frontiers | Frontiers in Marine Science

TYPE Editorial
PUBLISHED 24 June 2024
DOI 10.3389/fmars.2024.1442796

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OPEN ACCESS

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RECEIVED 02 June 2024
ACCEPTED 10 June 2024
PUBLISHED 24 June 2024

CITATION
Polo-Silva CJ and Bustamante C (2024) Editorial: The use of stable isotope ecology in sharks.
Front. Mar. Sci. 11:1442796.
doi: 10.3389/fmars.2024.1442796

Editorial: The use of stable isotope ecology in sharks

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KEYWORDS

stable isotope, isotopic niche, elasmobranchs, nursery areas, storage samples

Editorial on the Research Topic
The use of stable isotope ecology in sharks

The development of biochemical approaches such as isotopic analysis in elasmobranchs has made it possible over time to investigate aspects that may have been unlikely a few years ago. Since its introduction 40 years ago, the use of isotopic applications in chondrichthyans has become a tool that allows us to obtain eco-trophic information on species without endangering or killing them. This is especially true for endangered species of sharks. The basic principles behind stable isotope analysis are quite simple. As a predator eats its prey, atoms of that prey are incorporated into that predator's tissues through the process of digestion, which means that on an atomic level, you truly are what you eat. This means that by comparing an animal's average isotope ratio with that of their environment or potential prey, we can determine its diet and habitat usage.

The isotopes commonly used in trophic studies of sharks are $\delta^{13}C$ and $\delta^{15}N$ (Hussey et al., 2012; Kim et al., 2012; Estupiñán-Montaño et al., 2021; Calle-Moran et al., 2023). $\delta^{13}C$ is an indicator of the energy source, i.e. where the species tends to feed (De Niro and Epstein, 1978; Phillips, 2014), while $\delta^{15}N$ is an indicator of the trophic level as well as the extent of its niche, as it tends to increase markedly between the different links in the trophic web (DeNiro and Epstein, 1981; Fry, 2006). Using this tool it has been possible to estimate more precisely the position or trophic level that a species can occupy in each ecosystem (Hussey et al., 2011; Estupiñán-Montaño et al., 2017), which prey species how wide or diverse its isotopic niche width can be and how flexible a population can be in moving between different habitats with different carbon sources (> $\delta^{13}C$ and $\delta^{15}N$) (Kim et al., 2012; Tamburin et al., 2019). Similarly, this same tool has allowed us to learn a little more about tissue physiology and how, depending on the turnover rate, these tissues incorporate isotopic signals from the food in each tissue, so we can see different temporal feeding windows, allowing us in many cases to reconstruct the feeding ontogeny of a species (Hussey et al., 2012; Kim et al., 2012; Kiszka et al., 2015). Other studies have focused on evaluating the effects that some reagents could have on the $\delta^{13}C$ and $\delta^{15}N$ values stored in specific tissues, the effects could be different between groups or species (Kim and Koch, 2012; Bashir et al., 2020). However, there are a few approaches where the goal could be to use the SIA to propose conservation and management measures. An effective ecosystem-based fisheries management plan would require, among other things, detailed data on diet and food web interaction. If we improve our understanding of their biology and ecology, including what they eat, we can improve conservation management strategies and protect threatened marine life, such as sharks.

This Research Topic for Frontiers in Marine Science included manuscripts that focused on the use of the SIA approach to estimate or corroborate the use of specific habitats as nursery areas and the various biases and issues that researchers need to address when using tissues that have been stored or processed with different reagents. Paez-Rosas et al. used this tool to identify a nursery area for scalloped hammerhead sharks in the Eastern Tropical Pacific (ETP) by analyzing isotopic signals in the skin of newborns throughout the region, including the Galapagos Marine Reserve (GMR). The results showed that the *S. lewini* hatchlings found in the GMR have isotopic information similar to that of adult females living in the Galapagos archipelago, suggesting that they are direct descendants of these females. In contrast, shark newborns found off the continental coast of Ecuador have isotopic signatures similar to those of adult females from different locations in the ETP. Barragan-Barrera et al. proposed potential nursery areas for bonnethead (*S. tiburo*) and Caribbean sharpnose (*C. porosus*) sharks off the Panamanian Caribbean coast. Their results revealed a higher proportion of small-adult sharks in the nursery area. The lack of competition between these two sympatric species, which use the prey available in coastal areas, allows for the coexistence of these two species.

Mohan et al. examined the habitat use and migratory patterns of young White Sharks (*Carcharodon carcharias*) by analyzing vertebrae obtained from coastal Mexican artisanal fisheries off central Baja California in the Pacific Ocean. The authors found that the mean δ^{15}N values at the vertebral edges of sharks from the Gulf of California were +5‰ higher than those from the Pacific Ocean. This difference indicates intense denitrification in the Gulf food web and validates stable isotope analysis (SIA) as a method for tracking migration between these regions.

Shen et al. and Bennet-Williams et al. investigated how certain reagents affected the isotopic values of stored samples. Shen et al. initially assessed the impact of ethanol on the isotopic values of 12 predators and discovered significant in δ^{13}C during the first 28 days. After this period, the variability decreased substantially. Based on their findings, the researchers recommended that samples of oceanic species stored in museums could be used for lipid extraction to obtain reliable isotopic results. Bennet-Williams et al. tested various reagents to reduce lipid and urea bias in tissue samples. They found that a combination of Deionized Water (DW) and Chloroform/Ethanol was most effective in standardizing δ^{13}C and δ^{15}N values in muscle and fin tissues. However, because of considerable individual variation, DW + CL E was unsuitable for plasma. Consistent results were observed for red blood cells (RBC), indicating that DW + CL E may be effective for these tissues. Nevertheless, further research is required to understand species-specific effects.

These manuscripts emphasize the importance of using stable isotope analysis (SIA) to validate critical habitats for endangered species like sharks. They also highlight the potential of museum-stored samples treated with protective reagents to infer a species' trophic ecology and history, aiding in the development of management measures.

Author contributions

CP-S: Writing – original draft, Writing – review & editing. CB: Writing – review & editing.

Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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