

Fishing, Management, and Conservation of the Nassau Grouper, *Epinephelus striatus*, in the Mexican Caribbean

ALFONSO AGUILAR-PERERA, CARLOS GONZÁLEZ-SALAS, and HAROLD VILLEGAS-HERNÁNDEZ
Departamento de Biología Marina, Universidad Autónoma de Yucatán, A.P 4-116 Itz'inná, C.P. 97100, Mérida, Yucatán, México

ABSTRACT

The Nassau grouper, *Epinephelus striatus*, is one of the twenty groupers (out of 162 species worldwide) recently considered by IUCN as endangered in the Western Atlantic where a lack of a precautionary principle and an uncontrolled fishing, mostly during spawning aggregations, has rendered its population to be at risk. In the Mexican Caribbean, northern part of the Mesoamerican Reef System, it is secondary as a fishing target after the Caribbean spiny lobster (*Panulirus argus*) and the Queen conch (*Strombus gigas*). However, it is fished during spawning aggregations in December, January and February. Recently, there has been a progressive concern by fishers and fisheries authorities to incipiently regulating its fishery, mainly within marine protected areas (MPAs). Such concern emerges from adopting regulations derived from an official ban (February-March) from another serranid (*E. morio*) and the management plans from the MPAs. Unfortunately, no clear fishery statistics are available nor an official ban for *E. striatus* operates specifically. Currently, in the Mexican Caribbean its fishery status is considered as unknown, and its management is not properly enforced nor efficiently designed for areas (with spawning aggregations sites, such that of Mahahual) outside MPAs. Local fishers and authorities are eager to establish an official protection (federal) for this grouper due to conservation initiatives promoted by The Nature Conservancy linking fishers, managers and scientists through workshops. A strong recommendation for better manage this grouper is to find ways that fishers, managers, and scientists from Mexico, Belize, Guatemala and Honduras adopt the better science to protect it.

KEY WORDS: Nassau grouper, Coral Reef, Spawning aggregations, Mexican Caribbean

Pesca, Manejo y Conservación del Mero Nassau, *Epinephelus striatus*, en el Caribe Mexicano

El mero Nassau, *Epinephelus striatus*, es uno de los veinte meros (de 162 especies a nivel mundial) considerado recientemente por la IUCN como en peligro en el Oeste Atlántico, donde una carencia del principio precautorio y una pesca descontrolada, centrada principalmente en las agrupaciones de desove, ha ocasionado su población quede en riesgo. En el Caribe mexicano, parte norte del Sistema Arrecifal Mesoamericano, es un objetivo pesquero secundario después de la langosta (*Panulirus argus*) y el caracol rosa (*Strombus gigas*). No obstante, es capturado durante agrupaciones de desove en diciembre, enero y febrero. Recientemente, hay una preocupación creciente de pescadores y autoridades pesqueras para regular incipientemente su pesquería, principalmente dentro de áreas marinas protegidas (AMPs). Tal preocupación surge del adoptar regulaciones derivadas de una veda oficial (Febrero-Marzo) de otro serránido (*E. morio*) y de planes de manejo de las AMPs. Desafortunadamente, no existen estadísticas pesqueras claras ni tampoco una veda oficial para *E. striatus*. Actualmente, en el Caribe mexicano su estatus pesquero es considerado como desconocido y el manejo no está diseñado eficientemente para áreas fuera de AMPs (con agrupaciones de desove como la de Mahahual). Pescadores y autoridades locales están en disposición de establecer una protección oficial federal para este mero debido a las iniciativas de conservación promovidas por The Nature Conservancy vinculando pescadores, manejadores y científicos a través de talleres. Una recomendación sustancial para manejar mejor este mero es encontrar la manera que pescadores, manejadores y científicos de México, Belice, Guatemala y Honduras adopten la mejor ciencia para protegerlo.

PALABRAS CLAVES: Mero Nassau, arrecife coralino, agrupación de desove, Caribe mexicano

Pêche, Gestion et Conservation du Merou de Nassau, *Epinephelus striatus* dans la Caraïbe

Le mérou de Nassau, *Epinephelus striatus*, est un des 20 Serranidae (sur 126 connus dans le monde) récemment considéré par l'IUCN comme espèce en danger dans l'Atlantique Ouest où un manque de principe de précautions et une pêche incontrôlée, surtout pendant les rassemblements pour le frai a mis sa population en danger. Dans la Caraïbe mexicaine, partie nord du système des récifs mésoaméricains, il est d'importance secondaire dans la pêche après la langouste (*Panulirus argus*) et le Lambi (*Strombus gigas*). Cependant, il est pêché pendant les rassemblements pour frayer en décembre, janvier et février. Récemment, il y a eu une prise de conscience progressive par les pêcheurs et les autorités des pêches pour commencer à réguler sa pêche, principalement à l'intérieur des aires marines protégées. Une telle prise de conscience émerge de l'adoption des réglementations dérivées d'un interdit officiel (février-mars) pour un autre mérou (*E. morio*) et les plans de gestion des AMP. Malheureusement, il n'existe pas de statistiques de pêche ni d'interdit officiel pour *E. striatus*. Couramment, dans la Caraïbe mexicaine, son statut est considéré comme inconnu et sa gestion n'est pas convenablement mis en application ni élaboré efficacement pour les zones en dehors des AMP (avec des sites d'agrégation de ponte, telle que Mahahual). Les pêcheurs et les autorités locales sont impatients d'établir une protection (fédérale) officielle pour ce mérou grâce aux initiatives de conservation promues par « The Nature Conservancy » qui relie pêcheurs, gestionnaires et scientifiques à travers des ateliers. Afin de mieux gérer ce mérou, il est fortement recommandé de trouver des moyens pour que pêcheurs, gestionnaires et scientifiques du Mexique, de Bélize, du Guatemala et du Honduras adoptent de meilleures politiques scientifiques pour le protéger.

MOTS CLÉS: Mérou de Nassau, récif corallien, agrégations de ponte, fréquence de ponte

INTRODUCTION

The Nassau grouper, *Epinephelus striatus*, is among the most commercially important groupers from coral reefs of Western Atlantic and Caribbean Sea, where it is commonly captured using hook and line, speargun and traps (Sadovy and Eklund 1999). It is one of the twenty groupers (out of 162 species worldwide) recently considered by IUCN as endangered in the Western Atlantic where a lack of a precautionary principle and an uncontrolled fishing has rendered its population to be at risk. A peculiar reproductive strategy involves building spawning aggregations at relatively shallow sites in coral reefs during full moon days. Such strategy is very predictable in space and time; thus, historically these aggregations have been known by fishers who have exploited them in various areas of the region, such as Jamaica, Cayman Islands, Virgin Islands, Cuba, Belize, Mexico (Sadovy and Eklund 1999). Many of these aggregations have shown evidence of disappearance (Sadovy and Domeier 2005). Due to the high vulnerability of *E. striatus*, the International Union for the Conservation of Nature enlists this grouper as endangered (Cornish and Eklund 2003). In the region, some countries have established regulations, including the use of marine protected areas, gear (speargun) bans, and closed seasons, for mitigating the fishery impact.

Currently, the Nassau grouper is being a concern of many scientists and international organizations to the level of many of these are considering a regional, Caribbean-wide initiative to regulate its fishing and develop appropriate monitoring protocols for a sustainable management. Consequently, studies diagnosing its current situation acquire great value as points of reference.

In Mexico, *E. striatus* is commonly found off the eastern Yucatan Peninsula (Quintana Roo) in shallow coral reefs of the northern part of the Mesoamerican Barrier Reef System. Fishers know of its spawning aggregations and have exploited them for more than 70 years using gears including hook and line, speargun, and gill nets. While the fishery importance of *E. striatus* is secondary after those of the Caribbean lobster (*Panulirus argus*) and queen conch (*Strombus gigas*), in the past (1960s) it was one of the most important fisheries (Aguilar-Perera 1994). Currently, relatively little is known in terms of its fishery situation and conservation status. Consequently, this work aims to address:

- i) A general diagnosis based on available fishery records,
- ii) Its current situation on fishery management at local and federal levels, and
- iii) A perspective on conservation and research initiatives.

MATERIALS AND METHODS

A survey was conducted in order to diagnose the current situation of the Nassau grouper in terms of fishing, management and conservation in Quintana Roo, Mexico, following a strategy based on interviews to fishermen, managers, and scientists from the region. Additionally, data gathering of technical papers and landing records from the fishery authority were also considered. Visits to fishermen cooperatives (Pescadores de Banco Chinchorro, Langosteros del Caribe, Pescadores de Xcalak, Pescadores de Vigia Chico) were decisive for acquiring the fishermen's perspective on the Nassau fishery, while interviews to managers (Comisión Nacional de Áreas Marinas Protegidas, Comisión Nacional de Acuacultura y Pesca, Centro Regional de Investigaciones Pesqueras) provided information on the initiatives taken by the government for fishing regulations and enforcement. Some interviews to scientists were also conducted to determine the research so far conducted on this species.

RESULTS

Fishing

At least 29 fishermen (patriarchs) of cooperatives from Quintana Roo (the only three from southern area and one from the central area) were interviewed. According to them, there is not any control on properly recording the catches taken mainly from spawning aggregations. Actually, the Nassau grouper (Mero del Caribe) is secondary in commercial importance for the region after the spiny lobster (*Panulirus argus*) and queen conch (*Strombus gigas*). There is not any specific fishermen fleet dedicated to fishing this grouper; thus, such fishing occurs opportunistically by the end of the year and at the beginning of another one (winter). At this time, it is not possible to know how many fishermen are devoted to catch this grouper at a given place and moment.

Historically, the fishing gear used by fishermen began with handlines by 1950s and progressively moved to using hawaian sling then to speargun. This latter was used more often, until 1990s when it was banned. Eventually, fishermen used gillnets for more than five years. This situation applies only to the southern Quintana Roo (near Belize). However, in central Quintana Roo fishermen argued they only use handlines, since the Nassau grouper is found in deep areas. More than 80% of fishermen assured that the situation of fishing the spawning aggregations is a problem for the grouper since fishermen have perceived that the aggregation has progressively been displaced. In southern Quintana Roo, fishermen argued they are not using the speargun anymore, but handlines. This latter occurs in Xcalak, where less than 10 fishermen catch this grouper from aggregations only. They said that only during winter is "rentable" to fish this grouper since along the year is not abundant. Regarding their perception on the ecological aspects of this aggregation, they said that the

full moon is determinant for the presence of this fish in the aggregation sites; they argued that January is even better in terms of abundance compared to December. Fishermen that used speargun also said that groupers are an easy target since their calm behavior when aggregating allows the fishermen to approach them and catch them with speargun.

Fishery statistics compiled from the fishery authority (CONAPESCA) do not specify their records on landings from Quintana Roo by species. The generic name for groupers in the statistics recorded by the fishery authority is labeled as “mero”. Consequently, the only statistic available from these records under the “mero” showed

monthly series since 1998 to 2007 (Figure 1). There is not a consistency in the peaks of abundance corresponding to the reproductive seasons (December, January and February) when spawning aggregations for Nassau grouper usually occur. However, when data was plotted annually, a progressive decline in landings is evident (Figure 2) in spite the species identity remains unknown. In general, due to a lack of data on fishing effort (number of boats, fishermen, fishing gear), and the unknown identity of the species recorded by fishery authorities, we must argue that the fishery status of Nassau grouper is unknown.

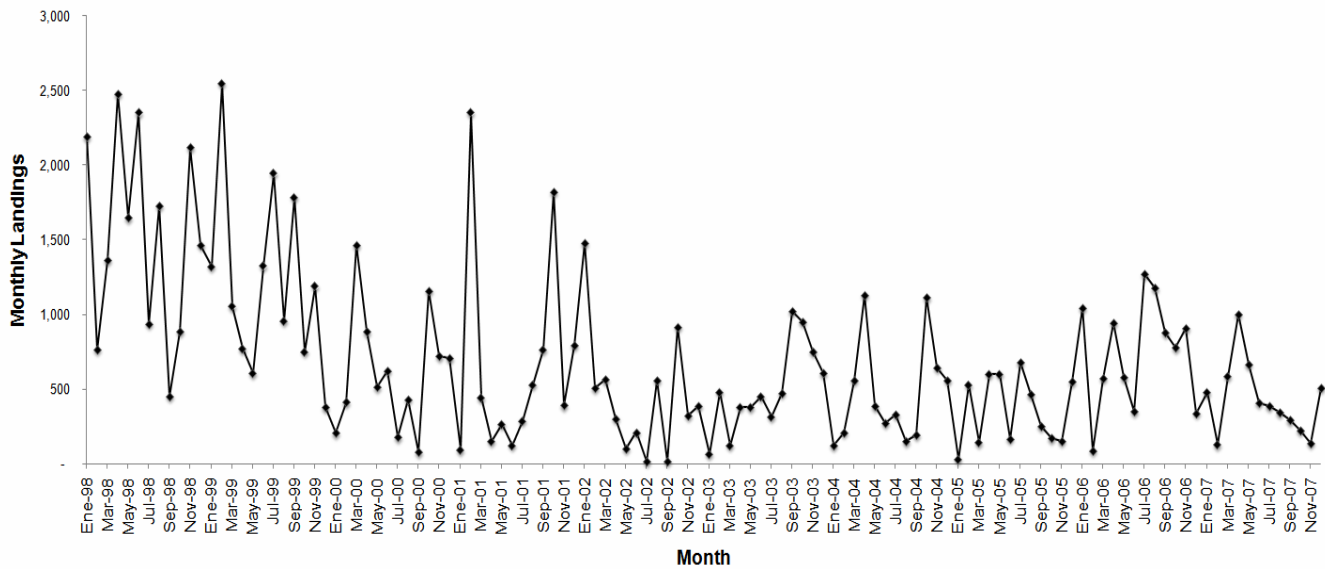


Figure 1. Monthly landings (kg) labelled as “mero”, potentially corresponding to Nassau grouper *Epinephelus striatus* from southern Quintana Roo, México, for January 1998 to December 2007. Source: CONAPESCA (2008).

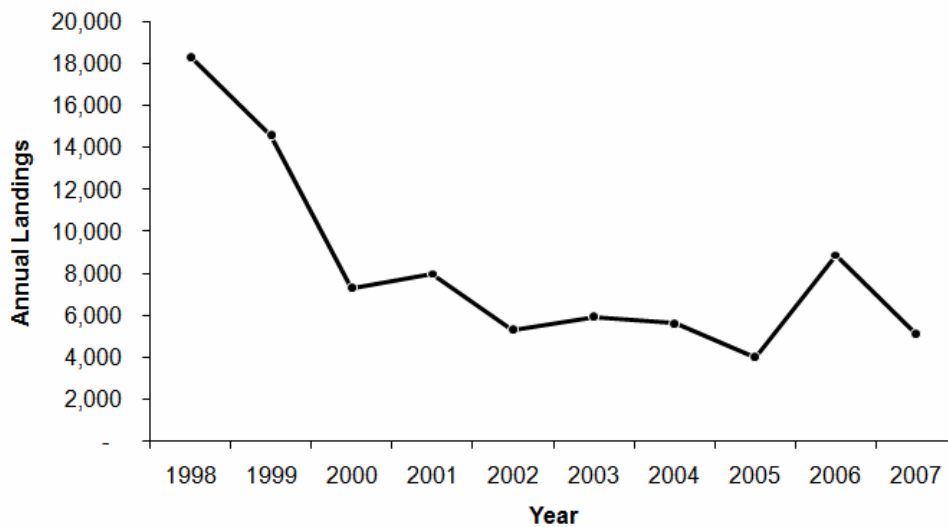


Figure 2. Annual landings (kg) labelled as “mero”, potentially corresponding to Nassau grouper *Epinephelus striatus*, from southern Quintana Roo, México, (Mexican Caribbean) during 1998-2007. Source: CONAPESCA (2008).

Management

The “Mero del Caribe”, as it is catalogued the Nassau grouper in Mexico, is considered a target species according to the National Fishery Chart. This Chart established, among its guidelines and strategies, the need to evaluate grouper populations from the Gulf of Mexico. On this sense, the fishery authority has been working on establishing the Mexican Official Standard NOM-065-PESC-2006 to regulate the harvesting of grouper species within the federal jurisdiction of waters of the Gulf of Mexico and Mexican Caribbean. However, this work still remains as a project and needs first to be authorized by the fishing authority at the federal level. This means that the enforcement and application of this official document needs to be accepted yet by the federal government. There is another official document, but already accepted by the government and fully applied which confers a ban to the Red grouper (*E. morio*); this ban is enforced from February 15 to March 15 every year that corresponds to Red grouper’s reproductive peak. However, such strategy barely includes the reproductive season of Nassau grouper (December-February). Despite this scenario, the fishermen from the Caribbean follow such a ban and avoid fishing Nassau grouper.

According to managers, the use of speargun is not allowed for catching Nassau grouper, and what is only allowed is hook and line during non-reproductive periods and outside the marine protected areas. The enforcement and surveillance by MPA managers take place for all fish species within the area and do not for Nassau grouper only. According to CONAPESCA, there is no any size limit for Nassau, since it is not a direct fishery as it is the case of lobster (*Panulirus argus*) and queen conch (*Strombus gigas*).

CONSERVATION

The first initiative for studying the Nassau grouper emerged in 1990s (Aguilar-Perera 1994, Aguilar-Perera and Aguilar-Dávila 1996) due to fishermen accounts on the spawning aggregation in Mahahual, a fishermen village in

southern Quintana Roo. The Centro de Investigaciones de Quintana Roo began studies on such aggregations for documenting it in terms of biological and ecological components. Eventually, many other sites along the coast of Quintana Roo where this grouper aggregates were registered (Sosa-Cordero *et al.* 2002, Medina-Quej *et al.* 2004). Recently, one of these aggregation sites (Blanquizal, Xcalak) has been investigated (Bolio-Moguel 2007). The characteristics of Nassau grouper both in Mahahual and Xcalak are illustrated in Table 1. The mean size of groupers in Xcalak for 2004 was relatively larger to that of groupers in Mahahual from 1991 to 1997. The spawning aggregation in Mahahual was verified scientifically in 1991 when the abundance reached around 1,000 individuals (Aguilar-Perera 1994). Eventually, a decrease in abundance was evident not only through visual censuses but also in landings; the aggregation disappeared from the traditional site of aggregation in 1997 (Aguilar-Perera 2006). Unfortunately, there has not been any monitoring to determine the return of the aggregation to such a site. According to fishermen, since Mahahual is not located within any MPA is being fished (even with speargun), and it has not received any protection after 1997 when a regulation forbidding its fishing was enacted.

In 2002, an initiative derived from the Mesoamerican Barrier Reef System Program was promoted to document the aggregation sites along the Quintana Roo’s coast through interviews applied to fishermen to identify how many sites and of which species were being fished (Sosa-Cordero *et al.* 2002). Part of this information and other reports (Loreto-Viruel *et al.* 2006) were used to build Table 2. At least 28 sites have been identified by fishermen in both central and southern regions of Quintana Roo. In the southern Quintana Roo, only two have been verified scientifically: Mahahual and Xcalak. Of these sites only the one in Xcalak is under protection since it is within the Xcalak Reefs National Park. According to fishermen interviews, the Nassau grouper is captured in the Banco Chinchorro Marine Biosphere Reserve; however, the

Table 1. Size and sex ration of Nassau grouper (*E. striatus*) in several localities in the Mexican Caribbean.* both sexes. na = information not available, N = number of individuals

Site	Size range (cm)		Sex ratio		Length-Weight relationship	N	Year	Source
	Females	Males	Females	Maless				
Mahahual	57.6	58.7	374	260	0.0711xTL ^{2.4223}	634	1991-93	Aguilar-Perera & Aguilar-Davila (1996)
	59.6	60.8	28	42	nd	70	1991	Sosa-Cordero & Cardenas-Vidal (1991)
	58.7	57.8	440	338	nd	778	1991-97	Aguilar-Perera (2006)
Xcalak	65	64	133	70	0.0342xTL ^{2.8198}	203	2001-02	Medina-Quej et al. (2004)
	65*		4100*		nd	4100	2004-05	Bolio-Moguel (2007)

presence of aggregation sites still remains to be verified scientifically. Of the aggregation sites pointed out by Sosa-Cordero *et al.* (2002) for the central coast of Quintana Roo, at least five were verified by the NGO Amigos de Sian Ka'an in 2006. Of these latter sites, only two located in the Sian Ka'an Biosphere Reserve showed Nassau grouper spawning aggregations (San Juan-Chenchomack and Nichehabin, see Table), but only the one in Nichehabin showed up a substantial abundance of groupers (800) in 30 m deep. This site was identified for the first time from fishermen accounts in 2005, and still there is not information about size and sex ratio of groupers aggregated (Figure 3).

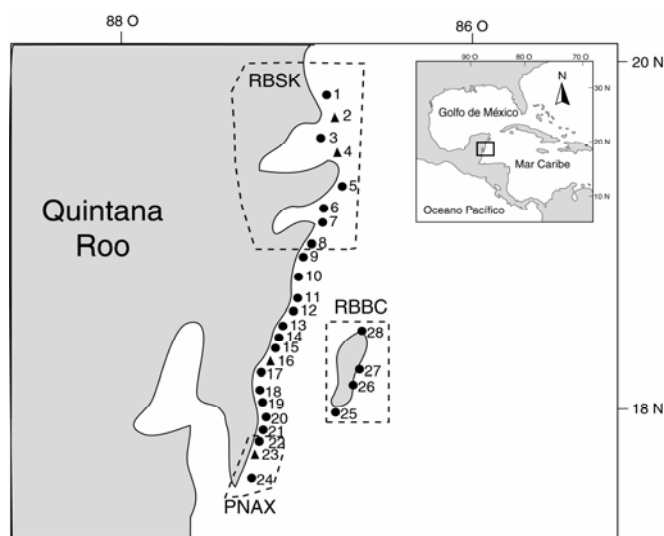


Figure 3. Nassau grouper, *Epinephelus striatus*, aggregation sites in Quintana Roo's coast, Eastern Yucatan Peninsula (Mexican Caribbean). At least 28 sites are mentioned by local fishermen in interviews (Sosa-Cordero *et al.* 2002) from which only 4 have been scientifically verified through visual censuses *in situ* (▲). The others (24) still remain to be verified (●). Dotted lines represent approximate boundaries of marine protected areas: Sian Ka'an Marine Biosphere Reserve (RBSK), Banco Chichorro Marine Biosphere Reserve, and Xcalak Reefs National Park. The Nassau grouper aggregation sites are: 1 Xamach, 2 Nichehabin, 3 Punta Hualostoc, 4 San Juan Chenchomac 5 Punta Pájaros, 6 Quebrado de Chal, 7 Punta Herrero, 8 Punta Mosquitero, 9 Punta Pulticub, 10 Pozas Gorilas, 11 Frente a Cazona, 12 Uvero -anegado, 13 Río Indio, 14 Faro viejo, 15 Chac-chí (Benque Soya), 16 Mahahual, 17 Río Bermejo (Martina), 18 Puerto Angel-El Castillo, 19 Punta Herradura, 20 Xahuayxol, 21 Hobná - Xcayal, 22 Punta Gavilán, 23 Blanquizal-Sta Julia, 24 Quebrado de Xcalak, 25 Cayo Lobos, 26 La Herradura-Cassel, 27 Glenview, 28 Cayo Norte.

DISCUSSION

The current situation of the "Mero del Caribe" (Nassau grouper) in terms of fishing, management and conservation

requires a greater attention by the government in order to establish official regulations offering an ecosystem based management for conserving its population in the Mexican Caribbean. While the Fishery National Chart considers this grouper as a target species, the fishermen consider it as secondary after the fishery of lobster (*Panulirus argus*) and Queen conch (*Strombus gigas*). Some fishermen consider this grouper as a plus in their captures that comes by the end of each year and the beginning of the next. The number of fishermen advocated to capture this grouper is unknown, but what it is known is that the most prevalent fishing gears were the hook and line and the speargun. Currently, only the hook and line is allowed, but the speargun is illegally used.

The fishery statistics available, as compiled by CONAPESCA, do not allow estimating clearly how much is taken from the Nassau grouper population. The economic value of many fishes in Mexico is taken according to generic names (e.g., grouper, snapper, etc). Consequently, not only fishermen but also managers avoid making a further distinction by species. There is not any particular law regulating the captures of Nassau grouper in the Mexican Caribbean. Official documents that indirectly may regulate the fishing are the Mexican Official Standard NOM-009-PESC-1993, which refers to bans for wildlife. There is a project for another Mexican Official Standard NOM-065-PESC-2006, which refers to regulate various grouper species in the Gulf of Mexico and Mexican Caribbean; this latter NOM is not yet in place. Likewise, there is a specially designed ban for the Red grouper (*E. morio*) which is observed by fishermen from the Mexican Caribbean but it covers only from February 15 to March 15; this latter is barely the reproductive season for *E. striatus*. Lastly, some other fishermen also follow the very brief guidelines established in some marine protected areas; however, other fishermen do not know about this latter.

While a substantial effort has been devoted in attempting to document the presence of Nassau grouper aggregations in at least 28 sites along the Quintana Roo's coast (Sosa-Cordero *et al.* 2002), only five sites have been verified. Of these latter, only two have basic documentation on biological characteristics, the aggregation off Mahahual (Aguilar-Perera 1994, 2006) and the one off Xcalak (Medina-Quej *et al.* 2004). The aggregation site off Mahahual needs to be revisited to determine if the aggregation that disappeared from the traditional aggregation site has returned. In terms of abundance, the site off Xcalak remains as the most relevant (Medina-Quej *et al.* 2004, Bolio-Moguel 2007).

Regarding conservation initiatives, The Nature Conservancy has promoted and supported studies for documenting fish spawning aggregations in Quintana Roo, such is the case of funding studies to document the Nassau grouper aggregation sites in the Sian Ka'an Biosphere Reserve (Loreto-Viruel *et al.* 2006).

“Esta iniciativa ha permitido conocer que al menos dos sitios son importantes para *E. striatus*. Asimismo, TNC ha apoyado iniciativas de CONANP para estudiar agrupaciones de desove pero se desconoce aún los resultados en relación a *E. striatus* en Banco Chinchorro. La administración de RBBC, dentro del marco de trabajo del Sistema Arrecifal Mesoamericano (SAM), ha promovido talleres e intercambios con pescadores. Estas actividades, junto con las promovidas por TNC desde inicios de 2000, han sensibilizado a varios pescadores por lo que hoy día los pescadores están en disposición de colaborar con iniciativas de conservación en relación a la regulación oficial de la pesca de *E. striatus*. Asimismo, TNC en 2007 catalizó la formación de un grupo de trabajo denominado Grupo de Trabajo de Agregaciones Reproductivas de la Península de Yucatán para abordar asuntos relacionados con agrupaciones de desove y vincular varios actores dentro de cooperativas de pescadores, agencias de gobierno (CONANP, CONAPESCA, CRIP), ONGs (ASK, Razonatura) y Academia (UADY).”

RECOMMENDATIONS

While the Nassau grouper has a secondary importance in Quintana Roo, it is being fished mainly during its annual spawning aggregations. Consequently, it is recommendable that CONAPESCA promptly determine the most appropriate mechanisms for recording clearly and comprehensively the catches year-round. We recommend as a first step for the Nassau grouper being considered by the fishery authorities in Mexico is the elaboration of a “ficha técnica” (technical synopsis) by SAGARPA-CONAPESCA to be considered at the federal level and susceptible of being included in the National Fishery Chart. It is necessary that educational institutions, research centers and NGOs joint efforts to address social-ecological studies leading to a better comprehension on the ecology and management of Nassau grouper in the Mexican Caribbean. In terms of research, it is necessary to determine the level of demographic connectivity among the 28 identified sites (if they are really active) through acoustic tagging and monitoring. This latter will be needed to determine the potential migratory routes and time lasting on aggregation sites. Likewise, it is also recommended to scientifically verify the sites that still remain to be documented. Genetic studies will also be useful in order to determine the potential relationships of Nassau grouper populations between Mexico and Belize. Outreach will be a very important component to educate people on the importance of protecting the spawning aggregations. On this endeavor, NGOs will play a vital role to link scientists, managers, users (fishermen), and decision-makers in order to address the scientific knowledge, socio-economic needs and conservation aspects conducting to the protection of the Nassau grouper under a regional level including Mexico, Belize, Honduras and Guatemala.

ACKNOWLEDGEMENTS

This publication was possible due to the support of the people of the United States of America through USAID. The content of this publication is responsibility of UADY Foundation and the University Autonomous of Yucatan and it does not reflect necessarily the point of view of The Nature

Conservancy, USAID or the Government of the United States of America. We thank participant fishermen from the cooperatives Banco Chinchorro, Langosteros del Caribe, Xcalak; specially to Prisciliano Pérez Cansino, Jesús Mex Matos, Arnulfo Catzin Dzul, Nemesio Salazar, Marcelo González, Jorge Batún, Román González, Gerardo Ariola, Miguel Polanco, Hipólito Silva López, Marcelo Huicab Tah, Guadalupe Cetina Martín, Andrés Galavíz Villanueva, Max Caleb, Margarito Mallorca May, Luis Alfonso Cetina Sánchez, Luis Aurelio Chí Dzib, Ermilo Red Villanueva, Nerio Aragón Villanueva, Alias "Obi", Alias "Yuca", Alias "Mono"; y pescadores de la Cooperativa Vigía Chico (Tulum): Carmen Alberto Sánchez, Tomas Mendoza, Alfredo Sierra (Freddy), Guadalupe Villanueva, Gerardo Cruz, Julio Lugo, Alejandro Velázquez Cruz, David Alfredo, Martín Draga, Cristian Chulín, Manuel Mendoza Argáez. We also thank to scientists Alejandro Medina Quej and Juan Manuel Castro Pérez (Instituto Tecnológico de Chetumal) and MPAs managers: Omar Ortiz, Pablo Zamorano, Fredy Martín Sierra (Reserva de la Biosfera de Sian Ka'an). Also thanks to government officers Cecilia Quiroga (Centro de Investigaciones Pesqueras, Puerto Morelos), Maricarmen García Rivas, Felipe Fonseca Peralta (Reserva de la Biosfera Banco Chinchorro y Parque Nacional Arrecifes de Xcalak), Isabel Bravo, José Manuel Cárdenas Magaña (CONAPESCA-Chetumal).

LITERATURE CITED

- Aguilar-Perera A. 1994. Preliminary observations on the spawning aggregation of Nassau grouper, *Epinephelus striatus*, at Mahahual, Quintana Roo, Mexico. *Proceedings of the Gulf and Caribbean Fisheries Institute* **43**:112–122
- Aguilar-Perera, A. and W. Aguilar-Dávila. 1996. A spawning aggregation of Nassau grouper *Epinephelus striatus* Pisces: Serranidae in the Mexican Caribbean. *Environmental Biology of Fishes* **45**:351–361
- Aguilar-Perera, A. 2006. Disappearance of a Nassau grouper spawning aggregation off the southern Mexican Caribbean coast. *Marine Ecology Progress Series* **327**: 289–296
- Bolio-Moguel, K.M. 2007. Caracterización y descripción pesquera del sitio de agrupación de peces “El blanquizal –Santa Julia”, Quintana Roo, México: Invierno 2004-Primavera 2005. Tesis Maestría. ECOSUR, 90 pp.
- Carter, J, G.J. Marrow, and V. Pryor. 1994. Aspects of the ecology and reproduction of Nassau grouper, *Epinephelus striatus*, off the coast of Belize, Central America. *Proceedings of the Gulf and Caribbean Fisheries Institute* **43**:65–111
- Cornish, A. and A.M. Eklund. 2003. *Epinephelus striatus*. In: IUCN 2007. 2007 IUCN Red List of Threatened Species. <www.iucnredlist.org>.
- Loreto-Viruel, R., A. Franquesa Rinos, T. Mendoza Cime, J.C. Lugo Martín, N.G. Velázquez, D.A. Martín Draga,
- E. Najera Hillman, L. Alavarez, H.A. Martín Sierra, and N. Requena. 2006. Verification and monitoring of spawning aggregation sites in the Sian Ka'an Biosphere Reserve. Technical Report. The Nature Conservancy and Amigos de Sian Ka'an. 14 pp.
- Medina-Quej, A, A.R. Herrera-Pavón, G. Poot-López, E. Sosa-Cordero, K. Bolio-Moguel, and W. Haddad. 2004. Estudio preliminar de la agregación del mero *Epinephelus striatus* en ‘El Blanquizal’ en la costa sur de Quintana Roo, México. *Proceedings of the Gulf and Caribbean Fisheries Institute* **55**:557–569.
- Sadovy, Y. and P.L. Colin. 1995. Sexual development and sexuality in the Nassau grouper. *Journal of Fish Biology* **46**:961–976.
- Sadovy, Y. and A.M. Eklund. 1999. Synopsis of the biological data on the Nassau grouper *Epinephelus striatus* (Bloch, 1792) and the Jewfish, *E. itajara* (Lichtenstein, 1822) NOAA Tech Rep NMFS 146.
- Sadovy, Y. and M. Domeier. 2005. Are aggregation-fisheries sustainable? Reef fish fisheries as a case study. *Coral Reefs* **24**:254–262
- Sosa-Cordero, E. and J. Cárdenas-Vidal. 1996. Estudio preliminar de la pesquería de mero *Epinephelus striatus* del Sur de Quintana Roo. *Proceedings of the Gulf and Caribbean Fisheries Institute* **44**:56–72.

Table 2. Spawning aggregation sites for Nassau grouper (*E. striatus*) identified in the central and southern Mexican Caribbean (Quintana Roo) by fishermen interviews. NGO = non-governmental organization, SCIENT = scientific, MPA = Marine Protected Area, RBSK = Reserva de la Biosfera Sian Ka'an, PNAX= Parque Nacional Arrecifes de Xcalak, RBBC = Reserva de la Biosfera Banco Chinchorro, CONANP = Comisión Nacional de Areas Naturales Protegidas. Source: (a) Carranza 1955, (b) Craig 1966, (c) Solís-Ramírez 1966, (d) Miller 1982, (e) Sosa-Cordero et al. 1991, (f) Aguilar-Perera 1994, (g) Aguilar-Perera y Aguilar-Dávila 1996, (h) Medina-Quej et al. 2002, (i) Sosa-Cordero et al. 2002, (j) Amigos de Sian ka'an y TNC 2006, (k) Medina-Quej y Sosa-Cordero 2006, (l) Aguilar-Perera 2006, (m) Bolio-Moguel 2007.

Aggregation site	Verified	Verified by	Date of Verification	Depth (m)	MPA	No. aggregated fish	Fishing Ban	Fishing	Fishing gear	Source
Punta Xamach	NO	NO	?	?	RBSK	?	YES	?	?	I
San Juan-Chenchomac	YES	NGO	Feb-Mar 2006	35-40	RBSK	25	YES	SI	Handlines	i, j
Nicheabin	YES	NGO	Feb-2006	33-38	RBSK	800	YES	SI	Handlines	J
Punta Hualostoc	YES	NGO	Feb-2006	30-33	RBSK	NO	YES	NO	?	i, j
Punta Pájaros	YES	NGO	Feb-2006	30-35	RBSK	NO	YES	NO	?	i, j
Quebrado de Chal	NO	NO	NO	?	RBSK	?	YES	?	?	I
Punta Herrero (faro)	NO	NO	NO	?	RBSK	?	YES	?	?	I
Mahahual	YES	SCIENT	Dec-1991	6-20	NO	500-1000	NO	YES	Speargun, gillnets Handlines	f, g, m
Punta Mosquitero	NO	NO	NO	?	RBSK	?	?	?	?	I
Punta Pulticub	NO	NO	NO	?	NO	?	?	?	?	I
Pozas Gorilas	NO	NO	NO	?	NO	?	?	?	?	i
Frente a Cazona	NO	NO	NO	?	NO	?	?	?	?	i
Uvero –anegado	NO	NO	NO	?	NO	?	?	?	?	i
Río Indio	NO	NO	NO	?	NO	?	?	?	?	e, f, g, i
Faro viejo	NO	NO	NO	?	NO	?	?	?	?	i
Chac-chí	NO	NO	NO	?	NO	?	?	?	?	a, c, d, e, f, g
Río Bermejo	NO	NO	NO	?	NO	?	?	?	?	i
Puerto Angel	NO	NO	NO	?	NO	?	?	?	?	i
Punta Herradura	NO	NO	NO	?	NO	?	?	?	?	e, f, g
Xahuayxol	NO	NO	NO	?	NO	?	?	?	?	e, f, g
Hobná–Xcayal	NO	NO	NO	?	PNAX C	?	?	?	?	i, k
Punta Gavilán	NO	NO	NO	?	PNAX C	?	?	?	?	e, f, g, k
Blanquizal–Sta Julia	YES	SCIENT	Dec-2004	15-30	PNAX C	3000-4000	YES	YES	Handlines, bottom lines	h, k, m
Quebrado de Xcalak	?	?	?	?	PNAX C	?	?	?	?	i, k
Cayo Norte	?	?	?	?	RBBC	?	?	?	?	i
Glenview	?	?	?	?	RBBC	?	?	?	?	i
La Herradura–Cassel	YES	CO-NANP	2006	?	RBBC	800	YES	YES	Speargun	b, d, e, f, g
Cayo Lobos	?	?	?	?	RBBC	?	?	?	?	e, f, g