Comparison of Methods for Estimating Relative Abundance of White Crappie

L. E. Miranda, *U.S. Fish and Wildlife Service, Mississippi Cooperative Fish and Wildlife Research Unit,*[1] *P.O. Drawer BX, Mississippi State, MS 39762*

J. C. Holder,[2] *Mississippi Cooperative Fish and Wildlife Research Unit, P.O. Drawer BX, Mississippi State, MS 39762*

M. S. Schorr, *Mississippi Cooperative Fish and Wildlife Research Unit, P.O. Drawer BX, Mississippi State, MS 39762*

Abstract: We investigated the relation among estimates of abundance and size structure of white crappie (*Pomoxis annularis*) determined with electrofishing, trapnetting, and rotenone sampling in 4 Mississippi lakes in 1987–1989. We also examined the relations between angler harvest and estimates provided by each gear to determine whether estimates made by sampling could be used to index angling success. Electrofishing yielded 4 fish/man-hour in fall and 6 in spring, and trapnetting yielded 24 fish/man-hour in fall and 9 in spring; rotenone sampling during summer yielded 8 fish/man-hour. Estimates of abundance of fish ≥20 cm long were usually correlated among gears and between seasons, but those of fish <20 cm long were not. These correlations suggest that any of these gears could be used to monitor trends in abundance of white crappie ≥20 cm long, but each would give different trends in abundance of fish <20 cm long. Indices of size structure provided by the gears generally differed significantly within seasons, and between seasons for the same gear. Estimates of relative abundance of fish ≥20 cm long based on spring electrofishing and trapnetting were correlated with angling success.

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Crappie (*Pomoxis* spp.) are important game fishes in southeastern reservoirs and oxbows, constituting about one-third of the total sportfish harvest by anglers (Campbell et al. 1976, Ploskey et al. 1986). Despite the considerable interest in crappie fishing, management efforts have been concentrated primarily on species

[1]Sponsored jointly by Mississippi State University; Mississippi Department of Wildlife, Fisheries and Parks; U.S. Fish and Wildlife Service; and Wildlife Management Institute.

[2]Present address: Florida Game and Freshwater Fish Commission, 551 North Military Trail, West Palm Beach, FL 33415

of *Micropterus* and *Morone*, and crappie populations have generally been left unmanaged. This lack of attention has been due partly to sampling difficulties. The dynamic nature of crappie abundance (Swingle and Swingle 1967) and spatial distribution (Ferguson 1958, Gebhart and Summerfelt 1974) has prevented the collection of reliable data for use in management.

Traditionally, monitoring of reservoir fish populations in the southeast has been conducted with electrofishing, rotenone, and gillnetting gears. However, several agencies have begun trapnetting as part of their routine sampling program. The increased use of trapnetting to monitor crappie populations seemingly was stimulated by recent success with this gear in midwestern states. Reportedly, trapnetting can efficiently collect numerically large samples which provide fairly accurate representations and assessments of crappie populations (Colvin and Vasey 1986, Boxrucker and Ploskey 1988, McInerny 1988).

Sampling with all of these gears can be costly and inefficient, particularly when populations in several lakes must be monitored simultaneously. To determine whether these gears provided equivalent data, we investigated the relation between estimates of abundance and size structure determined with electrofishing, trapnetting, and rotenone sampling. Because most population statistics and indices are based on the number and size of fish, we compared estimates of relative abundance according to fish length groups. Additionally, to determine whether samples collected by the different methods could be used to monitor trends in the fishery, we examined the relation between angler harvest and estimates of population density provided by the 3 gears.

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Methods

The study was conducted in 4 lakes in different regions of Mississippi: Columbus (northeast), Grenada (northcentral), Moon (northwest), and Ross Barnett (central). These lakes are generally large (>1,000 ha) and shallow (mean depth <7 m) with varying water level fluctuations and macrophyte coverage.

Electrofishing and trapnetting samples were collected in March–May (spring) and October–December (fall), from fall 1987 through spring 1989. Electrofishing with a 240-V AC boat-mounted generator was conducted during daylight in nearshore areas randomly selected throughout each lake. Each sample consisted of 30 minutes of continuous electrofishing, and 20–30 samples were taken per lake each season and year. Trap nets had 13-mm square mesh and consisted of 2 front box frames with center braces and dimensions 0.9 × 1.8 m, 4 0.8-m diameter hoops, and a single 0.9 × 15.0-m lead. Nets were set in water <9 m deep in areas subjectively selected throughout each lake and fished at 5- to 7-day intervals. A total of 8–63 nets was fished per lake each season and year. White crappie collected by electrofishing and trapnetting were separated into centimeter groups and counted.

We collected rotenone samples in subjectively selected sites throughout each lake during late July and August 1987 and 1988 following methodology in Davies and Shelton (1983). Each year, 2 sites were sampled in Columbus Lake, 3 in Grenada, 2 in Moon, and 6 in Ross Barnett. Surface area of the sites ranged from 0.4 to 2.4 ha. All white crappie were separated into centimeter groups and counted.

Angler surveys were conducted at each lake during March–May in 1988 and 1989 to obtain data on catch per effort. At Columbus, Grenada, and Moon lakes we interviewed anglers at selected access sites during 8 week days and 4 weekend days selected at random. Access creels were conducted between 1000 and 1700 hours. At Ross Barnett Lake we interviewed anglers during a roving creel survey. A total of 18 days was sampled with the roving survey which was conducted in a 4-hour period selected at random within a 12-hour day divided into 3 equal periods. Data recorded during access and roving creels included total number of white crappie harvested, number of anglers in the fishing party, and number of hours fished. Angler effort was estimated as the product of number of hours fished and number of anglers in a fishing party.

Data Analyses

Collections made by electrofishing, trapnetting, and rotenone were separated into fish <13, 13–19, and ≥20 cm long. Catch by electrofishing was computed as number of fish per hour of sampling, catch by trapnetting as number of fish per net per day (24 hours), and catch by rotenone as number of fish per hectare. Angler harvest per hour (HPH) was computed as the total number of white crappie caught divided by the total angling effort. Estimates of HPH included effort directed at all fish species.

For electrofishing and trapnetting, we compared fall against following spring estimates of abundance using a paired *t*-test. Each pair ($N = 8$) represented the log-transformed mean abundances of each season in a given lake and sampling year.

We calculated Pearson product-moment correlation coefficients (r) to assess association 1) among estimates of relative abundance made in the same season with different gears, 2) between estimates of relative abundance made in different seasons with the same gear; and 3) between estimates of HPH and those of relative abundance obtained with the sampling gears.

We tested whether the distribution of catch among size groups remained constant for a given gear over different seasons or for different gears within the same season. In particular, we tested the ratios of fish <13 cm to those ≥13 cm, and ≥13 cm to those ≥20 cm, corresponding respectively to the young-adult ratio (YAR) and proportional stock density (PSD) indices described by Anderson and Gutreuter (1983). For these analyses we tabulated data in 2-way contingency tables and tested for similarities in distributions using PROC CATMOD (SAS Inst., Inc. 1985). Statistical differences were declared at the 5% level of significance.

Results of Discussion

Electrofishing catch rates of white crappie (Table 1) in the 4 lakes during the 2 years of this study average 22/hour in fall and 36/hour in spring and were not statistically different. Trapnetting catch rates averaged 5 fish/day in fall, and 2/day in spring, and were statistically different. Higher trapnetting catch per effort in fall was primarily due to a greater catch of fish <20 cm long, also reported in other studies (Boxrucker and Ploskey 1988, McInerny 1988). Densities of white crappie in rotenone samples averaged 1,051/ha. Variability of mean catch fluctuated between seasons and among gears and size groups (Table 2).

Electrofishing required about 1.5 hour per sample (0.5 hour for collection and 1.0 hour for data recording and boat travel between sites), trapnetting required about 0.75 hour per sample (0.25 hour for set and retrieval of net and 0.5 hour for data recording and travel between sites), and rotenone sampling required about 16 hours per sample. In terms of fish/man-hour, electrofishing yielded 4 fish in fall and 6 in spring, and trapnetting yielded 24 fish in fall and 9 in spring. Rotenone sampling during summer yielded 8 fish/man-hour. These estimates were based on 2-man crews for electrofishing and trapnetting and 6-man crews for rotenone sampling.

Trapnetting catch rates in our study were lower than those reported previously (Colvin and Vasey 1986, Boxrucker 1988, McInerny 1988). Some of the differences were probably related to soak times; our nets were fished for 5–7 days, while in the other studies nets were fished for 1–2 days. Schorr and Miranda (1989) reported that catch per day of white crappies increased sharply with soak time, peaked in 1–3 days, and decreased thereafter.

Abundance estimates based on rotenone, fall electrofishing, and fall trapnetting for fish <13 or 13–19 cm long were not significantly correlated (Table 3). For fish ≥20 cm long, abundance in rotenone samples was significantly correlated with abundance in fall electrofishing and trapnetting, and abundance in fall trapnetting with abundance in fall electrofishing. Spring electrofishing and trapnetting catch rates of fish ≥20 cm were correlated with each other, and with catch rates of fish ≥20 cm in rotenone samples taken in the previous summer. Trapnetting estimates of abundance obtained in fall were not correlated with those obtained in spring. Electrofishing estimates of abundance obtained in fall were correlated with those obtained in spring for fish <13 and ≥20 cm. Angling HPH was correlated with spring electrofishing and trapnetting catch rates of fish ≥20 cm, but not with catch rates based on rotenone, fall electrofishing, or fall trapnetting.

Table 1. Catch per effort of 3 length groups (cm), young-adult ratio (YAR), and proportional stock density (PSD) of white crappie collected by electrofishing (*N*/hour), trapnetting (*N*/day), rotenone sampling (*N*/ha), and harvested by anglers (*N*/hour) in 4 Mississippi lakes, summer 1987–spring 1989.

Season and index	Lake							
	Columbus	Grenada	Moon	Ross Barnett	Columbus	Grenada	Moon	Ross Barnett
	Year 1				Year 2			
				Electrofishing				
Fall								
<13	0.47	1.29	5.68	0.33	0.90	2.33	12.33	0.75
13–19	6.06	2.36	4.16	0.72	7.40	7.00	11.68	0.94
≥20	45.29	7.00	6.34	4.11	35.90	3.87	8.24	0.69
All	51.82	10.64	16.16	5.17	44.20	13.20	32.24	2.38
YAR	0.01	0.14	0.54	0.07	0.02	0.22	0.62	0.46
PSD	88	75	60	85	83	36	41	42
N	467	149	212	71	442	198	400	38
Spring								
<13	0.18	0.80	17.47	0.44	0.04	1.87	96.31	0.06
13–19	2.55	0.67	15.69	1.13	0.64	2.93	34.62	1.31
≥20	40.09	15.80	17.79	6.88	18.23	5.75	6.31	3.00
All	42.82	17.27	50.95	8.44	18.91	10.55	137.23	4.38
YAR	<0.01	0.05	0.52	0.06	<0.01	0.22	2.35	0.01
PSD	94	96	53	86	97	66	15	70
N	471	259	536	135	261	158	862	71
				Trapnetting				
Fall								
<13	0.55	5.76	13.03	0.60	0.48	0.96	2.35	0.26
13–19	0.70	0.90	2.98	0.46	0.70	0.29	2.69	0.58
≥20	2.51	0.01	0.19	1.61	2.38	0.10	1.70	0.29
All	3.76	6.67	16.23	2.66	3.55	1.34	6.74	1.13
YAR	0.17	6.32	4.11	0.29	0.16	2.50	0.54	0.31
PSD	78	2	6	78	77	25	39	33
N	426	623	895	419	1,441	445	495	446
Spring								
<13	1.84	0.24	2.30	0.10	0.10	0.07	1.63	0.07
13–19	1.38	0.12	1.22	0.12	0.12	0.14	0.77	0.05
≥20	1.75	0.53	0.79	0.96	0.72	0.38	0.17	0.38
All	4.97	0.89	4.32	1.18	0.94	0.60	2.57	0.50
YAR	0.59	0.37	1.14	0.09	0.11	0.14	1.74	0.17
PSD	56	81	39	89	86	73	18	89
N	584	247	536	476	278	188	729	139
				Rotenone				
Summer								
<13	419.79	1,939.36	163.08	1,409.27	430.54	462.07	551.03	1,222.71
13–19	419.05	112.60	97.60	29.23	139.54	94.71	284.16	65.48
≥20	252.36	19.82	30.89	41.59	81.89	32.99	77.84	31.65
All	1,091.20	2,071.78	291.57	1,480.08	651.96	589.77	913.02	1,319.84
YAR	0.63	14.65	1.27	19.96	1.94	3.64	1.52	12.58
PSD	38	15	24	59	37	26	21	33
N	2,230	7,590	227	3,523	1,342	2,021	729	3,142
				Creel				
Spring								
All	1.14	0.69	0.94	0.81	0.87	0.50	0.41	0.59
N	4,861	1,134	296	1,398	2,876	635	168	708

Table 2. Coefficient of variation of the mean (SE/mean) catch of white crappie collected by electrofishing, trapnetting, and rotenone sampling. Values represent the average from 4 Mississippi lakes, summer 1987–spring 1989.

	Length group (cm)		
Season	<13	13–19	≥20
		Electrofishing	
Fall	46	22	16
Spring	54	37	11
		Trapnetting	
Fall	23	29	34
Spring	30	29	21
		Rotenone	
Summer	14	23	20

Table 3. Pearson correlation coefficients (*r*) among estimates of relative abundance of white crappie determined with electrofishing (*N*/hour), trapnetting (*N*/day), and rotenone sampling (*N*/ha) conducted in 4 Mississippi lakes, summer 1987–spring 1989. Asterisks denote significant ($P \leq 0.05$) correlations.

	Length group (cm)		
Sampling method	<13	13–19	≥20
Fall trapnetting × fall electrofishing	0.32	0.41	0.79*
Spring trapnetting × spring electrofishing	0.47	0.45	0.87*
Fall trapnetting × rotenone	−0.16	0.19	0.74*
Spring trapnetting × rotenone	−0.58	0.71*	0.79*
Fall electrofishing × rotenone	−0.36	0.60	0.86*
Spring electrofishing × rotenone	−0.26	0.34	0.84*
Fall trapnetting × spring trapnetting	0.58	0.60	0.54
Fall electrofishing × spring electrofishing	0.96*	0.65	0.86*
Spring trapnetting × spring angler harvest	—	—	0.92*
Spring electrofishing × spring angler harvest	—	—	0.85*

Estimates of YAR and PSD indices differed significantly between gears within seasons, and between seasons for the same gear, with the exception of PSD's estimated with spring and fall electrofishing. In general, electrofishing and trapnetting provided higher estimates of YAR in fall than in spring, rotenone provided higher YAR estimates than trapnetting, and trapnetting yielded higher estimates than electrofishing, particularly in fall (Table 1). Electrofishing and trapnetting provided higher estimates of PSD in spring, but the seasonal difference in electrofishing estimates was not statistically significant. Rotenone sampling provided the lowest PSD estimates and electrofishing the highest.

Disagreement in size ratios and relative abundance estimates among gears and seasons are probably affected by a combination of factors, including gear selectivity, size-differential changes in vertical and horizontal distribution, and temporal changes in population size structure due to growth and mortality. Selectivity of trapnetting and electrofishing gears for larger fish is well documented (Latta 1959, Laarman and Ryckman 1982, Reynolds 1983, Boxrucker and Ploskey 1988, Schorr and Miranda 1989). This selectivity results in overestimates of PSD and underestimates of YAR. Seasonal changes in distribution occur in relation to water temperature and reproductive cycles. Adult crappie (about 16–19 cm long; Goodson 1966) tend to move toward shallow littoral waters in spring, where they are more easily captured by nearshore electrofishing and by trap nets normally fished within 5 m of the surface. These changes in distribution would result in overestimates of PSD and underestimates of YAR, and in disagreement in seasonal estimates of relative abundance. Temporal changes in population size structure resulting from growth and mortality would likely have large effects on YAR, moderate effects on PSD, and could account for the lack of correlation between seasonal estimates of relative abundance.

Implications to Sampling

Our results suggest that if electrofishing, trapnetting, and rotenone sampling were used within any of the seasons considered, they would provide similar trends in abundance of white crappie ≥20 cm long. The gear and season of choice could then be selected on the basis of sampling convenience, ability to provide large sample sizes, catch per man-hour, and efficiency in sampling other species of interest. Additionally, estimates of relative abundance of fish ≥20 cm long based on electrofishing and trapnetting were correlated with angler HPH when obtained in the same season, at least for spring. This suggests that estimates based on sampling by any of these gears could be used to monitor trends in fishing success.

Our results also indicated that estimates of abundance of fish <20 cm long based on the different gears and seasons were generally not correlated. This suggests that trends determined from catches with different gears, or in different seasons, would be different. Clearly, only 1 or none of the trends can be accurate. The challenge is determining which gear and season combination provides adequate data for monitoring abundance of fish <20 cm long. Of the gears considered in our study, we suspect that rotenone sampling provides the most accurate estimates. However, because rotenone sampling is usually done in late summer, strength of the newest year class could not be adequately monitored in lakes where it is dictated by events in fall and winter. Trapnetting, although biased for larger fish, may provide a better representation of fish <20 cm long than electrofishing because it collects relatively more smaller fish.

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