

## Review of Northern Pike Toolbox Regulations Implemented Spring 2003

by

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*Abstract* – The Minnesota Department of Natural Resources Northern Pike Technical Committee developed a toolbox of special regulations for Northern Pike *Esox Lucius* in the early 2000's and those regulations were implemented on 58 lakes in 2003. The regulations were designed to improve or preserve existing Northern Pike size structure in various types of populations and included a 24-36" protected slot limit with a three fish bag limit with only one over 36" allowed, a 30" minimum size limit with a bag limit of one, and a 40" minimum size limit with a bag limit of one. Gill-net data collected as part of regular fisheries surveys pre (1993 to 2003) and post (2006 to 2018) regulation implementation was summarized as proportion of catch  $\leq 20"$ ,  $\geq 24"$ , and  $\geq 30"$  in regulation lakes and control lakes (statewide regulation; three fish bag limit with one fish over 30"). Binomial mixed models were fitted to the data to test for an effect of the regulations on each size category of Northern Pike. Gill-net catch rates of a potential prey (Yellow Perch *Perca flavescens*) and competitor (Walleye *Sander vitreus*) were also examined pre- and post-regulation using Student's t-tests. In lakes with the protected slot and 30" minimum size limits the proportion of Northern Pike catch  $\leq 20"$  decreased and the catch  $\geq 24"$  increased, consistent with regulation goals. The proportion of Northern Pike catch  $\geq 24"$  also increased in control lakes, however the magnitude of the increase was much smaller compared to the protected slot and 30" minimum lakes. Only in protected slot limit lakes was there a significant difference in the proportion catch of Northern Pike  $\geq 30"$  and no significant changes were detected in any size category of Northern Pike sampled from 40" minimum lakes. Generally, these results are consistent with the special regulation goals, where the proportion catch of larger fish increased or was preserved (did not decline).

## Introduction

In 2002 the Minnesota Department of Natural Resources (MN DNR) Northern Pike Regulations Work Group (now known as the Northern Pike Technical Committee) developed a special regulation toolbox with the goal of creating more variety and quality in Northern Pike fishing opportunities in the state. Three special regulations were proposed for application to suitable lakes including options for Northern Pike populations with different recruitment and growth patterns, to accommodate the variety of population types that exist on the Minnesota landscape. For populations with low recruitment where the goal was to preserve or restore large fish in the population, a 40"-minimum (40-min) size limit was proposed, coupled with a one fish daily, or possession, limit ("bag limit"). For populations with low recruitment where the goal was to improve densities of both medium and large Northern Pike, a 30"-minimum (30-min) was proposed coupled with a one fish bag limit. And for populations with moderate to high recruitment where the goal was to provide opportunities for harvest of small fish while at the same time increasing densities of large fish, a 24-36" protected slot limit (PSL) was proposed, with only one fish over 36" allowed and a total bag limit of three.

Fisheries Area Management Offices throughout the state proposed lakes on which to implement the special toolbox regulations and new regulations went into effect on March 1, 2003 on 58 lakes. To aid in evaluating the toolbox regulations, several lakes were simultaneously chosen for comparison as control lakes which remained under the statewide regulation for Northern Pike during this time period, a three fish bag limit with only one over 30" allowed. In 2013 an initial review of the regulations was completed but found that likely more time was needed to determine the effectiveness of the regulations, especially given the slow growth and longevity of Northern Pike (Rodney Pierce, unpublished data). On March 1, 2018 the statewide regulation for Northern Pike changed as the MN DNR implemented new regulations which varied by geographic zones of the state. Zones reflected differences in Northern Pike growth and recruitment primarily driven by the different dominant lake habitats in the various

ecoregions of the state. This changed the regulation imposed on control lakes for this study and thus the study was concluded with final data collection in 2018.

The purpose of this review was to determine whether the special toolbox regulations implemented in 2003 were successful in improving or maintaining quality Northern Pike size structure, relative to the pre-regulation time period as well as a group of control lakes. The information gained in this study will aid managers' decisions on whether to continue special regulations on these lakes or to drop them in favor of the new statewide zone regulations.

## Study Design and Data Analysis

A total of 83 lakes were included in this study (Figure 1), 32 control lakes, three 30-min lakes, six 40-min lakes, and 42 PSL lakes. Sixteen Fisheries Management Areas and 23 lake classes (Schupp 1992) were represented (Table 1). These special toolbox regulations were implemented on more lakes than are included in this study, some of the lakes had a regulation change mid-way through the period (e.g., 5<sup>th</sup> and 6<sup>th</sup> Crow Wing in Hubbard County where the 40"-minimum was changed to the PSL in 2011), a significant change in lake management (e.g., Hanging Horn in Carlton County, initially a control lake, is now managed as a coldwater fishery for stream trout), or did not have enough data collected to be informative for the study (e.g., Little Woman in Cass County).

Northern Pike were collected with MN DNR standard gill nets during fisheries management lake assessments from 1993 to 2018 (MN DNR 1993, MN DNR 2017). Gill-net catch rates of Northern Pike have correlated with population estimates, and the utility of catch rates for monitoring changes in relative abundance within a lake was previously described by Moyle (1950) and Pierce and Tomcko (2003). Pre-regulation data included fish collected during assessments which took place from 1993 to 2003, and post-regulation data included fish collected from 2005 to 2018. Thus, data collected from 2004 to 2005 were not included in this analysis to allow a lag time of two years for Northern Pike populations to begin to respond to the regulations.

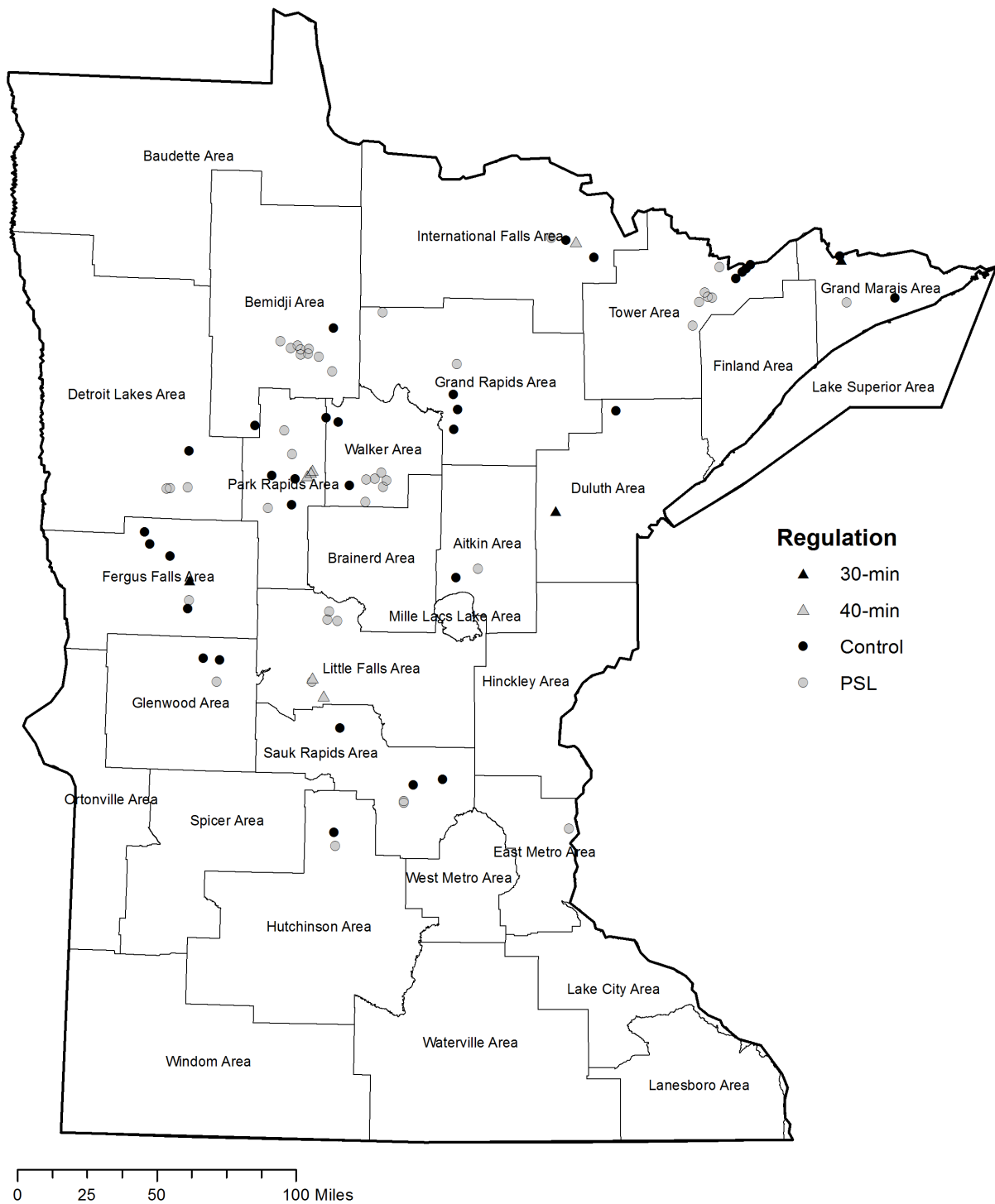


FIGURE 1. Lakes with special toolbox regulations for Northern Pike reviewed in study. Regulation types ("Reg") include a three fish bag limit with a 24-36" protected slot with one over 36" allowed ("PSL"), a one fish bag limit with a 30" minimum ("30-min"), and one fish bag limit with a 40" minimum ("40-min"), and control lakes under the contemporary statewide regulation for Northern Pike (three fish bag limit, one fish over 30" allowed; "control").

TABLE 1. Lake names (followed by Division of Waters number) and class information for systems, sorted by Fisheries Management Area, examined for change after the implementation of special toolbox regulations for Northern Pike in 2003. Regulation types ("Reg") include a three fish bag limit with a 24-36" protected slot with one over 36" allowed ("PSL"), a one fish bag limit with a 30" minimum ("30-min"), and one fish bag limit with a 40" minimum ("40-min"), and control lakes under the contemporary statewide regulation for Northern Pike (three fish bag limit, one fish over 30" allowed; "control"). Also listed are mean gill net catch per unit effort (number of fish per net; standard error) for Northern Pike (NOP), Walleye (WAE), and Yellow Perch (YEP) during pre-regulation (1993 to 2003) and post-regulation (2006 to 2018) periods and the difference ( $\Delta$ ) between the two periods.

Area and Lake	Reg	Class	NOP Pre	NOP Post	NOP $\Delta$	WAE Pre	WAE Post	WAE $\Delta$	YEP Pre	YEP Post	YEP $\Delta$
<b><u>Aitkin</u></b>											
Long (01-0089-00)	PSL	23	5.55 (1.58)	4.42 (0.33)	-1.13	0.87 (0.27)	0.58 (0.00)	-0.29	0.00 (0.00)	0.17 (0.16)	0.17
Lone (01-0125-00)	control	23	19	9.50 (1.72)	-9.50	0.89	1.89 (0.89)	1.00	11.67	2.78 (0.11)	-8.89
<b><u>Bemidji</u></b>											
Boy (04-0049-00)	PSL	27	16.56 (1.27)	7.73 (0.37)	-8.82	9.18 (2.60)	4.67 (0.35)	-4.51	50.42 (7.65)	27.82 (12.09)	-22.60
Turtle River (04-0111-00)	PSL	25	6.77 (0.65)	6.09 (0.42)	-0.68	10.08 (1.61)	3.91 (0.35)	-6.17	23.47 (9.04)	5.40 (0.59)	-18.06
Three Island (04-0134-00)	PSL	39	11.5	6.42 (0.37)	-5.08	8.13	2.42 (0.67)	-5.71	49	21.46 (6.43)	-27.54
Beltrami (04-0135-00)	PSL	25	7.39 (0.28)	5.95 (1.06)	-1.45	5.11 (2.22)	2.28 (0.73)	-2.84	15.78 (11.33)	5.34 (1.35)	-10.44
Movil (04-0152-00)	PSL	25	9.00 (1.33)	9.67 (0.54)	0.67	5.50 (1.25)	2.97 (0.27)	-2.53	14.50 (3.67)	10.81 (3.95)	-3.69
Little Turtle (04-0155-00)	PSL	34	12.67 (3.34)	13.70 (4.53)	1.04	7.06 (2.72)	4.96 (0.94)	-2.09	27.39 (13.83)	9.48 (0.55)	-17.91
Turtle (04-0159-00)	PSL	27	5.55 (1.35)	9.22 (0.76)	3.67	6.83 (0.54)	8.25 (1.97)	1.42	32.19 (10.85)	24.22 (4.40)	-7.97
Campbell (04-0196-00)	PSL	34	9.89 (0.00)	10.67 (3.58)	0.78	7.28 (1.16)	2.82 (0.45)	-4.46	19.38 (8.94)	9.00 (5.73)	-10.38
Deer (04-0230-00)	PSL	31	6.84 (2.17)	7.80 (1.03)	0.96	4.00 (2.50)	1.46 (0.16)	-2.54	31.00 (24.33)	2.50 (0.73)	-28.50
Blackduck (04-0069-00)	control	27	5.74 (0.33)	5.25 (1.84)	-0.49	19.06 (1.67)	13.53 (2.59)	-5.53	57.77 (7.10)	39.20 (10.69)	-18.57
Itasca (15-0016-00)	control	25	9.46 (1.54)	8.89 (3.44)	-0.57	13.59 (5.09)	7.61 (1.63)	-5.98	93.34 (51.16)	47.86 (9.79)	-45.47
<b><u>Detroit Lakes</u></b>											
Cotton (03-0286-00)	PSL	27	13.71 (5.21)	12.06 (2.18)	-1.65	6.79 (2.54)	7.78 (1.98)	0.99	21.38 (0.20)	14.06 (0.51)	-7.31
Little Floyd (03-0386-00)	PSL	31	21.25 (4.75)	24.72 (1.45)	3.47	5.40 (2.60)	5.33 (1.93)	-0.07	11.32 (10.49)	7.00 (3.19)	-4.31
Floyd (03-0387-00)	PSL	27	16.25 (8.25)	14.44 (2.10)	-1.81	4.69 (0.19)	4.00 (0.36)	-0.69	14.19 (8.94)	1.34 (0.33)	-12.85
Strawberry (03-0323-00)	control	27	9.71 (1.54)	15.17 (2.34)	5.46	18.69 (2.69)	12.62 (0.95)	-6.07	5.69 (4.81)	1.72 (0.71)	-3.97
<b><u>Duluth</u></b>											
Prairie (69-0848-00)	30-min	5	1.59 (0.08)	2.55 (0.37)	0.96	2.79 (1.21)	2.08 (0.50)	-0.71	5.09 (2.09)	11.09 (4.34)	6.00
Elliot (69-0642-00)	control	19	10.96 (2.07)	7.33 (1.78)	-3.63	0.89 (0.36)	0.00 (0.00)	-0.89	3.85 (0.60)	2.56 (2.22)	-1.30

TABLE 1 continued.

Area and Lake	Reg	Class	NOP Pre	NOP Post	NOP Δ	WAE Pre	WAE Post	WAE Δ	YEP Pre	YEP Post	YEP Δ
<b>East Metro</b>											
Big Carnelian (82-0049-00)	PSL	24	9.69 (2.62)	8.32 (1.69)	-1.38	0.90 (0.47)	0.75 (0.50)	-0.15	0.53 (0.24)	0.19 (0.06)	-0.34
<b>Fergus Falls</b>											
West Battle (56-0239-00)	PSL	27	8.76 (0.92)	6.15 (0.79)	-2.61	5.09 (0.91)	4.59 (0.62)	-0.50	18.07 (2.96)	20.65 (6.30)	2.58
Otter Tail (56-0242-00)	30-min	26	4.02 (0.66)	3.50 (0.24)	-0.52	17.05 (2.73)	16.03 (1.00)	-1.02	66.15 (14.51)	41.93 (3.24)	-24.23
Clitherall (56-0238-00)	control	22	4.38 (0.80)	6.59 (1.58)	2.21	6.05 (0.86)	4.93 (0.63)	-1.12	22.69 (5.46)	5.40 (0.76)	-17.29
Star (56-0385-00)	control	22	7.87 (1.01)	9.79 (0.86)	1.92	7.88 (0.92)	9.28 (0.35)	1.40	24.18 (7.90)	17.15 (5.70)	-7.03
North Lida (56-0747-01)	control	27	4.45 (0.48)	5.37 (0.21)	0.92	9.48 (1.32)	9.67 (1.93)	0.19	15.79 (3.94)	2.42 (0.87)	-13.37
Lizzie (56-0760-01)	control	27	5.40 (0.67)	6.38 (0.88)	0.98	6.67 (0.17)	4.38 (0.63)	-2.29	3.64 (1.57)	0.74 (0.31)	-2.90
<b>Glenwood</b>											
Lakota (21-0106-00)	PSL	22	11.85 (1.30)	18.25 (0.25)	6.40	6.14 (0.46)	4.04 (2.46)	-2.10	1.97 (0.22)	0.63 (0.20)	-1.34
Ida (21-0123-00)	control	22	7.56 (0.94)	9.80 (1.29)	2.23	7.20 (1.34)	9.03 (1.32)	1.82	8.21 (2.39)	1.68 (0.75)	-6.52
Chippewa (21-0145-00)	control	22	5.97 (2.15)	3.08 (0.38)	-2.89	13.22 (2.57)	9.47 (1.36)	-3.75	18.64 (7.33)	1.19 (0.53)	-17.44
<b>Grand Marais</b>											
Little Cascade (16-0347-00)	PSL	12	7.75 (0.25)	10.17 (0.36)	2.42	--	--	--	8.88 (0.63)	4.83 (0.58)	-4.04
Loon (16-0448-00)	30-min	1	0.99 (0.47)	0.60 (0.19)	-0.40	0.45 (0.09)	0.60 (0.13)	0.15	--	--	--
Pickereel (16-0097-00)	control	14	6.22 (1.83)	8.78 (1.39)	2.56	--	--	--	7.22 (2.92)	7.33 (2.33)	0.11
Gunflint (16-0356-00)	control	1	0.81 (0.37)	0.51 (0.12)	-0.30	8.36 (1.67)	4.49 (1.30)	-3.87	2.26 (0.65)	0.80 (0.38)	-1.45
<b>Grand Rapids</b>											
North Star (31-0653-00)	PSL	25	3.71 (0.96)	2.13 (0.29)	-1.59	3.13 (0.04)	3.83 (0.50)	0.71	3.71 (1.71)	11.55 (3.87)	7.84
Island (31-0913-00)	PSL	27	7.73 (0.94)	8.75 (1.29)	1.02	4.37 (0.17)	9.56 (2.04)	5.19	51.54 (12.47)	86.18 (24.92)	34.64
Bass (31-0576-00)	control	25	7.53 (0.60)	6.57 (0.50)	-0.96	3.20 (0.40)	4.20 (0.80)	1.00	15.77 (0.30)	6.37 (0.70)	-9.40
Rice (31-0717-00)	control	27	6.00 (0.58)	4.00 (1.75)	-2.00	0.00 (0.00)	0.09 (0.09)	0.09	2.17 (0.08)	1.75 (0.42)	-0.42
Moose (31-0722-00)	control	27	2.71 (0.21)	1.86 (0.40)	-0.86	8.17 (0.67)	6.17 (1.12)	-2.00	53.38 (1.37)	41.19 (10.68)	-12.19
<b>Hutchinson</b>											
Minnie-Belle (47-0119-00)	PSL	27	13.04 (3.68)	11.11 (0.93)	-1.93	8.13 (1.28)	6.53 (1.05)	-1.61	2.73 (1.14)	3.08 (1.10)	0.35
Ripley (47-0134-02)	control	38	10.95 (6.61)	5.72 (0.61)	-5.23	2.84 (1.28)	3.45 (0.77)	0.61	17.67 (16.11)	22.06 (11.38)	4.38

TABLE 1 continued.

Area and Lake	Reg	Class	NOP Pre	NOP Post	NOP Δ	WAE Pre	WAE Post	WAE Δ	YEP Pre	YEP Post	YEP Δ
<b>International Falls</b>											
Ash (69-0864-00)	PSL	5	4.81 (0.32)	3.78 (0.36)	-1.04	1.63 (0.20)	5.26 (2.81)	3.63	54.85 (29.69)	67.93 (15.23)	13.08
Elephant (69-0810-00)	40-min	5	0.71 (0.08)	2.44 (0.56)	1.73	7.67 (1.49)	9.15 (4.62)	1.48	55.29 (23.34)	35.48 (21.14)	-19.81
Kjostad (69-0748-00)	control	10	2.00 (0.39)	1.85 (0.45)	-0.15	1.56 (0.46)	1.55 (0.45)	0.00	1.85 (0.80)	1.74 (0.86)	-0.11
Blackduck (69-0842-00)	control	5	3.07 (0.95)	4.20 (0.98)	1.13	6.35 (1.14)	8.88 (0.98)	2.53	71.42 (19.19)	56.87 (20.81)	-14.55
<b>Little Falls</b>											
Alexander (49-0079-00)	PSL	22	2.42 (0.63)	2.77 (0.45)	0.34	9.16 (2.50)	5.92 (0.74)	-3.24	21.33 (5.73)	12.65 (4.75)	-8.68
Shamaineau (49-0127-00)	PSL	27	7.07 (0.90)	4.73 (0.97)	-2.33	6.20 (1.02)	4.45 (0.53)	-1.75	13.20 (6.16)	12.20 (2.52)	-1.00
Fish Trap (49-0137-00)	PSL	25	5.28 (0.55)	8.96 (1.79)	3.67	5.30 (1.02)	4.98 (0.45)	-0.32	10.62 (4.23)	13.19 (4.71)	2.57
Long (Burtram) (77-0027-00)	PSL	27	11.11 (8.22)	9.39 (1.83)	-1.72	6.89 (4.22)	3.89 (0.67)	-3.00	35.89 (18.56)	14.95 (1.16)	-20.94
Cedar (49-0140-00)	40-min	23	6.75 (0.42)	8.17 (1.00)	1.42	0.17 (0.16)	2.09 (0.42)	1.92	0.00 (0.00)	0.59 (0.58)	0.59
Bass (77-0024-00)	40-min	23	8	10.32 (0.49)	2.32	6.17	1.39 (1.22)	-4.79	0.67	1.75 (1.75)	1.08
<b>Park Rapids</b>											
Big Mantrap (29-0151-00)	PSL	25	7.90 (1.23)	7.34 (0.46)	-0.56	0.30 (0.10)	0.00 (0.00)	-0.30	45.17 (19.24)	34.33 (2.54)	-10.83
George (29-0216-00)	PSL	27	9.00 (1.11)	12.25 (1.08)	3.25	12.45 (0.88)	6.59 (0.42)	-5.86	19.50 (4.06)	8.30 (4.63)	-11.21
Blueberry (80-0034-00)	PSL	41	11.34 (0.17)	14.83 (2.42)	3.50	7.58 (2.75)	2.67 (1.27)	-4.91	11.17 (0.67)	28.22 (5.17)	17.06
9th Crow Wing (29-0025-00)	40-min	23	1.84 (0.17)	5.33 (1.07)	3.50	2.00 (0.33)	1.78 (0.59)	-0.22	10.00 (3.33)	12.22 (1.69)	2.22
10th Crow Wing (29-0045-00)	40-min	29	3.50 (1.33)	10.11 (2.41)	6.61	4.42 (1.25)	0.94 (0.58)	-3.48	18.67 (6.16)	2.94 (1.06)	-15.72
8th Crow Wing (29-0072-00)	40-min	31	3.00 (0.45)	5.59 (0.53)	2.59	8.41 (1.16)	5.52 (0.97)	-2.89	74.89 (23.28)	77.04 (21.09)	2.15
Duck (29-0142-00)	control	31	1.11 (0.22)	0.44 (0.27)	-0.67	11.84 (4.17)	14.25 (2.64)	2.41	8.83 (0.50)	2.42 (0.85)	-6.41
Bell Taine (29-0146-00)	control	25	4.58 (1.00)	5.89 (0.88)	1.31	6.21 (0.71)	7.56 (0.82)	1.35	1.55 (0.37)	2.58 (1.79)	1.04
Fish Hook (29-0242-00)	control	27	16.72 (2.89)	13.10 (1.59)	-3.62	4.04 (0.71)	6.61 (0.56)	2.57	4.51 (0.09)	6.17 (1.30)	1.66
<b>Sauk Rapids</b>											
Mink (86-0229-00)	PSL	38	1.25 (1.25)	10.73 (2.85)	9.48	5.50 (0.00)	3.33 (0.98)	-2.17	50.25 (0.00)	12.00 (4.62)	-38.25
Somers (86-0230-00)	PSL	30	0.55 (0.55)	9.80 (2.95)	9.25	10.20 (6.12)	3.87 (1.62)	-6.33	101.60 (43.97)	38.47 (15.96)	-63.13
Eagle (71-0067-00)	control	38	2.30 (0.47)	8.25	5.95	--	--	--	--	--	--
Pine (73-0136-00)	control	31	2.88 (0.87)	3.75 (1.25)	0.88	0.38 (0.13)	0.58 (0.25)	0.20	39.84 (39.66)	0.25 (0.25)	-39.59
Locke (86-0168-00)	control	24	3.8	6.50 (5.00)	2.70	--	--	--	--	--	--

TABLE 1 continued.

Area and Lake	Reg	Class	NOP Pre	NOP Post	NOP Δ	WAE Pre	WAE Post	WAE Δ	YEP Pre	YEP Post	YEP Δ
<b><u>Tower</u></b>											
Basswood (38-0645-00)	PSL	2	3.93	2.45	-1.48	--	--	--	--	--	--
South Farm (38-0778-00)	PSL	7	0.71 (0.29)	2.39 (0.28)	1.68	3.09 (0.91)	6.00 (1.21)	2.92	4.38 (0.13)	6.45 (2.98)	2.07
Farm (38-0779-00)	PSL	7	1.11 (0.03)	1.59 (0.39)	0.48	6.01 (0.42)	7.94 (1.13)	1.94	2.39 (0.53)	3.95 (0.62)	1.56
Garden (38-0782-00)	PSL	7	0.73 (0.02)	1.65 (0.34)	0.92	2.52 (0.19)	2.94 (0.12)	0.42	1.40 (0.26)	3.16 (0.35)	1.76
Birch Reservoir (69-0003-00)	PSL	7	2.17 (0.09)	1.44 (0.21)	-0.73	11.80 (1.51)	12.85 (1.54)	1.05	3.59 (0.41)	3.31 (0.28)	-0.28
White Iron (69-0004-00)	PSL	7	3.33 (0.81)	2.10 (0.38)	-1.24	6.56 (0.89)	9.21 (1.76)	2.65	6.81 (0.72)	8.50 (0.81)	1.69
Sucker (38-0530-00)	control	6	1.50 (0.29)	2.06 (0.84)	0.56	7.31 (0.72)	8.39 (0.94)	1.07	2.41 (0.30)	1.45 (0.78)	-0.96
Birch (38-0532-00)	control	7	4.15 (0.32)	3.17 (0.17)	-0.98	10.30 (1.69)	13.86 (2.64)	3.56	3.63 (0.64)	1.81 (1.36)	-1.83
Newfound (38-0619-00)	control	3	4.03 (0.69)	3.34 (0.33)	-0.69	8.03 (0.65)	8.04 (0.04)	0.01	0.47 (0.35)	0.38 (0.30)	-0.09
Moose (38-0644-00)	control	7	4.50 (0.72)	5.21 (0.54)	0.71	2.69 (0.44)	4.60 (0.18)	1.91	0.33 (0.21)	0.10 (0.02)	-0.23
<b><u>Walker</u></b>											
Little Boy (11-0167-00)	PSL	22	7.38 (1.07)	7.98 (0.70)	0.61	10.35 (1.50)	8.93 (0.92)	-1.42	27.58 (6.04)	36.00 (9.15)	8.42
Wabedo (11-0171-00)	PSL	22	5.10 (0.98)	7.06 (0.92)	1.97	3.19 (0.40)	3.44 (0.65)	0.25	27.03 (4.36)	13.46 (3.38)	-13.57
Girl (11-0174-00)	PSL	25	11.28 (0.50)	12.41 (2.97)	1.13	2.45 (0.33)	1.74 (0.10)	-0.70	3.56 (2.56)	2.67 (1.83)	-0.89
Woman (11-0201-00)	PSL	22	5.85 (0.10)	4.37 (0.64)	-1.48	7.43 (0.78)	9.69 (1.65)	2.26	40.88 (7.09)	23.11 (12.51)	-17.77
Ada (11-0250-00)	PSL	27	10.34 (3.18)	10.71 (1.65)	0.37	2.31 (0.16)	1.50 (0.27)	-0.81	0.17 (0.05)	0.38 (0.11)	0.21
Child (11-0263-00)	PSL	31	7.33 (2.05)	10.17 (3.43)	2.83	1.28 (0.36)	1.28 (0.34)	0.00	6.11 (3.39)	7.89 (2.17)	1.78
Pleasant (11-0383-00)	control	27	16.61 (1.34)	17.29 (1.68)	0.69	5.25 (0.68)	4.11 (0.35)	-1.14	19.92 (3.14)	4.96 (1.53)	-14.96
Crooked (11-0494-00)	control	27	9.15 (0.52)	6.95 (0.84)	-2.21	5.60 (1.96)	5.45 (0.11)	-0.15	31.84 (6.16)	5.78 (2.55)	-26.06
Steamboat (11-0504-00)	control	22	4.59 (0.90)	8.00 (1.14)	3.42	4.40 (0.62)	4.33 (1.38)	-0.06	40.79 (16.43)	43.16 (25.94)	2.37

Size categories of Northern Pike were chosen for comparison with general fisheries management goals in mind. For each regulation type, we compared the pre- and post-regulation proportion of Northern Pike caught in gill nets that were:  $\leq 20''$ ,  $\geq 24''$ , and  $\geq 30''$ . We used a generalized linear mixed effects model with a binomial error structure and logistic link function to compare changes in population size structure in special regulations lakes relative to that in control lakes under the statewide regulation across the pre- and post-regulation time periods. The model included a time period by regulation type interaction as fixed effects; these were used to test for different proportions of size classes between regulation and control lakes. The model also included sample year and lake as random effects to account for within year and lake correlations among size structure observations:

$$P(N_{under}, N_{over}) = \text{time} * \text{regulation} + (1/\text{year}) + (1/\text{lake}) + \epsilon_{i,j}$$

where  $P(N_{under}, N_{over})$  is the proportion of Northern Pike in one size category relative to those not in the category. Time is the pre- and post-regulation time period, regulation is the Northern Pike regulation applied to each lake in 2003,  $(1/\text{year})$  and  $(1/\text{lake})$  are the random year and lake effects, and  $\epsilon_{i,j}$  is the error term.

We also summarized the average catch per unit effort (number per gill net, CPUE) and proportion of Northern Pike in the various size categories in the pre- and post-regulation period and compared the difference ( $\Delta$ ) among lakes within Fisheries Management Areas and lake classes. We also hypothesized that Yellow Perch and

Walleye CPUE may respond to changes in Northern Pike populations, thus overall CPUE of those additional species was also summarized for each time period and similarly compared. Linear models with normal error structure were used to quantify changes in Walleye and Yellow Perch CPUE across Northern Pike regulation types as well as the change in Northern Pike, Walleye, and Yellow Perch CPUE over all lakes. One sample student's t-tests were used to test whether the average change in CPUE ( $\Delta$ ) across lakes was different from zero for Northern Pike, Walleye, and Yellow Perch. All statistical analyses were conducted in R (R Core Team 2018), using the dplyr, lme4, and ggplot2 packages. Alpha was set at 0.05 and *p*-value annotation includes degrees of freedom in subscript.

## Results

The PSL and 30-min showed decreases in the proportion of Northern Pike  $\leq 20''$  and increases in the proportion  $\geq 24''$  which were greater than the changes in the control lakes ( $P < 0.01$  in all four cases; Table 2). There was no significant change in the proportion of Northern Pike  $\leq 20''$  in the control lakes ( $P = 0.15$ ) but the proportion of Northern Pike  $\geq 24''$  did increase in control lakes ( $P = 0.05$ ). There was a slight but significant increase in the proportion of Northern Pike  $\geq 30''$  in PSL lakes ( $P = 0.05$ ), the proportion of Northern Pike  $\geq 30''$  did not change significantly in any other group of lakes ( $P > 0.2$  in all cases). Proportions of Northern Pike in each size category did not change significantly with the implementation of the 40-min ( $P > 0.65$  in all cases). Within Fisheries Management Areas, individual lake results varied with regard to changes in the proportion of Northern Pike in various size categories across regulation types (Table 3).



Yellow Perch and Walleye CPUE tended to be lower in the post-regulation period (Table 1), with negative  $\Delta$  observed in a majority of lakes. However, the change in Walleye CPUE and Yellow Perch CPUE were not significantly different across lakes with different Northern Pike regulations ( $P_3 = 0.78$ , and  $P_3 = 0.85$  respectively; Figure 2). Overall, Walleye and Yellow Perch CPUE was lower in the post-regulation period, for

Walleye mean  $\Delta = -0.83$  ( $P_{77} < 0.01$ ) and for Yellow Perch mean  $\Delta = -7.31$  ( $P_{78} < 0.01$ ). The change in CPUE of all Northern Pike was not different among populations with different regulation types ( $P_3 = 0.11$ ) did not change overall ( $P_{82} = 0.18$ ). There was no correlation between the change in Northern Pike CPUE and Walleye or Yellow Perch CPUE ( $P_{76} = 0.20$  and  $P_{77} = 0.33$ , respectively; Figure 3).

TABLE 2. Average proportion of Northern Pike caught in gill nets in various size categories before (Pre) and after (Post) the implementation of special regulations ("Reg"), as well as the percent change between the periods ( $\Delta$ ). Averages were estimated with a binomial mixed model. Pre data were collected from 1993 to 2003, Post data were collected from 2006 to 2018. Bold print indicates the model estimated a significant change between the two periods for the regulation and size category. Regulation types include a three fish bag limit with a 24-36" protected slot with one over 36" allowed ("PSL"), a one fish bag limit with a 30" minimum ("30-min"), and one fish bag limit with a 40" minimum ("40-min"), and control lakes under the contemporary statewide regulation for Northern Pike (three fish bag limit, one fish over 30" allowed; "Control").

Reg	$\leq 20''$ Pre	$\leq 20''$ Post	$\leq 20'' \Delta$	$\geq 24''$ Pre	$\geq 24''$ Post	$\geq 24'' \Delta$	$\geq 30''$ Pre	$\geq 30''$ Post	$\geq 30'' \Delta$
Control	0.73	0.70	-3%	0.09	0.11	<b>2%</b>	0.01	0.01	0%
PSL	0.76	0.64	<b>-12%</b>	0.07	0.15	<b>8%</b>	0.01	0.02	<b>1%</b>
30-min	0.41	0.17	<b>-25%</b>	0.29	0.53	<b>25%</b>	0.03	0.06	3%
40-min	0.31	0.29	-2%	0.29	0.33	4%	0.05	0.07	2%

TABLE 3. Mean proportion and standard error in parenthesis of Northern Pike (NOP) in various size categories before (Pre) and after (Post) the implementation of special regulations ("Reg"). Pre data were collected from 1993 to 2003, Post data were collected from 2006 to 2018. The number of lakes sampled in each period is indicated by "N". No data were included from the years 2004 and 2005 to allow for regulations to affect populations before comparing data. Regulation types include a three fish bag limit with a 24-36" protected slot with one over 36" allowed ("PSL"), a one fish bag limit with a 30" minimum ("30-min"), and one fish bag limit with a 40" minimum ("40-min"), and control lakes under the contemporary statewide regulation for Northern Pike (three fish bag limit, one fish over 30" allowed; "control").

Area and Lake	Reg	N Pre	N Post	≤ 20" Pre	≤ 20" Post	≤ 20" Δ	≥ 24 " Pre	≥ 24 " Post	≥ 24 " Δ	≥ 30" Pre	≥ 30" Post	≥ 30" Δ
<b><u>Aitkin</u></b>												
Long	PSL	3	2	0.86 (0.05)	0.83 (0.03)	-0.03	0.03 (0.02)	0.08 (0.02)	0.05	0.00 (0.00)	0.00 (0.00)	0.00
Lone	control	1	2	0.91	0.87 (0.07)	-0.05	0.05	0.11 (0.06)	0.06	0.00	0.04 (0.03)	0.04
<b><u>Bemidji</u></b>												
Turtle River	PSL	3	3	0.81 (0.07)	0.79 (0.03)	-0.02	0.03 (0.02)	0.07 (0.02)	0.04	0.01 (0.01)	0.02 (0.00)	0.01
Three Island	PSL	1	3	0.72	0.69 (0.01)	-0.03	0.05	0.18 (0.04)	0.12	0.00	0.04 (0.01)	0.04
Movil	PSL	2	3	0.87 (0.05)	0.75 (0.00)	-0.12	0.06 (0.02)	0.11 (0.02)	0.06	0.01 (0.01)	0.02 (0.01)	0.01
Little Turtle	PSL	2	3	0.85 (0.06)	0.85 (0.00)	0.00	0.04 (0.00)	0.03 (0.01)	-0.01	0.01 (0.01)	0.00 (0.00)	0.00
Turtle	PSL	3	3	0.73 (0.07)	0.70 (0.05)	-0.03	0.08 (0.02)	0.12 (0.03)	0.05	0.04 (0.02)	0.02 (0.01)	-0.02
Campbell	PSL	2	3	0.91 (0.03)	0.87 (0.05)	-0.04	0.03 (0.01)	0.03 (0.01)	0.00	0.01 (0.01)	0.00 (0.00)	0.00
Deer	PSL	2	4	0.63 (0.02)	0.44 (0.04)	-0.18	0.13 (0.02)	0.23 (0.03)	0.10	0.02 (0.02)	0.04 (0.02)	0.03
Boy	PSL	3	3	0.88 (0.02)	0.86 (0.06)	-0.02	0.04 (0.01)	0.07 (0.04)	0.03	0.01 (0.00)	0.01 (0.01)	0.00
Beltrami	PSL	2	4	0.58 (0.08)	0.58 (0.07)	0.00	0.21 (0.10)	0.20 (0.04)	-0.01	0.02 (0.01)	0.02 (0.01)	0.00
Blackduck	control	2	3	0.81 (0.01)	0.65 (0.05)	-0.16	0.06 (0.02)	0.16 (0.04)	0.10	0.01 (0.01)	0.00 (0.00)	0.00
Itasca	control	2	3	0.87 (0.02)	0.89 (0.02)	0.02	0.02 (0.01)	0.03 (0.02)	0.01	0.00 (0.00)	0.01 (0.01)	0.01
<b><u>Detroit Lakes</u></b>												
Cotton	PSL	2	3	0.88 (0.06)	0.92 (0.04)	0.04	0.04 (0.00)	0.03 (0.02)	-0.01	0.00 (0.00)	0.00 (0.00)	0.00
Little Floyd	PSL	2	3	0.87 (0.04)	0.73 (0.04)	-0.14	0.03 (0.01)	0.06 (0.03)	0.03	0.00 (0.00)	0.00 (0.00)	0.00
Floyd	PSL	2	3	0.74 (0.04)	0.77 (0.06)	0.02	0.10 (0.01)	0.08 (0.02)	-0.02	0.02 (0.01)	0.01 (0.00)	-0.01
Strawberry	control	2	3	0.95 (0.03)	0.91 (0.02)	-0.04	0.03 (0.01)	0.02 (0.01)	-0.01	0.00 (0.00)	0.00 (0.00)	0.00
<b><u>Duluth</u></b>												
Prairie	30-min	2	2	0.74 (0.04)	0.37 (0.06)	-0.37	0.03 (0.03)	0.30 (0.01)	0.27	0.00 (0.00)	0.00 (0.00)	0.00
Elliot	control	3	2	0.93 (0.01)	0.83 (0.12)	-0.09	0.05 (0.00)	0.06 (0.04)	0.01	0.03 (0.01)	0.00 (0.00)	-0.03

TABLE 3 continued.

Area and Lake	Reg	N Pre	N Post	≤ 20" Pre	≤ 20" Post	≤ 20" Δ	≥ 24 " Pre	≥ 24 " Post	≥ 24 " Δ	≥ 30" Pre	≥ 30" Post	≥ 30" Δ
<b>East Metro</b>												
Big Carnelian	PSL	3	2	0.82 (0.05)	0.85 (0.03)	0.03	0.04 (0.02)	0.05 (0.02)	0.02	0.00 (0.00)	0.01 (0.01)	0.01
<b>Fergus Falls</b>												
West Battle	PSL	3	4	0.83 (0.03)	0.72 (0.06)	-0.12	0.06 (0.01)	0.15 (0.05)	0.09	0.01 (0.01)	0.00 (0.00)	-0.01
Otter Tail	30-min	3	10	0.67 (0.10)	0.35 (0.03)	-0.32	0.13 (0.05)	0.31 (0.03)	0.17	0.03 (0.01)	0.05 (0.01)	0.02
Clitherall	control	4	4	0.63 (0.07)	0.62 (0.07)	-0.01	0.16 (0.02)	0.15 (0.02)	-0.02	0.02 (0.01)	0.02 (0.01)	0.00
Star	control	4	5	0.86 (0.07)	0.91 (0.02)	0.05	0.06 (0.03)	0.05 (0.02)	-0.01	0.01 (0.01)	0.00 (0.00)	-0.01
North Lida	control	5	5	0.72 (0.03)	0.81 (0.03)	0.08	0.11 (0.03)	0.06 (0.02)	-0.05	0.01 (0.00)	0.00 (0.00)	-0.01
Lizzie	control	3	4	0.93 (0.03)	0.83 (0.07)	-0.11	0.02 (0.01)	0.07 (0.04)	0.04	0.00 (0.00)	0.00 (0.00)	0.00
<b>Glenwood</b>												
Lakota	PSL	3	2	0.87 (0.04)	0.88 (0.03)	0.00	0.06 (0.02)	0.04 (0.02)	-0.02	0.00 (0.00)	0.00 (0.00)	0.00
Ida	control	5	3	0.80 (0.03)	0.72 (0.02)	-0.08	0.05 (0.01)	0.08 (0.02)	0.03	0.00 (0.00)	0.01 (0.00)	0.01
Chippewa	control	3	3	0.82 (0.03)	0.80 (0.02)	-0.02	0.05 (0.00)	0.08 (0.03)	0.03	0.00 (0.00)	0.01 (0.01)	0.01
<b>Grand Marais</b>												
Little Cascade	PSL	2	3	0.61 (0.11)	0.55 (0.10)	-0.06	0.10 (0.04)	0.06 (0.05)	-0.04	0.00 (0.00)	0.00 (0.00)	0.00
Loon	30-min	4	3	0.04 (0.03)	0.00 (0.00)	-0.04	0.86 (0.08)	0.89 (0.11)	0.03	0.24 (0.09)	0.44 (0.17)	0.20
Pickerel	control	3	3	0.83 (0.14)	0.82 (0.03)	-0.01	0.13 (0.10)	0.01 (0.01)	-0.12	0.00 (0.00)	0.00 (0.00)	0.00
Gunflint	control	3	3	0.14 (0.07)	0.06 (0.06)	-0.08	0.61 (0.20)	0.67 (0.10)	0.06	0.00 (0.00)	0.44 (0.06)	0.44
<b>Grand Rapids</b>												
North Star	PSL	2	2	0.57 (0.00)	0.35 (0.03)	-0.22	0.15 (0.01)	0.45 (0.00)	0.30	0.06 (0.04)	0.15 (0.06)	0.09
Island	PSL	2	3	0.75 (0.04)	0.42 (0.07)	-0.34	0.15 (0.01)	0.26 (0.06)	0.11	0.03 (0.03)	0.00 (0.00)	-0.02
Bass	control	2	2	0.94 (0.02)	0.93 (0.02)	-0.01	0.02 (0.01)	0.00 (0.00)	-0.02	0.01 (0.00)	0.00 (0.00)	0.00
Rice	control	2	2	0.66 (0.02)	0.60 (0.01)	-0.06	0.18 (0.01)	0.20 (0.02)	0.02	0.01 (0.00)	0.04 (0.04)	0.02
Moose	control	2	4	0.72 (0.05)	0.43 (0.04)	-0.29	0.05 (0.02)	0.17 (0.04)	0.12	0.02 (0.02)	0.05 (0.02)	0.04
<b>Hutchinson</b>												
Minnie-Belle	PSL	5	4	0.86 (0.05)	0.46 (0.05)	-0.40	0.03 (0.01)	0.22 (0.02)	0.19	0.00 (0.00)	0.03 (0.01)	0.03
Ripley	control	2	2	0.85 (0.01)	0.67 (0.05)	-0.18	0.08 (0.05)	0.09 (0.00)	0.01	0.01 (0.01)	0.00 (0.00)	-0.01

TABLE 3 continued.

Area and Lake	Reg	N Pre	N Post	≤ 20" Pre	≤ 20" Post	≤ 20" Δ	≥ 24 " Pre	≥ 24 " Post	≥ 24 " Δ	≥ 30" Pre	≥ 30" Post	≥ 30" Δ
<b><u>International Falls</u></b>												
Ash	PSL	3	3	0.54 (0.10)	0.04 (0.02)	-0.50	0.10 (0.00)	0.70 (0.02)	0.60	0.03 (0.01)	0.16 (0.04)	0.13
Elephant	40-min	3	3	0.00 (0.00)	0.21 (0.05)	0.21	0.73 (0.13)	0.40 (0.06)	-0.33	0.30 (0.15)	0.01 (0.01)	-0.29
Kjostad	control	3	3	0.74 (0.14)	0.44 (0.04)	-0.30	0.12 (0.06)	0.28 (0.03)	0.15	0.01 (0.01)	0.11 (0.04)	0.10
Blackduck	control	3	3	0.38 (0.09)	0.16 (0.08)	-0.22	0.33 (0.16)	0.47 (0.10)	0.13	0.12 (0.05)	0.08 (0.04)	-0.05
<b><u>Little Falls</u></b>												
Alexander	PSL	3	4	0.66 (0.12)	0.52 (0.06)	-0.13	0.07 (0.04)	0.17 (0.04)	0.10	0.00 (0.00)	0.01 (0.01)	0.01
Shamaineau	PSL	3	4	0.90 (0.01)	0.78 (0.06)	-0.12	0.03 (0.01)	0.10 (0.03)	0.06	0.01 (0.00)	0.03 (0.02)	0.02
Fish Trap	PSL	3	4	0.87 (0.05)	0.72 (0.04)	-0.15	0.02 (0.01)	0.11 (0.02)	0.09	0.00 (0.00)	0.01 (0.01)	0.00
Long	PSL	2	2	0.59 (0.20)	0.48 (0.15)	-0.11	0.19 (0.16)	0.22 (0.08)	0.03	0.00 (0.00)	0.03 (0.00)	0.03
Cedar	40-min	2	2	0.39 (0.05)	0.73 (0.05)	0.34	0.22 (0.04)	0.08 (0.01)	-0.14	0.02 (0.00)	0.00 (0.00)	-0.02
Bass	40-min	1	2	0.85	0.43 (0.18)	-0.42	0.04	0.17 (0.02)	0.12	0.02	0.03 (0.01)	0.01
<b><u>Park Rapids</u></b>												
Big Mantrap	PSL	2	3	0.56 (0.22)	0.42 (0.06)	-0.14	0.12 (0.09)	0.33 (0.08)	0.21	0.01 (0.01)	0.04 (0.01)	0.04
George	PSL	2	2	0.59 (0.03)	0.61 (0.02)	0.02	0.07 (0.00)	0.22 (0.01)	0.15	0.00 (0.00)	0.03 (0.02)	0.03
Blueberry	PSL	2	3	0.74 (0.07)	0.53 (0.01)	-0.21	0.15 (0.09)	0.22 (0.01)	0.08	0.09 (0.07)	0.04 (0.03)	-0.05
9 <sup>th</sup> Crow Wing	40-min	2	3	0.39 (0.31)	0.17 (0.03)	-0.23	0.23 (0.02)	0.55 (0.04)	0.32	0.05 (0.05)	0.20 (0.04)	0.15
10 <sup>th</sup> Crow Wing	40-min	2	3	0.39 (0.23)	0.41 (0.10)	0.01	0.39 (0.28)	0.32 (0.08)	-0.07	0.06 (0.02)	0.07 (0.01)	0.01
8 <sup>th</sup> Crow Wing	40-min	3	3	0.07 (0.01)	0.00 (0.00)	-0.07	0.63 (0.08)	0.79 (0.05)	0.16	0.21 (0.03)	0.32 (0.08)	0.11
Duck	control	2	3	0.31 (0.06)	0.23 (0.15)	-0.09	0.44 (0.19)	0.49 (0.09)	0.05	0.25 (0.13)	0.06 (0.06)	-0.19
Bell Taine	control	2	3	0.76 (0.09)	0.83 (0.04)	0.06	0.06 (0.01)	0.05 (0.02)	-0.01	0.00 (0.00)	0.00 (0.00)	0.00
Fish Hook	control	2	3	0.87 (0.01)	0.78 (0.02)	-0.09	0.06 (0.02)	0.08 (0.00)	0.02	0.01 (0.01)	0.03 (0.00)	0.02
<b><u>Sauk Rapids</u></b>												
Mink	PSL	1	3	0.90	0.36 (0.16)	-0.54	0.10	0.25 (0.02)	0.15	0.00	0.05 (0.03)	0.05
Somers	PSL	1	3	0.82	0.30 (0.08)	-0.52	0.00	0.29 (0.08)	0.29	0.00	0.06 (0.04)	0.06
Eagle	control	2	1	0.68 (0.32)	0.48	-0.20	0.14 (0.14)	0.18	0.05	0.00 (0.00)	0.00	0.00
Pine	control	2	2	0.69 (0.22)	0.64 (0.11)	-0.05	0.10 (0.10)	0.12 (0.08)	0.02	0.00 (0.00)	0.07 (0.07)	0.07
Locke	control	1	2	0.84	0.46 (0.12)	-0.38	0.11	0.28 (0.16)	0.18	0.05	0.08 (0.03)	0.03

TABLE 3 continued.

Area and Lake	Reg	N Pre	N Post	≤ 20" Pre	≤ 20" Post	≤ 20" Δ	≥ 24 " Pre	≥ 24 " Post	≥ 24 " Δ	≥ 30" Pre	≥ 30" Post	≥ 30" Δ
<b>Tower</b>												
Basswood	PSL	1	1	0.71	0.35	-0.36	0.12	0.38	0.26	0.03	0.08	0.05
South Farm	PSL	2	3	0.29 (0.04)	0.40 (0.08)	0.11	0.08 (0.08)	0.22 (0.07)	0.13	0.00 (0.00)	0.00 (0.00)	0.00
Farm	PSL	2	3	0.62 (0.00)	0.46 (0.08)	-0.16	0.08 (0.08)	0.31 (0.07)	0.23	0.04 (0.04)	0.04 (0.04)	0.00
Garden	PSL	2	3	0.45 (0.05)	0.55 (0.03)	0.10	0.06 (0.06)	0.17 (0.06)	0.11	0.00 (0.00)	0.02 (0.02)	0.02
Birch Reservoir	PSL	4	4	0.66 (0.07)	0.49 (0.08)	-0.17	0.09 (0.04)	0.30 (0.05)	0.20	0.00 (0.00)	0.11 (0.04)	0.11
White Iron	PSL	3	4	0.67 (0.07)	0.64 (0.07)	-0.03	0.05 (0.01)	0.23 (0.03)	0.18	0.01 (0.01)	0.02 (0.01)	0.01
Sucker	control	3	2	0.45 (0.07)	0.24 (0.12)	-0.21	0.26 (0.04)	0.52 (0.16)	0.26	0.04 (0.04)	0.07 (0.03)	0.03
Birch	control	3	2	0.31 (0.11)	0.43 (0.09)	0.12	0.40 (0.13)	0.35 (0.04)	-0.05	0.16 (0.03)	0.10 (0.04)	-0.06
Newfound	control	3	2	0.45 (0.14)	0.35 (0.13)	-0.11	0.34 (0.08)	0.43 (0.10)	0.09	0.04 (0.02)	0.13 (0.01)	0.09
Moose	control	3	2	0.59 (0.06)	0.58 (0.00)	-0.01	0.12 (0.00)	0.15 (0.09)	0.03	0.01 (0.01)	0.07 (0.05)	0.06
<b>Walker</b>												
Little Boy	PSL	4	5	0.86 (0.02)	0.67 (0.04)	-0.19	0.03 (0.02)	0.15 (0.03)	0.12	0.01 (0.00)	0.01 (0.01)	0.01
Wabedo	PSL	4	4	0.43 (0.05)	0.62 (0.02)	0.19	0.21 (0.03)	0.16 (0.03)	-0.05	0.06 (0.02)	0.04 (0.01)	-0.02
Girl	PSL	2	3	0.92 (0.01)	0.87 (0.01)	-0.05	0.03 (0.01)	0.08 (0.01)	0.05	0.00 (0.00)	0.01 (0.00)	0.01
Woman	PSL	5	3	0.80 (0.06)	0.66 (0.08)	-0.13	0.06 (0.01)	0.14 (0.05)	0.08	0.01 (0.01)	0.01 (0.01)	-0.01
Ada	PSL	3	3	0.77 (0.06)	0.80 (0.03)	0.04	0.07 (0.03)	0.15 (0.01)	0.07	0.03 (0.02)	0.05 (0.00)	0.02
Child	PSL	3	3	0.91 (0.05)	0.87 (0.03)	-0.05	0.06 (0.05)	0.07 (0.01)	0.01	0.01 (0.01)	0.01 (0.01)	0.00
Pleasant	control	4	4	0.93 (0.01)	0.95 (0.00)	0.02	0.02 (0.00)	0.01 (0.00)	0.00	0.00 (0.00)	0.00 (0.00)	0.00
Crooked	control	2	2	0.80 (0.01)	0.81 (0.12)	0.00	0.08 (0.02)	0.07 (0.06)	-0.01	0.02 (0.02)	0.00 (0.00)	-0.02
Steamboat	control	4	3	0.50 (0.04)	0.64 (0.10)	0.14	0.21 (0.03)	0.19 (0.04)	-0.02	0.06 (0.04)	0.01 (0.01)	-0.04

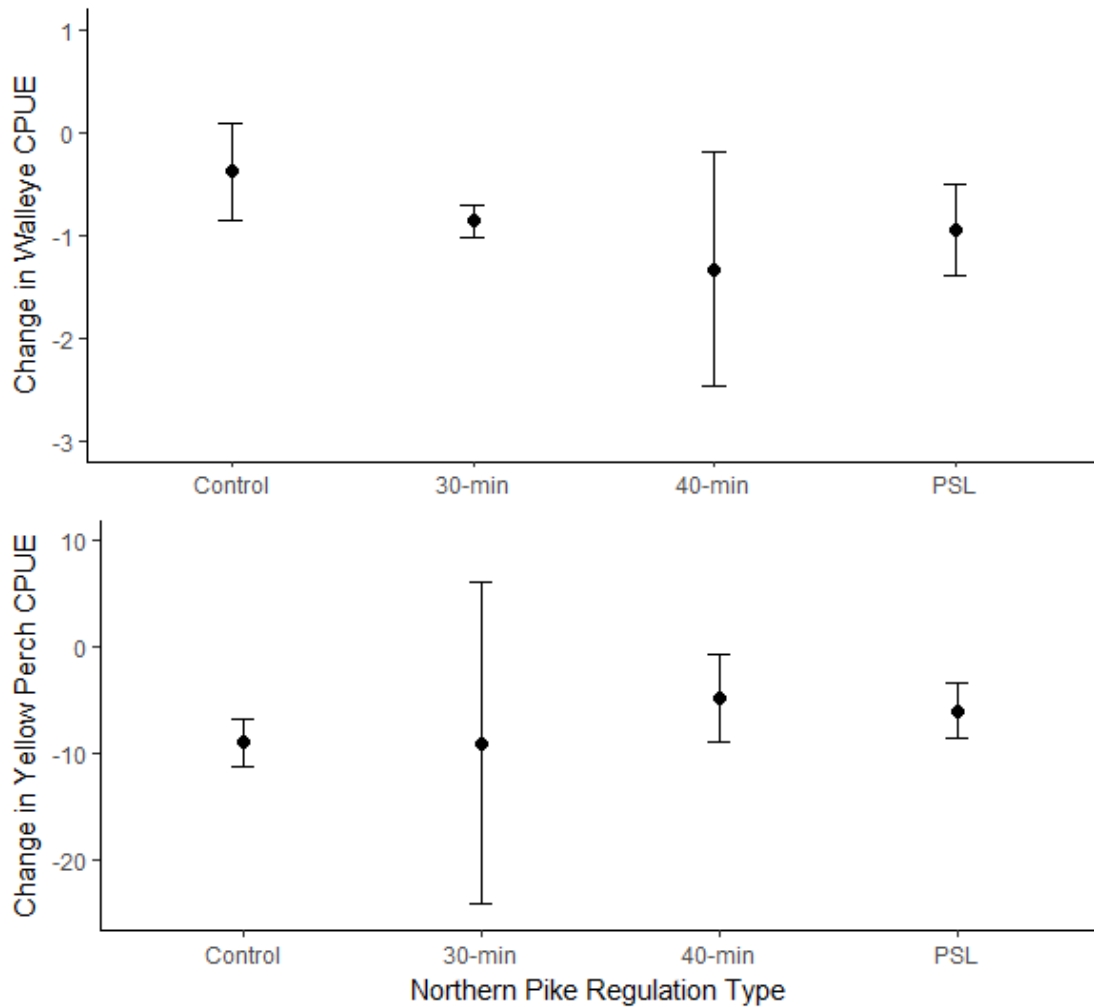


FIGURE 2. Average change ( $\pm$ SE) in Walleye and Yellow Perch mean gill net catch per unit effort (CPUE) after various Northern Pike special regulations were put into place in 2003. Northern Regulation types ("Reg") include a three fish bag limit with a 24-36" protected slot with one over 36" allowed ("PSL"), a one fish bag limit with a 30" minimum ("30-min"), and one fish bag limit with a 40" minimum ("40-min"), and control lakes under the contemporary statewide regulation for Northern Pike (three fish bag limit, one fish over 30" allowed; "control").

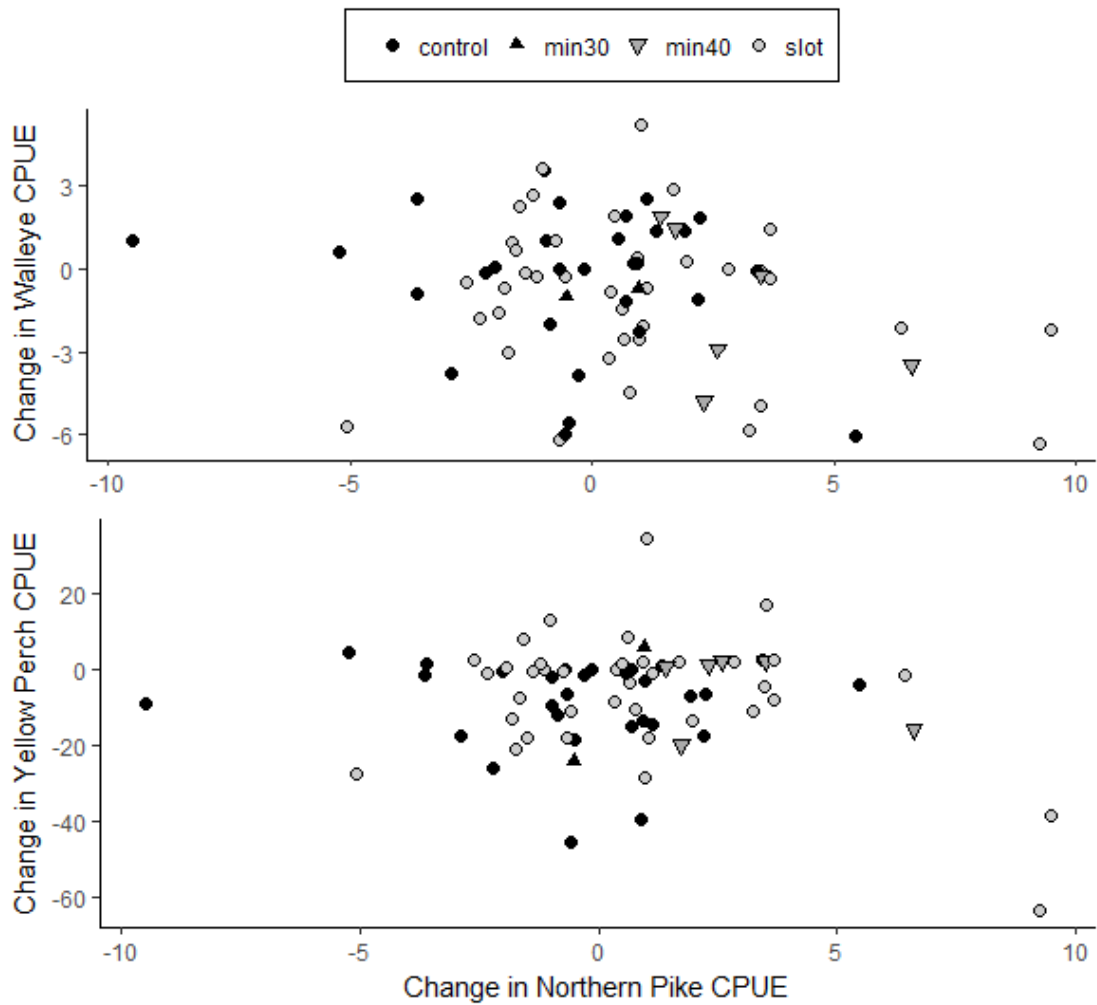


FIGURE 3. Mean change in Walleye and Yellow Perch gill net catch per unit effort (CPUE) across the mean change in Northern Pike CPUE after the implementation of special regulations for Northern Pike in 2003. Northern Pike regulation types ("Reg") include a three fish bag limit with a 24-36" protected slot with one over 36" allowed ("PSL"), a one fish bag limit with a 30" minimum ("30-min"), and one fish bag limit with a 40" minimum ("40-min"), and control lakes under the contemporary statewide regulation for Northern Pike (three fish bag limit, one fish over 30" allowed; "control").

## Discussion

Overall these special toolbox regulations were effective at changing or preserving Northern Pike size structure. The PSL and 30-min reduced the number of small Northern Pike ( $\leq 20$ " ) and increased the number of larger Northern Pike ( $\geq 24$ " ), indicating improvements in size structure. No changes were observed in populations where the 40-min regulation was implemented. Although the control lakes in this study also experienced some positive changes in Northern Pike size structure, the changes in the lakes with PSL and 30-min special regulations were greater than the observed changes in the control lakes.

The lakes chosen for the special toolbox regulations may have been uniquely likely to experience success. Fisheries Area Managers chose the lakes while taking into account several characteristics, from the existing Northern Pike population traits, to spawning habitat availability and fishing pressure. Thus if lakes had been randomly selected to receive these regulations, the same successes may not have been observed in this timeframe. Even so, some of the Northern Pike populations in this study appear not to have responded as well to the regulations as other lakes. In those cases Fisheries Area Managers may take into account considerations such as fishing pressure and compliance with the regulation which may have inhibited its effectiveness (Pierce and Tomcko 1997); however, it is also important to consider that the analyses for individual lakes are more affected by sampling error and limited amounts of survey data. Estimates of the overall effectiveness of the regulations from the mixed model approach utilize data across all lakes, which helps account for some of the error associated with sampling (Bolker et al. 2008).

During the course of this analyses, questions from management staff arose about whether results could be summarized by Fisheries Management Area or lake class. Unfortunately, small sample sizes within those types of groupings resulted in low replication and thus low power in analysis. For example, while many lake classes were represented in this study, only two lake classes (25 and 27) had five or more

control and regulation lakes. We considered using a lake classification with fewer groupings for analysis, the classes presented in Cross (2018). However, at the time of analysis that classification method was still relatively new and many of the lakes in the study had not yet been assigned a class according to that system. Future investigations may consider continuing to look for lake factors which create Northern Pike populations amenable to certain regulations.

Northern Pike exhibit relatively slow growth causing populations to take many years to respond to size-based regulations (Pierce 2010a, Pierce 2010b). Stakeholders may have difficulty with the length of time regulations take to reshape Northern Pike populations, thus communicating expectations at the outset of embarking on this type of management action may be helpful for maintaining user buy-in. An initial evaluation of these regulations after ten years did not show the same changes in the population metrics (Rodney Peirce, unpublished data), that were observed by adding an additional five years of post-regulation data. Other populations may need even more time to change enough to allow detection. Detection time must be balanced with social considerations of how long stakeholders are willing to wait to see changes.

Walleye and Yellow Perch populations in these lakes did not exhibit population improvements. As top-level predators, Northern Pike have the potential to interact with Walleye and Yellow Perch through predation and competition (Goeman and Spencer 1992, Fayram et al. 2005) and we might expect that changes in Northern Pike abundance and size structure would result in changes in these other species as well. While the PSL and 30-min regulations reshaped Northern Pike size structure, overall mean CPUE between the two time periods for Northern Pike did not change. The decrease in Walleye and Yellow Perch CPUE observed here mirror previously documented trends in Minnesota's overall gill-net catch (Bethke and Staples 2015) indicating that these changes may be driven by factors beyond Northern Pike regulations.



The Northern Pike toolbox regulations implemented in 2003 appear to have achieved the goals they set out to meet. Fisheries managers may still want to review individual lakes to determine if some populations would benefit more from changing to the new statewide zone regulations or simply more time for the regulation to have a measureable effect. For some lakes where the results were less positive than the overall results, fisheries managers may seek to simplify regulations in their Area by reverting to the statewide regulations, especially now that the regulations

are more tailored to the different ecoregions in Minnesota. However, the majority of the lakes in this study would fall under the North-central zone regulation which has a much less restrictive protected slot limit of 22-26" and managers should be cautioned that many Northern Pike currently protected by these special toolbox regulations here would likely be subject to harvest under the statewide regulation. There may be an opportunity to modify the toolbox to provide an intermediate regulation that would maintain the quality that has been built up but afford more harvest opportunities.

### **Acknowledgments**

Patrick Schmalz, Melissa Trembl and members of the MN DNR Northern Pike Technical Committee and other Area Management Staff provided a review of an earlier version of this manuscript. Thank you to the many MN DNR Section of Fisheries staff who worked on these lake assessments, providing data for these analyses.

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APPENDIX 1. Mean catch per unit effort followed by standard error in parenthesis of Northern Pike (NOP) in various size categories before (Pre) and after (Post) the implementation of special regulations ("Reg"). Pre data were collected from 1993 to 2003, Post data were collected from 2006 to 2018. No data were included from the years 2004 and 2005 to allow for regulations to affect populations before comparing data. Regulation types include a three fish bag limit with a 24-36" protected slot with one over 36" allowed ("PSL"), a one fish bag limit with a 30" minimum ("min30"), a one fish bag limit with a 40" minimum ("min40"), and control lakes under the contemporary statewide regulation for Northern Pike (three fish bag limit, one fish over 30" allowed; "control").

Area and Lake	Reg	N Pre	N Post	≤ 20" Pre	≤ 20" Post	≤ 20" Δ	≥ 24"Pre	≥ 24"Post	≥ 24" Δ	≥ 30" Pre	≥ 30" Post	≥ 30" Δ
<b><u>Aitkin</u></b>												
Lone	control	1	2	16.44	8.17 (2.17)	-8.28	0.89	0.89 (0.33)	0.00	0	0.33 (0.22)	0.33
Long	PSL	3	2	4.63 (1.17)	3.63 (0.37)	-1.00	0.22 (0.15)	0.38 (0.13)	0.15	0.00 (0.00)	0.00 (0.00)	0.00
<b><u>Bemidji</u></b>												
Blackduck	control	2	3	4.67 (0.20)	3.58 (1.34)	-1.09	0.33 (0.07)	0.73 (0.27)	0.40	0.03 (0.03)	0.02 (0.02)	-0.01
Itasca	control	2	3	8.25 (1.58)	7.94 (3.36)	-0.31	0.17 (0.08)	0.17 (0.05)	0.00	0.00 (0.00)	0.03 (0.03)	0.03
Boy	NA	3	3	14.56 (1.13)	6.56 (0.59)	-8.00	0.69 (0.22)	0.53 (0.34)	-0.16	0.11 (0.06)	0.07 (0.07)	-0.04
Beltrami	NA	2	4	4.22 (0.44)	3.64 (0.86)	-0.58	1.56 (0.78)	1.08 (0.15)	-0.47	0.17 (0.06)	0.14 (0.05)	-0.03
Turtle River	PSL	3	3	5.55 (0.96)	4.82 (0.48)	-0.73	0.22 (0.12)	0.42 (0.09)	0.20	0.07 (0.04)	0.11 (0.02)	0.04
Three Island	PSL	1	3	8.25	4.42 (0.29)	-3.83	0.63	1.17 (0.29)	0.54	0	0.25 (0.07)	0.25
Movil	PSL	2	3	7.79 (0.71)	7.22 (0.43)	-0.57	0.54 (0.29)	1.08 (0.13)	0.54	0.08 (0.08)	0.19 (0.10)	0.11
Little Turtle	PSL	2	3	10.56 (2.00)	11.56 (3.88)	1.00	0.50 (0.17)	0.33 (0.06)	-0.17	0.06 (0.06)	0.04 (0.04)	-0.02
Turtle	PSL	3	3	4.19 (1.45)	6.47 (0.90)	2.28	0.39 (0.03)	1.11 (0.26)	0.72	0.17 (0.08)	0.17 (0.08)	0.00
Campbell	PSL	2	3	9.00 (0.33)	9.00 (2.60)	0.00	0.28 (0.06)	0.33 (0.17)	0.06	0.06 (0.06)	0.04 (0.04)	-0.02
Deer	PSL	2	4	4.33 (1.50)	3.42 (0.45)	-0.92	0.83 (0.17)	1.79 (0.34)	0.96	0.08 (0.08)	0.38 (0.13)	0.29
<b><u>Detroit Lakes</u></b>												
Strawberry	control	2	3	9.13 (1.13)	13.76 (2.27)	4.64	0.27 (0.10)	0.27 (0.14)	0.00	0.00 (0.00)	0.00 (0.00)	0.00
Cotton	PSL	2	3	12.29 (5.29)	10.97 (1.94)	-1.32	0.46 (0.13)	0.32 (0.16)	-0.14	0.04 (0.04)	0.00 (0.00)	-0.04
Little Floyd	PSL	2	3	18.20 (3.20)	18.00 (1.95)	-0.20	0.67 (0.33)	1.28 (0.61)	0.61	0.10 (0.10)	0.06 (0.06)	-0.04
Floyd	PSL	2	3	12.38 (6.75)	10.94 (2.31)	-1.44	1.44 (0.56)	1.10 (0.18)	-0.34	0.19 (0.06)	0.14 (0.04)	-0.05
<b><u>Duluth</u></b>												
Prairie	30-min	2	2	1.17 (0.00)	0.96 (0.29)	-0.21	0.04 (0.04)	0.75 (0.08)	0.71	0.00 (0.00)	0.00 (0.00)	0.00
Elliot	control	3	2	10.11 (2.02)	6.17 (2.28)	-3.94	0.52 (0.07)	0.33 (0.22)	-0.19	0.26 (0.04)	0.00 (0.00)	-0.26

APPENDIX 1 continued.

Area and Lake	Reg	N Pre	N Post	≤ 20" Pre	≤ 20" Post	≤ 20" Δ	≥ 24" Pre	≥ 24" Post	≥ 24" Δ	≥ 30" Pre	≥ 30" Post	≥ 30" Δ
<b>East Metro</b>												
Big Carnelian	PSL	3	2	7.88 (2.60)	5.88 (2.38)	-2.00	0.31 (0.11)	0.44 (0.31)	0.12	0.04 (0.04)	0.13 (0.13)	0.08
<b>Fergus Falls</b>												
Otter Tail	30-min	3	10	2.80 (0.82)	1.16 (0.14)	-1.64	0.47 (0.09)	0.97 (0.11)	0.50	0.10 (0.03)	0.17 (0.04)	0.07
Clitherall	control	4	4	2.68 (0.44)	4.30 (1.26)	1.62	0.73 (0.20)	0.88 (0.10)	0.14	0.07 (0.05)	0.10 (0.04)	0.03
Star	control	4	5	6.77 (1.12)	8.85 (0.88)	2.08	0.42 (0.16)	0.43 (0.14)	0.01	0.08 (0.04)	0.03 (0.02)	-0.05
North Lida	control	5	5	3.24 (0.42)	4.32 (0.25)	1.08	0.48 (0.13)	0.32 (0.09)	-0.16	0.05 (0.01)	0.01 (0.01)	-0.04
Lizzie	control	3	4	5.02 (0.58)	5.14 (0.48)	0.12	0.13 (0.07)	0.50 (0.33)	0.37	0.02 (0.02)	0.00 (0.00)	-0.02
West Battle	PSL	3	4	7.31 (0.85)	4.42 (0.63)	-2.89	0.53 (0.17)	0.85 (0.19)	0.32	0.11 (0.06)	0.02 (0.02)	-0.09
<b>Glenwood</b>												
Ida	control	5	3	6.08 (0.81)	7.06 (0.86)	0.98	0.36 (0.10)	0.72 (0.10)	0.35	0.01 (0.01)	0.07 (0.01)	0.06
Chippewa	control	3	3	4.83 (1.71)	2.42 (0.32)	-2.42	0.28 (0.10)	0.22 (0.07)	-0.06	0.00 (0.00)	0.03 (0.03)	0.03
Lakota	PSL	3	2	10.24 (0.72)	16.00 (0.75)	5.76	0.71 (0.28)	0.67 (0.42)	-0.04	0.03 (0.03)	0.00 (0.00)	-0.03
<b>Grand Marais</b>												
Loon	30-min	8	6	0.26 (0.10)	0.11 (0.07)	-0.14	0.93 (0.20)	0.63 (0.06)	-0.30	0.09 (0.03)	0.17 (0.06)	0.09
Pickerel	control	3	3	5.67 (2.22)	7.22 (1.18)	1.56	0.44 (0.29)	0.11 (0.11)	-0.33	0.00 (0.00)	0.00 (0.00)	0.00
Gunflint	control	3	3	0.39 (0.20)	0.10 (0.06)	-0.28	0.11 (0.01)	0.27 (0.05)	0.16	0.00 (0.00)	0.10 (0.06)	0.10
Little Cascade	PSL	2	3	4.50 (0.75)	5.50 (0.80)	1.00	0.75 (0.25)	0.58 (0.46)	-0.17	0.00 (0.00)	0.00 (0.00)	0.00
<b>Grand Rapids</b>												
Bass	control	2	2	7.07 (0.40)	6.13 (0.60)	-0.93	0.17 (0.10)	0.03 (0.03)	-0.13	0.07 (0.00)	0.03 (0.03)	-0.03
Rice	control	2	2	3.96 (0.29)	2.42 (1.08)	-1.54	1.08 (0.17)	0.75 (0.25)	-0.33	0.08 (0.00)	0.08 (0.08)	0.00
Moose	control	2	4	1.96 (0.29)	0.77 (0.16)	-1.19	0.13 (0.04)	0.35 (0.14)	0.23	0.04 (0.04)	0.10 (0.04)	0.06
North Star	PSL	2	2	2.08 (0.58)	0.75 (0.17)	-1.33	0.54 (0.13)	0.96 (0.12)	0.42	0.17 (0.08)	0.33 (0.17)	0.17
Island	PSL	2	3	5.80 (0.40)	3.58 (0.69)	-2.22	1.13 (0.20)	2.24 (0.74)	1.11	0.23 (0.23)	0.02 (0.02)	-0.21
<b>Hutchinson</b>												
Ripley	control	2	2	9.28 (5.83)	3.78 (0.11)	-5.50	0.50 (0.06)	0.50 (0.06)	0.00	0.06 (0.06)	0.00 (0.00)	-0.06
Minnie-Belle	PSL	5	4	11.71 (3.76)	5.22 (0.99)	-6.49	0.27 (0.06)	2.42 (0.08)	2.15	0.04 (0.03)	0.33 (0.12)	0.29

APPENDIX 1 continued.

Area and Lake	Reg	N Pre	N Post	≤ 20" Pre	≤ 20" Post	≤ 20" Δ	≥ 24"Pre	≥ 24"Post	≥ 24" Δ	≥ 30" Pre	≥ 30" Post	≥ 30" Δ
<b>International Falls</b>												
Elephant	40-min	3	3	0.00 (0.00)	0.52 (0.20)	0.52	0.42 (0.04)	0.89 (0.13)	0.47	0.17 (0.08)	0.04 (0.04)	-0.13
Kjostad	control	3	3	1.44 (0.36)	0.81 (0.27)	-0.63	0.26 (0.13)	0.52 (0.16)	0.26	0.04 (0.04)	0.19 (0.07)	0.15
Blackduck	control	3	3	1.21 (0.59)	0.76 (0.54)	-0.45	0.86 (0.40)	1.85 (0.43)	0.99	0.29 (0.11)	0.25 (0.08)	-0.04
Ash	PSL	3	3	2.63 (0.56)	0.15 (0.07)	-2.48	0.48 (0.04)	2.63 (0.26)	2.15	0.15 (0.04)	0.59 (0.15)	0.44
<b>Little Falls</b>												
Cedar	40-min	2	2	2.67 (0.50)	6.00 (1.17)	3.33	1.50 (0.17)	0.67 (0.00)	-0.83	0.17 (0.00)	0.00 (0.00)	-0.17
Bass	40-min	1	2	6.5	4.55 (2.05)	-1.95	0.33	1.72 (0.12)	1.38	0.17	0.28 (0.12)	0.12
Alexander	PSL	3	4	1.44 (0.19)	1.50 (0.33)	0.06	0.22 (0.14)	0.48 (0.15)	0.26	0.00 (0.00)	0.02 (0.02)	0.02
Shamaineau	PSL	3	4	6.29 (0.80)	3.85 (1.02)	-2.44	0.24 (0.06)	0.40 (0.05)	0.16	0.04 (0.02)	0.08 (0.06)	0.04
Fish Trap	PSL	3	4	4.60 (0.57)	6.33 (1.17)	1.73	0.12 (0.06)	1.06 (0.30)	0.95	0.03 (0.03)	0.10 (0.06)	0.08
Long	PSL	2	2	8.11 (7.00)	4.61 (2.17)	-3.50	0.83 (0.17)	1.83 (0.39)	1.00	0.00 (0.00)	0.28 (0.06)	0.28
<b>Park Rapids</b>												
9th Crow Wing	40-min	2	3	0.67 (0.50)	0.89 (0.31)	0.22	0.42 (0.08)	2.83 (0.54)	2.42	0.08 (0.08)	1.00 (0.19)	0.92
10th Crow Wing	40-min	2	3	1.67 (1.33)	4.56 (1.81)	2.89	0.92 (0.42)	2.83 (0.59)	1.92	0.17 (0.00)	0.67 (0.19)	0.50
8th Crow Wing	40-min	3	3	0.22 (0.06)	0.00 (0.00)	-0.22	1.78 (0.06)	4.33 (0.32)	2.56	0.63 (0.16)	1.67 (0.26)	1.04
Duck	control	2	4	0.36 (0.14)	0.08 (0.05)	-0.28	0.44 (0.11)	0.25 (0.18)	-0.19	0.25 (0.08)	0.06 (0.06)	-0.19
Bell Taine	control	2	3	3.58 (1.17)	4.92 (0.88)	1.33	0.25 (0.00)	0.25 (0.05)	0.00	0.00 (0.00)	0.03 (0.03)	0.03
Fish Hook	control	2	3	14.48 (2.32)	10.28 (1.39)	-4.20	0.94 (0.14)	1.01 (0.07)	0.07	0.19 (0.06)	0.37 (0.07)	0.18
Big Mantrap	PSL	2	3	4.73 (2.47)	3.09 (0.45)	-1.64	0.87 (0.53)	2.44 (0.65)	1.57	0.03 (0.03)	0.28 (0.07)	0.25
George	PSL	2	2	5.28 (0.39)	7.50 (0.92)	2.22	0.61 (0.06)	2.67 (0.17)	2.06	0.00 (0.00)	0.33 (0.17)	0.33
Blueberry	PSL	2	3	8.33 (0.67)	7.78 (1.12)	-0.56	1.67 (1.00)	3.22 (0.31)	1.56	1.00 (0.83)	0.50 (0.33)	-0.50
<b>Sauk Rapids</b>												
Eagle	control	2	1	1.72 (1.06)	4	2.28	0.25 (0.25)	1.5	1.25	0.00 (0.00)	0	0.00
Pine	control	2	2	1.79 (0.04)	2.42 (1.08)	0.63	0.38 (0.37)	0.33 (0.17)	-0.04	0.00 (0.00)	0.17 (0.17)	0.17
Locke	control	1	2	3.2	3.50 (3.00)	0.30	0.4	1.00 (0.33)	0.60	0.2	0.33 (0.17)	0.13
Mink	PSL	2	3	1.13 (1.13)	3.60 (1.47)	2.48	0.13 (0.13)	2.73 (0.94)	2.61	0.00 (0.00)	0.60 (0.31)	0.60
Somers	PSL	4	3	0.45 (0.45)	2.93 (1.16)	2.48	0.00 (0.00)	3.27 (1.45)	3.27	0.00 (0.00)	0.73 (0.47)	0.73

APPENDIX 1 continued.

Area and Lake	Reg	N Pre	N Post	≤ 20" Pre	≤ 20" Post	≤ 20" Δ	≥ 24"Pre	≥ 24"Post	≥ 24" Δ	≥ 30" Pre	≥ 30" Post	≥ 30" Δ
<b><u>Tower</u></b>												
Sucker	control	3	2	0.70 (0.23)	0.39 (0.06)	-0.31	0.41 (0.13)	1.17 (0.72)	0.76	0.04 (0.04)	0.11 (0.00)	0.07
Birch	control	3	2	1.26 (0.45)	1.33 (0.33)	0.07	1.69 (0.60)	1.08 (0.08)	-0.60	0.67 (0.17)	0.31 (0.14)	-0.36
Newfound	control	3	2	1.78 (0.52)	1.10 (0.32)	-0.69	1.36 (0.43)	1.44 (0.44)	0.09	0.17 (0.10)	0.43 (0.01)	0.26
Moose	control	3	2	2.69 (0.57)	3.00 (0.33)	0.31	0.57 (0.10)	0.72 (0.39)	0.16	0.06 (0.03)	0.32 (0.24)	0.26
Basswood	PSL	1	1	2.8	0.85	-1.95	0.47	0.9	0.43	0.13	0.2	0.07
South Farm	PSL	2	3	0.21 (0.13)	0.94 (0.20)	0.74	0.08 (0.08)	0.56 (0.20)	0.47	0.00 (0.00)	0.00 (0.00)	0.00
Farm	PSL	2	3	0.69 (0.02)	0.74 (0.25)	0.04	0.08 (0.08)	0.47 (0.11)	0.38	0.04 (0.04)	0.04 (0.04)	0.00
Garden	PSL	2	3	0.31 (0.02)	0.91 (0.19)	0.60	0.04 (0.04)	0.28 (0.10)	0.24	0.00 (0.00)	0.05 (0.05)	0.05
Birch Reservoir	PSL	4	4	1.42 (0.17)	0.66 (0.11)	-0.76	0.21 (0.08)	0.43 (0.10)	0.22	0.00 (0.00)	0.15 (0.06)	0.15
White Iron	PSL	3	4	2.34 (0.81)	1.30 (0.27)	-1.04	0.17 (0.06)	0.44 (0.05)	0.27	0.03 (0.03)	0.05 (0.03)	0.02
<b><u>Walker</u></b>												
Pleasant	control	4	4	15.44 (1.29)	16.48 (1.59)	1.04	0.25 (0.07)	0.23 (0.07)	-0.02	0.00 (0.00)	0.02 (0.02)	0.02
Crooked	control	2	2	7.26 (0.63)	5.50 (0.17)	-1.76	0.72 (0.16)	0.56 (0.44)	-0.16	0.19 (0.19)	0.00 (0.00)	-0.19
Steamboat	control	4	3	2.42 (0.60)	5.36 (1.44)	2.94	0.87 (0.09)	1.40 (0.15)	0.53	0.17 (0.06)	0.09 (0.04)	-0.08
Little Boy	PSL	4	5	6.30 (0.80)	5.42 (0.65)	-0.88	0.31 (0.17)	1.18 (0.20)	0.88	0.07 (0.04)	0.12 (0.06)	0.05
Wabedo	PSL	4	4	2.26 (0.60)	4.42 (0.63)	2.16	1.06 (0.25)	1.10 (0.12)	0.04	0.23 (0.04)	0.25 (0.06)	0.02
Girl	PSL	2	3	10.39 (0.39)	10.74 (2.58)	0.35	0.33 (0.11)	0.93 (0.21)	0.59	0.00 (0.00)	0.11 (0.06)	0.11
Woman	PSL	5	3	4.63 (0.36)	2.81 (0.16)	-1.83	0.35 (0.03)	0.67 (0.34)	0.32	0.08 (0.05)	0.02 (0.02)	-0.06
Ada	PSL	3	3	8.28 (2.96)	8.40 (1.00)	0.12	0.56 (0.11)	1.57 (0.34)	1.02	0.19 (0.10)	0.54 (0.10)	0.35
Child	PSL	3	3	6.56 (1.78)	8.61 (2.62)	2.06	0.50 (0.42)	0.83 (0.42)	0.33	0.11 (0.11)	0.11 (0.06)	0.00

APPENDIX 2. Average catch per unit effort (number per net night; CPUE) of Northern Pike caught in gill nets in various size categories before (Pre) and after (Post) the implementation of special regulations ("Reg"), as well as the difference between the periods ( $\Delta$ ). Pre data were collected from 1993 to 2003, Post data were collected from 2006 to 2018. Regulation types include a three fish bag limit with a 24-36" protected slot with one over 36" allowed ("PSL"), a one fish bag limit with a 30" minimum ("30-min") and one fish bag limit with a 40" minimum ("40-min"), and control lakes under the contemporary statewide regulation for Northern Pike (three fish bag limit, one fish over 30" allowed; "Control").

Reg	$\leq 20''$ Pre	$\leq 20''$ Post	$\leq 20''\Delta$	$\geq 24''$ Pre	$\geq 24''$ Post	$\geq 24''\Delta$	$\geq 30''$ Pre	$\geq 30''$ Post	$\geq 30''\Delta$
Control	5.07	4.82	-0.26	0.53	0.65	0.12	0.10	0.11	0.01
PSL	6.06	5.46	-0.59	0.52	1.16	0.63	0.09	0.18	0.08
30-min	1.38	0.72	-0.66	0.49	0.74	0.25	0.05	0.13	0.08
40-min	2.03	2.75	0.72	0.87	2.21	1.34	0.22	0.61	0.39