

A Brief History and Aspects of the Fishery Biology of Black Grouper (*Mycteroperca bonaci*) at Bermuda

Una Breve Historia y Aspectos de la Biología de la Pesca del Mero Negro (*Mycteroperca bonaci*) en Bermudas

Une Brève Histoire et Aspects de la Biologie de la Pêche du Mérrou Noir (*Mycteroperca boudebess*) à Bermudes

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ABSTRACT

Black grouper (*Mycteroperca bonaci*) are an historically important species in Bermuda's reef fishery but until recently little was known of their biology. They were taken in large numbers by fish pots up until the 1970s but reported landings declined dramatically from 1975 - 1981 before partially recovering. Following the Fish Pot Ban of 1990, only hook-and-line fishing was permitted and landings remained relatively low. A gear innovation (trolling) in 2001 increased catchability and landings rose substantially. The need for detailed biological information for management of this revitalized fishery prompted the current study. Black grouper were found to be protogynous hermaphrodites transforming from female to male in the size range 105 – 115 cm FL (22 – 29 kg). Transverse sections of polished otoliths (sagittae) were used to estimate age. Black grouper are relatively slow-growing and long-lived. The oldest specimen was 33 years old, and the age at sexual transition was approximately 11 - 14 years. This information is pivotal in understanding the population structure in order to enact appropriate management measures. As black groupers form spawning aggregations in Bermuda, these aggregation sites are seasonally closed to all fishing to protect the spawning population.

KEY WORDS: Black grouper, fishery, reproduction, age and growth, spawning aggregations, Bermuda

INTRODUCTION

Black grouper (*Mycteroperca bonaci*) are the second largest serranid found in the tropical western Atlantic (Heemstra and Randall 1993) and are a target species in a number of reef fisheries, e.g. Florida (Crabtree and Bullock 1998). Several studies have been conducted on the biology of black grouper in the wider Caribbean region including Mexico (Brule et al. 2003), Brazil (Texiera et al. 2004) and Florida (Crabtree and Bullock 1998). Black groupers were included in studies of spawning aggregation sites in Belize (Heyman and Kjerfve 2008, Paz and Sedberry 2008). Black grouper (locally known as rockfish) have been an important species in Bermuda's reef fishery for many years. Smith (1958) reported some preliminary findings about the biology of black grouper in Bermuda and the associated fishery. Black grouper were taken in large numbers by fish pots in the 1960s and 1970s, but reliable landings statistics were not available to track landings until 1975. Smith (1971) stated that black grouper was one of the most important species in the Bermuda fishery with 27 – 32 kg individuals common in the 1960s.

MATERIALS AND METHODS

Most of the specimens examined for this study were provided by cooperating fishermen. Freshly caught specimens were packed on ice at sea in large coolers. They were examined as soon as feasible after landing, often the same day. Length was measured as fork length (FL) to the nearest cm. As black grouper have a truncated caudal fin, FL and total length (TL) are essentially the same. Whole weight was measured with an electronic scale to the nearest 0.5 kg. Gonads were removed and weighed to the nearest gram. They were examined macroscopically to determine sex and spawning condition. Females with ovaries containing hydrated eggs were deemed to be spawning. Males with running-ripe testes were considered to be spawning-ready. The sagittal otoliths were removed from the skull cavity and were washed in fresh water, dried and stored in envelopes. We followed the same protocol for preparing otoliths for aging as outlined in Crabtree and Bullock (1998). Briefly, transverse thin sections were cut to include the core area of the sagitta and were then hand-polished until the growth rings could be clearly observed. Counts of presumed annuli were made using compound microscopes with transmitted light by two independent readers to establish age estimates. A marginal increment analysis conducted by Crabtree and Bullock (1998) found that only one annulus was laid down a year in Florida black grouper.

RESULTS AND DISCUSSION

Brief History

Reported landings of black grouper in 1975 (the first year of reliable statistics) were 39,560 kg. (Table 1). Landings declined over 78% in the next six years with only 8,559 kg reported landed in 1981. Anecdotal evidence suggests that this may have been the result of intensive trap fishing at spawning aggregation sites, but it has not been possible to validate this assertion. Landings slowly increased again through the 1980s reaching 22,763 kg in 1989 (Table 1). Following the Fish Pot Ban in 1990, and with only hook-and-line fishing permitted, landings declined precipitously demonstrating the importance of fish pots in the Bermuda reef fishery (Luckhurst 1996). Reported landings in 1991, the year after the Fish Pot Ban were

only 1,195 kg (Table 1). Landings remained relatively low through the 1990s but there appeared to be increased targeting of black grouper by hand-lining. In 2001, there was a gear innovation (trolling with lures) to catch black grouper in the shallower parts of the reef platform. This innovation increased catchability and landings rose substantially in the following year (2001 - 4,460 kg vs. 2002 - 9,811 kg) as most of the fishery adopted the gear innovation. The high value of black grouper and market demand resulted in increased fishing effort by trolling, and by 2005 landings had reached almost 20,000 kg (Table 1). Landings have remained above 21,000 kg for the four most recent years of data (2010 – 2013). An analysis of the sizes of black grouper caught by trolling (n = 250, mean = 24.8 kg) vs. handline (n = 149, mean = 29.2 kg) indicated that the mean size of specimens caught by trolling was significantly smaller than those caught by handline (ANOVA, $F = 23.07$, $p < 0.0001$). Given the size at sexual transition of 22 - 29 kg (see fishery biology section below), this indicates that the majority of fishes taken by trolling were probably females. The current minimum legal size is 95 cm FL, which is approximately 13 kg in weight. This size is well below the mean size of those fish taken by trolling (24.8 kg). The bag limit for black grouper is one fish per boat per day. There is anecdotal evidence that this bag limit is often exceeded. The value of black grouper in the Bermuda market is such that fishermen are often willing to risk fines if they are caught exceeding the bag limit, as the economic gain is substantial compared to the fine.

Fishery Biology

Data were collected from a total of 163 specimens from 1991 to 2007. Specimens were examined opportunistically as they became available. The length-weight relationship (Figure 1) had a high correlation coefficient ($R^2 = 0.984$) indicating that a length measurement alone would allow a reasonable estimate of weight in future sampling if a suitable scale was not available.

In common with many larger grouper species, black grouper were found to be protogynous hermaphrodites (Crabtree and Bullock 1998, Brule et al. 2003, Texiera et al. 2004) transforming from female to male in Bermuda in the size range 105 - 115 cm FL (Figure 2). This transitional size range equates to a weight range of 22 - 29 kg. Crabtree and Bullock (1998) found a larger transitional size range (95 - 131 cm TL) from a larger sample size (n = 1,166) of fishes from south Florida. Only two Bermuda specimens out of 163 examined were considered to be transitional individuals (Figure 2) which suggests that sexual transition must occur rapidly. The largest male examined was 152 cm FL and weighed 65.5 kg. This specimen is larger than the maximum size of 133 cm TL listed for this species (Heemstra and Randall 1993). However, the largest individual examined by Crabtree and Bullock (1998) was 1518 mm TL, a size almost identical to the largest Bermuda specimen.

Black grouper were found to be relatively slow-growing and long-lived (Figure 3). The oldest specimen was 33 years old but the largest specimen (152 cm FL) was only 24 years old (Figure 3). The oldest individual aged by Crabtree and Bullock (1998) was also 33 years old. The

Table 1. Reported landings (in kg whole weight) of black grouper from Bermuda's commercial fishery. Note decline after Fish Pot Ban in 1990 and increase in 2002 after gear innovation. See text for details.

Year	Landings	Year	Landings
1975	39,560	1995	6,228
1976	38,584	1996	2,790
1977	32,253	1997	2,757
1978	21,926	1998	4,320
1979	28,477	1999	6,425
1980	20,037	2000	5,850
1981	8,559	2001	4,459
1982	6,403	2002	9,811
1983	9,680	2003	8,737
1984	11,761	2004	10,759
1985	12,165	2005	19,997
1986	17,360	2006	17,865
1987	18,048	2007	22,216
1988	18,405	2008	15,862
1989	22,763	2009	15,892
1990	3,864	2010	21,034
1991	1,995	2011	21,429
1992	1,524	2012	21,570
1993	4,633	2013	21,195
1994	3,742		

age at sexual transition of Bermuda black grouper was estimated to be approximately 11 - 14 years. In comparison, Crabtree and Bullock (1998) found that 50% of the females in their study had transformed to males by age 15.5 years (121.4 cm TL).

Spawning Aggregations

Anecdotal information from patriarch fishermen suggested that spawning aggregations of black grouper had been exploited in Bermuda for many years using fish pots. However, accurate information regarding sites and seasonality was largely unavailable. With the assistance of a co-operating fisherman, a spawning aggregation site was located off the east end of Bermuda in 2004 between two previously existing seasonally protected areas for red hind (*Epinephelus guttatus*) which have been protected for many years (Luckhurst and Trott 2009). A preliminary

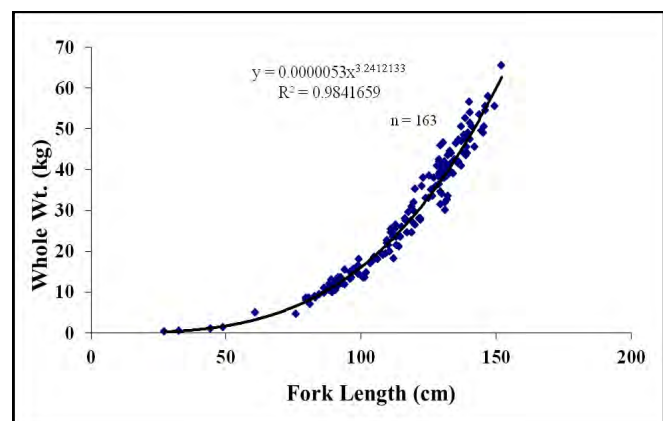


Figure 1. Length – weight relationship of Bermuda black grouper.

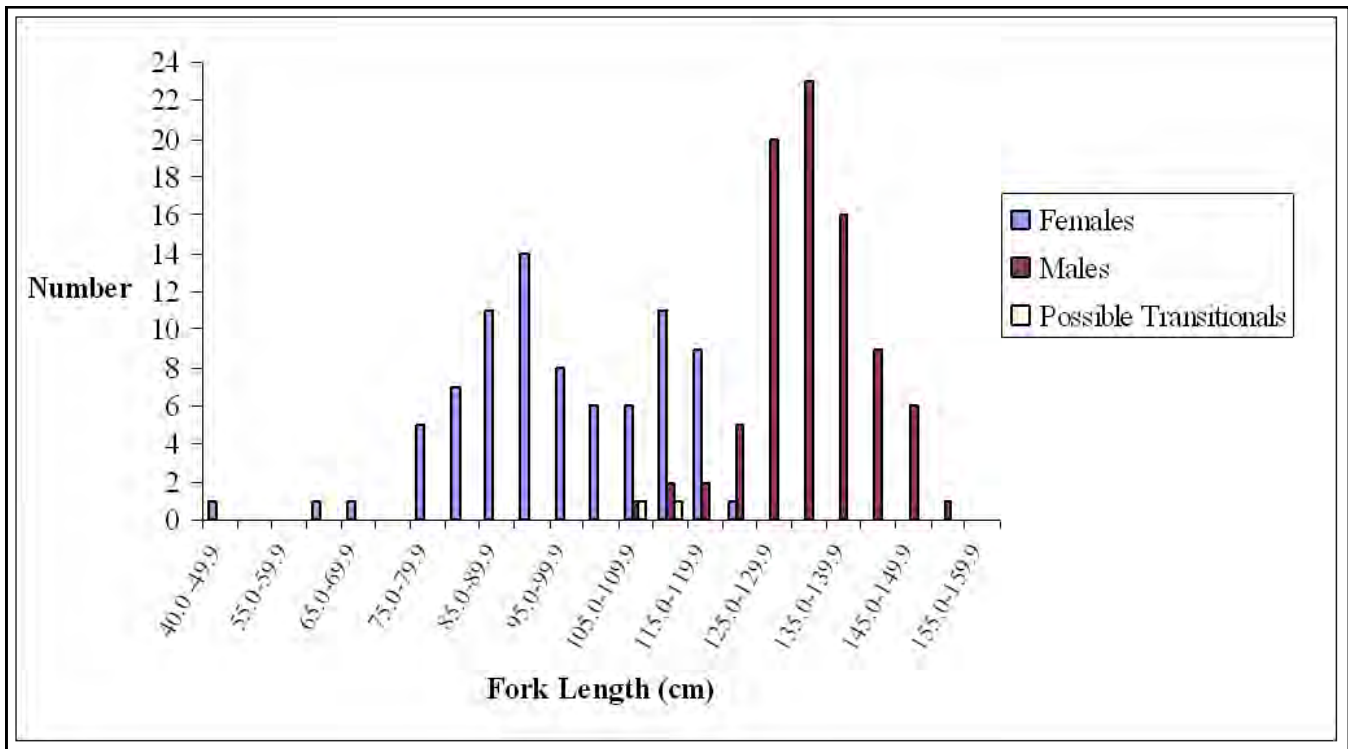


Figure 2. Length-frequency distribution of Bermuda black grouper (n = 163).

assessment of abundance and behavior was conducted in 2005 (Luckhurst 2010) and legislation was enacted the following year to afford protection to the site by incorporating it into a single, reconfigured seasonally protected area (Figure 4) (Trott, unpublished data). An acoustic telemetry research program commenced at the site in 2008 to determine residence times and seasonality of occurrence. The results from 2008 - 2009 indicated that fish were present at the site from April to November suggesting a more protracted spawning period than that of red hind (May - August). Mean residence time for males was two

weeks per lunar period but ranged from 2 - 23 days (Trott, unpublished data). The two females monitored spent far less time at the site (4 - 9 days per lunar period), and this is consistent with the finding that females arrived days after males were already present at the site (Luckhurst 2010). Greatest abundance detected was during the last quarter of the lunar phase and the three days after, which is consistent with the data on residence time and lunar periodicity reported by Heyman and Kjerfve (2008) from Belize. As a result of the protracted spawning period indicated by the acoustic telemetry data, the immediate area around the black grouper site was closed using a temporary 90-day closure period under Bermuda Fisheries legislation (Figure 4). This closure period was implemented in 2008 and has continued each year until the present.

The ability of fisheries managers to respond and implement measures in the face of new information concerning an exploited species, e.g. the discovery of a spawning aggregation, is dependent upon the legislation under which the fishery is managed. Emergency measures which can be implemented in a timely manner can often be critical in ensuring that the spawning output from an aggregation is maintained for the long-term benefit of the species and the health of the fishery.

ACKNOWLEDGEMENTS

We wish to thank commercial fishermen Kevin Gregory, Andrew Card, Linwood Outerbridge and Andrew Marshall for their assistance with this study and for sharing their knowledge of black grouper. Joanna Pitt produced Figure 4. and also provided some assistance with the study.

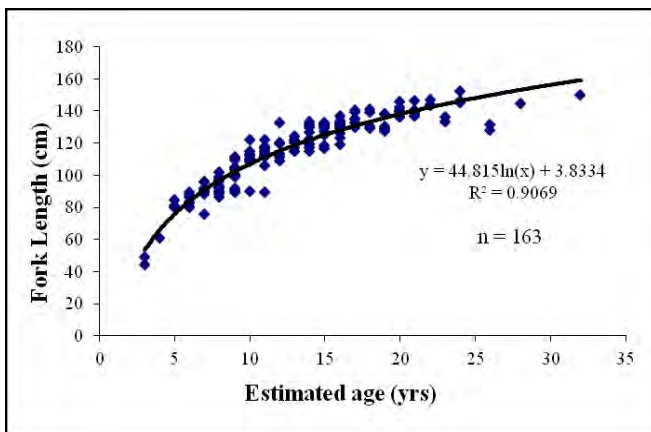


Figure 3. Length-at-age graph of Bermuda black grouper. Oldest male was 33 years old.

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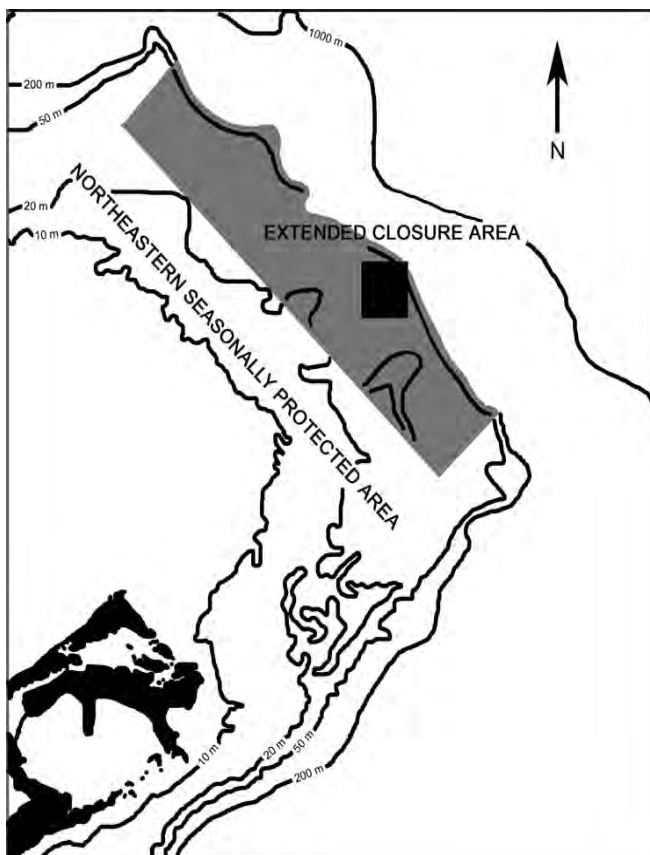


Figure 4. Map of seasonally protected area for red hind (grey area) off the east end of Bermuda incorporating the black grouper spawning aggregation site extended closure area (black square). See text for details of area closure.