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Sharks with frickin' laser beams: Exploring the use of elemental and isotopic analyses to understand the life history and ecology of sharks

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Overexploitation of fisheries has placed increased pressure on global fish stocks, fuelled primarily by human consumption demand. Sharks, which may be targeted or incidental catch, are particularly vulnerable to overfishing due to their slow growth, low fecundity, and late maturation age. Current perceptions of elasmobranch (sharks and rays) life history are informed through age and growth studies based on preconceptions that calcifying structures such as vertebrae and dorsal spines are indicators of the animals' temporal and environmental characteristics. Current ageing methods often leave elasmobranchs systematically underaged, which in turn can have severe management implications, impacting demographic analysis and estimation of population recovery rates. Therefore, validating ageing techniques and enhancing our ability to infer habitat use across ages is fundamental to proper management.

The growth mechanisms of shark vertebrae and the incorporation of trace elements (and their isotopic signatures) into the internal structure of vertebrae is poorly understood. Further, the extent of the information that can be gathered by analysing trace elements along the growth axis of vertebrae is still nascent with respect to proven applications on teleost otoliths. To find a cost- and time-efficient ageing technique that removes ambiguity and seeks to validate conventional methods (optical microscopy), vertebrae from pelagic, coastal and riverine species have been selected and analysed to discriminate the presence of elemental/isotopic variations in their vertebrae. Various beam-based analyses have been used including SEM-EDS, EPMA, μXRF, LA-ICP-MS and LA-MC-ICP-MS.

Elemental distribution within the vertebrae varied significantly between species from different habitat types, and variances were more pronounced in coastal and riverine species that are exposed to terrigenous runoff. We find that μXRF effectively improved the visibility of ageing structures (less so for SEM-EDS, EPMA).

In situ characterization of radiogenic Sr isotopic ratios ($^{87}Sr/^{86}Sr$ by LA-MC-ICP-MS) within the ageing structures is thought to reflect ambient environmental ratios in marine and riverine settings, and this has been robustly evidenced here by comparing vertebrae and riverine $^{87}Sr/^{86}Sr$. This demonstrates potential for Sr isotopes to be an informative indicator for reconstructing age-related movements, particularly for species exposed to terrigenous runoff within their life histories.