EDITOR'S NOTE: The use of regulations in managing fish populations is one of the most important tools available to a manager, particularly in large bodies of water such as reservoirs. Recent research findings have shown great promise in the use of a slot size limit to manipulate fish stocks. This concept has been primarily applied to centrarchids but may also apply to other taxonomic groups. The importance of reservoirs to sport fishing in the United States has been documented in numerous recent studies such as the hunting and fishing surveys conducted by the U.S. Fish and Wildlife Service every 5 years. The following papers are directed at the theme of using size limits to manage largemouth bass in large reservoirs. Gary Novinger has emphasized the topics that should be considered in the design of future studies and Dick Anderson has asked a series of questions that should stimulate thinking about what can be done to manage these fisheries. Both authors provide the background associated with the use of size limits in the management of largemouth bass to fulfill angler expectations. These papers should stimulate readers into deep thought about this subject. We encourage readers to comment on these papers or share their thoughts in *Fisheries*. We believe discussions of this subject or others in future issues of *Fisheries* would be useful to other fishery biologists.

OBSERVATIONS ON THE USE OF SIZE LIMITS FOR BLACK BASSES IN LARGE IMPOUNDMENTS

Gary D. Novinger

ABSTRACT

There is a growing interest among fisheries managers and anglers in the use of size limits for management of black basses (*Micropterus* spp.) in large impoundments. Few published results are currently available to help managers determine if a size limit is needed, what size limit should be selected, and whether or not post-limit changes are due to the regulation. Decisions on size limits can be made more effectively if managers develop plans with clear-cut objectives; carefully consider the influence of bass recruitment, growth, and mortality; conduct well-designed studies; and communicate results. Future efforts should take into account the diversity of angler expectations. I believe that size limits will improve the quality of fishing for largemouth bass in many large impoundments if they are applied properly.

Gary D. Novinger

Picture in your mind the following discussion between two fisheries biologists as they head for the coffee urn during a break at a national conference. "How's that 16-inch length limit working on Bigmouth Reservoir?" asks George. "Pretty good so far—anglers are catching a lot more bass now and I think we'll soon have more bass over 16 inches," Jim answers. "Good," says George, "We're getting a lot of pressure to put the same size limit on Lake Mossback, our biggest reservoir. Bass fishing hasn't been very good for several years, but we're not sure if a size limit is the answer. What do you think?"

THE AUTHOR: **Gary Novinger** has been a fisheries research biologist with the Missouri Department of Conservation since 1973. From 1973 to 1978 his research centered on management problems associated with largemouth bass and bluegill in ponds and small lakes. From 1978 to the present, he has studied black basses in large reservoirs; particularly harvest regulations and factors affecting year-class strength. He received his B.A. and M.A. from the University of Missouri at Columbia.

Conversations similar to this are increasingly common as more and more states consider size limits on black basses (*Micropterus* spp.) at their large reservoirs. I made an informal survey of several state agencies within the North Central Division of AFS during December 1982 and found that at least seven states within the Division had size limits on bass at one or more of their large impoundments (over 500 acres). The same was true for 10 of 14 states in the Southern Division of AFS, according to a 1981 questionnaire by their Reservoir Committee. Size limits that have been or are being used at large impoundments include minimum length limits of 12, 13, 14, 15, 16, and 18 inches; and protected length ranges (slot limits) of 11–14, 12-15, 14–18, and 15–20 inches.

The purpose of minimum size limits is to help rebuild depleted stocks of bass by reducing total annual mortality of bass smaller than a specified size (Anderson 1974), or to prevent depletion of bass stocks in new lakes. The expected benefits of minimum size limits are increased numbers of bass caught (although the majority must be released); greater abundance of legal-size bass; and, in some cases, increased predation on such species as gizzard shad (*Dorosoma cepedianum*) and bluegill (*Lepomis macrochirus*). Slot length limits are used to reduce annual mortality of bass in a particular size range, but the regulations allow harvest of bass smaller and larger than protected sizes (Anderson 1976). Harvest of the smaller bass is usually needed to maintain satisfactory growth and satisfactory recruitment into and through protected sizes. Expected results include more protected-size bass available for anglers, and greater predation on intermediate-size gizzard shad and bluegill.

Although size limits are being widely used at large impoundments, there remains a high degree of uncertainty and confusion about these regulations. Is a size limit the best management option? What kind of size limit should be selected? If changes occur in the fishery, which ones and what proportion can be ascribed to the regulation?

The purpose of this article is to share some thoughts and experiences concerning size limits and, hopefully, to reduce the likelihood that a regulation will be used in the wrong place. As fisheries managers we must maintain our credibility with anglers by making decisions about size limits that will result in improved fishing success.

INITIAL CONSIDERATIONS

There is no "cookbook" or manual on the proper use of size limits in large reservoirs. Publication of results of initial investigations in several states is just beginning. Although much remains to be learned, I believe there are some important considerations that will improve our ability to manage fisheries.

The first step should be to document the problem (or opportunity for improvement). A problem exists if one or more characteristics of a bass fishery do not measure up to whatever is considered satisfactory. What levels should be considered satisfactory for population characteristics such as size structure and abundance, or angling characteristics like catch rates and harvest? Sure it's difficult to take that first step and say "This is what we (or anglers) consider satisfactory," but we must describe where we want to go before we can decide how to get there, or realize when we have arrived.

After the cause (not the symptom) of the problem or opportunity is identified, consider the management options. Keep in mind that the present status of a bass population and the possibilities for change are governed by recruitment, growth, and mortality. Knowledge about these rate functions should help the manager decide if a size limit should be used, and what kind of size limit would be most effective.

Recruitment (defined here as abundance of age-I bass in spring samples) is highly variable in many reservoirs (Summerfelt 1975). The density-dependent effects of recruitment on growth and mortality in bass populations make it an important factor affecting the success of size limits. In some lakes, recruitment may be high enough that the elimination of angling mortality under a minimum size limit may result in too many small bass for the available prey. Growth may decline and natural mortality may increase for sublegal-size bass. Angler catch rates for sublegal-size bass may become quite high, but few bass survive to legal size. Such lakes are probably candidates for a slot length limit to maintain densities of small bass low enough for satisfactory growth. Minimum size limits should be more successful in lakes where recruitment is low to moderate as evidenced by rapid growth of age-I and age-II bass.

Mortality, particularly that portion due to angling, is important for at least two reasons. Angling mortality, prior to a size limit, is an indicator of how much good a minimum length limit will do; the higher the angling mortality on the sizes of bass to be protected, the greater the potential increase in legal-size bass. An important assumption is that natural mortality will not increase much, allowing a net decrease in total mortality of bass smaller than the size limit. The anticipated reduction in total mortality could potentially fail to occur because of poor angler compliance (discussed later); stresses associated with high densities of bass, as mentioned above; or stresses caused by catch-and-release. Although catch-and-release mortality has been reported as high as 38% (Rutledge and Pritchard 1977), such mortality should be negligible (Hackney and Linkous 1978) unless bass are subjected to rough handling or are hooked in the esophagus (Pelzman 1978).

Knowledge of the existing annual mortality of bass larger than the prospective size limit is important in determining how much improvement to expect in the abundance of trophy or memorable-size bass. Some investigators believe that the numbers of very large bass will not increase as much as they initially hoped because anglers remove a high proportion of the bass soon after they reach legal size. Estimates of exploitation, specifically for bass over 15 or 16 inches, are rare, but total annual mortality typically exceeds 50% for those larger fish in Missouri reservoirs currently being studied by R. Dent, K. Richards, and myself.

Growth is probably the easiest rate to measure in a reservoir bass population and it should be helpful in making decisions on size limits. Slow growth tends to eliminate minimum size limits from consideration if harvest is highly important, because the longer the time required to attain legal size, the greater the losses due to natural mortality. Populations in which the 8- to 12-inch bass exhibit slow annual growth are likely candidates for slot length limits. Use some caution when assessing growth from length-at-age data averaged for a year class. Size-selective harvest may remove faster-growing individuals of a year class as they reach a size desirable to anglers and leave the slower-growing bass from which length at age is determined (Ricker 1975, p. 215). It may be more meaningful to assess growth by examining annual length increment as a function of length at the start of a growing season (Reynolds and Babb 1978).

Getting information about the rate functions can be expensive or difficult. Is it worth the effort? That probably depends on the value of the fishery and the potential harm that could result from an incorrect decision. If quantitative measurements are not possible, try at least to describe the rates in a qualitative manner.

RESULTS TO DATE

Results presented at various workshops and conferences, and in personal communications, indicate that catch rates and estimated catch of bass (where catch includes released bass) will increase in lakes where length limits are selected to protect size groups experiencing high angling mortality. Estimated annual catch of sublegal-size bass may equal or exceed estimated numbers present in a lake (Paragamian 1982). Catch can improve by 2–3 times that experienced prior to a minimum length limit. Catch rates by people fishing specifically for bass have improved in some Missouri lakes from one bass per 5 to 10 hours to about one bass per hour. Another improvement, frequently overlooked, is the number of anglers successful in catching at least one bass. Prior to the 15-inch length limit at Table Rock Lake, Missouri, fewer than one-half of the anglers even caught a bass during a day of fishing. Now, 70% or more may get a bass to the boat.

(Continued)

The numbers of bass harvested annually may be less than one-half of what it was before a minimum size limit. Some decrease is inevitable, of course, but I think most biologists expected the decline in numerical harvest to be offset by the harvest of increased numbers of legal-size bass, and a total weight harvested that is equal to, or greater than, before a size limit. However, my general impression is that abundance and harvest of bass larger than a size limit are usually less than expected. Angler harvest rates at Missouri lakes with 15-inch length limits are only one bass per 20 to 25 hours of bass fishing in some years, although there are years when anglers average one legal bass per 8 to 10 hours (unpublished data). My own experience with the 15-inch length limit at Table Rock Lake indicates that the size limit there provides about 50% more bass over 15 inches than could be expected without the regulation.

Another expected benefit of minimum size limits—better utilization of prey—seems to have occurred in some of the Indiana reservoirs where bluegill are the principal prey (J. Janisch, personal communication). Results are similar to those for small impoundments (Ming and McDannold 1975)—better growth and increased numbers of larger bluegill. Where gizzard shad are the principal prey, I am not aware of any studies that document greater utilization of adult shad, or any change in abundance or size distribution of gizzard shad as a result of a minimum size limit on bass. On the other hand, few people have collected sufficient data on gizzard shad to look for changes.

Angler compliance is essential to the effective use of size limits, perhaps more than with any other harvest restriction. Non-compliance has been considerable in some cases. Paragamian (1982) studied a 14-inch minimum length limit at Big Creek Lake, Iowa, and found 28–39% of the bass harvest were sublegals, although most were within ½ inch of legal size. Sublegal bass accounted for 20–42% of the estimated harvest of largemouth bass in four Oklahoma reservoirs during the second and third years of a 14-inch minimum length limit (Mense 1981). Sublegal bass accounted for 0–63% of the largemouth bass harvested during the first and second years of a 15-inch minimum length limit on two Kansas reservoirs (Gabelhouse 1980). An evaluation of a 12- to 15-inch slot length limit on two public fishing lakes in Missouri found that non-compliance was 30% at Watkins Mill Lake, but was 14% with greater enforcement effort at Jamesport Community Lake (S. Eder, personal communication). Although some amount of enforcement is necessary, a size limit will probably not succeed without a high degree of voluntary compliance. Public meetings and the use of various news media to explain the need for the regulation and discuss potential results can be very helpful for developing voluntary compliance.

Reactions of anglers to minimum size limits have been mixed, depending in part, I believe, on their individual angling abilities and what they expect from a bass fishing trip. Organized bass fishing groups have been very supportive of minimum size limits (Pelzman 1979), and of catch-and-release fishing in general (Bryan 1983). These groups have often supported fisheries agencies' efforts to establish size limits; in fact, bass clubs in at least three states reportedly campaigned successfully for size limits over the objections of biologists.

There has been little organized opposition to size limits on large impoundments in most states. However, this may not indicate complete approval, but rather the reluctance of unorganized anglers to complain. I believe it is possible that

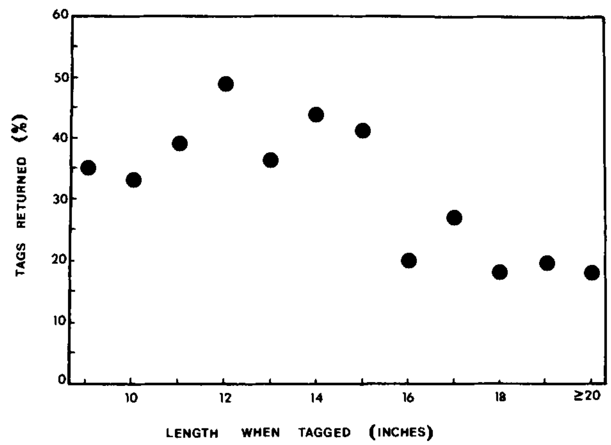

Figure 1. Relationship between tag return rate and total length of 1,256 largemouth bass tagged with Floy FD68B tags during April and May 1975 at Table Rock Lake, Missouri. Returns were monitored for 12 months during which a reward of $1 to $100 was offered. Numbers of bass tagged per inch-group ranged from 39 to 296.

high minimum size limits, like 15 inches, may discriminate against less-experienced or less-capable anglers who want to harvest bass. How does this happen? Tagging data available from Table Rock Lake suggest that catchability of bass decreases with size (Fig. 1). Larger bass appear to be more difficult to catch. I suspect that less-experienced or less-capable anglers can catch at least an occasional small bass, but a disproportionately smaller share of the legal-size bass. Thus they may be participating in the "sacrifice" of releasing bass, but not reaping much of the benefit in harvest.

Regardless of ability, some anglers may simply put a higher priority on keeping bass than on high catch rates or trophy size. For those anglers, even catch rates of 20 or 30 bass per day may not count for much if in a week of fishing they catch only one bass they can keep. Their idea of a quality fishing experience may be very different from the trophy angler or people who fish primarily for the catching.

FUTURE EFFORTS

Future fisheries management should give more consideration to the kinds of bass fishing that anglers want. I think it's reasonable to assume that almost all bass anglers want to catch at least one bass in a day of fishing. But beyond that there is a diversity of needs and expectations. Some anglers fish for a trophy, some fish just for fun, and some fish for the skillet. The relative proportion of these needs should be addressed when setting objectives for large impoundments. What does this mean in regard to describing satisfactory size structure, satisfactory growth rates, or desirable levels of other traits of a bass population? I suggest that there is no one kind of population that is "best" in all cases. "Satisfactory" is relative to what we are trying to achieve.

Using size limits to meet the needs of this diverse group of anglers may require innovative approaches. The present slot length limits are a step in the right direction, allowing anglers to harvest some of the smaller, more easily caught bass. Another approach that may be useful at lakes with high angler effort and variable bass recruitment is the simultaneous use of low minimum and high slot length limits (for example, a combination 13-inch minimum and 16- to 19-inch slot). Opportunities may exist at some impoundments for regulation zones that might include areas with no size restrictions, areas with slot or minimum length limits, and areas with no-harvest or trophy-only regulations.

Part of the uncertainty about the use of size limits is due to the lack of published results. It is true that modern size limits have not been in effect for long on large reservoirs and some long-term studies are just now being completed, but it is surprising, given the number of lakes involved, that so little information is available. If the state of our knowledge is to improve, the results must be assembled and communicated.

This carries with it a responsibility to design studies that do in fact allow an assessment of the effects of size limits. Given the dynamic nature of most large lakes, information to describe bass populations and angling success should be collected for at least 2 to 3 years before and after implementing a size limit. Evaluations without pre-regulation data can only determine whether or not the resulting fishery is desirable. The true effects of the size limit may never be known.

Sufficient data should be gathered in a size limit evaluation to determine not only "what" happened, but as much of the "why" as possible. Unexpected fluctuations in any of several variables may mask the success or failure of a regulation. Consider the following hypothetical example showing the potential impact of three different levels of recruitment after imposition of a 15-inch minimum length limit (Table 1). Pre-regulation conditions are recruitment of 100 bass to age-II and 50% annual survival of age groups II through V. If the size limit is successful, survival of age-II bass could increase to 75% (situation A, Table 1), and with recruitment equal to the pre-regulation level, the abundance of 15-inch and larger bass will be 50% greater than before the size limit. If recruitment declines temporarily to 50 age-II bass (situation B), the abundance of 15-inch and larger bass will be about 25% lower than before the regulation, in spite of increased survival of age-II bass due to the size limit. A temporary increase in recruitment (situation C) may result in greater numbers of 15-inch and larger bass even though survival of age-II bass remains at 50%, as it might if anglers do not comply with the size limit.

It would be difficult for a manager in this example, armed only with information on angling success, to reach a correct conclusion about the effectiveness of the size limit. Without the "why" information we lose an opportunity to learn and, worse yet, we may reach an erroneous conclusion about a regulation. Fisheries managers certainly cannot measure every variable in a fishery. However, from a list of all variables that might be important, it should be possible to select and prioritize a smaller, more-attainable list. Size structure, age structure, and abundance of a bass population, sampled in a similar manner each year, should be considered minimum data. These characteristics should provide at least qualitative assessments of recruitment, mortality, and growth.

Size limits can bring about changes in bass populations and bass fishing success, even in large impoundments. Success with size limits will be enhanced if we develop management plans with clear-cut objectives; consider carefully the influence of bass recruitment, growth, and mortality; conduct well-designed studies; and communicate results. The diversity of anglers' needs and expectations should be considered in the development of management plans. There is no doubt in my mind that the quality of bass fishing can be improved in many large impoundments, and properly-applied regulations will be one of the principal tools.

LITERATURE CITED

Anderson, R. O. 1974. Problems and solutions, goals and objectives of fishery management. Proc. Annu. Conf. Southeast. Assoc. Game Fish Comm. 27(1973):391–401.

———. 1976. Management of small warmwater impoundments. Fisheries 1(6):5–7, 26–28.

Bryan, H. 1983. The role of the fishery resource in the recreational angling experience. Report submitted to the Sport Fishery Research Foundation, Washington, D.C. 32 pp.

Gabelhouse, D. W., Jr. 1980. Black bass length limit investigations. Final Rpt., D-J Proj. F-15-R. Kansas Fish and Game Commission. 83 pp.

Hackney, P. A., and **T. E. Linkous.** 1978. Striking behavior of the largemouth bass and use of the binomial distribution for its analysis. Trans. Am. Fish. Soc. 107(5):682–688.

Mense, J. B. 1981. Largemouth bass length limit investigations. Final Rpt., D-J Proj. F-39-R. Oklahoma Department of Wildlife Conservation. 38 pp.

Ming, A., and **W. E. McDannold.** 1975. Effect of length limit on an overharvested largemouth bass population. Pages 416–424 *in* R. Stroud and H. Clepper, eds. Black bass biology and management. Sport Fishing Institute, Washington, D.C.

(Continued)

Table 1. Potential impacts of a 15-inch minimum length limit on survival and abundance of a year class of largemouth bass in successive years. Variations in recruitment, indicated by the numbers of age-II bass, may mask the success (situation B) or failure (situation C) of the regulation to change survival.

				Post-regulation					
		Pre-regulation		Situation A		Situation B		Situation C	
Age	Length (inches)	Number	Survival (%)	Number	Survival (%)	Number	Survival (%)	Number	Survival (%)
II	12	100		100		50		200	
			(50)		(75)		(75)		(50)
III	15	50		75		38		100	
			(50)		(50)		(50)		(50)
IV	17	25		38		19		50	
			(50)		(50)		(50)		(50)
V	18	12		19		10		25	

Paragamian, V. L. 1982. Catch rates and harvest results under a 14.0 inch minimum length limit for largemouth bass in a new Iowa impoundment. North Am. J. Fish. Manage. 2(3):224–231.

Pelzman, R. J. 1978. Hooking mortality of juvenile largemouth bass, *Micropterus salmoides*. Calif. Fish Game 64(3):185–188.

———. 1979. Effects of a 305-mm (12.0-inch) minimum size limit on largemouth bass, *Micropterus salmoides*, at Merle Collins Reservoir. Calif. Fish Game 65(3):141–150.

Reynolds, J. B., and **L. R. Babb.** 1978. Structure and dynamics of largemouth bass populations. Pages 50–61 *in* G. Novinger and J. Dillard, eds. New approaches to the management of small impoundments. North Central Division, Am. Fish. Soc., Spec. Publ. No. 5.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Fish. Res. Board Can. Bull. 191. 382 pp.

Rutledge W. P., and **D. L. Pritchard.** 1977. Hooking mortality of largemouth bass captured by artificial lures and natural bait. Pages 103–107 *in* R. Barnhart and T. Roelofs, eds. Catch and release fishing as a management tool. Humboldt State University, Arcata, CA.

Summerfelt, R. C. 1975. Relationship between weather and year-class strength of largemouth bass. Pages 166–174 *in* R. Stroud and H. Clepper, eds. Black bass biology and management. Sport Fishing Institute, Washington, D.C.