Stock Annex Flounder (*Platichtys flesus*) in Subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic)

Stock specific documentation of standard assessment procedures used by ICES.

Stock: Flounder (*Platichtys flesus*) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic)

Working Group: WGBFAS

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Main modifications: Updates in text; New paragraph on recently described flounder species; Information about historical surveys was removed; Standardized effort calculation method added; Information about LBI calculations method added.

A. General

A.1. Stock definition

ICES SD 24 and 25 were defined as a new assessment unit for flounder at the Data Compilation for Benchmark Workshop on Baltic Flatfish Stocks (DCWKBALFLAT, ICES 2014) in 2013, thereby changing the decisions made at the previous ICES/HELCOM workshops WKFLABA (ICES, 2010) and WKFLABA2 (ICES, 2012).

The stock is considered separated from the other flounder populations occurring in the Baltic Sea.

First of all, there are significant disparities between two sympatric flounder populations (since 2018 considered as two separate species) in the Baltic Sea, which differ in their spawning habitat, egg characteristics (Nissling *et al*., 2002; Nissling and Dahlman, 2010) and genetics (Florin and Höglund, 2008; Hemmer-Hansen *et al*., 2007a; Figure 1), although they utilize the same feeding grounds in summer - autumn (Nissling and Dahlman, 2010).

Taking into account contrasting reproductive flounder behaviours in the Baltic Sea: offshore spawning of pelagic eggs and coastal spawning of demersal eggs, Momigliano *et al.* (2018) distinguished two flounder species in the Baltic Sea. Both of them are present in the management area (SD 24 and 25). According to survey data from 2014 and 2015, the share of offshore spawning *Platichthys flesus* and the coastal spawning - newly described species *Platichthys solemdali*, was estimated to be approximately 85 and 15% respectively (Ojaveer *et al.,* 2017). It is not possible at this stage to separate the proportion of this species in either stock assessment or fisheries, as external morphological characters cannot discriminate between European and Baltic flounders. The two taxa can be clearly distinguished based on gamete physiology and morphology (Momigliano *et al.,* 2018).

Platichthys solemdali produce small and heavy eggs which develop at the bottom of shallow banks and coastal areas in the northern part of the Baltic Proper. Spermatozoa from Baltic flounders (*P. solemdali*) activate at salinities as low as 3–4 psu, but successful fertilization, requires a salinity of at least 6 psu (Nissling *et al.*, 2002; Momigliano *et al.*, 2018). They were established as a one stock/assessment unit comprised of SDs 27, 28.1, and 29-32, but they can also inhabit e.g. SD 25 (Nissling and Dahlman, 2010).

Platichthys flesus (the group to which flounder in SDs 24-25 belong) is distributed in the southern and the deeper eastern part of the Baltic Sea and spawn at 70–130 m depth. Its pelagic eggs are far larger and lighter than *P. solemdali* sp. nov., (Solemdal, 1971, 1973; Nissling *et al.*, 2002; Momigliano *et al.*, 2018). The activation of their spermatozoa and fertilization occurs at an average of 10-13 psu, whereas an average salinity required to obtain neutral egg buoyancy is 13.9-26.1 psu (Nissling *et al.*, 2002).

There are also differences within the European flounders, which led to the designation of three stocks/assessment units at the DCWKBALFLAT: SD 22 and 23; SD 24 and 25; SD 26 and 28 (ICES 2014). There is evidence of a differentiation between SD 22 and 23 from SD 24 and 25 based on egg buoyancy (Nissling *et al.*, 2002), length at maturity (Table 1), and to some extent genetics (Hemmer-Hansen *et al.*, 2007b). Although there is no physical connection between SD 22 and SD23, flounder in these areas are assumed to be connected through the western part of SD 24.

Flounder in SD 24 and 25 are also different from flounder in SD 26 and 28.2 based on separate spawning areas (Figure 2), and tagging data indicate no dispersal between these areas (Cieglewicz, 1963; Otterlind, 1967; Vitinsh, 1976). Trends in survey CPUE are inconclusive and the extent of exchange of early life stages between the areas is unknown (Figure 3). Therefore, the distinction between these two stocks should be further examined, e.g. whether a more consistent assessment with lower uncertainty would be obtained if these two units are merged. For the time being, it was decided to assume two separate stocks.

Table 1. Length-range at 50% maturity for flounder in different ICES SD based on individual countries data from the WKBALFLAT data call. Flounder in SD 22 mature at a much greater size than flounder in other areas. There are no data available from SD 23 & 27.

SD	22	23	24+25	26	27	28
LM50 (cm)	25–26		15–21	14–21		18–19

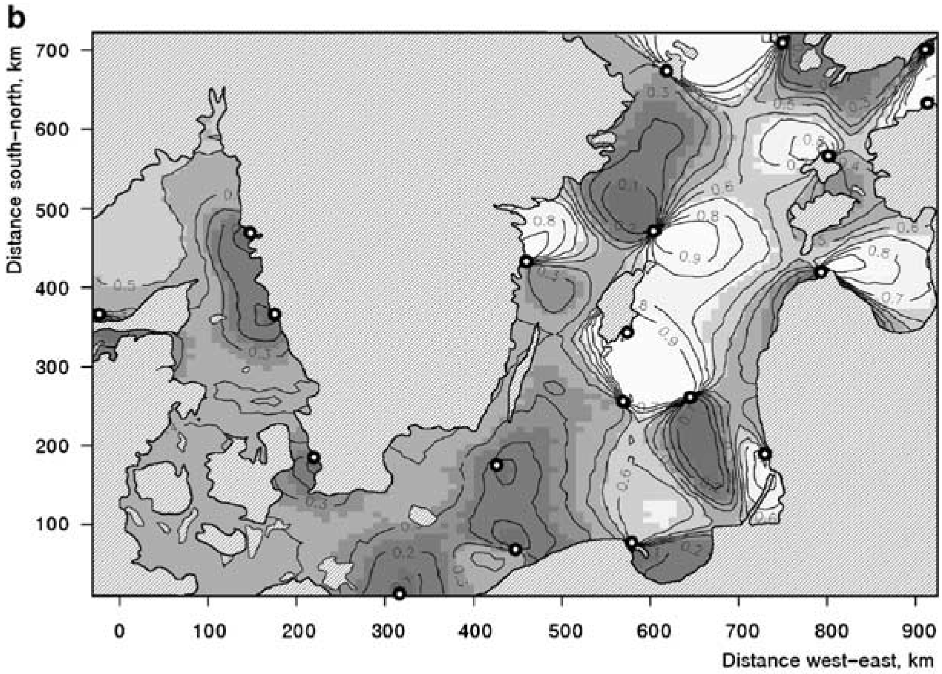


Figure 1. Map of posterior probabilities of population membership (number of populations = 2 and 50 000 iterations). Lighter areas correspond to higher probability to belong to the demersal population, sampling locations are indicated with white dots (Florin and Höglund, 2008).

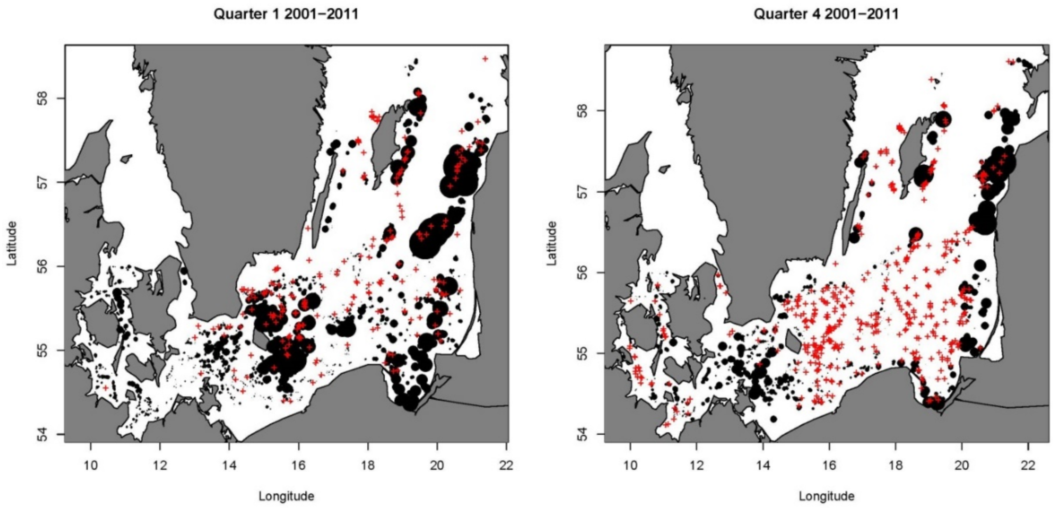


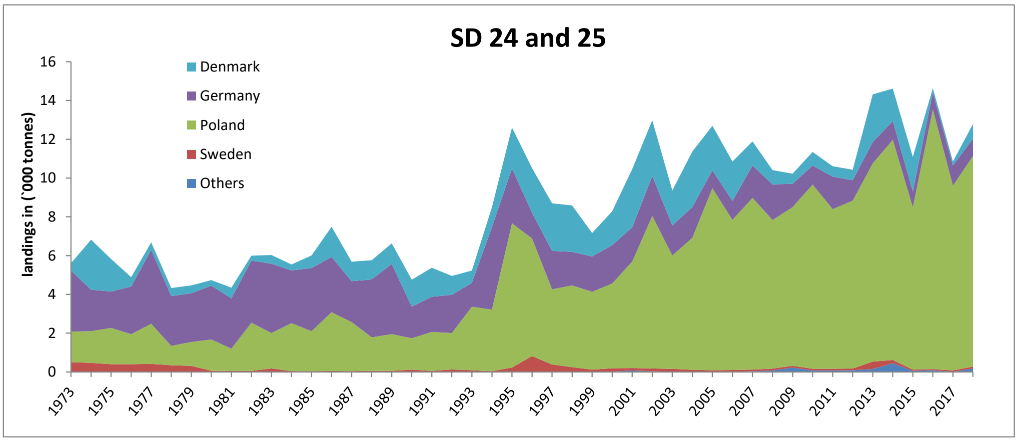
Figure 2. Average relative distribution of flounder biomass in the BITS survey in quarter I (spawning time) and quarter IV from years 2001–2011. Bubble size is proportional to biomass, red crosses means zero catch.

Figure 3. Survey indices from BITS survey quarter I for flounder in different SD.

A.2. Fishery

The fishing season spans mainly between months June to February. The total landings of this stock increased from 4000 to 7000 t in 1973–1993, and to 8000–14 500 t after 2000. Some high landings in the mid-1990s are due to misreporting (cod was reported as flounder). In 2003 the landings decrease compared to 2002, which was partly due to the longer summer ban for the cod trawl fishery and partly due to German trawlers that did not target flounder in 2003. In 2004 the flounder landings increased again and remained around 10 000 t.

In Subdivisions 24 and 25, Poland, Denmark, and Germany are the main fishing nations (Figure 4). Polish landings increased during the 2000s and are at least 60% of the total landings, while Danish landings show a decreasing trend in the 2000s.



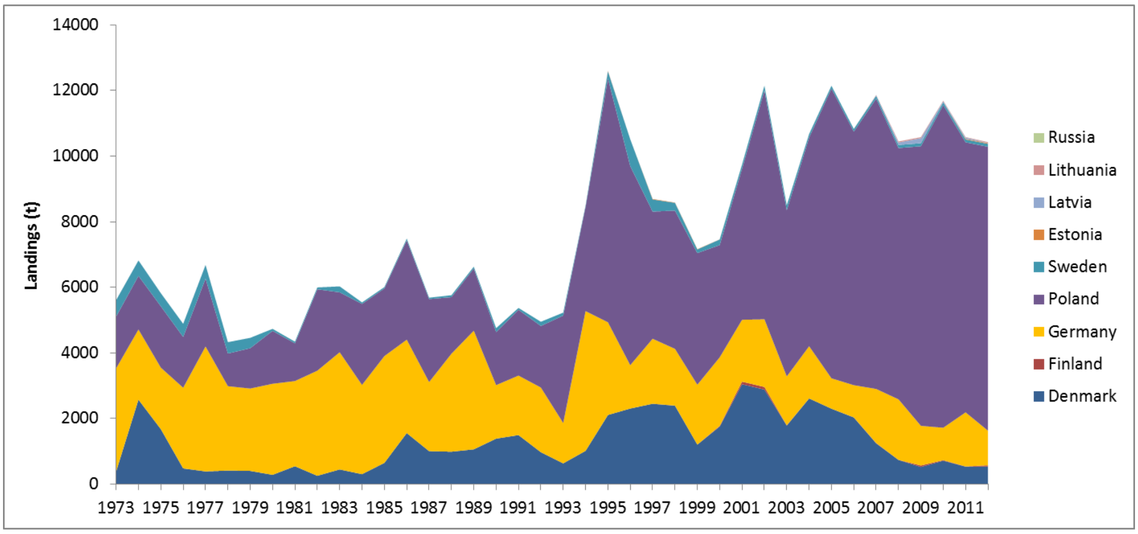


Figure 4. Flounder in SD 24–25. Landings in tonnes by country.

In Poland, trawl and gillnet fishing directed to flounder is common. Polish flounder catches increase when cod resources decrease. About 60% of the Polish landings are from the directed flounder fishery in the Polish EEZ (SD 26 included).

The Danish landings are mainly bycatch in the cod fishery. The major season for flounder by-catch is winter, where some fishing boats may catch up to two tonnes per day, depending on depth and area. Most flounder are caught in the area east and southeast of Bornholm (SD 25). There is a high variability between years. The amount of the flounder catch discarded depends on price and size of the flounder. In the most recent years the price declined and therefore the amount of flounder discarded increased.

German flounder landings are also mainly bycatch in the cod-directed fishery, but in ICES SD24 there is a German trawl fishery directed to flounder, in particular in the 3rd and in the 4th quarters. The German flounder landings depend largely on the market situation (price and demand for flounder). In 2007, some periods of good prices for flounder were reported by the fishers. Therefore the variation in the landing cannot be considered as an indicator for the stock size.

<u>Council Regulation (EC) No 2187/2005 of 21 December 2005 concerning the flounder stock in ICES Subdivisions 24 and 25:</u>

Under Article 14, 1. *The flounder shall be regarded as undersized if it is smaller than the minimum size of 23 cm.*

Under Article 15, 1. *Undersized fish shall not be retained on board or be transshipped, landed, transported, stored, sold, displayed or offered for sale, but shall be returned immediately to the sea.*

Additional national rules concerning flounder:

Until 2007, it was not allowed to land female flounders, caught in the German 12 Nm zone from 1 February to 30 April.

A.3. Ecosystem aspects

Flounder from SD 24-25 spawns in the Arkona Deep, the Slupsk Furrow, and the Bornholm Deep. Spawning takes place from March to May. After spawning, flounders migrate to feeding grounds in shallow coastal waters (Bagge, 1981; ICES, 1978).

For the flounder stock in SD 24 and 25 the reproductive volume is defined by ≥12.0 psu and ≥2 ml O_2/l. Therefore, the recruitment success can fluctuate depending on the hydrological condition on the spawning grounds.

B. Data

B.1. Commercial catch

Landings in tonnes are available from Denmark, Germany, Poland and Sweden from 1973 onwards. For other countries data are available for the following years: Finland 1996-onwards, Estonia 1995, 1997–2000 and 2009– onwards, Lithuania 1995 and 2007– onwards, Latvia 1998, 2000 and 2004– onwards (Table 2).

Table 2. Overview of available landings data per country.

	Denmark	Germany	Poland	Sweden	Finland	Estonia	Lithuania	Latvia
Years with total landings data	1973 - present	1973 - present	1973 - present	1973 - present	1996 - present	1995	1995	1998
						1997–2000	2007–present	2000
						2009–present		2004–present

Available age samples from landings based on recommended age determination methods using slicing or breaking and burning technique for age reading, recommended by WKARFLO (ICES 2007; 2008) and WKFLABA (ICES, 2010), are presented in Table 3.

Table 3. An overview of available age samples from landings based on the recommended age determination methods (available samples for different countries are marked yellow; DE – Germany, DK – Denmark, LV – Latvia, PL – Poland, SE- Sweden).

	SD24				SD25			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
2000					PL			
2001					PL			
2002					PL			
2003	PL							
2004	PL				PL			
2005	PL				PL			
2006	PL				PL			SE
2007	PL				PL, SE			
2008	PL	DE	DE	DE	PL	DE		DE, SE
2009	DE	DE	DE	DE	PL, DE, SE	DE		DE, SE
2010	PL	DE	DE	DE	PL, DE, SE, LV	DE		DE, SE
2011	PL	PL, DE	PL, DE	PL, DE	PL, DE,SE	PL,DE	PL	PL, SE
2012	PL, DE, DK	PL, DE, DK	PL, DE, DK	PL, DE, DK	PL, SE	PL, DE	PL	PL, DE, SE

The common discard ratio cannot be applied, because the discard ratio in both subdivisions varies between countries, gear types, and quarters and additionally discarding practices are controlled by factors such as market price and cod catches.

During WKBALFLAT (ICES, 2014) the quality of the estimations of discards was questioned. The main problem was very high flounder discards, which exceed the landings or sometimes are even 100% of the catch. When no discard data are available for particular stratum and there was no landing of flounder assigned, then the discard was also estimated as non-existent, which is not necessarily true. This leads to an underestimation of discards, and therefore the current discard estimates should not be used in the provision of advice. Due to this constraint the WKBALFLABA recommended to recalculate discards, and to consider an alternative approach to deriving discard ratios that would be less prone to underestimation of discards.

Since 2014, discards have been estimated by a new method which raises discard rate by all demersal fish landings. In cases when there is no discard rate available for a stratum, it is borrowed from other strata according to allocation scheme, considering differences in discard patterns between subdivisions, countries, gear types and quarters. The highest discards in subdivisions 24 and 25 can be assigned to Denmark and Sweden (but only in 2014). Germany and Poland have the moderate discards, although the discard rate for Poland is relatively low.

Age samples from discards based on the recommended age determination methods have been available from Sweden from 2006 and 2008–2012, Poland from 2007 and 2009–2012, Germany since 2008, and Denmark from 2012 (Table 4).

Table 4. An overview of age samples available from discards based on the recommended age determination methods (available samples for different countries are marked red; DE – Germany, DK – Denmark, PL – Poland, SE- Sweden).

	SD24				SD25			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
2000								
2001								
2002								
2003								
2004								
2005								
2006								SE
2007					PL			
2008	DE	DE	DE	DE		DE		DE, SE
2009	DE	DE	DE	DE	PL, DE	DE		DE, SE
2010	DE	DE	DE	DE	PL, DE, SE	DE		DE, SE
2011		PL, DE	PL, DE	PL, DE	DE, SE	PL, DE		SE
2012	DE, DK	PL, DE, DK	PL, DE, DK	PL, DE, DK	PL, DE, SE	PL, DE		DE, SE

B.2. Biological data

Weight-at-age in catch, weight-at-age in landings, and weight-at-age in discards were estimated separately. Weights were assigned only for the years where ages from the new aging procedure (WKARFLO; ICES 2007, 2008) were available (since 2000).

Weight-at-age in the stock was estimated by applying weight-length relationship with length data from age–length key and averaging obtained weights within age groups.

Mature proportion were calculated using BITS survey data. A logistic regression on length was used to estimate the maturity at length m(L):

$$logit(m(L)) = \alpha + \beta L$$

and finally the mean maturity-at-age is estimated in the same manner as the mean weights:

$$E(m(L)|A = a) = \sum_k m(k)P(L = k|A = a)$$

(see WKBALFLAT 2014, WD 5.1).

The previously used age reading method (from whole otoliths) was considered inappropriate to flounder, because it resulted in high inconsistencies in age reading. The most problematic was ageing the old fish, for which the otoliths tend to grow in thickness rather than in length (ICES, 2008). In these cases, the rings on the edge of the whole otoliths are not visible because they overlapped, and consequently the age is underestimated.

B.3. Surveys (BITS-Q1, BITS-Q4)

The Baltic International Trawl Survey (BITS) covers the area of the flounder stock in 24 and 25. Since 2001 the BITS has been carried out using the stratified random design and the standard gear (TV3). BITS surveys are performed twice a year, in 1st and 4th quarter. BITS surveys in SD 24 are performed by Germany and since 2016 also by Poland, and in SD 25 are performed by Poland, Denmark and Sweden. Data from that survey are available in DATRAS database. However, it should be noted, that age data in DATRAS contains age information derived by different age determination methods (both the old age reading method as well as the recommended method of slicing or the breaking and burning technique). It was agreed that for assessment purposes, only the recommended aging method should be used. Survey age data determined with the recommended method have been available for SD 24 since 2009 (Germany) and for SD 25 from Poland for 1st quarters of 2000–2002, 2004–2010, since 2011 for both 1st and 4th quarters; from Denmark since 2012 and from Sweden since 2007.

B.4. Commercial CPUE

Effort data back to 2009 is available for all countries. As countries have not used the same approach, the effort was standardized within each country and weighted by the national demersal fish (cod and flounder) landings from SD 24–25.

Standardized (SE) effort by average effort by country (se) was calculated from equation:

$$se = \frac{f_c}{avg\ f_c}$$

where: f_c – effort by country c

Standardized effort by total demersal landings (SE) in year (y) by country (c) was calculated from equation:

$$\mathrm{SE} = \sum \left(L_{\mathrm{y,c}} \cdot se_{y,\mathrm{c}}\right) \div \sum L_{y,\mathrm{c}}$$

$L_{y,c}$ – landings by country and year

B.5. Other relevant data

During WKBALFLAT 2014, possibilities for undertaking an age/length based analytical assessment were explored.

Length-distributions from commercial catches are available for SD 24 from Denmark, Germany, Latvia, Poland and for SD 25 from Germany, Latvia, Poland, Sweden in the period from 2000 onwards (different time-range depending on country).

Length-distributions from survey are available for SD 24 from Germany and from SD 25 from Denmark, Poland, and Sweden for the period from 2000 onwards.

Age-data are considered to be applicable only when the ageing was conducted using recommended methods (slicing and staining or breaking and burning technique) as recommended by WKARFLO (ICES, 2007, 2008) and WKFLABA (ICES, 2010).

Due to time constraints, only some of the statistical slicing model settings were tested. Thus, if the statistical slicing method should be used in future to derive the historical part (i.e. when age length keys from otoliths are not available) of the number-at-age for the catches and the surveys, it is important that more model settings are tested than done during WKBALTFLAT. Moreover, it is also crucial that the results obtained from any slicing methods (i.e. knife edge and/or statistical), in terms of number-at-age, are compared with the number-at-age structure derived from otolith reading for the same sample (ICES, 2014).

C. Assessment: data and method

The flounder stock in SD 24-25 belongs to category 3: Stocks for which survey-based assessments indicate trends (ICES DLS approach, ICES 2012).

Model used: Data Limited Stock Category 3.2. Stock trend model based on scientific surveys

Model Options and input data types and characteristics:

Stock trend is estimated using the Biomass Index from BITS-Q1 and BITS-Q4 surveys. The index is calculated by length-classes, and covers the period from 2001 onwards.

The Biomass-Index is a product of the calculated CPUE by length and average-weight per length-class. The catch per unit of effort (number/hour) uses only fish ≥20 cm from BITS-Q1 and BITS-Q4 survey and the data are extracted from the ICES DATRAS database, because the survey is not covering shallow waters, where juvenile flounder (mostly smaller than 20 cm) occur.

The values are averaged from all (incl. 0 catch) daytime hauls weighted by depth stratum area. The average weight per length-class is calculated from a length-weight relationship based on BITS-data to cover all length-classes. Weight-at-length was estimated as an average weight at length for data from 1991–2013, separately for 1st and 4th quarter. Next, to such data weight-length relationships of the form $w=aL^b$ were fitted, where a and b are parameters. Parameters obtained for the subdivisions 24-25 were: a=0.0078 and b=3.10 for 1st quarter and a=0.0125 and b=2.98 for 4th quarter.

Both BITS-Q1 and BITS-Q4 surveys are aggregated into one annual index value for a given year (using geometric mean between quarters). The Biomass-Index is calculated for each year. Advice for this stock is updated every three years.

The stock status is evaluated by calculating length based indicators applying the LBI method developed by WKLIFE V (ICES, 2015). Commercial landings from InterCatch from 2014–onwards are used to estimate CANUM. Whereas the biological parameters: L_{inf} and L_{mat} are calculated using survey data from DATRAS. For estimating L_{inf} data from 2012–onwards (as the recommended ageing technique was implemented by all of the countries since 2012 onwards) from Q1 and Q4, and for both sexes are taken. In the case of L_{mat} data for females are derived from 2001–onwards, only from Q1, as distinguishing between mature and immature fish were possible only for this time of the year.

The results are compared to standard length-based reference values to estimate the status of the stock (Table 5).

Table 5. Description of the selected LBI

Indicator	Calculation	Reference point	Indicator ratio	Expected value	Property
$L_{max5\%}$	Mean length of largest 5%	L_{inf}	$L_{max5\%}$ / L_{inf}	>0.8	Conservation (large individuals)
$L_{95\%}$	95th percentile		$L_{95\%}$ / L_{inf}		
P_{mega}	Proportion of individuals above L_{opt} + 10%	0.3–0.4	P_{mega}	>0.3	
$L_{25\%}$	25th percentile of length distribution	L_{mat}	$L_{25\%}$ / L_{mat}	>1	Conservation (immatures)
L_c	Length at first catch (length at 50% of mode)	L_{mat}	L_c/L_{mat}	>1	
L_{mean}	Mean length of individuals >L_c	$L_{opt} = \frac{3}{3+M/k} \times \mathbf{L_{inf}}$	L_{mean}/L_{opt}	≈1	Optimal yield
L_{maxy}	Length class with maximum biomass in catch	$L_{opt} = \frac{3}{3+M/k} \times \mathbf{L_{inf}}$	L_{maxy} / L_{opt}	≈1	
L_{mean}	Mean length of individuals >L_c	$L_{F=M}$ = ($0.75L_c$+$0.25L_{inf}$)	L_{mean} / $L_{F=M}$	≥1	MSY

H. Other Issues

During WKABALFLAT (ICES, 2014) it was decided that the new tuning fleet for this stock should be calculated using only data derived from the new ageing method, thereby changed the decisions made at the previous meetings (ICES, 2005; ICES, 2010) where the survey data from the German BITS SD 24 quarter 1 and 4 and the survey data from the Polish BITS quarter 1 SD25 were used as tuning fleets in the tentative assessments for flounder in SD2425.

Due to time constraints and the need for further work on data to obtain reliable estimates of discards, only one assessment model was attempted. It was a difference version of the Schaefer stock-production model. After improving discard estimates, the second recommended model - SAM should be applied.

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Annex 1: Summary of the most recent Data Call for fle-2425. AC: Submission of data requested through accessions@ices.dk; IC: Submission of data requested through InterCatch.

Stock	Country	Aggregation level of the InterCatch data	Quantity landed	Age comp landings	Quantity discarded	Age comp discards	Mean weight at age in the landings	Mean weight at age in the discards	Effort	Sexual maturity data	Sex ratio
fle-2425	Denmark	Q	IC	IC	AC	IC	IC	IC	IC	DATRAS	DATRAS
fle-2425	Estonia	Q	IC		AC				IC		
fle-2425	Finland	Q	IC		AC				IC		
fle-2425	Germany	Q	IC	IC	AC	IC	IC	IC	IC	DATRAS	DATRAS
fle-2425	Latvia	Q	IC		AC				IC		
fle-2425	Lithuania	Q	IC		AC				IC		
fle-2425	Poland	Q	IC	IC	AC	IC	IC	IC	IC	DATRAS	DATRAS
fle-2425	Russia	Q	IC		AC				IC		
fle-2425	Sweden	Q	IC	IC	AC	IC	IC	IC	IC	DATRAS	DATRAS