

Current Status of Conservation and Management of Reef Fish Spawning Aggregations in the Greater Caribbean

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ABSTRACT

A total of 35 species in ten families are known to form spawning aggregations in the greater Caribbean. The current status of reef fish spawning aggregations by country and species is presented for the region. There appears to be a general declining trend in the landings from most spawning aggregation sites. Principally in the past 10 years, several countries in the region have implemented conservation measures to protect spawning aggregation sites. The majority of these measures involve seasonally closed areas and there have been positive effects demonstrated from active management of spawning aggregations. A number of sites (principally Nassau grouper) have disappeared in the past 25 years and urgent management action is required to address increasing fishing pressure. The elements of a regional conservation and management strategy for spawning aggregations are presented as are suggestions for the dissemination of information about spawning aggregations in the region.

KEY WORDS: Spawning aggregations, Caribbean, management, conservation, status

Estado Actual de la Conservación y de la Gerencia de las Agregaciones de Desovo de Peces de Arrecifes en el Caribe

Se revisa el estado actual de las agregaciones de desove de los peces de arrecife en el Caribe. En los últimos 10 años más países han puesto las medidas de conservación en ejecución para proteger los sitios de las agregación, la mayoría de estas áreas están estacionalmente cerradas. Un número de sitios han desaparecido en los últimos 25 años y una acción urgente de manejo es requerida para poder tratar de eliminar la presión y el aumento de la pesca en estas áreas. Los elementos de una estrategia regional de la conservación y de la gerencia serán discutidos.

PALABRAS CLAVES: Agregaciones de desovo de peces, conservación, Caribe

INTRODUCTION

Reef fish spawning aggregations are documented throughout most of the Caribbean and Central America but appear to be more common in the northern and western portions of this geographical region. The essential element of a spawning aggregation (SPAG) is that it has a relatively high level of predictability in space and time. Domeier and Colin (1997) defined two different types of spawning aggregations, "transient" and "resident" using the following three criteria:

- i) The frequency of aggregations,
- ii) The longevity of aggregations, and
- iii) The distance traveled by fish to the aggregation.

Groupers and snappers form "transient" aggregations with the following characteristics:

- i) Fish frequently migrate long distances to the aggregation site sometimes using specific routes (e.g. Nassau grouper; Bolden 2000),
- ii) Aggregations typically form for only 1-3 months of the year,
- iii) The duration of the aggregation is from several days (e.g. Tiger grouper; Sadovy et al. 1994) to a few weeks,
- iv) The formation of aggregations is entrained to the lunar cycle, and
- v) Aggregations occur during a limited period of the year (environmental parameters such as water temperature or rate of change of temperature appear to be important factors in the timing of aggregations) (e.g. Red hind; Luckhurst 1998).

In contrast, "resident" aggregations are characterized by their frequency of occurrence (often daily), short travel distances and limited duration (often 1-2 hours). Most "resident" spawning aggregations occur with reef fish species which are generally non-commercial such as parrotfishes (Scaridae), wrasses (Labridae) and surgeonfishes (Acanthuridae). Spawning behaviour of many of these species is described in Colin and Clavijo (1988).

Given these differences in the two aggregation types, there are some generalizations which can be made concerning "transient" spawning aggregations. Both groupers and snappers are comprised of higher trophic level species and the larger species in each of these two families tend to form aggregations. It appears that all reproductive activity takes place in these aggregations as there is no evidence of spawning in these species outside the aggregation (Sadovy 1996). Thus, the total annual reproductive output of the population occurs at the SPAG sites.

The major threat to SPAGs in the greater Caribbean region is overfishing. Although there may be some evidence that habitat damage (e.g. hurricanes impacting on reef habitats) could be a factor, it is clear that overfishing is the factor which needs to be addressed as a priority. Fishing effort at SPAGs typically removes the oldest and largest fish from the population (Coleman et al. 2000). Most grouper species are protogynous hermaphrodites (change sex from female to male) which means that the largest fish in the population are generally males (Shapiro 1987). The removal of a large number of males through aggregation fishing may lead to disruption of the entire spawning pattern of the species (Coleman et al. 1999). A

recent survey of the status of reef fish stocks in the U.S. indicated that 73% of the species considered most overfished are protogynous hermaphrodites (Coleman et al. 2000).

The depletion of reef fish resources which form SPAGs in the greater Caribbean region has both negative ecological and socio-economic impacts, but these effects are not, as yet, well documented. These impacts can potentially be mitigated by the development and improvement of marine resource management measures at both the level of the specific site and at the national level.

RESOURCE MANAGEMENT PRINCIPLES FOR REEF FISH SPAWNING AGGREGATIONS

It is now widely recognized that the management of multi-species coral reef and warm-temperate fisheries using most conventional fishery management tools is unlikely to achieve the level of success desired by resource managers (Coleman et al. 1999). There is rarely a sufficient level of understanding of interspecific and community-level interactions to direct management action at a given species (Lindeman et al. 2000) without negative or unforeseen ecological impacts. In the absence of detailed biological information and understanding of the dynamics of the populations of the target species, it is unreasonable and impractical to pursue finely tuned management programs. However, the formation of SPAGs at well-defined times and locations by a number of different species offers a management option which can be both simple and effective. Although the state of knowledge of the dynamics of SPAGs is limited, there exists compelling evidence which indicates that intense fishing pressure at SPAG sites is not sustainable in the long-term (e.g. Gag grouper; Koenig et al. 2000). Therefore, a practical approach to managing SPAGs is to take management / conservation steps to limit fishing mortality to prevent the depletion of the SPAG. Without timely management action, some SPAGs may simply disappear. This is well documented for Nassau grouper at various locations in the wider Caribbean (Sadovy and Eklund 1999).

When fishing mortality of males is high, there may be an insufficient number of males available to fertilize all of the spawning females. This can lead to reduced reproductive output from the population. In addition, the removal of males may cause a greater female-bias in the population sex ratio to develop, further contributing to the disruption of the reproductive process (Coleman et al. 1999). In the case of gonochoristic species such as snappers, the largest females make a disproportionate contribution to the reproductive output of the population (size-fecundity relationships are usually exponential – or, in other words, “bigger females produce many more eggs”) (e.g. Red snapper; PDT 1990). The removal of many large females due to aggregation fishing similarly reduces the reproductive output of the population (Coleman et al. 1999). From the foregoing, it is clear that the guiding principle for the management of SPAGs is the reduction of fishing mortality at these sites. At vulnerable sites, the elimination of fishing mortality through

permanent closure of the site may be the only practical management option if the site is to remain reproductively viable.

SUMMARY OF CURRENT STATUS OF SPAWNING AGGREGATIONS BY COUNTRY OR JURISDICTION IN THE GREATER CARIBBEAN REGION

A list of the species documented to form spawning aggregations in the region (Table 1) indicates that there are a total of 10 families and 35 species involved. As expected, the list is dominated by the commercially important groupers (*Serranidae*) and snappers (*Lutjanidae*) with eight and seven species respectively. However, the jacks (*Carangidae*) which are also commercially important in the region, have a number of species listed although relatively few observations have been documented of the formation of SPAGs by these species. The other commercially important families are the grunts (*Haemulidae*) and the wrasses (*Labridae*, one species). Virtually all of the species listed in Table 1 may potentially be captured with non-selective Antillean fish traps but there is little directed fishing effort for a number of the reef fish species listed here because they are generally not commercially exploited.

The evaluation of the number of SPAGs and their status in the region (Table 2) is based on the best information available. However, the documentation of SPAGs in the different countries in the region is highly variable. Evaluation of their current status is even more variable. In some instances, there is published information and data on given sites while for a number of others, there is only anecdotal information. With increasing awareness of the importance of SPAGs in the region, the acquisition of information and data should increase substantially.

It is clear from Table 2 that the majority of SPAG sites appear to be suffering declines in landings and that the Nassau grouper in particular has been significantly impacted by fishing pressure with the disappearance of a number of SPAGs in different countries (Sadovy and Eklund, 1999). The only species/sites which appear to be stable are those which have specific management measures in place for SPAGs (principally seasonal area closures). It is not possible to prove cause and effect but these findings strongly suggest that active management of SPAGs (centred on limiting fishing mortality) can be highly beneficial to the populations under exploitation.

Table 1. List of species documented to form spawning aggregations in the greater Caribbean region. The species list is based on published accounts of spawning or documentation by scientific observers of one or more of the criteria associated with spawning aggregations. Not all species included meet the criteria established by Dorneier and Colin (1997) to designate a spawning aggregation species but are included on the basis of unpublished scientific observations.

Family	Species	Common Name
Serranidae	<i>Epinephelus adscensionis</i>	Rock hind
	<i>E. guttatus</i>	Red hind
	<i>E. itajara</i>	Goliath Grouper
	<i>E. striatus</i>	Nassau grouper
	<i>Mycteroperca bonaci</i>	Black grouper
	<i>M. microlepis</i>	Gag grouper
	<i>M. tigris</i>	Tiger grouper
	<i>M. venenosa</i>	Yellowfin grouper
Lutjanidae	<i>Lutjanus analis</i>	Mutton snapper
	<i>L. apodus</i>	Schoolmaster
	<i>L. cyanopterus</i>	Cubera snapper
	<i>L. griseus</i>	Gray snapper
	<i>L. jocu</i>	Dog snapper
	<i>L. synagris</i>	Lane snapper
Acanthuridae	<i>Ocyurus chrysurus</i>	Yellowtail snapper
	<i>Acanthurus bahianus</i>	Ocean surgeon
	<i>A. coeruleus</i>	Blue tang
Haemulidae	<i>A. chirurgus</i>	Doctorfish
	<i>Anisotremus surinamensis</i>	Black margate
	<i>Haemulon album</i>	White margate
	<i>H. plumieri</i>	White grunt
Mullidae	<i>H. sciurus</i>	Blue-striped grunt
Mullidae	<i>Pseudupeneus maculatus</i>	Spotted goatfish
Scaridae	<i>Scarus iserti</i>	Striped parrotfish
	<i>Sparisoma rubripinne</i>	Yellowtail parrotfish
Carangidae	<i>Carangoides ruber</i>	Bar jack
	<i>Caranx bartholomaei</i>	Yellow jack
	<i>C. crysos</i>	Blue runner
	<i>C. hippos</i>	Crevalle jack
	<i>C. latus</i>	Horse-eye jack
	<i>Seriola dumerili</i>	Greater amberjack
Labridae	<i>S. rivoliana</i>	Almaco jack
	<i>Lachnolaimus maximus</i>	Hogfish
Balistidae	<i>Canthidermis sufflamen</i>	Ocean triggerfish
Ostraciidae	<i>Lactophrys trigonus</i>	Buffalo trunkfish
	<i>L. triquetter</i>	Smooth trunkfish

Table 2. Summary of current status of spawning aggregations (SPAGs) in the greater Caribbean area by country and species. Only commercially exploited species are listed. Countries with documented spawning aggregations are listed from north to south. Status refers primarily to documented fishery landings but may include fishery independent evaluation of given aggregation sites. Status reflects an overall trend in recent years but may not accurately reflect the current status (2002) as changes can occur rapidly at SPAG sites.

Country/ State	Total SPAG Sites	Species Involved	Current Status (Landings)	Reference / Source
Bermuda	3	Red Hind	Stable	Luckhurst, 1996; MS
Bahamas	4	Nassau Grouper	Disappeared	Luckhurst, 1996
	22	Nassau Grouper	Declines Heavily expl.	Braynen, pers. comm., Ray et al., 2000
Turks and Caicos Islands	5	Nassau Grouper	Lightly exploited	Clerveaux, pers. comm.
Florida	3	Cubera snapper	Declines	Lindeman et al., 2000
25 total sites including : Dry Tortugas	1	Dog snapper	?	Lindeman et al., 2000
	8	Gray snapper	?	Lindeman et al., 2000
Key West area	1	Lane snapper	?	Lindeman et al., 2000
Gulf Coast	4	Mutton snapper	Declines	Lindeman et al., 2000
	2	Schoolmaster snap	?	Lindeman et al., 2000
	1	Yellowtail snap	?	Lindeman et al., 2000
	?	Black grouper	Declines ?	Eklund et al., 2000
	2?	Gag grouper	Declines	Coleman et al., 1996
	?	Scamp	Declines	Coleman et al., 1996
	>4?	Goliath grouper	Protected	Sadovy & Eklund, 1999
Cuba (21 total sites)	10	Cubera snapper	Declines	Claro and Lindeman, in press
	3	Dog snapper	Declines	Claro and Lindeman, in press
	3	Gray snapper	Declines	Claro and Lindeman, in press
	13	Lane snapper	Declines	Claro and Lindeman, in press

Table 2 continued:

Country/ State	Total SPAG Sites	Species Involved	Current Status (Landings)	Reference / Source
	12	Mutton snapper	Declines	Claro and Lindeman, in press
	5	Black grouper	Declines	Claro and Lindeman, in press
	9	Nassau grouper	Declines	Sadovy & Eklund, 1999
	6	Yellowfin grouper	Declines	Claro and Lindeman, in press
	1	White margate	Declines	Claro and Lindeman, in press
Mexico - Quintana Roo	7	Nassau grouper	Declines / 1 Disappeared	Aguilar-Perera and Davis, 1996
Campeche	1	Yellowfin grouper	Heavily expl.?	Tuz-Sulub, in press
Bank	1	Red hind	Mod. expl. ?	
Belize	1	Cubera snapper	Heavily expl.	Heyman, pers. comm.
(13 total sites)	4	Dog snapper	Heavily expl.	Heyman, pers. comm.
	3	Mutton snapper	Heavily expl.	Heyman, pers. comm.
	?	Yellowtail snap.	?	Heyman, pers. comm.
	9	Nassau grouper	Declines / Disappeared	Paz and Grimshaw, 2001 Sala et al., 2001
	5	Black grouper	Lightly expl?	Heyman, 2001
	4	Tiger grouper	Lightly expl?	Heyman, 2001
	2	Yellowfin grouper	Lightly expl?	Heyman, 2001
	?	Red hind	Lightly expl?	Heyman, 2001
Honduras - Guanaja	1	Nassau grouper	Disappeared?	Fine, 1992; Sadovy & Eklund, 1999
Cayman Islands	6	Nassau grouper	Declines	Bush et al, MS
	5	Tiger grouper	Lightly expl.	Bush, pers. comm.
	2	Mutton snapper	Lightly expl.	Bush, pers. comm.
Jamaica	1	Lane snapper	Heavily expl	Aiken, pers. comm.
Dominican Republic	1	Nassau grouper	Disappeared?	Sadovy & Eklund, 1999

Table 2 continued:

Country/ State	Total SPAG Sites	Species Involved	Current Status (Landings)	Reference / Source
Puerto Rico	4	Red hind	Declines	Matos-Caraballo, 1997
	1	Tiger grouper	Declines	Matos-Caraballo et al,
	3	Nassau grouper	Disappeared	Sadovy & Eklund, 1999
	1	Mutton snapper	Declines?	Garcia-Moliner, 2000
U.S. Virgin Is.	3	Red hind	Stable	Beets & Friedlander, '99
	3	Nassau grouper	Disappeared	Olsen & Laplace, 1976
British Virgin Islands	3	Red hind	Lightly expl.	Eristhee, pers. comm.
	1	Nassau grouper	Lightly expl.	Eristhee, pers. comm.
	2	White margate	Lightly expl.	Eristhee, pers. comm.

SUMMARY OF FISHERIES MANAGEMENT MEASURES RELATED TO SPAWNING AGGREGATIONS IN THE GREATER CARIBBEAN REGION

There have been a number of fisheries management measures implemented for SPAGs in the region (Table 3) but the majority have only been in place for 10 years or less. Bermuda was the first jurisdiction to specifically protect SPAG sites in 1974 (Luckhurst, 1996) followed by other management measures some years later. In many jurisdictions, management and regulations have been put in place "too late", after significant declines in spawning biomass have occurred. Because the understanding of the dynamics of SPAGs and the time frame of depletion has been slow to accumulate, management action has often not been taken with the urgency necessary to redress the depletion of populations. Once the spawning population biomass falls below some threshold value then recovery under management may not occur even after a number of years. The rate of recovery is likely to be species dependent.

The only scientifically documented examples of the presumed effects of management on SPAGs are for the red hind. In three jurisdictions, significant increases in mean size were observed following the seasonal closure of red hind SPAG sites - Puerto Rico (Matos-Caraballo, 2002), U.S. Virgin Islands (Beets and Friedlander, 1999) and Bermuda (Luckhurst, MS). Similar documentation of the beneficial effects of site closures for other species forming SPAGs has not yet appeared in the published literature.

Table 3. Summary of existing fisheries management measures related to SPAGs by species and country or jurisdiction.

Country	Species	Management Action / Year	Remarks
Bermuda	Red hind	Seasonal area closure (May-August) of 2 sites - 1974	Landings declined in following years before stabilization after trap ban
	Red hind	6) Seasonal closure of additional SPAG site -1990 2) Seasonal (May-August) bag limit of 10 fish per boat per day - 1990	1) increased number of protected sites to 3. 2) To limit sale of fish caught illegally at SPAG sites
	Red hind Black grouper Yellowmouth grouper	Minimum legal sizes for listed species - 1996 Bag limit - 1 fish /boat /day, for black and yellowmouth grouper - 1996	To assist in protection of spawning stock biomass and to aid in population recovery
	Grouper - Red Nassau, Tiger, Yellowfin	No take/no possession - 1996	Protect to allow population recovery of grouper species with low abundance
Bahamas	Grouper and rockfish	Landing of grouper < 3 lbs. is prohibited - 1986	Protect spawning grouper biomass
	Nassau grouper	Seasonal closure of High Cay site, Andros - 1998-2001	Closures for 3 x 10 day periods around full moon
	Nassau grouper	Seasonal closure of 2 sites, Long Island - 1999-2001	Closures for 3 x 10 day periods around full moon
Florida (Riley's Hump)	Mutton snapper	Seasonal closure (May-June) of designated area - 1998-2001	Protect SPAG site
	Snappers - Mutton, Gray, Cubera, Dog, Yellowtail	Permanent closure of designated area - 2001	Protection of multi-species SPAG site
E. Gulf of Mexico	Goliath grouper	Protected species - 1991, no take, no possession	Abundance at SPAG sites has slowly increased
Mexico (Yucatan)	Nassau grouper	No spearfishing at SPAG site Mahahual - 1993	Declines in abundance due to heavy fishing pressure
Belize	Nassau grouper	Seasonal closure at Glover's Reef - 1990?-1998?	Conservation measure
	All aggreg. spp.- groupers and snappers	Permanent closure of 13 SPAG sites throughout the country - 2002?	Unprecedented cooperation between Govt., fishers and NGOs for conservation
Cayman Islands	Nassau grouper	No spearfishing at SPAG sites, no trapping within 1 nm of SPAG Protected Area during spawning season (Nov. 1-Mar. 31) - 1990s? Alternate year fishing strategy starting 2003, bag limit 12 fish/boat/day when in fishing years	Reduction of fishing mortality by gear restrictions/ catch limits and temporal closures

Table 3 continued:

Puerto Rico	Red hind	Seasonal closure of 4 SPAG sites off west coast - 1995	Increase in CPUE and mean size, west coast - 1996-99
U.S. Virgin Is.	Mutton snapper Red hind	Seasonal closure of SPAG site in St. Croix - 1995? Seasonal closure of SPAG site in St. Thomas - 1990	No data on efficacy of measure is available Mean size increased; sex ratio less skewed - 1997
British Virgin Is.	Red Hind	Seasonal ban (Jan - Mar) on possession of red hind - 1999	Eliminates market for fish taken at SPAG sites

CONCLUSIONS AND RECOMMENDATIONS

Given the disappearance of a number of Nassau grouper SPAG sites and the general declining trend of landings at most SPAG sites in the region, the need for active management and conservation measures is apparent. In the locations where SPAG management has been implemented, there has been a positive impact on stock condition and often in a relatively short time frame. There is growing recognition of the ecological significance of SPAG sites to the balance of coral reef ecosystems and the need to conserve these sites.

The following recommendations are made to mitigate the effects of overfishing of SPAGs. They are mainly derived from the elements outlined for a Caribbean Regional Conservation Strategy for Reef Fish Spawning Aggregations (Luckhurst 2002). The recommendations are generally listed in priority order but should be adapted to the specific conditions found at each site:

- i) Eliminate fishing mortality at vulnerable SPAG sites. If permanent closure of a site is not possible then a seasonal closure should be invoked. There should be a sense of urgency for management /conservation action as SPAGs may show sudden and rapid declines under intense fishing pressure.
- ii) Incorporate known SPAG sites into planning programs for Marine Protected Areas (MPAs) to provide permanent protection of SPAG sites. This is often the best option for the protection of SPAG sites as it has multiple benefits for the health of the coral reef ecosystem.
- iii) Develop and implement monitoring programs involving scientists and user groups within the community to evaluate the effect of management /conservation measures. The demonstration of the positive effects of management to user groups can be a compelling factor in developing support.
- iv) Develop community-based management programs for SPAG sites to the fullest extent possible. Full participation in the management process by all of the user groups affected by management measures will greatly increase the probability of success.
- v) Provide viable economic alternatives to those user groups who are displaced from SPAG sites as a result of management action.

It is recommended that a network be established of marine resource managers, scientists and fishermen at key sites throughout the region to promote the systematic collection of information and data about SPAGs. This should enhance our knowledge of the numbers and diversity of SPAG sites in the region. The use of a standardized protocol for data collection should be promoted in order to facilitate comparisons amongst sites. The data and information collected through this proposed regional network should be provided to an international umbrella organization such as SCRFA (Society for Conservation of Reef Fish Aggregations) which is developing a global database on SPAGs.

The efficient dissemination of information regarding SPAGs to relevant organizations within the region including government departments, academic institutions and Non-Governmental Organizations (NGOs) could be accomplished by using the Gulf and Caribbean Fisheries Institute (GCFI) website (www.gcfi.org).

The annual GCFI meeting could provide the ideal forum to evaluate and coordinate ongoing SPAG-related activities in the greater Caribbean.

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