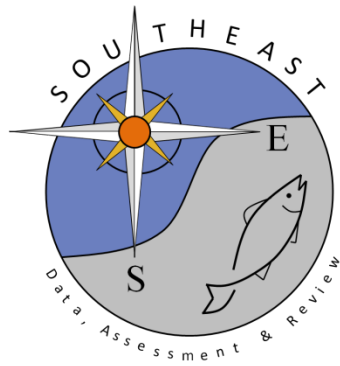# Release mortality of undersized fish from the snapper-grouper complex off the North Carolina coast

Anthony S. Overton, John Zabawski, Kenneth L. Riley
2008

SEDAR60-RD13

11 July 2018

Release Mortality of Undersized Fish from the Snapper–Grouper Complex off the North Carolina Coast

ANTHONY S. OVERTON*

Department of Biology, East Carolina University, Greenville, North Carolina 27858-4353, USA

JOHN ZABAWSKI

3950 Victory Lane, Winterville, North Carolina 28590, USA

KENNETH L. RILEY

Department of Biology, East Carolina University, Greenville, North Carolina 27858-4353, USA

Abstract.—Red porgy *Pagrus pagrus*, scamps *Mycteroperca phenax*, and gags *M. microlepis* support valuable recreational and commercial fisheries in North Carolina. Fish in the snapper–grouper complex are managed to prevent overfishing and maintain a stable spawning stock. We investigated postrelease mortality of 263 undersized red porgy, scamps, and gags that were captured by angling and subjected to short-term (2 h) and long-term (48 h) holding experiments. Fish were caught at depths ranging from 15 to 45 m using traditional bottom-fishing hook-and-line gear. Catch per unit effort ranged from 0.11 to 1.80 fish/rod-hour (FRH) for sublegal-sized fish and from 0.06 to 0.50 FRH for legal-sized fish. Nontarget species predominated in the catch (N = 1,135), but the red porgy was the most frequently caught individual species (N = 196). The effects of short-term (2-h) holding within species were similar between fish held in different locations (oxygenated live well or cage anchored to the seafloor); mortality did not differ between the two holding location groups. Mortality of fish subjected to short-term holding in the live well was 6.1%; mortality of fish in the submerged cage was 10.5% for the 2-h holding period and 12.3% for the 48-h holding period. There was no significant effect of anatomical hook location on mortality of gags or scamps. However, hook location significantly affected survival of red porgy; individuals hooked in the lip were 11.34 times more likely to survive than fish hooked in other locations. The results of this study suggest that short-term holding is appropriate for assessing mortality of undersized fish caught offshore in a hook-and-line fishery.

The snapper–grouper complex off the Atlantic coast of the southeastern USA consists of demersal tropical and subtropical species that are generally confined to coral reefs, rocky outcrops, and artificial reef communities along the continental shelf. These species are highly valued as food and game fishes and are heavily exploited by commercial and recreational fishermen

throughout their range (Coleman et al. 1999; Coleman et al. 2000). The South Atlantic Fishery Management Council is responsible for the conservation and management of the snapper–grouper fishery that extends throughout the Exclusive Economic Zone (322 km) of North Carolina, South Carolina, Georgia, and Florida to 83°W longitude (NRC 1999). The fishery consists of 73 species that include snappers (Family Lutjanidae), groupers and sea basses (Serranidae), porgies (Sparidae), grunts (Haemulidae), tilefishes (Malacanthidae), triggerfishes (Balistidae), wrasses (Labridae), and jacks (Carangidae; SAFMC 1983).

Of the snapper–grouper species common to the coastal and offshore waters of North Carolina, only a few (10–14 species) contribute substantially to recreational and commercial landings. A fishery management plan was developed in the early 1980s to protect the snapper–grouper fishery. The status of these stocks varies annually even though fishery management plans and regulations were instituted. Many species of the snapper–grouper complex do not have minimum size limits or daily harvest quotas. However, common species, such as the red porgy *Pagrus pagrus*, scamp *Mycteroperca phenax*, and gag *M. microlepis*, are regulated through minimum size limits and daily harvest quotas to prevent overexploitation. This management approach allows for small fish to be returned to the population to contribute to the existence of the stock and to reduce the chances of growth overfishing and recruitment overfishing.

The working assumption underlying the use of size limits as a management strategy is that a high percentage of the undersized fish that are released alive will survive and return to the population, and that these undersized fish will therefore be subjected only to natural mortality until attaining a legally harvestable size. Such regulations, however, may alter the age and size structures of a population, resulting in an increased probability of catching small, undersized fish (Schirri-

* Corresponding author: overtona@ecu.edu

TABLE 1.—Description of primary offshore angling locations for red porgy, scamps, and gags off the North Carolina coast, 2003–2004. All fishing was done along live rock and hard bottom.

Site	Latitude (N)	Longitude (W)	Distance from shore (km)	Depth (m)
A	35.271667	−75.256111	24	24–26
B	34.189167	−76.608330	58	27–31
C	33.600556	−76.503889	124	31–45

pa and Legault 1999). These discarded, undersized fish are susceptible to high rates of release mortality because of stress from capture and handling, asphyxia in air, hooking injury and trauma, and predation (Parker 1985, 1991). Furthermore, species of the snapper–grouper complex are highly susceptible to hyperbaric injury caused by the rapid inflation of the swim bladder during capture from depths as shallow as 21 m (Rogers et al. 1986; Render and Wilson 1996). Methods for deflating the swim bladder of fish to be released have been well developed. These methods vary slightly by species, are difficult to perform on a vessel in rough seas, and can cause additional injury to fish if not performed correctly (Render and Wilson 1993; Wilson and Burns 1996; Collins et al. 1999).

Some life history characteristics, including slow growth, slow maturation, and high site fidelity, may increase the vulnerability of a species to overfishing (Mendoza and Larez 2004). A low incidence of release mortality can significantly affect populations over time. For example, an individual in a population with 20% release mortality will probably die if caught and released repeatedly (Bartholomew and Bohnsack 2005). This is a realistic possibility, because many reef species exhibit high site fidelity to known fishing locations and are susceptible to recapture because of their aggressive feeding behavior (Coleman et al. 1999).

Increasing the survival of undersized fish will contribute to an increase in spawning stock biomass. There is considerable evidence that large discard quantities represent forgone production and yield, leading to future economic losses for the fishery (Trumble et al. 2000; Davis 2002). A recent stock assessment of red porgy suggested that effective monitoring of the stock's recovery, especially under further fishing mortality reduction, would require more detailed information on discards (SAFMC 2002). Stock assessments of species in the snapper–grouper complex indicate a need for research to quantify discard rates and discard mortality. For many species in the complex, postrelease mortality and discard estimates

are unavailable. Managers understand and often clearly state the potential problems of using inaccurate discard mortality rates.

The goal of this study was to investigate the effects of hooking and capture on the mortality rates of undersized red porgy, scamps, and gags captured off the coast of North Carolina. The specific objectives were to (1) assess survival at 2 and 48 h postrelease for fish subjected to stress associated with hook-and-line fishing, (2) compare the effects of different holding methods on postrelease mortality, and (3) generate hook-and-release mortality estimates for the snapper–grouper complex and provide recommendations for stock management.

Methods

We conducted a controlled study of angler catches in an offshore, mixed-species recreational fishery. Fish were collected from three distinct areas that were located approximately 50–150 km east of Atlantic Beach, North Carolina (Table 1). We used a Global Positioning System unit and depth recorder to collect location and depth data for each fishing site. We also recorded the time and duration of each sampling period.

We made 23 offshore fishing trips from June 2003 to May 2004. Aboard a 9.1-m research vessel, four to seven anglers fished throughout the day between 0830 and 1830 hours. Fish were caught along the bottom at depths ranging from 15 to 45 m. To minimize capture-related stress, fish were brought to the boat quickly using heavy fishing tackle. The terminal tackle included a 226- or 454-g bottom-fishing rig of the type that is traditionally used by anglers in the snapper–grouper fishery. Two hook types (circle or J-hooks) assigned to small (2/0 and 3/0) and large (4/0 and 6/0) size categories were randomly assigned to each double-hook drop rig.

After capture, fish were brought onboard the research vessel and the hook was removed. Each specimen was identified and measured for total length (TL; mm). The angler's name, rod and reel type, hook type, anatomical hooking location (i.e., lip or other), and condition of the fish were recorded. To identify individuals, each fish was tagged with a uniquely numbered anchor tag (Floy Tag, Inc., Seattle, Washington). Tags were implanted intramuscularly below the dorsal fin. Prior to their use in experiments, fish were held in an onboard, oxygenated tank (190 L) that received flow-through seawater (33–35 practical salinity units) from the site of collection. Fish were kept in the onboard holding tank for no more than 1.5 h before use in experiments. Experimental treatments consisted of holding fish in the oxygenated onboard tank or

TABLE 2.—Mean total length (TL; mm) for sublegal red porgy, scamps, and gags collected by angling off the coast of North Carolina, 2003–2004. Minimum legal harvest size is for fish collected in coastal waters 0.0–4.8 km from the coast and the Exclusive Economic Zone (4.8–322.0 km).

Species	Legal size (mm)	Sample size	Percent sublegal	Sublegal fish TL	
				Mean (SE)	Range
Red porgy	355	196	78.6	312.7 (3.2)	210–354
Scamp	508	34	64.1	395.7 (11.9)	165–495
Gag	610	33	53.2	476.6 (14.1)	295–573

placing them into cages anchored at the site of collection.

Two cage designs were used to assess fish survival after capture; the first was a 1.6-m^3 round cage (diameter = 1.8 m; length = 0.6 m), and the second was a 2.0-m^3 square cage (length = 1 m; width = 1 m; depth = 2 m). Cages were covered in 1.3-cm, knotless nylon trawl webbing. Approximately 5 kg of steel rebar were added to each cage for structural support and to anchor the cages to the seafloor. Each cage had approximately 150 m of nylon rope and a Styrofoam buoy attached to mark the location of deployment.

Short-term mortality was defined as the number of fish that were dead after a 2-h holding period. The 2-h holding treatment consisted of two subtreatments. One group was held in the onboard tank, while the other group was placed within a cage and returned to the seafloor at the site of collection. Fish densities were similar (15.6–23.4 kg/m^3) between the onboard holding tank and seafloor cages. At the end of the 2-h holding period, the fish from the onboard tank and retrieved cages were examined, and the respective numbers of dead fish were counted. Caged fish were returned to the sea floor, and their mortality was assessed again at 48 h (i.e., long-term mortality). The same handling and holding techniques were used for fish from both groups.

Data were collected on different hooking variables to evaluate their effects on postrelease mortality. We used logistic regression to model the effects of holding location (surface tank and seafloor cage) on mortality at 2 h. If there was no significant difference, the two holding locations for the 2-h trials were combined, and a logistic model was applied to test the effect of hook location, hook size, and holding period on mortality of captured fish. The standard logistic regression model was fitted as

$$P = e^\eta / (1 + e^\eta),$$

where P is the probability of mortality, e is the base of natural logarithms, and η is a linear combination of the independent variables (i.e., $\eta = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3$, where β_0 is the regression intercept; β_1, β_2, and β_3 are the regression coefficients; and X_1, X_2, and X_3 represent the independent variables for holding period, hook location, and hook size, respectively). A maximum likelihood statistic that followed a chi-square distribution (null hypothesis: all explanatory variables in the model are zero) was used to assess the significance of the model. Estimates of the coefficients, associated odds ratios, and logistic regression were generated using the Statistical Analysis System (version 9.0, SAS Institute, Inc., Cary, North Carolina). Differences were considered significant at P-values of 0.05 or less.

Results

By hook-and-line sampling, we collected 1,401 fish representing 24 different species. Collection efforts were often hampered by poor weather, hooking of nontarget species, poor fishing conditions, and angler illnesses. The most frequently caught species (percent of total catch) were black sea bass *Centropristis striata* (21.6%), white grunts *Haemulon plumierii* (20.1%), and red porgy (14.5%). Red porgy (74.2%), gags (12.3%), and scamps (13.5%) predominated in the catch of undersized fish from the snapper–grouper complex. We collected a total of 263 fish for use in experiments (Table 2). The length distributions of experimental fish were variable (Figure 1). Most experimental red porgy were near the legal size limit of 355 mm TL. For the other two species, the lengths were more uniformly distributed.

Most fish used in experiments were hooked in the lip (92.3%) and experienced little or no apparent injury (Table 3). Of those hooked in anatomical areas other than the lip, 36.8% experienced mortality. The combined total mortality for all collected target species was 9.9%. Hooking mortality differed among species and was highest in scamps (43.8%; total $N = 34$), followed by red porgy (37.5%; total $N = 196$) and gags (13.3%; total $N = 33$).

There were no significant differences in 2-h postrelease survival between fish held in onboard tanks and submerged cages for red porgy ($\chi^2 = 0.457$, $P = 0.499$), scamps ($\chi^2 = 0.001$, $P = 0.973$), or gags ($\chi^2 = 0.024$, P
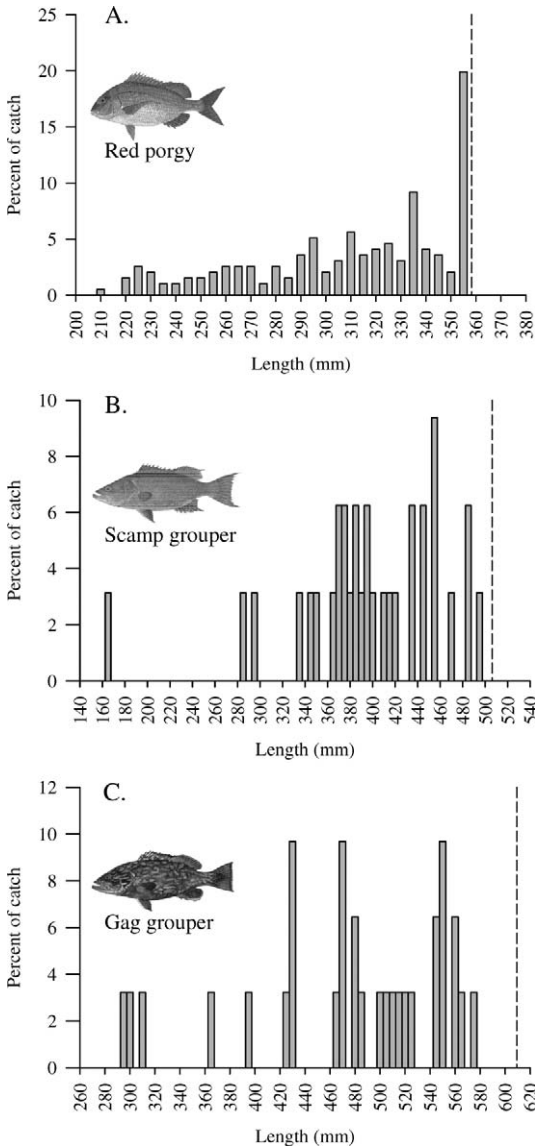
FIGURE 1.—Length distributions (percent of catch) of undersized (**A**) red porgy, (**B**) scamps, and (**C**) gags collected by hook and line off the coast of North Carolina (dashed line = minimum legal size for harvest). Species illustrations are from Raver (1984).

$= 0.457$). Overall 2-h mortality was 6.1% for fish in the onboard tanks and 10.5% for fish in submerged cages. Fish held for 48 h in submerged cages experienced 12.3% mortality, which was not significantly different from the 2-h postrelease mortality of cage-held fish ($\chi^2 = 0.112$; $P = 0.734$).

The independent variables of the logistic model for hook size, hook location, and holding period did not significantly affect the survival of scamps or gags (Table 4). Mortality was low for lip-hooked gags (22.6%), scamps (19.4%), and red porgy (3.3%). Hook location significantly ($\chi^2 = 11.53$, $P < 0.001$) affected the survival of red porgy. Individuals hooked in the lip had a higher likelihood of surviving than those hooked in other anatomical locations. The odds ratio was 11.34, suggesting that the odds of survival for fish hooked in the lip was about 11 times that of fish hooked in other areas. Of the red porgy hooked in areas other than in the lip, approximately 35.7% died.

During sampling, large predators (e.g., great barracuda *Sphyraena barracuda*, king mackerel *Scomberomorus cavalla*, and carcharhinid sharks) were observed at the surface of the water adjacent to the boat. When possible, we quantified predation mortality of target fish during capture and after release. Approximately 1.3% of our total catch was preyed upon by large predatory fish during capture or after release. Most predation (95%) occurred while fish were being reeled to the surface. Predation on released fish occurred when fish could not decompress and submerge below the surface of the water. We could not positively identify the species of every predator on every occasion. Sharks and great barracuda were the most frequently observed.

Discussion

The postrelease mortality of undersized red porgy, scamps, and gags varied among species when caught via the hook-and-line techniques described. For this study, which targeted small fish, anglers preferred live-baited J-hooks over circle hooks of similar size. Specifically, the J-hooks were 2/0–6/0 in size and the hook point was not offset. The short shank of the live-baited J-hooks was preferred because anglers considered it to be less visible to finicky predators. The hooking success rate was also higher among anglers fishing with J-hooks. Among the 263 captured experimental fish, 250 (95%) were collected on J-hooks and 13 (5%) were collected on circle hooks. Studies have demonstrated that the use of circle hooks can significantly reduce postrelease mortality and injury of discarded fish (Bacheler and Buckel 2004; Cooke and Suski 2004; Beckwirth and Rand 2005); however, recreational and commercial anglers targeting the snapper–grouper complex off North Carolina still continue to use traditional J-hooks when fishing by rod and reel.

In recent years, anglers have increasingly shown interest in fishery conservation through successful release of undersized fish. The focus of this approach in the offshore snapper–grouper fishery addresses releasing small, undersized fish and bycatch. Most

TABLE 3.—Percent survival (sample size in parentheses) of gags, scamps, and red porgy angled off the coast of North Carolina and held in onboard tasks and submerged cages. Survival was assessed relative to anatomical hooking location holding period, and hook size (small = 2/0 and 3/0; large = 4/0 and 6/0). Hook size was randomly assigned, and hooks were used with terminal tackle.

Species	Hook location		Holding period		Hook size	
	Lip	Other	2	48	Small	Large
Gag	77.4 (31)	100 (2)	100 (13)	65.0 (20)	83.3 (12)	76.2 (21)
Scamp	80.6 (31)	33.3 (3)	72.3 (11)	78.3 (23)	76.9 (26)	75.0 (8)
Red porgy	96.7 (182)	64.3 (14)	92.3 (143)	100 (53)	95.0 (120)	93.4 (76)

research to date has focused on developing new fishing gear and terminal tackle that would reduce injury and mortality of fish while maintaining or improving catch per unit effort (Muoneke and Childress 1994). The methods developed for assessing postrelease mortality in our study could be used in future studies of other high-value species of the snapper–grouper complex. No significant difference was observed between short-term (2-h) and long-term (48-h) mortality in holding experiments; therefore, short-term holding practices may be appropriate for evaluating catch-and-release mortality associated with an offshore hook-and-line fishery.

Fish with fully closed (physoclistous) swim bladders (e.g., snappers and groupers) will experience some level of barotrauma when caught and rapidly retrieved from depth (Gotshall 1964; Rogers et al. 1986; Render and Wilson 1996). We did not attempt to deflate swim bladders in this study. Fish were collected at depths from 15 to 45 m, and most were caught within a narrower range of 25–35 m. We attempted sampling at depths up to 75 m but were unable to anchor the cages to the seafloor because of strong tides and currents. Therefore, we confined our study to fishing locations with depths less than 45 m. Fish captured at these depths exhibited signs of swim bladder trauma, including swollen abdomens, eversion of esophagus or stomach, and an inability to resubmerge after release.

Estimates of short- and long-term postrelease mortality are necessary to improve fish mortality estimates used in stock assessment models and to assist resource managers in developing appropriate regulations for size limits and daily quotas. We observed mortality rates exceeding 13% in our targeted species. The catch-and-release mortality estimates we observed differ significantly from previously published estimates for the snapper–grouper complex off the coast of North Carolina. Red porgy in our study had a postrelease mortality rate of 37.5%, which is three times the estimate reported by Rudershausen et al. (2007). Additionally, those authors reported 0.0%

mortality for gags and 23.0% mortality for scamps, whereas our estimates were 13.3% for gags and 43.8% for scamps. The differences in mortality estimates are probably related to differences in methodologies for estimating postrelease mortality. In lieu of cages, Rudershausen et al. (2007) used a scoring system (Patterson et al. 2000) that depends on the appearance of overall fish condition at capture (i.e., gastric distention and bleeding) as an indicator of fish well-being.

In comparison with other studies along the south-west Atlantic, we observed 8% mortality in fish held for 2 h, whereas Collins (1991) observed 19% mortality among 19 reef fish species captured at 36 m. We also observed 24% mortality of scamps caught at depths ranging from 15 to 35 m, whereas Wilson (1992) observed 100% mortality of scamps captured at depths greater than 35 m. In contrast to Wilson's (1992) study, Wilson and Burns (1996) reported only 9% mortality for scamps and gags collected at 43 m. Clearly, there are discrepancies among estimates of postrelease mortality in species of the snapper–grouper complex, and additional studies are needed to address the effects of treatments (e.g., hooking injuries and handling practices) and their interaction with environmental variables (e.g., depth, temperature, and water

TABLE 4.—Summary of logistic regression analyses of the effect of hook size (large or small), hook location (lip or other), and holding period (2 or 48 h) on postrelease survival of undersized red porgy, scamps, and gags caught by hook and line off the coast of North Carolina, 2003–2004 (χ^2 = chi-square).

Species	Independent variable	χ^2	Odds ratio	P
Red porgy	Hook size	0.506	1.620	0.478
	Hook location	11.53	11.636	<0.001
	Holding period	0.003	<0.001	0.961
Scamp	Hook size	0.223	1.604	0.634
	Hook location	2.682	9.963	0.110
	Holding period	0.014	1.120	0.981
Gag	Hook size	0.341	1.934	0.789
	Hook location	0.001	1.062	0.999
	Holding period	0.012	>1,000	0.944

quality). The results of these studies will help resource managers develop models and a regulatory framework for maximizing yield based on improved estimates of postrelease mortality.

Acknowledgments

References

Bacheler, N. M., and J. A. Buckel. 2004. Does hook type influence the catch rate, size, and injury of grouper in a North Carolina commercial fishery? Fisheries Research 69:303–311.

Bartholomew, A., and J. A. Bohnsack. 2005. A review of catch-and-release angling mortality with implications for no-take reserves. Reviews in Fish Biology and Fisheries 15:129–154.

Beckwirth, G. H., Jr., and P. S. Rand. 2005. Large circle hooks and short leaders with fixed weights reduce incidence of deep hooking in angled red drum. Fisheries Research 71:115–120.

Coleman, F. C., C. C. Koenig, A. M. Eklund, and C. B. Grimes. 1999. Management and conservation of temperate reef species in the grouper–snapper complex of the southeastern United States. Pages 233–242 in J. A. Musick, editor. Life in the slow lane. American Fisheries Society, Symposium 23, Bethesda, Maryland.

Coleman, F. C., C. C. Koenig, G. R. Huntsman, J. A. Musick, A. M. Eklund, J. C. McGovern, R. W. Chapman, G. R. Sedberry, and C. B. Grimes. 2000. Long-lived reef fishes: the grouper–snapper complex. Fisheries 25(3):14–21.

Collins, M. R. 1991. Survival estimates for demersal reef fishes released by anglers. Proceedings of the Gulf and Caribbean Fisheries Institute 44:470–482.

Collins, M. R., J. C. McGovern, G. R. Sedberry, H. S. Meister, and R. Pardieck. 1999. Swim bladder deflation in black sea bass and vermillion snapper: potential for increasing post-release survival. North American Journal of Fisheries Management 19:828–832.

Cooke, S. J., and C. D. Suski. 2004. Are circle hooks an effective tool for conserving marine and freshwater recreational catch-and-release fisheries? Aquatic Conservation 14:299–326.

Davis, M. W. 2002. Key principles for understanding fish bycatch discard mortality. Canadian Journal of Fisheries and Aquatic Sciences 59:1834–1843.

Gotshall, D. W. 1964. Increasing tagged rockfish (genus Sebastodes) survival by deflating the swim bladder. California Fish and Game 50:253–260.

Mendoza, J. J., and A. Larez. 2004. A biomass dynamics assessment of the southeastern Caribbean snapper-grouper fishery. Fisheries Research 66:129–144.

Muoneke, M. I., and W. M. Childress. 1994. Hooking mortality: a review for recreational fisheries. Reviews in Fisheries Science 2:123–156.

NRC (National Research Council). 1999. Sustaining marine fisheries. National Academy Press, Washington D.C.

Parker, R. O. 1985. Survival of released red snapper. Progress Report to South Atlantic and Gulf of Mexico Fisheries Management Councils, Charleston, South Carolina, and Tampa, Florida.

Parker, R. O. 1991. Survival of released fish: a summary of available data. Final Report to South Atlantic and Gulf of Mexico Fisheries Management Councils, Charleston, South Carolina, and Tampa, Florida.

Patterson, W. F., III, G. W. Ingram, R. L. Shipp, Jr., and J. H. Cowen. 2000. Indirect estimation of red snapper (Lutjanus campechanus) and gray triggerfish (Balistes capriscus) release mortality. Proceedings of the Annual Gulf and Caribbean Fisheries Institute 53:526–536.

Raver, D., Jr. 1984. Fishes of the southeastern United States. U.S. Fish and Wildlife Service, National Conservation Training Center, Shepherdstown, West Virginia. Available: images.fws.gov/. (July 2006).

Render, J. H., and C. A. Wilson. 1993. Mortality rate and movement of hook-and-line caught and released red snapper. Final Report for Cooperative Agreement Number NA90AAHMF762 Marine Fisheries Initiative (MARFIN) Program. Coastal Fisheries Institute, Center for Coastal, Energy, and Environmental Resources, LSU-CFI-93-8, Louisiana State University, Baton Rouge.

Render, J. H., and C. A. Wilson. 1996. The effect of gas bladder deflation on mortality of hook-and-line caught and released red snappers: implications for management. Pages 244–253 in F. Arreguin-Sanchez, J. L Munro, M. C. Balgos, and D. Pauly, editors. Biology and culture of tropical groupers and snappers. International Center for Living, Aquatic Resources Management Conference Proceedings 48, Makati City, Philippines.

Rogers, S. G., H. T. Langston, and T. E. Targett. 1986. Anatomical trauma to sponge-coral reef fishes captured by trawling and angling. U.S. National Marine Fisheries Service Fishery Bulletin 84:697–704.

Rudershausen, P. J., J. A. Buckel, and E. H. Williams. 2007. Discard composition and release fate in the snapper and grouper commercial hook-and-line fishery in North Carolina, USA. Fisheries Management and Ecology 14:103–113.

SAFMC (South Atlantic Fishery Management Council). 1983. Fishery management plan, regulatory impact review, and final environmental impact statement for the snapper–grouper fishery of the South Atlantic Region. National Marine Fisheries Service, Washington D.C.

SAFMC (South Atlantic Fishery Management Council). 2002. Stock assessment of South Atlantic red porgy. National Marine Fisheries Service, Washington, D.C.

Schirripa, M. J., and C. M. Legault. 1999. Status of the red snapper in U.S. waters of the Gulf of Mexico: updated

through 1998. National Marine Fisheries Service, Southeast Fisheries Science Center, Contribution SFD 99/00-75, Miami, Florida.

Trumble, R. J., S. M. Kaimmer, and G. H. Williams. 2000. Estimation of discard mortality rates for Pacific halibut bycatch in groundfish longline fisheries. North American Journal of Fisheries Management 20:931–939.

Wilson, R. R. 1992. Survivorship of released red groupers in the Eastern Gulf grouper fishery. U.S. National Marine Fisheries Service, Southeast Regional Office, Marine Fisheries Initiative Final Report NA90AA-H-SKI 18, St. Petersburg, Florida.

Wilson, R. R., and K. M. Burns. 1996. Potential survival or released groupers caught deeper than 40 m based on shipboard and in-situ observations, and tag recapture data. Bulletin of Marine Science 58:234–257.