MINIMUM SIZE LIMITS FOR REEF FISHES

GENE R. HUNTSMAN, National Marine Fisheries Service, NOAA, Southeast Fisheries Center, Beaufort Laboratory, Beaufort, NC 28516

CHARLES S. MANOOCH, III, National Marine Fisheries Service, NOAA, Southeast Fisheries Center, Beaufort Laboratory, Beaufort, NC 28516

Abstract: Implementation of minimum size limits is an administratively simple method of maximizing yield-per-recruit and, probably, total yield from reef fisheries. However, size limits may not guarantee ample escapement to older ages and, consequently, adequate reproduction of those species which undergo sex reversal. Further, size limits may place unnacceptably severe restriction on certain portions of reef fisheries. Finally, most undersize reef fishes taken by hook and line from deep water will likely die of injuries caused by pressure change. Based on growth data of fishes from the United States South Atlantic, Gulf of Mexico or southern Caribbean, size limits (TL) that would maximize yield-per-recruit for the following species are: *Pagrus pagrus*, 369 mm; *Rhomboplites aurorubens*, 324 mm; *Haemulon plumieri*, 314 mm; *Lutjanus campechanus*, 407 mm; *Lutjanus synagris*, 356 mm; *Ocyurus chrysurus*, 403 mm; *Centropristis striata*, 233 mm; *Epinephelus morio*, 635 mm; *Epinephelus guttatus*, 363 mm; and *Mycteroperca microlepis*, 649 mm.

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In this paper we offer a discussion of the need for, method of determining, and advantages and disadvantages of implementing minimum size limits for several species of reef fishes.

The Fishery Conservation and Management Act of 1976 (FCMA) provides not only the means of, but also an imperative for, management of marine fishery resources occupying the zone between 3 and 200 miles of the United States, its territories, and Puerto Rico. Management authority under FCMA is embodied in Regional Fishery Management Councils, and those of the Gulf of Mexico, Caribbean, and South Atlantic have placed high priority on establishment of management plans for reef fisheries (also known as snapper-grouper fisheries).

While the Councils have nuemrous choices of goals for management plans, the plans will achieve their goals principally through the use of 3 basic devices: (1) limits on effort, (2) limits on catch, and (3) regulation of the quality of the catch; i.e., restricting the catch to fish of certain ages, a certain sex, or to fish greater than some minimum size.

Minimum sizes are most appropriate as a management tool for fishes, like reef fishes, that achieve their maximum sizes slowly and have great life spans. In this paper we evaluate the use of size limits in managing reef fisheries.

COMPUTATION OF MINIMUM SIZE LIMITS

While examination of fishery regulation from numerous sources suggests that minimum size limits are often based on intuition or on political consensus, we feel that yield per recruit models (Beverton and Holt 1957; Ricker 1975) allow logical determination of resource-oriented minimum size limits.

Yield per recruit (Y/R) models allow the examination of the response of yield from cohort of fishes (over the life span of the cohort in the fishery) to the variables of recruitment age, and fishing mortality (which is proportional to effort). The shape of the 3 dimensional surface generated by the Y/R model can be used to determine a minimum size that maximizes the yield from the fishery.

The algorithm for our yield per recruit model, modified from Beverton and Holt (1957), assumes isometric growth and is:

$$\underline{Y} = Fe^{-Mr}W^{\infty}\frac{1}{Z} - \frac{3e^{-Kr}}{Z+K} + \frac{3e^{-2Kr}}{Z+2K} - \frac{e^{-3Kr}}{2+3K}$$

where,

t = age in years,

t_o = theoretical age at length "0",
R = annual number of recruits at age t_R,
$t\lambda$ = maximum age in fishery,
F = instantaneous rate of fishing,
M = instantaneous rate of natural mortality,
$L\infty$ = asymptotic length of a fish,
$W\infty$ = asymptotic weight of a fish,
K = growth coefficient,
r = $t_R - t_o$,
n = $t_2 - t_{R12}$,
Z = $F + M$, and
Y = yield in weight.

Estimates of parameters t_o, K, and $L\infty$ are derived from the von Bertalanffy (1938) growth equation, and $W\infty$ is estimated as the weight on a length-weight regression which corresponds to $L\infty$.

Determination of the Y/R surface is facilitated by the computer program BM007 (Personal communication, L. Massey, National Marine Fisheries Services, Beaufort, NC). BM007 requires a relatively small amount of memory, is written in FORTRAN, and can be implemented on most computer systems. The program output is digital, and must be transposed by hand to graph paper if isometric yield lines are to be drawn.

The shape of the yield per recruit surface is determined by growth parameters derived from von Bertalanffy equations and by estimates of M, the instantaneous natural mortality rate. A detailed examination of our quest for valid parameters estimates occurs in our yield per recruit analysis of the South Atlantic Bight reef fishery[a], but for the purpose of this paper, we feel it sufficient to state that growth parameter estimates were taken from literature sources, while estimates of M generally stem from the relationship of M to the von Bertalanffy growth parameter K (Table 1), or from reasonable assumptions. These estimates of M are crude but over the range of likely values affect little the yield surface and resulting suggested minimum size limits. To the best of our knowledge we furnished an overestimate of M (often in addition to a "reasonable" estimate). Yield per recruit models using overestimates of M will, while underestimating true yield for any combination of age at recruitment and F, suggest ages at recruitment that are less and fishing mortalities that are greater than the true values needed to achieve a given fraction of the maximum available catch. Thus, overestimating M will result in minimal restrictions on the fishery. An overestimate will suggest allowing the imposition of more effort on, and taking younger fish from, the fishery than would true M.

The choice of fishes for which size limits were determined was based on importance of the species to commercial and recreational reef fisheries and on the availability of growth information.

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[a]Yield per recruit models of some reef fishes of the U.S. South Atlantic Bight. G. R. Huntsman, C. S. Manooch III, L. L. Massey, and C. B. Grimes. National Marine Fisheries Service, Beaufort, NC 28516.

Table 1. Minimum sizes which will produce maximum yield for 10 species of reef fish.

Species		*Minimum Size*	*Growth Data Source*		*M*	*K*	$<^{\infty}$
Common Name	*Scientific name*	*Total length in inches (mm)*	*Author(s)*	*Area*			
Red porgy	*Pagrus pagrus*	14.5 (369)	Manooch and Huntsman, 1977	North & South Carolina	0.20	0.096	763
White grunt	*Haemulon plumieri*	12.0 (314)	Manooch, 1976	North & South Carolina	0.4 & 0.6	0.108	640
Vermilion snapper	*Rhomboplites aurorubens*	13.0 (324)	Grimes, 1976	North & South Carolina	0.25	0.198	627
Red snapper	*Lutjanus campechanus*	16.0 (407)	Futch and Bruger, 1976	Florida West Coast	0.30	0.333	692
Lane snapper	*Lutjanus synagris*	14.0 (356)	Alegria and Menezes, 1970	NE Brazil	0.20	0.230	505
Yellowtail snapper	*Ocyurus chrysurus*	16.0 (403)	Piedra, 1969	Cuba	0.20	0.160	477
Black sea bass	*Centropristis striata*	9.0 (233)	Mercer[a]	North and South Carolina	0.30	0.220	350
Red grouper	*Epinephelus morio*	25.0 (635)	Moe, 1969	Florida West Coast	0.20	0.179	792
Red Hind	*Epinephelus guttatus*	14.0 (363)	Burnette-Herkes, 1975	Bermuda	0.20	0.180	420
Gag	*Mycteroperca microlepis*	25.5 (649)	Manooch and Haimovici, 1978	North & South Carolina	0.20	0.121	1,290

[a]Linda Mercer, Virginia Institute of Marine Sciences, Gloucester Point, Virginia.

Our rationale for establishing minimum size limits is illustrated by examination of a representative yield per recruit model, in this case for the red porgy (*Pagrus pagrus*) (Fig. 1). Our method was to choose a size (age transposed to length from the appropriate von Bertalanffy growth curve) that allowed the taking of a substantial fraction (usually 80% or more) of the maximum possible yield over all values of fishing mortality. For the red porgy, where M = 0.20, the maximum Y/R is 300 g available only where F is greater than 0.5 and at recruitment ages greater than V years. Thus, setting the minimum size limit at 369 mm, which is the von Bertalanffy predicted size at age V, will guarantee that the yield per recruit will be maximized if F is near 1.0 and will never be below 250 g, except at very low F (< 0.1).

Varying the recruitment age would not prevent decreased yield at low F, for when F is low the yields are nearly identical over a wide range of recruitment ages. Therefore the minimum size limit has no effect on yields if effort is low, but exerts its effect as F increases and prevents diminished Y/R at high F.

ADVANTAGES AND DISADVANTAGES OF MINIMUM SIZE LIMITS

Minimum size limits derived in the way we describe offer both advantages and disadvantages. The most prominent advantage is that total weight harvested from a cohort may be maximized. Further, in the case of reef fishes, it is likely that size limits would maximize the total long-term yield because for most species the minimum size (age) equals or exceeds the age of sexual maturity. This last hypothesis needs more examination though because the relationship of the size and age structure of the parent stock to reproductive success and ultimate recruitment is poorly known. In the groupers, for instance, protogyny indicates that F must be maintained at a sufficiently low level to allow some quantity of fish to achieve the age of sex reversal so that enough males for successful spawning exist, despite the fact that yield from a cohort would not be reduced at high F.

Minimum size limits are administratively appealing. They can be applied and enforced easily, and without the necessity for elaborate administrative and reporting systems required by management systems such as limited entry or quotas. In fact, minimum size limits can be effective in producing maximum biological yield (again

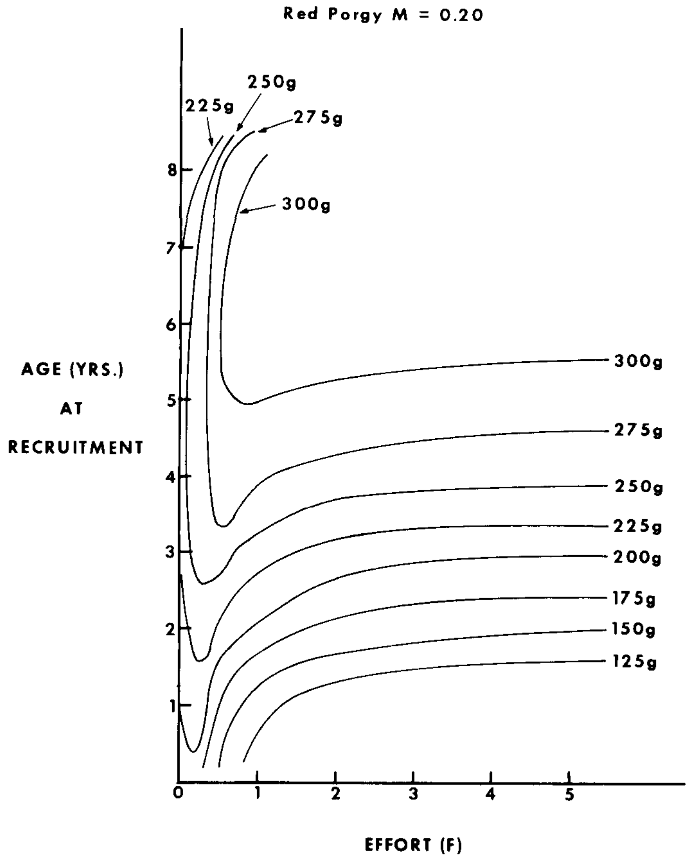

Fig. 1. Yield per recruit in weight (g) for red porgy.

assuming reproductive success) despite unlimited entry. Consequently, size limits appeal to many who view marine fishing as embodying the frontier spirit, and resent direct control of economic activity.

A major disadvantage of minimum size limits is that the usual gear in reef fisheries, hook and line and traps, are not size selective, and that released fish may die because of pressure induced trauma inflicted during capture. But although released fish may not reenter the population, we believe size limits would dissuade fishermen from fishing at times and places that sublegal fish are common. The contagious distribution of reef fishes by species and size should make the dissuasion effect important.

A more important disadvantage to minimum sizes is that they would initially impact more heavily on some sectors of reef fisheries than others. For instance, 36% of the black sea bass (*Centropristis striata*) caught by South Crolina's inshore headboats (March-June 1977) and over 97% of the vermilion snapper (*Rhomboplites aurorubens*) taken by Northeast Florida headboats (January-December 1977) are smaller than the maximum-yield minimum sizes. Similarly, Florida's recreational anglers reportedly take many grouper at or near the state's 305 mm TL minimum legal size. Immediate imposition of maximum-yield minimum sizes would severely restrict these 3 recreational fisheries. If the small mean size of fish currently caught in those fisheries is the result of heavy fishing pressure, managers could incrementally implement maximum-yield size limits by beginning with a size limit only slightly above the mean size now taken, and by gradually increasing the size limit as the mean size in the population increases. If, on the other hand, the small fish reflect an ecological size stratification of the population, maximum-yield minimum size limits could not be implemented with equal impact on existing fisheries.

The weighing of the advantages and disadvantages of minimum size limits, and the decision of whether or not to use them are the responsibility of the Fishery Management Councils. No plans now exist that call for size limits on reef fishes. It is a certainty that if size limits are ever imposed, they will be used with other management devices, all designed to reflect social, biological and economic conditions and all structured to provide the maximum benefit of the resource to society.

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