



- Fish and cephalopods monitoring on the Bay of Biscay and Celtic 1
- Sea continental shelves 2
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- 10 Abstract

11 The demersal fish and cephalopod communities of the continental shelves of the Bay of Biscay and the Celtic Sea 12 have been monitored for more than 30 years by the EVHOE series of fisheries surveys. Since 1987, a total of 4247 13 stations have been sampled in the fall with a GOV bottom trawl in a depth range of 15 to 600m. The main objective 14 of these surveys is to monitor 22 benthic fish stocks and 10 cephalopods but also to provide a description of the 15 distribution of a total of 250 fish and 50 commercial invertebrate taxa. The dataset 16 (https://doi.org/10.17882/80041) provides abundance and biomass information by station for all obsertion axa. 17 Size distributions for a selection of species are also available. These data are part of a larger set of standardized 18 European surveys that provide essential information for monitoring demersal communities in the Northeast 19 Atlantic. We propose 🔤 a critical analysis of the dataset especially in terms of the evolution of the sampling 20 effort and strategy as well as the taxonomic precision.

#### 21 1 Introduction

22 In North-East Atlantic, monitoring of exploited populations is based on an European network of observation 23 surveys at sea for both pelagic (International Pelagic Surveys, IPS) and benthic (International Bottom Trawl 24 Surveys, IBTS) species. This network is included in the European Data Collection Multi Annual Program 25 (Decision (EU) 2016/1701, EU-MAP Commission EU/2016/1251) to 🔤 fort the implementation of the European 26 Common Fisheries Policy (CFP). Even if the data must be combined with caure Moriarty et al. 2020), these 27 scientific surveys provide consistent and standardized data (common protocols  $\frac{1}{1000}$  in ICES, 2017) to ICES 28 assessment and science groups. In particular, the data allow stock assessors to analyze spatial and temporal 29 variations in the distribution and relative abundance of fish populations (notably pre-recruits) as well as those of 30 the biological parameters of the exploited species. These data thus provide fisheries independent abundance indices 31 for commercially valuable species and to collect hydrographical and environmental information.

32 On the basis of scientific surveys carried out in the North Sea, France aimed to develop comparable monitoring in

33 the Bay of Biscay. In this context, a French groundfish survey, named EVHOE ("EValuation Halieutique de l'Ouest

- 34 Européen", ICES name "FR-EVHOE-Q4") was initiated in 1987, after two exploratory surveys in 1973 and 1976. 35
- A research vessel, "RV Thalassa" (construction year 1960, 6 = h length, 10.4 m width, 5 m draught), deployed 36 a standardized bottom trawl (GOV) to sample different strata in terms of bathymetry and latitude. Benthic and
- 37 demersal fish and cephalopods catches were identified, tri + reighted, measured and some specific species are
- 38 aged, sexed and their sexual maturity are described. The prospected area was extended in the whole Celtic Seas





- since 199 g. 1), year of the starting of the new French research vessel also named "Thalassa" (constru 39
- 40 year 1996, 73.65 m length, 14.9 m width, 6.1 m draught).
- 41 EVHOE covers the Celtic Sea (ICES divisions 7fghj) and the French part of the Bay of Biscay (ICES divisions
- 8ab). The surveys were carried out in the fall from the end of Or and the classification of sampling stations among the 42
- survey months is shown in Fig.2) and extend from 15 to 600m depth. The collection of robust biological and 43
- 44 environmental data allowed to month 22 ben 📻 ish and 10 cephalopods stocks (ICES 2019) from the North-
- 45 East Atlantic.

#### 46 Table 1: List of stocks monitored by EVHOE survey or for which the data are used for the calculation of

assessment indices 47

Components	Species	Stock (ICES divisions)	ICES code	
	Capros aper	678	boc.27.6-8	
	Chelidonichthys cuculus	3-8	gur.27.3-8	
	Gadus morhua	7.e-k	cod.27.e-k	
	Calana and and and	67	sho.27.67	
	Galeus melastomus	89.a	sho.27.89a	
	Lepidorhombus whiffiagonis	7.b-k8abd	meg.27.7b-k8abd	
	Lepidorhombus boscii	7.b-k8abd	ldb.27.7b-k8abd	
	Leucoraja fullonica	67	rjf.27.67	
	Leucoraja naevus	678.abd	rjn.27.678abd	
	Lophius budegassa	7.b-k8.abd	ank.27.78abd	
T7*1	Lophius piscatorius	78abd	mon.27.78abd	
FISN	Melanogrammus aeglefinus	7.b-k	had.27.7.b-k	
	Merlangius merlangus	7.b-ce-k	whg.27.7b-ce-k	
	Merluccius merluccius	3.a46-8.abd	hke.27.3a46-8abd	
	Micromesistius poutassou	1-91214	whb.27.1-91214	
	Mustelus asternos	1-101214	sdv.27.nea	
	Pagellus bog	678	sbr.27.6-8	
	Phycis blennoides	1-101214	gfb.27.nea	
	Raja clavata	8	rjc.27.8	
	Scomber scombrus	1-89.a14	mac.27.nea	
	<i>a 1: 1: · · 1</i>	67.a-ce-j	syc.27.67a-ce-j	
	Scyllorninus canicula	8.abd	syc.27.8abd	
		7.agj (FU19)	nep.fu.19	
7	N7 1	7.gh (FU20-21)	nep.fu.2021	
rustaceans	Nephrops norvegicus	7.gf (FU22)	nep.fu.22	
		8.ab (FU23-24)	nep.fu.2324	
	Alloteuthis	8.ab	-	
	Illex coindetti	8.ab	-	
	Loligo forbesi	8.ab	-	
	Loligo vulgaris	8.ab	-	
	Rossia macrosoma	8.abd	-	
Cephalopods	Sepia elegans	8.abd	-	
	Sepia officinalis	8.abd	-	
	Sepia orbinyana	8.abd	-	
	Todarodes sagittatus	8.ab	-	
	Todaropsis eblanae	8.ab	-	

48 49 place to progressively monitor the entire marine ecosystem. In addition to the fish and cephalopods species 50 historically observed, the entire benthic invertebrate communication "benthos") as captured by the trawl has now been recorded since 2008. It provides information on regional biodiversity, improves our understanding of the structure 51





52 and functioning of communities, and addresses new issues related to human impacts from the effects of regional 53 activities such as fishing to global effects such as climate change (e.g. Poulard and Blanchard 2005, Rochet, 54 Trenkel et al. 2005) implementation of the Marine Strategy Framework Directive (MSFD) in 2008 planned 55 monitoring programs to provide data concerning offshore areas. The EVHOE survey was identified as a platform for observing the entire marine ecosystem of the Bay of Biscay and the Celtic Sea. An optimization work was 56 57 realized from 2013 to 2015 to implement new protocols able to provide new data like seafloor litter replastics, 58 zooplankton, contaminants, submarine noise (derived from AIS vessel tracking records) or hydrological data 59 (Baudrier et al., 2018).

- 60 In the present paper we provide details of the long term dataset for fish and cephalopods collected on the
- 61 continental shelves of the Bay of Biscay and the Celtic Sea during the EVHOE survey. Non-commercial
- 62 invertebrate ("Benthos") data are not included in this first dataset; they will be the subject of a-later addition.

#### 63 2 Data and methods

64 The EVHOE dataset provides information on catch of benthic and demersal fish and cephalopods of the Bay of Biscay and the Celtic Sea from 1987 to 2020. At the beginning of the series of surveys, the observations were 65 66 exclusively carried out in the Bay of Biscay. From 1997 onwards the observation area has taken its current 67 extension including the entire Celtic Sea. The research vessel (1 🔤 also changed in 1997. The "old" R/V Thalassa ("Thalassa I"), the first French stern trawler dated of 1960 and used since the beginning of EVHOE survey was 68 69 replaced by the actual R/V Thalassa ("Thalassa 1 ince 1996. Thalassa II is 73.65 m long and 14.9 m wide 70 trawler (gross tonnage of 3022 t). An intercalibration experiment based on paired hauls was conducted in 1996 to 71 estimate conversion coefficients between vessels (Pelletier, 1998). The temporal continuity of data time series may 72 be hindered by a change in survey vessel and become a biais for estimating the abundance of populations in 73 fisheries science.

#### 74 2.1 Sampling strategy and gear

75 The usual season of observation is in autumn, but two years (1988 and 1991) also offered additional spring 76 observations (Mahé & Poulard, 2005) but these data are not included into the published dataset. On the other hand, a few years weight nissing from the data series for autumn sampling (1991, 1993, 1996, 2017); the absence of a 77 survey in these years were usually due to technical problems with the R/V. The studied area was limited to the 78 79 Bay of Biscay, between the latitudes 43°40'N and 48°30'N, from 1987 to 1989. In 1990, the prospected area was 80 extended to the South part of the Celtic Sea (latitude 51°15'N). During the change of research vessel in 1997, a revision of the objectives and sampling protocols was carried out and the observer on area was extended to the 81 82 whole Celtic Sea.





Table 2: Chronology for the survey IBTS-Q4-EVHOE of the main features of the data acquisition
 protocols

Year	Vessel	Areas	Sampling strategy	Fishing gear & geometry sensors	Data management	Comments		
1973 & 1976		Bay of Biscay				Preliminary test surveys "RessGasc" not included into the dataset		
1987- 1989	sa I	Discay		GOV36/47 no	Data input in 2 steps: onboard	Start of the EVHOE series		
1990- 1995	Thalas	Bay of Biscay		gear sensors	paper and copy in "local spreadsheet	Missing year: 1991 (spring only) and 1993		
1996		southern and central Celtic Sea		GOV36/47 Gear sensors (Scanmar, not recorded)	/database"	No data: intercalibration of R/V Thalassa I and II		
1997		Bay of Biscay and whole Celtic Sea	Randomly	GOV36/47 Gear sensors (Scanmar /	Data input in 2 steps: onboard paper forms & writing in a	First EVHOE survey with Thalassa II		
1998- 2015			Bay of Biscay and whole Celtic Sea	II ESSET Bay of Biscay and whole Celtic Sea		Marport from 2014, not recorded)	Microsoft-Access database	
2015	Thalassa II						Data input in 1 step with Allegro c. software* & writing in centralized/ database ("Harmonie"**)	Implementation of the new on-board data entry system "Allegro campagne"
2016						GOV36/47 (Marport sensors	Adding a	New sampling strategy, strata Cn7, Cc7,Cs7 not included in the new scheme
2017					Fixed	explorer, data recorded from 2017 onwards)	electronic ichthyometer	Year not included into the dataset (only 15 points sampled due to technical issues)
2018- 2019					Tixeu		Data control tools	2019 missing points into strata Cn2 and Cn3 due to meteorological issues
2020					implementation ***	relocation of 4 stations of the Celtic Sea (within the same strata) to comply with UK MPA areas		

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\* <u>www.ifremer.fr/allegro/ ;</u> \*\* Leblond et al. 2008 ; \*\*\* R shiny application for data control ("TUTTI

86 controller")

The trawl used for sampling is a GOV 36/47 ("Grande Ouverture Verticale", see description in ICES, 2017). From the standard GOV trawl, the Exocet Kite is replaced by additional buoyancy 66 floats in-stead of 60, and 21 floats of 4 litters compensate for the weight of Marport sensors placed intervention in increasing and the gear has an average horizontal opening around 20.6 m (wingspread range between 17 and 22m) and vertical opening around 4m (range from 3.5 to 5m). The doors are plane-oval of 1350 kg. Trawl sweeps of different lengths are used

92 depending on the operating depth: sweep of 50 m for depths less than 140 m, sweeps of 100 m for deeper depths





93 The net is fitted with a 20 mm codend liner. During the trawling, the gear parameters were monitored by "Scanmar" 94 system (Table 2) and in recent years by "Marport" system. The parameters that are monitored are the door spread, 95 the wing spread, the headline height and the height of and rope. They allow appreciating the behavior of the 96 gear during fishing operations but also to assess the accor even the volume sampled. The accuracy of trawling 97 parameters has therefore evolved over time and the data from the trawl geometry sensors were not recorded until 98 year\_2017. In order to preserve the homogeneity of the dataset, and despite the existence of actual trawl parameters 99 s recorded from 2017 onward, standard median value of horizontal trawl opening (20.6 m) is utilized. The 100 swept area (about 0.076 km<sup>2</sup> for a standard 30' tow) was then calculated from the distance covered by the trawl. 101 The file also provides the duration of the haul, which is a useful standard effort value when combining data from 102 different surveys using a similar fishing gear. Moreover, the trawl is equipped with a CTD probe allowing for each 103 station to record temperature, depth and salinity profiles (the latter only for stations less than 300m deep). 104 Additionally, a number of navigational parameters or meteorological variables were also-monitored but are not 105 included into the published datase =

106 The sampling scheme defined a geographic stratification that separates the Bay of Biscay in 2 areas and the Celtic Sea into 3-areas and seven depth strata from 20 m to 600 m (Fig. 1 and Table 3). From 1987 to 2015, the sampling 107 strategy followed a stratified random strategy (Fig. 1). A Neyman allocation on numbers vanance averaged on the 108 109 4 most important commercial species (hake, the two species of monkfish and northern megrim) was utilized to set 110 tl 🚌 mber of stations per stratum. The number of stations pro 😑 phal to the surface of the stratum and minimum 111 of two stations per stratum. Each sampled station was obtained by random selection from a set of reference stations 112 trawlable in the sampled area with the aim of sampling at least 140 stations per year. The area covered included 113 only the Bay of Biscay in 1987, it was extended to the southern part of the Celtic Sea from 1990 (not sampled in 1994 and 1995 following damage to the propulsion engine) and since 1997 has diversed the whole of the Bay of 114 115 Biscay and the Celtic Sea.

116 From 2016, the sampling strategy was changed to a fixed sampling strategy. The reason for this change was that 117 the spatial coverage of some large strata was to  $\frac{1}{1000}$  ly variable from  $\frac{1}{10000}$  ear to another. Thus, depending on the 118 random selection of points, areas of significant size were not provide the stabilization of sampling points also 119 facilitated analyses that aimed at studying the spatial structures of species or communities and their evolution over 120 time. Finally, this change made it possible to better harmonize the sampling strategies with the "IBTS" campaigns 121 of other countries. The random selection of stations in 2016 (total number = 155) has been utilized as the reference 122 sampling scheme for the next years. The new sampling design did not include some stations into the Celtic deeper 123 strata (Cs7,Cc7 and Cn7), as well as the points sampled in some part of the shallowest strata of the Bay of Biscay 124 (e.g. some rarely sampled points into enclosed bays). In the central-eastern part of the Celtic sea, we added 4 125 additional to complete strata coverage.

Sampling was carried out with straight tows during the daylight, lasting 30 minutes at the bottom (a minimum of 20 minutes accepted in the protocols to validate a haul) at a constant speed of 4 knots. Some tows were stopped before the end of the total trawl time when excessively high tensions were detected (a sign of large catches) or more recently (from 2018 onward) when a strong pelagic acoustic signal was observed from the on-board sounders. These tows were considered valid and included in the dataset when they lasted at least 20 minutes and that the fishing gear has not suffered any damage. They represent less than 10% of the tows (about 2 to 14 tows per year) with higher proportions in recent years due to the improved control of the trawl variables described above.





Name	Code	denth (m)	Surface (km <sup>2</sup> )
EVHOE survey	EVHOE	ucpin (iii)	235420
Bay of Biscay area	GG		75856
Southern BoB sector	Gs	116	15308
strata 1	Gs1	27	1960.11
strata 2	Gs2	44	4641.41
strata 3	Gs3	111	4014.68
strata 4	Gs4	156	2994.62
strata 5	Gs5	187	441.75
strata 6	Gs6	379	599.35
strata 7	Gs7	508	656
Northern BoB sector	Gn	121	60548
strata 1	Gn1	26	8201.69
strata 2	Gn2	63	11771.07
strata 3	Gn3	105	17327.21
strata 4	Gn4	137	18854.03
strata 5	Gn5	184	1612.12
strata 6	Gn6	302	1090.2
strata 7	Gn7	518	1691.76
Celtic Sea area	MC		159564
Southern Celtic sea sector	Cs	151	63269
strata 4	Cs4	139	41500.49
strata 5	Cs5	175	15204.87
strata 6	Cs6	252	3995.49
strata 7	Cs7	457	2564.25
Central Celtic Sea sector	Cc	127	59025.29
strata 3	Cc3	105	20267.46
strata 4	Cc4	128	28211.7
strata 5	Cc5	164	5309.6
strata 6	Cc6	307	3490.58
strata 7	Cc7	512	1746.04
Northern Celtic Sea sector	Cn	81	37270.1
strata 2	Cn2	68	14828.35
strata 3	Cn3	99	22441.75

# 133 Table 3: Description of sampling strata for IBTS-Q4 Evhoe.

# 134 2.2 Samples sorting, species identifications, biological measurements and sampling

135 Wherever possible, the entire catch was sorted, with fish and commercial shellfish, crustaceans and 136 cephalopods species identified to the lowest taxonomic level. On the other hand, when the total catch in the trawl was too large (e.g. several tons of small pelagic fish), only a fraction of the total catch was fully processed (mostly 137 138 1/2 to 1/4 and exceptionally >1/5 of the total catch weight). For the partially sorted part, individuals of rare or 139 particularly large species were still extracted and processed. On average for the recent years (from 2014), those partially processed tows represented 11 to 18% of the total number of stations. Due to a lack of data, this proportion 140 could not be properly assessed for surveys pr = 2014. It can be assumed that this proportion may have been 141 142 higher in the past, particularly at Thalassa I, due to less efficient sorting facilities.

143Individuals lengths were recorded for most fish species and some commercially important cephalopods144and shellfish species. Individuals Length was measured at the lower half-centimetre level for small species of145pelagic fish, and to the lower 1 cm level for all other fish and cephalopods species. A representative sample was146selected (ideally >10 times the number of length classes) when the number of individuals caught was too large to





be fully measured on board. Sex was determined for a set of fish and commercial invertebrates species (32 to 54
species depending on years and 107 species for the whole time series). For about 20 fish species, ageing material
was collected (otoliths, ilicia or scales) and individual weight, length measurements and determination of maturity
stages from 2000 onwards were carried out with a sampling strategy following a stratified allocation by length
class and by sex. However, these data required significant revision and were not included in the submitted version
of the dataset. They will be the subject of an additional publication.

153 Data entry on board was initially carried out on paper forms that were then copied to computer databases. Starting 154 in 1997, on the R/V Thalassa 2, a computer system for recording catches ("pupitri") allowed for the automated 155 banking of species and their total weight, with individuals-informations-(sex, counts, size measurements, maturity) still being entered on paper forms. These data were then transferred to an internal database under "Microsoft 156 157 Access" software (database specific to the EVHOE campaign, not standardized with others IFREMER databases). 158 From 2014 onwards, data was recorded on board with an open-source software especially developed for fisheries 159 surveys ("Allegro Campagne" software, http://www.ifremer.fr/allegro/, https://forge.codelutin.com/projects/tutti). 160 From 2016 onwards, the lengths were also measured using an electronic ichthyometer directly connected to the 161 data management system. Only the sizes of the largest individuals (> 85cm) and the weight data of the sub-samples 162 and individuals fish were still entered manually. In addition, a set of automated data control and correction tools 163 were put in place in recent years (both within the "Allegro" software and from separate dedicated tools greatly 164 improved in 2020). These tools have been applied a posteriori on the whole data series; the EVHOE dataset 165 proposed here (Laffargue et al. 2021) has therefore been significantly corrected.

166 The dataset consists of 3 tables in a ".csv" file format (Table 4): the "Haul" table provides stations metadata, the 167 "Catch" table including taxa number and biomass, the "Size" table providing length and sex observations for a 168 short list of species. The data provided are identical to the raw data stored in IFREMER's internal database 169 ("Harmonie") and have not been subject to any modifications other than those necessary to recalculate the total 170 catch in the event of subsampling. The "World Register of Marine Species" (WoRMS Editorial Board, 2020) was 171 used to update the taxonomy (valid names and Aphia ID) by utilizing dedicated R packages (« worms 0.2.2" and 172 "worrms 0.4.0"). The provision of this dataset makes it possible to give it an official reference 173 (https://doi.org/10.17882/80041), to make updates more easily accessible and, above all, to provide additional 174 information that is not included in the ICES databases, particularly in connection with the evolution of the 175 protocols. The proposed format will make it possible to link the data coming from other biological compartments 176 (e.g. benthos) or environmental observations observed on the same survey but not included in the original 177 protocols.

A set of videos made on board provide additional elements of understanding of all the operations performed andthe protocols applied (Lesbats et al. 2019a,b).

# 180 Table 4: Tables and fields included in the EVHOE dataset





Field name	Data table		:	Description
	Haul	Catch	Size	
Survey	Х	Х	Х	Survey name
Year	Х	Х	Х	year of sampling
StationID	Х	Х	Х	unique haul ID
Month	Х			month of the sampling
Distance	Х			sampled distance in m
Area	Х			sampled area in km <sup>2</sup>
Duration	Х			haul duration in minutes
Lat	Х			Haul latitude in decimal degrees
Lon	Х			Haul longitude in decimal degrees
Depth	Х			mean depth of the sampled station in m
Taxa		Х	Х	scientific name of the taxa
AphiaID		Х	Х	International unique code for taxa
Number		Х	Х	number of individuals for a given haul, length or sex category
WeightKg		Х		Total weight in kg for the taxa in the haul
Sex			Х	individuals sex category, N:not observed, I:undetermined, M:male, F:female
Length			Х	length class of the individuals in cm

In addition to a description of the data, we propose a short critical analysis by comparing in particular the evolution
 of the specific richness on the whole series. These results are based on a bootstrap analysis using richness estimates
 from a random selection of stations and from 1000 permutations (R specaccum function from vegan 2.5.6 library,

184 Oksanen et al 2019, R Core Team 2019).

# 185 3 Data availability

186 The updated EVHOE dataset is provided on the SEANOE platform (Laffargue et al. 2021, https://doi.org/10.17882/80041) which includes automatic duplication to the EMODnet marine data portal (https://www.emodnet-ingestion.eu). The raw collected data were currently banked on an IFREMER's internal general database (Harmonie) collecting in a standardized way the whole data flow of IFREMER fisheries information system (https://sih.ifremer.fr/Donnees). Moreover, the data were annually reported to the ICES database DATRAS (http://www.ices.dk/marine-data/data-portals/Pages/DATRAS.aspx).

# 192 4 Discussion: dataset content & quality

193 The EVHOE series dataset offers a standardized observation of all bentho-demersal ichthyofauna, cephalopods 194 species and some large invertebrates for a long-term series of 32 and 22 years for the Bay of Biscay and Celtic Sea 195 respectively. This survey series inventoried a total of 658 marine taxa (Fig. 3A). The proposed dataset includes





196 250 "fishes" (including 34 elasmobranchs, Fig. 3C) and 50 "commercial" invertebrates species (mainly 197 cephalopods and some crustaceans, gastropods and bivalvia, Fig. 3B-D) but does not include the 408 taxa of others 198 non-commercial invertebrates ("benthos") recently inventoried (from 2008 onwards). In the complete dataset for 199 both the Bay of Biscay and the Celtic Sea, pelagic fish largely dominate the catches both in number and biomass 200 (Fig. 4) with 6 main species (Capros aper, Trachurus trachurus, Micromesistius poutassou, Scomber scombrus, 201 Engraulis encrasicolus and Sardina pilchardus) and this even if the trawl used does not target and presents a very 202 relative efficiency for this compartment. Among the demersal fish for the whole series of data, 3 species 203 (Merluccius merluccius, Trisopterus minutus, Trisopterus luscus) largely dominated the catches in the Bay of 204 Biscay, in the Celtic Sea the pout (T.minutus) is also among the main species but this area stands out with the 205 dominance of Trisopterus esmarkii, haddock (Melanogrammus aeglefinus) and whiting (Merlangius merlangus). 206 However, the complete biological dataset, particularly for the Bay of Biscay (1987-present), should be considered 207 with caution. The change of vessel in 1996 and the intercalibration work has shown significant differences in the 208 catchability of the gears for some of the species caught. A number of conversion parameters between the 2 research 209 vessels were proposed (Pelletier, 1998) but they do not cover all the species observed. Moreover, some species are 210 poorly captured by the gear used (e.g. burrowing crustaceans like Nephrops, or flating like Solea solea) or the 211 sampling strategy does not correctly reflect their distribution for part or all of their life history (e.g. species with 212 juvenile in shallow water nurseries). The low sampling effort in the shallowest areas (strata 1) in comparison with 213 the diversity of habitats and associated communities makes the description of benthic communities by this dataset 214 unreliable in this strata.

215 Observed total species richness varies among year and main areas with three main periods (Fig. 5A-B): years 1987 216 to 1990 with a lower richness, years 1992 to 2000 with intermediate values and highest values for the years after 217 2000 (with the exception of a low value in 2003). The similarity of the species list within these years groups is 218 also stronger (see cluster results for the years, Fig. 5C-D). Although at the survey level an evolution of the sampling 219 strategy may account for differences in diversity (*e.g.* "apparition" of *Trisopi* esmarkii in 1990 linked to the 220 extension in the Celtic Sea), these variations can not only be attributed to a change in the sampling strategy or to 221 a natural evolution of the monitored ecosystems. We-can notice that there is greater variability in species richness 222 during the first decade of the data series, particularly visible for the Bay of Biscay areas (Gs, Gn), with interannual 223 variations that are sometimes very large despite an equivalent sampling effort per area. Overall, a «-stabilisation » 224 of the annual specific richness has been observed from the 2000s onwards, which mainly reflects a better 225 consideration of all species and a reliability or stabilization of the two points skills of the on-board teams. Diversity 226 analysis or monitoring of a particular species must take into account possible observation deficiencies. For 227 example, the species Arnoglossus imperialis is relatively less frequent in the initial part of the survey series (1987-228 1992) compared to the more recent period. This difference most probably comes from confusion with the closely 229 related species A. laterna. Moreover, new taxonomic determination efforts increased the number of species 230 considered as (e.g. from 2010 onward 11) species added to the previously sepiolidae family). 231 A table provided in the appendix summarized the information about the taxa with identification issues or 232 improvements that occurred during the EVHOE time series. 233 Moreover, difficulties of identification for some rare species or including not very obvious morphological criteria

reduces the validity of this series for some taxe that should be considered with caution (Appendix A). Even if we do not explicitly propose a priori regrouping or modification of the dataset, some of those species should be





236 considered for grouping for part or the whole time series according to the desired applications. However, the 237 accuracy of the determination has globally increased and become more reliable over time. The stabilization of the 238 sorting effort, the reduction of the work-load (e.g. sorting conveyor belts of the Thalassa 2) and the improvement 239 of the sorting quality thanks to the support of the new computer tools but also the improvement of the quality of 240 the species determination are important factors in the quality increase of the EVHOE series. This stabilization of 241 quality is especially important for analysis and development of relevant indicators in a context of important 242 changes in marine communities under the double effect of local or global anthropogenic pressures (e.g. fishing or 243 climate).

244 The observation scale of EVHOE survey is particularly relevant for covering certain populations, fish stocks or 245 even the biogeographical dimension for certain monitored species. These data are already valued in an operational 246 framework to provide useful indices for fish stock assessment (IFREMER 2020, ICES 2020, Tab.1) or for the 247 assessment of marine ecosystems as developed, for example, for the European Marine Strategy Framework 248 Directive (MSFD, EC, 2008 ; EC, 2017) or in the OSPAR Convention (OSPAR, 2017). The environmental status 249 of fish biodiversity or fisheries resources is assessed from common indicators using EVHOE data (Brind'Amour 250 & Delaunay, 2018 ; Foucher & Delaunay, 2018). Under the MSFD implementation, the EVHOE scientific survey 251 integrates the monitoring program due to standardised methods for monitoring, including spatial and temporal 252 sampling strategies (EC, 2020 ; France, 2015). These data are used to calculate an abundance indice to fill the 253 D1C2 criterium relative to the abundance of fish population. Time series of the indice are analyzed to describe the 254 ecological status of the demersal fish group. It guides the definition of environmental objectives and measures 255 program to achieve or maintain good environmental status of French marine ecosystems. Differents parameters 256 collected during EVHOE were used to evaluate other criteria as D1C3 relative to demographic characteristics or 257 D1C4 relative to geographical distribution of fish population. In another framework, OSPAR Convention aims to 258 achieve a network of well-managed marine protected areas which is ecologically coherent. The quality status of 259 the North-East Atlantic is regularly assessed. EVHOE data were used to calculate different indicators as FC1 -260 Recovery in the population abundance of sensitive fish species, FC2 - Proportion of large fish (Large Fish Index) 261 or FW3 - Size composition in fish communities (OSPAR, 2017).

We can also note the interest of the data produced to identify certain elements of the remarkable diversity that is all the more appreciable with the improvement in the quality of species determination. In particular, the detection of rare or new species in the study area are valuable data for characterizing regional biodiversity and judging the evolution of continental shelf communities.

266 The strength of this series also lies in the additional data (hydrological, other biological compartments) acquired

267 simultaneously and offering an increasingly complete panorama of the ecosystems of the continental shelves in

the fall period. These additional observations, which are sometimes relatively recent, are processed independently

269 of this dataset and will be the subject of subsequent publications.

### 270 5 Table caption

- 271 Table 1: List of stocks monitored by EVHOE survey
- 272 Table 2: Chronology of the main features of the data acquisition survey IBTS-Q4-EVHOE
- 273 Table 3: Description of sampling strata for IBTS-Q4 Evhoe.
- 274 Table 4: Description of data tables and associated fields





#### 275 6 **Figure caption**

276 Figure 1: Sampling area of IBTS-Q4 EVHOE survey A. description of the strata for each sectors, Celtic Seas (Cn:north,Cc:central, Cs:south) and the bay of Biscay (Gn:north, Gs:south) and positions of the 277 278 sampled points. B - initial randomly stratified sampling plan (1987), C - addition of the Celtic sea (1997), D 279 - stabilized sampling plan (2016 to now). Roman numerals of the ICES divisions are also indicated (8.a to 280 8.f and 7.d to 7.j).

- 281 Figure 2: Distribution of stations sampled for the whole Evhoe time series, A. proportion by sampling months, B. proportion by sampling sectors for autumn survey (only for autumn months: 9,10,11,12). The 282 283 black lines on both graphs indicates the total number of sampled stations by year.
- 284 Figure 3: Number of taxa observed for the whole time series, A. number per classes for all the taxa 285 (including the benthos species), B. number per order for fishes taxa only, C. number per classes for commercial list of taxa only (standard evhoe protocole) and D. for "commercial invertebrates" taxa. 286

Figure 4: Abundance in number and biomass of the 10 main species observed in the Celtic Sea during 287 288 EVHOE 1997-2018 and in the Bay of Biscay during EVHOE 1987-2018 for 4 main groups of species: Benthic 289 Demersal Actinopterygii, Pelagic Actinopterygii, Elasmobranchii and Commercial invertebrates.

290 Figure 5: Boxplots of the fish taxa richness as obtained from bootstrap analysis of the sampling station 291 richness. The colors indicates the clusters depending on years similarities. Analysis is separately performed

- 292 for the Bay of Biscay and the Celtic Sea for the whole available time series
- 293

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Figure 1: Sampling area of IBTS-Q4 EVHOE survey A. description of the strata for each sectors, Celtic
Seas (Cn:north,Cc:central, Cs:south) and the bay of Biscay (Gn:north, Gs:south) and positions of the
sampled points. B - initial randomly stratified sampling plan (1987), C - addition of the Celtic sea (1997), D
- stabilized sampling plan (2016 to now). Roman numerals of the ICES divisions are also indicated (8.a to
8.f and 7.d to 7.j).

![](_page_13_Picture_1.jpeg)

![](_page_13_Picture_2.jpeg)

![](_page_13_Figure_3.jpeg)

Figure 2: Distribution of stations sampled for the whole Evhoe time series, A. proportion by sampling
months, B. proportion by sampling sectors for autumn survey (only for autumn months: 9,10,11,12). The
black lines on both graphs indicates the total number of sampled stations by year.

372

![](_page_14_Picture_1.jpeg)

![](_page_14_Picture_2.jpeg)

![](_page_14_Figure_3.jpeg)

373

Figure 3: Number of taxa observed for the whole time series, A. number per classes for all the taxa
(including the benthos species), B. number per order for fishes taxa only, C. number per classes for
commercial list of taxa only (standard evhoe protocole) and D. for "commercial invertebrates" taxa.

![](_page_15_Picture_1.jpeg)

![](_page_15_Picture_2.jpeg)

	Celtio	: sea	Bay of Biscay		
	1997-	2020	1987-2020		
	1557-	2020	1507 2020		
	composition by weight (11.88% of total catch)	composition by number (5.43% of total catch)	composition by weight (9% of total catch)	composition by number (4.48% of total catch)	
	Melanogrammus aeglefinus 23.8 %	Trisopterus minutus 29.8 %	Metuccius metuccius 26.9 %	Trisopterus minutus 43.2 %	
	Trisopterus minutus 18.5 %	Trisopterus esmarka 22.3 %	Trisopterus minutus 25.2 %	Merluccius merluccius 21.2 %	
Benthic	Metangkis metangus 15.8 %	Melanogrammus aegletinus 11.7 %	Trisoptenus luscus 17.2 %	Argentina sphyraena 12 %	
Dentine	Metuccus metuccus 6.0 % Traceterus esmarki 7.9 %	Argentina sphyraena 7.7 % Merlanoka merlanova 7.6 %	Argentina situs 10.2 % Concer concer 14.6 %	Gadoulus argenteus 44%	
Demersal	Argentina silus    5.3 %	Merlucous merlucous	Argentina sphyraena 4.4 %	Merlangus merlangus 2 %	
• ·· · ·	Extrigia gumantus	Gadoulus arpenteus 3 4 %	Lophia placatorius	Arpentina sikus 1.6 %	
Actinopterygii	Lepidorhombus whiffagonis 3.6 %	Extraja gumandus 3.4 %	Mertangka mertangus 2.6 %	Pomatoschistus minutus 1.1 %	
	Cheldonichthys cuculus 35%	Argentina silus 2.1%	Lepidortombus whiffagoris 2.4 %	Chelidonichthys cuculus 0.9 %	
	Autres 7 %	Autres 4.1%	Autres 4.7%	Autres 1.7 %	
	0 20 40 80 100	0 20 40 80 100	0 20 40 60 80 1	00 0 20 40 60 100	
	composition by weight (29.38% of total catch)	composition by number (29.62% of total catch)	composition by weight (45.24% of total catch)	composition by number (\$4.59% of total catch)	
	Capros aper 39.1 %	Capros aper 53.3 %	Trachuna trachuna 45.9 %	Trachurus trachurus 44.5 %	
	Trachurus trachurus 50.7 %	Mcromesiatius poutassou 20.3 %	Mcromesatus poutassou 22.6 %	Micromesiatius poutassou 24.7 %	
Pelaaic	Mcromesistius poutansou 17.3 %	Trachurus trachurus 18.5 %	Scomber scombrus 14.2 %	Engravits encrassicolus 15.2 %	
, enagie	Closes harmons 51%	Scomber scombrus 4.6 %	Engrauls encrasicolas 6.5 % Carros aner 6.5 %	Capros aper 5.7 %	
Actinoptervaii	Sartina pikhardus 0.4 %	Sprattus sprattus   1.4 %	Sardina pilchardus 41%	Sprattus sprattus	
1 /5	Sprattus sprattus 0.2 %	Engraulis escrasicolas 0.3 %	Trachurus mediterraneus 0.9 %	Sandina pächandus 🗍 2.4 %	
	Engraulis enorasicolus 0.1 %	Satina pitriantus 0.2 %	Spramus sprattus 0.7 %	Trachurus mediterraneus 0.8 %	
	Mola mola 0 %	Athenina presbyter 0 %	Scomber collas 0.2 %	Atherina presbyter  0.1%	
	Autors 0 %	Autres 0 %	Autores 0 %	Autres 0.1%	
	0 25 45 65 80 100	0 20 40 60 60 100	0 20 40 60 80 1	0 20 40 60 100 100	
	composition by weight (2.55% of total catch)	composition by number (0.18% of total catch)	composition by weight (1.45% of total catch)	composition by number (0.18% of total catch)	
	Scylorhinus cancula 48.1 %	Scylorhnus canicula 07.9 %	Scylortinus canicula 50.1 %	Scylorhinas canicula 53.3 %	
	Squalus acanthias 15.7 %	Etmopherus spinax 13.2 %	Galeus melastomus 20.3 %	Galeus melastomus 35 %	
Elasmobranchii	Leucoraja naevus 11 %	Lescoraja naevus 0.7 %	Leucoraja naevus 14.5 %	Leucoraja naevus 5.8 %	
	Diptuna bata 5%	Raja montagui 2.2 %	Rea clavata 4.1 %	Raja clavata 0.7 %	
	Etropteus spinas	Mostelus asterias 2 %	Mustelus asterias 1.7 %	Mysobatis aquila 0.6 %	
	Raja montagui 🚺 3.1 %	Galeus melastomus 0.8 %	Leucoraja circularis 1.4 %	Squalus acanthias 0.5 %	
	Galeorinus galeus 3 %	Dipturus batis 0.7 %	Etropterus spinas 12 %	Leucoraja circularis 02%	
	Raja microscellata 1.3 %	Leucoraja futorica 0.5 %	Dearia calcea 0.5 %	Deatia calcea 0.2 %	
	Autres 2.5%	Autres 0.0%	Autres 1 %	Autres 0.3%	
	0 20 40 60 100	0 20 40 60 60 100	0 20 40 60 80 Y	00 0 20 40 80 80 900	
	composition by weight (1.12% of total catch)	composition by number (0.9% of total catch)	composition by weight (1.52% of total catch)	composition by number (1.31% of total catch)	
	illex coindetii 47.4 %	litex coindeti	litex coindeti 38.6 %	Alloteuthis 51.7 %	
~ · ·	Lolgo forbesi 17.7 %	Loigo forbesi 22.7 %	Loligo vulgaris 25.6 %	Illex coindeti 22.5 %	
Commercial	Dedone cimona 0.2 %	Alateutia 10.1%	Cancer paperse 7.6 %	Loligo vulgaris 7%	
invertebrate	Todaropsis eblanae 5.5 %	Todaropsis eblanae	Adoteuthis 3.9 %	Lolgo forbesi 🛛 3 %	
mventebrule	Caroer pagurus a 4.9 %	Sepioldae ]] 3.4 %	Sepia officinalis 📗 3.9 %	Munida 2.6 %	
	Maja brachydactyla 2.3 %	Munida interreta 3.1 %	Eledone ciritosa    2.7 %	Aequipecten opercularis 2.6 %	
	Aloteuths [1.0 % Paromola cevient [0.7 %	Munda (2.2.%) Eledose cintosa (1.7.%)	odaropsis ebianie      Z # %     Nephrops norvegicus     Z # %	Munida rugosa 1.3 %	
	Sepia orbignjana 0.7 %	Sepia elegans 1.3 %	Pecter maximus 1.8 %	Sepioldae 1.2 %	
	Autres 1.4 %	Autres ]] 2 %	Autres 3.6 %	Autres    2.1 %	
	0 20 40 80 80 900	0 20 40 60 80 500	0 20 40 60 80 1	00 0 20 40 60 80 100	

378

379 Figure 4: Abundance in number and biomass of the 10 main species observed in the Celtic Sea during

380 EVHOE 1997-2018 and in the Bay of Biscay during EVHOE 1987-2018 for 4 main groups of species: Benthic

381 Demersal Actinopterygii, Pelagic Actinopterygii, Elasmobranchii and Commercial invertebrates.

![](_page_16_Picture_1.jpeg)

![](_page_16_Picture_2.jpeg)

![](_page_16_Figure_3.jpeg)

384 Figure 5: Boxplots of the fish taxa richness as obtained from bootstrap analysis of the sampling station

385 richness. The colors indicates the clusters depending on years similarities. Analysis is separately

386 performed for the Bay of Biscay and the Celtic Sea for the whole available time series

387 7 Appendix

![](_page_17_Picture_1.jpeg)

![](_page_17_Picture_2.jpeg)

Taxonomic group	Dominant species	Rarer species	Comments
Malacostraca	Munida intermedia, M. rugosa	M. rutllanti	species only considered at the genus level at the beginning of the series. Identification at species level from 2007 onward simultaneously with the development of the observation of the "Benthos"; rarer species remain less easily detectable and identifiable on board
	Loligo forbesii, L. vulgaris, Alloteuthis spp.		Not easy identification between young individuals of the genus Loligo or even with the Alloteuthis which leads to errors during the whole series.
Cephalopoda	Sepiolidae		Taken into account from 1995 onward but initially misidentified as « Sepiola or Sepiola atlantica » were regrouped into <i>Sepiolidae</i> . This family encompasses 11 species identified from 2010 onward. The small Rossiinae (large adult identified as <i>Rossia spp</i> ) have generally been put into generic <i>Sepiolidae</i> by mistake before 2010.
	Rossia macrosoma	R. palpebrosa	Only large individuals identified as belonging to these taxa (the smaller ones confused with others <i>Sepiolidae</i> ). <i>R.palpebrosa</i> only began to be determined in 2016.
Myxini		Remora brachyptera, Remora remora	Very rare, the presence of the 2 species is possible and confusions are possible
Holocephali	Chimaera monstrosa,	Hydrolagus mirabilis	Very deep species <i>H. mirabilis observed</i> only in 2004 but possible error
	Deania calcea	D. profundorum	<i>D. profundorum</i> only from 2010 with criteria provided by specialists (MNHN) but irregularity of identification still currently due to probable confusion.
Elasmobranchii	Dasyatis pastinaca	D. tortonesei	<i>D.tortonesei</i> identified only from 2015 with MNHN* expertise and more obvious criteria (criteria have been refined in 2019).
	Raja undulata, Raja microocellata		Raja microocellata more rare before 2000 due to probable confusion
	Raja montagui	Raja bravhyura	The criteria are difficult (even for specialists) and errors are possible especially before 2010 but still likely in recent years.
	Scyliorhinus canicula	Scyliorhinus stellaris	Sporadically identified at the beginning of the series, S.stellaris appears more frequent from 2010 which may show confusion between the 2 species.

Appendix A - List of	species at risk of	misidentification	during all or 1	part of the EVHOE	time series.
TT	······································				

![](_page_18_Picture_1.jpeg)

![](_page_18_Picture_2.jpeg)

Taxonomic group	Dominant species	<b>Rarer species</b>	Comments
inopterygii	Dipturus batis	Dipturus cf intermedia	Distinction of these 2 species only since 2017; they have always been grouped in <i>D. batis</i> before.
	Torpedo marmorata	Torpedo nobiliana	Confusion between these 2 species is very likely, only the name <i>T. marmorata</i> was used in the database until 2019.
	Alosa alosa, Alosa fallax		Potential identification errors between both species on small individuals especially at the beginning of the series
	Ammodytes tobianus, Hyperoplus lanceolatus	Ammodytes marinus, Gymnammodytes semisquamatus, Hyperoplus immaculatus	Errors in identification have been frequent; new criteria have been implemented in 2019
	Argentina silus, A. sphyraena		For some part of the time series, the occurrence of <i>Argentina sphyraena</i> in the deeper area is doubtful. Small <i>A.silus</i> individuals may have been confused with <i>A.sphyraena</i> .
	Argyropelecus spp		Deep-sea species rarely caught - identifications sometimes made by specialists but likely errors during the series
	Arnoglossus imperialis, A. laterna	A. thori	Confusion with <i>A. thori</i> is unlikely, but confusion between <i>A. imperialis</i> and <i>A. laterna</i> may have existed during the series; the criteria have been refined since 2019.
Ac	Callionymus lyra	C. reticulatus	Errors of identification have been frequent; the
	C. maculatus		criteria have been refined since 2019.
	Coelorinchus caelorhincus	Hymenocephalus italicus Nezumia aequalis	Possible misidentifications before 2017 between these rarely caught species with difficult identification criteria
		Nezumia sclerorhynchus	
	Diplodus spp		Rare taxa but potentially 4 species poorly identified
	Engraulis encrasicolus	E. cf. albidus	Although described in the study area but rare <i>E. albidus</i> not easily identified; criteria better defined since recent years but remains difficult to sort with very high abundances of the much more frequent <i>E. encrasicolus</i>
	Labrus bergylta, L. mixtus		species rarely caught and possible confusion during the whole time series

![](_page_19_Picture_1.jpeg)

![](_page_19_Picture_2.jpeg)

Taxonomic group	Dominant species	Rarer species	Comments
	Lampanyctus crocodilus	L. intricarius	For these deep-sea species, the identifications were carried out by specialists few years but the series probably contains errors
		Liparis liparis Liparis montagui	To be considered with caution, species very rarely caught and difficult identification criteria.
	Molva molva, M. macrophthalma	M. dypterygia	Inversion of occurrence from the 2000s onwards in favour of <i>M.macrophthalma</i> due to a reduction of the identification error as compared to the beginning of the series especially with the improved identification supports and criteria between ( <i>M. dypt.</i> and <i>M. macrophthalma</i> ).
	Notoscopelus kroyeri	N. caudispinosus, N. elongatus	For these deep-sea species, the identifications were carried out by specialists.
	Pagellus spp		Errors of identification have been frequent, especially for young individuals; the criteria have been refined since 2018.
	Pomatoschistus minutus Lesueurigobius friesii	P. lozanoi, P. norvegicus, P. pictus, Gobius paganellus	The size of the individuals and the difficulties of identification make certain determinations unreliable, particularly of <i>P. minutus</i> ( <i>e.g.</i> only 1 species of the genus <i>Pomatoshistus</i> before 2002).
	Scorpaena		Difficulties in identification lead to frequent errors. The species <i>Scorpaena elongata</i> is most probably mistakenly identified and has not been described in the Bay of Biscay from others studies.
	Syngnathus acus	S. phlegon, S. rostellatus, S. typhle	Identifications are difficult and errors are likely to occur during the data series; greater attention paid to these species after 2017.
	Trachurus trachurus	T. mediterraneus, T. picturatus	The sometimes very high abundance of horse mackerel in the catches and a consecutive important sub-sampling make the detection of closely resembling but rarer species more difficult.
	Trisopterus luscus, T. minutus	T. esmarkii	Absence of <i>T. esmarkii</i> especially before 1990 linked to defects of the sampling plan in relation to the distribution area of the species

\* MNHN: Museum National d'Histoire Naturelle (French National Museum of Natural History)

### Author contribution

Preparation of the manuscript: P.Laffargue<sup>1</sup>, D. Delaunay, F.Garren

![](_page_20_Picture_1.jpeg)

![](_page_20_Picture_2.jpeg)

# Data analysis and illustration: P.Laffargue<sup>1</sup>, D. Delaunay

Dataset preparation and processing: V.Badts, O.Berthele, A.S.Cornou, P.Laffargue

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# **Competing interests**

The authors declare that they have no conflict of interest.