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Fish Community Responses to the Introduction of Muskellunge in Minnesota Lakes

Michael L. Knapp[1]*, Steven W. Mero[2], David J. Bohlander[1], and David F. Staples[3]

[1] *Brainerd Area Fisheries*
Minnesota Department of Natural Resources
1601 Minnesota Drive
Brainerd MN 56401

[2] *Grand Rapids Area Fisheries*
Minnesota Department of Natural Resources
1201 E. Hwy 2
Grand Rapids MN 55744

[3] *Fisheries Research Group*
Minnesota Department of Natural Resources
5463-C West Broadway
Forest Lake MN 55025

Abstract—We evaluated responses of seven fish species to muskellunge by comparing catch per unit effort (CPUE) before and after muskellunge were stocked in 41 Minnesota lakes composed of 12 lake classes. The species examined were: northern pike *Esox lucius*, walleye *Sander vitreus*, yellow perch *Perca flavescens*, bluegill *Lepomis macrochirus*, black crappie *Pomoxis nigromaculatus*, white sucker *Catostomus commersoni*, and tullibee *Coregonus artedi*. We found no significant decreases in mean CPUE among the lakes for any species after muskellunge stocking, either for the stocked lakes as a whole or within lake classes. There was a significant increase in mean CPUE for bluegill over the entire group of lakes and within lake class 24, in addition to an increase in mean CPUE for black crappie sampled by gill nets in lake class 25. Nevertheless, there was large variability in the changes in CPUE among lakes, and several individual lakes had significant increases or decreases in mean CPUE for some species following muskellunge stocking. Because the selection of lakes for muskellunge introductions must follow established, biologically-based guidelines and thus cannot be chosen at random, it is not statistically valid to extend these conclusions to lakes not chosen in this manner. The lack of consistent negative changes in mean CPUE after stocking suggests these fish species have generally coexisted well with muskellunge in these lakes at the densities that have resulted from stocking.

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*Corresponding author: michael.knapp@dnr.state.mn.us

Introduction

In 2003, Minnesota identified 105 lakes and six river systems as muskellunge or hybrid muskellunge waters (Younk and Pereira 2006). Native muskellunge waters are present in all three major drainage basins of Minnesota: Hudson Bay; Mississippi River; and Lake Superior. The majority of these muskellunge waters are found in north-central and Twin Cities metropolitan areas, although some muskellunge exist in all regions of the state. Forty-four lakes and all six rivers are recognized as native muskellunge water. In addition, muskellunge are present in the following border waters with Canada and Wisconsin: Lake of the Woods; Rainy River; Rainy Lake; St. Louis River Estuary; and St. Croix River.

Management of muskellunge *Esox masquinongy* in Minnesota has focused on developing high quality trophy fisheries. Younk and Pereira (2006) described trends in Minnesota's muskellunge fishery that included an increase in the number of 40 in and larger fish and an increase in the proportion of successful anglers following an increase in minimum size regulations. Angler reported catches of 50 in and larger muskellunge have increased steadily from 1995 through 2004 with 163 such fish reported in 2004 (Muskies, Inc data). Recent statewide survey estimates conducted by Schroeder and Fulton (2005) found approximately 9.3% of resident anglers in Minnesota had fished for muskellunge in 2003. Based on total resident angler license sales of just over 1.2 million in 2003, this corresponds to approximately 110,000 resident muskellunge anglers. Additionally, a previous study of non-resident anglers indicated approximately 5% had targeted muskellunge while fishing in Minnesota (Currie and Fulton 2001). Based on the number of non-resident licenses sold in 2000 (roughly 250,000), approximately 12,500 non-resident anglers targeted muskellunge. The recent estimates of anglers fishing for muskellunge in Minnesota indicate substantial growth in the sport of muskellunge fishing compared to previous estimates by management professionals (Wingate 1986). These characteristics lead many anglers and fisheries professionals to conclude that Minnesota's muskellunge program has been successful.

A successful program considers both biological and social aspects of a fishery. Angler expectations vary widely, and when public comment is sought for selection of new muskellunge waters, anglers are often divided in their interests. In particular, some anglers have expressed concern over the impacts to popular game fish from adding a top-level predator to aquatic ecosystems. Minnesota has 41 lakes with stocked populations of Mississippi (MS) strain muskellunge and standardized fisheries assessments (MN DNR, 1993) are conducted regularly on these lakes; however, information from these lakes has never been pooled together to evaluate changes in other fish species over time.

To evaluate if muskellunge were having any effects on fish communities, we determined whether there was a change in relative abundance of other fish species following muskellunge stocking. We analyzed existing data at three levels: at the individual lake level, pooled over lake-classes (Schupp 1992), and for all stocked muskellunge lakes combined. This broad based approach should help detect whether or not muskellunge have a consistent effect on other species and should be useful to resource professionals and the angling public in making informed decisions.

Methods

Younk and Pereira (2006) identified 105 lakes and six rivers in Minnesota with muskellunge. Of those, there are 41 lakes currently managed by stocking MS strain muskellunge (Table 1). The MS strain first used in 1982 represents the current and future direction of muskellunge management in Minnesota. The strain was chosen for its superior growth characteristics and spatio-temporal differences in spawning characteristics compared to northern pike (Younk and Strand 1992; Strand 1986). This study focused on the subset of MS-stocked muskellunge lakes.

Table 1.—Selected characteristics of individual lakes included in this study. Year stocked represents the first substantial and successful stocking of muskellunge. Some early introductions were strains other than the Mississippi currently stocked in Minnesota.

Name	Lake Class	DOW Number	Area (acres)	Max Depth	Location (County)	Year Stocked
Alexander	22	49-0079-00	2,763	64	Morrison	1988
Big Mantrap	25	29-0151-00	1,556	68	Hubbard	1957
Bald Eagle	24	62-0002-00	1,269	36	Ramsey	1982
Beers	25	56-0724-00	195	61	Otter Tail	1977
Bemidji	22	4-0130-00	6,420	76	Beltrami	1978
Big	27	4-0049-00	3,533	35	Beltrami	1969
Cedar	25	1-0209-00	1,769	105	Aitkin	1994
Cross	25	58-0119-00	943	30	Pine	1977
Detroit	22	3-0381-00	3,083	89	Becker	1989
Dumbbell	5	38-0393-00	437	40	Lake	1971
East Rush	24	13-0069-01	1,359	24	Chisago	1968
Eagle	24	27-0111-00	291	34	Hennepin	1982
Elk	23	15-0010-00	271	93	Clearwater	1982
Forest	24	82-0159-00	2,251	37	Washington	1989
Fox	24	46-0109-00	1,041	20	Martin	1999
French	24	66-0038-00	816	56	Rice	1974
Harriet	24	27-0016-00	335	87	Hennepin	1974
Independence	24	27-0176-00	844	58	Hennepin	1971
Island	32	58-0062-00	510	42	Pine	1982
Island Reservoir	2	69-0372-00	8,112	94	St. Louis	1972
Little Wolf	31	11-0505-00	490	24	Cass	1982
Lobster	25	21-0144-00	1,308	65	Douglas	1968
Mille Lacs	26	48-0002-00	132,516	42	Mille Lacs	1984
Miltona	22	21-0083-00	5,838	105	Douglas	1982
Minnetonka	22	27-0133-00	14,004	113	Hennepin	1977
North Star	25	31-0653-00	1,059	90	Itasca	1989
Oscar	38	21-0257-00	1,040	25	Douglas	1985
Owasso	24	62-0056-00	384	37	Ramsey	1982
Pelican	22	56-0786-00	3,986	55	Otter Tail	1978
Plantagenet	22	29-0156-00	2,529	65	Hubbard	1982
Pleasant	24	62-0046-00	585	58	Ramsey	1978
Round	29	49-0056-00	121	20	Morrison	1990
Shamineau	27	49-0127-00	1,626	52	Morrison	1988
St. Croix	22	82-0001-00	8,209	78	Washington	1989
Sugar	24	86-0233-00	1,015	69	Wright	1970
Vermillion	2	69-0378-00	40,557	76	St. Louis	1984
West Battle	27	56-0239-00	5,624	108	Otter Tail	1963
West Rush	25	13-0069-02	1,464	42	Chisago	1968
Waconia	27	10-0059-00	2,996	37	Carver	1984
White Bear	22	82-0167-00	2,416	83	Washington	1975
Zumbro	25	55-0004-00	606	43	Olmstead	1994

We investigated changes in catch rates for five primary species in each lake. These species chosen are present in nearly all of the study lakes and are commonly sampled using standard survey methods. Northern pike *Esox lucius*, walleye *Sander vitreus*, yellow perch *Perca flavescens*, and white sucker *Catostomus commersoni* were sampled using standard experimental gill nets. These nets have five panels with mesh sizes ranging from 0.75 in to 2.0 in bar measure. Each panel is 6 ft tall by 50 ft in length and sewn to the others in ascending mesh size. Bluegill *Lepomis macrochirus* populations were sampled using trap nets with a 0.75 in bar measure mesh size, a 3 ft high by 6 ft wide frame, and a 40 ft lead. We used catch per unit effort (CPUE, number per overnight net set) as a measure of relative abundance for each species. Tullibee *Coregonus artedi* and black crappie *Pomoxis nigromaculatus* are also important in some Minnesota lake communities and were included for lakes where they were regularly caught. Individual lakes were typically sampled at the same time each year using the same net locations during each assessment. These population assessments generally occurred in June, July, or August. No ice-out or spring trap net data were included. No attempts were made to correct CPUE for seasonal trends in northern pike and walleye CPUE as described by Grant et al. (2004).

The date of stocking was denoted as the point at which muskellunge were introduced and regularly stocked as fingerlings or larger into a particular lake. Pre-stocking years included surveys occurring during the first year of stocking since muskellunge were stocked in the fall. It is generally accepted within the MN DNR that muskellunge fry stocking during the early years of the management program was unsuccessful in establishing fisheries. Hanson et al. (1986) also found muskellunge fry survival was generally low and therefore we considered fry-stocked years prior to fingerling or larger size fish being stocked as pre-stocked. Some lakes contained native populations of muskellunge in very low numbers or had muskellunge introduced in very low numbers prior to regular stocking. In these cases, the effect of these few fish was assumed to be negligible and surveys conducted prior to regular stocking were also considered to be pre-stocking.

Data were analyzed at three levels: individual lake, pooled by lake class, and all MS-stocked lakes pooled together. For an individual lake, we used a two-sample Wilcoxon rank-sum test (Wilcoxon 1945) to compare the mean CPUE of a species before and after muskellunge were introduced. The Wilcoxon rank-sum test is a non-parametric analog of a traditional *t*-test, and is more robust to small sample sizes and violations of normality assumptions (Berry and Lindgren 1996) common in the CPUE data. The test is used to determine if the typical CPUE value is different between the pre- and post-stocking periods. Results of the individual lake and species data are presented in Tables 2-9.

Lakes in the same class (Schupp 1992) and thus similar in their physical and chemical characteristics were pooled, with lake classes 22, 24, 25, and 27 containing 32 of the 41 lakes. Pooled analyses over the entire group of MS-stocked lakes and within these four lake-classes were conducted with paired Wilcoxon rank-sum tests. For the paired analyses, we first calculated the difference (D) in average CPUE following muskellunge stocking for each lake in the group, where D_i = mean $PostCPUE_i$ – mean $PreCPUE_i$ for survey i. The D values for each species in MS-stocked lakes are given in Figure 1. We then tested whether the typical D value for a group of lakes was different from zero: if $D < 0$, then CPUE following muskellunge stocking is generally lower for that group; if $D > 0$, CPUE is generally higher. Results are presented in Table 10.

All results were considered significant at the $\alpha = 0.05$ level, though the statistical power to detect small changes in CPUE was generally low because of low sample sizes within individual lakes and high variability inherent in CPUE data, both from sampling variability and natural variation in abundance. Additionally, there was considerable variation in the difference (D) of CPUE values among MS-stocked lakes (Figure 1) that hindered our ability to detect if there were small changes in CPUE over the groups of lakes. In some cases, data prior to or after the initial muskellunge

Table 2. —Mean gill net catch per unit effort (CPUE) for northern pike in individual lakes pre and post muskellunge stocking. Within quartiles indicates if the mean CPUE post muskellunge stocking is below (N), above (Y+) or contained within (Y) the interquartile range for the lake class.

Name	Lake Class	Mean CPUE Pre	Mean CPUE Post	2 tail P Value	Number of Surveys Pre	Number of Surveys Post	Within Quartiles Post
Island Reservoir	2	2.32	1.80	0.31	2	7	Y
Vermillion	2	1.34	0.98	0.08	9	22	N
Dumbbell	5						
Alexander	22	5.00	2.90	0.17	5	5	N
Bemidji	22	3.63	2.62	0.30	3	7	N
Detroit	22	12.04	6.29	**0.04***	5	4	Y
Miltona	22	5.63	4.15	0.08	3	8	Y
Minnetonka	22	5.94	11.83	**0.04***	3	12	Y+
Pelican	22	9.64	6.80	0.13	3	8	Y
Plantagenet	22	4.66	3.00	0.38	3	4	Y
St. Croix	22		0.46	na	0	3	N
White Bear	22	6.21	8.93	0.70	3	6	Y+
Elk	23	6.30	3.30	0.29	1	4	Y
Bald Eagle	24	3.11	4.78	0.31	4	4	Y
Eagle	24	5.28	7.04	0.70	3	6	Y
East Rush	24	2.20	2.58	1.00	1	8	Y
Forest	24	4.69	5.96	0.92	7	4	Y
Fox	24	0.56	0.19	0.40	16	7	N
French	24		1.75	na	0	7	Y
Harriet	24	5.10	0.64	**0.03***	4	7	N
Independence	24	1.50	3.31	0.24	2	8	Y
Owasso	24	4.59	3.73	0.44	8	4	Y
Pleasant	24	0.60	0.70	1.00	1	6	N
Sugar	24	0.89	17.92	0.24	1	5	Y+
Beers	25	2.82	1.64	0.77	2	3	N
Big Mantrap	25		5.21	na	0	7	Y
Cedar	25	5.11	5.20	1.00	5	2	Y
Cross	25	0.53	1.35	0.30	4	7	N
Lobster	25	1.70	8.00	na	1	8	Y
North star	25	4.10	3.13	0.47	4	4	Y
West Rush	25	2.30	1.51	0.17	1	8	N
Zumbro	25		1.45	na	0	2	N
Mille Lacs	26	2.81	1.28	**0.001***	11	21	Y
Big	27	7.96	12.94	0.19	2	7	Y+
Shamineau	27	5.55	7.01	0.54	4	5	Y
Waconia	27	1.86	1.13	0.17	5	6	N
West Battle	27	1.27	6.80	0.16	1	9	Y
Round	29	6.80	6.80	1.00	3	1	Y
Little Wolf	31	0.47	0.78	1.00	3	4	N
Island	32	1.72	3.57	0.14	5	5	Y
Oscar	38	3.07	2.20	0.77	3	5	Y

Table 3. —Mean gill net catch per unit effort (CPUE) for walleye in individual lakes pre and post muskellunge stocking. Within quartiles indicates if the mean CPUE post muskellunge stocking is below (N), above (Y+) or contained within (Y) the interquartile range for the lake class.

Name	Lake Class	Mean CPUE Pre	Mean CPUE Post	2 tail P Value	Number of Surveys Pre	Number of Surveys Post	Within Quartiles Post
Island Reservoir	2	7.55	7.92	1.00	2	7	Y
Vermillion	2	12.35	14.38	0.08	10	22	Y+
Dumbbell	5	3.78	14.97	**0.05***	3	10	Y+
Alexander	22	12.18	8.44	0.40	5	5	Y
Bemidji	22	6.79	12.07	0.25	3	7	Y+
Detroit	22	7.16	6.41	0.27	5	4	Y
Miltona	22	9.51	15.63	0.92	3	8	Y+
Minnetonka	22	1.56	4.47	**0.03***	3	12	Y
Pelican	22	15.45	10.61	0.61	3	8	Y+
Plantagenet	22	4.87	14.80	**0.05***	3	4	Y+
St. Croix	22		0.90	na	0	3	N
White Bear	22	2.67	3.65	0.52	3	6	N
Elk	23	13.70	6.78	0.29	1	4	Y+
Bald Eagle	24	1.02	2.93	0.11	4	4	Y
Eagle	24	0.67	3.96	0.09	3	6	Y
East Rush	24	17.80	3.43	0.17	1	8	Y
Forest	24	2.03	4.99	**0.01***	7	4	Y
Fox	24	9.01	2.29	**0.03***	16	7	Y
French	24		2.92	na	0	7	Y
Harriet	24		8.37	na	0	7	Y+
Independence	24		9.68	na	0	8	Y+
Owasso	24	0.39	2.45	**0.05***	3	4	Y
Pleasant	24	0.40	7.44	0.21	1	6	Y+
Sugar	24	0.56	5.42	0.24	1	5	Y
Beers	25	2.94	0.47	0.15	2	3	N
Big Mantrap	25		0.19	na	0	4	N
Cedar	25	1.28	3.05	0.18	5	2	Y
Cross	25	2.60	0.61	**0.03***	4	7	N
Lobster	25	0.20	2.60	na	1	8	Y
North star	25	1.86	3.58	0.31	4	4	Y
West Rush	25	7.90	2.21	0.18	1	8	Y
Zumbro	25						
Mille Lacs	26	15.01	14.53	0.77	11	21	Y
Big	27	7.42	6.60	0.88	2	7	Y
Shamineau	27	11.70	5.36	0.07	4	5	Y
Waconia	27	1.11	7.20	**0.04***	5	6	Y
West Battle	27	10.80	6.29	0.30	1	9	Y
Round	29	0.70	2.00	na	3	1	Y
Little Wolf	31	3.02	7.35	**0.05***	3	4	Y+
Island	32	4.26	4.76	1.00	6	5	Y+
Oscar	38	3.42	8.46	**0.04***	3	5	Y+

Table 4. —Mean gill net catch per unit effort (CPUE) for yellow perch in individual lakes pre and post muskellunge stocking. Within quartiles indicates if the mean CPUE post muskellunge stocking is below (N), above (Y+) or contained within (Y) the interquartile range for the lake class.

Name	Lake Class	Mean CPUE Pre	Mean CPUE Post	2 tail P Value	Number of Surveys Pre	Number of Surveys Post	Within Quartiles Post
Island Reservoir	2	1.77	7.25	0.06	2	7	Y+
Vermillion	2	24.28	28.88	0.18	9	22	Y+
Dumbbell	5	13.36	10.49	0.50	5	10	Y
Alexander	22	22.22	46.44	**0.05***	5	5	Y
Bemidji	22	67.54	99.65	0.65	3	7	Y+
Detroit	22	4.20	2.67	0.39	5	4	N
Miltona	22	20.34	22.34	0.47	3	8	Y
Minnetonka	22	13.69	10.49	0.52	3	12	Y
Pelican	22	25.00	8.65	0.61	3	8	Y
Plantagenet	22	50.72	42.50	0.60	3	4	Y+
St. Croix	22		1.21	na	0	3	N
White Bear	22	2.28	3.13	1.00	3	6	N
Elk	23	20.00	13.58	0.72	1	4	Y
Bald Eagle	24	8.77	18.59	0.56	4	4	Y
Eagle	24	0.50	27.53	**0.03***	3	6	Y
East Rush	24	39.90	44.34	0.56	1	8	Y+
Forest	24	10.15	9.58	0.51	7	4	Y
Fox	24	24.91	9.23	0.33	16	7	Y
French	24		54.31	na	0	7	Y+
Harriet	24	64.92	76.52	0.92	4	7	Y+
Independence	24	35.28	41.94	0.90	2	8	Y+
Owasso	24	21.25	13.34	0.82	8	4	Y+
Pleasant	24	116.00	16.31	0.21	1	6	Y
Sugar	24	0.44	1.22	0.56	1	5	N
Beers	25		1.04	na	0	3	N
Big Mantrap	25		44.96	na	0	7	Y+
Cedar	25	3.22	2.50	0.56	5	2	Y
Cross	25	9.53	13.14	0.78	4	7	Y
Lobster	25	1.80	4.30	na	1	8	Y
North star	25	11.87	5.18	0.47	4	4	Y
West Rush	25	69.90	49.77	0.56	1	8	Y+
Zumbro	25	7.95	11.45	0.62	6	2	Y
Mille Lacs	26	14.38	61.05	**0.001***	11	21	Y+
Big	27	63.63	40.61	0.46	2	7	Y
Shamineau	27	24.88	10.33	0.27	4	5	Y
Waconia	27	17.91	12.56	0.52	5	6	Y
West Battle	27	7.27	17.34	0.16	1	9	Y
Round	29	8.30	8.80	na	3	1	Y
Little Wolf	31	66.07	106.17	0.38	3	4	Y+
Island	32	27.73	64.73	0.32	6	5	Y+
Oscar	38	22.30	22.82	0.55	3	5	Y+

Table 5. —Mean trap net catch per unit effort (CPUE) for bluegill in individual lakes pre and post muskellunge stocking. Within quartiles indicates if the mean CPUE post muskellunge stocking is below (N), above (Y+) or contained within (Y) the interquartile range for the lake class.

Name	Lake Class	Mean CPUE Pre	Mean CPUE Post	2 tail P Value	Number of Surveys Pre	Number of Surveys Post	Within Quartiles Post
Island Reservoir	2	0.16	0.21	0.88	2	7	N
Vermillion	2	10.75	29.72	0.15	2	20	Y
Dumbbell	5						
Alexander	22	40.90	57.20	na	4	1	Y+
Bemidji	22	0.14	0.76	0.85	3	4	N
Detroit	22	72.28	51.15	0.90	5	4	Y+
Miltona	22	17.09	27.23	0.62	2	6	Y
Minnetonka	22	62.50	96.40	0.20	3	4	Y+
Pelican	22	5.30	52.72	**0.02***	3	8	Y+
Plantagenet	22	0.08	0.40	0.15	2	3	N
St. Croix	22		1.17	na	0	3	N
White Bear	22	44.70	35.33	0.52	3	6	Y
Elk	23	14.50	38.25	0.72	1	4	Y
Bald Eagle	24	26.95	42.45	0.66	4	4	Y
Eagle	24	20.00	48.95	**0.04***	3	5	Y
East Rush	24	2.00	6.32	0.66	1	7	N
Forest	24	34.67	59.13	0.36	7	3	Y
Fox	24	3.74	3.24	0.97	16	7	N
French	24		29.49	na	0	7	Y
Harriet	24	44.08	144.93	0.07	4	7	Y+
Independence	24	11.90	34.34	0.36	2	8	Y
Owasso	24	54.63	278.13	0.14	10	4	Y+
Pleasant	24	6.10	9.50	1.00	1	5	Y
Sugar	24	5.56	51.77	0.24	1	5	Y
Beers	25	55.56	65.50	0.77	2	3	Y+
Big Mantrap	25		35.78	na	0	7	Y
Cedar	25	23.74	21.95	0.85	5	2	Y
Cross	25	4.35	5.11	0.64	4	7	N
Lobster	25	66.60	41.60	na	1	8	Y
North star	25	10.48	12.50	0.59	6	4	Y
West Rush	25	1.50	10.42	0.38	1	7	Y
Zumbro	25						
Mille Lacs	26						
Big	27		9.54	na	0	8	Y
Shamineau	27	41.50	49.87	1.00	3	3	Y+
Waconia	27	12.65	32.05	0.11	4	6	Y
West Battle	27	11.07	69.88	0.16	1	9	Y+
Round	29	286.40	78.00	na	3	1	Y+
Little Wolf	31	11.53	11.55	0.86	3	4	Y
Island	32	31.65	31.42	0.68	5	5	Y
Oscar	38	34.30	7.94	0.07	3	5	Y

Table 6. —Mean gill net net catch per unit effort (CPUE) for white suckers in individual lakes pre and post muskellunge stocking. Within quartiles indicates if the mean CPUE post muskellunge stocking is below (N), above (Y+) or contained within (Y) the interquartile range for the lake class.

Name	Lake Class	Mean CPUE Pre	Mean CPUE Post	2 tail P Value	Number of Surveys Pre	Number of Surveys Post	Within Quartiles Post
Island Reservoir	2	1.35	2.92	0.13	2	7	Y
Vermillion	2	3.51	2.97	0.14	10	22	Y
Dumbbell	5	54.40	3.55	**0.01***	5	10	Y
Alexander	22	0.98	0.58	0.34	5	5	N
Bemidji	22	3.07	6.45	**0.04***	3	7	Y+
Detroit	22	4.04	1.96	0.17	6	4	Y
Miltona	22	3.33	1.88	0.18	3	8	Y
Minnetonka	22	0.73	0.26	**0.04***	3	12	N
Pelican	22	2.69	2.26	0.90	3	8	Y
Plantagenet	22	3.95	6.83	0.11	3	4	Y+
St. Croix	22						
White Bear	22	0.77	0.23	0.09	3	6	N
Elk	23	0.70	1.00	na	1	4	Y
Bald Eagle	24	2.34	0.87	0.24	4	4	Y
Eagle	24						
East Rush	24	1.10	0.43	na	1	8	Y
Forest	24	0.18	0.02	**0.02***	7	4	N
Fox	24	0.73	0.10	0.31	16	7	N
French	24		0.11	na	0	7	N
Harriet	24	1.17	3.10	0.78	4	7	Y+
Independence	24	1.39	0.60	0.35	2	8	Y
Owasso	24	0.41	0.69	0.32	10	4	Y
Pleasant	24	1.40	0.17	0.20	1	6	N
Sugar	24		0.30	na	0	5	N
Beers	25	0.41	0.00	na	2	3	N
Big Mantrap	25		1.59	na	0	6	Y
Cedar	25	0.38	0.05	0.24	5	2	N
Cross	25	1.97	2.31	0.74	4	7	Y
Lobster	25	0.00	0.20	na	1	8	N
North star	25	0.17	0.43	0.31	4	4	N
West Rush	25	0.80	0.54	na	1	8	Y
Zumbro	25	4.81	19.28	0.24	6	2	Y+
Mille Lacs	26						
Big	27	1.76	1.63	0.88	2	7	Y
Shamineau	27	3.68	0.51	**0.04***	4	5	N
Waconia	27						
West Battle	27	1.60	1.41	0.49	1	9	Y
Round	29						
Little Wolf	31	0.33	1.23	0.22	3	4	Y
Island	32	1.14	0.96	1.00	6	5	Y
Oscar	38	0.24	0.84	0.08	3	5	Y

Table 7. —Mean gill net catch per unit effort (CPUE) for black crappies in individual lakes pre and post muskellunge stocking. Within quartiles indicates if the mean CPUE post muskellunge stocking is below (N), above (Y+) or contained within (Y) the interquartile range for the lake class.

Name	Lake Class	Mean CPUE Pre	Mean CPUE Post	2 tail P Value	Number of Surveys Pre	Number of Surveys Post	Within Quartiles Post
Island Reservoir	2	0.04	0.08	0.55	2	7	N
Vermillion	2						
Dumbbell	5						
Alexander	22						
Bemidji	22						
Detroit	22	0.54	0.73	0.71	5	4	Y
Miltona	22						
Minnetonka	22	5.12	3.86	0.35	3	12	Y+
Pelican	22	1.84	0.34	0.41	2	8	Y
Plantagenet	22						
St. Croix	22		1.53	na	0	3	Y+
White Bear	22	3.19	1.48	0.16	3	6	Y+
Elk	23						
Bald Eagle	24	14.33	19.21	1.00	4	4	Y+
Eagle	24	8.82	22.72	0.19	3	6	Y+
East Rush	24	8.50	12.26	1.00	1	8	Y
Forest	24	10.53	10.00	0.92	7	4	Y
Fox	24	5.88	10.97	**0.01***	16	7	Y
French	24		36.43	na	0	7	Y+
Harriet	24	13.65	11.38	0.64	4	7	Y
Independence	24	23.56	38.07	0.51	2	8	Y+
Owasso	24	4.43	7.05	0.19	8	4	Y
Pleasant	24	25.20	13.56	0.45	1	6	Y+
Sugar	24	0.56	2.40	0.23	1	5	N
Beers	25	1.31	1.44	1.00	2	3	Y
Big Mantrap	25		5.64	na	0	7	Y+
Cedar	25	3.98	4.15	0.91	5	2	Y+
Cross	25	1.88	2.24	1.00	4	7	Y
Lobster	25	2.80	5.03	na	1	8	Y+
North star	25						
West Rush	25	1.70	11.36	0.33	1	8	Y+
Zumbro	25	1.34	5.33	0.13	6	2	Y+
Mille Lacs	26						
Big	27						
Shamineau	27	0.98	2.47	0.46	4	5	Y
Waconia	27	19.60	13.78	1.00	5	6	Y+
West Battle	27	0.27	0.45	1.00	1	9	Y
Round	29						
Little Wolf	31						
Island	32	3.08	2.32	0.65	6	5	Y
Oscar	38	8.29	5.26	0.76	3	5	Y

Table 8. —Mean trap net catch per unit effort (CPUE) for black crappies in individual lakes pre and post muskellunge stocking. Within quartiles indicates if the mean CPUE post muskellunge stocking is below (N), above (Y+) or contained within (Y) the interquartile range for the lake class.

Name	Lake Class	Mean CPUE Pre	Mean CPUE Post	2 tail P Value	Number of Surveys Pre	Number of Surveys Post	Within Quartiles Post
Island Reservoir	2	0.73	0.57	1.00	2	6	N
Vermillion	2						
Dumbbell	5						
Alexander	22						
Bemidji	22						
Detroit	22	0.36	0.61	0.17	6	4	Y
Miltona	22						
Minnetonka	22	5.37	3.95	0.59	3	4	Y+
Pelican	22	61.90	0.40	0.18	1	8	Y
Plantagenet	22						
St. Croix	22						
White Bear	22	0.83	1.55	1.00	3	6	Y
Elk	23						
Bald Eagle	24	25.43	13.98	0.31	4	4	Y
Eagle	24	7.61	12.65	1.00	3	5	Y
East Rush	24	8.50	8.50	0.66	1	8	Y
Forest	24	4.85	2.25	0.37	7	3	Y
Fox	24						
French	24		20.50	na	0	7	Y
Harriet	24	10.95	14.79	0.92	4	7	Y
Independence	24	57.80	21.23	0.18	1	8	Y+
Owasso	24	15.57	10.10	0.94	10	4	Y
Pleasant	24	15.30	13.12	1.00	1	5	Y
Sugar	24	0.11	0.54	0.56	1	5	N
Beers	25	0.73	0.55	1.00	2	3	N
Big Mantrap	25		4.17	na	0	7	Y+
Cedar	25						
Cross	25	5.00	3.17	0.17	4	6	Y
Lobster	25						
North star	25						
West Rush	25	1.40	6.66	0.38	1	7	Y+
Zumbro	25						
Mille Lacs	26						
Big	27						
Shamineau	27						
Waconia	27	2.98	7.93	0.34	4	6	Y+
West Battle	27	0.64	0.82	0.73	1	9	Y
Round	29						
Little Wolf	31						
Island	32	5.51	9.27	0.68	5	5	Y+
Oscar	38						

Table 9. —Mean gill net net catch per unit effort (CPUE) for tullibee in individual lakes pre and post muskellunge stocking. Within quartiles indicates if the mean CPUE post muskellunge stocking is below (N), above (Y+) or contained within (Y) the interquartile range for the lake class.

Name	Lake Class	Mean CPUE Pre	Mean CPUE Post	2 tail P Value	Number of Surveys Pre	Number of Surveys Post	Within Quartiles Post
Island Reservoir	2						
Vermillion	2	12.36	12.39	0.90	10	22	Y+
Dumbbell	5						
Alexander	22						
Bemidji	22	7.28	9.31	0.25	3	7	Y+
Detroit	22	2.05	0.75	0.11	6	4	Y
Miltona	22	0.86	0.85	0.47	3	8	Y
Minnetonka	22						
Pelican	22	4.53	0.65	1.00	3	8	Y
Plantagenet	22	10.33	2.60	0.82	3	4	Y
St. Croix	22						
White Bear	22						
Elk	23	2.70	21.58	0.29	1	4	Y+
Bald Eagle	24						
Eagle	24						
East Rush	24						
Forest	24						
Fox	24						
French	24						
Harriet	24						
Independence	24						
Owasso	24						
Pleasant	24						
Sugar	24		0.63	na	0	5	Y
Beers	25						
Big Mantrap	25		0.44	na	0	6	N
Cedar	25	1.94	0.05	0.24	5	2	N
Cross	25						
Lobster	25						
North star	25	6.91	3.10	0.67	4	4	Y
West Rush	25						
Zumbro	25						
Mille Lacs	26	13.63	11.18	0.51	11	21	Y
Big	27	0.90	3.34	0.46	2	7	Y
Shamineau	27						
Waconia	27						
West Battle	27	4.20	4.33	0.48	1	9	Y
Round	29						
Little Wolf	31						
Island	32						
Oscar	38						

Figure 1. Pooled differences (D = mean Post-stocking CPUE minus mean Pre-stocking CPUE) in abundance indices following muskellunge stocking for seven fish species.

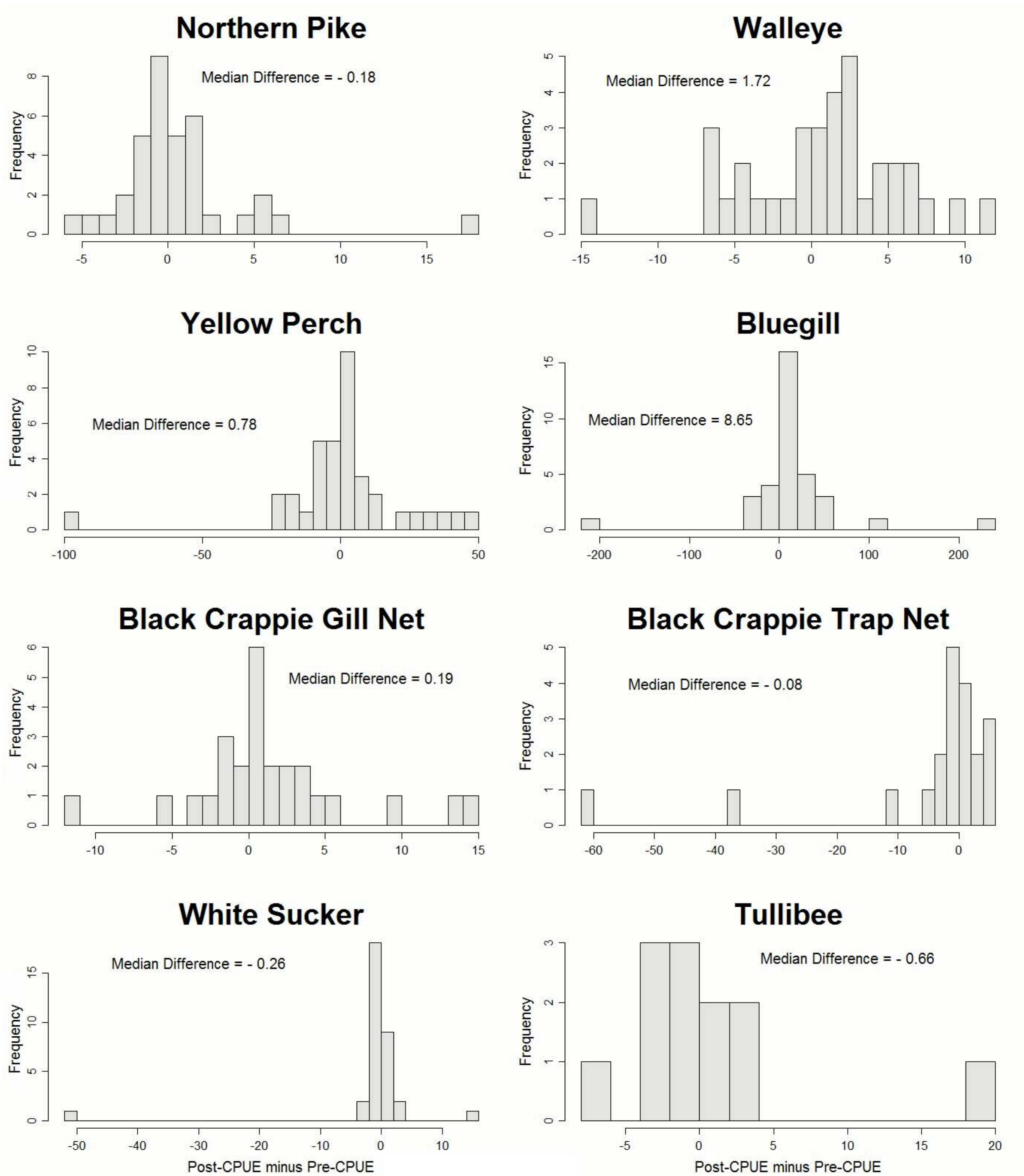

Table 10. —Mean catch per unit effort (CPUE), weight (Wt), and results of paired Wilcoxon tests for all MS-stocked lakes combined and for lake classes 22, 24, 25, and 27.

Lake Class 27	Northern Pike	Northern Pike (Wt)	Walleye	Walleye (Wt)	Yellow Perch	Bluegill	Black Crappie GN	Black Crappie TN	White Sucker	Tullibee
Mean CPUE Pre	3.87	2.58	5.82	2.06	25.52	31.45	6.59	11.58	3.20	5.64
Mean CPUE Post	4.29	2.88	6.25	2.04	26.51	41.63	8.67	7.15	1.90	5.08
Median D	-0.18	0.21	1.72	-0.15	0.78	8.65	0.19	-0.08	-0.26	-0.66
p-value	0.76	**0.02***	0.29	0.11	0.53	**0.01***	0.20	0.63	0.32	0.50
Number of lakes Pre	36	30	35	29	37	34	26	20	33	12
Number of lakes Post	40	36	40	37	41	38	29	22	36	14
Lake Class 22										
Mean CPUE Pre	6.59	2.21	7.52	1.92	25.75	30.37	2.67	17.12	2.45	5.01
Mean CPUE Post	5.22	2.43	8.55	1.50	26.34	35.82	1.59	1.63	2.56	2.83
Median D	-1.57	0.22	1.95	-0.18	-0.34	5.38	-1.38	-0.59	-0.45	-1.30
p-value	0.53	0.20	0.29	**0.05***	0.94	0.23	0.20	0.58	0.73	0.28
Number of lakes Pre	8	8	8	8	8	8	4	4	8	5
Number of lakes Post	9	9	9	9	9	9	5	4	8	5
Lake Class 24										
Mean CPUE Pre	2.85	3.17	3.99	2.04	32.21	20.96	11.55	16.24	1.09	na
Mean CPUE Post	4.42	3.72	4.90	2.39	28.45	64.39	16.74	11.77	0.64	na
Median D	0.83	1.03	2.51	0.04	2.61	23.45	3.19	-2.18	-0.65	na
p-value	0.22	**0.04***	0.62	1.00	0.76	**0.01***	0.13	0.29	0.29	na
Number of lakes Pre	10	8	8	6	10	10	10	9	8	na
Number of lakes Post	11	11	11	11	11	11	11	10	10	na
Lake Class 25										
Mean CPUE Pre	2.76	2.57	2.80	2.27	17.38	27.04	2.17	2.38	1.22	4.43
Mean CPUE Post	3.44	2.77	1.82	2.24	16.54	27.55	5.03	3.64	3.05	1.20
Median D	-0.35	-0.37	-0.14	-0.17	0.89	1.39	1.30	-0.18	0.20	-2.85
p-value	1.00	0.25	0.53	0.75	0.83	0.68	**0.04***	1.00	0.87	0.37
Number of lakes Pre	6	4	6	5	6	6	6	3	7	2
Number of lakes Post	8	6	7	7	8	7	7	4	8	3

Table 10. Continued

Lake Class 27	Northern Pike	Northern Pke (Wt.)	Walleye	Walleye (Wt.)	Yellow Perch	Bluegill	Black Crappie GN	Black Crappie TN	White Sucker	Tullibee
Mean CPUE Pre	4.16	2.28	7.76	1.97	28.42	21.74	6.95	1.81	2.35	2.55
Mean CPUE Post	6.97	2.45	6.36	1.81	20.21	40.34	5.57	4.38	1.18	3.84
Median D	3.22	-0.03	-2.67	0.05	-9.95	19.40	0.18	2.57	-0.19	1.29
p-value	0.20	1.00	0.58	1.00	0.36	0.18	1.00	0.37	0.18	0.37
Number of lakes Pre	4	4	4	4	4	3	3	2	3	2
Number of lakes Post	4	4	4	4	4	4	3	2	3	2

D = mean Post-stocking CPUE minus mean Pre-stocking CPUE for a given group of lakes.
p-value is for 2-way test of Ho: Median D = 0 using a paired Wilcoxon test.
***** indicates median D is significantly different from zero

stocking were insufficient to conduct any statistical comparisons.

As a form of control, mean CPUE was compared to statewide lake class quartiles to determine if the relative abundance of fish species in this study has differed since the introduction of muskellunge. Catches within the interquartile range (between first and third quartile values) can be viewed as normal for that lake class (Schupp 1992; see appendices for lake class quartile data). Comparisons of the proportion of muskellunge-stocked lakes within the interquartile range before and after muskellunge stocking should demonstrate whether the abundance of a given species in stocked lakes changed relative to the non-stocked lakes.

Results

For northern pike, there was no significant change in CPUE following muskellunge stocking within lake classes or for all MS-stocked lakes combined (Table 10). Mean weight of northern pike significantly increased overall for MS-stocked lakes, and within lake class 24 (Table 10). Mean northern pike CPUE declined significantly in three lakes while one lake had a significant increase (Table 2). Post-stocking CPUE was within the lake class interquartile range for 58% of the lakes, and 33% of the lakes were below the interquartile range (Table 2); this distribution is similar to years before the introduction of muskellunge when 64% of the lakes were within the interquartile range and 28% were below.

Mean walleye CPUE was not significantly different overall for the MS-stocked lakes or for pooled lake classes (Table 10). There was a significant increase in CPUE for 8 lakes following muskellunge stocking, and a decline in 2 lakes (Table 3). No significant difference was found in the mean weight of walleye across all 41 lakes, but mean weight declined slightly in lake class 22 (Table 10). There were no significant differences in mean weights in other lake classes. Mean CPUE for walleye after the introduction of muskellunge was within the interquartile range for 55% of the lakes and above the third quartile in 33% of the lakes (Table 3). This compares favorably to the years prior to muskellunge stocking when 40% were within the interquartile range and 34% were above the third quartile.

Mean CPUE of yellow perch increased in three lakes (Table 4), with no significant differences for the pooled MS-stocked lakes or lake classes (Table 10). Mean post-stocking CPUE was within the interquartile range 51% of the time and above the third quartile in 37% of the cases (Table 4) compared to 51% and 35%, respectively, for pre-stocked years.

Following muskellunge stocking, bluegill trap net CPUE significantly increased for the entire group of 41 lakes and within lake class 24 (Table 10). Two lakes had significant increases in mean bluegill CPUE following muskellunge introduction (Table 5). Mean post-stocking CPUE was within the interquartile range for the lake class 54% of the time compared to 59% before muskellunge were stocked. Mean CPUE was above the third quartile for the lake class 26% of the time after muskellunge were stocked (Table 5) compared to 15% before muskellunge were stocked.

Post-stocking white sucker CPUE was not significantly different from pre-stocking years across all 41 lakes or within lake classes (Table 10). Mean white sucker CPUE declined significantly in four lakes, while one lake had a significant increase in CPUE (Table 6). Mean post-stocking CPUE was within the interquartile range 53% of the time and below in 36% of the cases (Table 6) compared to 48% and 33%, respectively, during pre-stocking years.

Relative abundance of black crappies was measured using gill nets and trap nets. Mean CPUE was not significantly different for gill nets or trap nets for all 41 lakes combined or for individual lake classes, with the exception of an increase in gill net CPUE in lake class 25 (Table 10). Mean black crappie CPUE was significantly higher in one lake sampled with gill nets (Table 7), but no significant differences in trap net CPUE were found in any lake (Table 8). Gill net catches were within the interquartile range 45% of the time and exceeded the third quartile 48% of the time (Table 7) compared to 58% and 31%, respectively, prior to muskellunge stocking. Trap net catches were within the interquartile range 59% of the time, exceeding the third quartile in 27% of the lakes (Table 8), compared to 55% and 35%, respectively, for pre-stocked years.

Mean tullibee CPUE in the pooled sample of all MS-stocked lakes and lake classes were not significantly different during post-stocking years (Table 10). Mean CPUE was not significantly different in any individual lake (Table 9). Post-stocking catches were within the interquartile range for 64% of the lakes and above in 21%. Prior to muskellunge introduction, 67% of the lakes were within the interquartile range and 33% were above.

Discussion and Management Implications

Our results indicate that fish communities in lakes actively managed for muskellunge in Minnesota continue to do well while experiencing similar variation in abundance as other Minnesota lakes. The lack of consistent declines in CPUE for any species over the group of MS-stocked lakes suggests these fish species have generally coexisted well with introduced muskellunge populations. Furthermore, comparisons with statewide lake class quartiles showed that MS-stocked lakes maintained similar abundance levels relative to non-stocked lakes.

Though muskellunge stocking doesn't appear to have a pervasive effect on fish communities, there were 16 significant increases and 9 significant declines for some species in individual lakes associated with muskellunge introduction. Even so, these changes do not imply a benefit or harm to the fishery. Unfortunately, there are not enough data for some of these lakes to determine whether muskellunge stocking was the cause of the increase or decline, or if the observed changes are spuriously correlated with the introduction of muskellunge. Many factors besides muskellunge have influenced fish communities and abundances in these lakes. Changes in fishing pressure, angler knowledge, and fishing technology along with changes to the lake environment including habitat, productivity, and climate have all played a role in shaping the fish communities that exist today. Fisheries management changes such as northern pike stocking, various walleye stocking regimes, and regulation changes have also been important influences on fish communities.

This study was intended to evaluate past management with a simple before and after muskellunge introduction comparison in all of the stocked lakes, and not to predict specific outcomes in future lakes. Precisely predicting the response of other Minnesota lakes to muskellunge stocking using these data is not technically feasible because of the natural variation inherent in all wild fish populations. We also acknowledge that the lakes in this report represent a non-random group of waters chosen based on their potential for successful muskellunge introductions, and therefore the conclusions should be applied only to other Minnesota lakes using the same guidelines.

Our results suggest the existing muskellunge management program has established muskellunge populations while generally maintaining the abundance and weight of sympatric northern pike populations. Many studies have focused on the negative relationship between northern pike and muskellunge (Dombeck et al. 1986, Inskip 1986; Inskip and Magnuson 1986; Johnson 1981; Threinen and Oehmcke 1950), with the northern pike considered to have an ecological advantage when the two species coexist, especially during early life stages (Hess and Hartwell 1978). Potential effects of northern pike on muskellunge was beyond the scope of this study, though we note quality muskellunge populations have been maintained in the presence of various densities of northern pike. Considering the failures of earlier muskellunge fry stocking and that successful muskellunge populations have been maintained with fall fingerling stocking, current management that avoids interactions during the early life stages appears to be effective for minimizing negative interactions between the two species.

Walleye and muskellunge management do not appear to be in conflict. Fayram et al. (2005) found a positive relationship between electrofishing catch rates for muskellunge and walleye in 20 Wisconsin lakes, suggesting that direct competition or predation was unlikely between these two species. This study found no significant difference in walleye CPUE following muskellunge stocking over the group of 41 lakes. Eight lakes showed significant increases in walleye CPUE after muskellunge were stocked while only 2 lakes had significant decreases. Though we did not attempt to separate the effects of muskellunge from changes in walleye stocking strategies, our data illustrate walleye populations can be maintained or improved in the presence of muskellunge.

Grant et al. (2004) found a statewide decrease in the catch rates of black crappies sampled in gill nets in Minnesota from 1982-1997. In contrast, this study showed no significant decreases in black crappie catch rates at any level, and showed an increase in gill net CPUE within lake class 25. The lack of any significant declines in black crappie CPUE in MS-stocked lakes during a 15-year period of statewide decline is evidence that muskellunge and black crappies can coexist successfully.

White sucker, tullibee, and yellow perch are important prey species for muskellunge and other predator fish species. No significant differences were found for any of the pooled data, suggesting that despite these species' importance as prey (Bozek et al. 1999), the introduction of muskellunge has not appeared to be detrimental to these species. Further, numerous study lakes did not contain tullibee and we did not find significant decreases in other potential prey species in their absence.

Muskellunge management within the state has been scientific, systematic, and conservative over the last 25 years. Research on muskellunge spawning habitat and the performance of various genetic strains has been the foundation for the current program. More consistent and specialized sampling has led to a greater understanding of muskellunge population dynamics. The lake selection process for muskellunge stocking has focused on lakes with diverse fish communities that are typically larger in acreage for the best potential for success. Improvements in muskellunge culture techniques have increased cost effectiveness while consistently producing larger fall fingerlings with higher survival rates. Still, muskellunge stocking rates have been conservative. Fall fingerling stocking has averaged only 0.37 muskellunge per surface acre annually, or about one fish per acre every three years. Minnesota has also adopted a systematic and conservative approach to muskellunge fishing regulations to reflect the primary management goal of providing trophy-fishing opportunities. As a result of this work, Minnesota is considered a destination location for muskellunge anglers throughout the country.

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Appendix A. Lake Class 2 CPUE quartile values for the species examined in this study. Values are presented by gear

Species	Gear	1st quartile	Median	3rd quartile
Black crappie	gill net	0.19	0.30	0.78
Black crappie	trap net	1.33	2.06	2.59
Bluegill	trap net	6.79	17.33	33.12
Northern pike	gill net	1.06	1.62	2.35
Walleye	gill net	3.61	6.32	10.79
White sucker	gill net	1.43	2.00	3.00
Yellow perch	gill net	1.43	4.53	6.80

Appendix B. Lake Class 5 CPUE quartile values for the species examined in this study. Values are presented by gear

Species	Gear	1st quartile	Median	3rd quartile
Walleye	gill net	2.00	5.00	9.67
White sucker	gill net	2.33	4.75	8.69
Yellow perch	gill net	1.71	5.22	14.13

Appendix C. Lake Class 22 CPUE quartile values for the species examined in this study. Values are presented by gear

Species	Gear	1st quartile	Median	3rd quartile
Black crappie	gill net	0.22	0.42	1.14
Black crappie	trap net	0.25	0.75	1.74
Bluegill	trap net	3.73	15.28	42.85
Northern pike	gill net	3.00	5.00	7.89
Tullibee	gill net	0.50	1.56	5.20
Walleye	gill net	4.01	6.61	9.63
White sucker	gill net	1.02	2.00	3.49
Yellow perch	gill net	7.06	17.14	33.87

Appendix D. Lake Class 23 CPUE quartile values for the species examined in this study. Values are presented by gear

Species	Gear	1st quartile	Median	3rd quartile
Black crappie	gill net	0.33	0.78	1.67
Bluegill	trap net	7.74	19.83	43.38
Northern pike	gill net	2.19	5.00	8.70
Tullibee	gill net	1.25	3.79	10.43
Walleye	gill net	1.00	2.37	5.00
White sucker	gill net	0.48	1.00	2.00
Yellow perch	gill net	1.48	4.55	13.81

Appendix E. Lake Class 24 CPUE quartile values for the species examined in this study. Values are presented by gear type.

Species	Gear	1st quartile	Median	3rd quartile
Black crappie	gill net	2.50	6.91	16.50
Black crappie	trap net	1.83	6.50	21.16
Bluegill	trap net	7.54	23.13	62.50
Northern pike	gill net	1.50	3.75	7.29
Tullibee	gill net	0.33	0.56	2.25
Walleye	gill net	1.17	2.82	6.33
White sucker	gill net	0.40	1.00	2.17
Yellow perch	gill net	2.00	10.50	27.94

Appendix F. Lake Class 25 CPUE quartile values for the species examined in this study. Values are presented by gear type.

Species	Gear	1st quartile	Median	3rd quartile
Black crappie	gill net	0.50	1.17	2.67
Black crappie	trap net	0.75	1.46	3.18
Bluegill	trap net	5.61	17.25	42.27
Northern pike	gill net	3.13	5.25	8.50
Tullibee	gill net	0.67	2.28	6.46
Walleye	gill net	1.25	3.00	5.50
White sucker	gill net	0.50	1.33	3.50
Yellow perch	gill net	2.50	9.00	24.17

Appendix G. Lake Class 26 CPUE quartile values for the species examined in this study. Values are presented by gear type.

Species	Gear	1st quartile	Median	3rd quartile
Northern pike	gill net	0.92	1.63	4.31
Tullibee	gill net	4.91	12.83	17.65
Walleye	gill net	3.34	8.33	14.79
White sucker	gill net	0.79	1.41	2.43
Yellow perch	gill net	9.86	18.50	57.14

Appendix H. Lake Class 27 CPUE quartile values for the species examined in this study. Values are presented by gear type.

Species	Gear	1st quartile	Median	3rd quartile
Black crappie	gill net	0.39	1.00	2.69
Black crappie	trap net	0.36	0.90	2.32
Bluegill	trap net	4.39	16.21	48.97
Northern pike	gill net	2.76	5.06	9.00
Tullibee	gill net	0.77	2.14	6.18
Walleye	gill net	3.25	5.50	8.81
White sucker	gill net	0.88	2.00	4.00
Yellow perch	gill net	7.00	18.17	46.33

Appendix I. Lake Class 29 CPUE quartile values for the species examined in this study. Values are presented by gear type.

Species	Gear	1st quartile	Median	3rd quartile
Bluegill	trap net	8.25	24.00	50.08
Northern pike	gill net	4.80	8.44	12.50
Walleye	gill net	0.50	1.50	3.00
Yellow perch	gill net	2.00	7.83	21.50

Appendix J. Lake Class 31 CPUE quartile values for the species examined in this study. Values are presented by gear type.

Species	Gear	1st quartile	Median	3rd quartile
Black crappie	trap net	0.67	1.54	3.38
Bluegill	trap net	6.14	21.50	46.60
Northern pike	gill net	3.50	6.67	10.50
Walleye	gill net	1.33	2.50	5.00
White sucker	gill net	0.50	1.38	2.67
Yellow perch	gill net	3.40	13.25	43.56

Appendix K. Lake Class 32 CPUE quartile values for the species examined in this study. Values are presented by gear type.

Species	Gear	1st quartile	Median	3rd quartile
Black crappie	trap net	0.82	2.00	3.97
Bluegill	trap net	9.50	23.00	57.33
Northern pike	gill net	3.50	6.21	8.85
Walleye	gill net	0.50	1.25	2.33
White sucker	gill net	0.33	0.75	1.67
Yellow perch	gill net	1.00	3.00	10.28

Appendix L. Lake Class 38 CPUE quartile values for the species examined in this study. Values are presented by gear type.

Species	Gear	1st quartile	Median	3rd quartile
Black crappie	gill net	1.67	6.83	17.50
Bluegill	trap net	3.51	15.92	57.13
Northern pike	gill net	2.00	4.67	10.75
Walleye	gill net	0.75	1.67	3.75
White sucker	gill net	0.50	1.08	2.25
Yellow perch	gill net	2.00	8.50	22.25

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Edited by:
Donald L. Pereira, Fisheries Research and Policy Manager
Gary Phillips