Identification of Risk Areas of Sea Turtle Poaching on the Island of Boa Vista, Cape Verde: Using a Statistical and GIS-based Approach

Stephanie Butera[1]; Airton Jesus [1]; María Medína Suarez[2]; Thomas Reischig[3]

1: Fundação Tartaruga Cabo Verde; sybutera@gmail.com, a.jesus@turtle-foundation.org

2: Cabo Verde Natura 2000; caboverdenatura2000@gmail.com

3: Turtle Foundation Germany; reischig@turtle-foundation.org

Introduction

Poaching of nesting females for meat remains an anthropogenic threat to the endangered loggerhead sea turtle population on Boa Vista, Cabo Verde. Due to the recent introduction of a law that can send poachers to jail for their crimes, the activities of a special team employing conservation dogs and night vision drones to support law enforcement, and increased opportunities for community members to work in sea turtle conservation, poaching has significantly decreased. However, illegal taking of sea turtles from the beaches is still a problem that must be addressed by appropriate conservation actions. This project aims to confirm areas on Boa Vista that are known to be at high risk of sea turtle poaching and predict new areas using their proximity to geographic features that contribute to the selection of poaching sites.

Methods

Statistical analysis of the poaching point distribution

A kernel density map was produced from the distribution of poaching cases from 2018-2020 to determine whether it was clustered, random, or dispersed. G and K functions were performed in R-Stat to determine the significance of poaching point clustering by measuring the distances between points. The G-Function measures the distances from points to their nearest neighbor, while the K-Function measures the distances from each point to all other points in the distribution. 100 Monte Carlo simulations were then performed on the G and K outputs to ensure that the clustered distribution cannot be the result of a stochastic process, but rather determined by outside factors. The outputs of the Monte Carlo simulations are envelopes surrounding the theoretical line of the G and K Functions representing the range of possible random distributions given the number of points.

Spatial analysis of causative geographic features

The following geographic features were selected due to informed belief that they influence locations where poaching occurs: roads, hotels, research camps, and towns. The distances from each poaching site and pseudo absence site to the nearest of each geographic feature were calculated and logistic regression analysis was then used to determine the significance and degree of influence that each geographic feature has on the likelihood of poaching in its proximity, if any. The logistic regression aided in ranking the geographic features from greatest to least influence on the selection of locations to kill turtles. To confirm the ranking, surveys with five ex poachers, now working in sea turtle conservation, were also conducted. Nesting abundance per study area was expressed to be an important factor in beach selection, therefore it was added to the list of factors for the final analysis. To complete the model, a weighted overlay of the selected features was used to determine areas of high risk. Each feature was given a buffer to cover the area that it is expected to affect. The buffer areas were given scores that either added to or subtracted from the final score, depending on whether distance from that feature attracts or deters poachers. The feature layers were superimposed in QGIS, and the score for each pixel was calculated by multiplying the scores of each layer. Known hotspots should receive higher scores, and other areas that score high indicate areas that require increased surveillance as it is predicted that poaching may occur more frequently in those areas than has been reported.

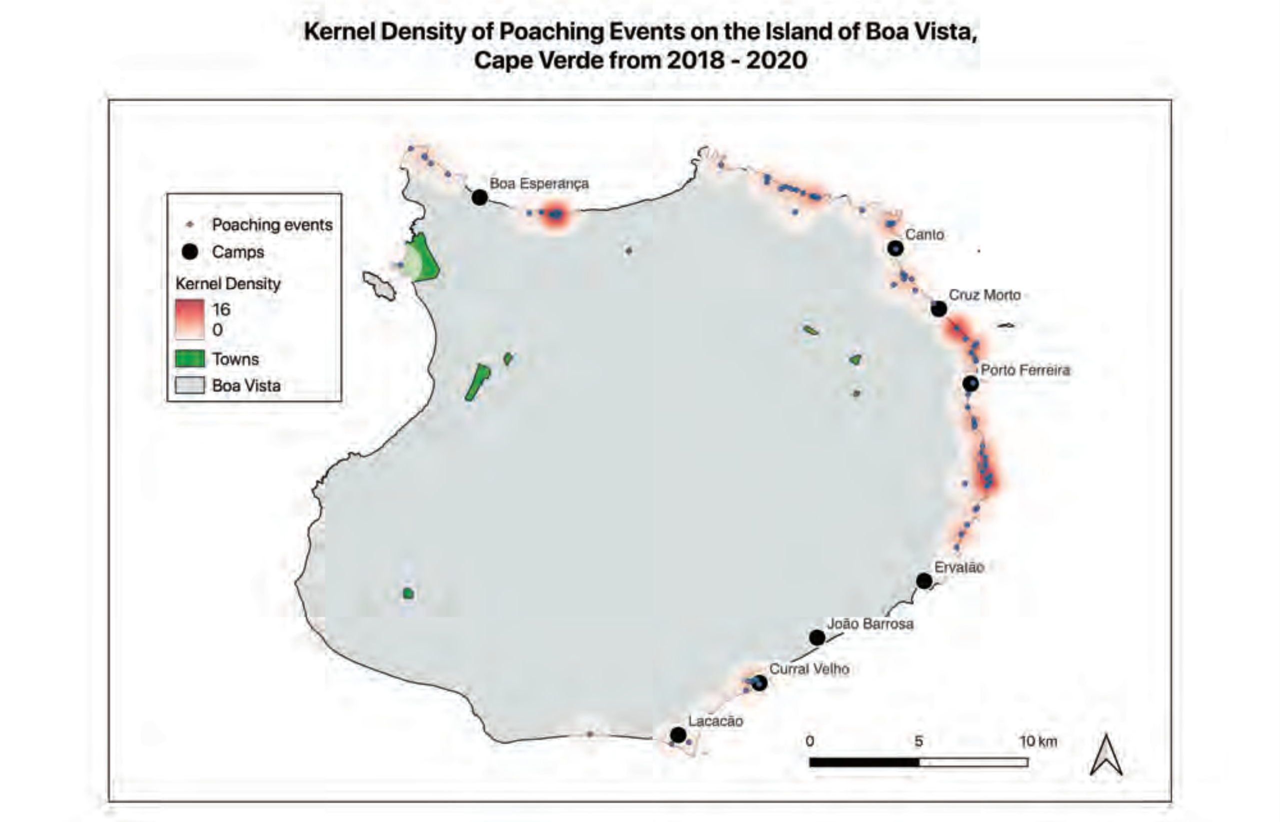

Figure 1: The Kernel Density map displays several hotspots of poaching activity. One of greatest concern is on the eastern coast of the island near the research camps of Cruz Morto and Porto Ferreira. Another can be seen on the northern coast near Boa Esperança.

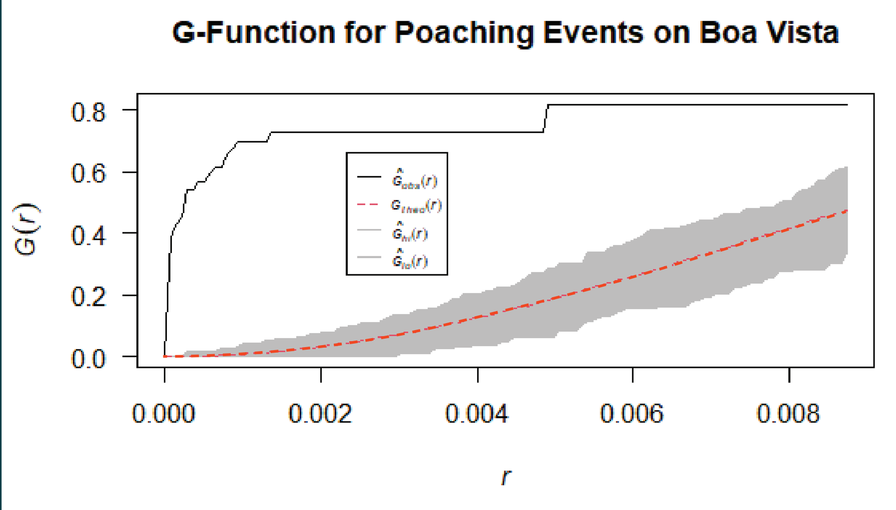

Figure 2: The steep increase indicates that the distribution of poaching incidents is clustered. The line of observed data differs from the random Poisson output at all points and falls outside of the Monte Carlo envelope, also indicating that the distribution is significantly clustered.

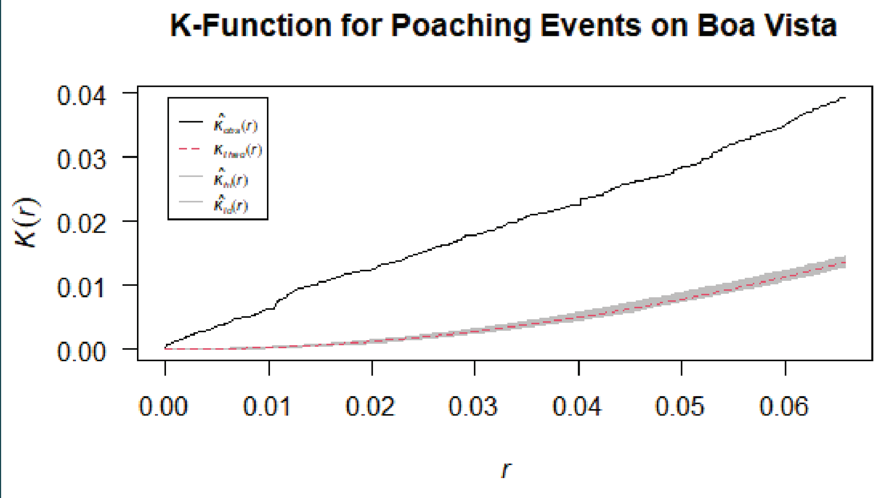

Figure 3: The observed K-Function output for the poaching point distribution differs from the random Poisson output and the Monte Carlo envelope, demonstrating significant clustering of the distribution.

Results and Discussion

Statistical analyses

The kernel density map in Fig. 1 revealed several poaching hotspots around the island and the distribution of points was visually clustered. The G and K function statistics confirmed that the data is indeed clustered, and therefore it is appropriate to continue with the spatial modeling. The graphs in Fig. 2 and 3 display that both the G and K Function results for the poaching point distribution were far above what could be expected from a randomly distributed set of points, even after 100 Monte Carlo simulations. The G-Function curve shows a steep increase over a short distance which is also indicative of a clustered dataset. The results of the logistic regression analysis, shown in Fig. 4, proved that all of the geographic features chosen have significant influence on the selection of poaching sites. Camps, roads, and hotels all showed a negative influence, meaning that poachers choose to avoid going to beaches in close proximity to these features. Towns on the other hand have a positive influence on site selection, meaning that it is preferable to choose beaches closer to home.

Interviews

The information gathered during the interviews was both informative for this project and for overall protection and conservation strategies on the island. The interviews revealed that the most important deciding factor for beach selection by poachers is its density of turtles. Distance from their town was not as important as the nesting abundance of the beach because they wanted to be certain to return with turtle meat. Interviewees confirmed the results of the logistic regression, indicating that they avoid major roads to elude law enforcement, contrary to what was originally hypothesized. The interviews also revealed that the drone team is an effective deterrent, admitting that they caused fear and uncertainty, however the team must take care to remain unpredictable, as predictability greatly reduces the deterrent effect. All of the participants said that they stopped poaching when they started working for NGOs protecting turtles. The change in attitude correlates with being given the opportunity to contribute to conservation directly. Building positive relationships between NGOs and communities, through capacity building, financial support for resource-generating activities, and including local community members in conservation efforts, has also contributed to a reduction in poaching in the past few years.

Weighted Overlay analysis

The results of the overlay modeling (Fig. 5) show consistency with the poaching hotspots visible in the kernel density map (Fig.1), despite not including any poaching data. The area of highest risk, and highest density of poaching in the past, is on the eastern coast of the island. This is due to the nesting abundance being far greater than the rest of the island and its close proximity to the three northern towns where poaching is more common. There are several stretches of beach where nesting data is unavailable due to lack of daily monitoring. This is also reflected in the distribution of poaching events. An area of possible interest in the south western coast of the island should be further investigated, as it is close to a small town but nesting abundance and dead turtle counts are ambiguous.

Figure 4: The results of the logistic regression analysis in R-Stat display that all of the geographic features selected have a significant influence on poaching site selection.

Coefficients:

	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	7.712e+00	1.524e+00	5.059	4.21e-07 ***
camps	-1.284e-03	2.131e-04	-6.024	1.70e-09 ***
hotels	-1.283e-04	6.073e-05	- 2.113	0.034564 *
roads	-9.545e-03	1.815e-03	-5.259	1.45e-07 ***
towns	3.883e-04	1.059e-04	3.667	0.000245 ***

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

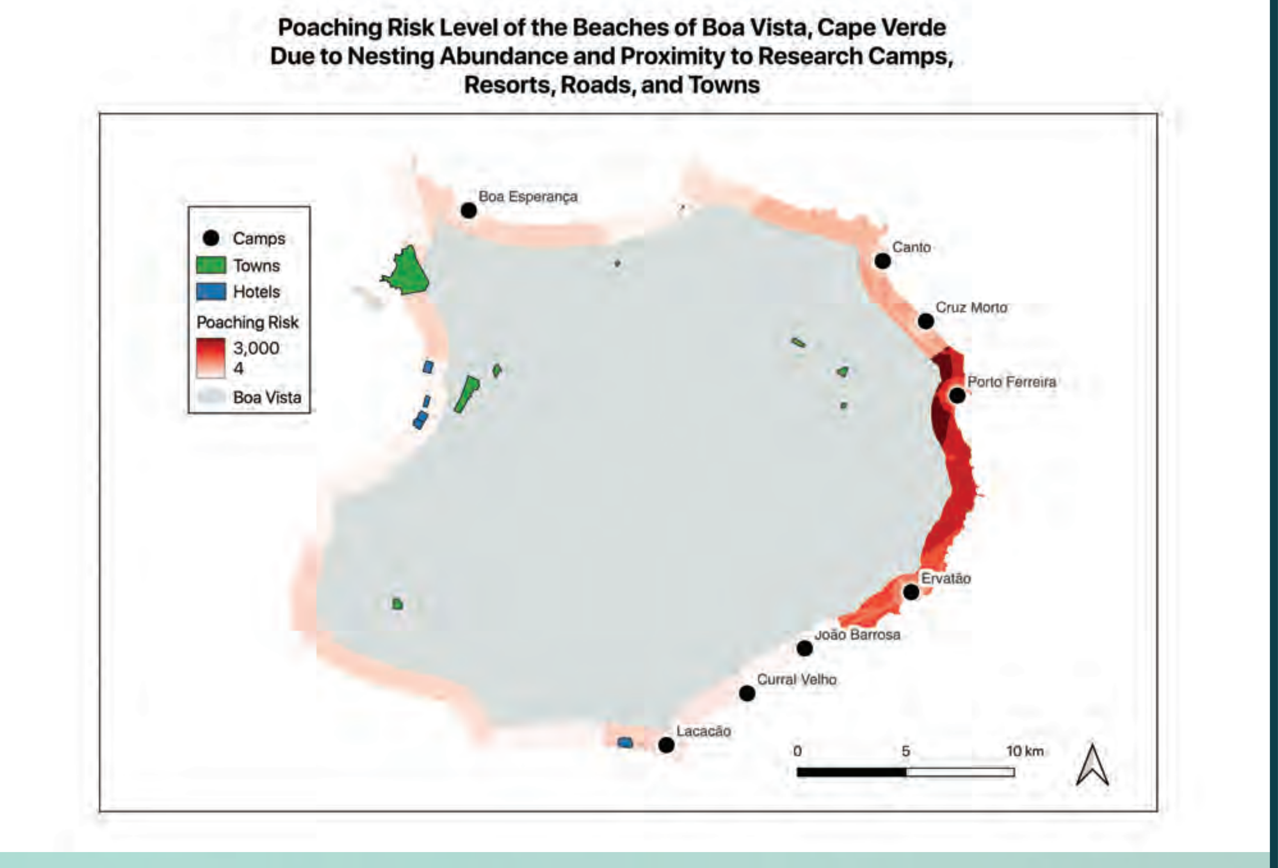

Figure 5: Weighted overlay output. The beaches predicted to be at highest risk of sea turtle poaching are the same as those hotspots in the Kernel Density map. There are a few beaches where nesting abundance data is deficient at this time therefore further research is required to complete the model.