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MICROLEPIS),
FROM THE NORTHEASTERN GULF OF MEXICO.

ALLYN G. JOHNSON AND CHRISTOPHER C. KOENIG
National Marine Fisheries Service
Southeast Fisheries Science Center
Panama City Laboratory
3500 Delwood Beach Road
Panama City, FL 32408, U.S.A.

ABSTRACT

The age and size structure, year class abundance in the fishery and juvenile abundance in the seagrass habitat of gag, Mycteroperca microlepis, in the northeastern Gulf of Mexico were examined from 1989 to 1994. We examined growth marks on otoliths from 1,539 gag (55% commercial and 45% recreational fishery); age ranged from 1 to 26 years for fish 332 to 1,290 mm total length (mm TL). Von Bertalanffy growth equation parameters for 1991-1994 were Lì (maximum attainable length) = 1261.0 mm TL, K (growth coefficient) = 0.139, and to (hypothetical age at zero length) = -1.3143. Juvenile gag absolute abundance was estimated in seagrass habitat of St. George Sound, Florida by using a 5 meter otter trawl with known sampling efficiency. Abundance estimates (number per hectare) for the years 1989-1994 were 388 in 1989, 3.9 in 1990, 460 in 1991, 180 in 1992, 1,035 in 1993,and 11 in 1994. The alternating year pattern of high-low abundance was also evident in the age-structure of the fishery (1989, 1987, 1985 were high and 1988, 1986, 1984 were low), and suggests that juvenile abundance estimates may be useful to forecast future fishery production.

Key Words: Abundance, Age, Fishery, Gag, Juvenile

INTRODUCTION

The gag (Mycteroperca microlepis: Serranidae) is a reef-dwelling grouper that inhabits temperate to tropical waters of the western Atlantic Ocean and Gulf of Mexico. It is a protogynous hermaphrodite (McErlean and Smith, 1964) that occurs from Massachusetts, U.S.A., to Rio de Janeiro, Brazil (Briggs, 1958). McErlean (1963) indicated that the center of abundance in the Gulf of Mexico was the reef environment of the west coast of Florida. Gag are common along shallow reef tracts as well as shelf break areas in depths of only a few meters to at least 150 m (Bullock and Smith, 1991). Total fishery landings of gag in the United States are between 1.5 and 3 million kg per year (Schirripa and Goodyear, 1994; J. Bennett, NMFS, Miami, FL, pers. comm.). Peak spawning of gag occurs in February and March (Collins et al., 1987; Gilmore and Jones, 1992; Hood and Schlieder, 1992), and pelagic juveniles settle in high-salinity estuaries during April and May (McErlean, 1963; Keener et al., 1988; Mullaney, 1991). After 5 to 6 months of rapid growth, juvenile gag leave the estuarine habitat in early fall and migrate to shallow offshore reef habitats (Keener et al., 1988; Mullaney, 1991). Mean juvenile settlement dates in St. George Sound, Florida, were May 7, April 27, and May 8, for 1989, 1991, and 1992, respectively. The mean size at estuarine egress in 1991 was 145 mm standard length (SL) and ranged from 130 to 160 mm SL (Koenig, unpublished data). Shallow estuarine seagrass beds appear to be an important habitat of early juvenile gag along the gulf coast of Florida (McErlean, 1963). Juvenile settlement is synchronized with the spring increase in primary and secondary productivity in the northwest Florida seagrass habitat (Koenig, unpublished data). On the gulf coast of Florida there is extensive potential seagrass nursery habitat; 3,000 km2 occur in the Big Bend area alone (Zieman and Zieman, 1989). Age and growth information on Gulf of Mexico gag collected from the fishery indicate that gag are a long-lived (26 years) and grow rapidly during their first 5 years of life (McErlean 1963, Hood and Schlieder 1992, and Johnson et al. 1993). We present here the results of two independent studies on the life history of gag off northwest Florida. These studies are: (1) age- size structure and relative abundance of year classes in the fishery of gag in the commercial and recreational fisheries, and (2) juvenile abundance from a seagrass nursery habitat in St. George Sound, FL. These studies were conducted independently over a five year period (1989-1994).

MATERIALS AND METHODS

Two independent investigations on gag are integrated in this report, thus the materials and methods are present in two sections.

Age and size structure and abundance in the fishery The gag fisheries (commercial and recreational) at Panama City, Florida, were randomly sampled (sampled without regard to month, fish size, etc.) from February 1991 to August 1994. These fisheries are hook and line fisheries that operate in the panhandle area of Florida. The commercial fishery may exceed the geographic range of the recreational fishery, but it is confined to the northeast sector of the gulf. Of 1,608 fish that were sampled 1,539 were used for the determination of age structure in the fishery. These 1,539 (95.7% of the total) were used because two independent annuli counts of sectioned and unsectioned otoliths were in agreement. Forty-five percent of these specimens were collected from the recreational fishery and 55% from the commercial. Processing of otoliths (whole and sections), back-calculation of total length (TL) at mark deposition, and statistical analyses followed the procedures of Johnson et al. (1993). We back-calculated TL at age using the final annulus present at time of capture (following the recommendations of Vaughan and Burton 1994) using the direct proportional method of Lea (1910). The year class membership was determined using the following procedure: if the month of collection was January to July, then age is the number of completed opaque marks plus 1, but if the month of collection was July to December then age is the number of completed opaque marks.

Juvenile Abundance in s Seagrass Habitat

Estimates of absolute abundance of juvenile gag in seagrass habitat of eastern St. George Sound, Florida, were made annually from 1989 to 1994. Methods of determining juvenile gag abundance were given in Koenig and Colin (in press). In general, the methods involved applying the Jolly-Seber mark-recapture method within each of three square sampling stations (each 150 meters on a side) located in seagrass beds totalling 15.4 km2 in area. Samples were taken by standard tows (150 meter, 1.8 km/hr) tows with a 5-meter otter trawl. Koenig and Colin (in press) provided estimates of absolute abundance (numbers per unit area) which allowed the estimation of capture efficiency and the effects of habitat condition and fish size on capture efficiency. The appropriate capture efficiency estimates were then applied to spatially random standard tows made annually over the seagrass reference area of St. George Sound. We assume that this seagrass reference area is representative of juvenile gag abundance over a broad area of coastal north Florida from St. Marks to St. Andrew Bay and that juvenile gag recruit to the fishery located offshore in the same geographical area.

RESULTS AND DISCUSSION

The Fishery

Analysis of the timing of otolith margin deposition indicated that the opaque margin was deposited between January and August; the greatest proportion of fish with an opaque margin occurred in May (Fig. 1). This information is in agreement with the analysis of gag otolith bands by Hood and Schlieder (1992). This in combination with the tetracycline age-validation work of Collins et al. (1987) indicates that the opaque mark is annually deposited during spring and summer in the northeastern Gulf of Mexico. The deposition of the marks on the otolith with regard to distance of distal edge of the mark from the primordium was similar to the mark distribution reported by Hood and Schlieder (1992). Our age 1 to age 6 mark distance ranges and means in mm were: mark 1 range = 1.1-2.4 and mean = 1.7, mark 2 range = 1.6-3.9 and mean = 2.3, mark 3 range = 2.0-4.5 and mean = 2.8, mark 4 range = 2.3-4.8 and mean = 3.2, mark 5 range = 2.7-4.6 and mean = 3.5, and mark 6 range = 2.9-4.8 and mean = 3.9. Von Bertalanffy growth equations were developed using the last back-calculated TL at age data pooled for 1991-1994 (Table 1). The equation indicates that TL at age of gag is larger (20-60 mm) than the equations of Hood and Schlieder (1992). Both equations indicate that gag are larger at age than the equation for 1979-1980 northwest Florida gag (Johnson et al. 1993).

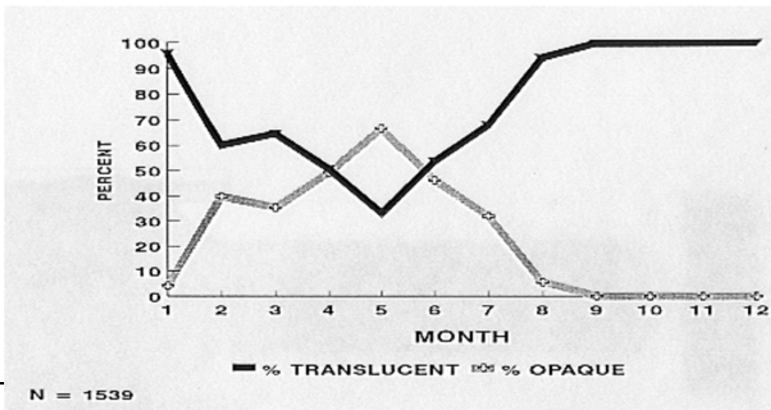

Figure 1. Gag otolith margin appearance by month from the northeastern Gulf of of Mexico, 1991 - 1994.

Figure 1. Gag otolith margin appearance by month from the northeastern Gulf of Mexico, 1991-1994.

These differences indicate that age, size and growth relationships should be determined on a regional basis and periodically revised to obtain currently accurate growth parameters. The age composition of the gag fishery during 1991-1994 shows that the year classes present contributed differently to the fishery (Table 2), and these differing contributions can be followed from year to year. For example, 1989 produced a strong year class that contributed 2.43% of the 1991 sample, 23.67% of the 1992 sample, 52.46% of 1993 sample, and 49.81% of 1994 sample, while the 1988 year class was poor and contributed 0.81% of 1991 sample, 7.73% of 1992 sample, 7.60% of 1993 sample, and 11.62% of 1994 sample. This alternating year pattern of strong and weak year classes is evident in all four years of sampling the fishery. The high productionyears were (odd numbered) 1989, 1987, and 1985 and the lowproduction years were (even numbered) 1988, 1986, and 1984. The minimum legal size for gag in the fishery is 20 inches TL (508mm TL) (Gulf of Mexico Fishery Management Council 1994). Usingback-calculations of TL at age for the last annulus we estimatethat 31.5% of age 2, 79.1% of age 3, 97.2% of age 4, and 98 to 100%of the fish age 5 and older have obtained the legal size of 20inches TL. Based on our four years of data, the mean cumulative exploitation of age 5 gag is 59%, age 6 is 81% and age 7 is 90%. Thus, by the age of seven only about 10% of the fish in a cohort remain.

Juvenile Abundance

The annual abundance of juvenile gag in seagrass beds in St. George Sound was high in odd years and low in even years (Table 3). This same pattern appears to persist in the fishery age structure back to 1985 (Table 2). The causes of this pattern of alternating high years of juvenile abundance are unknown. In this paper we assume that annual abundance determinations made in St. George Sound are indicative of juvenile gag abundances throughout the panhandle area of Florida from St. Marks to St. Andrew Bay. There is some evidence to support this assumption. In 1993, when juvenile gag abundance in St. George Sound was high, there were reports of high juvenile abundance in St. Joseph Bay (Michael Beck, Department of Biological Sciences, Florida State University, pers. comm.) and in St. Andrew Bay (William Fable, NMFS, Panama City, pers. comm.). We also assume that high levels of juvenile abundance in seagrass result in high regional catch levels several years later. That is, we assume that adult gag do not, for the most part, migrate great distances and become part of fisheries distant from the nursery areas. Evidence to support this assumption, at least for late juveniles, comes from fishermen who report large numbers of late juveniles offshore following egress of a large year class. The two patterns of alternating years of high-low abundance (fishery and juvenile) are summarized in Table 4 where the year class contributions to the fishery are pooled over the four years of sampling. Because the various cohorts have had different histories of exposure to the fishery, the fishery abundance values are only a relative estimate of abundance. The comparison of the alternating year high-low fishery and juvenile abundance patterns suggests that the fishery will experience strong recruitment from the 1991 year class beginning in 1995, and again from the 1993 year class beginning in 1997.

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Table 1. Von Bertalanffy growth parameters of gag, *Mycteroperca microlepis*, from the northeastern Gulf of Mexico.

Year of collection	Von Bertalanffy growth parameters[1]		
	L_∞ ± S.E.	K ± S.E.	t_0 ± S.E.
1991	1667.45±539.42	0.0717±0.0411	-3.0128±1.1122
1992	1196.24±77.74	0.1589±0.0239	-1.2693±0.2543
1993	1121.66±36.92	0.1905±0.0188	-0.7848±0.2160
1994	1338.11±44.05	0.1321±0.0107	-0.9939±0.1938
1991-1994	1261.04±29.9551	0.1394±0.0081	-1.3143±0.1300

[1] L_∞ = maximum attainable total length in mm.
K = growth coefficient.
t_0 = hypothetical age in years at which fish would have zero length.

Table 2. Age distribution of gag in 1991-1994 collections from the fishery from northeastern Gulf of Mexico.[1]

Adjusted age (yrs)	Year of collection[2]			
	1991	1992	1993	1994
1			1(0.18)	
2	6(2.43)	12(5.80)	20(3.53)	4(0.78)
3	2(0.81)	49(23.67)	53(9.36)	29(5.62)
4	*25(10.12)	16(7.73)	297(52.46)	70(13.57)
5	36(14.58)	*60(28.99)	43(7.60)	257(49.81)
6	^133(53.85)	25(12.08)	*61(10.77)	60(11.62)
7	14(5.66)	^35(16.90)	27(4.77)	*32(6.20)
8	14(5.66)	2(0.97)	^43(7.60)	14(2.71)
9	11(4.45)	1(0.48)	8(1.41)	^20(3.88)
10	4(1.62)	1(0.48)	4(0.71)	11(2.13)
11		2(0.97)	1(0.18)	2(0.39)
12	1(0.41)	1(0.48)	1(0.18)	2(0.39)
13				4(0.78)
14	1(0.41)	1(0.48)	1(0.18)	2(0.39)
15			2(0.35)	
16			1(0.18)	2(0.39)
17			1(0.18)	3(0.58)
18		2(0.97)	1(0.18)	
19				1(0.19)
20			1(0.18)	1(0.19)
21				1(0.19)
22				
23				1(0.19)

[1] Age is adjusted for time of year fish were collected. If month of collection was January to July then age is number of completed annuli plus 1, and if month of collection is July to December then age is number of completed annuli.

[2] Number of fish and in parenthesis () is percent of collection. Dominant year classes: 1989 underlined, 1987 *, and 1985 ^.

Table 3. Annual abundance of juvenile gag in two seagrass beds in eastern St. George Sound, Florida.

Year	Tow sample area (m^2)	Trawl efficiency (%)	Mean number gag/tow	No. of tows	Abundance no./hectare (mean±S.E.)[1]
1989	300	43	5.00	32	388± 38.0
1990	300	43	0.05	240	3.9± 2.0
1991	300	43	5.90	150	460± 36.0
1992	300	43	2.33	12	180± 35.0
1993	300	43	14.00	4	1,085±140.0
1994	300	43	0.14	72	11± 1.2

[1] Mean ± S.E. is mean and one standard error.

Table 4. Contribution to 1991-1994 gag fishery in the northeastern Gulf of Mexico based on year class (1994-1981) and juvenile abundance (1989-1994).

Year class	No. of fish	Percent of collection	Juvenile abundance[1]
1994	0	0	11 ± 1.2
1993	0	0	1085 ± 140.0
1992	5	0.33	180 ± 35.0
1991	49	3.26	460 ± 36.0
1990	135	8.97	3.9 ± 2.0
1989	609	40.47	388 ± 38.0
1988	121	8.04	
1987	178	11.83	
1986	102	6.78	
1985	231	15.35	
1984	35	2.33	
1983	21	1.40	
1982	18	1.20	
1981	1	0.07	

[1]Juvenile abundance in number/hectare (mean±S.E.) from Table 3.