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MANAGEMENT BRIEF

Effectiveness of Venting and Descender Devices at Increasing Rates of Postrelease Survival of Black Sea Bass

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Abstract
We tested the ability of venting and descender (recompression) devices to increase the relative survival of released Black Sea Bass *Centropristis striata*, a physoclistous reef species with high discard rates in hook-and-line fisheries that operate in the U.S. Atlantic Ocean and Gulf of Mexico. We caught fish via hook and line from waters that were 38 m deep, a depth where Black Sea Bass often exhibit signs of barotrauma and may be unable to submerge after release. Fish were conventionally tagged and vented with either an 11-gauge cannula or a 16-gauge needle, descended using a descender (recompression) device, or released as tagged controls (no venting or recompression). Tests of independence were used to determine the relationship between submergence and treatment (excluding recompressed fish) as well as between submergence and tag return rate. Tag-recapture data were used to inform a Cox proportional hazards model that evaluated the survival of fish treated with each experimental device relative to the control group. A significantly greater proportion of fish submerged when treated with either venting device relative to the controls, and the fish that submerged had a greater proportion of tag returns relative to those that did not submerge. Venting and recompression increased postrelease survival compared with the controls. The results provide guidance to managers who seek methods to reduce discard mortality rates in hook-and-line fisheries for this important species. Future studies should examine the use of these devices at a range of depths to determine their effectiveness.

The growth in recreational fishing has resulted in an increased impact to fish stocks (Arlinghaus et al. 2019). Over half of the 47 billion marine and freshwater fish caught annually worldwide are released (Cooke and Cowx 2004) but many of these individuals experience postrelease mortality when discarded. Discard mortality is recognized as a globally important fisheries issue, partly due to the increasing impact of recreational fishing (Hall et al. 2000; Davis 2002; Shertzer et al. 2019). Management strategies to reduce discard mortality often include attempts to reduce the number of regulatory discards as well as to encourage or require devices to treat discarded individuals (Alverson et al. 1994; GMFMC 2007). Recreational fishers can be integral in developing and using devices that increase postrelease survival of the fish that they discard (Cooke and Schramm 2007; Brownscombe et al. 2017), thereby reducing their impacts on the stocks that they exploit.

The Black Sea Bass *Centropristis striata* is one species in the complex of physoclistous reef fishes that often experiences pressure-related trauma (barotrauma) when caught from depths greater than approximately 20 m (Collins et al. 1999; Rudershausen et al. 2007, 2014). This postrelease mortality can result from an inability of fish to submerge. This warrants the study of devices that fishers can employ to potentially increase survival by improving the rates of postrelease submergence success.

The rate of discard is a significant issue in the U.S. Atlantic Ocean and Gulf of Mexico recreational and commercial hook-and-line Black Sea Bass fisheries; Marine Recreational Information Program data (MRIP 2019) reveal that the annual combined number of discarded Black Sea Bass in these fisheries has exceeded the number landed for every year this century (Figure 1). In addition, the percentage of total catch that is released in the recreational fisheries in these regions has increased steadily in the last several decades; released Black Sea Bass now comprise approximately 80% of total annual catch in these fisheries. This increase warrants the study of devices that can promote the health of these stocks by reducing mortality among discarded individuals.

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Venting and recompression devices have been investigated to determine whether they increase postrelease survival of some physoclistous reef fish species (e.g., Drumhiller et al. 2014; Runde and Buckel 2018; Bellquist et al. 2019). However, despite this body of research, the relative effectiveness of venting versus descending remains uncertain. A meta-analysis demonstrated that venting does not increase postrelease survival across a range of species and provided evidence against the effectiveness of this practice (Wilde 2009). In contrast, Eberts and Somers (2017) concluded that there was no difference in the effectiveness between venting and recompression but recommended species- and context-specific research to elucidate best practices for increasing postrelease survival rates. Despite continued uncertainty regarding its effectiveness, venting is a voluntary technique used by some fishers in the U.S. Atlantic region (P. J. Rudershausen, unpublished) because they believe that it helps increase survival among discarded reef fishes.

We tested whether venting or recompression devices increased postrelease survival of Black Sea Bass. We collected tag-recapture data to inform models that evaluated the effectiveness of each device; tag-recapture has proven to be an effective sampling technique for Black Sea Bass because of the fidelity of this species to reef sites that results in high (~20%) recapture rates (Rudershausen et al. 2014). We worked at a depth where this species is commonly found over the continental shelf (Bacheler and Ballenger 2015) and where obvious barotrauma (e.g., stomach eversion) is common among individuals caught via hook and line (Rudershausen et al. 2014). This research provides timely information for managers who need solutions that stakeholders both find acceptable and can easily apply in their own fishing activities.

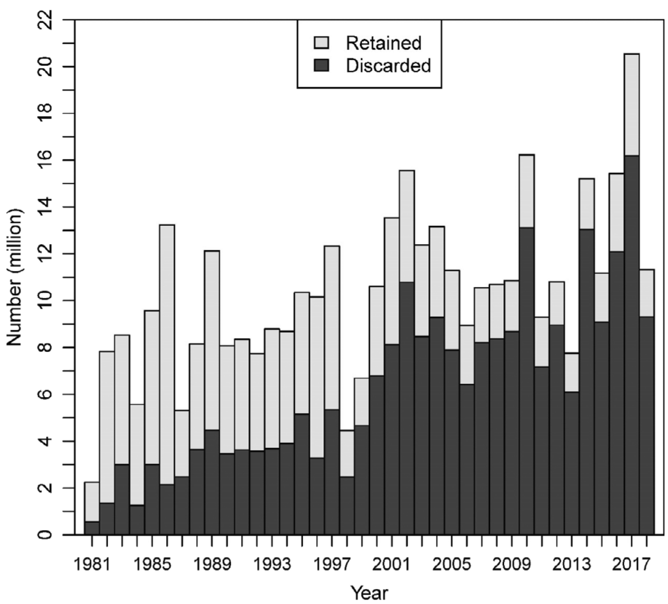

FIGURE 1. Stacked histogram of the annual number of discarded and retained Black Sea Bass in the U.S. Atlantic and Gulf of Mexico recreational hook-and-line fisheries from 1981 through 2018. Dark gray bars indicate discarded individuals and light gray bars indicate retained individuals. Data are from the NOAA Marine Recreational Information Program Web site (MRIP 2019).

METHODS

We conducted fishery-independent research trips onboard an 8-m research vessel. The trips were made to a single location that was approximately 2 km^2 in area and located 25 km east of Cape Lookout, North Carolina. This low-relief natural reef site lies in waters approximately 38 m deep. Fishing activity and the releasing of Black Sea Bass were conducted during daylight in all seasons except summer (June–September) over a running 4-year period (2015–2019). Sea surface temperature (°C) was measured by an onboard SONAR transducer during each of the tagging trips to the site; these temperatures ranged from 14°C to 28°C. All fishing activity for Black Sea Bass was conducted manually with fishing rods and reels equipped with 27-kg braided line. Fishing reel drags were set to approximately 5 kg. Terminal tackle consisted of high-low bottom rigs constructed from 68-kg monofilament nylon line, a 0.45-kg sinker, and two 3/0 hooks baited with cut squid *Loligo* sp. These terminal gear and bait types are typical of those used by recreational fishers targeting Black Sea Bass in the U.S. South Atlantic region (Rudershausen, unpublished).

The experimental devices that we tested were (1) an 11-gauge, commercially available Fishers Choice FVT-001 venting tool (hereafter, "venting cannula"), (2) a 16-gauge venting needle available as part of Florida Sea Grant's Novak Venting Tool Kit, and (3) a commercially available Blacktip Catch and Release Recompression Device attached to a 5-kg ballast (Figure 2). Each of the two venting devices was used to vent fish through the release of trapped gases by inserting the cannula or needle into the abdominal cavity behind the pectoral fins. The recompression device was connected to a dedicated rod and electric reel (not used to angle fish) over the duration of each trip. This recompression device has spring-loaded jaws that are attached to the mandible of a fish to be released; the jaws of the device open after the device contacts the sea floor.

Each individual was measured for TL (mm) and tagged with a uniquely numbered Floy FD-94 T-bar anchor tag before its release. The tag was inserted with a tagging gun into the dorsal musculature between the pterygiophores; this tag type and anatomical tagging location avoid incidentally venting fish and thus confounding the experimental effects of venting, which could occur with inserting an

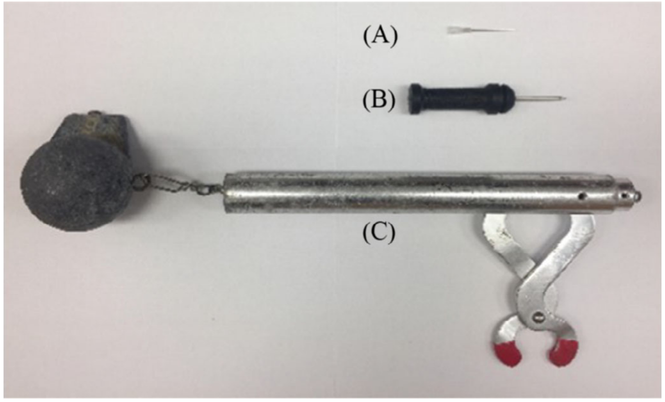

FIGURE 2. Devices tested for their effectiveness at increasing postrelease survival of Black Sea Bass that were caught and released in waters 38 m deep off of the coast of North Carolina. The types of the devices are as follows: **(A)** 16-gauge needle supplied as part of Florida Sea Grant's Novak Venting Tool Kit, **(B)** 11-gauge commercially available venting cannula, and **(C)** commercially available Blacktip catch-and-release recompression device attached to ballast. [Color figure can be viewed at afsjournals.org]

internal anchor tag into the abdomen (Rudershausen et al. 2014). We tagged Black Sea Bass across all sizes captured, because individuals of current recreational legal size in the U.S. South Atlantic (≥330 mm TL) must be released during intermittent closed seasons (when the recreational quota for a fishing year is reached) or when a fisher exceeds the daily possession limit. Individuals were tagged regardless of the type of visible barotrauma (e.g., abdominal swelling, stomach eversion into the buccal cavity or out of the mouth, exophthalmia, intestinal prolapse). The four treatments were rotated to maintain equivalent sample sizes. There were slight differences in the final number of fish tagged among the four groups, as a result of some fish escaping overboard after being tagged but before being vented or recompressed. Fish that were hooked in any of their vital organs (i.e., gills, stomach/esophagus, or eyes) were released without tagging and not used in any analyses.

Analyses.— We conducted separate analyses between data on release observations versus tag-recapture data. The data on release observations were used in two separate chi-square tests of independence to determine whether (1) postrelease submergence success was independent of treatment group (for the three non-recompressed groups), and (2) postrelease submergence success was independent of reported recaptures. Logistic regression was used to determine the relationship between submergence success and fish TL. Statistical significance for the tests of independence and for the regression coefficient of TL on submergence success were evaluated at $\alpha = 0.05$. These analyses were conducted with the base package in R (R Core Team, Vienna).

The relative survival of Black Sea Bass treated with each experimental device relative to controls was estimated by fitting a Cox proportional hazards model (Cox 1972) to the tag-recapture data. This type of analysis has been previously applied to estimate discard mortality of reef fishes (Sauls 2014; Runde et al. 2019). It compares the occurrence and timing of the first recapture for each tagged individual by evaluating instantaneous "risk" of an event (recapture) at time *t* conditioned on survival to that time. In our case, the model used untreated (control) fish as a reference group with which the individuals treated with experimental devices are compared. The Cox model is semi-parametric in that the underlying hazard function can assume any distribution while modeled covariates are assumed to be linearly related to the hazard function. The model is well-suited to estimate postrelease survival of fishes from tag-recapture studies because it permits staggered entry of newly tagged individuals into the studied population and does not require that the researcher know the fate of every marked individual upon completion of the study. This approach extends the utility of relative risk models that evaluate the survival of fish released in various conditions (Hueter et al. 2006) by also considering potentially meaningful covariates of postrelease survival (Sauls 2014). The Cox model assumes that the long-term processes of natural and fishing mortality operate independently of the treatment group to which a fish belongs (i.e., fishing and natural mortality are equivalent among treatment groups). Further, the Cox model assumes that (1) any tagging-related mortality and tag loss act on treatment groups in the same way, (2) that the probability of mortality due to catch and release is not influenced by the time of entry into the population or can be corrected for by including temporal covariates into the model, and (3) that study specimens are randomly encountered upon marking (Cox 1972).

We applied a Cox model with an assumed constant hazard rate for each fish with a reported tag. The response data were the presence/absence of a recapture event for each tagged individual and "time-to-event"—the number of days that the fish was either at-large between tagging and its first reported recapture, or August 8, 2019 (1,895 running study days) if the fish was either not recaptured or recaptured but not reported. The model was fitted to right-censored data whereby an individual was no longer evaluated after its first reported recapture or the study period ended without a reported recapture for an individual. Treatment type was considered a categorical effect. A continuous covariate considered in the model was fish TL; we included TL because fish size has been found to be related to submergence success for some physoclistous species (e.g., Hannah et al. 2008). The TL values were centered before model fitting. Submergence success was not considered as a covariate in the Cox model because this response was not present with recompressed fish. We did not consider barotrauma as a binary covariate because we could not rule out latent barotrauma for tagged fish that lacked obvious clinical signs of it.

The group of fish that were tagged on each trip was exposed to a unique set of conditions, including sea surface temperature, temperature profile, and sea state, the effects of which we were unable to adequately control in our analyses. In addition, these groups were subjected to a variable amount of recapture effort based on stochastic conditions including researcher availability and weather conditions. While water temperature has been found to affect discard mortality rates of demersal fishes (Davis 2002; Curtis et al. 2015), we did not fit the Cox model to water temperature explicitly; the probability of recapture for the group of marked fish could instead have been a function of our ability to revisit the sample site over a timeframe to recapture fish while they were still alive and in the study area. These facts led us to model the tagging date (tagging trip number) as a random effect in the model to make inferences about treatment effects over a broader set of study subjects (in this case, trips with different environmental conditions); this is the general usage of a random effect in other applications (Bolker et al. 2009).

The mixed-effects Cox model was fitted through the coxme package in R (Therneau 2018) and the coxme function within that package. The meaningfulness of each fixed effect on discard survival was evaluated by determining whether its partial regression coefficient differed from zero ($\alpha = 0.05$). For a categorical covariate in the model (treatment type), R estimates the exponentiated coefficient of each treatment level with respect to the baseline level for the covariate (in this case, the control). Each level of a categorical factor or a continuous factor is considered biologically meaningful when its 95% confidence set about its mean exponentiated effect does not overlap one. In addition to the mixed-effects model, a second Cox model was run with just fixed effects through the survival package in R (Therneau 2019). A likelihood ratio test (χ^2 test statistic) was then used to determine the significance of incorporating the random effect into the mixed-effects model. Finally, AIC was used to compare parsimony between the mixed-effect and fixed-effect models.

RESULTS

We made 45 tagging trips over the course of the study. A total of 1,748 Black Sea Bass were tagged and released; 446 of these were untreated controls while 436 were tagged and treated with the venting cannula, 433 with the venting needle, and 433 with the recompression device. For recaptured fish, the mean time to recapture (SD) was 54 (44), 59 (44), 61 (54), and 69 (86) d for control fish and those treated with the venting cannula, venting needle, and recompression device, respectively. Across all tagged fish, the TL (SD) averaged 285 (57) mm and ranged from 145 to 460 mm. There was a total of 434 tag returns. Of these, 81 were control fish, 114 were treated with the venting cannula, 115 were treated with the venting needle, and 124 were treated with the recompression device. This corresponded to tag return rates of 18.2, 26.1, 26.6, and 28.6% for these four respective groups (overall return rate of 24.8%). Ten tag returns were by recreational and commercial fishers while all other tag returns were by the researchers during directed trips to the site.

The assumption of independence between submergence success and experimental group (excluding recompressed fish) was rejected ($\chi^2 = 116.4$, df $= 2$, $P < 0.001$); 76.9% (343/446) of control fish, 95.6% (417/436) of fish treated with the venting cannula, and 96.8% (419/433) of fish treated with the venting needle submerged immediately after release. The assumption of independence between tag returns and submergence success was also rejected ($\chi^2 = 20.6$, df $= 1$, $P < 0.001$); 25.4% (300/1,179) of fish that submerged had their tags returned while 8.0% (11/137) of fish that did not submerge immediately had their tags returned. The effect of fish TL on submergence success was not significant ($z = 0.785$, $P = 0.431$).

Survival functions estimated via the Cox model varied among treatment groups. While the proportion of fish whose tags were not returned declined over time for each

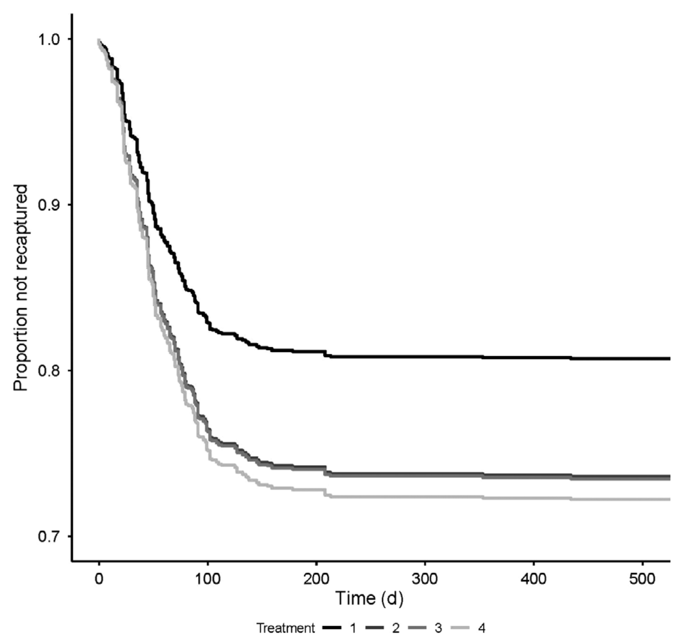

FIGURE 3. Mean estimated survival function, $\hat{S}(t)$, for Black Sea Bass that were caught and released in waters 38 m deep off of the coast of North Carolina from 2015 to 2019. $\hat{S}(t)$ was estimated from fitting a Cox proportional hazards model to time-to-recapture data for individuals subjected to the following treatments: (1) controls, (2) venting with an 11-gauge cannula, (3) venting with a 16-g needle, and (4) recompression. Each treatment has its own grayscale (see legend). The *x*-axis is the time (d) between tagging and recapture. There were 1,895 running study days; the maximum value of the *x*-axis has been truncated to 500 d to help magnify changes in the response among treatments.

group (Figure 3), this proportion was greatest for control fish and least for recompressed fish. The rates of relative survival for fish treated with the venting cannula, venting needle, and recompression device, respectively, were greater than those for control fish; the 95% confidence intervals for the mean rates for each of these three experimental groups did not overlap with the assumed rate of survival of controls (1.0; Table 1). The mean increase in fish survival was 48, 51, and 51% for the venting cannula, venting needle, and recompression device, respectively, relative to the controls (Table 1). There was no difference in the effectiveness among the three experimental devices as their 95% confidence intervals overlapped widely (Table 1). The partial regression coefficient for the TL was both significant ($P < 0.001$) and positive, with a 0.7% increase in survival for each unit (mm) increase in TL (Table 1).

The random effect "tagging trip" improved model fit. The likelihood ratio test examining the importance of the random effect indicated significance ($\chi^2 = 198.4$, $P < 0.001$). Additionally, the mixed-effects model provided a more parsimonious fit when comparing its AIC value (6,021.0) with the AIC value from the fixed-effects model (6,219.4). The among-trip standard deviation of the intercept was 1.043.

DISCUSSION

Effect of the Experimental Devices on Relative Survival

We found that each of the three devices increased the discard survival of Black Sea Bass relative to the untreated controls, and the magnitude of the increase was similar among them. The results from this study demonstrate the utility of each experimental device at increasing postrelease survival and should thus refine the range of options that fishery managers can utilize to help increase the survival of discarded Black Sea Bass in the U.S. Atlantic and Gulf of Mexico hook-and-line fisheries. The positive effect of larger fish size on postrelease survival could be due to size-related susceptibility to barotrauma by smaller fish or size-selective mortality by pelagic or demersal fish predators.

The ability of recompression devices to increase postrelease survival compared with untreated fish has been demonstrated in a variety of physoclistous fish species including (but not limited to) rockfishes *Sebastes* spp. (Hochhalter and Reed 2011), Red Snapper *Lutjanus campechanus* (Drumhiller et al. 2014; Curtis et al. 2015), and Snowy Grouper *Hyporthodus niveatus* (Runde and Buckel 2018). Thus, the finding that recompression increases survival rates of Black Sea Bass reeled from relatively high pressures (approximately 5 atm) is not surprising. However, the ability of venting to increase postrelease survival has been more uncertain. For example, Wilde (2009) argued against venting and concluded that the risk of further injury outweighed its potential benefits. Hannah et al. (2008) found that venting did not increase survival of rockfishes *Sebastes* spp. that were unable to submerge on their own. In contrast, Sumpton et al. (2010) found that venting promoted postrelease survival across a variety of reef species while Drumhiller et al. (2014) and Curtis et al. (2015) found that venting was as effective as recompression at increasing rates of postrelease survival among telemetered Red Snapper. Pulver (2017) found for several species of deepwater groupers (family Serranidae) that the predicted probability of survival increased by at least 50% when using venting compared with releasing groupers untreated. Our results are consistent with these latter studies that have demonstrated the benefits of venting for increasing postrelease survival.

TABLE 1. The number of individuals tagged, number of tags returned, and proportion of tags returned along with the mean and 95% confidence intervals (CI) of exponentiated partial regression coefficients from fitting a mixed-effects Cox proportional hazards model to mark–recapture data on Black Sea Bass that were caught and released in waters 38 m deep off of the coast of North Carolina from 2015 to 2019. Fixed effects in the model included treatment (control, venting cannula, venting needle, and recompression device) and fish TL (mm). The random effect was tagging date and its importance to model fit is reported in text; the results in this table are representative across all tagging dates. The *z*-score and associated statistical significance (*P*-value) for treatment and length were each evaluated at $\alpha = 0.05$. The effect of the control was fixed at the value of 1 and the other treatments were evaluated relative to the control.

Factor	Treatment level	Number tagged	Number returned	Proportion returned	Mean partial regression coefficient	95% CI for regression coefficient	z	*P*
Treatment	Control	446	81	0.182	1.000		NA	NA
	Venting cannula	436	114	0.261	1.481	1.113–1.971	2.69	0.0088
	Venting needle	433	115	0.266	1.516	1.139–2.017	2.85	0.0044
	Recompression	433	124	0.286	1.513	1.141–2.007	2.87	0.0041
TL					1.007	1.006–1.009	8.54	0.0001

With appropriate training, venting can be as effective as recompression, as was found in this study. Two of the authors of the present study who performed the venting are experienced users of these devices. We noticed rapid healing of vented fish in this study, and individuals that were recaptured in as little as 1 week appeared to have completely healed at the site of venting. Inexperienced users of venting tools are potentially more apt to ineffectively vent and possibly expose fish to further injury. For example, our observations are that some anglers believe that the everted stomach in some barotraumatized fish is the swim bladder; this often leads to puncture of the stomach rather than venting in the proper location (Rudershausen, unpublished). This potentially exposes the fish to infection. Additional errors made by inexperienced venters can include venting to the wrong depth in the fish; such errors may be compounded by the number of venting attempts (i.e., number of punctures) or the large body size of some fish, which may require more gas to be expelled. In this study, Black Sea Bass required one puncture given their small size relative to other closely related physoclistous species.

The success of venting (even when applied by an experienced user) can be variable within and between species. Fish size, depth of capture, and handling time can influence venting success (Sauls 2014). As mentioned above, larger barotraumatized fish often suffer from greater volumes of expanded internal gas, which may require several venting attempts for alleviation or may persist even after several attempts (Rudershausen, unpublished). In addition to potential differences in how venting is applied, varying sampling designs may lead to different conclusions of its effects. For example, Collins et al. (1999) determined that venting cannulas increased postrelease survival of Black Sea Bass relative to untreated controls, but cages were used to lower the study fish back to the bottom. Caging eliminates at least two sources of predation mortality that we observed among released individuals (i.e., seabirds such as the American herring gull *Larus smithsonianus* and midwater predators such as the Atlantic Sharpnose Shark *Rhizoprionodon terraenovae*). Thus, caging is likely to bias survival higher because it reduces or eliminates predation mortality (Raby et al. 2014). In addition to being an issue in estimating the survival of vented fish relative to the controls, caging is also an issue in comparing venting and recompression of fish because fish are essentially recompressed inside the cage.

Additionally, variations in sterilization techniques or repeated usage of a venting device may contribute to different conclusions among studies. We chose not to sanitize venting devices between uses because we wanted to mimic how they appear to be used in the fishery (Rudershausen, unpublished); this may have reduced their effectiveness relative to being sanitized. Another explanation for discrepancies among studies of venting is the anatomical differences in the species researched relative to the dimensions (length and diameter) of the venting devices. The size of Black Sea Bass captured in this study allowed the venter a large target area in which to insert the device. The effectiveness of venting to de-gas individuals caught at the depth in this study (38 m) can be easily observed by the abdomen becoming more flaccid and the girth of the body decreasing after venting. These factors may have contributed to the contradictory findings between our study and the Wilde (2009) meta-analysis; these differences reinforce the suggestion for species- and depth-specific studies to test the effectiveness of venting (Brownscombe et al. 2017; Eberts and Somers 2017) rather than forming conclusions about its effectiveness across species, depths, and environments.

The clinical signs of barotraumatized Black Sea Bass typically include abdominal swelling or abdominal swelling combined with stomach eversion into the buccal cavity (Rudershausen, unpublished). These conditions may be more effectively ameliorated by venting or recompression than, for example, barotraumas such as intestinal prolapse, which may be less easily reversed. A mechanism for these greater rates of survival among Black Sea Bass treated with venting or recompression at the depth researched in the present study (38 m) appears to be their ability to increase the rates of submergence following release. For individuals in this study, venting increased submergence success relative to the controls, and submergence success was related to increased postrelease survival. In other words, submergence after release was promoted by venting. We ran a post hoc Cox model that also evaluated the effectiveness of the experimental devices in promoting submergence. The follow-up model was only fitted to data on fish that self-submerged or were recompressed. In other words, the model fit excluded data on floating fish. The effect of treatment was not significant in this follow-up model. These results provide further evidence that the inability to submerge was predictive of the fate of Black Sea Bass that were released at this depth and that the effectiveness of these devices was related to their ability to promote voluntary submergence (through venting) or involuntarily submergence (through recompression). The small fraction of floating fish whose tags were returned suggests that some individuals were able to submerge after our observation of them had concluded.

Logistics of Venting and Recompression

Time and ease of use, fisher experience, and perceptions about the effectiveness of the devices at increasing postrelease survival are issues for their acceptance and use by recreational fishers (Cooke and Schramm 2007; Scyphers et al. 2013). Some recompression devices have been found to have greater user error rates than others (Bellquist et al.

2019), which may influence stakeholder receptiveness for using them. The number of Black Sea Bass whose postrelease fates are potentially impacted by using more efficiently applied and more widely accepted venting devices (relative to recompression devices: Crandall et al. 2018) depends on the depths at which they are effective and the number of fish caught at each depth. We are unsure of the proportion of released reef fish that are vented or recompressed by recreational fishers in the U.S. South Atlantic; a voluntary online survey has been commenced to collect these types of data in this region (available at myfishcount.com). It is likely that the usage of these devices will increase with education and outreach programs that focus on how to correctly apply them (Scyphers et al. 2013; Runde 2019). A survey of recreational fishers targeting reef species in the Gulf of Mexico found that 64% of them used venting (Scyphers et al. 2013), which indicates their receptiveness to practice release techniques that they believe will help conserve stocks.

There is an inconvenience associated with recompression relative to venting. Time requirements, expense, and ease of use have all been cited as reasons for why marine recreational fishers are more likely to vent rather than recompress (Crandall et al. 2018). While commercially available devices are often relatively expensive (e.g., approximately US$60 for a SeaQualizer device), homemade devices (e.g., inverted milk crate or inverted barbless hook: Theberge and Parker 2006) can be constructed with little investment. Recompression devices such as the SeaQualizer can be incorporated into normal fishing operations, which can alleviate ease-of-use concerns. For example, the SeaQualizer contains a snap that can be attached to fishing gear or a loop in the standing line above the terminal tackle, which allows the angler to use the device while simultaneously redeploying baited gear on the same drop to the bottom. Moreover, it can be used in configurations that allow multiple fish releases at once. The South Atlantic Fishery Management Council has recently approved Amendment 29 to its snapper–grouper management plan, which requires fishers to have recompression devices onboard their vessels when possessing reef fish in U.S. South Atlantic federal waters. To the best of our knowledge, however, there is no estimate of projected usage rates, even if devices are required to be present.

In the present study, we found that the experimental devices are effective at a specific depth. Studies evaluating the effectiveness of these devices in shallower waters, along with fishery-dependent data on captures by depth, would allow managers to estimate the reductions in mortality that are achievable with these devices over the full range of depths where (1) barotrauma is an issue in affecting postrelease survival of Black Sea Bass and (2) where hook-and-line fisheries occur over the U.S. Atlantic and Gulf of Mexico continental shelves. Researchers wishing to pursue additional studies of these devices on Black Sea Bass would benefit from considering the numbers of trips, numbers of fished tagged, percentage of recaptures, and precision of relative survival estimates in this study to gauge how to best allocate time and funds to sampling other depths.

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