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Consiglio Nazionale delle Ricerche

SHORT TERM MOBILITY REPORT

STOCK STRUCTURE OF *CHAENOCEPHALUS ACERATUS* (CHANNICHTHYIDAE, TELEOSTEI) IN THE SOUTH SHETLAND ISLANDS BY TRACE ELEMENTS ANALYSIS OF OTOLITHS

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INTRODUCTION

The Scotia Sea icefish, *Chaenocephalus aceratus* (family Channichthiydae) is distributed exclusively in the Atlantic sector of the Southern Ocean, living in the seasonal pack-ice zone along the Southern Scotia Arc Islands and tip of the Antarctic Peninsula, as well as around Bouvet Island (Iwami & Kock 1990). In particular, it is among the most abundant fish species within the benthic community inhabiting the continental shelf around Elephant South Shetland Islands (Kock & Stransky 2000). The Scotia Sea icefish was caught as by-catch in commercial trawls until the 1989/90 season, since when the Commission of the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR) closed the main fishing areas along the Southern Scotia Ridge to commercial finfish exploitation. This has allowed the species to recover toward original stock levels (Kock & Jones 2005).

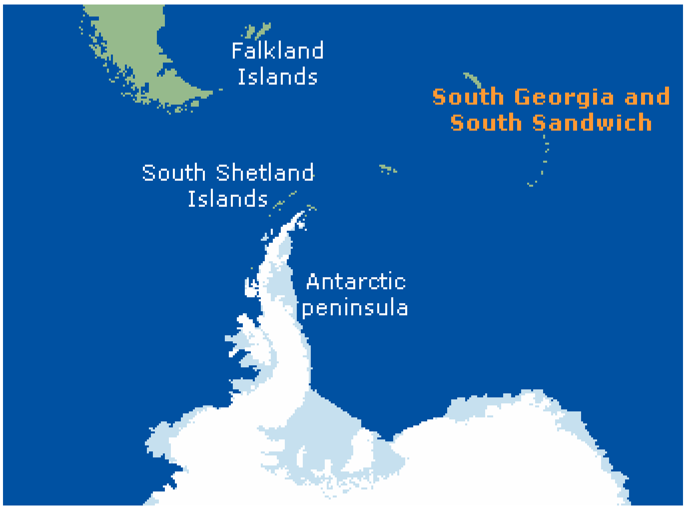
The juvenile pelagic phase in most icefish is poorly understood, but may last 2-4 years (Kock 2005). Larval *C. aceratus* are a consistent part of the assemblages found in the central Bransfield Strait (Loeb *et al*. 1993), where circulation is characterized by a gyre (Hofmann *et al*. 1996). However, wind-forcing and proximity of the Antarctic Circumpolar Current fronts to the Peninsula influence rates of advection (Fach & Klinck 2006), and oceanic waters can dramatically alter these assemblages. As a result, advective mortality during the larval stage may substantially determine recruitment to the benthic community on the shelves. Estimating the duration and consequent exposure of larvae to these physical processes, is therefore critical to understanding population structure across its geographical distribution.

Although the life span or longevity estimated using otolith readings generally agreed among studies and between different geographical areas (Kompowski 1990; La Mesa *et al*. 2004), the instantaneous growth rate and growth performance of *C. aceratus* was significantly higher at South Georgia than at Elephant Island and the South Shetland Islands (La Mesa *et al*. 2004). These discrepancies may be the result of population differences (La Mesa *et al*. 2004). Growth differences are good indicators of ecological separation over the life history, and hence spatially discrete populations: differences only persist if they are not homogenized by movement (La Mesa *et al*. 2004). Moreover, this evidence agrees with variation in morphometric and meristic characters between the South Shetland, South Orkney and South Georgia Islands and rates of infestation with larval nematodes (Siegel 1980). Breeding activity has been found at each area, and downstream at Bouvet Island (Detrich *et al*. 2005), consistent with the idea of spatially discrete populations that correspond to each area.

A relatively recent approach to study stock structure and to evaluate the extent of panmixia among fish populations is the analysis of trace elements, such as barium, strontium, manganese, magnesium, laid down in the sagittal otoliths. Otolith chemistry, indeed, reflect the hydrography to which a fish is exposed, and, once incorporated, provides a permanent record linked to the otolith chronology, which can be used to elucidate movement-at-age between water masses. Applying the aforementioned approach, we planned to examine rates of movement and mixing of the Scotia Sea icefish across the Southern Scotia Arc in the Atlantic sector of the Southern Ocean.

RESEARCH ACTIVITIES

Samples of *C. aceratus* to be compared were collected in four different sites across the Southern Scotia Arc, namely off King George Island (South Shetlands), off Elephant Island and around South Georgia (respectively off the north-west and south-east coasts) (see below).



Due to technical constraints, 25 adult specimens ranging from 50 cm to 65 cm of total length were randomly selected from each site. On the basis of previous ageing data (La Mesa *et al*. 2004), the specimens selected for the chemical analysis attained approximately 10-18 years of age. Using the facilities in the Southern Ocean Living Resources Laboratory of Old Dominion University (Norfolk, Virginia, USA), one sagittal otolith was randomly selected from each pair, weighed to mg and stored in vials. Each otolith was ground using a Hillquist Thin Section Machine in order to obtain transverse thin sections of about 0.5 mm of thickness. Otolith sections were then put on glass slides with a thermoplastic resin (Crystalbond) and polished on lapping wheel cloths.

Final processing was done in a class-100 clean room. We rinsed all sections in milli-Q water under a laminar flow hood and lapped each manually using clean plastic clamps and Mark V Laboratory polishing film (Mark V Laboratory, East Granby, Connecticut). Each otolith was lapped successively on three pieces of clean 3 μm film and finished on 0.3 μm film. One otolith from each site was randomly selected and mounted in random order on a petrographic slide (previously cleaned with HNO_3) using silicon glue. The mounted sections were rinsed, sonicated for 5 min, then rinsed again twice, all in milli-Q water, and left to dry under a positive flow hood.

Otoliths for elemental analysis were stored in sterile envelopes and processed to the Woods Hole Oceanography Institution Laboratory in Falmouth (Massachussets). We used a Finnegan Mat Element 2 double-focusing sector-field inductively coupled plasma mass spectrometer (ICP-MS) to examine otoliths for minor and trace element chemistry. Samples were introduced in automated sequence (Chen *et al*. 2000) using a laser ablation system and a PFA microflow nebulizer. The ablated otolith material from the sample cell was mixed in the spray chamber with aerosol of 1% HNO_3 introduced by the nebulizer, and the mixture was then carried to the ICP torch. Laboratory calibration standards consisted of known concentration, multi-element solution introduced to the spray chamber by the nebulizer as an aerosol before being carried to the ICP torch. To control for operational variability in the laser ICP-MS, a randomized blocks design was used with each petrographic slide as the blocking factor considered randomly drawn, with each of the four sampling sites considered a fixed treatment. Blank and standard readings were obtained before and after random presentation of the otolith sections in each block.

Following the initial working plan, we undertook trace element analysis of the nucleus and in proximity of the otolith edges, in order to measure differences in the chemistry characterizing the different aforementioned geographic areas and to be able to separate fish exposed to different environmental conditions during their early life history corresponding to population structure, respectively. To sample the otolith edge, we used a line raster type with a laser beam of diameter 20 µm, frequency at 10 Hz, and power at 60%, travelling about 900 µm along the proximo-dorsal edge of the otolith section at 6 $\mu m \cdot s^{-1}$. To sample the nucleus, we used a grid raster type 200 µm x 200 µm following the same procedure mentioned above. Otolith sections were analysed for ^{48}Ca, ^{25}Mg, ^{55}Mn, ^{88}Sr and ^{138}Ba and reported as ratios to ^{48}Ca. To calculate element:Ca (Me/Ca) ratios, background counts were subtracted from otolith counts by interpolating between readings taken before and after each block of otoliths, and the corrected otolith counts were converted to Me/Ca concentrations using the standards.

Currently, data processing from the trace element analyses carried out in Usa are still in progress. Multivariate statistical approaches (multivariate discriminant analysis, multi dimensional scaling, etc.) will be applied to the whole data set of element concentrations, to evaluate the power of the chemical analysis to discriminate fish living in different geographical areas. In this way we will be able to estimate the extent and rate of mixing (or panmixia) among populations of the Scotia Sea icefish living in different areas, as well as to test the existence of different nursery areas throughout their geographical distribution. We plan to submit results of the study for publication in peer-review journals.

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