

Occurrence and Management of a Spawning Aggregation of Bluestriped Grunt (*Haemulon sciurus*) in Bermuda

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ABSTRACT

In 2001, the Bermuda Marine Resources Division became aware of a potential spawning aggregation of Bluestriped grunt (*Haemulon sciurus*) at the eastern end of the island. Local fishermen reported that, around the new moon in May, catches of Bluestriped grunt were substantially higher than the rest of the year. This observation was largely substantiated by analysis of historical landings and samples collected at the site in subsequent years. The gonads of many fish caught at the site around the new moons in May of 2001, 2002 and 2006 were in an advanced state of maturation and a number of fish were in spawning condition. However, it appears that the timing of aggregation formation and spawning is variable, as females with hydrated eggs were also observed around the full moons in May of 2007 and 2008 and the new moons in June of 2007 and 2008. The duration of the spawning aggregation has not yet been determined. In 2005, an amendment to the Fisheries Act 1972 gave the Minister responsible for the Environment the authority to place an immediate prohibition on fishing in any designated fish aggregation area by providing notice to the public in the Official Gazette. Using this legislative provision, a ban on fishing in the Bluestriped grunt aggregation area was first implemented in May 2007 for a two month period. The aggregation was also closed to fishing during May and June of 2008 and 2009 in order to allow additional data collection and research.

KEY WORDS: Spawning aggregation, Bluestriped grunt, *Haemulon sciurus*, Bermuda

Frecuencia y Manejo de las Agregaciones Reproductivas del Ronco Carite (*Haemulon sciurus*) en Bermuda

Durante el año 2001, la División de Recursos Marinos de Bermuda se dio cuenta de una agregación reproductiva potencial del ronco carite (*Haemulon sciurus*) en el extremo oriental de la isla. Los pescadores locales reportaron que, durante los días de luna nueva en mayo, las capturas del ronco carite se incrementaban considerablemente en relación con el resto del año. Esa observación fue corroborada en gran medida a través del análisis de los desembarques históricos y las muestras recopiladas en los años posteriores. Las gónadas de muchos peces capturados en el lugar durante los días de luna nueva en mayo, de los años 2001, 2002 y 2006, se encontraban en un estado de maduración avanzado y un número de peces ya estaban en condición de desove. No obstante, parece que el tiempo de la formación de agregación y el desove varía, ya que se observaron hembras con huevos hidratados durante los días de luna llena en mayo de 2007 y 2008 y durante los días de luna nueva en junio de 2007 y 2008. La duración de la agregación aún no ha sido determinada. En el año 2005, una enmienda a la Ley de Pesca de 1972, le otorgó al Ministro responsable del Medio Ambiente la autoridad para prohibir de manera inmediata la pesca en cualquier área designada de agregación de peces notificándose en Gaceta Oficial. Haciendo uso de dicha disposición legal, primero se implementó, en mayo de 2007, una prohibición de pesca en el área de agregación del ronco carite durante un período de dos meses. La agregación fue cerrada también a la pesca durante los meses de mayo y junio de 2008 y 2009.

PALABRAS CLAVES: Agregaciones reproductivas, ronco carite, *Haemulon sciurus*, Bermuda

L'occurrence et la Gestion d'une Agrégation de Frai du Grogneur À Raies Bleues (*Haemulon sciurus*) Aux Bermudes

En 2001, la Division des ressources marines des Bermudes a pris connaissance d'une agrégation de frai potentielle de grogneur à raies bleues (*Haemulon sciurus*) à l'extrémité orientale de l'île. Les pêcheurs locaux ont indiqué que, autour de la nouvelle lune de mai, les captures de grogneur à raies bleues étaient sensiblement plus élevées que durant le reste de l'année. Cette observation a été largement prouvée par l'analyse des débarquements historiques et des échantillons collectés sur le site au cours des années suivantes. Les gonades des poissons capturés sur les lieux vers les nouvelles lunes en mai 2001, 2002 et 2006 étaient dans un état avancé de maturation et un certain nombre de poissons étaient en état de frai. Toutefois, il semble que le calendrier de la formation de l'agrégation et le frai est variable, comme les femelles avec des œufs hydratés ont également été observées autour de la pleine lune en mai 2007 et 2008 et les nouvelles lunes en juin de 2007 et 2008. La durée de l'agrégation de frai n'a pas encore été déterminée. En 2005, un amendement à la Loi sur les pêcheries de 1972 a donné au ministre chargé de l'Environnement le pouvoir de placer une interdiction immédiate de la pêche dans toute zone désignée de concentration de poissons, en publiant des avis au public dans le Journal officiel. Utilisant cette disposition législative, l'interdiction de la pêche dans la zone d'agrégation de grogneurs à raies bleues a d'abord été mise en œuvre en mai 2007 pour une période de deux mois. L'agrégation a également été fermée à la pêche durant mai et juin 2008 et 2009 afin de permettre la collecte de données supplémentaires et la recherche.

MOTS CLÉS: Agrégation de frai, grogneur à raies bleues, *Haemulon sciurus*, Bermudes

INTRODUCTION

The Bluestriped grunt is associated with tropical and sub-tropical reefs in the Western Atlantic (Gaut and Munro 1983, Carpenter 2002, Froese and Pauly 2009). Its relatively small size makes it an important prey species for larger predators. Although of comparatively minor commercial importance in the Caribbean region (Froese and Pauly 2009), Bluestriped grunts were important as live baits in the historical Bermuda grouper fish pot fishery of the 1960s and 1970s and may have some current importance in the recreational fishery in Bermuda, although this has not been quantified.

In 2001, the Marine Resources Division became aware of a potential spawning aggregation of Bluestriped grunt at the eastern end of the island. One senior fisherman claimed that this aggregation had been fished by commercial fishermen for possibly 50 years. The timing of the aggregation appeared to correspond well with the collection period of live baits for use in fish pots leading up to the period of grouper spawning aggregations (May-June). With a decline in commercially important grouper species from 1975 to 1981 (Luckhurst 1996) and a subsequent ban on fish pots in 1990 (Burnett-Herkes and Barnes 1996), species that had previously been unimportant as food fish became more common in the marketplace. Bluestriped grunts found a place in the market as “white meat” fillets and based on reported landings data, it appears that by the mid-1990s fishing at the aggregation site had increased.

Problems arose at the site in 2001 due to the difficulties that some commercial fishermen were having in selling their grunt catches and it was asserted that this was due to the large quantities of grunt fillets being illegally sold to the market by unlicensed/recreational fishermen. Observations by Fisheries wardens from 2003 - 2006 indicated that there could be up to 50 fishing vessels a night fishing on the aggregation during peak fishing periods. Many of these vessels were unlicensed and Fisheries regulations prohibit the sale of fish caught from such vessels. As there is no requirement for recreational fishers to report their catch, fish landed by these fishermen were not enumerated. However, it was ascertained by inspection and interviews with fishermen that a vessel could catch 200+ Bluestriped grunts in one night while the aggregation was present. A simple extrapolation with regard to the number of grunts which could potentially be taken from the aggregation in one night equalled 10,000 grunts (i.e. 50 vessels X 200 grunts per vessel).

This appears to be the first documented instance of a *Haemulon sciurus* spawning aggregation, and reproductive information in general on this species is scarce. The peak reproductive period for Bluestriped grunt in Jamaican waters is reported to be during January and February with high percentages of active and ripe individuals also present in November - December and March - April (Gaut and Munro 1983). In Bermuda, peak spawning appears to occur in May and June.

METHODS

The aggregation area is located at the eastern end of Bermuda beginning at the shoreline and is approximately 1.73 sq. km. in size (Figure 1). The area consists of predominantly sandy bottom with small coral rubble patches but also contains some larger coral reefs. The majority of the specimens examined in this study ($n = 777$) were obtained from four cooperative commercial fishermen who captured the fish by handline at the site. Specimens were also acquired from the area in 2007 and 2008 ($n = 123$) through the trapping efforts of Marine Resources/Fisheries staff. Fish obtained from the fishermen were generally filleted; therefore, fish weights and subsequent estimates of gonadosomatic indexes were not possible. However, specimens caught in traps in 2007 and 2008 were landed whole and somatic and gonad weight data were collected from these individuals. The fork length (FL) of all specimens was measured to the nearest 0.1 cm.

Bluestriped grunt gonads were examined macroscopically and the sex and reproductive state of individuals was estimated using the criteria outlined in Munro and Thompson (1983). The gonadosomatic index (GSI) was calculated from ovaries of female specimens using the following equation: $GSI = (\text{ovary weight}/\text{gonad-free fish weight}) * 100$. Temperature data were collected at the site by a dive computer in 2007 and by daily temperature readings from Onset data loggers located near the site in 2008.

RESULTS AND DISCUSSION

Evaluation of Study Area as a Spawning Aggregation Site

Domeier and Colin (1997) defined a spawning aggregation as “a group of conspecific fish gathered for the purposes of spawning, with fish densities or numbers significantly higher than those found in the area of aggregation during the non-reproductive periods”. They also stated that these aggregations form at “specific places and times”. Based on the Bermuda Bluestriped grunt data collected and analysed to date, it appears that the study site meets these criteria. The gonads of fish captured at the site were in an advanced state of maturation and indirect evidence of spawning was observed by the presence of hydrated eggs in a number of female ovaries. During May and June, Bluestriped grunts appeared to be present in the area in considerably larger numbers than at other times of the year. In addition, this species seemed to be more abundant during specific moon phases as catches of Bluestriped grunt tended to increase around the new moon. Dive surveys conducted on the site during daylight hours in 2007 were not successful in locating the aggregation. However, visibility at the site was poor due to strong currents and sediment suspension. In addition, catches of Bluestriped grunt are known to increase after dusk; therefore, it is possible that the grunts seek shelter in the reefs during the daytime and then reform the aggregation

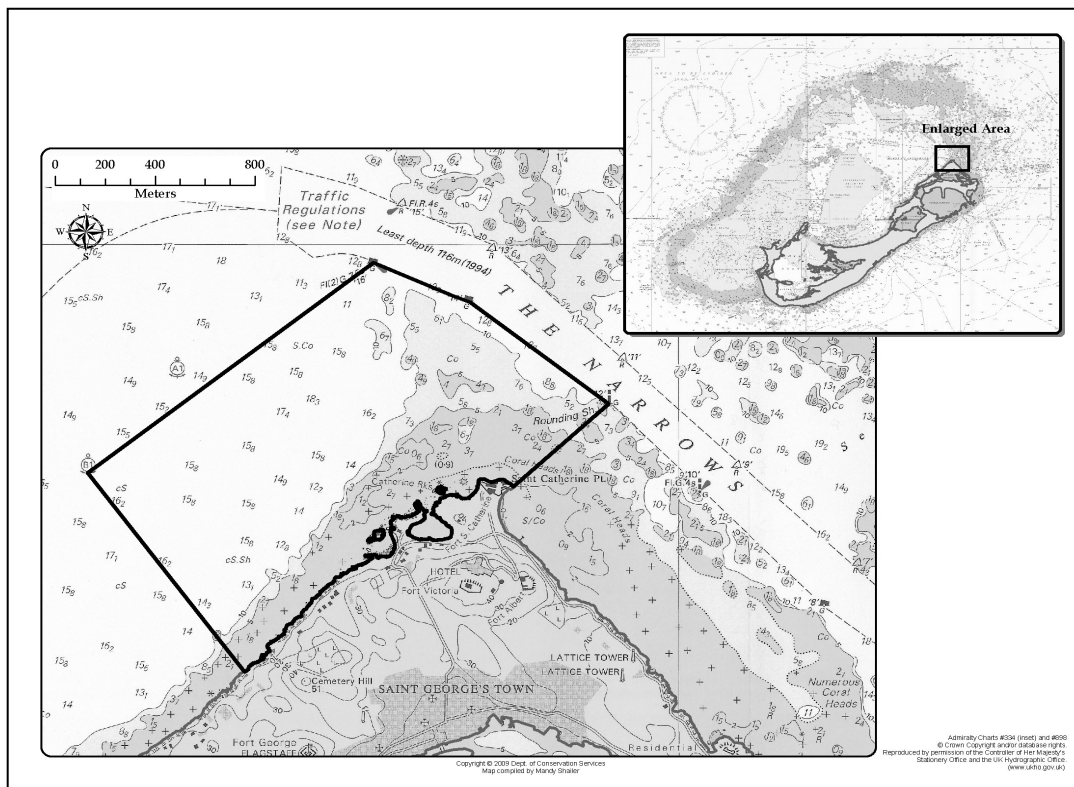


Figure 1. Map of Bermuda and detail of the aggregation area located at the eastern end of the island. Area size = 1.73 sq. km.

over the sandy bottom at dusk. Once present in the area, the aggregation does not appear to persist for more than one week. However, more research is needed to define the duration of the aggregation period.

No published accounts were found in the scientific literature with regard to the occurrence of spawning aggregations of Bluestriped grunt and there are no records of this species in the global spawning aggregation database (SCRFA 2009). However, there are anecdotal accounts of Bluestriped grunt aggregations from fishermen in Belize (Heyman, Texas A&M University Pers. comm.) which still need to be confirmed. There is also documented evidence that a congeneric species, the white margate (*Haemulon album*), forms spawning aggregations in Belize (Heyman and Kjerve 2008) and extended abdomens were noted in females in an aggregation of another congeneric species, the white grunt (*H. plumieri*), off the west coast of Florida (Moe 1966).

Timing of Aggregation Formation and Spawning

An analysis of historical landings data indicates that from 1994 - 1997, approximately one-third of the annual grunt landings were taken in May and June. Thereafter, the proportion of grunts caught in these months increased, presumably as more fishermen became aware of the aggregation site, to an average of over 50% of the annual landings. From 1998 - 2006, the majority of grunts were captured in May, with a high in 2005 of just over

74% of the annual landings taken in May of that year. However, in 2007 and 2008, a higher proportion of the annual landings of grunts were taken in June (Table 1). It was ascertained from interviews with fishermen that the majority of the grunts landed were Bluestriped grunts taken at the aggregation site.

An examination of data collected from the site suggests that the Bluestriped grunt aggregation forms around the new moon in May but this appears to be somewhat dependent on water temperature (Table 2). The limited temperature data available indicates that a temperature of approximately 22°C may be a threshold for the formation of the aggregation and spawning. It appears that when the new moon is early in May, water temperature may not be high enough to promote aggregation formation, and spawning may not occur or may be limited. In these circumstances, the period around the new moon in June seems to be the primary time of reproduction (Table 2). However, more detailed data are needed for confirmation. In addition, the timing of aggregation formation and reproductive activity appears variable as females in spawning condition were observed around the full moons of May 2007 and 2008 and the new moons of June 2007 and 2008 (Table 2). In Cuba, Claro et al (2001) found mature and spawning individuals from November to April with the highest GSI values in November.

Table 1. Annual landings of bluestriped grunt and landings for the months of May and June by number of fish and weight (kgs) for the years 1994 - 2008. Percentages of the annual landings (numbers of fish) for the months of May and June are also given.

Year	Annual landings No. fish	Annual landings Wt - kgs	May landings No. fish	May landings Wt - kgs	May -% of annual	June landings No. fish	June landing Wt - kgs	June - % of annual
1994	5174	2109	1253	550	24.2	625	288	12.1
1995	5693	2826	1035	565	18.2	821	503	14.4
1996	10847	4440	1200	502	11.1	1947	1079	17.9
1997	5940	2677	831	382	14.0	1305	690	22.0
1998	8322	3457	3001	1070	36.1	893	563	10.7
1999	8804	3459	4255	2213	48.3	778	241	8.8
2000	11617	5047	7139	3197	61.5	1227	592	10.6
2001	6305	2674	2796	1399	44.3	661	319	10.5
2002	4796	1865	3050	1277	63.6	242	91	5.0
2003	4185	?	2521	?	60.2	152	60	3.6
2004	3681	1460	2145	954	58.3	101	26	2.7
2005	6814	3186	5071	2581	74.4	208	96	3.1
2006	5256	2115	2558	1136	48.7	501	174	9.5
2007*	2603	1026	182	68	7.0	711	347	27.3
2008**	4478	2118	483	240	11.0	1969	995	45.5

Table 2. Daily sampling summary giving date, lunar phase, collection method, water temperature, number of males, number of females, number of specimens of unknown sex, number of ripe females and number of females with hydrated eggs.

Date	Lunar phase	Collection method	Water temp.°C	No. males	No. females	Sex unknown	No. Ripe Females	Females with hydrated eggs No. (%)
22-May-01	New - 1	Line		33	31	3	31	?
28-May-01	New + 5	Line		21	12	3	12	?
14-Jun-01	New - 7	Line			1		10	1 (100%)
12-May-02	New	Line		30	15	5	10	?
13-May-02	New + 1	Line		68	32	15	32	?
16-May-02	New + 4	Line		4	1		1	
26-May-06	New - 1	Line		44	32	14	2	1 (?)
27-May-06	New	Line		117	72	39	17	6 (?)
29-May-06	New + 2	Line		7	3		3	1 (33%)
11-May-07	New - 5	Line						
14-May-07	New - 2	Line						
16-May-07	New	Line	21.7	1				
23-May-07	New + 7	Trap						
26-May-07	Full - 5	Trap			1		1	
27-May-07	Full - 4	Trap		4	2		2	2 (100%)
31-May-07	Full	Trap		1				
1-Jun-07	Full + 1	Trap/Line	22.8	6	1		1	
5-Jun-07	Full + 5	Trap		2	1		1	
6-Jun-07	Full + 6	Trap		1				
8-Jun-07	New - 7	Trap		11	4		4	3 (75%)
9-Jun-07	New - 6	Trap		4				
13-Jun-07	New - 2	Trap	23.9	5	2		2	1 (50%)
14-Jun-07	New - 1	Trap		1				
15-Jun-07	New	Trap		8	3		3	2 (67%)
16-Jun-07	New + 1	Trap		1	5		5	5 (100%)
17-Jun-07	New + 2	Trap						
18-Jun-07	New + 3	Trap		14	1		1	1 (100%)
19-Jun-07	New + 4	Trap		3	3		2	
21-Jun-07	New + 6	Trap		1				
20-May-08	Full	Trap	21.9	9	3		3	
23-May-08	Full + 3	Trap	22.7	14	4		4	2 (50%)
27-May-08	Full + 7	Trap	22.1	3	0			
29-May-08	New - 5	Trap	22.3	4	1		1	
3-Jun-08	New	Line	23.4	79	41		41	18 (46%)
4-Jun-08	New + 1	Trap	23.9	2				
5-Jun-08	New + 2	Line	24.4	29	12	4	12	

Analysis of mean GSI from ovaries collected at the aggregation site during 2007 showed a general increasing trend in the weeks leading up to the new moon in June, with peak GSI just after the new moon (Figure 2). A subsequent drop in GSI in the week following the new moon suggests that the majority of spawning occurred during that week. A high GSI value was also observed in late May 2007, a week before the full moon on June 1st. These results highlight the variability that was observed in the spawning periodicity of Bluestriped grunt. The GSI values obtained in 2007 ranged from 1.48 to 16.53 with a mean value of 6.53. In Cuba, the mean GSI value obtained for ripe females was 3.5 with a range of 1.0 – 9.7 (Claro *et al.* 2001). Our values are higher, however the sample sizes were small and more detailed information is needed to clarify the reproductive pattern.

Aggregation Sizes, Sex Ratios and Ages

The size-frequency distributions of individuals (active and inactive) taken at the aggregation site are shown in Figure 3. Data were pooled for 2001 - 2002 and 2007 - 2008 to achieve adequate sample sizes. Size classes ranged from 18 cm (which included individuals between 18.0 and 18.9 cm FL) to 35 cm (which included individuals between 35.0 and 35.9 cm FL). There were differences in the size-frequency distributions between years and this may be due to annual variability in recruitment (which could be linked to high fishing mortalities at the site) or variation in aggregation dynamics relative to the sampling dates and/or times. Therefore, caution should be exercised when comparing yearly size distributions of samples taken from the spawning aggregation.

Daily samples, with the exception of the 16th and 19th of June 2007, were male-biased, and this was observed in both line caught and trap caught samples (Table 2). This suggests that males may be present at the aggregation site for longer periods than females, a phenomenon known in

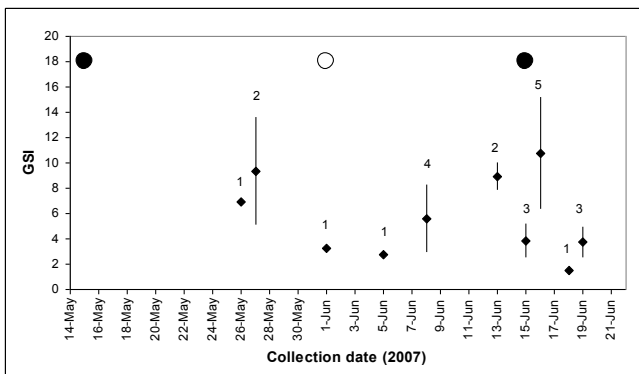


Figure 2. Mean gonadosomatic index (GSI) and standard deviation for ovaries taken from females captured in May and June of 2007. Sample sizes are given for each day. Closed circle indicates new moon and open circle full moon.

groupers species (e.g. Matos-Caraballo *et al.* 2006), or alternatively, that there was differential feeding behaviour. Selective removal of males by fishing at the spawning aggregation could result in sperm limitation and ultimately

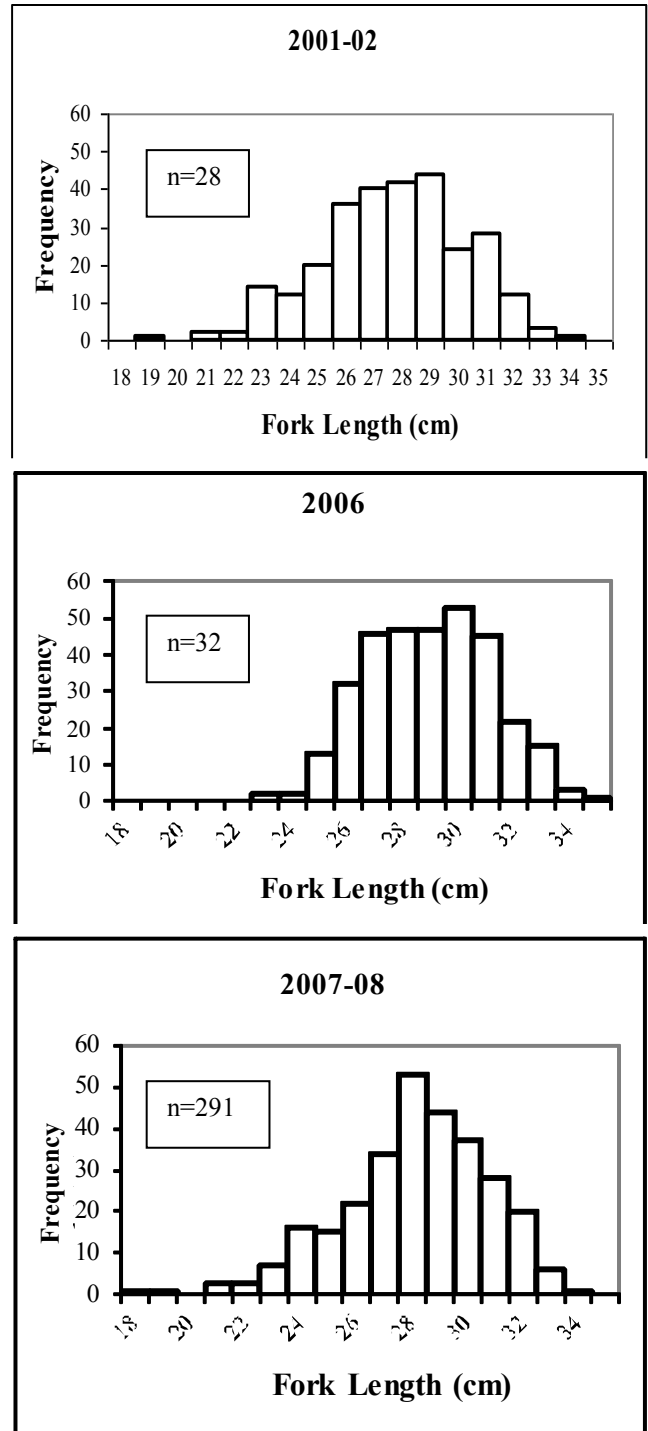


Figure 3. Size-frequency distributions of Bluestriped grunt collected at the spawning aggregation area between 2001 and 2008. Data were pooled for 2001 - 2002 and 2007 - 2008.

to lower reproductive success in this species (Levitán and Petersen 1995). An age distribution of sampled individuals (see Pitt *et al.* this volume for age parameters of Bluestriped grunt from the site) indicates that young males are disproportionately affected by fishing at the aggregation, with 4 and 5 year old males the most frequently taken (Figure 4). Furthermore, males over the age of 18 years are rare. Thus, it appears that male Bluestriped grunts are not as long-lived as their female counterparts.

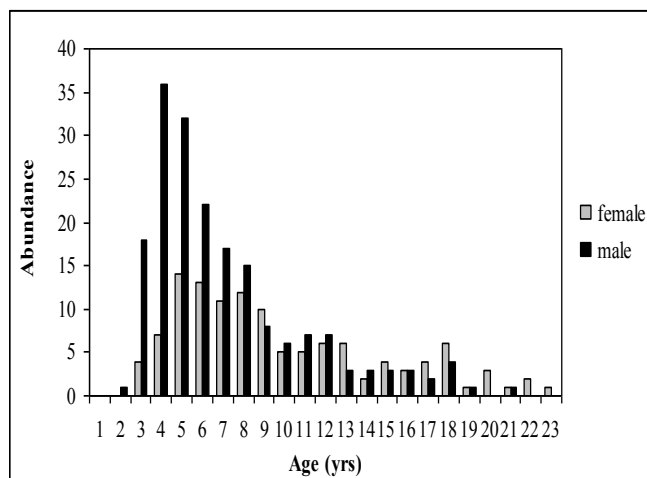


Figure 4. Age distribution of Bluestriped grunt sampled, pooled across sampling years. n = 120 females, n = 189 males.

Management Measures

Because of the ecological importance of the Bluestriped grunt, the Marine Resources Division acted to implement protection for the identified spawning aggregation site of this species during the period of highest vulnerability. This was done using a 2005 amendment to the Fisheries Act 1972 which made provision for the Minister responsible for the Environment to place a ban on fishing in any designated fish aggregation area by notice to the public in the Official Gazette. This amendment was put in place due to the length of time (two years) that it took to gain protection for an aggregation of black grouper (*Mycteroperca bonaci*) discovered in 2003. A seasonal closure of the black grouper aggregation area was implemented after creating an Order under the Fisheries Act 1972, however, the legislative process was considered to be too lengthy and it was deemed necessary to have a mechanism to effect protection more rapidly due to the vulnerability of spawning aggregations to overfishing.

Following the collection of more Bluestriped grunt samples from the study site in 2006 and a preliminary analysis of data which indicated reproductive activity in the area, a prohibition was placed on fishing on the aggregation site in May of 2007 for a two month period. The aggregation was also closed to fishing in May and June of 2008 and 2009 to allow additional data collection and

research. A recommendation can be made to establish a permanent closure of the site once the dynamics of the spawning aggregation are better defined.

An analysis of landings data indicated that overall numbers of fish caught in 2007 and 2008 decreased from the two years previous to the fishing ban (Table 1). This is believed to be due to the closure of the aggregation area. However, the numbers of fish taken in June of 2007 and 2008 were higher than in the two years before the closure (Table 1). Interviews with fishermen and observations by Fisheries wardens revealed that some fishermen had experienced success in fishing around the boundary of the aggregation area and may have been catching fish migrating to or from the site. This finding highlighted the need to continue research on this site to more clearly define the dynamics of the aggregation. It may be necessary to adjust the boundaries of the closed area to provide a larger buffer zone around the aggregation in order to afford greater protection to this species.

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