Validation of a Mutton Snapper (*Lutjanus analis*) Spawning Aggregation in the Mutton Snapper Seasonal Closed Area, St. Croix, U.S. Virgin Islands

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ABSTRACT

In 1993, the Caribbean Fishery Management Council and Government (CFMC) declared an area south of St. Croix seasonally closed from March 1 – June 30th to protect the reported spawning aggregation(s) of mutton snapper (*Lutjanus analis*) south of St. Croix. In 1994, the Government of the U.S. Virgin Islands (USVI) followed with a similar declaration, resulting in a 2 nm sq. area seasonally closed to fishing. In 2005 (CFMC) and 2006 (USVI), a seasonal prohibition on the harvest of mutton snapper from April 1 – June 30th was implemented in federal and territorial waters. From March – July 2009 we used visual censuses, hook and line catches and fisher interviews to validate the seasonal occurrence of mutton snapper spawning aggregation(s) within the Mutton Snapper Seasonal Closed Area (MSSCA). Fishing was performed two to three nights each month from three days before to five nights after the full moon. Of the 95 fish caught 65 were males and 30 females. Visual censuses on scuba were undertaken at dusk within the MSSCA, however, zero to a maximum of two fish were detected on each dive and no aggregation of *L. analis* was observed either in the water column or near the substrate. The peak spawning occurred in May and June. The largest female had a FL 65.3 cm, weighed 5.85 kg with a GSI of 4.0. The largest male had a FL 66.0 cm, weighing 5.73 kg with a GSI of 2.1.

KEY WORDS: Coral reef, management, *Lutjanus analis*

Validación de un Snapper del Cordero (*Lutjanus analis*) Frezando la Agregación en el Encierro Estacional del Área de los Snapper del Cordero, St. Croix, los E.E.U.U. Islas Vírgenes

En 1993, el consejo y el gobierno del Caribe (CFMC) de la gerencia de la industria pesquera declararon un sur del área del St. Croix se cerró estacional de del 1 de marzo al 30 de junioth para proteger las agregaciones de freza divulgadas de los snapper del cordero (*Lutjanus analis*) sur del St. Croix. En 1994, el gobierno de los E.E.U.U. Islas Vírgenes (USVI) siguieron con un declaración similar, dando por resultado 2 nanómetro sq. área cerrada estacional a la pesca. En 2005 (CFMC) y 2006 (USVI) una prohibición estacional en la cosecha de los snapper del cordero del 1 de abril al 30 de junioth fue puesto en ejecución en aguas federales y territoriales. A partir de marcha - julio de 2009 utilizamos censos visuales, gancho y línea retenes y las entrevistas del pescador para validar la ocurrencia estacional de las agregaciones de freza de los snapper del cordero dentro del encierro estacional del área de los Snapper del cordero (MSSCA). La pesca fue realizada dos a tres noches cada mes a partir de tres días antes a cinco noches después de la Luna Llena. De los 95 pescados cogidos 65 estaban los varones y 30 hembras. Los censos visuales en la escafandra autónoma fueron emprendidos en la oscuridad dentro del MSSCA, sin embargo, cero a un máximo de dos pescados fue detectado en cada zambullida y ninguna agregación de *L. analis* fue observado en la columna del agua o acercan al substrato. La freza del pico ocurrió en mayo y junio. La hembra más grande tenía un FL 65.3 centímetros, pesados 5.85 kilogramos con un GSI de 4.0. El varón más grande tenía un FL 66.0 centímetros, pesando 5.73 kilogramos con un GSI de 2.1.

PALABRAS CLAVES: Filón coralino, gerencia, *Lutjanus analis*

Validation d'une Agregation de Reproduction de Vivaneau Sorbe (*Lutjanus analis*) hors St. Crois, Îles Vierges des États-Unis

En 1993, le Caribbean Fishery Management Council and Government(CFMC) a déclaré une zone au sud de Sainte-Croix saisonnièrement fermée du 1er mars - 30 juin pour protéger les agrégations de reproduction de vivaneau sorbe (*Lutjanus analis*) au sud de Sainte-Croix. En 1994, le Gouvernement des îles Vierges américaines (USVI), suivie par une déclaration similaire, résultant en une zone fermée à la pêche saisonnière de 2 nm carrés. En 2005 (CFMC) et 2006 (USVI) une interdiction saisonnière de la récolte de vivaneau sorbe du 1er avril - 30 juin a été mise en œuvre dans les eaux fédérales et territoriales. De mars - juillet 2009, nous avons utilisé un recensement visuel, des prises au crochet et à ligne et des enquêtes de pêcheurs, afin de valider l'apparition saisonnière d'agrégation de frai de vivaneau sorbe dans la zone fermée. Des 93 poissons capturés avec un hameçon et à la ligne, 61 étaient des mâles mûrs et 29 femelles mûres. La pêche a été effectuée de trois jours avant à cinq nuits après la pleine lune. Le pic de la période de reproduction a eu lieu en mai et juin. La plus grande des femelles était FL 63.3 cm, pesant 4.71 kg avec une GSI de 2,9. Le plus grand mâle était FL 66,0 cm, pesant 5.73 kg avec une GSI de 2,1.

MOTS CLÉS: *Lutjanus analis*, vivaneau sorbe, USVI

INTRODUCTION

Spawning aggregations of snapper and grouper are vulnerable to targeted fishing by recreational and commercial fishers on known spawning aggregations (Beets and Friedlander 1992, Claro and Lindeman 2003, Nemeth 2005). Targeted fishing of spawning aggregations in the US Virgin Islands occurred in the 1960s and 1970s resulting in the loss of a Nassau grouper (*Epinephelus striatus*) aggregation on St. Croix by 1971 and the sharp decline in an aggregation off St. Thomas in 1975 - 1976 (Olson and LaPlace 1978) with the eventual loss of the aggregation in the 1980's. Loss of the Nassau grouper spawning aggregation focused fisher attention on the importance of protecting aggregations and resulted in

seasonal closure of the red hind (*E. guttatus*) spawning aggregation south of St. Thomas. A similar seasonal closure for red hind was instituted on Lang Bank, St. Croix.

While snapper appear to be less vulnerable to overfishing, there is evidence targeted fishing of spawning aggregations has caused the decline of some species (Claro *et al*. 2009, Matos-Caraballo *et al*. 2006). Puerto Rican commercial fishers reported a significant decline in catches of *Lutjanus analis* (Matos-Caraballo *et al*. 2006). In Cuba, the highest catches of *L. analis* were often obtained during the reproductive period (April to August) with the peak spawning months of May and June accounting for 35 - 40% of the annual catch of this species (Claro *et al*. 2009). Catches of *L. analis* in Cuba were stable until the early 1990's when there were drastic reductions in catches attributed to:

i) A reduction of commercial fishing effort owing to a national crisis that reduced the availability of fishing supplies and gear, and
ii) The development of an intense subsistence fishery in the Archipelago Sabana-Camaguey that targeted *L. analis* among other species.

In 1997 - 1998 catches increased to nearly former levels, but then again declined since 1998 annual catches have been slowly declining and are more variable for the years prior to 1990 (Claro *et al*. 2009).

In 1993, the US Department of Commerce, based on the recommendation of the Caribbean Fishery Management Council (see the CFMC's Amendment 2 to the Fishery Management Plan for the Reef Fish Fishery of Puerto Rico and the USVI) established a seasonal closed area to protect the spawning aggregation of *L. analis* in the southwest corner of St. Croix (58 FR 53145) (see Quinn and Kojis In press for location map). Because only a portion of the spawning area occurred in federal waters, joint territorial and federal protection was essential to protect the spawning aggregation. In 1994, the USVI government established compatible regulations within their area of jurisdiction to establish a seasonally closed area deemed adequately sized to protect the mutton snapper spawning aggregation. The joint efforts of the two governments established an annual seasonal closed area for *L. analis* from March 1 to June 30.

The *Lutjanus analis* aggregation within the seasonally closed area was targeted by St. Croix fishers for many years, even after the implementation of the seasonal closed area. Because fishers often targeted the aggregation at night, enforcement was problematic. In order to increase compliance and improve enforcement, the U.S Department of Commerce in 2005 (50CFR622.33(a)(7)) and USVI Government in 2006 (VIRR 9A 316-14 (c)) implemented regulations to prohibit possession of mutton snapper during the presumed peak spawning months, April 1 to June 30, each year in federal and territorial waters.

NOAA National Marine Fisheries Service (NMFS) Southeast Data, Assessment, and Review (SEDAR) 14 (2007) Review Workshop recommended monitoring spawning aggregations for density (abundance indices) and population parameters such as sex ratio and size of fish.

Partnership with fishers to conduct research was also strongly endorsed by SEDAR 14. (2007). USVI fishers have often expressed dissatisfaction with the lack of monitoring of the status of spawning aggregations after seasonal closures have been put in place. Management of species by seasonal closing spawning areas to all fishing and prohibiting possession of a species during spawning periods can have profound socio-economic effects, especially in the short term, because of the high CPUE of high value fish that occurs when spawning aggregations are fished. Monitoring the effectiveness of regulations protecting spawning aggregations is needed.

Owing to concerns expressed by fishers and managers regarding the status of the *Lutjanus analis* aggregation, a study was conducted to:

i) Determine if mutton snapper still aggregated within the Mutton Snapper Seasonal Closed Area (MSSCA),
ii) Sample mutton snapper within the MSSCA during the main spawning months to obtain a measure of their abundance (CPUE) and the sex ratio of fish within the spawning aggregation, and
iii) Using fish purchased from fishers in March and July and fish sampled from the MSSCA, determine annual spawning period.

MATERIALS AND METHODS

Fishing Dates and Technique

Lutjanus analis have been recorded to spawn around full moon in the spring and early summer in the northern hemisphere. In the USVI, it is generally thought that mutton snapper (also known as virgin snapper in the USVI) aggregate to spawn annually from March to June.

Permits to fish within the MSSCA and retain fish caught within the MSSCA and during the seasonal closure were obtained from both the US Virgin Islands Department of Planning and Natural Resources (DPNR) and the US Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS).

Fishing for *L. analis* was conducted in 2009 around the full moon in April, May, and June inside the MSSCA (Table 1). Fishing was conducted by experienced St. Croix fishermen as well as scientific personnel each fishing day. Fishing commenced at dusk at around 18:15h in April, 18:30h in May and 19:00h in June and continued until a maximum of 23:30h on nights no or few *L. analis* were caught or until about half the permitted quota of 30 fish per month was caught. Since, only five fish were caught in April, the quota for May was increased to make up for the April shortfall.

Table 1. Days fished for *Lutjanus analis* in the Mutton Snapper Seasonal Closed Area in relation to full moon (0 = date of full moon, numbers refer to days before (-) or after full moon). Sampling days in bold.

Day of month	April Sampling days	April Full moon	May Sampling days	May Full moon	June Sampling days	June Full moon
6	**x**	**-3**		-3		-1
7	**x**	**-2**		-2		0
8		-1		-1		1
9		0		0	**x**	**2**
10		1		1		3
11		2	**x**	**2**	**x**	**4**
12		3	**x**	**3**	**x**	**5**
13	**x**	**4**		4		6

Fishing was done using hand lines with primarily single J hooks (hook size 7 - 8) and 60 - 200 lb test line. Weights were used only occasionally. Lines were baited with round robin (*Decapterus sp.*), hardhead (*Atherinomorus stipes*), and ballyhoo (*Hemiramphus brasiliensis*). A fluorescent light was attached to the top of the center console to help attract fish and allow fishers to see what they were doing. Chumming with cut up bait (primarily ballyhoo) started shortly before fishing commenced and continued periodically during fishing. Fishing line was paid out into the current until it was near the bottom.

Scuba Diving Searches for *Lutjanus analis*

To locate primary spawning aggregation sites of *L. analis* divers were deployed at sites within the MSSCA known by local fishers as excellent fishing sites for *L. analis*. Both stationary point counts and roving diver searches were used to estimate fish abundance. Point counts recorded fish within a 10 m radius of the diver for four minutes. Roving diver searches were conducted using Nitrox (32%) at 20-30 m and typically lasted 50 - 60 min. Two or three roving divers would swim at a constant speed and survey a 10 m wide area while towing a surface buoy. Dives were conducted in April, May and June on and near the shelf edge within the MSSCA. In June dives were done from the boat anchored on the fishing site and searches for *Lutjanus analis* done just prior to fishing in the area fished.

Fish Abundance Assessment by Fishing Effort

To determine fishing effort, the number of lines in the water, start and finish time for fishing and number of individuals of each species of fish caught were recorded for each fishing date. Only *Lutjanus analis* were retained in catches for analysis.

Biometric and Gonad Analysis

L. analis were purchased from fishers in March and July before and after the seasonal closure. Each mutton snapper was weighed using a Pesola 5 kg mechanical scale or a AWS 20 kg digital scale. Fork length was measured using a tape measure or a Picket 76 mm plastic fish measuring board. Fish were dissected, sex determined and gonads removed, photographed and immediately weighed.

Fish purchased in March were frozen and analyzed after thawing. Fish length shortens after freezing. Therefore, the length for frozen fish was adjusted based on the difference in fork length of four fish before and after freezing. Fish caught or purchased after March were not frozen and were analyzed within 24 hours of sampling.

RESULTS

Catch per Unit Effort

The catch rate for *Lutjanus analis* in the MSSCA was highest in May and June (Figure 1). In April, fishing was done on three nights, two nights before the full moon and one night after the full moon (Table 1). Only a few *L. analis* were caught in April, and only on fishing nights before the full moon. No fish were caught four days after full moon in April, even though 13 *L. analis* were caught in less than three hrs on the 4th day after full moon in June.

***In situ* Observations**

Divers did not locate any spawning aggregation within the MSSCA using roving diver or point count surveys. No more than *Lutjanus analis* were seen on any dives conducted in April to June. Even when dives were conducted immediately before fishing commenced, no *L. analis* were seen. Consequently, no estimate of fish density is possible.

Reproductive Aspects

L. analis are dioecious. Of the 95 fish caught in the MSSCA, males were twice as abundant as females (Table 2).

The gonad somatic index (GSI - gonad weight (g) *100/weight of fish (g)) for *L. analis* was highest in April, May and June. GSI was lower and more variable in July.

This was the only month in which a female was found with a spent gonad. This female was sampled on July 18 which was 11 days after full moon (Figure 2, Table 3).

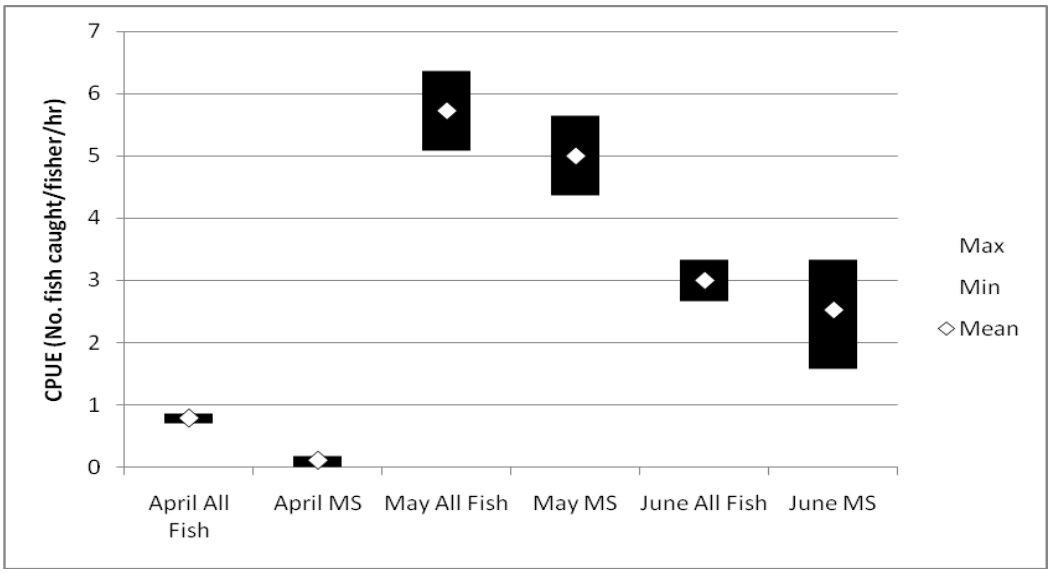

Figure 1. Catch per unit effort for all fish and *Lutjanus analis* (MS) caught in the Mutton Snapper Seasonal Closed Area in 2009 during the three months of the seasonal closure. Number of fishing days/fish caught per month: April = 3/5, May = 2/59, June =3/31.

Table 2. Ratio of number of male to number of female *Lutjanus analis* caught in Mutton Snapper Seasonal Closed Area during the area and seasonal closures.

Month	Male	Female	Sex Ratio
April	2	3	0.7
May	43	16	2.7
June	20	11	1.8
Total	65	30	2.1

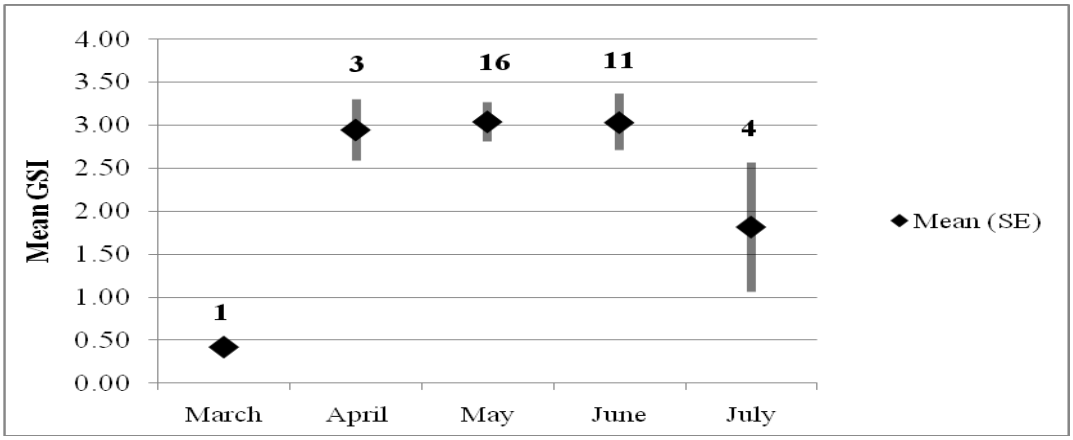

Figure 2. *Lutjanus analis* - Female mean gonad somatic index (GSI) (gonad weight (g)*100/ weight of fish (g)). Number above each symbol is number of females sampled.

Length-weight Ratio

The length weight relationship was calculated for male (n = 70) and female (n = 35) *Lutjanus analis* collected between 24 March and 29 July 2009 (Figure 3). The relationship is very highly significant ($p < 0.001$).

Table 3. Mean gonad somatic index (GSI) and standard error (SE) for males and females and mean fork length (FL) and range of FL of *Lutjanus analis* sampled.

	March		April		May		June		July	
	F	M	F	M	F	M	F	M	F	M
N	1	3	3	2	16	43	11	19	4	3
Mean GSI (SE)	0.42	0.17 (0.05)	2.94 (0.36)	2.14	3.04 (0.22)	2.86 (0.21)	3.03 (0.34)	3.03 (0.31)	1.82 (0.75)	0.93 (0.24)
Mean FL (mm) (range)	599	441 (386-475)	615 (590 - 635)	555 (490-620)	539 (410 - 633)	472 (367 - 600)	518 (393-625)	506 (375-660)	601.5 (550 - 653)	628 (605-644)

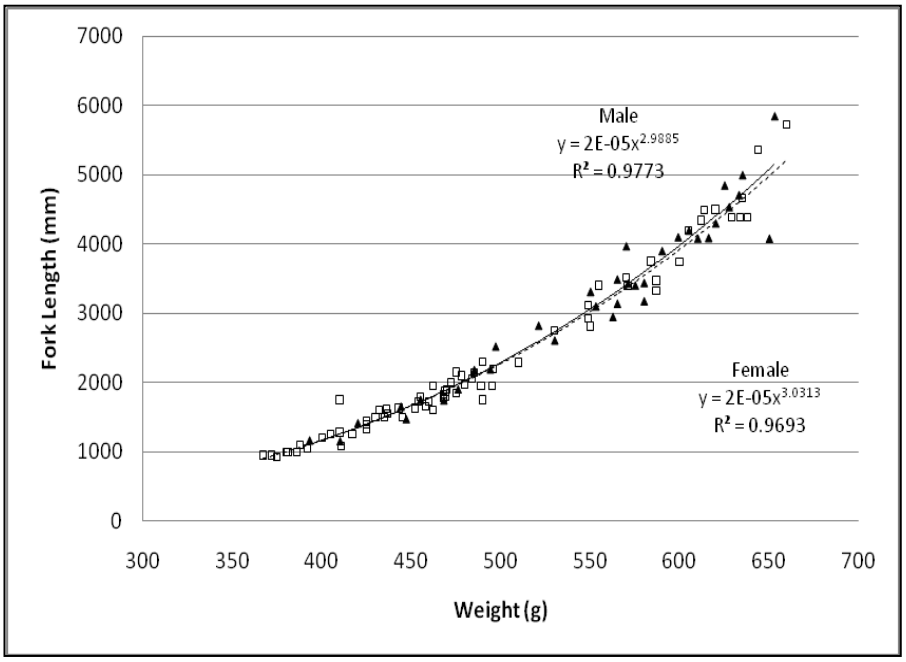

Figure 3. Length weight relationship for male (n = 70) (open squares) and female (n = 35) (filled triangles) *Lutjanus analis* collected between 24 March and 29 July 2009.

DISCUSSION

The goal of this study was to provide information on the status of the *Lutjanus analis* spawning aggregation within the MSSCA on St. Croix, U.S. Virgin Islands, verify the spawning period for this species, and provide life history information. *L. analis* spawn from February to September in the Caribbean (Table 4). The peak spawning period was reported as May and June in Cuba (Claro *et al*. 2009) and April to June in Belize (Heyman and Kjerfve 2008). Spawning months on St. Croix show a similar pattern to Cuba and Puerto Rico with the exception that spawning continues to at least July in St. Croix. Because fish were not sampled in August or September in St. Croix, it is not known if *L. analis* aggregate to spawn in these months as well. The declining GSI in males and females at the end of July (Figure 2 and Table 3) and the occurrence of a spent ovary in a female collected July 18, 2009, 11 days after the July full moon, indicated that the annual spawning cycle was at or near its end.

Table 4. Months with evidence of spawning of *Lutjanus analis* in selected studies from the Caribbean.

Location	Feb.	March	April	May	June	July	August	Sept
Cuba[1]			x	x	x	x	x	
Cuba[2]			x	x	x	x	x	x
Puerto Rico[3]			x	x	x			
Belize[4]	x	x	x	x	x	x	x	
This study			x	x	x	x		

[1]Claro et al. 2009
[2]Claro et al. 2003. Summary of all sites - spawning months varied among sites
[3] Matos-Caraballo *et al*. 2006
[4]Heyman and Kjerfve 2008

The MSSCA has been under management since 1994 by both the Government of the USVI and the US Government. However, prior to this study no survey of the *L. analis* population in the MSSCA had been conducted. While no aggregation was detected during dives conducted in 2009, the high CPUE of *Lutjanus analis* in May and June and the high GSI values from March through July indicated that mutton snapper still aggregate to spawn within or in the vicinity of the MSSCA and, likely do so, in fairly large numbers. The spawning aggregation appears to be robust despite fairly heavy fishing pressure that continued even after the establishment of the area closure. However, since the implementation of the seasonal possession prohibition in federal and territorial waters, it appears fishing pressure on the aggregation has been curtailed.

No spawning or large numbers of *L. analis* were observed either near the bottom or in the water column during scuba surveys. Considering that the scuba observations were made as unobtrusively as possible with only two or three divers in the water and with dives commencing just before dusk and until darkness made further observations impossible, it is difficult to explain why less than 30 minutes after dives were completed that *L. analis* was easily caught in large numbers in May and June. Possibly, the fish are in water > 35m and the chumming and light on the boat drew them to shallower waters where they were caught. Further efforts during the 2010 spawning season will attempt to actually sight the spawning aggregation, make a determination of the size of the population, and describe the spawning behavior.

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