Research Summaries

From pattern to process: recent marine turtle publications advance our understanding of oceanographic influences on marine turtle biology and demography

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When I was asked to write this summary of what I considered to be the key research articles in marine turtle ecology to emerge over the past year, I knew there would be some difficult choices ahead. Indeed, we're in a golden time in marine turtle research; today there are more researchers studying more questions in more places than ever before. And thanks to this research, we've got a better handle on a wide palate of topics; from physiology and behavior to social science and economics; from long-term nesting beach monitoring to the ecology of turtles at sea. While we've no doubt strengthened the foundation of knowledge for these and other topics, for this review I'd like to shed attention on a rather new line of research, one that blends a variety of new technologies and novel approaches. Here I describe a 'set' of papers that have a common theme which reflects an important area of research, critical in fact, as together these papers represent the intersection between three important fields: oceanography, marine turtle demography, and fisheries management. These are by no means the only papers on these topics, yet they do show the research community's movement beyond simply describing the patterns we see in marine turtles, and reflect the growing investment 'we' are making toward understanding the reasons why turtles do what they do, and how we can use that information to improve fisheries management.

Caut, S., E. Guirlet, E. Angulo, K. Das & M. Girondot. 2008. Isotope analysis reveals foraging area dichotomy for Atlantic leatherback turtles. *PLoS ONE* 3: 1845-1853.

Stable isotope analysis is a blossoming research tool in the study of marine turtles and the paper by Caut *et al.* is a fine example of how this technology can be used to get at 'big picture' concepts such as the influence of migration and foraging area on nesting remigration intervals. Based on the paradigm of 'you are what you eat', marine turtles – just like humans, or butterflies, or neotropical song birds, or great whales – integrate the isotopic signatures of their surroundings, the foods they eat and the water they drink. This information is stored in their body's soft tissues for a period of weeks to months such that a skin or blood sample collected from a turtle at a nesting beach can provide some insights about the habitat characteristics, and diet, from the area previously occupied prior to nesting. In Caut *et al.* (2008) the authors use stable isotopes as dietary tracers to reveal the isotopic characteristics of feeding grounds of leatherback females (*Dermochelys coriacea*) nesting in French Guiana. Caut *et al.* show that there is a strong difference in the stable carbon and nitrogen isotope signatures between leatherback turtles that are 2-yr vs. 3-yr remigrants to the nesting beaches of Yalimapo beach in French Guiana, South America. With these results, the research team suggests that these two groups have substantial differences in their choice of feeding habitats (offshore vs. more coastal) and foraging latitude (North Atlantic vs. West African coasts). And while this 'match' between isotope signatures in tissue and the specific oceanic region that produces such a signature is more speculative than based on hard data, this study is the first paper to examine how dichotomies in habitat selection among individuals in the same nesting population may drive variability in remigration interval.

Saba, V., J. Spotila, F. Chavez & J. Musick. 2008. Bottom-up and climatic forcing on the worldwide population of leatherback turtles. *Ecology* 89: 1414-1427.

Much like the previous paper, this landmark paper by Saba *et al.* provides a fantastic account of the oceanographic mechanisms that drive variability in the remigration interval of leatherback turtles. This is a follow up paper to a Saba *et al.* paper published in 2006 in the Journal of Applied Ecology (volume 44, pages 395–404). However, I focus on this paper published in Ecology because it provides a more global perspective that encompasses leatherbacks and the influence of oceanography on reproductive output in the Pacific, Atlantic, and Indian Oceans. Saba *et al.* conduct an extensive review of leatherback nesting and migration data in light of net primary production at post-nesting migratory regions and foraging areas. They show how influences of oceanographic processes of decadal oscillation and El Niño Southern Oscillation (ENSO) are two major forces that impact the periodicity of leatherback nesting. For me, the major point of the paper was that lower productivity and inconsistent oceanography of the Pacific Ocean may render some Pacific leatherbacks more susceptible to variable reproductive output, and thus in a more precarious position when it comes to population recovery. The paper does not delve deeply into questions about how much the human factor has helped, or hindered, leatherback population recovery, but it is another shining example of how marine turtle research has graduated from simple pattern recognition and is now addressing the underlying processes that influence a population's reproductive output. Not to mention, the paper does a great job at taking something that could be rather technical and putting it into understandable language for those not familiar with oceanographic concepts.

Chaloupka, M., N. Kamezaki & C. Limpus. Is climate change affecting the population dynamics of the endangered Pacific loggerhead sea turtle? 2008. *Journal of Experimental Marine Biology and Ecology* 356: 136-143.

Moving on from studying how oceanography may impact the remigration intervals of marine turtles, we now arrive at a paper that works to distill the potential effects of oceanography on nesting trends of a population – loggerheads (*Caretta caretta*) in the Pacific Ocean. Chaloupka *et al.* use well established modeling approaches to explore whether sea water temperatures in the Pacific Ocean affect the long-term nesting population dynamics for loggerheads nesting in Japan and Australia. Interestingly, they found that both Pacific 'stocks' have been exposed to slowly increasing trends in mean annual sea surface temperature (SST) in their respective foraging habitats over the past 50 years. Why is this important? Because Chaloupka's team demonstrates that regardless of decade or population, there was an inverse correlation between nesting abundance and mean annual SST in the oceanic foraging regions during the year prior to the nesting season, such that warmer waters resulted in lower nesting abundance. Chaloupka *et al.* go on to explain how temperature may affect primary productivity and food availability, but the take-home message is that warming regional ocean temperatures could potentially lead to long-term decreases in nesting and recruitment unless Pacific loggerheads adapt by shifting their foraging habitat to cooler regions. While this may not be the 'smoking gun' that people are looking for to explain the slow recovery of loggerheads in the Pacific, it certainly shows that there is potential for other factors outside of fisheries bycatch to be impacting a population's capacity to recover. Much like the approach of Saba *et al.* (2008), this is a paper that represents the intersection between oceanographic studies with marine turtle reproductive output. Obviously, a central theme to the marine turtle conservation community is population recovery, thus I consider this paper, and others like it (see Saba *et al.* above) to be among the most important areas that scientific research can help inform marine turtle conservation. I hope it is a research area that will continue to expand in the future!

Howell, E.A., D.R. Kobayashi, D.M. Parker, G.H. Balazs & J.J. Polovina. TurtleWatch: a tool to aid in the bycatch reduction of loggerhead turtles *Caretta caretta* in the Hawaii-based pelagic longline fishery. 2008. *Endangered Species Research* 5: 267-278.

In this contribution to the Theme Section 'Fisheries bycatch: problems and solutions' of Endangered Species Research, Howell *et al.* show how understanding the oceanographic drivers to sea turtle movements and habitat use can be used to better manage fisheries in relation to their impacts on turtles. This study focuses on loggerhead turtles in the central North Pacific, and uses satellite telemetry and remotely sensed oceanographic data to show that loggerhead turtles closely track sea surface frontal zones. More importantly, the authors have taken this understanding 'online' with fisheries management of U.S. longline fleets in the North Pacific. Howell's team has developed a first-of-its-kind management tool that has resulted in substantial acclaim. Fishers now have a better understanding of the oceanographic forces that dictate loggerhead movements. And of course they don't want to interact with sea turtles during their fishing efforts, so for many fishers on the high seas, this is a welcome product. The great aspect of this is that many vessels have satellite internet, and thus are able to get this information real-time while they are at sea. And there is strong evidence that TurtleWatch works! As reported in Howell *et al.* (2008) the observed fleet movement during the initial fishing efforts of 2007 was to the north of the area recommended for avoidance by the TurtleWatch product (north of the 18.5°C isotherm), and despite increased fisheries effort compared to previous years, the loggerhead turtle bycatch rates were lower. Granted, fisheries bycatch avoidance may not be so straight forward all around the world, but this paper shows the potential for products to be developed that blend our understanding of marine turtle habitat use with remotely sensed satellite data and that can be quickly disseminated to fishers to help them avoid turtle interactions. As far as publication goes, I can't think of a better venue than Endangered Species Research, due to its numerous special focus issues and the fact that it is freely available online; I only wish that more journals moved to 'free access' format. In closing, I must admit that I work for the same agency (NOAA) that Howell and his colleagues work for. But in this present case I have watched from the sidelines and have not been involved with the development or implementation of the TurtleWatch product in any way.