Supplementary Material

Supplementary Table 1. Spatial environmental and biotic predictor variables collated for species distribution models from Stephenson et al. (2020a) and not included in the final model. Further details for each environmental variable are available in Stephenson et al. (2020a) and details on the biotic variables are available in Pinkerton et al. (2020).

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| **Abbreviation** | **Full name** | **Temporal resolution** | **Description** | **Units** |
| *Beddist* | Benthic sediment disturbance | Static | One-year mean value of friction velocity derived from (1) hourly estimates of surface wave statistics (significant wave height, peak wave period) from outputs of the NZWAVE\_NZLAM wave forecast, at 8-km resolution, (2) median grain size (d50), at 250 m resolution, (3) water depth, at 25-m resolution. Benthic sediment disturbance from wave action was assumed to be zero where depth ≥ 200m. | ms-1 |
| *BotNi* | Bottom nitrate | Static | Annual average water nitrate concentration at the seafloor (using NZ bathymetry layer) based on methods from Reynolds et al. (2002). The oceanographic data used to generate these climatological maps were computed by objective analysis of all scientifically quality-controlled historical data from the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Atlas of Regional Seas database (CARS2009, 2009). | umol l-1 |
| *BotOxy* | Dissolved oxygen at depth | Static | Annual average water oxygen concentration at the seafloor (using NZ bathymetry layer) based on methods from Reynolds et al. (2002). Oceanographic data from CARS2009 (2009). | ml l-1 |
| *BotPhos* | Bottom phosphate | Static | Annual average water phosphate concentration at the seafloor (using NZ bathymetry layer) based on methods from Reynolds et al. (2002). Oceanographic data from CARS2009 (2009). | umol l-1 |
| *BotSal* | Salinity at depth | Static | Annual average water salinity concentration at the seafloor (using NZ bathymetry layer) based on methods from Reynolds et al. (2002). Oceanographic data from CARS2009 (2009). | psu |
| *BotSil* | Bottom silicate | Static | Annual average water silicate concentration at the seafloor (using NZ bathymetry layer) based on methods from Reynolds et al. (2002). Oceanographic data from CARS2009 (2009). | umol l-1 |
| *BotTemp* | Temperature at depth | Static | Annual average water temperature at the seafloor (using NZ bathymetry layer) based on methods from Ridgway et al. (2002). Oceanographic data from CARS2009 (2009). | °C km-1 |
| *BPI\_fine* | BPI\_fine | Static | Terrain metrics were calculated using an inner annulus of 2 km and a radius of 12 km using the NIWA bathymetry layer in the Benthic Terrain Modeler in ArcGIS 10.3.1.1 (Wright et al. 2012). Bathymetric Position Index (BPI) is a measure of where a referenced location is relative to the locations surrounding it. | m |
| *Chl-a.Grad* | Chlorophyll-a concentration spatial gradient | Mean monthly | Smoothed magnitude of the spatial gradient of annual mean Chl-a. Derived from Chl-a described above. | mg m-3 km-1 |
| *DET* | Detrital absorption | Mean monthly | Total detrital absorption coefficient at 443 nm, including due to coloured dissolved organic matter (CDOM) and particulate detrital absorption. Estimated using quasi-analytic algorithm (QAA) applied to MODIS-Aqua data, blended with *adg\_443\_giop* ocean product (Werdell, 2019). | m-1 |
| *Ebed* | Seabed incident irradiance | Mean monthly | Broadband (400–700 nm) incident irradiance (E m-2 d-1) at the seabed, averaged over a whole year. Estimated by combining incident irradiance at the sea surface (Frouin et al., 2012) ; this table), diffuse downwelling irradiance attenuation (KPAR; this table) and bathymetric depth at monthly resolution. Derived from blended coastal (QAA) and open-ocean attenuation products. | E m-2 d-1 |
| *Kpar* | Diffuse downwelling attenuation | Mean monthly | vertical attenuation of diffuse, downwelling broadband irradiance (Photosynthetically Available Radiation, PAR, 400–700 nm). Merged coastal and open-ocean product based on MODIS-Aqua data. Coastal: estimated from inherent optical properties (QAA). Ocean: estimated from K490 using Morel et al. (2007). | m-1 |
| PAR | Photo-synthetically active radiation | Mean monthly | Daily-integrated, broadband, incident irradiance at the sea-surface based on day length, solar elevation and measurements of cloud cover from ocean colour satellites (Frouin et al., 2012). | Einsteins m-2 d-1 |
| *SeasTDiff* | Annual amplitude of sea floor temperature | Static | Smoothed difference in seafloor temperature between the three warmest and coldest months. Providing a measure of temperature amplitude through the year. | °C km-1 |
| *Sed.class* | Sediment classification | Static | Classification of Mud, Sand and Gravel layers (this table) using the well-established (Folk et al., 1970) classification. Subtidal rocky reefs (this table) were incorporated. This classification provides a broad measure of hardness Mud – Rock. | NA;  Mud;  Muddy gravel; Muddy sandy gravel;  sand;  Gravely mud; Gravelly sandy mud; Gravelly sand; Gravel; Rock |
| *SstGrad* | Sea surface temperature gradient | Mean monthly | Smoothed magnitude of the spatial gradient of annual mean SST. This indicates locations in which frontal mixing of different water bodies is occurring (Leathwick et al., 2006). Derived from SST described above at two resolutions and merged. | °C km-1 |
| *SuspPM* | Suspended particulate matter | Mean monthly | Indicative of total suspended particulate matter concentration. Based on SeaWiFS ocean colour remote sensing data (Pinkerton et al., 2005); modified Case 2 atmospheric correction; modified Case 2 inherent optical property algorithm. | Indicative of total suspended particulate matter concentration (g m-3) |
| *TC* | Tidal Current speed | Static | Maximum depth-averaged (NZ bathymetry) flows from tidal currents calculated from a tidal model for New Zealand waters (Walters et al., 2001). Tidal constituents (magnitude A and phase phi, represented as real and imaginary parts X + iY = A\*exp(i\*phi)) for sea surface height and currents (8 components) were taken from the EEZ tidal model, on an unstructured mesh at variable spatial resolution. The complex components were bilinearly interpolated to the output grid. | ms-1 |
| TempRes | Temperature residuals | Static | Residuals from a GLM relating temperature to depth using natural splines – this highlights areas where average temperature is higher or lower than would be expected for any given depth. | °C |
| VGPM | Net primary production by the vertically-generalised production model | Mean monthly | Daily production of organic matter by the growth of phytoplankton in the surface mixed layer, net of phytoplankton respiration. Estimated at monthly resolution based on satellite observations of chl-a, PAR and SST, and model-derived estimates of mixed-layer depth, using the vertically-generalised production model (Behrenfeld and Falkowski, 1997). | mgC m-2 d-1 |
| Oithona | *Oithona similis* | Static | Cyclopoid copepods, dominated by *Oithona similis* (97%). The remaining 3% is unidentified (Pinkerton et al., 2020). | Counts per 5 nautical mile Continuous Plankton Recorder (CPR) segment |
| Euphausiidae | Euphausiidae | Static | All adult and developmental stages of krill (generally not identified to species or genus). Most abundant identified species was *Thysanoessa macrura* (64%) (Pinkerton et al., 2020). | Counts per 5 nautical mile Continuous Plankton Recorder (CPR) segment |
| Foraminifera | Foraminifera | Static | Unidentified (97.8%) Foraminifera specimens (Pinkerton et al., 2020). | Counts per 5 nautical mile Continuous Plankton Recorder (CPR) segment |
| Fritillaria spp. | *Fritillaria* spp. | Static | Solitary, free-swimming larvacean, unidentified beyond genus (Pinkerton et al., 2020). | Counts per 5 nautical mile Continuous Plankton Recorder (CPR) segment |
| Pteropods | Pteropods | Static | Pelagic gastropods, predominately *Limacina* spp. (98.9%) (Pinkerton et al., 2020). | Counts per 5 nautical mile Continuous Plankton Recorder (CPR) segment |
| Zooplankton | Zooplankton | Static | Total abundance of all zooplankton types, including *Oithona similis*, Copepoda, Amphipoda, Chaetognatha, Euphausiidae, Foraminifera, *Fritillaria* spp., *Oikopleura* spp., Ostracoda, Pteropods, and “Other” (remaining identified organisms such as cephalopods and fish eggs comprising <1% of samples) (Pinkerton et al., 2020). | Counts per 5 nautical mile Continuous Plankton Recorder (CPR) segment |

Supplementary Table 2. Mean cross-validated estimates of model performance for the bootstrapped boosted regression tree (BRT) and random forest (RF) models (time series 2000 – 2020).

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| Years | Model type | Deviance explained (training data) | Deviance explained (evaluation data) | TSS (training data) | TSS (evaluation data) | AUC (training data) | AUC (evaluation data) |
| 2000–2020 | BRT model | 0.61 ± 0.06 | 0.37 ± 0.14 | 0.98 ± 0.02 | 0.71 ± 0.07 | 0.95 ± 0.01 | 0.90 ± 0.03 |
|  | RF model | 0.75 ± 0.04 | 0.51 ± 0.10 | 0.88 ± 0.03 | 0.73 ± 0.07 | 0.98 ± 0.01 | 0.92 ± 0.03 |