Supplementary Material

# Supplementary material S1

This part of supplementary material contains the list of species within each functional group included in the analysis.

**Supplementary Table S1.** List of functional groups and species within each group included in the Portuguese continental shelf ecosystem model.

|  |  |
| --- | --- |
| **Functional group** | **Species** |
| Seabirds | *Morus bassanus; Calonectris borealis; Alca torda; Puffinus mauretanicus; Uria aalge* |
| Minke whale | *Balaenoptera acutorostrata* |
| Common dolphin | *Delphinus delphis* |
| Striped dolphin | *Stenella coeruleoalba* |
| Bottlenose dolphin | *Tursiops truncates* |
| Harbour porpoise | *Phocoena phocoena* |
| Tunas | *Sarda sarda; Auxis rochei; Thunnus thynnus* |
| Sharks | *Galeus melastomus, Isurus oxyrinchus, Scyliorhinus canicular, Scyliorhinus stellaris, Scymnodon ringens, Mustelus mustelus, Centroscymnus coelolepis* |
| Rays | *Raja clavata; Raja brachyura; Leucoraja naevus; Raja montagui* |
| Hake | *Merluccius merluccius* |
| Squids | *Loligo vulgaris; Illex coindetii; Todaropsis eblanae; Alloteuthis subulata; Alloteuthis media* |
| Benthic cephalopods | *Octopus vulgaris; Eledone cirrhosa; Sepia officinalis*; *Sepiola* spp. |
| Horse mackerel | *Trachurus trachurus* |
| Blue jack mackerel | *Trachurus picturatus* |
| Chub mackerel | *Scomber colias* |
| Mackerel | *Scomber scombrus* |
| Demersal piscivorous fish | *Conger conger; Chelidonichthys lucernus; Helicolenus dactylopterus; Dicentrarchus labrax; Lophius budegassa; Lophius piscatorius* |
| Demersal invertivorous fish | *Trigla lyra; Serranus hepatus; Callionymus lyra; Chelidonichthys cuculus; Synchiropus phaeton; Lepidotrigla cavillone; Callanthias ruber; Mullus surmuletus; Mullus barbatus; Cepola macrophthalma;* Ammodytidae*;* Gobiidae |
| Benthopelagic piscivorous fish | *Zeus faber; Lepidopus caudatus; Belone belone; Phycis blennoides; Phycis phycis* |
| Benthopelagic invertivorous fish | *Trisopterus luscus; Micromesistius poutassou; Argentina sphyraena; Macroramphosus* spp.*; Capros aper; Gadiculus argenteus; Anthias anthias* |
| Flatfish | *Solea solea; Solea senegalensis; Pegusa lascaris; Microchirus azevia; Microchirus variegatus; Platichthys flesus; Citharus linguatula; Dicologlossa cuneata; Scophthalmus maximus; Scophtahlmus rhombus; Lepidorhombus boscii; Lepidorhombus whiffiagonis; Arnoglossus laterna* |
| Sparids | *Pagellus acarne; Pagellus erythrinus; Pagellus bogaraveo; Spondyliosoma cantharus ; Diplodus vulgaris; Diplodus bellottii; Diplodus annularis; Diplodus sargus; Pagrus pagrus; Pagrus auriga* |
| Anchovy | *Engraulis encrasicolus* |
| Sardine (adult and juvenile) | *Sardina pilchardus* |
| Bogue | *Boops boops* |
| Henslow’s crab | *Polybius henslowii* |
| Shrimps | Unspecified Crustacea natantia |
| Macrozoobenthos | Starfishes; annelids; sea urchins; sea cucumbers; bivalves; crustaceans; sea anemone; other benthic invertebrates |
| Suprabenthic invertebrates | Euphausiids, mysids, isopods and amphipods |
| Macrozooplankton | Zooplankton: length >3 mm, width >1 mm |
| Meso/microzooplankton | Zooplankton: length ≤3 mm, width ≤1 mm; including fish eggs |
| Phytoplankton | Phytoplankton |

# Supplementary material S2

This part of supplementary material contains a detailed explanation how time series data were obtained by performing stochastic SRA. These data were used to fit and drive the PCSE ecosim model. Also, these data were used as fishing mortality and observed biomass in the present study.

**Stochastic stock reduction analysis**

Stock reduction analysis (SRA) Kimura et al. (1984) constructs a population dynamic model with a Beverton-Holt stock-recruitment function (Beverton and Holt 1957) that simulates changes in abundance by subtracting estimates of mortality and adding estimates of new recruits from the population over time. SRA is carried out by using historical catch information to drive population models from a historical reference point near the beginning of the fishery. It is a less data-intensive method that can help to estimate how large the stock needed to be, in order to produce time-series of observed landings. In the SRA the key population parameters of the population dynamic model are adjusted until the simulation produces numbers near estimates from an independent estimate of absolute abundance. In Stochastic SRA (Walters et al. 2006) recruitment is assumed to have lognormally distributed annual anomalies (variability), that are considered by performing a large number of simulation runs with anomaly sequences chosen from normal prior distributions. In other words, Stochastic SRA determines what is the probability of obtaining the observed current population size estimate of stock *i,* given a mean recruitment curve by using variations and the historical catches.

**Material and methods**

The Stochastic SRA was performed using the Data-Limited Methods Toolkit (DLMtool) R package (Carruthers et al. 2014). In order to perform the analysis, the following information was required: historical catches, index of species abundance, life history information (Table B.1) and estimates of the variation in natural mortality rate mortality (M), Bertalanffy growth parameter (K) and a maximum length of the fish (Linf). Also, catch at age data could be included, however, due to lack of data, in this analysis, it was omitted. An existing operating model (OM) (obtained from De la Puente S., personal communication) has been adapted to the species of interest. The operating model that simulates the population dynamics based on SRA contains life-history parameters pertinent to the species of interest (Maxage -the maximum age of individuals that is simulated; M - natural mortality rate; K - Bertalanffy growth parameter that determines how fast fish approach Linf; Linf - the length of very old (infinitely old) fish, also called asymptotic length; to - an initial condition parameter that is the von Bertalanffy theoretical age at length zero; L50 - length at 50 percent maturity; L50\_95 - length increment from 50 percent to 95 percent maturity; a - length-weight parameter alpha; b - length-weight parameter beta and h - the steepness of the stock-recruitment relationship), inter-annual variability in natural mortality rate (M), growth parameter K and maximum length (Linf), and mean temporal trends in M, K, and Linf expressed as a percentage change in M, K and Linf, per year. All the parameters, excluding (Maxage, a and b) are expressed as lower and upper bounds of uniform distribution.

The life history parameters (excluding h) were obtained from FishBase online database (Froese, and Pauly 2018; FishBase) and are provided in Table S2 (Maxage, M, Linf, K, t0, L50, L50\_95, a, b). Lower and upper bounds of the steepness of the stock-recruitment relationship (h) distribution were assumed to be 0.2 and 0.99 for all species. Lower and upper bounds of Inter-annual variability in M, K and Linf were assumed to be 0 and 0.025 for K and Linf and 0 and 0.1 for M whereas lower and upper bounds of mean temporal trends in M, K, and Linf were assumed as -0.25 and 0.25.

Historical catch time-series (from 1950–2014) were obtained from the Sea Around Us project (Leitão 2014) while recent catch data (2014–2017) was provided by the Portuguese National Statistical Institute (INE). Independent estimates of abundance for all species except for anchovy were obtained from Portuguese bottom trawl surveys carried out in autumn (September-October) at predefined stations. For anchovy abundance, estimates were obtained from acoustic surveys (PELAGO survey series) performed annually in spring (April-May). Both, acoustic and bottom trawl surveys were performed by the Portuguese Institute of Sea and Atmosphere (IPMA).

In total, 100 iterations were performed for 12 species or group of species (list of species is available in Table S2) and the estimate of spawning stock biomass SSB representing 50th percentile (median) was used in ecosim analysis (plotted on Figure S2).

Species that are part of Rays and Sparids, for which historical catches were aggregated, were analysed jointly. With regards to the functional group Sparids, (that in Ecopath consists of *Pagellus* spp and *Pagrus* spp.) only *Pagellus* spp. were considered as there was a lack of abundance data for *Pargus* spp. Seabass (*Dicentrarchus labrax*) and forkbeard*(Phycis phycis)* were excluded for the same reason. As a result, the group demersal piscivorous fish consists of European conger and anglerfish. Benthopelagic piscivorous fish consists of silver scabbardfish, while benthopelagic piscivorous fish consists of pouting and blue whiting (Table S2).

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **EwE functional group** | **Blue jack mackerel** | **Atlantic mackerel** | **Bogue** | **Anchovy** | **Horse mackerel** | **Rays** | **Sparids** | **Demersal piscivorous fish (DFP)** | | **Benthopelagic piscivorous fish (BFP)** | **Benthopelagic invertivorous fish (BFI)** | |
|  |  |  |  |  |  |  |  |  | |  |  | |
| **Common name** | Blue jack mackerel | Atlantic mackerel | Bogue | Anchovy | Horse mackerel |  |  | European conger | Anglerfish | Silver scabbardfish | Pouting | Blue whiting |
| **Scientific name** | *Trachurus picturatus* | *Scomber scombrus* | *Boops boops* | *Engraulis encrasicolus* | *Trachurus trachurus* |  | *Pagellus* spp | *Conger conger* | *Lophius* spp | *Lepidopus caudatus* | *Trisopterus luscus* | *Micromesistius poutassou* |
| **Life history parameters** |  |  |  |  |  |  |  |  |  |  |  |  |
| Maxage | 21 | 11 | 19 | 7 | 20 | 22 | 14 | 48 | 22 | 10 | 5 | 8 |
| Natural mortality rate (M) | 0.37–0.42 | 0.28–0.64 | 0.21–0.48 | 0.49–1.11 | 0.18–0.42 | 0.16–0.38 | 0.26–0.59 | 0.06–0.15 | 0.15–0.35 | 0.23–0.53 | 0.56–1.28 | 0.42–0.96 |
| Linf | 32–64 | 43–47 | 32–36 | 19–25 | 39.3–58.1 | 95–104 | 21.8–49.6 | 229–265 | 108–157 | 125.3–195.4 | 36.2–46.7 | 28.1–48.4 |
| K | 0.07-0.38 | 0.196–0.272 | 0.166–0.280 | 0.32– 1.07 | 0.122–0.270 | 0.13–0.84 | 0.12–0.32 | 0.063–0.270 | 0.145–0.159 | 0.297–0.384 | 0.211–0.590 | 0.150–0.480 |
| t0 | -3.3– -0.2 | -2.9– -2.1 | -2.14– -0.96 | -4.09– 0.5 | -4.43– -0.31 | 0.71– -0.19 | -2.97– -0.45 | -2.4– 0.39 | -1.005– -0.48 | -0.53– -0.38 | -1.27–- 0.01 | -3.51– -0.35 |
| L50 (Lm) | 20–36 | 19–34 | 15–27 | 9.2–16.5 | 20.6–36.9 | 41–74 | 17.2–30.9 | 93.5–167.9 | 37.4-67 | 66.7–119.8 | 15.5–31.4 | 13.9–25.0 |
| L50\_95 (Lopt) | 1–8 | 0–1 | 2–3 | 0–1 | 0.6–5.4 | 9.3–19.2 | 1.2–12.2 | 40–57.2 | 4–12.4 | 4–8 | 2–4 | 2–4 |
| a | 0.00955 | 0.00646 | 0.01047 | 0.00468 | 0.00832 | 0.00253 | 0.01133 | 0.00046 | 0.01513 | 0.00046 | 0.00794 | 0.0038 |
| b | 2.96 | 3.05 | 3.00 | 3.10 | 2.96 | 3.22 | 3.04 | 3.25 | 2.95 | 3.06 | 3.10 | 3.15 |
| **Application in Ecosim** | Used as relative biomass and to calculate fishing mortality | Used as relative biomass and to calculate fishing mortality | Used as relative biomass and to calculate fishing mortality | Used as relative biomass and to calculate fishing mortality | Used to calculate fishing mortality | Used as relative biomass and to calculate fishing mortality | Used as relative biomass and to calculate fishing mortality | Used as relative biomass and to calculate fishing mortality | Used as relative biomass and to calculate fishing mortality | Used as relative biomass and to calculate fishing mortality | Used as relative biomass and to calculate fishing mortality | Used as relative biomass and to calculate  fishing mortality |

**Supplementary Table S2.** Description of parameters, with their data sources, used to perform stochastic stock reduction analysis (SRA). Parameter Maxage is the maximum

age of individuals that is simulated M is natural mortality rate; K is a curvature parameter, Bertalanffy growth parameter that determines how fast fish approach Linf; Linf is the length of very old (infinitely old) fish, also called asymptotic length; to is an initial condition parameter that is the von Bertalanffy theoretical age at length zero; L50 is the length at 50 percent maturity; L50\_95 is length increment from 50 percent to 95 percent maturity; a is length-weight parameter alpha and b is length-weight parameter beta. The parameters M, Linf, K, t0, L50, L50\_95 are represented as uniform distribution lower and upper bounds value range.

**Results**

The estimates of spawning stock biomass (SSB) for analysed species are presented in Figure S2. Also, for reference, historical catch and available abundance indices’ time-series are presented in the figure. The output of SRA expressed as the median of probability density function (considering 100 simulations) of spawning stock biomass (SSB) estimates were used as relative biomass and to obtain fishing mortality to fit and force the PCSE Ecosim model, respectively.

A close up of a map

Description generated with high confidence

**Supplementary Figure S2**. The estimates of spawning stock biomass (SSB) represented as second quartile (median) of the probability density function of (considering 100 simulations) (black line); catch (red dotted line) and abundance index (blue open points) for species in Portuguese continental shelf ecosystem.

# Supplementary material S3

This part of supplementary material contains Tables with cross-correlations between variables for each data group.

**Supplementary Table S3a.** Pearson cross-correlation matrix for variables included in fishing mortality data group. Variables that have cross-correlation >0.8 are in bold.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | F\_DFP | F\_Rays | F\_BFP | F\_Sparids | F\_BOG | F\_HOM | F\_BFI | F\_MAC | F\_.JAA | F\_ANE | F\_PIL | F\_HKE |
| F\_DFP | 1 |  |  |  |  |  |  |  |  |  |  | 0.5 |
| F\_Rays | 0.8 | 1 |  |  |  |  |  |  |  |  |  |  |
| F\_BFP | 0.7 | 0.6 | 1 |  |  |  |  |  |  |  |  |  |
| F\_Sparids | 0.5 | 0.8 | 0.2 | 1 |  |  |  |  |  |  |  |  |
| F\_BOG | 0.4 | 0.6 | -0.1 | 0.8 | 1 |  |  |  |  |  |  |  |
| F\_HOM | 0.5 | 0.6 | 0.2 | 0.7 | 0.6 | 1 |  |  |  |  |  |  |
| F\_BFI | -0.1 | 0.3 | -0.1 | 0.3 | 0.2 | -0.1 | 1 |  |  |  |  |  |
| F\_MAC | 0.4 | 0.7 | 0.0 | **0.9** | **0.9** | 0.6 | 0.3 | 1 |  |  |  |  |
| F\_JAA | -0.1 | -0.4 | -0.2 | -0.3 | -0.2 | -0.1 | -0.4 | -0.4 | 1 |  |  |  |
| F\_ANE | 0.2 | 0.1 | 0.5 | -0.1 | -0.2 | 0.1 | -0.3 | -0.2 | 0.3 | 1 |  |  |
| F\_PIL | 0.1 | 0.1 | 0.2 | 0.1 | 0.1 | -0.1 | -0.1 | 0.1 | -0.3 | -0.1 | 1 |  |
| F\_HKE | 0.5 | 0.3 | 0.7 | -0.2 | -0.3 | -0.3 | -0.1 | -0.3 | 0.0 | -0.1 | 0.1 | 1 |

**Supplementary Table S3b.** Pearson cross-correlation matrix for variables included in the environmental/climatic data group. Variables that have cross-correlation >0.8 are in bold.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | AMOm | AMOw | AMOs | NAOm | NAOw | NAOs | EAm | EAw | EAQs | SSTm | SSTw | SSTs | UIm | UIw | UIs |
| AMOm | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| AMOw | **0.9** | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| AMOs | **0.9** | 0.8 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |
| NAOm | -0.6 | -0.5 | -0.6 | 1 |  |  |  |  |  |  |  |  |  |  |  |
| NAOw | -0.3 | -0.3 | -0.3 | 0.7 | 1 |  |  |  |  |  |  |  |  |  |  |
| NAOs | -0.4 | -0.3 | -0.4 | 0.4 | -0.1 | 1 |  |  |  |  |  |  |  |  |  |
| EAm | 0.5 | 0.4 | 0.4 | -0.1 | 0.0 | -0.3 | 1 |  |  |  |  |  |  |  |  |
| EAw | 0.1 | 0.1 | 0.0 | 0.1 | 0.2 | -0.1 | 0.6 | 1 |  |  |  |  |  |  |  |
| EAs | 0.5 | 0.5 | 0.3 | -0.2 | 0.0 | -0.2 | 0.8 | 0.3 | 1 |  |  |  |  |  |  |
| SSTm | 0.5 | 0.5 | 0.4 | 0.0 | 0.2 | -0.3 | 0.5 | 0.1 | 0.6 | 1 |  |  |  |  |  |
| SSTw | 0.3 | 0.4 | 0.2 | 0.1 | 0.3 | -0.2 | 0.3 | 0.1 | 0.4 | 0.8 | 1 |  |  |  |  |
| SSTs | 0.5 | 0.5 | 0.5 | -0.1 | 0.1 | -0.3 | 0.6 | 0.1 | 0.7 | 0.9 | 0.6 | 1 |  |  |  |
| UIm | -0.2 | -0.1 | -0.2 | 0.3 | 0.3 | 0.0 | -0.1 | -0.2 | 0.1 | 0.1 | 0.2 | 0.1 | 1 |  |  |
| UIw | -0.3 | -0.2 | -0.2 | 0.5 | 0.6 | -0.1 | -0.2 | -0.3 | -0.2 | 0.0 | 0.1 | 0.0 | 0.6 | 1 |  |
| UIs | 0.3 | 0.5 | 0.2 | -0.3 | -0.3 | -0.1 | 0.3 | 0.2 | 0.4 | 0.1 | 0.1 | 0.1 | 0.3 | -0.4 | 1 |

**Supplementary Table S3c.** Pearson cross-correlation matrix for variables included in the observed biomass data group. Variables that have cross-correlation >0.8 are in bold.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **B\_ANE** | **B\_Sardine** | **B\_MAC** | **B\_HOM** | **B\_Sparids** | **B\_Flatfish** | **B\_HKE** | **B\_DFP** | **B\_JAA** | **B\_DFI** | **B\_MAS** | **B\_BFI** | **B\_Bogue** | **B\_BFP** | **B\_ceph** | **B\_Squids** | **B\_Rays** | **B\_Tunas** | **B\_Sharks** | **B\_PIL\_Juv** |
| **B\_ANE** | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **B\_Sardine** | -0.6 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **B\_MAC** | 0.4 | -0.8 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **B\_HOM** | 0.1 | -0.5 | 0.7 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **B\_Sparids** | 0.5 | -0.8 | 1.0 | 0.7 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **B\_Flatfish** | 0.0 | 0.2 | -0.2 | 0.0 | -0.2 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **B\_HKE** | 0.4 | 0.0 | -0.2 | -0.7 | -0.2 | 0.0 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **B\_DFP** | 0.7 | -0.2 | 0.0 | -0.5 | 0.0 | 0.1 | **0.9** | 1 |  |  |  |  |  |  |  |  |  |  |  |  |
| **B\_JAA** | 0.5 | -0.2 | 0.4 | -0.2 | 0.4 | -0.1 | 0.6 | 0.7 | 1 |  |  |  |  |  |  |  |  |  |  |  |
| **B\_DFI** | 0.3 | -0.3 | 0.0 | 0.0 | 0.1 | 0.7 | 0.1 | 0.3 | 0.1 | 1 |  |  |  |  |  |  |  |  |  |  |
| **B\_MAS** | 0.2 | 0.0 | 0.4 | 0.5 | 0.3 | -0.1 | -0.4 | -0.2 | 0.0 | -0.2 | 1 |  |  |  |  |  |  |  |  |  |
| **B\_BFI** | -0.5 | 0.4 | -0.5 | -0.5 | -0.6 | 0.2 | 0.3 | 0.1 | -0.3 | 0.0 | -0.5 | 1 |  |  |  |  |  |  |  |  |
| **B\_BPG** | 0.6 | -0.8 | **0.9** | 0.4 | **0.9** | -0.2 | 0.2 | 0.4 | 0.6 | 0.2 | 0.1 | -0.4 | 1 |  |  |  |  |  |  |  |
| **B\_BFP** | 0.8 | -0.2 | -0.1 | -0.5 | 0.0 | 0.1 | 0.8 | **0.9** | 0.5 | 0.3 | -0.1 | 0.0 | 0.2 | 1 |  |  |  |  |  |  |
| **B\_ceph** | -0.2 | -0.1 | 0.1 | 0.2 | 0.1 | 0.4 | -0.3 | -0.2 | -0.1 | 0.5 | -0.2 | 0.1 | 0.1 | -0.3 | 1 |  |  |  |  |  |
| **B\_Squids** | 0.2 | 0.1 | -0.4 | -0.7 | -0.3 | 0.0 | 0.6 | 0.6 | 0.2 | 0.3 | -0.5 | 0.4 | -0.1 | 0.6 | -0.1 | 1 |  |  |  |  |
| **B\_Rays** | 0.8 | -0.8 | 0.8 | 0.3 | 0.8 | -0.1 | 0.4 | 0.6 | 0.5 | 0.3 | 0.1 | -0.3 | 0.9 | 0.5 | 0.0 | 0.1 | 1 |  |  |  |
| **B\_Tunas** | -0.2 | 0.6 | -0.7 | -0.9 | -0.7 | 0.0 | 0.7 | 0.4 | 0.2 | -0.1 | -0.4 | 0.5 | -0.4 | 0.3 | -0.2 | 0.6 | -0.3 | 1 |  |  |
| **B\_Sharks** | 0.0 | -0.2 | 0.1 | 0.1 | 0.2 | 0.5 | 0.0 | 0.0 | -0.1 | 0.6 | 0.0 | 0.2 | 0.2 | 0.0 | 0.4 | 0.1 | 0.2 | -0.1 | 1 |  |
| **B\_PIL\_Juv** | -0.6 | 0.6 | -0.7 | -0.5 | -0.7 | 0.0 | 0.0 | -0.2 | -0.3 | -0.1 | -0.5 | 0.5 | -0.7 | -0.2 | 0.0 | 0.3 | -0.7 | 0.4 | -0.2 | 1 |

**Supplementary Table S3d.** Pearson cross-correlation matrix for variables included in the modelled biomass data group. Variables that have cross-correlation >0.8 are in bold.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **B\_Phytoplankton** | **B\_Meso\_Micro** | **B\_Macrozooplankton** | **B\_Supra\_inv** | **B\_Macro** | **B\_Shrimps** | **B\_PIL** | **B\_PIL\_Juv** | **B\_ANE** | **B\_Henslow.s.crab** | **B\_JAA** | **B\_MAC** | **B\_DFI** | **B\_MAS** | **B\_BFI** | **B\_HOM** | **B\_BOG** | **B\_Sparids** | **B\_Flatfish** | **B\_BFP** | **B\_Ben\_Cephalopods** | **B\_Minke** | **B\_Squids** | **B\_Sharks** | **B\_Rays** | **B\_Comon\_dolphin** | **B\_Hake** | **B\_Seabirds** | **B\_DFP** | **B\_Stripped\_dolphin** | **B\_Harbor\_porpoise** | **B\_Bottlenose\_dolphin** | **B\_Tunas** |
| **B\_Phytoplankton** | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **B\_Meso\_Micro** | 0.8 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **B\_Macrozooplankton** | **0.9** | 0.9 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **B\_Supra\_inv** | 0.5 | 0.5 | 0.4 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **B\_Macro** | 1.0 | 0.8 | **0.9** | 0.6 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **B\_Shrimps** | **0.9** | 0.8 | **0.9** | 0.7 | **0.9** | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **B\_PIL** | -0.5 | **-0.9** | -0.7 | -0.1 | -0.5 | -0.5 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **B\_PIL\_Juv** | -0.5 | -0.7 | -0.7 | 0.1 | -0.5 | -0.5 | 0.8 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **B\_ANE** | 0.7 | 0.6 | 0.7 | 0.4 | 0.7 | 0.7 | -0.4 | -0.4 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **B\_Henslow.s.crab** | **0.9** | **0.9** | 1.0 | 0.5 | **0.9** | **1.0** | -0.7 | -0.6 | 0.7 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **B\_JAA** | 0.3 | -0.2 | 0.0 | 0.5 | 0.3 | 0.2 | 0.6 | 0.5 | 0.4 | 0.0 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **B\_MAC** | 0.5 | 0.7 | 0.6 | 0.0 | 0.4 | 0.4 | **-0.9** | -0.7 | 0.1 | 0.6 | -0.6 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **B\_DFI** | **0.9** | **0.9** | **0.9** | 0.7 | **0.9** | **0.9** | -0.6 | -0.4 | 0.7 | **0.9** | 0.2 | 0.5 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **B\_MAS** | 0.8 | 0.8 | **0.9** | 0.0 | 0.7 | 0.7 | **-0.9** | -0.8 | 0.6 | 0.8 | -0.3 | 0.8 | 0.7 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **B\_BFI** | 0.3 | 0.1 | 0.0 | 0.8 | 0.3 | 0.3 | 0.4 | 0.5 | 0.2 | 0.1 | 0.7 | -0.3 | 0.4 | -0.3 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **B\_HOM** | **0.9** | **0.9** | **0.9** | 0.3 | **0.9** | 0.8 | -0.8 | -0.7 | 0.8 | **0.9** | 0.0 | 0.7 | **0.9** | **0.9** | 0.0 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **B\_BOG** | 0.7 | **0.9** | **0.9** | 0.3 | 0.7 | 0.7 | **-0.9** | -0.8 | 0.5 | 0.8 | -0.3 | 0.8 | 0.8 | **0.9** | -0.2 | **0.9** | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **B\_Sparids** | 0.8 | 0.8 | **0.9** | 0.1 | 0.7 | 0.7 | **-0.9** | -0.8 | 0.6 | **0.9** | -0.3 | 0.7 | 0.7 | **1.0** | -0.3 | **0.9** | **0.9** | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **B\_Flatfish** | 0.4 | 0.0 | 0.1 | 0.6 | 0.4 | 0.3 | 0.4 | 0.5 | 0.2 | 0.1 | 0.8 | -0.3 | 0.3 | -0.2 | 0.9 | 0.0 | -0.2 | -0.3 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **B\_BFP** | 0.7 | 0.4 | 0.6 | 0.2 | 0.7 | 0.6 | -0.2 | -0.3 | **0.9** | 0.6 | 0.5 | -0.1 | 0.5 | 0.4 | 0.1 | 0.6 | 0.3 | 0.5 | 0.3 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **B\_Ben\_Cephalopods** | 0.8 | 0.6 | 0.8 | 0.1 | 0.8 | 0.6 | -0.6 | -0.5 | 0.4 | 0.7 | -0.1 | 0.6 | 0.6 | 0.8 | -0.2 | 0.8 | 0.7 | 0.8 | 0.1 | 0.4 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |
| **B\_Minke** | 0.6 | 0.8 | 0.8 | 0.0 | 0.6 | 0.6 | **-0.9** | **-0.9** | 0.5 | 0.8 | -0.5 | 0.7 | 0.6 | **0.9** | -0.5 | 0.8 | **0.9** | **1.0** | -0.5 | 0.4 | 0.7 | 1 |  |  |  |  |  |  |  |  |  |  |  |
| **B\_Squids** | 0.8 | 0.6 | **0.9** | 0.0 | 0.8 | 0.6 | -0.6 | -0.6 | 0.5 | 0.8 | 0.0 | 0.6 | 0.6 | **0.9** | -0.2 | 0.8 | 0.7 | 0.9 | 0.1 | 0.5 | 1.0 | 0.7 | 1 |  |  |  |  |  |  |  |  |  |  |
| **B\_Sharks** | -0.1 | -0.6 | -0.4 | 0.3 | -0.1 | -0.2 | 0.8 | 0.8 | 0.0 | -0.4 | 0.8 | -0.7 | -0.2 | -0.7 | 0.7 | -0.5 | -0.7 | -0.7 | 0.8 | 0.2 | -0.4 | -0.8 | -0.4 | 1 |  |  |  |  |  |  |  |  |  |
| **B\_Rays** | 1.0 | 0.7 | **0.9** | 0.5 | **0.9** | 0.8 | -0.4 | -0.4 | 0.8 | 0.8 | 0.4 | 0.2 | 0.8 | 0.7 | 0.2 | 0.8 | 0.6 | 0.7 | 0.4 | 0.8 | 0.7 | 0.6 | 0.8 | 0.0 | 1 |  |  |  |  |  |  |  |  |
| **B\_Comon\_dolphin** | 0.7 | 0.8 | **0.9** | 0.0 | 0.7 | 0.6 | **-0.9** | -0.8 | 0.5 | 0.8 | -0.4 | 0.7 | 0.6 | **1.0** | -0.4 | **0.9** | 0.9 | **1.0** | -0.4 | 0.4 | 0.8 | **1.0** | 0.8 | -0.8 | 0.6 | 1 |  |  |  |  |  |  |  |
| **B\_HKE** | 0.2 | -0.2 | -0.1 | 0.6 | 0.2 | 0.2 | 0.6 | 0.6 | 0.1 | -0.1 | **0.9** | -0.5 | 0.2 | -0.4 | 0.8 | -0.1 | -0.4 | -0.4 | **0.9** | 0.3 | -0.1 | -0.6 | -0.1 | **0.9** | 0.3 | -0.5 | 1 |  |  |  |  |  |  |
| **B\_Seabirds** | 0.6 | 0.8 | 0.8 | 0.0 | 0.6 | 0.6 | **-0.9** | -0.8 | 0.4 | 0.8 | -0.4 | 0.8 | 0.6 | 1.0 | -0.4 | 0.8 | **0.9** | **0.9** | -0.4 | 0.3 | 0.8 | **0.9** | 0.8 | -0.8 | 0.5 | 1.0 | -0.5 | 1 |  |  |  |  |  |
| **B\_DFP** | **0.9** | 0.7 | **0.9** | 0.2 | **0.9** | 0.8 | -0.6 | -0.6 | 0.8 | 0.9 | 0.2 | 0.4 | 0.8 | 0.8 | -0.1 | **0.9** | 0.8 | **0.9** | 0.1 | 0.7 | 0.8 | 0.8 | 0.9 | -0.3 | **0.9** | 0.8 | 0.0 | 0.8 | 1 |  |  |  |  |
| **B\_Stripped\_dolphin** | 0.6 | 0.0 | 0.4 | 0.3 | 0.6 | 0.5 | 0.3 | 0.2 | 0.5 | 0.4 | 0.8 | -0.4 | 0.4 | 0.1 | 0.3 | 0.3 | -0.1 | 0.2 | 0.6 | 0.8 | 0.4 | 0.0 | 0.4 | 0.5 | 0.7 | 0.0 | 0.7 | 0.0 | 0.5 | 1 |  |  |  |
| **B\_Harbor\_porpoise** | 0.0 | -0.5 | -0.3 | 0.4 | 0.0 | 0.0 | 0.8 | 0.7 | 0.1 | -0.2 | **0.9** | -0.8 | -0.1 | -0.6 | 0.7 | -0.3 | -0.6 | -0.6 | 0.8 | 0.3 | -0.3 | -0.6 | -0.3 | **1.0** | 0.2 | -0.7 | **0.9** | -0.7 | -0.2 | 0.7 | 1 |  |  |
| **B\_Bottlenose\_dolphin** | **0.9** | 0.5 | 0.8 | 0.5 | **0.9** | 0.8 | -0.2 | -0.2 | **0.9** | 0.7 | 0.5 | 0.0 | 0.8 | 0.5 | 0.4 | 0.7 | 0.4 | 0.5 | 0.5 | **0.9** | 0.6 | 0.4 | 0.6 | 0.2 | **1.0** | 0.4 | 0.4 | 0.3 | 0.8 | 0.8 | 0.4 | 1 |  |
| **B\_Tunas** | 0.0 | -0.5 | -0.2 | 0.4 | 0.0 | 0.0 | 0.8 | 0.8 | -0.1 | -0.2 | 0.8 | -0.7 | 0.0 | -0.6 | 0.7 | -0.4 | -0.5 | -0.5 | 0.7 | 0.1 | -0.1 | -0.6 | -0.2 | 0.8 | 0.1 | -0.6 | **0.9** | -0.6 | -0.1 | 0.6 | 0.8 | 0.2 | 1 |

**Supplementary Table S3e.** Pearson cross-correlation matrix for variables included in the ecosystem indices data group. Variables that have cross-correlation >0.8 are in bold.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Dem/Pel B** | **PredB** | **Kempton Q** | **Shannon** | **Tot C** | **Dem C** | **Pel C** | **Dem/Pel C** | **Pred C** | **TLc** | **TLco** | **R** | **FCI** | **H** | **A/C** | **TotP/TotB** |
| **Dem/Pel B** | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **Pred B** | -0.4 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **KemptonQ** | **0.9** | -0.5 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **Shannon** | 0.6 | -0.4 | 0.7 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |
| **Tot C** | 0.8 | 0.1 | 0.6 | 0.4 | 1 |  |  |  |  |  |  |  |  |  |  |  |
| **Dem C** | 0.5 | 0.5 | 0.5 | 0.2 | 0.7 | 1 |  |  |  |  |  |  |  |  |  |  |
| **Pel C** | -0.8 | 0.8 | -0.8 | -0.7 | -0.4 | 0.0 | 1 |  |  |  |  |  |  |  |  |  |
| **Dem/Pel C** | 0.9 | -0.2 | **0.9** | 0.6 | 0.8 | 0.7 | -0.7 | 1 |  |  |  |  |  |  |  |  |
| **Pred C** | 0.6 | 0.4 | 0.6 | 0.4 | 0.7 | **0.9** | -0.2 | 0.7 | 1 |  |  |  |  |  |  |  |
| **TLc** | -0.7 | 0.4 | -0.5 | -0.5 | -0.7 | 0.0 | 0.7 | -0.6 | -0.2 | 1 |  |  |  |  |  |  |
| **TLco** | -0.5 | 0.8 | -0.4 | -0.4 | -0.1 | 0.4 | 0.8 | -0.3 | 0.2 | 0.6 | 1 |  |  |  |  |  |
| **R** | 0.3 | **-0.9** | 0.3 | 0.4 | -0.2 | -0.6 | -0.7 | 0.1 | -0.4 | -0.4 | -0.9 | 1 |  |  |  |  |
| **FCI** | 0.8 | -0.8 | 0.7 | 0.6 | 0.4 | -0.1 | **-0.9** | 0.6 | 0.1 | -0.7 | -0.8 | 0.7 | 1 |  |  |  |
| **H** | 0.3 | 0.7 | 0.2 | 0.1 | 0.7 | 0.8 | 0.2 | 0.5 | 0.8 | -0.1 | 0.6 | -0.8 | -0.2 | 1 |  |  |
| **A/C** | -0.7 | 0.8 | -0.6 | -0.6 | -0.2 | 0.3 | **0.9** | -0.4 | 0.0 | 0.7 | **0.9** | **-0.9** | **-0.9** | 0.4 | 1 |  |
| **TotP/TotB** | 0.7 | -0.7 | 0.6 | 0.5 | 0.4 | -0.1 | **-0.9** | 0.5 | 0.1 | -0.7 | **-0.9** | 0.8 | 0.8 | -0.4 | **-0.9** | 1 |

# Supplementary material S4

This part of supplementary material contains results of the Regime shift analysis (STARS) performed separately on each variable.

**Table S4 of the supplementary material.** Results of the Regime shift analysis (STARS) performed on each variable Presented STARS regime shift years were identified in time series using p ≤ 0.05 and for values designated with \* regime shift was detected at p ≤ 0.1. Symbols ↑ and ↓ indicate increasing and decreasing trend respectively. Abbreviations and full names of the variables used in the analysis are shown.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Abbreviation** | **Full name** | **Shift mid-**  **90s** | **Shift mid-2000s** | **Shift mid-2010s** |
| **FM** | **Fishing mortality** | |  |  |
| F\_DFP | Demersal piscivorous fish |  | 2001↓ |  |
| F\_Rays | Rays |  | 2002↓ | 2010↓ |
| F\_BFP | Benthopelagic piscivorous fish | 1995↑ | 2003↓ |  |
| F\_Sparids | Sparids | 1994↓ | 2004↓ | 2016↓ |
| F\_BOG | Bogue | 1993↓ |  |  |
| F\_HOM | Horse mackerel |  | 2000↓ | 2015↑ |
| F\_BFI | Benthopelagic invertivorous fish |  |  | 2014↓ |
| F\_MAC | Mackerel | 1993↓ |  | 2011↓ |
| F\_JAA | Blue jack mackerel |  |  | 2015↑ |
| F\_ANE | Anchovy | 1996↑ | 2005↓ | 2016↑ |
| F\_PIL | Sardine |  |  | 2014↓ |
| F\_PIL\_Juv | Juvenile sardine |  |  | 2015↓ |
| F\_HKE | Hake |  |  | 2015↓ |
|  |  |  |  |  |
| **ENV** | **Environmental variables** |  |  |  |
| SSTm | Mean sea surface temperature | 1998↑ |  | 2011↑ |
| SSTw | Winter sea surface temperature | 1999↑ |  | 2012↑ |
| SSTs | Summer sea surface temperature | 1998↑ |  | 2011↑ |
| UI\_m | Mean Upwelling index |  |  | 2015↑ |
| UI\_w | Winter Upwelling index |  |  | - |
| UI\_S | Summer Upwelling index |  |  | 2016↑ |
| **CLIM** | **Climatic indices** |  |  |  |
| AMOm | Mean Atlantic multidecadal oscillation | 1997↑ |  | 2016↑ |
| AMOw | Winter Atlantic Multidecadal oscillation | 1995↑ |  | 2016↑ |
| AMOs | Summer Atlantic Multidecadal oscillation | 1998↑ |  |  |
| NAOm | Mean North Atlantic oscillation | - | - | - |
| NAOw | Winter North Atlantic oscillation |  |  | 2014↑ |
| NAOs | Summer North Atlantic oscillation |  | 2007↓ |  |
| EAm | Mean Eastern Atlantic pattern | 1998↑ |  | 2014↓ |
| EAw | Winter Eastern Atlantic pattern |  |  | 2014↓ |
| EAs | Summer Eastern Atlantic pattern | 1998↑ |  | 2016↓ |
|  |  |  |  |  |
| **B\_obs** | **Observed biomass** |  |  |  |
| B\_ANE\_o | Anchovy | 1997↓ | 2007↑ |  |
| B\_PIL\_o | Sardine | 1996↓ | 2009↓ |  |
| B\_MAC | Mackerel | 1995↑ | 2005↑ |  |
| B\_HOM\_o | Horse mackerel |  |  | 2013↑ |
| B\_Sparids\_o | Sparids | 1996 | 2004 | 2014\*↑ |
| B\_Flatfish\_o | Flatfish | - | - | - |
| B\_HKE\_o | Hake | 1993↓ | 2009↑ |  |
| B\_DFP\_o | Demersal piscivorous fish | 1993↓ | 2007↑ |  |
| B\_JAA\_o | Blue jack mackerel |  | 2004\*↑ | 2016\*↓ |
| B\_DFI\_o | Demersal invertivorous fish |  |  |  |
| B\_MAS:o | Chub mackerel |  |  |  |
| B\_BFI\_o | Benthopelagic invertivorous fish |  | 2006↓ | 2015↑ |
| B\_BOG\_o | Bogue |  | 2004↑ | 2012↑ |
| B\_BFP\_o | Benthopelagic piscivorous fish | 1994↓ | 2009↑ |  |
| B\_Ben\_Ceph | Benthic cephalopods |  |  |  |
| B\_Squids\_o | Squids | 1992↓ |  |  |
| B\_Rays\_o | Rays |  | 2005↑ | 2012↑ |
| B\_Tunas\_o | Tunas | 1992↓ |  |  |
| B\_Sharks\_o | Sharks |  |  |  |
| B\_PIL\_Juv\_o | Juvenile sardine |  | 2006↓ |  |
|  |  |  |  |  |
| **B\_model** | **Modelled biomass** |  |  |  |
| B\_ANE\_m | Anchovy | 1994↓ |  |  |
| B\_PIL\_m | Sardine | 1998↓ |  | 2010↓ |
| B\_MAC\_m | Mackerel |  |  | 2012\*↑ |
| B\_HOM\_m | Horse mackerel |  |  | 2010↑ |
| B\_Sparids\_m | Sparids |  | 2004↑ | 2013\* |
| B\_Flatfish\_m | Flatfish | - | - | - |
| B\_HKE\_m | Hake | - | - | - |
| B\_DFP\_m | Demersal piscivorous fish |  |  | 2014\*↑ |
| B\_JAA\_m | Blue jack mackerel | 1992↓ |  |  |
| B\_DFI\_m | Demersal invertivorous fish |  |  | 2010↑ |
| B\_MAS\_m | Chub mackerel |  | 2001↑ | 2011↑ |
| B\_BFI\_m | Benthopelagic invertivorous fish |  | 2003↓ |  |
| B\_BOG\_m | Bogue | 1999↑ |  | 2010↑ |
| B\_BFP\_m | Benthopelagic piscivorous fish | 1995↓ |  | 2012\*↑ |
| B\_Ben\_Ceph\_m | Benthic cephalopods |  | 2007↑ | 2015↑ |
| B\_Squids\_m | Squids |  | 2003↑ | 2014↑ |
| B\_Rays\_m | Rays |  |  | 2010\*↑ |
| B\_Hcrab\_m | Henslow’s crab |  | 2009↑ |  |
| B\_Tunas\_m | Tunas | - | - | - |
| B\_Minke\_m | Minke whale |  |  | 2015\*↑ |
| B\_Sharks\_m | Sharks | - | -- | - |
| B\_Common\_dolphin\_m | Common dolphin |  | 2003\*↑ | 2014\*↑ |
| B\_Seabirds\_m | Seabirds |  |  | 2013\*↑ |
| B\_Stripped\_dolphin\_m | Stripped dolphin | \_ | \_ | \_ |
| B\_Harbor\_porpoise\_m | Harbor porpoise | 1992\*↓ | 2002\*↓ |  |
| B\_Phyto\_m | Phytoplankton |  |  | 2011↑ |
| B\_MesoMicrozoo\_m | Mesozooplankton/Microzooplankton |  | 2009↑ |  |
| B\_Macrozoo\_m | Macrozooplankton |  | 2008↑ | 2013↑ |
| B\_Supra\_Inv\_m | Suprabenthic invertebrates | - | - | - |
| B\_Macrozoobenthos\_m | Macrozoobenthos |  |  | 2012↑ |
| B\_Shrimps\_m | Shrimps |  | 2009↑ |  |
| B\_PIL\_Juv\_m | Juvenile sardine |  | 2000↓ | 2012↓ |
| B\_Bottlenose\_dolphin\_m | Bottlenose dolphin |  | 2009\*↑ |  |
|  |  |  |  |  |
| **indices** | **Ecosystem indices** |  |  |  |
| Dem\_Pel B | Demersal per Pelagic biomass | 1999↓ |  | 2012\*↓ |
| Dem\_Pel C | Demersal per Pelagic catch | 1995↓ | 2004↓ |  |
| Pred B | Predatory biomass |  |  | 2012↑ |
| Pred C | Predatory catch | 1994↓ |  |  |
| Kempton Q | Kempton’s diversity index | 1998↓ | 2004↓ | 2016↓ |
| Shannon | Shannon diversity index |  |  | 2012↓ |
| Tot C | Total catch | 1999↓ |  |  |
| Dem C | Demersal catch | 1994↓ |  | 2015↑ |
| Pel C | Pelagic catch |  |  | 2011↑ |
| mTLc | The trophic level of the catch |  |  | 2012↑ |
| mTLco | The trophic level of the community |  |  | 2011↑ |
| FCI | Fins cycling index |  |  | 2011↓ |
| A\_C | Relative ascendency |  |  | 2010\*↑ |
| R | Redundancy |  |  | 2011↓ |
| H | Entropy | 1992↓ |  | 2014↑ |
| TotP\_TotB | Turnover rate |  |  | 2010↓ |