EVALUATION OF GILL NET AND ROTENONE SAMPLING TECHNIQUES WITH TOTAL RESERVOIR DRAWDOWN

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ABSTRACT

The effectiveness and selectivity of monofilament and multifilament gill netting and area rotenone sampling in a shallow, 15.3-ha impoundment were determined. Estimates of species present, relative abundance, length-frequency distributions and standing crops were determined by the sampling techniques and compared with total fish populations estimated by rotenone treatment of the entire impoundment. Each sampling device furnished close approximations of species present and relative abundance of dominant fishes, but gill netting was the most economical method of determining these two statistics. Area rotenone sampling provided the only adequate length-frequency data. Rotenoning surveys misrepresented the overall standing crop of fishes, but apparently furnished accurate standing crop estimates for sections of the impoundment sampled.

Surveys are conducted on public and private waters to inventory fish populations and to locate and evaluate management problems. Estimates of species composition, relative abundance and standing crop are often required, but reliability of these statistics is contingent upon the effectiveness and selectivity of sampling gear.

Several investigations have been conducted concerning selectivity of fish sampling techniques. Powell et al. (1971) compared catches of five gear types in Boyd Reservoir, Colorado, and concluded gill nets furnished the best approximations of relative abundance. Jester (1973) tested nine differently colored gill nets and found most colored nets caught less fish than white nets and were selective toward individual species. Bennett and Brown (1969) reported electrofishing and gill netting provided reliable estimates of species composition. Barry (1967) and Hayne et al. (1967) found standing crop estimates from cove rotenone sampling misrepresented individual species abundance, but closely approximated the total standing crop of fishes in reservoirs.

This study was conducted to determine the effectiveness of monofilament and multifilament gill nets and area rotenone sampling in determining fish species composition, relative abundance, length frequency and standing crop.

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MATERIALS AND METHODS

From May through June, 1973 and 1974, research was conducted on the J. D. Murphree Wildlife Management Area, 8 km south of Port Arthur, Texas. Levees divide the area into 11 compartments which are primarily used for research concerning management of coastal freshwater marshland. Each compartment is characterized by shallow sloughs, a peripheral canal and extensive areas of emergent vegetation. In Compartment 4, (15.26 ha, Fig. 1) 18 monofilament and 18 multifilament gill net sets and three area rotenone samples were made during the study period. Area A (0.15 ha) and B (0.17 ha) were treated with

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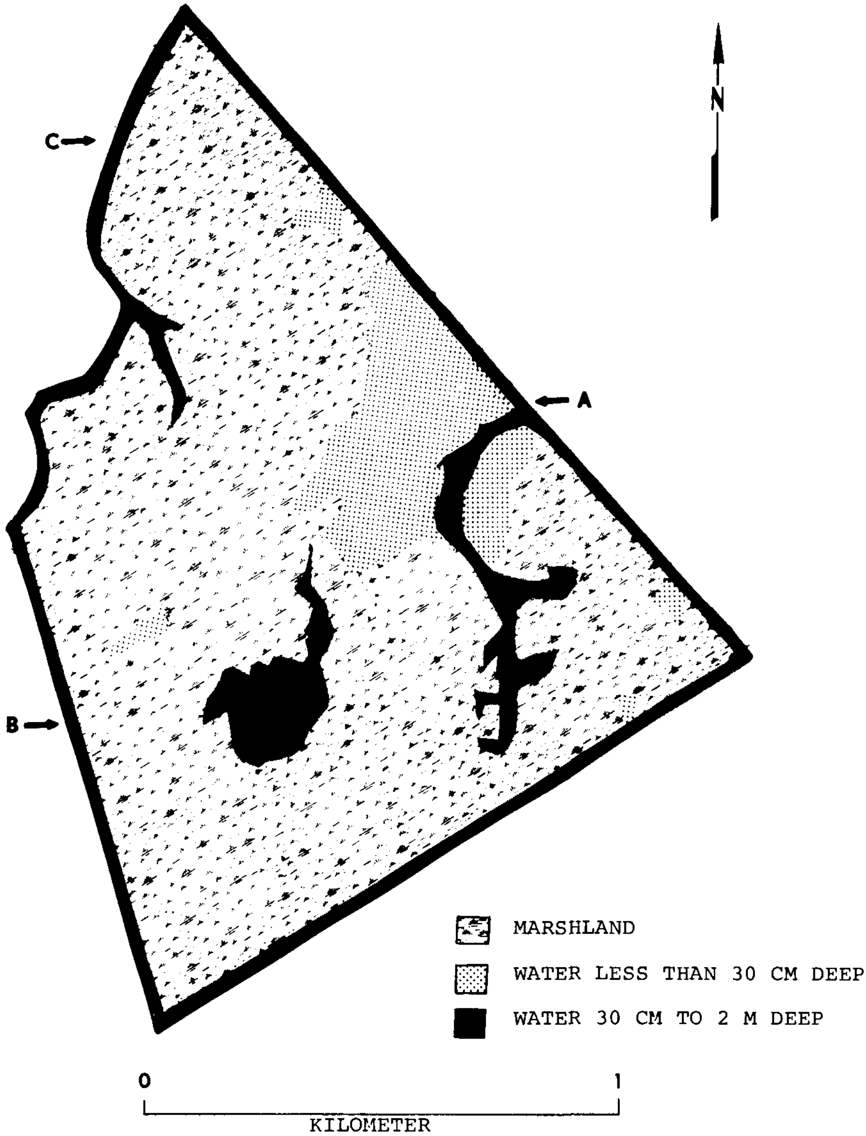

Figure 1. Compartment 4 of the J. D. Murphree Wildlife Management Area showing rotenone sampling areas A, B and C.

rotenone in 1973 and Area C (0.23 ha) in 1974. Costs of each sampling effort were estimated in terms of salaries, travel expenses and equipment expenditures.

Each gill net measured 45.7 m long by 2.4 m (hobbled to 1.8 m). Panels were 7.6 m long and varied in bar mesh size from 2.5 cm to 8.9 cm by 1.3 cm increments. Mesh materials were No. 139 multifilament and No. 5 monofilament webbing. Fishes were separated by net type (monofilament or multifilament), sorted by species, weighed and measured (total length).

Areas were sampled with 5% liquid rotenone applied at a rate of 2 ppm total ingredient. Nylon block-off nets were used to delimit and prevent fishes from leaving or entering sample areas. Each net measured 128.0 m long by 4.6 m deep and was constructed of No. 3 nylon webbing with 1.9 cm mesh (ace weave). Prior to treatment, approximately 100 fish were collected, tagged and released into each sample area. The number of marked fish recaptured was used to estimate percent recovery of fish within the treated areas. During the 4-day collecting period, specimens were sorted by species, measured to inch group and counted. Due to decomposition, fish within each inch group were weighed only on the day of treatment. Weights for fish recovered on subsequent days were estimated from length-weight relationships calculated from data taken on the first day of the fish collection. Crappie under 7.6 cm were designated "crappie sp." because of the problem in differentiating between small white and black crappie.

During June, 1974, Compartment 4 was lowered to approximately 4.8 ha and treated with 5% liquid rotenone (2 ppm total ingredient). To determine percent recovery, 457 fish were tagged and released throughout the compartment. Fish were collected and processed for 4 days following treatment.

Species present, relative abundance, length-frequency distributions and standing crops were estimated using the sampling techniques described. Effectiveness and selectivity of each sampling method were evaluated by comparing these approximations with the total fish populations estimated from rotenone treatment of Compartment 4. Wilcoxon's signed-rank test and a single sample t-test were used for comparisons involving relative abundance and standing crop estimates, respectively.

RESULTS AND DISCUSSION

Species Composition

Nineteen species of fish were collected during the total rotenone treatment of Compartment 4 (Table 1). Monofilament and multifilament gill nets and area rotenone sampling collected 16, 14 and 13 species respectively. Striped mullet and bantam sunfish were not collected with either type of gill net. Channel catfish and yellow bass were absent from area rotenone and multifilament gill net collections. Area rotenone sampling also failed to capture blue catfish. With the exception of bantam sunfish, species missed by each gear were uncommon in Compartment 4. The small size of bantam sunfish probably accounted for their absence from netting collections. Apparently, even the 2.5-cm bar mesh webbing was too large to capture this species.

In a similar study, Sandow (1971) reported gill net sampling furnished a complete list of species present. Bennett and Brown (1969) obtained reliable estimates from gill net and electrofishing collections. However, a combination of at least two types of sampling devices were found to provide the best estimate of species composition (Smith 1949, Moyle and Burrows 1954, Powell et al. 1971). A combination of monofilament gill net and area rotenone samples furnished eighteen of the species in Compartment 4.

Relative Abundance

Comparisons of relative abundance of fishes were made only with data collected during 1974, the year Compartment 4 was rotenoned, to avoid any significant yearly changes in fish populations that might have occurred. Gill netting appeared to be selective against centrarchids. Collections from monofilament and multifilament nets had a low percent catch of warmouth, bluegill, redear sunfish and largemouth bass (Table 1). Alligator gar, yellow bullhead, and black crappie were apparently highly susceptible to gill net sampling; their relative abundance (numbers and weights) was overestimated by the two types of netting. Although area rotenone sampling was effective in capturing most centrarchids, this method provided low estimates of relative abundance for bluegill, largemouth bass and black crappie. All sampling devices (nets and rotenone treatments) furnished low abundance estimates of spotted gar but overestimated bowfin, gizzard shad, black bullhead and white crappie.

Table 1. Relative abundance of each species captured by monofilament and multifilament gill nets, area rotenone sampling, and total reservoir rotenone treatment, Compartment 4, J. D. Murphree Wildlife Management Area, Texas, 1974 (Brackets contain percent statistics).

Species*	*Monofilament Gill Nets*		*Multifilament Gill Nets*		*Area Rotenone Samples*		*Total Reservoir Treatment*	
	Number	*Weight (kg)*	*Number*	*Weight (kg)*	*Number*	*Weight (kg)*	*Number*	*Weight (kg)*
Spotted gar	26(12.26)	20.74(20.64)	19(12.92)	15.39(19.78)	53(8.53)	8.16(12.46)	10622(13.06)	2745.76(27.01)
Alligator gar	13(6.13)	6.28(6.25)	13(8.84)	11.96(15.37)	3(0.49)	0.85(1.30)	304(0.37)	459.78(4.52)
Bowfin	20(9.44)	28.94(28.80)	16(0.89)	29.43(37.83)	77(12.44)	35.60(54.38)	5763(7.09)	2439.03(23.99)
Gizzard shad	18(8.49)	4.84(4.82)	6(4.08)	1.47(1.89)	9(1.46)	2.22(3.39)	461(0.56)	78.17(0.77)
Carp	3(1.41)	5.22(5.20)	2(1.36)	3.91(5.03)	0(0.00)	0.00(0.00)	276(0.34)	483.50(0.76)
Blue catfish	1(0.47)	1.47(1.46)	1(0.68)	0.57(0.73)	0(0.00)	0.00(0.00)	9(0.01)	15.33(0.15)
Black bullhead	11(5.19)	4.39(4.37)	7(4.76)	2.58(3.32)	6(0.98)	3.12(4.77)	634(0.78)	155.14(1.53)
Yellow bullhead	32(15.10)	12.99(12.93)	10(6.81)	3.21(4.13)	3(0.49)	0.26(0.40)	939(1.16)	267.02(2.63)
Channel catfish	1(0.47)	0.97(0.97)	0(0.00)	0.00(0.00)	0(0.00)	0.00(0.00)	116(0.14)	74.56(0.73)
Yellow bass	1(0.47)	0.10(0.10)	0(0.00)	0.00(0.00)	0(0.00)	0.00(0.00)	154(0.19)	11.74(0.12)
Warmouth	11(5.19)	1.61(1.60)	14(9.52)	1.76(2.27)	199(32.19)	8.48(12.95)	10363(12.74)	598.79(5.89)
Bluegill	38(17.92)	4.44(4.42)	40(27.21)	3.95(5.08)	182(29.51)	3.34(5.10)	41100(50.54)	1788.34(17.59)
Redear sunfish	1(0.47)	0.13(0.13)	4(2.72)	0.45(0.58)	0(0.00)	0.00(0.00)	3346(4.11)	260.47(2.56)
Spotted sunfish	0(0.00)	0.00(0.00)	0(0.00)	0.00(0.00)	9(1.47)	0.39(0.60)	1020(1.26)	26.60(0.26)
Bantam sunfish	0(0.00)	0.00(0.00)	0(0.00)	0.00(0.00)	24(3.90)	0.14(0.21)	994(1.22)	9.15(0.09)
Largemouth bass	5(2.36)	1.60(1.59)	2(1.36)	0.20(0.26)	2(0.24)	0.30(0.46)	1964(2.41)	382.59(3.76)
White crappie	3(1.42)	0.68(0.68)	1(0.68)	0.20(0.25)	48(7.81)	1.98(3.02)	267(0.33)	25.07(0.25)
Black crappie	28(13.21)	6.07(6.04)	12(8.17)	2.71(3.48)	3(0.49)	0.63(0.96)	2377(2.92)	213.03(2.10)
Crappie sp.*	0(0.00)	0.00(0.00)	0(0.00)	0.00(0.00)	0(0.00)	0.00(0.00)	238(0.30)	2.09(0.02)
Striped mullet	0(0.00)	0.00(0.00)	0(0.00)	0.00(0.00)	0(0.00)	0.00(0.00)	381(0.47)	129.07(1.27)
Totals								
No.	212(100.00)		147(100.00)		618(100.00)		81328(100.00)	
Wt.		100.47(100.00)		77.79(100.00)		65.47(100.00)		10165.23(100.00)

*Common names taken from Bailey, 1970.
**All crappie under 7.6 cm in total length.

Several investigators have discussed the difficulty in obtaining accurate relative abundance estimates by gill net and rotenone sampling techniques. Hayne et al (1967) noted a species may be overestimated because it is more abundant in the sample or because other species are less abundant. Each value depends upon all other values, and over- or under-representation has no simple interpretation. Carlander (1953) and Moyle (1950) studied selectivity of gill nets and concluded relative abundance of one species can be studied in time and space, but gill nets cannot be used for comparing the true relative abundance between species. According to Sanderson (1960) and Carter (1957), the main problem in determining relative abundance by cove rotenone techniques is that schooling and pelagic species may or may not be present in proportion to their actual abundance at the time of sampling.

Despite their limitations, gill net and cove rotenone sampling have provided reliable estimates of relative order of abundance of major fish species in reservoirs (Hayne et al. 1967, Sandow 1971, Powell et al. 1971). Dominance of major species in this study (spotted gar, bowfin, warmouth and bluegill) was reflected in collections by each sampling method. No statistical differences were found between estimates from sampling methods and complete rotenone treatment (Wilcoxon's signed-ranks test, 0.05 level).

Multifilament gill netting was the most economical method of estimating relative abundance of fishes. Materials for six multifilament and six monofilament gill nets cost approximately $318 and $360, respectively. Salaries and traveling expenses associated with 18 gill net sets cost approximately $420, while expenses for three area rotenone samples (4-day collection period) exceeded $5,000; rotenone samples involving 2-day collection periods were estimated to cost around $3,000. When equipment expenditures were added to the above figures, the cost difference between gill netting and area rotenone sampling was increased considerably.

Length-Frequency

Spotted gar, bowfin, warmouth and bluegill were the only fishes taken in sufficient numbers to allow length-frequency distribution comparisons. The selectivity of the sampling methods was similar for each of these species and can be illustrated by the length-frequency estimates for bowfin (Fig. 2).

Length-frequency distributions of gill net catches were similar. Monofilament and multifilament nets failed to capture smaller inch groups and consequently underestimated abundant segments of the fish populations. In contrast, the area rotenone sample

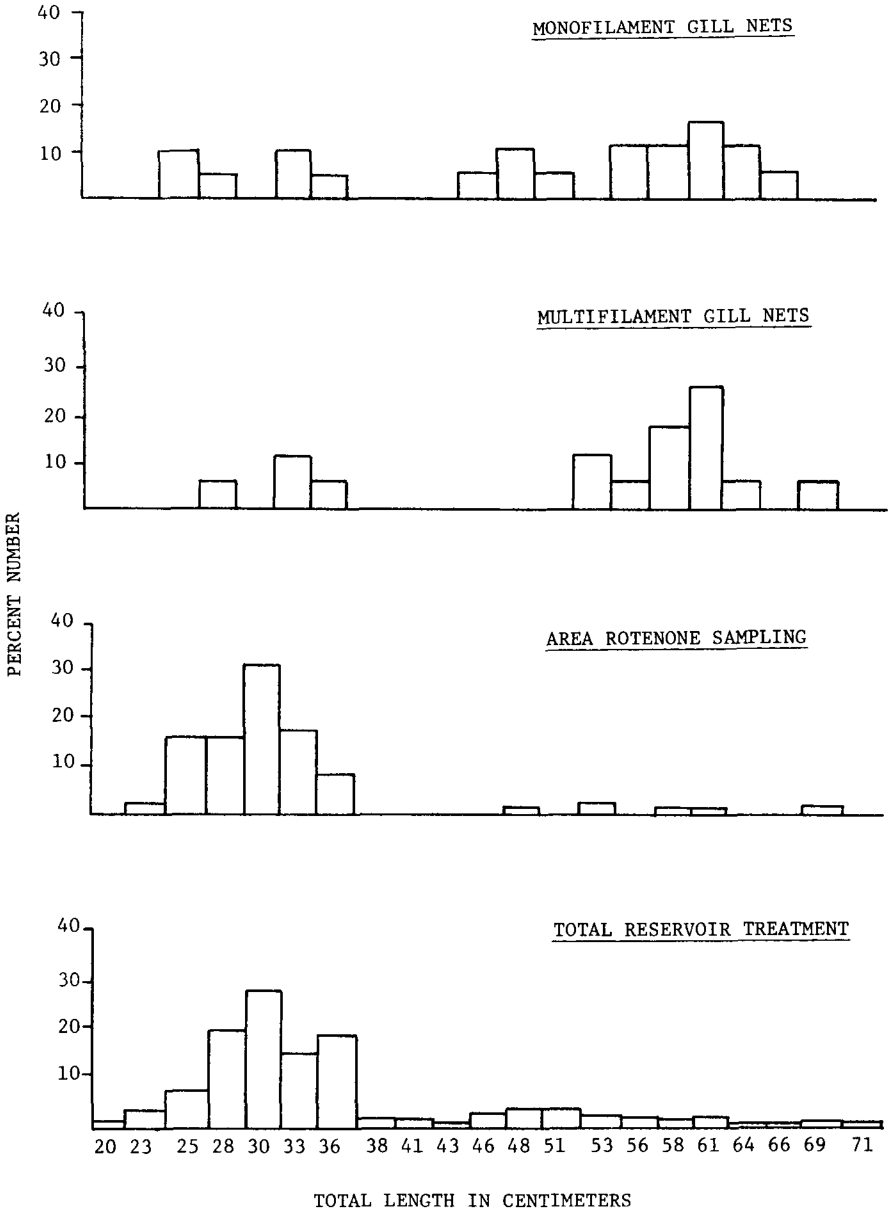

Figure 2. A comparison of the length-frequency distributions of bowfin collected by monofilament and multifilament gill nets, area rotenone sampling, and the total rotenone treatment of Compartment 4, J. D. Murphree Wildlife Management Area, 1974.

furnished a better representation of inch groups present, collecting most size groups in proportion to their estimated total abundance in Compartment 4.

Previous investigations have found inaccuracies associated with length-frequency estimates determined from gill netting and rotenone treatment techniques. Barry (1967) conducted studies on Lenape and Bischoff Reservoirs, Indiana, and reported cove rotenone samples and general fishery surveys (using gill nets, electrofishing gear and cylindrical traps) misrepresented length-frequency distributions of certain sunfish species.

Tarzwell (1942) reported cove rotenone sampling to be less selective for size groups than other collecting techniques. Carter (1957) concluded this method furnished length-frequency data valid for determining fish survival, growth and year class strength.

Gill nets with mesh sizes smaller than the 2.5-cm bar mesh size used in this study may have captured smaller fishes, but it is doubtful the gear would collect these size groups in proportion to their actual abundance. Heard (1962) reported low catch efficiencies for gill net meshes 2.5 cm and smaller. Latta (1959) and Watt (1956) discussed the selectivity of netting devices and concluded smaller fishes move less than larger ones and are less susceptible to capture by passive fishing gears. Despite these conditions, mesh sizes smaller than 2.5 cm have proven effective for qualitative sampling (Heard 1962) and may be useful for collecting small species such as threadfin shad which are noted for their extensive movements in reservoirs.

Standing Crop

Area rotenone sampling was the only technique from which standing crop estimates were obtained. Due to static conditions in the compartment throughout the study period we assumed standing crops remained relatively constant, and therefore, results of rotenone samples taken in both 1973 and 1974 from the three sample areas (A, B and C) were compared to those from the total rotenone treatment of Compartment 4.

Standing crop estimates from each rotenone sample misrepresented standing crops of individual species and the total standing crop of Compartment 4 (Table 2). Data from Sample Area A overestimated standing crops whereas data from Area B tended to underestimate them. Although Area C was sampled 3 weeks prior to the total compartment treatment, it provided low estimates for standing crops of most species. The reasons for these findings were not apparent. According to Carter (1957), inability to recover all fishes, absence of certain size groups due to depth distribution, and relative susceptibility of different fishes to rotenone are factors which prevent accurate quantitative measurements. The sample from Area C did, however, yield good standing crop estimates for bowfin, warmouth, and spotted and bantam sunfishes.

High percentage tag returns (67-86%) during area rotenone samples suggest standing crop estimates may have been accurate for the sections of the reservoir sampled. Carter (1957) stated relative estimates of standing crop for different sections of an impoundment can be effectively approximated by rotenone sampling. These estimates, when made throughout a study period, should reflect major changes occurring in a fish community.

Area estimates of standing crops combined yielded a mean value (500.17 kg/ha) that was not statistically different (single sample t-test, 0.05 level) from the total standing crop of Compartment 4 (667.44 kg/ha). However, the large variation in standing crop estimates of the area rotenone samples (range from 279.76 to 931.97 kg/ha) was a factor in this test's non-significance. Possibly an accurate standing crop estimate for an impoundment can be obtained by sampling several coves varying in size, depth, abundance of vegetation, etc. Sandow (1971) has reported the mean standing crop of fishes taken from three cove rotenone samples reasonably represented the true total standing crop of an impoundment.

CONCLUSIONS

Monofilament and multifilament gill nets and area rotenone sampling furnished close approximations of species present in Compartment 4. A combination of monofilament gill nets and area rotenone samples furnished a complete list of species, and relative abundance estimates, as determined by each sampling technique, were statistically similar to the total fish community. The rotenone survey technique was the most reliable method

Table 2. Standing crop estimates (kilograms/hectare) determined from three rotenone samples and the complete rotenone treatment of Compartment 4, J. D. Murphree Wildlife Management Area, 1973 through 1974.

*Species**	*Sample Area*			*Sample Areas Combined*	*Total Reservoir*
	A	*B*	*C*	*(Mean)*	*Treatment*
Spotted gar	205.33	26.94	36.04	89.44	180.26
Alligator gar	0.00	0.00	3.78	1.26	30.19
Bowfin	57.58	0.28	157.39	71.75	160.13
Gizzard shad	12.30	0.13	9.83	7.42	5.17
Carp	0.00	0.66	0.00	0.22	31.75
Blue catfish	0.00	0.00	0.00	0.00	1.01
Black bullhead	29.10	7.19	13.78	16.70	10.19
Yellow bullhead	8.19	2.64	1.31	4.05	17.53
Channel catfish	0.00	0.00	0.00	0.00	4.90
Yellow bass	0.00	0.00	0.00	0.00	0.77
Warmouth	137.58	84.71	37.52	86.59	39.32
Bluegill	268.60	72.79	14.77	118.72	117.41
Redear sunfish	1.27	1.53	0.00	0.93	17.10
Spotted sunfish	7.58	19.75	1.68	9.68	1.75
Bantam sunfish	8.71	8.75	0.61	6.02	0.60
Largemouth bass	11.69	8.85	1.53	7.36	25.12
White crappie	0.55	0.80	8.74	3.01	1.65
Black crappie	137.87	10.41	2.79	50.36	13.98
Crappie sp.*	45.62	34.05	0.00	26.56	0.13
Striped mullet	0.00	0.28	0.00	0.10	8.48
Total	931.97	279.76	289.77	500.17	667.44
Confidence Intervals	830.58-1061.57	256.32-307.90	254.12-337.06		653.41-682.09

*All crappie under 7.6 cm in total length.

of obtaining length-frequency data. Rotenone collections misrepresented the total standing crop, but area estimates may reflect major changes in the standing crop of an impoundment.

Comparisons of effort and cost spent on the operation of each survey method showed area rotenone sampling involved a much greater expenditure of man-hours and equipment. Gill netting was more economical for estimating species present and relative abundance of fishes. Rotenone operations may only be justified for comprehensive investigations when year class strengths and fish standing crop estimates are required.

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