Sources of otolith morphology variation at the intra-population level: directional asymmetry and diet

SFI days
26 th -27 th May 2016
Marseille (France)

Mille T.(1) , Ernande B. (1) , Pontual H. de (2) , Villanueva C. (2) & Mahé K.(1)

(1) IFREMER, Centre Manche Mer du Nord, Laboratoire ressources halieutiques, BP 699, 62321 Boulogne-sur-mer, France.
(2) IFREMER, Centre de Bretagne, Sciences et Technologies Halieutiques, Z.I. Pointe du Diable, CS 10070, 29280 Plouzané, France.
tiph.m88@hotmail.fr

Supported by

Introduction

Otoliths are calcified structures located in Osteichthyes' inner ear that are involved in audition and balance. Their morphology is used as an indicator of various ecological processes or properties. This application requires identifying the endogenous and exogenous factors that act simultaneously as sources of shape variation. This thesis aims at detecting and quantifying the relative contributions of directional asymmetry and diet to otolith shape variation at the intra-population level.

Materials & Methods

❖ Elliptical Fourier analysis

- 4 Elliptic Fourier descriptors by harmonic
- → high number of descriptors & redundancy between them
- Principal component analysis (PCA) → reduce number of dimensions.
- Number of components selected → Broken stick model
- Output → Shape matrix

Individual	PC1	PC2	PC3	...
1				
2				
...				

❖ Geometric morphometrics: Semi-landmarks

- 60 equally distributed points along otolith contour starting from the tip of the rostrum.
- Generalized Procruste Analysis
- Slinding based on procrustes distance for the superimposition.
- Procrustes residuals →Shape matrix

Individual	PC1	PC2	PC3	...
1				
2				
...				

❖ Statistical analyses

Shape matrix ~ Explanatory matrix

Redundancy analysis → Complete model

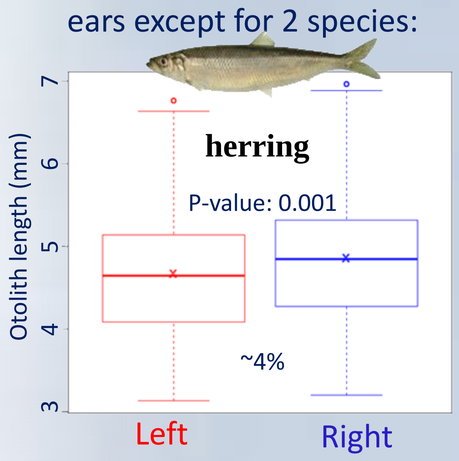
Stepwise elimination → Selected model

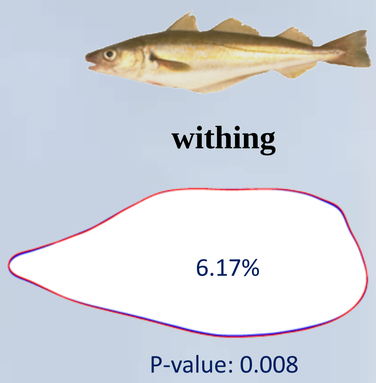
Permutation test

- Significance of factors & model
- Partial RDA → Strict contribution of each single factor

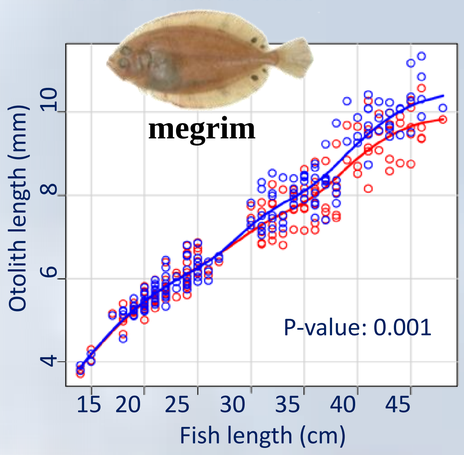
Sagittal otolith morphogenesis asymmetry in marine fishes

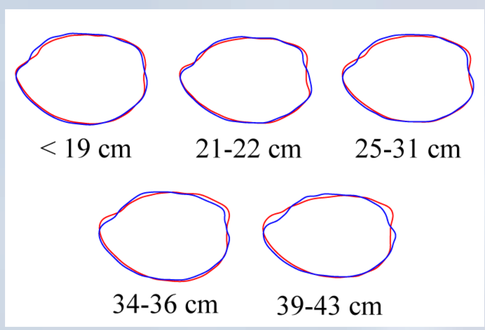
➢ 4 roundfishes: No difference in otolith shape between right and left inner ears except for 2 species:





➢ 4 flatfishes: Directional asymmetry; widest and longest otolith is located on the blind side.





Mean percent difference = 9.57%
P-value: 0.001

➢ Shape asymmetry does not exceed 18%.

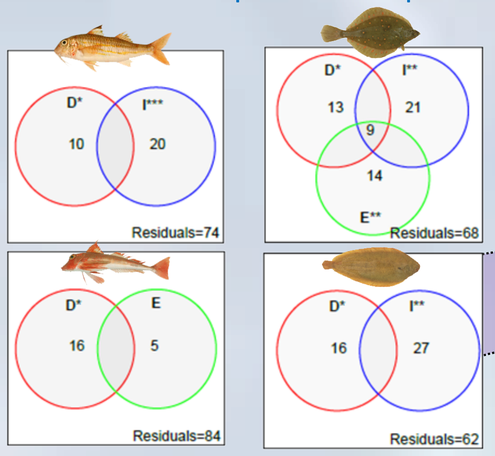
→ Suggests canalization process that ensures acoustic and vestibular functions.

Mille, T. , Mahe, K. , Villanueva, M.C. , De Pontual, H. , & Ernande, B. (2015). Sagittal otolith morphogenesis asymmetry in marine fishes. *Journal of Fish Biology* **87**, 646–663.doi:10.1111/jfb.12746.

Is diet correlated with otolith shape in marine fish?

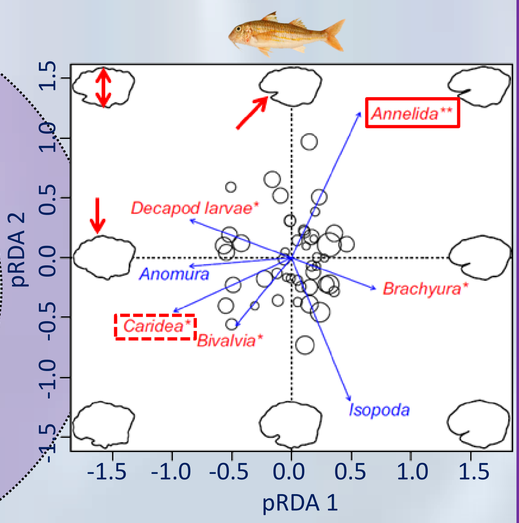
1) Is diet correlated with otolith shape variation?

Diet is related to with otolith shape for four species.



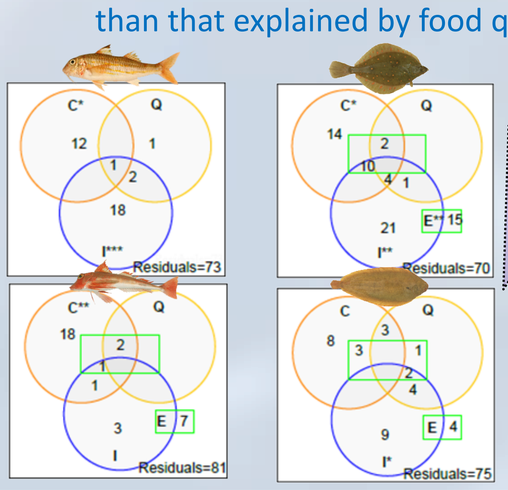
2) Which prey categories are involved?

Shape is influenced by both primary and secondary prey categories. Diet affects otolith shape at both global and finer scales.



3) What is the respective contribution of food quantity and composition to otolith shape variation?

Otolith variation explained by food quality is higher than that explained by food quantity.

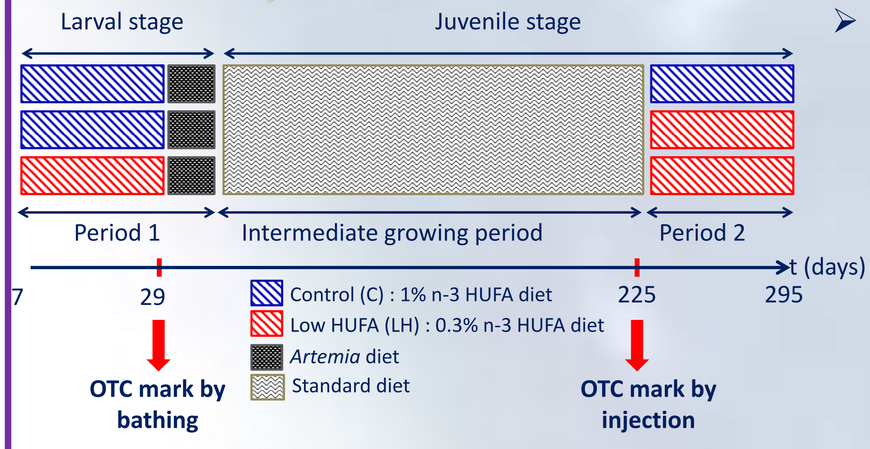


European plaice **Striped red mullet**

Common sole **Red gurnard**

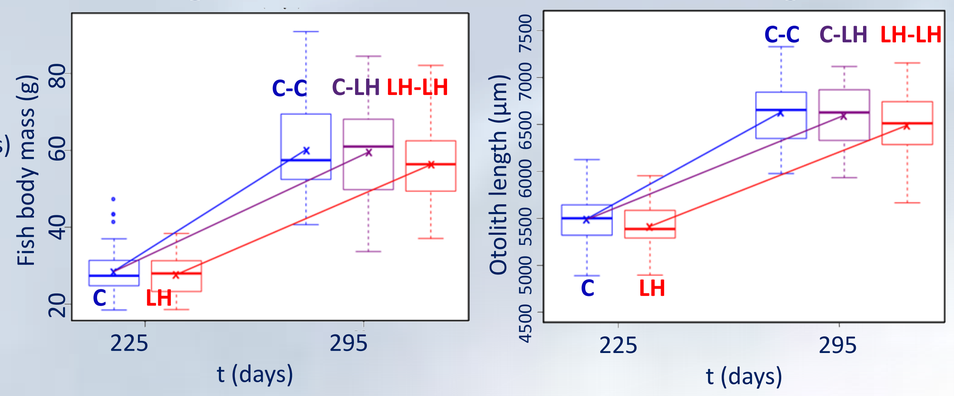
Individual matrix (I), Environmental matrix (E), Diet matrix (D), Relative diet composition (C), Total prey weight (Q)
* <5% ** <1% *** <0.1%,.

Diet composition influences otolith shape of sea bass (*Dicentrarchus labrax*) to a limited extent due to ontogenetic canalization



➢ No treatment effect on initial and final fish weights as well as on somatic growth.

➢ No treatment effect on initial and final otolith lengths as well as on otolith growth.



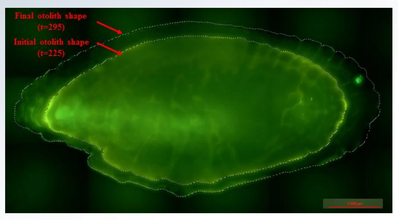
➢ Persisting effect of Period 1 treatment on initial otolith shape and on otolith morphogenesis contrary to Period 2 treatment.

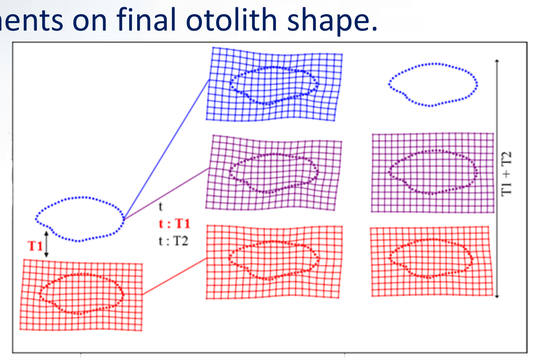
➢ No effect of dietary treatments on final otolith shape.

➢ n-3 HUFA directly affects otolith morphogenesis independently from otolith growth on the otolith and somatic growth.

➢ Food composition influences the otolith's morphogenetic trajectory at larval stage.

➢ No effect of dietary treatments on final otolith shape → Compensatory response suggesting ontogenetic canalization.





Conclusions & Perspectives

❖ Directional asymmetry:

1. Flatfishes: otolith on the blind side is larger and longer than on the occular side.
→ Standardization measures: shape, chemistry…
2. Shape asymmetry does not exceed 18%.
→Canalization: maintain function of the inner ears.
→Perspective: study of the proximal-distal gradient on two inner ears of the same individual.

❖ Diet:

1. Both in situ and experimental studies to reveal the diet composition effect.
→ Perspective: carbon stable isotopes in muscle / otolith (different time scales).
2. Experimental studies to evaluate direct effects of diet on otolith morphology.
→ Increase of mark number & consider other species.
→ Food composition in terms of amino acids, especially the glutamate concentration.
→ Multifactor effects and their interaction.

❖ Implication of intra-population variation for stock identification

→ Necessity to disentangle variations associated with different biological organization levels.