Defining Marine Protected Areas for Yellowfin and Nassau Grouper Spawning Aggregation Sites

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ABSTRACT

Most large groupers (Serranidae) form annual spawning aggregations (FSA) at predictable times and locations, which makes them extremely vulnerable to over-fishing. Seasonal or permanent fishery area closures can provide effective protection, but defining biologically relevant boundaries is difficult due to limited knowledge of the area occupied or the movement and migration patterns associated with spawning. The aim of this study was to determine the spatial and temporal pattern of movement and migration associated with spawning aggregations of Nassau (*Epinephelus striatus*) and yellowfin (*Mycteroperca venenosa*) grouper within the Grammanik Bank, a small (1.5 km^2) seasonal closure on the southern shelf edge of the US Virgin Islands. Five male and 5 female groupers of each species were acoustically tagged and released on the aggregation site. An array of acoustic receivers was strategically placed in an overlapping curtain around the FSA. Data indicate that both species commonly moved 1 to 3 km in a few hours and could cover 20 km in a 24 hr period. Movements of tagged groupers at the spawning site carried them outside the existing closure boundaries and exposed them to fishing mortality on a daily basis. Moreover, we identified migratory pathways of both species which linked the Grammanik Bank closure and another large marine protected area (MCD) 3 km west. These results indicate that the existing Grammanik Bank boundaries are too small and should be increased to at least 10 km^2 and include primary migration pathways.

KEY WORDS: Grouper spawning aggregations, marine protected areas, management, acoustic telemetry

Definir las Áreas Protegidas Marinas para la Trucha Salmonada y el Grouper de Nassau que Frezan Sitios de la Agregación

La mayoría de los groupers grandes (Serranidae) forman las agregaciones de freza anuales (FSA) en las horas y las localizaciones fiables, que las hace extremadamente vulnerables a la pesca excesiva. Area de la industria pesquera pueden proporcionar la protección eficaz, pero definir límites biológico relevantes es difícil debido al conocimiento limitado del área ocupada o de los patrones del movimiento y de la migración asociados a la freza. La puntería de este estudio era determinar el patrón espacial y migración asociados a agregaciones de freza de *Epinephelus striatus* y *Mycteroperca venenosa* dentro del banco de Grammanik, (1.5 km^2) un encierro estacional pequeño en el borde meridional del estante de los E.E.U.U. Islas Vírgenes. Cinco groupers masculinos y 5 femeninos de cada especie acústico fueron marcados con etiqueta y lanzados en el sitio de la agregación. Un arsenal de receptores acústicos fue colocado estratégico en una cortina traslapada alrededor del FSA. Los datos indican que ambas especies movieron 1 a 3 kilómetros sobre algunas horas y podrían comúnmente cubrir 20 kilómetros en 24 períodos de la hora. Los movimientos de groupers marcados con etiqueta en el sitio de freza los llevaron fuera de los límites existentes del encierro y los expusieron a la mortalidad de la pesca sobre una base diaria. Por otra parte, identificamos caminos migratorios de ambas especies que ligaron el encierro y otra área protegida marina grande (MCD) del banco de Grammanik 3 kilómetros de del oeste. Estos resultados indican que los límites existentes del banco de Grammanik son demasiado pequeños y deben ser aumentados por lo menos a 10 km^2 e incluir caminos primarios de la migración.

PALABRAS CLAVES: Agregaciones de freza del grouper, gerencia, marinas áreas protegidas, telemetría acústica

Définir des Secteurs Protégés marins pour la Truite Saumonnee et la Mérou de Nassau Engendrant des Émplacements D'agregation

La plupart des grands mérous (Serranidae) forment les agrégations engendrantes annuelles (FSA) aux heures et aux endroits prévisibles, qui les rend extrêmement vulnérables à l'exploitation trop intensive. Les fermetures saisonnières ou permanentes de secteur de pêche peuvent assurer la protection efficace, mais définir des frontières biologiquement appropriées est dû difficile à la connaissance limitée du secteur occupé ou des modèles de mouvement et de migration liés à engendrer. Le but de cette étude était de déterminer le modèle spatial et temporel du mouvement et la migration liés aux agrégations engendrantes de Nassau (*Epinephelus striatus*) et le mérou de truite saumonnée (*Mycteroperca venenosa*) au sein de la banque de Grammanik, une petite (1.5 km^2) fermeture saisonnière sur le bord méridional d'étagère des USA Îles Vierges. Cinq mérous masculins et 5 femelles de chaque des espèces ont été acoustique étiquetés et libérés sur l'emplacement d'agrégation. Une rangée de récepteurs acoustiques a été stratégiquement placée dans un rideau de recouvrement autour du FSA. Les données indiquent que les deux espèces ont généralement déplacé 1 à 3 kilomètres en quelques heures et pourraient couvrir 20 kilomètres dans des 24 périodes d'heure. Les mouvements des mérous étiquetés à l'emplacement engendrant les ont portés en dehors des frontières existantes de fermeture et les ont exposées à la mortalité de pêche quotidiennement. D'ailleurs, nous avons identifié des voies migratrices des deux espèces qui ont lié une fermeture de banque de Grammanik et un grand secteur protégé marin différent (MCD) 3 kilomètres d'occidental. Ces résultats indiquent que les frontières existantes de banque de Grammanik sont trop petites et devraient être grimpées jusqu'au moins à 10 km^2 et inclure des voies primaires de migration.

MOTS CLÉS: Agrégations engendrantes de mérou, gestion, secteurs protégés marins, télémétrie acoustique

INTRODUCTION

Most large groupers (Serranidae) form annual spawning aggregations (FSA) at predictable times and locations, which makes them extremely vulnerable to overfishing. Seasonal or permanent fishery area closures can provide effective protection, but defining biologically relevant boundaries is difficult due to limited knowledge of the area occupied or the movement and migration patterns associated with spawning. In the Virgin Islands Nassau (*Epinephelus striatus*) and Yellowfin grouper (*Mycteroperca venenosa*) spawn on the Grammanik Bank from February to April during the week after the full moon. In 2005 a 1.5 km^2 three month seasonal closure was established to protect these groupers during the spawning season. It was unknown the extent of grouper movements during spawning and unclear if the size of this closure was large enough to encompass these movements during the spawning season. The aim of this study was to determine the spatial and temporal pattern of movement and migration associated with spawning aggregations of Nassau (*Epinephelus striatus*) and yellowfin grouper within the Grammanik Bank, a small (1.5 km^2) seasonal closure on the southern shelf edge of the US Virgin Islands.

METHODS

This study was conducted during the 2007 and 2008 spawning season. In 2007 an array of 8 acoustic receivers was strategically placed in an overlapping curtain covering about 6 km^2 around the FSA site. Each acoustic receiver had a detection range of about 400 m radius. Five male and 5 female groupers of each species were collected using baited fish traps, sexed using ultrasound imaging, acoustically tagged with Vemco V16 acoustic tags and released by divers on the aggregation site. The transmitter identification code, date and time of arrival and departure were recorded for each fish that passed within 400 m of a receiver and these data were archived until the receiver was downloaded. At the end of the first spawning season, acoustic receivers were downloaded, and preliminary data indicated that groupers moved well beyond this 6 km^2 area. In 2008 the acoustic array was expanded to 21 receivers which covered about 13 km^2 area. An additional five male and five female groupers of each species were acoustically tagged and released on the aggregation site. At the end of the second spawning season acoustic receivers were downloaded and data analyzed using two methodologies. The first method examined the spatial movement patterns of individual groupers across the acoustic array. These movements were plotted on a benthic habitat map and provided an idea of the extent of movements, habitat usage and migratory pathways. The second method provided an estimate of residence time on the FSA site and temporal patterns of movement. Each time a fish was detected by a receiver, an individual dot was plotted on a map within the acoustic detection circle. The more detections that were received by a particular receiver, the more dots that were plotted with its area.

RESULTS AND DISCUSSION

Data indicate that both species commonly moved 1 to 3 km in a few hours and could cover 20 km in a 24 hour period. Movements of tagged groupers at the spawning site carried them outside the existing closure boundaries and exposed them to fishing mortality on a daily basis. Nassau and yellowfin groupers spent an average of 75% and 44% of their time within the Grammanik Bank closure. We identified the migratory pathways of both species. Nassau and yellowfin groupers primarily used two of three deep (50 m) parallel linear reefs that were east-west in orientation and parallel to the shelf edge. The linear reef that ran along the edge of the shelf was not used by any tagged fish. The linear reef about 300 - 500 m north of the shelf edge was used mostly by Nassau grouper. The northern most linear reef which was about 1 km from the shelf edge was used mostly by yellowfin grouper. Of particular interest, these migratory pathways linked the Grammanik Bank closure and another large 41 km^2 marine protected area (Marine Conservation District) 3 km west. Our data indicated that 56% of tagged Nassau and 63% of tagged yellowfin grouper traversed into the MCD repeatedly during spawning and entered the eastern edge of the MCD after they departed the FSA site at the end of the spawning season. These results indicate that the existing Grammanik Bank boundaries are too small. If the boundaries are increase to about 7.5 km^2 and included the primary migration route of the Nassau then the level of protection of both Nassau and yellowfin grouper increase to 96% and 60%, respectively. If the size of the closure is increase to about 11.5 km^2 and includes the primary yellowfin migration corridor then the level of protection of both Nassau and yellowfin grouper increase to 99% and 97%, respectively. This study highlights the importance of understanding the spatial and temporal aspects of fish at spawning aggregating sites. This study also provides a novel method of adaptive management that reduces the uncertainty of MPA placement by defining biologically-relevant boundaries which can be justified to fishermen and other stakeholders.