Supplementary Material

Table S1: Pearson's pairwise correlation matrix between the seven environmental variables used to build the 2D ecological niche model for the area of the study region only (35-75˚S). PP = primary productivity, SSS = sea surface salinity, SST = sea surface temperature, $SSdO_2$ = sea surface dissolved oxygen.

	Bathymetry	**$SSdO_2$**	**PP**	**SSS**	**SST**
Bathymetry	1	0.15	-0.03	-0.21	-0.18
$SSdO_2$	0.15	1	-0.58	-0.77	-0.97
PP	-0.03	-0.58	1	0.42	0.64
SSS	-0.21	-0.77	0.42	1	0.76
SST	-0.18	-0.97	0.64	0.76	1

Table S2: Results of variable permutation importance for both 2D*all*, 2D*sub* and 3D model approaches. Variables in bold are the highest ranking variable per model. Bathy = Bathymetry, PP = primary productivity, Temp = temperature, Sal = Salinity.

Species	2D*all*					2D*sub*					3D				
	Bathy	dO_2	PP	Sal	Temp	Bathy	dO_2	PP	Sal	Temp	Bathy	dO_2	PP	Sal	Temp
E. antarctica	4.5	4.4	5.5	2.9	**82.7**	9.1	14.6	6.5	2.5	**67.3**	10.3	0.6	5.1	5.0	**79.0**
E. carlsbergi	8.2	7.3	**34.6**	17.2	32.8	18.3	19.0	18.5	12.8	**31.3**	21.6	6.1	**27.9**	24.9	19.5
G. bolini	12.0	5.0	10.0	8.3	**64.6**	7.1	11.8	4.5	0.0	**76.7**	29.8	4.5	11.2	20.3	**34.1**
G. braueri	4.7	10.0	7.8	10.6	**66.9**	8.2	8.4	6.2	2.2	**75.2**	15.0	6.1	5.6	8.1	**65.2**
G. fraseri	3.7	8.9	2.0	20.1	**65.2**	4.1	1.2	4.5	14.7	**75.5**	10.5	8.0	17.9	28.5	**35.1**
G. nicholsi	10.4	9.0	12.0	**34.5**	34.1	**34.4**	11.1	2.3	24.7	27.4	**44.5**	2.9	5.5	17.1	30.0
G.opisthopterus	2.2	11.6	3.8	12.5	**69.9**	12.3	5.7	4.6	8.5	**68.9**	11.7	2.7	8.9	15.9	**60.8**
K. anderssoni	1.5	9.5	12.9	22.6	**53.6**	1.9	15.9	8.8	6.3	**67.0**	9.5	4.9	19.0	23.8	**42.8**
P. bolini	2.8	4.1	16.0	7.0	**70.1**	2.4	**39.6**	25.4	2.4	30.1	3.2	5.1	28.5	2.6	**60.5**
P. tenisoni	0.7	5.5	6.2	7.8	**79.9**	1.8	7.0	7.7	7.9	**75.6**	20.9	0.0	26.1	**51.2**	1.8

Table S3: Comparison of 2D*sub* 3D model predictions in relation to their spatial range overlap and niche overlap as measured by relative rank and *I* metrics. Mean and standard deviation (±1 SD) values for each depth band are in bold.

	metric	*E. antarctica*	*E. carlsbergi*	*G. bolini*	*G. braueri*	*G. fraseri*	*G. nicholsi*	*G. opisthopterus*	*K. anderssoni*	*P. bolini*	*P. tenisoni*	Mean	± 1 SD
0	n records	106	3	0	24	3	4	7	23	11	2	18	32
	Range overlap (%)	0.97	0.86	0.95	0.86	0.97	0.97	0.83	0.75	0.88	0.54	0.86	0.13
	Niche overlap (rel.rank)	0.93	0.81	0.81	0.91	0.90	0.85	0.93	0.81	0.82	0.80	0.86	0.05
	Niche overlap (I)	0.97	0.96	0.95	0.97	0.99	0.93	0.97	0.95	0.91	0.84	0.94	0.04
50	n records	73	4	6	14	10	13	0	34	11	1	17	22
	Range overlap (%)	0.96	0.80	0.95	0.66	0.97	0.97	0.81	0.80	0.89	0.57	0.84	0.14
	Niche overlap (rel.rank)	0.93	0.81	0.84	0.89	0.89	0.85	0.89	0.82	0.86	0.81	0.86	0.04
	Niche overlap (I)	0.97	0.96	0.96	0.96	0.99	0.94	0.94	0.96	0.94	0.86	0.95	0.03
100	n records	69	6	4	16	7	8	2	15	6	3	14	20
	Range overlap (%)	0.93	0.75	0.91	0.64	0.97	0.82	0.85	0.86	0.87	0.66	0.83	0.11
	Niche overlap (rel.rank)	0.92	0.80	0.82	0.87	0.89	0.87	0.88	0.84	0.87	0.82	0.86	0.04
	Niche overlap (I)	0.97	0.96	0.96	0.96	0.99	0.95	0.94	0.97	0.96	0.90	0.96	0.02
200	n records	192	24	8	39	10	55	1	38	20	3	39	57
	Range overlap (%)	0.80	0.80	0.66	0.79	0.95	0.84	0.95	0.81	0.79	0.76	0.81	0.08
	Niche overlap (rel.rank)	0.91	0.82	0.76	0.90	0.86	0.87	0.93	0.88	0.85	0.81	0.86	0.05
	Niche overlap (I)	0.96	0.97	0.94	0.99	0.97	0.97	0.99	0.98	0.96	0.87	0.96	0.03
500	n records	113	35	37	60	31	52	12	78	61	25	50	29
	Range overlap (%)	0.93	0.62	0.72	0.78	0.94	0.78	0.95	0.83	0.59	0.90	0.80	0.13
	Niche overlap (rel.rank)	0.88	0.83	0.76	0.88	0.84	0.82	0.91	0.83	0.83	0.85	0.84	0.04
	Niche overlap (I)	0.94	0.98	0.95	0.98	0.95	0.97	0.99	0.97	0.96	0.91	0.96	0.02
800	n records	96	14	18	66	16	17	34	49	24	1	34	29
	Range overlap (%)	0.96	0.54	0.75	0.74	0.70	0.53	0.99	0.64	0.53	0.73	0.71	0.16
	Niche overlap (rel.rank)	0.85	0.76	0.75	0.86	0.77	0.71	0.91	0.74	0.78	0.80	0.79	0.06
	Niche overlap (I)	0.97	0.97	0.94	0.96	0.92	0.93	0.99	0.94	0.95	0.83	0.94	0.04
1000	n records	39	1	2	23	4	2	9	19	2	0	10	13
	Range overlap (%)	0.96	0.50	0.66	0.73	0.46	0.45	0.99	0.37	0.59	0.62	0.63	0.21
	Niche overlap (rel.rank)	0.82	0.73	0.69	0.81	0.71	0.65	0.90	0.64	0.73	0.75	0.74	0.08
	Niche overlap (I)	0.92	0.96	0.92	0.93	0.88	0.92	0.98	0.91	0.93	0.75	0.91	0.06

Electrona antarctica
Model: 2Dall

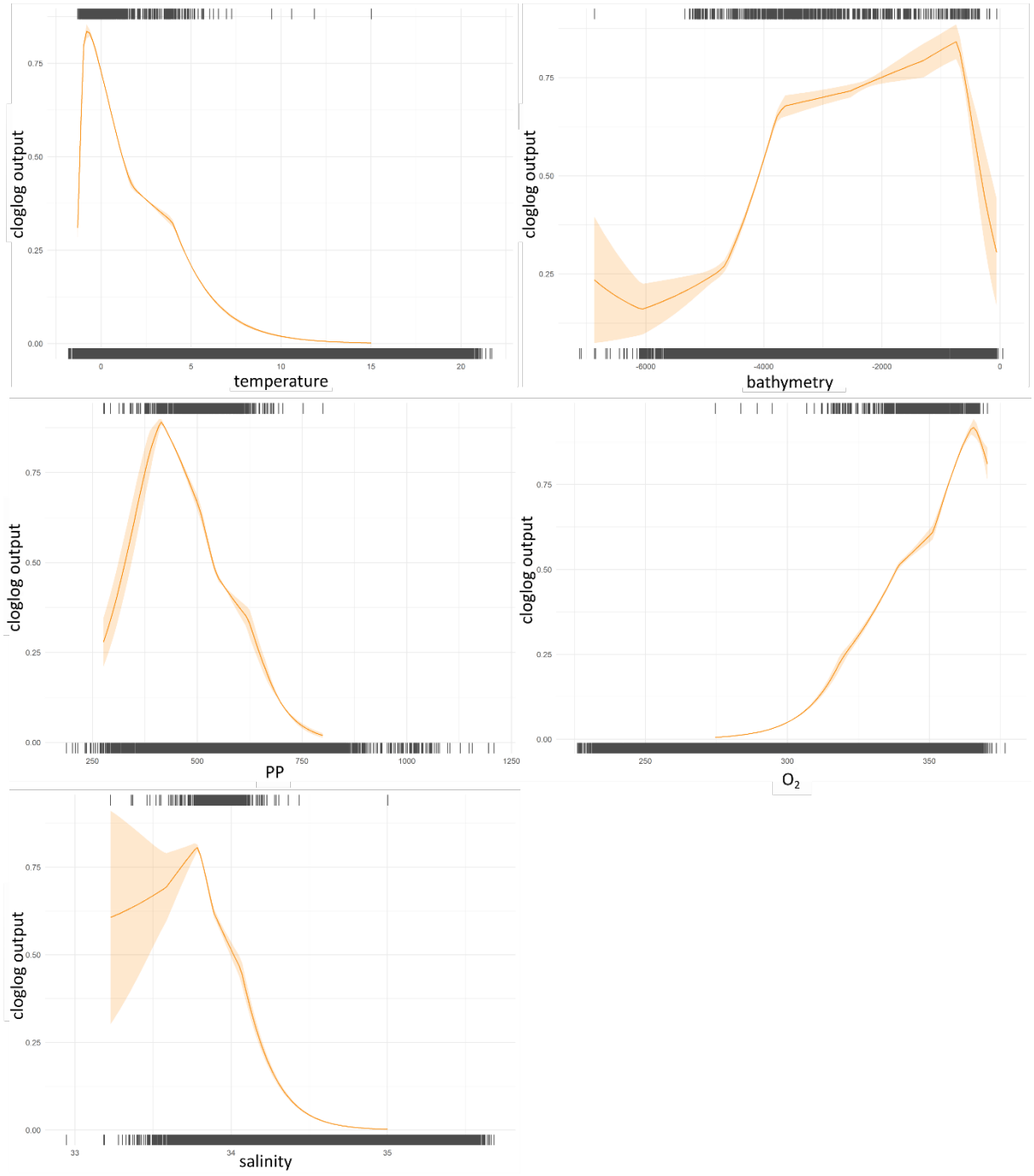

Figure S1: Univariate response curves for *Electrona antarctica* using the 2D*all* modelling approach. Each curve displays the averaged value of the prediction across its environmental range. Ribbon denotes the standard deviation error, top bars are the rug of presence locations and bottom bars are the rug of the background locations.

Electrona antarctica
Model: 2Dsub

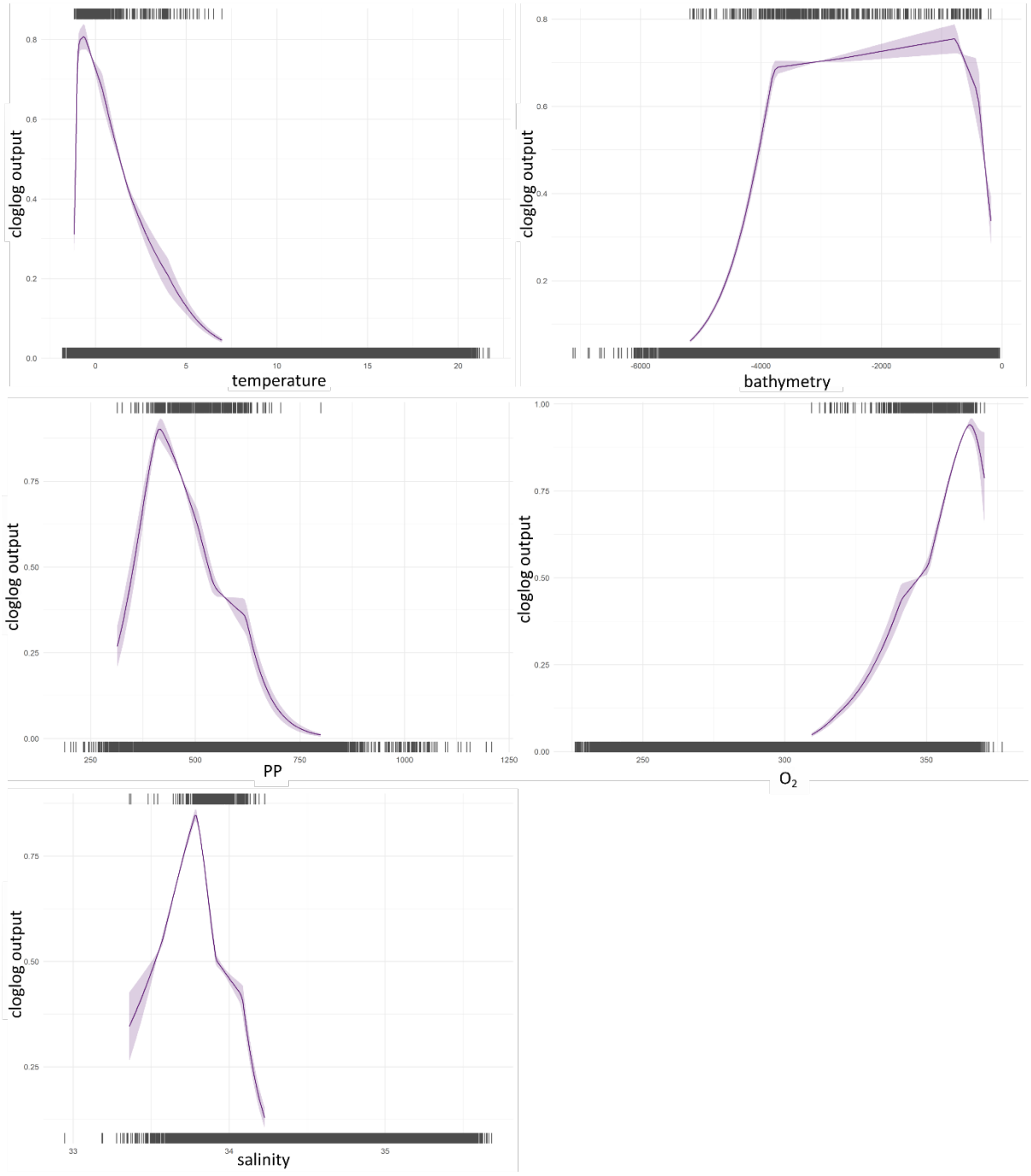

Figure S2: Univariate response curves for *Electrona antarctica* using the 2D*sub* modelling approach. Each curve displays the averaged value of the prediction across its environmental range. Ribbon denotes the standard deviation error, top bars are the rug of presence locations and bottom bars are the rug of the background locations.

Electrona antarctica
Model: 3D

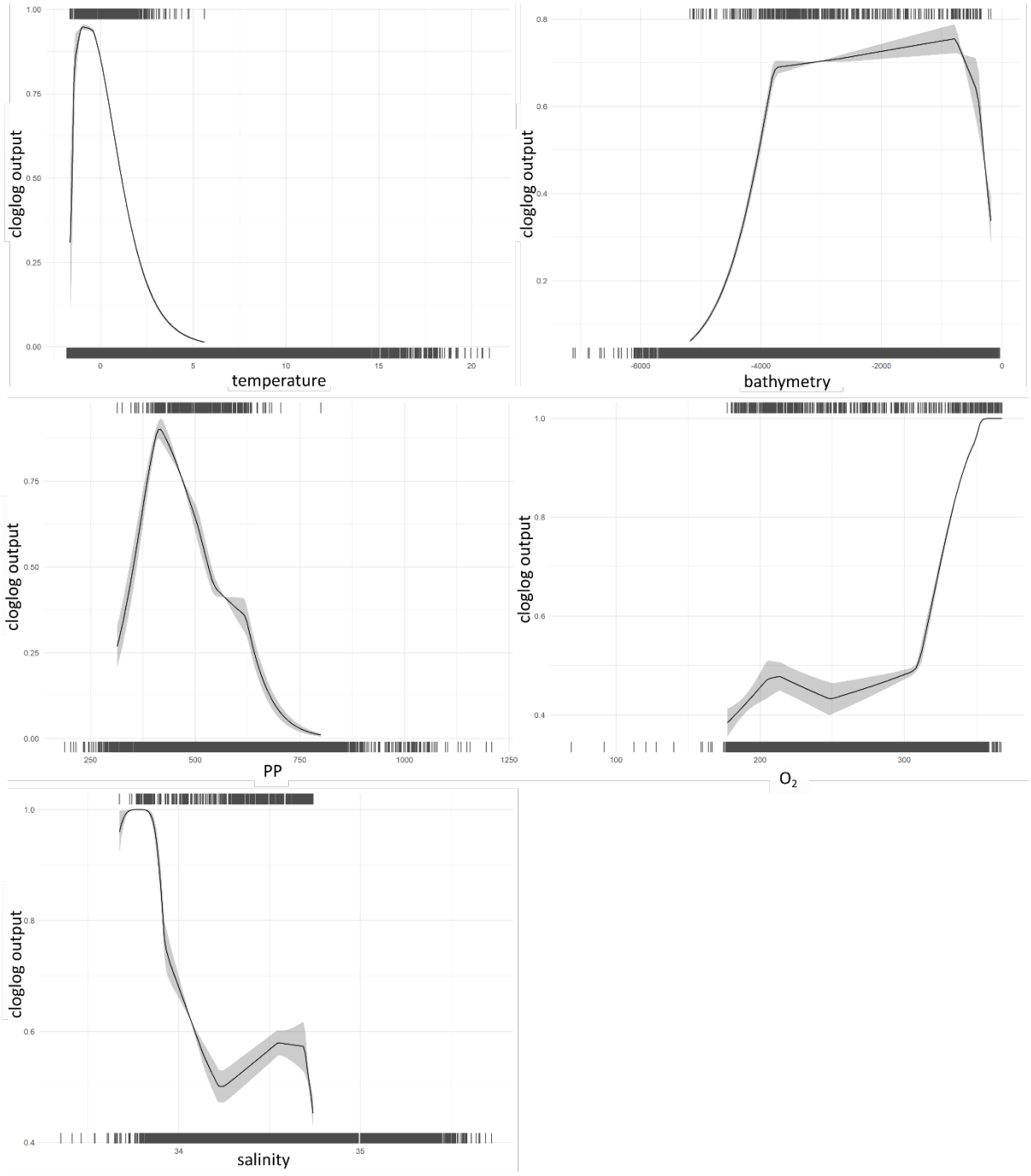

Figure S3: Univariate response curves for *Electrona antarctica* using the 3D modelling approach. Each curve displays the averaged value of the prediction across its environmental range. Ribbon denotes the standard deviation error, top bars are the rug of presence locations and bottom bars are the rug of the background locations.

Electrona carlsbergi
Model: 2Dall

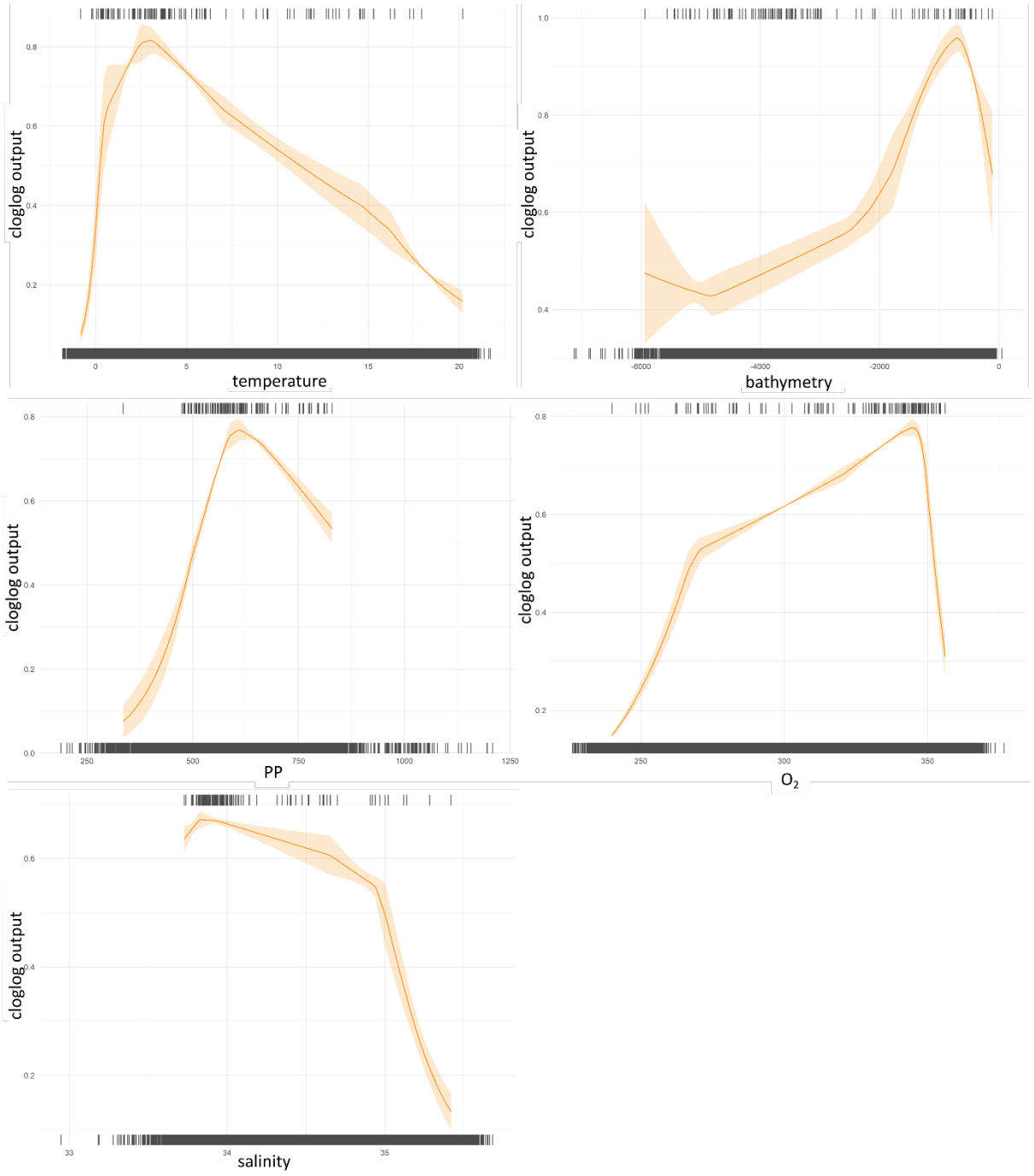

Figure S4: Univariate response curves for *Electrona carlsbergi* using the 2D*all* modelling approach. Each curve displays the averaged value of the prediction across its environmental range. Ribbon denotes the standard deviation error, top bars are the rug of presence locations and bottom bars are the rug of the background locations.

Electrona carlsbergi
Model: 2Dsub

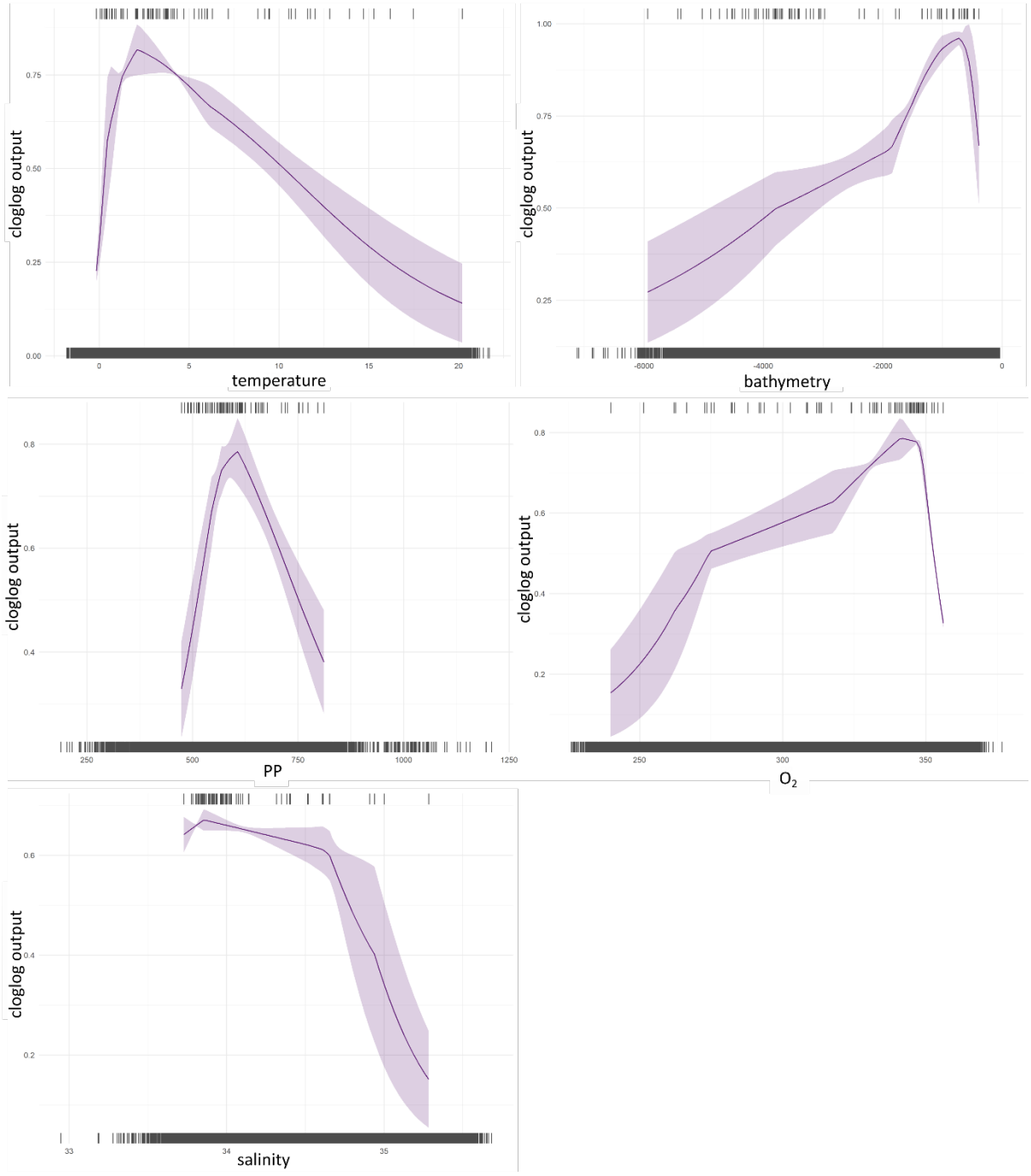

Figure S5: Univariate response curves for *Electrona carlsbergi* using the 2D*sub* modelling approach. Each curve displays the averaged value of the prediction across its environmental range. Ribbon denotes the standard deviation error, top bars are the rug of presence locations and bottom bars are the rug of the background locations.

Electrona carlsbergi
Model: 3D

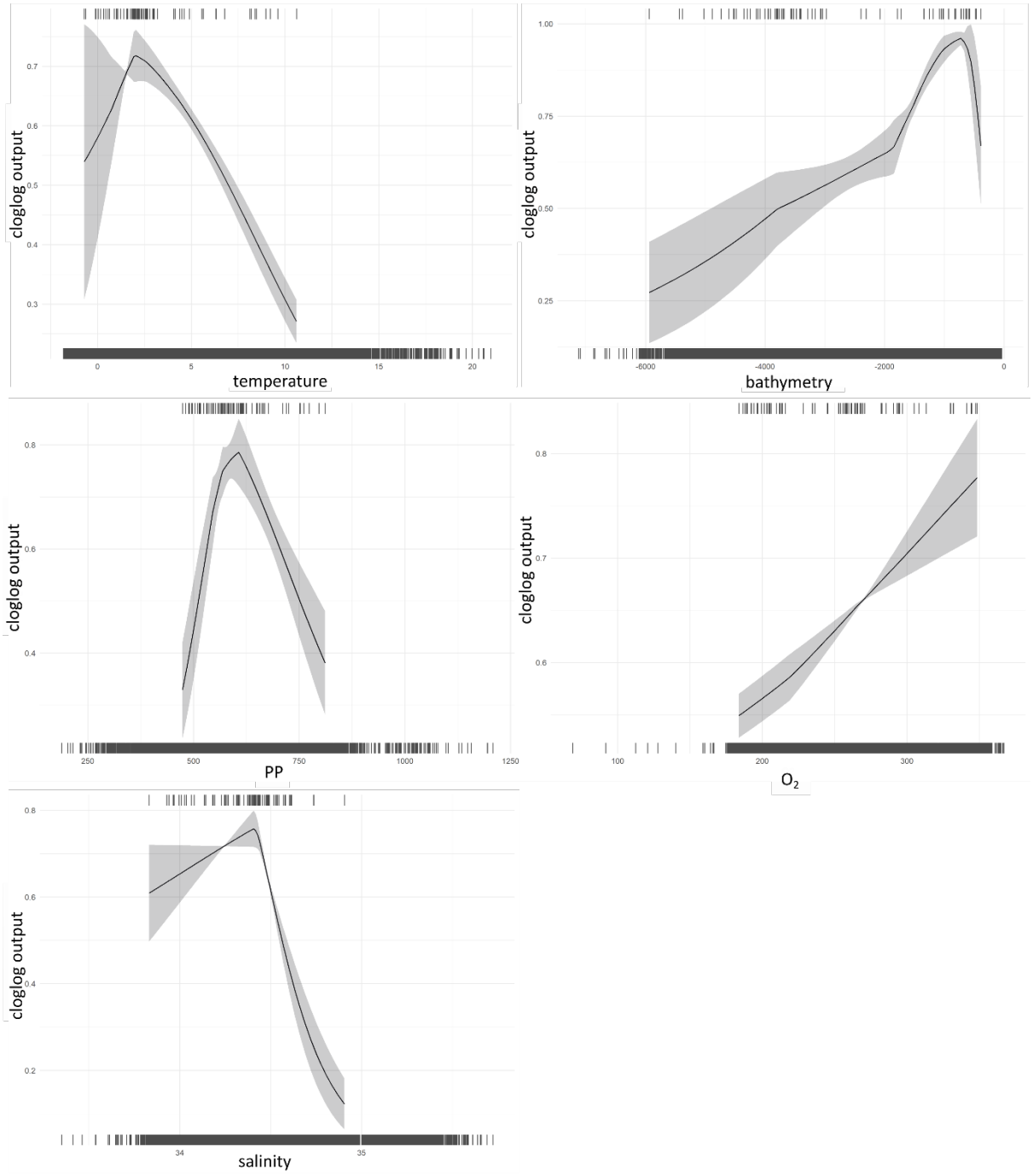

Figure S6: Univariate response curves for *Electrona carlsbergi* using the 3D modelling approach. Each curve displays the averaged value of the prediction across its environmental range. Ribbon denotes the standard deviation error, top bars are the rug of presence locations and bottom bars are the rug of the background locations.

Gymnoscopelus bolini
Model: 2Dall

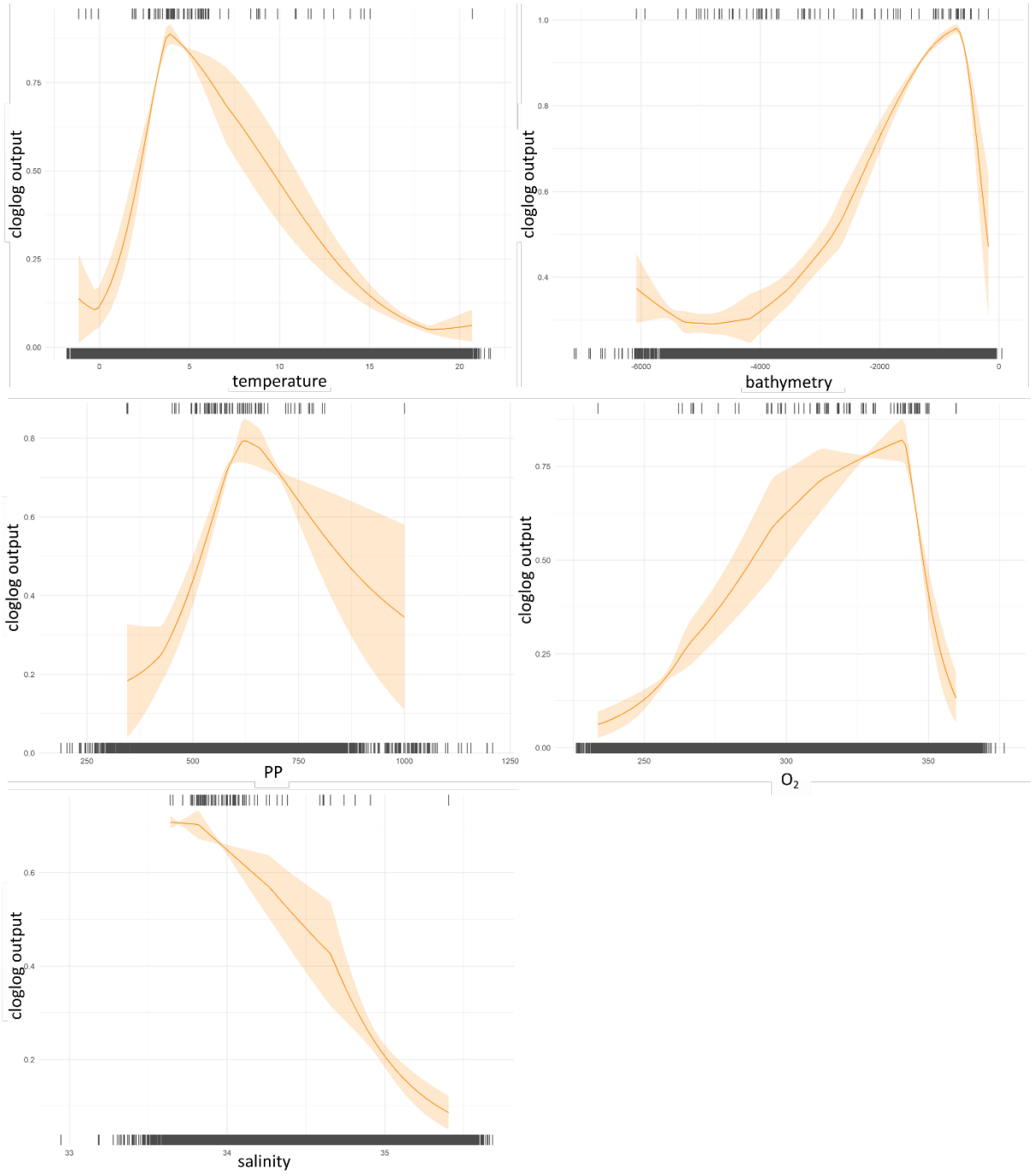

Figure S7: Univariate response curves for *Gymnoscopelus bolini* using the 2D*all* modelling approach. Each curve displays the averaged value of the prediction across its environmental range. Ribbon denotes the standard deviation error, top bars are the rug of presence locations and bottom bars are the rug of the background locations.

Gymnoscopelus bolini
Model: 2Dsub

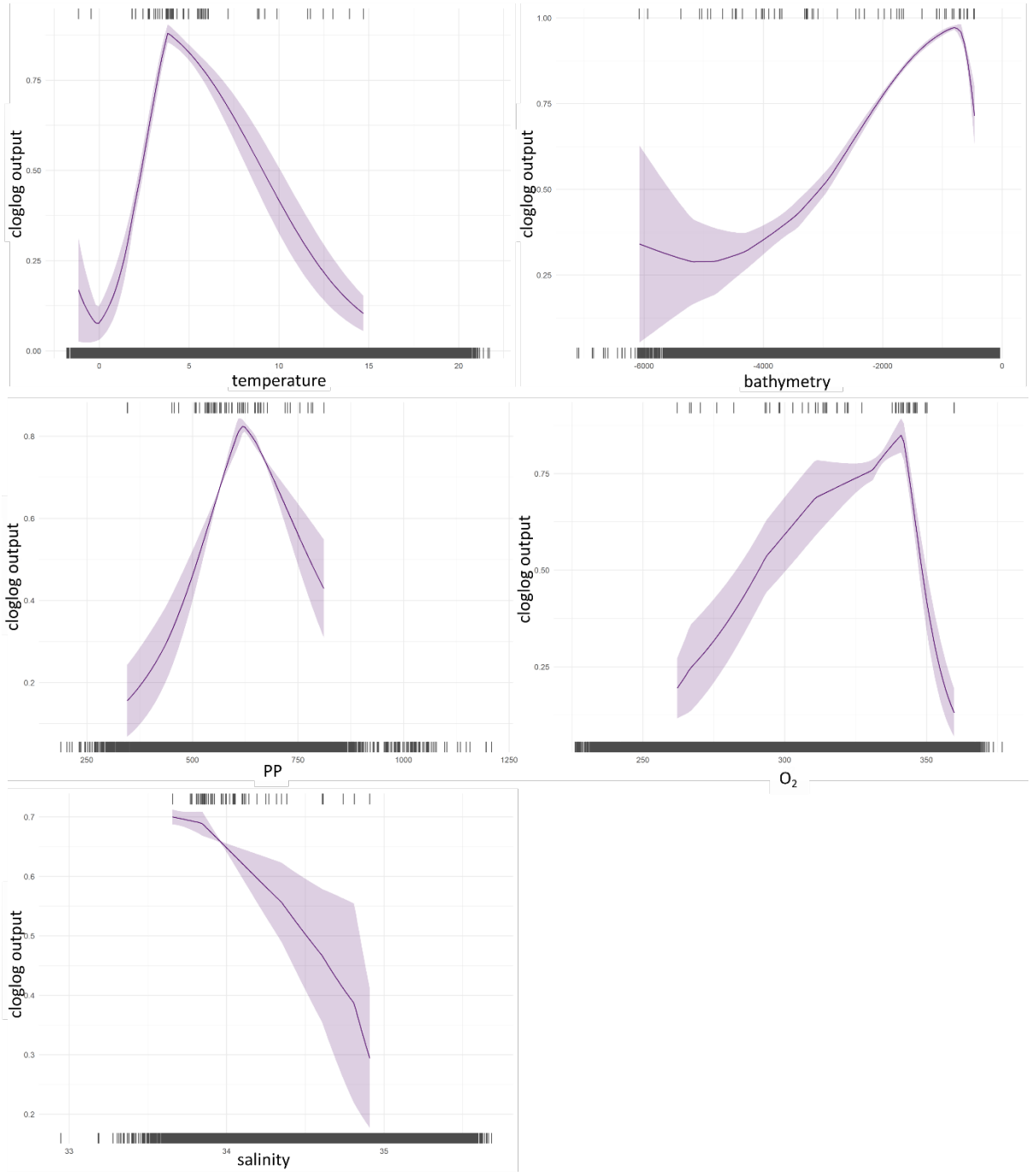

Figure S8: Univariate response curves for *Gymnoscopelus bolini* using the 2D*sub* modelling approach. Each curve displays the averaged value of the prediction across its environmental range. Ribbon denotes the standard deviation error, top bars are the rug of presence locations and bottom bars are the rug of the background locations.

Gymnoscopelus bolini
Model: 3D

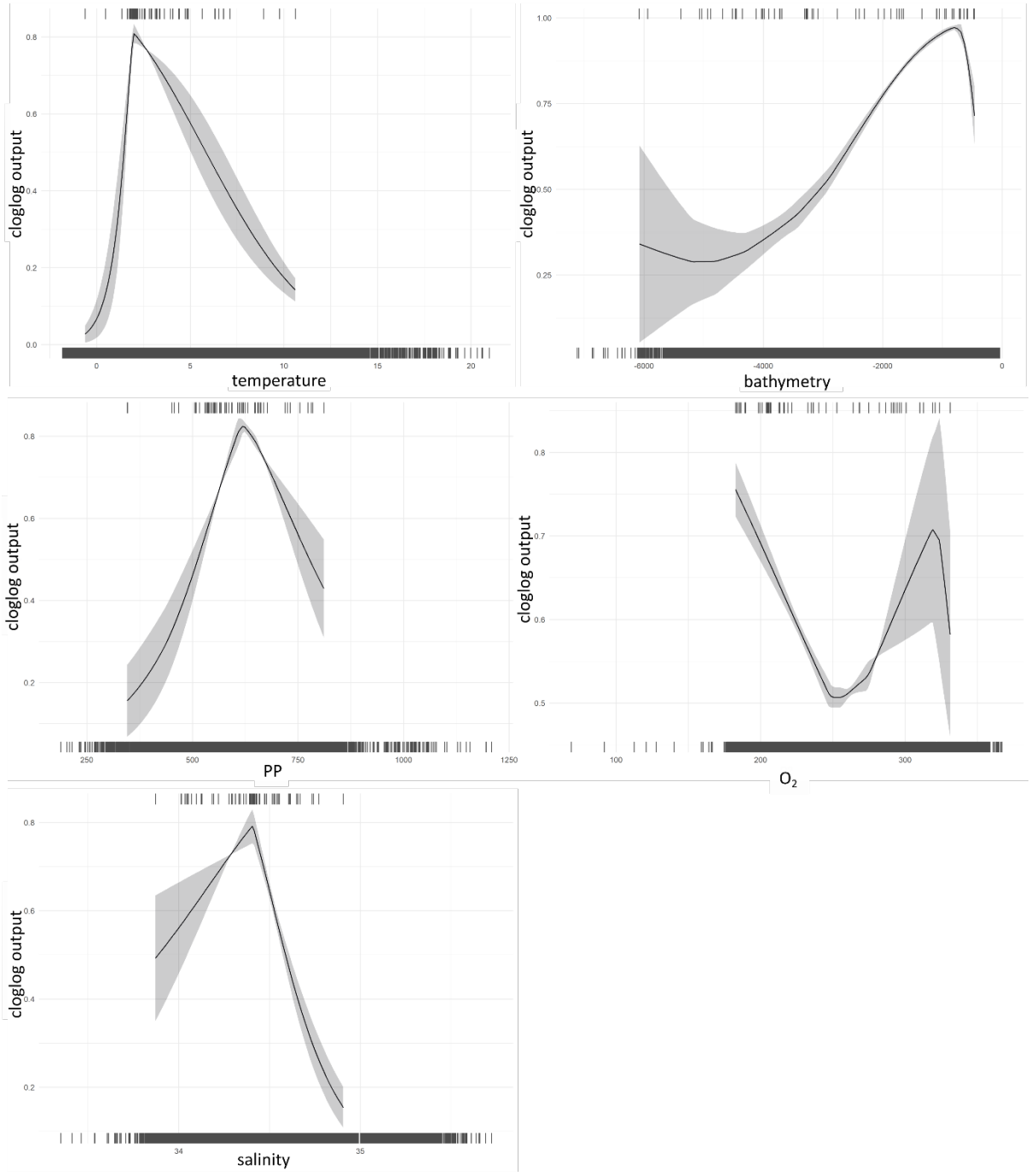

Figure S9: Univariate response curves for *Gymnoscopelus bolini* using the 3D modelling approach. Each curve displays the averaged value of the prediction across its environmental range. Ribbon denotes the standard deviation error, top bars are the rug of presence locations and bottom bars are the rug of the background locations.

Gymnoscopelus braueri
Model: 2Dall

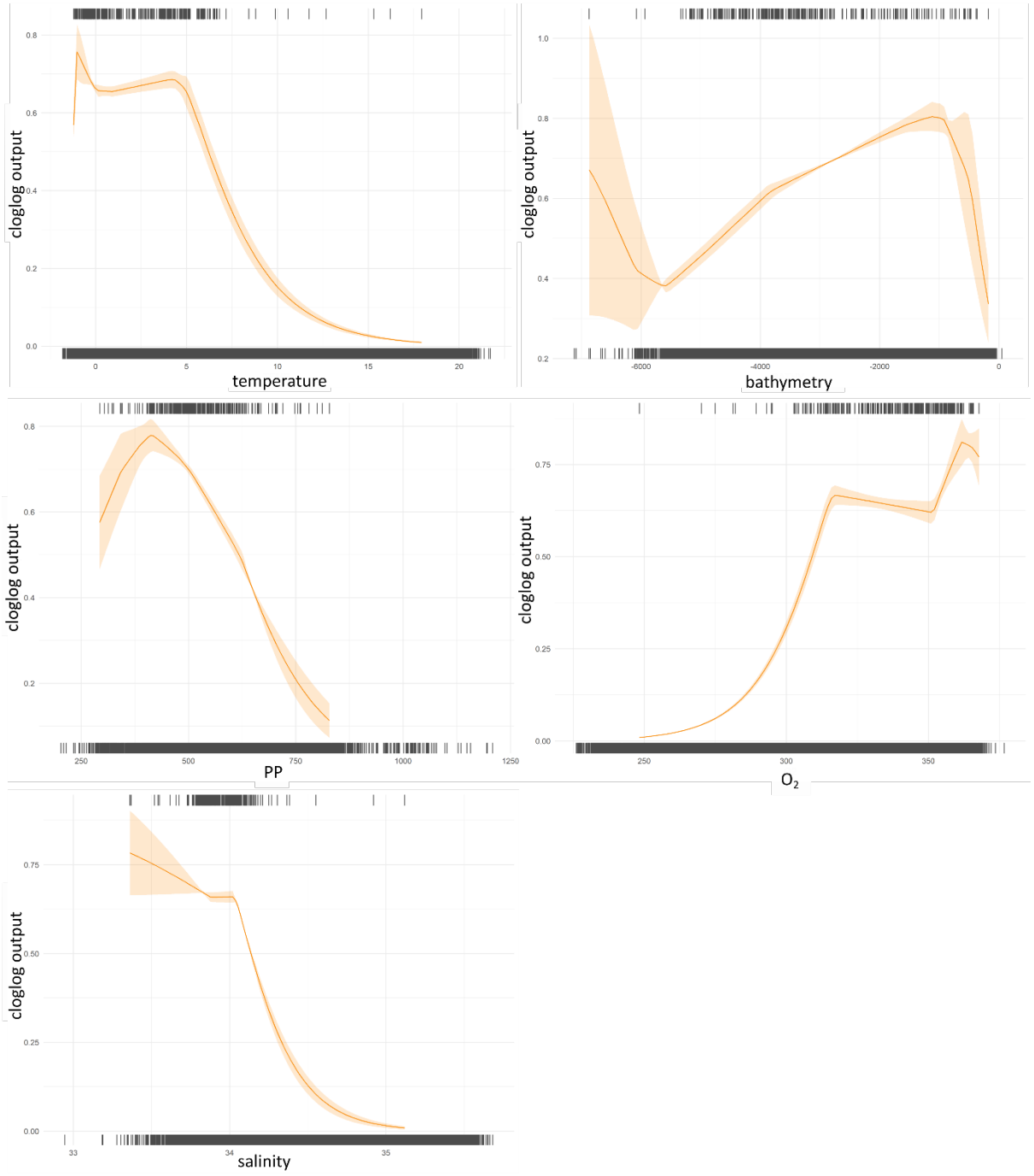

Figure S10: Univariate response curves for *Gymnoscopelus braueri* using the 2D*all* modelling approach. Each curve displays the averaged value of the prediction across its environmental range. Ribbon denotes the standard deviation error, top bars are the rug of presence locations and bottom bars are the rug of the background locations.

Gymnoscopelus braueri
Model: 2Dsub

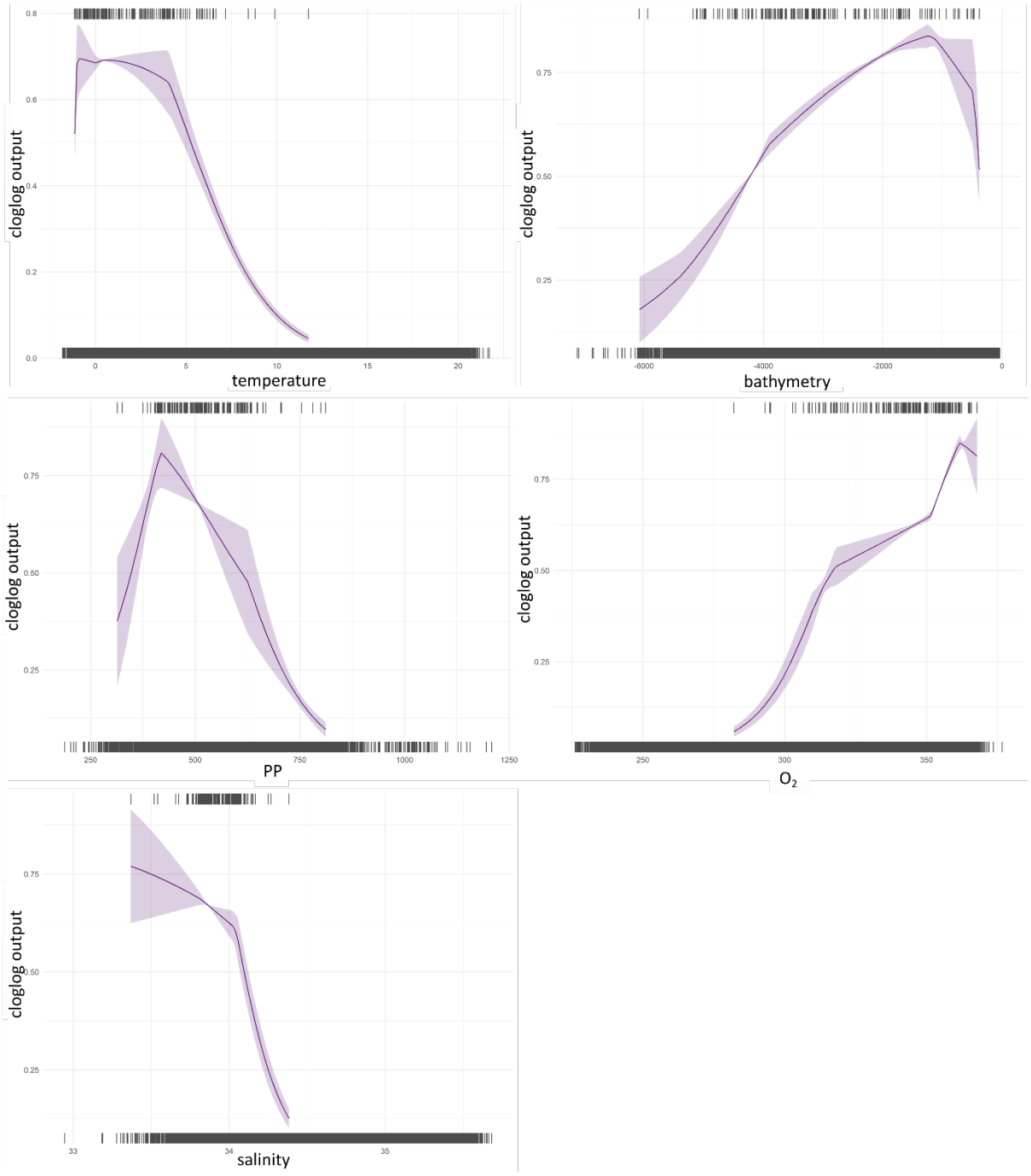

Figure S11: Univariate response curves for *Gymnoscopelus braueri* using the 2D*sub* modelling approach. Each curve displays the averaged value of the prediction across its environmental range. Ribbon denotes the standard deviation error, top bars are the rug of presence locations and bottom bars are the rug of the background locations.

Gymnoscopelus braueri
Model: 3D

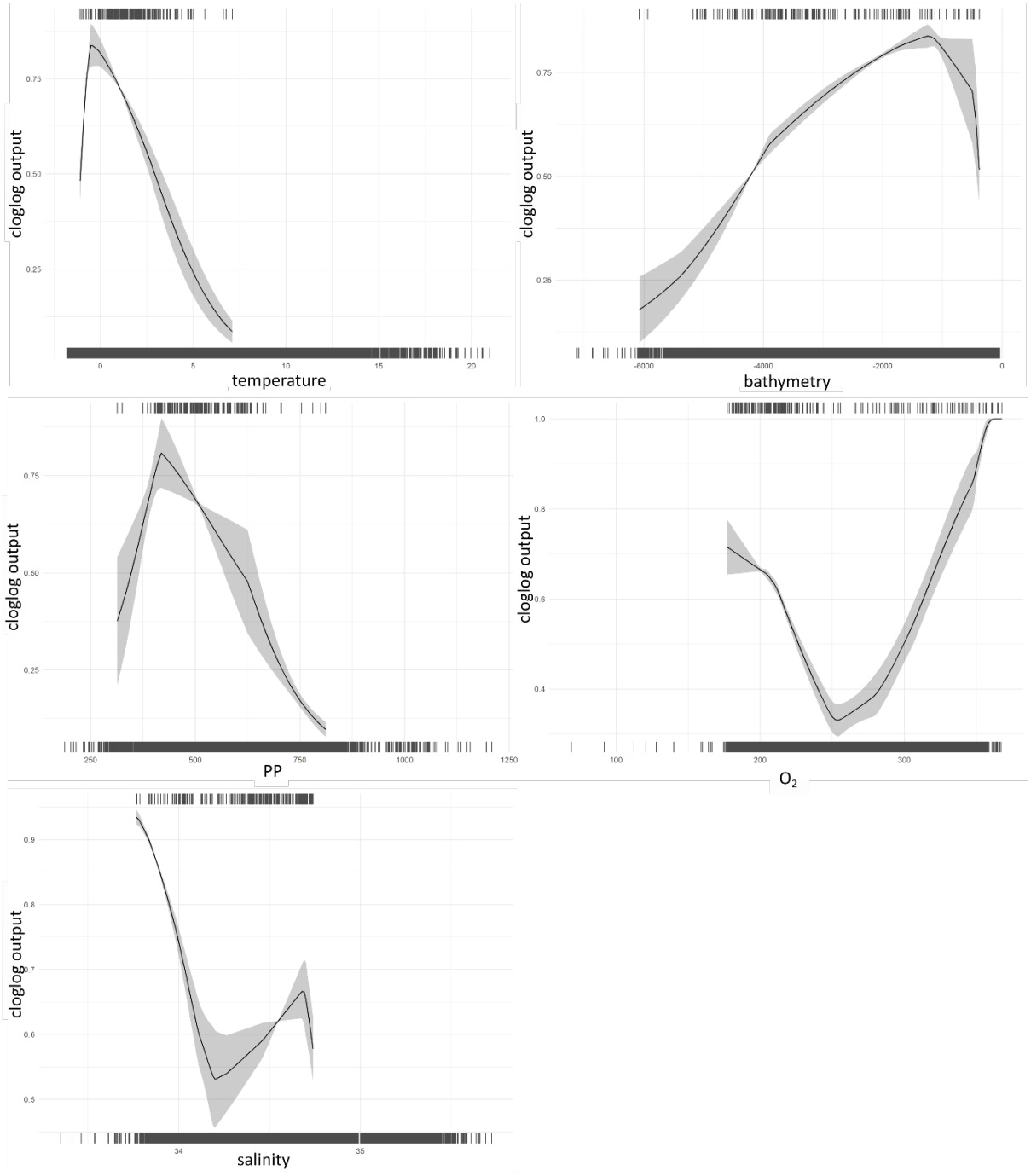

Figure S12: Univariate response curves for *Gymnoscopelus braueri* using the 3D modelling approach. Each curve displays the averaged value of the prediction across its environmental range. Ribbon denotes the standard deviation error, top bars are the rug of presence locations and bottom bars are the rug of the background locations.

Gymnoscopelus fraseri
Model: 2Dall

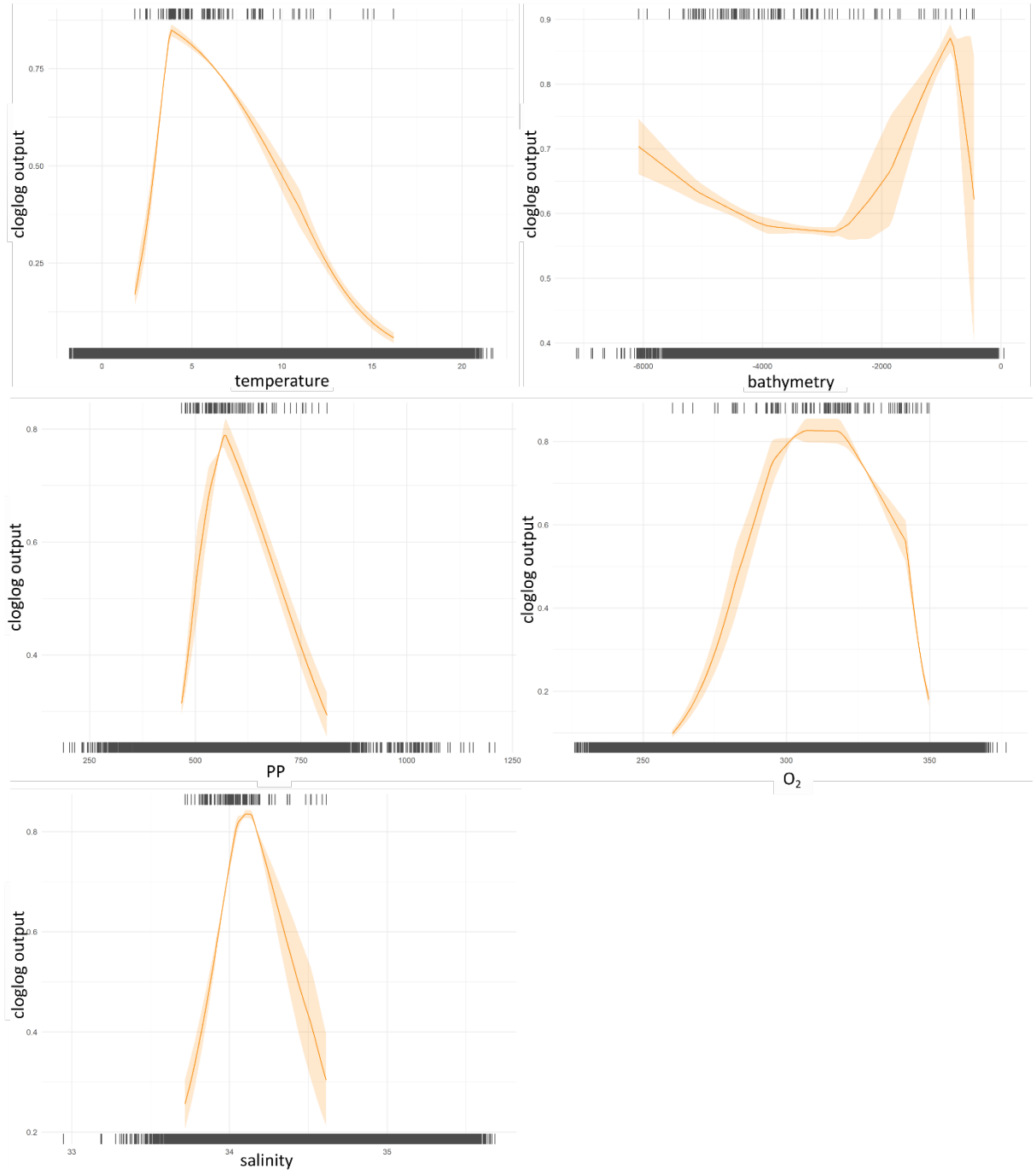

Figure S13: Univariate response curves for *Gymnoscopelus fraseri* using the 2D*all* modelling approach. Each curve displays the averaged value of the prediction across its environmental range. Ribbon denotes the standard deviation error, top bars are the rug of presence locations and bottom bars are the rug of the background locations.

Gymnoscopelus fraseri
Model: 2Dsub

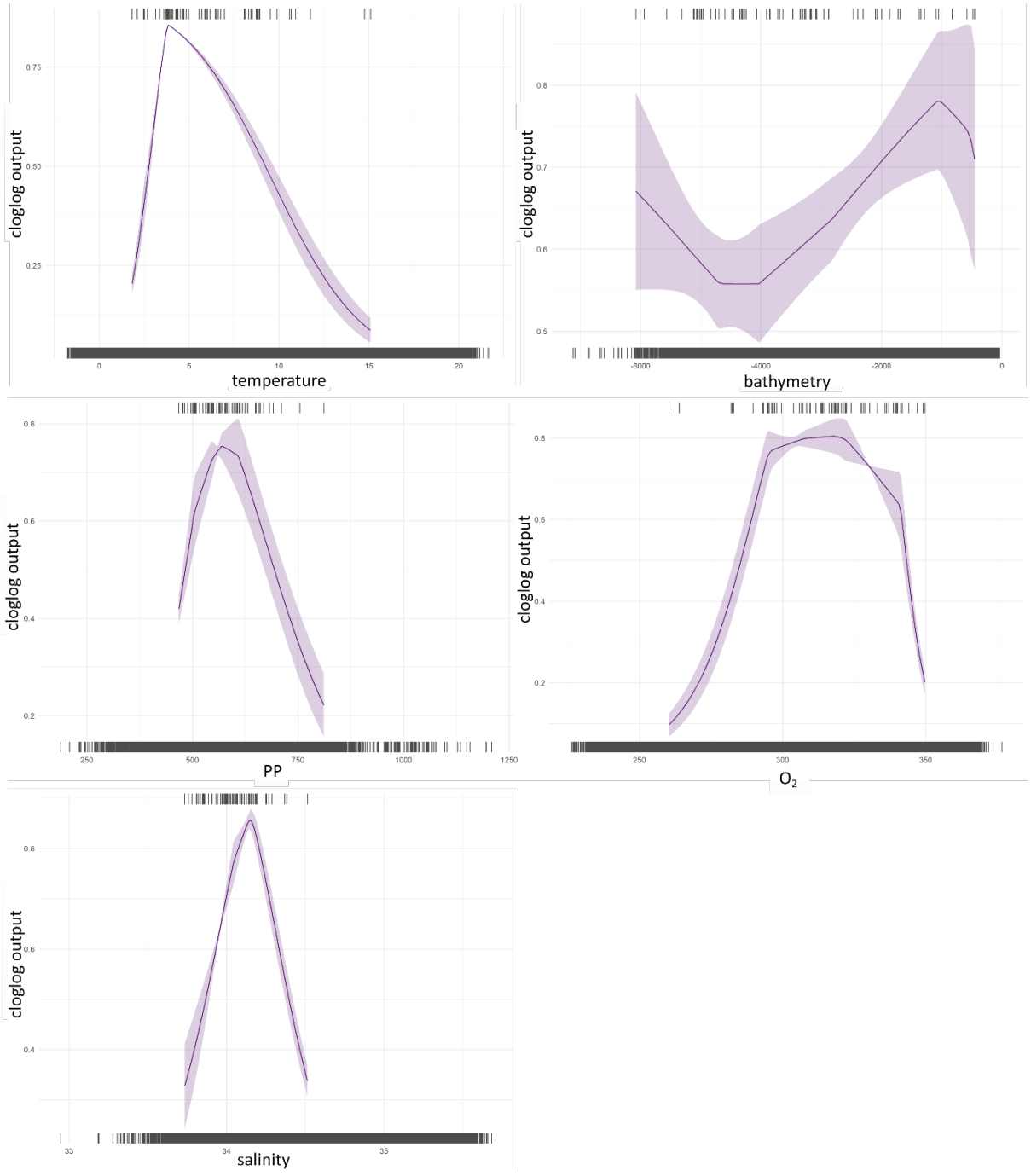

Figure S14: Univariate response curves for *Gymnoscopelus fraseri* using the 2D*sub* modelling approach. Each curve displays the averaged value of the prediction across its environmental range. Ribbon denotes the standard deviation error, top bars are the rug of presence locations and bottom bars are the rug of the background locations.

Gymnoscopelus fraseri
Model: 3D

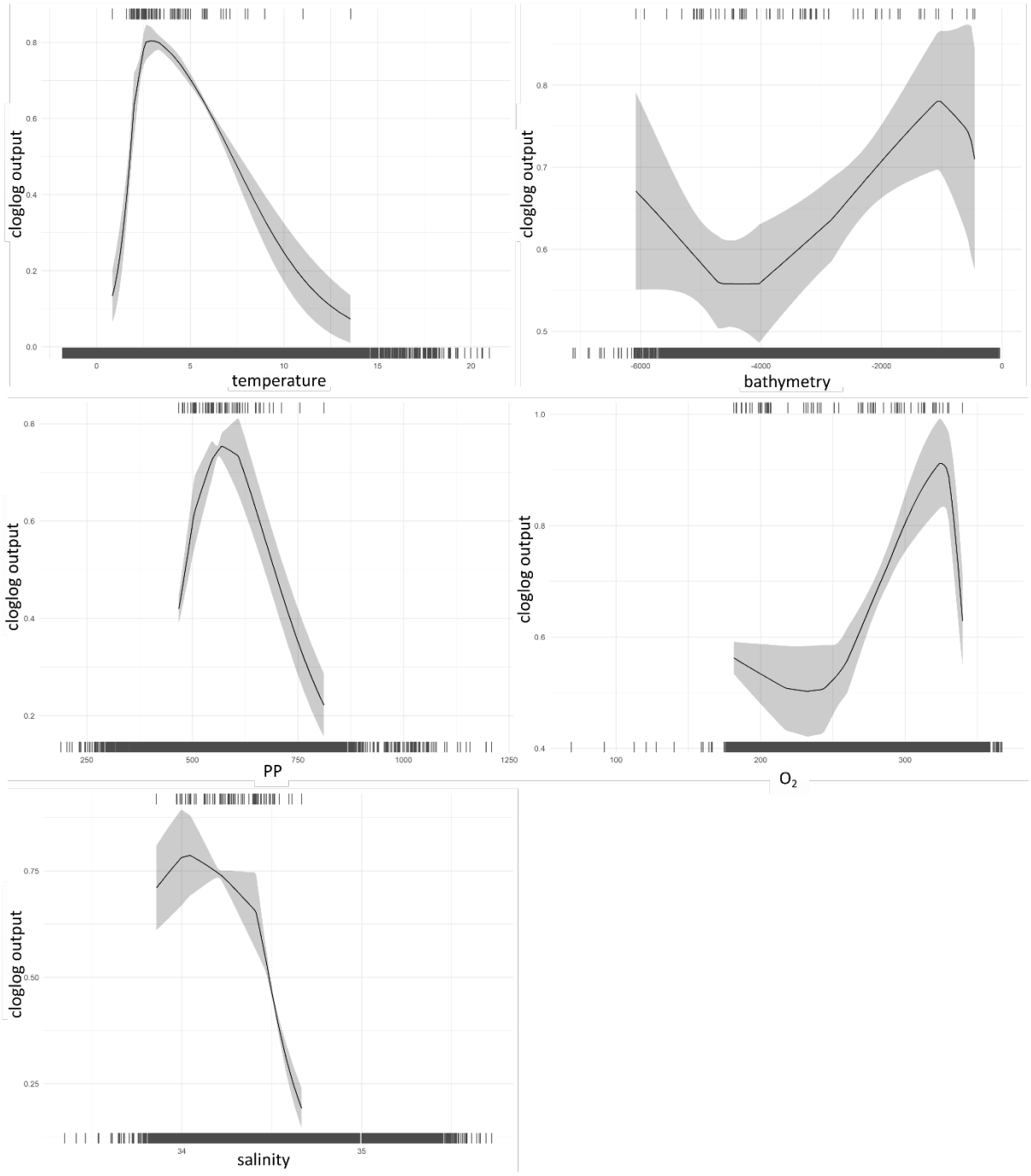

Figure S15: Univariate response curves for *Gymnoscopelus fraseri* using the 3D modelling approach. Each curve displays the averaged value of the prediction across its environmental range. Ribbon denotes the standard deviation error, top bars are the rug of presence locations and bottom bars are the rug of the background locations.

Gymnoscopelus nicholsi
Model: 2Dall

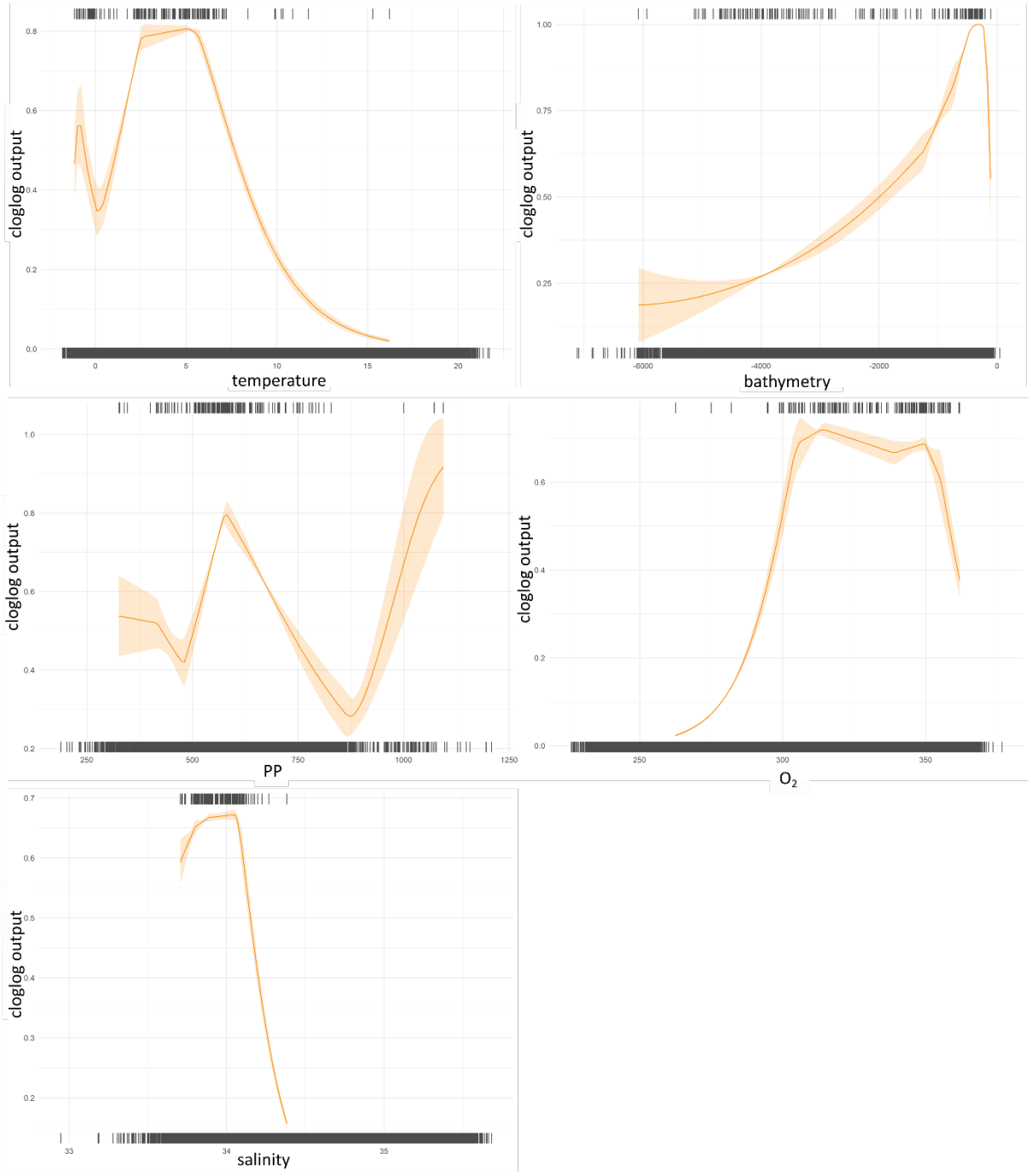

Figure S16: Univariate response curves for *Gymnoscopelus nicholsi* using the 2D*all* modelling approach. Each curve displays the averaged value of the prediction across its environmental range. Ribbon denotes the standard deviation error, top bars are the rug of presence locations and bottom bars are the rug of the background locations.

Gymnoscopelus nicholsi
Model: 2Dsub

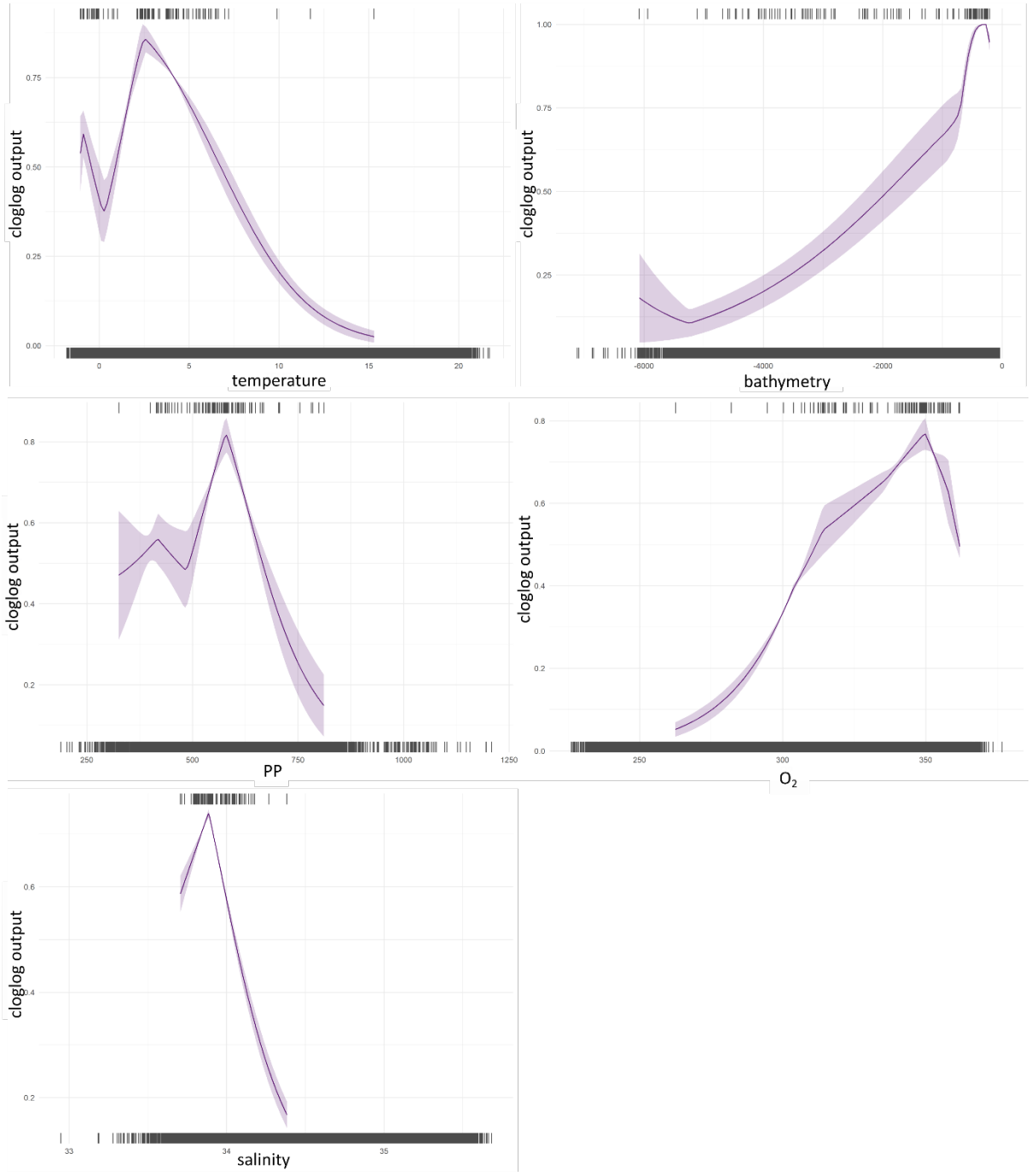

Figure S17: Univariate response curves for *Gymnoscopelus nicholsi* using the 2D*sub* modelling approach. Each curve displays the averaged value of the prediction across its environmental range. Ribbon denotes the standard deviation error, top bars are the rug of presence locations and bottom bars are the rug of the background locations.

Gymnoscopelus nicholsi
Model: 3D

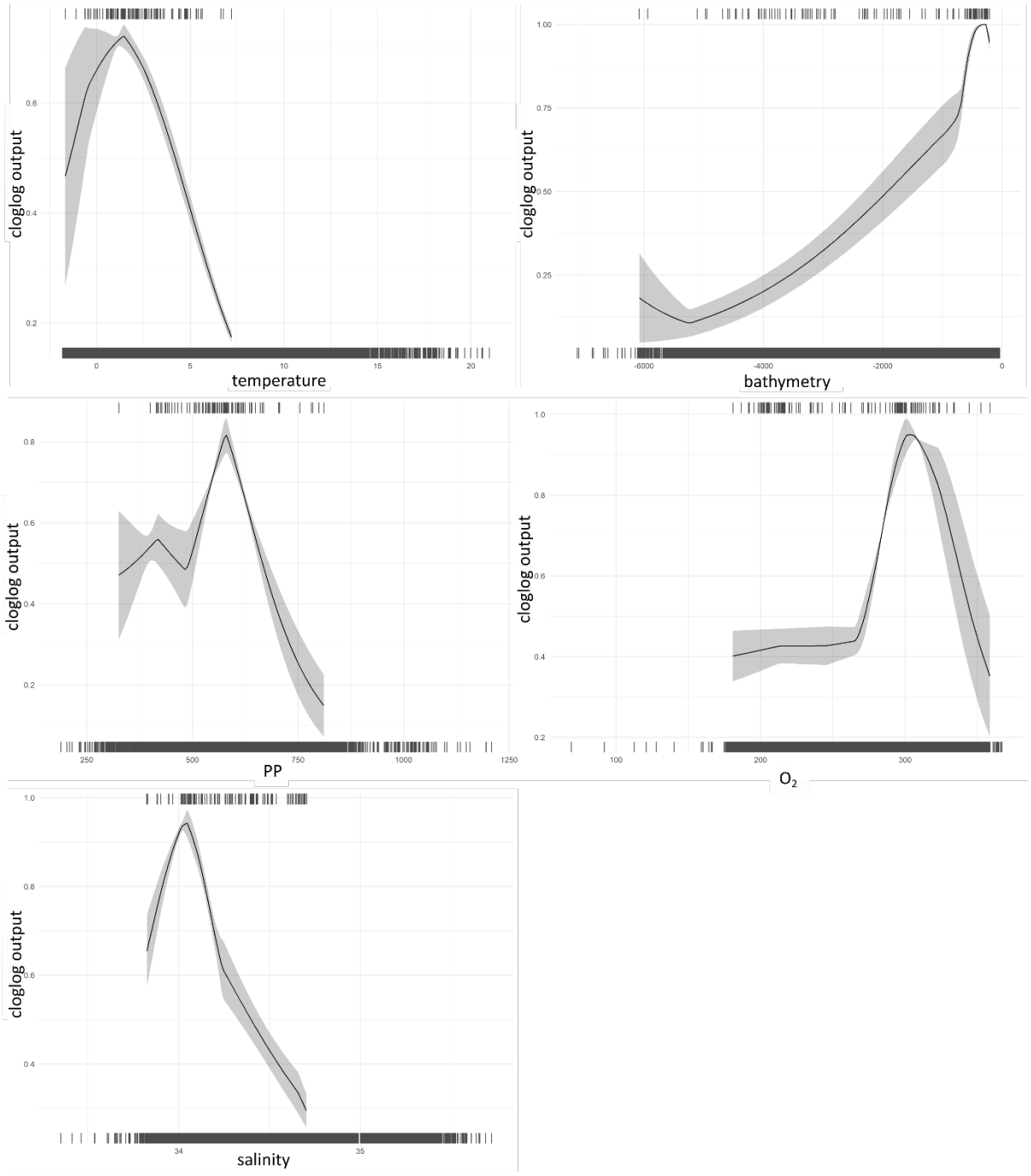

Figure S18: Univariate response curves for *Gymnoscopelus nicholsi* using the 3D modelling approach. Each curve displays the averaged value of the prediction across its environmental range. Ribbon denotes the standard deviation error, top bars are the rug of presence locations and bottom bars are the rug of the background locations.

Gymnoscopelus opisthopterus
Model: 2Dall

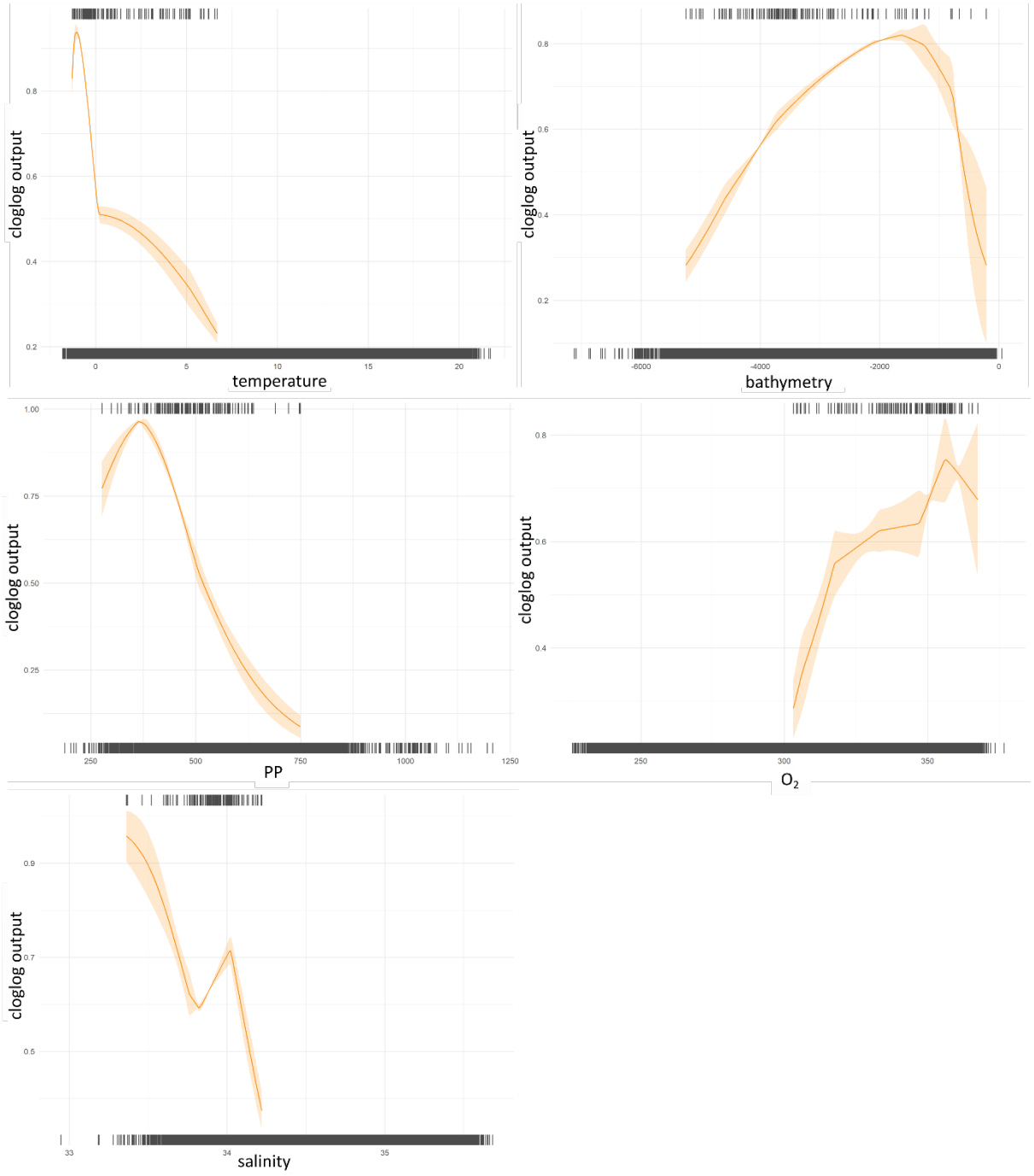

Figure S19: Univariate response curves for *Gymnoscopelus opisthopterus* using the 2D*all* modelling approach. Each curve displays the averaged value of the prediction across its environmental range. Ribbon denotes the standard deviation error, top bars are the rug of presence locations and bottom bars are the rug of the background locations.

Gymnoscopelus opisthopterus
Model: 2Dsub

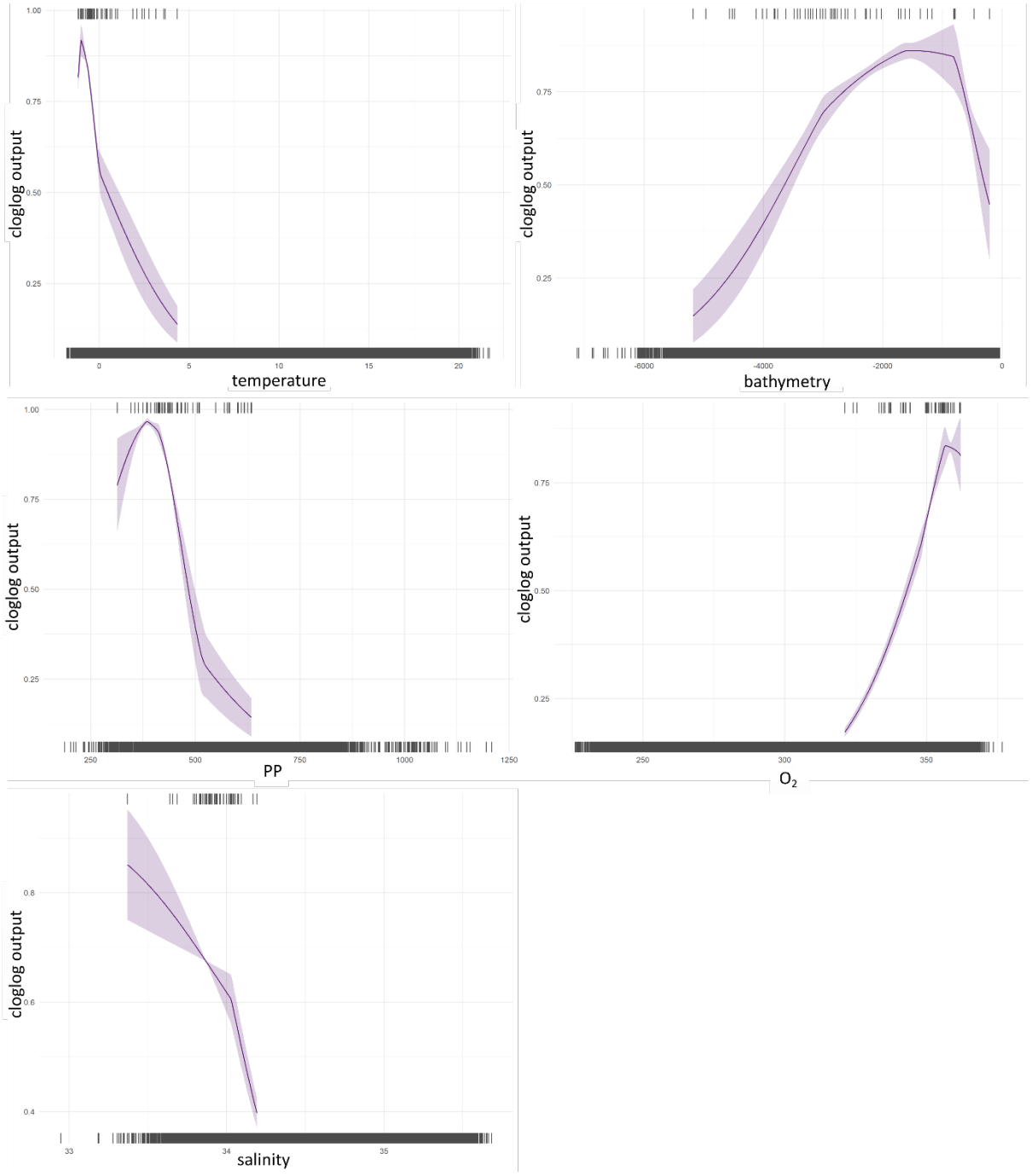

Figure S20: Univariate response curves for *Gymnoscopelus opisthopterus* using the 2D*sub* modelling approach. Each curve displays the averaged value of the prediction across its environmental range. Ribbon denotes the standard deviation error, top bars are the rug of presence locations and bottom bars are the rug of the background locations.

Gymnoscopelus opisthopterus
Model: 3D

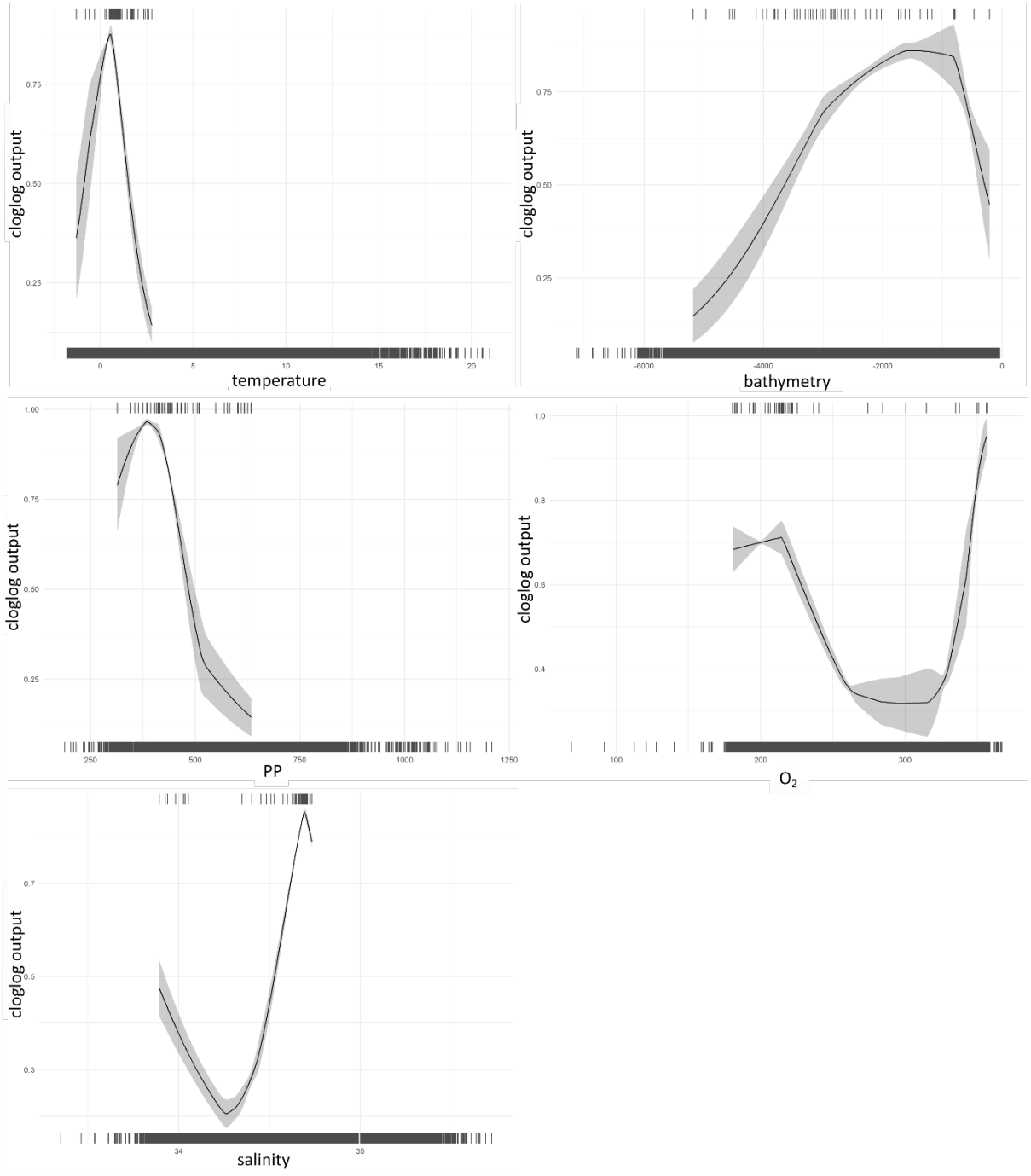

Figure S21: Univariate response curves for *Gymnoscopelus opisthopterus* using the 3D modelling approach. Each curve displays the averaged value of the prediction across its environmental range. Ribbon denotes the standard deviation error, top bars are the rug of presence locations and bottom bars are the rug of the background locations.

Krefftichthys anderssoni
Model: 2Dall

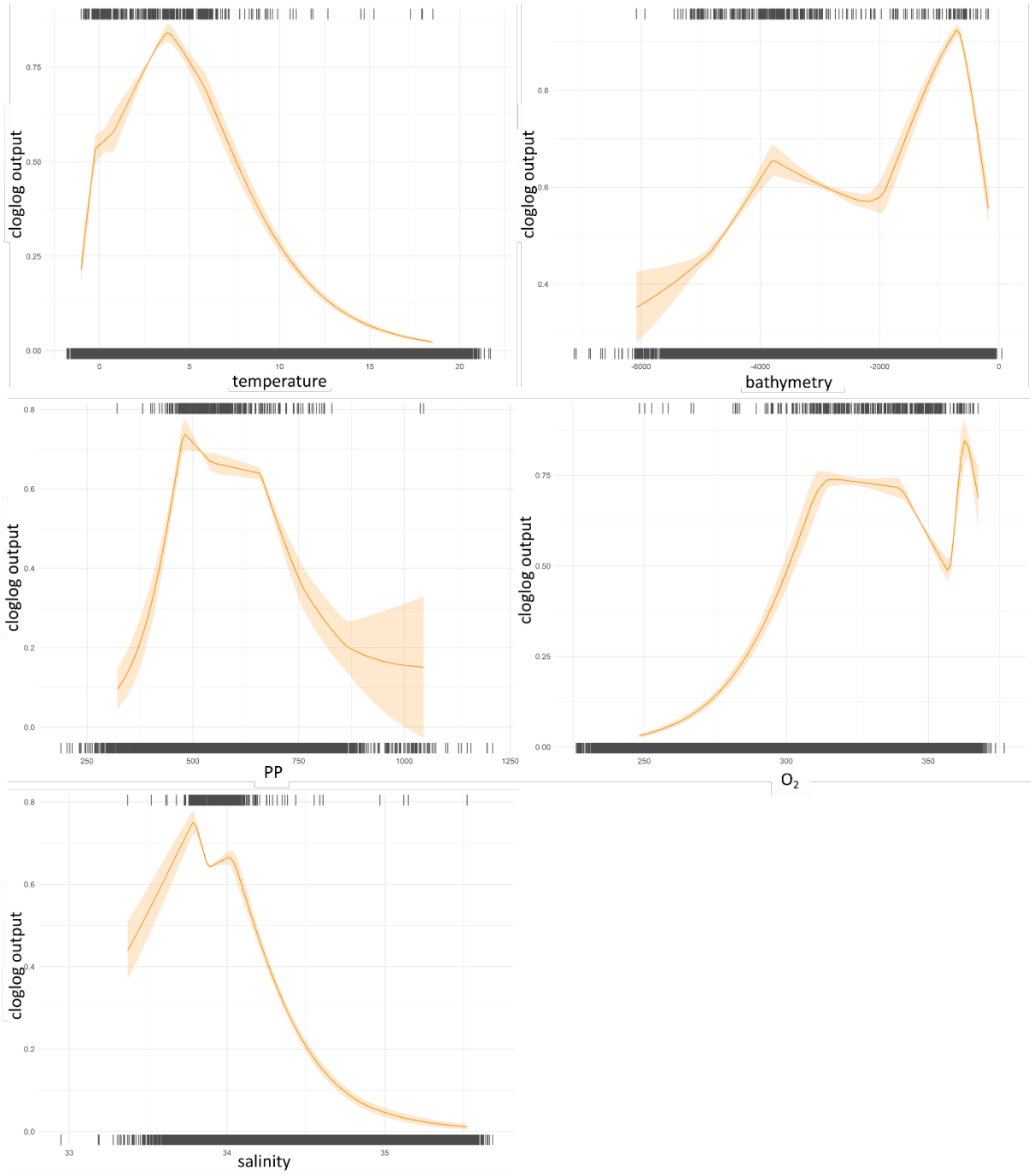

Figure S22: Univariate response curves for *Krefftichthys anderssoni* using the 2D*all* modelling approach. Each curve displays the averaged value of the prediction across its environmental range. Ribbon denotes the standard deviation error, top bars are the rug of presence locations and bottom bars are the rug of the background locations.

Krefftichthys anderssoni
Model: 2Dsub

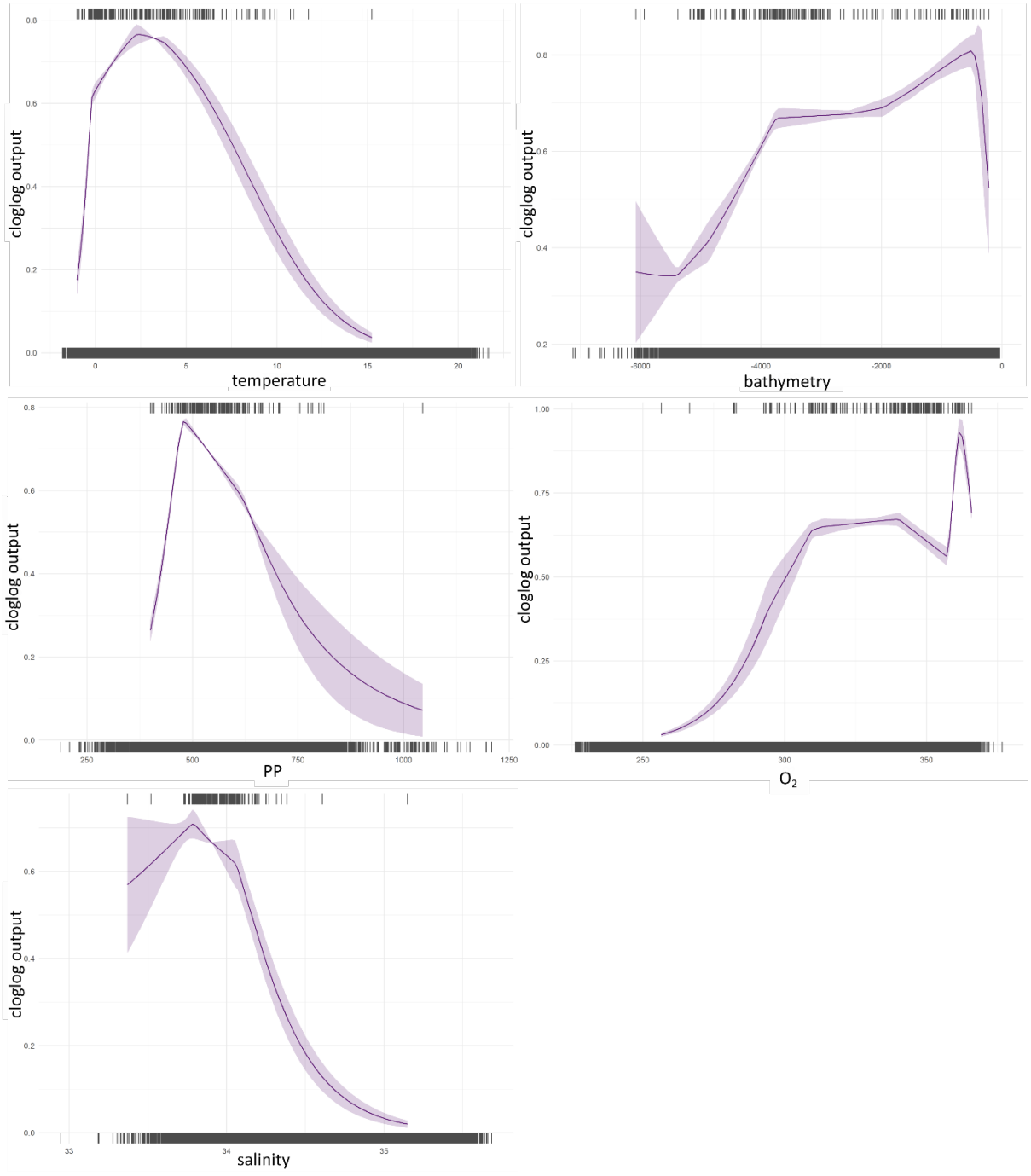

Figure S23: Univariate response curves for *Krefftichthys anderssoni* using the 2D*sub* modelling approach. Each curve displays the averaged value of the prediction across its environmental range. Ribbon denotes the standard deviation error, top bars are the rug of presence locations and bottom bars are the rug of the background locations.

Krefftichthys anderssoni
Model: 3D

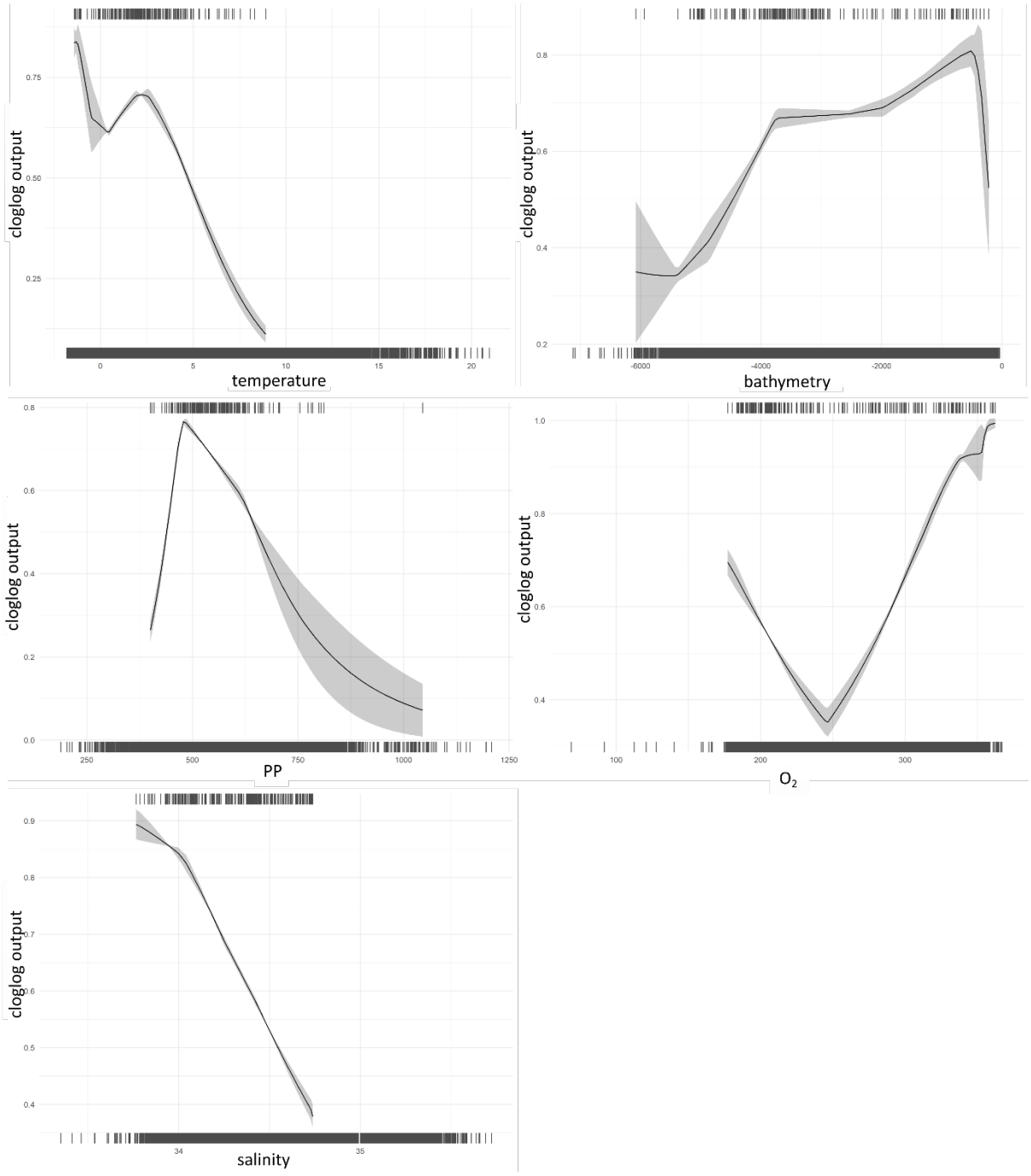

Figure S24: Univariate response curves for *Krefftichthys anderssoni* using the 3D modelling approach. Each curve displays the averaged value of the prediction across its environmental range. Ribbon denotes the standard deviation error, top bars are the rug of presence locations and bottom bars are the rug of the background locations.

Protomyctophum bolini
Model: 2Dall

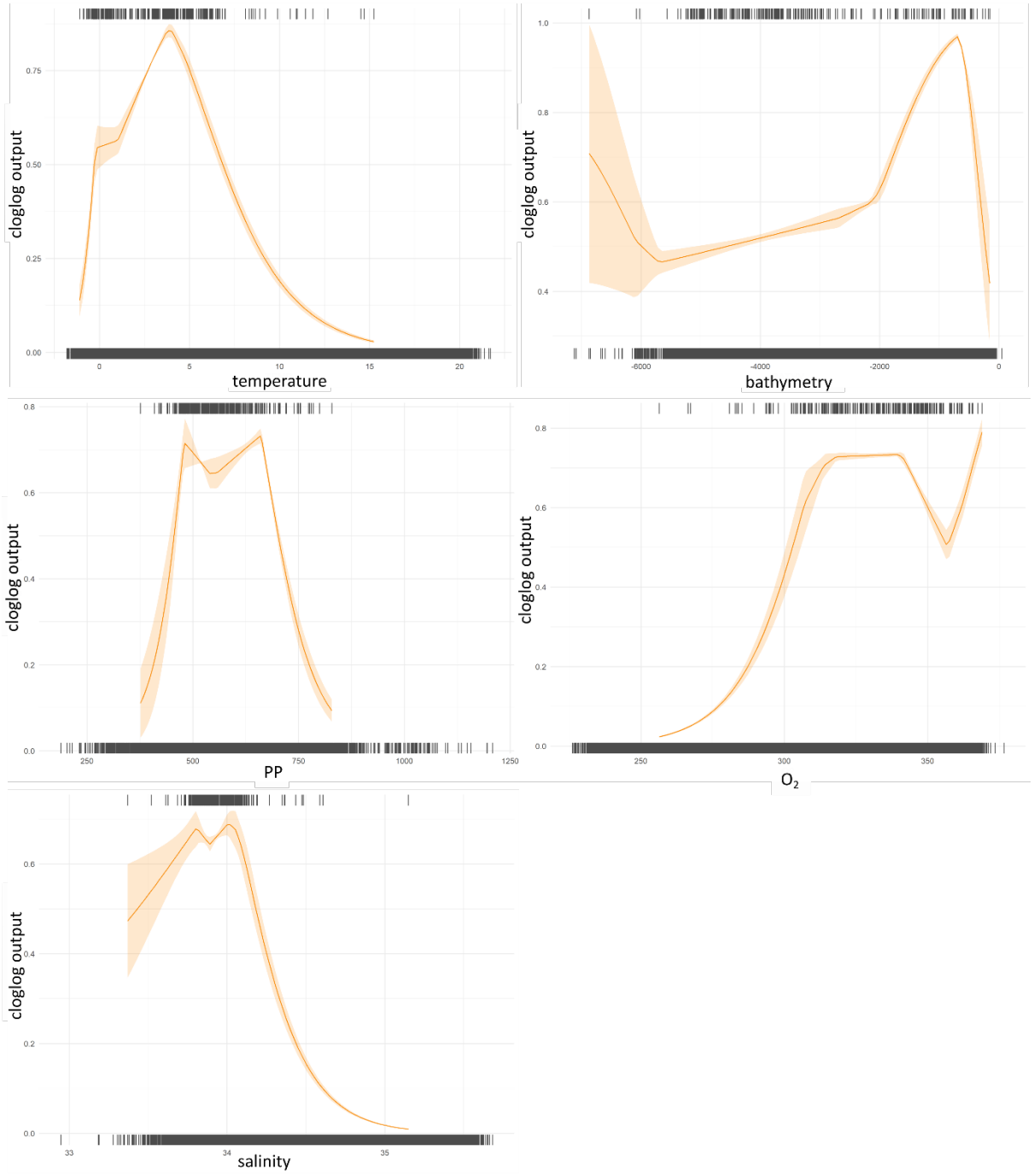

Figure S25: Univariate response curves for *Protomyctophum bolini* using the 2D*all* modelling approach. Each curve displays the averaged value of the prediction across its environmental range. Ribbon denotes the standard deviation error, top bars are the rug of presence locations and bottom bars are the rug of the background locations.

Protomyctophum bolini
Model: 2Dsub

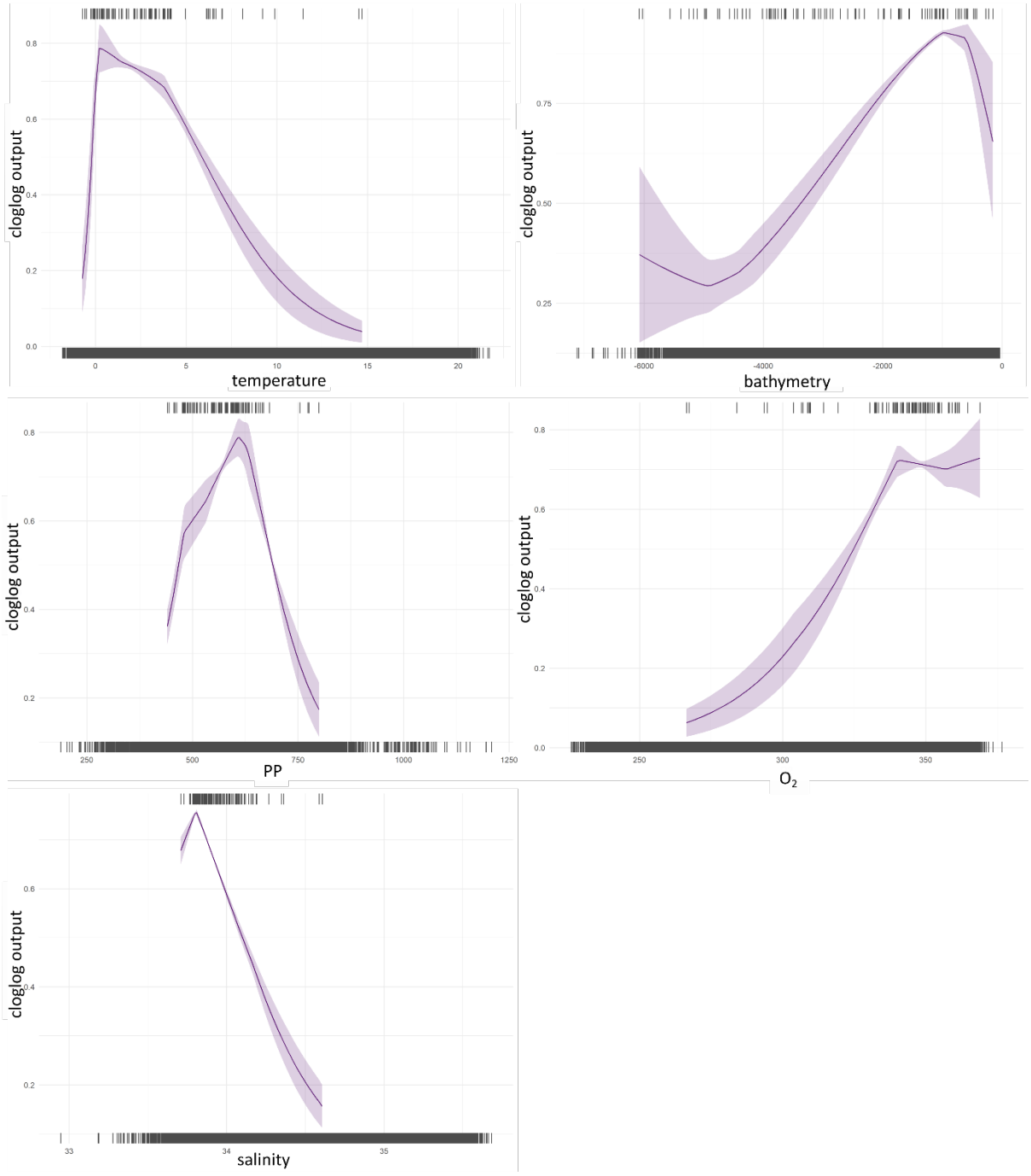

Figure S26: Univariate response curves for *Protomyctophum bolini* using the 2D*sub* modelling approach. Each curve displays the averaged value of the prediction across its environmental range. Ribbon denotes the standard deviation error, top bars are the rug of presence locations and bottom bars are the rug of the background locations.

Protomyctophum bolini
Model: 3D

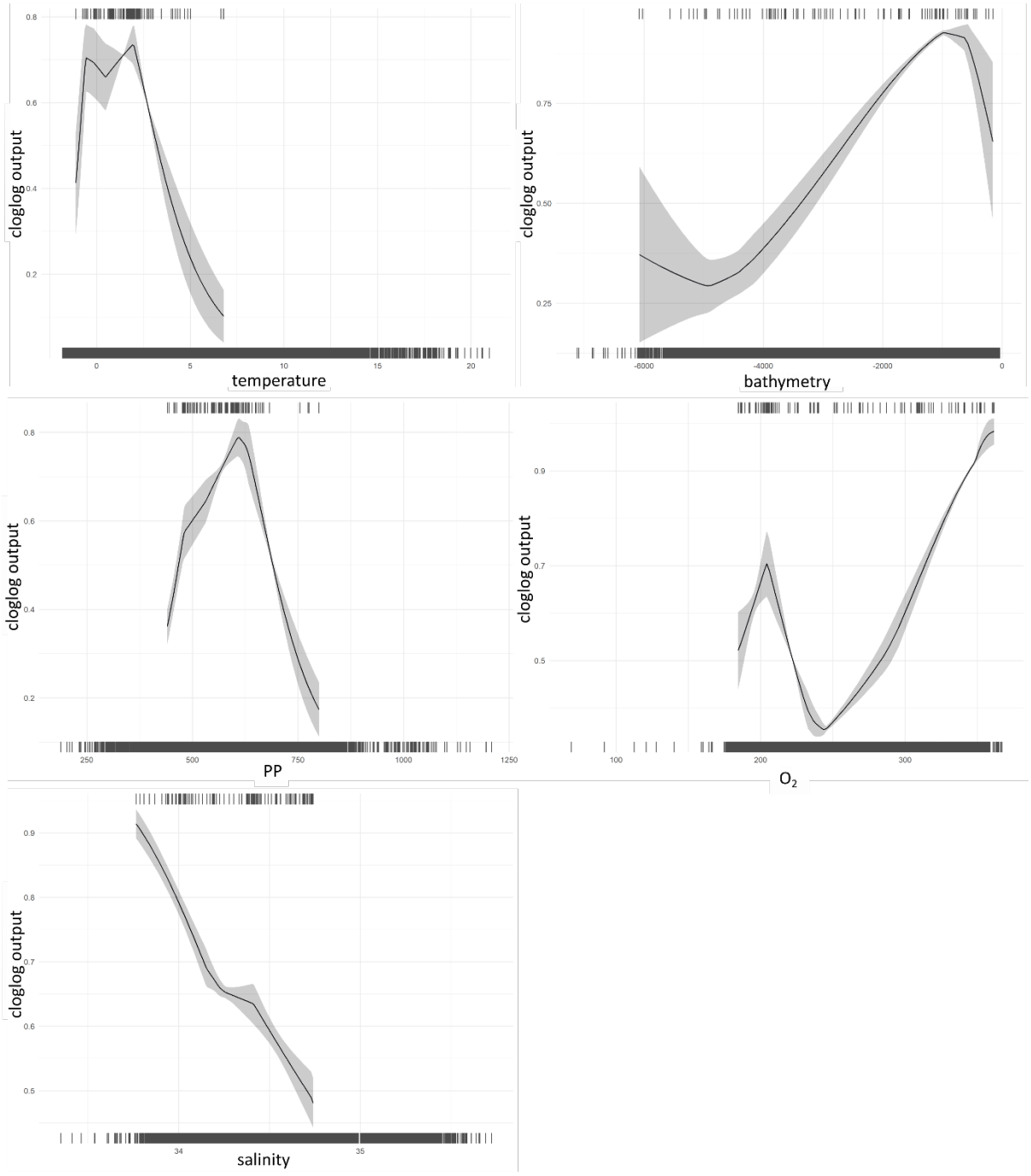

Figure S27: Univariate response curves for *Protomyctophum bolini* using the 3D modelling approach. Each curve displays the averaged value of the prediction across its environmental range. Ribbon denotes the standard deviation error, top bars are the rug of presence locations and bottom bars are the rug of the background locations.

Protomyctophum tenisoni
Model: 2Dall

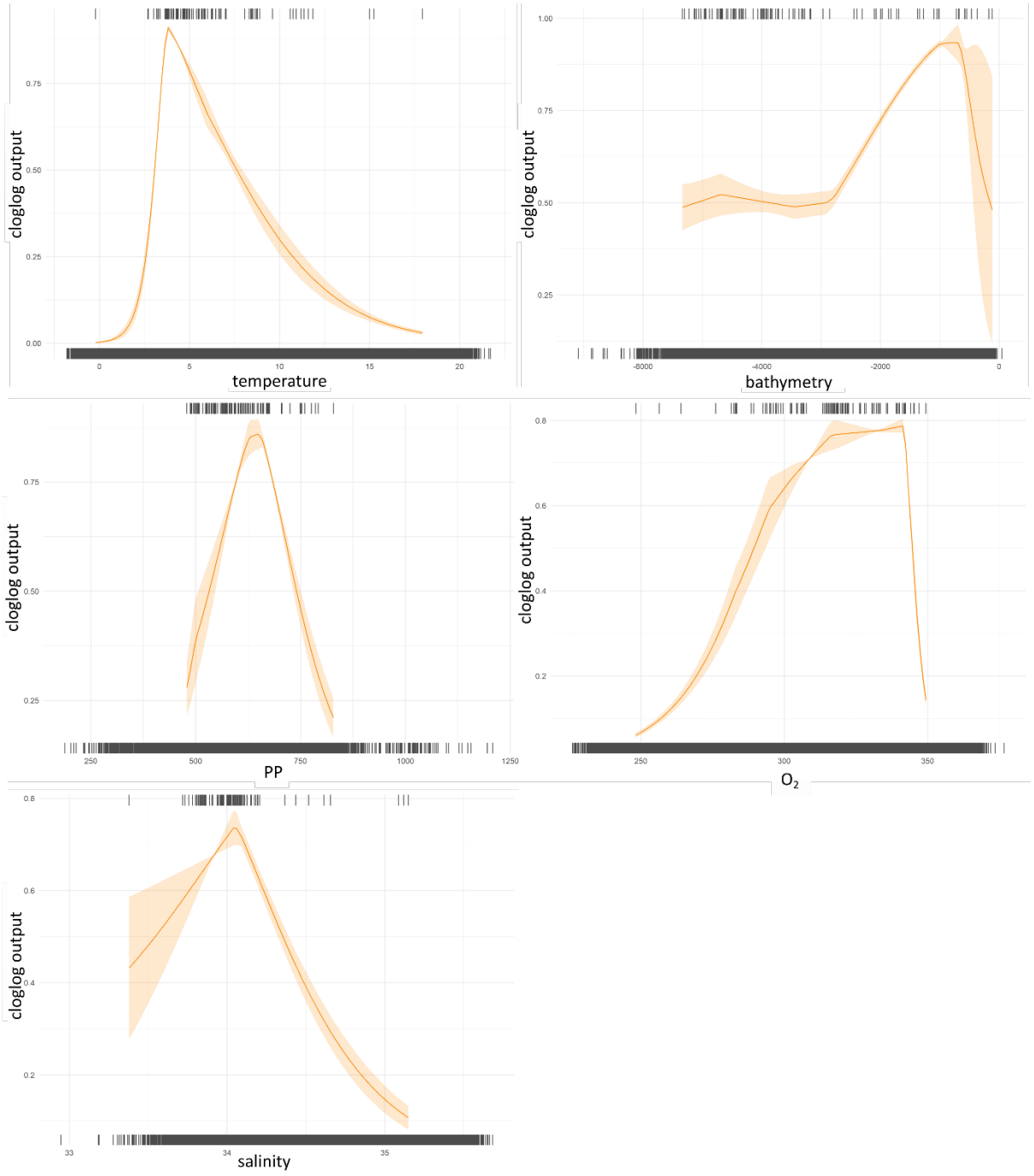

Figure S28: Univariate response curves for *Protomyctophum tenisoni* using the 2D*all* modelling approach. Each curve displays the averaged value of the prediction across its environmental range. Ribbon denotes the standard deviation error, top bars are the rug of presence locations and bottom bars are the rug of the background locations.

Protomyctophum tenisoni
Model: 2Dsub

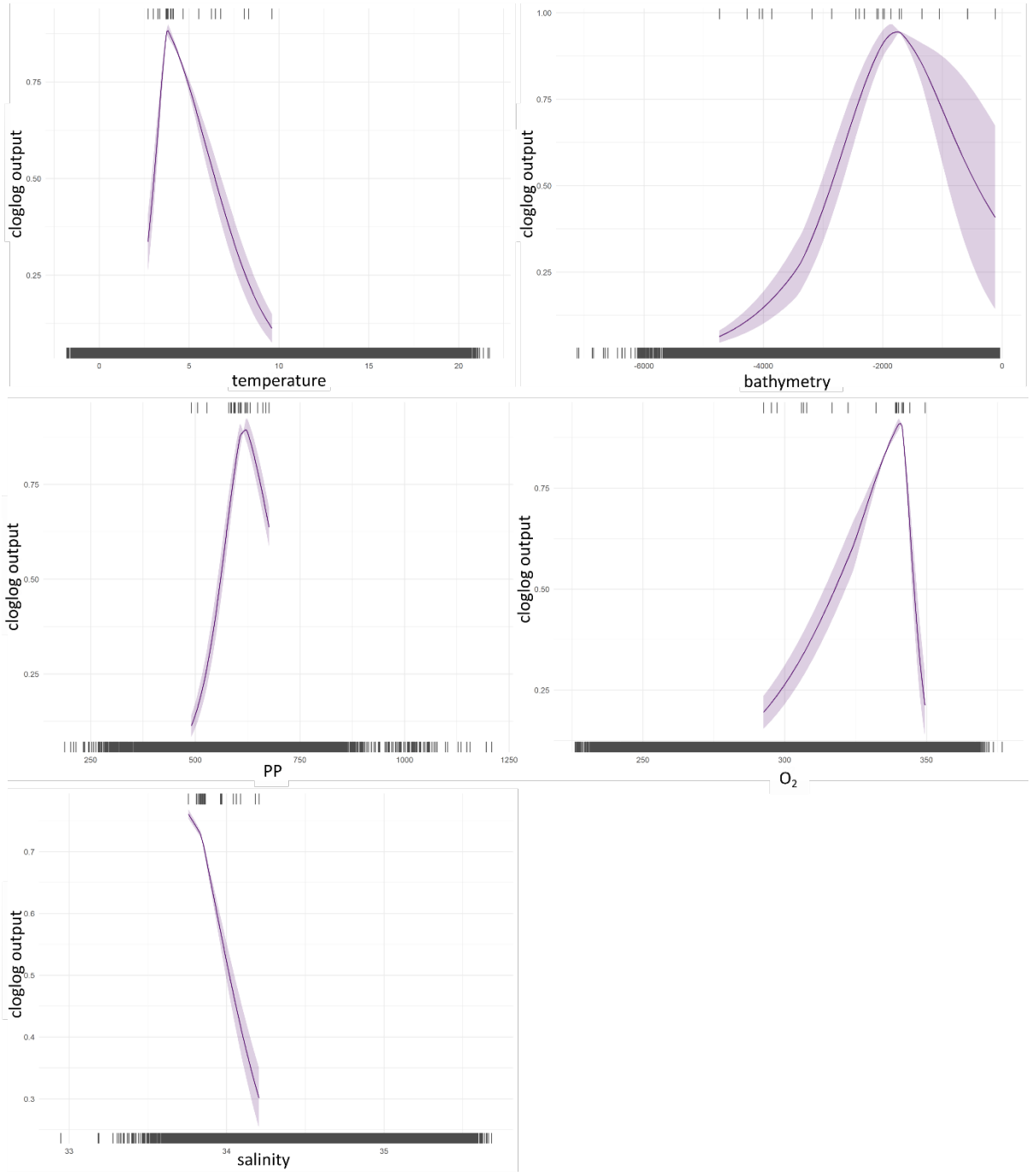

Figure S29: Univariate response curves for *Protomyctophum tenisoni* using the 2D*sub* modelling approach. Each curve displays the averaged value of the prediction across its environmental range. Ribbon denotes the standard deviation error, top bars are the rug of presence locations and bottom bars are the rug of the background locations.

Protomyctophum tenisoni
Model: 3D

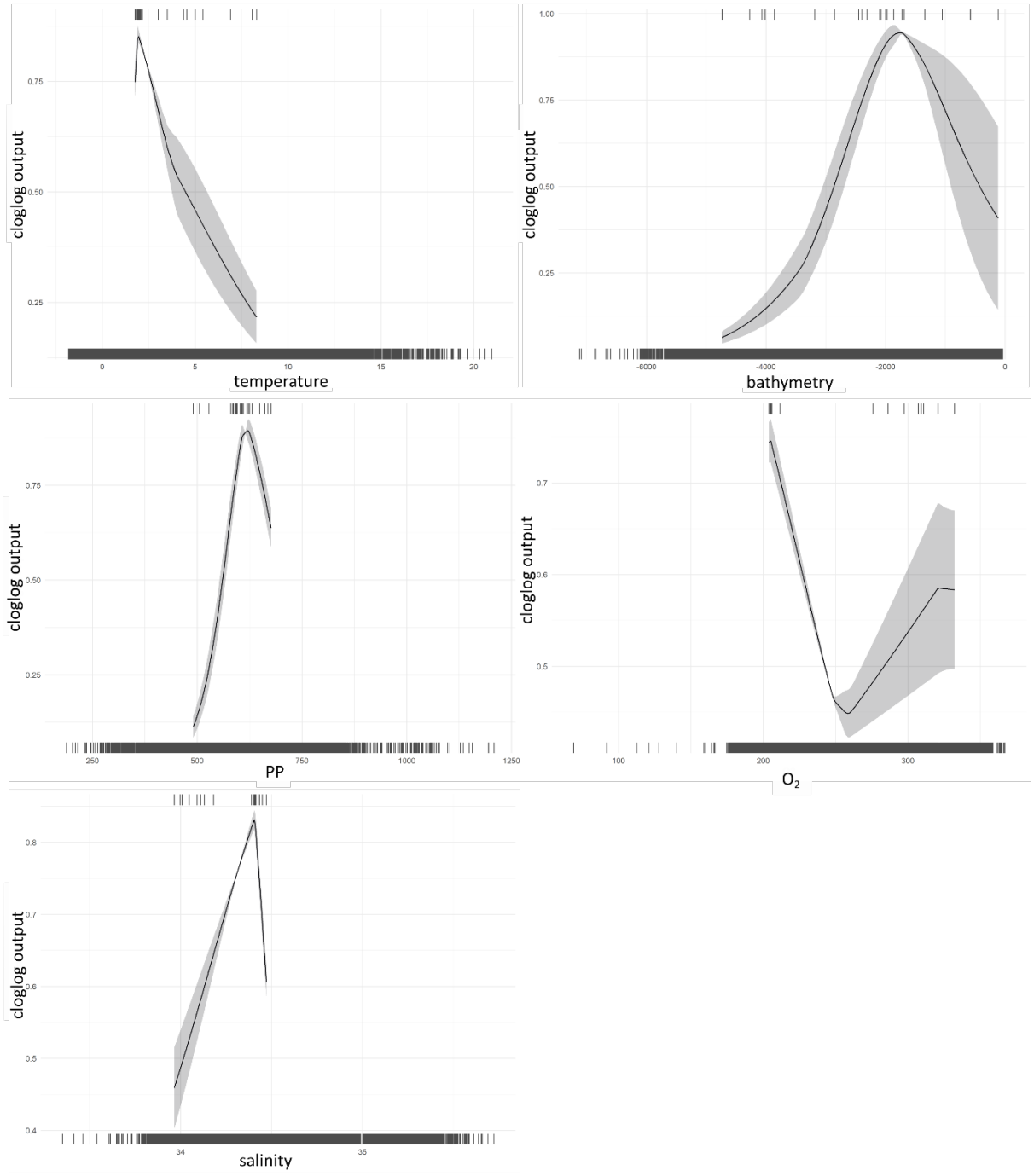

Figure S30: Univariate response curves for *Protomyctophum tenisoni* using the 3D modelling approach. Each curve displays the averaged value of the prediction across its environmental range. Ribbon denotes the standard deviation error, top bars are the rug of presence locations and bottom bars are the rug of the background locations.

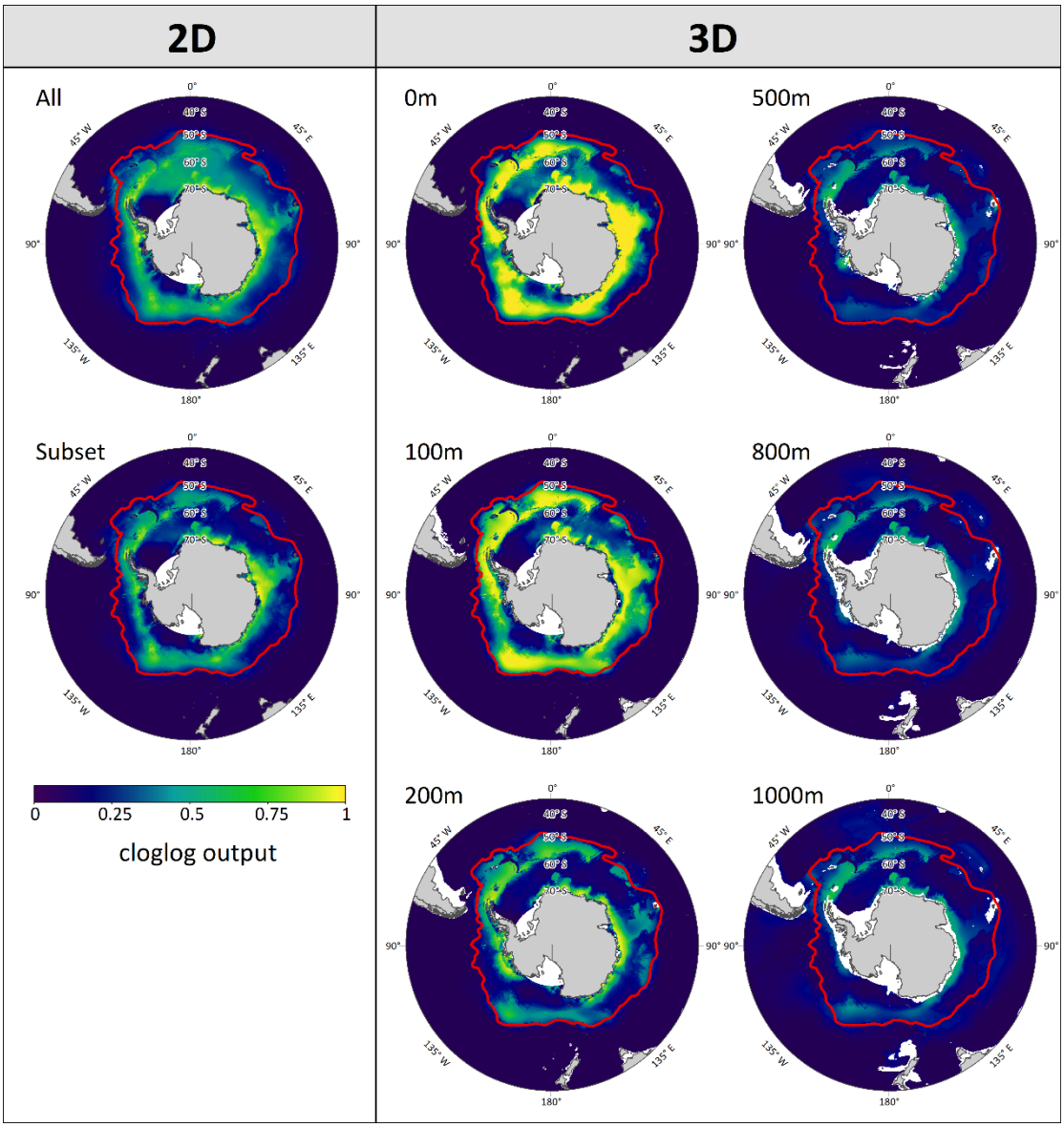

Figure S31: Comparison of estimated conditional probability of presence for *Electrona antarctica* using 2D*all* (using all available occurrence records and sea surface environmental data), 2D*sub* (as 2D*all*, but built using only the same occurrence records as in the 3D model) and 3D (matches occurrence records with environmental variables from a similar depth from which the animals were caught) approaches. The red line denotes the position of the Polar Front from (Orsi & Harris 2001, updated 2015).

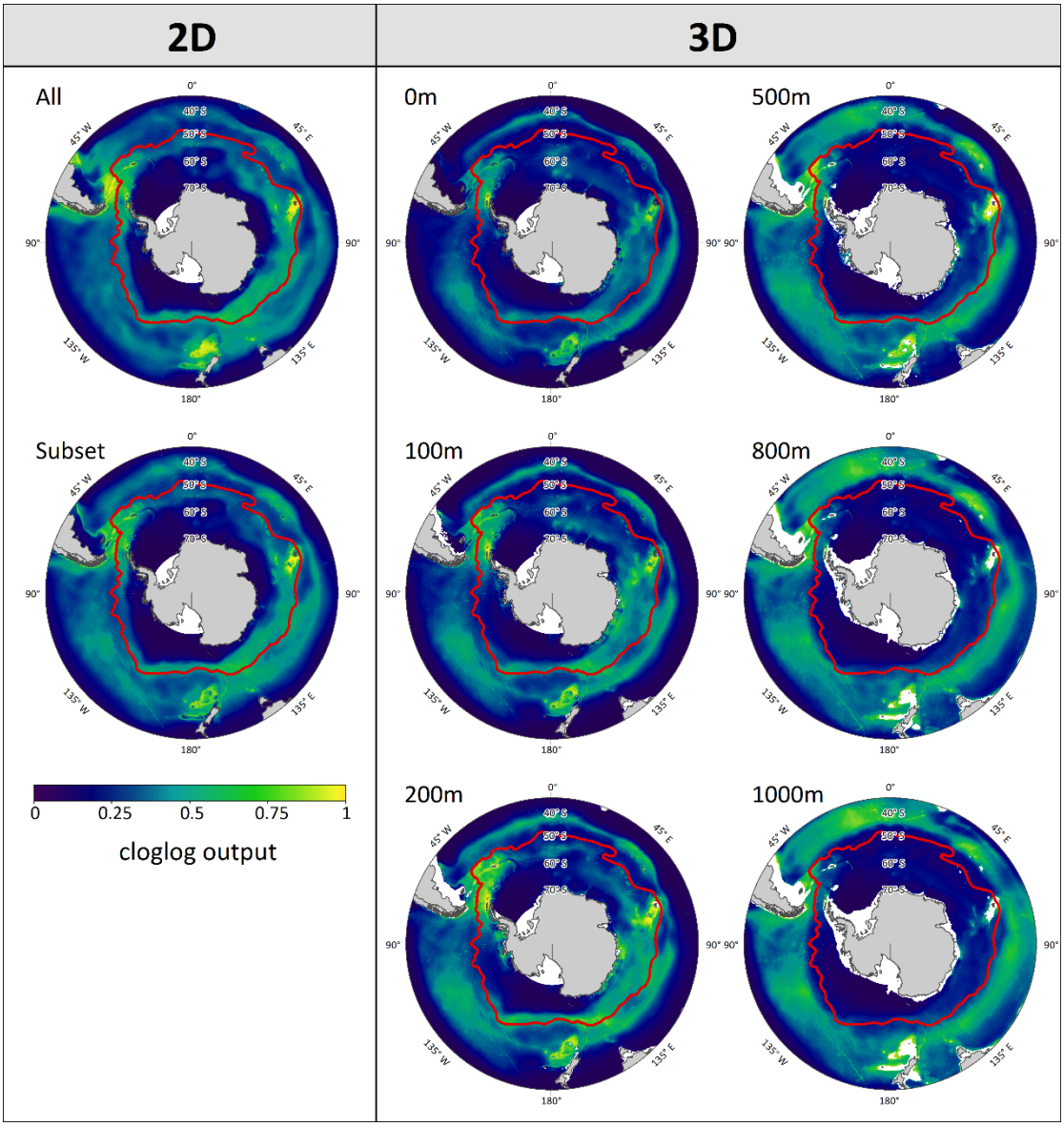

Figure S32: Comparison of estimated conditional probability of presence for *Electrona carlsbergi* using 2D*all* (using all available occurrence records and sea surface environmental data), 2D*sub* (as 2D*all*, but built using only the same occurrence records as in the 3D model) and 3D (matches occurrence records with environmental variables from a similar depth from which the animals were caught) approaches. The red line denotes the position of the Polar Front from (Orsi & Harris 2001, updated 2015).

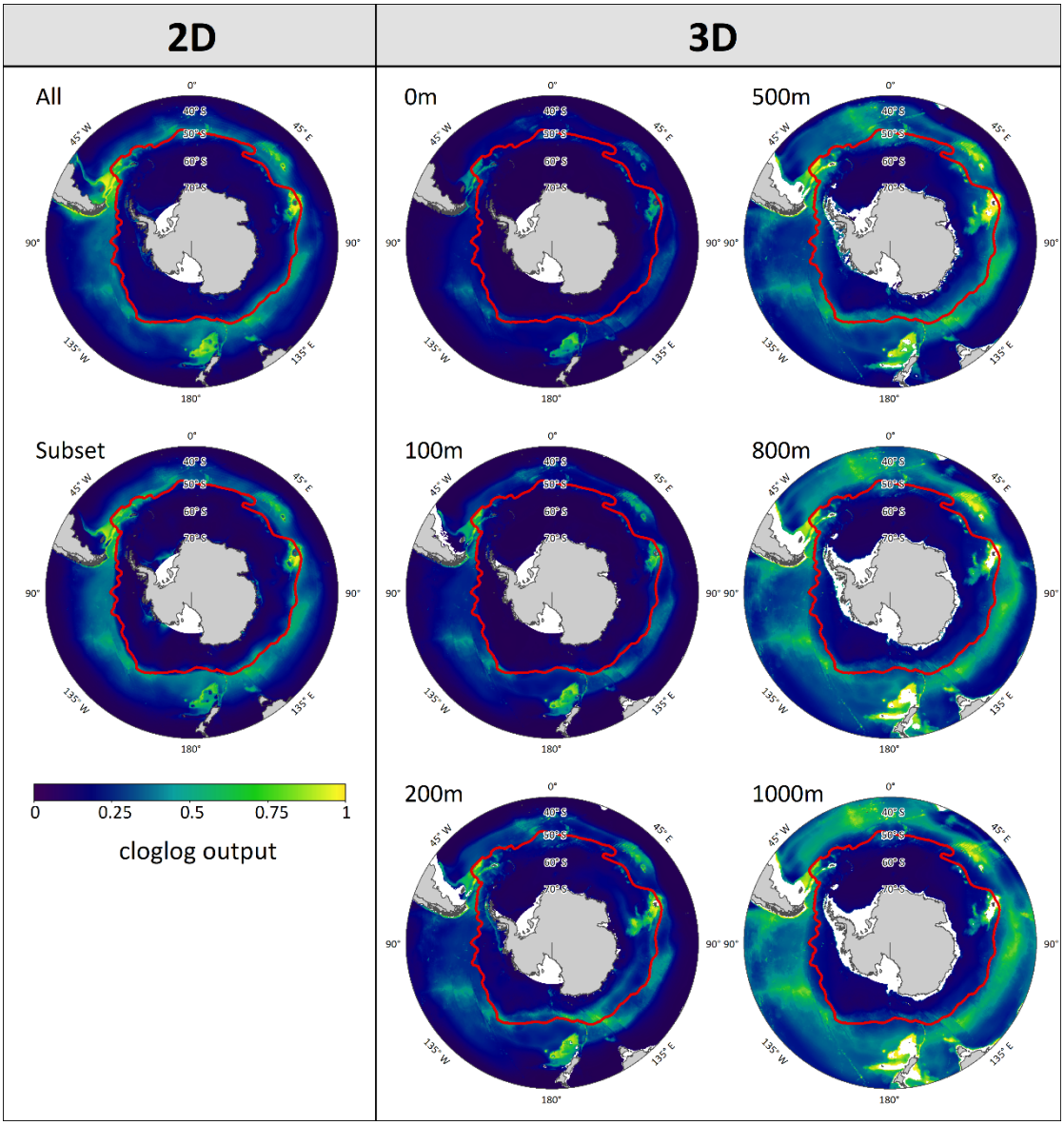

Figure S33: Comparison of estimated conditional probability of presence for *Gymnoscopelus bolini* using 2D*all* (using all available occurrence records and sea surface environmental data), 2D*sub* (as 2D*all*, but built using only the same occurrence records as in the 3D model) and 3D (matches occurrence records with environmental variables from a similar depth from which the animals were caught) approaches. The red line denotes the position of the Polar Front from (Orsi & Harris 2001, updated 2015).

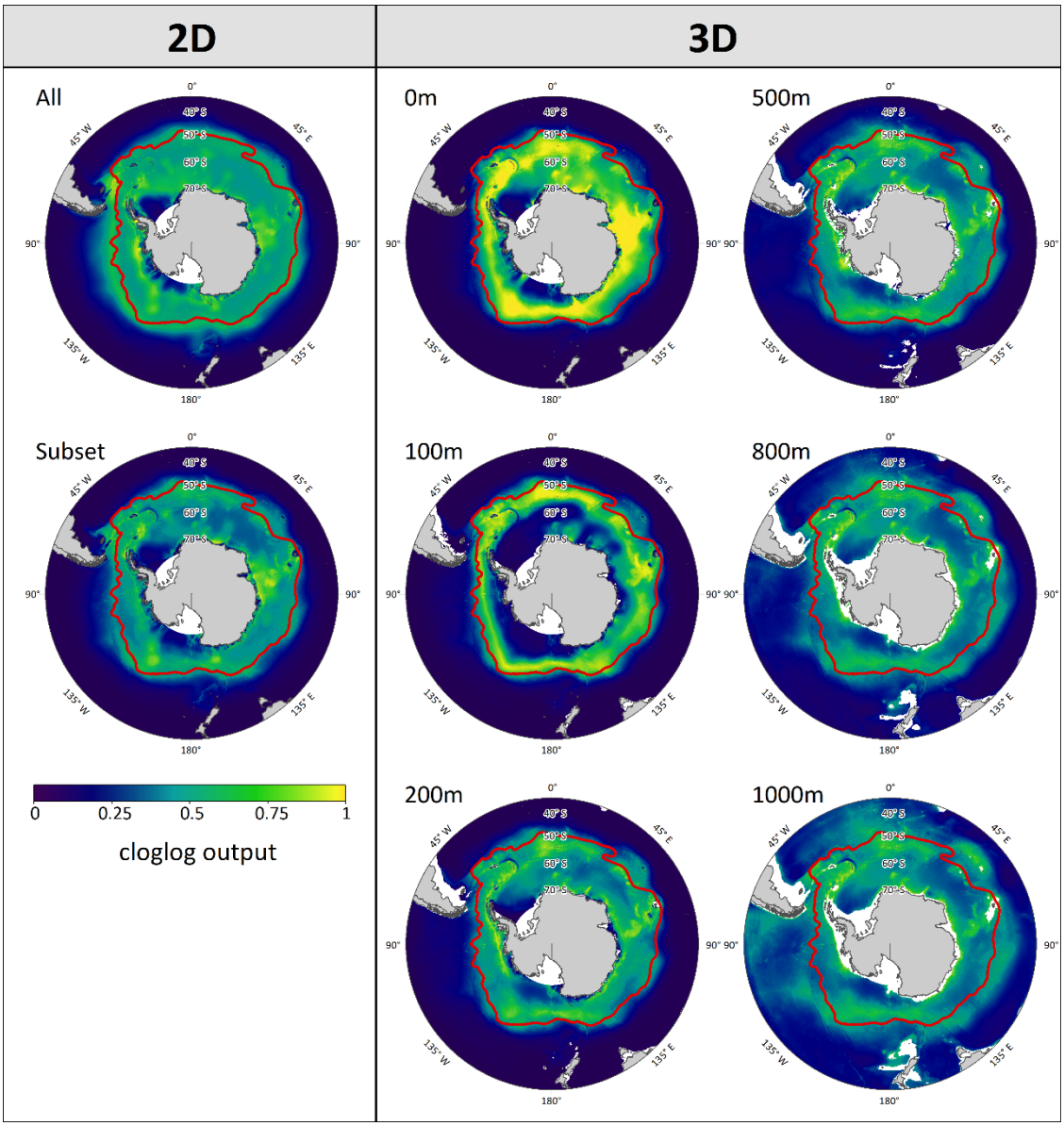

Figure S34: Comparison of estimated conditional probability of presence for *Gymnoscopelus braueri* using 2D*all* (using all available occurrence records and sea surface environmental data), 2D*sub* (as 2D*all*, but built using only the same occurrence records as in the 3D model) and 3D (matches occurrence records with environmental variables from a similar depth from which the animals were caught) approaches. The red line denotes the position of the Polar Front from (Orsi & Harris 2001, updated 2015).

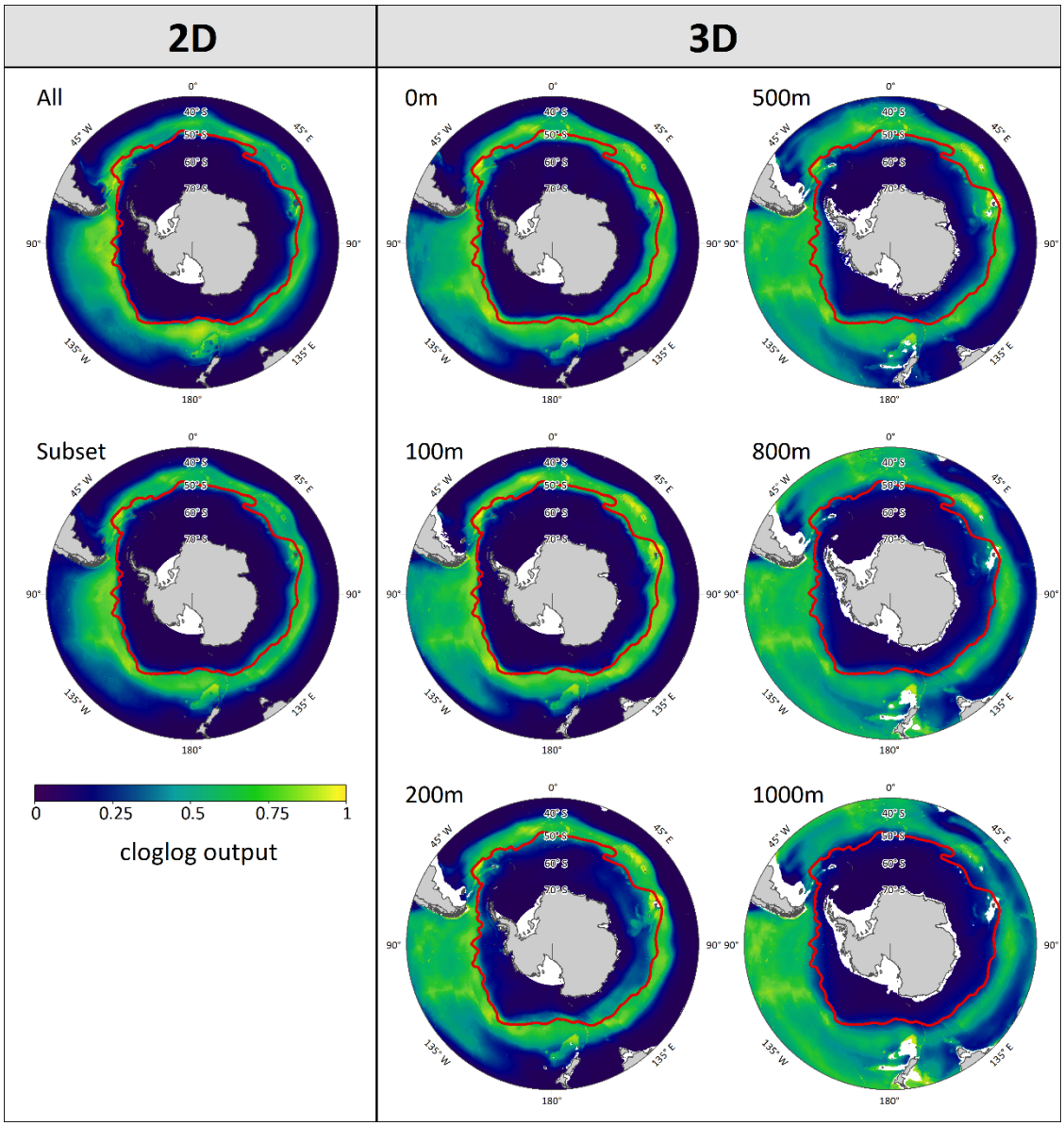

Figure S35: Comparison of estimated conditional probability of presence for *Gymnoscopelus fraseri* using 2D*all* (using all available occurrence records and sea surface environmental data), 2D*sub* (as 2D*all*, but built using only the same occurrence records as in the 3D model) and 3D (matches occurrence records with environmental variables from a similar depth from which the animals were caught) approaches. The red line denotes the position of the Polar Front from (Orsi & Harris 2001, updated 2015).

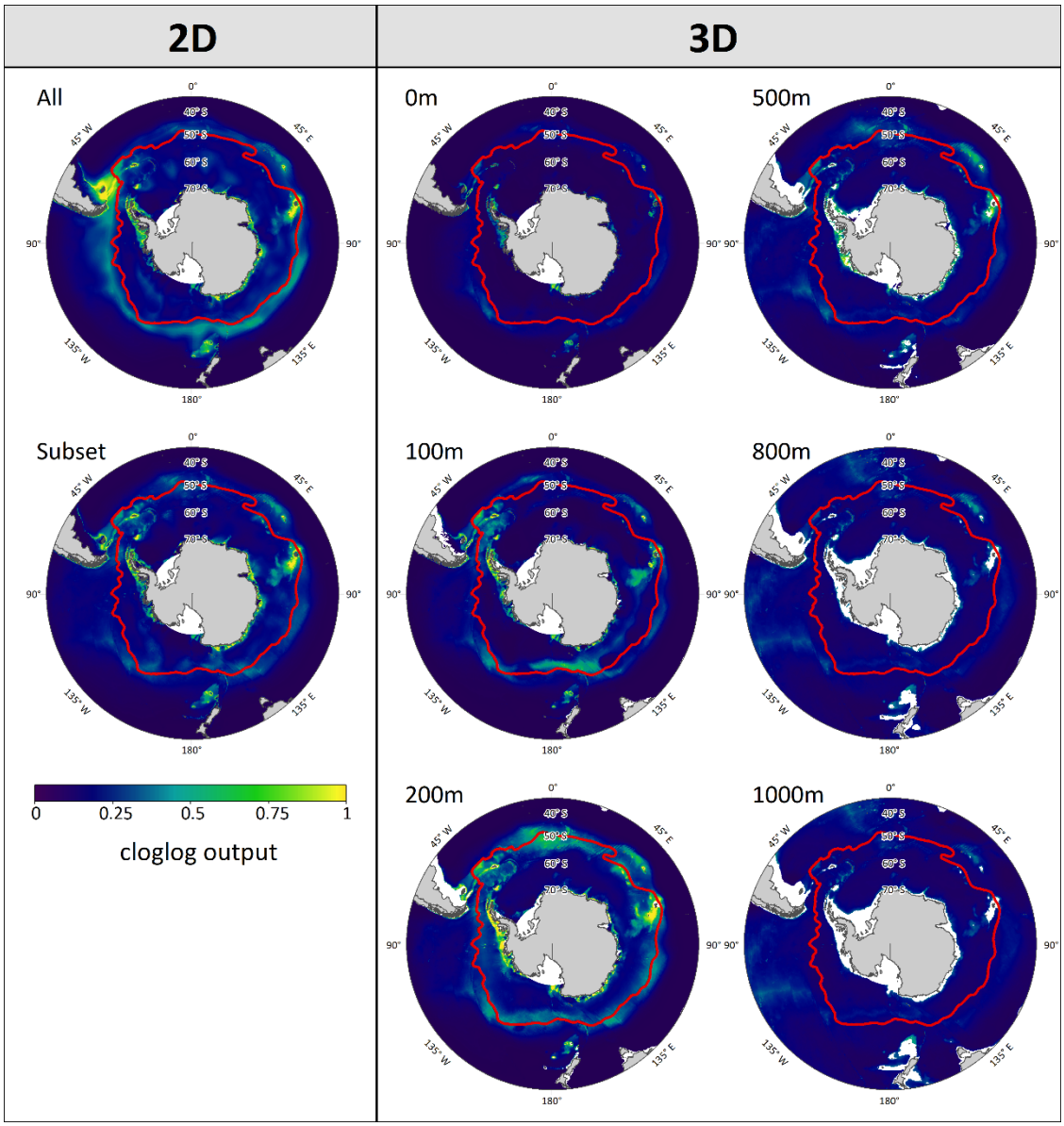

Figure S36: Comparison of estimated conditional probability of presence for *Gymnoscopelus nicholsi* using 2D*all* (using all available occurrence records and sea surface environmental data), 2D*sub* (as 2D*all*, but built using only the same occurrence records as in the 3D model) and 3D (matches occurrence records with environmental variables from a similar depth from which the animals were caught) approaches. The red line denotes the position of the Polar Front from (Orsi & Harris 2001, updated 2015).

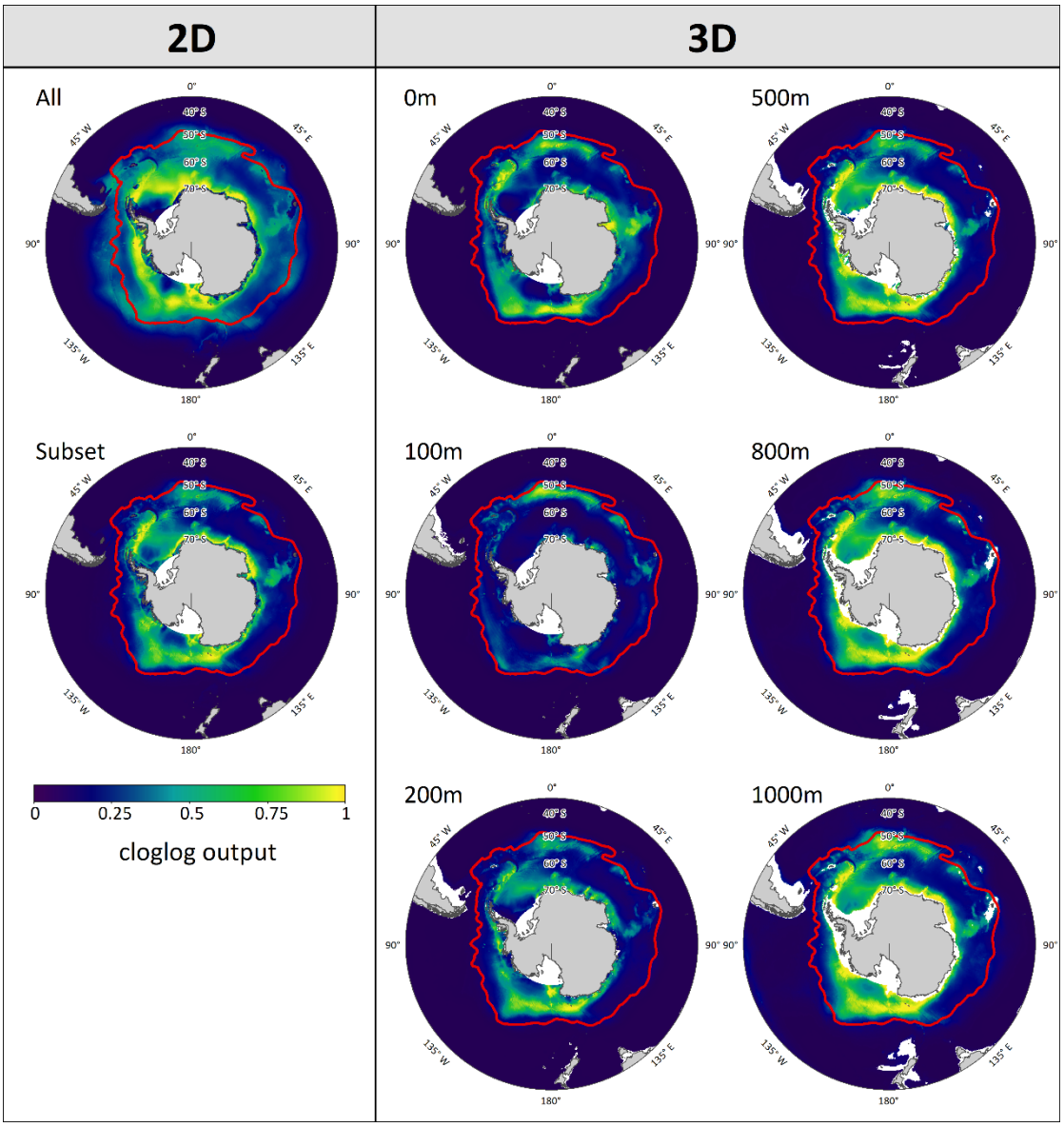

Figure S37: Comparison of estimated conditional probability of presence for *Gymnoscopelus opisthopterus* using 2D*all* (using all available occurrence records and sea surface environmental data), 2D*sub* (as 2D*all*, but built using only the same occurrence records as in the 3D model) and 3D (matches occurrence records with environmental variables from a similar depth from which the animals were caught) approaches. The red line denotes the position of the Polar Front from (Orsi & Harris 2001, updated 2015).

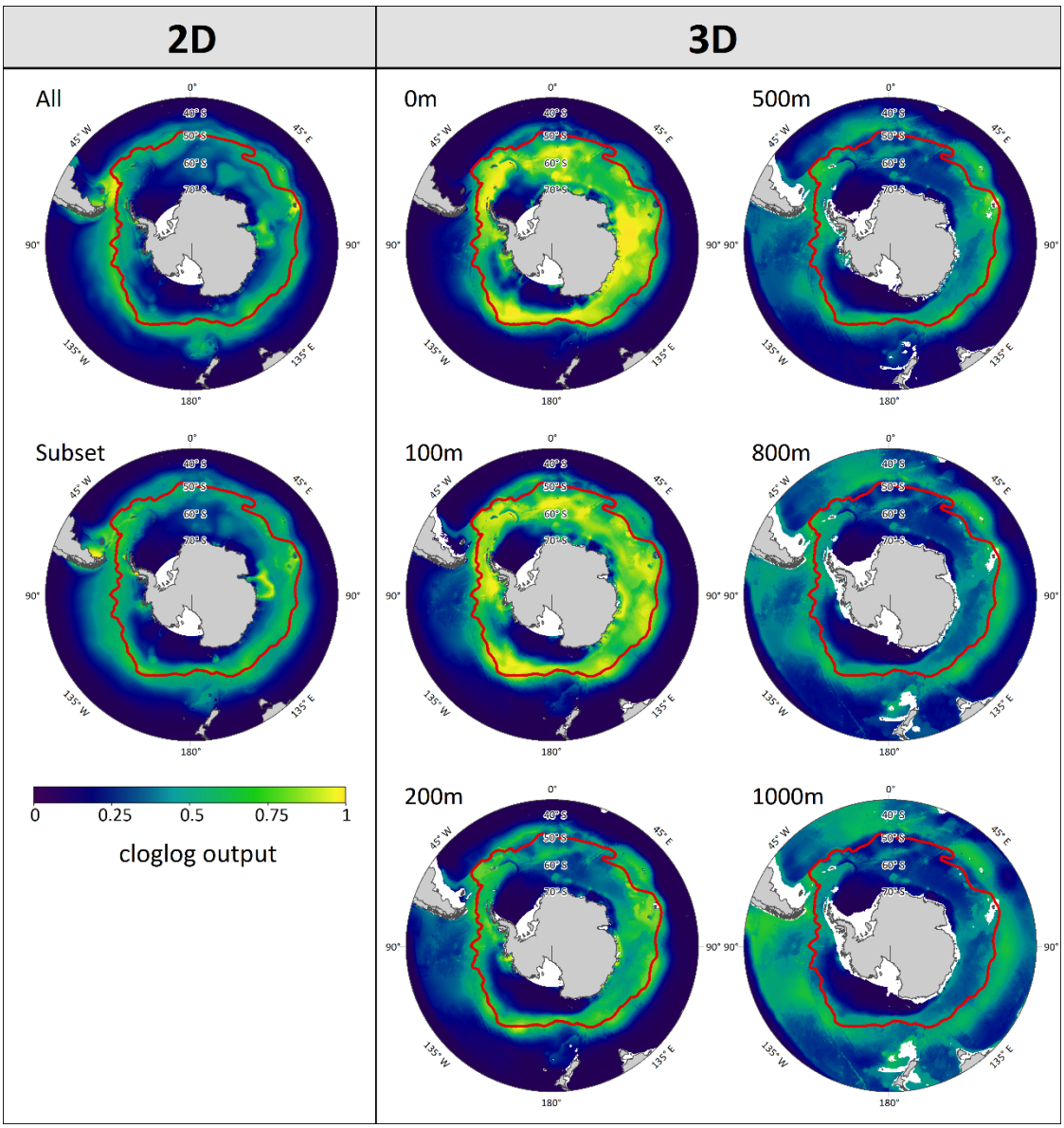

Figure S38: Comparison of estimated conditional probability of presence for *Krefftichthys anderssoni* using 2D*all* (using all available occurrence records and sea surface environmental data), 2D*sub* (as 2D*all*, but built using only the same occurrence records as in the 3D model) and 3D (matches occurrence records with environmental variables from a similar depth from which the animals were caught) approaches. The red line denotes the position of the Polar Front from (Orsi & Harris 2001, updated 2015).

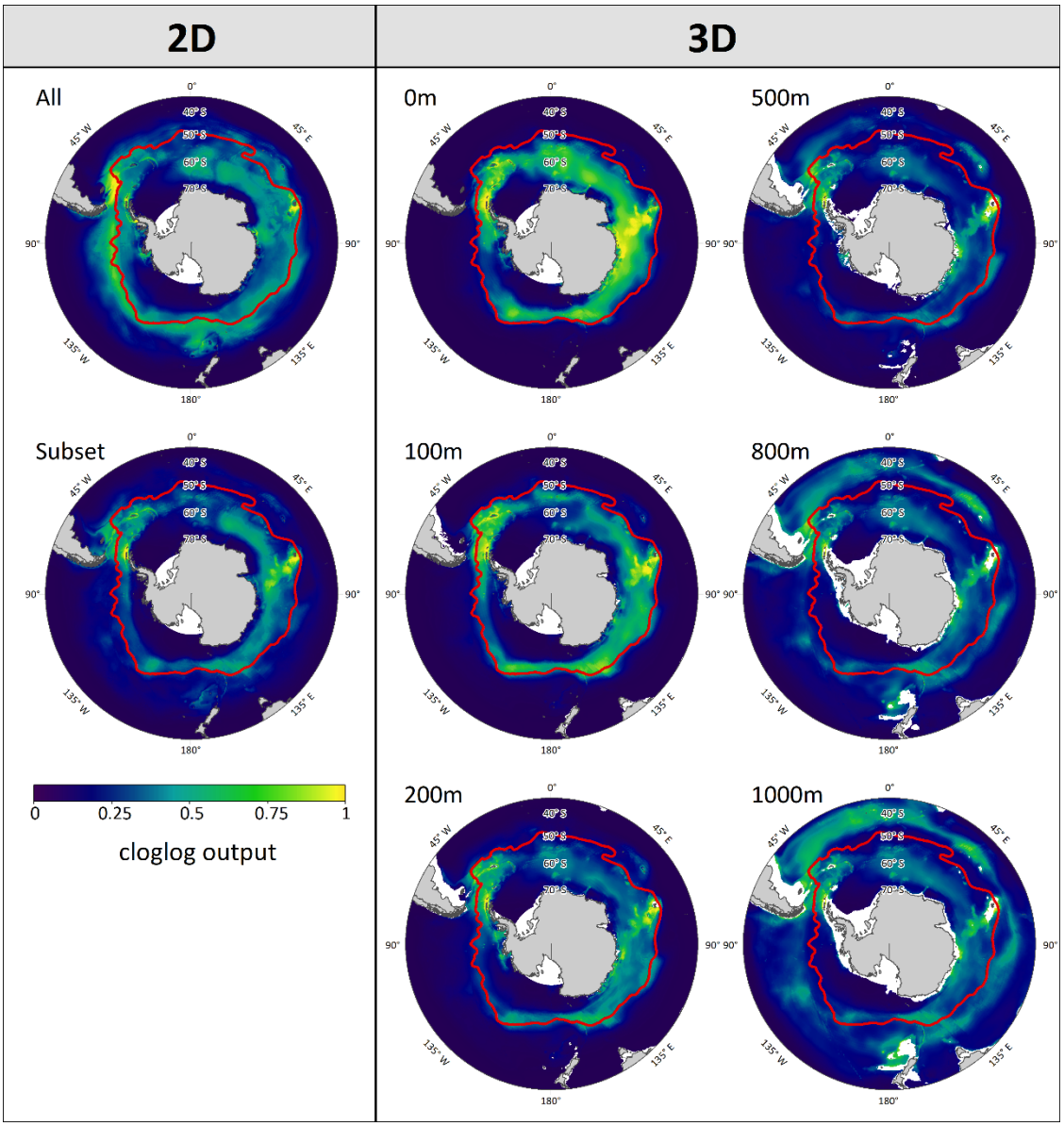

Figure S39: Comparison of estimated conditional probability of presence for *Protomyctophum bolini* using 2D*all* (using all available occurrence records and sea surface environmental data), 2D*sub* (as 2D*all*, but built using only the same occurrence records as in the 3D model) and 3D (matches occurrence records with environmental variables from a similar depth from which the animals were caught) approaches. The red line denotes the position of the Polar Front from (Orsi & Harris 2001, updated 2015).

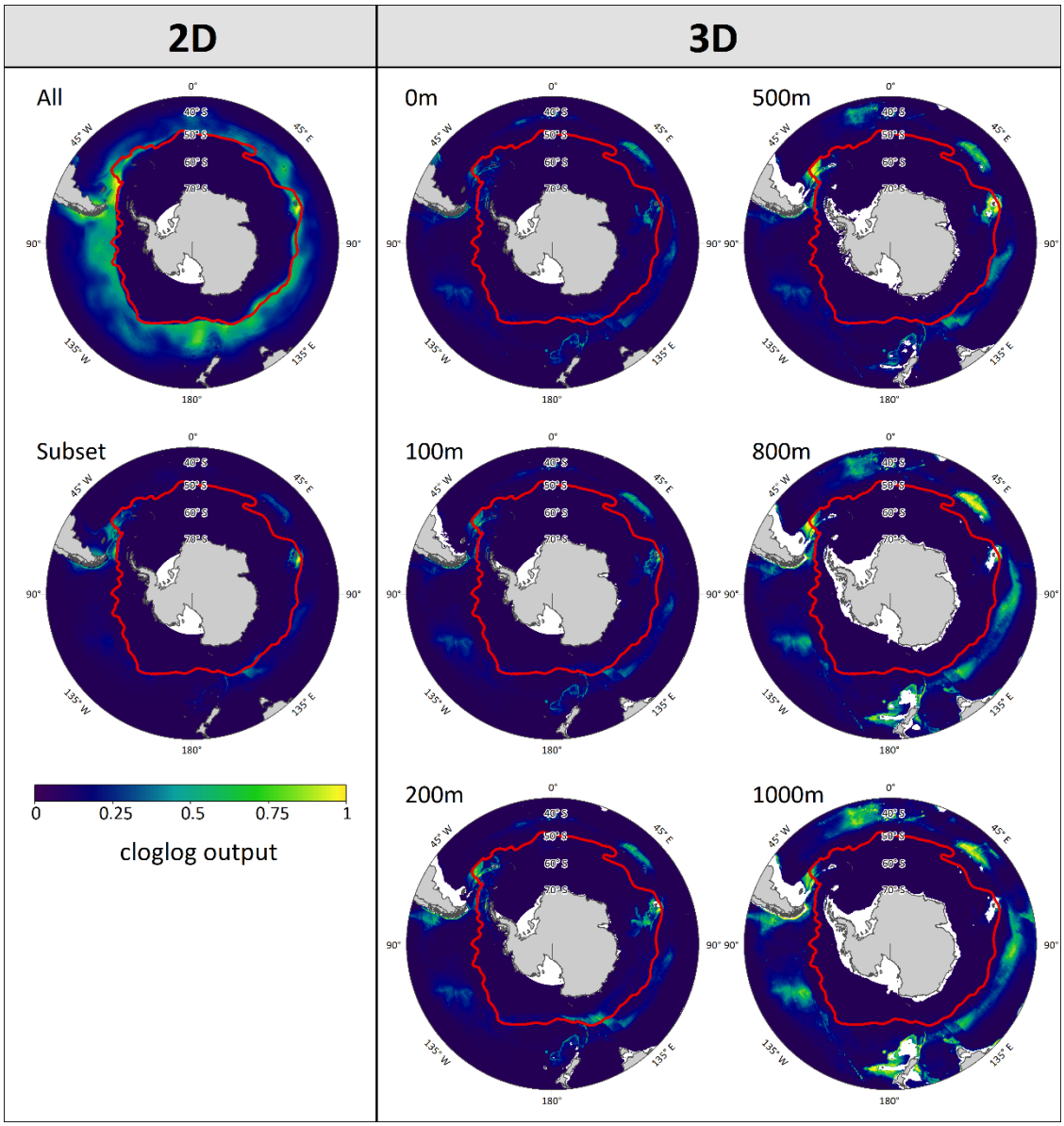

Figure S40: Comparison of estimated conditional probability of presence for *Protomyctophum tenisoni* using 2D*all* (using all available occurrence records and sea surface environmental data), 2D*sub* (as 2D*all*, but built using only the same occurrence records as in the 3D model) and 3D (matches occurrence records with environmental variables from a similar depth from which the animals were caught) approaches. The red line denotes the position of the Polar Front from (Orsi & Harris 2001, updated 2015).