Development of an Alternative Novel Method for Monitoring Recovery on Spawning Aggregations

KEY WORDS: Nassau grouper, *Epinephelus striatus*, spawning aggregations, monitoring, recovery

STEPHANIE ARCHER[1]*, SCOTT HEPPELL[1], BRICE SEMMENS[2,3], CHRISTY PATTENGILL-SEMMENS[3], PHILLIP BUSH[4], CROY MCCOY[4], SELENA HEPPELL[1], and BRADLEY JOHNSON[4]
[1]*Department of Fisheries and Wildlife, 104 Nash Hall, Oregon State University, Corvallis, Oregon 97331 USA.* *Stephanie.Archer@oregonstate.edu. [2]*NOAA Northwest Fisheries Science Center, 4726 3bth Ave. NE Seattle, Washington 98105 USA.* [3]*Reef Environmental Education Foundation (REEF), PO Box 246, Key Largo, Florida 33037 USA.* [4]*Department of the Environment, Cayman Islands Government, P.O. Box 486GT, Grand Cayman, Cayman Islands.*

Desarrollo de Una Metodología Para Monitorear la Recuperación de las Agrupaciones de Desove

PALABRAS CLAVE: Méro de Nassau, *Epinephelus striatus*, agrupaciones de desove, monitorear, recuperación

Élaboration d'une Méthode Originale pour Surveiller le Rétablissement sur des Agrégation de Ponte

MOTS CLÉS: Mérou rayé, *Epinephelus striatus,* agrégation de ponte, surveiller, rétablissement

EXTENDED ABSTRACT

Many spawning aggregations have been fished beyond the point of sustainability, leading to increased calls for protection through seasonal and/or site-specific fishery closures. Once a closure has been put in place, monitoring the aggregation is imperative in order to learn whether protections lead to the recovery of populations. Current methods for monitoring the status of spawning aggregations rely on simple counts, usually combined with capturing a subset of the fish to collect data such as length and weight. Handling fish during the spawning aggregation can be stressful for the fish, which could ultimately lead to decreased spawning success, increased susceptibility to predators, or increased mortality through capture trauma or infection. Here we present a novel method for monitoring fish on a spawning aggregation that does not require the capture and handling of the fish. We show that reliable length-distribution data can be collected by divers using a video-based system with parallel lasers calibrated to a specific distance apart. Annual changes in size distribution can be used as one measure of the health of the population, because the technique can detect recruitment of new individuals into the spawning population. In addition to tracking size distribution trends over time, the length distribution information can be combined with a length-weight regression and an estimate of total number present in order to accurately estimate spawning biomass. We discuss the validation and application of this method with a spawning aggregation of Nassau grouper, *Epinephelus striatus*, in the Cayman Islands.

BACKGROUND

Spawning aggregations of marine fish are a widespread phenomenon which typically account for the majority of the reproductive output for species which form them. Most species which form spawning aggregations are often predictable in time and space which makes these large gatherings of fish prime targets for fishing efforts. The unusual density of at an aggregation combined with their predictable nature makes spawning aggregations particularly prone to overexploitation. Largely, as a result of historic and current fishing pressure the numbers of fish attending most spawning aggregations throughout the Caribbean are declining and many aggregations have ceased to form entirely.

Spawning aggregations have a clear importance for the persistence of those species which form them. Therefore, the declining status of most spawning aggregations has led to rising concerns over the population stability of aggregating species. These concerns have led to a rapid increase in the amount of protection afforded to spawning aggregations, and consequently an increase in monitoring programs. Active monitoring programs have started both where protections have been put into place and at aggregations which have yet to be protected. Monitoring programs are essential if we hope to understand how different management actions and strategies affect both the number of fish attending a spawning aggregation as well as recruitment of new spawning fish to the aggregation. Despite the prevalence and importance of monitoring programs there is still a question of how to best monitor fish during such a sensitive life stage.

Traditional monitoring strategies for spawning aggregations include: collecting data from active fisheries landings, various hands-on methods employed by scientists to determine lengths and weights, and population estimates from divers on the aggregation. Unfortunately, there are many problems with all of these methods. The protective measures taken at many spawning aggregations include at minimum a seasonal closure of the fishery. Logically, in situations where the fishery has been closed it is impossible to rely on data from fisheries catches. Hands-on methods employed by researchers yield reliable and consistent data, yet the number of data points is often low and these methods stress the fish during their reproductive period. Increased stress during such a sensitive life stage may increase susceptibility of spawning fish to predation and disease as well as directly reduce the reproductive output of the spawning aggregation, counteracting the intent of protecting the spawning aggregation. Finally, population estimates from divers are imprecise and variable from diver to diver and from year to year. The variability in the data generated by diver observation makes the detection of true trends difficult because of the low signal-to-noise ratio. Low power to detect a trend increases the length of time observation is necessary before a high level of confidence can be placed in the estimated population trends. In the face of the problems with current monitoring strategies, the Grouper Moon Project, a collaborative project between the Cayman Islands Department of the Environment (CIDOE) and the Reef Environmental Education Foundation (REEF), has developed a novel technique coined the video-laser technique, with the aim of reducing reliance on an active fishery, stress to the fish, and variability in the data.

METHODS

The video-laser technique combines a method often employed by submersible surveys with a diver-operated video system to provide consistent counts of fish present on the aggregation as well as information on the length distribution of those fish. An aluminum bracket was constructed to hold an underwater video camera and two waterproof lasers (Figure 1). The distance between the two lasers was calibrated to be 250 mm and was accurate at distances up to 50 ft from the laser bracket. For each dive made on the aggregation, the diver-operator turned on both the video camera and the lasers upon entering the water. The diver then made one slow pass through the aggregation, pointing the laser bracket at each fish encountered. After the first pass through the aggregation the diver-operator swam back by the aggregation attempting to collect the whole of the aggregation in a video panorama.

The video collected during the aggregation was then brought into video editing software, Adobe Premier Pro®. The video was then scanned and a still image was created for each fish which appears approximately perpendicular to the camera with both lasers located on the fish and the whole of the fish in the frame. The still images were then imported into an image analysis software program, Image J (Rasband 2009). For each image, the scale of the analysis software was set using the known distance between the two laser points on the fish of 250 mm using the Set Scale function under the Analyze tab in Image J. The total length of the fish was then measured using the Measure function, also under the Analyze tab in Image J. The fish in each image was measured and the lengths were compiled into a database for future analysis.

APPLICATION OF THE METHOD

The Grouper Moon team has been using the video-laser technique to monitor the status of an aggregation of Nassau grouper, *Epinephelus straitus*, off of the West end of Little Cayman Island, Cayman Islands, British West Indies. In 2001 local fishermen "rediscovered" the West end Little Cayman Island aggregation site. At the time of its rediscovery the aggregation was estimated to attract 7,000 -8,000 fish (P. Bush, Cayman Islands Department of Environment Pers. communication). In 2003, after two years of intense fishing by local fisherman, the Cayman government closed the aggregation site (and in fact all aggregation sites active and extinct in the Cayman Islands) to all fishing for a period of eight years in order to determine if long-term closure of Cayman Nassau grouper spawning aggregation sites is warranted. Monitoring of this aggregation via video-laser technique has been in place since 2004.

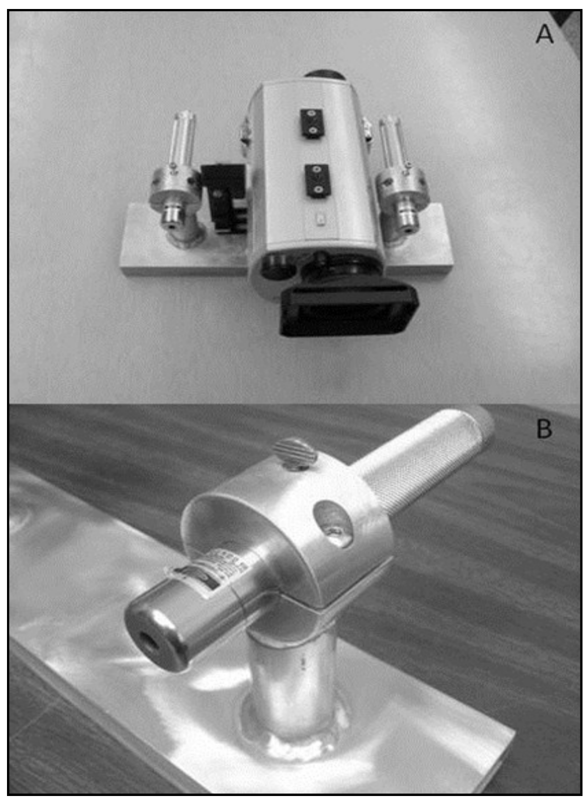

Figure 1. The specially constructed aluminum laser bracket. Panel A shows the bracket with both lasers and video camera attached. Panel B is a close-up of one of the lasers on the bracket. Lasers on the bracket are turned on by turning the screw at the top of this panel.

We were able to validate the laser-video technique in 2005 when Nassau grouper were caught off of the aggregation for a tagging study. While the fish were removed from the water, prior to tag implantation, they were weighed (to the nearest gram) and measured (to the nearest mm). The length distribution of fish caught for the tagging study was compared to the length distribution of fish measured using the video-laser technique in 2005 using a Kolmogorov-Smirnov two sample test to test for differences in the two distributions. The two distributions were not significantly different ($D = 0.1356$, $p = 0.0758$).

Using the data collected by the video-laser technique the Grouper Moon team has begun to gain some understanding of the trends in length distribution on the aggregation; we have also been able to use the information to estimate biomass and investigate behavioral trends at the aggregation. Biomass estimates have been constructed by combining information from the length distribution derived yearly from the video-laser technique, estimated number of fish present at the aggregation from the video panoramas, and a length-weight relationship derived during a tagging study conducted at the aggregation in 2005. For each year the length distribution was compared to known distribution structures such as the normal distribution and the logistic distribution. The most similar distribution, judged using a Kolmogorov-Smirnov test, was said to characterize the distribution. The number of fish at the aggregation was estimated by constructing a still image panorama of the aggregation from the video panorama. The number of fish in the still image was then counted using the Analyze Particles function under the Analyze tab in Image J. Divers estimated the percent of fish at the aggregation at the time each video panorama was captured, but not in the visible band (i.e. at cleaning stations, etc). The number of fish counted in the band was then estimate was then scaled by this percentage and a total number of fish present at the aggregation was estimated. This estimation was then used with the known distribution structure found to characterize the length distribution to create a random set of fish lengths within that distribution. These lengths were then placed into the length-weight curve derived in 2005 and summed to create a total biomass estimate.

Nassau grouper exhibit three color phases on the aggregation which are not seen during non-reproductive periods. These color phases are the white-belly, black, and bicolor. There is anecdotal evidence that the proportion of fish displaying the bicolor phase increases as the night of spawning draws closer, ultimately peaking on the night of spawning. By recording the color phase of each fish measured by the video-laser technique we will be able to amass empirical evidence to support the anecdotal claims which will ultimately lead to a better understanding of the behavior of Nassau grouper at spawning aggregations.

While this technique cannot replace simple counts of fish on an aggregation, it can help reduce the amount of noise surrounding meaningful trends which may be hidden within the data already collected. In addition to its usefulness in elucidating trends in the composition of the spawning population this method also provides potentially enlightening information regarding behavior of fish on the aggregation. This method provides a wealth of useful information without stressing the spawning fish and without relying on an active fishery for data collection.

LITERATURE CITED

Rasband, W.S. 2009. Image J. U. S. National Institutes of Health, Bethesda, Maryland, USA, http://rsb.info.nih.gov/ij/, 1997-2009.