5 years of Industry survey

Does the industry survey improve current stock assessments for plaice and sole?

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IMARES rapport C039/16

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Samenvatting

Dit rapport beschrijft de resultaten van de bedrijfssurvey; een jaarlijkse survey op schol en tong aan boord van de commerciële vissersschepen UK45 en OD1. De survey is gefundeerd op de wens van de visserijsector om zelf gegevens aan te leveren voor bestandsschattingen, welke op een commercieel representatieve manier gevangen zijn. Van de survey werd verwacht dat deze de bestandsschattingen nauwkeuriger zou maken en het vertrouwen van de visserijsector in bestandsschattingen zou vergroten.

Tijdens de survey wordt de zuidelijke en centrale Noordzee op een gestandaardiseerde manier bemonsterd met commerciële tuigen, waarbij alle schol en tong vangsten worden geregistreerd. Vervolgens worden deze vangsten omgezet naar aantallen vissen per visserijinspanning, apart voor de verschillende leeftijdsgroepen. In totaal zijn er tijdreeksen opgebouwd van vijf (UK45) en vier (OD1) jaar welke de relatieve veranderingen van de schol en tong vangsten weergeven per leeftijdsgroep.

Vergeleken met de visserijonafhankelijke surveys (BTS; Beam Trawl Survey en SNS; Sole Net Survey) worden er in de bedrijfssurvey meer vissen gevangen en van gemiddeld van een grotere lengte. Dit heeft echter geen invloed op de trends zichtbaar in de individuele vangstsuccesreeksen, welke redelijk overeen komen. In dit rapport werden, ter evaluatie van de bedrijfssurvey, de tijdreeksen van de bedrijfssurvey toegevoegd aan de bestandsschatting modellen van schol en tong en vergeleken met de originele bestandschatting resultaten.

Voor zowel schol als tong levert de toevoeging van de bedrijfssurvey vangstsuccesreeks aan de bestandsschatting minimale verschillen in uitkomst. Met toevoeging van de bedrijfssurvey gegevens wordt de paaibiomassa schatting van zowel tong als schol iets lager geschat. De schatting van de visserijsterfte wordt met toevoeging van de bedrijfssurvey gegevens juist iets hoger geschat. De toevoeging van de bedrijfssurvey vangstsuccesreeks leidt, doordat meer gegevens met dezelfde trend worden gebruikt, tot een hogere precisie van de tong bestandsschatting. Naast resultaten van de bedrijfssurvey voor de bestandsschatting, is ook het proces van de bedrijfssurvey van belang omdat het samenwerking tussen wetenschappers en vissers stimuleert en daardoor mogelijk een positief effect heeft op het vertrouwen van vissers in bestandsschattingen.

Een mogelijk vervolg van de bedrijfssurvey kan als check dienen van de bestaande visserijonafhankelijke surveys. Hierdoor is het waarschijnlijk dat schommelingen tussen jaren zullen verminderen. Ook in de toekomst blijven indirecte resultaten van de bedrijfssurvey belangrijk. De actieve samenwerking tussen vissers en wetenschappers gedurende de bedrijfssurvey en het gebruik van zelf verzamelde gegevens in bestandsschattingen is goed voor het vertrouwen van de vissers in de bestandsschattingen.

De genoemde voordelen van een voortzetting van de bedrijfssurvey gelden alleen als de bedrijfssurvey gegevens daadwerkelijk worden meegenomen in de bestandsschattingen. Deze beslissing moet door de ICES werkgroep WGNSSK worden goedgekeurd op en soort-specifieke benchmark. Ondanks dat de ICES WGNSSK leden werkzaam bij IMARES positief zijn over het meenemen van de resultaten van de bedrijfssurvey in bestandsschattingen, kan IMARES geen garantie geven dat hiertoe wordt besloten op een benchmark.

Summary

This report describes the results of the industry survey; an annual survey targeting sole and plaice on-board of the commercial fishing vessels UK45 and OD1. The survey was set up following the wish of the fishing industry to deliver data for stock assessments themselves, which are collected using commercially representative fishing gears. This survey was expected to make stock assessment results more accurate and to increase trust of the fisheries industry in stock assessments.

The southern and central North Sea were sampled with a standardized method using commercial fishing gears during the survey, in which all plaice and sole catches were recorded. Subsequently, these catches were converted to numbers of fish per unit of fishing effort, for the different age groups separately. Time series of five (UK45) and four (OD1) years are collected in total, representing the relative changes in plaice and sole catches per age group.

Compared with the fisheries independent surveys (BTS; Beam Trawl Survey and SNS; Sole Net Survey), the industry survey caught more fishes and, on average, fishes of a larger length. This didn't affect the trends observed in the individual catch success rate series, which are fairly similar. To evaluate the industry survey, the results of the industry survey were included to stock assessment models of plaice and sole. This report presents the comparison with traditional stock assessment results.

For both plaice and sole, the addition of the industry survey indices to the stock assessment, resulted in minimal differences. The spawning stock biomass of both plaice and sole is estimated to be a little smaller after inclusion of industry survey data to the stock assessment. The estimations of fishing mortality, on the other hand, slightly increase. The inclusion of industry survey data resulted, due to the inclusion of more aligned data, in a higher precision of the sole stock assessment. Besides these effects, the process of having an industry survey is of importance, as the cooperation between researchers and fishermen has a positive effect on the trust of fishermen in stock assessments.

Possible continuation of the industry survey could be used as a check of the fisheries independent surveys. By doing so, it is likely that changes between years are minimised. Indirect results of an industry survey are important in the future as well. Active cooperation between scientists and fishers in the industry survey and by the usage of self-collected data in stock assessments has a positive impact on the trust of fishermen in stock assessment results.

All above mentioned benefits of a continuation of the industry survey are only valid if the industry survey results are actually included in the stock assessments. This decision must be approved by the ICES working group WGNSSK during a species-specific benchmark. Despite that ICES WGNSSK members working at IMARES have a positive attitude towards including industry data in stock assessments, IMARES cannot give any guarantee that such positive decision will be made at a benchmark.

1 Introduction

1.1 F-project and observers

The industry survey reviewed in this report is an project based on the results of the F-Project that started in 2002. The F-project started with the aim to improve quality, transparency and legitimacy of the scientific fisheries advice for North Sea plaice (*Pleuronectes platessa*) and sole (*Solea solea*) (Quirijns *et al.* 2007). As a result of this cooperative research project between fishers, scientists and policy-makers (ministry), a shared understanding of the data and models used in stock assessments was established for the participants. In addition, a reference fleet was created, with the aim to collect detailed catch data that could be used as a tuning series in plaice stock assessments. Unfortunately, the ICES working group WGNSSK did not include the data series in the stock assessment for various reasons (Quirijns *et al.* 2007). The collection of (survey)data remained therefore in the hands of the scientists, with little to no contribution from the fishers. To stimulate discussion, increase transparency and improve cooperation, fishers were invited every year from 2007 onwards to join the annual scientific Beam Trawl Survey (BTS) as observers. All constructive comments of the fisher' observers were gathered and translated into action points. All actions that could be undertaken easily, without additional funding and/or harm to the time series of the BTS, were implemented. A cluster of comments reflected the fisher' doubt that outcomes of the BTS were in line with commercial fishing practice, such as the gear configuration and the locations chosen to sample. Although the fishermen understood that these changes could not be made in the BTS, they did wonder whether outcomes would differ if a survey would be developed that would be more in line with the practice of commercial fishing. This led to the idea to develop an industry survey.

1.2 Preparatory phases industry survey

The project to establish an industry survey comprised of three successive phases. In the first phase (2009), a feasibility study was performed (Quirijns *et al*. 2010). This resulted in a tested experimental design and multiple (inter)national discussions about the goals of such an industry survey. It was concluded that the idea of an industry survey was supported by fishers, (international) scientists and policy-makers and that it was feasible to perform an industry survey.
In the second phase (2010) of the industry survey project, the added value of an industry survey was investigated (Quirijns and Miller, 2011). This was studied in a comparative fishing experiment, in which a commercial fishing vessel fished side-by-side with the research vessels during the BTS (both the ISIS and the Tridens II). Based on these comparative hauls, it was concluded that an industry survey was likely to improve the accuracy of the indices used in the plaice and sole stock assessments, especially for the larger (and thus older) individuals. In addition, it would create the opportunity to expand the sampled area and collect data on species that are caught less frequently by the research vessels. Finally, it was assumed that an industry survey would increase fishers' trust in stock assessment results and indirectly in related management decisions. Based on the positive output of the first two phases of the project, the third and final phase, the execution of an industry survey, was started in 2011 for 5 consecutive years.

1.3 Annual Industry survey

During 2011-2015, the industry survey was performed annually. This survey consisted of two commercial fishing vessels sampling the North Sea for plaice and sole based on a predetermined survey protocol. Each year, an initial briefing was held with all participants of the survey in which the survey protocol and possible deviations from previous years were discussed. Directly after the execution of the industry survey, the survey was evaluated and possible improvements or necessary adjustments were discussed. In 2011, the survey started with the vessels GO4 and UK45 (Rasenberg *et al.* 2012), both fishing with traditional tickler chain beam trawl gears. The GO4 was sold to Belgian fishers in November 2011 and therefore could no longer participate in the industry survey in the next years. An alternative was found in the OD1, a vessel using pulse gears. As it was expected that the pulse gear would become an important gear in the Dutch fleet, it was decided that having a pulse gear made sense. In the years 2012, 2013 and 2014, the survey was performed onboard the vessels UK45 (tickler chain beam trawl) and OD1 (pulse) (Rasenberg and Machiels, 2013; Rasenberg *et al.* 2014; Reijden *et al.* 2014). At the end of 2014, the UK45 switched to pulse gears. This resulted in a break in the time series, which was undesirable. In collaboration with the fishing industry, it was decided that a third vessel should participate in the industry survey, mimicking the UK45 in previous years. The UK64, a vessel comparable with the UK45, participated in the survey of 2015, using the traditional tickler chain beam trawl gears previously used by the UK45. Both vessels performed 39 hauls side-by-side, to determine a conversion factor in catch efficiency between the new (pulse) and old (tickler chain beam gear) fishing gear (Hal and van der Reijden, 2016).

1.4 Evaluation of the industry survey

At the start of the industry survey project, it was stated that a time series of at least five years should be generated before usage in stock assessments could be considered. One of the goals set for the industry survey was to make stock assessments of plaice and sole “more accurate”. This increased accuracy of the stock assessment results was expected to result in a higher precision of the Spawning Stock Biomass (SSB) and Fishing mortality (F) estimates, due to an increase of data input. Participating scientists trusted indices of the fisheries independent surveys and therefore, expected similar indices for the industry survey and consequently no remarkable deviating SSB and F estimates. The fishing industry expected that the industry survey would result in higher catches and therewith higher SSB estimates. This report evaluates the results of the industry survey project by estimating the impact of industry survey data inclusion in stock assessments for plaice and sole.

2 Materials and Methods

2.1 Vessels, gears and sampling stations

In total 4 vessels participated in the industry survey (see Table 1 for gear specifications), which covered the southern and central North Sea and the German Bight (Figure 1). The standard, commercial practices were sustained during the industry survey, resulting in different fishing speeds and gear specifics. Trawl duration was standardized at 30 minutes. In 2011, the GO4 and UK45 sampled the North Sea using tickler chain beam trawl gears with 24 (GO4) and 56 (UK45) hauls (Rasenberg *et al*. 2012). The GO4 was replaced by the OD1 in 2012, which started a new time series using pulse fishing gears. In 2012, 2013 and 2014, the industry survey was executed by the UK45 (tickler chain beam trawl) and the OD1 (pulse gears) with around 40 hauls for the OD1 (2012: 40; 2013: 39; 2014: 40) and 40-44 for UK45 (2012: 40; 2013; 44; 2014: 44). In 2015, the UK64 fished side-by-side with the UK45 during the industry survey for two weeks, resulting in 39 co-sampled hauls and 4 additional hauls for the UK45 (Reijden *et al*. 2015). This was necessary as the UK45 switched to pulse fishing gears at the end of 2014 and by doing a comparative sampling the catches of the UK45 could be adjusted for the effect of the pulse (see 2.3.2 and Hal and van der Reijden, 2016). The OD1 followed the standard protocol and executed 40 hauls in 2015.

Table 1. Gear specifications of the vessels in the industry survey

	UK45 (tickler chain)	**GO4**	**OD1**	**UK64**	**UK45 (pulse)**
Gear width	12 m	12 m	12 m	12 m	12 m
Mesh size (net)	100 mm	100 mm	100 mm	100 mm	100 mm
Mesh size (cod-end)	75 mm	80 mm	80 mm	67 mm*	80 mm
Fishing speed	6.5 knots	6.5 knots	4.8-5 knots	6.5 knots	4.8-5 knots
Years active	2011-2014	2011	2012-2015	2015	2015
Tickler chains	7	8	-	7	-
Ticklers	18	10	-	18	-
Electrodes	-	-	24	-	24
Conductors per electrode	-	-	10	-	24
Pulse frequency	-	-	45 Hz	-	60 Hz
Pulse duration	-	-	430 µs	-	330 µs

* Due to the deliverance of wrong nets. The survey protocol required 75 mm. This is discussed in more detail in Hal and van der Reijden (2016).

2.2 Data collection

The skipper registered for each sampled haul the date, time and location of shooting and heaving the net. Also haul number, haul duration, water depth, wind speed and wind direction were recorded. Catches from starboard- and portside were handled separately. All sole and plaice in the starboard net were collected. Both species were visually separated in undersized fish (<24 cm sole and <27 cm plaice) and landings by the fishers. Then the fish were measured to the cm-below (e.g. 15.0 – 15.9 =15 cm). In case the catches were large (>100 individuals), a subsample was taken from the sorted catch (undersized or landings), measuring for instance half or a quarter of the total number individuals caught, depending on the amount caught. This subsample however never resulted in less than 50 measured individual fishes. For age readings, otoliths were collected. Otolith-sampled fishes were measured to the mm-below (e.g. 154.0 – 154.9 = 154.0 mm) and gender was determined. All sole was sampled for otoliths per 1 cm length class per ICES rectangle. Plaice was sampled from 30 cm and larger, with 2 fishes per 1 cm length class per ICES rectangle. Otoliths were collected onboard, registered and stored for age-readings in the laboratory. Data was entered using the program Billie, a specially designed program to enter survey data, checked for type-errors and subsequently imported in the IMARES database for storage.

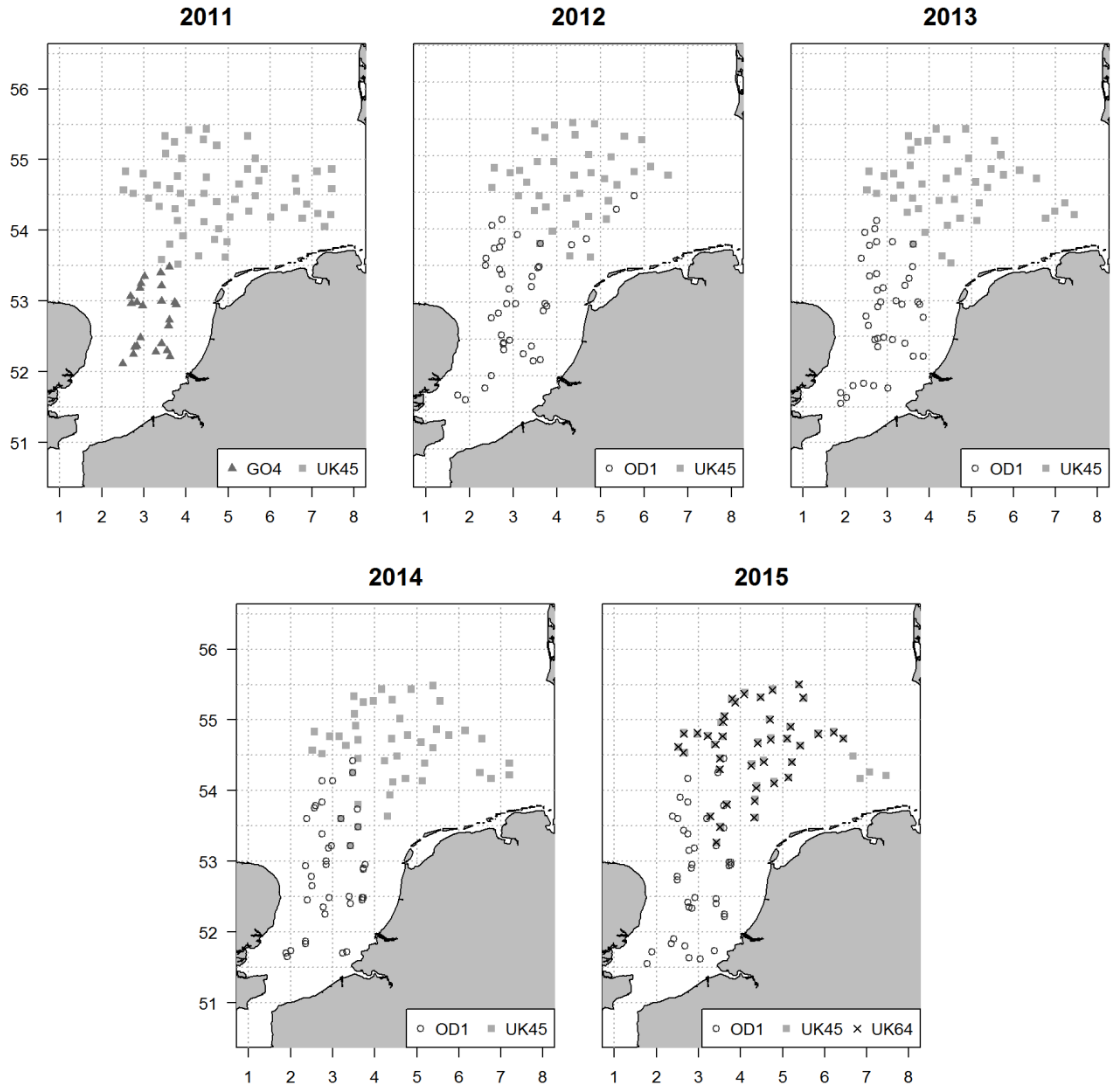

Figure 1. Fishing locations of the industry survey over the years (2011-2015).

2.3 Incorporation in stock assessment

Only data from the UK45 (5 years) and the OD1 (4 years) for plaice and sole were incorporated in stock assessments. As time series are necessary to use survey data in stock assessments, data collected by the GO4 was not used. Data of the UK64 was used to estimate a conversion factor between the new pulse and traditional tickler chain beam trawl gear of the UK45 in 2015 (see Hal and van der Reijden, 2016). To calculate an index series as used in stock assessments, one needs to calculate the total numbers per hour (nr/h) of fish caught per age class (so-called 'numbers-at-age').

2.3.1 Raising measured fish to numbers-at-length

The measured fish represented the total catch of the starboard net. If a subsample was taken, the counted numbers of fish per length class are multiplied with the subsampling factor (e.g. if only a quarter of the undersized plaice is measured, the counted numbers per length class are multiplied by 4). The counted numbers per length class were multiplied with 2 to compensate for the non-measured portside net (with the assumption that portside and starboard side have similar catches) and then divided by the duration of the haul (in hours) to obtain numbers-at-length (in nr/h).

2.3.2 Conversion of UK45 catches in 2015

The UK45 fished four years with tickler chain beam trawl gears before it switched to pulse gears at the end of 2014. To compensate for this time series break, a comparative fishing experiment was conducted during the industry survey of 2015 (Hal and van der Reijden, 2016). With this comparative fishing study, a conversion factor was calculated to transform $UK45_{pulse}$ catches to equivalent $UK45_{tickler\ chain}$ catches. For plaice, this conversion factor was depending on the length of the fish, with significantly more small plaice caught by the pulse trawl and more large plaice caught by the tickler chain beam trawl. See Hal and van der Reijden (2016) for a discussion of this observed difference in catchability. The formula given in (1) gives the relation between length and conversion factor, with L representing the length of the fish in meters (Hal and van der Reijden, 2016).

(1) $$Conversion\ factor = \frac{\frac{1}{\left(1+e^{-(3.119619-16.072281\mathbf{L}+16.335673\mathbf{L}^2)}\right)}}{\left(1-\frac{1}{\left(1+e^{-(3.119619-16.072281\mathbf{L}+16.335673\mathbf{L}^2)}\right)}\right)}$$

For sole, it was decided that because of the low accuracy of the length-based conversion factor proposed in Hal and van der Reijden (2016), a more conservative conversion factor was used. Sole catches were higher in the pulse trawl, with no clear length dependency. A conversion factor based on CpUE ratio resulting in 1.1885 was used for the whole length range. Using the conversion factors as described above, the catches of the UK45 in 2015 were transformed to catches representative for the tickler beam trawl, by dividing total number (per length) by the corresponding conversion factor. These numbers were then used as numbers-at-length.

2.3.3 Converting numbers-at-length to numbers-at-age

The numbers-at-length were converted to numbers-at-age. For a selection of length-measured fish, the age class was determined by otolith-readings. Otolith sampling is performed in the industry survey as an addition to the otolith sampling in the BTS (both RV Tridens and RV Isis) to increase accuracy. Age data of both programmes is combined to establish an age-length relation (ALK; age-length key), in which for each length class, the likelihood of being a certain age is determined. The ALK is likely to vary spatially (i.a. due to size-dependent migration), and therefore, spatially separated ALKs are determined using the flatfish areas shown in figure 2 (left). Using the ALK of the according flatfish area, the numbers-at-length are multiplied with the corresponding chance of being a certain age class being that length. These proportions are then summed per age class for all the length classes.

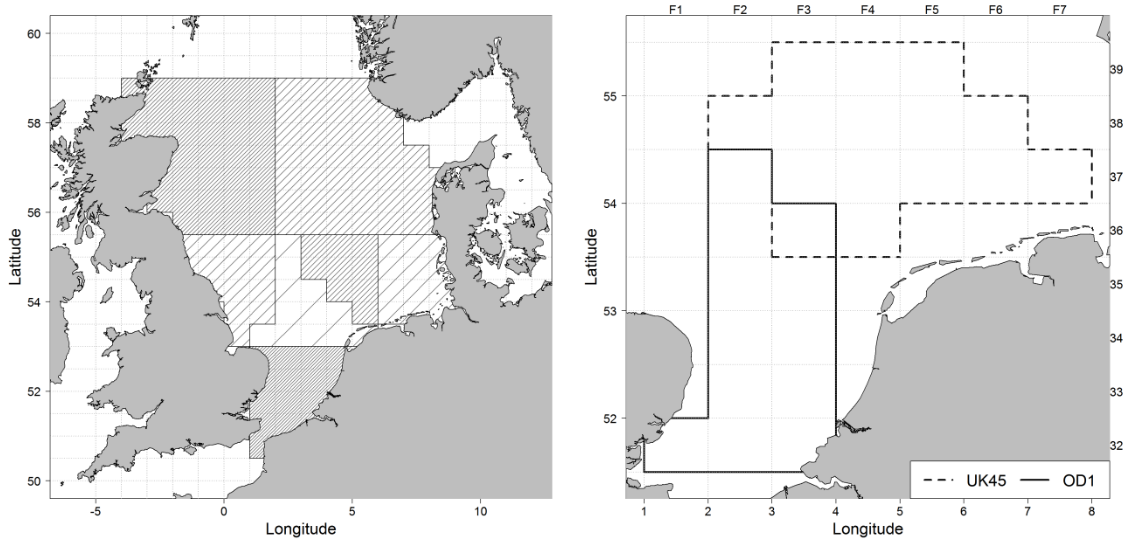

Figure 2. Spatial areas for age-length relations used in the BTS and industry survey (left) and index areas for both vessels in the industry survey.

2.3.4 Include index in stock assessment model

Only data from those ICES rectangle that are sampled more than 75% of the years during the industry survey are used to calculate indices. By doing so, effects of variation in the sampling design on the abundance time series are reduced. For the UK45, this area included the German Bight samples introduced in 2013, but excluded the ICES rectangle 35F3 as this area was sampled only in 2014 and 2015 (figure 2, right). The OD1 had more variation in sampling area and therefore the index excludes the rectangles 37F3, 37F5 and 36F4 but includes the rectangle 32F3, introduced in 2013.

The indices coming from the industry surveys were incorporated in the existing stock assessments for plaice and sole, as they are done by ICES in the ICES Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK; see ICES, 2015). The stock assessment done for plaice is extended survivors analysis (XSA), while the sole assessment is based on a maximum likelihood approach, using tensor splines to describe the F-at-age matrix. Because XSA needs the full catch-at-age matrix to be present in the stock assessment, the effect of the 2015 index data cannot be estimated in the assessment (only the data up to and including 2014). For sole, an assessment for 2015 can be done, in which all available indices can be used, in the absence of the 2015 catch-at-age data.

Because the catchability for 1-year-old fish in the industry survey is expected to be low (owing to the mesh size of the commercial gear), that age group was excluded from the indices from the industry surveys. For each species, assessments using only fisheries independent surveys (as done by ICES WGNSSK) were compared to assessments including fisheries independent surveys + UK45 index, and assessments including fisheries independent surveys + UK45 +OD1 index.

For the assessments, the F estimates and SSB estimates are compared, and the catchability and “influence” for the different indices is presented. This “influence” is based on the age-dependent fleet weights for the assessment of plaice based on XSA, and the estimated age-dependent standard deviation in the likelihood function of the assessment for sole. For more information about stock assessment models and data used in stock assessments, see the (Dutch) brochure of ProSea and IMARES (Prosea and IMARES, 2014).

3 Results

3.1 Plaice

Over the years, a total of 337 678 plaice were caught in the industry survey by the four participating vessels (table 2). Plaice was caught most frequently in the northern part of the industry survey, with relatively small catches in the most southern ICES rectangles (figure 3).

Table 2. Plaice catches (absolute number and number and weight per hour fishing) per vessel per year.

	Ship	2011	2012	2013	2014	2015	Total
Absolute numbers	**GO4**	22 798	-	-	-	-	22 798
	UK45	69 015	28 628	45 034	63 272	24 647	230 596
	OD1	-	11 403	12 917	12 363	15 480	52 163
	UK64	-	-	-	-	32 121	32 121
	Total	91 813	40 031	57 951	75 635	72 248	337 678
Numbers per hour fishing	**GO4**	1 886.7	-	-	-	-	-
	UK45	2 464.8	1 431.4	2 047.0	2 876.0	1 141.9	-
	OD1	-	570.1	662.4	618.1	774.0	-
	UK64	-	-	-	-	1 690.6	-
Weight per hour fishing	**GO4**	203.3	-	-	-	-	-
	UK45	297.7	248.3	311.6	415.0	192.4	-
	OD1	-	73.9	100.7	86.5	108.9	-
	UK64	-	-	-	-	271.4	-

The majority of the plaice catches by the UK45 and the OD1 were in the range of 18-26 cm (figure 4). The Beam Trawl Survey (ISIS only) caught less plaice and on average smaller individuals (9-17 cm). Between years, this pattern varied little, with only in 2011 more smaller plaice caught by the UK45 in the industry survey (see figures A1-5 in Annex A for annual plaice length frequencies). This may be caused by the variation in sampling area between the years, as the UK45 covered more stations in the German Bight in 2011.

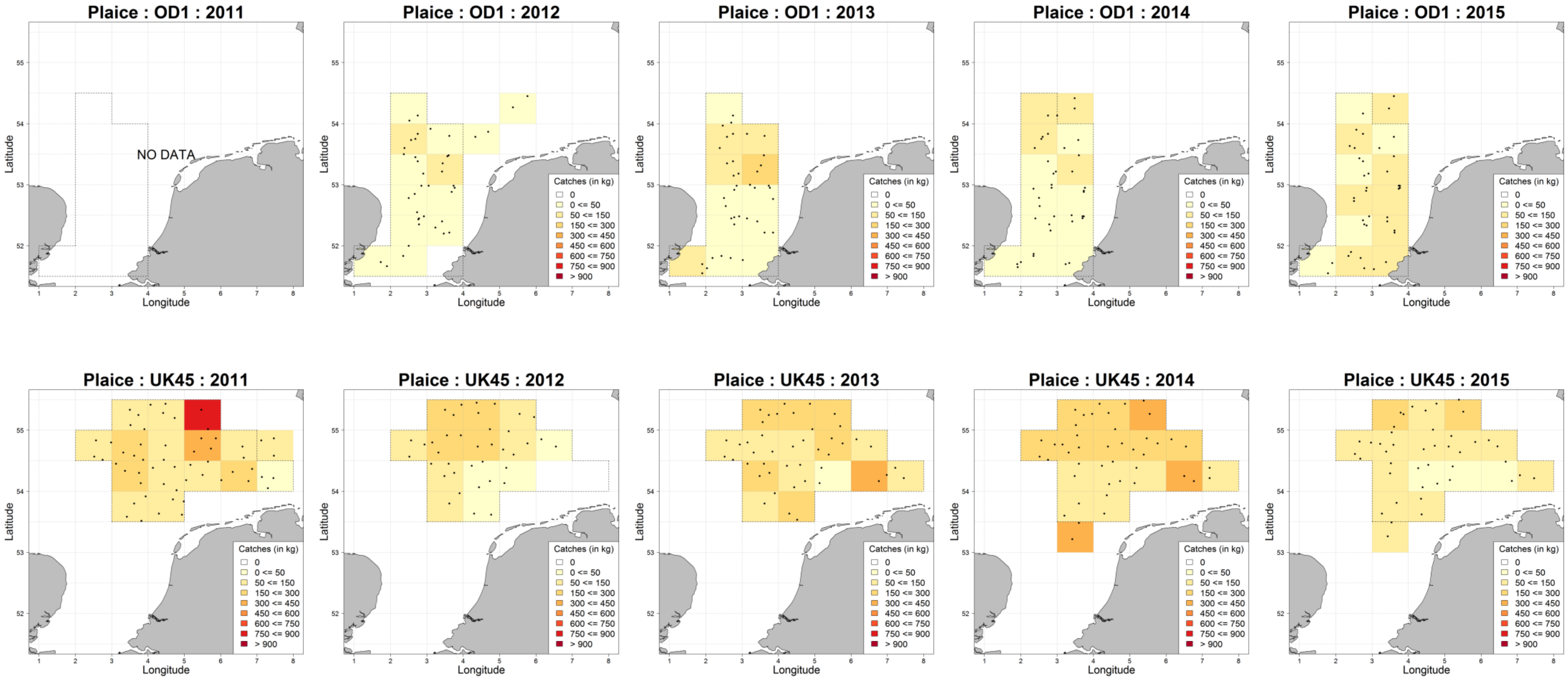

Figure 3. Plaice catches (kg) per ICES rectangle for the OD1 (above) and UK45 (under) for 2011 (left) to 2015 (right).

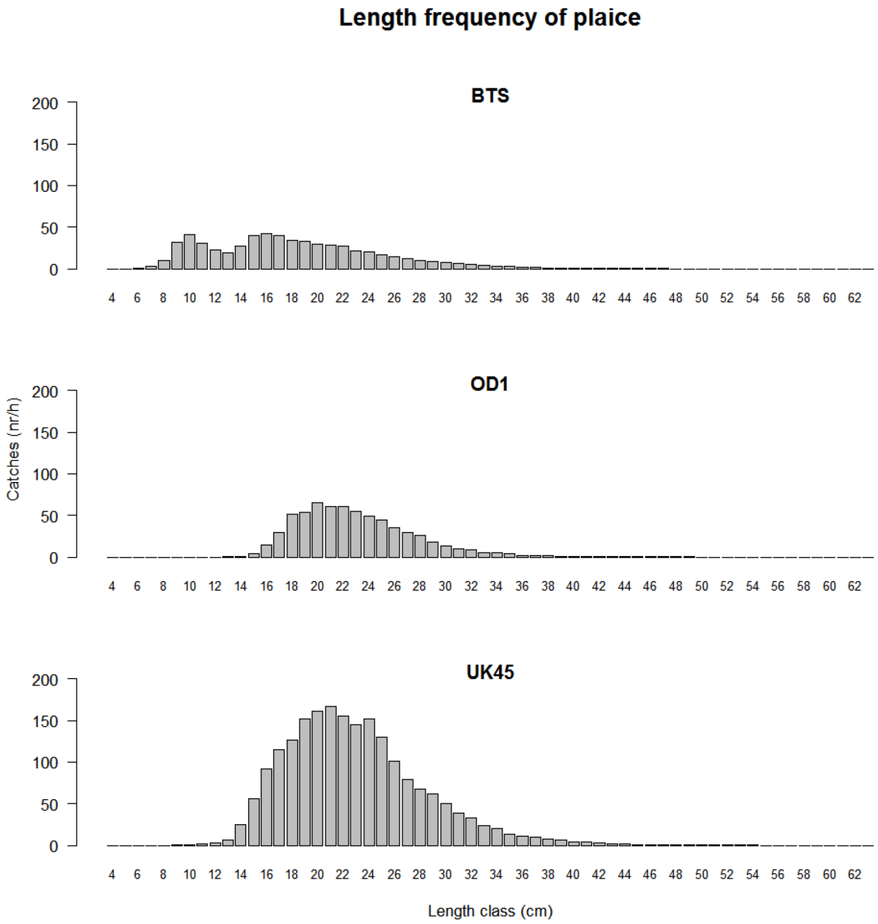

Figure 4. Length frequency of plaice catches in the Beam Trawl Survey (both ISIS and Tridens) and the industry survey (separate for each vessel). Averaged over the 5 consecutive years.

3.1.1 Numbers-at-age

Figure 5 gives the relative age-structured index values for the fisheries independent surveys used in the assessments and the two industry surveys for plaice. For each age group, the relative total catch is given, which represent the increase or decrease relative to the average total catch of all years for that age group. For the BTS time series, catches of the Tridens and the ISIS are combined. The Sole Net Survey (SNS) is only included for the first 3 ages, while the industry survey is excluded for the first age group. Visual inspection of the indices learns that in general, trends of the surveys match fairly well. Small deviating catches can be observed, for instance in age 3 where the UK45 show an increase for 2014 and the other vessels do not. No adjustments to increase alignment between indices have been conducted, as indices represent actual catches per vessel.

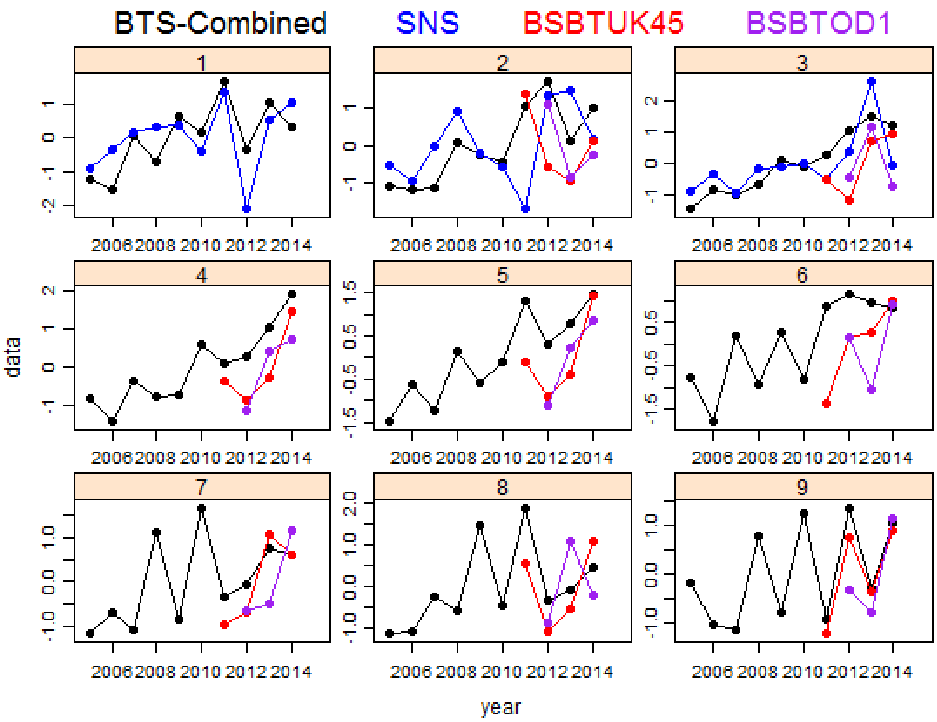

Figure 5. For each age class (1-9), index values for plaice are presented for the fisheries independent surveys used in the assessment (BTS-combined and SNS) and the data of the different vessels in the industry survey.

3.1.2 Effect in stock assessment

The stock assessment results in an estimation of the spawning stock biomass (SSB) and an estimation of the fishing mortality (F). Both are linked, as biomass is regulated by fishing mortality. Comparing the time series of SSB (figure 6, upper panel) and F (figure 6, lower panel) indicates that the incorporation of the industry surveys does slightly change the SSB and F estimates, mainly in the most recent time period (latest 2 years). The differences among the different runs (with and without inclusion of (part of) the industry survey data) are minimal, with the inclusion of the industry survey data leading to slightly lower SSBs and slightly higher F values.

The stock assessment model calculates the catchability of the different indices. This catchability is based on the number of individuals per hour for each age group. Comparing the estimated catchabilities for the two industry surveys with the combined BTS survey (all expressed in the assessment as n/hr) shows that the UK45 has the highest catchability (Figure 7). This is most likely caused by the fact that the UK45 fishes with commercial fishing gears in the central North Sea (with relatively high plaice densities) at a high fishing speed. However, owing to the limited number of years that this survey has run, the standard deviation of the estimated catchabilities is large. The catchability for the OD1 index is lower, but also has lower standard deviations. As the OD1 is fishing in the southern North Sea, it is expected that the OD1 catches less plaice as the density of plaice is relatively low in that area. The combined BTS has a fairly constant catchability for all ages, with low standard deviations because of its long time series.

To estimate the most recent developments in the stock, the stock assessment model matches the trends of indices with all possible model results. When multiple indices are used in a model, the stock assessment model determines an general trend, generated with individual contributions of each index. For 2014 assessment results, these contributions of the different indices are shown in Figure 8. The two industry survey indices combined have between approximately 45 and 58% of the weight for age groups 2-8. This means that the general trend used by the stock assessment is for ~50% depending on the industry survey data.

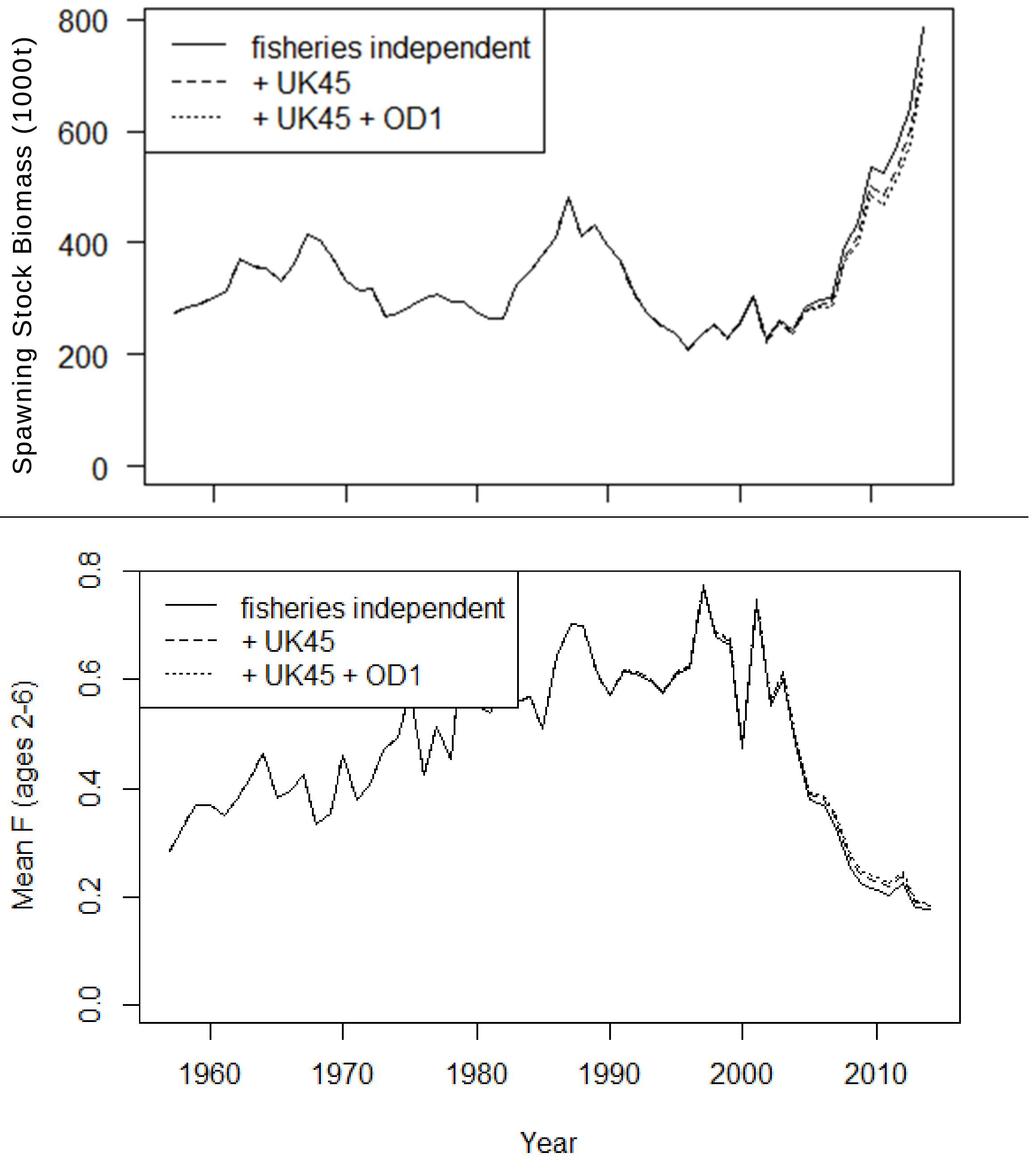

Figure 6. Time series of plaice spawning stock biomass (upper panel) and fishing mortality (lower panel) compared for the different assessments.

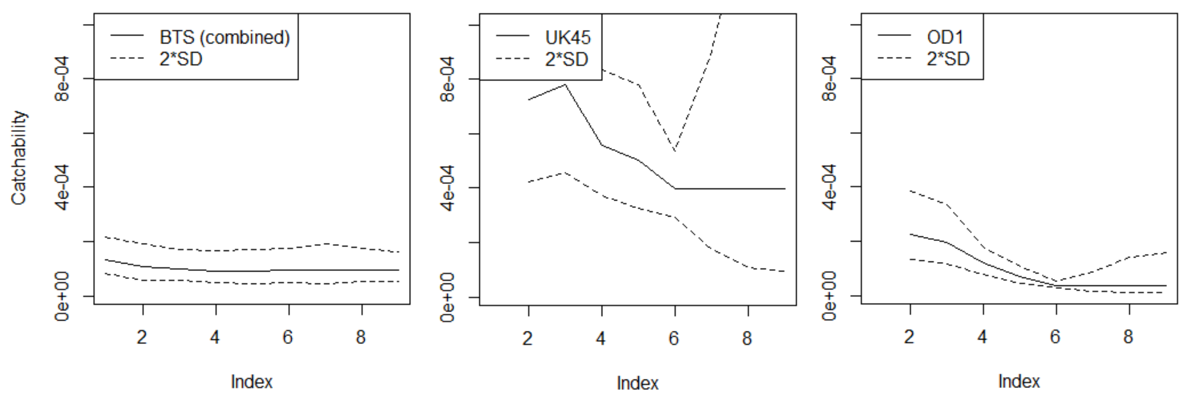

Figure 7. Estimated catchabilities (nr/h) at age (horizontal axis) for the BTS (left), UK45 (mid) and OD1 (right). Drawn lines indicate means, dashed lines indicate means ± 2 standard deviations.

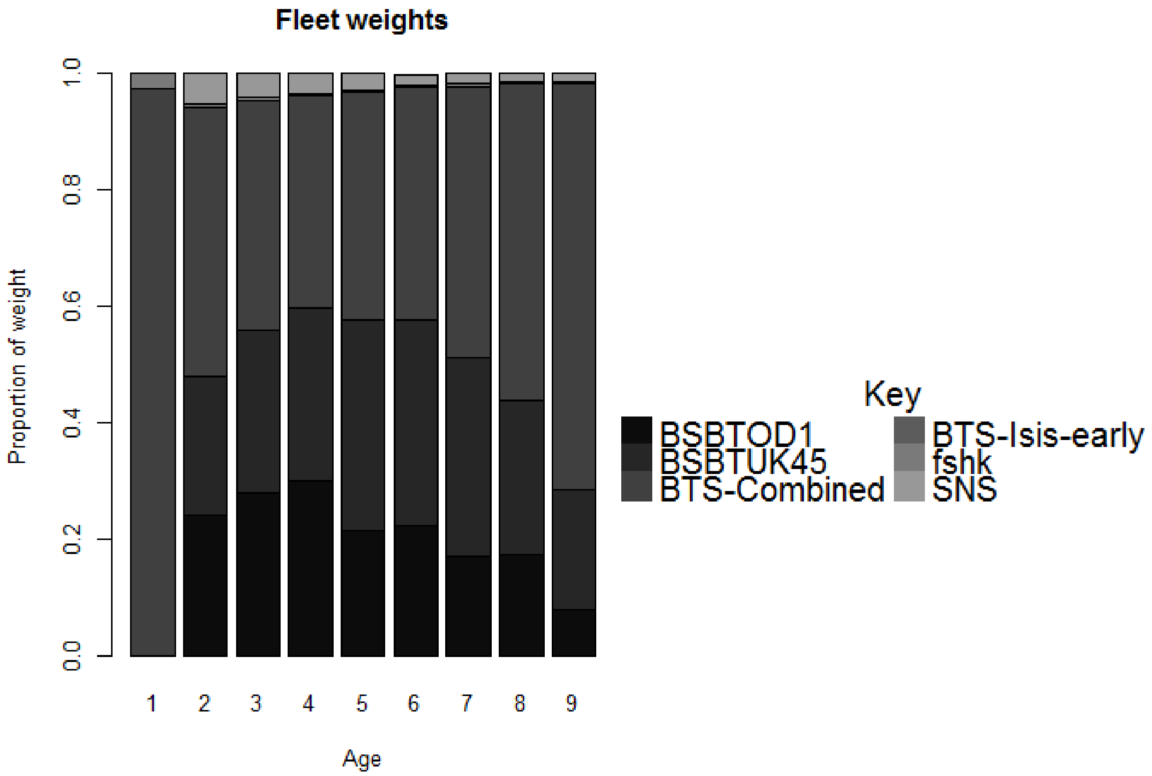

Figure 8. Proportion of fleet weights for the different ages in the XSA stock assessment for plaice.

3.2 Sole

Over the years, a total of 20 638 sole were caught in the industry survey by the four participating vessels (table 3). Most sole was caught in the most southern ICES rectangles, the German Bight and in the ICES rectangles near the Cleaver bank (figure 9).

Table 3. Sole catches (absolute numbers and number and weight per hour fishing) per ship per year

	Ship	2011	2012	2013	2014	2015	Total
Absolute numbers	**GO4**	2 256					2 256
	UK45	3 388	2 367	1 686	2 126	2 016	11 583
	OD1		1 081	1 074	1 413	1 809	5 377
	UK64					1 422	1 422
	Total	5 644	3 448	2 760	3 539	5 247	20 638
Numbers per hour fishing	**GO4**	186.7	-	-	-	-	-
	UK45	121.0	118.3	76.6	96.6	93.4	-
	OD1	-	54.0	55.1	70.7	90.5	-
	UK64	-	-	-	-	74.8	-
Weight per hour fishing	**GO4**	29.9	-	-	-	-	-
	UK45	17.5	15.1	14.6	17.5	14.4	-
	OD1	-	9.4	11.6	16.2	17.3	-
	UK64	-	-	-	-	10.8	-

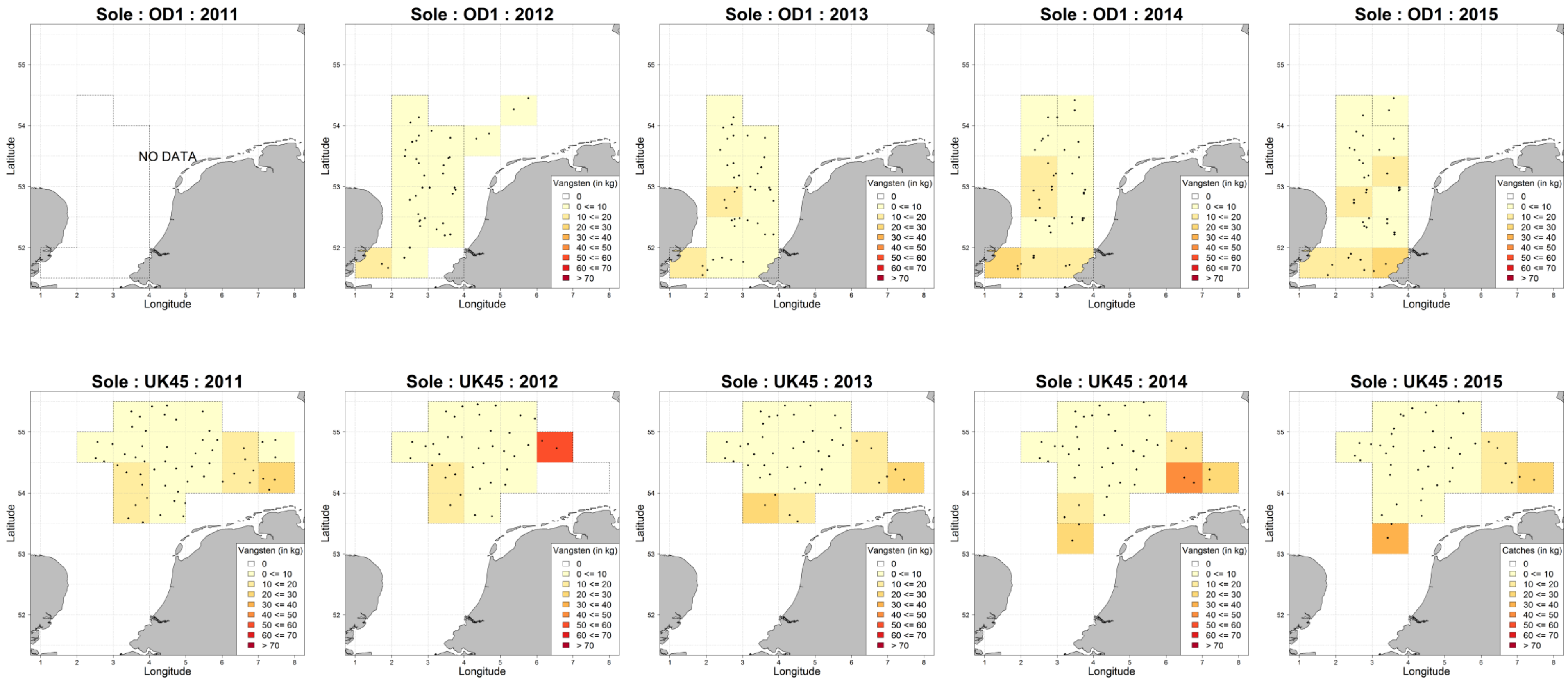

Figure 9. Sole catches (kg) per ICES rectangle for the OD1 (above) and UK45 (under) for 2011 (left) to 2015 (right).

The majority of the sole catches by the UK45 and the OD1 were in the range of 22-27 cm and 24-29 cm respectively (figure 10). The Beam Trawl Survey (ISIS only, as Tridens is not covering sole fishing grounds) caught less sole and on average smaller individuals (16-24 cm). The Sole Net Survey caught a similar range of length classes (15-24 cm) as the BTS, but all in a very low frequency (figure 10). Over the years, this pattern showed little variation (see figures B1-5 in Annex B for annual sole length frequencies).

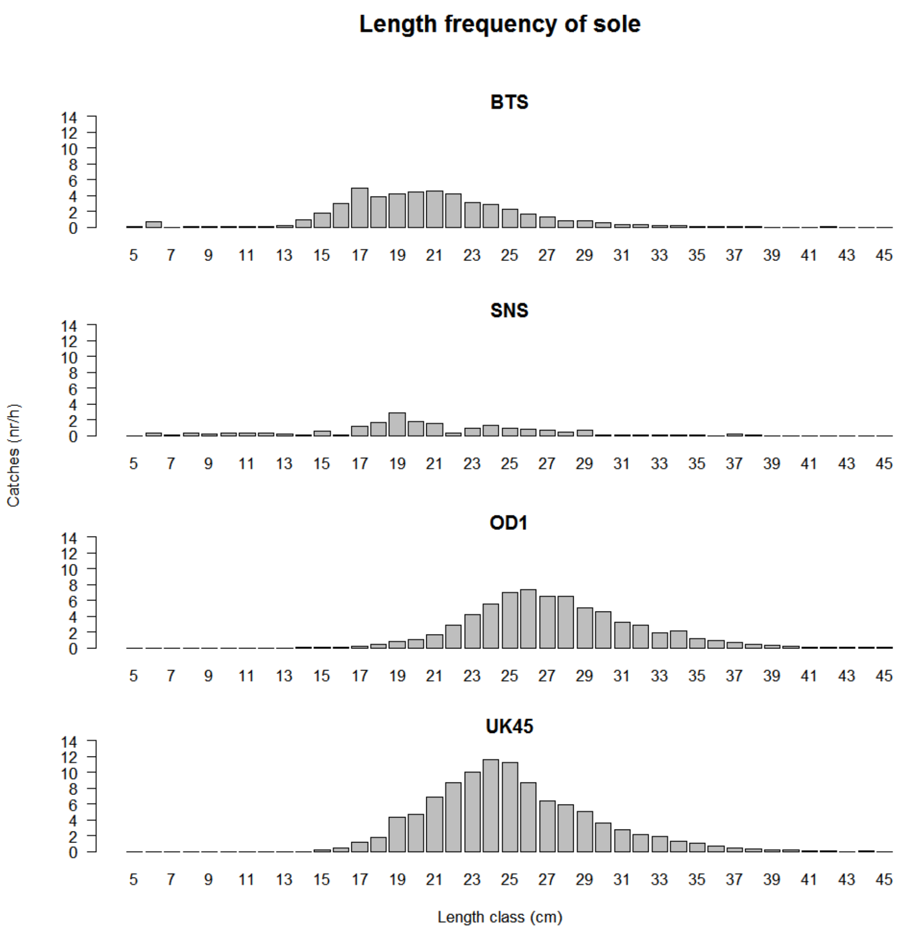

Figure 10. Length frequency of sole catches in the Beam Trawl Survey (ISIS only), the Sole Net Survey (ISIS and GO58) and the industry survey (separate for each vessel). Averaged over the 5 consecutive years. Note: in 2012, the SNS was executed with the Tridens II. Due to deviating catches, it has been excluded in the analysis.

3.2.1 Numbers-at-age

In the sole assessment, the fisheries independent indices used in the stock assessment come from the BTS-ISIS and the SNS. The sole indices for the UK45 in 2015 are corrected for the change in gear that occurred in 2015, using the length independent conversion factor described in section 2.3.2. Like for plaice, the different indices for sole match the different indices fairly well (Figure 11). The exception is that the index values for the UK45 are lower than expected in 2015, especially for ages 2, 5, and 6. This is in contrast to the other indices that estimate those year classes to be strong.

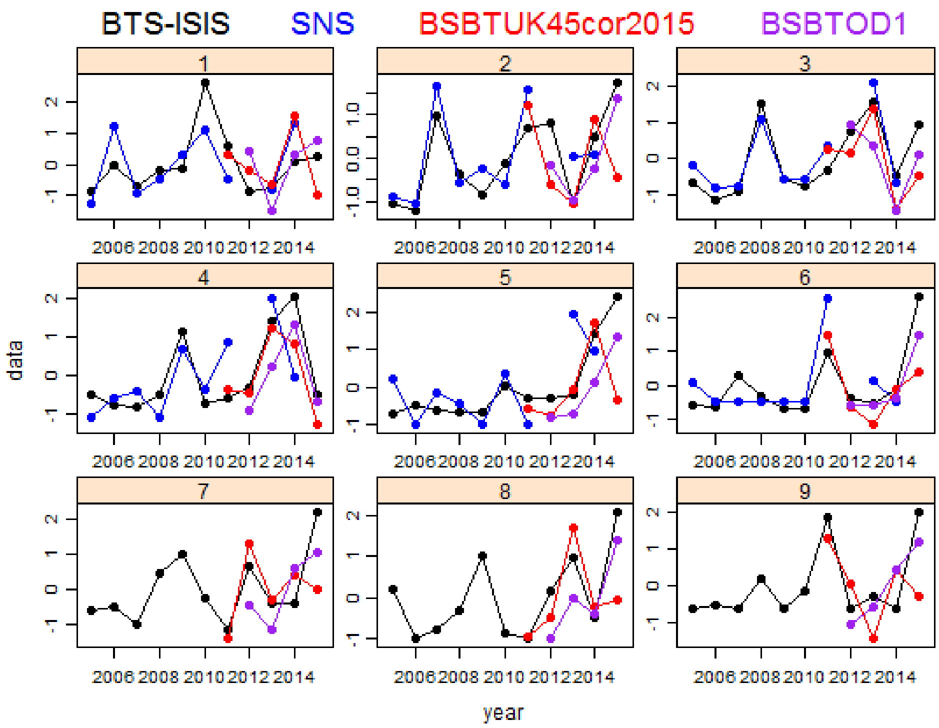

Figure 11. For each age class (1-9), index values for sole are presented for the fisheries independent surveys used in the assessment (BTS-ISIS and SNS) and the data of the different vessels in the industry survey.

3.2.2 Effect in stock assessment

3.2.2.1 Current (2014) assessment

Incorporating the industry survey indices in the sole assessment has a small influence on the estimates of SSB and F (Figure 12, upper and lower panel respectively). The SSB estimates are slightly lower in the final year when adding the industry survey indices, while the F estimates in the final year are slightly higher. Importantly, the precision of the estimates of F increases: the standard deviation of the F estimate in the 2014 (the final year of the assessment) decreases from 0.042 to 0.034 (at F estimates of approximately 0.25 per year). This increase in precision is the result of the inclusion of the additional information coming from the industry surveys.

The estimated catchabilities for the two industry surveys are substantially higher than the catchability from the BTS-ISIS survey that is used in the assessment (Figure 13), while all these indices are expressed as n/hr. Most likely, this is caused by the commercial fishing gears employed in the industry survey at sole specific fishing grounds such as the very southern North Sea (ICES rectangles 32F1, 32F2) and the German Bight. The mean estimates of the two industry surveys have similar dome-shapes. Unfortunately the assessment method used for sole does currently not provide estimates of uncertainty of these catchability estimates. Therefore, it could be that the dome-shape of the catchability estimates is only an artefact of the assessment model.

The two industry surveys have low estimated standard deviations in their likelihood components, indicating the response of the assessment to the information in the indices is high (Figure 14). The two industry surveys thus have a substantial contribution to the assessment.

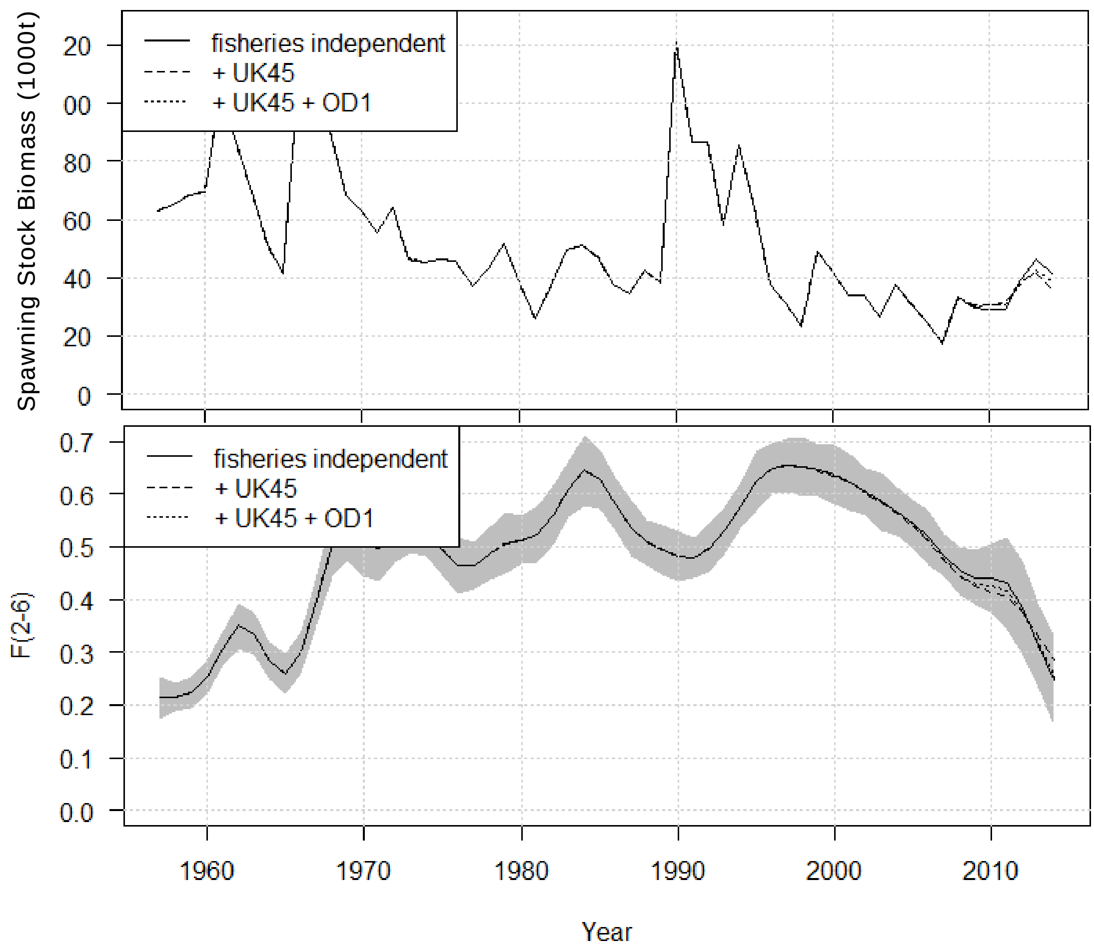

Figure 12. Time series of plaice spawning stock biomass (upper panel) and fishing mortality (lower panel) compared for the different assessments. The grey area in the bottom panel depicts the 95% confidence interval of the assessment with only fisheries independent indices.

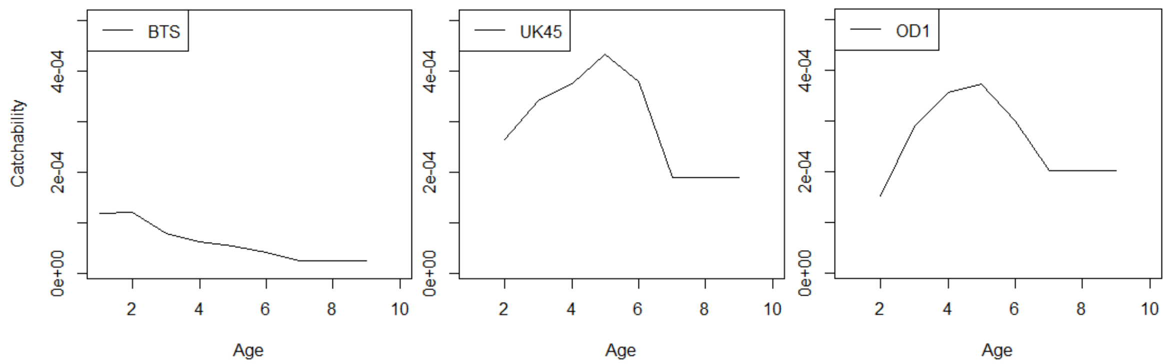

Figure 13. Estimated catchabilities (nr/h) at age (horizontal axis) for the BTS (left), UK45 (mid) and OD1 (right). The line indicates the mean.

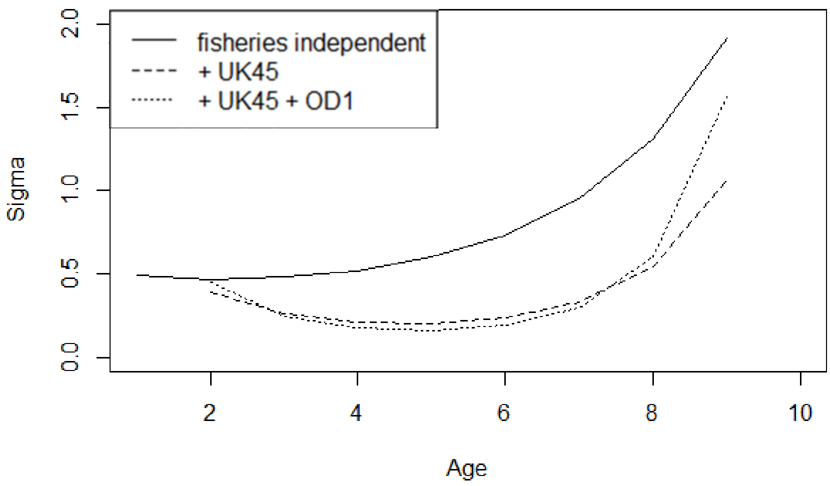

Figure 14. Estimated standard deviations in the likelihood components for the different surveys. Low standard deviations indicate a high response of the assessment to the observations in the surveys.

3.2.2.2 A "what if" assessment including 2015 indices

The sole assessment can be run without catches, but with the 2015 BTS indices and industry survey indices. The SSB and F estimates are given in Figure 15 (upper and lower panel respectively). Clearly, only adding the UK45 index has a marked effect on the results, with a decrease in SSB and an increase in F. This is due to the low index values for ages 2,5, and 6. However, adding both the UK45 and OD1 indices results in an assessment that is almost indistinguishable from the assessment with only fisheries independent surveys.

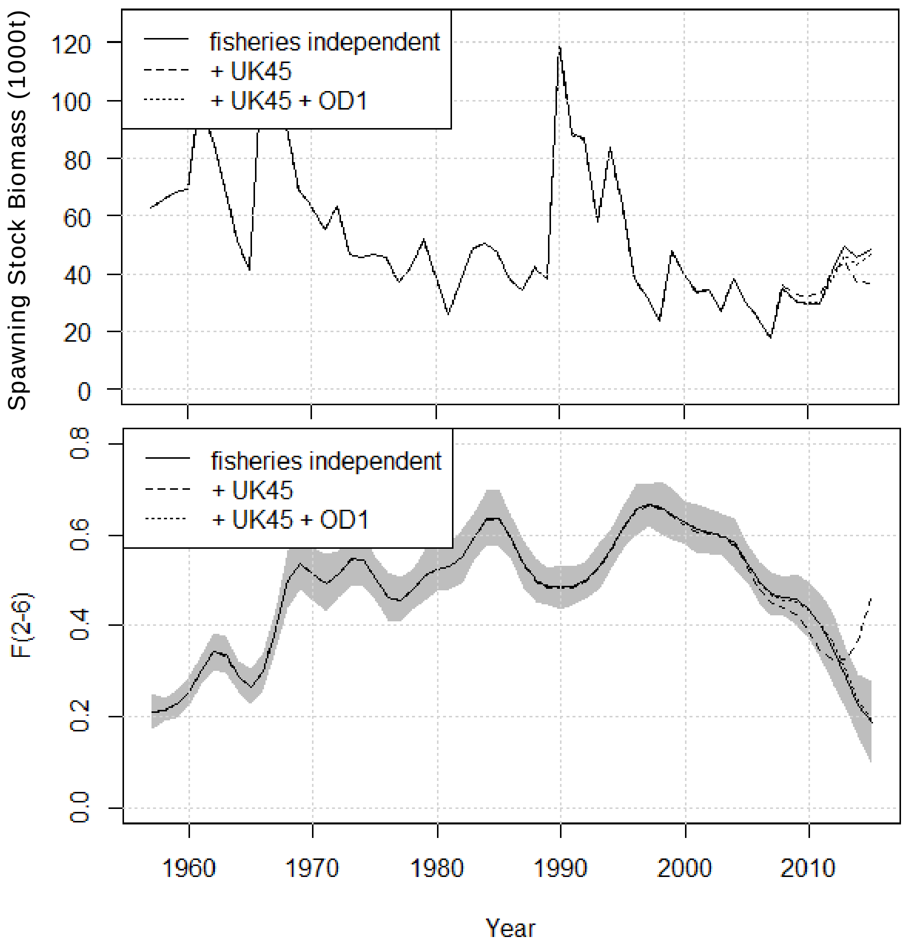

Figure 15. Time series of sole spawning stock biomass (upper panel) and fishing mortality (lower panel) compared for the different assessments, including the available 2015 indices. The grey area in the bottom panel depicts the 95% confidence interval of the assessment with only fisheries independent indices.

4 Discussion

The industry survey has been performed for 5 consecutive years by the UK45 and for 4 years by the OD1. Using commercially representative fishing gears, both vessels sampled a large part of the central and southern North Sea. This resulted in high plaice and sole catches, which were on average larger than the plaice and sole caught in the fisheries independent surveys SNS and BTS.

The addition of the two industry survey indices appears to have little effect on the outcomes of the most recent ICES WGNSSK assessments for plaice and sole. For both species, the mean F appears to be slightly higher in the final year of the assessment (2014), while the mean SSB appears to be slightly lower. This is not to say that inclusion of the industry surveys will always result to higher F estimates and lower SSB estimates: this could change in the future. The limited difference in terms of SSB and F that results from the inclusion of the two industry survey does not result from the fact that these get little weight in determining the outputs of the assessments. Rather, the two industry survey indices get a lot of weight (45-58% for plaice age 2-8) in the assessments, judging from the fleet weights in the XSA assessment for plaice and the low standard deviations in the likelihood components for these indices for sole.

Importantly, the precision of the sole assessment increases, as indicated by the substantial reduction in the standard deviation of the fishing mortality estimate in the final year. This is the result of the increased amount of consistent information available to the assessment. When including only the UK45 index in 2015 to a “what if” assessment, this results in substantial changes in the development of SSB and F, probably as a consequence of the inconsistency of the 2015 index compared to the other indices. Due to the lower catches of the UK45 in 2015 than in previous years, the stock assessment model creates a general trend of decreasing biomass. This then results in decreased SSB and increased F estimates. Observed low catches of the UK45 in 2015 could not be explained during the evaluation of the industry survey and might just represent ‘bad luck’. Likewise, it could be possible that the UK45 index represents actual population trends which are not yet observed by the BTS, due to ‘lucky hauls’ in the BTS. The inclusion of both the UK45 and the OD1 results in an assessment in line with an assessment where only the fisheries independent indices are used. The OD1-index shows a similar trend as the BTS and consequently the deviating trend of the UK45 is of less importance for the general trend. A similar reaction should be evoked by a deviating trend in the BTS index opposite of UK45 and OD1 indices. However, this requires that fisheries dependent survey indices will be treated with equal trust as fisheries independent surveys when deviating trends are observed.

4.1 Continuation

Based on the results presented in this report, it can be concluded that the inclusion of the industry survey indices does not result in substantial increases of the spawning stock biomass estimations, as some fishers did expect at the start of the project. Although the industry survey catches much more plaice and sole, the higher catches show comparable trends over time with the fisheries independent surveys. However, due to the increased amount of aligned data, the precision of the sole assessment increased, and a similar reaction is expected for the plaice stock assessment. Especially sole has low data input (BTS-ISIS, SNS and the commercial catch series) and an alternative source of information is useful to check the information presented. Especially in years with deviating catches (for instance by failure of fisheries independent surveys due to weather conditions), such a check could reduce yearly variance in SSB estimates. At the moment, TAC-advice is not taking confidence intervals in consideration. However, with the increasing attention to multi-species and mixed-fisheries assessments, confidence intervals of single species assessments may become more important. The above described positive results of the industry survey are only to be expected if ICES decides to include the industry survey indices to the stock assessments. This decision, however, cannot be guaranteed as only at a benchmark such decision could be made. For plaice, the next benchmark is scheduled in spring 2017, while the next benchmark for sole is not yet scheduled, but will be held in 2019 or 2020.

To stimulate acceptance of inclusion of the industry survey indices by ICES, the survey design and stability in implementation should be ensured. During the 5 years of the industry survey, two major changes to the original survey design have occurred: at first, the GO4 was sold to a Belgian fisher and was therefore replaced by the OD1. As a consequence, only 4 years of data are available for the southern North Sea. The second major change to survey design was due to a shift in fishing gears by the UK45. Although a comparative fishing experiment has reduced the impact of this change, both changes show the difficulty of implementing a standardized survey design by an innovative sector. In addition to the changes in gear, some minor changes in sampling location have taken place. These changes are obviated by the establishment of index areas which should be sampled >75% of the years. Future expansions, shifts or exclusions of sampling area are not recommended, but can potentially be dealt with. However, it would be wise to keep in mind that the inclusion of new sampling stations will take multiple years before inclusion in index calculations is considered.

Based on the execution of the industry survey for 5 years, it can be concluded that an industry survey can result in useful indices which can be used additive to fisheries independent survey indices. The industry survey may not lead to substantial different estimates of SSB and F in stock assessments, precision of the sole stock assessment increased and a similar trend is expected for plaice. Moreover, an industry survey indirectly results in increased cooperation and herewith possibly in increased trust in stock assessments. However, these benefits are only valid if the industry survey data are included in the stock assessments.

5 Conclusions

- The industry survey project resulted in a 5-year time series of the UK45 and a 4-year time series of the OD1, in which sole and plaice were sampled according to a standardized survey protocol.
- The industry survey resulted in fairly similar indices for plaice and sole as the BTS indices, although the industry survey indices were based on much more fishes than the BTS indices.
- Inclusion of the industry survey indices has little impact on stock assessment results for plaice and sole.
- Inclusion of the industry survey indices positively affects precision of the sole stock assessment. A similar effect is expected for plaice. This has as consequence that yearly variation in SSB and F estimates will probably reduce.
- Continuation of the industry survey would be more beneficial for the sole stock assessment than for plaice, as data included in the sole stock assessment is more limited. The industry survey index could serve as a check of the BTS-ISIS index.
- An industry survey index is solely included in stock assessments when approved at species-specific benchmarks at ICES. This cannot be guaranteed.
- Besides the discussed effect of the industry survey on stock assessments, the industry survey contributes to the trust that fishermen have in stock assessments results.

6 Quality Assurance

IMARES utilises an ISO 9001:2008 certified quality management system (certificate number: 187378-2015-AQ-NLD-RvA). This certificate is valid until 15 September 2018. The organisation has been certified since 27 February 2001. The certification was issued by DNV Certification B.V. Furthermore, the chemical laboratory of the Fish Division has NEN-EN-ISO/IEC 17025:2005 accreditation for test laboratories with number L097. This accreditation is valid until 1th of April 2017 and was first issued on 27 March 1997. Accreditation was granted by the Council for Accreditation. The scope can be found at the website of the Council for Accreditation (www.rva.nl).

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Justification

Report C039/16
Project Number: 4301502002

The scientific quality of this report has been peer reviewed by a colleague scientist and a member of the Management Team of IMARES.

Approved: Marloes Kraan
Researcher

Signature:

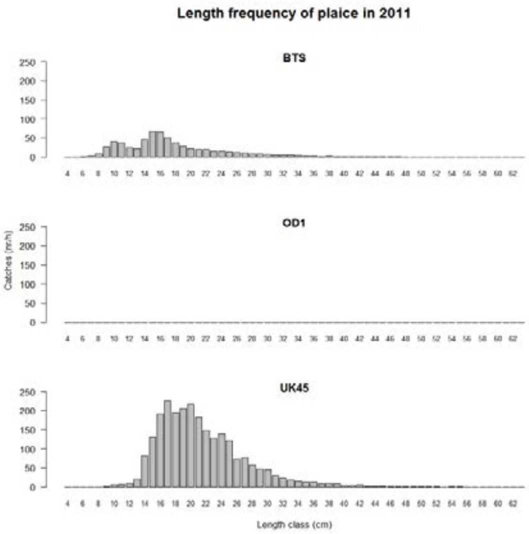
Date: 08/04/2016

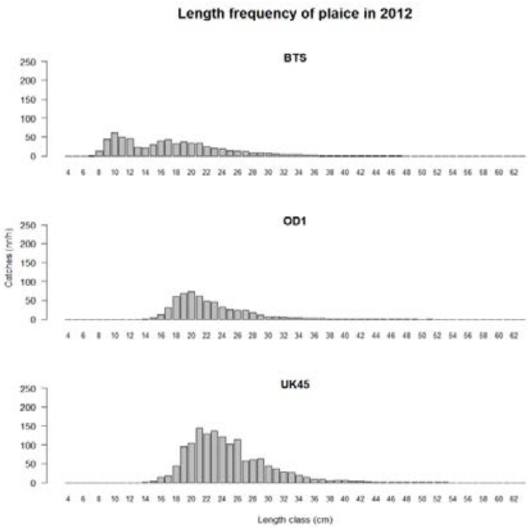
Approved: Dr.ir. T.P. Bult
Business Unit Manager

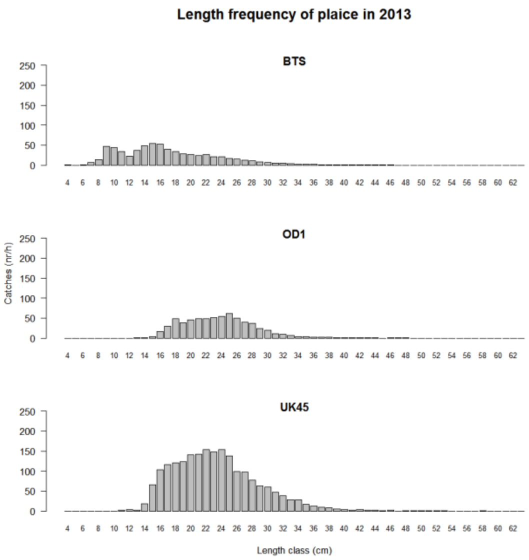
Signature:

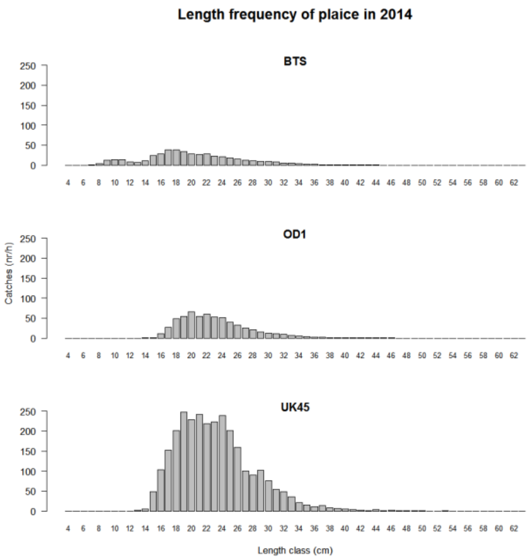
Date: 08/04/2016

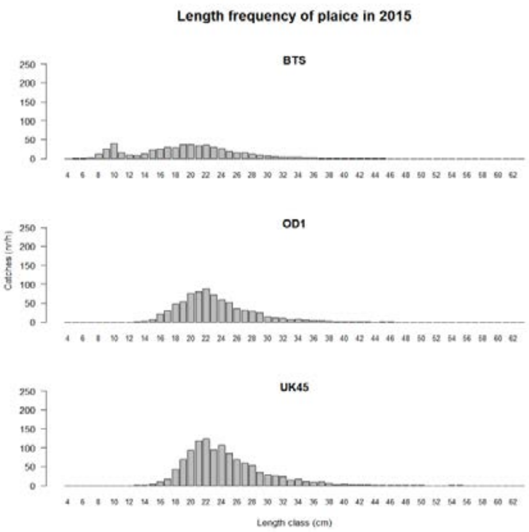
Annex A. Annual plaice length frequencies





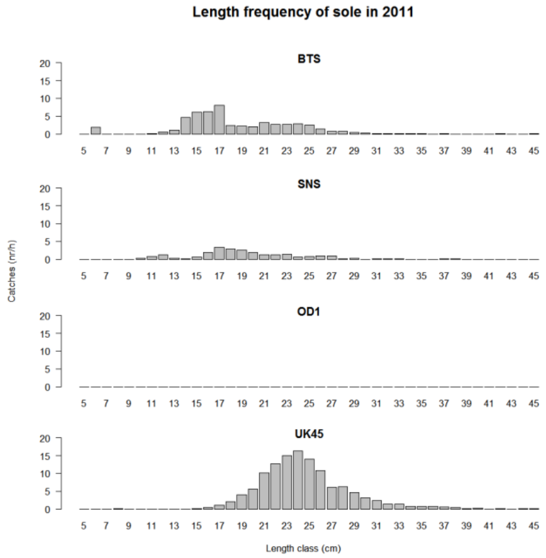


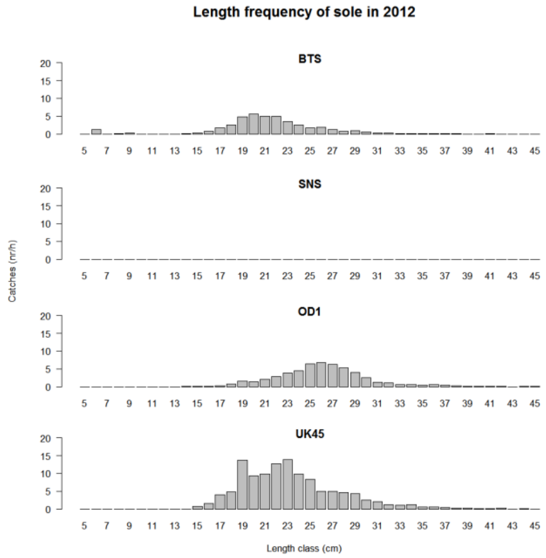


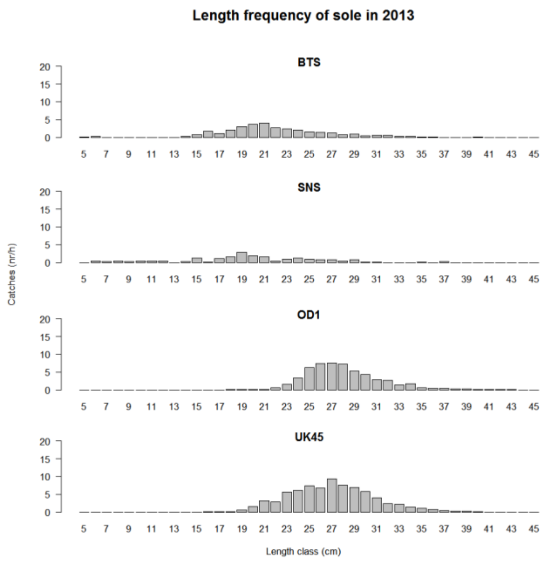


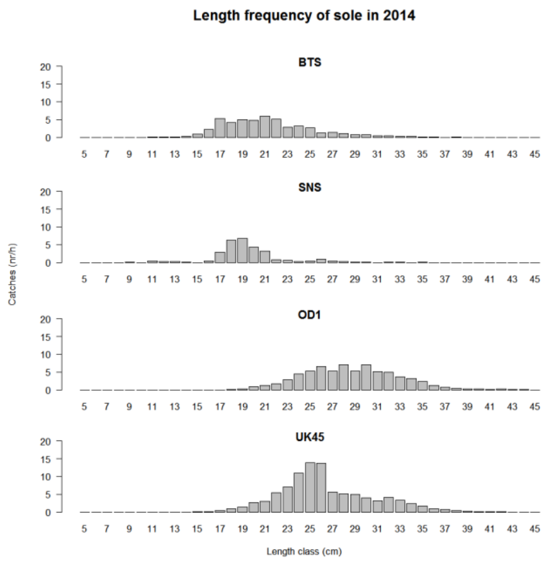
Figures A1-A5. Length frequency of plaice in 2011(A1), 2012 (A2), 2013 (A3), 2014 (A4), and 2015 (A5).

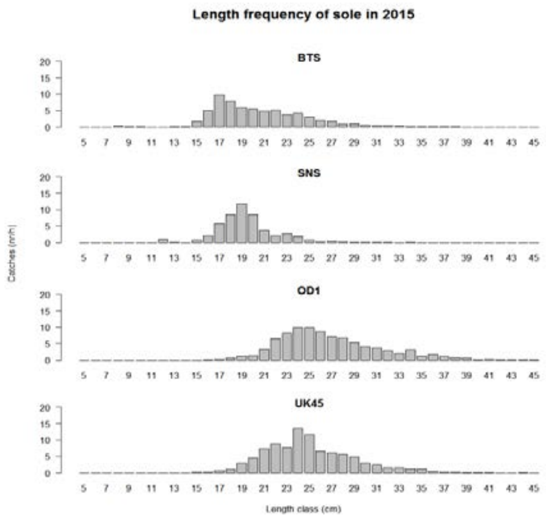
Annex B. Annual sole length frequencies











Figures B1-B5. Length frequency of sole in 2011(B1), 2012 (B2), 2013 (B3), 2014 (B4), and 2015 (B5).

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'To explore the potential of marine nature to improve the quality of life'

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