Notice on SEDAR Working Papers

Red Snapper Discard Mortality Working Paper

Prepared by the SEDAR 24 Red Snapper Discard Mortality Working Group - May 2010

Chip Collier, Group Leader

Discard mortality is an important estimation included in stock assessments and rebuilding projections calculated from a stock assessment. Discard mortality rate can be impacted by several factors including: fish size, sea conditions, temperature, air exposure, handling, light conditions, sea conditions, and delayed mortality (Davis 2002). The longer fish are exposed to these fishing related factors and the more severe these factors are, the greater the cumulative stress on the fish (Rummer and Bennett 2007). The impacts of many of these factors are difficult to track or quantify and have lead to variability in determining discard mortality rates. The discard mortality rate of South Atlantic red snapper is of particular concern due to the high recreational (40%) and very high commercial (90%) discard mortality rates estimated for the last stock assessment (SEDAR 15). The rates were based on scientific reports, the Gulf of Mexico (GOM) red snapper assessment (SEDAR 7), and commercial and headboat logbook depths.

Several studies have been conducted to estimate a discard mortality rate for red snapper with values varying from 1 to 93% (Table 1). Most of these studies have focused on red snapper in the Gulf of Mexico where the commercial red snapper fishery operates much differently from the snapper grouper fishery off the US South Atlantic both in depths fished and gear used to target red snapper. Understanding the causes of red snapper discard mortality will be important to determining an appropriate estimate of discard mortality for red snapper.

In order to address the issue of discard mortality, a working group was put together prior to SEDAR 24. There were two conference calls to discuss issues that needed to be addressed in the working document. Two primary causes of discard mortality were indentified: hooking related injuries and barotrauma. Secondary factors of red snapper discard mortality were temperature or season of capture, predation, and size. Other factors were considered such as additional predation by dolphins, air exposure, and use of regulatory discard as bait but these factors were not considered by the workgroup to be significant factors of discard mortality for red snapper in the South Atlantic.

Hooking Related Injuries

Hooking related injuries are exacerbated by the biting behavior of red snapper when they attack prey/bait. They also swallow their prey quickly. This leads to deep ingestion of hooks quickly as opposed to how suction feeders like red grouper gulp and manipulate prey in their mouth (Burns 2009). To evaluate the role hook mortality plays in species survival, moribund red snapper caught aboard headboats in both the South Atlantic and Gulf of Mexico were necropsied. Necropsy results from headboat caught fish showed red snapper suffered greatest from acute hook trauma (49.1%), almost equaling all other sources (50.9%) of red snapper mortality combined in the headboat fishery in waters less than 42 meters [140 feet (Figure 1)]. Acute mortality occurred when a J hook punctured a major blood vessel or organ (Figure 2). If the hook was oriented upward when swallowed, it usually punctured the duct of Cuvier also known as the anterior cardinal vein of the heart. If the hook was oriented downward, it typically punctured or destroyed the liver (Burns et al. 2004).

In addition to acute hook mortality, latent (delayed) mortality was also high (29%). These hook related injuries occurred at all depths but were not all visible upon capture and many fish survived for five days in laboratory tanks. Fish appeared to swim, behave, and feed normally for the first two days of captivity. By the third day, the fish rested on the bottom of the tank and stopped feeding. The delayed mortality of some red snapper captured on headboats was due to a vital internal organ being nicked by a J hook (Burns et al. 2004, Burns et al. 2008). Drop by drop the fish slowly bled to death over five days (Figure 3). Blood from the injured organ pooled in the ventral coelom (Burns et al. 2004).

Barotrauma

All fish with closed swim bladders (physoclistic) suffer barotraumas injuries caused by rapid decompression from depth; however, mortality varies not only by depth but between species based on anatomy, physiology, and behavior. A marine species' swim bladder must not only be kept inflated at 5% of the fish's body volume but at a pressure equal to that of the surrounding water. Swim bladder volume follows Boyle's law which states changes in volume must be inversely proportional to changes in pressure if all other parameters remain constant. This means a decrease in hydrostatic pressure will cause an increase in the volume of gas in the swim bladder. Pressure at the water's surface is 1 atomsphere (atm) and increases by 1 atm, or 14.7 pounds per square inch, per each 10 meters of descent. A fish swimming near the surface is only subject to the pressure of 1 atm. At 10 meters, the pressure increases to 2 atm. When a fish swims up or is pulled up from 10 meters to the surface, the swim bladder expands as pressure decreases. The fish must deflate the swim bladder to prevent over buoyancy inhibiting controlled movement (Marshall 1970). Physoclistic fish are incapable of rapid deflation and rely on diffusion of swim bladder gases via a dense network of bundles of arterial and venous blood capillaries called rete mirable housed within the swim bladder walls. They adjust absorption or secretion of gases as needed. Swim bladder gases, often nitrogen, oxygen and carbon dioxide, diffuse into the rete as long as gas pressure within the swim bladder is greater than that in the capillary blood. Although difference in gas pressure varies with water depth, deflation rate is proportional to the area and complexity of the rete and to circulation speed (Marshall 1970).

Although Wilson and Burns (1996) have shown red grouper, gag, and scamp can potentially survive decompression in sufficient numbers to justify a minimum size rule if fish are rapidly allowed to return to the corresponding habitat depth, differences in morphology influence survival. Red snapper have smaller (in relation to total body size) swim bladders when compared to other species such as red grouper. The three layers of the red snapper swim bladder are composed of thicker tissue when compared to red grouper which have very thin tissue. As a result of the smaller sized and thicker swim bladder, when swim bladder ruptures occur, the red snapper swim bladder ruptures are smaller than those of red grouper at the same depths. When the swim bladder ruptures, swim bladder gases are immediately released into the fish's body cavity causing internal trauma. Trauma severity is dependent upon the quantity of gas released (depth dependent) and fish physiology (Burns et al. 2008).

The smaller red snapper swim bladder contains more retal area in the swim bladder than red grouper by fish length ($p<0.001$), which Brown-Peterson and Overstreet (Burns et al. 2008) postulated should increase gas exchange rates. Higher exchange efficiency of a smaller volume of gases combined with thicker tissue probably resulted in the smaller swim bladder tears observed in red snapper. Additionally, unlike the red grouper swim bladder, most rete in red snapper swim bladders were segregated from gas gland cells probably reducing the amount of hemorrhaging. This separation was especially apparent in smaller red snapper swim bladders (Brown-Peterson and Overstreet as cited in Burns et al. 2008).

The intimate association of larger blood vessels, rete, and gas gland tissue in red grouper probably leads to increased retal hemorrhaging with rapid decompression in all lengths of red grouper. Brown-Peterson and Overstreet stated that "histological results show overall that red snapper survive rapid decompression better than red grouper, as evidenced by reduced mortality, smaller and less frequent tears in the swim bladder, and less of a tendency to hemorrhage, particularly in smaller fish. The higher percentage of rete area in the swim bladder of red snapper compared with red grouper suggests swim bladder gasses may be exchanged more rapidly in red snapper, allowing greater survival after rapid decompression." (Burns et al. 2008)

Despite differences in severity of internal trauma, in all fish that survived, regardless of species and simulated depth, swim bladder ruptures showed signs of healing within 24 hours with tissue on both sides of the rupture tenuously connected along its entire length. All fish swim bladders healed enough to be functional within 2-4 days after removal from the chambers. Even extensive ruptures in both species healed within this time period. The inner layer (submucosa) healed first allowing the swim bladder to hold gas. Newly healed tissue was nearly transparent and became increasingly opaque over time as the other layers, the muscularis mucosa (middle smooth muscle layer) and tunica externa (outer layer of connective tissue) healed. At the end of one month, the only visible sign of rupture was a line of scar tissue that persisted over time providing a physiognomic indicator of previous ruptures in caught and released fish. New ruptures did not occur in areas previously ruptured. It may be that the thicker scar tissue is more resistant to new injury than areas without scar tissue (Burns 2009).

Smaller fish of both species survived rapid decompression from depth better than larger fish (personal communication with commercial fishermen, Patterson et al. 2001). Histological data by Brown-Peterson and Overstreet appear to support this claim (Burns et al. 2008). They reported that although retal hemorrhaging was significantly higher in red grouper than in red snapper when adjusted for length, the percentage of both red grouper and red snapper with hemorrhaging in both rete and the swim bladder increased significantly by 50 mm fork length increments (Figure 5). Additionally, they reported hemorrhaging was rare in small red snapper compared with large red snapper.

Koenig (2002) also found a positive trend for survival of smaller red grouper and red snapper over their larger counterparts during his analysis of the relationship between size and mortality for both species caught at 35 m and 40 m and maintained in his in situ cage experiments. These findings also agree with those of Wilson (1993) who reported that none of the large (> 737 mm) red grouper or scamp in his in situ cage experiments at 73 m survived. Only the smaller (< 584 mm) fish caught at every station survived. He found size at recapture to be important, with only fish < 584 mm surviving in his in situ cages at depths of 43-73 m for up to the eight-day project observation period.

A common physiognomic feature of barotrauma is stomach prolapse. In simulated depth experiments conducted in fish hyperbaric chambers following rapid decompressed from 21.3 and 27.4 m, red snapper were able to recover and begin normal feeding within one hour because the fish's stomach muscles pulled the stomach back into place. When red snapper were rapidly decompressed from 42.7 m, they fed normally within four hours. When laboratory experimental red snapper were compared with those caught on hook-and-line, necropsies of red snapper caught off headboats from depths > 10 m showed evidence of recent stomach prolapse through the presence of the "esophageal ring." Externally, these fish appeared healthy and well fed. The presence of food in their stomachs indicated that they were feeding normally and supports findings reported for chamber experiment fishes.

Several studies have focused on depth as an important factor in determining discard mortality due to the visible impact of barotrauma. Studies conducted in shallow water (<35 m or 115 feet) estimated discard mortality rates of 20% or less (Parker 1985, Render and Wilson 1994, Patterson et al. 2002, Burns et al. 2006). Studies conducted in deeper waters generally estimated higher discard mortality rates ranging from 17% to 93% (Gitschlag and Renaud 1994, Burns et al. 2004, Nieland et al. 2007, Burns 2009, Diamond and Campbell 2009, Stephen and Harris 2009). This increase in discard mortality rate with increasing depth is an expected result and has been described for red snapper and other snapper grouper species (Patterson et al. 2001, Burns et al. 2002, Patterson et al. 2002, Rudershausen et al. 2007, Stephen and Harris 2009).

To account for increasing discard mortality rate with increasing depth, three models were investigated to describe these depth effects (Figure 6). Two of the models (Burns et al. 2002, Diamond et al. unpublished data) used a logistic regression function to model the mortality rate and one used a linear trend (Nieland et al. 2007). All three of the models had overlap in the estimation of discard mortality particularly between 50 and 90 meters. The discard mortality linear model had a higher discard mortality rate for red snapper caught in depths less than 40 meters than the other two studies (Nieland et al. 2007). This was likely due to the commercial fishing practices they observed in the GOM. These fishermen were fishing with bandit fishing reels with terminal gear consisting of 20 hooks spread over 4.5 to 6 meters (S. Baker, Jr, personal communication). Typical recreational fishermen in the South Atlantic and GOM as well as commercial fishermen in the South Atlantic fish for snapper/grouper species with terminal gear having less than 5 hooks (Gulf and South Atlantic Fisheries Foundation 2008). The other two models describing discard mortality were related to delayed discard mortality rate. Koenig (Burns et al. 2002) used a cage study to determine the effects of depth on red snapper. Additionally, red snapper and gag grouper data were combined in the model since there was no significant difference in the percent mortality at depth. The Diamond et al. (unpublished) combined data from several different studies including the Burns et al. 2002. The discard mortality curves from these two studies were similar with less than 20% discard mortality for fish caught in less than 20 meters increasing to 100% mortality for fish caught in 90+ meters. Average minimum depth (43 m, 140 feet) for the charterboat and commercial fishery were the same (SEDAR 15). The average maximum depth in the charterboat fishery (58 m, 190 feet) was less than the average maximum depth reported in the commercial fishery (71 meters, 233 feet) (SEDAR 15). An average depth fished for commercial fishermen that caught red snapper was estimated to be 43 meters (140 feet) based on logbook data (SERO 2010). This value compares well to a fishery observer program that observed estimated mean depth fished in the South Atlantic to be 45 meters (149 feet) (Gulf and South Atlantic Fisheries Foundation 2008). Unfortunately, actual depths of where red snapper are captured and released are not available. An estimate of red snapper density by depth is also unavailable.

Venting fish to reduce the effects of barotraumas and discard mortality of red snapper has been researched. Red snapper caught in shallow water experience little benefit from venting (Render and Wilson 1994, Burns et al. 2002, Burns et al. 2008). In fact, venting fish may cause increased mortality for a variety of species (Wilde 2009). However vented red snapper caught in waters deeper than 42 meters had increased survival compared to non-vented red snapper (SEDAR 7, Burns et al. 2008).

Smaller red snapper, which survive barotraumas better than larger fish, are normally found shallower water while larger fish are typically caught in deeper water (Burns et al. 2008). Most red snapper show very little movement from areas where the fish were originally tagged (Patterson et al. 2001, Burns et al. 2008). If fish did migrate long distances, these fish were typically captured at different locations after environmental events such as hurricanes (Patterson et al. 2001). Recaptured red snapper in the Atlantic demonstrated a northerly or southerly migration probably due to the narrow shelf (Burns et al. 2008).

Secondary Discard Mortality Factors

Other issues discussed were the time red snapper would be expected to spend on the deck of commercial and recreational vessels in the South Atlantic (air exposure), hook type, water temperature differences, and predation. Koenig (Burns et al. 2002) described holding fish on the deck for three to eighteen minutes in the GOM to determine the effect of air exposure on mortality rates. This length of air exposure is not likely to happen in the South Atlantic since the maximum number of hooks most fishermen will use is five with most fishermen using one to two hooks compared to the 20 hook rally rig used in the GOM. This information was used in the previous assessment SEDAR 15; however, information on the fishing gear presented by commercial fishermen and included in Gulf and South Atlantic Fisheries Foundation (2008) demonstrated that the commercial fishermen would likely retain red snapper on the deck of the boat for extended periods of time (greater than one minute) (Stephen and Harris 2010, personal communication Ben Hartig and Kenny Fex, commercial fisherman).

Hook type has been discussed as a potential mechanism to reduce discard mortality. Circle hooks have been attributed to reducing discard mortality in some species. However, Burns et al. (2008) found that there was not a significant decrease in discard mortality for red snapper caught on circle hooks compared to J hooks. SEDAR 7 stated red snapper discard mortality decreased by 50% with circle hooks caught fish compared to those caught with J hooks. A decrease in mortality with circle hooks was also noted by Koenig (Burns et al. 2002) and Rummer (2007).

The seasonal capture of red snapper occurs from April to November as mentioned by the fishermen in the release mortality workgroup. Still getting information on bottom temperature.

Predation has been reported on discarded snapper grouper species (Parker 1991). Sharks, barracuda, and amberjack were likely candidates to eat small red snapper as they return to the bottom or float at the surface. Likelihood of predation would depend on several factors including the red snapper ability to swim to the bottom, swimming speed, and response to predator as well as predator type, density, and affinity for red snapper (Campbell et al. 2010).

Estimates of Red Snapper Discard Mortality

Commercial

Recreational

Literature Cited

Burns, K. M., C. C. Koenig, and F. C. Coleman. 2002. Evaluation of multiple factors involved in release mortality of undersized red grouper, gag, red snapper, and vermilion snapper. Mote Marine Laboratory Technical Report No. 814. MARFIN Grant NA87FF042. 60 p.

Burns, K. M., N. Parnell and R. Wilson. 2004. Partitioning release mortality in the undersized red snapper bycatch: comparison of depth versus hooking effects. MARFIN final report No. NA97FF0349, Mote Marine Laboratory Technical Report 932. 36 p.

Burns, K. M., N. J. Brown-Peterson, and R. M. Overstreet. 2006. Geographic comparison of age, growth, reproduction, movement, and survival of red snapper off the state of Florida. Mote Marine Laboratory Technical Report 1147 (MARFIN Grant # NA17FF288). 80 p.

Burns, K.M., N.J. Brown-Peterson, R.M. Overstreet, J. Gannon, P. Simmons, J. Sprinkle and C. Weaver. 2008. Evaluation of the Efficacy of the Current Minimum Size Regulation for Selected Reef Fish Based on Release Mortality and Fish Physiology. Mote Marine Laboratory Technical Report No. 1176 (MARFIN Grant # NA17FF2010) 75 p.

Burns, K. M. 2009. Evaluation of the Efficacy of the Minimum Size Rule in the Red Grouper and Red Snapper Fisheries With Respect to J and Circle Hook Mortality and Barotrauma and the Consequences for Survival and Movement. Dissertation to College of Marine Science, University of South Florida. 201 p.

Campbell, M. D., Patino, R., Tolan, J., Strauss, R., and Diamond, S. L. 2010. Sublethal effects of catch-and-release fishing: measuring capture stress, fish impairment, and predation risk using a condition index. – ICES Journal of Marine Science, 67: 513–521.

Diamond, S., and Campbell, M. D. 2009. Linking “sink or swim” indicators to delayed discard mortality in red snapper. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science, 1: 107–120.

Gitschlag, G.R. and M.L. Renaud. 1994. Field experiments on survival rates of cages and released red snapper. North American Journal of Fisheries Management 14:131-136.

Koenig, C. 2001. Preliminary results of depth-related capture-release mortality of dominant reef fish in the eastern Gulf of Mexico. Report to the Gulf of Mexico Fishery Management Council. 5 p.

Manooch, C. S., Potts, J. C., Vaughan, D. S., and Burton, M. L. 1998. Population assessment of the red snapper from the southeastern United States. Fisheries Research, 38: 19–32.

Marshall, N.B. 1970. ‘Poissons sans poids’. *The Life of Fishes*. Universe Books. New York. p. 67-80.

Nieland, D. L., Fischer, A. J., Baker, M. S., and Wilson, C. A. 2007. Red snapper in the northern Gulf of Mexico: age and size composition of the commericial harvest and mortality of regulatory discards. American Fisheries Society Symposium, 60: 301–310.

Parker, R. O. Jr. 1985. Survival of released red snapper progress report. NOAA, National Marine Fisheries Service, Southeast Fisheries Center, Beaufort Laboratory, Beaufort, NC. 8 p.

Parker, R. O. Jr. 1991. Survival of released reef fish—a summary of available data. Preliminary report to NOAA, National Marine Fisheries Service, Southeast Fisheries Center, Beaufort Laboratory, Beaufort, NC. 6 p.

Patterson, W. F. III, J. C. Watterson, R. L. Shipp, and J. H. Cowan Jr. 2001. Movement of tagged red snapper in the Northern Gulf of Mexico. Transactions of the American Fisheries Society 130: 533-545.

Patterson, W. F. III, G. W. Ingram Jr., R. L. Shipp, J. H. Cowan Jr. 2002. Indirect estimation of red snapper (*Lutjanus campechanus*) and gray triggerfish (*Balistes capriscus*) release mortality. Gulf and Caribbean Fisheries Institute 53: 526-536.

Render, JH. and C.A. Wilson. 1994. Hook-and-line mortality of caught and release red snapper around oil and gas platform structural habitat. *Bulletin of Marine Science* 55:1106-1111.

Rudershausen, P.J., Buckel, J.A., Williams, E.H. 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.

Rummer, J. L., and Bennett, W. A. 2005. Physiological effects of swim bladder overexpansion and catastrophic decompression on red snapper. Transactions of the American Fisheries Society 134: 1457–1470.

Rummer, J. L. 2007. Factors affecting catch and release (CAR) mortality in fish: Insight into CAR mortality in red snapper and the influence of catastrophic decompression. American Fisheries Society Symposium 60: 123-144.

SEDAR 7. 2004. Southeast data assessment and review: stock assessment report of Gulf of Mexico red snapper. National Marine Fisheries Service, Southeast Fisheries Science Center, National Oceanic and Atmospheric Administration, Miami, FL.

SEDAR 15. 2007. Southeast data assessment and review: stock assessment report of South Atlantic red snapper. National Marine Fisheries Service, Southeast Fisheries Science Center, National Oceanic and Atmospheric Administration, Miami, FL.

SERO (NMFS Southeast Regional Office). 2010. Projected combined effects of Amendments 13C, 16, and 17A regulations on south Atlantic red snapper removals. Report to the South Atlantic Fishery Management Council. 19p.

Stephen, J. A. and P. J. Harris. 2010. Commercial catch composition with discard and immediate release mortality proportions off the southeastern coast of the United States. Fisheries Research 103: 18-24.

Wilson, R. 1993. An *in –situ* study of the survivorship of the undersized bycatch in the red grouper fishery. MARFIN grant # NA17FF0387-01. 39 p.

Wilson, R.R. and K.M. Burns. 1996. Potential survival of released groupers caught deeper than 40 m based on shipboard and *in situ* observations, and tag-recapture data. *Bulletin of Marine Science* 5(1):234-247.

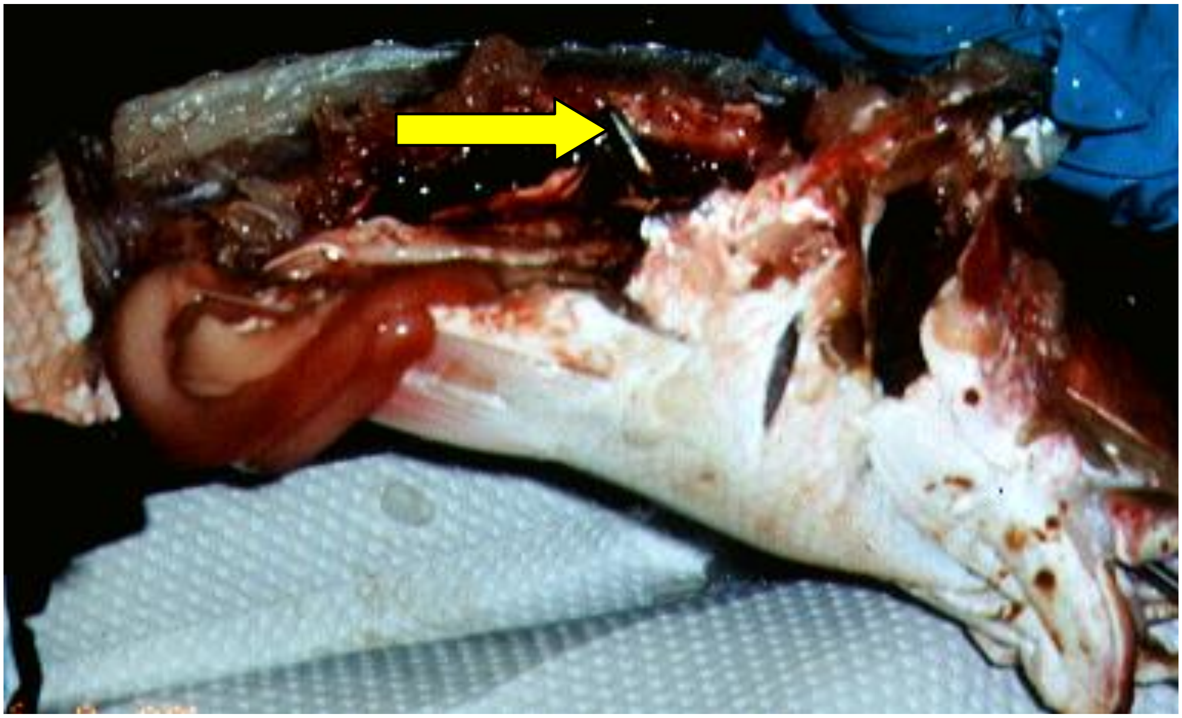

Figure 1. Acute mortality of red snapper caused by a J-hook. (Source: Burns et al. 2004)

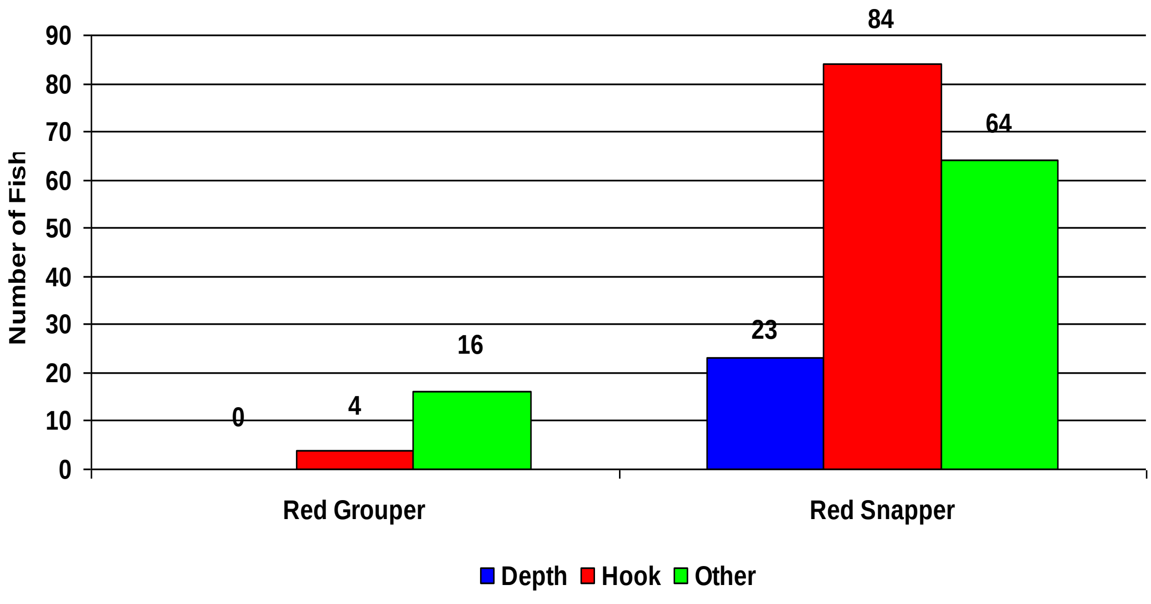

Figure 2. Acute mortality of red grouper and red snapper partitioned by cause of death (depth, hook, or other). (Source: Burns et al. 2004)

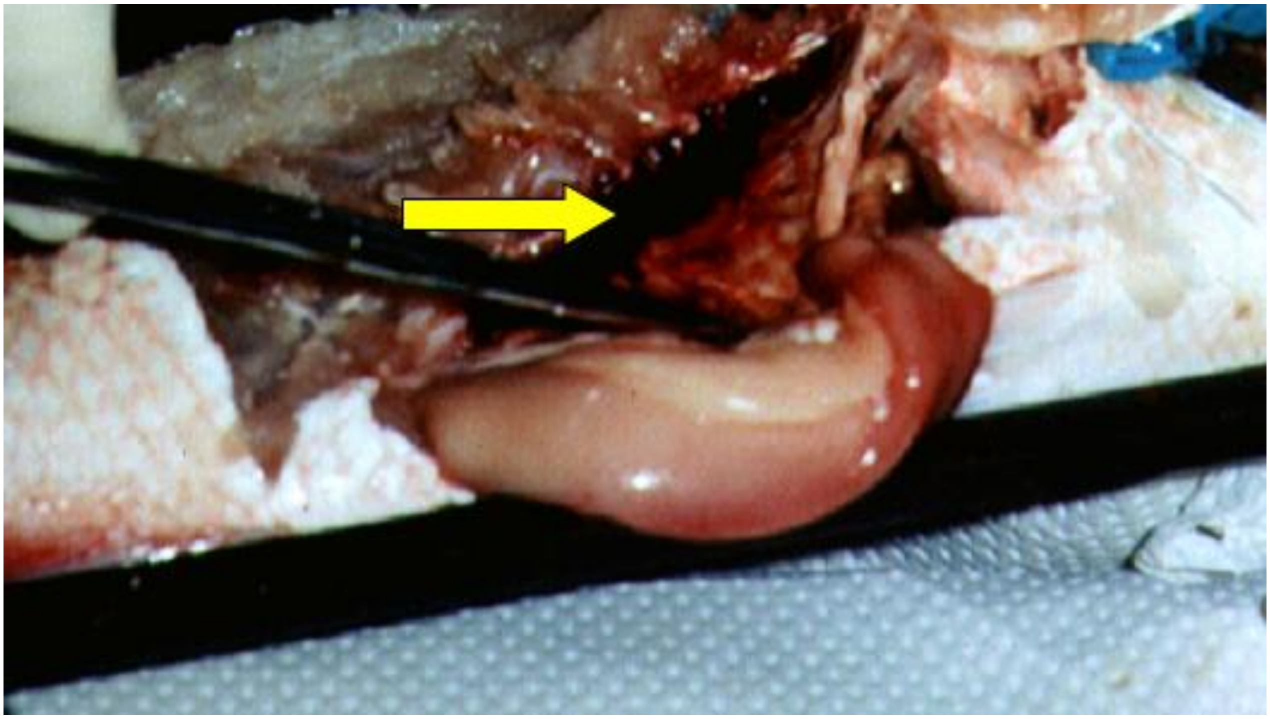

Figure 3. Blood pooled in the coelom of a red snapper that died due to latent mortality associated with an injured organ. (Source: Burns et al. 2004)

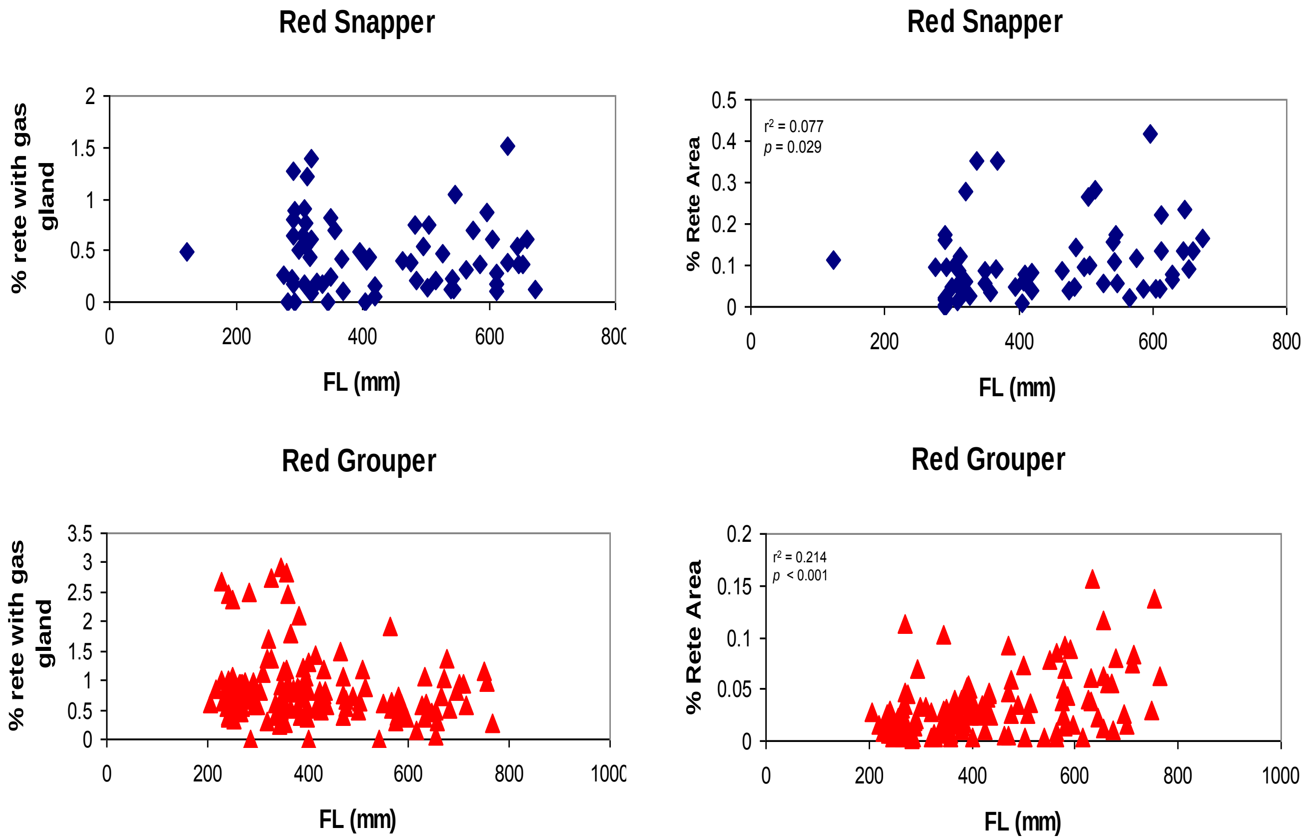

Figure 4. Percent of rete with gas gland and the percent rete area in the swim bladder of red snapper and red grouper by length (FL, mm). (Source: Burns et al. 2008)

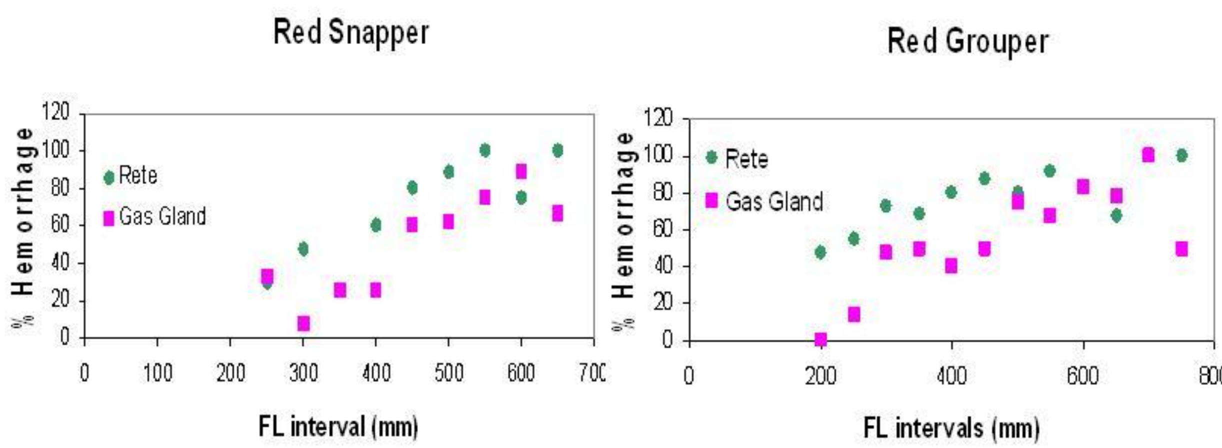

Figure 5. Percent of red snapper and red grouper with retal and gas gland hemorrhaging by 50 mm fork length intervals. (Source: Burns et al. 2008)

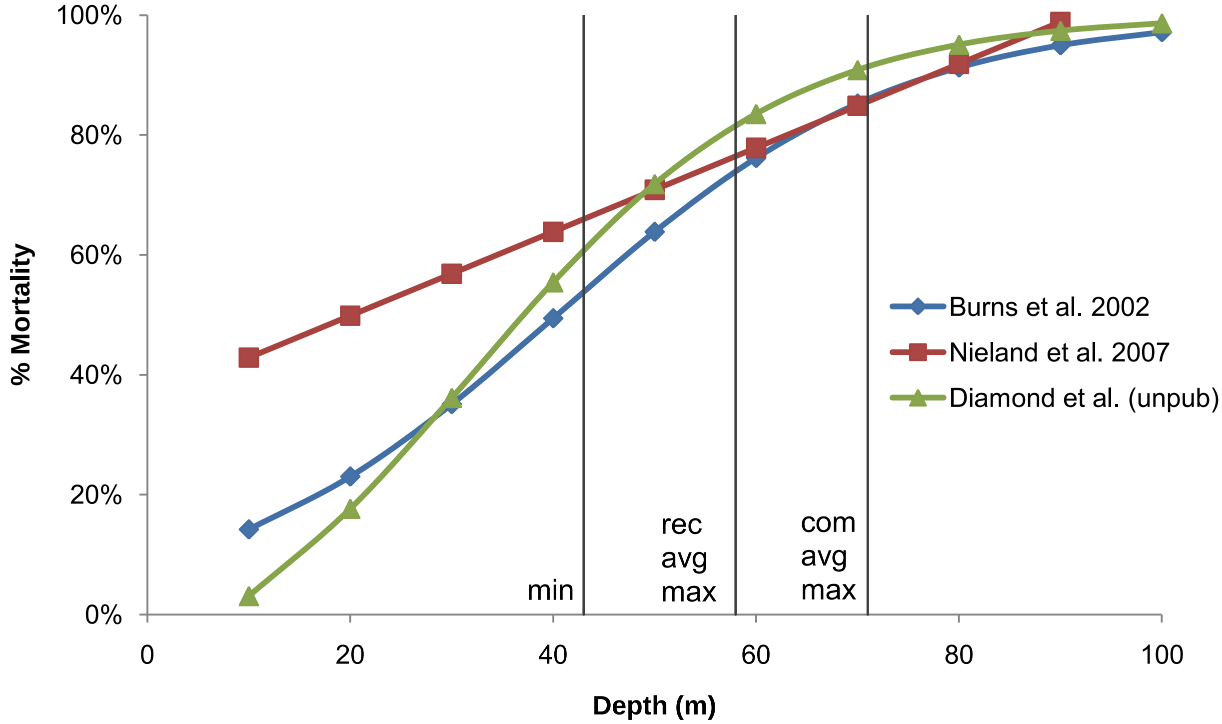

Figure 6. Discard mortality functions by depth (m) for red snapper derived from Burns et al. (2002), Nieland et al. (2007), and Diamond et al (unpublished data). Min= average minimum depth of South Atlantic headboat and commercial trips with red snapper reported in logbooks (43 meters). Rec avg max= average maximum depth of South Atlantic headboat trips with red snapper reported in logbooks (58 meters). Com avg max= average maximum depth of South Atlantic commercial trips with red snapper reported in logbooks (71 meters).

Table 1. Red snapper discard mortality studies, fishing sector, type of study, gear used in study, sample size (N), depth range of the study, and mortality type reported. Type of study includes a literature search (lit), laboratory (L), surface observation (S), cage study (C), and tagging study (T). Gears include hook and line gears and bandit reels. Mortality rates were separated into surface mortality, delayed mortality, and total mortality.

							Depth Range		Mortality Type		
Research Documents	Year	Sector	Area	Type	Gear	N	Meters (range)	Feet	Surface	Delayed	Total
Parker	1985		GOM/SA	L S C	H&L	44	30			11-12%	
Parker	1991		GOM/SA	Lit							
Gitschlag and Renaud*	1994	Rec	GOM	C	H&L	55	50	164		36%	
Gitschlag and Renaud*	1994	Rec	GOM	S	H&L	232	21-40	69-131	1-44%		
Render and Wilson	1994	Rec	GOM	C	H&L	282	21	69		20%	
Burns et al.	2002	Rec	GOM/SA	S C	H&L				See Figure 5		
Patterson et al.	2002	Rec	GOM	T S	H&L	2,232	21-32	69-105	14%		
Burns et al.	2004	Rec	GOM/SA	L S C	H&L		0-61.3+	0-201			64%
Rummer and Bennett	2005		GOM	L			0-110	0- 361			25-90%
Burns et al.	2006	Rec	GOM/SA	T S	H&L	590	0-30.8+	0-101	12%		
Nieland et al.	2007	Com	GOM	S	Bandit	2,900	43 (9-83)	141	69%		
Burns et al.	2008	Rec	GOM/SA	L T S	H&L	5,317	10.4-42.7	34-140			
Burns	2009	Rec	GOM/SA	L T S	H&L	1,259	10.4-42.7	34-140	13.60%	57%	
Diamond and Campbell	2009	Rec	GOM	C	H&L	320	30, 40, 50	98, 131, 164	17%	64%	
Stephen and Harris	2009	Com	SA	S	Bandit	67	50-70 (20-300)	164-230	93%		
Diamond et al. (unpubl)		Both	GOM/SA	M					See Figure 5		
Assessments											
Manooch et al.	1998	Both	SA	Lit	All		All				10-25%
SEDAR 7	2005	Com	GOM	Lit	All		50-80+				71-88%
SEDAR 7	2005	Rec	GOM	Lit	All		20-40+				15-40%
SEDAR 15	2009	Com	SA	Lit	All		43-71 (18-823)	141-233			90%
SEDAR 15	2009	Rec	SA	Lit	All		43-58 (20-274)	141-190			40%

*Same paper

Table 2. Red snapper discard mortality studies that described either an increase in discard mortality rate with increasing depth or other significant mortality factor.

Research Documents	Year	Depth Effect	Mortality Factors
Parker	1985		Predation does occur for fish less than 400 mm
Parker	1991	Yes	Reef fish survival inversely related to depth
Gitschlag and Renaud	1994	Yes	
Render and Wilson	1994		Season and Season x Treatment
Burns et al.	2002	Yes	Non-Vented survived better
Patterson et al.	2002	Yes	Smaller fish survive better
Burns et al.	2004	Yes	Hook related injury was the highest source of mortality
Rummer and Bennett	2005	Yes	
Burns et al.	2006	Yes	Hook related injury to internal organs has significant impact. Venting helps at depths greater than 29.9m
Nieland et al.	2007	Yes (Weak)	
Rummer	2007	Yes	Venting, retrieval rate, hook type, temperature difference, surface predators, handling time and hook location
Burns et al.	2008	Yes	
			Circle hooks do not significantly reduce mortality.
Burns	2009	Yes	
Diamond and Campbell	2009	Yes	Interaction of depth and season, sea surface temp, surface and bottom difference
Diamond et al. (unpubl)		Yes	