Competence of Non-random Electrofishing Sampling in Assessment of Structural Indices

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Abstract: Electrofishing for largemouth bass (*Micropterus salmoides*) in sites selected because they are judged to have habitat favored by bass can often yield higher catch per effort than in sites selected randomly, resulting in reduced effort or more precise estimates. Although samples selected subjectively could misrepresent relative abundance, they may or may not affect population indices derived from length-weight data, such as length-frequency and condition indices. We compared indices obtained at randomly-selected sites with indices obtained at subjectively-selected sites. The latter sites provided more largemouth bass, overestimated Proportional Stock Density and Relative Stock Density ($P < 0.05$), but did not affect Relative Condition ($P > 0.05$). We conclude that judgment sampling may misrepresent a largemouth bass population's abundance and structure.

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Management of reservoir largemouth bass fisheries requires periodic sampling to monitor population structure. This entails collecting data concerning fish lengths, weights, age, and abundance. Electrofishing with a boat-mounted generator is probably the most economical, reliable, and frequently used method for sampling largemouth bass in reservoirs (Reynolds and Simpson 1978, Woodrum 1979, Reynolds 1983). Samples obtained by electrofishing in large reservoirs are generally taken along shoreline areas by selecting fixed lengths of shoreline, or by selecting a starting point and then sampling continuously for a fixed amount of time. Sampling sites are selected randomly using various statistically-based designs or non-randomly by subjectively choosing areas easily accessible or expected to yield abundant largemouth bass collections (Johnson and Nielsen 1983).

Statistical procedures require that the samples are obtained in a random fashion in order to make valid inferences about populations from samples. When sampling fish in shoreline areas randomization may be achieved if: 1) sampling sites are selected at random, or 2) sampling sites are selected subjectively and fish are randomly distributed throughout the shoreline. Large impoundments, however, contain a wide range of littoral habitats and largemouth bass exhibit definite habitat preferences (Trautman 1957) in addition to schooling and aggregating behaviors (Miller 1975). Thus, sample sites selected subjectively may misrepresent abundance or population parameters influenced by distributional and behavioral peculiarities.

Simple indices that describe the size structure and condition of populations are often used by fishery biologists to arrive at conclusions concerning the management of largemouth bass fisheries. Computation of these indices generally require few data that can be collected at relatively low cost. Thus, indices are convenient when several populations must be monitored and managed with limited manpower resources. Some indices often used in assessment of largemouth bass populations are Relative Condition (Wr), Proportional Stock Density (PSD) and Relative Stock Density (RSD) (Anderson and Gutreuter 1983). These indices are derived from length and weight data only, and may or may not be affected if computed from samples collected in habitats favored by largemouth bass. Collections in such sites may yield higher catch per effort, resulting in: 1) reduced effort demand, or 2) more precise estimates of structural indices (i.e., values with narrower confidence intervals) due to larger sample size. Our objective was to determine if catch per effort and estimates of structural indices obtained in sites selected subjectively because they appeared to have habitat favored by largemouth bass were significantly different from estimates obtained in sites selected at random.

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Methods

Largemouth bass populations in Aberdeen, Aliceville, Bay Springs, Columbus, and Lock A lakes, located along the Tennessee-Tombigbee Waterway in northeastern Mississippi, were sampled by electrofishing from 1983 to 1986. The lakes were impounded by the U.S. Army Corps of Engineers primarily for navigation and recreation, and differ in age, morphometric features, and habitat composition. Except for Bay Springs Lake, the northernmost impoundment in the waterway, Tennessee-Tombigbee Waterway reservoirs are shallow, averaging roughly 2 m (Table 1). Deep water areas are limited to the navigational canal, old river channel, and inundated sloughs.

Electrofishing was conducted using AC supplied from a boat-mounted, 230-volt, generator linked to a voltage pulsator to provide variable output. Sample units consisted of 30-minute runs during daylight hours with an emphasis on shoreline areas. The crew was composed of a boat driver and a person netting fish from the bow.

Samples were taken at sites selected randomly and non-randomly. Random samples were selected by placing a numbered grid (0.4 km^2) over a map of each lake and choosing grids using a table of random numbers. Grids containing habitat

Table 1. Physical characteristics of the 5 study lakes in the Tennessee-Tombigbee Waterway, Mississippi.

Lake	Date of impoundment[a]	Surface area (ha)	Average depth (m)	Shoreline development
Aberdeen	Jan 1984	1,668	2.0	7.8
Aliceville	Dec 1979	3,359	2.2	11.6
Bay Springs	Apr 1984	2,711	8.2	15.4
Columbus	Jan 1981	3,606	2.0	13.9
Lock A	Oct 1981	370	1.4	2.4

[a]Denotes month and year during which the reservoir reached full pool.

unsuitable for electrofishing, such as deep pelagic habitats or inaccessible shoreline areas, were omitted. Non-random samples were chosen subjectively based on the availability of largemouth bass habitat, such as points where the old river channel joins the navigational canal, submerged creek channels and roadways, weed beds, fallen trees and brush, stump fields, flooded timber, and other structures associated with the littoral zone. The same biologist selected the non-random sites throughout the study.

Indices of abundance and population structure were determined according to collection (interpreted here as a set of random and non-random samples collected in a given lake at a given time) and type of sample. Relative abundance, expressed as catch per effort (CPE), was computed as the number of largemouth bass captured per hour of electrofishing. Relative weight (Wr), an index of condition, and Proportional Stock Density (PSD) and Relative Stock Density (RSD-38), indices of length-frequency, were calculated from length-weight data as described by Anderson and Gutreuter (1983).

Indices provided by each type of sample were compared using two-way, or block, classification procedures. Each collection represented a block. The object of blocking was to extract the variation between collections, resulting from differences in lakes and time, so that observed differences would largely be due to type of sample. Estimates of CPE and Wr obtained with random and non-random sampling were compared using 2-way ANOVA (Ray et al. 1982:119–137). Because PSD and RSD-38 represent binomially distributed ratios, they were compared using a logit function which models the logs of ratios of multinomial probabilities (Ray et al. 1982:257–285).

Results and Discussion

A total of 334 samples taken from 1983 through 1986 yielded 4314 largemouth bass (Table 2). CPE ranged from 12-57 largemouth bass/hour and was significantly greater ($P < 0.001$) when fish were sampled in sites selected non-randomly (Table 3). Non-random samples yielded, on the average, 7 more bass per hour than randomly selected samples. Consequently, a reservoir's relative abundance of largemouth bass would be overestimated when computed from samples taken in areas

Table 2. Characteristics of 21 electrofishing collections obtained with randomly and non-randomly selected samples in five impoundments of the Tennessee-Tombigbee Waterway, Mississippi, 1983–1986.

Parameter	Random	Non-random	Total
Number of 30-min samples	148	186	334
Average number of samples/ collection	7	9	16
Number of largemouth bass	1,635	2,679	4,314
Average number of largemouth bass/collection	78	119	197

Table 3. Mean catch per hour (CPE), mean Relative Condition (Wr), Proportional Stock Density (PSD), and Relative Stock Density (RSD-38) of largemouth bass populations in 5 Tennessee-Tombigbee Waterway impoundments sampled at randomly (R) and non-randomly (NR) selected sites, 1983–1986. F and χ^2 statistics were used to test whether the estimates obtained with non-random sampling were different from those obtained randomly.

	CPE		Wr		PSD		RSD-38	
Collection	R	NR	R	NR	R	NR	R	NR
Lock A (Sep–Oct 1983)	53	57	92	87	8	28	5	9
Lock A (Mar–Apr 1984)	28	36	87	87	17	20	8	12
Lock A (Oct 1984)	24	41	85	87	11	18	4	7
Lock A (Apr 1985)	43	57	87	86	11	26	7	19
Lock A (Oct 1985)	20	30	82	89	37	50	11	24
Bay Springs (Oct 1985)	16	21	90	90	38	59	26	37
Aliceville (May 1983)	21	28	88	91	36	39	20	23
Aliceville (Oct–Nov 1983)	39	30	85	89	31	47	17	34
Aliceville (Mar–Apr 1984)	16	20	90	88	47	36	27	38
Aliceville (Oct 1984)	36	35	89	88	32	26	15	14
Aliceville (Mar 1986)	16	22	87	87	44	48	18	22
Columbus (Sep–Oct 1983)	18	29	91	91	24	25	10	16
Columbus (Mar–Apr 1984)	12	19	88	90	31	27	15	11
Columbus (Oct 1984)	26	31	92	91	36	37	25	18
Columbus (Mar 1985)	12	15	90	93	54	66	15	27
Columbus (Nov 1985)	20	40	87	84	46	34	24	18
Columbus (Apr 1986)	20	35	92	90	55	55	24	19
Aberdeen (Nov 1984)	26	30	90	87	21	28	6	11
Aberdeen (Apr 1985)	21	12	88	94	46	48	25	20
Aberdeen (Oct–Nov 1985)	13	23	87	90	39	45	28	21
Aberdeen (Apr 1986)	22	33	90	91	37	36	11	14
Statistic	F = 18.12		F = 0.88		χ^2 = 7.56		χ^2 = 3.90	
P value	0.001		0.360		0.006		0.042	

with disproportionately high amounts of largemouth bass habitat. Such samples may reduce effort demand and be useful in detecting changes in abundance over time in a given reservoir if method of site selection is held constant or the same areas are sampled repeatedly. However, if prime bass habitat tends to remain at or near carrying capacity, samples taken in such areas may detect only drastic changes or no changes in CPE. We did not investigate this objection; however, it may be settled by monitoring CPE in permanent stations selected at random and permanent stations selected subjectively, and comparing the trends of each type of station.

Length-frequency indices were also affected by method of site selection. PSD and RSD-38 values ranged widely among collections (Table 3). Within collections, PSD and RSD-38 values obtained with non-random sampling were significantly larger ($P \leq 0.05$) than those obtained randomly. This suggests that reservoir habitats thought by biologists to shelter more bass may also hold a greater proportion of the lake's large bass, at least within the lakes examined. Condition of largemouth bass, Wr, remained fairly constant among collections; thus, method of site selection did not affect the estimates ($P = 0.360$) (Table 3).

The degree to which random or subjective sampling affected CPE and length-frequency indices appears to be related to abundance and distribution of prime largemouth bass habitat within a lake. In Lock A and Bay Springs lakes, good largemouth bass habitat was sparsely distributed and easily distinguished; thus, samples selected subjectively ordinarily were able to provide more choice habitat than random samples. However, Aliceville, Columbus, and Aberdeen lakes typically contained abundant and widespread habitats considered to be attractive to largemouth bass; consequently, habitats examined by random and non-random samples were more uniform. As a result, CPE and length-frequency indices in Aliceville, Columbus, and Aberdeen lakes were less consistently different (Table 3).

Electrofishing surveys in large impoundments typically consist of samples taken at randomly selected sites, permanent sampling stations, or representative segments of the shoreline (Aggus et al. 1980, King et al. 1981, Carline et al. 1984). A random design provides unbiased estimates of population parameters and should be used when the objective is to describe abundance (CPE) or compare abundance among reservoirs. However, random sampling in large impoundments can be inefficient and expensive if it involves extensive travel between sampling sites and/or if large sample sizes are needed. Permanent sampling stations can reduce logistic problems and make sampling more efficient (Johnson and Nielsen 1983). Permanent sampling sites may be used to monitor changes in abundance of a population over time, and may provide satisfactory data when knowledge of true relative abundance is not required. King et al. (1981) compared estimates of biomass and a size index of largemouth bass derived from samples collected in permanent and random sites in a large reservoir. They reported no difference between the 2 types of sampling sites with respect to the parameters estimated. Their permanent sites, however, were originally selected at random. The selection of representative segments of a shoreline is subjective because the sample is restricted to units thought by someone to be especially typical or convenient for sampling. Therefore, they could bias CPE as seen in our study and should not be used to estimate true relative abundance; however, they could be used to monitor changes in abundance over time if used as permanent stations.

Our study suggested that sampling design may also affect some estimates of structural indices. A population's Wr can apparently be estimated adequately with samples selected subjectively. Indices of length-frequency, however, could be biased if computed from samples taken in sites chosen because they appear to have habitat favored by largemouth bass. This argument may also apply to any other schemes involving judgment sampling. Length-frequency indices determined from sites selected subjectively may be useful in monitoring changes in a largemouth bass population, but only if the sampling conditions and the subjectivity in site selection can be held constant.

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