Hogfish Otolith Shape Analysis According to Its Ontogenic Stages, Size, and Collection Areas

Análisis de la Forma del Otolito de la Doncella de Pluma Según el Estadio Ontogénico, la Talla y el Sitio de Colecta de los Individuos

Analyse de la Forme des Otolithes du Labre Capitaine en Relation avec le Stade de Développement, la Taille et la Région de Collecte des Individus

OCÉANE MINSTER[1,2], XIMENA RENÁN[2]*, and THIERRY BRULÉ[2]
[1]*Faculté des Sciences Exactes et Naturelles. Université des Antilles. P ôle Guadeloupe Pointe-à-Pitre, Guadeloupe 97110 France.*
[2]*Centro de Investigación y de Estudios Avanzados del Instituto Politécnico Nacional Unidad Mérida, Departamento de Recursos del Mar, Mérida, Yucatan 97310 México.*
*ximena.renan@cinvestav.com

EXTENDED ABSTRACT

Introduction

In the southern Gulf of Mexico hogfish *Lachnolaimus maximus* is exploited all along the coast of Yucatán as an associated species in the grouper and lobster fishery. Due to the red grouper´s volume catches decline, the annual catch of hogfish has increased from 21 to 360 tonnes between 2002 and 2012 (Mexicano-Cíntora et al., 2007, SAGARPA, 2012). The risks of overfishing (the *L. maximus* fishery is not regulated in México), as well as the destruction of its natural habitats, represent important threats for this species. In order to achieve a rational management of a fishery, the presence of heterogeneity within an exploited stock implies the application of specific control measures for each of the fractions of the stock that can react in a distinct way to fishing pressure. It is therefore important to generate information on the identity and structure of hogfish stocks, which has not been the subject of any previous study.

Methods

Hogfish were captured in three distinct marine areas of Campeche Bank, near the port cities of Celestún, Dzilam de Bravo and Río Lagartos, which correspond to regions with the highest hogfish´s volume landings and that present distinct hydrological conditions. Individuals were collected for 19 discontinuous months (from July 2011 to March 2015), by professional fishermen from the Yucatan artisanal fleet, using spear gun and hookah at depths between 6 to 22 m. All specimens were measured (TL, FL, SL; cm) and weighed (TW, SW, GW; g). Gonads were extracted for analysis using standard histological techniques to confirm the type of sexuality of the species, sex, and gonad development phase of the individuals. Finally, for each individual, the two sagittae were extracted through the gill arch, cleaned in alcohol and kept dry in paper pouches. This study focuses on shape analysis of 89 hogfish´s left sagittae taking into account collection areas, ontogenic stages and sizes. Otoliths were air dried, gold and platinum sputter-coated, and mounted on an aluminum stub using double-sided carbon tape. Images were acquired through a SEM Phillips XL30 at 25 to 10 Kv. Otolith morphometrics (19 variables), shape indexes (7 variables) and otolith contour description (512 *radii* of Discrete Wavelet Transform WLT4) were based in Volpedo and Echeverria (2003); Tuset et al. (2008) and Avigilano et al. (2014, 2016) and obtained using image processing software Image Pro Plus 7 and Age and Shape. Size effects were removed by dividing each otolith shape variable between their respective otolith lengths. Radii were standardized prior to statistical analysis by dividing each one by the mean radial length. To explore the possible differences between otolith shape with size, ontogenic stages and fishing sites, statistical analyses such as Principal Components (PCA) and Discriminant analysis (DA) were performed.

Results and Discussion

After the digitization of otoliths images by SEM, the use of morphometric, indexes variables and otolith shape data revealed significant differences in the morphology of otoliths between individuals related to ontogenic stages, size and fishing site. The most notable modifications of otolith shape related to size of individuals were an obvious increase in the length, perimeter and area but also the change from a larger and wider *antirostrum* in juveniles to a lengthening of the *rostrum* in adults. Fractal dimension and the variability of the otolith contour increases reflecting a more irregular shape associated with size. PCA ordination revealed that 9 morphometric and indexes variables (rectangularity, fractal dimension, diameter maximum, *excisura* area, a*ntipostrostrum* width and length, *postrostrum* length, *postexcisura* area and otolith area) accounted for 50% of the variability of the data. The increase in the length and area of the otolith could also be observed related to ontogenic stages. *Excisura* area, the proportion of the otolith area occupied by the *sulcus* and the length of the *postrostrum* develop through the ontogenic stages from females to transitionals and to males. Juveniles displayed a rectangular otolith whereas adults showed an ellipsoidal shape. Results from the DA showed consistent differences in otolith morphometrics and indexes due to ontogenic stages: juveniles: 100% classification success; females: 96.77%; males: 100%. The anterior (DA: 95.51%) and posterior (DA: 98.99%) subsections of the otolith contour by WLT4 also discriminate between ontogenic stages. Fractal dimension

and WLT reflect an increase in the irregularity of the otolith contour form juveniles to adults. Changes in otolith shape by fishing site could be observed in the three fishing sites: Celestún where individuals displayed a more rectangular and wider otoliths, in Dzilam de Bravo where otoliths were also rectangular but with irregular (more fractal) contours and in Río Lagartos where they displayed a pronounced *excisura.* PCA showed that rectangularity, diameter maximum, fractal dimension and *excisura* area accounted for more than 40% of the variability of the data between areas. DA displayed consistent differences between fishing areas: Celestún (94.44%); Dzilam de Bravo (94.12%) and Río Lagartos (100%). The otolith contour described by the anterior subsection could discriminate between areas (97.75%) whereas the discrimination by the posterior subsection was poor (56.18%). Differences in otolith shape due to increment in size have been registered in other species as the morphology of otolith becomes more complex with size. Ontogenic stages are partially related to fish size since hogfish is a protogynous hermaphrodite where the same individual matures and changes sex, as it grows bigger and older. But also, because as seen in some groupers there are changes in growth rate (growth stanzas) near the sexual maturity and the sex change, and therefore a change in otolith shape. The otolith shape differences associated to the fishing sites may be due to the heterogeneous environmental conditions from the west to the east were seabed goes from sandy covered with phanerogams (Celestún), muddy with phanerogams and macroalgae (Dzilam de Bravo) and rocky covered with macroalgae and soft corals (Río Lagartos). Also, the western (Celestún) region is influence by the Gulf of Mexico whereas the eastern (Río Lagartos) by the Caribbean Sea conditions. Underground fresh water discharges in Celestún and Dzilam de Bravo produce changes in water salinity and temperature and an upwelling during April- Sept from the east changes temperature and productivity in Río Lagartos. More studies need to be performed in order to answer what is the cause of the observed differences in hogfish´s otolith shape, but this work validates the interest of the use of otoliths in ichthyological studies and brings new data on the hogfish population of the Campeche Bank.

KEYWORDS: Hogfish, otolith shape, morphometrics, wavelet, Gulf of Mexico

ACKNOWLEDMENTS

Study research was possible through the funding of The Science and Technology Council of Mexico (CONACyT) grant SEP CONACyT CB-2015/254556. Collections were authorized by fishing licenses No. PFF/DGOPA-037/14; PFF/DGOPA-080/15 from SAGARPA/CONAPESCA. We thank Ana Ruth Cristóbal Ramos for her technical assistance in the acquisition of the otolith SEM digital images.

LITERATURE CITED

Avigliano, E., C.F.R. Martinez, and A.V. Volpedo. 2014. Combined use of otolith microchemistry and morphometry as indicators of the habitat of the silverside (*Odontesthes bonariensis*) in a freshwater–estuarine environment. *Fisheries Research* **149**:55 - 60.

Avigliano, E., L.A. Jawad, and A.V. Volpedo. 2016. Assessment of the morphometry of saccular otoliths as a tool to identify triplefin species (Tripterygiidae). *Journal of the Marine Biological Association of the United Kingdom* **96**(5):1167 - 1180.

Mexicano-Cíntora, G., C.O. Leonce-Valencia, S. Salas, and M.E. Vega-Cendejas. 2007. *Recursos Pesqueros de Yucatán: Fichas Técnicas y Referencias Bibliográficas*. Centro de Investigación y Estudios Avanzados del IPN (CINVESTAV) Unidad Mérida. 1a Edición. Mérida, Yucatán, México.

SAGARPA (Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación) and A. López-González. 2012. Carta *Nacional Pesquera*. Diario Oficial de la Federación DCCVII 18.

Tuset, V.M., A. Lombarte, and C.A. Assis. 2008. Otolith atlas for the western Mediterranean, north and central eastern Atlantic. *Scientia Marina* **72**(S1):7 - 198.

Volpedo, A.V. and D.D. Echeverría. 2003. Ecomorphological patterns of the sagitta in fish on the continental shelf off Argentine. *Fisheries Research* **60**:551 - 560.