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Red Snapper in the Northern Gulf of Mexico: Age and Size Composition of the Commercial Harvest and Mortality of Regulatory Discards

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Abstract.—Red snapper *Lutjanus campechanus* were sampled from commercial landings from the Gulf of Mexico (GOM) off Louisiana from October 2001 to May 2004. Fork length (FL), eviscerated weight, otoliths (both sagittae), and sex determinations were taken from 2,900 specimens; FL was subsequently converted to total length (TL) with the equation TL = 1.073 (FL) + 3.56. Red snapper ages (N = 2,867) estimated from counts of opaque annuli in otoliths ranged from 1 to 14 years; however, the vast majority (97.7%) of these were ages 2 to 6 years and the modal age was 3 years. Total lengths among 2,897 specimens ranged from 278 to 940 mm, modal TL was 400 mm, and 98% of all specimens were less than 600 mm TL. We also investigated the fate of red snapper regulatory discards (individuals <381 mm [15 in] TL) during 16 trips on working commercial vessels; over two-thirds of 4,839 red snapper assigned among four discard fate categories (ranging from alive and vigorous to dead) were returned to the water either in moribund or dead condition. Among 399 potential discards retained for age and length analyses, 86% were between 12 and 15 in (305–381 mm) TL and 85% were 2 years of age. The minimum size regulation appears to do little to protect juvenile red snapper from commercial fishing mortality. Heavy red snapper mortality, which begins as bycatch mortality in shrimp trawls, continues as discard mortality at sub-legal lengths when they first recruit to the offshore fishing grounds, and persists as harvest mortality among the youngest legal year- and size-classes. If the minimum size limit is intended to provide a respite from such mortality, a reconsideration of the utility of the minimum length regulation in the commercial harvest of red snapper may be warranted.

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Introduction

Red snapper *Lutjanus campechanus* in the Gulf of Mexico (GOM) have been intensively managed by the Gulf of Mexico Fisheries Management Council (GMFMC) since 1991. Both the commercial and recreational fisheries are currently constrained by size limits, trip or creel limits, seasonal closures, and quotas in an attempt to achieve a spawning potential ratio (SPR) of 30% and to allow populations to recover; however, the species has remained overfished in the GOM (Schirripa and Legault 1997,1999; SEDAR 2005). Accurate information on the age and size composition of the red snapper commercial harvest is necessary to monitor year-class strength, conduct stock assessments, and document population recovery.

The longevity of red snapper can no longer be disputed. Recent studies estimating red snapper ages from otolith annuli have incrementally increased estimates of the potential life span of the species to over 50 years (Szedlmayer and Shipp 1994; Manooch and Potts 1997; Patterson 1999; Baker and Wilson 2001; Patterson et al. 2001a; Wilson and Nieland 2001). However, few of these age classes are represented among the red snapper commercial harvest from the northern GOM off Louisiana during any given year. Our previous studies (Wilson et al. 1994; Wilson and Nieland 1998; Wilson and Nieland 2000; Wilson and Nieland 2001) have been overwhelmingly populated with specimens at the youngest end of the red snapper age spectrum and older specimens have become increasingly rare in the harvest.

Minimum size regulations have been applied to both the recreational and commercial red snapper fisheries with the purpose of both providing a respite from heavy fishing mortality and allowing opportunity to spawn. The GMFMC successively applied minimum size limits for commercially harvested red snapper of 13 in (330 mm) total length (TL) in 1984, 14 in (356 mm) TL in 1994, and 15 in (381 mm) TL in 1995. The current 15 in minimum size likely has resulted in a drastic increase in the numbers of commercial regulatory discards; anecdotes of large numbers of red snapper discards drifting behind commercial boats are common along the Louisiana coast. A 1998 fishery independent "snapshot" of red snapper randomly sampled from among the mortalities resulting from the explosive removal of an offshore petroleum platform showed that the majority (55%) of the red snapper population associated with the platform was less than the legal minimum size (Nieland and Wilson 2003). Similar platforms in the northern GOM are very popular red snapper fishing locations among both recreational and commercial fishers.

The greatest importance of discard mortality estimates is in their application to assessments of populations; however, to date most discard mortalities applied to the red snapper commercial fishery have been based on little direct observation. A mid-1990s observer program aboard handline (commercial) red snapper vessels documented that only 1.6% of total catch was discarded dead (Goodyear 1995); however, due to protrusion of the eyes and stomachs among the discards that swam down, it was suggested that many of these small red snapper suffered delayed mortality. Indeed, Goodyear (1995) variously applied discard mortalities of 10–33% in his analyses of red snapper yield per recruit at several different minimum size limits. Schirripa and Legault (1997, 1999) applied discard mortalities of 33% and 20% to the commercial and recreational fisheries, respectively, in their assessments of red snapper populations in the GOM. In addition to overt mortality, delayed mortality (as above) due to barotrauma (Rummer and Bennett 2005) and subsequent predation of struggling discards by dolphins, barracudas, jacks, sharks, and even brown pelicans (personal observations) may

also significantly increase mortality among red snapper regulatory discards in both fisheries.

The primary objectives of this research were to describe the distributions of ages and sizes and to estimate release mortality and age structure of regulatory discards in the red snapper commercial fishery in the northern GOM. Our specific goals were to: 1) Randomly sample the commercial harvest of red snapper from the northern GOM during 2001–2004 seasons and use counts of otolith annuli to estimate the ages of same; 2) determine the distributions of ages and lengths within these catches; 3) compare age and length distributions to previous studies in 1995–1997 and 1997–2000; and 4) investigate both the catch-and-release mortality and the age composition of red snapper regulatory discards.

Methods

Sample collections spanned four years and six red snapper commercial fishing seasons commencing in October 2001 and ending in May 2004. All of our sampling efforts focused on the red snapper commercial landings in Cameron, Louisiana, where a substantial portion of the Louisiana red snapper fishing fleet is based. Also, several boats from Panama City, Florida, routinely offload their catches in Cameron. The majority of these snapper were caught within NOAA Fisheries statistical grids 16, 17, and 18 which, not coincidentally, historically have been the leading contributors to the total commercial harvest of red snapper in the GOM (Schirripa and Legault 1999). Our sample population was drawn from those catches that were available on the sampling days; catch location and depth of capture were unavailable in all cases. Randomization of specimens sampled was attempted by simply selecting the next available individual from a moving conveyor belt. Fork length (FL) in mm, eviscerated weight (EW) in kg, and sex (when it could be determined with certainty) were recorded and sagittal otoliths were removed from all specimens. Red snapper otolith sections were prepared and ages were estimated as described in Cowan et al. (1995) and Wilson and Nieland (2001). Total length was estimated from FL with the equation TL = 1.073 (FL) + 3.56 (Wilson and Nieland 2001). Data from similar red snapper sampling efforts undertaken in 1995–1997 (Wilson and Nieland 1998; sampled in Leeville, LA) and 1997–2000 (Wilson and Nieland 2000; sampled in Cameron, LA) are used for comparative purposes.

The mortality of red snapper regulatory discards was assessed aboard appropriately permitted commercial fishing vessels operating out of Port Fourchon, LA. We (one person per vessel per trip) assessed the condition of undersize red snapper returned to the water during the course of normal fishing operations; no discards were assessed either during severely inclement weather or at night. We used four condition states taken from Patterson et al. (2001c):

1) Fish oriented toward the bottom and swam down vigorously,
2) Fish appeared disoriented upon entering the water, but soon oriented toward the bottom and swam down slowly,
3) Fish appeared very disoriented upon entering the water and remained at the surface, and
4) Fish was either unresponsive or dead upon entering the water.

At each fishing opportunity, water depth and fishing depth were recorded. The relationship between capture depth and percent of likely mortalities (discards in categories 3 and 4) was examined with linear regression of data from all fishing opportunities in which five or more discards were assessed. Further, each trip a maximum of 25 obvious red snapper mortalities from among the potential dis-

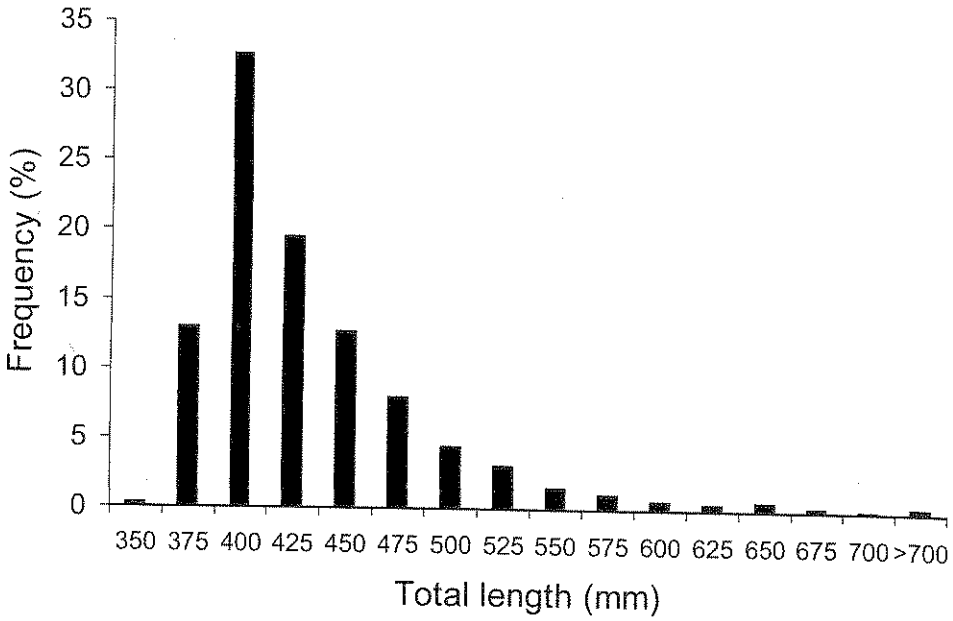

Figure 1. Total length frequency histogram for red snapper *Lutjanus campechanus* from the commercial harvest of the northern Gulf of Mexico, 2001–2004. Sample size = 2,897.

cards were sampled by our personnel for age and length analysis as outlined above.

Results

Red snapper (N = 2,900) were sampled from the commercial harvest of the species during the project period: 593 in 2001, 734 in 2002, 887 in 2003, and 686 in 2004; 42% were sampled from October to December and 58% were sampled from February to May. Among all specimens 884 were males, 981 were females, and 1,035 were of unresolved gender (the fish are landed in eviscerated condition). Total lengths, EW, and ages are available for 2,897 and 2,619 and 2,867 specimens, respectively.

Red snapper in our sample population from the commercial harvest ranged from 278 to 940 mm TL; however, due to the 15 in TL minimum size applied to the commercial red snapper fishery, only four specimens under 370 mm TL were sampled. The distribution of TL binned in 25 mm increments is distinctly unimodal with that mode seen at 400 mm (Figure 1). Fully 98% of all specimens were under 600 mm TL. Figure 2 shows the distributions of TL for red snapper similarly sampled from the commercial harvest during 1995–1997, 1997–2000, and 2001–2004. Length distributions during the 1995–1997 and 1997–2000 sampling efforts were quite similar and showed only minor variations; however, the 2001–2004 sample population was considerably enriched at TL < 450 mm and substantially depauperate at TL ≥ 600 mm. Modal lengths were in the vicinity of 400–425 mm and the preponderances of individuals were less than 600 mm TL in all three cases.

During the 2001–2004 sampling effort, red snapper of ages 1–14 years were encountered; however, the vast majority (97.7%) of these were ages 2–6 years, the modal age was 3 years, and only six specimens were age 10 years or older (Figure 3). The sampling efforts of 1995–1997 and of 1997–2000, during which the maximum ages observed were 48

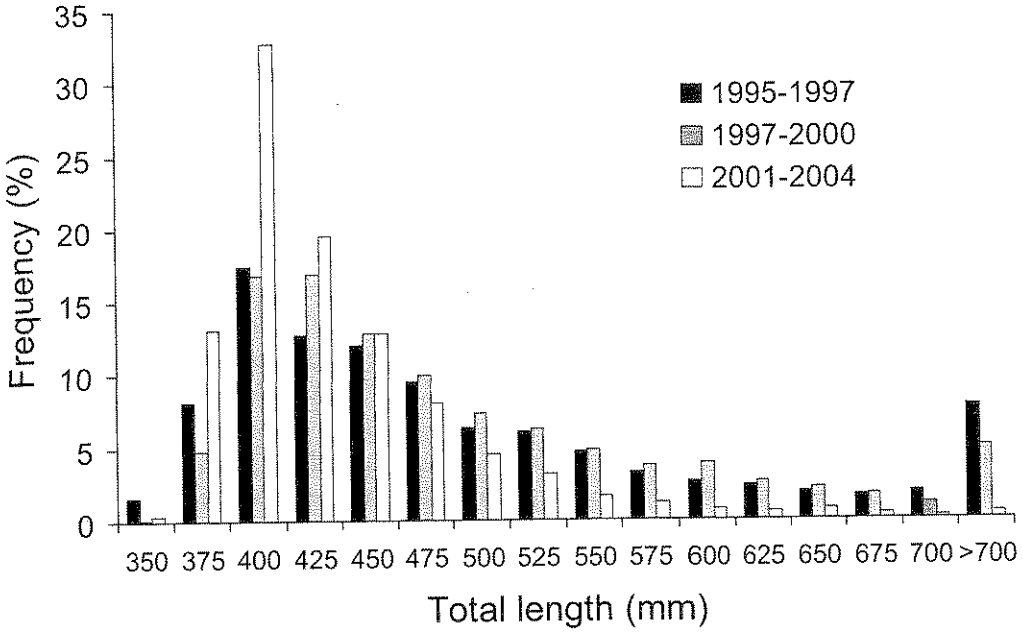

Figure 2. Total length frequency histogram for red snapper *Lutjanus campechanus* from the commercial harvest of the northern Gulf of Mexico, 1995–1997, 1997–2000, and 2001–2004. Samples sizes = 2,091, 2,947, and 2,897, respectively.

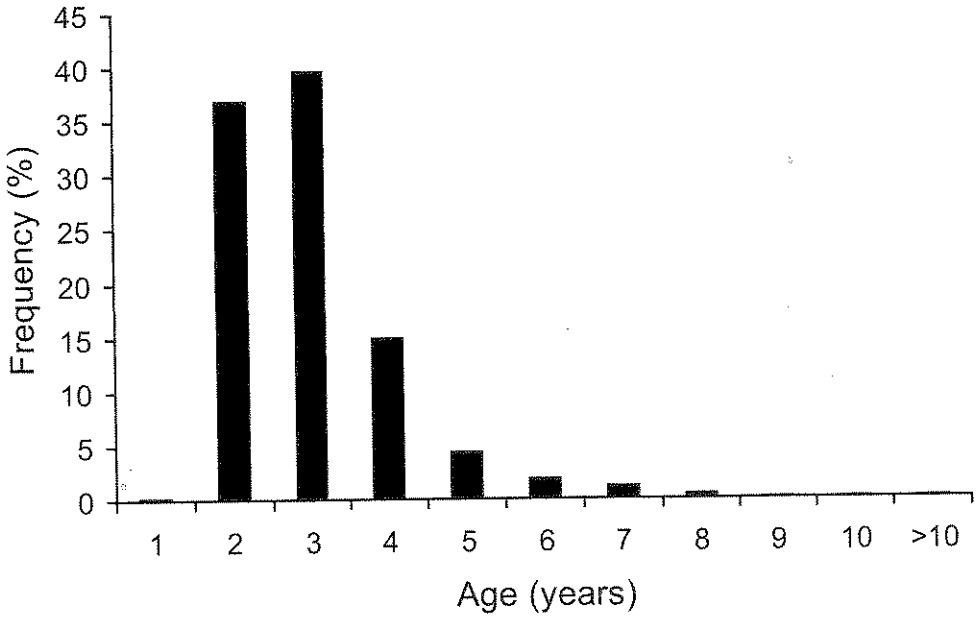

Figure 3. Age frequency histogram for red snapper *Lutjanus campechanus* from the commerical harvest of the northern Gulf of Mexico, 2001–2004. Sample size = 2,867.

years and 39 years, respectively, also showed that the bulk of the commercial catch during these years was individuals of ages 2–6 years (Figure 4). The modal age of 3 years has remained unchanged over the last decade, but, fluctuation notwithstanding, the numbers of age 2 red snapper in the harvest now is nearly equal to that of age 3 individuals. There have been concomitant decreases in the proportions of individuals at all ages older than 3 years. Specimens over age 10 years, a group that in our experience has never been abundantly represented in the harvest, reached their lowest numbers during the most recent sampling effort (Figure 4).

Mortality among red snapper regulatory discards in this study was both very high and related to depth of capture. A total of 4,839 discards from 273 fishing opportunities during 16 fishing trips was observed and characterized for release condition; all were caught with multi-hook (#10 circle hook) gear deployed from "bandit" reels at depths of 9–85 m (mean = 46 m). Among the discards 778 (16%) swam down vigorously, 714 (15%) swam down slowly or erratically, 1,765 (36%) were alive but could not swim down, and 1,582 (33%) were dead. There was a significant positive relationship between capture depth and percent mortality (proportion of discards in categories 3 and 4) (Figure 5) for all fishing opportunities where five or more discards were assessed:

$$\% \text{ mortality} = 0.70 \times \text{depth (m)} + 35.88 \ (F = 35.65, P < 0.0001, r^2 = 0.16).$$

Among 399 potential red snapper regulatory discards retained for age and size analyses, TL ranged from 248 to 380 mm (10–15 in) with a mean and modal TL of 335 mm (13 in); 86% of all specimens were ≥ 300 mm (12 in). Ages among these ranged from 1 year to 4 years with 2 year old individuals (86%) clearly dominating the sample population.

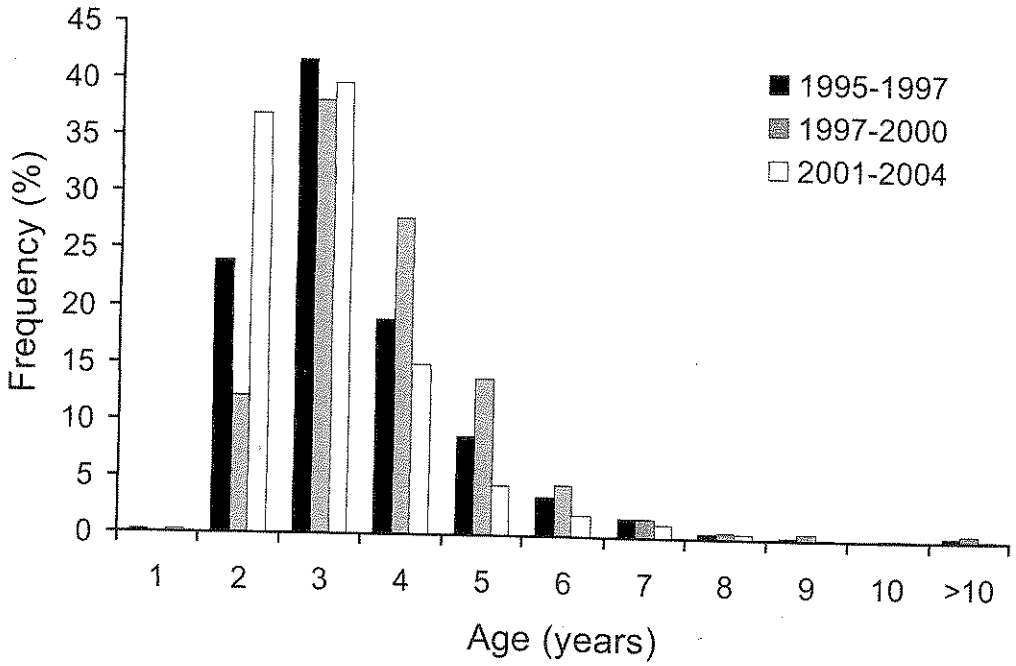

Figure 4. Age frequency histogram for red snapper *Lutjanus campechanus* from the commerical harvest of the northern Gulf of Mexico, 1995–1997, 1997–2000, and 2001–2004. Sample sizes = 2,083, 2,908, and 2,867, respectively.

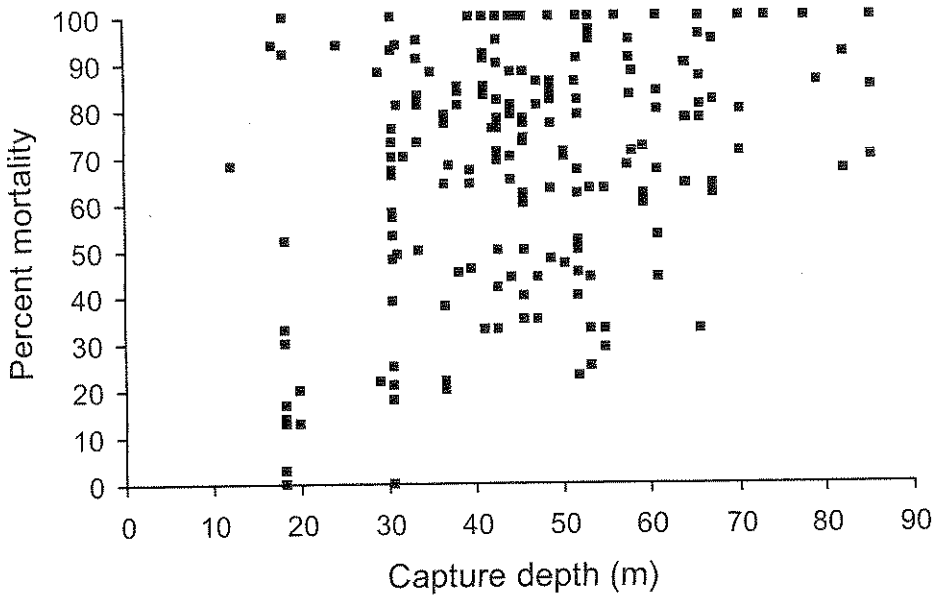

Figure 5. Percent mortality (categories 3 and 4) at capture depth for red snapper *Lutjanus campechanus* regulatory discards from the commercial fishery in the northern Gulf of Mexico, 2001–2003. Only fishing opportunities in which five or more discards were assessed are plotted.

Discussion

Heavy red snapper fishing mortality, which begins as bycatch mortality in shrimp trawls (Schirripa and Legault 1997,1999; SEDAR 2005), continues as discard mortality at sub-legal lengths when juveniles first recruit to the offshore fishing grounds, and persists as harvest mortality among the youngest legal year- and size-classes. Red snapper commercial fishermen are currently allowed a Gulf-wide quota of 2,114 metric tons (mt) (4.65 million lb), two-thirds of which is allocated to a winter season beginning in February and one-third to an autumn season which has begun in either September or October. Additionally, both the winter and autumn seasons are currently open to red snapper harvest only for the first 10 d of each successive month until the quota is achieved. The trip limit of 0.91 mt (2000 lb) for holders of federally issued reef fish permits and the modest number of available fishing days has resulted in a derby fishery that necessitates maximum catch in a minimum of time.

To compete in this derby fishery, many red snapper fishermen have concentrated their efforts at the numerous offshore oil and gas platforms of the northern GOM, particularly those closest to port. These easily located structures can hold large numbers of red snapper (Continental Shelf Associates 1982; Putt 1982; Stanley and Wilson 1990; Stanley 1994). The usual routine (called rig hopping) involves test fishing at successive platforms until a large and readily caught population of red snapper is found. Under the appropriate conditions and with some good fortune, a single trip may last less than one day. Thus, red snapper are harvested as close to port as is possible (usually in relatively shallow waters) and as soon as they achieve legal size as fast-growing 2 year olds, as 3 year olds, or shortly thereafter; they disappear from the fishery, due either to mortality or to emigration to alternative,

more remote habitats that are largely unfished, within a few years. The heavy harvest sustained by the younger age-classes of red snapper in the northern GOM appears to have produced populations showing symptoms (decreasing size at age (Nieland et al. 2007, this volume), decreasing size at maturity (Woods 2003)) of overfishing and concomitant juvenescence.

Efforts to estimate discard mortality in the red snapper recreational fishery have produced numbers comparable to those reported above for the commercial fishery. Two studies simulating techniques used in the red snapper recreational fishery have estimated mortality of regulatory discards to range between 1% and 44% and increasing with depth of capture (Gitschlag and Renaud 1994; Render and Wilson 1994). Patterson (2001b) calculated a red snapper discard mortality of 13% from analyses of release condition and recapture rates for red snapper caught with recreational gear in relatively shallow waters off Alabama. Among red snapper less than 18 in (450 mm) TL released from headboats in Texas waters, 15.2% floated off and 1.4% were discarded dead (Dorf 2003).

Given the gamut of life-threatening circumstances that a red snapper regulatory discard must face, it may not be unreasonable to expect a near 100% mortality of discards in the commercial fishery. Based on qualitative characteristics of the discard release conditions we observed, fully 69% of specimens returned to the water were either near death (category 3) as evidenced by their failure to resubmerge or dead (category 4). Additional mortality due to either piscine or mammalian predators may occur on specimens that are trying, perhaps struggling, to return to depth. Should an individual survive the catch and release experience and should it avoid various predators as it swims down, there is also the possibility of long-term mortality due to internal injuries (Rummer and Bennett 2005). Additional studies are needed to determine the level of, as well as spatial and temporal patterns in, both short-term and long-term mortality of discarded red snapper.

Depth of capture had a significant effect on the proportions of discards in the most severely distressed categories: As capture depth increased, the percentage of all discards recorded in categories 3 and 4 increases (Figure 5); however, neither is the magnitude of the effect very strong (slope = 0.70) nor is the relationship very tight (r^2 = 0.16). Whereas discards in Categories 1 and 2 are more likely to be observed at the shallowest capture depths, high percentages of moribund and dead discards are also seen at depths as shallow as 20 m. According to Boyle's law, as pressure decreases 50%, the volume of gas will increase by a factor of two. Thus a red snapper brought to the surface from 80 m will experience a twofold increase in volume of the air bladder at 40 m, an additional twofold increase at 20 m, another at 10 m, and another when at the surface. This exponential increase in gas volume in the air bladder at decreasing depths suggests that the greatest potential for internal injury/trauma may actually occur as the fish approaches the surface from even the shallowest of depths.

No commercial fisher wants to catch undersized fish; it is a waste of time and energy, it increases overhead, and it is potentially detrimental to the population from which one is harvesting. Indeed, fishers generally use hooks of a size that will exclude smaller fish from becoming hooked. However, even with precautions in place, undersized fishes are going to be caught. The larger diameter, manually, electrically or hydraulically powered reels (often called "bandit" reels) used almost exclusively in the commercial fishery assuredly bring hooked fish to the surface faster than could normal recreational gears. Thus the prospect of injury to hooked fish

due to hydrostatically-induced barotrauma (eyes bulging, intestine protruding from anus, air bladder distended and stomach protruding from mouth, etc.) is enhanced.

Discard mortality observed in this study (69%) is considerably higher than the current estimate (33%) used historically in red snapper stock assessment models. These findings certainly warrant investigating the sensitivity of these models to high estimates of discard mortality. Even if this increased level of mortality has little effect on the calculations of allowable catch and quotas, it may still warrant reconsideration of the utility of the minimum length regulation on the commercial harvest of red snapper. However, both the intense fishing mortality and the heavy discard mortality of young red snapper will continue to negatively impact populations of the species in the northern GOM.

Postscript: The most recent red snapper stock assessment (SEDAR 2005), which was prepared concurrently with this manuscript, recognizes the high release mortality experienced by regulatory discards in both the commercial and recreational fisheries. As a result, regulatory discard mortalities in the commercial fishery ranging from 71% to 82% were applied to analyses of the red snapper population in the GOM. Based on the SEDAR findings, the GMFMC recently has decreased the total allowable catch (TAC) for the combined fisheries in the GOM from 4,145 mt (9.12 million lb) to 2,954 mt (6.5 million lb) with the prospect of additional decreases in TAC in the near future. The minimum size for harvest of red snapper in the commercial fishery was also decreased from 15 in (381 mm) to 13 in (330 mm). The commercial fishery for red snapper is now also managed under an Individual Fishing Quota System (IFQ) that should operate to either diminish or completely end the derby fishing seen in previous years.

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