Bathymetric Features as Predictors of Elephant Seal Rookeries

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Abstract

As the northern elephant seal *Mirounga angustirostris* population increases, new rookeries are being established in unexpected locations, posing a number of threats for humans, the elephant seals, and other animals. The goal of this study is to model rookery placement evaluating the hypothesis that rookeries are correlated with major bathymetric features. Logistic regression analyses were done using distance from rookeries to combinations of bathymetric variables including seamounts, banks, isobaths, and escarpments. Using Akaike Information Criterion (AIC) weights, our analyses suggest that rookeries are most likely to occur near seamounts/banks and the 400 m isobath. Akaike weight averages (importance values) indicate that the distance to seamounts and banks are the most important factors. Future studies can utilize our models to assess new rookery locations. This predictive ability may help guide local development policies and mitigate future conflicts.

Figure 1: Male elephant seal interacting with cattle near Piedras Blancas rookery.

Introduction

Northern elephant seal life history

Elephant seals spend the majority of their lives at sea but come to land to mate, give birth, and molt. The seals gather at rookeries (a.k.a. colonies) for these events. The species was nearly hunted to extinction in the 19th century (Stewart et al 1994) but is now increasing rapidly (Lowry et al 1996).

Population expansion = more rookeries

Rookeries used to be located exclusively on islands but have recently formed unexpectedly near developed areas, causing problems due to lack of human preparation. For example, elephant seals established a rookery adjacent to Highway One near San Simeon, CA in 1990 (see Figure 1).

Problems with elephant seals

Elephant seals are large, potentially dangerous animals, requiring management of humans and domesticated animals near rookeries to prevent undesirable incidents and physical harm (Figure 1). Epizootic diseases are of great concern for both the seals and other animals, including humans (Daszak et al 2000). Elephant seals are particularly at risk of disease due to their poor genetic diversity (Brownell et al 2000).

Utility of modeling rookeries

With the establishment of new rookeries it is important to learn which factors are correlated with rookery location, so we can develop a predictive model of rookery placement. Predictive models can guide coastal development policies and mitigate negative impacts.

Research Question

Are elephant seal rookeries randomly located or are they correlated with major bathymetric features?

Methods

Coordinates for each of the California rookeries were estimated. We generated 120 random coastal locations from available rookery habitat within California (Figure 2).

Tarsier Environmental Modeling Framework (Watson and Rahman 2002) was used for the bathymetric modeling process. From a bathymetry map we extracted vectors representing each seamount, bank, ridge, escarpment, 200 m, and 400 m isobaths along the California coast (Figure 2). Vectors were converted to distance rasters; each pixel in the rasters represents a physical location with a distance value for each bathymetric feature (Figure 3).

We fitted the data to 25 logistic regression models using R. Each model contained a different combination of variables (seamounts & banks, ridges & escarpments, 200 m isobath, 400 m isobath, and latitude). Akaike Information Criterion (AIC) weight values were calculated and compared to determine the best fit model (Burnham and Anderson 2002). Importance values for each variable were calculated (Burnham and Anderson 2002). Data from the two best fit models were standardized for comparison.

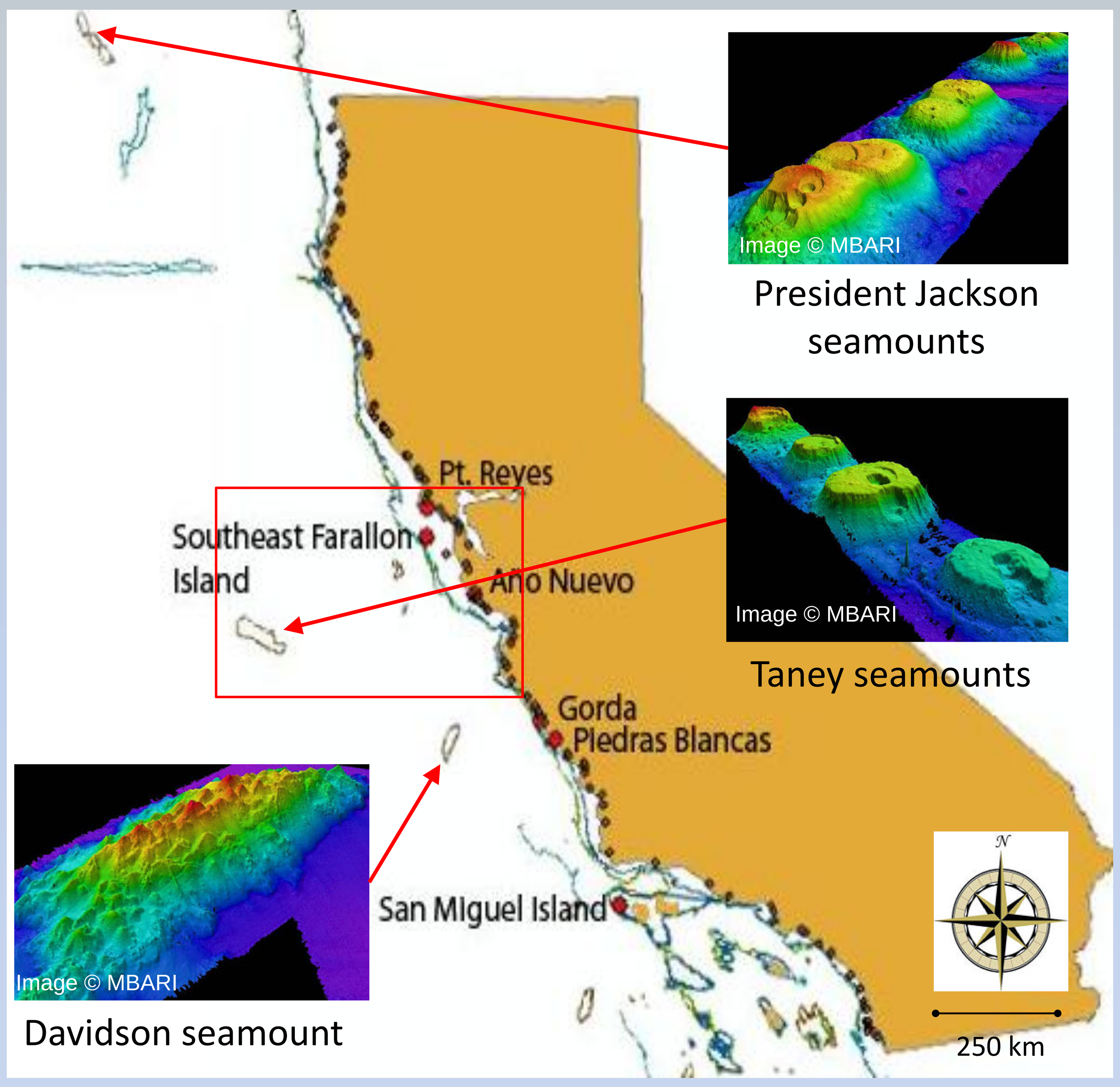
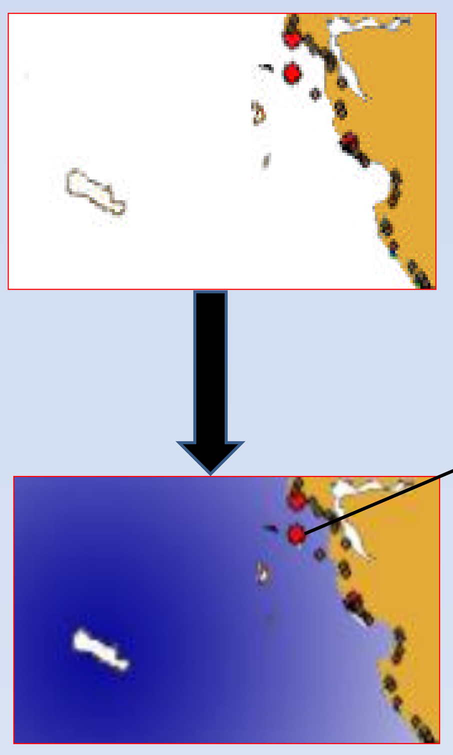


Figure 2: Map of California with rookeries (red circles), random coastal locations (green circles), seamounts, banks, escarpments, ridges, 200 m isobath, and 400 m isobath. Inset image enlarged below.

Figure 3: Distance Rasters

1) Map of bathymetric features and coastal locations.



2) Distance raster; color indicates distance (dark blue= closer to seamount and light blue= far from seamount).

ROOKERY	DISTANCE (m)
Piedras Blancas	127,457
Point Reyes	42,972
Farallon Island	43,599
Gorda	106,486
Año Nuevo	88,486
San Miguel Island	64,143

3) Color at a location was translated into a distance.

Results: AIC Weights

The best model (AIC weight 0.196) included the 400 m isobath and seamounts & banks (Table 1). Standardized coefficient values were -13.741 (400 m isobath) and -4.796 (seamounts & banks). The second best fit model (AIC weight 0.182) included the 200 m isobath and seamounts & banks (Table 1). The model with no relationship between rookery location and bathymetric features had a weight value of zero. Importance values for each variable were: seamounts/banks= 0.871, 400 m isobath= 0.572, 200 m isobath= 0.554, escarpments/ ridges= 0.342, and Northing= 0.262.

Model	AIC Weight	Variable(s)
12	0.196	B4+SM
11	0.182	B2+SM
17	0.102	N10+B4+SM
20	0.094	B2+SM+ES
22	0.068	B2+B4+SM
14	0.032	B2+ES
24	0.032	B2+B4+SM+ES
19	0.021	N10+B4+ES
25	0.016	N10+B2+B4+SM+ES
23	0.011	B2+B4+ES
7	0.004	N10+B2
5	0.001	SM
1	0.000	1
6	0.000	ES

Table 1: AIC weights for each model. SM= seamounts & banks, ES= escarpments & ridges, B4= 400m isobath, B2= 200m isobath, N10= Northing, 1= no variables.

Conclusions and Policy Implications

The model comparisons suggest that **elephant seal rookery placement is not random**; a short distance to seamounts, banks, the 200 m isobath, and the 400 m isobath are important factors for rookery location. Seamounts and banks were the most important variables, which highlights their ecological significance and provides support for their protection.

We imply that rookeries located near seamounts and banks may thrive because they provide rich food sources for naïve weaned pups. Adult elephant seals forage in the pelagic zone at depths below 400 m, and over the continental shelf and at the continental shelf break at depths less than 200 m (Le Boeuf and Laws 1994). Rookery location close to these depths would ensure nearby feeding areas.

In summary, the data strongly support models where proximity to a seamount and/or bank and the 400 m isobath is important to rookery location. Small rookeries should be assessed using this methodology to determine their likely success, allowing managers to preemptively implement measures to keep humans and seals safe and apart before problems arise.

Future Work

Future models could be refined by including rookeries on several islands off Baja; they were not assessed due to lack of bathymetry data. A more complete model could also include beach characteristics, degree of protection from waves, upwelling zones, and currents.

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