

**A COMPARISON OF SUMMER GILL NETTING AND TRAP NETTING
TO FALL TRAP NETTING FOR SAMPLING CRAPPIE
POPULATIONS IN MINNESOTA LAKES¹**

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Abstract. --Summer (June through August) gill netting and trap netting for sampling black crappie *Pomoxis nigromaculatus* and white crappie *P. annularis* was compared to fall trap netting in Minnesota lakes. No clear advantage for evaluating abundance and size structure of crappie populations was evident in 40 lakes netted during both summer and fall. Catch-per-unit-effort (CPUE) of black crappie in gill nets was significantly lower than CPUE in trap nets for 2,811 surveys from the statewide data base, but white crappie CPUE in gill nets was significantly higher than CPUE in trap nets. Significantly smaller individuals of both species were captured in gill nets. Black crappie CPUE in gill nets was more precise, while black crappie CPUE in trap nets was better correlated with angler catch per hour and harvest per hectare. White crappie CPUE in gill nets was also more precise, but neither CPUE in gill nets nor in trap nets was significantly correlated with angler catch indices. A negative correlation existed between net catch length frequencies and angler harvest length frequencies. Catch distributions of black crappie in gill nets was less positively skewed than catch distributions in trap nets in summer or fall. Skewness of catch distributions and coefficient of variation of black crappie CPUE in trap nets were significantly affected by the number of locations sampled. Trap net catches in lakes where less than seven locations were sampled appeared not to be representative of the true population. Length-frequency distributions of black crappie differed significantly between gear in 42% of the sampled lakes, and length-frequency distributions of white crappie differed significantly in 70% of the lakes. Fall trap netting caught a larger range of lengths than summer gill netting or trap netting, and crappie > 254 mm or < 76 mm were more likely to be caught. Fall trap netting should be considered in large deep lakes when the summer survey catch is inadequate.

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Introduction

Populations of black crappie *Pomoxis nigromaculatus* and white crappie *P. annularis* in Minnesota lakes have been sampled during standard lake surveys with experimental gill nets since 1935 and trap nets since 1951 (Schupp 1992). Most lake surveys have been done during summer (June through August) because net catches were thought to be less variable than net catches during spring or fall (Scidmore 1970). Many species move less in summer and age 0-fish would not reach sizes susceptible to capture (Scidmore 1970).

Studies elsewhere have shown that catch-per-unit-effort (CPUE) of black crappie and white crappie in trap and gill nets varied among months sampled. CPUE of both crappie species in gill nets and trap nets in Iowa impoundments varied substantially among months, however, seasonal trends were not observed (McWilliams et al. 1974). Kelley (1953) reported that black crappie CPUE in trap nets set in the backwaters of Pool 8 of the Mississippi River was significantly higher in spring and fall than in summer, but white crappie CPUE did not differ significantly among seasons. CPUE of stock-sized black crappie in trap nets in a natural South Dakota lake was also significantly higher in spring and fall than during summer (Guy and Willis 1991).

Spring or fall trap netting accurately reflected age and size structures, and densities of black and white crappie caught by angling in some impoundments. Black crappie CPUE during spring and fall were significantly correlated with catch rates of black crappie by anglers during the same seasons (McInerny 1988). Length frequencies of black crappie caught in 19 mm bar mesh trap nets and by anglers in spring, and in 25 mm mesh trap nets and by anglers in fall did not significantly differ (McInerny 1988). White crappie CPUE in fall or spring trap netting were significantly correlated with angler harvest in Missouri and Mississippi reservoirs (Colvin and Vasey 1986; Colvin 1991; Miranda 1990). Boxrucker and Ploskey (1988) reported that fall trap netting provided higher catch and better estimates of age and size structure of white crappie populations in Oklahoma reser-

voirs than spring trap netting, spring or fall electrofishing, or fall gill netting. Effectiveness of summer gill and trap netting to estimate abundance and size structure of black and white crappie populations in natural Minnesota lakes has not been determined.

Study objectives were to determine how well summer gill and trap netting reflected abundance and size structure of black and white crappie populations in Minnesota lakes, and to compare summer net catches to fall trap net catches.

Methods

Data Collection

Three data sets were used to evaluate summer gill and trap netting of black and white crappie. Data on CPUE and mean weight (total pounds/total number of crappie caught per lake) in experimental gill and trap nets set during summer (June through August) were acquired from the statewide data base. This data base contained records from standard lake surveys and assessments conducted in Minnesota lakes between 1951 and 1989 (Schupp 1992). Black crappie were caught in 2,811 surveys and white crappie in 280 surveys.

Black and white crappie populations in 40 lakes (21 to 442 hectares; 1.2 to 33 m deep) were sampled with trap nets during fall 1989, 1990, or 1991 (Table 1). Fifteen locations equidistant from each other within each lake were netted. All captured crappie were identified, and total lengths were measured to the nearest mm. Scales from five individuals from each 1-cm length group were removed and aged. Age-0 crappie were identified by aging scale impressions made on acetate strips.

Data from standard lake surveys or assessments done in the same 40 lakes during the summer (June, July, or August) of the same year were obtained from management. Data included number of gill and trap net sets, number of black and white crappie per gill and trap net lift, and length-frequency distributions (13 mm length groups if < 304 mm; 25 mm length groups if \geq 304 mm) of each crappie species in gill and trap nets. Two to 12 locations within each lake were sampled with experimental gill

Table 1. Maximum depth (m) and surface area (hectares) of 40 Minnesota lakes sampled for black and white crappie during 1989, 1990, or 1991.

Lake	County	Year sampled	Maximum depth	Surface Area
Crystal	Blue Earth	1991	3.0	154
Duck	Blue Earth	1990	7.6	117
George	Blue Earth	1990	8.5	32
Loon	Blue Earth	1991	2.1	305
Mountain	Cottonwood	1990	2.4	88
Andrew	Douglas	1991	24.4	393
Blackwell	Douglas	1990	12.5	113
Freeborn	Douglas	1990	5.5	98
Maple	Douglas	1991	23.8	330
Oscar	Douglas	1990	5.8	255
Pocket	Douglas	1990	10.7	111
Clear	Jackson	1990	2.7	183
Fish	Jackson	1990	8.2	116
Round	Jackson	1990	2.7	414
Andrew	Kandiyohi	1990	7.9	329
Carrie	Kandiyohi	1989	7.9	33
Elizabeth	Kandiyohi	1991	2.7	427
Florida	Kandiyohi	1991	12.2	273
Games	Kandiyohi	1991	12.8	208
Henderson	Kandiyohi	1991	12.8	30
Little Bass	Kandiyohi	1989	9.1	21
Long	Kandiyohi	1990	13.7	116
Emily	Lesueur	1990	11.3	110
Rays	Lesueur	1990	9.8	63
Big Swan	Meeker	1989	9.8	254
Betsy	Meeker	1989	8.8	60
Dunn	Meeker	1991	6.1	57
Long	Meeker	1989	8.5	66
Richardson	Meeker	1989, 1991	14.3	45
Union	Meeker	1989	10.6	36
First Fulda	Murray	1989	2.7	48
Sarah	Murray	1989	1.2	442
Scandinavian	Pope	1991	14.9	160
Fox	Rice	1991	14.3	125
Horseshoe	Stearns	1990	17.4	223
Cedar	Wright	1991	32.9	339
French	Wright	1990	15.2	134
Granite	Wright	1991	10.4	137
Ida	Wright	1990	7.9	32
Pleasant	Wright	1991	22.6	206

nets and 3 to 14 locations with trap nets. Generally, more locations were sampled in larger lakes.

Summer gill and trap netting was also done in conjunction with creel surveys on 32 lakes. Most creel surveys were conducted between mid-May and late September-early October. Fishing pressure was estimated from angler counts. Numbers of harvested black and white crappie were estimated from angler interviews (Malvestuto 1983). Madison Lake, Blue Earth County, was the only lake where sufficient numbers of black and white crappie were mea-

sured during a creel survey, and where both species were captured in trap and gill nets.

Experimental gill nets used in this study were 76 m long by 1.8 m deep, and consisted of five 15.2 m panels of 38, 51, 64, 76, and 102 mm mesh stretch. Trap nets consisted of a single 0.9 x 12.2 m lead attached to a double 0.9 x 1.8 m frame with a codend consisting of five 0.8 m diameter hoops. Mesh size of all trap nets was 19 mm bar mesh. Gill nets were set on the bottom, off shore, and at or above the thermocline. Leads of trap nets were usually secured to the shore, and nets were stretched perpendicular to the shoreline. Trap nets were set off shore when water depths were too shallow to immerse the net throat or when aquatic macrophytes along the shore were so dense that the lead line of the net lead did not contact the lake bottom. All gill and trap nets were set during the day and lifted the following day.

Data Analyses

Kruskal-Wallis tests (H) were used to determine if CPUE or mean weight per lift of black crappie and white crappie differed significantly ($P \leq 0.05$) between gill and trap nets from the statewide data base (Zar 1974). Spearman's rank correlations were used to determine if associations between CPUE in gill and trap nets were significant (Zar 1974).

Mean CPUE of black and white crappie in summer gill nets, summer trap nets, and fall trap nets were calculated for each of the 40 sampled lakes. Coefficient of variation (CV) of CPUE, skewness coefficients of the catch distribution, and range of catch of each species by gear type were also calculated for each lake. Total lengths, measured in fall, were converted to English units, and grouped into 0.5-in length groups if < 12 in and into 1.0-in groups if ≥ 12 in for comparisons with standard lake survey data. Numbers of 0.5-in and 1.0-in length groups of black and white crappie in summer gill nets, summer trap nets, and fall trap nets for each lake were determined.

One way ANOVA or Kruskal-Wallis tests were used to determine if mean CPUE, mean CV of CPUE (when $CPUE \geq 1/\text{lift}$), mean skewness coefficients, mean range of catch, and

mean range of 0.5- and 1.0-in length groups among lakes differed significantly among gear-season combinations (Zar 1974). Chi-square contingency tests were used to determine if length-frequency distributions of each crappie species in summer gill and trap nets, and angler catch were significantly different. Associations among selected variables were analyzed with Spearman's rank correlations.

Influences of individual net catches on CPUE of black and white crappie were also analyzed. Effects of the high and low net catch on the variation of CPUE among lakes were determined by regression analyses. Coefficients of variation of CPUE, excluding the net with the highest catch, were compared with CV of CPUE including all catches for each netting at each lake. Analysis of variance or Kruskal-Wallis tests were used to determine if CV (when CPUE $\geq 1/\text{lift}$) including and excluding the highest net catch among lakes significantly differed. The highest net catch was interpreted to affect CV of CPUE if CV including the highest net catch differed significantly from CV excluding the highest net catch.

Results

Summer Gill Netting Vs Summer Trap Netting

Statewide Database.--Gill nets caught significantly fewer and smaller black crappie, but caught significantly more and smaller white crappie than summer trap net sets (Tables 2 and 3). CPUE of black crappie in gill nets was significantly correlated with CPUE of black crappie in trap nets, and CPUE of white crappie in gill nets was significantly correlated with CPUE of white crappie in trap nets (Table 4).

Summer Surveys and Assessments, 1989-1991

Black crappie were caught in gill nets in 36 lakes and in trap nets in 39 of the 40 sampled lakes (Table 5). White crappie were caught in gill nets in 10 lakes and in trap nets in 11 lakes (Table 6).

Gill nets also caught fewer black and white crappie than summer trap nets in the 40 sampled lakes, but the differences were not significant

(Tables 2 and 3). CPUE in gill nets was significantly correlated with CPUE in trap nets for black crappie (Table 4). The correlation for white crappie was not significant.

Variation in net catches within lakes was inversely related to CPUE. Rank correlations between CPUE and CV of CPUE ranged from -0.61 to -0.84 (all significant, $P < 0.05$) for the four combinations of species and netting.

Relative variation was lower among lakes with high CPUE than among lakes with low CPUE for both gears. Coefficients of variation of black and white crappie CPUE in gill and trap nets were frequently below 100 when CPUE was $\geq 1/\text{lift}$, but almost always above 100 when CPUE was $< 1/\text{lift}$ (Tables 5 and 6).

Mean CV of black crappie CPUE in gill nets among lakes was lower, but did not differ significantly from mean CV in trap nets when CPUE of both gears was $\geq 1/\text{lift}$ (Table 2). Mean CV of white crappie CPUE in gill nets, however, was significantly lower than mean CV of white crappie CPUE in summer trap nets among lakes when both CPUEs were $\geq 1/\text{lift}$ (Table 3).

Catch ranges of black and white crappie in gill and trap nets were often wide (> 50), and distributions of net catches of each species in each gear were usually positively skewed (Tables 5 and 6). Mean ranges of black crappie catch in gill and trap nets among lakes did not differ significantly (Table 2). The mean range of white crappie catch in gill nets among lakes was significantly lower than the mean range of catch in trap nets (Table 3). Catch distributions of black crappie in gill nets among lakes were significantly less skewed than catch distributions in trap nets (Table 2). Skewness of white crappie catch distributions between gill and trap nets did not differ significantly among lakes (Table 3).

Length-frequency distributions of both crappie species differed between gill and trap nets. Gill nets usually caught smaller crappie than trap nets (Table 7). Length frequencies of black crappie caught in gill and trap nets differed significantly in 42% of the sampled lakes where black crappie were caught in both gear types (Table 8). Length frequencies of black crappie between gears differed significantly in

Table 2. Mean catch-per-unit-of-effort, mean weight per fish, mean coefficient of variation of CPUE (when CPUE $\geq 1/\text{lift}$), mean skewness coefficients of catch distributions, mean range of net catches (when CPUE $\geq 1/\text{lift}$), and mean range of 12.7 mm (0.5-in) and 25.4 mm (1.0-in) length groups of black crappie among Minnesota lakes during summer gill netting (SGN) and summer trap netting (STN), summer gill netting and fall trap netting (FTN), and summer trap netting and fall trap netting.

Variable	Means		Statistic	df	P
<i>Summer gill netting versus summer trap netting</i>					
Catch-per-unit-effort ^a	SGN = 8.1	STN = 9.6	H = 6.00	1	0.0142
Mean weight per fish (lbs) ^a	SGN = 0.30	STN = 0.35	H = 171.5	1	<0.0001
Catch-per-unit-effort ^b	SGN = 12.5	STN = 33.5	H = 1.78	1	0.1813
Coefficient of variation	SGN = 80	STN = 96	F = 3.58	1,52	0.0640
Skewness coefficient	SGN = 0.44	STN = 0.85	F = 5.48	1,66	0.0222
Range of net catches	SGN = 25	STN = 33	F = 1.25	1,52	0.2694
Range of length groups (in)	SGN = 3.2	STN = 3.9	F = 1.97	1,80	0.1638
<i>Summer gill netting versus fall trap netting</i>					
Catch-per-unit-effort	SGN = 10.8	FTN = 9.7	F = 0.12	1,80	0.7293
Coefficient of variation	SGN = 73	FTN = 128	F = 45.10	1,46	<0.0001
Skewness coefficient	SGN = 0.42	FTN = 1.52	F = 53.97	1,66	<0.0001
Range of net catches	SGN = 26	FTN = 61	H = 5.63	1	0.0177
Range of length groups (in)	SGN = 3.2	FTN = 6.0	F = 32.99	1,80	<0.0001
<i>Summer trap netting versus fall trap netting</i>					
Catch-per-unit-effort	STN = 14.4	FTN = 9.7	H = 0.50	1	0.4780
Coefficient of variation	STN = 94	FTN = 128	F = 13.10	1,46	0.0007
Skewness coefficient	STN = 0.91	FTN = 1.54	F = 13.34	1,72	0.0005
Range of net catches	STN = 35	FTN = 57	H = 1.26	1	0.2609
Range of length groups (in)	STN = 3.9	FTN = 6.0	F = 18.62	1,80	<0.0001

^a Statewide lake survey data base

^b Forty lakes, 1989-1991

Table 3. Mean catch-per-unit-of-effort, mean weight per fish, mean coefficient of variation of CPUE (when CPUE $\geq 1/\text{lift}$), mean skewness coefficients of catch distributions, mean range of net catches (when CPUE $\geq 1/\text{lift}$), and mean range of 12.7 mm (0.5-in) and 25.4 mm (1.0-in) length groups of white crappie among Minnesota lakes during summer gill netting (SGN) and summer trap netting (STN), summer gill netting and fall trap netting (FTN), and summer trap netting and fall trap netting.

Variable	Means		Statistic	df	P
<i>Summer gill netting versus summer trap netting</i>					
Catch-per-unit-effort ^a	SGN = 10.8	STN = 10.1	H = 4.21	1	0.0402
Mean weight per fish (lbs) ^a	SGN = 0.25	STN = 0.33	H = 47.5	1	<0.0001
Catch-per-unit-effort ^b	SGN = 10.8	STN = 14.3	H = 0.60	1	0.4358
Coefficient of variation	SGN = 38	STN = 98	F = 19.58	1,10	0.0013
Skewness coefficient	SGN = 0.50	STN = 0.83	H = 1.03	1	0.3099
Range of net catches	SGN = 25	STN = 157	H = 6.59	1	0.0103
Range of length groups (in)	SGN = 2.3	STN = 2.3	F = 0.00	1,24	0.9599
<i>Summer gill netting versus fall trap netting</i>					
Catch-per-unit-effort	SGN = 12.5	FTN = 4.4	H = 0.01	1	0.9181
Coefficient of variation	SGN = 38	FTN = 100	F = 11.49	1,10	0.0069
Skewness coefficient	SGN = 0.63	FTN = 1.28	F = 2.33	1,18	0.1445
Range of net catches	SGN = 25	FTN = 29	F = 0.06	1,10	0.8081
Range of length groups (in)	SGN = 2.3	FTN = 5.0	F = 7.40	1,24	0.0119
<i>Summer trap netting versus fall trap netting</i>					
Catch-per-unit-effort	STN = 33.4	FTN = 4.4	H = 1.71	1	0.1908
Coefficient of variation	STN = 113	FTN = 106	F = 0.11	1,14	0.7424
Skewness coefficient	STN = 0.86	FTN = 1.36	H = 1.40	1	0.2371
Range of net catches	STN = 125	FTN = 23	H = 4.88	1	0.0272
Range of length groups (in)	STN = 2.3	FTN = 5.0	F = 8.94	1,24	0.0064

^a Statewide lake survey data base

^b Forty lakes, 1989-1991

Table 4. Spearman's rank correlation coefficients (by crappie species) for comparisons of CPUE among summer gill netting, summer trap netting and fall trap netting, and for comparisons between CPUE determined during summer netting and angler catch per hour, and harvest per acre in Minnesota lakes.

Comparison	r	df	P
BLACK CRAPPIE			
Summer gill netting vs summer trap netting ^a	0.51	2,809	<0.01
Summer gill netting vs summer trap netting ^b	0.47	39	<0.01
Summer gill netting vs fall trap netting	0.43	39	<0.01
Summer trap netting vs fall trap netting	0.53	39	<0.01
Summer gill netting vs angler catch per hour	0.36	32	<0.05
Summer gill netting vs angler harvest per acre	0.48	32	<0.01
Summer trap netting vs angler catch per hour	0.51	24	<0.01
Summer trap netting vs angler harvest per acre	0.61	24	<0.01
WHITE CRAPPIE			
Summer gill netting vs summer trap netting ^a	0.42	278	<0.01
Summer gill netting vs summer trap netting ^b	0.52	11	>0.05
Summer gill netting vs fall trap netting	0.74	11	<0.01
Summer trap netting vs fall trap netting	0.85	11	<0.01
Summer gill netting vs angler catch per hour	0.17	7	>0.05
Summer gill netting vs angler harvest per acre	0.18	7	>0.05
Summer trap netting vs angler catch per hour	0.53	7	>0.05
Summer trap netting vs angler harvest per acre	0.58	7	>0.05

^a Statewide lake survey data base

^b Forty lakes, 1989-1991

29% of June, 35% of July, and 75% of the August samples (Table 8). Length frequencies of white crappie in gill and trap nets differed significantly in 70% of the sampled lakes, but no seasonal trend was evident (Table 8).

Summer Netting Vs Fall Trap Netting

Mean CPUE, CV of CPUE, and ranges of net catches of both crappie species in fall trap nets varied considerably among lakes (Tables 5 and 6). Catch distributions of black and white crappie in fall trap nets within each lake were all positively skewed (Tables 5 and 6).

CPUE of each crappie species in summer gill and trap nets were similar to CPUE in fall trap nets. Mean black crappie CPUE in summer gill or trap nets among lakes did not differ significantly from mean black crappie CPUE in fall trap nets (Table 2). Mean CPUE of white crappie in summer gill and trap nets among lakes were higher than CPUE of white crappie in fall trap nets, however, differences were not significant (Table 3). CPUE among each gear-season combination for both species were positively correlated and significant (Table 4).

Two notable exceptions were observed where substantially more black crappie were caught by fall trap netting than by summer netting. Fifteen total crappie were caught from both Andrew and Maple lakes in Douglas County during summer net surveys. Mean CPUE in fall trap nets was 38.6 at Andrew Lake and 8.5 at Maple Lake (Table 5). Both lakes are larger than 315 hectares and maximum depths exceed 23 m (Table 1). Net catches from Cedar Lake in Wright County were highest during summer surveys (Table 5). Cedar Lake was the deepest (32.9 m) lake netted and exceeds 315 hectares (Table 1).

Differences in CPUE of summer netting for black crappie were related to lake size and depth (Table 9). Summer gill net CPUE was significantly higher from lakes \leq 121 hectares than from lakes $>$ 121 hectares regardless of depth. Summer trap net CPUE was significantly higher from lakes \leq 121 hectares with maximum depths $>$ 9 m, but not from shallower lakes. There were no significant differences in CPUE of fall trap nets related to lake size and depth.

Variation in fall trap net catches was inversely related to CPUE for both crappie spe-

Table 5. CPUE of black crappie \geq age-1 caught in summer gill nets, summer trap nets, and fall trap nets (standard error in parentheses), coefficients of variation (CV) of CPUE, coefficient of variation of CPUE excluding the highest net catch (CVM), range of net catches, skewness coefficients of net catch distributions (Skew), and number of nets set (N) at 40 lakes in Minnesota, 1989-1991.

Lake	Summer Gill Nets				Summer Trap Nets				Fall Trap Nets			
	CPUE(SE)	CV(CVM)	Range	Skew N	CPUE(SE)	CV(CVM)	Range	Skew N	CPUE(SE)	CV(CVM)	Range	Skew N
Crystal	0.4(0.2)	137(200)	0-1	0.41 5	3.2(1.4)	112(117)	0-9	0.82 6	7.5(3.2)	165(137)	0-46	2.28 15
Duck	17.5(5.0)	69(51)	3-39	0.82 6	11.8(3.4)	58(72)	2-17	-0.84 4	2.6(0.9)	131(119)	0-12	1.50 15
George	34.2(11.0)	64(81)	3-51	-0.84 4	2.3(1.3)	99(0)	1-5	0.71 3	10.9(2.3)	81(75)	0-31	0.74 15
Loon	3.8(0.9)	45(33)	2-6	0.43 4	23.1(4.3)	52(47)	6-44	0.34 8	14.3(3.3)	90(74)	0-49	1.23 15
Mountain	1.4(0.7)	108(141)	0-3	0.21 5	18.5(11.2)	171(90)	0-95	2.09 8	4.1(1.2)	105(104)	0-13	0.91 15
Andrew (Douglas)	1.2(0.5)	91(115)	0-2	-0.41 5	0.4(0.3)	198(265)	0-2	1.56 8	38.6(12.4)	124(133)	0-126	0.84 15
Blackwell	31.8(11.2)	71(81)	6-56	-0.08 4	5.9(1.8)	85(90)	2-13	0.66 8	22.2(10.6)	185(179)	1-145	2.14 15
Freeborn	0(0)				0.2(0.2)	185(265)	0-1	1.15 8	0.8(0.4)	172(191)	0-4	1.40 15
Maple	1.6(0.5)	71(77)	0-3	-0.27 5	0.7(0.4)	133(167)	0-2	0.59 7	8.5(2.7)	123(124)	0-32	1.01 15
Oscar	5.2(1.2)	67(70)	0-10	0.17 8	7.2(2.8)	143(129)	0-36	1.70 14	2.5(1.0)	153(111)	0-15	2.44 15
Pocket	1.3(0.9)	115(141)	0-3	0.38 3	14.8(7.2)	119(129)	0-44	0.79 6	13.7(4.4)	123(128)	0-49	0.91 15
Fish	0(0)				3.8(1.3)	102(77)	0-12	1.35 8	0.9(0.4)	156(136)	0-5	1.88 15
Clear	0.2(0.2)	200(∞)	0-1	1.16 4	0.2(0.2)	282(∞)	0-2	2.27 8	0.6(0.3)	203(205)	0-4	2.13 14
Round	1.0(0.5)	122(115)	0-3	0.91 5	4.9(1.2)	71(76)	0-9	0.07 8	2.1(0.6)	100(96)	0-7	1.05 15
Andrew (Kandi.)	0(0)				0.4(0.4)	283(∞)	0-3	2.27 8	2.6(1.5)	225(137)	0-23	3.10 15
Carrie	16.0(3.0)	26(∞)	13-19	0.00 2	18.2(7.4)	91(87)	0-43	0.54 5	11.8(5.2)	172(113)	0-80	2.74 15
Elizabeth	1.6(1.2)	163(200)	0-6	1.15 5	7.2(2.5)	102(68)	1-25	1.71 10	0.6(0.3)	168(190)	0-3	1.51 14
Florida	0.5(0.3)	115(173)	0-1	0.00 4					1.1(0.4)	152(128)	0-6	2.06 15
Games	1.4(0.4)	81(79)	0-3	-0.04 5	3.0(1.7)	135(77)	0-11	1.79 6	15.3(9.3)	201(126)	0-105	2.55 11
Henderson	0(0)				10.8(4.6)	96(67)	1-28	1.00 5	2.1(0.4)	79(70)	0-6	0.92 15
Little Bass	1.0(1.0)	141(∞)	0-2	0.00 2	1.8(0.9)	107(82)	0-5	1.02 5	0.2(0.1)	280(374)	0-2	2.62 15
Long (Kandi.)	7.3(4.0)	93(61)	2-15	0.56 3	9.0(3.9)	138(154)	1-33	1.46 10	0.5(0.2)	172(177)	0-3	1.63 15
Emily	61.3(16.1)	64(38)	26-135	1.18 6	114.0(23.4)	106(22)	78-158	0.35 3	80.3(29.2)	141(147)	0-338	1.38 15
Rays	40.0(8.5)	52(42)	20-74	0.66 6	13.8(6.3)	91(123)	1-25	-0.05 4	6.7(2.1)	121(119)	0-26	1.15 15
Big Swan	18.8(5.1)	95(101)	0-46	0.24 12	1.4(0.6)	129(153)	0-4	0.72 8	1.9(0.6)	121(124)	0-7	1.29 15
Betsy	11.3(3.6)	78(70)	4-26	0.72 6	5.2(2.3)	97(47)	1-14	1.27 5	7.3(2.5)	134(80)	0-40	2.65 15
Dunn	14.7(3.6)	59(42)	5-30	0.84 6	11.2(3.9)	70(88)	0-18	-0.83 4	5.9(1.5)	100(91)	0-21	1.35 15
Long (Meeker)	8.5(3.4)	99(48)	3-25	1.52 6	4.2(1.4)	65(75)	1-7	-0.19 4	12.7(4.8)	146(142)	0-62	1.55 15
Richardson(1989)	60.7(9.4)	38(31)	32-97	0.40 6	31.0(14.7)	95(49)	11-74	0.99 4	15.3(5.1)	128(121)	0-66	1.37 15
Richardson(1991)	19.8(5.5)	68(52)	9-43	0.88 6	46.5(21.9)	94(100)	1-103	0.36 4	6.7(2.2)	129(135)	0-25	1.26 15
Union	6.5(1.8)	69(69)	0-13	0.00 6	1.8(0.9)	98(100)	0-4	0.43 4	0.7(0.3)	146(152)	0-3	1.18 15
First Fulda	10.0				32.8				19.9(3.2)	63(57)	1-48	0.60 15
Sarah	2.2				14.0				8.3(3.7)	170(122)	0-55	2.59 15
Scandinavian	1.8(0.5)	61(67)	0-3	-0.87 5	0.1(0.1)	283(∞)	0-1	2.27 8	0.5(0.1)	111(120)	0-1	0.13 15
Fox	2.0(1.1)	108(100)	0-5	0.69 4	0.2(0.2)	200(∞)	0-1	1.15 4	0(0)			
Horseshoe	4.0(1.8)	118(80)	1-14	1.59 7	21.3(6.1)	91(78)	2-64	1.18 10	29.3(5.8)	77(70)	4-82	0.96 15
Cedar	3.8(1.3)	95(82)	0-11	1.12 8	5.0(1.8)	112(84)	0-19	1.64 10	0.6(0.32)	164(176)	0-3	1.33 15
French	22.5(3.2)	35(24)	13-36	0.69 6	112.7(16.6)	36(38)	58-154	-0.23 6	31.2(9.7)	121(121)	0-117	1.38 15
Granite	14.5(3.0)	50(52)	6-23	0.00 6	9.4(3.9)	109(49)	2-32	1.78 7	2.9(1.1)	143(139)	0-14	1.50 15
Ida	13.5(4.0)	72(60)	3-30	0.68 6	8.0(1.6)	41(35)	4-12	0.00 4	2.5(0.8)	121(124)	0-9	0.93 15
Pleasant	0.8(0.3)	90(91)	0-2	0.23 6	8.5(2.1)	78(70)	0-22	0.78 10	0.9(0.5)	209(232)	0-6	2.01 15

^a Nets vandalized or tipped by high winds were not reset.

Table 6. CPUE of white crappie \geq age-1 in summer gill nets, summer trap nets, and fall trap nets (standard error in parentheses), coefficient of variation (CV) of CPUE, coefficient of variation of CPUE excluding highest net catch (CVM), range of net catches, skewness coefficients of net catch distributions (Skew), and number of nets set (N) at 40 lakes in Minnesota.

Lake	Summer gill nets				Summer trap nets				Fall trap nets			
	CPUE(SE)	CV(CVM)	Range	Skew N	CPUE(SE)	CV(CVM)	Range	Skew N	CPUE(SE)	CV(CVM)	Range	Skew N
Duck	43.8(13.6)	76(38)	16-108	1.40 6	84.0(46.0)	110(121)	8-208	0.57 4	1.9(0.4)	88(78)	0-6	0.82 15
Mountain Round	0.4(0.2)	137(200)	0-1	0.41 5	11.5(5.2)	128(127)	0-41	1.14 8	1.7(0.6)	122(125)	0-6	0.91 15
Carrie	65.0(6.0)	13(∞)	59-71	0.00 2	0.2(0.2)	185(265)	0-1	1.15 8	0.7(0.6)	146(152)	0-3	1.18 15
Elizabeth	0.4(0.4)	224(∞)	0-1	1.50 5	5.6(3.1)	124(116)	0-17	0.94 5	4.7(1.2)	103(97)	0-16	1.07 15
Emily	0.2(0.2)	249(332)	0-2	1.79 6	3.7(2.3)	189(213)	0-20	1.73 3	1.0(0.3)	131(132)	0-4	0.87 15
Big Swan	0.2(0.2)	36(35)	6-15	0.30 6	0.6(0.3)	147(184)	0-2	0.80 8	0.3(0.2)	185(199)	0-2	1.61 15
Dunn	10.5(1.5)	0(0)	0-2	2.22 12	146.3(86.7)	119(85)	15-398	0.95 4	0.4(0.3)	264(254)	0-4	2.91 15
Long (Meeker)	0(0)	43(40)	5-19	-0.17 6	1.0(0.7)	141(173)	0-3	0.82 4	8.1(1.4)	66(65)	0-18	0.42 15
Richardson(1989)	12.0(2.1)	33(30)	7-17	0.14 4	68.2(25.0)	73(63)	22-134	0.49 4	0.2(0.1)	280(374)	0-2	2.62 15
Richardson(1991)	11.7(1.6)	0.2	18.7(2.1)	27(29)	86.0(41.6)	97(61)	19-206	0.90 4	7.9(3.8)	176(148)	0-52	2.39 15
Sarah	0.2	18.7(2.1)	9-23	-1.33 6	1.6	62(61)	6-47	-0.03 6	20.6(4.1)	77(78)	0-47	0.40 15
French	18.7(2.1)	27(29)	9-23	-1.33 6	25.7(6.4)	62(61)	6-47	-0.03 6	0.3(0.2)	223(254)	0-2	2.04 15
									10.1(2.3)	89(72)	0-35	1.41 15

^a Nets vandalized or tipped by high winds were not reset.

Table 7. Ranges of 0.5- and 1.0-in length groups (smallest to largest fish) of black crappie and white crappie caught in gill (SGN) and trap nets (STN) set during summer, and trap nets set in fall (FTN) at 40 Minnesota lakes, 1989-1991.

Lake	County	Length range (Smallest to largest fish)		
		SGN	STN	FTN
BLACK CRAPPIE				
Crystal	Blue Earth	0.0(9.0)	6.0(4.0 to 10.0)	7.5(3.0 to 10.5) ^a
Duck	Blue Earth	4.5(4.0 to 8.5)	3.5(6.0 to 9.5)	6.5(3.0 to 9.5) ^a
George	Blue Earth	2.5(6.0 to 8.5)	1.0(7.0 to 8.0)	6.5(3.5 to 10.0) ^a
Loon	Blue Earth	2.0(7.5 to 9.5)	4.0(7.0 to 11.0)	7.5(3.0 to 10.5) ^a
Mountain	Cottonwood	1.5(7.5 to 9.0)	4.5(6.0 to 10.5)	8.0(3.0 to 11.0) ^a
Andrew	Douglas	2.5(8.5 to 11.0)	5.0(6.0 to 11.0)	8.0(4.0 to 12.0)
Blackwell	Douglas	5.0(5.0 to 10.0)	6.0(4.0 to 10.0)	6.0(4.5 to 10.5)
Freeborn	Douglas	0.0	0.5(8.5 to 9.0)	5.5(8.5 to 13.0)
Maple	Douglas	4.0(4.5 to 8.5)	0.0(5.0)	7.5(3.0 to 10.5)
Oscar	Douglas	6.5(4.0 to 10.5)	7.5(4.5 to 12.0)	7.5(4.5 to 12.0)
Pocket	Douglas	2.5(4.5 to 7.0)	7.0(3.5 to 10.5)	8.5(2.5 to 11.0) ^a
Clear	Jackson	0.0(8.0)	1.5(9.0 to 10.5)	2.5(8.0 to 10.5)
Fish	Jackson	0.0	5.5(5.5 to 11.0)	7.5(2.5 to 10.0) ^a
Round	Jackson	1.5(10.5 to 12.0)	4.0(10.0 to 14.0)	12.5(2.5 to 15.0) ^a
Andrew	Kandiyohi	0.0	4.0(7.0 to 11.0)	6.0(4.5 to 10.5)
Carrie	Kandiyohi	5.5(4.0 to 9.5)	3.5(4.5 to 8.0)	4.5(5.0 to 9.5)
Elizabeth	Kandiyohi	3.5(4.0 to 7.5)	7.5(4.0 to 11.5)	8.5(3.0 to 11.5) ^a
Florida	Kandiyohi	1.0(7.0 to 8.0)	0.0	9.5(3.5 to 13.0) ^a
Games	Kandiyohi	3.5(4.0 to 7.5)	5.5(3.5 to 9.0)	6.0(4.0 to 10.0)
Henderson	Kandiyohi	0.0	4.5(7.5 to 12.0)	4.5(7.5 to 12.0)
Little Bass	Kandiyohi	0.5(4.0 to 4.5)	3.5(3.5 to 7.0)	5.0(3.5 to 8.5) ^a
Long	Kandiyohi	3.5(4.5 to 8.0)	3.0(6.5 to 9.5)	2.5(6.0 to 8.5)
Emily	Lesueur	4.0(4.0 to 8.0)	4.0(4.0 to 8.0)	3.5(5.0 to 8.5)
Rays	Lesueur	4.0(4.0 to 8.0)	3.5(4.5 to 8.0)	5.0(3.5 to 8.5) ^a
Big Swan	Meeker	3.0(7.5 to 10.5)	1.0(8.0 to 9.0)	1.0(8.0 to 9.0)
Betsy	Meeker	5.5(5.5 to 11.0)	4.0(6.5 to 10.5)	7.5(3.0 to 10.5) ^a
Dunn	Meeker	5.5(4.0 to 9.5)	2.5(6.5 to 9.0)	7.0(3.0 to 10.0) ^a
Long	Meeker	4.0(4.0 to 8.0)	2.5(6.0 to 8.5)	7.0(5.0 to 12.0)
Richardson(89)	Meeker	6.5(4.0 to 10.5)	3.5(6.0 to 9.5)	4.0(5.0 to 9.0)
Richardson(91)	Meeker	4.0(5.5 to 9.5)	2.0(7.0 to 9.0)	7.0(3.5 to 10.5) ^a
Union	Meeker	4.0(4.0 to 8.0)	5.0(4.0 to 9.0)	3.0(5.0 to 8.0)
First Fulda	Murray	2.5(5.5 to 8.0)	4.5(5.5 to 10.0)	4.5(6.0 to 10.5)
Sarah	Murray	6.5(4.5 to 11.0)	4.5(7.5 to 12.0)	7.0(6.0 to 13.0)
Scandinavian	Pope	1.5(5.0 to 6.5)	0.5(5.5 to 6.0)	7.0(3.5 to 10.5)
Fox	Rice	4.0(6.0 to 10.0)	0.0(6.5)	0.0
Horseshoe	Stearns	5.0(3.5 to 8.5)	6.5(3.5 to 10.0)	6.0(4.0 to 10.0)
Cedar	Wright	6.0(5.0 to 11.0)	4.5(5.0 to 9.5)	7.5(3.0 to 10.5) ^a
French	Wright	4.5(4.0 to 8.5)	5.0(4.5 to 9.5)	6.0(6.0 to 12.0)
Granite	Wright	5.5(4.0 to 9.5)	6.5(4.0 to 10.5)	6.0(4.5 to 10.5)
Ida	Wright	4.5(4.5 to 9.0)	4.0(6.0 to 10.0)	3.0(6.5 to 9.5)
Pleasant	Wright	2.0(7.0 to 9.0)	7.5(3.5 to 11.0)	6.5(4.5 to 11.0)
WHITE CRAPPIE				
Duck	Blue Earth	3.0(6.0 to 9.0)	2.0(6.5 to 8.5)	2.5(7.0 to 9.5)
Mountain	Cottonwood	1.0(8.0 to 9.0)	3.0(7.5 to 10.5)	6.5(4.0 to 10.5) ^a
Round	Jackson	0.0	0.0(9.5)	9.0(2.5 to 11.5) ^a
Carrie	Kandiyohi	4.5(4.0 to 8.5)	4.0(4.5 to 8.5)	4.0(5.5 to 9.5)
Elizabeth	Kandiyohi	1.0(5.5 to 6.5)	4.5(7.5 to 12.0)	8.5(3.0 to 11.5) ^a
Emily	Lesueur	0.0(8.0)	0.0	5.5(6.5 to 12.0)
Big Swan	Meeker	1.5(8.0 to 9.5)	1.0(8.0 to 9.0)	1.0(8.5 to 9.5)
Dunn	Meeker	4.0(5.0 to 9.0)	2.0(6.5 to 8.5)	7.0(3.5 to 10.5) ^a
Long	Meeker	0.0	1.0(11.0 to 12.0)	3.0(8.0 to 11.0)
Richardson(89)	Meeker	4.5(4.5 to 9.0)	4.0(6.0 to 10.0)	4.5(5.0 to 9.5)
Richardson(91)	Meeker	5.0(4.0 to 9.0)	3.0(7.0 to 10.0)	8.5(3.0 to 11.5) ^a
Sarah	Murray	0.0(10.0)	0.5(9.0 to 9.5)	1.0(10.0 to 11.0)
French	Wright	5.5(4.5 to 10.0)	4.5(4.5 to 9.0)	3.5(5.5 to 9.0)

^a denotes age-0 crappie captured

Table 8. Chi-square statistics (χ^2) and probabilities (P) that length frequencies of black and white crappie caught in gill nets (SGN) and trap nets (STN) set in 40 Minnesota lakes during summer surveys were from the same population, 1989-1991.

Lake	Month sampled	Chi square statistics			Sample size	
		χ^2	df	P	SGN	STN
BLACK CRAPPIE						
Crystal	June	2.432	5	0.7868	2	19
Duck	June	9.815	7	0.1993	101	47
George	June	0.582	5	0.9888	114	4
Loon	July	10.690	8	0.2198	15	140
Mountain	July	6.392	9	0.7001	7	148
Andrew	June	3.750	4	0.4409	6	3
Blackwell	August	53.170	11	<0.0001	127	47
Freeborn	July				0	2
Maple	June	6.964	4	0.1378	8	5
Oscar	August	33.810	15	0.0036	42	101
Pocket	July	24.210	9	0.0040	4	89
Clear	July	3.000	2	0.2231	1	2
Fish	July				0	30
Round	August	4.423	6	0.6196	5	39
Andrew	June				0	3
Carrie	July	7.860	9	0.5483	91	25
Elizabeth	June	36.990	13	0.0004	6	67
Florida	July				2	0
Games	June	4.675	6	0.5861	6	18
Henderson	June				0	54
Little Bass	July	1.877	3	0.5983	2	9
Long	June	27.920	8	0.0005	22	90
Emily	July	12.750	6	0.0471	162	145
Rays	August	14.520	7	0.0426	240	55
Big Swan	August	7.400	6	0.2844	211	11
Betsy	August	40.400	10	<0.0001	68	26
Dunn	June	6.649	8	0.5749	80	28
Long	June	16.570	8	0.0349	50	17
Richardson(89)	June	9.532	12	0.6569	364	26
Richardson(91)	June	6.008	6	0.4222	87	86
Union	August	19.850	8	0.0109	38	7
First Fulda	June	29.860	7	0.0001	20	164
Sarah	August	26.910	9	0.0014	9	69
Scandinavian	July	1.477	3	0.6876	9	2
Fox	July	0.900	3	0.8254	8	1
Horseshoe	July	36.820	13	0.0004	27	109
Cedar	June	17.520	10	0.0637	30	50
French	July	19.290	10	0.0368	136	185
Granite	July	20.260	10	0.0269	87	66
Ida	July	17.870	10	0.0571	79	32
Pleasant	July	10.700	12	0.5552	5	85
WHITE CRAPPIE						
Duck	June	24.560	6	0.0004	150	142
Mountain	July	1.176	6	0.9781	2	92
Round	August				0	2
Carrie	July	20.050	9	0.0179	86	28
Elizabeth	June	33.000	10	0.0003	2	31
Emily	July				1	0
Big Swan	August	2.300	3	0.5100	3	5
Dunn	June	10.150	7	0.1803	63	67
Long	June				0	4
Richardson(1989)	June	64.870	10	<0.0001	61	134
Richardson(1991)	June	48.940	10	<0.0001	32	118
Sarah	August	9.000	2	0.0111	1	8
French	July	42.690	9	<0.0001	112	120

Table 9. Geometric means of CPUE of black crappie caught in summer gill nets, summer trap nets, and fall trap nets in relation to lake area and maximum depth, 1989-1991.

Gear	≤ 120 hectares	> 120 hectares
	Maximum depth ≤ 9.1 m	
Summer gill nets	8.08 ^a	1.72
Summer trap nets	5.15	3.40
Fall trap nets	3.75	2.47
	Maximum > 9.1 m	
Summer gill nets	16.60 ^a	2.84
Summer trap nets	14.83 ^a	2.87
Fall trap nets	6.14	4.46

^a $P \leq 0.05$

cies. Significant rank correlations ($P < 0.05$) between CPUE and CV of CPUE were -0.34 for black crappie and -0.86 for white crappie.

Variation of catch in summer gill and trap nets was usually lower than variation in fall trap nets. Mean CV of black crappie CPUE in summer gill and trap nets among lakes (where $CPUE \geq 1/\text{lift}$) were both significantly lower than CV of black crappie CPUE in fall trap nets (Table 2). Mean CV of white crappie CPUE in summer gill nets among lakes was also significantly lower than CV of white crappie CPUE in fall trap nets, however, CV of white crappie CPUE in summer and fall trap nets among lakes did not significantly differ (Table 3).

Net catch ranges and distributions were usually smaller during summer gill and trap netting than during fall trap netting. Mean range of black crappie catch in summer gill nets among lakes was significantly lower than mean range of catch in fall trap nets, but mean range of black crappie catch in summer and fall trap nets among lakes were not significantly different (Table 2). Mean range of white crappie catch in summer gill nets and fall trap nets among lakes were not significantly different, but mean range of catch in summer trap nets was significantly higher than mean range of catch in fall trap nets (Table 3).

Skewness coefficients of black crappie catch in summer gill and trap nets were significantly lower than skewness coefficients of black crappie catch in fall trap nets (Table 2). Skewness coefficients of white crappie catch in summer

gill and trap nets, and fall trap nets were not significantly different (Table 3).

Summer gill and trap netting caught narrower length ranges of black and white crappie than fall trap netting. Mean ranges of 13 and 25 mm length groups of black and white crappie in summer gill and trap nets were significantly smaller than mean ranges of length groups of each species in fall trap nets among lakes (Tables 2 and 3). Black and white crappie < 100 mm were seldom caught in summer gill and trap nets, and age-0 fish of neither species were caught (Table 7). Conversely, fall trap netting often caught fish < 100 mm. During fall, age-0 black crappie were caught in 39% of the sampled lakes, and age-0 white crappie in 38% of the lakes with white crappie populations.

Larger crappie of both species were caught more often during fall. Black crappie ≥ 254 mm were caught in 24% of the lakes gill netted and 49% of the lakes trap netted during summer, and in 73% of the lakes trap netted during fall (Table 7). Black crappie ≥ 305 mm were caught in 2% of the lakes gill netted and 10% of the lakes trap netted during summer, and in 22% of the lakes trap netted during fall. White crappie ≥ 254 mm were caught in 15% of the lakes gill netted and 38% of the lakes trap netted during summer, and in 62% of the lakes trap netted during fall. White crappie ≥ 305 mm were caught in 15% of the white crappie lakes trap netted during summer and in 8% of the lakes trap netted during fall. Gill nets did not sample white crappie ≥ 305 mm.

Factors Affecting the Analysis of Net Catches

The number of sampled locations and catch in individual nets strongly affected the skewness of catch distributions and related measures of variation. Differences between the crappie species were also observed.

The number of locations sampled affected skewness of catch distributions in summer gill and trap nets. Skewness coefficients of black crappie catch in summer gill and trap nets within lakes were positively correlated with the number of locations where nets were set (Table 10). Skewness coefficients of black crappie catch in summer trap nets were also significantly corre-

lated with lake surface area since more locations were sampled in larger lakes (Table 10).

Differences in skewness of catch distributions between summer and fall trap netting were affected by the number of locations sampled. Catch of black crappie in summer trap nets among lakes, where less than seven locations were sampled, were significantly less skewed than in fall trap nets at the same lakes (Table 11). In lakes where seven or more locations were sampled with summer trap nets, skewness

of black crappie catch in summer trap nets and fall trap nets did not significantly differ (Table 11). Similar results were observed for white crappie caught in summer trap nets, however, sample sizes were small and no differences were significant.

Differences in skewness of catch distributions between summer gill netting and fall trap netting were not related to the number of locations sampled. Black crappie catch in summer gill nets were significantly less skewed than

Table 10. Spearman's rank correlations between coefficient of variation of catch-per-unit-of-effort (when CPUE > 1/lift) of black and white crappie in summer gill nets, summer trap nets and fall trap nets, and skewness coefficients of catch distributions in nets; and Spearman's rank correlations between these two coefficients and range of net catches within lakes, number of net sets, maximum depth, and lake surface area, 1989-1991 (* = $P \leq 0.05$; ** = $P \leq 0.01$).

Variable	Summer gill nets		Summer trap nets		Fall trap nets	
	r	df	r	df	r	df
BLACK CRAPPIE						
<i>Coefficient of variation</i>						
Skewness coefficient	0.26	29	0.79**	29	0.85**	28
Range of net catches	-0.45*	29	0.02	29	0.26	28
Number of net sets	-0.13	29	0.33	29	-0.10	28
Maximum depth	-0.02	29	0.04	29	0.00	28
Surface area	0.16	29	0.27	29	0.25	28
<i>Coefficient of skewness</i>						
Range of net catches	0.25	33	-0.18	36	-0.03	38
Number of net sets	0.37*	33	0.58**	36	-0.14	38
Maximum depth	-0.20	33	0.05	36	-0.21	38
Surface area	0.06	33	0.36*	36	0.14	38
WHITE CRAPPIE						
<i>Coefficient of variation</i>						
Skewness coefficient	0.54	4	0.78**	7	0.74**	6
Range of net catches	0.41	4	-0.54	7	-0.13	6
Number of net sets	0.65	4	0.38	7	-0.49	6
Maximum depth	0.38	4	-0.74*	7	-0.12	6
Surface area	0.32	4	0.21	7	0.10	6
<i>Coefficient of skewness</i>						
Range of net catches	-0.63*	8	-0.25	9	-0.42	11
Number of net sets	0.24	8	0.51	9	0.28	11
Maximum depth	-0.47	8	-0.84**	9	0.20	11
Surface area	0.57	8	0.25	9	0.23	11
BLACK CRAPPIE in lakes with white crappie						
<i>Coefficient of variation</i>						
Skewness coefficient	0.77	4	0.90**	7	0.79*	6
Range of net catches	0.31	4	0.30	7	-0.10	6
Number of net sets	0.65	4	0.40	7	0.07	6
Maximum depth	-0.38	4	-0.51	7	0.08	6
Surface area	0.32	4	-0.14	7	-0.11	6
<i>Coefficient of skewness</i>						
Range of net catches	0.14	8	0.23	9	0.36	11
Number of net sets	0.22	8	0.57	9	0.21	11
Maximum depth	0.09	8	-0.23	9	-0.06	11
Surface area	0.31	8	0.05	9	0.05	11

Table 11. Coefficients of variation of catch-per-unit-of-effort and skewness coefficients of black and white crappie catches in summer gill nets (SGN), summer trap nets (STN), and fall trap nets (FTN) associated with selected numbers of net sets within 40 Minnesota lakes, 1989-1991.

Category (Summer netting only)	Coefficients		Statistic	df	P
BLACK CRAPPIE					
<i>Coefficients of variation</i>					
Lakes with < 6 gill nets set	SGN = 79	FTN = 130	F = 9.78	1,18	0.0058
Lakes with ≥ 6 gill nets set	SGN = 69	FTN = 126	F = 50.25	1,26	<0.0001
Lakes with < 7 trap nets set	STN = 88	FTN = 131	F = 17.26	1,30	0.0002
Lakes with ≥ 7 trap nets set	STN = 106	FTN = 122	F = 0.66	1,14	0.4310
<i>Coefficients of skewness</i>					
Lakes with < 6 gill nets set	SGN = 0.16	FTN = 1.5	F = 34.77	1,32	<0.0001
Lakes with ≥ 6 gill nets set	SGN = 0.69	FTN = 1.48	F = 23.70	1,32	<0.0001
Lakes with < 7 trap nets set	STN = 0.44	FTN = 1.58	F = 24.87	1,34	<0.0001
Lakes with ≥ 7 trap nets set	STN = 1.35	FTN = 1.50	F = 0.49	1,36	0.4891
WHITE CRAPPIE					
<i>Coefficients of variation</i>					
Lakes with < 6 gill nets set	(insufficient sample size)				
Lakes with ≥ 6 gill nets set	SGN = 43	FTN = 99	F = 6.85	1,8	0.0307
Lakes with < 7 trap nets set	STN = 98	FTN = 100	F = 0.01	1,10	0.9051
Lakes with ≥ 7 trap nets set	STN = 126	FTN = 158	F = 1.08	1,2	0.4083
<i>Coefficients of skewness</i>					
Lakes with < 6 gill nets set	SGN = 0.64	FTN = 0.95	H = 0.43	1	0.5127
Lakes with ≥ 6 gill nets set	SGN = 0.62	FTN = 1.42	F = 1.81	1,12	0.2032
Lakes with < 7 trap nets set	STN = 0.66	FTN = 1.30	H = 1.33	1	0.2496
Lakes with ≥ 7 trap nets set	STN = 1.20	FTN = 1.47	F = 0.25	1,6	0.6334

catch in fall trap nets among lakes regardless of the number of gill net locations sampled (Table 11). Similar results were observed for white crappie, but the differences were not significant.

Lower coefficients of variation were associated with the less skewed catch distributions from summer gill and trap netting (Table 11). Coefficients of variation for summer trap net CPUE of black crappie was significantly lower than for fall trap nets if fewer than seven locations were netted, but did not differ significantly if seven or more locations were netted. Coefficient of variance for summer gill net CPUE of black crappie was significantly lower than for fall trap nets regardless of the number of locations netted. Results for white crappie were similar, but were not significant.

The highest net catch accounted for most of the variation for both net types and both sampling periods. The net with the highest catch of black crappie explained 97% of the variation of CPUE for gill nets, 87% of the variation for summer trap nets, and 92% of the variation for fall trap nets among lakes ($P < 0.0001$, $df = 1, 36$ to 38). The lowest net catch explained an

additional 10% of the variation of black crappie CPUE for summer trap nets, but only an additional 1% of the variation for summer gill nets and fall trap nets ($P \leq 0.0193$; $df = 2, 36$ to 38). The highest net catch of white crappie explained 78% of the variation of CPUE for gill nets, 98% of the variation for summer trap nets, and 72% of the variation for fall trap nets ($P \leq 0.0001$; $df = 1, 10$ to 11). An additional 21% of the variation of white crappie CPUE for gill nets was explained by the lowest net catch ($P < 0.0001$; $df = 2, 9$), but the lowest fall trap net catch (always zero) did not explain any additional variation. Nearly all (99.6%) of the variation of CPUE of white crappie for summer trap nets was explained by the highest and lowest net catch ($P = 0.0001$; $df = 2, 9$).

The net with the highest catch also affected CV of CPUE. Within lakes, CV usually decreased when the highest net catch was excluded if CPUE was $\geq 1/\text{lift}$ and increased, sometimes becoming infinite, if CPUE was $< 1/\text{lift}$ (Tables 5 and 6). Among lakes, CV of black crappie CPUE for gill nets did not change significantly if the highest net catch was excluded, but was

significantly reduced for summer trap nets (Table 12). Coefficients of variation of white crappie CPUE ($\geq 1/\text{lift}$) for summer gill nets, summer trap nets, and fall trap nets among lakes did not change significantly when the net with the highest catch was excluded (Table 12).

Other variables were significantly correlated with CV of CPUE. Coefficient of variation of black crappie CPUE in summer gill nets was negatively correlated with the range of net catches among lakes (Table 10). Coefficient of variation of black crappie CPUE and white crappie CPUE in summer trap nets and fall trap nets among lakes were significantly correlated with respective skewness coefficients (Table 10).

Species specific differences were also observed. Skewness coefficients of black crappie catch in trap nets were not significantly correlated with maximum depth, however, skewness coefficients of white crappie catch in the same lakes were negatively correlated with maximum depth (Table 10).

Summer Netting Vs Angler Crappie Catch

Crappie harvest (number caught/hectare) and catch rates (number caught/hour) by anglers,

and crappie CPUE in gill and trap nets varied among lakes where creel surveys were done (Table 13). Black crappie CPUE in gill and trap nets were significantly correlated with black crappie harvest and catch rates (Table 4). Trap net catches were more strongly correlated than gill net catches. White crappie CPUE in gill nets and trap nets were not significantly correlated with either harvest or catch rates of white crappie, however, sample sizes were small (Table 4).

Length frequencies of black and white crappie caught in summer gill and trap nets does not reflect length frequencies of angler harvested crappie. At Madison Lake, length frequencies of black crappie ≥ 203 mm harvested by anglers differed significantly from those caught in gill and trap nets during summer 1988 and 1989 (Table 14). Length frequencies of white crappie in gill nets and caught by anglers did not differ significantly during summer 1988, but did differ significantly during summer 1989 (Table 14). Length frequencies of white crappie in trap nets and caught by anglers did not differ significantly in either year, however, sample sizes were small (Table 10).

Table 12. Mean coefficients of variation (CV) of catch-per-unit-of-effort ($\geq 1/\text{lift}$) of black and white crappie in summer gill nets, summer trap nets, and fall trap nets, and mean CV of CPUE excluding the net with the highest catch (CVM) among 40 Minnesota lakes, 1989-1991.

Gear	CV	CVM	Statistic	df	P
BLACK CRAPPIE					
Summer gill nets	74	67	$F = 0.95$	1,50	0.3337
Summer trap nets	97	80	$F = 4.05$	1,60	0.0487
Fall trap nets	130	114	$F = 3.24$	1,56	0.0771
WHITE CRAPPIE					
Summer gill nets	43	34	$H = 0.27$	1	0.6015
Summer trap nets	116	113	$F = 0.01$	1,16	0.9077
Fall trap nets	103	95	$F = 0.21$	1,12	0.6566

Table 13. Surface area (hectares), maximum depth (m), method of pressure estimate (s = stratified random, n = nonuniform probability), method of harvest estimate (r = roving creel survey, a = access creel survey), angler harvest (crappie/hectare), angler catch rates (crappie/hr kept), gill net CPUE and trap net CPUE at Minnesota lakes where creel surveys were done and black or white crappie were harvested or netted.

Lake	Area (hectares)	Maximum depth (m)	Pressure Method	Harvest Method	Creel Statistics		Net catch		
					Harvest	Catch	Gill	Trap	
BLACK CRAPPIE									
Artichoke	814	4.0	s	r	0.51	0.2	35.3	0.0	
Big Stone	5,004	4.9	s	a	0.07	TR ^a	3.6		
Birch	520	13.7	s	r	3.8	0.4	2.2	0.8	
Clear	183	2.7	s	r	0.3	TR	0.2	0.2	
Crane	1,375	24.4	s	a	2.5	0.1	0.2		
Dudley	51	18.3	s	r	30.3	0.1	1.0	0.5	
Elysian	770	4.0	s	r	0.3	TR	11.6	12.9	
Fish	124	8.2	s	r	0.2	TR	0.0	3.7	
French	363	17.1	s	r	9.5	0.1	179.0	6.7	
Horseshoe	169	8.5	s	r	157.6	0.6	58.9	63.7	
Hunt	65	8.2	s	r	108.3	0.7	32.5	2.2	
Island	221	12.5	s	r	19.6	0.2	0.7	30.3	
Kabetogama	10,429	18.3	s	a	0.4	TR	0.6		
Little Pine	157	11.0	s	r	1.7	TR	1.4	1.4	
Loon	275	2.4	s	r	0.0	0	0.0	0.3	
Madison (1988)	451	18.0	s	r	37.4	0.1	67.3	41.5	
Madison (1989)	451	18.0	s	r	77.7	0.1	45.5	49.8	
Mazaska	277	15.2	s	r	19.6	0.1	12.0	6.9	
Mille Lacs	53,650	10.7	n	a	0.02	TR	0.5		
Namakan	5,688	45.7	s	a	0.1	TR	0.1		
Nest	383	12.2	s	r	14.5	0.1	6.2	2.2	
North Lida	2,544	17.7	s	r	0.2	TR	0.0	0.0	
Oliver	208	5.5	s	r	0.05	TR	1.8	1.9	
Rainy	21,919	49.1	s	a	0.2	TR	0.2		
Rice	635	12.5	s	r	0.3	TR	4.9	2.9	
Round	415	2.7	s	r	0.6	TR	1.0	4.9	
Sand Point (1984)	2,300	56.1	s	a	0.7	TR	2.8		
Sand Point (1985)	2,300	56.1	s	a	0.2	TR	1.2		
South Lida	347	14.6	s	r	3.6	TR	0.3	1.5	
Square	79	20.7	s	r	4.3	TR	1.0	1.0	
Sturgeon	569	12.2	s	r	2.6	TR	1.0	0.5	
Sunfish	48	9.1	s	r	150.0	0.4	0.0	42.5	
Ten Mile	1,890	63.4	s	r	1.1	TR	0.3	0.0	
West Battle	2,230	32.9	s	r	0.6	TR	0.2	0.6	
Wirth	15	7.6	s	r	158.1	0.2	22.5	16.8	
WHITE CRAPPIE									
Dudley	51	18.3	s	r	0.7	TR	0.0	0.0	
Elysian	770	4.0	s	r	0.1	TR	0.0	0.2	
French	363	17.1	s	r	0.7	TR	7.2	0.0	
Horseshoe	169	8.5	s	r	30.6	0.1	0.6	0.3	
Hunt	65	8.2	s	r	35.5	0.2	0.0	0.5	
Madison (1988)	451	18.0	s	r	18.2	TR	21.7	5.5	
Madison (1989)	451	18.0	s	r	32.7	0.1	2.3	2.5	
Sunfish	48	9.1	s	r	6.3	TR	0.3	0.0	
Wirth	15	7.6	s	r	2.6	TR	0.0	0.6	

^aTR - trace

Table 14. Chi square statistics (χ^2) and probabilities (P) that length frequencies of black and white crappie ≥ 200 mm in sampled in gill nets or trap nets were the same as length-frequencies of black and white crappie harvested by anglers during the same period, Madison Lake, Blue Earth County, June 1988 and 1989.

Gear	Year	Chi square statistics			Sample size	
		χ^2	df	P	Net	Creel
BLACK CRAPPIE						
Gill net	1988	19.23	6	0.0038	9	66
Gill net	1989	28.47	4	<0.0001	48	315
Trap net	1988	25.31	5	<0.0001	31	66
Trap net	1989	16.71	4	0.0022	30	315
WHITE CRAPPIE						
Gill net	1988	10.18	6	0.1174	5	12
Gill net	1989	14.61	4	0.0056	17	78
Trap net	1988	4.47	6	0.6130	2	12
Trap net	1989	0.31	4	0.9890	8	7

Discussion

No clear advantage for estimating abundance and size structure of black and white crappie was evident for any of the netting types and seasons. Summer gill nets caught fewer crappie, but the catch was less variable than either summer or fall trap netting. Crappie caught in gill nets, however, tended to be smaller than those caught in trap nets. Fall trap net catches were more variable than either summer net type, but crappie > 254 mm were more likely to be caught and age-0 fish were sampled only in fall. Significant differences in length frequencies between summer gill and trap net catches were common, but we do not know which gear was better for estimating size-structure.

CPUE from summer gill and trap netting of both crappie species were correlated with angler harvest and catch rates. Correlations were stronger for summer trap netting than for summer gill netting. Length frequencies from both gears, however, differed from length frequencies caught by anglers in Madison Lake. Length frequencies from nets is a poor measure of angler harvest which is in contrast to the results reported by McNerny (1988).

Correlations between CPUE in summer nets and catch indices by anglers in Minnesota lakes were lower than correlations between CPUE in fall trap nets and angler catches reported elsewhere. Studies by Colvin and Vasey (1986),

Colvin (1991), McNerny (1988), and Miranda (1990) reporting strong correlations ($r \geq 0.80$) were done on man-made impoundments rather than on natural lakes. Physical factors that affect crappie net catch are probably more diverse among natural lakes than among reservoirs. Reservoirs are typically created by damming relatively narrow valleys so that the deepest water is usually located near the dam, and the slope of the bottom perpendicular to shore is probably more uniform within most of the reservoir. The location of the deepest water and steepness of shoreline slopes within and among natural lakes is more varied.

Variation in year-class strengths could have contributed to the significantly different length frequencies from Madison Lake and could have weakened correlations between CPUE and angler catch indices. Strengths of consecutive year-classes of black and white crappie in Minnesota lakes were highly variable, and some year-classes were not represented (McNerny and Cross in press; Minnesota Department of Natural Resources unpublished data). Anglers in Minnesota rarely harvested crappie < 180 mm (Minnesota Department of Natural Resources unpublished data), and typically find and harvest larger crappie from older age classes that appear less vulnerable to either type of netting.

Size specific spatial distribution, variable year-class strength, and net mesh sizes affected CPUE, skewness of net catches, and variation. Spatial distribution patterns during summer

suggests that more crappie size groups would be vulnerable to gill netting than trap netting. During summer, black crappie in natural lakes in Michigan, South Dakota, and Ontario were most concentrated in water 2.1 to 4.9 m deep (Hall and Werner 1977; Guy et al. 1992; Keast and Fox 1992). Hall and Werner (1977) also reported that black crappie concentrations in a Michigan lake were more than 15 m offshore during summer.

White crappie ≤ 152 mm inhabit offshore open water areas near the surface, while white crappie > 254 mm occupy deep water (> 4.3 m deep) during summer (Grinstead 1969; Gebhart and Summerfelt 1975; O'Brien et al. 1984; Markham et al. 1991). Smaller and larger white crappie could be less susceptible to capture in trap nets during summer because trap nets sampled shallow shoreline habitats. Size-specific spatial distribution of black crappie has not been reported.

Crappie (one or two year classes) vulnerable to gill netting were probably more uniformly distributed within offshore habitats which resulted in less skewed net catch distributions and relatively low CV. This would lead to more precise estimates of crappie CPUE caught in gill nets than in trap nets. Conversely, wider length ranges of crappie consisting of several year classes, each with different spatial distribution patterns, probably contributed to the more skewed catch distributions and higher variation during summer and fall trap netting. Moyle (1949), and Moyle and Lound (1960) reported that skewness of net catch distributions reflects habitat uniformity and behavior patterns of sampled fish.

Net mesh sizes probably affected CPUE and size-selectivity of summer netting. Smaller and larger black and white crappie should have been susceptible to gill netting because these nets sampled deeper, offshore habitats, however, small mesh sizes could have limited the catch of larger individuals. Grinstead (1969) reported that 254 to 376 mm white crappie in an Oklahoma reservoir were captured in experimental gill nets where the largest mesh size was 152 mm stretch. Muoneke et al. (1992) reported white crappie up to 445 mm, in another Oklahoma reservoir, were captured in experimental gill

nets with mesh sizes as large as 203 mm stretch. The largest mesh size of gill nets used in Minnesota was 102 mm stretch.

Trap net catch variation of black and white crappie in lakes where few (< 7) locations were sampled during summer probably did not represent the true population variation. Skewness coefficients in lakes where less than seven locations were sampled with trap nets were low and sometimes negative, but were more positive in lakes where ≥ 7 locations were sampled with trap nets during summer and fall. Moyle (1949), and Moyle and Lound (1960) reported that the distribution of fish catch in nets within Minnesota lakes were usually positively skewed. Consequently, positive skewness in catch distributions of black and white crappie in trap nets is probably more representative of the actual of the population distribution.

Physical characteristics unique to each lake could have affected CPUE and subsequent reported correlations. Because correlations of variables were among lakes and within years rather than among years and within lakes, those characteristics unique to each lake that affect catches in nets were incorporated. For example, black crappie CPUE in summer and fall trap nets at Big Swan Lake, Meeker County, were low compared to CPUE in gill nets. Suitable locations to set trap nets were limited. Bottom contours perpendicular to shore in this lake had little slope, consequently, the frames of these trap nets were seldom submerged, even when nets were set 9 to 15 m offshore. Black crappie in Michigan and Ontario lakes are usually found in deeper water than where these nets could be set (Hall and Werner 1977; Keast and Fox 1992) and were probably less vulnerable to trap netting. The higher catches in fall trap nets from Andrew and Maple lakes may also be unique to those waters. Significant differences in length frequencies between summer gill and trap net catches were common, and we do not know which gear was better for estimating size-structure.

None of the gear-season combinations effectively caught age-0 crappie, due to the mesh sizes being too large. Age-0 crappie were caught in trap nets set at several lakes during the fall, however, 19 mm bar mesh was too large to

effectively sample age-0 crappie. First-year growth of black and white crappie was usually ≤ 76 mm (McInerny and Cross in press; Minnesota Department of Natural Resources unpublished data). Trap nets with 13 mm or 16 mm bar mesh captured high numbers of age-0 white crappie (61 to 119 mm) in impoundments in Kansas, Missouri, and Oklahoma (Willis et al. 1984; Colvin and Vasey 1986; Boxrucker and Ploskey 1988), but not in natural lakes in Minnesota (Minnesota Department of Natural Resources unpublished data).

Species specific differences in gill and trap netting were expected because each species has specific habitat requirements. Little is known about specific habitat requirements of either crappie species, however, black crappie seem to be less successful in turbid water than white crappie (Ellison 1984). Habitat requirements likely differ because the natural ranges of each species differ. The black crappie range includes all of Minnesota, whereas white crappie populations are found only in the southern half of the state (Scott and Crossman 1979).

Management Implications

Standard lake surveys and assessments were adequate to assess abundance of black and white crappie for most of the lakes netted in this study. Very low summer net catch, however, may not indicate low crappie populations as shown by the samples at Andrew and Maple lakes. Fall trap netting should be considered if there is a concern that summer net catches are not representative and crappie management is a priority. Crappie > 254 mm and < 76 mm are also more likely to be caught by fall trap netting.

A minimum of seven trap net locations within a lake should be sampled for the catch to better represent the sampled fish population. The number of habitats sampled with summer gill nets were usually adequate during this study, but an insufficient number were sampled by summer trap netting.

Specialized trap netting can also be done in lakes where standard trap netting does not work or gives inadequate sample sizes. For example, trap nets set offshore along steep bottom gradi-

ents or using trap nets with longer leads could result in larger and more representative samples in lakes such as Big Swan.

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