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[Management Brief]

Catch Rates and Selectivity among Three Trap Types in the U.S. South Atlantic Black Sea Bass Commercial Trap Fishery

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Abstract.—We compared selectivity and catch rates of black sea bass *Centropristis striata* between two experimental trap types: back-panel traps (50.8-mm-mesh back panels; 38.1-mm mesh in all other panels), which represent the new legal minimum mesh configuration; and all-panel traps (50.8-mm mesh in all panels), which are electively used by a subset of fishers. Catches in both experimental trap types were compared with catches in control traps (38.1-mm mesh in all panels). Traps were fished from October 2006 to March 2007 in waters 12–30 m deep in Onslow Bay, North Carolina. Correlation analyses were used to examine postrelease condition of discarded black sea bass in relation to fish density in traps and capture depth. We found that mean catch rates of sublegal-sized black sea bass (<254 mm total length) were lower for control traps than for both experimental traps and were lower for back-panel traps than for all-panel traps; however, catch rates of legal-sized fish were not different among trap types. Median black sea bass size increased with trap mesh size. Modeled selectivity for each experimental trap type was relatively knife-edged (i.e., characterized by a narrow selection range); both experimental trap types caught smaller proportions of sublegal-sized fish and higher proportions of legal-sized fish than did control traps. Estimated immediate mortality rates of black sea bass discards were 3.7 (control), 1.1 (back panel), and 0.7% (all panel). Less-favorable release condition was positively correlated with fish density and depth. Combining immediate discard mortality over observed depths (common depths for this fishery) and losses from observable barotrauma, the assumed mortality rate of discarded black sea bass in the U.S. South Atlantic commercial trap fishery (15%) may be too high.

The abundance and fate of discarded fishes are of increasing concern in fisheries worldwide. Quantification of bycatch and discard mortality rates is important for effective management of stocks (Hall et al. 2000), because discard mortality reduces biomass and yield in many fisheries (Crowder and Murawski 1998). In the USA, the Magnuson–Stevens Fishery Conservation and Management Act requires regional fishery management councils to implement measures that minimize bycatch and discard mortality. Methods to reduce bycatch include time and area closures and gear size and mesh modifications. Reef fish catch rates and size selectivity, for example, are influenced by trap mesh size and fish body depth (Bohnsack et al. 1989; Stewart and Ferrell 2003).

The black sea bass *Centropristis striata* is a protogynous hermaphrodite. Its range extends the full length of the U.S. Atlantic coast, where it is associated with structured habitats. Like other serranids, black sea bass possess physoclistous swim bladders that expand when they are retrieved rapidly from deep water. Their capture from waters deeper than about 20 m can result in swim bladder rupture (which can force the stomach out the mouth), bulging eyes (exopthalmia), tissue emphysema, and intestinal prolapse (cloacal protrusions; Rogers et al. 1986). These signs of barotrauma may cause immediate or delayed mortality (Collins et al. 1999). Based on mortality rates determined by Collins et al. (1999), the South Atlantic Fishery Management Council (SAFMC) assumes that 15% of discarded black sea bass will die in the commercial fishery (regardless of gear type; SEDAR 2005). Sublegal-sized black sea bass that escape through the mesh before the traps are retrieved or early during retrieval (i.e., when traps are still close to the bottom) avoid potentially lethal barotrauma.

Traps account for 78% of the commercial harvest of black sea bass in the U.S. South Atlantic; the majority of these trap landings are made in North Carolina (NOAA Fisheries 2007). Trap regulations in this

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fishery recently have been changed several times. Regulations from 1999 to 2006 required the use of at least 38.1-mm mesh (square or hexagonal measure) for the outside walls of traps and the inclusion of at least two 50.8-mm square or circular escape vents. Vents affixed to the external walls of traps have been used in the South Atlantic region and in the U.S. mid-Atlantic region to allow escape of sublegal-sized individuals (<254 mm total length [TL]). However, research in mid-Atlantic waters has found that vents do not efficiently allow for escape of sublegal black sea bass (Fisher et al. 2004).

The overfished status of black sea bass in the U.S. South Atlantic increases the importance of optimizing trap mesh size. Amendment 13C to the SAFMC snapper–grouper fishery management plan requires one entire side of the trap (the back panel, which is generally opposite the line used to retrieve the trap) to be made of at least 50.8-mm mesh; the other five sides are 38.1-mm mesh (back-panel traps; SAFMC 2006). This rule was adopted partly over concerns that high catch rates of sublegal black sea bass in vented, 38.1-mm-mesh traps resulted in large numbers of discarded, pressure-traumatized fish that died after release. In theory, having larger mesh on at least one side of the trap increases the likelihood that sublegal-sized fish will escape before they experience substantial changes in pressure. Research in other trap fisheries targeting demersal species indicates that selectivity occurs mostly through the back panel (Stewart and Ferrell 2003). A subset of fishers in the U.S. South Atlantic electively use traps made of 50.8-mm mesh throughout (all-panel traps); their reasoning is that catches of legal-sized black sea bass can be maintained in these traps while further decreasing catches of sublegal fish. Research on catch rates of black sea bass from traps has been conducted in mid-Atlantic waters (Shepherd et al. 2002; Fisher and Rudders 2003; Fisher et al. 2004), but there have not been comparable studies of catch rates among mesh sizes required or electively used in the U.S. South Atlantic.

This study was undertaken to determine whether all-panel traps would further reduce the number of discarded black sea bass (and therefore the sorting time required by a fisher) in comparison with discards in the newly mandated back-panel traps. To estimate selectivity, these experimental trap types were compared with control traps in which all panels were made of 38.1-mm mesh. Catch rates and immediate discard mortality rates were also compared among the three trap types. Specific objectives were to (1) compare catch rates between legal- and sublegal-sized black sea bass; (2) compare median fish size among trap types; (3) correlate fish condition at release with capture depth and fish density in the traps; (4) model proportional retention of black sea bass in each experimental trap type; and (5) develop a relationship between black sea bass body depth and length over a range of sizes commonly captured in the fishery.

Methods

Thirteen day trips were taken in Onslow Bay, North Carolina, from October 2006 to March 2007 aboard the FV *Barbara Lynn*, a 13-m, diesel-powered vessel equipped with a hydraulically operated trap puller that retrieves traps at a rate of roughly 0.6 m/s. A total of 30 traps (10 traps/type) were fished each day after being set the previous day; observers were onboard on each day of trap retrieval.

Traps were constructed of 12-gauge, vinyl-coated square mesh. Square mesh is the type most commonly used in this fishery because it is more durable and does not bend as easily as hexagonal mesh. The all-panel trap (50.8-mm mesh in all panels) was tested because roughly half of the trap fishers between Beaufort, North Carolina, and Murrells Inlet, South Carolina, use this type; the remaining fishers use the back-panel trap (50.8-mm-mesh back panel and 38.1-mm mesh in all other panels; Tom Burgess [commercial fisher], Sneads Ferry, North Carolina, personal communication). The control traps (38.1-mm mesh in all panels) are no longer allowed and are being replaced with the all-panel and back-panel traps. Depending on the specific panel measured, the internal square mesh size is actually smaller than the quoted mesh size due to vinyl coating on the wire; therefore, internal mesh size is roughly 35 mm (47 mm diagonally) for the 38.1-mm mesh and 47 mm (66 mm diagonally) for the 50.8-mm mesh. Externally, traps were 61 cm long and wide and 56 cm high. Each trap had a single chamber (i.e., no upper versus lower parlors), two funnel entrances on opposite sides, and a cylindrical bait well that extended through the full depth of the trap (Figure 1). Two 16-mm-diameter, rebar square frames were attached to the bottom of each trap.

Traps were baited with equal volumes of previously frozen Atlantic menhaden *Brevoortia tyrannus* and were fished in waters of 12–30-m depth. Traps were deployed in random fashion at a minimum distance of 200 m from the nearest neighbor. The total number of traps (30) was not always fished within the same location each day, but equal numbers of the three trap types were deployed in close proximity. Overnight soak time ranged from 18 to 26 h. Depth (m) was recorded when traps were pulled.

Upon retrieval of each trap, fish were sorted in a culling tray, identified to species, and counted. Each black sea bass was measured for TL (center of the

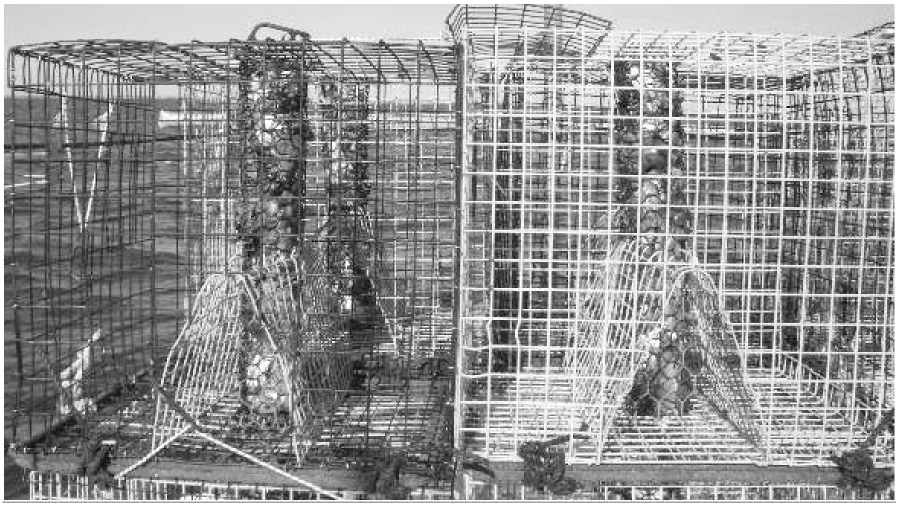

FIGURE 1.—Photograph of an all-panel trap (50.8-mm mesh in all panels; left) and a back-panel trap (50.8-mm mesh in the back panel, 38.1-mm mesh in all other panels; right) used to commercially harvest black sea bass in the U.S. South Atlantic.

caudal fin; mm). All sublegal and some marginally legal black sea bass were released and assigned one of four possible condition scores: (1) alive, oriented towards bottom, and swimming downward vigorously; (2) alive, oriented towards bottom, and swimming downward slowly or erratically; (3) alive but floating at the surface; and (4) dead or unresponsive (Patterson et al. 2000). Fish with a score of 3 or 4 were assumed to eventually die; no particular fate was assumed for fish with a score of 1 or 2 (Nieland et al. 2007). The presence or absence of obvious barotrauma signs (stomach protruding into esophagus or out of the mouth; bulging eyes; or prolapsed anus) was recorded for each black sea bass.

The probability, $\Phi(l)$, that black sea bass were retained by an experimental trap type was computed using a three-parameter proportionality model for paired data (Wileman et al. 1996):

$$\Phi(l) = \frac{p[\exp(a+bl)]}{(1-p)+[\exp(a+bl)]},$$

where l is TL (mm) and a, b, and p are parameters with values determined through maximum likelihood approaches. Estimates of standard errors about each parameter were also determined using published approaches (Wileman et al. 1996). Parameter p is relative fishing intensity, calculated as the probability of a black sea bass entering the experimental trap type divided by the fish's combined probability of entering the experimental and control trap types. The incorporation of p is important because it cannot be assumed that control gear and experimental gear fish with equal power (Wileman et al. 1996). The model was fitted using observed data (catch in experimental trap type/catch in experimental trap plus control trap). To our knowledge, this particular model has not been used to model selectivity in any trap fishery for black sea bass.

We used estimates of a and b in a conventional two-parameter logistic model to graph contact selectivity (r) at incrementally larger values of l (10-mm TL bins; Wileman et al. 1996; Millar and Fryer 1999):

$$r(l) = \frac{\exp(a+bl)}{1+[\exp(a+bl)]}.$$

We used a logistic function to model selectivity because that model fit the raw data and because the width and depth of funnel entrances exceeded the body width and depth of even the largest black sea bass that could be encountered. For each trap type, we also computed the TL at which 50% of the black sea bass were selected (l_{50}) and the selection range (difference between TLs of fish that had 75% and 25% chances of selection). A narrower selection range will translate to a steeper nonlinear selection curve (see Wileman et al. [1996] for these equations).

A body depth–TL relationship was developed for black sea bass by employing least-squares linear regression. Such a model for black sea bass may be used to determine the optimal mesh size given future changes to the minimum length limit.

We compared mean catch per unit effort (CPUE; number of fish/trap) of legal and sublegal black sea bass among trap types using one-way analysis of variance (ANOVA; $\alpha = 0.05$) or with the Kruskal–Wallis H-test when the ANOVA assumption of

TABLE 1.—Estimates of variables or parameters in a proportionality function, $\Phi(l) = p[\exp(a + bl)]/[(1 - p) + \exp(a + bl)]$ (where $\Phi(l)$ = probability of trap selection, p = relative fishing intensity, l = total length [TL], and a and b = parameters with values determined through maximum likelihood approaches: Wileman et al. 1996), used to examine differences in black sea bass catch between back-panel traps (50.8-mm mesh in the back panel; 38.1-mm mesh in all other panels) and all-panel traps (50.8-mm mesh in all panels) set in Onslow Bay, North Carolina (l_{50} = TL at which 50% of black sea bass were selected; SR = selection range, calculated as the difference between TLs of fish that had 75% and 25% chances of selection).

Parameter or variable	Estimate	SE
	Back panel trap	
a	−26.21	1.29
b	0.10	0.01
p	0.52	0.01
l_{50}	260.52	1.35
SR	21.84	1.16
	All panel trap	
a	−34.44	1.84
b	0.13	0.01
p	0.52	0.01
l_{50}	264.84	1.11
SR	16.91	0.95

homoscedasticity could not be satisfied. Median lengths of black sea bass were also compared among trap types via a Kruskal–Wallis H-test. Tukey's honestly significant difference test and its nonparametric analog were used to make pairwise comparisons of CPUE and median size.

Median release condition was compared among trap types via a Kruskal–Wallis H-test. The relationship between black sea bass release condition score and density of fish (all species) in traps, capture depth, or deck time (s) was tested with Spearman's rank correlation (coefficient = r_s; $\alpha = 0.05$). The data for the latter test were collected from a sample of four control traps where deck time was measured, whereas the first two correlations were conducted on all trap types combined. Spearman's rank correlation was also used to test the association between depth and (1) black sea bass density in traps or (2) presence of external barotrauma signs for all trap types combined.

Results

The total number of trap sets was 130 for control traps (i.e., 10 traps × 13 nights), 129 for back-panel traps, and 127 for all-panel traps; 5,612 black sea bass (56.0% sublegal) were captured in control traps, 2,336 (10.9% sublegal) were captured in back-panel traps, and 2,037 (5.9% sublegal) were captured in all-panel traps. Four trap sets were excluded because of trap loss or damage or latch failure. The mean water depth at which traps were set was 20.7 m (SE = 5.9). Black sea bass predominated in the catch of each trap type; bank sea bass *C. ocyurus*, spottail pinfish *Diplodus holbrookii*, and scup *Stenotomus chrysops* were the three most abundant bycatch fish species in the traps.

For black sea bass caught in back-panel traps, the l_{50} was 261 mm and the selection range was 22 mm (Table 1). For black sea bass caught from all-panel traps, the l_{50} was 265 mm and the selection range was 17 mm. Selectivity of each experimental trap type relative to control traps displayed a relatively knife-edged pattern (Figure 2).

We used 160 black sea bass ranging in length from 188 to 372 mm to model the body depth–TL relationship, which was described as:

$$\text{body depth} = 0.942 + (0.272 \times \text{TL}),$$

where each measurement is in millimeters ($r^2 = 0.888$). The regression probably included fish in both developing and spawning condition and thus might have overestimated the width of black sea bass during nonspawning periods.

The CPUE of legal black sea bass was $\log_e(x + 1)$ transformed to correct for unequal variances among the three trap types. There was no significant difference in the mean CPUE of legal black sea bass among the three trap types ($F = 2.35$, df = 2, $P = 0.097$). In contrast, a logarithmic transformation did not correct for unequal variances among the three trap types for sublegal black sea bass; differences among CPUEs of sublegal-sized fish were significant ($H = 222.5$, df = 2, $P < 0.001$). Back-panel traps had a significantly greater CPUE of sublegal-sized fish than did full-panel traps ($P = 0.006$), and control traps had a significantly greater CPUE of sublegal fish than did either experimental trap type (all $P < 0.001$; Table 2).

Median lengths of black sea bass were 248 mm in control traps, 281 mm in back-panel traps, and 290 mm in all-panel traps (Figure 3); median length differed significantly among trap types ($H = 2{,}503.6$, df = 2, $P < 0.001$). Median length was significantly greater for each experimental trap type than for control traps and was greater for all-panel traps than for back-panel traps (all $P < 0.001$).

Postrelease indices of black sea bass suggested that immediate mortality occurred in 3.3% of releases. Across the three trap types, 96.7% of individuals were given postrelease condition scores of 1 or 2 (Table 3). There was a significant difference in median postrelease condition score among the three trap types ($H =$

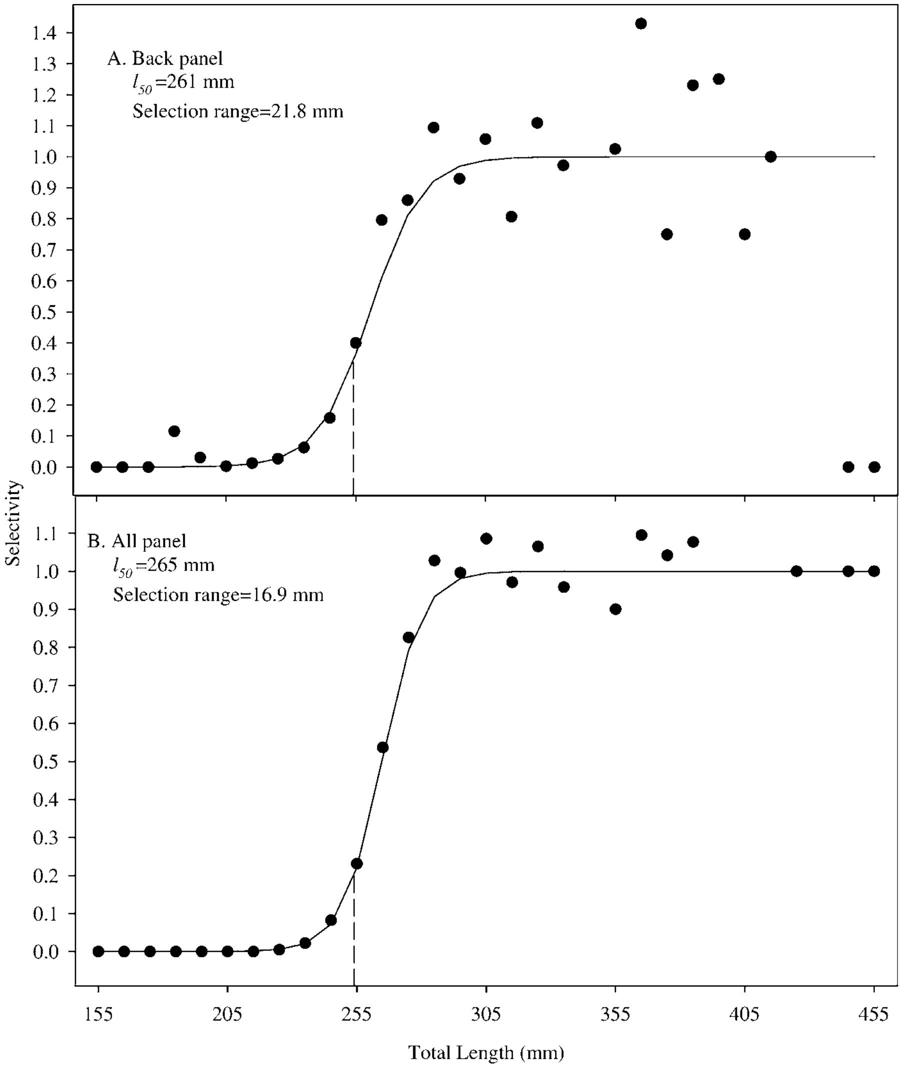

FIGURE 2.—Selectivity graphed as a logistic function (solid line) of the total length (TL; mm) of black sea bass caught in Onslow Bay, North Carolina (2006–2007), by use of two experimental trap types: **(A)** back-panel traps (50.8-mm mesh in the back panel; 38.1-mm mesh in all other panels) and **(B)** all-panel traps (50.8-mm mesh in all panels). Dark circles represent the proportion of black sea bass (catch in experimental traps/catch in control traps [i.e., those with 38.1-mm mesh in all panels and no release vents]) retained for each 10-mm TL bin, l_{50} is the TL at which 50% of fish were selected, selection range is the TL difference between fish with a 75% chance of selection and those with a 25% chance of selection, and the vertical dashed line represents commercial minimum TL limit (254 mm).

10.77, df = 2, P = 0.005), but the three post hoc pairwise comparisons were not significant ($P > 0.05$).

Spearman's rank correlation of postrelease condition score versus fish density ($r_s = 0.167$) or capture depth ($r_s = 0.278$) was positive and significant ($P < 0.001$). Black sea bass with obvious signs of barotrauma constituted 4.16% of the total number captured. Deck time (range = 5–650 s) was not correlated with postrelease condition score of black sea bass (r_s = –0.016, P = 0.774; number released = 338). The presence of barotrauma signs was correlated with depth ($r_s = 0.240$, $P < 0.001$). Black sea bass density in traps was also correlated with depth ($r_s = 0.103$, $P < 0.043$). The trend of increasing rates of gastric distention with capture depths up to 25 m paralleled the trend of immediate release mortality; immediate estimates of

TABLE 2.—Mean catch per unit effort (number of fish/trap) for all fish species or black sea bass (all, sublegal size, or legal size) captured in Onslow Bay, North Carolina, by use of three trap types: control traps (38.1-mm mesh in all panels; 130 trap sets), back-panel traps (50.8-mm mesh in the back panel, 38.1-mm mesh in all other panels; 129 sets), and all-panel traps (50.8-mm mesh in all panels; 127 sets). Within a row, means sharing the same letter did not differ significantly ($P > 0.05$).

	Control		Back panel		All panel	
Category	Mean	SE	Mean	SE	Mean	SE
All fish species	55.4	2.9	22.7	1.2	20.5	1.8
Black sea bass						
All	44.4	2.8 z	18.0	1.0 y	16.1	1.4 y
Sublegal size	25.1	1.9 z	1.9	0.2 y	0.9	0.1 x
Legal size	19.2	1.2 z	16.1	0.9 z	15.2	1.4 z

mortality were lower and gastric distention rates were higher for fish captured at 25–30-m depths than for fish captured at 20–25-m depths (Figure 4).

Discussion

Mesh sizes that reduce selectivity on undersized fish will reduce mortality from confinement in traps, barotrauma, handling, and predation during confinement and after release (Bohnsack et al. 1989). Both the newly required back-panel traps and the electively used all-panel traps maintained the catch rates and size spectrum of legal-sized black sea bass while reducing sublegal catch rates in comparison with those in control traps. Further, all-panel traps reduced sublegal black sea bass catch rates relative to those in back-panel traps. It is important to note that control traps were not used to simulate the commercial traps used prior to regulation of mesh size (those traps, by contrast, had two square escape vents). Control traps in this study were used to catch all black sea bass sizes present, which enabled development of selectivity curves for the two experimental trap types. The two experimental trap types were compared with each other to determine whether further regulation would benefit fishers (reduced sorting time) and fish (lower discard mortality). If one assumes that Fisher et al.'s (2004) findings of no difference in catch rates between vented and unvented 38.1-mm-mesh traps apply to our study area, then comparisons between our control traps and the two experimental trap types show the benefit of switching to either the back-panel trap or the all-panel trap.

The narrow selectivity range (relatively knife-edged pattern) and l_{50} from each experimental trap type demonstrate that these traps are highly efficient at retaining legal black sea bass while selecting against sublegal fish. This pattern in a trap fishery demonstrates that fish are escaping through the mesh if they are physically capable (Stewart and Ferrell 2003) and is similar to patterns observed in the mid-Atlantic fishery, where larger vent sizes selected for larger fish (Shepherd et al. 2002). We witnessed few black sea bass escaping through mesh as our traps were pulled or briefly held at the surface before being hauled on deck; traps and fish could be observed from about 6 m to the surface. Thus, the majority of sublegal black sea bass in experimental traps must either exit the trap before retrieval, when they feel a disturbance in the trap, or soon after retrieval has begun. Given any of these scenarios, these fish would avoid the rapid pressure changes associated with being brought to the surface.

There were differences in median sizes of black sea bass and in proportionality parameters a and b between the all-panel and back-panel traps. Between the two trap types, 95% confidence intervals did not overlap for a but did overlap slightly for b. These size and selectivity differences probably resulted from the inability of some smaller black sea bass to find or escape through the back panel. An advantage of using traps as a commercial gear is that changes in mesh size produce greater selectivity than do changes in hook size (Bohnsack et al. 1989).

Selectivity of fish traps is believed to be a function of back-panel mesh size and fish body depth (Stewart and Ferrell 2003). Based on catch results and selectivity calculations, 50.8-mm mesh appears to be a nearly optimal mesh size for retaining black sea bass of the current legal minimum size. A 254-mm black sea bass is predicted to have a body depth of 70 mm, which is very close to the actual internal diagonal measurement (66 mm) of 50.8-mm square mesh.

The average CPUE of legal black sea bass was not significantly different among the three trap types. In contrast, there was a highly significant decrease in the average CPUE of sublegal black sea bass between control traps and each experimental trap type and between the two experimental trap types. Thus, the selectivity of each experimental trap type did not compromise the catch of legal black sea bass. Shepherd et al. (2002) found that traps with a rectangular vent (28.6 × 146 mm) decreased the catch of sublegal black sea bass relative to that in unvented traps. In contrast to

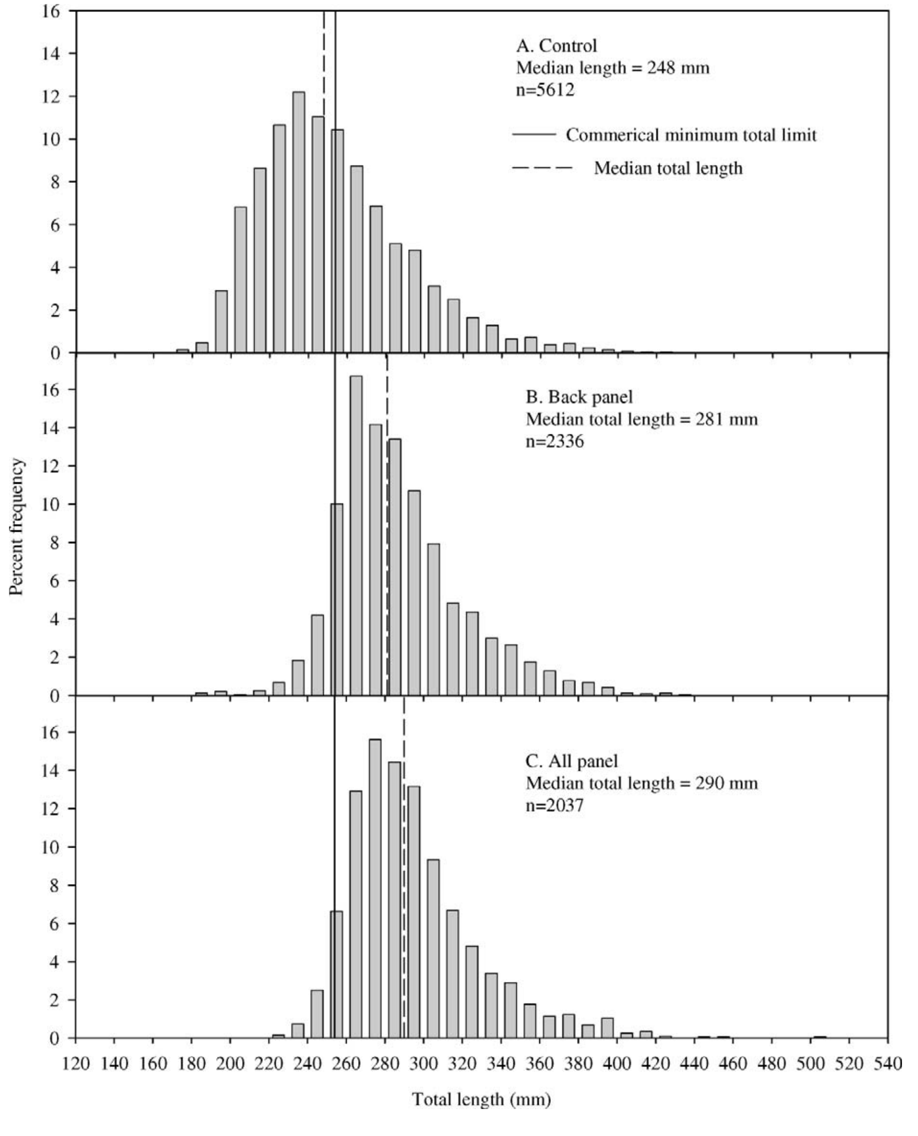

FIGURE 3.—Length frequency histograms (bars = 10-mm total length [TL] bins) of black sea bass captured in Onslow Bay, North Carolina (2006–2007), by use of three trap types: **(A)** control traps (38.1-mm mesh in all panels), **(B)** back-panel traps (50.8-mm mesh in the back panel; 38.1-mm mesh in all other panels), and **(C)** all-panel traps (50.8-mm mesh in all panels). The dashed vertical line represents the median TL captured in a given trap type; the solid line represents the commercial minimum TL limit (254 mm).

rectangular vents, Fisher et al. (2004) found that in mid-Atlantic waters, the numbers of sublegal black sea bass (<279 mm TL) retained in traps with 50.8-mm square vents equaled that in unvented traps; those authors felt that the small size of the vent (in relation to trap volume) and crowding may have limited the ability of sublegal-sized fish to find and use the vent.

For minimum size limits to be effective, a high percentage of sublegal fish either must not be caught or must survive catch and release over the range of capture depths (Burns and Restrepo 2002). Our results on discard mortality are dependent on assumptions related to delayed mortality. If it is assumed that the observed or presumed rates of immediate discard mortality of black sea bass are similar to estimates of delayed mortality, then the 15% mortality rate among discards (i.e., the rate used for black sea bass assessments; SEDAR 2005) should be adjusted

TABLE 3.—Number of black sea bass released after capture in three trap types within Onslow Bay, North Carolina, and percentages assigned to four postrelease condition categories (1 = alive, oriented towards bottom, swimming downward vigorously; 2 = alive, oriented towards bottom, swimming downward slowly or erratically; 3 = alive but floating at the surface; 4 = dead or unresponsive). Trap types were control (38.1-mm mesh in all panels), back panel (50.8-mm mesh in the back panel, 38.1-mm mesh in all other panels), and all panel (50.8-mm mesh in all panels). Presumed mortality (%) included all fish that had a score of 3 or 4 and any fish (regardless of score) that had obvious signs of barotrauma (stomach protruding into the esophagus or out of the mouth; exopthalmia; intestinal prolapse).

Trap type	Number released	Condition score				Presumed mortality (%)
		1	2	3	4	
Control	3,093	94.6	1.6	0.2	3.5	5.9
Back panel	388	97.7	1.3	0.3	0.8	2.1
All panel	139	98.6	0.7	0	0.7	3.6

downward. On the other hand, if mortality occurs in fish with both observable and unobservable signs of barotrauma, then the currently used rate of 15% may be close to the actual rate.

Mortality of black sea bass that were observed upon release was low. Collins et al. (1999) found 85% survival of black sea bass captured at 20–23-m depths and 88% survival for those captured at 29–35-m depths and subsequently held in cages for 24 h. However, it is unknown whether individuals with obvious barotrauma signs but good release condition scores (1 or 2) avoid predation in attempting to return to the bottom or whether these fish eventually heal; thus, the percentage of fish that died immediately upon release in our study should be considered a minimum estimate because some fish with and without externally observable signs of barotrauma will die. Of the 119 black sea bass with a postrelease condition score of 3 or 4 (fish that were either dead or presumed to eventually die), only one individual (caught at 27.4 m) had obvious signs of barotrauma; mortality in the other 118 individuals was caused by barotrauma that could not be externally observed or by other factors.

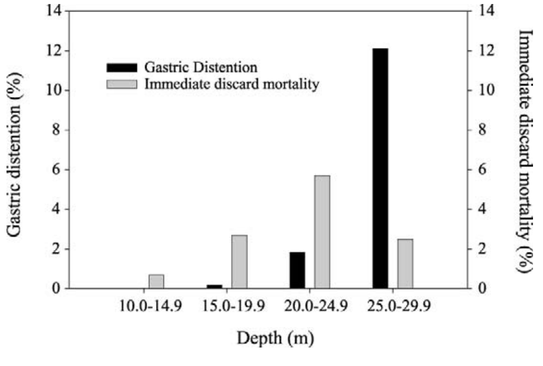

FIGURE 4.—Percentage of black sea bass (by 5-m depth bins) captured in traps in Onslow Bay, North Carolina (2006–2007), that exhibited external signs of barotrauma (i.e., gastric distention; black bars, primary *y*-axis) and percentage that exhibited immediate discard mortality (as inferred from a postrelease condition score of 3 or 4, defined in Table 3; gray bars, secondary *y*-axis). No fish were captured at 11–12- or 26–27-m depths. None of the 3,452 fish caught at depths less than 19 m had external barotrauma signs. Sample sizes were unequal among depth bins.

Although rates of immediate mortality of black sea bass appear low, future research is needed to accurately determine delayed mortality rates and the effects of barotrauma. This may resolve the discrepancy between the discard mortality rate of 15% used for assessment of this species in the U.S. South Atlantic and our observed rate of 0.9% (across back-panel and all-panel traps). The assumption of a 15% discard mortality rate for the entire commercial fishery may still approximate reality if hook-and-line operations have greater percentages of discarded fish that die upon release (from deep hooking and other factors).

The relationship between deck time and postrelease condition score was not significant. Thus, deck time is not expected to contribute to mortality in this fishery because the upper range of deck times in our study was greater than that in typical trapping operations; fish that are trapped commercially are not measured unless they are close to the minimum size. Depending on fish density in traps, discarded fish are exposed to air for roughly 15–60 s before being released. All trapped fish are dumped into a smooth, black plastic culling tray moistened from sea spray and the dumping of other traps. Because fish are dumped directly into a culling tray (instead of being pulled from traps individually), sublegal black sea bass only need to be handled once during typical trapping operations.

In this fishery, discard mortality of black sea bass may be more a function of water depth and fish density inside traps than handling or deck time. Immediate release mortality of black sea bass was positively correlated with depth but also with fish density in traps (density was higher at greater depths). At very high densities (>100 fish/trap), many black sea bass had opaque eye corneas, probably from being scratched by fins of other fish in the trap or by the trap itself. Such density-dependent trauma may contribute to increased rates of immediate or delayed discard mortality. Our finding of a greater rate of observed mortality with depth is consistent with other work on this species (Collins et al. 1999).

Our work supports the findings of Bohnsack et al. (1989) that mesh size can be optimized in a trap fishery for a reef species to reduce discard mortality of sublegal individuals. The mandatory back-panel trap drastically reduces the catch rate of sublegal black sea bass. However, the observed decrease in average CPUE of sublegal fish between the two experimental trap types should also be considered in future black sea bass management discussions. Eleven of 26 fishers in the study area elect to use the all-panel trap. Using our CPUE data and assuming that (1) our cooperating fisher approximates the annual effort in the U.S. South Atlantic commercial trap fishery (i.e., 4,000 trap lifts/fisher) and (2) no individuals are recaptured, use of the all-panel trap by each of the 26 trap fishers (instead of only 11 fishers) would eliminate the handling and discard of roughly 60,000 additional sublegal black sea bass each year.

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