You can't swim from the past!

Using otolith micro-chemistry to explore range-expansion in gilthead seabream (*Sparus aurata*)

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WHY?

Gilthead seabream *Sparus aurata* is a highly valued commercial and recreational species. Over recent decades, it has started to appear more frequently in southern areas of the UK. This is thought to be in response to warming sea temperatures.

As otoliths develop, they accumulate chemical elements from the surrounding water via the gills and blood. *S. aurata* is a coastal euryhaline species, undergoing trophic migrations between different marine and estuarine water bodies with different chemical signatures. Previous studies[1] have successfully used differences in trace element signatures analysed from known points of otoliths to identify past migration patterns.

δ^{18} oxygen otolith signatures are associated with ambient water temperature[2]. Reconstructing thermal histories will indicate where an individual has spent the summer months (UK or further south). If an individual is from a self-sustaining UK population, then this signature should correlate with past UK sea temperature trends.

Otolith microchemistry has the potential to:

- Locate key nursery areas for juvenile *S. aurata* in the UK
- Identify whether individuals caught in the UK demonstrate broad or fine scale site fidelity over their life span (in the UK or further afield)

Greater understanding of this target fish will benefit sea-anglers and fishers, the coastal tourism sector and conservationists managing the long term sustainability of inshore fisheries.

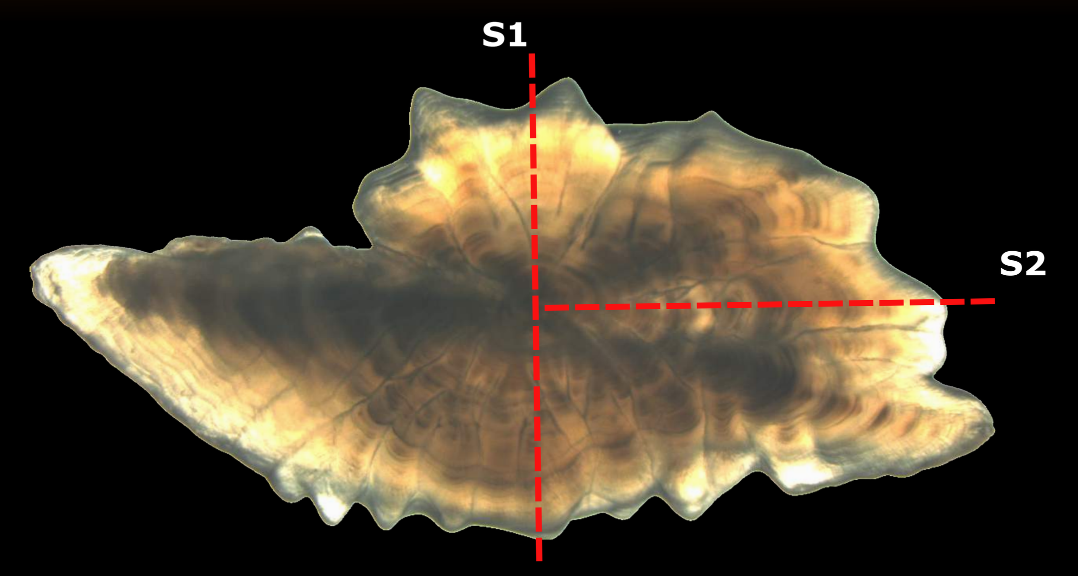

Figure 1. Left sagittal otolith showing location of section cuts. S1 was olished to show the core. S2 was prepared to to maximise temporal resolution between growth rings

HOW?

S. aurata sagittal otoliths were collected from 8 individuals caught at different coastal sites in the UK 2015-16. Locations were the Helford Estuary, Cornwall (n6), the Fal Estuary, Cornwall (n1) and Portland, Dorset (n1).

Trace Elements
The left otolith was prepared for trace element analysis. After extraction, they were decontaminated with ultrapure nitric acid 60%, rinsed and sonicated for 5 minutes with ultrapure water. After being embeded in epoxy resin, two cuts were made to each otolith (Fig.1) and polished (S1 down to within 20microns of the core). Trace elements were measured using laser ablation inductively coupled plasma mass spectrometry (LA-ICPMS). Standard reference materials (NIST and MACS-3) were used to calibrate and control for machine drift. 51micron diameter transects on each section were analysed for Li, B, Na, Mg, Al, P, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Rb, Sr, Y, Cd, Sn, Cs, Ba, Pb, Th (Fig 2.). The R package elementR[3] was used to reduce the elemental data, and data were expressed as ratios to Ca.

δ18 Oxygen
Sections of the right otoliths were cut for stable isotope analysis in the same way as the left. Sub-samples of known age were obtained by milling a path using a computer controlled New Wave Research Micromill (Fig 3.). Samples were stored in glass vials for mass spectrometry analysis.

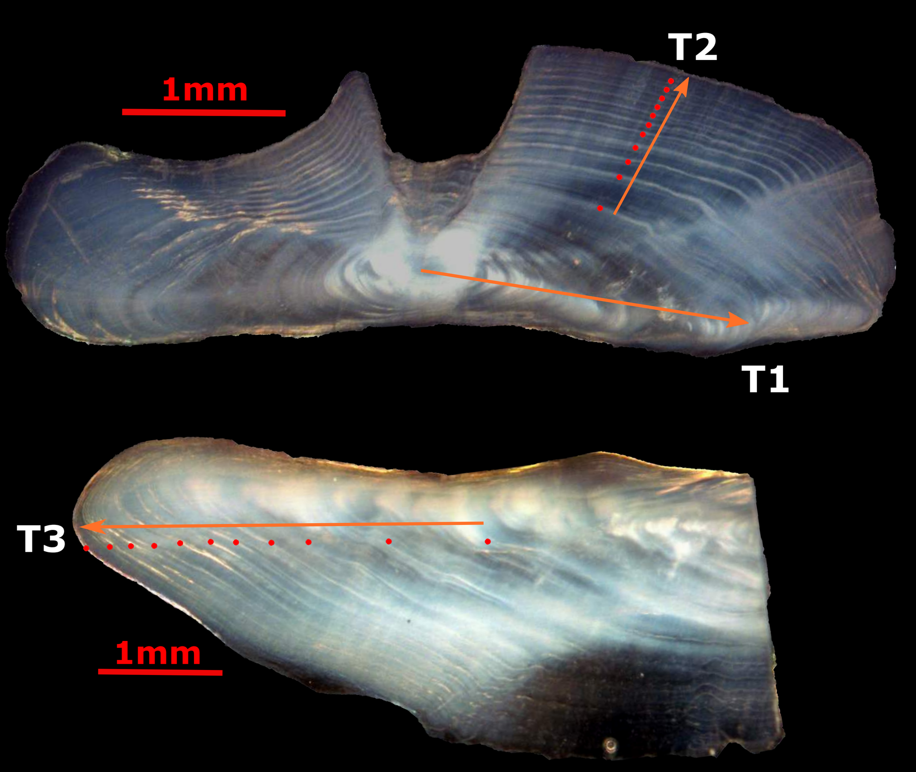

Figure 2. Example of transects analysed on otolith sections S1 (upper) and S2 (lower). Red dots show positioning of the translucent *annuli* used to define different years

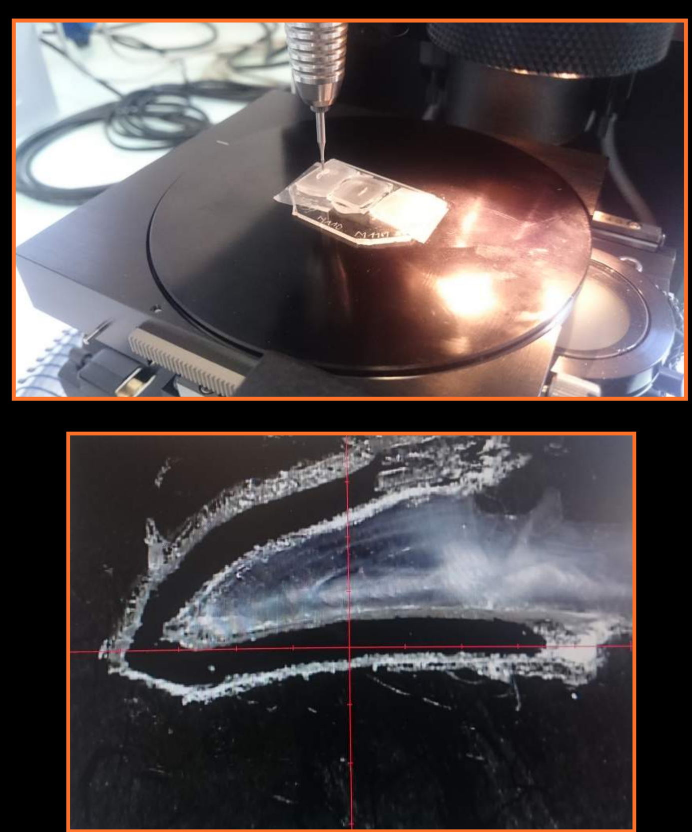

Figure 3. Micromill drill set up (upper). Otolith sample processed down to the first year of life (lower)

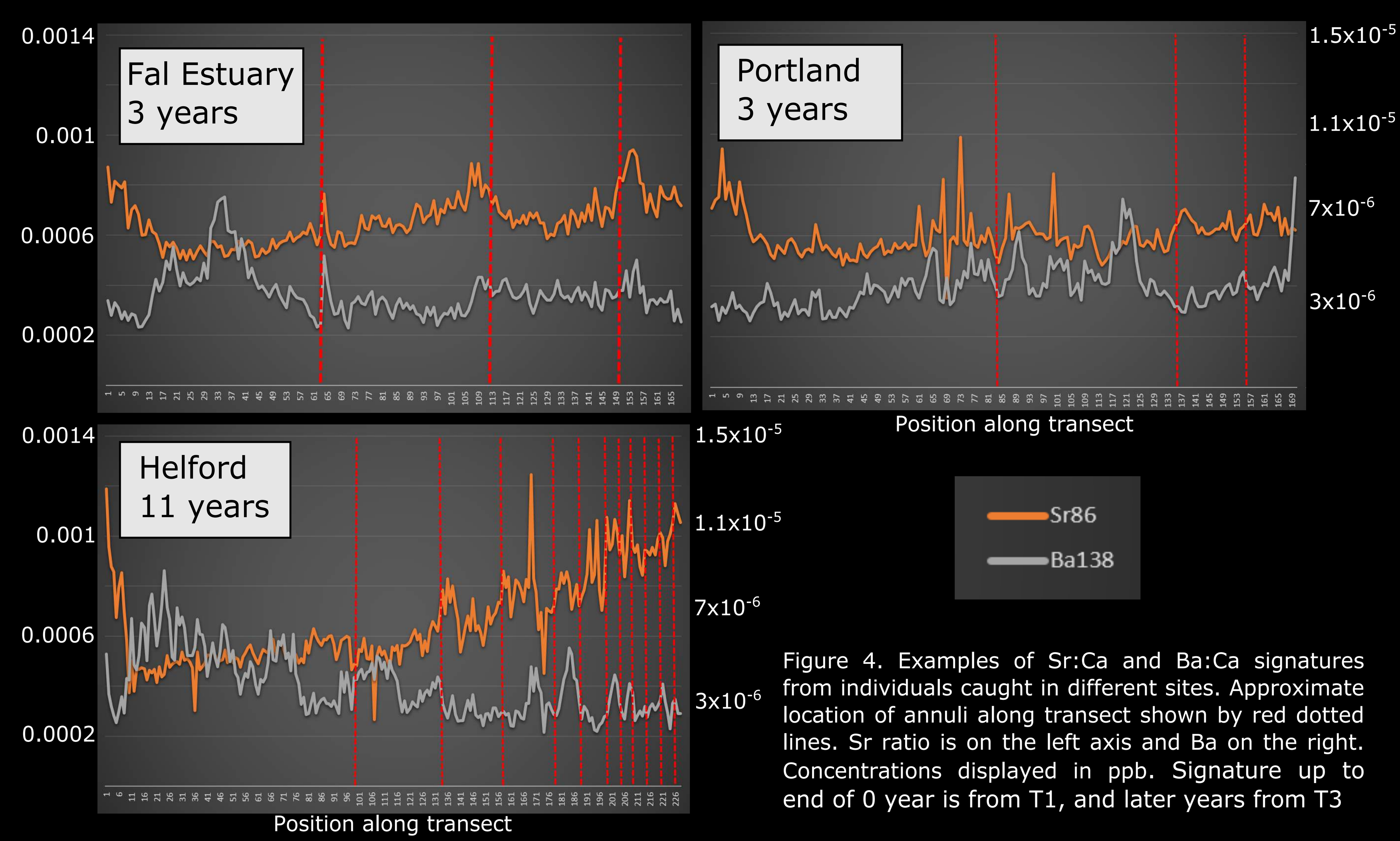

Figure 4. Examples of Sr:Ca and Ba:Ca signatures from individuals caught in different sites. Approximate location of annuli along transect shown by red dotted lines. Sr ratio is on the left axis and Ba on the right. Concentrations displayed in ppb. Signature up to end of 0 year is from T1, and later years from T3

PRELIMINARY RESULTS: TRACE ELEMENT

Signatures were obtained for 8 individual fish. Elements that were consistently recorded in transects were B, Na, Mg, P, Sr, and Ba. Initial inspection of the data suggested Sr:Ca and Ba:Ca signatures from individuals from the Fal Estuary and Portland show a different pattern to those caught in the Helford (Fig. 4). Sr and Ba have both been reported to be indicators of salinity and temperature changes. Observed increases of these elements around some of the annuli could indicate movement between marine and estuarine environments.

Other elements recorded in samples included Cr, Mn, Co, Cu, Zn and As. With the right choice of statistical method it might be possible to assign otolith fingerprint signatures to sites and locate key nursery areas.

FUTURE WORK

- Determine whether the combined element signatures can be used for habitat discrimination using a larger number of samples
- Reconstruct thermal history of individuals through analysis of δ^{18} oxygen samples
- Sr isotope composition to assign geographic area

References: **1)** Mercier, L., Mouillot, D., Bruguier, O., Vigliola, L., & Darnaude, A. (2012). Multi-element otolith fingerprints unravel sea−lagoon lifetime migrations of gilthead sea bream Sparus aurata. Marine Ecology Progress Series, 444(October 2015), 175–194.; **2)** Devereux I (1967) Temperature Measurements from Oxygen Isotope Ratios of Fish Otoliths. Science 155: 1684–1685.; **3)** Sirot, C., Guilhaumon, F., Ferraton, F., Darnaude, A., Panfili, J., and Child, A. (2016). elementR: A shiny application for reducing elemental LA-ICPMS data from solid structures. R package version 1.0. https://CRAN.R-project.org/package=elementR package version 1.0. https://CRAN.R-project.org/package=elementR