Age validation, movements and growth rates of tagged gag (*Mycteroperca microlepis)*, Black Sea Bass (*Centropristis striata)* and Red Porgy (*Pagrus pagrus)*

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1996

SEDAR60-RD10

9 July 2018

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COLLINS, M.R., S.B. VAN SANT and G.R. SEDBERRY. 1996. Age validation, movements and growth rates of tagged gag (*Mycteroperca microlepis*), black sea bass *(Centropristis striata)* and red porgy *(Pagrus pagrus)* [*Movimientos y tasa de crecimiento a partir de datos de marcado del cuna aguají* (Mycteroperca microlepis), *del Serrano Estriado* (Centropristis striata), *y del Pargo* (Pagrus pagrus)], p. 158-162. *In* F. Arreguín-Sánchez, J.L. Munro, M.C. Balgos and D. Pauly (eds.) Biology, fisheries and culture of tropical groupers and snappers. ICLARM Conf. Proc. 48, 449 p.

Abstract

Ages of fishes are commonly estimated by counting opaque bands in the otoliths, but direct evidence to validate the annual nature of these bands is lacking for most species. Therefore, gag (*Mycteroperca microlepis*), black sea bass (*Centropristis striata*), and red porgy (*Pagrus pagrus*) were tagged, injected intramuscularly with oxytetracycline (OTC) and released. Otoliths were acquired from eleven gag at large for 225-603 days, five black sea bass at large for 206-355 days, and one red porgy at large for 341 days. Transverse sections of the otoliths were examined microscopically under white and ultraviolet light. Numbers of opaque bands distal to the fluorescent OTC mark were consistent with the hypothesis that these opaque bands are produced annually. Most individuals were recaptured at or near the two study sites. Growth rates were calculated for comparison with previous estimates.

Resumen

La edad de los peces es comunmente estimada por conteo de bandas opacas en los otolitos, pero se carece de evidencias directas para validar la naturaleza anual de estas bandas para la mayor parte de las especies. En consecuencia el cuna aguají (Mycteroperca microlepis), *el serrano estriado* (Centropristis striata) *y el pargo* (Pagrus pagrus) *fueron marcados, inyectados intramuscularmente con oxitetraciclina (OTC), y liberados. Después de 225-603 días los otolitos de once cuna aguají fueron obtenidos, cinco del serrano estriado después de 206-355 días, y uno del pargo después de 341 días. Secciones transversales de los otolitos fueron analizadas al microscopio bajo luz blanca y luz ultravioleta. El número de bandas opacas distales de la marca fluorescente de OTC fueron consistentes con la hipótesis de que estas bandas opacas son producidas anualmente. La mayoría de los peces fueron recapturados dentro o cerca de los sitios de estudio. Las tasas de crecimiento fueron calculadas para comparación con estimaciones previas.*

Introduction

Validation of the annual nature of marks (annuli) in hard parts of fishes ensures the accuracy of age estimates generated by counting the marks (Beamish and McFarlane 1983). Validation is usually based on indirect evidence, most commonly on marginal increment analyses of monthly samples of fish (e.g., Wenner et al. 1986; Collins et al. 1987) (see also Manickhand-Heileman and Philipp, this vol.). Direct evidence can be produced by examination of hard parts of known-age fish or by marking hard parts and examining them after a known period of time. One common method of marking hard parts is by injecting, feeding or immersing fish in the antibiotic oxytetracycline (OTC), which is incorporated into bony parts and fluoresces when the structure is examined under ultraviolet light (Hettler 1984; Foreman 1987; Marking et al. 1988) (see also Bush et al., this vol.).

Age and growth of most species of economically important reef fishes from the Atlantic coast of the southeastern United States have been described, but evidence for validation has been indirect. The primary objective of this study was to directly validate ages for several species of reef fishes. Secondary objectives were to gather information on growth rates and movements.

Methods

Reef fishes were captured by angling and trapping during 1987-1990 at two natural reef sites in 22-m and 27-m depths near Charleston, South Carolina, USA. Prior to tag application, the swim bladder was deflated with a hypodermic needle, total lengths (TL) were measured to the nearest mm, and a weight-dependent dosage of OTC was injected intramuscularly (McFarlane and Beamish 1987). Weights were estimated from length-weight relationships [(gag *Mycteroperca microlepis*) Manooch and Mahmovici 1978; red porgy (*Pagrus pagrus*) Dias et al. 1972; black sea bass (*Centropristis striata*) Wenner et al. 1986)]. During 1987, Petersen disk tags were attached below the dorsal fin and approximately 70 mg OTC per kg body weight of Liquamycin LA-200 was injected into the dorsal musculature. During 1988-1990, internal anchor tags were inserted into the abdomen and approximately 50 mg OTC per kg body weight of Anchor Oxy-Tet 100 was injected into the dorsal musculature. The address of our laboratory and instructions to save the tag and head were printed on all tags.

When recaptures of tagged fish were reported by commercial or recreational fishers we asked for the fish's length and the recapture date and location, and we attempted to acquire the head or sagittal otoliths. In most cases, however, only the date and location were provided. When fish were recaptured by project personnel during tagging operations, those that had been at large for less than six months were generally measured and released. Some fish that were at large for more than six months and all that were at large for more than 12 months were sacrificed, measured and the otoliths removed and stored dry. Further processing was restricted to otoliths from fish recaptured after at least 200 days at large. Only fish at large for at least 90 days with lengths measured by project personnel were used in calculations of growth rates (recapture length - tagging length) / days at large).

Otoliths were embedded in paraffin, and transverse sections (ca. 0.5-mm thick) through the core of one otolith per fish were cut with a Buehler Isomet low speed saw. Sections were placed in nonfluorescing immersion oil and examined under white light and ultraviolet light at 40x and 100x using a Nikon Labophot microscope with an epifluorescence attachment. Age estimates were based on the number of opaque zones visible on the otolith section.

Results and Discussion

The brand and/or dosage of OTC used during the first year of this study caused lesions to form in the vicinity of the injection site, at least for gag. In addition, several fish were recaptured with the Petersen disk tags deflected posteriorly and torn partially through the musculature, and a few recaptured fish had evidence of OTC injection but only a scar or wound at the site of tag insertion (Van Sant et al. 1994). These problems were apparently eliminated in subsequent years by changing the tag type and the brand and dosage of OTC.

Validation analyses were restricted to otoliths of 11 gag, five black sea bass and one red porgy since otoliths were not acquired or the time at large was less than 200 days for most of the recaptured fish. Gag, black sea bass, and red porgy used in analyses were at large for 225-603 days, 206-355 days, and 341 days, and their otoliths displayed 2-7, 4-7, and 4 opaque zones, respectively. A fluorescent OTC mark was visible in all otoliths examined, and all otoliths showed growth beyond the OTC mark. Six gag, four black sea bass, and the red porgy had formed one opaque zone distal to the OTC mark.

Our results agreed with the periods of peak annulus formation, as determined from marginal increment analyses, reported in previous studies from this geographic area (May-August for gag, Collins et al. 1987; April-June for black sea bass, Wenner et al. 1986; and March-April for red porgy, Manooch and Huntsman 1977). Because our fish were tagged and recaptured during various months, including months of peak annulus formation, comparing the number of observed opaque zones distal to the OTC mark with the number to be expected if they were deposited annually is not straightforward. For all gag, two black sea bass, and the red porgy, the expected number is a range of two (e.g., 0-1). However, in no case does the observed number of opaque zones disagree with the expected number or range, supporting the hypothesis that the zones are annual marks in the age groups examined (Fig. 1).

The scarcity of tag returns from locations other than the study sites suggests that most gag, red porgy, and black sea bass moved little. Most tag returns were from within 7 km of the tagging site, confirming results from previous tagging studies that reported little movement by reef fish in this region (Parker et al. 1979; Ansley and Davis 1981; Parker 1990). However, a few fish moved substantial distances. One red porgy at large for 62 days moved 17 km northwest, and another at large for 24 days moved 54 km northwest. A black sea bass at large ≥90 days was recaptured at an artificial reef 22 km northeast of the study site. One small gag at large for 1 021 days moved 54 km southwest, and another that was at large for 646 days moved 93 km northeast. The greatest movements were by large (>75 cm TL) gag. Long distance movements of three large individuals suggested a possible spawning migration to southern Florida (Van Sant et al. 1994).

To minimize the effects of handling stress and possible measurement error on mean growth rate estimates, only fish that were at large ≥90 days and that were measured upon recapture by project personnel were utilized in calculations of mean growth rates. Mean growth rates (±SD) in terms of TL were 0.15 (0.08) mm/day for gag, 0.17 (0.08) mm/day for black sea bass, and 0.17 (0.05) mm/day for red porgy (Table 1). Our growth rates for gag and red porgy are similar to daily growth increments estimated from mean back-calculated (Manooch and Halmovid 1978) and mean observed (Collins et al. 1987) lengths for gag, and from mean back-calculated lengths for red porgy (Manooch and Huntsman 1977). However, our growth rate for black sea bass appears to be substantially greater than daily growth

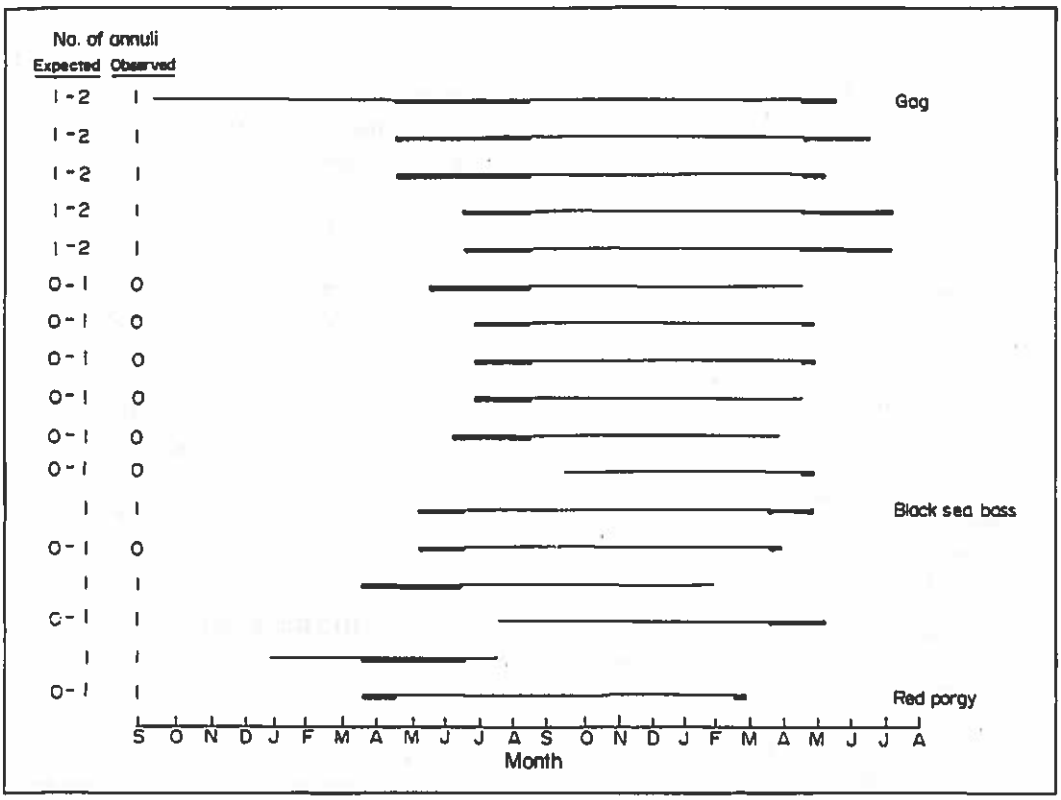

Fig. 1. Months at large (years pooled) and numbers of expected and observed annuli distal to the tetracycline mark for each fish used in validation analyses, with months of peak annulus formation (from the literature) indicated by bold line segments. [*Meses (año promedio) y número esperado y observado de annuli distales de la marca de tetraciclina para cada pez utilizado en el análisis de validación, con meses pico de formación de annuli (tomado de la literatura) indicado por la línea gruesa.*]

Table 1. Number of individuals, and mean (±SD) total length (TL, in mm), days of freedom, and growth rate (mm/day), of gag (*Mycteroperca microlepis*), black sea bass (*Centropristis striata*), and red porgy (*Pagrus pagrus*) tagged off South Carolina. Only individuals measured by project personnel at recapture and at large for at least 90 days were used in growth rate analyses. [*Número de individuos, longitud total (LT, en mm) media (± D.S.), días de libertad, y tasa de crecimiento (mm/día) del cuna aguají* (Micteroperca microlepis), *serrano estriado* (Centropristis striata), *y pargo* (Pagrus pagrus) *marcados en aguas afuera de Carolina del Sur. Sólo individuos medidos por personal del proyecto al momento de la recaptura, y con el tiempo de liberación >90 días fueron usados en la estimación de la tasa de crecimiento.*]

Item	Gag	Black sea bass	Red porgy
No. tagged	155	270	121
No. recaptured	43	45	8
No. for analysis	19	15	2
TL at release	613 ±119	349±40	350±12
TL at recapture	656±130	381±35	395±11
Days free	300±152	197±72	284±81
Growth rate	0.15±0.08	0.17±0.08	0.17±0.05

increments calculated from mean back-calculated lengths (Wenner et al. 1986).

We suggest two modifications to our methodology for future validation studies. Greater emphasis on public relations (e.g., news releases, presentations to fishing groups) might increase the number of recaptured fish from which otoliths are obtained, as the necessity of retaining heads would be better understood by the public. Concentrating mark and recapture efforts at times other than peak annulus formation would allow the expected number of opaque zones distal to the OTC mark to be a single number rather than a range. This would simplify comparisons of observed and expected numbers.

Acknowledgements

We appreciate the assistance in our tagging operations provided by the crew members of the *R/V Palmetto* and *R/V Lady Lisa* and by numerous MARMAP personnel. Charles A. Barans and Charles A. Wenner provided valuable comments on the manuscript. This study was funded by the National Marine Fisheries Service (Southeast Fisheries Center) and the South Carolina Wildlife and Marine Resources Department through the MARMAP contract. This is Contribution No. 311 from the South Carolina Marine Resources Center.

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