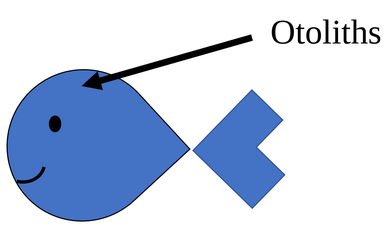
Spawning time of herring (*Clupea harengus*) effects the otolith shape

Background

Herring (*Clupea harengus*) is a fish that usually is 25-37 cm long and can be found from Cape Cod in South to Barentshavet in North. They, like other bone fish, have otoliths. Otoliths are two small bone crystals that are located on both sides near the brain. The otoliths grow with the fish, meaning that young fish have smaller otoliths than larger fishes. The otoliths form annual rings that can tell the fishes age (like with a tree). Also other information, like growth or ambient temperature of fish, can be obtained from otoliths. Analyses of otoliths are important and can give us information about where the fish have been (by looking at temperature for example) and much more.

Figure 1: Otolith where you can see the ring structure



Method

A total of 924 otoliths were collected and photographed from herring that were caught in autumn and spring seasons from 2014 until 2018. The otoliths were categorized in three different genetic groups by SNP analyses; autumn (N = 58), heterozygote (N = 20) and spring (N = 444). The remaining otoliths were not genetically assigned. We analyzed the photographed otoliths by using shapeR inside the R environment.

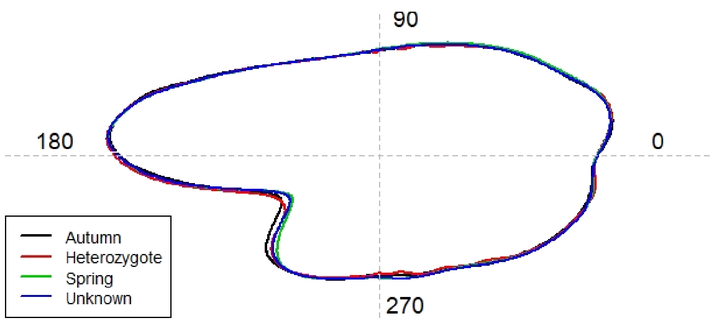


Figure 2: mean otolith outline based on Wavelet reconstruction for herring in the four genetic groups. The numbers are angels in degrees.

Table 1: Overview of how R placed the otolith in the genetic groups without knowing the genetic date, only the previously data about how the groups are different. Prediction where the otoliths belongs based on the otoliths and on the left side is the original genetic assignment.

	Autumn	Heterozygote	Spring
Autumn	17	2	39
Heterozygote	1	2	17
Spring	14	7	442

Research question

- **Does the spawning season of herring effect the shape of the otoliths?**

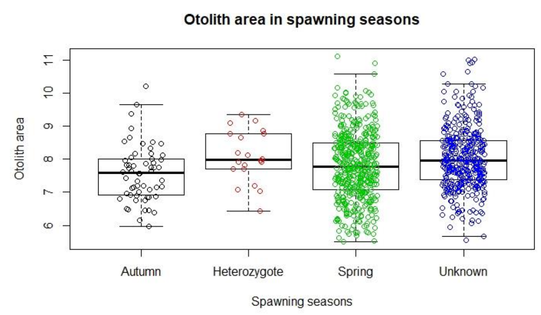


Figure 3:Otolith area in spawning seasons. On the x-axis are the different spawning seasons shown and the y-axis show the otolith length in mm.

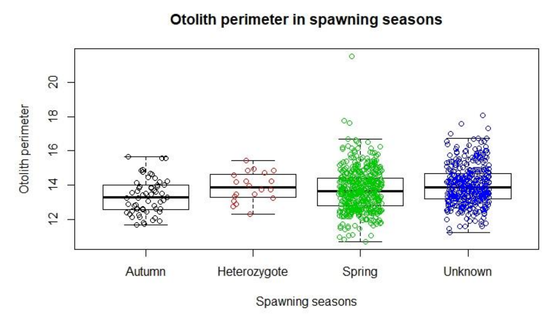


Figure 4: Otolith perimeter in spawning seasons. On the x-axis are the different spawning seasons shown and the y-axis show the otolith length in mm.

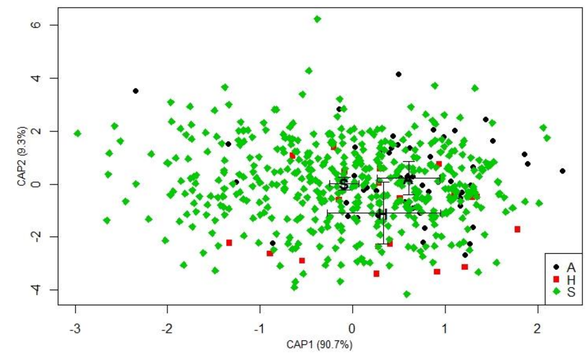


Figure 5: Otoliths shape of herring with different spawning seasons. The letters in the plot represent the mean value of each seasons, spring (S), autumn (A) and heterozygote (H). Difference plot symbols represent each individual otolith in the spawning seasons.

Key results

- The otolith area and length of the four genetic groups are significantly different where otoliths of spring spawners are larger (Figure 2; area $p<0.006$; length $p<0.0016$)
- The otolith perimeter and width of the four genetic groups are not significantly different (Figure 3; perimeter $p<0.857$; width $p<0.143$)
- The otolith form is represented of 64 coefficients in an analysis (Figure 5). The numbers at the axis show the extent to which the first axis can explain the difference between the groups in the analysis. Fish length or width has no significance. The x-axis can explain 90,7% of the difference between the different spawning seasons, and the y-axis can only explain 9,3%.
- Cross-validation showed that only 29% of the otoliths from the genetic group autumn were reassigned correctly, 10% of the heterozygote and 95% of the spring group (Table 1).
- Future research is that I want to investigate if we can predict the spawning season for a herring by only locking at the otoliths. This could not be answered within this study. The assignment of unknown otoliths to their spawning season was not possible because of the limited number of autumn spawning otoliths that was used in this study.

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