



Comparing chemical signatures in the otoliths of juvenile rockfish (*Sebastes jordani* and *Sebastes entomelas*) to water chemistry along central California: What can they tell us?



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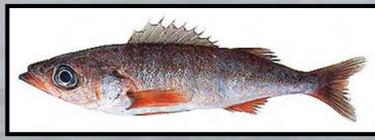
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Introduction

Marine communities are strongly influenced by the delivery of pelagic juveniles that recruit into local populations. Interannual variation in the delivery of young can drive both year-class strength and population structure of many marine species^{1,2}. An ecologically and economically important genus that resides within the Monterey Bay National Marine Sanctuary (MBNMS) is that of *Sebastes*, the rockfishes. Surveys conducted by the National Marine Fisheries Service (NMFS), Santa Cruz have been monitoring the abundance and distribution of pelagic juvenile rockfish within MBNMS for 25 years. Over time, abundance of juveniles has been shown to be highly variable, with the years of lowest abundance coinciding with years of low upwelling intensity (El Niño). Understanding how oceanographic conditions, such as upwelling, influence variability of juvenile abundance is fundamental to our knowledge of marine populations, ecosystems and the fisheries they support¹. To address this issue we will use otolith microchemical techniques. Otoliths are bony structures in fish that have been shown to record water chemistry³. Our initial focus will be on barium, an element that depletes rapidly in surface waters and will be a clear indicator of upwelling. Upon completion, this will be one of the first studies to use comparative water and otolith chemistries for an open coastal marine system to directly relate environmental history to growth and condition of pelagic juveniles.



Sebastes entomelas (Widow)



Sebastes jordani (Shortbelly)

Objectives

Using comparative analyses between water and otolith chemistry, we will address the effect of environmental influence on growth and likely survival of pelagic juvenile rockfish in three steps.

- Identify water masses:** Using chemistry and satellite sea surface temperature, we will describe key water masses along central California⁴, including areas of major upwelling, the San Francisco estuary outflow, and the upwelling shadow of Monterey Bay^{5,6}.
- Test otolith reliability:** We will assess the relationships between otolith chemical signatures and water masses from which they were collected to see if otoliths can reliably indicate water mass residency.
- Assess effects on growth rate:** we will examine how exposure to different water masses affects growth rate, a proxy for larval condition and survival⁶.

Methods

Sample Collection:

- Both seawater and juvenile rockfish samples were collected during the NMFS annual pelagic juvenile rockfish survey (May4 - June18, 2007 & 2008) aboard the NOAA R/V *David Starr Jordan*.
- Three passes were made through the central California region that includes 82 stations. Midwater trawls (30m) were conducted at night for a duration of 15 minutes. Rockfish were sorted, identified, measured to standard lengths, and frozen.
- Seawater samples are collected at each station using a GO FLO water sampler at 25m. Samples were filtered, preserved with a spike of HCl and frozen.
- Oceanographic data (temperature, salinity, chlorophyll, and ocean depth) were acquired by a CTD and on board fluorometer.

Lab Analysis:

- Otoliths from each fish were removed. One was prepped for elemental analysis and the other was set aside for aging. Elemental otoliths were maintained in a laminar flow clean-hood to prevent contamination by particulates. Each otolith was mounted in crystal bond medium sulcus groove up, and polished until the edges were free of crystal bond (Fig.2). Each sample was sonicated in Milli-Q water for 10 minutes, rinsed and dried in the clean-hood.
- Inductively coupled plasma mass spectrometry (ICPMS) was used to quantify the trace element concentrations in both the seawater and the otoliths. The element to calcium ratios for Ba, Mn, Mg and Sr were quantified. Otoliths are analyzed in conjunction with a laser that allows for targeted ablation around the outer edge of each sample: last five days of growth (Fig.2).

Results

Objective 1: Identify Key Water Masses along Central California

- Barium concentrations were higher where upwelling was taking place in both 2007 and 2008 (Fig 1).
- We verified areas of upwelling using sea surface temperature maps acquired by satellite.
- The highest barium concentrations and coldest temperatures appear to match up.
- The greater the upwelling intensity, the stronger the barium signature (2007 vs. the stronger upwelling experienced in 2008).

Objective 2: Verify the Seawater Signature in the Otolith

- 2007
 - We are seeing a match-up between otoliths and seawater of high barium concentration (Fig 3).
 - Otoliths are also showing a trend in barium decrease as you move offshore.

Ba:Ca ratios and SST for seawater

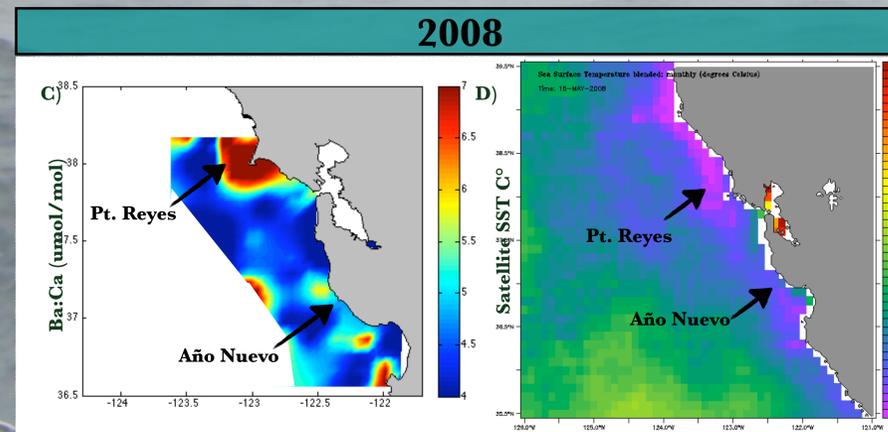
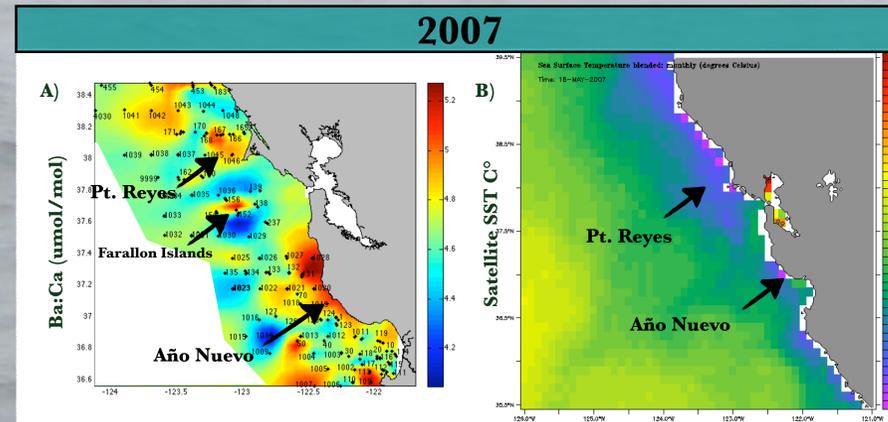


Figure 1) Plots A and C map the barium:calcium ratios (umol/mol) for 2007 and 2008 respectively. Concentrations are averages over the length of the cruise (~40days). Plots B and D map the sea surface temperature C°(SST) as acquired by satellite and averaged over a month coinciding with the time of sampling.

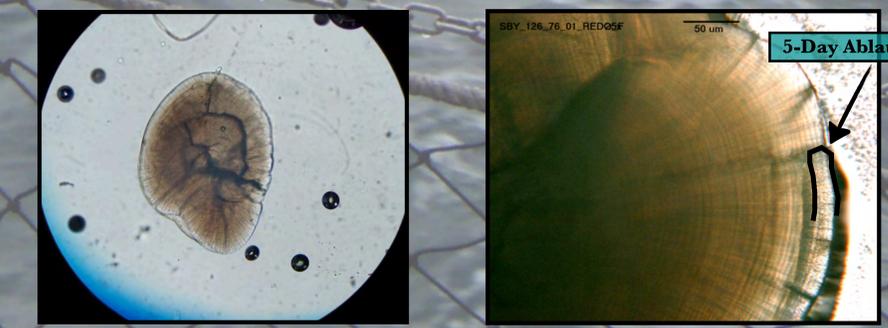


Figure 2) Two shortbelly otoliths. Otoliths are photographed prior to ablation (left) and post ablation (right). We aimed to ablate the outer five days of each sample

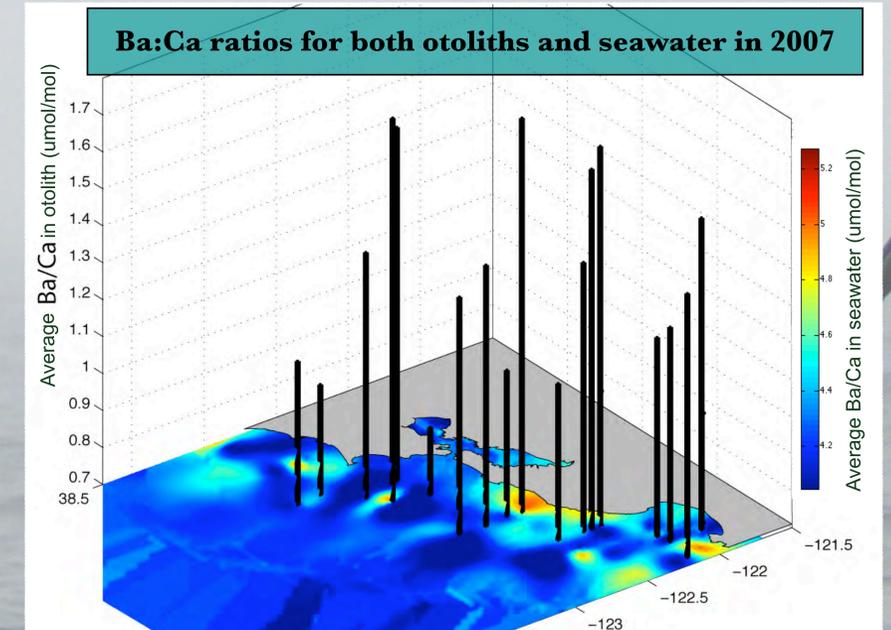


Figure 3) The black bars are the average shortbelly (2007) otolith barium:calcium (umol/mol) ratios. Bars have been plotted over the average Ba:Ca (umol/mol) ratios found in the 2007 seawater.

Ongoing Work

- Comparing seawater and otolith chemistry using more rigorous statistical techniques (multivariate and geostatistical methods).
- Exploring multi-elemental signatures (Mn, Mg, and Sr in addition to Ba)
- Analyze 2008 otoliths.
- Objective 3: Assess effects on growth rate
 - Is there a difference in growth rate between fish from upwelled vs. non-upwelled water?
 - Otolith ring counts and increment measurements.

Discussion

These preliminary results indicate predictability of upwelling locations and their chemical composition. For at least barium, concentrations in the seawater are reflected in the otoliths. We hope to expand this to multi-elemental signatures in the near future. Upon completion, this project will evaluate the effects of different water masses on growth, which underpins survival and likely recruitment success, for two species of rockfish. This has wide applications of interest to fisheries and the design (i.e. location and spacing) of marine protected areas. In general, this work will aid in our understanding of environmental effects on larval dispersal and replenishment variability, a crucial gap in our understanding of marine ecosystem dynamics.

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Widow rockfish image: afsc.noaa.gov, Shortbelly rockfish image: portfish.com