Indirect Estimation of Red Snapper (*Lutjanus campechanus*) and Gray Triggerfish (*Balistes capriscus*) Release Mortality

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ABSTRACT

Release mortality was estimated indirectly for red snapper and gray triggerfish in the northern Gulf of Mexico from condition of tagged fish. Condition at release was assessed for tagged red snapper (n = 2,932) and gray triggerfish (n = 842) based upon their swimming behavior. Condition-1 was assigned to fish that oriented toward the bottom and swam down vigorously. Fish in condition-2 oriented toward the bottom but swam erratically. Fish in condition-3 swam very erratically and remained at the surface, while fish in condition-4 were unresponsive and presumed dead. Overall, 86.5% of red snapper and 99.2% of gray triggerfish were released in condition-1. Depth of capture, fish size, and transporting fish prior to release significantly affected red snapper release condition ($p < 0.01$). Of 550 recaptured red snapper, 98.4% were released in condition-1, while 100% of 160 recaptured gray triggerfish were released in condition-1. Release condition significantly affected recapture rate for red snapper ($p < 0.001$). Comparisons with reported estimates of release mortality for red snapper indicate that the cumulative percentage of fish released in conditions other than condition-1 may serve as a proxy for acute release mortality. Further research is required to validate this approach; however, it may prove to be a practical method to evaluate release mortality in recreational and commercial fisheries through observer programs.

KEY WORDS: Reef fish, release mortality, tagging

INTRODUCTION

Reef fishes support valuable commercial and recreational fisheries in the U.S. south Atlantic and Gulf of Mexico (GOM), but many economically and ecologically valuable species in the snapper/grouper complex currently are estimated to be overfished (Anon. 1998, Coleman et al. 1999, 2000, Collins et al. 1999). Management of these reef fisheries is complicated by fish life history characteristics that include slow growth, late maturity, high site fidelity, and protogyny (Coleman et al. 1999, 2000, Huntsman and Waters 1987, Parish 1987). Furthermore, reef fisheries in a given geographic area typically target a variety of species, thus, traditional single-species management is often difficult or untenable (Ault et al. 1997;

Bohnsack 1996; Coleman et al. 2000; Gobert 2000).

Red snapper (*Lutjanus campechanus*) support the most economically valuable fishery in the GOM snapper/grouper complex, and are among the most targeted fishes by GOM commercial and recreational fishers (Goodyear 1995, Minton and Heath 1998, Stanley and Wilson 1990). This species is a long-lived apex predator that ranges from North Carolina to Florida in the U.S. south Atlantic, and from Florida to Yucatan in the GOM (Hoese and Moore 1998). The GOM red snapper stock has been subjected to heavy fishing pressure since the 1800s and is currently estimated to be severely overfished (Goodyear 1995, Schirripa and Legault 1999). Management measures first were implemented in the late 1980s, and have evolved since then, to increase red snapper spawning stock biomass (GMFMC 2000) (Table 1). Despite overfished status, combined commercial and recreational landings of GOM red snapper averaged ($\pm$ SE) 3.26 ($\pm$ 0.35) x 10^3 metric tons from 1990 to 1998 (Figure 1). Also during this time period, estimates of recreational discards rose sharply (Figure 1), likely in response to increasing management regulations (Table 1).

Table 1. History of management regulations for recreational and commercial red snapper fisheries in the GOM since 1990. Recreational size limit in 1999 changed to 457 mm TL from June through August to extend the recreational season. Length of 2000 commercial season is projected.

	Recreational			Commercial	
Year	Size Limit mm TL	Bag Limit	Season days	Size Limit mm TL	Season days
1990	330	none	365	330	365
1991	330	7	365	330	236
1992	330	7	366	330	94
1993	330	7	365	330	104
1994	356	7	365	356	78
1995	381	5	365	356	52
1996	381	5	366	381	86
1997	381	5	330	381	71
1998	381	4	272	381	67
1999	381*	4	240	381	64
2000	406	4	200	381	60**

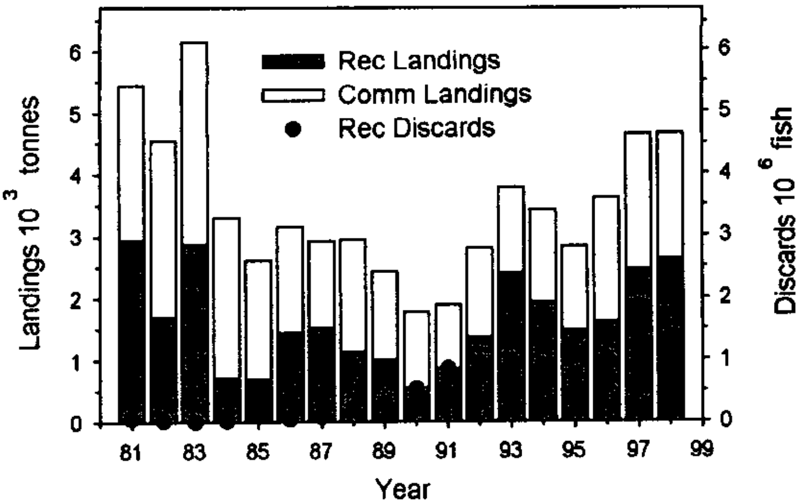

Figure 1. Reported recreational and commercial landings of red snapper in the U.S. GOM. Estimated numbers of live recreational discards are also given (Source of data: Schirripa and Legault (1999)).

Declining abundances of, as well as increasing management regulations on, red snapper and other overfished GOM reef fishes, such as gag grouper (*Mycteroperca microlepis*) and red grouper (*Epinephelus morio*), appear to have caused a shift in fishing effort to previously less exploited species (Ault et al. 1997, Schirripa 1996). Gray triggerfish (*Balistes capriscus*) experienced an increase in landings in the late 1980s and early 1990s, followed by a steady decline (Figure 2). Similar trends were observed for GOM vermilion snapper (*Rhomboplites aurorubens*) (Schirripa 1996), which is now considered to be approaching an overfished condition (Anon. 1998). The status of the GOM gray triggerfish stock is unknown, but concern over trends in landings of gray triggerfish and other reef fishes prompted the Gulf of Mexico Fishery Management Council (GMFMC) in 1995 to create a 20-fish aggregate recreational bag limit for reef fishes not covered by species-specific bag limits (GMFMC 1995). Most recently, the GMFMC introduced a 305 mm total length (TL) size limit for gray triggerfish (GMFMC 1999).

Traditionally, fisheries management measures such as size limits, fishing quotas, and seasonal closures have been used by managers in the southeastern U.S. and GOM to limit fishing mortality on reef fish resources; however, protected size ranges or species may incur incidental mortality due to hooking and release while fishers target legal-sized fish or other species (Collins et al. 1999, Gitschlag and Renaud 1994, Schirripa and Goodyear 1994). High rates of incidental catch coupled with high release mortality rates can negate potential gains of conservation measures (Goodyear 1995, Murphy et al. 1995, Schirripa and Goodyear 1994). As part of tagging studies conducted in the northern GOM off the coast of Alabama, we indirectly estimated release mortality of tagged red snapper and gray triggerfish based upon visual assessment of their condition at the surface following release. The need for further validation of our approach is discussed, as well as its potential use for estimating release mortality through fishery observer programs.

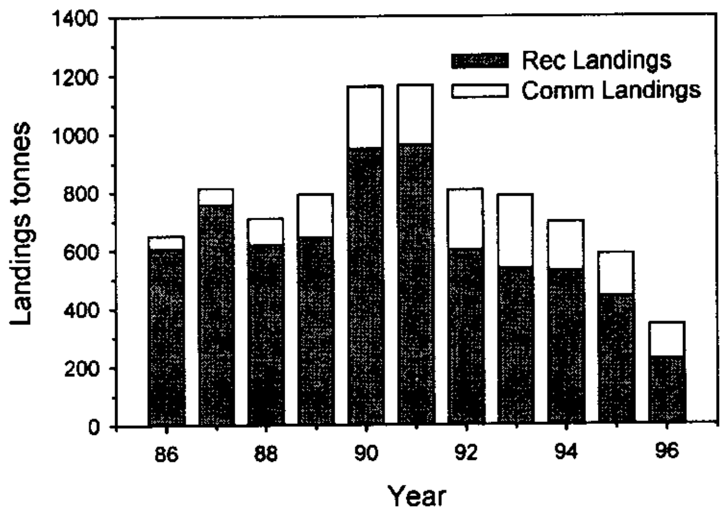

Figure 2. Reported U.S. GOM recreational and commercial landings of gray triggerfish from 1986 to 1996. (Source of data: Skip Lazauski, Alabama Department of Conservation, Marine Resources Division, Gulf Shores, AL 36524)

METHODS

Red snapper and gray triggerfish were tagged and released over reef sites off the coast of Alabama during two separate tagging studies. Red snapper were tagged over nine artificial reef sites on 28 tagging trips from March 1995 to July 1998 (Figure 3). Three sites each were located at water depths of 21, 27, and 32 m. Gray triggerfish were tagged over two natural hardbottom sites on 24 tagging trips from July 1997 to March 2000 (Figure 3). Gray triggerfish tagging sites were located at water depths of 24 and 35 m.

Tagging trips were made aboard a chartered fishing boat and methods were the same for each study except where noted below. Fish were captured over reef sites with rod and reel fished with straight-shank barbed hooks (3/0 size for red snapper and 1/0 size for gray triggerfish). Once hooked, fish were retrieved slowly from the bottom (approximate rate = 0.5 m/s) and placed in holding tanks with running seawater. Individuals were measured (TL and fork length (FL)) and then tagged by inserting an internal anchor tag through a small (< 5mm) incision made with a scalpel in the abdominal cavity. Tags were yellow Floy FM-89 anchor tags and each was marked with a tag number, the word "reward," and a phone number for fishers to report tag recoveries. In each study, a $5 reward was offered for tag returns, with a chance to win $500 in a drawing of tag returners.

Once tagged, red snapper were either released immediately overboard or transported (up to 0.5 hours) in holding tanks to other tagging sites for release. All gray triggerfish were released over their site of capture. Condition of tagged fish was assessed visually based upon their swimming behavior at the surface (Table 2). The effect of fish size, season of capture (winter, spring, summer, fall), depth of capture, and transportation prior to release on red snapper release condition was tested with logistic regression (SAS, Inc. 1996). In the model, fish released in condition-1 were coded as a one and fish released in other conditions were coded as zeroes.

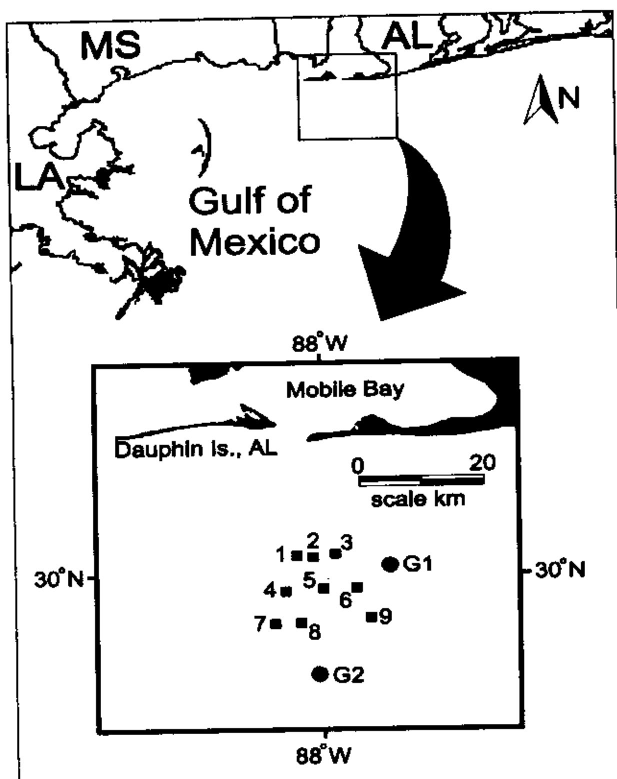

Figure 3. Map of region off the coast of Alam\bama where tagging studies were conducted. Red snapper tagging sites (labeled 1 - 9) and gray triggerfish tagging sites (labeled G1 and G2) are shown.

Tagged fish from both studies were recaptured at tagging sites on subsequent tagging trips and were reported by recreational and commercial fishers (through October 2000). The effect of release condition on red snapper recapture rate was tested with contingency table analysis (SAS, Inc. 1996).

Table 2. Release conditions for tagged red snapper and gray triggerfish.

Condition	Characteristics Displayed by Fish
1	Fish oriented toward the bottom and swam down vigorously.
2	Fish appeared disoriented upon entering the water, oriented toward the bottom, but swam erratically.
3	Fish appeared very disoriented upon entering the water and remained at the surface.
4	Fish was either dead or unresponsive upon entering the water.

RESULTS

Two thousand two hundred thirty-two red snapper were tagged; 879 were transported prior to release and 2,053 were not. Mean TL (± SE) of tagged individuals was 335.1 (± 1.34) mm. Overall, 86.5% of tagged red snapper were released in condition-1 (Table 3). The logistic regression computed on release condition was significant ($\chi^2_{d.f.=4}$ = 109.9, $p < 0.001$). Depth of capture ($\chi^2_{d.f.=1}$ = 15.95, $p < 0.001$), fish size ($\chi^2_{d.f.=1}$ = 8.52, $p = 0.004$), and transportation prior to release ($\chi^2_{d.f.=1}$ = 53.39, $p < 0.001$) all significantly affected whether tagged fish were released in condition-1; season was not significant ($\chi^2_{d.f.=1}$ = 1.20, $p = 0.273$). The probability that fish were released in condition-1 significantly decreased with increasing depth, transportation prior to release, and decreasing fish size. Five hundred ninety-four recaptures were made of 550 tagged red snapper (Table 4); 42 fish were recaptured twice and one fish was recaptured three times. Two hundred thirty-five recaptures were made on tagging trips and 359 recoveries were reported by fishers. Of the 550 recaptured individuals, 98.4% were released in condition-1 at tagging. Release condition significantly affected red snapper recapture rate (contingency table analysis: $\chi^2_{d.f.=3}$ = 74.3, $p < 0.001$).

Eight hundred forty-two gray triggerfish were tagged; 589 fish were tagged at the 24 m depth site (G1) and 253 were tagged at the 35 m depth site (G2). Mean FL (± SE) of tagged individuals was 297.1 (± 1.39) mm. Overall, 99.2% of gray triggerfish were released in condition-1. One fish in condition-2 and two fish in condition-3 were released at site G1, and one fish in condition-2 and three fish in condition-3 were released at site G2.

Table 3. Number and percentage of tagged red snapper released in condition-1

Transport	Depth of Capture Site 21 m	27 m	32 m	Overall in Condition-1
Fish Transported	91.1% (113 of 124)	79.8% (280 of 351)	74.0% (299 of 404)	78.7% (692 of 879)
Fish not Transported	91.1% (856 of 940)	91.1% (460 of 505)	87.0% (529 of 608)	89.9% (1,845 of 2,053)
Mean in Condition-1	91.1% (968 of 1,064)	86.4% (740 of 856)	81.8% (828 of 1,012)	86.5% (2,537 of 2,932)

Table 4. Number and percentage of tagged and recaptured red snapper released in each condition. Percentages are of total sample size (n = 2,932).

Red Snapper Release Condition	Tagged Red Snapper not Recaptured	Recaptured Red Snapper	Total
1	1,996 68.1%	541 18.5%	2,537 86.6%
2	152 5.2%	5 0.17%	157 5.4%
3	134 4.6%	3 0.10%	137 4.7%
4	100 3.4%	1 0.03%	101 3.3%
Total	2,382 81.3%	550 18.7%	2,932 100.00%

One hundred ninety-six recaptures were made of 160 gray triggerfish . One hundred seventy-four recaptures were made on tagging trips and 22 recoveries were reported by fishers. Nineteen fish were recaptured twice, seven fish were recaptured three times, and one fish was recaptured four times. All recaptures were released at tagging in condition-1.

DISCUSSION

Release condition of gray triggerfish generally was assessed to be excellent, as most tagged fish disappeared from sight immediately upon entering the water. No statistical tests were performed on gray triggerfish condition because nearly all fish were released in condition-1, and 100% of recaptured individuals were released in condition-1. The high return rate at tagging sites infers that gray triggerfish display high site fidelity. Moreover, multiple recaptures of some individuals provide further evidence that capture and release, as well as tagging, did not significantly affect the apparent health of gray triggerfish.

For red snapper, condition at release was significantly lower for fish transported prior to release. While it is unlikely that commercial and recreational fishers would transport fish prior to releasing them, this result illustrates that increased handling of fish decreased their condition. That release condition was significantly lower for smaller fish has important implications for size limits that are designed to protect young fish from fishing mortality. This result suggests that small fish may be more vulnerable to release mortality than larger fish; however, Gitschlag and Renaud (1994) reported there was no significant difference in red snapper release mortality estimates between fish smaller and larger than 30 cm TL. Lastly, decreasing release condition with increasing depth reflects trends in release mortality reported by Gitschlag and Renaud (1994) for red snapper and by Wilson and Burns (1996) for red grouper and scamp (*Mycteroperca phenax*).

Gitschlag and Renaud (1994) reported that estimates of red snapper release mortality rates inferred from the condition of released fish at the surface were similar to mortality estimates from *in situ* caging experiments conducted at similar depths. They and Render and Wilson (1994) reported that most of the mortality suffered by red snapper held in cages or laboratory tanks occurred soon after capture. Render and Wilson (1994) also reported there was no significant difference in mortality between tagged and untagged individuals. Szedlmayer and Shipp (1994) held 30 tagged red snapper in laboratory tanks for six months with no mortality or signs of infection, implying individuals that did not suffer acute tagging mortality (i.e., fish released in condition-1) likely would not suffer chronic injuries leading to death. Patterson et al. (in review) reported that fish tagged in the present study grew at similar rates as otolith-aged individuals, which also implies no chronic effects of tagging.

Based on these studies, and the fact that nearly all recaptures of tagged red snapper in the present study were of fish released in condition-1, we hypothesize that the cumulative percentage of tagged fish released in conditions other condition-1 may serve as a conservative (indirect) estimate of release mortality. Following this logic, estimated release mortality for gray triggerfish would be less than 1%. Overall, estimated release mortality for tagged red snapper would be 13.5%, which is within the range of release mortality estimates reported from previous studies.

Render and Wilson (1994) reported an overall release mortality rate of 20% for red snapper caught off Louisiana. Gitschlag and Renaud (1994) presented data from several studies of red snapper release mortality, and mean mortality rate (± SE) was 14% (± 4.5) for studies (n = 7) that were conducted at depths similar to the present study.

Our results, as well as those of Gitschlag and Renaud (1994), indicate that release condition of fish at the surface may serve as proxy for release mortality. Controlled experiments are needed, however, to validate that release condition of individual fish correlates to release mortality, especially over greater depth and fish size ranges than those of the present study. In particular, the likelihood of survival for fish that appear in poor condition at release and the likelihood of mortality for fish that appear healthy need to be examined.

Accurate estimation of discard rates and release morality rates is critical to fishery managers that must consider the effect of release mortality on stock-specific production while attempting to maximize yield per recruit (Goodyear 1995, Schirripa and Goodyear 1994). If it can be shown that release condition accurately approximates survival potential of individual fish, then the approach presented here may have broader applications for indirectly estimating release mortality. For example, observer programs could be established to estimate discard rates and release mortality of fish caught incidentally and released by recreational and/or commercial fishers.

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