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# Age Estimates of Two Large Misty Grouper, *Epinephelus mystacinus* (Serranidae) from Bermuda with a Comparison of the Age of Tropical Groupers in the Western Atlantic

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***SHORT COMMUNICATION***

# AGE ESTIMATES OF TWO LARGE MISTY GROUPER, *EPINEPHELUS MYSTACINUS* (SERRANIDAE) FROM BERMUDA WITH A COMPARISON OF THE AGE OF TROPICAL GROUPERS IN THE WESTERN ATLANTIC

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## Introduction

The Bermuda Seamount is the most northerly known location for the misty grouper (*Epinephelus mystacinus*) in the western North Atlantic, but this species is broadly distributed as far south as Trinidad, as well as in the Galapagos Islands in the eastern Pacific (Heemstra and Randall 1993). Adults are reported to be solitary, deep-water predators in the depth range 100-400 m, and are thought to prefer high relief, hard bottom slope habitats (Bullock and Smith 1991). They are presumed to be protogynous hermaphrodites and slow-growing, characteristics that are common in the epinepheline groupers (Heemstra and Randall 1993). In Cuba, they are an incidental catch in the deep-water fishery that primarily targets snappers (Lutjanidae) (Claro et al. 2001) and have been reported to be the dominant grouper in the deep-water fishery in the US Virgin Islands (Heemstra and Randall1993). An active fishery has now developed in Puerto Rico (E. Pineiro, pers. comm., Caribbean Fishery Management Council, Puerto Rico); landings of misty grouper from 2004-2006 ranged from 2,175–3,361 kg (G. Garcia-Moliner, pers. comm., Caribbean Fishery Management Council, Puerto Rico). Misty grouper are included in Grouper Unit 4 in the Caribbean Fishery Management Council's Management Plan. The six species in this unit are considered overfished but misty grouper are excluded from current management action (G. Garcia-Moliner, pers. comm.). However, considering the developing fishery in Puerto Rico, it is apparent that more information is needed about the biology of this species to help guide management decisions.

Groupers were the largest category in the fishery landings in Bermuda until the mid-1970s when stocks of many grouper species became severely overfished (Luckhurst 1996; Smith-Vaniz et al. 1999). As a result, local fishermen commenced fishing in deeper water (270–360 m) in an attempt to maintain grouper catch levels; the most common species taken was the misty grouper (peaked at 7,400 kg in 1979; Luckhurst 1996). By 1981, misty grouper landings declined substantially and fishermen started setting lines in greater depths (to 650 m) to target wreckfish, *Polyprion americanus* (B. Luckhurst, pers. obs). These two species plus deep-water lutjanids were subjected to intense fishing pressure around the Bermuda platform, and suffered precipitous declines when the limited habitats (depth strata) for these species were overexploited (Luckhurst 1996).

Misty grouper are known to attain at least 54 kg and 115 cm total length (TL) (Heemstra and Randall 1993) although a maximum size of 160 cm TL is reported (Appeldoorn et al. 1987, cited in www.FishBase.com). Recently, two specimens (152 and 157 mm TL) were landed by commercial fisherman from the edge of the Bermuda platform, providing documentation of the maximum size which may be attained by this species. There are no age and growth studies on misty grouper (Heemstra and Randall 1993; www.FishBase.com). Therefore, the age data presented here, although not validated, represent the first estimates of maximum longevity and support Campana's (2005) statement that, "methods for validating ages of deep-sea fishes are urgently required." We compared the age estimates of our misty grouper specimens with the age of a large wreckfish (45.5 kg) taken from a similar but deeper-water habitat. In addition, we provide a comparison of the maximum ages of 9 other species of grouper in the western Atlantic.

## Materials and Methods

Both misty grouper specimens were caught on commercial vertical longline gear set in 220-300 m around the edge of the Bermuda platform in 2000 and 2001, whereas the wreckfish was caught in about 650 m using the same gear type in 1995. The TL (cm) and whole weight (kg) were recorded for each fish and the sagittal otoliths were removed, washed, dried and weighed. Transverse sections were cut, polished and decalcified with saturated EDTA at a pH of 7.4 (Secor et al. 1991). We initially made counts of the opaque zones (interpreted as annuli) on the transverse sections at 40X magnification with a light microscope to establish initial age estimates. As a result of the very closely spaced and large number of increments visible, we then increased to

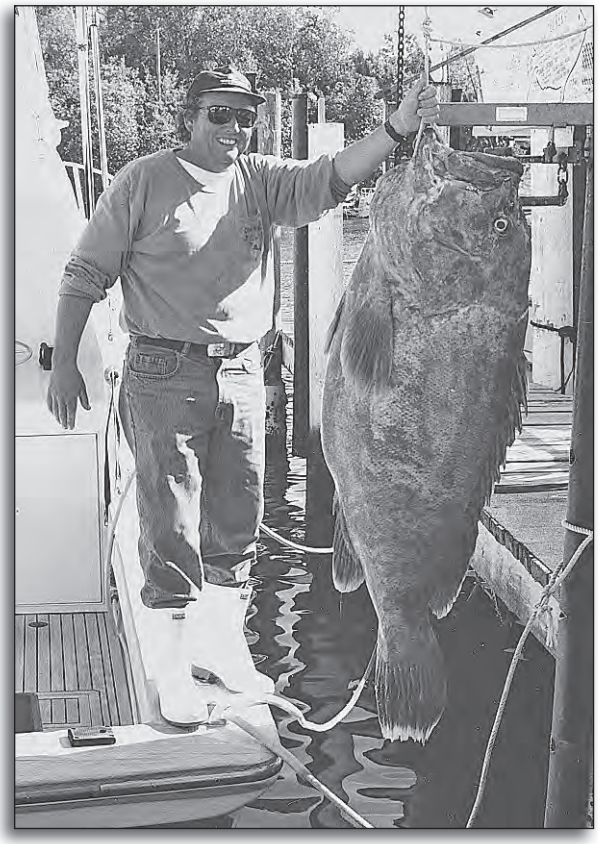

***Figure 1.*** *Photograph of 75.5 kg misty grouper caught by Alan DeSilva in March 2000. Photo by Craig Soares.*

100X magnification in order to achieve better resolution. We made repeated independent counts of the increments observed at 100X and also did counts on a Scanning Electron Microscope (SEM) at 160X. There was good correspondence between our counts at 100X (98%) and 160X (97%). Our final age estimates were agreed through discussion and consensus. Although radiometric dating is one of the best methods for age estimation in long-lived fish (Morales-Nin and Panfili 2005), this technique was not available to us at the time this research was conducted.

The otoliths of many deep-water species show growth zones that are similar to those interpreted as annuli in shallow water species (Bergstad 1995, Morales-Nin and Panfili 2005). We interpreted the increments that we observed in these sagittal preparations in the same manner that we have employed in studies of shallow water species in Bermuda, e.g. lane snapper, *Lutjanus synagris* (Luckhurst et al. 2000) and black grouper, *Mycteroperca bonaci* (B. Luckhurst, unpublished data).

Finally, as we were not able to validate the increments as annuli, we compared our misty grouper otolith microstructure to that of the wreckfish (a similar deep-water species) prepared using the identical protocol. The micro-morphology of the otoliths of the two species is very similar and the results we obtained are consistent with the findings of Peres and Haimovici (2004) in their study of southwestern Atlantic wreckfish.

## Results and Discussion

The two misty groupers were caught in two consecutive years (Table 1), but in different sections off the edge of the Bermuda platform, whereas the wreckfish was caught five years earlier. It is interesting to note the similarity in the length and weight of the two misty grouper (Table 1), both caught in similar depths. One of the striking aspects of the misty grouper is its large girth (Figure 1), which contributes significantly to its weight. The capture of these two misty grouper specimens has increased the documented maximum weight for the species by over 20 kg (Heemstra and Randall 1993). The TL of the larger specimen is only 3 cm shorter than the maximum reported for the species (Appeldoorn et al. 1987).

The estimated ages of the misty groupers were: specimen #1 (157 cm) - 150 years and specimen #2 (152 cm) - 135 yrs (Table 2). As there are no age estimates available in the literature for misty grouper (Heemstra and Randall 1993) with which to compare the ages of our two specimens, we are only able to evaluate our estimates in comparison with other serranid species that have been aged (Table 2). In the absence of validation, the Bermuda wreckfish was included to provide a basis of comparison for a similar deep-water species from the same general location. The otolith microstructure of the misty grouper and wreckfish (Figure 2) were very similar. As a result, we interpreted the increments (opaque zones) that we counted in both the misty grouper and the wreckfish as annuli. We estimated the age of our wreckfish at 60 yrs; since the oldest published age of a wreckfish is 81 yrs (Peres and Haimovici 2004), our estimate seemed reasonable.

A number of studies (Dwyer et al. 2003, Kerr et al. 2004,

***TABLE 1.*** *Capture details and sizes of two misty groupers and one wreckfish from Bermuda whose ages were estimated using sectioned sagittal otoliths.*

| Species | Date of capture | Depth of capture (m) | Whole weight (kg) | Total length (cm) |
|---|---|---|---|---|
| Misty grouper #1 | March 11, 2000 | 270 | 75.5 | 157 |
| Misty grouper #2 | April 12, 2001 | 220 | 74.5 | 152 |
| Wreckfish | October 1, 1995 | 650 | 45.5 | 134 |

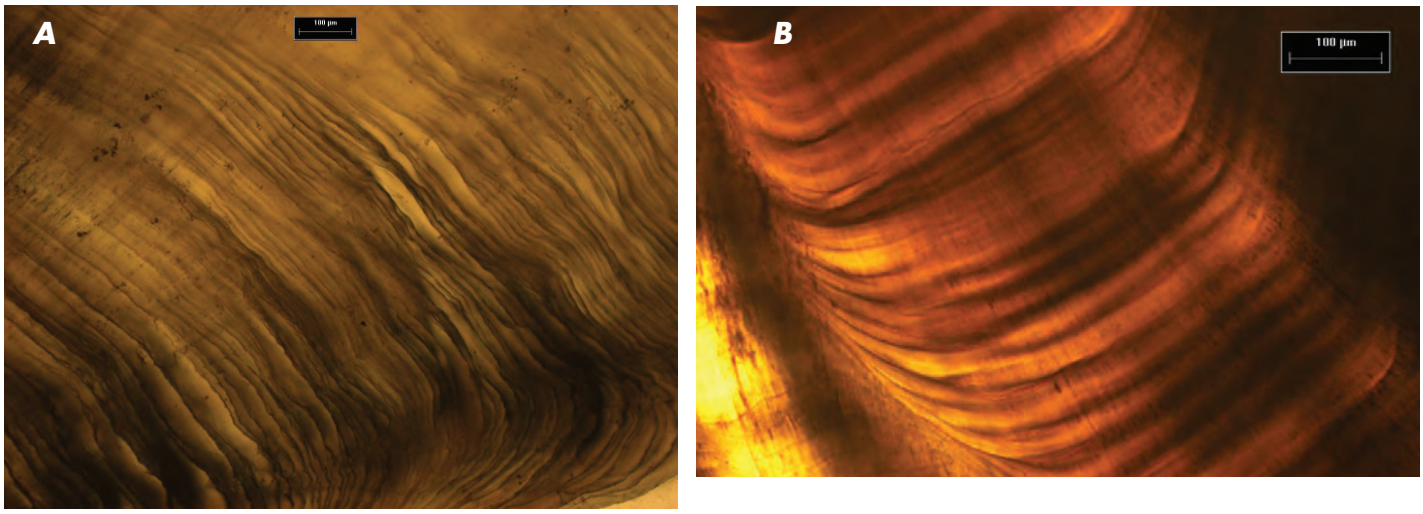


**Figure 2.** *Photomicrographs of portions of sectioned sagittal otolith microstructure. (A) Misty grouper* Mycteroperca mystacinus *(SEM magnif. X160). (B) Wreckfish* Polyprion americanus *(light magnif. X100). Scale bar = 100 µm.*

***TABLE 2.*** *Maximum total length (TL) and age estimate of medium and large-sized wreckfish (Polyprionidae) and groupers (Serranidae) from the tropical western Atlantic.*

| **Species (Common name)** | **Max. size TL (cm)** | **Max. age (yrs)** | **Reference** |
|---|---|---|---|
| *Polyprion americanus* (Wreckfish) | 192 | 81 | Peres and Haimovici (2004) |
| *P. americanus* (Wreckfish) | 134 | 60 | present study |
| *Epinephelus flavolimbatus* (Yellowedge grouper) | 98.5 | 35 | Manickchand-Heileman and Phillip (2000) |
| | 114.8 | 85 | Cook (2007)<br>Cook et al. (in press) |
| *E. guttatus* (Red hind) | 72 | 22 | Luckhurst et al. (1992) |
| *E. itajara* (Goliath grouper) | 250 | 37 | Bullock et al. (1992) |
| *E. morio* (Red grouper) | 90 | 25 | Moe (1969) |
| *E. mystacinus (#1)* (Misty grouper) | 157 | 150 | present study |
| *E. mystacinus (#2)* (Misty grouper) | 152 | 135 | present study |
| *E. nigritus* (Warsaw grouper) | 200 | 41 | Manooch and Mason (1987) |
| *E. niveatus* (Snowy grouper) | 109 | 29 | Wyanski et al. (2000) |
| *Mycteroperca bonaci* (Black grouper) | 151.8 | 33 | Crabtree and Bullock (1998) |
| *M. interstitialis* (Yellowmouth grouper) | 82.7 | 41 | Manickchand-Heileman and Phillip (2000) |
| *M. microlepis* (Gag) | 116.9 | 26 | Harris and Collins (2000) |

Watters et al. 2006) confirm that the ages of large, old fish determined with transverse section microscopy show some underestimation compared to radiometric methods, but the life history interpretation made from the data is the same. Watters et al. (2006) concluded that it is appropriate "to use traditional cross-sectional methods (thin section or break-and-burn) to estimate age for *Sebastes rufus*", as not all fishery scientists have access to radiometric technology. Therefore, we argue that it is better to have a potentially underestimated age estimate for misty grouper than none at all, such that these data can be input into classical methodologies in fishery management, including determination of a von Bertalanffy growth model.

With age estimates of 150 and 135 yrs, our misty grouper specimens appear to be the oldest groupers reported to date in the literature. Interestingly, although the specimens were similar in size, their age estimates differed by 15 yrs. This is possibly due to the fact that as such long-lived species approach asymptotic length, TL will likely increase in very small increments each year. The three largest serranid species, namely, goliath grouper, warsaw grouper and black grouper (Table 2) have reported maximum ages of 37, 41 and 33 yrs, respectively. However, a smaller species, the yellowedge grouper, has been validated with a maximum age of 85 yrs (Cook 2007, Cook et al. in press). The differences in age estimates between misty grouper and the shallow water goliath grouper and black grouper may be a reflection of the deep-water habitat of misty grouper where growth rates appear to be considerably slower (Morales-Nin and Panfili 2005). The reasons for greater longevity in deep-water are uncertain but may be related to altered physiological processes relative to environmental parameters. For example, an analysis of four scorpaenid rockfishes, *Sebastes* spp., indicated that longevity increased exponentially with maximum depth of occurrence (Cailliet et al. 2001), possibly related to low temperature and light levels. Although studies of deep-water, long-lived species have been increasing as these fisheries expand globally (Morales-Nin and Panfili 2005), there is currently insufficient data to determine if such a relationship may hold true for serranids.

In comparison to other deep-water species from different fish families for which there are reliable age estimates, our misty groupers rank amongst the oldest fishes. For example, the maximum age reported for 10 species of slope rockfishes (*Sebastes* spp.; NPFMC 2002) was 140 yrs, with only two species exceeding 100 yrs (Andrews et al. 2002). However, the majority had maximum ages of over 50 yrs. Additionally, age estimates for the orange roughy, *Hoplostethus atlanticus*, using several different aging techniques, have provided maximum age estimates up to 149 yrs (Bergstad 1995), whereas sablefish, *Anoplopoma fimbria* age estimates range up to 70 yrs (Heifetz et al. 1999).

It appears that the age estimates for our misty grouper specimens are broadly consistent with other deep-water teleosts that have been aged. These age estimates extend the maximum longevity of grouper species from the western Atlantic and appear to be amongst the oldest bony fishes aged to date. This lends credence to earlier findings that deep-water fish species can be very long-lived with slow growth rates, characteristics that make them highly vulnerable to even moderate levels of fishing effort (Hopper 1995). Significantly, the capture of such fish, using vertical longline gear at the listed depths, invariably results in 100% mortality. As a consequence, any fishery management measures that are put into effect for deep-water fisheries must account for this factor.

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