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ABSTRACT

Four potential *Epinephelus guttatus* (red hind spawning) aggregation sites were sampled in the Southeast of Tortola during full moons of January and February 2002. These sites were re-sampled in 2003 with the addition of another site in the North of Tortola. Three of the sites in the South and the one in the North were historical aggregation areas located with the assistance of local fishers. The sites were fished with hand lines, spear guns, and fish traps. Site B produced 67 red hind, many of which were in a mature active reproductive state. The male to female ratio at the site was 1:2.9. A dive on site B revealed a structurally complex habitat dominated by flattened overhanging stony corals and a depth of 40 to 42 meters. The other three sites sampled did not produce as many fish as site B and had much more skewed sex ratios. The size distribution for red hind appears to be fairly similar for BVI, USVI, and Puerto Rico, however more large males were collected during our sampling than have been reported in those areas. Based on gonosomatic indices and reproductive stages, spawning is believed to have occurred during the week of January's full moon in 2002. Mean size of fish from Northern sites (33.6 ± 6.1 cm TL) was significantly different from fish caught at Southern sites (37.7 ± 6.5 cm TL), but not significantly different from the mean size of red hind landed at the BVI fishing complex (33.9 ± 5.81 cm TL). The following year between January and March, 220 red hind fish were tagged and released at spawning aggregation sites in a preliminary attempt to examine spawning migration distances. No tagged fish were recaptured at the sites nor have they been reported captured in the territory. The results presented here are preliminary and are the initiation of a long-term study to assess the status of the red hind in BVI. Future research will focus on red hind movement within the territory, and migration across territory boundaries on the insular shelf.

KEY WORDS: BVI, red hind, spawning aggregations

Investigaciones Preliminares sobre la Pesqueria de Tofia en Las Islas Virgenes Inglesas

Las Islas Virgenes Inglesas (BVI), USVI, y Puerto Rico se localizan en el mismo estante continental. Sin embargo, las poblaciones de tofia en BVI no han sido tan explotadas como los de USVI y Puerto Rico. Tofia tiene un alto valor comercial y en el año pasado represento aproximadamente 17% de la pecsca comercial arrecifal por peso en BVI. Con la desaparición virtual del mero gallina, es discutiblemente el pez arrecifal mas importante económicamente del territorio.

Datos limitados existen para las pesquerías de BVI, así que la condición del tofia esta incierta. En los 1990's, pescadores reportaron un descenso dramático en los números de tofia, junto con una disminución en el tamaño medio. En 1996, el Ministerio de Recursos cerro la pesquería para los meses de diciembre, enero, y febrero. Los efectos de este cierre no se han investigado.

Datos sobre la pesca se han colectado rutinariamente en BVI en el pueblo de Road Town desde noviembre 2001. En 2002, un estudio por el Departamento de Conservación y Pesquerías se empezo sobre la condición de tofia en las aguas de BVI. La primera fase del estudio concentró en obtener el ayuda de pescadores locales para localizar los agregaciones de desove, caracterizar la dinámica de los agregaciones, comparar la composición del tamaño con el tamaño medio en el BVI fuera de tiempos de desove, proporciones de sexo, y el tiempo y duración de los agregaciones de desove. La segunda fase concentró en un estudio de la marca y la recaptura en agregaciones de desove en el territorio.

PALABRAS CLAVES: Agregaciones de desove, tofia, tamaño

INTRODUCTION

Epinephelus guttatus (red hind), a protogynous hermaphrodite, forms short-term aggregations to spawn. The biology of the red hind is well studied and spawning aggregations have been identified in Puerto Rico and the U.S. Virgin Islands (USVI) (Garcia-Moliner 1986, Colin et al. 1987, Sadovy et al. 1994). In these areas, fish are known to aggregate in large groups on banks close to the edge of the insular platform during the months of January and February. Spawning occurs around the full moon, in small clusters containing one male and one to several females.

In 1990, a spawning aggregation closure was implemented off the island of St. Thomas in the USVI; a result of concerns that heavy fishing pressure on red hind during the spawning season had contributed to a marked decrease in the population size, average body size and male to female aggregation sex ratio (Beets and Friedlander 1992, Sadovy and Figuerola 1992, Sadovy et al. 1994). By 1997, studies indicated that the number and size of fish in the hind aggregation inside the closed area had increased, and a more even aggregation sex ratio was present (Beets and Friedlander 1999).

The British Virgin Islands (BVI), USVI and Puerto Rico are located on the

same continental shelf. Red hind populations in BVI have not been exploited as heavily as they have been in USVI and Puerto Rico however. Red hind has a high commercial value and in the last year represented approximately 17 percent of the reef-fish by weight caught commercially in the BVI. With the virtual disappearance of the Nassau grouper, it is arguably the most economically important reef fish in the territory.

Limited catch data exist for BVI fisheries, so the status of the red hind stock is uncertain. Fish catch data has been routinely gathered from the Government Fishing Complex in Road Town since November 2001 and fishers have been asked to broadly indicate where they are fishing, using a four km^2 grid. A detailed database has been created of catch total and divided into total weight by species and sample length and weight. As sample weight and individual fish of each sample are linked to the grid square, maps can be derived to characterize various aspects of the fishery (Mills et.al 2003).

In the early 1990s fishers reported a dramatic decline in red hind numbers, along with a marked decrease in average size. Operating on the precautionary principal, the Ministry of Natural Resources and Labor, in 1996, closed down the hind fishery for the months of December, January and February. The effects of this closure have not been investigated.

In 2002, the status of red hind in BVI waters became the focus of a long-term study initiated by the Conservation and Fisheries Department. The first phase of the study focused on obtaining assistance from local fishermen to locate traditional red hind aggregation sites. Our objectives were to identify positive spawning areas and begin to characterize the spawning group dynamics, including size composition, sex ratios and timing and duration of aggregation and spawning. Comparison of fish size at spawning aggregations and fish landed at the BVI fishing complex could give insights on the status of redhind fish stocks in the BVI.

The following year the study focused on tagging redhind fish in a preliminary attempt to establish site fidelity of redhind in the BVI and distance they travel to spawning aggregations. Fish mark and recapture projects (visual, acouctic and satellite) have been successfully used in fish movement studies to estimate home ranges (Eristhee et al.) migration routes and distances of species of interest. Few studies have attempted to track fish from spawning aggregations. Colin (1992) tagged grouper and recaptured one 110 Km from where it was tagged. Carter et al. (1994) implanted an acoustic tag in a Nassau grouper at Caye Glory on the Belize barrier reef. Two years later the fish was recaptured in Yucatan, 240 km from where it was tagged. Sadovy (1994) recovered a tag two years after, 18 km from where the red hind had been tagged at a spawning site.

The limitations of visual mark and recapture projects are well documented; however, it remains the most simple and cost-effective technique for estimating migration routes and distances traveled by fish. Essentially, fish are captured measured and tagged with “spaghetti”, nylon dart tags. When time and location of recapture is established, distance traveled as well as growth rate may be inferred if size and other morphometric data were recorded at the time of first capture.

MATERIALS AND METHODS

Landed Catch Data

Fish catch data have been routinely gathered from the Government Fishing Complex in Road Town since November 2001, and fishers have been asked to broadly indicate where they are fishing, using a four km^2. Data collectors visited the BVI fishing complex approximately three times a week, early in the mornings from November 2001 to March 2004. This enabled them to collect data from fish, delivered in the evening and early morning, prior to being processed at the fishing complex. Catches were separated by species, with each species being placed in individual trays. The total weight of each species was obtained using a digital industrial scale capable of taking measurements up to 1/10,000 of a gram.

Total lengths were measured for all red hind caught and the weight of individual fish was measured on a digital scale. 533 measurements of total length (L) and weight (W) of red hind caught in BVI waters were collected at the Fishing Complex. Additionally, 106 such pairs of data were collected as part of a study of spawning aggregations. Another 39 data pairs and 181 measurements of total length (L) were obtained as part of a tagging study carried out by the Fisheries Division of the Conservation and Fisheries Department. The size of Redhind landed at the BVI fishing complex were then compared with those caught at spawning aggregation sites around the territory.

Identification of Traditional Spawning Aggregation Sites

BVI fishers identified several potential spawning sites during informal interviews, all of which were marked and recorded. Logistics and weather limited our sampling efforts to the area southeast of Tortola, though one site in the Northeast was sampled in 2003. Mr. Warren Durant, and David Issac, commercial fishermen who have successfully fished red hind for over thirty years, directed and accompanied staff to several banks on the southeast edge of the BVI's offshore shelf and the North Anegada Bank that historically have held large numbers of fish around the full moons of December and January. An additional site was added after drift fishing a bank close to a historical site yielded several large ripe females. Figure 1 show sites sampled during the study.

Sixteen fish traps baited with squid were deployed on four sites. Traps were constructed of black plastic coated wire (51 mm^2 mesh) braced with cut birch branches. Trap dimensions were 0.9 x 1.2 x 0.5 m. Two buoys were tied to each trap with 45 m of polypropylene line. Traps were pulled, emptied and re-baited approximately every other day from 26 January 2002 until 27 February 2002 as weather permitted. By then, catches had declined, and most females had ovaries in post-spawning condition. After 4 February, two sites, which had caught very few fish, were not sampled as heavily. Some of the traps on these sites (A and D) were moved to the two sites that had produced more fish during the week of the full moon (B and C). SCUBA dives were made on site A on 25 January 2002 and site B on 6 February 2002. Both areas

were filmed for later characterization of habitat. Five red hind were collected by spear gun during the dive at site B.

All fish collected by trap, spear gun or hook and line were taken to the laboratory for examination. They were measured to the nearest millimeter (fork length, FL), weighed to the nearest gram, and sexed. Ovaries and testes were staged macroscopically according to staging criteria from Sadovy et al. (1994). Ovaries were weighed to the nearest .01 g for gonosomatic index [GSI = 100(ovary weight/somatic weight)] analysis. Catch per unit effort for each site was calculated based on number of fish collected per trap pulled. Sex ratios were calculated for both the overall collection period and for each site. Average GSI for each collection date was calculated and the relative proportion of female individuals in each maturation stage on each collection date was determined.

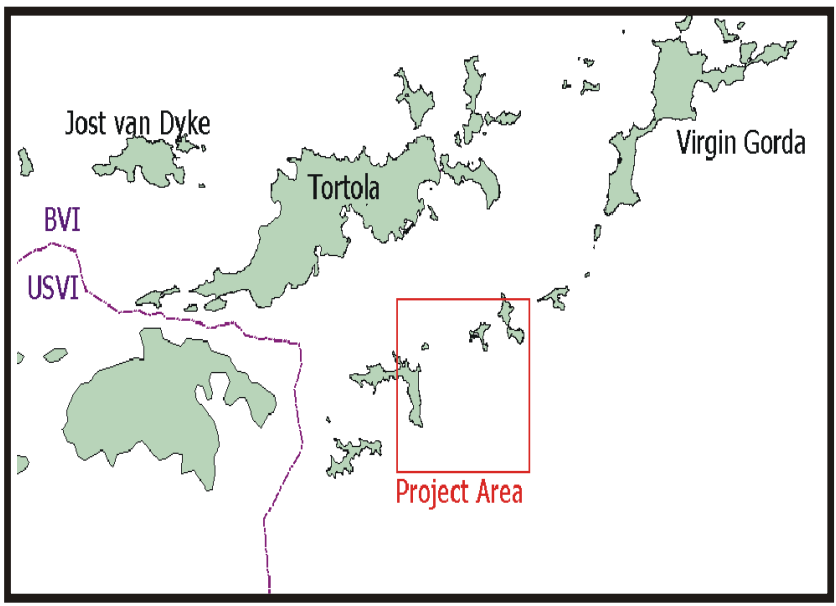

Figure 1. Map of the British Virgin Islands showing locations of the sites sampled for red hind in 2002 and 2003.

Spawning Migration Distances

In 2003, researchers in USVI reported successful in examination of redhind gonads using ultrasound technology (Rick Nemeth Pers. comm.). Sacrificing fish for GSI analyses was discontinued as concerns that aggressive sampling for macroscopic staging of gonads of redhind, at spawning aggregation sites may lead to critical reduction of aggregation numbers increased.

Redhind fish were caught at spawning aggregation sites around the territory, tagged, and released. Each fish was measured to the nearest millimeter, tagged through the dorsal musculature, swim bladders were

deflated using a sterile hypodermic needle, and the fish were released. Each tag contained a unique identification number and contact information, should fishers recapture the fish. Each tag was color coded based on the location where the fish was caught to facilitate rapid identification of tagging location when the fish was recaptured. GPS coordinates of tagging locations were recorded and added to the Territory's Fish Catch Database to facilitate analysis of distance traveled to and from spawning aggregation sites.

Statistical Analyses

Statistical analyses were carried out using SPSS 11.0 statistical package. Data were tested for normality and homogeneity of variance, and in some instances transformed using natural log so as to conform to the conditions necessary for parametric testing.

RESULTS AND CONCLUSION

Traditional Spawning Aggregation Sites

During the study, 121 red hind were caught by hook and line, spear gun or fish trap in th southern part of the BVI. Number of fish caught, CPUE, and sex ratio all differed significantly in the four sites sampled. Site B, the bank found by drift fishing near the historical aggregation area, produced the most fish, highest CPUE, and closest ratio of males to females (1:2.9).

We believe site B to be an active spawning site. During a dive on the site, eight days after January's full moon, we observed over 60 relatively large red hind, the majority suspended over coral bottom. The fish neither hid nor swam away when approached. The site is a relatively small bank in 40 - 42 meters of water, dominated by stony corals and sponges. The substrate is highly complex with many places for fish to escape predators. A dive at the nearby site A was less promising. The bank was 30 - 32 meters deep, had a much less structurally complex habitat, and few red hind were observed. Site C, approximately 4 kilometers to the southwest, produced 32 fish, most of which were in a mature active reproductive stage during the week of full moon. The sex ratio was highly skewed towards females however. This bank may be an over-exploited historic spawning bank, or may be close to a more active spawning aggregation. Site D produced only six fish, five of which were males. This is no reason to believe that any spawning activity was occurring on this site. There was significant difference in mean size of fish caught by the different gear types, with larger fish being caught by traps (Table 1. $F = 10.31$ $p < 0.01$), possibly because traps formed refuges on the bottom during aggregations; however when all logistics were considered the use of handlines was the preferred method of fish capture.

Table 1. Showing means, size ranges and results of ANOVA comparisons of redhind fish caught in the BVI when grouped by gear type, sex and origin.

Grouping Factors		Observations (N)	Means ± SD (cm)	Size Range (cm)	Test Statistic	P - Value
Gear	Handline	10	31.7 ± 5.0	25.2 – 41.7		
	Spear Guns	5	46.4 ± 3.2	41.4 – 50.1	F= 10.31	< 0.01
	Trap	94	37.7 ± 6.0	25.8 - 52.8		
Sex	Males	21	44.8 ± 5.1			
	Females	84	35.4 ± 5.4		t= 6.91	< 0.01
* Origin	N. Spag. Site	204	33.6 ± 6.1	25.3 – 48.9 20.0 – 56.0		
	S. Spag Site	138	37.7 ± 6.5	23.0 – 52.8	F= 23.35	< 0.01
	BVI Fishing Complex	533	33.9 ± 5.8	21.0 – 67.1		

When the data was grouped by sex, (Table 1) mean length of males was 44.8 ± 5.1 cm (n = 21) and ranged from 33.9 cm to 52.8 cm FL and females (n = 84) had a mean length of 35.4 ± 5.4 cm and ranged from 25.2 to 48.9 cm FL. Males were significantly larger than females (independent t test: $t = 6.91$, $p < 0.01$). Length frequencies for males and females are shown in Figure 2. Size ranges found for males and females were similar to those seen in Puerto Rico and USVI (Sadovy 1994, Beets and Friedlander 1999), with the exception of some larger males being present in BVI samples. The sex ratio over the study period was 1:4.0, significantly different from unity ($p < 0.005$, chi-square). Spawning activity appeared to occur around full moon in January in 2002. Female GSIs and the proportion of mature active ovaries over time show a peak within a week of full moon (Figure 3 and 4).

A traditional spawning bank in the Northern region of the BVI produced 204 fish, with a mean length of 33.6 ± 6.1 cm; ranging from 20.0 to 56.0 cm (Table 1). Fifty percent of the fish at this site were caught in one hour of fishing. Fish are only caught at this site during January and March, (David Issac Pers. comm.). ANOVA, followed by Tukey HSD test revealed that a significant difference exist between the size of fish caught at Southern spawning aggregation sites, Northern spawning aggregation site and fish landed at the BVI Fishing complex. No significant difference was identified between fish caught at Northern spawning aggregation sites and those landed at the BVI fishing Complex. This result could indicate that the majority of redhind landed at the BVI fishing complex comes from the Northern part of the territory, and that redhind populations in the Northern part of the territory may be separate and distinct from those in the Southern part of the territory.

Evidence for this may be provided by genetic and tagging studies. Mean size of fish in the North is smaller than those in the Southern part of the territory (Table 1) possibly because of heavier fishing pressure at Northern fishing grounds, as evidenced by reported fishing locations provided by fishers as part if data collected at the BVI fishing complex. The proximity of Southern spawning aggregation sites to international shipping lanes may provide some protection for red hind as fishers are reluctant to place fish traps in areas where they are frequently lost to boat traffic.

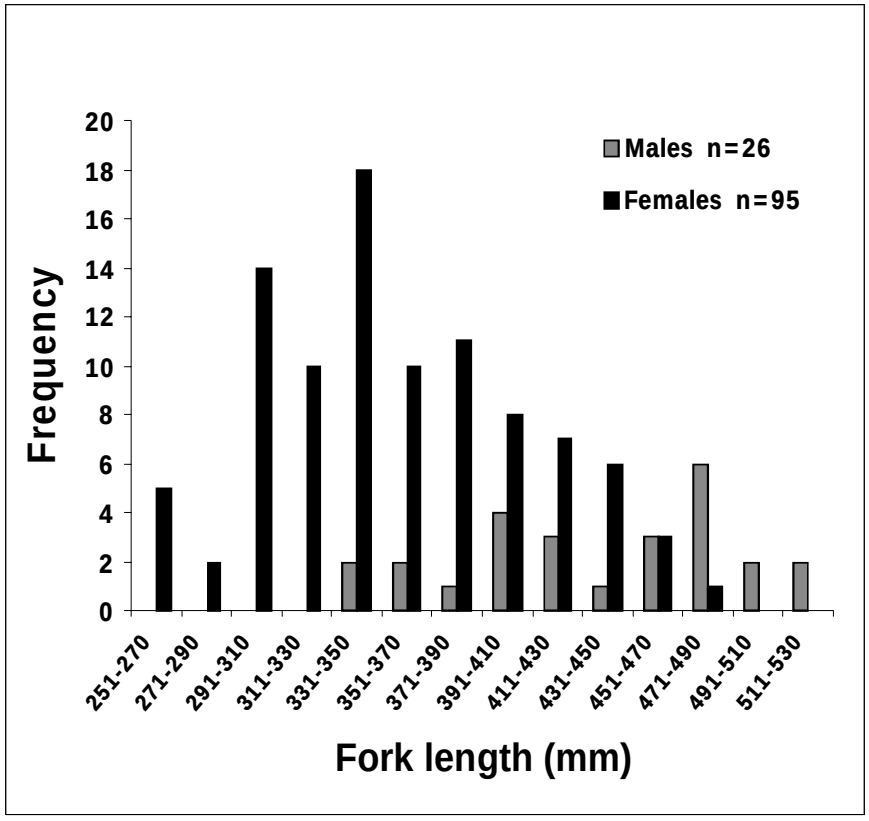

Figure 2. Size frequency distribution of male and female red hind collected in the BVI during 2002. Sample sizes (n) of each sex are given.

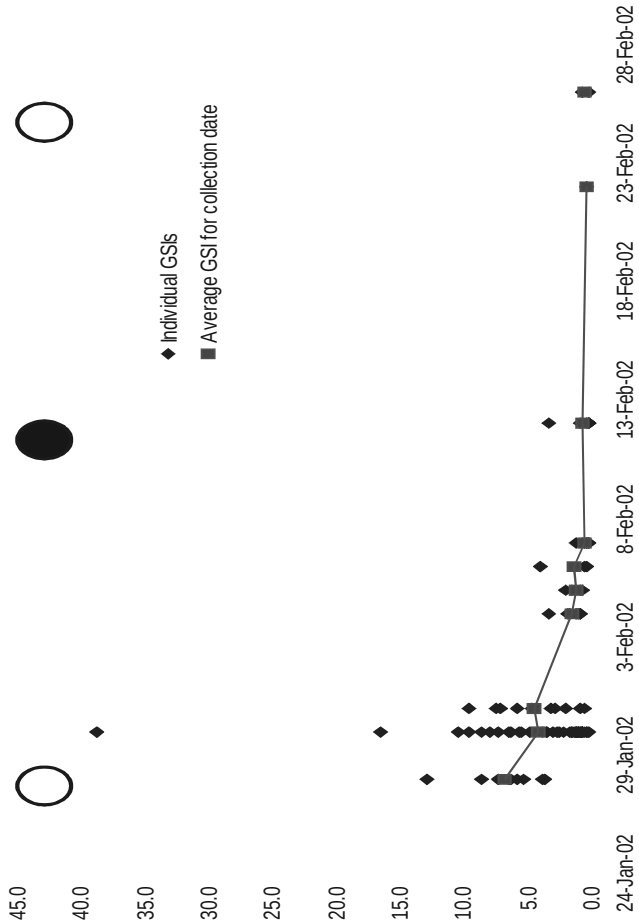

Figure 3. Frequency of female red hind that are maturing (F2), mature active (F3) and post-spawning (F4) for each collection day. Open circles indicate full moon and closed circle new moon.

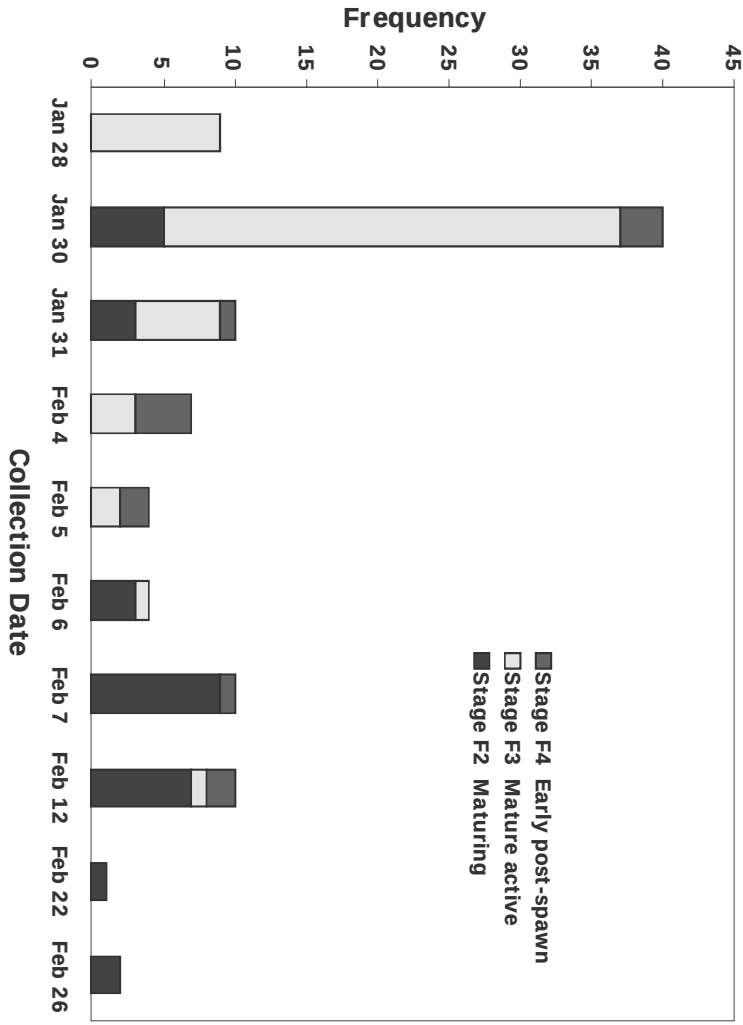

Figure 4. Frequency of female red hind and the stage of gonads for each collection day, maturing (F2), mature active (F3) and post-spawning (F4).

Spawning Migration Distances

Two hundred and twenty (220) fish were tagged during the spawning aggregation months (January – March) 2003. Mean size of fish tagged was 33.2 ± 6.0 cm ranging in size from 20.0-56.0 cm. No tagged fish were recaptured. It is possible that fish were preyed on, when released, by large predators often seen at spawning aggregation sites. Innovative methods of returning fish to the bottom after tagging may play a role in ensuring recaptures in future tagging studies.

Analysis of the small data set represents only a preliminary examination of questions to be addressed in assessing the status of red hind in BVI waters. A larger data set would provide a more rigorous examination of the results presented here. Sustaining red hind populations in BVI waters are not only critical for BVI fisheries, but could play a key role in keeping populations on other areas of the shelf (i.e. USVI and Puerto Rico) at sustainable levels. The west moving Caribbean current and associated eddies are complex and poorly understood, but "upstream" banks on the common insular shelf could conceivably supply recruits to areas as far away as Hispanola. Future research will focus on genetic differences and similarities across the shelf, a continued examination of spawning migration distances, and determining whether year round aggregation site closures would be a more effective management tool for red hind in the BVI than the currently imposed seasonal closure.

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