Age, growth, and maturity of black grouper (*Mycteroperca bonaci*) – Crabtree and Bullock (1998) revisited

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Introduction

Crabtree and Bullock (1998) studied the life history, morphometrics, age and growth, reproduction, and maturity of black grouper (*Mycteroperca bonaci* (Poey 1860)) in the southeastern United States, and confirmed the findings of Garcia-Cagide and Garcia (1996) that this species was a protogynous hermaphrodite [i.e., individuals are born as females, and may transform to males at some time later in life (Sadovy and Shapiro 1987)]. Previously, Manooch and Mason (1987) had provided length-weight, age and growth, and some estimates of total mortality using catch curves for this species caught by anglers on head boats. More recently, Rénan et al. (2001), Brulé et al. (2003), and Brulé et al. (2005) provide details on life history, reproductive strategies, and composition of the diet of juvenile black groupers in the southern Gulf of Mexico. Zatcoff (2001) discussed aspects of the genetic stock structure of black grouper in the southeastern United States. This document uses data from specimens collected by Crabtree and Bullock (1998) and Lew Bullock (personal communication) as well as more recent data (Table 1) collected by biological surveys in the southeastern United States [National Marine Fisheries Service (NMFS) Southeast Fisheries Science Center (SEFSC) Trip Interview Program, SEFSC Head Boat Survey, NMFS Marine Recreational Fishery Statistics Survey (MRFSS), Gulf States Marine Fisheries Commission (GSMFC) Fisheries Information Network (FIN) Biological Sampling Program, Florida Fish and Wildlife Conservation Commission's (FWC) Fish and Wildlife Research Institute (FWRI) Fishery Independent Monitoring Program (FIM) and Biological Sampling, and some additional information from the NMFS Cooperative Research Program (CRP), NMFS Southeast Bottom Longline Observer Program, and a small number of additional specimens from a variety of other sources]. The analyses provided in this report are intended to update the relationships described in Crabtree and Bullock (1998) and provide some alternatives to the age, growth and maturity relationships based upon the aging of specimens (otoliths) adjusted for the time of year of annulus deposition in black grouper.

Stock Definition and Description

Among the common names historically used in the U.S. for *Mycteroperca bonaci* are black grouper, carbarita (or carberita), carbos, true black grouper and southern black grouper (Moe, 1963), and snider grouper and junefish (Smith et al. 1975). Black grouper (fig. 1) in the southeastern United States (the northern most part of their range) have been found chiefly in southern Florida and the Florida Keys, and specimens are recorded from Massachusetts to Texas (Bullock and Smith, 1991). The range of black grouper extends to southeastern Brazil and east to Bermuda (fig. 2; Ocean Biogeographic Information System, accessed on July 22, 2009).

This species is often found associated with rocky ledges and coral reefs from 10-100 m (fig. 3; Bullock and Smith, 1991, Brulé et al., 2003). In the northern hemisphere, black grouper are more often caught in the southeastern Gulf of Mexico (fig. 4), southern Gulf of Mexico [e.g, Campeche Banks (Brulé et al., 2003)], and the Caribbean [e.g., spawning aggregations off the coast of Belize (Paz and Sedberry, unpublished manuscript)]. In the southeastern US (fig. 4), black grouper are caught more commonly in the Florida Keys along the reef tract, and are caught along high relief areas in deeper waters off of the west coast of Florida to the Florida Middle Grounds and off of the east coast of Florida. Larger and older individuals are caught more often in deeper waters (fig. 3 a, b; see also Brulé et al. 2003).

Gag (*Mycteroperca microlepis*), a species of grouper similar in appearance to *M. bonaci* (fig. 5), is sometimes referred to as "black grouper[1]" by both recreational and commercial fishers. Except in the Florida Keys, gag is more frequently caught off of Florida's west coast than *M. bonaci*. There is confusion in the identification of these species by some fishers and outdoors writers (figs 6- 8). In addition, the recreational landings recorded in the NMFS Marine Recreational Fishery Statistics Survey (MRFSS) appear to have different percentages of "black grouper" and gag in the earlier portion of the time series than in the later years (e.g, 1981-1987 Florida east coast, and 1981-1989 Florida west coast; fig. 9), and it is probable that some of the interviewers did not distinguish between these two species particularly during the early portion of the time series. The NMFS Head Boat Survey does not appear to have these issues, although there are occasional instances of black grouper reported from some areas that appear questionable. Potential methods to adjust the reported recreational catches of black grouper and gag in the U.S. portion of the Gulf of Mexico were discussed during SEDAR 10 (see Phares et al., 2006).

Prior to 1986, the reporting of groupers landed and sold commercially did not separate groupers in the landings data by species. Beginning in 1986, several species of groupers were reported separately (including black grouper and gag). However, there is also confusion in the time series of commercial catches of "black grouper" (referring to black grouper or gag, and possibly other species of grouper) by seafood dealers in the early portion of this time series, and methods to adjust the reported commercial catches of black grouper and gag in the U.S. Gulf of Mexico using dockside samples from the Trip Interview Program were discussed during SEDAR 10 (see Chih and Turner, 2006).

[1] The conventions in this document are that black grouper will refer only to *M. bonaci*, gag will refer only to *M. microlepis*, and "black grouper" (in quotes) will refer to uncertain identifications of groupers in catches from commercial and recreational fisheries that may or may not have included specimens of *M. bonaci*.

The unadjusted time series of reported landings (commercial and recreational) for black grouper (and gag) are uncertain and inaccurate. Therefore, inferring the distribution of the stock of black groupers from the reported commercial and recreational fisheries landings alone without a rigorous analysis of the underlying data is unwise and not recommended.

Zatcoff (2001) examined the population genetics of black grouper in the southeastern U.S. and Caribbean using microsatellite DNA from specimens collected in the Florida Keys (116 specimens), Campeche Banks (Mexico, 75 specimens), Belize (51 specimens), and Bermuda (52 specimens). The conclusions were that there was genetic homogeneity among samples from the Florida Keys, Mexico, and Belize which indicated that these specimens belonged to single stock of black grouper. The specimens from Bermuda were differentiated from the other areas, and represent a separate stock of black grouper in the west central Atlantic (Zatcoff 2001). Currently, there is no other published information on the genetics of black grouper available from the southeastern US, Caribbean, or southern Atlantic Ocean.

Natural Mortality

One of the more important yet difficult to accurately estimate population parameters required for many stock assessment models is natural mortality (M). Approaches for estimating natural mortality rely on catch curves (for lightly exploited or unexploited portions of populations) , mark-recapture experiments, or empirical relationships (meta-analyses) of catch curve data and the maximum observed age of a species (Hoenig 1983, Alagaraja 1984, Lorenzen 1996, Lorenzen 2005), growth [Alverson and Carney 1975 (as cited in Quinn and Deriso 1999, Ralston 1987, Jensen 1996], age at 50% maturity and growth parameters (Beverton and Holt 1956), or average temperature and growth parameters (e.g., Pauly 1980, Pauly and Binohlan 1996). The advice usually given is to provide a range for natural mortality using a variety of approaches (Quinn and Deriso 1999). There have been no experimental (i.e., mark-recapture) estimates of natural mortality of black grouper in the southeastern U.S. Manooch and Mason (1987) used catch curves to estimate total mortality (Z) and Pauly's (1980) approach to estimate M for black grouper, Huntsman et al. (1992) used Pauly's (1980) and Hoenig's (1983) approaches for estimating M, and Potts and Brennan (2001) used a range of M estimates for their analyses.

An approach (Hoenig 1983) frequently used in SEDARs is based upon a regression derived from several estimates of natural mortality and maximum observed age from lightly or unexploited populations of animals (including fish). Hewitt and Hoenig (2005) have recommended using the regression parameters derived using all of the populations studied, though some researchers prefer to use only the parameters derived from populations of fish. The maximum observed age of black grouper from samples in the fishery is 33 years (Table 4). From a meta-analysis of natural mortality in several populations of animals (including fish) that were unexploited or lightly exploited

(Hoenig 1983; Hewitt and Hoenig 2005), $M=\exp[1.44-0.982*\ln(t_{max})]$, where t_{max} is the maximum age observed for a species. For black grouper, M is estimated to be $0.136 \cdot yr^{-1}$ by this method.

Another approach is to place bounds on possible estimates of natural mortality by constructing catch curves [an estimate of total mortality (Z)] from sampling or fisheries catches. There are many considerations to building catch curves from fisheries data, not the least of which are the representativeness of the samples and factors such as selectivity by fishing gears, annual recruitment variability, annual variability in mortality factors, and variability in the areas fished by different fishers. The data available for the construction of a catch curve for black grouper are not ideal and black grouper have been fished heavily in some areas. But, a portion of the long line catches may have suitable data for this task. The long line fishery for reef fish in Florida developed in the late 1970s, and chiefly operated, since the late 1980s, in waters of the Gulf of Mexico. This fishery, because of management regulations, is in deeper portions (>36 meters or 20 fathoms) of the range of habitats where black grouper live, and tends to catch larger and older fish than are observed in other modes of fishing (Fig. 10; see also Brulé et al. 2003 for a discussion of a similar situation on the Campeche Banks with long line fishermen in 40-210 m waters catching more large fish than spearfishers and hook-and-line fishermen in 4-20 m waters). In the Florida Keys, long line targeting reef fish are restricted to areas deeper than 36 meters north of the Dry Tortugas (≈24° 35' N. or west of 83º W [Gulf of Mexico Fishery Management Council (GMFMC) jurisdiction] and are not allowed in waters managed by the South Atlantic FMC. Effectively, the restrictions on the use of long lines in the reef fish fishery may allow a portion of the black grouper population to remain relatively lightly exploited once these animals move into water depths less frequently fished by recreational anglers and commercial hook-and-line fishermen in the Florida Keys and southern Florida.

A catch curve was constructed using the data collected by port samplers participating in the NMFS Trip Interview Program (TIP) from 2000-2008 (Table 10). There are not enough years available nor are the data suitable for following an entire cohort, so data for all years were combined by age. Through inspection of the data (Fig. 11), ages 8 and older appear fully vulnerable to this gear. If there are ages of the population less vulnerable to fishing pressure, these ages may appear less frequently in the catch. Such may be the case with black grouper, as animals of age 15 and older are less frequent in the long line catches. An exponential curve was fit to this portion of the data (animals with ages 15 and older), and an estimate of total mortality (Z) = $0.111 \cdot yr^{-1}$ (95% CI 0.071-0.151) was obtained (Fig. 11). Since Z = fishing mortality (F) + M, an estimate of Z can be use to place an upper bound on M.

Other approaches for estimating M will undoubtedly be discussed at the data workshop, and are left as an exercise for that meeting.

A single natural mortality rate may not apply to all ages. Survivorship may be expected to be lower in younger aged fish (where density-dependent factors and predation may be greater) and a little higher in the older ages for fish in the population than is predicted by an exponentially declining survivorship curve. Lorenzen's (2005) method, developed through a meta-analysis of the relationships between length, age, and natural mortality, was used to derive an age-specific M using a "target" M [$0.136 \cdot yr^{-1}$ from Hoenig's (1983) method] obtained above. Black grouper appear to be fully vulnerable (i.e., living in habitats available to the fishery and caught by at least some fishing gears) by age 3. The age-specific rates (Table 5) were scaled for ages 3 to 33 to $0.136 \cdot yr^{-1}$ [the estimate of M obtained from Hoenig's (1983) equation].

Discard Mortality

There are no experimental studies of discard mortality (i.e., mortality after catch was released) for *M. bonaci* (black grouper) available. Wilson and Burns (1996), Overton and Zabawski (2003), McGovern et al. (2005), and Ruderhausen et al. (2007), studied aspects of discard mortality in the closely related species *M. microlepis*. Hook placement, depth of capture, and venting of the swim bladder are important factors in the survival of released reef fish. There is a distinct relationship between depth of capture and mortality of released gag (McGovern et al. 2005). Dead discards in the 2001 gag assessment (Ortiz 2006) were estimated using two different methods. The first method used a fixed proportion of the total discards for consistency with a previous assessment of gag (Turner et al. 2001) and some previous reef fish assessments. Discard mortality in recreational fisheries was assigned as 20% of discards, and commercial discard mortality was assigned as 30% of discards. The second method used in the gag assessment (Ortiz 2006) assigned discard mortality on the basis of the probable depth of capture in recreational and commercial fisheries. Lacking any information specifically for black grouper, discard mortality estimates may have to be inferred from similar species such as gag and use similar values such as used in the recent assessments of gag in the southeastern U.S.

Age

Sectioned or whole otoliths have been used to estimate ages of black grouper by several studies (e.g., Manooch and Mason, 1987, Crabtree and Bullock 1998), and validation of the ages has been through marginal increment (translucent zone on the edge of an otolith) analysis. Annulus formation in this species is typically in March-April, and one ring is formed each year (Crabtree and Bullock 1998). Manooch and Mason (1987) reported ages as annuli counts, and Crabtree and Bullock (1998) used the average of six annuli counts (three reads each by two readers, with the calculation of a coefficient of variation (cv)) to estimate the age of black grouper. Crabtree and Bullock also rejected the otolith if the cv of the annuli counts exceeded 12%.

Otolith sections used in the Crabtree and Bullock (1998) study were re-examined and re-aged with the new criteria to compare with their published results (growth curve, size and age at maturity analysis, and size and age in the proportion of females in population (an estimate of the size of transition for protogynous species). All but seven of the 1,060 slides used in the Crabtree and Bullock (1998) study were relocated and re-aged (Table 8). Otolith sections which were rejected (133 slides) by Crabtree and Bullock (1998) based on the cv exceeding 12% were also re-examined and an age was determined if the section was considered readable (Table 8). The agreement (Average Percent Error (APE)) between the Crabtree and Bullock (1998) annuli counts and the re-counts for SEDAR 19 was 3.5% (J. Tunnell, FWRI Fish Biology Section, Age and Growth Lab, personal communication). Unfortunately, the Manooch and Mason (1987) otolith slides could not be located for use in SEDAR 19 and were not included in this analysis. A spreadsheet with the total lengths, annuli counts, and month and year of collection from Manooch and Mason (1987) was available; however, without an analysis of the marginal increment on these otoliths it would not be possible to apply the same criteria for aging as was used for SEDAR 19.

Mycteroperca bonaci (black grouper) otoliths from collection sources (e.g., projects listed inTable 3) other than from Crabtree and Bullock (1998) were obtained from the NMFS Panama City and Beaufort Laboratories and FWRI. Whole black grouper otoliths were embedded in Araldite two-part epoxy and cut using a Buehler Isomet low-speed saw. Four diamond wafering blades each separated by a 0.4 mm aluminum spacer were used to yield three sections that were mounted on a microscope slide and covered with Flo-Texx mounting media. Otolith sections were viewed under a stereomicroscope with either transmitted or reflected light. Counts of annuli and edge type were recorded for each readable otolith. Three different categories for edge type were used: otoliths with an annulus on the margin of the section are classified as edge type 2, otoliths with an edge type 4 have a translucent marginal zone up to 2/3 complete, otoliths with an edge type 6 have a translucent marginal zone greater than 2/3 complete. Each otolith was read twice with each read independent, and discrepancies in annuli counts and edge types were resolved. A subsample of 20% of the otoliths [excluding otoliths from Crabtree and Bullock (1998) which were analyzed separately] was read by all readers for precision and quality control (Campana 2001), and the APE for this subsample was 4.78%.

Because one annulus is formed each year in black grouper, the number of annuli is the age of the specimen. The formation of an annulus in black grouper frequently occurs in March-April (Crabtree and Bullock 1998), so specimens caught early in the year often show a relatively large translucent zone (i.e., marginal increment) at the edge of their otoliths. The interpretation for these specimens is that these fish were caught before the next annulus was formed. Annuli counts for specimens with marginal increments that are 2/3 or more complete during this time of year around annulus formation can be adjusted to a biological age (e.g., Campana 2001), and many of the SEDARs have used this technique in their age determinations [e.g., SEDAR 19 (red grouper; Reichert et al. 2009), SEDAR 15A (mutton snapper; Tunnell et al. 2007), SEDAR 10 (gag; Reichert et al. 2005)].

Annulus count, edge type and capture date were used to estimate the age of a fish based on a January 1st birth date. The age of a fish with an edge type 2 or 4 was equal to the number of annuli. The age of a fish caught prior to June 1st with an edge type 6 (a large translucent zone) is equal to the number of annuli plus 1. The age of a fish with edge type 6 caught on or after June 1st, is equal to the number of annuli.

Ages were determined for a total of 2,281 otoliths, including the 1,055 re-aged from the Crabtree and Bullock (1998) study (Table 3). The maximum observed age for *M. bonaci* specimens was 33 years, and 3 of the 4 (the 4th specimen had no information available for the gear used or mode of fishing) specimens of this age were obtained from commercial long line fishermen. Of the 18 specimens aged 29 years or older, 11 were from long lines (of the other 7, 6 were from unspecified commercial gears and one had no gear or mode of fishing information). Of the 222 specimens aged 15 years and older, 93% of the specimens came from the commercial fishery (69% from long lines, 19% from unspecified gears, 2% from hook and line), 4% from the recreational fishery (2% from head boats, 1% from charter boats, 1% from tournaments), and 3% were from unspecified modes of fishing. It is possible that older specimens could be harvested by gears other than long lines and commercial fishing, and that there was more emphasis on sampling in the long line catches than in other modes and gears. However, there has been sampling of fish for length measurements and otoliths in other modes and gears by commercial and recreational samplers, and if older black grouper were being landed frequently in other modes and by other gears they should have been sampled. So, it is very likely that long lines are deployed in deeper habitats where older black grouper are more frequently encountered and that other gears and modes of fishing do not fish those areas as frequently. Brulé et al. (2003) also noted smaller (and presumably younger) *M. bonaci* in shallower waters (4-20 m) taken by spearfishers and hook-and-line fishermen compared with larger specimens from deeper waters (40-210 m) taken by long line fishermen off the Campeche Banks.

Growth

Aged specimens (including total lengths, either directly measured or converted from standard length or fork (=”midline”) length) from all of the sampling projects (Table 3) were available for use in constructing growth curves for black grouper. A series of analyses (Table 8; nonlinear Von Bertalanffy regressions using SAS Proc NLIN) were conducted to compare the results presented in Crabtree and Bullock (1998). We re-created and verified all of the results from their growth curve analysis. Variations on the acceptance criteria and some small revisions to the Crabtree and Bullock (1998) data were used for subsequent analyses. All of the variations using annuli counts (including the acceptance of previously rejected annuli counts) made little difference in the growth parameters obtained (Table 8). Using the new adjusted ages (annuli counts adjusted by the marginal increment criteria listed above) had a larger impact on the growth parameters. Adding the otolith data collected since Crabtree and Bullock (1998) had a larger impact on the growth parameters (Table 9), and restricting the analyses to those specimens which were of legal size prevailing at the time of collection from the commercial or recreational fishery made very little difference in the final parameters of the growth curve.

Manooch and Mason (1987) and Huntsman et al. (1992) also provided estimates of growth parameters for *M. bonaci* (fig. 13) reasonably similar to the growth curve presented in fig. 12, though the specimens that were aged at the time were largely from the head boat fishery and it is likely that neither of those studies had ages from many specimens caught in deeper waters. In fact, the oldest specimen in the Manooch and Mason (1987) study was aged at 14 years.

Reproduction

M. bonaci (black grouper) is a protogynous hermaphrodite (i.e., the gonads function first as ovaries and then transform into testes) (Garcia-Cagide and Garcia 1996, Crabtree and Bullock 1998, Brulé et al. 2003, Teixeira et al. 2004). The timing of peak gonad development in the southeastern U.S. and the Campeche Banks (Mexico, southern Gulf of Mexico) is during December-March, though females with vitellogenic oocytes occur in all months of the year (Crabtree and Bullock 1998, Brulé et al. 2003). Garcia-Cagide and Garcia (1996) note that spawning of black grouper in Cuban waters takes place from November to May with peaks in November and February. In the southern hemisphere in waters off northeastern Brazil, spawning probably occurs from April to September (Teixeira et al. 2004).

The length- and age-at-maturity of females and proportion of females at length and age (Table 10, figs. 14, 15) were estimated from data originally presented in Crabtree and Bullock (1998). The data were fit using a logistic regression (Proc NLIN, SAS ver. 9.2) for the proportion of mature females at length using

$$\text{Proportion}_{\,(\textbf{mature}\ \female)} = 1 / (1+(e^{\mathbf{r*(TL-L_{50})}})) \ ,$$

where TL is the total length of the specimen in millimeters and $\text{Proportion}_{(\textbf{mature}\ \female)}$ is either a 0 (immature) or 1 (mature) based upon Crabtree and Bullock’s (1998) histological analyses of specimens. The regression estimates the slope of the relationship (r) and the length estimate ($L_{\mathbf{50}}$) at 50% maturity. Similarly, the proportion of mature females at age were fit to the logistic regression

$$\text{Proportion}_{\,(\textbf{mature}\ \female)} = 1 / (1+(e^{\mathbf{r*(Age-A_{50})}})) \ ,$$

where Age is either the average annuli counts from Crabtree and Bullock (1998) or the ages adjusted for the marginal increment type and time of year (SEDAR 19), and $\text{Proportion}_{(\textbf{mature}\ \female)}$ is either a 0 (immature) or 1 (mature) based upon Crabtree and Bullock’s (1998) histological analyses of specimens. The proportion of females at length or age (a measure of the length- and age-at-transition from female to male in protogynous species was modeled similarly, where specimens were coded as a 1 (female) or 0 (male) based on the histological analyses. The logistic regressions solved for the slope (r) and either the length ($L_{\mathbf{50}}$) or age ($A_{\mathbf{50}}$) at which the proportion of females was estimated to be 50% of the sample population. The parameters and other statistics from these regressions are presented in Table 10.

The length, age, and maturity data were re-examined using recommendations to restrict these types of analyses to just before the onset of the spawning for the stock when postspawning females would be expected to be uncommon (Hunter and Macewisc 2003) to compare with the results of Crabtree and Bullock (1998) which included specimens collected throughout the year in the analyses. Females which have already spawned and show no indications of atresia in their ovaries may be difficult to differentiate from immature females and their inclusion can often lead to smaller and younger estimates of size- and age-at-maturity, respectively (Hunter and Macewisc 2003). Additionally, the age-at-maturity of females and proportion of females at age were re-analyzed using the ages adjusted for the marginal increment type rather than the average annuli count used in Crabtree and Bullock (1998).

Crabtree and Bullock (1998) estimated the length (L_{50}) at which half of the females were mature (often used as an estimate of the size-at-maturity) as 825 mm (fig. 14a; 95% CI 816-834 mm; Table 10) using specimens caught throughout the year. After restricting the analyses to include those specimens caught during months just prior to the onset of spawning to the peak of the spawning season (January-March) in the southeastern US, the L_{50} estimate increased to 856 mm (fig. 14b; 95% CI 840-871 mm; Table 10). Brulé et al. (2003) usd specimens collected during all months of the year and estimated the length-at-maturity (L_{50}) in *M. bonaci* from the Campeche Banks at 739 mm TL (estimated from their value of 72.1 cm FL, using the conversion equation in Table 14). This lower value for the length-at-transition was influenced by the inclusion of specimens caught throughout the year, and it would be interesting to compare the L_{50} values based upon specimens selected from the time period corresponding to the peak spawning period.

The age (A_{50}) at which half of the females were mature was estimated by Crabtree and Bullock (1998) as approximately 5.2 years using average annuli counts of specimens taken throughout the year (fig. 15a; 95% CI 5.1-5.4 years; Table 10). Restricting the specimens collected to the January-March period increases the A_{50} to about 5.7 years (fig. 15b; 95% CI 5.6-5.9 years; Table 10) using average annuli counts. Using the annuli counts and adjusting for the marginal increment and time of year of collection to give an adjusted age for specimens taken throughout the year increased the A_{50} from 5.2 (fig. 15a) to 5.7 years (fig. 15c; 95% CI 5.4-6.0 years; Table 10). Restricting the specimens to the January-March period and using the adjusted age for specimens resulted in an A_{50} of 6.5 years (fig. 15d; 95% CI 6.2-6.8 years; Table 10) compared to 5.7 years using the average annuli counts (fig. 15b). Restricting the analyses to specimens collected during the spawning season and using the ages adjusted for the marginal increment type significantly increased the estimated age at which half of the females were mature.

The length at transition (L_{50}) and age at transition (A_{50}) in which 50% of the population was female (fig. 16; Table 10) was estimated by Crabtree and Bullock (1998) as 1214 mm (95% CI 1203-1224 mm) and 15.5 years (95% CI 14.7-16.2 years) using specimens caught during all months of the year. Because Crabtree and Bullock (1998) based the age at transition on average annuli counts, these data were re-analyzed using ages based on annuli counts, marginal increment type, and time of year. The age at transition (A_{50}) using the adjusted ages where 50% of the population was estimated to be female was 16.0 years (95% CI 15.3-16.8 years; fig. 16; Table 10). Brulé et al. (2003) estimated the length-at-transition in M. bonaci as 1143 mm TL (estimated from their value of 1114 mm FL, using the conversion equation in Table 14).

Movements and Migrations

There are some studies and anecdotal reports on movements and aggregations of *M. bonaci* (presumably related to spawning in most accounts) in the Florida Keys (Eklund et al. 2000, DeMaria 1996), Belize [Sala et al. 2001 (with an account of spawning activity just after sunset), Paz and Sedberry unpublished manuscript, Heyman 2001, Heyman and Requena 2002), Cuba (Claro and Lindeman 2003), and northeastern Brazil (Teixeira et al. 2004, possibly feeding aggregations).

There have also been some acoustic telemetry studies on short-term movements *M. bonaci* in the Florida Keys (Lindholm et al., 2005, Farmer 2009), though most of the tagged fish were below the predicted length at maturity). Lindholm et al. (2005) tagged and acoustically monitored 5 *M. bonaci* [380-740 mm SL (= 469-888 mm TL using equation in Table 14)] in the Conch Reef and Davis Reef areas (seaward of Key Largo and Tavernier in the upper Keys) , and Farmer (2009) tagged and acoustically monitored movements of 3 *M. bonaci* (500-749 mm TL) in the Dry Tortugas Research Natural Area (i.e., below the L_{50} of 855 mm TL). Black grouper may be more active during the crepuscular hours of the early morning and during daylight hours than at other hours of the day (Farmer 2009; Lindholm et al. 2005), and daily movements averaged 210 m (Farmer 2009) though one of the fish tagged by Lindholm et al. (2005) moved 4 km from the release site before returning to Conch Reef on the next day. There was no significant relationship between daily movements of *M. bonaci* and lunar phase detected (Farmer 2009), though there may be some relationship between aggregation activity prior to and after sunset, lunar phase (days after a full moon) and spawning aggregations in *M. bonaci* (Eklund et al. 2001, Sala et al. 2001) with actual spawning observed after sunset (Sala et al. 2001).

There is information off of the north coast of the Yucatan peninsula on the habitat of juvenile *M. bonaci* (105-455 mm TL) in shallow waters (1-10 m) characterized as irregular hard bottom of limestone outcrops or rocks surrounded by sandy areas (Brulé et al. 2005). Sites at which juvenile black grouper were found were shallow rocky reef habitats which had either high vertical relief with crevices, caves, and small dispersed rocks. FWRI's Fishery Independent Program (FIM) collected a few small black grouper specimens (Table 1), chiefly in the lower Indian River area (fig. 4). The gears (seines, otter trawls) used by the FIM for typical collections would not be appropriate for sampling in rocky reef habitats and therefore it is unsurprising that so few specimens were recorded by this program. Data from sampling in shallow waters (1-34 m) of the Florida Keys by the FWC Reef-fish Visual Survey (Muller and Acosta 2009) indicate that there is some trend for juveniles to be smaller in shallower waters and larger in deeper locations, but the trend is not particularly strong in juvenile black grouper (fig. 17). Catch information from fisheries (data from Crabtree and Bullock 1998, Brulé et al.

2003) indicate that specimens of black grouper from shallow reef habitats (4-20 m) are typically smaller than those caught in deeper waters (40-210 m) generally (fig. 3), and that fish move from shallower to deeper habitats as they increase in length can be inferred from these data.

Meristics and Conversion Factors

Four types of length measurements [standard length (SL), midline length or fork length (FL), total length with the tail laid flat (TL-"natural"), and total length with the tail compressed (TL)] and two types of weight measurements (whole or round weight, and gutted weight) have been taken on black grouper. In some surveys, one measurement is typically taken (e.g, total length by the Head Boat Survey, fork length by the MRFSS) or different types of lengths may be taken (TIP, FWRI). Multiple types of measurements of lengths and weights on specimens by Bullock (personal communication), Crabtree and Bullock (1998), and FWRI biological sampling were used to develop conversions between measurement types. Length-length (untransformed data) and length-weight ($\log_{10}$ transformed data) relationships were developed by Crabtree and Bullock (1998) (Tables 11, 12). Data from Crabtree and Bullock (1998) were combined with additional measurements from Lew Bullock (personal communication) and the other sources of measurements (Table 3). There were a few corrections made to the data from Crabtree and Bullock (1998) based upon Lew Bullock's field data sheets, and a few corrections were also made to the field data sheets (obvious data recording errors, and omissions of some measurements as a result of an outlier analysis) by Crabtree and Bullock (1998). Likewise, the additional measurements were subjected to outlier analyses. Measurements included in the simple linear regressions were subjected to two rounds of outlier analyses by computing standardized residuals (e.g., Zar 1984). In the first round of outlier analysis, standardized residuals greater than 10 (statistically highly unlikely) were examined for data recording errors and revised if possible or excluded from the next round. In the second round of outlier analysis, standardized residuals greater than 4 ($P<0.0001$) were examined and revised if possible or excluded from the final round of analysis. The third round became the final analyses shown in Tables 13 and 14.

Black grouper have a relatively flat tail, but there is a small difference between total lengths measured with the tail flat (TL-"natural") or with the tail compressed. In Crabtree and Bullock (1998), total length measurements were taken with the tail compressed (Hubbs and Lagler, 1964). To maintain consistency with Crabtree and Bullock (1998), total lengths known to be taken with the tail compressed were used to develop the regressions of TL, and a regression between TL-natural and TL were developed. The gutted to whole weight regression was computed only on specimens where the weight was measured before and after gutting.

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Table 1. Number of *M. bonaci* (black grouper) otoliths aged from biological surveys in the southeastern US by project name, mode of fishing, and gear. Coast assignment based upon latitude/longitude, descriptions of locations, or area fished (NMFS Shrimp Grid System or Head Boat Area Fished) on data collection records.

PROJECT	<missing>	Atlantic Ocean	Gulf of Mexico	Total
Crabtree and Bullock (1998)	218	595	242	1,055
FWRI FIM	.	15	4	19
FWRI (FIN-BIOSTAT)	.	18	3	21
NMFS HEAD BOAT SURVEY	.	25	2	27
FWRI (HEAD BOAT)	.	7	.	7
FWRI (Biological Sampling)	.	3	1	4
NMFS MRFSS (FWRI)	.	6	.	6
NC DEHNR	.	7	.	7
NMFS TIP	7	155	977	1,139
FWRI TOURNAMENT	.	.	3	3
Total	225	831	1,232	2,288

Mode of fishing	<missing>	Atlantic Ocean	Gulf of Mexico	Total
<missing>	13	7	3	23
CM (Commercial)	175	165	1,139	1,479
FI (Fishery-Independent)	.	15	4	19
HB (Head Boat)	3	37	28	68
PC (Party/Charter)	.	43	4	47
PR (Private/Rental Boat)	1	8	.	9
RC (other Recreational)	1	3	1	5
SC (Special Collections)	31	553	36	620
SS (Surveys)	1	.	.	1
TR (Tournaments)	.	.	17	17
Total	225	831	1,232	2,288

Gear	<missing>	Atlantic Ocean	Gulf of Mexico	Total
<missing>	97	24	50	171
BANDIT RIG	.	29	27	56
COLD KILL	.	1	.	1
HOOK AND LINE GEARS	14	168	64	246
LONG LINE	78	19	1,031	1,128
FIM SEINES	.	14	2	16
FIM OTTER TRAWLS	1	1	2	4
SPEARFISHING	33	574	56	663
TRAPS	2	1	.	3
Total	225	831	1,232	2,288

Table 2. Number of *M. bonaci* (black grouper) otoliths aged by area fished by coast (NMFS Shrimp Grids or Head Boat Area Fished). Area Fished assignment either based upon latitude/longitude or by area fished code on data collection records.

Area Fished	<missing>	Atlantic Ocean	Gulf of Mexico	Total
<missing>	225	34	27	286
1	.	21	.	21
1.1	.	.	3	3
1.9	.	324	.	324
2	.	5	.	5
2.8	.	.	509	509
2.9	.	312	.	312
3.9	.	.	187	187
4.1	.	.	1	1
4.9	.	.	274	274
5.1	.	.	1	1
5.3	.	.	1	1
5.9	.	.	186	186
6.9	.	.	32	32
7.9	.	.	2	2
8.9	.	.	3	3
9.9	.	.	2	2
10.9	.	.	1	1
16	.	.	1	1
21	.	.	1	1
21.9	.	.	1	1
707	.	2	.	2
708	.	9	.	9
709	.	7	.	7
714.9	.	1	.	1
719	.	2	.	2
728.9	.	9	.	9
732.9	.	2	.	2
736.1	.	15	.	15
736.9	.	2	.	2
740	.	2	.	2
741	.	2	.	2
741.9	.	46	.	46
744	.	3	.	3
744.1	.	1	.	1
744.9	.	6	.	6
748	.	8	.	8
748.1	.	3	.	3
748.9	.	15	.	15
Total	225	831	1,232	2,288

Table 3. Number of *M. bonaci* (black grouper) otoliths aged by project and year of collection.

Year	Crabtree and Bullock 1998	NMFS Trip Interview Program	NMFS Head Boat Survey	NMFS MRFSS (FWRI, FIN biological sampling)	North Carolina DEHNR	FWRI FIM	FWRI and FIN (biological sampling)	Total
1979	0	0	1	0	0	0	0	1
1980	0	0	17	0	0	0	0	17
1982	0	0	1	0	0	0	0	1
1984	3	0	1	0	0	0	0	4
1985	1	0	1	0	0	0	0	2
1986	3	0	1	0	0	0	0	4
1990	5	0	0	0	0	0	0	5
1991	6	1	0	0	0	0	0	7
1992	2	2	0	0	1	0	0	5
1993	9	3	1	0	0	1	0	14
1994	129	0	0	0	0	0	0	129
1995	504	0	0	0	0	0	0	504
1996	393	2	0	0	0	0	0	395
1997	0	2	1	0	0	2	0	5
1998	0	5	0	0	0	0	0	5
1999	0	19	0	0	0	2	0	21
2000	0	16	0	0	0	1	0	17
2001	0	54	1	0	0	0	4	59
2002	0	55	0	0	0	1	7	63
2003	0	99	1	4	1	0	4	109
2004	0	133	0	1	3	6	8	151
2005	0	174	1	0	1	0	1	177
2006	0	270	0	0	0	0	5	275
2007	0	178	0	0	1	6	6	191
2008	0	109	0	1	0	0	0	110
2009	0	17	0	0	0	0	0	17
Total	1,055	1,139	27	6	7	19	35	2,288

Table 4. *M. bonaci* (black grouper) - number of otoliths aged with lengths by age and year.

	Year																										
Age	**1979**	**1980**	**1982**	**1984**	**1985**	**1986**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Total**
0	.	.	.	.	.	.	.	.	.	1	.	.	1	.	.	2	1	.	1	.	5	.	.	6	.	.	17
1	.	.	.	1	.	.	.	.	.	.	4	18	4	2	.	.	.	.	.	.	1	.	.	.	.	.	30
2	.	1	.	.	.	.	.	.	1	1	10	29	49	.	.	3	.	1	1	1	.	.	.	.	.	.	97
3	.	2	.	.	1	.	.	1	1	3	5	79	53	2	2	1	1	6	2	4	2	1	2	.	9	.	177
4	.	5	1	.	.	1	1	.	.	1	23	62	87	.	.	6	2	9	13	10	8	11	9	16	6	1	272
5	.	3	.	.	.	.	1	3	.	1	10	124	24	.	2	2	.	12	11	13	7	17	27	21	9	1	288
6	1	1	.	.	.	1	.	2	1	3	7	45	42	.	.	3	4	3	12	15	24	24	36	19	14	.	257
7	.	2	.	1	.	.	.	.	1	2	12	16	15	1	.	.	1	7	9	12	24	27	39	34	18	1	222
8	.	1	.	.	.	.	.	.	.	.	12	17	15	.	.	1	2	6	5	8	25	32	51	28	15	2	220
9	.	1	.	.	.	.	.	.	.	.	6	15	14	.	.	.	.	1	3	5	7	16	34	21	8	2	133
10	.	.	.	.	.	.	.	.	.	1	10	11	9	.	1	.	2	3	1	6	12	12	28	13	14	3	126
11	.	.	.	.	.	.	.	.	.	.	3	13	11	.	.	1	.	1	1	5	5	7	13	5	5	.	70
12	.	.	.	.	.	.	.	.	.	.	9	18	9	.	.	.	.	1	2	2	2	7	13	8	6	2	79
13	.	1	.	.	.	.	1	.	.	.	2	3	6	.	.	.	.	2	1	1	4	4	7	6	2	1	41
14	.	.	.	.	.	.	.	.	.	.	3	4	3	.	.	.	1	2	.	8	1	5	5	5	2	.	39
15	.	.	.	.	.	1	.	.	.	.	1	4	7	.	.	.	.	1	.	3	2	2	.	1	.	.	22
16	.	.	.	.	.	.	.	.	.	.	.	1	3	.	.	.	.	.	.	2	2	2	4	1	1	1	17
17	.	.	.	.	.	.	.	.	1	.	.	1	2	.	.	.	.	.	.	1	6	.	1	1	.	.	13
18	.	.	.	.	.	.	.	.	.	.	2	5	6	.	.	.	.	.	1	2	1	2	.	.	.	1	20
19	.	.	.	1	.	.	.	.	.	.	.	4	6	.	.	.	1	.	.	1	4	1	1	.	.	.	19
20	.	.	.	.	.	.	.	.	.	.	1	3	1	.	.	.	.	.	.	3	.	1	1	1	.	.	11
21	.	.	.	.	.	.	.	.	.	.	1	8	8	.	.	1	.	.	.	.	.	1	.	1	.	.	20
22	.	.	.	.	.	.	.	.	.	.	.	7	3	.	.	.	1	1	.	.	2	.	1	2	.	.	17
23	.	.	.	1	.	.	.	.	.	.	2	2	4	.	.	.	.	.	.	.	.	1	1	1	.	1	13
24	.	.	.	.	.	.	.	1	.	.	1	2	.	.	.	.	.	.	.	1	1	1	1	.	.	.	8
25	.	.	.	.	.	.	.	.	.	1	1	2	1	.	.	.	1	.	.	1	1	1	.	.	.	.	9
26	.	.	.	.	.	1	.	.	.	.	1	2	2	.	.	.	.	1	.	2	2	1	.	.	1	.	13
27	.	.	.	.	.	.	1	.	.	.	.	3	4	.	.	1	.	1	.	2	.	.	1	.	.	1	14
28	.	.	.	.	.	.	1	.	.	.	.	3	2	.	.	.	.	.	.	.	.	.	.	.	.	.	6
29	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	1	1	.	.	.	.	4
30	.	.	.	.	.	.	.	.	.	.	.	2	1	.	.	.	.	.	.	.	1	.	.	.	.	.	4
31	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	4
32	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1	.	.	.	.	.	2
33	.	.	.	.	1	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	1	.	.	4
Total	1	17	1	4	2	4	5	7	5	14	129	504	395	5	5	21	17	59	63	109	151	177	275	191	110	17	2,288

Table 5. Number of M. bonaci (black grouper) specimens aged from the long line fishery, 1994-2008.

	Year															
Age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	2
4	0	1	0	0	0	1	0	3	3	5	1	5	8	3	1	31
5	0	6	2	0	0	0	0	5	6	8	2	14	18	12	3	76
6	1	9	15	0	0	1	1	3	8	14	19	20	31	11	9	142
7	3	6	8	0	0	0	1	5	7	9	22	24	35	28	12	160
8	0	10	11	0	0	0	0	6	5	7	20	31	47	24	13	174
9	1	11	12	0	0	0	0	0	3	5	5	16	31	17	8	109
10	1	8	6	0	0	0	2	2	1	5	11	11	27	11	13	98
11	2	10	3	0	0	0	0	0	1	5	4	7	13	5	5	55
12	0	13	6	0	0	0	0	1	1	2	2	5	9	7	5	51
13	0	2	4	0	0	0	0	2	1	0	4	4	7	6	2	32
14	1	4	3	0	0	0	0	2	0	8	1	5	4	4	2	34
15	0	1	6	0	0	0	0	1	0	2	2	2	0	1	0	15
16	0	1	3	0	0	0	0	0	0	2	2	2	3	0	0	13
17	0	0	1	0	0	0	0	0	0	1	6	0	1	1	0	10
18	1	2	5	0	0	0	0	0	1	1	1	1	0	0	0	12
19	0	2	2	0	0	0	1	0	0	1	4	1	1	0	0	12
20	0	3	0	0	0	0	0	0	0	3	0	1	1	1	0	9
21	0	7	6	0	0	0	0	0	0	0	0	1	0	1	0	15
22	0	4	2	0	0	0	1	1	0	0	2	0	1	2	0	13
23	0	1	2	0	0	0	0	0	0	0	0	1	1	1	0	6
24	0	1	0	0	0	0	0	0	0	1	1	1	1	0	0	5
25	0	1	1	0	0	0	1	0	0	1	1	1	0	0	0	6
26	1	1	2	0	0	0	0	1	0	2	1	1	0	0	1	10
27	0	2	2	0	0	1	0	1	0	2	0	0	1	0	0	9
28	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	3
29	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	3
30	0	2	0	0	0	0	0	0	0	0	1	0	0	0	0	3
31	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
32	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	2
33	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Total	11	109	105	0	0	3	7	34	37	85	114	156	240	136	75	1112

Table 6. Natural mortality (M) vector by age scaled to Hoenig's estimate (M=0.136, t_{max}=33 years) using Lorenzen's (2005) method, calculated over ages 3-33 years. Total lengths estimated at mid-year from growth curve parameters (L_∞=1364.7 mm, k=0.1348, t_0 = -1.0125; Fig. 11).

Age	TL (mm)	M
0	252	0.489
1	392	0.344
2	515	0.274
3	622	0.233
4	716	0.206
5	797	0.187
6	869	0.173
7	932	0.162
8	986	0.154
9	1034	0.148
10	1076	0.142
11	1112	0.138
12	1144	0.134
13	1172	0.131
14	1196	0.129
15	1217	0.127
16	1236	0.125
17	1252	0.124
18	1266	0.122
19	1279	0.121
20	1290	0.120
21	1299	0.119
22	1307	0.119
23	1315	0.118
24	1321	0.118
25	1326	0.117
26	1331	0.117
27	1335	0.116
28	1339	0.116
29	1342	0.116
30	1345	0.116
31	1348	0.115
32	1350	0.115
33	1352	0.115

Table 7. *M. bonaci* (black grouper) - number of otoliths aged by total length (25 mm size class intervals).

TL_class (mm) lower boundary	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	total
25	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
100	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
125	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4
150	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	8
175	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
200	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
225	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
250	.	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	8
275	.	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6
300	.	3	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5
325	.	2	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	7
350	.	6	9	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	16
375	.	2	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10
400	.	.	15	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	17
425	.	1	12	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	15
450	.	.	10	9	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	19
475	.	.	13	19	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	34
500	.	.	7	23	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	32
525	.	.	7	20	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	34
550	.	.	6	21	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	34
575	.	.	1	20	12	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	33
600	.	.	.	17	26	6	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	50
625	.	.	1	14	22	10	6	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	54
650	.	.	1	16	53	7	1	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	82
675	.	.	.	7	43	17	9	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	79
700	.	.	.	5	33	23	10	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	72
725	.	.	.	3	23	38	14	5	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	85
750	.	.	.	.	14	34	23	6	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	79
775	.	.	.	.	12	41	28	5	3	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	90
800	.	.	.	.	8	41	37	16	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	107
825	.	.	.	.	3	41	29	26	11	2	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	113
850	.	.	.	.	.	13	36	27	14	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	91
875	.	.	.	.	.	7	20	21	25	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	78
900	.	.	.	.	.	6	20	32	28	12	5	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	106
925	.	.	.	.	1	2	11	25	31	11	5	1	.	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	89
950	.	.	.	.	.	1	6	15	25	13	4	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	68
975	.	.	.	.	.	1	4	9	21	11	11	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	60
1000	.	.	.	.	1	.	1	7	16	17	13	3	4	.	1	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	64
1025	.	.	.	.	1	.	1	10	22	11	18	5	4	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	74

Table 7. (cont.) *M. bonaci* (black grouper) - number of otoliths aged with lengths by age and total length size class (lower boundary, 25 mm intervals).

TL_class (mm) lower boundary	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	total
1050	.	.	.	.	.	.	1	7	8	19	12	5	6	3	1	.	.	.	.	.	.	.	.1	.	.	.	.	.	.	.	.	.	.	.	69
1075	.	.	.	.	.	.	.	1	5	14	21	11	10	3	2	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	69
1100	.	.	.	.	.	.	.	.	2	7	15	11	10	3	2	.	1	.	1	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	54
1125	.	.	.	.	.	.	.	1	1	6	8	6	7	7	3	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	40
1150	.	.	.	.	.	.	.	.	.	3	9	7	12	5	5	2	1	1	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	47
1175	.	.	.	.	.	.	.	.	.	.	1	5	10	6	3	2	2	1	1	.	1	1	.	.	.	.	1	1	.	.	1	1	.	.	37
1200	.	.	.	.	.	.	.	.	.	.	1	5	8	5	7	5	2	1	.	1	2	2	2	2	.	.	1	.	.	.	.	.	.	.	44
1225	.	.	.	.	.	.	.	.	.	.	1	1	2	4	2	3	1	1	4	1	2	2	.	.	.	.	2	1	.	.	.	.	.	.	27
1250	.	.	.	.	.	.	.	.	.	.	.	1	3	2	5	4	3	3	2	2	.	.	.	.	2	2	2	1	.	.	.	.	.	.	32
1275	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	4	3	3	2	3	.	6	4	2	.	.	1	1	1	.	.	.	.	.	33
1300	.	.	.	.	.	.	.	.	.	.	.	.	1	.	5	1	1	1	1	2	2	4	.	.	3	1	2	2	.	1	1	1	.	.	29
1325	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	5	3	1	1	1	2	1	1	1	1	2	.	.	.	.	1	22
1350	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	2	3	2	2	2	3	1	3	2	3	2	2	.	2	2	1	33
1375	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	2	2	.	1	.	1	.	1	2	.	.	1	12
1400	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	1	.	.	1	2	.	.	.	.	.	.	6
1425	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	2	.	1	.	.	1	.	.	.	.	.	1	6
1450	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	2
1475	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	1
1500	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1
Total	17	30	97	177	272	288	257	222	220	133	126	70	79	41	39	22	17	13	20	19	11	20	17	13	8	9	13	14	6	4	4	4	2	4	2,288

Table 8. Comparison of *M. bonaci* (black grouper) growth curves[a] using otoliths from Crabtree and Bullock (1998).

	Crabtree and Bullock (1998)	Crabtree and Bullock (1998)*	Otoliths re-read for SEDAR 19	Otoliths re-read for SEDAR 19	Otoliths re-read for SEDAR 19	Otoliths re-read for SEDAR 19	Otoliths re-read for SEDAR 19
	criteria to accept: avg # annuli (2 readers* 3 reads, cv <=12%	*re-run, some data revisions, and same criteriafor aging	new annuli counts of C&B non-rejects	new annuli counts (includes C&B rejects)	new adjusted ages (includes C&B rejects)	new adjusted ages plus annuli counts on missing slides (includes C&B rejects)	new adjusted ages and Bullock extra slides (includes C&B rejects)
n	927	927	920	1024	1024	1031	1055
L_{inf}	1306.2 (8.05)	1306.8 (8.08)	1308.0 (8.23)	1312.9 (8.02)	1321.7 (8.61)	1322.5 (8.56)	1328.5 (8.39)
K	0.169 (0.0037)	0.1685 (0.0037)	0.1683 (0.0038)	0.1653 (0.0036)	0.1557 (0.0035)	0.1553 (0.0035)	0.1539 (.0034)
t_0	-0.768 (0.0640)	-0.7707 (0.0639)	-0.7647 (0.0646)	-0.7943 (0.0637)	-0.6046 (0.0687)	-0.6120 (0.0683)	-0.6235 (0.0688)
Regression MSE	4207.1	4211.2	4243.6	4468.2	4755.4	4735.0	4830.1
adj. approx r^2	0.941	---	---	---	---	---	---
Crabtree and Bullock (1998) rejected slides	133	133	133	---	---	---	---
C&B missing slides	---	---	7	7	7	---	7
Bullock (pers. comm.) missing slides	---	---	---	---	---	---	2
Slides difficult to read (rejected)	---	---	---	29	29	29	29
Total processed	1060	1060	1060	1060	1060	1060	1093
additional records without otoliths or length	109	109	109	109	109	109	167
Total records	1169	1169	1169	1169	1169	1169	1260

[a] standard errors of the parameter estimates are shown in parentheses.

Table 9. *M. bonaci* (black grouper) growth curves [otoliths aged for SEDAR 19, specimens collected for Crabtree and Bullock (1998) and by other biological sampling sources (see Table 1)].

	All otoliths for SEDAR 19	All Otoliths for SEDAR 19
	criteria to accept: adjusted age>=0 and TL>0.	Criteria to accept: adjusted age>=0, TL>0. For otoliths collected from recreational or commercial fishers, TL>=existing minimum size limits in effect at the time of harvest .
N	2,288	2,271
L_{inf}	1365.8 (7.98)	1364.7 (7.94)
K	0.1343 (0.0025)	0.1348 (0.0025)
t_0	-1.0281 (0.0646)	-1.0125 (0.0648)
Regression MSE	5972.8	5958.6
Crabtree and Bullock (1998) rejected slides	---	---
C&B missing slides	7	7
Bullock (pers. comm.) missing slides	2	2
Slides difficult to read (rejected)	29	29
C&B accepted slides (6 reads, cv<=12%)	920	918 (2 below minimum size limits excluded)
Bullock (pers. comm.) extra slides	31	31
Crabtree and Bullock (1998) rejected slide reads included	133	133
additional new slides	1233	1218 (15 below minimum size limits excluded)
Total slides with ages	2288	2271

[a] standard errors of the parameter estimates are shown in parentheses.

Table 10. Results of logistic regressions for length-at-maturity, age-at-maturity, and length-at-transition or age-at-transition of females to males for *M. bonaci* in the southeastern U.S. Length is measured as total length in millimeters.

Length -at-Maturity or Proportion Females-at-Length regressions	**n**	**p**	**MSE**	**r**	**se**	**L_{50} (mm)**	**se**
Length-at-maturity (all months)[a]	783	< 0.05	0.0785	0.0198	0.00174	825.3	4.6538
Length-at-maturity (January-March)[b]	*236*	*< 0.05*	*0.0698*	*0.0258*	*0.00400*	*855.6*	*7.7537*
Length-at-transition (50% males) (all months)[a]	890	< 0.05	0.0228	-0.0158	0.00124	1213.7	5.4577

Age-at-Maturity or Age-at-Transition (50% Females) regressions	**n**	**p**	**MSE**	**r**	**se**	**A_{50} (years)**	**se**
Age-at-maturity (all months, avg. annuli counts)[a]	617	< 0.05	0.0876	1.3724	0.1340	5.202	0.0779
Age-at-maturity (all months, adjusted ages)[b]	*617*	*< 0.05*	*0.0922*	*1.1754*	*0.1144*	*5.741*	*0.0938*
Age-at-maturity (January-March, avg. annuli counts)	236	< 0.05	0.0815	1.3873	0.2525	5.6909	0.1611
Age-at-maturity (January-March, adjusted ages)[b]	*236*	*< 0.05*	*0.0770*	*1.6809*	*0.3262*	*6.4828*	*0.1465*
Age-at-transition (50% females) (all months, avg. annuli counts)[a]	696	< 0.05	0.0245	-0.3518	0.0279	15.4693	0.3898
Age-at-transition (50% females) (all months, adjusted ages)[b]	*696*	*< 0.05*	*0.0244*	*-0.3498*	*0.0278*	*16.0297*	*0.3885*

[a] re-analyzed data from Crabtree and Bullock (1998)

[b] *Italicized regressions are analyses performed for SEDAR 19 Black Grouper using samples from a subset of months and/or ages derived from annuli counts adjusted for the marginal increment type and time of year.*

Table 11. Length-length relationships for *M. bonaci* (black grouper) from Crabtree and Bullock (1998; Table 1) except where noted. [TL measurement with tail compressed.]

Regression y=a+bx [Crabtree and Bullock (1998)] (dependent variable from independent variable)	n	intercept		slope		r^2
		a	(standard error (se))	b	(se)	
SL (mm) from FL(mm)	1,134	-23.712	(0.6852)	0.883	(0.0008)	0.999
SL (mm) from TL (mm)	1,141	-21.611	(0.7743)	0.858	(0.0009)	0.999
FL (mm) from SL (mm)	1,134	27.607	(0.7514)	1.131	(0.0011)	0.999
FL (mm) from TL (mm)	1,150	1.641	(0.5223)	0.973	(0.0006)	0.999
TL (mm) from SL (mm)	1,141	26.186	(0.8757)	1.164	(0.0012)	0.999
TL (mm) from SL (mm) [a]	209	*17.8*		*1.10*		
TL (mm) from FL (mm)	1,150	-1.317	(0.5378)	1.028	(0.0006)	0.999
Whole Weight (grams) from Gutted Weight (grams)[b]	638	81.519	(12.9253)	1.056	(0.0014)	0.999

[a] Garcia-Cagide and Garcia (1996) also list a length-length relationship for lengths measured in centimeters. Shown in italics is the equivalent conversion in millimeters.
[b] With revisions to data used, a=79.371, b=1.056

Table 12. Length-weight relationships for *M. bonaci* (black grouper) from Crabtree and Bullock (1998; Table 1). [TL measurement with tail compressed.]

Regression $\log_{10}(y)=\log_{10}(a)+b*\log(x)$ [Crabtree and Bullock (1998)]	n	intercept		slope		r^2
		a	(se)	b	(se)	
$\log_{10}$(whole weight[grams]) from $\log_{10}$[TL(mm)][a]	772	-5.457	(0.0323)	3.218	(0.0115)	0.995
$\log_{10}$(whole weight[kg]) from $\log_{10}$[TL(mm)][b]	*772*	*-8.457*	*(0.0323)*	*3.218*	*(0.0115)*	*0.995*
ln(whole weight[kg]) from ln[TL(mm)][c]	*772*	*-19.473*	*(0.0743)*	*3.218*	*(0.0115)*	*0.995*

[a] With revisions to data used, n=773, r^2=0.990
[b] Crabtree and Bullock (1998) regression converted to kilograms
[c] Crabtree and Bullock (1998) regression converted to natural logarithms for comparison with Table 6 in this report .

Table 13. Length-length relationships for *M. bonaci* (black grouper), data from Crabtree and Bullock (1998) and other sources of biological measurements. [TL measurement with tail compressed.]

Regression y=a+bx (dependent variable from independent variable)	n	intercept		slope		r^2	Mean Square Error	Min (x)	Max (x)
		a	(se)	b	(se)				
SL (mm) from FL(mm)	1,320	-23.8492	(1.163)	0.8827	(0.001)	0.997	60.6580	238	1,495
SL (mm) from TL (mm)	1,338	-22.2831	(0.719)	0.8588	(0.001)	0.999	66.4041	51	1,325
FL (mm) from SL (mm)	1,338	32.870	(1.262)	1.1231	(0.002)	0.997	214.3628	191	1,325
FL (mm) from TL (mm)	1,339	1.7134	(0.452)	0.9727	(0.001)	0.999	25.2675	238	1,538
TL (mm) from SL (mm)	1,338	26.9632	(0.812)	1.1630	(0.001)	0.999	89.9276	51.2	1,325
TL (mm) from SL (mm), specimens SL 50-300 mm[a]	5	2.3372	(0.185)	1.2135	(0.019)	0.999	2.2548	51.2	305
TL (mm) from FL (mm)	1,339	-1.4386	(0.466)	1.0276	(0.001)	0.999	27.1049	238	1,495
Whole Weight (kg) from Gutted Weight (kg)	636	1.006	(0.002)	1.0549	(0.001)	0.999	0.0009	0.44	58.64
Whole Weight (kg) from Gutted Weight (kg) (*no intercept model*)	636			1.061	(0.001)			0.44	58.64
Gutted Weight (kg) from Whole Weight (kg)	635	-.0569	(0.002)	0.9459	(0.001)	0.999	0.0540	0.47	61.59
Gutted Weight (kg) from Whole Weight (kg) (*no intercept model*)	635			0.941	(0.001)			0.47	61.59
TL-"natural[b]" (mm) from SL (mm)	74	21.2854	(11.871)	1.1595	(0.019)	0.981	280.5774	435	1,135
TL-"natural[b]" (mm) from FL (mm)	137	-2.8410	(4.442)	1.0193	(0.006)	0.995	70.3761	387	1,336
TL (mm) from TL-"natural[b]" (mm)	78	4.2981	(4.090)	1.0097	(0.006)	0.998	28.9184	528	1,252

[a] The SL-TL relationship for specimens below 300 mm TL suggested the use of a different predictive equation than for larger specimens.
[b] TL-"natural" is the total length with the tail in a natural position rather than compressed.

Table 14. Length-weight relationships for *M. bonaci* (black grouper), with additional data. [TL measurement with tail compressed.]

Regression ln(y)=ln(a)+b*ln(x)	n	intercept		slope		r^2	Mean Square Error	Min (x)	Max (x)
		ln(a)	(se)	b	(se)				
ln(whole weight[kg]) from ln[FL(mm]	2,552	-18.5545	(0.006)	3.0843	(0.010)	0.972	0.0266	206	1,495
ln(gutted weight[kg]) from ln[FL(mm]	2,420	-18.8956	(0.045)	3.1306	(0.007)	0.990	0.0089	314	1,495
ln(whole weight[kg]) from ln[TL(mm]	904	-19.2684	(0.063)	3.1863	(0.010)	0.992	0.0097	77.5	1,525.4
ln(gutted weight[kg]) from ln[TL(mm]	1,075	-19.0487	(0.051)	3.1438	(0.008)	0.994	0.0062	334	1,525.4

Fig. 1. *Mycteroperca bonaci* (black grouper).

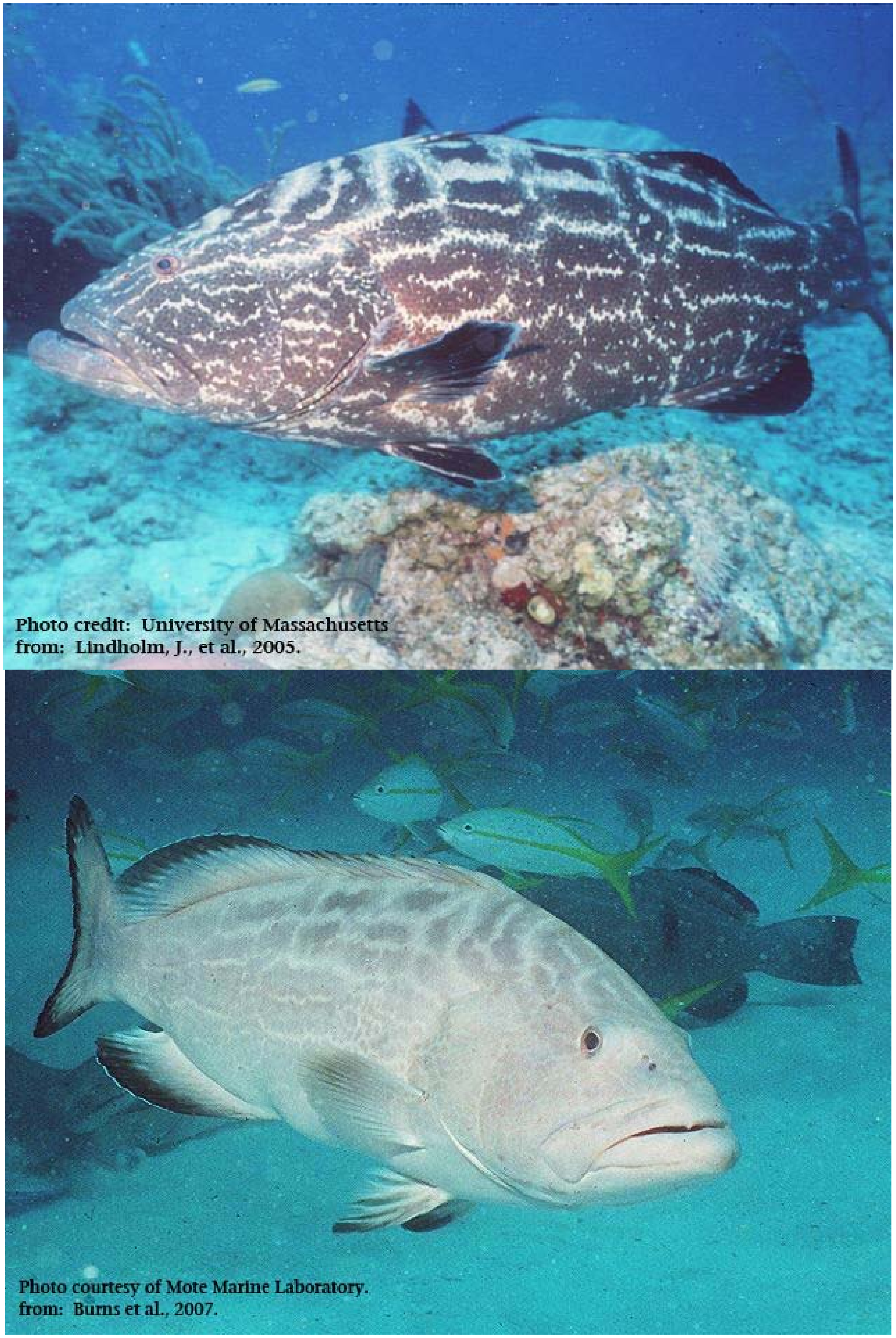
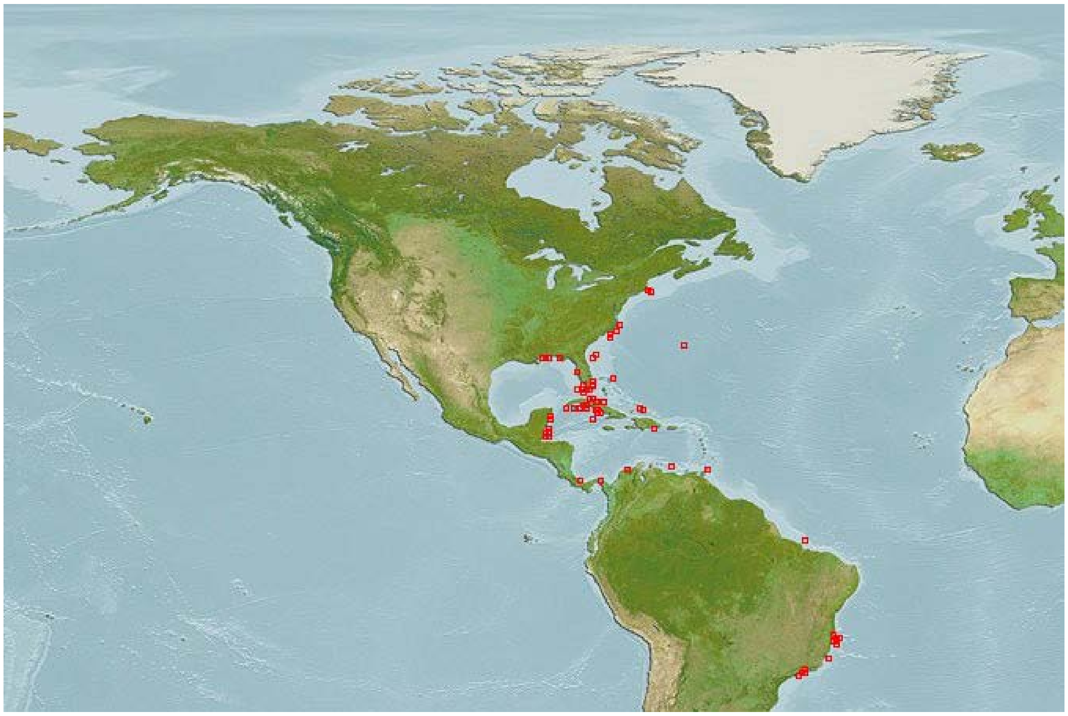


Fig. 2. *M. bonaci* (black grouper) catch and distribution; (a) Catch locations of specimens of *M. bonaci* in the Western hemisphere (OBIS, 2009); (b) Distribution map for *M. bonaci* in the Western Hemisphere (from AquaMaps, Kaschner et al., 2008).

a. Documented locations of catch in OBIS



b. Estimated distribution of black grouper (Kaschner et al., 2008)

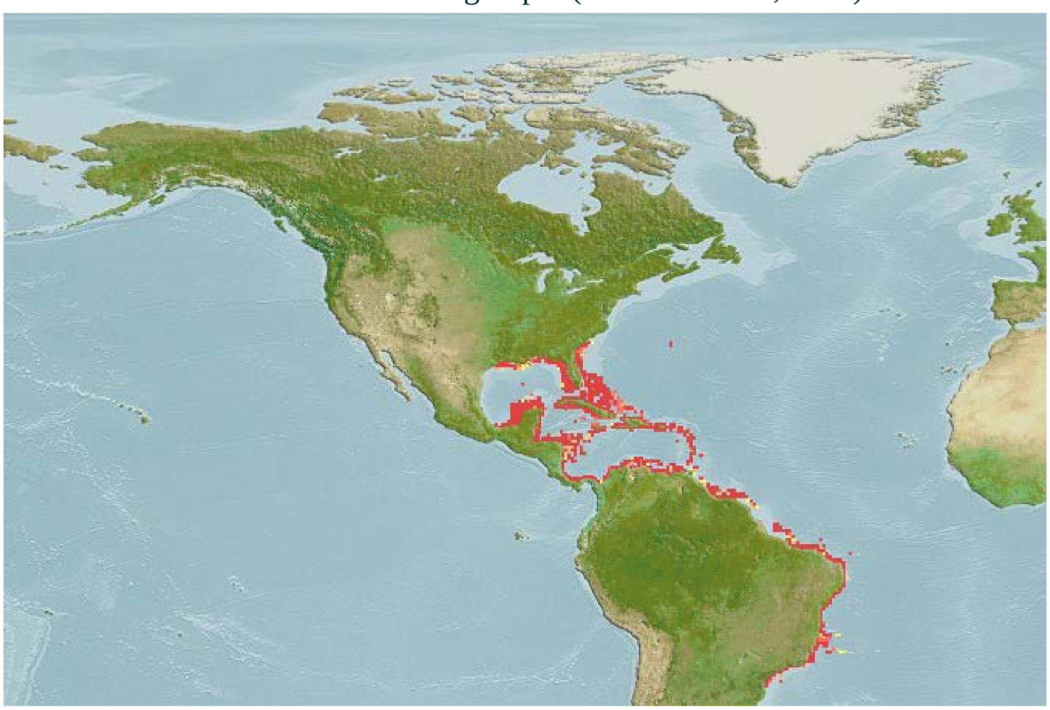
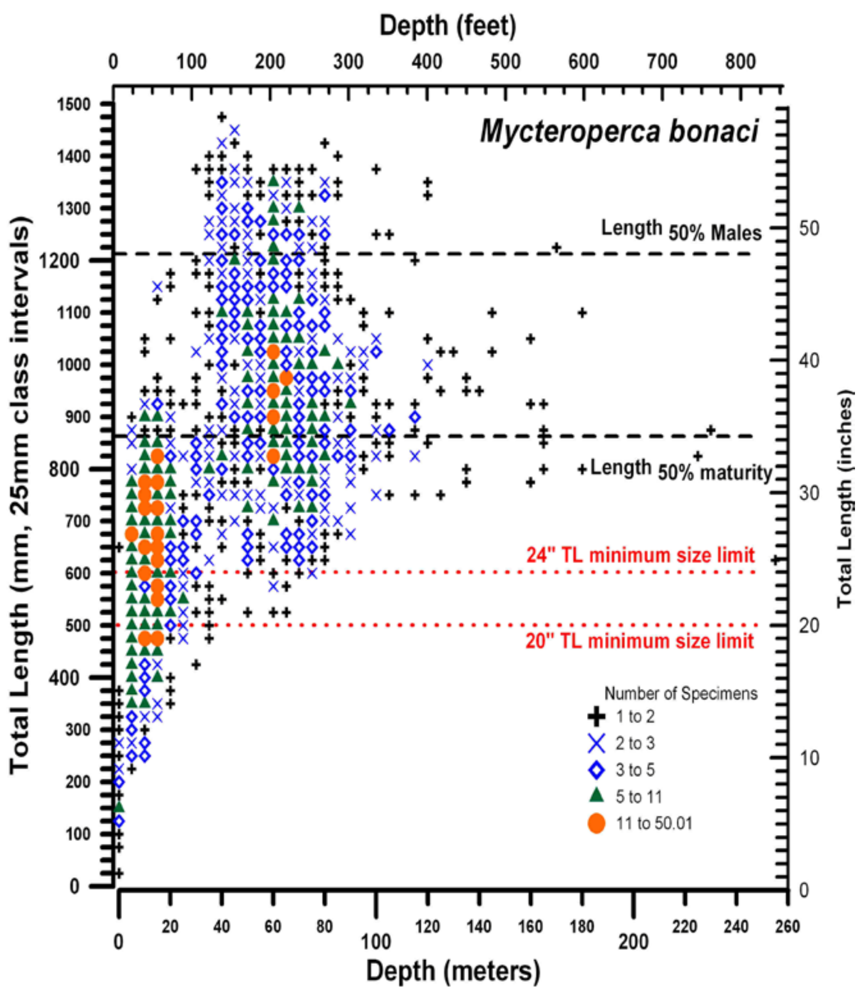


Fig. 3. *M. bonaci* (black grouper) specimens by length and age and depth of catch, 1978-2008. [Data sources: Bullock (personal communication), NMFS Trip Interview Program, Florida FWC/GSMFC FIN biological sampling, otolith data.]

a. Black grouper specimens by length and depth



b. Black grouper specimens by age and depth

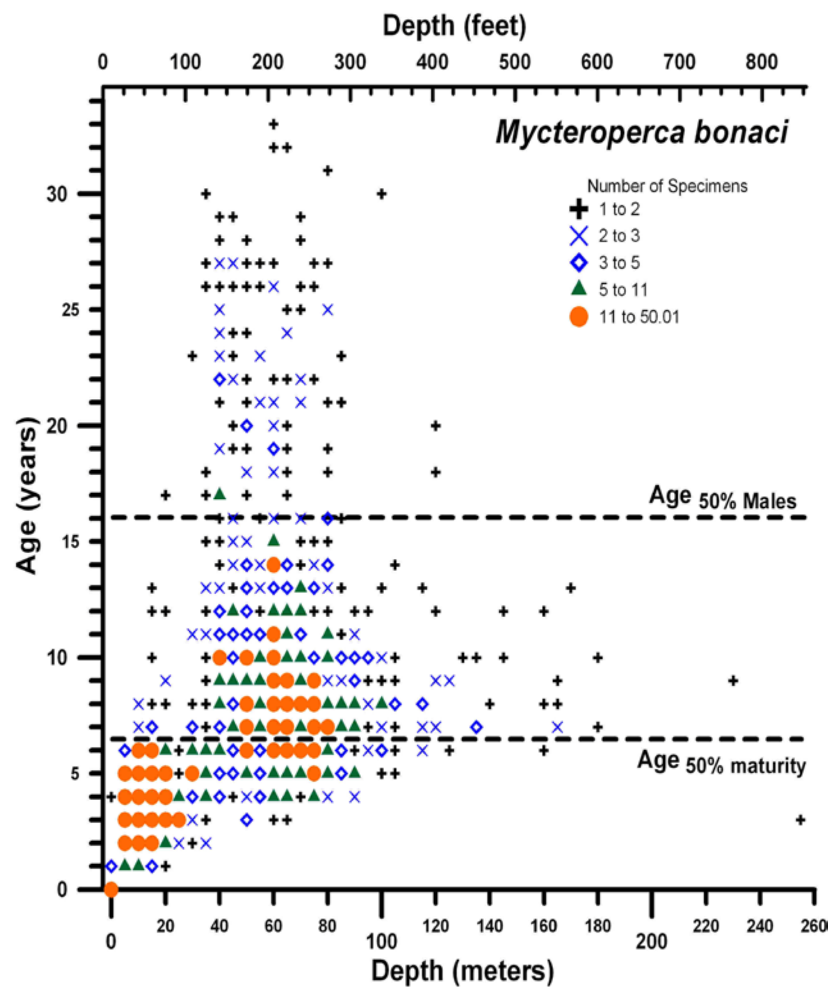


Fig. 4. Catch locations (latitude/longitude, area fished, reef or bottom feature name known) of aged M. bonaci (black grouper) specimens in the U.S. southeastern region, 1978-2008.

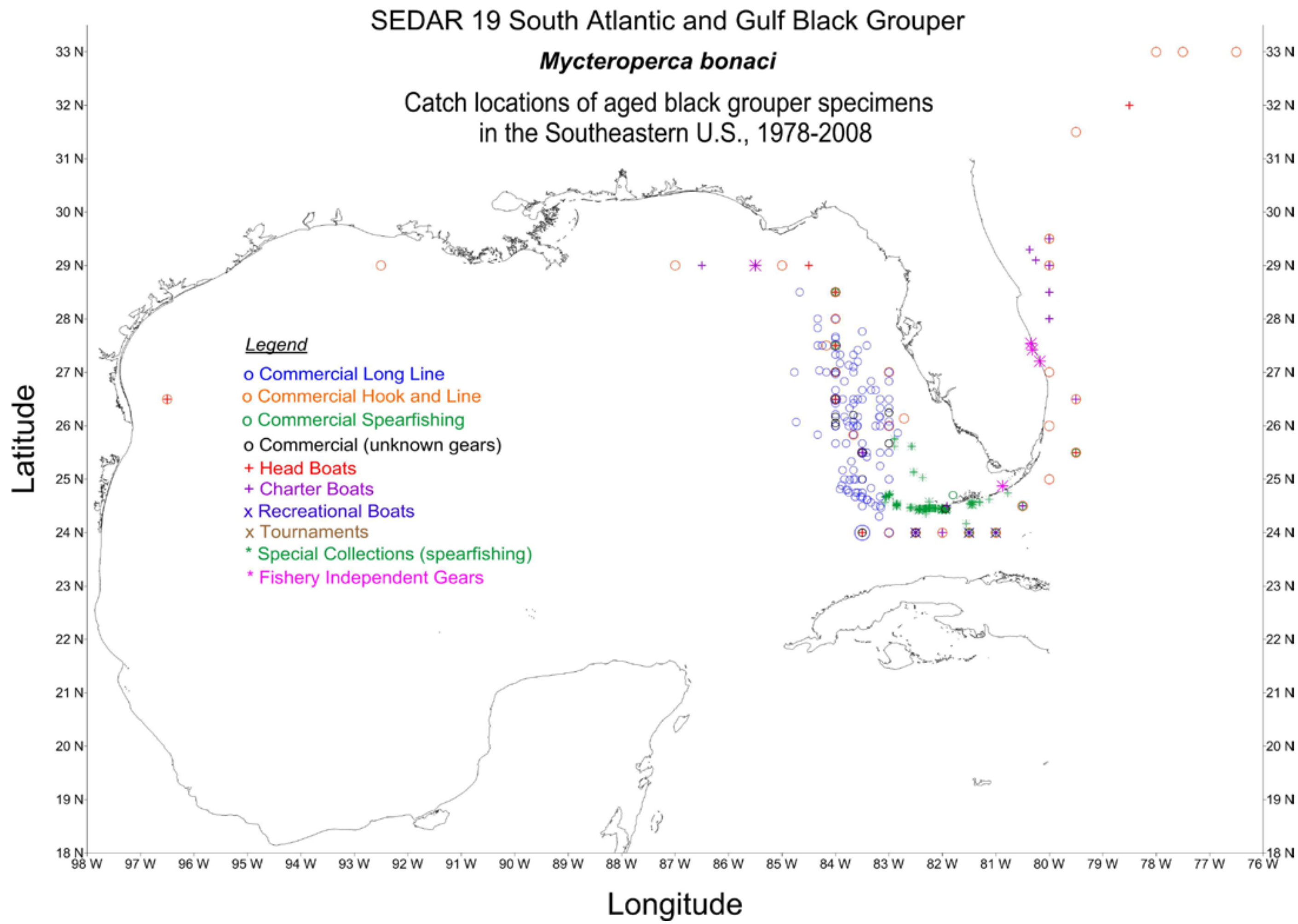


Fig. 5. (a) *M. bonaci* (black grouper); and (b) gag (*M. microlepis*), the species similar in appearance; (c) close-up of brassy spots on the body of *M. bonaci* (black grouper).

Fig. 6. St. Petersburg Times newspaper article excerpt from June 4, 1976 noting catches of an 80 pound carberita (=black grouper, *M. bonaci*) and 12 “black grouper” (=gag, *M. microlepis*) to 30 pounds by the head boat “Admiral Too” out of Cortez (Manatee County on Florida’s west coast). Also noted were catches of “black grouper” (=gag) in the 20-31 pound range by anglers on the charter boat “Shark” fishing “The Elbow” (Big Elbow and Little Elbow), an area of bottom around the 30 fathom contour line with relatively high relief (Moe, 1963).

4 MANATEE TIMES ■ FRIDAY, JUNE 4, 1976

sports

Snook fishing tournament opens at Anna Maria

A snook fishing tournament has been started by the Anna Maria City Pier for June.

There will be two divisions to the tournament, one for the largest number of snook by any one person for the month, and the other for the largest (heaviest) individual snook taken during the month. There will be two prizes awarded in each of these two divisions.

IN ADDITION, there will be an overall grand prize for the greatest poundage of snook caught by any one angler during the month.

Entry fee is $1 per person, and to be eligible, the snook must be caught from the Anna Maria City Pier.

Snook are a game fish. The minimum legal length is 18 inches, and there is a limit of four snook per person per day. It's also very important to note that there is a possession limit of four snook per person. No person at anytime may have more than four snook in his possession.

All those entering the tournament should be aware of this. They also should know that snook may be taken only by the use of a hook and line, and by no other method.

PIER FISHING

OUTDOORS

BOB BENDER

GULF CATCHES

The big Admiral party boats out of Cortez are finding Gulf of Mexico bottom fishing productive these days. On Sunday's regular 7 a.m. trip, the Admiral Too returned with 950 pounds of fish, including 800 pounds of black grouper to 28 pounds and red snapper to 14 pounds. The biggest fish was a 150-pound jewfish.

Those aboard the Admiral's Lady for a two-day trip this past weekend caught 1,800 pounds of fish. This included an 80-pound carbarita, 50 red snapper to 20 pounds and 12 black grouper to 30 pounds.

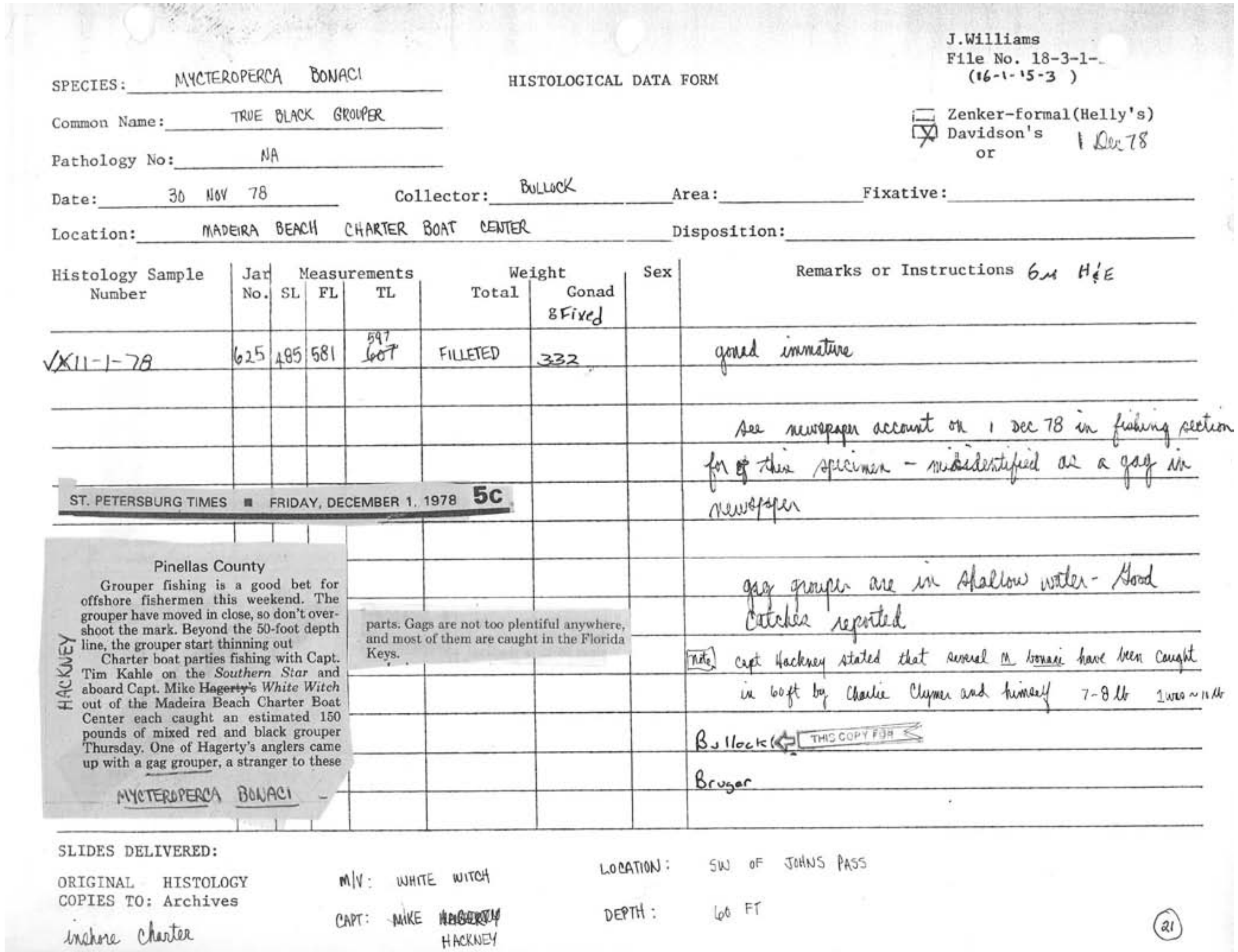
SPEAKING OF GOOD BOAT CATCHES, Capt. Dave Davis' party aboard the big charterboat Shark out of Sarasota scored well in the Old Salt Tournament this past weekend. They fished in 120 to 220 feet of water, 50 to 90 miles offshore. They headed on a 257 degree course from Big Sarasota Pass and fished at Little Elbow then north to Big Elbow and finally to the Mexican Pride wreck in 126 feet of water due west of Bean Point, the north tip of Anna Maria Island.

Altogether they boated between 1,300 and 1,400 pounds of fish. The catch include 29 little tuna (false albacore) to 13 pounds; 38 amberjack to 30 pounds; two wahoo weighing 64 and 22 pounds; five blackfin tuna between 22 and 25 pounds; a 38-pound cobia; 10 dolphin in the 3-4 pound class; 23 red and mangrove snapper; and three black grouper 20 to 31 pounds.

THEY RAISED one billfish, a sail, but it missed the bait by a couple of feet.

On a regular trip Monday, the Shark worked 20 miles offshore around the sunken barge and brought back eight jack crevalle to 15 pounds and 10 amberjack to 30 pounds. The two largest of each species will be mounted by the fishermen.

Fig. 7. Laboratory notebook page from November 30, 1978 from Bullock (personal communication) with an excerpt from the St. Petersburg Times (December 1, 1978) as an example of the confusion in the identification of black grouper and gag by anglers and outdoors writers.



J.Williams
File No. 18-3-1-
(16-1-15-3)

HISTOLOGICAL DATA FORM

SPECIES: MYCTEROPERCA BONACI

Common Name: TRUE BLACK GROUPER

Pathology No: NA

☐ Zenker-formal(Helly's)
☒ Davidson's 1 Dec 78
or

Date: 30 NOV 78 Collector: BULLOCK Area: Fixative:

Location: MADEIRA BEACH CHARTER BOAT CENTER Disposition:

Histology Sample Number	Jar No.	SL	FL	Measurements TL	Weight Total	Gonad 8 Fixed	Sex	Remarks or Instructions 6 μ H&E
√XII-1-78	625	485	581	597 607	FILLETED	332		gonad immature
								See newspaper account on 1 Dec 78 in fishing section for of this specimen – misidentified as a gag in newspaper
								gag grouper are in shallow water - Good catches reported
								Note capt Hackney stated that several M. bonaci have been caught in 60 ft by Charlie Clymer and himself 7-8 lb 1 was ~ 11 lb
								Bullock THIS COPY FOR
								Bruger

ST. PETERSBURG TIMES ■ FRIDAY, DECEMBER 1, 1978 5C

Pinellas County

Grouper fishing is a good bet for offshore fishermen this weekend. The grouper have moved in close, so don't overshoot the mark. Beyond the 50-foot depth line, the grouper start thinning out.

Charter boat parties fishing with Capt. Tim Kahle on the *Southern Star* and aboard Capt. Mike ~~Hagerty's~~ HACKNEY *White Witch* out of the Madeira Beach Charter Boat Center each caught an estimated 150 pounds of mixed red and black grouper Thursday. One of Hagerty's anglers came up with a gag grouper, a stranger to these parts. Gags are not too plentiful anywhere, and most of them are caught in the Florida Keys.

MYCTEROPERCA BONACI

SLIDES DELIVERED:

ORIGINAL HISTOLOGY
COPIES TO: Archives

inshore charter

M/V: WHITE WITCH
CAPT: MIKE ~~HAGERTY~~ HACKNEY

LOCATION: SW OF JOHNS PASS
DEPTH: 60 FT

(21)

Fig. 8. Laboratory notebook page from June 1, 1986 from Bullock (personal communication) with an excerpt from the Naples Daily News (June 10, 1986) noting the catch of a large black grouper (*M. bonaci*) in 125 feet of water on the west Florida shelf.

SPECIES:

FILE #: 601.01.01

COMMON NAME: black grouper

Date: 9 June 86 Collector: BULLOCK ☐ Cull and give age

Location: Capri Isles - Capt Danny Duffy - 394-3452

Embedment: Paraffin ☑ or Plastic ____ (type)

Stain: H & E, 6 um ☑ or

Disposition:

Histology Sample Number	Jar No.	TL	FL	SL	Total Weight	Gonad Weight	Sex	Class	Remarks or Instructions
VI-1-86			1251	1073	83 ½ lb	whole	♂		GROSS APPEARANCE OF GONAD
			49¼"	42½"					= creamy like male

COMPLETED / STAINED / SECTIONED / EMBEDDED / GROSSED

Isles of Capri Fisherman Hooks Potential World Record Grouper

By STEVE HART
Staff Writer

MARCO ISLAND — Tom Hardesty of the Isles of Capri, fishing Sunday aboard Capt. Danny Duffey's "Johnny-J," landed what may be a world record carborita grouper.

The fish, which weighed out at 83½ pounds, if certified properly and identified by the International Game Fish Association as a carborita could become the world record catch for that particular species of grouper. The world record is a 74-pound carborita caught out of St. Petersburg.

Hardesty hooked the grouper approximately 50 miles out in the Gulf of Mexico in 125 feet of water. Hardesty said they were fishing with live jack cravelle as bait, using 80-pound test line, a custom built rod and a Penn International reel. The day's catch also included eight other grouper, four red snapper and a jewfish grouper.

Hardesty and Duffey fish out of the Pelican Bend Marina on the Isles of Capri. He said he contacted the IGFA Monday morning and was told that the association also had an 84-pound grouper awaiting certification. But that grouper couldn't be properly identified as a carborita.

The other fish in question, caught off Panama City, has been tentatively indentified as a Warsaw grouper, according to Hardesty.

Photo by Steve H

TOM HARDESTY, LEFT, CAPT DANNY DUFFEY ... with 83½-pound carborita grouper caught Sunday.

PARASITES= isopoda in mouth (sent to Williams) sent to Williams/Puerto Rico 6/18/86

NAPLES DAILY NEWS Tues., June 10, 1986

ORIGINAL HISTOLOGY
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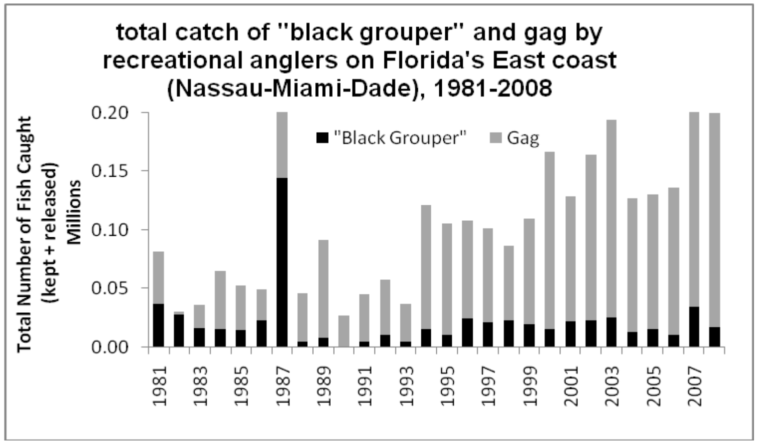
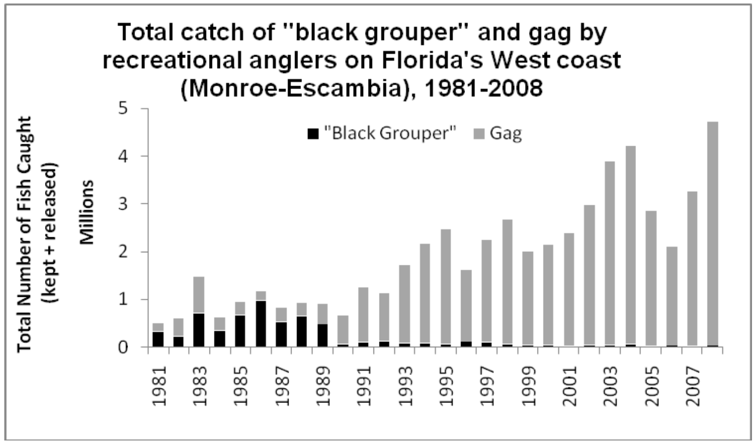
COLLECTOR- BULLOCK

Fig. 9. Recreational catches of “black grouper” and gag in Florida. Total catches (harvests and releases) of these two species from the NMFS Marine Recreational Fishery Statistics Survey, 1981-2008 for Florida: (a) East coast, (b) West coast; Percentage of “black grouper” and gag in the total catch of “black grouper”+gag: (c) East coast, (d) West coast.

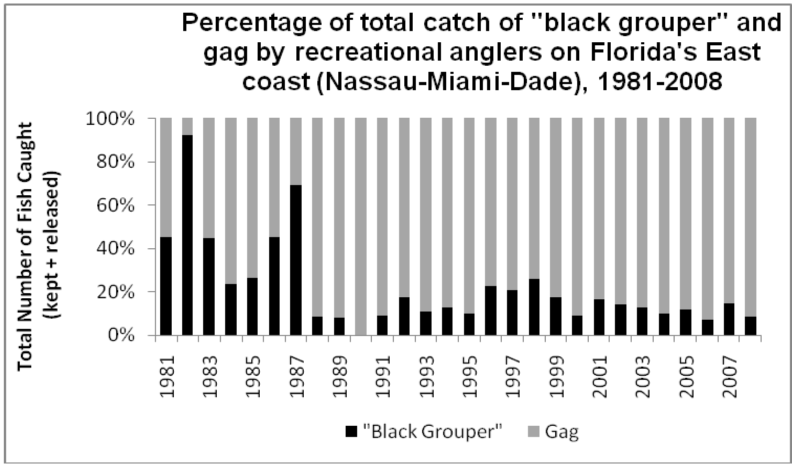
a. East coast total catches of “black grouper” and gag



b. West coast total catches of “black grouper” and gag



c. East coast percentage of “black grouper” + gag catches



d. West coast percentage of “black grouper” + gag catches

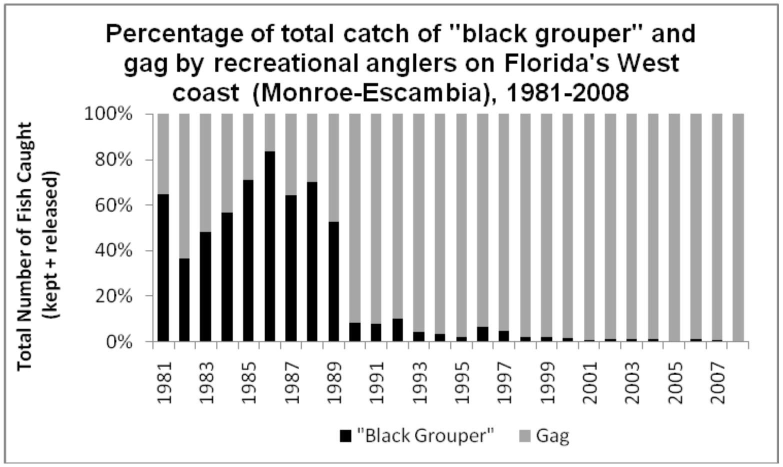
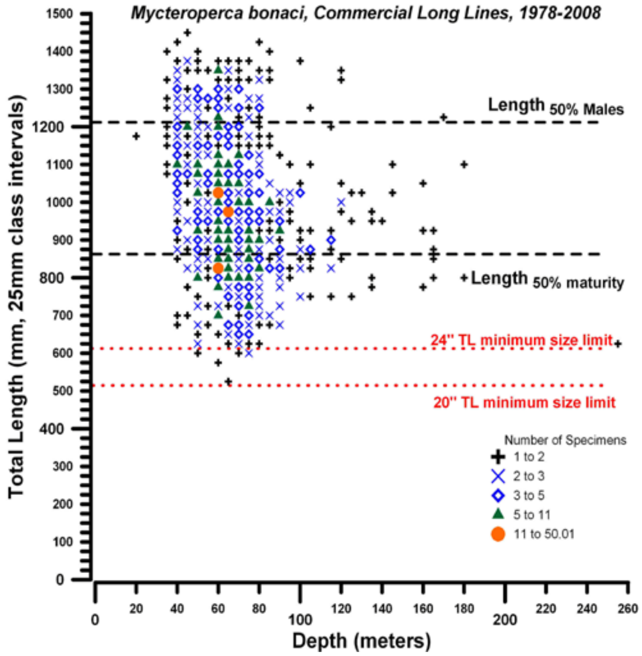
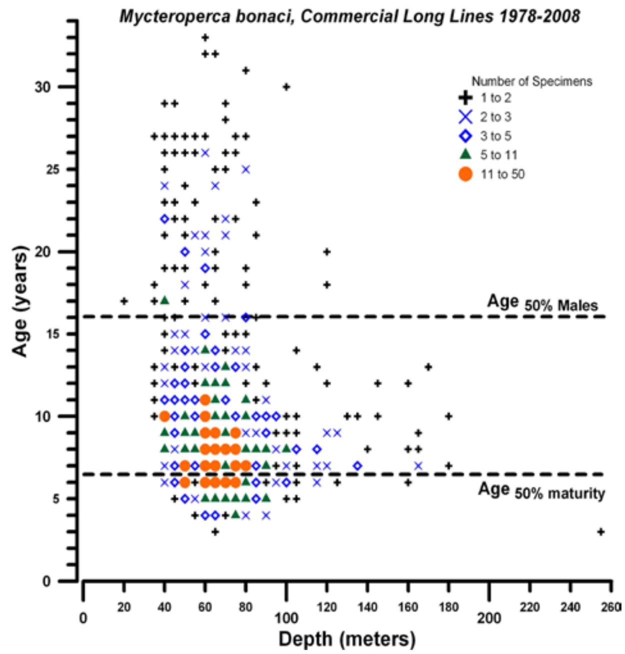


Fig. 10. Black grouper specimens by length or age and depth of catch, by fishing mode and gear, 1978-2008. Commercial long line specimens: a) length, b) age; Commercial hook and line specimens: c) length, d) age; Recreational specimens: e) length, f) age; Tournament specimens: g) length, h) age; Special collections and Fishery Independent specimens: i) length, j) age.

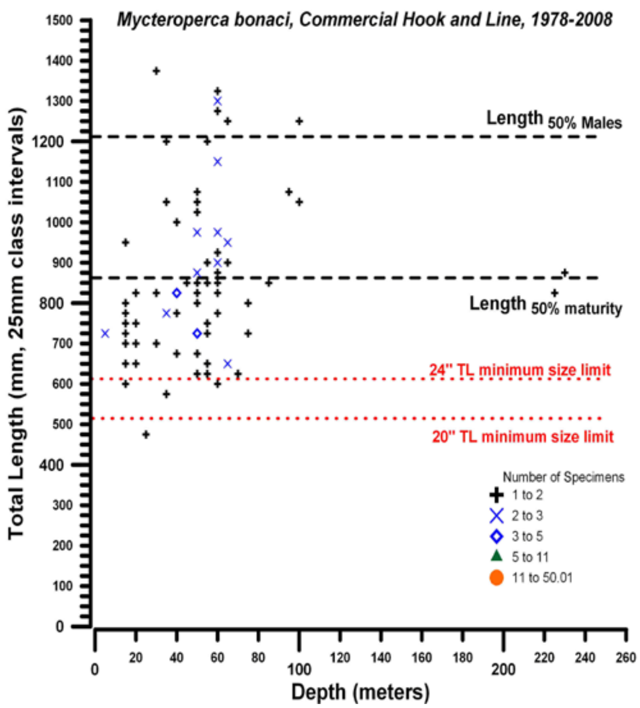
a. Commercial Long Line Specimens, length



b. Commercial Long Line Specimens, age



c. Commercial Hook and Line Specimens, length



d. Commercial Hook and Line Specimens, age

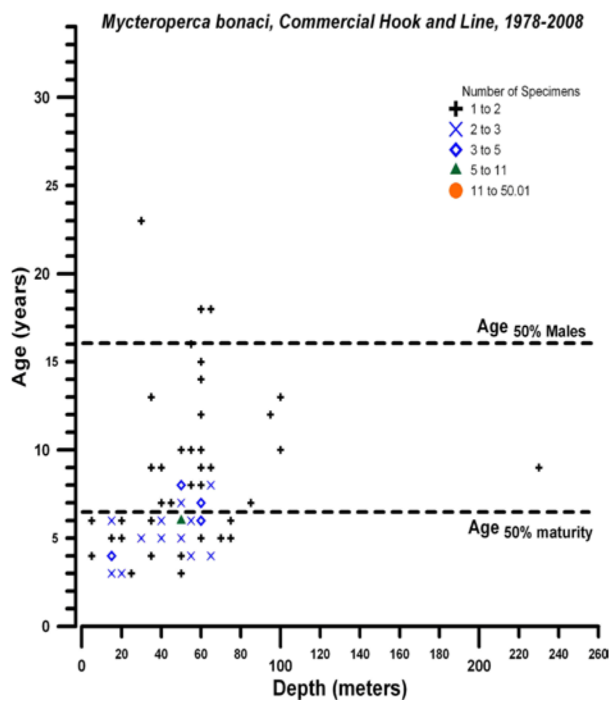
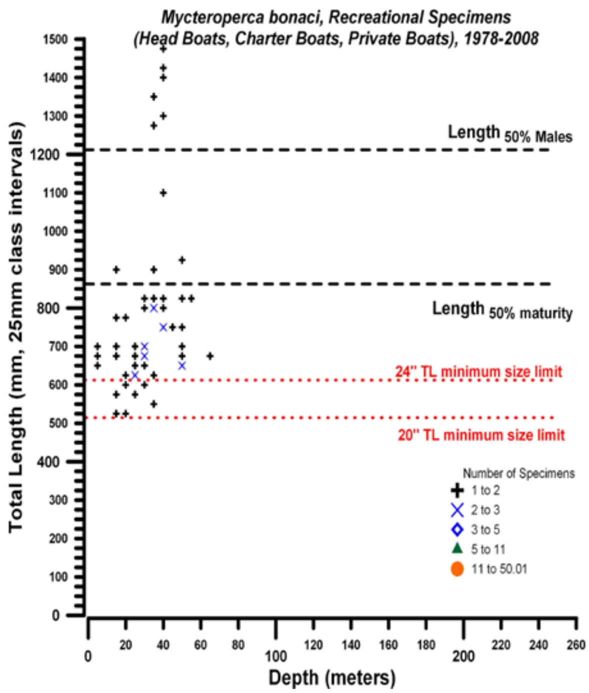
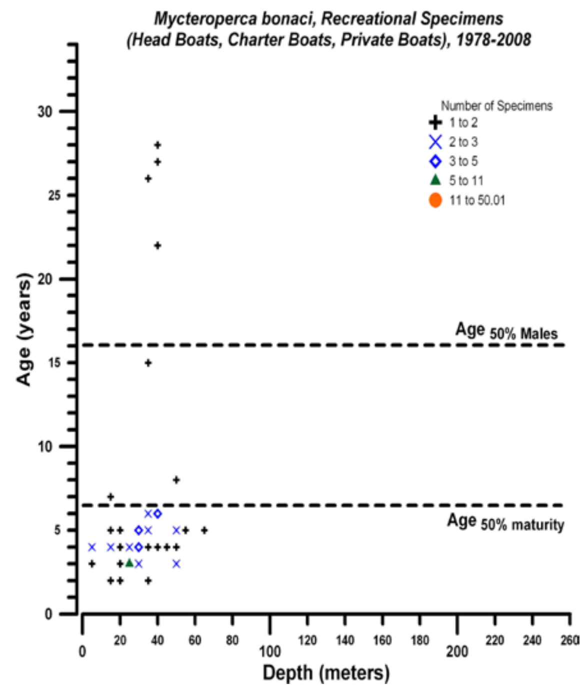


Fig.10. (cont.). Black grouper specimens by length or age and depth of catch, by fishing mode and gear, 1978-2008. Commercial long line specimens: a) length, b) age; Commercial hook and line specimens: c) length, d) age; Recreational specimens: e) length, f) age; Tournament specimens: g) length, h) age; Special collections and Fishery Independent specimens: i) length, j) age.

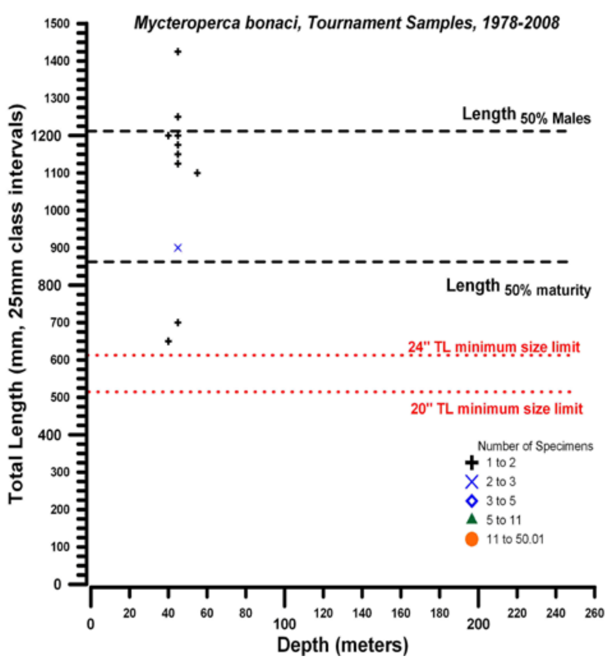
e. Recreational Specimens, length



f. Recreational Specimens, age



g. Tournament Samples, lengths



h. Tournament Samples, ages

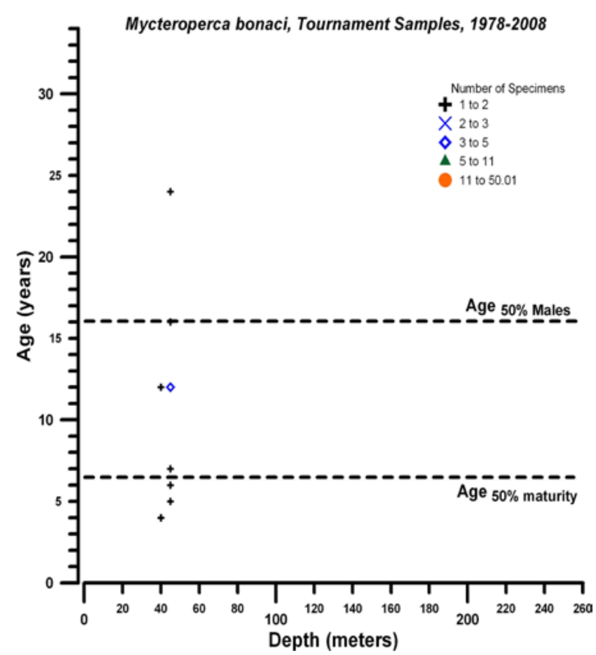
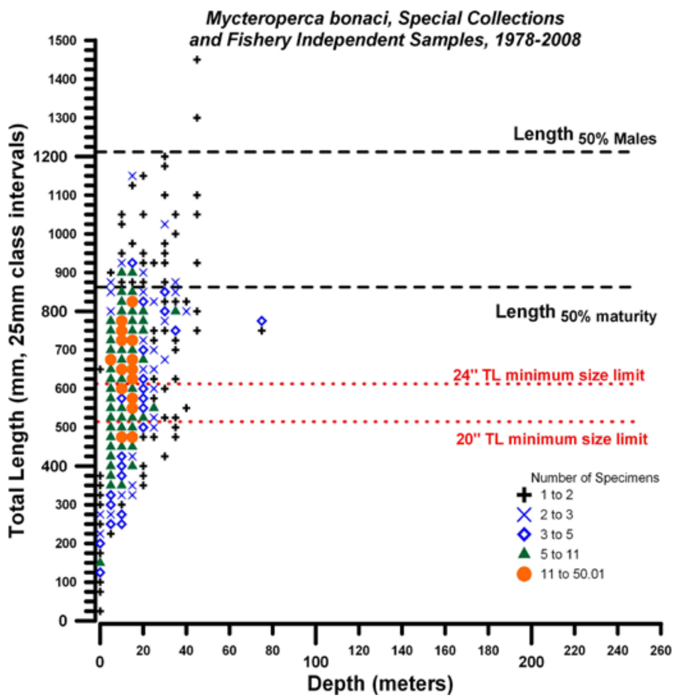


Fig.10. (cont.). Black grouper specimens by length or age and depth of catch, by fishing mode and gear, 1978-2008. Commercial long line specimens: a) length, b) age; Commercial hook and line specimens: c) length, d) age; Recreational specimens: e) length, f) age; Tournament specimens: g) length, h) age; Special collections and Fishery Independent specimens: i) length, j) age.

a. Special Collections, Fishery Independent, length



b. Special Collections, Fishery Independent, age

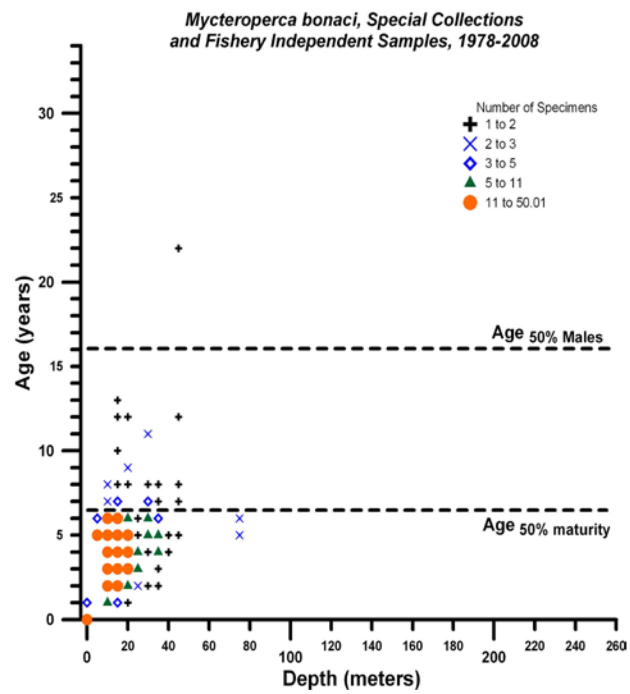


Fig. 11. Catch curve generated from long line catches, 2000-2008. Regression of numbers in catch against age for individuals 15-33 years old to obtain an estimate of total mortality (Z) from these age classes.

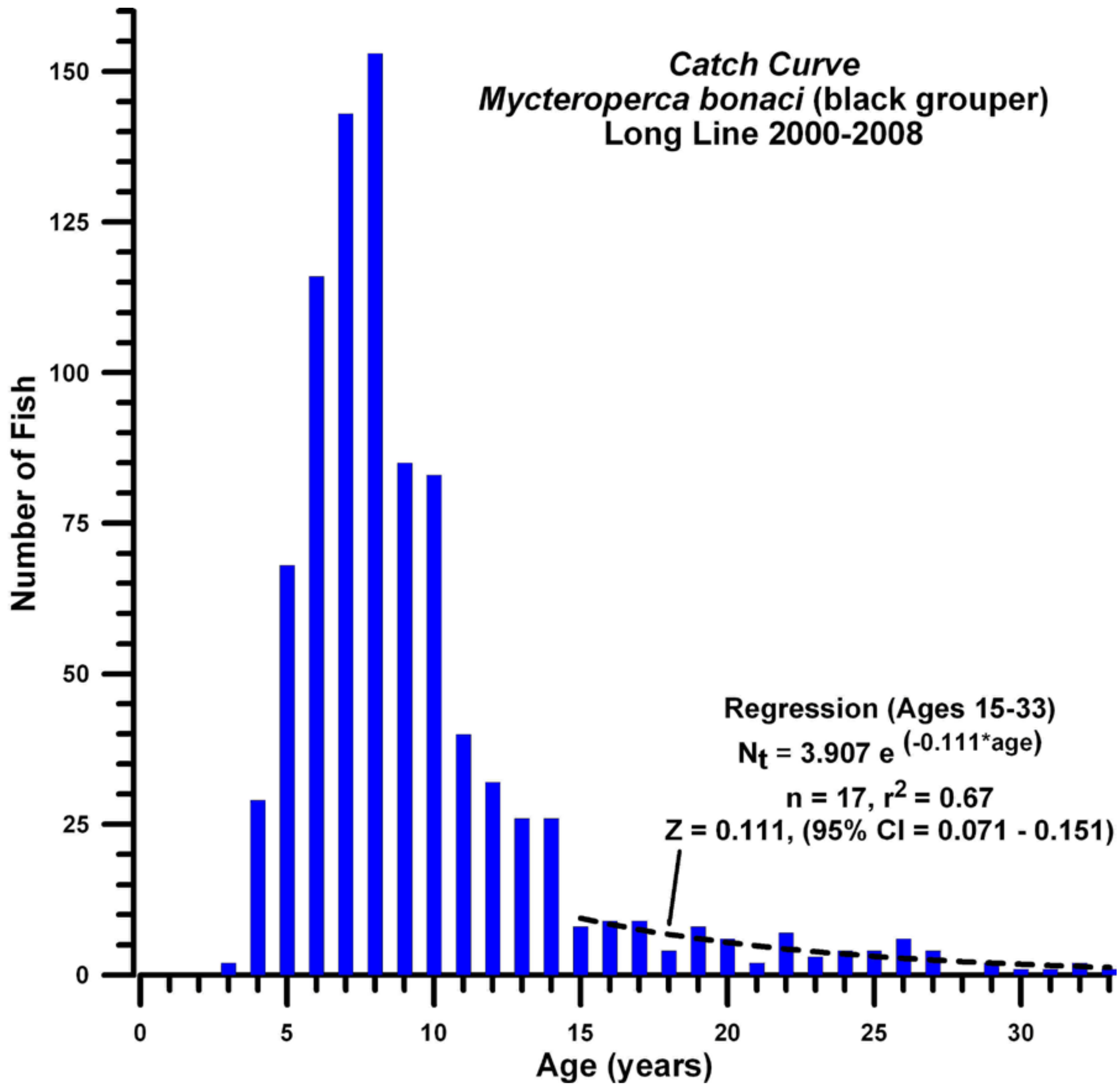


Fig. 12. *M. bonaci* (black grouper) total length (TL) versus age relationship in the southeastern US. Undersized specimens measured from recreational and commercial catches were omitted from the regression.

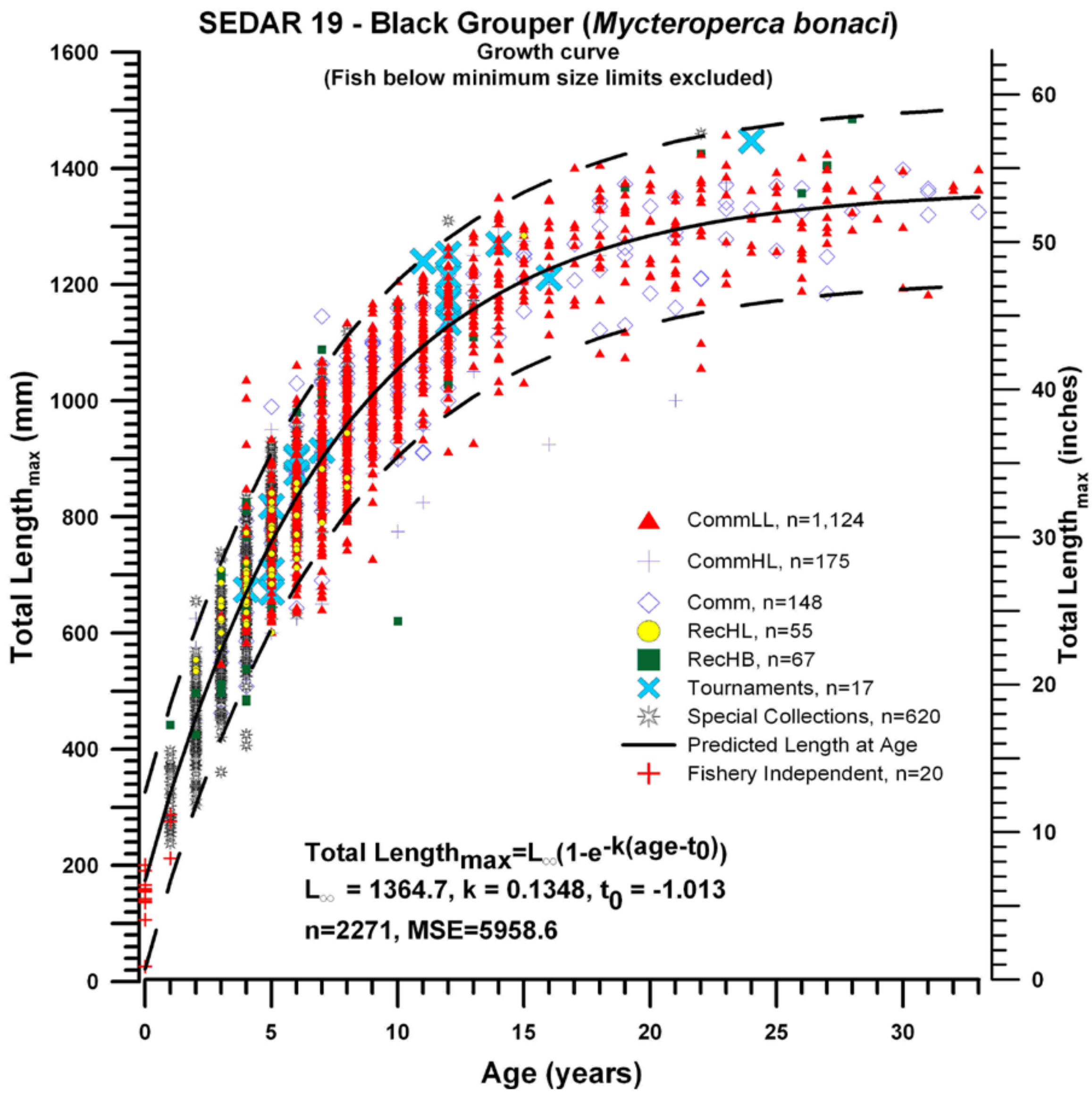


Fig. 13. Comparison of growth curves for *M. bonaci* (black grouper) from Manooch and Mason (1987), Crabtree and Bullock (1998), and new analyses for SEDAR 19.

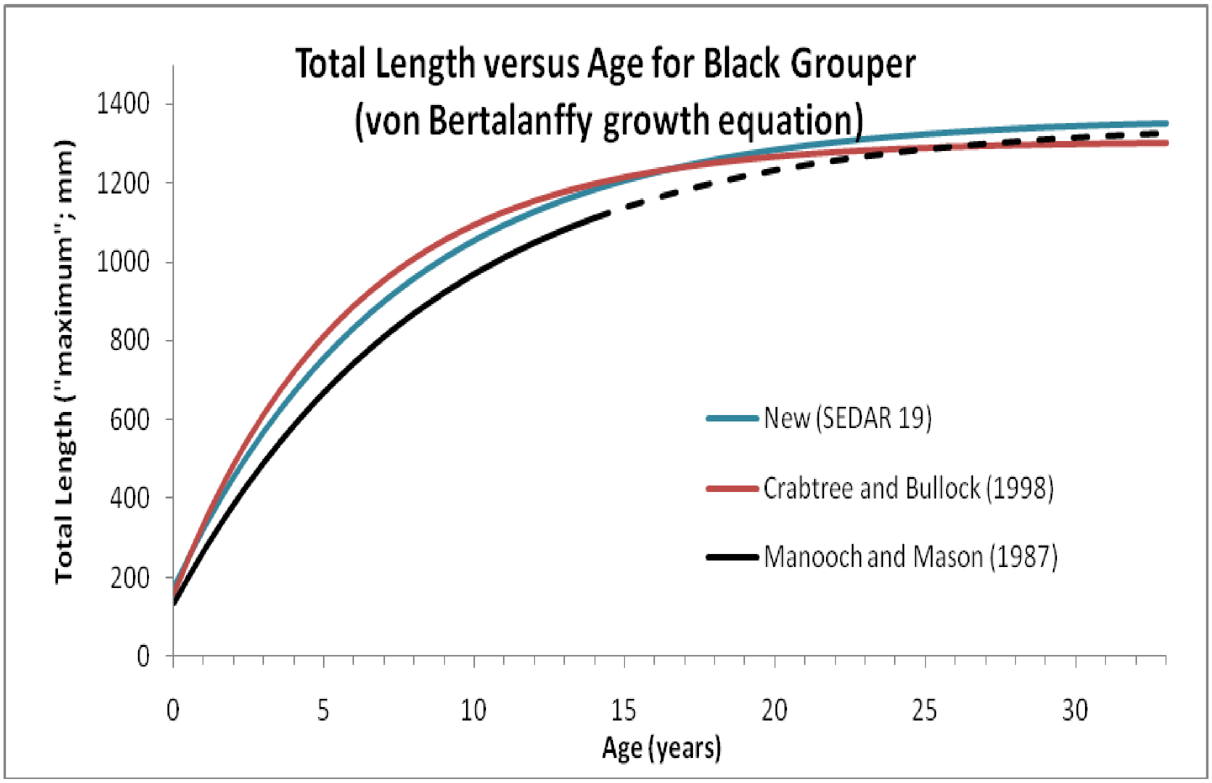
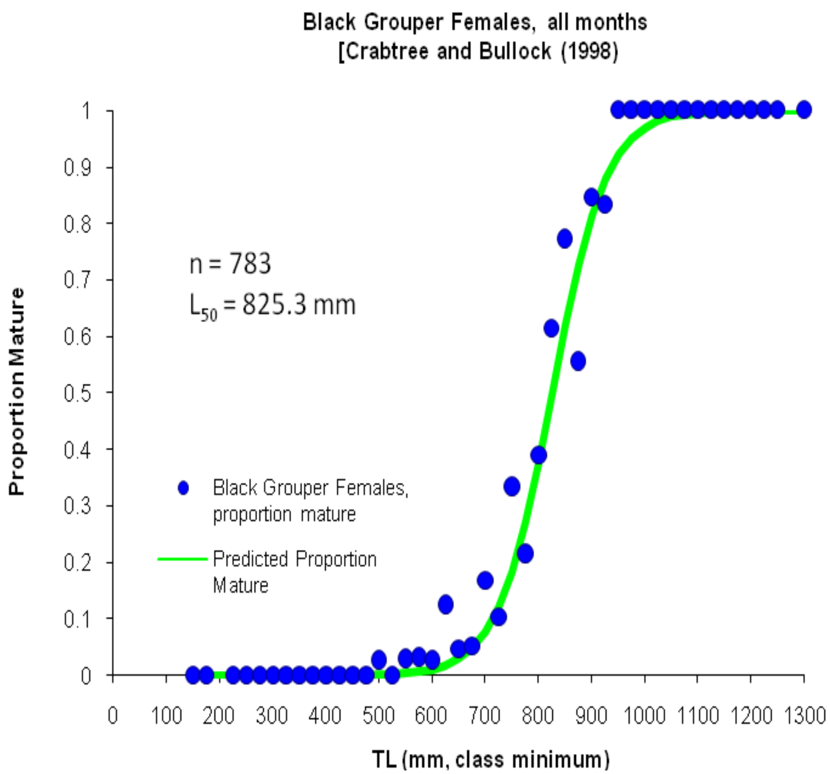


Fig. 14. Comparison of *M. bonaci* (black grouper) estimated maturity at length; (a) all months (Crabtree and Bullock, 1998); (b) peak spawning season (January-March; SEDAR19). All data from Crabtree and Bullock (1998).

a. Length at 50% female maturity, all months (Crabtree and Bullock 1998)



b. Length at 50% female maturity, peak spawning season (January-March) only (data from Crabtree and Bullock 1998)

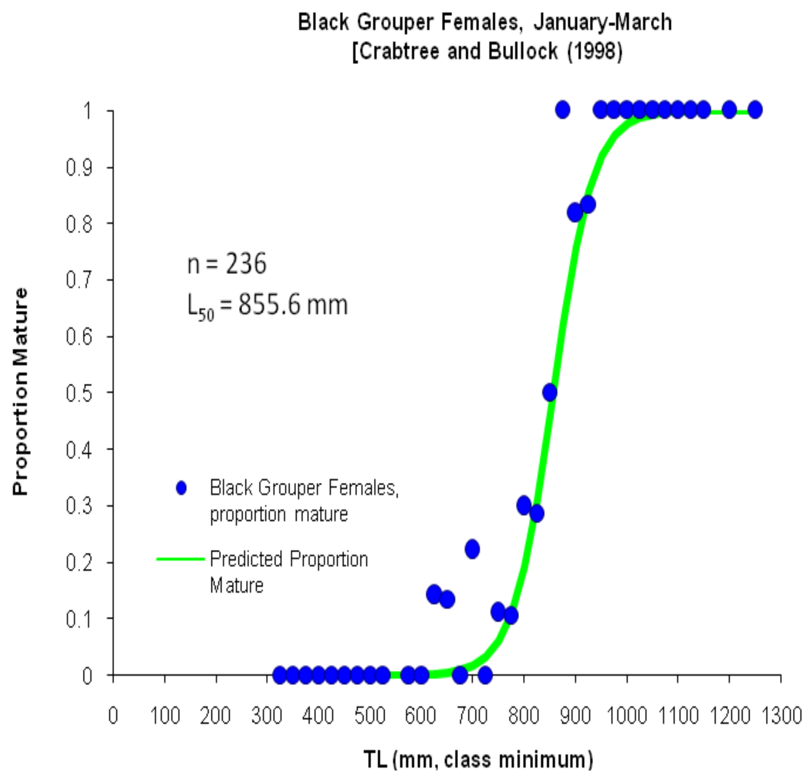
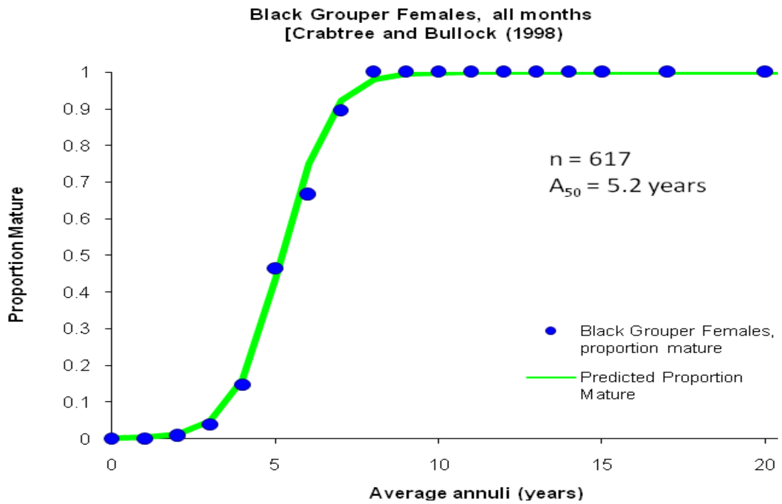
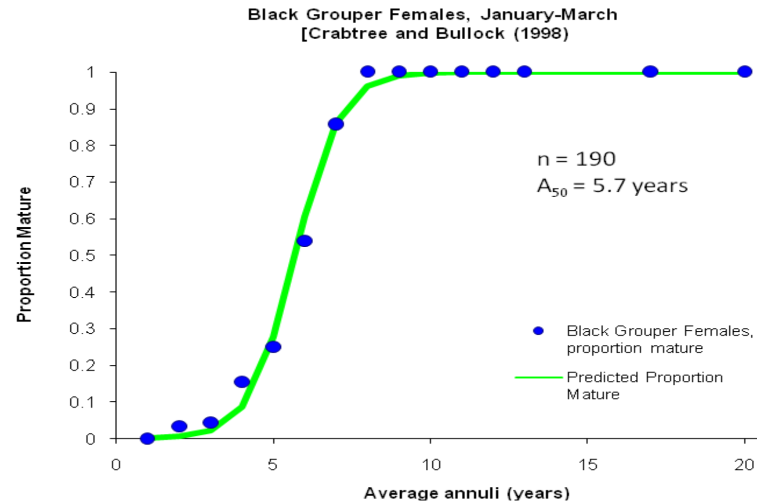


Fig. 15. Comparison of *M. bonaci* (black grouper) estimated maturity at age using average annuli counts (a, b; Crabtree and Bullock, 1998) or adjusted age (c, d; SEDAR19) for all months and during the peak of the spawning period.

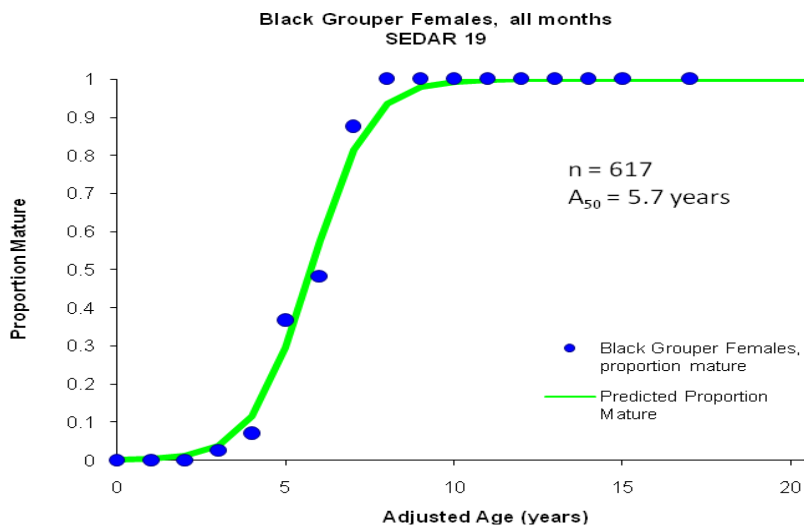
a. Estimated age at 50% female maturity, all months (using average annuli counts; Crabtree and Bullock 1998)



b. Estimated age at 50% female maturity, peak spawning season (January-March) only (data from Crabtree and Bullock 1998)



c. Estimated age at 50% female maturity, all months (using adjusted ages; SEDAR 19)



d. Estimated age at 50% female maturity, peak spawning season (January-March) only (adjusted ages; SEDAR 19)

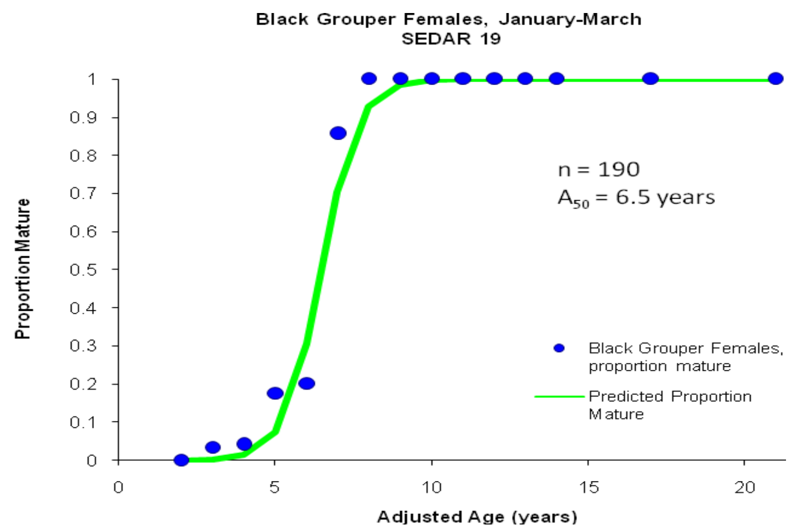
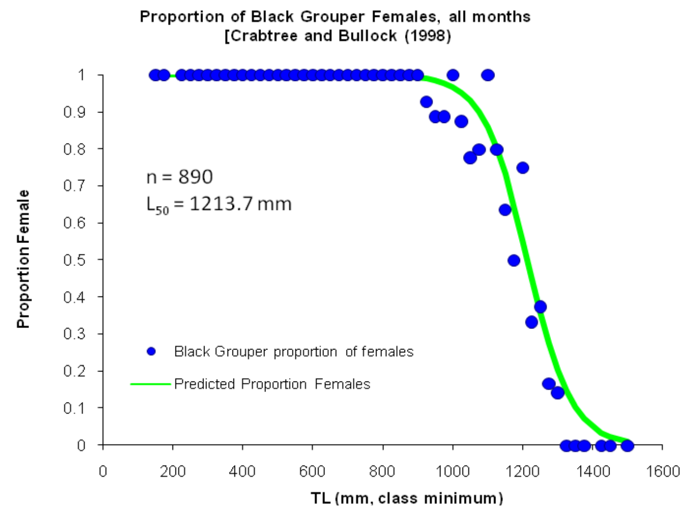
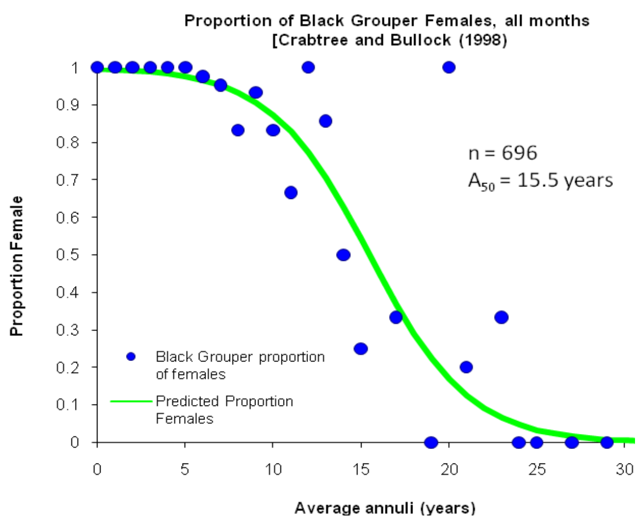


Fig. 16. *M. bonaci* (black grouper) estimated proportion of females at length (a; Crabtree and Bullock, 1998), and a comparison of the estimated proportion of females at age using average annuli counts (b; Crabtree and Bullock, 1998) and adjusted ages (c; SEDAR 19) for all months.

a. Estimated proportion of females at length (Crabtree and Bullock, 1998)



b. Estimated proportion of females at age using average annuli counts (Crabtree and Bullock 1998)



c. Estimated proportion of females at adjusted age (annuli counts adjusted for marginal increment and time of year; SEDAR 19)

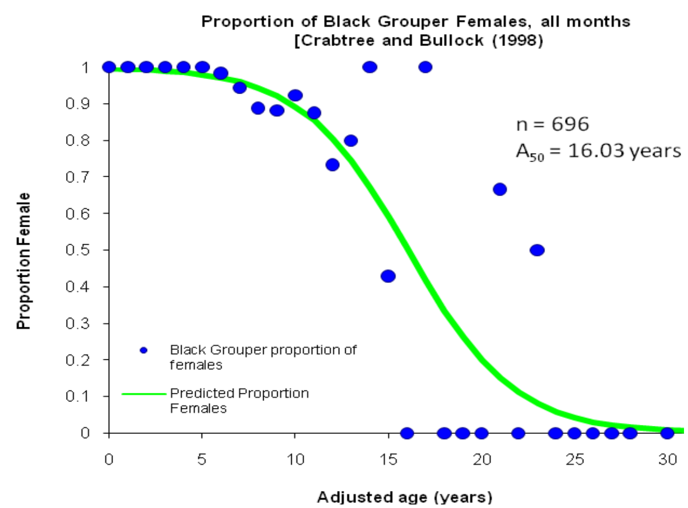


Fig. 17. Estimated total length (mm) of black grouper observed in the FWC Visual Survey by depth.