Let Them Come to You: Reinventing Management of the Snapper-Grouper Complex in the Western Atlantic: A Contribution to the Data Poor Fisheries Management Symposium

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Déjelos Llegar a Usted: Reinventar la Gestión Del Complejo Pargo-Mero en el Atlántico Occidental: Una Contribución para cl Simposio de Gestión Pesquera Pobre Datos

Laissez-Les Venir á Vous: Réinventer la Gestion du Complexe Vivaneau-Mérou Dans L'ouest de l'Atlantique : Une Contribution pour le Colloque en Gestion Mauvaise Pêche Données

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ABSTRACT

In the Western Atlantic region, encompassing the US South Atlantic, Gulf of Mexico, and wider Caribbean, the snapper-grouper complex serve as important targets in multi-species fisheries, many of which have experienced significant declines. These fishes share similar life history characteristics including long lives, late reproductive maturity, and spawning in aggregations. Governance capacity is limited and uneven throughout this large and diverse region and resources are limited for fisheries independent sampling. As a result, these fisheries are considered "data-poor" and management decisions are often made with little information. How can this be addressed? We pose that fisheries managers should invest fisheries dependent data collection efforts at the time and location of spawning aggregations. If it is assumed that some portion of the stock aggregates to spawn each year, accurate counts at multiple sites can offer direct measures of the overall population size. Similarly, age, length, and sex frequency data, and size-specific fecundity can be gathered efficiently at spawning aggregation sites. Recent findings indicate that many spawning sites share common geomorphological characteristics, (e.g. reef promontories on shelf edges) and that many sites serve multiple members of the snapper-grouper complex. Relevant information for better stock assessments for many data poor stocks might be efficiently gathered by monitoring multi-species spawning sites through grouper and snapper spawning seasons. We urge that managers consider a paradigm shift for monitoring, data collection, and rebuilding - let them come to you.

KEY WORDS: Data-poor fisheries, stock assessment, spawning aggregation, snapper-grouper complex, fisheries

INTRODUCTION AND PROBLEM STATEMENT

The Snapper-Grouper Complex

Snappers and groupers are top predators and comprise most of the highly desired and heavily exploited fishes in the U.S. South Atlantic, Gulf of Mexico and the Wider Caribbean, supporting commercial and recreational fishing, diving and tourism industries, and coastal culture. Snappers and grouper assemblages transcend jurisdictions of eight U.S. states, three U.S. regional fisheries management councils (Caribbean, Gulf of Mexico, and South Atlantic), as well as the waters of 28 nations and territories throughout the Wider Caribbean including the eastern edge of Central America and northern South America.

Many of these species share similar life-history characteristics that reduce their resilience to fishing pressure—they are long-lived, slow to reproductive maturity, and migrate to spawn in aggregations (Huntsman and Waters 1987, Coleman et al. 1999, 2000). In spite of their critical role in ecosystem function and socio-economics, there is little known about timing and location of transient spawning aggregations for most species and areas, nor about the complex set of interacting physical and ecological forces that govern their formation. Indeed, the location of reef fish spawning aggregations represents a critical information gap, hindering implementation of ecosystem based fisheries management (Sale et al. 2005, Appeldoorn 2008, Crowder and Norse 2008).

A recent synthesis from the wider Caribbean illustrated that many groupers and snappers spawn within transient, multi-species fish spawning aggregations (tFSAs) that occur at predictable times and places (Kobara et al. 2013). Once discovered by fishermen, these spawning sites are fished extensively, sometimes to extirpation. This is particularly troublesome for those long-lived species of the snapper grouper complex, whose life history patterns renders them vulnerable to exploitation and slow to recover. tFSA sites, the species and populations, the ecological system in which they play a critical role, and the cultural and economic systems that depend on them, are all at risk from intensive fishing at mass spawning sites.

Existing Management Paradigms and Status of Stocks

Because of their shared life history characteristics and shared habitats, the "snapper-grouper complex" has traditionally been targeted within multi-species fisheries (Lindeman et al. 2000, Ault et al. 2005, Kadison et al. 2006, Patterson III et al. 2012). Yet fisheries management in U.S. federal waters, as governed by the Magnusson-Stevens Fishery Conservation and

Management Act (MSFCMA), is applied mostly at the level of stocks. In U.S. waters, regional fisheries management councils are required to set annual catch limits (ACLs) to prevent overfishing of each stock. ACLs depend on reliable stock assessments developed using complex models that rely on input data about the stock including age and length frequencies, spawning stock biomass, age-specific fecundity, and catch rates. ACLs are regulated via Fishery Management Plans (FMPs) that may also stipulate size limits, seasonal and area closures, and in some cases, moratoria on all harvest for overfished species.

Many snapper and grouper stocks have experienced significant declines, some to critical levels (Sadovy De Mitcheson et al. 2008; Sadovy De Mitcheson and Erisman 2012). Managers have responded with reduced ACLs and an assortment of species-specific regulations that reduce fishing access. Because of the multi-species nature of the snapper-grouper complex, unintended by-catch and mortality of managed species regularly occurs (regulatory discard) and some species are harvested below allowable levels to avoid overfished species (Lindeman et al. 2000, Ault et al. 2005, Kadison et al. 2006, Patterson III et al. 2012), which contributes to inefficient management.

The management of these species is limited by information (e.g. basic life history statistics, catch and effort data, and landings information), which is difficult and expensive to obtain. Most snapper and grouper stocks in the Western Atlantic can be considered data-poor (Honey et al. 2010) or data-limited (CFMC 2009, SAFMC, 2012b) i.e. reliable stock assessments cannot be produced or suffer from high degrees of uncertainty due to a lack of catch and life history data.

Though scientific information is often limited, fishermen who target snapper and grouper maintain a deep understanding of the ecology of these species. It is well documented that fishermen have discovered most reef fish spawning aggregations, prior to their "verification" by scientists (Johannes 1998, Lindeman et al. 2000, Sedberry et al. 2006, Heyman 2011). Fishermen's Local Ecological Knowledge (LEK) is not well synthesized, but their knowledge of tFSAs if properly and respectfully collected by fisheries researchers and managers, can complement data from other sources (fisheries dependent and independent data, bathymetry, visual observations) to rapidly construct a holistic understanding of a resource (Mackinson and Nøttestad 1998, Neis et al. 1999, Heyman 2011). Further, the collaboration of fishermen in fisheries data collection that leads to management decisions increases their trust and confidence in the process and can lead to increased compliance.

It is our contention that within all three sub regions of the western Atlantic, monitoring at multi-species spawning aggregation sites will likely contribute to more robust stock assessments for multiple species; while protection of these sites will contribute to rebuilding and maintenance of snapper and grouper stocks throughout their natural range. The first step in this process depends on locating and documenting the existence of spawning aggregations. This paper offers a brief status and situational analysis for the three sub-regions of interest: the wider Caribbean, the U.S. South Atlantic and the U.S. Gulf of Mexico. The wider Caribbean situation provides proof of concept for the other two regions where knowledge of aggregation is less extensive. Finally, the paper offers discussion of the rationale for monitoring spawning sites for better stock assessments, the value of cooperating with fishermen, the benefits of protecting tFSAs and suggestions for the way forward.

RESULTS

The Caribbean Situation Analysis and Proof of Concept

In order to address the data gap on the biogeography of transient fish spawning aggregations (tFSAs), specialists convened a regional workshop, "Characterization and prediction of transient reef fish spawning aggregations in the Gulf and Caribbean Region", held in Cumaná, Venezuela as part of the 62nd Annual Gulf and Caribbean Fisheries Institute (GCFI) meeting on November 5, 2009. The workshop, sponsored by National Science Foundation's Virgin Islands Experimental Program for Stimulating Competitive Research (VI EPSCoR), included over 50 participants from 18 countries around the Caribbean. Each participant compiled data on the location of multi-species tFSAs in their region, the species-specific timing of spawning, their conservation status, and reported on the types of information collected through scientific investigations and local knowledge.

The study documents 108 transient spawning aggregation sites from the Wider Caribbean, which largely consisted of groupers (Epinephelinae), snappers (Lutjanidae), and jacks (Carangidae). Most members of the snapper-grouper complex in the Wider Caribbean are considered transient spawning species and are the focus of this paper. Historically, nearly all transient fish spawning aggregation (tFSA) sites have been first located by fishermen (Johannes and Neis 2007, Sadovy de Mitcheson et al. 2008). As large numbers of valuable fish are concentrated in small areas, catch per effort is high and fishermen can harvest large numbers in short periods of time. These infrequent events are highly predictable (e.g. Nassau groupers during full moon in December and January). Detailed studies in Belize (Kobara and Heyman 2010) and the Cayman Islands (Kobara and Heyman 2008) support the hypothesis that transient multi-species snapper-grouper spawning sites occur at locations with a predictable and distinctive geomorphology, i.e. at bending shelf edges or reef promontories in 20 - 60 m water depth, adjacent to deep waters (Heyman and Kobara 2012, Kobara et al. 2013), and that they are used for spawning throughout the year. One such site in Belize, for example, harbors 17 spawning species, including most of the important Caribbean snappers and groupers (Heyman and Kjerfve

2008). The predictive ability of the model was tested in Belize where the locations of two previously undocumented, multi-species snapper-grouper spawning aggregation sites were predicted using geomorphological information extracted from satellite imagery (Kobara and Heyman 2010). Another site was recently predicted and verified in 2012 in Banco Chincoro, off the Yucatan coast of Mexico (Heyman et al., In press).

Synthesis from the wider Caribbean suggests that transient, multi-species reef fish aggregations occur predictably at shelf edges, associated with vertical and horizontal curvature and these sites can be located through collaborative research using a combination of fisher knowledge, bathymetric maps and models, and other ancillary data (Kobara et al. 2013). To document and verify these aggregations, a combination of techniques have been employed including underwater visual observations and videography (e.g. Heyman et al. 2004, Kaddison et al. 2006, Heyman and Kjerfve 2008); fishery dependent data collection on age, growth, fecundity, and maturity and passive acoustic monitoring (e.g. Rowell et al. 2011, 2012, Schärer et al. 2012a,b, 2014).

Status of Spawning Aggregation Knowledge and Protection in South Atlantic Region

Spawning aggregations in the South Atlantic remain somewhat elusive in spite of major efforts (Sedberry et al. 2006; Schonenburg et al. 2009). Efforts to predict and verify multi-species aggregation have intensified in recent years given interest in their protection For the South Atlantic Region, following intensive data mining efforts associated with the South Atlantic Fisheries Management Council (SAFMC) Marine Protected Areas (MPA) expert work group meetings (SAFMC 2012a, b, 2013), NOAA Fisheries Southeast Fisheries Science Center (NOAA SEFSC); LGL Ecological Research Associates, Inc. (LGL), and the Marine Resources Regional Mapping and Assessment Program (MARMAP) are trying to predict the timing and location of multi-species spawning aggregation sites in the South Atlantic. To do so, fishery dependent and independent data are being synthesized into predictive models that are being validated with existing data (Farmer *et al*., in prep.) and will require intensive field verification.

Verification work has begun by the author, in cooperation with commercial fishermen. To date, however, most sites remain uncharacterized and have no site-based monitoring or management.

Status of Spawning Aggregation Knowledge and Protection in the US Gulf of Mexico

Snappers and groupers are fished extensively and account for 93% of the annual commercial reef fish landings from the US Gulf of Mexico (GMFMC 2013). In spite of these high landings, very few spawning sites have been documented. Working collaboratively with fishermen, multi-species spawning aggregations of gag, scamp and red snapper were documented along the west Florida shelf edge, in the eastern of the Gulf of Mexico (Koenig et al. 2000; Coleman et al. 2011). These aggregation sites are associated with ridges, ledges and pinnacles (vertical discontinuities) along the shelf edge. The Madison Swanson Fishing Reserve, Steamboat Lumps, and the Edges Reserves on the west Florida shelf were created in large part to protect these multi-species spawning sites (Koenig et al. 2000, Coleman et al. 2011)

With the exception of the western Florida shelf, the Gulf of Mexico is the least well-studied of all regions with regards to the timing and location of grouper and snapper spawning aggregations. The most likely place for them to occur, based on studies from the Wider Caribbean and the eastern Gulf, would be the banks on the northwestern Gulf of Mexico, which have both vertical and horizontal discontinuity in the correct depth zones, and are close to the continental shelf.

Initial studies will be needed to map local expert knowledge and use bathymetric maps to make geomorphological predictions of possible locations. The methodology developed for the Caribbean and presently being forged for the South Atlantic will be followed. Interestingly, it may be that oil and gas platforms, near the shelf edge, may now serve as spawning areas. As predictions become available, field-validation will commence as appropriate. At present, there has been no comprehensive study of the location of spawning aggregations on the offshore banks of the northwestern Gulf of Mexico, and to date, no such aggregations have been documented.

DISCUSSION

Rationale for Monitoring at Aggregation Sites for Stock Assessments

Salmon fisheries are perhaps the best monitored and best managed set of species in the world. This is due in large part to the fact that fishers and managers take advantage of their natural history whereby the salmon return to their natal rivers to spawn. Because of this, fisheries data collection is concentrated in space and time, allowing extremely efficient allocation of sampling, monitoring, enforcement, and management resources. Thus the accuracy of stock assessments can be increased and the critical life history stages are protected so as to promote maximum sustainable harvest.

Using the same logic, species within the snapper-grouper complexes that spawn in transient but predictable aggregations can and should be monitored at their spawning sites, rather than when the fish are dispersed into their home ranges that may span hundreds of thousands of square miles. Since multi-species snapper-grouper spawning aggregations have been identified in many areas of the Wider Caribbean (Kobara et al. 2013) and the eastern Gulf of Mexico (Coleman et al. 2011), the same might be true for the banks of the northwest Gulf of Mexico (Heyman 2008) and the U.S. South Atlantic.

The Value of Cooperative Science with Fishermen

Because of their continuous interaction with the environment and the resources, fishermen maintain a deep ecological understanding of the species they target. This information can complement scientific research and provide practical information that can be used in management (Pitcher et al. 1998, Johannes et al. 2000, Berkes 2012). Interviews with fishermen may provide valuable local ecological knowledge (LEK), especially with regards to where and when large aggregations of spawning fish occur (Johannes 1998, Sedberry et al. 2006, Johannes and Neis 2007). The wider Caribbean region offers an extensive set of examples of scientists working with fishermen to map, characterize, and protect multi-species snapper-grouper spawning aggregations (e.g. Lindeman et al. 2000, Claro et al. 2001, Heyman and Kjerfve 2008, Granados Dieseldorff et al. 2013).

Commercial fishermen are typically dubious of assisting in the collection of fisheries related data because they believe this information will be used to further restrict harvest within their fishery. Due to the limited amount of data available within the snapper-grouper complex, fishermen are becoming more aware that management regulations based on insufficient and incomplete datasets can have serious unintended consequences (e.g. stocks being considered overfished when they are healthy or *vice versa*).

When fishermen participate in research, they become cognizant of the methods used to collect data and the way that the data are used to guide management decisions. They are more trusting of the data and more supportive of subsequent stock assessment results (Mackinson and Nøttestad 1998, Neis et al. 1999, Heyman 2011). This increases their support for additional cooperative research and data collection projects. Furthermore, their involvement in the research contributes to fishermen's sense of pride and worth, fosters their sense of responsibility for stewardship, and leads to a functional and adaptive management process (Mackinson and Nøttestad 1998, Berkes 2012, Heyman and Granados-Dieseldorff 2012).

Benefits of Protecting Reef Fish Spawning Aggregations

Several examples illustrate that small, year-round reserves at multi-species spawning aggregation sites can promote rapid recovery of reef fishes. Protection of a red hind (*Epinephelus guttatus)* spawning aggregation in the Virgin Islands led to a 400x increase in red hind biomass aggregating at the site in only four years (Beets and Friedlander 1999). The same site showed continued increasing density and size of individuals within the aggregation, but site protection may also have contributed to an observed overall increase in the mean length and weight of red hind caught in the commercial fishery between 1997 and 2003 (Nemeth 2005). Riley's Hump, along the curving shelf edge in the Dry Tortugas, Florida, USA, exemplifies the case where a multi-species aggregation has recovered since its protection (Burton et al. 2005). The site is also known to export larvae from these spawning fish, which contribute to stocks outside the reserve. Nassau grouper have shown significant recovery after the protection of their spawning aggregations in the Cayman Islands (Heppell et al. 2012). Perhaps the most interesting, promising and exciting finding is that protection of spawning sites for red hind promoted the recovery of other species, including yellowfin grouper (*Mycteroperca venenosa*) and Nassau grouper (Kadison et al. 2009). Protecting multi-species spawning aggregation sites serves as a spatially efficient way to contribute to rebuilding multiple stocks, which in turn can lead to increased fishing opportunity.

Spawning aggregation sites are generally small. The multi-species spawning aggregation site at Gladden Spit (Figure 1), for example, measured only about 500 m × 120 m (6 ha) along the shelf edge (Heyman and Kjerfve 2008). This small size makes the areas difficult to find; but also makes their protection within small reserves politically feasible and allow greater fishing opportunity outside of MPAs. Their small size also allows for efficient patrolling and enforcement. Finally, discrete protected areas serve as naturally convenient sites to monitor multiple stocks (Heyman et al. 2010) contributing to more accurate stock assessments.

SUMMARY AND OUTLOOK

In summary, protecting multi-species spawning aggregation sites can be accomplished with relatively small reserves. These reserves in turn can promote recovery of the species that aggregate to spawn at these sites, increase spawning and larval production for many snapper and grouper species, and aid species recovery in surrounding areas through adult migration and larval export. Finally, the sites serve as convenient locations to collect life history data that can be used to increase the accuracy of stock assessments for many data poor species of the snapper grouper complex.

Our ultimate aim is a network of fishermen, scientists, and managers, throughout the western Atlantic who cooperatively predict, characterize, monitor, and manage multi-species snapper-grouper spawning aggregations within a network of small marine reserves. This network should provide data that together support assessment, management, maintenance and recovery of the snapper grouper complex and the ecological, economic and socio-cultural resources that depend on them. This vision is consistent with the recently endorsed Declaration of Miami from the Food and Agriculture Organization of the United Nations (FAO Western Central Atlantic Fishery Commission 2014).

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