Evaluation of Summer Seining in Kansas Reservoirs[1]

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Abstract: Data from August samples of fish in quarter (90° arc) hauls of a 15.2- × 1.8-m bag seine were analyzed to determine effectiveness of seining for detecting species presence, forecasting future relative abundance of larger length classes of the same species, and assessing the value of seining as an indicator of prey availability for piscivores in Kansas reservoirs. The data set contained 98 reservoir-years of samples from 24 impoundments with 2–7 years of data per reservoir. The median number of hauls per reservoir and year was 19; the range was 10–30. Bag seines effectively sampled only small fish, most <140 mm. Presence was accurately detected in 100% of the reservoir-years sampled for gizzard shad and ranged from 90% to 97% for minnows, white bass, lepomid sunfishes, and freshwater drum. Presence was detected correctly from 80% to 90% of the time for red shiner, largemouth bass, channel catfish, brook silverside, and bluegill but <80% of the time for other species. Gizzard shad, minnows, lepomid sunfishes, and red shiner were the only species or groups that could be effectively sampled in most reservoirs with a geometric mean of 25 or fewer hauls per year. Effective sampling was defined as the capability of detecting 100% changes in mean catch with 80% certainty at $\alpha = 0.05$. Correlations of mean catch with reservoir physicochemical characteristics suggested some reasons for the wide variation in catch among reservoirs but provided little insight into types of reservoirs most appropriate for seining. Poor sampling effectiveness was associated with low abundance of fishes vulnerable to seining, small sample areas (0.018 ha) per haul, and the necessity of sampling only areas with gently sloping, unobstructed bottoms. Seine catches were of no value for predicting the future relative abundance of the same species in larger length classes, and of limited value for predicting walleye and gizzard shad recruitment

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to a 25.4-mm mesh gill net. In Melvern Reservoir, seining underestimated densities of most species and median lengths of gizzard shad compared with estimates from 2 cove-rotenone samples. Length frequencies and numbers of gizzard shad in seine catches provided some indication of growth, potential for recruitment, and availability to young piscivores. Seine catch was an easily obtained, although poor indicator, of prey availability.

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Seines are used by many state fishery agencies to sample fishes in near-shore waters of reservoirs in summer. In 1985, 14 states sampled with seines in a standardized way (Aggus et al. 1986). All 14 sampled in summer during daylight hours, although some sampled at night or in other seasons as well, 13 used seines longer than 9.1 m, 11 used seines with mesh sizes 6.4 mm, and 10 used bag seines, often with reduced mesh sizes in the bag. Most sampled a fixed number of sites based upon lake size but effort varied widely. Procedures included quarter (90°) hauls (5 states), 180° hauls (1), and a fixed length of shoreline (5).

Common objectives of conservation agencies that seine reservoirs in summer included evaluation of reproductive success, prey-fish abundance, and fry and fingerling stocking success. Generally, catch per haul was used to index relative abundance. Seines also have been used to evaluate species composition and obtain population data.

Despite continued use of seines by conservation agencies, few publications have addressed the value of the method for sampling reservoir fishes. Researchers have studied the utility of seines 30.5 m long for assessing species composition (Bennett and Brown 1969), community balance (Swingle 1956, Herring 1980), population size (Fredin 1950), recruitment (Kramer and Smith 1962, Newburg and Schupp 1986), and prey availability for piscivores (Johnson et al. 1988). Bayley and Austen (1987) examined the efficiency of a 9.1-m × 1.6-m beach seine in ponds.

In this study, data collected by Kansas Department of Wildlife and Park's personnel were analyzed to evaluate the effectiveness of bag seining for detecting species presence, predicting the future abundance of the same species in larger length classes 1–2 years later, and assessing the value of seining as a meaningful indicator of prey availability for piscivores.

Methods

A standardized sampling design was used to minimize biases associated with location, time of year, seine size, and water clarity. Samples of fish were collected in August from 24 Kansas reservoirs by fisheries biologists using 15.2-m × 1.8-m, 6.4-mm-mesh bag seines. The median number of hauls per reservoir and year was 19; the range was 10–30. All samples were quarter (90° arc) hauls (Swingle 1956) taken from standardized sampling sites during daylight hours. Preliminary sampling seldom indicated significant differences between day and night catches, probably because high turbidity in most Kansas reservoirs ($\bar{x}$ Secchi disk transparency = 51.5 cm; N = 22 reservoirs) minimized seine avoidance by fish during the day. In sampling, a seine was fully extended perpendicular to shore from a pivot end on shore, and the distal end was swept over an area of about 0.018 ha in a 90° arc to shore. Fish were sorted by species and measured to the nearest cm. Number per haul was used to index relative abundance.

The seining data set contained 98 reservoir-years of samples from 24 impoundments with a range of 2–7 years of data per reservoir. We assigned a catch of zero for species missing from a sample if it was captured in other seine samples or other gears in the same reservoir during the year. All data were transformed to common logarithms of catch + 1, which made sample variances independent of means and distributions more normal.

Detecting Presence

The 95th percentile length group of fishes seined was considered the maximum length group effectively sampled. This criterion usually only excluded sporadic catches of a few fishes that were significantly longer (>100 mm) than the 95th percentile length.

The percent of average annual catches exceeding zero was used to assess the value of seining for detecting the presence of species known to occur in each impoundment. For example, a 31% "detection" value for a species occurring in every reservoir would show that seining was effective in detecting its presence in only 30 of 98 reservoir-years sampled.

Sampling Effectiveness

The number of samples needed to be 80% certain of detecting 100% differences in mean catch (at α = 0.05) was considered the minimum for effective sampling and was calculated from Sokal and Rohlf (1969):

$$N \geqslant 2(\sigma/\delta)^2\{t_{\alpha[\nu]} + t_{2(1-P)[\nu]}\}^2,$$

where N = required sample size, σ = true standard deviation, δ = smallest true difference to be detected (100%); ν = degrees of freedom of the sample standard deviation, α = significance level (0.05), P = the desired probability (80%) that a difference will be found to be significant if it is as small as δ, $t_{\alpha[\nu]}$ and $t_{2(1-P)[\nu]}$ = tabled t statistics with ν degrees of freedom and probabilities of α = 0.05 and 2(1 − P), respectively. An estimate of sample standard deviation for a reservoir and species or group was entered, and the formula was solved in an iterative fashion. Geometric means of required sample sizes were calculated from estimates of N for individual reservoirs and species or groups of fish. Geometric means were less inflated than arithmetic means by a few exceptionally high estimates for some reservoirs. We also calculated geometric means after excluding any estimates of N >100 to obtain required sample sizes for those reservoirs where fishes could be sampled effectively with reasonable effort. We could not envision anyone expending more effort if they were aware beforehand that effective sampling required >100 hauls in a reservoir. We ranked poorly sampled species from most to least effectively sampled according to the geometric mean *N* for all reservoirs and the more effectively sampled species or groups by geometric means that excluded estimates of $N > 100$.

Average catches in seines were regressed on physical characteristics of reservoirs to help explain high variation in catch among reservoirs. Physical characteristics included reservoir age, surface area, storage ratio (average volume/annual discharge), mean depth, maximum depth, maximum vertical fluctuation in water level per year, shoreline development, and length of growing season (frost-free days per year).

Recruitment

We used regression to explore the value of annual catches in bag seines for predicting future relative abundance of larger length classes of the same species or group. All catches were standardized by reservoir to the grand mean and standard deviation (all reservoir years) to minimize inherent among-reservoir variation. Future relative abundance was indexed by catches of 152–254 mm largemouth bass (*Micropterus salmoides*) per hour of electrofishing in April–May (spring), of 152–254 mm white crappie (*Pomoxis annularis*) per trap-net night in October–November (fall), and of other species caught in 25.4-mm-mesh gill nets in fall. The range in length of fish caught in gill nets was about 140–254 mm, except walleye (*Stizostedion vitreum*) which ranged from 200 to 450 mm. Gill net catches of different species were regressed on bag-seine catches of the same species from the same reservoir in August, 1 or 2 years earlier.

Prey Availability

The value of seining as an indicator of prey availability for piscivores was assessed by regressing average body condition (W*r*, Wege and Anderson 1978) of 152–254 mm sport fish in fall (spring for 152–254 mm largemouth bass) on catches of prey fishes in seines the previous August. We also regressed catches of sport fishes ranging from 152 to 254 mm in length in gears other than seines on bag-seine catches of small (<140 mm) "prey" fishes the previous August. Prey included total catch (all species ≤140 mm), gizzard shad (*Dorosoma cepedianum*), minnows (primarily *Notropis* spp. and *Pimephales* spp.), and lepomid sunfishes (primarily orangespotted sunfish, *Lepomis humilis*; bluegill, *Lepomis macrochirus*; and green sunfish, *Lepomis cyanellus*).

Samples of largemouth bass were collected with a boat electroshocker with pulsed DC at 220 volts and 2.4–5.5 kw. Gill nets were 30.5 × 2.4 m with 25.4-mm bar-mesh monofilament webbing hung at ½ basis. Trap nets used to sample crappies had 12.7-mm mesh hung on 1.2- × 1.5-m frames, with a 15.2-m lead of 12.7-mm mesh multifilament nylon. Two 0.41-ha samples were collected from Melvern Reservoir in 1986 and 1987 with standard cove rotenone methods (Davies and Shelton 1985).

Results and Discussion

Detecting Presence

Bag seines effectively sampled only small fish (most <140 mm; walleye and common carp, *Cyprinus carpio* <190 mm), which included young of species that attain large sizes and all ages of fishes that are small as adults, such as minnows (Table 1). According to 95th-percentile length groups of fish, catches of most species >140 mm could be considered incidental, except those of walleye and common carp. Minnows, darters, and logperch had the lowest 95th-percentile length groups.

The simplest test of a sampling method is its ability to detect accurately the presence of a species or group with a reasonable amount of effort. The presence of gizzard shad was accurately detected in every reservoir and year sampled (N = 98). The percent of reservoir-years in which presence was accurately detected was 97 for minnows, 95 for white bass (*Morone chrysops*), 93 for lepomid sunfishes, and 92 for freshwater drum (*Aplodinotus grunniens*). Presence was detected accurately 80%–90% of the time for red shiner (*Notropis lutrensis*), largemouth bass, channel catfish (*Ictalurus punctatus*), brook silverside (*Labidesthes sicculus*), and bluegill, but <80% of the time for other species (Table 1).

Sampling Effectiveness

Findings of this study contradict the widely-held belief that seining is an effective method for sampling many fishes in reservoirs (Aggus et al. 1980). Only 7 species and 2 composite groups of fish were sampled effectively with an geometric mean of <60 seine hauls per year (all reservoirs) or with fewer than an average of 40 hauls per year in reservoirs where these fishes could be sampled with reasonable effort (Table 1). Only gizzard shad, minnows, lepomid sunfishes, and red shiner were sampled effectively enough in most reservoirs to be 80% certain of detecting a 100% change in mean catch with ≤25 hauls per year. Lepomid sunfishes met this criterion only in 17 of 24 reservoirs.

Effectiveness apparently is related in part to the abundance of species vulnerable to seining. Effort required to sample a species effectively varied significantly among the 24 impoundments and tended to be lower for abundant fishes. Therefore, the average required sample sizes (Table 1) may not be broadly applicable to other reservoirs. Ranges in geometric mean catches were high even for the more effectively sampled species or groups, as follows: total catch (16.8–160.1), gizzard shad (1.4–135.0), minnows (0.7–8.9), lepomid sunfishes (0.1–9.5), red shiner (0.1–5.3), and bluegill (0.1–8.4).

Correlations of mean seine catch by reservoir with physical variables suggested some reasons for among-reservoir variations but provided little insight into the types of reservoirs best sampled with seines. Correlations suggest that young-of-year (YOY) gizzard shad production is more successful and consistent in northern Kansas than in southern Kansas, whereas the opposite is true for channel catfish. Mean catches of gizzard shad per reservoir were negatively correlated with growing season length ($P < 0.05$) and catches of gizzard shad and minnows were positively

Table 1. Median and 95th percentile length groups of fishes sampled with a 15.2-m bag seine, the percent of reservoir-years in which the presence of a species or group was accurately detected, and geometric mean sample sizes required to detect 100% population changes with 80% certainty at a 5% level of significance. The number of reservoirs used in calculating means are given in parentheses, and means were not calculated when $N < 4$.

Fish species or group	Median length group (mm)	Ninety-fifth percentile length group (mm)	Percent accurate detection with 10–20 hauls	Mean required sample size: Excluding reservoirs with $N > 100$	Mean required sample size: All reservoirs
Gizzard shad (*Dorosoma cepedianum*)	80	130	100	4 (23)	5 (24)
Minnows	40	80	97	12 (23)	13 (24)
Lepomid sunfishes (*Lepomis* spp.)	40	130	93	22 (17)	38 (24)
Red shiner (*Notropis lutrensis*)	40	60	86	25 (23)	26 (24)
Bluegill (*Lepomis macrochirus*)	40	120	82	30 (16)	48 (22)
Freshwater drum (*Aplodinotus grunniens*)	50	130	92	32 (16)	40 (19)
Largemouth bass (*Micropterus salmoides*)	70	130	86	34 (19)	49 (24)
White bass (*Morone chrysops*)	60	120	95	35 (19)	35 (19)
Channel catfish (*Ictalurus punctatus*)	60	110	86	39 (16)	58 (22)
Suckermouth minnow (*Phenacobius mirabilis*)	60	80	48	43 (8)	81 (14)
Logperch (*Percina caprodes*)	50	70		53 (9)	81 (15)
White crappie (*Pomoxis annularis*)	40	120	77	52 (11)	82 (20)
Darters (*Etheostoma* spp.)	40	80	78	54 (10)	82 (16)
Black crappie (*Pomoxis nigromaculatus*)	50	120	68	72 (5)	86 (6)
Emerald shiner (*Notropis atherinoides*)	40	80	50	35 (4)	88 (8)
Green sunfish (*Lepomis cyanellus*)	40	90	55	42 (4)	89 (16)
River carpsucker (*Carpiodes carpio*)	70	130	78	43 (10)	89 (20)
Bluntnose minnow (*Pimephales notatus*)	40	70	56	47 (7)	90 (14)
Common carp (*Cyprinus carpio*)	120	180	75	44 (10)	93 (22)
White x striped bass hybrid (*Morone* sp.)	60	110	53		95 (7)
Walleye (*Stizostedion vitreum*)	150	180	50	34 (7)	98 (16)
Longear sunfish (*Lepomis megalotis*)	40	110	64*		98 (4)
Brook silverside (*Labidesthes sicculus*)	40	70	84	51 (4)	106 (9)
Orangespotted sunfish (*Lepomis humilis*)	40	90	71	53 (6)	114 (19)
Spotted bass (*Micropterus punctulatus*)	40	90	76		115 (7)
Sand shiner (*Notropis stramineus*)	40	70	55		119 (9)
Bigmouth buffalo (*Ictiobus cyprinellus*)	50	80	46		146 (7)
Smallmouth buffalo (*Ictiobus bubalus*)	60	100	40		164 (8)
Fathead minnow (*Pimephales promelas*)	50	90	43		166 (7)
Golden shiner (*Notemigonus crysoleucas*)	50	80	56		175 (14)
Slim minnow (*Pimephales tenellus*)	30	50	29		
Common shiner (*Notropis cornutus*)	60	70	33		

correlated with storage ratio ($P < 0.10$). Channel catfish catches were positively correlated with growing season ($r = 0.58$; $P < 0.01$) and water level fluctuation ($r = 0.44$; $P < 0.10$) and negatively correlated with mean depth ($r = -0.46$; $P < 0.05$), Secchi disk transparency ($r = -0.42$; $P < 0.05$), and storage ratio ($r = -0.42$; $P < 0.10$). Catches of lepomid sunfishes were negatively correlated with reservoir age ($r = -0.44$; $P < 0.05$). Channel catfish reproduction apparently is best in shallow turbid, southern Kansas reservoirs with high rates of water exchange and above average fluctuation. Gizzard shad and minnows apparently are more productive in reservoirs with relatively low water exchange rates, and sunfishes reproduce better in new reservoirs than in old ones.

We believe the poor sampling effectiveness of a 15.2-m long bag seine was due in part to the small area sampled per haul, low catches, and biased selection of sampling sites suitable for seining. Except for gizzard shad, zero catches per haul were common for most species, as were low geometric mean catches per impoundment. Changes in catch among years were more accurately detected for composite groups of fishes such as all fish, minnows, and lepomid sunfishes than for the individual species making up these groups.

Sampling sites selected for seining had gradually sloping, smooth, unobstructed bottoms, while adjacent areas often contained brush, boulders, rubble, or aquatic or herbaceous vegetation that precluded sampled. Mean densities (*N*/ha) in 2 0.41-ha cove-rotenone samples from Melvern Reservoir were higher for most species than average densities in 20 0.018-ha seine hauls from the same reservoir and years. Coves sampled not only were larger than individual seine sites but also had greater diversity of structure (rock, vegetation, brush) in the water. As a percent of average densities (number/ha) in 2 cove samples, seine catches accounted for only 2% of the minnows, 6% of the gizzard shad and lepomid sunfishes, 8% of the channel catfish, 11% of the orangespotted sunfish, 14% of the red shiners, 25% of the freshwater drum, 33% of the bluegill, and 48% of the largemouth bass. Densities of white crappie sampled by both methods were similar. Walleye and white bass had densities that were 2.5 times higher in seine than in rotenone samples, perhaps because these species prefer areas near mouths of coves and open water.

Ratios of densities in seine hauls to those in cove-rotenone samples varied among years and probably vary among impoundments and coves as well, depending on the habitat present in coves. The lowest ratios (fish/ha seined-to-fish/ha poisoned) were for important prey fishes (minnows, gizzard shad, and sunfishes) most often sampled effectively with bag seines with <25 hauls per year. Johnson et al. (1988) also found that average density of gizzard shad estimated from hauls with a 12-m seine were significantly lower than that estimated in 0.15-ha shoreline rotenone samples ($83.0 \pm 24.5\%$ mean difference). The reason for variation in effectiveness among species probably is more complicated than just the size of the area sampled. If differences result from species-specific habitat preferences, ratios for composite groups such as minnows or sunfishes also may vary depending on the relative number of different species in a sample. The most troublesome aspects of underestimating prey density by seining relative to densities by rotenone sampling are that 1) rotenone samples underestimate true densities unless adjustments are made for nonrecovery and distributions of fish, and 2) inferences about bioenergetics of prey-predator relations cannot be made without some degree of accuracy in quantitative measures. Densities of fish (fish/ha) estimated by seining only provide an index to abundance.

Doubling or tripling Kansas' sampling effort would do little to increase the number of fishes effectively sampled (Table 1). Only gizzard shad and minnows had mean required sample sizes of <20 hauls per year. If effort were increased to 60 hauls per year, it would exceed the geometric mean sample size required to effectively sample 7 additional species or groups. However, the percent of reservoirs where 60 hauls per year actually provided effective sampling was 71 for red shiner, 58 for lepomid sunfishes and white bass, and only 47 for freshwater drum, 41 for bluegill and channel catfish, and 33 for largemouth bass. If effort were doubled to 40 hauls per year, it would exceed the mean sample size required to effectively sample 4 species or groups in addition to gizzard shad and minnows (Table 1). Doubling or tripling of sampling effort could not be justified for statewide monitoring, but might be useful for studies where effective sampling of a species is required. The best approach for setting sampling sizes on a statewide basis would be to determine required sample sizes for each reservoir and species or group because required effort for most species varies widely among reservoirs. In Kansas reservoirs where sampling was possible with a reasonable amount of effort, an average of 22 hauls effectively sampled important prey fishes.

Finding ways to reduce sampling effort was difficult. From 4 to 8 man-days were required to take seine hauls from 20 different locations in a reservoir when fishes were sorted by species and cm length groups. The number of man-days of effort depended on the number of fish caught and the time required to measure them. Limiting processing to species or groups of fish and sizes that were most often effectively sampled (total catch, gizzard shad, minnows, and lepomid sunfishes <140 mm long) probably would not reduce effort significantly because these groups made up over 90% of catches.

The importance of measuring prey was indicated by lengths that gizzard shad attained by August. For example, if gizzard shad densities are below average and these fish attain a 75th-percentile length of 100 mm by August, they have grown too large to be swallowed by 200-mm largemouth bass, 230-mm white bass, 254-mm white crappie, or 254-mm walleye (Jenkins and Morais 1978). In other words, predators of the lengths described above would experience a 25% reduction in the availability of gizzard shad by August in an "average" year. These data and an inverse relation between the median length of gizzard shad in August and the geometric mean number per seine haul suggests that strong spawns may be as desirable for slowing growth as they are for providing abundant prey. The equation was log(median length) = 2.085 − 0.151 log(N/haul + 1), with length in mm (r^2 = 0.25; P = 0.0001; N = 74.

Recruitment

Mean annual catch of small fish (most <140 mm; walleye <190 mm) in seines was not of value for predicting future catches of larger fish of the same species. The average catch of largemouth bass <140 mm in seines in August was not correlated with mean annual catch per hour of electrofishing for 152–254-mm largemouth bass in spring, 1 or 2 years later. Mean catches of 152–254-mm white crappie in trap nets in fall and of similar sized channel catfish, white bass, bluegill, and freshwater drum in 25.4-mm mesh gill nets in fall could not be correlated with mean seine catches of the same species in August, 1 or 2 years earlier. These conclusions must be tempered by the possibility that consecutive strong and weak year classes in the 152–254-mm length range could have reduced our ability to detect significant correlations.

The only significant correlations obtained were for walleye (r = 0.35; P = 0.0299; N = 41) and gizzard shad (r = −0.32; P = 0.0194; N = 54), but seine catches explained <12% of the variation in gill-net catches the next year. The median length of gizzard shad and walleye in seine hauls was 80 and 150 mm, respectively. Median lengths in 25.4-mm-mesh gill nets were 180 mm for gizzard shad and 280 mm for walleye. The positive correlation between mean annual walleye catch in seines and its catch in 25.4-mm-mesh gill nets a year later suggests that 150–190-mm walleye will recruit to a fishery. Most other YOY fishes do not reach this size by August and do not recruit consistently. The inverse correlation of the mean gill-net catch of gizzard shad with its mean catch in seines the previous year probably resulted from a single strong year class suppressing the development of subsequent year classes for several years, as observed by Willis (1987). The suppression mechanism could involve production of high densities of YOY that have low survival because they grow slowly, are exposed to predation longer, and are more vulnerable to disease and winter kill due to poor body condition. Median lengths of gizzard shad in seines were inversely correlated with geometric mean catches in seines the same year. High densities of YOY gizzard shad in Kansas reservoirs apparently resulted in poor growth and poor recruitment, whereas low densities resulted in rapid growth and good recruitment.

In this study, reservoirs with high average seine catches of gizzard shad <140 mm tended to have low average catches of 152–254-mm gizzard shad in 25.4-mm-mesh gill nets (r = −0.50; P = 0.0190; N = 24). This relation may be a density-dependent phenomenon, influenced by winter kill of adults in northern Kansas, because average reservoir catches of young gizzard shad in seines were inversely correlated with the length of the growing season (r = −0.51; P = 0.0112; N = 24). Northern Kansas reservoirs consistently have large numbers of YOY gizzard shad in August, likely because adult populations rarely develop in sufficient numbers to suppress YOY survival. By contrast, populations in southern Kansas reservoirs are dominated by adults that may adversely affect year-class development and survival of YOY.

The seemingly poor capability of seine catches for explaining future variation in catches of 152–254-mm fish of the same species is not surprising because 95th-percentile lengths of most species were ≤140 mm (≤190-mm for walleye and common carp). Highly variable survival of most small fishes vulnerable to seines apparently prevents reliable forecasts of year-class strength. Bayley and Austen (1987) found that 76 and 100 random hauls with a 9.14- × 1.83-m beach seine were required to obtain efficiency estimates within ±20% of the mean efficiency of the gear for 25–30-cm largemouth bass (efficiency = 48.6%) and 12–15-cm bluegill (efficiency = 28.8%). Presumably these sizes of largemouth bass and bluegill would recruit, but they are not well sampled with 20 or fewer hauls of a seine ≤ 15.2 m long in most Kansas reservoirs. Newburg and Shupp (1986) found that growth was a better indicator of recruitment for largemouth bass than densities estimated by shoreline seining. In this study, catches of 152–254-mm fish of any species by gill nets, trap nets, or electrofishing were not correlated with median lengths of the same species in seines in August the previous year.

Prey Availability

August catches of gizzard shad were directly correlated with the mean body condition (Wr) of several 152–254-mm sport fishes such as white bass (r = 0.18; P = 0.200; N = 52), white crappie (r = 0.33; P = 0.007; N = 65), and black crappie, *Pomoxis nigromaculatus* (r = 0.34; P = 0.050; N = 34) in fall and of largemouth bass (r = 0.25; P = 0.200; N = 32) in spring. Interestingly, August catches of lepomid sunfishes were inversely related to the condition of the same piscivores, but these correlations probably are spurious, resulting more from strong inverse relations between the relative abundance of YOY gizzard shad and lepomid sunfishes than from true cause and effect.

The relative abundance of gizzard shad was an important factor affecting the condition of some young piscivores and the relative abundance of small lepomid sunfishes. Growth of YOY gizzard shad apparently is slowed when their densities are high. Slow growth results in gizzard shad being a major food item for a longer period of time for young piscivores. When less dense, YOY gizzard shad grow rapidly and become unavailable to young predators sooner than when their densities are high. Body condition of many young piscivores was poor in many reservoir years when seine catches of YOY gizzard shad were low and seine catches of small sunfishes were high. We found that average reservoir catches of lepomid sunfishes and gizzard shad in seines were inversely correlated (r = −0.48; $P > F$ = 0.0166; N = 24), perhaps because of competition between YOY gizzard shad and sunfishes (Kirk and Davies 1987 and Ali and Bayne 1987).

The catch of several species of sport fishes ranging from 152 to 254 mm in fall (152–254-mm largemouth bass in spring) was positively correlated with the seine catch of lepomid sunfishes the previous August. Mean catch of sunfishes in a bag seine was the most significant correlate with the fall gill net catches of 152–254-mm channel catfish (r = 0.31; P = 0.0005; N = 76) and striped bass, *Morone saxatilis* (r = 0.70; P = 0.0072; N = 13), spring electrofishing catches of largemouth bass (r = 0.46; P = 0.0001; N = 77), and fall trap net catches of white crappie (r

= 0.33; P = 0.0018; N = 73). These correlations may result from cause-effect relations in which abundant YOY sunfishes provide prey and enhance predator survival (Davies et al. 1982; Timmons and Pawaputanon 1981), or sunfishes ≤140 mm and 152–254-mm piscivores could be from the same year class and exhibit similar responses to environmental conditions. We believe that the latter hypothesis is most probable in this study, because the condition of several piscivores was positively related to the relative abundance of YOY gizzard shad the previous August, whereas no positive correlations were obtained between piscivore condition and seine catches of sunfishes. Nevertheless, if relations between seine catches of lepomid sunfishes and future catches of young piscivores were consistent, they could prove useful for predictive purposes.

Future Considerations

Alternative methods for sampling small prey fishes need to be explored and compared to shoreline seining. In this study, seine catches of small fishes considered prey (i.e., catch of all fishes ≤140 mm, gizzard shad, minnows, and lepomid sunfishes) were the only species or groups of species that could be effectively sampled with an average of ≤22 hauls in most reservoirs. Relative catches of these prey fishes in seines were correlated with the future body condition of several 152–254 mm sport fishes. However, seine catches of most sport fishes <140 mm were of no value for predicting the future year-class strength, at least as defined in this study (i.e., future relative abundance of 152–254 mm fish same species assessed with gears other than seines).

A doubling of sampling effort to 40 hauls (8–16 man-days) or tripling to 60 hauls (12–24 man-days) would be about equivalent to the effort required to sample 2 or 3 0.41-ha areas of shoreline or coves using block nets and rotenone. Advantages of sampling 0.41-ha or larger areas with rotenone are that it would provide more information on community composition and prey availability than seining and could be used in areas with rocks, brush, timber, or vegetation that often concentrate small fish. Disadvantages are that required effort often exceeds what is available (a minimum of 8 man-days is required to sample 1 0.41-ha cove), and therefore an insufficient number of coves can be sampled to quantify sample variation. In addition, predator standing crops measured in rotenone samples of shallow coves that are common in Kansas reservoirs are so low that there is little value in making traditional predatory-prey comparisons.

A promising alternative to cove sampling would be to sample 6–10 randomly-selected, 0.05-ha areas of shoreline with rotenone. A 61-m seine or plastic barrier could be laid out in a 15.2-m × 30.5-m rectangle parallel to shore and sampled with rotenone. A similar technique used by Timmons et al. (1979) to sample areas of 0.015 ha provided coefficients of variation of 50% for largemouth bass. This is considerably less than the average CV for largemouth bass in seine samples from Kansas (>100%). Johnson et al. (1988) obtained coefficients of variation of 60% for gizzard shad with 11 quadrat rotenone samples of 0.15 ha each, compared to average CV's of 50 ± 27% (SD) obtained in this study. Although these CV's for gizzard shad are comparable, findings of this study and of Johnson et al. (1988) showed that densities and median sizes of gizzard shad are underestimated by seining. Median lengths of most species that grow to 200 mm were significantly lower in seine samples from Melvern Reservoir in 1985 and 1986 than they were in cove samples taken in the same years.

Advantages of sampling small areas with rotenone include the ability to sample areas larger than can be sampled with seines and those with submerged structure. A disadvantage may be that more effort is needed to obtain acceptable levels of accuracy. Sampling of a 0.05-ha area also has advantages over traditional rotenone of large coves because it provides sufficient replication to allow estimates of sample variance. Based upon effort needed to sample 0.015-ha areas (Timmons et al. 1979) and 0.15-ha areas (Johnson et al. 1988), 7 0.05-ha areas probably could be sampled with the same amount of effort now expended for seining (20 hauls and fish processing). The goal would be to determine the relative abundance of prey, so fish >200 mm would not have to be processed. Small fish could be netted, put in coolers, and taken to the lab for length and weight measurements.

Literature Cited

Aggus, L. R., G. P. Ploskey, and R. M. Jenkins. 1986. Survey of state sampling methods to identify new regional or national data bases on reservoir fishery resources. Funded by the Grants In Aid Comm., Internatl. Assoc. Fish and Wildl. Agencies under U.S. Fish and Wildl. Service Contr. FWS-14-16-0009-84-025. 32pp.

Aggus, L. R., J. P. Clugston, A. Houser, R. M. Jenkins, L. E. Vogele, and C. H. Walburg. 1980. Monitoring of fish in reservoirs. Pages 149–175 *in* C. H. Hocutt and J. R. Stauffer, Jr., ed. Biological monitoring of fish. Lexington Books, Lexington, Mass.

Ali, A. B. and D. R. Bayne. 1987. Food related problems in bluegill populations of West Point Reservoir. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 39:207–215.

Bayley, P. B. and D. J. Austen. 1987. Comparative analysis of fish populations in Illinois impoundments: gear efficiencies and standards for condition factors. Ill. Nat. Hist. Surv., Aquat. Biol. Sect. Tech. Rep. 87/14 52pp.

Bennett, C. D. and B. E. Brown. 1969. A comparison of fish population sampling techniques on Lake Raymond Gary, Oklahoma. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 22:425–444.

Davies, W. D. and W. L. Shelton. 1985. Sampling with toxicants. Pages 199–213 *in* L. A. Nielson, and D. L. Johnson. Fisheries Techniques. Am. Fish. Soc., Bethesda, Md.

———, W. L. Shelton, and S. P. Malvestuto. 1982. Prey-dependent recruitment of largemouth bass: a conceptual model. Fisheries 7(6): 12–15.

Fredin, R. A. 1950. Fish population estimates in small ponds using the mark and recovery techniques. Iowa State J. Sci. 24(4): 363–384.

Herring, J. 1980. Fish population estimate methods evaluated by a total drawdown. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 33:393–401.

Jenkins, R. M. and D. I. Morais. 1978. Prey-predator relations in the predator-stocking-evaluation reservoirs. Proc. Annu. Conf. Southeast Assoc. Game and Fish Comm. 30:141–157.

Johnson, B. M., R. A. Stein, and R. F. Carline. 1988. Use of a quadrat rotenone technique and bioenergetics modeling to evaluate prey availability to stocked piscivores. Trans. Am. Fish. Soc. 117:127–141.

Kirk, J. P. and W. P. Davies. 1987. Competitive influences of gizzard shad on largemouth bass and bluegill in small impoundments. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 39:116–124.

Kramer, R. H. and L. L. Smith, Jr. 1962. First year growth of the largemouth bass (Micropterus salmoides, Lacepede) and some related ecological factors. Trans. Am. Fish. Soc. 89:222–233.

Newburg, H. J. and D. H. Schupp. 1986. Shoreline seining for young-of-the-year largemouth bass as a method of predicting recruitment to the anglers catch. Minn. Dep. of Nat. Resour. Invest. Rep. 388:1–25.

Sokal, R. R. and F. J. Rohlf. 1969. Biometry. W. H. Freeman and Co., San Francisco, Calif. 776 pp.

Swingle, H. S. 1956. Determination of balance in farm fish ponds. Trans. North Am. Wildl. Conf. 21:298–322.

Timmons, T. J. and O. Pawaputanon. 1981. Relative size relationship in prey selection by largemouth bass in West Point Lake, Alabama-Georgia. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 34:248–252.

———, W. L. Shelton, and W. D. Davies. 1979. Sampling reservoir fish populations in littoral areas with rotenone. Proc. Annu. Conf. Southeast Assoc. Fish and Wildl. Agencies 32:474–484.

Willis, D. W. 1987. Reproduction and recruitment of gizzard shad in Kansas reservoirs. N. Am. J. Fish. Manage. 7:71–81.

Wege, G. J. and R. O. Anderson. 1978. Relative weight (Wr): a new index of condition for largemouth bass. Pages 79–91 *in* G. D. Novinger and J. G. Dillard, eds. New approaches to the management of small impoundments. North Cent. Div. Am. Fish. Soc. Spec. Publ. 5.