WORKING GROUP ON IMPROVING SURVEY DATA FOR ANALYSIS AND ADVICE (WGISDAA; outputs from 2021 meeting)

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i Executive summary

The Working Group on Improving use of Survey Data for Assessment and Advice (WGISDAA) deals with various topics related to survey data such as experimental survey design, analysis of survey data, and its use in assessment models. The working group serves to bring together experts in data collection and statistical analysis and stock assessment in order to ensure the best possible science.

WGISDAA reviewed a new combined survey index for Northern Shelf haddock based on a Delta-GAM model. The new index combines the North Sea International Bottom Trawl Survey (NS-IBTS) survey with the surveys west of Scotland and thus provides a more complete coverage of the stock. The new index has improved internal consistency compared to any of the surveys used in isolation and should thus be considered for the upcoming benchmark.

The effect of bottom oxygen conditions on survey catch rates of cod and plaice in the Baltic Sea were examined. Low oxygen conditions were hypothesized to be the cause of low catch rates in 2019 by the Baltic Working Group (WGBFAS). While significant effects of oxygen conditions were found for both species, plaice was found to be tolerant of borderline hypoxic conditions. It was noted that record high catches of plaice occurred in 2014 and 2015, where oxygen conditions were the worst in the time series. Oxygen conditions did therefore not seem to be the cause of low catches of plaice in 2019. Survey indices for Western Baltic cod from a model that included bottom oxygen showed very little difference compared to the currently used indices.

WGISDAA reviewed plans for the upcoming Workshop on Unavoidable Survey Effort Reduction (WKUSER2) and recommended future directions. Additionally, preliminary work on survey indices for three North Sea species were presented: plaice, starry ray, and horse mackerel, and potential further analyses were discussed.

ii Expert group information

Expert group name	Working group on improving survey data for analysis and advice (WGISDAA)
Expert group cycle	Annual
Year cycle started	2021
Reporting year in cycle	1/1
Chair(s)	Casper W. Berg, Denmark
Meeting venue(s) and dates	5-7 October 2021, Virtual meeting (13 participants)

1 Combined Q1 survey index and abundance maps for Northern Shelf haddock

Introduction

The assessment of haddock in Subarea 4, Division 6.a and Subdivision 20 (referred to hereafter as Northern Shelf haddock) is conducted annually with catch and survey data (ICES, 2021a). It is a category 1 stock assessment which uses TSA (Fryer, 2001).

Prior to 2014, haddock were assessed as two separate stocks: one in Subarea 4 and Subdivision 20 by WGNSSK, and the other Division 6.a by WGCSE. The Benchmark Workshop for Northern Haddock (WKHAD) in 2014 concluded that haddock in the two areas should be combined and assessed as a single stock (ICES, 2014). It was further concluded that only the North Sea IBTS Q1 and Q3 should be used to tune the Northern Shelf haddock assessment. The Scottish surveys conducted in West of Scotland cover a relatively small area compared to the North Sea and as a result were not considered to be reliable indicators of the dynamics of the whole Northern Shelf. The current indices therefore, provide only partial coverage of the stock. As part of preparation for the Benchmark Workshop for fish stocks in the North Sea and Celtic Sea (WKNSCS), the potential for developing an index covering the whole stock area (using the Q1 surveys) is being explored.

First an overview of surveys available for tuning the Northern Shelf haddock assessment is provided. Then, its main part contains an analysis of the international North Sea and Scottish West Coast surveys conducted in Q1. The goal of this analysis is to derive a new combined Q1 index covering the whole stock area. The method applied here follows the same statistical modelling approach used to develop indices for use in the assessment of herring in the North Sea and West of Scotland (ICES, 2019), cod in the North Sea (Berg et al., 2014; ICES, 2021b) and whiting in West of Scotland (ICES, 2021b). The document also provides diagnostics to identify gains and possible problems associated with the combined index. The delivered index is intended to potentially be used in annual assessments of the Northern Shelf haddock stock.

Data and methods

Data

Data available for use in constructing a quarter 1 survey index covering the Northern Shelf area include:

- Scottish first-quarter west coast groundfish survey (ScoGFS-WIBTS-Q1): all ages 1 and older, years 1985–2010
- Scottish first-quarter west coast groundfish survey (UK-SCOWCGFS-Q1): all ages 1 and older, years 2011–2021
- NS-IBTS covering the North Sea and Division 3a: all ages 1 and older, years 1983–2021 (Figure 1.1).

The indices for ScoGFS-WIBTS-Q1 are shown in Table 1.1. These were used in the assessment of haddock in West of Scotland before 2014.

In 2011, the Scottish Groundfish Surveys covering the west of Scotland were re-designed and hence the data are denoted using two separate survey identifier codes and the indices (stratified mean values) are assumed to be different time series. The 'old' Scottish survey

(ScoGFS-WIBTS-Q1) was performed using a fixed station format with the GOV survey trawl together with the West Coast ground gear rig 'C'. The 'new' survey (UK-SCOWCGFS-Q1) follows a stratified random design and uses a GOV with ground gear 'D' (replacing 'C'), allowing for trawling on rougher ground, and also aimed at increasing the comparability between Scottish and Irish surveys that would facilitate both being used to assess gadoids west of Scotland. The results from the analysis of two comparative trials provide strong evidence that there is no difference in catchability for haddock between ground gear C and ground gear D (ICES, 2012).

The indices for UK-SCOWCGFS-Q1, not currently used to tune the assessment of Northern Shelf haddock, are shown in Table 1.2.

The NS-IBTS is an internationally co-ordinated survey and operates according to standard procedures (ICES, 2020). The majority of the quarter 1 NS-IBTS surveys use a GOV with ground gear 'A'. However, since 1985, Scotland has used ground gear 'B' (with larger rubber discs) in the northern areas (north of 57°30'N) to allow for trawling on rougher ground. Apart from GOV hauls, there were a number of hauls taken with a different gear, H-18 (in the first two years of the German NS-IBTS). The indices for NS-IBTS-Q1, which are currently used to tune the assessment of Northern Shelf haddock, are shown in Table 1.3.

Initially, data from the three surveys were downloaded from DATRAS. The data were extracted in the 'Exchange Data' format, i.e. they were in three segments:

- haul meta-data (HH records),
- species length-based information (HL records),
- species age-based information (CA records).

The HH records included haul data (such as date, vessel, gear, time of day, tow duration, depth, latitude and longitude). The HL records included fish numbers-at-length. The CA records included ALKs.

During initial exploratory analysis, it was found that some CA records for ScoGFS-WIBTS-Q1 were incomplete. For example, the hauls numbers (haul.id) for 1986–1996 were missing in these records, while the haul numbers were present in the respective HH and HL records. The haul numbers in the CA records for 1985 were also missing, but this was known beforehand as hauls in the CA records before 1986 were usually aggregated. In addition, it was found that there were no CA records in DATRAS for 1995 for any species including haddock. Given the incompleteness of the data for this survey in DATRAS, it was decided to use data for the West Coast available from the Marine Laboratory database rather than those from DATRAS. For this purpose, the data for the West Coast for ScoGFS-WIBTS-Q1 were converted to the DATRAS format. Pre-1986, hauls in the CA records were aggregated and hence those for West of Scotland are omitted from the analysis.

The data for the three surveys were combined into one dataset spanning the period 1983–2021. More detailed information on the GOV gear was used which included the ground gear category (this information is not routinely stored in DATRAS). The category 'Gear' for GOV in the dataset was modified by adding 'A', 'B' etc. to 'GOV', thus coding the gear category as 'GOVA', 'GOVB' etc. Only hauls in Subarea 4, Division 6.a and Subdivision 20 were used in the calculations of the index.

Age–length keys

Age–length keys were estimated using the spatially varying continuation ratio logits (CRL) model described in Berg and Kristensen (2012). This approach combines GAMs and CRL to model the probability of age given length and spatial coordinates, and does not involve any area stratification. The 'fitALK' function in the DATRAS r package (Kristensen and Berg, 2012) was used to estimate an ALK for each haul based on the age data available in the same subset of data described above. The ALKs are estimated for ages 0–8+.

Parameters are estimated separately for each combination of year y in order to account for population structure. The model used is:

$$\text{logit}(\pi_{ay}[\mathbf{x}_i]) = \alpha_{ay} + \beta_{ay} l_i + s_{ay}(lon_i, lat_i)$$

where π is the conditional probability of a fish being of age a; i denotes the ith fish; l denotes the length of the fish; lon and lat are the geographical coordinates where the haul was taken; sa is a two-dimensional thin plate spline; αa and βa are ordinary regression parameters to be estimated. BIC was used for selecting the amount of smoothness imposed on the spline.

The estimated ALKs were then applied to the length frequency data for each haul to estimate numbers-at-age for each haul.

Delta-GAM model

The analysis of the combined index was conducted using a GAM-based delta-lognormal model. The model accounts for a number of explanatory variables and is described in Berg *et al.* (2014). The model has previously been found to give a better fit to survey data compared to other GAM-based approaches (Berg *et al.*, 2014). It consists of two parts: one that describes the probability for a non-zero catch (binomial response) and another that describes the distribution of a catch given that it is non-zero (positive continuous). The response in the model is numbers at age per haul or 1/0 for the non-positive part of the model. Each age group in the given model was estimated separately (age groups 1–8+).

To conduct the analysis, a tentative model was developed of the form:

$g(\mu_i) = Year_i + f_1(lon_i, lat_i) + f_2(Depth_i) + f_3(timeofday_i) + f_4(timeofyear_i) + Gear_i + U(Ship_i) + \log(HaulDur_i)$

where μ_i is the expected numbers-at-age in the ith haul, $g(\mu_i)$ is the link function, $Year_i$ is a categorical effect of the year, f_1 is the smoothing function of the interaction of longitude (Lon_i) and latitude (Lat_i) in the ith sampling location, f_2 is the smoothing function of depth, f_3 is the smoothing function of the time of day, f_4 is the smoothing function of the time of year, $Gear_i$ is a categorical effect of the gear (including ground gear effect, see above) and U is a random vessel effect. An offset was used for the effect of haul duration ($HaulDur_i$).

Smooth terms were specified in the above GAM formula in different ways. The spatial location was used as a thin plate regression spline ('tp'). 'Depth' and 'time of year' were also used as a thin plate regression spline ('ts'), but with a modification to the smoothing penalty with which the term could be shrunk to zero. 'Vessel' was specified as a random effect ('re'). 'Time of day' was used as a cyclic cubic regression spline ('cc').

To find the optimal model from a set of candidate models, forward selection was applied starting with the model with no predictor variables (apart from haul duration, Model 0). AIC was used as the model selection criterion. The predictor variable that explained the highest amount of variation in haddock numbers was the geographical position (Model 1, see below). Subsequently, other predictor variables were added one at a time, each time selecting the variable that resulted in the highest improvement in explaining the variation in haddock numbers. The geographical location was followed by year, depth, ship, time of day, gear and time of year. All the predictors from the tentative model were selected for the final model (Model 7).

Model 0: $g(\mu_i) = \log(HaulDur_i)$

Model 1: $g(\mu_i) = \log(HaulDur_i) + f_1(lon_i, lat_i)$

Model 2: $g(\mu_i) = \log(HaulDur_i) + f_1(lon_i, lat_i) + Year_i$

Model 3: $g(\mu_i) = \log(HaulDur_i) + f_1(lon_i, lat_i) + Year_i + f_2(Depth_i)$

Model 4: $g(\mu_i) = \log(HaulDur_i) + f_1(lon_i, lat_i) + Year_i + f_2(Depth_i) + U(Ship_i)$

Model 5: $g(\mu_i) = \log(HaulDur_i) + f_1(lon_i, lat_i) + Year_i + f_2(Depth_i) + U(Ship_i) + f_3(timeofday_i)$

Model 6: $g(\mu_i) = \log(HaulDur_i) + f_1(lon_i, lat_i) + Year_i + f_2(Depth_i) + U(Ship_i) + f_3(timeofday_i) + Gear_i$

Model 7: $g(\mu_i) = \log(HaulDur_i) + f_1(lon_i, lat_i) + Year_i + f_2(Depth_i) + U(Ship_i) + f_3(timeofday_i) + Gear_i + f_4(timeofyear_i)$

The model prediction was conducted as follows: the abundance estimates were obtained by first dividing the survey area into small subareas of approximately equal size. For each subarea, where at least one haul was taken, one representative haul position was selected (thereby leaving unsampled sub-areas out of the analysis). This process was included in the model by using the function 'getGrid' from the 'surveyIndex' package (Berg, 2016). The expected catches were summed for each year and age. These values were then divided by the number of grid points and multiplied by two to obtain the survey index in numbers per hour.

The model settings were chosen with reference to previous implementations (Berg *et al.*, 2014; ICES, 2019). The 'cutOff' was set as 0.1 (see Berg, 2016). All values below 'cutOff' were treated as zero. This is required because the length to age conversion may produce numbers that are very close to zero, which is problematic for the log-normal distribution.

Results

Model 7 which included geographical location, year, depth, ship, time of day, gear and haul duration was found to be the best choice for the stock in Q1, based on AIC and BIC (Table 1.4). The internal consistency was generally high among the tested models and resulted to a large extent from using spatial and interannual effects in the first instance. Adding more effects to the model resulted only in a slight improvement in this respect.

The indices were derived by summing predictions from the selected model and are shown in Figure 1.2. It can be seen that there were a number of relatively strong year-classes (notably the 1999 year-class) with a detectable peak. The confidence intervals were narrow in the whole time-series.

The effect of the explanatory variables on the model estimates (only for the smoothers) can be seen in Figures 1.3–1.6. These plots are shown for two categories of response: binomial response and positive continuous described earlier. There was some age-specific variability in the spatial distribution, more evident for abundance models (Figure 1.3, lower panel). Haddock were widely distributed mainly in the northern and central North Sea and on the West Coast. The

young age groups (ages 1 and 2) were less abundant in these areas. Depth was a relatively important explanatory variable. The catch rates increased with depth up to a maximum at around 100 m with another smaller peak (at 220-250 m in the abundance models) , and decreased thereafter at greater depths (Figure 1.4). The effect of time of day was marked for most age groups (in the abundance models only) with higher catch rates during the day (Figure 1.5). The effect of time of year was least influential compared to the other smoothers. It could clearly be seen only for ages 2–5 and 8+ in the abundance models (Figure 1.6).

The combined index is shown in Table 1.5.

Maps of haddock distribution on the Northern Shelf (Figure 1.7) were obtained by predicting abundance on a grid of haul positions while indices were obtained by summing model predictions over the relevant parts of the grid, where nuisance parts of the model (predictor variables), were held constant to remove their effect. These maps show the averaged distribution by age in the study period. More detailed maps of haddock distribution by age and year can be found in the Annex of the working document on the WGISDAA SharePoint (Figure A.1).

Index diagnostics

The index diagnostics that follow demonstrate the level of between and within-survey consistency for the four-tuning series: ScoGFS-WIBTS-Q1, UK-SCOWCGFS-Q1, NS-IBTS-Q1 and the combined NS-WC-Q1.

A residual analysis of the model showed no serious deficiencies (Figure 8). Spatial residuals by age group and year can be found in the Annex (Figure A.2).

Figure 9 compares the calculated scaled indices. The index was similar for the survey series involved, regardless of the area being surveyed. There was a rather high consistency among the surveys with distinct peaks and valleys in the respective surveys. This was the case for all age groups.

The mean standardised catch proportions at age per year show some similarities among the four-tuning series for the year-classes and years where the series overlap (Figure 10). The plots indicate strong year classes (1999, 2005, 2009 and 2014 year-classes), but also series of markedly weak year classes. In most cases, year class tracking was reasonably consistent. No clear year effect could be seen in the time-series.

The log catch curves for the four tuning series are shown in Figure 11. The curves for ScoGFS-WIBTS-Q1 (shown for ages 1–8) are relatively linear and not very noisy. Those in UK-SCOWCGFS-Q1 (also shown for ages 1–8) were noisier. The curves for NS-IBTS-Q1 (shown for ages 1–6+) were rather linear only in the first half of the time-series, while the signal was noisier in the second half of the time-series. Combining the index for the two areas resulted in smooth catch curves (shown for ages 1–8+). They show a fairly steep and consistent drop in abundance.

The within-survey correlation plots in Figure 12 indicate that the surveys generally show significant correlation between consecutive age groups. For the four-tuning series, there is a general consistency in the estimates of year-class strength across age groups, but the points are more scattered for old age groups. The correlations in NS-WC-Q1 were generally higher compared to those in NS-IBTS-Q1.

Discussion

The present analysis of the whole Q1 data set for Northern Shelf haddock delivers a combined index.

There are several advantages of using a combined index for assessments of fish stocks. In this particular case, the combined index provides a more complete representation of the population compared to the respective indices used on their own. This is supported by the diagnostics shown for the different survey series, with the combined index appearing less noisy and with better internal consistency than the individual Q1 indices.

In the present formulation of the model, a fixed spatial effect over time is assumed. This means that with missing data in some years, it is still possible to calculate the index. This will not be possible with models including an interaction between spatial distribution and year effects. The inclusion of the interaction term was initially considered, but it was deemed as having little effect on the index or the internal consistency. As a result, the model without the interaction term was retained.

In conclusion, one Q1 survey series can potentially be used in the assessment of Northern Shelf haddock. It covers a sufficiently long time period. The index can be recalculated annually as new surveys are completed providing up to date fisheries independent information on the stock.

Table 1.1. The abundance index in the 'old' Scottish West Coast Q1 survey. The numbers are standardised to catch-rate per ten hours.

		ScoGFS-WIBTS-Q1							
Year	Effort	Age							
	(hours)	1	2	3	4	5	6	7	8
1985	10	1104	4085	68	80	141	388	27	1
1986	10	753	1669	1877	17	14	47	90	5
1987	10	5518	446	460	690	25	34	25	67
1988	10	571	3610	303	112	246	10	4	8
1989	10	178	488	1701	98	49	69	5	1
1990	10	2577	87	54	296	26	6	36	3
1991	10	1591	1763	92	25	184	9	4	15
1992	10	3618	1193	321	12	13	28	6	1
1993	10	5371	5922	675	167	0	2	18	2
1994	10	1151	2300	787	126	39	3	1	8
1995	10	7112	1074	1697	485	65	30	10	4
1996	10	4401	3742	315	456	125	20	11	3
1997	10	4262	2018	1915	147	151	53	2	1
1998	10	5034	2720	616	562	40	64	19	7

1999	10	941	2989	687	168	128	15	11	2
2000	10	7936	553	440	97	13	20	1	3
2001	10	3421	5762	143	146	34	16	6	1
2002	10	2339	3246	5293	56	70	24	9	3
2003	10	2650	1696	1449	1874	23	34	18	4
2004	10	1397	2765	869	1199	609	11	3	5
2005	10	573	633	1402	351	512	402	5	3
2006	10	633	892	539	397	156	170	51	2
2007	10	99	2019	296	121	192	82	89	65
2008	10	86	113	1094	98	84	71	13	15
2009	10	42	113	147	1445	29	43	63	7
2010	10	706	111	26	71	452	23	4	9

Table 1.2. The abundance index with variance in the 'new' Scottish West Coast Q1 survey. The numbers are stand-ardised to catch-rate per ten hours.

UK-SCOWCGFS-Q1									
Year	Effort	Age							
	(hours)	1	2	3	4	5	6	7	8
2011	10	23.8	3977.3	312.1	116.4	104.9	826.7	11.0	12.9
2012	10	147.1	129.5	3492.6	94.0	80.6	58.4	420.6	7.7
2013	10	52.5	175.9	50.9	2832.4	70.7	58.9	14.4	275.4
2014	10	529.0	118.4	104.2	35.8	1486.4	19.5	16.8	11.6
2015	10	6800.3	379.3	200.8	63.1	38.6	1699.1	10.4	5.4
2016	10	560.2	6963.5	343.8	39.1	23.0	9.4	617.8	4.5
2017	10	2171.4	1698.9	8314.5	314.7	26.7	21.4	1.7	409.3
2018	10	398.0	1332.2	1181.8	4000.0	65.4	6.9	2.6	2.2
2019	10	7636.7	608.1	823.7	400.9	2180.5	10.0	2.2	1.5
2020	10	957.7	4741.6	390.6	599.4	159.4	1447.3	8.2	9.7
2021	10	1523.8	3568.6	3006.6	183.7	211.1	49.7	507.7	2.2

Table 1.3. The abundance index in the North Sea Q1 survey. The numbers are standardised to catch-rate per hour.

		NS-IBTS-Q1					
Year	Effort	Age					
	(hours)	1	2	3	4	5	6+
1983	1	302.3	403.1	89.5	116.4	13.2	2.0
1984	1	1072.3	221.3	127.8	20.4	20.9	4.6
1985	1	231.0	833.3	107.6	32.3	3.6	6.6
1986	1	573.0	266.9	303.5	17.9	6.5	2.2
1987	1	912.6	328.1	45.2	58.3	4.3	2.4
1988	1	101.7	677.6	97.1	12.7	14.0	2.1
1989	1	219.1	97.4	273.0	16.6	2.1	4.7
1990	1	217.4	139.1	33.0	50.4	3.2	1.8
1991	1	680.2	134.1	25.0	4.3	8.5	2.4
1992	1	1141.4	331.0	17.0	3.0	0.7	2.2
1993	1	1242.1	519.5	152.4	8.8	1.1	1.0
1994	1	227.9	491.1	97.7	23.3	1.6	0.8
1995	1	1355.5	201.1	176.2	24.4	5.3	0.8
1996	1	267.4	813.3	65.9	46.7	7.7	3.1
1997	1	849.0	354.8	466.8	25.0	15.2	3.4
1998	1	357.6	420.9	103.5	112.6	8.8	5.4
1999	1	211.1	222.9	127.0	48.2	36.6	4.3
2000	1	3688.8	106.6	48.6	24.5	15.6	10.0
2001	1	892.5	2196.2	75.9	14.5	6.3	6.4
2002	1	57.3	472.5	1307.4	9.1	6.8	4.0
2003	1	88.0	39.1	240.4	529.4	5.3	2.4
2004	1	71.9	79.3	37.0	176.5	325.3	1.1
2005	1	70.3	52.0	38.5	14.1	54.7	102.0
2006	1	1149.3	46.1	28.6	9.9	4.9	50.8
2007	1	109.7	964.0	36.1	15.0	3.1	21.4
2008	1	61.5	107.6	241.6	14.9	1.6	6.4
2009	1	55.7	187.7	100.8	129.8	2.6	2.0

2010	1	672.0	70.6	67.7	50.8	89.2	8.8
2011	1	46.0	781.2	101.6	35.9	47.8	100.0
2012	1	15.2	103.8	400.0	24.6	18.0	26.6
2013	1	58.2	24.6	32.5	93.8	6.5	9.4
2014	1	24.1	104.0	18.4	50.0	126.1	20.5
2015	1	390.8	32.7	30.0	3.9	9.1	24.6
2016	1	111.4	413.5	17.1	12.0	2.0	14.0
2017	1	218.5	138.5	222.6	8.6	3.1	4.4
2018	1	47.0	155.7	54.9	67.8	1.0	1.4
2019	1	153.1	126.2	150.8	22.5	77.3	2.4
2020	1	2355.8	162.5	61.3	55.1	8.5	22.3
2021	1	1510.4	1442.5	105.0	23.8	28.5	13.1

Table 1.4. Summary of models 0–7. The column 'edf' (effective degrees of freedom) contain the effective number of parameters. The columns 'ΔAIC' and 'ΔBIC' contain the change in AIC and BIC from from Model 0 to Model 7. The columns 'wAIC' and 'wBIC' are weights in AIC and BIC. The column 'IC' shows the internal consistency.

	edfs	AIC	ΔAIC	wAIC	BIC	ΔBIC	wBIC	IC
Model 0	16.0	636198.7	141203.6	0.000	636355.2	120884.6	0.000	NA
Model 1	1092.6	530803.4	35808.3	0.000	541492.5	26021.9	0.000	NA
Model 2	1812.9	502490.6	7495.5	0.000	520226.3	4755.7	0.000	0.916
Model 3	1785.4	498338.4	3343.3	0.000	515804.9	334.3	0.000	0.917
Model 4	2007.6	496231.6	1236.5	0.000	515872.0	401.4	0.000	0.915
Model 5	2043.7	495752.5	757.4	0.000	515746.2	275.6	0.000	0.915
Model 6	2079.0	495165.2	170.1	0.000	515504.0	33.4	0.000	0.921
Model 7	2093.0	494995.1	0.0	1.000	515470.6	0.0	1.000	0.920

Table 1.5. The abundance index in the combined Q1 survey. The numbers are standardised to catch-rate per hour.

		NS-WC-IBTS-Q1							
Year	Effort	Age							
	(hours)	1	2	3	4	5	6	7	8+
1983	1	311.1	401.8	68.0	63.8	10.8	2.2	0.2	0.4
1984	1	1653.5	217.3	114.1	17.0	14.6	2.5	0.5	0.2
1985	1	343.3	758.4	110.3	31.5	4.5	3.9	0.6	0.3
1986	1	693.9	182.5	268.7	19.1	6.8	1.2	1.1	0.2
1987	1	1067.3	232.9	54.6	45.2	3.3	1.3	0.2	0.5
1988	1	168.8	415.3	77.3	12.1	7.8	0.8	0.2	0.5
1989	1	176.9	72.6	171.5	13.5	2.0	3.0	0.3	0.2
1990	1	256.7	81.2	34.2	31.6	2.7	0.5	0.8	0.1
1991	1	725.7	143.8	30.7	7.6	6.6	1.3	0.1	0.3
1992	1	1005.2	299.1	35.8	2.9	2.0	1.2	0.2	0.2
1993	1	1641.5	502.0	135.4	13.8	0.9	0.3	0.7	0.4
1994	1	301.4	469.2	108.4	19.2	2.5	0.6	0.0	0.4
1995	1	1993.3	189.1	152.6	22.7	5.5	0.8	0.2	0.3
1996	1	684.8	630.1	78.7	37.1	5.5	1.3	0.2	0.1
1997	1	1138.1	329.6	243.4	21.7	9.7	1.9	0.5	0.1
1998	1	408.2	330.5	92.9	62.4	7.0	2.7	0.9	0.3
1999	1	202.0	151.8	98.7	24.5	15.8	1.8	1.0	0.5
2000	1	5082.2	119.1	46.4	17.8	5.2	3.3	0.6	0.3
2001	1	928.1	1460.8	77.1	11.8	4.7	1.8	1.0	0.5
2002	1	88.6	438.1	579.8	13.9	5.1	1.6	1.0	0.5
2003	1	85.1	69.6	224.6	205.5	3.9	1.2	0.8	0.7
2004	1	63.0	77.5	38.5	87.3	71.3	1.1	0.6	0.4
2005	1	66.4	44.9	32.6	10.7	25.0	26.0	1.3	0.5
2006	1	357.2	44.9	24.9	8.7	4.0	7.7	10.1	1.1
2007	1	85.8	277.5	24.8	8.0	3.3	1.6	3.8	5.6
2008	1	66.5	64.6	137.5	8.8	2.4	1.0	0.7	3.2
2009	1	51.7	46.3	39.7	44.1	2.6	0.9	0.6	1.5

2010	1	350.9	41.8	30.5	13.7	19.3	1.5	0.5	0.9
2011	1	34.2	225.0	35.6	11.1	7.9	12.1	0.4	0.5
2012	1	21.9	32.8	162.4	12.3	7.3	3.8	4.7	0.4
2013	1	53.2	17.5	19.8	50.2	5.4	2.8	1.4	2.7
2014	1	50.0	25.2	10.4	8.8	21.0	1.5	1.0	1.7
2015	1	404.9	32.6	17.3	3.5	5.0	10.8	0.6	1.2
2016	1	101.1	176.2	17.5	4.5	1.6	1.0	5.1	0.3
2017	1	147.2	74.0	98.1	6.4	2.0	0.5	0.5	2.1
2018	1	67.4	77.0	39.4	28.6	1.8	0.6	0.1	0.9
2019	1	250.2	33.8	35.9	7.6	10.9	0.6	0.2	0.3
2020	1	382.1	109.5	19.6	11.8	3.6	5.4	0.1	0.2
2021	1	891.1	414.6	57.8	6.5	6.9	1.5	3.4	0.1

Figure 1.1: Catch weight per haul in three survey series: ScoGFS-WIBTS-Q1, UK-SCOWCGFS-Q1 and NS-IBTS-Q1 – by survey, gear and country. Non-zero catch is shown as bubbles and zero catch is shown as grey crosses.

Figure 1.2: Indices derived from a delta-GAM model fit to data from the three Q4 surveys (black line) with 95% confidence limits (in grey). Indices are derived by summing model predictions on a spatial grid. The survey index calculated using the stratified mean method for ICES statistical rectangles as strata are shown as red points. The indices are mean-standardised.

Figure 1.3: Effect of longitude and latitude by age group on log number per haul in two models: binomial response (upper panel) and positive continuous (lower panel). The contours show the estimate of the smooth (red=low values, yellow=high values). The dots show the locations of the covariate values on the longitude-latitude plane. No confidence limits are displayed in this plot.

Figure 1.4: Effect of depth by age group on log number per hour (smoothing function) in two models: binomial response (upper panel) and positive continuous (lower panel).. The grey bands are 95% confidence limits.
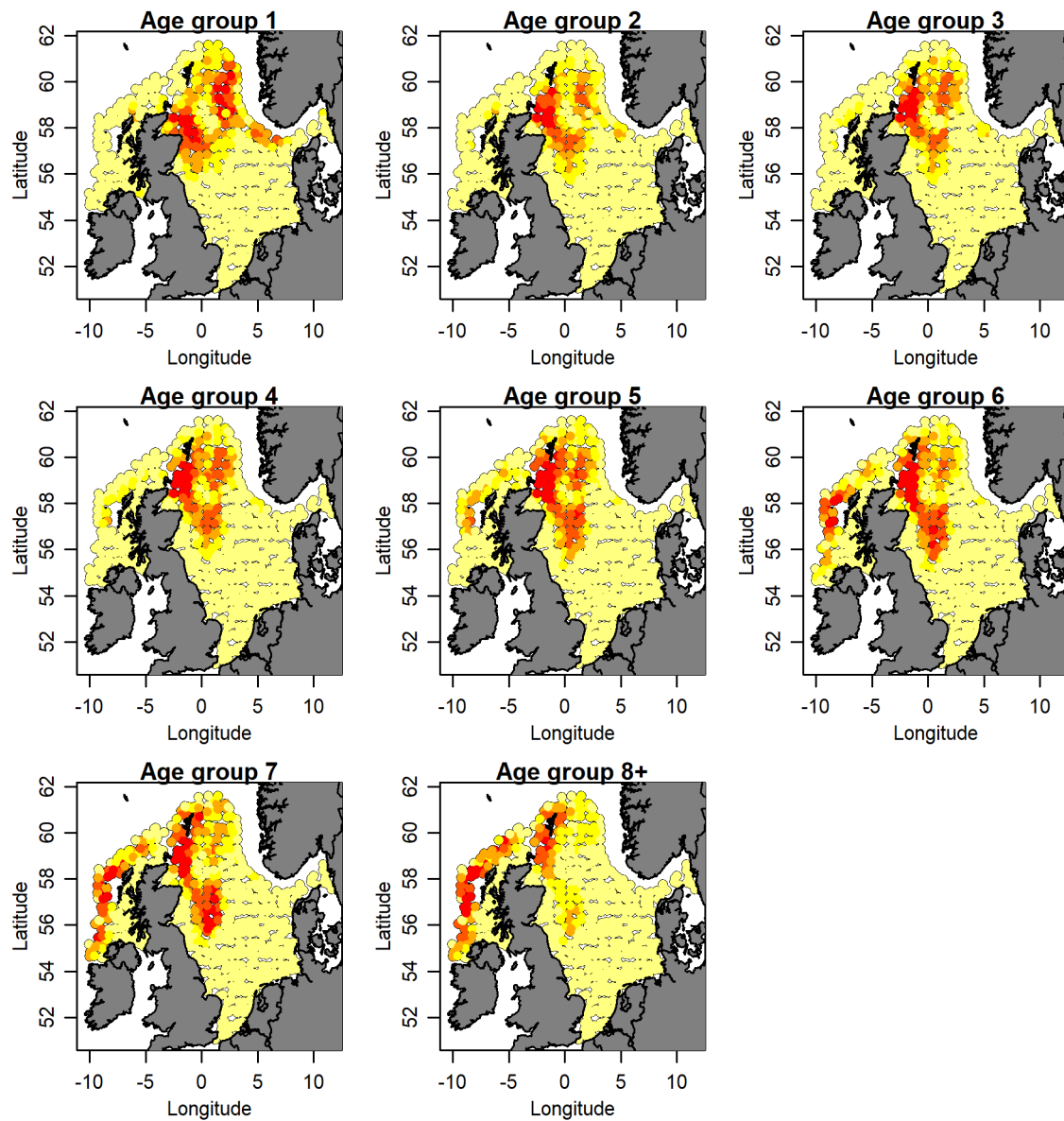
Figure 1.5: Effect of time of day by age group on log number per hour (smoothing function) in two models: binomial response (upper panel) and positive continuous (lower panel). The grey bands are 95% confidence limits.

Figure 1.6: Effect of time of year by age group on log number per hour (smoothing function) in two models: binomial response (upper panel) and positive continuous (lower panel).. The grey bands are 95% confidence limits.

Figure 1.7: Abundance maps by age group obtained by fitting the delta-GAM model.

Figure 1.8: Normalised residuals by age group from fitting the delta-GAM model.

Figure 1.9: Scaled survey indices (Z-scores) from the four survey series. The abundance index for NS-IBTS-Q1 is shown only for ages 1−6+.

Figure 1.10: Standardised proportions at age per year ("spay") for the four survey series. The positive values are shown in red, the negative values are shown in blue.
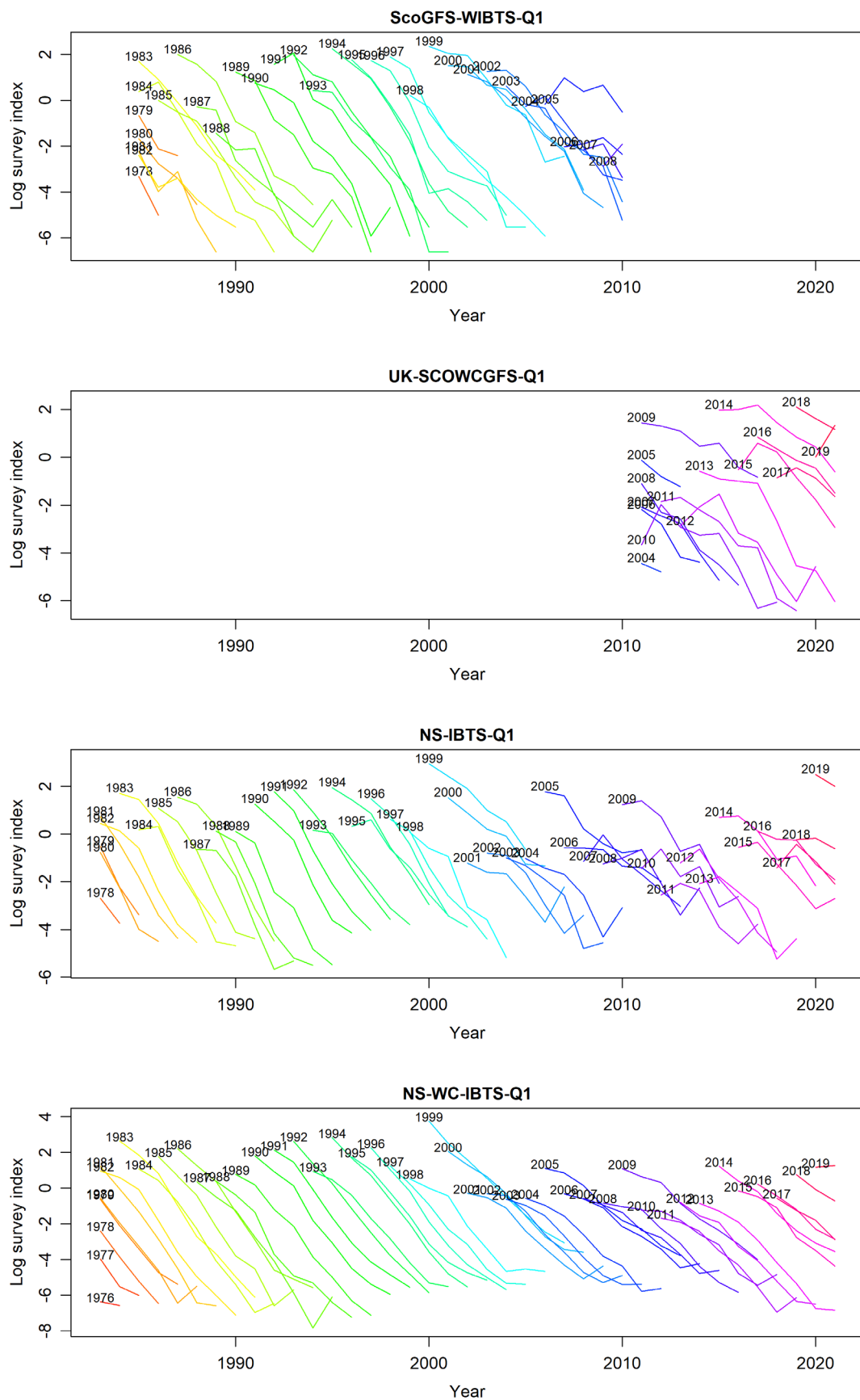
Figure 1.11: Log abundance indices by year with a line for each cohort, for the four survey series. The spawning date of each cohort is indicated at the start of each line.
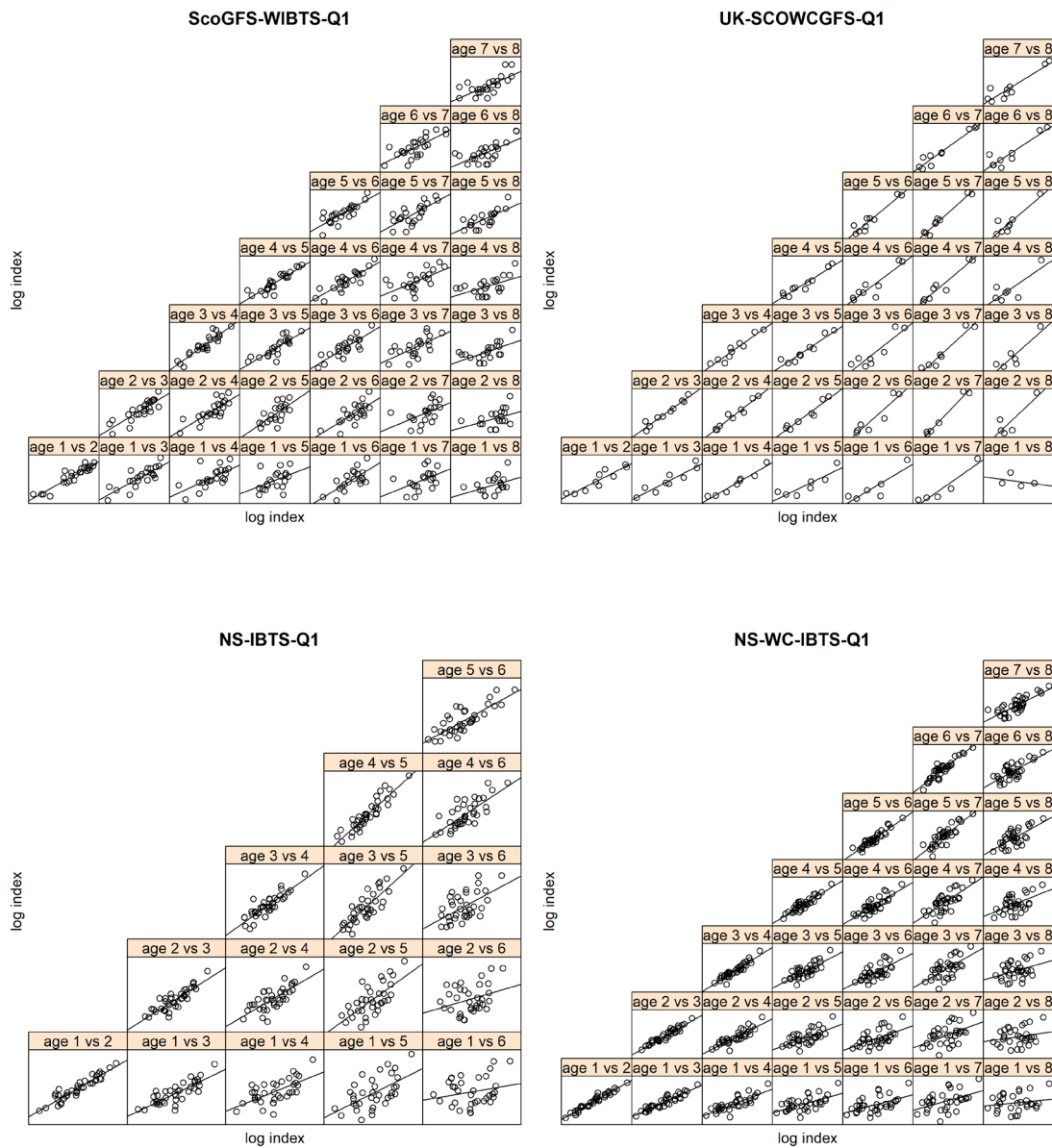
Figure 1.12: Within-survey correlations comparing index values at different ages for the same year classes for the four survey series. The straight line is a linear regression.

2 Influence of bottom oxygen conditions on Baltic cod and plaice survey indices

The 2019 Q4 BITS survey indices indicated marked decline of plaice and cod in the south-west Baltic. WGBFAS (2020) subsequently identified wide-spread hypoxia as a possible explanation of the low catches. The 2019 Q4 survey data were excluded from the plaice assessment for this reason, but were retained for cod. The WG and the ADG highlighted the need for better understanding of hypoxic events on survey variability. Some preliminary results from a project at DTU Aqua (HypCatch) investigating these issues were presented and discussed at WGISDAA.

The bottom oxygen conditions in ICES areas 21-25 in the period 1991-2021 was first estimated from all the oxygen measurements available in the ICES oceanographic database using a generalized additive model (GAM), see figure 2.1.
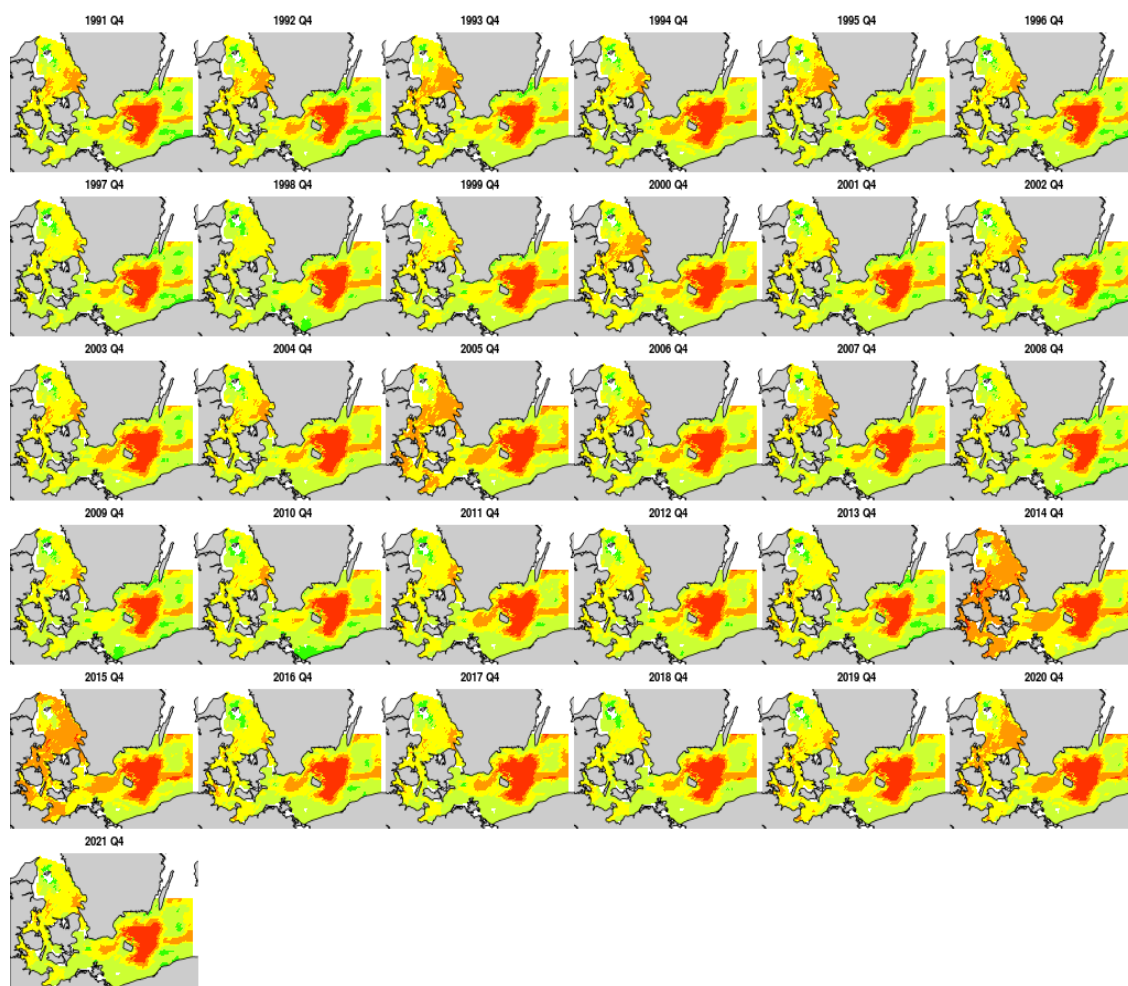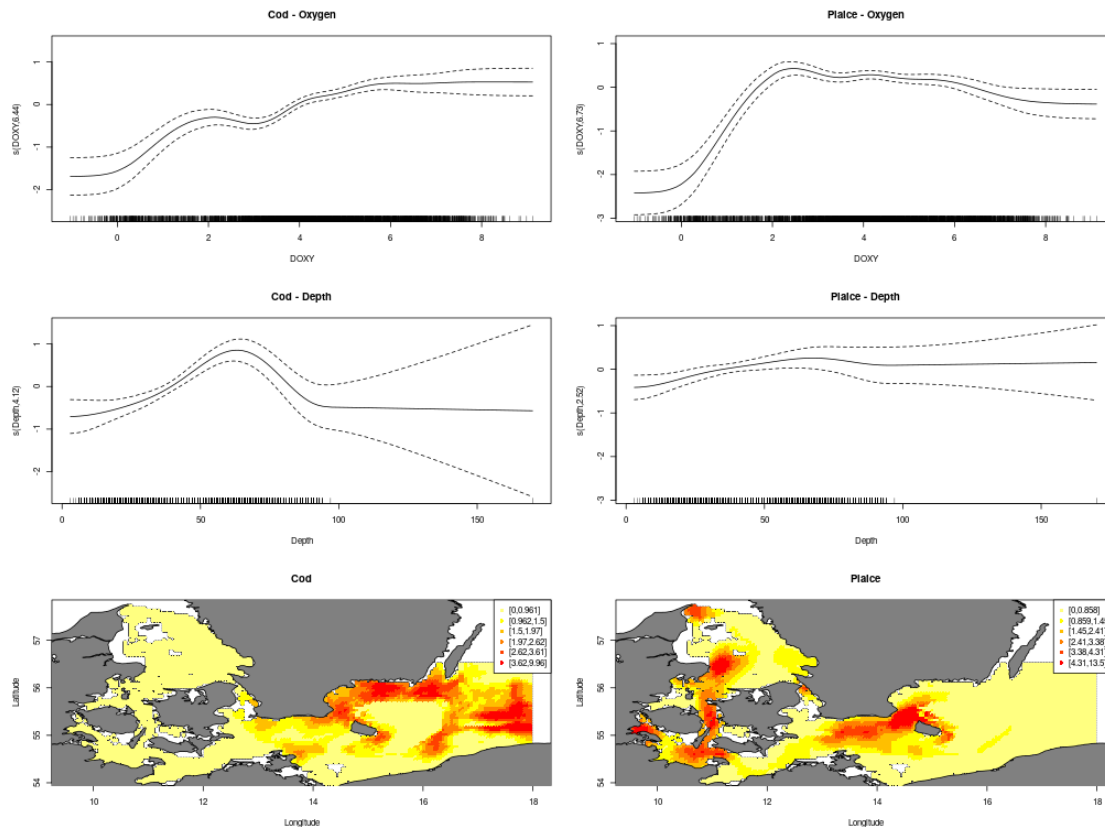

Figure 2.1: Bottom oxygen concentration in quarter 4. Red color indicates <2, orange 2-4, yellow 4-6, light green 6-8 and green >8 ml/L.

In this period the years 2014 and 2015 were identifed as having markedly lower oxygen concentration than any other years in the time series. Next step was to estimate standardized CPUE for cod and plaice from the Q4 BITS survey using a Delta-Lognormal GAM (Berg et. al. 2014), which included the bottom oxygen concentration as an explanatory variable.

Figure 2.2: Estimated effect of oxygen (top), depth (middle), and average spatial distribution (bottom) for cod(left) and plaice (right).

The results indicated that for plaice there is a sharp decline in CPUE when oxygen concentration drops below 2 mL/L. This sharp decline was however only apparent when area 25, which includes the permanently hypoxic Bornholm basin, was included in the analysis. For cod a more gradual response to oxygen concentration was found regardless of whether area 25 was included or not. Surprisingly the highest catch rates of plaice were actually found in the south-west Baltic in 2014 and 2015 where oxygen concentrations were at the lowest point in the time-series (mostly in the 2-4 mL/L range). This indicates that unlike cod, plaice do not avoid areas with borderline hypoxic conditions, and hence that the low CPUE of plaice in 2019 cannot be explained by the oxygen conditions.

It was further examined whether oxygen data could improve the survey indices for the cod assessment. Model based indices are calculated by summing expected CPUE over a fixed grid of virtual trawl positions using a reference gear, vessel, etc. If oxygen concentration is known in the entire grid in every year and relation between CPUE and oxygen has been established, more accurate predictions can be made in areas that were not actually trawled. Put in another way, if the chosen survey sampling positions by chance were all very low in oxygen compared to the overall oxygen level in the stock area, the resulting indices would be biased downwards, unless oxygen is included in the model. So, inclusion of oxygen informs the model about the spatial

distribution of cod, but not about the total abundance in a given year, since there are already free intercept parameters for each year. A comparison between the cod indices with and without inclusion of oxygen is shown in figure 2.3. Although there are some differences they are mostly minor and within the confidence limits, and when the effects of the different indices on the assessment are compared (Figure 2.4) the differences are negligible. The conclusion was therefore that there is no immediate need to switch models for WBcod.
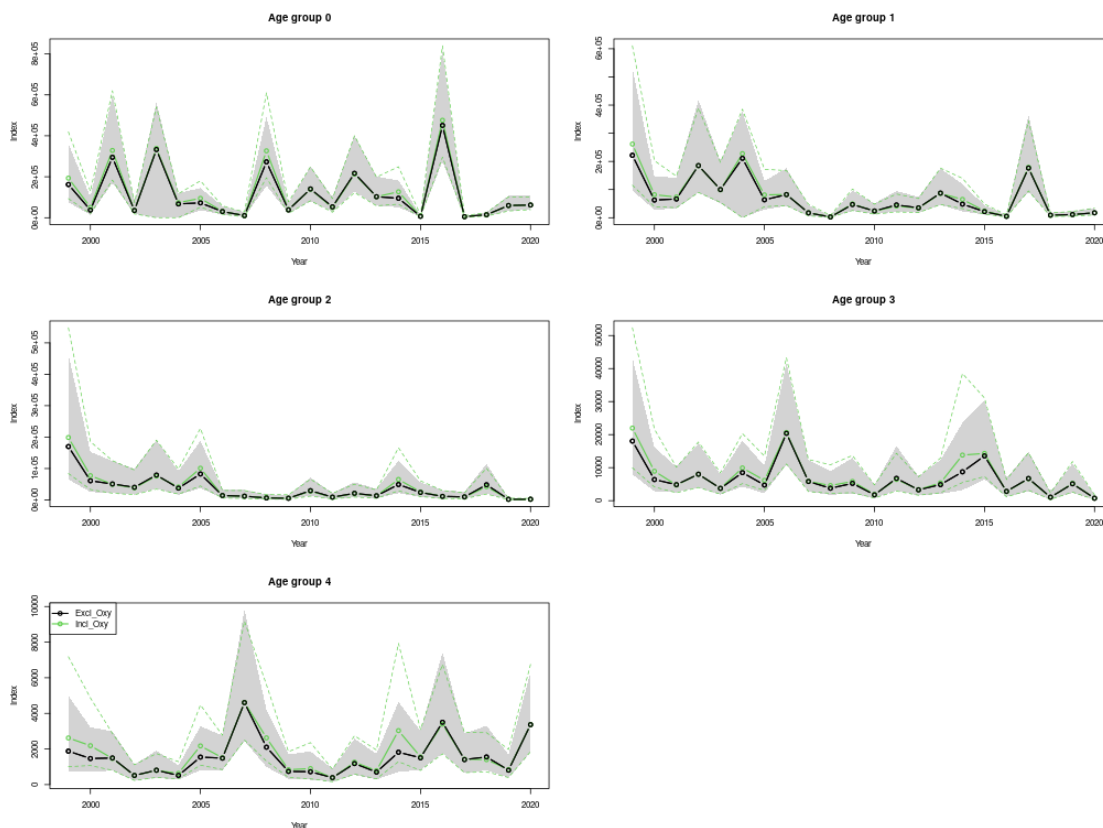

Figure 2.3: WBcod survey indices with (green) and without (black) inclusion of oxygen in the model.
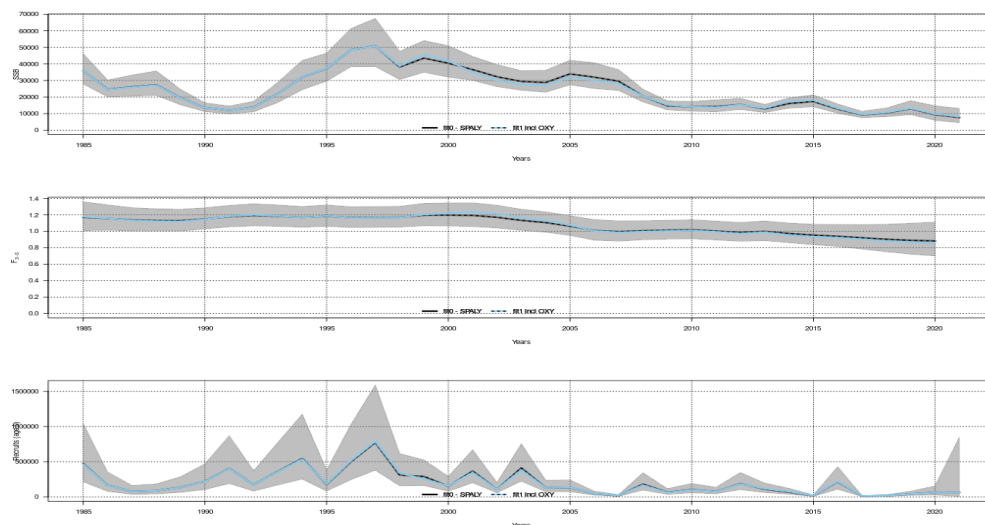

Figure 2.4: WBcod SAM assessment comparison using indices with (blue) and without (black) oxygen effect included.

Finally, it should be pointed out, that this analysis did not address the problem of potential changes in catchability due to different vertical distribution of cod in response to bottom oxygen conditions. In order to properly account for the vertical distribution of cod additional data is needed such as acoustic measurements along the trawl survey stations. It was noted however, that the survey index residuals in the WBcod assessment model for the years 2014 and 2015 do not appear unexpectedly low, i.e. at least no drastic signs of reduced catchability when oxygen is low.

3 WKUSER2 planning

Stan Kotwicki presented the update on preparations for Workshop on Unavoidable Survey Effort Reduction 2 (WKUSER2), which will examine issues associated with the changes to survey effort with respect to the data quality and management implications. The previous workshop WKUSER (2020) identified that such changes are recurring theme in many monitoring agencies, and more coherent planning and a long-term response strategy is desirable. The WGISDAA reviewed plans for the WKUSER2 and recommended future directions on four key topics. The topics and WGISDAA comments are described below.

- Survey design for flexibility. The workshop will review and summarise desired attributes of survey design that allow for flexibility when dealing with unavoidable reductions and increases in survey effort and need to expand survey into new areas of species expansion due to changes in the ecosystem.

Additional feedback from WGISDAA: Random and stratified random designs are most flexible because they allow for changes in survey effort without causing issues with survey consistency. However, systematic survey often offer more precise estimates. The challenge for WKUSER2 will be to work on the framework to figure out the tradeoffs between different designs, precision, and sampling efficiency. It was also noted that model based approaches can deal with systematic and random sampling equally well. Index surveys with fixed station design are generally less desirable because their variances may be underestimated. Important question that should be discussed at WKUSER2 is if how to assess survey performance (with respect to data products precision) using either design- or model-based estimators.

- Combining surveys, dealing with data gaps. Collate advice on methods to estimate combine data from different sources, how to deal with data gaps and how to perform survey calibrations.

When designing new surveys (or redesigning old surveys), which may be combined with other surveys it is important to allow for temporal and spatial overlap between surveys to help estimate appropriate calibration factors between surveys. The extend of overlap that needs to be considered is difficult to estimate and advice from WKUSER2 is desirable on this topic. Environmental covariates maybe helpful in combining data from different areas especially in situation when sampling in different areas was not done in the same frequency. Surveys should consider collections of covariate data that is useful in combining data with neighboring surveys. WKUSER2 should discuss methods for combining data using model-based estimators (e.g. GAMs, VAST). Open question remains on how to combine surveys done at different times especially when fish are moving between survey areas.

- Modelling and simulations. Further develop model-based estimation, model validation through simulations, use of auxiliary information to improve survey data proucts, including appropriate propagation of uncertainty.

WGISDAA commented that some tools, such as model based operating models, are already being developed for simulations. It is important to develop standard set of diagnostics for operating and estimation models for use in survey simulations. Additionally it would be prudent for survey groups to plan for the survey expansions in the future in response to ongoing changes is species distributions across many large marine ecosystems. It was also noted that it is important to consider density dependent effects on the efficiency of the survey trawl. For example size of the trawl maybe be too small to

adequately sample in the areas of high density. Additionally it was noted that sampling efficiency of the trawl can be affected by density of species of interest as well as the total density of all the species caught by the trawl

- Tools and technology development. Describe the development of methods that aim to provide quantitative decision-making tools that describe the effects on the quality of the survey deliverables and ultimately advisory products.

Tools for diagnostics for model-based estimators and for operating models used in simulations are needed. Many tools are already available but knowledge about some of these tools is limited to small groups. WKUSER22 could work on creating a list of existing tools, give recommendations on their utility, and propose new tools that are still in need of development.

4 Survey indices for North Sea plaice

During this year's WGISDAA meeting, North Sea plaice coordinator presented two survey studies for the upcoming benchmark.

Two coastal surveys have been carried out for younger age plaice abundance indices: SNS (since 1970, targeting age 1) and DYFS (since 1990, targeting age 0). In recent years, age 0-1 are shifting towards offshore areas. As a result, the two surveys might provide incomplete and contradictory information. Additionally, their survey catchability can no longer be assumed to be constant across years in the assessment. To solve this issue, the aim was to extract combined indices by age (using delta-gam method) for the assessment. The process includes two steps: 1) apply delta-gam indices for each survey individually and compare to the inhouse design-based indices; 2) apply delta-gam indices for both surveys. Some suggestions and discussions from WGISDAA were: 1) it is more sensible that the catch is linearly correlated to the swept area, therefore, use log-transformed swept area instead of the untransformed. 2) Model-based method is less sensitive to single extreme value (e.g. age 0 DYFS year 2018) than design-based method. 3) Some discussions took place about the role of age 0 indices in the assessment (assessment age 1-10+) and what should be the best criteria in judging the quality of age 0 indices. Compared to the other ages, age 0 has a much higher variance (large sampling error) and variable natural mortality. As a result, age 0 is less likely to receive a high weight in the assessment, and its main role lies in the forecast.

BTS and NS-IBTS Q3 are two surveys covering similar area in the North Sea, and historically, they have shown very similar signals for all ages of plaice In recent year's assessment, higher survey weights were switched from BTS to NS-IBTS for older ages; leaving out NS-IBTS has led to unexpectedly substantially reduced SSB. Major questions lie in the quality and consistency of the two surveys around the Scottish coast (roundfish area 3). In this study, ICES CPUE indices were calculated per roundfish area, focusing on area 3. Internal consistency and between survey consistency were computed for period 2001-2010 and 2011-2020, respectively. Results showed a reduced internal consistency in both surveys for area 3. Suggestions from WGISDAA were: 1) cohort plots or catch curves can provide better information on total mortality and ability in tracking cohort than internal consistency; 2) investigate biomass indices; 3) for each survey, investigate the proportion of abundance or total biomass coming from each area. Maybe the proportion is different between the surveys; 4) checking other surveys around area 3, e.g. Scottish west coast (Irish sea) surveys; 5) it is likely that the scale of indices are different between BTS and NS-IBTS (due to different catchability). This might influence the estimated variance of the survey and as a results the survey weight. It is suggested to standardize the survey indices for the assessment.

5   Absolute index for North Sea starry ray

The starry ray (*Amblyraja radiata*) stock in the North Sea is an ICES category 3 stock assessed by WGEF. Its assessment is based on a relative abundance index computed from the NS-IBTS Q1 and Q3 survey data. Van Overzee *et al.* (2019) attempted to estimate, instead of a relative index, an absolute index that would represent the minimum total population size in order to estimate removal from the stock by the Dutch MSC-certified otter trawl and flyshoot fisheries. Data from the NS-IBTS (Q1 and Q3) and the BTS (Q3) were extracted, and an R-INLA approach was taken to model the abundance per haul in space and time. This resulted in an annual total abundance estimate, and combined with an average weight per individual, to an annual total biomass estimate. The estimate in considered to be a minimum, as the catchability of the survey is assumed to be 1.

WGISDAA provided several technical suggestions for the R-INLA procedure. Other suggestions were to model the biomass directly, reduce the study area to the central and northern North Sea only, repeat the procedure using GAMs and/or VAST for comparison with R-INLA, and investigate the length distribution of the surveys and compare with commercial catches. The latter may be particularly relevant to see whether the fisheries mostly discard young individuals. If so, then a total stock size index that includes young individuals (as opposed to an SSB index, for instance) would be relevant for management and advice to assess the trend of the stock.

6 Dealing with single large hauls for North Sea horse mackerel

North Sea horse mackerel is a pelagic species that is frequently found close to the bottom. It is assessed by WGWIDE as a category 3 stock using a model-based abundance index in number per hour. The index is calculated based on NS-IBTS data from Q3 and FR-CGFS data from Q4. Although from different quarters, horse mackerel is most abundant in the North Sea during Q3 (Rückert *et al.*, 2002) and moves hereafter towards the Channel to overwinter. Survey data are split by length, and two separate indices are calculated for juveniles (≤20 cm) and adults (>20 cm). There is concern that particularly the juvenile abundance index is influenced by occasional single large hauls, mainly the ones in 1991 and 2010 during the FR-CGFS and in 2016 and 2018 during the NS-IBTS. Leaving out these four hauls leads to a big reduction in the index value for those years, showing their influence on the index. WGISDAA suggested that the impact of large hauls could be reduced by modelling biomass instead of abundance. This would also be preferred as the A-B ratio that is calculated from the index is applied to catch in weight.

WGISDAA had several suggestions relating to the modelling procedure. Including spatial effects may improve the model by considering the spatial locations and number of the samples in each survey area. This would also allow for interpolation in cases of missing samples, such as the lack of samples from UK stations of the FR-CGFS in 2020 (ICES, 2021). The inclusion of historic catches from the NS-IBTS from other quarters than Q3 could be also assessed, particularly Q4. The current hurdle model models the abundance as a function of Year and Survey, after which the fitted values per year and survey are weighted by a factor that considers the larger survey area of the NS-IBTS and a difference in the wingspread of the gear. However, the latter is most likely a double correction, as such a difference is likely already accounted for by the Survey effect in the model. WGISDAA also recommended to investigate the Year effects for each survey and the interactions between Year and Survey to see whether there is an issue of unbalanced sampling: a lower year effect could be for instance due to less sampling rather than a lower abundance. Additionally, it is advised to evaluate other assumed distributions than the once currently used for the non-zero part of the model (e.g. delta-lognormal, negative binomial with other link than log-link) and assess model diagnostics (e.g. QQ-plot). Finally, it could be interesting to take the variance into account when calculating the A-B ratio, so that index values with a large confidence interval are weighted less, although this is outside the scope of the North Sea horse mackerel assessment, and more of a topic for the assessment methodology of ICES data-limited stocks in general.

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Annex 1:   List of participants

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Annex 2:   Resolutions

The **Working Group on Improving use of Survey Data for Assessment and Advice** (WGIS-DAA), chaired by Casper W. Berg, Denmark, will meet online, 5–7 October 2021 to:

a)   To work together with assessment working groups to provide resolution to assessment issues prioritized by the assessment working groups (Science Plan codes: 5.1);

b)   To work together with survey working groups to provide resolution to problems associated with index calculations, survey design changes (proposed or realized) to ensure efficient and effective use of survey resources. (Science Plan codes: 3.1, 3.2).

c)   Initiate with ACOM and secretariat a process to identify upcoming issues associated with the use of survey data in benchmarks. This should be initiated as soon as the benchmark process is started. (Science Plan codes: 5.1).

d)   Review the output from the topic specific workshops initiated by WGISDAA and document more general principles learned from the specifc cases dealt with in TOR a and b.

e)   Discuss future direction of and needs of WGISDAA and drafting a new 3 years resolution.

WGISDAA will report by Nov. 15 2021 for the attention of the ACOM/SCICOM Committee.

Supporting information

Priority	This group will feed the results of its work directly into the assessment and hence advisory process. As such it should be considered central and of high priority.
Scientific justification	WGISDAA provides specific resolutions to individual assessment and survey issues. In addition it catalogues, classifies and and reviews the methods for resolving these issues in order to provide "self-help" for other working groups and benchmarks. The working group provides an important link between experts on surveys, assessments, and statistical analysis in order to provide the best possible science an efficient use and collection of survey data.
Resource requirements	The key additional resource requirement is the group needs particpation of the key players in the relevant assessment, survey or benchmark group. This would be in addition to work required for the normal operations of these groups. Essentially, this would involve key personnel attending the relevant WGISDAA meeting, and where required, personnel from WGISDAA attending the relevant requesting EG..
Participants	Dependant on information requests, but normally less than 10 core members.
Secretariat facilities	None.
Financial	No financial implications.
Linkages to advisory committees	ACOM, Benchmark process and assessment EGs as well as Survey EGs will be the key clients for the work of WGISDAA
Linkages to other committees or groups	WGISDAA will have strong links to to survey working groups under SSGIOMP, and in particular to the work of WGISUR. Given surveys as an important source of wider ecosystem data there will also be important links to groups under SSGIEA.
Linkages to other organizations	None specific.