OSPAR COMMISSION

Pilot Assessment of Feeding Guilds

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Pilot Assessment of Feeding Guilds

Contributors

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Contents

Key Message

Spatially extensive decreases in planktivore feeding guild biomass lower in the food web were evident in the North Sea and Bay of Biscay sub-divisions. In contrast, biomass of the pisco-crustivore and piscivore feeding guilds higher in the food web increased in the Celtic Seas region and Bay of Biscay sub-division.

Message clé

Des diminutions spatialement étendues de la biomasse de la guilde alimentaire planktivore située plus bas dans le réseau trophique étaient évidentes dans les sous-divisions de la mer du Nord et du golfe de Gascogne. En revanche, la biomasse des guildes alimentaires des pisco-crustivores et des piscivores, situées plus haut dans le réseau trophique, a augmenté dans la région des mers celtiques et la sous-division du golfe de Gascogne.

Background (brief)

Food web indicators can reveal how ecosystems are responding to environmental change and anthropogenic pressure in a way that cannot be inferred from studying habitat, species or assemblages alone. Systematic differences in response of typically smaller bodied organisms, feeding lower in the food web (planktivores) relative to those with bigger bodies that utilise different resources (benthivores,pisco-crustivores) and feed higher up the food web (piscivores), could profoundly alter the uptake of nutrients and the efficiency of communities in converting resources into biomass (i.e. ecosystem functioning which supports the provision of ecosystem services).

Inventories of trophic interactions have been collated worldwide, across biomes, and can be applied to infer food web structure and energy flow. Work presented here aimed to further develop a feeding guild indicator, as proposed by Garrison & Link (2000) and Thompson et al. (2020), which uses stomach contents information to group predators into common functional roles within the food web.

Stomach contents data were collated with support from EuroMarine. The newly collated dataset contains >23 000 unique predator-prey interactions from >1 250 000 fish stomachs from across the North Atlantic and Arctic Oceans. The data are used to demonstrate how feeding guilds (i.e. predator groupings based on their taxonomy, body size and diet) can be defined systematically and in a way that is conducive to their application internationally across ecosystems. These guilds are then applied to survey data collected from across the OSPAR Maritime Area to demonstrate observed changes in the relative dominance of key energy pathways that are critical to maintaining ecosystem structure and function.

Background (extended)

Natural food webs are made up of many complex interactions which are largely determined by the size of the interacting organisms because predators are systematically larger than their prey (Brose et al., 2019; Petchey et al., 2008; Woodward et al., 2005). The behaviour of organisms relating to their evolutionary history, including adaptations for specific habitats, also determines whether organisms interact. These properties can be used to predict food web structure and dynamics and categorise predators into functional feeding groups useful for ecosystem status assessment (Garrison and Link, 2000a, 2000b; Thompson et al., 2020). Yet size-, taxon- and diet information have not been synthesised in a marine ecosystem indicator to date because of the large number of observations needed to understand change in many species' diets through maturity. This issue is particularly pertinent for understanding and managing the impact of human activities on marine ecosystems where species distributions, body size, and thus interactions, are changing in response to fishing and climate change, for example (Hiddink and ter Hofstede, 2008; Kortsch et al., 2015;

Magurran et al., 2015; Perry et al., 2005; Simpson et al., 2011), with changes projected to continue worldwide (Cheung et al., 2013, 2009; Fernandes et al., 2020; Jones and Cheung, 2015; Queirós et al., 2018).

This FW7 Candidate Indicator shows a data-driven, reproducible approach to feeding guild assessment that incorporates predator and prey size and predator foraging (e.g. planktivory vs piscivory) that can be used to understand change in ecosystem structure and function across OSPAR Regions. This feeding guild indicator monitors change in the biomass and species richness of differing feeding guilds (currently comprised of fish and elasmobranch only) once individuals have been grouped by a common functional role within the food web. Contrasting directions of change in feeding guild biomasses and species richness demonstrates that there is both change in food web structure (i.e. a change in the distribution of biomass and species across the food web) and functioning as the relative importance of different energy pathways is altered.

Assessment Method

Guild classification

Stomach contents data

The candidate indicator draws together stomach contents data primarily collected from the North Atlantic shelf seas, with important contributions from the Norwegian and Barents Seas in the Arctic Ocean (Figure a). These data come from a combination of previously published and unpublished sources, including DAPSTOM (Pinnegar, 2019), ICES Year of the Stomach (ICES, 1997; www.ices.dk/marine-data/data-portals/Pages/Fish-stomach.aspx), and contributions from NOAA and URI (USA), IEO, CSIC-ICM and CSIC-IIM (Spain), SIME and SLU (Sweden), MFRI (Iceland), IMR (Norway), Ifremer (France), BSS and LKN.SH (Germany; FishNet, https://www.nationalpark-wattenmeer.de/wissensbeitrag/fishnet/). The data contain >2m observations from >1.2m stomach samples. After removing samples collected from freshwater and those with missing predator or prey taxonomy, predator size, location or time information, there were a total of 682457 unique stomach samples, representing 14049 unique interactions between 227 predator species and 2157 prey taxa.

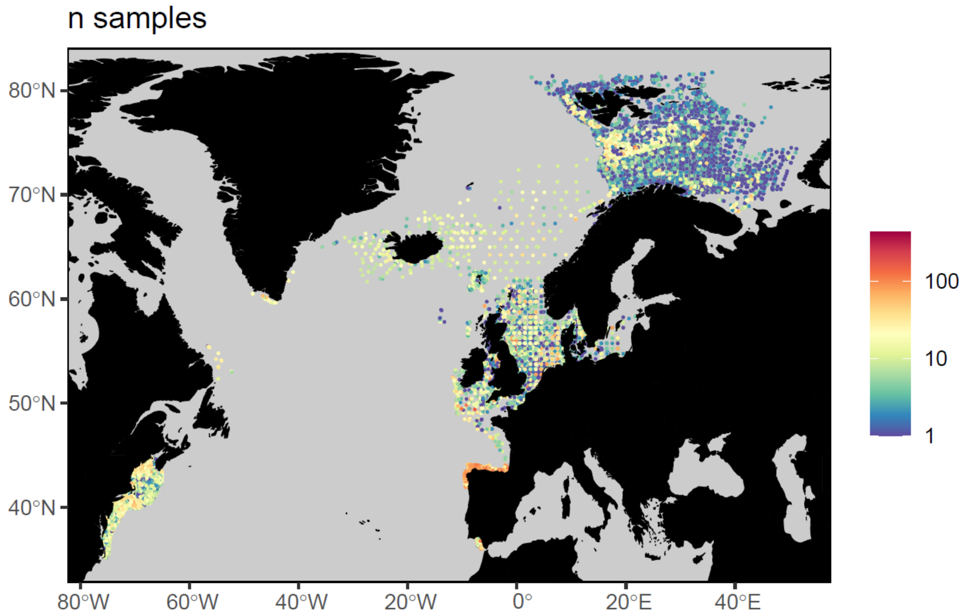

Figure a: Number of stomach samples per haul and haul locations.

Predator categories

Predators were categorised by taxa (typically species) and size. 20 equal size bins were used to categorise predator mass along a Log10 transformed gradient from 0.1 micrograms to 190 tonnes (i.e. capable of capturing organisms from plankton to blue whales). Data for each predator (i.e. taxa size class) was then estimated across all available samples, with means calculated for % (e.g. relative prey biomass) and continuous data (e.g. prey individual mass).

Prey counts, biomass and predator-prey mass ratio

Prey counts and biomass (wet weight in grams) were available for 55% of the stomach contents data used here. Where prey biomass was unavailable, mean individual prey mass was estimated using linear mixed effects models. Models of predator-prey body mass scaling can be improved by incorporating species traits (Brose et al., 2019). Species-resolved information is valuable when managing fish populations, so fish taxonomy and prey traits (i.e., their functional group; zooplankton, benthos, fish, nekton or other) were applied to improve model fit. Log10 transformed prey biomass (g) was fit as the response, with log10 transformed predator body mass (g), predator species and prey functional group combinations (e.g. cod-zooplankton, cod-benthos, cod-fish and sprat-zooplankton.) as predictors, with an interaction term between predator body mass and predator species and prey functional group combinations. And because prey biomass is reported as the sum of all prey for a given prey taxa, often alongside a count of individuals in the stomach contents data, prey count was fit as an offset in the model. Random intercepts were used for different datasets (e.g., Dapstom and ICES Year of the Stomach), years, sites (a 3 by 3 grid based on latitudinal and longitudinal gradients, each split into 3 equal lengths), sample ID (i.e., identifying all unique samples), and the number of stomachs sampled (some stomach samples contained in Dapstom and ICES Year of the Stomach were pooled when processing). The Akaike information criterion (AIC) was used on nested models to assess the importance of all predictors. The full model had the lowest AIC by >2 units meaning all predictors were retained. Predictions of mean individual prey mass were then multiplied by their counts to give prey biomass per stomach sample where prey biomass data were missing. Where there were no observations of prey biomass for unique predator species and prey functional group combinations (e.g., an interaction was observed but only documented with prey count information), or predictions had relatively high standard error (above or below 10%, e.g., where there were few observations) a model was used with the predator species and prey functional group moved to the random effects, with random slopes for each predator species and prey functional group combination, to predict mean individual prey mass. Where prey counts were unavailable, observed prey biomass was divided by mean individual prey mass, as estimated above. Results from the models are provided in the FW7 CEMP alongside model summary tables to demonstrate model performance.

The scaling relationship between predator and prey mass, often measured using predator-prey mass ratios (henceforth PPMR), constrains energy flow through ecosystems (Barnes, Maxwell, Reuman, & Jennings, 2010; Brose et al., 2008; Brose, Williams, & Martinez, 2006; Schneider, Scheu, & Brose, 2012; Trebilco, Baum, Salomon, & Dulvy, 2013). High PPMRs, where predators typically have many weak interactions by feeding on relatively small prey, help to maintain stability in food webs (Blanchard et al., 2011; Brose et al., 2006; McCann et al., 1998; Otto et al., 2007; Rooney et al., 2006) and ecosystem functioning (Schneider et al., 2016, 2012; Wang and Brose, 2018) because they dampen strong oscillatory dynamics. As such, high PPMR interactions can help mitigate perturbations from climate change, among other stressors (Binzer et al., 2016). PPMR estimates show significant inter-species variation due to differing foraging strategies (Scharf et al., 2000), such that change in species composition can be the biggest driver of change in community-wide PPMR (Reum et al., 2019). Systematic change in predators with relatively high PPMRs in response to anthropogenic pressure would therefore be useful to detect to better understand how changes in feeding guilds may affect ecosystem functioning. Biomass weighted PPMR was estimated (after Reum et al., 2019) for each taxa size class.

Cluster analysis

Guilds were assigned in R version 4.02 using the stats package (R Core Team, 2020) and based on cluster analysis using the 'ward D2' agglomeration method on Bray-Curtis dissimilarities between predator diets. Dissimilarities were based on log10 transformed mean individual prey mass (g), log10 transformed mean biomass weighted PPMR and the mean % biomass contribution of zooplankton (including fish <0.5g), benthos, nekton (other than fish) and fish. All variables were rescaled to values of or between 0 and 1. Prey were assigned to functional groups after Webb & Vanhoorne (Webb and Vanhoorne, 2020) using the “worrms” package (Chamberlain, 2019).

A relatively simple set of feeding guilds was used (n = 4) in order to elegantly capture a broad set of ecosystem components while also explore change in both feeding guild biomass and their species richness in the survey data. This also corresponds with MSFD guidance which calls for four guilds relevant for fish to be defined: planktivores, pelagic and demersal sub-apex predators and apex predators. The cluster-based method performed better than when predators were randomly assigned to guilds. Multiple distinct feeding guilds can therefore be robustly categorised even where small subsets of predator stomach contents are considered (i.e., n = 30 stomach samples; see CEMP Guideline: Combined guideline for processing of survey data for fish and food webs common indicators FC2, FC3, FW3 and FW7 (Agreement 2018 - 05)). Predators with fewer than 30 samples have not been classified into guilds.

Changing the number of feeding guilds could be justified, depending on the question, and would be straightforward to implement by taking a different level in the classification tree following Thompson et al. (2020). This is seen as a strength in the candidate indicator approach because feeding guilds are hierarchically structured much like how taxonomic or other trait information has been organised. A table which details the branches from two to five feeding guilds has been provided so that future assessments could choose the level of complexity that suits the needs of the assessment. And, because it is a data-driven, reproducible approach, new information can be systematically integrated to 1) further resolve the number of feeding guilds that can be confidently characterised, 2) their composition and 3) test if seasonal to annual changes in feeding behaviour provides evidence for dynamical classifications.

Spatial and temporal change in feeding guild responses

This is a trend-based assessment. Analysing feeding guild biomass provides simultaneous information on ecosystem structure and functioning, e.g., by revealing areas of high planktivore biomass (structure) which is also indicative of high energy flux between plankton and fish (functioning). Change in feeding guild species richness provides a measure of functional redundancy where, e.g., relatively low or decreasing feeding guild species richness indicates low or decreasing functional redundancy.

The new feeding guild classifications have been applied to processed otter trawl survey data for the Northeast Atlantic shelf seas collected between 1997–2020 (Lynam and Ribeiro, 2022) to reveal spatial and temporal change in the distributions of feeding guild biomass and species richness. Compared with quarter 2 and 3, data from quarters 1 and 4 typically have longer time-series available over much of the study region and so were preferentially selected. Where data from quarters 1 or 4 were not available, otter trawl data from other quarters were used. Table a provides information on the surveys used and their spatial and temporal ranges. The temporal assessment covers 1997-2020 because the majority of the surveys considered have at least a near complete time-series covering that period. Longer time-series do exist for some surveys but including these data would mean looking at long-term change for some areas, but short-term change for others which could confound interpretation.

Spatial gradients and temporal change in the distribution of feeding guild biomass and their species richness were determined for many groundfish surveys carried out across four separate Regions: Greater North Sea, Celtic Seas, Bay of Biscay and Iberian Coast, and the Wider Atlantic (Table a). The strata used here replicate those used for the common food web indicators FC3 and FW3 (Agreement 2018 - 05). Ecological subdivisions were determined for the Greater North Sea using a simplification of those strata proposed by the European Union financed project Towards a Joint Monitoring Programme for the North Sea and Celtic Sea (JMP NS / CS) that took place in 2013, and building upon work in the European Union VECTORS project (Vectors of Change in European Marine Ecosystems and their Environmental and Socio-Economic Impacts) that examined the significant changes taking place in European seas, their causes, and the impacts they will have on society. In other OSPAR Regions, the strata from the survey design were considered appropriate to represent the ecological subdivisions.

The candidate feeding guild indicator classified 92% of the surveyed biomass which included 120 taxa size classes. However, many rare taxa size classes observed in the survey data (n = 366, representing 8% of the surveyed biomass) remain unclassified due to insufficient stomach contents data. The perspective of change is therefore weighted towards predators contributing most to community biomass and ecosystem functioning. Pearson's correlation coefficients were used to identify areas of significant temporal change in feeding guild responses per strata. The process of defining feeding guilds, assigning them to survey data and analysing spatial and temporal change in their biomass and species richness are illustrated in Figure b. Haul-level estimates of feeding guild biomass and their species richness have been provided.

Table a: Otter trawl surveys, the Region in which they operate, the period over which they have been undertaken and the number of unique hauls (n).

Survey acronym[1]	**OSPAR region[1]**	**Quarter[1]**	**Years**	***n***
BBICFraOT4	BBIC	4	1997-2020	1693
BBICnSpaOT4	BBIC	4	2011-2018	902
BBICPorOT4	BBIC	4	2005-2018	1045
BBICsSpaOT1	BBIC	1	2000-2020	673
BBICsSpaOT4	BBIC	4	2002-2020	691
CSFraOT4	CS	4	1997-2020	1180
CSIreOT4	CS	4	2003-2020	2353
CSNIrOT1	CS	1	2008-2020	756
CSNIrOT4	CS	4	2009-2020	698
CSScoOT1	CS	1	1997-2020	1082
CSScoOT4	CS	4	1997-2020	1210
GNSFraOT4	GNS	4	1998-2020	1907
GNSIntOT1	GNS	1	1997-2020	8827
WAScoOT3	WA	3	1999-2020	701
WASpaOT3	WA	3	2006-2018	1019

1. Survey acronym convention: First 2 to 4 capitalised letters indicate the OSPAR Region (BBIC: Bay of Biscay and Iberian Coast; CS: Celtic Seas; GNS: Greater North Sea; WA – Wider Atlantic). Next capitalised and lowercase letters signify the country involved (Spa: Spain; Bel: Belgium; Por: Portugal; Fra: France; Eng: England; Ire: Republic of Ireland; Nir: Northern Ireland; Sco: Scotland; Ger: Germany; Int: International; Net: The Netherlands. International refers to the two international bottom trawl surveys carried out in the Greater North Sea under the International Council for the Exploration of the Sea (ICES). In the Bay of Biscay and Iberian Coast Region, Spanish surveys are further delimited by (n) for surveys operating in the northern Iberian Coast area and (s) for surveys operating in the southern Iberian Coast area. Next two capitalised letters indicate the type of survey (OT: otter trawl). Final number indicates the season in which the survey is primarily undertaken (1: January to March; 3: July to September; 4: October to December).

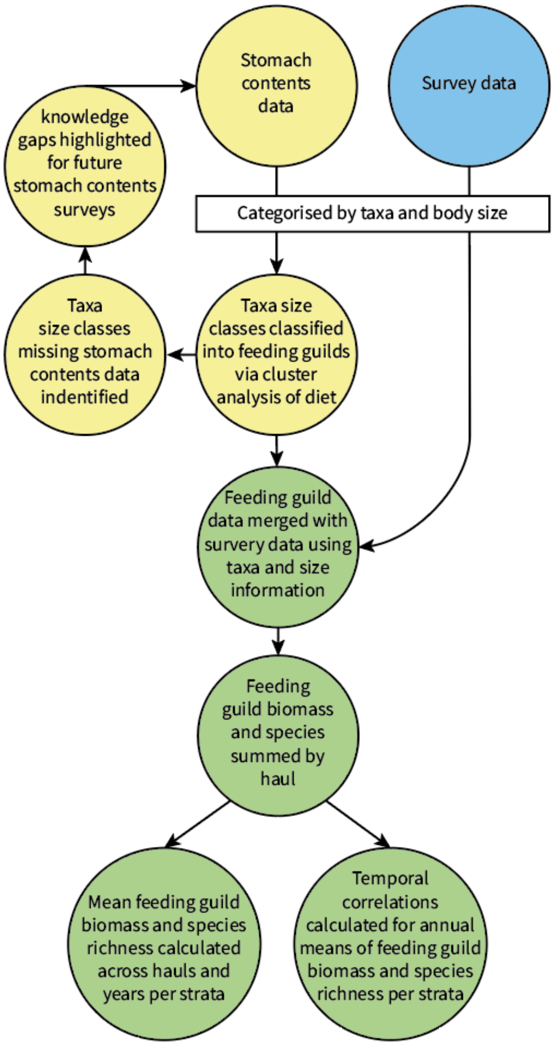

Figure b: The process used to classify feeding guilds based on predator stomach contents data, assign them to survey data and calculate feeding guild responses across the assessment strata. Yellow circles = stomach contents data, blue circle = otter trawl survey data, green circles = survey data with feeding guild information appended.

Results (brief)

Guild descriptions

Omnivory was ubiquitous, with all prey groups occurring in the diet of all feeding guilds, albeit to quite different levels (Figure 1). The four feeding guilds have been named based on the % biomass of prey functional groups as follows, planktivores, benthivores, pisco-crustivores and piscivores. Differences between feeding guilds were related to predator size, which correlated positively with piscivory and negatively with planktivory. Small size classes of species often occur in the planktivore guild, moving to another guild as they increase in size, with multiple medium to larger size-classes of a species often in the same guild (Figure 1 and Table 1). The guild hierarchy table reveals that the planktivore guild can be split into two which enables a sub-apex pelagic guild to be classified and thus all guilds captured following MSFD guidelines.

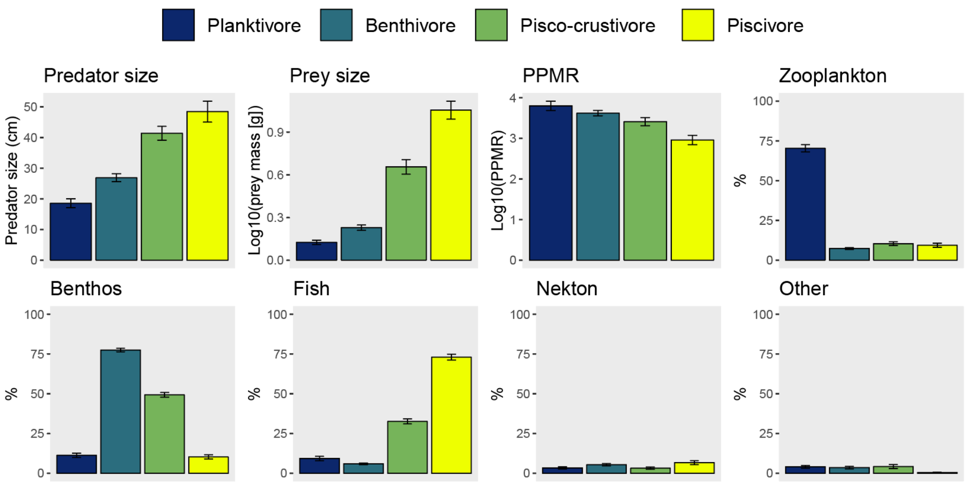

Figure 1: Differences between guilds in predator and prey size, predator-prey mass ratios (PPMR), and % biomass contribution of different prey functional groups. Values are based on means taken across taxa size classes. Error bars represent standard error.

Table 1: Taxa, size bin (Agreement 2018 - 05), feeding guild (Plank = planktivore, Benth = benthivore, P-crust = pisco-crustivore, Pisc = piscivore), minimum and maximum predator sizes (cm) per size bin, and the distribution of stomach samples by taxa size class (n) in the newly compiled stomach contents dataset and which are observed in the survey data.

Taxa	**S. bin**	**Min cm**	**Max cm**	**Feeding guild**	***n***
Ammodytes	11	7	14	Plank	144
Ammodytes	12	14	27	Plank	104
Argentina silus	13	20	36	Plank	145
Argentina silus	14	36	65	Plank	141
Argentina sphyraena	12	11	21	Plank	60
Clupea harengus	10	3	6	Plank	32
Clupea harengus	11	6	11	Plank	275
Clupea harengus	12	11	20	Plank	359
Clupea harengus	13	20	36	Plank	1605
Clupea harengus	14	36	67	Plank	202
Echiichthys vipera	12	9	17	Plank	383
Engraulis encrasicolus	12	11	21	Plank	72
Etmopterus spinax	12	13	24	Plank	184
Etmopterus spinax	13	24	44	Plank	240
Gadus morhua	10	3	5	Plank	625
Gadus morhua	11	5	10	Plank	2373
Galeus atlanticus	13	27	50	Plank	134
Galeus melastomus	12	14	27	Plank	1081
Galeus melastomus	13	27	51	Plank	1847
Galeus melastomus	14	51	96	Plank	712
Gobiidae	10	3	5	Plank	53
Helicolenus dactylopterus	11	5	8	Plank	64
Hoplostethus mediterraneus	12	8	15	Plank	35
Hoplostethus mediterraneus	13	15	27	Plank	48
Hyperoplus lanceolatus	12	15	28	Plank	295

Lepidopus caudatus	13	45	82	Plank	96
Lepidorhombus whiffiagonis	11	6	12	Plank	44
Lepidorhombus whiffiagonis	12	12	21	Plank	2388
Lepidorhombus whiffiagonis	13	21	38	Plank	8874
Melanogrammus aeglefinus	9	2	3	Plank	31
Melanogrammus aeglefinus	10	3	6	Plank	138
Merlangius merlangus	9	2	3	Plank	260
Merlangius merlangus	10	3	6	Plank	743
Merlangius merlangus	11	6	11	Plank	1422
Merlangius merlangus	12	11	20	Plank	29299
Merluccius merluccius	11	6	11	Plank	498
Merluccius merluccius	12	11	21	Plank	9093
Micromesistius poutassou	12	12	21	Plank	3054
Micromesistius poutassou	13	21	38	Plank	4373
Sardina pilchardus	13	19	35	Plank	110
Scomber scombrus	12	11	19	Plank	480
Scomber scombrus	13	19	35	Plank	11519
Scomber scombrus	14	35	64	Plank	5684
Scophthalmus rhombus	12	9	16	Plank	96
Scyliorhinus canicula	12	15	27	Plank	1223
Sebastes norvegicus	13	15	28	Plank	861
Sebastes norvegicus	14	28	53	Plank	901
Sprattus sprattus	11	6	11	Plank	652
Sprattus sprattus	12	11	21	Plank	322
Trachinus draco	13	20	37	Plank	193
Trachurus trachurus	12	10	19	Plank	268
Trachurus trachurus	13	19	36	Plank	2450
Trachurus trachurus	14	36	67	Plank	190
Trisopterus esmarkii	10	3	6	Plank	46
Trisopterus esmarkii	11	6	11	Plank	751
Trisopterus esmarkii	12	11	19	Plank	620
Trisopterus esmarkii	13	19	35	Plank	108
Trisopterus minutus	11	5	10	Plank	31
Zeus faber	11	4	8	Plank	40
Zeus faber	12	8	15	Plank	512
Agonus cataphractus	11	5	9	Benth	124
Amblyraja radiata	12	11	20	Benth	76
Amblyraja radiata	13	20	38	Benth	1465
Anarhichas lupus	12	12	21	Benth	431
Anarhichas lupus	13	21	36	Benth	1316
Anarhichas lupus	14	36	65	Benth	1127
Anarhichas lupus	15	65	114	Benth	490
Arnoglossus imperialis	12	11	19	Benth	38
Arnoglossus laterna	11	7	11	Benth	164
Arnoglossus laterna	12	11	20	Benth	150
Callionymus lyra	12	10	21	Benth	744

Callionymus lyra	13	21	44	Benth	1330
Chelidonichthys cuculus	11	6	10	Benth	74
Chelidonichthys cuculus	12	10	18	Benth	938
Chelidonichthys cuculus	13	18	33	Benth	3995
Chelidonichthys lucerna	13	17	33	Benth	911
Chelidonichthys obscurus	12	11	19	Benth	94
Chelidonichthys obscurus	13	19	35	Benth	511
Chimaera monstrosa	14	55	100	Benth	60
Chimaera monstrosa	15	100	183	Benth	51
Ciliata mustela	12	13	23	Benth	64
Citharus linguatula	12	11	20	Benth	156
Conger conger	12	21	36	Benth	641
Dicentrarchus labrax	12	10	18	Benth	39
Dicentrarchus labrax	13	18	33	Benth	144
Enchelyopus cimbrius	12	13	23	Benth	63
Enchelyopus cimbrius	13	23	42	Benth	86
Eutrigla gurnardus	11	5	10	Benth	31
Eutrigla gurnardus	12	10	19	Benth	6053
Gadus morhua	12	10	19	Benth	10464
Gadus morhua	13	19	34	Benth	47461
Gaidropsarus macrophthalmus	11	6	12	Benth	205
Gaidropsarus macrophthalmus	12	12	22	Benth	587
Glyptocephalus cynoglossus	13	22	38	Benth	68
Helicolenus dactylopterus	12	8	15	Benth	1329
Hippoglossoides platessoides	11	6	11	Benth	81
Hippoglossoides platessoides	12	11	20	Benth	1957
Lepidorhombus boscii	11	6	11	Benth	151
Lepidorhombus boscii	12	11	21	Benth	13160
Lepidorhombus boscii	13	21	37	Benth	14638
Lepidorhombus boscii	14	37	68	Benth	51
Lepidotrigla cavillone	11	5	9	Benth	49
Lepidotrigla cavillone	12	9	17	Benth	56
Lepidotrigla dieuzeidei	12	9	17	Benth	65
Leucoraja naevus	13	23	42	Benth	231
Limanda limanda	11	6	10	Benth	68
Limanda limanda	12	10	18	Benth	1119
Limanda limanda	13	18	33	Benth	3972
Lumpenus lampretaeformis	12	21	50	Benth	86
Malacocephalus laevis	12	15	28	Benth	32
Melanogrammus aeglefinus	11	6	10	Benth	357
Melanogrammus aeglefinus	12	10	19	Benth	10466
Microchirus variegatus	12	10	18	Benth	45
Microstomus kitt	12	10	18	Benth	94

Microstomus kitt	13	18	33	Benth	577
Microstomus kitt	14	33	60	Benth	583
Mullus surmuletus	12	9	17	Benth	163
Mullus surmuletus	13	17	30	Benth	887
Mullus surmuletus	14	30	55	Benth	66
Nezumia aequalis	12	13	25	Benth	74
Pagellus acarne	13	16	28	Benth	776
Pagellus acarne	14	28	51	Benth	614
Pagellus erythrinus	13	15	29	Benth	111
Pagellus erythrinus	14	29	54	Benth	121
Phycis blennoides	12	11	21	Benth	1199
Phycis blennoides	13	21	37	Benth	569
Phycis blennoides	14	37	66	Benth	92
Platichthys flesus	10	3	5	Benth	524
Platichthys flesus	11	5	10	Benth	120
Platichthys flesus	12	10	18	Benth	94
Platichthys flesus	13	18	33	Benth	1071
Pleuronectes platessa	11	5	10	Benth	359
Pleuronectes platessa	12	10	18	Benth	1835
Pleuronectes platessa	13	18	33	Benth	7216
Pleuronectes platessa	14	33	62	Benth	2075
Pomatoschistus minutus	11	6	10	Benth	64
Raja clavata	12	13	24	Benth	154
Raja clavata	13	24	43	Benth	1475
Raja clavata	14	43	77	Benth	3013
Raja clavata	15	77	138	Benth	638
Raja montagui	13	21	37	Benth	553
Raja montagui	14	37	65	Benth	1512
Scophthalmus maximus	11	5	9	Benth	141
Scorpaena notata	12	8	15	Benth	56
Scorpaena notata	13	15	27	Benth	34
Serranus hepatus	12	8	15	Benth	134
Solea solea	12	10	19	Benth	224
Solea solea	13	19	34	Benth	453
Solea solea	14	34	62	Benth	39
Spondyliosoma cantharus	13	16	29	Benth	112
Trigla lyra	12	10	19	Benth	731
Trigla lyra	13	19	35	Benth	568
Trigla lyra	14	35	66	Benth	29
Trisopterus luscus	12	9	17	Benth	812
Trisopterus luscus	13	17	31	Benth	3146
Trisopterus luscus	14	31	56	Benth	207
Trisopterus minutus	12	10	18	Benth	1510
Trisopterus minutus	13	18	32	Benth	883
Urophycis chuss	12	9	17	Benth	60
Urophycis chuss	13	17	31	Benth	2390

Urophycis chuss	14	31	59	Benth	2434
Amblyraja radiata	14	38	72	P-crust	2017
Brosme brosme	14	34	61	P-crust	94
Chelidonichthys cuculus	14	33	60	P-crust	67
Chelidonichthys lucerna	14	33	61	P-crust	299
Conger conger	13	36	63	P-crust	7539
Conger conger	14	63	110	P-crust	299
Dicentrarchus labrax	14	33	61	P-crust	45
Eutrigla gurnardus	13	19	35	P-crust	10341
Gadus morhua	14	34	64	P-crust	88031
Helicolenus dactylopterus	13	15	28	P-crust	1713
Helicolenus dactylopterus	14	28	52	P-crust	182
Hippoglossoides platessoides	13	20	35	P-crust	5343
Hippoglossoides platessoides	14	35	63	P-crust	506
Hippoglossus hippoglossus	13	19	35	P-crust	137
Hippoglossus hippoglossus	14	35	62	P-crust	166
Leucoraja naevus	14	42	73	P-crust	520
Limanda limanda	14	33	59	P-crust	240
Melanogrammus aeglefinus	13	19	35	P-crust	23072
Melanogrammus aeglefinus	14	35	64	P-crust	12683
Melanogrammus aeglefinus	15	64	118	P-crust	1134
Pollachius pollachius	13	19	35	P-crust	110
Pollachius virens	13	19	35	P-crust	724
Scophthalmus maximus	12	9	16	P-crust	103
Scyliorhinus canicula	13	27	49	P-crust	6584
Scyliorhinus canicula	14	49	88	P-crust	5808
Spondyliosoma cantharus	14	29	54	P-crust	171
Squalus acanthias	12	14	25	P-crust	55
Amblyraja radiata	15	72	137	Pisc	103
Eutrigla gurnardus	14	35	65	Pisc	476
Gadus morhua	15	64	118	Pisc	28208
Gadus morhua	16	118	217	Pisc	705
Hippoglossus hippoglossus	15	62	113	Pisc	42
Hyperoplus lanceolatus	13	28	53	Pisc	133
Lepidorhombus whiffiagonis	14	38	70	Pisc	545
Lophius budegassa	12	9	16	Pisc	168
Lophius budegassa	13	16	31	Pisc	216
Lophius budegassa	14	31	58	Pisc	371
Lophius budegassa	15	58	108	Pisc	61
Lophius piscatorius	12	8	15	Pisc	145
Lophius piscatorius	13	15	29	Pisc	1279
Lophius piscatorius	14	29	57	Pisc	682
Lophius piscatorius	15	57	112	Pisc	223
Merlangius merlangus	13	20	37	Pisc	61886
Merlangius merlangus	14	37	67	Pisc	4132

Merluccius merluccius	13	21	38	Pisc	7377
Merluccius merluccius	14	38	69	Pisc	2042
Merluccius merluccius	15	69	126	Pisc	58
Molva macrophthalma	12	17	31	Pisc	993
Molva macrophthalma	13	31	55	Pisc	131
Molva macrophthalma	14	55	98	Pisc	37
Pollachius pollachius	14	35	64	Pisc	38
Pollachius virens	14	35	65	Pisc	7197
Pollachius virens	15	65	122	Pisc	2015
Pomatomus saltatrix	13	18	34	Pisc	952
Pomatomus saltatrix	14	34	64	Pisc	849
Scophthalmus maximus	14	29	54	Pisc	2058
Scophthalmus maximus	15	54	98	Pisc	563
Scophthalmus rhombus	13	16	30	Pisc	219
Scophthalmus rhombus	14	30	56	Pisc	1111
Squalus acanthias	13	25	46	Pisc	3400
Squalus acanthias	14	46	85	Pisc	5463
Squalus acanthias	15	85	156	Pisc	358
Zenopsis conchifer	13	19	33	Pisc	72
Zenopsis conchifer	14	33	57	Pisc	48
Zeus faber	13	15	29	Pisc	944
Zeus faber	14	29	55	Pisc	625

Spatial and temporal change in feeding guild responses

There was clear spatial structure and regions of contrasting temporal change across feeding guilds and the various responses (Figure 2 and Figure 3). Planktivore biomass and species richness were generally highest off the northwest coast of Scotland, around the north and west coast of Ireland, in the Irish Sea and in the Bay of Biscay (French continental shelf). Benthivore biomass and species richness were highest in the north and west coast of Ireland, in the Irish Sea with relatively and uniformly high biomass across the North Sea and Bay of Biscay. Pisco-crustivore and Piscivore biomass and species richness generally increased moving west and north across the study area.

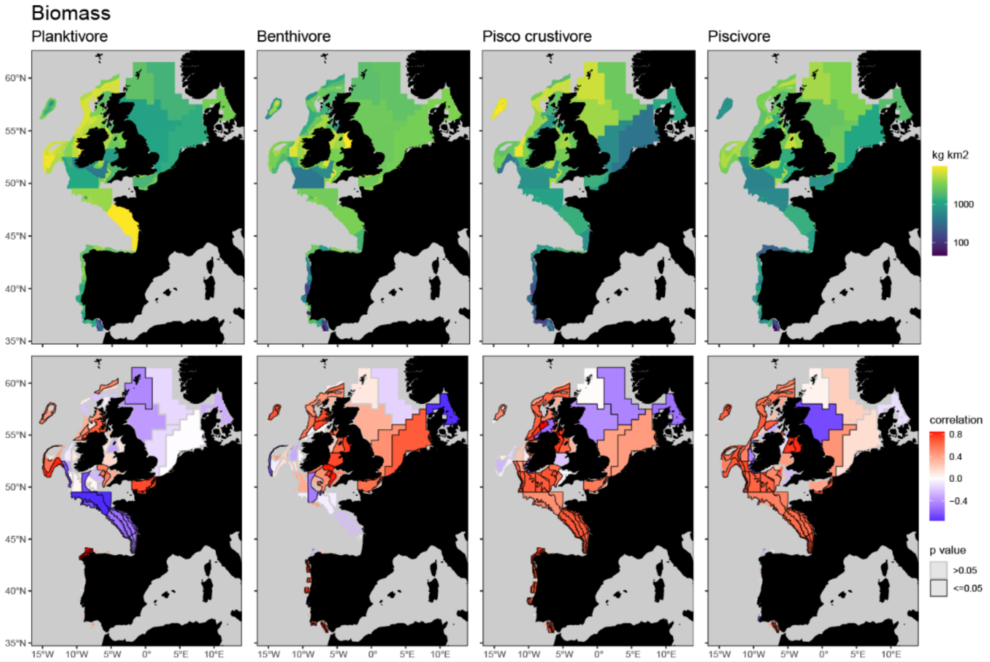

Figure 2: Mean spatial distribution (top row) and temporal change (bottom row) in feeding guild biomass by assessment strata based on otter trawl data. Temporal increases are shown by red cells (Pearson's correlation values between 0 and +1) and declines in blue cells (correlation values between 0 and -1). Assessment strata where the temporal change (correlation) is significant are highlighted with black borders.

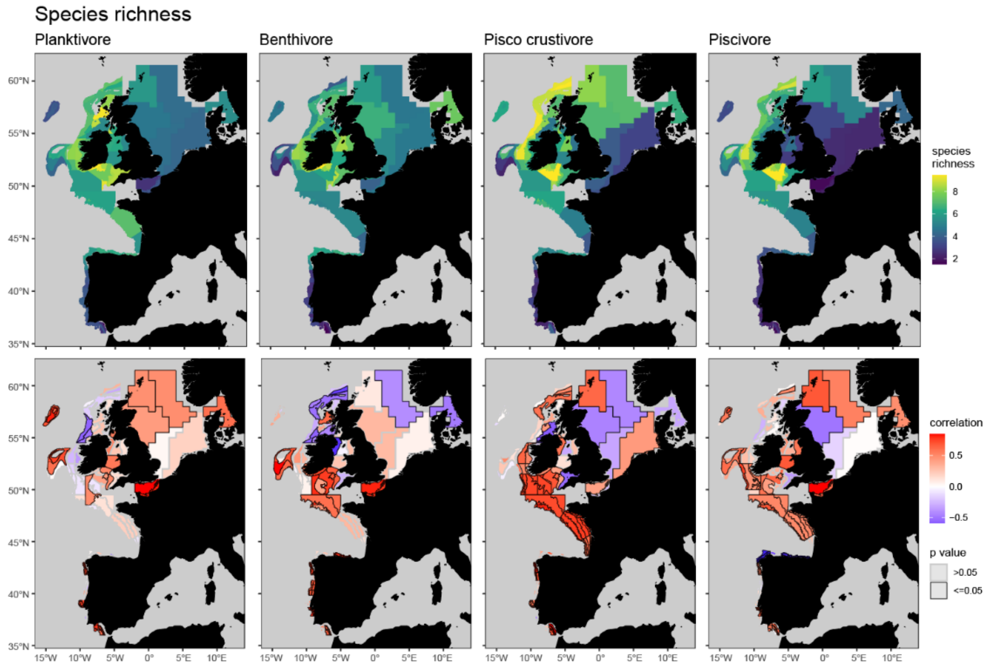

Figure 3: Mean spatial distribution (top row) and temporal change (bottom row) in feeding guild species richness by assessment strata based on otter trawl data. Temporal increases are shown by red cells (Pearson's correlation values between 0 and +1) and declines in blue cells (correlation values between 0 and -1). Assessment strata where the temporal change (correlation) is significant are highlighted with black borders.

Temporal trends in planktivore responses showed declines in biomass in the Celtic Sea, Bay of Biscay and north-western North Sea, and increases in the English Channel, Bristol Channel, along the north western coast of Spain and in the northwest of the study region (Figure 2 and Figure 3). Increases in planktivore species richness were evident in patches along the west-facing Iberian coast, in the wider Atlantic, in the English Channel, around the south-eastern coast of Ireland, in the northern North Sea and in the Kattegat, with more minor declines off the northwest coast of Ireland. Benthivore biomass was increasing in the Irish Sea, around the northwest coast of Scotland, in the wider Atlantic off Scotland, in the southern North Sea and eastern English Channel, with patchy increases along the west-facing Iberian coast. There were small scale and minor decreases in benthivore biomass in the Kattegat, south of Ireland and in the wider Atlantic to the west or Ireland. Benthivore species richness was increasing in the English Channel, south and west of Ireland, with decreases northwest of Scotland, in the northwest of the North Sea and in the Kattegat. Pisco-crustivores biomass and species richness were decreasing in the west and northeast of the North Sea, in the Kattegat and between Scotland and Northern Ireland but increasing over much of the rest of the study area. Piscivore biomass was increasing across much of the west of the study region from the Bay of Biscay to the northwest of Scotland, in the south-western North Sea and in parts of the Irish Sea and Gulf of Cadiz. Piscivore biomass was decreasing in the western North Sea and in the coastal region along the west coast of Ireland. Piscivore species richness was increasing in the north and north-eastern North Sea, in the Kattegat, English Channel, Irish Sea, wider Atlantic off Scotland over much of the Celtic Sea, with some patchy increases also off the west-facing Iberian coast. Piscivore species richness showed declines along the coast of northern Spain and in the western North Sea.

Conclusion (brief)

This pilot assessment shows that fish populations and their diversity are changing at different rates and even in different directions across the food web across OSPAR Regions. For instance, in the Bay of Biscay and Celtic Sea there were extensive temporal decreases in the biomass of consumers lower in the food web (planktivores) which contrasted with increases in those higher up (pisco-crustivores and piscivores). This demonstrates that the dominant energy pathways upon which species rely are already altering. Such changes could impact nutrient uptake and transfer efficiency across the food web, on feeding conditions for commercial fish species, higher predators (birds and mammals) and alter the extent of natural pressure on fish prey (e.g. plankton, benthos).

Knowledge Gaps (brief)

Taxa size classes observed in the surveys but not yet classified into feeding guilds because of insufficient stomach contents data. Maps showing where unclassified biomass and species are most prominent and changing through time are provided alongside a table to direct future stomach sampling towards those predators and areas currently under-sampled (Figure 4 and Table 2).

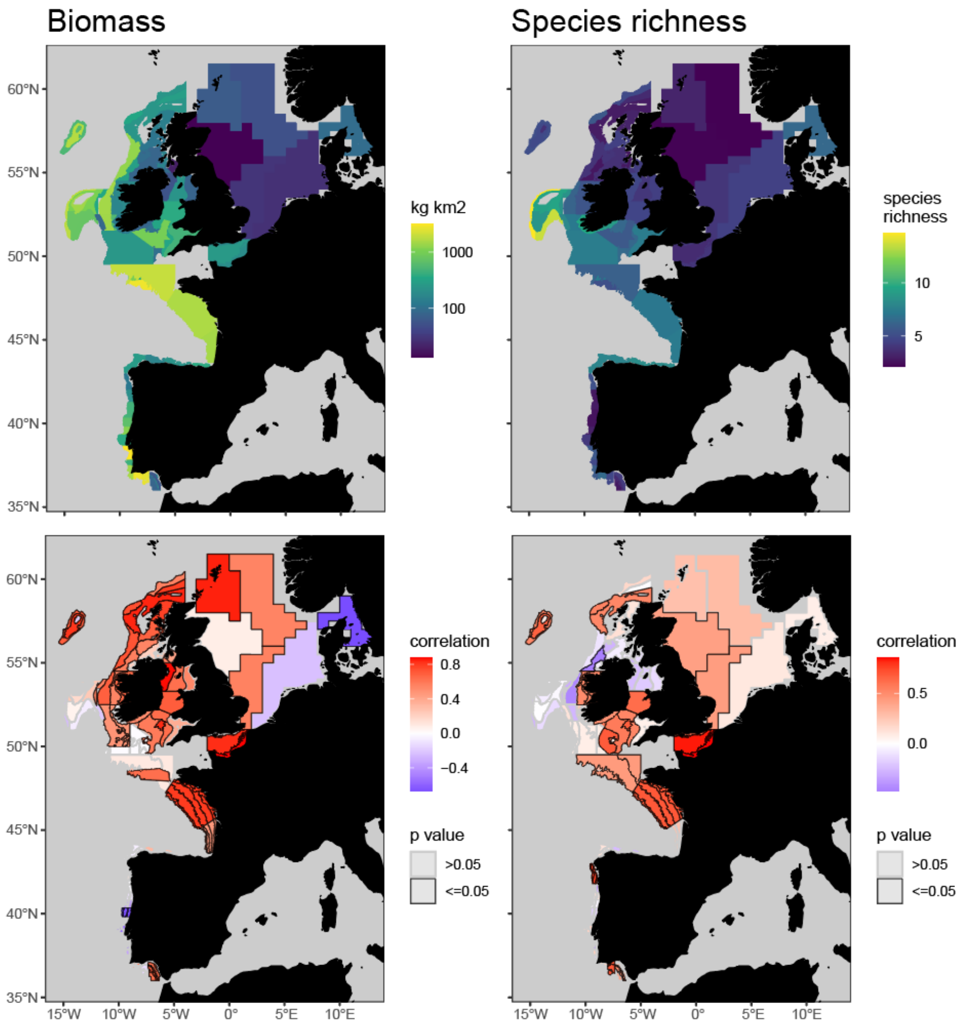

Figure 4: Mean spatial distribution (top row) and temporal change (bottom row) in unclassified fish biomass (left column) and species richness (right column) by assessment strata based on otter trawl data. Temporal increases are shown by red cells (Pearson's correlation values between 0 and +1) and declines in blue cells (correlation values between 0 and -1). Assessment strata where the temporal change (correlation) is significant are highlighted with black borders.

Table 2: Taxa and sizes observed in the survey data with insufficient stomach contents data to be classified into feeding guilds. Fish are ordered by the sum of their biomass (kg per km2) observed across all hauls to help direct future stomach sampling by prioritising those contributing most to the fish assemblage across the study region.

Taxa	**Min cm**	**Max cm**	**Sum kg per km2**
Capros aper	8	16	3240041
Trachurus trachurus	5	10	1042657
Capros aper	4	8	441428
Trachurus picturatus	9	16	428259
Sebastes viviparus	15	28	419466
Sardina pilchardus	11	19	389717
Gadiculus argenteus	10	18	360658

Argentina sphyraena	21	38	337196
Trachurus picturatus	16	30	313069
Engraulis encrasicolus	6	11	265764
Capros aper	16	31	242370
Sebastes viviparus	8	15	221067
Mustelus asterias	50	92	176023
Molva molva	77	142	132724
Scomber colias	19	33	114984
Galeorhinus galeus	82	153	111270
Conger conger	110	191	95179
Gadiculus argenteus	6	10	89462
Trachurus mediterraneus	18	34	86786
Scyliorhinus stellaris	85	160	84060
Platichthys flesus	33	60	79759
Maurolicus muelleri	36	58	77134
Boops boops	18	33	76843
Lepidion eques	23	39	76313
Molva molva	42	77	73287
Diplodus vulgaris	15	27	68597
Dipturus batis	102	187	61092
Mustelus asterias	92	167	55315
Raja brachyura	70	125	55209
Chimaera monstrosa	30	55	54496
Deania calcea	87	154	54264
Dipturus batis	187	343	48680
Dipturus batis	55	102	41609
Argentina silus	11	20	40851
Scyliorhinus stellaris	45	85	36300
Trachurus mediterraneus	10	18	32564
Dicentrarchus labrax	61	114	30554
Pollachius pollachius	64	116	30073
Micromesistius poutassou	38	69	29757
Raja brachyura	39	70	29703
Scomber colias	10	19	29396
Scymnodon ringens	70	128	27806
Deania calcea	49	87	26632
Cyclopterus lumpus	38	71	23205
Lophius piscatorius	112	217	22100
Dipturus nidarosiensis	126	226	21348
Raja undulata	74	137	19993
Glyptocephalus cynoglossus	38	67	19115
Serranus hepatus	95	175	18942
Cyclopterus lumpus	20	38	18593
Sprattus sprattus	3	6	18436
Coelorinchus caelorhincus	8	15	16722
Galeorhinus galeus	153	286	15889

Argentina sphyraena	6	11	15738
Sardina pilchardus	6	11	15568
Boops boops	10	18	14845
Micromesistius poutassou	6	12	14300
Molva macrophthalma	98	174	14125
Mustelus mustelus	46	90	12942
Mora moro	34	61	12709
Leucoraja circularis	78	142	12328
Myoxocephalus scorpius	15	28	12301
Spondyliosoma cantharus	9	16	11753
Raja microocellata	68	123	11751
Raja montagui	65	115	10425
Sparus aurata	16	30	10399
Trachurus mediterraneus	5	10	10053
Dipturus batis	30	55	9798
Coelorinchus caelorhincus	27	49	9779
Dasyatis pastinaca	62	116	9115
Mustelus asterias	28	50	8518
Trachurus mediterraneus	34	65	8370
Scymnodon ringens	39	70	8338
Callionymus maculatus	11	21	8108
Hoplostethus mediterraneus	27	50	8077
Mora moro	19	34	7896
Leucoraja circularis	44	78	7040
Microchirus variegatus	18	33	6951
Raja undulata	40	74	6807
Galeorhinus galeus	44	82	6685
Etmopterus spinax	44	79	6577
Phycis blennoides	66	119	6512
Epigonus telescopus	17	32	6417
Trachinus draco	11	20	6258
Chimaera monstrosa	16	30	5688
Cepola macrophthalma	21	54	5475
Coelorinchus caelorhincus	49	89	5401
Arnoglossus laterna	104	180	5207
Raja microocellata	37	68	5060
Lepidion eques	14	23	5014
Zeus faber	55	105	4936
Raja brachyura	125	224	4908
Macroramphosus scolopax	12	23	4820
Buglossidium luteum	9	16	4815
Trachyrincus scabrus	16	28	4786
Boops boops	33	61	4731
Diplodus vulgaris	27	50	4630
Brosme brosme	61	109	4603
Buglossidium luteum	5	9	4532

Dasyatis pastinaca	34	62	4519
Aphanopus carbo	69	122	4475
Glyptocephalus cynoglossus	13	22	4232
Argyrosomus regius	35	67	4138
Lamna nasus	102	193	4120
Sparus aurata	30	56	4022
Agonus cataphractus	9	18	3903
Trachurus picturatus	30	54	3795
Conger conger	191	333	3780
Mustelus mustelus	90	178	3735
Scyliorhinus stellaris	24	45	3647
Merlangius merlangus	227	416	3638
Molva molva	23	42	3553
Molva molva	142	262	3511
Callionymus maculatus	5	11	3439
Trisopterus luscus	5	9	3383
Malacocephalus laevis	28	54	3366
Leucoraja fullonica	46	83	3341
Brama brama	29	51	3266
Malacocephalus laevis	54	103	3219
Argyrosomus regius	18	35	3207
Leucoraja fullonica	83	151	3188
Dalatias licha	74	136	3188
Scorpaena scrofa	27	51	3183
Balistes capriscus	29	53	3133
Chelon labrosus	31	56	3091
Atherina presbyter	6	11	3079
Dipturus oxyrinchus	81	139	3021
Trachinus draco	37	67	2950
Nezumia aequalis	25	47	2763
Zenopsis conchifer	57	99	2762
Dicologlossa cuneata	11	20	2735
Mola mola	36	66	2683
Hydrolagus mirabilis	24	44	2618
Mola mola	19	36	2615
Callionymus lyra	5	10	2591
Merlangius merlangus	67	123	2547
Spondyliosoma cantharus	5	9	2470
Dasyatis pastinaca	116	215	2446
Coelorinchus caelorhincus	15	27	2354
Sarda sarda	21	38	2353
Coelorinchus caelorhincus	89	163	2336
Pagellus acarne	9	16	2319
Cepola macrophthalma	54	137	2262
Alosa fallax	38	69	2262
Chelidonichthys lucerna	61	114	2217

Macroramphosus scolopax	6	12	2213
Myoxocephalus scorpius	8	15	2188
Coelorinchus caelorhincus	4	8	2137
Diplodus bellottii	8	15	2086
Dalatias licha	41	74	2039
Umbrina canariensis	17	31	2039
Somniosus microcephalus	94	168	2018
Raja brachyura	22	39	1947
Maurolicus muelleri	23	36	1858
Entelurus aequoreus	18	37	1814
Alosa fallax	21	38	1813
Myliobatis aquila	38	82	1795
Torpedo marmorata	27	51	1753
Beryx splendens	26	48	1740
Myxine glutinosa	21	36	1738
Lamna nasus	193	364	1678
Diplodus bellottii	15	27	1672
Lepidopus caudatus	25	45	1669
Atherina presbyter	11	20	1664
Scophthalmus maximus	16	29	1635
Lithognathus mormyrus	30	56	1625
Centrolophus niger	36	63	1617
Xiphias gladius	80	145	1520
Scophthalmus rhombus	56	104	1519
Dipturus nidarosiensis	70	126	1491
Epigonus telescopus	9	17	1490
Blennius ocellaris	9	17	1483
Pagrus pagrus	27	51	1464
Ammodytes	27	52	1462
Pagellus bellottii	15	28	1426
Echiichthys vipera	5	9	1422
Dicologlossa cuneata	20	37	1399
Spicara maena	9	17	1398
Dasyatis tortonesei	62	116	1352
Dasyatis tortonesei	116	215	1328
Mola mola	66	123	1296
Dipturus oxyrinchus	139	238	1243
Diplodus vulgaris	8	15	1217
Spicara maena	17	31	1208
Pagellus bogaraveo	16	29	1177
Gaidropsarus vulgaris	35	62	1164
Beryx decadactylus	26	47	1149
Engraulis encrasicolus	132	243	1129
Alepocephalus rostratus	41	74	1121
Centrolophus niger	63	110	1056
Gaidropsarus vulgaris	19	35	1016

Tetronarce nobiliana	69	131	1008
Syngnathus acus	8	14	994
Galeus atlanticus	15	27	984
Liparis liparis	13	23	980
Capros aper	2	4	918
Alepocephalus rostratus	22	41	918
Notacanthus bonaparte	19	34	916
Scomber colias	33	58	902
Labrus mixtus	18	31	902
Hippoglossus hippoglossus	113	204	880
Brama brama	51	91	868
Sebastes viviparus	5	8	859
Entelurus aequoreus	37	75	843
Anguilla anguilla	58	105	835
Beryx splendens	14	26	833
Dicentrarchus punctatus	61	105	829
Arnoglossus imperialis	6	11	825
Trisopterus minutus	3	5	807
Deania profundorum	48	86	803
Trachyrincus scabrus	9	16	800
Rajella bathyphila	126	226	792
Microstomus kitt	5	10	787
Notacanthus bonaparte	34	63	775
Balistes capriscus	16	29	760
Liparis liparis	7	13	758
Pagellus bogaraveo	29	53	746
Taurulus bubalis	16	30	684
Nezumia aequalis	47	87	664
Taurulus bubalis	9	16	663
Argyrosomus regius	67	129	660
Maurolicus muelleri	58	94	646
Raja undulata	22	40	645
Zeus faber	105	201	639
Malacocephalus laevis	199	381	638
Lepidotrigla cavillone	17	30	630
Serranus cabrilla	17	33	627
Notoscopelus kroyeri	118	220	623
Pagrus pagrus	51	96	614
Labrus bergylta	30	55	598
Tetronarce nobiliana	37	69	580
Molva dypterygia	48	88	573
Gadiculus argenteus	3	6	571
Chelidonichthys lucerna	9	17	568
Trachipterus arcticus	111	207	556
Gasterosteus aculeatus	5	9	556
Scymnodon ringens	21	39	556

Sarda sarda	38	69	554
Sphoeroides pachygaster	27	51	554
Sphoeroides pachygaster	14	27	553
Boops boops	5	10	542
Bathysolea profundicola	12	21	542
Cyclopterus lumpus	11	20	540
Anthias anthias	10	20	528
Schedophilus medusophagus	27	49	527
Nemichthys scolopaceus	66	123	517
Schedophilus medusophagus	49	92	513
Alosa fallax	11	21	503
Lumpenus lampretaeformis	8	21	495
Pegusa lascaris	18	32	492
Sparus aurata	56	104	490
Leucoraja circularis	142	255	481
Scyliorhinus canicula	88	157	478
Xiphias gladius	145	262	471
Lithognathus mormyrus	16	30	461
Molva dypterygia	88	159	441
Engraulis encrasicolus	3	6	440
Chelon labrosus	56	101	436
Zeugopterus norvegicus	8	14	431
Scymnodon ringens	128	234	428
Squalus blainville	45	84	423
Leucoraja fullonica	25	46	419
Molva dypterygia	27	48	415
Heptranchias perlo	73	133	413
Microchirus variegatus	5	10	396
Deania calcea	28	49	395
Scyliorhinus canicula	9	15	395
Centrophorus granulosus	76	136	388
Myoxocephalus scorpius	28	53	387
Diplodus sargus	30	54	369
Syngnathus acus	25	46	362
Alopias vulpinus	157	303	355
Argyrosomus regius	9	18	351
Enchelyopus cimbrius	7	13	346
Mullus surmuletus	5	9	343
Xenodermichthys copei	11	21	337
Argentina sphyraena	3	6	337
Citharus linguatula	20	37	332
Epigonus telescopus	32	61	327
Deania profundorum	86	153	327
Coryphaenoides rupestris	90	162	327
Leucoraja circularis	24	44	327

Hippoglossoides platessoides	3	6	324
Dicentrarchus punctatus	35	61	321
Leucoraja naevus	13	23	320
Mustelus mustelus	23	46	316
Myliobatis aquila	82	175	314
Nezumia aequalis	4	7	309
Polyprion americanus	53	100	305
Scomber scombrus	64	117	300
Sarpa salpa	29	54	298
Dipturus oxyrinchus	47	81	296
Acantholabrus palloni	16	30	295
Notoscopelus kroyeri	10	18	286
Rajella bathyphila	70	126	285
Pholis gunnellus	13	24	282
Hydrolagus mirabilis	44	79	280
Trachipterus arcticus	60	111	275
Lophius budegassa	5	9	267
Nesiarchus nasutus	73	134	267
Gaidropsarus vulgaris	11	19	262
Pomatoschistus minutus	3	6	258
Stomias boa	25	45	256
Agonus cataphractus	18	36	253
Scorpaena loppei	8	14	248
Rostroraja alba	73	134	244
Amblyraja radiata	6	11	242
Umbrina canariensis	31	56	241
Sebastes viviparus	28	50	241
Serranus cabrilla	9	17	239
Raja clavata	138	248	239
Pagellus bogaraveo	9	16	239
Halargyreus johnsonii	12	22	234
Dipturus batis	16	30	232
Raja miraletus	26	46	230
Diplodus annularis	15	27	229
Synaphobranchus kaupii	22	38	227
Torpedo torpedo	56	110	223
Callanthias ruber	9	17	223
Aphia minuta	3	5	222
Trachurus trachurus	3	5	219
Rostroraja alba	134	248	219
Mora moro	61	110	218
Acipenser sturio	80	148	218
Chimaera monstrosa	9	16	216
Torpedo marmorata	14	27	207
Torpedo marmorata	51	98	207

Alosa alosa	19	34	207
Echiichthys vipera	17	31	204
Citharus linguatula	6	11	202
Labrus bergylta	17	30	201
Raja asterias	39	69	200
Maurolicus muelleri	3	5	196
Phycis phycis	33	59	193
Pollachius virens	10	19	190
Lycodes vahlii	18	32	189
Maurolicus muelleri	5	9	185
Pagellus bellottii	8	15	179
Lycodes vahlii	10	18	174
Solea senegalensis	18	34	173
Pagellus erythrinus	8	15	172
Leucoraja naevus	73	130	167
Argentina silus	6	11	166
Alepocephalus bairdii	40	72	165
Argentina sphyraena	38	69	162
Acantholabrus palloni	9	16	159
Stomias boa	14	25	158
Anguilla anguilla	32	58	154
Raja miraletus	46	82	153
Dicentrarchus punctatus	21	35	152
Pagrus auriga	27	52	151
Brosme brosme	19	34	149
Xenodermichthys copei	6	11	149
Limanda limanda	3	6	147
Alosa alosa	34	61	147
Taurulus bubalis	5	9	146
Symphodus roissali	28	52	145
Pomadasys incisus	16	31	144
Alosa fallax	6	11	144
Aphanopus carbo	39	69	144
Cyttopsis rosea	14	27	143
Arnoglossus laterna	4	7	143
Nesiarchus nasutus	40	73	142
Sprattus sprattus	71	130	141
Umbrina canariensis	9	17	140
Cepola macrophthalma	8	21	138
Diplodus annularis	8	15	138
Belone belone	61	110	135
Raja montagui	12	21	133
Diplodus cervinus	28	50	132
Raja microocellata	20	37	132
Pagrus pagrus	15	27	130
Galeorhinus galeus	23	44	129

Polymetme thaeocoryla	12	22	128
Mora moro	11	19	127
Echiodon drummondii	18	41	124
Ephippion guttifer	27	51	121
Galeus melastomus	8	14	120
Blennius ocellaris	17	32	120
Gobius niger	5	9	119
Lepidion eques	39	66	119
Etmopterus spinax	7	13	115
Halargyreus johnsonii	7	12	114
Solea solea	6	10	113
Dentex canariensis	28	53	111
Sardinella aurita	19	36	109
Malacocephalus laevis	8	15	109
Rostroraja alba	40	73	108
Galeus atlanticus	50	93	108
Scorpaena loppei	25	45	106
Synchiropus phaeton	13	28	102
Dasyatis tortonesei	34	62	101
Merluccius merluccius	3	6	101
Alepocephalus bairdii	22	40	100
Liparis montagui	8	16	96
Malacocephalus laevis	103	199	94
Dalatias licha	22	41	94
Malacocephalus laevis	4	8	93
Beryx decadactylus	14	26	88
Microchirus boscanion	9	17	85
Ctenolabrus rupestris	10	18	83
Belone belone	34	61	82
Arnoglossus thori	10	18	81
Beryx decadactylus	47	85	80
Engraulis encrasicolus	21	39	80
Zeugopterus punctatus	8	14	80
Molva molva	12	23	78
Callionymus reticulatus	6	12	78
Molva dypterygia	15	27	77
Pagrus auriga	52	98	77
Labrus mixtus	31	55	77
Microchirus boscanion	5	9	74
Serranus hepatus	4	8	74
Microchirus azevia	17	31	72
Gaidropsarus vulgaris	3	6	71
Myxine glutinosa	36	63	69
Lepidopus caudatus	82	150	68
Nezumia aequalis	7	13	67
Callionymus maculatus	3	5	66

Gadiculus argenteus	18	32	66
Polymetme corythaeola	13	23	65
Myxine glutinosa	12	21	65
Buglossidium luteum	16	29	65
Phycis phycis	18	33	65
Hyperoplus lanceolatus	8	15	65
Lycodes gracilis	11	26	63
Maurolicus muelleri	2	3	63
Helicolenus dactylopterus	52	94	63
Osmerus eperlanus	6	11	61
Zoarces viviparus	12	23	61
Synaphobranchus kaupii	12	22	61
Zeugopterus norvegicus	4	8	61
Arnoglossus rueppelii	12	22	57
Trachyrincus scabrus	49	88	56
Arctozenus risso	13	24	56
Oxynotus paradoxus	73	133	55
Stomias boa	82	147	55
Atherina presbyter	3	6	55
Lampanyctus crocodilus	12	23	52
Hygophum benoiti	30	54	51
Pholis gunnellus	24	44	51
Ciliata mustela	7	13	50
Anthias anthias	20	41	50
Caranx rhonchus	8	17	50
Galeus murinus	43	79	49
Pegusa lascaris	10	18	49
Myoxocephalus scorpius	5	8	49
Umbrina cirrosa	31	58	49
Sardina pilchardus	35	64	48
Oxynotus paradoxus	40	73	48
Mugil cephalus	31	59	48
Arnoglossus imperialis	19	35	48
Gobius niger	9	17	46
Ciliata mustela	23	41	46
Deania profundorum	27	48	46
Hyperoplus lanceolatus	4	8	46
Alosa agone	17	33	45
Dicologlossa cuneata	6	11	45
Squalus blainville	25	45	44
Alepocephalus rostratus	12	22	43
Callionymus maculatus	21	41	42
Symphodus bailloni	15	28	41
Labrus mixtus	10	18	41
Rajella bathyphila	39	70	41
Microchirus theophila	17	32	40

Sphyraena sphyraena	36	69	39
Sprattus sprattus	21	38	38
Uranoscopus scaber	29	53	38
Ephippion guttifer	14	27	37
Dipturus nidarosiensis	39	70	37
Trachyrincus scabrus	28	49	37
Syngnathus acus	14	25	36
Citharus linguatula	3	6	36
Alosa alosa	11	19	36
Raja asterias	69	123	35
Coryphaenoides rupestris	27	50	35
Lepidion eques	8	14	35
Pollachius pollachius	11	19	35
Molva macrophthalma	10	17	34
Lampanyctus crocodilus	7	12	34
Halargyreus johnsonii	22	40	34
Scyliorhinus stellaris	13	24	33
Pomadasys incisus	8	16	33
Cyttopsis rosea	8	14	33
Lepidotrigla dieuzeidei	17	31	33
Pagrus pagrus	8	15	31
Lepidotrigla dieuzeidei	5	9	31
Callionymus reticulatus	12	26	31
Trigla lyra	5	10	30
Coryphaenoides rupestris	50	90	29
Myliobatis aquila	18	38	29
Syngnathus rostellatus	9	15	29
Pomatoschistus minutus	33	58	28
Bathysolea profundicola	21	39	28
Callanthias ruber	5	9	28
Spicara smaris	10	18	27
Maurolicus muelleri	9	14	27
Glyptocephalus cynoglossus	7	13	27
Echiodon dentatus	20	36	26
Spicara maena	5	9	26
Scomber scombrus	6	11	26
Liparis liparis	4	7	26
Gnathophis mystax	20	36	26
Ruvettus pretiosus	77	140	26
Pagellus acarne	5	9	25
Aphia minuta	5	8	25
Myoxocephalus scorpioides	18	32	25
Gaidropsarus vulgaris	6	11	24
Trachinus draco	6	11	24
Chaunax pictus	14	27	24
Myctophum punctatum	6	10	24

Hymenocephalus italicus	13	24	24
Galeus melastomus	96	181	24
Galeus murinus	24	43	24
Diplodus sargus	16	30	23
Raja brachyura	12	22	23
Dentex gibbosus	31	57	22
Dipturus oxyrinchus	28	47	22
Petromyzon marinus	63	109	22
Scorpaena scrofa	8	15	21
Liparis montagui	4	8	21
Solea senegalensis	34	62	21
Chaunax pictus	27	49	21
Monochirus hispidus	8	14	20
Lepidorhombus boscii	3	6	20
Hymenocephalus italicus	24	43	20
Pagellus erythrinus	4	8	18
Dasyatis pastinaca	18	34	18
Hyperoplus lanceolatus	53	101	18
Syngnathus acus	4	8	18
Arnoglossus thori	5	10	17
Ciliata septentrionalis	9	16	17
Cyttopsis rosea	27	49	17
Symphurus nigrescens	6	11	17
Nerophis ophidion	25	50	17
Gasterosteus aculeatus	9	17	17
Alosa agone	33	62	17
Micromesistius poutassou	4	6	17
Raja clavata	7	13	17
Nemichthys scolopaceus	36	66	17
Dentex maroccanus	15	29	17
Scorpaena loppei	14	25	17
Polymetme thaeocoryla	22	40	17
Phycis blennoides	6	11	16
Blennius ocellaris	4	9	16
Leucoraja circularis	13	24	16
Uranoscopus scaber	16	29	16
Trachyrincus scabrus	5	9	16
Pterycombus brama	28	53	16
Salmo salar	32	59	16
Dipturus nidarosiensis	22	39	16
Benthodesmus simonyi	60	104	16
Chelidonichthys lastoviza	18	33	15
Hydrolagus mirabilis	13	24	15
Labrus bergylta	9	17	15
Dentex gibbosus	17	31	14
Dentex canariensis	15	28	14

Chelidonichthys lastoviza	10	18	14
Microchirus theophila	9	17	14
Naucrates ductor	28	53	14
Eutrigla gurnardus	3	5	14
Rajella bathyphila	22	39	13
Raja undulata	12	22	13
Ciliata septentrionalis	5	9	13
Stromateus fiatola	27	50	13
Chlorophthalmus agassizi	11	22	13
Scorpaena scrofa	15	27	13
Centrolabrus exoletus	19	33	13
Buglossidium luteum	3	5	13
Helicolenus dactylopterus	3	5	13
Deania calcea	16	28	13
Rajella fyllae	43	80	12
Trachipterus trachypterus	66	123	12
Trachipterus arcticus	32	60	12
Chauliodus sloani	18	33	12
Monochirus hispidus	14	25	12
Lophius piscatorius	4	8	12
Stomias boa	8	14	12
Coryphaenoides rupestris	15	27	12
Chelidonichthys lucerna	5	9	12
Ciliata septentrionalis	16	29	11
Plectorhinchus mediterraneus	30	54	11
Chelidonichthys obscurus	35	62	11
Cyclopterus lumpus	6	11	11
Spratelloides lewisi	11	20	11
Dentex maroccanus	29	56	11
Notoscopelus kroyeri	5	10	11
Macrourus berglax	18	35	11
Zeugopterus punctatus	14	26	11
Pegusa lascaris	5	10	10
Osmerus eperlanus	11	20	10
Hoplostethus mediterraneus	4	8	10
Sarpa salpa	16	29	10
Pholis gunnellus	7	13	10
Lycenchelys sarsii	10	16	10
Dentex gibbosus	9	17	9
Gaidropsarus biscayensis	7	12	9
Torpedo marmorata	7	14	9
Symphurus nigrescens	11	19	9
Gaidropsarus mediterraneus	23	42	9
Mustelus asterias	15	28	9
Macrourus berglax	35	65	9

Triglops murrayi	9	19	9
Raja montagui	7	12	8
Lepidopus caudatus	14	25	8
Alosa agone	9	17	8
Synaphobranchus kaupii	38	66	8
Ophidion barbatum	23	42	8
Sardina pilchardus	3	6	8
Hygophum benoiti	16	30	8
Petromyzon marinus	21	36	8
Arctozenus risso	24	44	7
Brama brama	16	29	7
Coryphaenoides rupestris	8	15	7
Zenopsis conchifer	11	19	7
Melanostomias bartonbeani	22	40	7
Entelurus aequoreus	9	18	7
Agonus cataphractus	2	5	7
Spicara smaris	18	35	7
Parablennius gattorugine	9	17	7
Coelorinchus caelorhincus	2	4	7
Arctozenus risso	7	13	7
Zeugopterus punctatus	4	8	7
Umbrina canariensis	5	9	7
Centrolophus niger	21	36	7
Synaphobranchus kaupii	7	12	7
Arnoglossus rueppelii	6	12	6
Ctenolabrus rupestris	5	10	6
Zeugopterus regius	8	14	6
Zoarces viviparus	23	43	6
Arnoglossus laterna	20	34	6
Echiichthys vipera	31	58	6
Raniceps raninus	17	29	6
Nezumia aequalis	2	4	6
Maurolicus muelleri	14	23	6
Argyrosomus regius	5	9	6
Schedophilus medusophagus	14	27	6
Gaidropsarus mediterraneus	12	23	6
Clupea harengus	2	3	6
Benthodesmus elongatus	35	60	6
Trisopterus minutus	32	59	6
Leucoraja fullonica	14	25	6
Zenopsis conchifer	6	11	6
Epigonus denticulatus	6	10	5
Triglops murrayi	5	9	5
Diaphus dumerilii	6	11	5
Callionymus maculatus	41	81	5
Glyptocephalus cynoglossus	4	7	5

Gaidropsarus biscayensis	12	22	5
Nessorhamphus ingolfianus	36	66	5
Argyropelecus olfersii	4	8	5
Ophidion barbatum	13	23	5
Leucoraja naevus	7	13	5
Serranus scriba	16	30	5
Etmopterus pusillus	24	44	5
Raja miraletus	14	26	5
Anthias anthias	5	10	5
Sigmops bathyphilus	24	43	5
Microstomus kitt	3	5	5
Gaidropsarus macrophthalmus	22	42	5
Capros aper	1	2	5
Spinachia spinachia	30	57	5
Halobatrachus didactylus	28	51	5
Conger conger	12	21	5
Gnathophis mystax	36	67	5
Scorpaena loppei	5	8	5
Syngnathus acus	46	82	4
Petromyzon marinus	36	63	4
Gadella maraldi	20	35	4
Lepidorhombus whiffiagonis	3	6	4
Macrourus berglax	10	18	4
Lampetra fluviatilis	18	32	4
Symphodus bailloni	8	15	4
Serranus hepatus	15	28	4
Lycenchelys sarsii	16	26	4
Raniceps raninus	9	17	4
Pomatoschistus minutus	10	18	4
Magnisudis atlantica	13	24	4
Benthodesmus elongatus	60	104	4
Naucrates ductor	15	28	4
Spinachia spinachia	16	30	4
Argyropelecus olfersii	8	15	4
Lampetra fluviatilis	32	58	4
Microchirus azevia	9	17	4
Chelon labrosus	17	31	3
Chimaera monstrosa	5	9	3
Symphodus melops	9	17	3
Zoarces viviparus	7	12	3
Paraliparis membranaceus	9	17	3
Pontinus kuhlii	16	30	3
Trachurus picturatus	5	9	3
Myoxocephalus scorpioides	10	18	3
Mora moro	6	11	3

Caranx rhonchus	17	32	3
Argentina silus	3	6	3
Belone belone	19	34	3
Synchiropus phaeton	6	13	3
Serrivomer beanii	36	66	3
Gaidropsarus argentatus	21	39	3
Sphoeroides pachygaster	7	14	3
Labrus mixtus	6	10	3
Microchirus ocellatus	9	16	3
Myctophum punctatum	3	6	3
Anguilla anguilla	18	32	3
Boops boops	3	5	3
Notacanthus bonaparte	10	19	3
Sigmops bathyphilus	13	24	3
Scorpaena porcus	8	15	3
Callionymus lyra	2	5	3
Gadella maraldi	11	20	3
Polymetme corythaeola	7	13	2
Epigonus denticulatus	10	18	2
Alosa alosa	6	11	2
Trachurus mediterraneus	3	5	2
Echiodon drummondii	8	18	2
Paraliparis membranaceus	5	9	2
Symphodus roissali	15	28	2
Callionymus reticulatus	3	6	2
Macroramphosus scolopax	3	6	2
Pomatoschistus minutus	2	3	2
Bathysolea profundicola	7	12	2
Centrolabrus exoletus	10	19	2
Pomadasys incisus	4	8	2
Spinachia spinachia	5	9	2
Diplodus vulgaris	5	8	2
Lycodes vahlii	5	10	2
Zeus faber	2	4	2
Pagellus bellottii	4	8	2
Chauliodus sloani	10	18	2
Buglossidium luteum	2	3	2
Arnoglossus thori	18	33	2
Spratelloides lewisi	6	11	2
Melanonus zugmayeri	12	22	2
Neoraja iberica	12	22	2
Chelidonichthys obscurus	6	11	2
Hygophum benoiti	9	16	2
Callanthias ruber	17	31	2
Serranus scriba	9	16	2
Echiodon dentatus	11	20	2

Arnoglossus imperialis	3	6	2
Pagrus pagrus	4	8	2
Nessorhamphus ingolfianus	20	36	2
Macroparalepis affinis	13	24	2
Peristedion cataphractum	23	44	1
Diplecogaster bimaculata	2	4	1
Lycodes gracilis	5	11	1
Petromyzon marinus	12	21	1
Ophichthus rufus	38	72	1
Diplodus sargus	9	16	1
Argyropelecus hemigymnus	2	4	1
Argyropelecus gigas	8	15	1
Echiostoma barbatum	12	22	1
Cepola macrophthalma	3	8	1
Lestidiops jayakari	11	21	1
Syngnathus rostellatus	15	25	1
Chlorophthalmus agassizi	6	11	1
Limanda limanda	2	3	1
Spondyliosoma cantharus	2	5	1
Mullus surmuletus	3	5	1
Peristedion cataphractum	12	23	1
Benthodesmus simonyi	35	60	1
Scomberesox saurus	28	49	1
Raniceps raninus	5	9	1
Alepocephalus bairdii	12	22	1
Rostroraja alba	21	40	1
Pagrus auriga	14	27	1
Callionymus reticulatus	26	55	1
Lepidion eques	5	8	1
Chaunax pictus	8	14	1
Chelidonichthys lastoviza	6	10	1
Hippocampus hippocampus	8	16	1
Scomberesox saurus	15	28	1
Pleuronectes platessa	3	5	1
Syngnathus rostellatus	5	9	1
Polymetme thaeocoryla	7	12	1
Myxine glutinosa	7	12	1
Hoplostethus atlanticus	6	12	1
Leptoclinus maculatus	8	18	1
Paralepis coregonoides	13	24	1
Zeugopterus regius	14	25	1
Hippocampus hippocampus	5	8	1
Ceratoscopelus maderensis	6	11	1
Raja brachyura	7	12	1
Liparis montagui	16	30	1
Lycodes gracilis	26	59	1

Parasudis fraserbrunneri	12	21	1
Ciliata mustela	4	7	1
Syngnathus typhle	17	31	1
Cyclopterus lumpus	3	6	1
Serranus cabrilla	5	9	1
Squalus blainville	13	25	1
Dipturus oxyrinchus	16	28	1
Ciliata septentrionalis	3	5	1
Osmerus eperlanus	4	6	1
Galeus atlanticus	8	15	1
Alepocephalus rostratus	7	12	1
Centrolabrus exoletus	6	10	1
Hydrolagus mirabilis	7	13	1
Thunnus thynnus	9	18	1
Echiodon drummondii	41	91	1
Microchirus variegatus	3	5	1
Stromateus fiatola	8	15	1
Phycis phycis	10	18	1
Chirostomias pliopterus	12	22	1
Gobius paganellus	5	9	1
Centroscyllium fabricii	15	26	1
Argyropelecus olfersii	2	4	1
Lumpenus lampretaeformis	3	8	1
Gadella maraldi	6	11	1
Mustelus mustelus	12	23	1
Parablennius gattorugine	5	9	1
Polymetme corythaeola	23	42	1
Epigonus telescopus	5	9	1
Gaidropsarus mediterraneus	7	12	1
Gadiculus argenteus	2	3	1
Symphodus melops	5	9	1
Symphodus bailloni	5	8	1
Xenodermichthys copei	3	6	1
Trachyscorpia cristulata	9	17	1
Carapus acus	20	36	1

- Feeding guild responses to environmental and anthropogenic pressures were not considered here but will be in future (e.g. following Thompson et al., 2020, 2021)
- The knock-on effects of change in feeding guilds across assemblages (plankton, benthos, top-predators) requires further research.
- Where diet data are not yet available (e.g. Portugal), feeding guilds have been inferred based on data from adjacent areas.
- Morphological analysis of stomach contents may under-sample certain prey, e.g. those comprised of only soft tissues.
- PPMRs are based on prey weights from stomach contents and may thus be affected by varying levels and rates of digestion.

- Top-predators (e.g. seabirds, cetaceans) and organisms lower in the food web (e.g. benthos, plankton) have not yet been classified into guilds but diet databases for such taxa do exist and could be included in future.
- Pelagic fish species and juvenile fish are under-sampled using trawls. Acoustic methods and catchability corrections can be applied to address some of these issues, but have not yet been applied at the scale of the OSPAR area.

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Assessment Metadata

Field	Data Type	
Assessment type	List	Pilot Assessment
SDG Indicator	List	14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans
Thematic Activity	List	Biological Diversity and Ecosystems - Targeted actions for the protection and conservation of species, habitats and ecosystem processes
Relevant OSPAR Documentation	Text	Agreement 2018 – 05 CEMP Guideline: Combined guideline for processing of survey data for fish and food webs common indicators FC2, FC3, FW3 and FW7.
Linkage	URL	The feeding guild publication this candidate indicator pilot assessment developed from: A feeding guild indicator to assess environmental change impacts on marine ecosystem structure and functioning - Thompson - 2020 - Journal of Applied Ecology - Wiley Online Library Open access pre-print: Microsoft Word - Thompson et al Feeding guilds_preprint (researchgate.net) Survey data were downloaded from: Lynam, C. P., & Ribeiro, J. (2022). *A data product derived from Northeast Atlantic groundfish data from scientific trawl surveys 1983-2020.* https://doi.org/https://doi.org/10.14466/CefasDataHub.126
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Our vision is a clean, healthy and biologically diverse North-East Atlantic Ocean, which is productive, used sustainably and resilient to climate change and ocean acidification.

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