linking spawning habitat to YOY muskellunge production. This information can be used to identify areas in need of protection and to provide targets for habitat restoration efforts.

Organization

The Research Foundation for and on behalf of State University of New York, College of Environmental Science and Forestry

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Evidence of Consultation with the Niagara River Greenway Commission

This project proposal was judged consistent with the Niagara River Greenway Plan by the Niagara River Greenway Commission on 16 November 2010. We have not received any comments or suggestions for revision from the Commission to date; any comments received

from the Commission, and our response, will be forwarded to the Greenway Ecological Fund Standing Committee.

Evidence of Consultation with Affected Municipalities, Counties, or Indian Nations

N/A – Project activities will not be conducted on municipal, county, or Indian Nation lands.

Evidence of Consultation with State and Federal Agencies

The NYSDEC is a project cooperator and has reviewed this application in full. NYSDEC project reviewers were Mike Wilkinson and Tim DePriest (Buffalo office, phone: 716-851-7010). We obtained collector's permits from the Ontario Ministry of Natural Resources (OMNR) for work conducted during 2007-2009, and we provided OMNR with a summary report of our activities; we will again obtain all required permits for future work. Our OMNR point of contact was Alistair Mathers (Picton, Ontario office, phone: 613-476-8733). Consultation with U.S. federal agencies was not applicable for this project and therefore not conducted.

Operation and Maintenance Plan

N/A – No permanent physical structures are being built.

Project Consistency with the Niagara River Greenway Plan (NRGP)

Our project will advance several principles outlined in the NRGP, especially *Sustainability*, *Ecological Integrity*, and *Restoration*. The results obtained from our surveys of the nearshore fish assemblage and aquatic vegetation will be used to track changes through time, thereby providing a measure of ecological sustainability and integrity, especially in response to habitat restoration efforts. Understanding how herbivory by non-native rudd affects aquatic vegetation will help biologists manage for fish populations that sustain the ecological integrity of the Greenway. The results obtained from Objectives 2 and 3 will be important when designing projects that seek to restore nearshore habitat important to spawning fishes. Our project will also advance the NRGP's principles of *Partnerships* and *Community* by continuing the collaborative effort between the NYSDEC, SUNY-ESF, Buffalo State-SUNY, and the Niagara Musky Association to gain knowledge about the Greenway's aquatic resources (letters of support from

each organization are enclosed). These partnerships are critical for conservation of public ecological resources such as the muskellunge fishery.

This project will strongly support the NRGP's goals to *Protect and Restore Environmental Systems* and *Promote Long Term Sustainability* by identifying areas in need of protection and habitat restoration, and providing information needed to preserve native fishes. As critical habitats are protected and restored, improvements to native sport fish populations (e.g. muskellunge) will attract more anglers, even from out of state, who will spend money locally and help *Spark Revitalization and Renewal*.

Our project proposal is consistent with the criteria *Priority Status: Restoration of Niagara River Ecosystem* because our results can be used to guide preservation and restoration of the native fishes and vegetation that comprise the nearshore aquatic community. Project activities will be conducted almost entirely within the *Focus Area*; assessment of muskellunge spawning in Ontario waters may be conducted. We believe that all aspects of our project are *Implementable*, because they build on existing data and research efforts completed during 2007-2010—our prior experience allows us to propose a realistic workload and budget. Several *Matching Funds* will contribute to this project, including contributions from the Niagara Musky Association, the NYSDEC, SUNY-ESF, and Buffalo State-SUNY (see budget for dollar amounts). The results of this project will provide *Clear Benefit*s to the Greenway and local community by obtaining information required for proper management and restoration of nearshore fishes and aquatic vegetation.

Project Consistency with State and Federal Laws

NYSDEC collaborators reviewed the project description for consistency with state laws, and NYSDEC staff will be involved with most project activities, providing real-time consultation on any changes to the project. We will obtain a collector's permit from OMNR for any activities in Ontario waters, and therefore be in compliance with all Ontario laws. Our proposed activities do not require exemption from federal laws, so U.S. agencies were not consulted.

Efforts and Opportunities to Obtain Matching Funds

Approximately $72,561.00 in matching funds will support this project. The NYSDEC has agreed to provide services (salary, mileage, etc.), but the amount is unknown at this time. Buffalo

State-SUNY will provide a cost-share of $3,000.00 (waived laboratory fees). The Niagara River Musky Association has pledged a minimum of $1,500.00 to support this project. A cost-share of $68,061.00 will be provided by SUNY-ESF in the form of salary, tuition, and indirect costs. Additional cost-shares, which cannot be quantified at this time, will likely include (1) salary of SUNY-ESF employees participating in field sampling, (2) storage fees waived by Buffalo State-SUNY, and (3) volunteers assisting with data collection for Objective 3.

Existing Costs as of 31 August 2007

We will not use any awarded Greenway Funds to defray obligations, operations, or maintenance costs existing prior to 31 August 2007.

Land Ownership Associated with Project

N/A

Project Budget

Field sampling and laboratory experiments will be conducted during 2011 to achieve the project objectives. Data entry, analysis, and report writing will be ongoing during the term of the project. The total amount of funding being requested is $199,361.00 (see Table 1 for a detailed budget).

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Table 1. Proposed budget for 2011 activities.

Activity	Approximate dates	Item	Cost
Objective 1: seining and habitat survey at nearshore sites	1 - 5 Aug	Lodging	1,000
		Per diem	300
		Mileage	200
		Supplies	1,000
		Boat fuel	105
Objective 2: laboratory experiment to quantify selection of aquatic plant species by rudd	June - July	Lodging	1,200
		Per diem	300
		Mileage	488
		Supplies	1,500
		YSI probe	3,000
		Temp. loggers	1,920
Objective 3: Muskellunge spawning study	April - Aug	Lodging	3,000
		Per diem	750
		Mileage	913
		Supplies	2,550
		Boat fuel	1,050
		Water level loggers	1,750
Boat purchase			30,000
Boat maintenance			1,500
Postdoctoral researcher (Kapuscinski)	1 Jan - 31 Dec	Salary	52,000
		Benefits	20,930
Graduate Student (Crane)	1 Jan - 31 Dec	Salary	10,000
		Benefits	1,300
Technician 1	May 1 - 30 Sept	Salary	7,200
		Benefits	1,224
Farrell	1 Jan - 31 Dec	Salary	4,710
		Benefits	2,295
Indirect costs			47,177
Year 1 total			199,361

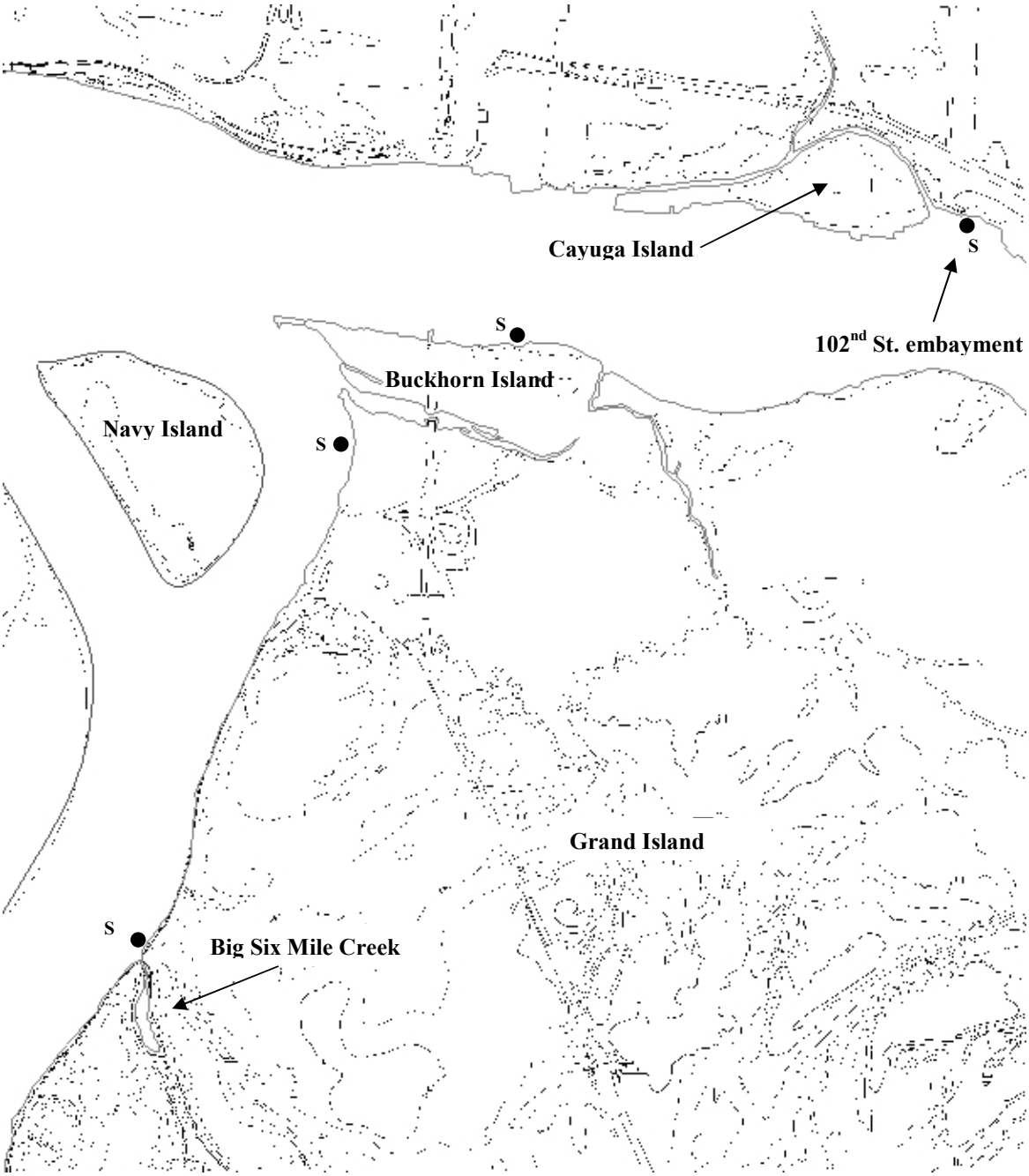

Figure 1. Image of a portion of the upper Niagara River, depicting proposed seining sites (**S**).

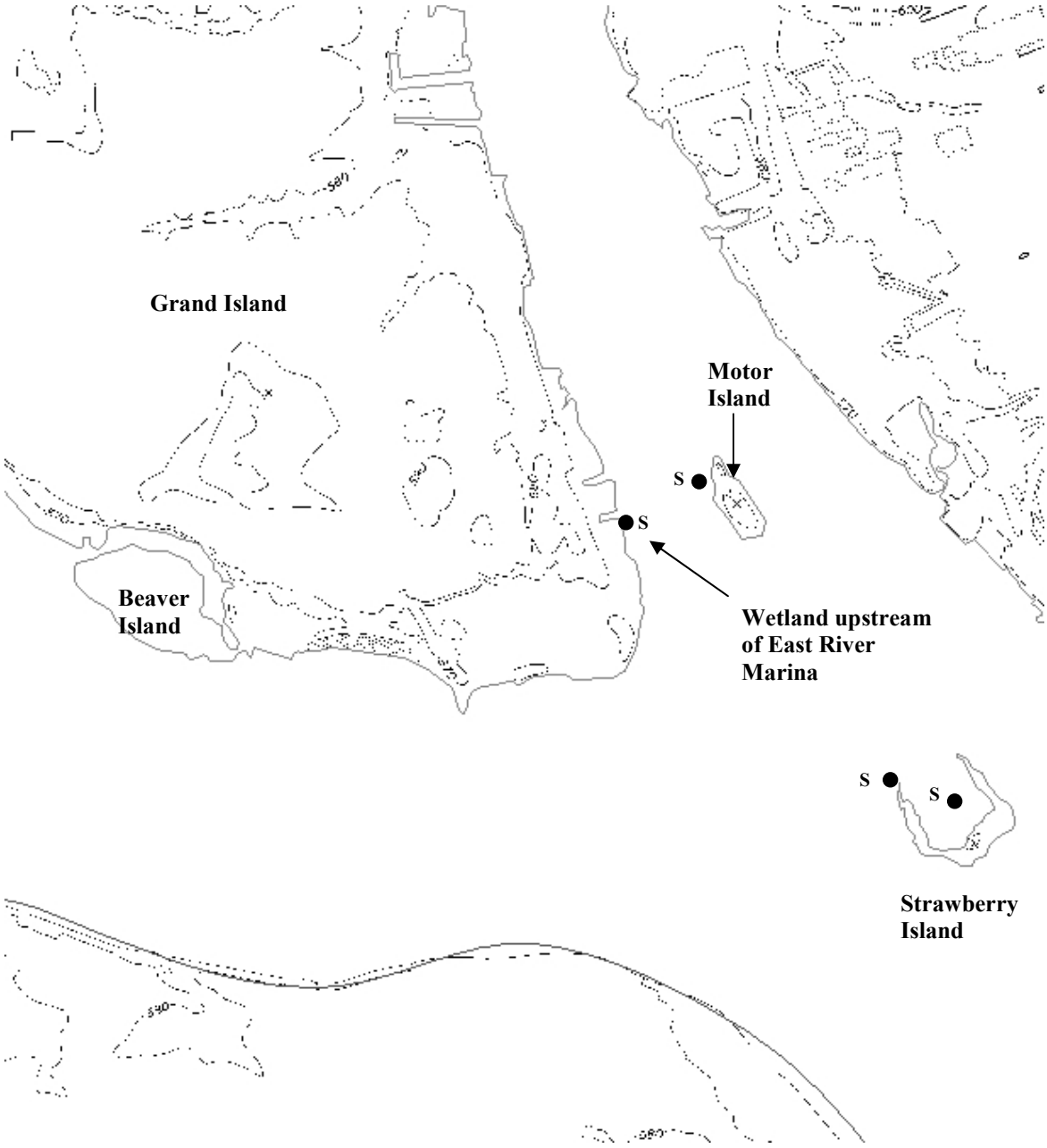

Figure 2. Image of a portion of the upper Niagara River, depicting proposed seining sites (**S**).

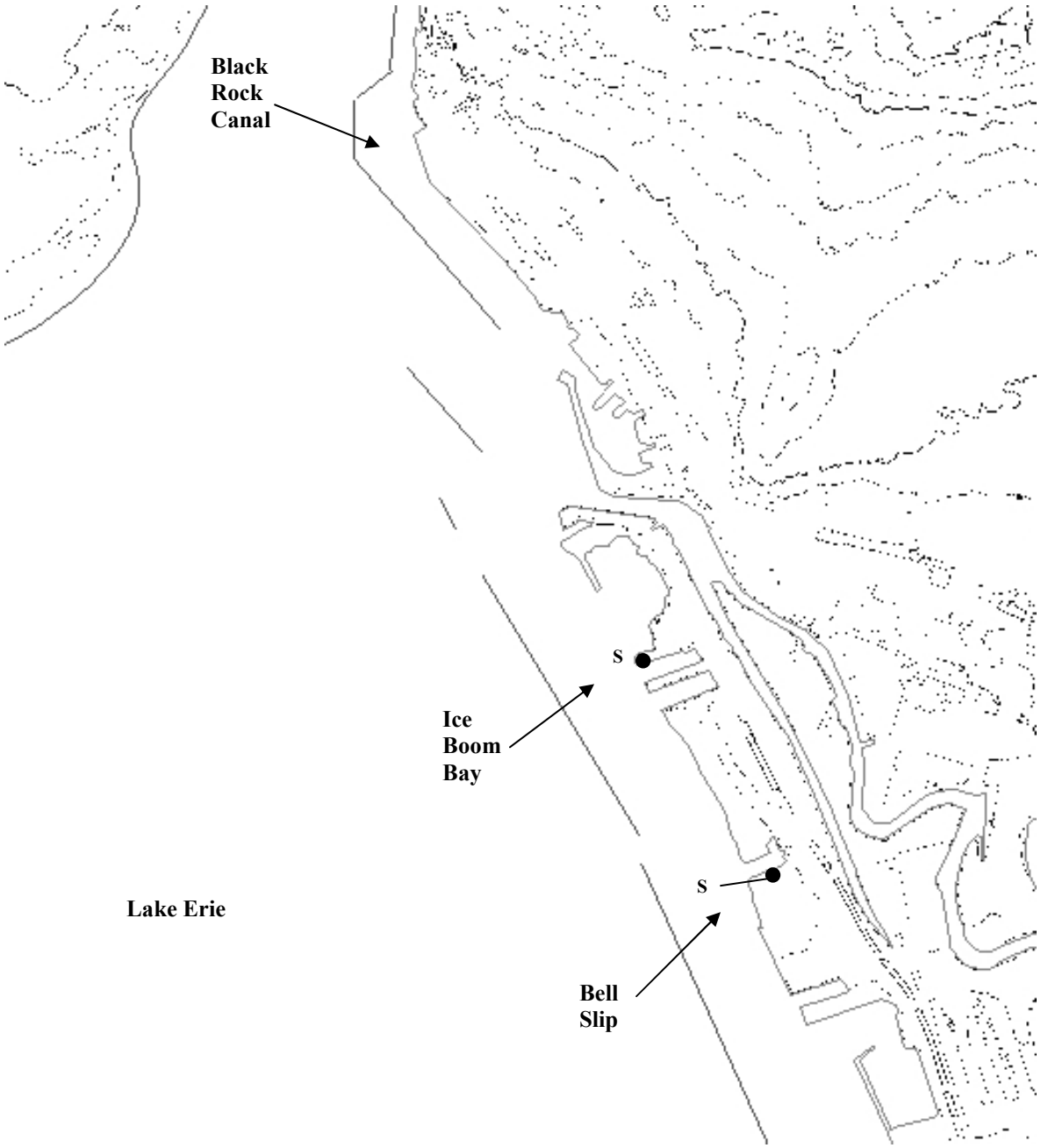

Figure 3. Image of a portion of the Buffalo Harbor, Lake Erie, depicting proposed seining sites (**S**).

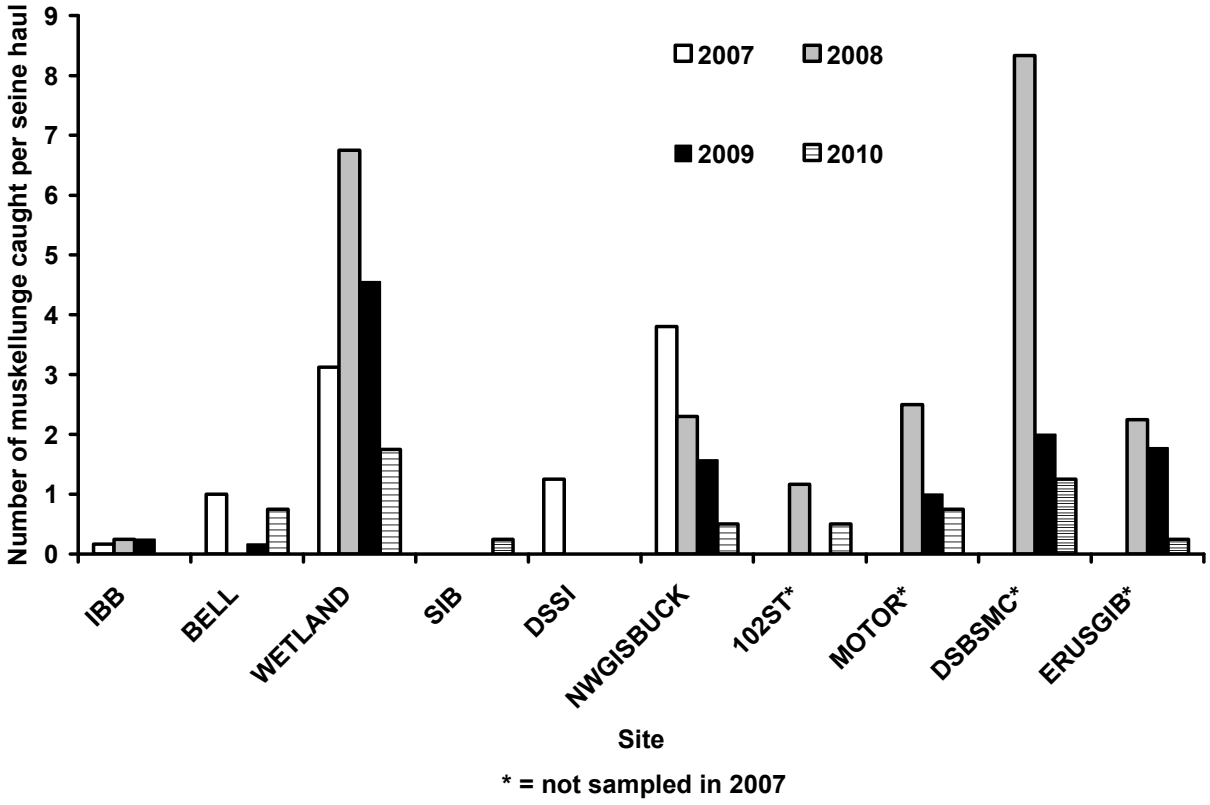

Figure 4. Catch rate (number per seine haul) of young-of-year muskellunge at sites surveyed with a fine-mesh seine each year during 2007-2010. IBB = Ice Boom Bay (Buffalo Harbor), BELL = Bell Slip (Buffalo Harbor), WETLAND = outside of break-walls protecting the wetland on the southeast tip of Grand Island (upper Niagara River; UNR), SIB = Strawberry Island Bay (UNR), DSSI = immediately downstream of Strawberry Island off the western arm (UNR), NWGISBUCK = northwest Grand Island south of Buckhorn Island (UNR), 102ST = 102nd Street Bay (UNR), MOTOR = northwest Motor Island (UNR), DSBSMC = downstream of Big Six Mile Creek, and ERUSGIB = east river upstream of the north Grand Island Bridge (UNR).