What to do when spiny dogfish lie about their age?

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Introduction

Spiny dogfish (*Squalus suckleyi*) have been aged using annuli counts on dorsal fin spines since the 1930s. However, this historical method results in low precision of age estimates, particularly for older fish exhibiting spine erosion, prompting a search for improved methods of ageing. Spiny dogfish were aged by historical methods using dorsal fin spines and by a proposed new method involving vertebral thin sections. Centrum edge analysis confirmed an annual banding pattern on vertebrae. Ages were determined by multiple readers using both fin spines and vertebrae thin sections obtained from the same specimens. We estimated inter-reader precision and variance associated with each structure. The two structures yielded similar ages for younger animals, while for older animals age agreement depended on the quality of the thin sections. Similar to other ageing structures, individual variability can impact thin section quality, particularly in larger, older animals. We were unable to fully validate vertebral thin section ages of larger, older animals because of variability in thin section quality and a limited sample size. Each method has advantages and disadvantages. The dorsal fin spine method was validated previously by both oxytetracycline and bomb radiocarbon dating, but between-reader agreement was poor. Moreover, worn or broken dorsal fin spines, common in older animals, require another step, where lost annuli are estimated through regression methods, which introduce an additional source of error into age estimation. In comparison, the vertebral thin section method substantially improved between-reader agreement and does not require the additional regression step, but processing of vertebrae is time consuming, the quality of the thin section impacts the age estimates, and validation of ages for larger animals has not yet been realized. In summary, the vertebrae thin section method is promising, but more work is required to examine individual variability in thin sections (i.e. quality) and ages need to be compared among the two methods from a larger sample size of large, old fish that have been age validated by bomb radiocarbon dating.

Historical Method – Dorsal Fin Spine

Step 1-Count visible annuli on dorsal fin spine

Step 2- Measure Enamel Base Diameter (EBD), determine the last readable point (LRP) and measure diameter at this point (LRD)

Step 3-Determine if spine is worn based on LRP

Step 4-Estimate number of worn or lost annuli

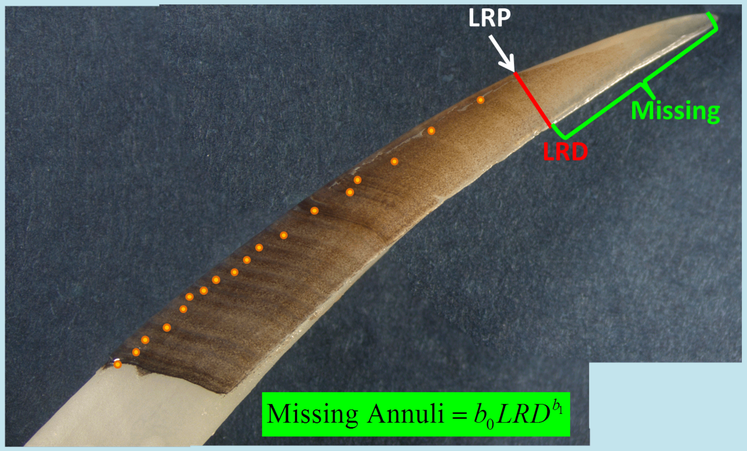

Figure 1. Orange dots denote annuli, arrow points to the last readable point (LRP), red line is the diameter of the spine at the LRP (LRD). The green brackets shows the portion of the spine that is worn, in which the number of missing annuli need to be estimated.

Proposed Method - Vertebrae

Step 1-Clean, section, decalcify and mount vertebrae thin sections

Step 2- Count visible annuli on centrum

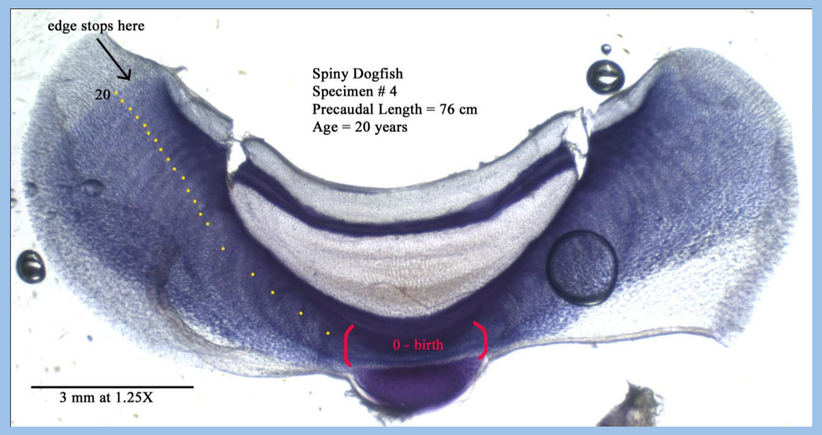

Figure 2. Stained vertebra thin section with annuli denoted by yellow dots, embryonic growth marked by red brackets.

Results

- **Between reader variability significantly reduced with vertebrae**
- **Annual periodicity of banding pattern on vertebrae validated by edge type**
- **Vertebrae ages are significantly lower than spine ages for unworn spines**

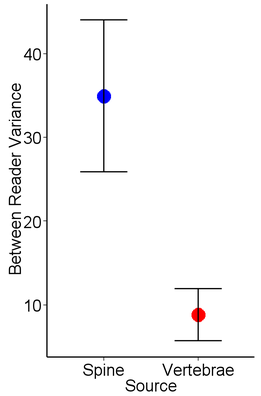

Figure 3. Mean between reader variance for spines and vertebrae. Error bars are 95% confidence intervals around the mean variance.

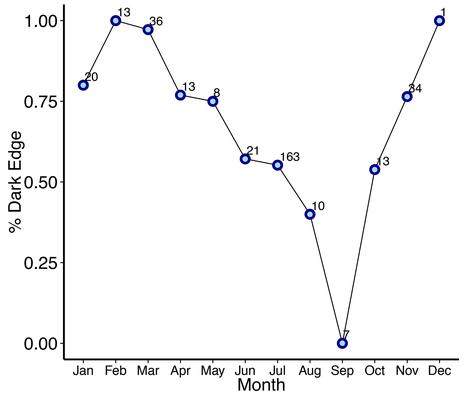

Figure 4. Edge type by month. Numbers represent the number of samples each month. Darker edges are prominent in winter months, when growth is slower, and lighter edges are prominent in late summer and fall with fast growth.

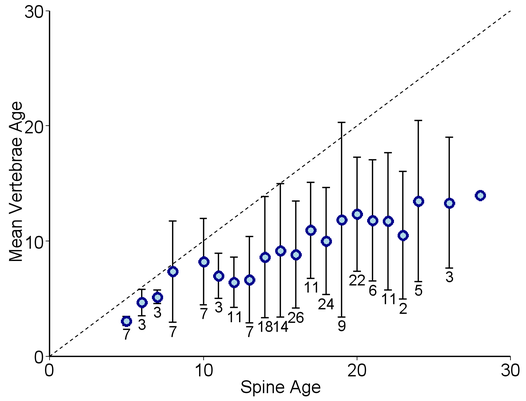

Figure 5. Age bias plot of mean vertebrae age compared to spine age. Error bars are the 95% confidence interval around the mean. Numbers are the sample size of vertebrae at each spine age. Diagonal line is a 1:1 replacement line. All samples are from unworn spines, where the last readable point (LRP) is <2.45.

How do you choose a best method?

Both methods have pros and cons

Fin Spines

PROS

- Validated: OTC tagging, bomb radiocarbon
- Fast, easy and inexpensive

CONS

- Poor reader agreement
- Highly uncertain

Vertebrae

PROS

- Annual periodicity validated by edge type
- Improved agreement
- Reduced uncertainty

CONS

- Lab intensive and time consuming and relatively costly (to spines)

Ages from unworn Spines should equal ages from vertebrae, however…

Vertebrae Ages ≠ Unworn Spine Ages

Conclusions

- Vertebrae thin section method is promising
- More work is necessary to investigate individual variability in thin sections (i.e. not all vertebrae stain equally)
- Need an increased sample size from larger, older animals

NPRB Project 1106 and 1106B "Improved aging techniques and growth models for spiny dogfish (*Squalus suckleyi*) in the Gulf of Alaska" January 2012 – January 2015

Acknowledgements: *The authors thank NPRB for project funding, Patrick McDonald and Nikki Atkins at the NWFSC age lab and Sandy Rosenfeld at the WDFW age lab for contributing reads for this study.*

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