Regional Fish Spawning Aggregation DRAFT Fishery Management Plan (FSAFMP) for the WECAFC region

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Executive Summary

At a regional workshop on Nassau Grouper held in 2008 and coordinated by the Caribbean Fishery Management Council (CFMC) and the Western Central Atlantic Fishery Commission (WECAFC), a proposal for the establishment of a WECAFC/CFMC *ad hoc* working group on Nassau Grouper was made. Participants recognized declines in the species, which was already considered to be endangered (IUCN Red List). The major threat to this species was the uncontrolled exploitation of its spawning aggregations throughout the Wider Caribbean region. The species was further listed as critically endangered, and also added to the SPAW Protocol in 2018, given its continued decline over the last decade in many countries.

A dedicated working group on Spawning Aggregations was then created under the WECAFC/CFMC/OSPESCA (Central American Fisheries Organization)/CRFM (the Caribbean Regional Fisheries Mechanism). *? What is the Name of the workgroup?* This Spawning Aggregation Working Group met in Miami in 2013 and 2018. The Declaration produced from the Miami meeting was then adopted during the 2018 meeting. At the 2018 meeting, the Working Group recommended the elaboration of a regional Fish Spawning Aggregation Fishery Management Plan (FSAFMP), with an initial focus on the Nassau grouper and mutton snapper as representatives of the grouper and snapper species complex. The FSAFMP is expected to be presented for consideration at the WECAFC 17th session to be held in July 2019.

Groupers and snappers in the WECAFC region are valuable to multiple countries and stakeholders whether for food, livelihoods from fish sales, ecological functions or dive tourism. These species provide considerable income in the region and play important ecosystem roles as predator components of the marine environment. Many of the larger species in these groups form aggregations to reproduce (spawn). It is now clear, however, that the uncontrolled exploitation of their spawning aggregations can seriously threaten these natural resources, both commercially and biologically.

Declines in population abundance from uncontrolled aggregation-fishing can affect communities and stakeholders in many different economic sectors and even far from the spawning sites. Of particular concern are the negative impacts to small-scale and artisanal fisheries that depend heavily on reef fishes. Direct losses occur when aggregations decline, resulting in reduced catches of aggregated fish and their roe, or in the reduction in eco-tourism opportunities. Moreover, there is an increasing interest in aggregation diving and this can be highly profitable; indeed, the non-extractive value of an aggregation site can be higher than the catch value. In addition to direct losses, indirect losses resulting from declines occur over areas well beyond the aggregation sites because these aggregations also support major fishery stocks at national and regional scales. When aggregations decline or in extreme cases disappear, therefore, so too do the entire fisheries that depend on them, including fishers, communities and businesses, across the region.

Sustainable and productive fisheries depend fundamentally on establishing a balance between fishing intensity (the number and frequency of removals) and successful reproduction to replenish exploited populations. Without this balance, overfishing will ultimately lead to reduced catches, reduced fishery recruitment downstream, and even stock collapse. To help avoid these undesirable situations, tools such as minimum size measures are being progressively accepted as a sound measure globally, thus allowing sufficient juveniles to survive to reproduce. But successful reproduction also needs adults to have the opportunity to survive long enough to find a mate and fertilize eggs. In the case of aggregating species this means that adults need to migrate to aggregations and have the time and opportunity to release their sperm and eggs to complete the cycle of life.

A growing number of countries globally, as well as in the WECAFC region, now recognize the importance of healthy (i.e. viable and productive) fish spawning aggregations, and so are working towards achieving their full protection. In other words, we could consider spawning aggregations as akin to ‘capital’ in a bank (i.e. maintaining a broodstock base) that is managed to generate the highest ‘interest’ (enough juveniles to produce the next generation). Such an approach to management approach brings the greatest benefits to the greatest number of people over the widest area, over the longest time period and is ultimately the direction we need to be headed. In acknowledging the key role that aggregations play in the life cycle of many reef fishes, we also now recognize that their management can be particularly challenging and calls for the precautionary approach. Particular aspects such as ‘hyperstability’ and ‘depensation’ can make declines in population numbers difficult to detect and impede recovery if these are not factored into management and conservation planning.

Drawing on the recommendations from earlier meetings and on the Declaration of Miami, this FSAFMP calls for the application of good and expanded science to identify, inform and determine the status of all known and exploited Fish Spawning Aggregation (FSA) sites in the WECAFC region and identify the timing of spawning seasons of groupers and snappers. It builds on lessons learned from successful management initiatives in the region over at least the last 15 years. In ten case studies we highlight factors that have led to progress and success in several countries. These factors include broad consultation, especially with small-scale fisher involvement, good science, government commitment and long-term planning, among other factors.

As recommended, while this FSAMP is intended to provide a framework for all aggregating groupers and snapper of interest in the WECAFC region, it initially focused on Nassau grouper (*Epinephelus striatus*) and mutton snapper (*Lutjanus analis*). It calls for the WECAFC Secretariat and members, and other regional fishery organizations, to provide the necessary support needed to engage fishers, especially small-scale and artisanal fishers, and other key stakeholders, directly in FSA characterization (e.g. status assessment and mapping of known sites), conservation and management, and to fund necessary research and actions. Multi-sectoral working groups, including fishers, government, NGOs and academics, among others, need to work together to implement management actions at both national and international levels to prioritize and protect FSAs. Management measures need to be adaptive and to consider the possible changes that will result from climate change as well as broader environmental and ecosystem-related considerations. Regional scale measures will be needed to increase cooperation to strengthen enforcement of adopted measures (closed seasons, closed areas, sales bans, etc.), and to address illegal, unreported and unregulated (IUU) fishing and trade.

For the *critically endangered* Nassau grouper, in addition to national level management plans, a regional seasonal closure for all commercial and recreational fishing of Nassau grouper in all known aggregation sites and during all known aggregation periods should be established, *at least for the period 1 December – 31 March.* No export should be permitted during the closed season and domestic sales bans could be considered to support other conservation actions.

For the *near threatened* mutton snapper, in addition to national level management plans and spatial protection measures, regional-level seasonal protection during aggregation periods should be established, *at least for the period 1 April – 31 July* to protect spawning events and pre-spawning migrations. No export should be permitted during the closed season and domestic sales bans could also be considered to support other conservation actions.

Both the Nassau grouper and the mutton snapper are, or once were, important contributors to the economy and food security of the WECAFC region. Over time and collectively they have produced tens of thousands of tonnes of fish and have represented an important component of the grouper/snapper fisheries, and domestic and international trade in the region, bringing in millions of dollars for economies. The loss of these resources is not trivial. As we have seen elsewhere in global fisheries, the more vulnerable or susceptible species will disappear first, then it is only a matter of time before those next most vulnerable will share the same fate, and so on. Success with managing these species will not only restore or improve the benefits they bring to the region, but will also teach us valuable lessons for other aggregating species into the future.

The selection of these two species from iconic families as priorities should encourage application and testing of this FMP. The species are somewhat similar in maximum size attained (1 m), both are relatively long-lived (>20 years). Yet they also differ and comparing the overall status of the FSAs of both species, and their respective fisheries, around the region is instructive. For example, the endangered Nassau grouper is now widely acknowledged to be of highest conservation priority: many aggregations have already disappeared and most that remain are highly reduced from former levels. Urgent and immediate action is needed to stem further declines and support recoveries at multiple sites. By contrast, while some aggregations are highly depleted for the near threatened mutton snapper, no spawning aggregations are recorded as extirpated by fishing, though many mutton snapper FSAs are growth-overfished and are undergoing some level of hyperstability with substantial population declines. Many factors may influence why these two species differ in their resilience to fishing, if indeed they do, but it is clear that different species may respond differently to aggregation-fishing and it would be valuable to seek to understand why. This is an essential step in prioritizing species, as well as FSA sites within, for future management and conservation actions.

While more research is clearly needed on many groupers and snappers in the region, from biological to fishery to economic, for the Nassau grouper and mutton snapper there is already sufficient understanding to be able to initiate management planing in some countries and across the region. There is not the time to collect significant additional data before starting the management action planning process; these activities can be done simultaneously. A combination of seasonal and site protections, supported by complementary measures, for example, does not require knowledge of all existing aggregation sites. Moreover, several case studies herein point the way to best practices for management.

Moving forwards, in addition to the identification of spawning aggregation sites and seasons, studies are needed on the economic value of spawning aggregations (both extractive and non-extractive values, and the value of catches outside of the reproductive season), while education and outreach are essential to gain the understanding and support of the broader public and political sectors in the community, especially the fishing sectors. Socio-economic impacts of proposed management measures need to be assessed and alternative livelihood options developed for those fishers likely to be most seriously affected by aggregation protection and management. A much better understanding of domestic and internal trade networks is needed to improve traceability in preparation for markets that increasingly require this, and to help tackle IUU.

Finally, due attention is also called to existing instruments or statements of concerns that specifically address the urgent need to manage spawning aggregations. Protection of spawning areas is recommended in the FAO Code of Conduct (1995) and Calls to Action at the global level have increased in the last 15 years. For example, Statements of Concern recognizing the management need for sustaining coral reef fish spawning aggregations at the global level were formally adopted by the IUCN World Conservation Congress in Bangkok in 2004 and the International Coral Reef Initiative (ICRI) in Mexico 2006. Sustainable Development Goal 14 highlights the need to specifically address overfishing and IUU fishing, using science-based management planning, particularly for small, developing nations. Countries are reminded to ensure the full implementation of international law as reflected in United Nations Convention on Law of the Sea, including existing regional and international regimes for the conservation and sustainable use of ocean resources.

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Spawning aggregation of Nassau grouper: Photo Jim Hellman

Acronyms

ACS Association of Caribbean States
BNSAWG Belize National Spawning Aggregations Working Group
BREEF Bahamas Reef Environment Educational Foundation
CARIFORUM Forum of the Caribbean, Group of Asian, Caribbean and Pacific States
CARICOM Caribbean Community Regional Integration
CFMC Caribbean Fisheries Management Council
CITES Convention on International Trade in Endangered Species of Wild Fauna and Flora
CIDoE Cayman Islands Department of Environment
CLME Caribbean Large Marine Ecosystem
CONANP Comisión Nacional de Áreas Naturales Protegidas
CONAPESCA Comisión Nacional de Acuacultura y Pesca
CRFM Caribbean Regional Fisheries Mechanism
CPUE Catch per Unit Effort
DNER Department of Natural and Environmental Resources (Puerto Rico)
EBM Ecosystem Based Management
FAO Food and Agriculture Organization of the United Nations
FKNMS Florida Keys National Marine Sanctuary
FWC Fish and Wildlife Conservation Commission
GSI Gonadosomatic Index
ICCAT International Commission for the Conservation of Atlantic Tunas
INPESCA Instituto Nicaragüense de la Pesca y la Acuicultura
IUCN International Union for the Conservation of Nature
IUU Illegal, Unreported and Unregulated Fishing
LFA Logical Framework Approach
LME Large Marine Ecosystem
MCS Monitoring, Control and Surveillance
MPA Marine Protected Area
MRFSS Marine Recreational Fisheries Statistics Survey Program
MRIP Marine Recreational Information Program
MSC Marine Stewardship Council
NOAA National Oceanographic and Atmospheric Administration
NTZ No-Take Zone
OLDEPESCA Organización Latinoamericana de Desarrollo Pesquero (Latin American Organization for Fisheries Development)
OECS Organization of Eastern Caribbean States
OSPESCA Organización del Sector Pesquero y Acuícola del Sistmo Centroamericano (Central American Fisheries and Aquaculture Organization)
REEF Reef Environmental Education Foundation
SAFMC South Atlantic Fishery Management Council
SCRFA Science and Conservation of Fish Aggregations
SEA Southern Environmental Association
SICA Sistema de la Integración Centroamericana (Central American Integration System)
SPAW Specially Protected Areas and Wildlife
UNEP United Nations EnvironmentalProgram
UVI University of the Virgin Islands
VMS Vessel Monitoring System
WECAFC Western Central Atlantic Fishery Commission
WCMC World Conservation Monitoring Center
WCS Wildlife Conservation Society

1.0 BACKGROUND

A regional workshop on Nassau Grouper was held on the 20th and 21st October, 2008 coordinated by the Caribbean Fishery Management Council (CFMC) and the Western Central Atlantic Fishery Commission (WECAFC). Within the recommendations of that meeting a proposal for the establishment of a CFMC/WECAFC ad hoc working group on Nassau Grouper was made. The joint Working Group was established by the fourteenth session of WECAFC in February 2012.

The first meeting of the CFMC/WECAFC, Central American Fisheries Organization (OSPESCA) and the Caribbean Regional Fisheries Mechanism (CRFM) Working Group on Spawning Aggregations was held in Miami, United States of America, from 29th to 31st October 2013. At that time, the meeting brought together 23 experts working on fish spawning aggregations from all over the Western Central Atlantic region. The working group expressed concern for ongoing declines in stocks of many aggregating species, not just the Nassau grouper but also other groupers and snappers in the Wider Caribbean Region, the reduced numbers of their aggregations, the relatively smaller sizes (i.e. number of fish) of remaining aggregations and the implications of these declines for their fisheries, many of which were heavily dependent on the aggregations. They also verified that the status of Nassau Grouper, goliath grouper (and several other species including the mutton snapper) stocks in the Wider Caribbean Region, where sufficient information was available to evaluate, were often considered "overexploited", some stocks were regarded as "depleted" while information was lacking entirely for some stocks. The working group further emphasized the high ecological and biological value of reef fish that aggregate to spawn (focusing on groupers and snappers) for the ecosystem and marine biodiversity in the region, and for improving regional food security and livelihoods (FAO Report No. 1059).

***Plate 1**. First meeting of the CFMC/WECAFC/OSPESCA/CRFM Working Group, October 2013, Miami, USA*

The second meeting of the CFMC/WECAFC/OSPESCA/CRFM Working Group on Spawning Aggregations was held on the 27th to 29th March, 2018 in Miami, Florida, USA. The Declaration of Miami developed at the 2013 meeting was adopted during the 2018 meeting. This time, the Working Group recommended the production of a draft framework for a regional fish spawning aggregation fishery management plan (FSAFMP) with an initial focus on the Nassau Grouper and mutton napper as focal species used for the development of the Plan template. The draft plan was to be formulated for presentation to the WECAFC at the next appropriate meeting. Subsequently, the development of the full FSA plan would be completed in 2020 for a full range of aggregating snapper and grouper species of interest to the WECAFC region. The Plan will include specific actions in regards to the management and conservation of spawning aggregations outlined at the working group second meeting and in follow-up projects, following robust and appropriate management practices.

Plate 2 *Second meeting of the CFMC/WECAFC/OSPESCA/CRFM Working Group, March 2018, Miami, USA*

The regional FSAFMP has as its general goal the establishment of a systematic management regime for important grouper and snapper spawning aggregation sites, times, and associated fisheries within the WECAFC geographical area. This management regime will take place within the framework of sustainable fishing with consideration for ecological balance and socio-economic benefits for all direct and indirect stakeholders. The plan will initially focus on the Nassau Grouper and mutton napper but the objectives and related activities will be applicable to the management of other aggregating species of groupers and snappers and, potentially, other families of fishes going forwards.

2.0 OBJECTIVES

Acknowledging the high economic and ecological importance of exploited fishes that aggregate to spawn in coastal fisheries in the WECAFC region, recognizing the threats these species face when exploited on unmanaged aggregations and acknowledging the serious negative impacts on fishers and source countries if spawning aggregations are further compromised or lost, this FMP addresses the following six objectives. These objectives are based on the outcomes of the CFMC/WECAFC/OSPESCA/CRFM Working group.

1. To integrate the urgent need and rationale for protecting spawning aggregations from overexploitation, particularly in the case of threatened fish stocks and fisheries, in national and regional fisheries management and conservation planning, in a practical and timely manner.

2. To identify species and spawning aggregations in most need of priority management and to determine the current state of knowledge regarding their biology, fisheries, aggregation status and management needs; test species to be Nassau grouper and mutton snapper;

3. To provide monitoring frameworks for collecting key biological, socio-economic, fishery and trade information to develop management and conservation protocols for achieving sustained production of these renewable natural resources nationally and regionally; to include both aggregation and non-aggregation collected data where relevant.

4. To apply and integrate the best available information as identified in 2 and 3 above and develop interdisciplinary, community-based strategies for successful spawning aggregation management in national and regional management mechanisms, traceability, instruments and planning for priority species;

5. To significantly increase awareness, engagement and understanding of the high importance of protecting spawning aggregations, especially among key stakeholders, for maintaining food security, economic benefits (whether from associated fisheries or ecotourism), equitable resource use, and biodiversity conservation;

6. To integrate spawning aggregation management into broader marine environmental planning and evolving challenges including ecosystem-scale management, climate change and international trade.

3.0 THE NEED TO PRESERVE REEF FISH SPAWNING AGGREGATIONS IN THE WECAFC REGION

Introduction

Many valuable and highly considered reef fishes in the WECAFC region, including most of the medium to larger groupers and snappers, reproduce in mass spawning aggregations that form for brief periods at specific times and places each year. As far as we know, these are the only times and places that such species reproduce. Since aggregations attractive the biggest fish and are highly predictable, they are very easy to overfish. If this happens and aggregations decline to very low levels, the remaining fish produce too few eggs to sustain larger populations and the fisheries they support, often across more than one country. Hence spawning aggregations must be adequately safeguarded to sustain fisheries on spawning aggregations of fishes into the future.

When fishing levels were low or just for subsistence, spawning aggregations sustained themselves, allowing some fish to be removed by fishing while enough ripe adults remained to reproduce and replenish fish populations. However, as coastal fisheries became increasingly commercialized, and fishery operations expanded further offshore, where many grouper and snapper aggregations are located, more of these were targeted. New technologies allowed them to be relocated more easily and they also became much more targeted than in the past. Between the late 1970s and 1990s, major declines or collapses in several Nassau grouper fisheries were detected as landings declined. Since most catches were taken from their spawning aggregations, this targeted fishing was clearly a major factor. This species was once one of the most commonly-taken groupers in the insular Caribbean; today it is considered to be critically endangered and is the first reef fish to be listed on the SPAW protocol. Several other aggregating groupers and snappers are showing similar trends. For example, red snapper (*Lutjanus campechanus*) aggregations in the Florida Keys were also fished to commercial extinction. Other groupers for which aggregation management is key are the red hind, *Epinephelus guttatus*, gag grouper, *Mycteroperca microlepis*, Goliath grouper, (*E. lanceolatus*), yellowfin grouper, *M. venenosa*, among others.

Of particular concern are the negative implications of declining reef fish populations to small-scale and artisanal fisheries that depend heavily on them, at least seasonally. Such losses occur both ***directly** and **indirectly***. *Direct losses* occur when aggregations decline, resulting in smaller catches from the aggregations themselves and, in some areas, from the loss of possible eco-tourism opportunities from dive tourism on FSAs. *Indirect losses* from such declines are far more wide-ranging and affect many more people because these aggregations can be the source of national and regional fisheries for these species. When aggregations decline or disappear, so too do the fisheries that depend on them. This situation impacts fishers, communities and businesses across the region, including those who never exploit the aggregations themselves but depend on the fish generated by these reproductive gatherings. In addition, many species spawn at sites used by other species in other times of the year, when these multi-species sites are fished over many months of the year, cascading ecological impacts to habitats from gear and anchors and from bycatch of other species can multiply.

Species of the grouper (Epinephelidae) and snapper (Lutjanidae) families are among the most valued (culturally and economically) of reef fishes and are important sources of food and livelihoods in the WECAFC region. They also comprise an important component of the predator biomass of coral reef ecosystems (e.g. Bellwood et al, 2004). Most groupers and several snappers proposed for listing as threatened, or NT, on the International Union for Conservation of Nature (IUCN) Red List form spawning aggregations (www.iucnredlist.org update November 2018 for Epinephelidae) and the overexploitaton of their aggregations is the major threat.

The need for a Precautionary Approach

It turns out that the Nassau grouper is not an exceptional case. The loss of, or severe declines in, spawning aggregations of multiple commercially important groupers and snappers have now occurred with important implications for many coastal fisheries and stakeholders, both directly and indirectly. However, despite a history, over several decades, of a growing number of measures to manage the fisheries of many of these species, declines continue and more concerted action is clearly necessary for many species.

As we learn more about declines in FSAs, garner lessons from management attempts (see Section 5.0) and as research improves, it is clear that a **precautionary approach** is needed to safeguard them. This is because of the way that fishing activity interacts with aggregated fish and because of the behaviour of the fish themselves. If these two issues are not considered or accommodated in management, including monitoring and planning, then declines will continue and recovery will be increasingly difficult to achieve. For example, if a population is allowed to reach a highly depleted state before declines are stopped, an obvious example being the Nassau grouper, recovery can be particularly challenging. In this regard, two specific aspects of aggregation dynamics need to be factored into management planning: **hyperstability** and **depensation**. These factors can (1) result in the status of a particular aggregation being difficult to detect before the number of fish have radically dropped (*hyperstability*), and (2) mean that aggregations allowed to drop to very low numbers may be particularly slow to recover (d*epensation*). These are further explained in the Box below and in the Appendix in more detail. Both may have occurred in the case of the Nassau grouper.

Hyperstability. Spawning aggregations may provide the majority of annual catches. Landings data from these catches (ideally in the form of catch per unit of effort [CPUE]) may be the main or only source of information on the condition of the fishery. However, this may not be a good indicator of abundance due to *'Hyperstability'* which can obscure population declines because fish continue to aggregate to reproduce even as their overall population numbers decline. As a result, their CPUE can appear high even if the population is declining. For this reason, fishery data should be collected both from aggregations and on the fishery from other, non-aggregating, times of the year.

Depensation. It is typically assumed that fisheries are subject to *compensation* (i.e density dependence), i.e. as a population declines, it effectively compensates for the declining numbers by increasing its *per capita* (per fish) population growth rate. However, the opposite can occur in some species at low population levels, especially when large numbers of animals gain benefits from being in large groups, as is likely the case of spawning aggregations. In other words these species may be particularly productive only when their aggregations are above some size threshold. This effect (also known as the Allee Effect) is often a factor accounting for poor recovery from reduced population levels. Marine examples include queen conch, *Strombus gigas* (Stoner and Ray-Culp 2000) and fishes (e.g. Maroto and Moran 2013).

Climate change

A growing literature based on both modelling and empirical evidence is examining a variety of features of warming coastal oceans in relation to fishes and fisheries (e.g., Pinsky et al. 2013; Melin et al., 2016; SFSC, 2017). Some primary impact scales and their relationships are detailed in Portner and Peck (2010) including organismal physiological and behavioural responses, population-level changes including mortality, growth and reproduction, and ecosystem-level changes in productivity and food web interactions. Pankhurst and Munday

(2011) examine impacts on reproductive events in reef fishes as well as impacts on larvae which are more sensitive than adults, with an emphasis on ocean acidification challenges to larval sensory systems.

Spawning reef fishes represent an under-evaluated life stage that can be susceptible to warming ocean waters (Asch and Erisman, 2018). Using the Nassau grouper, these authors calculated the thermal niche and ecological niche breadth of both non-spawning and spawning adults. The thermal niche of spawners was narrower, indicating that the spawning life stage may be a bottleneck constraining adaptation options to warming ocean tenperatures. They concluded that Nassau grouper conservation should include consideration of these and other aspects of changing phenology, as climate effects may amplify population declines and reduce or otherwise alter the impacts of conservation measures.

Many species that mutton snapper and Nassau grouper feed upon or feed upon them, will be exposed to a variety of factors related to climate change over coming decades. Conservation actions should take shifting distributions and physiological as well as ecological vulnerabilities and responses into account (Pinsky et al. 2013). Climate change can also affect pre-spawning migrations in multiple manners. There are also a number of potential effects of climate change on the larval products of spawning aggregations which are beginning to be examined in a variety of coastal marine taxa (Pankhurst and Munday, 2011; Asch, 2015). Climate change effects may exacerbate population declines in highly fished populations and constrain management efforts in multiplicative manners (SFSC, 2017). Modelling suggests that fisheries production in tropical reef, systems in particular, are particularly susceptible to declines under different climate change scenarios but that good management can help to reduce impacts (Cheung et al., 2010, 2018).

In sum, management of aggregating species and particularly their aggregations calls for several considerations and types of information beyond the typical management approaches applied to coastal small-scale fisheries and using both fishery-dependent and –independent monitoring of fish. To assess the fishery, fishery-dependent catch information is needed, ideally using aggregation catch per unit of effort (CPUE). These should be collected in a standardized way to understand the history and current condition of, and trends in, a fishery (catches, sizes, fishers involved, fishing operations, sales patterns and social context, changes in fishing effort over time, etc.). Fishery-independent data are also important; this can be done by divers or, for deep sites, by ROV. Simple technologies using acoustics or cameras can be used to monitor some dive sites remotely. Populations in general and aggregations in particular should not be permitted to get too small before management is implemented. The implications of climate change also need to be considered in relation to possible impacts on reproduction. Precautionary management is needed and the FAO voluntary Code of Conduct Article 6.8 is particularly relevant to spawning area protection.

International Calls to Action and initiatives to safeguard FSAs

Over almost two decades, the recognition of the need to conserve fish spawning aggregations has been growing and is reflected in the following calls to actions and initiatives emerging over this time period.

2006: *International Coral Reef Initiative* (ICRI) meeting in Mexico: ICRI statement on Coral Reef Fish Spawning Aggregations - The recommendation urges governments to establish sustainable management programmes for sustaining and protecting reef fish and their spawning aggregations, including a range of spatial and seasonal measures that can be adapted to local needs and circumstances. Further the recommendation requests international and regional fisheries management organizations as well as non-governmental organizations to take action to promote and facilitate the conservation and management of fish spawning aggregations, including by raising awareness of the long term ecological, economical and societal values of spawning aggregations and in respect of their high vulnerability to uncontrolled fishing.

2004: The *IUCN World Conservation Congress* at its 3rd Session in Bangkok, Thailand, 17–25 November 2004: (Rec 3.100, p.115 Reef Fish Spawning Aggregations)

1. URGES governments to establish sustainable management programmes for sustaining and protecting reef fish and their spawning aggregations, including a range of spatial and seasonal measures that can be adapted to local needs and circumstances; and
2. REQUESTS international and regional fisheries management organizations as well as non-governmental organizations to take action to promote and facilitate the conservation and management of fish spawning aggregations, including by raising awareness of the longterm ecological, economical and societal values of spawning aggregations.

1995: *FAO Code of Conduct for Responsible Fisheries* Article 6.8 of the General Principles calls for:

6.8 All critical fisheries habitats in marine and fresh water ecosystems, such as wetlands, mangroves, reefs, lagoons, nursery and spawning areas, should be protected and rehabilitated as far as possible and where necessary. Particular effort should be made to protect such habitats from destruction, degradation, pollution and other significant impacts resulting from human activities that threaten the health and viability of the fishery resources.

2000-present: *Science and Conservation of Reef Fish Aggregations (SCRFA).* A global effort underway to promote and foster the protection and management of fish spawning aggregations and to raise awareness of the problems of aggregation fishing has been led by SCRFA, an international NGO (www.SCRFA.org/database/). A regional initiative is in place which seeks to document and disseminate information on FSAs in the Greater Caribbean Area (Kobara et al., 2017: http://geo.gcoos.org/restore/) and a national-level initiative exists for Belize; Belize National Spawning Aggregation Working Group (http://www.spagbelize.org/). All initiatives include the compilation of data on spawning aggregations and materials on monitoring and managing them. They are all of value to governments, biologists and the general public for raising awareness and moving the protection/management/conservation agendas forwards.

4.0 RATIONALE FOR A REGIONAL FSAFMP

Introduction

The need for governance at geographical scales that match major biophysical processes in the oceans relevant to diverse marine fisheries often demands regional approaches that can encompass the waters and resources of several or many countries. For example, the dispersive larval phases of most commercially exploited marine fishes and long distance movements by the adults of some species mean that populations can span multiple countries and may not always be well-served by applying spatial measures alone, such as marine protected areas, unless they are large enough to accommodate target species' movements or spawning aggregation sites or are part of a well-designed network that factors in migration routes and ontogenetic shifts, among other considerations. Given that many aggregating species regularly move over very large areas as larvae or large areas as migrating adults, management at the regional level may often have to be considered.

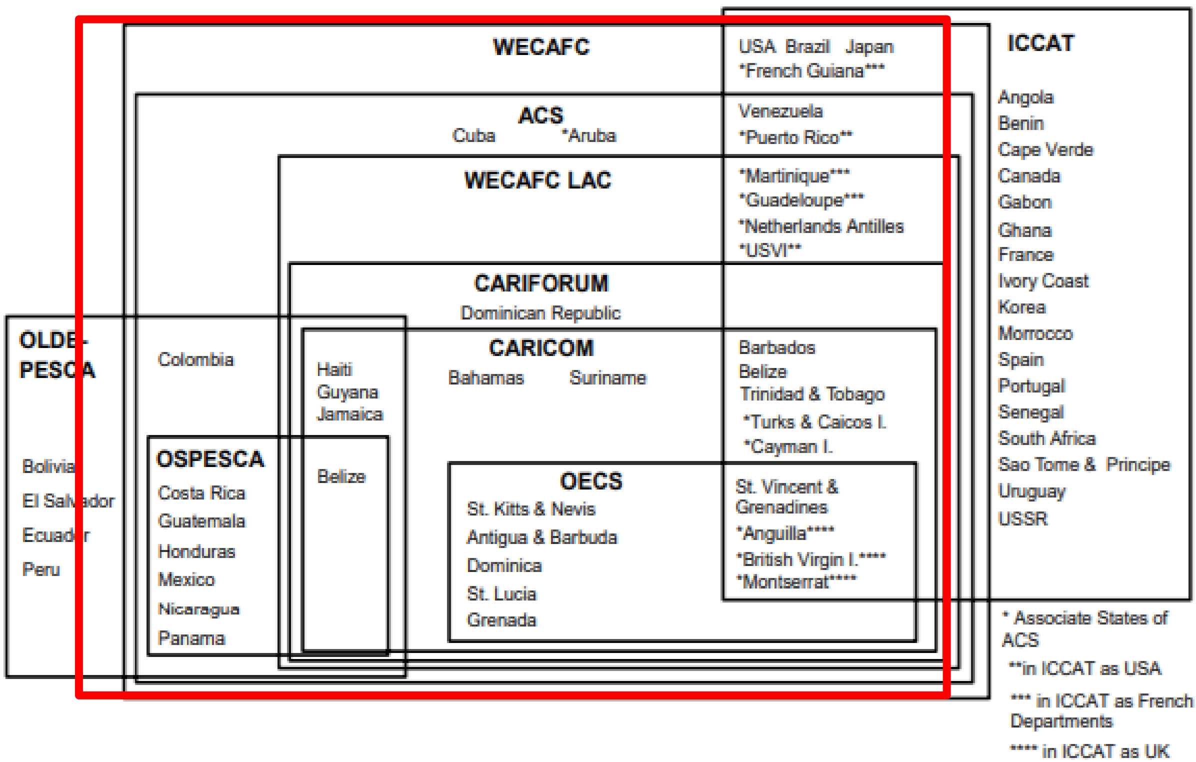

Figure 1. Countries that fall within the WECAFC remit in the Caribbean and tropical western Atlantic (within red box) and how these are nested within and relate to the various fishery-related bodies of the region. . Membership of regional and international organisations with responsibility for fisheries management and development in the Wider Caribbean (WECAFC = FAO West Central Atlantic Fishery Commission, ACS = Association of Caribbean States, CARICOM= Caribbean Community and Common Market, OECS =Organisation of Eastern Caribbean States, LAC= Lesser Antilles Committee, OLDEPESCA = Latin American Organisation for Fisheries Development, OSPESCA = Central American Fishery and Aquaculture Sector Organisation, ICCAT = International Commission for the Conservation of Atlantic Tunas) (Chakalall et al. 2007).

The geopolitical complexity and ocean governance of the Wider Caribbean appear to be more challenging than in many other regions. Hence both local (national) and regional (international) considerations are important when managing marine resources. About 40 countries make up the WECAFC region (Figs. 1 and 2). These countries include the entire geographic ranges of the mutton snapper and Nassau grouper, as well as many other reef fish species of commercial importance that aggregate to spawn in the WiderCaribbean and Brazil.

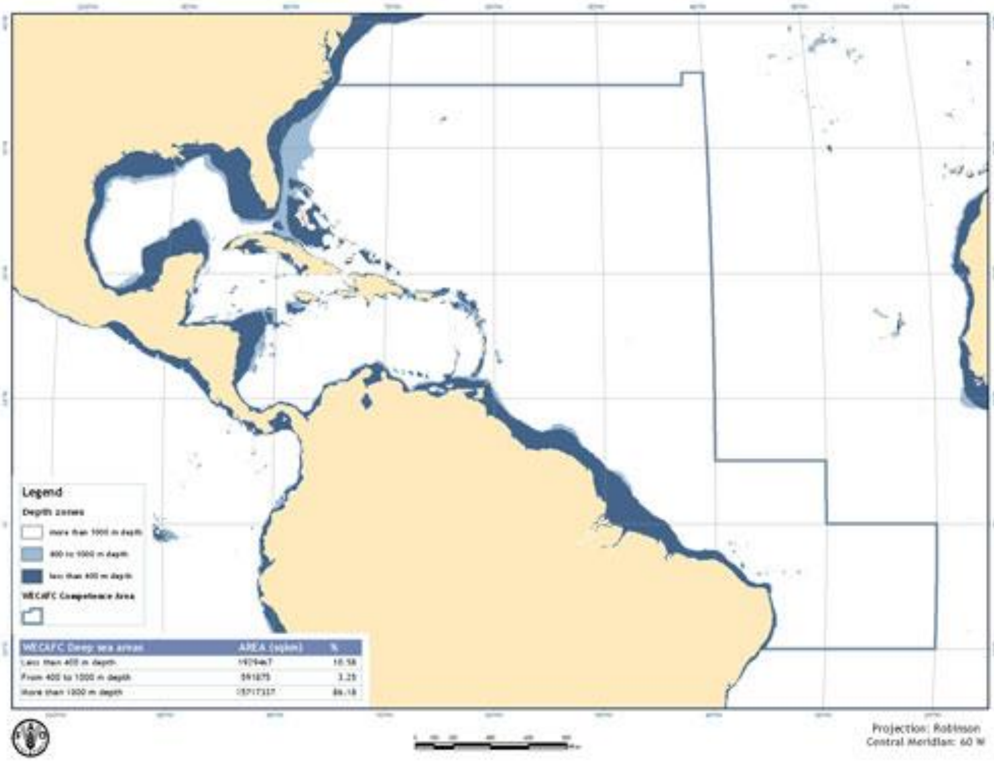

Figure 2. Area of the WECAFC remit in the Caribbean and tropical western Atlantic showing depth zones: dark blue is < 400 m; light blue is 400 to 1,000 m; white is > 1 000 m depth.

Regional movements and population structuring

Both larval and adult groupers and snappers can move over large distances during their lifetimes, a factor that management planning must accommodate (see also Source Document Section 10). Juveniles can also undergo extensive cross-shelf movements, from inshore nurseries to deeper adult habitats during their development. During the spawning season, animals might be quite mobile. Individual adult mutton snapper and Nassau grouper, for example, can move across waters shallower than 400 m (dark blue in Fig. 2) for large distances while travelling to and from spawning sites: >30 km for mutton snapper (Feeley et al., 20180 and >200 km for Nassau grouper (Bolden 2000). Moreover, larvae have the potential to move extensively across some regions, while local retention can also occur. Certain serranid species show planktonic larval durations above 40 days and snappers above 20-25 days (Lindeman et al. 2006). The resulting population structuring of such species may often encompass several or many national boundaries requiring collaborative and coordinated work among multiple WECAFC countries.

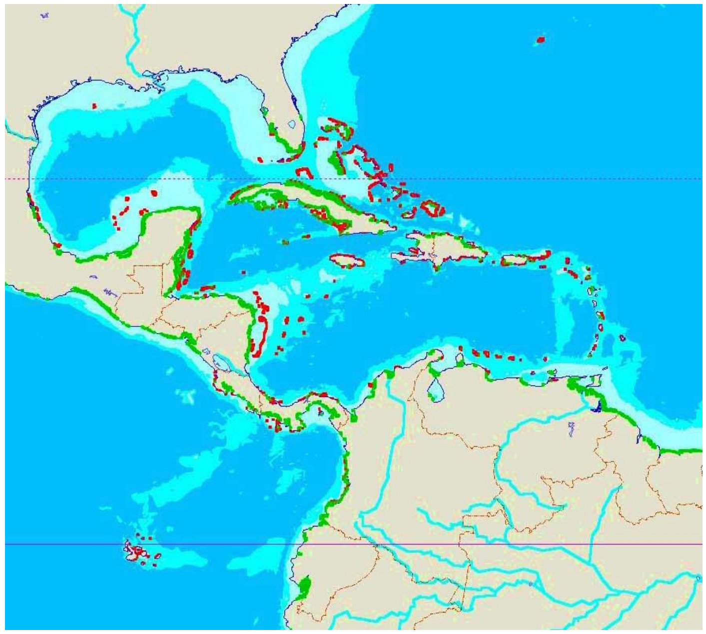

Figure 3 Coral reefs and mangroves of greater Caribbean; shallower waters are lighter**:** http://biogeodb.stri.si.edu/caribbean/en/pages/generalinfo

Clearly population biology needs to be integrated into the management planning (Sherman et al., 2016). In mutton snapper and Nassau grouper, juveniles may migrate out from seagrass or mangrove areas to shallow and deep reefs, while adults can undertake long migrations across reef platform areas each year to and from their spawning sites which are often on the edges of coastal platforms (Fig. 3; see also Source Documents Section 10). Genetic studies suggest a partial degree of population substructuring across the region for both species. Simulation studies of larval movements of both species across the Mesoamerican Barrier Reef suggest potential for widespread connectivity in the region that would call for regional management (Martinez et al. 2019).

Mutton snapper sampled off St. Croix may represent a different demographic stock to that on the adjacent Puerto Rican platform (Carson et al., 2011) (Fig. 4). A review of studies on biophysical modeling of snapper larval transport from Cuban aggregation sites suggested that larval dispersal was very site-dependent (Kough et al. 2016) and also has various FSA management implications (Claro et al. 2018). North Cuba sites supply many larvae to the Bahamas and the Turks and Caicos but also can show considerable self-recruitment of larvae within Cuba. South coast sites showed even higher self-recruitment and also supplied larvae to Hispaniola, the Cayman Islands, Jamaica and other countries. There is decade-scale evidence for both local larval retention and long-distance transport of mutton snapper larvae from differing Cuban spawning sites (Kough et al. 2016). Collectively, all studies suggest complex metapopulation structuring within and among countries that is driven in part by production of larvae from FSAs: both national and trans-national measures are needed to manage these species.

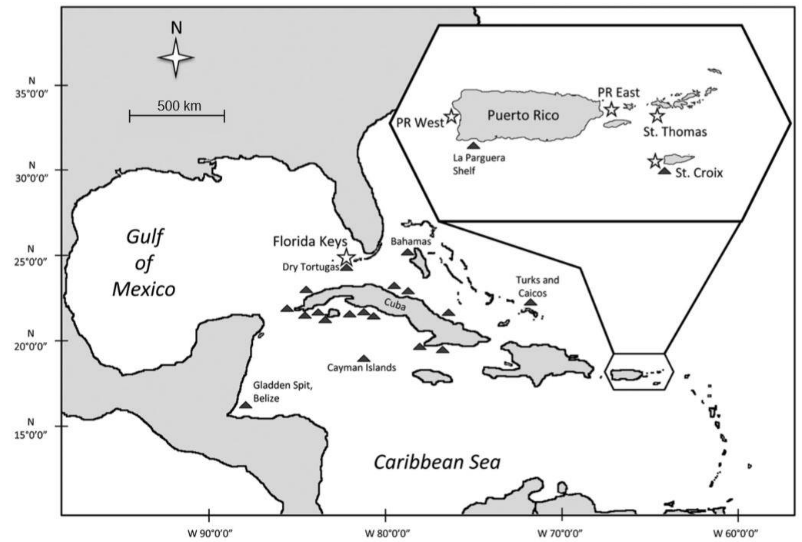

Figure 4. Map of mutton snapper (*Lutjanus analis*) collection sites and known sites of spawning aggregations in the Caribbean Sea and Florida Keys. Collection sites are represented by stars; known aggregation sites are represented *by triangles* (Carson et al. 2011). The map is not a complete map of mutton snapper aggregations as currently understood (see Table 3).

For the Nassau grouper, there is also evidence of both local recruitment and regional population structuring as well as reduced genetic diversity due to past fishing. Genetic variation in mitochondrial DNA microsatellites, and single nucleotide polymorphisms for Nassau grouper suggested three potential barriers to larval dispersal (Jackson et al., 2014) (Fig. 5). The genetically isolated regions identified mirror those seen for other invertebrate and fish species in the Caribbean basin (e. g. Diaz-Ferguson et al. 2010; 2012). Using microsatellites from Nassau groupers from the USVI FSA (which disappeared and is since undergoing recovery) and from the less exploited Cayman Is., Bernard et al. (2015) did not detect any population structuring between the two locations but did find a genetic bottleneck in the USVI FSA, presumably as a result of historical overfishing. In the Bahamas, studies using microsatellites found no marked overall population structuring and high genetic diversity although there was weak significant genetic differentiation across the country (Sherman et al., 2017). The authors suggest that a pronounced historic decline may have occurred in Bahamain Nassau grouper prior to the start of fishing activities and noted evidence for popultion bottlenecks in three islands and signs of inbreeding at two islands. Tracking studies using drogues suggest that local recruitment can occur based on studies in the Bahamas and Cayman Islands (Colin 1992; Heppell et al. 2011).

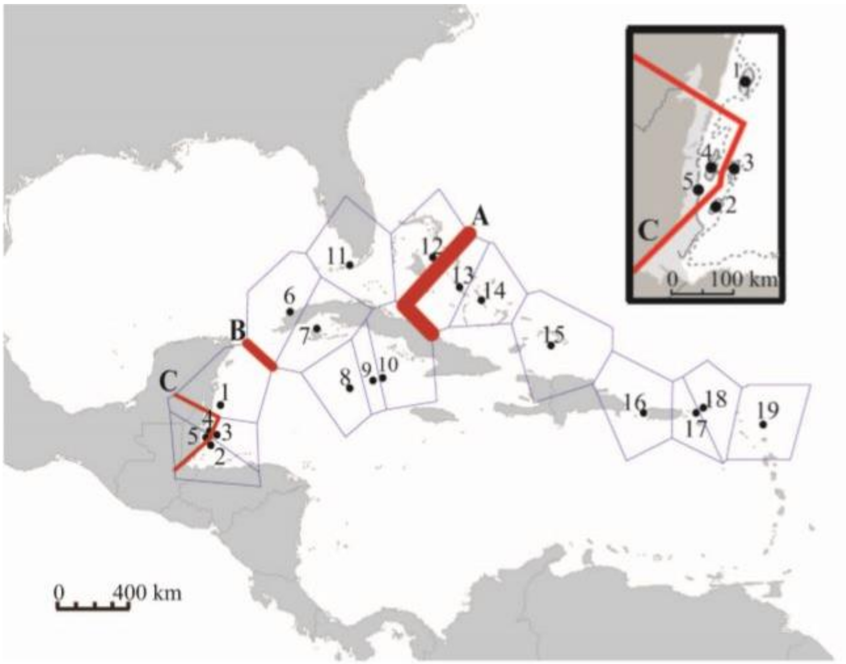

Figure 5. Genetic barriers (i.e. barriers to larval dispersal) indicated between Nassau grouper subpopulations. Barriers are ranked in order of impermeability (A through C), with thickness of barrier lines proportional to the frequency with which a given barrier is observed in replicate analyses and indirectly proportional to permeability (Jackson et al., 2014). The numbers in the figure show the tissue collection sites.

Regional Management Opportunities and Capacities

While there is a broad consensus on the need to protect snapper and grouper spawning aggregations as a critical life stage to maintain viable populations and sustainable levels of fishing, several actions identified in this FMP are also needed to prevent over-exploitation, and promote population stability. Thus, effective implementation of the FMP requires more collaboration, including extensive community-based outreach at national, regional and local levels to advance better understanding among key stakeholders, and to maintain food security, economic benefits, equitable resource use, and biodiversity conservation. In this sense, the Fish Spawning Aggregation working group should collaborate and coordinate with other WECAFC working groups such as the Deep-Sea Fisheries; Illegal, Unreported and Unregulated (IUU) Fishing; and Fishery Data and Statistics Working Groups, to achieve these common goals.

In addition to action at national levels, effectiveness of some management measures can be facilitated and enhanced through integration of measures at sub-regional scales, given the transboundary nature of these stocks, shared larval pools and population connectivity. For instance, the Organization of Eastern Caribbean States (OECS) and its Ocean Governance and Fisheries Unit have developed the Eastern Caribbean Regional Ocean Policy. The OECS can contribute to this current process by adopting harmonized FSA regulations across countries and by supporting necessary research, education/outreach and conservation programs, as identified in the regional FSAFMP. Those actions need to be progressively integrated in their respective Plans of Action.

Furthermore, recommended actions can be adopted by the Caribbean Regional Fisheries Mechanism (CRFM) which is comprised of three units, the Ministerial Council, the Forum and the Executive Committee which work to promote efficient management, conservation and development of aquatic resources in the CARICOM States.

The Forum and Council usually review and approve any proposed cooperative arrangement in support of fisheries monitoring, research and management, and also encourage cooperation between the Member States, with later adoption by the Ministerial Council.

The Caribbean Fisheries Management Council (CFMC) has the responsibility of producing management plans for fishery resources in the US Caribbean Exclusive Economic Zone off Puerto Rico and the US Virgin Islands. Formal adoption of this plan would advance the core CFMC mission and would require the approval of the US Secretary of Commerce, as well as the Governments of Puerto Rico and the U.S. Virgin Islands.

Similarly, the Central America Fisheries and Aquaculture Organization (OSPESCA), composed of the Ministerial Council, Steering Committee and Commission of Fisheries Directors of the countries of the Central American Integration System (SICA), can adopt this regional plan for SICA countries. Since OSPESCA is responsible for the establishment of regional policies and programs, projects and agreements on fisheries and aquaculture-related matters, it can issue binding regulations under the SICA legal framework.

An important aspect of regional cooperation and collaboration relates to important cross-cutting needs such as reducing IUU fishing. The issue of IUU is variously addressed by most regional fisheries management bodies and progress is being slowly achieved but much more needs to be done at regional and local scales. For instance, CRFM has developed the Caribbean Community Common Fisheries Policy under which flag States have a duty to ensure that vessels flying their flag do not conduct IUU fishing within the EEZs of other States. States that do not pay due attention to this issue can be held responsible for such activity if they fail to take all necessary measures to meet their international legal obligations. This topic is critical, considering that many FSAs are located far offshore, where many administrative authorities do not have the capabilities to enforce existing or new regulations.

Finally, WECAFC countries have committed to the Sustainable Development Goals (SDGs) of the Convention on Biological Diversity which include SDG 14: **Conserve and sustainably use the oceans, seas and marine resources for sustainable development (**https://sdgcompass.org/wp-content/uploads/2016/04/Goal_14.pdf), of particular relevance to this FMP. SDG 14 goals include targets that specifically address regulation of harvesting and ending overfishing and IUU, and conserving at least 10% of coastal and marine areas, using science-based management plans. In particular, there is an emphasis on positive treatment of Least Developed Countries and Small Island Developing States. Also highlighted are the needs to increase scientific knowledge, develop research capacities and transfer marine technology to improve ocean health and to enhance the contributions of marine biodiversity. States must also ensure the full implementation of international law as reflected in UNCLOS, for States party to it, including, where applicable, existing regional and international regimes for the conservation and sustainable use of oceans and their resources.

5.0 CASE STUDIES: WHAT WE HAVE LEARNED FROM GROUPER AND SNAPPER MANAGEMENT IN THE WECAFC REGION

Introduction

Management of aggregating species in the WECAFC began to increase about two decades ago, after workers in several countries began to realize that aggregations were being lost and that these were not isolated cases. The focus initially was on the iconic and declining Nassau grouper for which landings were dropping in fisheries across much of its geographic range. The species was listed as threatened in 1996 and again in IUU the national fishery collapsed in Cuba, where once its landings were substantial, between 1975 and 1985 (Claro et al., 2009). Fishery declines were directly attributable to the heavy exploitation of spawning aggregations. As more declines in landings of a growing number of aggregating species occurred across the region, the direct linkage of uncontrolled exploitation of the spawning aggregations to these declines became increasingly evident. As a result, initiatives were developed in diverse countries to manage and preserve these essential life history events as fundamental to the health and future of aggregating species. These management efforts on different species in different countries yielded varying outcomes and it is of much interest to learn from these experiences.

Ten case studies are briefly reviewed in Table 1, two covering mutton snapper, four Nassau grouper and several other groupers, to draw from lessons learned. Outcomes of management varied from failure to stem declines (e.g. Nassau grouper in Cuba), to possible stabilization of numbers or early indications of recovery (e.g. Nassau grouper in Belize), to clear signs of recovery (e.g. Nassau grouper in Cayman Is.; mutton snapper in Florida). Outcomes applied either to particular protected aggregations or, more generally, to the status of the target species. Examples from other grouper case studies supplement this discussion (red hind, jewfish, and gag grouper).

Lessons learned

Considering lessons from the ten case studies, several key elements clearly emerged as important for management success in these case studies. Among these, ten points emerged in multiple cases that could provide guidance for future management initiatives (details in Table 1).

1. Long-term commitment/support is needed from government to ensure that sufficient time (at least a decade) of consistent and effective protection is in place (e.g. Belize, Cayman Is.), to recover depleted aggregations/fisheries. Effective protection means full protection from fishing using clear and robust legislation. Protection should be introduced before aggregation sizes drop too low because this might make recovery more difficult (e.g. Cuba, Cayman Is., Belize).
2. Fisher involvement from the initial development of management planning is particularly important and there are several examples where fishers recognized problems with the fishery and requested help (e.g. Mexico, Caymans, USVI). Initially reluctant acceptance by fishers can often lead to acceptance later even if fishers do not always see benefits (Cayman Is., Belize, USA, Puerto Rico) but particularly if they do and hence assessments of fisheries after protection is important (e.g. USVI, Cayman Is., Belize, Puerto Rico). Fishers have often been key in identifying exploited sites (e.g. Bahamas, Belize, Mexico, Puerto Rico,

USA, USVI). In some instances, commercial fishers have been more supportive of spatial protection than recreational fishers (e.g. Cuba, Florida).

3. Education and outreach to stakeholders and the wider public to create understanding of the need for management and political and public support is very important and needs to be sustained (e.g. Belize, Cayman Is., Bahamas);
4. Consistency in regulations is important at both temporal and spatial scales. For example, differences between State and Federal water measures, or measures that are short-term or temporary or inconsistent across the country (e.g. Bahamas, Puerto Rico), appear to be much less effective than long term and consistent planning (e.g. Cayman Is.). Loopholes created to accommodate specific interests can lead to poaching and confusion, making enforcement more challenging (e.g. Belize, Puerto Rico); such cases tend to be associated with weak political will to manage spawning aggregations.
5. In addition to spatial and seasonal measures, which are needed to protect aggregating fishes, ancillary measures could help improve the fishery, including sales bans during protected seasons, minimum sizes, bag limits and requirements, such as skin-on, for filleted fish. The SAFMC has long had spawning season bans on multiple grouper species and at least two snappers, highlighting the need to also consider whether sites are multi-species FSAs.
6. Multi-stakeholder groups, consultations and co-operation are extremely powerful for developing management initiatives that are widely endorsed. Such can involve fishers, indigenous communities, government, NGOs (national and international) and academics (e.g. Belize, Florida Keys, Cayman Is. Bahamas). The inclusion of fishers appears to be particularly important (Belize, Florida Key, Cayman Is.).
7. The support of scientists and others who work on monitoring and mapping of aggregations, and conduct scientific studies, is key to developing effective management and conservation plans and assessing the outcomes of management (e.g. USVI, Puerto Rico, Cayman Is., Belize, Bahamas). Such support allows for adaptive management and could be expanded to collect socio-economic data. Fishery monitoring and research needs to be done at the species level.
8. Monitoring, control and enforcement is particularly difficult in remote areas (Florida, Belize, Bahamas, etc.), with international poaching risks in some (Bahamas and Belize). This calls for increased efforts in collaborative and cross-border policing and the use of modern technologies. Illegal fishing is a major problem in some areas, especially where enforcement capacity is weak, and hence multiple measures may also be needed in such cases (see 5 above).

Once aggregations have regained healthy numbers, society needs to decide whether to continue effective management or to maintain aggregation closures for the benefit derived from the eggs/young fish produced in aggregations which are the source of the fishery for others in the region. Ultimately society might decide that, like the widespread use of minimum sizes to ensure that fish can mature to replenish exploited populations, spawning aggregations should be fully protected to maximize overall fisheries benefits across wide regions and multiple fishing sectors and other interested stakeholders.

Table 1 – TEN CASE STUDIES: Considerable and important work has been carried out over the last few decades on several species of groupers and snappers in the WECAFC region which have been extremely valuable for the lessons learned. Ten case studies are elaborated in the following table and key lessons learned are summarized below the table. (Nemeth 2005 MEPS, Nemeth et al. 2006, Heyman 2011, Horadam 2014, Brown 2017, Kadison et al. 2017,Olson et al. 2018; Sherman et al. 2016, Claro et al., 2018, Agar et al 2019).

Key factors	**Nassau grouper (Cuba)**	**Nassau grouper (Cayman Is.)**	**Jewfish (USA)**	**Red Hind (USVI)**	**Red hind (Puerto Rico)**	**Nassau grouper (Belize)**	**Gag grouper (USA)**	**Nassau grouper (Bahamas)**	**Mutton Snapper (Mexico)**	**Mutton Snapper (USA)**
Fisher involvement in planning	Typically little.	Strong fisher engagement on each island	Some fisher involvement during consultation	St. Thomas (STT) and St. Croix (STX)- fishers either very or partly involved in creation of closed areas	MPA designation with fisher consultation and in island-wide ban	Fishers involved in monitoring and identification of FSAs; much consultation	Involved through government consultation process	Fisher involvement in research, monitoring and management has been limited	One NTZ created at request of fishers. Fishers participate in monitoring landings and SCUBA surveys of FSAs	Commercial and recreational fishers involved in designing one NTZ. No protection for a different FSA due to recreational fishers.
Fisher acceptance of management	NTZs largely accepted by fishers except sport fishers which fish aggregatio ns	Many initially resistant, now more general acceptance because realize need and some see benefits.	Most accept although not some diver-fishers	STC: Some accepted seasonal closed area but not all. Acceptance increased as saw benefits. STX; few fishers accepted seasonal closure.	Acceptance grew over time with some reservations and calls for better MCS	Many accepted closures although some poaching continued.	Commercial fishers mostly target FSAs. NTZ accepted by some fishers. Year-round protection of all FSAs not accepted.	Growing acceptance of regulation possibly due to establishment of fixed seasonal closure. Fishers reluctant to accept need to protect FSAs year-round.	Fishers requested protection of one FSA and willingly participate in monitoring.	Accept some but not all measures; better acceptance for size and bag limits.
Type of FSA management	Few NTZ on some spawning sites. Some minimum size limits. Many FSAs and staging areas not protected.	Seasonal and spatial protection long term, no take sale or possession, slot limits, bag limits and gear restrictions.	Moratorium	Seasonal and spatial measures; trap fishing banned year – round. Spear and hook and line allowed out of season.	Island-wide ban in season and variable duration spatial bans at several sites. Compatible regulations State/Federal for capture, possession and sale during season.	All spawning sites with seasonal protection, and size limits and closed FSAs. A skin patch is mandatory for fillets	Seasonal protection and several reserves. Stock assessments do not address FSA fishing.	Closed season and minimum size limit.	One NTZ; no legislations specific to the species	Minimum size, daily recreational bag limits, one NTZ and commercial trip limits in season.
Mgt effectiveness as judged by fishery status or surveys	No longer an important fishery, landings	Significant increases in numbers at two three sites and reappearance of	Increases noted in juveniles	Significant sign of population improvement at STT but not STX	Not yet assessed for Puerto Rico and fishery data generally	Recovery one site , variable stable/declini ng at others	State of fishery in decline; proportion of males from 20% to 2%	Status of many sites unclear, some gone, some declined. Landings declined	Current status not clear	Good to very good management effectiveness for the MPA

	seriously reduced.	an aggregation			unreliable. Mona island NTZ showed no changes over 13 yrs.		which may be compromising reproduction	86% in two decades.		at Riley's Hump. S No direct FSA management at Western Dry Rocks. D
Enforcement capacity and effectiveness	nforcement often effective among commercial fishers. But there are no rules to protect various FSAs, which appear to be used more by sport fishers.	Varies by island. seasonal closures enhanced enforcement effectiveness	Many fishers comply, although some divers poach.	Lacking enforcement capacity at both local and federal levels on all islands	Poor supervision limits effectiveness, with low intervention rates	Enforcement capacity overall low due to lack of funding but strong at some times and places. Co-managed by WCS, SEA and government	Enforcement variable but generally poor. Need for strong modern enforcement program and legal system. VMS not on many fishing boats.	Both low due to large number of FSAs and large area, lack of funding and capacity. Need inter-agency cooperation to strengthen surveillance and address IUU.	Minimal. Fishing cooperatives conduct community surveillance of NTZ but lack power to act. CONANP enforce MPA but not fisheries. CONAPESCA lack inspectors and equipment.	FWC inspects landings in one area but offshore site enforcement can be limited
Compliance with regulations	Appears acceptable for size limits and a few no-take areas	Generally good, although varies by islands. Improved when regulations clearer and stronger.	Fair fisher compliance; poaching large fish is hard to do covertly.	St. Thomas fishers show more compliance with regulations than St. Croix fishers with regard to poaching in fishery closed areas	Low compliance during 3-month ban; better in two seasonal MPAs and at third MPA different regulations challenge enforcement.	Voluntary compliance with FSA closures relatively high but waned and allowed foreign IUU; some prosecutions.	Variable, but illegal fishing continues by both commercial and recreational fishers.	Compliance varies for closed season and size limits. More effective enforcement needed.	Fishers generally comply with the NTZ	Most recreational and commercial fishers largely comply.
Leadership, driving forces	Scientists and some NGOs. Government management and research institutions.	Long term collaborations among CIDoE; REEF; other government; local island businesses.	Dive ecotourism industries; scientists	CFMC working closely with the STT and STX Fisher Associations. Academics conduct supporting research.	Mainly scientists and conservation NGOs. Little from fishers due to little convening opportunity. Govt. leadership weak.	Excellent collaboration among fishers, scientists, government, NGOs as The BNSAWG over two decades; regularly meeting, monitoring	Scientists. Fishers generally support seasonal closures but not the year-round closures of FSAs needed in this case.	Scientists, environmental NGOs and the government drive conservation for Nassau grouper. Currently, leadership spearheaded by The Bahamas Nassau Grouper	Community fishing cooperatives are strong allies and have exclusive access rights (TURFs) for lobster and tend to apply this to all the species so each community/cooperative has a vested interest to protect	NTZ involved a specific initiative with many agency and NGO partners. Open FSA has had limited conservation momentum.

						and database.		Working Group.	their fishing grounds.	
Communication, outreach	None or very limited for this species. More focus on snappers with higher landings.	Extensive, collaborative efforts of REEF/CIDoE Grouper Moon project; seminars, public meetings, school curricula, documentaries	Could be significantly improved: ignorance exists about aggregations	Annual announcements of closures and other regulations (CMFC). Outreach by UVI's Marine Advisory Service and USVI Division of Fish and Wildlife.	Government bulletins & calendars issued with closed seasons (CFMC and Sea Grant). Information variously picked up by social media.	Communication + outreach (including videos, posters, T shirts, publications), & community meetings. WCS shows videos in closed season.	Outreach not the major problem.	Communication and outreach includes posters, brochures, PSAs, documentaries, flyers, public presentations, meetings, TV and radio. Some materials target students and teachers.	Little outreach for snappers. Most FSA work has focussed on groupers, mostly Nassau.	Some from FKNMS, FWC and SAFMC in public workshops
Availability of underlying science and other fishery information	Catch information by region dates back to 1960. Many FSAs have been identified without resources for follow-up studies.	Extensive; collaborative efforts of REEF/CIDoE Grouper Moon project. 18+ years of research plus historical CIDoE research programs. Much UVC work and novel science.	Much published on biology & ecology including some spawning locations and season.	UVI research on life history, genetics, biology, ecology, acoustic tracking, fishery independent surveys, mapping. Fishery data generally unreliable. Limited port sampling.	Much science including biology, mapping, acoustic tracking but few UVC data. Fishery data unreliable so hard to assess management effectiveness..	Underlying science good, including site characterization, mapping and regular monitoring across multiple sites.	Good underlying science but poor acceptance by NMFS and Councils of need for widespread NTZ and adequate legal system.	Many publications dating back to the 1970s, onr FSAs, ecology, telemetry, biology, management and genetics. More monitoring and FSA characterization are needed.	Little available science especially for snappers. Landing information is "fin-fish" so cannot identify species-specific trends. Only two Mutton snapper FSAs visually verified.	Extensive research conducted by FWC, FKNMS and NOAA at NTZ. Less so at open FSA site in a heavily used areas.
Political will	Little political interest in Nassau since it is so reduced.	Long-term commitment from CIDoE built political will for decision making at multiple levels of government	Many politicians misinformed - jewfish seen purely as a 'fishery' species – yet dive tourism more profitable to Florida	Little political will or funding to support commercial fisheries port sampling or population assessments, etc.	Little or even negative political will to support, adapt or improve FSA closures despite evidence of need.	Very good and broad political will to manage and conserve NG	Little political will and weak resistance to fishing exemptions that weaken existing legislation.	Some political will but need for improved cooperation within and amongst government agencies and others.	Political will supports requests from fishing communities to create NTZs with NGOs covering most costs. Little will to create species-specific fishery regulations as snapper not a priority.	To support size limits and bag restrictions but not as much for NTZs in last decade.
Case study provided by:	*Rodolfo Claro*	*Croy McCoy, Scott Heppell, Bradley Johnson*	*Christopher Koenig*	*Rick Nemeth*	*Michelle Scharer*	*Will Heyman, James Azueta*	*Chris Koenig*	*Krista Sherman*	*Stuart Fulton*	*Alejandro Acosta Don DeMaria*

6.0 THE RESOURCES AND THEIR FISHERIES AND TRADE: Nassau grouper and mutton snapper

Introduction to Nassau grouper and mutton snapper

The Nassau grouper and mutton snapper are important components of multi-species reef fisheries in coastal areas of the WECAFC region (Sections 6.1 and 6.2). Snappers and groupers comprise some of the most valued species in these fisheries. They are important for livelihoods, as food, in local economies and international trade, as well as for artisanal and industrial scale fisheries. They also have ecological roles as intermediate-level reef predators. Because of their vulnerable, aggregation-based spawning biology, their fisheries can only sustain light to moderate levels of fishing pressure, at best producing a few thousands to tens of thousands of tonnes per year in total within the region. Accordingly, they need to be managed acknowledging their particular biological characteristics.

The mutton snapper and Nassau grouper are particularly vulnerable to overfishing due to their habit of forming aggregations for reproduction. Being generally consistent and predictable in space and time, these aggregations have been a prime target for fisheries for decades throughout most of the WECAFC region. For both species the majority of annual catches are (or once were, in the case of those fisheries that have largely collapsed) taken when they aggregate to spawn or are migrating *en masse* to their seasonal spawning aggregations. Although in the past low levels of subsistence fishing on aggregations was evidently sustained, intensification of fishing and, in particular commercialization, has led to heavy fishing pressure that cannot be sustained on these aggregations. However, most spawner-based fisheries are not yet managed or, where management measures have been introduced, not managed effectively because measures were insufficient, inappropriate and/or were not enforced. In most cases data on these fisheries are poor.

As a result many mutton snapper and Nassau grouper populations have declined, some substantially, throughout their geographic ranges. As seafood demand increases for high quality reef fishes, more of these fisheries are predicted to decline unless they can be managed effectively, particularly if local aggregations are fished to ecological extinction. Declines across the region have occurred to such an extent that the **Nassau grouper** (https://www.iucnredlist.org/species/7862/46909843), once the most important grouper in the insular Caribbean, is now considered to be commercially extinct in much of its range. It is classified as **Critically Endangered** on the IUCN Red List, and NOAA recently listed it as threatened under the Endangered Species Act (ESA) of 1973, as amended. As a reflection of its depleted status, it was added to the SPAW protocol in 2018, the first commercial reef fish to be included. The **mutton snapper** is listed in the **Near Threatened** category of the IUCN Red List (http://www.iucnredlist.org/details/12416/0). For commercial fishes to be reduced enough to be subject to such conservation concern is indeed worrying from the perspective of losses to biodiversity, food security and earnings, and the situation clearly merits serious attention. Ensuring sustainability of fisheries resources is receiving global attention as a fundamental part of several of the Sustainability Development Goals that relate to natural capital and the benefits that humans gain from it (https://www.un.org/sustainabledevelopment/sustainable-development-goals/).

Effective fisheries regulation depends on an understanding of biology and ecology, socio-economic factors and associated fisheries and trade. In the case of aggregating species, information on the timing, location and dynamics of their spawning aggregations and the fisheries on these, are particularly important for developing conservation and management plans. The following sections address biology and trade issues relevant to this FMP. More general information on the biology and ecology, distribution, ecological role and an introduction to the aquaculture potential of the two target species are covered the **Source Documents (Section 10)**.

The following sections describe how this fishery operates, provide brief biological information and provide country-level trends in catches, where available, to profile what is known of the Nassau grouper amd mutton snapper resources currently and over time. Information is also included on regulations that specifically seek to manage these species, with other relevant and complementary measures referred to. Limited information is available on sizes of capture and domestic and international trade. For full details and referencing see **Source Documents**.

6.1 Nassau grouper

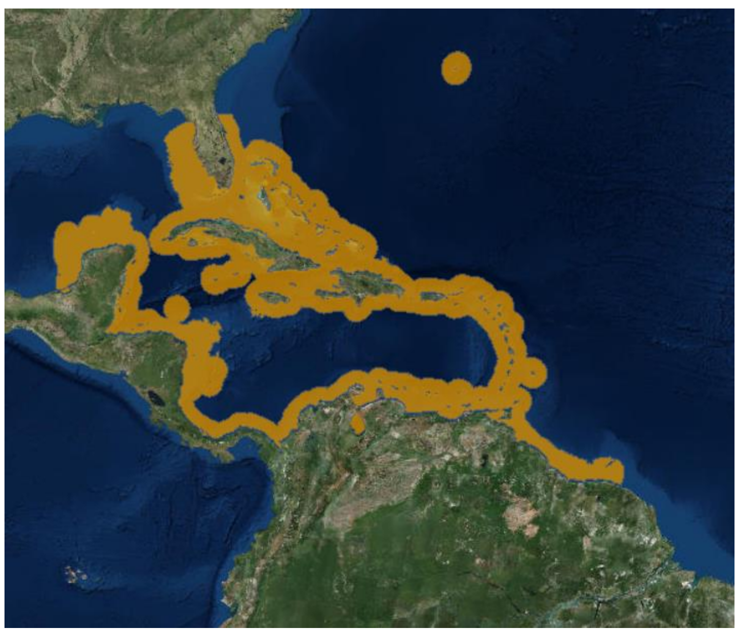

Figure 6. Geographic distribution of the Nassau grouper, *Epinephelus striatus* (IUCN Red List)

Biology Summary (see Source Document Section 10.1 for details)

The Nassau grouper occurs almost entirely within the WECAFC region, distributed from Cape Canaveral, Florida, south along the U.S., Bermuda, across the Gulf of Mexico from the Florida Keys, the Flower Garden Banks, and Tuxpan, Mexico, throughout the Caribbean Sea, and along the South American coast to French Guiana (Fig. 6). The species prefers clear water with high relief coral reefs or rocky substrate. Early juveniles inhabit inshore habitats including macroalgal clumps, seagrass beds and coral reefs and adults migrate out to deeper waters down to at least 140 metres. Individuals have been recorded to regularly descend to depths of 255 metres during the spawning season.

The species is only known to reproduce in its annual spawning aggregations and has a relatively short spawning season of 1-3 months each year. These months fall variously within the period December (possibly November) to March, depending on location and full moon timing, although it can vary somewhat depending on location. Hundreds to, historically, tens of thousands of fish gather at approximately the same locations each year and stay for about a week. Spawning occurs over a few days around the time of the full moon and within a relatively narrow temperature range of 25–26°C. In some areas, pre-spawners have been noted and/or exploited moving in groups to spawning sites; in Cuba, for example, movements of Nassau grouper are referred to as *corridas* and such movements may also happen at non-spawning times. Aggregation sites are typically drop-off areas at the edges of coastal platforms/reef channel openings and outer reef promontories. Sexual maturation occurs at about above about 40 cm TL or above for both sexes but is variable. The species can attain almost 30 years of age and exceed 1 m in TL.

The Nassau grouper is known to move over large distances, both in adult and pelagic phases. Individually identified adults can migrate over 200 km within a few months between their home reefs and spawning aggregation sites, while juveniles migrate out from nursery areas to deeper waters with growth. Recent population analyses suggest population sub-structuring to cover three extensive areas across the range of the species, indicate weak sub-structuring in the Bahamas and suggest some loss of genetic diversity in the USVI probably due to overfishing. Tracking studies, whereby drogues were released at spawning sites and times also suggest that local recruitment can occur, based on studies in the Bahamas and Cayman Islands.

Commercial and recreational fisheries and trade

Introduction

In the early 1900s the Nassau grouper was the most important exploited grouper in the insular Caribbean and many of the catches came from their annual spawning aggregations and adult fish movements to reach them. In many cases the aggregations yielded much of the annual fishery catch although the species is also caught at other, non-reproductive, times of the year. However, heavy fishing at predictable spawning sites has now removed a massive proportion of the spawning stock in most regions and thereby substantially reduced annual reproductive output, and hence landings, within and across metapopulations (see below). This has resulted in serious declines in fisheries of Nassau grouper throughout the region, including those countries where fisheries were once substantial due in part to large shelf areas (e.g. Belize, The Bahamas, Mexico, Cuba). While migrating groups of pre-spawners may also be a target of fishing, as in Cuba (e.g. Claro et al., 2009), these movements do not appear to be well-documented within the WECAFC region generally. Declines have occurred in almost all countries where the species is caught, as judged by catches. Underwater visual census data also reflect these declines with very few of the species now seen on regular transects (such as those by REEF; also see review in Hill and Sadovy 2013).

Catch data

Out of about **40** countries included in its range, spawning aggregations have been reported in about **13** countries or political units with over **100** aggregation sites indicated or described (Table 2). Many of these sites were identified using elevated seasonal catch trends or presence of high proportions of ripe fish and fisher knowledge as indicators of aggregation occurrence and aggregation fishing. Some data come from underwater surveys of aggregated fish numbers by divers. However, many of the sites once known to exist evidently no longer form or have far fewer fish than they once did, hundreds rather than thousands or tens of thousands (Figure 7).

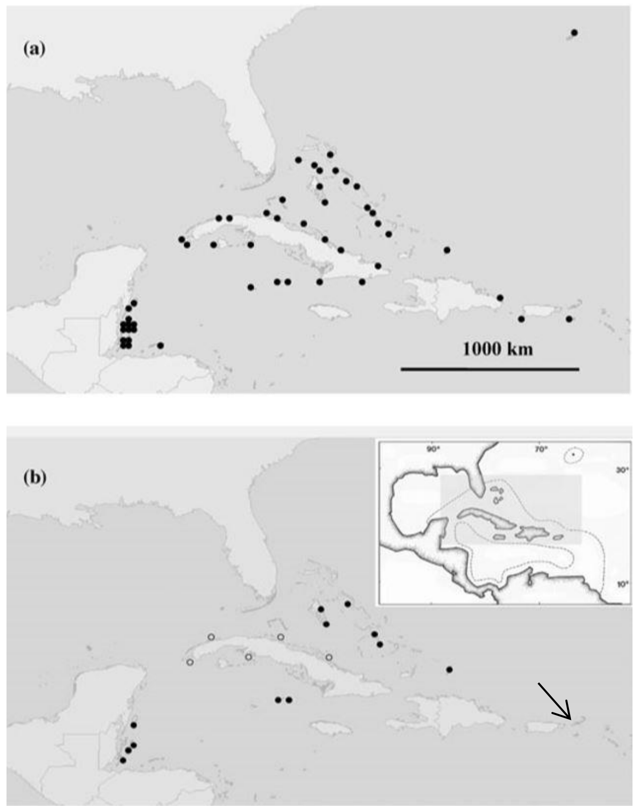

Figure 7. Known spawning aggregations of Nassau grouper; each circle can represent more than one aggregation in the indicated area. Inset shows full geographic range. (a) All known aggregations reported since 1884. Each closed circle represents up to several reported sites. In the few cases where aggregation numbers were estimated, these ranged from approximately 10,000 to somewhere between 30,000 and 100,000 fish. (b) Closed circles represent sites believed to exist today with fish numbers estimated at between 100 and 3000 (estimates from fishing and direct observations) and open circles of uncertain status. Recently noted site is indicated by arrow (Hill and Sadovy 2013).

Noteworthy gaps in information on either fisheries or aggregations of Nassau grouper exist in parts of central America as well as in the lesser Antilles, particularly in the southern parts of the Caribbean despite the presence of both suitable reef habitat and the species. Possible reasons for lack of data on aggregations of this species in these locations include that:

- data on Nassau grouper have not been/are not being collected;
- aggregations no longer occur in these locations, never did occur or were never formally documented;
- grouper fishery data are collected but not at the species level, or fisheries data are not collected in a standardized way and hence cannot be used to indicate trends or fisheries condition;
- aggregations occur but are not fished, are too small to be evident, or have never been located.

Much can be understood of a fishery when fishery catch data are collected over the long-term and in a standardized way and compiled at the species-specific level. Data do not appear to be regularly provided by many countries across the region to FAO which would enable a global perspective of fishery but there are several useful long-term datasets that provide an indication of trends over time. In The Bahamas, landings peaked at 500 mt (1997-8) and at about 90 mt in Belize in the 1960s (see country sections below). The Bahamas banks were once major fishing grounds for Nassau grouper and still produce fish each year but reported landings over three decades have dropped to < 200 mt reported in 2017 (Fig. 8). The long-term detailed Cuban dataset, for which monthly data by region were collected over more than five decades (Fig. 9), show that annual national catches reported dropped about 1,700 mt (1963) to negligible today (Claro et al. 2009). Current information is particularly needed from other countries where the there are extensive areas of suitable habitat for the species, such Belize and Mexico, because these countries, together with Cuba and The Bahamas, likely account for a significant proportion of the global population of the species.

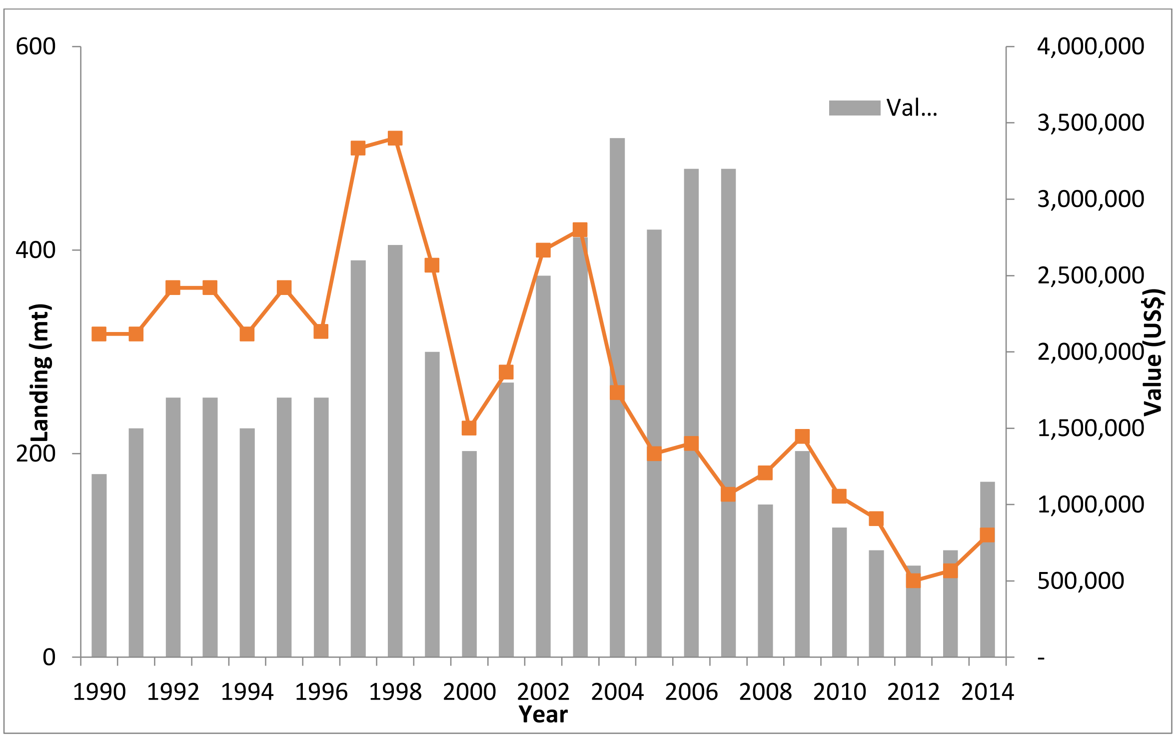

Figure 8. Landings by weight (mt) and value (US$) of Nassau grouper in the Bahamas from 1990 to 2017 (Gittens, 2011; Gittens pers. comm.)

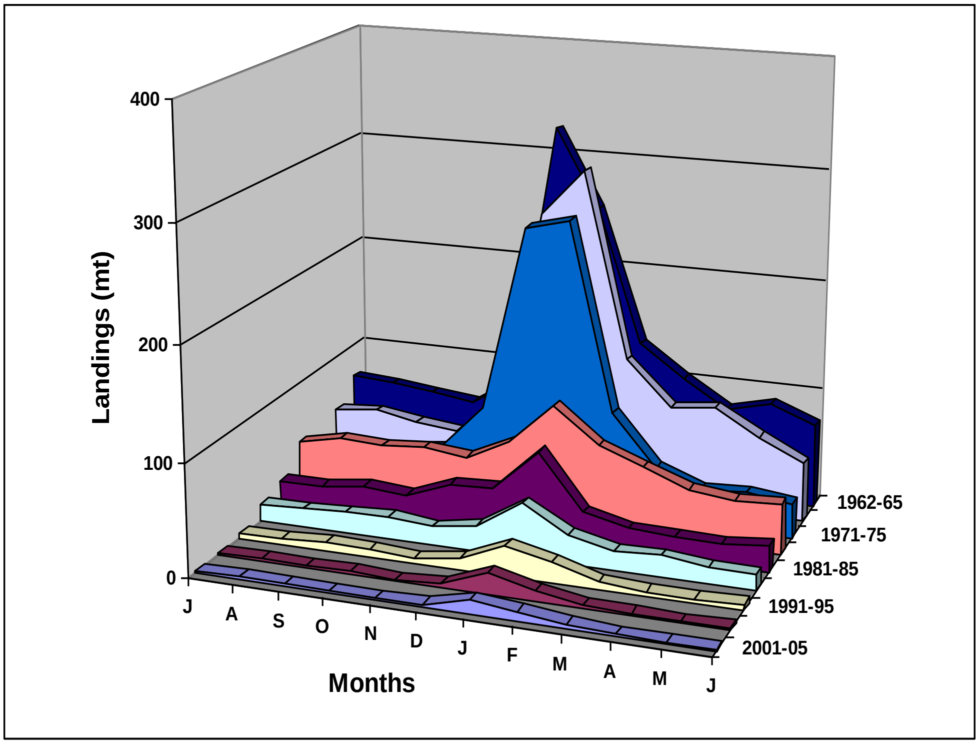

Figure 9. Average monthly catches by five-year periods (Claro et al. 2009) of the Nassau grouper, *Epinephelus striatus*. Aggregation period is December to February with highest catches in January (historically). Indications are that landings have stayed at low levels over the last 20 years.

Available information on known or possible exploited spawning aggregation locations and times, fisheries and condition and species-specific management measures are compiled (Table 2) and the fisheries and known stock condition covered in more detail in the Source Document.

Table 2. Known or possible exploited spawning aggregation sites of Nassau grouper (*Epinephelus striatus*) in the WECAFC region and relevant management measures. FK: fisher knowledge; NTZ: no-take zone. No recent information for many sites. For country-level information, see Source Documents. * Note that several generic fishery management measures are also in place in many areas that can benefit the mutton snapper though spawning aggregationsare not the specific management target. Examples incluse: controls on set nets across channels, long bottom trawls; generic minimum sizes, bag limits and other gear controls are likely to confer some protection on the species.

Country	Aggrega-tion Sites	Peak Spawing relative to full moon TBC	Estimated Status	*Aggregation Management	References
Bahamas	About 30 sites described	Mainly December/ January/February	Current status of many sites unknown. National landings declined 80 percent by weight from peak in late 1990s to 2017 (Fig. x). About 30 viable aggregations remain but declines at many; losses of some including disappearances at Cat Cay (Fig. x) and some at Long Is. Considerable IUU is occurring in southern waters, including on FSAs from Dominican Republic vessels.	Size limit of 1.36 kg introduced late 1980s, after which an increasing suite of management measures introduced. 1998 - 2000 partial seasonal closures of sites at Long Island, High Cay, and Andros. From 2004 year on year closures for 1-2 months between Dec and Feb in but from 2015 permanent seasonal protection Dec 1 – March 31. No sale in closed season. Ongoing illegal fishing especially by foreign vessels. Exports not permitted except on recreational vessel catches. A skin-on policy aids fish identification of fillets.	Smith, 1972; Colin 1992; Sadovy (1997)- Vallierre Deleveaux and Lester Gittens, pers. comm., Bahamas Dept. of Fisheries; Garcia-Moliner and Sadovy 2008; Erisman et al, 2013; Sherman et al. 2016
Belize	At least 15 spawning sites are known	Mainly December/ January	Much reduced over two decades. Some FSAs once had tens of thousands of fish. Those surveyed (2003-2012) contain < 100 to a few thousand fish recently (n=7 monitored sites) each. Numbers not notably recovering despite full protection but appear to be stable so further declines may have been averted. Glovers Reef has 80% decline in 25 years (15,000 to 3,000 fish). IUU by Guatemala and Honduras vessels.	All 13 known spawning sites protected. Minimum capture size (50.8 cm) since 2003. Site protection at 11 aggregation sites since 2003 and two more protected more recently. Closure Dec 1-Mar 31. Fish to be landed whole and no sale or possession allowed in closed season. A skin-on policy aids fish identification of fillets.	Sala et al., 2001, Carter et al., 1994, Heyman and Requena 2002. Paz and Truly 2007. Hill and Sadovy de Mitcheson 2013, Burns and Tewfik, 2016, Gibson et al. 2007
Bermuda	4 known sites historically	May-July	From healthy numbers in the 1950s landings dropped in the 1970s, from 75,000 tonnes in 1975 to less than 10,000 t in 1981 and no site remains. Drop of 95% and still no recovery despite protection. Average sizes also declined.	Species fully protected.	Luckhurst 1996; Hill and Sadovy de Mitcheson 2013

Cayman Islands	7 sites known (5 well-known) and two decreasing. One may have shifted in location.	Between Dec and March	Declined until the early 2000s before management put in place. Some FSAs once considered on brink of collapse. Two aggregations now back to thousands of fish; a third, smaller, one not recovering so well. Some illegal fishing appears to be occurring.	Management increased steadily over time and is well implemented resulting in increasing numbers. All FSAs are protected from Nov 1-Mar 31. No possession or sale permitted over same period. Slot size permitted in non reproductive season is 16"-24" and no more than 5 fish per fishing vessel per day can be kept Nassau Grouper may not be taken on spear gun	Whaylen et al. 2003, 2007; Rand et al. 2005; Bush et al. 2006; Semmens et al. 2012
Cuba	Current status of over 20 known sites poorly known; FSAs known since the 1800s.	Between Dec and March	All regions show massive declines in catch, all sites are overfished. Condition of this fishery overall is extremely reduced.	Management measures increased over years but not well enforced and not specific for Nassau grouper, except minimum size 32 cm FL effective 1996. Fish must be sold to government enterprise.	Claro et al., 2009; Claro et al. 2001 and Claro and Lindeman 2003; Claro et al., 2018; Vilaro Diaz 1884
Dominican Republic	One site known historically	?	No longer known and probably has disappeared.	No management	Sadovy de Mitcheson et al., 2012; P. C. Colin, pers. comm.
Honduras	5 sites with a further 7 suspected.	Between Dec and March	Mostly unknown but possibly gone, one decreasing. Nassau grouper landings increased til end of 1980s and early 1990s and then declined. At one site aggregation declined from approximately 10,000 fish to less than 500 in 2 years	Illegal exports are reported.. Aggregation sites protected from fishing between December and March	Hill and Sadovy de Mitcheson 2013; Box and Bonilla Mejia 2008; Fine 1990, 1992
Mexico	28 sites reported but only 4 verified.	Between Dec and March	Best known sites are Mahahual and Xcalak. Mahahual had up to 15,000 fish present collapsed by 1996. Xcalak is largest known in Mexico with 4,100 fish in 2004-5. Nichehabin and San Juan Chenchomac sites confirmed by diving, one with 800 fish.	Xcalak FSA is in a National Park. Prohibition on use of gillnets at spawning aggregation sites.	Aguilar Perera, 1994, 2006, 2007, Aguilar-Perera et al. 2009, Fulton et al. 2018, Fulton et al. 2016, Fulton et al. 2017

Puerto Rico	Two known and fished from 1950s onwards. One SW Puerto Rico and one at Mona Is.	Between Dec and March	Aggregation sites apparently longer exist	Species protected in both Federal and State waters but commercially extinct. From 1985 measures to protect species sequentially introduced from minimum size, seasonal closure to moratorium. Take and possession in US federal waters (9-200 nautical miles) prohibited in November 1990; take, sale, and pursuit in state waters (up to 9 nautical miles) prohibited in March 2004.	Hill and Sadovy de Mitcheson 2013
Turks – Caicos	1 known	Between Dec and March	Status unknown but probably good as fishing pressure low on the species	One aggregation site protected at Northwest Point Marine National Park, Providenciales.	Rudd 2003, National Parks Ordinance and Subsidiary Legislation CAP. 80 of 198
U.S., Florida Keys	Historically sites may be indicated, but little evidence of NG FSAs in the Keys since at least the 1970s.	?	Status of any existing aggregation not known. Even after moratorium the species has not recovered.	Multiple measures to protect the species including a moratorium in State and Federal waters, with possession now prohibited and the species is on the ESA. Take and possession prohibited in federal waters in November 1990 and in state of Florida in 1993; protected in Dry Tortugas Marine Reserve and Florida Keys National Marine Sanctuary; listed as Species of Concern by US NMFS.	Hill and Sadovy de Mitcheson 2013

U.S. Virgin Islands	2	Between Dec and March	Nassau grouper fishery collapsed in late 1970s about time of first aggregation loss. One site possibly undergoing recovery	In 1990s possession prohibited and MPAs put in place (e.g. Grammanik Bank). Some gear restrictions. In 2006 no possession or harvest and no fileting at sea. Spawning season closure from 3 December 2005 to 14 February 2006, established at Grammanik Bank, St. Thomas; Hind Bank Marine Conservation District – former FSA protected in 1998. No take or possession from US federal waters (3–200 nautical miles offshore) entered into effect in 1990	Sadovy de Mitcheson et al., 2012; Olsen and LaPlace 1979; Munro and Blok 2005; García-Moliner and Sadovy 2007, Kadison et al., 2010, Nemeth et al., 2009
Venezuela, Los Roques	Anecdotal evidence identifies spawning aggregatio ns in Los Roques, Venezuela	?	No information	No known protection of the species	Hill and Sadovy de Mitcheson 2013; Boomhower et al. 2010

Fishing operations

The species is fished commercially and recreationally by hand-lines, longlines, Antillean fish traps, spear-guns (often with the use of compressors) and gillnets. Fishing is/was especially high during the reproduction season focused on spawning aggregations. Fishing techniques vary by country and over time, as population abundance declined and different fishing techniques became possible, or necessary, across its geographic distribution.

Recreational

There is very little information available on the recreational fishery component of this species despite considerable interest in the north Bahamas from US-based recreational fishers. In the Bahamas, Nassau grouper are targeted by artisanal/subsistence, recreational and commercial fisheries. Recreational landings data between 1986-91 shows that the Nassau grouper harvest in the US decreased both in terms of total weight landed and average size. As a result of this decrease in yield, which occurred in both recreational and commercial fisheries, the Caribbean (1990), South Atlantic (1991) and the Gulf of Mexico (1996) Fishery Management Councils and the state of Florida (1993) prohibited take and possession of Nassau grouper. In the 1990s, most catch from the recreational fishery was from private/rental boats (detailed in Sadovy and Eklund 1999). Both recreational and commercial catches of Nassau grouper were higher from the Florida-Gulf of Mexico than from the Florida-Atlantic coast from 19861993 (NMFS General Canvass Landings System). In Cuba speargun was used both commercially and recreationally. Despite controls on this gear type, an important recreational fishery persisted, using both hook and line and spear-gun, on the spawning aggregation sites in the northern Cuban Archipelago (Sadovy and Eklund 1999).

Commercial

Commercial exploitation of this species in the WECAFC region was reported as long ago as the 1800s and early 1900s (Vilaro-Diaz 1884; Rudd 2003) with greatest catches taken during the spawning seasons. A more intensive fishery phase started around the 1950s when the species was caught by multiple small boats, which were replaced by larger commercial vessels around the 1960s such as the case of the Bahamas and Cuba (Smith and Zeller 2013; Claro et al., 2001). As landings declined, the number of boats involved in the fishery of the species dropped.

In Central America (Belize – Nicaragua) and Mexico, this grouper was caught initially with hook and line, shifting to scuba and spear-gun to increase catch effectiveness, a change believed to have had significant impacts on natural populations, and the loss of several spawning aggregation sites (Sala et al, 2001, Colas-Marrufo et al 2002, Sadovy de Mitcheson 2012). In many places, such as Honduras, there are currently no longer any dedicated commercial boats that fish for Nassau grouper (Zepeda et al. 2011) and only small-scale boats now take the species due to severe population reductions.

Nassau grouper is also caught during non-aggregation times. For example, Paz and Truly (2007) and Sala et al. (2001) mentioned that, in the early 1970s, the species was taken throughout the year, and noted that 14% of the adult population was removed annually by year-round fishing in Belize.

Domestic and international trade

Nassau grouper is a highly valuable commodity important for both trade and food security for local Caribbean coastal communities and in the tourism sector. The species is traded fresh and frozen, whole and filleted. Unfortunately, very few quantitative data are available about this trade because the species is usually commercialized only as a 'grouper' or 'cherna', which may include at least 5 – 6 associated species, or as fillets.

To fully understand the extent and nature of the economic value in this species data are variously needed on trade (both domestic and international), socio-economics (who depends on these species and how are they used recreationally and commercially), non-extractive values (such as eco-tourism) and also the income from both spawning and non-spawning seasons. Data on typical fish size being marketed as well as the form of the trade (i.e. whole or filleted, fresh or frozen) is largely lacking.

For *domestic trade* around the region several studies provide insights into domestic trade practices, sizes marketed and volumes. In the Bahamas, Sullivan-Sealey et al. (2002) conducted market surveys and interviews on the Nassau grouper and found that almost one third of the fish traded were likely immature or reproductively inactive based on the known size range of late juveniles and early adults (528 +/- 61 mm TL.). Of a total of 54,000 fish landed during the 6-month survey period, Nassau groupers made up an average of 10% (by number) with June being the lowest (4%) and October being the highest (13%). Honduras used to export much of this species but since its landings declined substantially this species tends to be sold to local markets for national consumption and not for export (Zepeda et al. 2011).

In Belize, Nassau grouper production is mostly for local markets by independent fishermen and cooperative members, hotels and private individuals. Therefore, most sales tend to come from unreported landings. Both fish and roe are sold. It was estimated that fillets were sold at US$ 5.5 –7.7/kg in 2000-2001, providing approximately $US 7,000 for fillets and $US 1,000 for roe per season (annually). These numbers may represent $US 40/fishermen/day which is 4 times the minimum wage in Belize, and represents a strong incentive to catch the species for a small number of fishers (Belize Fisheries Department 2001, Villanueva 2004, Paz & Grimshaw 2001). Currently, no significant international trade in Nassau grouper (whole or fillet) takes place with this species originating from Belize.

Based on the Puerto Rico Department of Natural Resources monitoring of landings, Juhl & Suarez-Caabro (1972) estimated that 193.2 mt of groupers were landed and valued in $US 138,000 (representing the 80% of the landings). By 1988, this production of Nassau grouper was estimated in 0.9 mt valued at $US 2,071 (US$ 1.16/kg) (Matos & Sadovy 1990). Just before the species moratorium in 2002, the landings of Nassau grouper reached 8.5 mt that were valued at $US 18,708 (US$ 1.75/kg) (Matos-Caraballo 2006), and reduced to 0.1 mt valued in $US 260 ($US 2.27/kg) (Matos-Caraballo 2012). This product is traded locally.

Annual consumption of groupers in Turks and Caicos is about 85 mt, of which 60% are landed locally with Nassau grouper the most commonly consumed grouper and supplied directly to hotels and restaurants by a small number of artisanal fishers based in Providenciales. Local restaurants tend to use locally and fresh produced species. Fresh and frozen finfish imports are taxed at a rate of 40% reducing their competitiveness in the TCI market (Murray 2004).

Regarding *international trade*, the United States is by far the major importer of groupers in the region although how much of this is Nassau grouper is not known. Groupers likely to include Nassau grouper are imported from Belize, Honduras, The Bahamas, the Cayman Islands and possibly elsewhere. For example, the NOAA Fisheries Trade Center (NOAA Fisheries Trade Center (https://www.st.nmfs.noaa.gov/st1/trade/monthly_data/TradeDataCountryMonth.html) indicated that grouper imports from Belize between 1993 and 1996 totaled 18.3 mt valued at US$64.171 (US$1.3-3.6/kg), mostly traded during the Nassau grouper reproductive season. Belizean imports re-appeared in 2016 with 239 mt valued in US$ 2,404 (US $10.1/kg). The proportion of Nassau grouper in these transactions remains unknown, but the possibility that these include Nassau grouper cannot be discounted. The Bahamas exported about 5.0-7.9 mt (US$ 3.2-4.5/kg) at the beginning of the 1990's, increasing to a maximum of 78.5 mt (US$4.3/kg) by 1998; since 2007 this amount varied from 6.4 to 51.9 mt (US$7.6/kg on average). Many of these exports were done shortly after or during the Nassau reproductive season although the species being traded is not known. Although Deleveaux (2016) reported the practice (although not a regulation as such) that Nassau grouper cannot be exported, given that Nassau grouper represent the most frequently landed grouper, it is not clear which groupers are being exported to the United States if not the Nassau grouper. Edison Deleveaux (pers. comm. 2018) indicated the red grouper (*Epinephelus morio*) is the major grouper exported but this species is unlikely to be common in The Bahamas, so Nassau exports are likely to be occurring. Recreational boats are allowed to keep their catch and many Nassau grouper may enter the US through this route.

Honduras has been an important exporter to the US markets historically. Between 1996 and 2007 the Nassau grouper was traded through three main processing plants: J.B. Seafood in Guanaja, Flying Fish in Roatán and Caribbean Seafood in La Ceiba (Zepeda et al., 2011). Those exports represented approximately 7% of the total grouper exports of the country and declined to approximately 0.7% in 2008. It is believed that the Nassaus were captured on the Mosquitia coast, outside of the Golfo de

Honduras. Zepeda et al. (2011) indicated that up to 95% of the groupers exported to the US from Honduras used to be Nassau grouper, but that currently this species makes up only a fraction of the commercial industrial and artisanal fisheries. This trend for the Nassau grouper as single species was not detectable from the NOAA Fisheries Trade Center which indicates constant grouper imports from Honduras with 22-91 mt traded annually between 1992 – 1999 (US$ 2.4-2.6/kg). Grouper exports declined from 25 – 8.7 mt/year in the 2000's (US$ 4.9-6.5/kg) but increased to 271 and then 576 mt in 2016 and 2017 respectively (US$ 7.7-8.7/kg) (Table 7). The sources or species involved in this grouper trade is not known.

Grouper exports to the United States from other countries occur in smaller volumes. From the Turks & Caicos, US grouper imports during 1990 and 1991 averaged 3.2 mt valued on average at US$ 9,204, but increased markedly the following year with 60.7 mt valued US$ 156,292 (US $ 2.5-3.4/kg). US imports also occurred in 2012 and 2013 with a total of 9.4 and 12.5 mt valued in US$ 79,424 and US$ 85,026 traded (US$ 8.4-6.8/kg respectively with a substantial porton going to Florida (Murray 2004). In the case of Nicaraguan exports to the US, the database from NOAA Fisheries Trade Center indicates constant grouper transactions beginning in 1990. The trade initially increased from 0.5 mt (US$ 2.3/kg) in 1990 to the peak of 180.7 mt (US$ 4.7/kg) in 1988, with a steady decline thereafter to 40 mt (US$ 8.9/kg) in 2017. However, the species composition is not clear. Grouper exports from the Lesser Antilles are unlikely to include many Nassau groupers.

In addition to recreational fishing, which is poorly understood for this species, the Nassau grouper provides other benefits to the tourism industry. In the Turks and Caicos it is highly valued by the dive tourism and restaurant industries. Fishing pressure has been relatively low historically and the population appears to still be healthy (Rudd 2003, Vo et al. 2014), although effort to supply local markets has recently increased (Dept. of Environment and Coastal Resources Turks and Caicos Islands 2008). In Belize, where dive tourism is an important source of income to the country, Sala et al. (2001) estimated that live Nassau grouper (non-extractive value) was worth 20 times the extractive value at one site in Belize. Divers enjoy seeing and photographing aggregated groupers.

Management

While there been a growing suite of management measures introduced across the region over many few decades which provide differing levels of protection to Nassau grouper; overall and with a few notable exceptions (see Case Studies Section5). Several regulations and spatial management measures apply specifically to the Nassau grouper (Table 2) and many other measures may also benefit the species. Species-specific measures variously range from area to seasonal protection, seasonal sales controls and 'skin-on' requirments, minimum sizes, sales and possession controls and a moratorium. In addition to species-specific regulations, a range of more general fishery management measures and controls could benefit this species. These include MPAs (including NTZs not on aggregation sites), controls on gear (especially the restrictions on set net on the Cuban platform), bag limits, etc. Minimum sizes could be more widely applied and DNA testing to determine which groupers are being traded internationally would be useful for improving traceability and controlling this trade more closely. If international trade is significant in this species, then a CITES App II listing might support its oversight, management and conservation. Given the concerns over IUU for this species, larger fishing vessels and recreational vessels could be required to carry VMS to enable them to be tracked and tackle this threat to the species.

The Nassau gouper is variously protected in Belize, Bahamas, Bermuda, Cayman Islands, Cuba, Puerto Rico, United States Virgin Islands, Mexico and the US following major declines in fisheries and significant losses of spawning aggregations in most of these countries. However, sustained enforcement has been highly problematic in most locations (Aguilar-Perera & Aguilar-Davila 1996, Sadovy & Eklund 1999, Sala et al. 2001, Whaylen et al. 2004, Sadovy de Mitcheson et al. 2008, Claro et al. 2009. www.scrfa.org database). Despite a considerable suite of management measures for this species throughout the region, problems with enforcement and compliance, with a few noteworthy exceptions, mean that many are largely ineffective (Garcia-Moliner & Sadovy 2008).

Overview

In general it is clear that Nassau grouper populations have decreased wherever exploited throughout the WECAFC, with very few exceptions, in many cases substantially, and that the species merits serious conservation attention. Massive drops in landings, several fishery collapses and the loss of, or declines in, the great majority of known spawning aggregations collectively signal that its reproductive capacity is severely compromised. Declining aggregations and catches that include significant numbers of juveniles are seriously compromising the future of this species, both economically and biologically and it should be treated with the highest priority for management.

Certainly efforts to increase enforcement, especially to reduce IUU in areas such as Belize and The Bahamas where substantial effort is being directed towards management but is undermined by foreign vessels entering the countries, is needed and modern technologies could perhaps be applied in support of this. International trade could possibly be better controlled by a CITES Appendix II listing, while DNA testing of traded fish and fillets could advance understanding of which groupers dominate international trade and the role of Nassau grouper in this trade.

6.2 Mutton snapper: resource, fisheries and trade

Figure 10. Geographic distribution of the mutton snapper, *Lutjanus analis* (IUCN Red List)

Biology Summary *(see Source Document Section 10.2 for details on biology and ecology)*

The mutton snapper occurs almost entirely within the WECAFC region (Fig. 10). It is a shallow-water snapper that utilizes several reef habitats throughout its life. The species is only known to reproduce in its annual spawning aggregations and has a relatively short spawning season of 2-3 months each year. These months fall variously within the period April to July, depending on location. Spawning in aggregations occurs around or just after the full moon. However, over large areas and even within a single country, as in the case of Cuba, spawning seasons can differ slightly in different places (e.g. around Cuba peak seasons can vary from May and June, to June and July to July and August). Such possible variation is important to consider in the case of temporal protection measures. Aggregation sites have sandy, rocky and or coral habitat and occur on outer reef slopes. These are typically adjacent to deeper waters and most recorded sites occur at 20-40 m. Sexual maturation occurs at 30-40 cm TL or above for both sexes (see Source Document Section 10.2).

Commercial and recreational fisheries and trade

Introduction

The mutton snapper is captured traditionally across the insular and continental platforms (20-70 m) of the Wider Caribbean region, as juveniles and adults, as part of a multi-specifies, multi-habitat and shared resource, often known as the snapper-grouper fishery complex. It is caught from Cape Canaveral to Dry Tortugas, the United States and Mexican waters of the Gulf of Mexico, across the Greater Antilles, the Caribbean waters in Mexico (Tamaulipas, Veracruz, Tabasco, Campeche, Yucatán and Quintana Roo), and across the Caribbean waters in Central America (mainly Belize, Guatemala, Honduras, Nicaragua), as well as in South America (Colombia, Venezuela and Brazil).

The annual spawning aggregations and adult fish movements/migrations to reach them support many fisheries and local economies. Benefits derive *directly* from aggregation-fishing and from eco-tourism, and *indirectly* from the young produced in aggregations which survive to replenish the fishery over wide areas outside of the reproductive season. While a relatively small number of aggregations yield much of the annual fishery catch, significant landings are also taken widely outside of the reproductive season (See Fig. SD8 for monthly landings in Cuba from 1966-2005 in Source Document). However, heavy fishing at predictable spawning sites can quickly remove a large proportion of the spawning stock and thereby substantially reduce annual reproductive output which depletes the fishery as a whole in a serial fashion, aggregation loss after aggregation loss.

Catch data

Although mutton snapper spawning aggregations have long been targeted by fishers throughout much of their geographic range, detailed information on both fisheries and aggregations of this species is lacking for most (78%) countries in the WECAFC region. Out of over 40 countries included in its range, spawning aggregations have been reported in **about 12** countries or political units with at least **25** aggregation sites indicated (Table 3). Many of these sites were identified using highly elevated seasonal catch trends and fisher knowledge as indicators of spawning aggregations.

Many data gaps on mutton snapper fisheries and spawning aggregations occur in some areas of large coastal platforms and abundant coral reefs where the species likely occurs in abundance e.g. the Bahamas, Brazil, Honduras, Guatemala, particularly in the lesser Antilles and southern parts of the Caribbean (e.g., Kobara et al., 2013). More information is also needed from areas where aggregations are suspected, such asHispaniola and Central America in areas of large shallow systems, where seagrass, mangrove, and patch reefs, habitats well-suited to the species occur. Possible reasons for lack of data on this species in these locations include that:

- data on mutton snapper have not been/are not being collected
- aggregations no longer occur in these locations, or were never properly documented when they did occur, or are too small to be obvious;
- snapper fishery data are collected but mutton snapper data are combined with many other snapper species in landings data (very common),
- fisheries data are not collected in a standardized way and hence cannot be used to indicate trends or fisheries condition;
- aggregations occur but are not fished, or have never been located;

Much can be understood when fishery data are collected over the long-term and in standardized manners. This information enables biological and socio-economic analyses and facilitates both management planning and assessment of management outcomes (i.e. adaptive management). It also helps to identify problems with a fishery before these get too serious to make adaptive management possible. There are various examples of the importance of linking management to biological monitoring. In the case of Puerto Rico, two of the primary weaknesses in management are the absence of baseline data before management regulations were established, and the lack of systematic monitoring of populations once regulations were in place (Scharer-Umpierre, 2013). A similar situation is the mutton snapper closure established in 1996 in St. Croix. The first preliminary study of this aggregation was not conducted at this site until 2012, despite the fact that this was a very important commercial species and there was considerable evidence that the species was being fished illegally during the spawning season (Kojis and Quinn 2010, Nemeth, 2014).

Data on fisheries landings, irrespective of fishing sector, of mutton snapper are available from relatively few countries despite the fact it is caught in almost all of the approximately 40 countries where it occurs (See Source Document). Many countries only report data at the family level (i.e. Lutjanidae; snappers). Highest annual national (commercial) catches at the species level were in Brazil at about 3,000 mt (2011), while in Cuba landings peaked at 1,356 mt in 1987 and at about 550 mt in Florida in 1992. In the US Gulf of Mexico and South Atlantic recreational landings peaked in 1992 with 547 mt (O'Hop et al., 2015). According to available national landings data, mutton snapper catches range from tens to several thousand mt annually with catches heavily influenced by location, size of area(s) fished and stock condition.

Data on landings of mutton snapper are not regularly reported to FAO but several medium to long-term national-level datasets reveal something of the volumes and trends over time in countries across the region. Data from Cuba (1935 to 2017) and Brazil (1998-2011), countries with large coastal platforms well-suited to this species, show how landings peaked and then declined (Cuba, from the 1980s to current) or are gradually on the increase (Brazil) (Figure 11). In the case of Brazil, however, formerly abundant areas such as the northeast and southeast have seen declines with mutton snapper now mainly landed in Espirito Santo (Caltabellotta et al., 2016); hence rising landings may be due to shifts in major fishing areas for this species (Fig. 12). Annual national landings in these two countries have exceeded or once exceeded 1,000 tonnes. Of course, these catch trends correlate with changing effort as well as stock size.

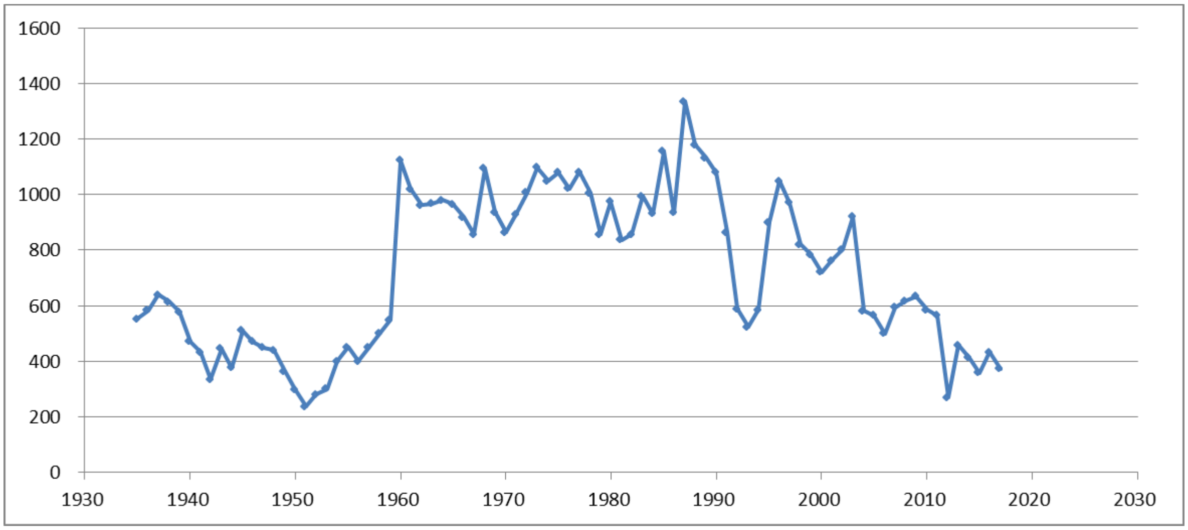

Figure 11. Total landings (in mt) of mutton snapper, *Lutjanus analis*, from 1935 to 2017 (Rodolfo Claro, pers. comm. Cuban Fisheries Statistics)

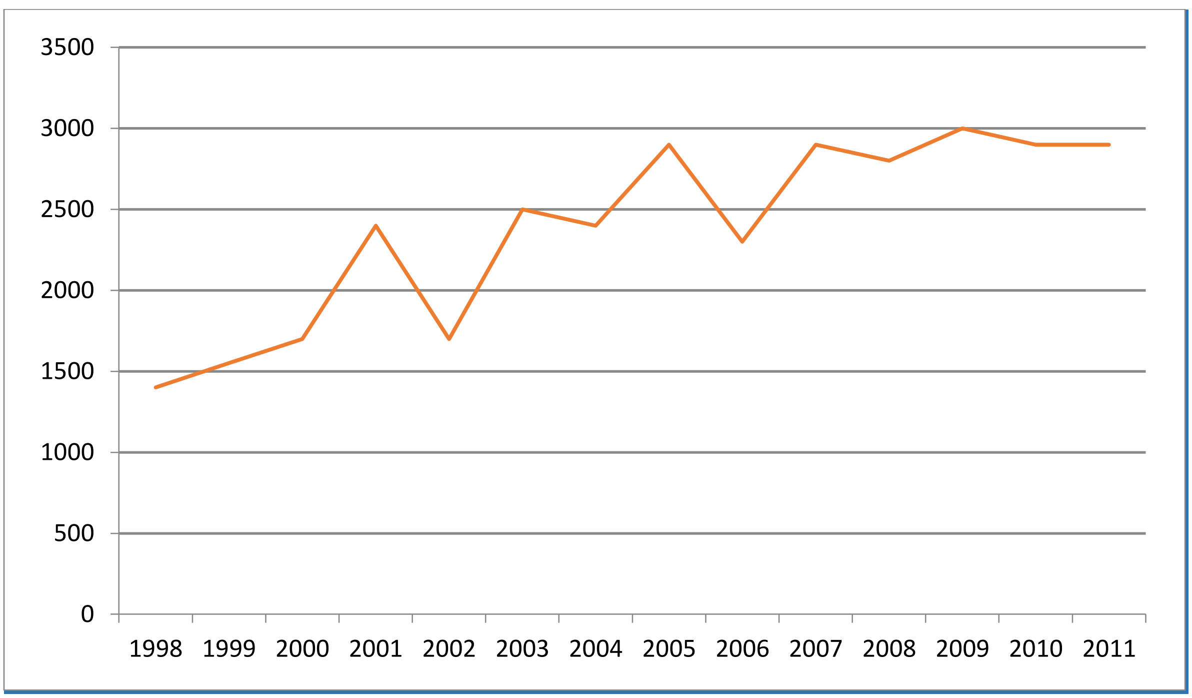

Figure 12. Total landings (mt) of mutton snapper, *Lutjanus analis*, for 1998 to 2011 from Brazil (Data from IBAMA and MPA).

Table 3. Known or probable exploited spawning aggregation sites of mutton snapper (*Lutjanus analis*) in the WECAFC region and relevant management measures. NTZ: no-take zone. FK=Fisher Knowledge; No recent information for many sites, see source documents. * Note that several generic fishery management measures are also in place in many areas that can benefit the mutton snapper though spawning aggregationsare not the specific management target. Examples incluse: controls on set nets across channels, long bottom trawls; generic minimum sizes, bag limits and other gear controls are likely to confer some protection on the species.

Country	Site	Peak Spawning relative to full moon	Estimated Status	Aggregation Management*	References
Bahamas	Long Island, North Cape Santa Marta				SCRFA dbase www.SCRFA.org (from Eggleston, 2002, pers. comm)
Belize	Gladden Spit	May-Jun; -2 to +7	Fishing caused substantial declines. Current recovery.	Restricted access to site and NTZ (2003). FK driven co-manag., incl. dive tourism. Snapper fillets must have skin on.	Graham et al., 2007; Heyman & Kjerve, 2008; Granados-D. et al., 2013
Brazil, Bahia	Many sites	Apr-Jul	Fished, declined.	Limited.	Freitas et al., 2013; França and Olavo, 2015
Cuba, North Coast	Cabo San Antonio (Western-most edge of island)	May-Jun; full to +7	Declined.	Site in national park, not in NTZ.	Claro & Lindeman, 2003
	Corona de San Carlos	May-Jun; full to +7	Declined.	None.	Claro & Lindeman, 2003; Claro et el. 2018
	Cayo Mono	May-Jun; full to +7	Declined.	Limited. In local protected area.	Claro & Lindeman 2003; Claro et al. 2018
	Cayo Mégano de Nicolao	May-Jun; full to +7	Declined.	None.	Claro & Lindeman, 2003
	Cayo Caiman Grande	May-Jun; full to +7	Declined.	Limited. Site in NTZ in national park.	Claro & Lindeman, 2003; Quirós-E.& Rodríguez-M. 2007; Claro et el. 2018

	Cayo Sabinal	May-Jun; full to +7	Slightly declined.	Declined	Claro & Lindeman, 2003
Cuba, South Coast	Cabo Corrientes	May-Jun; full to +7	Slightly declined	Site in NTZ in national park. Assisted by dive tourism business.	Claro & Lindeman, 2003; Rojas & Monteagudo, 2009; Claro et el. 2018
	Cayo San Felipe	May-Jun; full to +7	Slightly declined.	None. In National Park but not in NTZ.	Claro & Lindeman, 2003; de la Guardia et al. 2018;
	Cayo Avalos	May-Jun; full to +7	Slightly declined.	None.	Claro & Lindeman, 2003
	Cayo Guano	May-Jun; full to +7	Declined.	None.	Claro & Lindeman, 2003
	Banco de Jagua	May-Jun; full to +7	No data	None.	Claro & Lindeman, 2003
	C. Bretón	May-Jun; full to +7	Declines	Limited. Site in national park, not in NTZ	Claro & Lindeman, 2003; Claro et el. 2018
	Cabo Cruz	May-Jun; full to +7	Slightly declined.	Limited. Site in national park, w/o NTZ.	Claro & Lindeman, 2003; Claro et el. 2018
	Bajo Mandinga	May-Jun; full to +7	Slightly declined.	None.	Claro & Lindeman, 2003
Mexico, Quintana Roo	Banco Chinch.	Dry season: Mar-Jun	Fishery catch peaks in spawn. months.	In biosphere reserve (1996), not in NTZ.	Sosa Cordero et al. 2002; Castro-Perez, 2011; Heyman et al. 2014.; Castro-Perez et al. 2018
	Punta Herrero	May-June	Insufficient catch data	In NTZ in federal MPA (1996, 2013). An aggregation of 1,500 mutton snapper was visually sighted: no gamete release seen.	Fulton et al. 2018 https://theoryandpractice.citizenscienceassociation.org/articles/10.5334/cstp.118/
Nicaragua			Few data	Minimum size 30 cm TL	Barnuty Navarro 2013
Puerto Rico	"Many places around island"	Apr-June; Full	Fished. Many caught before sexual maturation.	Temporal closure: Apr-May PR; Apr-Jun federal waters. Annual catch limit for snapper incl. mutton snapper. No sale of MS during season, unless imported. PR and federal seasons do not fully overlap.	Matos-Caraballo et al., 2006; Esteves Amador, 2005; Scharer-Umpierre, 2013
Turks – Caicos	West Caicos	Apr-May; Full	Unknown	Unknown	Domeier et al., 1996

U.S., Florida Keys	Riley's Hump	May-Jul, Full to +7	No fishing. Current recovery.	Tortugas S. Ecol. Reserve, 2001; Full NTZ.	Domeier et al., 1996; Domeier & Colin, 1997; Lindeman et al., 2000; Burton et al., 2005; Feeley et al., 2018
	W. Dry Rocks	May-Jun, ____	Heavily fished.	Inside FKNMS, no spatial or temporal protection at site.	Gladding & Demaria, pers. comm.; Lindeman et al., 2000; Heyman, unpubl. data
	Whistle Buoy	No inform.	Unknown, fished.	Inside FKNMS, no spatial or temporal protection at site.	Gleason et al., 2011
	Watson Reef	No inform.	Unknown, fished.	Inside FKNMS, no spatial or temporal protection at site.	Gleason et al., 2011
U.S. Virgin Islands	St. Croix Cons. Area	May-Jun	Declines, limited information.	Temporal closure: April–Jun, inclusive in federal & territorial waters. No sale of MS during season unless imported.	Kojis & Quinn, 2010; Nemeth, 2012
Venezuela, Los Roques	Cayo Sal	May-Jun	Fished.	National Park, in NTZ	Boomhower et al. 2010; Romero et al. 2011
	Sebast-opol	May-Jun	Fished.	National Park, in NTZ	Boomhower et al. 2010; Romero et al. 2011

In addition to the common absence of species-level data, few countries record or study sizes of landings (exceptions have included Colombia, Brazil, Cuba and Puerto Rico). Size data are important for two primary reasons; the first is that landing volumes can be sustained even when declining by catching larger numbers of smaller fish; the second is that an increase in smaller fish catches will eventually include more juveniles which will undermine the reproductive capacity of the stock. Alos, the species is sometimes marketed as the red snapper which might obscure trade, if not landings, data.

Fishing operations

Commercial fishing on mutton snapper occurs in shallow waters with boat seines, beach gill nets, set nets, hooks and lines with electric or manual winches, bottom longlines, traps and divers using spearfishing (Hunstman 1976, Cervigon et al., 1993; Claro, 1981a) (Plates 3-6). In Cuba, Set nets are used in channels that congregate groups of migrating pre-spawners (Claro et al. 2001) during the reproductive seasons. Spawning aggregations are often heavily targeted by commercial fishers and are a particularly important source of annual catches, believed to contribute to around 50% of the total catch of the species in some areas (see Source Decument).

Plate 3 Artisanal boat that fishes at Pedro Bank, Jamaica (2006). Photo: Steven Smikle (left). Industrial long line fishing boat Ocean Dream (2005) (right). Photo: Martha Prada.

Plate 4 Fishes at Serrana Bank, Colombia, on board industrial long line fishing boat Ocean Dream (2003). Photo: Cap. Austin Buck.

Plate 5 Fishing at Green Moon (Nicaraguan rise shelf edge) by industrial trap fish boat at 40-50 m depth (March 2003). Photo : Larry James

Plate 6.; Artisanal lines for capture of deep water groupers and snappers, Old Providence Island (March7 2007) (three photos on left). Photo: Ling Jay. Traditional fishing box for artisanal fishers in San Andres Island (2004). Photo: Martha Prada .

Commercial fishing activities for mutton snapper usually occur early in the morning or at dusk, over 10–16 days that encompass the days just before and following 2-3 full moon periods each year (Andy Maldonado, pers. comm., 2018). Fishers traditionally fish for this snapper in most Caribbean countries in April, May and June, the reproductive period, including the United States, Cuba, La Española, the Bahamas, Belize, among others (Borton & Williams 1986, Burton, 1997, Beaver 2000, Burton 2002, Claro & Lindeman 2008, Graham et al 2008), although this timing can vary even at the national level between years. For example, in Belize, it was reported by Graham et al. (2008) that fishing peaks from March through June before mid-month if the full moon falls before mid-month.

Alternatively, if the full moon falls after mid-month, fishers will fish the aggregation from March through May. Thus, it is possible that not all aggregation sites are fished throughout the entire season or that the peak spawning season varies by a month or so from year to year in a region (also reported by Claro and Lindeman, 2003, and Reyes et al., 2015). Smaller catch peaks happen in July-August or September-December. Those peaks may be associated with feeding migrations towards shallow waters (Reyes et al. 2015).

Recreational fishers target this species as a prized game fish by bottom fishing or trolling with medium or light equipment using monofilament or braided lines of 20-30 pounds and lures or live/fresh/frozen bait to enhance the 'feeling' in the fight. This snapper battles hard on the line and can be a challenging game fish. Whole or half sardines, small (2-3 inches) pieces of ballyhoo, crabs, shrimp and both rigid and rubber lures are good for bait. Hook sizes ranging from 5/0 to 7/0 are preferred if large snappers are expected in the area. Spear fishing is also utilized.

In general, recreational fishing effort in the US Caribbean is thought to be high (Cummings 2007a), but until recently (2000 in Puerto Rico and 2011 in the USVI), very few surveys documented it and the scale of mutton snapper catches in this sector is not known. Apparently, in these islands recreational fishing activity is particularly intense during holidays such as Easter week and summer vacations when large numbers of families camp along the shore and harvest fish and shellfish in nearshore waters (Cummings 2007a).

The sparse information available precludes assessment of the recreational fisheries in general in most Caribbean countries, with a few exceptions. Among these are examples from the US South Atlantic region and the US Caribbean (Puerto Rico), regions where information has been collected through the NOAA Marine Fisheries Service and its Marine Recreational Fisheries Statistical Survey (MRFSS) and Fisheries Releases Marine Revised (MIPR) programs. Online information on the number of angler trips and associated catch and effort estimates is available (https://www.st.nmfs.noaa.gov/recreational-fisheries/data-and-documentation/queries/index-note use GoogleChrome). These data are highly variable and suggest that approximately 22 mt of mutton snapper are being caught recreationally in Puerto Rico annually, with the lowest amount in 2014 (6.2 mt) and the highest amount in 2016 (54.2 mt). The species is prized in warmer Florida state waters and recreational fishing accounted for more fishing mortality in Florida than commercial or headboat fisheries (O'Hop *et al.* 2015).

Domestic and International trade

The mutton snapper fishery is important domestically and in international trade in both industrial and artisanal sectors. The species supplies domestic markets with fresh and frozen fillets or whole fish considered to be of exceptionally good quality, and often labelled (and priced) as "red snapper". In most Caribbean islands, mutton snapper, as several other high-value species, are typically sold directly to hotels, restaurants, and fish markets for local consumption, particularly when captured by commercial fishers. This trade sector appears to be poorly documented by volume or fish sizes. In Cuba "sport fishers" often sell their catch totally or partially to private restaurants or directly to consumers and this trade is not reported (Rodolfo Claro, pers. comm. 2019). In Nicaragua, landings data for mutton snapper from 2005 to 2015 increased overall from 5.5 mt to 29 mt with an average of 74% taken by the artisanal sector, the rest by the industrial sector (Anuarios Estadisticos de Pesca de ADPESCA, (2001, 2005; INPESCA 2006-2015). (http://www.inpesca.gob.ni/index.php?option=com_content&view=article&id=18&Itemid=100).

Data on exports of this species are limited but export trade for snappers to the US market is clearly considerable and from multiple countries. While much of the international snapper trade is documented at the family (i.e. snapper) level, there are a few exceptions. Cunha et al. (2012) found mutton snapper to be the tenth most abundant reef fish exported from Rio Grande do Norte, Brazil. Cheek and throat tissue from larger mutton snapper are sometimes considered to be gourmet items. Brazil exports large volumes of snappers to the US market with mutton snapper comprising a significant proportion of these (Caltabellota et al 2016). In general, most of the exported snapper products (fresh/frozen fillets or fresh/frozen whole fish) from the Wider Caribbean region are sent to US markets although it is not possible to determine the proportion of mutton snapper from these data, though it is likely to be substantial. Other noteworthy recent exporters of snappers (unknown species composition) are Trinidad & Tobago, Suriname, Belize (Gongora 2013), Nicaragua and the Bahamas.

Other importer countries recently include Spain (15%), Honduras (2.8%), France (1.39%), El Salvador (0.92%), Mexico (0.88%), among others (Anuario Estadistico de Pesca 2015). Unfortunately, this document does not mention what proportion of their snapper imports came from the Caribbean, the proportion of snappers in general, or volumes of mutton snapper in particular.

Management

Several regulations and management measures apply specifically for mutton snapper spawning aggregations (Table 3), including spatial closures, seasonal closures, seasonal sales controls and 'skin-on' requirements. However, in many countries they are not managed at all. In addition to species-specific regulations, a range of more general fishery management measures and controls could benefit this species. There are some general quota regulations for snappers that include mutton snapper among the list of controlled species, but no species-specific quotas. Other general measures include controls on gear (especially the restrictions on set net and long bottom trawls on the Cuban platform), bag limits, etc. Some countries have generic examples of these measures at the scale of "snappers" or specific species but many do not. Considering the numbers of older juveniles being taken, i.e. below about 30 cm size control measures could be more widely utilized. Considering issues around illegal fishing, larger fishing vessels and recreational vessels should be required to carry VMS to enable their movements to be tracked. There are very few trade regulations, especially regarding export controls or documentation.

Overview

It is clear that mutton snapper populations have decreased in most countries, sometimes substantially; particularly where spawning aggregations are exploited. Considering all countries for which information is available there have been drops to 50% of earlier catches, sometimes much more, over the last two decades in some areas, with increases in others (e.g. Brazil). The fishery is considered deteriorated in Mexico, reduced in parts of Cuba but not overfished, declined in parts of Brazil and not overfished in Puerto Rico and the Gulf of Mexico, South Atlantic region of the USA. Loss of overall reproductive capacity, through aggregations declines where ripe adults are taken before they have a chance to spawn, is a particular concern. Being a large species, with a sexual maturation size of about 30-40 cm, many fish are taken while still juveniles, sometimes as bycatch of other fisheries (e.g. Gulf of Mexico). If too few fish survive to adulthood and then reach aggregations for successful spawning, fisheries will not continue.

The collection of catch/landings data, by volume and fish size and at the species-level is urgently needed. Focus should be on enacting and enforcing spawning season closures, enforced spatial closures, and the protection of pre-spawning migrations (which may occur before seasonal closures go into effect). Consideration should also be given to reducing juvenile catch and also to safeguarding large fecund fish, the 'megaspawners', which contribute disproportionately to the number of eggs produced due to high fecundity. In this regard, while reports of ciguatera poisoning from this fish, for instance, off St. Thomas, US Virgin Islands (Olsen et al. 1984) could be a negative factor for the trade of large individuals of mutton snapper, but may also help to conserve larger, highly fecund females.

7.0 MANAGEMENT MEASURES FOR NASSAU GROUPER AND MUTTON SNAPPER

The following key management measures need to be addressed and adequately resourced to effectively manage aggregating species and safeguard their spawning aggregations. Ten core activities are identified. They are not strictly in chronological order because multiple actions may need to be considered/conducted and/or planned for simultaneously. Since there is existing information for the two target species and because many of their aggregations and fisheries are in poor condition and at risk of loss, without prompt action, action on several of these activities can be commenced immediately.

1. **Prioritize the need, and strengthen the case, for better resource management of Nassau grouper and mutton snapper, particularly for their aggregations, by compiling and presenting historical and current information and lessons learned from management and conservation efforts to date. With this information analyze the effectiveness of existing policies and regulations (e.g., spatial closures, sales, landings, size limits, bag limits, temporal closures, etc.) in offering population sustainability for the target species at subregional / regional level.**

Justification: There is typically insufficient funding and other resources to study in detail and effectively manage all species included in the demersal multi-species coastal fisheries of the WECAFC region. Therefore species and fisheries need to be prioritized for management according to their fishery importance and/or their conservation status; their ecosystem role may also be an important consideration. According to these criteria, the Nassau grouper and mutton snapper have been selected as a focus of this plan with a special focus on preserving spawning aggregations because of their widely acknowledged high vulnerability to overexploitation.

Implementation: Species that aggregate to spawn and that are or once were caught on their aggregations should be prioritized for management, data collection and monitoring. Species that are considered to be threatened globally (such as according to IUCN Red List criteria and categories or listed on a CITES appendix) or nationally, as well as species that are or once were important (economically or culturally) could be prioritized for management. Information needs to be compiled regarding their fishery and aggregation status to initiate management planning and further research with a strong focus on their known spawning aggregations. Existing information can be used to schedule additional work and to begin the management planning process. Current management measures should be evaluated to determine their effectiveness to better safeguard and manage the two focal species and their aggregations at the national level. Promote the development of national fisheries, commercial and recreational, and conservation plans for these two species.

2. **Create specific fisheries management and conservation stakeholder networks aimed at increased understanding of the importance of healthy FSAs in fisheries management and local economies at regional and sub-regional levels.**

Justification: Decisions regarding fisheries are often taken by high-level government officials, sometimes advised by scientific study but often with insufficient involvement from different stakeholders. The involvement of different stakeholders is important because each sector can bring a different perspective and understanding to an issue which helps to move towards best possible solutions. Different stakeholders may derive different types of benefits from spawning aggregations. For example, those fishing on aggregations derive direct benefits but if catch rates on aggregations are unsustainable then other fishers suffer indirectly through declines in their catches outside of aggregation times and seasons as the stocks decline. This has clearly been seen with Nassau grouper.

Hence equity issues call for inclusion of stakeholders who are both directly and indirectly affected by loss of aggregations. In another example, dive tourism may not be compatible with fishing. Given that special attention is needed to engage indigenous people and in relation to artisanal and subsistence and other small-scale fisheries, these sectors need to be included in networks and are usually eager to express their concerns and recommendations. However, these inputs can go unheard because of fishers' low levels of organization and empowerment and lack of opportunities for engagement. The tourism sector may be concerned about divers seeing fish in the water or about sufficient fish for restaurant menus, NGOs may have conservation or equity interests while government may be particularly concerned about costs and capacity for enforcement.

Implementation: Create a regional advisory group under/or in collaboration with the SAWG to analyse existing survey protocols for fish species that aggregate to spawn and their aggregations, and adopt the most convenient approaches in the region for documenting, monitoring and managing. Look for opportunities for international cooperation in conducting spawning aggregagation surveys, including the formation of teams integrated by scientists, managers and fishers. This group can advise on the selection of priorities in research, management and monitoring at the subregional level for aggregations and to tie into other regional initiatives relevant to the wider remit of coastal and environmental management. Resources need to be committed to enable this convening to occur with special efforts made to bring in small-scale, artisanal, subsistence fishers and other key stakeholders who might otherwise struggle to be heard.

3. **Identification and documentation of all known and exploited spawning aggregation sites and determination of spawning seasons for mutton snapper and Nassau grouper.**

Justification: The spawning sites and times of Nassau grouper and mutton snapper are known in parts of the WECAFC region or may be incompletely documented. Knowledge of spawning sites and/or seasons is essential for the application of spatially and/or seasonally defined fisheries management measures. Multiple factors that affect spawning sites, when considering management action, also need to be considered, ranging from impacts due to coastal or offshore development and water quality.

Implementation: Work collaboratively and in broad consultation with stakeholders to join human, technical and financial resources that can produce maps of known spawning aggregations and identify the duration of major spawning seasons across the shelf platforms of the region, including on the shelf edge and deeper reef slope where aggregations are often located. Studies and information collection on locations and seasons of spawning can be conducted in various ways and often at low cost, ranging from fisher/community/trader interviews to surveys of market sites and fish catch landing areas. Underwater or fishery surveys of reported aggregation sites can be used to validate verbal reports and to collect more detailed information for management planning. Deeper sites (beyond diving depth) could be done by ROV; this would need more significant funding commitment. Mapping efforts and determination of spawning seasons should begin at the national level and be scaled up through regional cooperation mechanisms and all available technologies applied.

4. **Establish a synchronized and strategic regional closed season for protecting spawning aggregations, wherever feasible**

Justification: A harmonized regional closed season for Nassau grouper would significantly help reduce overall fishing mortality and contribute to its mating and spawning success, hereby supporting reproduction and population replenishment. A harmonized approach at the regional level would also greatly facilitate the monitoring and patrolling needed to counteract illegal fishing (including cross-border) and should lead to improvement of catches across the region through improving population resilience and connectivity. This approach could be strengthened by complementary measures such as controls on possession for commercial purposes. For the mutton snapper, regional level seasonal closures are also generally feasible and practical.

Implementation: The adoption of a species-specific closed season at regional or subregional levels can be developed through existing mechanisms like CRFM, CFMC, OSPESCA, OLDEPESCA and WECAFC. It can be adjusted in response to variability in spatial/ temporal patterns once monitoring data become available on prioritized species or using existing information. Special protocols should be in place in order to enforce this regulation. Fisheries managers can facilitate compliance through better communication and education within the communities concerned and beyond and by taking a more holistic approach. For example, enforcement could be vastly improved if the commercial trading of focal species during the closed season is also limited. Seasonal protection should be long enough to provide a buffer that accommodates year on year variations in spawning time and needs to be precautionary in its application given the reduced fishery status of both species. For Nassau grouper, at least the period 1 December to 31 March, inclusive, and for mutton snapper from April to July, inclusive should be considered.

5. **Evaluate/update existing monitoring protocols, adjust and adopt one for the WECAFC region, and implement it with the objective of improving standardized collection of fishery-dependent data at spawning and non-spawning times and minimizing impacts on spawning fish; should include promotion of digital reporting initiatives and guidelines for dive tourism.**

Justification: Data on the catches and sizes of aggregating snappers and groupers, including Nassau grouper and mutton snapper and with some notable exceptions, are typically poor or incomplete, as they are often not organized with statistical rigour, represent only short time periods, or may only be collected at a higher taxon level (such as *Lutjanus* or *Epinephelus* spp. or even just as 'groupers' or 'snappers'). Species-level data are essential for meaningful monitoring and management. In addition, local consumption (including non-marketed catch) is seldom included in catch statistics, and international trade only sporadically documented to species level. Fishing effort is a key variable, particularly because most models use catch per unit of effort (CPUE) as a measure of abundance. The efficiency of effort often changes over time by virtue of changes in fishing techniques and fishing grounds and hence the measure of fishing effort is essential for understanding the likely meaning of changes in catch levels (CPUE). All such data can be collected relatively easily, cheaply and simply with good planning and collaboration from stakeholders.

Implementation: Agree to form regional advisory group under/or in collaboration with the SAWG (as part of (2) above) that will evaluate/update catch and effort databases existing at national and subregional levels, and propose strategies and applications for the improvement/introduction of data collection and processing at the regional level especially for the two focal species. Seek to optimize possibilities for collaborative work, standardization of data collection protocols, and to increase compliance for reporting (see (8) below). Resulting strategies may need to include: (1) design of better-structured survey formats at the species level and for prioritized groupers and snappers; (2) development of protocols and mechanisms to facilitate and increase fishers' reporting and engagement; (3) work on improving and integrating existing digital databases at the national and subregional level: (4) establishing platforms for data sharing and exchange to make data more readily and immediately available to workers in the region, and (5) establishing subregional guidelines for conducting tourism activities at or around FSA sites, to avoid interference with the reproductive processes of the two species.

6. **Collection of socio-economic data in relation commercial, recreational and subsistence fisheries, ecotourism, local and international trade, and considering food security.**

Justification: The actual or potential socal and economic importance of a fishery is of major importance when assessing research and management priorities and financial support allocation and considering beneficiary sectors, while cultural considerations may also be important for certain iconic species or in certain countries. For example, for some countries the Nassau grouper, in particular, is highly appreciated and of historic importance. Assessment of the economic value for fishers (especially small-scale, artisanal and subsistence), community and trader livelihoods, tourism, as well as for food security importance, assists stakeholders, NGOs, government and others in prioritization of actions and determining relevance to the country. Assessment of aggregation versus non-aggregation catches is needed to assist in determining the relevance of each season (reproductive verus non-reproductive) to total annual catch volumes and different fishing sectors to ensure equity of benefits from these fisheries.

Implementation: Data on the income derived from Nassau grouper and mutton snapper for fisher communities, both during aggregation and non-aggregation seasons, and in the tourism sector could be collected by questionnaires and/or by trade and market/retail sector surveys. Interviews could also establish the use of the species for subsistence versus for commercial purposes. Traders surveys could determine local versus export trade volumes and would be useful for determining the national and international trade components of the selected species' fisheries. Identify and address regional /subregional socio-economic needs at species-specific levels.

7. **Produce / reproduce online and printed educational materials (brochures, fliers, maps, films, videos, bumper stickers, training modules, manuals, handbooks pamphlets, posters etc.) on fishing guidelines, regulations, catch landings, FSA protection, and consider other communication options.**

Justification: Considering the importance for successful management of an understanding of, and public support for, managing fisheries effectively and particularly of safeguarding spawning aggregations, there is a critically important role for correct information on the key focal species and the importance of their aggregations to reach stakeholders and the public at large. However, notwithstanding the several excellent national level education campaigns and outreach initiatives for Nassau grouper, including several widely distributed films, there still remains need within the region to create public awareness about both species, their aggregations and their fisheries, and related environmental and conservation issues. As experience has shown (see Case Studies section) education/outreach can be a key factor in the success or failure of conservation and/or management efforts. Where outreach is weak, it is often the case that progress in fisheries management and compliance remains low; conversely, strong and ongoing outreach is a key element in management success stories.

Implementation: Develop education and outreach programmes aimed at: 1) informing and convincing stakeholders and decision-makers of the importance of safeguarding the spawning aggregations of the Nassau grouper and mutton snapper for benefits from food and income from the fishery as a whole (i.e. not just from fish caught at aggregations but including the young produced by aggregations); 2) highlighting the importance of data collection, scientific analysis, research, training, and capacity-building to manage a shared living marine resource; 3) explaining to inspectors/enumerators the purpose and use of the data collected and why data need to be accurate, standardized and collected long-term; 4) increasing awareness among fishers and processors around the roles of Nassau grouper and mutton snapper in the ecosystem and the impact of fishing and market demand on their sustainability; 5) teaching law enforcement officers and judiciary of the importance of compliance and legal fishing for fishery sustainability and the threat to fish populations of IUU; and 6) teaching school children and the general public about the need for environmental protection and conservation of marine resources and the particular importance of spawning aggregations for reproduction and population resilience. A ListServe or other dedicated online platform for information exchange would be valuable for making data and educational materials readily available.

8. **International and cross-department 'intelligence' exchange to address illegal (including poaching), unregulated and unmonitored (IUU) trade and measures to ensure traceability and to strengthen enforcement.**

Justification: As with any open water marine fisheries, the enormous size of the region's maritime area represents a challenge for law enforcers. IUU fishing is a serious problem and regional cooperation in coordinated patrolling is greatly and increasingly needed, as many countries in the region lack the resources to enforce their own maritime space. The problem intensifies for particularly valuable species and/or when catches decline in one area forcing fishers to move to other areas, sometimes into different countries. In addition, as international demand for fish from outside the WECAFC region grows this problem is set to intensify, conflicts over limited resources likely to become more of an issue into the future, and hence better and stronger measures are needed to keep IUU to a minimum.

Implementation: To address this issue, bilateral and multilateral agreements should be put in place between range states, possibly by subregion. There is a need to agree to address IUU and local poaching issues at regional and international levels. Protocols to be developed to include, *inter alia*, linkages between enforcement/coastguard, customs, fisheries and port authorities and relevant fisherfolk groups. A mechanism for shared intelligence and the black-listing of vessels which regularly contravene regulations could be considered. Conduct regional workshops among enforcement authorities, legal advisors and judiciary personnel across the region to promote the sharing/exchange of information and experiences in the prosecution of IUU fishing and to highlight the importance of enforcing the law and of prosecuting offenders.

9. **Increase understanding of the regional and sub-regional trade networks and patterns during the spawning and non-spawning seasons, and elucidate trade chains.**

Justification: Export markets and consumers increasingly demand traceability of food products throughout the supply chain and, given that demand for the highly regarded groupers and snappers is growing, such expectations should begin to apply for the Nassau grouper and mutton snapper. To better understand and control trade, reduce IUU and prepare for the movement towards more oversight and controls on seafood trade, traceability plays a key role in various export markets. Traceability has the advantage that legal and illegal fishing practices can be separated and may sometimes allow legally harvested products to fetch higher prices. Traceability provides additional benefits in terms of supporting hygienic handling of the product, quality and food safety.

Implementation: Stakeholder working groups agree to develop a traceability system following existing international guidelines and protocols, such as the application of the EC catch certification, already used by various countries. For fish that are processed prior to sale (i.e. not sold intact), a policy of retaining some skin-on fillets would assist in identification to species level in some cases; this has already been successfully applied for the Nassau grouper in the Bahamas. No exports should be permitted during protected seasons. The introduction of standard catch certification forms could facilitate trade in mutton snapper and Nassau grouper. The adoption of the EU catch certificate format, as presented in Appendix II of EC REGULATION 1005/2008 "To Prevent, Deter and Eliminate

Illegal, Unreported and Unregulated (IUU) Fishing", would facilitate trade and traceability, using a best-practice approach.

10. **Identify and resolve highest priority additional biological data needs for determining spawning seasons, spawning migrations and spawning aggregation sites of target species as well as for integrating spawning aggregation management into broader ecosystem management, climate change and coastal planning initiatives, measures and legislation.**

Justification: Key information on biology, ecology and connectivity of focal species could greatly improve and further refine fishery management planning and, ultimately effectiveness and the social and economic benefits derived therefrom within the wider regional ecosystem. Information on nursery areas, spawning season and aggregation sites, size of sexual maturation, longevity and genetic population structuring may be needed, if not already available. Such information would help to finetune management as well as ensure that buffer zones and precautionary measures are applied that will also be robust over time to accommodate seasonal fluctuations in spawning and spatial or temporal changes in migration routes or spawning sites due to natural variability and climate shifts. Possible impacts on spawning fish by divers need to be investigated to establish suitable guidelines as should the implications of habitat disturbance from coastal or mining activities.

Implementation: Studies to finetune management may require cooperation among multiple countries which are hosting and benefiting from shared populations. Moving forwards, the development of a research plan would be enhanced by consideration of outcomes of measures indicated in (1)-(9) above through regionally defined priorities in research and monitoring, time series data for stock assessments and further studies of the species' role in the ecosystem, climate change effects, genetic connectivity and other issues related to an ecosystem-based management approach. The use of an Ecosystem Approach to Fisheries is essential to create buy-in and ownership for management, to ensure implementation after the planning phase as well as to ensure that other relevant plannng needs are considered, such as those in relation to coastal development and other environmental impacts.

8.0 INTO THE FUTURE; CONSERVATION AND MANAGEMENT PLANNING

Introduction

The overall objective of this regional FSAFMP is to guide the implementation of management MEASURES (previous section) that address SIX identified management OBJECTIVES (see page 11). The aim is for national, regional or subregional level actions to successfully sustain populations of groupers and snappers that aggregate to spawn and safeguard the benefits these bring to society in the WECAFC region. The FMP is based on the recommedations of adopted during the 2018 Miami meeting of the Working Group. Once the FSAFMP plan has been formulated and approved, the CFMC/WECAFC/OSPESCA/CRFM Working Group should provide the conditions for the adoption and subsequent implementation in the areas of influence of WECAFC.

The ecosystem approach broadly forms the basis of this Regional Fishery Management Plan, enhancing partnerships and collaborations throughout the Wider Caribbean region to improve the long-term governance of aggregating species fisheries across the Caribbean; the high importance of including the small-scale fishing sectors in deliberations is specifically recognized. This section of the FMP provides a LOGICAL FRAMEWORK and a WORK PLAN, both in table format, intended to guide governments and others in this work. The Work Plan and Logic Framework both address the six core objectives and are supported by the information and guidance provided in Annexes 1-20.

Note that it is inevitable that there is some overlap between the activities and issues identified against the different objectives. This overlap is not redundant but, rather, aims to ensure that each objective can be considered as a unit while also recognizing that all the units ultimately need to be variously addressed, to a great or lesser extent in different parts of the region, according to needs, capacities and opportunities.

Logic Framework and Work Plan

The Logic Framework follows the conventional format, with indicators and activities to achieve the six planned objectives, while the Work Plan takes these same objectives and briefly identifies key activities, time-frames and actors. The 20 Guidance Annexes support them both.

Overall, the current strategies for acquiring, compiling, reviewing, and analyzing biological and socio-economic data from diverse fisheries sectors across the Wider Caribbean region are overalL, weak and need considerably more attention to be made effective at both national and transnational scales. Hence, in addition to regular data collection needs in fisheries, and considering the many challenges of monitoring and managing small to medium scale fisheries, inclusion of innovative tools (digital reporting), allocation of higher budget of monitoring, educational campaigns and collaborative national and sub-regional agreements are all needed. Such advances would greatly improve resource management to counteract both declining trends in many of the species' populations and undesirable activities, such as illegal fishing.

Regional and sub-regional initiatives for better compliance, enforcement and surveillance programs, already in use for other fishery resources such as the spiny lobster and the queen conch, need to be extended to include the Nassau grouper and mutton snapper. National plans to counteract illegal, unreported and undetermined fishing and trade may also need to be adjusted to accommodate these species and lessons learned from lobster and queen conch management could perhaps be applied to aggregating fish species of interest. There is also a real need to understand the international trade component which is very poorly understood or controlled.

The GUIDANCE ANNEXES (1-20), address the range of relevant issues and provide detailed breakdowns and descriptions intended for reference to guide decision-making for managing aggregating species in the WECAFC region, considering both national and regional elements. This section of the draft FMP lays out a series of general principles, guidelines, practices, need, priorities, protocols, and criteria to consider for collecting and using relevant information and measures to safeguard and/or recover aggregating species of interest and importance in the region.

LOGIC FRAMEWORK

Objectives	Actions	Indicators	Means of verification	Assumptions
1. To integrate the urgent need and rationale for protecting spawning aggregations from overexploitation, particularly in the case of threatened fish stocks and fisheries, in national and regional fisheries management and conservation planning, in a practical and timely manner.	1. Prioritize the need for better management of FSAs by presenting historical perspectives on the two species' population declines, including successes and failures in management initiatives, and highlighting the very real risks to fisheries of aggregation declines and losses.	-Increased public and governmental understanding of and support for better fisheries management and FSA conservation. -Increased fisher outreach and understanding of the urgent need to safeguard spawning aggregations to ensure healthy fisheries.	- Increase in numbers of fishers participating in regional workgroups and public forums. -Increase in numbers of media publications on the importance of FSAs. -Measurable actions by government agencies to protect FSAs.	-National fisheries agencies commit to the inclusion of fisherfolk & other relevant stakeholders in FSA management, including NGOs, recreational, subsistence and commercial sectors, tourism and seafood trade sectors.
	2. Actively promote fisher participation in support of regional / subregional planning and conservation strategies on improved fisheries management.	-Strengthen regional fishers, government officers and other NGOs working together and collaboratively in support of FSA planning and conservation.	-Increase in online and published reports denoting broad stakeholder participation.	-Existing working relationships with fishers, or active engagement of fishers from key commercial and recreational sectors.
	3. Creation of specific fisheries management and conservation networks/working groups inclusive of multiple stakeholders aimed at increased understanding of the importance of, and need for, healthy FSAs in fisheries management at regional and sub-regional levels.	-Number of fisheries management and conservation networks/working groups promoting healthy FSA. -Number of events where best practices in FSA management are presented and discussed. -Increase in number of fishers, managers, and scientists participating in regional special FSA forums. -Inclusion in working groups or	-Increase in activity reports on promotion of healthy FSAs. -Regional events proceedings e.g. GCFI – other and other relevant venues/forums. -Document events where FSAs are discussed and post information on ListServ. -Stakeholder representation broad as indicated by diverse network/group composition.	-Regional and sub-regional actors will commit to data sharing practices to better understand FSA. -There are funding available for increased participation in regional FSA events. -Relevant groups or organizations will incorporate sessions or discussions on FSAs in

		networks of wide range of stakeholders including fishers of target species who fish and do not fish their aggregations, the tourism sector, conservation and other relevant NGOs, etc.		schedules of activities.
2. To identify species and spawning aggregations in most need of priority management and to determine the current state of knowledge regarding their biology, fisheries, aggregation status and management needs; test species to be Nassau grouper and mutton snapper	4. Identify and resolve highest priority biological data needs for determining spawning migrations and aggregation sites and seasons of target species using a broad range of methods.	-Increase in field research on FSAs active locations and timing of spawning aggregations of target species using fishery-dependent and –independent means and including Fisher's Knowledge (FK). -Identify pre-spawning migration routes and timings and estimate catchment areas. -Locations and timings of spawning site locations or migration routes made available to managers and stakeholders but may not be made publicly accessible if such information is considered to be sensitive.	-Increase in numbers of peer-review publications on FSAs of target species biology and management. -Incorporation of new data into management planning and stock assessments.	-Research will be supported by both funding and manpower in countries with FSA occurrence. -Agree on rights to public access of information on FSA sites of target species.
	5. Identify FSAs at risk of extinction that need immediate protection efforts (triage sites), for the target species.	-Direct or indirect evidence of pending FSA extinction. -Degree of dependence of local communities on FSA, both directly (fishing on FSA) and indirectly benefiting from the young produced by the FSA.	-Documentation by experts and community leaders in support for priority conservation sites. - Verification of site locations or times indicated by FK or other oral means.	-Government staff and local fishers will work together to prevent extinction events and to verify reported sites.
	6. Wherever possible, utilize new technological approaches and innovations to study deep water FSA sites.	-Increase in number of studies of deep water environments where aggregations are exploited or reported from using new technologies, including passive and	-Increase in published reports on deep-water FSAs used in management.	-Scientists and fishers collaboratively work together. -Funding is made to

		active acoustics, ROVs, AUVs, etc.		available to study deep water environments.
	7. Develop sub-regional stock assessments for the selected species, at least every five years; to assess management outcomes and to adapt to possible shifts location and/or timing of spawning via regular updates.	-Stock assessments for the two species are available for at least three countries or at subregional level. Ideally these should be in different regions of the WECAFC region to capture must of the species ranges.	-Increase in technical documents on population status of the two species are available at least every five years in key regions.	-Data collection is improved and utilization of innovative stock assessments (data-limited) techniques are applied.
3. To provide monitoring frameworks for collecting key biological, socio-economic, fishery and trade information to develop management and conservation protocols for achieving sustained production of these renewable natural resources nationally and regionally; to include both aggregation and non-aggregation collected data where relevant.	8. Improve standardized collection of fishery-dependent data at spawning and non-spawning times, including promotion of digital reporting initiatives.	-Datasets on fishery dependent data on NG and MS are available and improved. -Catch and effort digital reporting exists for at least three countries or at subregional levels. -Studies of spatial and temporal patterns of the fishing pressure on the two species, and its relationships with spawning aggregations.	-Fishery dependent datasets. -Degree of implementation of catch and effort digital reporting. -Increase in number of studies on the species reproductive success.	-Fishers take an active role in reporting their catch and effort. -Funding for implementation of digital reporting is available.
	9. Analyze existing monitoring protocols, adjust and adopt one for the Wider Caribbean region, and implement it.	-A consensus-based, multi-lingual, and standardized FSA monitoring protocol is co-produced and adopted by the FSA Working Group. -Degree of budget increases to implement FSA protocol. -% of advance in the FSA protocol implementation.	-Technical reports documenting the utility of the new standard protocol. -Endorsement of the protocol by leading government, NGO and university actors.	-All stakeholders will work to share ideas to develop a fully-utilized product. -The FSA Working Group is able to meet and reach agreements. -Countries support the FSA Working Group recommendations. -FSA monitoring is supported by subregional political will.
	10. Involve Caribbean fisherfolk regional and subregional organizations for compilation of traditional knowledge on MS and	-% increase of information provided by fisherfolk organizations to improve determination of species population status.	-Increase in number of technical reports that include information from fisherfolk organizations.	-Fisherfolk organizations collaborate with scientists in improving understanding the two species population

	NG that can be added to scientific analysis of their population status.			status. -Funding and engagement ensure that these collaborations and participations can occur.
	11. Analyze effectiveness of existing policies and regulations (e.g., spatial closures, sales, landings, size limits, bag limits, temporal closures, etc.) in offering population sustainability of the target species at subregional / regional level.	-Availability of management effectiveness evaluations at subregional / regional level.	-Technical documents evaluation effectiveness of management regulations at subregional / regional level.	-Government agencies collaborate with and institutionalize key recommendations.
	12. Increase understanding of the regional and sub-regional trade networks and patterns during the spawning and non-spawning seasons.	-Open trade network databases are established and improved at national/subregional level.	-Functional URLs showing the trade databases. -Technical reports analyzing trade patterns.	-Countries establish regulations allowing the creation of national/subregional trade databases.
	13. Develop regional strategies for alternative livelihoods to communities with high degree of FSA dependence.	-Caribbean fisherfolk subregional organizations provide information on communities with high the degree of FSA dependence. -Alternative livelihoods are being built at regional / subregional level.	-Census of communicates with high degree of FSA dependence. -Increase in budget allocation for alternative livelihoods.	-Communities accept to take an active role in protecting FSA.
	14. Identify and address regional /sub-regional socio-economic needs at species-specific and multi-species levels.	-% of information provided by fisherfolk organizations to improve determination of species population status increases. -Increase in fisher outreach. -Use existing FK education tools (e.g., GCFI's GMA Program).	-Technical documents reporting greater participation of fishers in regional workgroups and management decision-making.	-Fisheries agencies are committed to Fisherfolk in management. -Fisherfolk organizations collaborate with scientists in improving understanding the two species population status.
	15. Identify dependence on spawning aggregations as well as on MS and NG taken outside of spawning times for evaluating	-Availability of core retail business data for cost benefit analyses that show alternative outcomes with and without FSA conservation and	-Progress in FSA conservation that is linked to educating users on the economic benefits of FSA conservation.	-Community leaders support government and NGO efforts.

	income generation and food security and both subsistence and commercial uses. Evaluations to also include tourism or other non-extractive benefits from healthy aggregations.	for different stakeholder sectors.		-Other, non-extractive, sectors participate in evaluations.
	16. Promote the development of national fisheries and conservation plans for NG and MS.	-Number of national plans for NG and MS aimed to the conservation of the FSA.	-A technical group (scientists and fishers) provide advice to countries in developing their national FSA conservation plans.	-Countries welcome technical advice and are interested in developing their national conservation plans. -Universities and local through national fisheries agencies commit to funding robust research programs.
4. To apply and integrate the best available informati on as identified in 2 and 3 above and develop interdisciplinary, community-based strategies for successful spawning aggregation management in national and regional management mechanisms, instruments, traceability, and planning for priority species.	17. Establish a synchronized (if possible) and strategic regional closed season for protecting spawning aggregations.	-Number of countries having a synchronized regional closed season for protecting spawning aggregation.	-Regulations adopted at national, sub-regional or regional basis establishing a synchronized closed season.	-FSA working group is able to get support for the establishment of a common closed season.
	18. Agree on rights to public access of information on spawning aggregations of target species.	-A policy about sharing the database information is defined.	-A policy document for sharing data on FSA is accepted and of public access.	-Trust is developed among stakeholders, and scientists.
	19. Improve species and source traceability and marketing accuracy for enforcement and food safety purposes.	-Increases in enforcement actions and measures securing food safety.	-Enforcement actions are more defensible. - National and regional food safety is measurably improved for snappers and groupers.	-Agencies and industry can develop and expand best practices using the latest technological advances.
	20. Develop regional strategies for alternative livelihoods and deliver to communities with high degree of FSA dependence.	-Caribbean fisherfolk sub-regional organizations provide information on communities with high the degree of FSA dependence. -Alternative livelihoods are being built at regional / sub-regional level.	-Census of communities or other stakeholders with high degree of FSA dependence. -Increase in budget allocation for alternative livelihoods.	-Communities take a more active FK role in protecting FSAs by use of income derived by alternative livelihoods.
	21. Establish sub-regional guidelines	-Number of guidelines for	-Tourism operators' annual	-Scientists, managers and

	for conducting tourism activities at or around FSA sites, to avoid interference with the reproductive processes of the two species.	conducting tourism activities at FSA sites available. -Number of visitors educated about the importance of maintaining healthy FSAs.	reports.	tourism operators work collaboratively in applying sound practices at FSA. - Tourism industry representatives will work constructively to develop and adopt the guidelines.
	22. Conduct public updates on the status of NG and MS.	-Number of events presenting updates of the status of MS and NG.	-Increase in stakeholders, especially fishers, who have a better understanding of the resources. - Production of user-friendly information updates.	-Active stakeholders participation will require effective agency communications.
	23. Develop regional / sub-regional criteria for specific FSA legislation based on science to manage and protect FSAs (locations and or seasons).	-Adjusted FSA legislation based on regional/sub-regional recommendations.	-Regulations are enacted and published.	-There is support and funding to enact and enforce regulations.
	24. Engage regional RFMOs and NGOs in the implementation of the regional management plan.	-Number of regional FSA meetings held.	-FSA meetings reports.	-Resources for cooperation and coordination are available.
5. To significantly increase awareness, engagement and understanding of the high importance of protecting spawning aggregations, especially among key stakeholders, for maintaining food security, economic benefits (whether from associated fisheries or ecotourism), equitable resource use, and biodiversity	25. Develop marketing and awareness campaigns for the general public on the importance of healthy aggregations to maintain ecosystem services and socio-economic benefits.	-Number of campaigns developed to highlight the relevance of these two species FSA. -Increase in the use of social media to promote healthy FSA for these two species. -Number of web servers promoting viable populations of these two species.	-Increase in campaigns products. -Campaigns evaluation reports. -Increase in FSA online searches.	-Countries are interesting in promoting healthy FSAs of MS and NG and understand their importance for fisheries and livelihoods.
	26. Caribbean stakeholders of all genders are actively interacting with SCRFA and other NGOs and	-Number of stakeholders utilizing SCRFA information on these two species.	-SCRFA web site containing significant and increasing information on these two	-SCRFA offers a good source of information for Caribbean stakeholders interested in

conservation.	educational initiatives and relevant regional institutions regarding education programs and on-line materials.	-SCRFA is able to compile majority of existing educational and outreach materials in collaboration with other relevant regional database	species, particularly on their FSAs. -Other regional websites and initiatives linked up for cross-referencing on FSA information and information sharing.	FSA of NG and MS. -Materials are user friendly and available in several languages.
	27. Produce / reproduce online and printed educational materials (brochures, fliers, maps, films, videos, bumper stickers, training modules, manuals, handbooks pamphlets, posters etc.) on fishing guidelines, regulations, catch landings, FSA protection, etc.	-Reports of the educational materials produced / reproduced.	-Example of the educational materials available.	-Countries are willing to share their educational material on FSA.
	28. Promote the collaborative work of the regional working group on FSA issues.	-Priority actions to be developed by the FSA working group. -% progress of the FSA working group activities.	-Working group technical reports.	-Funding is available to keep a functional FSA working group active and productive.
6. To integrate spawning aggregation management into broader marine environmental planning and evolving challenges including ecosystem-scale management, climate change, and especially in relation to illegal, unregulated and unmonitored fishing and international trade.	29. Estimate macro- and meso-scale larval connectivity patterns within the target species.	-Connectivity indices for different FSA source areas based on coupled biophysical models and genetics as applicable.	-Publications that provide new regional and sub-regional connectivity information appear.	-More funding is available to expand connectivity research efforts.
	30. Identify the possible spatial and/or temporal implications of climate change on the spawning processes for these two species.	-Thermal tolerance and other indices of climate vulnerability are developed and tested in the field.	-Publications that provide new climate vulnerability information or modelling on FSAs.	-Research will expand despite limited funding. -Scientist are able to join efforts and resources.
	31. Examine whether criteria for MPA establishment includes the conservation of FSAs and also are sufficiently flexible to allow for buffer zones/times to accommodate shifts in spawning seasonality and/or location over time.	-Number of MPA Management Plans that include FSA conservation criteria increase.	-Management plans include FSA criteria.	-MPA managers and NGOs measurably increase their focus on FSAs during planning.
	32. Develop special FSA provisions for indigenous peoples to maintain their food security	- Culturally-sensitive work is conducted to coordinate planning of new FSA regulations with local	-FSA conservation regulations do not disrupt culturally significant, non-destructive, activities	-All government and local indigenous stakeholders coordinate with mutually

	through subsistence only use access.	indigenous populations.	associated with FSAs.	agreed objectives.
	33. Agree on needs to address IUU, including poaching regional and international levels by enhanced communication, coordination and integration of enforcement capacity and information sharing.	-Improved enforcement and adjudication resources are funded and sustained for high priority FSAs. -The judiciary is briefed and informed regarding the seriousness and broader implications of violations of FSA management measures.	-Measureable reductions in IUU and/or local poaching. -More members of the judiciary take violations of relevant legislation seriously for a higher prosecution rate.	-High levels of cooperation among agency personnel, researchers and, most importantly, fishers.
	34. Conduct regional workshops among enforcement authorities, legal advisors and judiciary personnel across the region to promote the sharing/exchange of information and experiences in the prosecution of IUU fishing.	-% of increase of workshops on enforcement and legal aspects of FSA exploitation of NG and MS. -Successful prosecutions of IUU cases are disseminated regionally.	-Workshops reports and evaluations on IUU fishing increase. -Published information successful legal cases involving IUU fishing.	-FSAs are integrated into regional / sub-regional initiatives to counteract IUU fishing.
	35. Work closely with Interpol and CaribeWEN to track and enforce regulations compliance.	-Correspondences amongst countries, Interpol and CaribeWEN.	- Number of cases of illegal fishing resolved.	-All focal points collaborate at the highest levels. -Consider black-listing of constant offenders and information sharing of same.
	36. Include Nassau grouper for CITES App. II, addition to the SPAW III listing.	-Achievement of NG listing through documentation of international trade data. -Molecular testing may be necessary in major import centres when fish labelling is suspect.	-Measureable improvements in international trade of NG and reduction in its illegal trade.	-Early, frequent, and sustained collaboration among key stakeholders.

WORK PLAN; note that the six objectives (first column) are abbreviated from their full form as presented in the LOGIC FRAMEWORK

Objectives	Activity	Timeframe	Responsible Parties
1. Integrate urgent need, and rationale, for protecting spawning aggregations in national and regional fisheries management and conservation planning.	- Finalize FMP revision and complete its adoption process. -Compile or enhance existing and relevant biological, ecological and economic data on target species. - Identify and address data needs. - Develop, revise and generate support for involvement by and of key stakeholders and the creation of management and conservation networks/working groups focusing on reef fish spawning aggregations.	-2019 and ongoing -2020 and ongoing	-Spawning aggregation working group, WECAFC, CFMC, OSESCA, CRFM -WECAFC FSA Workgroup, CFMC, OSPESCA, CRFM, & country fisheries authorities
2. identify species and spawning aggregations for priority management, assess existing knowledge base and evaluate management measures.	- Update information on locations and timing of exploited spawning aggregations of target species. -Develop the appropriate regional species-specific legislation for effective protection especially for at risk FSAs. -Consider sales bans during closed seasons, if applicable. -Compare and evaluate the relative importance of using spatial versus temporal measures or some combination using new technologies and innovations. -Develop a sub-regional stock assessment at least every five years. -Identify pre-spawning migrations routes, if any.	-2019 and ongoing. -Repeated every five years -2020 and ongoing	-Fisheries agencies, Universities, NGOs, Fisher organizations, Fishing business, leaders -Indigenous communities -Fisheries agencies, fisheries stakeholders -Fisheries agencies, universities, NGOs and fishers
3. Provide monitoring frameworks to collect key data to safeguard future productivity of aggregating fishes.	- Monitoring fishery dependent data in a standardized manner both at spawning and non-spawning times. -Update existing protocols for data collection to include data on FSA. -Fishery dependent monitoring should include data from recreational and commercial fisheries, as needed. -Involve the Caribbean fisherfolk, sub-regional and regional organizations data collection and other management activities of the FSAs. -Analyse the effectiveness of existing policies and regulations. Increase knowledge of trade networks. -Use information to identify FSA dependent fishers to minimize impacts. Socio-economic needs will be properly identified. -Development of fisheries and conservation plans.	-2019 and ongoing 2020 and ongoing	-National fishery agencies, Universities, Fisher organizations, Recreational sector -Fisheries agencies, universities, all stakeholders Government agencies and universities -Government agencies, fishers and NGOs, funding agencies -Fisheries agencies and stakeholders -Fisheries agencies, universities, all stakeholders
4. Apply and integrate the best available information to develop strategies for successful spawning aggregation management,	-Establish regional synchronized closed seasons. -Improve traceability at the sub-regional and regional levels. -Develop regional strategies for alternative livelihoods including the guidelines for	- 2019 and ongoing	-Fisher organizations, NGOs, National and regional fishery agencies

nationally and regionally.	conducting tourism on FSAs. -Develop sub-regional and regional criteria for FSA legislation based on science by engaging all relevant stakeholders including RFMOs through establishing multi-stakeholder task groups.	-2020 and ongoing	-Fisheries agencies, fishers organization and marine tourism sector -Fisheries agencies, fishers, RFMOs, universities and funding agencies
5. Increase awareness, engagement and understanding regarding importance of and need to equitably safeguard spawning aggregations for the benefits they can bring and their biodiversity role.	- Revise information for educational purposes so it is up-to-date, include legislation, fishery dependent and independent data, and relevance of conservation. -Build publicly available data summaries and publish new and existing information. -Create public networks to access updated information on FSAs population for different stakeholders. -Promote SCRFA and other NGOs educational materials both printed and digital. -Develop public marketing and awareness campaigns to promote the importance of healthy FSAs. -Propose Nassau grouper for inclusion on CITES App. II. -Develop alternative livelihoods for stakeholders affected negatively by aggregation protection.	-2019 and ongoing -2020 and ongoing	Spawning aggregation working group -Fisheries agencies, NGOs, fishers organizations -SCRFA, NGOs, fisheries agencies fisheries agencies, NGOs, RFMOs -Fisher organizations, NGOs, National and regional fishery agencies, IUCN Groupers & Wrasses Specialist Group
6. Integrate spawning aggregation management into marine environmental planning, factor in ecosystem-scale considerations, climate change, illegal, unregulated and tackle unmonitored fishing and international trade.	-Estimate macro and meso-scale larval connectivity patterns for the targeted species and identify the impact on climate change on these species. -Identify other emerging research priorities, including trade transparency, socio-economic and equity issues associated with the fishing of FSAs. -Revisit the criteria for the creation of MPAs to address the suitability of FSAs conservation -Develop special FSA provisions for indigenous communities to address food security. -Identify, mitigate, and address IUU fishing issues, with a primary focus in regulated areas and better protection for unregulated areas. -Develop working alliances with stakeholders working in regional enforcement including but not limited to Interpol and CARIBEWEN.	- 2019 and ongoing	-National and regional fishery agencies NGOs, fisher organizations Universities Enforcement agencies -Fisheries agencies, Universities and fishers organizations -Fisheries agencies, indigenous communities -Fisheries agencies, fishing stakeholders, RFMOs, IUU fishing working groups

9. Guidance Annexes 1-20

1. **Summaries of basic knowledge on biology, ecology, and other appropriate information relevant to management and conservation.**
    - Basic biological and ecology information is important for fishery management. Sections 3.1 and 3.2 highlight the main reproductive information necessary while Appendices 1 and 2 provide greater background to the two targe species, Mutton snapper and Nassau grouper.
2. **Criteria for species and site selection and prioritization.**
    - When should a species be managed and how is that decision made and how are sites prioritized for management?
3. **Protocol to manage and conserve newly identified FSA sites**
    - Previously undocumented aggregations may be discovered by chance or through research; how should these be handled?
4. **Enforcement and implementation**
    - Challenges in relation to enforcement and management policy.
5. **Management practices/needs.**
    - A range of different approaches is available to manage aggregations sites and times. These are outlined along with the pros and cons of different measures.
6. **Outreach and education needs.**
    - Education and outreach are essential for successful fishery management and need to be appropriately designed and pitched to reach all stakeholders. What materials are needed and, who should be targeted and in what ways?
7. **Sustainable financing methods to implement the FMP.**
    - Successful fishery management calls for many measures and activities which variously cost money. How can these actions be maintained on an economically sustainable and practical basis?
8. **Research priorities and data gaps.**
    - Certain research areas are in greater need of attention in relation to management and should be prioritized while specific data gaps, such as population structuring, connectivity, socioeconomics and education needs, and fishery condition and monitoring need particularly urgent attention.
9. **Importance of no-take marine reserves to protect FSAs in the region.**
    - Marine protected areas are often considered to protect spawning aggregation sites and will be suitable in some cases and less so in others. However, on their own, small MPAs will be good to protect aggregation sites but usually not large enough to cover the catchment area of many species likely to be priorities for management. Hence additional management measures will be likely.
10. **Importance of seasonal protective measures to protect FSAs in the region.**
    - Seasonal management can be effectively used to protect aggregated fish, in combination with other measures to address the fishery as a whole. Seasonal approaches have been often applied around the tropics for aggregating groupers and can be particularly effective when linked to sales bans during the same period. They are also useful when there is not knowledge of all aggregation site locations.
11. **Information on international commercial trade of aggregating fish.**
    - International trade in reef fishes is important for some countries and increasing demand globally and declining supples in many regions is leading to growing pressures from some countires to source reef fishes through international trade. Groupers and snappers are particularly valuable among reef

fishes and decisions may be needed regarding the relative value to source countries of domestic (including for tourism) versus export markets.

12. Existing legislation

- The range of existing legislation and regulations to manage and protect spawning aggregations and aggregating fish species (spatial/temporal/sales/other) is examined. .

13. Impacts on spawning areas

- Different factors can affect spawning fishes and aggregation sites. Emphasis is given not only on the impacts of fishing effort on spawning aggregations, but also on impacts on the sites themselves and on associated habitat from anthropogenic factors (e.g. construction, pollution, tourism, mineral extraction, noise), including the potential impacts of climate changes

14. Scope for emergency measures

- The capacity of governments to quickly protect threatened species or spawning aggregations is examined because of the known susceptibility of aggregations to sudden collapse as well as the ability to fish out previously unexploited aggregations within a few years of discovery.

15. Gaps in policies and fishery priorities

- Policies and national priorities for fisheries i.e. what are fisheries objectives for governments where Mutton snapper and Nassau grouper are important local species and is the management of these species consistent with the national objectives? Any obvious gaps?

16. Collaboration on research, monitoring and management

- The need for national-level standardized monitoring programmes is widely recognized to document status of and trends in fisheries. For most species under consideration in this FMP, populations and stocks are likely to cross international boundaries. Regional collaboration on research and management is often needed for species that cross national boundaries either in the planktonic or in the benthic life history stages. It is important to recognize the likely transboundary nature of many stocks and how international actions can be used to improve management.

17. Regional instruments over time and space

- Regional measures such as agreements and conventions are binding within the states that have ratified them. These can be very broad, such as the United Nations Convention on the Law of the Sea (UNCLOS) which provides the legal framework for the conservation, management and exploitation of marine resources in a sustainable manner and the Agreement on Port State Measures (PSMA) is a binding international agreement to specifically target illegal, unreported and unregulated (IUU) fishing: its objective is to prevent, deter and eliminate IUU fishing by preventing vessels engaged in IUU fishing from using ports and landing their catches. Various countries have signed bilateral or multi-lateral agreements for fishing within their jurisdictional waters bring fisheries management to a regional and more localized scale. The broader measures apply since their adoption while bilateral agreements are negotiated periodically. Measures such as the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) regulates the trade and management of specific species. Certain species that construct important reef habitat have been listed under Appendices II and III to afford them substantial protection. The Specially Protected Areas and Wildlife (SPAW) Protocol of the Cartagena Convention is mandated to take the necessary measures to protect and manage ecologically important ecosystems as well as threatened species.

18. Enforcement

- What enforcement is in place now and what are the enforcement capacities and needs. What is working and what can be considered to improve and enhance enforcement.

19. Illegal (also referred to as 'poaching'), unmonitored and unregulated fishing

- Illegal, unreported and unregulated (IUU) fishing is defined as fishing that is conducted contrary to legal conservation and management measures currently in place around the world. The WECAFC Region, which also consists of Small Island Developing States, is especially challenged as the fisheries industry continues to be weakened by the prevalence IUU fishing. Why and how is it occurring.

20. Use of VMS

- VMS is a term used to describe systems that are used in commercial fishing by environmental and fisheries regulatory organizations to track and monitor the activities of fishing vessels in the territorial waters and Exclusive Economic Zone (EEZ) of a country. The EEZ can extend up to 200 nautical miles from the coast. VMS are used to improve the management and sustainability of the marine resources, and accountability of vessels, by tracking vessel movement, prompting proper fishing practices, preventing illegal fishing and protecting and enhancing the livelihoods of fishers.

ANNEXES 1-20

Annex 1: Collection of current knowledge on biology and ecology

Collection of information on biology and ecology		
Information type	**Description**	**Relevance**
Taxonomy and description	Molecular data on species to identify fillets without heat or skin patch. Larval and juvenile phases to be described for some species.	Would assist in enforcement and monitoring Identification of early, including planktonic, life history stages could assist in understanding the ecology and connectivity of the species.
Geographic distribution	Describes the range of the species and the habitats that they utilize.	Important habitats could receive protective attention.
Age, growth and mortality (natural and fishing)	Need to understand growth rates, size and age of sexual maturation, and mortality rates.	Important parameters for life history and fishery management. These parameters are important for fishery modelling and for measures such as minimum or maximum size controls.
Trophic biology	Describes the food web and possible diet changes over time.	Contributes to understanding of species role in the ecosystem and relative importance if there are shifts in abundance of either predators or prey species.
Behaviour	Migrations or other movements at different life history phases, responses to different types of fishing gear, etc.	An understanding of behaviour can help to tailor management actions around spatial use, temporal measures or in relation to gear types.
Reproduction and pre-spawning migrations.	Mode of spawning, aggregating behaviour, possible depensatory effects and aggregation dynamics.	The conditions for ensuring reproductive output may vary between species according to sexual selection, sexual pattern (gonochorism versus hermaphroditism), size of maturation, sex ratios, etc. and need to be understood to ensure productive populations and enable recovery from depleted states.
Age and or size distributions and proportions of juveniles in catches.	Data on sizes and/or ages to be collected from fisheries on a regular basis to track possible changes over time that could provide information on population condition in response to fishing.	Size distributions are important for detecting changes over time and possible indicators of overfishing (such as an increasing proportion of juveniles being caught or loss of large megaspawners)

Population structuring and connectivity; this addresses both the catchment area of focus aggregations and the biological population structure ?	Population sub-structuring (genetic studies), if any, and catchment areas(tagging studies) of focal aggregations. Biophysical modelling of larval transport from spawning aggregations.	Important for identifying spatial management units, especially since population or spawning aggregation catchment areas can be hundreds of square km and span national boundaries.

Annex 2: Criteria for species and site selection and prioritization

Criteria for species prioritization and site selection

Criteria	Description	Comments relevant for prioritization
Conservation status of species	• Determine the conservation status of the species at national regional or international (e.g. CITES, SPAW and IUCN) levels.	Species already considered threatened or which have been seriously depleted, locally or regionally always merit prioritization for conservation or management action. This could involve a range of measures inclusive of a moratorium. A Species Action plan could be drafted. Legislation may need to be developed if none exists to address threatened marine fishes. It is difficult to determine the status of a species in heavily depleted areas if there are no baseline data to compare with. In a case like this the precautionary approach should be used and precedents and experiences from elsewhere used as guidance.
Fishery condition of species	• Evaluate the condition of the fishery of the species by collecting landings data and catch sizes both at aggregations (if these are exploited) and during non-spawning times of the year.	Management measures should be immediately adopted for any exploited transient aggregation as a precautionary approach and considering their proven vulnerability to fishing. Emphasis should be given to over exploited aggregations and species. Appropriate restorative actions should be implemented for depleted species to include reduction of fishing pressure.
Degree and purpose of aggregation behaviour	• Determine the degree and purpose of aggregation at any given site. • Determine whether the aggregation is 'resident' or 'transient'*	Certain fish aggregations are not for spawning but for feeding purposes, resting or use of cleaning stations. Spawning aggregation are important for reproduction and are typically much briefer and more predictable and associated with greatly increased catchability; hence they can be particularly susceptible to overexploitation. Spawning aggregations can be few and large or many and small within the species range. The former (transient) can be more vulnerable to targeted overfishing and would be a priority for management.
Landings and fishery-related data from spawning aggregations	• Landing data should be collected from aggregation catches to monitor aggregation condition. • Determine numbers of	Morphometric (size) and sex data and catch volumes (ideally per unit of fishing effort-CPUE) should be collected. These data will assist with determining the biological and socio-economic status of any given species and any trends identified will help to assess the condition of the aggregation. Size data are also important for determining whether certain

	fishers who exploit the aggregation site. • Determine timing of spawning and identify any variability in the location of the aggregation area. • Determine whether fishing occurs on pre-spawning migrations to the aggregation site.	large fish are only found at the aggregations; sometimes these only come up from deeper waters, where they may be less accessible to fishing, at spawning times. These large fish may represent particularly large genotypes that may need conserving or may include female megaspawners which are particularly important for reproductive output. The number of recreational and commercial fishermen operating on the study site should be noted. Sex can usually be readily determined in ripe fishes. Declines in landings (weight/number of fish) (unrelated to effort reduction or weather), CPUE or mean size are signs of possible overfishing.
Landings and fishery-related data from non-spawning periods	• Landings data should be collected from non-aggregation catches to assess fishery condition.	Landings data from aggregating species taken outside of the aggregation period are important to avoid the risk of not detecting population declines due to 'hyperstability' (refer to Section x). Fish sizes, volumes, CPUE, weights should be collected during the non-aggregating period.
'New' aggregations	'New' aggregations are those that not exploited and may not yet have been discovered by fishers or others.	It is not recommended to locate or reveal the locations of any 'new' spawning aggregations unless there is already appropriate national legislation in place to protect them and enforcement is already adequate and effective. Revealing sites and not protecting them runs a high risk that they will be depleted before measures can be put in place to adequately manage them because such measures take so long to put in place. In general, those aggregations that are not known are likely to be the best protected and may be functioning as important remaining refuges for some overfished species.

Annex 3: Protocol for management and conservation of newly identified sites and seasons

Protocol for management and conservation of newly identified sites and seasons

Scenario	**Recommendations**
Newly documented exploited sites and seasons	• Site characterization (bathymetry, environmental and physical data, species, fish numbers and sizes, timing and area) by conducting visual surveys, video and still imagery as a starting point. • Collection of historical background, accounts from traditional knowledge, local fishery officers, biologists, fish houses, recollections of catches, and any other anecdotal observations. • Use the generated information to make management decisions in relation to appropriate site and or seasonal protection measures.
Exploited site identified by fishers either directly or through	• Site characterization for the same above-mentioned parameters using the same methodologies as well as more advanced ones.

interviews	• Collection of historical background, reliable accounts, anecdotal observations, logbooks and any existing literature. • Collection of additional data at landing sites through surveys and morphometric measurements; fishery-dependant data. • Use the generated information to make management decisions in relation to site and or seasonal protection measures.
Previously unknown sites discovered by research or by chance	• It is not advisable to seek new or unknown spawning sites in countries where there are no existing management or emergency measures that could be used to protect a newly identified site to ensure precautionary protocols are followed; the best protected aggregations are those that are unknown. Note that new legislation can take years to be approved. • Caution should be taken in communicating a newly discovered location especially if it is in good condition since exploitation can rapidly follow discovery; any information should be limited to use of relevant parties such as the government or NGOs. • Any new site location should only be made public after protective measures are in place or if there is appropriate legislation is available that would enable immediate protection. Note that seasonal protection measures may be an option if site protection measures are unlikely to be effective (due to remote location of aggregation, limited enforcement capacity, etc.). Moreover seasonal protection is recommended in the absence of good knowledge on aggregation locations.

Annex 4: Management practices/needs

Management practices and needs

Management Practices

Options

Various countries in the WECAFC area have independently adopted management practices to manage priority species, mainly the Nassau Grouper, and to an extent the Mutton Snapper. Some countries have only one management regime or a combination of various.

Designation of protected areas	When designating a protected area, make provisions for spawning aggregations and ensure that the area is large enough to accommodate shifting of specific spawning sites was well as staging and migration areas, if necessary. Policies and rules can offer some form of protection in the absence of specific regulations.
Total protection of a species	This measure is the most extreme when aggregation of a species is severely threatened or depleted. When stocks normalize then the protection can be lifted. However, if fishing on the aggregation is entirely uncontrolled and considered to be excessive, closure should be considered, at least in the short term and until it comes under management.
Enactment of special regulations for a specific species	Ensure that relevant regulations are comprehensive and complete enough to avoid loopholes. Regulations should address: species, aggregation sites, migration corridors (if any), closure periods (seasonal protection of aggregation site, sales, landings, possession, etc.), minimum and maximum sizes, bag limits, skin patches,

	landing of fish whole and catch logs and fishing effort. Where international trade is a major threat to a species consideration should be given to a CITES Appendix II listing. Threatened species legislation at the national level may need to be developed or enacted.
Limit fishers in a fishery	If a spawning aggregation site is open to fishing, then there should be a limit to the number of fishers that can participate especially if fishing is for commercial purposes (i.e. not just for local subsistence needs). To ensure the sustainability of the species, fishers that stop fishing in an area for more than one year should not be replaced immediately until the status of that aggregation is fully established; this will usually take at least 5-10 years for the long-lived groupers and snappers.
Limit visitation time for tourism on spawning aggregations to minimize disturbance to spawning or disruption to behaviour.	Should have regulations in place for tourism visitation on spawning aggregation sites to be out of the water before the fish start to aggregate for spawning. This avoids possible disturbance of a spawning aggregation. In cases where large numbers of divers are interested to dive, consider limiting the number of divers in the water at any one time.

Annex 5: Enforcement and implementation

Enforcement and implementation

Challenges	Options
Many countries do not have any regulations for the protection of spawning aggregations of any species.	Gather scientific information and then formulate and enact needed regulations to protect priority species such as Nassau Grouper and Mutton Snapper.
Regulations for spawning aggregations may not be fully understood by fishers and the public in general.	There is the need for a sensitization campaign to explain in the simplest form, the regulations, and importance of healthy aggregations for the sustainability of the resource as well as possible fines and penalties for infractions.
Even if countries have regulations for the protection of spawning aggregations these may contain loop holes that fishers take advantage of.	Identify the gaps and take corrective measures.
Countries that have good regulations do not have the resources to enforce them.	There is the lack of equipped vessels, trained personnel and fuel for patrols and response to target illegal fish. Fisheries enforcement is not a priority in many WECAFC countries. Organize fisheries enforcement with other scheduled events so as to capitalize on resources.
When arrests are made on illegal fishing on spawning aggregations, many countries do not have the necessary infrastructure for successful prosecution.	Regional prosecution capacity building is needed in the region via workshops. At these workshops countries with good prosecution practices can share and exchange information. The judiciary may not take fishing violations seriously or consider them important and need to be advised regarding their severity and implications for livelihoods and food.

Annex 6: Identify needed outreach and education actions

Outreach and education objectives, current activities and actions needed

Objective	Current activities	Actions needed and by whom
Direct stakeholders awareness for closer collaboration	Identification of fishers using known spawning aggregation sites. Environmental conservation materials such as brochures, maps, fishing guidelines, regulations, info graphics, training modules, manuals, handbooks pamphlets, posters, fliers, films, videos, bumper stickers and catch landings information exist and is hosted on various websites with different permission access.	Need to determine catch landings, currently and, if possible, historically, along with morphometric data from specific spawning aggregations. This work should be conducted by the fishing authorities with the assistance of independent researchers whenever available. The information is then relayed to the fishers through public consultations to get feedback. Fisheries and environmental authorities, supported by NGOs should continue with the production of this vital information.
General public awareness to deter illegal fishing of spawning aggregations	Environmental conservation materials such as brochures depicting the life cycle of the Nassau Grouper and Mutton Snapper and their importance in sustainable fishing as well as videos on the protection of spawning aggregations, closed seasons and other management measures also exist. Need for public to understand the importance of spawning aggregations for fish and fisheries and the relevance of protecting them for food security and livelihoods.	Fisheries and environmental authorities as well as NGOs should continue these efforts. Videos are very effective for the general public to understand the need to protect spawning aggregations and at the same time discourage the purchasing of products especially during closed seasons in support of management measures.
Awareness for public officials and decision makers to support spawning aggregation conservation efforts	Special position papers describing the importance of spawning aggregations in sustainable fisheries and the needed regulations to protect them.	Need lobbying efforts by the fishing authorities, fishers and the conservation non-governmental organizations with high level government officials to enact needed legislation to protect spawning aggregations.
Availability of materials that can be used by any country	The above-mentioned materials are available but is globally scattered. SCRFA website has very comprehensive materials from around the globe. Materials need to be adaptable to local and regional contexts.	The materials could be hosted on a regional website for easy access and modification by any country for national use. The effort can be spearheaded by the OSPESCA/CRFM/CFMC/WECAFC Working group.

Seek funding from donor agencies	Samples of environmental education materials are available for donor agencies. There is limited funds available for spawning aggregation outreach and education.	National fisheries authorities and NGOs should present the scientific data along with these material to obtain funding to continue to monitor and collect vital data for decision making. Funding is needed as It is very expensive to run environmental advertisements especially in countries that do not have mandatory free public service advertisement by private media houses.

Annex 7: Identify possible sustainable financing mechanisms to implement FMP at national and regional levels

Sustainable Financing

Option	Description	Comments
1	The Spawning Aggregations Fisheries Management Plan will seek funding from resources provided by the CFMC, SICA, CARICOM and WECAFC Member Countries whenever available. A plan coordination should be established which must submit a proper cost-benefit analysis on the advantage of contributions that multiply the benefit for the people and promote the sustainability of the spawning aggregations.	Many of the participating countries under WECAFC are already heavily burdened with contributions to many other ongoing projects and initiatives. However, WECAFC countries can integrate spawning aggregation monitoring and protection, especially for Nassau Grouper and Mutton Snapper, in their yearly operational plans.
2	Seek alliances and partnerships with other regional and international cooperation entities interested in responsible fisheries and aquaculture to generate an implementation plan.	FAO, EU CARIFORUM Agreement, TNC, GEF, NOAA
3	Continue collaboration with the "Caribbean Large Marine Ecosystem and Adjacent Regions" (CLME+) Project which is expected to enter its third phase in 2020.	Should lobby the CLME+ countries to support the project in its future endeavours. A spawning aggregation monitoring and management project could be developed and implemented by WECAFC along with the working group within the next phase of the project if it materializes.

Annex 8: Identify relevant research priorities and data gaps

Identified research priorities

Area	Description	Comments
Aggregation areas	There is the need to identify and document all exploited	Many reported spawning aggregation

and migration pathways, if any	spawning aggregation areas in each country, as well as migration pathways if these exist.	areas, or pre-spawning aggregation migration pathways, if these occur, have not yet been validated by study and mapping. National maps of spawning aggregations need to be developed identifying exploited Nassau Grouper and Mutton Snapper aggregations. Mapping to consider core spawning areas and also surrounding areas where fish might move to temporarily between spawning periods but during the spawning season.
Aggregation times and those of pre-spawning aggregations (if any)	There is a need to document the reproductive seasons of target species and the timing of formation of aggregations and, if any, pre-spawning migrations.	Document the migration and aggregation periods of target species,
Aggregating species at spawning aggregation sites	Once an area has been identified, there is the need for information about which target species of interest are using the area and whether and how they differ in terms of their timing and spatial use during spawning and aggregation.	Many spawning aggregation areas are used by multispecies. The priority species aggregating at identified sites need to be determined and both the area and habitat of aggregation documented and timing of spawning identified. At multi-species aggregation sites several species may occur there but timing of spawning may differ among the species.
Fishery	Need to identify if there is a fishery associated with a spawning aggregation site and qualify its status. Need to determine number of fishers fully or partially dependent on aggregations and if for subsistence and/or commercial purposes. Consider introduction of innovative tools for reporting of catches, such as using digital reporting.	Many aggregation sites are over exploited and some depleted. Some aggregation sites might be very valuable or important to local fishers, while some might provide supplementary income or are less important for annual income. Some aggregations may be important to supply food for local communities. Adapt existing digital reporting tools, such as electronic logbooks or telephone apps to assist in fishery reporting.
Education	Public education on spawning aggregations is needed for direct and indirect stakeholders. Education needs range from awareness about why aggregations are of key importance for fishes and to maintain fisheries, to the need to manage, the need to	Education on regulations is very important for fishers to abide and the general public for not purchasing products during closed seasons and outside legal size limits.

	have and enforce laws and the importance of following through to prosecutions as necessary.	Maps with accompanying regulations need to be distributed. Radio and television ads would ideal.
Trade	Identification and description of trade at the national, regional and/or international levels in priority species. Need to understand sales networks both into local businesses (including direct food outlets and packaging/processing facilities) and for export or import during the spawning and non-spawning seasons, particularly if species are protected in some way.	Once the trade of a species has been established, management measures can be developed/better enforced for that trade especially if a species is on the appendix of any agreement or convention and if there is illegal trade involved. This information is particularly important where IUU is known or suspected and needs to be stopped and may require molecular testing kits to identify species from fillets or processed fish.
Socio-economic issues	Identification if any community is dependent on spawning aggregations for income generation or food security. Special provisions with guidelines should be made for indigenous peoples and for food security.	Revenue generation can be quantified and alternative livelihoods and sources of food can be identified if necessary to alleviate high fishing pressure on specific sites or as alternative during protected periods.
Information exchange	There is the need for information on the different methodologies and equipment used in monitoring spawning aggregations. Data generated can be exchanged especially by countries having shared fisheries resources on specific species.	Methodologies can be adopted for the monitoring of specific species. Monitoring capacity building can be exchanged between countries. Duplication of monitoring efforts can be avoided.

Annex 9: Importance of no-take marine reserves to protect FSAs in the region

Importance of no-take reserves to protect FSAs		
Reserve type	**Description**	**Comments**
No-take marine reserves	This type of reserve offers more protection as the area can be large and can incorporate several spawning sites as well as pre-spawning migration pathways. Larger no-take areas can also accommodate aggregation sites that might shift slightly from year to year and could be suitable for multiple species if they are using different habitats in the same general spawning area. Fishing is not allowed during the whole year and the spawning area habitat is fully protected. Protects the movement patterns of	Many spawning aggregation sites and for various species can be protected by this type of reserve, as well as the habitat. Adult mortality is lower since there is protection during an aggregation and during the rest of the year. Larger areas provide protection of juveniles since it includes various critical habitats and nursery areas. Larger areas could also accommodate more of the catchment area of an aggregation site or a larger proportion of a biological population. The legislation for this type of reserve, apart

	territorial species such as the Nassau Grouper.	from no fishing, also manages other activities conducted within its boundaries. Most MPAs are not large enough for aggregating species, which can move over large areas as adults and enforcement is often weak. Particularly large fish may be protected since these sometimes only come up from deeper water, where they may be harder to catch at other times, to spawn. These include megaspawners; females which contribute disproportionately to reproductive output.
Spawning aggregation reserves or protected area that is too small for the species.	Involves the temporary closure to fishing during spawning aggregations. Can increase aggregation sizes. Can increase reproductive output. Can allow natural behaviors to continue undisturbed. For example, sexual selection or social interactions that might be relevant for sex change.	A reserve size can be too small and ineffective as an aggregation may move somewhat from year to year. High fishing pressure just outside an aggregation reserve, or on pre-spawning migrating adults, can impact the aggregation population. Legislation usually involves only no fishing for a specific species during the aggregation period and needs to consider migrations and multiple species.

Annex 10: Importance of seasonal protective measures to protect FSAs in the region

Importance of seasonal protection to FSAs		
Reserve type	**Description**	**Comments**
Closure of fishery during the annual spawning season	Would require determination of spawning season to include period of pre-spawning migration, if any.	Protects fish while they are spawning. Particularly large fish may be protected since these sometimes only come up from deeper water, where they may be harder to catch at other times, to spawn. These include megaspawners; females which contribute disproportionately to reproductive output May need to include a buffer period because spawning seasons can shift earlier or later according to lunar timing or other factors.
Banning of sales or possession during the annual spawning season	Would involve a prohibition on sales, exports, marketing or possession during the protected season. Would need public (including consumers and trader/exporters) outreach to gain public support and understanding.	If seasonal protection is difficult to enforce, then sales bans or possession bans could be introduced as well. This combination has worked well in parts of the Pacific, such as Palau. Allowance for subsistence use only may be considered.

Annex 11 Information on international commercial trade of aggregating fish

		Internation Trade	
Nassau Grouper	**Mutton Snapper**	**Conservation/management measures**	**Comments**
Unknown but suspected or recently recorded between several countries		Currently included on USA Endangered Species Act. National protection in various countries (Bahamas, Belize, Cayman Islands, Puerto Rico, USA); forms of protection vary according to countries and there still exist many loop holes in the national legislations. Currently on SPAW Annex III. Listed as endangered on the IUCN Red List (proposed for uplisting).	Excellent food source in its range, high fishing pressure, especially on aggregations, has severely depleted viable populations. National legal catches are not high but species are highly valued so even small export volumes can be lucrative and pressures to trade grouper internationally are growing. Nassau grouper is/has been exported from Honduras and may be exported from The Bahamas to the United States. Illegal catches by fishers from neighbouring countries are not landed nationally (as far as is known but this needs investigation) so catch volumes are unknown. If international trade is a threat then CITES APP II is relevant. Maybe sold as grouper 'fillets' which calls for molecular techniques to rapidly identify the species.
	Unknown in the Caribbean Region but could be traded as high value red snapper	Magnuson-Stevens Act USA. Specific regulations in some countries in its range, including USA. Listed as near-threatened on the IUCN Red List.	The Mutton Snapper is regarded as an excellent food source and as a result, high fishing pressures have been applied to spawning aggregations. Sometimes sold as the valued red snapper. Regulations have been enacted to include commercial limits, bag limits for recreational fishing, closed seasons for spawning sites and minimum weights (see Table x).

Annex 12: Relevant existing legislation and regulations and the history of protection of aggregations and aggregating fish species (spatial/temporal/sales/other)

Existing legislation to protect Nassau Grouper and Mutton Snappers during the spawning aggregation period

Species		**Measure**	**Description**
Nassau Grouper	**Mutton Snapper**		
		Full protection status for target species	Prohibit the taking of the species anywhere in a country. Once recovered, the productivity of its population can provide a healthy non-spawning

			season fishery.
Yes	Yes	**Annual closed season**	Implement the closed season from November of any year to March the following year (i.e. during the appropriate spawning period for the species). Countries may vary slightly (and larger countries may have to consider differences in timing in different areas).
Yes	Yes	**Bag limit**	Impose a daily catch limit of X fish/person/day during the open season.
Yes	Yes	**Size limit**	Impose a size limit of 45 – 60 cm for grouper and 25 cm FL and 45.7 cm TL for snapper.
Yes	Yes	**Landing the species whole or with skin patch if it is in fillet form**	Landing of whole fish may need specific landing sites to be designated. However, there is an opportunity to collect valuable data. The use of skin patch is a more practical preparation after landing. Species can be identified via skin patches on the fish markets and stores. It is already in practice in some areas.
Yes	Yes	**Fishing ban on designated spawning areas**	Ban the taking of these species on all designated spawning areas indefinitely.
		Realignment of designated spawning areas	Change the current boundaries of designated spawning areas to more realistically accommodate the potential shifting of spawning aggregations, based on research.

Annex 13 Impacts on spawning areas.

Measures to address human interventions on spawning aggregation sites

Source of possible impact	Regulations/Intervention
Coastal development (construction)	Formulation and enactment of modern coastal development policy plans. The plans should specify development areas, percentage of development, buffer zones, mangrove and littoral forest protection, MPA etc. Spawning aggregation sites should be incorporated to the plans under development.
Pollution	Pollution can be in the form of sediments, chemicals or materials such as plastics, bottles etc. There should be strictly no dumping of any materials or chemicals in the coastal waters of any country. This would be relevant for spawning areas close to land, or offshore sewage outfalls.
Dredging	Legislated dredging guidelines (including no dredging on coral formations and other sensitive habitats, the use of curtains, restriction on sediment volumes, no dredging during low tides and all dredging should be supervised).

Tourism	Tourism on spawning aggregations should be well managed, if it is allowed. Management could enact legislation to have divers out of the water by a certain time before the fish aggregate to spawn; the use of engines should be minimized while tourists are diving in order to lower noise pollution and the numbers of divers might have to be controlled. The presence of divers in the water, air bubbles from the SCUBA gear and noise from vessel engines have been documented to affect aggregations by causing the fish to go into deeper waters to aggregate and to take longer to aggregate. A total ban on tourists on diving in spawning aggregations should be implemented especially in the cases of threatened species or particularly depleted aggregation sites.
Climate change	Rising sea level, higher temperatures and ocean acidification are predicted to impact the timing of spawning and the spawning aggregations of a wide range of marine species and fisheries worldwide. Measures necessary to mitigate the impacts of climate change on spawning aggregations are still not fully understood. However, relieving the high fishing pressure on these aggregations may give them time to adapt naturally and provide populations with some resilience to accommodate abiotic and biotic changes.

Annex 14: Scope for emergency measures to protect spawning aggregations

Emergency measures for managing spawning aggregations and aggregating fish species

Emergency measures	**Description**
Total ban on a specific species	Governments should be able to declare immediate total fishing ban on any species , or on its aggregations, if these are determined or suspected to be depleted. Since threshold levels for aggregating species below which concerns arise over populations viability, as a guideline if aggregation catches have dropped by more than 50% over two consecutive years, protection should be seriously considered to prevent numbers dropping too low . This step is taken if there is no other alternative but the decision should include stakeholders.
Temporary closure on any area	This measure should be taken if the science on any spawning aggregation is not complete but there is good reason for concern. Data collection should run parallel with the closure in order to decide to open the area or continue with its closure.
Total ban on specific fishing gear	Certain gear such as baited traps are very effective in trapping spawning aggregation fish since during this time a species needs high levels of energy to complete the spawning process and some species (like the Nassau grouper) are very social and are attracted to join assembled fish, as in traps. As a result, they should be banned from fishing close to protected areas or in the vicinity of spawning fish to avoid trapping them as they move into and out of the aggregation site. Large set nets or gill nets should not be used to catch ripe fish migrating to spawning sites to or on the aggregated fish at the FSA.

Annex 15 Policies and national priorities for fisheries in relation to species that aggregate to spawn and are exploited on spawning aggregations.

Nassau Grouper and Mutton Snapper Fisheries Policies and Priorities

Policies & National Priorities	Gaps	Recommendations
Protection of spawning aggregations using regulations	Many regulations have loopholes.	Revisit the regulations and take the necessary measures to make them comprehensive.
Integration of spawning aggregation management in national fisheries plans	Many countries still do not have official management plans.	Incorporate management of spawning aggregation when formulating national management plans and revise and incorporate into existing plans as a priority consideration.
Protective measures for threatened marine fish species		Ensure there is legislation that can be used to protect species considered to be at risk of extinction until their recovery. Develop national species conservation lists of threatened species or, if none, consider regional or global conservation status according to regional (e.g. SPAW) or global (e.g. IUCN) assessments and listings
Targeted enforcement	Remote areas neglected.	Incorporate spawning aggregation enforcement into daily operational plans and providing more resources during these aggregations. Explore acoustic technologies to support enforcement at remote FSA areas, look into available technologies to help enforcement programs to become more effective. Consider complementary measures such as sales bans and enforce at market points and landing areas. This can be complemented by using seasonal/temporal protective measures instead of or in addition to spatial protective measures.
Stakeholder involvement	Many stakeholders using spawning aggregations are not consulted.	Identify all relevant stakeholders and integrate them in the planning process and decision making. Provide mechanisms for bottom-up participation into decision taken process. That requires specific education programs.
Case documentation	Successful management examples are still not properly documented.	Properly documented cases can serve as best practices and adopted by other countries. Training is needed in developing strategies to obtain good material that withstands legal processes, along with record of the chain of custody. Special regulations in how to deal with international offenders are also needed.

Political will	Politicians are hesitant to enact strict legislation especially during election years.	Need to educate national leaders on the importance to protect spawning aggregations as this rebuilds fisheries and the trophic integrity of the ecosystems.
	Management measures are often not put in place until populations are extremely reduced which could slow potential recovery	Establish clear benchmarks or targets which will trigger management if exceeded. Ensure that these are appropriate for the species to introduce conditions for rapid recovery and before populations have reached a threatened status. In particular it is important to safeguard reproductive capacity as a core part of fishery management which includes protection of sufficient juveniles, megaspawners and aggregation sites.

Annex 16 Collaboration on research, monitoring and management (national and international)

Areas of collaboration and management

Area	Description	Comments
Ecological assessment	Assessment methods for evaluating spawning aggregation sites can be made available and might be more useful if standardized across a region.	The assessments can be used not only for spawning aggregation sites but for general protection of spatial seascapes.
	Reports and data can be exchanged to compare aggregation areas in the region to look at similarities in structure, depth, current patterns and benthos.	Transboundary protection of habitat or seascapes may be more effective in some cases.
Biological assessment	Assessment methods for monitoring and studying spawning aggregations would be standardized and applied regionally.	Regional patterns and distributions might aid in more biologically meaningful scales of protection for target species.
	Genetic studies would help to determine population structure.	Population structure is an important component in identifying management units.
Governance	A compilation of the governance measures for managing the Nassau Grouper and Mutton Snapper can be made available in electronic format.	Countries will be able to adopt the governance measures that best suit a specific spawning aggregation site.
Enforcement	The different enforcement methods, experiences and successful cases of enforcement should be documented.	Countries can benefit from the best case scenarios and also do not need to duplicate efforts.
	The documentation should address joint planning and enforcement with other agencies such as the navy and coast guard and co-managers.	Regional spawning aggregation site monitoring training for enforcement can be conducted at the regional level.

	The level and nature of IUU may need to be determined or estimated. Cooperation in the implementation of relevant regional instruments (see next section)	IUU is a serious enforcement challenge in some areas and needs to be addressed. Revise effectiveness of existing regional and national IUU plans. Regional measures call for multiple countries to ensure that they are effectively in place and operational.
Research methods and tools	A compilation of existing research methods and tools can be made available in electronic format.	Countries can use the research methods and tools that they can best afford in order to collect the necessary scientific data for decision making.
Environmental management	Management of marine resources in the WECAFC area is the direct responsibility of the government management authorities. However, co-management has been delegated to various non-governmental organizations in a few countries which in turn bring their unique environmental management regimes.	A list of the management institutions (and contact details for key personnel) for a given spawning aggregation site should be made available for direct contact by any government or institution to request or contribute information.
Coastal community participation	Best practice in managing spawning aggregations can be developed with the participation of coastal communities that depend on the resource.	Failure to involve community participation in the management of any spawning aggregation site is likely to lead to failure.

- **Annex 17**: Regional Instruments - Regional measures/consistency over time and across space

Regional Instruments addressing fisheries

Name	Description	Objective (s)	Nassau Grouper/Mutton Snapper Protection
Code of Conduct for Responsible Fisheries (FAO)	The Code, which was unanimously adopted on 31 October 1995 by the FAO Conference, provides a necessary framework for national and international efforts to ensure sustainable exploitation of aquatic living resources in harmony with the environment. It also includes a general principle on spawning	1) establish principles, in accordance with the relevant rules of international law, for responsible fishing and fisheries activities, taking into account all their relevant biological, technological, economic, social, environmental and commercial aspects; 2) establish principles and criteria for the elaboration and implementation of national policies for responsible conservation of fisheries resources and fisheries management and development;	The Code does not directly identify specific species but encompasses the Nassau Grouper and Mutton Snapper fisheries to be conducted in a responsible manner including the establishment of policies and regulations for the sustainability of these species. Article 6.8 specifically

	areas (Article 6.8).	3) serve as an instrument of reference to help States to establish or to improve the legal and institutional framework required for the exercise of responsible fisheries and in the formulation and implementation of appropriate measures; 4) provide guidance which may be used where appropriate in the formulation and implementation of international agreements and other legal instruments, both binding and voluntary; 5) facilitate and promote technical, financial and other cooperation in conservation of fisheries resources and fisheries management and development; 6) promote the contribution of fisheries to food security and food quality, giving priority to the nutritional needs of local communities; 7) promote protection of living aquatic resources and their environments and coastal areas; 8) promote the trade of fish and fishery products in conformity with relevant international rules and avoid the use of measures that constitute hidden barriers to such trade; 9) promote research on fisheries as well as on associated ecosystems and relevant environmental factors; and 10) provide standards of conduct for all persons involved in the fisheries sector.	addresses spawning areas: *6.8 "All critical fisheries habitats ……… nursery and <u>spawning areas</u>, should be protected and rehabilitated ……… protect such habitats from destruction, degradation, pollution and other significant impacts resulting from human activities that threaten the health and viability of the fishery resources"*
Voluntary Guidelines for Securing Sustainable Small Scale Fisheries (FAO)	The Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (the SSF Guidelines) is the first internationally agreed instrument dedicated entirely to the immensely important - but until now often neglected – small-scale	1.1 The objectives of these Guidelines are: a)to enhance the contribution of small-scale fisheries to global food security and nutrition and to support the progressive realization of the right to adequate food, b)to contribute to the equitable development of small-scale fishing communities and poverty eradication and to improve the socio-economic situation of fishers and fish workers within the context of sustainable fisheries management, c)to achieve the sustainable utilization,	The Guidelines support responsible fisheries and sustainable social and economic development for the benefit of current and future generations. Within this context, responsible fisheries for the Nassau Grouper and Mutton Snapper can be embraced as small scale fisheries in many fishing communities depend on

	fisheries sector. The SSF Guidelines complement the Code of Conduct for Responsible Fisheries, which, alongside the fishing provisions of the UN Convention on the Law of the Sea, is the most widely recognized and implemented international fisheries instrument.	prudent and responsible management and conservation of fisheries resources consistent with the Code of Conduct for Responsible Fisheries (the Code) and related instruments, d)to promote the contribution of small-scale fisheries to an economically, socially and environmentally sustainable future for the planet and its people, e)to provide guidance that could be considered by States and stakeholders for the development and implementation of ecosystem friendly and participatory policies, strategies and legal frameworks for the enhancement of responsible and sustainable small-scale fisheries, and f) to enhance public awareness and promote the advancement of knowledge on the culture, role, contribution and potential of small-scale fisheries, considering ancestral and traditional knowledge, and their related constraints and opportunities. 1.2 These objectives should be achieved through the promotion of a human rightsbased approach, by empowering small-scale fishing communities, including both men and women, to participate in decision-making processes, and to assume responsibilities for sustainable use of fishery resources, and placing emphasis on the needs of developing countries and for the benefit of vulnerable and marginalized groups.	these resources. The guidelines are voluntary in nature but many countries are adopting them in their national legislations.
Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	CITES is an international agreement between governments. Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten their survival. Because the trade in wild animals and plants crosses national borders, efforts to regulate it require international cooperation to safeguard certain species from over-	CITES works by subjecting international trade in specimens of selected species to certain controls. All import, export, re-export and introduction from the sea of species covered by the Convention has to be authorized through a licensing system. Each Party to the Convention must designate one or more Management Authorities in charge of administering that licensing system and one or more Scientific Authorities to advise them on the effects of trade on the status of the species and to develop the non-detriment finding (NDF) that is necessary for exports to occur. The species covered by CITES are listed in three appendices, according to the degree of	Neither the Nassau grouper or mutton Snappers are included on any CITES Appendix. However, if any of these species warrant listing in order to ensure their sustainability, a proposal can be formulated by any leading country (or countries) and will then be evaluated by FAO after submission to CITES for consideration at a CoP meeting. While little information is available on international trade in these species (see

	exploitation. CITES was conceived in the spirit of such cooperation. Today, it accords varying degrees of protection to more than 35,000 species of animals and plants, whether they are traded as live specimens, derived products (ivory, shark fin), fur coats or dried herbs.	protection they need. Since 2002, a growing number of vulnerable and commercially valuable fishes have been added to CITES Appendix II because of the threat that international trade poses to the species. This includes one reef fish, the Humphead wrasse (*Cheilinus undulatus*) in 2004. Given that seafood is heavily traded internationally and that pressure to trade reef fishes is intensifying, an Appendix II listing may help to enhance trade controls, provide a potential for raising funds and improve oversight of the species to reduce threats and improve enforcement.	Section x) this is certainly occurring and if it represents a major threat to the species an Appendix II proposal might be warranted. The Nassau grouper, in particular, should be considered.
Specially Protected Areas and Wildlife (SPAW)	SPAW was adopted in 1990, and entered into force in 2000 under the Cartagena Convention. It is mandated to take the necessary measures to protect, preserve and manage in a sustainable way and at a regional (i.e. multi-national): 1. areas that require protection to safeguard their special value, and 2. threatened or endangered species of flora and fauna."	1) Significantly increase the number, and improve the management of, protected and/or managed areas in the Wider Caribbean Region (WCR), including support to national and regional conservation management strategies and plans. 2) Support the conservation of threatened and endangered species and sustainable use of natural resources to prevent them from becoming threatened or endangered. 3) Develop strong regional capability for information exchange, training and assistance, in support of national biodiversity conservation efforts; Coordinate activities, and develop synergies, with the Secretariat of the Convention on Biological Diversity (CBD) **,** as well as other biodiversity-related treaties and initiatives	Signatories to the SPAW protocol are obliged to make provisions for all threatened or endangered species on the territory of each Party to be given a protected species status, and the control, and if need be, banning of their capture, gathering, possession, trade and disruption. The species for protection are listed under three Annexes. The Nassau Grouper was added to App III after the meeting of 13 March 2017. Under App III exploitation is authorized but regulated to ensure and maintain population at an optimal level.
Large marine ecosystems (LMEs) are regions of the world's oceans, encompassing coastal areas from river basins and estuaries to the seaward	Most, if not all, of the countries where this spawning aggregation management plan will be implemented, are part of the Caribbean Large Marine Ecosystem + Project. (CLME+) is a 5-year project (2015-2020) implemented by the	1. Catalysing implementation of the Strategic Action Programme for the sustainable management of shared Living Marine Resources in the Caribbean and North Brazil Shelf Large Marine Ecosystems (CLME+ region).	The project aims at facilitating Ecosystem-Based Management (EBM) and implementation of the Ecosystem Approach to Fisheries (EAF) in the CLME+ region, to ensure the sustainable and climate-resilient

boundaries of continental shelves and the outer margins of the major ocean current systems.	United Nations Development Programme (UNDP and co-financed by the Global Environment Facility (GEF).		provision of goods and services from shared living marine resources. A Strategic Action Programme is being implemented under which the Nassau Grouper and Mutton Snapper are indirectly addressed under the Strategy 4 – ecosystems based management for reefs and associated sub-based ecosystems.
Traceability/trade	A seafood traceability program works through the collection or retention of data regarding the harvest, landing, and chain of custody of certain fish and fish products imported or exported by the various countries.	1. Includes the data reporting and record-keeping procedures necessary to ensure traceability of seafood products from harvest to the point of entry into a country; 2. Includes no new reporting requirements for domestic landings of wild-caught seafood as the data would be available in national programs; 3. Does not include a consumer-facing labelling or certification scheme. It is a business-to-government program limited to the collection, review and verification of data considered essential for tracing fish and fish products from harvest to point of entry into a country; and 4. Is designed to build upon existing resources and processes, aiming to maximize effectiveness and efficiency, while minimizing impacts on the fishing and seafood trade community. 5. For example, under the CLME+ lobster subproject, a traceability program is being expanded to other marine species, to be operational by 2020 for the OSPESCA countries WECAFC is well advanced with a traceability scheme.	Various traceability schemes exist worldwide for marine products. However, harmonization and standardization remains a problem. A global framework for legal and traceable seafood, especially in the capture fishery sector, has been recommended to reduce IUU fishing by making it difficult for products with IUU origin to enter the legal supply chain. It is recommended that the fish spawning aggregation working group, at its next meet, identify regional traceability systems in which the Nassau Grouper and the Mutton Snapper fisheries are represented.
Seafood safety and sustainability **e.g. Marine Stewardship Council, certification (www.MSC.org) and HACCP**	Process for detecting contamination and ensuring safe seafood supply (HACCP). A system for certifying sustainably practiced	To ensure that seafood is safe to eat. In the case of groupers and snappers that particularly relates to minimizing risks of ciguatera and heavy metal contamination. To promote and encourage sustainable fisheries when there is a consumer appetite	Ciguatoxin and heavy metal contamination are particularly issues with larger/older fishes which may be found at aggregations when some come up from deeper waters.

system for food safety hazards (Goulding, 2016)	fisheries which requires full chain of custody information and formal fishery assessments.	for fish produced sustainably. Currently involves an expensive process of certification which is difficult to apply to small reef fisheries but is feasible to consider.	With growing consumer appetite for sustainably produced fish, the market for MSC certification will grow and may be applicable to grouper and snapper fisheries, especially those for export. Common polices at OECS may be important to consider here. In addition MARPOL.

Annex 18: Enforcement

Existing enforcement capacities

Capacities	Description	Comments
Intelligence gathering	Gathering of information on illegal fishing on spawning aggregations and fishing in general.	The information usually is provided by the fishing community. A good working relation is needed between the enforcement authorities and the fishers. Sometimes field biologists supply such intelligence. It would be useful to trial a central database system of app for a more systematic reporting system.
Patrols at sea and on land	Enforcement patrols are conducted at sea at spawning aggregation sites and adjacent areas. Where there is seasonal protection is in place and no fishing or sales allowed, patrols can be conducted at landing sites, in restaurants and in markets as well as inspections of exporting companies and shipments, where relevant.	Many times the mere presence of enforcement officials serves as a deterrent for illegal fishing. However, constant routine patrols are not sustainable and may need to be concentrated on illegal fishing hotspots. Countries can adopt existing fisheries enforcement standard operating procedures manuals. Market, restaurant and fish house inspections are often easier than at-sea patrols and can be effective. Development of a DNA testing kit for rapid assessment of target species when only fillets are available would be useful.
Prosecution	The ability to prosecute perpetrators of illegal fishing activities in a court of law. The Judiciary need to be encouraged to take fishery violations seriously.	Countries can adopt existing fisheries prosecution manuals and follow through from apprehension to prosecution. Can also benefit from more regional prosecution capacity-building where successful

		cases can be discussed.
Equipment confiscation	Many countries do not confiscate equipment of illegal fishing offenders.	Confiscation of equipment (boats, engines, fishing gear, products) is a deterrent for illegal fishing and is widely practiced globally. Many countries have successfully prosecuted illegal fishing on Nassau Grouper and Mutton Snapper spawning aggregations.
Inter & intra coordination	It involves mainly information-sharing and joint patrols within units of an existing enforcement agency as well as other enforcement agencies.	Joint enforcement saves resources especially fuel which is the most expensive operational cost. In many countries, the police departments, navies and coast guards can conduct fisheries enforcement and it is mandated by law.
Divulgence of prosecution results	Successful prosecution should be divulged to the general public.	Divulgence on successful prosecutions acts also act as a deterrence for illegal fishing especially in those cases where the perpetrators go to jail. It can also encourage law enforcement officers who see that their, sometimes risky, actions to apprehend poachers is meaningful.
Ecotourism operations	Ecotourism operations occur in the vicinity of a spawning aggregations and diving on the aggregated fish may be occurring.	Diver presence can help protect sites from extractive activities but regulation of the number of divers and timing of dives might be necessary to avoid disturbance of aggregated fish.

Annex 19: Illegal, unregulated and unmonitored fisheries (including illegal fishing) situation

IUU identified problems in the region

Problem	Description
Fishing unauthorized & undersized fish (usually below sexual maturation)	Illegal fishing of conch, lobster and finfish in various countries including Jamaica, Bahamas and Belize, shrimp in Guyana and Suriname and tuna in Eastern Caribbean islands. Fish spawning aggregations are also a target for these illegal activities.
Inadequate MCS	Lack of trained fisheries, police and coast guard officers; lack of equipment, such as boats and communication equipment, in many countries. Fuel costly.
Foreign vessels encroachment	Fishers from neighbouring countries illegally fish the waters of other countries.
Fishing during the closed season and in closed areas	Inability to properly monitor illegal fishing during the closed seasons and in closed areas. Spawning aggregations are a special target because of their vulnerability to fishing during mating and spawning (high catchability).
Use of prohibited gear and methods	Inability to control the use of explosives, chemicals, plant toxins, nets with undersize mesh sizes, non-biodegradable traps.
Unreported and misreported	Lack of personnel to monitor and verify fish catch (volumes and sizes)

catches	
Non IUU plan implementation	Many countries have not developed their IUU plans of action or are not implementing them.
Lack of or inadequate coordination and communication between agencies	Coordination is needed among the fisheries departments, coast guards, prosecution units, etc., for standardizing training and implementing operational plans.
Inadequate legislation	Low fines and penalties; absence of forfeiture provisions; pending legitimation (legitimization??) and implementation of legislation. .

Annex 20: Use of vessel monitoring systems (VMS) or other boat tracking devices.

Commonly used vessel monitoring systems

Type	**Description**	**Comments**
Satellite Based VMS	A satellite-based VMS involves the monitoring of vessels within certain areas for the purpose of ascertaining with precision a vessel's location and the type of activity in which it is engaged. A fishing vessel has a secured beacon which transmits signals intermittently which are picked up by a satellite that in turns relays the information to a ground station. The ground station then provides the data to the client.	Very accurate but it is relatively expensive due to the sophistication of the hardware and the charge for every sent signal by the service provider. With recent technologies, catch data and other relevant information can be sent via the signal sent by the vessel. Mostly used in industrial fisheries
General Packet Radio Services (GPRS)	This system covers patchy and limited areas using phone technology from land-based mobile phone towers. However, it has the ability to continue logging vessel position when a signal is lost and can then transmit when signal returns.	Can optimize its performance by using high quality marine antennas. This system is more applicable to nearshore fisheries and smaller or artisanal vessels since it is limited by mobile phone coverage. Can be affordable based on phone data prices and can be applied to authorized fishing vessels to monitor navigation in or around spawning aggregations; 'geo-fencing- of spawning aggregations can be programed into the monitoring software.
Very High Frequency Time Division Multiple Access	Use a dedicated radio frequency to transmit data. Transmissions are possible up to 40 nautical miles depending on the height of antennae installed on vessels and shore towers. There are no transmission costs once the system is set up, other than a VHF license cost.	Affordable, however it is limited in range and more applicable to nearshore than offshore fisheries.

10. SOURCE DOCUMENT
10.1 Nassau grouper

Taxonomy and Distinctive Characteristics

A distinctive species of moderate size with large eyes and robust body. Range of colour is wide, changing in moments from almost white, to bicolored to dark brown according to behavioural state. Only dots around the eyes and a blotch on the caudal peduncle do not change. Adults and juveniles of similar colouration

Geographic Distribution

Geographic Range
The Nassau grouper is distributed in the western Atlantic from Cape Canaveral, Florida south along the U.S., Bermuda, the Bahamas, in the Gulf of Mexico from the Florida Keys, the Flower Garden Banks, and Tuxpan, Mexico along the northern Yucatan to northwestern Cuba, throughout the Caribbean Sea, and along the South American coast to French Guiana (Hickerson *et al*. 2008, Robertson and Van Tassell 2015). It does not occur in Brazil (Heemstra and Randall 1993, Moura 2001).

Habitat and depth range
This species prefers clear water with high relief coral reefs or rocky substrate (Sadovy and Eklund 1999). Early-stage juveniles inhabit inshore habitats including macroalgal clumps, seagrass beds and coral reefs (Eggleston 1995, Dahlgren 1998, Claydon and Kroetz 2007). It occurs to a depth of at least 140 metres, but individuals have been recorded to regularly descend to depths of 255 metres during the spawning season (Starr et al. 2007).

Biology & Ecology

Eggs and Larvae
Nassau grouper larvae are rarely reported from offshore waters (Leis1987) and little is known of their movements or settlement patterns. Research that has followed released eggs has shown both that these are retained close to shore and that they can also be advected offshore (as determined by drogues released at the time of spawning and which drift with water currents) (Colin 1992 and Heppell et al. 2011). Collections of pelagic larvae were made 0.8 – 16 km off Lee Stocking Island, Bahamas, at 2-50 m depth, and from tidal channels (Greenwood, 1991).

Fertilized eggs are pelagic, measure about 1 mm in diameter, and have a single oil droplet about 0.22 mm in diameter (Guitart-Manday and Juárez-Fernandez 1966). Artificially fertilized eggs in seawater of 32 parts per thousand salinity or above are neutrally or positively buoyant and measure 0.86-1.0 mm (mean 0.92 mm) in diameter, with a single oil globule averaging 0.24 mm (Colin 1992, Powell and Tucker 1992). The larvae develop elongate dorsal and pelvic fin spines for buoyancy and protection that are reabsorbed prior to transformation.

Preflexion and flexion epinephelinae larvae are difficult to identify positively as *Epinephelus striatus*, although certain combinations of pigment, fin spinelets, and spine lengths narrow down possibilities (Kendall 1979, Johnson and Keener 1984, Powell and Tucker 1992). With postflexion larvae greater than 7.4 mm SL it is possible to separate Nassau grouper from other groupers, except for *E. adscensionis*, on the basis of dorsal and anal fin ray counts, spinelet configuration, second first-dorsal-fin spine length relative to SL, and capture location

(Powell and Tucker 1992). Larvae attain a maximum size of 30 mm SL (average 23.4 mm) by 36 days after presumptive spawning (Shenker et al. 1993).

Settlement & Juvenile Stages

Limited data on recruitment of larvae onto reefs suggest that their onshore transport can rely heavily on cross-shelf winds and currents and occurs in short pulses during highly limited periods each year (Shenker et al. 1993). Recruitment of Nassau grouper larvae occurs at an average of 32 mm TL (Eggleston 1995). After hatching, pelagic larval duration may range from 42-70 days with transformation from pelagic to demersal form occurring in less than one week (Powell and Tucker 1992, Tucker and Woodward 1994).

Newly settled fish (mean = 31.7 mm Total Length (TL), standard deviation (SD) = 2.9, N = 31) near Exuma Cays, Bahamas, were found within coral clumps (*Porites* spp.) covered by masses of macroalgae (primarily the red alga L*aurencia* spp.) (Randall, 1983; Eggleston 1995). Young fish were found in deeper water banks and offshort reefs after emerging from algal habitat at several months of age.

Adults

Although there can be overlap between juvenile and adult habitats there is normally a positive correlation between size and depth. Nassau grouper are diurnal or crepuscular in their movements (Collette and Talbot 1972) and do not usually move far from cover (Starck and Davis 1966).

Nemeth and coworkers (University of the Virgin Islands) found a significant positive relationship between body size and home range for fish tagged in Lameshur Bay, St. John, with mean minimum convex polygon variations from 89.5-9913.9 m^2. Recent studies in a marine reserve in Cuba suggest that relative densities may control movements, changes in location, and, possibly, home range size (Amargós et al. 2010).

Age and Growth and Mortality

Repeated monthly censuses of a presumed cohort indicated that juvenile density decreased sharply after settlement, until fish emerged from algal habitat at several months of age, and thereafter remained relatively constant (Dahlgren 1998). These data suggest low natural mortality after just a few months.

Estimates of natural mortality (M), based on length-frequency data from Nassau grouper taken on unexploited banks in Jamaica, ranged from 0.17 to 0.30 (Thompson and Munro 1978).

The maximum age recorded for Nassau grouper is 29 years, using sagittal otoliths from the Cayman Islands (Bush et al. 1996, 2006) (Fig. 8). Using length-frequency analysis, which tends to exclude younger animals, a theoretical maximum age at 95% asymptotic size is 16 years. Other maximum age estimates include individuals of up to 9 years in the heavily exploited Virgin Islands fishery (Olsen and LaPlace l979), 12 years in northern Cuba, 17 years in southern Cuba (Claro et al. 1990), and 21 years from the Bahamas, assuming, as demonstrated in some locations, that rings are formed annually (Sadovy and Colin 1995). These differences in maximum age estimates are due to the samples available for aging and methodological differences. Individuals of more than 12 years of age are not common in fisheries, with more heavily fished areas yielding much younger fish on average. Generation time (the average age of parents in the population) is estimated as 9-10 years based on average fish size from an unexploited aggregation in Belize, the growth curve from the five Cayman Island spawning aggregations, and the SL-TL conversion curve from Sadovy and Colin (1995).

Age and growth in Nassau grouper has been examined by size-frequency analyses, tagging studies, field observations, and reading annular rings in sagittal otoliths (Bush et al. 2006). Most studies indicate rapid growth, about 10mm/month for small juveniles. Mean monthly growth of Nassau juveniles 30-270 mm TL on artificial and natural reefs in the Virgin Islands was 8.4 to 11.7 mm/month, determined during six visual censuses over 11 months, (Beets and Hixon 1994). Similarly, juveniles sampled at Lee Stocking Island in the Bahamas grew at about 10 mm/month between 32 and 85 mm TL (Eggleston 1995). Near sexual maturity at about 4-7 years, Nassau grouper growth slows to about 2mm/month, with lower rates in larger or sexually mature fish (Bush et al. 2006)

Total mortality (Z), using length frequency data, was estimated at 0.55 in Cuba. With a low natural mortality (M) determined to be 0.18, this indicates a fishing mortality (F) of 0.37 (Baisre and Paez 1981).

Trophic Biology

The Nassau grouper is a top-level predator on coral reefs. Nassau grouper are unspecialized-ambush-suction foragers (Randall 1965, Thompson and Munro 1978) that swallow prey whole (Werner 1974, 1977). Numerous studies describe Nassau grouper as piscivorous as adults (Randall and Brock 1960, Randall 1965, Randall 1967, Parrish 1987, Carter et al. 1994, Eggleston et al. 1998). This species takes many types and sizes of food and moves among different habitats, such as seagrass beds and coral reefs, at different life-history stages or reproductive phases, or while hunting**.** Groupers are unspecialized, bottom-dwelling, solitary predators (Randall and Brock 1960, Randall 1965, 1967)

Behavior

Sullivan and de Garine-Wichatitsky (1994) estimated that individuals moved at least 400 m/day and 20 m or more from their home reefs. Mean home range area was calculated at 18,305m2 +/- 5,806 (SE) (Bolden 2001). Nassau grouper had larger home ranges at less structurally complex reefs and resource availability (habitat and prey) influences home range size more than body size (Bolden 2001). Bolden (2001) investigated diel activity patterns via continuous acoustic telemetry and found Nassau groupers are more active diurnally and less active nocturnally with activity peaks at 1000 and 2000 hours. Also see Reproductive Biology below.

Population structure

There is evidence, based on genetic variation in mitochondrial DNA (mtDNA), microsatellites, and single nucleotide polymorphisms, of genetic differentiation among Nassau grouper subpopulations in the Caribbean region with three potential barriers to larval dispersal (Jackson *et al* . 2014). Genetically isolated regions identified in this study mirror those seen for other invertebrate and fish species in the Caribbean basin. Oceanographic regimes in the Caribbean may largely explain patterns of genetic differentiation among Nassau grouper subpopulations. Regional patterns observed warrant standardization of fisheries management and conservation initiatives among countries within genetically isolated regions (Jackson et al. 2014). Using microsatellites from Nassau groupers from the USVI FSA (which disappeared and is since undergoing recovery) and from the less exploited Cayman Is., Bernard et al. (2015) did not detect any population structuring between the two locations but did find a genetic bottleneck in the USVI FSA, presumably as a result of historical overfishing. In the Bahamas, studies using microsatellites found no marked overall population structuring and high genetic diversity although there was weak significant genetic differentiation across the country (Sherman et al., 2017).

Ecosystem role

Nassau grouper is an apex predator and, as such plays an important functional role on reefs (Bellwood et al., 2004). Information on predation upon groupers is largely lacking, although sharks were reported to attack Nassau groupers at spawning aggregations in the Virgin Islands (Olsen and LaPlace 1979) and there is one report of cannibalism in this species (Silva Lee 1974). No predation was observed on spawning fish in the Bahamas, despite the presence of sharks in the area (Colin 1992). Early post-settlement juvenile preferences for macroalgae rather than seagrass beds are probably related, in part, to higher levels of predation in seagrass beds (Nadeau and Eggleston 1996). Reports of lionfish predation on small reef fish and small life stages are a concern throughout the Caribbean as the invasive spread has widened (Albins and Hixon 2008).

Reproductive Biology

Sexual pattern and spawning mode

Reproduction is only known to occur during annual spawning aggregations, in which dozens to a few thousand (today) to (historically) tens of thousands of fish briefly gather to spawn (Smith 1972, Olsen and LaPlace 1979, Colin et al. 1987, Fine 1990, Fine 1992, Colin 1992; Starr et al., 2007). Many fish travel long distances to arrive at predictable places during the few weeks, spread over several months, usually January and February, each year when spawning occurs and then return to their home reefs (Sadovy and Eklund 1999).

Nassau grouper pass through a juvenile (gonadal) bisexual phase (the gonads consist of both immature spermatogenic and immature ovarian tissue), and mature directly as male or female (Sadovy and Colin 1995). Although the Nassau grouper is capable of changing sex following hormone injection (one Nassau grouper reproduced as a female and subsequently as a male approximately 6 months later, following an LHRH-a implant in captivity (Watanabe et al. 1995b) natural sex change has not been confirmed. The close affinity of this species with other hermaphroditic serranids accounts for the gonad structure of this species and, although it may retain a capacity for natural sex change, available evidence indicates that this is not typical and that the Nassau grouper is functionally gonochoristic (separate sexes) (Sadovy and Colin 1995).

During spawning, Nassau groupers gather in small temporary clusters, within the larger aggregation, comprised of one or possibly several, dark coloured females followed by many bicoloured fish, probably males. The cluster rises up into the water column, releases large clouds of egg and sperm and rapidly returns to the substrate. Spawning occurs during a narrow time window at dusk (Colin 1992). This species exhibits highly synchronized seasonal migrations to specific sites, typically located on outer reef drop offs, where hundreds to tens of thousands of individuals aggregate to spawn (Starr et al. 2007). Migrations by individuals to spawning aggregations can exceed 200 km in one season (Bolden 2000, Dahlgren et al. 2016). Individuals may spend many weeks away from their home reefs during the spawning season, but spend a relatively limited time on the actual spawning site (Dahlgren et al. 2016).

Passive acoustics and acoustic telemetry studying movements of Nassau grouper in protected areas in the USVI and Belize have increased understanding of fish movements during the spawning period revealing that they can go deep between spawning months in Belize (Starr et al., 2007) and that they aggregate outside of the typical spawning period in the USVI (Rowell et al., 2015). Such information is important for fine-tuning the timing and location of protective measures.

Sexual maturation, Sex ratios

Male and female Nassau grouper typically mature between 400 and 450 mm SL (440 and 504 mm TL), with most individuals attaining sexual maturity by about 500 mm SL (557 mm TL) and about 4-5 years of age (Sadovy and Eklund 1999), although the smallest mature fish recorded in Cuba was a male in the 360-390mm TL size class (Claro et al. 1990)

Aquaculture

The Nassau grouper is considered a prime species for aquaculture. In the late 1980s and into the 1990s, considerable progress was made in hatchery spawning and rearing of groupers under aquarium conditions (Tucker 1992, Watanabe et al. 1995, Tucker et al. 1996). Twenty-seven tagged, 31-month old fish (310-380mm TL), which had been raised from eggs in captivity, survived at least 200 days in the field with one fish moving 12 km in eight days (Roberts et al. 1995).

Country-level accounts – Nassau grouper

The Bahamas

The Bahamas is an important country in the distribution of this species due to its extensive shallow platform with large areas of suitable coastal nursery and juvenile and adult coral reef habitat. The most recent overview of this species conservation and management in the country is that of Sherman et al. (2016). The species is, or was, mainly taken on its aggregations between November and March and is the only species with some form of aggregation protection in the country. It has been reported by fishers that there is a slight difference (by one month) in the peak of spawning activity for Nassau grouper in northern parts of The Bahamas compared to more southern areas. However, as enforcement capabilities do not allow inspectors to determine where grouper were caught when landed, a single closed season spanning the entire Bahamas is needed (Gittens 2013). This is one reason why The Bahamian government has attempted combinations of site-specific and country-wide Nassau grouper spawning site closures since 1998. In recent years the entire Nassau fishery was closed during the general peak of spawning (December – February) with areas such as High Cay receiving the further protection of being declared a marine protected area during the same period (loc. cit.).

In terms of weight, Nassau grouper is the 4th most important commercial fishery resource in the Bahamas Exclusive Economic Zone (behind spiny lobster, queen conch, snappers) (Deleveaux 2016). Also reported (loc. cit.) was an additional 20.6 mt of grouper fillets, but the proportion of these that are from Nassau grouper is unknown, despite the 'skin-on' policy. Annual landings of the species were mainly from aggregations between November and February but mainly December and January.

http://www.tribune242.com/news/2015/dec/03/grouper-season-has-now-closed/.

Plate SD1. Dominican fishers fishing illegally in the South Bahamas in 2013 (left) and illegally caught Nassau groupers. Photos: Casuarina McKinney.

After decades of declines, from an annual high of about 500 mt in the late 1990s, 2014 landings of this species totaled 127.4 mt, ranked fifth in value ($USD 1,084,993), and accounted for approximately 1.1% of the country total landings that year . By 2017 only 50 mt were reported for an overall decline of about 10-fold in two decades (Sadovy and Eklund 1999, Ehrhardt and Deleveaux 2007, Cheung et al. 2013, Deleveaux 2016, Sherman et al., 2016; Dept. Fisheries Bahamas & FAO 2016; Lester Gittens, pers. comm.) (Fig. 8). This serious decline in landings and CPUE was not mirrored in other exploited taxa in the country which might indicate a change in fishing effort or market conditions for the species, or does indeed reflect a differential loss in this species compared to other fish species (as was noted for Nassau grouper in Cuba's snapper/grouper fishery, Claro et al. 2009). It is the only reef fish known to be heavily and widely taken on its spawning aggregations in the country and is, or was, reportedly heavily poached in southern and northwestern waters, especially by Dominican fishers (Fig. SD1).

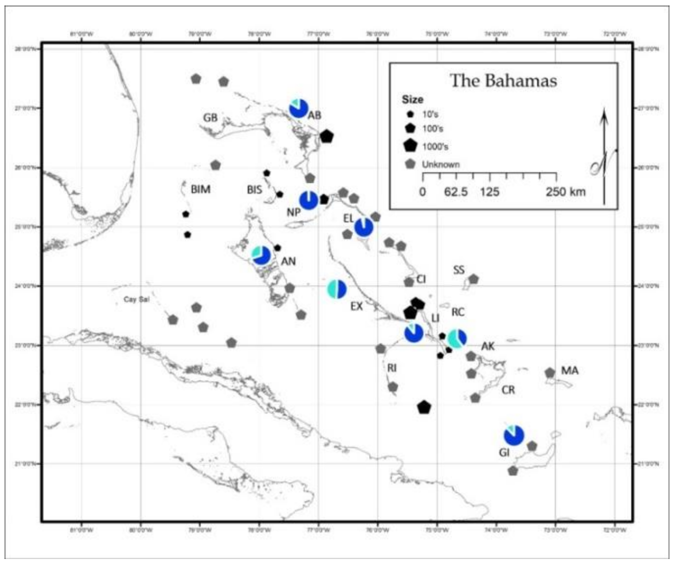

Figure SD1. Sherman. K.D., Dahlgren, C.P., Knowles, L.R. (2018) Nassau Grouper (*Epinephelus striatus*) Conservation Management Plan for The Commonwealth of The Bahamas. Prepared for the Department of Marine Resources, Nassau, Bahamas. With permission

The most comprehensive and updated map of spawning site locations across the country is that of Sherman et al. (Fig. SD1). Buchan (2000) reported fishing from throughout the Great and Little Bahamas Banks, the Cay Sal Bank and Crooked and Acklins Islands. Sullivan-Sealy et al. (2002) noted that in New Providence bank five Nassau grouper spawning aggregation sites are reported, including off High Cay, Andros Island and in the northern Berry Islands, although their current status is not known. At these sites, spearfishing and fish-trapping, in particular, resulted in significantly higher CPUE than other fishing methods (Cheung et al. 2013). Compressor-based spear and gillnet fishing were the primary methods used by the Montagu Ramp fishermen (Cushion and Sullivan-Sealey 2007).

These data do not include the recreational and subsistence use of the species (FAO, 2009), nor do they factor in underreporting (Cheung et al. 2013) thus the estimates provided above are expected to be somewhat lower than actual landings. However, the indicated trend is likely to be real since there is no reason to believe that the relationship between estimated and actual catches has changed markedly over time. Smith and Zeller (2013), in their Bahamas fisheries catch reconstruction, mentioned that removals from the sport fishery alone represented more than half (55% or 490,000 t) of the total catches (all fishes).

There is clearly a strong need to apply a precautionary approach in the managing of The Bahamas' Nassau grouper fishery and, while several measures are in place, more are needed. Currently, several management measures exist to protect all commercially fished species, including the Nassau grouper. These include prohibition of the use of SCUBA gear for commercial fishing, utilization of multispecies and multi-habitat marine protected areas, bag limits for foreign recreational or sports fishers and the limiting of commercial fishing to Bahamians only. All groupers must also be at least 3lbs (1.36 Kg) in order to be landed (Gittens 2013). Necessary measures include strengthening the enforcement on existing closures of spawning aggregation sites, significantly improved monitoring, control and surveillance to address serious illegal fishing problems (Dahlgren et al. 2016), and management of fishing effort during non-spawning seasons.

Additional measures may be needed because seasonal closures were probably enacted too little and too late for the species (Sherman et al., 2016). These authors also recommended an increase from ≥3 lb (≥1.36 kg) to ≥5 lb (≥2.27 kg) minimum size to ensure that the species is allowed to reproduce at least once prior to capture. Although Nassau grouper may attain sexual maturity from ~3 lb (≥480 mm TL), first time migrators in The Bahamas are 540 mm TL or greater (Dahlgren et al. 2016). This differs from observations in the Caribbean, where size at first migration is ≥440 mm TL (e.g. Semmens et al. 2007).

The Bahamas (as also the Cayman Is. and Belize) has run excellent educational and outreach programmes for many years and these have almost certainly resulted in greater acceptance and understanding among the greater public about this species (Plate SD2).

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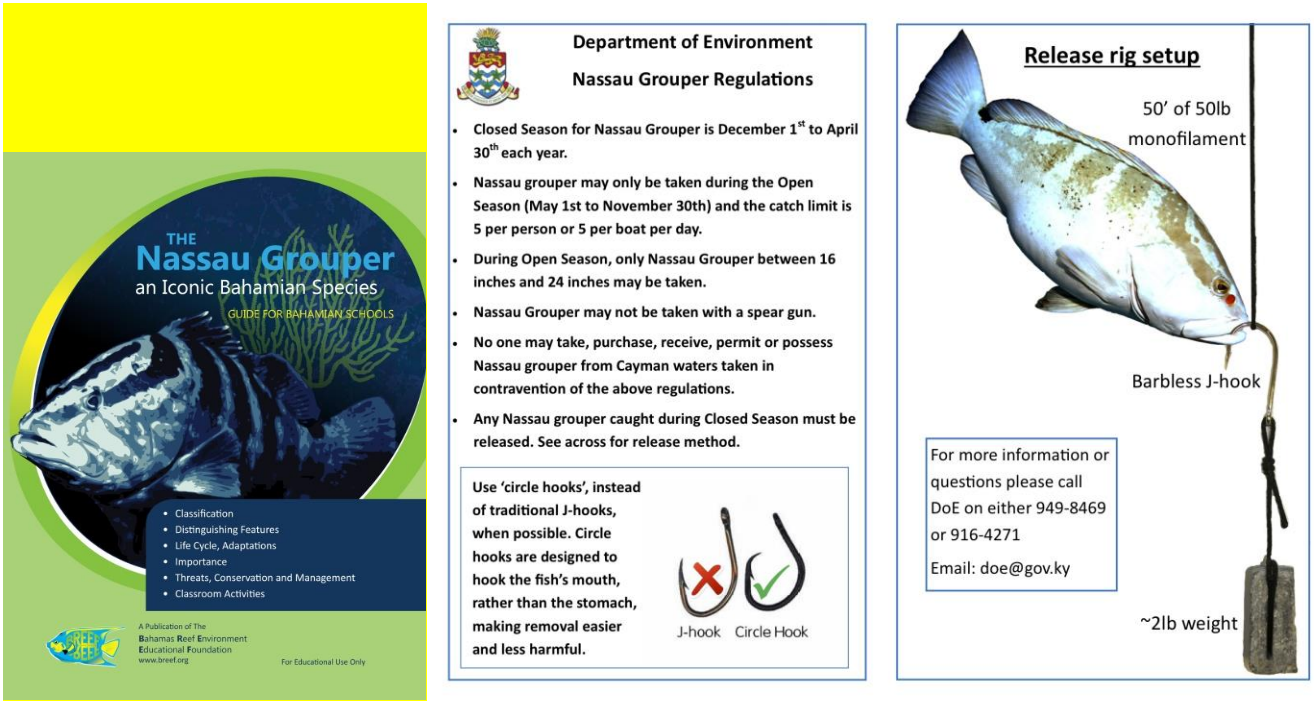

Plate SD2 Education and outreach materials from the Bahamas, Belize and the Cayman Islands.

Failure to stem the decline in populations of Nassau grouper in The Bahamas is likely due to a number of factors including: (1) high market demand and non-compliance with established fishery regulations; (2) inadequate enforcement and ongoing IUU; and (3) limited understanding of reproductive biology, population structure, landings and dynamics to inform fishery regulations. Smith and Zeller (2013), for instance, reconstructed total catches for the Bahamas fisheries from 1950-2010 and concluded that probably a more appropriate estimate would be 2.6 times larger than the officially reported landings. Discrepancies were attributed mostly to unreported catches from the sport and the subsistence fisheries which represent a major impact on species and stocks and are usually not included in national statistics (Thompson 1989). Knowledge of what is actually happening in the fishery is essential for effective management. It is also possible that the invasive red/common Lionfish (*Pterois volitans/miles*), known to prey on early juvenile Nassau grouper since at least 2007, may be affecting population levels (Albins & Hixon 2008, Morris & Akins 2009, Green et al. 2012, Albins 2013, Pusack 2013).

The decrease in Nassau grouper production is of major concern for The Bahamas, given that the annual economic contribution from the fishery sector ranges between US$ 620 thousand and 2.8 million, with an average of US $1.5 million (Cheung et al. 2013). These are conservative estimates because revenue from recreational and tourism-related activities are not included (Rudd & Tupper 2002). These authors highlighted the need for more and better economic valuation studies for Nassau grouper to highlight the socioeconomic benefits of conserving the species for a broad range of stakeholders. Some formerly important sites have been lost entirely, such as Cat Cay (Plate SD3).

Plate SD3. Cat Cay Bahamas 2013 during Nassau grouper aggregation season. Photo. Krista Brown (Erisman et al., 2013).

<u>Belize</u>

The Nassau grouper was once the second most commonly caught fish in Belize (Carter et al. 1994). Although fishing for this species took place year-round, the most intensive fishing occurred for about six weeks during the time of the full moon in December and January on Nassau grouper spawning aggregations (Carter 1986, 1989). Its landings today are a tiny proportion of former volumes, a situation which ultimately led to fishery management, particularly of its spawning aggregation sites (Plate SD4).

Following decades of declines from overfishing, catches were further reduced after 2000 due to the closure of 11 sites (Zepeda et al. 2011; Gongora 2013) all of which were declining, according to various information sources. For instance, Paz and Grimshaw (2001) mentioned that resident fishers at Sandbore Cay claim that 20,000-30,000 Nassau grouper were present at aggregation sites in the mid 1980's, but that by the late 1990s aggregations were much smaller despite no decline in fishing pressure. Similarly, Cay Glory had been fished since the 1920s and provided a catch rate of up to 1,200-1,800 Nassau groupers per boat per spawning season during the 1960s (Craig 1969). However, by 2001, fishers caught only 9 Nassau groupers out of an aggregation of 21 groupers at the same site (Paz & Grimshaw 2001). A survey in January 2001 showed that only 2 out of the 9 traditional spawning sites had more than 150 Nassau groupers; the rest of the sites have now been fished out (Heyman 2001, Paz & Grimshaw 2001). At Glover's Reef the Nassau grouper aggregation was estimated to harbour around 15,000 individuals in 1975, declining by 80% to less than 3,100 groupers by 1999-2000 (Sala y Ballesteros 2001) and to about a thousand in 2011 and 2012. In Dog Flea Caye 300-400 fish of 30-60 cm TL were removed in just one week in January of 2000 by three to six (Paz and Grimshaw 2001). Also noteworthy is that, even in the the early 1990s, a comparison of sizes in an unexploited versus and exploited aggregation showed clear differences with smaller average sizes of both males and females in the latter.

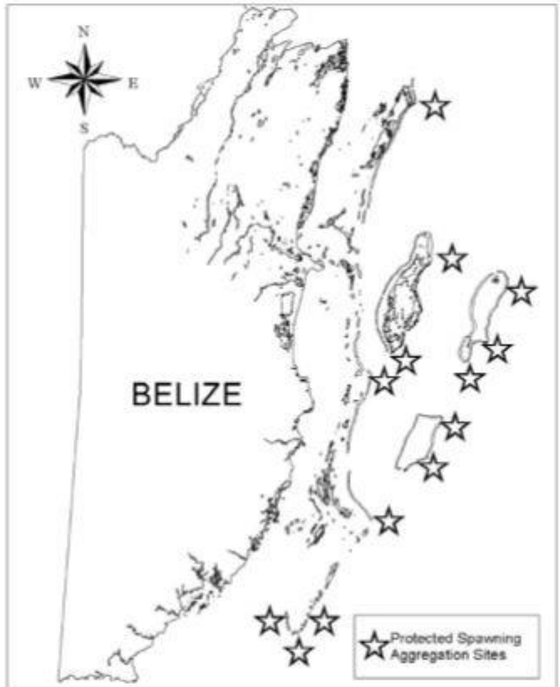

Figure SD2 Map showing location of the 13 protected spawning aggregation sites in Belize: 11 sites declared in 2002 as marine reserves specially for the protection of the spawning sites and two sites encompassed by fully-protected zones within previously-declared marine protected areas (Gibson et al., 2007).

Fishers noted that out of 12 known spawning aggregation sites, 3 are now extinct, 2 have little more than 500 individuals, another 2 sites have fewer than 50 individuals, and the last 5 sites are of undetermined status. Since Nassau groupers were protected many years ago in Belize fishermen have been reluctant to report catching them or being in possession of them and fish are often filleted to avoid detection (Brian Luckhurst, pers. comm. Sept. 2012). This has made landings or catch trends difficult to follow although the ongoing underwater visual census surveys at several sites provide an important indication of patterns over time (see below). Thirteen sites have now been protected (Figure SD2).

Although Belizean fishermen believe that natural populations can decline for reasons other than localized fishing pressure, considering that level of fishing has remained low for over a decade now, they could not identify those reasons. One major issue appears to be illegal fishing in the south of the country by Honduran and Guatamalen vessels (Hakai magazine, 2017). In the last 3 years, very few fishers have been caught violating the fisheries regulation and these were arrested by fisheries enforcement personnel and were charged and fined in a Magistrate Court (Gongora 2013).

Declines overall in Belize have been serious. In the 1960s, reports indicate that 90 mt per spawning season were produced, with up to 2 mt / day from just one aggregation site. Production declined to around 75 mt by 1975 but the species was still very important in 1994, when Glover's Reef produced 24 mt (Paz and Truly 2007, Bannerot et al.1987, Luckhurst 1996, Paz & Grimshaw 2001). Loopholes in protection which allowed for exceptions to the fishing (both seasonal and spatial) ban during the reproductive season undermined the protective efforts until all sites were protected during the aggregation season (Gibson 2007, Burns and Tewfik 2016).

Very possibly as a result of a range of national conservation measures introduced since 2002 there are now anecdotal reports of increases in Nassau grouper catches. Consistent with these indications the Belize National Spawning Aggregation Working Group reported in 2009 that numbers of Nassau grouper at Sandbore had increased, and very encouragingly, the maximum count at Emily was 3,000 groupers, the highest number recorded over the seven-year period of the surveys. However, researchers recognized that these numbers are still much lower than those recorded historically at the site, and cannot yet be viewed as a sign of success, as such low populations tend to show fluctuations from year to year (Belizean Spawning Aggregation Working Group 2009). Underwater surveys at 3 of the regularly monitored sites (Gladden Spit, Mauger Caye, Sandbore and in the 2012-2013 season revealed counts of only 200 to 1200 fish (Gongora 2013).

The Belize National Spawning Aggregation Working Group (http://www.spagbelize.org) was created in July 2001 and has played an important role in the management and monitoring of the Nassau groupers spawning aggregation sites. It was established in response to a nation-wide survey of spawning aggregations of the Nassau grouper in early 2001 that revealed very low numbers of spawning fish. After 2003, the Working Group was revitalized and has been meeting regularly on a quarterly basis to share data and develop management strategies, develop outreach materials, etc. It has been key to making progress with managing this species in the country (Gibson 2007, Gibson et al., 2007, Heyman 2011, Gongora 2013)

Plate SD4 Nassau grouper in a spawning aggregation in Belize. A bi-colour individual ripe with swollen belly (left) and aggregation fish (right). Photo: Enric Sala

British Virgin Islands

Little information is available on Nassau grouper in the British Virgin Islands although anecdotal accounts suggest that considerable landings still occur, although not from aggregations. Cumulative data from REEF (2003-2013) show sightings of 107 Nassau grouper in 2003 surveys (density index 1.2, sighting frequency 5.3%) across the 10-year period (http://www.reef.org/db/reports/dist/species/TWA/0097/2003-01-01/2013-04-07).

In the mid-1990s, large Nassau grouper were still being caught east of Pajaros Point, Virgin Gorda, but these were incidental and not targeted catches (Munro and Blok 2005). More recently, fishers report that medium-sized Nassau grouper are still quite common but that aggregations are no longer actively targeted. Only a few Nassau grouper were reported as landed at the BVI Fisheries Complex during the winter months of 2003 (Munro and Blok 2005). Based on the findings of a survey conducted in January to February 2003, Munro and Blok (2005) found no evidence of any spawning aggregation from a previously reported site on the Saba shelf. Fishers interviewed claimed that they could catch 20-40 Nassau groupers per day at the site 15-20 years ago. There is a closed season for Nassau grouper between March 1 and May 31 (Munro and Blok 2005).

Cayman Islands

In the Cayman Islands, historical fishing at the five known aggregation sites (Fig. 13) produced thousands of Nassau grouper annually and included the sale of catch to Jamaican vessels in the 1970's (Whaylen et al. 2004). In 1985, recognizing the importance of these three spawning areas, a general license was issued under the Restricted Marine Areas (Designation) Regulations allowing access by residents, but restricting them to fishing by hook-and-line only. In 1986, increasing complaints from fishermen of a decline in both numbers and size of fish taken from the fishery during the last several years, prompted the implementation of a monitoring program by the Department of the Environment (Bush 2013).

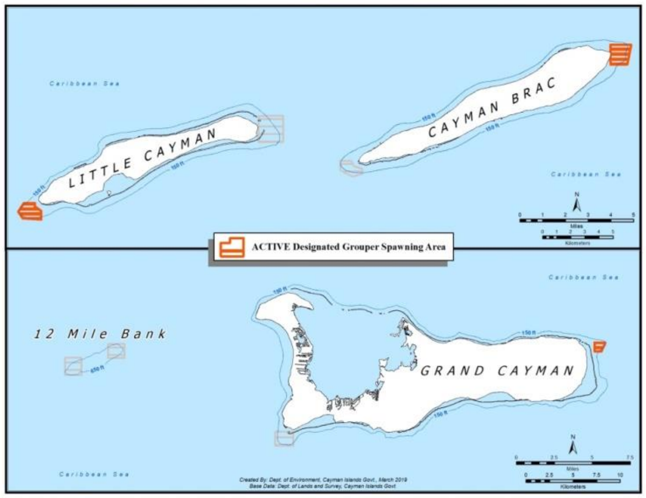

Figure SD3 Active designated protected spawning aggregation areas in the Cayman Is. With permission.

A landing monitoring program (1987-2001) from 3 main historical spawning aggregation sites showed declining trends in catch, size, and CPUE (Phillippe Bush, Secretary of the Marine Conservation Board, pers. comm., spawning aggregation workshop 2017) (Fig. SD3). In 2001 & 2002, approximately 4000 fish were taken from a newly discovered spawning aggregation site at the west end of Little Cayman, essentially having a pre-fishing aggregation estimated at 7000-8000 individuals. A series of management measures have been put in place, based on a comprehensive series of research studies over almost two decades (e.g. Heppell et al. 2012, Semmens at al. 2012, Shouse et al. 2018).

Bush et al. (2006) reported the following chronology of fishing activity on Nassau grouper in the Cayman Islands:

a) Between 1984 and 1990, the Cayman Brac site was dormant and the fishing fleet of Cayman Brac targeted the northeast spawning aggregation of Little Cayman (the two islands are five nautical miles apart). In 1991, an aggregation was found approximately 1.2 km north of the dormant Cayman Brac site, and has since been heavily fished.
b) By 1993, the Little Cayman site was inactive. Continued monitoring through 2001 showed continuing declines in both catch and size of fish from the aggregations of Grand Cayman and Cayman Brac. Of the two other aggregations, located near Grand Cayman, one (Southwest site) was fished until 1990, after which it no longer formed, and the other (Twelve-Mile Bank) still yields a variable, albeit low, number of fish.
c) In 2001, another aggregation which (according to anecdotal reports) had not been fished since the late 1960s, was 're-discovered' at the western end of Little Cayman, and heavily fished during the 2001 and 2002 spawning season. Approximately 4,000 fish were taken from this aggregation during 20 days of fishing (Whaylen et al

2004). Pre-fishing abundance for this aggregation is estimated at over 7,000 fish. This aggregation is believed to be the last healthy spawning aggregation of Nassau groupers in the Cayman Islands.

Regarding data collection, from 1987 through 1992, data on catch, catch-per-unit- effort, and size, were collected during spawning season from the three main spawning sites. Age data were obtained by analyzing sagittal otoliths taken from 479 fish, and the aging technique was validated in 1992 by use of captive fish injected with oxytetracycline (Bush et al 1996). Sampling of catch and size data from the three main aggregations continued through 2001 (Bush 2013).

Catch, CPUE, and size from these three spawning aggregations have declined over the 15 year period. Catch from Grand Cayman and Little Cayman during the early years of the monitoring period was in the low hundreds and has since dwindled. In Cayman Brac, while catch was in the low thousands during the initial years following the re-discovery of the spawning aggregation, it too has declined drastically in the last six years. Catch-per-unit-effort and size for all three islands show similar marked trends. The Little Cayman site was abandoned in 1993 when the aggregation ceased to form (Bush 2013) (https://www.reef.org/programs/grouper-moon-project-protecting-caribbean-icon)

This species may still be relatively abundant in the Cayman Islands compared to many other locations (Patengill-Semmens & Semmens 2003) because of management measures successfully undertaken over almost 2 decades. The fishery was once considered to be on the brink of collapse and as a result there was introduction of fishery regulations and protection of spawning aggregations. The aggregation sites have been protected for almost 15 years, and species abundance is showing promising signs of recovery in at least one aggregation site (Semmens et al. 2007, Heppell et al. 2012). Numbers have recently increased in at least two sites and in 2016 the Cayman Islands government enacted a comprehensive set of regulations aimed at recovering Nassau Grouper (https://www.reef.org/news/press-releases/cayman-islands-enacts-sweeping-science-based-reforms-nassau-grouper-fishery). The regulations and include:

- All take, possession, or sale of Nassau Grouper is prohibited from December through April, inclusive (during the spawning months for the species)
- When take is permitted (May – November), only fish between 16"-24" can be kept and no more than 5 Nassau Grouper per fishing vessel per day can be kept
- Nassau Grouper may not be taken on spear gun

The Cayman Islands now have a total of 8 designated grouper spawning areas covering an area of 17.56 square kilometers. Of the six known historical Nassau grouper spawning aggregations sites in the Cayman Islands, three are fished-out, two are in serious decline, and one, though affected by two years of heavy fishing, still relatively healthy. Despite the current ban on fishing local aggregations, our goal is to convince residents that this practice is unsustainable in any measure, and should permanently cease (Bush 2103). Nassau grouper stocks in the Cayman Islands have demonstrated some degree of resilience under fishing pressure, perhaps due to the cumulative effects of inclement weather during the aggregation seasons, relatively low artisanal fishing pressure, good public outreach, and a possible shifting of aggregation sites that remain unfished (Whaylen et al., 2007), as well as protection and regular on-site presence of researchers that could discourage illegal fishing. This is an excellent and very encouraging example that recovery can begin to occur with the right measures effectively in place and a good foundation of science. However, given the challenges of management it may be that these aggregations are better protected on a permanent basis to act as seeds to the fishery at other times of the year.

Cuba

The Cuban Nassau grouper fishery collapsed in the 1970s-1980s but once accounted for approximately 35–50% of the national captures in coastal fisheries (Fig. 9). Historically, most were taken in the Archipelago Sabana-

Camagüey region of north-central Cuba) area although up until 1969, an important proportion of this catch was also obtained from the Bahamas shelf. Fishing pressure on the Nassau grouper increased notably after 1959, reaching 1,700 mt annually in 1963 and since then landings declined sharply suggesting that it is more vulnerable to fishing, or more heavily targeted, than other reef fish species, almost certainly due to heavy targeting of spawning aggregations which continue to account for the great majority of its much lower annual landings (Claro et al. 2009, Sadovy de Mitcheson et al. 2008).

According to landings data provided by the Laboratorio de Investigaciones Pesqueras (LIP), the "cherna criolla" produced a total of 29.2 mt in 2011, and this production was reduced to only 7.7 mt in 2016 and 11.9 in 2017 in Cuba (Courtesy of Servando Valle, August 2018: 2012=24.8 mt; 2013=11.1 mt; 2014=21.8 mt; 2015=16.9). These declines in landings represent a drop from the 1963 peak to 2017 of almost 150 times. There were once many spawning site locations known (Fig. SD4).

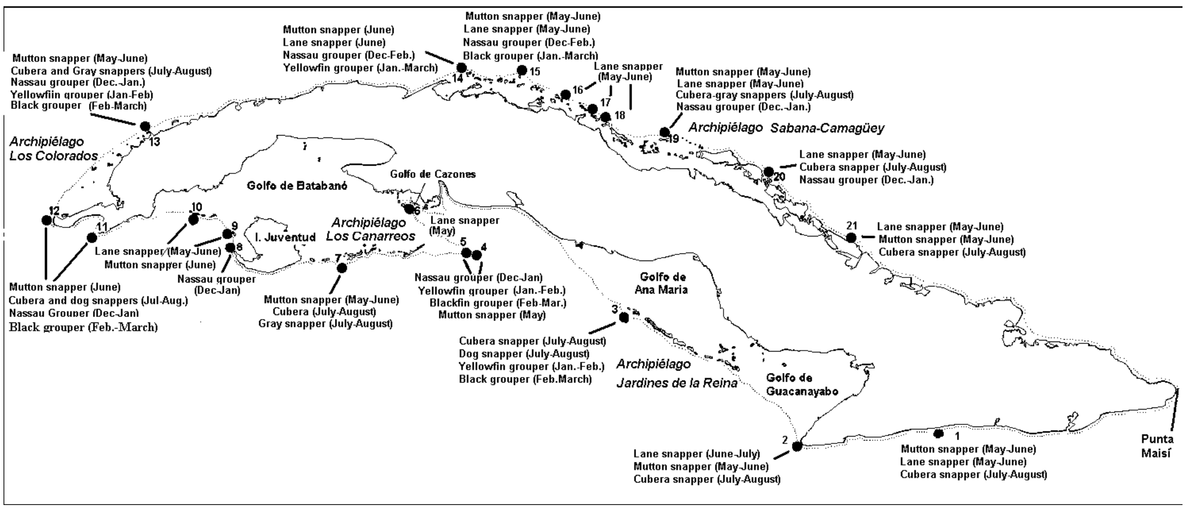

Figure SD4 Approximate locations of spawning aggregations areas of Nassau grouper and mutton snapper, as well as other groupers and snappers in coastal waters of Cuba – status indicates that known prior to 2003. Little information is available on their status today (modified from Claro and Lindeman, 2003).

<u>Colombia</u>

In Colombia, a maximum of 120 mt of Nassau grouper was captured in the early 1990s, but since the early 2000s we have not been able to locate any landings data but past abundances have not been seen in a decade (Prada et al. 2004). Interestingly, no large spawning aggregations have ever been reported for this species off the Colombian coast (Hooker et al. 2010, Sadovy de Mitcheson et al. 2012).

<u>Dominican Republic</u>

The current status of Nassau grouper is largely unknown although indications are that the species has been largely depleted from local reefs (J. Mateo, Consejo Dominicano de Pesca y Acuicultura, Edif. Secretaría de Agricultura, pers. comm. to R. Hill, NMFS, 2012). Reports suggest that large fish can still be seen in the fish markets on the north coast (J. Mateo, Consejo Dominicano de Pesca y Acuicultura, Edif. Secretaría de Agricultura, pers. comm. to R. Hill, NMFS, 2012) although the locations from which those catches derive are unknown. Illegal fishing by Dominican vessels in Bahamas waters for this species has been reported (Plate 1). Cumulative data from REEF (2003-2013) show sightings of only 4 Nassau grouper in 116 surveys (density index 1.3, sighting frequency 3.4%) across the 10-year period. All sighting in these samples (n=84, 4 Nassau grouper/ density index: 1.3, sighting frequency: 4.8%) were from Manzanillo Bay to Cabo Engano on the north coast (http://www.reef.org/db/reports/dist/species/TWA/0097/2003-01-01/2013-04-07). Data from Sadovy (1997) indicated one known spawning aggregation from Punta Rusia although status was listed at the time, as "probably disappeared." Underwater coral reef visual censuses in the Dominican Republic produced no records of Nassau grouper (Schmitt and Sullivan 1994).

Honduras

Significant declines in landings began in the 1960s. Fine (1990) documented uncontrolled fishing of Nassau grouper spawning aggregations in the early 1990s and reported that, at one site close to Guanaja, local and foreign vessels reduced the aggregations from approximately 10,000 fish to less than 500 over just 2 years; fishers removed from there approximately 13.64 mt per season (Fine 1990, 1992). Other aggregations probably occurred in the area historically, but have since declined, according to anecdotal fisher accounts (Box & Bonilla, 2008). Zepeda et al. (2011) reported that declines were believed to be in response to intense fishing pressure during the reproductive season at aggregation sites. Other possible factors in catch declines were shifts to more valuable species (spiny lobster, queen conch) and the moratorium on the Nassau grouper imposed by the USA.

This species evidently collapsed in 2004 (Funnes et al. 2015) and thus at present it is not a target for most commercial fishing boats although remains important for some communities (e.g. fishermen from the north coast of Utila Island) for which the species comprises approximately 25% of their landings during the reproductive season. It is likely that Hondurans fish illegally at night in nearby Belizean banks, particularly during February (Zepeda et al. 2011). Although once valuable and even exported (Box and Canty 2010; Zepeda et al., 2011), the Nassau grouper is nowadays only considered to be an important source of income for several communities living in the Islas de la Bahia (Guanaja, Utila, Roatan). These artesanal fishermen utilize 4 - 6 traps per deployed on aggregation sites, 30-45 m in depth, over 3-4 days after and before the full and new moons. It is estimated that a total of about 150-200 traps are set during the entire reproductive season from December to March (Zepeda et al. 2011). Due to bad weather conditions present in the Caribbean in those months, however, fishermen can sometimes be prevented from deploying or collecting their traps for long periods of time.

Despite the commercial importance of the finfish fisheries and the emergence of new export markets no management strategies have been established for this sector in Honduras (Box & Canty 2010). Zepeda et al. (2011) reported that the Nassau fishery in Honduras has still not recovered from the intense fishing pressure of the past.

Jamaica

The Nassau grouper has largely disappeared from Jamaican fishery catches. Even by the 1970s there were concerns about the predominantly small, mostly juvenile, sizes being taken in the fishery compared to unexploited areas. When asked about present conditions, K. Aiken (University of West Indies, pers. comm. to R. Hill, NMFS, 2012) stated that while Nassau grouper were occasional in the 1970s, they are now rare. "I haven't seen one since 2011, and only at one location at the extreme east of Jamaica."

Lesser Antilles

In the Lesser Antilles, Nassau grouper was reported to be very scarce, such as in St. Eustatius (Munro & Blok, 2005). On the Antigua-Barbuda bank, according to findings of a survey conducted in January and February 2003, Munro & Blok (2005) reported that around 102 mt of finfish were landed in 2002, of which the grouper proportion accounted for approximately 6 mt. He also mentioned that several grouper aggregations were fished from 1960 to the 1980, when these became a target in several small banks of Jost Van Dyke to Anegada and on the seamount south of Virgin Gorda. Since then, large groupers were no longer targeted in the British Virgin Islands. Very little is known about the fishing for Nassau grouper in other islands of the Lesser Antilles.

Mexico

In Mexico, at least seven aggregation sites have been fished along the Yucatan Peninsula since the beginning of the 20th century (1910-1920) (Aguilar-Perera 1994). In the Mexican Caribbean, knowledge on the existence of FSAs came from native fishers in the 1950s with the Nassau grouper as the most important fish. The first scientific documentation of an FSA in Mexico was that of the Nassau grouper off Mahahual, in the southern coast of the Mexican Caribbean; native fishers helped to document the history of this aggregation that was internationally traded (Aguilar-Perera 1994; Aguilar-Perera 2013).

Despite data paucity, the Nassau grouper fishery in Mexico was probably once very important for several local communities. Sosa-Cordero et al. (2009) reported that the areas of Punta Iná and Xpuhá, located south of Playa del Carmen 30-35 years ago sustained highly productive fisheries that took fish from spawning aggregations of cherna (*E. striatus*), abadejo-negrillo (*M. bonaci*) and cabrilla-Payaso (*E. guttatus*). Initially, the catches were made only with hook and line, but after Cozumel divers introduced SCUBA and harpoon diving to achieve higher catches there was a marked decline in fish. Several authors considered these changes to be a key factor in the decline and later disappearance of the reproductive aggregation (Miller 1982; Castro-Pérez et al., 2011). Similarly, the production of "cherna" in Majahual, estimated at about 24 mt in the 1950s, declined to a mere 3 mt by 1990 (Aguilar-Perera 2006). Landings from the Alacranes reef are believed to have been about 42.2 mt in 1982 declining to 30.7 by 1987 (Colas-Marrufo et al. 2002).

In general, the average grouper (all grouper combined and mainly Red grouper, *E. morio*) catch in Mexico was 11,243 tons per year (2006 to 2011); of which the Gulf of Mexico and the Caribbean Sea contribute between 90% and 95% of the total catch (SAGARPA 2011) with an economic income of $Mex 334 million (approximately $US 17.4 million). The state of Yucatán contributes 85% of the total catch of the Gulf of Mexico and 77% nationally (SAGARPA, 2011). However, the proportion of Nassau grouper is not known.

For most other species, however, the stock status or condition of fish aggregations in the southern Gulf of Mexico and Mexican Caribbean remains elusive for fisheries managers and government entities due to a lack of studies; thus little is known on their fishery status (Aguilar-Perera and Tuz Sulub 2012). There is an urgent need to determine the exploitation levels and economic value these aggregations to propose a special protection condition preventing further exploitation of these aggregations. However, some counts of Nassau groupers at aggregations have been made over several decades (cited in Aguilar-Perera 2013) although current status of most is unknown; Alacranes reef (3,000 fish), Bajos del Norte (5,000 fish), Mahahual (1,000 but now disappeared); Niche-jabin (800 fish).

Management in Mexico for Nassau grouper does not seem to have been effective, or its effectiveness is not known. A Nassau grouper spawning site was closed to fishing, but fishers placed gillnets across the reef around the spawning site to catch pre-spawning groupers that were moving towards the aggregation near Mahahual, southern coast of Quintana Roo(Aguilar-Perera & Aguilar Davila 1996). There has been a one-month ban on grouper fishing in Mexico since 2005 The only strict regulation for fishing groupers is an annual one-month ban (February 15 to March 15) established in 2005 for all (17) grouper species in the southern Gulf of Mexico and Mexican Caribbean but focused on the red grouper (Aguilar-Perera 2013). Also, a normative regulation (NOM-065-PESC-2007) established in 2010 provides complementary criteria to regulate the grouper fishing. None of these latter legal instruments consider the existence or the importance of spawning aggregations (loc. cit.). In 2014, this ban was extended to two months (Aguilar-Perera 2016). In the Mexican Caribbean, several important spawning sites are located within MPAs (e.g., Xcalak Reef National Park and Sian Ka'an Biosphere Reserve; Medina Quej *et al.* 2004, Fulton *et al*. 2016). Under the "Refugios Pesqueros" (Fishery Refuges) initiative, the Mexican fishing authority (CONAPESCA) also designated several no-take areas based on the request of fishing organizations with civil support (Diario Oficial de la Federación 2012). Management and monitoring are needed for the Nassau grouper (Aguilar-Perera 2013).

Nicaragua

According to the Instituto Nacional de Pesca de Nicaragua that publishes online annual fisheries statistics (http://www.inpesca.gob.ni/index.php?option=com_content&view=article&id=18&Itemid=100) grouper/*mero* (all groupers) annual landings from the Caribbean Sea progressively increased from 18 mt in 1992 to 324 mt in 2006, accounting for approximately 10% of total finfish production. Over the last decade or so grouper landings declined to about 104 mt in 2015, recently representing only 3.8% of total finfish production. The proportion of Nassau grouper in these landings is not known (Barnuty Navarro 2013), but the combined grouper/*mero* category accounted for 78 and 86% of the landings from November to April in 2000 and 2005 respectively. In addition, national annual reports indicated that while from 1992 -1997 catches were 100% artisanal, this situation shifted thereafter with the introduction of industrial boats from 1998 to 2006 (artisanal production 41-59%). After this time the grouper/*mero* production reverted to becoming artisanal activity again (80%), because the industrial fleet focused mainly on spiny lobsters and queen conch.

Very little appears to be known about the Nassau grouper and it is not managed at the species level except for a minimum size measure of 45 cm TL (Barnuty Navarro 2013).

Puerto Rico

In Puerto Rico, grouper landings in general were estimated at around 193.2 mt in 1971 (Julh & Suarez-Caabro 1972), declining to 42.5 mt in 1988 (Matos & Sadovy 1990), and then peaking in 2002 with total landings of 90.6 mt (Matos-Caraballo 2005). Since then, grouper production in Puerto Rico has decreased to 17 mt in 2011 (Matos-Caraballo 2012). In particular, Nassau grouper landings in state waters totaled 0.9 mt in 1988 (Matos-Caraballo 1990), reached its maximum of 8.5 mt in 2002, accounting for 9.4% of the total grouper landings (Matos-Caraballo 2005), and then significantly decline thereafter to only 0.1 mt (0.7% of the grouper landings) by 2011 (Matos-Caraballo 2012).

Indicated reductions may be due to several factors in addition to real declines in Nassau grouper around Puerto Rico. A moratorium on fishing for the species (both state and federal waters) was introduced in 2002. Also, due to species terminology, reports on the landings of this species, mainly from state waters, could be confused with another grouper. In some areas of Puerto Rico the Nassau is referred to as “mero cherna” which is also used in other areas for the red hind (*Epinephelus guttatus*). In addition, the Puerto Rico Fishing Regulations were published in 1998 and only went into full force in 2002, which may also account for declines in catches corresponding to enforcement of federal and local regulations.

Current fishery-dependent data available for these species is unsuitable for trends analyses. Difficulties associated with inconsistent data collection methods, lack of species-specific landings, misreporting from commercial fisheries and little or no information from the recreational sector make population evaluations problematic. The fishery-dependent recreational fishery data available is limited and contains high uncertainty due to the rarity of many of these species (Schärer-Umpierre, 2013)

Turks and Caicos Islands

Nassau grouper in the Turks and Caicos Islands is not subjected to significant commercial fishing pressure, as far as is known, and is considered to be in healthy condition with relatively high densities in some areas. Tupper (2002) and Tupper & Rudd (2002) reported densities in the range of 0.45 to 0.9 individuals per 100 square metres, higher on deeper reefs and with no difference in fish length by depth (Tupper 2002, Tupper & Rudd 2002, Rudd 2003, Rudd 2004). Chiappone et al. (2000) reported a density of 0.35-0.62 Nassau grouper per 100 square metres at South Caicos sites. These figures compare favourably against 0.01 per 100 square metres in the nearby depleted Florida area and 0.16-0.20 per 100 square metres in the Bahamas during non-spawning times. The Nassau grouper is recognized for its economic importance for dive tourism in the country where encounters with such large groupers are very appealing to divers (Rudd & Tupper 2002).

During two weeks dockside monitoring (Apr 11-28, 2008), Landsman et al. (2008) reported that substantial numbers of sexually mature Nassau grouper are harvested, but there is still cause for concern that juveniles are harvested at a rate that may eventually be unsustainable. In their work, CPUE for Nassau grouper was 0.44 fish/fisherman/hour and 2.18 kg/fisherman/hour, with spear gun being the most utilized fishing gear. They concluded that concentration of fishing effort in specific locations results in shifting fishing pressure, combined with both increasing demand from tourism and the unique biological aspects of the Nassau grouper, necessitates prompt managerial action.

United States

Fishery dependent data from the U.S. showed marked declines and severe fluctuations in catch rates through the 1980's until a ban on capture of Nassau grouper was enacted in 1990 (National Marine Fisheries Service Database). The Nassau grouper fishery in Florida suggested once healthy sub-population(s) in southeastern US mainland waters (Sadovy & Eklund, 1999). However, the population off the southeastern coast of the United States was listed as threatened under Endangered Species act (https://www.fisheries.noaa.gov/topic/laws-policies#endangered-species-act); threatened species are those likely to become endangered in the foreseeable future unless action is taken. The American Fisheries Society determined that the species still occupies its historical range, although overutilization through historical harvest has reduced the number of individuals, which were once abundant (Springer and McErlean, 1962; Sadovy and Eklund 1999).

Despite being legally protected from harvest in U.S. waters for more than a quarter of a century, Nassau grouper is a slow-growing species that has lost more than half of its known fishing aggregations throughout the Caribbean to overfishing. Although the National Marine Fisheries Service concluded that the Nassau grouper is not currently in danger of extinction throughout all or a significant portion of its range, it is likely to become so within the foreseeable future (Federal Registry June 29 2016) (https://www.federalregister.gov/documents/2016/06/29/2016-15101/endangered-and-threatened-wildlife-and-plants-final-listing-determination-on-the-proposal-to-list).

Consistent with the fishery-dependent data, fishery-independent surveys over the last decade indicate the presence of very low numbers, only a few hundred fish at sites in the Florida Keys (Alejandro Acosta, Florida Fish & Wildlife Conservation Commission, pers. comm. 2012).

U. S. Virgin Islands

In the US Virgin Islands, the Nassau grouper fishery was considered heavily exploited from the 1960's through the 1980s. Munro and Blok (2005) reported that aggregations on the Barracouta Bank, north of St. Thomas, were fished to extinction by the late 1970s, while the site produced around 2.3 mt/day in its peak (Kadison et al. 2010). Following the collapse of the Nassau grouper fishery in the USVI in the late 1970s (Olsen and La Place 1979), there was no known significant spawning aggregation for this species on the shelf south of St. Thomas or St. John. However, local fishermen claim that the bank is not a historical location for spawning, but rather the Nassau used the area approximately 4 km to the west exclusively, that was fished out by 1980. It is hypothesized that the Nassau grouper now utilizing the Grammanik Bank are a small sub-population of that original spawning group (Kadison et al. 2010). On St. Croix, where no Nassau grouper aggregation is believed to exist, only limited numbers of adult or juvenile Nassau groupers have been observed in underwater surveys (Kadison et al. 2010, Hill & Sadovy de Mitcheson 2013).

Despite over 10-years of no-take protection for the Nassau grouper, this species has made no appreciable recovery in either of the known spawning aggregation locations while its numbers remain extremely low (Semmens et al. 2007, Kadison et al. 2017). Understanding the status of spawning aggregations is critical to their management. In the USVI, nearly all of the species that form transient spawning aggregations are either declining or have insufficient information to evaluate their status, even though management regulations have been in place for 5 to 10 years. These regulations include 3 US federal marine protected areas, 3 federal and local seasonal area closures and 3 areas with limited protection (Rick Nemeth, pers. comm. 2013).

SOURCE DOCUMENT

10.2 Mutton snapper

Taxonomy and Distinctive Characteristics

Mutton snapper are one of approximately 20 species in the western Atlantic in the family Lutjanidae. Globally, the family includes approximately 125 species in 20 genera within five subfamilies worldwide. Three subfamilies are represented in the region: Lutjaninae (*Lutjanus*, *Ocyurus*, and *Rhomboplites*), Etelinae (*Etelis* and *Pristipomoides*), and Apsilinae (*Apsilus*).

Mutton snapper is most commonly confused with lane snapper (*Lutjanus synagris*) in younger life stages but can be discriminated by possession of 14 dorsal rays and oblique lateral yellow stripes. Adults can be confused with other reddish snappers from deep water, but the presence of a small dorsolateral spot, fin meristic counts, and other characters aid identification (Anderson, 2003).

Geographic Distribution

Geographic Range

This species is distributed across much of the North and South American shores of the western Atlantic. The adult range is from Cape Hatteras, North Carolina south along the U.S. coast, the Bahamas, the Gulf of Mexico from the Florida Keys north to Tampa, the Mississippi Delta region and from Texas (Corpus Christi) south along Mexico to Cuba, throughout the Caribbean Sea, and along South America to Santa Catarina, Brazil (Cervigón 1993, Anderson, 2003). Its depth range is 1-95 m (Thompson and Munro 1974, Allen 1985), and may be deeper. This geographic region includes approximately 40 countries and at least eight international fishery management organizations, see Conservation Status below.

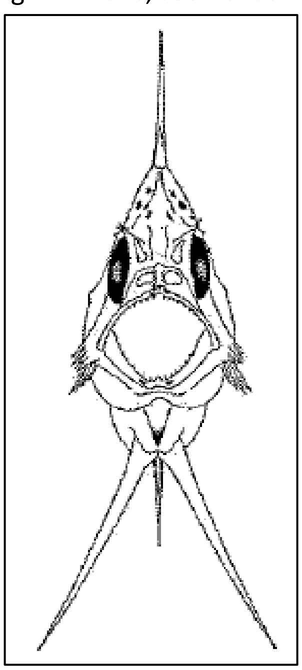

Figure SD5. Frontal view, 8.3 mm larva. Lindeman et al., 2006.

Habitat and Depth Range

The species occurs from low salinity habitats to the outer shelf, 0-100 m at least. A variety of seagrass, mangrove, patch reef and shelf-edge coral habitats can be used according to different stages of sexual maturation. More information is collated below by life stage.

Biology & Ecology

Early Life History

Eggs and Larvae

Published larval descriptions are available for *L. analis* (Clarke et al. 1997; Llanes et al, 2013) and at least six other species of W. Atlantic lutjanids (Lindeman et al. 2006). Eggs of laboratory-reared specimens had a single oil globule at the anterior end of yolksac larvae (Clarke et al, 1997). The oil globule diameter was 0.13-0.22 mm; hatch size was 2.2-2.5 mm. Developing larvae showed preopercle spines by 3 mm, 2-4 at first with 5-8 spines present by flexion (Figure SD5). Length at flexion ranged from 4.4-6.0 mm. Fins develop as follows: D1, P2, C, A, D2, P1 (based on appearance of fin elements). There were 16-17(13-23) melanophores along the ventral tail midline with enlarged melanophores.

Larval *Lutjanus* abundances offshore have been reported as generally low relative to other species (Rojas, 1970, Powles, 1977, Richards 1984.). Species-level biological studies of larval attributes including predation were identified by D'Alessandro et al. (2010) and D'Alessandro et al (2013)

Settlement & Juvenile Stages
Based on smallest specimens, settlement sizes are from 10-15 mm SL (Starck, 1970; Lindeman et al., 2000) Post-larvae begin the settling process to the shelf between 11 and 18 mm length and have been estimated to have a larval period of 31 days based on otolith increment counts from 7 specimens (27-37 days range).

Early juvenile pigmentation emerges rapidly and from approximately 20-50 mm SL includes at least five green/brown lateral bands & transparent fins. By 22 mm SL, over five thin yellow lateral stripes are also present (Lindeman et al., 2006). A small dorsolateral spot is centered over the lateral line; this spot can shift dorsad & decrease in relative size with growth. Settlers and early juveniles can be similar in appearance to the co-occurring lane Snapper, *L. synagris,* but mutton Snapper have parallel lateral yellow stripes, 12 dorsal rays, not 14, and darker lateral banding.

Early juvenile and juvenile stages can inhabit grass flats, mangroves, algae and rubble mixtures or shallow reefs (Allen 1985; Claro, 1981). Juveniles (Plate SD5) and adults display various pigment patterns some of which can be based on intraspecific interactions and feeding (Mueller et al., 1994). They are reported at salinities ranging from 4.5 to 37.3 ppm (Christensen, 1965), and at temperatures ranging from 14.4 - 34 ºC (Alperin and Schaefer, 1965; Christensen, 1965). Alperin and Schaefer (1965) reported the presence of juvenile *L. analis*, ranging from 39 to 72 mm FL, in waters as far north as Long Island, New York, where adults are not found.

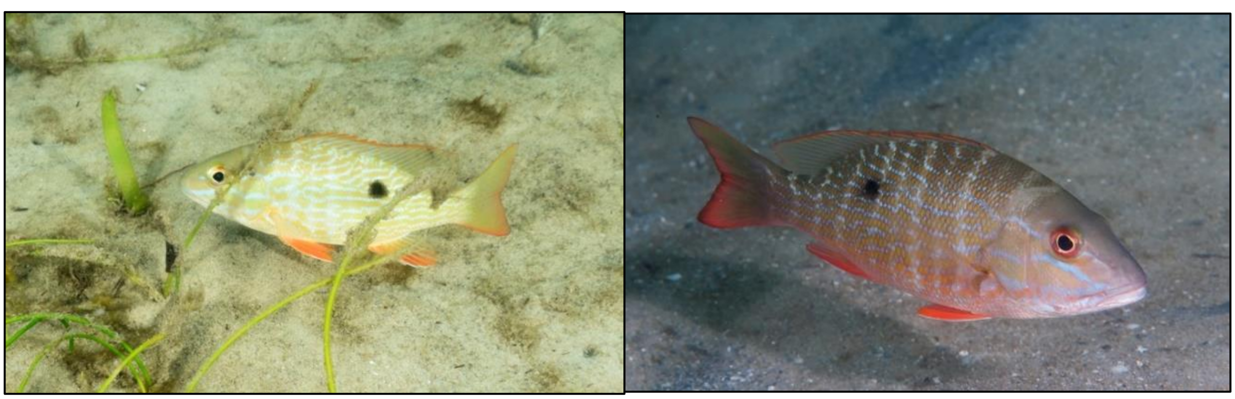

Plate SD5 Left: juvenile mutton snapper, 15 cm TL, 4 m depth, Palm Beach County, Florida. Right: Juvenile mutton snapper, 10 cm TL, 1 m depth, Palm Beach County, Florida. Photos: D. Snyder

Adults
Adults frequently inhabit coral, hardbottom, and sandy areas adjacent to reef/rubble habitat (Claro 1981). They are found on the continental shelves as well as in clear, insular waters. They are also frequently found over hard bottoms covered with vegetation or in bays and estuaries, along mangrove coasts, and can form small groups which spread out during the night (Randall, 1967). Adults also can be found in mangroves roots. In Venezuela,

the species is most abundant between 40-70 m (Cervigon, 1993). It is most common at 25ºC with salinity levels greater than 30 ppm (Claro and Lindeman, 2008). More information on adult biology follows.

Age, Growth, and Mortality

Studies of age and growth in this species show considerable variation in some findings based on methods for determining annuli, sources of fishes, and regional geographic variation (Burton 20002). In summary, maximum total length can exceed 90 cm TL commonly to 50-70 cm (e.g., Anderson, 2003; Castro-Perez et al,, 2018), with maximum age being variable but typically less than 20 years (Claro et al. 1981; Burton 2002). For the US Atlantic and Gulf of Mexico mutton snapper stock assessment (O'Hop et al. 2015), used a maximum age of 40 years and 50% maturity of 3.7 years. The maximum reported age in Burton (2002) from east Florida sampling was 29 years.

Trophic Biology

Feeds mainly on fishes, crustaceans, and molluscs (Randall, 1967; Anderson, 2003). Proportions of fishes, crustaceans and mollusks in the diet vary among regions, years, and life stages (Randall, 1967; examples in Claro and Lindeman, 2008). The eggs released from spawning aggregations at Gladden Spit in Belize can be preyed upon by whale sharks (Graham and Castellanos, 2012).

Behavior

A relatively solitary species, the species can occur in small groups outside the spawning season but does not typically form the large resting schools known for many other snapper species. Randall (1967) suggested that *L. analis* is more nomadic (roving) than other snapper species. It can feed during the day and night (Randall, 1967).

Muller et al. (1994) conducted detailed studies on *L. analis* behavior in seagrass beds with artificial reefs in the Exuma Cays, Bahamas. In juveniles and adults (15 –65 cm FL) the most common diurnal and nocturnal activities were chasing and intra-specific displacing (leaving a resting or feeding site to face an intruder) and feeding. Mueller et al. (1994) suggested that large *L. analis* dominate smaller fish through social interactions. The occurrence of dark bands on the body was associated with displacing activity, while the dark coloration on the nape was related to chasing.

Due to their larger size, adults do not seem to have many predators, which allows them to forage during the day on marine seagrass beds and sandy areas. Other snapper species of similar size, however, such as *L. cyanopterus, L. jocu*, stay closer to the habitat (Claro and Lindeman, 2008).

Population Structure

In the larger Caribbean region, there is relatively limited information on size and age structure in the species. Much information is from fishery stock assessments. In most countries, there is an assumption of substantial modifications to natural population structure due to decades of fishing removals of many size classes. Age-class structure has been examined by O'Hop et al. (2015; Table 4.3) for southeast U.S. populations of mutton snapper based largely on fishery-dependent data. Numbers of fishes by year of age from 1981 to 2013 were estimated with evidence for relatively volatile recruitment (5x variability). Younger age classes trended down and reached their lowest points since 1999 during 2010-2012 (O'Hop et al., 2015).

The population genetics and connectivity of mutton snapper in the U.S. Caribbean and the Florida Keys were assessed by Carson et al. (2011). Estimates of average long term effective population sizes differed significantly and different demographic stocks at some of the localities studied were suggested. In the CFMC, Puerto Rico, St. Thomas, St. John, and St. Croix, are managed as a single management unit. SEDAR (2007) presented a two-stock hypothesis, with one stock on the Puerto Rican insular platform (Puerto Rico and St. Thomas/St. John) and a second stock around St. Croix based on prevailing surface currents, low probability of larval input, and adult movements. The genetic evidence in Carson et al. (2011) is consistent with the hypothesis that mutton snapper off St. Croix may represent a different demographic stock and, also, suggests different demographic stocks on the Puerto Rican platform.

Complicated metapopulation biology includes the effects of a) annually variable species-specific connectivity with other countries, b) annually variable patterns of larval recruitment, and c) the effects of decades of fishing removal on multiple ages and sizes of fishes across dozens of countries. Natural predation as well has complex and variable effects on population structure (Ruttenberg et al. 2011). Mueller (1994) provided evidence of social dominance hierarchies in which adults influenced the behaviour and distribution of juveniles on patch reefs in the Bahamas.

Larval transport information is available at annual and decadal scales for eight Cuban sites for five species of snappers, including mutton snapper (Paris et al. (2005; Kough et al. 2016). Across all regions the majority of larvae spawned are estimated at annual and decadal scales to recruit within Cuba. Southeast and north-central Cuba had highest estimated within-region retention levels. Southwest and northwest sites exported relatively more larvae out-of-region.

Larval export from snapper populations on the Cuban shelf likely contribute to the replenishment of smaller shelf fisheries in Jamaica, the Caymans, and Haiti from southeast Cuba, and the Bahamas and Turks and Caicos from northern Cuba (Kough et al., 2016). Cuba's shelf areas are much larger than most of these islands. Connections to Mexico, Belize, and the Colombian Archipelago were not common, though each species had at least one site and year when possible (Kough et al., 2016). The southeast US is a destination for Cuban snapper larvae but with low relative volume and frequency at annual and decadal scales (Table 1; Paris et al., 2005; Kough et al., 2016), with opportunities to apply network analysis to improve best MPA practices for reef fish spawning aggregations (Claro et al., 2018).

Genetic analyses of mutton snapper population connectivity in the region are limited. However, Carson et al., (2011) suggested that larval transport and adult movement may not be sufficient to maintain population sustainability across the region and that there may be different demographic stocks. Carson et al., (2011) provide a reason to not overfish these centers of reproduction: they are also centers of genetic mixing across a variable bio-physical seascape (Kough et al. 2016).

Drifter vials were used to estimate the potential dispersal and distribution of mutton snapper recruits originating from Riley's Hump in the Dry Tortugas (Domeier, 2004). Results indicated that Riley's Hump is be a upstream source of mutton snapper recruits for the Florida Keys and southeastern Florida.

In a molecular genetics study of mutton snapper throughout much of their range in Brazil, Dias Junior (2012) found a single panmictic population with high genetic diversity. Genetic connectivity beyond the Amazon delta and into the Greater Caribbean appears unstudied for this species. New information suggests that there are substantial reef systems within the immense area influenced by the Amazon Delta that include lutjanids (Moura et al., 2016). These may provide genetic corridors for reef fishes between Brazil and the Greater Caribbean.

Ecosystem Role

Species that form spawning aggregations require a major mobilization of energetic resources. Over many biological scales, across very broad distances across many habitats. In a review of ecosystem scale issues involving spawning aggregations, Nemeth (2012) emphasized the energy transfer associated with feeding, excretion, and propagule release across a wide array of benthic and pelagic habitats. These issues can be further examined at the scale of catchment areas, staging areas, and courtship arenas (Nemeth, 2012). The propagules from spawning aggregations at Gladden Spit in Belize are preyed upon by whale sharks (Graham and Castellanos, 2012). The whale sharks may time their movements to take advantage of these massive pulsed of protein.

Reproductive Biology

Sexual Pattern and Spawning Mode The species is gonochoristic and it's only known spawning mode is in transient spawning aggregations of short duration annually, around the full moon period over several months in spawning groups. Data from Riley's Hump in the Florida Keys show that most snapper stay about 10 days around the full moon at this offshore spawning site before returning to home foraging grounds (Feeley et al. 2018). Seasonal migrations were repeated by individual fish during the summer spawning season (May through August). Castro Perez et al. (2018) measured the size structure of harvested mutton snapper during a spawning aggregation at the Banco Chinchorro Biosphere Reserve in Quintana Roo, Mexico (Figure SD6).

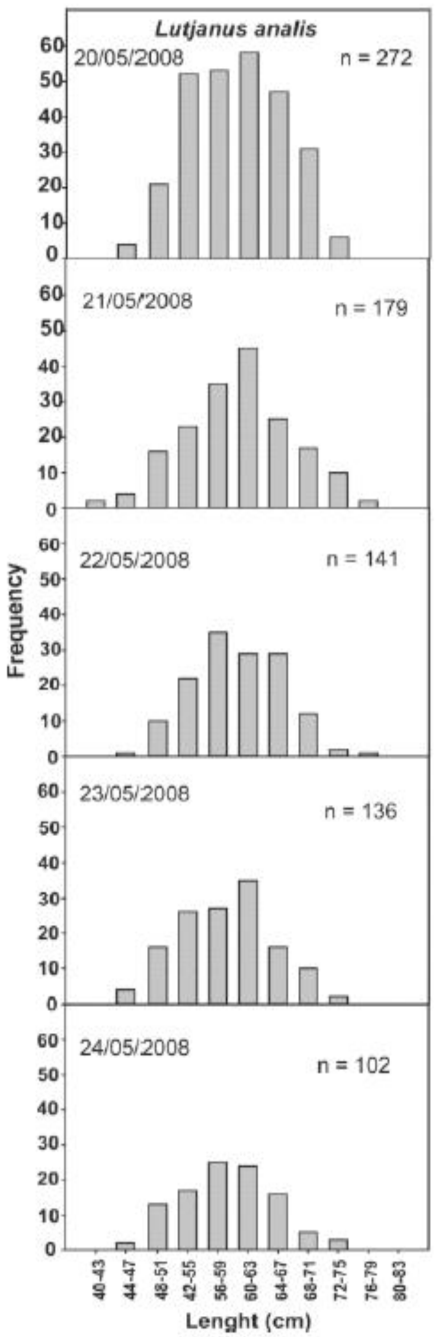

Figure SD6. Length frequency distributions of mutton snapper during a spawning aggregation, Banco Chinchorro, Mexico (from Castro-Perez et al. 2018).

Pre-spawning migrations
Migrations to the spawning site include many ecological and physiological drivers. These pre-spawning migrations involve major mobilization and movement of individual and group biomass across multiple shelf habitats over months (e.g., Nemeth, 2012) and often attract considerable fishing mortality before reaching the spawning site (Claro et al., 2009). Information on pre-spawning migrations is limited for most sites.

Seasonality of Spawning
Many temporal and spatial scales are co-associated in migratory aggregation spawning, with much of the time consumed by the actual movements to the site (Figure SD7). Peak spawning months and lunar phases for known mutton snapper aggregation sites in the Western Atlantic are itemized in Table 3.

Almost all aggregation sites showed May and June as the peak spawning months. There is also evidence of three month peaks in Puerto Rico from April to June (Matos-Caraballo., 2006) and at Rileys Hump from May-July (Feeley et al., 2018). According to Lorenzo (1985), *L. analis* spawns mainly during July and August in Venezuela, with a reproductive period from May to October.

In Brazil, Texeira et al. (2010) and Freitas et al. (2013) found that mutton snapper spawn between spring and autumn in the Southern Hemisphere; they are austral winter spawners in contrast to northern hemisphere summer spawning mutton snapper populations. In NE Brazil spawning appears to occur throughout the year, although it exhibits peaks from February to April and November to December (Ferreira et al. 2004). Spawning occurs in groups that form within the larger aggregation (Plate SD6).

Plate SD6. Group spawning in mutton snapper. Photos taken at Gladden Spit seconds prior to spawning and 3-5 days after the full moon in May at approximately 1.30 pm local time. Photographer: Douglas David Seifert.

In Cuba the reproduction period ranges from March to September, although, spawning takes place only a week per month. Peak spawning occurs in May and June at temperatures of 26 to 28ºC; however, some fish spawn during July and August (Claro, 1981, 1983, García-Cagide et al. 2001). The larger specimens with best physiological conditions (body adiposity, condition factor, etc.) spawn during the peak spawning event of the year taking place in May or June (Claro, 1981, 1983).

Sexual maturation, Sex ratios

Sexual maturation information for mutton snapper in Cuba is based largely on Claro (1981; 1983). A summary of information available information is available in Table SD1. In the NW, SW (Claro. 1981) and NE (Bendazoli. 1979) regions of the Cuban shelf, individuals reached estimated sexual maturity at four years and more than 40-45 cm FL. 60% of mature specimens were in the 5-6 year age class. Mean length at maturation (>50% of specimens are mature) was 500 cm in males, 520 cm in females in NW and SW Cuba (Claro. 1981). Males matured before females. In the NE, Bendazoli (1979) estimated length of maturation at 530 cm for males and 545 cm for females. Experienced fishers in western Cuba stated that snappers which spawn during May and June are much larger (weight 2–5 kg) than those spawning in July and August (1.6 - 3 kg; Claro. 1981).

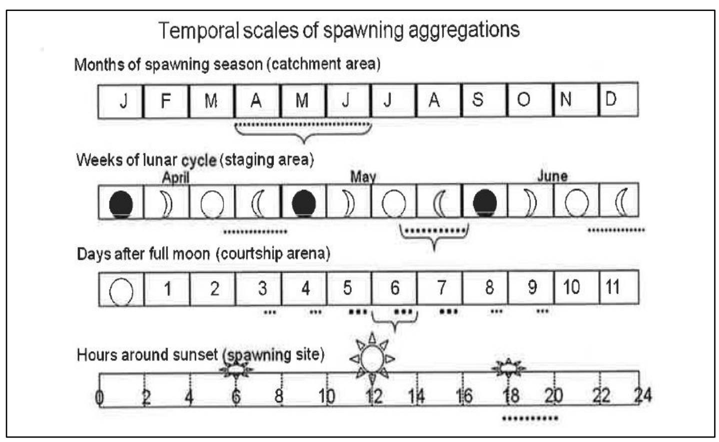

Figure SD7. Nested scales of spawning in mutton snapper in the U.S.V.I. (from Nemeth, 2012). **…..** = peak spawning activity.

Table SD1. Sizes of sexual maturity, sexual differentiation and gonadal maturation (FL) of mutton snapper in the Western Atlantic. SD: Size at sexual differentiation; Min: Minimum size of maturation; M: Average size of sexual maturation; A: Age of sexual maturation (yr); Lmax: Maximum observed length. * - Calculated from data in the literature. **: sex unknown.

	Sexual Maturation									
SD (cm)	Min (cm)		M (cm)		A (years)		M / Lmax		Region	Reference
	F	M	F	M	F	M	F	M		
18-20	41	38	52	50	5-6	5.6	0.72	0.65*	**SW & NW Cuba**	Claro, 1981; García-Cagide et al. 2001
			46		2**			0.62	**S Florida**	Ault et al., 1998
			54	53	5-6	5-6	0.71	0.69	**NE Cuba**	Bendazoli. 1979
			~39						**St. Croix, USVI**	Kojis and Quinn, 2011
			52	39	5	3	0.62	0.50	**Florida**	Burton, 2002
			49**		6				**Venezula**	Palazón González, 1986

Estimates from other regions show mutton snapper reaching sexual maturity after three years (Watanabe et al. 2001; Barbieri and Colvocoresses 2003; SEDAR 2008). In the Colombian Atlantic, Erhardt and Meinel (1977) found mature specimens from 32 cm FL, while in NE Brazil Ferreira et al. (2004) reported mature specimens from 28 cm FL.

Snappers may show substantial geographic spatial and temporal variability in reproduction (Grimes, 1987; García-Cagide et al. 2001). Robins (1972) commented on fundamental differences in life history attributes such as reproduction among species from continental and insular environments of the Caribbean. Aggregations are still unknown for many areas of the Caribbean and further research may reveal variability in spawning not currently accounted for.

Gametogenesis

Histological analyses of ovaries at various stages of maturation in several regions of Cuba demonstrated that vitellogenesis in *L. analis* is synchronous with each individual spawning all oocytes in one month (García-Cagide et al., 2001). However, the final maturation process (ovulation) is asynchronous. The ovaries exhibit oocytes in development, along with empty follicles, indicating a single female spawns multiple times during the reproductive cycle.

García-Cagide et al. (2001) concluded that spawning takes place in 4-5 batches each year (details of batch releases across spawning months not provided). Specimens with developing gonads (stage III) as well as mature gonads (stage IV) were found from March to August. However, highest proportions of mature individuals with highest GSI values were in May and June. The apparently extended spawning period is due to the stepwise spawning of different specimens each month. It appears that those larger specimens presenting best physiological conditions (body adiposity, condition factor, etc.) (see Claro, 1983) spawn during the peak period in May or June (Claro, 1981).

The highest GSI values in SE Florida waters are observed from April to July (Barbieri et al. (2003). Specimens with developing gonads as well as mature gonads are found in SW and NW Cuba from March to August, however the highest proportion of mature individuals with the highest GSI values is observed in May and June. In Cuba, the presence of specimens with highly variable degree of maturation and GSI values and the rapid appearance of mature individuals is evidence that maturation and spawning occur rapidly, probably in less than a month (Claro. 1981; García-Cagide et al. 2001).

Attributes of the ecology of pre-spawning individuals of mutton snapper have been examined (Claro 1981 and Claro, 1983). These and additional papers by Cuban researchers have emphasized the large metabolic mobilization required for gametogenesis, which is highly dependent on prey availability for spawners 6 to 9 months beforehand (e.g., Claro, 1983; García-Cagide et al. 2001; Bustamante et al. 2001).

Fecundity and Effective Egg Production
More information is needed on the potential contributions of female spawners from differing metapopulations towards replenishment of mutton snappers around the region. Considerable variability may be present within (e.g., annually variable food availability) and among populations based on multiple bio-physical factors. The available numbers per individual fish reinforce the potential results from protecting spawners. Estimates of fecundity for mutton snapper in the continental U.S. range from 0.37 to 1.4 million eggs/female (Watanabe 2001; Barbieri and Colvocoresses 2003). Claro (1981) estimated fecundity of 16 specimens from northwest Cuba. Numbers of vitelogenic oocytes fluctuated from 0.7 to 4 million. Rojas (1960) found 1.36 million eggs in a 512 mm FL specimen. The relative fecundity (oocytes/gm body weight) also increased with size in specimens 5-6 years old with fecundity from 1.3 and 2 million oocytes (Claro and Lindeman, 2008). Further information on egg production in snapper and grouper species in Cuba is available in García-Cagide et al. (2001).

Aquaculture

L. analis is considered to be a prospective species for mariculture, adapts easily to captive conditions and accepts both fresh and prepared diets (Rene et al., 1984). Consequently, experiments have been carried out since the 1980s to examine its mariculture potential. Wedler et al. (1980) obtained a growth of 25 cm in 6 months, from juveniles of 16-18 cm, and Thouard et al. (1989) reported that *L. analis* had better yields in cage culture than other snappers such as *L. apodus, L. synagris* and *O. chrysurus*.

Although the gonads of *L. analis* appear to be very susceptible to manipulation (gonadal development of brood stock may be inhibited by anding stress), spawning has been induced by injections of Human Chorionic Gonadotropin (500-1500 IU / kg of body weight) and with LHRH -a (100 mµ g / kg) (Watanabe et al., 2001a). To facilitate the growth and development of the larvae, artificial substrates have been used with success in mesocosm systems enriched with phyto- and zooplankton. However, high mortalities occur during the early stages of development, especially at the beginning of external feeding and during metamorphosis (Benetti et al., 2001a; 2001b). This is not unusual for marine pelagic-spawning species but mortality levels need to be reduced to improve the viability of the species for commercial culturing.

Large numbers of juveniles have been produced using intensive culture methods and live food (microalgae, rotifers, brine shrimp) successfully used. Preliminary results show that *L. analis* can reach a commercial size (450 g) in 16 months using recirculation systems and commercial diets (50-56% of proteins) (Watanabe et al., 2001a, Benetti et al., 2001a, 2002). Experiments in Florida in which approximately 10,500 juveniles were cultured in circular ponds, indicated that cultured fish reach greater weight at equal size than under natural conditions, with a 70% survivorship (Benetti et al. 2002).

The culture of *L. analis* hs been conducted on a pilot scale in Florida, South Carolina and Puerto Rico. Commercial scale growth systems, including recirculating tanks and floating cages, depend mainly on the development of efficient methods to control reproduction, fertilization and rearing of larvae to ensure a consistent supply of juveniles, which is a determining factor for achieving mass culture (Alarcón et al., 2001; Benetti et al., 2001a; Watanabe et al., 2001a).

The Aquaculture Center of the Florida Keys, in Marathon Cay, was able to maintain broodstock for extended periods (each one with approximately 800 mm LH in length and approximately 9-10 kg in weight). These fish adapted sufficiently to captive conditions such that they spawn spontaneously every month from the full moon, for four days in a row (4 spawning each individual), without any type of manipulation, at a temperature of about $26^{o}C$.

In Cuba, a biologist at the Centro de Investigaciones Pesqueras, reported that they were able to produce 2.6×10^4 juveniles (average weight of 16 g ± 3.8 g three months after breeding), with most released in climatic and hydro-chemical conditions determined to be favourable for the species (Reyes et al 2015). Other farmed fish were utilized for educational purposes with primary students.

In Colombia, Botero and Ospina (2002) raised 127 juveniles (125-178 g weight, 22.3 ± 1.4 cm LT average) in a floating cage, with an artificial diet for 118 days at a density of 15.9 ind./m2 and obtained an individual daily weight increase of 3.16 g / day and a specific growth rate (TEC) of 1.06% / day.

Country-specific information on mutton snapper fishery and trade status

The Bahamas

In The Bahamas, the 'snapper' fishery has long been important. A recent review indicated that for 1986, snapper (all species) catches were estimated at around 725.8 mt but had dropped to only 189.5 mt in 1992, increasing since then to around 600-700 mt/year (Department of Marine Resources and FAO 2016). FAO statistics indicate that a total of 568.56 mt of snappers were landed in the Bahamas in 2007, representing 6.8% of the total commercial landings for the country in that year (http://www.fao.org/fishery/facp/BHS/en#CountrySector-Statistics). The mutton snapper is part of a collective 'snapper' category and is believed to account for a relatively important proportion of snapper catches used for national consumption and trade, and for exports. However, the above report did not indicate the species composition of the snapper landings and hence the relative importance of Mutton snapper in these landings is not known.

Belize

Very little catch information is available specifically for the mutton snapper fishery in Belize although the species has been caught since at least the the 1950s at Gladden Spit. Overall, however, there are clear indications of declining catch per unit effort and increasing effort. At Gladden Spit, the CPUE declined from 4.1 to 1.7 kg per man-hour between 2000 and 2002, the catch/boat/day fell from 82.1 kg in 2000 to 64.0 kg in 2002, while the fishing effort significantly increased from 12.6 to 16.9 hours/boat/day (Graham et al. 2008): the researchers interviewed 13 local boat captains who indicated that, prior to 1992, 60–80 boats sometimes fished the aggregation site daily (during the spawning season), representing over 200 fishers. The Belize Central Statistical Office recorded that mutton snapper from Gladden Spit represented approximately 16.4% of the national finfish in 2000, at approximately 84 mt, excluding direct sales to individuals or restaurants (CSO 2001). Catch data at this site after 2002 indicated fairly consistent catches until about 2007, after which catches increased somewhat along with the number of boats; in 2011 about 20 boats were catching about 20 tonnes from the site (Granados-Dieseldorff et al., 2013). This was a substantial decrease from about 75 tonnes caught by approximately 70 boats in 1987 from when the first record was available (loc. cit).

Granados-Dieseldorff et al. (2013) discuss the small traditional fishery of mutton snapper at the Gladden Spit aggregation site that occurs from March to June for two weeks in each month. Fishing is limited to handlines and daylight hours. This and other information suggest that fishing impacts on pre-spawners may be relatively limited in this location. Information on the possible catchment areas that are the sources of fish that travel to Gladden Spit is not available to estimate the functional migration areas for this species. Mutton snapper spawning aggregations at Gladden Spit have been historically exploited by a small-scale commercial fishery (Graham et al. 2008; Heyman and Kjerve, 2008). Various traditional and co-management-based efforts have produced a sustained spawning aggregation co-management system (Granados-Dieseldorff et al., 2013). Management also uses dive-based tourism to promote conservation (Heyman et al. 2010).

In 2000 the government joined with stakeholders to co-manage aggregation sites; management measures to limit fishers at Gladden Spit during the spawning season were established in 2003 and implemented in 2006 (Granados-Dieseldorff et al., 2013). Enforcement increased after 2006 when managers had more resources for patrols and were able to conduct landing surveys and underwater visual censuses. Despite the substantial decrease in fishing effort after 1992, fishing nonetheless continued. Indeed, Belizean mutton snapper spawning aggregations and pre-spawning migrations are believed to have contributed substantially to national annual reef fish landings over the past 60 years (Sala et al. 2001). The spawning aggregation sites are currently protected by marine reserves although problems like illegal fishing persist and management is not fully effective. Therefore, a combined approach to rectify the situation, including a reproductive seasonal catch closure, and large-scale, actively enforced, no-take, MPAs incorporating reproductive migratory pathways, have been proposed (Graham et al. 2008); the current status of this initiative could not be determined. Catch sizes draft regulations, including the mutton snapper, are awaiting adoption. Migratory pathways, especially in the South Water Caye Marine Reserve, has been established by the expansion of the no-take zones outside the barrier reef.

Brazil

The mutton snapper is mainly caught by artisanal fisheries using handlines (Frédou & Ferreira 2005) and traps (Ribeiro 2004), especially in the northeast region. Teixeira et al (2010) found no direct evidence of spawning aggregations for mutton snapper in Brazil but indirect evidence suggests that the species aggregates to spawn. Freitas et al. (2013), in detailed interviews with fishers on the large Abrolhos Bank, received no clear indications of mutton snapper aggregations in the area, despite a sizeable fishery for the species and despite indications of aggregations for other snappers. França and Olavo (2015) reported on a fishery-dependent study, verified by fishers, that identified multiple possible mutton snapper aggregations in the eastern state of Bahia, with peak CPUE periods from April to July (Table 1).This paper is the only one with substantive indirect evidence (seasonal elevated landings) of a mutton snapper aggregation available in the literature for the Brazilian shoreline.

According to Caltabellota et al (2016) mutton snapper accounts for 30% of the snapper landings by weight (approximately 3,015 mt in 2011). Landings of snappers have decreased over the last decade in the northeast and southeast regions of Brazil, while remaining steady in the north. During 1998–2007, the state of Ceará was responsible for approximately 35% of all 'snapper' landings, followed by the state of Espirito Santo with 16% and the state of Bahia with 15%. Fishing mortality rates for this and other snappers (yellowtail and lane snappers) exhibit clear signs of overexploitation. However, because landings data are recorded only in broad categories of mixed species ("snappers") it is not possible to assess the status of this species in particular. The snapper fishery was considered of high concern, with medium vulnerability because of an estimated population decrease by 45% within three generations (ICMBio 2014).

In east Brazil, a stock assessment conducted by Klippel *et al*. (2005) estimated that the mutton snapper stock was moderately overexploited. For the northeastern coast, the stock is considered to be overexploited at 20% above the recommended level (Fredou *et al*. 2009). In northeast Brazil, mutton snapper is one of the most common snappers, both in abundance and catch, and considered overexploited and with low resiliency (Begossi *et al*. 2012). This species is exploited by artisanal hand-line fleets in the state of Pernambuco, Brazil (Gomes de Mattos and Maynou 2009). In the Abrolhos Reef system, the species was reported but ranked below <0.1 in percentage of total biomass (Francini-Filho 2008). In Rio de Janeiro, the species is harvested as juveniles, a practice detrimental to stock structure for slow-growing species (Begossi *et al*. 2012).

Colombia and Venezuela

In Colombia, this species is second only to Lane snapper (*L. synagris*) in importance to the lutjanid fishery (Acero and Garzon 1985). The species is mainly caught by artisanal fisheries using handlines, especially in northern Colombia (Majarrez et al. 2005). A total of 23.9 mt in 2006 and 10.4 mt in 2007 of mutton snapper were reported from continental Caribbean waters, with around 77% captured by artisanal fishers from Santa Marta and Riohacha areas, utilizing gill nets (92%) and lines 8% (CCI-MinAgricultura 2007). Although available data suggest that the species does not represent more than 1% of the finfish landings by weight, it appears that this species dominated the fish biomass in 1995 when exploratory trawls along the Colombian Caribbean platform (NE zone) estimated availability of Lutjanidae of high commercial value (lane and mutton snappers) to be 2,403 mt comprising up to 14.7% of the total fish biomass (Manjarres et al. 2005). In Colombia, surveys indicated that around 73% of the Mutton snapper captured have an average size of 44.4 cm total length (TL), ranging from 33.8 – 55 cm TL (Olaya 2010). However, Arteaga et al. (2004) reported average size to be 57.7 cm TL, with females being more abundant during the reproductive season. However, INCODER-CCI (2007) recognized that a reduction of the mutton snapper mean size was occurring in commercial landings, with most fish caught measuring a mean of 33.8 cm TL in 2007; these are likely to be close to or below the size of sexual maturation.

The species is fished with many gears in Venezuela (Cervigon 2003).

<u>Cuba</u>

The mutton snapper was historically one of the most heavily targeted snappers in Cuba. This fishery began at least in the 1930's increasing from several hundred mt/year to over 1,200 mt in the 1980s and then decreased to around 800 mt/year and 400 mt most recently (Pozo, 1979; Claro, 1981b; Claro et al., 2001; Claro & Lindeman, 2008; Claro & Valle, 2013) (Fig. SD4). Hence, catch was relatively stable until the early 1990s when a major decline began due to reduced commercial effort, intense subsistence fishing, and historical overexploitation of spawning aggregations (Claro *et al*. 2009). Traditionally, about 50% of the landings were from Archipelago Sabana-Camaguey, north-central Cuba. Ranging from small to major declines, evidence based on catches suggests that spawning aggregations have decreased in size (Claro *et al*. 2009). Landings in northeastern Cuba were relatively stable from 1970s to 1995, but by 2010 catches had declined over 50% from more than 400 mt to 145 mt.

Recently, landing estimates provided by the Laboratorio de Investigaciones Pesqueras de Cuba show that this species contributed to around 35.7% of the total finfish landings in 2011 (717.3 mt) and declined to 18.5% (373.7 mt) in 2017 (data courtesy of Servando Valle). Recreational and subsistence fisheries, for which mutton snapper is a target species, are not registered, but since the late 1990's they are believed to be increasing. At about this time, some restrictions on fishing effort and protection of the juvenile stages were introduced to address mutton snapper population declines.

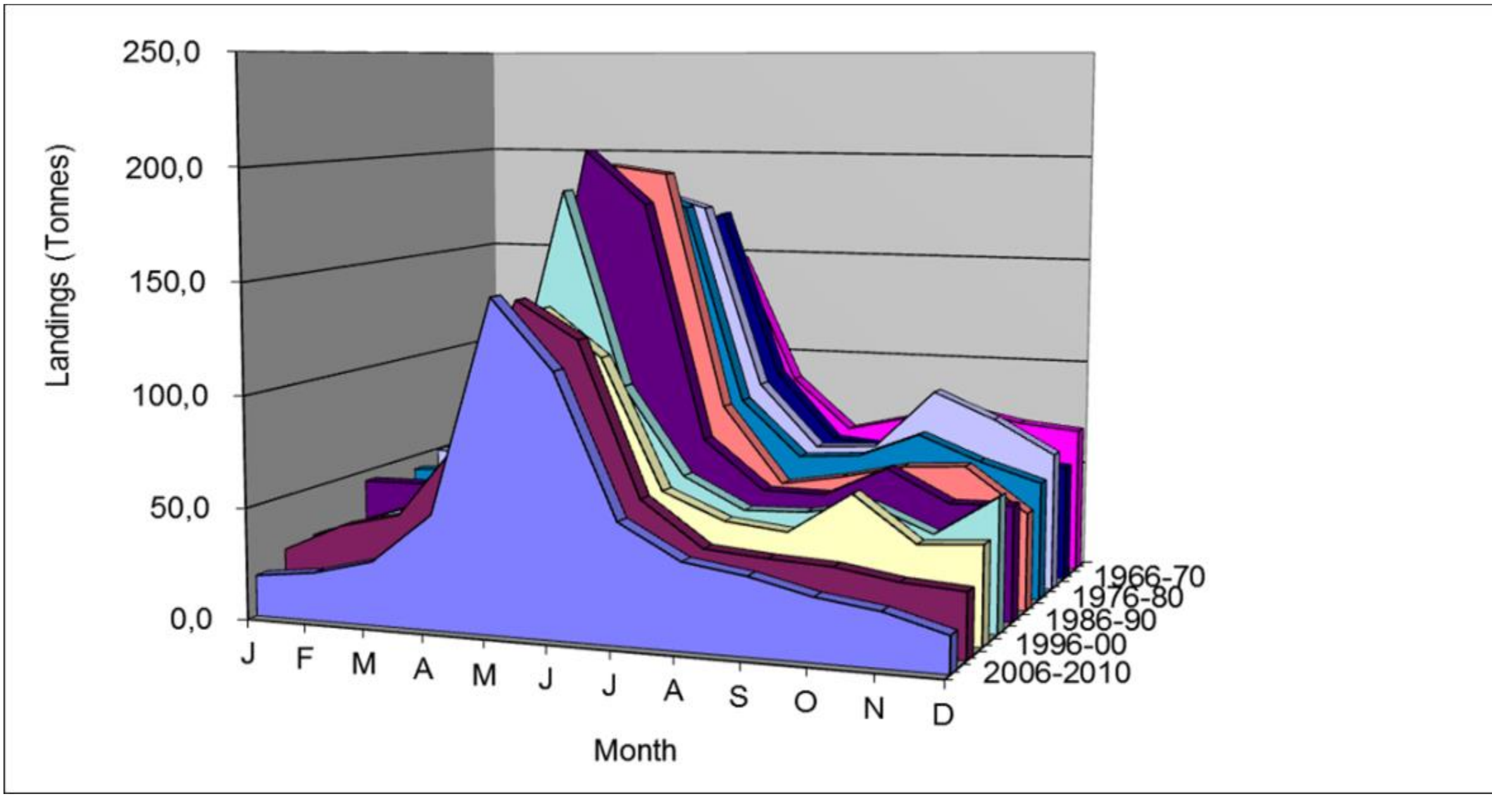

Figure SD8. Average monthly catches by five-year periods from 1966 to 2010 (Claro and Valle, 2013) of the mutton snapper, *Lutjanus analis*. Aggregation period is April to August with highest catches in May –June . With permission

The mutton snapper reproductive season extends from April to August with 35–40% of the national annual catch taken between May and June, the peak reproductive season (Figure SD8) from spawning aggregations (Pozo, 1979; Claro, 1981a; Claro et al., 2001; Claro and Lindeman, 2008). During this period the highest proportion of adult fish was captured, with juveniles (<45cm FL) prevailing in catches during other months of the year.

Fourteen spawning sites have been identified based on substantial long-term fishery data and fisher knowledge, eight on the north coast and siz in the south. Most sites are in MPAs, but many are not inside no-take MPAs, or enforcement of any relevant measures is highly variable (Claro et al., 2018). The current status of most aggregation sites is not known and a coordinated focus on regional advisory bodies to plan and stimulate targeted fishery- and fishery-independent aggregation research and conservation is recommended by Claro et al. (2018).

At present the species is not considered overfished (Reyes et al 2015). It is possible that because fishing effort is not equal in all regions and that the spawning season varies in different fishing zones (Anuario estadistico de pesca 2007) this could allow for total landings to continue to look reasonable when consolidated at the national level even if local landings are declining; this possibility should be investigated. However, considering that non-government commercial fishing is not being included in the population analysis, lack of recreational data, and bearing in mind the use of highly selective fishing gears (spear fishing) that occurs while fishing spawning aggregations, other scientists believe that the current situation is far from satisfactory and that the reproductive capacity (adults and spawning fish) may already be compromised (Claro et al. 2009). De la Guardia et al. (2018) have suggested the use of the precautionary principle in the fisheries management of this species. Personnel from the Laboratorio de Investigaciones de Cuba will soon be conducting a new stock assessment for this species across all four sections of the Cuban platform (Servando Valle, personal communication 2019).

De la Guardia et al. (2018) have highlighted concerns about the snapper fishery on the western end of the Gulfo de Batabano on the southwest coast, including fishing practices at spawning aggregation sites which could threaten snapper populations, fisheries sustainability, and even the ecosystem itself. The size of fished mutton snapper ranged between 14 and 86 cm FL, with a mode between 30 and 40 cm FL. Only 7% of the individuals were under the minimum legal size (25 cm FL), and approximately 40% of the 354 individuals measured showed mature gonads (De la Guardia et al 2018). These authors have suggested that maintaining the current exploitation regime may compromise the reproductive capacity of the fish stocks and lead to recruitment overfishing. They recognized the mutton snapper and Cubera snapper, *L. cyanopterus,* were the most reduced of the snappers, and that these species are highly vulnerable and highly susceptible to overfishing.

The mutton snapper has comprised about 2.4-2.8% of the total snapper landings between 1986 and 2005 (Claro 2007). The species is not currently considered to be overfished (Reyes et al., 2015) although its trends in landings vary across the country. For example, in some areas landings have long been relatively stable, in the northeast, however, there has been a marked decline Fig. SD9).

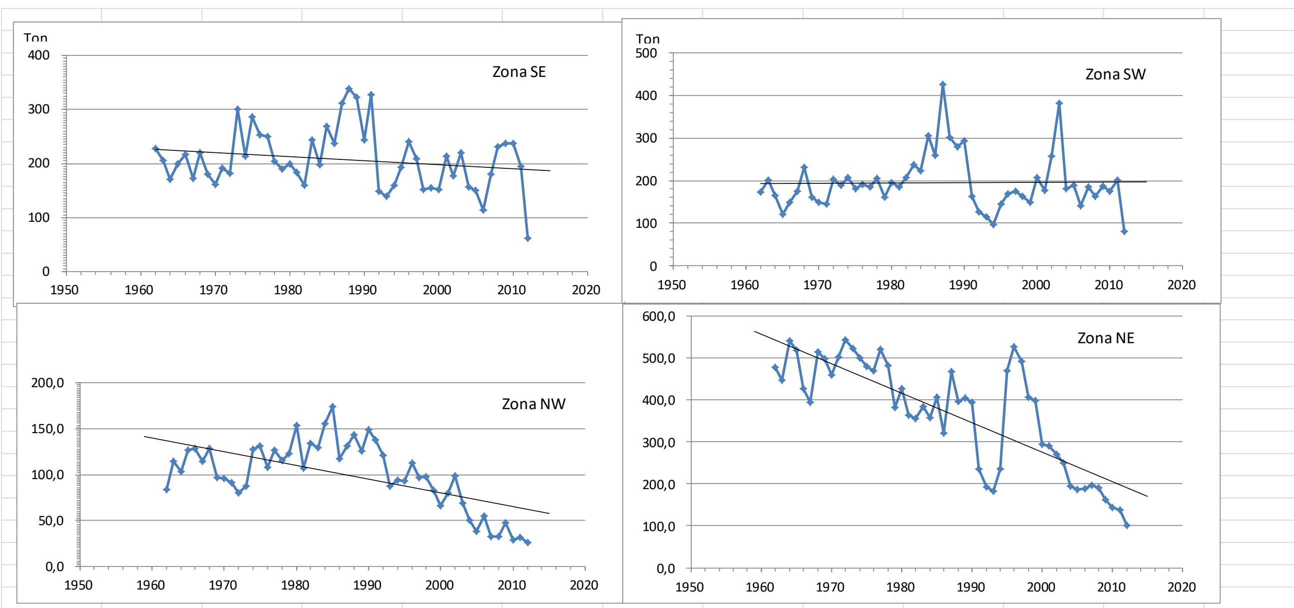

Figure SD9 Landings data (mt) from different regions in Cuba for 1960-2014 in four zones around Cuba for mutton snapper (Rodolfo Claro, Cuba National Fisheries Statistics).

<u>Lesser Antilles</u>

In the Lesser Antilles (from the US Virgin Islands to the south of Granada), probably largely due to their narrow insular platforms, shallow water snapper catches are not significant (Mahon 1993). However, in the late 1960's and early 1970's snappers and groupers dominated exploratory deep-water resource catches throughout the Caribbean comprising from 43-92% of the catch by weight in the lesser Antilles, according to FAO/UNDP survey (Mahon 1990). He also mentioned the use of hook and line (bottom longline, snapper reels, and hook and lines) to capture almost exclusively snappers and groupers. Overall, this large group of islands contributes less than 2% of the snapper stocks caught in the shallower waters of the western Atlantic, where the main resources are extracted from deeper waters of the insular slope (Sylvester and Damman, 1974, Prescod et al. 1996). Data on snapper catches need to be updated.

In the case of Grenadines islands, Mohammed and Rennie (2003) reported that from 1950-1980, the Grenadines exhibited a greater dependence on demersal fisheries captured with hand and troll lines by small artisanal vessels and traditional fishing gear (snappers in general represented 85% of the fish landings in 1978). In their reconstruction of the fisheries, it was described that in the 1980's a semi-industrial fleet was introduced along with the use of longline through the transfer of skill and technology from Cubans to Grenadian fishers. While these targeted mostly large pelagic stocks it was also estimated that inshore catches declined drastically from about 700 mt in 1986 to as low as 74 t in 1999, 89%; these would certainly have included snappers. Subsequently catches have increased to 139 t in 2001. Unfortunately, they did not detail the decline in the proportion of snappers, or of certain species, and more recent data are needed to determine current condition of these fisheries.

Mexico (Quintana Roo)

At the beginning of the fishery, captures of inshore finfish in the Mexican Caribbean were estimated between 1,493 mt in 1963 and increased to 3.014 mt in 1972; from this amount, inshore snappers likely represented around 90% and mutton snapper in particular, accounted for 10%, for around 134.4 mt and 271.3 mt respectively (Klima 1976). Currently, the Mexican Caribbean snapper fishery in the Yucatán, Campeche and Veracruz is considered deteriorated, and at its maximum sustainable yield in Tamaulipas, Quintana Roo and Tabasco (SAGARPA-CONAPESCA 2014).

This species is caught as bycatch in commercial fisheries that target *L. campechanus* (red snapper) in the Mexican waters of the Gulf of Mexico. It is sold in the domestic markets of, mainly, Mexico City and Guadalajara (SAGARPA 2012). Juveniles are extensively caught in the shrimp fishery, but no official statistics are available at this time. Landings of mixed snapper species in Mexico have fluctuated but appear relatively stable from 1970s to 1996, with little data subsequently (INP 2000).

Castro-Pérez et al (2011) presented fishery-dependent evidence of a mutton snapper spawning aggregation in Banco Chinchorro during the dry season (March to June). Heyman et al. (2014) provided additional information on the Banco Chinchorro site. Fulton et al. (2018) identified Punta Herrero as an additional mutton snapper spawning site in southern Quintana Roo and detailed fisher knowledge/citizen science efforts to further characterize and protect aggregations, in part based on Sosa Cordero et al. (2002).

In Mexico, mutton snapper landings are not distinguished from the collective snapper landings in the country which is referred to simply as the 'snapper' (*guachinango*) category. Snappers, as in many countries of the region, are fished by both commercial and recreational fishers. In general, the *guachinango* accounts for around 19% of the Mexican fish production by weight, with an increase in annual production of 5.7% over the last 10 years (SAGARPA-CONAPESCA 2014).

Nicaragua

In Nicaragua, most mutton snapper (76% on average in the last in the last 10 years) captured in Caribbean waters is taken by the artisanal fleet. Nicaragua is a country with a strong fishing tradition with fishing operations increasing particularly since 1989 when the industrial fishing fleet increased its presence in Caribbean waters.

Total finfish production from the Caribbean in Nicaragua in 2015 totaled 2,708 mt of which the snapper production was 1,229 mt (45%), and mutton snapper production was 21,61 mt, accounting for 1.8% of the snapper landings. The mutton snapper in Nicaragua is fished at industrial and artisanal levels, on average 26% and 74% (by weight) respectively (Table 2). Landings data for from 2005 to 2015 increased overall from 5.5 mt to 29 mt with an average of 74% taken by the artisanal sector, the rest by the industrial sector (Anuarios Estadisticos de Pesca de ADPESCA, (2001, 2005; INPESCA 2006-2015) (http://www.inpesca.gob.ni/index.php?option=com_content&view=article&id=18&Itemid=100).

Very little appears to be known about the mutton snapper specifically and it is not managed at the species level except for a minimum size measure of 30 cm TL (Barnuty Navarro 2013), which is below the size of sexual maturation.

Puerto Rico

In Puerto Rico most landings are from traps and/or pots, and hook and line fishing and the species is taken both commercially and recreationally. Fishers have reported that mutton snapper aggregations occur in many places around the island near the full moon of April, May and June and this is supported by higher fishery landings in those months (Matos-Caraballo et al, 2012).

A stock assessment for the commercial fishery of mutton snapper in the US Caribbean, focusing on Puerto Rico, was conducted in 2007 (using data from 1983 to 2005) (Cumings 2007a). It was estimated that commercial landings went from 48.1 mt in 1983 to a maximum of 68.5 mt in 2000, dropping to 30.5 mt in 2005. Uncorrected recent reported annual landings from the commercial fishery in Puerto Rico varied between 12.4 and 10.9 mt (2007 to 2011), around 9 mt less compared the 2005 unadjusted reported values (Matos 2012). Data compiled and adjusted by scientists at the NOAA Southeast Fisheries Science Center in Miami, FL, indicated that an average of 192 mt / year (standard deviation 3.62) was landed by commercial fishers in Puerto Rico (data from 2010 – 2016), declining to 12.1 mt in 2017 (the year that hurricanes Irma and Maria hit the islands). Even with the adjustment in the reported data, mutton snapper landings are still poorly understood because, according to Matos et al. (2004), the species is often confused with deep water snappers, particularly the silk snapper (*L. vivanus*) and so is frequently reported and marketed as silk snapper.

In addition, recreational landings data are collected by the Department of Natural and Environmental Resources with the support of the NOAA MRFSS available since the year 2000, and compiled by NOAA's Southeast Science Center. Using the Puerto Rico dataset, it was possible to estimate that 38.3 mt were landed recreationally in 2000, and 44.6 mt and 40.1mt in 2003 and 2008 respectively with an average of 17.6 mt / year landed from 2010-2016 (standard deviation of 16.8 mt). It is believed that snappers in general make up the majority of the recreational landings in state waters.

The MIRP catch data estimated that the number of mutton snappers harvested in Puerto Rico varied from around 25,881 fish in 2000, increasing to 35,963 fish in 2016, but totalled only 4,100 individuals in 2014. However, these data have a high coefficient of variation (0.32, 0.48 and 0.74 respectively) highlighting the uncertainty of the estimates.

The Puerto Rican and the US Virgin Islands population managed by the Caribbean Fishery Management Council considers mutton snapper current stock exploitation status as not undergoing overfishing, and stock biomass status was not considered to be overfished. Through the 23-year time series from 1983 to 2005, commercial catches declined 50% (SEDAR 2007, Table 2). Removals from hook and line gear accounted for some 46% of the removals across all years, while pots or traps accounted for about 28.5% (SEDAR 2007).

Biostatistical length data from commercial catch (hook and line) samples in Puerto Rico from 1984 to 2006, suggest that mean maximum lengths for mutton snapper in Puerto Rico are variable and range from 54 to 79 cm FL with mean maximum weight varying between 2.4 and 8.9 kg (Cummings 2007a). Matos-Caraballo et al. (2002) on the other hand, reported that approximately 42% of the mutton snapper captures in Puerto Rico are below 33 cm FL and vary according the fishing gear, with seine fisheries capturing smaller individuals than traps or hook and lines.

Turks and Caicos Islands

The Fisheries Department of the Turks and Caicos Islands (TCI) has had some success in collecting information on finfish, including shallow reef fish, deep-slope fish, coastal pelagic fish, and large pelagic fish (Lockhard et al. 2015). The catch history of these various fisheries is unknown. To counteract this situation, a dedicated research vessel was used to survey the three banks which form the TCI. Mutton snapper catch rates were low within the near shore pelagic resource, and it is considered unlikely they would support a significant commercial fishing operation (Medley & Nines 1995). In a recent effort to reconstruct the marine fisheries catches Ulman et al. (2015) estimated that the finfish fishery has been highly selective, carried out by hook and line, with majority of the production being for domestic consumption. They estimated that total finish catches from the TCI amounted to just over 39,000 mt from 1950–2012, consisting mainly of bonefish, and to a much lesser extent, snappers, grunts and sharks.

Fish populations appear to be in relatively good shape compared to neighboring islands and traditionally preferred species are still available. Indeed, finfish are mainly opportunistically caught by fishers targeting lobster, since both reef fish and lobster occupy the same habitat (Rudd 2002). No specific references to mutton snappers are available, but the Lutjanidae family in general is considered to be among the preferred fish for local communities and visitors (Ulman et al. 2015).

US Virgin Islands

There is substantial indirect evidence of a spawning aggregation site on the southwest coast of St. Croix that is managed as the Mutton Snapper Seasonal Closed Area. The evidence is based on fishery-dependent catch data and GSI, and the site has long been known to fishers (Kojis and Quinn, 2010). Multiple habitat and fishery attributes of this area have been characterized (Quinn and Kojis, 2010).

Unfortunately, these scientists could not conduct a stock assessment for the US Virgin Islands because no data were available at the time of the analysis, a situation that persists. Recent data on commercial fishing, indicate that an annual average of 3.6 mt (standard deviation 0.6 mt) was landed in St. Thomas-St. John from 2011 – 2016. However, no data from the US Virgin Islands recreational landings or captures of mutton snapper are available (Southeast Science Center database).

In terms of length data, capture lengths ranged from 46 to 78 cm FL and mean maximum weight was between 9.3 kg and 11.4 kg from samples taken between 1994 and 2006 (J. Bennett, pers. com., Cummings 2007a). Available length data from 2013-2015 in the US South-Atlantic region indicated that more than 95% of mutton snapper commercial landings from the Gulf of Mexico and more than 95% of the recreational captures are larger than 20 inches FL (50.8 cm FL) (Gulf of Mexico Fishery Management Council 2017).

<u>United States</u>

Florida: There are two aggregation sites identified with direct evidence. Best known is that at Riley's Hump in the Dry Tortugas. An aggregation of mutton snapper was described by Domeier et al (1996) and Domeier and Colin (1997). Interviews with fishers generated a table of multiple possible lutjanid spawning aggregation sites in the Lower Keys including at Rileys Hump (Lindeman et al., 2000). Subsequent to initial creation of no-take protection for this site and its enforcement (Plate SD7), Burton et al. (2005) documented evidence of recovery at the site. Substantial additional research has occurred at the site since (e.g., Locascio and Burton, 2016; Feeley et al. 2018).

Plate SD7 The 53' enforcement catamaran, M/V Gladding, operated by NOAA.. The vessel is based out of Key West, Florida.

Fishers have long harvested a mutton snapper spawning aggregation near the Western Dry Rocks, south of Key West (Lindeman et al., 2000). Located on the Boca Grande Bar, a narrow, shallow ridge south of Western Dry Rocks, the site has been described with a summary of related histological evidence (W. Heyman, unpubl. data). The site is particularly fished by recreational boats. Plate SD8 shows fishing pressure during a May spawning event. Both the site at Riley's Hump and at Western Dry Rocks are considered in the separate Case Studies section (Section 5.0).

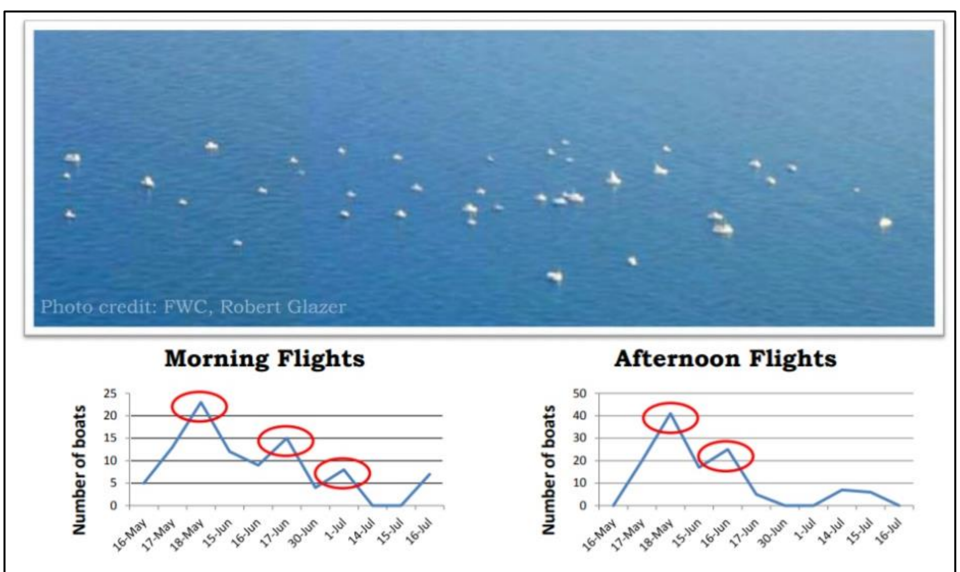

Plate SD8 Aerial surveys of fishing vessels at the Boca Grande Bar aggregation site, Florida Keys (source: FL FWC). The white dots are fishing boats at the site.

In SE waters of Florida commercial mutton snapper catches increase from March to September, peaking in July or August, while in the Florida Keys the capture peak occurs in April or May (Figure SD10), coinciding with the months of reproduction (Beaver 2000). Gleason et al. (2011) also identified Whistle Buoy and Watson Reef, off Key Largo as possible mutton snapper spawning sites. In addition, Eklund et al. (2000) observed mutton snapper schools associated with spawning aggregations of black grouper (*Mycteroperca bonaci*) in the northern Keys.

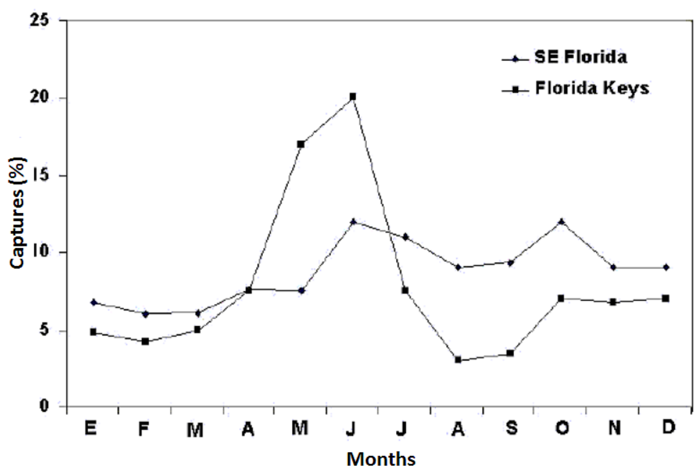

Figure SD10. Seasonal variation of *Lutjanus analis* landings (percentage) in two zones of Florida, eastern US. Taken from (Beaver 2000). The aggregation season is May-July in Florida Keys which is when landings peak.

US Gulf of Mexico and South Atlantic: The species is prized in warmer Florida state waters and recreational fishing accounted for more fishing mortality in Florida than commercial or headboat fisheries (O'Hop *et al.* 2015). According to the latest stock assessment in the US Gulf of Mexico and the South Atlantic region (2013), the mutton snapper is considered a single stock, centered in South Florida (O'Hop et al. 2015). This assessment reported that recreational fishing landed 489.6 mt in 1981, peaked in 1992 with 546.9 mt and decreased to 269.3 mt in 2013. Estimated recreational landings from the Atlantic coast of the US peaked in 2008 at 772,798 individuals with 2014 landings at 280,281 individuals (NMFS 2015b). In addition, the commercial fishery landed 55.9 mt in 1981, peaked in 1989 with 163.8 mt and decreased to 28.8 in 2013. They also estimated approximately 20 – 27 mt/year being released live during 1995-2013 based on data from the MRFSS and the MRIP.

In 2013, the SEDAR Update Assessment of mutton snapper in both the US South Atlantic and GOM concluded that the maximum fishing mortality threshold was 0.18 per year (defined as fishing mortality rate associated with a spawning potential ratio of 30%) and using prior SAFMC and GMFMC protocols, mutton snapper was not considered overfished or to be undergoing overfishing. Despite declines from peak numbers, the stock is responding positively to the progressive increase in fishing regulations (O'Hop et al. 2015).

Nonetheless, the recent assessment also mentioned that stakeholders and law enforcement personnel have expressed concerns to the South Atlantic Fishery Management Council about overexploitation of mutton snapper specifically when the species is aggregated to spawn and fisheries experts recommended a lowering of the catch (i.e. reduce the annual catch limits) given the fact that the stock of the species is smaller than estimated in the previous assessment completed in 2008 (O'Hop et al. 2015).

Mutton snapper is sometimes taken in incidental catches or as bycatch. For example, in the US section of the Gulf of Mexico mortality in young juveniles from shrimp trawlers have been considered as a limiting factor for the overall health of the mutton snapper stocks in these areas (O'Hop et al. 2015).

Venezuela

In Parque Nacional Archipielago de Los Roques, considering reef characteristics likely to be associated with mutton snapper aggregation sites and according to local fisher accounts and indirect evidence of spawning aggregations (high seasonal landings and a significant increase in numbers observed) Cayo Sal and Boca de Sebastopol were identified as aggregation sites (Boomhower, 2010). Using interviews with fishers and fisheries +landings Romero et al. (2011) identified the primary fishery sites for mutton Snapper as Punta Salina (Cayo Sal), followed by Boca de Cote, Gran Roque and Sebastopol.

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