WORKSHOP ON THE PRODUCTION OF ABUNDANCE ESTIMATES FOR SENSITIVE SPECIES (WKABSENS)

VOLUME 3 | ISSUE 96

ICES SCIENTIFIC REPORTS

RAPPORTS SCIENTIFIQUES DU CIEM

ICES INTERNATIONAL COUNCIL FOR THE EXPLORATION OF THE SEA
CIEM CONSEIL INTERNATIONAL POUR L'EXPLORATION DE LA MER

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ISSN number: 2618-1371

ICES Scientific Reports

Volume 3 | Issue 96

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Recommended format for purpose of citation:

ICES. 2021. Workshop on the production of abundance estimates for sensitive species (WKABSENS). ICES Scientific Reports. 3:96. 128 pp. https://doi.org/10.17895/ices.pub.8299

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Contents

i Executive summary

The Workshop on the production of annual estimates of abundance of sensitive species (WKABSENS) met to define sensitive species, collate ICES assessments of abundance where these are available, and estimate indices of their abundance per swept-area where not, for the OSPAR area. The analyses identified 140 potentially sensitive species or species complexes, among which 10 are diadromous and three are coastal, 20 have uncertain species ID and nine were identified as sensitive in only one of the sources examined. Among the sensitive species and species complexes, there was sufficient data to provide abundance indices for 50 species, of which 16 had existing stock assessments whereas the workshop derived abundance estimates for the remaining 34 species from survey data. Three statistical modelling approaches (binomial, General Additive Models (GAMs) and VAST) and were explored and the final abundance indices were calculated using GAMs. The species were divided into stocks before estimating abundance indices where these could be identified from the spatial distribution of the species in the survey. The group considered that a similar analysis using data from additional surveys, commercial indices or data from bycatch observers can potentially provide improved abundance estimates for species with variable or low catchability, such as deep-water and pelagic species.

ii Expert group information

Expert group name	Workshop on the production of annual estimates of abundance of sensitive species (WKABSENS)
Expert group cycle	Annual
Year cycle started	2021
Reporting year in cycle	1/1
Chair	Anna Rindorf, Denmark
Meeting venue and dates	14–18 June 2021, online meeting (25 participants)

1 Terms of reference

Workshop on the production of annual estimates of abundance of sensitive species

The **Workshop on the production of annual estimates of abundance of sensitive species** (WKABSENS), chaired by Anna Rindorf, Denmark, met online 14–18 June 2021 to fulfil the following ToRs (see Annex 2):

a) Consider the applicability of the ICES list of sensitive fish species for OSPAR FC1 (Recovery in the population abundance of sensitive fish species).
b) Split the list into:
    i. Species with existing ICES assessments (including reference points);
    ii. Species for which no ICES assessments currently exist.
c) Calculate swept-area indices and create a data product as input to OSPAR common indicators for fish and foodwebs:
    i. Define criteria to select surveys and time-series for analysis;
    ii. Discuss and agree in algorithm(s) to infill missing data at genus or family level;
    iii. Agree on the approach to estimate single species population abundance density per year.
d) Discuss and agree on criteria of data capable to support formal assessment. The selection of assessment units will be informed by available information, data, and knowledge from other ICES expert groups.
e) Calculate individual survey-based assessments for all sensitive species and create a data product to OSPAR informed by Table 2 Biological information (see Annex 3).

2 Criteria for a species to be listed as sensitive

WKABSENS reviewed the list produced by the ICES Workshop on Fish of Conservation and Bycatch Relevance (WKCOFIBYC, ICES, 2021c) based on species listed in scientific literature, listed in hard and/or soft legislation, and species listed as threatened by IUCN. Species for which the reasoning for inclusion on the list was unclear to WKABSENS were: *Gobius cobitis*, *Gobius couchi*, *Lycodes esmarkii*, *Pomatoschistus microps,* and *Pomatoschistus minutus*. The goby species have—with the exception of *G. couchi* which was not investigated—been ranked by Greenstreet et *al*. (2012a; b), Rindorf *et al*. (2020), the ICES Working Group on the Ecosystem Effects of Fishing Activities–WGECO (ICES, 2015), and the ICES Working group on Biodiversity–WGBIODIV (ICES, 2018e) as resilient to fishing and would not appear to be relevant on a list of sensitive species. *L. esmarkii* appeared to be an error as the source of the classification as 'sensitive' could not be re-traced. The Greenstreet *et al*. (2012b) method identified more sensitive species than the Rindorf *et al.* (2020) method, as Greenstreet *et al.* (2012b) defined the most sensitive 30% of the species as 'sensitive' whereas Rindorf *et al.* (2020) defined sensitive species as species which can sustain a lower fishing mortality than the most sensitive major commercial species (*Pollachius virens*). The species identified by the Greenstreet *et al.* (2012b) method only included *Chelidonichthys lucerna*, *Cyclopterus lumpus*, *Gadus morhua*, *Labrus bergylta*, *Merluccius merluccius*, *Pollachius pollachius*, *Pollachius virens*, *Scophthalmus maximus*, *Sebastes mentella*, *Sebastes norvegicus,* and *Zoarces viviparus*. These species were retained on the list but it was agreed to flag their sensitivity as uncertain. *Squalus acanthias* was added to the list as it was recorded by Greenstreet *et al.* (2012b), Rindorf *et al*. (2020), WGECO (ICES, 2015), and WGBIODIV (ICES, 2018e) as sensitive but was not included by WKCOFIBYC (ICES, 2021c).

Whether species were landed commercially or not was not considered as a criterion in species sensitivity. Hence, the list includes both species which are valuable bycatch in fisheries, target species and species that are caught but discarded. Some species were listed by WKCOFIBYC (ICES, 2021c) as sensitive in some areas only. WKABSENS considered that species sensitivity should be an inherent trait of the species and hence species should be listed in all areas where they occur unless there is clear evidence that the species in some areas are less sensitive to fishing.

The WKCOFIBYC list (ICES, 2021c) included the diadromous species *Acipenser oxyrinchus*, *Acipenser sturio*, *Acipenser* spp, *Alosa alosa*, *Alosa fallax*, *Alosa* spp., *Anguilla Anguilla*, *Coregonus maraena*, *Coregonus oxyrinchus*, *Coregonus* spp., *Lampetra fluviatilis,* and *Salmo trutta* and the predominantly coastal *Hippocampus* species. These species are sensitive due to the combined pressures in their marine and freshwater/coastal environment but are not necessarily sensitive to fishing alone.

Table 2.1 includes all the species listed along with any concerns that were raised by WKSKATE (ICES, 2020), Daan (2001) or WGEF (ICES, 2020t).

The final list of the 140 species relevant in the OSPAR area is given in Table 2.1, along with the number of hauls in which the species was observed in all hauls in DATRAS.

Table 2.1. Sensitive species, AphiaID including misclassifications and decisions on when to analyse species together.

Species	AphiaID	Comment	Observed in no of hauls in DATRAS
Acipenser oxyrinchus	151802	Diadromous	0
Acipenser spp.	125618	Diadromous	0
Acipenser sturio	126279	Diadromous	2
Alopias spp.	105740	Poor catchability in demersal trawl	0
Alopias superciliosus	105835	Poor catchability in demersal trawl	0
Alopias vulpinus	105836	Poor catchability in demersal trawl	1
Alosa spp.	125715 416357	Diadromous	
Alosa alosa	126413	Diadromous, uncertain species ID, abundance indices combined with *A. fallax*	121
Alosa fallax	126415	Diadromous, uncertain species ID, abundance indices combined with *A. alosa*	1424
Amblyraja radiata	105865 148824	Some reports of misidentification issues with *R. clavata*	10368
Anarhichas denticulatus	126757		3
Anarhichas lupus	125912 126758		1689
Anarhichas minor	126759		9
Anguilla anguilla	125620 126281 125425	Diadromous	1062
Apristurus laurussonii	105807		24
Apristurus spp.	105727		0
Argyrosomus regius	127007		150
Brama brama	126783		97
Brosme brosme	126447		674
Carcharhinus falciformis	105789		0
Carcharhinus longimanus	105794		0
Carcharodon carcharias	105838		0
Centrophorus granulosus	105899	Uncertain species ID, abundance indices combined with *C. uyato*	1

Species	**AphiaID**	**Comment**	**Observed in no of hauls in DATRAS**
Centrophorus squamosus	105901		55
Centrophorus uyato	105902	Uncertain species ID, abundance indices combined with *C. granulosus*	0
Centroscyllium fabricii	105906		28
Centroscymnus coelolepis	105907		55
Centroscymnus crepidater	105908		66
Cetorhinus maximus	105837		1
Chelidonichthys lucerna	127262 274877	Sensitivity uncertain as only identified as sensitive in Greenstreet *et al.* (2012b)	13744
Chimaera monstrosa	105824		1794
Chlamydoselachus anguineus	105831		0
Conger conger	125624 126285 125427		8233
Coregonus maraena	712453	Diadromous, uncertain species ID, Abundance indices combined for all *Coregonus* spp.	0
Coregonus oxyrinchus	154238	Diadromous, uncertain species ID, Abundance indices combined for all *Coregonus* spp.	4
Coregonus spp. (excluding *C. oxyrhinchus*)	127178 127180 126139	Diadromous, uncertain species ID, Abundance indices combined for all *Coregonus* spp.	4
Coryphaenoides rupestris	158960		185
Cyclopterus lumpus	127214	Sensitivity uncertain as only identified as sensitive in Greenstreet *et al.* (2012b)	4186
Dalatias licha	105910		171
Dasyatis pastinaca	105851		140
Dasyatis tortonesei	105852		9
Deania calcea	105903 105905	Not distinguished from *D. profundorum* (105905) prior to 2002 (Portuguese surveys)/2012 (Spanish surveys) so the two species are combined	410
Dentex dentex	273962		2
Dicentrarchus punctatus	126976		21

Species	AphiaID	Comment	Observed in no of hauls in DATRAS
Dipturus batis complex	105762 105869 148868 711847 711846	Uncertain ID, combined *Dipturus*, *D. batis*, *D. flossada* and *D. intermedia* in abundance indices.	2446
Dipturus nidarosiensis	105871		52
Dipturus oxyrinchus	105872 293392		51
Ephippion guttifer	127413		6
Epigonus telescopus	126858		288
Epinephelus marginatus	127036		0
Etmopterus princeps	105911		49
Etmopterus pusillus	105912		18
Etmopterus spinax	105913		975
Gadus morhua	126436	Sensitivity uncertain as only identified as sensitive in Greenstreet *et al*. (2012b)	47258
Galeorhinus galeus	105820	Some reports of identification issues with *Mustelus* spp.	919
Galeus melastomus	105812 105811	Uncertain species ID between *G. melastomus* and *G. atlanticus* (105811) hence the two species are joined in analyses	3905
Galeus murinus	105813		20
Glaucostegus cemiculus	1016062		0
Glaucostegus spp.	269225		0
Gymnura altavela	105856		0
Helicolenus dactylopterus	127251		8228
Hexanchus griseus	105833		316
Hippocampus guttulatus	154776	Coastal, catchability to trawl uncertain	21
Hippocampus hippocampus	127380	Coastal, catchability to trawl uncertain	316
Hippocampus spp.	126224	Coastal, catchability to trawl uncertain	16
Hippoglossus hippoglossus	127138		540
Hoplostethus atlanticus	126402		40

Species	**AphiaID**	**Comment**	**Observed in no of hauls in DATRAS**
Hydrolagus mirabilis	105826		117
Isurus paucus	105840		0
Labrus bergylta	126865	Sensitivity uncertain as only identified as sensitive in Greenstreet *et al.* (2012b)	17
Lamna nasus	105841		13
Lampetra fluviatilis	101172		234
Lepidorhombus whiffiago-nis	127146		15358
Leucoraja circularis	105873		444
Leucoraja fullonica	105874		442
Leucoraja naevus	105876		8507
Lophius budegassa	126554		5926
Lophius piscatorius	126555		19728
Macrourus berglax	126472		35
Manta spp.	105755		0
Merluccius merluccius	126484	Sensitivity uncertain as only identified as sensitive in Greenstreet *et al*. (2012b)	25873
Mobula birostris	1026118		0
Mobula mobular	105858		0
Mobula spp.	105756		0
Mola mola	127405		57
Molva dypterygia	126459		368
Molva macrophthalma	126460		2471
Molva molva	126461		6185
Mora moro	126497		356
Mustelus spp.	105732	Uncertain species ID, abundance indices combined with *M. mustelus* and *M. asterias*. Some reports of identification issues with *Galeorhinus galeus*	376
Mustelus asterias	105821	Uncertain species ID, abundance indices combined with *Mustelus* and *M. mustelus*. Some reports of iden-tification issues with *Galeorhinus galeus*	4051
Mustelus mustelus	105822	Uncertain species ID, abundance indices combined with *Mustelus* and *M. asterias*. Some reports of identi-fication issues with *Galeorhinus galeus*	653

Species	AphiaID	Comment	Observed in no of hauls in DATRAS
Mycteroperca fusca	127038		0
Myliobatis aquila	105860		18
Oxynotus centrina	105914		0
Oxynotus paradoxus	105915		2
Petromyzon marinus	101169 101174 101163		106
Phycis blennoides	125475 126501		5414
Pollachius pollachius	126440	Sensitivity uncertain as only identified as sensitive in Greenstreet *et al.* (2012b)	1449
Pollachius virens	126441	Sensitivity uncertain as only identified as sensitive in Greenstreet *et al.* (2012b)	8472
Polyprion americanus	126998		9
Pomatomus saltatrix	151482		1
Raja brachyura	367297 105882 271509	Including misclassified *Bathyraja brachyurops*. Some reports of misidentification issues with *R. montagui*	1683
Raja clavata	105883	Some reports of misidentification issues with *A. radiata*	10499
Raja microocellata	105885		700
Raja montagui	105887	Some reports of misidentification issues with *R. brachyura*	7548
Raja undulata	105891		684
Rajella bathyphila	105892		19
Rajella fyllae	105894		39
Rajella lintea	105870 1019591		2
Rhinobatidae	105712		0
Rhinobatos rhinobatos	105898		0
Rhinochimaera atlantica	105830		24
Rostroraja alba	105896		10
Salmo trutta	127187		73

Species	AphiaID	Comment	Observed in no of hauls in DATRAS
	223866		
Sciaena umbra	127010		0
Scophthalmus maximus	127149 154473	Sensitivity uncertain as only identified as sensitive in Greenstreet *et al.* (2012b)	12833
Scophthalmus rhombus	127150		7797
Scorpaena scrofa	127248		109
Scyliorhinus canicula	105814 399562		27800
Scyliorhinus stellaris	105815		1505
Scymnodon ringens	105918		204
Sebastes marinus	127253	Uncertain species ID, abundance indices combined with *S. mentella* and *S. norvegicus*	4
Sebastes mentella	127254	Uncertain species ID, abundance indices combined with *S. marinus* and *S. norvegicus*	86
Sebastes norvegicus	151324	Uncertain species ID, abundance indices combined with *S. mentella* and *S. marinus*	45
Sebastes viviparus	127255		1482
Somniosus microcephalus	105919		2
Sparus aurata	151523		69
Sphyrna lewini	105816		0
Sphyrna tudes	105818		0
Sphyrna zyganea	105819		0
Sphyrnidae	105694		0
Squalus acanthias	105923 160604 160616		6311
Squatina squatina	105928		0
Synaphobranchus kaupi	126328 125436		349
Tetronarce nobiliana	321911 157868 321911		54
Torpedo marmorata	271684		349

Species	AphiaID	Comment	Observed in no of hauls in DATRAS
Trachyrincus scabrus	126482		360
Umbrina cirrosa	127012		0
Zoarces viviparus	127123	Sensitivity uncertain as only identified as sensitive in Greenstreet *et al*. (2012b)	3518

3 Data pre-processing

3.1 Swept-area calculation

3.1.1 ICES FlexFiles and OSPAR data

To derive abundance/biomass observations per unit of area, swept-area estimates were added to the haul data available through the ICES DATRAS platform (HH in the exchange file). Swept-area estimates were taken from ICES DATRAS (FlexFile) and OSPAR data products and matched with the haul data by survey, ship, quarter, year, month, day, and haul number.

The swept-area information in the FlexFiles does not cover all the hauls recorded in the HH data (95 838 hauls). For some surveys, swept-area estimates are available back to 2004, however, for other surveys, swept-area information is only available for the most recent years. In addition, none of the beam trawl surveys are included in the FlexFile data but is estimated as the product of beam width and swept distance. In total, 24 699 swept-area estimates were available from the ICES FlexFile data.

Table 3.1. Number of hauls included in the ICES FlexFile data by survey and year (2004–2021).

	EVHOE	FR-CGFS	IE-IAMS	IE-IGFS	NIGFS	NS-IBTS	ROCKALL	SCOROC	SCOWCGFS	SP-ARSA	SP-NORTH	SP-PORC	SWC-IBTS
2004	138	0	0	159	0	636	0	0	0	48	0	79	145
2005	143	0	0	140	1	647	38	0	0	23	0	78	149
2006	127	0	0	168	2	630	32	0	0	23	0	82	134
2007	145	0	0	171	2	629	42	0	0	78	0	93	151
2008	147	0	0	166	53	648	37	0	0	82	0	79	124
2009	135	0	0	164	121	642	41	0	0	83	0	80	131
2010	139	0	0	176	120	665	0	0	0	80	0	80	59
2011	151	0	0	159	119	640	0	45	112	82	0	80	0
2012	130	0	0	172	119	630	0	36	130	70	0	79	0
2013	140	0	0	176	112	622	0	31	92	83	0	80	0
2014	155	0	0	170	113	591	0	47	121	85	0	80	0
2015	148	73	0	147	121	643	0	42	120	86	115	160	0
2016	157	73	107	172	124	621	0	48	123	89	113	160	0
2017	25	66	109	149	120	618	0	41	117	89	113	80	0
2018	155	73	116	153	122	613	0	41	116	86	113	80	0
2019	149	65	129	161	122	598	0	44	124	89	113	79	0
2020	156	59	70	127	116	600	0	40	113	89	109	81	0

	EVHOE	FR-CGFS	IE-IAMS	IE-IGFS	NIGFS	NS-IBTS	ROCKALL	SCOROC	SCOWCGFS	SP-ARSA	SP-NORTH	SP-PORC	SWC-IBTS
2021	0	0	0	0	0	329	0	0	63	0	0	0	0

The OSPAR data covers a larger part of the HH data including the beam trawl surveys (*n* = 49 759).

Table 3.2. Number of hauls included in the OSPAR data by survey and year (1983–2021).

	BTS	EVHOE	FR-CGFS	IE-IGFS	NIGFS	NS-IBTS	PT-IBTS	ROCKALL	SCOROC	SCOWCGFS	SWC-IBTS
1983	0	0	0	0	0	380	0	0	0	0	0
1984	0	0	0	0	0	459	0	0	0	0	0
1985	0	0	0	0	0	515	0	0	0	0	59
1986	0	0	0	0	0	526	0	0	0	0	38
1987	64	0	0	0	0	540	0	0	0	0	50
1988	70	0	66	0	0	404	0	0	0	0	50
1989	82	0	61	0	0	426	0	0	0	0	46
1990	181	0	75	0	0	379	0	0	0	0	90
1991	198	0	81	0	0	424	0	0	0	0	105
1992	179	0	60	0	79	344	0	0	0	0	75
1993	178	0	65	0	89	374	0	0	0	0	85
1994	173	0	88	0	82	363	0	0	0	0	77
1995	194	0	89	0	77	338	0	0	0	0	101
1996	234	0	61	0	82	329	0	0	0	0	106
1997	218	129	90	0	85	363	0	0	0	0	122
1998	218	125	83	0	89	677	0	0	0	0	111
1999	245	119	102	0	87	721	0	41	0	0	121
2000	250	120	101	0	85	701	0	0	0	0	137
2001	252	151	108	0	100	771	0	44	0	0	134
2002	311	152	98	0	113	759	66	29	0	0	141
2003	305	148	96	150	119	746	0	60	0	0	153
2004	389	138	92	159	102	721	0	0	0	0	145
2005	336	143	108	140	94	726	89	38	0	0	149
2006	299	127	106	168	90	709	88	32	0	0	132

	BTS	EVHOE	FR-CGFS	IE-IGFS	NIGFS	NS-IBTS	PT-IBTS	ROCKALL	SCOROC	SCOWCGFS	SWC-IBTS
2007	360	145	96	171	102	697	96	42	0	0	147
2008	333	147	101	166	53	719	87	37	0	0	123
2009	361	135	100	164	120	682	93	41	0	0	127
2010	320	139	87	176	120	694	87	0	0	0	58
2011	323	151	103	159	117	723	86	0	45	112	0
2012	346	129	94	172	118	708	0	0	36	130	0
2013	351	140	93	176	112	711	93	0	31	92	0
2014	289	155	94	170	112	665	81	0	47	121	0
2015	297	148	73	147	120	726	90	0	42	120	0
2016	300	157	73	172	124	741	85	0	48	123	0
2017	330	25	66	149	118	714	88	0	41	117	0
2018	354	155	73	153	120	713	49	0	41	116	0
2019	341	148	65	161	121	696	0	0	44	124	0
2020	342	155	59	127	115	695	0	0	40	113	0
2021	0	0	0	0	0	374	0	0	0	63	0

Most FlexFile observations (n = 20 600) are also included in the OSPAR data and allow a direct comparison. Only 528 out of 20 600 matching observations have exactly the same swept-area (based on the wingspread) estimate. Nevertheless, rounding the swept-area estimates up to 4 digits, corresponding to a mean fault tolerance of 0.15% with respect to the mean, results in 13 626 exact matching swept-area estimates, while only 287 swept-area estimates have a fault of 20% or more with respect to the mean swept-area.

In summary, the swept-area estimates in both data products align pretty well and do not indicate a clear difference between the swept-area estimates of both datasets. Nevertheless, in case both a FlexFile and OSPAR swept-area estimate was available for a single observation in the HH data, the FlexFile swept-area estimate was taken. The reason for this is that these estimates are calculated by national experts with knowledge of the survey, and are, in some cases, based on national databases. Hence, it is likely that they contain more accurate information compared to the OSPAR estimates which are estimated based on the information contained in the DATRAS HH exchange files.

3.1.2 HH swept-area imputation

For the HH observations that could not be allocated a swept-area estimate from the FlexFile or OSPAR data, swept-areas were estimated based on the information included in the FlexFile and OSPAR data.

A stepwise approach was followed to estimate the width of the gear (door spread, wing spread or beam width) and the trawled distance based on the available information in the HH data.

Door and wing spread were estimated using linear regression. The following linear (mixed) models were fitted to the data by gear type:

$$gearspread\ /\ log(gearspread) \sim \beta_0 + \beta_1 x\ depth + \beta_2\ x\ sweeplength + \theta_{Surv} + \tau_{Ship} + \varepsilon$$

$$gearspread\ /\ log(gearspread) \sim \beta_0 + \beta_1 x\ depth + \beta_2\ x\ sweeplength + \theta_{Surv} + \varepsilon$$

$$gearspread\ /\ log(gearspread) \sim \beta_0 + \beta_1 x\ depth + \beta_2\ x\ sweeplength + \varepsilon$$

$$gearspread\ /\ log(gearspread) \sim \beta_0 + \beta_1 x\ depth + \beta_2 x\ warplength + \theta_{Surv} + \tau_{Ship} + \varepsilon$$

$$gearspread\ /\ log(gearspread) \sim \beta_0 + \beta_1 x\ depth + \beta_2 + warplength + \theta_{Surv} + \varepsilon$$

$$gearspread\ /\ log(gearspread) \sim \beta_0 + \beta_1 x\ depth + \beta_2 + warplength + \varepsilon$$

$$gearspread\ /\ log(gearspread) \sim \beta_0 + \beta_1 x\ depth + \theta_{Surv} + \tau_{Ship} + \varepsilon$$

$$gearspread\ /\ log(gearspread) \sim \beta_0 + \beta_1 x\ depth + \theta_{Surv} + \varepsilon$$

$$gearspread\ /\ log(gearspread) \sim \beta_0 + \beta_1 x\ depth + \varepsilon$$

All models included an intercept (β_0), a linear depth effect with slope given by the coefficient of β_1, and a linear effect of the sweep or warplength with slope given by the coefficient of β_2. All models were fitted with two different link functions, identity and logarithmic, for the gear width (wing or door-spread), while the error term (ε) is assumed to follow a Gaussian distribution. In case the data contained three or more different surveys or ships, random effects were included to account for differences between surveys and ships (θ_{Surv} and τ_{Ship}). Models that included both sweep and warp-length as a covariate were not considered to avoid multi-collinearity. After fitting the models to the FlexFile and OSPAR data, the models were ordered according model performance, hereto, the root mean squared error (RMSE) was calculated.

Finally, the regression model with the lowest RMSE, taking into account the available covariates in the HH data, was used to predict door and wingspread.

For the gears appearing in the HH data, but not in the FlexFile and OSPAR data, alternative models were fitted to the FlexFile/OSPAR data by survey. The same approach was followed, but the model included an alternative random effects structure in case three or more different levels of these factors (gear and ship) were available:

$$gearspread\ /\ log(gearspread) \sim \beta_0 + \beta_1 x\ depth + \beta_2\ x\ sweeplength + \theta_{Gear} + \tau_{Ship} + \varepsilon$$

$$gearspread\ /\ log(gearspread) \sim \beta_0 + \beta_1 x\ depth + \beta_2\ x\ sweeplength + \theta_{Gear} + \varepsilon$$

$$gearspread\ /\ \ log(gearspread) \sim \beta_0 +\ \beta_1 x\ depth +\ \beta_2\ x\ sweeplength + \varepsilon$$

$$gearspread\ /\ \ log(gearspread) \sim \beta_0 +\ \beta_1 x\ depth +\ \beta_2 x\ warplength + \theta_{Gear} +\ \tau_{Ship} + \varepsilon$$

$$gearspread\ /\ \ log(gearspread) \sim \beta_0 +\ \beta_1 x\ depth +\ \beta_2 + warplength + \theta_{Surv} + \varepsilon$$

$$gearspread\ /\ \ log(gearspread) \sim \beta_0 +\ \beta_1 x\ depth +\ \beta_2 + warplength + \varepsilon$$

$$gearspread\ /\ \ log(gearspread) \sim \beta_0 +\ \beta_1 x\ depth + \theta_{Gear} +\ \tau_{Ship} + \varepsilon$$

$$gearspread\ /\ \ log(gearspread) \sim \beta_0 +\ \beta_1 x\ depth + \theta_{Gear} + \varepsilon$$

$$gearspread\ /\ \ log(gearspread) \sim \beta_0 +\ \beta_1 x\ depth + \varepsilon$$

Remark that before the regression was performed, missing depth information was added to the HH data (1451 out of 95 964 hauls) using the following regression model:

$$log(depth) \sim \beta_0 +\ s(lon, lat,\ k = 200) +\ \varepsilon\ \text{; with } \varepsilon \sim N(0, \sigma^2)$$

For the surveys deploying the beam trawl gear, the gear width was fixed, and assumed to be the width of the beam.

In case the distance was missing in the HH data, it was estimated using the available information in the HH data according to the following order:

$$Distance = Groundspeed\ x\ Haulduration$$

$$Distance = HaversineDistance(Shoot\ lon\_lat, Haul\ lon\_lat)$$

$$Distance = \overline{Grounspeed}_{Ship}\ x\ Haulduration$$

$$Distance = \overline{Grounspeed}_{Survey\ x\ Country}\ x\ Haulduration$$

$$Distance = \overline{Grounspeed}_{Survey}\ x\ Haulduration$$

$$Distance = \overline{Groundspeed}\ x\ Haulduration$$

$$Distance = \overline{Distance}_{Ship\ x\ Year}$$

$$Distance = \overline{Distance}_{Ship}$$

$$Distance = \overline{Distance}_{Survey\ x\ Year}$$

$$Distance = \overline{Distance}_{Survey}$$

3.2 Species misidentification

A number of species are not reliably determined to species level or are identified only to family or genus level. Species listed as sensitive and sometimes registered only to family or genus level include *Raja* sp/Rajidae, *Lophius* sp/Lophidae and Phycidae. From 1983 onwards, recordings of *Raja*/Rajidae larger than 5 cm occur in 55 hauls in the total of 88 469 hauls (0.06%). The other families/genera occur in 14 and 18 hauls, respectively. There are additional examples where only one species is recorded in the genus/family (e.g. *Conger* sp.). These are not included here as the species can reliably be reassigned to species level. WKABSENS decided not to reassign species from genus to species levels in cases where more than one species occurred in the data as the number of cases was small. WKABSENS recommends using both misrepresentations and correct representations (see Table 2.1 for AphiaID to be used).

The Workshop on the use of surveys for stock assessment and Reference Points for Rays and Skates WKSKATE (draft report, ICES, 2021) suggested excluding individuals smaller than 5 cm and this procedure was also followed in WKABSENS. WKSKATE further considered that it could be valuable to distinguish between juvenile and mature individuals or to use biomass rather than abundance. WKABSENS considered that biomass indices can be highly affected by single large individuals for rare species and therefore abundance should be preferred. In order to distinguish between immature and mature individuals, dividing individuals based on length at 50% maturity was considered a valid approach, but given the large number of species not attainable within the workshop.

3.3 Estimation of number caught per haul

Analysing data from DATRAS requires knowledge of the data as well as decisions in cases of apparently conflicting information. To estimate the number caught per haul of each of the species above, the following steps were conducted:

1. Download ICES DATRAS data (HH & HL; Note that there was an error in the column names of the surveys SP-PORC year 2016 and SWC-IBTS year 1987 which was corrected.)
2. Create a unique Haul-ID: Survey * Year * Quarter * Country * Ship * Gear * StNo * HaulNo
3. Remove hauls with duplicated ID's in HH (differences in WindSpeed)
4. Remove hauls if haul-ID is not in HL (no length or number data available for the haul)
5. Merge HH and HL and SweptArea index based on Haul-ID
6. Predict StatRec if NA
7. Use gear categories for gear
8. Only keep hauls that fulfil the criteria:

   a. HaulVal == “V”
   b. StdSpecRecCode == 1
   c. SpecVal ∈ (1,4,7,10)
   d. Lat != NA & Lon != NA
9. Combine Scottish surveys and Rockall surveys:
   a. SCOWCGFS → SWC-IBTS
   b. SCOROC → ROCKALL
10. Convert -9 to NA
11. Assign species to AphiaID (WKABSENS Table)
12. Combine AphiaIDs for species were several AphiIDs are observed (misclassification)
13. Remove hauls based if species are not recorded according to bycatch and standard species codes
14. Remove hauls from BITS survey that use different gears than TVS or TVL and remove hauls from NIGFS survey that occurred before 2007 due to inconsistent sampling
15. Create dummy dataset with N = 0
16. Subset data based on AphiaID list in table 2.1
17. Estimate numbers (Count)
   a. If HLNoAgeLngt == NA, use TotalNo and set SubFactor = 1
   b. Multiplier = HaulDur/60 if DataType ∈ (“C”)
   c. Multiplier = SubFactor if DataType ∈ (“S”,“R”)
   d. Count = HLNoAtLngt * Multiplier
18. N = sum Count for Haul-ID and round

3.4 Criteria for determining methods for different species

WKABSENS divided the species into four groups according to the occurrence of the species/species complex in DATRAS (Table 3.3). Further analyses may reveal that species in category 2 can possibly attain estimates according to the method of category 1, but time constraints did not permit this to be attempted for all species.

Table 3.3. Categorization of species abundance estimators based on species occurrence in all DATRAS hauls.

Category	Data in DATRAS	Abundance estimate
1	Species reported in 100 or more hauls in DATRAS	Statistical modelling of abundance and distribution
2	Species reported in 1–100 hauls in DATRAS	Species categorized as rare in surveys. Percentage of hauls in DATRAS where the species occurs is given together with links to DATRAS mapping tool provided to demonstrate distribution
3	Species not reported in DATRAS	Species categorized as rare in surveys, information may be available from commercial observer programmes.

3.5 Criteria for excluding surveys

Surveys which have never caught a certain species were excluded from all analyses of that species as they do not provide information on abundance and furthermore resulted in estimation issues. Furthermore, surveys with less than five years of data were also excluded from further analyses in category 1 as were surveys outside the OSPAR regions investigated. This meant the exclusion of the Deep water survey (four years of data), Irminger Sea International Deep pelagic survey (one year of data) and the Norwegian Sea International Deep pelagic survey (four years of data). Further, the Canadian Maritimes Trawl Survey was excluded as the spatial coverage is far from the other surveys. A list of the years and surveys included is given in Table 3.4. The coverage of the surveys can be seen in Figure 3.1.

Table 3.4. List of the years and surveys included.

Survey	Quarter	Years
BITS	1	1996–2020
BITS	4	1999–2020
BTS	1	2006–2020
BTS	3	1985–2020
BTS	4	2006–2020
DYFS*	3	2002–2020
DYFS	4	2002–2020
EVHOE	4	1997–2020
FR-CGFS	4	1998–2020
IE-IGFS	4	2003–2020
NIGFS	1	2006–2020
NIGFS*	4	2006–2020
NS-IBTS	1	1967–2020
NS-IBTS	3	1991–2020

Survey	Quarter	Years
PT-IBTS*	4	2002–2018
ROCKALL*	3	1999–2020
SNS*	3	2002–2020
SNS*	4	2004–2019
SP-ARSA*	1	1996–2020
SP-ARSA*	4	2002–2020
SP-NORTH*	3	2001–2010
SP-NORTH*	4	1990–2020
SP-PORC*	3	2001–2020
SP-PORC	4	2003–2007
SWC-IBTS	1	1985–2020
SWC-IBTS	2	1995–1995
SWC-IBTS*	4	1990–2020

* **Missing years**

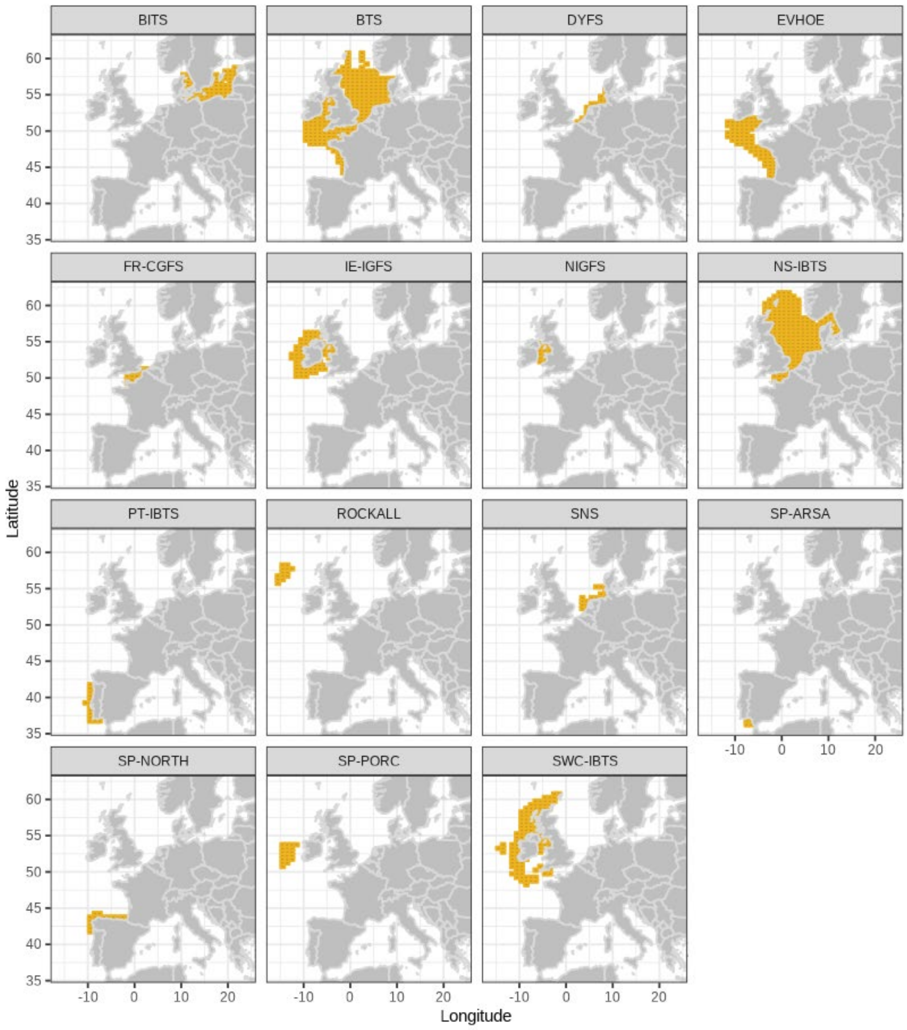

Figure 3.1. Spatial coverage of the surveys included.

3.6 Issues to consider in modelling

3.6.1 Gear effects

There are both differences and similarities between the gears used and reported in DATRAS (Table 3.5 and Table 3.6). In some cases, the differences are related mainly to scaling of the gear (e.g. TVS and TVL, see Table 3.6) whereas in other cases, the differences are substantial (e.g. between BT and GOV, see Table 3.6), WKABSENS sought to derive an approach that takes advantage of our knowledge that some gear types are more similar than others. The group divided the gear into categories with the assistance of Rob Kynoch and Finlay Burns (Table 3.5) and these categories were subsequently used as fixed effects in a Generalized Additive Model (GAM, Hastie and Tibshirani 1990) model (see Section 4.3 on GAMs).

The trawls were categorized based on the information on trawl height and ground contact under the assumption that wing spread swept-area is accounted for separately in the model:

a) Beam trawls can be grouped together. They are similarly rigged but will differ by swept-area, which is dictated by beam length. Beam trawl headline would be around 0.6 m and the low headline trawls ~2.5–3 m and therefore are a separate category;
b) GOV gear can be split into two categories: clean gear and rock-hoppers/bobbins;

c) Herring bottom opening trawls can be grouped into the GOV type A gears. These were nets used in IBTS prior to standardizing in 1982. Given their similar properties to the GOV (i.e. high opening), it’s likely there was agreement to move from herring trawls to GOV;

d) Norwegian Campbell trawl is also a high headline height so can also be grouped into GOV type A gears;

e) Baka trawls are low headline nets, ~2.5 m compared with the ~5.5 m of GOVs. The exception is the Porcupine baka, which has a higher headline;

f) Foto midwater is a pelagic gear. ‘Pelagic trawlnet Kabeljaubomber’ is also classified as pelagic though there is no detailed information on this gear available;

g) Old gears are grouped together with unknown bottom trawls: Granton, Vinge, bottom trawl FGAV019 and Sov-Net.

This resulted in the groupings in Table 3.6.

Table 3.5. Gear categories.

Gear category	Description
BT	Beam trawls
TV	TV-3 trawl used in BITS
GOV CL	Demersal trawl with clean gear and high headline net: herring bottom trawls, GOV with groundgear A, porcupine baka
GOV GG	Demersal trawl with rock-hoppers or old bobbin disks and high headline net: GOV used in Scottish surveys above 57.5 and in Irish surveys, Norwegian Campbell
BAK CL	Demersal trawls with clean gear and low headline net: baka trawls
BAK GG	Demersal trawls with rock-hoppers/bobbins and low headline net: Aberdeen 48 foot
PEL	Midwater and pelagic trawls with limited bottom contact: Foto midwater and ‘Pelagic trawlnet Kabeljaubomber’
OTT	Remaining trawl types

Table 3.6. Gear categories used in GAM analysis.

Survey	Gear	Gear name	Gear category	Notes and references
BITS	TVL	Large TV Trawl	TV	A type of TV-3 trawl, with 930 meshes in circumference, for vessels with engine more than 600 KW. Denmark added a stone panel. On Latvian surveys the TVL is used with rock-hopper. (ICES, 2014)
BITS	TVS	Small TV Trawl	TV	A type of TV-3 trawl, with 520 meshes in circumference, for vessels with engine less than 600 KW. (ICES, 2014)
BTS	BT4	Beam Trawl 4 m	BT	UK-Cefas and Iceland 4-m beam trawls have a flip up rope, while Belgium 4-m beam trawl has no flip-up rope. (ICES, 2019f)
BTS	BT4A	Four m Beam trawl, aft	BT	(ICES, 2019f)
BTS	BT4AI	Four m Beam trawl, aft - in IrishSea q3 BTS	BT	(ICES, 2019f)
BTS	BT4P	Four m Beam Trawl, port	BT	(ICES, 2019f)
BTS	BT4S	Four m Beam Trawl, starboard	BT	(ICES, 2019f)
BTS	BT7	Seven m Beam trawl	BT	Ticklers. (ICES, 2019f)
BTS	BT8	Eight m Beam trawl	BT	Flip up rope, ticklers. (ICES, 2019f)
DYFS	BT3	Beam Trawl 3 m	BT	Beam trawls but these are shrimp trawls. Demersal Young Fish survey, so are gear more tailored to smaller fish (ICES, 2021b).
DYFS	BT6	Beam Trawl 6 m	BT	Beam trawls but these are shrimp trawls. Demersal Young Fish survey, so are gear more tailored to smaller fish (ICES, 2021b).
EVHOE	GOV	GOV Trawl	GOV_CL	Without exocet Kite which is replaced by 6 additional floats (ICES, 2010).
FR-CGFS	GOV	GOV Trawl	GOV_CL	Double sweeps (Moriarty *et al*., 2020).

Survey	Gear	Gear name	Gear category	Notes and references
IE-IGFS	GOV	GOV Trawl	GOV_GG for Irish West Coast Groundfish Survey (covering ICES Division VIa (south) and VIIb (north), VIIb and VIIj); GOV_CL for Irish Sea and Celtic Sea covers ICES Division VIIa and VIIg	Standard GOV survey gear (ICES, 2010; 2015; Moriarty *et al*., 2020).
NIGFS	ROT	Rock-hopper otter trawl	GOV_GG	Double sweep with 16-inch bobbins (ICES, 2010; Moriarty *et al*., 2020).
NS-IBTS	ABD	Aberdeen 18 ft trawl	BAK_GG	Used to collate info on age-0 fish so presumably effective at catching small fish
NS-IBTS	BOT	Bottom Trawl	OTT	
NS-IBTS	DHT	Dutch Herring Trawl	GOV_CL	
NS-IBTS	FOT	Foto midwater trawl	PEL	
NS-IBTS	GOV	GOV Trawl	GOV_CL	
NS-IBTS	GRT	Granton trawl	OTT	
NS-IBTS	H12	Herring Bottom Trawl 120 feet	GOV_CL	
NS-IBTS	H18	Herring Bottom Trawl 180 feet	GOV_CL	
NS-IBTS	HOB	High Opening Bottom Trawl	GOV_CL	
NS-IBTS	HOB	High Opening Bottom Trawl	GOV_CL	
NS-IBTS	HT	Herring Bottom Trawl	GOV_CL	Designed for herring. Used in International Young Fish Survey (ICES, 1999).
NS-IBTS	KAB	Pelagic trawlnet Kabeljaubomber	PEL	
NS-IBTS	SOV	SOV-NET	OTT	

Survey	Gear	Gear name	Gear category	Notes and references
NS-IBTS	VIN	Vinge trawl	GOV_CL	International Young Fish Survey (ICES, 1999)
PT-IBTS	CAR	Bottom trawl FGAV019	CAR	Without rollers in the groundrope. https://datras.ices.dk/Home/Descriptions.aspx
PT-IBTS	NCT	Norwegian Campell Trawl 1800/96	GOV_GG	Groundrope with bobbins, with a 20 mm codend mesh size. https://datras.ices.dk/Home/Descriptions.aspx
ROCKALL	GOV	GOV Trawl	GOV_GG	
SCOROC	GOV	GOV Trawl	GOV_GG	(ICES, 2017) https://www.ices.dk/data/Documents/DATRAS%20Manuals/Survey%20de-sign%20for%20ROCKALL%20and%20SWC-IBTS.pdf
SNS	BT6	Beam Trawl 6 m	BT	
SP-ARSA	BAK	Baka trawl	BAK_CL	International Young Fish Survey (ICES, 1999)
SP-NORTH	BAK	Baka trawl	BAK_CL	International Young Fish Survey (ICES, 1999)
SP-PORC	PORB	Porcupine Baka	GOV_CL	With a footrope and a headline, codend is 20 mm
SWC-IBTS	GOV	GOV Trawl	GOV_GG if above 57.5 lat; GOV_CL if below 57.5	

4 Statistical analyses of survey data

4.1 Approach to abundance assessment

The species listed were individually examined to determine which approach should be used to produce the abundance indices. Species not listed in Table 4.1 were not assessed due to low occurrence (< 100 hauls observing the species in DATRAS) and lack of an existing ICES assessment. Three different methods were explored to estimate abundance indices, probability of catching a species in a binomial model, VAST, and GAMs.

Table 4.1. Species individually examined to determine which approach should be used to produce the abundance indices.

Species	Considerations	Assessment source
Amblyraja radiata	GAM model. The existing stock assessment uses only two surveys and has lower temporal coverage.	GAM
Anarhichas lupus	No existing abundance assessment	GAM
Anguilla anguilla	Existing stock assessment integrates other sources of information than DATRAS. Indices derived from DATRAS analyses are forwarded to WGEEL	WGEEL
Argyrosomus regius	No existing abundance assessment	GAM
Brosme brosme	Existing stock assessment integrates other sources of information than DATRAS. Indices derived from DATRAS analyses are forwarded to WGDEEP	WGDEEP
Chelidonichthys lucerna	No existing abundance assessment	GAM
Chimaera monstrosa	No existing abundance assessment	GAM
Conger conger	No existing abundance assessment	GAM
Coryphaenoides rupestris	No existing abundance assessment except in 3A. Difficult to discern if 3A is a separate populations from the sparse data.	GAM
Cyclopterus lumpus	No existing abundance assessment	GAM
Dasyatis pastinaca	No existing abundance assessment	GAM
Dipturus batis complex	No existing abundance assessment	GAM
Etmopterus spinax	No existing abundance assessment	GAM
Gadus morhua	Full stock assessments used	WGNSSK, WGCSE, WGBFAS
Galeorhinus galeus	No existing abundance assessment	GAM
Galeus melastomus	Existing stock assessments use selected DATRAS data only while the GAM model uses all available survey data (additional surveys). Limited evidence of separate populations.	GAM
Helicolenus dactylopterus	No existing abundance assessment	GAM

Species	Considerations	Assessment source
Hexanchus griseus	No existing abundance assessment	GAM
Hippocampus hippocampus	No existing abundance assessment	GAM
Hippoglossus hippoglossus	No existing abundance assessment	GAM
Lampetra fluviatilis	No existing abundance assessment	GAM
Lepidorhombus whiffiagonis	Full stock assessments used	WGBIE
Leucoraja circularis	No existing abundance assessment	GAM
Leucoraja fullonica	No existing abundance assessment	GAM
Leucoraja naevus	Existing stock assessments use selected DATRAS data only while the GAM model uses all available survey data (additional surveys). Limited evidence of separate populations.	GAM
Lophius budegassa	Existing stock assessment integrates other sources of information than DATRAS. Indices derived from DATRAS analyses are forwarded to WGBIE and WGCSE	WGBIE, WGCSE
Lophius piscatorius	Existing stock assessment integrates other sources of information than DATRAS. Indices derived from DATRAS analyses are forwarded to WGBIE	WGBIE
Merluccius merluccius	Existing stock assessment integrates other sources of information than DATRAS.	WGBIE
Molva dypterygia	Existing stock assessment integrates other sources of information than DATRAS.	WGDEEP
Molva macrophthalma	No existing abundance assessment	GAM
Molva molva	Existing stock assessment integrates other sources of information than DATRAS.	WGDEEP
Mustelus spp.	Existing stock assessments use selected DATRAS data only. Limited evidence of separate populations.	GAM
Phycis blennoides	Existing stock assessment integrates other sources of information than DATRAS.	WGDEEP
Pollachius pollachius	No existing abundance assessment	GAM
Pollachius virens	Existing stock assessment integrates other sources of information than DATRAS.	WGNSSK
Raja brachyura	Existing stock assessments use selected DATRAS data only while the GAM model uses all available survey data (additional surveys). Limited evidence of separate populations.	GAM
Raja clavata	Existing stock assessments use selected DATRAS data only while the GAM model uses all available survey data (additional surveys). Limited evidence of separate populations.	GAM

Species	Considerations	Assessment source
Raja microocellata	Existing stock assessments use selected DATRAS data only while the GAM model uses all available survey data (additional surveys).	GAM
Raja montagui	Existing stock assessments use selected DATRAS data only while the GAM model uses all available survey data (additional surveys). Limited evidence of separate populations.	GAM
Raja undulata	Existing stock assessments use selected DATRAS data only while the GAM model uses all available survey data (additional surveys).	GAM
Scophthalmus maximus	Existing stock assessments used in the North Sea, the Channel and Skagerrak, GAMs elsewhere.	WGNSSK, GAM
Scophthalmus rhombus	Existing stock assessments used in the North Sea, the Channel and Skagerrak, GAMs elsewhere.	WGNSSK, GAM
Scyliorhinus canicula	Existing stock assessments use selected DATRAS data only while the GAM model uses all available survey data (additional surveys).	GAM
Scyliorhinus stellaris	Existing stock assessments use selected DATRAS data only while the GAM model uses all available survey data (additional surveys).	GAM
Sebastes mentella	Existing stock assessments used	NWWG
Sebastes norvegicus	Existing stock assessments used	NWWG
Sebastes viviparus	No existing abundance assessment	GAM
Squalus acanthias	Existing stock assessments used	WGEF
Torpedo marmorata	No existing abundance assessment	GAM
Zoarces viviparus	No existing abundance assessment	GAM

The species for which ICES stock assessments were used are classified into areas assessed, stock codes and references to latest ICES advice in the Table 4.2 below:

Table 4.2. ICES assessed stocks by area, stock codes and reference of latest advice.

Species	Area assessed (stock code)	Latest ICES assessment
Anguila anguila	North Sea and "elsewhere" (ele.27.37.nea)	ICES, 2020k
Brosme brosme	Wide (usk.27.3a45b6a7.912b)	ICES, 2019g
Gadus Morhua	Greater North Sea (cod.27.47d20)	ICES, 2020j
	Celtic Seas, Greater North Sea, and Oceanic Northeast Atlantic (cod.27.7e-k)	ICES, 2020i
	Celtic Seas ecoregion (cod.27.6a)	ICES, 2020f

Species	Area assessed (stock code)	Latest ICES assessment
	North Sea (cod.27.21)	ICES, 2019b
	Celtic Seas (cod.27.7a)	ICES, 2020h
Lepidorhombus whiffiagonis	Bay of Biscay and the Iberian Coast, Celtic Seas, Greater North Sea and Oceanic Northeast Atlantic (meg.27.7b-k8abd)	ICES, 2020m
	Bay of Biscay and Iberian Coast (meg.27.8c9a)	ICES, 2020n
Lophius budegassa	Greater Northern Sea, Celtic Seas, and Bay of Biscay and Iberian Coast (ank.27.78abd)	ICES, 2020c
	Celtic Seas, Greater North Sea, and Oceanic Northeast Atlantic (anf.27.3a46)	ICES, 2020a
	Bay of Biscay and the Iberian Coast (ank.27.8c9a)	ICES, 2020b
Lophius piscatorius	Celtic Seas, Greater North Sea, and Oceanic Northeast Atlantic (anf.27.3a46)	ICES, 2020a
	Bay of Biscay and the Iberian Coast, Celtic Seas, Greater North Sea, and Oceanic Northeast Atlantic (mon.27.78abd)	ICES, 2020s
	Bay of Biscay and the Iberian Coast, Celtic Seas, Greater North Sea, and Oceanic Northeast Atlantic (mon.27.8c9a)	ICES, 2020r
Merluccius merluccius	Bay of Biscay and the Iberian Coast (hke.27.3a46-8abd)	ICES, 2019d
	Bay of Biscay and the Iberian Coast (hke.27.8c9a)	ICES, 2019c
Molva dypterygia	Arctic Ocean, Greenland Sea, Icelandic Waters, Norwegian Sea and Oceanic Northeast Atlantic (bli.27.5a14)	ICES, 2019a
	Celtic Seas and Faroes grounds (bli.27.5b67)	ICES, 2020d
Molva molva	Celtic Seas, Faroes, Icelandic Waters, and Oceanic Northeast Atlantic (lin.27.5b)	ICES, 2021a
	Northeast Atlantic and Arctic Ocean (lin.27.3a4a6-91214)	ICES, 2019e
Phycis blennoides	Northeast Atlantic (gfb.27.nea)	ICES, 2020l

Species	Area assessed (stock code)	Latest ICES assessment
Pollachius virens	Celtic Seas, Faroes, and Greater North Sea (pok.27.3a46)	ICES, 2020o
Scophthalmus maximus	Greater North Sea (tur.27.4)	ICES, 2020q
	Greater North Sea (tur.27.3a)	ICES, 2020p
Scophthalmus rhombus	Celtic Seas and Greater North Sea (bll.27.3a47de)	ICES, 2020e
Sebastes mentella	Greenland Sea and Oceanic Northeast Atlantic (reb.27.14b)	ICES, 2018b
	Arctic Ocean, Greenland Sea, Icelandic Waters, Norwegian Sea and Oceanic Northeast Atlantic ecoregions (reb.27.5a14)	ICES, 2018c
Sebastes norvegicus	Arctic Ocean, Celtic Seas, Faroes, Greenland Sea, Icelandic Waters, Norwegian Sea, and Oceanic Northeast Atlantic (reg.27.561214)	ICES, 2018d
Squalus acanthias	Northeast Atlantic and adjacent seas (Widely distributed; dgs.27.nea)	ICES, 2020b

The abundances values used for the ICES stocks listed above (Table 4.2) are shown in Annex 3, Table A11.

4.2 Approach for rare species

An assessment procedure based on the binomial model was applied to investigate the information that can be derived from presence-absence in cases when the data were not considered sufficient to assess trends by GAMs. The binomial model predicts the probability of n successful outcomes of a Bernoulli experiment that has two possible outcomes e.g. the toss of a coin or obtaining a six or not from a roll of a dice. The binomial distribution then gives the probability of k successes in n trials of the experiment with a fixed probability of the single success p (e.g. heads on a coin p = 0.5 or six on a dice p = 0.167):

$$P(k|n,p) = \binom{n}{k} p^k (1-p)^{n-k} \qquad \text{(Eq.1)}$$

The cumulative distribution function of the binomial distribution determines the probability of k or fewer successes:

$$P(X \leq k|n,p) = \sum_{i=0}^{k} \binom{n}{i} p^i (1-p)^{n-i} \qquad \text{(Eq.2)}$$

Using the cumulative distribution function, it is possible to determine the values of k for which Eq.2 is below a predefined significance threshold, e.g. $\alpha < 0.05$. These values of k represent the lower tail of the binomial distribution (Table 4.1) and any observed k in this tail would indicate a significant deviation from an expected mean. Hence the largest k value for which Eq.2 is $< \alpha$ can be used as a threshold $k_{sig.}$ to identify the significant deviation from the expected mean. Thus, where the number of occurrences in n hauls within the assessment period is equal to or is fewer than the maximum k required to satisfy the condition $P(X \leq k|n,p) < \alpha$ we can say that there is a significant decrease in occurrences relative to the reference period for which p was set.

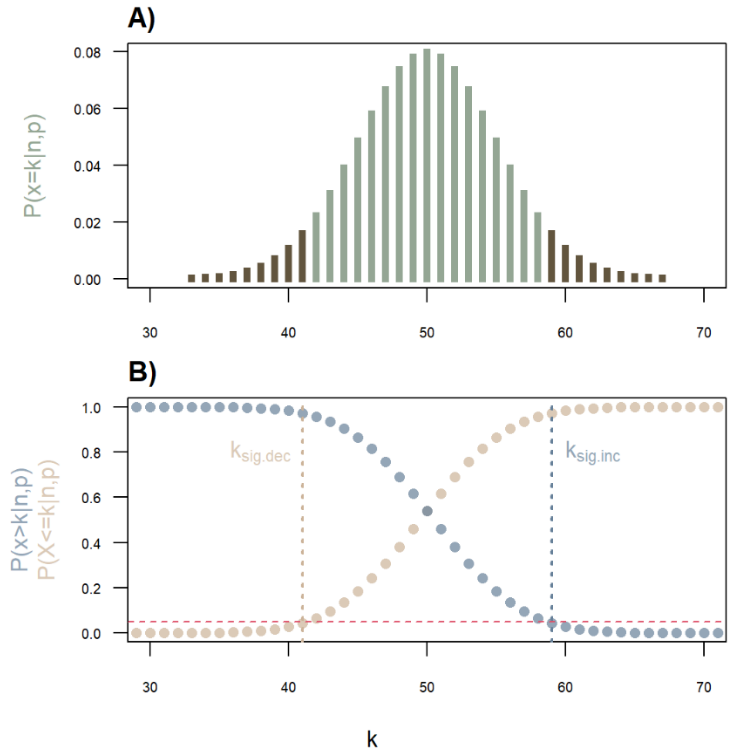

Figure 4.1. The concept of using the binomial distribution to identify significant deviations from the expected number of *k* successes. In this example *n* = 100 and *p* = 0.5. A) The probability function as in Eq.1 indicates that *k* = 50 has the highest probability. B) Using the cumulative distribution function from Eq.2, one can calculate which numbers of *k* would be unlikely to observe (k_{sig}). Here, $k_{sig.dec}$ indicates the lower threshold (*k* = 41) and $k_{sig.inc}$ the upper threshold (*k* = 59). Hence observing fewer than 42 successful trials would be significantly unlikely, as would the observation of more than 58 successful trials.

The binomial distribution can be used to estimate the probability of observing k occurrences of a species in a survey in a particular assessment period (with n total hauls) once we have an estimate of the probability p of detecting the species in a single haul. The key assumptions here are that each haul in the survey data are considered an independent Bernoulli-experiment and the probability p of detecting the species is constant throughout the survey. If these conditions are met, p can be estimated from the frequency of occurrence of the species in the survey in a chosen reference period, where the frequency of occurrence is simply the number of hauls with occurrence divided by the total number of hauls. According to Eq.2, a threshold $k_{sig.}$ can be set, at which any observed k in the assessment period becomes significantly unlikely and thus indicates a statistically relevant decline in occurrence when compared to an expected occurrence derived from the reference period.

Accordingly, the counter-event for the upper tail of the binomial distribution can be used to set a threshold for indicating a statistically significant increase (where the probability is below the predefined significance threshold) in the species occurrence in the assessment period as follows:

$$P(X > k|n,p) = 1 - P(X \leq k|n,p) = 1 - \sum_{i=0}^{k}\binom{n}{i}p^i(1-p)^{n-i} \quad \text{(Eq.3)}$$

and,

$$P(X \geq k|n,p) = P(X > (k-1)|n,p) = 1 - \sum_{i=0}^{k-1}\binom{n}{i}p^i(1-p)^{n-i} \quad \text{(Eq.4)}$$

If the number of occurrences in n hauls within the assessment period is equal to or greater than the minimum k required to satisfy the condition $P(X \geq k|n,p) < \alpha$ we can say that there is a significant increase in occurrences relative to the reference period for which p was set.

The assessment approach demonstrated here uses occurrence data from 53805 hauls compiled from the BTS (Quarters 1, 3, and 4), DYFS (Quarters 3 and 4) and NS-IBTS (Quarters 1 and 3) surveys to assess changes in occurrence for 55 species in the Greater North Sea (OSPAR region II) from 1967 until 2020 (Table 4.3).

Table 4.3. Number of hauls by year (1967–2020) for each survey in OSPAR region II used in the analysis.

Year	BTS_1	BTS_3	BTS_4	DYFS_3	DYFS_4	NS-IBTS_1	NS-IBTS_3
1967	0	0	0	0	0	122	0
1968	0	0	0	0	0	135	0
1969	0	0	0	0	0	122	0
1970	0	0	0	0	0	130	0
1971	0	0	0	0	0	167	0
1972	0	0	0	0	0	201	0
1973	0	0	0	0	0	192	0
1974	0	0	0	0	0	246	0
1975	0	0	0	0	0	332	0
1976	0	0	0	0	0	340	0
1977	0	0	0	0	0	406	0
1978	0	0	0	0	0	449	0
1979	0	0	0	0	0	501	0
1980	0	0	0	0	0	404	0
1981	0	0	0	0	0	340	0
1982	0	0	0	0	0	331	0
1983	0	0	0	0	0	393	0
1984	0	0	0	0	0	425	0

Year	BTS_1	BTS_3	BTS_4	DYFS_3	DYFS_4	NS-IBTS_1	NS-IBTS_3
1985	0	0	0	0	0	464	0
1986	0	0	0	0	0	472	0
1987	0	64	0	0	0	479	0
1988	0	70	0	0	0	404	0
1989	0	82	0	0	0	427	0
1990	0	182	0	0	0	379	0
1991	0	199	0	0	0	424	295
1992	0	181	0	0	0	375	363
1993	0	374	0	0	0	374	342
1994	0	337	0	0	0	363	307
1995	0	364	0	0	0	340	250
1996	0	355	0	0	0	329	320
1997	0	385	0	0	0	363	253
1998	0	380	0	0	0	404	274
1999	0	408	0	0	0	358	366
2000	0	363	0	0	0	386	316
2001	0	416	0	0	0	430	342
2002	0	420	0	191	79	420	341
2003	0	417	0	261	23	417	329
2004	0	497	0	183	89	376	346
2005	0	443	0	234	82	390	337
2006	152	410	116	241	63	381	329
2007	158	468	116	0	105	373	324
2008	157	432	110	199	61	392	328
2009	156	469	113	186	79	398	284
2010	170	427	116	225	91	374	320
2011	170	429	114	215	97	397	327
2012	162	454	116	402	83	389	319
2013	162	459	116	503	84	393	318

Year	BTS_1	BTS_3	BTS_4	DYFS_3	DYFS_4	NS-IBTS_1	NS-IBTS_3
2014	183	397	0	543	77	340	327
2015	268	460	0	494	132	374	352
2016	274	455	0	458	113	360	381
2017	256	432	0	492	86	377	337
2018	232	458	0	451	109	364	349
2019	264	449	0	371	99	352	344
2020	162	374	0	478	64	340	355
Sum	**2926**	**12510**	**917**	**6127**	**1616**	**19214**	**9775**

Fifty-five species present in OSPAR region II were selected based on species lists from WGECO, WGBIODIV, and WKCOFIBYC. Species that were observed ten times or less over the whole period were excluded.

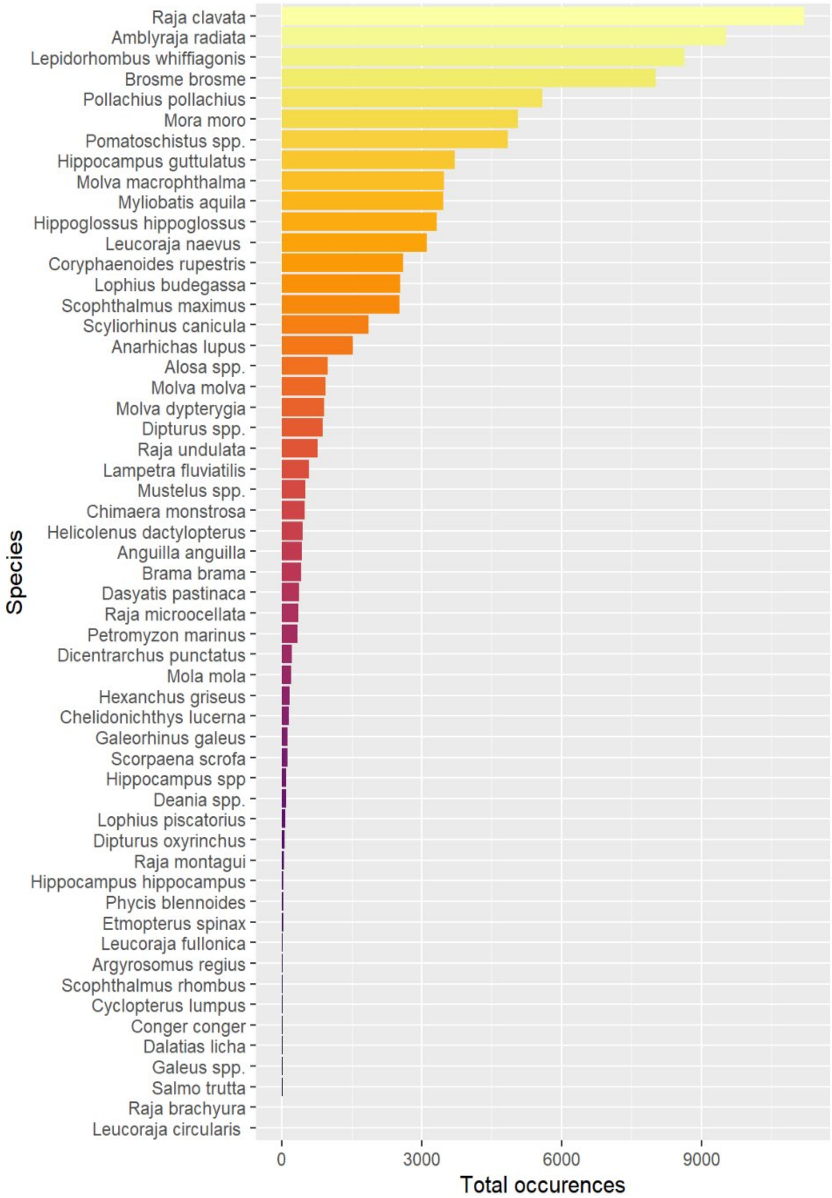

Figure 4.2. Total number of observed occurrences by species in OSPAR region II (Greater North Sea) between 1967 and 2020.

Two reference periods were compared to a six-year assessment period (2015–2020, Table 4.3). The two reference periods were from 1967 until 2014 (long-term, rpa) and from 2009 until 2014 (short-term, rp6) comparing the occurrences during the fully available time-series and a six-year period previous to the assessment period (Figure 4.3).

Using the binomial approach for pollack (*Pollachius pollachius*) a significant decrease in occurrence is evident, both in the long-term and short-term reference periods (Figure 4.3). Based on this finding the occurrence of pollack would be assessed as “declining”.

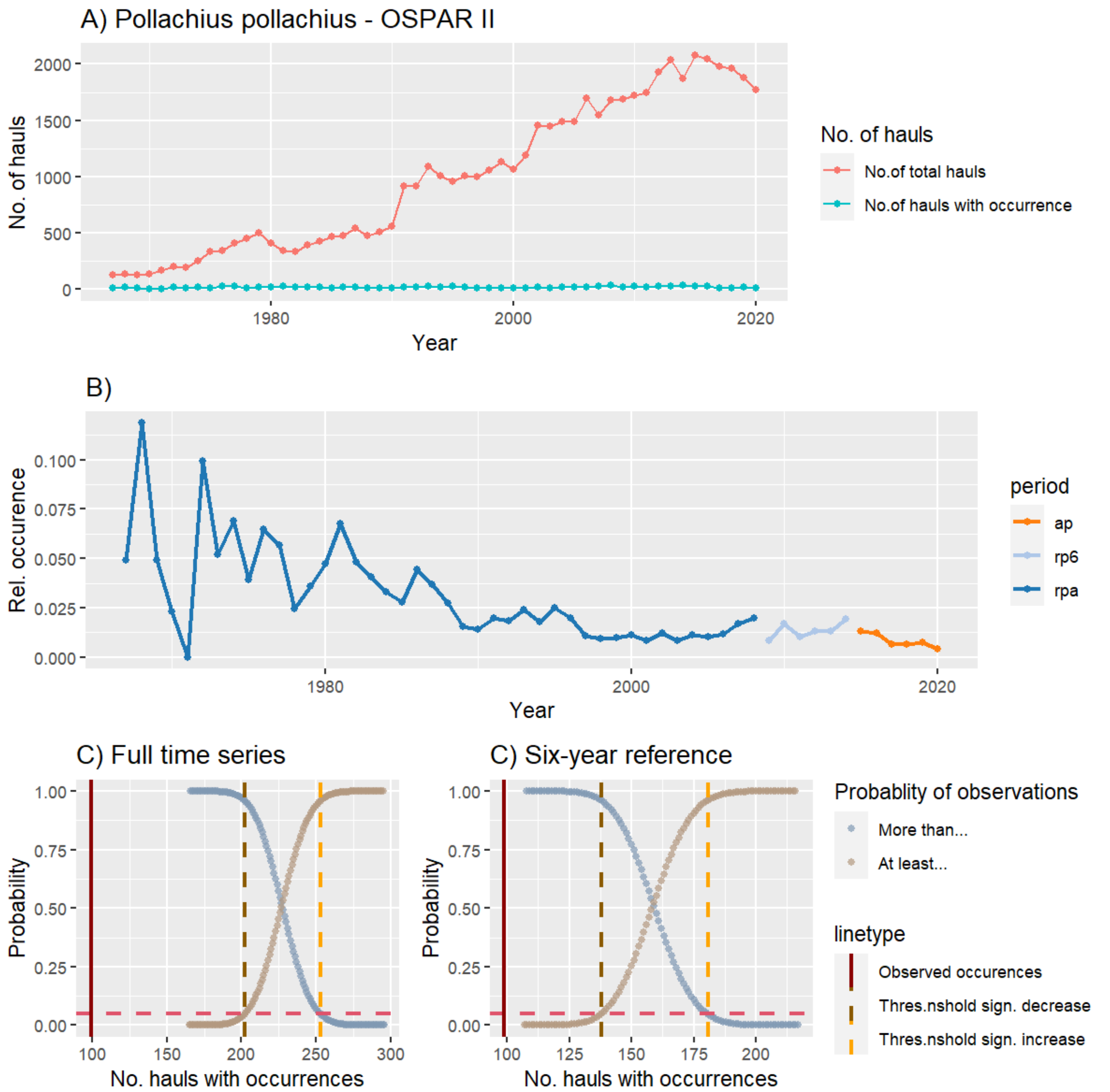

Figure 4.3. Assessment of the occurrences of pollock (*Pollachius pollachius*) based on the binomial approach. A) The number of total hauls vs. the number of hauls with occurrences. B) The frequencies of occurrence by year in the three time periods (ap = assessment period, rp6 = short-term reference period, rpa = long-term reference period of the full time-series, including rp6 but excluding ap). C) Assessment of occurrences in the assessment period vs. the long-term reference period. D) Assessment of occurrences in the assessment period vs. the short-term reference period. The line colour representing observed occurrences in the assessment indicates a significant decline (red) or increasing/stable occurrence (green).

Contrary, the occurrence of tope (*Galeorhinus galeus*) was assessed as stable when compared to the long-term reference period and as increasing when compared to the short-term reference period (Figure 4.4).

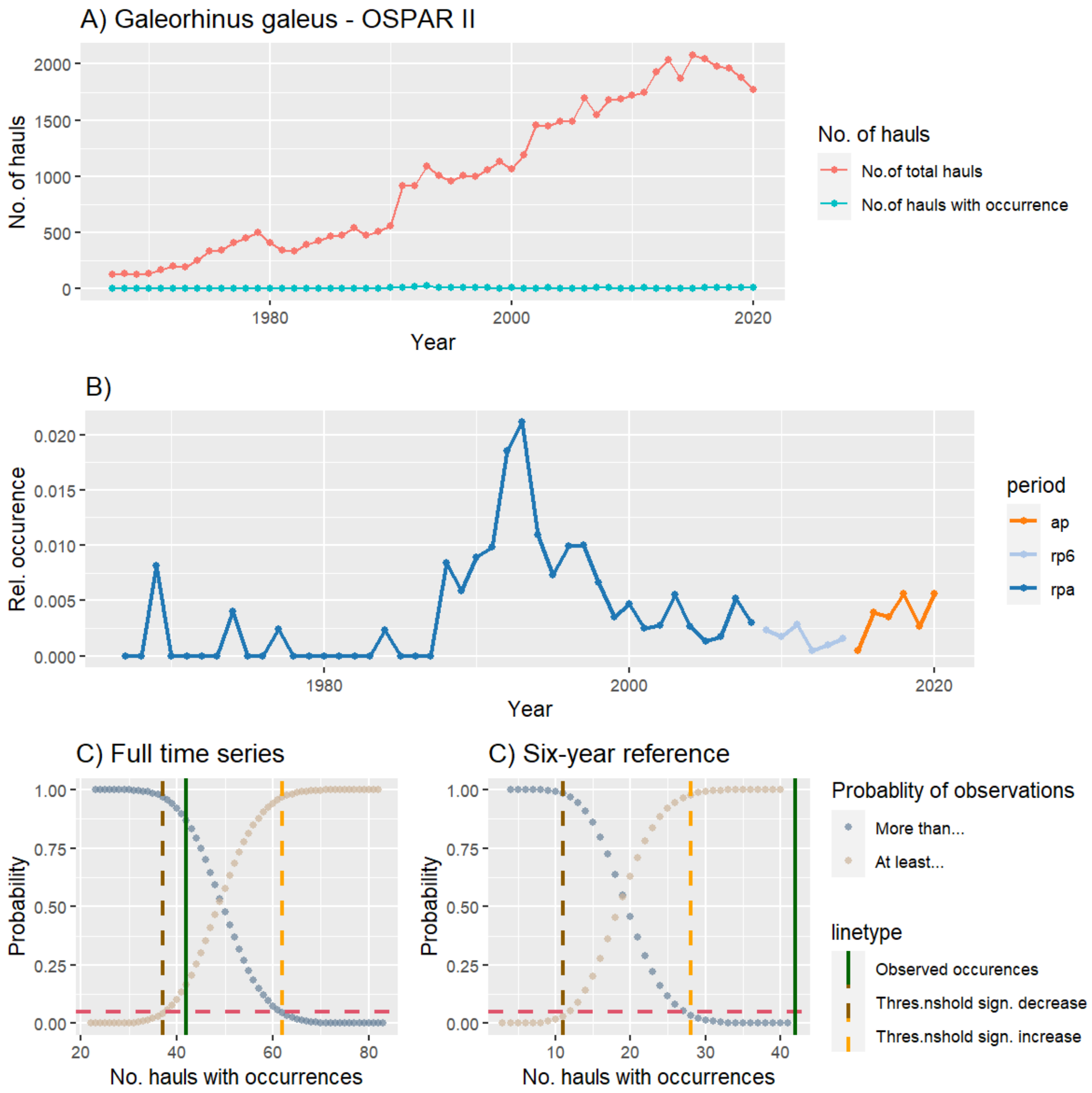

Figure 4.4. Assessment of the occurrences of tope (*Galeus galeorhinus*) based on the binomial approach. Legends and labels as in Figure 4.3.

For blue ling (*Molva dypterygia*) the binomial assessment indicates a significant increase during the assessment period when compared to rp6 and a stable occurrence when compared to rpa (Figure 4.5). Note that the significant increase is based on only two occurrences in the assessment period vs. zero occurrences in rp6, which demonstrates the sensitivity of the binomial approach in extreme data-limited situations. Due to the low occurrences in rp6 the binomial approach is not able to detect a significant decline.

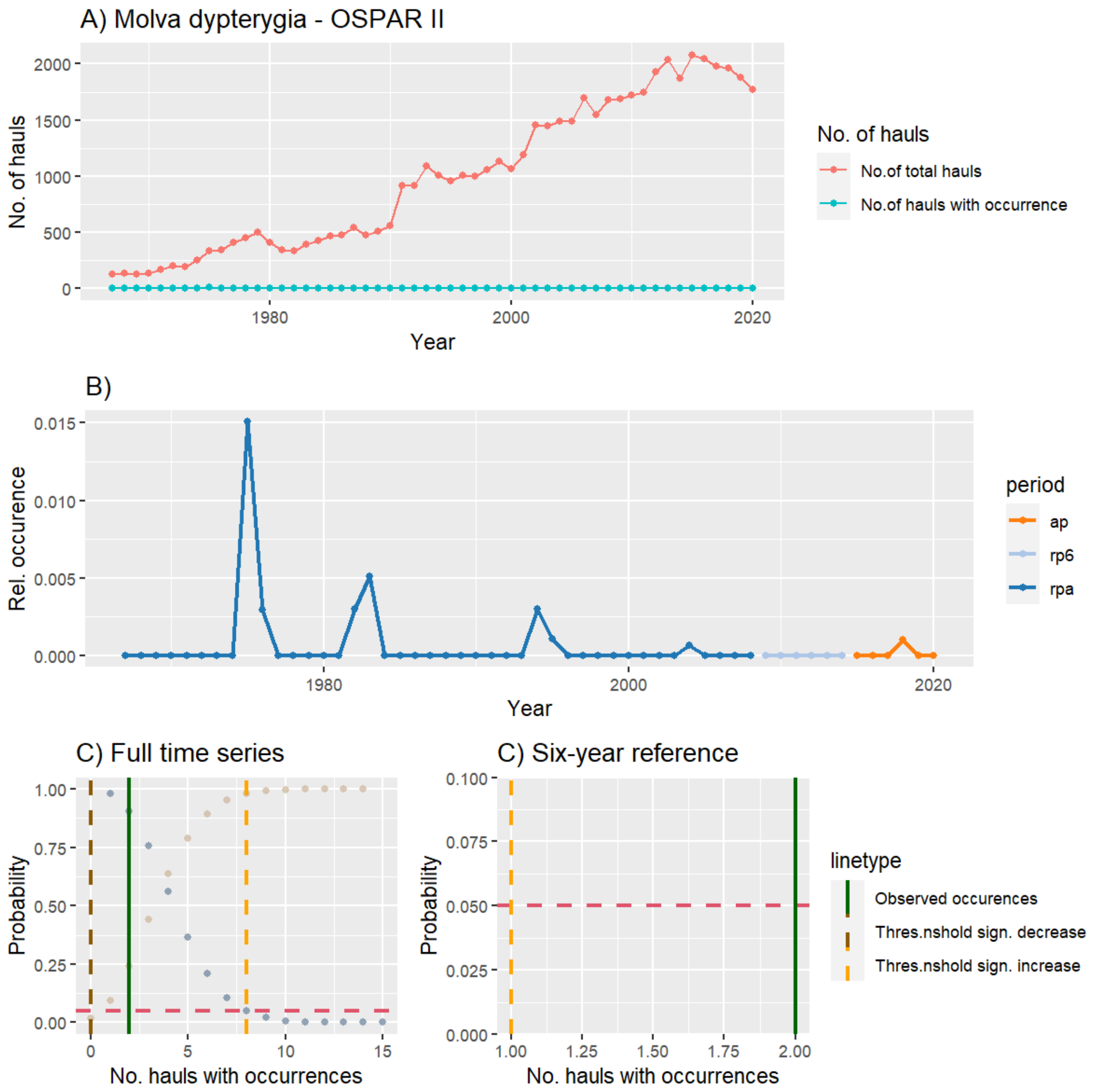

Figure 4.5. Assessment of the occurrences of blue ling *Molva dypterygia* based on the binomial approach. Legends and labels as in Figure 4.3.

Table 4.4 shows the assessment results for the 55 selected species in the Greater North Sea and Table 4.4 shows the meta-results of these 55 assessments. In the long-term reference period 48 out 55 species (= 87%) could be assessed, in the short-term reference period 51 out 55 (= 93%). This high assessment rate demonstrates the versatility of the binomial assessment approach. Compared to the long-term reference period, 16 species (33%) of the assessed species showed a decline in the assessment period, whereas only 11 species (22%) were declining when compared to the short-term assessment period.

For ten species a significant decline was evident when comparing the occurrences of the assessment period against the long-term reference period, while for four species (European eel, sea lamprey, tusk, and wolfish), this decline was not evident when comparing the short-term reference and assessment periods. Hence the inclusion of old, yet incomplete data, can be important to track the true status of rare species and should be considered despite limitations in survey data from the 1960s–1980s as mentioned below.

Table 4.4. Binomial assessments for 55 rare species found in the fisheries surveys of region OSPAR II (Greater North Sea). Rarity is the ratio between the number of hauls with occurrences divided by the total number of hauls and hence small values denote rarely caught species. Thresholds (Thr) indicate occurrences that indicate a significant decline or increase in the assessment period (ap) vs. the long-term reference period (rpa) or the short-term (six years) reference period (rp6). Note that these results are part of the worked example of the presence-absence analysis but not the final assessment result.

Species	Rarity	Occurrence in AP	$Thr_{Dec.RPA}$	$Thr_{Dec.RP6}$	$Thr_{Inc.RPA}$	$Thr_{Inc.RP6}$	Status Ap-rpa	Status ap-rp6
Alosa spp.	0.01848	167	205	229	257	283	Declining	Declining
Amblyraja radiata	0.17966	1220	2283	1281	2428	1396	Declining	Declining
Anarhichas lupus	0.02848	127	359	104	426	142	Declining	Stable
Anguilla anguilla	0.00789	52	87	43	122	70	Declining	Stable
Brama brama	0.00028	0	0	8	9	23	Declining	Declining
Brosme brosme	0.00772	34	89	26	125	47	Declining	Stable
Chelidonichthys lucerna	0.15113	1980	1648	2322	1776	2468	Increasing	Declining
Chimaera monstrosa	0.00281	35	22	18	43	38	Stable	Stable
Conger conger	0.00906	257	50	93	78	129	Increasing	Increasing
Coryphaenoides rupestris	0.00015	0	NA	NA	6	4	Not assessed	Not assessed
Cyclopterus lumpus	0.04896	205	636	357	721	422	Declining	Declining
Dasyatis pastinaca	0.00017	3	NA	0	5	9	Not assessed	Stable
Dipturus oxyrinchus	8.00E-05	1	NA	NA	4	1	Not assessed	Increasing
Dipturus spp.	0.00693	186	39	61	65	91	Increasing	Increasing
Etmopterus spinax	0.0016	45	5	6	18	20	Increasing	Increasing
Galeorhinus galeus	0.00407	42	37	11	62	28	Stable	Increasing
Galeus spp.	0.00098	28	2	5	12	17	Increasing	Increasing
Helicolenus dactylopterus	0.01641	411	111	33	150	57	Increasing	Increasing
Hippocampus guttulatus	0.00032	7	NA	0	7	7	Increasing	Increasing
Hippocampus hippocampus	0.00217	86	3	14	14	31	Increasing	Increasing
Hippocampus spp	6.00E-05	3	NA	NA	0	0	Increasing	Increasing
Hippoglossus hippoglossus	0.00823	73	86	31	121	55	Declining	Increasing

Species	Rarity	Occur-rence in AP	$Thr_{Dec.RPA}$	$Thr_{Dec.RP6}$	$Thr_{Inc.RPA}$	$Thr_{Inc.RP6}$	Status Ap-rpa	Status ap-rp6
Lampetra fluviatilis	0.003	62	18	33	37	57	Increasing	Increasing
Lepidorhombus whiffiagonis	0.06996	1125	689	821	778	916	Increasing	Increasing
Leucoraja circularis	0.00051	2	2	1	13	10	Declining	Stable
Leucoraja fullonica	0.0016	33	8	14	22	31	Increasing	Increasing
Leucoraja naevus	0.06248	858	654	666	740	753	Increasing	Increasing
Lophius budegassa	0.01078	446	25	76	47	110	Increasing	Increasing
Lophius piscatorius	0.16283	2389	1707	1938	1836	2075	Increasing	Increasing
Mola mola	2.00E-05	0	NA	NA	2	1	Not as-sessed	Not as-sessed
Molva dypterygia	3.00E-04	2	0	NA	8	1	Stable	Increasing
Molva molva	0.05843	645	653	492	739	568	Declining	Increasing
Mustelus spp.	0.04773	842	443	828	516	924	Increasing	Stable
Petromyzon mari-nus	0.00136	8	10	4	26	16	Declining	Stable
Phycis blennoides	0.00375	112	16	43	34	70	Increasing	Increasing
Pollachius pol-lachius	0.01699	99	202	138	253	181	Declining	Declining
Pomatoschistus spp.	0.06544	1299	575	1361	657	1479	Increasing	Declining
Raja brachyura	0.01746	343	144	237	188	292	Increasing	Increasing
Raja clavata	0.09526	1313	1008	1192	1113	1304	Increasing	Increasing
Raja microocellata	0.00955	114	93	88	130	124	Stable	Stable
Raja montagui	0.06516	1161	609	845	693	941	Increasing	Increasing
Raja undulata	0.00629	120	47	96	75	133	Increasing	Stable
Salmo trutta	0.00045	1	2	1	12	10	Declining	Declining
Scophthalmus max-imus	0.10521	1339	1148	1205	1258	1317	Increasing	Increasing
Scophthalmus rhombus	0.09134	1052	1023	1271	1128	1386	Stable	Declining
Scorpaena scrofa	2.00E-05	0	NA	NA	2	1	Not as-sessed	Not as-sessed
Scyliorhinus canic-ula	0.21113	3431	2132	3357	2273	3521	Increasing	Stable

Species	Rarity	Occurrence in AP	$Thr_{Dec.RPA}$	$Thr_{Dec.RP6}$	$Thr_{Inc.RPA}$	$Thr_{Inc.RP6}$	Status Ap-rpa	Status ap-rp6
Scyliorhinus stellaris	0.00648	126	48	130	76	172	Increasing	Declining
Sebastes spp.	0.00066	1	4	NA	16	4	Declining	Not assessed
Sebastes viviparus	0.01443	86	169	40	216	65	Declining	Increasing
Sparus aurata	4.00E-05	1	NA	NA	2	1	Not assessed	Increasing
Squalus spp.	0.0474	361	570	264	651	321	Declining	Increasing
Tetronarce nobiliana	0.00019	4	NA	NA	5	1	Not assessed	Increasing
Torpedo marmorata	0.00209	67	6	18	20	38	Increasing	Increasing
Zoarces viviparus	0.03489	610	321	648	383	734	Increasing	Declining

Table 4.5. Meta-results for the 55 sensitive species recorded in the surveys from OSPAR region II.

Status	No. of species AP-RPA	No. of species AP-RP6
Declining	16	11
Increasing	27	29
Stable	5	11
Not assessed	7	4

4.2.1 Thinking ahead: aggregating single species assessment results

The binomial assessment provides a confidence in an observed decline or increase. Based on $\alpha = 0.05$ we can assert with 95% confidence that any assessed decline or increase is true. Probst (2017) suggests a generic aggregation approach for assessment results with equal confidence, again based on the binomial distribution as shown in Eq.2. In this case, however, k is the number of species with no significant decline, and p is defined by $\alpha = 0.05$, i.e. the confidence of the status for non-declining species (hence $p = 0.95$), and n is the number of assessed species (= 48).

For the long-term in the OSPAR II assessment with 32 stable or increasing species (see Table 4.5) Eq.2 fills as:

$$P(X \leq 32|48, 0.95) = \sum_{i=0}^{48} \binom{48}{i} 0.95^{i} (0.05)^{48-i} < 0.001$$

Observing only 32 non-declining species is therefore very unlikely and below a significance threshold of 0.05. The highest k at which $P(X \leq k \mid 48, 0.95) < 0.05$ is at $k = 42$. Accordingly, observing less than 43 species with stable or increasing status would indicate a significant deviation from the expected mean based on the values of k, n and p. Because the total number of stable (= 5) or increasing (= 27) species is only 32 (Table 4.5), the suite of rare fish species assessed in this study in OSPAR region II would therefore not achieve an aggregated assessment result which was indicative of a Good Environmental Status (GES).

4.2.2 The limits of the binomial approach

There are limits for the binomial approach to assess the significance of a decline in cases were *p* and/or *n* are low (Table 4.6). In these circumstances the cumulative distribution function does not approach probabilities below 0.05 and hence k_{sig} cannot be determined. In other words, due to low sample sizes and frequencies of occurrence the probability of not encountering a species for at least once is rather probable (p > 0.05). Contrary, the probability of an increase can always be significantly determined. This finding may have implications for the assessment target such as suggested by Greenstreet *et al.* (2012) or Probst and Stelzenmüller (2015), i.e. whether to use the assessment against a significant decline or increase in determining the status of a species.

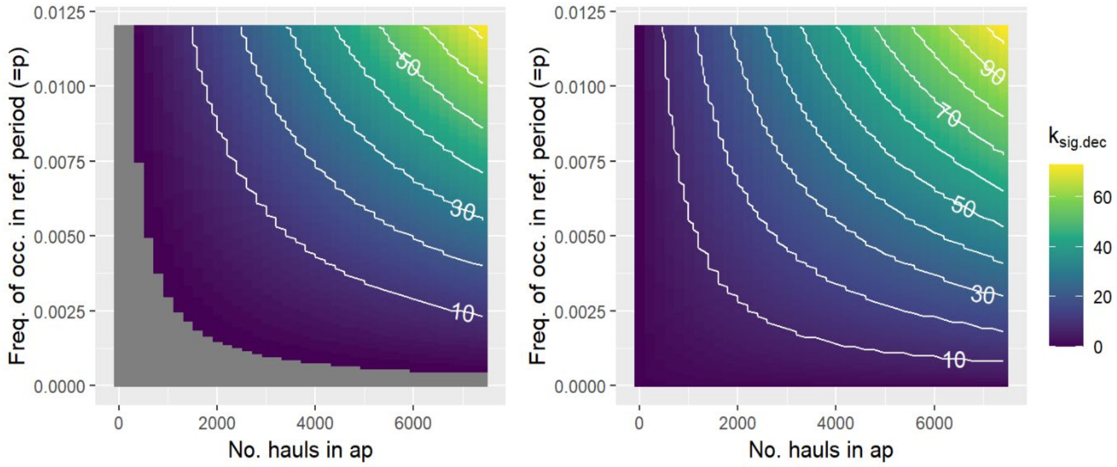

Figure 4.6. The relationship between the number of hauls in the assessment period (ap), the frequency of occurrence in the reference period (p) and the significance limits for observed occurrences in the assessment period (ksig) for predicting decreases (right) and increases (left). Note the grey area in the left panel indicating the inability to identify significant declines because the number of hauls and/or p are too low.

The definition of the reference period requires careful consideration. There are many reports and records of biases especially for data that were measured before the 1980s (Greenstreet and Moriarty, 2017; Moriarty *et al.*, 2017). For example, in the initial years of many surveys not all species were recorded, and even in those where all species were sampled, not all records may have been reported to the ICES DATRAS database. Similarly, issues may arise with species identification that has changed over time. Hence the absence or presence of a species can be solely based on inconsistent classification emphasizing the importance of quality assurance when combining survey data from different periods and surveys (Greenstreet and Moriarty, 2017).

The temporal consistency of the same survey in different quarters of the year may not be provided. The NS-IBTS from quarter 1 dates back to 1967, whereas data from quarter 3 was only available from 1991 onwards. Also, the survey gears and protocols (including haul time in quarter 3) have changed through time, making the combination of data from different surveys and quarters challenging.

Applying the binomial assessment approach assumes that the frequency of occurrence in the reference periods equals the probability of occurrence in the reference period. However, due to temporal and spatial autocorrelation of occurrences this central assumption may be confounded under given circumstances, e.g. if occurrences were strongly autocorrelated in space or in time. While this is also true for the GAM approach, GAMs account for at least part of this variation through spatio-temporal changes in the mean. The robustness of the binomial approach against potential violations of assumptions therefore remains to be tested.

4.2.3 A first attempt to explore the robustness of the binomial assessment approach

As mentioned before the definition of the reference period requires careful consideration and might influence the assessment outcome for the occurrences in the assessment period. Furthermore, the choice of included surveys may affect the number of observed occurrences. To analyse the influence of these factors, the occurrence of blue ling (*Molva dypterygia*) was analysed using different reference periods and different combinations of surveys as data sources (Figure 4.7).

Blue ling were first reported in 1975 in IBTS in Q1 and they have since been reported in all the following surveys also: EVHOE Q4, NS-IBTS Q3, ROCKALL Q3, SP-PORC Q3, SWC-IBTS Q1 and SWC-IBTS Q4.

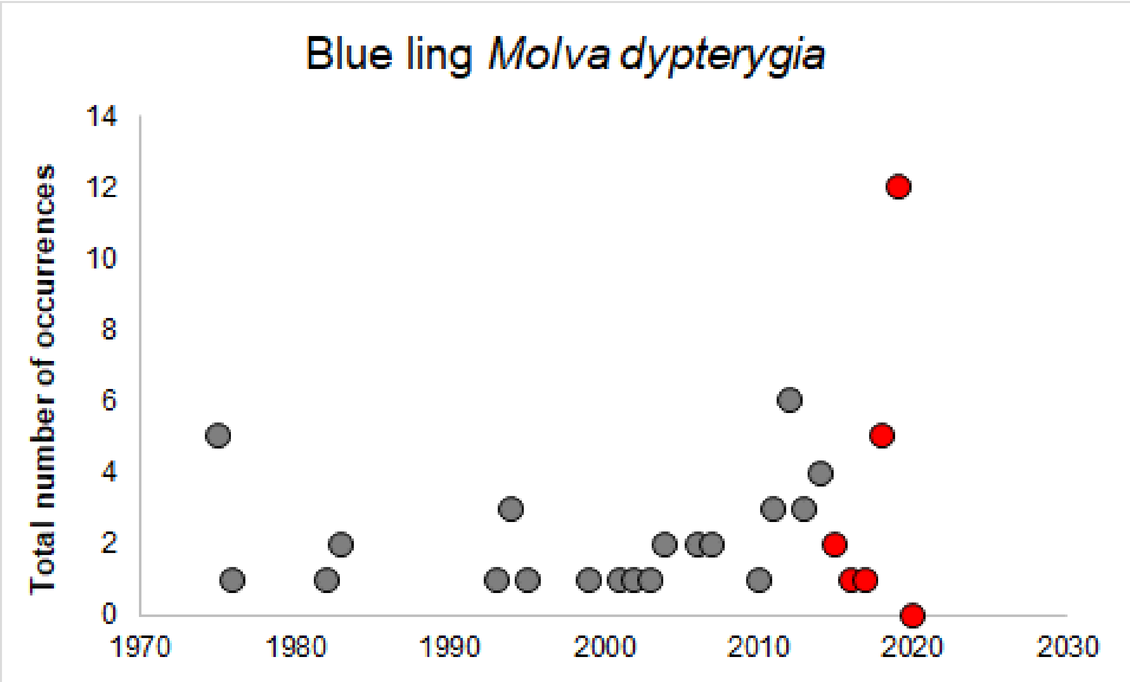

Figure 4.7. Total number of occurrences per year from all surveys where blue ling (*Molva dypteriygia*) were recorded at least once showing the assessment period in red (last 6 years, 2015–2020) vs. the reference period (1975–2014; zero occurrence are not plotted in the reference period).

In the reference period there were 41 occurrences in 30 241 hauls and thus an estimated probability of occurrence of 0.0014. In the assessment period blue ling had 21 occurrences in 6523 hauls. Based on the binomial model, we would expect up to 14 occurrences in 6523 hauls but the probability of 21 occurrences or more is < 0.01 (Figure 4.8 right) suggesting a significant increase in occurrences since 2015. There is no evidence of a decrease in occurrences in 2015–2020 since a significant departure from the binomial model would require less than four occurrences (Figure 4.8 left).

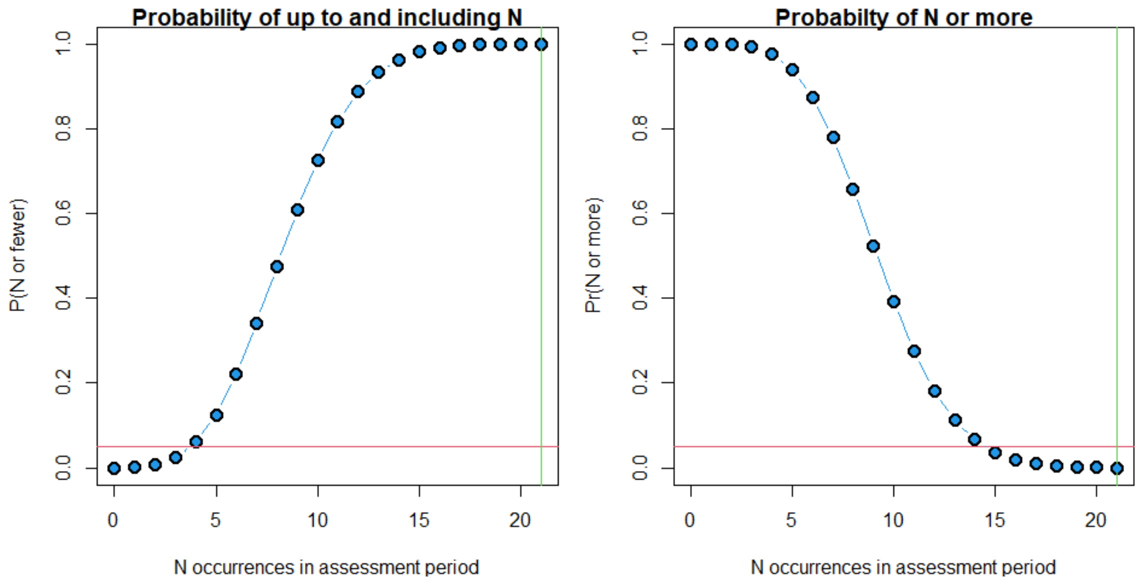

Figure 4.8. Cumulative probability of recording n or fewer occurrences (left) and the probability of n or more occurrences (right) given probability of occurrence in the reference period in all surveys (1975–2014) where the green line is number of occurrences of Blue ling in all surveys (2015-2020). Red horizontal line indicates P=0.05.

If blue ling does not compose a single population over the whole area covered by all surveys, it would be inappropriate to define the reference period between 1975 and 2014, as each survey started in a different year. Adjusting the reference period to the first common year each survey has reported the presence of blue ling, we repeat the above analysis with a reference period 2000–2014 and an assessment period as before. Based on the observed number of occurrences and hauls in the assessment period and the frequency of occurrence in the reference period the conclusion of a significant increase does not change, although $k_{sig.}$ changes (Table 4.3; Figure 4.9).

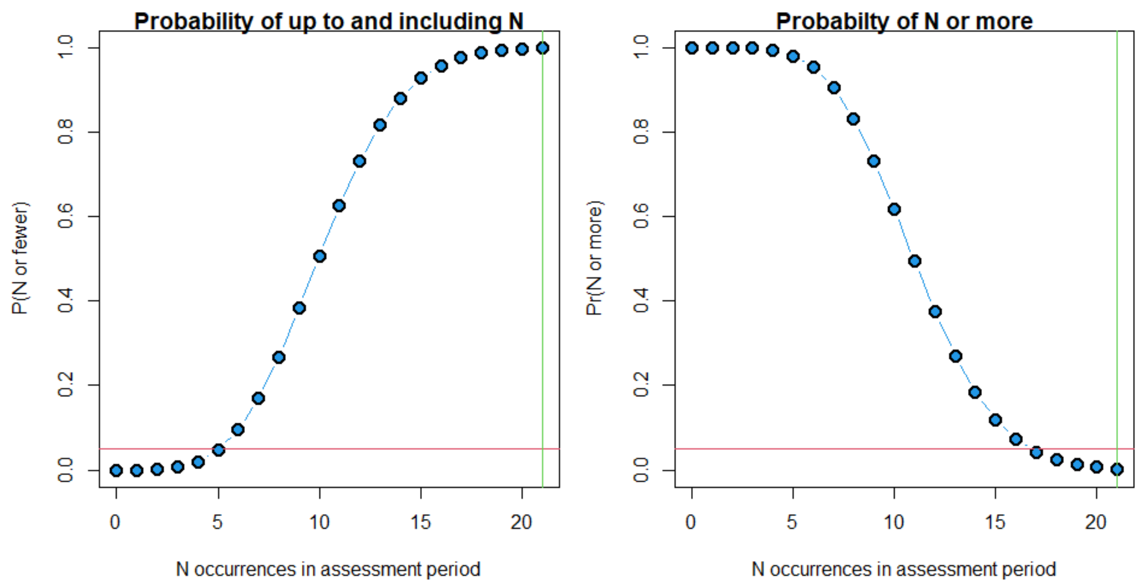

Figure 4.9. Cumulative probability of recording n or fewer occurrences (left) and the probability of n or more occurrences (right) given probability of occurrence in the reference period in all surveys (2000-2014) where the green line is number of occurrences of blue ling in all surveys (2015-2020). Red horizontal line indicates P=0.05.

If each survey is analysed separately, it is interesting that a significant increase in the period 2015–2020 is found for SWC IBTS Q4 relative to the reference period 2000–2014 (Figure 4.10). However, it is not possible to identify a significant decrease due to the small number of occurrences in the reference period (7 occurrences in 971 hauls) that leads to a very low estimated probability of detection (0.007). Nevertheless, since the species was recorded on 6 occasions in 291 hauls we can conclude that the occurrences have increased in the survey and thus there is no evidence of a decrease.

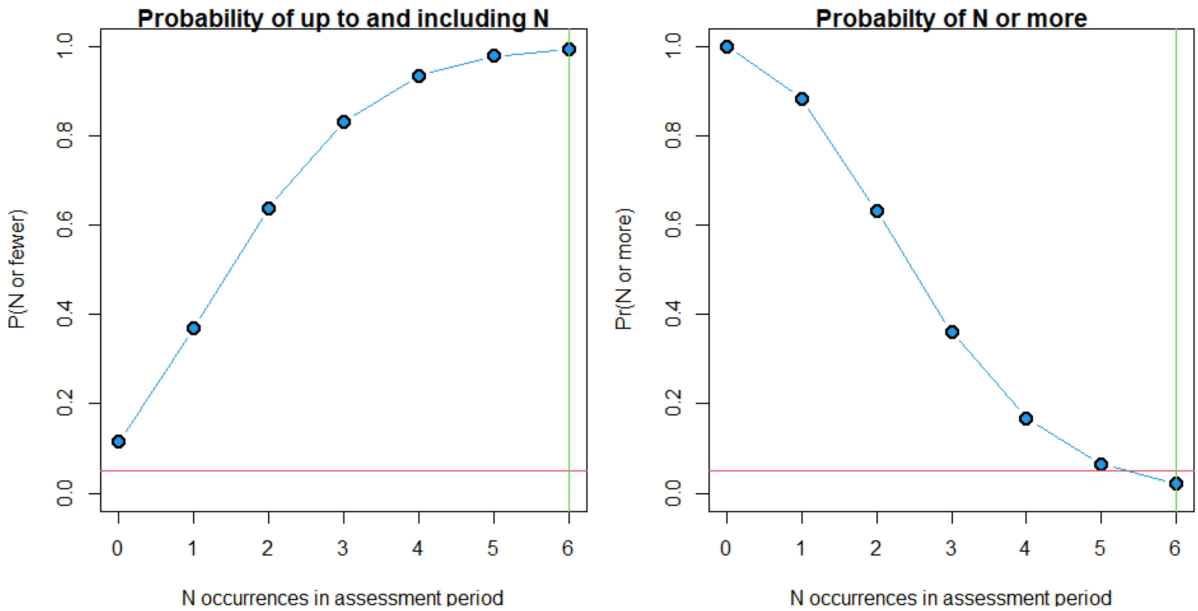

Figure 4.10. Cumulative probability of recording n or fewer occurrences (left) and the probability of n or more occurrences (right) given probability of occurrence in the reference period in SWC IBTS Q4 (2000–2014) where the green line is number of occurrences of blue ling in SWC IBTS Q4 (2015–2020). Red horizontal line indicates P = 0.05.

Table 4.6. Assessment results on the three case studies of blue ling (*Molva dypterygia*) using different reference periods and survey combinations.

Case study	1975-2014 All surveys (Figure 4.8)	2000-2014 All surveys (Figure 4.9)	2000-2014 SWC-IBTS Q4 (Figure 4.10)
Frequency of occurrence in reference period (*p*)	41/30241 = 0.00136	26/15976= 0.00163	7/971= 0.00721
Number of hauls in assessment period (*n*)	6523	6523	291
Occurrence in assessment period (*k*)	21	21	6
Threshold increase	>14	>16	>5
Threshold decline	<4	<6	NA
Assessment result	Increase	Increase	Increase

Table 4.6 indicates that the assessment results for the occurrence of blue ling are consistent and not influenced by the definition of the reference period or data sources. This is a first indication of the robustness of the binomial approach, but deeper analysis on more species and survey/time combinations will foster a better understanding of how robust the assessment results of the binomial approach might be.

4.3 GAM

4.3.1 Background

Generalized Additive Models (GAMs, Hastie and Tibshirani, 1990) can be used to estimate abundance of fish populations while correcting for confounding factors such as spatial position of the haul, depth, time of day, or swept-area (Stefansson, 1996; Petrakis *et al.*, 2001; Piet, 2002; Adlerstein and Ehrich, 2003; Beare *et al.*, 2005; Berg *et al.*, 2014). GAMs allow the definition of non-linear smooth relations between the response (e.g. abundance) and explanatory variables (e.g. year, season, and position of haul).

The overall annual abundance of sensitive species was estimated based on spatio-temporal GAMs. We use the approach and R (R Core Team 2021) packages described in Berg *et al.* (2014). The mgcv (Wood 2006) package is slightly modified to allow more flexibility with input data and work with overall biomass without an age structure. The model includes a smooth development of the mean over space and time. Smooth distribution in time is particularly desirable for long-lived species like most of the sensitive species. Note that the study includes *Pomatoschistus spp* but this group was later removed from the sensitive list and should therefore be disregarded in subsequent use of the data.

4.3.2 Material and methods

4.3.2.1 Data

The number of individuals caught per haul was estimated for each species based on the DATRAS dataset and according to the steps described in Section 3.3. For six species (*Anarhichas lupus, Chelidonichthys lucerna, Cyclopterus lumpus, Leucoraja naevus, Scophthalmus rhombus, Scyliorhinus canicula*), two distinct subpopulations were defined based on assessments presented during the workshop (see Section 4). The number of hauls that caught at least one individual of a certain population[1] (non-zero hauls) varied between populations and ranged from 1 to close to 19 000 over the whole region and period covered by the surveys. As the spatio-temporal GAMs (at least as defined in this study) require a comprehensive dataset, only populations with at least 100 non-zero hauls were considered for this analysis, resulting in 50 suitable populations presented in the Table 4.7. Any statistical rectangle, where the species were never observed was removed from the analysis for that species. We refer to the remaining statistical rectangles with at least one occurrence as the realized habitat for a specific species. Similarly, any year prior to the year where a species was first observed was removed from the analysis. Preliminary analysis showed, that highly fragmented time-series can lead to model fitting problems and model instability. Thus, the first year of the time-series was removed, if it was followed by no observations in the subsequent two or more years. Furthermore, following species-specific adjustments were made:

- *Alosa spp*: remove data if Longitude < 7 as *Alosa spp* in the Baltic/Kattegat/Skagerrak were spatially separated from more western *Alosa spp* and there were few western *Alosa spp* caught as judged from the spatial distribution of survey catches.
- *Amblyraja radiata*: remove data if Longitude < –6, Longitude < –4 and Latitude < 60, Longitude < –3 and Latitude < 55 as WGEF considered that these specimens were misidentified as *Raja clavata.*

[1] Note that we use the term 'population' rather than 'species' to account for the six species with two subpopulations.

Table 4.7. Data and model type information for each population: Minimum year of time-series after data processing described in main text, number of zero and non-zero hauls (numbers and percentage), and model type describing whether GAM+ includes parametric gear effect (1), without gear effect (2), or without gear and random effect (3).

Population	Min. year	Zero hauls	Non-zero hauls	Non-zero hauls [%]	Model type
Alosa spp	1968	16629	584	3	1
Amblyraja radiata	1967	28805	9665	25	1
Anarhichas lupus (NorthSea)	1967	26613	1546	5	1
Anguilla Anguilla	1977	27555	732	3	1
Argyrosomus regius	1997	700	148	17	1
Brosme brosme	1974	8834	535	6	1
Chelidonichthys lucerna (North48)	1985	40902	10654	21	1
Chelidonichthys lucerna (South48)	1990	4874	1064	18	1
Chimaera monstrosa	1975	6173	750	11	1
Conger conger	1975	22057	5758	21	1
Cyclopterus lumpus (CentralBaltic)	1999	5582	1004	15	2
Cyclopterus lumpus (WesternBal-tic)	1967	7593	1287	14	1
Dasyatis pastinaca	1996	6236	100	2	1
Dipturus spp	1967	16540	1707	9	1
Etmopterus spinax	1972	4572	280	6	1
Galeorhinus galeus	1984	28146	640	2	1
Galeus spp	1985	8205	1379	14	1
Helicolenus dactylopterus	1985	24032	5735	19	1
Hexanchus griseus	1999	2067	192	8	1
Hippocampus hippocampus	1997	12526	301	2	1
Hippoglossus hippoglossus	1967	21020	464	2	1
Lampetra fluviatilis	1991	17405	188	1	1
Leucoraja circularis	1990	7152	336	4	1
Leucoraja fullonica	1983	7072	359	5	1
Leucoraja naevus (North42)	1967	31989	6777	17	1
Leucoraja naevus (South42)	2000	1650	255	13	1
Lophius budegassa	1985	20218	3916	16	1

Population	Min. year	Zero hauls	Non-zero hauls	Non-zero hauls [%]	Model type
Lophius piscatorius	1967	39806	15263	28	1
Molva macrophthalma	1997	1798	494	22	1
Molva molva	1967	42179	5692	12	1
Mustelus spp	1976	40957	4295	9	1
Petromyzon marinus	1980	12245	102	1	1
Phycis blennoides	1984	15786	3461	18	1
Pollachius pollachius	1967	38239	1433	4	1
Pomatoschistus spp	1967	52763	4321	8	1
Raja brachyura	1972	25319	1551	6	1
Raja clavata	1967	53159	8795	14	1
Raja microocellata	1993	8324	609	7	1
Raja montagui	1967	35108	5984	15	1
Raja undulata	1990	8421	627	7	1
Scophthalmus maximus	1967	59183	10174	15	1
Scophthalmus rhombus (CelticSeas)	1983	8876	1560	15	1
Scophthalmus rhombus (NorthSea)	1967	40407	5477	12	1
Scyliorhinus canicula (North48)	1971	41466	18920	31	1
Scyliorhinus canicula (South48)	1990	2501	3928	61	1
Scyliorhinus stellaris	1998	11128	1175	10	1
Sebastes viviparus	1968	16811	1525	8	1
Squalus spp	1967	44997	5059	10	1
Torpedo marmorata	1990	3525	328	9	1
Zoarces viviparus	1970	22410	3062	12	1

4.3.3 Modelling approach

Two spatio-temporal GAMs were fitted to the DATRAS dataset for each population. The first model, labelled GAM+, represents the full model with all relevant explanatory variables:

$$g(\mathrm{N_i}) = f_1(Lon_i, Lat_i) + f_2(Year_i, Lon_i, Lat_i) + f_3(timeOfYear_i, Lon_i, Lat_i) + f_4(Depth_i) + Gear_i + U(i)_{Ship:Gear} + log(SweptArea_i)$$

where N_i refers to the number of individuals in the i^{th} haul with link function (g), here a log link, f_1 represents a two-dimensional Duchon spline on the geographical coordinates of haul i , Lon and Lat refers to Longitude and Latitude of haul i, f_2 represents a three-dimensional Tensor product smooth, 1D Thin plate smooth for time domain and two-dimensional Duchon spline for space domain, f_3 represents a three-dimensional Tensor product smooth, 1D Cyclic cubic regression spline for time and two-dimensional Duchon spline for space, f_4 represents a 1D thin plate spline for effect of bottom depth, $Gear_i$ is a parametric gear effect in the categories described in Table 3.6, $U(i)_{Ship:Gear} \sim \mathbb{N}(0, \sigma_u)$ is a random effect for the ship:gear interaction of haul i, and the swept-area (SweptArea) was estimated as described in Section 3.1.2.

The second model, labelled GAM, represents a simpler model structure without the gear and random ship:gear effect:

$$g(N_i) = f_1(Lon_i, Lat_i) + f_2(Year_i, Lon_i, Lat_i) + f_3(timeOfYear_i, Lon_i, Lat_i) + f_4(Depth_i) + log(SweptArea_i)$$

For two populations (*Hexanchus griseus, Cyclopterus lumpus*), there was only one gear category left after the data processing and thus even GAM+ did not include the parametric gear effect. For one population (*Molva macrophthalma*), there was only a single gear and ship:gear category, and thus GAM+ and GAM were identical ('Model type' in Table 4.7).

We used the same procedure to estimate the indices of abundance as described in Berg *et al.* (2014):

- Divide the realized habitat into small subareas of approximately equal size (20 km edge length);
- Choose one haul position to be representative for each subarea (here the one closest to the spatial centroid of all hauls in the given subarea);
- Take the sum over all predicted abundances using the same reference gear, time of the year, depth, and swept-area for the chosen haul position.

The standard deviation, coefficient of variation (CV), and 95% confidence intervals of the abundance indices were estimated based on bootstrapping. Given that n_y denotes the number of hauls in a given year, a bootstrap dataset is created by resampling the dataset with replacement, taking n_y hauls for each year from the data. All parameters (incl. smoothing parameters) and the abundance index are re-estimated for each bootstrap dataset. The estimation of the standard deviation is based on 1000 bootstrap datasets. For more information about the prediction and bootstrapping procedure, please refer to Berg *et al.* (2014).

In addition, we applied the stratified mean method that takes the average number caught by rectangle, and then the average over all rectangles of the realized habitat. This method used to be the standard approach for the estimation of abundance indices within ICES and serves as a baseline to compare the GAM estimated indices with.

4.3.4 Results

Overall, the abundance indices based on the stratified mean and the two GAM models describe similar trends (Figure 4.11 and Figure 4.12). However, for some populations the trend and/or scale relative to the mean index differs between the methods, for example for *Conger conger, Dipturus spp., Lophius budegassa* and *L. piscatorius*, and both populations of *Scyliorhinus canicula*. For all of these populations, the standardized abundance estimated by GAM shows less pronounced peaks at the beginning of the time-series and indicates higher abundance during more recent decades than the abundance estimated by stratified mean.

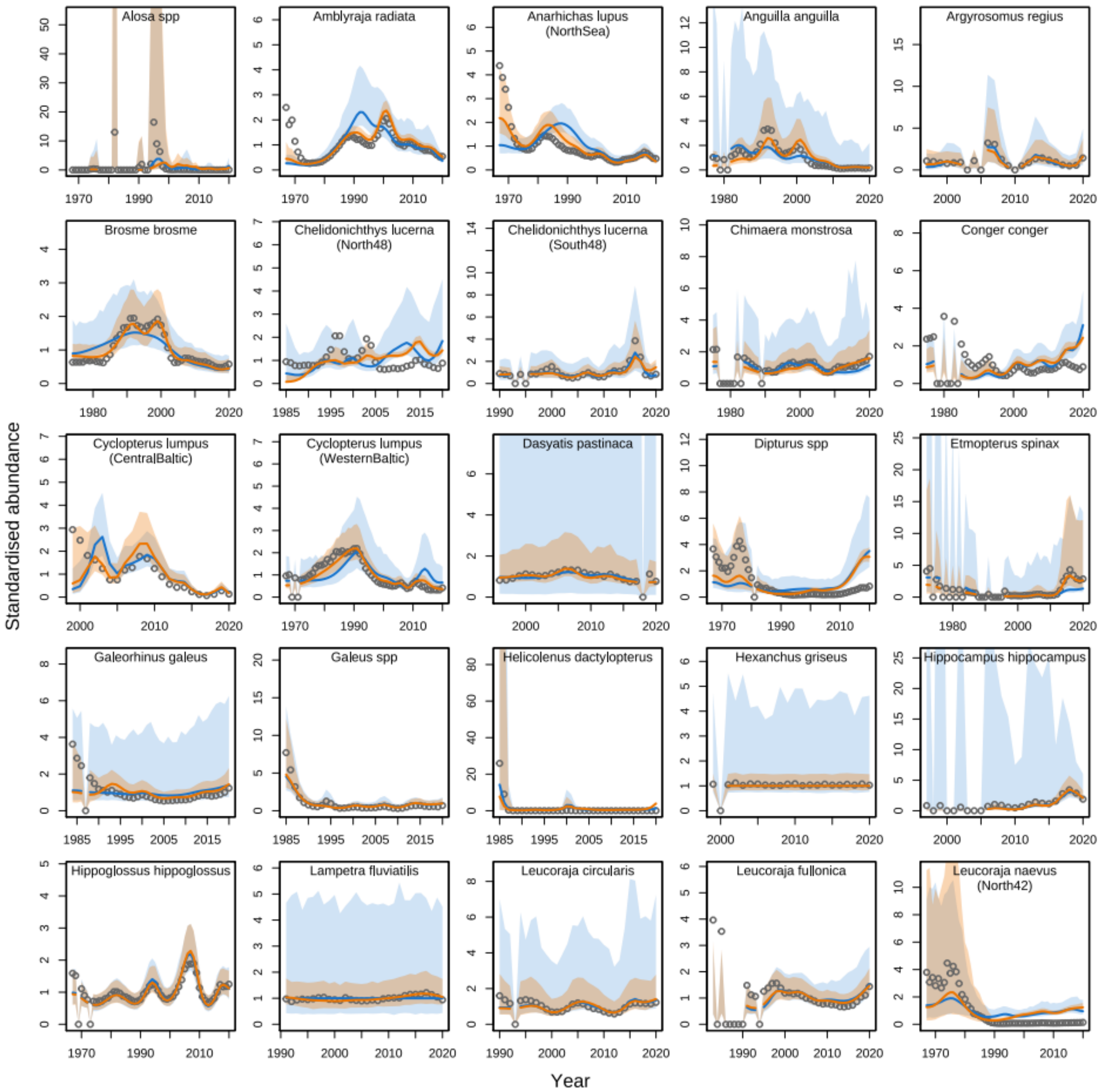

Figure 4.11. Standardized abundance indices based on stratified mean, GAM+ and GAM for the first 25 out of 50 stocks. Circles represent stratified mean, red = GAM and blue =GAM+. Shaded area is 95% confidence interval of the mean.

The abundance indices based on the two GAMs describe similar patterns for all populations. The main difference between the two models is the estimated uncertainty of the indices as indicated by the 95% confidence intervals (Figure 4.11 and Figure 4.12) and the CV (Table 4.8). The CV of GAM+ ranges up to 3 005 268 with an average CV of 74 182. However, these high values are mainly due to seven populations with a CV > 100 (*Hippocampus hippocampus, Leucoraja naevus* (South42), *Pomatoschistus spp, Raja microocellata, Raja undulata, Torpedo marmorata, Zoarces viviparus*). Without these populations the average CV is 2.21. In comparison, the simpler GAM models have an overall average CV of 0.22 and a maximum of 1.2 (*Etmopterus spinax*). The CV is negatively correlated with the number of non-zero hauls, ratio of non-zero hauls to total hauls, number of non-zero hauls per year, as well as the number of gear categories and surveys (Figure 4.13).

The standardized abundance index in the last 10 years is lower than the overall average for 20 and 22 out of 50 populations for GAM+ and GAM, respectively (Table 4.8).

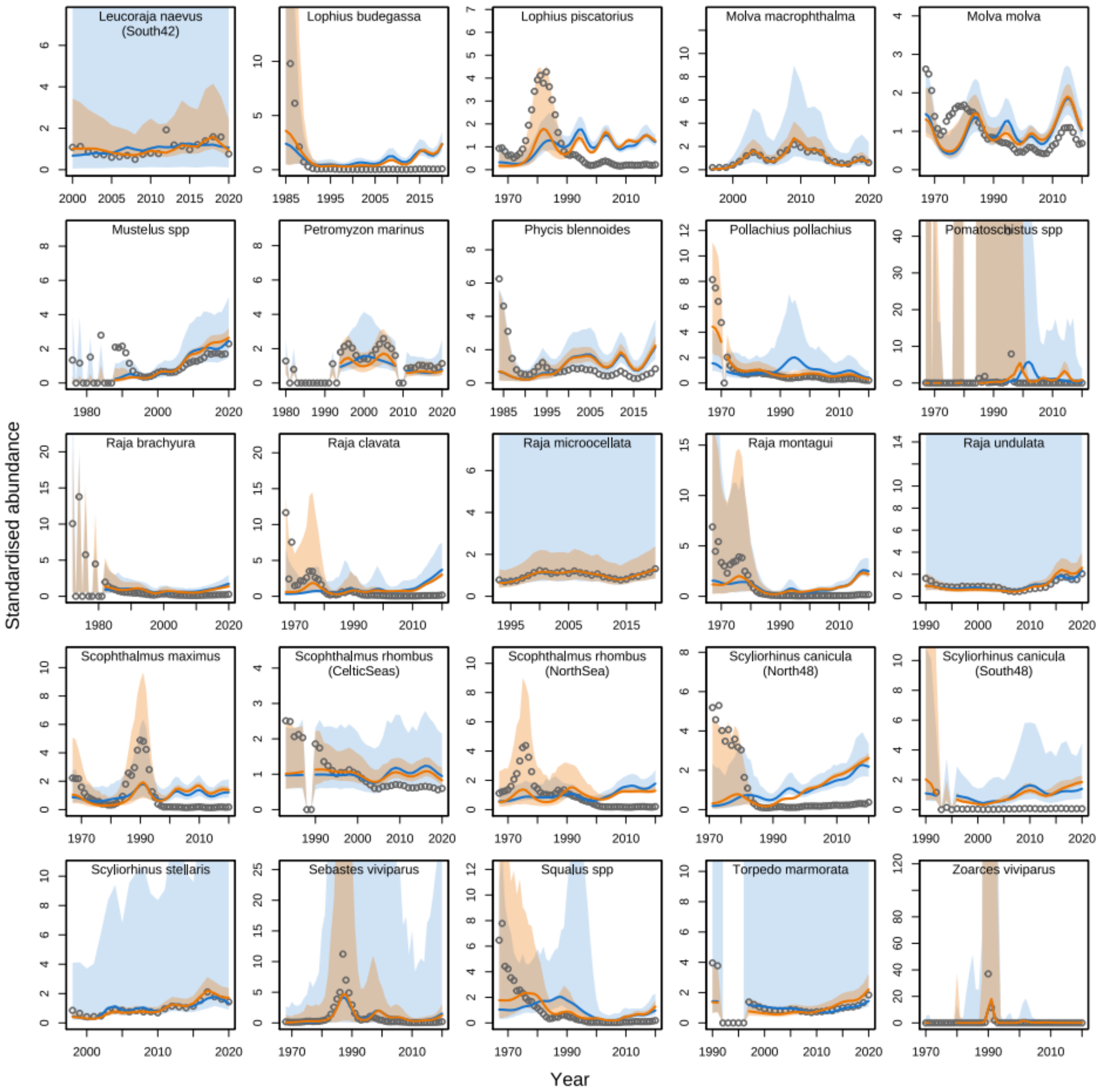

Figure 4.12. Standardized abundance indices based on stratified mean, GAM+ and GAM for the second 25 out of 50 stocks. Circles represent stratified mean, red GAM and blue GAM+. Shaded area is 95% confidence interval of the mean.

Table 4.8. Estimated average abundance index over last 10 years based on stratified mean, GAM+, and GAM, coefficient of variation (CV) for GAM+ and GAM, as well as model recommendation for abundance index estimation.

Population	ID	Strat. mean	$Index_{GAM+}$	$Index_{GAM}$	CV_{GAM+}	CV_{GAM}	Recom-mended model
Alosa spp	ID1	0.456	0.658	0.591	1.095	0.421	GAM
Amblyraja radiata	ID2	0.522	0.738	0.849	0.305	0.076	GAM+
Anarhichas lupus (NorthSea)	ID3	0.459	0.544	0.507	0.226	0.19	GAM+
Anguilla anguilla	ID4	0.207	0.224	0.227	5.354	0.224	GAM
Argyrosomus regius	ID5	0.541	1.096	1.121	0.884	0.529	GAM+
Brosme brosme	ID6	0.508	0.464	0.493	0.326	0.219	GAM+

Population	ID	Strat. mean	$Index_{GAM+}$	$Index_{GAM}$	CV_{GAM+}	CV_{GAM}	Recom-mended model
Chelidonichthys lucerna (North48)	ID7	1.169	1.415	1.438	0.496	0.055	GAM+
Chelidonichthys lucerna (South48)	ID8	1.235	1.439	1.469	0.631	0.3	GAM+
Chimaera monstrosa	ID9	3.094	0.979	1.512	3.616	0.308	GAM
Conger conger	ID10	2.191	1.954	1.909	0.267	0.08	GAM+
Cyclopterus lumpus (CentralBaltic)	ID11	0.591	0.474	0.477	0.223	0.204	GAM+
Cyclopterus lumpus (WesternBaltic)	ID12	0.38	0.944	0.591	0.428	0.145	GAM+
Dasyatis pastinaca	ID13	0.825	0.871	0.809	40.128	0.47	GAM
Dipturus spp	ID14	2.79	2.32	2.197	0.436	0.093	GAM+
Etmopterus spinax	ID15	2.77	1.239	2.844	6.546	1.173	GAM
Galeorhinus galeus	ID16	1.136	1.19	1.098	1.283	0.201	GAM
Galeus spp	ID17	1.577	0.837	0.852	0.274	0.214	GAM+
Helicolenus dactylopterus	ID18	2.041	0.409	1.004	0.309	0.107	GAM+
Hexanchus griseus	ID19	1.466	1.048	1.048	1.302	0.167	GAM
Hippocampus hippocampus	ID20	2.233	2.104	2.166	239.614	0.294	GAM
Hippoglossus hippoglossus	ID21	0.786	0.934	0.955	0.205	0.186	GAM+
Lampetra fluviatilis	ID22	1.638	1	1.108	1.319	0.26	GAM
Leucoraja circularis	ID23	1.526	1.125	1.115	2.038	0.348	GAM
Leucoraja fullonica	ID24	1.359	1.296	1.235	0.339	0.158	GAM+
Leucoraja naevus (North42)	ID25	1.762	1.008	1.068	0.27	0.098	GAM+
Leucoraja naevus (South42)	ID26	1.661	1.155	1.128	4770.488	0.756	GAM
Lophius budegassa	ID27	1.854	1.391	1.33	0.207	0.064	GAM+
Lophius piscatorius	ID28	1.366	1.249	1.332	0.116	0.036	GAM+
Molva macrophthalma	ID29	1.087	0.952	0.939	0.868	0.258	GAM+
Molva molva	ID30	1.645	1.492	1.522	0.171	0.077	GAM+
Mustelus spp	ID31	2.73	2.541	2.73	0.363	0.077	GAM+

Population	ID	Strat. mean	$Index_{GAM+}$	$Index_{GAM}$	CV_{GAM+}	CV_{GAM}	Recom-mended model
Petromyzon marinus	ID32	0.744	0.958	0.942	0.485	0.308	GAM+
Phycis blennoides	ID33	2.299	1.343	1.413	0.287	0.102	GAM+
Pollachius pollachius	ID34	0.242	0.748	0.547	0.422	0.165	GAM+
Pomatoschistus spp	ID35	1.22	0.654	1.749	243.141	0.232	GAM
Raja brachyura	ID36	1.751	1.318	1.109	0.231	0.137	GAM+
Raja clavata	ID37	1.756	2.349	1.899	0.358	0.063	GAM+
Raja microocellata	ID38	1.036	0.998	0.99	3005267.867	0.302	GAM
Raja montagui	ID39	2.42	1.811	1.686	0.188	0.076	GAM+
Raja undulata	ID40	1.868	1.57	1.775	10415.368	0.18	GAM
Scophthalmus maximus	ID41	1.645	1.1	1.321	0.261	0.071	GAM+
Scophthalmus rhombus (CelticSeas)	ID42	1.383	1.159	1.032	0.414	0.137	GAM+
Scophthalmus rhombus (NorthSea)	ID43	1.759	1.559	1.254	0.175	0.087	GAM+
Scyliorhinus canicula (North48)	ID44	2.194	1.92	2.178	0.22	0.038	GAM+
Scyliorhinus canicula (South48)	ID45	1.47	1.325	1.443	0.821	0.125	GAM+
Scyliorhinus stellaris	ID46	1.62	1.359	1.543	8.597	0.15	GAM
Sebastes viviparus	ID47	3.449	0.714	0.59	12.29	0.509	GAM
Squalus spp	ID48	0.822	0.676	0.763	0.37	0.148	GAM+
Torpedo marmorata	ID49	1.644	1.166	1.662	617683.729	0.16	GAM
Zoarces viviparus	ID50	0.642	0.091	0.134	70401.335	0.4	GAM

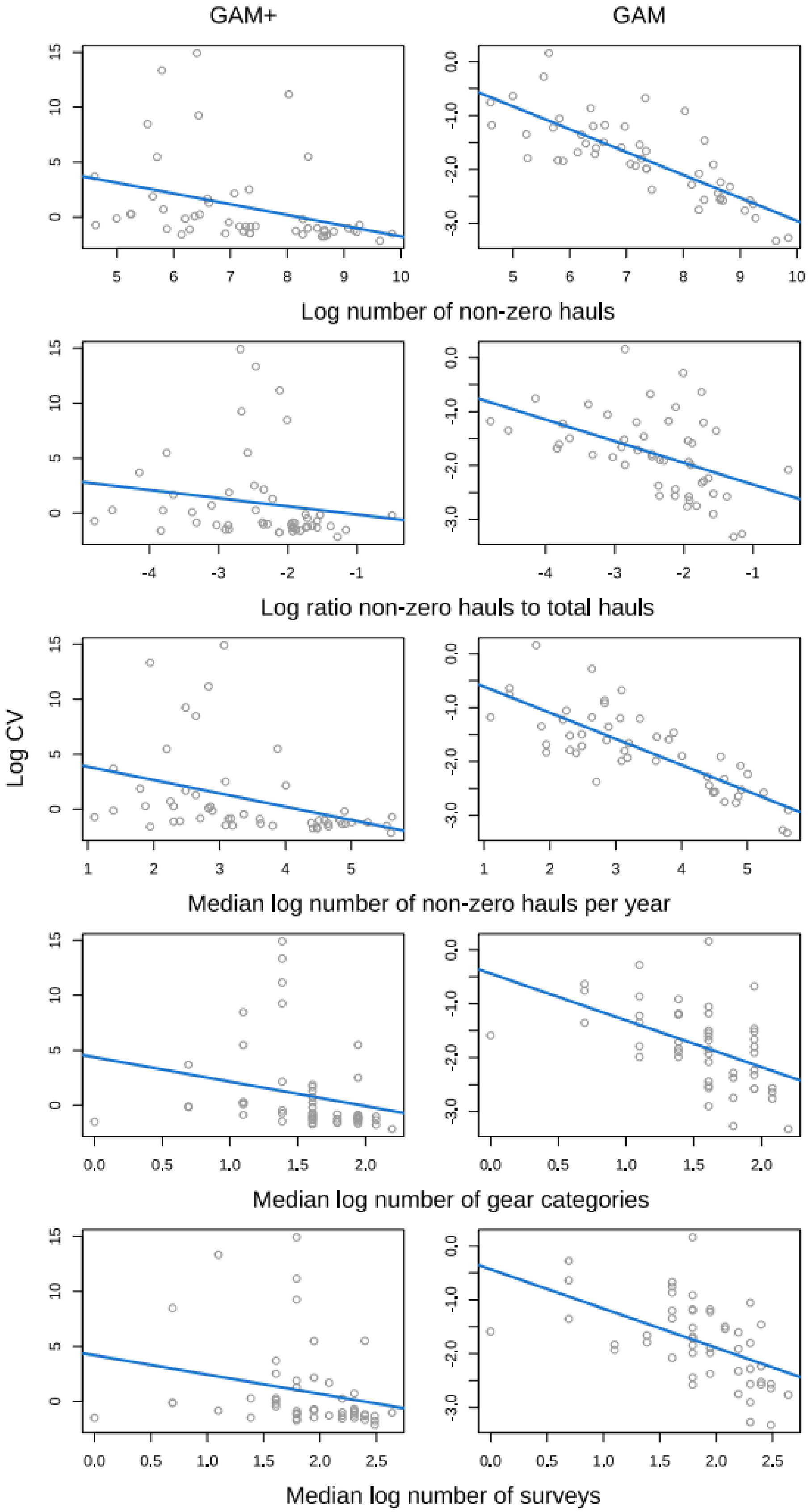

Figure 4.13. Correlation of log CV with number of non-zero hauls, ratio of non-zero hauls to total hauls, median number of non-zero hauls per year, median number of gear categories, and surveys.

Figure 4.14 and Figure 4.15 show the overall spatial patterns of the abundance for all populations and all surveyed years.

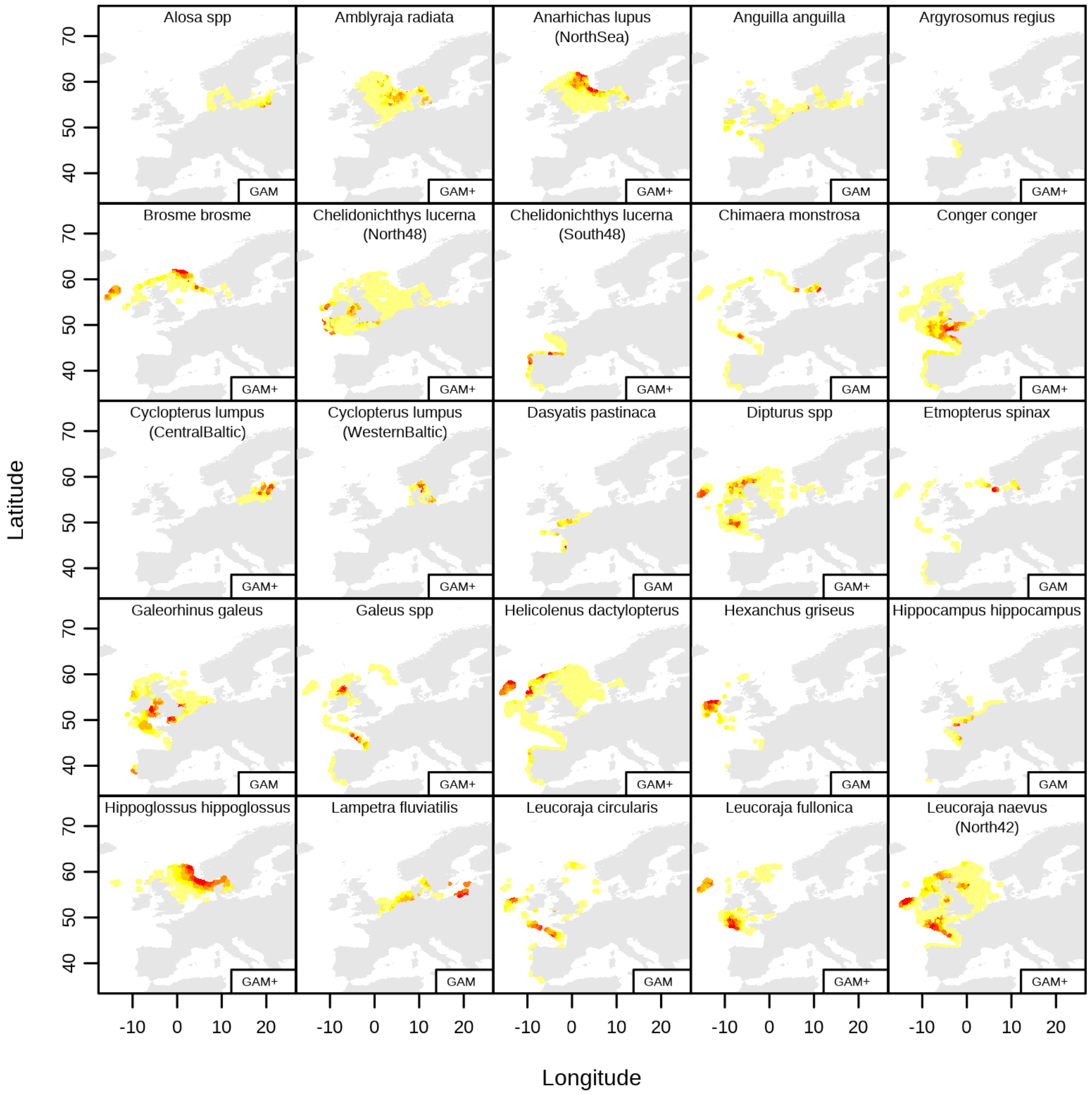

Figure 4.14. Spatial patterns of abundance for the first 25 out of 50 species. Colour scale indicates high (red) to low abundance (yellow) and is population-specific. Note that maps are only representative of realized habitat (statistical rectangles with at least one occurrence over whole time period).

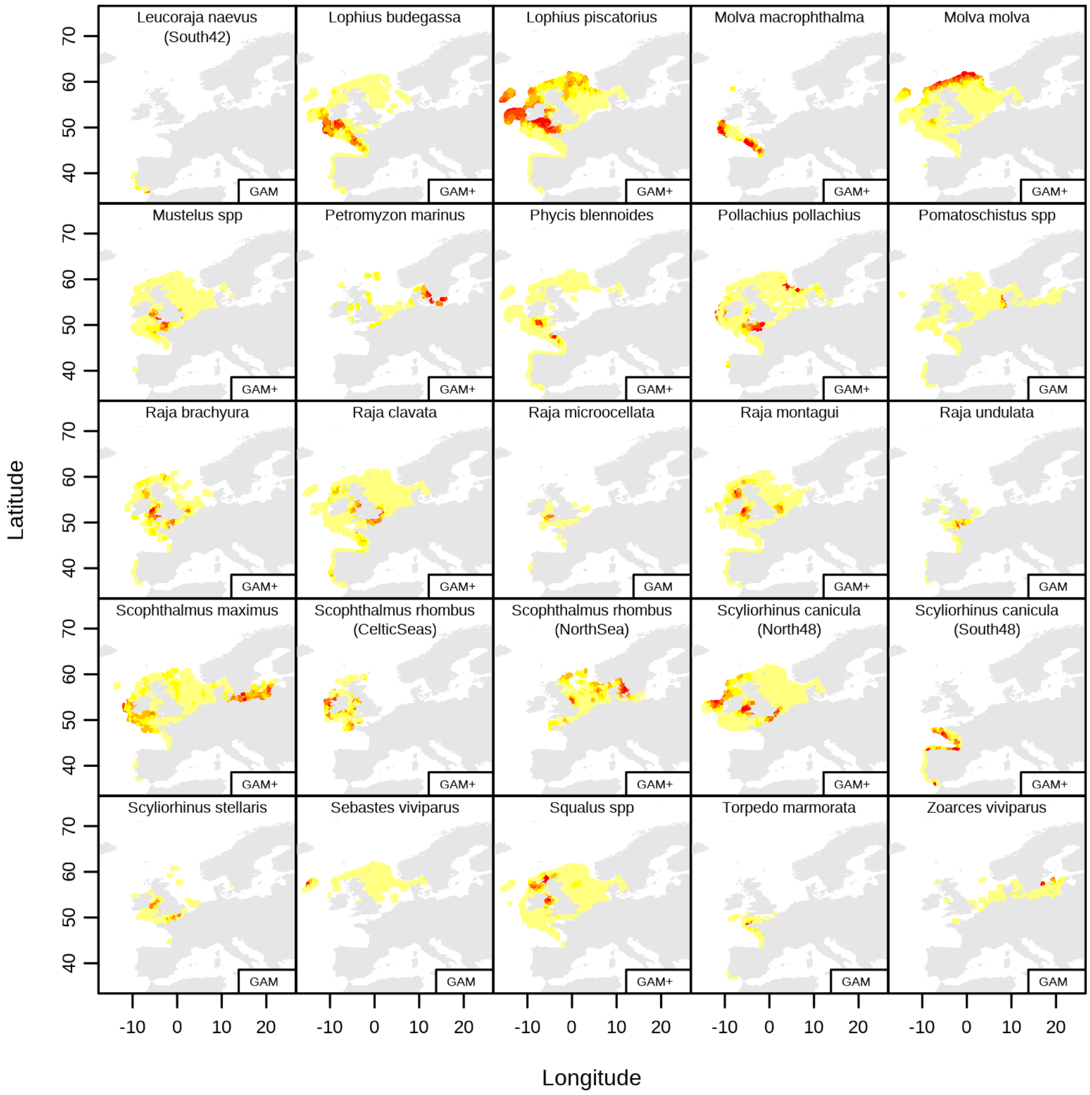

Figure 4.15. Spatial patterns of abundance for the second 25 out of 50 species. Colour scale indicates high (red) to low abundance (yellow) and is population-specific. Note that maps are only representative of realized habitat (statistical rectangles with at least one occurrence over whole time period).

4.3.5 Discussion and future work

The high CV estimated by GAM+ for some populations can partly be attributed to the fact that some gear categories with very small number of non-zero hauls (1–5) might have a large effect on the bootstrapped standard deviation. However, other factors such as poor spatial overlap between different surveys (with different gears) might also have contributed to the high CVs. Future research should investigate the populations and models with a very high CV for GAM+. Here, we recommend to use the simpler GAM without the parametric gear effect when the CV of GAM+ is above 1.

This threshold results in the recommendation of the simpler GAM for 18 populations (see 'Recommended model' in Table 4.8). For five populations (*Chimaera monstrosa, Etmopterus spinax, Pomatoschistus spp, Torpedo marmorata, Zoarces viviparus)*, the absolute percentage difference in the average abundance index during the last ten years is larger than 20%. However, the temporal trend of the index is still similar for these populations (Figure 4.11 and Figure 4.12). An important aspect to consider is the use of the realized habitat, meaning that only statistical rectangles were used where the species occurred at least once. When species are observed in new statistical rectangles in future, where they have not been recorded in the past, these rectangles are added to the realized habitat and a vector with zero observations for preceding years is being added to the dataset. Thus, potentially shifting or changing trends in the abundance index in previous years. Nevertheless, it is unlikely that the GAMs would converge and give meaningful results if all statistical rectangles were used. Future work could explore the possibility to establish suitable habitats instead of using the realized habitats or to at least include potential gaps (i.e. missing statistical rectangles between other rectangles with observations) in the spatial distribution. However, this should not be done for potential subpopulations. Furthermore, future work could include a retrospective analysis to evaluate the robustness of estimated abundance indices and contribute to the selection of the most suitable model.

4.4 VAST

The Vector Autoregressive Spatio-Temporal model (VAST; Thorson, 2019) is a spatio-temporal delta-generalized linear mixed model that is well suited to standardize survey or fisheries independent data. The model consists of two linear predictors, a model for presence-absence, and a model for the positive catch rate. Spatial, temporal, and spatio-temporal variation are governed by random effects process models in each linear predictor. Likewise, a random effect model may be included to account for differences in catchability between vessels.

VAST was applied to derive an index of relative abundance for starry ray (*Amblyraja radiata*) in the North Sea based on the NS-IBTS Q1 data. A spatial grid with 2000 cells was defined for spatial interpolation, while all temporal and spatio-temporal models were modelled as independent and identically distributed processes. A logit link function was used for the presence/absence data, and a logarithmic link function was used for the positive catch rates with a Gamma distributed observation model. The model is fitted in Template Model Builder package (TMB; Kristensen *et al.*, 2016) in R (R Core Team 2021) which allows fast estimation of random effects using the Laplace approximation.

The VAST software automatically generates a number of model diagnostics and outputs (Figure 4.16 to Figure 4.19).

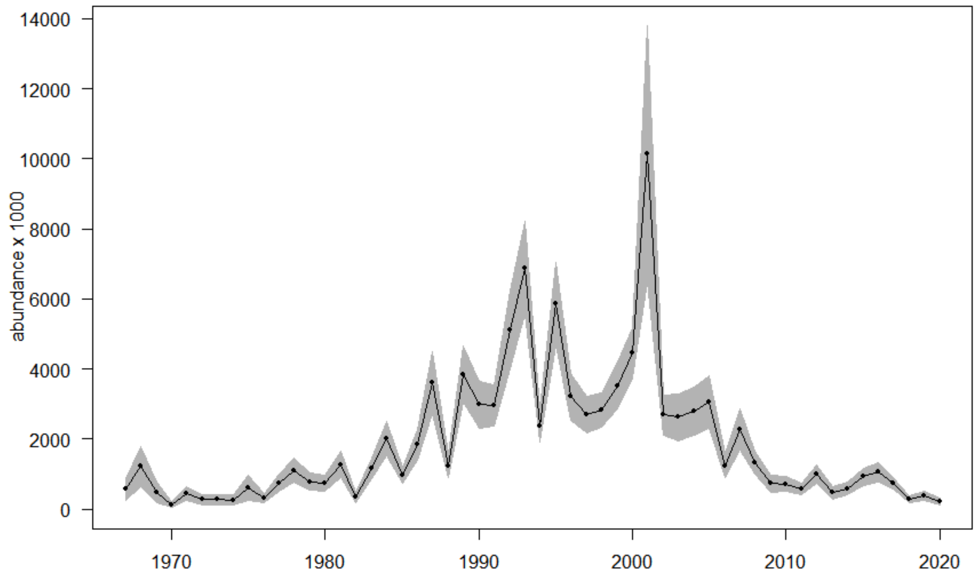

Figure 4.16. *Amblyraja radiata* index of abundance (NS-IBTS Q1 1967-2020). The grey shade represents the 95% confidence interval.

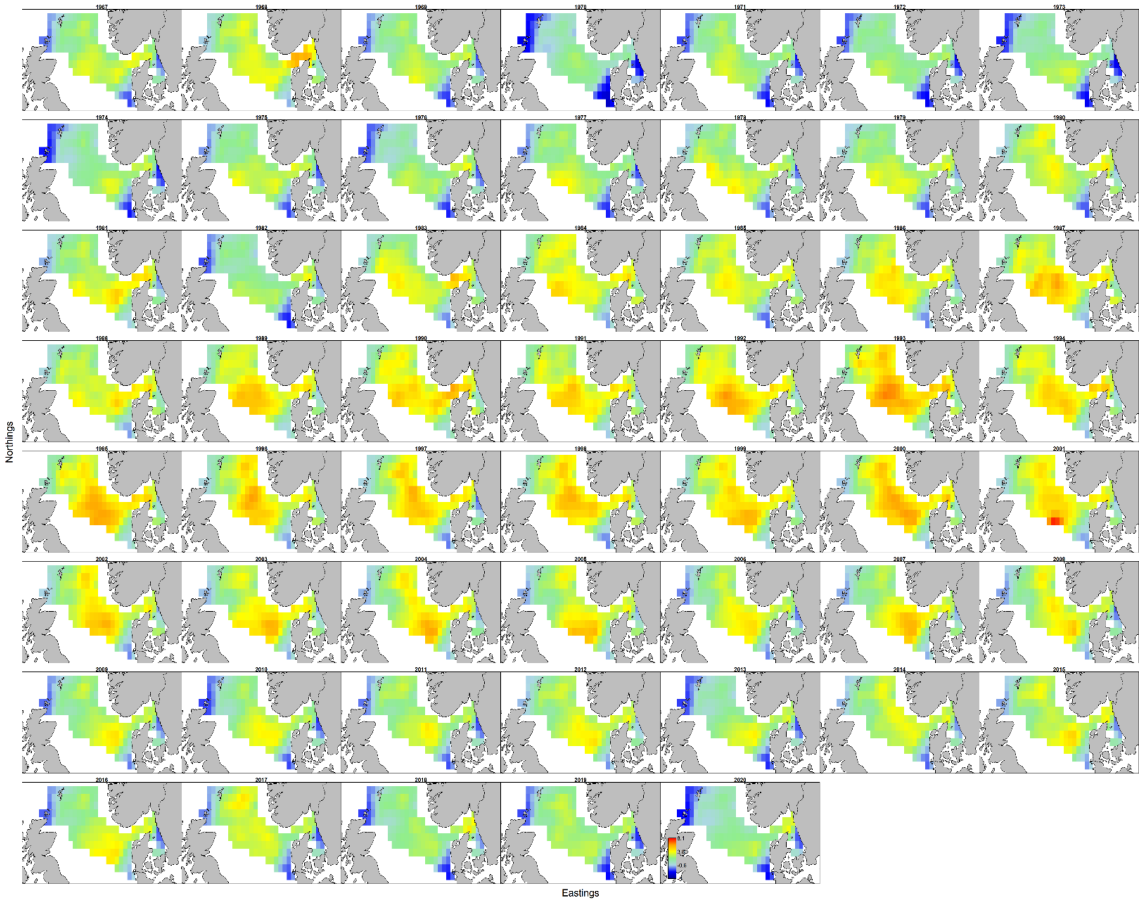

Figure 4.17. Log density maps of *Amblyraja radiata* by year from 1967 to 2020.

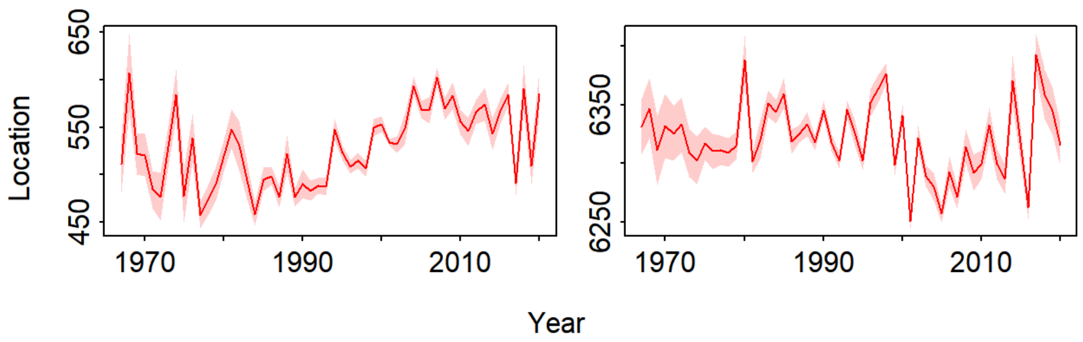

Figure 4.18. Centre of gravity over time (Eastings; left panel and Northings; right panel).

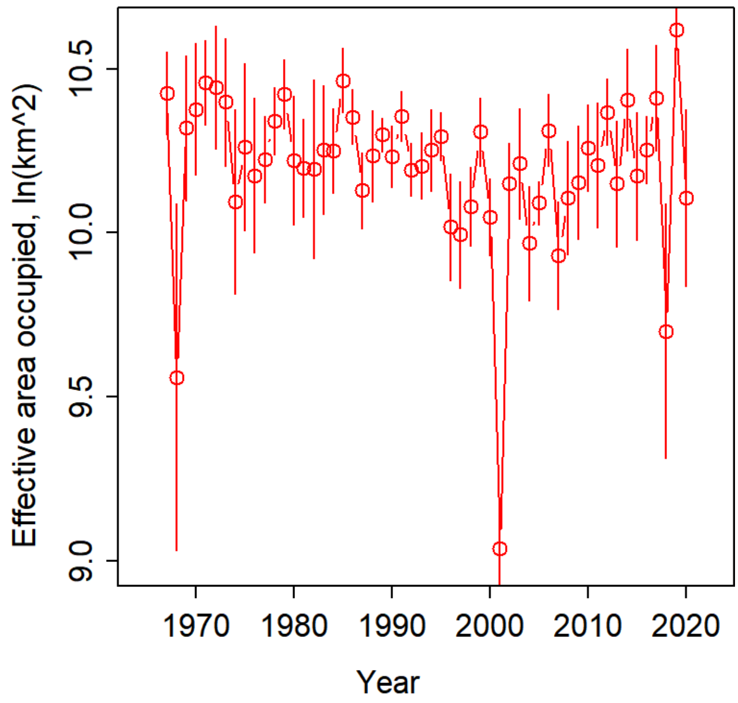

Figure 4.19. Effective log occupied area of *Amblyraja radiata* in the North Sea.

5 Spatial assessment units

WKABSENS reviewed distributional maps and selected reports from assessment working groups to investigate the evidence of the occurrence of several populations in the surveyed area. Species which were recorded in less than 1000 hauls were assumed by default to be one population in the surveyed area. Results on elasmobranchs were discussed with WGEF before a final decision was made. Species not listed were assumed to be one population (Table 5.1)

Table 5.1. Analysis of number of populations of the sensitive species analysed at WKABSENS.

Species	Populations as derived from distribution in surveys and review
Alosa spp.	A separate population in the Baltic and Kattegat (east of 7°E). Sporadic in other areas and likely too sparse to allow indices to be reliably estimated outside the Baltic Sea/Kattegat.
Amblyraja radiata	One population with the distribution centred in the North Sea. According to WGEF, individuals recorded west of UK and in the Channel are likely to be misidentified. *R. clavata* and surveys in these areas should not be included.
Anarhicas lupus	One population in the North Sea/Skagerrak/Kattegat and a separate (part of a) population at Rockall (west of 10°E).
Chelidonichthys lucerna	One population off the Spanish/Portuguese coast and another in the northern Celtic Seas. The two were divided at the northern border of the Bay of Biscay (48°N).
Conger conger	One population throughout the surveyed area
Cyclopterus lumpus	Genetic evidence suggests two separate populations in the central and western Baltic/Kattegat/Skagerrak (8-13.5°E and east of 13.5 °E). Sporadic elsewhere.
Dipturus batis complex	One population throughout the surveyed area. Distribution maps were also investigated separately for each species ID but did not reveal spatial segregation between species. Further analyses may provide more information on the contribution of the different species to the complex.
Galeus melastomus/atlanticus	One population throughout the surveyed area. However, probably not well sampled by surveys due to the deeper distribution of this species.
Helicolenus dactylopterus	One population throughout the surveyed area but probably not well sampled by surveys due to the deeper distribution of this species.
Lepidorhombus whiffiagonus	Several stocks assessed by ICES in separate subdivisions.
Leucoraja naevus	Distribution seems to reflect one southern population around southern Portugal and Spain, a mid-latitude population in the Bay of Biscay and southern Celtic Sea and a northern population in the North Sea and west of the UK and Ireland. The current ICES advice assumes one population from the Bay of Biscay and north. Therefore, the populations were divided north and south of 42°N. However, this decisions should be revisited in future as more knowledge becomes available.
Lophius budegassa	The distribution of *L. budegassa* is continuous, making it questionable if populations are separate populations. WKABSENS will produce survey indices for review in future benchmarks.
Lophius piscatorius	There is some evidence in the distribution of this species of two separate populations separated between France and Spain (45°N). The North Sea individuals do not seem to be separated from the west of Scotland individuals. WKABSENS will produce survey indies for review in future benchmarks.

Species	Populations as derived from distribution in surveys and review
Molva molva	One population throughout the surveyed area. WKABSENS will produce survey indies for review in future benchmarks.
Mustelus spp.	There appears to be only one population, but it is unclear what role the uncertain species ID plays in this conclusion. WKABSENS will produce survey indices for review in future benchmarks.
Phycis blennoides	One population throughout the surveyed area. WKABSENS will produce survey indies for review in future benchmarks.
Raja brachyura	Seems to be one population, perhaps with some local structure. The population off Portugal is separated from the remaining distribution (42ºN).
Raja clavata	This seems to be a single coastal distribution possibly with local subpopulations. According to WGEF, genetic evidence seems to indicate only one population. There is anecdotal evidence that areas which are not sampled also contain thornback rays. More work should be dedicated to identification of populations for this species.
Raja montagui	Seems to be a single coastal distribution, possibly with a separate subpopulations but with a gap between a southern population south and north of 45ºN.
Scophthalmus rhombus	Assessed species in the Baltic Sea and North Sea/Channel. Separate west of UK index will be produced by WKABSENS (surveys other than the North Sea and Baltic Sea surveys).
Scyliorhinus canicula	This species is likely to have several substocks but knowledge of this is too limited within the group to use the information in this analysis. WKABSENS continued with separate evaluations north and south of 48ºN.
Scyliorhinus stellaris	Considered one population by WKABSENS, though there may be local subpopulations. Prior to 2002, there may be issues with the reporting of survey catches of this species in some surveys to DATRAS. Hence, abundance indices should be considered reliable only from 2002 onwards.
Squalus acanthias	One population assessed by ICES. Survey indices will be provided to the stock assessor for inspiration. The stock assessment uses survey data not uploaded to DATRAS as well as commercial data and hence is expected to have more information than a simple survey index.

6 Abundance estimates

Abundance estimates from species with existing ICES assessments enter as third party assessments (including reference points). For the species for which abundance is assessed in other working groups, **WKABSENS extracted the abundance assessment results from ICES Stock Assessment Graphs** (SAG, Annex 3, Table A11)**.** For the species for which abundance is not regularly assessed by ICES, the estimated (GAM/GAM+) abundance indices are used (Annex 3, Tables A1–A10) and forwarded for inspiration to the relevant ICES WG for possible inclusion at the next benchmark.

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Annex 2: Resolutions

The **Workshop on the production of annual estimates of abundance of sensitive species** (WKABSENS), chaired by Anna Rindorf*, Denmark, will be established and meet online 14–18 June 2021 to:

a) Consider the applicability of the ICES list of sensitive fish species for OSPAR FC1.
b) Split the list into:
   i. Species with existing ICES assessments (including reference points);
   ii. Species for which no ICES assessments currently exist;
c) Calculate swept-area indices and create a data product as input to OSPAR common indicators for fish and food webs;
   iii. Define criteria to select surveys and time-series for analysis;
   iv. Discuss and agree in algorithm(s) to infill missing data at genus or family level;
   v. Agree on the approach to estimate single species population abundance density per year;
d) Discuss and agree on criteria of data capable to support formal assessment; The selection of assessment units will be informed by available information, data and knowledge from other ICES expert groups.
e) Calculate individual survey-based assessments for all sensitive species and create a data product to OSPAR informed by Table 2 Biological information, see below.

WKABSENS will report 15 September 2021 for the attention of the Advisory Committee and the Ecosystem Observation Steering Group.

Priority	High, in response to a special request from OSPAR to provide abundance outputs for all otter and beam trawl surveys in the North East Atlantic and regional seas based on DATRAS. The outputs of this workshop will feed directly into the ICES advisory process and the advice will be used by OSPAR to update the common indicators FC1, FC2, FC3, FW3 for the QSR 2023.

Scientific justification	Data from groundfish surveys intended to sample commercial fish species populations to support formal stock assessments under the European Union's Common Fisheries Policy (CFP) can also be used to monitor and assess the status of broader fish community to support implementation of ecosystem-based management (EBM) among others. Two sensitivity metrics have already been developed (see OSPAR IA 2017 for methodologies) to assess the extent of population recovery among sensitive fish species based on species' life trait information: Average Life-history Trait (ALHT) and Proportion Failing to Spawn (PFS). This workshop focuses on the generation of abundance indices to support OSPAR common indicators for fish biodiversity (FC1, FC2, FC3) and foodwebs (FW3). The following supporting material is provided to guide the implementation of ToRs a-d: Tor a) ICES WGECO, WGBIODIV and WKCOFIBYC have worked to compile a list of fish species (commercial and non-commercial) of conservation concern (threatened, sensitive, or already listed in legislation) for biodiversity assessments. The list is structured by relevance, geography (ICES ecoregion) and according to which legal, scientific or other designations of being sensitive are relevant. WKABSENS will review the lists and agree to use them as a basis for estimates of abundance. Tor b) The species in the adopted list will be split into species with an existing ICES assessment and species without an existing ICES assessment. Abundance estimates from species with existing ICES assessments enter as 3rd party assessments (including reference points). Some of the ICES assessed stocks have age or length-based assessment methods (estimates of stock size or SSB), others have only survey-based assessments of stock size while others have no abundance estimates and only catch information. WKABSENS will extract the assessment results from ICES Stock Assessment Graphs SAG and calculate abundance estimates based on the available information/approaches discussed at WKABSENS? For species where no ICES assessment currently exists, survey-based indices should be available as ICES data products and will be calculated as follows: Tor c) Data from the groundfish surveys in Table 1 will be considered. WKABSENS will determine which datasets from each survey are available for analysis for the OSPAR region II, III and IV

Table 1. Surveys considered in the OSPAR Groundfish Survey Assessment data products for IA2017 that will inform Tor c) (from "Derivation of Groundfish Survey Monitoring and Assessment Data Products for the Northeast Atlantic Area") *Source: https://data.marine.gov.scot/sites/default/files//SMFS%200816.pdf)*

Survey Acronym	Previous name(s)	Country	Years of Data	Vessels	Quarter	Gear Type	Subregion	Data Source
GNSIntOT1	Q1 IBTS	International	1983-2016	Multiple ships	1	Otter (GOV)	Greater North Sea	DATRAS
GNSIntOT3	Q3 IBTS	International	1998-2016	Multiple ships	3	Otter (GOV)	Greater North Sea	DATRAS
GNSFraOT4	FR CGFS	France	1988-2015	Thalassa II, Gwen Drez	4	Otter (GOV)	Greater North Sea	DATRAS
CSScoOT1	SWC Q1 IBTS	Scotland	1985-2015	Scotia II, Scotia III	1	Otter (GOV)	Celtic Seas	DATRAS
CSScoOT4	SWC Q3 IBTS	Scotland	1985-2015	Scotia II, Scotia III	4	Otter (GOV)	Celtic Seas	DATRAS
CSIreOT4	IE IGFS	Ireland	2003-2015	Celtic Explorer	4	Otter (GOV)	Celtic Seas	DATRAS
CSNIrOT1	Q1 NIGFS	Northern Ireland	1992-2015	Corystes	1	Otter (ROT)	Celtic Seas	NDB 92-07, DATRAS 08-15
CSNIrOT4	Q4 NIGFS	Northern Ireland	1992-2015	Corystes	4	Otter (ROT)	Celtic Seas	NDB 92-07, DATRAS 08-15
CS/BBFraOT4	EVHOE	France	1997-2014	Thalassa II	4	Otter (GOV)	Celtic Seas, Bay of Biscay	DATRAS (Cors. NDB)
BBIC(s)SpaOT1	SP-ARSA	Spain	1993-2014	Cornide de Saavedra, F de P Navarro	1	Otter (BACA)	Bay of Biscay and Iberian Coast	NDB
BBIC(n)SpaOT4	SP-North	Spain	1990-2014	Cornide de Saavedra, F de P Navarro	4	Otter (BACA)	Bay of Biscay and Iberian Coast	NDB
BBIC(s)SpaOT4	SP-ARSA	Spain	1997-2014	Cornide de Saavedra, F de P Navarro	4	Otter (BACA)	Bay of Biscay and Iberian Coast	NDB
BBICPorOT4	PT-IBTS	Portugal	2001-2011	Capricornio, Noruega	4	Otter (NCT)	Bay of Biscay and Iberian Coast	DATRAS
WAScoOT3	Rockall	Scotland	1999-2015	Scotia II, Scotia III	3	Otter (GOV)	Wider Atlantic	DATRAS
WASpaOT3	PS-PORC	Spain	2001-2014	Vizconda de Eza	3	Otter (PBACA)	Wider Atlantic	DATRAS
GNSNetBT3	BTS	The Netherlands	1987/1996-2015	Isis, Tridens II	3	Beam (8m)	Greater North Sea	DATRAS
GNSEngBT3	BTS	England	1990-2015	Carhelmar, Corystes, Endevour	3	Beam (4m)	Greater North Sea	DATRAS
GNSGerBT3	BTS	Germany	2002-2015	Solea I, Solea II	3	Beam (7m)	Greater North Sea	DATRAS
CSEngBT3	BTS/VIIa	England	1993-2014	Corystes, Endevour	3	Beam (4m)	Celtic Seas	DATRAS

(i) Data collected on the surveys comprises the numbers of each species of fish sampled in each trawl sample, measured to define length categories (see Table 2)

Table 2. Biological information in the new product (from "Derivation of Groundfish Survey Monitoring and Assessment Data Products for the Northeast Atlantic Area" https://data.marine.gov.scot/sites/default/files//SMFS%200816.pdf)

Field	Unit	Description
HaulID		Unique haul identifier (SurveyAcronym/Ship/Year/HaulNo)[1] (*H*)
SpeciesSciName		Unique species name for each species sampled across the NE Atlantic[2] (*S*)
FishLength(cm)	cm	Integer numbers indicating fish length to the 'cm below'[3] (*L*)
IndivFishWght(g)	g	Estimated weight of individual fish of specified species and length[4] ($W_{S,L}$)
Number		Total number of fish of specified species and length in the catch[5] ($N_{S,L,H}$)
DensAbund(N_sqkm)	km^{-2}	Abundance density estimate[6,8] ($D_{nos,S,L,H} = N_{S,L,H} / A_{H,WING}$)
DensBiom(kg_Sqkm)	kg km^{-2}	Biomass density estimate[7,8] ($D_{biom,S,L,H} = (N_{S,L,H} \times W_{S,L}) / A_{H,WING}$)

(ii) By dividing the species catch numbers-at-length by the area swept by the trawl on each sampling occasion, the catch data are converted to estimates of fish density-at-length, by species, at each sampling location in each year. Summing these trawl-sample species density-at-length estimates across all trawl samples collected within each sampling stratum in each year (e.g. ICES statistical rectangles), and dividing by the number of trawl samples within each stratum per year, gives an estimate of the density (of each species and length category) within each sampling stratum in each year. Summing these sample stratum density estimates across all sampling strata sampled in each year, and dividing by the number of strata sampled, provides estimates of the average density (N), of each species (s) and length category (l), in each year, across the whole area covered by the survey. Summing these density estimates (Ns,l / km2) across all length classes provides the required estimate of species population abundance density (Ns / km2) in each year for each survey.

Indicators of abundance of sensitive species rely on the availability of species-level identification data and abundance-at-length data. Where coarser resolution identification

	data or just species count data is available, a k-Nearest-Neighbour (kNN) have been used to model the missing information and resolve genus-or family-level identifications to species-level , and species count data to abundances-at-length. In some cases the kNN model could not adequately resolve genus-or family-level data to species level. Where this was the case, all the species identification information was merged so that all individuals of a genus or family were recorded at the genus or the family level, whichever was the finest level resolution possible (see https://data.marine.gov.scot/sites/default/files/SMFS%200816.pdf for reference) (iii) WKABSENS will establish the number of sensitive species encountered by each survey. These species are very rare and the data available can be too sparse to support a robust assessment. WKABSENS will establish a criteria based on a percentage of occasions encountered/specie/survey by which the data can be used for assessments. (iv) WKABSENS will discuss the adequacy of the kNN model or discuss other alternatives for resolving genus- or family level data to species level.
Resource requirements	ICES Data Centre, Secretariat and the advisory process.
Participants	The participation should reflect the diverse scientific competence needed to fulfil the objectives of the workshop. If requests to attend exceed the meeting capacity available, ICES reserves the right to allocate participants based on the experts' relevant qualification. Participation of stakeholders is not committed.
Secretariat facilities	Remote meeting assistance will be facilitated for the dates of the workshop. Also, assistance from the ICES Data Centre and Advisory Department will be provided.
Financial	Covered by OSPAR special requests to ICES.
Linkages to advisor committees	Direct link to ACOM.
Linkages to other committees or groups	WGECO, WGBIODIV, WKCOFIBYC, IBTSWG, WGBEAM.
Linkages to other organizations	OSPAR.

Annex 3: Abundance estimates for ICES stocks

Table A1. Estimated abundance index from recommended model (GAM+ or GAM; see Table 4.8) for first 5 out of 50 populations. Each ID corresponds to a specific population (see Table 4.8).

Year	Alosa spp ID1 Index	Alosa spp ID1 Low	Alosa spp ID1 Up	Ambly-raja radiata ID2 Index	Ambly-raja radiata ID2 Low	Ambly-raja radiata ID2 Up	Anarhichas lupus (NorthSea) ID3 Index	Anarhichas lupus (NorthSea) ID3 Low	Anarhi-chas lupus (NorthSea) ID3 Up	An-guilla an-guilla ID4 Index	An-guilla anguilla ID4 Low	An-guilla anguilla ID4 Up	Argyroso-mus regius ID5 Index	Argyroso-mus regius ID5 Low	Argyroso-mus regius ID5 Up
1967				0.267	0.192	0.607	1.045	0.701	2.229						
1968	0	0	0	0.263	0.19	0.61	1.038	0.696	2.081						
1969	0	0	0	0.252	0.187	0.596	1.016	0.696	1.934						
1970	0	0	0	0.233	0.174	0.537	0.977	0.715	1.746						
1971	0	0	0	0.215	0.164	0.442	0.938	0.7	1.574						
1972	0	0	0	0.201	0.154	0.383	0.904	0.698	1.45						
1973	0	0	0	0.194	0.151	0.375	0.881	0.704	1.327						
1974	0.314	0.133	7.268	0.194	0.15	0.364	0.873	0.689	1.334						
1975	0.315	0.121	7.319	0.201	0.156	0.387	0.88	0.71	1.331						
1976	0.294	0.12	10.998	0.218	0.166	0.4	0.907	0.731	1.365						
1977	0	0	0	0.249	0.192	0.453	0.964	0.769	1.442	0.363	0.199	1.636			
1978	0	0	0	0.294	0.231	0.521	1.046	0.839	1.507	0.378	0.207	1.57			
1979	0	0	0	0.355	0.278	0.651	1.15	0.93	1.646	0	0	0			

Year	Alosa spp ID1 Index	Alosa spp ID1 Low	Alosa spp ID1 Up	Amblyraja radiata ID2 Index	Amblyraja radiata ID2 Low	Amblyraja radiata ID2 Up	Anarhichas lupus (NorthSea) ID3 Index	Anarhichas lupus (NorthSea) ID3 Low	Anarhichas lupus (NorthSea) ID3 Up	Anguilla anguilla ID4 Index	Anguilla anguilla ID4 Low	Anguilla anguilla ID4 Up	Argyrosomus regius ID5 Index	Argyrosomus regius ID5 Low	Argyrosomus regius ID5 Up
1980	0	0	0	0.435	0.343	0.762	1.273	1.041	1.809	0.481	0.316	1.558			
1981	0	0	0	0.532	0.419	0.905	1.404	1.154	2.024	0	0	0			
1982	6.338	0.439	422.441	0.645	0.505	1.109	1.533	1.251	2.185	0.701	0.414	2.028			
1983	0	0	0	0.769	0.63	1.321	1.649	1.382	2.328	0.825	0.488	2.323			
1984	0	0	0	0.903	0.709	1.56	1.752	1.466	2.456	0.921	0.552	2.704			
1985	0	0	0	1.047	0.825	1.734	1.844	1.509	2.637	0.967	0.581	2.785			
1986	0	0	0	1.203	0.965	2.194	1.911	1.585	2.718	0.938	0.623	2.309			
1987	0	0	0	1.371	1.078	2.448	1.951	1.582	2.737	0.908	0.593	2.069			
1988	0	0	0	1.558	1.226	2.685	1.958	1.596	2.813	0.969	0.66	2.275			
1989	0	0	0	1.764	1.355	3.079	1.924	1.571	2.745	1.195	0.74	2.982			
1990	0.199	0.031	15.566	1.981	1.514	3.541	1.854	1.519	2.59	1.637	1.043	4.149			
1991	0.162	0.029	18.794	2.187	1.711	3.997	1.758	1.433	2.566	2.262	1.355	5.862			
1992	0	0	0	2.312	1.773	4.167	1.625	1.321	2.359	2.728	1.724	6.185			
1993	0	0	0	2.305	1.757	4.049	1.477	1.162	2.157	2.613	1.689	6.148			
1994	0.807	0.068	94.883	2.177	1.65	3.826	1.316	1.073	1.884	2.058	1.384	4.462			
1995	1.545	0.142	210.818	2.002	1.522	3.562	1.162	0.908	1.692	1.549	1.069	3.384			

Year	Alosa spp ID1 Index	Alosa spp ID1 Low	Alosa spp ID1 Up	Amblyraja radiata ID2 Index	Amblyraja radiata ID2 Low	Amblyraja radiata ID2 Up	Anarhichas lupus (NorthSea) ID3 Index	Anarhichas lupus (NorthSea) ID3 Low	Anarhichas lupus (NorthSea) ID3 Up	Anguilla anguilla ID4 Index	Anguilla anguilla ID4 Low	Anguilla anguilla ID4 Up	Argyrosomus regius ID5 Index	Argyrosomus regius ID5 Low	Argyrosomus regius ID5 Up
1996	2.46	0.371	212.687	1.846	1.402	3.347	1.034	0.825	1.543	1.256	0.854	2.673			
1997	3.375	0.728	135.749	1.755	1.307	3.287	0.943	0.739	1.436	1.204	0.819	2.747	0.41	0.098	2.249
1998	4.104	1.743	71.436	1.733	1.335	3.31	0.889	0.692	1.336	1.402	0.969	3.035	0.448	0.115	2.157
1999	3.927	2.596	22.952	1.739	1.315	3.205	0.859	0.659	1.351	1.862	1.276	3.639	0.704	0.255	2.494
2000	2.34	1.681	8.807	1.707	1.309	3.063	0.83	0.657	1.256	2.407	1.659	4.371	1.148	0.528	3.71
2001	1.486	1.099	4.107	1.6	1.224	2.843	0.779	0.597	1.177	2.587	1.88	4.342	1.069	0.401	3.615
2002	2.211	1.396	5.917	1.437	1.1	2.651	0.698	0.542	1.071	2.235	1.734	3.547	0.698	0.183	2.951
2003	3.319	1.934	9.282	1.267	0.953	2.277	0.601	0.468	0.923	1.67	1.338	2.465	0	0	0
2004	2.791	1.783	7.118	1.134	0.841	2.108	0.513	0.386	0.803	1.227	1.03	1.758	0.677	0.203	2.696
2005	2.355	1.687	5.977	1.05	0.753	1.983	0.446	0.349	0.697	0.969	0.847	1.37	0	0	0
2006	2.489	1.806	6.809	1.014	0.754	2.065	0.403	0.307	0.63	0.844	0.721	1.249	3.119	1.096	13.009
2007	2.01	1.459	5.322	1.016	0.727	1.921	0.383	0.294	0.608	0.791	0.658	1.167	3.069	0.944	12.236
2008	1.714	1.345	3.709	1.025	0.728	2.079	0.379	0.281	0.607	0.735	0.617	1.091	1.275	0.386	5.77
2009	1.73	1.152	4.193	1.008	0.752	2.023	0.388	0.29	0.636	0.61	0.511	0.915	0.423	0.125	1.849
2010	0.809	0.61	1.942	0.957	0.669	1.917	0.404	0.308	0.646	0.436	0.366	0.668	0	0	0
2011	0.448	0.344	1.137	0.898	0.639	1.628	0.425	0.301	0.667	0.292	0.25	0.445	0.416	0.136	1.542

Year	Alosa spp ID1 Index	Alosa spp ID1 Low	Alosa spp ID1 Up	Amblyraja radiata ID2 Index	Amblyraja radiata ID2 Low	Amblyraja radiata ID2 Up	Anarhichas lupus (NorthSea) ID3 Index	Anarhichas lupus (NorthSea) ID3 Low	Anarhichas lupus (NorthSea) ID3 Up	Anguilla anguilla ID4 Index	Anguilla anguilla ID4 Low	Anguilla anguilla ID4 Up	Argyrosomus regius ID5 Index	Argyrosomus regius ID5 Low	Argyrosomus regius ID5 Up
2012	0.562	0.407	1.344	0.857	0.609	1.642	0.457	0.326	0.729	0.216	0.189	0.348	1.115	0.434	3.851
2013	0.771	0.518	1.884	0.853	0.621	1.604	0.508	0.386	0.834	0.199	0.173	0.339	2.075	0.757	7.312
2014	0.724	0.493	1.684	0.878	0.616	1.683	0.582	0.441	0.922	0.216	0.187	0.38	1.722	0.618	5.821
2015	0.405	0.297	0.848	0.898	0.638	1.815	0.66	0.502	1.065	0.24	0.208	0.41	1.169	0.422	3.857
2016	0.275	0.239	0.555	0.859	0.629	1.595	0.699	0.524	1.125	0.251	0.211	0.415	0.86	0.315	3.096
2017	0.384	0.309	0.855	0.74	0.539	1.374	0.668	0.498	1.07	0.241	0.194	0.415	0.615	0.204	2.3
2018	0.496	0.4	1.038	0.586	0.447	1.074	0.574	0.43	0.918	0.221	0.18	0.372	0.515	0.183	1.938
2019	0.637	0.452	1.374	0.45	0.343	0.811	0.47	0.356	0.735	0.203	0.168	0.345	0.67	0.246	2.31
2020	1.205	0.648	3.946	0.365	0.283	0.689	0.399	0.286	0.685	0.194	0.157	0.364	1.802	0.696	5.646

Table A2.Estimated abundance index from recommended model (GAM+ or GAM; see Table 4.8) for ID6 to ID 10 populations. Each ID corresponds to a specific population (see Table 4.8).

Year	Brosme brosme	Brosme brosme	Brosme brosme	Chelidonichthys lucerna (North48)	Chelidonichthys lucerna (North48)	Chelidonichthys lucerna (North48)	Chelidonichthys lucerna (South48)	Chelidonichthys lucerna (South48)	Chelidonichthys lucerna (South48)	Chimaera monstrosa	Chimaera monstrosa	Chimaera monstrosa	Conger conger	Conger conger	Conger conger
	ID6	ID6	ID6	ID7	ID7	ID7	ID8	ID8	ID8	ID9	ID9	ID9	ID10	ID10	ID10
	Index	Low	Up	Index	Low	Up	Index	Low	Up	Index	Low	Up	Index	Low	Up
1967															
1968															
1969															
1970															
1971															
1972															
1973															
1974	0.894	0.635	1.895												
1975	0.901	0.648	1.709							1.614	1.014	4.078	1.155	0.755	2.626
1976	0.916	0.68	1.853							1.607	1.021	4.243	1.215	0.799	2.766
1977	0.941	0.725	1.802							0	0	0	1.316	0.862	2.774
1978	0.972	0.725	1.797							0	0	0	0	0	0
1979	1.006	0.795	1.856							0	0	0	0	0	0
1980	1.043	0.804	1.872							0	0	0	1.558	0.801	4.125
1981	1.082	0.844	1.98							0	0	0	0	0	0
1982	1.123	0.856	2.194							1.383	0.91	3.252	0	0	0
1983	1.166	0.917	2.138							0	0	0	1.012	0.437	3.277

Year	Brosme brosme	Brosme brosme	Brosme brosme	Chelidonichthys lucerna (North48)	Chelidonichthys lucerna (North48)	Chelidonichthys lucerna (North48)	Chelidonichthys lucerna (South48)	Chelidonichthys lucerna (South48)	Chelidonichthys lucerna (South48)	Chimaera monstrosa	Chimaera monstrosa	Chimaera monstrosa	Conger conger	Conger conger	Conger conger
	ID6	ID6	ID6	ID7	ID7	ID7	ID8	ID8	ID8	ID9	ID9	ID9	ID10	ID10	ID10
	Index	Low	Up	Index	Low	Up	Index	Low	Up	Index	Low	Up	Index	Low	Up
1984	1.211	0.91	2.367							1.22	0.804	3.183	0	0	0
1985	1.259	0.956	2.514	0.439	0.117	2.587				1.127	0.742	2.826	0.557	0.248	1.717
1986	1.307	0.923	2.685	0.407	0.14	2.072				1.027	0.683	2.506	0.414	0.208	1.315
1987	1.355	1.001	2.618	0.374	0.138	1.551				0.934	0.664	2.141	0.333	0.182	0.922
1988	1.4	1.03	2.842	0.371	0.182	1.237				0.857	0.579	1.952	0.303	0.164	0.783
1989	1.44	1.049	2.9	0.404	0.237	1.357				0	0	0	0.318	0.188	0.857
1990	1.476	1.079	2.935	0.467	0.276	1.329	0.754	0.358	2.262	0.768	0.577	1.754	0.376	0.226	0.825
1991	1.506	1.128	2.904	0.575	0.354	1.441	0.766	0.35	2.412	0.76	0.567	1.725	0.476	0.306	1.047
1992	1.521	1.145	3.107	0.759	0.493	1.838	0.823	0.409	2.282	0.786	0.633	1.645	0.584	0.393	1.262
1993	1.519	1.136	2.749	0.944	0.632	2.251	0	0	0	0.831	0.633	1.7	0.598	0.399	1.202
1994	1.505	1.156	2.722	1.006	0.682	2.535	0.961	0.507	2.611	0.888	0.661	2.063	0.511	0.349	1.041
1995	1.482	1.12	2.758	0.962	0.683	2.359	0	0	0	0.962	0.683	2.295	0.426	0.307	0.824
1996	1.457	1.105	2.631	0.894	0.616	1.99	1.015	0.527	3.017	1.044	0.764	2.395	0.395	0.284	0.767
1997	1.43	1.067	2.789	0.854	0.599	1.893	1.018	0.514	2.851	1.1	0.743	2.606	0.454	0.339	0.853
1998	1.397	1.052	2.632	0.921	0.647	1.979	1.028	0.542	3.189	1.113	0.748	2.66	0.608	0.457	1.058
1999	1.349	1.01	2.483	1.081	0.747	2.501	1.044	0.513	3.211	1.115	0.774	2.512	0.861	0.646	1.508
2000	1.285	0.983	2.257	1.095	0.749	2.796	1.052	0.548	3.073	1.176	0.854	2.685	1.132	0.843	2.002
2001	1.202	0.926	2.079	0.935	0.643	2.203	0.965	0.494	2.556	1.31	0.991	2.864	1.242	0.946	2.083

Year	Brosme brosme	Brosme brosme	Brosme brosme	Chelidonichthys lucerna (North48)	Chelidonichthys lucerna (North48)	Chelidonichthys lucerna (North48)	Chelidonichthys lucerna (South48)	Chelidonichthys lucerna (South48)	Chelidonichthys lucerna (South48)	Chimaera monstrosa	Chimaera monstrosa	Chimaera monstrosa	Conger conger	Conger conger	Conger conger
	ID6	ID6	ID6	ID7	ID7	ID7	ID8	ID8	ID8	ID9	ID9	ID9	ID10	ID10	ID10
	Index	Low	Up	Index	Low	Up	Index	Low	Up	Index	Low	Up	Index	Low	Up
2002	1.11	0.877	1.949	0.806	0.573	1.696	0.83	0.457	2.15	1.423	1.092	3.045	1.172	0.895	2.008
2003	1.017	0.772	1.727	0.756	0.535	1.506	0.707	0.396	1.955	1.421	1.054	3.031	1.063	0.805	1.806
2004	0.928	0.725	1.593	0.737	0.538	1.455	0.69	0.41	1.907	1.268	0.915	2.779	1.034	0.76	1.793
2005	0.846	0.657	1.444	0.771	0.554	1.501	0.835	0.476	2.133	1.055	0.74	2.236	1.107	0.833	1.869
2006	0.771	0.599	1.366	0.905	0.694	1.822	0.997	0.561	2.458	0.862	0.622	2.001	1.255	0.932	2.203
2007	0.706	0.538	1.254	1.104	0.812	2.247	0.974	0.511	2.562	0.748	0.556	1.656	1.374	1.002	2.42
2008	0.651	0.508	1.221	1.29	0.96	2.478	0.742	0.405	1.933	0.731	0.54	1.548	1.354	0.99	2.423
2009	0.608	0.464	1.205	1.44	1.083	2.889	0.625	0.362	1.554	0.807	0.605	1.681	1.207	0.874	2.282
2010	0.575	0.421	1.071	1.554	1.133	3.231	0.781	0.441	2.071	0.95	0.686	2.046	1.051	0.773	2.034
2011	0.549	0.395	1.06	1.673	1.211	3.562	1.149	0.638	3.234	1.108	0.78	2.338	0.997	0.736	1.902
2012	0.527	0.387	1.05	1.766	1.246	4.179	1.262	0.612	3.817	1.212	0.926	2.463	1.083	0.801	2.014
2013	0.503	0.368	0.972	1.656	1.153	3.931	1.066	0.526	3.355	1.29	1.007	2.51	1.343	0.986	2.524
2014	0.479	0.355	0.927	1.422	0.989	3.485	1.158	0.563	3.876	1.402	1.119	2.78	1.737	1.255	3.147
2015	0.455	0.334	0.884	1.204	0.803	3.024	1.99	0.906	6.526	1.501	1.243	2.711	2.012	1.439	3.526
2016	0.435	0.322	0.85	1.038	0.678	2.812	2.989	1.26	9.406	1.551	1.285	2.865	2.027	1.516	3.576
2017	0.423	0.315	0.852	0.99	0.649	2.659	2.219	1.028	6.288	1.62	1.28	3.229	1.988	1.481	3.719
2018	0.419	0.313	0.812	1.125	0.738	3.369	1.042	0.583	2.802	1.728	1.326	3.308	2.161	1.661	3.511
2019	0.423	0.309	0.865	1.436	0.943	3.891	0.695	0.425	1.681	1.823	1.457	3.477	2.703	2.02	4.256

Year	Brosme brosme	Brosme brosme	Brosme brosme	Chelidonichthys lucerna (North48)	Chelidonichthys lucerna (North48)	Chelidonichthys lucerna (North48)	Chelidonichthys lucerna (South48)	Chelidonichthys lucerna (South48)	Chelidonichthys lucerna (South48)	Chimaera monstrosa	Chimaera monstrosa	Chimaera monstrosa	Conger conger	Conger conger	Conger conger
	ID6	ID6	ID6	ID7	ID7	ID7	ID8	ID8	ID8	ID9	ID9	ID9	ID10	ID10	ID10
	Index	Low	Up	Index	Low	Up	Index	Low	Up	Index	Low	Up	Index	Low	Up
2020	0.428	0.298	0.83	1.842	1.238	4.51	0.821	0.537	1.991	1.881	1.423	3.988	3.488	2.679	5.544

Table A3. Estimated abundance index from recommended model (GAM+ or GAM; see Table 4.8) for populations with ID 11 to ID 15. Each ID corresponds to a specific population (see Table 4.8).

Year	Cyclopterus lumpus (Central Baltic) ID11 Index	Cyclopterus lumpus (Central-Baltic) ID11 Low	Cyclopterus lumpus (Central-Baltic) ID11 Up	Cyclopterus lumpus (WesternBaltic) ID12 Index	Cyclopterus lumpus (WesternBaltic) ID12 Low	Cyclopterus lumpus (WesternBaltic) ID12 Up	Dasyatis pastinaca ID13 Index	Dasyatis pastinaca ID13 Low	Dasyatis pastinaca ID13 Up	Dipturus spp ID14 Index	Dipturus spp ID14 Low	Dipturus spp ID14 Up	Etmopterus spinax ID15 Index	Etmopterus spinax ID15 Low	Etmopter spinax ID15 Up
1967				0.764	0.452	1.92				1.157	0.713	4.57			
1968				0.765	0.489	1.89				1.129	0.682	4.495			
1969				0	0	0				1.05	0.622	3.779			
1970				0.766	0.461	1.756				0.94	0.559	3.414			
1971				0	0	0				0.865	0.507	3.329			
1972				0.769	0.466	1.823				0.844	0.43	3.692	2.573	0.732	22.293
1973				0.771	0.444	1.741				0.877	0.43	4.031	2.499	0.745	24.692
1974				0.773	0.465	1.789				0.947	0.401	4.299	0	0	0
1975				0.776	0.482	1.907				1.028	0.384	5.502	2.136	0.878	13.864
1976				0.781	0.456	1.785				1.087	0.385	5.807	1.877	0.845	9.748
1977				0.788	0.464	1.984				1.074	0.397	5.777	0	0	0
1978				0.798	0.484	1.789				1.015	0.441	5.717	1.429	0.614	8.131
1979				0.818	0.501	1.956				0.926	0.393	4.137	0	0	0
1980				0.851	0.531	1.876				0.815	0.362	3.659	1.171	0.527	6.559
1981				0.896	0.568	1.901				0	0	0	0	0	0
1982				0.959	0.579	2.202				0.628	0.32	2.477	1.027	0.439	6.657

Year	Cyclopterus lumpus (Central Baltic) ID11 Index	Cyclopterus lumpus (Central-Baltic) ID11 Low	Cyclopterus lumpus (Central-Baltic) ID11 Up	Cyclopterus lumpus (WesternBaltic) ID12 Index	Cyclopterus lumpus (WesternBaltic) ID12 Low	Cyclopterus lumpus (WesternBaltic) ID12 Up	Dasyatis pastinaca ID13 Index	Dasyatis pastinaca ID13 Low	Dasyatis pastinaca ID13 Up	Dipturus spp ID14 Index	Dipturus spp ID14 Low	Dipturus spp ID14 Up	Etmopterus spinax ID15 Index	Etmopterus spinax ID15 Low	Etmopter spinax ID15 Up
1983				1.039	0.609	2.321				0.559	0.312	1.988	0	0	0
1984				1.143	0.656	2.69				0.505	0.289	1.707	0.921	0.474	4.558
1985				1.267	0.734	2.767				0.464	0.261	1.678	0.852	0.431	4.513
1986				1.408	0.851	3.298				0.437	0.249	1.601	0.741	0.406	4.015
1987				1.563	0.946	3.503				0.427	0.246	1.362	0.613	0.35	3.567
1988				1.724	1.095	3.7				0.432	0.221	1.447	0	0	0
1989				1.879	1.145	3.9				0.45	0.251	1.427	0	0	0
1990				2.015	1.235	4.084				0.478	0.266	1.565	0	0	0
1991				2.12	1.361	4.697				0.511	0.295	1.589	0.225	0.14	2.134
1992				2.061	1.245	4.566				0.541	0.296	1.615	0	0	0
1993				1.896	1.203	4.139				0.568	0.318	1.624	0	0	0
1994				1.702	1.044	3.766				0.592	0.323	1.667	0	0	0
1995				1.504	0.94	3.343				0.612	0.348	1.624	0	0	0
1996				1.321	0.817	3.011	0.994	0.769	2.15	0.625	0.357	1.604	0.16	0.103	2.077
1997				1.171	0.711	2.587	1.007	0.769	2.205	0.635	0.382	1.508	0.178	0.109	1.328
1998				1.063	0.638	2.352	1.037	0.775	2.42	0.643	0.406	1.557	0.219	0.124	1.173
1999	0.347	0.133	1.241	0.997	0.598	2.359	1.08	0.796	2.438	0.64	0.382	1.479	0.245	0.14	1.401

Year	Cyclopterus lumpus (Central Baltic) ID11 Index	Cyclopterus lumpus (Central-Baltic) ID11 Low	Cyclopterus lumpus (Central-Baltic) ID11 Up	Cyclopterus lumpus (WesternBaltic) ID12 Index	Cyclopterus lumpus (WesternBaltic) ID12 Low	Cyclopterus lumpus (WesternBaltic) ID12 Up	Dasyatis pastinaca ID13 Index	Dasyatis pastinaca ID13 Low	Dasyatis pastinaca ID13 Up	Dipturus spp ID14 Index	Dipturus spp ID14 Low	Dipturus spp ID14 Up	Etmopterus spinax ID15 Index	Etmopterus spinax ID15 Low	Etmopter spinax ID15 Up
2000	0.478	0.213	1.572	0.953	0.587	2.029	1.118	0.807	2.704	0.624	0.384	1.417	0.232	0.123	1.145
2001	1.077	0.644	2.106	0.908	0.582	2.01	1.106	0.825	2.699	0.601	0.368	1.409	0.202	0.119	1.088
2002	2.281	1.602	3.877	0.847	0.563	1.785	1.065	0.755	2.536	0.588	0.371	1.385	0.197	0.125	1.111
2003	2.627	1.805	4.539	0.769	0.502	1.632	1.049	0.722	2.584	0.594	0.37	1.394	0.232	0.143	1.374
2004	1.446	0.99	2.434	0.692	0.437	1.441	1.118	0.805	2.884	0.616	0.387	1.428	0.313	0.188	1.591
2005	1.029	0.718	1.712	0.624	0.433	1.334	1.277	0.927	2.977	0.646	0.411	1.353	0.437	0.256	2.18
2006	1.356	0.995	2.235	0.554	0.379	1.164	1.443	1.064	3.294	0.671	0.445	1.476	0.544	0.312	2.535
2007	1.471	1.079	2.218	0.475	0.326	0.961	1.415	1.059	3.25	0.684	0.439	1.385	0.506	0.275	2.38
2008	1.628	1.191	2.506	0.444	0.306	0.889	1.212	0.868	3.057	0.697	0.456	1.534	0.396	0.242	1.867
2009	1.846	1.34	2.874	0.503	0.346	0.945	1.018	0.787	2.657	0.741	0.49	1.664	0.321	0.208	1.382
2010	1.677	1.25	2.6	0.643	0.433	1.229	0.971	0.682	2.218	0.836	0.544	1.805	0.314	0.199	1.386
2011	1.248	0.922	1.906	0.813	0.546	1.624	1.022	0.702	2.572	0.996	0.654	2.275	0.388	0.243	1.617
2012	0.778	0.579	1.256	1.002	0.632	2.136	1.074	0.822	2.509	1.226	0.8	2.802	0.68	0.39	2.711
2013	0.704	0.531	1.15	1.218	0.688	2.896	1.064	0.783	2.686	1.518	0.983	3.575	1.463	0.827	6.435
2014	0.661	0.47	1.149	1.328	0.778	3.021	0.959	0.72	2.15	1.854	1.202	4.499	2.856	1.557	14.144
2015	0.335	0.253	0.525	1.212	0.667	2.805	0.867	0.677	2.046	2.193	1.418	5.055	4.18	2.234	20.156
2016	0.138	0.104	0.232	0.995	0.54	2.386	0.807	0.593	1.843	2.512	1.687	5.685	4.507	2.392	21.231

Year	Cyclopterus lumpus (Central Baltic) ID11 Index	Cyclopterus lumpus (Central-Baltic) ID11 Low	Cyclopterus lumpus (Central-Baltic) ID11 Up	Cyclopterus lumpus (WesternBaltic) ID12 Index	Cyclopterus lumpus (WesternBaltic) ID12 Low	Cyclopterus lumpus (WesternBaltic) ID12 Up	Dasyatis pastinaca ID13 Index	Dasyatis pastinaca ID13 Low	Dasyatis pastinaca ID13 Up	Dipturus spp ID14 Index	Dipturus spp ID14 Low	Dipturus spp ID14 Up	Etmopterus spinax ID15 Index	Etmopterus spinax ID15 Low	Etmopter spinax ID15 Up
2017	0.102	0.08	0.163	0.805	0.438	1.782	0.774	0.566	1.922	2.817	1.869	6.058	4.021	2.129	18.537
2018	0.196	0.161	0.296	0.706	0.424	1.565	0	0	0	3.116	2.017	7.19	3.508	1.877	16.074
2019	0.374	0.283	0.608	0.678	0.416	1.539	0.758	0.534	1.902	3.387	2.179	7.932	3.353	1.904	15.909
2020	0.202	0.147	0.347	0.683	0.406	1.414	0.766	0.56	1.794	3.58	2.335	7.702	3.484	1.793	16.023

Table A4. Estimated abundance index from recommended model (GAM+ or GAM; see Table 4.8) for populations with ID 16 to ID 20. Each ID corresponds to a specific population (see Table 4.8).

Year	Galeorhinus galeus ID16 Index	Galeorhinus galeus ID16 Low	Galeorhinus galeus ID16 Up	Galeus spp ID17 Index	Galeus spp ID17 Low	Galeus spp ID17 Up	Helicolenus dactylopterus ID18 Index	Helicolenus dactylopterus ID18 Low	Helicolenus dactylopterus ID18 Up	Hexanchus griseus ID19 Index	Hexanchus griseus ID19 Low	Hexanchus griseus ID19 Up	Hippocampus hippocampus ID20 Index	Hippocampus hippocampus ID20 Low	Hippocampus hippocampus ID20 Up
1967															
1968															
1969															
1970															
1971															
1972															

Year	Galeorhinus galeus ID16 Index	Galeorhinus galeus ID16 Low	Galeorhinus galeus ID16 Up	Galeus spp ID17 Index	Galeus spp ID17 Low	Galeus spp ID17 Up	Helicolenus dactylopterus ID18 Index	Helicolenus dactylopterus ID18 Low	Helicolenus dactylopterus ID18 Up	Hexanchus griseus ID19 Index	Hexanchus griseus ID19 Low	Hexanchus griseus ID19 Up	Hippocampus hippocampus ID20 Index	Hippocampus hippocampus ID20 Low	Hippocampus hippocampus ID20 Up
1973															
1974															
1975															
1976															
1977															
1978															
1979															
1980															
1981															
1982															
1983															
1984	1.047	0.471	3.851												
1985	1.028	0.459	3.355	4.537	2.689	13.843	14.27	0.622	846.974						
1986	0.979	0.511	2.848	3.739	2.484	10.064	4.584	0.319	244.466						
1987	0	0	0	2.764	1.836	7.103	0.778	0.113	14.127						
1988	0.895	0.5	2.289	1.929	1.35	3.854	0.206	0.069	1.658						
1989	0.915	0.584	2.074	1.341	0.932	2.592	0.104	0.053	0.508						
1990	1.007	0.705	1.84	0.974	0.701	1.801	0.079	0.044	0.337						

Year	Galeorhinus galeus	Galeorhinus galeus	Galeorhinus galeus	Galeus spp	Galeus spp	Galeus spp	Helicolenus dactylopterus	Helicolenus dactylopterus	Helicolenus dactylopterus	Hexanchus griseus	Hexanchus griseus	Hexanchus griseus	Hippocampus hippocampus	Hippocampus hippocampus	Hippocampus hippocampus
	ID16	ID16	ID16	ID17	ID17	ID17	ID18	ID18	ID18	ID19	ID19	ID19	ID20	ID20	ID20
	Index	Low	Up	Index	Low	Up	Index	Low	Up	Index	Low	Up	Index	Low	Up
1991	1.177	0.897	1.984	0.768	0.547	1.374	0.093	0.062	0.22						
1992	1.382	1.079	2.084	0.713	0.527	1.344	0.144	0.093	0.288						
1993	1.507	1.193	2.295	0.722	0.477	1.725	0.185	0.112	0.38						
1994	1.469	1.185	2.124	0.682	0.4	2.817	0.137	0.095	0.318						
1995	1.314	1.043	1.935	0.537	0.351	2.205	0.1	0.077	0.221						
1996	1.143	0.913	1.714	0.402	0.253	1.155	0.101	0.07	0.34						
1997	1.029	0.821	1.518	0.351	0.245	0.727	0.139	0.078	0.669				0.086	0.027	0.785
1998	1.011	0.796	1.472	0.383	0.27	0.733	0.264	0.139	0.943				0	0	0
1999	1.059	0.826	1.601	0.521	0.383	0.951	0.849	0.403	2.589	1.048	0.875	1.569	0.096	0.036	0.564
2000	1.101	0.876	1.719	0.699	0.505	1.231	3.087	1.137	11.571	0	0	0	0	0	0
2001	1.056	0.831	1.618	0.758	0.555	1.309	2.974	1.276	9.043	1.048	0.844	1.552	0	0	0
2002	0.931	0.72	1.444	0.653	0.479	1.119	1.391	0.73	3.259	1.048	0.861	1.594	0.124	0.047	0.631
2003	0.805	0.63	1.25	0.558	0.396	1.041	0.821	0.46	2.106	1.048	0.868	1.516	0	0	0
2004	0.725	0.571	1.147	0.551	0.397	1.085	0.498	0.303	1.056	1.048	0.859	1.568	0	0	0
2005	0.695	0.543	1.054	0.632	0.471	1.235	0.294	0.191	0.525	1.048	0.857	1.556	0	0	0
2006	0.707	0.552	1.102	0.805	0.552	1.711	0.203	0.14	0.351	1.048	0.865	1.553	0.364	0.185	1.048
2007	0.741	0.587	1.146	0.916	0.637	1.952	0.174	0.111	0.316	1.048	0.868	1.529	0.559	0.298	1.512
2008	0.764	0.612	1.194	0.725	0.48	1.546	0.159	0.102	0.292	1.048	0.872	1.539	0.499	0.269	1.378

Year	Galeorhinus galeus ID16 Index	Galeorhinus galeus ID16 Low	Galeorhinus galeus ID16 Up	Galeus spp ID17 Index	Galeus spp ID17 Low	Galeus spp ID17 Up	Helicolenus dactylopterus ID18 Index	Helicolenus dactylopterus ID18 Low	Helicolenus dactylopterus ID18 Up	Hexanchus griseus ID19 Index	Hexanchus griseus ID19 Low	Hexanchus griseus ID19 Up	Hippocampus hippocampus ID20 Index	Hippocampus hippocampus ID20 Low	Hippocampus hippocampus ID20 Up
2009	0.766	0.602	1.192	0.516	0.365	0.981	0.146	0.094	0.299	1.048	0.874	1.55	0.323	0.17	0.831
2010	0.767	0.587	1.203	0.456	0.324	0.849	0.128	0.085	0.226	1.048	0.857	1.549	0.287	0.166	0.691
2011	0.8	0.637	1.244	0.538	0.393	0.982	0.13	0.094	0.22	1.048	0.868	1.519	0.467	0.273	1.094
2012	0.873	0.681	1.378	0.743	0.54	1.384	0.156	0.11	0.26	1.048	0.858	1.549	0.974	0.636	1.894
2013	0.965	0.738	1.526	0.958	0.681	1.631	0.173	0.118	0.297	1.048	0.852	1.548	1.321	0.87	2.574
2014	1.043	0.799	1.633	1.013	0.727	1.797	0.185	0.116	0.38	1.048	0.86	1.558	1.14	0.743	2.245
2015	1.079	0.833	1.676	0.912	0.681	1.588	0.216	0.135	0.492	1.048	0.873	1.522	1.141	0.8	2.142
2016	1.091	0.871	1.649	0.801	0.605	1.412	0.274	0.162	0.604	1.048	0.868	1.57	1.851	1.343	3.198
2017	1.119	0.874	1.712	0.77	0.568	1.376	0.368	0.228	0.661	1.048	0.846	1.583	3.385	2.43	5.704
2018	1.194	0.955	1.848	0.798	0.582	1.48	0.523	0.354	0.962	1.048	0.883	1.561	4.654	3.469	7.661
2019	1.332	1.035	2.036	0.864	0.663	1.509	0.801	0.541	1.319	1.048	0.853	1.553	3.923	2.895	6.383
2020	1.483	1.149	2.394	0.968	0.713	1.786	1.267	0.884	2.103	1.048	0.874	1.537	2.805	2.183	4.385

Table A5. Estimated abundance index from recommended model (GAM+ or GAM; see Table 4.8) for populations with ID 21 to ID 25. Each ID corresponds to a specific population (see Table 4.8).

Year	Hippoglossus hippoglossus	Hippoglossus hippoglossus	Hippoglossus hippoglossus	Lampetra fluviatilis	Lampetra fluviatilis	Lampetra fluviatilis	Leucoraja circularis	Leucoraja circularis	Leucoraja circularis	Leucoraja fullonica	Leucoraja fullonica	Leucoraja fullonica	Leucoraja naevus (North42)	Leucoraja naevus (North42)	Leucoraja naevus (North42)
	ID21	ID21	ID21	ID22	ID22	ID22	ID23	ID23	ID23	ID24	ID24	ID24	ID25	ID25	ID25
	Index	Low	Up	Index	Low	Up	Index	Low	Up	Index	Low	Up	Index	Low	Up
1967	1.024	0.644	1.77										1.388	0.461	9.077
1968	1.008	0.664	1.793										1.395	0.515	10
1969	0	0	0										1.42	0.479	9.897
1970	0.873	0.598	1.456										1.476	0.503	10.361
1971	0.786	0.55	1.224										1.556	0.568	9.227
1972	0.711	0.527	1.091										1.654	0.649	8.629
1973	0	0	0										1.763	0.706	9.459
1974	0.616	0.43	0.953										1.853	0.739	9.707
1975	0.605	0.423	0.965										1.903	0.749	10.216
1976	0.62	0.452	0.971										1.892	0.845	10.524
1977	0.67	0.488	1.034										1.786	0.778	8.947
1978	0.741	0.542	1.11										1.644	0.727	7.531
1979	0.823	0.595	1.226										1.488	0.717	6.924
1980	0.895	0.677	1.345										1.313	0.658	5.042
1981	0.945	0.708	1.44										1.149	0.643	3.684
1982	0.959	0.713	1.492										0.998	0.602	3.014
1983	0.933	0.692	1.43							0.97	0.455	3.55	0.861	0.533	2.668

Year	Hippoglossus hippoglossus ID21 Index	Hippoglossus hippoglossus ID21 Low	Hippoglossus hippoglossus ID21 Up	Lampetra fluviatilis ID22 Index	Lampetra fluviatilis ID22 Low	Lampetra fluviatilis ID22 Up	Leucoraja circularis ID23 Index	Leucoraja circularis ID23 Low	Leucoraja circularis ID23 Up	Leucoraja fullonica ID24 Index	Leucoraja fullonica ID24 Low	Leucoraja fullonica ID24 Up	Leucoraja naevus (North42) ID25 Index	Leucoraja naevus (North42) ID25 Low	Leucoraja naevus (North42) ID25 Up
1984	0.875	0.629	1.324							0	0	0	0.744	0.473	2.085
1985	0.8	0.58	1.242							1.055	0.51	3.369	0.651	0.424	1.782
1986	0.722	0.525	1.1							0	0	0	0.588	0.401	1.445
1987	0.667	0.501	1.029							0	0	0	0.553	0.395	1.378
1988	0.648	0.473	1.004							0	0	0	0.544	0.389	1.16
1989	0.675	0.479	1.036							0	0	0	0.555	0.413	1.099
1990	0.762	0.579	1.139				0.936	0.575	2.917	0	0	0	0.583	0.448	1.081
1991	0.91	0.671	1.371	1.028	0.769	1.762	0.927	0.566	2.51	0.789	0.497	1.921	0.627	0.484	1.176
1992	1.136	0.869	1.704	1.015	0.747	1.626	0.907	0.554	2.218	0.687	0.465	1.462	0.685	0.53	1.232
1993	1.359	1.027	2.007	0.99	0.702	1.643	0	0	0	0.662	0.497	1.488	0.734	0.553	1.317
1994	1.46	1.073	2.133	0.963	0.662	1.623	0.968	0.537	2.484	0	0	0	0.739	0.539	1.298
1995	1.386	1.018	2.006	0.942	0.636	1.596	1.03	0.608	2.587	0.8	0.574	1.541	0.699	0.502	1.219
1996	1.184	0.865	1.749	0.926	0.581	1.608	1.077	0.666	2.759	1.012	0.697	1.92	0.633	0.469	1.163
1997	0.975	0.721	1.483	0.916	0.607	1.638	1.051	0.682	2.531	1.303	0.903	2.344	0.588	0.448	1.092
1998	0.838	0.624	1.245	0.908	0.625	1.672	0.94	0.63	2.212	1.553	1.113	2.664	0.575	0.44	1.056
1999	0.783	0.584	1.169	0.899	0.618	1.563	0.79	0.526	1.798	1.596	1.223	2.561	0.582	0.449	1.063
2000	0.809	0.598	1.232	0.893	0.62	1.626	0.694	0.469	1.469	1.518	1.147	2.371	0.6	0.464	1.132
2001	0.919	0.669	1.368	0.897	0.61	1.505	0.706	0.501	1.535	1.467	1.098	2.318	0.63	0.475	1.153

Year	Hippoglossus hippoglossus	Hippoglossus hippoglossus	Hippoglossus hippoglossus	Lampetra fluviatilis	Lampetra fluviatilis	Lampetra fluviatilis	Leucoraja circularis	Leucoraja circularis	Leucoraja circularis	Leucoraja fullonica	Leucoraja fullonica	Leucoraja fullonica	Leucoraja naevus (North42)	Leucoraja naevus (North42)	Leucoraja naevus (North42)
	ID21	ID21	ID21	ID22	ID22	ID22	ID23	ID23	ID23	ID24	ID24	ID24	ID25	ID25	ID25
	Index	Low	Up	Index	Low	Up	Index	Low	Up	Index	Low	Up	Index	Low	Up
2002	1.111	0.81	1.657	0.91	0.605	1.64	0.82	0.526	1.667	1.488	1.146	2.378	0.67	0.506	1.305
2003	1.375	1.024	2.064	0.925	0.641	1.589	0.994	0.734	1.974	1.525	1.149	2.391	0.707	0.541	1.283
2004	1.68	1.287	2.387	0.934	0.641	1.564	1.166	0.826	2.569	1.49	1.111	2.401	0.74	0.56	1.409
2005	1.986	1.562	2.82	0.935	0.647	1.544	1.279	0.89	2.708	1.374	1.034	2.248	0.773	0.581	1.519
2006	2.223	1.678	3.191	0.936	0.638	1.568	1.31	0.938	2.684	1.234	0.927	2.046	0.806	0.59	1.696
2007	2.277	1.756	3.244	0.947	0.655	1.647	1.258	0.956	2.415	1.137	0.867	1.842	0.827	0.616	1.629
2008	2.072	1.6	3.008	0.967	0.696	1.58	1.148	0.851	2.238	1.108	0.85	1.912	0.838	0.626	1.68
2009	1.647	1.232	2.481	0.988	0.68	1.665	1.006	0.786	2.04	1.126	0.892	1.959	0.849	0.646	1.511
2010	1.178	0.879	1.738	1.004	0.689	1.704	0.842	0.594	1.714	1.147	0.863	1.894	0.866	0.658	1.575
2011	0.83	0.622	1.211	1.022	0.694	1.741	0.706	0.504	1.495	1.146	0.887	2.075	0.886	0.67	1.536
2012	0.639	0.461	1.006	1.047	0.702	1.81	0.674	0.48	1.324	1.121	0.836	2	0.916	0.704	1.571
2013	0.582	0.414	0.927	1.082	0.743	1.865	0.773	0.52	1.547	1.094	0.822	2.053	0.963	0.735	1.616
2014	0.635	0.459	0.985	1.12	0.745	1.938	0.992	0.637	2.073	1.087	0.811	2.244	1.023	0.777	1.752
2015	0.787	0.574	1.19	1.153	0.781	1.904	1.258	0.798	2.547	1.113	0.795	2.423	1.08	0.831	1.861
2016	1.006	0.751	1.605	1.174	0.799	2.003	1.363	0.897	2.69	1.178	0.824	2.522	1.112	0.847	1.975
2017	1.206	0.889	1.788	1.176	0.779	2.052	1.3	0.851	2.596	1.281	0.881	2.668	1.1	0.822	2.002
2018	1.28	0.95	1.888	1.152	0.796	1.903	1.278	0.823	2.557	1.432	0.991	3.101	1.051	0.788	2.033
2019	1.228	0.935	1.809	1.101	0.766	1.841	1.345	0.935	2.514	1.642	1.182	3.428	0.992	0.742	1.797

Year	Hippoglossus hippoglossus	Hippoglossus hippoglossus	Hippoglossus hippoglossus	Lampetra fluviatilis	Lampetra fluviatilis	Lampetra fluviatilis	Leucoraja circularis	Leucoraja circularis	Leucoraja circularis	Leucoraja fullonica	Leucoraja fullonica	Leucoraja fullonica	Leucoraja naevus (North42)	Leucoraja naevus (North42)	Leucoraja naevus (North42)
	ID21	ID21	ID21	ID22	ID22	ID22	ID23	ID23	ID23	ID24	ID24	ID24	ID25	ID25	ID25
	Index	Low	Up	Index	Low	Up	Index	Low	Up	Index	Low	Up	Index	Low	Up
2020	1.144	0.811	1.848	1.049	0.762	1.737	1.459	1.051	2.873	1.865	1.344	3.612	0.953	0.727	1.787

Table A6. Estimated abundance index from recommended model (GAM+ or GAM; see Table 4.8) for populations with ID 26 to ID 30. Each ID corresponds to a specific population (see Table Table 4.8).

Year	Leucoraja naevus (South42)	Leucoraja naevus (South42)	Leucoraja naevus (South42)	Lophius budegassa	Lophius budegassa	Lophius budegassa	Lophius piscatorius	Lophius piscatorius	Lophius piscatorius	Molva macrophthalma	Molva macrophthalma	Molva macrophthalma	Molva molva	Molva molva	Molva molva
	ID26	ID26	ID26	ID27	ID27	ID27	ID28	ID28	ID28	ID29	ID29	ID29	ID30	ID30	ID30
	Index	Low	Up	Index	Low	Up	Index	Low	Up	Index	Low	Up	Index	Low	Up
1967							0.322	0.145	0.997				1.447	0.978	2.507
1968							0.318	0.146	0.991				1.381	0.937	2.431
1969							0.306	0.143	0.939				1.194	0.865	2.086
1970							0.287	0.137	0.767				0.924	0.689	1.512
1971							0.269	0.149	0.654				0.706	0.535	1.116
1972							0.256	0.148	0.639				0.558	0.431	0.922
1973							0.253	0.145	0.565				0.47	0.35	0.839
1974							0.262	0.148	0.588				0.426	0.304	0.912
1975							0.286	0.158	0.649				0.41	0.268	0.893
1976							0.329	0.183	0.772				0.418	0.277	1.061
1977							0.407	0.227	0.927				0.461	0.298	1.09
1978							0.519	0.297	1.17				0.537	0.344	1.208
1979							0.668	0.374	1.401				0.654	0.434	1.391
1980							0.837	0.513	1.686				0.814	0.557	1.552
1981							1.009	0.62	2.044				1.004	0.722	1.895
1982							1.155	0.749	2.196				1.189	0.867	2.108
1983							1.249	0.82	2.344				1.32	0.946	2.298

Year	Leucoraja naevus (South42)	Leucoraja naevus (South42)	Leucoraja naevus (South42)	Lophius budegassa	Lophius budegassa	Lophius budegassa	Lophius piscatorius	Lophius piscatorius	Lophius piscatorius	Molva macrophthalma	Molva macrophthalma	Molva macrophthalma	Molva molva	Molva molva	Molva molva
	ID26	ID26	ID26	ID27	ID27	ID27	ID28	ID28	ID28	ID29	ID29	ID29	ID30	ID30	ID30
1984							1.283	0.856	2.485				1.362	0.994	2.365
1985				2.403	0.491	34.709	1.264	0.858	2.378				1.314	0.978	2.269
1986				2.2	0.499	25.245	1.182	0.823	2.134				1.164	0.857	1.929
1987				1.837	0.524	14.892	1.082	0.771	1.894				0.996	0.761	1.706
1988				1.42	0.52	6.565	1.006	0.745	1.546				0.88	0.674	1.453
1989				1.037	0.481	3.176	0.982	0.769	1.5				0.829	0.632	1.368
1990				0.733	0.419	1.63	1.019	0.815	1.453				0.83	0.635	1.366
1991				0.532	0.357	1.002	1.121	0.932	1.485				0.873	0.684	1.379
1992				0.44	0.304	0.802	1.324	1.104	1.739				0.977	0.781	1.474
1993				0.431	0.291	0.887	1.569	1.308	2.032				1.127	0.897	1.642
1994				0.454	0.28	0.932	1.748	1.448	2.298				1.256	1.002	1.868
1995				0.473	0.295	0.978	1.76	1.471	2.305				1.271	1.004	1.825
1996				0.446	0.305	0.825	1.533	1.282	2.046				1.134	0.882	1.655
1997				0.385	0.269	0.691	1.223	1.028	1.583	0.064	0.024	0.408	0.939	0.735	1.408
1998				0.366	0.259	0.645	1.01	0.859	1.311	0.069	0.027	0.343	0.793	0.624	1.15
1999				0.418	0.287	0.75	0.942	0.811	1.213	0.131	0.051	0.483	0.722	0.594	1.021
2000	1.011	0.691	3.429	0.528	0.345	0.955	1.013	0.85	1.329	0.328	0.126	1.123	0.724	0.581	1.026
2001	1.02	0.73	3.248	0.641	0.435	1.103	1.188	1.016	1.521	0.696	0.302	2.155	0.786	0.642	1.083
2002	1.024	0.781	2.903	0.669	0.477	1.095	1.394	1.178	1.832	1.202	0.517	3.584	0.859	0.709	1.17

Year	Leucoraja naevus (South42)	Leucoraja naevus (South42)	Leucoraja naevus (South42)	Lophius budegassa	Lophius budegassa	Lophius budegassa	Lophius piscatorius	Lophius piscatorius	Lophius piscatorius	Molva macrophthalma	Molva macrophthalma	Molva macrophthalma	Molva molva	Molva molva	Molva molva
	ID26	ID26	ID26	ID27	ID27	ID27	ID28	ID28	ID28	ID29	ID29	ID29	ID30	ID30	ID30
2003	1.013	0.791	2.678	0.619	0.45	0.96	1.517	1.28	1.952	1.583	0.649	5.294	0.872	0.711	1.16
2004	0.924	0.724	2.47	0.552	0.405	0.869	1.474	1.244	1.928	1.303	0.555	4.859	0.806	0.66	1.09
2005	0.822	0.652	2.14	0.537	0.397	0.853	1.308	1.114	1.669	0.745	0.344	2.903	0.723	0.588	0.994
2006	0.763	0.616	2.034	0.634	0.452	0.994	1.099	0.927	1.443	0.686	0.32	2.464	0.669	0.547	0.938
2007	0.724	0.592	1.918	0.906	0.649	1.433	0.936	0.803	1.199	1.086	0.461	3.674	0.672	0.545	0.954
2008	0.705	0.558	1.695	1.227	0.849	1.942	0.878	0.745	1.132	1.626	0.689	5.404	0.734	0.588	1.038
2009	0.785	0.594	2.185	1.243	0.857	1.993	0.92	0.768	1.171	2.661	1.155	8.962	0.85	0.69	1.204
2010	0.924	0.666	2.47	0.953	0.67	1.52	0.997	0.844	1.267	2.303	1.099	7.565	1.009	0.816	1.41
2011	0.862	0.633	2.193	0.723	0.529	1.133	1.037	0.867	1.342	1.747	0.83	5.299	1.197	0.935	1.707
2012	0.82	0.613	2.227	0.704	0.504	1.068	1.038	0.877	1.333	1.753	0.757	5.443	1.399	1.087	2.034
2013	0.972	0.675	2.619	0.947	0.673	1.474	1.059	0.892	1.367	1.544	0.695	4.941	1.597	1.236	2.373
2014	1.184	0.78	3.338	1.428	1.017	2.251	1.154	0.953	1.509	0.827	0.376	2.723	1.768	1.363	2.651
2015	1.133	0.772	3.043	1.792	1.304	2.832	1.315	1.095	1.745	0.516	0.228	1.812	1.861	1.432	2.709
2016	1.122	0.777	2.899	1.692	1.26	2.672	1.463	1.215	1.905	0.415	0.18	1.445	1.827	1.398	2.644
2017	1.414	0.926	3.878	1.405	1.017	2.1	1.505	1.262	1.984	0.449	0.213	1.427	1.661	1.292	2.359
2018	1.594	1.008	4.152	1.293	1	1.918	1.421	1.213	1.823	0.732	0.34	2.578	1.41	1.125	2.035
2019	1.248	0.84	3.536	1.578	1.174	2.308	1.295	1.111	1.631	0.888	0.402	3.034	1.174	0.936	1.677
2020	0.935	0.669	2.421	2.352	1.727	3.498	1.207	1.036	1.525	0.648	0.306	2.379	1.026	0.793	1.512

Table A7. Estimated abundance index from recommended model (GAM+ or GAM; see Table 4.8) for populations with ID 31 to ID 35. Each ID corresponds to a specific population (see Table 4.8).

Year	Mustelus spp	Mustelus spp	Mustelus spp	Petromyzon marinus	Petromyzon marinus	Petromyzon marinus	Phycis blennoides	Phycis blennoides	Phycis blennoides	Pollachius pollachius	Pollachius pollachius	Pollachius pollachius	Pomatoschistus spp	Pomatoschistus spp	Pomatoschistus spp
	ID31	ID31	ID31	ID32	ID32	ID32	ID33	ID33	ID33	ID34	ID34	ID34	ID35	ID35	ID35
	Index	Low	Up	Index	Low	Up	Index	Low	Up	Index	Low	Up	Index	Low	Up
1967										1.579	0.953	4.352	0.031	0.012	515.487
1968										1.532	0.966	3.929	0.028	0.01	759.299
1969										1.394	0.895	4.061	0	0	0
1970										1.209	0.799	3.199	0.017	0.006	129.453
1971										0	0	0	0.016	0.006	50.691
1972										0.912	0.569	2.684	0.019	0.007	17.035
1973										0.82	0.469	2.4	0	0	0
1974										0.758	0.456	2.461	0	0	0
1975										0.715	0.399	2.436	0	0	0
1976	0.227	0.02	4.752							0.685	0.403	2.365	0	0	0
1977	0	0	0							0.671	0.369	2.127	0.017	0.003	154.07
1978	0.266	0.022	4.675							0.669	0.404	2.151	0.029	0.001	252.225
1979	0	0	0							0.682	0.423	1.905	0.073	0.001	558.861
1980	0	0	0	1.177	0.751	3.677				0.707	0.457	1.912	0	0	0
1981	0.338	0.043	3.219	0	0	0				0.738	0.481	2.059	0	0	0
1982	0	0	0	1.109	0.795	2.927				0.766	0.514	2.251	0	0	0
1983	0	0	0	0	0	0				0.78	0.518	2.044	0	0	0
1984	0.298	0.043	2.758	0	0	0	0.675	0.153	5.629	0.778	0.528	2.094	0	0	0

Year	Mus-telus spp ID31 Index	Mus-telus spp ID31 Low	Mus-telus spp ID31 Up	Petromyzon marinus ID32 Index	Petromyzon marinus ID32 Low	Petromyzon marinus ID32 Up	Phycis blen-noides ID33 Index	Phycis blen-noides ID33 Low	Phycis blen-noides ID33 Up	Pollachius pollachius ID34 Index	Pollachius pollachius ID34 Low	Pollachius pollachius ID34 Up	Pomato-schistus spp ID35 Index	Pomato-schistus spp ID35 Low	Pomato-schistus spp ID35 Up
1985	0	0	0	0	0	0	0.611	0.135	5.013	0.767	0.506	2.234	0.047	0.009	6628.022
1986	0	0	0	0	0	0	0.481	0.129	2.934	0.759	0.465	2.436	0.034	0.017	1679.658
1987	0	0	0	0	0	0	0.365	0.124	1.757	0.781	0.42	2.828	0.096	0.033	181.206
1988	0.283	0.074	1.4	0	0	0	0.283	0.101	1.241	0.852	0.434	2.776	0.251	0.066	266.621
1989	0.343	0.107	1.412	0	0	0	0.237	0.101	0.841	0.978	0.465	3.641	0.338	0.127	474.107
1990	0.438	0.15	1.577	0	0	0	0.219	0.095	0.783	1.157	0.51	4.169	0.398	0.134	2394.922
1991	0.555	0.222	1.662	0	0	0	0.236	0.097	0.846	1.384	0.57	5.013	0.445	0.179	5510.323
1992	0.633	0.264	1.71	1.133	0.824	2.67	0.333	0.13	1.177	1.638	0.75	5.692	0.313	0.223	615.701
1993	0.601	0.279	1.505	0	0	0	0.486	0.205	1.57	1.87	0.871	7.116	0.398	0.271	334.801
1994	0.486	0.242	1.185	1.378	0.944	3.1	0.592	0.237	2.104	2.02	1.004	6.377	0.704	0.364	1414.636
1995	0.374	0.198	0.846	1.511	0.996	3.418	0.594	0.26	1.78	2.049	1.048	6.686	1.38	0.482	11839.067
1996	0.314	0.178	0.678	1.649	1.117	4.068	0.577	0.294	1.468	1.938	1.024	5.908	2.214	0.693	50428.691
1997	0.315	0.184	0.641	1.8	1.165	4.612	0.644	0.352	1.434	1.726	0.965	5.049	2.948	1.416	5426.523
1998	0.375	0.216	0.808	1.979	1.298	4.869	0.825	0.497	1.694	1.492	0.807	4.048	5.235	3.451	1628.597
1999	0.489	0.283	1.002	2.165	1.317	5.639	1.106	0.642	2.193	1.296	0.73	3.326	6.703	4.023	342.607
2000	0.624	0.356	1.313	2.292	1.413	6.066	1.388	0.814	2.738	1.17	0.697	2.913	3.802	2.644	47.019
2001	0.719	0.41	1.441	2.301	1.462	5.836	1.564	0.955	3.054	1.115	0.643	2.835	2.149	1.383	6.466
2002	0.75	0.451	1.623	2.206	1.439	5.63	1.607	0.947	3.056	1.101	0.654	2.642	0.605	0.501	1.007
2003	0.755	0.447	1.571	2.075	1.403	4.994	1.643	0.976	3.191	1.086	0.633	2.982	0.459	0.365	0.695

Year	Mus-telus spp ID31 Index	Mus-telus spp ID31 Low	Mus-telus spp ID31 Up	Petromyzon marinus ID32 Index	Petromyzon marinus ID32 Low	Petromyzon marinus ID32 Up	Phycis blen-noides ID33 Index	Phycis blen-noides ID33 Low	Phycis blen-noides ID33 Up	Pollachius pollachius ID34 Index	Pollachius pollachius ID34 Low	Pollachius pollachius ID34 Up	Pomato-schistus spp ID35 Index	Pomato-schistus spp ID35 Low	Pomato-schistus spp ID35 Up
2004	0.793	0.466	1.608	1.959	1.294	4.645	1.71	1.075	3.23	1.04	0.634	2.604	0.543	0.434	0.8
2005	0.899	0.513	1.809	1.86	1.248	4.164	1.709	1.034	3.332	0.963	0.569	2.397	0.834	0.669	1.215
2006	1.105	0.666	2.16	1.752	1.222	4.134	1.533	0.974	3.012	0.869	0.535	2.187	1.441	1.125	2.08
2007	1.428	0.877	2.982	1.62	1.05	3.909	1.222	0.774	2.18	0.781	0.476	1.889	1.694	1.317	2.646
2008	1.8	1.003	3.623	1.453	0.99	3.556	0.979	0.633	1.782	0.739	0.496	1.664	1.303	0.983	2.045
2009	2.105	1.266	4.201	0	0	0	0.91	0.576	1.673	0.752	0.503	1.596	1.017	0.772	1.574
2010	2.271	1.293	4.38	0	0	0	1.035	0.683	1.901	0.801	0.536	1.764	0.931	0.727	1.52
2011	2.349	1.395	4.729	1.046	0.738	2.662	1.382	0.935	2.524	0.863	0.572	1.839	1.106	0.869	1.669
2012	2.416	1.386	4.715	0.992	0.665	2.275	1.74	1.243	3.091	0.936	0.617	2.055	1.692	1.264	2.678
2013	2.483	1.465	5.098	0.959	0.666	2.278	1.549	1.072	2.712	0.989	0.642	2.256	2.855	2.045	5
2014	2.514	1.512	5.054	0.927	0.63	2.205	1.078	0.758	1.831	0.979	0.631	2.179	4.025	2.763	7.343
2015	2.48	1.479	4.977	0.889	0.615	2.21	0.782	0.563	1.377	0.893	0.566	2.024	3.189	2.23	6.231
2016	2.427	1.477	4.826	0.857	0.587	2.065	0.734	0.509	1.363	0.772	0.495	1.824	1.613	1.203	2.834
2017	2.433	1.443	5.039	0.852	0.576	2.054	0.928	0.622	1.759	0.648	0.403	1.412	0.789	0.636	1.192
2018	2.545	1.573	5.044	0.894	0.6	2.191	1.314	0.891	2.461	0.537	0.357	1.239	0.533	0.434	0.75
2019	2.768	1.66	5.56	1.008	0.627	2.559	1.769	1.204	3.222	0.455	0.296	1.02	0.643	0.491	0.974
2020	2.998	1.809	6.089	1.158	0.674	3.694	2.158	1.44	3.811	0.41	0.255	0.984	1.048	0.716	1.741

Table A8. Estimated abundance index from recommended model (GAM+ or GAM; see Table 4.8) for populations with ID 36 to ID 40. Each ID corresponds to a specific population (see Table 4.8).

Year	Raja brachyura ID36 Index	Raja brachyura ID36 Low	Raja brachyura ID36 Up	Raja clavata ID37 Index	Raja clavata ID37 Low	Raja clavata ID37 Up	Raja microocellata ID38 Index	Raja microocellata ID38 Low	Raja microocellata ID38 Up	Raja montagui ID39 Index	Raja montagui ID39 Low	Raja montagui ID39 Up	Raja undulata ID40 Index	Raja undulata ID40 Low	Raja undulata ID40 Up
1967				0.34	0.197	6.592				1.551	0.278	21.407			
1968				0.342	0.195	4.949				1.524	0.298	24.137			
1969				0.348	0.21	4.189				1.447	0.308	18.233			
1970				0.363	0.22	3.643				1.339	0.291	12.921			
1971				0.39	0.25	3.047				1.26	0.303	10.496			
1972	3.604	0.715	31.697	0.432	0.273	2.271				1.229	0.301	8.919			
1973	0	0	0	0.489	0.315	2.332				1.24	0.42	10.29			
1974	3.171	0.716	23.228	0.558	0.342	2.566				1.287	0.423	11.266			
1975	0	0	0	0.635	0.377	2.872				1.35	0.368	11.263			
1976	2.33	0.651	15.289	0.706	0.425	3.901				1.405	0.436	10.464			
1977	0	0	0	0.742	0.447	4.118				1.425	0.444	12.013			
1978	0	0	0	0.751	0.445	4.103				1.422	0.467	10.428			
1979	1.37	0.473	7.775	0.731	0.446	3.07				1.392	0.512	7.804			
1980	0	0	0	0.672	0.426	2.467				1.288	0.534	5.425			
1981	0	0	0	0.604	0.395	2.041				1.149	0.579	4.234			
1982	1.035	0.425	5.266	0.542	0.36	2.107				0.974	0.551	2.772			
1983	1.011	0.433	4.146	0.5	0.315	2.158				0.778	0.469	2.096			
1984	1.021	0.513	3.758	0.49	0.316	2.602				0.589	0.371	1.446			

Year	Raja brachyura ID36	Raja brachyura ID36	Raja brachyura ID36	Raja clavata ID37	Raja clavata ID37	Raja clavata ID37	Raja microocellata ID38	Raja microocellata ID38	Raja microocellata ID38	Raja montagui ID39	Raja montagui ID39	Raja montagui ID39	Raja undulata ID40	Raja undulata ID40	Raja undulata ID40
1985	1.056	0.542	3.333	0.519	0.315	2.694				0.432	0.293	1.073			
1986	1.108	0.6	3.778	0.599	0.373	3.808				0.317	0.226	0.831			
1987	1.157	0.685	3.202	0.728	0.415	5.065				0.252	0.181	0.663			
1988	1.19	0.694	2.931	0.871	0.571	4.581				0.231	0.171	0.522			
1989	1.204	0.752	2.864	0.97	0.632	3.437				0.248	0.19	0.577			
1990	1.208	0.793	2.703	0.996	0.662	3.058				0.301	0.235	0.617	0.949	0.554	2.077
1991	1.209	0.783	2.55	0.95	0.692	2.773				0.401	0.302	0.874	0.918	0.583	1.886
1992	1.202	0.79	2.415	0.818	0.598	2.086				0.573	0.427	1.272	0.834	0.558	1.517
1993	1.17	0.787	2.328	0.703	0.519	1.657	0.634	0.392	1.283	0.741	0.527	1.692	0.734	0.505	1.344
1994	1.082	0.735	2.195	0.659	0.493	1.618	0.653	0.44	1.244	0.764	0.557	1.61	0.652	0.431	1.207
1995	0.927	0.635	1.957	0.697	0.512	1.989	0.699	0.453	1.327	0.657	0.483	1.272	0.596	0.397	1.16
1996	0.735	0.491	1.578	0.813	0.56	2.494	0.77	0.52	1.44	0.509	0.387	0.902	0.57	0.383	1.143
1997	0.584	0.397	1.298	0.951	0.619	3.377	0.866	0.595	1.585	0.411	0.319	0.711	0.583	0.367	1.175
1998	0.511	0.379	1.279	1.039	0.707	4.225	0.976	0.668	1.805	0.368	0.284	0.649	0.61	0.395	1.196
1999	0.507	0.353	1.662	1.004	0.681	3.489	1.085	0.722	2.08	0.365	0.277	0.661	0.628	0.406	1.216
2000	0.54	0.369	1.661	0.862	0.574	2.714	1.158	0.781	2.205	0.391	0.301	0.688	0.625	0.411	1.245
2001	0.582	0.42	1.696	0.719	0.487	1.859	1.165	0.791	2.198	0.446	0.346	0.789	0.604	0.389	1.189
2002	0.622	0.446	1.525	0.632	0.446	1.461	1.134	0.745	2.074	0.512	0.392	0.872	0.586	0.398	1.149
2003	0.661	0.489	1.475	0.606	0.421	1.316	1.108	0.744	2.101	0.561	0.423	1.003	0.569	0.368	1.179
2004	0.691	0.52	1.436	0.63	0.458	1.379	1.117	0.759	2.108	0.577	0.437	1.013	0.541	0.362	1.084

Year	Raja brachyura ID36	Raja brachyura ID36	Raja brachyura ID36	Raja clavata ID37	Raja clavata ID37	Raja clavata ID37	Raja microocellata ID38	Raja microocellata ID38	Raja microocellata ID38	Raja montagui ID39	Raja montagui ID39	Raja montagui ID39	Raja undulata ID40	Raja undulata ID40	Raja un dulata ID40
2005	0.713	0.523	1.372	0.684	0.488	1.554	1.157	0.762	2.06	0.575	0.44	0.986	0.493	0.345	0.896
2006	0.721	0.538	1.337	0.757	0.521	1.946	1.189	0.809	2.26	0.578	0.425	1.027	0.445	0.319	0.763
2007	0.716	0.531	1.224	0.828	0.558	2.214	1.171	0.805	2.186	0.613	0.482	1.038	0.433	0.321	0.703
2008	0.71	0.536	1.31	0.887	0.599	2.201	1.118	0.753	2.048	0.693	0.533	1.157	0.476	0.362	0.769
2009	0.719	0.54	1.274	0.94	0.653	2.25	1.068	0.715	1.926	0.811	0.622	1.384	0.607	0.453	0.943
2010	0.759	0.57	1.329	1.012	0.691	2.373	1.034	0.718	2.008	0.918	0.702	1.491	0.801	0.624	1.23
2011	0.827	0.632	1.381	1.142	0.81	2.465	0.979	0.666	1.757	0.984	0.772	1.531	0.912	0.718	1.392
2012	0.917	0.696	1.566	1.352	0.972	2.899	0.89	0.585	1.626	1.035	0.794	1.617	0.937	0.751	1.416
2013	1.014	0.797	1.663	1.624	1.177	3.229	0.813	0.567	1.583	1.128	0.914	1.754	1.044	0.814	1.58
2014	1.105	0.879	1.818	1.909	1.334	3.898	0.799	0.565	1.463	1.311	1.04	2.051	1.412	1.085	2.12
2015	1.191	0.932	1.996	2.167	1.575	4.392	0.859	0.59	1.615	1.616	1.32	2.503	2.031	1.655	2.953
2016	1.292	1.004	2.185	2.424	1.722	5.145	0.953	0.666	1.761	2.018	1.61	2.965	2.399	1.918	3.456
2017	1.431	1.087	2.417	2.717	1.906	5.693	1.037	0.73	1.862	2.388	1.887	3.496	2.272	1.781	3.388
2018	1.61	1.236	2.666	3.051	2.161	6.442	1.104	0.743	2.04	2.583	2.049	3.72	2.036	1.603	3.003
2019	1.81	1.36	3.037	3.405	2.395	7.2	1.186	0.816	2.176	2.563	2.006	3.792	2.113	1.689	3.064
2020	1.978	1.48	3.366	3.7	2.568	7.461	1.279	0.86	2.391	2.483	1.892	3.778	2.592	2.062	3.996

Table A9. Estimated abundance index from recommended model (GAM+ or GAM; see Table 4.8) for populations with ID 41 to ID 45. Each ID corresponds to a specific population (see Table 4.8).

Year	Scophthalmus maximus ID41 Index	Scophthalmus maximus ID41 Low	Scophthalmus maximus ID41 Up	Scophthalmus rhombus (CelticSeas) ID42 Index	Scophthalmus rhombus (CelticSeas) ID42 Low	Scophthalmus rhombus (CelticSeas) ID42 Up	Scophthalmus rhombus (NorthSea) ID43 Index	Scophthalmus rhombus (NorthSea) ID43 Low	Scophthalmus rhombus (NorthSea) ID43 Up	Scyliorhinus canicula (North48) ID44 Index	Scyliorhinus canicula (North48) ID44 Low	Scyliorhinus canicula (North48) ID44 Up	Scyliorhinus canicula (South48) ID45 Index	Scyliorhinus canicula (South48) ID45 Low	Scyliorhinus canicula (South48) ID45 Up
1967	0.868	0.512	2.769				0.567	0.369	1.572						
1968	0.857	0.518	2.846				0.569	0.371	1.463						
1969	0.821	0.508	2.289				0.577	0.373	1.458						
1970	0.761	0.462	2.158				0.597	0.415	1.566						
1971	0.699	0.424	1.811				0.631	0.433	1.464	0.186	0.037	2.326			
1972	0.646	0.392	1.787				0.68	0.499	1.55	0.194	0.046	2.14			
1973	0.607	0.369	1.713				0.739	0.554	1.706	0.212	0.052	2.128			
1974	0.585	0.361	1.582				0.799	0.591	1.763	0.242	0.065	1.902			
1975	0.578	0.347	1.604				0.851	0.622	1.839	0.285	0.071	1.708			
1976	0.585	0.36	1.571				0.885	0.646	1.977	0.344	0.098	2.225			
1977	0.609	0.381	1.693				0.886	0.67	1.869	0.418	0.126	2.452			
1978	0.643	0.411	1.61				0.874	0.678	1.829	0.505	0.151	2.683			
1979	0.682	0.449	1.569				0.856	0.652	1.847	0.597	0.185	3.116			
1980	0.723	0.465	1.819				0.838	0.646	1.637	0.667	0.212	3.251			
1981	0.762	0.499	1.845				0.829	0.64	1.717	0.717	0.266	3.002			
1982	0.797	0.527	2.039				0.828	0.615	1.75	0.739	0.323	2.623			
1983	0.829	0.521	2.068	1.026	0.633	2.452	0.834	0.622	2.122	0.736	0.362	2.51			

Year	Scophthalmus maximus	Scophthalmus maximus	Scophthalmus maximus	Scophthalmus rhombus (CelticSeas)	Scophthalmus rhombus (CelticSeas)	Scophthalmus rhombus (CelticSeas)	Scophthalmus rhombus (NorthSea)	Scophthalmus rhombus (NorthSea)	Scophthalmus rhombus (NorthSea)	Scyliorhinus canicula (North48)	Scyliorhinus canicula (North48)	Scyliorhinus canicula (North48)	Scyliorhinus canicula (South48)	Scyliorhinus canicula (South48)	Scyliorhinus canicula (South48)
	ID41	ID41	ID41	ID42	ID42	ID42	ID43	ID43	ID43	ID44	ID44	ID44	ID45	ID45	ID45
	Index	Low	Up	Index	Low	Up	Index	Low	Up	Index	Low	Up	Index	Low	Up
1984	0.864	0.561	2.329	1.027	0.634	2.425	0.846	0.593	1.941	0.713	0.395	1.722			
1985	0.911	0.565	2.456	1.028	0.626	2.436	0.863	0.613	2.154	0.677	0.413	1.635			
1986	0.989	0.597	2.732	1.03	0.641	2.474	0.886	0.62	2.271	0.617	0.388	1.227			
1987	1.118	0.633	3.104	1.033	0.618	2.691	0.916	0.671	2.129	0.549	0.357	1.102			
1988	1.304	0.705	3.948	0	0	0	0.953	0.699	1.927	0.497	0.333	0.921			
1989	1.527	0.76	4.539	0	0	0	0.995	0.746	1.812	0.48	0.331	0.823			
1990	1.732	0.856	5.842	1.044	0.592	2.436	1.039	0.815	1.772	0.509	0.365	0.824	1.163	0.638	11.601
1991	1.834	0.942	6.362	1.047	0.648	2.679	1.081	0.855	1.727	0.586	0.434	0.959	1.116	0.609	10.774
1992	1.676	0.845	5.715	1.046	0.639	2.459	1.077	0.876	1.722	0.712	0.532	1.14	0.992	0.605	5.652
1993	1.352	0.761	3.835	1.04	0.637	2.487	1.006	0.809	1.574	0.863	0.634	1.385	0	0	0
1994	1.047	0.685	2.605	1.031	0.645	2.474	0.892	0.719	1.398	1.002	0.744	1.659	1.02	0.599	3.659
1995	0.85	0.575	2.035	1.024	0.645	2.418	0.777	0.61	1.247	1.083	0.796	1.859	0	0	0
1996	0.745	0.5	1.694	1.025	0.609	2.542	0.689	0.539	1.15	1.059	0.757	1.879	0.994	0.618	3.097
1997	0.699	0.47	1.484	1.037	0.643	2.427	0.633	0.484	1.031	0.961	0.701	1.598	0.918	0.601	2.53
1998	0.705	0.481	1.46	1.05	0.633	2.547	0.605	0.496	0.947	0.869	0.638	1.412	0.845	0.545	2.154
1999	0.778	0.527	1.578	1.04	0.641	2.447	0.601	0.495	0.942	0.83	0.623	1.263	0.693	0.443	1.677
2000	0.937	0.622	1.741	0.996	0.596	2.314	0.624	0.504	0.964	0.846	0.639	1.29	0.546	0.358	1.505
2001	1.147	0.763	2.117	0.93	0.561	2.071	0.681	0.568	1.039	0.903	0.701	1.365	0.461	0.241	1.58

Year	Scophthalmus maximus ID41 Index	Scophthalmus maximus ID41 Low	Scophthalmus maximus ID41 Up	Scophthalmus rhombus (CelticSeas) ID42 Index	Scophthalmus rhombus (CelticSeas) ID42 Low	Scophthalmus rhombus (CelticSeas) ID42 Up	Scophthalmus rhombus (NorthSea) ID43 Index	Scophthalmus rhombus (NorthSea) ID43 Low	Scophthalmus rhombus (NorthSea) ID43 Up	Scyliorhinus canicula (North48) ID44 Index	Scyliorhinus canicula (North48) ID44 Low	Scyliorhinus canicula (North48) ID44 Up	Scyliorhinus canicula (South48) ID45 Index	Scyliorhinus canicula (South48) ID45 Low	Scyliorhinus canicula (South48) ID45 Up
2002	1.288	0.86	2.312	0.858	0.526	1.941	0.764	0.618	1.191	0.984	0.772	1.549	0.544	0.205	2.029
2003	1.272	0.831	2.267	0.805	0.515	1.88	0.848	0.696	1.268	1.069	0.814	1.668	0.605	0.226	2.295
2004	1.157	0.8	1.954	0.789	0.481	1.819	0.915	0.75	1.366	1.138	0.861	1.783	0.578	0.235	2.337
2005	1.052	0.713	1.806	0.831	0.51	1.894	0.992	0.799	1.439	1.193	0.931	1.856	0.623	0.307	2.103
2006	1.01	0.698	1.701	0.935	0.557	2.164	1.109	0.893	1.629	1.241	0.963	1.863	0.809	0.425	2.622
2007	1.06	0.751	1.877	1.076	0.668	2.665	1.265	1.015	1.899	1.296	0.993	2.016	1.083	0.539	3.655
2008	1.186	0.839	2.057	1.2	0.714	2.572	1.419	1.136	2.03	1.363	1.052	2.072	1.386	0.695	4.813
2009	1.33	0.893	2.3	1.249	0.737	2.83	1.523	1.2	2.189	1.434	1.101	2.292	1.632	0.723	6.189
2010	1.382	0.983	2.443	1.214	0.776	2.825	1.571	1.266	2.29	1.487	1.159	2.234	1.746	0.736	6.246
2011	1.287	0.894	2.122	1.141	0.741	2.495	1.605	1.309	2.392	1.519	1.189	2.335	1.663	0.769	6.15
2012	1.115	0.765	1.877	1.085	0.692	2.287	1.635	1.34	2.434	1.547	1.175	2.363	1.414	0.636	5.212
2013	0.975	0.697	1.647	1.091	0.684	2.489	1.611	1.315	2.414	1.6	1.23	2.362	1.157	0.524	4
2014	0.92	0.652	1.578	1.16	0.722	2.342	1.53	1.264	2.323	1.699	1.313	2.657	1.062	0.476	4.231
2015	0.949	0.681	1.577	1.25	0.796	2.715	1.449	1.166	2.104	1.859	1.4	3.059	1.159	0.523	3.801
2016	1.03	0.736	1.795	1.307	0.808	2.943	1.411	1.14	2.07	2.057	1.546	3.632	1.296	0.61	4.739
2017	1.119	0.786	1.944	1.286	0.789	2.731	1.429	1.121	2.132	2.222	1.627	3.785	1.327	0.69	4.914
2018	1.18	0.85	2.081	1.192	0.736	2.59	1.505	1.224	2.258	2.275	1.683	3.941	1.317	0.73	3.999
2019	1.206	0.836	2.087	1.081	0.688	2.365	1.637	1.33	2.421	2.234	1.695	3.635	1.359	0.748	3.844

Year	Scophthalmus maximus	Scophthalmus maximus	Scophthalmus maximus	Scophthalmus rhombus (CelticSeas)	Scophthalmus rhombus (CelticSeas)	Scophthalmus rhombus (CelticSeas)	Scophthalmus rhombus (NorthSea)	Scophthalmus rhombus (NorthSea)	Scophthalmus rhombus (NorthSea)	Scyliorhinus canicula (North48)	Scyliorhinus canicula (North48)	Scyliorhinus canicula (North48)	Scyliorhinus canicula (South48)	Scyliorhinus canicula (South48)	Scyliorhinus canicula (South48)
	ID41	ID41	ID41	ID42	ID42	ID42	ID43	ID43	ID43	ID44	ID44	ID44	ID45	ID45	ID45
	Index	Low	Up	Index	Low	Up	Index	Low	Up	Index	Low	Up	Index	Low	Up
2020	1.214	0.855	2.129	0.998	0.627	2.257	1.78	1.401	2.721	2.184	1.668	3.353	1.493	0.78	4.761

Table A.10. Estimated abundance index from recommended model (GAM+ or GAM; see Table 4.8) for populations with ID 46 to ID 50. Each ID corresponds to a specific population (see Table 4.8).

Year	Scyliorhinus stellaris ID46 Index	Scyliorhinus stellaris ID46 Low	Scyliorhinus stellaris ID46 Up	Sebastes viviparus ID47 Index	Sebastes viviparus ID47 Low	Sebastes viviparus ID47 Up	Squalus spp ID48 Index	Squalus spp ID48 Low	Squalus spp ID48 Up	Torpedo marmorata ID49 Index	Torpedo marmorata ID49 Low	Torpedo marmorata ID49 Up	Zoarces viviparus ID50 Index	Zoarces viviparus ID50 Low	Zoarces viviparus ID50 Up
1967							1.043	0.297	10.988						
1968				0.071	0.009	1.307	1.037	0.306	13.194						
1969				0.076	0.009	1.134	1.02	0.322	9.216						
1970				0.091	0.01	1.039	0.999	0.339	7.772				0.016	0.006	1.041
1971				0.114	0.013	1.365	0.993	0.41	6.972				0.018	0.005	1.618
1972				0.145	0.018	1.373	1.015	0.456	5.484				0	0	0
1973				0.182	0.022	1.645	1.071	0.576	4.923				0	0	0
1974				0.218	0.026	1.931	1.152	0.631	4.652				0	0	0
1975				0.248	0.03	3.045	1.239	0.732	5.379				0	0	0
1976				0.266	0.028	2.784	1.303	0.803	4.626				0	0	0
1977				0.269	0.028	2.733	1.33	0.808	4.559				0	0	0
1978				0.271	0.036	3.054	1.391	0.758	4.831				0	0	0
1979				0.283	0.033	2.816	1.505	0.795	5.157				0	0	0
1980				0.329	0.031	3.344	1.615	0.828	5.788				0.149	0.004	44.327
1981				0.42	0.046	4.353	1.693	0.899	5.298				0.02	0.003	6.462
1982				0.593	0.061	7.722	1.715	0.931	5.991				0.005	0.002	0.533
1983				0.914	0.078	14.462	1.702	0.917	4.989				0.005	0.003	0.462
1984				1.487	0.122	20.015	1.71	0.925	4.828				0.008	0.005	1.052

Year	Scyliorhinus stellaris ID46 Index	Scyliorhinus stellaris ID46 Low	Scyliorhinus stellaris ID46 Up	Sebastes viviparus ID47 Index	Sebastes viviparus ID47 Low	Sebastes viviparus ID47 Up	Squalus spp ID48 Index	Squalus spp ID48 Low	Squalus spp ID48 Up	Torpedo marmorata ID49 Index	Torpedo marmorata ID49 Low	Torpedo marmorata ID49 Up	Zoarces viviparus ID50 Index	Zoarces viviparus ID50 Low	Zoarces viviparus ID50 Up
1985				2.441	0.157	34.319	1.788	1.039	5.316				0.012	0.008	0.924
1986				3.682	0.251	47.548	1.914	1.152	5.727				0.019	0.013	0.679
1987				4.653	0.374	67.34	2.025	1.224	5.857				0.039	0.021	2.372
1988				4.609	0.365	64.295	2.035	1.378	7.223				0.189	0.04	39.804
1989				3.673	0.391	43.235	1.925	1.27	7.449				2.078	0.07	847.837
1990				2.426	0.21	28.829	1.772	1.097	10.421	1.63	0.777	4.534	12.479	0.112	8715.114
1991				1.42	0.135	15.68	1.649	1.044	12.751	1.606	0.832	4.43	21.424	0.126	34814.041
1992				0.798	0.089	8.477	1.516	0.892	13.201	0	0	0	5.037	0.06	3792.621
1993				0.529	0.051	5.519	1.363	0.819	14.496	0	0	0	0.289	0.034	118.451
1994				0.473	0.042	5.702	1.176	0.697	16.154	0	0	0	0.037	0.02	2.472
1995				0.57	0.053	6.893	0.988	0.592	14.315	0	0	0	0.026	0.017	0.789
1996				0.861	0.095	8.995	0.826	0.449	11.956	0	0	0	0.024	0.015	2.525
1997				1.347	0.221	10.95	0.687	0.385	9.248	0.91	0.585	1.861	0.017	0.012	0.999
1998	0.415	0.244	0.806	1.842	0.413	9.324	0.56	0.334	6.241	0.854	0.57	1.78	0.016	0.011	0.211
1999	0.372	0.24	0.68	2.003	0.596	7.001	0.445	0.28	3.676	0.802	0.554	1.536	0.075	0.018	0.767
2000	0.285	0.198	0.481	1.747	0.571	5.787	0.346	0.242	1.857	0.751	0.519	1.431	0.593	0.173	2.759
2001	0.273	0.191	0.478	1.33	0.497	4.147	0.268	0.192	0.993	0.705	0.518	1.324	1.802	0.898	4.544
2002	0.381	0.284	0.597	1.031	0.399	3.051	0.214	0.157	0.778	0.678	0.475	1.25	1.926	1.082	4.083
2003	0.647	0.5	1.007	0.904	0.326	2.553	0.191	0.137	0.684	0.683	0.469	1.227	0.931	0.54	1.93

Year	Scyliorhinus stellaris ID46 Index	Scyliorhinus stellaris ID46 Low	Scyliorhinus stellaris ID46 Up	Sebastes viviparus ID47 Index	Sebastes viviparus ID47 Low	Sebastes viviparus ID47 Up	Squalus spp ID48 Index	Squalus spp ID48 Low	Squalus spp ID48 Up	Torpedo marmorata ID49 Index	Torpedo marmorata ID49 Low	Torpedo marmorata ID49 Up	Zoarces viviparus ID50 Index	Zoarces viviparus ID50 Low	Zoarces viviparus ID50 Up
2004	0.774	0.596	1.178	0.902	0.316	2.914	0.189	0.137	0.598	0.73	0.532	1.313	0.406	0.24	0.816
2005	0.7	0.544	1.091	0.934	0.357	3.049	0.198	0.148	0.637	0.8	0.576	1.435	0.254	0.163	0.473
2006	0.712	0.548	1.045	0.904	0.36	2.7	0.21	0.157	0.744	0.856	0.641	1.448	0.24	0.162	0.445
2007	0.768	0.606	1.161	0.751	0.274	2.23	0.234	0.167	0.726	0.855	0.65	1.382	0.307	0.207	0.533
2008	0.769	0.625	1.105	0.553	0.222	1.556	0.298	0.205	0.805	0.82	0.623	1.33	0.427	0.286	0.693
2009	0.719	0.579	1.077	0.405	0.179	1.165	0.405	0.265	1.087	0.818	0.647	1.322	0.467	0.324	0.787
2010	0.757	0.614	1.086	0.331	0.129	0.877	0.481	0.31	1.187	0.887	0.7	1.379	0.325	0.219	0.532
2011	1.002	0.803	1.445	0.312	0.134	0.811	0.498	0.337	1.085	0.993	0.791	1.509	0.193	0.137	0.307
2012	1.268	1.046	1.762	0.333	0.14	0.82	0.534	0.387	1.123	1.111	0.899	1.669	0.145	0.104	0.245
2013	1.209	0.978	1.707	0.377	0.171	0.911	0.598	0.428	1.126	1.262	1.049	1.821	0.145	0.096	0.267
2014	1.132	0.935	1.633	0.419	0.195	0.965	0.63	0.469	1.125	1.461	1.241	2.095	0.152	0.097	0.3
2015	1.32	1.098	1.838	0.451	0.21	1.13	0.618	0.462	1.119	1.647	1.395	2.332	0.144	0.091	0.311
2016	1.805	1.502	2.479	0.491	0.231	1.223	0.619	0.442	1.212	1.73	1.474	2.464	0.124	0.079	0.261
2017	2.208	1.769	3.114	0.572	0.249	1.306	0.666	0.451	1.446	1.747	1.505	2.506	0.107	0.072	0.194
2018	2.014	1.654	2.811	0.733	0.372	1.575	0.756	0.502	1.714	1.853	1.552	2.701	0.1	0.069	0.187
2019	1.753	1.453	2.489	0.977	0.445	2.18	0.869	0.575	2.155	2.178	1.853	3.1	0.108	0.073	0.198
2020	1.716	1.418	2.377	1.238	0.528	3.087	0.974	0.625	2.28	2.633	2.133	3.86	0.126	0.08	0.253

Table A11. Abundance estimates for species with existing ICES assessments extracted from ICES Stock Assessment Graphs SAG: https://standardgraphs.ices.dk/stockList.aspx.

Species Name	Area	Fish Stock code	Year	Index	Low	Up	Index Description
Anguilla anguilla	Elsewhere	ele.2737.nea	1996	24.94405137	15.7	40	SSB- recruitment indices
			1997	41.1731698	26	65	SSB- recruitment indices
			1998	16.55243179	10.5	26	SSB- recruitment indices
			1999	20.72574696	13	33	SSB- recruitment indices
			2000	19.42934414	12.2	31	SSB- recruitment indices
			2001	8.706201435	5.6	13.7	SSB- recruitment indices
			2002	13.39383818	8.5	21	SSB- recruitment indices
			2003	12.87311399	8.3	20	SSB- recruitment indices
			2004	7.343785695	4.7	11.5	SSB- recruitment indices
			2005	8.13566579	502	12.8	SSB- recruitment indices
			2006	5.82669935	3.8	9	SSB- recruitment indices
			2007	6.540185788	4.2	10.2	SSB- recruitment indices
			2008	5.49997103	3.5	8.6	SSB- recruitment indices
			2009	4.123178082	2.5	6.8	SSB- recruitment indices
			2010	4.45001918	2.8	7.2	SSB- recruitment indices
			2011	3.508016853	2.2	5.7	SSB- recruitment indices
			2012	5.180063287	3.1	8.6	SSB- recruitment indices
			2013	7.173747832	4.4	11.7	SSB- recruitment indices
			2014	12.08002427	7.4	20	SSB- recruitment indices
			2015	6.690044608	4.1	10.9	SSB- recruitment indices
			2016	8.454903771	5.1	14	SSB- recruitment indices
			2017	8.178389786	5	13.4	SSB- recruitment indices
			2018	8.624328129	5	14.8	SSB- recruitment indices
			2019	5.555688084	3.3	9.3	SSB- recruitment indices
			2020	6.477400921	3.8	11	SSB- recruitment indices
	North Sea	ele.2737.nea	1996	4.884281602	2.1	11.5	SSB- recruitment indices
			1997	4.258757794	1.81	10	SSB- recruitment indices
			1998	3.07993612	1.31	7.3	SSB- recruitment indices
			1999	6.505795174	2.7	15.5	SSB- recruitment indices
			2000	4.737579372	2	11.2	SSB- recruitment indices
			2001	1.001130595	0.43	2.4	SSB- recruitment indices
			2002	2.579040403	1.08	6.2	SSB- recruitment indices
			2003	1.938571654	0.8	4.7	SSB- recruitment indices
			2004	0.650984948	0.28	1.53	SSB- recruitment indices
			2005	1.105355638	0.46	206	SSB- recruitment indices
			2006	0.453286613	0.2	1.04	SSB- recruitment indices
			2007	1.256369854	0.55	2.9	SSB- recruitment indices
			2008	1.162356653	0.52	2.6	SSB- recruitment indices
			2009	0.830219939	0.37	1.84	SSB- recruitment indices
			2010	0.726098913	0.32	1.64	SSB- recruitment indices
			2011	0.491406126	0.22	1.08	SSB- recruitment indices
			2012	0.563112859	0.26	1.23	SSB- recruitment indices
			2013	1.744611054	0.79	3.8	SSB- recruitment indices
			2014	2.745778613	1.26	6	SSB- recruitment indices
			2015	0.871035731	0.4	1.9	SSB- recruitment indices
			2016	1.909147382	0.87	4.2	SSB- recruitment indices
			2017	1.160162754	0.54	2.5	SSB- recruitment indices
			2018	1.882611351	0.87	4.1	SSB- recruitment indices
			2019	1.427536714	0.66	3.1	SSB- recruitment indices
			2020	0.493436881	0.29	0.83	SSB- recruitment indices

Species Name	Area	Fish Stock code	Year	Index	Low	Up	Index Description
Brosme brosme	Widely distributed	usk.27.3a45b6a7-912b	2001	61.5748	54.9484	68.2011	Biomass index
			2002	53.1329	45.8702	60.3957	Biomass index
			2003	49.7572	42.8692	56.6452	Biomass index
			2004	59.8821	53.1422	66.622	Biomass index
			2005	69.6418	62.3028	76.9808	Biomass index
			2006	111.847	104.489	119.205	Biomass index
			2007	89.6579	82.5924	96.7235	Biomass index
			2008	107.264	99.9016	114.626	Biomass index
			2009	97.119	88.2438	105.994	Biomass index
			2010				Biomass index
			2011	120.83	113.695	127.966	Biomass index
			2012	140.674	133.478	147.871	Biomass index
			2013	138.125	130.437	145.813	Biomass index
			2014	123.089	114.766	131.411	Biomass index
			2015	137.427	130.169	144.685	Biomass index
			2016	128.035	119.333	136.737	Biomass index
			2017	106.392	95.3712	117.414	Biomass index
			2018	142.344	133.532	151.157	Biomass index

Species Name	Area	Fish Stock code	Year	Index	Low	Up	Index Description
Gadus morhua	Greater North Sea	cod.27.47d20	1963	145332	115009	183650	SSB
			1964	156998	126665	194595	SSB
			1965	192122	159523	231384	SSB
			1966	213317	177928	255745	SSB
			1967	242052	202313	289596	SSB
			1968	254923	219032	296695	SSB
			1969	251103	213477	295361	SSB
			1970	261273	222836	306341	SSB
			1971	264824	226257	309965	SSB
			1972	235810	201592	275837	SSB
			1973	209602	184592	238000	SSB
			1974	224993	197494	256321	SSB
			1975	203495	177299	233561	SSB
			1976	172037	147979	200007	SSB
			1977	145750	125744	168939	SSB
			1978	144872	128619	163179	SSB
			1979	143234	128040	160231	SSB
			1980	156274	140349	174007	SSB
			1981	164889	149311	182092	SSB
			1982	163862	147848	181610	SSB
			1983	135231	121678	150294	SSB
			1984	117474	105439	130883	SSB
			1985	116908	104794	130422	SSB
			1986	109166	98934	120457	SSB
			1987	111274	100492	123213	SSB
			1988	110252	101047	120296	SSB
			1989	102131	93109	112027	SSB
			1990	89061	80681	98312	SSB
			1991	87527	78569	97506	SSB
			1992	83873	74935	93878	SSB
			1993	84866	71802	100308	SSB
			1994	91184	76499	108688	SSB
			1995	104979	87800	125519	SSB
			1996	105387	88246	125859	SSB
			1997	90973	76622	108014	SSB
			1998	90540	75688	108308	SSB
			1999	76807	63728	92571	SSB
			2000	57987	48358	69533	SSB
			2001	56600	47554	67366	SSB
			2002	51327	43124	61090	SSB
			2003	53034	44473	63242	SSB
			2004	42657	35861	50741	SSB
			2005	45758	39373	53178	SSB
			2006	42682	37491	48591	SSB
			2007	74120	65664	83665	SSB
			2008	81504	72328	91845	SSB
			2009	86915	76171	99175	SSB
			2010	85417	72764	100270	SSB
			2011	91220	74953	111016	SSB
			2012	88072	71169	108989	SSB
			2013	93409	75478	115599	SSB
			2014	98484	80021	121208	SSB
			2015	109640	87997	136606	SSB
			2016	108512	87718	134237	SSB
			2017	97868	77997	122801	SSB
			2018	88071	68002	114062	SSB
			2019	65581	48621	88456	SSB
			2020	55725	39049	79522	SSB

Species Name	Area	Fish Stock code	Year	Index	Low	Up	Index Description
Gadus morhua	Celtic Seas, Greater North Sea, and Oceanic Northeast Atlantic ecoregions	cod.27.7e-k	1980	10072	7827	12960	SSB
			1981	12842	9895	16665	SSB
			1982	13051	10551	16143	SSB
			1983	10544	8804	12628	SSB
			1984	8306	6783	10171	SSB
			1985	9780	7933	12058	SSB
			1986	10887	8882	13345	SSB
			1987	10277	8489	12443	SSB
			1988	15904	11724	21573	SSB
			1989	22169	17221	28539	SSB
			1990	17586	14342	21564	SSB
			1991	11012	9271	13080	SSB
			1992	10284	7908	13374	SSB
			1993	13417	10300	17478	SSB
			1994	13451	10847	16679	SSB
			1995	13803	10738	17742	SSB
			1996	15768	12536	19834	SSB
			1997	14335	11728	17522	SSB
			1998	12844	10488	15729	SSB
			1999	10607	8755	12850	SSB
			2000	7421	6255	8804	SSB
			2001	8655	6566	11408	SSB
			2002	11585	9265	14486	SSB
			2003	9462	7981	11217	SSB
			2004	5591	4833	6467	SSB
			2005	4212	3670	4834	SSB
			2006	5552	4721	6531	SSB
			2007	6878	5853	8082	SSB
			2008	7095	6068	8297	SSB
			2009	5684	4889	6608	SSB
			2010	5613	4843	6505	SSB
			2011	9527	7984	11369	SSB
			2012	14921	12487	17830	SSB
			2013	10725	9106	12632	SSB
			2014	6329	5401	7416	SSB
			2015	6594	5582	7789	SSB
			2016	6049	5030	7273	SSB
			2017	3311	2786	3934	SSB
			2018	1748	1483	2060	SSB
			2019	1181	906	1540	SSB
			2020	1587	863	2913	SSB

Species Name	Area	Fish Stock code	Year	Index	Low	Up	Index Description
Gadus morhua	Celtic Seas ecoregion	cod.27.6a	1981	44062	38328	50654	SSB
			1982	43237	37953	49257	SSB
			1983	36446	32285	41142	SSB
			1984	30955	27500	34844	SSB
			1985	25764	22908	28978	SSB
			1986	22032	19434	24977	SSB
			1987	24596	21727	27845	SSB
			1988	27227	23524	31512	SSB
			1989	25277	21901	29172	SSB
			1990	19418	17100	22051	SSB
			1991	16295	14378	18467	SSB
			1992	14411	12802	16221	SSB
			1993	14297	12404	16479	SSB
			1994	14043	11706	16846	SSB
			1995	13142	10180	16965	SSB
			1996	11104	8271	14906	SSB
			1997	9386	6889	12787	SSB
			1998	9224	6627	12839	SSB
			1999	7771	5553	10875	SSB
			2000	6607	4729	9231	SSB
			2001	7025	4973	9925	SSB
			2002	6537	4660	9170	SSB
			2003	5303	3851	7303	SSB
			2004	3686	2747	4947	SSB
			2005	2600	1991	3395	SSB
			2006	2466	1963	3097	SSB
			2007	3101	2446	3930	SSB
			2008	3177	2486	4060	SSB
			2009	2578	2114	3144	SSB
			2010	2953	2435	3581	SSB
			2011	3868	3165	4728	SSB
			2012	3900	3192	4765	SSB
			2013	4022	3369	4800	SSB
			2014	4992	4164	5983	SSB
			2015	6227	5163	7510	SSB
			2016	6581	5458	7935	SSB
			2017	5895	4841	7179	SSB
			2018	3980	3233	4901	SSB
			2019	2448	1927	3112	SSB
			2020	2213	1482	3304	SSB

Species Name	Area	Fish Stock code	Year	Index	Low	Up	Index Description
Gadus morhua	North Sea	cod. 27.21	1997	2.7	2.4	3.192947846	Stock size Relative
			1998	2	1.78	2.358376306	Stock size Relative
			1999	1.93	1.72	2.229519659	Stock size Relative
			2000	1.47	1.31	1.702106407	Stock size Relative
			2001	1.26	1.13	1.467767109	Stock size Relative
			2002	1.24	1.1	1.456379777	Stock size Relative
			2003	1.08	0.97	1.226835146	Stock size Relative
			2004	0.99	0.87	1.053328172	Stock size Relative
			2005	1.23	1.09	1.215447814	Stock size Relative
			2006	1.28	1.13	1.19806715	Stock size Relative
			2007	0.89	0.8	0.805803544	Stock size Relative
			2008	0.54	0.49	0.487857259	Stock size Relative
			2009	0.22	0.197	0.181897639	Stock size Relative
			2010	0.197	0.174	0.15432831	Stock size Relative
			2011	0.28	0.24	0.207968635	Stock size Relative
			2012	0.37	0.31	0.294871955	Stock size Relative
			2013	0.64	0.55	0.527712919	Stock size Relative
			2014	0.89	0.77	0.72009889	Stock size Relative
			2015	1.4	1.18	1.175592154	Stock size Relative
			2016	1.1	0.93	0.995492515	Stock size Relative
			2017	0.61	0.51	0.598434242	Stock size Relative
			2018	0.44	0.35	0.418334603	Stock size Relative
			2019	0.21	0.12	0.202274969	Stock size Relative
	Celtic Seas	cod.27.7a	1993	1.372655831	-	-	Stock size Relative
			1994	1.035993189	-	-	Stock size Relative
			1995	0.876335907	-	-	Stock size Relative
			1996	1.302182789	-	-	Stock size Relative
			1997	1.228058523	-	-	Stock size Relative
			1998	1.523869493	-	-	Stock size Relative
			1999	1.465790576	-	-	Stock size Relative
			2000	0.847797717	-	-	Stock size Relative
			2001	1.275295709	-	-	Stock size Relative
			2002	2.688574767	-	-	Stock size Relative
			2003	2.118685288	-	-	Stock size Relative
			2004	0.793972132	-	-	Stock size Relative
			2005	0.909707894	-	-	Stock size Relative
			2006	0.47545821	-	-	Stock size Relative
			2007	0.450344349	-	-	Stock size Relative
			2008	0.440655115	-	-	Stock size Relative
			2009	0.351113576	-	-	Stock size Relative
			2010	0.521140027	-	-	Stock size Relative
			2011	0.757298851	-	-	Stock size Relative
			2012	0.748358833	-	-	Stock size Relative
			2013	0.825835857	-	-	Stock size Relative
			2014	0.900895247	-	-	Stock size Relative
			2015	1.639044714	-	-	Stock size Relative
			2016	1.052863999	-	-	Stock size Relative
			2017	0.902353523	-	-	Stock size Relative
			2018	0.404095998	-	-	Stock size Relative
			2019	0.664868088	-	-	Stock size Relative
			2020	0.426753799	-	-	Stock size Relative

Species Name	Area	Fish Stock code	Year	Index	Low	Up	Index Description
Lepidorhombus whiffiagonis	t, Celtic Seas, Greater North Se	meg.27.7b-k8abd	1984	70073.23588	67348.784	73191.42078	SSB
			1985	71056.91236	68194.409	74126.67355	SSB
			1986	71605.16576	68596.307	74865.13463	SSB
			1987	74940.52333	71776.451	78422.19884	SSB
			1988	65513.02724	62668.244	68545.74648	SSB
			1989	55178.93546	52537.656	58019.65109	SSB
			1990	47334.55346	44831.834	50013.16079	SSB
			1991	48570.69934	46142.643	51185.2557	SSB
			1992	50060.19448	47720.157	52598.55043	SSB
			1993	54160.31241	51734.384	56777.60511	SSB
			1994	53021.77479	50721.263	55464.5591	SSB
			1995	59106.9925	56477.044	61770.55549	SSB
			1996	53079.69693	50672.235	55586.87805	SSB
			1997	56649.47472	54281.832	59212.56403	SSB
			1998	58892.57523	56460.447	61482.37318	SSB
			1999	49575.21447	47385.13	51949.50579	SSB
			2000	50513.43338	48267.552	52913.03715	SSB
			2001	52068.80654	49714.319	54552.30183	SSB
			2002	47469.32051	45195.458	49780.54148	SSB
			2003	44197.36774	42308.286	46351.19303	SSB
			2004	39116.35202	37358.114	41035.46077	SSB
			2005	38661.00813	36944.891	40572.14918	SSB
			2006	36955.19483	35194.386	38732.03803	SSB
			2007	40344.01914	38558.042	42324.85449	SSB
			2008	44054.55434	42045.629	46182.17375	SSB
			2009	53375.96009	50886.044	56139.78863	SSB
			2010	53227.13274	50617.502	56178.94577	SSB
			2011	46225.41052	43750.129	48948.04504	SSB
			2012	48384.06328	45659.475	51573.40303	SSB
			2013	52921.23569	49584.712	56731.60191	SSB
			2014	65219.96556	60727.54	70366.19039	SSB
			2015	59295.52692	54743.953	64446.26575	SSB
			2016	68801.05225	63284.352	74861.72846	SSB
			2017	68651.88977	62960.094	74901.58957	SSB
			2018	92132.00283	83311.394	101668.3986	SSB
			2019	99708.05091	88629.385	111492.3948	SSB
			2020	107600	93126	123589	SSB
	Bay of Biscay and Iberian Coast	meg.27.8c9a	1986	2239	-	-	SSB
			1987	1859	-	-	SSB
			1988	2130	-	-	SSB
			1989	2283	-	-	SSB
			1990	2435	-	-	SSB
			1991	1550	-	-	SSB
			1992	1445	-	-	SSB
			1993	1349	-	-	SSB
			1994	1185	-	-	SSB
			1995	945	-	-	SSB
			1996	1288	-	-	SSB
			1997	1301	-	-	SSB
			1998	1300	-	-	SSB
			1999	1069	-	-	SSB
			2000	1034	-	-	SSB
			2001	755	-	-	SSB
			2002	711	-	-	SSB
			2003	811	-	-	SSB
			2004	774	-	-	SSB
			2005	779	-	-	SSB
			2006	759	-	-	SSB
			2007	682	-	-	SSB
			2008	611	-	-	SSB
			2009	633	-	-	SSB
			2010	708	-	-	SSB
			2011	1064	-	-	SSB
			2012	1072	-	-	SSB
			2013	974	-	-	SSB
			2014	1006	-	-	SSB
			2015	803	-	-	SSB
			2016	1081	-	-	SSB
			2017	1409	-	-	SSB
			2018	1627	-	-	SSB
			2019	1936	-	-	SSB
			2020	2427	-	-	SSB

Species Name	Area	Fish Stock code	Year	Index	Low	Up	Index Description
Lophius budegassa	Greater Northern Sea, Celtic Seas, and Bay of Biscay and Iberian Coast	ank.27.78abd	2003	1.043411224	0.663549	1.423273667	Biomass Index
			2004	1.030305314	0.678291	1.382319688	Biomass Index
			2005	0.893029768	0.594533	1.191527033	Biomass Index
			2006	1.29517947	0.923887	1.666472321	Biomass Index
			2007	1.48535922	1.04816	1.922558271	Biomass Index
			2008	2.595443268	1.964264	3.226622363	Biomass Index
			2009	1.960330823	1.445364	2.475298039	Biomass Index
			2010	1.942270674	1.375323	2.509218043	Biomass Index
			2011	1.828695661	1.330898	2.326493064	Biomass Index
			2012	1.811674302	1.235998	2.38735107	Biomass Index
			2013	2.094269522	1.549702	2.63883705	Biomass Index
			2014	1.783169092	1.303283	2.263054799	Biomass Index
			2015	1.50023507	0.992804	2.007665809	Biomass Index
			2016	2.335864659	1.755159	2.916569819	Biomass Index
			2017	2.877272337	2.877272	2.877272337	Biomass Index
			2018	4.369385211	3.376517	5.362253577	Biomass Index

Species Name	Area	Fish Stock code	Year	Index	Low	Up	Index Description
Lophius budegassa, L. piscatorius	Celtic Seas, Greater North Sea, and Oceanic Northeast Atlantic	anf.27.3a46	2005	38.617	23.479	53.755	B_index
			2006	40.985	34.478	47.492	B_index
			2007	50.392	43.676	57.108	B_index
			2008	53.546	42.421	64.671	B_index
			2009	38.06	32.987	43.133	B_index
			2010	42.279	30.429	54.129	B_index
			2011	33.254	24.846	41.662	B_index
			2012	36.325	29.704	42.946	B_index
			2013	38.395	31.02	45.77	B_index
			2014	52.884	42.769	62.999	B_index
			2015	67.915	58.782	77.047	B_index
			2016	77.946	66.831	89.06	B_index
			2017	87.896	74.222	101.569	B_index
			2018	77.661	66.258	89.064	B_index
			2019	58.575	46.189	70.962	B_index

Species Name	Area	Fish Stock code	Year	Index	Low	Up	Index Description
Lophius budegassa	Bay of Biscay and the Iberian Coast	ank.27.8c9a	1980	1.4112	0.6788	2.934	B/Bmsy
			1981	1.444	0.7652	2.7248	B/Bmsy
			1982	1.4701	0.8258	2.6169	B/Bmsy
			1983	1.5216	0.8703	2.6602	B/Bmsy
			1984	1.3323	0.7732	2.2959	B/Bmsy
			1985	1.0841	0.6419	1.8307	B/Bmsy
			1986	1.2231	0.7342	2.0375	B/Bmsy
			1987	1.6579	0.9826	2.7973	B/Bmsy
			1988	1.6984	0.9795	2.9448	B/Bmsy
			1989	1.2077	0.7013	2.0797	B/Bmsy
			1990	1.0532	0.606	1.8303	B/Bmsy
			1991	0.9497	0.5479	1.6463	B/Bmsy
			1992	0.8772	0.5053	1.5228	B/Bmsy
			1993	0.7935	0.4621	1.3626	B/Bmsy
			1994	0.6264	0.369	1.0634	B/Bmsy
			1995	0.6408	0.3832	1.0716	B/Bmsy
			1996	0.7355	0.4354	1.2423	B/Bmsy
			1997	0.7877	0.4729	1.3119	B/Bmsy
			1998	1.0805	0.6338	1.8422	B/Bmsy
			1999	1.2103	0.6958	2.1052	B/Bmsy
			2000	1.059	0.5993	1.8713	B/Bmsy
			2001	0.798	0.4516	1.4103	B/Bmsy
			2002	0.6205	0.3565	1.0799	B/Bmsy
			2003	0.6213	0.3576	1.0794	B/Bmsy
			2004	0.6582	0.3836	1.1296	B/Bmsy
			2005	0.5932	0.3471	1.014	B/Bmsy
			2006	0.7149	0.42	1.217	B/Bmsy
			2007	1.035	0.5943	1.8027	B/Bmsy
			2008	1.0648	0.618	1.8348	B/Bmsy
			2009	0.9128	0.5434	1.5335	B/Bmsy
			2010	0.9961	0.6087	1.6301	B/Bmsy
			2011	1.2007	0.7354	1.9605	B/Bmsy
			2012	1.4903	0.9183	2.4185	B/Bmsy
			2013	1.6052	1.0061	2.5612	B/Bmsy
			2014	1.6639	1.0719	2.5827	B/Bmsy
			2015	1.8395	1.1971	2.8265	B/Bmsy
			2016	2.0606	1.344	3.1592	B/Bmsy
			2017	1.8629	1.2258	2.8312	B/Bmsy
			2018	1.8758	1.2371	2.8442	B/Bmsy
			2019	1.7302	1.1404	2.625	B/Bmsy
			2020	1.6651	1.0782	2.5716	B/Bmsy

Species Name	Area	Fish Stock code	Year	Index	Low	Up	Index Description
Lophius piscatorius	Bay of Biscay and the Iberian Coast, Celtic Seas, Greater North Sea, and Oceanic Northeast Atlantic	mon.27.78abd	1986	43.07698477	31.56927	54.5847039	SSB
			1987	49.64558265	37.29874	61.99242308	SSB
			1988	48.02538717	35.98287	60.06790229	SSB
			1989	41.71914281	30.71859	52.71969552	SSB
			1990	36.251966	25.71263	46.79130155	SSB
			1991	36.58385238	26.84096	46.32674947	SSB
			1992	33.31202527	24.21072	42.41332596	SSB
			1993	34.01122719	24.71798	43.30447191	SSB
			1994	30.24695179	21.61899	38.87491752	SSB
			1995	30.97146807	22.32146	39.62147412	SSB
			1996	33.14813228	25.5914	40.70486851	SSB
			1997	33.4314471	25.85067	41.01222359	SSB
			1998	32.19804229	24.86915	39.52693403	SSB
			1999	30.16528916	23.08383	37.24674387	SSB
			2000	22.62285687	16.51365	28.7320664	SSB
			2001	23.94818432	17.35368	30.54268841	SSB
			2002	20.73355982	15.07118	26.39593753	SSB
			2003	20.66232703	16.14153	25.18311978	SSB
			2004	18.39783552	14.38229	22.41338225	SSB
			2005	20.01767953	15.69896	24.33639516	SSB
			2006	23.00190224	18.36593	27.63787706	SSB
			2007	26.11496115	20.68623	31.54369487	SSB
			2008	31.88937899	25.26659	38.51216767	SSB
			2009	37.70037166	30.28532	45.11542719	SSB
			2010	32.30423139	25.09445	39.51401533	SSB
			2011	29.67122595	22.35918	36.98326775	SSB
			2012	31.37493557	23.66163	39.08823943	SSB
			2013	32.37045006	25.08841	39.65248772	SSB
			2014	36.79230806	28.80758	44.77704078	SSB
			2015	44.55263244	34.77642	54.3288423	SSB
			2016	43.18036889	32.99491	53.36582899	SSB
			2017	48.62226894	36.91775	60.32679111	SSB
			2018	52.01914709	38.72905	65.30924379	SSB
			2019	63.22173187	47.52551	78.91795572	SSB
			2020	68.952	-	-	SSB
	Bay of Biscay and the Iberian Coast, Celtic Seas, Greater North Sea, and Oceanic Northeast Atlantic	mon.27.8c9a	1980	9766	5880.35	13652.57	SSB
			1981	11344	7882.92	14805.68	SSB
			1982	11882	9089.18	14675.22	SSB
			1983	10629	8384.44	12874.36	SSB
			1984	8811	7018.76	10602.78	SSB
			1985	8414	7074.1	9752.98	SSB
			1986	7768	6777.91	8757.37	SSB
			1987	4799	4084.23	5513.23	SSB
			1988	3140	2612.01	3667.67	SSB
			1989	2474	2180.33	2768.35	SSB
			1990	2407	2175	2639.26	SSB
			1991	2210	1986.63	2433.69	SSB
			1992	2111	1906.86	2314.24	SSB
			1993	1970	1776.83	2162.19	SSB
			1994	2060	1835.77	2284.43	SSB
			1995	2325	2053.26	2596.62	SSB
			1996	3285	2953.1	3616.36	SSB
			1997	4354	3990.18	4717	SSB
			1998	4745	4375.86	5113.32	SSB
			1999	4587	4205.98	4967.6	SSB
			2000	4249	3845.56	4651.84	SSB
			2001	3988	3556.67	4420.03	SSB
			2002	4188	3724.45	4651.93	SSB
			2003	4809	4306.54	5311.72	SSB
			2004	5880	5332.94	6426.6	SSB
			2005	6820	6221.72	7418.48	SSB
			2006	6537	5900.51	7172.91	SSB
			2007	6322	5633.18	7010.26	SSB
			2008	6685	5929.23	7439.93	SSB
			2009	7069	6250.19	7887.39	SSB
			2010	7180	6292.59	8066.49	SSB
			2011	7521	6545.66	8496.72	SSB
			2012	8312	7230.8	9393.28	SSB
			2013	9294	8077.81	10510.67	SSB
			2014	10432	9033.61	11829.99	SSB
			2015	10967	9357.91	12575.29	SSB
			2016	11417	9566.67	13267.33	SSB
			2017	11812	9663.33	13960.67	SSB
			2018	12344	9856.27	14832.13	SSB
			2019	12596	9810.53	15381.87	SSB
			2020	12476	9472.9	15479.9	SSB

Species Name	Area	Fish Stock code	Year	Index	Low	Up	Index Description
Merluccius merluccius	Bay of Biscay and the Iberian Coast	hke.27.3a46-8abd	1978	71702	59076.28	84328.722	SSB
			1979	91895	81550.52	102240.28	SSB
			1980	94241	84436.97	104045.6316	SSB
			1981	80167	71066.33	89268.266	SSB
			1982	64406	55934.98	72877.616	SSB
			1983	62898	55197.89	70598.9068	SSB
			1984	76056	68716.1	83396.302	SSB
			1985	72957	66541.32	79373.0836	SSB
			1986	54100	48363.22	59836.7828	SSB
			1987	39906	35162.29	44649.7096	SSB
			1988	43169	39025.18	47312.4164	SSB
			1989	42492	38871.16	46113.4392	SSB
			1990	39704	36768.79	42639.6136	SSB
			1991	38676	35882.38	41468.6176	SSB
			1992	37236	34489.32	39983.6752	SSB
			1993	36649	34238.74	39058.4592	SSB
			1994	28823	26756.22	30889.5828	SSB
			1995	28062	26175.4	29947.7962	SSB
			1996	33133	31172.66	35093.1352	SSB
			1997	28370	26526.58	30212.82128	SSB
			1998	22678	21153.6	24202.39588	SSB
			1999	26026	24368.21	27683.5896	SSB
			2000	28722	26914.28	30529.3218	SSB
			2001	34027	31999.23	36054.9748	SSB
			2002	34673	32439.51	36905.6868	SSB
			2003	35009	32707.9	37309.5048	SSB
			2004	40085	37667.14	42502.46	SSB
			2005	38523	36105.72	40939.476	SSB
			2006	30822	28675.33	32969.0664	SSB
			2007	36353	33848.68	38856.9156	SSB
			2008	41909	38725.6	45091.9968	SSB
			2009	62188	57352.9	67023.6984	SSB
			2010	114775	106490.8	123059.1752	SSB
			2011	190397	176804.2	203989.8156	SSB
			2012	215395	197859.1	232930.8652	SSB
			2013	218143	197748.4	238537.584	SSB
			2014	233524	209559.1	257488.92	SSB
			2015	277274	246700.7	307847.256	SSB
			2016	312407	273479.6	351334.364	SSB
			2017	297848	251528.1	344167.896	SSB
			2018	277482	222271.7	332692.26	SSB
			2019	285371	211397.8	359344.1	SSB
		hke.27.8c9a	1982	41103.84219	-	-	SSB
			1983	45800.36116	-	-	SSB
			1984	43047.61794	-	-	SSB
			1985	43140.68458	-	-	SSB
			1986	40023.91559	-	-	SSB
			1987	36765.51951	-	-	SSB
			1988	27027.23305	-	-	SSB
			1989	19896.42822	-	-	SSB
			1990	16278.63217	-	-	SSB
			1991	16449.69511	-	-	SSB
			1992	15512.64073	-	-	SSB
			1993	12766.86534	-	-	SSB
			1994	8898.646326	-	-	SSB
			1995	7093.353201	-	-	SSB
			1996	8512.172226	-	-	SSB
			1997	6476.628741	-	-	SSB
			1998	5705.562105	-	-	SSB
			1999	7400.959486	-	-	SSB
			2000	8665.819935	-	-	SSB
			2001	8790.566829	-	-	SSB
			2002	9160.747251	-	-	SSB
			2003	8880.207464	-	-	SSB
			2004	8829.539042	-	-	SSB
			2005	9157.615842	-	-	SSB
			2006	10432.1534	-	-	SSB
			2007	12206.18458	-	-	SSB
			2008	11955.358	-	-	SSB
			2009	13983.16431	-	-	SSB
			2010	13836.95907	-	-	SSB
			2011	16461.44366	-	-	SSB
			2012	15246.98392	-	-	SSB
			2013	13165.91882	-	-	SSB
			2014	15532.67371	-	-	SSB
			2015	13266.90175	-	-	SSB
			2016	13228.82421	-	-	SSB
			2017	14199.49918	-	-	SSB
			2018	16618.84085	-	-	SSB
			2019	17429.562	-	-	SSB

Species Name	Area	Fish Stock code	Year	Index	Low	Up	Index Description
Molva dypterygia	Celtic Seas and Faroes grounds	bli.27.5b67	1995	70230.36	41619.49	98841.22885	SSB
			1996	70392.13	42761.98	98022.27874	SSB
			1997	70535.18	43823.55	97246.81196	SSB
			1998	67936.14	43111.76	92760.51851	SSB
			1999	66277.92	42756.66	89799.18726	SSB
			2000	62014.69	40821.12	83208.26977	SSB
			2001	58730.58	39445.19	78015.97622	SSB
			2002	54451.56	36871.65	72031.47968	SSB
			2003	53756.50	36992.16	70520.84109	SSB
			2004	55342.84	39030.2	71655.47027	SSB
			2005	59043.85	42647.87	75439.82814	SSB
			2006	62534.20	46115.35	78953.04772	SSB
			2007	64605.04	48286.92	80923.14727	SSB
			2008	66921.29	50492.5	83350.07495	SSB
			2009	69647.25	52876.69	86417.80596	SSB
			2010	71677.53	54427.82	88927.24634	SSB
			2011	73190.79	55482.38	90899.20888	SSB
			2012	76136.37	57673.63	94599.11771	SSB
			2013	78807.49	59541.28	98073.68831	SSB
			2014	82714.55	62632.37	102796.7335	SSB
			2015	86575.28	65692.85	107457.7135	SSB
			2016	88188.55	66183.49	110193.6114	SSB
			2017	90119.13	67104.63	113133.629	SSB
			2018	94890.73	69963.72	119817.7311	SSB
			2019	97354.31	71535.99	123172.6309	SSB
			2020	99287.67	72569.31	126006.0275	SSB
	Arctic Ocean, Greenland Sea, Ice-landic Waters, Norwegian Sea and Oceanic North-east Atlantic	bli.27.5a14	2000	566.3	430.8863	701.713656	Biomass index
			2001	911.9	715.2944	1108.50564	Biomass index
			2002	929.4	708.9835	1149.816504	Biomass index
			2003	872.7	636.6521	1108.747896	Biomass index
			2004	975	715.104	1234.896	Biomass index
			2005	982	649.0234	1314.97656	Biomass index
			2006	1435	993.4218	1876.5782	Biomass index
			2007	1067.3	759.7895	1374.810476	Biomass index
			2008	1588.8	1199.544	1978.056	Biomass index
			2009	1982.5	1547.302	2417.6984	Biomass index
			2010	1767.7	1261.855	2273.545032	Biomass index
			2011				Biomass index
			2012	1362.6	868.5212	1856.67876	Biomass index
			2013	1680.4	1196.243	2164.556848	Biomass index
			2014	1412.1	1063.368	1760.832216	Biomass index
			2015	1110.7	771.0924	1450.307632	Biomass index
			2016	1103.2	698.8551	1507.544864	Biomass index
			2017	1085.8	777.2156	1394.38436	Biomass index
			2018	884.4	631.3201	1137.479904	Biomass index

Species Name	Area	Fish Stock code	Year	Index	Low	Up	Index Description
Molva molva	Celtic Seas, Faroes, Icelandic Waters, and Oceanic Northeast Atlantic	lin.27.5b	1996	15.34367094	5.324541	25.36280117	Biomass index
			1997	9.415678556	3.164047	15.66731055	Biomass index
			1998	9.909042314	1.808793	18.00929148	Biomass index
			1999	5.874988175	1.531492	10.21848416	Biomass index
			2000	6.774631782	2.228807	11.32045666	Biomass index
			2001	8.101786978	2.767583	13.43599075	Biomass index
			2002	7.855820417	3.503245	12.20839599	Biomass index
			2003	3.983293713	1.774584	6.192003313	Biomass index
			2004	17.91043371	5.099316	30.72155092	Biomass index
			2005	11.42754904	5.324757	17.53034106	Biomass index
			2006	8.443847828	3.813035	13.07466059	Biomass index
			2007	9.921300206	3.27779	16.56481091	Biomass index
			2008	14.00164552	3.256995	24.74629581	Biomass index
			2009	11.73633347	4.989683	18.48298344	Biomass index
			2010	22.05778263	4.769498	39.34606738	Biomass index
			2011	23.34762713	7.905076	38.79017819	Biomass index
			2012	19.78677462	6.138385	33.4351645	Biomass index
			2013	21.43503107	8.363187	34.50687482	Biomass index
			2014	33.35719552	4.092864	62.62152692	Biomass index
			2015	25.67335044	5.12375	46.22295079	Biomass index
			2016	22.26460334	7.976604	36.55260285	Biomass index
			2017	21.26795507	6.403492	36.1324184	Biomass index
			2018	11.94941793	6.947434	16.95140192	Biomass index
	Northeast Atlantic and Arctic Ocean	lin.27.3a4a6-91214	2000	62.5847	56.8498	68.3196	Biomass index
			2001	48.6921	42.9007	54.4835	Biomass index
			2002	49.7132	43.6898	55.7365	Biomass index
			2003	51.398	45.4697	57.3262	Biomass index
			2004	66.5267	60.3676	72.6859	Biomass index
			2005	73.1248	66.9894	79.2603	Biomass index
			2006	78.8236	73.0241	84.6232	Biomass index
			2007	69.1137	63.1297	75.0976	Biomass index
			2008	81.4419	74.886	87.9979	Biomass index
			2009	81.7195	75.102	88.3369	Biomass index
			2010	83.6724			Biomass index
			2011	101.951	95.8915	108.01	Biomass index
			2012	109.866	104.088	115.645	Biomass index
			2013	117.809	112.023	123.594	Biomass index
			2014	135.797	130.003	141.592	Biomass index
			2015	146.79	141.146	152.435	Biomass index
			2016	162.02	156.173	167.867	Biomass index
			2017	165.545	159.801	171.289	Biomass index
			2018	144.619	138.936	150.301	Biomass index

Species Name	Area	Fish Stock code	Year	Index	Low	Up	Index Description
Phycis blennoides	Northeast Atlantic	gfb.27.nea	2005	0.968393139	-	-	Biomass index
			2006	0.861719357	-	-	Biomass index
			2007	0.917821292	-	-	Biomass index
			2008	0.872873668	-	-	Biomass index
			2009	0.688364431	-	-	Biomass index
			2010	1.108529274	-	-	Biomass index
			2011	1.063958404	-	-	Biomass index
			2012	1.510384912	-	-	Biomass index
			2013	1.622304472	-	-	Biomass index
			2014	1.262763258	-	-	Biomass index
			2015	0.974245964	-	-	Biomass index
			2016	0.799228768	-	-	Biomass index
			2017	0.993522664	-	-	Biomass index
			2018	0.669483642	-	-	Biomass index
			2019	0.692470611	-	-	Biomass index

Species Name	Area	Fish Stock code	Year	Index	Low	Up	Index Description
Pollachius virens	Celtic Seas, Faroes, and Greater North Sea	pok.27.3a46	1967	152252	121198	191262	SSB
			1968	210476	170005	260580	SSB
			1969	276585	226175	338230	SSB
			1970	346060	287456	416611	SSB
			1971	461829	384613	554547	SSB
			1972	491096	411499	586090	SSB
			1973	523606	438789	624818	SSB
			1974	578302	486871	686903	SSB
			1975	517934	435093	616548	SSB
			1976	399712	333828	478599	SSB
			1977	325413	271390	390189	SSB
			1978	297647	247309	358230	SSB
			1979	278532	234019	331512	SSB
			1980	260299	220376	307454	SSB
			1981	248762	211641	292392	SSB
			1982	219830	189472	255052	SSB
			1983	219780	188883	255730	SSB
			1984	188722	162866	218683	SSB
			1985	165894	143863	191299	SSB
			1986	156348	135833	179960	SSB
			1987	165251	143555	190225	SSB
			1988	154533	132863	179738	SSB
			1989	126333	108997	146426	SSB
			1990	114507	98582	133004	SSB
			1991	107232	92832	123866	SSB
			1992	112573	98045	129254	SSB
			1993	119161	103065	137771	SSB
			1994	123438	106913	142517	SSB
			1995	142510	122764	165432	SSB
			1996	153695	132717	177989	SSB
			1997	191980	162923	226219	SSB
			1998	189382	161714	221784	SSB
			1999	198039	169005	232060	SSB
			2000	190738	164429	221257	SSB
			2001	198099	170468	230209	SSB
			2002	219417	189662	253839	SSB
			2003	207366	178076	241472	SSB
			2004	259445	222342	302741	SSB
			2005	253086	217814	294070	SSB
			2006	270709	232657	314984	SSB
			2007	252682	216215	295300	SSB
			2008	257281	219940	300962	SSB
			2009	254800	216849	299393	SSB
			2010	237453	200294	281506	SSB
			2011	187777	158153	222950	SSB
			2012	168706	142511	199716	SSB
			2013	172703	146181	204038	SSB
			2014	193901	164851	228069	SSB
			2015	199500	169764	234444	SSB
			2016	185528	157493	218552	SSB
			2017	206143	175503	242131	SSB
			2018	204242	173213	240829	SSB
			2019	196167	161126	238829	SSB
			2020	166726	121412	226155	SSB

Species Name	Area	Fish Stock code	Year	Index	Low	Up	Index Description
Scophthalmus maximus	Greater North Sea	tur.27.4	1981	15370.98176	11902.55	19850.11723	SSB
			1982	13709.38093	10447.23	17990.14335	SSB
			1983	12330.37578	9311.839	16327.40452	SSB
			1984	11346.20882	8613.597	14945.7259	SSB
			1985	11462.686	8980.43	14631.05635	SSB
			1986	10916.35675	8574.385	13898.00556	SSB
			1987	9746.673191	7521.879	12629.50968	SSB
			1988	8031.768942	6102.447	10571.05604	SSB
			1989	8015.484218	6131.072	10479.07881	SSB
			1990	6935.466104	5186.709	9273.836019	SSB
			1991	5774.362108	4092.993	8146.425202	SSB
			1992	5403.047213	3877.448	7528.899946	SSB
			1993	4877.398341	3574.803	6654.637337	SSB
			1994	4087.938479	3026.478	5521.67998	SSB
			1995	3696.445173	2874.84	4752.85789	SSB
			1996	3233.843751	2546.893	4106.080219	SSB
			1997	3540.860906	2915.356	4300.571565	SSB
			1998	3769.120087	3206.763	4430.095475	SSB
			1999	3657.671834	2876.433	4651.094484	SSB
			2000	4032.268034	3186.736	5102.143323	SSB
			2001	3880.647153	3093.989	4867.316832	SSB
			2002	3707.42432	3059.939	4491.917788	SSB
			2003	3065.144687	2588.967	3628.903424	SSB
			2004	2882.04713	2404.652	3454.219587	SSB
			2005	2977.580766	2456.385	3609.364298	SSB
			2006	3262.797311	2651.989	4014.287444	SSB
			2007	4056.588714	3324.366	4950.090975	SSB
			2008	4913.728409	4020.841	6004.895123	SSB
			2009	6009.357367	4930.423	7324.396576	SSB
			2010	5726.923421	4563.773	7186.521969	SSB
			2011	5390.664697	4216.084	6892.478393	SSB
			2012	5921.28256	4677.054	7496.510875	SSB
			2013	6893.564704	5536.213	8583.708461	SSB
			2014	8079.928009	6496.601	10049.1377	SSB
			2015	7896.196353	6165.151	10113.28223	SSB
			2016	8125.298182	6337.572	10417.31361	SSB
			2017	9023.092036	7227.296	11265.09614	SSB
			2018	8956.611721	7123.201	11261.91596	SSB
			2019	8217.628237	6357.37	10622.22459	SSB
			2020	8393.068226	-	-	SSB
		tur.27.3a	1975	1.68	0.83	3.4	B/Bmsy
			1976	1.65	0.86	3.2	B/Bmsy
			1977	1.51	0.79	2.9	B/Bmsy
			1978	1.39	0.72	2.7	B/Bmsy
			1979	1.31	0.68	2.5	B/Bmsy
			1980	1.29	0.67	2.5	B/Bmsy
			1981	1.29	0.67	2.5	B/Bmsy
			1982	1.31	0.68	2.5	B/Bmsy
			1983	1.33	0.69	2.6	B/Bmsy
			1984	1.37	0.71	2.7	B/Bmsy
			1985	1.43	0.74	2.8	B/Bmsy
			1986	1.49	0.77	2.9	B/Bmsy
			1987	1.54	0.8	3	B/Bmsy
			1988	1.53	0.79	3	B/Bmsy
			1989	1.44	0.74	2.8	B/Bmsy
			1990	1.32	0.68	2.6	B/Bmsy
			1991	1.16	0.6	2.3	B/Bmsy
			1992	1.07	0.55	2.1	B/Bmsy
			1993	1.05	0.54	2	B/Bmsy
			1994	1.05	0.54	2	B/Bmsy
			1995	1.05	0.54	2	B/Bmsy
			1996	1.02	0.52	1.97	B/Bmsy
			1997	0.94	0.48	1.81	B/Bmsy
			1998	0.86	0.44	1.67	B/Bmsy
			1999	0.83	0.43	1.6	B/Bmsy
			2000	0.82	0.43	1.6	B/Bmsy
			2001	0.85	0.44	1.64	B/Bmsy
			2002	0.89	0.46	1.74	B/Bmsy
			2003	0.96	0.5	1.87	B/Bmsy
			2004	1.02	0.53	1.98	B/Bmsy
			2005	1.05	0.54	2	B/Bmsy
			2006	1.09	0.56	2.1	B/Bmsy
			2007	1.13	0.58	2.2	B/Bmsy
			2008	1.11	0.57	2.2	B/Bmsy
			2009	1.05	0.54	2	B/Bmsy
			2010	0.99	0.51	1.92	B/Bmsy
			2011	1	0.52	1.94	B/Bmsy
			2012	1.08	0.56	2.1	B/Bmsy
			2013	1.22	0.63	2.4	B/Bmsy
			2014	1.38	0.71	2.7	B/Bmsy
			2015	1.48	0.76	2.9	B/Bmsy
			2016	1.45	0.75	2.8	B/Bmsy
			2017	1.28	0.66	2.5	B/Bmsy
			2018	1.09	0.56	2.1	B/Bmsy
			2019	1.09	0.55	2.1	B/Bmsy

Species Name	Area	Fish Stock code	Year	Index	Low	Up	Index Description
Scophthalmus rhombus	Celtic Seas and Greater North Sea	bll.27.3a47de	1995	19.67	-	-	Biomass index
			1996	19.1868	-	-	Biomass index
			1997	13.387	-	-	Biomass index
			1998	23.752	-	-	Biomass index
			1999	22.973	-	-	Biomass index
			2000	24.077	-	-	Biomass index
			2001	26.099	-	-	Biomass index
			2002	22.14958918	-	-	Biomass index
			2003	26.46310614	-	-	Biomass index
			2004	27.0618567	-	-	Biomass index
			2005	25.86078386	-	-	Biomass index
			2006	26.55667014	-	-	Biomass index
			2007	32.37892148	-	-	Biomass index
			2008	39.58013277	-	-	Biomass index
			2009	40.46727026	-	-	Biomass index
			2010	50.00820032	-	-	Biomass index
			2011	52.38522422	-	-	Biomass index
			2012	55.82	-	-	Biomass index
			2013	53.55327694	-	-	Biomass index
			2014	45.61211048	-	-	Biomass index
			2015	62.16034305	-	-	Biomass index
			2016	56.21023049	-	-	Biomass index
			2017	49.55422579	-	-	Biomass index
			2018	39.95594067	-	-	Biomass index
			2019	47.72687056	-	-	Biomass index

Species Name	Area	Fish Stock code	Year	Index	Low	Up	Index Description
Sebastes mentella	Arctic Ocean, Greenland Sea, Ice-landic Waters, Norwegian Sea and Oceanic North-east Atlantic ecoregions	reb.27.5a14	2000	134407	114918	153896	Biomass index
			2001	161733	132298	191169	Biomass index
			2002	95059	81750	108367	Biomass index
			2003	63179	55155	71203	Biomass index
			2004	96465	79970	112961	Biomass index
			2005	109196	81897	136495	Biomass index
			2006	123059	102631	143486	Biomass index
			2007	82062	67044	97079	Biomass index
			2008	80011	68729	91292	Biomass index
			2009	93653	77357	109949	Biomass index
			2010	77852	65863	89842	Biomass index
			2011				Biomass index
			2012	74604	63786	85422	Biomass index
			2013	70055	59126	80983	Biomass index
			2014	103051	83368	122733	Biomass index
			2015	107423	88732	126115	Biomass index
			2016	80855	70910	90801	Biomass index
			2017	125611	104006	147216	Biomass index

Species Name	Area	Fish Stock code	Year	Index	Low	Up	Index Description
Sebastes norvegicus	Arctic Ocean, Celtic Seas, Faroes, Greenland Sea, Icelandic Waters, Norwegian Sea, and Oceanic Northeast Atlanti	reg.27.561214	1971	406553	-	-	SSB
			1972	394172	-	-	SSB
			1973	395169	-	-	SSB
			1974	403262	-	-	SSB
			1975	408546	-	-	SSB
			1976	401493	-	-	SSB
			1977	404083	-	-	SSB
			1978	431468	-	-	SSB
			1979	452919	-	-	SSB
			1980	458335	-	-	SSB
			1981	451678	-	-	SSB
			1982	423483	-	-	SSB
			1983	386697	-	-	SSB
			1984	357778	-	-	SSB
			1985	334052	-	-	SSB
			1986	313003	-	-	SSB
			1987	288257	-	-	SSB
			1988	253986	-	-	SSB
			1989	224740	-	-	SSB
			1990	204411	-	-	SSB
			1991	183673	-	-	SSB
			1992	167354	-	-	SSB
			1993	154416	-	-	SSB
			1994	148451	-	-	SSB
			1995	146627	-	-	SSB
			1996	148694	-	-	SSB
			1997	150645	-	-	SSB
			1998	156488	-	-	SSB
			1999	158441	-	-	SSB
			2000	162123	-	-	SSB
			2001	166980	-	-	SSB
			2002	167168	-	-	SSB
			2003	168373	-	-	SSB
			2004	178183	-	-	SSB
			2005	184074	-	-	SSB
			2006	190673	-	-	SSB
			2007	200949	-	-	SSB
			2008	218427	-	-	SSB
			2009	234681	-	-	SSB
			2010	261787	-	-	SSB
			2011	289267	-	-	SSB
			2012	308918	-	-	SSB
			2013	330333	-	-	SSB
			2014	342322	-	-	SSB
			2015	353757	-	-	SSB
			2016	353091	-	-	SSB
			2017	348639	-	-	SSB
			2018	332059	-	-	SSB
			2019	315915	-	-	SSB
			2020	297105	-	-	SSB

Species Name	Area	Fish Stock code	Year	Index	Low	Up	Index Description
Squalus acanthias	Widely distributed (North East Atlantic and adjacent seas)	dgs.27.nea	1905	332529	318295.4	346762.6	SSB
			1906	330656	316473.8	344838.2	SSB
			1907	330095	315920.2	344269.8	SSB
			1908	329740	315565.4	343914.6	SSB
			1909	329406	315231.2	343580.8	SSB
			1910	328936	314765.4	343106.6	SSB
			1911	328611	314441.2	342780.8	SSB
			1912	328213	314046.6	342379.4	SSB
			1913	327526	313371	341681	SSB
			1914	326652	312512.4	340791.6	SSB
			1915	326171	312034.4	340307.6	SSB
			1916	325729	311594.4	339863.6	SSB
			1917	325853	311706	340000	SSB
			1918	326062	311902.8	340221.2	SSB
			1919	326276	312107.2	340444.8	SSB
			1920	325950	311788	340112	SSB
			1921	325200	311055.2	339344.8	SSB
			1922	324230	310105	338355	SSB
			1923	323257	309148	337366	SSB
			1924	322237	308141.8	336332.2	SSB
			1925	321062	306981.8	335142.2	SSB
			1926	319828	305762	333894	SSB
			1927	318494	304442.2	332545.8	SSB
			1928	316926	302892.2	330959.8	SSB
			1929	315130	301116.8	329143.2	SSB
			1930	313451	299453	327449	SSB
			1931	311182	297210.2	325153.8	SSB
			1932	309015	295063	322967	SSB
			1933	305689	291777	319601	SSB
			1934	301570	287704.6	315435.4	SSB
			1935	297536	283705.2	311366.8	SSB
			1936	293157	279358.2	306955.8	SSB
			1937	289275	275493.4	303056.6	SSB
			1938	284810	271050	298570	SSB
			1939	281990	268224.6	295755.4	SSB
			1940	278896	265129.8	292662.2	SSB
			1941	278713	264905.8	292520.2	SSB
			1942	278923	265073.8	292772.2	SSB
			1943	278867	264985.6	292748.4	SSB
			1944	279600	265676.8	293523.2	SSB
			1945	280476	266511.2	294440.8	SSB
			1946	281788	267774.8	295801.2	SSB
			1947	282112	268068	296156	SSB
			1948	280922	266868.4	294975.6	SSB
			1949	279035	264970.2	293099.8	SSB
			1950	276208	262130.8	290285.2	SSB
			1951	272899	258799.4	286998.6	SSB
			1952	266927	252819	281035	SSB
			1953	259669	245540.4	273797.6	SSB
			1954	253079	238907.8	267250.2	SSB
			1955	246053	231833.4	260272.6	SSB
			1956	238607	224336.2	252877.8	SSB
			1957	230488	216165.2	244810.8	SSB
			1958	223011	208635	237387	SSB
			1959	214696	200265.8	229126.2	SSB
			1960	207459	192973.8	221944.2	SSB
			1961	198988	184442	213534	SSB
			1962	189969	175353.6	204584.4	SSB
			1963	181386	166693	196079	SSB
			1964	171923	157137.2	186708.8	SSB
			1965	163247	148370.8	178123.2	SSB
			1966	157356	142404.2	172307.8	SSB
			1967	153273	138247.6	168298.4	SSB
			1968	149139	134048.8	164229.2	SSB
			1969	142476	127394	157558	SSB
			1970	136796	121821.8	151770.2	SSB
			1971	132152	117387.8	146916.2	SSB
			1972	127899	113352.2	142445.8	SSB
			1973	122463	108077.8	136848.2	SSB
			1974	117077	102796.8	131357.2	SSB
			1975	112330	98120.6	126539.4	SSB
			1976	107745	93593.4	121896.6	SSB
			1977	103011	88910.6	117111.4	SSB

Annex 4: Reviewer reports

Review of suitability of ICES workshop outputs to support advice in response to OSPAR request

Jens Rasmussen

OSPAR has requested advice from ICES to provide swept area estimates and abundance index outputs for all otter and beam trawl surveys in the Northeast Atlantic and regional seas based on the ICES Database of trawl surveys (DATRAS). The aim is to provide input to the assessment of OSPAR common indicators. Two specific components are detailed in order of priority

1. Swept area estimates for all hauls in the DATRAS database

2. Annual estimates of abundance of all species identified as sensitive, listed in the ICES WGBIODIV 2020 outputs – later refined to a collection of regional assessment lists per ecoregion defined during the ICES workshop WKCOFIBYC.

ICES has conducted two workshops to address approaches required to develop the advice: WKSAE-DATRAS – Workshop on the production of swept-area estimates for all hauls in DATRAS for biodiversity assessment and WKABSENS – Workshop on the production of annual estimates of abundance of sensitive species. This review examines the reports from the two workshops and assesses their suitability as basis for ICES advice to the OSPAR request. Given one report was formatted, but not published, and the other in draft, the main focus of the review is on methods and outputs rather than formatting and editorial issues.

The two workshops had terms of references to directly develop scripts and data products, but also extended to look at securing future data quality, methods, and documentation.

At the time of reporting, there was no (publicly or accessible) available data product from WKSAE-DATRAS or WKABSENS, so the review is based on the content of the reports and descriptions of methodology rather than detailed inspection of the data products themselves.

WKSAE-DATRAS focusses on the first part of the advice request – to generate swept area estimates for all relevant trawls in the DATRAS database. The report does however also highlight several considerations that needs to be made when using the estimates to determine abundance of species caught in the trawls.

The WKSAE-DATRAS report in particular addresses the challenge that there is a significant amount of haul records in the DATRAS database that does not include all the data required to calculate swept areas directly. Swept areas are estimated both for door and wind spreads of trawls, but many hauls in the database do not contain the data to provide both. Especially wing spreads are more challenging as many member countries participating in the surveys do not have sensor packages that allow recording of both door and wing positions on trawls.

Across the north sea IBTS survey, there are considerable variability in reporting between countries. Efforts to include more data has greatly increased across member countries in recent years (as summarised in Fig 4.12 in the report), but these were examined in detail during the workshop to identify best possible remedial action to increase inclusion of data.

Beam trawl surveys are overall treated differently with more fixed dimensions, although there are some minor variability in rigging between countries. WKSAE-DATRAS updated and included new data, covering the years 1985 to 2020. The updated beam trawl part of the output focuses on the requested offshore spatial coverage.

For each of the surveys, WKSAE-DATRAS examined relationships between door and wing spreads and relevant parameters such as towed distance, duration etc. to make it possible to derive and fill in missing estimates that the current DATRAS flexfile format would otherwise leave blank. Extracting an up to date dataset, methods from standard flex files, updated flex file approach and the previous approach for the OSPAR product were performed, and the updated data product include the same full spatial extent, and is aligned to the same format with two exception according to the report.

Overall, WKSAE-DATRAS has merged considerations from several previous approaches to provide the best possible estimates, examining as precise relationships as are possible, building upon work in other expert groups (WKBEAM, IBTSWG). Based on the information in the report, and the adoption of merged principles from previous exercises in expert groups and publication, the WKSAE-DATRAS output product for estimated swept areas is deemed suitable for use in advice.

The second part of the advice request, abundance indices of sensitive species, is addressed in the draft WKABSENS report.

The first step is to identify the sensitive species to include, and establish the criteria for inclusion or exclusion of records for which reliable swept area estimates can be obtained (from the first product)

While the original request from OSPAR refers to the list of sensitive species from WGBIODIV 2020 but it is understood that relevant staff from OSPAR were in agreement to utilise and updated list – Regional Assessment List in Annex 3 of the ICES Workshop on Fish Conversation and Bycatch Relevance (WKCOFIBYC). WKABSENS provide clear information on when species was classified as sensitive, based on the method presented in Rindorf *et al* (2020)[2] but including some additional species from some previous methods.

A full list of species that were considered is included in the report together with detailed information on additional selection criteria and count of the number of occurrences within the DATRAS dataset.

Rather surprisingly, WKABSENS has performed its own swept area calculation, using a separate method from the WKSAE-DATRAS product. There is no mention of the WKSAE-DATRAS report or data product in the report. It is not clear if the WKSAE product was not available at the time of WKABSENS. Nor is it clear which of the two products are intended to be presented as the first part of the OSPAR request – but providing one approach to deliver the swept area product and then using another approach to derive the abundance indices seems confusing since there is no comparison between the two products at the time of writing this report.

The remaining evaluation of the WKABSENS draft report is based on the assumption that this issue is addressed in the ICES advice process, and instead focuses on the approach to determine the abundance indices.

The report does detail a set of criteria for inclusion of data (Section 3.3), but they are highly reliant on users being experienced not only in the structure of DATRAS data, but also have additional business knowledge on the rationale for introduce some of the criteria (For example, removing hauls from NIGFS survey prior to 2007, since it is later referenced as 2006-2020 in table 3.5.1). This makes it somewhat difficult to interpret how much data were discarded/deselected as part of this process, and no summary is provided.

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[2] Rindorf, A., Gislason, H., Burns, F., Ellis, J.R., Reid, D. 2020.Are fish sensitive to trawling recovering in the Northeast Atlantic? Journal of Applied Ecology 57: 1936-1947. doi: 10.1111/1365-2664.13693

Subsequently, there are clear and unambiguous classification of species, and description of approaches for providing abundance indices where appropriate. The criteria for inclusion or exclusion of surveys for a given species are clear and well considered.

Gear groupings used for the subsequent modelling approach are detailed, and clearly defined.

The statistical analysis and modelling efforts in WKABSENS has to deal with a challenging set of data that often include a wide range of zero observations (e.g. zero inflated species), sparse recordings, or variable reporting levels over time. Thus, there will inevitably be strong limitations to the number of species that can be fully assessed.

WKABSENS reports on a total of 55 species, inclusive of species for which stock assessments are available. These 55 species were based on the lists from different working groups, and exclude species that were observed 10 times or less. It isn't entirely clear if this is 10 times within individual surveys (in which case their rarity is variable since the number of hauls in different surveys vary considerably) or across all available data.

An initial binomial model approach allow comparison of the full time series of presence-absence information with two different reference period, providing an indication of whether rarer species are declining, stable, or increasing. This approach provide a rapid overview and extends the species list slightly compared to the use of existing indices and the GAM analyses also carried out by WKABSENS.

The two GAM model approaches increases the demand of data availability to 100 non-zero abundance hauls of a given species or population (several species divided into subpopulations), resulting in a reduction to 50 eligible species. Additional consideration about the reduction of habitat scale and time series fragmentation are relevant for the application of GAMs. However, for the majority of species, the full spatio-temporal model with gear interactions could be utilised, with a few using a simpler model without gear interactions.

Results from a VAST mode was applied to a single species, but it is not really clear from the report was used for anything or is considered a candidate method for further work.

Overall this work leads to an extensive table of the 50 sensitive species with abundance indices originating either from the GAM models or existing ICES assessments.

The existing ICES assessments retrieved from SAG is covering 16 of the 50 species, with 34 other sensitive species. This is a large amount of work, and the report provides a good methodology session to explain the application of models.

It would be beneficial to have a clearer summary of each step of inclusion criteria of data on each level from survey, haul, and species. The information is in there for the most, but is somewhat scattered, and the rationale for the criteria is not always explained.

Overall, the outputs of the two workshops are comprehensive, and represents a large amount of work by collective experts. My main concern is the deviation in using two different approaches in determining the swept area indices across the two products. It may be a very minor issue, but there appears to have been no comparison, so the production of advice on this basis should be done with some caution.

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Review of the WKSAE-DATRAS and WKABSENS reports

By Dr. Noémi Van Bogaert (ILVO), Ir. Heleen Raat (ILVO), MSc. Ir. Loes Vandecasteele (UGent)

Request from *(name organisation)*	ICES
Contact within organisation *(name, email, tel)*	Lara Salvany
Request received	6/8/2021
Outcome of request required by client	1-2 page report with review comments
Request title	Review of the WKSAE-DATRAS and WKABSENS reports
Deadline date (requested)	Friday 20/8/2021

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1 WKSAE-DATRAS report

The ToRs of the WKSAE-DATRAS were as follows:

a) harmonize the selection of surveys and time series available in DATRAS for biodiversity assessments;
b) develop a script to calculate swept-area indices for biodiversity assessments;
c) calculate swept-area indices and create a data product as input to OSPAR common indicators for fish and foodwebs;
d) update the DATRAS calculation document to include reference to the new data product and field for biodiversity assessments.

During the working group the Marine Scotland Science (MSS)/OSPAR approach was adopted (described in Chapter 2) which includes data quality checks for the information needed for the calculation of swept-area, and the DATRAS approach (described in Chapter 3), which depends solely on correctly reported data from the national institutes. Several large data gaps were identified, in particular for several years of the North Sea IBTS, for which the authors propose the MSS/OSPAR approach as the way forward.

Overall, the research conducted during the workshop to produce this report addresses the initial ToRS well and is scientifically sound. However, t**he structure of the report could be improved to increase the readability of the text** by shortly introducing the different Chapters/topics somewhere in the Introduction. Additionally, text could be added on how the original ToRs/objectives were addressed and what the link is with the outcomes presented in the report. Other minor comments/questions have been added into the report and in Table 1 below. Furthermore, editorial corrections were made directly in the report using track changes.

Table 1: Detailed comments/questions on the WKSAE-DATRAS report (also marked in the document as comments)

Page number	**Comments WKSAE-DATRAS report**
2	Please add and discuss relevant parameters for Beam Trawl Surveys (*i.e.* beam width and distance)
3	Please explain footnotes of table in description under table or add reference to OSPAR version
3-4	Please describe the structure of the report; what will be presented in the different chapters? How do the outcomes link up to the original ToRs (maybe this could be added somewhere at the end near the Conclusions?
4	Elaboration on bullet point number 3: 'target species' seems to be missing from the text?
4	Include full terminology when mentioned first time in text with abbreviation in brackets
6	Include full terminology when mentioned first time in text with abbreviation in brackets
7	Figure 2.3: explain meaning of purple circles in the flow chart
8	Table 2.1: - not clear what is meant with 'sweep-length' - mention standard groundspeed can be obtained from survey manuals - explain why reasoning behind methodology for swept area calculation is not in line with the advice from WGBEAM 2021
9	Reference style slightly differs between individual references
11	Table 3.3: please provide sufficient detailed information, so CPUE calculations can be reproduced if desired by readers.
12	Table 4.1: - Selection details are not provided in Annex 5? Please explain reasoning behind year selection procedure. For example BE-BTS: why are the years 2005, 2006, 2008, 2009 and 2020 left out? - Not clear which DYFS surveys are included.
14	Table 4.3: is it possible to include similar table for the Beam Trawl Surveys?
16	Check if Figure referencing is correct
16	Check version and R reference
17, 44	How shorts vs. long? Add in brackets?
18	Add data years in caption similar to Figure 4.1
19	Add data years in caption similar to Figure 4.1
20	Please explain 'warp length'
30	Table 4.5: please explain duplicates and missing (Belgian) data?
32	Add description of abbreviation when mentioned first time
37	Could you add information in the caption on what the red circle indicates?
38	Make reference style consistent (brackets or no brackets etc.)

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39	Please be more consistent in the structuring of the text, especially with the order of the surveys in each chapter.
39	Table 5.1: please specify which BTS and DYFS surveys are included?
45	Figure windows with one caption should be together on one single page (Figure 5.6) Add R2 to regression lines on Figure 5.6
48	Reference? Extra info?
49	Table 6.1: Please explain * in table footnote. Why is the "BEBTS_not_in_previous" not included in the list as stated in the caption?

2 WKABSENS report

The ToRs of the WKABSENS report were as follows:

a) Consider the applicability of the ICES list of sensitive fish species for OSPAR FC1. Split the list into:
   - Species with existing ICES assessments (including reference points);
   - Species for which no ICES assessments currently exist;

b) Calculate swept-area indices and create a data product as input to OSPAR common indicators for fish and food webs;
   - Define criteria to select surveys and time-series for analysis;
   - Discuss and agree in algorithm(s) to infill missing data at genus or family level;
   - Agree on the approach to estimate single species population abundance density per year;

c) Discuss and agree on criteria of data capable to support formal assessment; The selection of assessment units will be informed by available information, data and knowledge from other ICES expert groups.

d) Calculate individual survey-based assessments for all sensitive species and create a data product to OSPAR informed by Table 2 Biological information, see Annex 2.

In Chapter 2 criteria for a species to be listed as sensitive were formulated and depending on the occurrence of the species in DATRAS, they were categorized into four groups (Chapter 3). Criteria for excluding specific surveys were discussed as well (Subtitle 3.5). Different approaches (e.g., binomial models, GAMs, VAST) to abundance assessment of sensitive species were explored in Chapter 4 and reference was made to existing stock assessment methods developed in other ICES working groups. For the selection of assessment units distributional maps and selected reports from assessment working groups were reviewed (Chapter 5). Lastly, individual survey-based indices for all sensitive species are presented in Annex 2 and discussed in Chapter 6.

Main comments:

1) While the main ToRs have been addressed by the working group, the readability of the report could be improved by sketching the outline of the different Chapters somewhere in the beginning of the text (or at the beginning of each Chapter) and **linking the different Chapters to each other and with the original ToRs/objectives**.
2) **More detail could be added to the Executive summary** (e.g. which methods were used to calculate abundance indices? What are their limitations)? to make it more informative. The executive summary should reflect the main outcomes from each Chapter/ToR.
3) **Chapter "4.4. VAST" lacks information/interpretation on the Figures that are presented**. In contrast to the binomial method & the GAMs which are well-explained we're missing info on why/when this method could be useful and why/when not (limitations).
4) **Review the Reference list:** see track changes in Table 2 below.

We have added other minor comments/questions to the report (and in Table 2). Furthermore, editorial corrections were made directly in the report using track changes.

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Table 2: Detailed comments/questions on the WKABSENS report

Page number	Comments WKABSENS report
Ex Sum	Remove instructions when doing final review
Ex Sum	Should the heading of this page be "acronym 2021". If not? Leave it blank.
Ex Sum	Spell out numbers lower than ten in full in text
Ex Sum	Add something about the models as these make up a large part of the report e.g. "Different statistical modelling approaches (binomial, GAMs, VAST) were evaluated" or "Abundance indices were estimated using General Additive Models (GAMs) according to the approach by Berg et al. (2014)"
1	Footnote still needs to be added to the *
1	Explain where FC1 indicator stands for.
2	Explain acronym when mentioned the first time
2	Something was wrong with the sentence, check if I altered this correctly
2	Greenstreet et al. (2012)a or b? check with reference list
2	See comment above
3	when selecting all surveys and years/quarters etc. in DATRAS? Could you add a bit more info on how these numbers were obtained?
4	2012a or b? See also the other Greenstreet references in the rest of the document
9	Add meaning of acronyms when mentioned the first time
9	DATRAS is capitalized
9	Explain why beam trawls are not included in the FlexFiles
12	Make reference to parameters used in equation in text below
14	Explain acronym when mentioned the first time
15	Why? I see that NIGFS (<2007) hauls have been included in Tables 3.1.2, 3.5.1
16	Add time range?
18	First time GAMs are mentioned; refer to section 4.3.1 where background on this modelling approach is provided and add original reference: Hastie T, Tibshirani R (1990) Generalized additive models. Chapman and Hall, London
18	Explain acronyms when mentioned the first time
23	Define low occurrence? Is it the same criterion as below 4.2 ("Species that were observed ten times or less over the whole time period were excluded." ?) or is it different?
23-24	Table 4.1.1 When 'existing stock assessments use selected DATRAS data only' is stated, please explain more into detail why the GAM model is more appropriate than ICES assessment?
25	Check lay-out of the first row in this Table
27	No reference for this Figure?
29	Does the colour coding in the first column indicate anything? If not, remove. If they mean something please add more info into the Table's caption
30	Spell out numbers when placed at the beginning of a sentence
31	Is this the official jargon?
34	This should be Table 4.2.2?
35	Please write these abbreviations consistently with or without capitals throughout the text, tables and figures
35	There are currently no yellow highlights in the table, please change
37	Please add reference where the term GES comes from
38	The same is true for the GAM approach?
39	Wrong Figure number, I adjusted this
40	Please add in caption what the red line means (same comment for the following figures below)
43	Add this reference please: Hastie T, Tibshirani R (1990) Generalized additive models. Chapman and Hall, London
43	See previous comment on spatial autocorrelation and dependency. Mention these? Maybe add something in the Discussion section of this part 4.3.4. An alternative to GAM could be INLA
43	Can you add a bit more detail on the data exploration and (violation of) assumptions (if there) for this model
43	Could you add the name of the package is it "mgcv"?)? As well as the author
44	Add reference
44	Put Latin names in italic
51	Latin species names should be in italic
53	Mention considered time periods again in caption
57	Spell out fully first time
57	Add time period (as the first year cannot be read clearly from the graph)
57	Add version R
58	Same comment as above. This picture is not easy to read (small axes), maybe consider to break up in time periods instead of showing all years

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58	Lacking reference to figures in text. Difficult to understand what we see
60	Figures 4.4.1-4.4.6 are not discussed anywhere in the main text. A short conclusion would help the reader in understanding the main outcomes of the VAST approach. Please also explain why the VAST model is described here? It wasn't mentioned as an approach in paragraph 4.1.
60	Axes unreadable, same comment as above. Please also add the time period in brackets
61	Table 5.1: please provide references upon which evidence is based.
62	Reference?
62	Refere to Innoray (WUR) & Raywatch (ILVO) projects?
62	'DATRAS'?
64 (References)	I rearranged the ICES references in a chronological order. Check list again
64	Double entry removed

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