USE OF ARTIFICIAL HABITATS AS RECRUITMENT SITES BY JUVENILE WILD FISH: EFFECTS OF FISH FARMS ON FISH DIET AND OTOLITH GROWTH

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VEŠTAČKA STANIŠTA KAO POTENCIJALNE NOVE NASEOBINE MLAĐI RIBA: EFEKAT RIBNJAKA NA ISHRANU I RAST OTOLITA

Apstrakt
Cilj ovog rada je identifikacija razlika u sastavu populacije i brojnosti morskih riba koje žive u blizini kaveznih sistema u poređenju sa kontrolnim lokacijama. Njihova identifikacija je pokušana analizom oblika otolita.

Ključne reči: oteoliti, stanište, marinski kavezni sistemi, morfometrija
Keywords: otolith, habitats, marine cages, morphometry

INTRODUCTION

Juvenile fish of more than 20 different species use off-shore floating sea cages as settlement habitats in the Mediterranean. These fish actively feed on the abundant zooplankton around the cages while, at the same time, they show a strong variation in the fatty acid profile of their tissues as an influence of the food pellets composition (Fernandez-Jover et al. 2009).

In the present work, surveys were conducted for identifying differences between the species composition and abundance of new settlers among farms and control rocky-shore environments and to test for variations in their diets. Some authors have pointed out that prey availability may influence otolith growth rates (Moksness et al. 1995, Morales-Nin et al. 1995), and recently, otolith morphology has been applied in order to differentiate reared and wild adult fish (Arechavala-Lopez et al. 2012). Consequently, otolith growth and morphology analysis were also applied in order to better understand which are the consequences for the ecology and growth performance of several fish species that use coastal farms as recruitment habitats in SW Mediterranean.

MATERIALS AND METHODS

The composition and abundance of juvenile fish around the cages was estimated at two farms situated off the coast of SE Spain (F1 and F2) and two control sites (C1 and C2) by means of transects of similar length (200 m^2). Fish were lately captured in order to confirm the species composition of the school, correct the visually-estimated size and to carry out diet and otolith analyses of the fish species *Atherina boyeri, Oblada melanura* and *Sarpa salpa*. In the laboratory, the left saggita of every fish was removed and a scaled photograph was taken for further image processing analysis. Otolith shape descriptors were measured from each otolith: area, perimeter, circularity, roundness, major and minor axes, aspect ratio and the standard length (SL)/Area ratio. Additionally, a closed-form Fourier analysis (Younker and Ehrlich, 1977) was applied to the otolith. This method decomposes the irregular shape of the contour into a series of orthogonal terms called the Elliptic Fourier Descriptors (EFDs) or harmonics. Additionally, otoliths of *A. boyeri* and *O. melanura* were further analyzed in order to identify differences in the rate of periodical growth zones deposition. An ANOVA test was used for univariate analysis and Linear Discriminant Analysis (LDA), based on previous Principal Components (PC) reductions of the variables (shape descriptors), was applied in order to detect if differences existed among farm-associated and control fish.

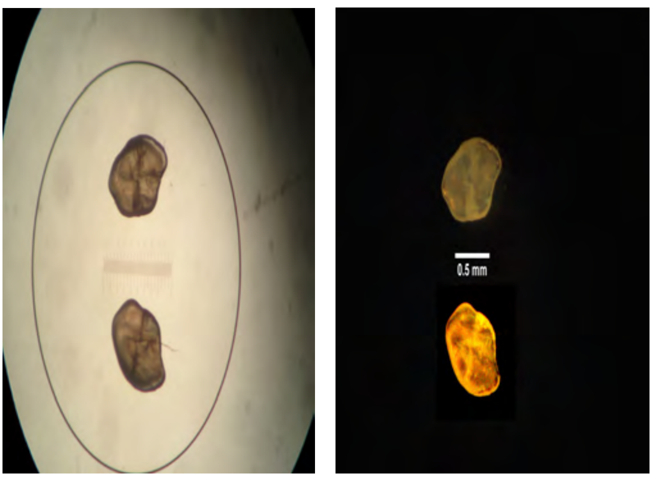

Figure 1. Example of image analysis for calculating the otolith shape descriptors.

RESULTS

No clear differences were found for the abundance and size distribution of fish among control and farm locations or diet composition, even diversity indexes were similar. However, a consistent pattern for all the studied species was a significant variation in shape descriptors principally identified through the aspect ratio index (Fig. 2), which was lower for farm-associated fish ($p<0.05$ for the three analyzed species). The otoliths shape modifications were effectively detected by the EFDs since the LDA correctly identified the farm or control origin for the 78.8%, 85.1% and 86.1% for *A. boyeri, O. melanura* and *S. salpa* individuals respectively. However, data on the rings deposition rate for *A. boyeri* and *O. melanura* was very variable and patters could not be concluded, as indicated by the lack of significant differences found for all the comparisons.

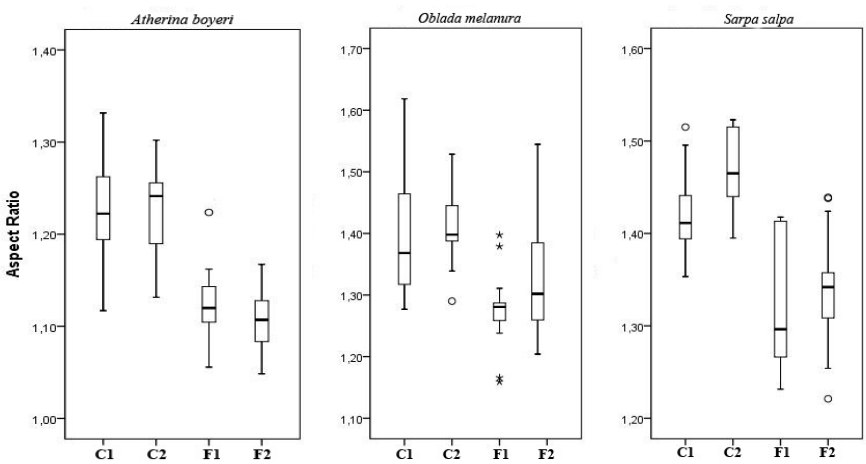

Figure 2. Results for the Aspect Ratio Index for control fish (C1 and C2) and farm-associated fish (F1 and F2).

DISCUSSION

Despite of failing to find differences in the diets of farm-associated fish, it has been nonetheless detected that there is an effect on the otolith morphology of these associated fish as shown by the modification in otoliths morphology, mainly reflected in the Aspect Ratio Index (a relationship between the major and minor axis of the otolith) since it reached higher values in control fish non-associated with fish farms. Differences were especially clear for *S. salpa* which also showed variations between control and farm-associated fish for the surface area of the otolith and its roundness.

Despite of this, it was not possible to detect differences in the periodical growth of the otolith rings. However, it is necessary to delve into this subject since farms act as both artificial reefs and enhanced fish attraction devices when aggregating a high number of fish of tens of different species, many of them of commercial interest. The use of artificial reefs has traditionally been applied to manage fish stocks for conservationist or resource management purposes, and presumably, cages can also have significant effects on local stocks if the synergistic effects of aquaculture enhance or damage these populations. Moreover, it is difficult to find similar artificial submerged structures with an equivalent size of a full production fish farm and with such an important capacity of fish aggregation.

CONCLUSION

In addition to the previously published effects on seasonal and spatial variations of associated species and the associated changes on fish physiology (Fernandez-Jover et al. 2009), it has been shown that there is also a change in the morphology of otoliths that can be effectively detected through the aspect ratio and the multivariate analysis of the EFDs. Despite of these results, it has not been demonstrated that the synergy of the observed changes entail negative effects on fish species that use floating cages as habitats for settlement.

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