Use of a Nursery Pond to Establish Smallmouth Bass in Beaver Reservoir, Arkansas

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Abstract: Production of smallmouth bass (*Micropterus dolomieu*) in 11-ha Beaver Nursery Pond was estimated from 1990 to 1994 to determine numbers of fish stocked in Beaver Reservoir. In 1990, 2 rapid population sampling methods, seining a known area and SCUBA transects, were tested against a Petersen mark-and-recapture estimate. Both sampling methods provided population estimates that did not differ significantly from mark-and-recapture values, but both generated greater confidence intervals. Annual production in the nursery pond by late June varied between 57,000 and 164,733 fish/year, with a mean of about 97,500 ± 59,750 (confidence interval, CI); mean total length of the smallmouth bass produced was 50 mm. Smallmouth bass were usually released into the reservoir in late June to reduce cannibalism, but during 1993 and 1994 fish were retained in order to assess growth and population changes. Post-June mean growth rate of young bass was as high as 0.46 mm/day and population declines were not statistically significant, indicating cannibalism was minor. Once in Beaver Reservoir, young smallmouth bass dispersed up to 5.2 km during the first 48 hours and up to 9 km after 24 days. Dispersal was principally directed down-lake. In 1992, wild-spawned smallmouth bass were discovered in Beaver Reservoir, the first time the species had spawned in that reservoir since the dam was closed in 1963. Subsequent year classes have been produced and the species has extended down-lake >36 km to the dam area.

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Smallmouth bass are native to the upper White River in Northwest Arkansas and were trapped behind Beaver Dam when it formed Beaver Reservoir in 1963 (Robison and Buchanan 1988). Smallmouth bass young-of-year (y-o-y) were collected in Beaver Reservoir during its first year of filling, but disappeared from annual collections thereafter (Keith 1964, Hodson 1966). In an attempt to re-establish smallmouth bass in Beaver Reservoir, Arkansas Game and Fish Commission (AGFC) began stocking y-o-y fish from Centerton State Fish Hatchery in 1981. By 1987, an estimated 350,000 fingerlings had been released (Bowman 1993), but annual seining, electrofishing, and cove rotenone collections by AGFC failed to capture any smallmouth bass (R. Fourt, AGFC, pers. commun.).

Arkansas Game and Fish Commission began using nursery ponds in association with mainstream reservoirs as grow-out facilities in the 1960s to assist in the introduction of new game fishes or to supplement production of existing fishes (Keith 1969). Most nursery ponds were constructed by constricting a cove mouth to control water flow and fish movement. These ponds filled during spring when reservoir levels were high and emptied during summer when reservoir levels declined. However, no suitable cove was available on Beaver Reservoir, necessitating construction of an 11-ha nursery pond adjacent to the reservoir in 1987 (Pardew 1992).

Beaver Nursery Pond was filled by water pumped from the reservoir and was drained by gravity through a 1.5-m gated culvert. Bales of hay were added to increase invertebrate production and fathead minnows (*Pimephales promelas*) stocked as forage, but no additional fish feeding took place. Most of the nursery pond substrate was clay and silt, making it poor spawning substrate for centrarchids. This was corrected through the addition of 250 automobile tires filled with gravel. Other tires were stacked in the shallow portion of the pond to provide spawning structure for forage fish. Gravel was also placed in 2 longitudinal shoals to provide additional spawning substrate for centrarchids. The nursery pond ranged to a depth of 3.3 m and fluctuated in water temperature more rapidly than the reservoir, often exceeding 32°C by early June. Additional reservoir water was added in order to maintain constant pond depth and size.

Between 1988 and 1994, AGFC reared smallmouth bass in Beaver Nursery Pond in an attempt to establish that species in Beaver Reservoir. In late March of each year, approximately 450 adults were captured from Bull Shoals Reservoir, transported to Beaver Nursery Pond, and allowed to spawn. Fathead minnows were stocked in early March and spawned in April. Smallmouth bass nests were observed in the gravel areas (tires and shoals) in April and early May. Young and adult smallmouth bass were usually released into Beaver Reservoir in late June when the youngest y-o-y reached approximately 80 mm total length (TL) and were thought to be preying on smaller bass.

Larger y-o-y fishes typically exhibit higher survival rates in the wild than smaller individuals (Oliver et al. 1979, Wicker and Johnson 1987). Larger fish are thought to be less vulnerable to predation, but losses of smaller fish to cannibalism may negate the advantages of stocking fewer, larger fish (Kraai et al. 1983, Heidinger et al. 1985). This study assessed growth and survival of y-o-y smallmouth bass in the nursery pond, but did not investigate differential survival of fish in the reservoir.

Little literature is available on nursery pond production or its success in introducing game fishes into the wild. Some aspects of nursery pond culture are similar to warm-water hatchery pond operations that have a long historic data base. However, the key to successful nursery pond operations is reduced effort and expense. Adult brood fish remain with the young until the nursery pond is emptied and no supplemental feeding is provided except for the initial stocking of forage fish. Arkansas Game and Fish Commission funded this study in order: 1) to evaluate several methods of estimating smallmouth bass numbers in Beaver Nursery Pond, 2) to assess changes in the cohort if release of fish is delayed beyond June, and 3) to determine if smallmouth bass establish in Beaver Reservoir as measured by reproduction.

Many people assisted in this study. Special thanks go to R. Fourt and R. Moore (AGFC) who assisted in most of the numerous nursery pond fish collections. Frequent assistance also came from L. Aberson, K. Flores, and Z. Brown (Ark. Coop. Unit). Dr. C. Annett and E. Dibble (Ark. Coop. Unit) made the SCUBA dives.

Methods

A Petersen mark-and-recapture index was utilized to initially estimate the y-o-y smallmouth bass population in Beaver Nursery Pond (Van Den Avyle 1993). On 15 June 1990, we marked 14,107 y-o-y smallmouth bass by removing a portion of the upper lobe of the caudal fin. For the following 5 days (16–20 Jun 1990), we seined the nursery pond perimeter sampling marked and unmarked bass, but no additional fish were marked.

We evaluated 2 more rapid and less invasive population estimation methods, seining a known area of the nursery pond and SCUBA transects, and compared those results to the mark-and-recapture estimate. To seine a known area of the pond, we divided the shoreline into 5 approximately equal reaches and made 5 quadrant seine hauls/reach each day. The collection technique was to stretch a 9.1-m long, 3-mm mesh seine directly out from shore to its full length, make a 1/4 circle haul into shore, count and measure fish, and then repeat the effort. Each seine haul sampled 66 m^2 of the pond, 5 consecutive seine hauls sampled 330 m^2, and 5 reaches sampled 1,650 m^2 of the nursery pond or 1.5% of the 110,000-m^2 area. We conducted known-area sampling over a 5-day period. Both the mark-and-recapture and known-area population estimations came from the same data set but were independently analyzed to avoid dependence.

Two SCUBA divers sampled 12 stratified random transects throughout the nursery pond on 18 and 19 June 1990 that ranged from 25 to 300 m long (Helfman 1983, Dibble 1991). Transects were stratified to include all substrate types (clay/silt, gravel, tire, and a small area of stone rip-rap) and various depths in the pond. Turbidity reduced visibility to about 1 m on either side of the transect tape, so areas surveyed ranged from 50 to 600 m^2. A total area of 3,400 m^2 was sampled.

Twenty-seven unbaited minnow traps were set throughout the pond on 17 June 1990 to evaluate dispersal of marked fish. Thirteen of the traps were set within 9.1 m of the pond edge and the remainder were set throughout the center of the pond; all traps were emptied on 18 and 19 June 1990.

After the intensive sampling effort in 1990, we continued to estimate the nursery pond y-o-y smallmouth bass production annually between 13 June and 6 July using the known-area seining method. In 1993 and 1994, y-o-y bass were retained in the nursery pond beyond June to provide an extended growing period and to evaluate changes in population numbers. Growth of young fish during this time was estimated by measuring total lengths of the first 50 fish collected from each of the 5 reaches of the nursery pond each month ($N = 250$). A few of these fish were preserved for food habit analysis.

In addition to the nursery pond collections, 14 seining stations were established in Beaver Reservoir both up- and down-lake from the nursery pond. Young-of-year *Micropterus* were collected from these stations with a 9.1-m, 3-mm mesh seine prior to release of the nursery pond fish to look for evidence of reservoir spawning by smallmouth bass. We continued to sample the reservoir stations after release of the nursery pond fish to determine dispersal and growth of nursery pond smallmouth bass in the reservoir. All *Micropterus* captured in the reservoir were preserved in 10% formalin for subsequent identification and measurement.

Data were analyzed using the statistical program StatMost (DataMost Corp., Salt Lake City, Utah). Population statistics (means and 95% CI) were calculated using methods in Brown and Austen (1996). A *t*-test was used to compare the various population estimations and the total length of nursery pond fish to reservoir fish in 1992. Chi-square was used to compare numbers of fish captured in the near-shore and center minnow traps, and the rates of growth and population decline were determined using simple linear regression analysis. Analysis of variance (ANOVA) was utilized to test differences among population estimates from different days and different reaches of the nursery pond.

Results

Nursery Pond Smallmouth Bass

Daily mark-and-recapture population estimates for y-o-y smallmouth bass ranged from 97,701 to 147,688 fish (Table 1). As daily estimates were not significantly different (analysis of variance, $P = 0.79$), they were combined for a mean of 117,816 ± 26,988 y-o-y smallmouth bass (95% CI, Brown and Austen 1996). Between 16 and 20 June 1990, we estimated the population size of y-o-y smallmouth bass daily using the known-area sampling method (Table 1). ANOVA failed to differentiate population estimates among the 5 reaches and 5 days ($P = 0.54$) so samples were combined for a mean estimate of 91,507 ± 33,676 y-o-y smallmouth bass. A paired *t*-test failed to differentiate daily known-area population estimates from daily mark-and-recapture estimates ($P = 0.13$).

The SCUBA population estimate yielded a lower value than the mark-and-recapture estimate. A total of 870 young smallmouth bass were observed by divers along the 12 transect (Table 2). Expansion of mean number of 0.366 fish/m^2 (CI = 0.482) to the total surface area of the nursery pond yielded a population estimate of 40,620 ± 53,000 fish. A *t*-test failed to differentiate between the SCUBA and mark-

Table 1. Population estimations of y-o-y smallmouth bass in Beaver Nursery Pond, 1990, using mark-and-recapture (MR) and known-area (KA) methods. Fish captured on 15 June were marked with a caudal fin clip; no other fish were marked.

Date	*N* captured fish	*N* marked fish	MR estimate	KA estimate
15 Jun	14,107			
16 Jun	1,901	273	97,925	126,733
17 Jun	1,695	161	147,688	113,000
18 Jun	1,247	153	114,322	83,133
19 Jun	996	106	131,446	66,400
20 Jun	1,024	147	97,701	68,267
Mean			117,816	91,507
(CI)			(±26,988)	(±33,676)

and-recapture population estimates ($P = 0.06$) due to the high variance in the SCUBA values (range 0.002–2.70 fish/m^2).

During the 2 days of minnow trapping in the nursery pond in 1990, 255 young smallmouth bass were captured; 31 of those were marked fish. A spurious Petersen mark-and-recapture index for the nursery pond smallmouth bass population calculated from fish in minnow traps was 112,856 ± 54,938 smallmouth bass. The 14 minnow traps placed in the center of the pond caught 137 fish, 12 of which were fin clipped. The 13 minnow traps located close to shore caught 118 fish, 19 of which were tagged. A chi-square test found no difference between numbers of fish captured from in-shore and off-shore traps ($\chi^2 = 0.126$, $P = 0.72$) and no difference between the number of marked fish in the 2 groups of traps ($\chi^2 = 2.80$, $P = 0.09$).

Table 2. Smallmouth bass observed in Beaver Nursery Pond during SCUBA population estimations, 18 and 19 June 1990. Soft bottom type is clay/mud; hard bottom type included tires (t), gravel (g), and larger stones (s) used as rip-rap.

Transect	Length (m)	Area (m^2)	Bottom type	*N* fish	*N* fish/m^2
1	100	200	soft	6	0.030
2	300	600	soft	41	0.068
3	100	200	soft	13	0.065
4	300	600	soft	3	0.005
5	100	200	soft	2	0.010
6	100	200	hard(t)	95	0.475
7	100	200	hard(g)	97	0.485
8	100	200	hard(s)	540	2.700
9	250	500	soft	10	0.002
10	25	50	soft	8	0.160
11	25	50	soft	19	0.380
12	200	400	soft	36	0.009
Total	1,700	3,400		870	
Mean					0.366

Estimates of y-o-y smallmouth bass stocked into Beaver Reservoir between 1990 and 1994 from Beaver Nursery Pond ranged between 30,333 and 164,733 fish (Table 3). Mean total lengths within the late June and early July period ranged between 45 and 53 mm, with maximum and minimum lengths of 29 and 87 mm during that same period. Overall mean length of smallmouth bass produced in Beaver Nursery Pond by late June was 50.0 ± 3.8 mm.

In 1993 and 1994, bass were retained in the nursery pond after 1 July to determine growth and population trends (Table 3). Rate of growth from 6 July through 10 September 1993 was 0.52 mm/day (TL = 46.6516 + 0.5215 × days, $P = 0.009$). Rate of growth between 6 and 29 July 1994 was 0.174 mm/day (TL = 58.9565 + 0.1739 × days, $P = 0.006$). A decline in numbers of y-o-y smallmouth bass retained in the nursery pond after 1 July could not be determined. In 1993, population estimates declined from 75,133 fish on 6 July to 30,333 fish on 10 September (Table 3); however, linear regression analysis failed to find the decline significant ($P = 0.97$). In 1994, the estimated population size actually increased between 7 and 29 July, likely due to variance in the population estimates.

To determine the extent of cannibalism in Beaver Nursery Pond, we examined stomachs of 313 young smallmouth bass between 12 and 22 June 1990; 60% of them contained food. Larval aquatic insects were the dominant food, found in 48% of the stomachs containing food, followed by cladocera (20%), copepods (18%), and fish (14%). Twenty-six young smallmouth bass consumed 40 fish and 85% of the fish consumed were fathead minnows. Young smallmouth bass that consumed fish were larger ($\bar{x}$TL = 66.2 mm) than bass consuming non-fish items ($\bar{x}$ = 47.1 mm). However, one of the largest fish found in 1990 (74 mm) had consumed only rotifers.

Adult broodfish in the nursery pond were another possible source of predation

Table 3. Lengths and estimated numbers of y-o-y smallmouth bass collected from Beaver Nursery Pond, 1990–1994. Populations were estimated by seining a known area. Asterisks denote dates pond was drained and fish stocked into Beaver Reservoir, Arkansas.

Year	Collection date(s)	Mean total length (range, mm)	Population estimate (95% CI)
1990	16–20 Jun		$\bar{x}$ = 91,507 (± 33,676)
	22 Jun*	52 (34–87)	
1991	11–14 Jun		$\bar{x}$ = 164,733 (± 65,231)
	17 Jun*	45 (29–83)	
1992	23 Jun*	53 (35–75)	57,000
1993	6 Jul	50 (34–64)	75,133
	29 Jul	64 (39–119)	51,333
	20 Aug	68 (56–81)	140,000
	10 Sep	87 (54–197)	30,333
	23 Sep*		
1994	13 Jun	50 (29–67)	60,933
	6 Jul	60 (44–81)	35,400
	29 Jul*	64 (44–137)	37,667

on young smallmouth bass. In 1990, we captured 27 broodfish in Beaver Nursery Pond by hook and line on the day before the pond was emptied into Beaver Reservoir. Fourteen of the broodfish had consumed fish, 12 stomachs were empty, and 1 adult bass had consumed a crayfish (Cambaridae). Of the 14 adult smallmouth bass eating fish, 11 had consumed fathead minnows and 3 had eaten young smallmouth bass.

Beaver Reservoir Smallmouth Bass

In 1990, smallmouth bass were released into Beaver Reservoir on 22 June, and within 48 hours young smallmouth bass were found at 4 seining stations on both sides of the reservoir. During the first 2 days of dispersal, young fish moved up-lake 1.0 km and down-lake 5.2 km from the nursery pond. Within 24 days, nursery pond fish had dispersed 9 km down-lake and 3.2 km up-lake. By the end of September, 344 young smallmouth bass had been collected from the reservoir; 17% were found up-lake, 6% directly across the reservoir from the nursery pond, and 77% had moved down-lake. Between July and September 1990, mean length of stocked smallmouth bass in Beaver Reservoir increased from 52 to 90 mm (12 mm/month) and mean weight increased from 1.7 to 7.7 g (2.0 g/month, Fig. 1). Condition factor for the cohort remained constant at 1.0 for the entire period.

Between 1990 and 1994, collections were made at the established seining stations in Beaver Reservoir prior to annual release of the nursery pond fish to determine if smallmouth bass had initiated spawning in the wild. On 22 June 1992, 1 day prior to release of fish from the nursery pond that year, 53 y-o-y smallmouth bass were collected from 6 seining stations on Beaver Reservoir. That sample of 571 young *Micropterus* consisted of 74% spotted bass (*M. punctulatus*), 17% largemouth bass (*M. salmoides*), and 9% smallmouth bass. Mean length of the wild reservoir smallmouth bass was 46 mm (range 32–59 mm), the same as the mean length of nursery pond fish sampled on 19 June; a *t*-test found no difference between the length frequencies of the 2 groups of fish ($P = 0.59$). Mean length of the wild smallmouth bass exceeded the mean length of young spotted bass ($\bar{x} = 41$ mm, range 32–55 mm) and young largemouth bass ($\bar{x} =$

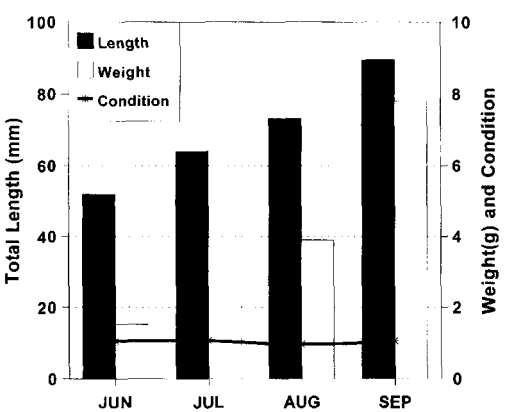

Figure 1. Mean length, weight, and condition of young smallmouth bass collected monthly from Beaver Reservoir, Arkansas, 1990.

43 mm, range 34–54 mm) collected at the same time. This was the first evidence of smallmouth bass spawning in Beaver Reservoir in 30 years.

Discussion

Seining a known area in Beaver Nursery Pond proved to be a rapid method of estimating smallmouth bass annual production. Variance for the known-area method was greater than for the mark-and-recapture model, but we believe ease of gathering the data offset this difference. High variance after 1 July resulted from larger fish avoiding the seine (Paloumpis 1958, Parsley et al. 1989). We never collected an adult smallmouth bass in the nursery pond by seining. This bias likely depressed the population and mean size estimates when the fish were held in the nursery pond in 1993 and 1994.

The low SCUBA population estimate was likely due to poor visibility associated with high turbidity, but also may have resulted from clumped distribution of young fish on the little available structure (rocks, tires, gravel) early in the season (Table 2). By late-June, the largest young fish were seen actively chasing smaller fish away from structure. The minnow trap findings indicate young smallmouth bass were distributed throughout the nursery pond, and that marked fish dispersed to the center as well as the edge of the pond. This is one of the conditions for both mark-and-recapture and known-area methods to validly estimate the population in the pond. The Petersen index estimation from minnow trap fish was also well within the confidence interval for both shoreline estimations.

Retention of smallmouth bass in Beaver Nursery Pond beyond the normal June release date resulted in a mean length increase of up to 0.52 mm/day. No significant population declines were recorded during either year that fish were retained, but variables including larger fish avoiding the seine and initiation of territories likely increased variance in the estimates. Losses due to cannibalism appeared to be minor when fathead minnows were available. Farquhar and Guest (1991) found smallmouth bass < 50 mm TL in Texas culture ponds fed predominantly on adult copepods, cladocerans, and insects, and reported no cannibalism. In Beaver Nursery Pond, young and adult smallmouth bass did consume some of the smaller bass, but conversion of small smallmouth bass into large smallmouth bass may be the most beneficial use of this component of the cohort if smaller fish are less likely to survive in the reservoir.

Smallmouth bass spawning in Beaver Reservoir has been recorded annually since 1992. In 1996, AGFC found y-o-y smallmouth bass near the dam, 36 km downlake from the nursery pond. Successful reproduction in Beaver Reservoir in 1992 may have resulted from annual stocking of y-o-y fish between 1988 and 1992 or from annual release of nursery pond brood fish. An unknown number of young and adult smallmouth bass were stocked via the nursery pond in 1988 and 1989 prior to this study, and Carlander (1977) reported 3- and 4-year-old smallmouth bass were capable of spawning. Lack of reservoir-spawned fish in 1990 and 1991 suggests young of the 1988 and 1989 year-classes produced the bass found in Beaver Reservoir in 1992 rather than stocked broodfish, but the reasoning is circumstantial.

Literature Cited

Bowman, D. W. 1993. Black bass in Beaver Reservoir and its tributaries: distribution and abundance in relation to water quality. M.S. Thesis, Univ. Ark., Fayetteville. 113pp.

Brown, M. L. and D. J. Austen. 1996. Data management and statistical techniques. Pages 17–61 *in* B. R. Murphy and D. W. Willis, eds. Fish. tech., 2nd ed. Am. Fish. Soc., Bethesda, Md.

Carlander, K. D. 1977. Handbook of freshwater fishery biology, vol. II. Iowa State Univ. Press, Ames, 431pp.

Dibble, E. D. 1991. A comparison of diving and rotenone methods for determining relative abundance of fish. Trans. Am. Fish. Soc. 120:663–666.

Farquhar, B. W. and W. C. Guest. 1991. Food habits and feeding selectivity of smallmouth bass in culture ponds. Pages 24–26 *in* D. C. Jackson, ed. First internat. smallmouth bass symp. Miss. State Univ., Mississippi State.

Heidinger, R. C., J. H. Waddell, and B. L. Tetzlaff. 1985. Relative survival of walleye fry versus fingerlings in two Illinois reservoirs. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 39:306–311.

Helfman, G. S. 1983. Underwater methods. Pages 349–369 *in* L. A. Nielsen and D. L. Johnson, eds. Fisheries tech. Am. Fish. Soc., Bethesda, Md.

Hodson, R. G. 1966. The first year life history of the largemouth bass (*Micropterus salmoides*) and spotted bass (*M. punctulatus*) in Beaver Reservoir, Arkansas. M.S. Thesis, Univ. Ark., Fayetteville. 100pp.

Keith, W. E. 1964. A pre-impoundment study of the fishes, their distribution and abundance, in the Beaver Lake drainage of Arkansas. M.S. Thesis, Univ. Ark., Fayetteville. 63pp.

———. 1969. Preliminary results in the use of a nursery pond as a tool in fishery management. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 23:501–511.

Kraai, J. E., W. C. Provine, and J. A. Prentice. 1983. Case histories of three walleye stocking techniques with cost-to-benefit considerations. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 37:395–400.

Oliver, J. D., G. F. Holeton, and K. E. Chua. 1979. Overwinter mortality of fingerling smallmouth bass in relation to size, relative energy stores, and environmental temperature. Trans. Am. Fish. Soc. 108:130–136.

Paloumpis, A. A. 1958. Measurement of some factors affecting the catch in a minnow seine. Iowa Acad. Sci. 65:580–586.

Pardew, M. G. 1992. Dispersal of stocked young-of-year smallmouth bass (*Micropterus dolomieu*) in Beaver Reservoir, northwest Arkansas, in 1990. M.S. Thesis, Univ. Ark., Fayetteville. 37pp.

Parsley, M. J., D. E. Palmer, and R. W. Burkhardt. 1989. Variation in capture efficiency of a beach seine for small fishes. North Am. J. Fish. Manage. 9:239–244.

Robison, H. W. and T. M. Buchanan. 1988. Fishes of Arkansas. Univ. Ark. Press, Fayetteville. 536pp.

Van Den Avyle, M. J. 1993. Dynamics of exploited fish populations. Pages 105–135 *in* C. C. Kohler and W. A. Hubert, eds. Inland fisheries management in North America. Am. Fish. Soc., Bethesda, Md.

Wicker, A. M. and W. E. Johnson. 1987. Relationships among fat content, condition factor, and first-year survival of Florida largemouth bass. Trans. Am. Fish. Soc. 116:264–271.