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Structural Irregularities in Sagittal Otoliths of Black Croaker (*Cheilotrema saturnum*) from Southern California

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Black croaker, *Cheilotrema saturnum*, is a sciaenid (Family Sciaenidae) common to the coastal nearshore ichthyofauna assemblage of southern California (Miller et al. 2008). Sciaenids, on average, are highly acoustic, both producing and receiving sonic vibrations via resonance through the swimbladder (Nelson 2006). Further acoustic sensing is facilitated by their relatively large sagittal otoliths, and extensive lateral line morphology (Nelson 2006; Helfman et al. 1997). Irregularities have been known to occur in sagittal otoliths, although this has historically been restricted to replacement of aragonite by vaterite as described in rockfishes (Love et al. 2002), salmon (Gauldie 1986, Sweeting et al. 2004), trout (Bowen et al. 1999, Melancon et al. 2005) and halibut (Tobin et al. 2005). During a characterization study of black croaker life history (Miller et al. 2008), irregularities were observed in a subset of sectioned otoliths. These irregularities often consisted of holes near the otolith core surrounded by discolored aragonite (personal observation). Additional sampling consistent with the methods described by Miller et al. (2008) was completed to investigate these irregularities.

A total of 805 samples were collected between 2001 and 2003 and stored in paper coin envelopes until later processing in the laboratory. The standard length (mm) and collection site were recorded for each individual, and the age was later determined by Miller et al. (2008). An additional 61 individuals were collected from Newport, California on 15 June 2004 using the same gill nets described by Miller et al. (2008). Sagittal otoliths from these individuals were preserved in 90% ethanol in the field and stored until processing in the laboratory. Each otolith was weighed to the nearest 0.0001 gram and heated in an oven at 200°C for 24 hrs, and reweighed. The percent weight loss was calculated after the otoliths were removed from the oven. Ten samples with percent weight losses ranging from 1.64% to 3.67% were sectioned using the same techniques used by Miller et al. (2008). The presence or absences of an irregularity in the section was recorded for each. An irregularity was classified as any depression on the face of the transverse section large enough to be seen under stereoscope magnification (Figure 1). Distribution of irregularities within the original 805 samples was examined by age class, mean standard length within each age class, and site of collection. The distribution of irregularities by site was ln(x) transformed to achieve a normal distribution. Percent weight loss and presence/absence of holes in otoliths from the 15 June 2004 collection and each distribution data set were statistically analyzed with a one-way analysis of variance (ANOVA; Sokal and Rohlf 1995).

Of the original 805 otoliths collected, 357 (44%) were observed with structural irregularities in the otolith (Figure 1). No significant differences were detected with

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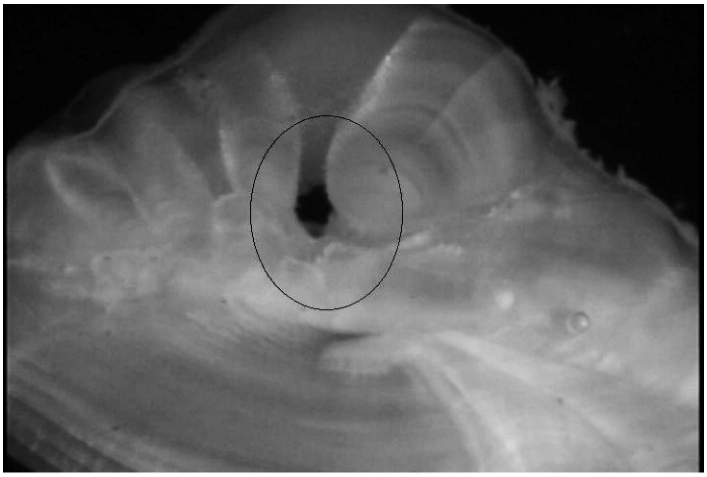
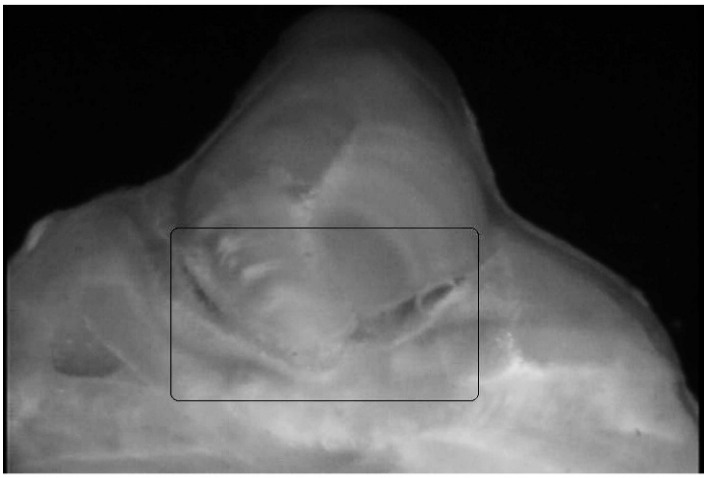


A.



B.

Fig. 1. Typical deformities observed in *Cheilotrema saturnum* sagittal otoliths, such as holes (A) and depressions (B) observed near the primordium on transverse sections of the otolith.

respect to age class (Figure 2; $F_{1,40} = 0.39$, $p = 0.54$), mean standard length in each age class ($F_{1,35} = 0.44$, $p = 0.51$), or collection site (Figure 2; $F_{1,14} = 0.29$, $p = 0.60$). Subsequent to heating, black croaker otoliths lost 2.54% of their mass, on average, ranging from 1.54% to 6.50%. In the 10 otolith subsample that was sectioned, deformities were significantly more common in sagittal otoliths that lost more than 2.5% of their mass after heating ($F_{1,8} = 34.43$, $p < 0.001$). The heating process applied to samples collected on 15 June 2004 accelerated the decomposition rate of organic material within the otolith, similar to what may have occurred while the otoliths were stored dry in paper envelopes without the addition of preservatives. The current investigation suggests that the appearance of irregularities in the section may be indicative of greater levels of organic material within the otolith, especially near the core. Such irregularities have not

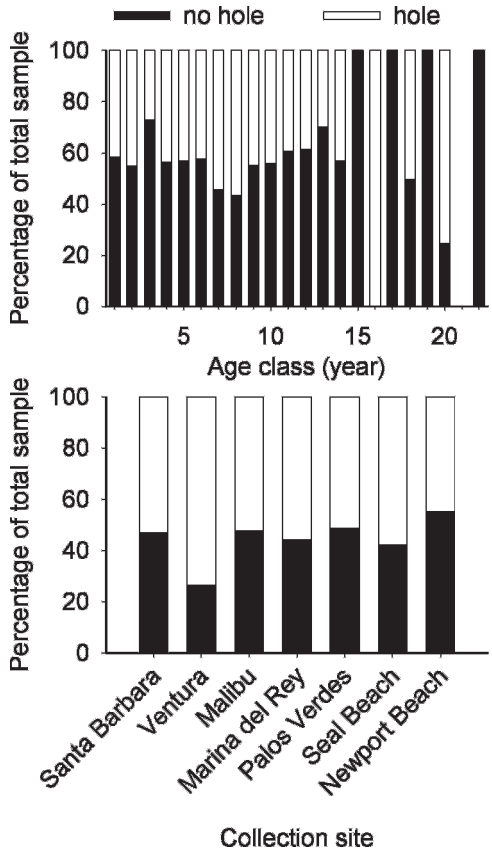


Fig. 2. Mean standard length of individuals with otolith irregularities and normal otoliths by age class and the distribution of occurrence of otolith irregularities as a percent of total observations by collection site in black croaker.

been observed in other sciaenids common to southern California, such as white croaker (*Genyonemus lineatus*; M. Love[2] personal communication), spotfin croaker (*Roncador stearnsii*; D. Pondella[3] personal communication), and California corbina (*Menticirrhus undulatus*; personal observation). Structural deformities, such as vaterite, have been observed in white seabass otoliths collected in southern California (J. Williams[4] personal communication), but such holes have not been described in sectioned white seabass otoliths.

These results suggest the irregularities observed in black croaker sagittal otoliths resulted from the decomposition of high organic content while awaiting processing. It is unknown what effect, if any, the high concentration of organic material has on the behavior of the individual. The occurrence of these irregularities in older size classes (Figure 2) indicates a lack of any deleterious impacts on the survivorship of black croaker. Furthermore, the absence of these irregularities in other members of the family

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common to southern California indicates the deposition of excess organic material in black croaker sagittal otoliths may be a species-specific anomaly.

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