WORKSHOP ON THE NORTH SEA REOPENING PROTOCOL (WKNSROP)

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i Executive summary

WKNSROP met to reconsider the autumn reopening protocol for North Sea stocks. The workshop evaluated the historical performance in relation to delivering improved recruitment estimates for short-term forecasts, and found it acceptable for cod, haddock, plaice and sole, but less so for whiting and saithe (although there were some mitigating factors for these). Increasing the D threshold used to trigger reopening above its current value of 1 did not lead to an increase in overall performance, and therefore it is recommended to stay at 1, unless there was a desire to lower the frequency of reopening, in which case it could be set at 2. The consistency of application, method used, and justification for ages used in the reopening protocol check were also evaluated. The continued use of RCT3 under default settings for the reopening check (apart from taper weighting that may be required for saithe), using an R package (*rct3*) maintained on the ICES GitHub repository, was recommended, along with using only a single age (usually the youngest age in the assessment, except for saithe) in the reopening check, and using the entire time series of corresponding assessment estimate in the RCT3 regression, apart from where the most recent estimate is considered too uncertain to be used (e.g. for cod, plaice and sole). One of the primary objectives of the workshop was to consider whether any information available during the intermediate year (the year WGNSSK meets and formulates advice for the following year) could be used to improve short-term forecast assumptions about fishing mortality. The most useful, and potentially readily available, source of information was reported landings up to the third quarter of the intermediate year, which were found historically to correlate strongly with landings for the full year (with r^2 values exceeding 0.9 in most cases). If such information were available to be used, then an additional reopening check for the intermediate year fishing mortality assumption would be needed, and several thresholds were tested (comparing the spring landings assumptions with the predicted annual landings based on the quarter 1-2 or 1-3 landings); the choice of threshold (e.g. 10, 15 or 20% difference for triggering reopening) would depend on the desired trade-off between frequency of reopening and accuracy of forecast assumptions. The workshop also discussed the need for reopening in the first place, given that it would be better, from the point of view of using the most up-to-date data and information, and saving workload, to only run the assessments and forecast, and provide advice once in the autumn. This was particularly the case for *Nephrops*, for which the spring advice only differs slightly from the preceding autumn advice, because the summer surveys have the biggest impact on the assessments, and data for these are only available for the autumn. It was therefore recommended that ICES once again discusses with clients the need for spring advice. The final result of the workshop was a revised reopening protocol, which includes the use of landings data for the intermediate year, if available.

ii Expert group information

Expert group name	Workshop on the North Sea reopening protocol (WKNSROP)
Expert group cycle	Annual
Year cycle started	2020
Reporting year in cycle	1/1
Chairs	José De Oliveira, UK
	Alexander Kempf, Germany
Meeting venues and dates	24–27 August 2020, Online meeting (18 participants)

1 Introduction

The current reopening protocol was devised in 2008 to deal with the shift from advice provided in the autumn (when WGNSSK was previously held) to the spring (ICES, 2008). This change was motivated by practical considerations (the Commission and other advice users requested it to allow more time for deliberations prior to fishing opportunities being set) and meant that results from the latest summer surveys were no longer included in the spring advice. Summer survey information is most important for estimating the size of recruiting year classes to the fishery because there is little or no data on these year-classes from the fishery. The reopening protocol was designed to lead to a reopening of advice only when information from the latest summer surveys were significantly different from the information and assumptions used in the spring advice. Annex 3 provides key extracts from the AGCREFA report of 2008, which describes the current reopening protocol.

A key source of uncertainty in fisheries management advice is the size of recruiting year classes. It is common for the size of recruiting year classes to be assumed based on the size of previous year classes (e.g. through a GM assumption). Summer surveys usually provide information (often the first information) that is relevant to the size of recruiting year classes. Therefore, the reopening protocol originally focussed on the reliable new information from summer surveys on the size of recruiting year classes. It made no consideration of other information that could be used to update the assumptions made for spring advice (e.g. information from the fisheries). Furthermore, the protocol has now been applied over a long period of time, during which the assessment and advice landscape has changed substantially, and consistency of application among stocks has eroded. It has therefore become time to reassess the protocol and update it to reflect current requirements.

The terms of reference for this workshop is provided in Annex 2 (Resolutions). The workshop was convened by correspondence over the period 24-27 August 2020, and this report reflects discussions and conclusions from the meeting. In particular, a new proposal for a reopening protocol is provided in Section 6. The other sections cover an evaluation of the historical performance of the reopening protocol (Section 2), a review of the current reopening protocol and methods (Section 3), consideration of the need for reopening, including for *Nephrops* (Section 4), and consideration of information that could be used to update the intermediate year assumptions on fishing mortality (including how such an update would be triggered). Recommendations from the workshop are provided in Section 7.

2 Historical performance of the reopening protocol

Under TOR c (Annex 2), WKNSROP was asked to check the historic performance of the current reopening protocol. WKNSROP analysed whether the recruitment assumptions used in June advice were further away from subsequent assessment estimates compared to the recruitment estimates used in autumn advice incorporating quarter three survey information. The recruitment assumptions were compared to estimates from the latest assessment in 2020. The comparison to the 2020 assessment can be regarded as most important because the latest assessment contains the best available knowledge on a given cohort. For North Sea cod and saithe, the whole assessment is rerun during the reopening procedure. Therefore, the SSB values at the start of the intermediate year (i.e. the survivors) were analysed additionally for these stocks.

To be able to carry out this analysis, the advice sheets and WGNSSK reports were screened for reopening events and associated forecast and assessment values. Implicitly, only the performance of the protocol as implemented by different stock assessors can be checked by this method. Inconsistencies in applying the protocol may have also influenced the historical performance for certain stocks (see Section 3).

Benchmarks can also lead to changes in assessment results. For this analysis, benchmarks were treated as a normal part of the ICES assessment procedure, reflecting the newest and best available knowledge about a stock or given cohort. Therefore, changes in recruitment estimates caused by benchmarks were implicitly treated in the same way as a normal update assessment.

Finally, the absolute percentage differences between recruitment values used in the forecasts and values from the 2020 assessment were calculated to judge whether a particular reopening event was a success. In addition, the D values used to judge whether a reopening is needed were tabulated to check whether higher thresholds for D (currently D<-1 or D>1) could improve the performance of the current reopening protocol. The higher the D value threshold, the higher the probability that the reopening is based on a significant signal from the surveys and not on noise. In addition to this, correlations between the D values triggering the reopening and the final change in TAC advice were also analysed.

Results

In total, 22 reopening events (26 cases, excluding SSB, because sometimes two age groups were updated) were analysed (Table 2.1). Utilizing the new survey information does not guarantee that the autumn recruitment estimates are closer to the 2020 assessment estimate compared to the assumptions made in the spring forecasts. For all stocks, cases could be identified where the reopening led to a larger difference compared to the 2020 assessment.

When summing up the absolute percentage differences over all reopening events for each stock, it turns out that the current reopening protocol as implemented by stock assessors leads overall to a smaller absolute percentage difference between the autumn forecasts and the 2020 assessment compared to the forecasts carried out in spring (Table 2.2). This is true for all stocks apart from North Sea whiting and saithe.

For North Sea whiting the special situation exists that not only recruitment values for the intermediate year, but also for the TAC year, were changed in autumn forecasts before 2018. Since the last benchmark in 2018, the recruitment age was changed from age 1 to age 0. Therefore, the bad performance of the 0-group index as a proxy for recruitment at age 1 during the TAC year is no longer relevant. Nevertheless, WKNSROP further analysed whether the 0-group index is a reliable proxy for whiting recruitment at age 0 (see Section 3.3.4).

For North Sea saithe, the performance check is not very informative because between 2018 and 2019 a serious error was detected in the assessment. Furthermore, the low internal correlation between the age 3 index in year y and age 4 index in year y+1 and consequences for the age groups to consider in the reopening protocol were evaluated (see Section 3.3.2).

Finally, it was checked whether increasing the D value threshold from 1 to ±1.5 or ±2 could improve the performance. Increasing the D value threshold to 1.5 only leads to 24 cases that would have triggered a reopening (Table 2.1). This includes cases with positive and negative performance. When increasing the D value threshold to 2 (so that a value greater than 2 triggers a reopening), only 12 cases (ignoring SSB) are left for reopening. From these 12 cases, 50% show a negative performance. With a D value threshold of one, the percentage decreases to 40% (ignoring SSB). Considering the cases that included SSB (cod and saithe), there was only one case where both recruitment and SSB showed improvement in the autumn compared to spring; in all other cases they showed opposite performance (the one improved while the other deteriorated, or vice versa).

There was a weak correlation between the D values and the final percentage difference in advice. However, especially for absolute D values between 0 and 2, hardly any correlation is visible (Figure 2.1).

Conclusions

Overall, the historical performance of the reopening protocol was acceptable for North Sea sole, cod, haddock and plaice, but less so for whiting. For saithe, only one reopening event could be analysed because a serious error in the assessment was detected between 2018 and 2019. In previous years, general discussions took place for this stock whether a reopening makes sense given the low weight of the IBTS Q3 index in the assessment, weak internal correlation between age 3 and age 4 in the following year and a general concern about year effects in survey indices (although the assessment accounts for the latter effect through the model configuration). For whiting and saithe, issues are further discussed in Section 3.

Increasing the D value to better ensure that the new information is significantly different to the forecast assumptions/estimates did not lead to an increase in overall performance. Therefore, the conclusion is that the D value threshold can be kept at ±1, unless ACOM decides that the frequency of reopening should be lowered. In this case, an increase of the D value threshold to ±2 would have led to a larger reduction of reopening events in the past, while an increase to ±1.5 only had a minor impact.

Reasons for a bad performance in some years are difficult to evaluate as they are additive and range from misleading survey information, to changes made in benchmarks, and general features of assessments such as retrospective patterns. In general, the reasons why forecasts turn out to be overoptimistic or too pessimistic are manifold. Annex 5 considers the case for North Sea cod, focussing on why short-term forecasts have recently tended to be more optimistic in terms of SSB compared to realised values in subsequent assessments. It was concluded that the largest biases (in terms of percentage difference) were caused by assumed recruitment followed by SSB, and are a consequence of the retrospective pattern in the assessment.

Table 2.1 Historical performance of the reopening protocol. Changes made to the intermediate year in the autumn forecasts. The colour means the absolute percentage difference between the value from autumn forecast and the 2020 assessment estimate is larger (red) or smaller (green) than the absolute percentage difference between the value used in the spring forecast and the 2020 assessment estimate.

Stock	Benchmarks since 2009	Year of the Reopening	Recruitment/SSB for intermediate year used in spring forecast	Recruitment/ SSB for intermediate year used in autumn forecast	Corresponding recruitment/SSB estimate in the 2020 assessment	Absolute percentage difference between recruitment/SSB used in spring forecast and recruitment/SSB estimate in the 2020 assessment	Absolute percentage difference between recruitment/SSB used in autumn forecast and recruitment/SSB estimate in the 2020 assessment	D value from RCT3 analysis	% advice change	Comments
SOL 4 (age2)	2015, 2020	2014	54268	65474	84319	35.6	22.3	2	3.6%	
SOL 4 (age1)	2015, 2020	2015	103741	135220	116658	11.1	15.9	1.18	-6.0%	
SOL 4 (age1)	2015, 2020	2017	86425	114581	143487	39.8	20.1	1.7	6.4%	
SOL 4 (age 2)	2015, 2020	2017	42068	62512	60370	30.3	3.5	1.48	6.4%	
SOL 4 (age1)	2015, 2020	2019	112788	476477	615999	81.7	22.6	4.4	42.4%	
PLE 420 (age1)	2015 (merged with 3a)	2014	936981	1309243	1615450	42.0	19.0	1.08	0.0%	TAC constraint
PLE 420 (age1)	2015 (merged with 3a)	2015	650882	826318	925208	29.7	10.7	1.97	1.3%	
PLE 420 (age1)	2015 (merged with 3a)	2017	105501	1562822	1407470	92.5	11.0	3.51	6.1%	
PLE 420 (age2)	2015 (merged with 3a)	2017	967855	1060739	793084	22.0	33.7	1.52	6.1%	
PLE 420 (age 1)	2015 (merged with 3a)	2018	894683	1171029	963668	7.2	21.5	2.21	2.3%	
PLE 420 (age 1)	2015 (merged with 3a)	2019	1287315	3413221	2865930	55.1	19.1	5.76	26.7%	
PLE 420 (age 2)	2015 (merged with 3a)	2019	827716	1155558	803982	3.0	43.7	3.74	26.7%	
WHG 47d (age 1)	2013, 2018	2013	2139711	1119366	776117	175.7	44.2	-3.68	-8%	
WHG 47d (age 1)	2013, 2018	2017	3339689	3815195	2045564	63.3	86.5	0.83	-2%	
WHG 47d (age 0)	2013, 2018	2018	11964329	7550007	12006098	0.3	37.1	-2.775	-3%	
HAD 46a20 (0 group)	2014; 2016	2014	2745080	14195000	6082750	54.9	133.4	5.229	4%	
HAD 46a20 (0 group)	2014; 2016	2017	4236000	1623000	1273838	232.5	27.4	-1.809	-1%	
HAD 46a20 (0 group)	2014, 2016	2018	3529010	1231000	2150928	64.1	42.8	-1.907	-4%	
HAD 46a20 (0 group)	2014, 2016	2019	3287400	20288000	12622694	74.0	60.7	3.536	34.10%	
Cod 47d20 (age 1)	2011, 2015	2016	196000	133000	111470	75.8	19.3	-1.623	<1%	
Cod 47d20 (SSB)	2011, 2015	2016	161135	168552	108512	48.5	55.3	-1.623	<1%	
Cod 47d20 (age 1)	2011, 2015	2017	692194	628520	284201	143.6	121.2	-1.975	-11.40%	
Cod 47d20 (SSB)	2011, 2015	2017	167711	152207	97868	71.4	55.5	-1.975	-11.40%	
Cod 47d20 (age 1)	2011, 2015	2019	136231	184342	156655	13.0	17.7	2.939	30.88%	
Cod 47d20 (SSB)	2011, 2015	2019	81224	80475	65581	23.9	22.7	2.939	30.88%	
POK 3a46 (age 3)	2016, 2019 IBP	2016	102000	109000	114203	10.7	4.6	1.71	15.74%	Serious error detected in 2018/2019
POK 3a46 (SSB)	2016, 2019 IBP	2016	239561	275345	185528	29.1	48.4	1.71	15.74%	Serious error detected in 2018/2019

Table 2.1 (continued). Changes made to the TAC year in autumn forecasts.

Stock	Benchmarks since 2009	Year of the reopening	Recruitment for TAC year used in spring forecast	Recruitment for TAC year used in autumn forecast	Corresponding recruitment estimate in the 2020 assessment	Absolute percentage difference between recruitment used in spring forecast and recruitment estimate in the 2020 assessment	Absolute percentage difference between recruitment used in autumn forecast and recruitment estimate in the 2020 assessment	D value from RCT3 analysis	% advice change	Comments
WHG 47d (age 1)	2013, 2018	2014	3687669	6038870	1775090	107.75	240.20	1.707	16%	0 group index as proxy for age 1 in the following year
WHG 47d (age 1)	2013, 2018	2015	3781580	8066061	1587988	138.14	407.94	2.42	26%	0 group index as proxy for age 1 in the following year
WHG 47d (age 1)	2013, 2018	2017	2443772	1012691	1216729	100.85	16.77	-3.06	-2%	0 group index as proxy for age 1 in the following year

Table 2.2 Overall performance of the reopening protocol by stock.

Stock	Sum of absolute percentages over the years (spring forecasts)	Sum of absolute percentages over the years (autumn forecasts)
Sole 4	198.5	84.6
Plaice 420	251.4	158.8
Whiting 47d	586.4	832.8
Haddock 46a20	425.4	264.3
Cod 47d20	376.1	291.7
Saithe 3a46	39.8	52.9

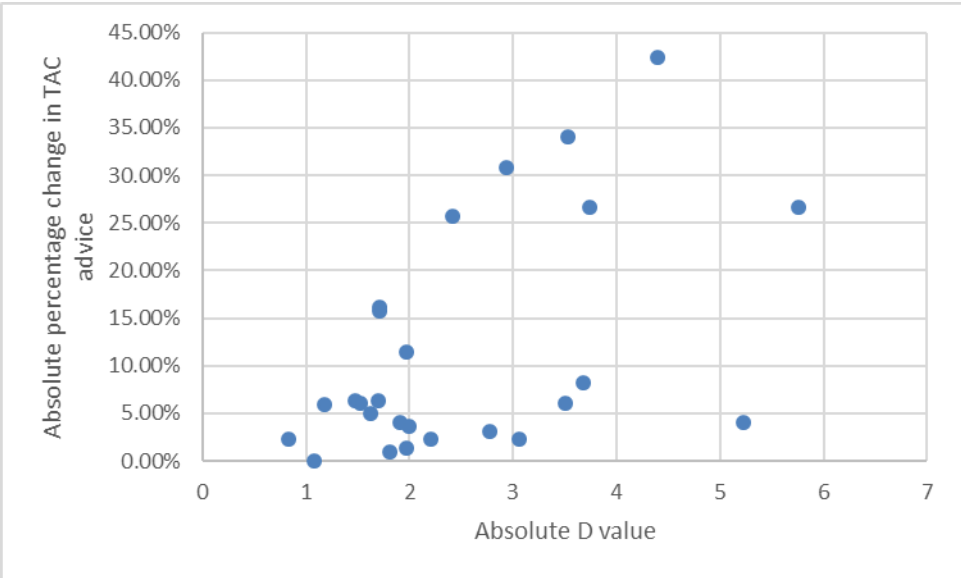

Figure 2.1. Correlation between absolute D values triggering the reopening and final absolute percentage change in TAC advice.

3 Review of the current reopening protocol and methods

3.1 Introduction

Since the current protocol was developed in 2008, there have been many benchmarks conducted and new assessment models introduced. The assessment and advice landscape has changed substantially, and as is bound to happen with a protocol that has been applied for many years, a number of inconsistences of application have crept in across stocks, both in terms of the settings applied and the data used. This section evaluates and compares how the protocol is currently applied across six stocks (cod, saithe, haddock, whiting, plaice and sole), highlighting differences in application across these stocks, and any issues that have developed. It also considers the choice of ages to be included in the protocol check, and issues around the use of RCT3.

3.2 Application of current protocol

Table 3.2.1 provides a summary of how the reopening protocol is currently used across the six category 1 WGNSSK stocks, and what is done once the reopening protocol is triggered. The purpose of this table is to compare the consistency of the application of the reopening protocol across the various stocks. Some issues that are raised are as follows:

a) What is the basis for deciding which ages to include as a check for whether the reopening protocol is triggered? There are clear differences of approach among the stocks (e.g. roundfish vs. flatfish). In Section 3.3, justification is provided for the ages to consider in the reopening protocol check for each stock.
b) What happens once the reopening protocol is triggered differs markedly amongst stocks, with some rerunning the assessment, while others simply update the short-term forecast. For assessments that are able to fit data for the intermediate year (e.g. SAM and TSA) it is possible to update the assessment once the reopening protocol is triggered – this is already the case for cod and saithe, but also possible for haddock and whiting (although not currently done). The current version of the assessment used for flatfish (the AAP model) is not able to fit intermediate year data, so updating these assessments once the protocol is triggered is not currently possible.
c) In order to allow assessment to fit data for the intermediate year, an assumption about F is needed for the intermediate year because of missing catch data (it is not yet available). An F assumption for the intermediate year is also required for the forecast, and this is not necessarily the same assumptions as used in the assessment, because the forecast is generally a separate procedure to the actual assessment. It should be possible to avoid this inconsistency with an identical and appropriate intermediate year F assumption for both the assessment and forecast.
d) Although most stocks use the same survey time series as used in the assessment (with new data points added) when considering reopening or conducting a forecast, some introduce time series not formally included in the actual assessment (such as age 0 from SNS and DFS for the flatfish, when the assessment starts with recruitment at age 1), in order to estimate recruitment strength for the intermediate year with RTC3. This raises the question that, if these time series are good enough for the short-term forecast, why are they not good enough for the assessment itself? This should be an issue to consider at the next benchmark for the affected stocks (plaice and sole).

e) The model settings for RCT3 are the same, regardless of whether RCT3 is used for the reopening check or for updating the forecast (see Table A3.1 in Annex 3). This wasn't always the case (e.g. for saithe). However, plaice is currently the exception, because the RCT3 used in the forecast switches shrinkage on, although it is not entirely clear why this is done.

f) There are cases where information used in RCT3 (as "new" information) has already been included in the assessment (e.g. for cod, IBTS Q1 is already included in the assessment, but is included again in the re-opening protocol RCT3 in the autumn) – although RCT3 leaves out the affected year-class from the assessment estimates used in the RCT3 regression, the assessment fit may have already been affected by information on this year-class; furthermore, the spring assumption already includes this "new" IBTS Q1 data when deriving the recruitment estimate for the intermediate year that is used in the spring forecast, so the D comparison (see equation 1 in Annex 3) will have the "new" IBTS Q1 data influencing both sides of the minus sign. Both of these factors introduce circularity in the procedure and should be avoided by incorporating only information about the year class of interest that has not previously been used in either the assessment or forecast. The converse is true for flatfish, where the reopening protocol does not include the DFS and SNS estimates of age 0, but it is justifiable to include these (because they represent new information on the year class of interest) if RCT3 has not been used in the spring forecast.

g) There are a number of RCT3 versions in use, some of which may not be reliable. It is important to put forward a packaged version that has gone through testing (see Annex 4).

Table 3.2.1. Summary of re-opening protocol and actions for each stock. Definition of years: y-1 = last year of catch data; y = intermediate year (year during which assessment is conducted); y+1 = forecast year (year for which advice is provided). DG=Delta-GAM. Based on WGNSSK 2019 report. Table A3.1 reference here can be found in Annex 3.

	Stock	Cod 47d20	Haddock 46a20	Whiting 47d	Saithe 3a46	Plaice 420	Sole 4
1	RCT3 settings for reopening protocol	As per Table A3.1	As per Table A3.1	As per Table A3.1	As per Table A3.1, but see 9	As per Table A3.1	As per Table A3.1
2	Recruitment age in the assessment	Age 1	Age 0	Age 0	Age 3	Age 1	Age 1
3	Year-class(es) checked in the reopening protocol	y-1	y	y	y-3 (partially recruited) y-4	y-1 y-2	y-1 y-2
4	New information for each year-class listed in 3 (and not previously used in the assessment)	y-1: DG IBTS Q3 (age 1)	y: IBTS Q3 (age 0)	y: IBTS Q3 (age 0)	y-3: IBTS Q3 (age 3) y-4: IBTS Q3 (age 4)	y-1: DG BTS Q3 (age 1) y-2: DG BTS Q3 (age 2) [Latest UK BTS not available for DG]	y-1: BTS ISIS Q3 (age 1) y-2: BTS ISIS Q3 (age 2)
5	Information included in RCT3 for each year-class listed in 3	y-1: DG IBTS Q1 & DG IBTS Q3 (both age 1)	y: IBTS Q3 (age 0)	y: IBTS Q3 (age 0)	y-3: IBTS Q3 (age 3) y-4: IBTS Q3 (age 4)	y-1: DG BTS Q3 (age 1) y-2: DG BTS Q3 (age 2)	y-1: BTS ISIS Q3 (age 1) y-2: BTS ISIS Q3 (age 2)
6	Procedure once reopening triggered	Assessment re-run including DG IBTS Q1 (as per spring assessment) and DG IBTS Q3 (as per 4)	Replace year-class y with RCT3 value from 1-5 and rerun MFDP forecast	Replace year-class y with RCT3 value from 1-5 and rerun MFDP forecast	Assessment re-run including new information from IBTS Q3 if protocol triggered for either year-class	Rerun RCT3 for year-classes for which protocol triggered, and conduct stf with these year-classes replaced	Rerun RCT3 for year-classes for which protocol triggered, and conduct stf with these year-classes replaced
7	If RCT3 is used as a basis for 6, how do settings differ from 1	N/A	No change	No change	N/A	Shrinkage towards mean switched on	No change
8	If RCT3 is used as a basis for 6, how does information used differ from the initial RCT3 of 1-5	N/A	No change	No change	N/A	y-1: DG BTS Q3 (age 1); SNS (age 0); DFS (age 0) y-2: DG BTS Q3 (age 1 & 2); SNS (age 0 & 1); DFS (age 0); DG IBTS Q1 (age 1); DG IBTS Q3 (age 1)	y-1: BTS ISIS Q3 (age 1); SNS (ago 0); DFS (age 0) y-2: BTS ISIS Q3 (age 1 & 2); SNS (age 0 and 1); DFS (age 0)

	Stock	Cod 47d20	Haddock 46a20	Whiting 47d	Saithe 3a46	Plaice 420	Sole 4
9	Issues to note	RCT3 in 5 includes information for year-class y-1 already used in the assessment, although SAM y-1 is omitted from RCT3 regression	None	None	RCT3 settings for reopening protocol adjusted to Table A3.1 since 2019	Year classes y-4, y-3, y-2 & y-1 omitted from RCT3 regressions, but for the forecast, y-4 & y-3 are included in AAP survivors DG BTS Q3 used in 5 & 8 does not include UK-BTS	Year classes y-4, y-3, y-2 & y-1 omitted from RCT3 regressions, but for the forecast, y-4 & y-3 are included in AAP survivors Benchmarked in 2020 (details may change)

3.3 Stock-specific issues

Issues that are specific to individual stocks are discussed in more detail below.

3.3.1 Cod (cod.27.47d20)

Year-class checked in the reopening protocol

The first (recruitment) age considered in the assessment of North Sea cod is age 1. We need to consider whether there is sufficient new information on this age during the intermediate year to consider its inclusion in the reopening protocol check, and whether there is already enough information on age 2 in the assessment to exclude it from this check. The only new information on age 1 during the intermediate year is from the NS-IBTS-Q1 and Q3 surveys. Log abundance curves from the NS-IBTS-Q1 survey show this age group to be partially recruited in most years (as demonstrated by a downward "hook" shape; Figure 3.3.1.2, left), while log abundance curves from the NS-IBTS-Q3 survey show a shallow to no hook shape (Figure 3.3.1.2, right). It is therefore justifiable to include age 1 in the reopening check given sufficiently new information for this age in the intermediate year from the NS-IBTS-Q3 survey, and partial information (and the only other data point) on this age in the NS-IBTS-Q1 survey from the same year. Age 2 appears to be fully recruited to the fishery and surveys, despite age 1 being only partially recruited to the fishery (Figure 3.3.1.1); information on this year-class (i.e. age 2 in the intermediate year) would have already been included in the assessment: from age 2 in the intermediate year for NS-IBTS-Q1, and from age 1 in the previous year for NS-IBTS-Q3 and the catch data. Therefore, it is justifiable to exclude age 2 from the reopening check as there is already sufficient information on it in the assessment.

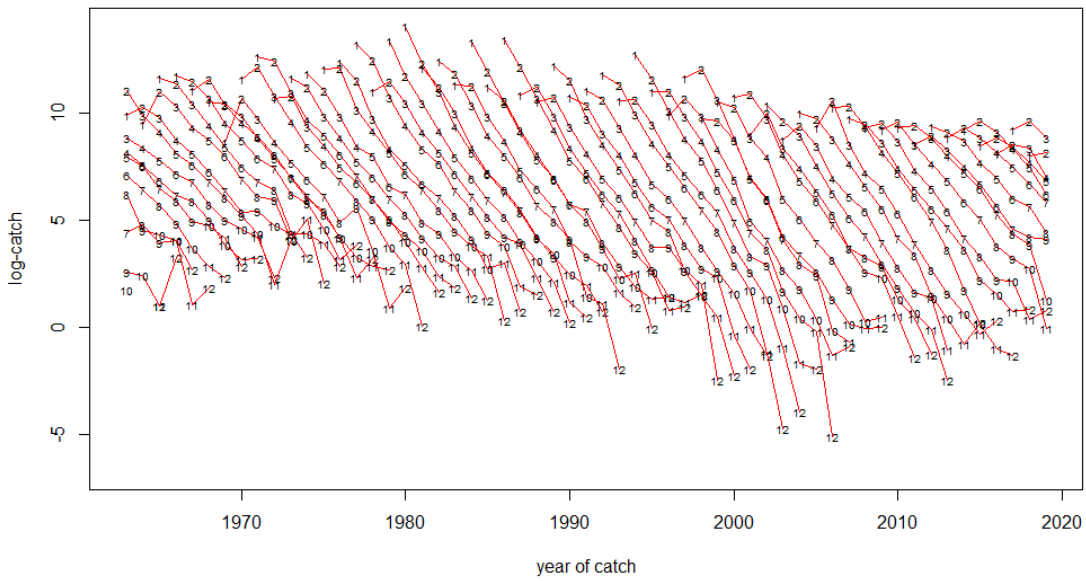

Figure 3.3.1.1: Log-catch cohort curves for North Sea cod.

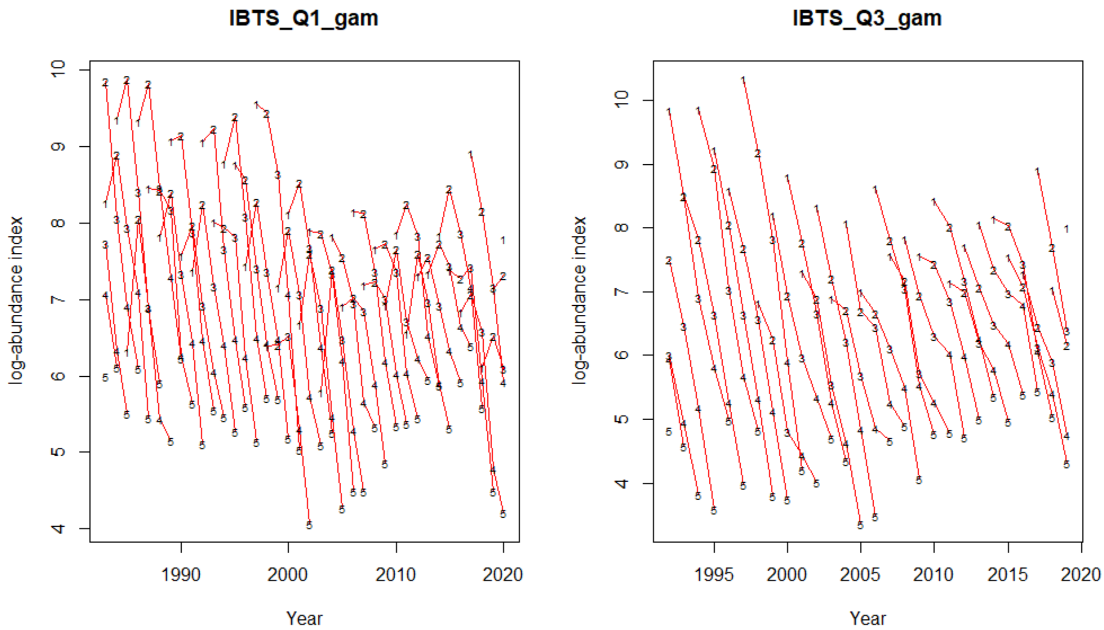

Figure 3.3.1.2: Log abundance curves for each cohort of North Sea cod derived from delta-GAM indices based on NS-IBTS-Q1 and NS-IBTS-Q3 survey data.

Information included in RCT3

There is some circularity in the current reopening procedure for cod due to inclusion of the NS-IBTS-Q1 index in the RCT3 check when that index has already been used in the May assessment and forecasts (see point f in Section 3.2 above). This circularity can be avoided by considering only the NS-IBTS-Q3 index in the RCT3 reopening check, because the NS-IBTS-Q3 will include new information on age 1. To examine the effects of this, the reopening protocol was rerun without the NS-IBTS-Q1 index for all years from 2015, when the NS-IBTS-Q3 was reintroduced into the assessment and an October reopening made possible, and the resulting D values and outcomes compared to those observed.

Table 3.3.1.1 shows that in most years the conclusions of the reopening check would have been the same. The only exception is 2018 when the advice was not reopened but would have been had the RCT3 check been run without the NS-IBTS-Q1 index included. In this case the D value of 1.041 only just exceeds the condition to trigger a reopening (i.e. D > 1) and although positive, indicating a stronger recruitment than assumed in May, a reopening would have revised the advice downwards, likely due to other changes in the stock upon rerunning the assessment.

Table 3.3.1.1: Comparison of D values and resulting reopening conclusions from including or not including the NS-IBTS-Q1 index in the RCT3 reopening check.

Assessment year	Include IBTS Q1		Omit IBTS Q1		Advice change
	D value	Conclusion	D value	Conclusion	
2015	-0.306	Not reopen	-0.533	Not reopen	
2016	-1.623	Reopen	-1.471	Reopen	<1%
2017	-1.975	Reopen	-2.519	Reopen	-11.40%
2018	0.741	Not reopen	1.041	Reopen	-5.71%
2019	2.939	Reopen	2.960	Reopen	30.88%

A regression of D values from including vs not including the NS-IBTS-Q1 index in RCT3 shows strong correlation and confirms that the conflict of outcomes in 2018 is a consequence of D falling towards the boundary of the reopening condition (Figure 3.3.1.3). There is therefore a minor impact on the reopening procedure by excluding the NS-IBTS-Q1 index, and this is recommended to avoid circularity.

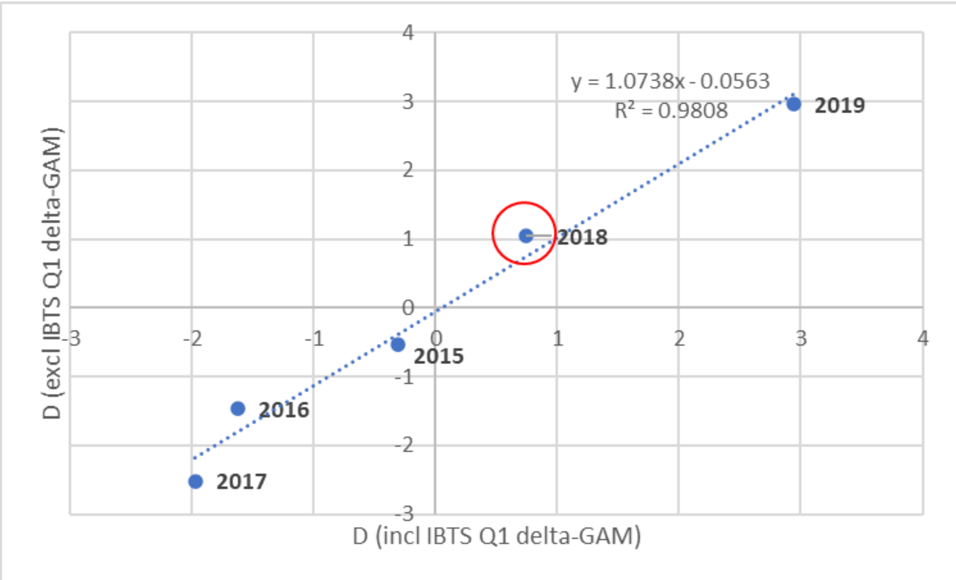

Figure 3.3.1.3: Regression of D values from including or not including the NS-IBTS-Q1 index in the RCT3 reopening check. The point for 2018, where reopening conclusions differ, has been highlighted.

3.3.2 Saithe (pok.27.3a46)

Saithe in the North Sea starts recruiting to the fisheries at age 3. Internal consistency of age 3 with other ages of the same year-class in the IBTS Q3 index, with age 3 as recruitment index, is however poor (low r^2, Figure 3.3.2.1), which suggests a partial recruitment of this age group. The catch curves per cohort for the IBTS Q3 index (Figure 3.3.2.2) furthermore show inconsistencies in the recruitment of age 3 among years, with the age group being partially recruited in some years (downward "hook" shape) and fully recruited in others. Therefore, age 3 estimates from IBTS Q3 index cannot be considered as providing reliable new information on age 3 in the intermediate year, and this age should be excluded from the reopening protocol check. Otherwise the RCT3 analysis might, on some occasions, trigger a reopening while the forecast was in a credible range, but the recruitment index was not reflecting the actual cohort strength.

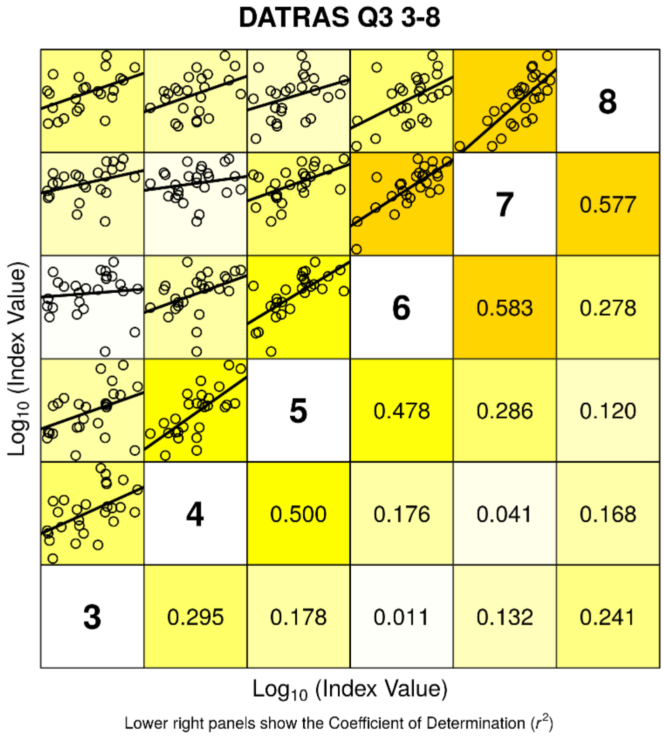

Figure 3.3.2.1. Internal consistency plot for NS saithe, age 3 to 8, in the IBTS Q3 survey index.

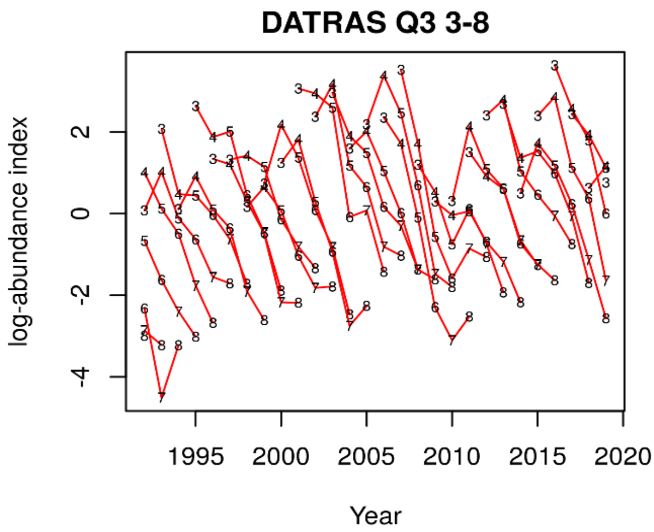

Figure 3.3.2.2. Catch curve per cohort for NS saithe, age 3 to 8, based on the IBTS Q3 survey index.

The age 4 group, on the other hand, seems to recruit more consistently across time and should therefore be preferred to trigger a reopening assessment. Note that, in the case where age 4 is used, it is not the recruitment forecast assumption (age 3) from the spring assessment which is evaluated, but rather the age 4 assessment estimate for the intermediate year (i.e. the survivors) from the spring assessment, which will be based on the age 3 IBTS Q3 survey index and age 3 catches in the year prior to the intermediate year. Both of these data reflect only partial recruitment of age 3, so the age 4 index from IBTS Q3 in the intermediate year potentially provides enough new information on this cohort to be considered as part of the reopening check. Furthermore, the basis for calculating the age 3 intermediate year estimate remains unchanged compared to the spring assessment and forecast (i.e. it will be a resampling of past recruitment estimates, as stipulated in the stock annex; this effectively means that the age 3 data for the intermediate year from IBTS Q3 is disregarded in the autumn forecast). Note that saithe starts recruiting at age-3, and age-4 already experiences a substantial (much higher than at age-3) fishing mortality (Figure 3.3.2.3). It can therefore be expected that the relationship between the estimated age-4 class strength (beginning of the year) and age-4 Q3 index will be more severely affected by changes in F among years than it would with the use of the recruiting age-class (at least for a stock where recruitment is consistent over the years). The considerably higher fishing mortality of age-4 saithe before the 2000s, in particular, may affect the RCT3 analysis, and it is therefore recommended that taper weighting be used in the RCT3 reopening check to deal with this feature.

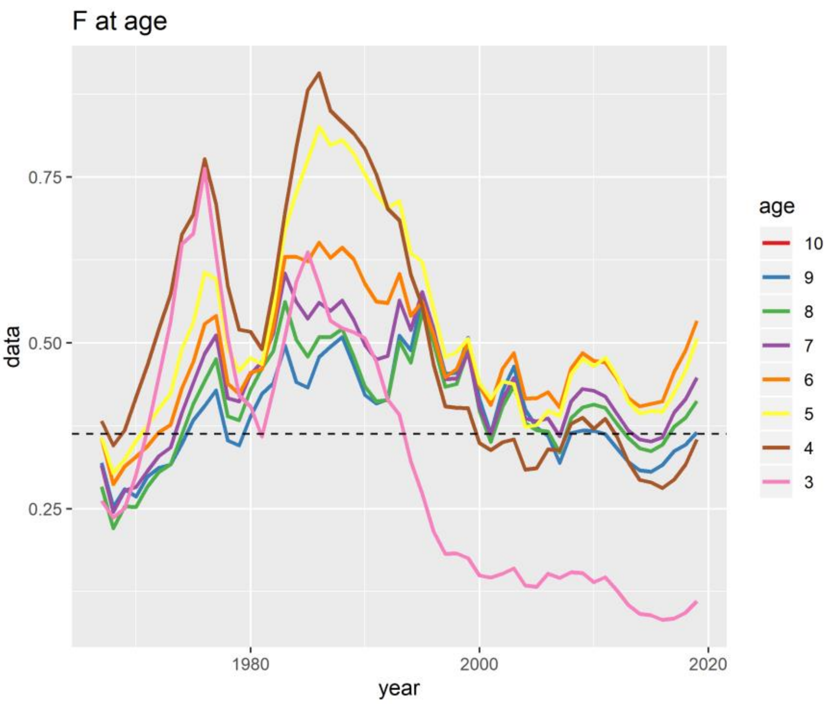

Figure 3.3.2.3. Fishing mortality at age for the final assessment model (ICES, 2020a) for North Sea saithe, scaled at F4–7.

3.3.3 Haddock (had.27.46a20)

The Northern Shelf haddock assessment (areas 4, 6a and 20) currently uses age-0 as the recruitment age. We need to consider whether there is sufficient new information available for age-0 during the intermediate year for the information to be included in the reopening protocol check, and whether there is already enough information on age-1 in the assessment to exclude it from this check. The IBTS Q3 survey log-catch curves indicate that age-0 haddock are, on the whole, fully recruited to this survey (straight cohort curves or shallow hooks in the bottom plot of Figure 3.3.3.1), and furthermore that within survey correlations between age-0 and subsequent ages within a cohort are strong (Figure 3.3.3.2). This implies that **introducing age-0 in the reopening protocol check is justified**. Although Figure 3.3.3.3 indicates that age-0 is only partially recruited to the fishery (hooked catch curves, and virtually all of those fish will be discarded), age-0 fish are well-represented in IBTS Q3 (as noted before), and corresponding cohorts are also well represented at age-1 subsequently in IBTS Q1 (top plot of Figure 3.3.3.1). Therefore, the year-class associated with age-1 in the intermediate year is covered reasonably well by existing data sources in the assessment, and therefore **there is no need to include age-1 in the reopening protocol check** with new information from IBTS Q3 in the intermediate year.

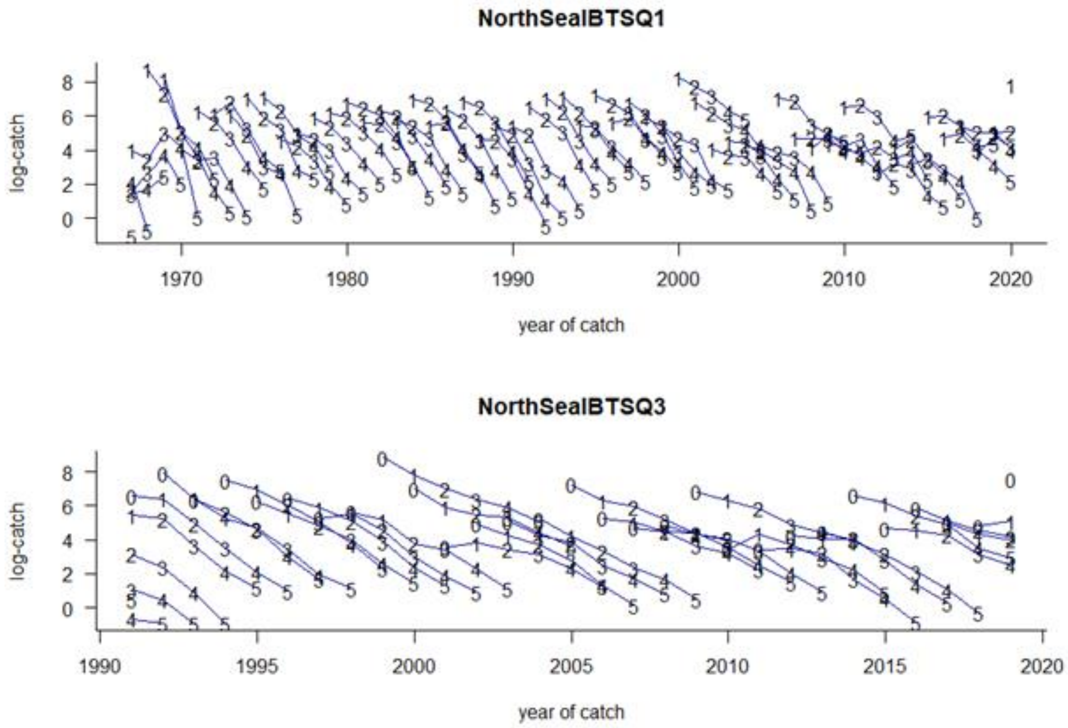

Figure 3.3.3.1. Haddock in Subarea 4, Division 6.a and Subdivision 20. Log abundance indices by cohort (survey "catch curves") for each of the survey indices.

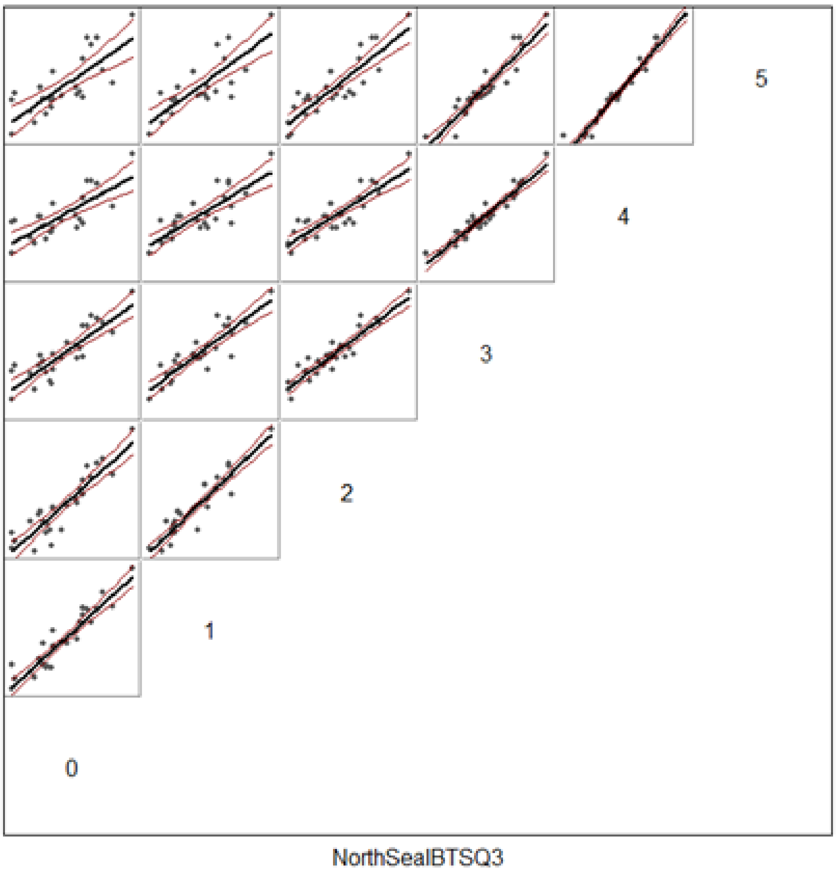

Figure 3.3.3.2. Haddock in Subarea 4, Division 6.a and Subdivision 20. Within-survey correlations for the IBTS Q3 survey series, comparing index values at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (with black points) represents a significant ($p < 0.05$) regression, while a thin line (with blue points) is not significant. Approximate 95% confidence intervals for each fit are also shown.

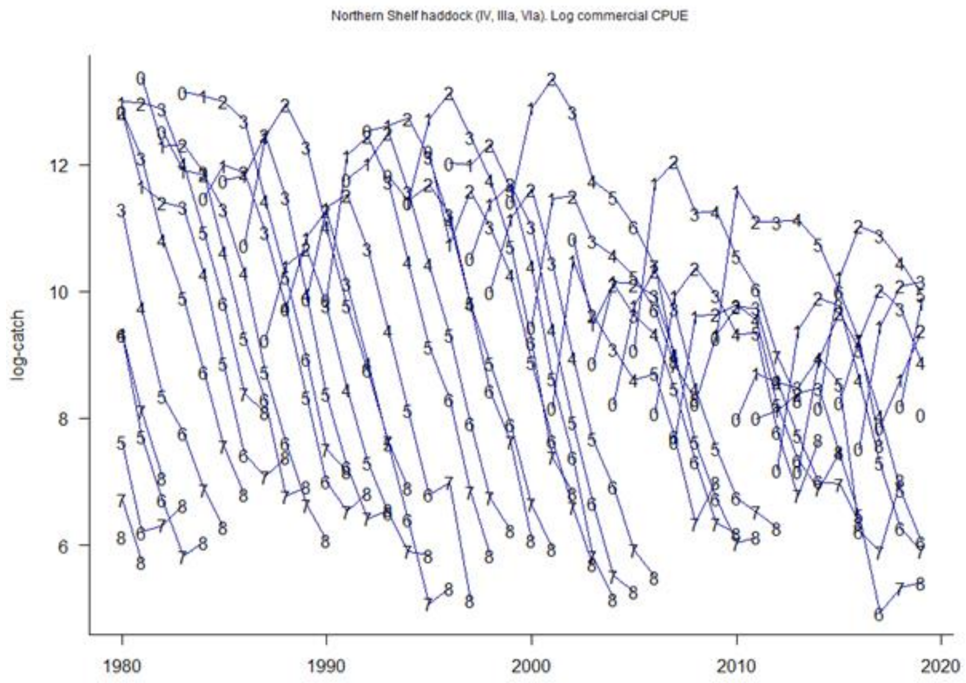

Figure 3.3.3.3. Haddock in Subarea 4, Division 6.a and Subdivision 20. Log catch curves by cohort for total catches.

3.3.4 Whiting (whg.27.47d)

Since the last benchmark in 2018, the re-opening procedure has been based on new available information from the summer survey (IBTS Q3) for recruitment at age 0. In the spring forecast, the assumption of the geometric mean of the recruitment time series (since 2002) is used for both intermediate year and TAC year recruitment at age 0. With new available IBTS Q3 data, the intermediate year assumption may be updated in autumn. When the reopening is triggered using the RCT3 recruitment estimate, the forecast (MFDP software) is rerun with the new RCT3 estimate for age 0 fish in the intermediate year.

The re-opening procedures showed mixed performance, because the RCT3 estimate in autumn has not necessarily improved the assumption of the intermediate year in comparison to recent model estimates (Section 2). However, the advice change with re-opening of the intermediate year assumption resulted in small changes of the advice from spring to autumn, between -2 and -8%.

With the last benchmark in 2018, the assessment model was updated and recruitment age changed from age 1 to age 0. We need to consider whether there is sufficient new information on age 0 during the intermediate year to consider its inclusion in the reopening protocol check, and whether there is already enough information on age 1 in the assessment to exclude it from this check. The survey catch curves show that age 0 recruited relatively consistently across cohorts to survey catch, with straight survey catch curves or shallow hooks (Figure 3.3.4.1, bottom). The survey index in Q3 for age 0 contains useful information, as we find significant within survey correlation, between ages 0 in year y and age 1 in year y+1 as well as older ages (Figure 3.3.4.2). Furthermore, there is correlation between survey index age 0 and recruitment estimates from the 2020 WGNSSK assessment (Figure 3.3.4.3). It was concluded that the IBTS index Q3 for age 0 can be used in the reopening procedure.

In contrast fish aged 0 are only partially recruited to the fishery, and show hooked catch curves (Figure 3.3.4.4). However, as noted above, age 0 is relatively consistently recruited to IBTS Q3, and also as age 1 in IBTS Q1 (Figure 3.3.4.1, top; although not as well as age 0 from IBTS Q3), and the year-class associated with age 1 in the intermediate year is therefore covered reasonably well by different data sources in the assessment, and there is no need to include it in the reopening protocol check with new information from IBTS Q3 in the intermediate year.

The reopening could continue to use the RCT3 estimate in a comparison to the intermediate year assumption. To improve the recruitment estimates in the forecast, it is recommended to rerun the assessment model with updated IBTS Q3 data and use the updated estimates of stock numbers at age for the intermediate year in the forecast. This would ensure recruitment estimates in the forecast resemble more closely to recruitment estimates of the following year assessment.

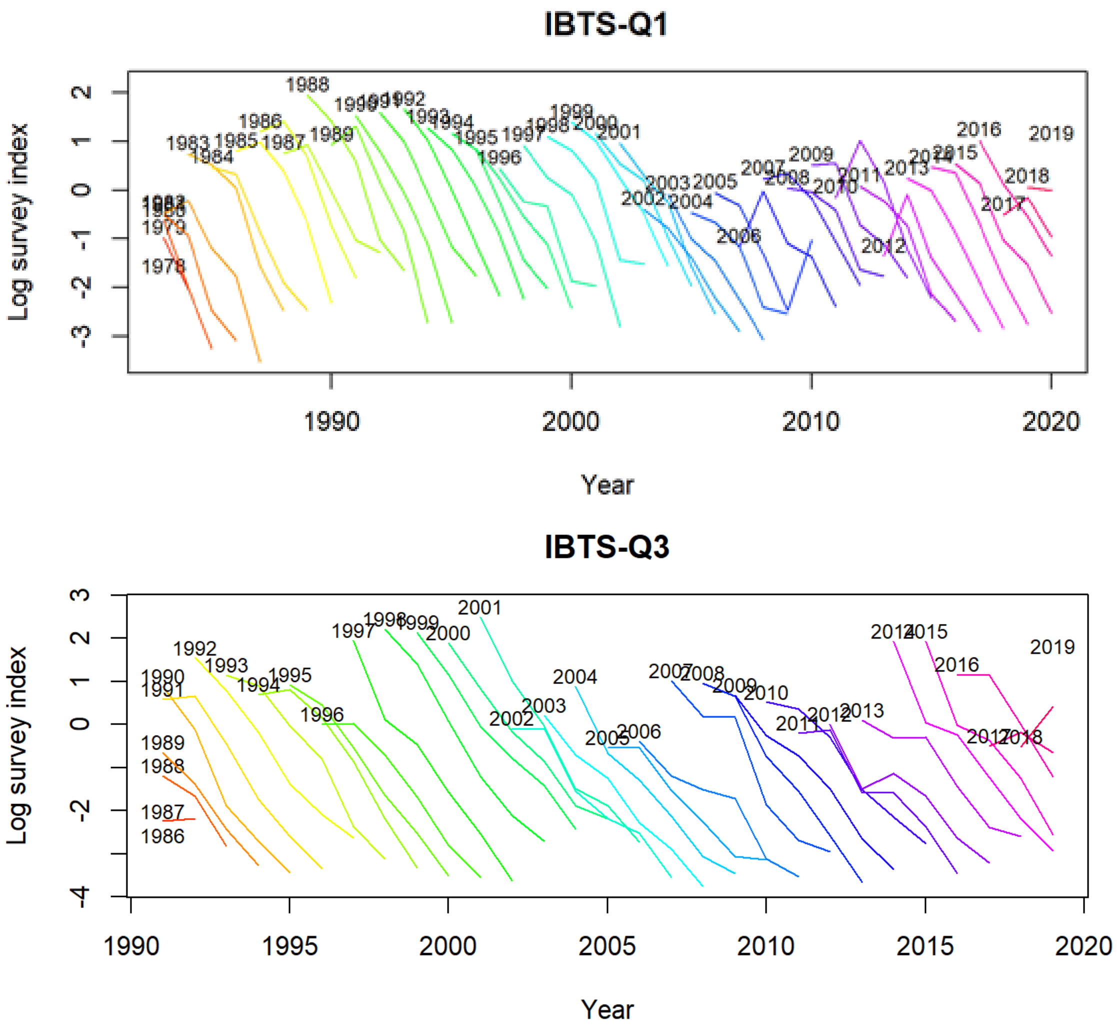

Figure 3.3.4.1 NS whiting. Survey catch curves for ages 1 to 5 (IBTS Q1, top) and ages 0 to 5 (IBTS Q3, bottom) per cohort.

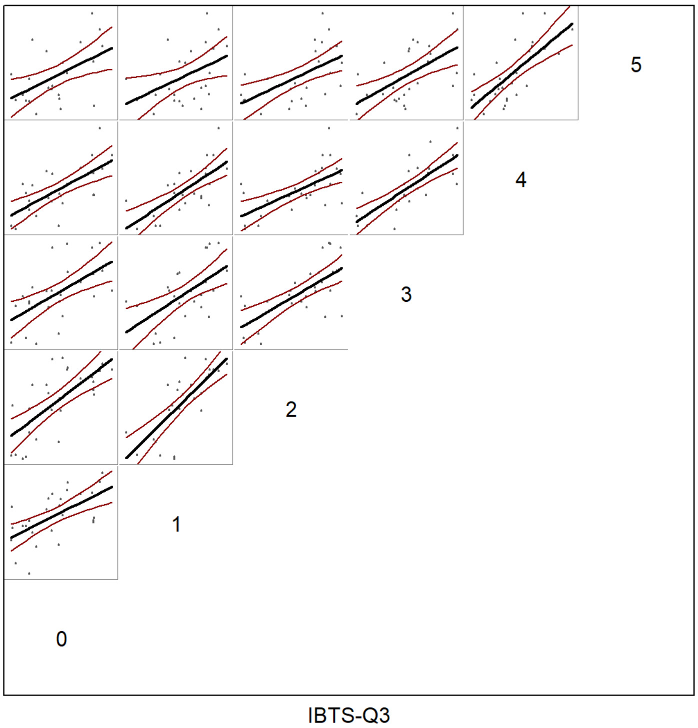

Figure 3.3.4.2 NS whiting. Internal consistency plot ages 0 to 5 in IBTS Q3.

Table 3.3.4.1 NS whiting. WGNSSK IBTS Q3 indices age 0 and SAM recruitment estimates at age (ICES, 2020a).

Year class	IBTS Q3 age 0	Recruitment (age 0)
1991	5.065	12891338
1992	13.232	14439252
1993	8.781	14041392
1994	5.687	12508211
1995	7.035	10103274
1996	2.832	8508724
1997	19.735	13261176
1998	25.563	21381453
1999	23.86	22391261
2000	18.681	19691138
2001	34.265	19880336
2002	2.566	11681507
2003	3.481	11122803
2004	6.8	12346238
2005	1.639	11717533
2006	1.894	9689112
2007	7.773	14055054
2008	7.281	14076546
2009	5.553	13280096
2010	4.725	12908918
2011	2.311	9733569
2012	2.828	7533155
2013	3.083	11429425
2014	19.385	15206992
2015	19.307	14077390
2016	9.005	15367324
2017	1.71	9926469
2018	1.687	12006098
2019	13.649	17760036

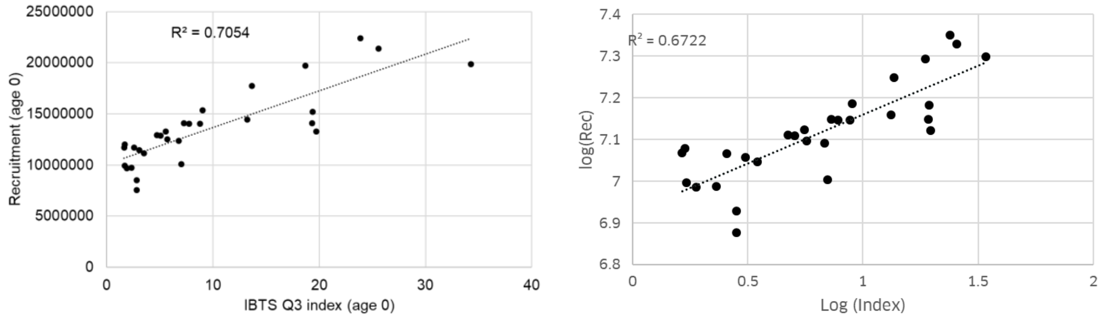

Figure 3.3.4.3 NS whiting. Correlation of index and recruitment estimates (left: linear scale, right: same data on log scale), based on the estimates shown in Table 3.3.4.1.

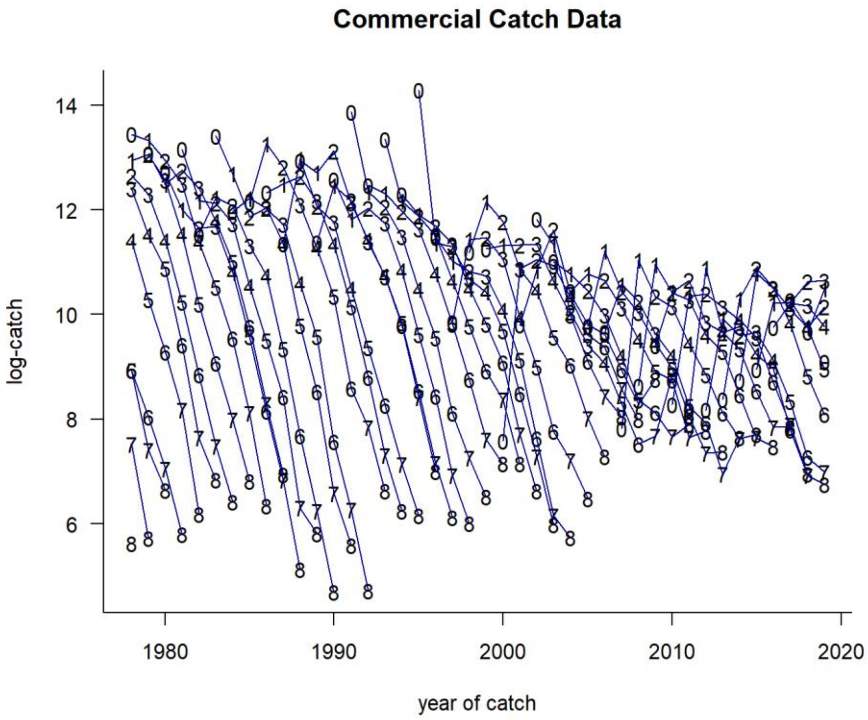

Figure 3.3.4.4 NS whiting. Commercial catch curves age 0 to 5 per cohort.

3.3.5 Sole (sol.27.4)

Excluding recent stock assessment recruitment estimates

Estimates of recruitment in the final years from stock assessment models are generally considered more uncertain, as less information is available for those cohorts. Recruitment (age 1) estimates for sole in the final year of the assessment are based on the two surveys used, and one of them (BTS) is designed to sample older ages (2+). Past RCT3 analyses for sole have been carried out excluding the recruitment estimates for the last three years. For example, the reopening analysis in 2019 included the recruitment estimates for the 1977 to 2014 year-classes.

The impact of excluding recent recruitment estimates was analysed based on the results and index data from the latest assessment of sole. If the final year recruitment is estimated to be large, as is the case with the 2018 sole year class, it might unduly influence the RCT3 estimate. Table 3.3.5.1 shows the resulting estimates for age 1 abundances for the 2019 year-class, computed by RCT3 using the model and settings currently applied to this stock: rec1 ~ SNS0 + BTS1 + DFS0, and no shrinkage. Including the 2018 strong year class (first column labelled "None") appears to have a larger effect in the estimate compared with the sequential removal of other years. A similar effect is observed in the last column, as the 2015 year-class, estimated to be lower than average, is dropped from the calculation.

Table 3.3.5.1. NS sole. Estimates of sole recruitment for the 2019 year-class (age 1 in 2020) obtained through RCT3 when none to four year-classes in the estimated recruitment series were excluded.

Years excluded	None	2018	2017-18	2016-18	2015-18
Predicted recruitment (2019 year-class)	33 149	37 396	37 229	37 350	35 085
Percentage change		12.8%	12.3%	12.7%	5.8%

The removal of different number of years, when the last year class was not as strong, was investigated by sequentially excluding one to five years, starting with the 2017 year-class, and estimating the strength of the subsequent year class (first column labelled "2018" in Table 3.3.5.2). The analysis was carried out for five years. The mean predicted recruitment across the five years of exclusion, and their coefficient of variation, are presented in Table 3.3.5.2. The comparison with the recruitment estimates from the 2020 stock assessment appears to indicate that recruitment predictions are not affected greatly by leaving out the last few years' estimates.

Table 3.3.5.2. NS sole. Comparison of sole RCT3 recruitment estimates for years 2018 to 2014 obtained by excluding one to five years of recruitment estimates.

Predicted year-class	2018	2017	2016	2015	2014
Mean predicted recruitment	344 661	99 293	103 853	56 751	145 085
CV prediction	2.63%	0.89%	1.13%	1.45%	0.52%
AAP estimated recruitment	616 179	108 700	143 480	73 331	116 715

Leaving out the last year estimate would safeguard against the effect of very large, and probably very low, values in the calculation, without having an important effect in all other years. In the case for sole, the RCT3 method should thus be applied leaving out the final year recruitment estimate only (instead of the current practice of the final three years).

Surveys to be included in RCT3 analysis

Two surveys are currently carried out that provide useful information on the strength of incoming year classes for sole: the Sole Net Survey (SNS) and the (DFS) (Figures 3.3.5.1 and 3.3.5.2). Indices of abundance for age 0 in the previous year are available at the time of the spring stock assessment. A prediction of age 1 recruitment in the intermediate year can then be obtained using the RCT3 method. In the case of the autumn reopening, an extra data point is available, namely the abundance of age 1 fish as signalled by the Q3 BTS (NL, DE, BE) survey. This data is considered not to provide a complete signal (ICES, 2020b) so the appropriateness of the autumn reopening for sole might be in doubt.

What difference the use of the BTS1 signal in the autumn makes to the recruitment forecast was investigated by applying the RCT3 method retrospectively, first as in the spring meeting, without the BTS1 data (but including the age 0 SNS and DFS data), and then as in the autumn, with BTS1 data for that year added (Table 3.3.5.3). The use of BTS1 in the autumn appears to increase the recruitment estimates. When compared with the estimates obtained by the AAP stock assessment, the autumn forecast with BTS are generally closer.

Table 3.3.5.3. NS sole. Comparison of sole recruitment estimates carried out using RCT3 when the Q3 BTS1 estimate for the last year is available (autumn) or not (spring).

Year-class	2018	2017	2016	2015	2014
Without BTS1 (spring)	354 376	101 448	69 874	38 044	99 878
With BTS1 (autumn)	489 991	124 151	141 070	52 251	118 346
AAP estimated recruitment	616 179	108 700	143 480	73 331	116 715

The comparisons presented here are all based on the results of the 2020 stock assessment, in which the information provided by the BTS survey on age 1 abundance is already used in the estimation of recruitment by the AAP model. A complete retrospective analysis would have to proceed carrying out the RCT3 analysis based on recruitment estimates that did not use any information on age 1 abundance in the current year. Despite this limitation, it provides some indications of issues that might require further exploration. The BTS survey targets older ages for sole and the quality of the information that it is able to provide on the abundance of young sole has been in doubt (ICES, 2020b). Nevertheless, until the issue is further investigated, reopening checks should continue for sole, because the above analysis does not indicate that a reopening check based on BTS age 1 in the intermediate year should yet be abandoned, and if RCT3 is not used in the spring forecast, then the reopening check should also include SNS and DFS data for this cohort at age 0 in the previous year. The choice of surveys for RCT3 and the quality of final year estimates of recruitment for sole (discussed in the preceding section) should be part of a comprehensive analysis by the next stock assessment benchmark.

The use of SNS and DFS age 0 in the spring forecast is recommended, because they provide new data on recruitment (age 1) in the intermediate year, but this remains a choice for WGNSSK when they discuss forecast settings.

The cohort associated with age 2 in the intermediate year already has a few data sources in the assessment, namely BTS age 1 (mostly fully recruited to the survey; Figure 3.3.5.3), SNS age 1 (mostly fully recruited to the survey; Figure 3.3.5.4), and age 1 in the catches (although they are only partially recruited to the fishery at this age; Figure 3.3.5.5), all in the year preceding the intermediate year. This cohort is therefore already well represented in the assessment and there is no need to include it in the reopening check.

The use of BTS age 1 information in the RCT3 prediction is only of relevance to the autumn update if the BTS Q3 data is made available on time. This might not be the case over the upcoming years if the request of WGBEAM is followed (ICES, 2020b).

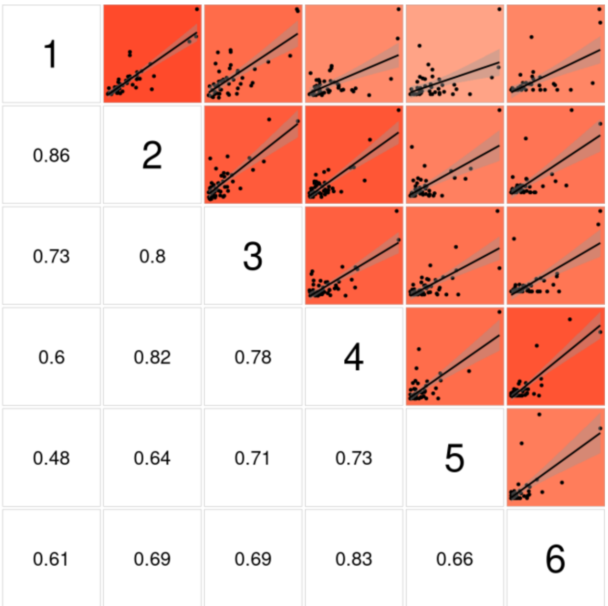

Figure 3.3.5.1. NS sole. Cross correlation by age for the SNS survey for North Sea sole

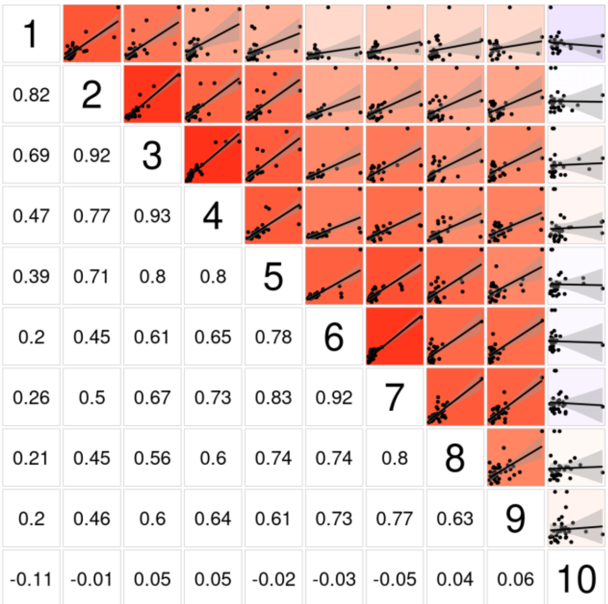

Figure 3.3.5.2. NS sole. Cross correlation by age for the BTS combined survey for North Sea sole.

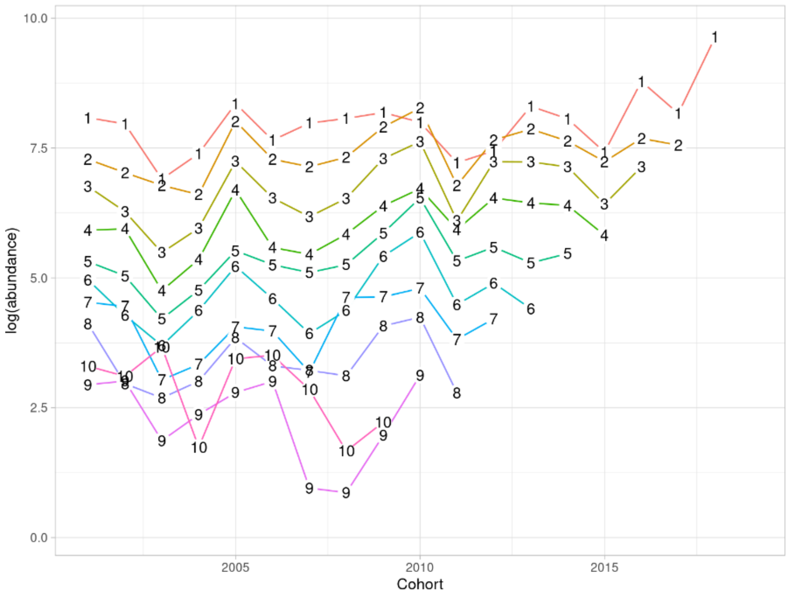

Figure 3.3.5.3. NS sole. BTS index catch curves for ages 1 to 10.

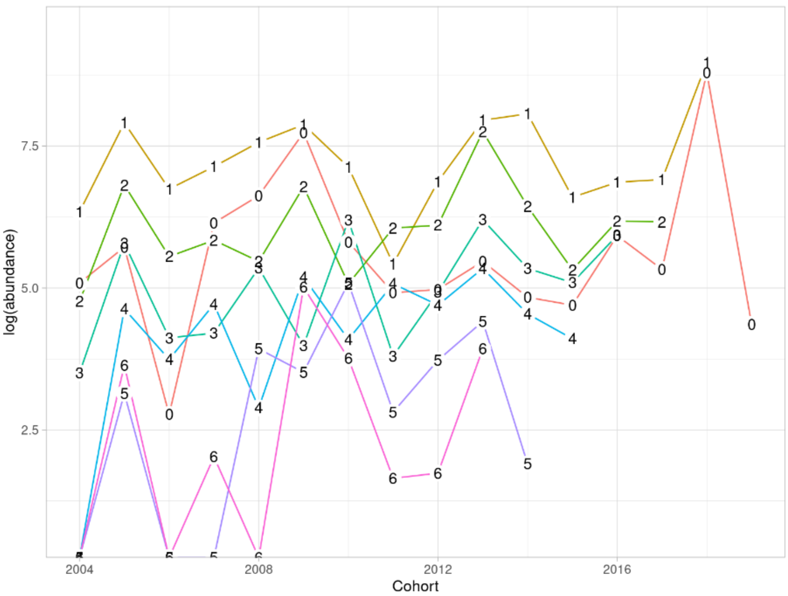

Figure 3.3.5.4. NS sole. SNS index catch curves for ages 0-6.

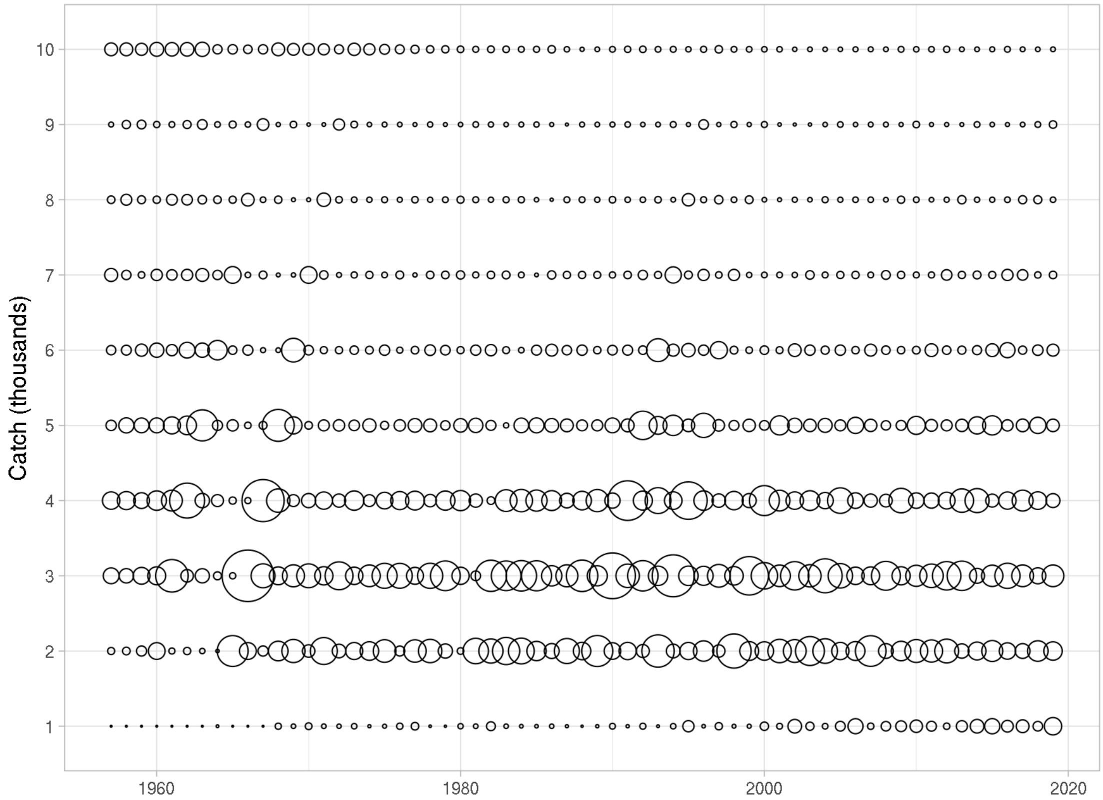

Figure 3.3.5.5. NS Sole. Time series of catch at age (in thousands).

3.3.6 Plaice (ple.27.3a4)

Excluding recent stock assessment recruitment estimates

The same procedure as for sole has been applied in recent years to North Sea plaice, where the last three recruitment estimates were left out of the RCT3 linear model. The effect of leaving out none to four years was also explored. The estimates obtained differ by less than 5%, even with the possible effect of strong year class (Table 3.3.6.1).

Table 3.3.6.1. Estimates of plaice recruitment for the 2019 year-class (age 1 in 2020) obtained through RCT3 when none to four years in the estimated recruitment series were excluded.

Years excluded	None	2018	2017-18	2016-18	2015-18
Predicted recruitment (2019 year class)	901 859	876 590	872 600	879 343	878 197
Percentage change		2.8%	3.2%	2.5%	2.6%

Estimates obtained by excluding up to five years when done retrospectively over the last five, also appear to be stable (Table 3.3.6.2).

Table 3.3.6.2. Comparison of RCT3 recruitment estimates for years 2018 to 2014 obtained by excluding one to five years of recruitment estimates.

Predicted year-class	2018	2017	2016	2015	2014
Mean predicted recruitment	4 966 991	833 456	1 172 236	836 180	357 534
CV prediction	6.53%	6.10%	4.74%	3.21%	2.37%
AAP estimated recruitment	2 865 930	963 668	1 407 470	1 004 770	925 208

As for sole, the RCT3 method should thus be applied leaving out the final year recruitment estimate only (instead of the current practice of the final three years).

Surveys to be included in RCT3 analysis

The same comparison as was carried out for sole on the spring and autumn estimates is presented in Table 3.3.6.3.

Table 3.3.6.3. Comparison of plaice recruitment estimates carried out using RCT3 when the Q3 BTS1 estimate for the last year is available (autumn) or not (spring).

Year-class	2018	2017	2016	2015	2014
Without BTS1 (spring)	4 867 736	904 438	1 242 138	937 175	339 795
With BTS1 (autumn)	5 808 433	1 083 692	1 612 567	1 165 718	523 302
AAP estimated recruitment	2 865 930	963 668	1 407 470	1 004 770	925 208

Compared to sole, autumn estimates of recruitment, including BTS age 1, are generally larger than the spring results (which only has age 0 data from SNS and DFS for the year-class in question). This could be related to the spatial coverage of SNS and DFS not matching the distribution of young plaice, or other factors making both surveys give different signals on cohort strength. However, catch-curves for BTS indicate that age 1 is generally fully recruited to the survey (top left plot, Figure 3.3.6.1), so provides new information on age suitable for a reopening check. The next benchmark for plaice should consider the choice of surveys for recruitment forecasting. In the meantime, it seems appropriate to include the intermediate year BTS age 1 estimate for a reopening check, and similar to sole, if RCT3 has not been used for the spring forecast, then the reopening check should also include age 0 data for this year-class from the SNS and DFS surveys.

The use of SNS and DFS age 0 in the spring forecast is recommended, because they provide new data on recruitment (age 1) in the intermediate year, but this remains a choice for WGNSSK when they discuss forecast settings.

The cohort associated with age 2 in the intermediate year already has a few data sources in the assessment, namely BTS age 1 (generally fully recruited to the survey; top left plot of Figure 3.3.6.1), SNS age 1 (fully recruited to the survey; top right plot of Figure 3.3.6.1), IBTS Q3 age 1 (partially recruited to the survey; bottom left plot of Figure 3.3.6.1), IBTS Q1 age 1 (partially recruited to the survey; bottom right plot of Figure 3.3.6.1), and age 1 in the catches (partially recruited to the fishery at this age; shown as hooks in Figure 3.3.6.2), all in the year preceding the intermediate year. This cohort is therefore already well represented in the assessment and there is no need to include it in the reopening check.

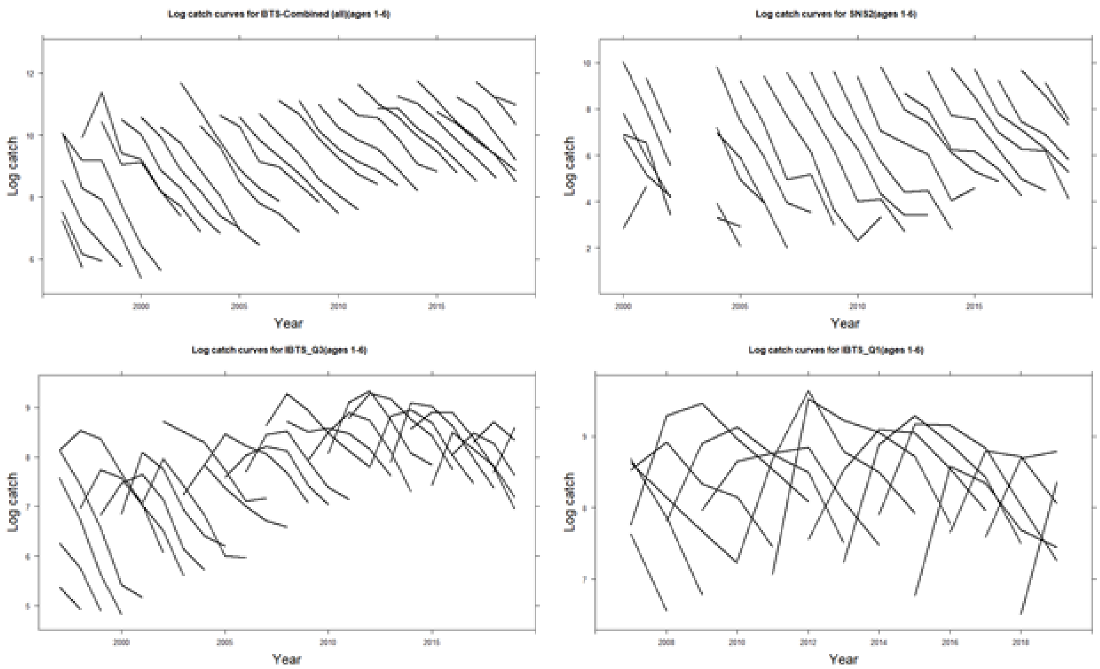

Figure 3.3.6.1. North Sea plaice. Catch curves for Surveys in age 1–6.

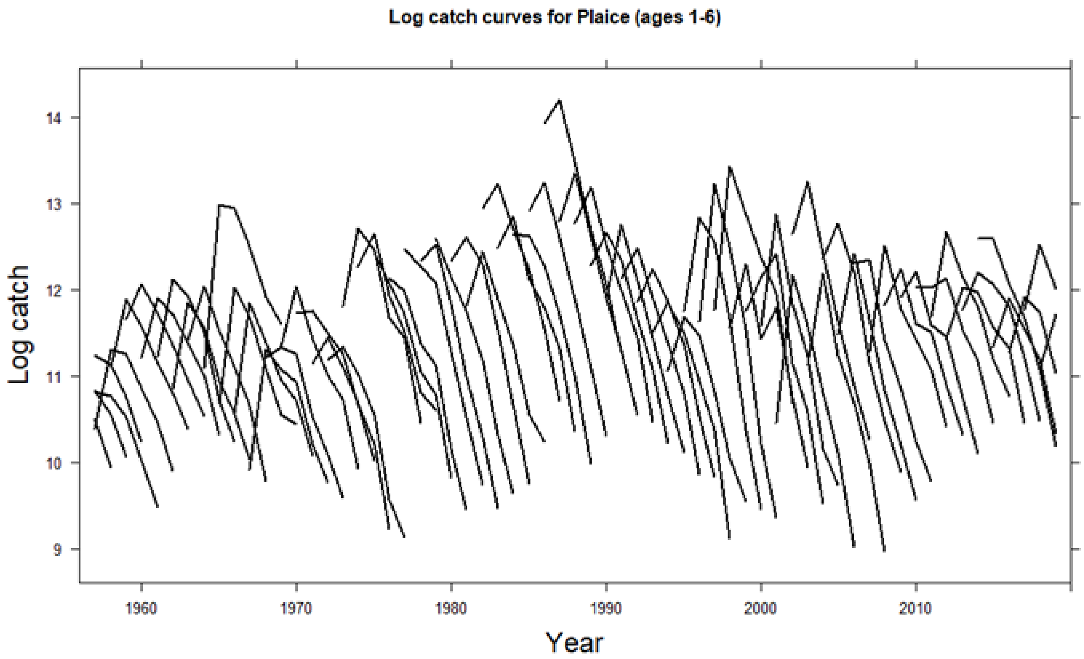

Figure 3.3.6.2. North Sea plaice. Catch curves for catches in age 1–6.

3.4 Alternatives to using RCT3

The current approach used to check reopening based on new recruitment information relies on an application of RCT3 which is then used in the calculation of D (Annex 3). There was, however, a brief discussion about whether an alternative check could be made based on rerunning the assessment to check whether there is a significant change from the spring assessment to the autumn assessment. This idea was found to be problematic for several reasons:

- Because it requires the autumn assessment to be rerun prior to the check, as opposed to the current approach which will only rerun the assessment after the check, it places an additional burden on the reopening process.
- Although significance tests for hypotheses about parameters are straight-forward when based on the same data set, this becomes trickier when assessments are based on different datasets (the autumn assessment will include more data than the spring assessment); furthermore, the assessment estimates that are to be compared (e.g. SSB, F and R) will not be independent, and the extent to which they are correlated is not clear (making significance testing difficult).

For these reasons, it was decided to keep the current approach of using the RCT3 estimate of the relevant age for the reopening check.

3.5 RCT3 software

The most up-to-date R version of RCT3 (Shepherd 1997) can be found on an R package (*rct3*) on the ICES GitHub repository (https://github.com/ices-tools-prod/rct3). This version has been tested against the original DOS program for reproducibility, and replaces previous versions that were available as sourced functions (https://code.google.com/archive/p/cpm-tools). Further comparison of the two versions were conducted during the working group and are presented in Annex 4. The recommendation is for stock assessors to use the R package version, which is maintained and will continue to be developed.

The main *rct3* function allows the user to specify the following settings for the regression:

- formula – A formula (R notation) for the model to be fit (e.g. numbers ~ index1 + index2). The resulting model will actually be fit to the log-transformed values of all variables (numbers and indices), but this should not be specified in the formula.
- data – A data object of the class "data.frame" with one column named 'yearclass' and other columns with the recruitment and the survey indices relevant for that recruitment value, named as specified in the formula.
- predictions – Defines which year classes to make recruitment predictions for. When predictions = NULL (default), predictions will be done for year classes that are NAs. The prediction is usually only for the final year class, unless when conducting a retrospective analysis.
- shrink – Logical value (TRUE or FALSE) used to define whether shrinkage to the mean historical value should be done following the prediction with the fitted regression model. The mean historical value is used as an additional estimate, with its weight corresponding to the observed historic variance of recruitment about the mean. The AGCREFA recommendation is to not apply shrinkage (Annex 3).
- power = 0 – Defines the degree of weighting applied to historical values in the regression (i.e. "tapering"; 0 = none, 1 for linear, 2 for bisquare, and 3 for tricubic weighting). The AGCREFA recommendation is not to use tapering (i.e. power = 0; Annex 3).
- range = 20 – The number of years used in the regression (prior to the prediction year). The recommendation is to include all historical years (e.g. range = nrow(data)).

- min.se – The minimum allowed standard error for inclusion of a given covariate term in the final combined regression (based on its partial prediction standard error). The AGCREFA recommendation is not to apply this restriction (i.e. min.se = 0).
- old – Logical value (TRUE or FALSE) indicating whether a value of 1.0 should be added to the indices prior to log scaling. This setting is included in order to reproduce results from the original RCT3 DOS program. This transformation may help in cases where indices equal zero, however it may have unintended consequences for indices with lower ranges of values.

The approach of Shepherd (1997) is to fit a "calibration" regression, which assumes that the explanatory variates (i.e. the indices) are the dominant source of errors that should be minimized by the regression fitting. This formulation is the inverse of typical linear models that minimize the response variable (i.e. the numbers in the case). The rationale for this reversal is that the numbers derived from assessments are thought to be relatively precise, whereas the index measurements are subject to relatively large sampling errors. The prediction of numbers is then based on the inverted form of the fitted regression, and the standard error of the prediction is the residual mean squared error of those derived predictions.

Two of the most important settings in the RCT3 model are in the application of shrinkage and/or tapering. Applying shrinkage has the effect of discounting extreme values through the additional down-weighting of predictions towards the historical mean. Tapering places lower weight on more distant historical values, and is used in cases where there is evidence of a shift in the quality of the survey index. Unless agreed upon within a benchmark process, the recommendation of AGCREFA is not to apply these weightings. To demonstrate the effects of applying shrinkage or tapering weightings in RCT3, the example of North Sea saithe (pok.27.3a46) is used. The example is helpful for illustration given that the model uses a single explanatory index (IBTS quarter 3) for the prediction of age 4 saithe numbers, allowing for easy visualization of the resulting regression.

Figure 3.5.1 shows the resulting regressions under the differing settings. The reported regression coefficients (i.e. intercept and slope) pass through the predictions when shrinkage is not used. When applied, shrinkage toward the mean is applied post-fitting, resulting in a shift of the regression prediction toward the historical mean (in this case, the shift is positive). The effect of increasing power for tapering discounts more historical values within the defined year range. In the case of saithe, where recent years have been associated with lower recruitment, increased tapering (i.e. power) decreases the regression slope and increases the intercept, resulting in lower predictions for 2019 numbers (2015 year-class) compared to when no tapering is used. Under all settings, the RCT3 predictions result in a significantly lower value than that assumed during the spring assessment, as determined by the distance metric; i.e. $|D|>1$.

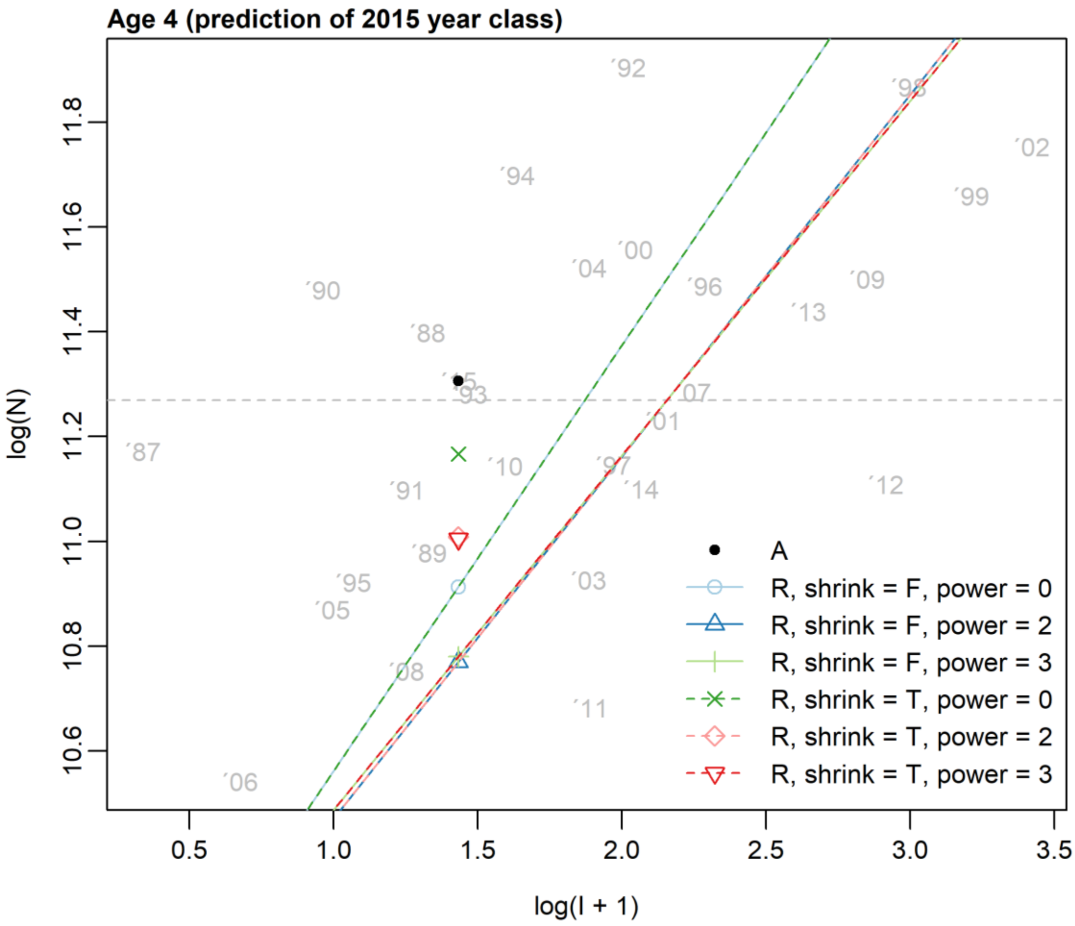

Figure 3.5.1. Comparison of RCT3 regression models fit under different settings for shrinkage ("shrink"; T=TRUE, F=FALSE) and tapering ("power"). Regressions (lines) and predictions (coloured symbols) are shown for an example from saithe (pok.27.3a46), where age 4 numbers in 2019 (year class = 2015) are predicted by their 2019 IBTS quarter 3 indices. Grey text indicates the historical data values, with text corresponding to the year class. For reference, the assumed 2019 numbers (2015 year class), used during the spring assessment for the purpose of forecasting, is shown as a filled black point, and the mean of age 4 numbers in the time series is indicated by the dashed horizontal grey line.

3.6 Summary and conclusions

When considering reopening based on recruitment, the general principle followed was that the age for which the assessment has limited or no information in the spring of the intermediate year and for which summer surveys during the intermediate year supply new or substantially new information, would be included in the reopening check. Furthermore, any age in the intermediate year for which the assessment already includes substantial information at earlier ages for that cohort would not be included in the reopening check. This has meant that for all stocks considered, only one age would be included in the intermediate year reopening check, generally the first age in the assessment, namely age 0 for whiting and haddock, age 1 for cod, plaice and sole. Saithe is unique because age 4 is considered suitable for the reopening check, but it is not the first age in the assessment; the reason for not using the first age (age 3) is because the IBTS Q3 survey only provides partial and variable information on this age, which does not correlate well with subsequent ages within a cohort for this survey. Because there is substantial fishing mortality on age 4, the RCT3 settings would require taper weighting for saithe to deal with increased fishing mortality on this age prior to 2000.

Generally, the full time series of assessment estimates for the selected age (mentioned above) is used in the RCT3 regression, apart from when the most recent estimate is considered too uncertain to be used – this is the case for cod (which is the only stock that uses intermediate-year information on recruitment in the assessment, but it is only one data point), plaice and sole (both of which rely on BTS Q3 recruitment estimate, which is considered more reliable for the older fish than the recruitment age 1, and on fishery information, for which age 1 is only partially recruited).

Regarding the RCT3 software, it is recommended that the R package *rct3*, found on the ICES GitHub repository (https://github.com/ices-tools-prod/rct3), be used. This version has been tested against the original DOS program for reproducibility, is maintained, and will continue to be developed.

4 Need for reopening

The need to rerun assessments and forecasts based on the reopening protocol creates extra effort for stock assessors and coordinators, but also for the ICES secretariat and ACOM members to produce the updated advice. It basically means that part of the work needs to be done twice a year, for June and autumn advice.

WKNSROP discussed whether the whole procedure is really needed and whether there would be alternatives to reduce the workload. Between 2015 and 2019 a reopening was triggered 22 times (see Table 2.1) for fish stocks and 15 times for *Nephrops* stocks creating a substantial workload. Since the assessments, forecasts and reopening procedures are different between *Nephrops* and fish stocks, they are discussed separately.

4.1 Fish stocks

The large number of reopening events for fish stocks indicates that the summer surveys often produce a significantly different signal from forecast assumptions. In cases where a reopening was triggered, the final change for TAC advice was often below 5%, but in five cases the change in TAC advice was above 20% (Table 2.1). This means that the benefit of the June advice can be questioned. There are no clear scientific arguments for advice to be delivered in June and then update again in autumn for those stocks for which the summer surveys are likely to bring new relevant information.

At the same time, it may be questioned whether the reopening itself is useful. Although the overall performance of the reopening was positive, in 40% of the cases analysed (see Section 2 2) the estimates used in the autumn forecasts were further away from the 2020 assessment estimates than the assumptions used for June advice. Assessments have their own uncertainties and often retrospective bias. Adding a datapoint to the assessment may lead to larger changes and often even in the opposite direction to the changes made during the reopening procedure. This can be seen in the cases with a negative reopening performance.

The current reopening procedure is the result of ICES clients insisting on having advice in June to start the negotiations for the TACs in the next year. Although this is a valid argument, it would be beneficial to discuss with stakeholders whether June advice is really needed, or whether advice in autumn may be sufficient, given that the autumn advice needs to be reopened anyhow in quite a number of cases. As alternative, there are also arguments to skip the reopening procedure given the historic performance of the protocol. However, it is difficult to decide whether the performance of the reopening protocol shown so far was bad enough to cancel the reopening procedure given that the overall performance was still positive. However, discussions in ACOM on this topic may lead to further conclusions.

4.2 Nephrops

Background

Nephrops is a commercially important species in the North Sea with well-established fisheries taking place in this region. Stock assessments on individual *Nephrops* FUs within Subarea 4 (Figure 4.2.1) make use of a number data sources, including TV surveys, length distributions and fishery data such as landings and effort. TV survey estimates of stock abundance in numbers are used to calculate a potential landings level based on a ‘harvest ratio’ defined as the ratio of total catch in numbers to stock abundance in numbers (Dobby *et al.*, 2007). The advisory process of *Nephrops* has been extensively reviewed and is described in detail in Leocadio *et al*. (2018).

Currently, *Nephrops* advice in the North Sea is released after the WGNSSK assessment meeting taking place in spring. The advice is based on forecasts presented at WGNSSK using both catch information (discard rates and mean weight in landings and discards) and survey abundance information collected in the year prior to the assessment meeting.

ICES applies a protocol for reopening advice for stocks when new information from fisheries-independent surveys becomes available after the spring advice. Most *Nephrops* TV surveys in the North Sea take place in summer (Table 4.2.1), implying that a new survey point on which forecasts may be based is available by the autumn. The protocol for *Nephrops* states that if the point estimate of survey abundance used for the spring advice differs by more than one standard deviation of the mean estimate from the new summer survey, then the reopening process is triggered (ICES, 2016). This process is fairly sensitive to small abundance fluctuations (see Figure 4.2.2) and in practical terms, for most *Nephrops* stocks, reopening is triggered every year resulting in advice being released twice per year. This working document aims to compare how much *Nephrops* advice has changed between consecutive advisory processes in recent years between autumn and spring, discussing the merits of the reopening process.

Methods

Advice values were obtained for ICES category 1 stocks in the North Sea as these are normally surveyed every year. Before 2015, it proved difficult to track advice values for both spring and autumn. For example, there appears to be no instances prior to 2015 where the reopening protocol was applied to FUs 7, 8 and 9. Additionally, there were no record of the reopening protocol being ever applied to FUs 3-4. For this reason, the analysis presented here was run for 2015-2020 on FUs 6, 7, 8 and 9. Despite there being no advice released for *Nephrops* stocks in 2020, in order to get an additional point in the analysis, the forecast advice presented at the 2020 WGNSSK meeting was used.

For each FU, the spring and autumn advice was plotted alongside each other and two percentage changes were calculated: (1) the change between autumn advice in year Y and spring advice in year Y+1; (2) the change between consecutive autumn advice each year – this is because the autumn advice, when given, is the one that is taken into account for the TAC setting.

Results and discussion

According to AGCREFA (ICES, 2008) for North Sea stocks, the need for an advice reopening protocol resulted from changing the timing of the advice for many stocks from autumn to spring in order to allow more time for deliberations prior to fisheries management decisions for the next calendar year. As such, scientific information from summer surveys is not available for consideration in the preparation for the spring advice, implying an inherent trade-off between more time for deliberations and the reliability of advice (ICES, 2008).

Results for FUs 6-9 show that autumn advice reopening was triggered a total of 15 out of 20 possible times between 2015 and 2019. For FUs 6, 7 and 8, the advice was reopened every year. For FU 9, the advice was never reopened in autumn due to the stability in the survey abundance (inter-year variation has been below one standard deviation), combined with relatively high confidence intervals (Figure 4.2.2). The change in advice between autumn and spring (before using the new survey data) was generally low, with values below 5% (Figure 4.2.3). The exception was the 2017 spring advice for FU 8 with the percentage change being just under 11%. Despite length frequencies in FU 8 being relatively stable over time, high recruitment pulses have been observed sporadically in this FU, and these are usually followed by an increase in the discard rate (ICES, 2018). Recruitment of small individuals to the fishery implies a decrease in the mean weight in catches, which is one of the parameters used in the forecasts. This is one of the factors that drives changes in the spring advice and explains the slighter higher percentage change between autumn and spring in FU 8.

In those instances where the reopening was triggered, the percentage change between spring and autumn advice in each year is much larger (6- 85%) than the values reported above for the autumn to spring comparison (Figure 4.2.3). This reflects the fact that the survey indicator is the most influential forecast input.

The use of the spring advice alone implies a gap of approximately 18 months between the abundance indicator and the agreement on TACs. As such, in order to use the most up to date information, it seems logical to keep providing advice in the autumn. However, the merits of giving advice in spring (when the change to the previous autumn advice is, as shown, very low) and subsequently (in most cases) updating the advice again in autumn, seems counter-intuitive and adds to the workload of already-stretched Marine Institutes.

From 2012, WGMIXFISH-ADVICE has been held so that mixed fisheries advice can be available alongside ICES single species advice in June. The close proximity of WGMIXFISH to that of WGNSSK often implied revised runs of the mixed fishery analysis taking place in autumn. For this reason, the WGMIXFISH-ADVICE has been moved to the autumn to ensure that sufficient time is available to develop and deliver advice for all species (ICES, 2017). This is particularly true for regions where some of the advice is released in the autumn such as Nephrops. For example, the advice for Nephrops stocks in Division 6.a and Subarea 7 covered by the WGCSE has moved from spring to autumn since 2014 (ICES, 2015). This raises the question of why North Sea Nephrops advice is still required twice a year. The results of the analysis presented here support that, if the spring advice is requested by ICES costumers, then the autumn advice (provided in the previous year) is likely to be a good proxy with generally minimal changes coming up when a new forecast is run in the following spring.

Conclusion/Recommendation

Analyses carried out at WKNSROP showed that the spring advice given each year differs very little from the previous year's autumn advice. This is explained by the fact that information on stock abundance for the current year is not available in time for the WGNSSK meeting. It is recommended that Nephrops advice in the North Sea is delayed until autumn to make use of the summer Nephrops UWTV surveys. Alternatively, if advice for Nephrops is still required in June, it is recommended that the preceding autumn advice is used.

Table 4.2.1. Timing of North Sea FUs summer surveys

FU	Ground	Country	Month
6	4.b - Farn Deeps	England	June
7	4.a - Fladen	Scotland	June
8	4.b - Firth of Forth	Scotland	August
9	4.a - Moray Firth	Scotland	August
3-4	3.a - Skagerrak-Kattegat	Denmark/Sweden	DK: April; SW: May/June

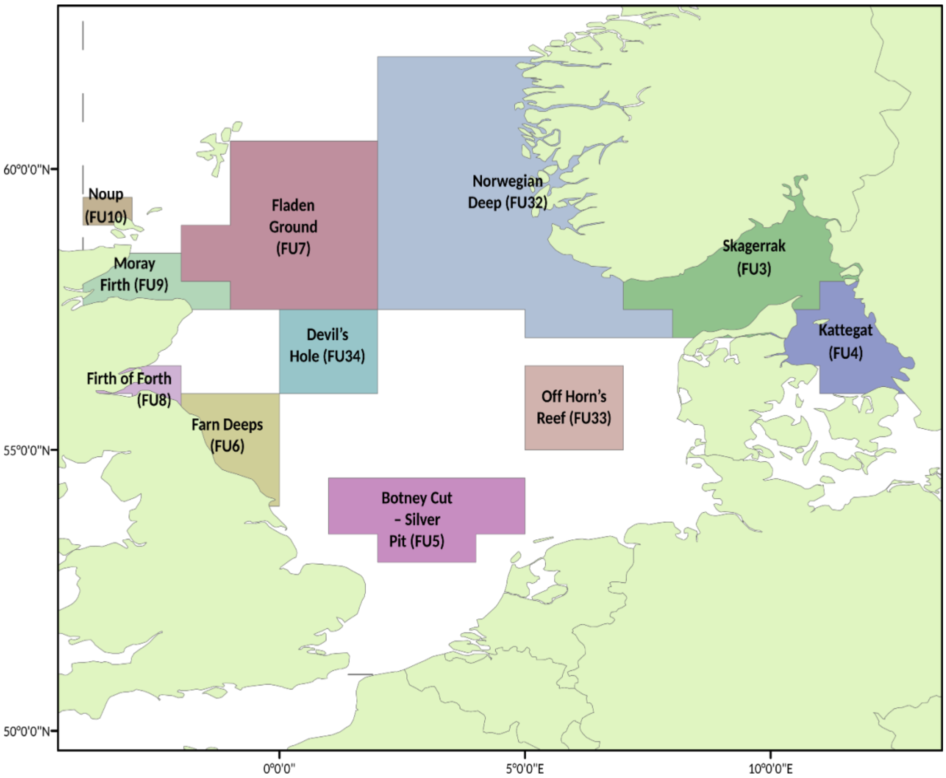

Figure 4.2.1. Functional Units in the North Sea, Skagerrak and Kattegat.

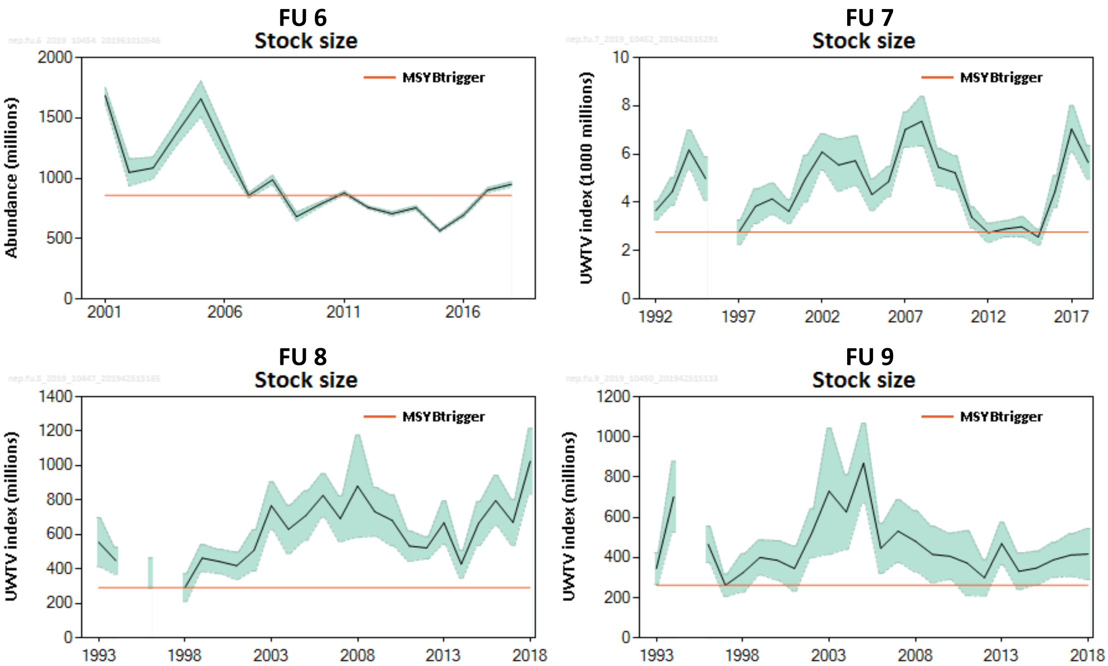

Figure 4.2.2. Underwater TV survey abundance for FUs 6, 7, 8 and 9. Shaded areas indicate 95% confidence intervals.

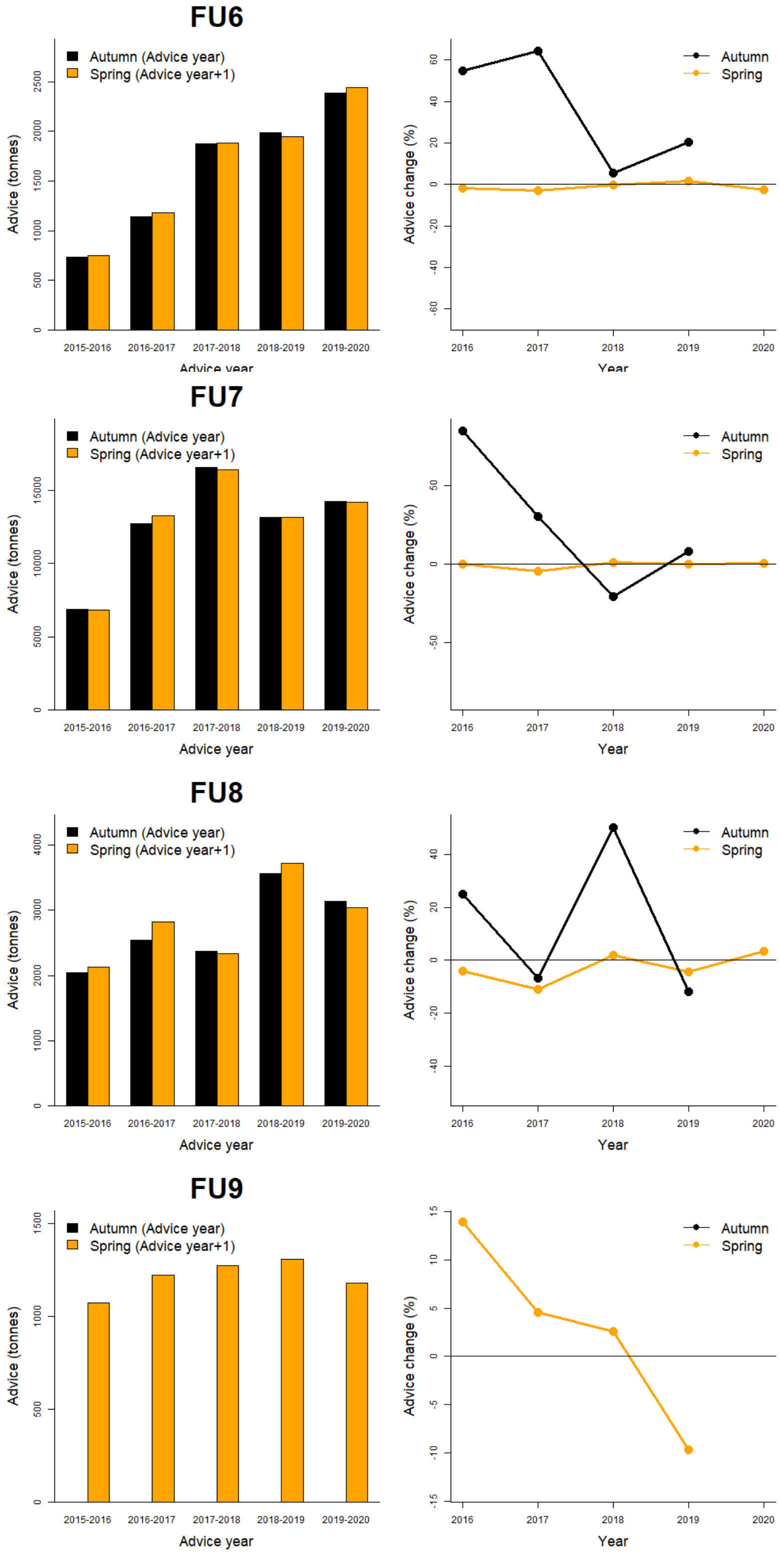

Figure 4.2.3. Comparison of spring and autumn total advice (left) and percentage changes (right) between autumn/spring advice (orange line) and autumn y/autumn y+1 advice (black line) for Nephrops FUs 6, 7, 8 and 9 in the period 2015–2020. [Note, the orange line for FU9 is the change from one spring advice to another spring advice the following year, which is different from the orange lines for the other FUs.]

5 Intermediate year assumptions on fishing mortality (F)

5.1 Introduction

Alongside assumptions on recruitment strength in the intermediate and TAC year are the assumptions for the fishing mortality F during the intermediate year, both of which can have a major impact on forecast results, and therefore on the advice for fishing opportunities.

In 2020, the advice for cod provides a good example of how sensitive the advice for fishing opportunities can be to assumptions made about the fishery (and resultant fishing mortality) in the intermediate year. Figure 5.1.1 illustrates two contrasting examples of fishing opportunities in the TAC year (orange dots) which differ markedly depending on what is assumed about the fishery in the intermediate year. Assuming a multiplier of 1 for the intermediate year (i.e. the intermediate year F is the same as the F in 2019, implying an F_{SQ} assumption) leads to a total catch in 2021 of 161 tonnes; in contrast, assuming the TAC is taken in the intermediate year (i.e. the F multiplier is markedly lower at 0.46 to achieve this) leads to a total catch in 2021 of 19 905 tonnes. Any additional information about the intermediate year F would therefore be helpful when it comes to producing a reliable forecast for the following year.

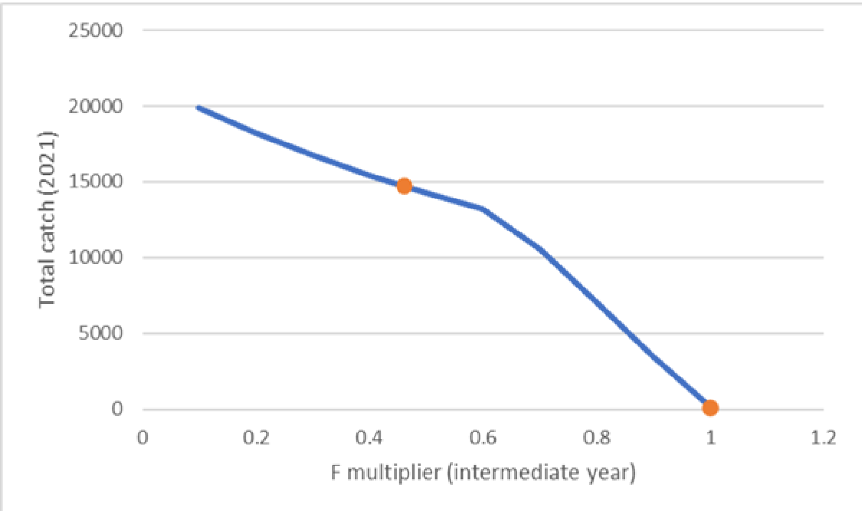

Figure 5.1.1. Cod 47d20. Total catches in 2021 corresponding to the MSY approach (i.e. F = F_{MSY}×SSB_{2021}/$B_{trigger}$ where this brings SSB above B_{lim} in 2022, and the F corresponding to SSB (2022) = B_{lim} otherwise) assuming different multipliers on F(2019) in the intermediate year. The orange dots correspond to full TAC utilisation (F multiplier of 0.46) and F status quo (F multiplier of 1).

Therefore, WKNSROP discussed the availability of data from the fishery in the intermediate year to be able to make more informed decisions on the intermediate year F during the reopening procedure. Based on historic data available from Intercatch to stock assessors, it was tested whether landings after quarter 1+2 or after quarter 1+2+3 can be used to predict landings during the full year. Based on the results, ways to include the knowledge on intermediate year landings in the current reopening protocol are proposed.

5.2 Availability of data on the fishery during the intermediate year

In general, two sources of information were identified that may be available at the time of the reopening procedure. These are fishing effort data from e.g., the first and second quarter, and information on quota uptake or absolute landings up to a certain month (e.g. August or September).

Participants at the workshop were representing Norway, the UK, Germany, France and the Netherlands. Belgium provided input via e-mail exchange. Therefore, all relevant countries apart from Denmark and Sweden were represented at the workshop.

Early in the discussions, it became obvious that in-year effort estimation based on logbooks or similar data sources would be very difficult to provide in time for the reopening. Participants indicated that it is unlikely to deliver such data for the UK, Norway, France, Belgium and the Netherlands. Therefore, updating the intermediate year assumption based on information from fishing effort of metiers in the intermediate forecast year was not discussed further.

In contrast, most participants indicated that it may be possible to deliver data on quota uptake or landings up to a certain month for the intermediate year of forecasts:

Norway: National authorities provide publicly available weekly updates on catch statistics for Norwegian fisheries catching saithe (broken down per fleet) and cod in the North Sea. Weekly reports are archived and accessible as far back as 2014. These include a total catch for the current year (and a comparison with the total catch up to the same week the year before), making it straightforward to estimate catches over quarter 1-2 or 1-3, as early as one week after completion of the last required quarter. Some recent catch reports may be missing from the weekly updates, but the percentage seems typically low: *e.g.* less than 3% retrospectively estimated for week 34, 2019, based on reports in 2019 and 2020.

UK-Scotland: It is possible to provide regular updates on landings statistics for Scottish fisheries catching cod, haddock, whiting, saithe, sole, plaice and *Nephrops* in the North Sea, as well as saithe and haddock West of Scotland. These updates include any quota swaps within the considered period.

UK-England: Information on quota uptake is currently not available for England. However, providing data to ICES on landings up to a certain date via a data call may be possible.

Germany: Information on quota uptake and landings up to a certain date can be retrieved from national authorities. Data from e-logbooks should be available more-or-less in real time while information from small vessels using normal logbooks is lagging behind. However, landings from small German vessels fishing in the North Sea are low.

Belgium: Information on quota uptake can be made available. Therefore, providing information on landings up to a certain date should also be possible.

France: Information on quota uptake is currently not available for France. Providing preliminary landing data up to a certain date via an ICES data call should be possible.

Netherlands: Information on quota uptake is not routinely available from the national authorities during the year. It is currently being collected and assembled with a large lag in time. Most likely these data cannot be expected to be provided in the required manner unless a legal requirement is established.

Denmark: No participant from Denmark

Sweden: No participant from Sweden

5.3 Relationships between landings up to a certain quarter and landings for the full year

After short discussions about whether information on quota uptake by country or landings up to a certain quarter would give more useful information, it became obvious that landings information from all relevant countries is clearly preferable. It finally needs to be checked whether predicted landings for the full year based on landings information up to quarter two or quarter three are in line with the assumed landings for the intermediate year in the forecasts. By just comparing the landings, it is implicitly assumed that the real discard rate is the same as assumed in the forecasts. This needs to be assumed as it is unlikely that actual information on discards can be made available during the year.

In order to predict the landings for the whole intermediate year based on information from a potential data call, strong relationships are needed between landings up to e.g., quarter 1+2 or quarter 1+2+3 and the landings for the full year.

For the six fish stocks under the reopening protocol (Nephrops stocks have no forecast) data were extracted from Intercatch to analyse the relationships between landings up to quarter two or quarter three and the landings for the full year (Figures 5.3.1–5.3.6).

A certain part of the landings information in Intercatch is provided on an annual basis and not by quarter. The annual values were redistributed assuming that the distribution over the quarters is the same as for the information provided by quarter, using the following formulation:

$$Q_{adj} = (Q \times T)/(T - A)$$

where Q is the quarter 1+2 or quarter 1+2+3 landings, T is the total quarterly landings, and A the landings that are only reported as annual values. In most cases and years, the proportion of annual values that needed to be redistributed was below 10%, but it can reach up to over 45% for some years and stocks. Therefore, relationships without the adjustment and with the adjustment are shown in Figures 5.3.1 to 5.3.6.

The relationships between landings up to quarter two or three and the landings for the full year were strong for all species. Relationships generally became stronger when taking into account the adjustment for landings reported on an annual basis (there were two exceptions, one of which was negligible, the other due to influential points in the regression). This was especially the case for North Sea haddock and saithe. Relationships were also stronger with landings up to quarter three than up to quarter two. When taking into account the adjustment for the annual values, the R squared values of the relationships ranged between 0.62 (whiting 47d) and 0.91 (plaice 4) using landings up to quarter two as explaining variable. The R squared values ranged between 0.84 (whiting 47d) and 0.99 (sole 4) when using landings up to quarter three. Apart for North Sea whiting, the relationships with adjusted values and landings up to quarter three as explaining variable had an R squared value above 0.9.

The reason for the strong relationships is that the proportions of landings up to quarter two or three to the landings for the full year stayed, in most cases, at a very similar level over the years analysed (Figure 5.3.7). A certain trend in the proportions over time was visible for whiting 47d and to a lesser extent for cod 47d20 and saithe 3a46 (especially proportions of landings up to quarters 2).

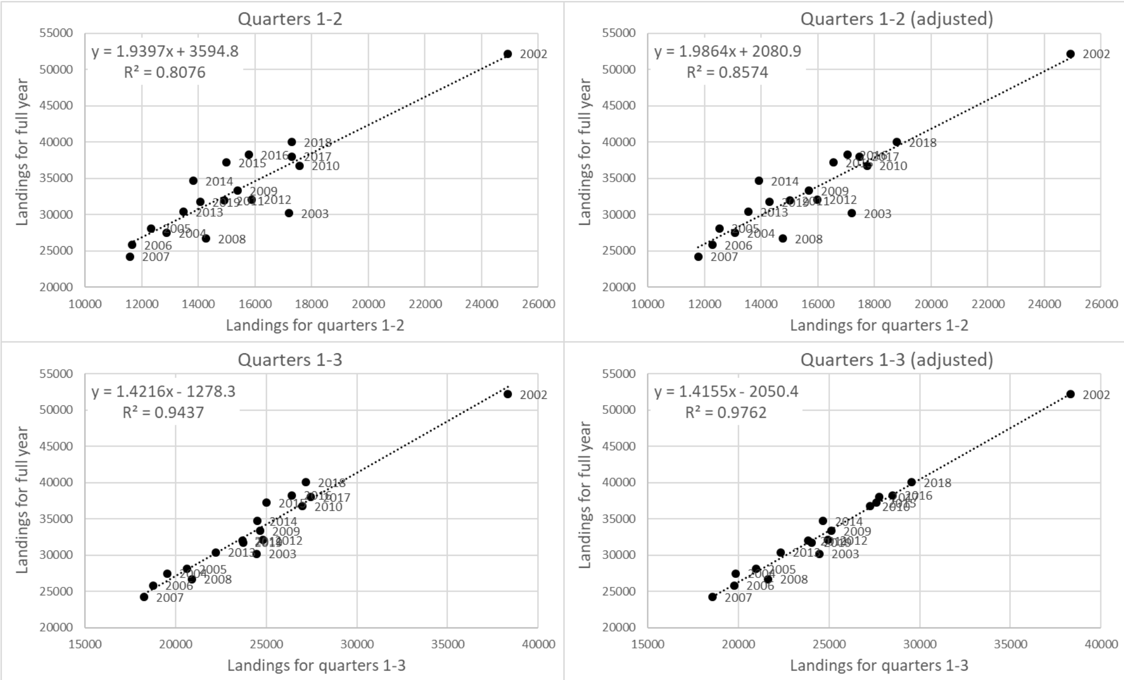

Figure 5.3.1. Cod 47d20. Relationships between total landings after Q 1&2 or Q 1&2&3 and landings for the full year as reported to Intercatch for the years 2002–2019. On the right are the relationships with values adjusted for landings reported annually.

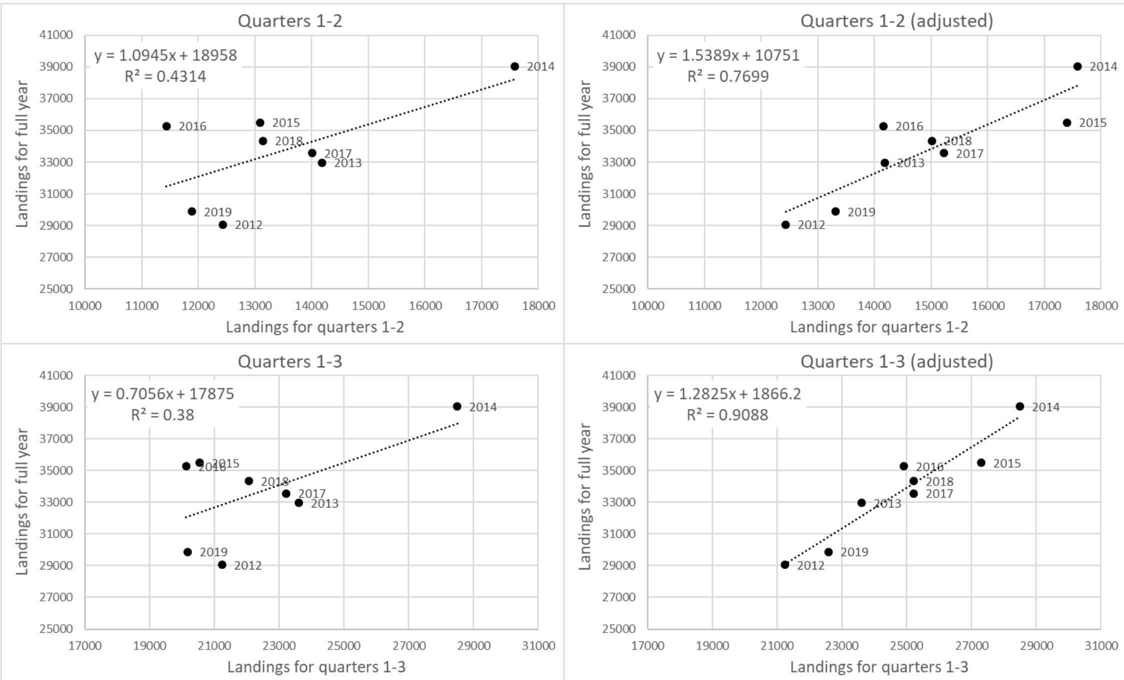

Figure 5.3.2. Haddock 46a20. Relationships between total landings after Q 1&2 or Q 1&2&3 and landings for the full year as reported to Intercatch for the years 2002–2019. On the right are the relationships with values adjusted for landings reported annually.

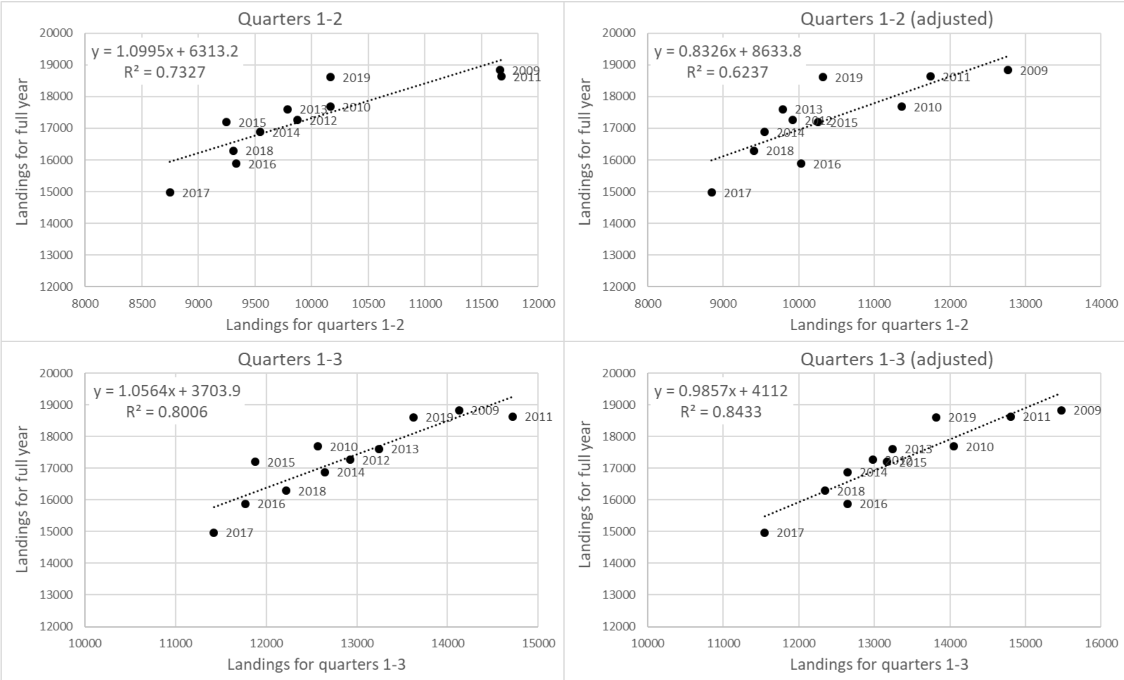

Figure 5.3.3. Whiting 47d. Relationships between total landings after Q 1&2 or Q 1&2&3 and landings for the full year as reported to Intercatch for the years 2009–2019. On the right are the relationships with values adjusted for landings reported annually.

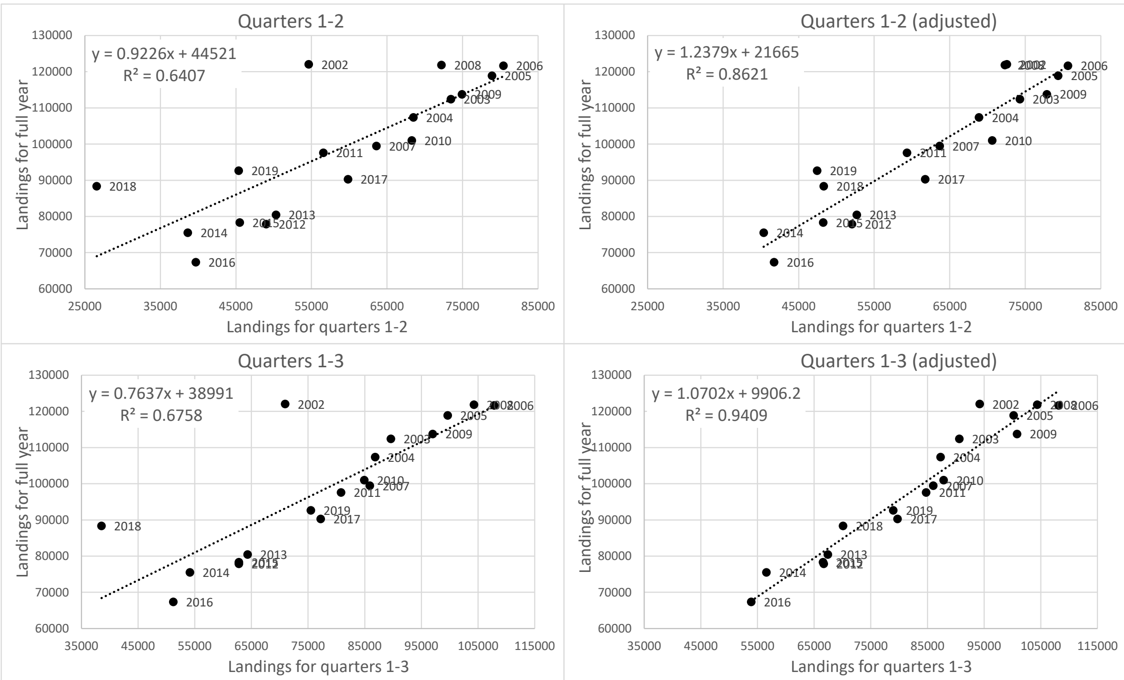

Figure 5.3.4. Saithe 3a46. Relationships between total landings after Q 1&2 or Q 1&2&3 and landings for the full year as reported to Intercatch for the years 2002–2019 (2002–2017 compiled by WGMIXFISH and 2018, 2019 by WGNSSK). On the right are the relationships with values adjusted for landings reported annually.

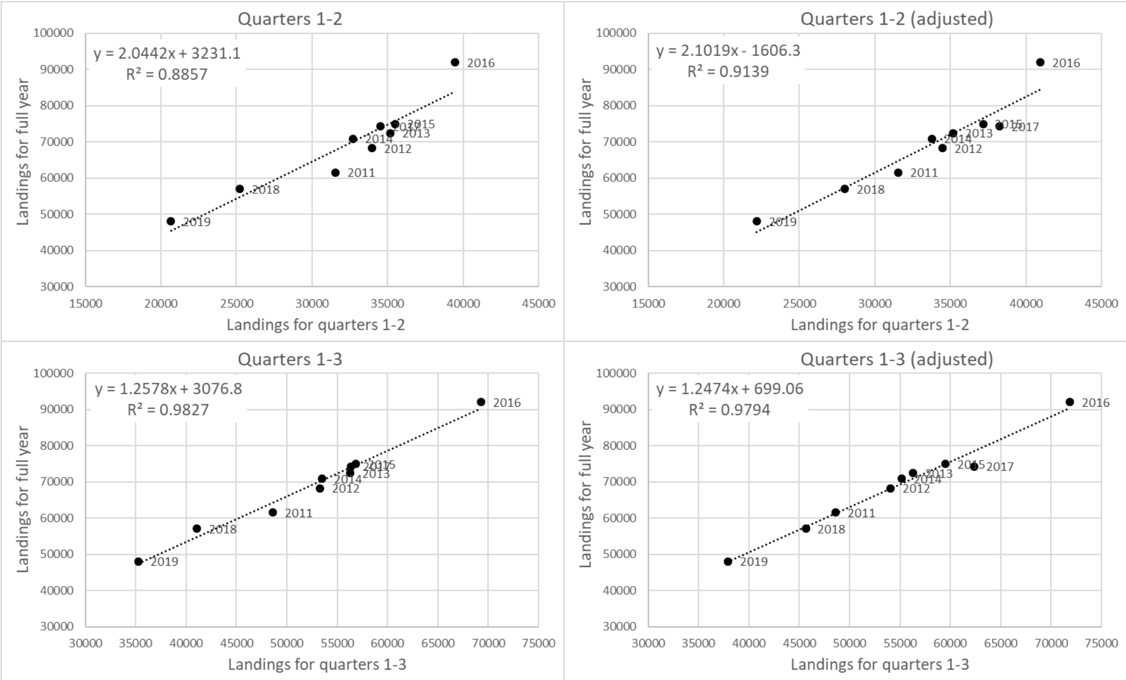

Figure 5.3.5. Plaice 420. Relationships between total landings after Q 1&2 or Q 1&2&3 and landings for the full year as reported to Intercatch for the years 2011–2019. On the right are the relationships with values adjusted for landings reported annually.

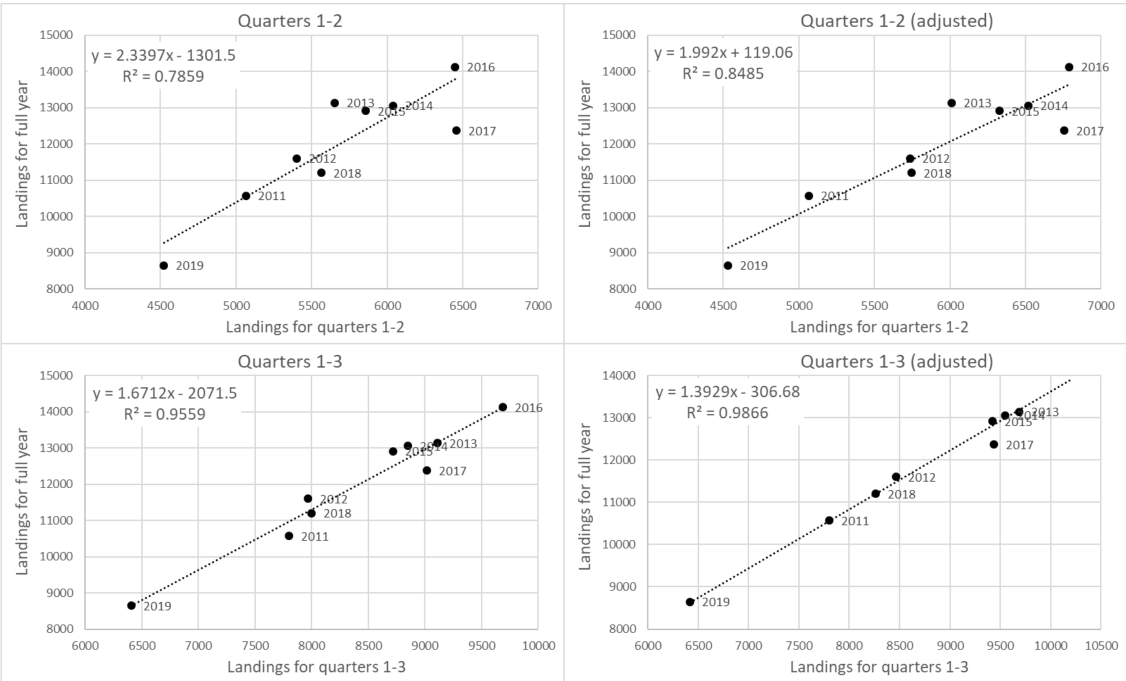

Figure 5.3.6. Sole 4. Relationships between total landings after Q 1&2 or Q 1&2&3 and landings for the full year as reported to Intercatch for the years 2011–2019. On the right are the relationships with values adjusted for landings reported annually.

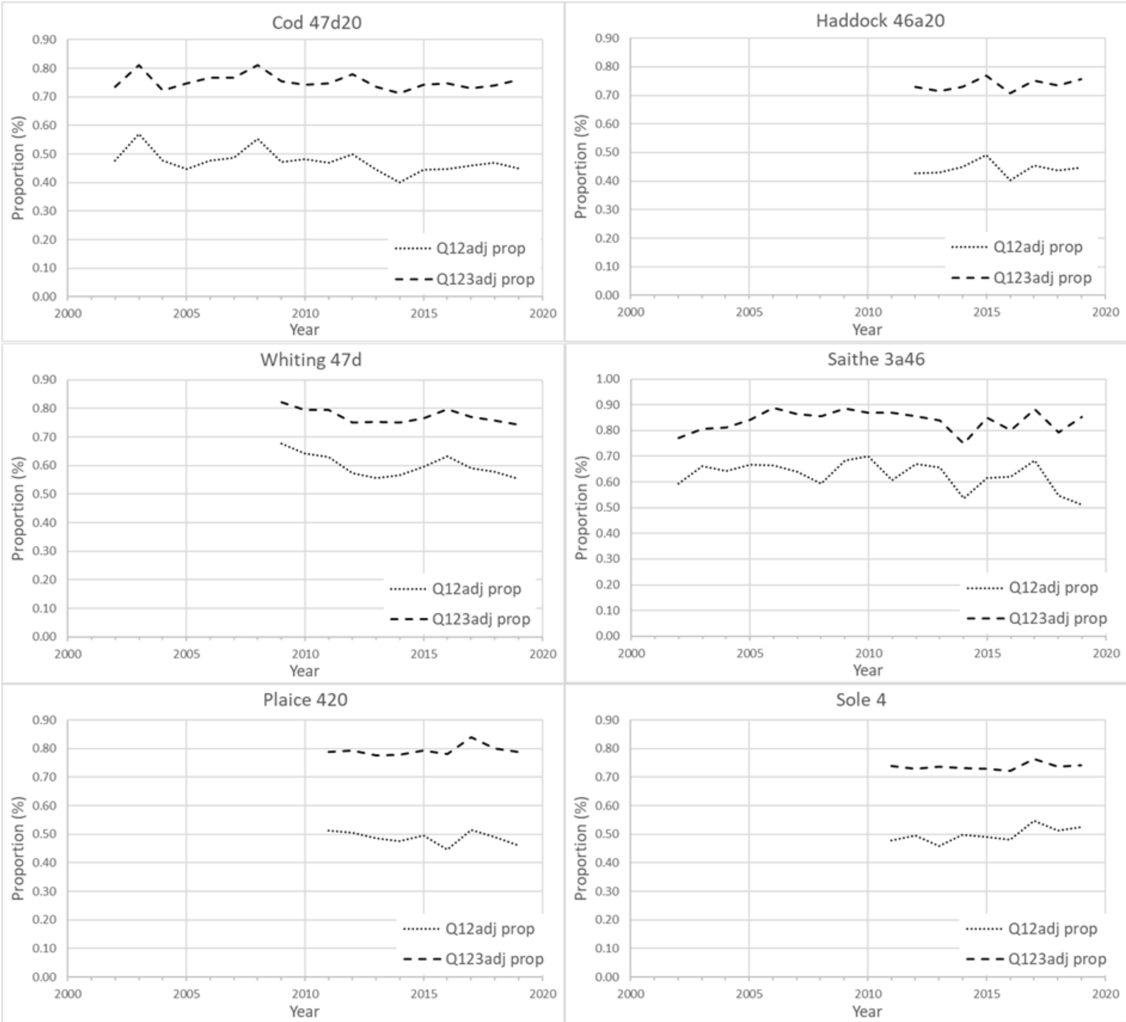

Figure 5.3.7. Proportion of landings for quarters 1-2 and for quarters 1-3 to the landings for the full year.

5.4 Example applications of reopening checks for the intermediate year assumption on F

The relationships between landings up to a certain time in the year and the landings for the full year can be used within a reopening protocol to check the intermediate year assumptions made for fishing mortalities. For this, the total landings that can be expected for the full year need to be predicted based on the relationships found in Section 5.3. The resulting value can be compared to the landings assumed for the intermediate year in the June forecasts. Next, to this a threshold triggering the reopening of advice needs to be agreed to judge whether the difference between the landings assumed in the June forecasts and the predicted landings based on the in-year landings information are acceptable or not.

In Tables 5.4.1–3 it is shown for the last 5 years whether a reopening would have been triggered with a threshold of 20%, 15% or 10% difference between the prediction based on the in-year information on landings and the June forecast assumption.

With a threshold of 20% a reopening would have been triggered in 9 out of 30 cases when using relationships with landings information up to quarter two and in 8 out of 30 cases when using landings information up to quarter three. A reopening would have been needed quite often for plaice 420 as the landings were often much lower than assumed in the June forecasts. No reopening would have been needed for cod 47d20 and saithe 3a46.

With a threshold of 15%, the number of reopening events would increase to 14 using in-year landings information up to quarter two, and 13 with landings information up to quarter three.

A threshold of 10% would have led in 18 or 22 cases (respectively for information up to quarter two, or quarter three) to a reopening of advice, and therefore in more than 50% of the cases.

Although the difference between the predicted landings for the full year and the observed landings for the full year was only in few cases above 10% (can be derived from Tables 5.4.1-3), there is a clear trade-off between an as low as possible threshold and a reasonable number of reopening events. If a reopening is triggered in nearly all years, it can be easily questioned why the whole procedure is needed and why assessments and forecasts are carried out in spring and not in autumn when all the information becomes available (see also Section 4).

Table 5.4.1 Comparison between June intermediate year assumption on landings (called "wanted catch" in advice sheets until 2019) and landings predicted based on in-year information up to quarter two or three (adjusted for annual values). A threshold of 20% difference was applied to decide whether a reopening is needed.

	Intermediate year assumptions				Landings observed		Predicted landings full year		Total landings	Conclusion	Conclusion
Year	F	Assumption	Catch	Wanted	Q12 adj	Q123 adj	pred Q12	pred Q123	Observed	Q12	Q123
Cod 47d20											
2015	0.4	Status quo	54121	42394	16564	27595	34983	37011	37205	NOT REOPEN	NOT REOPEN
2016	0.39	Status quo	56302	44837	17057	28513	35963	38310	38230	NOT REOPEN	NOT REOPEN
2017	0.35	Status quo	55207	41939	17482	27755	36808	37236	37994	NOT REOPEN	NOT REOPEN
2018	0.45	Status quo	49278	37649	18797	29559	39418	39790	40012	NOT REOPEN	NOT REOPEN
2019	0.49	TAC	35357	30271	14290	24058	30468	32004	31726	NOT REOPEN	NOT REOPEN
Haddock 46a20											
2015	0.233	Assessment model	39939	32581	17394	27302	37564	36958	35493	NOT REOPEN	NOT REOPEN
2016	0.378	Status quo	78980	62993	14163	24914	32411	33677	35275	REOPEN	REOPEN
2017	0.183	TAC	45084	39409	15226	25223	34106	34101	33556	NOT REOPEN	NOT REOPEN
2018	0.226	TAC	48990	43891	15011	25222	33763	34101	34341	REOPEN	REOPEN
2019	0.194	TAC	33956	30508	13316	22586	31060	30478	29873	NOT REOPEN	NOT REOPEN
Whiting 47d											
2015	0.23	Status quo	35592	21731	10251	13165	17169	17099	17195	REOPEN	REOPEN
2016	0.228	Status quo	31961	18537	10029	12644	16984	16585	15880	NOT REOPEN	NOT REOPEN
2017	0.244	Status quo	36466	20916	8845	11547	15998	15504	14974	REOPEN	REOPEN
2018	0.218	Status quo	29451	16961	9403	12346	16463	16292	16290	NOT REOPEN	NOT REOPEN
2019	0.199	Status quo	26131	16953	10315	13822	17222	17746	18609	NOT REOPEN	NOT REOPEN
Saithe 3a46											
2015	0.325	TAC	79702	72854	48248	66569	79727	81148	78307	NOT REOPEN	NOT REOPEN
2016	0.24	TAC	72442	68601	41748	53884	71253	67572	67360	NOT REOPEN	NOT REOPEN
2017	0.381	TAC	123135	106331	61747	79703	97324	95205	90263	NOT REOPEN	NOT REOPEN
2018	0.258	Status quo	100640	93947	48324	70108	79825	84936	88348	NOT REOPEN	NOT REOPEN
2019	0.36	Status quo	88709	81897	47448	78961	78684	94410	92661	NOT REOPEN	NOT REOPEN
Plaice 420											
2015	0.18	Status quo	142650	99252	37157	59516	78106	74915	74963	REOPEN	REOPEN
2016	0.17	Status quo	151362	109282	40960	71870	86099	90321	91959	REOPEN	NOT REOPEN
2017	0.202	Status quo	140662	96853	38245	62386	80393	78494	74217	NOT REOPEN	NOT REOPEN
2018	0.199	Status quo	131993	84964	28028	45638	58915	57609	57012	REOPEN	REOPEN
2019	0.193	Status quo	138919	76721	22189	37889	46642	47947	48061	REOPEN	REOPEN
Sole 4											
2015	0.25	Catch constraint	12761	11893	6328	9419	12723	12815	12912	NOT REOPEN	NOT REOPEN
2016	0.16	Catch constraint	13268	12021	6791	10207	13646	13911	14127	NOT REOPEN	NOT REOPEN
2017	0.2	Catch constraint	16123	14942	6757	9435	13579	12836	12370	NOT REOPEN	NOT REOPEN
2018	0.22	Status quo	14605	13568	5747	8260	11567	11199	11199	NOT REOPEN	NOT REOPEN
2019	0.22	Status quo	15137	13461	4533	6422	9148	8640	8647	REOPEN	REOPEN

Table 5.4.2 Comparison between June intermediate year assumption on landings (called “wanted catch” in advice sheets until 2019) and landings predicted based on in-year information up to quarter two or three (adjusted for annual values). A threshold of 15% difference was applied to decide whether a reopening is needed.

Intermediate year assumptions					Landings observed		Predicted landings full year		Total landings	Conclusion	Conclusion
Year	F	Assumption	Catch	Wanted	Q12 adj	Q123 adj	pred Q12	pred Q123	Observed	Q12	Q123
Cod 47d20											
2015	0.4	Status quo	54121	42394	16564	27595	34983	37011	37205	REOPEN	NOT REOPEN
2016	0.39	Status quo	56302	44837	17057	28513	35963	38310	38230	REOPEN	NOT REOPEN
2017	0.35	Status quo	55207	41939	17482	27755	36808	37236	37994	NOT REOPEN	NOT REOPEN
2018	0.45	Status quo	49278	37649	18797	29559	39418	39790	40012	NOT REOPEN	NOT REOPEN
2019	0.49	TAC	35357	30271	14290	24058	30468	32004	31726	NOT REOPEN	NOT REOPEN
Haddock 46a20											
2015	0.233	Assessment model	39939	32581	17394	27302	37564	36958	35493	REOPEN	NOT REOPEN
2016	0.378	Status quo	78980	62993	14163	24914	32411	33677	35275	REOPEN	REOPEN
2017	0.183	TAC	45084	39409	15226	25223	34106	34101	33556	NOT REOPEN	NOT REOPEN
2018	0.226	TAC	48990	43891	15011	25222	33763	34101	34341	REOPEN	REOPEN
2019	0.194	TAC	33956	30508	13316	22586	31060	30478	29873	NOT REOPEN	NOT REOPEN
Whiting 47d											
2015	0.23	Status quo	35592	21731	10251	13165	17169	17099	17195	REOPEN	REOPEN
2016	0.228	Status quo	31961	18537	10029	12644	16984	16585	15880	NOT REOPEN	NOT REOPEN
2017	0.244	Status quo	36466	20916	8845	11547	15998	15504	14974	REOPEN	REOPEN
2018	0.218	Status quo	29451	16961	9403	12346	16463	16292	16290	NOT REOPEN	NOT REOPEN
2019	0.199	Status quo	26131	16953	10315	13822	17222	17746	18609	NOT REOPEN	NOT REOPEN
Saithe 3a46											
2015	0.325	TAC	79702	72854	48248	66569	79727	81148	78307	NOT REOPEN	NOT REOPEN
2016	0.24	TAC	72442	68601	41748	53884	71253	67572	67360	NOT REOPEN	NOT REOPEN
2017	0.381	TAC	123135	106331	61747	79703	97324	95205	90263	NOT REOPEN	NOT REOPEN
2018	0.258	Status quo	100640	93947	48324	70108	79825	84936	88348	REOPEN	NOT REOPEN
2019	0.36	Status quo	88709	81897	47448	78961	78684	94410	92661	NOT REOPEN	REOPEN
Plaice 420											
2015	0.18	Status quo	142650	99252	37157	59516	78106	74915	74963	REOPEN	REOPEN
2016	0.17	Status quo	151362	109282	40960	71870	86099	90321	91959	REOPEN	REOPEN
2017	0.202	Status quo	140662	96853	38245	62386	80393	78494	74217	REOPEN	REOPEN
2018	0.199	Status quo	131993	84964	28028	45638	58915	57609	57012	REOPEN	REOPEN
2019	0.193	Status quo	138919	76721	22189	37889	46642	47947	48061	REOPEN	REOPEN
Sole 4											
2015	0.25	Catch constraint	12761	11893	6328	9419	12723	12815	12912	NOT REOPEN	NOT REOPEN
2016	0.16	Catch constraint	13268	12021	6791	10207	13646	13911	14127	NOT REOPEN	REOPEN
2017	0.2	Catch constraint	16123	14942	6757	9435	13579	12836	12370	NOT REOPEN	NOT REOPEN
2018	0.22	Status quo	14605	13568	5747	8260	11567	11199	11199	NOT REOPEN	REOPEN
2019	0.22	Status quo	15137	13461	4533	6422	9148	8640	8647	REOPEN	REOPEN

Table 5.4.3 Comparison between June intermediate year assumption on landings (called "wanted catch" in advice sheets until 2019) and landings predicted based on in-year information up to quarter two or three (adjusted for annual values). A threshold of 10% difference was applied to decide whether a reopening is needed.

	Intermediate year assumptions				Landings observed		Predicted landings full year		Total landings	Conclusion	Conclusion
Year	F	Assumption	Catch	Wanted	Q12 adj	Q123 adj	pred Q12	pred Q123	Observed	Q12	Q123
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2016	0.39	Status quo	56302	44837	17057	28513	35963	38310	38230	REOPEN	REOPEN
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2018	0.45	Status quo	49278	37649	18797	29559	39418	39790	40012	NOT REOPEN	NOT REOPEN
2019	0.49	TAC	35357	30271	14290	24058	30468	32004	31726	NOT REOPEN	NOT REOPEN
Haddock 46a20											
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2016	0.378	Status quo	78980	62993	14163	24914	32411	33677	35275	REOPEN	REOPEN
2017	0.183	TAC	45084	39409	15226	25223	34106	34101	33556	REOPEN	REOPEN
2018	0.226	TAC	48990	43891	15011	25222	33763	34101	34341	REOPEN	REOPEN
2019	0.194	TAC	33956	30508	13316	22586	31060	30478	29873	NOT REOPEN	NOT REOPEN
Whiting 47d											
2015	0.23	Status quo	35592	21731	10251	13165	17169	17099	17195	REOPEN	REOPEN
2016	0.228	Status quo	31961	18537	10029	12644	16984	16585	15880	NOT REOPEN	REOPEN
2017	0.244	Status quo	36466	20916	8845	11547	15998	15504	14974	REOPEN	REOPEN
2018	0.218	Status quo	29451	16961	9403	12346	16463	16292	16290	NOT REOPEN	NOT REOPEN
2019	0.199	Status quo	26131	16953	10315	13822	17222	17746	18609	NOT REOPEN	NOT REOPEN
Saithe 3a46											
2015	0.325	TAC	79702	72854	48248	66569	79727	81148	78307	NOT REOPEN	REOPEN
2016	0.24	TAC	72442	68601	41748	53884	71253	67572	67360	NOT REOPEN	NOT REOPEN
2017	0.381	TAC	123135	106331	61747	79703	97324	95205	90263	NOT REOPEN	REOPEN
2018	0.258	Status quo	100640	93947	48324	70108	79825	84936	88348	REOPEN	NOT REOPEN
2019	0.36	Status quo	88709	81897	47448	78961	78684	94410	92661	NOT REOPEN	REOPEN
Plaice 420											
2015	0.18	Status quo	142650	99252	37157	59516	78106	74915	74963	REOPEN	REOPEN
2016	0.17	Status quo	151362	109282	40960	71870	86099	90321	91959	REOPEN	REOPEN
2017	0.202	Status quo	140662	96853	38245	62386	80393	78494	74217	REOPEN	REOPEN
2018	0.199	Status quo	131993	84964	28028	45638	58915	57609	57012	REOPEN	REOPEN
2019	0.193	Status quo	138919	76721	22189	37889	46642	47947	48061	REOPEN	REOPEN
Sole 4											
2015	0.25	Catch constraint	12761	11893	6328	9419	12723	12815	12912	NOT REOPEN	NOT REOPEN
2016	0.16	Catch constraint	13268	12021	6791	10207	13646	13911	14127	REOPEN	REOPEN
2017	0.2	Catch constraint	16123	14942	6757	9435	13579	12836	12370	NOT REOPEN	REOPEN
2018	0.22	Status quo	14605	13568	5747	8260	11567	11199	11199	REOPEN	REOPEN
2019	0.22	Status quo	15137	13461	4533	6422	9148	8640	8647	REOPEN	REOPEN

5.5 Summary and conclusions

The work carried out during WKNSROP suggests that there is a straight-forward way to update the intermediate year assumption on F with information based on landings up to preferably quarter three. The relationships for all six stocks with forecasts under the reopening protocol were sufficiently strong to predict the likely amount of landings for the full year with a relatively low uncertainty. A comparison with the landings assumed in the June forecasts and an update of the intermediate year assumptions based on the predicted landings are the logical final steps. Therefore, including a check and update of the intermediate year assumption on F in the reopening protocol is justified from a scientific point of view.

However, in-year data availability is key for such an addition to the protocol. Not all experts indicated that it would be possible to deliver in-year information on landings up to quarter two or three (or something in between) without a legal obligation. At the same time, an official data call may be problematic as countries are not obliged to submit data from the current year in ”real time“ (information from ICES Secretariat). Nevertheless, a data call would look relatively straight forward and only asks for few variables (Table 5.5.1).

In conclusion, any addition to the reopening protocol likely needs to be based on a voluntary data submission by experts. If data cannot be made available, the respective steps in the proposed new reopening protocol (see Section 6) have to be skipped.

Another issue that cannot be solved by science alone is the question of an appropriate threshold to trigger a reopening based on intermediate year landings information. The relatively small differences observed between the predicted landings for the full year and the observed landings for the full year may justify thresholds as low as 10 percent. However, a 10 percent threshold would have led to a reopening in a large number of cases in the last 5 years. Therefore, input from ACOM is needed to decide on an appropriate threshold based on the intention to limit the number of reopenings to a manageable number of cases on the one hand, and making use of the existing information to provide better forecasts on the other. WKNSROP suggests a threshold between 10 and 20 percent.

Table 5.5.1. Variables and data (examples) needed for a reopening check on the intermediate year F assumption. Information could either be submitted to ICES accessions, or submitted directly to stock assessors.

Country	Year	Stock	Landings (t)	Landings up to date…
EXP	2020	cod.27.47d20	980	15.09.2020
EXP	2020	had.27.46a20	240	15.09.2020
EXP	2020	whg.27.47d	67	15.09.2020
EXP	2020	pok.27.3a46	5400	15.09.2020
EXP	2020	ple.27.420	1200	15.09.2020
EXP	2020	sol.27.4	450	15.09.2020

6 Proposal for updated reopening protocol

The following 5-step protocol is proposed as a replacement for the protocol developed during AGCREFA (Annex 3):

1. Ages to consider for reopening check:
   a) When selecting the ages to consider for the re-opening check, consideration should be given to how many times and to what extent a corresponding year-class has been observed in data sources used in the assessment (both fishery-dependent and -independent sources).
   b) In most cases, this will only be the first age used in the assessment; saithe is an exception, because this age (age 3) is not well sampled in either the fishery or surveys, so age 4 is used instead. In all cases, only the selected age is checked for the re-opening protocol for recruitment.

2. Re-opening check for recruitment:
   a) RCT3 to be used with the following settings:

Regression type?	C
Tapered time weighting required?	N*
Shrink estimates toward mean?	N
Exclude surveys with SE's greater than that of mean:	N
Enter minimum log S.E. for any survey:	0.0
Min. no. of years for regression (3 is the default)	3
Apply prior weights to the surveys?	N

***Taper weighting may be required for saithe to deal with variable and high F on age 4 prior to 2000**

   b) Only indices with new information (not previously included in the assessment or spring forecast) about the year-class in question (step 1) to be included.
   c) Full time series of assessment estimates for selected age (step 1) to be included, apart from the final estimate if uncertainty considerations warrant its exclusion.
   d) Re-opening triggered if $|D|>1$, where $D=(R-A)/S$ (Annex 3).

3. Forecast procedure once re-opening is triggered based on recruitment (step 2):
   a) Automatically update the intermediate year F assumption, if the required intermediate year data are available, based on an intermediate-year landings constraint using the relationship between landings for quarters 1-2 or 1-3 (depending on available data) and the total landings for the year (Section 5.3).
   b) For assessments that include intermediate year data:
      - Rerun the assessment with full data sets (including the new data).
      - Populate and rerun the forecast procedure with the resulting assessment estimates, and updated intermediate year F assumption (step 3a) if available.
   c) For assessments that do not include intermediate year data:
      - Rerun RCT3 with the settings of step 2, but using all indices that include information about the most recent year-class corresponding to the age selected in step 1.

  - Rerun the forecast procedure, replacing the spring value for the given year-class with the resulting RCT3 estimate, and updating the intermediate year F assumption (step 3a) if available.

4. Reopening check for intermediate year F assumption and forecast procedure if recruitment (step 2) has not triggered a reopening:

   a) Check whether the forecast assumption for the intermediate year landings is likely to be over or undershot by more than x% (ACOM to decide using Section 5.4), based on the historical analysis (Section 5.3) of the relationship between landings for quarters 1-2 or 1-3 (depending on available data) and the total landings for the year, if this data is available.

   b) If step 4a indicates a reopening, then rerun the forecast with the alternative intermediate year F assumption given in step 4a. No other change is made to the forecast apart from changing the intermediate year F assumption.

5. Procedure following re-opening

   a) ACOM to be notified of stocks for which re-opening is triggered, with accompanying revised forecasts, for approval.

   b) Once approved, EG to conduct audits and prepare revised advice sheets for the ADG, who will finalise advice for ACOM approval and release

7 Recommendations

It is recommended that:

1. Time series not formally included in the assessment, but used in the forecast to estimate the recruitment assumption for the intermediate year (such as age 0 DFS and SNS data for flatfish, when the youngest age in the assessment is age 1), be considered for inclusion in the assessment in future benchmarks;
2. ACOM discusses with clients that the autumn becomes the period when assessments and advice are developed for fish stock, and especially for Nephrops (arguments provided in Section 4). ACOM to discuss whether the performance of the reopening protocol shown so far (Section 2) is sufficient to further justify the effort put into the reopening of advice.
3. A data call be developed to acquire in-year landings information (preferably quarters 1-3) to check the appropriateness of the intermediate year F assumption in the spring forecast, as outlined in Section 5.5; furthermore, that the relationship used to evaluate the F assumption for re-opening (Section 5.3) be re-estimated every 3–5 years, for example during the benchmark process for a stock.
4. ACOM accepts the updated protocol as presented in Section 6, if ACOM and stakeholders come to the conclusion that a reopening is still needed.

8 References

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Annex 1: List of participants

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Annex 2: Resolution

2019/2/FRSG37 The Workshop on the North Sea reopening protocol (WKNSROP), chaired by Alexander Kempf, Germany, and José De Oliveira, United Kingdom, will be established and will meet 24–27 August 2020 by correspondence to:

a) Reconsider the autumn reopening protocol from ICES AGCREFA for North Sea stocks, particularly in relation to methods, settings and data (i.e. which age groups to consider) used, both for the reopening trigger mechanism, and for actual forecast update.
b) Consider the use of additional information for reopening that better informs the assumptions for the intermediate year in catch forecasts (e.g., information from the fisheries such as quota uptake, or fishing effort).
c) Evaluate the historic performance of the current reopening procedure in delivering improved recruitment estimates for short term forecasts.
d) Propose an updated reopening protocol taking into account timelines and data availability.

WKNSROP will report by 1 October 2020 for the attention of ACOM and FRSG.

Supporting Information

Priority	The work of ICES AGCREFA dates back to 2008, and there have been many benchmarks conducted and new assessment models introduced since then – the assessment and advice landscape has changed substantially, and it is time to revisit the protocol and to think about what additional information could be used in the forecasts when they are triggered by the protocol.
Scientific justification	As is bound to happen with a protocol that has been applied for many years, a number of inconsistences of application have crept in across stocks, both in terms of the settings applied and the data used. Also new methods could have emerged over time. TOR (a) deals with these aspects. In relation to the forecasts themselves, there is potentially more information and data available than is currently used, and TOR (b) explores if and how this additional information and data could be used directly in the forecast. TOR c will deliver an updated reopening protocol to be used in the coming years for the reopening of process.
Resource requirements	
Participants	
Secretariat facilities	
Financial	
Linkages to advisory committees	ACOM
Linkages to other committees or groups	WGNSSK
Linkages to other organisations	

Annex 3: Key extracts from the AGCREFA 2008

Method to determine if summer surveys provide reliable new information about recruitment

Advantages of using RCT3:

- It is generally applicable to the candidates for reopening advice based on summer survey information on recruiting year classes,
- It uses existing software that is readily available to the ICES community,
- It can be applied to a single survey or multiple surveys can be combined using inverse variance weighting,
- The statistical basis of the method is described in the primary scientific literature [Shepherd, J.G. 1997. Prediction of year-class strength by calibration regression analysis of multiple recruit index series. ICES Journal of Marine Science, 54: 741–752.],
- Software specifications can be standardized so that results are consistent and reproducible.

The RCT3 analysis gives a year-class strength prediction based on the survey information, and the standard error associated with the prediction. The difference between the assumed size of the recruiting year class in spring (before autumn surveys are available) and the RCT3 year-class strength estimates based on summer surveys, scaled to the internal standard error calculated by RCT3, is

$$D = (R - A)/S \qquad [1]$$

In this equation, R is the log Weighed Average Prediction from RCT3, A is the assumed year-class strength in spring assessment report, and S is the internal standard error from RCT3. Given recruitment series are indexed by j, and s_j is their respective standard error of an individual prediction, the internal standard error is defined as

$$S^2 = \left[\sum_j \left(1/s_j^2\right)\right]^{-1} \qquad [2]$$

based on the estimates of the individual standard errors by series (s_j). It represents a prior estimate of what we would expect the error of the final mean to be, taking account of the known errors of the individual estimates from which it is constructed (Shepherd, 1997).

ICES expert groups often use the regression and weighing analysis in RCT3 in combination with its capability to weigh the estimates toward the assessment means. However, for the proposed protocol for reopening advice, the assessment mean estimation of the year-class strength should not be taken into account. Table A3.1 gives the specifications that should be used to standardize application of RCT3.

Table A3.1. Specification for standardizing application of RCT3.

Regression type?	C
Tapered time weighting required?	N
Shrink estimates toward mean?	N
Exclude surveys with SE's greater than that of mean:	N
Enter minimum log S.E. for any survey:	0.0
Min. no. of years for regression (3 is the default)	3
Apply prior weights to the surveys?	N

Recommended protocol for reopening when summer survey data provides reliable new information about recruitment

A key judgement that must be made, is how certain should ICES be that summer surveys provide reliable new information. In theory (assuming normal statistics and that RCT3 estimates the internal standard error accurately), values of *D* can be interpreted as follows [adapted from the report, as there was clearly an error in the way it was originally written]:

$\lvert D\rvert > 0.67$	means there is at least a 50% probability that there is new information
$\lvert D\rvert > 1.0$	means there is at least a 67% probability that there is new information
$\lvert D\rvert > 2.0$	means there is at least a 95% probability that there is new information

It is important that the criteria used to trigger the reopening of advice be demanding enough (in terms of evidence that there is reliable new information) so that reopening is not common or frequent. Therefore the Group believes that there needs to be more than a 50:50 chance that there is new information, but it recognized that having 95% confidence (as is often used for statistical inferences) is too demanding for imprecise fisheries data. It recommends that reopening advice be triggered by a *D* value less than -1.0 or greater than 1.0.

The Group recommends the following protocol:

1. The appropriate Expert Group determines that summer survey data has been sufficiently quality assured to merit consideration as a basis for reopening advice. They document the steps that were taken to assure quality.
2. The appropriate Expert Group applies RCT3 (with the specification given in Table A3.1) to predict the size of recruiting year classes based on data from summer surveys.
3. The appropriate Expert Group calculates *D* according to Equation 1 using *R* and *S* from RTC3 (step 2) and *A* from the spring assessment.
4. If *D* is less than -1.0 or greater than 1.0, the process for reopening advice is triggered. If not, spring advice stands.
5. If reopening advice is triggered in step 4, the appropriate Expert Group updates assessment forecasts using the methodology deemed most scientifically appropriate by the expert group. In cases where the reopening of advice is triggered by recruitment that is higher than anticipated by the spring assessment, the trade-off between the short-term gain from increasing the catch in 2009 and the potential loss of catch in the medium term should be evaluated.
6. If reopening advice is triggered in step 4, the ACOM leadership designs a process to consider if spring 2008 advice should be changed to reflect the results of step 5.
7. If reopening advice is triggered in step 4, the appropriate Expert Group is available to responds to request from the ACOM leadership for additional information.

The AGCREFA report can be found here:

http://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/acom/2008/AGCREFA/AGCREFA_2008.pdf

Annex 4: Comparison of RCT3 versions

Marc Taylor and Colin Millar

A comparison was made between the currently-maintained GitHub R-package (rct3) and the previous script-based version of RCT3), the latter being a precursor to the current package. The most recent data for saithe (pok.27.3a46) was used in the demonstration, which is also simplified by the use of a single index (IBTS quarter 3) that facilitates the visualization of results. Variable settings for tapering and shrinkage were tested.

The results show that the rct3 R-package ("new") and script-based ("old") versions are identical in their reported predictions and regression statistics when the setting 'old = TRUE' is used in the new rct3 package (Figure A4.1). This setting adds a value of 1.0 to the indices before their log-transformation prior to model fitting. This is the only available setting in the old version, and thus is required for reproducibility. As mentioned in the rct3 package description, the use of this transformation should be done with caution, as it may have unintended consequences for indices with lower ranges of values.

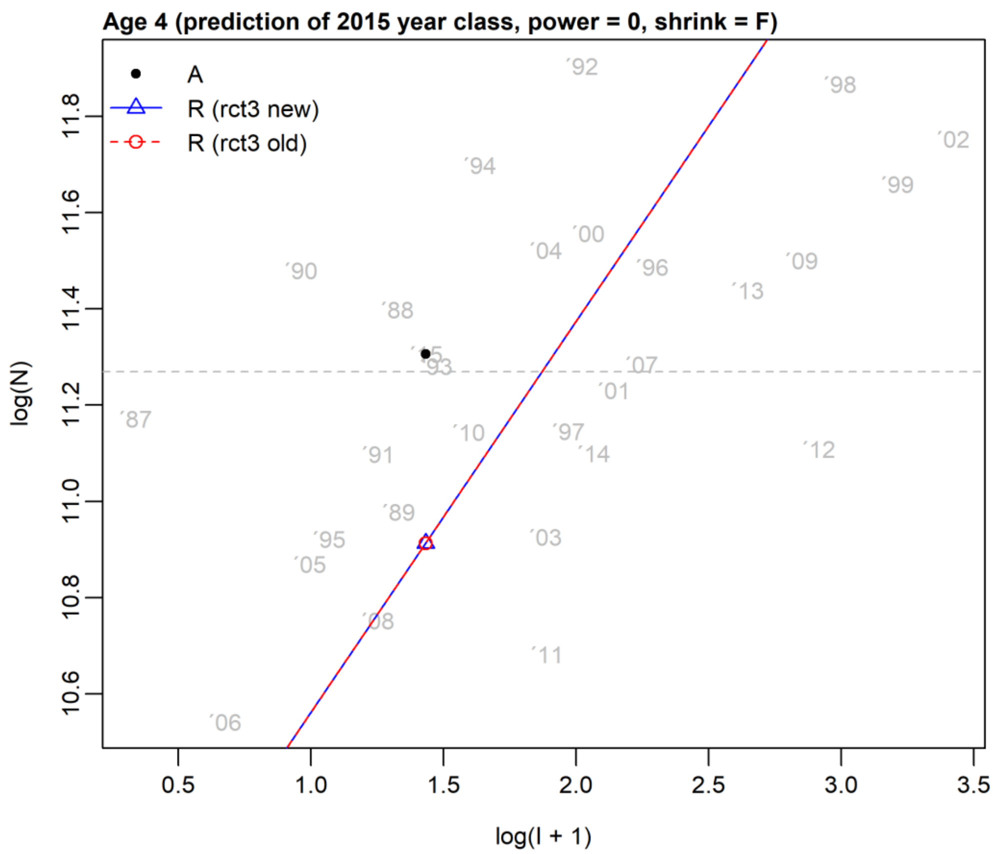

Figure A4.1. Comparison of reported predictions from R versions of RCT3. The "new" version refers to the rct3 R package, while the "old" version refers to a previous version of sourced functions. Regressions (lines) and predictions (coloured symbols) are shown for an example from saithe (pok.27.3a46), where age 4 numbers in 2019 (year class = 2015) are predicted by their 2019 IBTS quarter 3 indices. For reference, the assumed 2019 numbers used during the spring assessment for the purpose of forecasting is shown as a filled black point, and the mean of age 4 numbers in the time series is indicated by the dashed grey horizontal line.

Despite consistency in the predicted values and regression statistics, the old version reports a different prediction standard error, which affects the resulting distance metric (D) (see Annex 3, Eq. 1) (Figure A4.2). As a consequence, the threshold for reopening (|D >1.0) is ambiguous in many cases, depending on the version used.

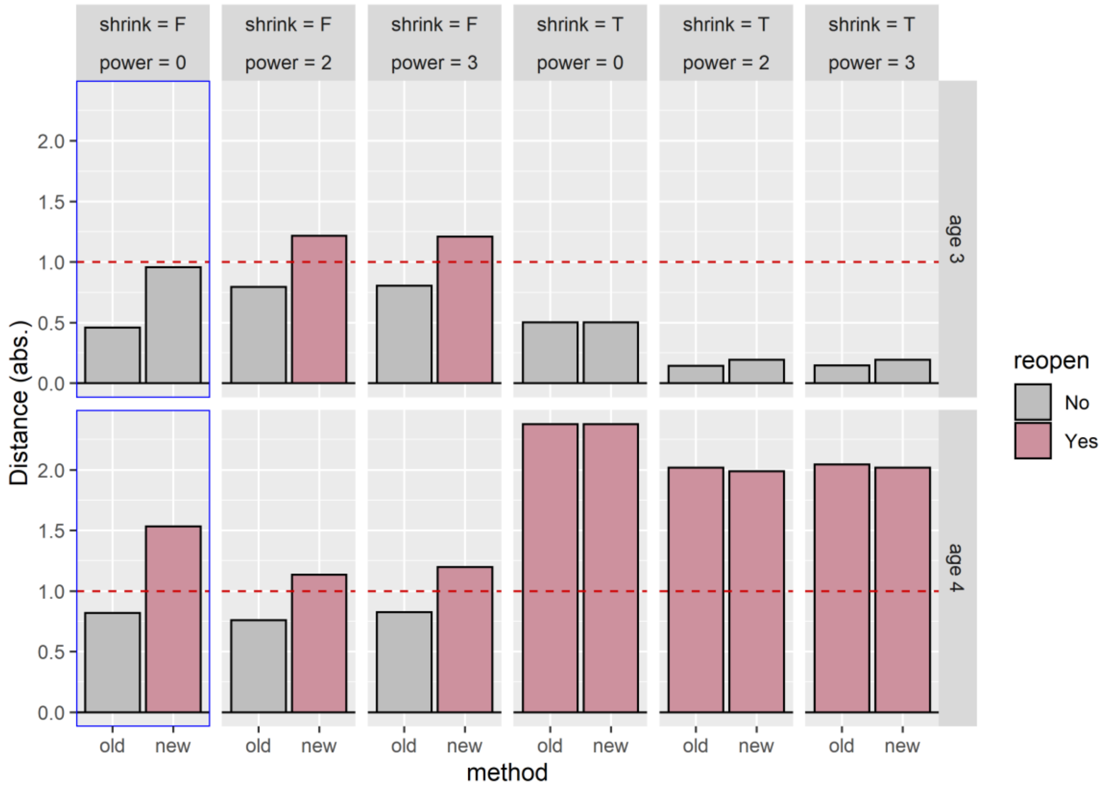

Figure A4.2. Comparison of the resulting distance metric (D) as estimated by the "new" (ICES GitHub R package, "rct3") and "old" (R scripted) RCT3 versions applied to data of ages 3 and 4 saithe (pok.27.3a46). Results are shown under different model settings for shrinkage ("shrink") and tapering ("power") weighting. Distance values exceeding 1.0 (dashed red line) should trigger a reopening of the assessment. The blue boxes indicate the default, AGCREFA-recommended, settings where no additional weighting (i.e. shrinkage or tapering) is applied.

The reasons for the underlying differences between the two versions were not investigated in detail; however several changes have been incorporated into the rct3 R-package that lead to results consistent with the original RCT3 DOS-based program. It is thus suggested that all RCT3 applications be done with the new R package in order to maintain a common methodology going forward. The package will continue to be developed with improved documentation and transparency. The addition of further diagnostic tools is planned, which include more informative warning and error messages when specific conditions are met (e.g. warnings of the pitfalls of using the "old" = TRUE setting, which adds 1.0 to all data before log-transformation). Further visualizations, might also aid users in the model interpretation. For example, Figure A4.3 shows the resulting partial predictions for each term in a more complicated model utilizing 12 different indices. Such visualizations would help in understanding the importance (i.e. weight) of each index to the overall prediction as seen through their relative confidence intervals.

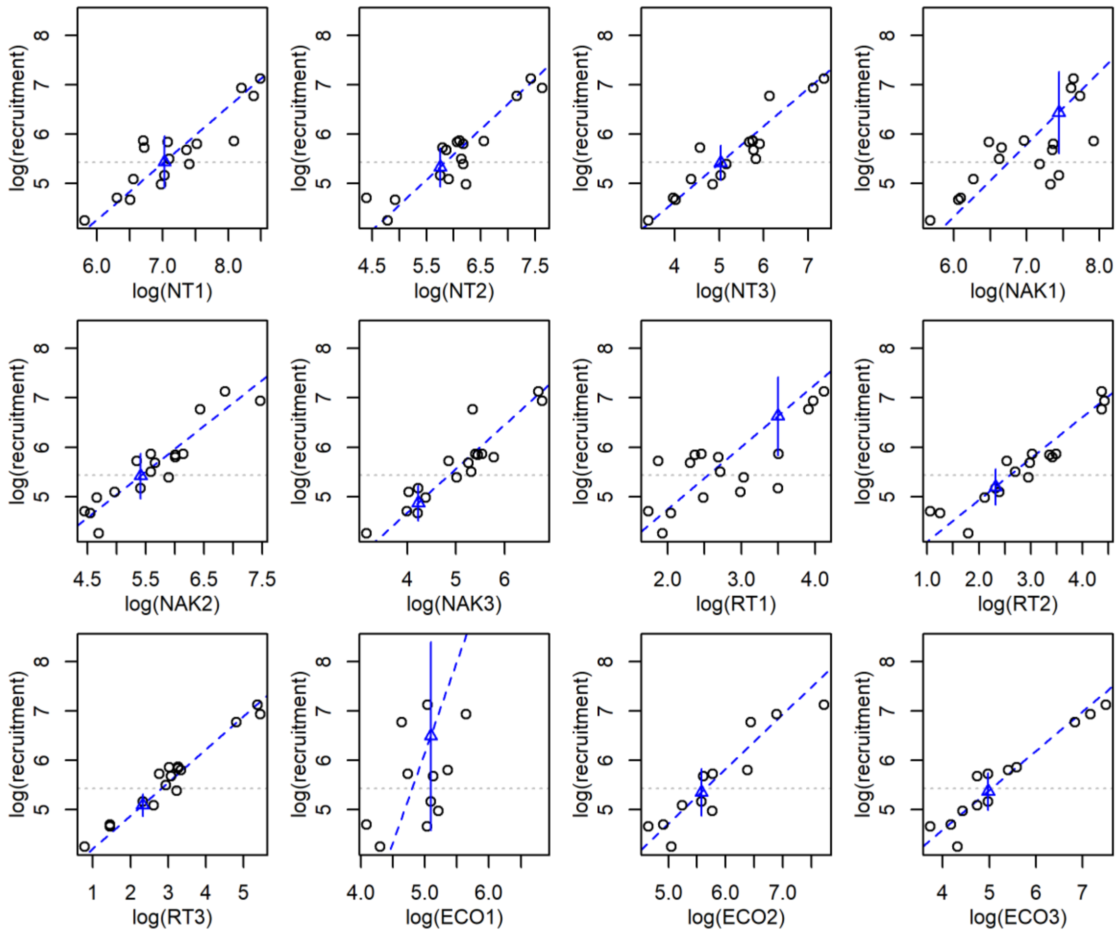

Figure A4.3. Visualization of individual term regressions (n = 12) derived from the rct3 package fitting. Regressions (coloured dashed lines) and predictions with associated errors (coloured symbols and vertical lines) are shown. The mean historical value is indicated by the dashed grey horizontal line. The data used are from an example data set included in the rct3 package, called "recdata".

Annex 5: Performance of Forecast Assumptions for North Sea Cod

Nicola Walker

Summary

For North Sea cod, there is the perception that short-term forecasts each year tend to be more optimistic in terms of SSB than realised values in subsequent years, as observed in the data and estimated by assessments. A comparison of the 2013 forecast assumptions with subsequent realised values from the 2014 assessment was conducted (ICES, 2015a) and the last benchmark for North Sea cod recommended that further comparisons with more years be made to get a better idea of potential biases (ICES 2015b). Here forecast assumptions from 2017 onwards are compared to realised values from subsequent assessments and observed data. The largest biases (in terms of percentage difference) are caused by assumed recruitment followed by SSB and are a consequence of the retrospective pattern in the assessment. Additionally, performance of the reopening protocol also relates to the retrospective pattern, with forecast assumptions performing better only when they are revised in the direction of the retrospective pattern. While there are directional biases for some ages in terms of biological and fishery assumptions, these are small in comparison.

Forecast assumptions

Forecast assumptions from 2017, when the last major change to the forecast procedure was made, are compared to realised values from subsequent assessments and observed data. The analysis includes three Working Group (WG) forecasts conducted in May and two October forecasts that were conducted in 2017 and 2019 after a reopening of the advice was triggered. This document considers all assumptions made up to calculation of SSB at the beginning of the TAC year.

Selectivity

Selectivity is taken as a three-year average. However, selectivities from the 2020 assessment indicate recent decreasing trends for ages 2 and 6+ and increasing trends for ages 3–4 (Figure A5app.1), thereby increasing the potential to overestimate selectivity of ages 2 and 6+ and underestimate selectivity of ages 3–4 when taking averages for forecasting. This is evident from Figure A5.1 and Table A5.1B which show that the selectivity of age 2 has been consistently overestimated and the selectivities of ages 3–4 mostly underestimated.

The forecasting software has been updated since the last benchmark, and the default setting for selectivity is now to let it emerge from the multivariate F-processes, thereby preserving the observed uncertainty in selectivity going into the forecast. This could be a better option than taking a three-year average and may be able to deal with recent trends in selectivity. In particular, the option to use a three-year average was written into the software for consistency with the stock annex and is not recommended by the developer.

In addition, selectivities are derived from fishing mortality and therefore revised with each new assessment. This can be seen from differences in intermediate year selectivity assumptions derived from May and October assessments (Table A5.1A) and in Figure A5.1 where different shapes indicate different selectivity estimates between assessments. For example, when looking at the 2019 assessment the forecasted selectivity for 2018 appears to have overestimated ages 5+, but revisions to the assessment in 2020 show the same forecasted values to be underestimates.

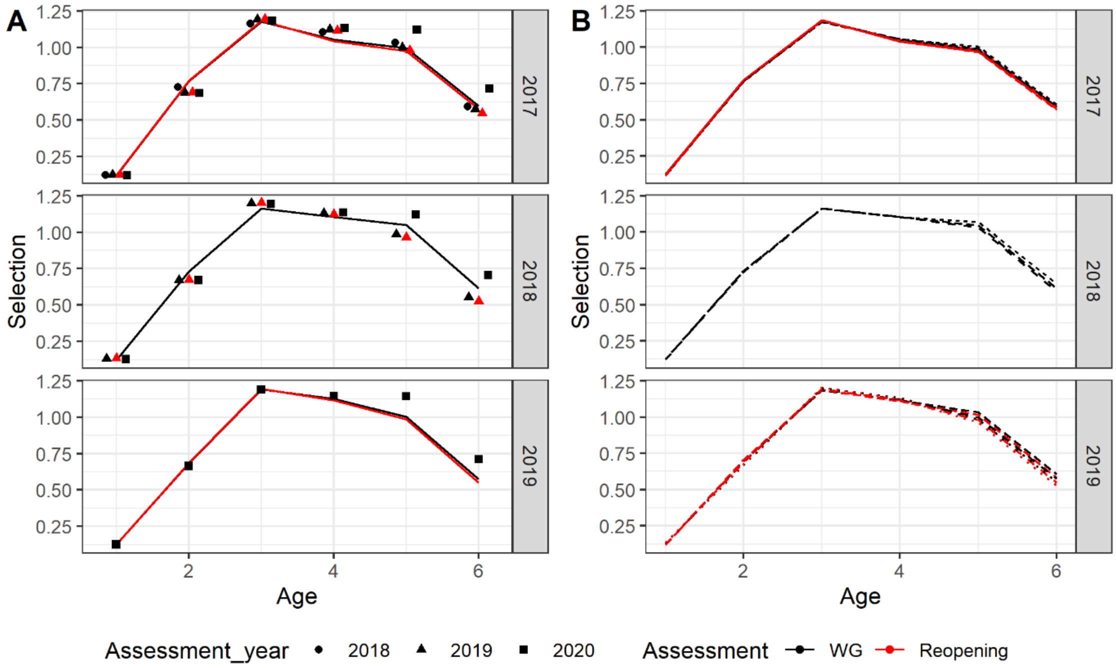

Figure A5.1. Performance of intermediate year selectivity assumptions. (A) Solid lines show the selectivity assumptions made for each forecast while points show realised selectivities for that year derived from subsequent assessments. (B) Selectivities from earlier years used to calculate three-year averages.

Table A5.1. Percentage difference between (A) intermediate year selectivity assumptions made in May compared to October when advice was reopened and (B) intermediate year selectivity assumptions and realised selectivities derived from subsequent assessments (as shown in Figure A5.1). Assessments and forecasts from the reopening procedure are highlighted in red.

A

Forecast	1	2	3	4	5	6+
2017	-2%	-1%	0%	1%	2%	4%
2019	-1%	-1%	0%	1%	2%	5%

B

Forecast	Assessment	1	2	3	4	5	6+
2017	*May forecast*						
	2018	-3%	6%	1%	-5%	-4%	1%
	2019	-3%	12%	-1%	-6%	-1%	4%
	2019	-4%	11%	-1%	-5%	1%	9%
	2020	-1%	12%	0%	-7%	-11%	-17%
	October forecast						
	2018	-1%	6%	2%	-6%	-6%	-3%
	2019	-1%	13%	-1%	-7%	-3%	0%
	2019	-2%	12%	-1%	-6%	-1%	5%
	2020	1%	13%	0%	-8%	-13%	-20%
2018	*May forecast*						
	2019	-6%	9%	-3%	-2%	6%	11%
	2019	-7%	8%	-3%	-1%	9%	17%
	2020	-4%	9%	-3%	-3%	-7%	-13%
2019	*May forecast*						
	2020	0%	3%	0%	-2%	-12%	-19%
	October forecast						
	2020	1%	3%	1%	-3%	-14%	-23%

Stock weights

Stock weights are taken as three-year averages for both intermediate and TAC years and because they are input to the assessment, are not revised year-to-year. Although there have been revisions to the catch data from which stock weights are derived, this analysis uses only the current data.

Stock weights have shown a gradual decline for ages 3+ in recent years (Figure A5app.2) thereby increasing the potential to overestimate stock weights when taking a three-year average for forecasting. Although this is apparent for most years and ages from Table A5.2, Figure A5.2 indicates the effect is small. The large percentage differences for age 1 (Table A5.2) are a consequence of smaller weights and a more variable time-series in comparison to other ages.

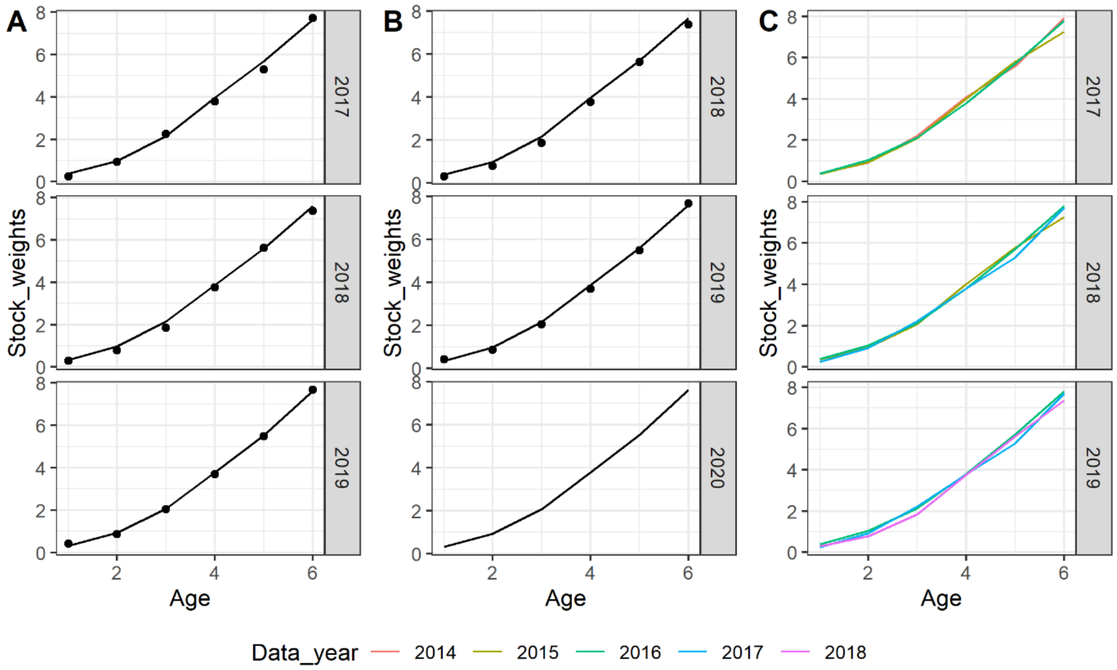

Figure A5.2. Performance of (A) intermediate year and (B) TAC year stock weight assumptions. Solid lines show the stock weight assumptions made for that year while points show realised stock weights for the same year derived from catch data available in subsequent years, with panel labels referring to data year. (C) Weights from preceding years used to calculate three-year averages in the relevant forecasting year (shown on the secondary y axis).

Table A5.2. Percentage difference between the assumed and subsequently observed stock weights for the intermediate and TAC years (as shown in Figure A5.2). Row names correspond to the year the assumption was made for.

	1	2	3	4	5	6+
	Intermediate year					
2017	54%	5%	-4%	5%	8%	-1%
2018	11%	23%	16%	3%	0%	3%
2019	-23%	8%	2%	3%	1%	-1%
	TAC year					
2018	28%	23%	16%	6%	1%	4%
2019	-18%	14%	6%	5%	2%	-1%

Maturity

Maturity for the intermediate year is derived from NS-IBTS-Q1 survey data and, aside from being a smoothed value, is not assumed. Maturity in the TAC year is taken as a four-year average of smoothed maturity estimates, for consistency with the start of the period over which the other data are averaged and to include the most recent estimate.

Trends in the smoothed maturities going into the four-year average appear unstable and in some cases the smoothers reverse with the addition of new data (Figure A5app.3). While there appears to be an overall decrease in maturity for most ages (Figure A5app.3), which could increase the potential to overestimate maturity in the forecasts, there is a high amount of interannual variability in the raw estimates and consequently no clear directional bias when comparing TAC year assumptions to observed maturities in subsequent years (Figure A5.3 and Table A5.3). The large percentage differences for age 1 (Table A5.3) are a consequence of lower maturity at younger ages.

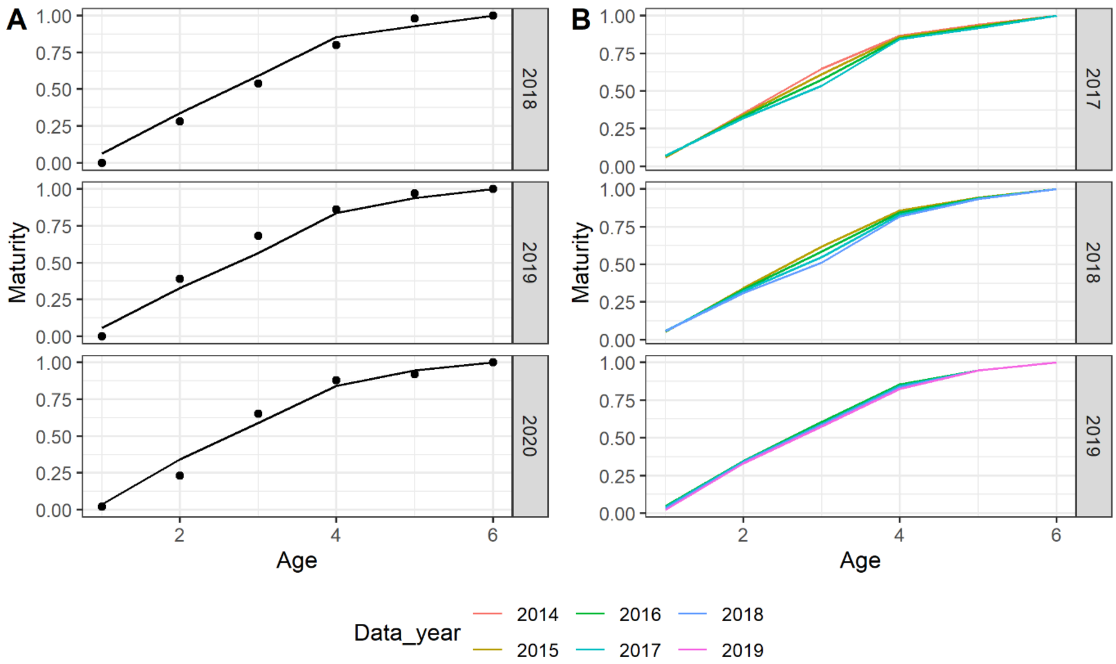

Figure A5.3. Performance of TAC year maturity assumptions. (A) Solid lines show the maturity assumptions made for a year while points show realised (unsmoothed) maturities derived for that year from survey data available in the subsequent year. (B) Smoothed maturities from earlier years used to calculate four-year averages in the forecasting year.

Table A5.3. Percentage difference between TAC year maturity assumptions and realised (unsmoothed) maturities derived from survey data available the following year (as shown in Figure A5.3). Row names correspond to the year the assumption was made for. The Inf values for age 1 are a consequence of observed zeros.

	1	2	3	4	5
2018	Inf	21%	10%	7%	-5%
2019	Inf	-16%	-16%	-3%	-3%
2020	84%	48%	-9%	-4%	3%

Natural mortality

Natural mortality is taken as a three-year average. However, natural mortality is updated only every three years and, because the last key run was performed in 2017, there are currently no realised estimates of M with which to compare recent forecast assumptions.

Landings fraction

The most recent year is used to split forecasted catch into landings and discards and because they are derived from the catch data, landings fractions are not revised year-to-year. It should be noted that the landings fraction does not impact the forecasted dynamics and is less crucial since introduction of the landing obligation and provision of catch, rather than landings, advice, but is nonetheless still included in the advice sheet.

Landings fractions appear highly variable for all ages over recent years (Figure A5app.4) which could result in both over- and under-estimations of landings fraction going into forecasts. This is evident from Figure A5.4 and Table A5.4 for all ages except age 3 which has shown a consistent increase since 2016 (Figure A5app.4) and therefore been underestimated in recent forecasts.

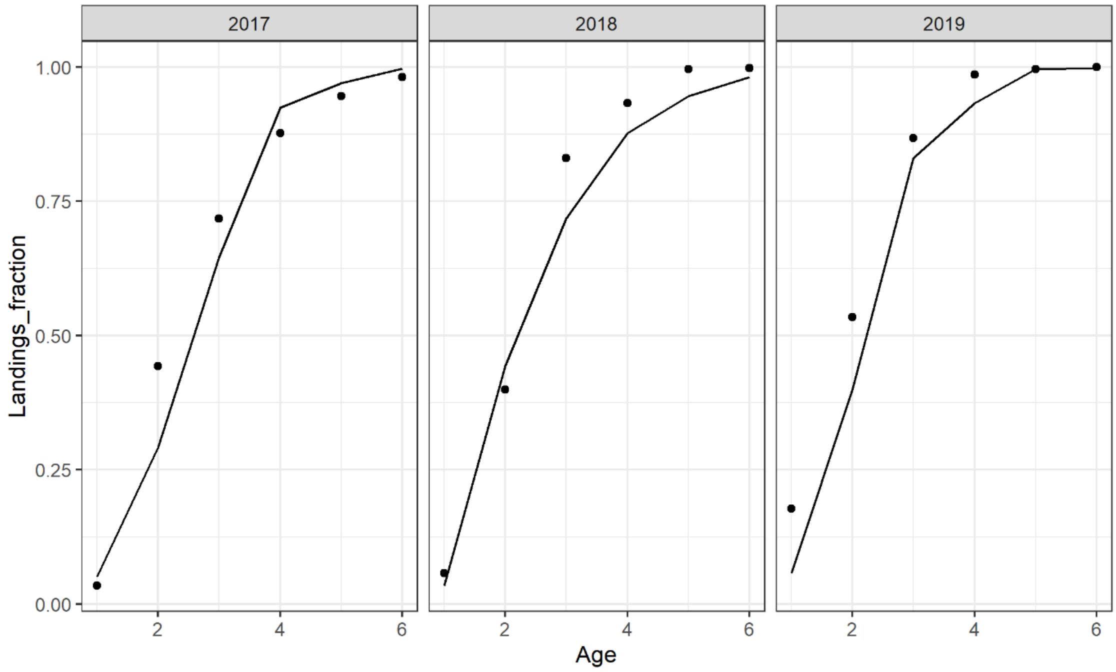

Figure A5.4. Performance of intermediate year landings fraction assumptions. Solid lines show the landings fraction assumptions made for each forecast while points show realised landings fractions derived from catch data available the following year.

Table A5.4. Percentage difference between intermediate year landings fraction assumptions and realised landings fractions derived from catch data available the following year (as shown in Figure A5.4).

	1	2	3	4	5	6+
2017	49%	-34%	-10%	5%	3%	2%
2018	-40%	11%	-14%	-6%	-5%	-2%
2019	-67%	-25%	-4%	-5%	0%	0%

Recruitment

Recruitment for the intermediate year is sampled from a normal distribution of the SAM assessment estimate while recruitment for the TAC year is sampled with replacement from 1998 to the final year of catch data.

Intermediate year assumptions tend to overestimate recruitment, due to the tendency for SAM to revise recruitment downwards each year (Figure A5.5 and Table A5.5; Mohn's ρ was calculated as 0.521 in 2020). The only exception is the 2019 WG forecast, where the assumption was revised upwards with the addition of new survey data in October, following the reopening protocol, and now appears to be an overestimate given the 2020 assessment.

In the absence of data for recruitment in the TAC year at the time of forecasting, the TAC year assumption is based on past assessment estimates which tend to overestimate recruitment when the incoming year-class is weak and underestimate when it is strong (Table A5.5).

In both cases, recruitment assumptions made in October, following triggering of the reopening protocol, were closer to subsequent assessment estimates when assumed lower than in the May forecast, consistent with the direction of the retrospective pattern (Table A5.5).

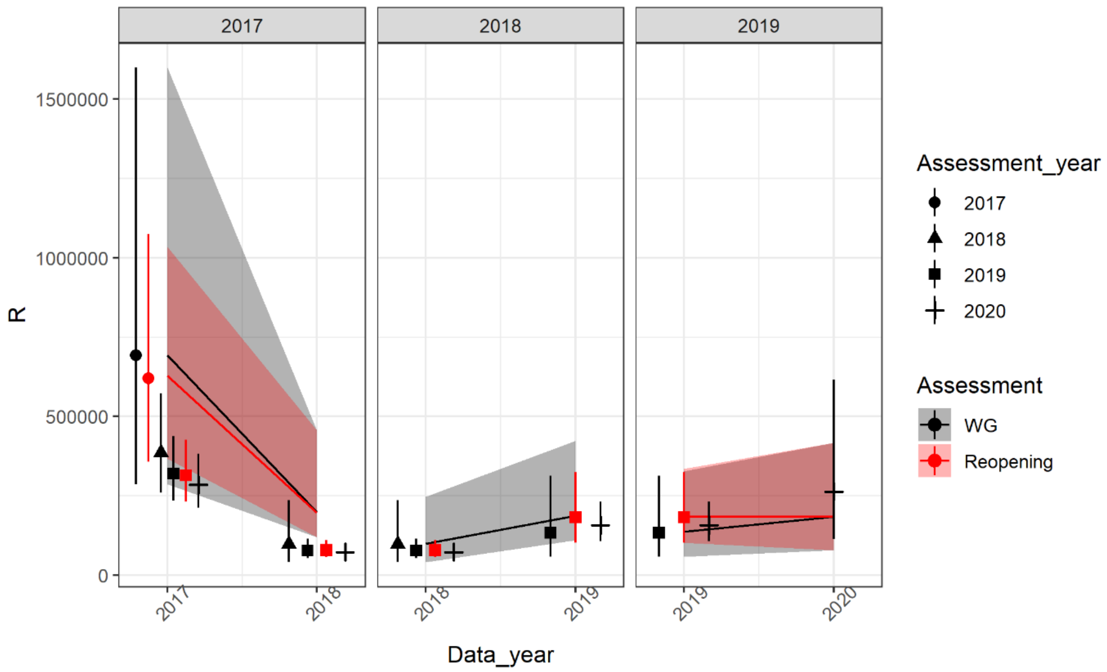

Figure A5.5. Performance of recruitment assumptions. Each panel shows the assumptions made in a forecasting year for both intermediate (sampled SAM estimate) and TAC (resampled) years. Solid lines and confidence bounds represent forecast assumptions while points with error bars show realised recruitment estimates from both the assessment on which the assumption was based and subsequent assessments.

Fishing mortality

Until 2018, a status quo fishing mortality was assumed for the intermediate year, under the assumption of similar effort. Given large reductions to TAC and advice since 2019, fishing mortality in the intermediate year has since been taken as that corresponding to the intermediate year TAC.

The intermediate year assumption consistently underestimates fishing mortality (Figure A5.6 and Table A5.6). Given that catches were in line with the TAC for years considered in this study, and the degree of underestimation grows each year (Table A5.6), this underestimation is likely a consequence of the retrospective pattern in the assessment (Mohn's ρ was calculated as -0.121 in 2020). Fishing mortality assumptions made in October, following triggering of the reopening protocol, were higher than those made in May and therefore closer to subsequent assessment estimates (Table A5.6).

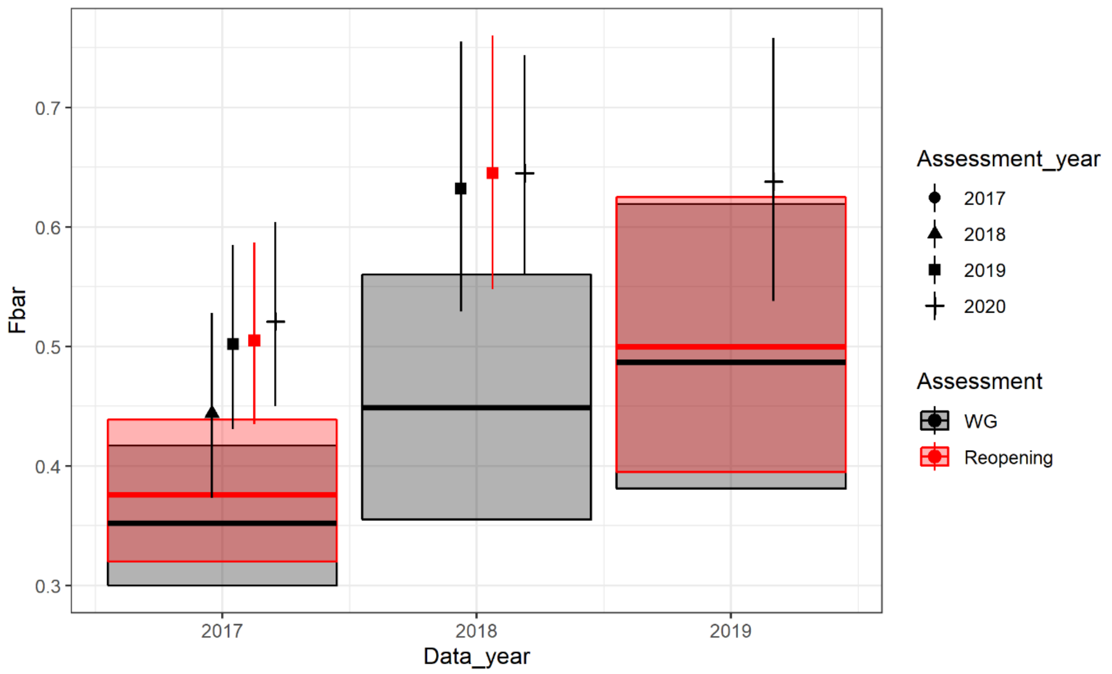

Figure A5.6. Performance of intermediate year fishing mortality assumptions. Crossbars represent intermediate year forecast assumptions while points with error bars show realised fishing mortality estimates for those years as estimated by subsequent assessments.

Spawning stock biomass

Spawning stock biomass in the intermediate year is derived from the estimated distribution of survivors from the SAM assessment multiplied by maturity data for the intermediate year and assumed stock weights (three-year average). SSB for the TAC year is derived by simulating the estimated survivors forward one year according to model and forecast assumptions and multiplying by assumed maturity (four-year average) and stock weights (three-year average).

SSB is consistently overestimated (Figure A5.7), with the degree of overestimation greater in the TAC year compared to the intermediate year and growing for both with each subsequent assessment (Table A5.7). Given maturity and stock weight assumptions showed low levels of directional bias, these overestimations are a consequence of the retrospective pattern in the assessment (Mohn's ρ was calculated as 0.286 in 2020). The causes of the retrospective pattern are not fully understood, but the large overestimations of recruitment combined with the fact that a proportion those recruits are considered mature may contribute.

SSB assumptions made in October, following triggering of the reopening protocol, were closer to subsequent estimates from assessments only when SSB was assumed lower than in the May forecast, consistent with the direction of the retrospective pattern (Table A5.7).

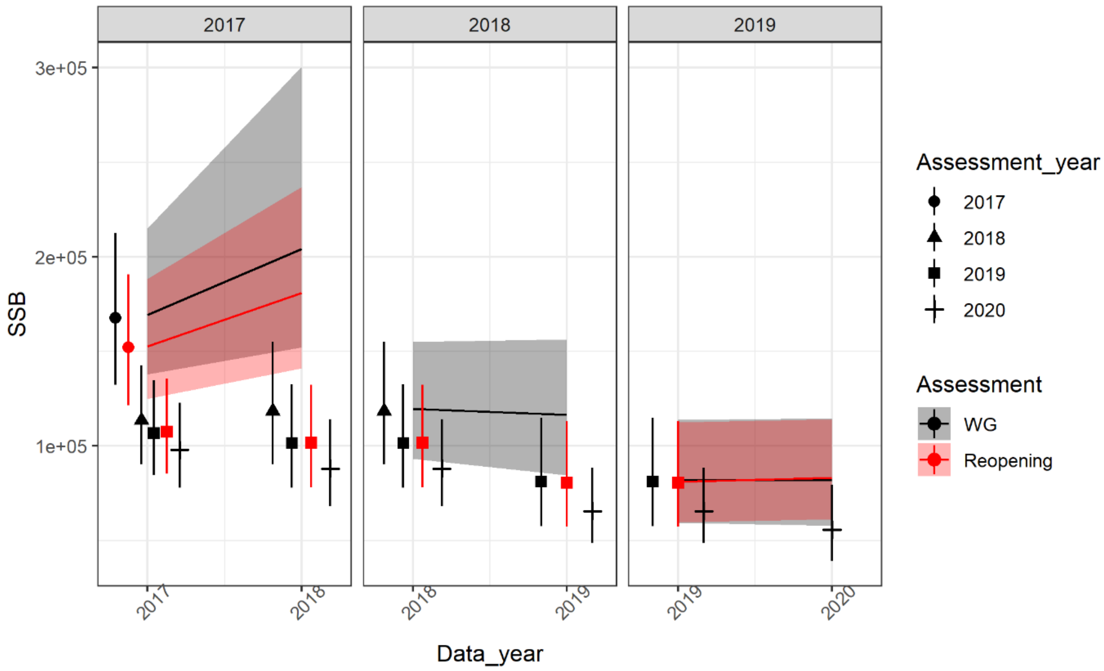

Figure A5.7. Performance of SSB assumptions. Each panel shows the assumptions made in a forecasting year for both intermediate and TAC years. Solid lines and confidence bounds represent forecast assumptions while points with error bars show realised SSB estimates from both the assessment on which the assumption was based and subsequent assessments.

Table A5.5. Comparison of recruitment assumptions and realised recruitment estimates from subsequent assessments (y+n where n=1, 2 or 3) with percentage difference shown in the coloured panels to the right. Forecasts and assessment results from triggering of the reopening protocol are indicated in red.

	Intermediate year				TAC year				Intermediate year					TAC year				
	Assumption	y+1	y+2	y+3	Assumption	y+1	y+2	y+3	y+1	y+1	y+2	y+2	y+3	y+1	y+1	y+2	y+2	y+3
2017	692194	385593	320063	284201	198216	97383	77677	72495	80%		116%	121%	144%	104%		155%	154%	173%
2017	628520		313774		196833		78158		63%		96%	100%	121%	102%		153%	152%	172%
2018	99387	77677	72495		186761	133583	156655		28%	27%	37%			40%	3%	19%		
		78158				181905												
2019	136231	156655			183333	262978			-13%					-30%				
2019	184342				183205				18%					-30%				

Table A5.6. Comparison of intermediate year fishing mortality assumptions and realised fishing mortality estimates from subsequent assessments (y+n where n=1, 2 or 3) with percentage difference shown in the coloured panel to the right. Forecasts and assessment results from triggering of the reopening protocol are indicated in red.

	Assumption	y+1	y+2	y+3	y+1	y+1	y+2	y+2	y+3
2017	0.352	0.444	0.502	0.521	-21%		-30%	-30%	-32%
2017	0.376		0.505		-15%		-25%	-26%	-28%
2018	0.449	0.632	0.645		-29%	-30%	-30%		
		0.645							
2019	0.487	0.638			-24%				
2019	0.5				-22%				

Table A5.7. Comparison of SSB assumptions and realised SSB estimates from subsequent assessments (y+n where n=1, 2 or 3) with percentage difference shown in the coloured panels to the right. Forecasts and assessment results from triggering of the reopening protocol are indicated in red.

	Intermediate year				TAC year				Intermediate year					TAC year				
	Assumption	y+1	y+2	y+3	Assumption	y+1	y+2	y+3	y+1	y+1	y+2	y+2	y+3	y+1	y+1	y+2	y+2	y+3
2017	169238	113502	106745	97868	204267	118387	101582	88071	49%		59%	57%	73%	73%		101%	101%	132%
2017	152766		107564		180990		101632		35%		43%	42%	56%	53%		78%	78%	106%
2018	119725	101582	88071		116380	81224	65581		18%	18%	36%			43%	45%	77%		
		101632				80475												
2019	81976	65581			81755	55725			25%					47%				
2019	81140				83301				24%					49%				

Conclusions

- The retrospective pattern in the assessment appears to be contributing heavily to biases in forecast assumptions, particularly those relating to recruitment, spawning stock biomass and fishing mortality.

- Performance of the reopening protocol also relates to the retrospective pattern, with forecast assumptions performing better only when they are revised in the direction of the retrospective pattern.

- Recent trends in fishery and biological data may contribute to biases in forecast assumptions. This study found small directional biases in stock weights and landings faction for some ages. Where there are persistent trends in such data, it should be considered whether they can be adequately modelled in the forecast.

- Recent developments to the forecast software offer an alternative way to forecast selection that is more consistent with the SAM model and should be considered in the forthcoming benchmark.

References

ICES 2015a. Report of the Working Group for the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 30 April–7 May 2014, ICES HQ, Copenhagen, Denmark. ICES CM 2014/ACOM:13. 1492 pp.

ICES. 2015b. Report of the Benchmark Workshop on North Sea Stocks (WKNSEA), 2–6 February 2015, Copenhagen, Denmark. ICES CM/2015/ACOM:32. 253 pp.

ICES. 2020. Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK). ICES Scientific Reports. 2:61. 1140 pp. http://doi.org/10.17895/ices.pub.6092

Appendix to Annex 5: Recent trends

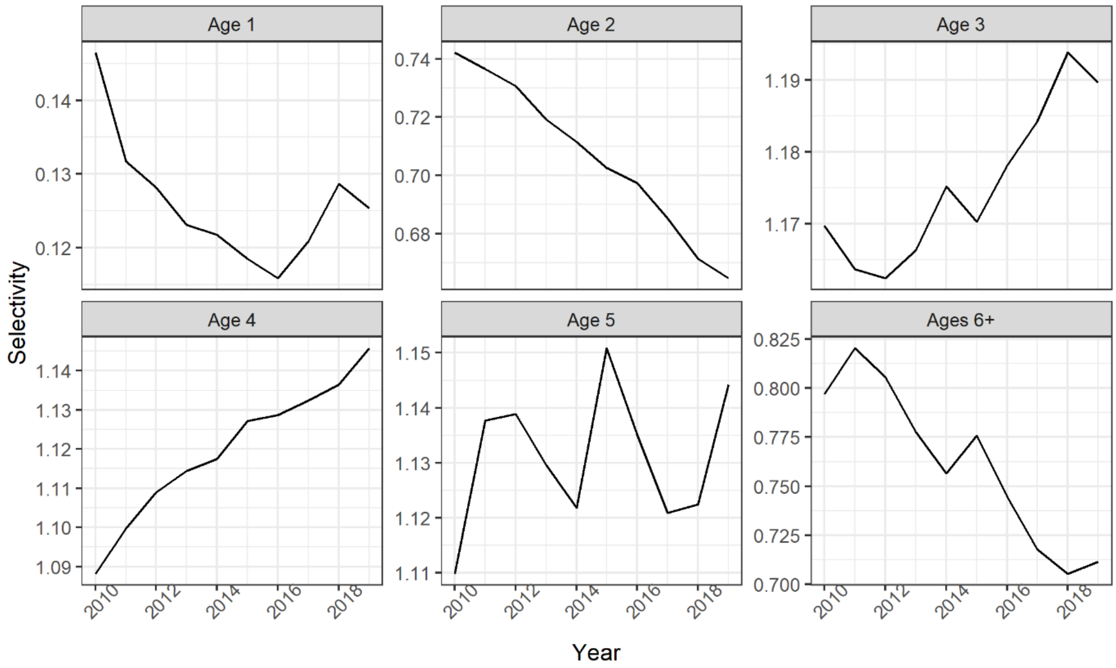

Figure A5app.1. Recent trends in selectivity-at-age, as derived from fishing mortality estimates from the 2020 stock assessment (ICES, 2020).

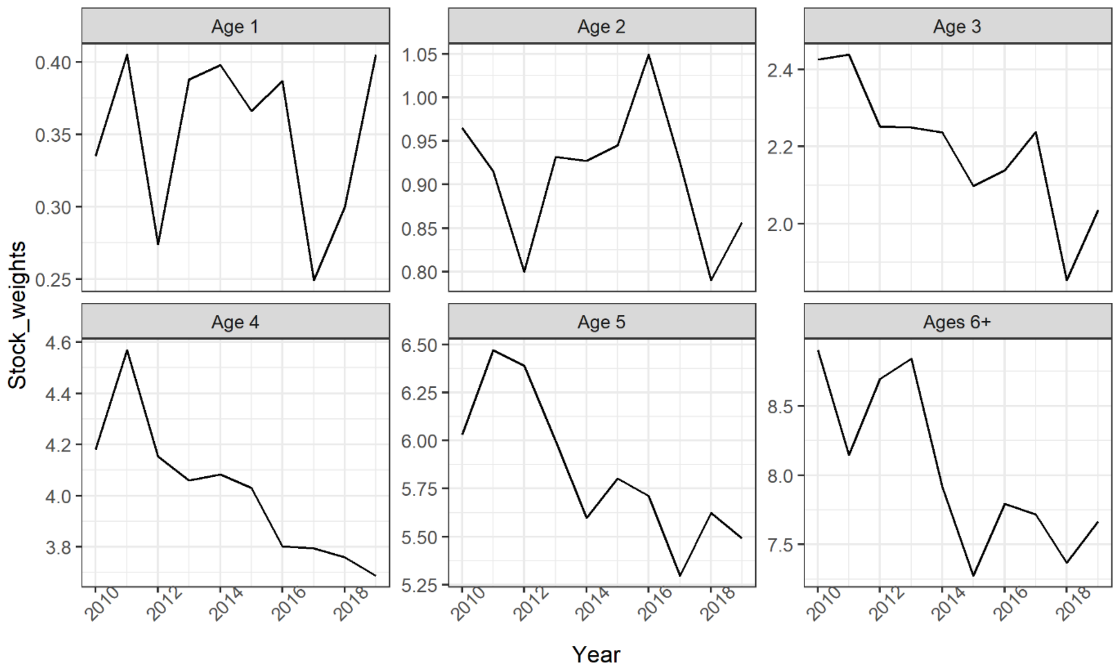

Figure A5app.2. Recent trends in stock weights-at-age.

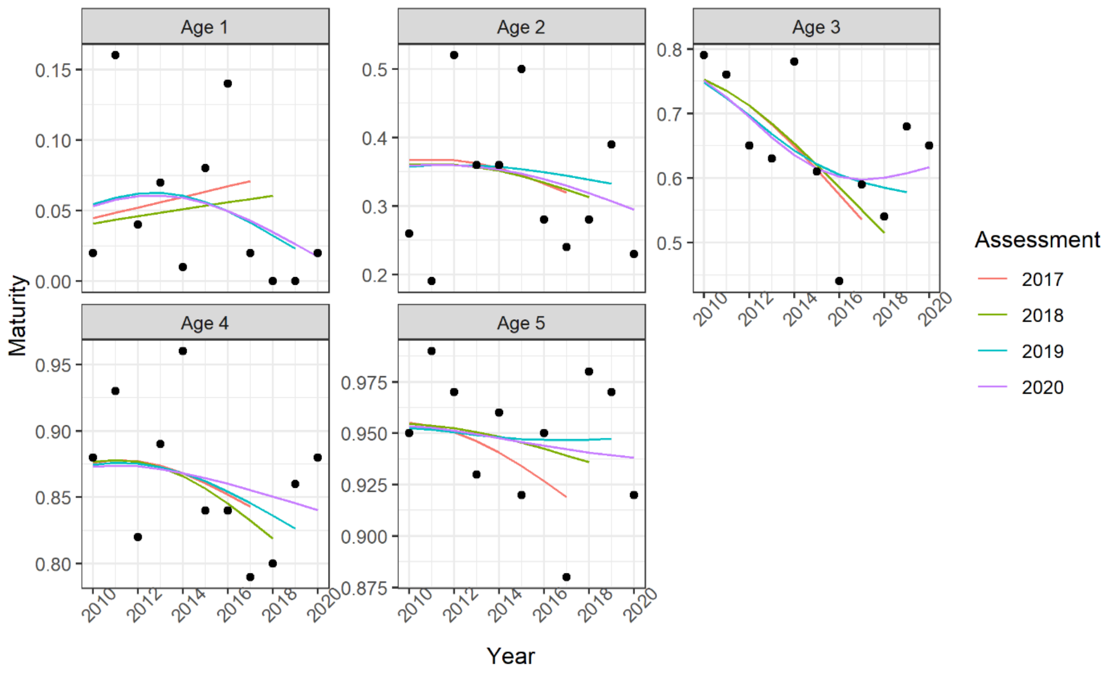

Figure A5app.3. Recent trends in maturity-at-age. Points show maturity estimates calculated from NS-IBTS-Q1 survey data while lines show smoothed estimates assumed in the corresponding assessment.

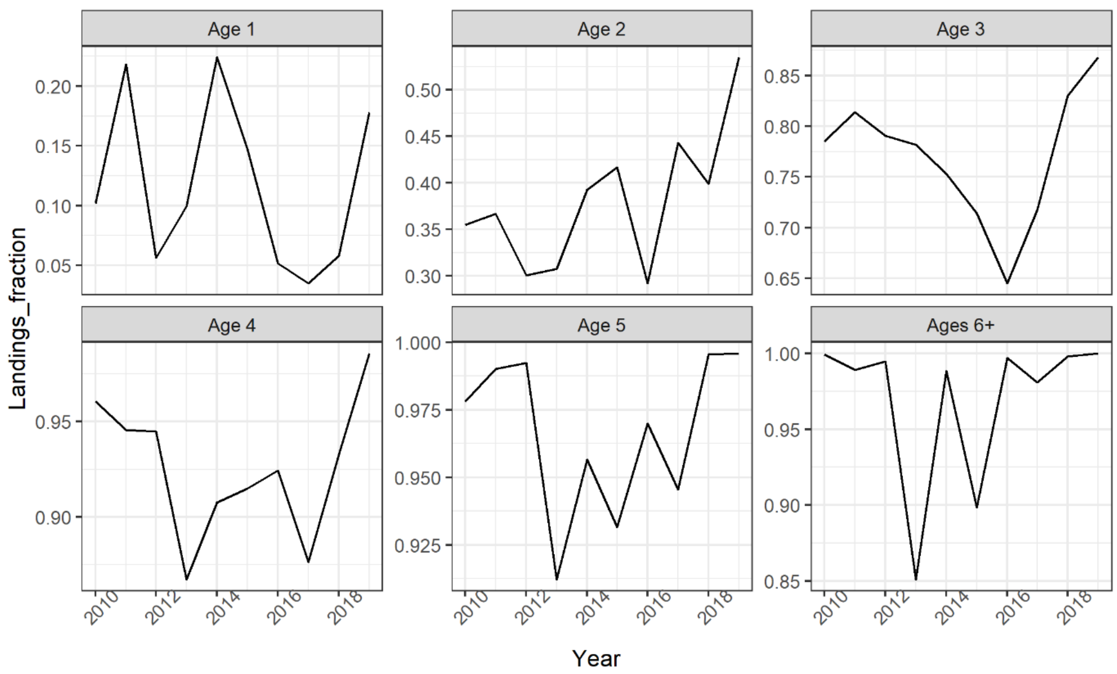

Figure A5app.4. Recent trends in landings fraction-at-age, i.e. landings / (landings + discards).