

Developing appropriate conservation measures for the seasonal whale shark feeding aggregation in Seychelles using ecological modeling tools

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Background: The whale shark feeding aggregation in the Seychelles has been studied in detail since 2002, including aerial survey and collection of environmental data. In these coastal waters previous tagging studies have shown whale sharks spend considerable time in the top 10m of water (44-60% of daylight hours). Although protected locally there is currently no management structure to conserve them outside of protected areas. This is the first attempt to develop Temporary Protected Areas using statistical modeling of their ecological distribution to conserve the aggregation.

Methods: Data on whale shark occurrence and distribution were collected via standardized aerial surveys from microlight aircraft that also recorded locations of surface-feeding schools of fish and environmental variables. These data were input into Geographical Information System (GIS) software to create density distribution maps; further layers generated included distance from the coastline, and chlorophyll-a (Chl-*a*) concentration (from MODIS satellite imagery). MAXENT ecological modeling software and Kernel Density Estimate analysis were used to produce a habitat suitability map and probability distribution estimate. The MAXENT model was tested using pseudo-absence data in a binomial generalized linear model.

Results: Chl-*a* concentration, distance from coast and fish schools were all found to influence whale shark presence and Maxent results closely matched those from the Kernel Density Estimate analysis. Predictions of suitable habitat for whale sharks avoided higher Chl-*a* concentrations, but showed positive correlations with schools of fish, possibly acting as a direct indication of zooplankton abundance. Whale sharks preferentially selected feeding areas close to the coast.

Conclusion: Maxent and Kernel Density Estimates can provide useful tools to guide the development of appropriate conservation and management of this species that take into consideration temporal behavior and ecology.

Key words: *Rhincodon typus*, whale shark, aerial survey, ecological distribution modeling, Maxent, Kernel Density Estimate, GIS, Protected Area