

Supporting information for:

Fin whale (*Balaenoptera physalus*) distribution modeling on their Nordic and Barents Seas feeding grounds. Marine Mammal Science

Diandra Duengen , Elke Burkhardt  & Ahmed El-Gabbas  *

Ocean Acoustics Group, Alfred-Wegener-Institut (AWI),

Helmholtz-Zentrum für Polar und Meeresforschung

* To whom correspondence should be addressed. E-Mail: ahmed.el-gabbas@awi.de

Table S1: Reference list of RV Polarstern cruises with fin whale sightings used in this study.

Cruise	Details
PS 115/1	Burkhardt E (2020) Whale sightings during Polarstern cruise PS115/1. PANGAEA. https://doi.org/10.1594/PANGAEA.924582
PS 115/2	Burkhardt E (2020) Whale sightings during Polarstern cruise PS115/2. PANGAEA. https://doi.org/10.1594/PANGAEA.924569
PS 108	Burkhardt E (2020) Whale sightings during Polarstern cruise PS108 (ARK-XXXI/3). PANGAEA. https://doi.org/10.1594/PANGAEA.924585
PS 107	Burkhardt E (2020) Whale sightings during Polarstern cruise PS107 (ARK-XXXI/2). PANGAEA. https://doi.org/10.1594/PANGAEA.924587
PS 100	Burkhardt E (2020) Whale sightings during Polarstern cruise PS100 (ARK-XXX/2). PANGAEA. https://doi.org/10.1594/PANGAEA.924701
PS 99/2	Burkhardt E (2020) Whale sightings during Polarstern cruise PS99.2 (ARK-XXX/1.2). PANGAEA. https://doi.org/10.1594/PANGAEA.924702
PS 99/1	Burkhardt E (2020) Whale sightings during Polarstern cruise PS99.1 (ARK-XXX/1.1). PANGAEA. https://doi.org/10.1594/PANGAEA.924703
PS 94	Burkhardt E (2020) Whale sightings during Polarstern cruise PS94 (ARK-XXIX/3). PANGAEA. https://doi.org/10.1594/PANGAEA.924704
PS 93/2	Burkhardt E (2020) Whale sightings during Polarstern cruise PS93.2 (ARK-XXIX/2.2). PANGAEA. https://doi.org/10.1594/PANGAEA.924705
PS 93/1	Burkhardt E (2020) Whale sightings during Polarstern cruise PS93.1 (ARK-XXIX/2.1). PANGAEA. https://doi.org/10.1594/PANGAEA.924706
PS 92	Burkhardt E (2020) Whale sightings during Polarstern cruise PS92 (ARK-XXIX/1). PANGAEA. https://doi.org/10.1594/PANGAEA.924707
PS 87	Burkhardt E (2020) Whale sightings during Polarstern cruise PS87 (ARK-XXVIII/4). PANGAEA. https://doi.org/10.1594/PANGAEA.924708
PS 86	Burkhardt E (2020) Whale sightings during Polarstern cruise PS86 (ARK-XXVIII/3). PANGAEA. https://doi.org/10.1594/PANGAEA.924709
PS 85	Burkhardt E (2020) Whale sightings during Polarstern cruise PS85 (ARK-XXVIII/2). PANGAEA. https://doi.org/10.1594/PANGAEA.924710
PS80/2	Burkhardt E (2021): Whale sightings during POLARSTERN cruise ARK-XXVII/2 (PS80/2). PANGAEA. https://doi.org/10.1594/PANGAEA.929095
PS 70	Burkhardt E (2020) Whale sightings during Polarstern cruise ARK-XXII/1c. PANGAEA. https://doi.org/10.1594/PANGAEA.924715
PS 70	Burkhardt E (2020) Whale sightings during Polarstern cruise PS ARK XXII/1a. PANGAEA. https://doi.org/10.1594/PANGAEA.924717
PS 72	Burkhardt E (2020) Whale sightings during Polarstern cruise ARK-XXIII/2. PANGAEA. https://doi.org/10.1594/PANGAEA.924713

Table S2: Variable transformations and variance inflation factor (VIF) values for final environmental variables used in the model (sd = standard deviation). For more information, see Table 1.

Variable	Transformation	VIF
Aspect		1.06
Bathymetry		3.27
Slope		1.17
Distance to Shore		2.82
Distance to 500 m isobath	square root	3.53
SSH sd	inverse	3.28
Current speed	natural log	2.07
SIC		2.64
Distance to sea ice edge		2.59
Salinity 0 sd	natural log	2.63
Salinity 100 m		2.18
Temp 0 sd		3.00
Temp 100 sd	natural log	1.80
Chlorophyll-a sd		1.38

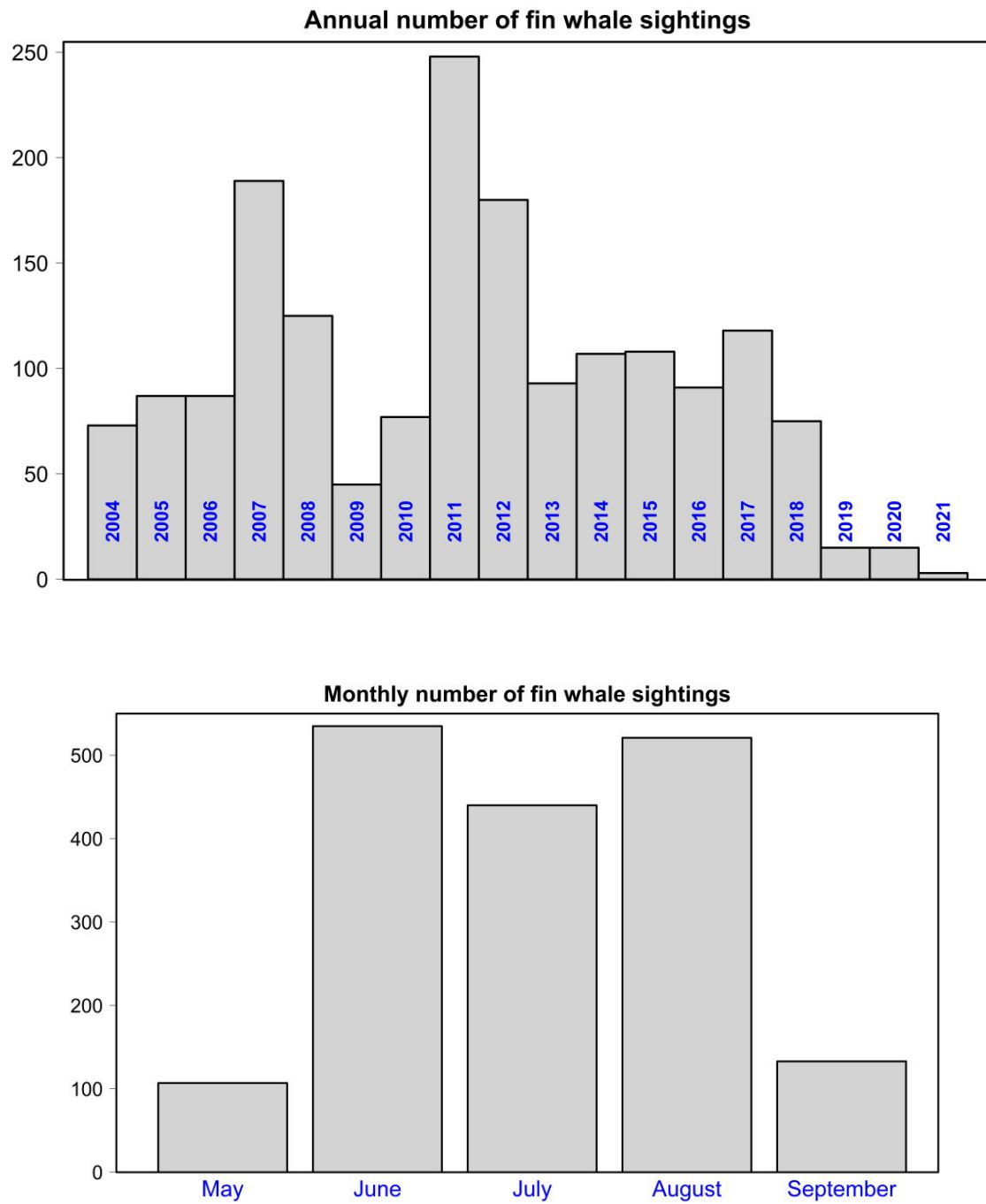


Figure S1: The number of quality-controlled fin whale sightings per year and month.

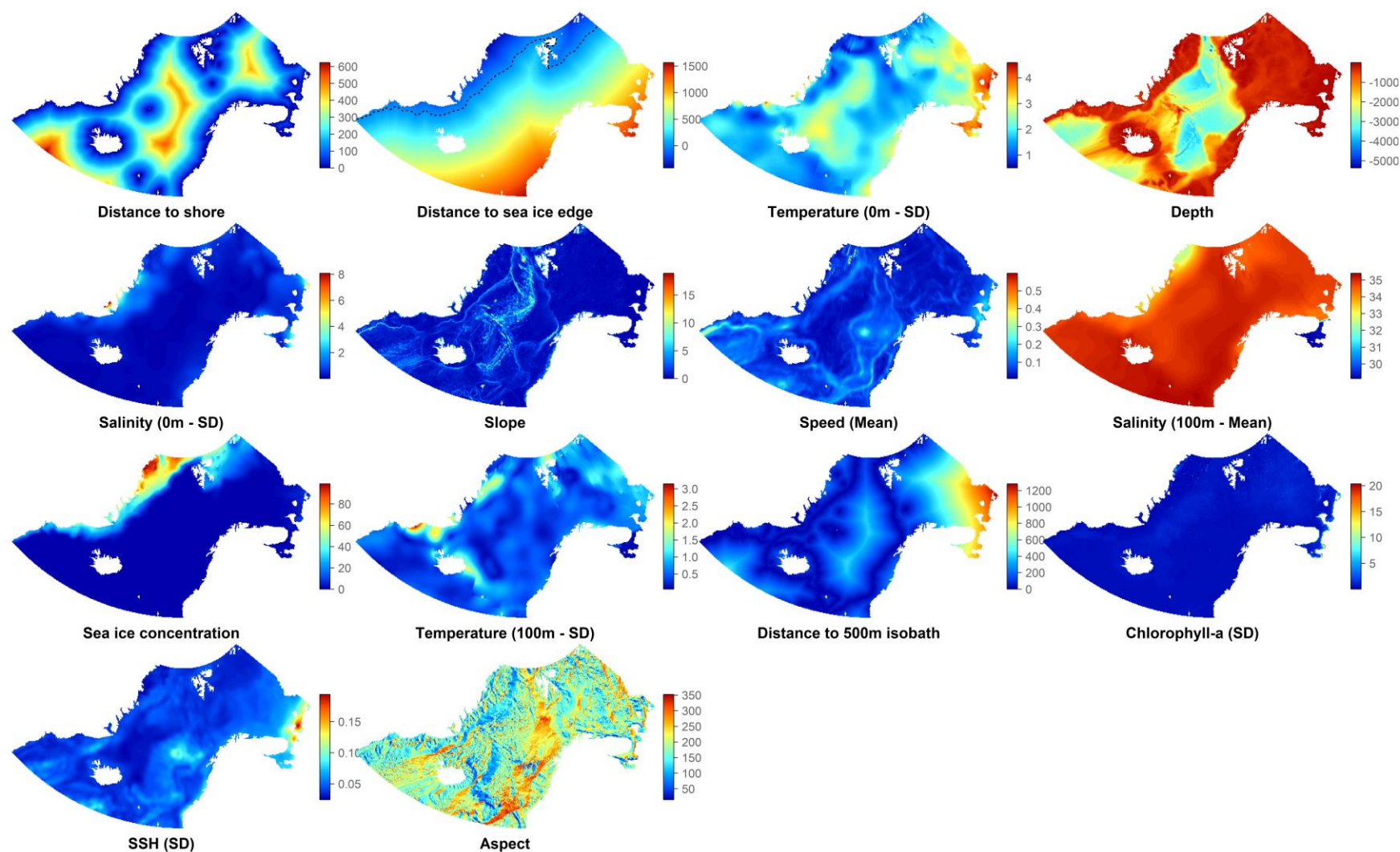


Figure S2: Maps for the 14 environmental variables used in the models. The dashed line in the second map depicts the mean location of the sea ice edge during summer. See Table 1 for more information on data sources, units and spatiotemporal resolution of original environmental predictors.

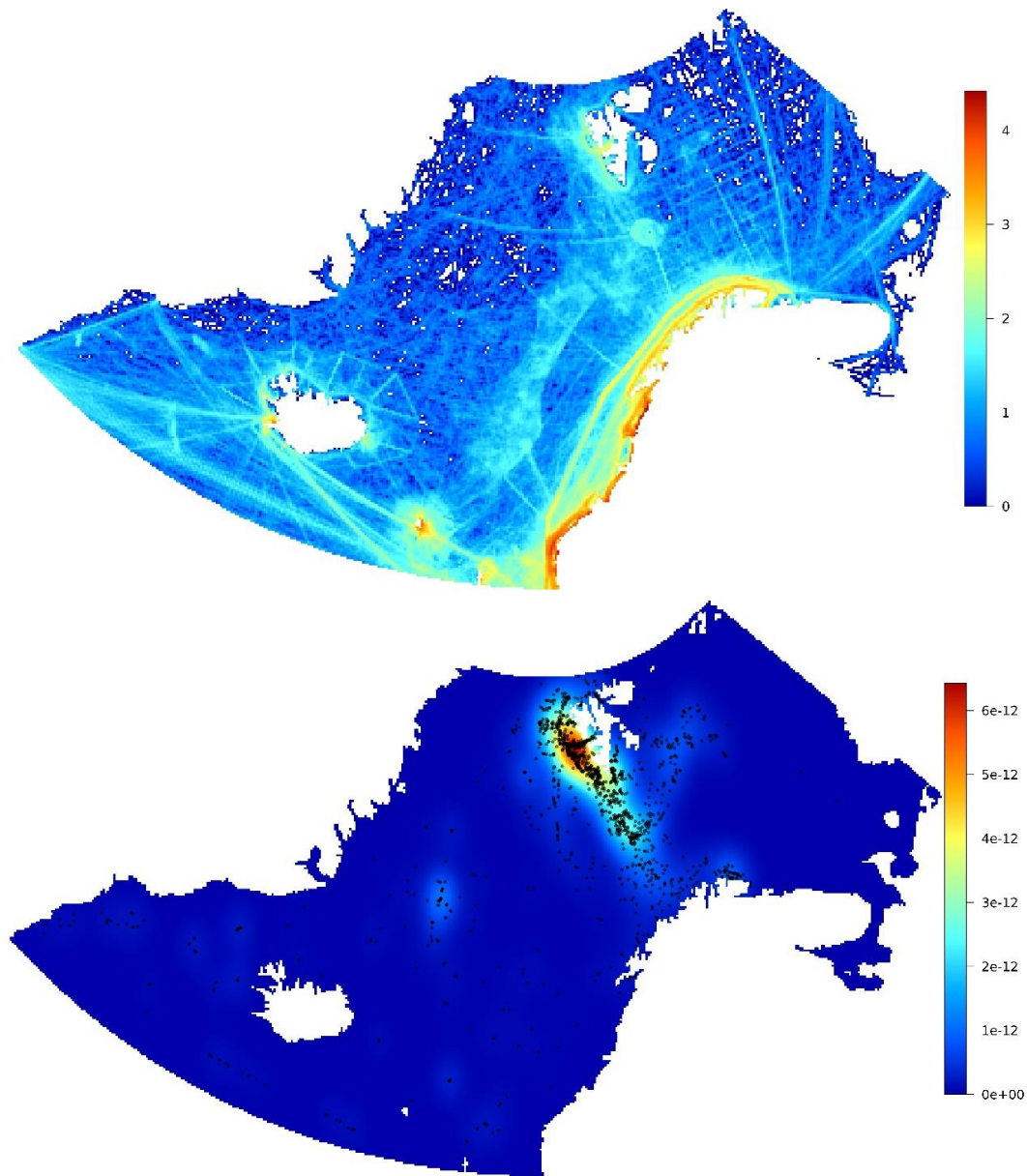


Figure S3: The estimated pattern of sampling efforts in the Nordic and Barents Seas. The first map represents the $\log_{10}$ number of ship tracks per cell (May to September 2004-2021). This map was used as a bias predictor in $\text{model}_{\text{effortTracks}}$. The second map showed the kernel density estimate for fin whale sightings. This map was used in $\text{model}_{\text{effortFW}}$ as a bias grid; i.e., background locations are sampled from the study area using this layer as sampling weight.

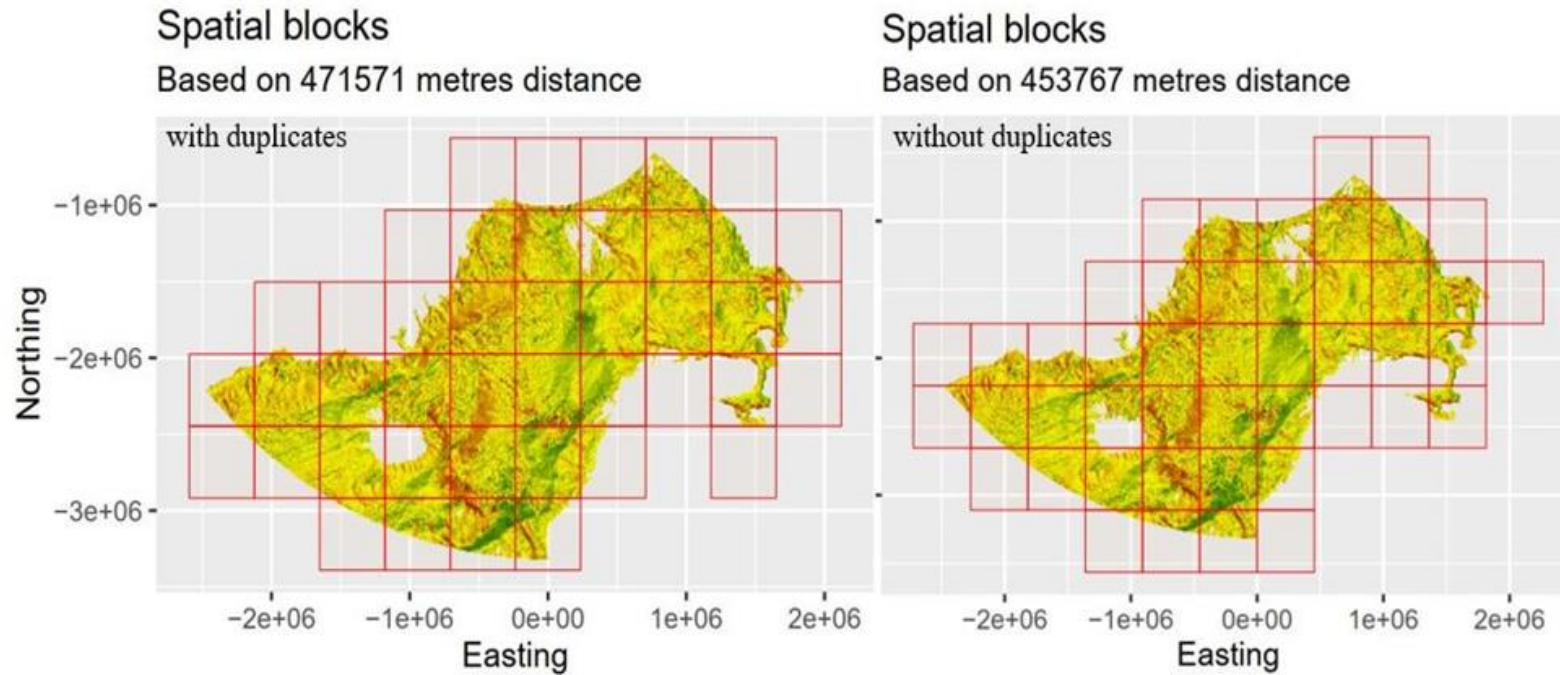
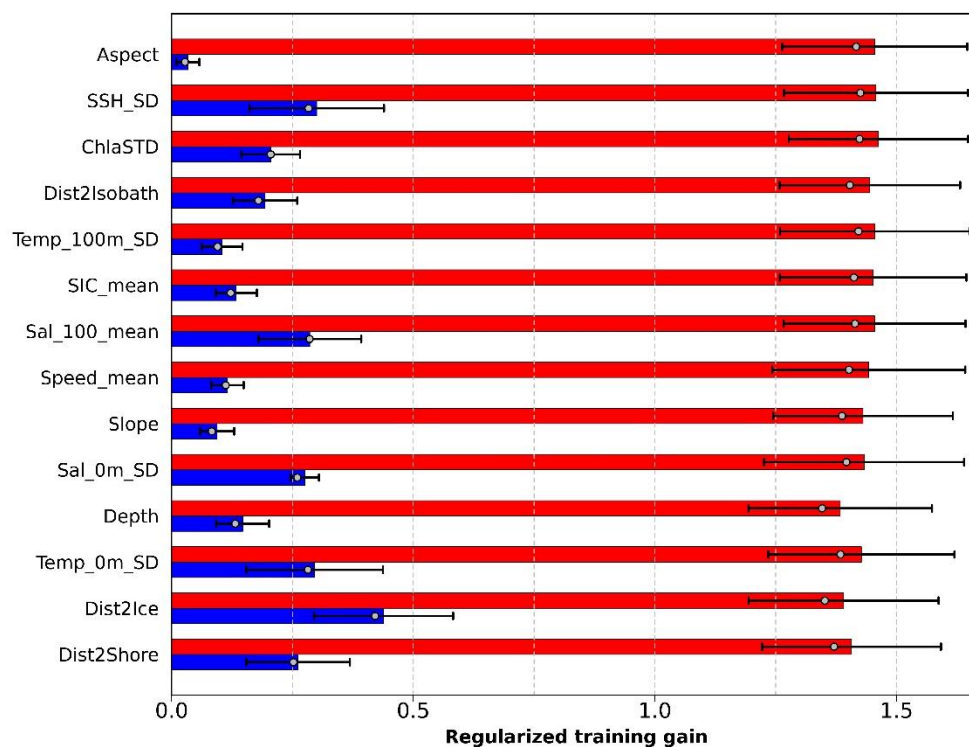
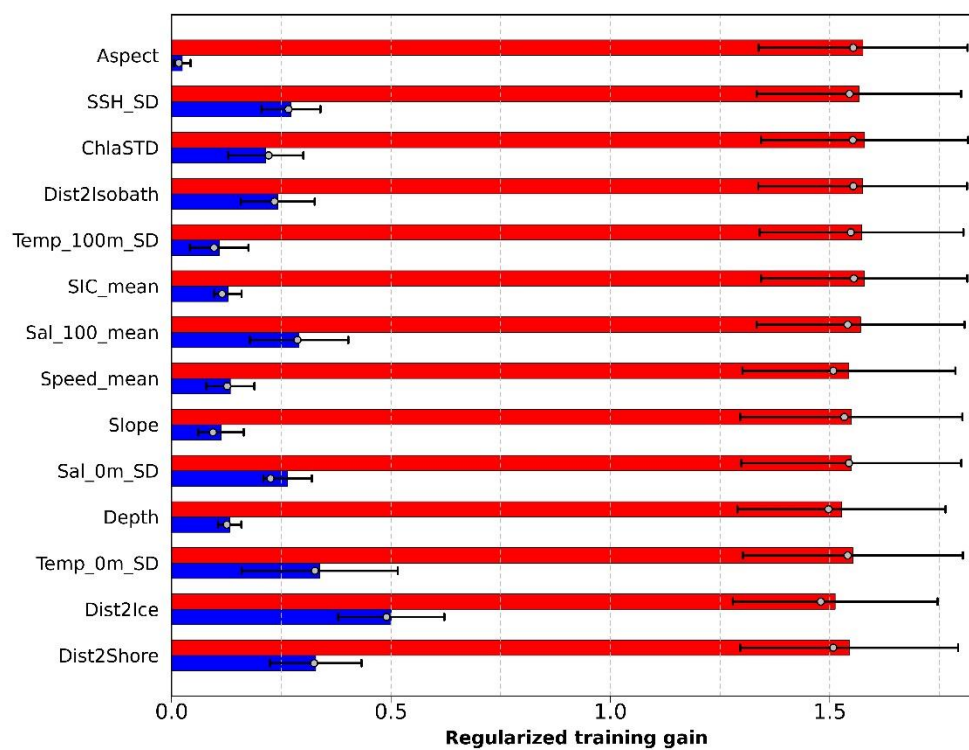
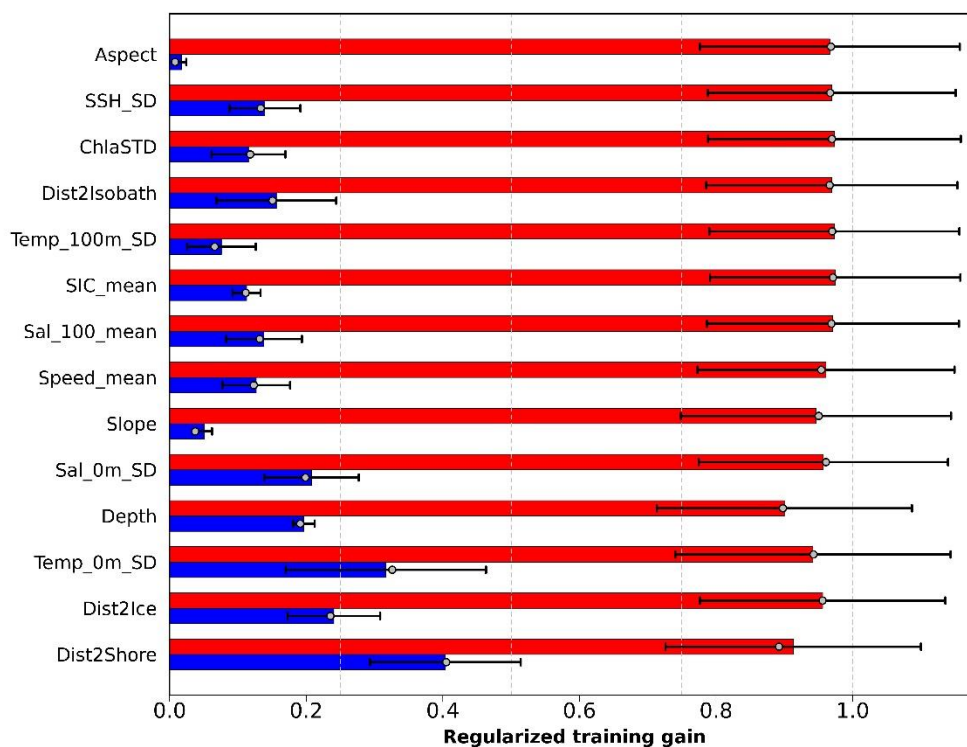


Figure S4: The spatial blocks used to cross-validate the models. The blocks to the left were used in all models, except for $\text{model}_{\text{rarefaction}}$, for which different blocks were estimated after removing duplicated sightings in each cell (right). Block size and how blocks were assigned to cross-validation folds were estimated using the *blockCV* R-package: 471.571 km for all models, except for $\text{model}_{\text{rarefaction}}$: 453.767 km.

(a) $\text{model}_{\text{rarefaction}}$ (b) $\text{model}_{\text{effortTracks}}$



(c) model_{effortFW}

Figure S5: Variable importance as measured by Jackknifing test: a) model_{rarefaction}, b) model_{effortTracks}; c) model_{effortFW}. The bars indicate the mean regularized training gain for cross-validated models, with error bars for standard deviation. Blue bars represent the model gain when each variable was used in isolation, while red bars show model gain when models were used without the variable. Results for the full model (without cross-validation) are shown as gray points. For more information on variable names, see Table 1. Results for model_{biased} / model_{accessibility} are shown in Figure 3.

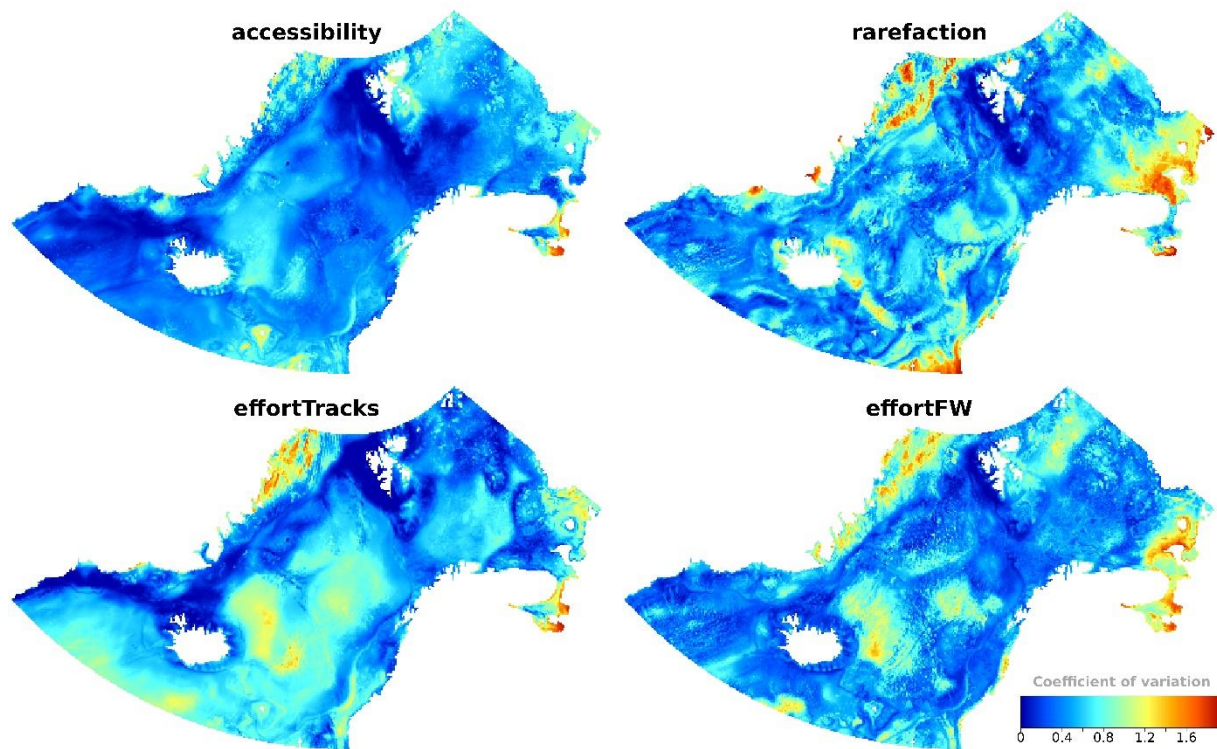
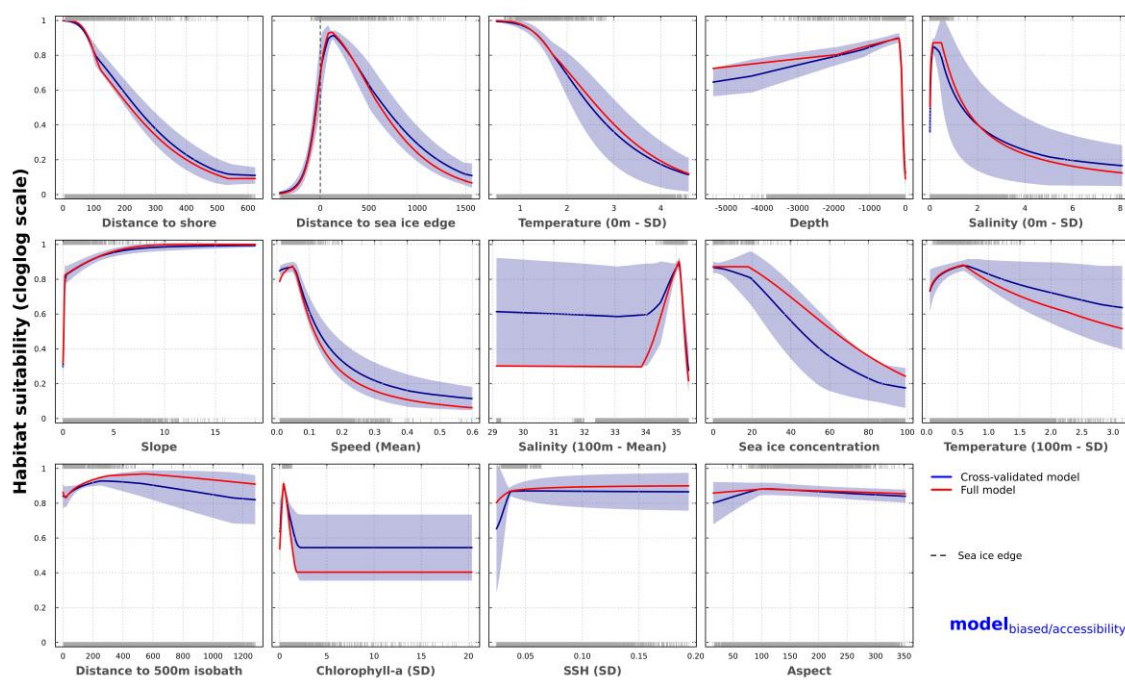
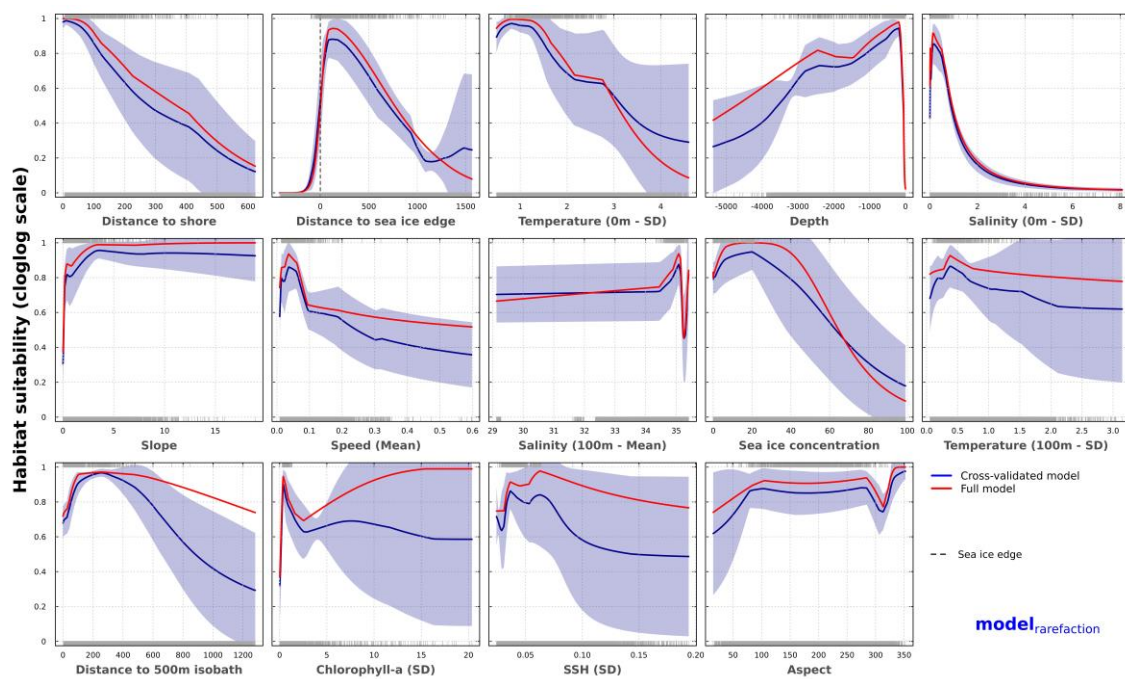


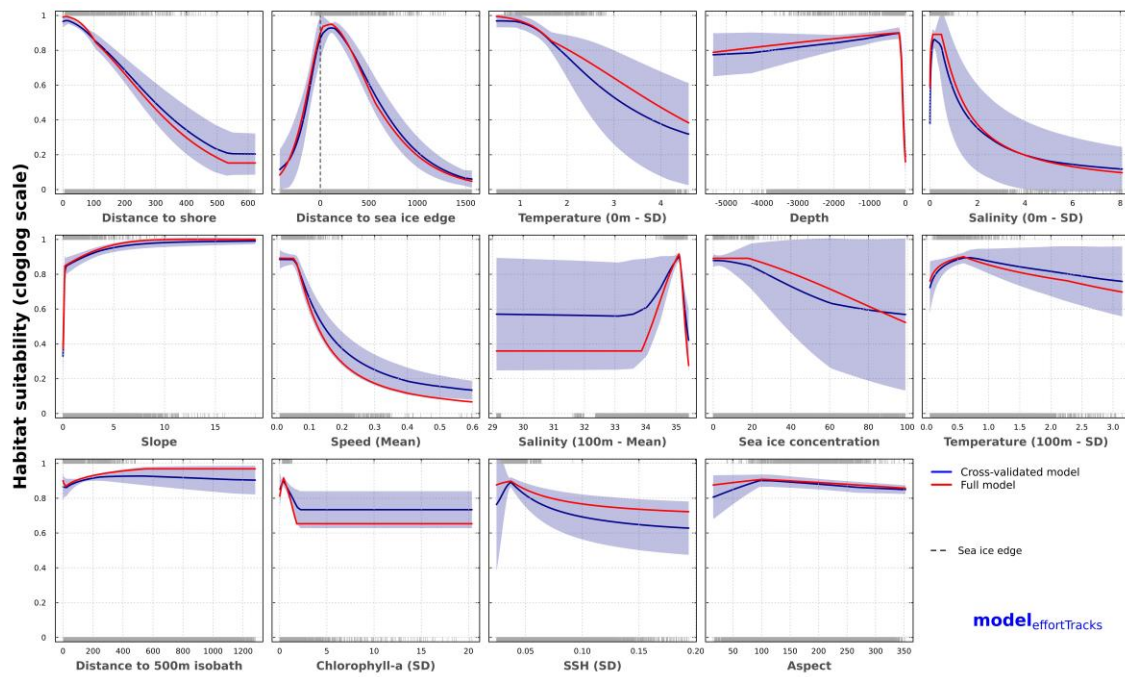
Figure S6: Coefficient of variation of fin whale habitat suitability for each sampling bias correction method. The coefficient of variation represents the ratio between the mean and standard deviation of cross-validated habitat suitability. Low values (blue) indicate little cross-validation variability, while high values (red) indicate higher variability. Similar maps representing model-specific mean predicted habitat suitability are shown in Figure 5.



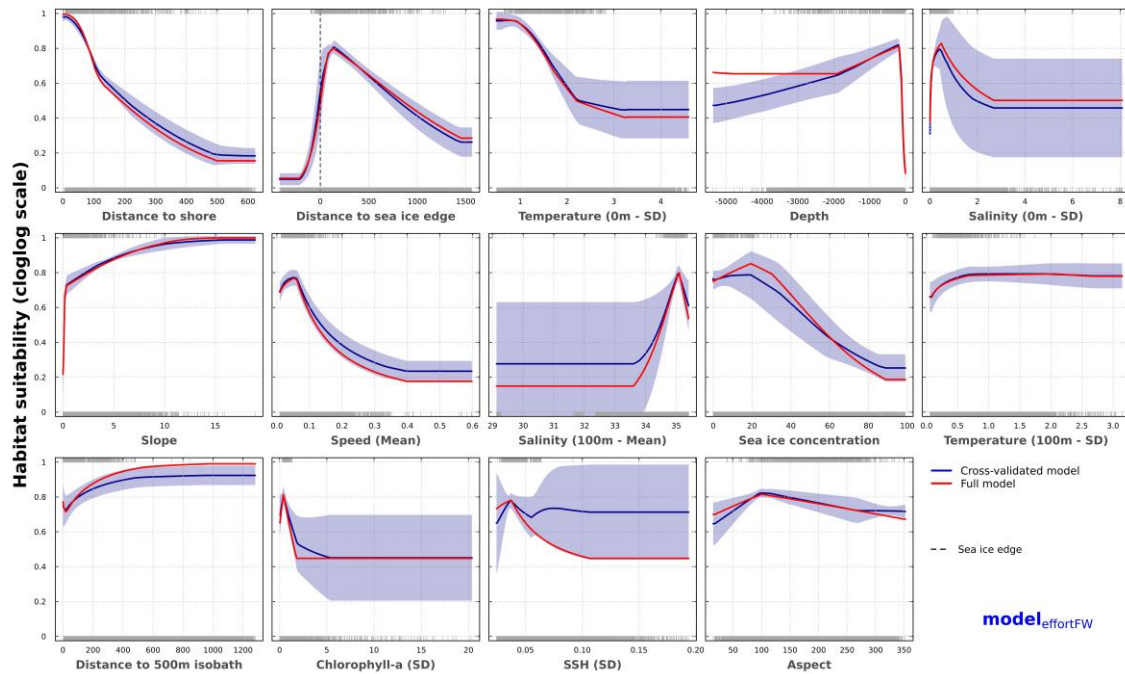
(a)



(b)



(c)



(d)

Figure S7: Marginal response curves of environmental variables used in each model. Blue lines and their shaded areas represent the mean and standard deviation of response curves for cross-validated models; red lines for full models. The upper gray ticks show values at species sightings (see Figure S10), while lower gray ticks are for values in the whole study area (background information).

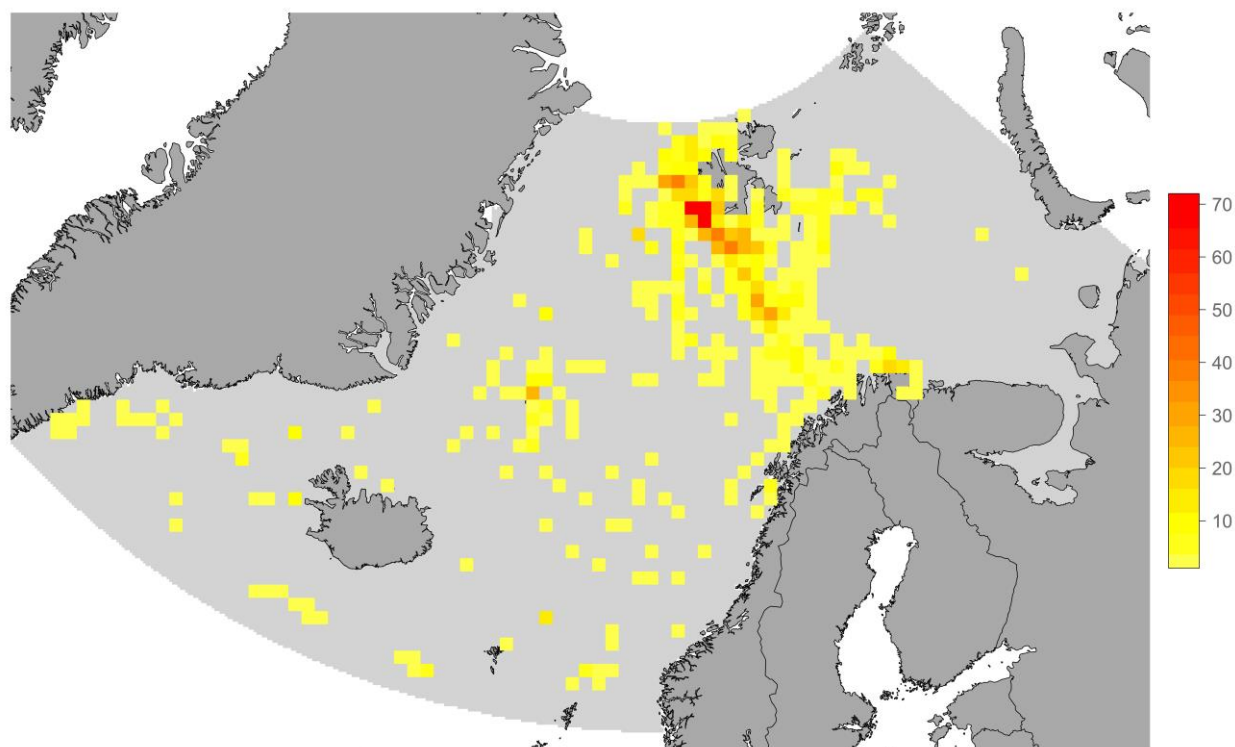


Figure S8: Number of fin whale sightings per 50×50 km grid. Lightgray-colored areas are locations without any sightings. Dark gray areas represent land. Color ranges from yellow for low number of sightings to red for high number of sightings.

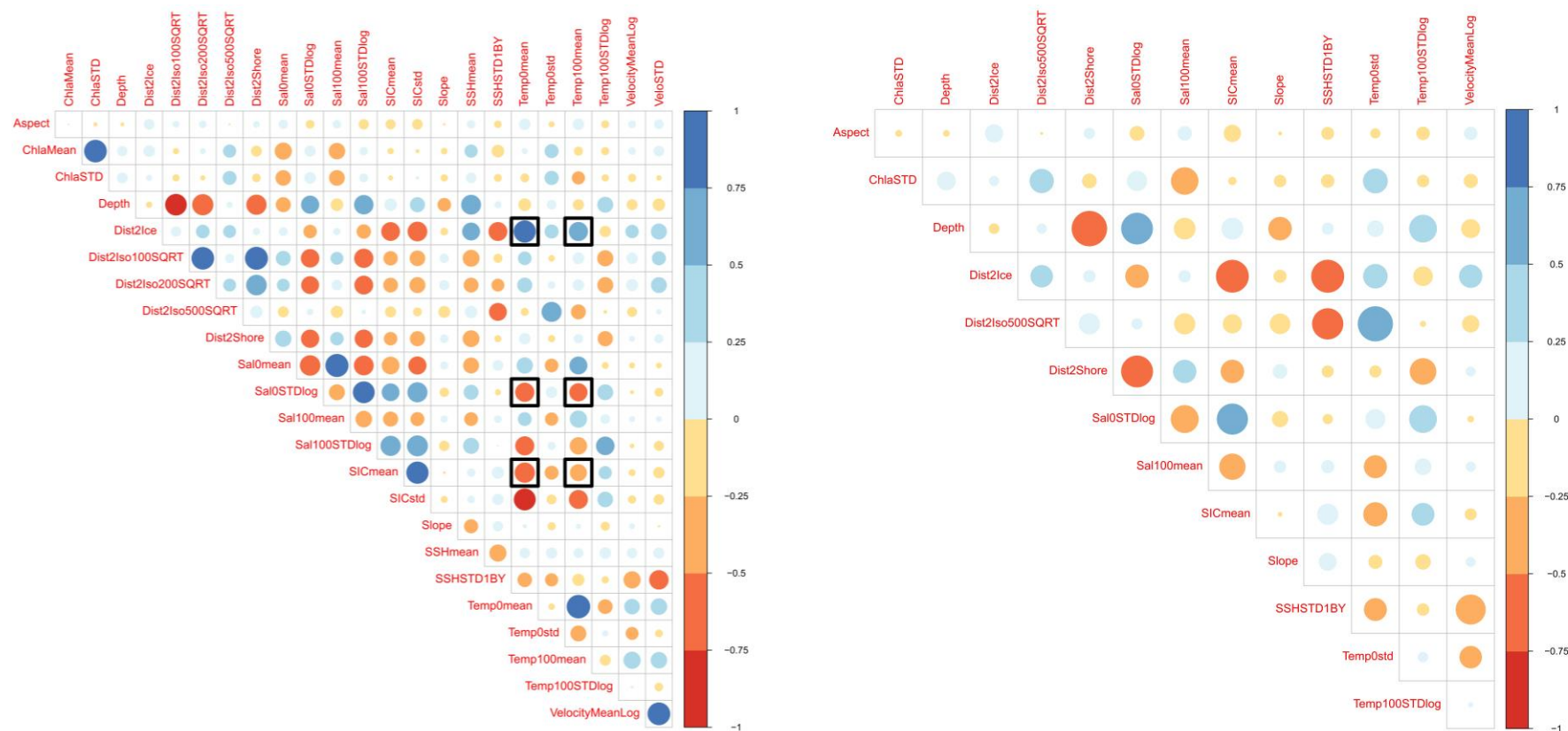
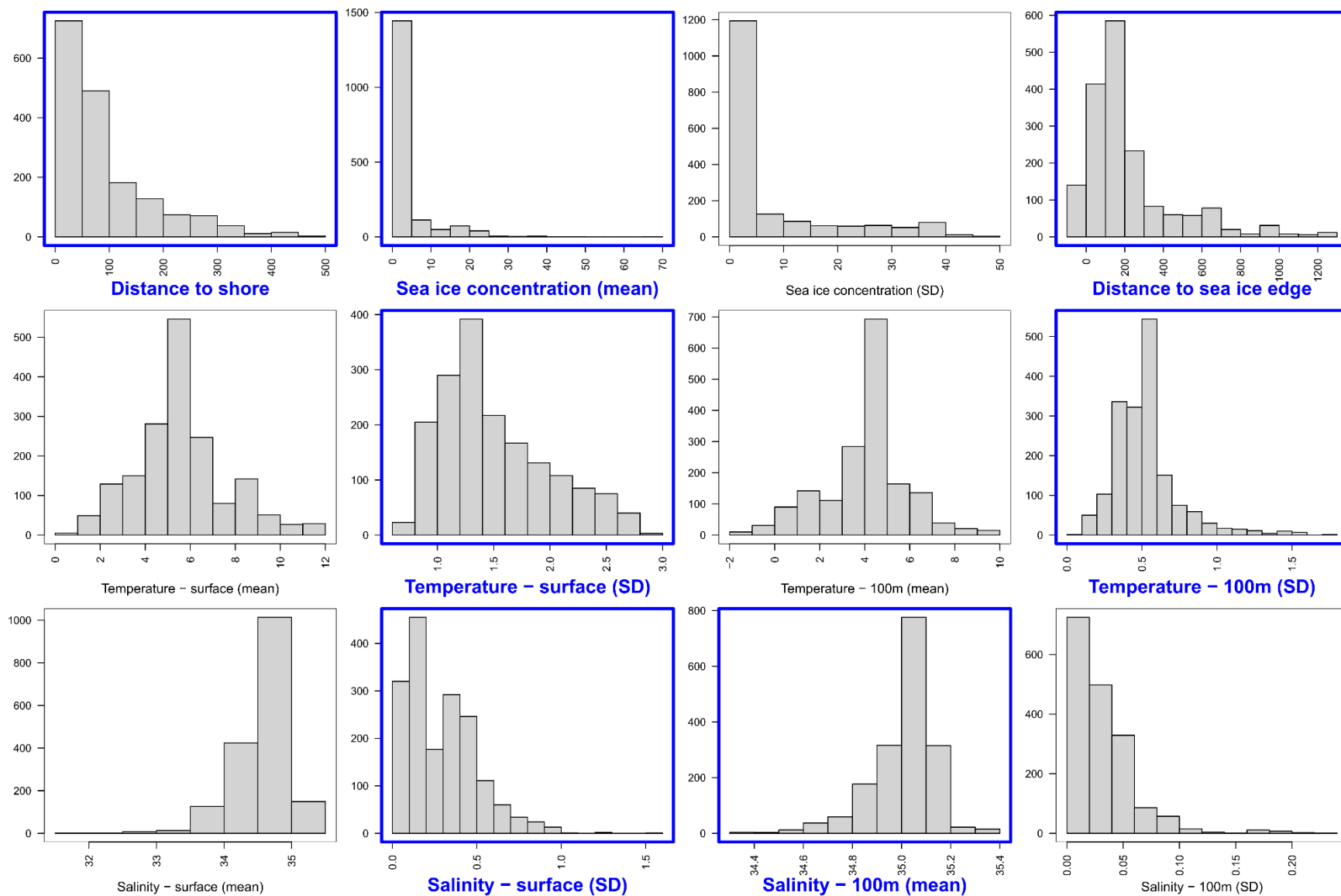


Figure S9: Pairwise Pearson correlation coefficient between environmental variables. Colors range from red for high negative correlation (-1) to blue for high positive correlation (1). The larger is the point, the higher is the absolute value of correlation. The plot to the left shows results for the 24 initial variables. The bold black squares show the high correlation between mean water temperature and other predictors used in the models, explaining why variables for mean temperature were excluded from the models. The right plot shows results for the less correlated 14 environmental variables used to run the models. See Figure S2 and Tables 1 and S2 for more details.



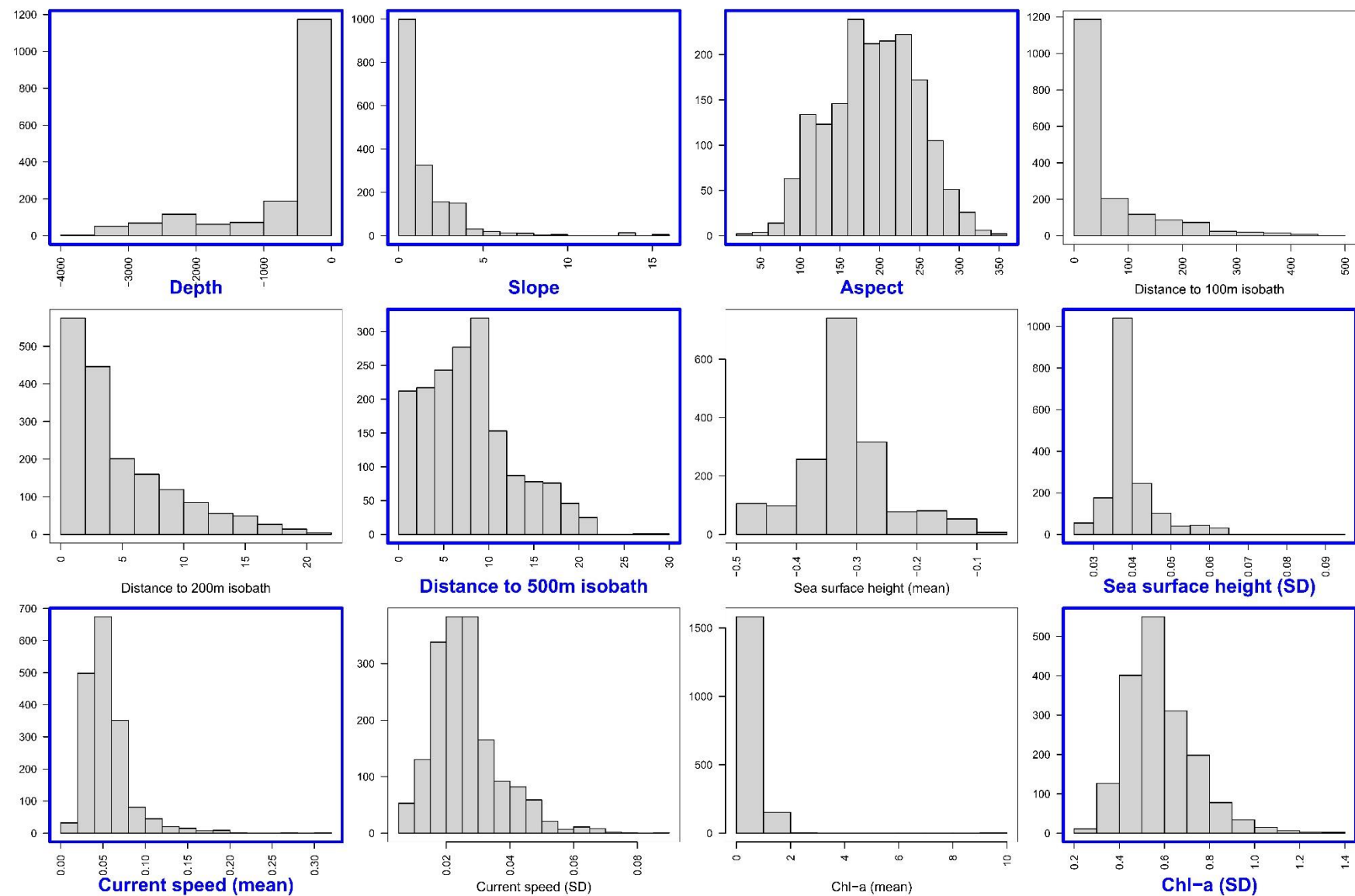


Figure S10: Histograms for values of environmental variables at fin whale sightings. The 14 environmental variables used to run the models are marked with bold blue boxes. See Figure S2 and Tables 1 and S2 for more details.