**Supplementary Material**

**Defining humpback whale (*Megaptera novaeangliae*) potential distribution in the Great Barrier Reef Marine Park: a two-way approach**

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# Supporting Information

*Table S1: ENMevaluate Results for Model C. The optimal model, indicated in bold, exhibits the lowest AICc, with a RM of 0.5 and the feature class combination LQH. Delta AICc denotes the difference between the AICc of each model and the smallest AICc across all models. FC (Feature Class), RM (Regularization Multiplier), AICc (Corrected Akaike Information Criterion).*

| Model ID | FC | RM | AICc | delta.AICc |
|---|---|---|---|---|
| 1 | L | 0.5 | 2886.554 | 87.10503 |
| 2 | LQ | 0.5 | 2852.066 | 52.6171 |
| 3 | H | 0.5 | 2813.013 | 13.56488 |
| 4 | LQH | 0.5 | 2799.449 | 0 |
| 5 | LQHP | 0.5 | 2810.247 | 10.79846 |
| 6 | LQHPT | 0.5 | 2851.962 | 52.51358 |
| 7 | L | 1.5 | 2886.848 | 87.39944 |
| 8 | LQ | 1.5 | 2890.566 | 91.11723 |
| 9 | H | 1.5 | 2824.764 | 25.31548 |
| 10 | LQH | 1.5 | 2808.93 | 9.48097 |
| 11 | LQHP | 1.5 | 2818.234 | 18.7853 |
| 12 | LQHPT | 1.5 | 2817.673 | 18.22488 |
| 13 | L | 2.5 | 2887.402 | 87.95355 |
| 14 | LQ | 2.5 | 2889.166 | 89.71704 |
| 15 | H | 2.5 | 2825.565 | 26.11633 |
| 16 | LQH | 2.5 | 2808.779 | 9.330468 |
| 17 | LQHP | 2.5 | 2816.363 | 16.91487 |
| 18 | LQHPT | 2.5 | 2821.745 | 22.29627 |
| 19 | L | 3.5 | 2888.207 | 88.75827 |
| 20 | LQ | 3.5 | 2890.172 | 90.72315 |
| 21 | H | 3.5 | 2839.108 | 39.65949 |
| 22 | LQH | 3.5 | 2813.149 | 13.70019 |
| 23 | LQHP | 3.5 | 2821.235 | 21.78683 |
| 24 | LQHPT | 3.5 | 2822.73 | 23.28091 |

*Table S2: ENMevaluate Results for Model D. The optimal model, indicated in bold, exhibits the lowest AICc, with a RM of 0.5 and the feature class combination LQH. Delta AICc denotes the difference between the AICc of each model and the smallest AICc across all models. FC (Feature Class), RM (Regularization Multiplier), AICc (Corrected Akaike Information Criterion).*

| Model ID | FC | RM | AICc | delta.AICc |
|---|---|---|---|---|
| 1 | L | 0.5 | 3872.803 | 85.73958 |
| 2 | LQ | 0.5 | 3845.644 | 58.5805 |
| 3 | H | 0.5 | 3840.337 | 53.27367 |
| 4 | LQH | 0.5 | 3806.982 | 19.91861 |
| 5 | LQHP | 0.5 | 3808.669 | 21.60565 |
| 6 | LQHPT | 0.5 | 3826.447 | 39.38378 |
| 7 | L | 1.5 | 3873.16 | 86.09699 |
| 8 | LQ | 1.5 | 3873.352 | 86.28944 |
| 9 | H | 1.5 | 3807.663 | 20.59966 |
| 10 | LQH | 1.5 | 3787.063 | 0 |
| 11 | LQHP | 1.5 | 3791.433 | 4.369695 |
| 12 | LQHPT | 1.5 | 3791.273 | 4.210336 |
| 13 | L | 2.5 | 3873.848 | 86.78545 |
| 14 | LQ | 2.5 | 3874.273 | 87.20971 |
| 15 | H | 2.5 | 3809.146 | 22.08329 |
| 16 | LQH | 2.5 | 3787.086 | 0.022679 |
| 17 | LQHP | 2.5 | 3792.218 | 5.155453 |
| 18 | LQHPT | 2.5 | 3788.68 | 1.61729 |
| 19 | L | 3.5 | 3874.834 | 87.77076 |
| 20 | LQ | 3.5 | 3875.617 | 88.55373 |
| 21 | H | 3.5 | 3814.354 | 27.29131 |
| 22 | LQH | 3.5 | 3793.891 | 6.827699 |
| 23 | LQHP | 3.5 | 3794.306 | 7.242731 |
| 24 | LQHPT | 3.5 | 3791.608 | 4.544829 |
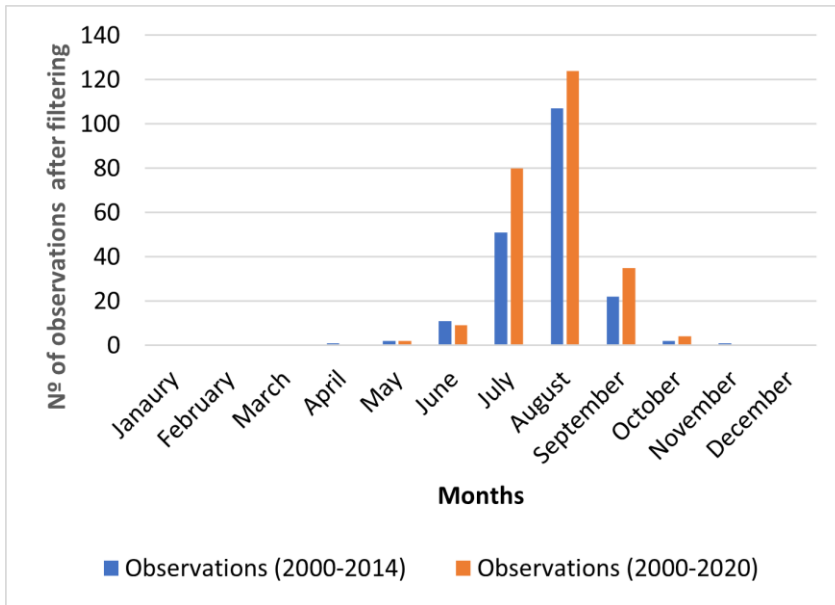
*Figure S1: Monthly distribution of HW sightings within the GBRMP after filtering, comparing the periods 2000-2014 (Blue) and 2000-2020 (Orange). A total of 3,682 (93.5%) records were removed from the 2000-2020 dataset, leaving 254 records.*
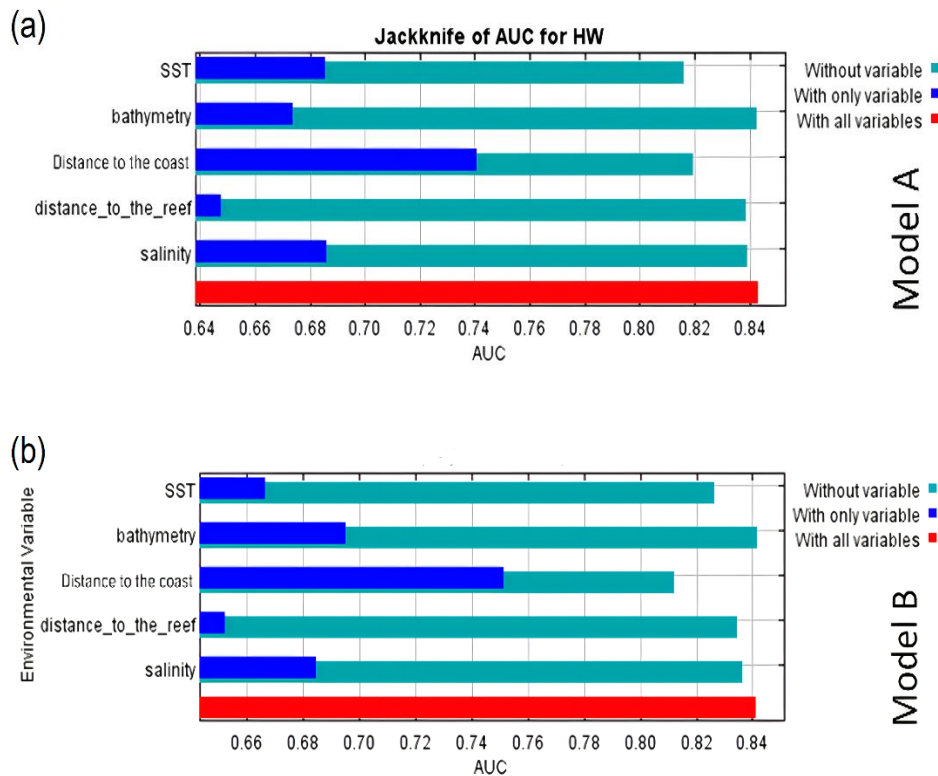


*Figure S2: Results of the jackknife test of variable importance to AUC for (a) Model A and (b) Model B. Blue bars represent the AUC values when each model uses only a single variable. Turquoise bars depict the*

AUC values when each model removes a single variable from the general model. Red bars represent the average AUC value across all test iterations for each model.
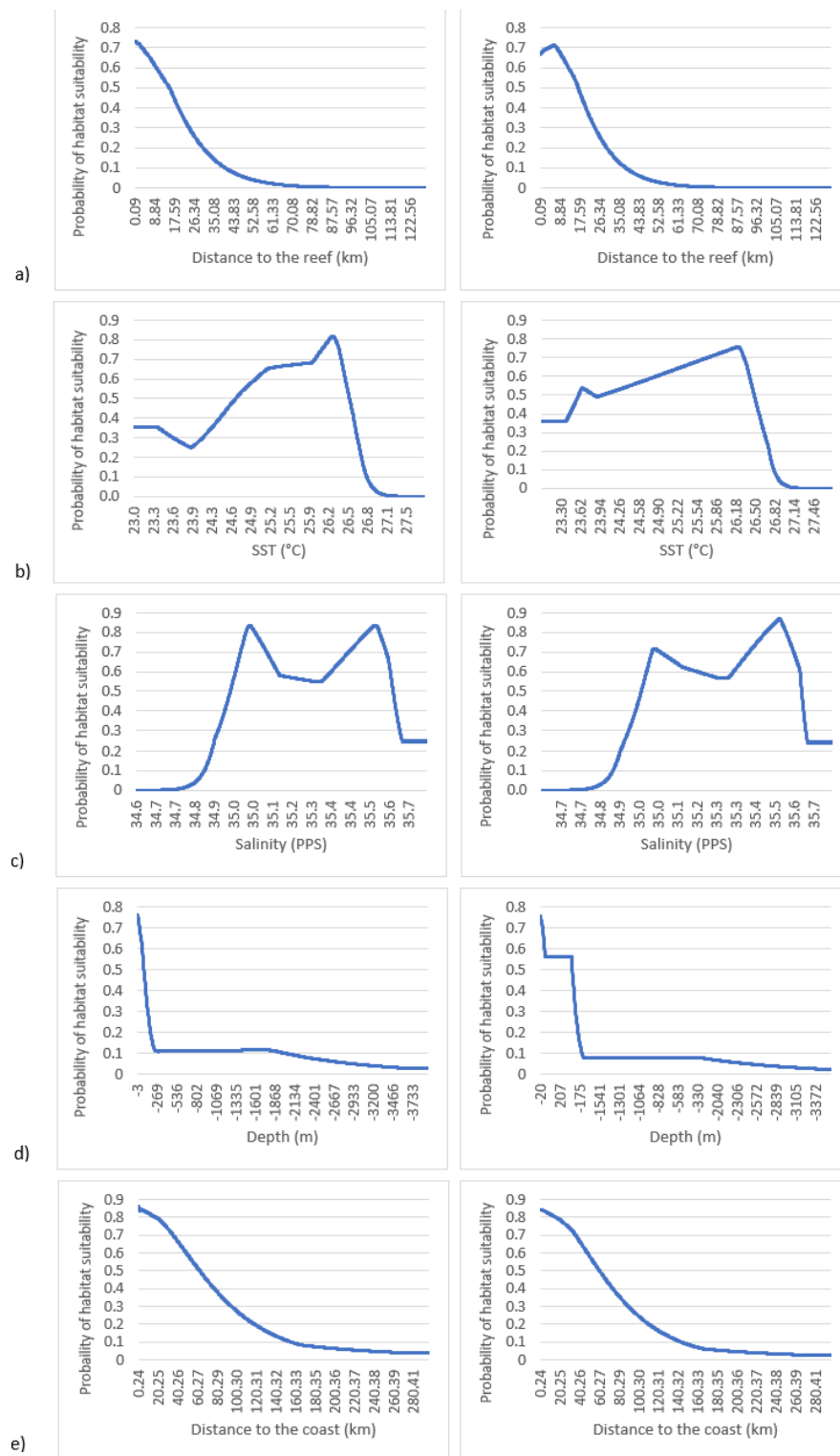


Figure S3: Response curves from Maxent for Model A (left) and Model B (right). These curves show how the shape of the response changes for a given variable, using only one variable at a time. Each of the graphs illustrates the relationship between the environmental

*suitability for Humpback whales (y-axis) and (a) Distance to the reef, (b) SST, (c) Salinity, (d) Bathymetry, (e) Distance to the coast, in the x-axes.*
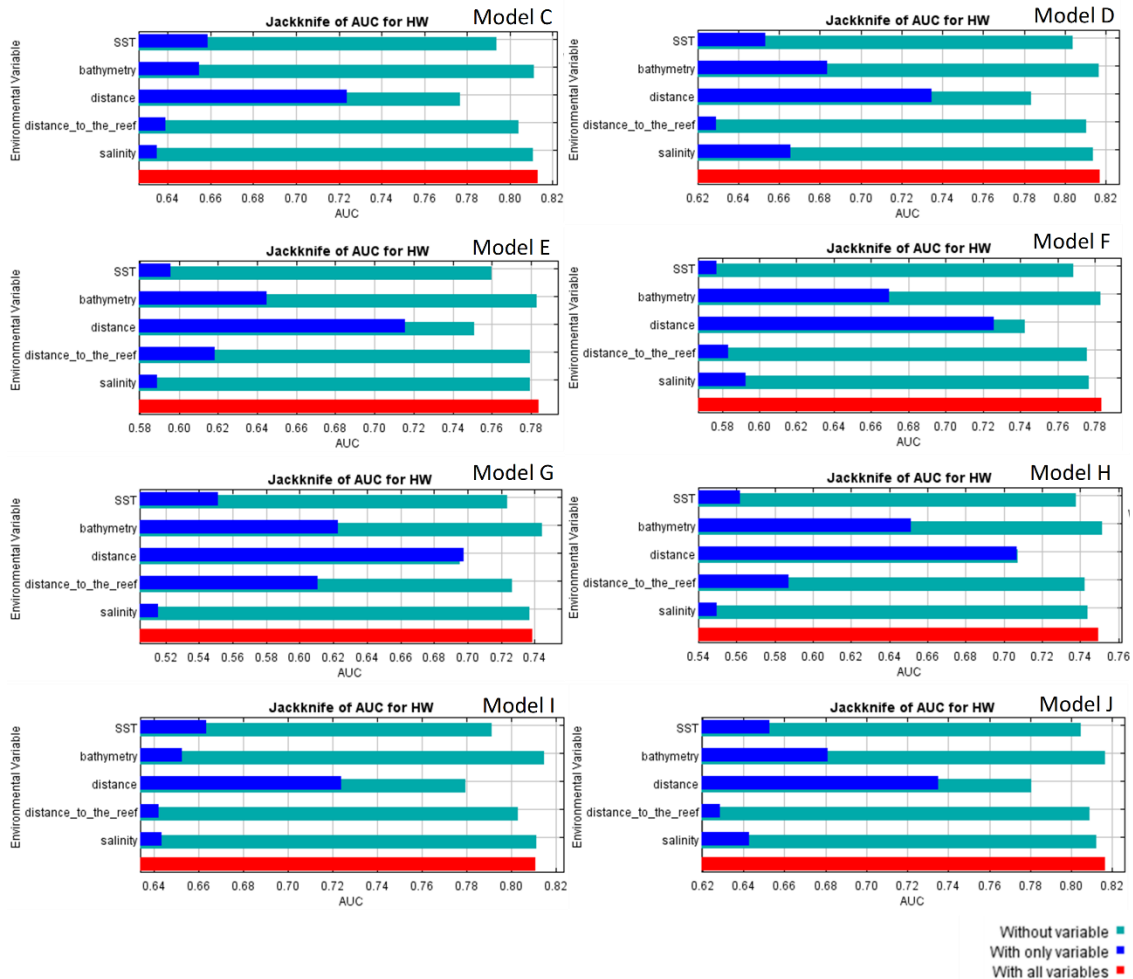


*Figure S4: Results of the jackknife test of variable importance for models C-H. Blue bars show each model's results using only a single variable; turquoise bars show each model's results when removing a single variable from the general model; red bars show each model's AUC results.*
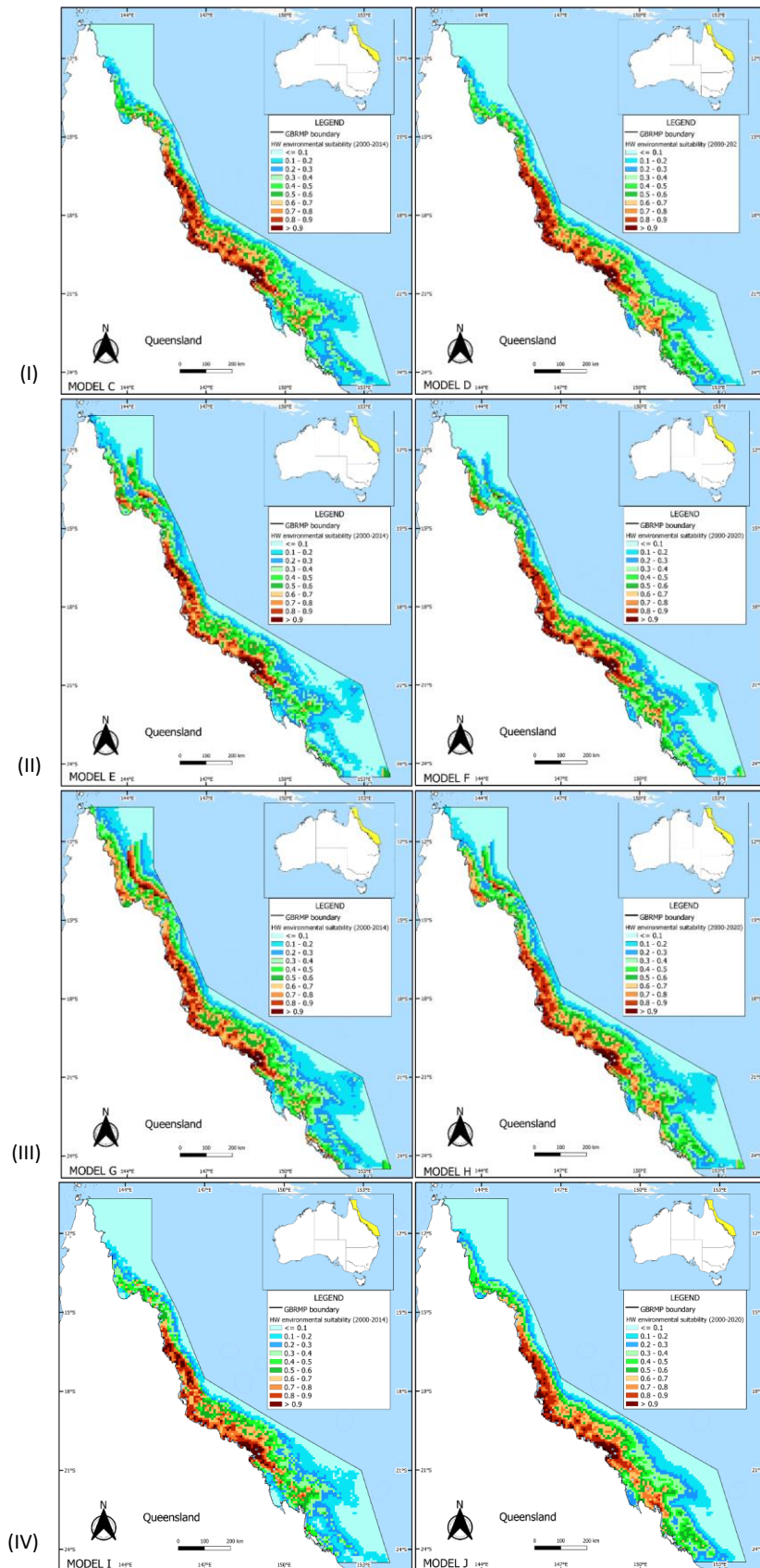
*Figure S5: Environmental suitability for HW in the GBRMP with (I) spatial rarefying, (II) bias file in Maxent, (III) two correcting methods, (IV) after tuning. Colour scale denotes habitat suitability ranging from 0 (light blue) to 1 (dark red). Models based on sightings between 2000 and 2014 (Models C, E, G, and*

*I) showed slightly smaller areas of high environmental suitability (>0.7) along the east coast of the GBRMP compared to those using data from 2000 to 2020 (Models D, F, H, and J). Furthermore, models E to H showed larger areas of habitat suitability above 0.5 between latitudes 12ºS to 15ºS than models C, D, I and J. Models with both bias corrections exhibited the broadest distribution among models C to J.*
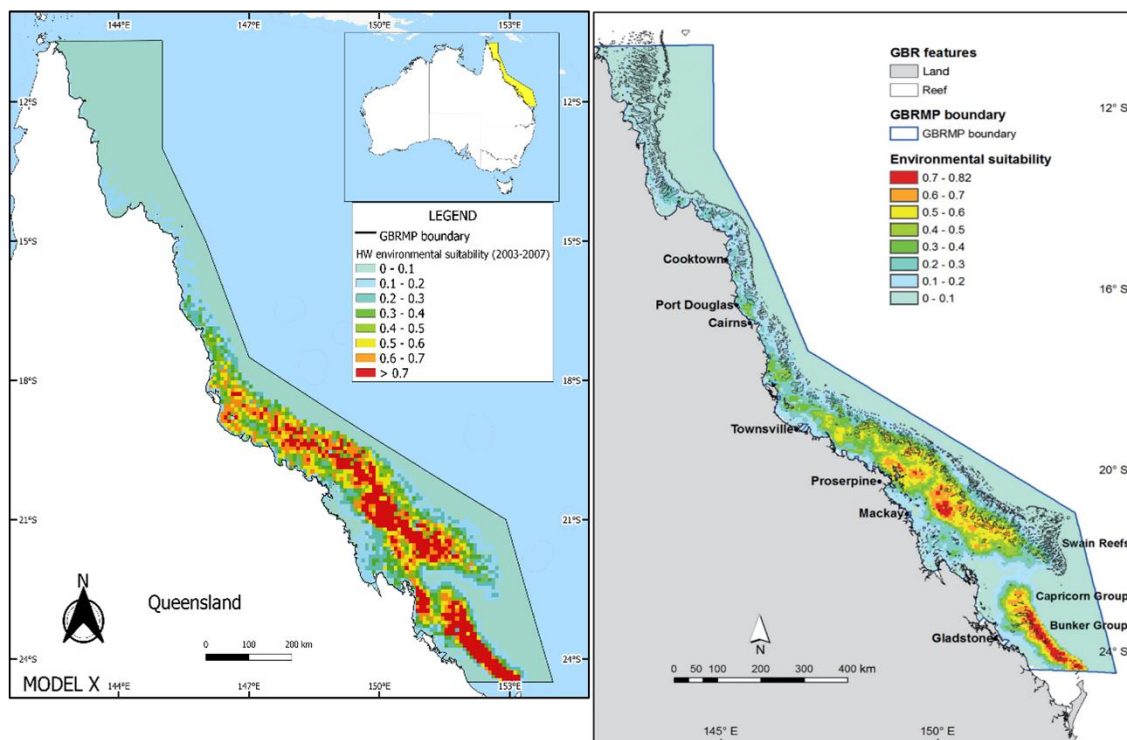


*Figure S6: Environmental suitability for HW in the GBRMP between 2003 to 2007. Model prediction of average environmental suitability using an approximation of the BPC dataset and the environmental predictors SST, Sal, Bathy, DC, and DR (Left). Model prediction of average environmental suitability developed in research from Smith et al. (2012), including sightings of HWs from the BPC aerial surveillance program and the environmental variables of Bathy, SST, DC and seafloor slope (Right).*
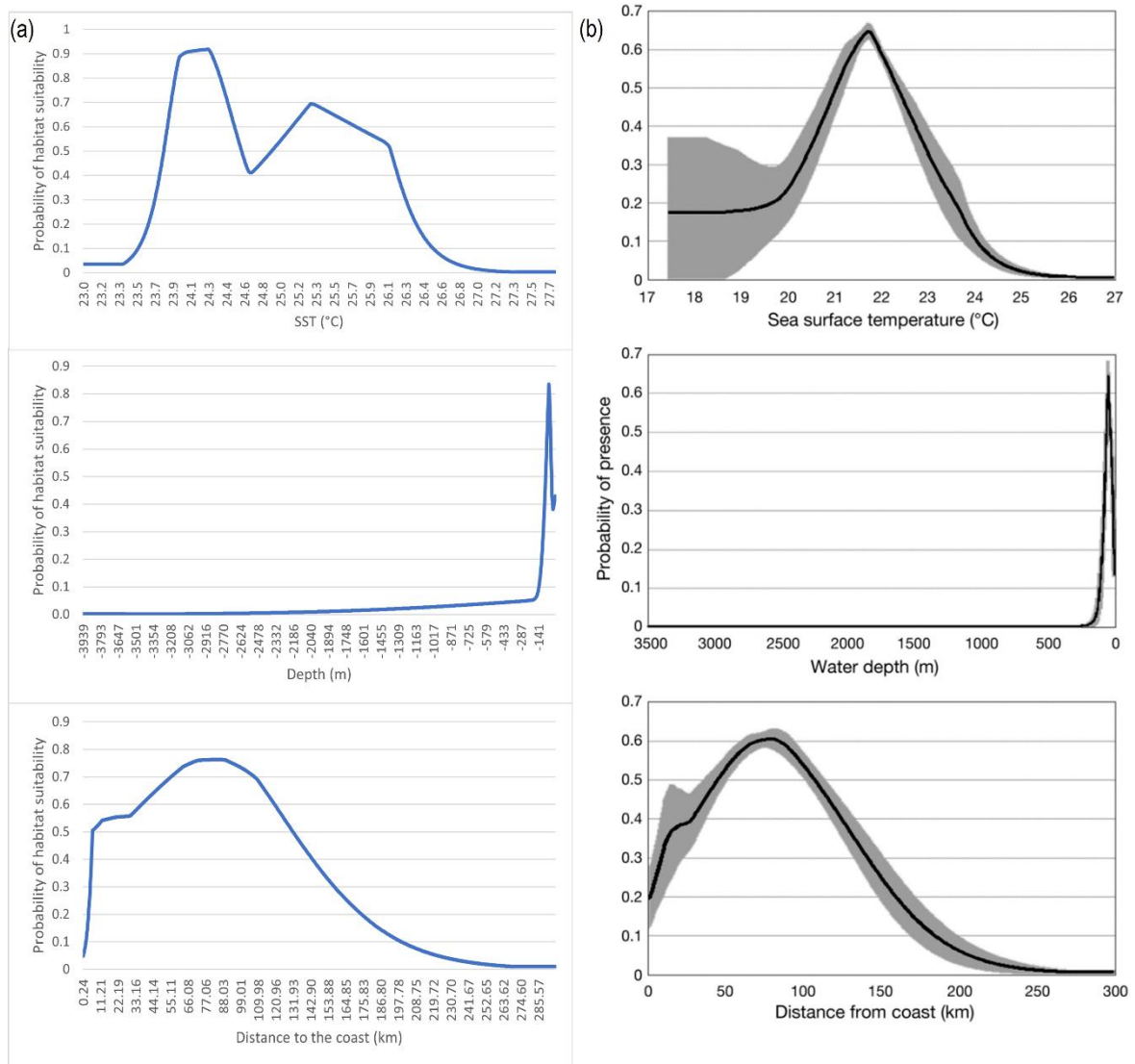
*Figure S7: Response curves depicting the relationship between the predicted probability of humpback whale occurrence and three environmental variables—SST, Bathymetry, and Distance to the coast. (a) Response curves for Model X. (b) Response curves for Smith et al.'s (2012) model.*
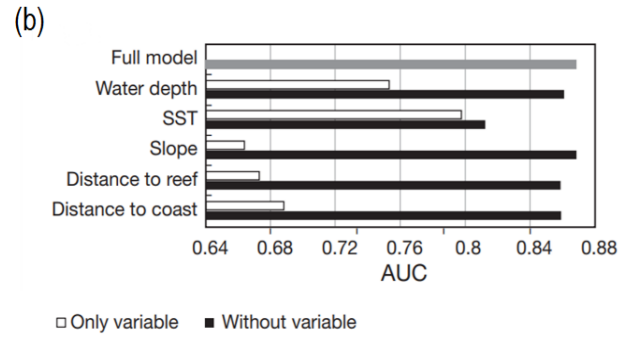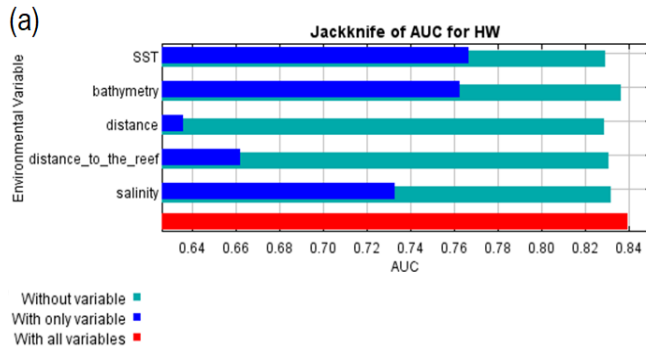
*Figure S8: Variable contributions from the jack-knife test to AUC of the (a) Model X and (b) Model by Smith et al. (2012) research. Blue/white bars represent the AUC values when each model uses only a single variable. Turquoise/black bars depict the AUC values when each model removes a single variable from the general model. Red/grey bars represent the average AUC value across all test iterations for each model.*
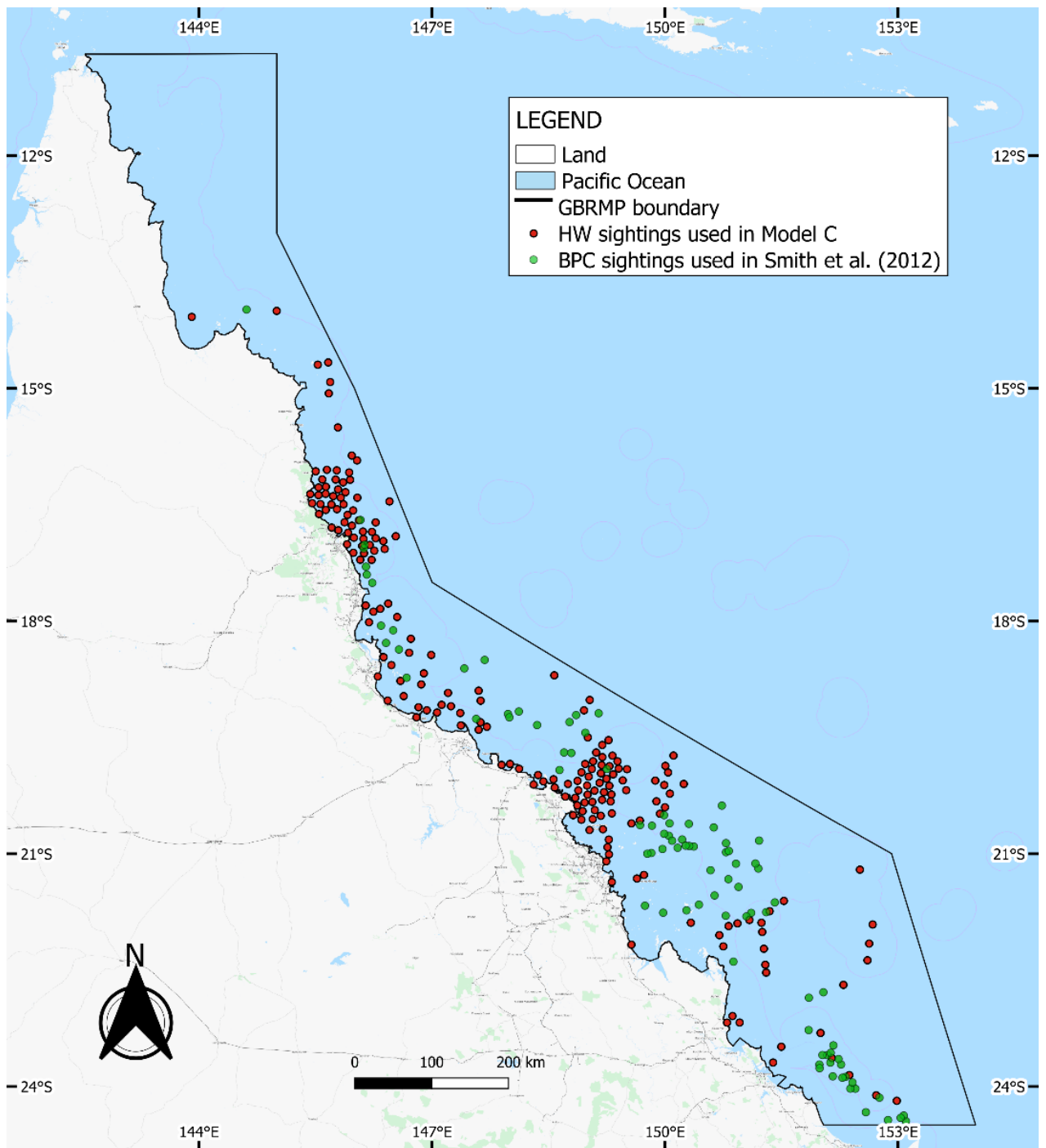
*Figure S9: Distribution of HW sightings as utilized in Model C, compared to Smith et al. (2012) within GBRMP.*