

Supporting Information for “Static species distribution models in the marine realm: the case of baleen whales in the Southern Ocean” – Diversity and Distributions

Table S1: Environmental predictors preparation

A) List of all initial variables and their derived predictors, unit, original temporal and spatial resolution, and data source.

Variable (#)	Derived predictor	Unit	Temporal resolution	Spatial resolution	Source
Bathymetry (6)	<ul style="list-style-type: none"> • Depth • Slope • Aspect • Distance to coast • Distance to 500m isobath • Distance to 1000m isobath 	m / °	---	30 arc-seconds	GEBCO (The General Bathymetric Chart of the Oceans; Weatherall et al., 2015)
Chlorophyll-a (2)	<ul style="list-style-type: none"> • Summer mean • Summer standard deviation 	mg m ⁻³	8-day composite 2002 – 2017	4 km	Sathyendranath et al. (2018)
Sea surface height (SSH) (2)	<ul style="list-style-type: none"> • Overall mean • Overall standard deviation 	m	Daily 1993 – 2017	¼ degree	Copernicus (https://www.copernicus.eu)
Speed (2)	<ul style="list-style-type: none"> • Overall mean • Overall standard deviation 	m s ⁻¹	Daily 1993 – 2017	¼ degree	Copernicus (https://www.copernicus.eu)
Temperature (25)	<ul style="list-style-type: none"> • Climatological mean (seasonal & overall mean) • surface, 100, 200, 500, and 1000m 	°C	1981 – 2010	¼ degree	Locarnini et al. (2018)
Salinity (25)	<ul style="list-style-type: none"> • Climatological mean (seasonal & overall mean) • surface, 100, 200, 500, and 1000m 	---	1981 – 2010	¼ degree	Zweng et al. (2018)
Sea Ice Concentration (12)	<ul style="list-style-type: none"> • Four custom seasons • mean & standard deviation • distance to the ice edge 	% m	Daily 2003–2010 and 2013–2017	6.25 km	Spreen et al. (2008)

B) List of 32 initially selected predictors based on data visualization and personal experience before excluding highly correlated predictors. The final list of predictors used to run the models is shown in Table 1 of the main text.

Variable (#)	Derived predictor		
Bathymetry (5)	• Depth	• Slope	• Distance to coast
	• Distance to 500m isobath	• Distance to 1000m isobath	
chlorophyll-a (2)	• Summer mean	• Summer SD	
sea surface height (SSH) (2)	• Overall mean	• Overall SD	
Speed (2)	• Overall mean	• Overall SD	
Temperature (6)	• Surface – Summer	• 100m – Fall	• 200m – Annual
	• Surface – Winter	• 100m – Spring	• 500m – Annual
Annual mean salinity (3)	• Surface	• 100m	• 200m
Sea Ice Concentration (12)	• Mean SIC – S1	• SD SIC – S1	• Distance to ice edge – S1
	• Mean SIC – S2	• SD SIC – S2	• Distance to ice edge – S2
	• Mean SIC – S3	• SD SIC – S3	• Distance to ice edge – S3
	• Mean SIC – S4	• SD SIC – S4	• Distance to ice edge – S4

Table S2: The results of the cross-validated Maxent models.

Model_{All} represents models run using all occurrences, while Model_{Unique} represents models run after removing duplicated occurrences within each 10×10 km cell. Model parameters and testing AUC columns show the best combination of feature classes (where ‘L’ linear, ‘Q’ quadratic, ‘H’ hinge, and ‘P’ product transformation) and regularization multiplier as well as the mean ± standard deviation of the testing AUC on spatial-block cross-validation. Block size represents the width of species- and model-specific spatial blocks. The number of occupied pixels represents the number of pixels (10×10 km) in the Southern Ocean with at least one sighting of each species.

Species	Model _{All}			Model _{Unique}			# occupied pixels
	<i>model parameters</i>	Testing AUC	block size (km)	<i>model parameters</i>	Testing AUC	block size (km)	
Antarctic minke whale	LQHP 0.5	0.85 ± 0.07	659.7	H 4	0.83 ± 0.06	640.4	11,798
Antarctic blue whale	LQHP 2	0.86 ± 0.13	1128.1	LQHP 1.5	0.84 ± 0.15	912.4	297
Fin whale	LQHP 1	0.8 ± 0.17	560.3	LQHP 0.5	0.79 ± 0.16	584.7	807
Humpback whale	LQHP 0.5	0.89 ± 0.07	472.5	LQHP 1	0.86 ± 0.05	390.2	2,812

Table S3: Summary of the comparison between this study's results and like studies on Antarctic blue, fin, and humpback whales in the SO. Important predictors, as identified by this study, are shaded dark grey in the column header ($> 5\%$ permutation importance for the full models, in descending order). Cell colours represent the agreement between our study results and other studies: green, high agreement; orange, some disagreement; red, high disagreement. Empty cells represent situations when the given predictor was not tested. Results for Antarctic minke whale are shown in Table 2.

Abbreviations used: SIC = sea ice concentration; SIE = sea ice edge; SSH = sea surface height; Chl-a = chlorophyll-a concentration; \checkmark = similar results; \oplus = positive relationship; \ominus = negative relationship; imp. = importance; Dist. = distance; SD = standard deviation; Temp. = water temperature.

Antarctic blue whale

This study		High importance ($>5\%$)							Low importance ($<5\%$)	
Other studies	SIC SD (34.7%)	SIC mean (13.3%)	Dist. to isobath (10.8%)	Temp. 200m (7.5%)	Depth (7.4%)	Dist. to SIE (6.2%)	Dist. to coast (5.6%)	Chl-a (3.4%)	SSH (2.9%)	
	\ominus	\ominus	\oplus	high at ~5000m	high near SIE	unclear	\oplus	\oplus		
Kasamatsu et al., 2000b				\ominus , high encounter rate at lower temperatures		high encounter rate near SIE				
Branch et al., 2007 Kasamatsu, 1988 Kasamatsu et al., 2000b Rankin et al., 2005						\checkmark				
Murase 2014					abundance peak at depth ~4000m, with an additional peak near 0m					
Thomisch et al., 2016		\checkmark								
Shabangu et al., 2017				high suitability at ~0°C SST	least suitability at around 5000m		high imp. / peak suitability close to coast, then sharply declined until ~1000 km	high imp. / high suitability at low chl-a	high imp. / \oplus , low suitability at SSH around -1.5 m and high elsewhere	
Širović and Hildebrand 2011				\oplus	more suitable at high depths			non-significant relationship		
Širović et al., 2004		\checkmark				\checkmark				

Fin whale

This study	High importance (>5%)						Low importance (<5%)		
	Dist. to SIE (20%)	SIC SD (18.8%)	mean SIC (15.5%)	Dist. to coast (14.8%)	SSH SD (8.8%)	Water temp. (6%)	chl-a (1.7%)	Depth (1%)	Slope (0.6%)
Other studies	moderate close or far from SIE	unclear	low at low SIC	close or far from the coast	⊖	⊖, highest <1.5°	unclear	small peaks at ~ 4500 and near 0m	⊕
Kasamatsu 1988 Kasamatsu et al., 2000b	⊕; high encounter rate far from SIE					⊕ with encounter rate			
Murase 2014							⊕ with abundance	three abundance peaks at depths of 4500, 2200, and 0m	
Santora et al., 2014						⊕ between SST and abundance			high at complex bathymetry
Scheidat et al., 2011	✓								
Širović et al. 2004	rarely reported near the SIE								
Williams et al., 2006				⊕, with minimum intensity close to it				low intensity in depths <1000m	

Humpback whale

This study	High importance (>5%)						Low importance (<5%)						
	SIC SD (24.3%)	Dist. to SIE (24.1%)	SIC mean (12%)	Dist. to coast (9.9%)	Dist. to isobath (7%)	SSH SD (6%)	SSH mean (4.8%)	Temp. (3.6%)	Speed (3%)	Depth (2.3%)	Chl-a (1.6%)	slope (0.8%)	salinity (0.3%)
	⊕ or unclear	high close or far north of SIE	⊖	very close or too far	⊖	⊕	⊖	unclear	weak ⊖	⊖	unclear	unclear	unclear
Andrews-Goff et al., 2018	high. Imp., lagged effect (2 month)	high. Imp.	high. Imp., lagged effect (1 month)										
Bombosch et al., 2014		ice-free areas and follows sea ice retreat											
Dalla Rosa et al., 2008				✓									
Friedlaender et al., 2011		highest suitability close to SIE								imp. predictor		imp. predictor, prefers rugged topography	
Kasamatsu et al., 2000b								no relationship with SST					
Murase 2014							two peaks at moderate and high SSH			⊖, but with small dip around 4,200m	⊖		⊖
Nowacek et al., 2011				✓									
Owen et al. 2019		✓						⊕, imp. predictor			⊖, imp. predictor	imp. predictor	
Riekkola et al., 2019		Lagged effect (1 month)					✓		low imp.				
Schall et al. 2020			weak correlation										
Thiele et al., 2004		highest suitability close to SIE		✓									
Van Opzeeland et al., 2013			acoustic presences at high SIC <td>✓</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>	✓									

Results of the Antarctic minke whale (Figures S1-5)

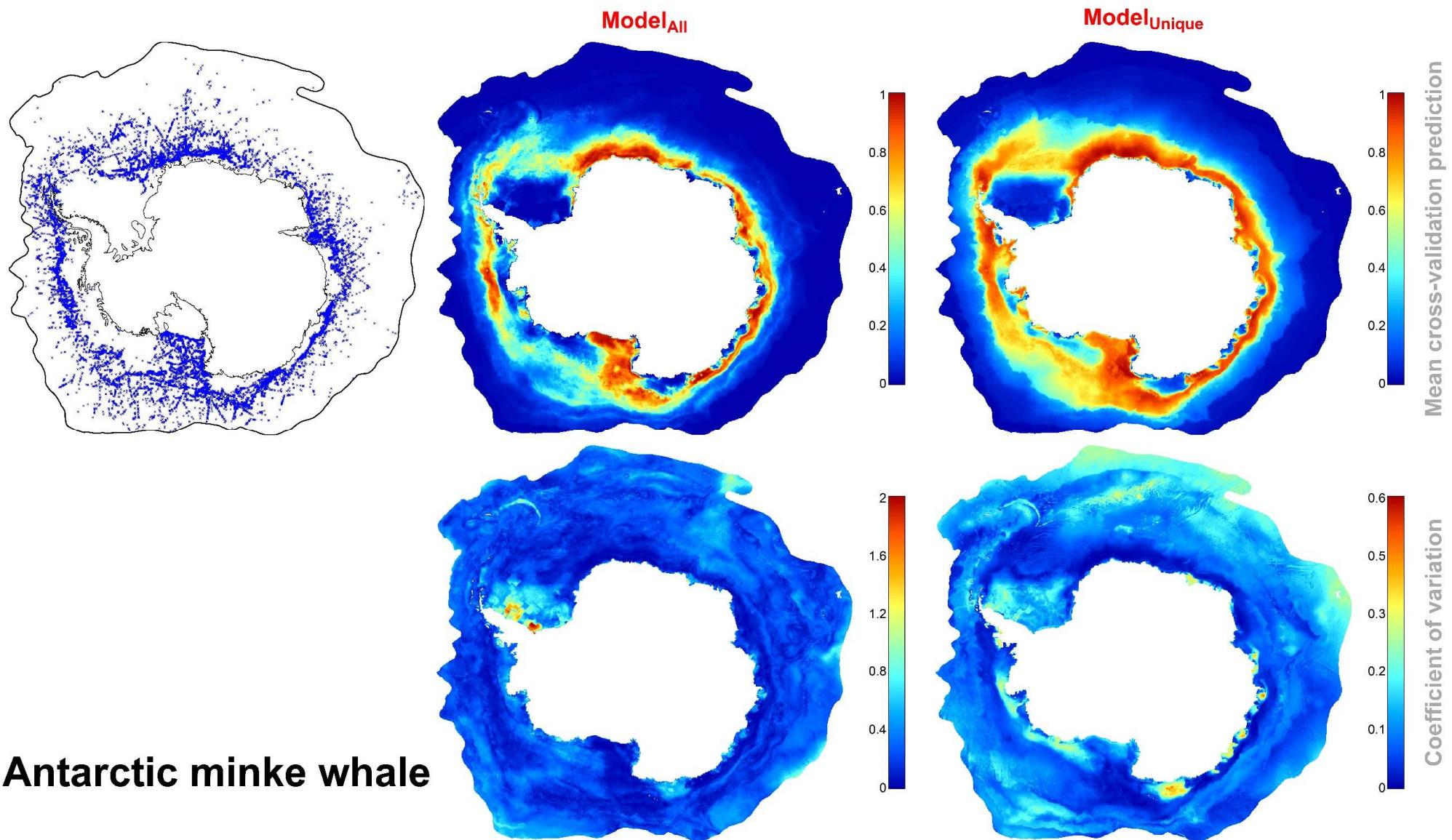


Figure S1: Mean and coefficient of variation of the predicted habitat suitability of the Antarctic minke whale on cross-validation. The top left map shows occurrences used to train the models. The coefficient of variation was calculated as the ratio between standard deviation and mean cross-validated habitat suitability.

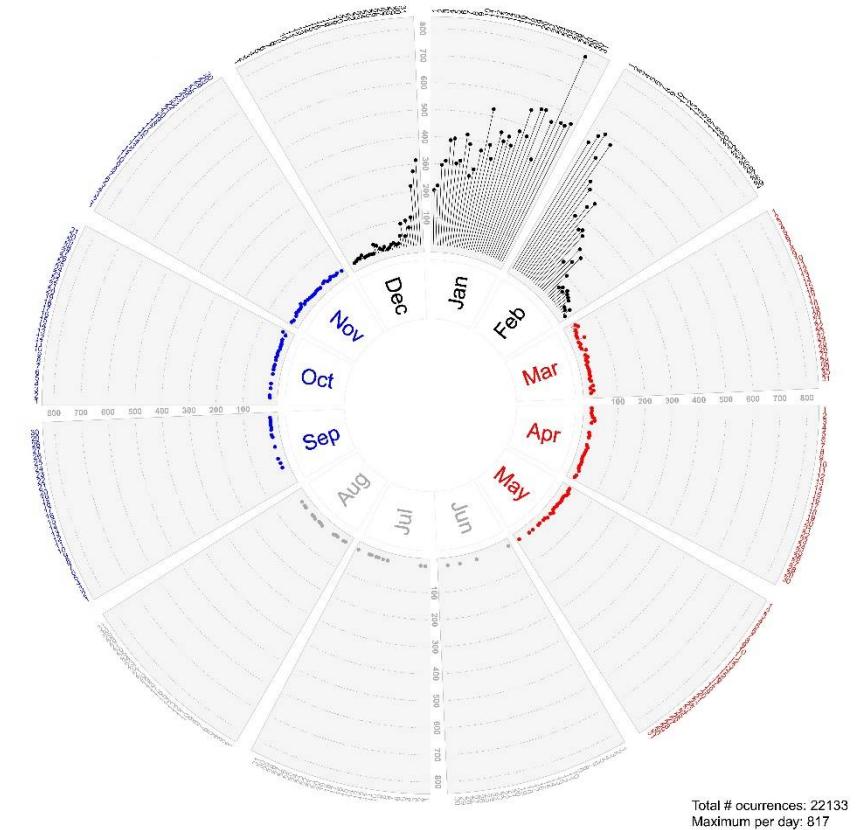
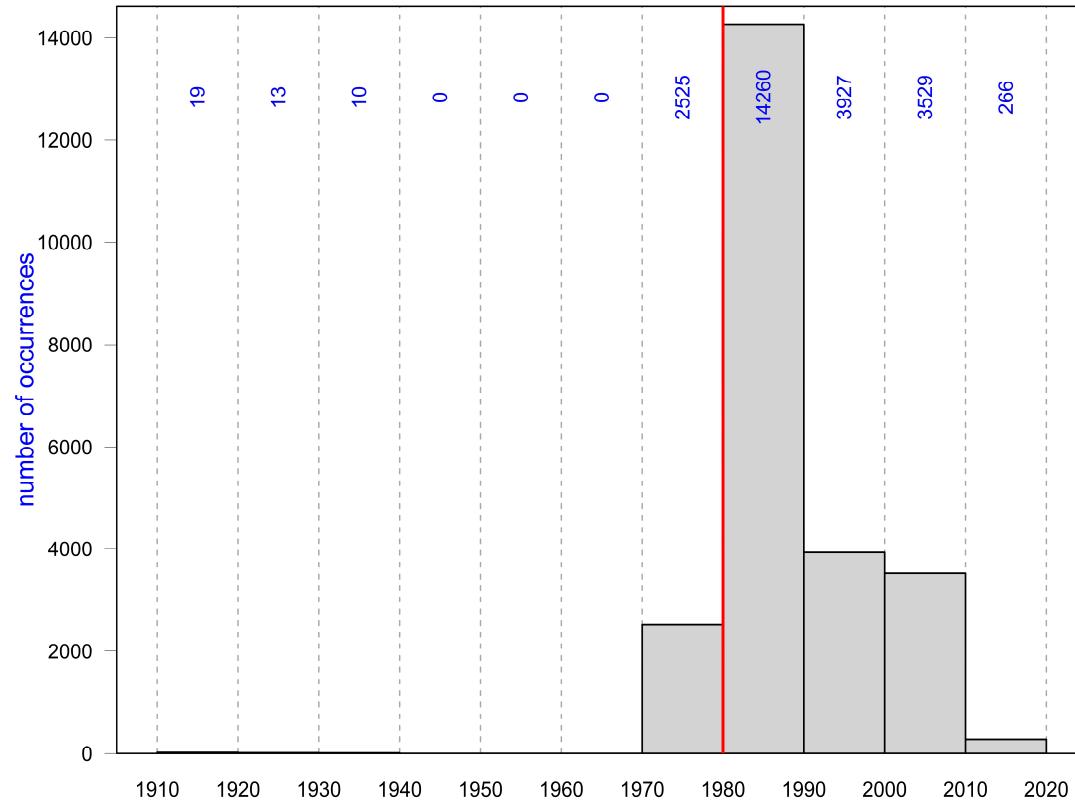


Figure S2: Temporal distribution of available occurrences for the Antarctic minke whale. The histogram shows the number of occurrences within each ten-year bin. The red vertical line differentiates occurrences excluded (before 1980) or included (after 1980) in the analysis. The right plot shows the number of occurrences after 1980 on each calendar day. The majority of occurrences was collected during summer months (particularly in January and February).

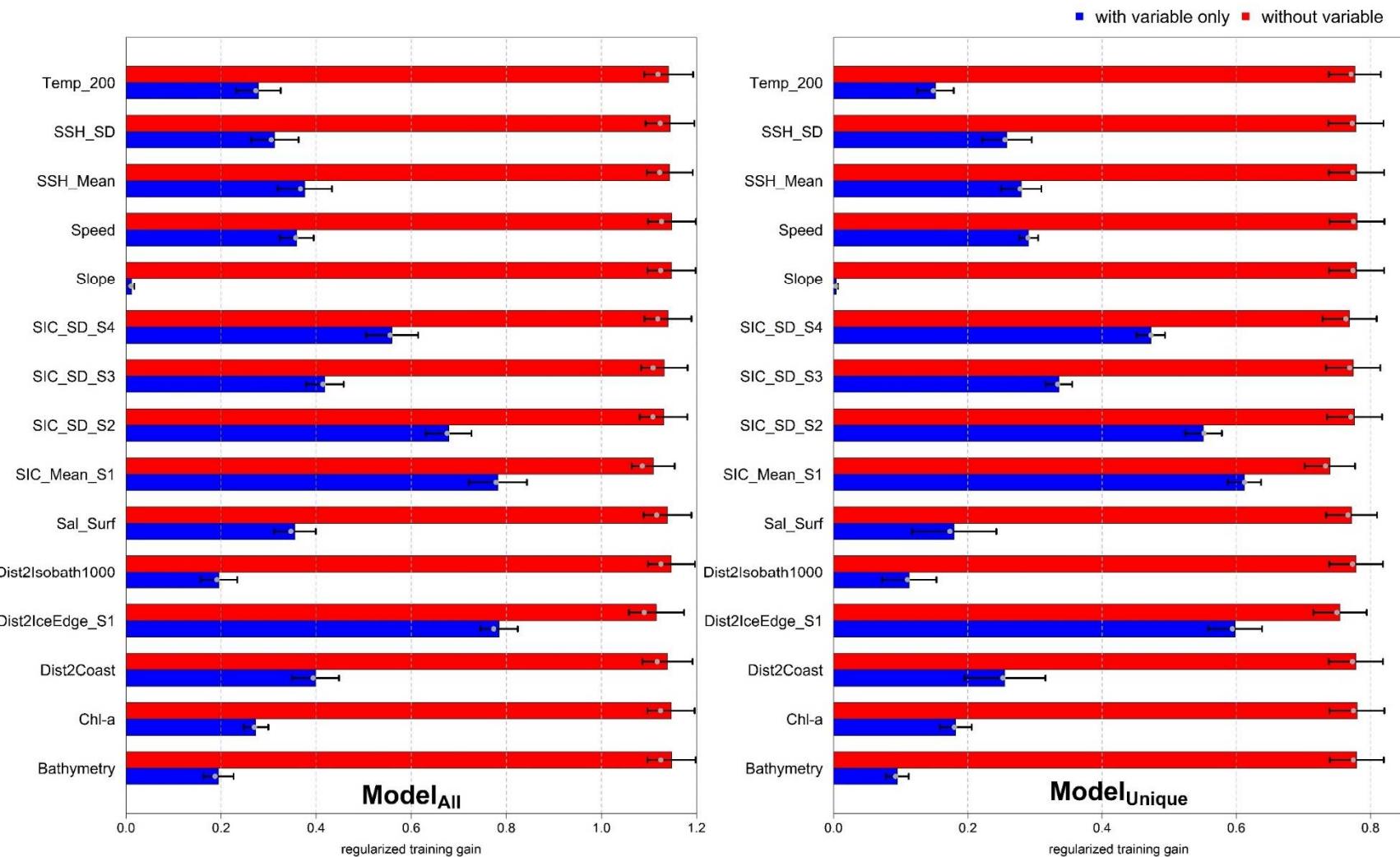


Figure S3: Results for Maxent's jackknifing test for Model_{All} (left) and Model_{Unique} (right) for the Antarctic minke whale. Red bars represent the cross-validated mean regularized training gain (a measure of goodness-of-fit) for sub-models calibrated using all predictors except the respective predictor. In contrast, blue bars represent complementary results for models calibrated only with the respective predictor. Error bars represent the standard deviation of the regularized training gain on cross-validation. Grey points show results for the full model, calibrated with no cross-validation. For more information on predictor abbreviations, see Table 1.

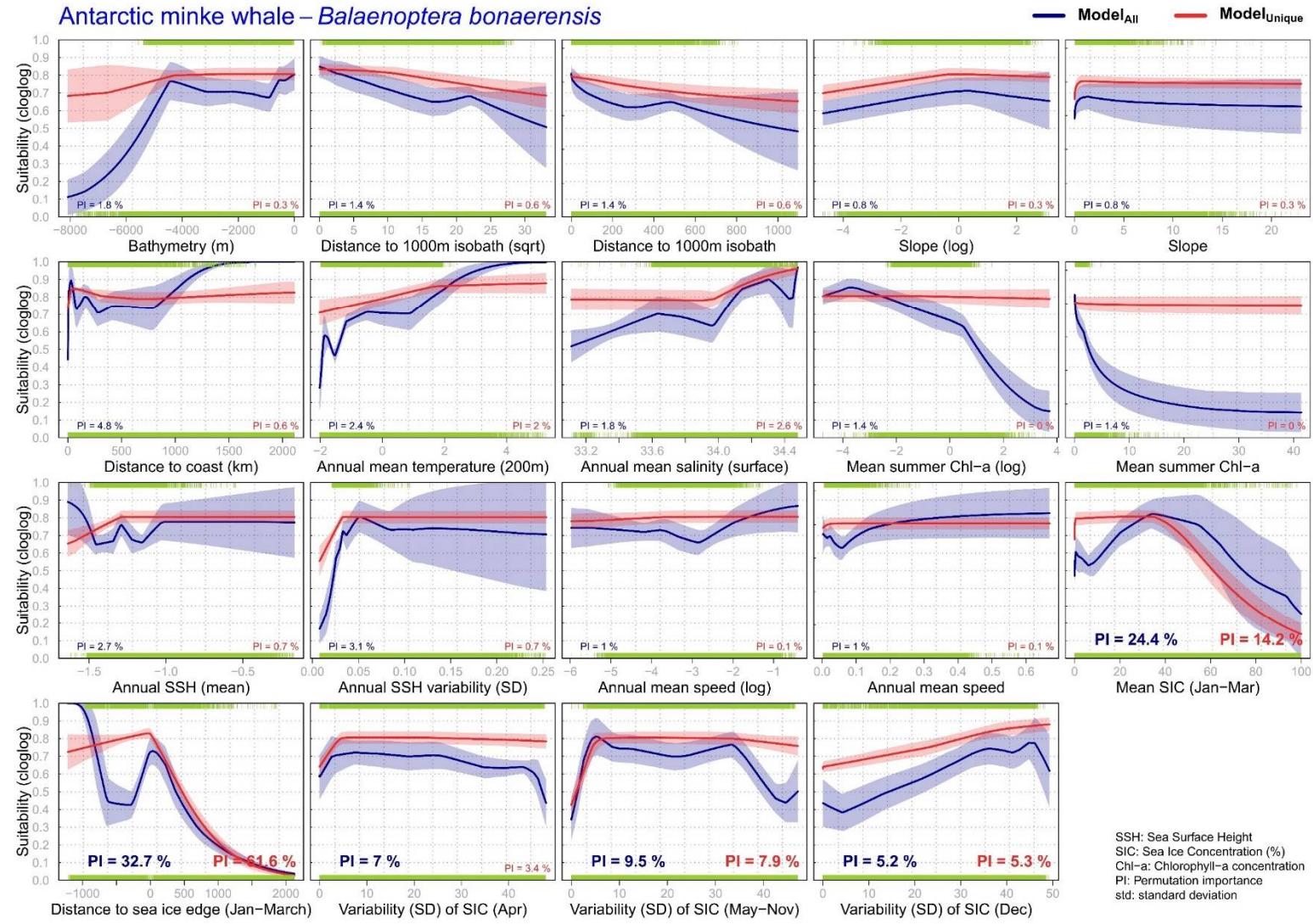


Figure S4: Marginal response curves for the Antarctic minke whale models. Response curves describe the cloglog prediction changes as each environmental predictor changes, with keeping all other predictors at their average value at training presences. As these response curves are sensitive to the fixed value of other predictors, we also provide the predicted values in the environmental space of the most important three predictors (see Figure S5). Solid blue lines and dashed area represent the mean and standard deviation of the cross-validated response curve of Model_{All}, while the red line and dashed area represents Model_{Unique}. PI represents the permutation importance of the predictor, with predictors with more than 5% permutation importance shown in a larger font. To make it easy to understand, transformed predictors (distance to 1000m isobath, slope, mean summer chlorophyll, annual variability of sea surface height, and annual mean speed) were also back-transformed for visualization. The top green rug shows values at species occurrences; similarly, the bottom rung shows values south of the Polar Front.

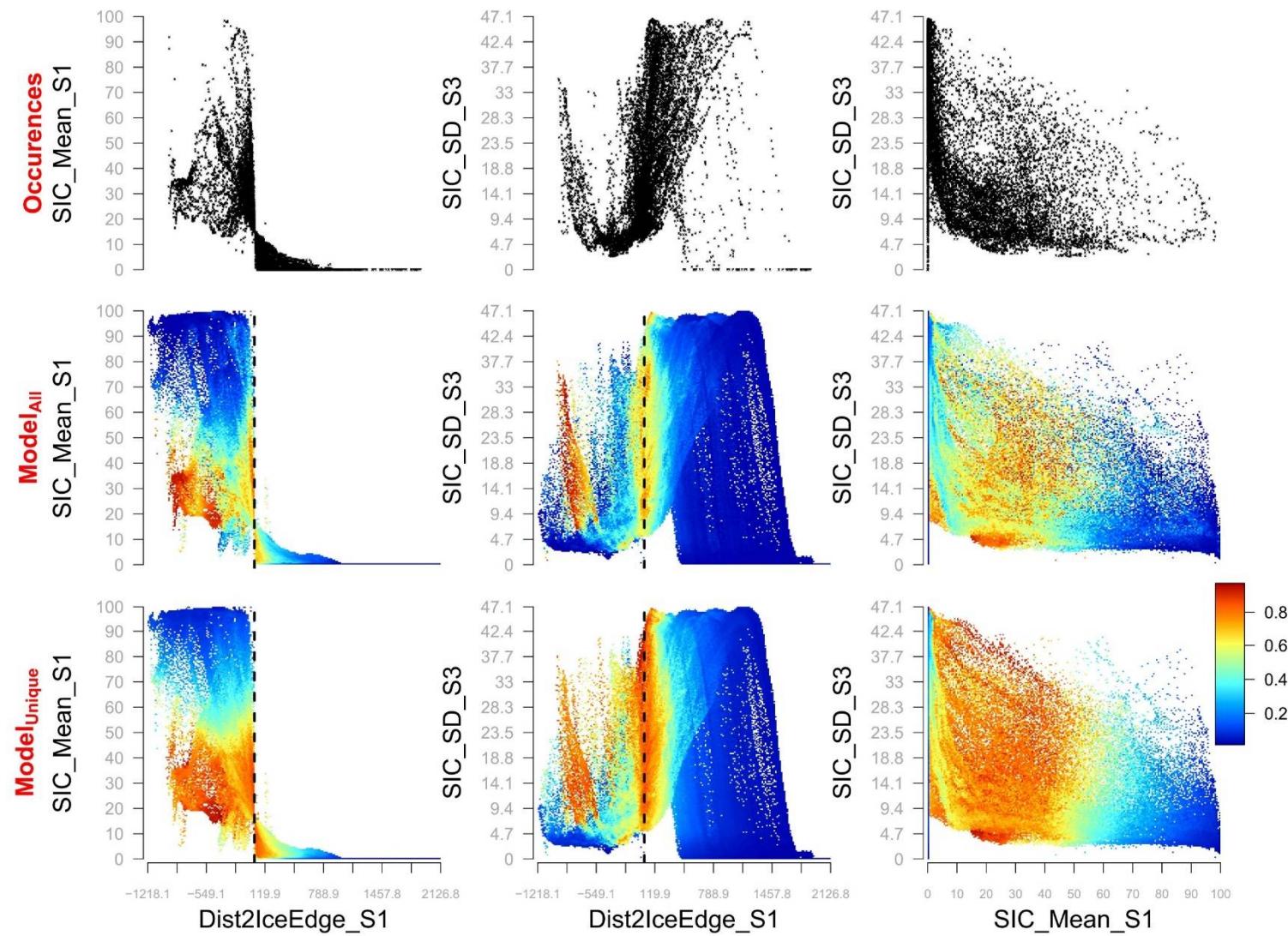


Figure S5: Mean habitat suitability of the Antarctic minke whale in the environmental space of the three most important environmental predictors. The first row shows combinations at species occurrences, while the second and third rows show predictions from **ModelAll** and **ModelUnique**, respectively. In each plot in the second and third row, mean habitat suitability at each respective combination was averaged over all available combinations of other predictors. White areas represent no available environmental combinations in the data. Colours range from blue (low prediction) to red (high prediction). For more information on the predictors acronyms used, see Table 1.

Results of the Antarctic blue whale (Figures S6-10)

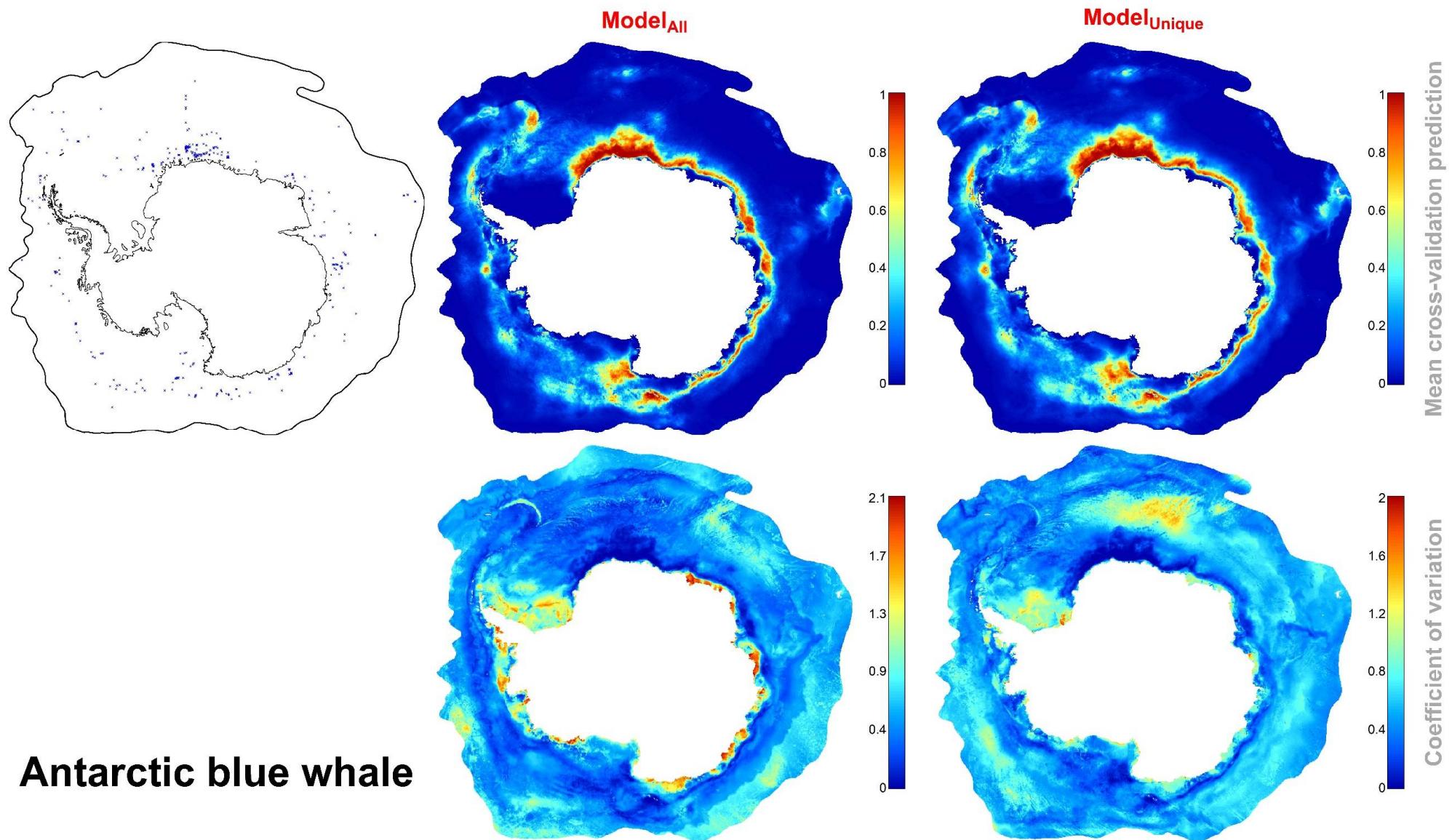


Figure S6: Mean and coefficient of variation of the predicted habitat suitability of the Antarctic blue whale on cross-validation. The top left map shows occurrences used to train the models. The coefficient of variation was calculated as the ratio between standard deviation and mean cross-validated habitat suitability.

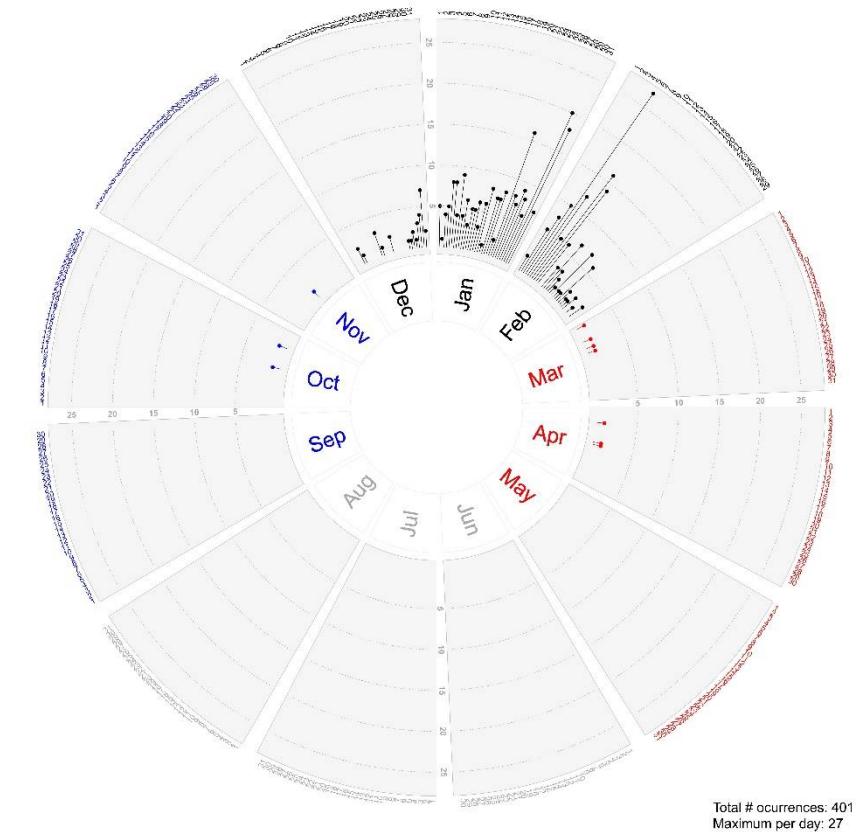
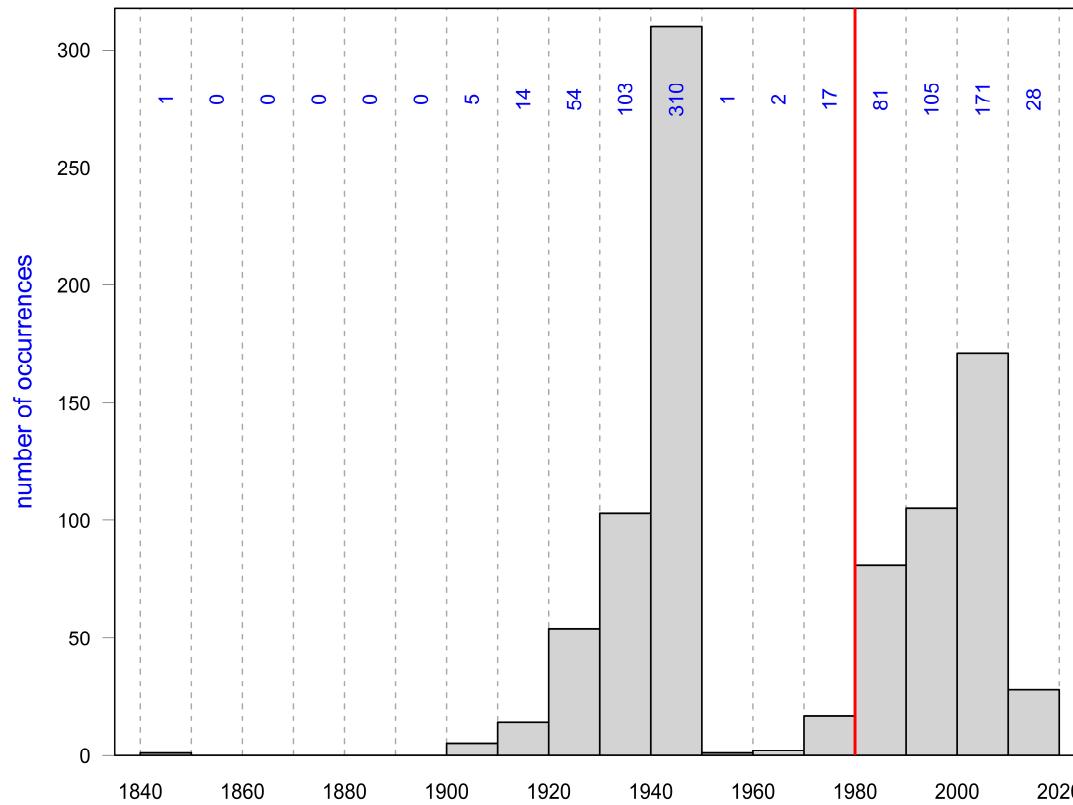


Figure S7: The temporal distribution of available occurrences for the Antarctic blue whale. The histogram shows the number of occurrences within each ten-year bin. The red vertical line differentiates occurrences excluded (before 1980) or included (after 1980) in the analysis. The right plot shows the number of occurrences after 1980 on each calendar day. The majority of occurrences was collected during summer months (particularly in January and February).

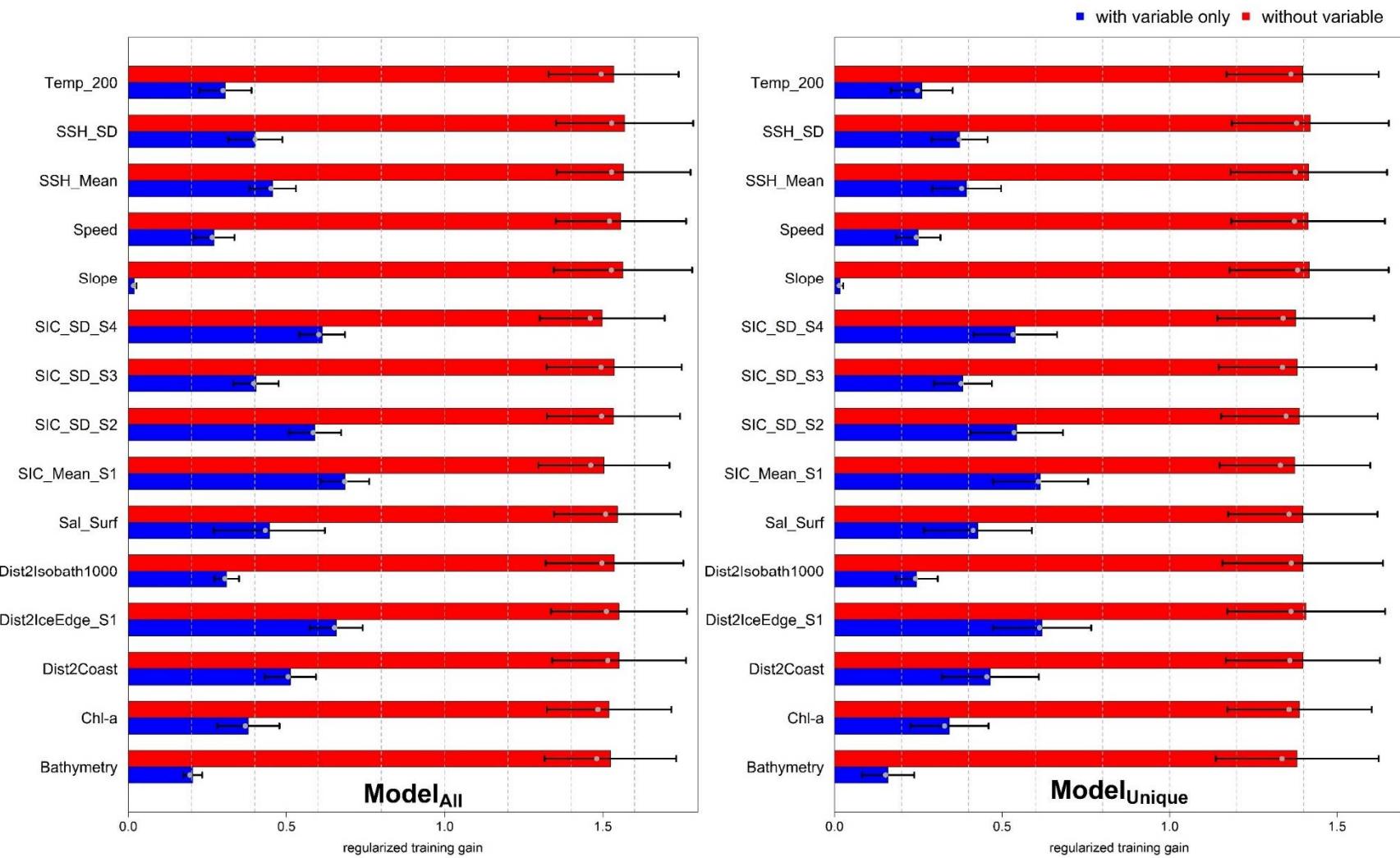


Figure S8: Results for Maxent's jackknifing test for Model_{All} (left) and Model_{Unique} (right) for the Antarctic blue whale. Red bars represent the cross-validated mean regularized training gain (a measure of goodness-of-fit) for sub-models calibrated using all predictors except the respective predictor. In contrast, blue bars represent complementary results for models calibrated only with the respective predictor. Error bars represent the standard deviation of the regularized training gain on cross-validation. Grey points show results for the full model, calibrated with no cross-validation. For more information on predictor abbreviations, see Table 1.

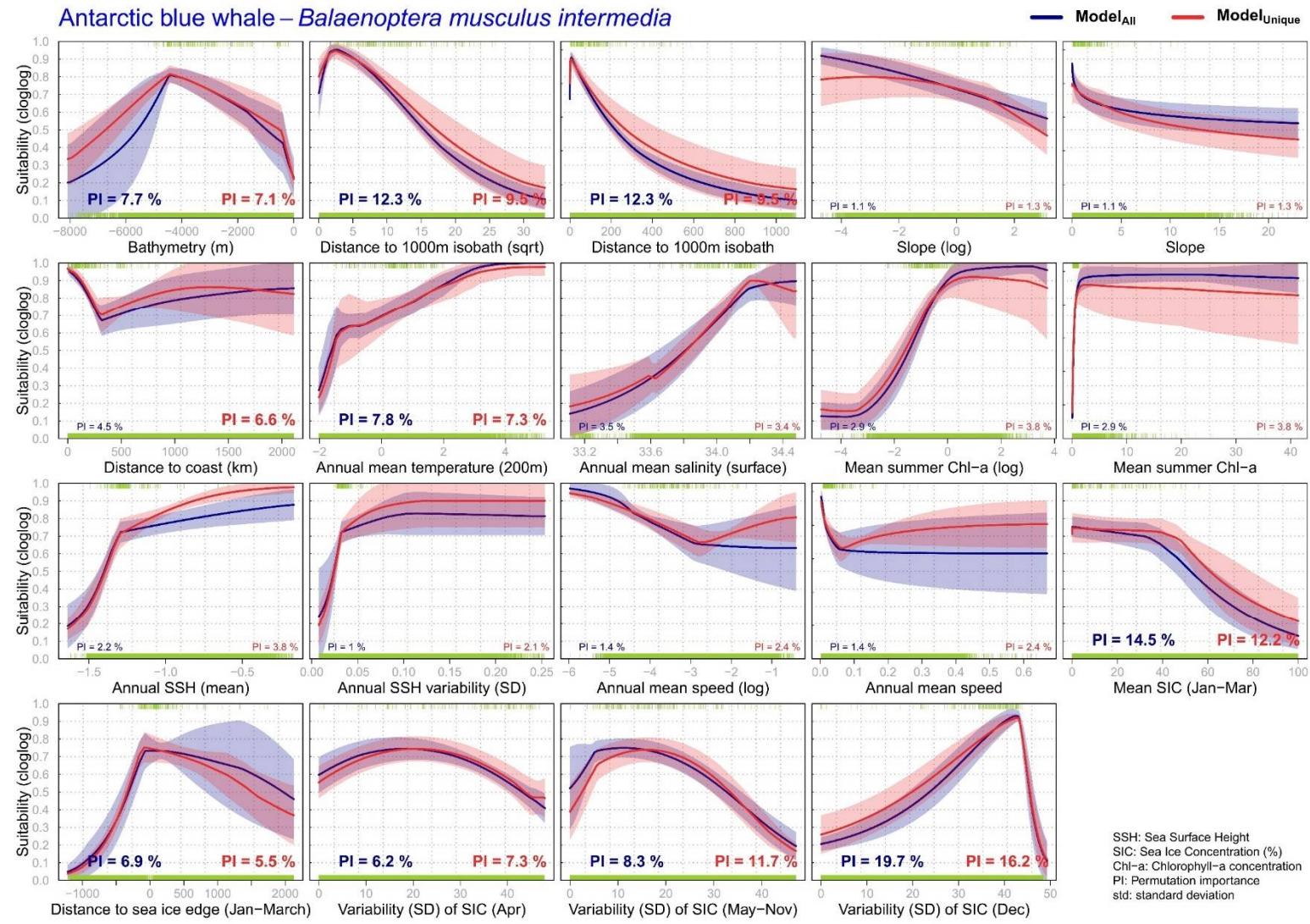


Figure S9: Marginal response curves for the Antarctic blue whale models. Response curves describe the cloglog prediction changes as each environmental predictor changes, with keeping all other predictors at their average value at training presences. As these response curves are sensitive to the fixed value of other predictors, we also provide the predicted values in the environmental space of the most important three predictors (see Figure S10). Solid blue lines and dashed area represent the mean and standard deviation of the cross-validated response curve of Model_{All}, while the red line and dashed area represents Model_{Unique}. PI represents the permutation importance of the predictor, with predictors with more than 5% permutation importance shown in a larger font. For better understanding, transformed predictors (distance to 1000m isobath, slope, mean summer chlorophyll, annual variability of sea surface height, and annual mean speed) were also back-transformed for visualization. The top green rug shows values at species occurrences; similarly, the bottom rung shows values south of the Polar Front.

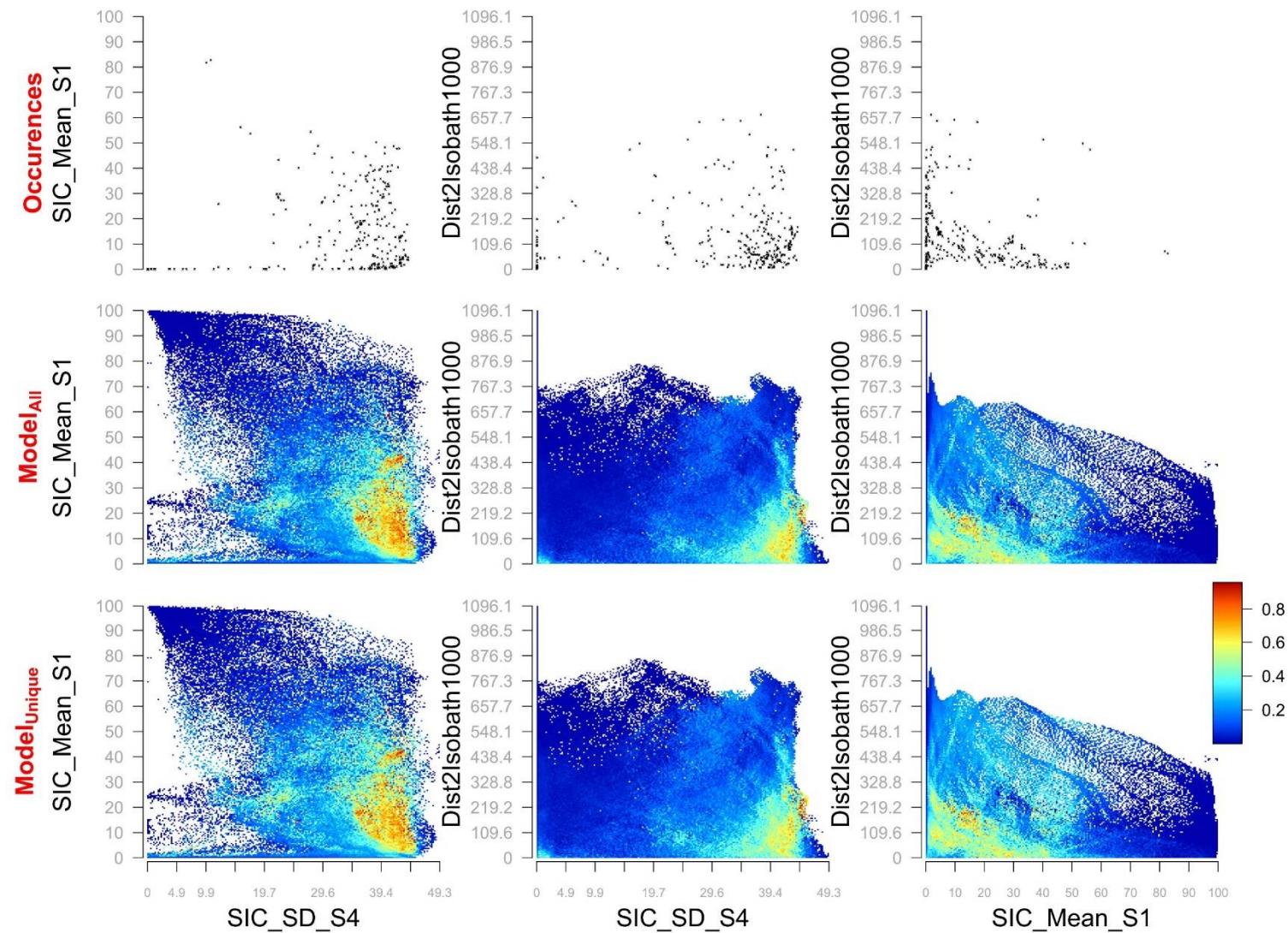


Figure S10: Mean habitat suitability of the Antarctic blue whale in the environmental space of the three most important environmental predictors. The first row shows combinations at species occurrences, while the second and third rows show predictions from Model_{All} and Model_{Unique}, respectively. In each plot in the second and third row, mean habitat suitability at each respective combination was averaged over all available combinations of other predictors. White areas represent no available environmental combinations in the data. Colours range from blue (low prediction) to red (high prediction). For more information on the predictors acronyms used, see Table 1.

Results of the fin whale (Figures S11-15)

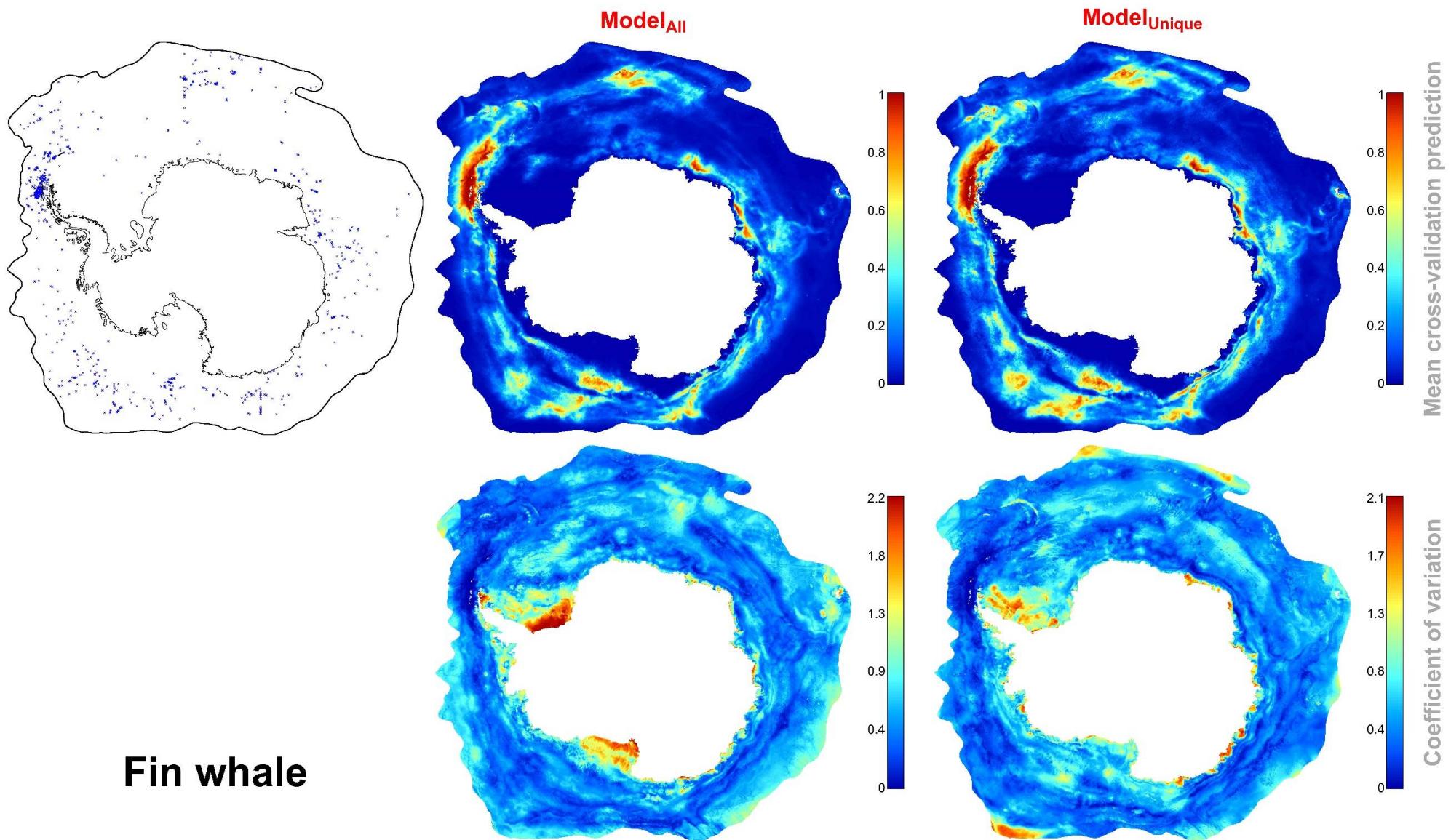


Figure S11: Mean and coefficient of variation of the predicted habitat suitability of the fin whale on cross-validation. The top left map shows occurrences used to train the models. The coefficient of variation was calculated as the ratio between standard deviation and mean cross-validated habitat suitability.

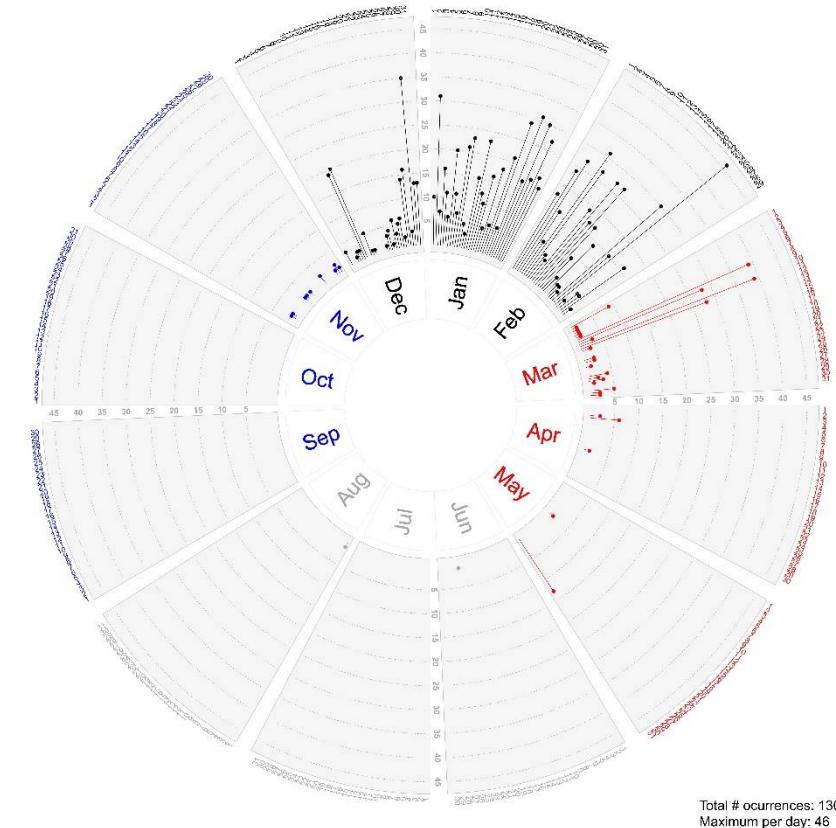
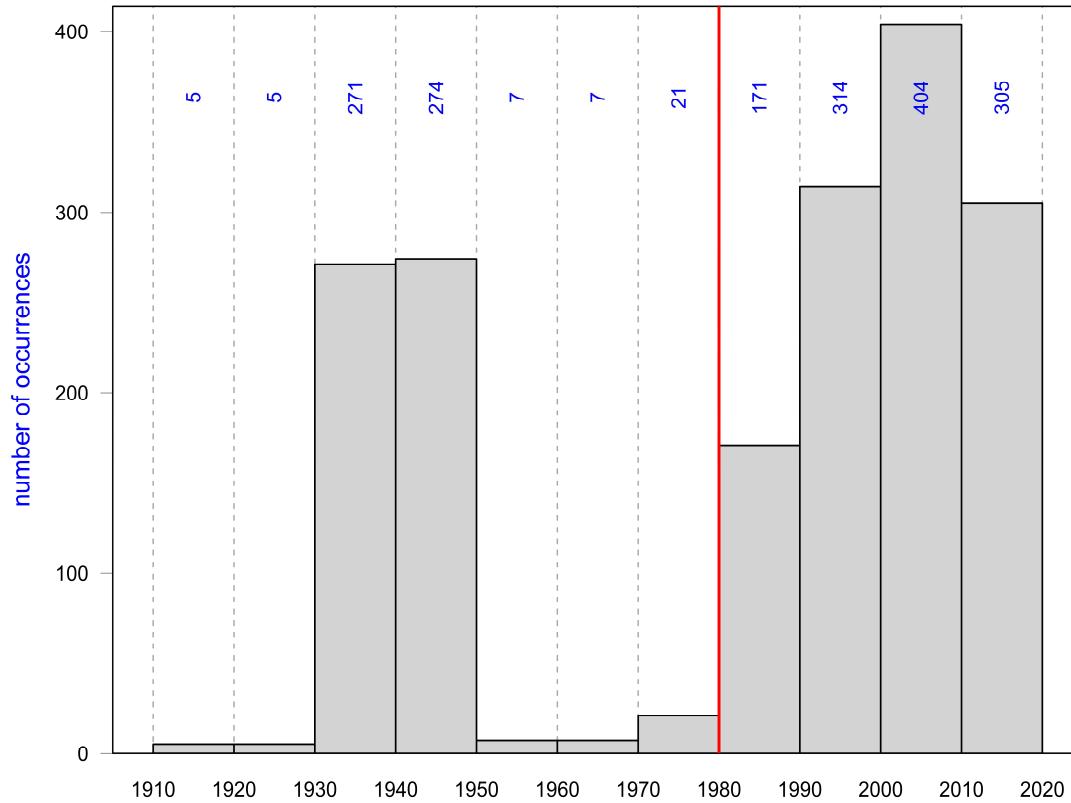


Figure S12: The temporal distribution of available occurrences for the fin whale. The histogram shows the number of occurrences within each ten-year bin. The red vertical line differentiates occurrences excluded (before 1980) or included (after 1980) in the analysis. The right plot shows the number of occurrences after 1980 on each calendar day. The majority of occurrences was collected during summer months (particularly in January and February).

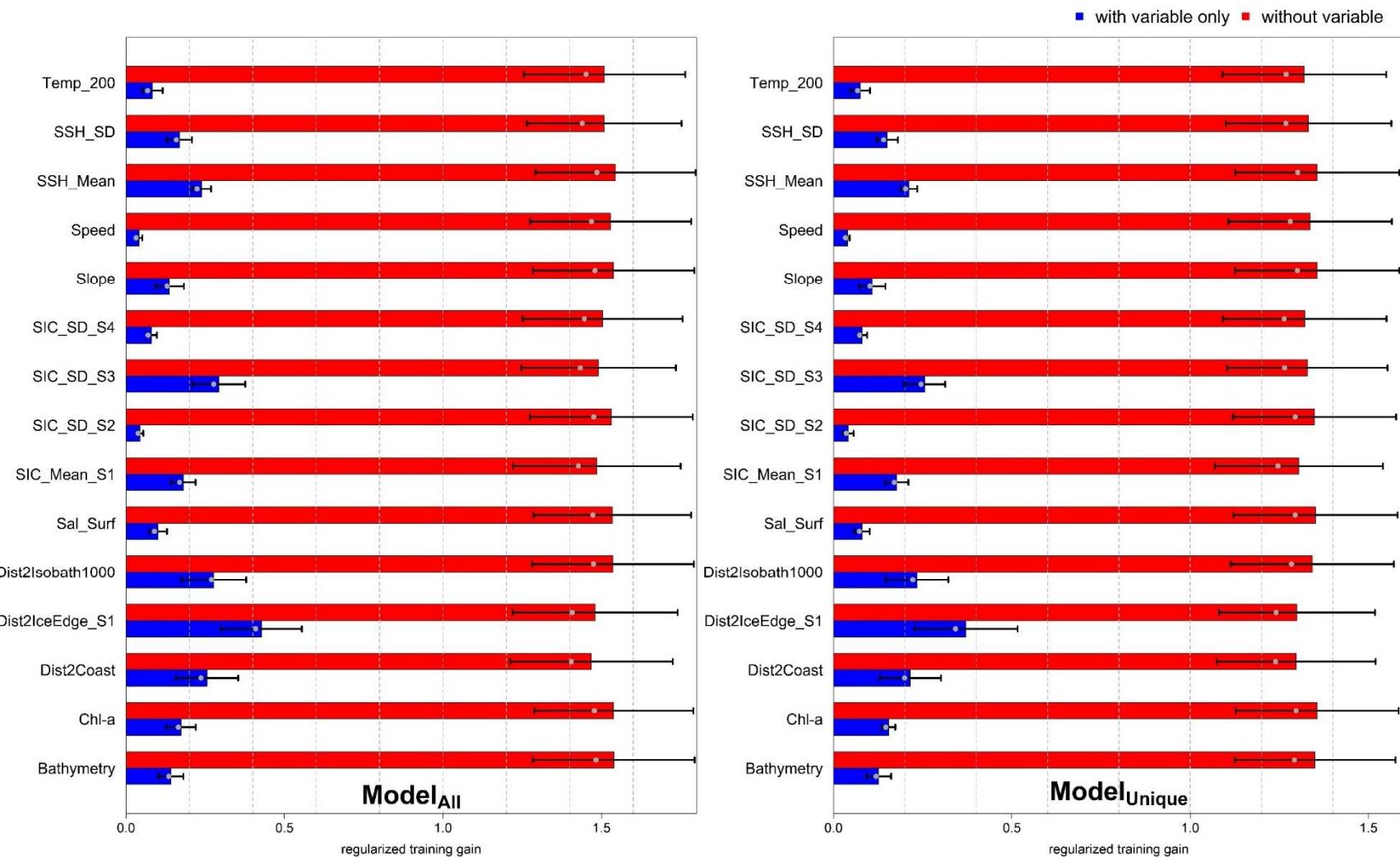


Figure S13: Results for Maxent's jackknifing test for Model_{All} (left) and Model_{Unique} (right) for the fin whale. Red bars represent the cross-validated mean regularized training gain (a measure of goodness-of-fit) for sub-models calibrated using all predictors except the respective predictor. In contrast, blue bars represent complementary results for models calibrated only with the respective predictor. Error bars represent the standard deviation of the regularized training gain on cross-validation. Grey points show results for the full model, calibrated with no cross-validation. For more information on predictor abbreviations, see Table 1.

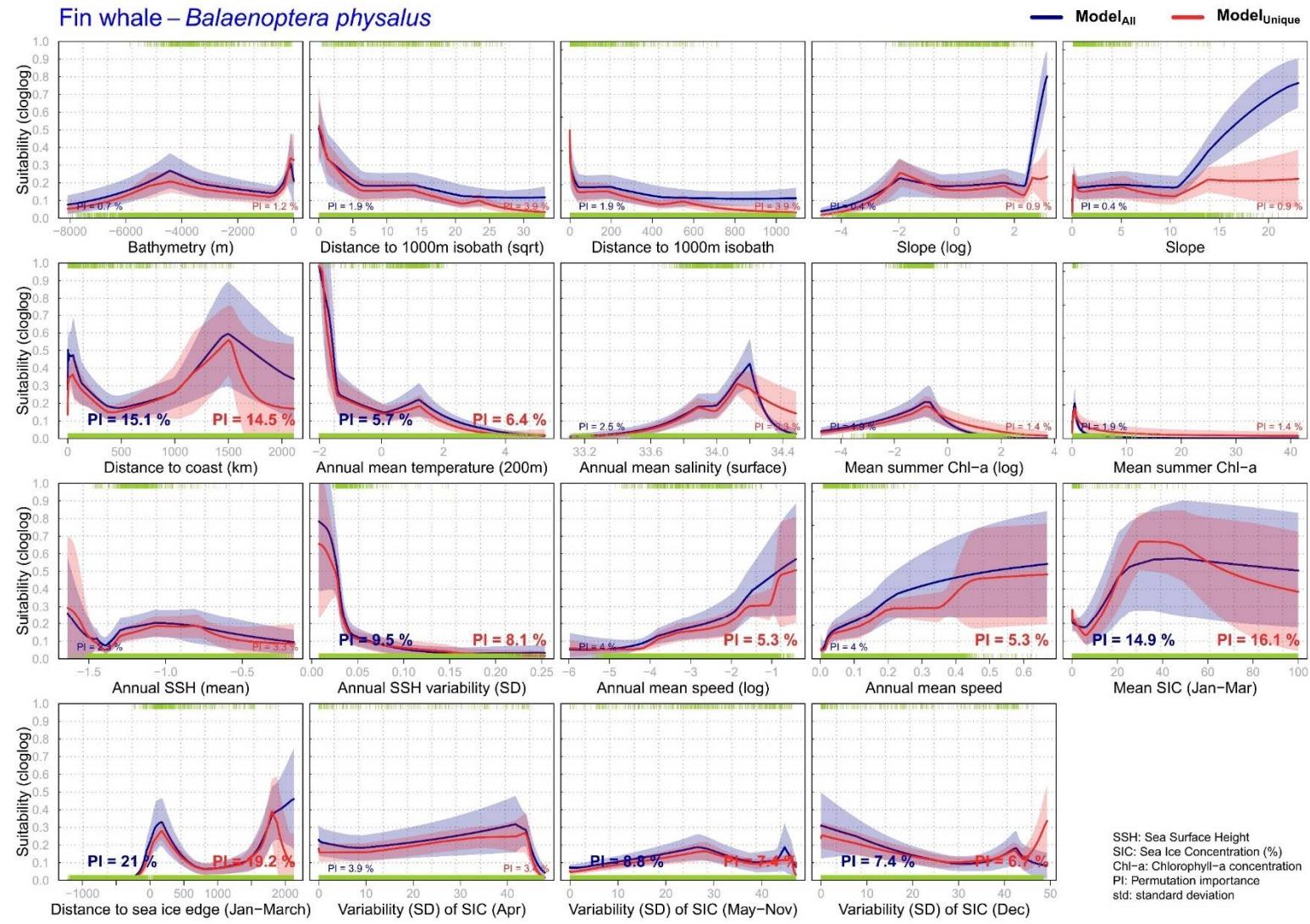


Figure S14: Marginal response curves for the fin whale models. Response curves describe the cloglog prediction changes as each environmental predictor changes, with keeping all other predictors at their average value at training presences. As these response curves are sensitive to the fixed value of other predictors, we also provide the predicted values in the environmental space of the most important three predictors (see Figure S15). Solid blue lines and dashed area represent the mean and standard deviation of the cross-validated response curve of ModelAll, while the red line and dashed area represents ModelUnique. PI represents the permutation importance of the predictor, with predictors with more than 5% permutation importance shown in a larger font. For better understanding, transformed predictors (distance to 1000m isobath, slope, mean summer chlorophyll, annual variability of sea surface height, and annual mean speed) were also back-transformed for visualization. The top green rug shows values at species occurrences; similarly, the bottom rung shows values south of the Polar Front.

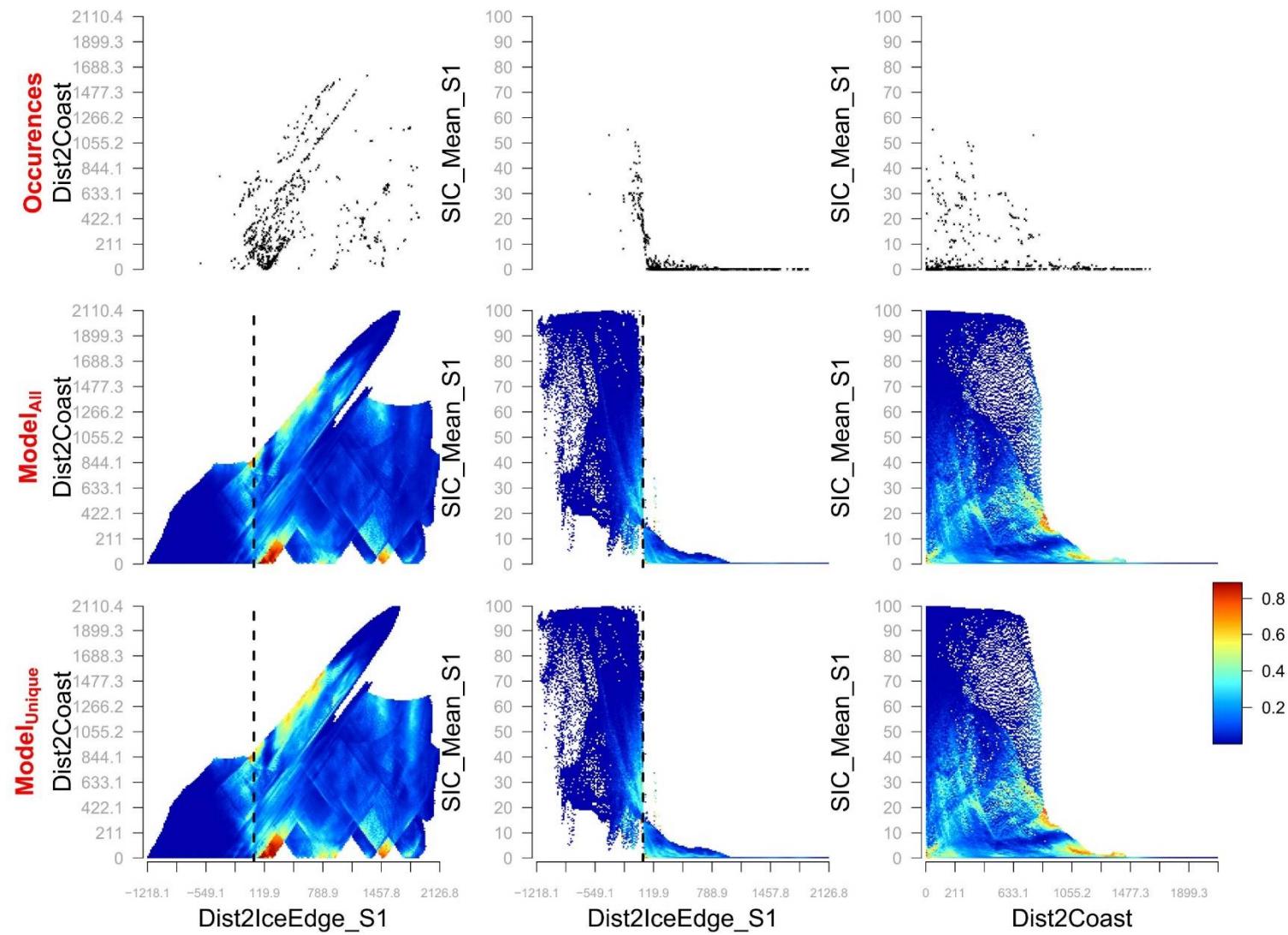


Figure S15: Mean habitat suitability of the fin whale in the environmental space of the three most important environmental predictors. The first row shows combinations at species occurrences, while the second and third rows show predictions from $\text{Model}_{\text{All}}$ and $\text{Model}_{\text{Unique}}$, respectively. In each plot in the second and third row, mean habitat suitability at each respective combination was averaged over all available combinations of other predictors. White areas represent no available environmental combinations in the data. Colours range from blue (low prediction) to red (high prediction). For more information on the predictors acronyms used, see Table 1.

Results of the humpback whale (Figures S16-20)

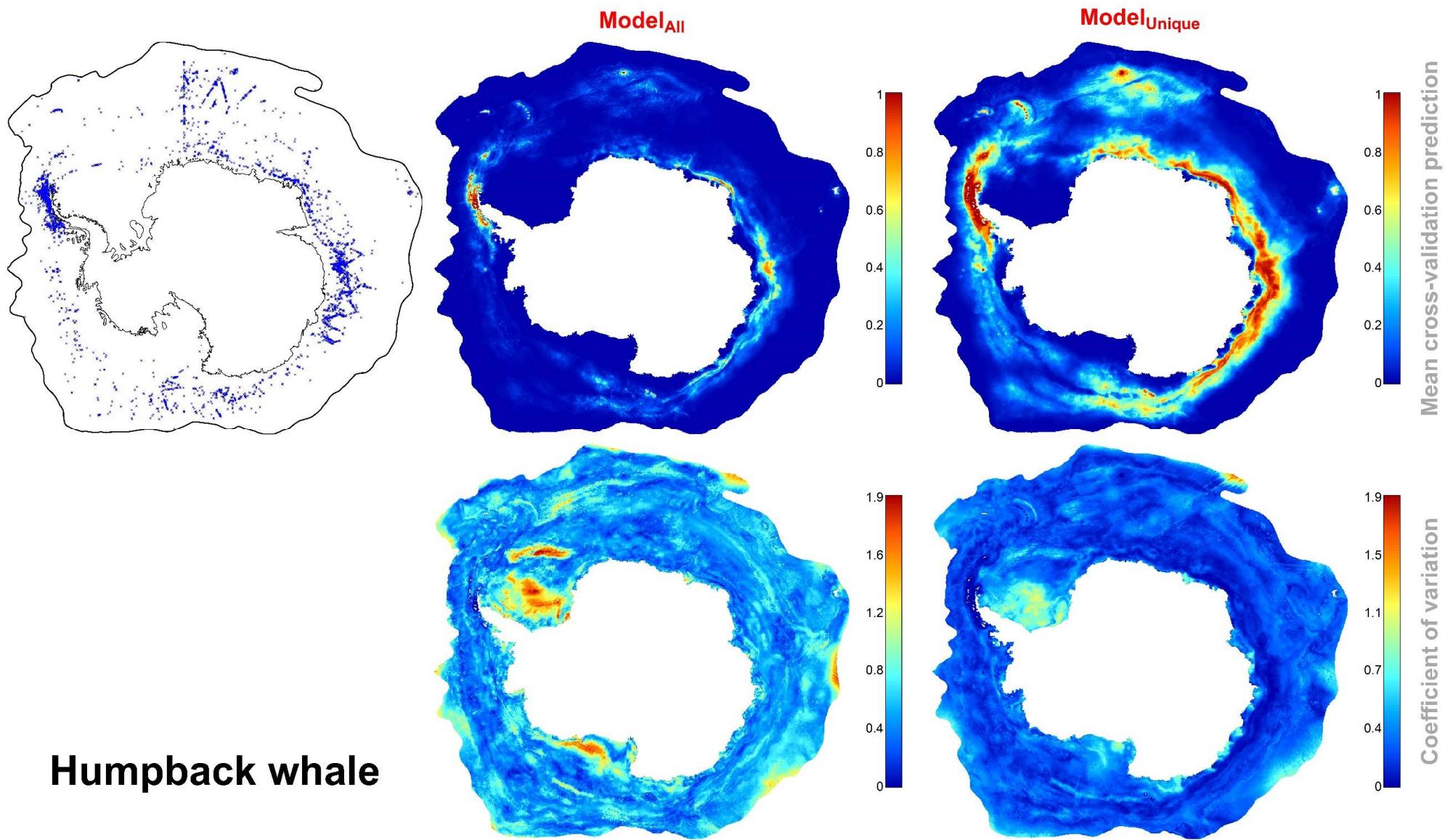


Figure S16: Mean and coefficient of variation of the predicted habitat suitability of the humpback whale on cross-validation. The top left map shows occurrences used to train the models. The coefficient of variation was calculated as the ratio between standard deviation and mean cross-validated habitat suitability.

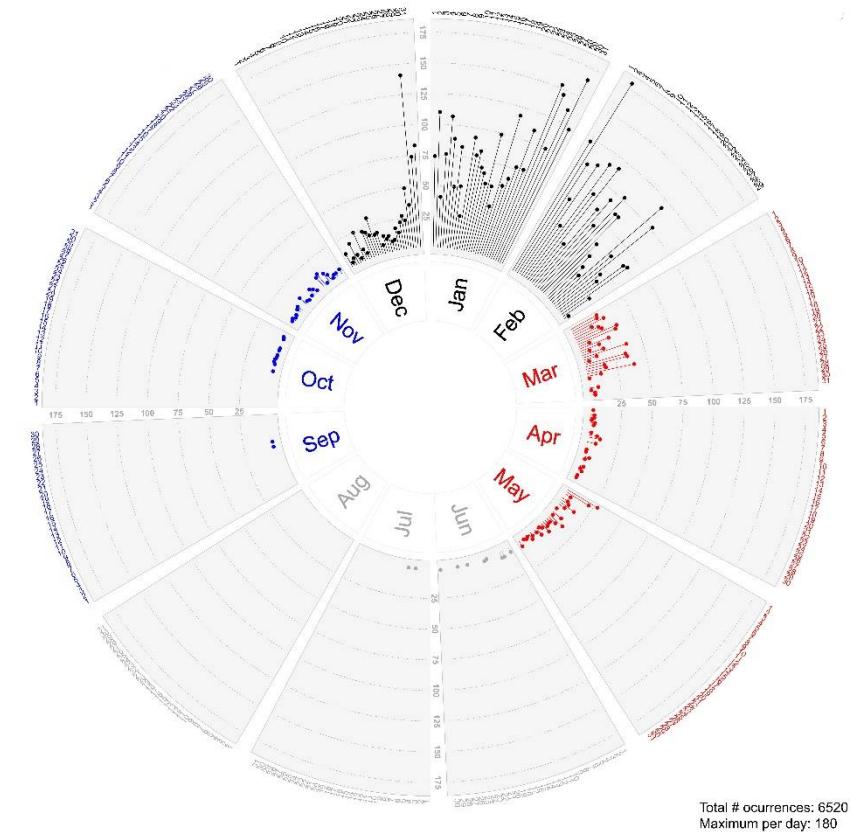
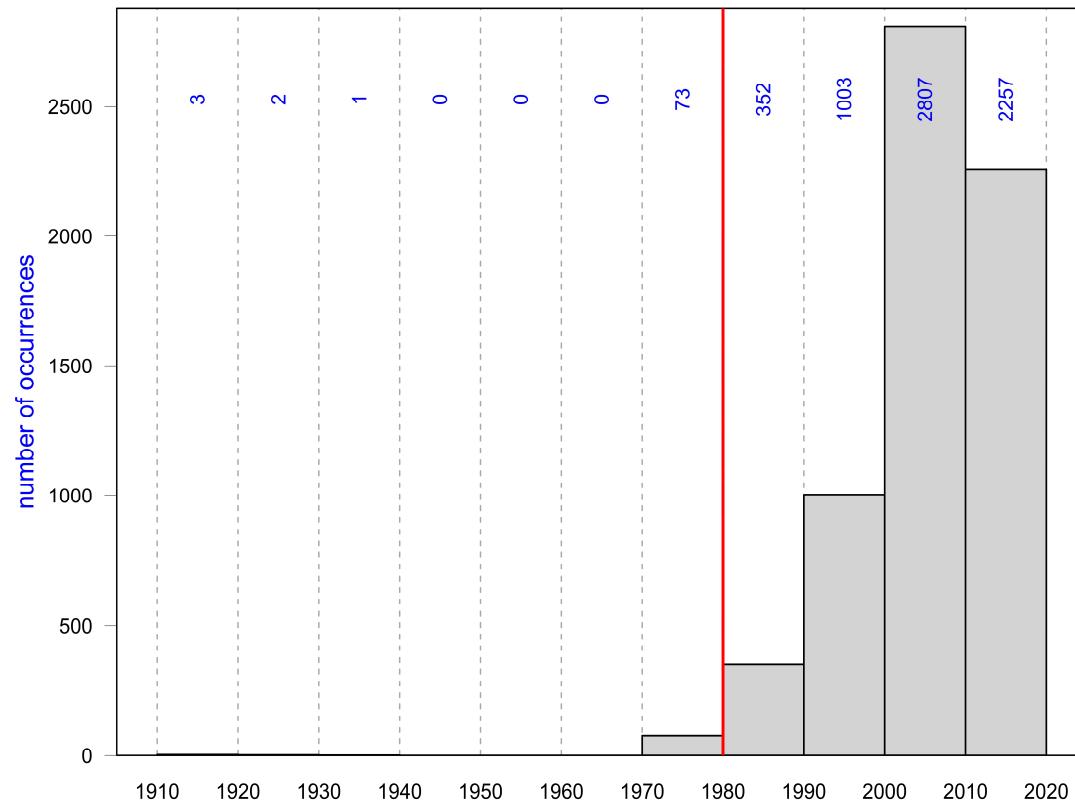


Figure S17: The temporal distribution of available occurrences for the humpback whale. The histogram shows the number of occurrences within each ten-year bin. The red vertical line differentiates occurrences excluded (before 1980) or included (after 1980) in the analysis. The right plot shows the number of occurrences after 1980 on each calendar day. The majority of occurrences were collected during summer months (particularly in January and February).

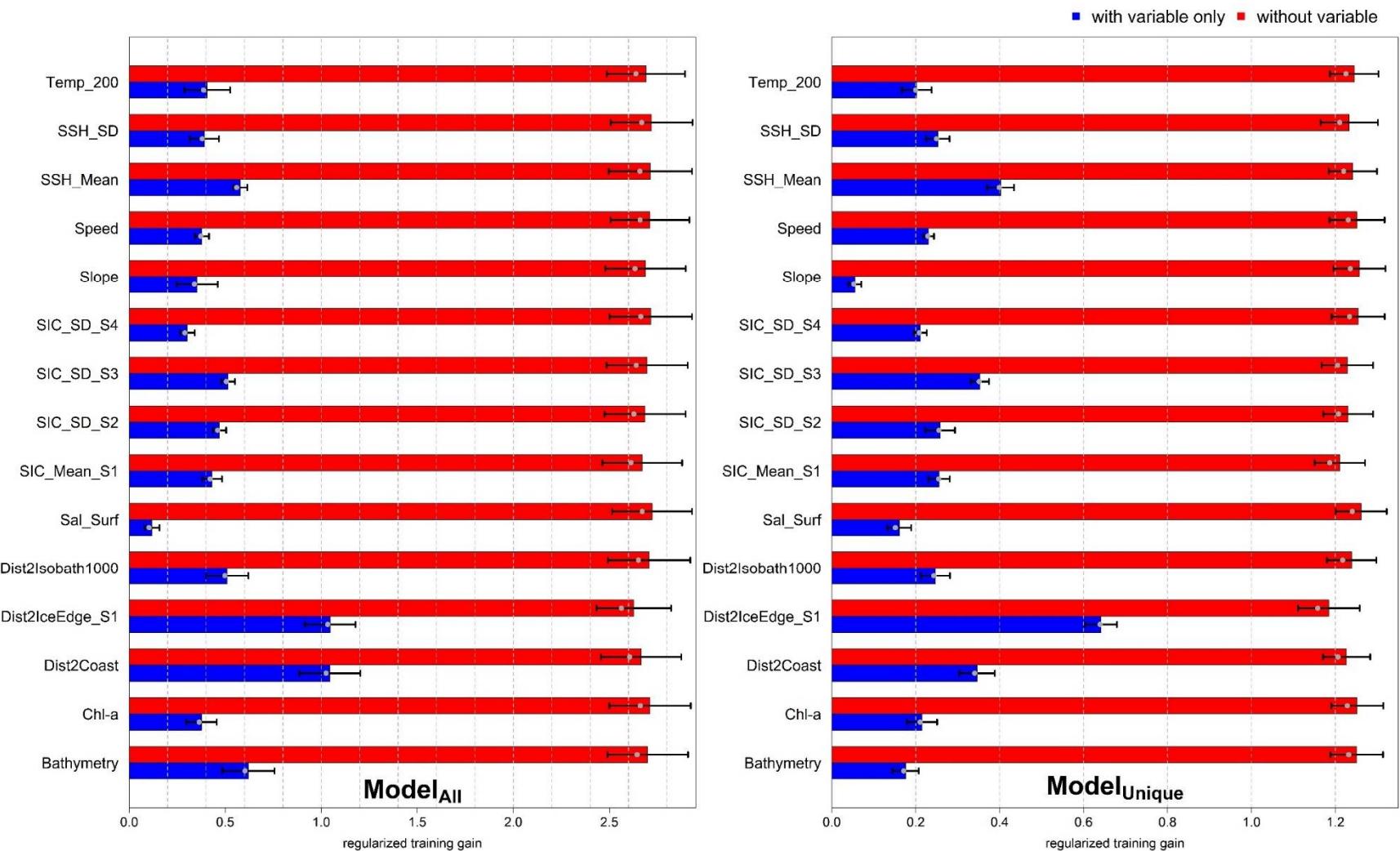


Figure S18: Results for Maxent's jackknifing test for Model_{All} (left) and Model_{Unique} (right) for the humpback whale. Red bars represent the cross-validated mean regularized training gain (a measure of goodness-of-fit) for sub-models calibrated using all predictors except the respective predictor. In contrast, blue bars represent complementary results for models calibrated only with the respective predictor. Error bars represent the standard deviation of the regularized training gain on cross-validation. Grey points show results for the full model, calibrated with no cross-validation. For more information on predictor abbreviations, see Table 1.

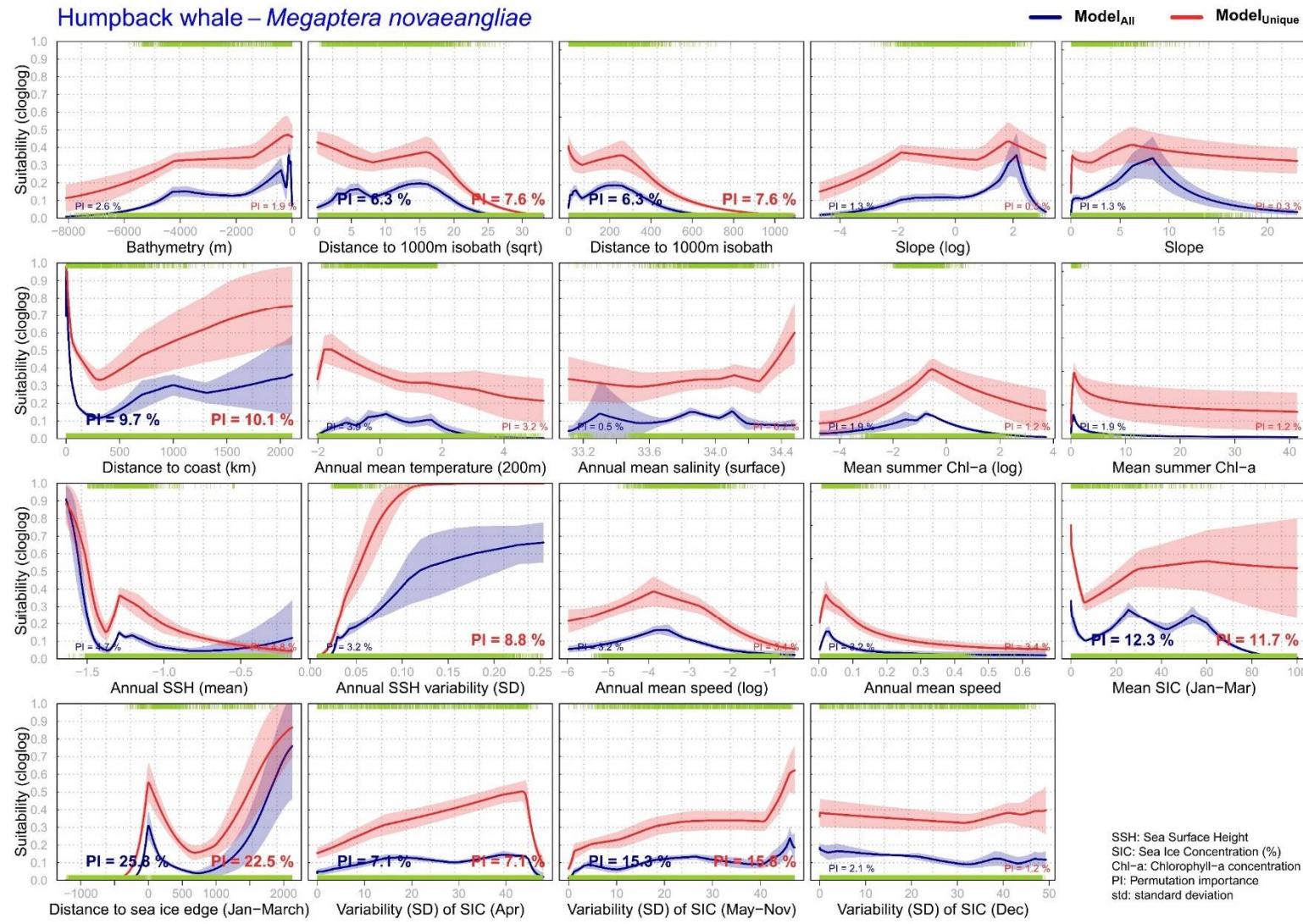


Figure S19: Marginal response curves for the humpback whale models. Response curves describe the cloglog prediction changes as each environmental predictor changes, with keeping all other predictors at their average value at training presences. As these response curves are sensitive to the fixed value of other predictors, we also provide the predicted values in the environmental space of the most important three predictors (see Figure S20). Solid blue lines and dashed area represent the mean and standard deviation of the cross-validated response curve of Model_{All}, while the red line and dashed area represents Model_{Unique}. PI represents the permutation importance of the predictor, with predictors with more than 5% permutation importance shown in a larger font. For better understanding, transformed predictors (distance to 1000m isobath, slope, mean summer chlorophyll, annual variability of sea surface height, and annual mean speed) were also back-transformed for visualization. The top green rug shows values at species occurrences; similarly, the bottom rung shows values south of the Polar Front.

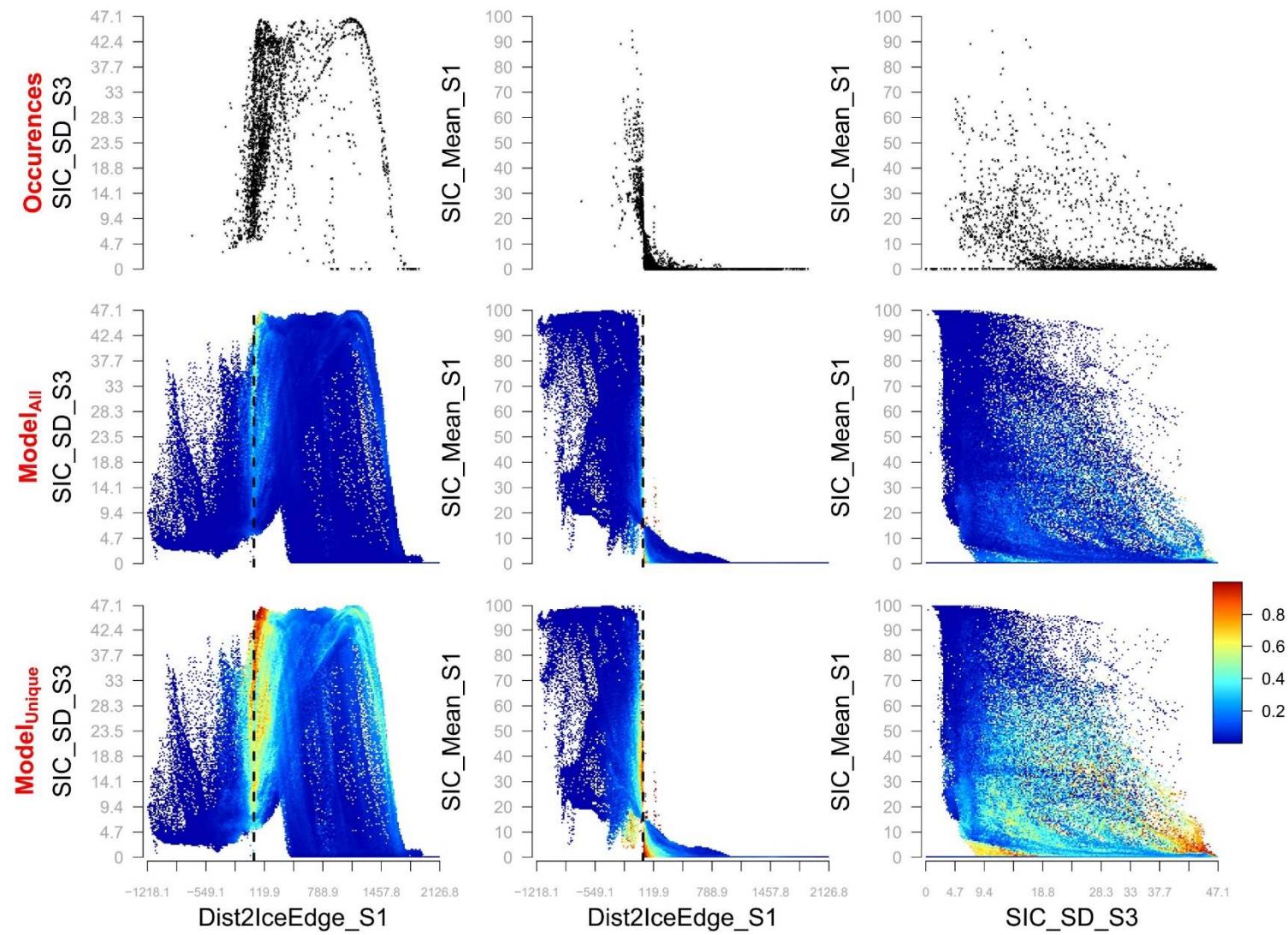


Figure S20: Mean habitat suitability of the humpback whale in the environmental space of the three most important environmental predictors. The first row shows combinations at species occurrences, while the second and third rows show predictions from $\text{Model}_{\text{All}}$ and $\text{Model}_{\text{Unique}}$, respectively. In each plot in the second and third row, mean habitat suitability at each respective combination was averaged over all available combinations of other predictors. White areas represent no available environmental combinations in the data. Colours range from blue (low prediction) to red (high prediction). For more information on the predictors acronyms used, see Table 1.

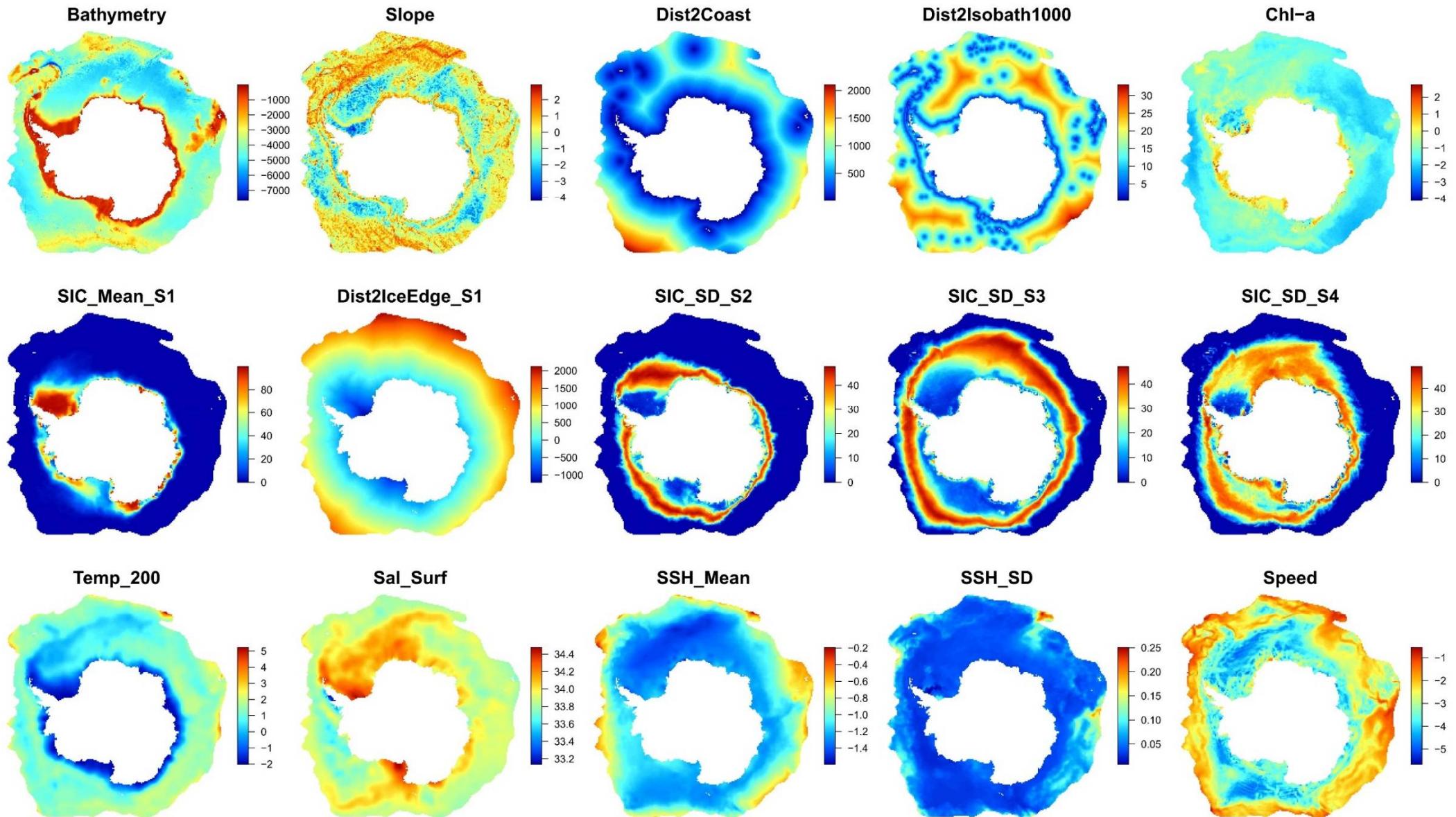


Figure S21: Maps of the 15 environmental predictors used to run the models. For more information on predictor abbreviations, see Table 1.

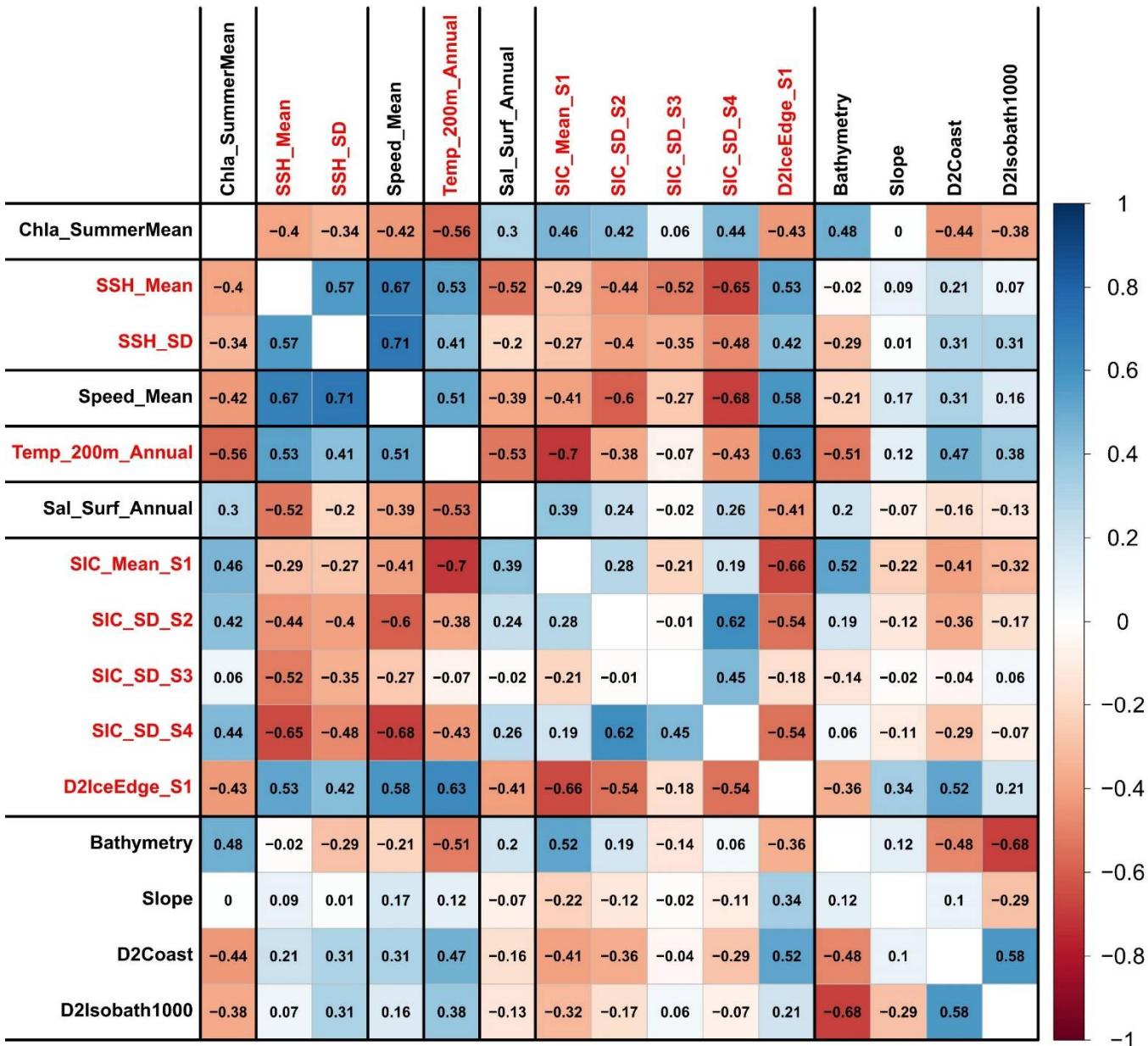
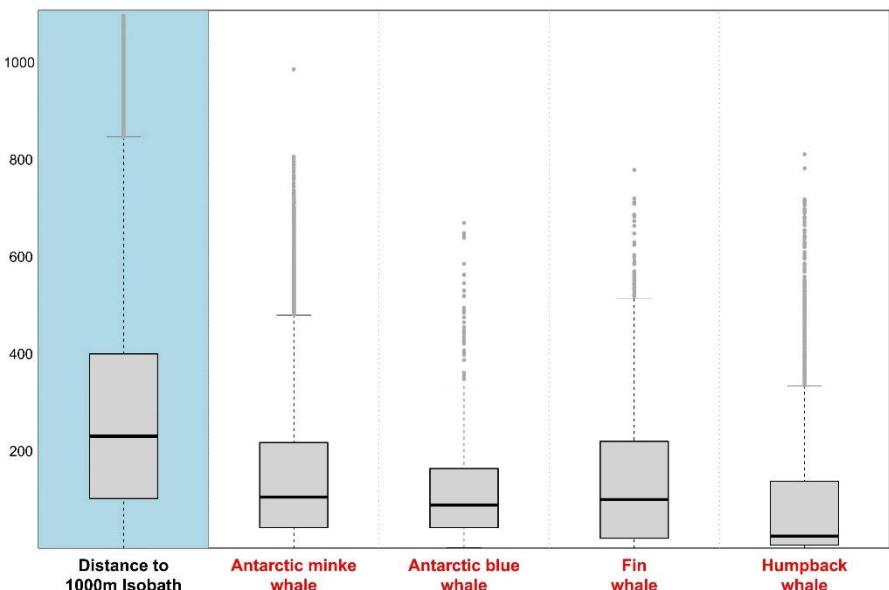
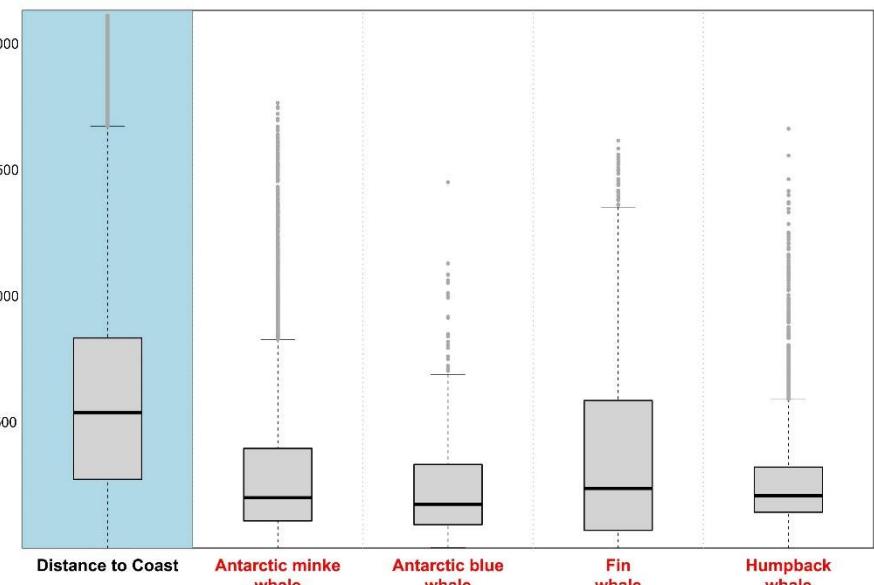
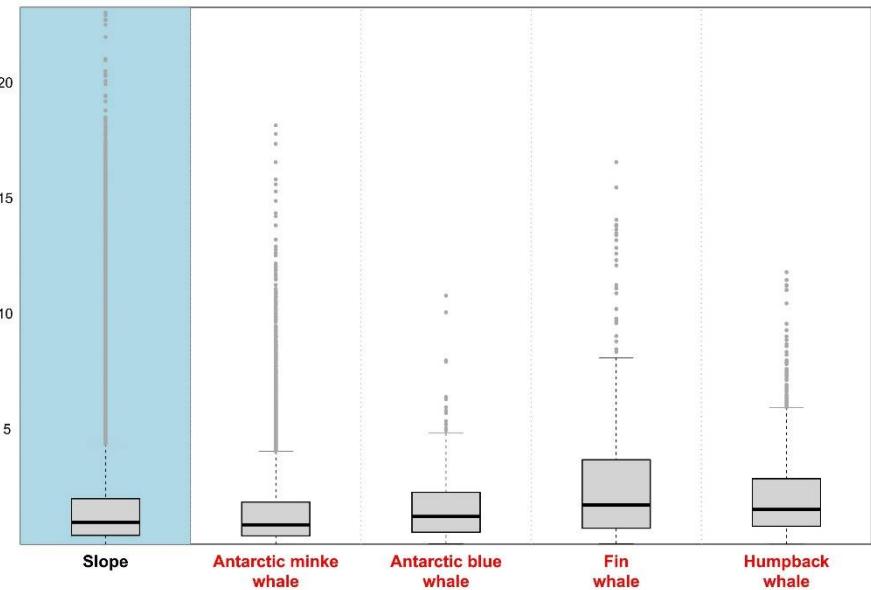
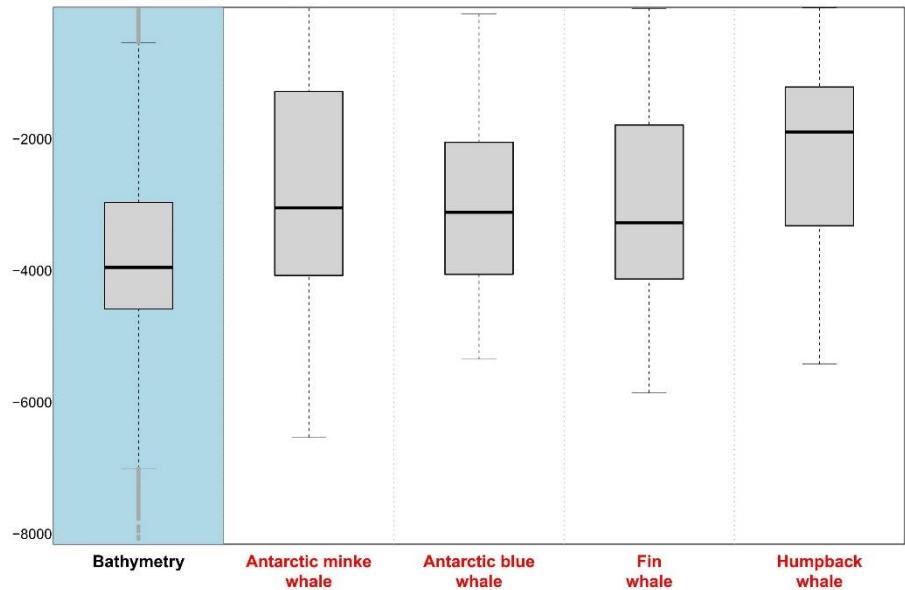
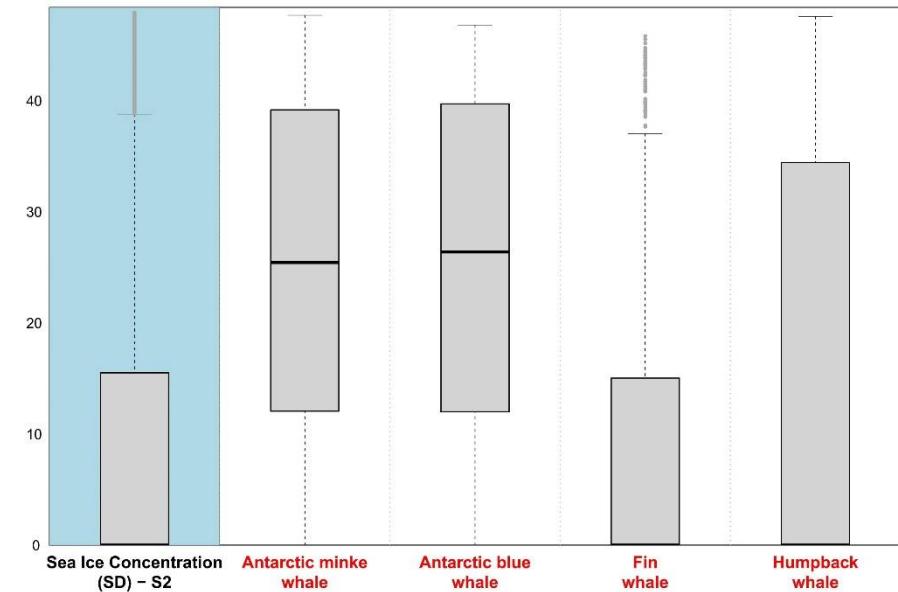
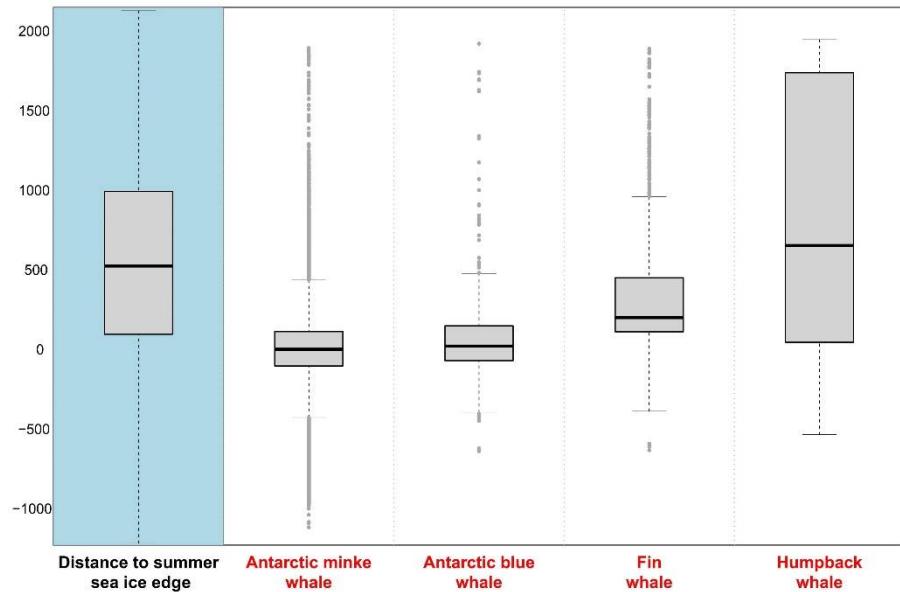
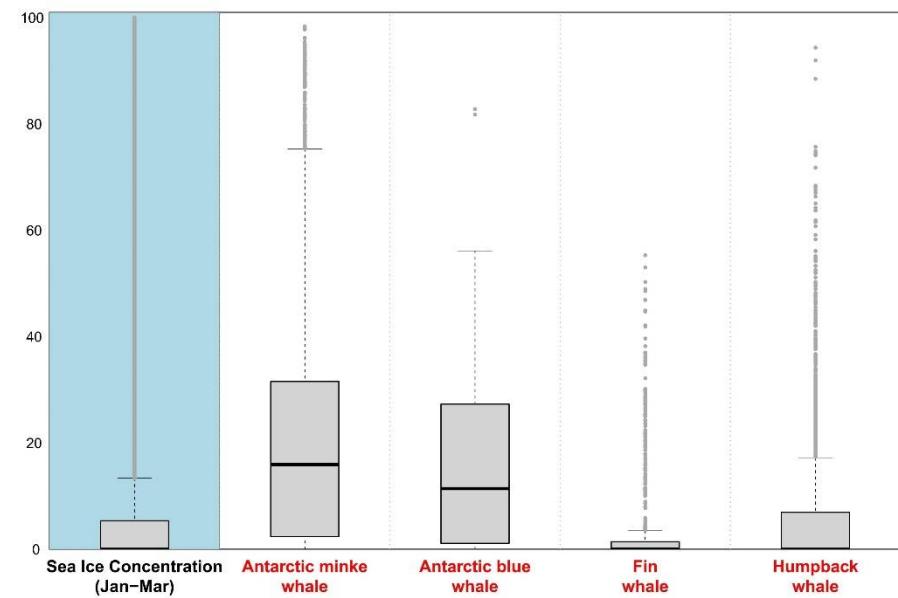
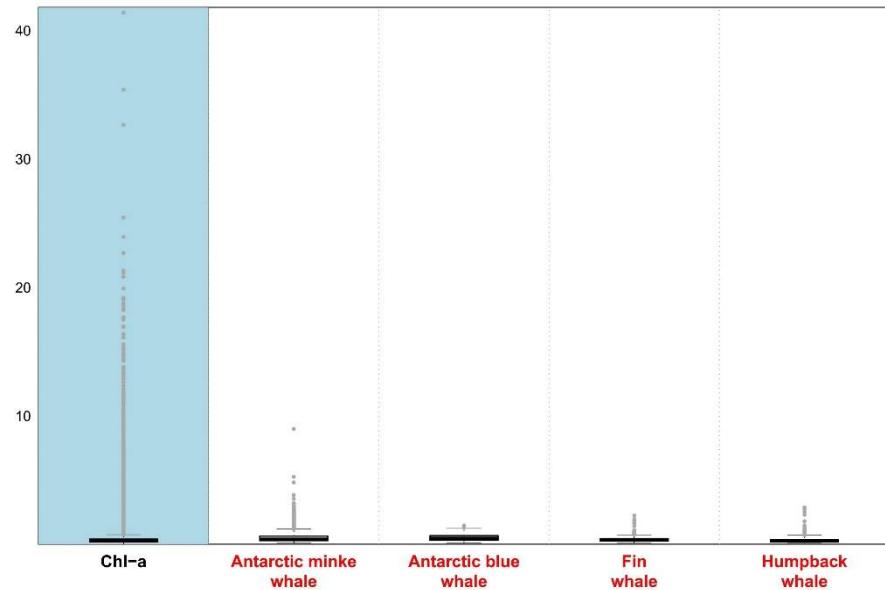
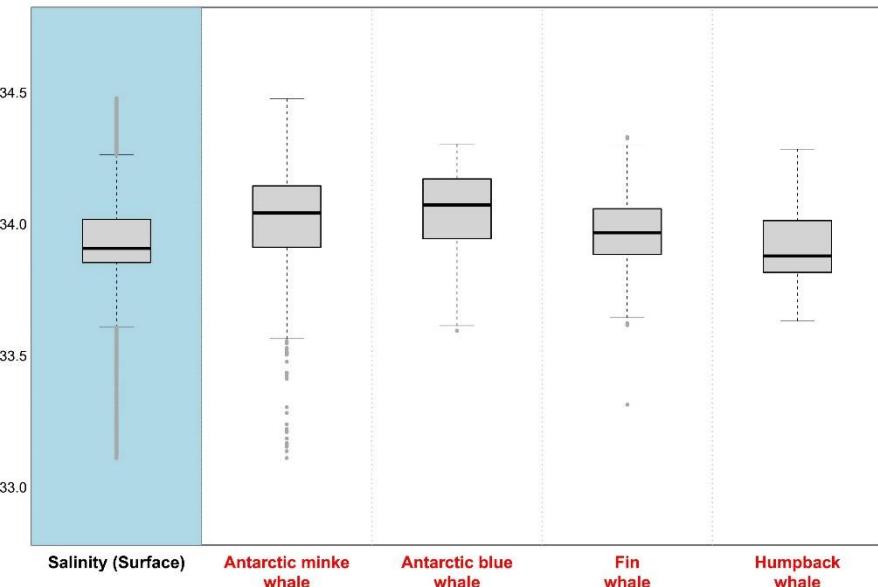
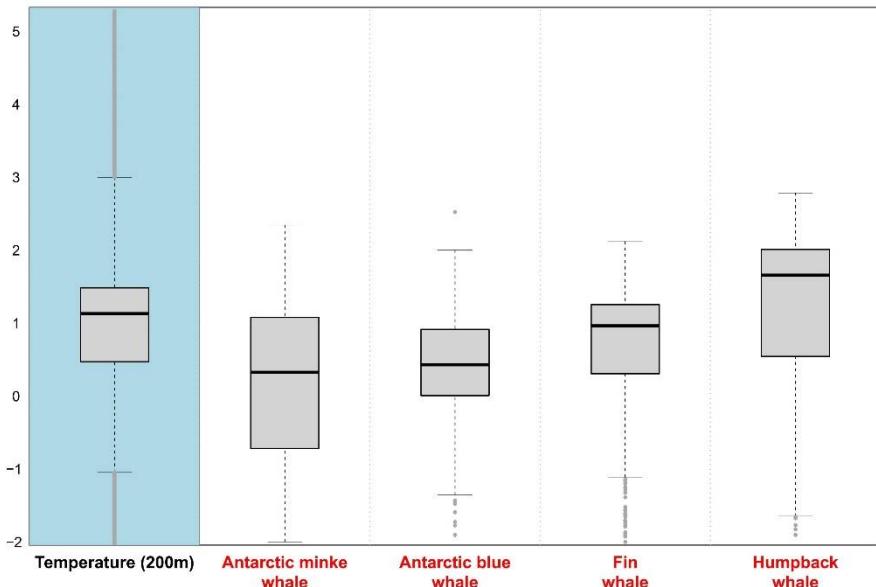
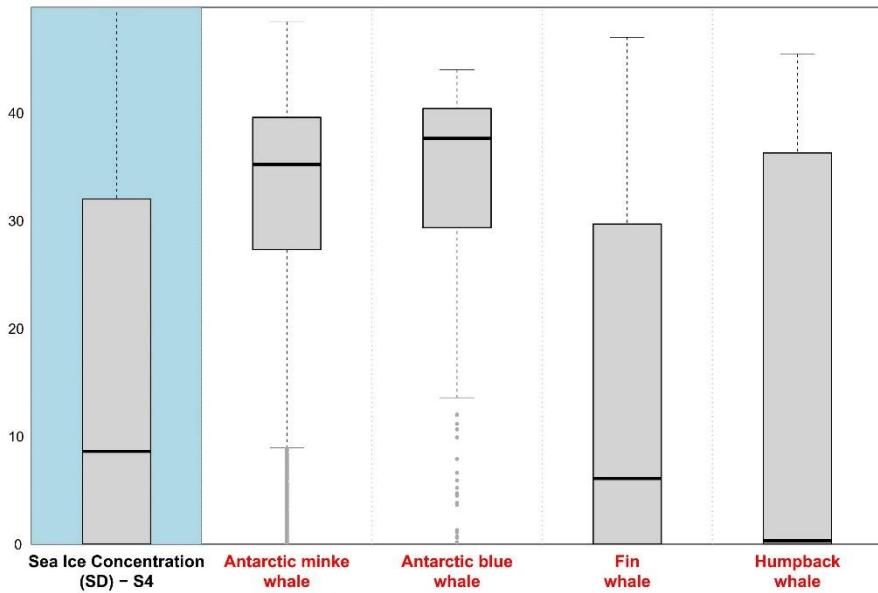
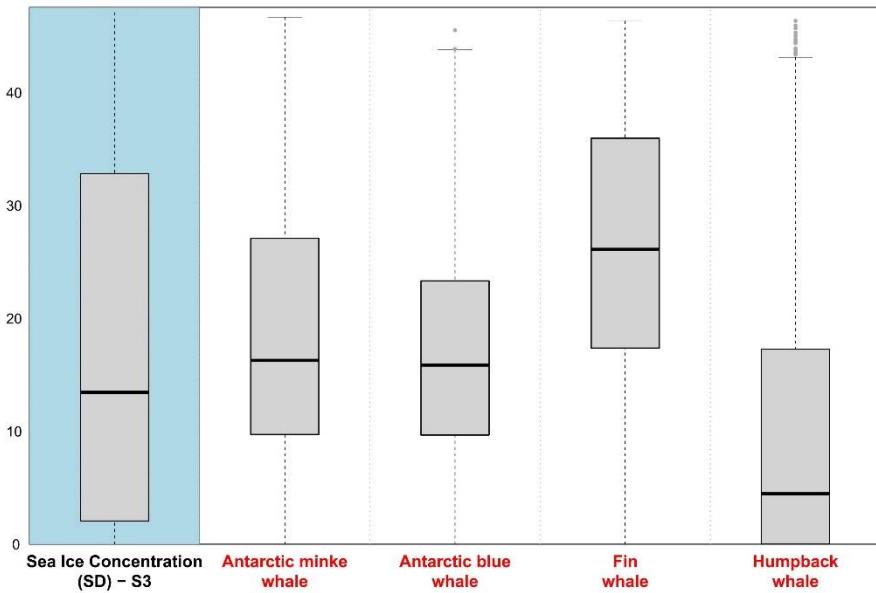


Figure S22: Pearson correlation coefficient between each pair of environmental predictors used to run the models. Highly correlated predictors were excluded in advance using variance inflation factor (see main text). The maximum value of the correlation coefficient is 0.71. Colours range from red (high negative correlation) to blue (high positive correlation). For more information on predictor abbreviations, see Table 1.







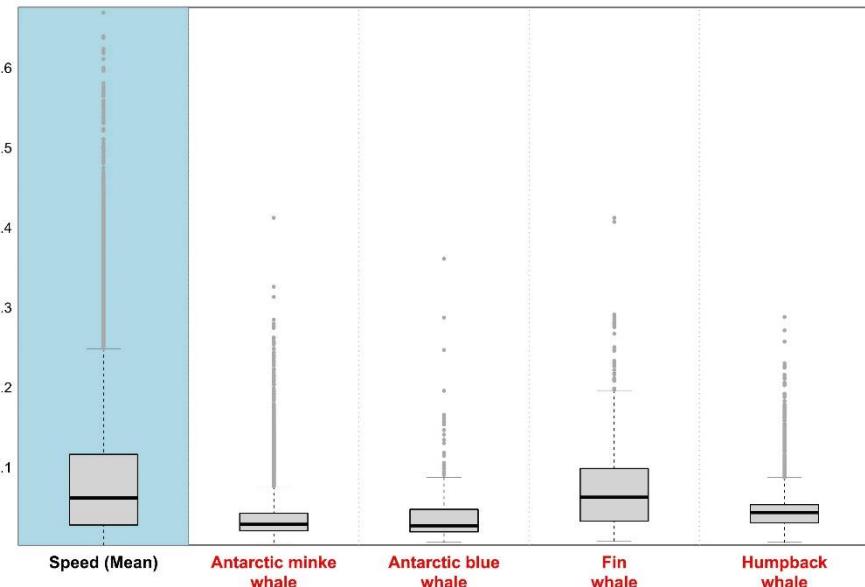
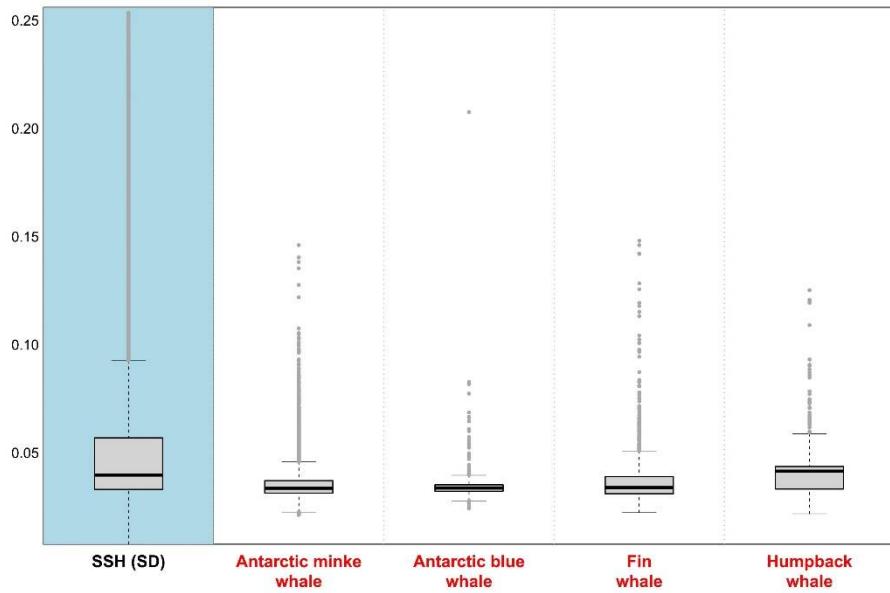
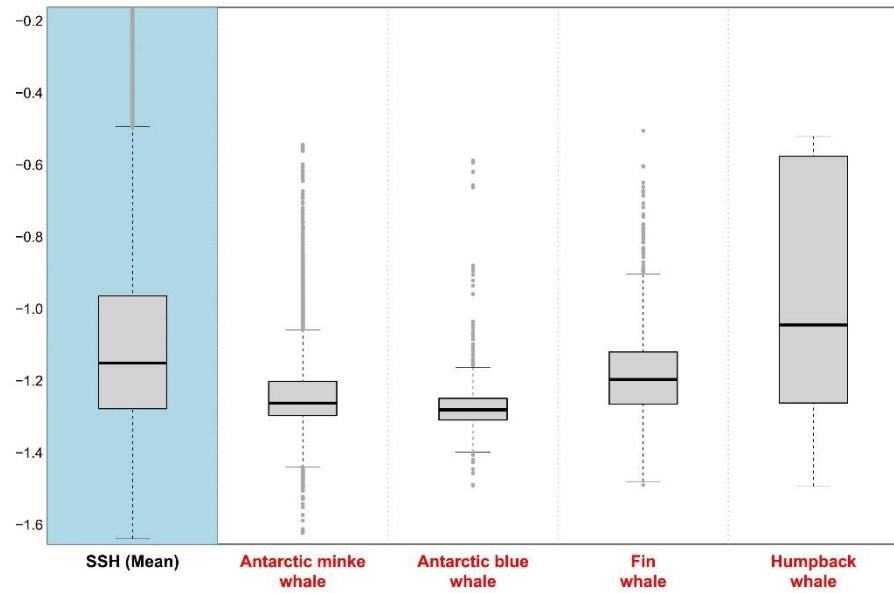
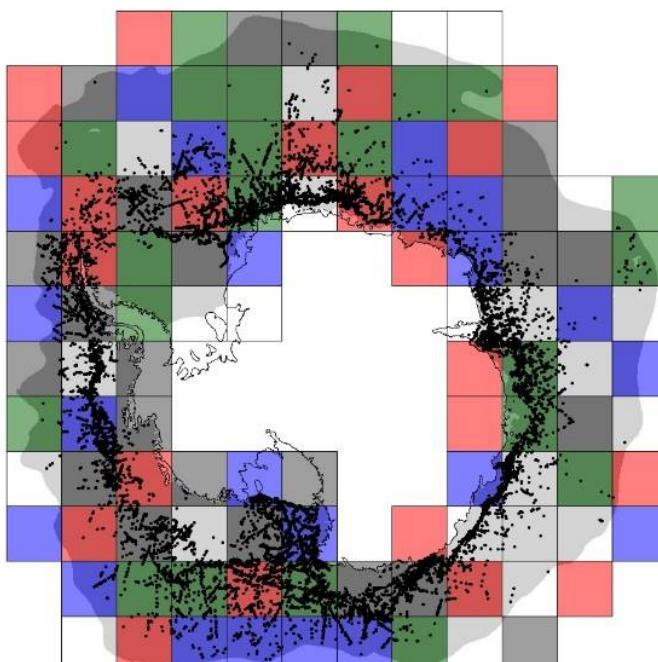


Figure S23: Boxplots comparing values of each environmental predictor south of the Polar Front with corresponding values at species-specific sightings. For more information on predictor abbreviations, see Table 1.

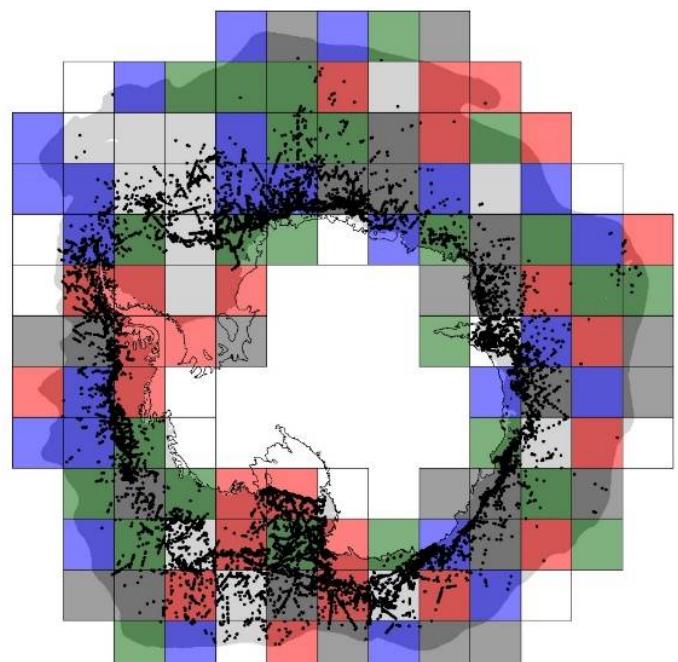
Antarctic minke whale

Model_{All}



659.7 km

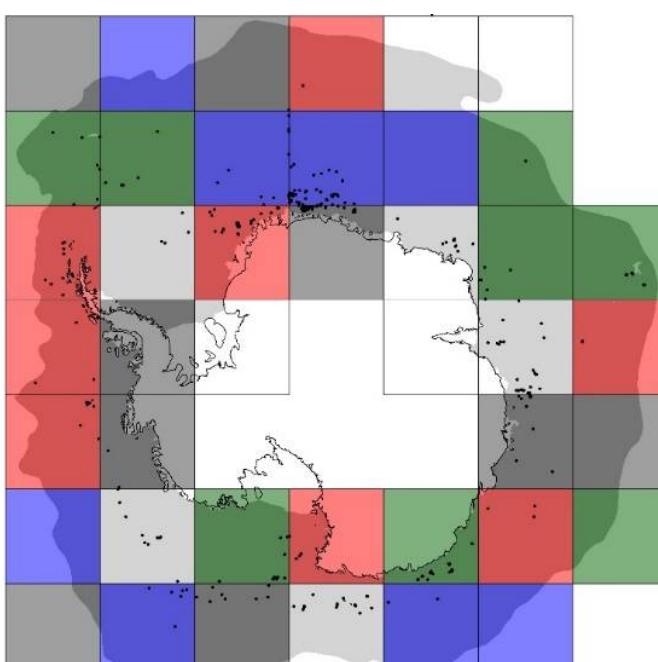
Model_{Unique}



640.4 km

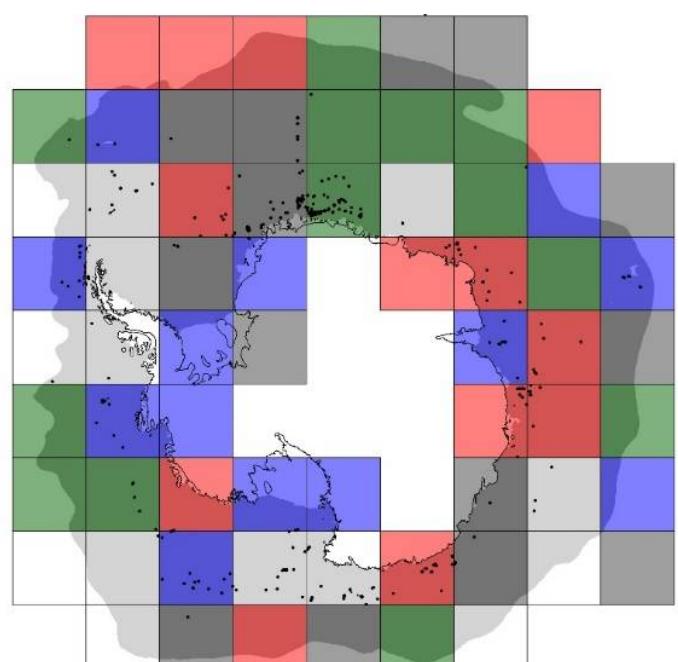
Antarctic blue whale

Model_{All}



1128.1 km

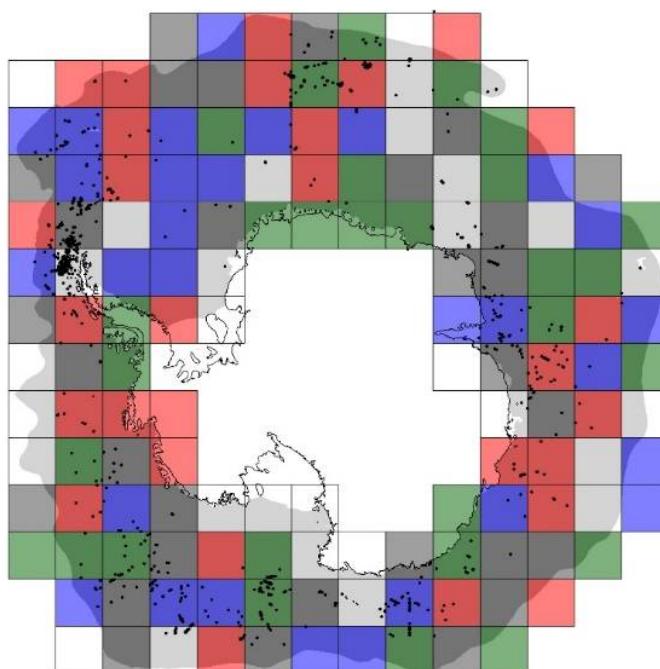
Model_{Unique}



912.4 km

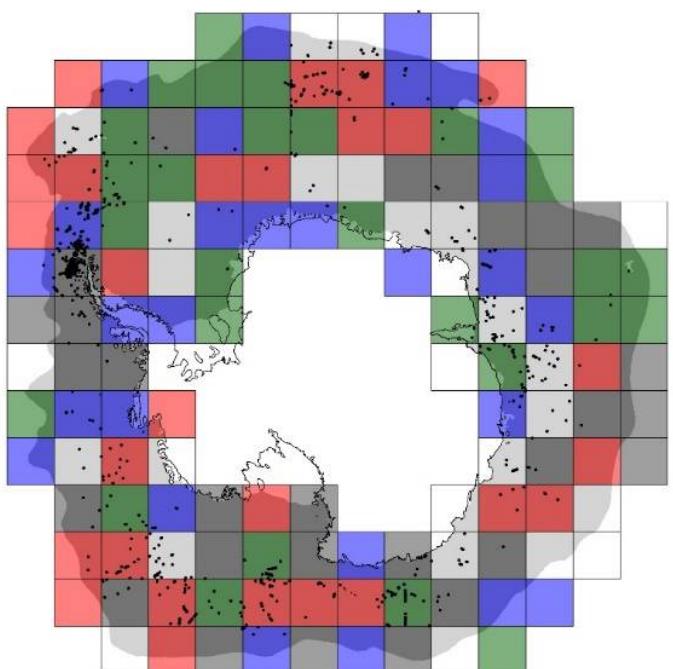
Fin whale

Model_{All}



560.3 km

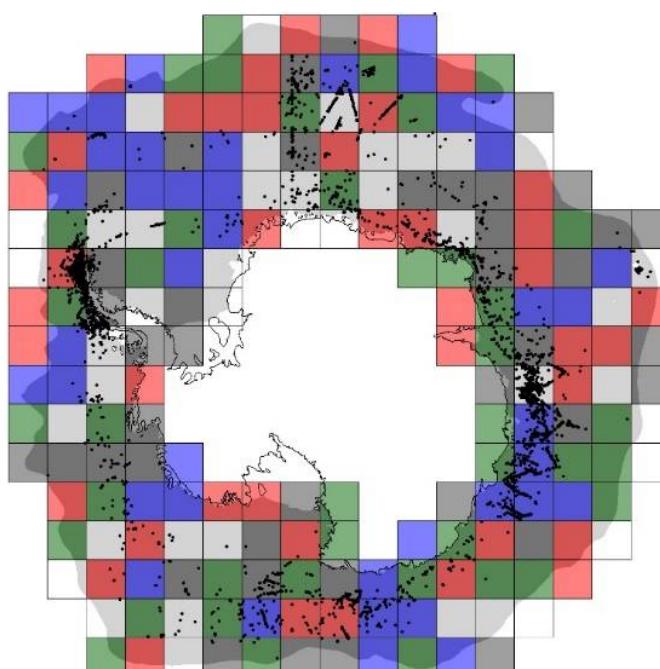
Model_{Unique}



584.7 km

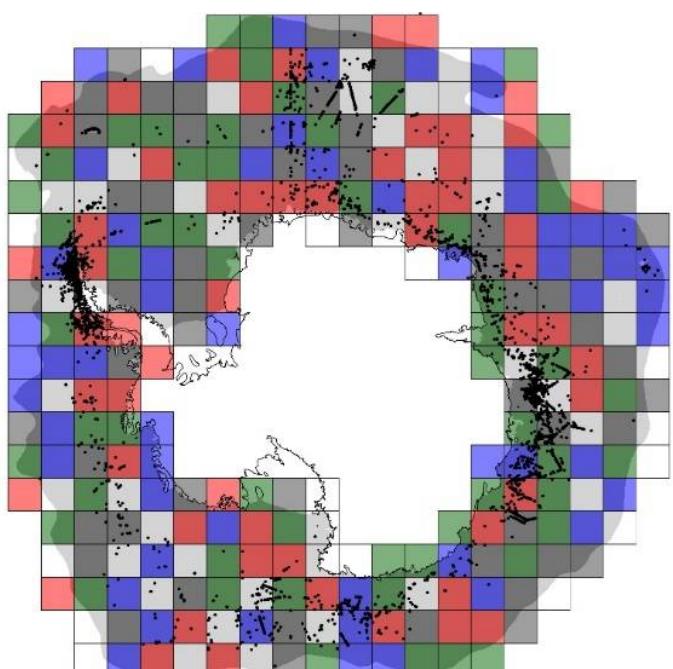
Humpback whale

Model_{All}



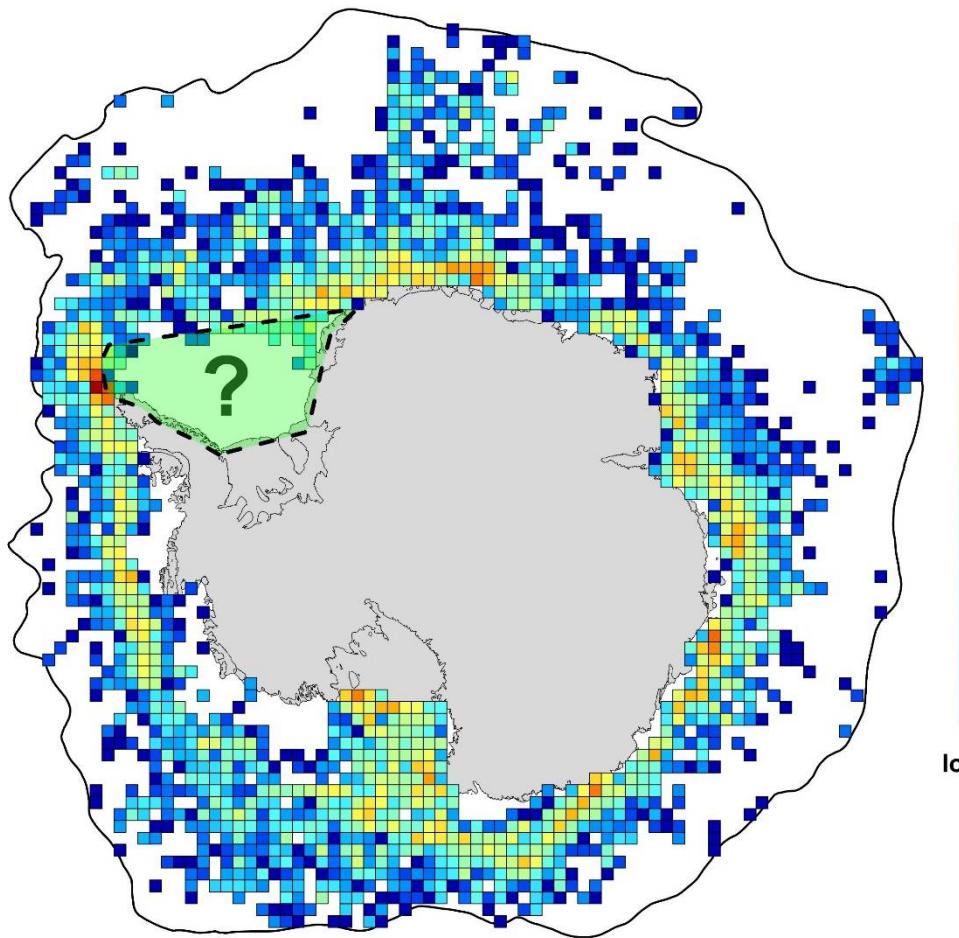
472.5 km

Model_{Unique}



390.2 km

Figure S24: The spatial allocation of blocks into species- and model-specific five-fold cross-validation. Block colour indicates how blocks were distributed into cross-validation folds. Model_{All} represents models run using all occurrences, while Model_{Unique} represents models calibrated after removing duplicated occurrences within each 10×10 km cell. The number below each map represents the size of each block in kilometre. Points represent species presence-only sightings used in this study



\log_{10}

2.5
2.0
1.5
1.0
0.5
0.0

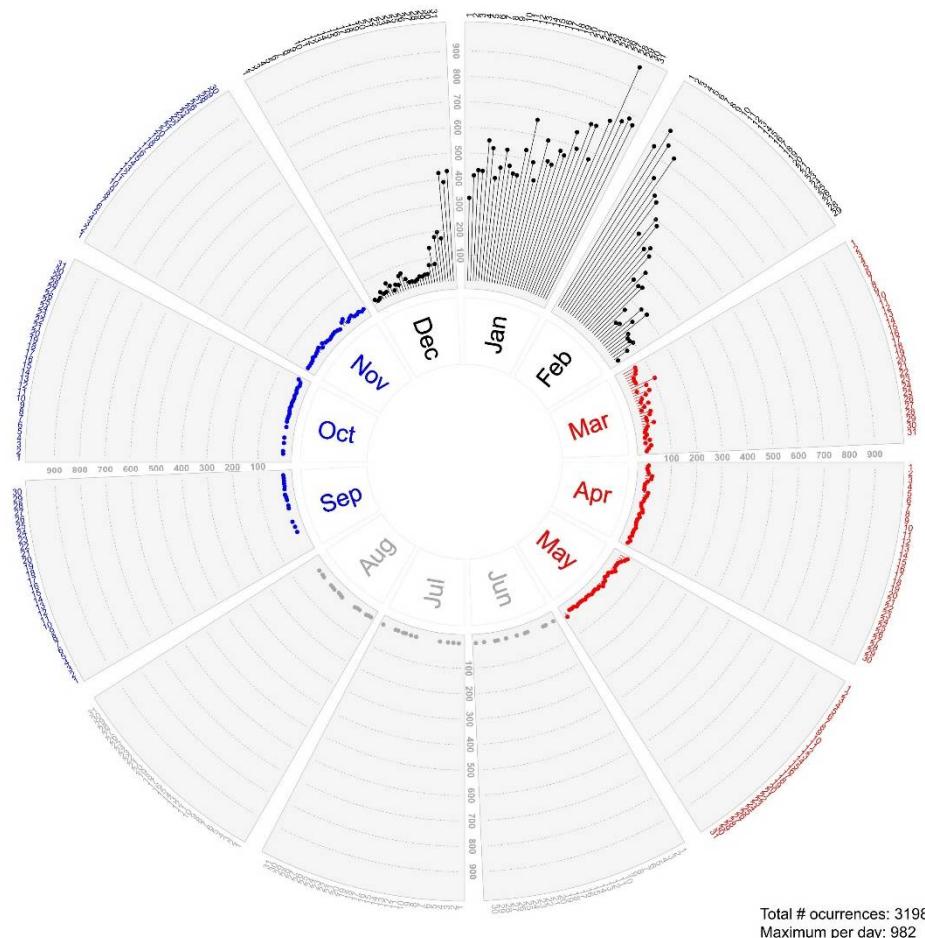


Figure S25: Spatiotemporal biases in species observation data. The map to the left shows the number of sightings used in this study (log-scale) per 100×100 km grid. Note the existence of high sampling bias towards the Antarctic Peninsula area and the absence of sightings from the majority of the Weddell Sea (dashed polygon). The plot to the right shows the number of sightings used in this study at each calendar day. There is an inevitable temporal bias in the visual observations data towards the summer months, particularly from the end of December to mid-April.

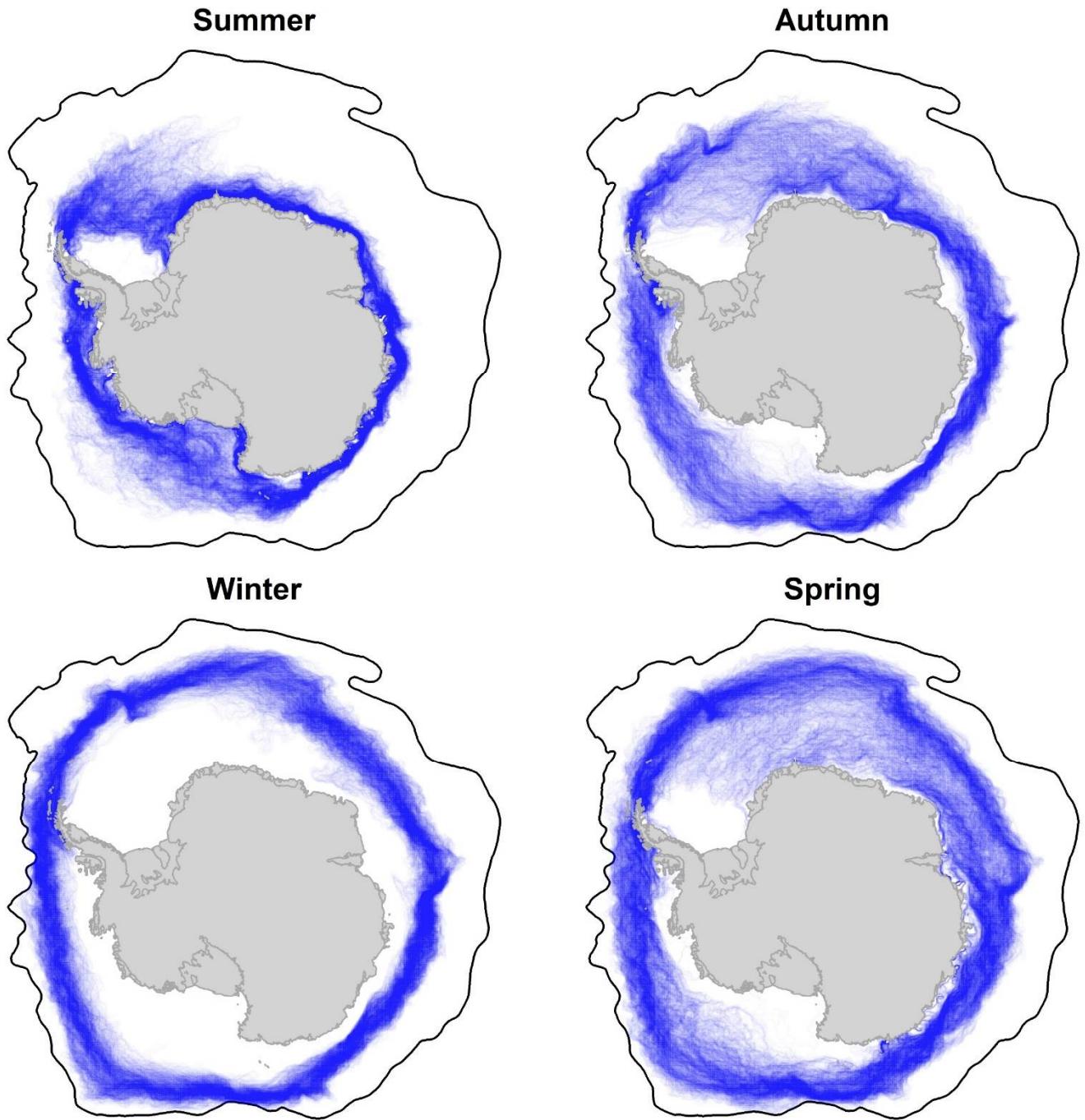


Figure S26: The seasonal distribution of daily sea ice edge from 2002 to 2019. Here, seasons were determined as three-month intervals from January.

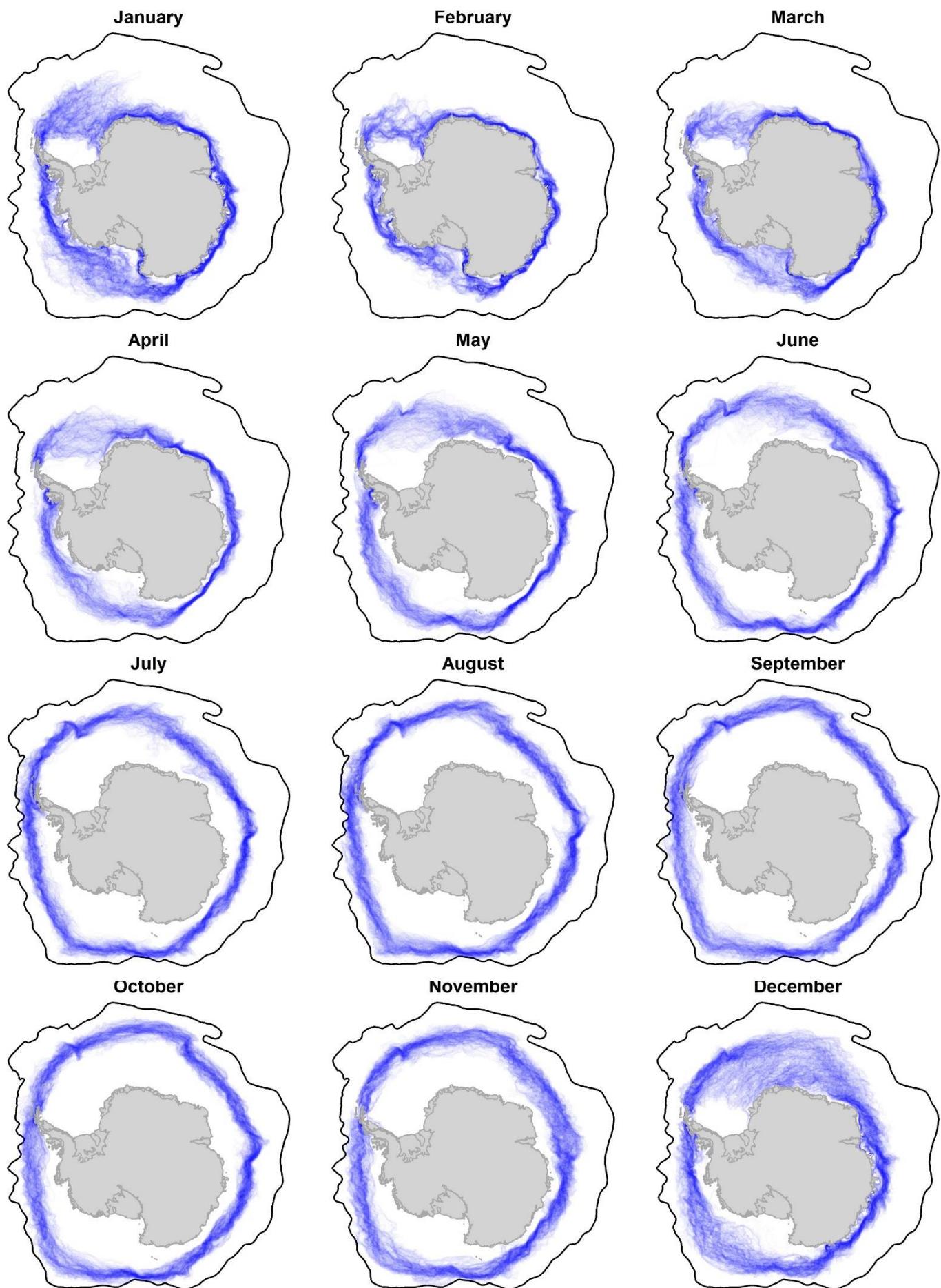
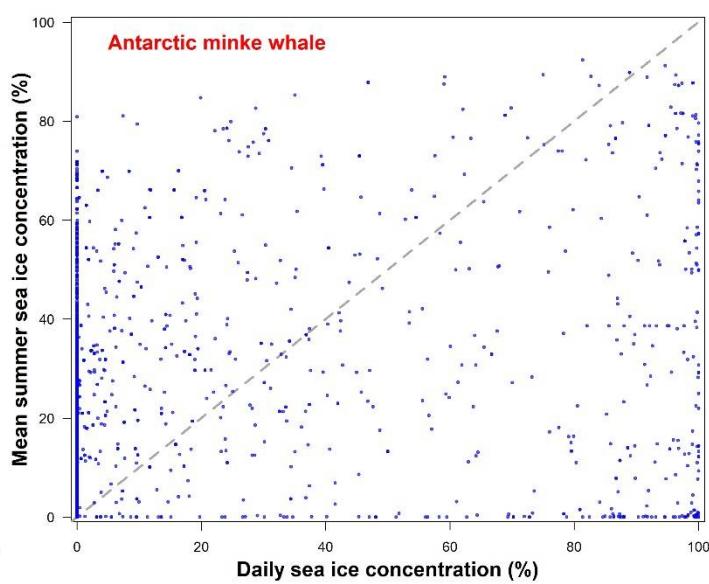
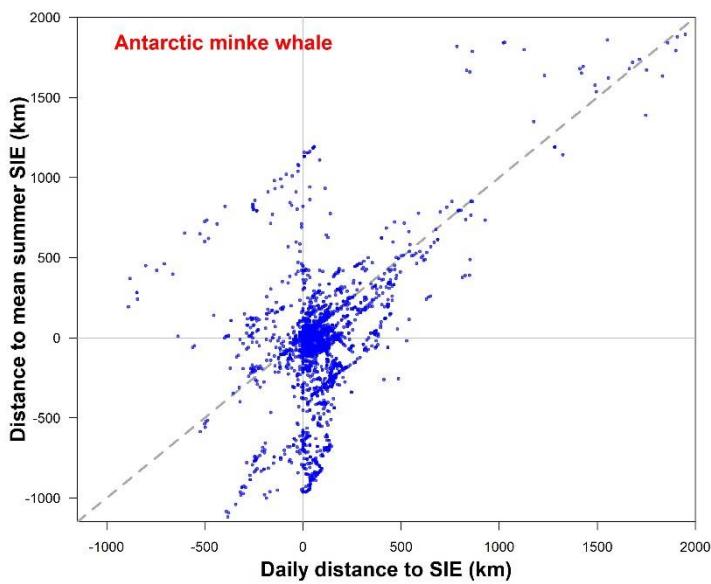
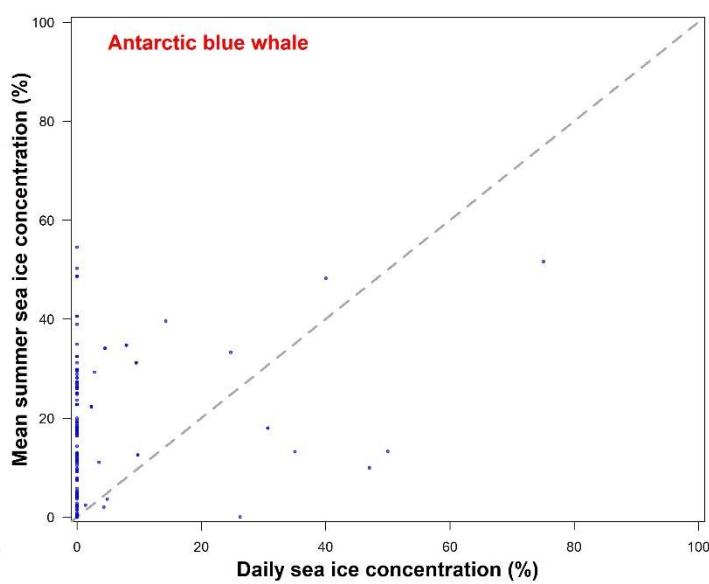
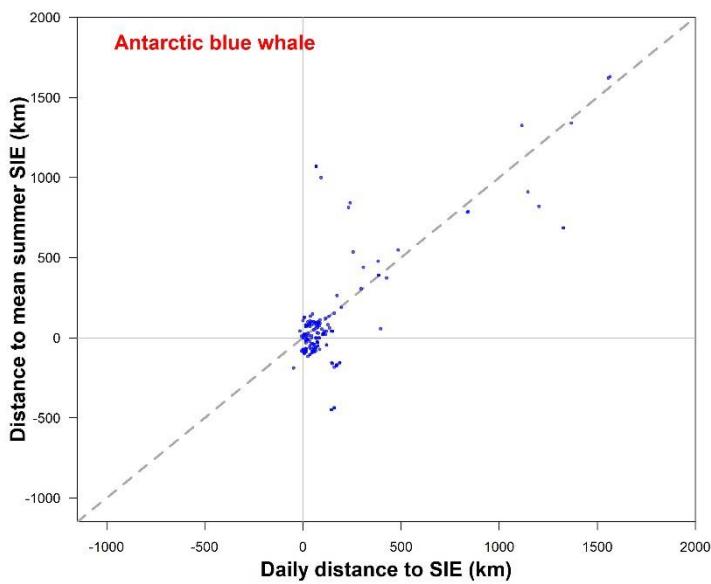


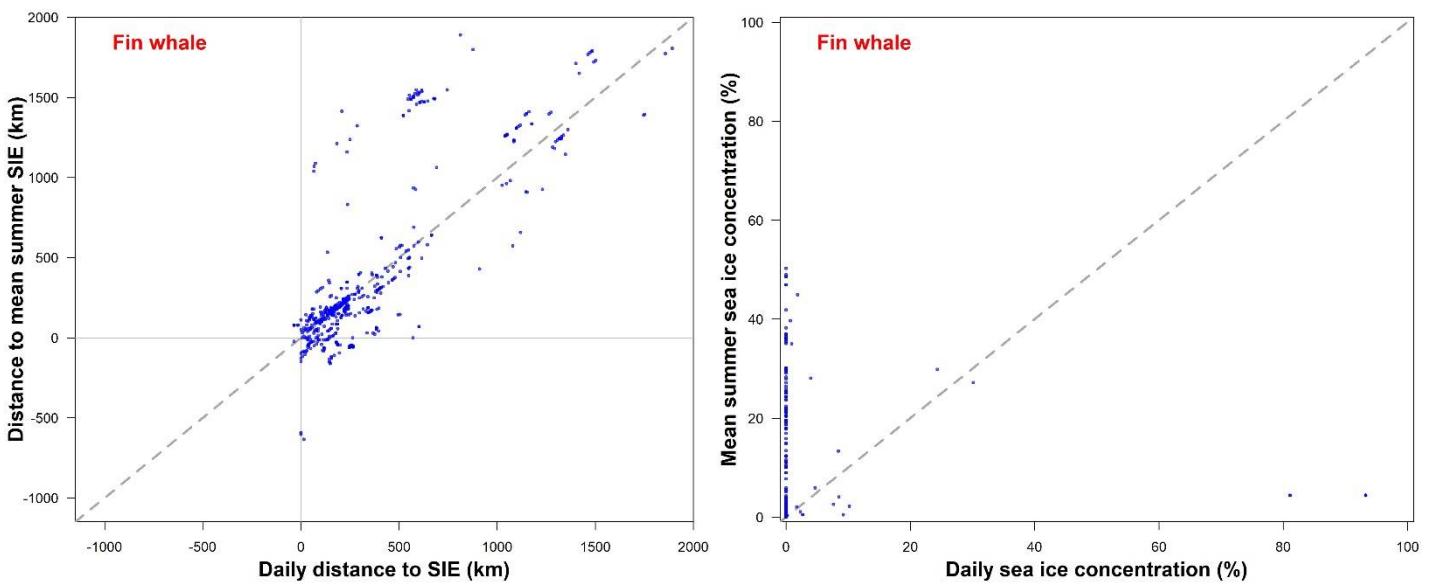
Figure S27: Monthly distribution of daily sea ice edge from 2002 to 2019.



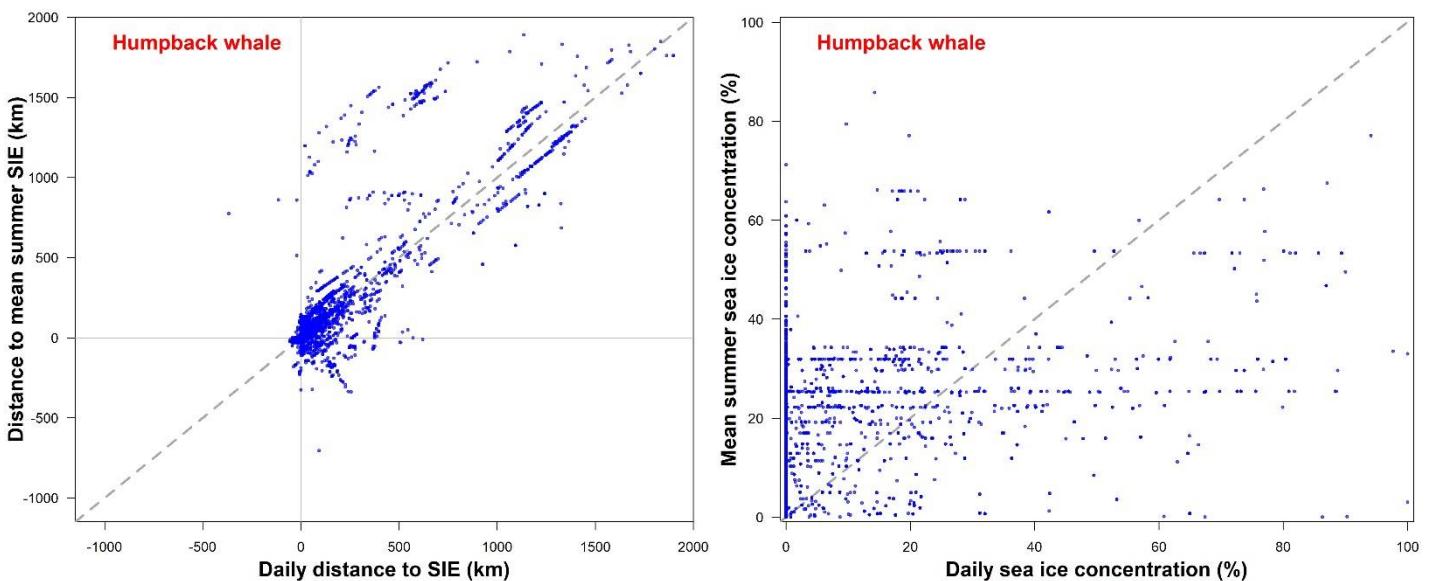
(A) Antarctic minke whale



(B) Antarctic blue whale



(C) Fin whale



(D) Humpback whale

Figure S28: Comparison between distance to sea ice edge (SIE, left plots) or sea ice concentration (SIC, right plots) at species sightings, either spatiotemporally matched with their respective daily distance to SIE or SIC (x-axis) or spatially matched with the mean distance to summer SIE or SIC (y-axis, predictors used in this study). Horizontal and vertical grey lines in the left plots represent the location of SIE. The dashed grey line represents the identity ($y=x$ relationship). It is clear that summarising highly dynamic environmental conditions (mean summer SIC or distance to summer SIE) has highly under- or over-estimated the correct values of SIC and SIE. This can greatly impact the performance of the static models and their inferences in the highly dynamic environment of the SO.

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Appendix 1: Data sources accessed via GBIF (<https://www.gbif.org/>) on 31st July 2018

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Appendix 2: Data sources accessed via iOBIS (<https://obis.org/>) on 26th July 2018

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- APIS - Antarctic Pack Ice Seals 1994-1999, plus historical data from the 1980s. <https://obis.org/dataset/7e92433a-d086-4527-ab2b-3af86bcbd083>
- Australian Antarctic Data Centre (2018). Whale catches in the Southern Ocean. <https://obis.org/dataset/54bf169c-13f6-44cd-8551-06b999c994a1>
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- Museums Victoria Mammalogy Collection - Marine records. <https://obis.org/dataset/4550423a-25fc-4028-ad91-e8f63ecbbc8b>
- National Whale and Dolphin Sightings and Strandings Database. <https://obis.org/dataset/0b91d8f6-a50e-44e4-b313-0df7f91f7483>
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Appendix 3: Data accessed via OBIS-SEAMAP (<http://seamap.env.duke.edu>) on 22nd August 2018

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- Happywhale. 2021. Happywhale - Fin Whale in Southern Ocean. <http://seamap.env.duke.edu/dataset/1753>
- Happywhale. 2021. Happywhale - Humpback Whale in South Atlantic Ocean. <http://seamap.env.duke.edu/dataset/1766>
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- Happywhale. 2021. Happywhale - Killer Whale in South Pacific Ocean. <http://seamap.env.duke.edu/dataset/1721>
- Happywhale. 2021. Happywhale - Killer Whale in Southern Ocean. <http://seamap.env.duke.edu/dataset/1720>
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Appendix 4: Reference list of Polarstern data used

Appendix 5: Reference list of PANGAEA (<https://www.pangaea.de/>) data used

- Herr, H.; Lehnert, L. S.; Siebert, U. (2018): Aerial cetacean survey Southern Ocean 2010/2011. PANGAEA, <https://doi.org/10.1594/PANGAEA.894934>
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