the Shellcracker

FLORIDA CHAPTER OF THE AMERICAN FISHERIES SOCIETY http://www.sdafs.org/flafs

July, 2014

President's Message:

Greetings from St. Petersburg! It is the season of fish slime and sunscreen here in Florida. Keep your eyes peeled for the soon-to–be-released tourism department slogan, 'Come for the ultraviolet spectrum stay for the fishing associated mucus'. It is the time for summer sampling and summer vacations. I know that many of us stay pretty busy during the summer but we need to make sure to take some time for family and friends. Hectic schedules can make us appreciate the moments that we share with those who are important to us; you can also show people from out of state just how warm it gets here. Hurricane season also influences a lot of which we do outdoors in Florida during this time of year. It seems odd but hurricanes can provide an opportunity to break from what is planned and experience new and random things.

Our student subunit has received the AFS Outstanding Student Sub-unit Award for 2014. They submitted an application detailing their many activities: a collaborative research paper, a great blog called "From Reefs to Rivers" (http://floridafisheriesscience.blogspot.com/), creating science videos, outreach to schools, and much more. The EXCOM and I are so very proud of all that they had accomplished. The subunit will receive the award at the Quebec City Annual Meeting in August.

The next Florida Chapter Meeting has been scheduled for February 17th – 19th, 2015. Our president-elect, Dr. Jennifer Rehage, is preparing a great symposium on interactions between fisheries-dependent and independent monitoring. The first call for papers and more information about the meeting will be in the October issue of the Shellcracker, but feel free to contact Jennifer rehagej@fiu.edu or myself if you have any questions.

A reminder that the upcoming joint AFS and TWS meeting is on the horizon in 2017. There will be plenty of work coming up and we will need all the support that we can get from you all. If you are interested in being involved in this process or taking a leadership role, please contact me at Chris.Bradshaw@myfwc.com or Kerry Kerry.Flaherty@myfwc.com.

Sincerely,

Chris Bradshaw
Florida Chapter President

Getting in Touch

American Fisheries Society
Florida Chapter
Officers

President
Chris Bradshaw
FWC/FWRI
100 8th Avenue SE
St. Petersburg, FL 33701
Phone: (727) 502-4717
Email: chris.bradshaw@MyFWC.com

President-Elect
Jennifer Rehage
Florida International University
11200 SW 8th Street, ECS 337
Miami, FL 33199
Phone: (305) 348-3804
Email: rehagej@fiu.edu

Secretary/Treasurer
Cheree Steward
FWC/FWRI
601 W. Woodward Ave.
Eustis, FL 32726
Phone: (352) 357-2398 ext. 244
Email: cheree.steward@myfwc.com

Newsletter Editor
Chris Wiley
FWC/DFFM
3900 Drane Field Road
Lakeland, FL 33811
Phone: (864) 648-3810
Email: chris.wiley@myfwc.com

Past President
Travis Tuten
FWC/FWRI
7922 N.W. 71st Street
Gainesville, FL 32653
Phone: (352) 955-3220 ext. 113
Email: travis.tuten@myfwc.com

American Fisheries Society
Florida Chapter
Student Sub-Unit
Officers

President
Ross Boucek
Florida International University
11200 SW 8th Street ECS 119
Miami, FL 33199
Phone: (239) 272-2771
Email: rbouc003@fiu.edu

Vice President
Chelsey Crandall
University of Florida
7922 NW 71st Street
Gainesville, FL 32653
Phone: (352) 392-9981
Email: kicksea@ufl.edu

Treasurer
Crystal Hartman
University of Florida
7922 NW 71st Street
Gainesville, FL 32641
Phone: (352)-215-3719
Email: c.hartman@ufl.edu

Check out our Parent Society's calendar at http://www.fisheries.org/calendar for other events not listed here!

Interested in contributing something to the Shellcracker? Email Chris Wiley at *chris.wiley@myfwc,com* with any articles or information that you would like to be included in the next issue. The deadline for the next issue is September 30th, 2014, so start fishing...

Condition and Estimated Survival of Reef Fishes Discarded Within a Recreational Fishery in the Gulf of Mexico*

Beverly Sauls

Fish and Wildlife Research Institute, Florida Fish and Wildlife Conservation Commission, Saint Petersburg, FL

*Portions of this work were recently published as part of a Master's thesis to the University of South Florida and in *Fisheries Research*. Remaining portions are currently in preparation for peer review. For more information, contact the author at Beverly.Sauls@MyFWC.com.

The Gulf of Mexico supports large recreational fisheries, and effort is highly concentrated off the western coast of Florida (Coleman et al. 2004, Hanson and Sauls 2011). In response to stock declines in the Gulf of Mexico, size limits have been increased, bag limits have been reduced, and the length of recreational fishing seasons have been adjusted in an effort to keep recreational harvest levels within management targets. This has translated into a growing portion of fish caught by recreational anglers that must be discarded. For every red snapper (*Lutjanus campechanus*), gag (*Mycteroperca microlepis*), and red grouper (*Epinephelus morio*) harvested by recreational anglers in the Gulf of Mexico during 2013, another 2.3, 5.6 and 6.0 fish, respectively, were estimated to be caught and released alive (personal communication, National Marine Fisheries Service, Fisheries Statistics Division, 6/11/14). The proportion of live discarded fish that suffer latent mortality is largely unknown, and stock assessments have relied on small-scale and controlled studies that often have limited applicability for estimating total removals in diverse fisheries (Campbell et al. in press).

This study addresses the need for methods to collect fisheries-dependent catch data that takes into account the fundamental shift from harvest to largely catch-and-release fishing, and directly measures the condition and survival of regulatory discards in situ (within the recreational fishery). The approach was to develop new survey methods that better characterize recreational fisheries so that stock assessments for important managed species may better quantify total removals, particularly with regards to discards. We actively engaged participants in the recreational hook-and-line fishery operating from the west coast of Florida in the collection of this data. Primary objectives were 1) to collect high resolution data on the depths and areas fished and the species composition, size distribution, and release condition of live discards; and 2) to develop a predictive model for survival of released reef fishes that may be applied to fisheries-dependent estimates of numbers of discards.

Methods

From June 2009 through December 2013, fishery observers accompanied passengers on fishing vessels in Florida that offer for-hire recreational fishing trips to target reef fishes in the eastern Gulf of Mexico. For-hire vessels include large party vessels, termed headboats, and charter boats that cater to smaller private fishing parties. Operators of more than 160 vessels voluntarily participated in this study. Vessels were randomly selected year-round for observer coverage from each of three regions (Figure 1).

Monthly sample quotas were assigned to single day charter trips and single day headboat trips in areas A and B, and multi-day (>24 hour) headboat trips in area C. Area D contained a small number of boats that infrequently target reef fishes offshore, and observers were able to conduct a small number of randomly sampled trips in this region.

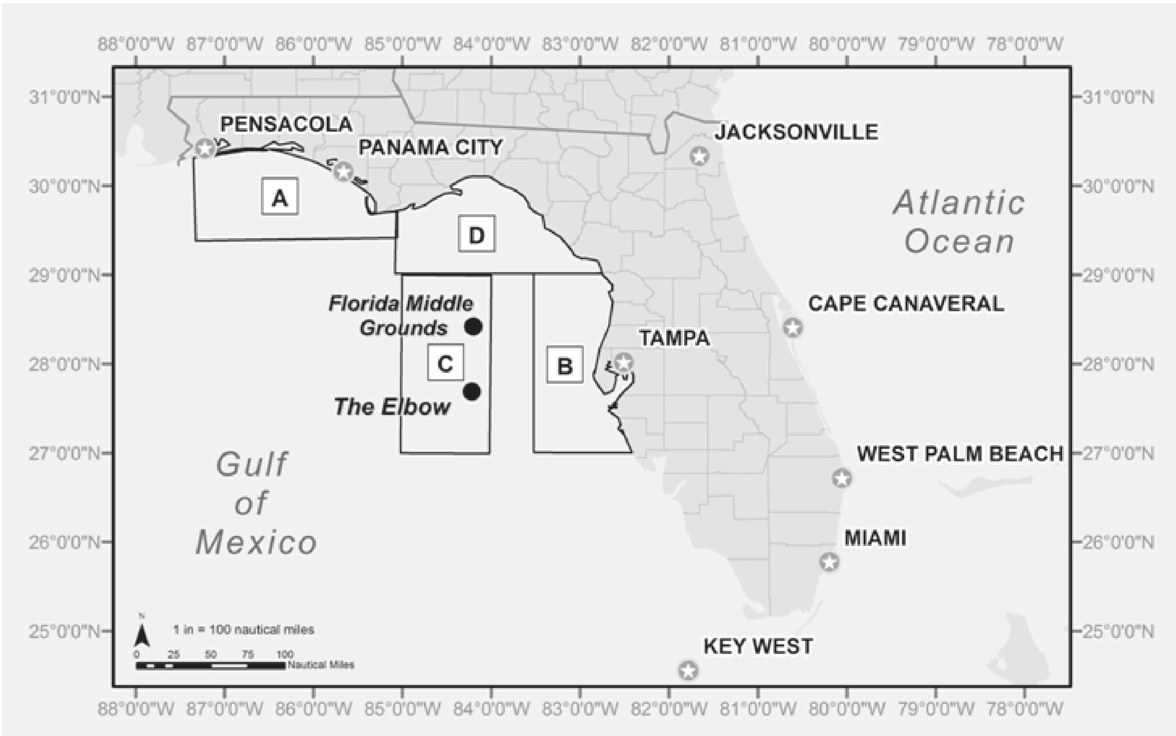

Figure 1. Study areas in the Gulf of Mexico. Box A represents the area where near-shore trips originating from the northwest panhandle region (NW) took place, Box B represents the area where near-shore trips originating from the Tampa Bay region (TB) took place, Box C represents the area where multi-day trips originating from the Tampa Bay region (TB) took place. Box D is the Big Bend region (BB) where only a small number of trips were sampled.

During a sampled trip, the captain provided the bottom depth and fishing location to the observer each time a vessel moved to a new fishing location and FWC biologists observed all fishing activity at each location. For headboats carrying a large number of passengers, a sub-sample of anglers was selected for observation. As passengers fished with recreational hook-and-line gear, observers recorded the species, length (midline), and whether the fish was harvested or discarded for each fish caught. For species in the Gulf of Mexico reef fish management group, observers also recorded hook location (lip, mouth, gill, throat, gut, eye, or external snag), barotrauma symptoms (none, bulging eyes, everted stomach, everted intestines), venting method used (not vented, swim bladder punctured with venting tool, stomach punctured, other), and release condition at surface (good, fish swam away immediately; fair, fish disoriented and slowly swam away; poor, fish alive and floating at surface; dead; eaten by predator). For red snapper, red grouper, gag, scamp (M. phenax), vermilion snapper (Rhomboplites aurorubens) and gray triggerfish (Balistes capriscus), observers marked fish with a conventional Hallprint plastic-tipped dart tag prior to release. Each tag had an external monofilament streamer labeled with a unique tag number, a toll-free phone number, and the word "REWARD". Recaptured fish may be reported to FWC's tag return hotline 24 hours a day and seven days a week, and a t-shirt with the phrase, "I caught a tagged reef fish" and an artist's image of a red snapper (courtesy of Diane Rome Peebles) was mailed to all respondents.

Tag-recapture percentages for conventional tag studies typically are low (10% or less); therefore, to improve recapture sample sizes additional fish were tagged from charter vessels hired by FWC in areas A and D (Figure 1) during the months of March through May in 2010–2013. Red snapper were targeted for capture, tagging, and release using recreational hook-and-line gear supplied by the vessel. Gag, red grouper, scamp, gray triggerfish and vermilion snapper caught during these trips were also tagged and released. Captains were only asked to target red snapper and were given no on where to fish or how to target fishing. Data collected during these trips was identical to data collected during randomly sampled recreational fishing trips on charter boats and headboats.

All live discards were assigned to one of three release condition categories (Table 1). To evaluate the timing and occurrence of recapture events among individual fish released in condition categories 2 and 3 relative to condition category 1, the PHREG procedure in SAS was used to construct a proportional hazards model (methods described in Sauls 2013, 2014). The response variable was the number of days a fish was at large before it was either reported as a recapture (coded as 1) or censored (coded as 0) at the end of the study. The treatment tested was release condition category, which was included as an independent class variable in the proportional hazards model. Control variables were also necessary to remove the variable effects of fishing pressure and subsequent tag-recapture rates across the large temporal spatial scales encompassed in the study. Control variables tested for entry into the model included region, time of year (month and year that fish were initially tagged and released), capture depth (meters), size at original capture (mm midline length), and possible interaction terms.

Table 1. Description of live release condition categories for reef fishes observed during recreational hook-and-line fishing.

Condition Category	Description
1. Not impaired, not vented	Fish immediately submerged without the assistance of venting and did not suffer internal hook injuries or visible injury to the gills.
2. Not impaired, vented	Fish was vented first and submerged immediately, and did not suffer internal hook injuries or visible injury to the gills.
3. Impaired	Fish was either initially disoriented before it submerged or remained floating at the surface (regardless of whether it was vented), suffered internal hook injuries, suffered visible injury to the gills, or any combination of the three impairments.

To estimate depth-dependent discard mortality, the number of live discards observed in conditions 1, 2 and 3 (N1, N2, and N3, respectively) at each 10-meter depth interval (e.g., where d = 1–10 meters, 11–20 meters) was first multiplied by the proportion of fish in each condition category estimated to survive. Discard mortality at each depth interval (Md) was expressed as a percentage using the equation:

$$Md = [1 - (N1*S1 + N2*2 + N3*3) / (N1 + N2 + N3)] * 100 \qquad (1)$$

where S1 is the absolute survival following catch-and-release for fish released in good condition (which is not truly known), and H2 and H3 are the estimated survival proportions for fish released in condition categories 2 and 3 (respectively), relative to fish released in condition category 1, derived from the proportional hazards model.

Because fish had to be captured in order to be tagged and released, there was no true control to reference the condition category 1 treatment group to. The majority of fish released in category 1 were caught from shallow depths, and individuals with hook injuries, visible gill injuries, potential internal injuries related to venting, or swimming impairments at the surface were excluded from this group. Therefore, it is reasonable to assume that discard mortality in this treatment was minimal. For this analysis, overall depth-dependent discard mortality was calculated separately under three assumptions for S1: 1) a maximum of 100% released in good condition survive (S1 = 1.000); 2) a minimum of 85% survive (S1 = 0.850); and 3) a median of 92.5% survive (S1 = 0.925). For the median assumption, uncertainty around overall discard mortality estimates for each depth interval was calculated by substituting S1 in equation 1 with the minimum and maximum assumed values of 0.85 and 1.0, and substituting point estimates for H2 and H3 in equation 1 with lower and upper 95% confidence limits for H2 and H3.

To estimate overall discard mortality across all depths, samples from single-day and multi-day trips were first weighted proportional to total fishing effort, and numbers of fish in each release condition category observed at each 10 meter depth interval were then summed. Weighted sums were multiplied by the point estimate for discard mortality (as well as the upper and lower confidence limits) at each depth interval (Md) to predict the number of discards observed at each depth that suffered latent mortality. Lastly, the total number of observed discards estimated to suffer mortality across all depths was divided by the total number of observed discards.

Results

More than 1,000 headboat and charter boat trips were randomly sampled over the course of this study, in addition to 72 directed red snapper tagging trips. The majority of red snapper discards were observed from fishing depths between 21 meters and 40 meters and re-submerged immediately with no visible impairments, though a large portion were vented prior to release (Figure 2). The majority of red snapper were tagged in the NW region, where the species is more abundant and accessible deep water is more accessible to single-day recreational fishing trips; whereas, the majority of red snapper tagged in the TB region were encountered during multi-day trips. A large proportion of gag and red grouper were caught from depths less than 21 meters, which is attributed to the fact that the majority were observed in the shallower nearshore TB region where both species are most abundant. Most gag and red grouper that re-submerged without impairments were not vented; however, the portion that was vented increased with increased capture depths. Almost all red snapper discards were observed either in the NW region or during multi-day trips in the TB region, which explains the deeper depths from which these discards were observed, and may also explain the higher incidence of venting for this species.

Recapture percentages varied among species and region, but where good numbers of fish were tagged in each category the overall trend was for higher recapture percentages from condition category 1 and decreasing percentages from categories 2 and 3, respectively, (Table 2). Red snapper, gag and red grouper all had sufficient numbers of tag and recapture observations across regions and years to evaluate relative survival among release condition groups. The effect of release condition was significant for all three species after controlling for covariates on recapture reporting rates (red snapper $\chi 2=96.2$, $p<0.0001$; red grouper $\chi 2=27.0$, $p<0.0001$; gag $\chi 2=6.5$, $p=0.039$). For all three species, fish which are able to submerge immediately without the assistance of venting (condition 1) survive at higher rates compared to fish in condition categories 2 and 3 (hazard ratios for condition 2 vs. condition 1 and condition 3 vs. 1 were less than 1.0, and 95% confidence intervals did not overlap with 1.0). Sample sizes for red snapper and red grouper were also sufficient to detect relative survivals that were significantly lower for impaired fish compared to fish that were vented (condition 3 versus condition 2), suggesting that venting may at least assist with re-submergence when fish do not have internal hook or gill injuries that may otherwise reduce their survival.

Table 2. Number (and percent) of tagged discards that were recaptured in each release condition category.

		NW	TB, nearshore	TB, off-shore	BB
Red Snapper	Numbers of fish recaptured:				
	Condition 1 (%)	791 (13.1)	1 (2.9)	13 (8.7)	13 (20.0)
	Condition 2 (%)	893 (9.8)	2 (3.6)	40 (7.8)	3 (5.6)
	Condition 3 (%)	131 (6.5)	0	12 (5.4)	2 (8.3)
Gag	Numbers of fish recaptured:				
	Condition 1 (%)	50 (16.7)	250 (10.0)	24 (13.3)	10 (6.8)
	Condition 2 (%)	48 (14.3)	5 (6.1)	28 (9.8)	0
	Condition 3 (%)	8 (17.4)	3 (3.6)	3 (4.3)	0
Red Grouper	Numbers of fish recaptured:				
	Condition 1 (%)	11 (7.5)	1,147 (13.1)	90 (19.6)	36 (14.1)
	Condition 2 (%)	33 (12.6)	44 (7.6)	154 (17.5)	0
	Condition 3 (%)	1 (1.9)	54 (8.5)	28 (11.8)	1 (6.3)

Estimated discard mortality increased with depth of capture for red snapper, gag and red grouper (Figure 3). When point estimates were regressed against median values for 10 meter depth intervals (x = 5m, 15m… n), there was a significant positive linear relationship (alpha 0.05) that explained 80% or more of variation (Figure 3). This functional relationship between depth of capture and survival may be applied broadly to any recreational hook-and-line fishery within the region for which proportions of discards captured from various depths is known. Overall discard mortality for the charter and headboat fisheries was estimated across all depths by calculating the proportions of fish discarded at various depths, weighted proportional to fishing effort among single-day and multi-day trip types. Overall mortality was highest for red snapper and point estimates ranged from 23.7% to 27.4%. Point estimates ranged between 9.6% and 18.5% for gag, and 9.7% and 14.5% for red grouper. Larger sample sizes are needed before relative survivals can be evaluated for gray triggerfish, vermilion snapper and scamp. Tag-return sample sizes for impaired fish were also too low to discern whether reduced survival was related to hook injury, gill injury, difficulty re-submerging, or a combination of factors for any species.

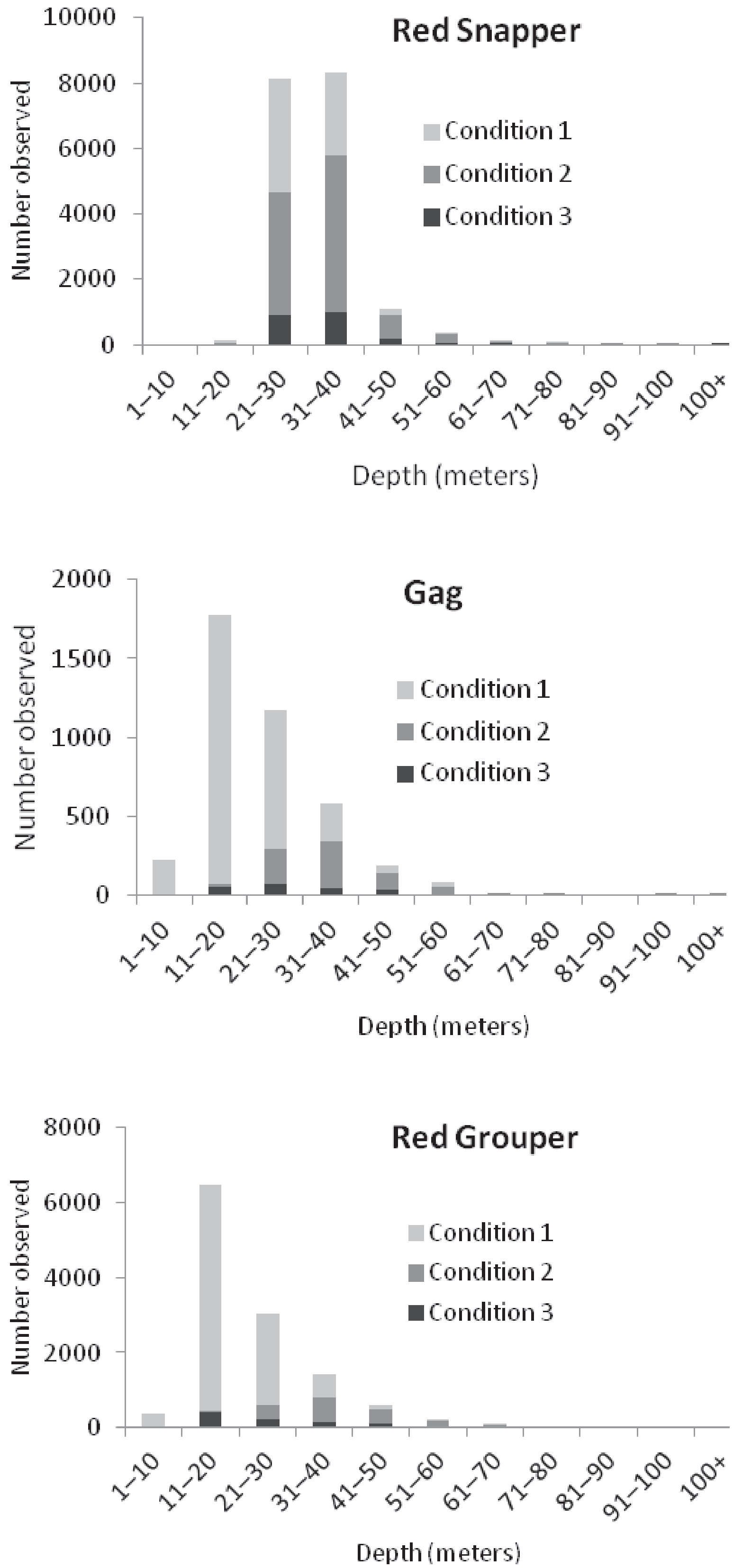

Figure 2. Numbers of discards observed in each depth interval by release condition category for red snapper, gags, and red grouper.

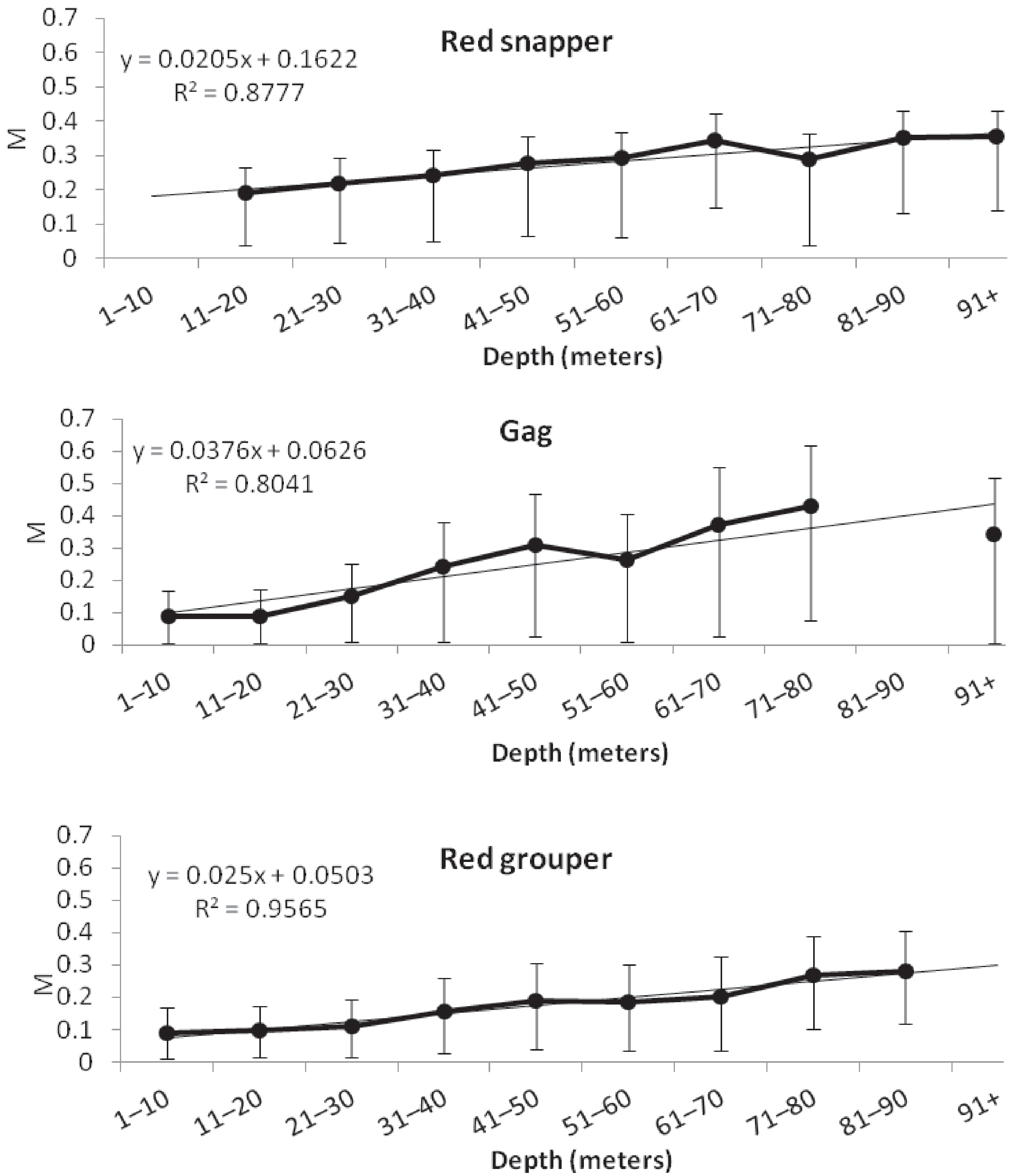

Figure 3. Estimated proportions of live discards from each depth interval that suffered mortality based on observed release conditions.

Conclusions

The results from this study indicate there are several key differences between regions and among trip types that should be accounted for when applying discard mortality rates to the reef fish fishery as a whole. First, regional differences in accessibility to deep water and the relative proportion of trips that take place at varied depths within each region should be considered when applying depth-dependent discard mortality rates. Exposure studies indicate that mortality for various reef fishes is low at shallow depths (<20m), increases to between 20% - 40% (depending on the species) at capture depths below a threshold between 30 or 40 meters, and increases to higher percentages in deeper depths (Wilson and Burns, 1996; Rummer, 2007; Rummer and Bennet, 2005; Rudershausen et al., 2014). Results reported herein also support this conclusion. In the TB region, the majority of trips take place in mean depths <20m, and most fishing effort in the NW region takes place in mean depths of 40 meters or less. Multi-day trips take place in deeper depths that are above the threshold for high mortality rates; however, these trips account for less than 3% of total fishing effort. Consequently, understanding where and how recreational fisheries operate is critical when assessing catch-and-release mortality. If this information is known, functional relationships between depth of capture and discard mortality described by studies such as this one may be applied appropriately to other recreational hook-and-line fisheries. FWC will continue to tag reef fishes and collect reported tag-returns so that these analyses may be updated as more data become available.

Acknowledgments

This work would not have been possible without support and assistance from the for-hire fishing industry in Florida and numerous recreational anglers who allowed biologists to observe their fish and reported tag recaptures. This work benefited from discussions and collaborations with numerous people at various stages, including various participants at Southeast Data, Assessment and Review (SEDAR) data workshops, where the ideas for this work were born and methods and results vetted. Thanks to J. Taylor, K. Frantz, K. Mesner and the rest of the staff who help man the FWC Tag Return Hotline. O. Ayala, C. Bradshaw, J. Wolfson, N. Goddard, C. Berry, R. Netro, S. Freed, T. Menzel and K. Morgan conducted field work and were integral in establishing cooperative relationships with the for-hire industry, their clients, and the public. B. Cermak, S. DeMay, C. Bradshaw and O. Ayala developed and managed databases. R. Cody provided administrative oversight, and L. Davis and V. Muir assisted with administrative support. M. Tran assisted with data entry and mail-outs. K. Fitzpatrick and K. Brennan provided a portion of data used in analyses. This work was funded by grants received through National Marine Fisheries Service (Ref: NA09NMF4540140; NA09NMF4720265; NA07NMF4540373/GSMFC sub-award # ACF-025-2007-06).

References

Campbell, M., W. Driggers, B. Sauls, J. Walter. In press. Release mortality in the red snapper fishery: a meta-analysis of three decades of research. Fisheries Bulletin.

Coleman, F., Figueira, W., Ueland, J., Crowder, L., 2004. The impact of United States recreational fisheries on marine populations. Science 305, 1958–1960.

Hanson, C., Sauls B., 2011. Status of recreational saltwater fishing in Florida: characterization of license sales, participation, and fishing effort. Am. Fish. Soc. Symp. 75, 355–365.

Rudershausen, P.J., J.A. Buckel and J.E. Hightower. 2014. Estimating reef fish discard mortality using sur face and bottom tagging: effects of hook injury and barotraumas. Canadian Journal of Fisheries and Aquatic Sciences 0(0): 1-7, e-first article 10.1139/cjfas-2013-0337.

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. Amer. Fish. Soc. Symp. 60: 123-144.

Rummer, J.L. and W.A. Bennett. 2005. Physiological effects of swim bladder overexpansion and catastrophic decompression on red snapper. Trans. Amer. Fish. Soc. 134: 1457-1470.

Sauls, B. 2013. Relative survival of gags Mycteroperca microlepis released within a recreational hook-and-l ine fishery: application of the Cox regression model to control for heterogeneity in a large-scale mark-recapture study. Master's Thesis presented to University of South Florida, Department of Marine Science, Marine Resource Assessment Program. Accessed 6/11/14 at: http://pqdtopen.proquest.com/pqdtopen/doc/1474904021.html?FMT=ABS

Sauls, B. 2014. Relative survival of gags Mycteroperca microlepis released within a recreational hook-and-line fishery: application of the Cox regression model to control for heterogeneity in a large-scale mark-recapture study. Fisheries Research 150: 18-27.

Wilson, R., Burns, K.M., 1996. Potential survival of released groupers caught deeper than 40m based on shipboard and in-situ observations, and mark-recapture data. Bull. Mar. Sci. 58, 234–247.

Student Section

Student Research Highlight

Coral reefs, landscapes of fear and pollution? Studies from the Medina Aquarius Underwater Research Lab!

Adam Zenone and Andy Shantz
Florida International University

Nine miles offshore of Key Largo, Florida, nestled next to Conch reef in 63 feet of water, remains the world's only underwater research habitat, the Medina Aquarius. As graduate students at FIU, Ph.D. candidate Andrew Shantz and I have had the opportunity to utilize the habitat for research into coral reefs that could only be conducted on a saturation dive. Unlike normal diving, saturation diving allows for us to spend 6-8 hours diving up to a depth of 95 feet. With this incredible gift of time we are able to ask questions about corals and their associated fish communities that could not be answered with field work from the surface. We will go into some detail shortly on these questions, however it might be useful to get an idea of what life on the Aquarius is like as a researcher.

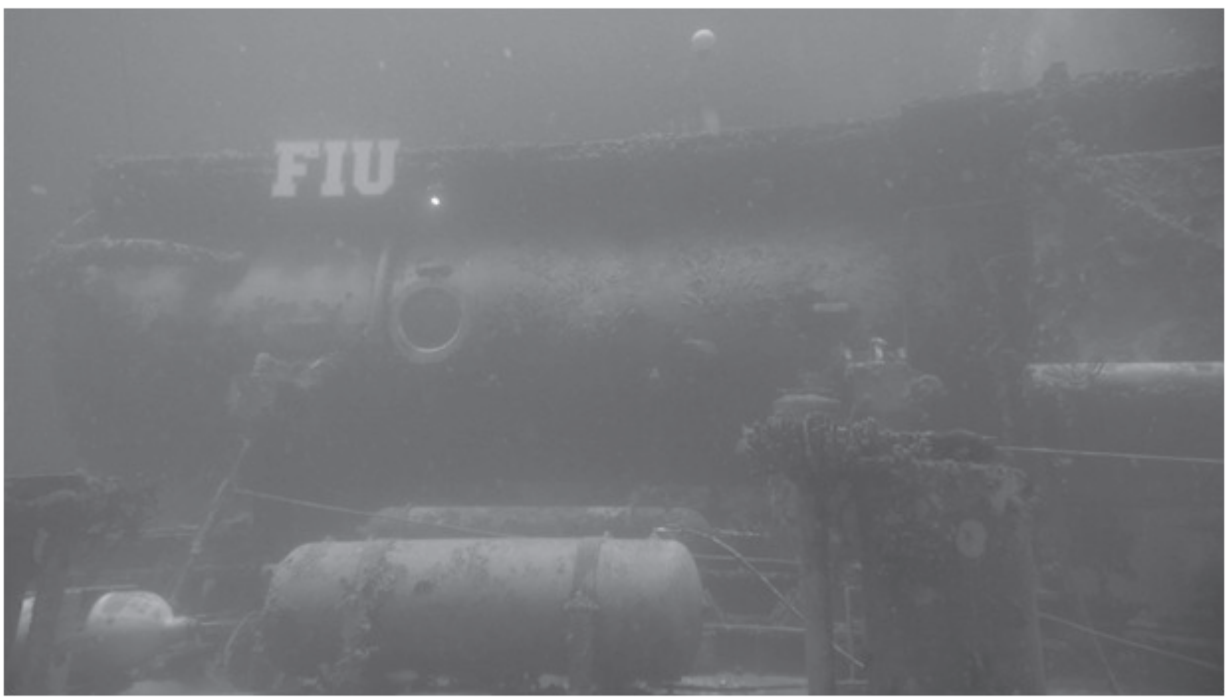

Figure 1- The Medina Aquarius underwater research station.

Our field days begin at 5 am and we are in the water before the sun rises at 6, usually we are joined at the galley viewport for breakfast by a resident Goliath grouper named Sylvia. Our morning dives are completed on a Kirby Morgan hard-hat connected to the habitat by an umbilical, allowing for an unlimited supply of air and communications with the base and other researchers. After spending several hours in the water, we return for breakfast.

We are not allowed open flames, and so just as in camping, most of our diet consists of freeze-dried foods cooked with hot water from the tap. Still not the worst stuff I've ever eaten in the field! Our afternoon dives are two cylinder SCUBA dives and can run an additional three hours. Fortunately for our work, refilling tanks is as simple as plugging a fill whip into the habitat and we can get right back out to our sites. For the next several hours, we enter data, and prepare our samples for the next day's deployment before our night dive. Our final dive of the day is also on umbilical, and usually ends around 9:30 or 10 PM. Ear drops in, bed time, and then we repeat the process! While it's a fairly rigorous schedule, at any moment we could look out the viewport and witness a seemingly endless number of new behaviors and fish interactions. With an idea of what it's like to live 60 feet underwater, it would be useful to go into some detail as to why we actually went down to Aquarius.

Figure 2 - Graduate students Andy Shantz (right) and Adam Zenone (left) prepare for an afternoon dive.

Coral reefs are one of the most unique and diverse landscapes on the planet. Although covering only ~0.3% of the world's oceans, these biological habitats house over 25% of the species of marine fishes on the planet. Annually, reefs provide protein that supports roughly 10% of the world's population and generate goods and services valued at as much as $375 billion per year. Despite their importance, coral reefs are in peril. Human impacts such as overfishing, nutrient pollution and climate change have caused the loss of over 25% of the planet's reefs in the last two decades. With such alarming declines, scientists fear that these fragile habitats may be the first ecosystem in recorded history driven to extinction by human activities.

Overfishing is frequently regarded as one of the greatest threats to the health of coral reefs. Healthy stocks of algae eating fishes crop algae on reefs and recycle nutrients to keep reefs in coral dominated states. While it is becoming increasingly well known that overfishing of herbivorous fishes can instigate shifts from coral- to algae-dominated reefs, we currently still do not understand the role large predatory fishes play in maintaining healthy coral reefs.

Worldwide, large predators such as grouper are often heavily targeted by fisherman for both food and sport. In many environments, the loss of such large predators can trigger drastic changes in the environment. Predators not only impact the environment through the consumption of prey species, but can have indirect effects that far exceed the body count of the prey consumed. For example, the reintroduction of wolves into Yellowstone National Park has initiated an environmental recovery that goes far beyond the wolves and elk that they eat. Rather than direct mortality, the fear of being eaten has driven elk to change the areas where they forage, allowing for the recovery of the parks previously declining aspen trees. From grazing herds and lions in the savannahs of Africa to snails and crabs along the shores of the Northern Atlantic these "landscapes of fear" that predators can create have been shown to regulate the feeding grounds of a myriad of animals across the planet. However, the effects of large predators on coral reefs are as of yet unknown.

Figure 3—A decoy grouper overlooks a treatment of seagrass.

To investigate how predators shape the behavior of reef fishes, the first portion of our research will utilize model predators and cutting edge hydro-acoustic technology. We will be placing highly desirable food sources (seagrass) across the reef in the presence and absence of model Black Grouper, an important but depleted game fish. To monitor changes in the behavior and feeding patterns of resident herbivores, high resolution imaging sonars will continuously record fish behavior in the area. This data, coupled with detailed observations about food consumption, will allow us to understand how herbivorous fishes balance foraging decisions with the risk of predation and better understand the role of predators on reefs.

The second portion of our research focuses on the impact of pollution on the corals that form coral reefs. Over the last century, humans have drastically altered the amounts of nutrients such as nitrogen and phosphorus in the environment. In addition to stimulating the growth of harmful algae on reefs, these nutrients can have direct impacts on corals themselves, and pose a significant threat to coral health.

The tropical coral reefs that we see around the world arise from the symbiotic relationship between a group of coral-animals, known as anthozoans, and a group of algae, known as Symbiodinium. In this relationship the carnivorous corals capture and digest drifting food, providing nutrients such as nitrogen for protein synthesis to both the coral and the symbiotic algae living within the coral tissue. In exchange, the Symbiodinium carry out photosynthesis, transforming energy from the sun into sugars to provide energy for both partners. However, nutrient pollution may unbalance this delicate relationship. Just like fertilizing a garden causes plants to grow, excess nitrogen in the environment can stimulate Symbiodinium growth, changing patterns of photosynthesis, resource sharing, and the internal physiology of the coral.

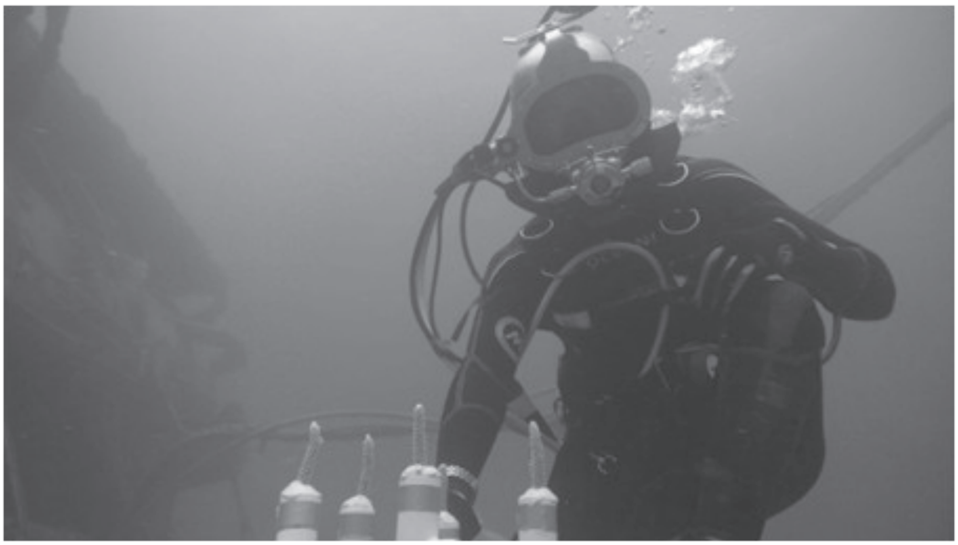

Figure 4 – Researcher Andy Shantz deploying his coral for nutrient treatments

Additional efforts will investigate these nutrient-induced changes in important reef forming corals. From the Medina Aquarius Base, we will simulate nitrogen enrichment on a select group of study corals. These corals will be monitored with finely-tuned fluorescence meters and microsensor arrays to conduct round the clock assessments of the impact of nitrogen pollution on the health, physiology, and photobiology of these critically endangered coral species. The culmination of these research efforts will hopefully allow us to better understand the complex processes and pressures that exist on coral reefs, and ideally will inform sound management policies worldwide to protect this critically important ecosystem.

Adam Zenone is a master's student in Dr. Kevin Boswell's lab at FIU (http://www2.fiu.edu/~kmboswel/Site/Welcome.html)

Andy Shantz is a Ph.D. candidate in Dr. Deron Burkepile's lab at FIU (http://aashantz.weebly.com/)