Stock Annex: Witch (*Glyptocephalus cynoglossus*) in Subarea 4 and divisions 3.a and 7.d (North Sea, Skagerrak and Kattegat, eastern English Channel)

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Witch (*Glyptocephalus cynoglossus*) in Subarea 4 and divisions 3.a and 7.d (North Sea, Skagerrak and Kattegat, eastern English Channel)
Working Group:	Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK)
Last updated:	May 2020
Last updated by:	Alexandros Kokkalis
Main modifications:	Information about commercial catches by country and biological data were improved. Also, results from the SAM model accepted at the last benchmark and updated at WGNKKS 2018 were added.

A. General

A.1. Stock definition

Witch flounder (*Glyptocephalus cynoglossus*) is a rather stationary species and the knowledge about stock identity is limited and based on old investigations (Molander 1935). Molander (1935) distinguished two stocks, one in the Kattegat (Division 3.aS) and one in the North Sea and Skagerrak (Division 3.aN and Subarea 4). However, as already reported by Molander in 1935, catches in the Kattegat are small and irregular and only at scattered places, at depth usually between 30 and 100 meters. The distribution of IBTS/BTS survey catches showed a continuum from 3.a into the Norwegian trench and the Northern part of Subarea 4 (Figure B.3.1.1.). Considering the results from surveys, the fact that catches in the Kattegat are sporadic and that there are no firm indications of spawning grounds in this area, witch flounder is assessed as a single stock in Subarea 4, Division 3.a and 7.d.

A.2. Fishery

A.2.1. General description

North Sea witch flounder is nowadays mainly landed and discarded by Denmark, Norway and Sweden in both areas (3.a and 4) and UK (Scotland and England) mainly in Subarea 4. A small fraction of the total landings are reported by The Netherlands and Belgium in Subarea 4 and Germany in both areas. The landings of witch in Division 7.d reported by France, UK-England and Belgium are almost negligible. In Division 3.a, Denmark is landing the largest amount of witch flounder, while in Subarea 4 it is

Scotland having the largest portion of the landings (Figure A.2.1.1.). Investigating the past 9 years (2009-2017) the dominant landing fleets are OTB_CRU_90_119_0_0_all (mixed *Nephrops*) in Division 3.a while in Subarea 4 OTB_DEF_<=120_0_0_all (Demersal trawls) and OTB_CRU_70_99_0_0_all (*Nephrops*) are landing the most of witch (Figure A.2.1.1.). It is noteworthy that the name of the fleets in InterCatch does not exactly reflect what is included in them, but it is more an overall grouping that is made to suit national sampling.

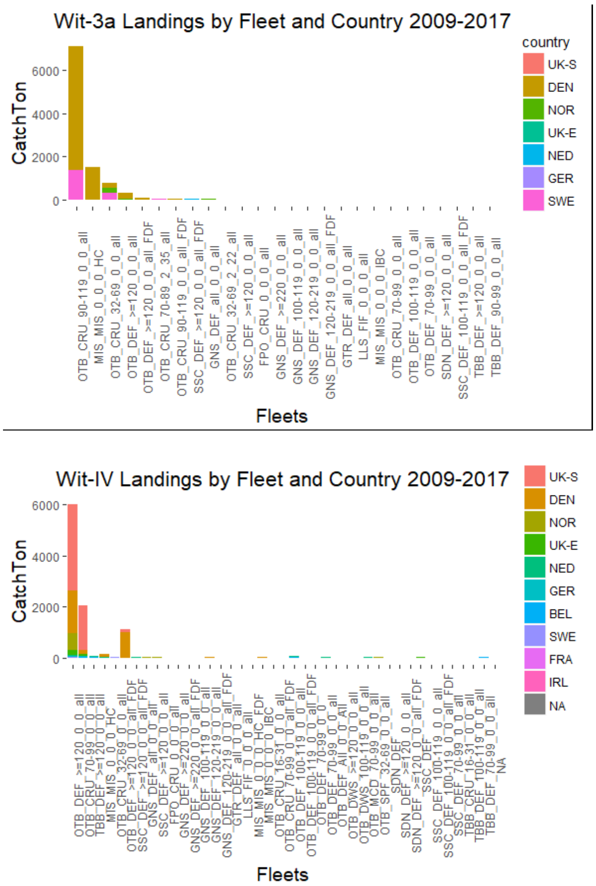

Figure A.2.1.1: Witch flounder landings by metiér and country during 2009–2017 in Division 3.a (top plot) and Subarea 4 (bottom plot)

A.2.2. Fishery management regulations

As a typical by-catch species, witch flounder has not been subject to any TAC limitations until 2006, when a combined TAC with Lemon sole (*Mikrostomus kitt*) was set in EU waters of Subarea 4 and Division 2.a. There is no Minimum Landing Size (MLS) specified in EU waters. In some coastal areas of England and Wales MLSs are enforced and the landing of witch below 28 cm is prohibited. Also, in Germany, Denmark, Scotland and Sweden the minimum landing size applied is 28 cm.

A.3. Ecosystem aspects

No specific ecosystem considerations were provided.

B. Data

B.1. Commercial catch

B.1.1. Landings data

B.1.1.1. Danish landings

The Danish landings are taken in Skagerrak (3.a) and in the Norwegian Deep (4.a East). At present, the majority of the landings are by-catches in mixed *nephrops* (OTB_CRU_90-119_0_0_all), *pandalus* (OTB_CRU_32_69_0_0_all) and demersal trawl fisheries (OTB_DEF_>=120_0_0_all)(Figure B.1.1.1.1).

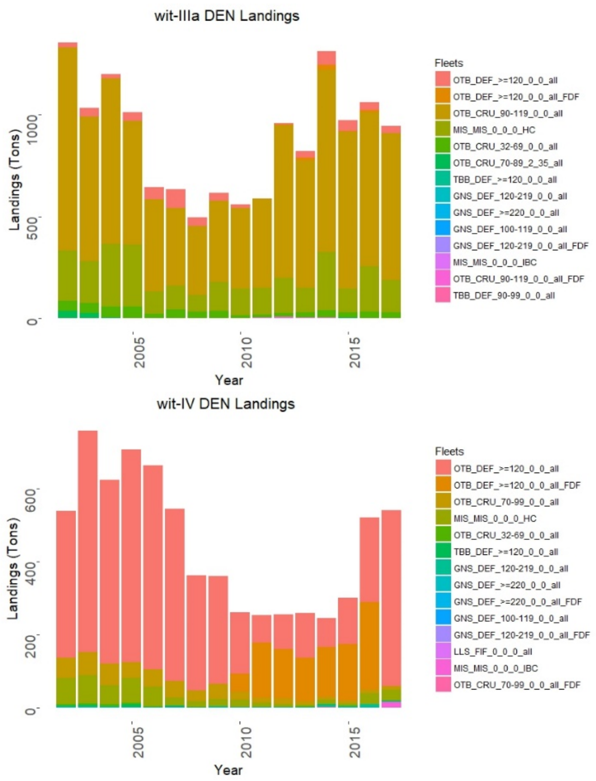

Figure B.1.1.1.1: Danish landings of witch by metiér and year in Division 3.a (left plot) and Subarea 4 (right plot)

B.1.1.1.1. Data coverage and quality

Not assessed

B.1.1.2. Swedish landings

In Sweden, the fisheries where witch flounder are caught are mainly the mixed *Nephrops* (OTB_CRU_90-119_0_0_all) and *Pandalus* (OTB_CRU_32_69_0_0_all) in 3.a and demersal fish fisheries (OTB_DEF_>=120_0_0_all) in Subarea 4. There is also an occasional witch flounder directed fishery in 3.a, consisting in demersal trawls with >30% witch but reported in Intercatch under OTB_CRU_90-119_0_0_all. In Subarea 4, minor quantity are caught by shrimp trawl fishery and seine where catches slightly increased the past 3 years (Figure B.1.1.2.1).

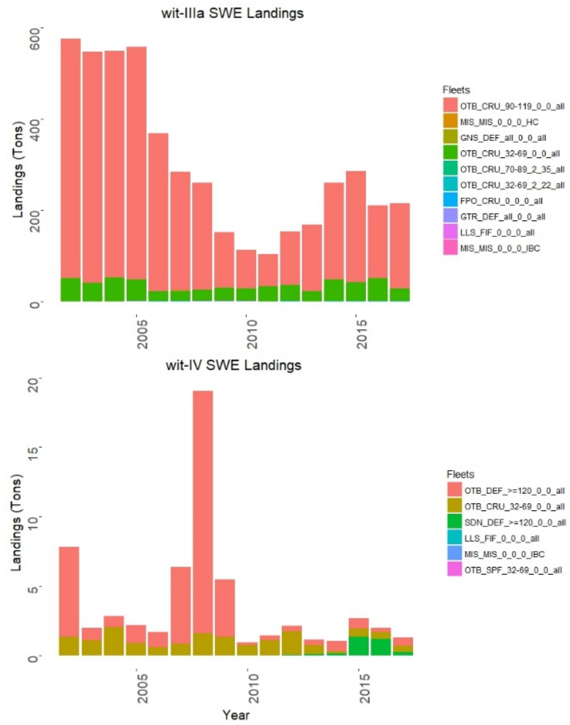

Figure B.1.1.2.1: Swedish landings of witch by metiér and year in Division 3.a (left plot) and Subarea 4 (right plot)

B.1.1.2.1. Data coverage and quality

Not assessed

B.1.1.3. Norwegian landings

In the Norwegian fishery, witch is caught in Subarea 4 mainly by demersal trawls (OTB_DEF_>=120_0_0_all) while in Division 3.a the *Pandalus* fishery (OTB_CRU_32-69_0_0_all) has the highest catch rate (Figure 5).

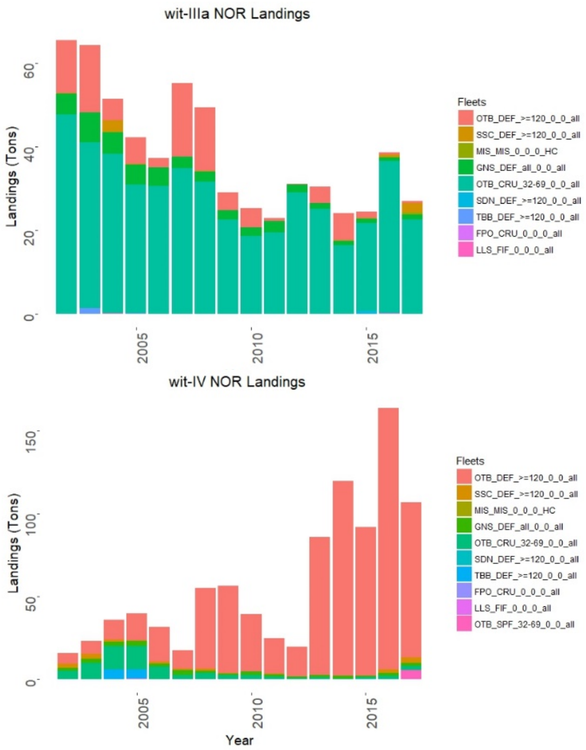

Figure B.1.1.3.1: Norwegian landings of witch by metiér and year in Division 3.a (left plot) and Subarea 4 (right plot)

B.1.1.3.1. Data coverage and quality

Not assessed

B.1.1.4. German landings

In Germany, which flounder is nowadays mainly caught by otter bottom trawl. Approximately 90% of the catches are taken with > 120 mm mesh opening. There are some minor catches with beam trawl and seine in Subarea 4.

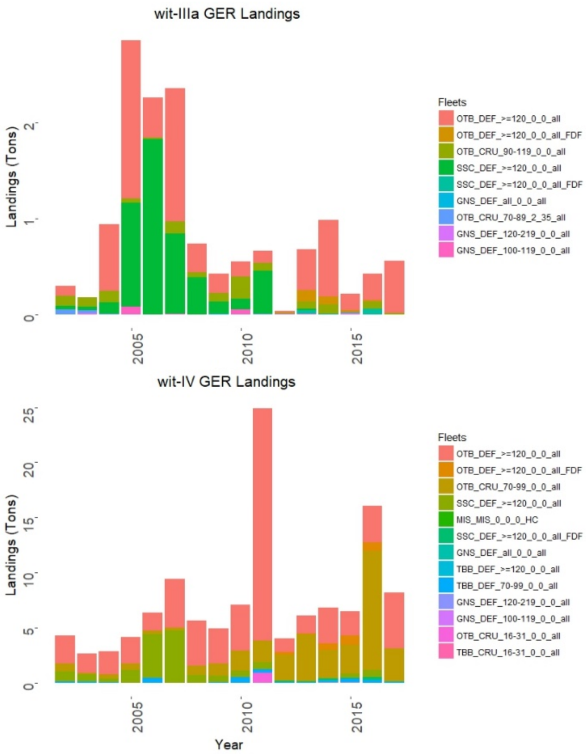

Figure B.1.1.5.1: German landings of witch by metiér and year in Division 3.a (left plot) and Subarea 4 (right plot).

B.1.1.4.1. Data coverage and quality

Not assessed

B.1.1.5. UK landings

In the UK English fishery, witch flounder is mainly caught in 4.a and 4.b. Beam trawlers took a big proportion of landings between mid-1980s and mid-2000s. Recently, the majority of the landings is by unspecified otter trawls, though some catches are taken by *Nephrops* trawls.

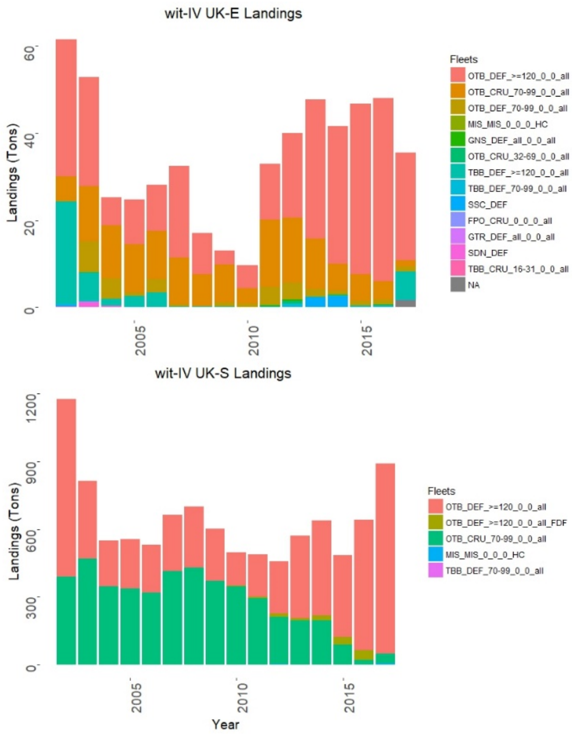

Figure B.1.1.4.1: UK landings of witch by metiér and year in Subarea 4 for England (right plot) and Scotland (right plot).

B.1.1.5.1. Data coverage and quality

Not assessed

B.1.1.6. Dutch Landings

In the Dutch fishery some minor catches of witch are taken in 3.a by the metiér SSC_DEF_>=120_0_0_all_FDF while in Subarea 4 by TBB_DEF_>=120_0_0_all and OTB_DEF_70-99_0_0_all.

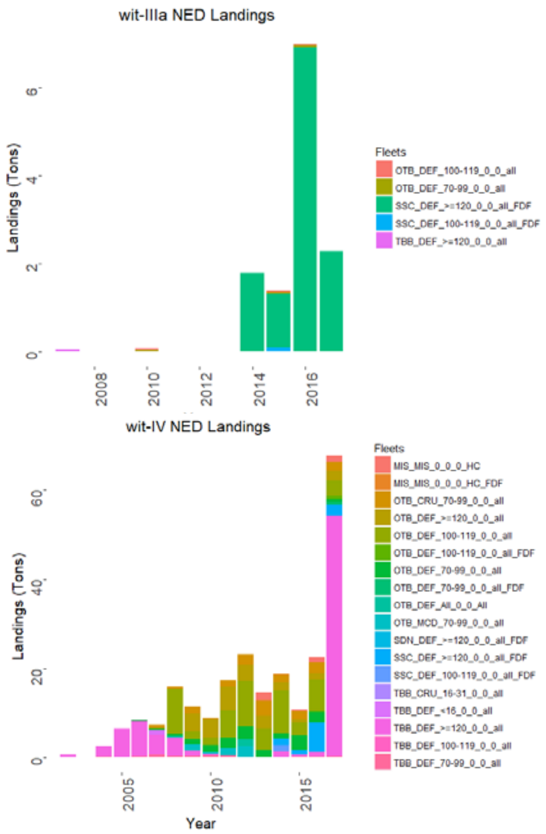

Figure B.1.1.6.1: Dutch landings of witch by metiér and year in Division 3.a (left plot) and Subarea 4 (right plot).

B.1.1.6.1. Data coverage and quality

Not assessed.

B.1.2. Discards estimates

In line with landings, discards of witch are reported by Denmark and Sweden in Division 3.a and Denmark, Scotland and Netherlands in Subarea 4. The main discarding fleets by country are shown in Figure B.1.2.1. In general, the discard rate is moderately low except for the first year of investigation (2002) when it was 34%. As problems were encountered when raising this year data, further investigation is needed. For the following period, the discard rate has been increasing from almost 10% in 2003 to 27% in 2010 and then decreasing again to 8% in 2017. However, it should be noted that not all métiers were sampled in every quarter and that raising procedure may not be adequate in all cases. Thus for some metiers the applied raising procedure might introduce some bias to the total discard estimates. An overview of the discard rates combined for all fleets is given in table B.1.2.

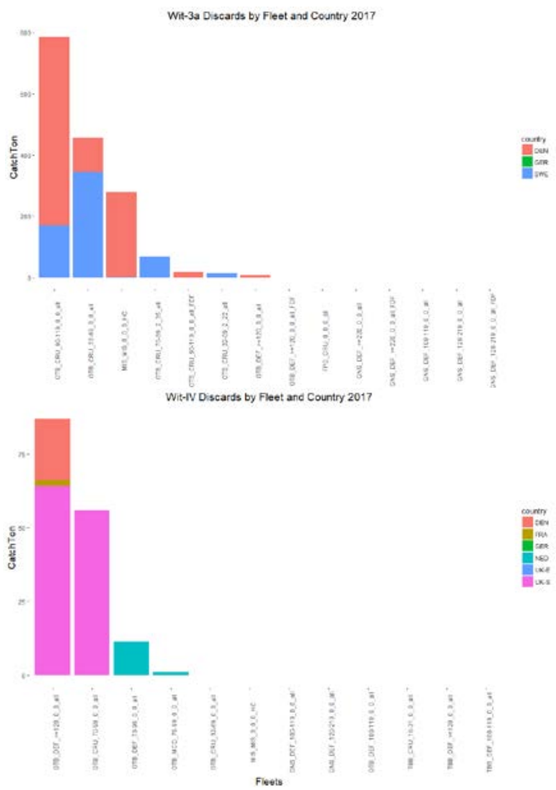

Figure B.1.2.1: Witch flounder discards by metiér and country during 2009–2017 in Division 3.a (left plot) and Subarea 4 (right plot).

Table B.1.2: Discards rate by year during the period 2002–2017 for all fleets combined.

Year	Discard rate
2002	0.343
2003	0.095
2004	0.108
2005	0.124
2006	0.112
2007	0.081
2008	0,137
2009	0.196
2010	0.268
2011	0.259
2012	0.222
2013	0.112
2014	0.103
2015	0.167
2016	0.125
2017	0.076

B.1.2.1. Danish data

The majority of the Danish discards are reported in mixed *nephrops* (OTB_CRU_90-119_0_0_all) and MIS_MIS_0_0_0_HC in Division 3.a and demersal trawl fisheries (OTB_DEF_>=120_0_0_all) in Subarea 4 (Figure B.1.2.1.1).

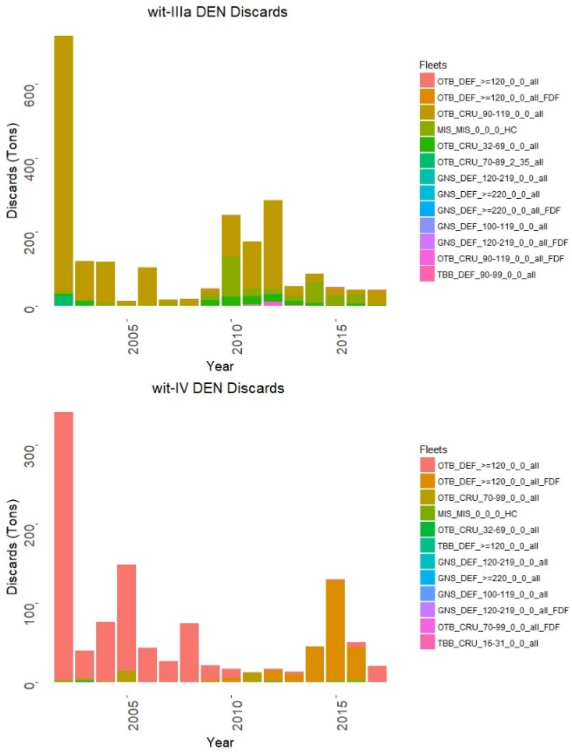

Figure B.1.2.1.1: Danish discards of witch by metiér and year in Division 3.a (left plot) and Subarea 4 (right plot).

B.1.2.1.1. Data coverage and quality

Not assessed.

B.1.2.2. Swedish data

Sweden reports discard only in Division 3.a mainly in *nephrops* fishery (OTB_CRU_90-119_0_0_all and OTB_CRU_70-89_2_35_all). The amount of witch discarded by the *pandalus* fishery (OTB_CRU_32-69_0_0_all) has decreased during the last few years (Figure B.1.2.2.1).

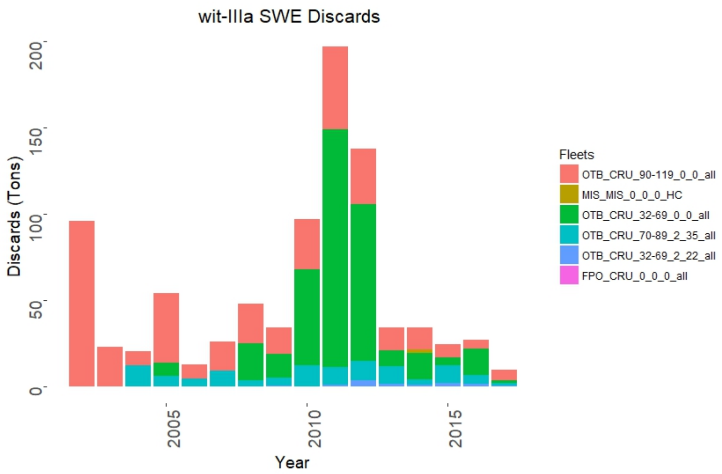

Figure B.1.2.2.1: Swedish discards of witch by metiér and year in Division 3.a.

B.1.2.2.1. Data coverage and quality

Not assessed.

B.1.2.3. UK-Scotland

Scottish discards of witch, as landings, are mainly reported by demersal (OTB_DEF_>=120_0_0_all) and *Nephrops* (OTB_CRU_70-99_0_0_all) trawls (Figure B.1.2.3.1).

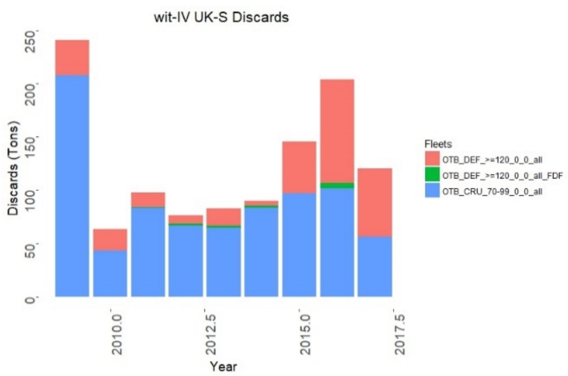

Figure B.1.2.3.1: Scottish discards of witch by metiér and year in Subarea 4.

B.1.2.3.1. Data coverage and quality

Not assessed

B.1.2.4. Dutch discards

The majority of witch in the Netherlands is discarded in the *nephrops* (OTB_CRU_70-99_0_0_all) and demersal OTB_DEF_70-99_0_0_all) fishery (Figure B.1.2.4.1).

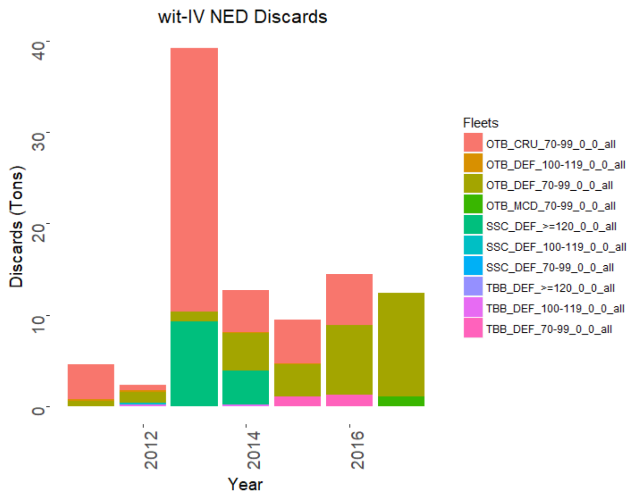

Figure B.1.2.4.1: Dutch discards of witch by metiér and year in Subarea 4.

B.1.2.4.1. Data coverage and quality

Not assessed.

B.1.3. Recreational catches

No information on recreational fisheries were dealt with.

B.2. Biological sampling

In 2009, witch flounder has been included as a mandatory species in the EU Data Collection Framework (2009). Since then, Sweden, Denmark and Scotland started to collected otoliths for age estimation. A comprehensive description of biological parameters of this stock can be found in WKNSEA 2018, WD3.

B.2.1. Weight at age

The landings, discards and catch weights-at-age were estimated after raising national observed data in InterCatch for the period 2009–2016 while the stock weights-at-age were obtained using IBTS data, quarter combined, from the same period. All weights show no real trend over time and become noisy at older age (WKNSEA 2018, WD3). For these reasons, it was suggested to use 8 as plus-group and use constant stock weights instead of annual values (Table B.2.1.1). The final decision was to use age 10 as plus-group. Catch mean weight at age is shown in Table B.2.1.2.

Table B.2.1.1: Stock weights at age use in the SAM model.

Age	1	2	3	4	5	6	7	8	9	10+
Stock weights (kg)	0.0055	0.0328	0.0772	0.151	0.234	0.336	0.377	0.429	0.443	0.495

Table B2.1.2. Catch mean weight at age for the years 2009–2017.

Year/Age	1	2	3	4	5	6	7	8	9	10+
2009	0.0122	0.035	0.099	0.136	0.197	0.26	0.29	0.35	0.34	0.47
2010	0.0140	0.032	0.071	0.125	0.22	0.32	0.35	0.30	0.34	0.45
2011	0.0129	0.048	0.100	0.170	0.21	0.29	0.39	0.40	0.47	0.52
2012	0.0118	0.036	0.109	0.178	0.24	0.28	0.34	0.40	0.47	0.46
2013	0.030	0.077	0.099	0.188	0.23	0.28	0.32	0.40	0.45	0.44
2014	0.0109	0.033	0.093	0.170	0.21	0.30	0.31	0.35	0.33	0.35
2015	0.0098	0.028	0.084	0.155	0.26	0.33	0.39	0.41	0.47	0.47
2016	0.0120	0.033	0.076	0.158	0.23	0.31	0.39	0.42	0.40	0.53
2017	0.0104	0.024	0.114	0.164	0.090	0.33	0.36	0.39	0.37	0.42

B.2.2. Maturity

Maturity of witch is recorded by Denmark and Sweden both during the International Bottom Trawl Surveys (IBTS) Q1 and Q3 (available in DATRAS) and during commercial sampling. Data from Swedish commercial samples from 2009 collected mostly on a monthly basis represent the biggest dataset (5800 records) and was therefore further explored (WKNSEA 1018, WD 3) and used in order to estimate the maturity ogives for stock assessment (Table 3). Since the assessment only includes ages up to 10, the proportion of age 10 is set equal to the average over ages 10-12, i.e. 0.851.

Table 3. Constant maturity ogives obtained using Swedish commercial samples 2009-2016 all quarters combined.

Age	1	2	3	4	5	6	7	8	9	10	11	12
Proportion mature	0	0	0.114	0.136	0.275	0.376	0.428	0.524	0.631	0.671	0.882	1

B.2.3. Natural mortality

The assessment currently uses a constant natural mortality rate of 0.2 for all ages and years.

B.2.4. Length and age composition of landed and discarded fish in commercial fisheries

The length distributions (total number caught by length group overall years divided by total number caught) for both landings and discards is shown in Figure B.2.4.1, while the age composition of landed and discarded fish is shown in Figure B.2.4.2

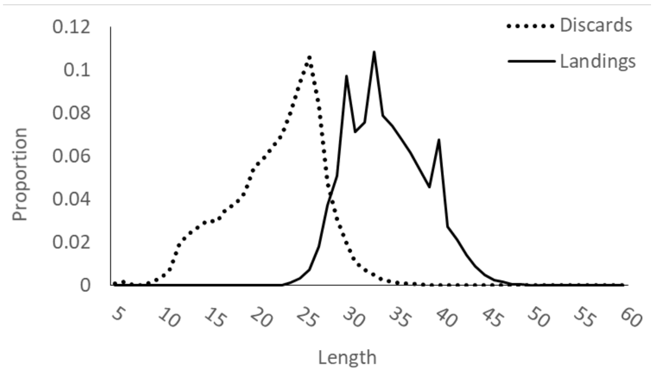

Figure B.2.4.1. Length distribution of witch in landings and discards

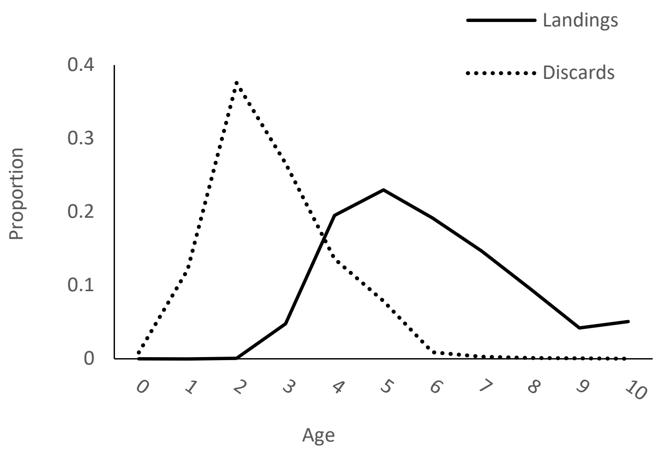

Figure B.2.4.2. Age distribution of witch in landings and discards.

B.3. Surveys

Two survey time-series exist which are useful for the witch 3a47d stock assessment model to be used as tuning indices. Those surveys for demersal fish species in the greater North Sea area are the International Bottom-trawl Survey (IBTS, 1st and 3rd Quarter) and the Beam Trawl Surveys (BTS, 3rd Quarter). While the BTS cover areas 4.b, 4.c and the English Channel (Division 7.d), the IBTS covers area 4.a, the Skagerrak (Division 3.aS) and Kattegat (Division 3.aS). Data exploration and results are included in WKNSEA 2018 (WD2).

Furthermore the use of the IMR deep water shrimp survey (held in national database) was mentioned as a potential future data source, but it has not been explored during the last the benchmark.

B.3.1. Survey design and analysis

Surveys descriptions can be found using the following link
http://datras.ices.dk/home/descriptions.aspx

The delta-GAM approach was used to generate survey indices by age from IBTS Q1 (ages 1–7) and IBTS Q3 (ages 1–6) for 2009-2016; no age data exists prior to 2009. No age data for witch existed in the BTS data. DATRAS-generated IBTS Q1 and Q3 indices by age were also provided by the ICES Data Centre for comparison. The two set of estimated indices by age where compared in order to choose the one to be included as tuning indices in assessment models. Given the better internal and external consistencies, the ICES indices at age were used in the SAM model.

Total biomass indices were also generated for IBTSQ1 and combined BTS-IBTS Q3 (Figure B.3.1.1).

However, witch flounder distribution does not peak at a certain depth range, indicating they are found at depths deeper than the surveys.

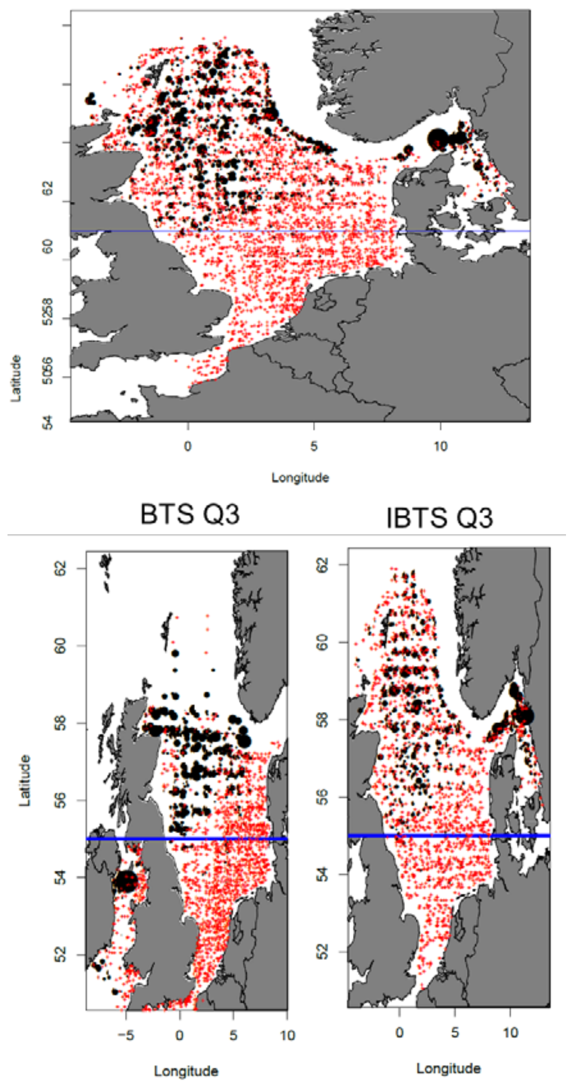

Figure B.3.1.1. All hauls combined during IBTSQ1 (left plot), BTSQ3 (middle plot) and IBTSQ3 (right plot). Sizes of bubbles are proportional to total catch weight. Red crosses represent zero catch hauls. The area above the blue line was used to calculate the survey index.

B.3.2. Survey data used

The DATRAS-generated IBTS Q1 and Q3 indices by age, provided by ICES, were used in the SAM model. Furthermore, two biomass indices are included in the SAM model along with total landings. The biomass surveys are calculated using data from the NS-IBTS in Q1 and a combination of NS-IBTS and BTS in Q3; only hauls north of 55 degrees North are included in the calculation of the biomass indices (Figure B.3.1.1).

C. Assessment methods and settings

C.1. Choice of stock assess model

Both the Surplus Production in Continuous Time (SPiCT) model and the State-space assessment model (SAM), an age-structured population model, were run in parallel at WKNSEA 2018. SPiCT was run for various data and model configurations (6 scenarios) and the diagnostics for the scenario with extended landings time-series and no n prior (shape parameter of Pella-Tomlinson) indicated that the model could potentially be used to provide management advice.

Three SAM models were implemented: 1) a standard model that fitted a short time-series starting in 2009, 2) an extended model that was run extending the time-series back in time (landings data from 1950), and 3) an extended model with two new exploitable biomass surveys presented at the Benchmark meeting. Model 1) performed well, but the retrospective runs were difficult to evaluate because of the very short time-series (just 8 years). The results of models 2) and 3) show similar trends, but the confidence intervals in the period covered by the two new exploitable biomass surveys were narrower.

C.2. Model used of basis for advice

The accepted assessment model during WKNSEA 2018 was the SAM Model 3.

The description of those assessment models are clearly outlined in Nielsen and Berg (2014) and Berg et al., 2014 so will not be presented here. Detailed information on settings and results from the two models can be found in WKNSEA 2018 WD4 and WD5. The basis of the biennial advice issued by ICES in 2017 was a survey trend based assessment applying method for data limited stocks (WGNSSK, 2017). This advice is valid for 2018 and 2019 and it was not re-opened during WGNSSK 2018.

C.3. Assessment model configuration

Final model configuration

Min Age: 1
Max Age: 10
Max Age considered a plus group (Yes)
The following matrix describes the coupling of fishing mortality state (normally only first row is used).
0 1 2 3 4 5 5 5 5 5
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1
Correlation of fishing mortalities across ages: AR1
Coupling of survey catchability parameters (normally only first row is used, as that is covered by fishing mortality).
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1
0 1 2 3 4 5 5 -1 -1 -1
6 7 8 9 10 10 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1
11 -1 -1 -1 -1 -1 -1 -1 -1 -1
12 -1 -1 -1 -1 -1 -1 -1 -1 -1
Density dependent catchability power parameters (if any).
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1
Coupling of process variance parameters for log(F)-process (normally only first row is used)
0 0 0 0 0 0 0 0 0 0
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1
Coupling of process variance parameters for log(N)-process
0 1 1 1 1 1 1 1 1 1
Coupling of the variance parameters for the observations.
0 0 0 0 0 0 0 0 0 0
1 1 1 1 1 1 1 -1 -1 -1
2 2 2 2 2 2 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1
3 -1 -1 -1 -1 -1 -1 -1 -1 -1
4 -1 -1 -1 -1 -1 -1 -1 -1 -1
Stock recruitment model code
Random walk
Years in which catch data are to be scaled by an estimated parameter
0
Fbar range: 4 to 8
Coupling of correlation parameters. NA's indicate where correlation parameters can be specified (-1 where they cannot).
1-2 2-3 3-4 4-5 5-6 6-7 7-8-8-9 9-10
NA NA NA NA NA NA NA NA NA
NA NA NA NA NA NA -1 -1 -1
NA NA NA NA NA -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1

Option for observational likelihood
"LN" "LN" "LN" "LN" "LN" "LN"
If weight attribute is supplied for observations this option sets the treatment (0 relative weight, 1 fix variance to weight).
0

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	2009-present	1-10+	Yes
Canum	Catch at age in numbers	2009-present	1-10+	Yes
Discards	Discards in tonnes	2009-present	1-10+	Yes
Landing fraction	Percent landed	2009-present	1-10+	Yes
Weca	Weight at age in the commercial catch	2009-present	1-10+	Yes
Stock weights	Weight at age IBTS	2009-present	1-10+	No
Mprop	Proportion of natural mortality before spawning	0.5		No
Fprop	Proportion of fishing mortality before spawning	0.5		No
Matprop	Proportion mature at age	2009-present	See WKNSEA 2018 WD3	No
Natmor	Natural mortality	2009-present		No

D. Short-term prediction

The short-term prediction is done using a stochastic forecast of the accepted SAM assessment, where the population is projected forward under the following assumptions:

(i) the selectivity, landing fraction during the forecasting period are assumed equal to the average estimates of the last 3 years of the assessment,

(ii) the recruitment during the forecasting period is sampled from the estimated recruitment of the last 3 years in the assessment,

(iii) the median F in the intermediate year is equal to the status quo F, and

(iv) the spawning stock biomass and catch come from a short-term forecast given the above assumptions.

A total of 11 scenarios are reported for the stock: F-based scenarios, where the F in the forecasting years is equal to F_{MSY}, $F_{MSYlower}$, $F_{MSYupper}$, F_{PA}, F_{lim}, F_{sq} and 0, Biomass based scenarios, where the fishing mortality in the forecasting years is so that the biomass after the TAC year is equal to B_{lim}, B_{PA}, and MSY $B_{trigger}$, and a scenario where the catch during the forecasting period is equal to the last advice (rollover-advice).

E. Medium-term prediction

No medium-term projections are done for this stock.

F. Long-term prediction

No long-term projections are done for this stock.

G. Biological reference points

	Type	Value	Technical basis

MSY Approach	MSY $B_{trigger}$	4745 t	B_{pa}
	F_{MSY}	0.154	EQsim analysis
	B_{lim}	3069 t	Breakpoint in the segmented regression accounting for autocorrelation
Precautionary Approach	B_{pa}	4745 t	$B_{pa} = B_{lim} * \exp(1.645 * \sigma)$ $\sigma = 0.265$
	F_{lim}	0.3	F_{lim} gives 50% probability of SSB > B_{lim} in the stochastic EqSim simulations
	F_{pa}	0.21	$F_{pa} = F_{lim} * \exp(-1.645\ \sigma F)$; $\sigma = 0.221$

After WKNSEA 2018 EqSIM simulations were conducted using data from the accepted SAM assessment for the witch stock in the Greater North Sea. These followed the ICES advice technical guidelines as published 20 January 2017 (ICES, 2017) for the estimation of the reference points.

Recruitment at-age 1 from the assessment was used. Though strong autocorrelation in recruitment values was evident, no historic trends were observed in the stock–recruitment relation and therefore the entire time-series from 1940 was utilized in the estimation of reference points.