

The Use of Satellite Telemetry to Monitor and Predict Habitat Use and Migration Corridors of Highly Mobile Shark Species

El uso de telemetría satelital para monitorear y predecir el uso del hábitat y los corredores de migración de especies de tiburones altamente móviles

L'utilisation de la télémétrie par satellite pour surveiller et prédire l'utilisation de l'habitat et les couloirs de migration des espèces de requins très mobiles

CHELSEA BLACK

¹University of Miami Rosenstiel School of Marine Atmospheric and Earth Science,
4600 Rickenbacker Causeway, Miami, FL 33145,
Chelsea.black@miami.edu

EXTENDED ABSTRACT

Understanding the distribution of marine species is critical for the development of conservation measures and predicting the potential impacts of global change on ecologically important species. As apex predators, sharks are at the top of a trophic cascade, influencing the control of prey populations. This top-down control makes them important indicators of climate and ecosystem changes (Hazen et al. 2019) and therefore important study species when investigating the response of species to global change. Satellite telemetry is a commonly used tool to understand the distribution of multiple coastal and pelagic species, movement patterns, and habitat use. Highly mobile shark species can traverse multiple oceans and across international boundaries, making it incredibly difficult to study their movements and implement proper conservation measures. This can lead to gaps in management as their entire habitat use or migration corridors are unknown and can shift in response to environmental changes. Additionally, their extensive geographic ranges lead them throughout multiple levels of protection and inside and outside of Marine Protected Areas (MPAs), which can serve as crucial areas to mitigate negative stressors on populations. For MPAs to be effective in protecting migratory shark species, we must investigate areas of habitat use or migration corridors and the environmental drivers behind them.

This research had three main objectives to determine this: (1) identify areas of shark co-occurrence for highly migratory sharks, (2) identify the environmental drivers behind this distribution and (3) identify where these areas of co-occurrence overlap with MPAs. To answer these questions, satellite telemetry data was downloaded from the Marine Biodiversity Observation Network's BioTrack project between the years 2010 and 2020 in the Gulf of Mexico, Caribbean, and Western North Atlantic. The most abundant telemetry data was collected from tiger (*Galeocerdo cuvier*), blue (*Prionace glauca*), scalloped hammerhead (*Sphyrna lewini*) and great hammerhead sharks (*Sphyrna mokarran*) which served as the study species. Data was collected using Smart Position and Temperature (SPOT) tags that gave the location and time of each shark. This data was then regularized and interpolated with a correlated random walk using the R package AniMOTUM (Johnsen et al. 2023). A state-space model was then applied to classify shark behavior as either habitat use (low geographical movement) or migration corridors (high geographical movements). To create habitat suitability models, this occurrence data was then run through MaxENT software using the environmental variables sea surface temperature (SST), bathymetry, chlorophyll concentration, and particulate organic carbon (POC). From these models, areas of overlap were identified for each species and compared spatially to MPAs.

Tiger shark (N=141) and blue shark (N=35) distribution for both habitat use and migration corridors was most influenced by SST and bathymetry, while scalloped (N=41) and great hammerhead (N=18) sharks were most influenced by bathymetry during both behavioral states. The area of migration corridors for both the wet (May-October) and dry (November-April) seasons show the largest geographical range with all four species overlapping in the Gulf of Mexico. When comparing habitat use to MPAs, less than 8% of areas classified as habitat use by all species is within these areas (7.33% dry season, 3.66% wet season). When comparing migration corridors to MPAs, less than 6% of areas classified as migration corridors is within these areas (4.83% dry season, 5.61% wet season).

While the migration corridors of all species had the greatest range extension (Figure 1), MPAs covered less than 6% of this area during both wet and dry seasons. Sharks are susceptible to fishing pressures as bycatch during their long-distance migration and the current MPA coverage is not adequate for the species in this study to afford much protection during this time. Habitat use was more protected, but still less than 8%. As habitat use is classified as areas of feeding, mating, or birthing, this is cause for concern as they represent necessary home ranges for these species. To maximize the efficacy of protected areas, it is critical to understand the species that are using these areas and to what extent they would benefit from the implementation of protected areas. In the case of the four shark species mentioned in this study, the greatest impact for protection would occur along the coast of the Gulf of Mexico where there is the highest species co-occurrence (Figure 2). This area also has the least restrictive protections in place and should be considered for targeted management of mobile shark species.

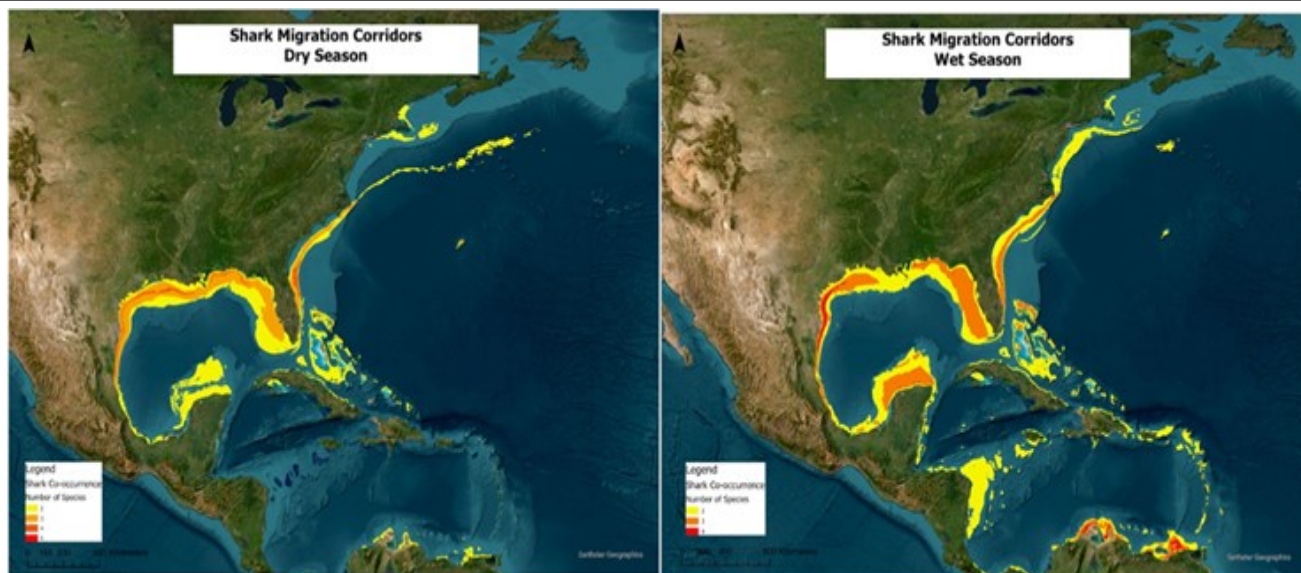


Figure 1. Migration corridors of tiger, blue, scalloped hammerhead and great hammerhead sharks.

Assessing where and to what extent these species are using MPAs can help inform directed management measures and influence the design of future protected areas, and this study highlights how habitat suitability modeling can be used to understand species distribution during two different behavior states. Because migratory sharks can have a wide geographic range linked to environmental variables such as temperature, monitoring their current and predicted movements will be paramount to assessing the efficacy of protected areas in the future under global change. Future directions of this study include using predicted environmental variables for the year 2100 to model future habitat use and migration corridors of

highly mobile shark species to highlight future areas of vulnerability and recommend them to be included as proposed protected areas. Migratory sharks have the potential to act as an umbrella species for conservation; identifying areas of multiple shark species co-occurrence will reveal areas of high ecological importance for marine biodiversity and where protective measures should be focused.

KEYWORDS: Satellite Telemetry, monitoring, habitat, corridors, sharks



Figure 2. Overlap of tiger, blue, scalloped hammerhead and great hammerhead sharks during habitat use and migra-

LITERATURE CITED

- Hazen, Elliott L., Briana Abrahms, Stephanie Brodie, Gemma Carroll, Michael G. Jacox, Matthew S. Savoca, Kylie L. Scales, William J. Sydeman, and Steven J. Bograd. "Marine top predators as climate and ecosystem sentinels." *Frontiers in Ecology and the Environment* 17, no. 10 (2019): 565-574.
- Johnsen, I. D., Grecian, W. J., Phillips, L., Carroll, G., McMahon, C., Harcourt, R. G., ... & Patterson, T. A. (2023). aniMotum, an R package for animal movement data: Rapid quality control, behavioural estimation and simulation. *Methods in Ecology and Evolution*, 14(3), 806-816.