Otolith stable isotope methods to infer migration strategies of age four adult Pacific Herring (Clupea pallasii)

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This research has taken place on the unceded and traditional territories of the Coast Salish, Nuu-Chan-Nulth, and Kwakwaka'wakw peoples

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Study Objectives

1. Can otolith stable isotopes be used to identify and differentiate migratory and non-migratory herring individuals?
2. Are there differences in the first-year growth of migratory and non-migratory herring in the SoG?

Introduction

Pacific Herring in the Strait of Georgia (SoG) mature after two years and spawn along the east coast of Vancouver Island in the spring before migrating to foraging grounds for the summer, located along the west coast (WCVI). This migratory population returns for overwintering. Some unknown proportion of Pacific Herring are non-migratory and remain as continual residents (1). While the non-migratory population has been previously documented, it lacks further authentication, and little is understood about the cause or variation in migratory behaviours (2). This has subsequently led to Pacific Herring being managed as a single aggregate stock across a larger bioregion.

Research conducted by UVic's Adult Salmon Diet Program has suggested that resident Herring are a major component of local Salmon summer diets and are vital to the regional food web (3). Recent ecosystem-level changes have led to shifts in Herring spawn time and distribution, declines in Salmon survival, increased pinniped abundance, and increased anthropogenic impact. These changes may influence an individual's decision to remain in the SoG or migrate.

This study will focus on using the otolith-stable isotopes of d13C and d18O to reconstruct migration histories of Pacific Herring in the SoG. Initially, differences in migrant and resident Herring otoliths will be used to discern if differences in otolith microchemistry can be utilized to differentiate migration types of individuals. Should this prove successful, these markers will be later applied to determine whether growth at critical life stages is connected to migration types and used to improve our understanding of the impact fisheries exploitation has on the SoG Pacific Herring stock.

Methodology

- Fish are collected during the summer from the two sub-populations of migratory and resident herring, as well as from the aggregate spawner stock during the spring
- Fish processing: measuring fish weight and length, lipid reading, scale removal for imaging, and otolith extraction
- Aging fish: measuring scale annuli and cross-referencing with measured otolith rings
- Otolith processing: measuring otolith weight, imaging both otoliths and powdering otoliths for stable isotope analysis by the UofCalgary Isotope Science Lab

Results

The preliminary sample results are graphed in Figure 1 to display the relationship between d18O and d13C for fish from the dataset. SoG non-migrant fish exhibited d13C values ranging between -3.93 and -3.0, and d18O values between -1.33 and -0.33. The WCVI fish exhibited d13C values between -3.3 and -1.95, and d18O values between 0.2 and 1.27. When grouped with a 95% CI, there is minimal overlap between the two groups. By contrast, the SoG Spawners produced d13C values ranging between -3.6 and -2.53, and d18O values between -1.3 and 1.3. When grouped by a 95% CI, SoG spawner values range across the regions of both other groups.

Discussion

Further research is required to determine if two distinct migration types exist within the SoG Pacific Herring population. Preliminary results support the hypothesis that environmental influences during the first-year growth of Herring may affect variations in migration type. Adult fish from the SoG non-migrants and WCVI groups did not have any overlap in their isotopic values while the SoG spawners exhibited a much larger range of values that fell within both groups. This indicates that isotopic signatures in Herring otoliths may be a viable resource to recognize and differentiate migratory and non-migratory fish.

Salinity in the SoG is controlled by abundant freshwater discharge from nearshore habitats. Consequently, the SoG exhibits a lower level of salinity compared to WCVI (4). This gradient is reflected in the scatterplot, as non-migrants possessed lower d18O values, which indicates they exist in warmer waters with lower salinity compared to migrant fish from cooler more saline offshore waters (5).

Further studies aimed to confirm whether first-year growth influences migration types may consider micro-milling the daily growth rings of primordial growth on fish otoliths and performing a high-precision micro-scale isotopic analysis to better elucidate the life histories of fish (6). SoG spawners with isotope signatures closest to the boundary between non-migrants and WCVI fish would be the most suitable candidates to further investigate the practicality of using otolith isotope values to discern migration type.

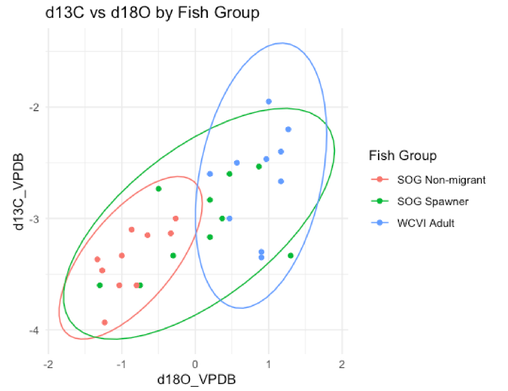
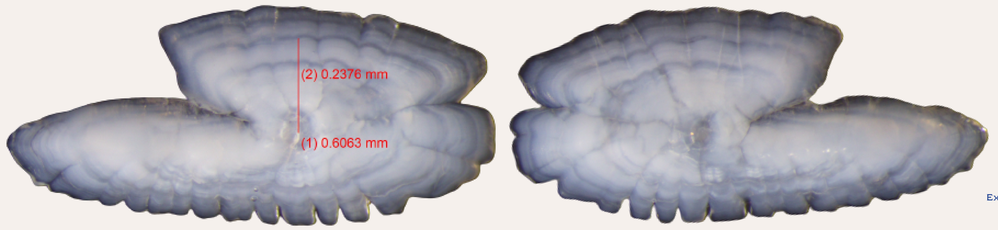


Figure 1. The relationship between d13C and d18O otolith-stable isotopes. Distinct groups appear after points in the scatter plot have been colour-coded to visualize the isotopic differences in SoG non-migrants, WCVI fish, and SoG spawners.



Example of aging Herring otoliths
Images by Anakin Bennett

Conclusion

Initial findings from the preliminary fish sample analysis indicate that otolith-stable isotopes may be used to identify and differentiate migratory and non-migratory herring individuals. If there exist two distinct migration types or potential sub-populations within the SoG Herring, effective stock separation is crucial for sustainable resource management and the conservation of biodiversity and ecosystem health. C. pallasii are a critical factor in local Chinook and Coho Salmon diets during the summer in the SoG and consequently are crucial species in supporting the ecosystem health of the SoG.

Following this study, investigation into the differences in first-year otolith growth between migrant and non-migrant fish is recommended to further determine whether growth at critical stages is connected to migration type selection in Pacific Herring.

Related Literature

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