Appendices

# Appendix 1: Environnemental variables correlation analysis

As common SDM methods, quantile regression is also sensitive to collinearity of the predictors and their selection should be based on sound knowledge of the mechanisms involved (Austin, 2007; Dormann, 2007; Merow et al., 2014)

We conducted a simple Pearson’s correlation analysis with rcorr and corrgram functions from the Rcmdrmisc and corrgram R libraries respectively (Fox, 2018; Wright, 2018). Results show a high correlation between depth and potential anomaly deficit



Figure A1.1: Correlation matrix of the different predictor used. Red indicates negative correlations while blue indicates positive ones. The value of the correlation is shown in the bottom triangle

# Appendix 2: Strengths and Weaknesses of quantile regression

QR methods have several advantages with regards to SDM. First, they do not need complex model selection procedure, as each environmental effect is modeled one by one. They are not as sensitive as conventional SDM to the existence of unmeasured factors (M. P. Austin & Niel, 2011; Mod et al., 2016), as long as the most limiting factors are included (Cade et al., 2005). However, the method does not consider factor interactions, including possible co-limitation or multiple limitation occurring at the same time (Rubio et al., 2003). As any other SDM, it is also sensitive to collinearity in the predictors.

Second, QR is generally more robust than ordinary least-squared regressions, in which the absolute value of an outlier can strongly influence the average response of the dependent variable. When modelling a quantile, the absolute value of an outlier has less impact on the shape of the model (Scharf et al., 1998). If many absences occurring along the environmental gradient are susceptible to pull down a model of the mean, these absences will have a moderated impact on a quantile model (Cade and Noon, 2003; Schröder et al., 2005).

# Appendix 3: Sediment

Table A3.1 : Table of number of sediments for each sediment category. nb: number

|  |  |  |
| --- | --- | --- |
| Sediment nb | Sediment category | Nb samples (% of total number of samples) |
| 1 | Coarse sediment | 122 (3.2%) |
| 2 | Compacted sediments or sedimentary bedrock | 1 (0.026%) |
| 3 | Mixed sediment | 829 (22%) |
| 4 | Mud, clay and sandy mud | 2183 (57%) |
| 5 | Sand and muddy sand | 388 (10%) |
| 6 | Sand, gravel and pebbles | 22 (0.57%) |
| 7 | Thin/discont. sedim. cover on bedrock | 5 (0.13%) |
| 8 | No sediment data available | 277 (7.2%) |

# Appendix 4: Individual species fitted QGAM models

All fitted QGAM models on the training dataset are available in the pdf “Annex4\_qgam\_models.pdf”. Each page corresponds to one of the 33 species.

Caption: Modelled log10 responses to the 10 selected environmental predictors. A and B: black dotted scatterplot of the log of positive biomasses of the species in response to the predictor. Red dots indicate model maximum biomass predictions. On top of the scatterplot, the marginal density shows the distribution of samples conditional to the predictor values. C: Boxplot of response to the sediment. The model prediction is the 99th quantile for each sediment class: 1= Coarse sediment, 2= Compacted sediment or sedimentary bedrock, 3= Mixed sediment, 4= Mud, clay and sandy mud, 5= Sand and muddy sand, 6= Sand, gravel and pebbles, 7= Thin or discontinuous sediment on bedrock

# Appendix 5: Individual species niche descriptors

For each species-predictor model, we calculated two descriptors of the niche: The mode is the maximum of the modelled response to the predictor. The range is calculated as the ratio of the difference between the range (max – min) of predictor values where the species has been found to the range of the same predictor over all the sampled stations of the Barents Sea.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| species | Abb. | Chla | days of ice | depth | S.bottom | S.surf | slope | SML | T.bottom | T.surf |
| *Amblyraja hyperborea* | Amb.hyp | 2.61 | 0 | 265 | 34.9 | 34.6 | 0.121 | 43.9 | 0.31 | 5.64 |
| *Amblyraja radiata* | Amb.rad | 0.96 | 1 | 52 | 33.5 | 34.7 | 0.002 | 53.2 | 1.76 | 7.96 |
| *Anarhichas denticulatus* | Ana.den | 1.05 | 0 | 390 | 35.0 | 35.0 | 0.616 | 53.2 | 1.45 | 7.13 |
| *Anarhichas lupus* | Ana.lup | 0.96 | 1 | 52 | 33.5 | 34.4 | 0.002 | 13.5 | 5.09 | 7.96 |
| *Anarhichas minor* | Ana.min | 0.77 | 3 | 52 | 33.5 | 34.5 | 0.082 | 53.2 | -1.84 | 5.08 |
| *Arctozenus risso* | Arc.ris | 0.14 | 0 | 390 | 35.1 | 35.0 | 0.002 | 53.2 | 2.43 | 10.11 |
| *Argentina silus* | Arg.sil | 0.82 | 0 | 253 | 35.1 | 34.6 | 0.137 | 53.2 | 5.09 | 10.11 |
| *Artediellus atlanticus* | Art.atl | 0.14 | 244 | 253 | 34.9 | 28.5 | 0.616 | 41.0 | 0.31 | -1.64 |
| *Aspidophoroides olrikii* | Asp.olr | 0.14 | 18 | 52 | 34.9 | 34.3 | 0.002 | 38.6 | -1.84 | 6.14 |
| *Boreogadus saida* | Bor.sai | 0.14 | 68 | 233 | 34.9 | 34.3 | 0.002 | 41.0 | -1.84 | 4.01 |
| *Clupea harengus* | Clu.har | 2.61 | 0 | 52 | 33.5 | 28.5 | 0.002 | 13.5 | 5.09 | 10.11 |
| *Cottunculus microps* | Cot.mic | 0.14 | 244 | 390 | 35.0 | 28.5 | 0.082 | 13.5 | 0.31 | -1.64 |
| *Gadiculus argenteus* | Gad.arg | 0.89 | 0 | 253 | 35.1 | 34.5 | 0.154 | 53.2 | 5.09 | 10.11 |
| *Gadus morhua* | Gad.mor | 0.14 | 244 | 184 | 34.9 | 34.0 | 0.616 | 35.5 | 0.92 | -1.64 |
| *Hippoglossoides platessoides* | Hip.pla | 0.71 | 3 | 126 | 34.9 | 34.6 | 0.002 | 53.2 | 0.69 | 5.08 |
| *Icelus* | Ice. | 0.14 | 68 | 126 | 33.5 | 28.5 | 0.002 | 13.5 | -1.84 | 5.08 |
| *Leptagonus decagonus* | Lep.dec | 0.14 | 90 | 253 | 34.9 | 34.4 | 0.121 | 42.1 | -0.33 | 4.55 |
| *Leptoclinus maculatus* | Lep.mac | 0.82 | 32 | 184 | 34.9 | 28.5 | 0.616 | 53.2 | 0.52 | 4.01 |
| *Liparidae* | Lip. | 0.14 | 244 | 290 | 34.9 | 28.5 | 0.616 | 13.5 | -1.84 | -1.64 |
| *Lumpenus lampretaeformis* | Lum.lam | 0.77 | 32 | 184 | 34.9 | 28.5 | 0.616 | 39.8 | 1.16 | 4.55 |
| *Mallotus villosus* | Mal.vil | 0.14 | 68 | 166 | 34.9 | 34.4 | 0.616 | 42.1 | -1.84 | -1.64 |
| *Melanogrammus aeglefinus* | Mel.aeg | 0.89 | 3 | 52 | 33.5 | 34.3 | 0.002 | 13.5 | 5.09 | 7.96 |
| *Micromesistius poutassou* | Mic.pou | 0.89 | 0 | 290 | 35.1 | 34.8 | 0.002 | 37.3 | 5.09 | 10.11 |
| *Pollachius virens* | Pol.vir | 0.89 | 0 | 215 | 35.1 | 34.4 | 0.616 | 53.2 | 5.09 | 10.11 |
| *Reinhardtius hippoglossoides* | Rei.hip | 0.14 | 244 | 390 | 35.0 | 28.5 | 0.616 | 13.5 | 1.16 | -1.64 |
| *Sebastes mentella* | Seb.men | 0.14 | 0 | 390 | 35.1 | 35.0 | 0.616 | 53.2 | 2.85 | 10.11 |
| *Sebastes norvegicus* | Seb.nor | 0.96 | 0 | 243 | 35.1 | 35.0 | 0.616 | 53.2 | 5.09 | 10.11 |
| *Sebastes viviparus* | Seb.viv | 0.82 | 0 | 253 | 35.1 | 34.5 | 0.616 | 53.2 | 5.09 | 10.11 |
| *Triglops murrayi* | Tri.mur | 0.66 | 50 | 52 | 33.5 | 28.5 | 0.002 | 13.5 | -1.84 | -1.64 |
| *Triglops nybelini* | Tri.nyb | 0.14 | 244 | 253 | 34.9 | 28.5 | 0.616 | 41.0 | 0.52 | -1.64 |
| *Triglops pingelii* | Tri.pin | 0.60 | 32 | 52 | 34.9 | 34.3 | 0.616 | 38.6 | -1.84 | 4.01 |
| *Trisopterus esmarkii* | Tri.esm | 0.89 | 0 | 233 | 35.1 | 34.6 | 0.175 | 46.9 | 5.09 | 10.11 |
| Zoarcidae | Zoa. | 0.14 | 244 | 265 | 35.0 | 28.5 | 0.616 | 41.0 | -1.84 | -1.64 |

Table A5.1: Mode of the species-predictor QGAM models. Abb.: abbreviated names; Chla: chlorophyll a average over march to august (mg/m3); depth(m); Sbottom and S.surf: bottom and surface salinity; SML: surface mixed layer depth (m); T.bottom and T.surf: bottom and surface temperature (°C)

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| species | Abb. | Chla | days of ice | depth | S.bottom | S.surf | slope | SML | T.bottom | T.surf |
| *Amblyraja hyperborea* | Amb.hyp | 100 % | 90 % | 95 % | 29 % | 57 % | 35 % | 76 % | 62 % | 75 % |
| *Amblyraja radiata* | Amb.rad | 77 % | 100 % | 99 % | 89 % | 100 % | 100 % | 99 % | 88 % | 88 % |
| *Anarhichas denticulatus* | Ana.den | 55 % | 61 % | 96 % | 58 % | 53 % | 100 % | 72 % | 60 % | 72 % |
| *Anarhichas lupus* | Ana.lup | 77 % | 91 % | 92 % | 79 % | 67 % | 73 % | 93 % | 87 % | 99 % |
| *Anarhichas minor* | Ana.min | 77 % | 91 % | 98 % | 62 % | 100 % | 100 % | 94 % | 81 % | 91 % |
| *Arctozenus risso* | Arc.ris | 59 % | 85 % | 75 % | 38 % | 58 % | 59 % | 78 % | 58 % | 79 % |
| *Argentina silus* | Arg.sil | 31 % | 16 % | 76 % | 54 % | 25 % | 77 % | 65 % | 67 % | 58 % |
| *Artediellus atlanticus* | Art.atl | 100 % | 100 % | 100 % | 81 % | 100 % | 93 % | 100 % | 100 % | 93 % |
| *Aspidophoroides olrikii* | Asp.olr | 27 % | 52 % | 68 % | 87 % | 70 % | 16 % | 84 % | 59 % | 68 % |
| *Boreogadus saida* | Bor.sai | 100 % | 100 % | 99 % | 90 % | 100 % | 100 % | 97 % | 68 % | 84 % |
| *Clupea harengus* | Clu.har | 60 % | 98 % | 76 % | 62 % | 72 % | 67 % | 93 % | 89 % | 85 % |
| *Cottunculus microps* | Cot.mic | 64 % | 93 % | 88 % | 33 % | 58 % | 50 % | 87 % | 69 % | 87 % |
| *Gadiculus argenteus* | Gad.arg | 34 % | 2 % | 69 % | 54 % | 26 % | 29 % | 61 % | 64 % | 34 % |
| *Gadus morhua* | Gad.mor | 82 % | 91 % | 100 % | 96 % | 100 % | 100 % | 100 % | 93 % | 95 % |
| *Hippoglossoides platessoides* | Hip.pla | 100 % | 100 % | 100 % | 96 % | 100 % | 100 % | 100 % | 94 % | 100 % |
| *Icelus* | Ice. | 43 % | 98 % | 94 % | 90 % | 72 % | 65 % | 93 % | 93 % | 76 % |
| *Leptagonus decagonus* | Lep.dec | 100 % | 100 % | 94 % | 82 % | 100 % | 72 % | 89 % | 73 % | 88 % |
| *Leptoclinus maculatus* | Lep.mac | 82 % | 100 % | 93 % | 89 % | 99 % | 93 % | 97 % | 77 % | 86 % |
| *Liparidae* | Lip. | 77 % | 100 % | 98 % | 87 % | 100 % | 75 % | 99 % | 67 % | 100 % |
| *Lumpenus lampretaeformis* | Lum.lam | 82 % | 91 % | 92 % | 62 % | 99 % | 92 % | 94 % | 86 % | 92 % |
| *Mallotus villosus* | Mal.vil | 100 % | 100 % | 99 % | 89 % | 66 % | 100 % | 100 % | 68 % | 82 % |
| *Melanogrammus aeglefinus* | Mel.aeg | 69 % | 100 % | 95 % | 96 % | 100 % | 92 % | 97 % | 100 % | 100 % |
| *Micromesistius poutassou* | Mic.pou | 54 % | 90 % | 74 % | 76 % | 100 % | 100 % | 82 % | 96 % | 80 % |
| *Pollachius virens* | Pol.vir | 55 % | 72 % | 92 % | 66 % | 65 % | 39 % | 83 % | 89 % | 83 % |
| *Reinhardtius hippoglossoides* | Rei.hip | 82 % | 100 % | 97 % | 74 % | 100 % | 100 % | 92 % | 89 % | 86 % |
| *Sebastes mentella* | Seb.men | 100 % | 100 % | 94 % | 68 % | 100 % | 100 % | 100 % | 90 % | 86 % |
| *Sebastes norvegicus* | Seb.nor | 57 % | 98 % | 90 % | 76 % | 34 % | 72 % | 81 % | 96 % | 80 % |
| *Sebastes viviparus* | Seb.viv | 34 % | 43 % | 85 % | 61 % | 25 % | 50 % | 67 % | 80 % | 57 % |
| *Triglops murrayi* | Tri.mur | 69 % | 100 % | 92 % | 68 % | 65 % | 92 % | 100 % | 93 % | 87 % |
| *Triglops nybelini* | Tri.nyb | 51 % | 100 % | 95 % | 77 % | 66 % | 72 % | 80 % | 60 % | 64 % |
| *Triglops pingelii* | Tri.pin | 29 % | 87 % | 62 % | 87 % | 72 % | 26 % | 85 % | 65 % | 65 % |
| *Trisopterus esmarkii* | Tri.esm | 65 % | 77 % | 87 % | 76 % | 55 % | 77 % | 96 % | 89 % | 75 % |
| Zoarcidae | Zoa. | 100 % | 100 % | 100 % | 100 % | 100 % | 100 % | 95 % | 94 % | 100 % |

Table A5.2: Range of the species-predictor QGAM models relative to the total sampled range of each predictor values over the Barents Sea. Abb.: abbreviated names; Chla: chlorophyll a average over march to august (mg/m3); depth(m); Sbottom and S.surf: bottom and surface salinity; SML: surface mixed layer depth (m); T.bottom and T.surf: bottom and surface temperature (°C)

# Appendix 6: Individual species habitat suitability maps

Habitat suitability and most limiting factors maps are available in pdf “Annex6\_hs\_maps.pdf”

Figure explanation: *Spatial predictions in 2013 of the species A) suitable habitat (maximum biomass) and B) most limiting predictor. Color indicates the predictor’s category: fixed (sediment, depth, slope), dynamic (all the others). Grey symbols indicate that the predictor is not very limiting (predicted biomass > 25% of the model maximum)*

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