Circle Hook Presentation

Slide 1. Dr. Karen Burns attended the NOAA sponsored International Circle Hook Symposium in Miami, FL on May 4-6, 2011.

SLIDE 2. In addition to presentations from researchers in the United States, scientists from 17 other nations gave presentations or presented posters.

SLIDE 3. Most of the presentations focused on the commercial long-line tuna fishery and on interactions between hooks and sea turtles. A few talks were on the use of circle hooks and recreational fisheries. Manuscripts from the presentations will be published in a Special Symposium Edition of the Bulletin of Marine Science.

SLIDE 4. The keynote address was given by Dr. Steven Cooke of Carleton University in Canada.

Dr. Cooke provided this slide that shows the number of studies using circle hooks conducted on various fish species. As you can see four of the groups are included in the effective and ineffective lists.

SLIDE 5. Presentations results were divided on the efficacy of circle hooks. The consensus was that it depends on many factors.

SLIDE 6. Another keynote speaker, Geir Sivertzen an executive of Mustad, Norway, also known as Dr. Hook provided definitions of J and circle hooks. He said the definition of a J hook is that the hook is in the shape of the letter J with the barb parallel to the shank. The definition of a circle hook is a hook where the barb is at a 90 degree angle to the shank. He also said that there were many hybrid circle hooks that were not true circle hooks. This can be confusing. One Australian researcher said he came all the way to Miami to find out that he was using one of these hybrid hooks, not a true circle hook. Additionally, he said that hook size is not standardized among manufactures. This may help to explain why two researchers conducted similar research using the same size circle hooks but had different results. If the researchers purchased their hooks from different manufactures, it is than likely they were using different hook sizes.

SLIDE 7. Another factor is ecomorphology. We group fish based on phylogeny. However, just because fish have a common progenitor, does not mean that they will react similarly to gear. Species of fishes within a family have evolved to fit within the niches in which they occur. A goliath grouper and red grouper mostly feed on invertebrates. After they are a year old, gag become piscivorous. Red grouper have low J hook mortality whereas gag have high J hook mortality. This is a result of differences in anatomy, physiology, and behavior.

SLIDE 8. Although fish mortality can result from the synergistic effect of a suite of factors, the focus of this research was to determine and compare effects of hook mortality on red grouper, a truly benthic species, and red snapper, a water column resident that often prefers vertical structure. Although these species occupy different niches, they often co-habitate off Florida and can be caught at the same sites with the same gear. The overall goal was to determine if both species reacted alike to identical conditions and gear by collecting traditional fisheries data and analyzing it in light of fish physiology, ecomorphology and behavior.

SLIDE 9. Both field and laboratory experiments were conducted to complement each other because of limitations of each approach. Field data provided information under real world conditions and fishing practices, but laboratory experiments helped to explain field results and increase understanding of fish/gear interactions. Various approaches were employed to determine the role hooks play in red grouper and red snapper mortality.

SLIDE 10: Necropsies were conducted on moribund fish caught aboard headboats to determine cause of death. Live fish of both species, caught off headboats, were brought back to the Lab to address latent mortality by holding the fish for a month to determine if any would die from internal hook trauma over time. . During this part of the study, red groupers were caught in shallow water (10-21m) so no damage attributable to barotrauma was apparent. Only 20% of red grouper acute mortalities were attributed to hook injuries. Research in deeper water and in fish hyperbaric chambers showed barotrauma to be a greater source of mortality for red grouper. Findings are supported by Bacheler and Buckel’s research off North Carolina, who found similar results. Red snappers were caught over a broader depth range of 10- 42 m but regardless of depth, hook mortality was the leading cause of death for red snapper. Necropsy results from headboat -client caught fish showed red snapper suffered the greatest acute J hook trauma (49.1%), almost equaling all other sources (50.9%) of red snapper mortality combined. Other sources included heat stress, handling, improper venting, and undetermined causes.

SLIDE 11: Although red grouper can be gut hooked, they are commonly jaw hooked. That results in low hook mortality.

SLIDE 12: Red snapper J hook mortality increased with depth.

SLIDE 13: Moribund fish captured by headboat clients were necropsied in the Lab. Red snapper J hook acute mortality was high and trauma included lacerations to internal viscera, gills, esophagus, and in several cases, organs were macerated. In all cases, blood loss was severe.

Some apparently healthy red snappers caught by clients aboard headboats, brought to the lab and held in large experimental tanks died from latent hook mortality 5 days after capture. Necropsies revealed that latent mortality occurred when J hooks nicked a vital organ, rather than puncturing it as in acute cases. Laboratory held red snapper looked, fed and behaved normally for 2 days before showing increasing signs of trauma as blood from nicked organs filled the body cavity drop by drop. As with acute hook mortality, red snapper latent hook mortality at 29% was much higher relative to red grouper at 7%.

SLIDE 14. An experimental design was integrated into an ongoing fish tagging program to test the effects of circle and J hook types on fish survival. Based on poll results of fishers participating in the tagging study, the circle hook used was a 4/0 Eagle Claw zero offset circle hook. Fish were tagged using plastic dart tags and released by researchers, student interns, and volunteers. Most tagging data were collected from private recreational and recreational-for-hire vessels. The study area covered the South Atlantic off the Florida east coast and the Gulf of Mexico with greatest coverage from Southwest Florida to the Florida panhandle.

SLIDE: 15. Overall, tag recapture rates were 7.6% for red grouper and 8.4% for red snapper. However, survival was much greater than stated because of under reporting, especially recaptures from headboats operating in the Gulf where the only recaptures reported were when Mote staff and student interns were aboard. Fishers and crew said they recaptured many tagged fish but they did not have time to report them. This was unfortunate because 56% of the fish were tagged off headboats. Another type of underreporting involved red grouper and immediate recapture. Fishers who caught, tagged and released red grouper, to catch the same fish as soon as they resumed fishing, did not report the recapture because they believed this did not constitute a true recapture.

SLIDE: 16. Circle hooks have been touted as a panacea for fish survival. Tag recaptures from J and 4/0 Eagle Claw zero offset circle hooks were compared. Tag recaptures were used to test two null hypotheses regarding recapture rates for fish caught on circle and J hooks that were tagged and released off private recreational and recreational-for-hire vessels. Almost 4,000 red grouper were caught on J hooks, tagged and released. 287 were reported recaptured - 836 were caught on circle hooks and 121 were recaptured. More than 2,000 red snapper were caught on J hooks and 269 were recaptured and more than 3,000 fish were caught on circle hooks and 258 fish were reported recaptured. A log likelihood G – test showed significant differences in survival for both species by hook type. Red grouper benefited from being caught on circle hooks; red snapper did not despite suffering high J hook mortality. Both null hypotheses were rejected.

SLIDE 17: There was relatively no difference in recapture between the two hook types for red snapper caught at shallow depths. However, twice as many red snapper were recaptured that were originally caught on J hooks when fish were caught at deeper depths (> 27.4 m) despite three times as many fish that were originally captured on the 4/0 Eagle Claw circle hooks.

SLIDE 18: Fish recaptures showed twice as many red grouper originally caught on circle hooks were recaptured; whereas more red snapper originally caught on J hooks were recaptured. Circle hooks reduced red grouper but not red snapper hook mortality. Bacheler and Buckel working off North Carolina, also found that most grouper were jaw hooked despite hook type, but for those that were gut hooked, gut hooking was significantly higher on fish hooked on J rather than circle hooks. They also found barotrauma to be a more important issue in groupers across all depths fished.

SLIDE 19. Looking at all fish tag returns in the tagging data base, at all depths, smoothed the data but trends remained. Even with such a disparity in the number of fish tagged per hook type, especially for red grouper with over 8,000 fish caught on J hooks and a little over 2,000 fish caught on circle hooks, more circle hooked red grouper were recaptured. Looking at red snapper and gag, both being piscivores, more recaptures occurred with J hooks for both than for the 4/0 Eagle Claw circle hooks. This was unfortunate, as both species have high J hook mortality.

SLIDE 20. To test the next hypothesis, dentition, jaw lever ratios, feeding type, and feeding behavior, including prey residence time in the mouth before swallowing were investigated.

To determine each species’ feeding mode, I compared dentition. Red grouper dentition are located on the left; red snapper on the right. Red grouper dentition included rows of small teeth that occurred on both the top and bottom pre-maxilla and canine teeth on both the upper and lower mandible. Red grouper have a larger mouth gape than red snapper at equal body size and numerous small teeth, many pointed inward associated with holding captured prey within the mouth rather than biting it Although both species have canine and conical teeth in the upper jaw, all red snapper teeth were larger. Another difference is that red snapper have fewer teeth and a separation between teeth in the lower jaw. This tooth arrangement is indicative of a predator that bites its prey as this arrangement provides better tooth penetration of soft tissue - an important adaptation for a piscivore that chases softbodied prey.

SLIDE 21: As you can see, many of the teeth in the red grouper lower mandible are pointed inward. The purpose of these teeth are to retain prey, much like those of a snake.

SLIDE 22: The teleost jaw has been described as a mechanism consisting of 2 levers; one for opening and one for closing. Ratios of measurements of jaw features using adult fish skulls can provide jaw lever ratios which indicate jaw strength and opening and closing velocity. Species that use their jaws to bite, shred, crush, or grip prey have higher jaw closing lever ratios than suction feeders. Although both red grouper and red snapper jaw lever ratios were high, this shows that both species have strong fast moving jaws. However; red grouper have somewhat faster jaws than red snapper that have stronger jaws.

SLIDE 23: Videos of fish feeding were slowed first by 50% and then down to 1/8th normal speed to determine different feeding types. Red grouper are suction feeders using their jaws to create pressure to draw in water and prey, like a vacuum cleaner. Stomach contents of wild caught adult fish show a diet of at least 50 – 90 % invertebrates drawn in and swallowed whole. Note the full bucal expansion.

SLIDE: 24. In this red grouper video, the shrimp was tethered to the dive weight with monofilament to keep it in view. You can see the shrimp get drawn into the mouth, however; the red grouper was confused by the monofilament tethering the shrimp; and spits it out. Notice the shrimp is not damaged when the red grouper spits it out because red grouper tend to swallow prey whole.

SLIDE: 25. Red snapper are biters. Although they will eat small prey whole, when chasing elusive prey throughout the water column, their strong jaws and tooth configuration are useful for penetrating soft bodied prey and ripping off pieces to swallow. Stomach contents of wild adult red snappers show they often have pieces of prey in their stomachs. The cracking sound you hear in the video will be the sound of the carapace breaking as the fish bites the shrimp in half. Also note that conspecifics will try to steal prey from each other so fish that have captured food successfully, remove themselves from others as fast as possible.

SLIDES: 26 & 27. Red snapper video.

SLIDE: 28. When fishing with J hooks, the fisher sets the hook and presumably the more time the angler has to set the hook while it is still in the fish’s mouth before swallowing, the better chance the hook will lodge in the fish’s jaw or mouth where it will do the least damage. The feeding videos were used to determine prey residence time in the mouth. By counting the number of frames/ second (based on the established time standard of 29 frames/second), for each complete successful feeding sequence, starting from prey capture to swallow, allowed me to compare the time prey remained in each species mouth. If prey residence time can be used as a proxy for a hook, this may help to explain the difference in red grouper and red snapper J hook mortality. Average time of prey residence in the red grouper mouth was about 2 seconds longer than in the red snapper mouth. This makes sense because red snapper are swallowing pieces of food while red grouper must orally manipulate their prey to get it into the proper position before swallowing it.

SLIDE 29: As to the difference in circle hook recaptures, another part of the answer may lie in the difference in pharyngeal teeth. According to Nick Parnell at Georgia Tech, red snapper pharyngeal teeth consist of rows of small fragile crystalline canine type teeth whose purpose is to keep food moving to the stomach. He said red grouper pharyngeals are more likely molariform and serve to help masticate prey on the way to the stomach. Pulling a hook backward in a red snapper would cause damage to red snapper pharyngeals, but would do little damage to those of red grouper. Dentition, feeding behavior, and prey residence time are very different between these two species. J Hook mortality was much higher for red snapper than red grouper. The 4/0 Eagle Claw zero offset circle hook did enhance survival for red grouper, but not red snapper. In fact, more J hooked red snapper were recaptured than those originally captured and tagged on the 4/0 Eagle Claw zero offset circle hook.

SLIDE 30: Will Patterson presented the work he has been doing in conjunction with Clay Porch and Andy Strehcheck at the Circle Hook Symposium on the effect of circle hook size on reef fish catch rate, catch composition and size distribution.

SLIDE 31: Will stated that they used 5/0, 9/0, 12/0, or 15/0 Mustad circle hooks to catch red snapper and other reef fishes in the northern Gulf. In addition, they were also video taping the fish community at the sites where they were fishing. Will stated that they also initially tried 3/0 Mustad circle hooks, but they as well as the 5/0 hooks produced deep hooking in the gills or esophagus of red snapper. Red Snapper fared better on the 9/0, 12/0, and 15/0 Mustad circle hooks.

SLIDE 32: Will stated that all 3 of the larger hook sizes captured red snapper. However, the largest hook sizes prevented fish with smaller mouth gapes from being caught. Species like red grouper with large mouth gapes could still be captured on the larger hooks.

SLIDE 33: Statement on this slide taken directly from Will Patterson’s presentation. Larger hook size did not diminish catch rate for red snapper but the catch rate for other species declined with larger hook sizes. This might be useful for selectivity processes but not if the catch of other reef fish species was an important part for the recreational or recreational for-hire fisheries. Will stated that at the 15/0 circle hook size, many of the species, such as tomtates simply disappeared from the catch. Choosing the larger sizes would place an undue burden on the recreational and recreational for hire fishery that depend on grunts and other reef fish species for components of their catch.

SLIDE 34: In addition, if the circle hooks being used are too large and only remove large mough gape species, this can change community structure.

SLIDE 35: Red groupers and red snappers demonstrate eco-morphological propensities in feeding morphology. The difference between piscivores and those species that tend to feed on invertebrates that translate into specific feeding behaviors may help clarify differences in J and circle hook mortality between the species and may prove useful in designing predictive models for determining J and circle hook mortalities for other species. In addition, it is evident from the Patterson, et al study, that circle hook size is important.

SLIDE 36: Regulations requiring the use of circle hooks without specifying hook dimensions for reef fishes can not only be ineffective but detrimental to the survival of some reef fish species. However, it should be remembered that hook size varies by manufacturer, so requiring hook use by size is not necessarily an option.

SLIDE 36: I’d like to thank Will Patterson and all the agencies that provided funding for this research and all those who helped conduct the study and provided supplies for this research.