Otolith microchemistry methods to infer migration patterns of Strait of Georgia herring in British Columbia, Canada

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Background

Strait of Georgia Herring

- The Strait of Georgia (SoG) herring population is the largest of seven stocks in British Columbia
- After spawning in the SoG in spring, adult herring migrate to West Coast Vancouver Island (WCVI) to feed along the continental shelf in summer until they return to the SoG in fall (Hourston and Haegele, 1980)
- Some herring do not migrate and remain in the SoG during the summer as non-migratory herring (Taylor, 1964)
- The SoG population is managed as a single, migratory stock

Non-migratory Herring

- Distribution and abundance of non-migratory SoG herring is poorly understood (DFO Science Stock Status Report B6-05, 2001)
- Historically, herring were available year-round to First Nations around the Salish Sea (Herring Research Priorities Workshop 2021)
- Low summer adult herring occurrence in the early 1990s (Haegele et al., 2004)
- Since 2017, age-2+ herring are the dominant prey item for adult Chinook Salmon in summer in the northern SoG (Figure 1.)

UVIC Adult Salmon Diet Program

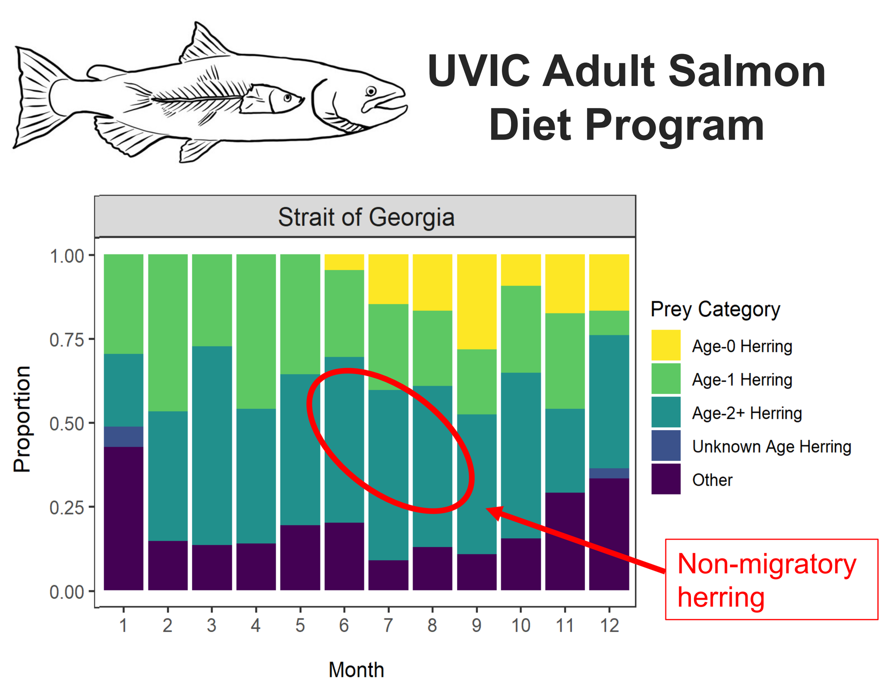


Figure 1. Mean individual proportional contribution of herring age classes to Chinook Salmon diets in the Salish Sea from 2017 to 2021. Herring ages were determined using measured body length and otolith-predicted body length. Taken from: ASDP 2021 Data Summary Report. Figure by: Wesley Greentree.

- No long-term data on SoG summer herring biomass
- We do not know what controls the occurrence or relative abundance of migratory vs non-migratory herring in the SoG population
- Non-migratory herring may be an important component of the SoG marine food web (Figure 1.)

Methods

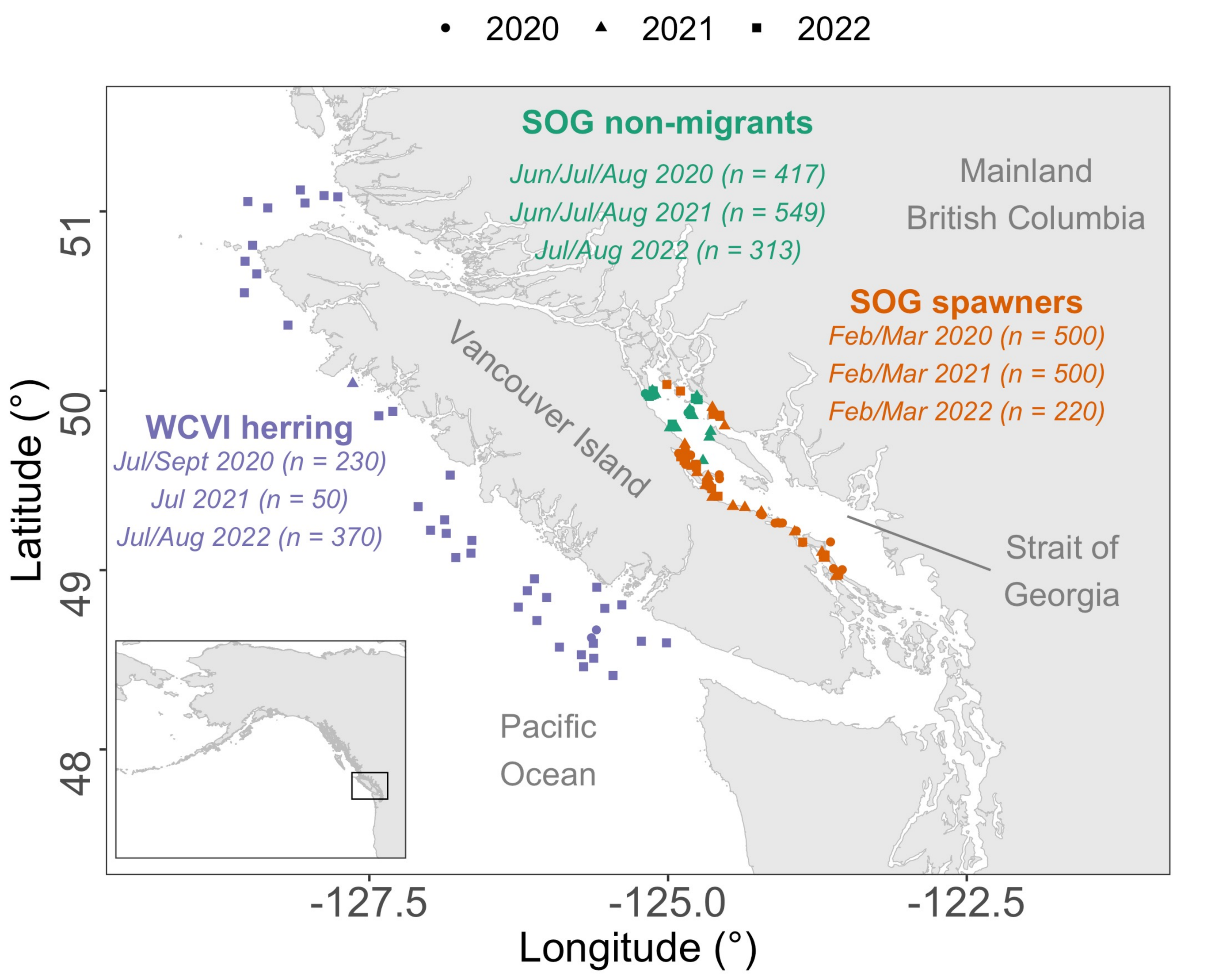
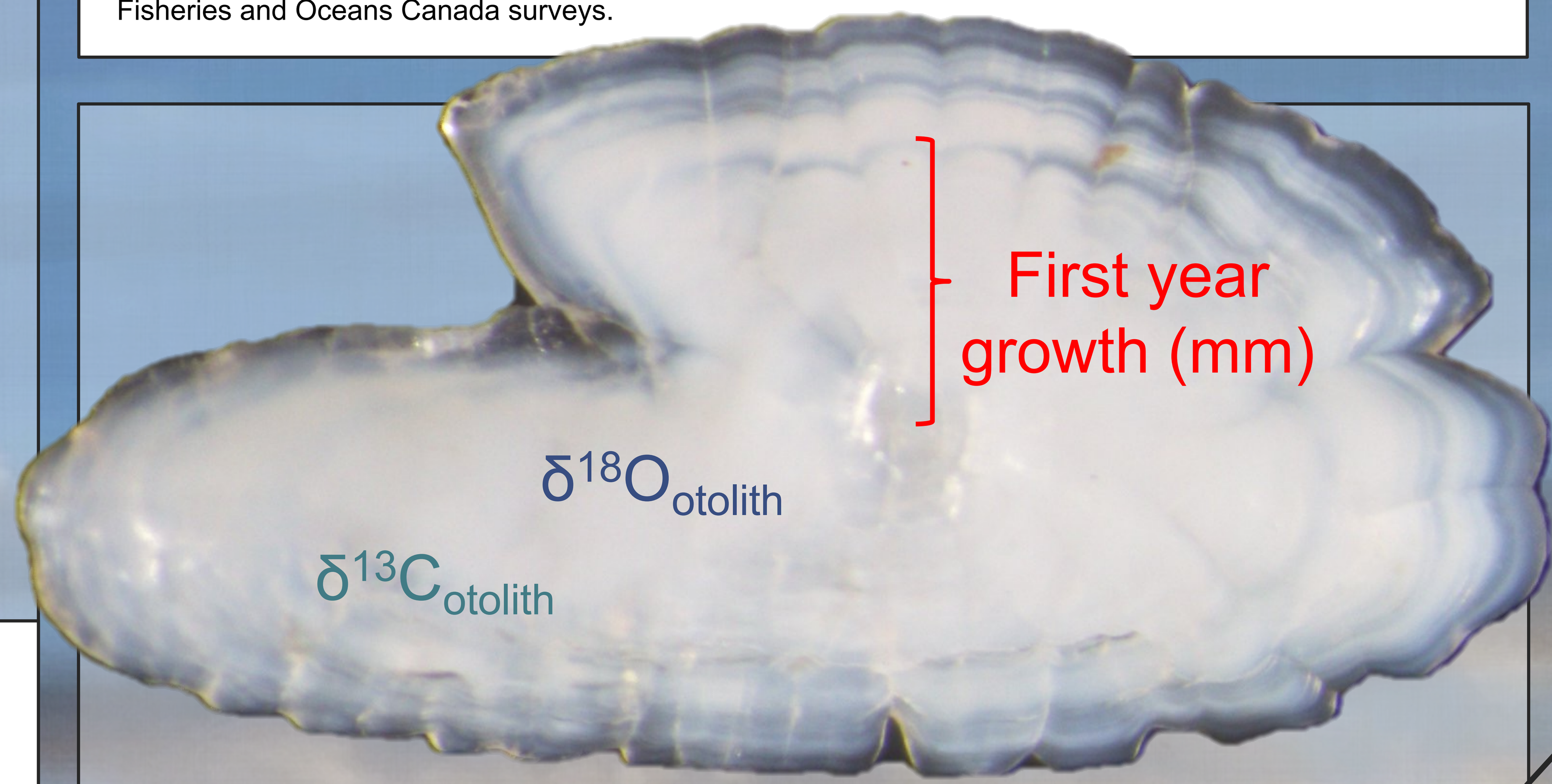


Figure 2. Capture locations of adult herring collected in 2020, 2021, and 2022, representing three groups of Strait of Georgia non-migratory herring, Strait of Georgia spawners, and herring captured along West Coast Vancouver Island. Herring were obtained through targeted jig sampling and sampled from Department of Fisheries and Oceans Canada surveys.



- Distance (mm) from the otolith core to the first winter growth zone is measured from photographs before isotope composition is determined via continuous flow isotope ratio mass spectrometry (CF-IRMS)

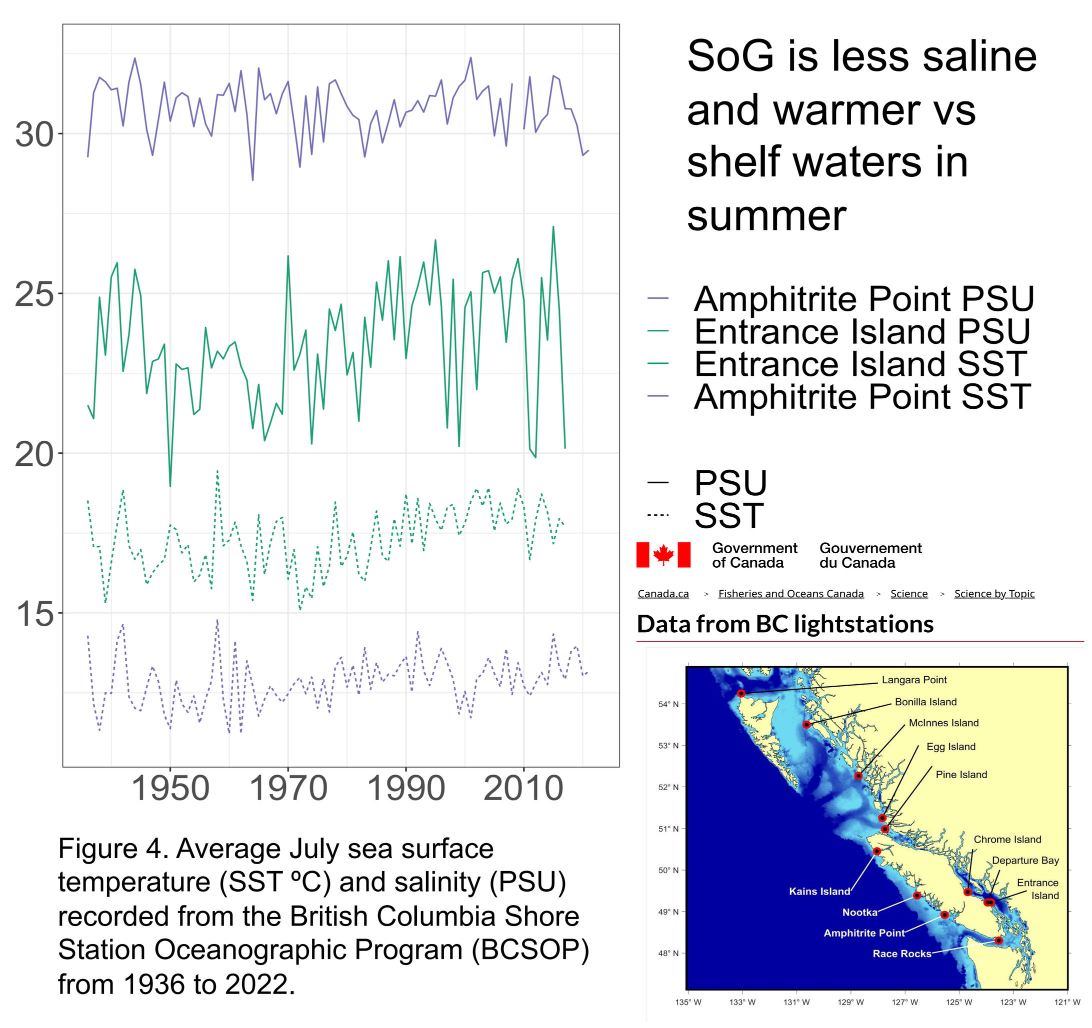


Figure 4. Average July sea surface temperature (SST °C) and salinity (PSU) recorded from the British Columbia Shore Station Oceanographic Program (BCSOP) from 1936 to 2022.

Preliminary Results

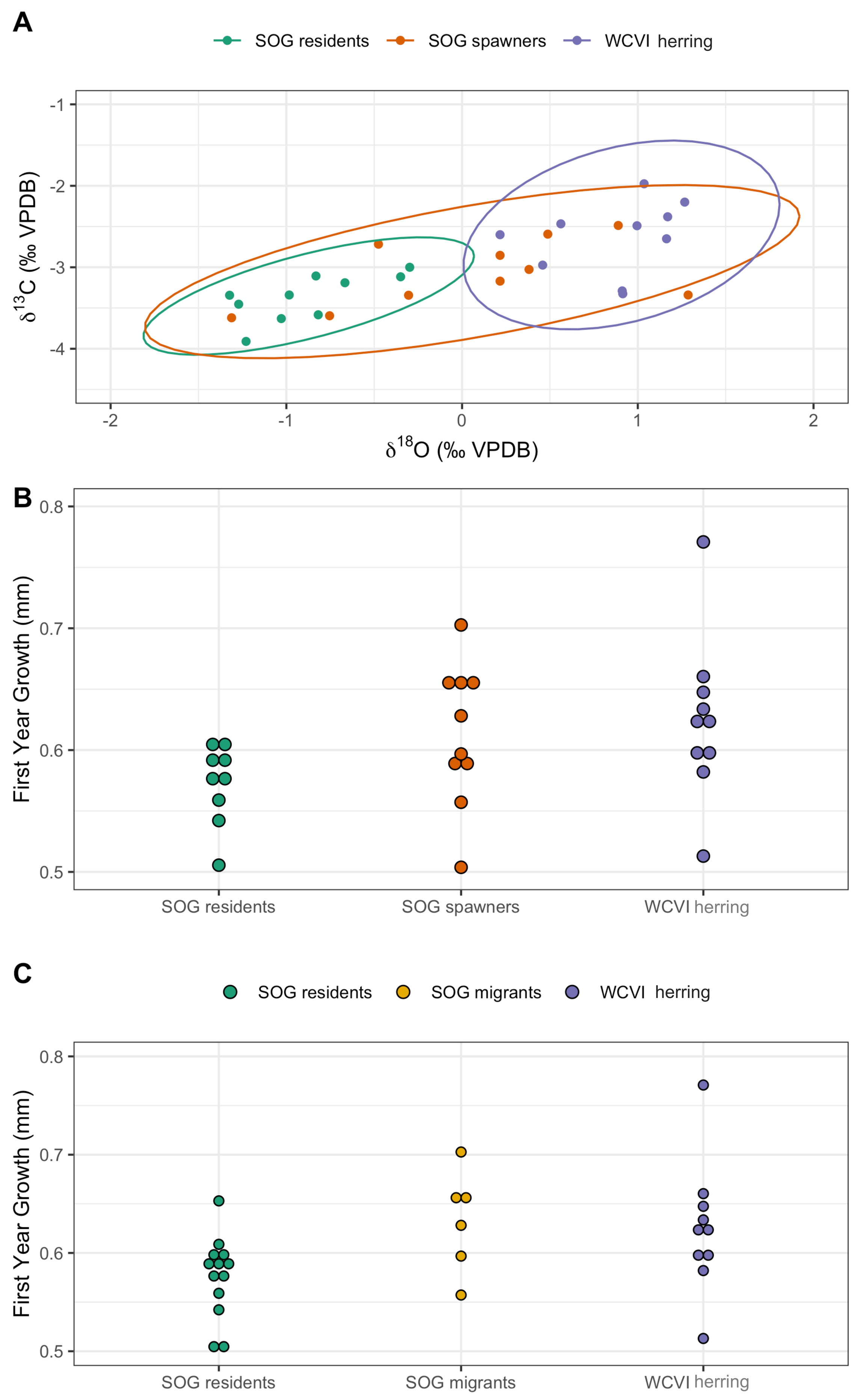


Figure 3. Whole otolith isotope (δ13C and δ18O) composition (A) and otolith first year growth (mm) comparisons (B,C) for age-4 Pacific Herring (n = 29) captured in 2020 from the SoG in spring (SoG spawners), summer (SoG non-migrants), and from West Coast Vancouver Island in summer (WCVI adults). Dotplot of first year growth (mm) proxied by otolith increment distance by collection (B) and by reclassifying spawners by migration type as suggested by otolith isotopes (C)

Otolith Microchemistry

- Distinct otolith $\delta^{13}C$ and $\delta^{18}O$ isotope composition suggests that stable isotopes are a useful 'natural tag' to differentiate non-migratory and migratory Pacific Herring
- $\delta^{13}C_{otolith}$ reflects $\delta^{13}C_{DIC}$ in seawater and $\delta^{13}C_{diet}$
- Nutrient-rich upwelling zones support high plankton growth rates, leading to higher $\delta^{13}C_{plankton}$ values
- $\delta^{18}O_{otolith}$ reflects salinity and temperature in the surrounding seawater
- Lower salinity and higher temperatures in SoG leads to lower $\delta^{18}O_{otolith}$ values (Figure 4.)

Otolith Growth Analysis

- Slower growing juvenile herring may be more likely to become non-migratory vs faster-growing juveniles may be more likely to become migratory (Hobson and Wassenaar, 2019)

Research Questions

1. Can otolith element composition be used to identify migration life history types in the Strait of Georgia population?
2. Do juvenile growth conditions influence whether individuals become migratory or non-migratory?

Next Steps

- Measure otolith isotope composition and first year growth in herring from other age classes and capture years (Figure 2.)
- Explore fine-scale otolith $\delta^{13}C$ and $\delta^{18}O$ isotope methods (e.g., SIMs core-to-edge line transects) on remaining otolith pairs to infer stage-specific movement patterns