# Addressing Recruitment in *Mycteroperca microlepis* Populations of the North Coast of Yucatan Peninsula: An Otolith Aging Approach

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ABSTRACT

Gag (*Mycteroperca microlepis*) is one of the grouper species that supports a major commercial fishery in the Yucatan Peninsula and also a recreational one in the southeastern United States. In the state of Yucatan it is a very important fishery resource since it represents the third most abundant species in the total catch biomass. Despite its importance, there is scarce information in Mexico about its population biology, recruitment, and juvenile period. Therefore, this work is focused on defining the time, age, and size in which settlement and recruitment take place. During a 19 months survey at the northern coast of Yucatan during 2000 and 2001, 928 gags were caught. All of these were juveniles since they have completed their metamorphosis, lived in a benthic habitat, and were sexually immature. Otoliths microstructure analysis was done using a polishing and etching technique and counting the number of annual rings and daily marks through a compound microscope. In order to authenticate the number and the source of each mark observation, an image analysis with a SEM was carried out. Two cohorts were established, the first one takes account of individuals of less than a year old displaying several daily and lunar marks, as the second one comprises individuals with two or more years of life, exhibiting two or more annual rings and other source marks. The otolith aging technique points out that recruitment is discontinuous for gag in the Yucatan coast and that the determined nursery areas support more than one annual cohort.

KEY WORDS: *Mycteroperca microlepis*, age, otoliths, recruitment

## Abordando el Reclutamiento de las Poblaciones de *Mycteroperca Microlepis* de la Costa Norte de la Península de Yucatán : Un Enfoque de Otolimetría

El Abadejo (*Mycteroperca microlepis*), es una de las especies de meros que es explotada por pesquerías comerciales en el sur del Golfo de México, así como pesquerías recreativas en el sureste de Estados Unidos. En el estado de Yucatán, es un recurso pesquero muy importante ya que representa la tercera especie mas

abundante en el volumen total de captura. A pesar de su importancia, la información en México sobre la biología de sus poblaciones, el recultamiento y su fase juvenil, es muy escasa o inexistente. Por lo tanto este trabajo tiene como objetivo definir el tiempo, edad y tamaño en el cual se da el asentamiento y el reclutamiento de esta especie. Novecientos veintiocho abadejos fueron capturados durante un período de muestreo de 12 meses, en la costa norte de Yucatán, durante el 2001. Todos los individuos fueron considerados como juveniles ya que presentaron una metamorfosis completa, inmadurez sexual y se encontraron asentados en ambientes bénticos. La técnica de otolimetría utilizada fue la de pulido y descalcificación, con conteo del número de anillos anuales o marcas diarias a través de un microscopio compuesto . Para verificar el numero y origen de cada marca observada, se realizó un análisis de imagen por medio de un MEB. Se estableció la existencia de 2 cohortes, la primera con individuos menores a un año de vida, que presentaron varias marcas diarias y lunares. La segunda cohorte con individuos de 2 o mas años de edad fue establecida ya que presentaban 2 o mas anillos de crecimiento u otras marcas. La técnica de otolimetría muestra que el reclutamiento del abadejo en las costas de Yucatán es discontinuo y que en las areas de crianza registradas se pueden encontrar individuos de diferentes cohortes anuales.

PALABRAS CLAVES: Abadejo, *Mycteroperca microlepis*, el recultamiento, Península de Yucatán

## INTRODUCTION

The coastal zone of the Yucatan State in Mexico has exceptional diversity and abundance of marine resources due to the physical and chemical characteristics prevailing there. Juvenile gags appear to be dependent on estuaries and near shore waters. Larvae are pelagic and drift towards shore with the influence of tides and currents (Rutten in press). Postlarval gags enter near shore waters where they settle and stay in these nursery areas for a period of time searching for food and protection. Settlement is apparently well synchronized with the spring increase in primary and secondary productivity in oyster beds, seagrass beds and other complex habitats. All of the juveniles are sexually immature. Five to six months later, juvenile gags leave the nursery area and egress to near shore reefs and wrecks (Koenig and Colin 1999). Changes in weather patterns and/ or rapid changes in water temperatures may precipitate mass emigration of gag from the estuaries (Ross and Moser, 1995).

Gags are heavily fished using a variety of gear and in different phases of their lives (Sadovy 1997). The fishing pressure on this species in Yucatan, as in other groupers, is greatest on larger individuals that are mainly males, since it is a protogynous hermaphrodite, resulting in the females changing sex at a smaller size (Koenig et al. 1996, Coleman et al. 1996). Juveniles are also captured within the coastal zone of the state since there are no management regulations on the minimum legal size.

The overfishing of adults and juveniles as well as the destruction or modification of their nursery have lead the Mycteroperca microlepis to be considered as a vulnerable specie in the Red List of the UICN (Morris et al. 2000). It is becoming generally accepted the only way to effectively protect this specie is by protecting their habitat. There is a clear need for more and better data on the biology of this grouper and so this article will provide information on the biology of juvenile gags and their recruitment. Using an otolith aging technique, time, age and size in which settlement and recruitment took place in the northern coast of Yucatan will be determined so as to have more tools to manage this resource.

## MATERIALS AND METHODS

All juvenile gags were captured with a small trawl net at Punta Caracol (21° 29.24 N, 87° 30.18 W) and Dzilam de Bravo (21° 25.05 N, 88° 52.20 W) in the northern coast of Yucatan where seagrass beds are conspicuous during 19 months survey from June 2000 to December 2001 (Figure1). Data registered for each sampled fish included collection date, location (using a GPS), total (TL) and standard length (SL) (cm), whole (TW) and gutted body weight (GW) (g). Both sagittae were carefully removed up through the gills and placed in an aqueous solution of alcohol for more than a week in order to clean all the membranes off them. Some gags were too small so the otoliths were not removed and some otoliths were broken, leaving only 715 pairs able to use and to establish the time in which settlement and recruitment took place.

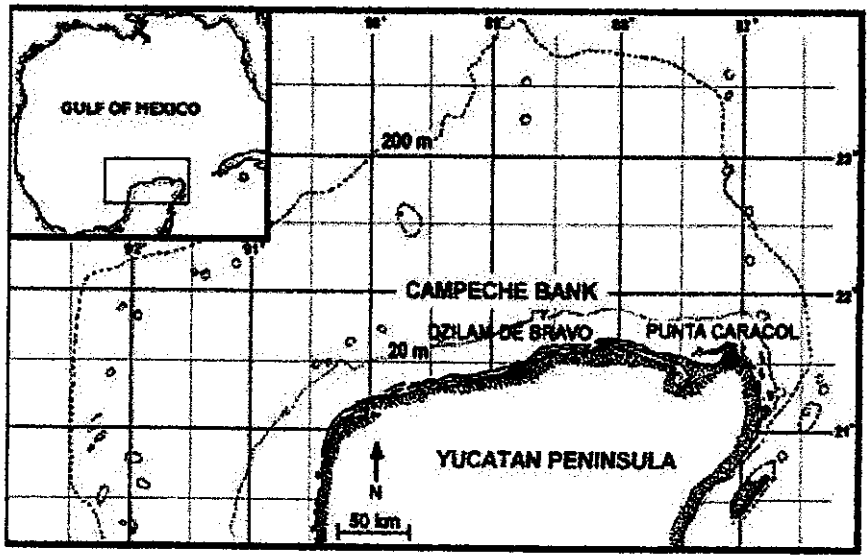


**Figure 1.** Map of the Campeche Bank and the northern coast of Yucatan Peninsula, showing the two fishing sites where gags were collected.

Once clean, the pair of otoliths was stored dry in paper bags. Only the left otolith was chosen, but in case it was lost or damaged the right one was used. Every pair of sagittae was weighed to the nearest milligram in order to obtain the average weight. For length and width, one sagitta was measured using a graph paper to the nearest millimeter. A correlation between the fish and otolith weight and the standard length and the otolith length were carried out. For the aging technique, 53 sagittae of 0.5 cm and 0.9 cm length were chosen. Each of the selected otoliths was observed by using a compound binocular microscope under reflected light immersed in camomil aromatic oil, which acts as a clearing agent. The number of opaque marks were read from the nucleus outward along their axis at a magnification of 0.7 X and 2.5 X for each one by two readers and the mean value was taken into account. It was taken into account that the underlying daily increment pattern is usually smooth and regular (Campana 1992).

The number of marks from each specimen was used to estimate the age of the fish in days for the smallest otoliths. For the largest otoliths, annual rings (annuli) in each sagitta were counted since the daily marks could not be clearly read. The same otoliths were cleansed with a paper towel and embedded in transparent epoxy resin. Each otolith was polished to the sagittal plane with 600 and 1000 grit paper until the nucleus was exposed. The cross-section was etched with EDTA (9% solution) for five minutes for the smaller otoliths and for 15 minutes the larger ones. The otoliths were then stained with Toludine blue in order to make the marks and annuli more evident to observe. Although greater time is required per sample, the quality of sample preparation and the precision of later microstructural examination is enhanced over other methods (Secor et al. 1992).

Once the source of the mark was established, a back calculation procedure was performed considering that every seven daily marks stands for a lunar mark and that the pelagic phase of the gag was 40 days (Koenig and Coleman 1998). The back calculation procedure used in this study only determines the probable settlement and birth date of each juvenile. Increments or marks were considered daily as they are formed at a constant frequency, and they often appear as a regular sequence with smooth transitions in both increment width and increment contrast (Campana 1992).

In order to authenticate the number and the source of each mark or annulus observation, an image analysis with a scanning electronic microscope (Hitachi S 520) was carried out (110 X to 600 X magnification). The otoliths were rinsed with alcohol before being rotary coated in a vacuum evaporator with 150 Å of gold-palladium alloy. The image analysis system was used because it provides three major advantages such as image enhancement, image manipulation and quantification of annuli (Campana 1992).

## RESULTS

From June 2000 to December 2001, 928 gags were caught at the northern coast of Yucatan in Punta Caracol and Dzilam de Bravo. Lengths for 715 individuals ranged in size from 6.2 to 48.7 cm and 5.9 to 43 cm total and standard length

respectively. Whole weight range from 4.2 to 1,105.9 g while gutted weight was 3.4 g to 1,008.4 g.

Otoliths length ranged from 0.25 to 2.2 cm and otoliths weight from 0.00053 to 0.54629 g. Fish standard length and fish weight correlated strongly with sagitta length ($r^2$ = 0.8056) (Figure 2) and sagitta weight ($r^2$ = 0.7099) (Figure 3) respectively.

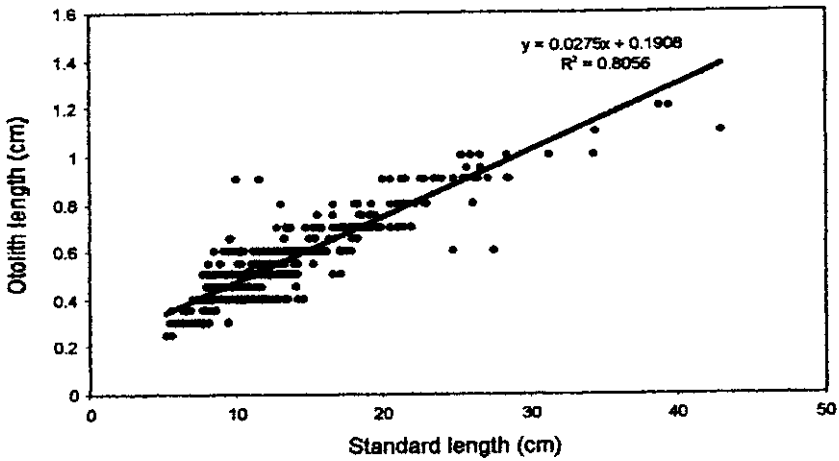


**Figure 2.** Regression of 715 gags between standard fish length and otolith length

The number of marks and annuli were read in 53 chosen otoliths It could be assessed that 30 sagittae, whose length was 0.5 cm display no annual ring or annuli. The largest 23 otoliths of 0.9 cm length display one or more annuli and no lunar mark was visible. It was established that these otoliths where from fishes of two different cohorts, the smallest ones belonging to a first cohort and the largest to a second.

Otoliths of fishes in the first cohort, seen with camomile oil, display several records from 5 to 20 lunar marks that represent an individual age of 75 days to 180 days, including 40 days that lasts the larval phase (Table1). The 30 individuals studied were younger than a year. Of these individuals 6 had 4 months, 2 had 5 months, 4 had 6 months, 11 individuals had 7 months and 7 had 8 months of life. These gags were captured between July 2000 and November 2001, and the probable date of recruitment was April to May for the smallest individuals (10.6cm mean standard length). The aging technique points out that juveniles had been recruited

primary in April and May to June or August.

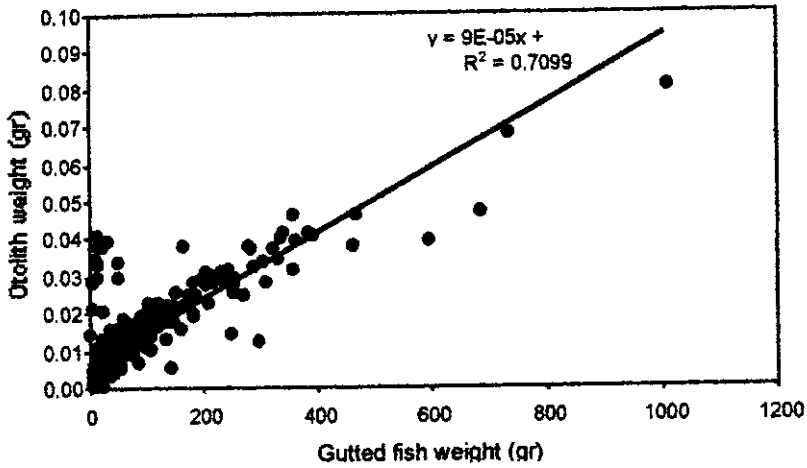


**Figure 3.** Regression of 715 gags between gutted fish weight and otolith weight

The standard length of cohort one (range 7.8- 27.5 cm) was significantly less than those of cohort two (ranges 10.0 - 28.6 cm). The relationship between the standard length of each individual of the cohort one, and the number of marks in their otoliths was statistically significant ($p = 0.142118$; $\alpha = 0.01$) but the correlation between variables was very weak (correlation coefficient = 0.078074).

Juvenile gags belonging to cohort the second cohort displayed 1 to 4 annuli, after the polishing and etching technique (Table 1). These annuli represent an age of one to four years for the juveniles. The standard length for individuals with one annulus, or one year of age, ranged form 11.5 to 28.6 cm and for individuals with two annuli ranged from 20.5 to 28.5 cm. Specimens with three and four annuli presented a standard length of 20.0 to 25.7 and 23.8 to 26.5 cm, respectively. The relationship between the standard length of each juvenile and the number of annuli displayed in each otolith was statistically significant ($p = 0.197684$; $\alpha = 0.01$) but the correlation between variables was very weak (correlation coefficient = 0.07772). All of these 23 individuals were capture between July 2000 to October 2001.

For the early recruits, or juveniles belonging to the first cohort, the deposition of lunar marks was observed every seven days. I was also assessed the number and source of the annuli seen in individuals of the second cohort, which display one to three annual rings. This was authenticated by taking into account the microstructure of the otolith seen through the SEM (Table 1).

**Table 1.** Results for the two different cohorts defined. A comparison between the three methods used.

| | Camomile Oil | | Polishing and Etching | | Image Analysis (SEM) | |
|---|---|---|---|---|---|---|
| | Lunar Mark | Annuli | Lunar Mark | Annuli | Lunar Mark | Annuli |
| **Cohort 1** | 5 - 20 | 0 | 0 | 0 | 5 - 20 | 0 |
| **Cohort 2** | 0 | 1 - 3 | 0 | 1 - 3 | 0 | 1 - 3 |

## DISCUSSION

*Mycteroperca microlepis* is a protogynous hermaphrodite (Bullock and Smith 1991), which exhibits a bathymetric distribution (Johnson and Collins 1994) and whose principal environments for their juvenile stage are in shallow water seagrass beds (Renán In press.). Through this study it can be assessed that early juvenile gags require this habitat as a nursery area although dependency for estuaries (Keener et al. 1988, Koenig and Colin 1999) was not observed since in Yucatan shore there are no estuaries

The stations where the individuals were captured in this study, Punta Caracol and Dzilam de Bravo, belong to two different natural protected areas which include one mile of sea habitat from the coastline. Notwithstanding, when these areas were decreed, the marine environment was not taken into account, and there are no management plans or fishing restrictions in any of them.

All of the gags studied were considered as juveniles since they have completed their metamorphosis, had settled in a benthic habitat, and were sexually immature (Kovác and Copp 1999). Pelagic gags recruited to the sea grass habitat as a single cohort in April and May after 40 days of pelagic stage, which agree with the time established by other authors (Koenig and Coleman 1998, Koenig and Colin 1999).

For these early recruits the deposition of lunar marks was observed every seven days. The mean size of the individuals at age 0 or younger than a year (10.6 cm) determined in this study agreed with the length established by Hood and Schlieder (1992) of 32.2 cm (maximum value TL) for individuals of the same age. The first individuals from this cohort were captured in July, and with the back-calculation analysis it could be determined that the first individuals ingress to the seagrass beds in April and May which agrees with the results from other authors (Rutten, In press; Ross and Moser, 1995).

From individuals belonging to cohort, two sectioned otoliths showed that annuli were laid down once a year. Although the validation to assert this was not carried out, different authors support this by the consistency of ring location from the otolith core and the positive correlation of otolith size and fish length (Hood and Schlieder 1992, Collins et al. 1996). The periods of peak annulus reported was in May to August, but in order to establish the time when these rings were formed in the otoliths studied, a marginal increment analysis is needed (Collins et al. 1987)

The otolith aging technique points out that recruitment is discontinuous for gag in the Yucatan coast where there is an evident peak of ingress once a year. Individuals spend their first years of life in these nursery areas where they become established to feed and protect themselves from predators (Jory and Iversen 1989). The results also determined that these nursery areas support more than one annual cohort, which indicates that gags are not a threat to each other and that they are recruitment-limited rather than resource-limited (Sadovy 1997).

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