APPENDIX 2

Maxent Model Summary:

This section summarizes a Maxent model run as a companion analysis to the GAM presence-absence habitat prediction, of probability of occurrence, for Pink-footed Shearwaters. Maxent is used for modeling species niches and distributions. It estimates the distribution of a species by finding the distribution which has maximum entropy (i.e., is closest to geographically uniform) based on constraints (observations and environmental data) (Elith et al. 2011). The output can be interpreted as the predicted probability of occurrence and is a leading method for working with non-systematic species surveys (Phillips 2006). Because the Pink-footed Shearwater data are from presence-absence surveys, Maxent may not be the best modelling tool for this habitat prediction; therefore, GAM was the primary model used. However, in combination with a bias layer that accounts for survey effort, this model may still yield accurate predictions (Phillips et al 2009). Pink-footed Shearwater observations and spatial environmental data from 1992-2019 used for this analysis were identical to that used in the GAM model. All zero observations were filtered out with observation data as Maxent runs with presence data on a grid and assumes all grid cells with no point occurrences are "absent". The bias layer was constructed by building a kernel density estimation using the *Kernel Density* tool in ArcGIS pro 2.9.0, from the presence-absence points, using a 3 km radius. The environmental predictors included latitude, slope, tidal current speed, average sea surface temperature, average distance to SST fronts, being on or off the continental shelf, distance to the shelfbreak (200-m isobath), distance to marine canyons and depth. An analysis cell size of 4 km^2 was chosen for the study area. Using the same standardized variables selected for the final GAM models, with the additional bias layer, we used the package ENMeval package in R 4.0.5 to select the optimal model settings (Kass et al. 2021). Once selected, we loaded the points and layers into Maxent software 3.4.4 and manually adjusted our parameters to reflect what was recommended.

Model Parameters:

- Thresholds: Linear, Quadratic, and Hinge
- Regulization multiplier: 2.5
- Outputs: Logistic
- 10-fold cross-validation
- Model iterations: 10,000

Results:

The AUC value averaged at 0.87 based on the 10-fold cross-validation test (Figure S1), indicating good overall performance and strong underlying relationships between the environmental predictors and presence observations.

Latitude was found to be the most important predictor of habitat suitability for Pink-footed Shearwaters. This was followed by Depth, SHELF, SSTaverage, SHELFdist, FRONTSaverage, Canyon, Tidal, and finally, Slope (Table S1). The cumulative contribution of Latitude was 54.9% with the probability of occurrence declining as latitude increases. Depth had a cumulative contribution of 33.4%. As water depth becomes shallower, the probability of occurrence increases. Birds were more likely to occur on the shelf, and closer to the shelfbreak (Fig S2). The probability of occurrence increased as SST increased until about 11C, then began decreasing once more. SHELFdist, FRONTaverage, CANYON, Tidal and Slope all had contributions close to zero.

From the analysis of the Generalized Additive Model (GAM), it became evident that both the presence of the SHELF and the distance to the SHELF played crucial roles. These factors appeared to hold greater importance compared to other variables. Interestingly, the relationship observed between the average Sea Surface Temperature (SST) front and the GAM was found to be somewhat contradictory. The GAM indicated a different relationship than what was expected based on the SST front average. However, when examining the relationship using the maximum entropy (maxent) approach, it appeared to be very weak. Despite these variations, the overall prediction maps displayed striking similarities (Fig S3; Fig 7). Nevertheless, the significance placed on the SHELF by the GAM model was evidently mirrored in the predictions, suggesting that this factor primarily contributed to the observed differences.

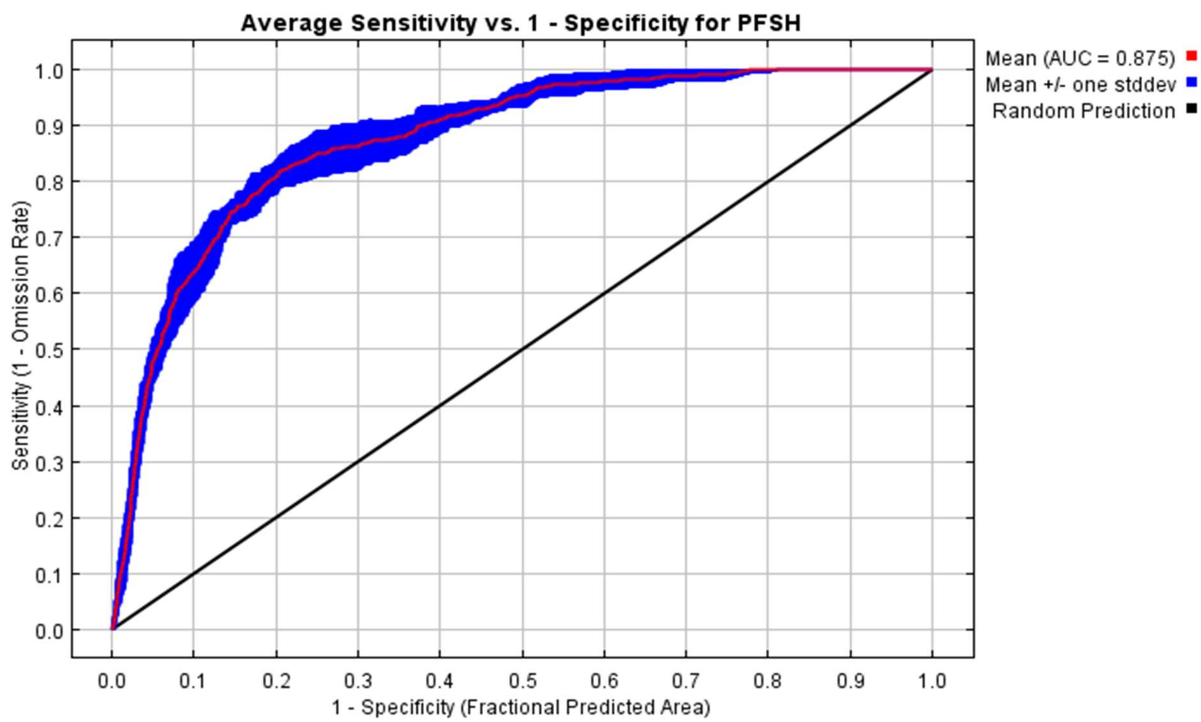

Figure A1 Receiver operator characteristic curve for the Maxent Pink-footed Shearwater model, based on presence data derived from at-sea survey data collected between 1992 and 2019.

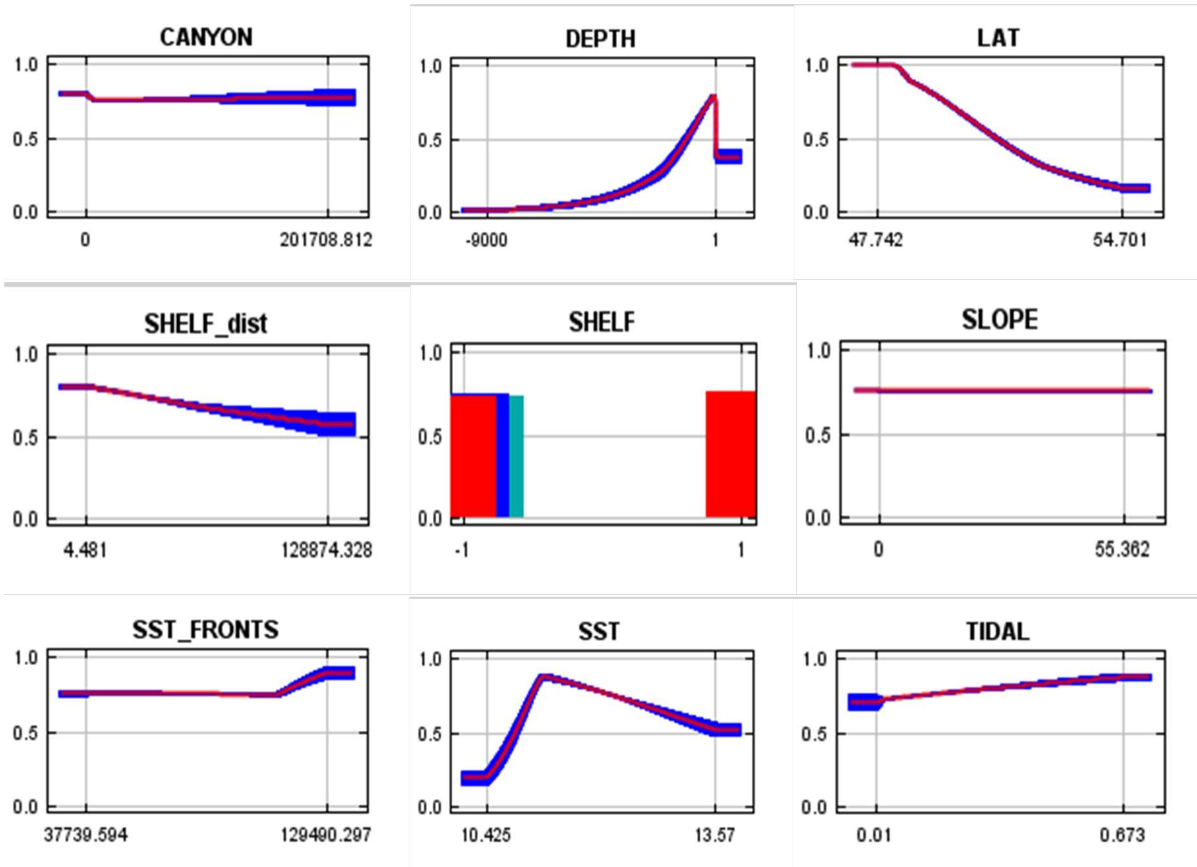

Figure A2 Response curves characterizing how each environmental variable affected the Maxent predictions.

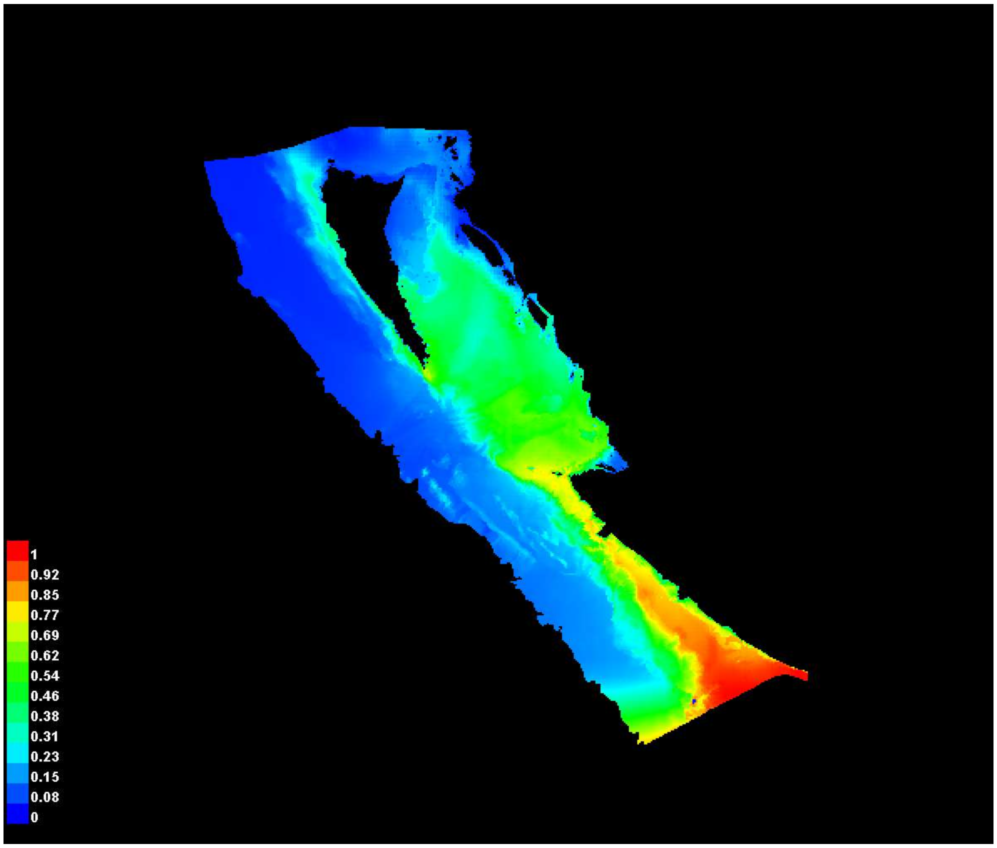

Figure A3 Predicted surface of probability of Pink-footed Shearwater presence in Canadian waters. Area in red show highest suitability, green indicates an intermediate suitability and areas in blue lower suitability.

TABLE A1. Estimates of relative contributions of environmental predictors to the Maxent model.

Variable	**Percent contribution**	**Permutation Importance**
LAT	54.9	53.5
Depth	33.4	36.9
SHELF	6	0.2
$SST_{average}$	3.8	6.9
$SHELF_{dist}$	0.8	1.7
$FRONTS_{average}$	0.6	0
Canyon	0.3	0.1
Tidal	0.2	0.7
Slope	0	0

References

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Kass JM, Muscarella R, Galante PJ, Bohl CL, Pinilla-Buitrago GE, Boria RA, Anderson RP. 2021. ENMeval 2.0: Redesigned for customizable and reproducible modeling of species’ niches and distributions. *Methods in Ecology and Evolution* 12:1602–1608.