Age Structure of Gag (*Mycteroperca microlepis*) in the Eastern Gulf of Mexico by Year, Fishing Mode, and Region

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ABSTRACT

Based on estimation of age structure from catches derived from the west Florida shelf, gag (*Mycteroperca microlepis*) stocks exhibit alternating strong and weak year classes. Four year classes (1985, 1989, 1993, 1996) were observed to exceed 40% of the total annual age structure by ages 4 - 6, the ages at full recruitment to the fishery. When sample locations were more precisely reported during 1998 - 1999, there was a slight trend towards older ages and increased ratio of males from the southwest Florida coast versus north of Tampa, the area where the fishery has historically been concentrated. The influence of gear on age-structure was quite apparent. In general, recreational hook-and-line gear captured the youngest fish, with increasing proportions of older ages occurring in commercial hook-and-line and long-line gears. Because of the catch patterns resulting from a strong 1993 year class, we suggest that gear selectivity by age is determined more by location and depths fished relative to the population distribution and less due to direct attributes of the gear, such as hook size or differences in fish behavior and susceptibility by size.

KEY WORDS: Age structure, gear selectivity, *Mycteroperca microlepis*

Estructura por Edades de la Cuna Aguají (*Mycteroperca microlepis*) en el Golfo de México Oriental por Modalidad de Pesca y Región

Se compararon muestras de cuna aguají procedentes de pesquerías comerciales y recreativas de los EE.UU. para identificar patrones espaciales y relacionados con el arte de pesca en la distribución por edades. Se encontró una tendencia hacia edades mayores y una mayor proporción de machos en la costa sudoeste de la Florida en comparación con el norte de Tampa, el área donde la pesquería se ha concentrado históricamente, indicando una posible diferencia geográfica en la estructura del stock. Los datos de capturas también indicaron que el stock adulto se centra alrededor de dos zonas de profundidad: en la plataforma intermedia y en la plataforma exterior, que corresponde a la presencia de paleo-arrecifes de la plataforma del oeste de la Florida que en su mayor parte no han sido mapados. La influencia del arte de pesca en la estructura por edades era bastante aparente. En general, la pesca recreativa con caña y anzuelo capturó los peces más jóvenes, mientras que las pesquerías comerciales de caña y anzuelo y palangre mostraban proporciones crecientes de edades mayores. Pero la influencia en las edades también estaba correlacionada con las profundidades en las que pescan comúnmente las respectivas artes de pesca. Debido al patrón de capturas que muestra una clase anual fuerte, sugerimos que la selectividad del arte de pesca por edades viene determinada más por la localidad y profundidad en la que se pesca en relación a la distribución de la población y en menor medida debido a atributos directos del arte de pesca, como los tamaños de anzuelos utilizados comúnmente o diferencias en el comportamiento de los peces y susceptibilidad por tallas.

PALABRAS CLAVES: *Mycteroperca microlepis,* modalidad de pesca, cuna aguají

INTRODUCTION

The broad shelf of the west coast of Florida is a highly productive source of economically important reef fish. Nearly 95% of the groupers and over 50% of the snappers taken from the U.S. Gulf of Mexico are landed on the west coast of Florida. Of the grouper species, gag grouper (*Mycteroperca microlepis*) is one of the more economically important in the south Atlantic and Gulf of Mexico (Sadovy 1990). Gag comprise about 31% of the approximately 10 million lb shallow-water grouper quota for the Gulf of Mexico (GMFMC 1999).

However, gag are currently approaching an overfished condition in the Gulf of Mexico (GMFMC 1999, NMFS, 2000). A recent assessment of the gag fishery identified a particular need for age and growth information and annual age-structure data for future assessments (Schirripa and Legault 1997). Our goal was to characterize available age data in order to detect any patterns in year-class variation over time. Expanded sampling and increased reporting of capture locations and gears used in 1998 and 1999 allowed us to examine differences in age structure by gear type and region; north versus south of 28 degrees (approximately the latitude of Tampa, Florida).

METHODS

To examine interannual patterns of age structure, an age data base was developed from otolith samples from National Marine Fisheries Service and state of Florida sampling programs (state/federal cooperative Trip Interview Program, Beaufort NMFS Headboat Program and Panama City NMFS Charter Boat Survey). Age frequencies from 1991 through 1994 were taken from Johnson and Koenig (in press) and were primarily based on hook-and-line caught fish from the commercial and recreational headboat and charter boat fisheries. Unpublished age data from Allyn Johnson (retired, NMFS Panama City Laboratory) were also available for years 1995 and 1996 from similar sources targeting catches from the northeast Gulf of Mexico. During December 1997 through 1999, we were able to obtain otolith samples across a better defined geographic gradient. Adult gag were sampled by NMFS and state port agents in cooperation with a MARFIN study (through Florida State University) of gag reproduction along a geographic gradient. Port agents recorded lengths, weights, gear used, and endeavored to determine the depth and location of capture to the nearest minute of latitude/longitude from interviews with fishermen. Often, however, only approximate locations were given. After 1997, collections differed from previous years in that many gag were being sampled from the west Florida shelf south of Tampa and more otolith samples were being taken from commercial long-liners.

We generally followed earlier aging methods used in northeastern Gulf studies (Johnson et al. 1993, Johnson and Koenig, in press) and determined the ages of gag from whole otoliths following the original interpretation in McErlean (1963). Older gag (greater than about eight annuli present) are difficult to age using whole otoliths and these otoliths were sectioned. We followed the processing method of Cowan et al. (1995). Whole and sectioned otoliths were assigned an age based on the count of annuli (opaque zones observed with reflected light) and the degree of marginal edge completion. Annulus counts were advanced a year in age after January 1st if their edge-type was a nearly complete translucent zone. After June 30, when opaque zone formation is underway or complete for gag in the Gulf of Mexico (Hood and Schlieder 1992, Johnson and Koenig, in press), all fish were assigned an age equal to the annulus count by convention. By this traditional method, an annual age cohort is based on a calender year rather than estimated time since spawning (Jearld 1983).

RESULTS AND DISCUSSION

Gag can be aged at relatively low cost as agreement between ages determined from whole and sectioned otoliths is high (Johnson and Koenig, in press) and most age determinations can be made reliably from whole otoliths. By 2000, two readers (GRF and NME) each had aged in excess of 1000 gag otoliths, and so by gaining moderate experience, could make independent estimates of age for comparison. The resulting measure of precision, average percent error (APE; Beamish and Fournier 1981), was 2.8 for the year-2000 age samples. This is a lower value than that determined during recent red snapper aging efforts (APE ranging 5.2 - 8, Allman et al. 2002) and less than the threshold (APE= 5) recommended for production aging (Morison et al. 1998). As aging precision is high, "readability" of the gag otoliths is relatively good.

The gag sample sizes for age frequency varied from about 300 to 800 fish each year (with the exception of 1997). Although these are not large data sets for understanding age structure, the lengths of the aged gag correspond to the lengths reported in a recent stock assessment. For example, in 1996, a dominant mode of small-sized gag, just reaching the minimum legal size limit, 508 mm (20"), was observed in the handline and powerline fishing gears (Schirripa and Legault 1997) and was detected among the aged gag as well (500 - 600 mm TL, Figure 1).

Generally during the 1990s, the sizes sampled reflect the 508 mm (20") legal size limit and often the annual modes are between 600-800 mm TL (25-30 inches) for the hook-and-line gear (Schirripa and Legault 1997, Figure 1). Since the U.S. gag fishery in the Gulf of Mexico is almost exclusively confined to the west Florida shelf and that the sizes of the aged gag match the length distributions reported in the last assessment, gives us some confidence to infer age structure from the fishery with the sample sizes of otoliths available to us.

Gag appear to be fully recruiting to the commercial fishery by age-4 or 5 and dominant year classes were observed to exceed 40% of the annual age structure at this age during some years (Figure 2). Specifically, dominant year classes were those apparent for at least 3 - 4 years and include the 1985, 1989, 1993 and 1996 year classes based on the available age data (Figure 2). An apparently strong 1993 year class, detectable as age-3 fish entering the fishery in 1996, provides an explanation of the notable 500 mm (20") size mode reported in a previous assessment (Schirripa and Legault 1997). Based on a juvenile survey, the 1993 year class was predicted to be a particularly strong year class (Koenig and Coleman 1999, Johnson and Koenig in Press) and appears to be the dominant year class harvested from 1996 through 1999 (Figure 2).

The pattern of strong and weak year classes detectable among the adult age structure monitored over time supports earlier findings of highly variable annual recruitment from juvenile surveys (Koenig and Coleman 1999, Johnson and Koenig, in press). Two previous age studies; one in the south Atlantic (Harris and Collins 2000) and one in the Gulf (Johnson et al. 1993) also detected changes in age-structure from age data sets collected at two intervals over 10 years apart. In both studies, the age-structure changes were hypothesized to be a result of changes in levels of fishing. Our results indicate that a likely explanation for change in adult age-structure is recruitment variation.

When we examined the age data for years with more complete gear information (1998 - 2000), there were apparent differences in the age structure by gear. Recreational-caught gag were the youngest each year with dominant modes at age-4 (1998 and 2000) and age-3 (1999) (Figure 3). Commercial hook-and-line gear and long-line gear showed dominant modes at age 5 (1998) and age 6 (1999) still tracking the strong 1993 year class. But long-line gear was tending to harvest older individuals with age-class frequencies not dropping below 1% until age 15 or 16 (Figure 3). On the west Florida shelf, bottom long-lining for reef fish is allowed to a depth as shallow as 20 fathoms. Since commercial hook-and-line and long line fisheries broadly overlap depth zones from the mid to outer shelf, the similarity in age structure between the two commercial fishing gears may not be surprising, particularly if a strong year class is present at the depths where the two gears overlap (e.g., 1998 and 1999). However, by 2000, the previously dominant 1993 year class was only apparent as 7-year olds in the long-line fishery while the younger 1996 year class was appearing to dominate in the commercial and recreational hook-and-line fishery. The patterns clearly seem to reflect the fishing gauntlet across depth, that is - youngest ages taken in the recreational sector, followed by commercial hook-and-line and finally commercial long-line sectors. These findings support earlier studies showing larger and older gag tend to be sampled from deeper water depths (Manooch and Haimovici 1978, Hood and Schlieder 1992).

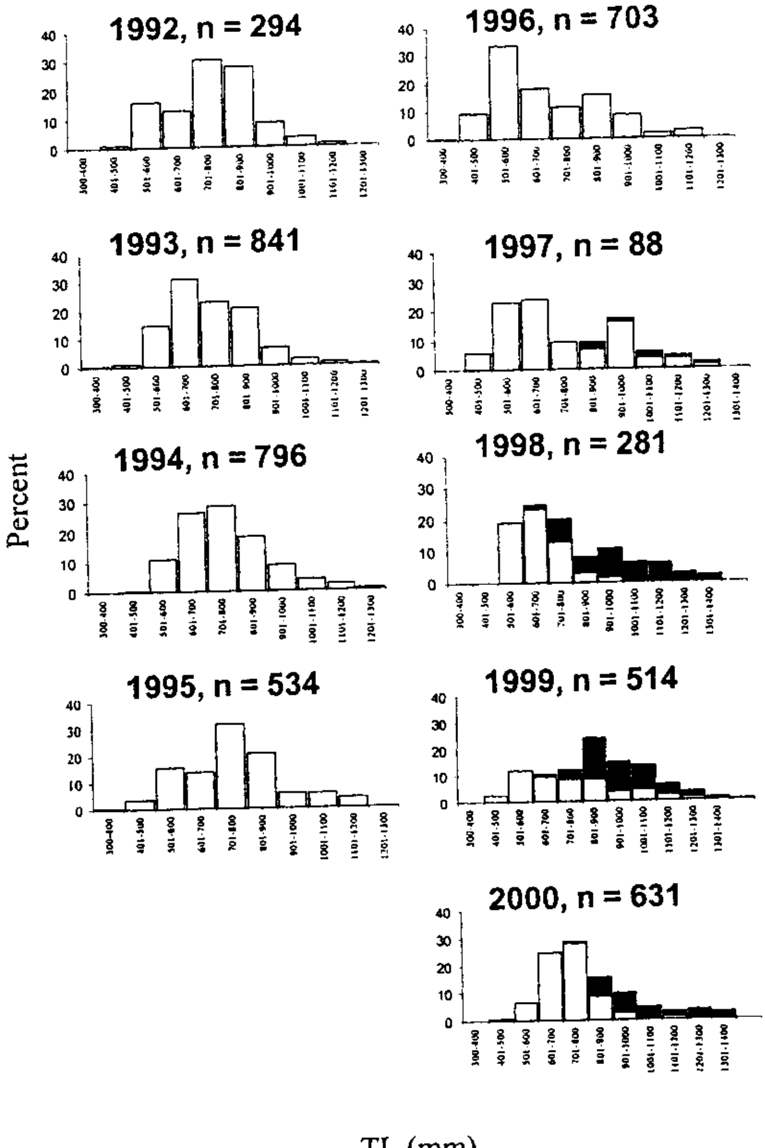

Figure 1. Size distribution of gag sampled for age. Hook-and-line data represented by open bars and long-line data are represented by black bars.

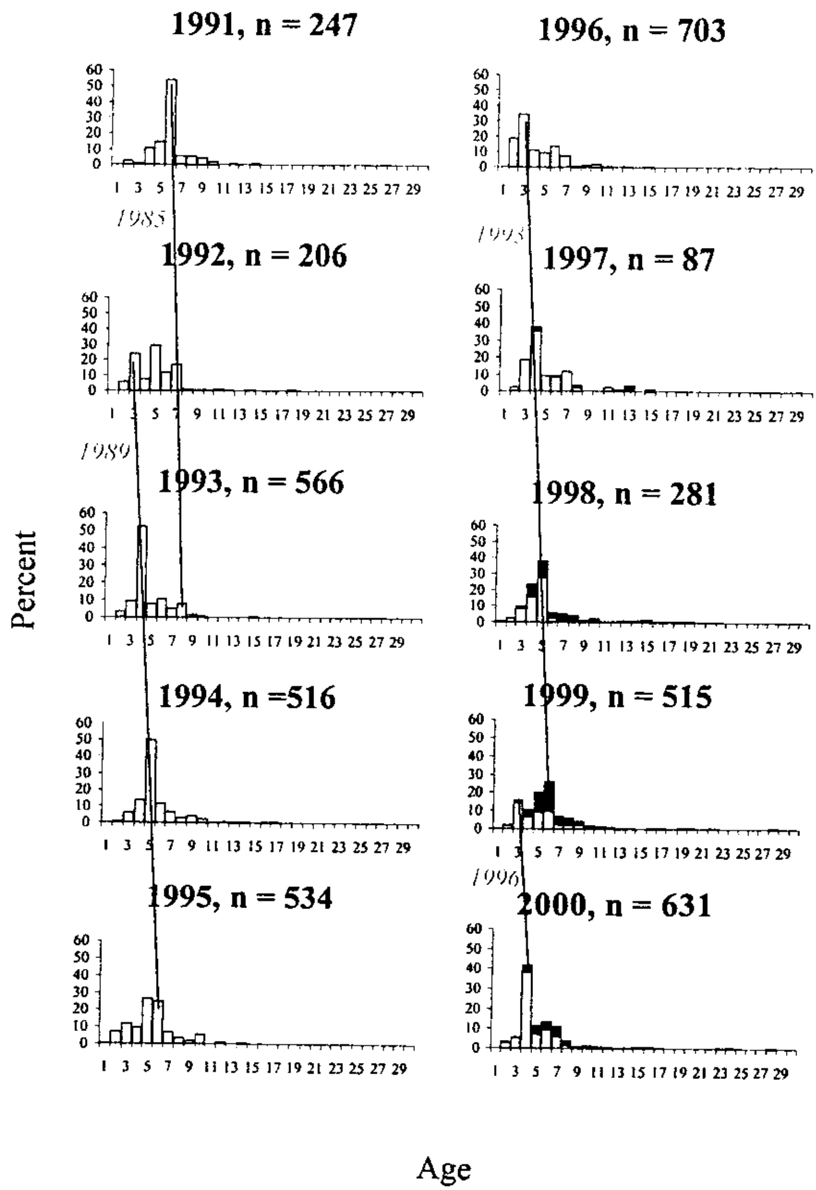

Figure 2. Gag age distribution. Hook and line data represented by open bars and long-line data are represented by black bars. Dominant year classes (1985, 1989, 1993, and 1996) are denoted by lines. 1991-1994 data from Johnson and Koenig (in Press).

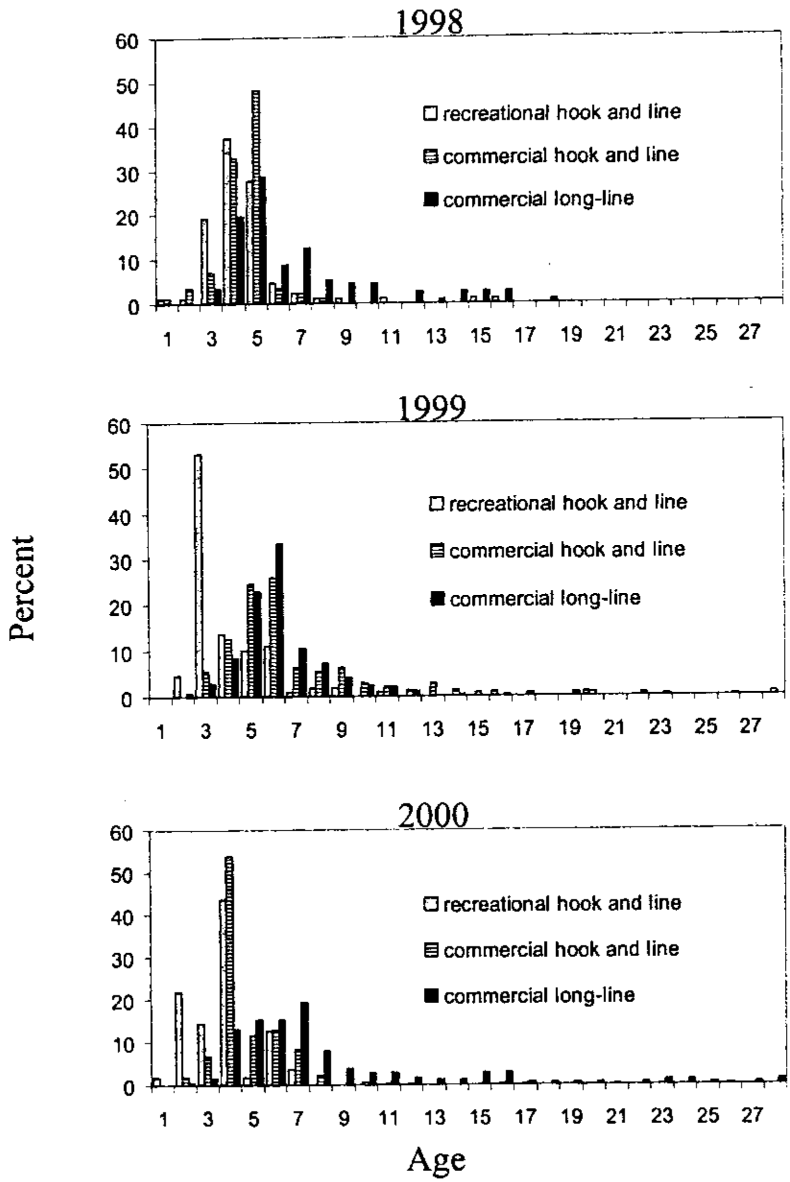

Figure 3. Age distribution by principal fishing modes for years 1998-2000. Age frequencies for each gear within each year were scaled to 100% for comparison.

We also wished to examine regional differences, and particularly compare an area where the fishery has been recently active (north of Tampa; Schirripa and Legault 1997) to an area where gag landings are much smaller (south of Tampa), possibly reflecting a geographic difference in the fishing effort experienced by the stock. From December 1997 through December 1999, gag were sampled by port agents returning otoliths, lengths, weights, and in most cases, gonads and information about gear, position and depth of capture in cooperation with a MARFIN study (Fitzhugh et al. 2000). For most of the gag sampled, we were provided enough information to distinguish catches from north and south of Tampa (about 28 degrees N latitude). This differs from previous Gulf of Mexico gag research where gag samples were taken from the mid to outer continental shelf north of Tampa (see Hood and Schlieder 1992, Coleman et al. 1996 and Collins et al. 1998), the general location where the fishery was known to primarily exist (Schirripa and Legault 1997). To our knowledge, these data represent the first substantial effort in sampling adult gag so far south (to the Tortugas) along the west Florida shelf.

Gag captured by hook-and-line (commercial and recreational) north of Tampa showed a notably skewed size distribution with a mode at 600-700 mm TL and with individuals ranging to greater than 1300 mm TL (Figure 4). Of the 256 gag, 215 were identified to sex with 4.65% being male. More larger gag were captured by hook-and-line gear south of Tampa with much higher frequencies of gag from size-classes greater than 900 mm TL (Figure 4). Of the 218 gag from this category, 125 were identified to sex, of which 14 % were male. Long-line gag sampled south of Tampa were generally larger than hook-and-line fish with a mode at 800-900 mm TL (Figure 4). This category represents the largest sample with 409 gag, of which, 231 were identified to sex and 17% were male. Only seven gag were sampled from long line catches north of Tampa and are not shown.

We compared age structure north and south of Tampa for commercial hook-and-line gag. Subdividing the data resulted in a much reduced sample size but some trends may be robust. Age structure between regions was similar but more older gag were evident from the southern hook-and-line catch (Figure 5). In 1998, most fish sampled in the north were age-4 and age-5 in contrast to a more evenly distributed age structure from samples taken south of Tampa. For both regions, the progression of year classes was notable as age-4 and age-5 fish dominated in 1998 and age-5 and age-6 fish dominated the age structure in 1999 (Figure 5).

By observing the alternating pattern of strong and weaker year classes progressing through the various fisheries, and by observing the pattern of catch from gears which tend to harvest at different depths, a hypothesis can be derived for gear selectivity. The largest factor affecting selectivity appears to be gag age and size differences occurring at depth and locality where a gear is fished, and to lesser degrees age/size differences in behavior, gear susceptibility or gear effects (hook size, etc.). An example which highlights the size/age-by-locality effect is the domination of 3-year olds in the commercial hook-and-line catch occurring only once within the decade. In 1996, the 3-year olds (1993 year class), independently observed to be a large year class via a juvenile survey, recruited to mid-shelf depths and frustrated many fishermen due to the high number of undersized discards (Fable 1996, Johnson et al. 1997). To clarify these age/size patterns, future research should focus on increased sampling for age and compare geographic differences between age-structure for long-line gear and similar components of the recreational fishery (e.g., private, head boat and charter) related to regional differences in fishing effort.

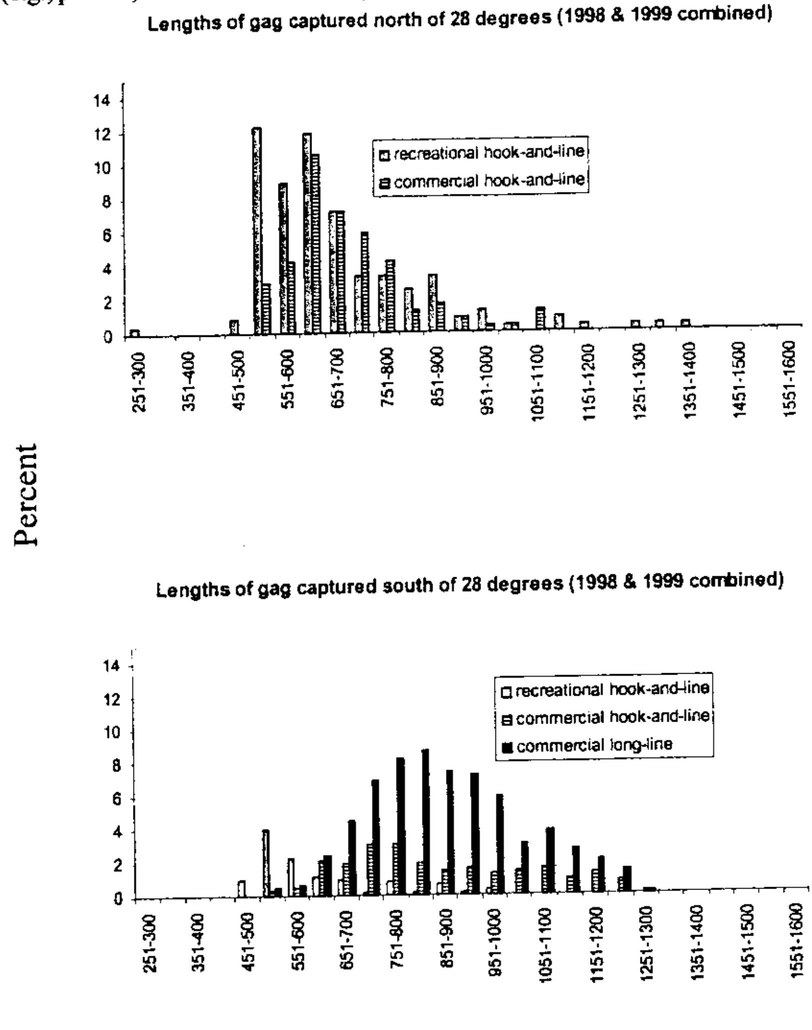

Figure 4. Length distributions of gag sampled for age by gear type, north and south of Tampa (28 degrees N. latitude) expressed as percent of total samples available for each region.

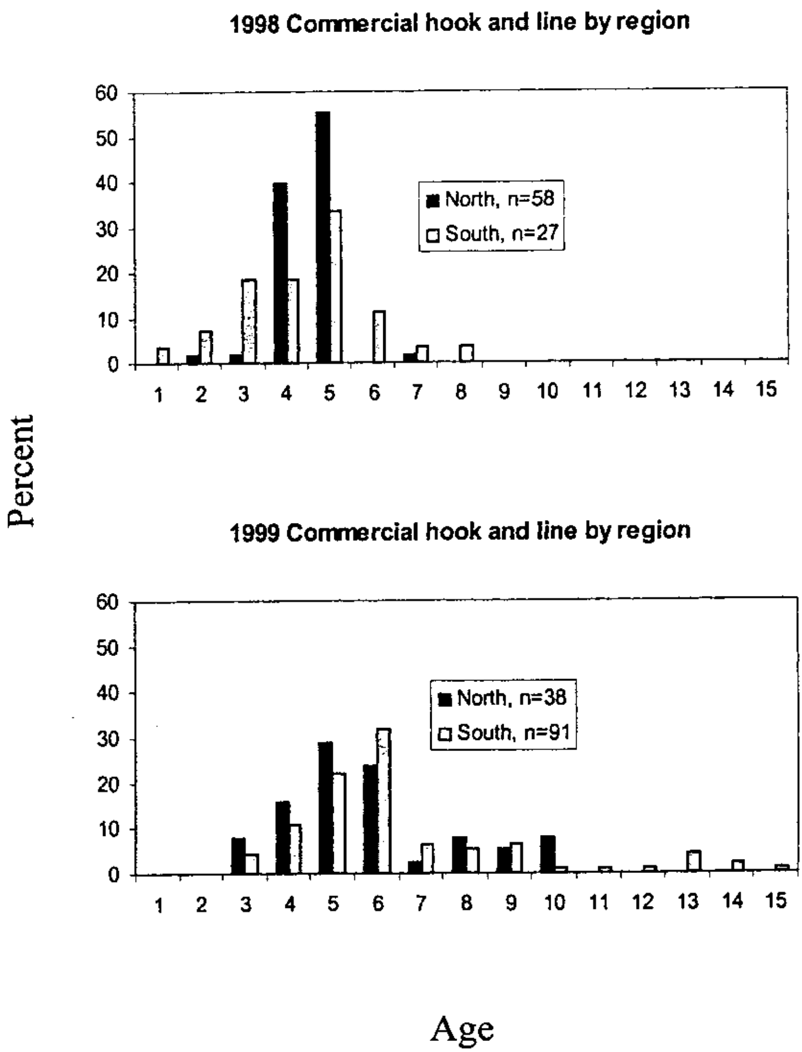

Figure 5. Age distribution of gag captured by commercial hook and line from locations north and south of Tampa (28 degrees N. latitude) for 1998 (top panel) and 1999 (bottom panel).

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