



# STABLE ISOTOPE ANALYSES OF SEA TURTLES: A REVIEW OF THREE RECENT GLOBAL REVIEWS AND DATA ASSESSMENTS

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Based on the concept of ‘you are what you eat’, stable isotope analysis (SIA) is a technique that helps sea turtle researchers learn about a turtle’s trophic ecology and, perhaps, its movements by analysing a very small (~1mg) sample of blood or skin. The use of this technique has been growing steadily during the past 20 years and scientists are using SIA in new ways to gain more and more information out of each biological sample. The approach has grown so much that we are now at a time where literally hundreds of papers have been published on stable isotope studies on every species of sea turtle, although few studies have focused on flatback turtles (*Natator depressus*) - but that is changing too!

With the huge increase in sea turtle SIA research projects, there have been a two recent review papers and one new database initiative that are worth exploring. Papers by Pearson *et al.* (2017) and Haywood *et al.* (2019) represent the first sea turtle-focused review articles, and while very different from each other, both offer intriguing insights into the breadth of application and the value of this technique for sea turtle research and conservation. In addition, a global database initiative for sea turtle SIA studies called MarTurtSI has recently been launched, and a paper by Figgenger *et al.* (2019) describes the database and provides a wealth of resources for people interested in learning about stable isotope research in sea turtles. Here we describe each of these papers and highlight their value for not only teaching people about the value of SIA for sea turtles, but also for identifying gaps in knowledge that may help direct new research.

**Pearson, R.M., J.P. van de Merwe, C.J. Limpus & R.M. Connolly. 2017. Realignment of sea turtle isotope studies needed to match conservation priorities. *Marine Ecology Progress Series* 583: 259-271.**

This paper by Ryan Pearson and colleagues reviews the literature on sea turtle isotope ecology, with the goal of

showing where the gaps are in SIA research so that future studies can help fill the void. The review comes in at about 9,200 words and has 65 citations. The paper doesn’t cover all the SIA studies out there, but instead focuses on those that can potentially inform management decisions. Indeed, conservation practitioners have often struggled to see the value of SIA for providing information that can be used in management. However, this paper does a great job at just that: it dispels the myth that SIA is an academic pursuit only. Through its methodical approach reviewing existing SIA studies per regional management unit (RMU) for each species, the paper underscores the value of SIA for sea turtle conservation and management and identifies what the priorities should be for future isotope research on sea turtles.

The paper starts with a strong introduction, then transitions into a methods section that lays out how the literature search was conducted and the studies for each RMU were organized. This is followed by a ‘Results and Discussion’ section that gives an overview of sea turtle isotope ecology and describes the isotope techniques used to study sea turtles. Perhaps the strongest part of the paper comes next, when the authors discuss the key tenets of SIA research, including diet-tissue SI relationships, tissue-tissue relationships and isotopic turnover, and sample preservation and preparation techniques. The paper then describes future methodological research priorities and the relevance of SIA studies for management. Pearson *et al.* (2017) finish by discussing the mismatch between geographic isotope studies and conservation priorities, with the goal of steering future research in directions that will help fill some of the information gaps in SIA for sea turtles. We found this to be a very interesting paper and at just about the right length to be able to have a ‘quick read’ to get the lay of the land for SIA research for sea turtles.

**Haywood, J.C., W.J. Fuller, B.J. Godley, J.D. Shutler, S.**

**Widdicombe & A.C. Broderick. 2019. Global review and inventory: How stable isotopes are helping us understand ecology and inform conservation of marine turtles. *Marine Ecology Progress Series* 613: 217-245.**

Julia Haywood and collaborators have written a traditional review paper on SIA applications to sea turtles. Logging in at over 22,000 words and citing 230 publications, this paper is a long-format review that includes the majority of the studies that had been conducted through 2018. The paper is quite different than that by Pearson *et al* (2017) in that it doesn't focus as much on the management value of SIA, but instead provides a detailed inventory of what's been done so far. The authors describe the current status of SIA in sea turtles and, like Pearson and colleagues, highlight gaps in existing knowledge while also suggesting future recommendations for analyses and interpretation of SIA data.

The paper starts with an introduction that describes the current state of SIA in sea turtles, gives background information on stable isotope analysis, and describes why a review is necessary at this point in time. Like Pearson *et al.* (2017) the methods describe how the authors conducted their literature search and give methodology that is very reproducible in case someone wants to do a similar review in the future. There is a Results and Discussion section that reviews studies on foraging and spatial ecology, with subsections on diet, global interspecies differences in isotope ratios, ocean basin differences in isotope ratios, ontogenetic shifts, migratory connectivity, foraging site fidelity, and foraging dichotomies. This is followed by a section on SIA vs. sea turtle size and growth that focuses on juveniles, adults, and reproductive output. Next is a discussion of applications of SIA for management and conservation. Though not as in-depth as that by Pearson *et al.* (2017), this paper too shows the value of SIA for informing conservation planning. The paper finishes with discussions about the limitations of SIA, additional analytical approaches, and key recommendations.

As of today, the paper by Haywood *et al.* (2019) is the quintessential review paper for SIA research on sea turtles. It's a long, dense read, but well worth it! The graphics in the paper are excellent and include nice maps showing geographical location of sea turtle SIA studies. It's a global review, but also probably the best resource out there for learning about what has been done- and where the information gaps are- in the Indian Ocean region. Reading this paper will certainly help researchers identify where more research focus is needed, which could be useful justification for those seeking funds to support projects. As with Pearson *et al.* (2017), we strongly recommend this paper for those interested in the topic and feel that

both these review papers are well worth the time to read!

**Figgenger, C., J. Bernardo & P.T. Plotkin. 2019. MarTurtSI, a global database of stable isotope analyses of marine turtles. *Scientific Data* 6: 16.**

The paper by Christine Figgenger and colleagues is a departure from the typical review paper in that its more of a go-to source for seeing and downloading the actual data and research objectives for over 130 different SIA sea turtle papers. While the actual paper itself is rather short (~3,800 words) and has relatively few citations (22 papers in the main article's literature cited), readers should not think that this is all there is. Quite the contrary! In fact, the paper is only a small part of what Figgenger *et al.* have to offer. In our opinion, the greatest value of this effort is the global database (MarTurtSI) which contains stable isotope data from six of seven marine turtle species ranging from juveniles to adults, in different developmental, feeding, and breeding habitats across multiple ocean basins. Importantly, this database is freely accessible to everyone, and offers downloadable supplemental resources from the *Dryad* Digital Repository that do a great job at summarising a large number of published papers.

Figgenger *et al.* (2019) examined 132 peer-reviewed publications and summarised information from each study (e.g. diet, species and regional differences, migratory connectivity, foraging site fidelity, foraging dichotomy, growth rate, adult size, reproductive output, and threats) by species and region. The archived datasets are a fantastic resource that gives interested researchers an easily accessible summary to which their own research results can be placed in context. The downloadable supplemental files include Excel files, which nicely organize SIA data for each species by life stage and size, sex, time of sampling, ocean basin, study site, and turtle size. There is even an Excel file with raw data that are organized such that each reviewed study has its own tab in the file, making it extremely easy to toggle among a vast number of studies and see the data in a well-organized way.

The MarTurtSI database initiative launched by Figgenger *et al.* (2019) is a one-of-a-kind resource! As per the authors' description, "MarTurtSI will be curated and updated with the aim of enabling continued comprehensive and global investigations into the trophic ecology of marine turtles especially in the face of climate change and other conservation challenges." There are data in the database that cover the Indian Ocean Region, but as with the review articles by Pearson *et al.* (2017) and Haywood *et al.* (2019), MarTurtSI shows that this region remains underrepresented in the stable isotope realm. However, we hope that by having this vital new resource, potential researchers should

be better equipped with information about where the gaps are, which in turn should identify opportunities for future research in the Indian Ocean and beyond.

## **CONCLUSION**

Without a doubt, the review papers by Pearson *et al.* (2017) and Haywood *et al.* (2019), and the MarTurtSI database described by Figgener *et al.* (2019) should be among the first papers read by researchers interested in starting stable

isotope research. Consulting these resources will ensure interested researchers apply methodology and analyses consistent with other sea turtle projects. Also, by reading these papers and their supplementary products, potential new SIA researchers will learn what's already been done, and thus be informed about where their efforts would be most effective. The recommendations made in these reviews can also be used to support grant applications for research that addresses the priority topics, sites and species throughout the Indian Ocean and South-East Asia.