Appendix

Table A1: Environmental variables used as covariates in habitat suitability models for crabeater seals (*Lobodon carcinophaga*) in the Weddell Sea.

Variable	Unit	Data Source	Temporal resolution	Original spatial resolution
Bathymetry (bath)	m	General Bathymetric Chart of the Oceans (British Oceanographic Data Centre) http://www.gebco.net	NA	0.02°
Ocean floor slope (slope)	◦	Bathymetry derivative	NA	0.02°
Sea surface temperature (sst)	°C	National Centres for Environmental Information https://www.ncdc.noaa.gov/oisst	Monthly	0.25°
Sea surface temperature anomalies (sstA)	°C	Sea surface temperature derivative	Monthly	0.25°
Sea surface temperature gradient (sst_grad)	◦	Sea surface temperature derivative	Monthly	0.25°
Sea surface height (ssh)	m	Ssalto/Duacs (Copernicus Marine and Environment Monitoring Service) http://marine.copernicus.eu	Daily	0.25°
Horizontal geostrophic current magnitude (currmag)	cm/s	Ssalto/Duacs (Aviso and Centre national d'études spatiales) http://www.aviso.altimetry.fr/duacs/	Weekly	0.25°
Eddy kinetic energy (eke) Calculated as eke = 0.5(curru2 + currv2)	cm^2/s^2	Ssalto/Duacs (Aviso and Centre national d'études spatiales) http://www.aviso.altimetry.fr/duacs/ Horizontal geostrophic current velocity (curru) Vertical geostrophic current velocity (currv)	Weekly	0.25°
Horizontal wind magnitude (windmag)	m/s	National Centres for Environmental Information http://www.esrl.noaa.gov/psd/	Daily	1.9°
Distance to continental shelf – i.e. the 500 m isobath (dist_shelf)	m	Bathymetry derivative https://data.aad.gov.au/metadata/records/Polar_Environmental_Data Distance to nearest area of sea floor of depth 500m or less. Processing steps: Distances calculated in km using the Haversine formula on a spherical earth of radius 6378.137km. Points in less than 500m of water (i.e. over the shelf) were assigned negative distances.	NA	0.02°
Distance to nearest polynya (dist_polynya)	m	https://data.aad.gov.au/metadata/records/Polar_Environmental_Data Source data: AMSR-E satellite estimates of daily sea ice concentration at 6.25km resolution	NA	6.26 km

		Pixels that were (on average) covered by sea ice for less than 35% of the year were identified. The distance from each grid point on the 0.1-degree grid to the nearest such polynya pixel was calculated in km using the Haversine formula on a spherical earth of radius 6378.137km. (NB the threshold of 35% was chosen to give a good empirical match to the polynya locations identified by Arrigo and van Dijken (2003), although the results were not particularly sensitive to the choice of threshold.		
Distance to canyon (dist_canyon)	km	https://data.aad.gov.au/metadata/records/Polar_Environmental_Data Distance to the axis of the nearest canyon. Source data: O'Brien and Post (2010) seafloor geomorphic feature dataset, expanded from O'Brien et al. (2009). Mapping based on GEBCO contours, ETOPO2, seismic lines. Processing steps: Distances to nearest canyon axis calculated in km using the Haversine formula on a spherical earth of radius 6378.137km. Reference: O'Brien, P.E., Post, A.L., and Romeyn, R. (2009) Antarctic-wide geomorphology as an aid to habitat mapping and locating vulnerable marine ecosystems. CCAMLR VME Workshop 2009. Document WS-VME-09/10	NA	0.1°
Ice concentration (ice)	%	NSIDC concentration data, processed by the SMMR/SSMI NASA Team http://nsidc.org/data/docs/daac/nsidc0051_gsfc_seaice.gd.html	Daily	12.5 km
Distance to ice edge (dist_ice_edge)	m	Ice concentration derivative: the shortest distance (metres) to the sea ice contour where ice concentration is <15%.	Daily	12.5 km
Ice standard deviation (ice_sd)	NA	Ice concentration derivative: standard deviation was calculated as the variation in ice concentration over the breeding season: September to November of 2017.	3 month composite	12.5 km
Ice thickness (ice_thick)		https://data.aad.gov.au/metadata/records/Polar_Environmental_Data	7 year composite	0.1°
Old ice (oldice)	%	https://data.aad.gov.au/metadata/records/Polar_Environmental_Data Proportion of time the ocean is covered by sea ice of concentration 85% or higher. Source data: AMSR-E satellite estimates of daily sea ice concentration at 6.25 km resolution Processing steps: Concentration data from 1-Jan-2003 to 31-Dec-2010 used. The fraction of time each pixel was covered by sea ice of at least 85% concentration was calculated for each pixel in the original (polar stereographic) grid. Data then regridded to 0.1-degree grid using triangle-based linear interpolation. Reference: Spreen, G., L. Kaleschke, and G. Heygster (2008), Sea ice remote sensing using AMSR-E 89 GHz channels, J. Geophys. Res., doi:10.1029/2005JC003384 https://seaice.uni-bremen.de/sea-ice-concentration/	7 year composite	0.1°
Old ice coefficient of variation (oldice_cv)	NA	A derivative from the old ice layer. The coefficient of variation was calculated using the data and time scale mentioned above.	7 year composite	0.1°
Surface heat flux (shflux)	W/m^2	https://data.aad.gov.au/metadata/records/Polar_Environmental_Data	3 month composite	0.1°

Surface heat flux standard deviation (shflux_sd)	NA	https://data.aad.gov.au/metadata/records/Polar_Environmental_Data	3 month composite	0.1°
Vertical mixing (vmix)	m/s	https://data.aad.gov.au/metadata/records/Polar_Environmental_Data	3 month composite	0.1°
Vertical mixing standard deviation (vmix_sd)	NA	https://data.aad.gov.au/metadata/records/Polar_Environmental_Data	3 month composite	0.1°
Salinity difference between 200 m and 600 m depth (sal200_600	psu	Source data: World Ocean Atlas 2013 version 2 (National Oceanographic Data Center, Silver Springs, MD, U.S.A.) https://www.nodc.noaa.gov/OC5/woa13/ Processing steps: Data from September to November 2017 were averaged, regridded to 0.1-degree grid using bilinear interpolation and the salinity difference between 200 m and 600 m depth was calculated.	3 month composite	0.25°
Salinity difference between 0 m and 600 m depth (sal0_200)	psu	Source data: World Ocean Atlas 2013 version 2 (National Oceanographic Data Center, Silver Springs, MD, U.S.A.) https://www.nodc.noaa.gov/OC5/woa13/ Processing steps: Data from September to November 2017 were averaged, regridded to 0.1-degree grid using bilinear interpolation and the salinity difference between the surface (0m) and 200m depth was calculated.	3 month composite	0.25°

Table A2: Environmental variables used as covariates in habitat suitability models for Weddell seals (*Leptonychotes weddellii*) in the Weddell Sea.

Variable	Unit	Data Source	Original spatial resolution
Bathymetry (meanbathy)	m	General Bathymetric Chart of the Oceans (British Oceanographic Data Centre) http://www.gebco.net	0.02°
Ocean floor slope (meanslope)	°	Bathymetry derivative	0.02°
Distance to glacier (glacierdist)	m		0.25°
Distance to Antarctica (distToShore)	m	Bathymetry derivative	0.25°
Distance to the 300 m bathymetrical contour (cont300dist)	m	Bathymetry derivative	0.25°
Distance to the 800 m bathymetrical contour (cont800dist)	m	Bathymetry derivative	0.25°
Is the grid cell over a oceanic trough (InTrough)	Yes/No	Bathymetry derivative	0.1°
Presence of ice in the preceding December (DecemberIcePresence)	presence/ absence	Derivative of ice data from The U.S. National Ice Center (NIC) https://nsidc.org/	0.25°
Persistence of ice in the last 2 years in the grid cell (Persistence2Years)	0-2 years	Derivative of ice data from The U.S. National Ice Center (NIC) https://nsidc.org/	0.25°
Predictability of ice during December in the last 5 years (PredictabilityDec5Years)	0-5 years	Derivative of ice data from The U.S. National Ice Center (NIC) https://nsidc.org/	1.9°
Persistence of ice in the last 3 years in the grid cell (Persistence3Years)	0-3 years	Derivative of ice data from the The U.S. National Ice Center (NIC) https://nsidc.org/	0.25°
Predictability of ice during October in the last 5 years (PredictabilityOct5Years)	0-5 years	Derivative of ice data from The U.S. National Ice Center (NIC) https://nsidc.org/	0.25°
Distance to the nearest ice edge (distNearestIceEdge)	m	Derivative of ice data from The U.S. National Ice Center (NIC) https://nsidc.org/	0.02°
Ratio of fast ice (fastIceRatio)	0-1	Derivative of ice data from The U.S. National Ice Center (NIC) https://nsidc.org/	
Fast ice width (fastIceWidth)	m	Derivative of ice data from The U.S. National Ice Center (NIC) https://nsidc.org/	6.26 km

Distance to the nearest Adélie penguin colony (ADPEdist)	m	(Ainley et al., 2015; Lynch & LaRue, 2014)	0.1°
Abundance/ size of the nearest Adélie penguin colony (ADPEabund)	Nr of penguins	(Ainley et al., 2015; Lynch & LaRue, 2014)	12.5 km
Distance to the nearest emperor penguin colony (EMPEdist)	m	(Fretwell et al., 2014)	12.5 km
Abundance/ size of the nearest emperor penguin colony (EMPEabund)	Nr of penguins	(Fretwell et al., 2014)	12.5 km

Footnote: All code and data for these variables can be found at: https://github.com/leosalas/FastIceCovars

Table A3: Change product importance scores from the species-specific habitat models, for each model and variable.

Species	Variable	Group	Mean proportional variable importance	Change Score	Change Importance Product
Weddell	ADPEabund	BRT	0.00	2	0.00
Weddell	ADPEabund	Max	0.00	2	0.00
Weddell	ADPEabund	RF	0.00	2	0.00
Weddell	ADPEdist	BRT	0.07	2	0.15
Weddell	ADPEdist	Max	0.08	2	0.16
Weddell	ADPEdist	RF	0.07	2	0.14
Weddell	cont300dist	BRT	0.09	2	0.18
Weddell	cont300dist	Max	0.19	2	0.38
Weddell	cont300dist	RF	0.10	2	0.20
Weddell	cont800dist	BRT	0.09	1	0.09
Weddell	cont800dist	Max	0.21	1	0.21
Weddell	cont800dist	RF	0.12	1	0.12
Weddell	DecemberIcePresence	RF	0.01	3	0.03
Weddell	DecemberIcePresence	BRT	0.00	3	0.01
Weddell	DecemberIcePresence	Max	0.01	3	0.02
Weddell	distNearestIceEdge	BRT	0.05	2	0.11
Weddell	distNearestIceEdge	Max	0.06	2	0.11
Weddell	distNearestIceEdge	RF	0.04	2	0.07
Weddell	distToShore	BRT	0.06	1	0.06
Weddell	distToShore	Max	0.04	1	0.04
Weddell	distToShore	RF	0.06	1	0.06
Weddell	EMPEabund	BRT	0.05	3	0.16
Weddell	EMPEabund	Max	0.06	3	0.18
Weddell	EMPEabund	RF	0.09	3	0.27

Weddell	EMPEdist	RF	0.23	2	0.46
Weddell	EMPEdist	Max	0.19	2	0.38
Weddell	EMPEdist	BRT	0.25	2	0.49
Weddell	fastIceRatio	BRT	0.02	3	0.07
Weddell	fastIceRatio	Max	0.01	3	0.02
Weddell	fastIceRatio	RF	0.02	3	0.05
Weddell	glacierdist	BRT	0.13	1	0.13
Weddell	glacierdist	Max	0.03	1	0.03
Weddell	glacierdist	RF	0.09	1	0.09
Weddell	InTrough	BRT	0.00	0	0.00
Weddell	InTrough	Max	0.00	0	0.00
Weddell	InTrough	RF	0.00	0	0.00
Weddell	meanbathy	Max	0.03	0	0.00
Weddell	meanbathy	RF	0.04	0	0.00
Weddell	meanbathy	BRT	0.05	0	0.00
Weddell	meanslope	BRT	0.05	0	0.00
Weddell	meanslope	Max	0.01	0	0.00
Weddell	meanslope	RF	0.03	0	0.00
Weddell	Persistence2Years	BRT	0.01	3	0.02
Weddell	Persistence2Years	Max	0.04	3	0.11
Weddell	Persistence2Years	RF	0.03	3	0.08
Weddell	PredictabilityDec5Years	BRT	0.05	3	0.16
Weddell	PredictabilityDec5Years	Max	0.00	3	0.00
Weddell	PredictabilityDec5Years	RF	0.06	3	0.18
Weddell	PredictabilityOct5Years	BRT	0.02	3	0.06
Weddell	PredictabilityOct5Years	Max	0.06	3	0.17
Weddell	PredictabilityOct5Years	RF	0.03	3	0.10
crabeater	bathy	RF	0.13	2	0.25
crabeater	bathy	BRT	0.07	2	0.13
crabeater	bathy	Max	0.14	2	0.29
crabeater	dist_canyon	BRT	0.05	1	0.05
crabeater	dist_canyon	RF	0.07	1	0.07
crabeater	dist_canyon	Max	0.05	1	0.05
crabeater	dist_shelf	RF	0.10	2	0.20
crabeater	dist_shelf	Max	0.02	2	0.04
crabeater	dist_shelf	BRT	0.04	2	0.09
crabeater	ice_edge_dist	RF	0.14	3	0.41
crabeater	ice_edge_dist	Max	0.11	3	0.32
crabeater	ice_edge_dist	BRT	0.28	3	0.83
crabeater	ice_sd	RF	0.10	3	0.29
crabeater	ice_sd	Max	0.10	3	0.29
crabeater	ice_sd	BRT	0.14	3	0.42
crabeater	oldice_cv	Max	0.06	2	0.11
crabeater	oldice_cv	BRT	0.04	2	0.09
crabeater	oldice_cv	RF	0.05	2	0.11

crabeater	sal200_600	RF	0.07	1	0.07
crabeater	sal200_600	BRT	0.06	1	0.06
crabeater	sal200_600	Max	0.10	1	0.10
crabeater	shflux_sd	RF	0.09	2	0.19
crabeater	shflux_sd	RF	0.09	2	0.19
crabeater	shflux_sd	Max	0.02	2	0.04
crabeater	shflux_sd	Max	0.02	2	0.04
crabeater	shflux_sd	BRT	0.03	2	0.06
crabeater	shflux_sd	BRT	0.03	2	0.06
crabeater	slope	RF	0.00	0	0.00
crabeater	slope	Max	0.05	0	0.00
crabeater	slope	BRT	0.05	0	0.00
crabeater	sst	RF	0.03	3	0.09
crabeater	sst	Max	0.15	3	0.46
crabeater	sst	BRT	0.03	3	0.10
crabeater	vmix	RF	0.07	2	0.14
crabeater	vmix	Max	0.06	2	0.12
crabeater	vmix	BRT	0.04	2	0.07
crabeater	vmix_sd	Max	0.07	1	0.07
crabeater	vmix_sd	RF	0.05	1	0.05
crabeater	vmix_sd	BRT	0.03	1	0.03
crabeater	windmag	BRT	0.07	2	0.14
crabeater	windmag	Max	0.05	2	0.10
crabeater	windmag	RF	0.06	2	0.13

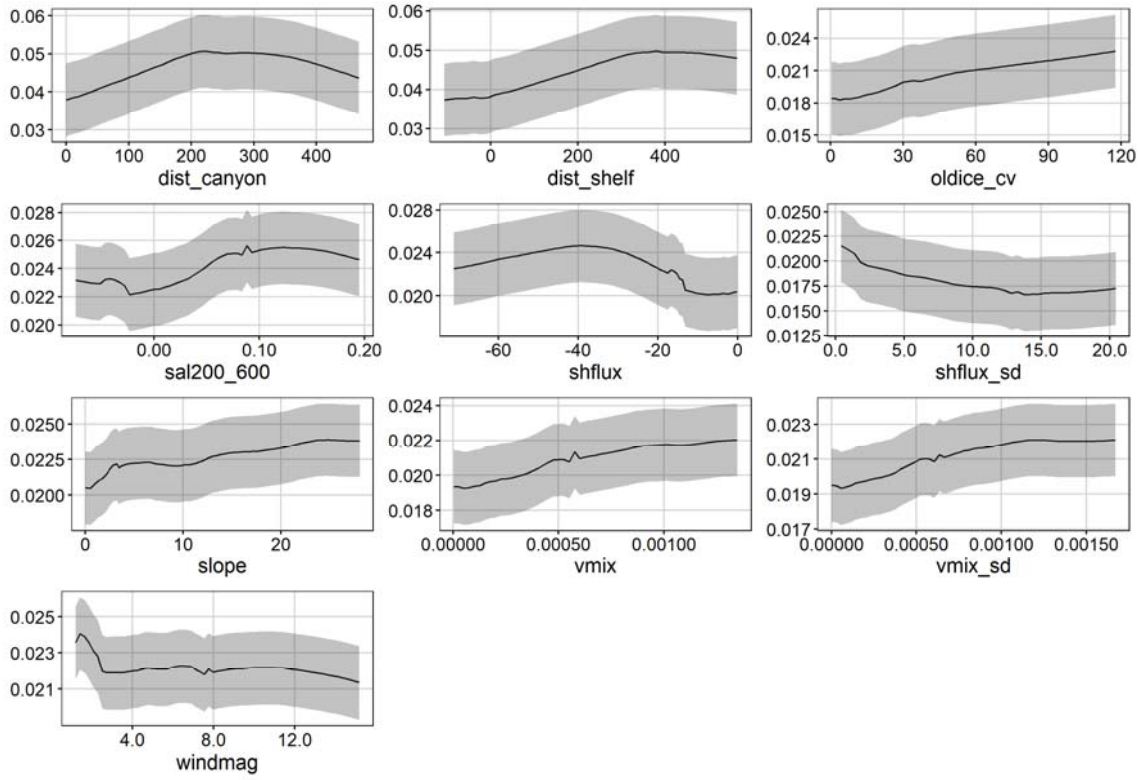

Figure A1: Partial dependence plots showing the relationship between the probability of crabeater seal (*Lobodon carcinophaga*) presence (± standard deviation across the models and bootstraps) and the remaining environmental variables that did not fall under the top 4.

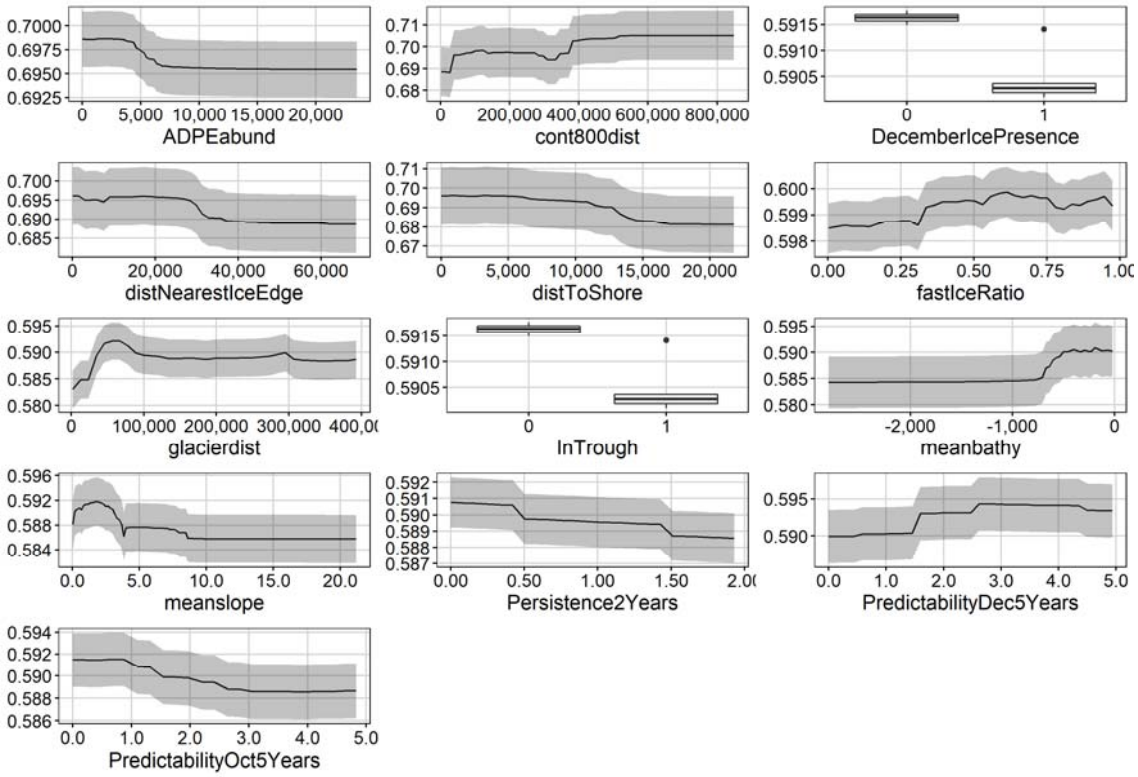

Figure A2: Partial dependence plots showing the relationship between the probability of Weddell seal (*Leptonychotes weddellii*) presence (± standard deviation across the models and bootstraps) and the remaining environmental variables that did not fall under the top 4.

Literature Cited:

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