STUDY PERFORMANCE REPORT

State: Michigan **Project No.:** F-80-R-15

Study No.: 230761 **Title:** Walleye dynamics in Michigan's Inland Waterway: the Burt-Mullett-Pickerel-Crooked lake system

Period Covered: October 1, 2014 to September 30, 2015

Study Objective: The objectives of this research are to: (1) Quantify timing and rates of Walleye (*Sander vitreus)* movement among lakes, in order to better understand potential source-sink dynamics of Walleye in these lakes, with an emphasis on the implication for the co-management of this species; (2) Identify important spawning locations within Mullett Lake and to determine the dynamics of larval and early juvenile Walleye, with an emphasis on determining factors potentially limiting their growth and survival; (3) Determine the diet of post-YOY Walleye in all of the lakes within the Inland Waterway, with an emphasis on comparing food web structure among these lakes, and the potential shift in food webs as the limnology of these lakes change over time; and (4) Determine the diet of larval yellow perch in all of the lakes within the Inland Waterway, with an emphasis on comparing diet selection among these lakes, and the potential limitations imposed by zooplankton abundance.

Summary: Assessment of larval fish density was expanded to include Black Lake and other lakes near the Inland Waterway in order to provide context and contrast to Inland Waterway results. Initial diet analysis of larval yellow perch documented a rapid shift in first feeding at approximately 6–8 mm where larvae predominantly began to feed upon copepod nauplii. Empty stomachs were prevalent in fish below 6 mm while most fish above 6 mm contained zooplankton prey. Stomach analysis of adult Walleye from the waterway was complemented with stable isotope analysis to quantify trophic ecology of Walleye among the lakes. Two manuscripts were submitted for publication; one focused on Walleye movement rates has been accepted, and the second focused on adult trophic ecology is under revision following review.

Findings: Jobs 2, 4, 5, and 6 were scheduled for 2014-15, and progress is reported below.

Job 2. Reproductive dynamics of Walleye in Mullett Lake.–As reported previously, ichthyoplankton trawls and drift nets were used to collect larval and early juvenile Walleye in early spring from 2011 through 2014. Across these years, 1100 ichthyoplankton samples were collected. In April of 2014, discussions with the region's fisheries biologists, primary investigators and respective graduate students revealed a need to compare the ichthyoplankton and zooplankton communities of the Inland Waterway to the planktonic communities found in other large water bodies within the northern Lower Peninsula of Michigan. By comparing several systems across a range of size, productivity, forage base, and prevalence of invasive organisms, it is expected that relevant patterns will emerge and provide insight into the early life history and recruitment dynamics of both Walleye and Yellow Perch *Perca flavescens*. In 2014, the sampling was extended to include Black, Grand, Long, and Hubbard lakes in order to increase our understanding of the variation as well as similarity within and among multiple systems in the northern Lower Peninsula of Michigan. In 2015, sampling efforts continued with the above waterbodies and were extended to include Higgins and Houghton Lakes.

Field sampling in 2015 began on May 20 and lasted approximately four weeks. During this time, 78 ichthyoplankton tows were collected from 8 of the above lakes (Table 1) and 117 zooplankton

tows were concurrently gathered (Table 2) to provide data on resource availability for larval Yellow Perch diet analysis. Due to the timing of inclement weather systems during the 2015 field season, our ability to conduct sampling on Mullett and Hubbard Lakes was reduced due to dangerous water conditions. Thus, scheduled sampling events for Mullett and Hubbard Lakes were cancelled at the discretion of the crew leader because of safety concerns for the vessel and crew. A total of 783 ichthyoplankton were collected in 2015 with yellow perch the most prevalent (Table 3). Rainbow smelt *Osmerus mordax* represented the remainder of the catch with a rare Walleye captured early in the season.

Of the eight lakes sampled during 2015, Higgins Lake yielded the highest catch per effort for larval fish (Table 3). On Crooked, Grand, Long, and Pickerel Lakes, catch per effort was also relatively high (Table 3), while Burt and Black Lakes yielded the lowest catch per effort (Table 3) for the 2015 field season. Laboratory processing of ichthyoplankton and zooplankton samples began immediately following field collection efforts and included the sorting, identification, enumeration, measurement, and double entry of collected data. To date, a total of 583 larval Yellow Perch from across the 10 study lakes have been processed for diet analysis (Table 5). In addition, 217 zooplankton samples have been processed to provide information on the density and size structure of available food resources across the variety of systems within our group of study lakes (Table 6).

Initial analysis of larval Yellow Perch diet across all study lakes show a clear progression of first feeding with length (Table 7). Fish below 6 mm often had empty stomachs, whereas fish above 6 mm nearly all contained some zooplankton prey. The diet of first feeding larval yellow perch consisted primarily of copepod nauplii and ostracods, but shifted to include nearly 50% Cyclopoid copepods as fish reached a length of 8 mm (Table 7).

Job 4. Title: Write annual performance report.–This annual performance report was completed. In addition, a project summary was prepared (Attachment 1).

Job 5. Title: Write manuscript.–We worked on two manuscripts (one evaluating the movement rates of Walleye, and another based on adult Walleye diet and isotope data) during the 2014-2015 performance period, and submitted both for publication.

Job 6. Title: Publish manuscript.–One of the manuscripts submitted, entitled "Estimating Walleye (*Sander vitreus*) Movement and Fishing Mortality Using State-Space Models: Implications for Management of Spatially Structured Populations" has been accepted for publication in the Canadian Journal of Fisheries and Aquatic Science, and is in the process of final type setting. The second manuscript, focusing on adult Walleye diet, is in revision following a favorable review.

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Date: October 1, 2015

Table 1.–Number of ichthyoplankton tows in 2015. The start date of 2015 was May 20, 2015. Each week consists of 7 consecutive calendar days.

Year	Week	Black	Burt	Crooked	Grand	Higgins	Houghton	Long	Pickerel	Totals
2015	1	0	0	0	0	0	16	0	0	16
	2	6	6	4	0	0	6	6	4	32
	3	12	4	0	0	8	0	0	0	24
	4	0	0	0	6	0	0	0	0	6
Totals		18	10	4	6	8	22	6	4	78

Table 2.–Number of zooplankton tows in 2015. The start date of 2015 was May 20, 2015. Each week consists of seven consecutive calendar days.

Year	Week	Black	Burt	Crooked	Grand	Higgins	Houghton	Long	Pickerel	Totals
2015	1	0	0	0	0	0	24	0	0	24
	2	9	9	6	0	0	9	9	6	48
	3	18	6	0	0	12	0	0	0	36
	4	0	0	0	9	0	0	0	0	9
Totals		27	15	6	9	12	33	9	6	117

Table 3.–Number of ichthyoplankton captured in 2015 trawl samples. Dashes (–) designate weeks in which no sampling occurred.

Year	Week	Black	Burt	Crooked	Grand	Higgins	Houghton	Long	Pickerel	Totals
2015	1	–	–	–	–	–	114	–	–	114
	2	66	28	60	–	–	86	81	60	381
	3	21	5	–	–	173	–	–	–	199
	4	–	–	–	89	–	–	–	–	89
Totals		87	33	60	89	173	200	81	60	783

Table 4.–Mean catch per tow of ichthyoplankton in trawl samples, 2015. Dashes (–) designate weeks in which no sampling occurred.

Year	Week	Black	Burt	Crooked	Grand	Higgins	Houghton	Long	Pickerel
2015	1	–	–	–	–	–	7.13	–	–
	2	11.00	4.67	15.00	–	–	14.33	13.50	15.00
	3	1.75	1.25	–	–	21.63	–	–	–
	4	–	–	–	14.83	–	–	–	–
Overall average		4.83	3.30	15.00	14.83	21.63	9.09	13.50	15.00

Table 5.–Total number of larval fish processed for diet analysis/lake/year.

Year	Black	Burt	Crooked	Grand	Higgins	Houghton	Hubbard	Long	Mullett	Pickerel	Totals
2011	–	15	15	–	–	–	–	–	10	15	55
2012	–	24	18	–	–	–	–	–	20	11	73
2013	–	13	20	–	–	–	–	–	10	20	63
2014	28	–	–	53	–	–	11	48	–	–	140
2015	41	25	20	27	40	58	–	24	–	17	252
Totals	69	77	73	80	40	58	11	72	40	63	583

Table 6.–Total number of zooplankton samples processed and enumerated/lake/year.

Year	Black	Burt	Crooked	Grand	Higgins	Houghton	Hubbard	Long	Mullett	Pickerel	Totals
2011	–	3	3	–	–	–	–	–	2	3	11
2012	–	5	4	–	–	–	–	–	4	3	16
2013	–	3	4	–	–	–	–	–	3	4	14
2014	17	–	–	13	–	–	18	11	–	–	59
2015	27	15	6	9	12	33	–	9	–	6	117
Totals	44	26	17	22	12	33	18	20	9	16	217

Table 7.–Preliminary summary of diet of larval Yellow Perch across all lakes.

Length (mm)	n	% Empty	% of diet Bosmina	Calanoid	Cyclopoid	Daphnia	Nauplii	Ostracod	other
4	19	26	0	0	1	0	36	57	5
5	56	41	0	0	4	0	88	6	3
6	71	35	1	1	13	0	47	39	0
7	93	8	5	1	36	0	46	11	0
8	89	6	7	2	53	0	35	3	0
9	51	0	2	5	60	0	33	0	0
10	48	0	16	6	69	0	7	1	0
11	26	0	11	7	73	1	8	0	0
12	23	0	23	15	39	2	21	0	0
13	26	0	23	16	51	2	6	2	1
14	28	0	10	21	33	1	34	0	0
15	26	0	22	15	47	2	13	0	1
16	14	0	20	28	48	1	1	1	1
17	6	0	13	12	66	9	0	0	0
18	1	0	44	6	0	28	0	0	22
19	2	50	32	29	13	23	0	0	3
20	3	0	40	30	18	12	0	0	0
21	1	0	33	18	3	31	0	0	15
Total n	583								