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AGE-SIZE STRUCTURE OF GAG, *Mycteroperca microlepis*, FROM THE NORTHEASTERN GULF OF MEXICO

Information on ages and sizes of fish is essential for determining stock dynamics, especially since age-structured analyses have become commonplace in fisheries (Hilborn and Walters, 1992). We present here the age and size data that we obtained for gag, *Mycteroperca microlepis*, from the northeastern Gulf of Mexico from two different time periods (a decade apart). Previous information on age-size structure of gag has come from the U.S. Atlanta coast (Manooch and Haimovici, 1978; Collins et al., 1987) and from the west-central coast of Florida (McErlean, 1963; Hood and Schlieder, 1992).

The gag is a demersal marine fish (Serranidae) that inhabits temperate to tropical waters of the western Atlantic Ocean. It is a protogynous hermaphrodite (McErlean and Smith, 1964) and occurs from Massachusetts, U.S.A., to Rio de Janeiro, Brazil (Briggs, 1958, 1971). McErlean (1963) indicated that the center of abundance in the Gulf of Mexico was the reef environment of the west coast of Florida. In the Gulf of Mexico, the gag is one of many species of reef fishes managed by the Gulf of Mexico Fishery Management Council (1989).

MATERIALS AND METHODS

The gag fisheries (recreational and commercial) at Panama City, Florida, were sampled from April 1979 to May 1980 (T1) and February to October 1991 (T2). These fisheries are mainly hook and line with some long line activities. Total length (TL in cm) was measured at the time of sampling for 332 gag in T1 and 238 gag in T2. One sagittal otolith of each fish was collected for age determination. The otoliths were stored dry until they were examined.

Otolith examination followed the methods described in McErlean (1963) and Manooch and Haimovici (1978) for surface examination and measurement of radii of presumed annuli (opaque, white bands). Each otolith, after surface examination, was sectioned through the core in the dorsoventral (transverse) plane with an Isomet[1] low-speed saw using the methods of Berry et al. (1977). The sections, 0.25 mm thick, were mounted with Flo-tex[1] cement on glass slides and examined with transmitted light at 20x magnification. The opaque (dark) bands were counted (the corresponding presumed annuli which appear as opaque, white bands using reflected light on the surface of whole otoliths). Each whole otolith and its section were examined twice. Only those fish for which both surface and section annuli counts coincided were used for further analyses. Back calculated size at age (final annulus present at time of capture) was determined by the method of Lea (1910). Counts and measurements of annuli along with fish TL were examined with SAS (SAS, 1988) programs and standard statistical procedures (general linear models and Duncan's multiple range test).

RESULTS

Surface and section counts of annuli coincided for 313 of 332 T1 gag and 207 of 238 T2 gag. The overall agreement between surface and section counts was 91% and the agreement between two readers was 97.5%.

The analyses of the age-length data obtained from the 1979-1980 (T1) gag and the 1991 (T2) gag indicated several differences between the collections. These differences were:

1. The mean fish size of 78.9 cm TL (n = 207) in T2 was significantly

larger than mean fish size of 72.5 cm TL (n = 313) in T1 (= 0.001).

2. T2 gag were significantly larger at capture and at age for all ages when adequate sample sizes were available to test for differences than T1 gag (ages 3-7 and ages 2-6 in Tables 1 and 2).

3. The age frequency distribution of T1 gag had relatively even contributions of 3-to-7-yr-old fish with 45.3% of the catch consisting of fish older than 5 yrs. The age frequency distribution of T2 gag indicated that the fishery was dependent predominantly on 5-yr-old fish (62.8% of the catch with fish over 5 yrs of age comprising 12%, a 33% reduction compared to T1. The contribution of less than 5-yr-old fish in T2 was 10% less than the contribution of this group of fish in T1 (25% in T2, 35% in T1, see Table 1).

4. The theoretical growth in length of the collections as described by von Bertalanffy equations were:

T1 - back-calculated length at age (Table 2)

$$L_t = 119.9\ (1 - e^{-0.1354(t+0.9060)})$$

95% *C.E.:* $L_\infty \pm 19.4$, $K \pm 0.0475$, $t_0 \pm 0.6092$

T2 - back-calculated length at age (Table 2)

$$L_t = 128.3\ (1 - e^{-0.12464(t+1.7207)})$$

95% *C.I.:* $L_\infty \pm 34.9$, $K \pm 0.0741$, $t_0 \pm 1.2009$

where L = total length (cm), t = years, C.I. = confidence interval, L_∞ maximum attainable length (cm), K = growth coefficient and, t_0 = hypothetical age (in years) at which fish would have zero growth.

The growth rate of gag was significantly greater in T2 than in T1 as indicated by differences in the SAS general linear model (P = 0.001) for slopes of the respective equations between the time periods.

DISCUSSION

The results of this study suggest a drastic change in the age-size structure of the gag population over the 11 years separating the two collections (1979-1980

Table 1. Mean size at capture by age of gag, *Mycteroperca microlepis*, from Panama City, Florida in 1979-80 (T1) and 1991 (T2).

Age (yrs)	T1 No. of fish	T1 Length at capture[1] $\bar{x}$	SD	Range	T2 No. of fish	T2 Length at capture[1] $\bar{x}$	SD	Range	T1/T2 Difference[2]
0	2	30.6	1.4	29.6- 31.6	-[3]	-	-	-	-
1	3	48.3	4.1	45.9- 53.1	2	50.0	0.0	50.0- 50.0	0.5200
2	10	54.7	8.1	40.8- 70.4	4	56.5	5.1	50.0- 61.0	0.6904
3	48	57.4	6.5	44.9- 79.6	17	67.5	5.5	55.0- 70.0	0.0001*
4	47	66.2	8.1	45.9- 79.6	29	75.1	5.2	68.0- 89.0	0.0001*
5	61	69.1	8.0	55.1- 88.8	130	79.7	5.9	60.0- 97.0	0.0001*
6	69	79.1	8.5	50.0- 95.9	10	90.6	9.7	71.0-104.0	0.0002*
7	43	84.5	6.4	69.4- 97.0	7	90.1	6.8	83.0-101.0	0.0373*
8	10	90.0	7.5	80.6-102.1	4	98.5	6.1	91.0-104.0	0.0701
9	16	91.3	7.9	77.6-107.2	4	98.0	3.2	95.0-102.0	0.1229
10	2	97.0	2.9	94.9- 99.0	-	-	-	-	-
11	2	99.5	0.7	99.0-100.0	-	-	-	-	-

[1] Total length in centimeters; $\bar{x}$ = mean, SD = standard deviation, and range = minimum and maximum lengths.

[2] Difference is probability that size at age is same between T1 and T2. Asterisk (*) = significant difference (alpha = 0.05, Duncan's multiple range tests).

[3] Dash (-) indicates no samples or data.

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Table 2. Mean back-calculated size by age of gag, *Mycteroperca microlepis*, from Panama City, Florida in 1979-80 (T1) and 1991 (T2).

Age	T1				T2				T1/T2
	No. of	Back-calculated length[1]			No. of	Back-calculated length[1]			Difference[2]
(yrs)	fish	x	SD	Range	fish	x	SD	Range	
0	2	30.6	1.4	29.6- 31.6	-[3]	-	-	-	-
1	3	32.6	1.7	30.6- 34.1	2	34.5	1.7	33.3- 35.7	0.3085
2	10	44.6	3.5	39.8- 50.6	4	50.9	4.9	44.4- 54.9	0.0177*
3	48	48.7	6.7	38.2- 70.3	17	56.0	5.4	45.6- 65.8	0.0001*
4	47	59.4	7.8	43.7- 74.7	29	66.8	4.7	57.7- 81.6	0.0001*
5	61	63.2	8.0	49.1- 87.5	130	72.4	5.6	54.5- 84.3	0.0001*
6	69	73.5	8.6	46.5- 89.9	10	83.1	9.3	67.3- 96.6	0.0016*
7	43	79.7	5.9	68.1- 91.2	7	82.5	9.7	65.5- 93.6	0.2890
8	10	86.2	7.9	77.1- 99.2	4	93.6	6.6	85.3-101.1	0.1228
9	16	86.9	8.3	72.5-102.8	4	93.1	3.0	90.0- 96.4	0.1656
10	2	92.4	3.2	90.1- 94.7	-	-	-	-	-
11	2	97.2	1.9	96.0- 96.6	-	-	-	-	-

[1] Total length in centimeters; x = mean, SD = standard deviation, and range = minimum and maximum lengths.
[2] Difference is probability that size at age is same between T1 and T2. Asterisk (*) = significant difference (alpha = 0.05, Duncan's multiple range tests).
[3] Dash (-) indicates no samples or data.

and 1991). Bullock and Smith (1991) also reported significant differences were apparent in length frequency distribuitons in gag depending on the period of capture. Although modal sizes of fish didn't change for hook and line caught fish between 1977-80 and 1988, a greater percentage of large fish were caught during the earlier period. They also suggest that the area of capture may have changed between the two periods. Our data (Table 3) also indicate a change in length-frequency distribution between T1 and T2. In T1, 21.7% of the fish were less than 60-cm TL, while in T2, 2.4% were less than 60-cm TL.

The fishery appears to have become more dependent on a narrow age range and the gag apparently are growing faster than in the past. These findings may indicate reactions to changes either in the environment or in the level of exploitation to which the gag are compensating (See Hocutt and Stauffer, 1980, for discussion). Changes in growth parameters in fish populations have been associated with both environmental and density dependent factors.

Table 3. Mean age at capture of gag, *Mycteroperca microlepis*, from Panama City, Florida in 1979-80 (T1) and 1991 (T2).

Length[1]	T1				T2			
	No. of	Age at capture[2]			No. of	Age at capture[2]		
interval	fish	x	SD	Range	fish	x	SD	Range
30- 39	2	0.0	0.0	0.0- 0.0	-[3]	-	-	-
40- 49	8	2.4	1.1	1.0- 4.0	-	-	-	-
50- 59	58	3.4	1.0	1.0- 6.0	5	1.8	0.8	1.0-3.0
60- 69	62	4.3	1.1	2.0- 7.0	22	3.7	1.0	2.0-5.0
70- 79	77	5.4	1.1	2.0- 9.0	83	4.6	0.7	3.0-6.0
80- 89	73	6.5	1.1	3.0- 4.0	74	5.1	0.5	4.0-7.0
90- 99	29	7.8	1.4	6.0-11.0	18	6.5	1.5	5.0-9.0
100-109	4	9.3	1.3	8.0-11.0	5	7.6	1.1	6.0-9.0

[1] Total length in centimeters;
[2] Age in years; x = mean, SD = standard deviation, and range = minimum and maximum ages.
[3] Dash (-) indicates no samples or data.

Temperature and water circulation patterns have been associated with declining mean length-at-age of Pacific whiting, *Merluccius productus* (Hollowed et al., 1988; Dorn, 1992). Density dependence has been shown in cases such as larval abundance with inversely proportional growth in herring, *Clupea harengus*, (Iles, 1967, 1968) and also inferred levels of fishery harvest as in the pre and post World War II fishery for North Sea plaice, *Pleuronectes platessa*, with reduced growth of all age groups after the war (reviewed in Cushing, 1981).

Whether the apparent growth changes in gag are the result of environmental factors (temperature, etc.) or in response to reduced population levels (more food, habitat, etc.) requires further investigation.

The von Bertalanffy growth parameters of the gag in this study and others are presented in Table 4. The equations are dependent on the size-age ranges of the collections. In our study, small fish (less than 30-cm TL) were scarce, because the fishery is regulated (in 1991, minimum size limit of 51-cm TL), and because small fish tend to be in shallower waters, whereas, the fishery is in deeper, offshore waters. Interpretations of differences in the growth equations are difficult to make owing to the lack of data on variances of the growth parameters and on information pertaining to differences in capture methods, collection areas, and the representativeness of the samples to their respective populations.

Additional studies are needed on the northern Gulf of Mexico gag resource to develop a better understanding of the current population parameters. Topics that need special attention are: size-age-sex structure, size-age-maturation structure, and size-age-fecundity structure.

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Table 4. Von Bertalanffy growth parameters of gag, *Mycteroperca microlepis*.

Area	Reference	Von Bertalanffy growth parameters[a]			Study period
		L_∞	K	t_0	
North and South Carolina	Manooch and Haimovici (1978)	1,290 mm TL	0.122	− 1.127	1972–1976
Florida (west coast)	Hood and Schlieder (1992)	1,190 mm TL	0.166	− 0.62	1977–1980
Florida (northwest coast)	This report	119.9 cm TL	0.1354	− 0.9060	1979–1980
		128.3 cm TL	0.1246	− 1.7207	1991

[a] L_∞ = maximum attainable growth; TL = toal length.
K = growth coefficient
t_0 = hypothetical age (in years) at which fish would have zero growth.

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