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Commercial catch composition with discard and immediate release mortality proportions off the southeastern coast of the United States

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ABSTRACT

The snapper-grouper fishery off the coast of the southeastern United States contains many exploited species that are governed under a multitude of species-specific regulations. Despite ample information on landed commercial catches, there is a critical need to characterize the entire commercial catch to identify catch composition, discard proportion and immediate release mortality proportions. This study recorded the lengths of all fish caught on a commercial snapper-grouper vessel and their subsequent disposition. Over 40 fishing days, the captain captured 55 species, but the majority of the catch (97%) was comprised of just 8 species (vermilion snapper, gray triggerfish, red porgy, black sea bass, tomtate, scamp, greater amberjack, and Almaco jack). Discard proportions were low overall, but varied by species, while immediate release mortality proportions were generally high (>40%). Species with high discard proportions were red porgy (56%), scamp (44%), bank sea bass (46%), and red snapper (42%). Three of these species also had high immediate release mortality proportions: red porgy – 82%, scamp – 98%, and red snapper – 93%. Species with both high discard proportions and high immediate release mortality proportions might indicate that current management regulations are not adequately protecting these stocks, as a large number of discarded fish do not survive.

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1. Introduction

The snapper-grouper fishery off the coast of the southeastern United States contains many exploited species that are governed under a multitude of species-specific regulations. By the third quarter of 2009, 10 of the snapper-grouper species were considered to be experiencing overfishing, 4 species were overfished, and many have an unknown status (NMFS, 2009). Management of the snapper-grouper species is complicated by complex life histories (e.g. slow growing, late maturity, protogyny, aggregation tendencies) and high fishing mortality (0.35–0.92) (Coleman et al., 2000).

Management restrictions are often in the form of limitations (i.e. size limits, quotas, closures) which result in at-sea discards. Many of the discarded fish are caught at deep depths, which have been correlated to an increase in immediate release mortality (Bacheler and Buckel, 2004; Collins et al., 1999; Wilson and Burns, 1996). Therefore, in this multi-species industry, species-specific regulations may not act as intended. Despite reaching set size limits, quotas, or seasonal closures, discarding and potential immediate release mortality continue to occur for non-targeted species that co-occur with other targeted species (Coleman et al., 2000). If these limits still results in high proportions of dead discarded fish, the limits are effectively protecting the species (Burns and Restrepo, 2002). While data is plentiful on landed commercial catches, there is little data available to determine discard and immediate release mortality proportions by species (Chen and Gordon, 1997). Adding this information to stock assessments allows for appropriate decisions for management regulations.

This study characterized the catch of a commercial snapper-grouper fisherman fishing off the southeastern coast of the United States by determining which species co-occur in the catch, species-specific length-frequencies, discard proportions, and immediate release mortality proportions. Management of these species relies heavily on species-specific minimum size limits, seasonal closures, and/or catch quotas (Table 1), resulting in unknown discard proportions and discard mortality rates. While discard studies are common in other fisheries, there are few published studies that characterize the entire catch and/or commercial immediate release mortality proportions for the snapper-grouper fishery (Guccione, 2005; Overton et al., 2008; Patterson et al., 2002; Rudershausen et al., 2007; Shertzer and Williams, 2008; Wilson and Burns, 1996). Furthermore, many of the discard mortality studies concentrated on only a few species. Our results clarify the effectiveness of

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Table 1
Summary of the management status (experiencing overfishing and/or overfished), and regulations during the study period (2004).

Species	Overfished	Overfishing	Regulations
Balistes capriscus (gray triggerfish)	Unknown	Unknown	12″ TL (238 mm FL)
Centropristis striata (black sea bass)	Yes	Yes	10″ TL (254 mm FL) Annual quota (Jun–May) 423,000 lb, gutted (till 5/31/08)
Epinephelus drummondhayi (speckled hind)	No	Yes	1 per vessel per trip May not be sold or traded; no transfer at sea
Epinephelus morio (red grouper)	No	Yes	20″ TL (489 mm FL)
Epinephelus nigritus (warsaw grouper)	No	Yes	1 per vessel per trip May not be sold or traded; no transfer at sea
Epinephelus niveatus (snowy grouper)	Yes	Yes	Annual quota 118,000 lb, gutted, with 175 lb trip limit (till 12/31/07)
Lopholatilus chamaeleonticeps (tilefish)	No	Yes	Annual quota 295,000 lb, gutted, with 4000 lb trip limit until 75% of quota is taken, then trip limit reduces to 300 lb (If 75% of quota has not been taken on or before Sept. 1, the trip limit will not be reduced).
Lutjanus campechanus (red snapper)	No	Yes	20″ TL (474 mm FL)
Mycteroperca bonaci (black grouper)	No	Yes	24″ TL (603 mm FL) In March & April possession limited to no more than 2 black grouper and/or gag individually or in combination with no sale.
Mycteroperca microlepis (gag grouper)	No	Yes	24″ TL (590 mm FL) In March & April possession limited to no more than 2 black grouper and/or gag individually or in combination with no sale.
Mycteroperca phenax (scamp)	Unknown	Unknown	20″ TL (471 mm FL)
Pagrus pagrus (red porgy)	Yes	No	14″ TL (307 mm FL) Annual quota 127,000 lb, gutted, January through April sale or purchase prohibited and possession is limited to 3 per person/day or 3 per person/trip, whichever is more restrictive. Commercial trip limit of 120 fish per trip May through December.
Rhomboplites aurorubens (vermilion snapper)	No	Yes	12″ TL (273 mm FL) Annual quota 1.1 million lb, gutted
Seriola dumerili (greater amberjack)	No	No	Florida waters: 36″ TL Annual quota: 1,169,931 lb with trip limit = 1000 lb Seasonal closure in April
Haemulon aurolineatum (tomtate)	Unknown	Unknown	No regulations

species-specific limits and provide empirical estimates for discard and immediate release mortality proportions for future stock assessments.

2. Methods

Sampling took place on a South Carolina commercial snapper-grouper fishing vessel from June through November 2004 when the captain of the participating vessel dedicated one or two multiple day fishing trips (total = 10 trips over 47 days; trip lengths 2–9 days, average 5 days) each month to the collection of fishery-dependent data (Fig. 1). A researcher was on board during the first two trips to train the captain on the data collection procedures and release condition; subsequently, data were recorded by the captain. Each trip contained multiple collections, where a collection consisted of the entire catch at any individual fishing location. All locations were selected by the captain as part of his normal routine and were between 31°38′N and 32°48′N (Fig. 1). During dedicated sampling trips, fishing operations were identical to normal operations, including sampling locations, fishing method, and fish handling. For all trips, the fishermen utilized the commercial electronic reels commonly used in this region. When targeting vermilion snapper, three reels, with terminal tackle consisting of 2 4/0 J-hooks and baited with Boston mackerel, were fished simultaneously by three crew members. When targeting snowy grouper, one reel consisting of 4 8/0 circle hooks and was baited with a variety of natural baits (e.g. Spanish sardine, cut bait, mackerel, and squid). Fishing occurred from sunrise to sunset and all fish were measured as soon as possible, with time on deck estimated by the captain as <1 min. Only if a fish showed visual signs of barotraumas, was it vented before release. At each separate fishing location latitude and longitude were recorded and the captain recorded all specimen data recorded through a Limnoterra electronic fish measuring board system. All specimens caught were identified to the lowest possible taxa. In instances where the captain was unsure of identification, either photographic images were taken or the species was retained to confirm identification. For each specimen length was measured (mm) in fork length (FL) when possible, otherwise, in total length (TL), and disposition status recorded. Disposition status was noted as kept, bait, or discarded. Kept fish were landed, while those classified as bait were used as bait during the remainder of the trip. Discarded catch was further classified into the following discard disposition categories, modified from Patterson et al. (2002): (1) rapidly descended; (2) slowly descended; (3) floated at surface before slowly descending; and (4) floated at the surface. The discard disposition analysis assumed that fish assigned to the last two categories (3 and 4) suffered immediate release mortality. Immediate release mortality, an indirect measure of survival through visual inspection of fish behavior after discard, was based on descriptions by Patterson et al. (2002) and Collins (1995). For categories 1 and 2, fish were assumed to have survived.

While our sample design was limited to one experienced commercial fisherman's catch in 1 year, his catches are typical of catches for commercial snapper-grouper fishermen in this region. Data from the 2005–2008 NFMS logbooks for bandit-reel fishermen that landed >20,000 lb/year (NMFS logbook data 4/9/2009) showed that our commercial fisherman was comparable to bandit-reel fishermen in the region with respect to number of crew, days at sea and landed species composition. Our fisherman's average crew (2.7 people) was similar to other crews, which averaged between 2.48 and 3.8 members. Days at sea were similar to other SC and GA fishermen (average 6–7 day trips), but higher than NC fishermen which generally have shorter 1 or 2 trips. Our fisherman's landed catch composition was similar to landed catches of other bandit-reel fisherman, although regional (state) differences occurred (Table 2). Other dif-

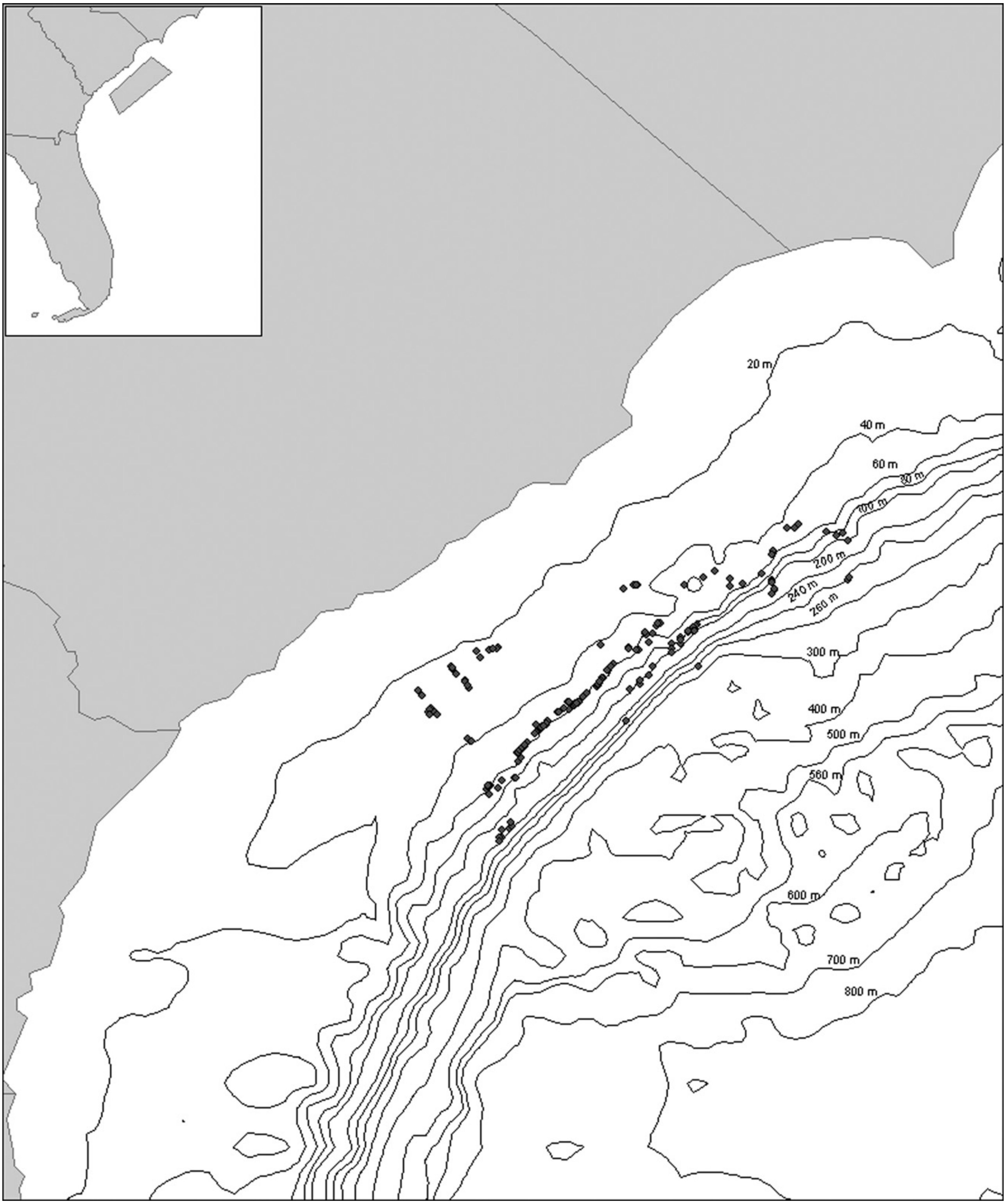

Fig. 1. Sample locations used in this study. All locations were chosen by the commercial captain, and were representative of his usual fishing locations off the coast of South Carolina.

ferences in landed catch are most likely due to differences in the targeted species, which data was not available for comparisons.

Discard and immediate release mortality proportions were calculated for each species. Discard proportions were the number of specimens discarded divided by the total number captured. Immediate release mortality proportion was the number of specimens assumed to die (discard categories 3 and 4) divided by the total number of specimens discarded. For species with over 20 discards, the immediate release mortality proportions were analyzed by size. When appropriate, a general linear regression of the proportions of surviving specimens by length bin was used to determine if length influenced survival. For species with size limits, survival and immediate release mortality frequencies of legal and sublegal specimens

Table 2
Summary of species catch composition ranked by abundance landed. State ranks are based on all snapper-reel fishermen who landed >20,000 lb/year.

Landed species	Our study	SC fishermen	GA fishermen	NC fishermen
Vermilion snapper	1	1	1	1
Gray triggerfish	2	5	2	3
Snowy grouper	3	12	15	10
Black sea bass	4	15	14	15
Red porgy	5	10	10	9
Greater amberjack	6	6	6	8
Scamp	7	3	7	5
Almaco jack	8	8	5	7
Gag grouper	12	2	4	4
Red snapper	15	11	3	18

Values are calculated from 2005 through 2008 from NMFS logbook surveys.

were compared using the χ^2 test statistic from a two-way contingency table.

3. Results

In nine of the trips (40 fishing days) the captain targeted vermilion snappers (*Rhomboplites aurorubens*) in mid-shelf to shelf-break waters (approximately between 20- and 80-m depth), while during the remaining trip (7 fishing days) the captain targeted snowy groupers (*Epinephelus niveatus*) in deeper slope waters (approximately >80-m depth). For the trips targeting vermilion snappers, 55 different species were caught, while the snowy grouper trip only captured 13 different species. Many the species were captured infrequently and in low abundances. During the snowy grouper trip, snowy groupers were the predominately caught species (84%), followed by red porgy (*Pagrus pagrus*; 5%), scamp (*Mycteroperca phenax*; 2%) and blueline tilefish (*Caulolatilus microps*; 2%). For trips targeting vermilion snapper, the predominantly caught species were vermilion snapper (81%), gray triggerfish (*Balistes capriscus*; 4%), red porgy (4%), black sea bass (*Centropristis striata*; 3%), tomtate (*Haemulon aurolineatum*; 2%), scamp (1%), greater amberjack (*Seriola dumerili*; 1%), and Almaco jack (*Seriola rivoliana*; 1%).

During trips targeting snowy grouper, there were very few discards ($n = 3$), so the remainder of the paper will concentrate on the trips targeting vermilion snapper. Discard proportions were low during each trip (6–15%), but individual species discard proportions varied considerably (Table 3). Of the 25 discarded species, the following 9 species had a substantial number of discards ($n > 25$): vermilion snapper, gray triggerfish, black sea bass, tomtate, red porgy, greater amberjack, scamp, bank sea bass (*Centropristis ocyurus*), and red snapper (*Lutjanus campechanus*). Discard proportions were high (>40%) for red porgy, scamp, bank sea bass and red snapper, and low (<25%) for the remaining species. From this study, it is now apparent that a common practice among fishermen in this region is to retain some captured dead fish for bait. Bait retention comprised a small share of the catch by species (<14%), and only five of the frequently caught species (vermilion snapper, red porgy, scamp, tomtate and bank sea bass) were retained for bait (Table 3). Many of these would have been discarded and recorded with a disposition of 4 (floating at the surface).

For the 9 species with a substantial number of discards, immediate release mortality (dispositions 3 and 4) proportions were greater than 45% (Table 3). Nearly all discarded gray triggerfish, greater amberjack, scamp and red snapper experienced immediate release mortality (proportions >90%). Black sea bass, tomtate and red porgy had high immediate release mortality proportions (66%, 72%, and 82%, respectively), while vermilion snapper and bank sea bass had moderate proportions (48% and 55%, respectively). For the most of the species with size-regulations, legal and sublegal specimens' immediate release mortality proportions were not significantly different (red snapper, $\chi^2 = 0.071$, $p = 0.7895$; black sea bass, $\chi^2 = 1.094$, $p = 0.2956$; gray triggerfish, $\chi^2 = 0.270$, $p = 0.6033$; scamp, $\chi^2 = 0.071$, $p = 0.7960$). Both vermilion snapper and red porgy had significant differences between immediate release mortality in legal and sublegal specimens ($\chi^2 = 85.098$, $p < 0.001$; $\chi^2 = 8.364$, $p = 0.0048$). For vermilion snapper and red porgy, immediate release mortality proportions were calculated by length bin. Vermilion snapper had a significant decrease in immediate release mortality proportion as size increased ($r^2 = 0.7939$, $p = 0.0008$), while red porgy showed no such relation ($r^2 = 0.1414$, $p = 0.1125$) (Fig. 2).

4. Discussion

The wide range of species ($n = 60$ in 23 families) caught by the commercial fisherman was indicative of the high diversity of reef-associated species that can be found off the coast of the southeastern United States. Despite this high diversity, 17 species comprised over 90% of the catch. This value is in target with NMFS logbook data for the southeastern United States, where the majority of the catch was comprised of 9–15 species.

In general, discard proportions were low indicating a low bycatch component in the snapper-grouper fishery. Due to the long-lived nature of many of the snapper-grouper species, even a low discard proportion may have significant impacts on the stock. The highest discard proportion was in red porgy, and this high value was due to a management regulation requiring a 120-fish trip limit. Multi-day trips are common for commercial fishermen off the coast of South Carolina thereby creating the potential for a high proportion of discards for this species. In contrast to the low discard proportions, immediate release mortality proportions were high for all discarded species. Species with both high discard proportion and high immediate release mortality proportion should be monitored closely to see if other regulations (e.g. marine protected areas or mixed-species quotas) might better protect these species.

This study revealed the extent to which commercial fishermen use captured fish as bait. In NMFS logbooks, these fish were recorded as "kept but not sold", a category which was typically thought to used for fish eaten on board. Stock assessment biologists have determined that the bait disposition needs to be quantified and recorded separately from release mortality values. While this quantity is still unknown for many species, stock assessment biologists have adjusted release mortality percentages upwards to account for this mortality (SEDAR, 2008).

The vermilion snapper discard proportion (10%) corresponded well with estimates used by the region's stock assessment process, Southeast Data Assessment and Review (SEDAR), where fisherman estimated 15–18% discard proportions for vermilion snapper (SEDAR, 2003b) and with a study by Rudershausen et al. (2007) that had 15% discard proportion. Our immediate release mortality proportions were higher than those indicated by fishermen in the SEDAR-02 (2003b) report and Rudershausen et al. (2007). Recently,

Table 3
Summary of all species caught in trips targeting vermilion snapper, including the number landed, disposition proportions, and immediate release mortality proportion.

Species		*N*	Disposition (%)				Immediate Release Mortality	
			Landed	Bait	Discard	Unk.	Number	Percent
Rhomboplites aurorubens[L]	Vermilion snapper	14,652	82.88	7.02	10.01	0.10	707	48.23
Balistes capriscus[L]	Gray triggerfish	732	96.31		3.69		25	92.59
Centropristis striata[L]	Black sea bass	514	82.10		17.90		61	66.30
Haemulon aurolineatum[P]	Tomtate	331	64.95	11.18	23.87		57	72.15
Pagrus pagrus[L,M]	Red porgy	650	32.31	11.23	56.15	0.31	301	82.47
Seriola dumerili[M]	Greater amberjack	199	75.88		23.62	0.50	44	93.62
Mycteroperca phenax[L]	Scamp	202	54.46	0.99	44.55		88	97.78
Seriola rivoliana[P]	Almaco jack	109	100.00					
Haemulon plumeiri[P]	White grunt	92	98.91		1.09		1	100.00
Diplodus holbrookii	Spottail pinfish	60	98.33	1.67				
Mycteroperca microlepis[L,M]	Gag	53	96.23		3.77		2	100.00
Centropristis ocyurus[P]	Bank sea bass	91	46.15	7.69	46.15		23	54.76
Lutjanus campechanus[L]	Red snapper	67	58.21		41.79		26	92.86
Epinephelus drummondhayi[M]	Speckled hind	27	100.00					
Cephalopholis cruentata[P]	Graysby	24	100.00					
Calamus nodosus[P]	Knobbed porgy	22	100.00					
Ocyurus chrysurus[L]	Yellowtail snapper	24	83.33	8.33	8.33		2	100.00
Lutjanus griseus[L]	Mangrove snapper	14	100.00					
Epinephelus niveatus[M]	Snowy grouper	15	93.33		6.67		1	100.00
Unknown	Unknown	13	100.00					
Epinephelus adscensionis[P]	Rock hind	12	100.00					
Selar crumenophthalmus	Bigeye scad	10	100.00					
Calamus bajonado[P]	Jolthead porgy	8	100.00					
Coryphaena hippurus[M]	Dolphin	7	100.00					
Rhizoprionodon terraenovae	Sharpnose Atlantic shark	6	100.00					
Calamus leucosteus[P]	Whitebone porgy	6	100.00					
Diplectrum formosum	Sand perch	8	75.00		25.00		2	100.00
Balistes vetula[P]	Queen triggerfish	5	100.00					
Seriola zonata[P]	Banded rudderfish	4	100.00					
Diplectrum bivittatum	Dwarf sand perch	5	80.00	20.00				
Scomberomorus cavalla	King mackerel	3	100.00					
Cephalopholis fulva[P]	Coney	2	100.00					
Pristigenys alta	Short bigeye	2	100.00					
Epinephelus nigritus[M]	Warsaw grouper	2	100.00					
Mycteroperca venenosa[L]	Yellow fin grouper	3	66.67		33.33			
Malacanthus plumeri	Sand tilefish	3	66.67		33.33		1	100.00
Epinephelus morio[L]	Red grouper	8	25.00		75.00		6	100.00
Lutjanus buccanella[L]	Blackfin snapper	1	100.00					
Paranthias furcifer	Creole fish	1	100.00					
Mycteroperca bonaci[L,M]	Black grouper	1	100.00					
Lobotes surinamensis	Atlantic tripletail	1	100.00					
Physiculus fulvus	Metallic codling	1	100.00					
Holacanthus ciliaris	Queen angelfish	1	100.00					
Bodianus rufus	Spanish hogfish	1	100.00					
Lagodon rhomboides	Pinfish	1	100.00					
Serranus notospilus	Saddle bass	4	25.00		75.00		1	33.33
Holocentrus adscensionis	Squirrelfish	4			100.00		4	100.00
Haemulon striatum	Striped grunt	3		33.33	66.67			
Myripristis jacobus	Blackbar soldierfish	2			100.00			
Haemulon melanurum	Cottonwick grunt	1		100.00				
Pomatomus saltatrix[M]	Bluefish	1		100.00				
Anchoa cayorum	Key anchovy	1			100.00			
Lutjanus analis[L,M]	Mutton snapper	1			100.00		1	100.00
Syngnathus pelagicus	Sargassum pipefish	1			100.00			
Lutjanus vivanus[L]	Silk snapper	1			100.00			

[L]Indicates a species managed with a size limit. [M]Indicates non-size related management limits. [P]Indicates a species managed with a limited access permit.

the immediate release mortality proportion was raised to 40% for the age-based SEDAR-17 (2008) assessment, which is close to the value found in this study. The small proportion of vermilion snapper retained for bait was similar to fishermen estimates for the SEDAR-02 (2003b) report. The proportions in this study provide empirical support for using fishermen estimates in stock assessments, when other data is not available. Vermilion immediate release mortality proportions were strongly correlated with size. Larger fish had lower proportions of immediate release mortality. The South Atlantic Fishery Management Council (SAFMC), which sets management regulations, has recently set a quota for vermilion snapper (Southeast Fishery Bulletin, October 7, 2009). After the quota has been reached, no more vermilion may be retained on a commercial vessel, which would result in the discard of all vermilion. Vermilion are frequently caught with many of the other species in this study, so it is not unreasonable to assume that after the vermilion fishery closes that there will still be vermilion snapper captured. Since larger vermilion have a relatively low immediate release mortality proportion, this regulation would likely work as intended and not create high immediate release mortality proportions.

While gray triggerfish had a low discard proportion, nearly all discarded fish were presumed dead (dispositions 3 and 4). This is in direct contrast to three Gulf of Mexico studies (Ingram, 2001; Patterson et al., 2002; SEDAR, 2005) which had low immediate release mortality proportions (<1–6%). The difference between the

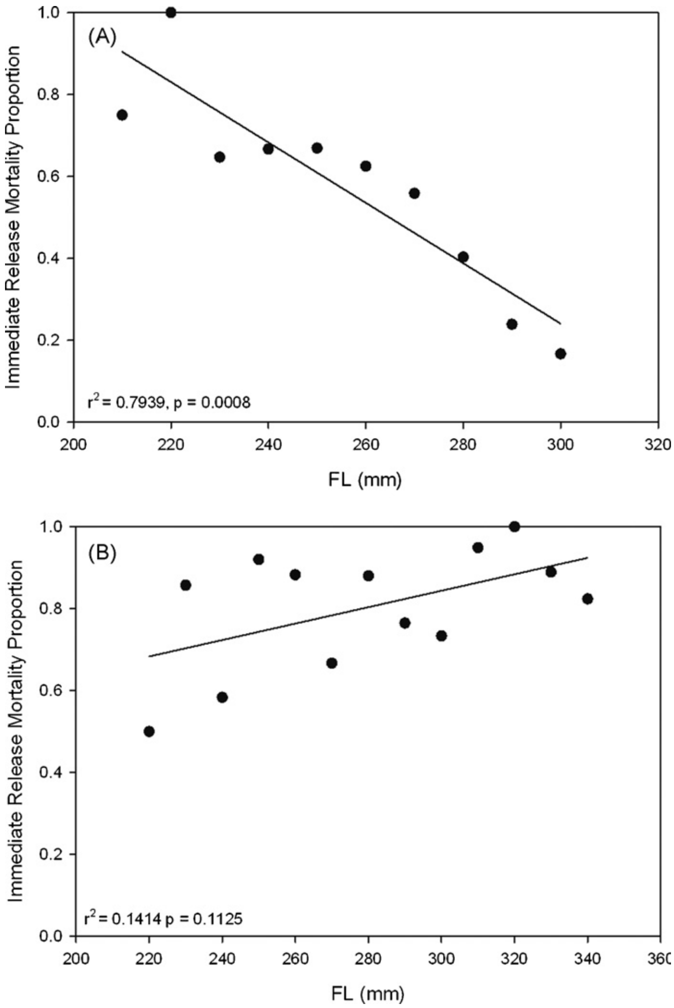

Fig. 2. Proportion of discarded vermilion snapper (A) and red porgy (B) assumed to have immediate release mortality by 10 mm size bins. Vermilion snapper immediate release mortality significantly decreased as size increased ($p = 0.0008$), while there was no significant relationship between size and immediate release morality for red porgy ($p = 0.1125$).

Gulf of Mexico studies and our study may be due to factors that were not quantified in this study such as depth at capture, speed of retrieval, time on deck, or ambient temperature.

Red porgy had a high discard proportion due to both minimum size limits (45% of the catch below minimum size) and trip limits (17% of discarded fish above the minimum size limit). Rudershausen et al. (2007), which used 1-day trips typical of the NC fishery, noted a sublegal red porgy discard proportion (25%). Our studies higher discard proportion includes both legal and sublegal specimens is directly related to the 120 fish/trip limit, with more red porgy discarded later in the trip. While our immediate release mortality proportions were higher than those found in the SEDAR (2002) and Rudershausen et al. (2007). Our immediate release mortality proportions may be higher due to the inclusion of the legal discards from the 120 fish/trip limit, and have recently been incorporated into the SEDAR-01 (2006) update report for red porgy.

Our black sea bass discard proportion (18%) was comparable to the 12% found in Rudershausen et al. (2007). Despite similar discard proportions, our immediate release mortality proportions of 66% was much higher than the 4% in Rudershausen et al. (2007) and the estimated 15% in the SEDAR stock assessment (SEDAR, 2003a). This difference with Rudershausen et al. (2007) is most likely due to the differences in capture depth as their capture depths were limited to between 20 and 40 m in depth (80% between 20 and 30 m), while our capture depths ranged from 20 to 80 m. Therefore, it is likely that barotraumas is contributing to our higher immediate release mortality proportions.

Our scamp discard proportions (44%) were slightly higher than those found in two studies in waters off North Carolina, where discard proportions were 35% (Rudershausen et al., 2007) and 28% (Bacheler and Buckel, 2004). The difference in discard proportion most likely is reflective of the fishing locations and hook sizes, which may reduce the chance of hooking a sublegal scamp. Immediate release mortality proportion (98%) was considerably higher than in Rudershausen et al. (2007) (23%), where the majority of scamp was caught in 20–30-m depth. In contrast, the majority of scamp captured in this study were caught along the shelf-break (~50–70 m). The barotrauma associated with greater depth was evident as many of our scamp were classified as floating at the surface.

Slightly less than half the red snapper caught were discarded (42%), but the immediate release mortality proportion was extremely high (93%). Our immediate release mortality proportion is comparable to the value of 90% used in the recent red snapper stock assessment (SEDAR, 2009), but higher than the 66% (Wilson et al., 2005) and 13% (Patterson et al., 2002) found in the Gulf of Mexico. Again, this difference can be attributed to differences in fishing depth. The majority of our red snapper were caught around the shelf-break (~50–70 m), while the Gulf of Mexico studies were much shallower.

5. Conclusions

This study's discard proportions were often in agreement with other studies, both Atlantic and Gulf of Mexico, proportions, but our immediate release mortality proportions were often higher. Our study had a higher number of days fishing, consisted of multi-day trips, had larger catches, and fished mainly along the shelf-break, all of which may have contributed to these differences. Other factors influencing these differences include: hooking location, hook type (circle versus J-hook), deck time, speed of retrieval and depth at capture. Personal communication from the captain indicated that most of his fish were mouth hooked and remained on deck for under 1 min.

For species with low discard proportions and low to moderate immediate release mortality proportions, size limit regulations are effective. For vermilion snapper, gray triggerfish and black sea bass, the majority of the catch was above the legal size limit, resulting in low discards. Further, immediate release mortality proportion was moderate for vermilion snapper and black sea bass. For these species, size limits are functioning as intended by protecting the smaller fish. Conversely, for species with both high discard proportions and high immediate release mortality proportions size limits may not be effective, as many of the discarded fish are not surviving. Red porgy, scamp, and red snapper had both high discard and immediate release mortality proportions. Additionally, the 120 fish/trip limit for red porgy is also contributing to high immediate release mortality proportions, especially for the multi-day trips common off South Carolina. Since fishermen in this region target a group of species, a mixed-species trip limit should be considered as an alternative management strategy. Using a mixed-species trip limit would also take into consideration some of the species that have no regulations restricting catch, such as tomtate and bank sea bass that were caught in sizeable numbers during this study. While this study provided unique information about the commercial catch composition, discard proportions, and immediate release mortality proportions discard mortality, it is based on one commercial fisherman's practices. Further investigations utilizing more fishermen and with more detailed methods (e.g. depth, hook location, time on deck) would provide a more accurate picture for managers.

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