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Regional size, age and growth differences of red grouper (*Epinephelus morio*) along the west coast of Florida

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Abstract

Red grouper (*Epinephelus morio*) were collected from the west coast of Florida, the central area of fishery harvest in U.S. waters, by fishery-dependent sources during 2000–2005. The west Florida shelf was divided into two regions: north (capture locations ≥28°N latitude) and south (capture locations <28°N latitude). Significant differences were found for age, length, and size-at-age by region and by gear; red grouper from the north were significantly younger and smaller on average than those from the south. Regional differences were also noted with respect to age progression; year class trends were only detected in the north. The 1996 year class dominated the landings in 2000–2001 (ages 4 and 5) and the 1999 year class dominated in 2004–2005 (ages 5 and 6). Regional data were fit to a size-modified von Bertalanffy growth model indicating smaller asymptotic length (L_∞) and faster growth rate (k) in the north (north: $L_\infty = 800$ mm, $k = 0.23$ mm year^{-1}, $t_0 = 1.12$; south: $L_\infty = 863$ mm, $k = 0.15$ mm year^{-1}, $t_0 = 0.05$). Mortality estimates derived from catch curves resulted in higher total and fishing mortality in the north for both gears. Alternative explanations of regional differences likely depend on nursery delineation and correlation to periodic environmental events such as red tides and hurricanes; all possibly important factors based upon anecdotal information. Nevertheless, our finding of regional demographic differences in red grouper from the west coast of Florida suggests a more complex population spatial structure for red grouper.
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Keywords: Red grouper; *Epinephelus morio*; Stock; Life history; Spatial and temporal scales

1. Introduction

Red grouper (*Epinephelus morio*) are widely distributed throughout the Gulf of Mexico, Caribbean, and U.S. South Atlantic waters. Recognized as one of the most valuable fishes, red grouper are a highly sought target species and adults have been fished from North Carolina to Brazil (Moe, 1969; Stiles and Burton, 1994). In U.S. Gulf waters, red grouper are classified as the major component (about 69%) of the shallow water grouper commercial fishery and are predominately harvested from the west Florida shelf in the northeastern Gulf (Schirripa et al., 1999). Although primarily fished along the inner to mid-continental shelf, the species ranges in depth from 2 to over 120 m (65 fm), mainly inhabiting reefs and hard bottom areas (Moe, 1969).

Because of red grouper's importance, it has received considerable research attention and basic information on life history and biology has been reported (Moe, 1969; Johnson and Collins, 1994; Burgos et al., 2007). However, the spatial scales relevant to the population dynamics of red grouper have not been explored. It is increasingly being realized that matching spatial scale to population attributes is important for understanding the underlying ecological processes that give rise to those attributes (Ray and Hastings, 1996; Sale, 1998). This change in focus, to more spatially structured information is especially needed for reef fishes that have affinities for patchy habitats and often show high degrees of site fidelity during some phase of their life span (Sale, 1998; Gust, 2004). However, if life history and demographic information, assumed to be homogenous over large "basin-wide" spatial scales, vary at smaller spatial scales, management objectives may be difficult to achieve (McIntyre and Hutchings, 2003; Gust, 2004).

To date, red grouper have been treated as a single stock in U.S. Gulf of Mexico waters for assessment and management

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purposes (NMFS, 2002; SEDAR, 2006). Genetic studies have not revealed any separate population structure or reproductive isolation among Gulf collections of red grouper based upon mitochondrial DNA (Richardson and Gold, 1997) or microsatellite genetic markers (Zatcoff et al., 2004). Genetic homogeneity alone may not be adequate to ascribe red grouper to a single Gulf stock. Despite the lack of genetic differentiation, Zatcoff et al. (2004) suggested that red grouper might have distinct stock structures due to possible separated distributions and evidence of little movement (Moe, 1966, 1972). Spatial distribution, demography and life history differences can often be an indication of stock structure even when evidence for genetic discrimination is lacking (Begg and Waldman, 1999; Dudgeon et al., 2000), as shown for red snapper (*Lutjanus campechanus*) in the Gulf of Mexico (Fischer et al., 2004).

The concept of managing separate stocks within a geographical area is new for fisheries in southeastern United States, but differentiation of stocks by statistical areas are and have been conducted in the Northwest Atlantic since the 1930s for multiple species (National American Council on Fishery Investigations currently the Northwest Atlantic Fisheries Organization). However, the rationalization of said areas were based on multiple factors; biological, stock structure, species distribution, oceanographic, submarine topography, administrative boundaries, the practicalities of data collection and the ability to regulate the fisheries (Halliday and Pinhorn, 1990). Ultimately for management regulation, it would be necessary to provide evidence that stocks from separate areas were insufficiently mixing and differences in age, growth, and maturity were consistent over time (e.g., Atlantic cod from the Gulf of St. Lawrence to the Georges Bank; McIntyre and Hutchings, 2003).

Accordingly, it was our objective to examine region-specific size, age and growth information for red grouper sampled from the west Florida shelf. We specifically desired to test whether demographic traits in size and age were uniform across the U.S. Gulf fishery for red grouper during the study period.

2. Materials and methods

2.1. Region identification and data collection

The present analysis is based on red grouper otoliths collected from commercial catches from the two primary gears (hand-line and long-line) used along the west Florida fishery during 2000–2005. These years were selected because they provide an increased and better balanced sample representation among gears and regions although, our records of red grouper age-structure sampling extend as far back as 1991 (Lombardi-Carlson et al., 2006). Measurements of fish lengths (fork or total length, to 1.0 mm), weights (whole or gutted, to 0.1 kg), and removal of otoliths were completed in the field. Information describing catch location (latitude, longitude, depth, or NMFS statistical shrimp grid) was reported with the otolith samples during routine Trip Interview Program (TIP) intercepts of commercial vessels and/or fish houses.

The west Florida shelf encompasses the area from Cape Sable to Cape San Blas within the eastern Gulf of Mexico (Smith, 1976) and was divided into two regions: north and south of 28°N latitude (just north of Tampa Bay, Fig. 1). The coastline of the west Florida shelf represents a shift from southern semi-tropical to northern temperate climate. The shelf is broad with the largest distance from the shoreline to the outer margins occurring below the 28° latitude. North of 28° the shelf has a low gradient with high density seagrass beds within 50 km and sparse seagrass beds extending as far as 100 km offshore (Moe, 1963; Zieman and Zieman, 1989). Furthermore, the northern offshore waters of the west Florida shelf are influenced by different levels of temperature, salinity, and sediment due to the climate, river discharge, and circulation patterns compared to the southern region (Zieman and Zieman, 1989; Wiseman and Sturges, 1999). Detailed information on capture locations was rarely available from port collections, but fish could clearly be identified as being harvested north or south of 28°N latitude based on port agent interviews of fishers. Fishers were more likely to divulge the direction, number of hours and/or number of nautical miles from port than specific capture locations of the catch. In addition to providing a north–south delineation along an environmental gradient, this latitude also offers a practical grouping of our data as it divides the spatial range of the west Florida fishery nearly in half (Schirripa et al., 1999; G. Davenport, personal communication, NMFS/SEFSC Miami).

2.2. Determining age

The sagittal otolith was used as the ageing structure (Moe, 1969). Red grouper ages were successfully read from both whole and sectioned otoliths (Johnson and Collins, 1994). Opaque bands were counted from the area just dorsal to a ridge formed by the sulcus acousticus; an area consistently used to obtain and combine accurate readings from both whole and sectioned otoliths. No meristic information was available to the readers during age estimation from otoliths.

Whole otoliths were submerged in water in a black watch glass, placed concave side up, and viewed through a stereomicroscope with the aid of reflected light from a fiber optic light source. Whole otoliths were manipulated with forceps to acquire a flat surface to age. This was helpful when bands were close together and in determining edge type. Each opaque band equated to one year of growth (annulus; Moe, 1969; Johnson and Collins, 1994; Stiles and Burton, 1994; Burgos et al., 2007). Edge types were recorded as opaque or translucent. If the otolith edge type was opaque, then the partially completed band was also counted as an annulus.

Whole otoliths that were judged by the readers to be difficult to interpret, either due to otolith thickness or to opacity, were sectioned using a Hillquist diamond-cutting saw (Cowan et al., 1995). Otolith sections were 0.7 mm in width. The sections were polished, sanded, and mounted on a slide. The number of opaque bands and the edge type were recorded.

Band count, edge type, and capture date were used to calculate the annual age of a fish based on a calendar year (Jearld, 1983). Otoliths were advanced one year in age if the outer translucent zone was complete by January 1 to June 30. For example, an otolith with two completed annuli and a large