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Using movement modelling to understand interactions with fisheries and inform spatial management of great white sharks in the southwest Indian Ocean

Modelling tracking data from large mobile marine predators can help understand the level of risk they face from exposure to fisheries and the level of protection they get from spatial management. We analysed the movement patterns of 33 white sharks satellite-tagged in South Africa to investigate (1) the influence of size, sex and season on their movement patterns, and (2) the spatial and temporal overlap with longline and gillnet fisheries and marine protected areas (MPAs) between 2012 and 2015. We fitted a 2-state hidden Markov model to quantify 'resident' and 'transient' movement, and investigate the effect of individual and temporal covariates on the transition probabilities between states. A model with sex, total shark length and a periodic function of day of the year (season) had the most support. All tagged white sharks were more likely to be in a resident state near the coast and a transient state away from the coast, while the probability of finding a shark in the transient state increased with shark size. White sharks overlapped with longline and gillnet fisheries within 25% of South Africa's Exclusive Economic Zone (EEZ) and spent 26% of their time exposed to these fisheries during the study period. We found that the fishery with the lowest spatial and temporal overlap (regional beach safety gear) reported the highest white shark catches, emphasising the need to combine spatiotemporal shark movement and fishing effort with reliable catch records to assess risks to shark populations more accurately. White shark exposure to beach safety gear corresponded with the catch composition of that fishery, providing support for a meaningful exposure risk estimate from the movement model. In terms of protection, white sharks spent significantly more time in MPAs than expected by chance, suggesting that MPAs can benefit large, mobile marine megafauna. This work demonstrates the benefits of combining statistical modelling with spatiotemporal information on risk exposure and protection, for improved conservation and management of endangered marine megafauna.