Stock Annex: Plaice in Subdivisions 21, 22, and 23 (Kattegat, Belt Sea, Sound)

Stock-specific documentation of standard assessment procedures used by the International Council for Exploration of the Sea (ICES).

Stock:	Plaice (*Pleuronectes platessa*) in Subdivisions 21, 22, and 23 (Kattegat, Belt Sea, Sound)
Working group:	WGBFAS
Date:	February 2015
Revised by:	Elliot Brown (DTU Aqua), Clara Ulrich (DTU Aqua)
Revisions:	May 2021, April 2019
Modified paragraphs:	Definition of F_{pa}, Stock weight-at-age, surveys, SAM settings, forecast, reference points
Last Benchmarked:	WKPLE, 2015

A. General

A.1 Stock definition

WKPESTO (ICES, 2012a) suggested recognizing Kattegat together with the Belt area and Western Baltic (Subdivisions 21, 22 and 23) as an independent stock. The stock was named PLE21-23. The suggestion was built on readily literature and information from historical tagging (Ulrich *et al.,* 2013). The split between Skagerrak and Kattegat was rather well documented but the border to Subdivision 24 was less conclusive. The suggestion was confirmed by SIMWG (ICES, 2012b). New information were later collected, including growth investigations, drift modelling of egg and larval movements and genetics (Ulrich *et al.,* 2016), but they did not affect this perception. These new information showed indeed little exchange between Kattegat and Skagerrak and did not provide conclusive evidence of extensive exchange between Subdivisions 22 and 24. The WKPLE (ICES, 2015) did thus not change the stock definition agreed in 2012 but recommended that the border between PLE21–23 and PLE24–32 is further investigated in future. This issue is still pending.

Spawning

All information available on population dynamics, including spawning, nurseries and migrations, is summarized in Ulrich *et al.* (2013; 2016) and references therein. Spawning in the Kattegat usually occurs in late February and early March at depths between 30 and 40 m and in temperatures at about 4°C. The main plaice spawning grounds are located in the south-western part of the Kattegat. Spawning sites have also been indicated along the Swedish Kattegat coast. Modelling studies have indicated that the Swedish coast was formerly occupied by extensive aggregations of adult fish during spawning time, and that the reduction of this component is mostly a recent feature.

Beyond the area 3.a, spawning is likely to take place in the Belt Sea and in the Sound. Free-floating eggs have found in the deeper basins in the southern Baltic Sea.

A.2. Fishery

A.2.1. General description

Plaice has long been considered as being not a target species, but only as bycatch in mixed trawl fisheries targeting mainly cod or *Nephrops*. However, this picture is changing with the decline in the cod stocks and the concurrent increase in plaice stocks in the Baltic, and plaice is increasingly considered a target species as such. The largest landings of plaice occur in 1st and 4th quarter in SD 22 in connection with the cod fishery and in 3rd quarter in SD 21 in connection with the *Nephrops* fishery. Because plaice has been considered as a bycatch species, the discard pattern, as observed in the observer program, is very fluctuating dependent on the actual market conditions for plaice (price), the quota situation for cod and local or individual discard traditions. As a consequence the Danish discard raising is based on effort (trips).

Countries involved in the fishery: Denmark, Germany, and Sweden.

A.2.2. Fishery management regulations

Days at sea regulation have been implemented in the Skagerrak and Kattegat areas between 2004 and 2018, as part of the EU cod management plans implemented in 2004 and 2008. These regulations have had a significant impact on fishing effort, with important reductions (ICES, 2018)

From 1 January 2017 plaice has been included in the EU landing obligation introduced in the Baltic Sea (SD 22–32), and from 2019 in Kattegat.

Kattegat (SD 21)
The fishery is dominated by Denmark, with Danish landings usually accounting for 80 to 90% of the total.

Kattegat landings have declined from 12 000 t in the seventies to less than 1000 t since 2009. The TAC for the area has been substantially higher than the actual landings estimates since 2005 (36% TAC uptake in 2018).

Belt (SD 23)
Trawl fishery is not allowed in the Belt and all landings are caught by gillnetters. The catches are insignificant.

Western Baltic (SD 22)
Plaice are caught by trawlers and gillnetters mostly. The minimum landing size is 25 cm. Plaice are often landed as bycatch from the cod fishery. Since 2009 SD 22 has become the area where most plaice catches come from.

B. Data

B.1 Commercial catch

B.1.1. Landings data

Landing statistics from Germany, Sweden, and Denmark are available back to 1972. Landings decreased from around 15 000 tonnes in the seventies to a rather stable level (2000–4000 tonnes) since the eighties. In 2017–2018 the landings from SD 21 were less than 1000 tonnes while the landings from SD 22 were around 2500 tonnes.

Denmark has in the whole period been dominating the catches with landing around 96% of the total landings in 1992 gradually decreasing to 66% in 2018, with increasing landings by Germany (buying quotas from Sweden and Denmark).

The quality of the landing statistics is believed to be good as it builds on logbook/sales slip information and misreporting is not believed to be an issue because quota regulation has not been limiting the fishery, except for Germany in recent years (before swapping). However, this not believed to have influenced the reliability of the landings significantly.

B.1.2. Discards estimates

Discard information have been compiled in InterCatch for the period since 2002 based on the EU data call in connection with the benchmark. It has not been possible to request pre-DCF-data in connection with the data call. The discard estimates are based on observer trips covering the important fisheries (otter trawl and Danish seines). The coverage is rather good as most significant strata (year, country, SD, quarter, fishery) are covered. The data are stratified on Active gears (trawls and seines) and Passive gears (gillnets). The Danish Discard raising is done outside InterCatch based on effort (number of trips) as no correlation between landed amounts of plaice, all species landed or fishing days and the amount of discard of plaice could be demonstrated during the benchmark (WD 4). The Swedish and German discard is based on tons of landings of plaice (method used by InterCatch). All burrowing of data for strata without or with insufficient sampling is done inside InterCatch.

Additional rules applied for discard estimation

All unsampled passive gear discards strata are assumed to have zero discard until 2016. In 2016 are un-sampled discard included by data extrapolation. However, the amount is insignificant compared with the sampled fraction of the discard.

Germany uses in 2010, 2013 and 2016 the fleet groups “All” and “MIS_MIS_0_0_0_HC” in SD21. In all cases where extrapolation has been made for fleet = “All” (2010) and “MIS_MIS_0_0_0_HC” (2013), the source has been a mix of all relevant sources (same SD, Q, catch category). Manual weighting has been used in order to put equal total weighting to Passive and Active. The fleets “All” and “MIS_MIS_0_0_0_HC” only constitute a very small percentage of the total stock catches in all three years.

Additional rules applied for allocation of biological information (landing and discard)
SWE 2005 SD23 Passive discard: no source data exists. DEN 2005 SD23 Active discard is used.

For SD23: SD21 has always been used as source data if needed.

If more than one source is used for discard estimation, manual equal weight is used.

The total discard per year was estimated to 4000 tonnes in 2002 decreasing to around 1300 tonnes in 2004 already and then being more a less stable around that level the rest of the period up to 2016. The overall discard percentage (all SDs) has been app. 45% in all years (31–56%).

B.2. Biological sampling

B.2.1. Maturity

The maturity ogives per year (running mean of three years) are shown in Figure 1. The mean ogive is shown in Figure 2. The data are calculated from 1st quarter surveys of NS-IBTS and BITS.

The mean of the period from 2002 to present is used for the assessment.

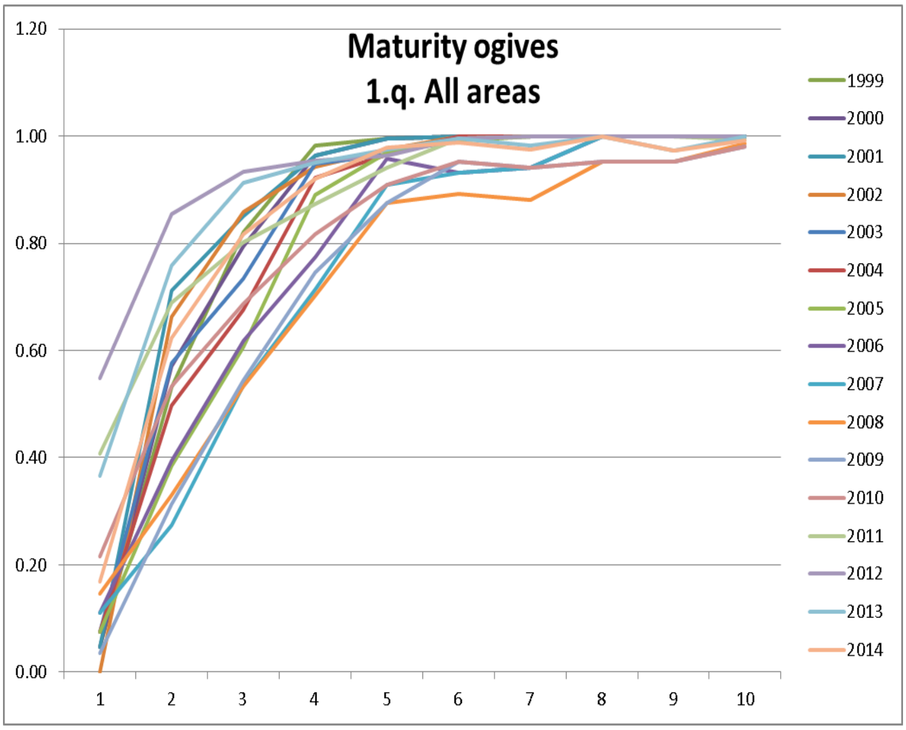

Figure 1. Maturity ogive per year (1999-2014).

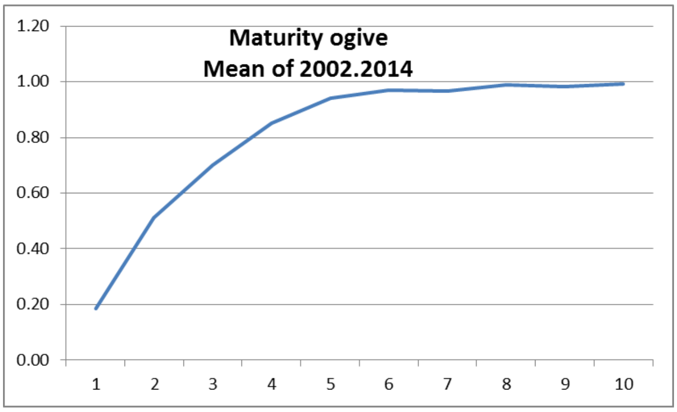

Figure 2. Constant maturity ogive based on average of 2002–2014.

B.2.2. Natural mortality

The natural mortality is in line with the North Sea plaice stock set to constant 0.1 for all age classes except age 1, which is set to 0.2. The reason for the low mortality is the lack of observed plaice in stomachs of potential predators.

B.2.3 Length and age composition of landed and discarded fish in commercial fisheries

The mean weight in landings, discards and catches by age were extracted from InterCatch for each individual year. The stock mean weights by age were calculated from the two first quarter surveys for each individual year. BITS data only exist for the period since 2008 and NS-IBTS only for the period since 2003. Therefore, the BITS series is extended backwards to 2003 based on the average of 2008 to 2012. The common mean weight in the stock is then calculated as the mean of the two surveys. However, in 2019 it was found out that the procedure used for computing this average was erroneous, computing only a simple average across all length classes without weighting by the number of individuals within each length class. This lead to a very high estimate of the mean weight of the older fish, being driven up by very few observations. A more standard procedure with weighted average was implemented in 2019 (the same procedure as used for Western Baltic cod).

The common series is finally extended backwards to 1999 based on the average of 2003 to 2007. Mean weight-at-age in the stock is given in Figure 3. The fluctuating stock mean weights of the older age classes is caused by the small number of individuals caught at the surveys and the extremely high variability of weight for these age classes. The constant mean weight is shown in Figure 4.

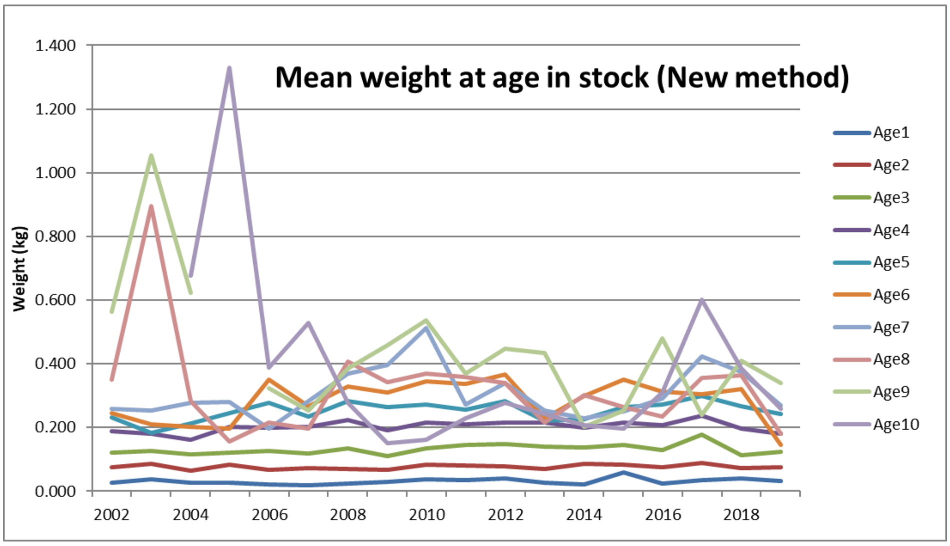

Figure 3. Mean weight-at-age in stock.

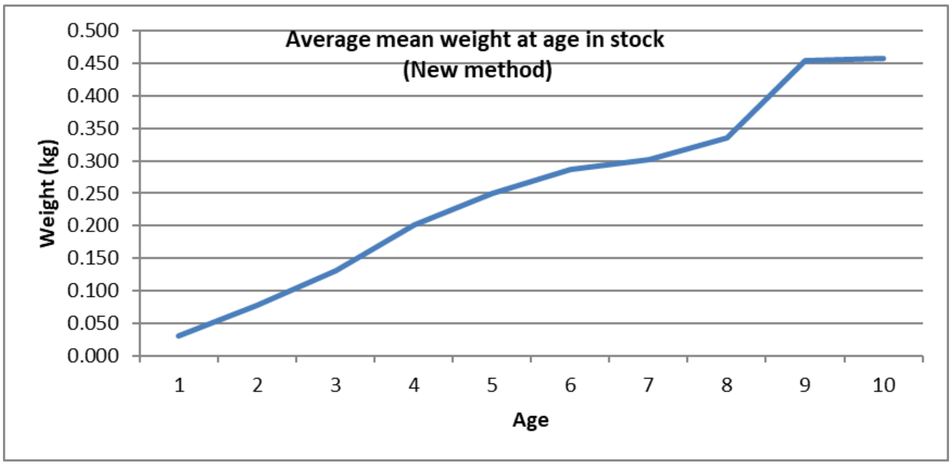

Figure 4. Constant mean weight-at-age in stock (average of 1999–2018).

B.3. Surveys

All available survey series were recalculated previous to the WGPLE in order to cover only the stock area. This area is not a standard option in DATRAS and has to be done manually. Four surveys are available covering the stock area (SD21, SD22, and SD 23) or part of it.

B.3.1. Survey data used

NS-IBTS 1st quarter. The dataseries includes all hauls from the survey in SD 21. All hauls carried out by Sweden using RV Argos (1991–2011) or RV Dana (2012–present year). The dataseries is available from 1991–present. The survey mostly covers the eastern part of SD 21 (Figure 5a). Approximately 25 hauls per year.

NS-IBTS 3rd quarter. The dataseries includes all hauls from the survey in SD 21. All hauls carried out by Sweden using RV Argos (1998–2010) or RV Dana (2011–present year-1). The dataseries is available from 1998–present. The survey mostly covers the eastern part of SD 21 (Figure 5b). Approximately 25 hauls per year.

BITS 1st quarter. The dataseries includes all hauls from the survey in SD 21, SD 22 and SD 23. All hauls carried out by Germany using RV Solea or by Denmark using RV Havfisken. The dataseries is available from 1998–present year and covers the complete stock area. Standard gear introduced in 2000. CPUE for years before 2000 are adjusted to common standard. Approximately 55 hauls per year. The survey covers the whole stock area (Figure 6a). In 2015 a new research vessel (26HF) replaced the RV Havfisken (HAF). A calibration exercise was carried out and the final report suggested that no calibration factor should be applied in order to maintain the time-series for plaice. This was in contrast to a preliminary report presented before the 2016 WGBIFS meeting, which suggested that a calibration factor should be applied. This was done for 2015 data in the 2016 assessment. Based on the final report data were revised in 2017 and therefore no calibration factor is applied in any years.

BITS 4th quarter. The dataseries includes all hauls from the survey in SD 21, SD 22 and SD 23. All hauls carried out by Germany using RV Solea or by Denmark using RV Havfisken. The dataseries is available from 1999–present year-1 and covers the complete stock area. Standard gear introduced in 2000. CPUE for years before 2000 are adjusted to common standard. Approximately 55 hauls per year. The survey covers the whole stock area (Figure 5b). In 2015 a new research vessel (26HF) replaced the HAF. A calibration exercise was carried out and a preliminary report suggests that a calibration factor should be applied in order to maintain the time-series. This was done for 2015 data in the 2016 assessment. Final report available before the 2017 assessment changes the conclusion and recommended that no calibration factor was applied. Therefore the survey dataseries was revised (data from 2015 only) and no calibration factor is applied for any years.

The two 1st quarter surveys and the two second-half-of-the-year surveys were combined using the smoothed GAM approach developed by Casper Berg (Berg *et al.,* 2014). Before 2019, only the ages up to 5 were included due to small numbers for age class 6 and 7 particularly in the start of the series. In WGBFAS 2019, this was changed, on the consideration that these age classes have been increasingly caught in the surveys after 2012 and that their inclusion in the index improved the assessment significantly. Both surveys include now ages 1-6.

Another change in the survey data was introduced in 2019. It was realized that at the time where WGBFAS meets, the age-readings for the most recent Q1 survey are usually completed by Sweden and Germany, but not by Denmark. These age readings represent more than half of the total age readings for the combined survey. As a consequence, the in-year Q1 survey index is highly uncertain, with strong deviations between the index calculated in one year and the same index calculated the following year when all age readings have been uploaded to DATRAS. It was decided in WGBFAS 2019 to remove that point from the time-series, until procedures are changed in Denmark and plaice otoliths are read before the Working Group. As such the assessment do not include information for the intermediate year.

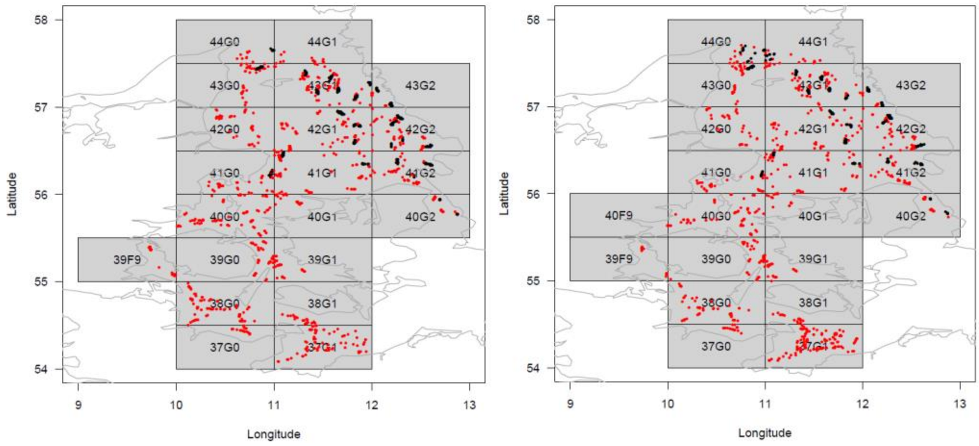

Figure 5 a+b. The spatial coverage for first quarter (left) and third + fourth quarter surveys. Red: BITS, black: NS-IBTS (up to 2014)

B.4. Commercial CPUE

No commercial CPUE is used in this assessment.

C. Assessment methods and settings

C.1. Choice of stock assessment model

Model used: State bases Assessment Model (SAM)

Software used: stockassessment.org

C.2. Model used of basis for advice

SAM run from stockassessment.org;

Model options

Commercial catches

Age group 0 has been excluded in input because mean weights-at-age 0 is highly inconsistent and is seldom even in discards.

Age group 7 has been recalculated to be +group. This is done in the model script (input data still have age 10 as +group)

Landings (tonnes) are available from all countries back to 1972 but not used in the assessments as SAM cannot use this information. Discards (CANUM, WECA) are only available back to 2002. Discards 1999–2001 are calculated as the plain average of 2002–2006 (5 years). Landing (CANUM and WECA) are available back to 1999.

F_{bar}= 3–5.

Tuning fleets

NS-IBTS 1st quarter and BITS 1st quarter combined by use of GAM-model (Berg *et al.*, 2014). Current year (Intermediate year) not included

NS-IBTS 3rd quarter and BITS 4th quarter combined by use of GAM-model (Berg *et al.*, 2014).

The tuning fleets include age class 1–6.

Coupling of the fishing mortality states for age 6 and 7 (WGBFAS 2019).

Coupling of catchability of age 4–5-6 for both tuning fleets.

Constant maturity and constant mean weight-at-age in stock

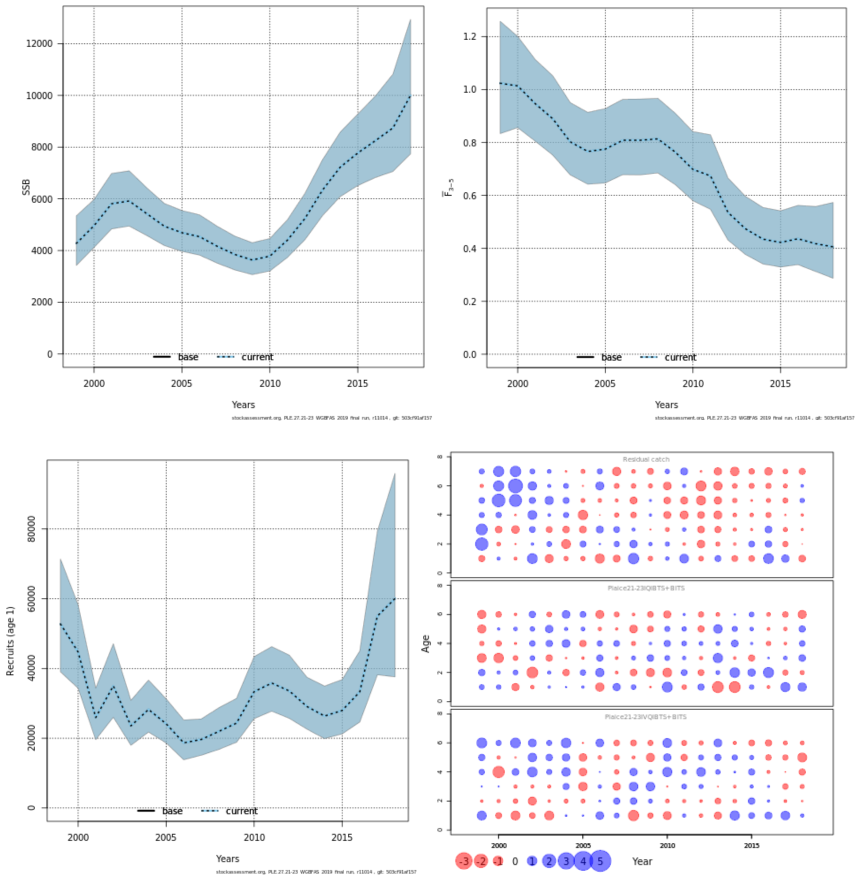

Figure 6. Assessment results from 2019. See WGBFAS reports for the annual assessment result.

C.3. Assessment model configuration

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1999–present	-	Yes
Canum	Catch-at-age in numbers	1999–present	1–7+	Yes
Weca	Weight-at-age in the commercial catch	1999–present	1–7+	Yes
W_{est}	Weight-at-age of the spawning stock at spawning time.	1999–present	1-7+	No
M_{prop}	Proportion of natural mortality before spawning	1999–present	1–7+	No
F_{prop}	Proportion of fishing mortality before spawning	1999–present	1–7+	No
Mat_{prop}	Proportion mature at age	1999–present	1–7+	No
Natmor	Natural mortality	1999–present	1–7+	No

D. Short–term prediction

Model used: State bases Assessment Model

Software used*:* SAM (stockassessment.org),

Initial stock size: Output from SAM

Maturity: Mean of the whole time-series

F and M before spawning: 0 for all age groups (output from SAM)

Weight-at-age in the stock: Mean for the whole time-series

Weight-at-age in the catch: output from SAM, 3 years average

Exploitation pattern: output from SAM, 3 years average

Intermediate year assumptions: SQ

Stock–recruitment model used: Average of whole time-series

Procedures used for splitting projected catches: output from SAM, 3 years average

E. Biological reference points

E.1. Estimation of reference points

The reference points were updated in 2019, following the revisions in the assessment setup.

Data are from the base run PLE.27.21-23_WGBFAS2019_Final Run

The software EQSIM (https://github.com/wgmg/msy) was used to analyse the stock–recruit relationship. Bootstrap estimations (with replacement) of the stock–recruit relationship were run 1000 times (n_{samp} = 1000) with the options to include a mix of models including: the Ricker, a segmented regression (so-called hockey stick), and the Beverton and Holt (Figure 7).

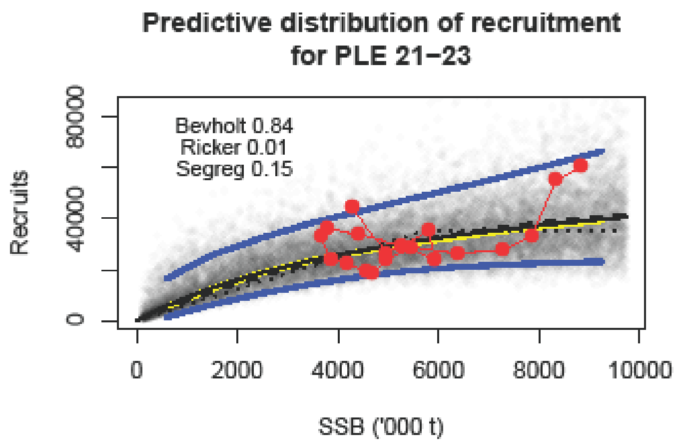

Figure 7. Predicted distribution of a mixed model putting most weight to the BH model.

The estimation procedure resulted in an AIC weighting scheme favoured the B&H, which is different from the previous trial in 2017 where the run favoured a Ricker. This difference is due to the two high year classes (recruitment in 2017 and 2018).

However, the WGBFAS 2019 agreed that this functional relationship would need to be confirmed by more data years in future before being used as the basis for F_{MSY}. Therefore, EqSim was still run with segmented regression, using B_{lim} as the breakpoint for the SRR. (the EQSIM model “Segreg”; Figure8). B_{lim} was set to the historical lowest SSB value (B_{loss}), In this case this is the SSB in 2009 equal to 3635 tonnes.

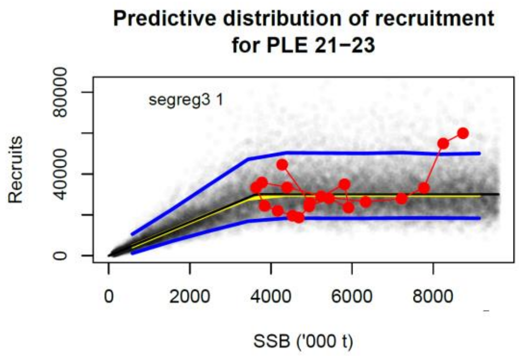

Figure 8. Predicted distribution of recruitment using a segmented regression model and setting breakpoint to B_{loss}.

The B_{pa} is estimated to be 4730 tons ($B_{pa} = B_{lim}$*exp(sigma*1.645)). Sigma = 0.16. Results from EQSIM (Table 1 and Figure 9) provides the basis for the estimate of F_{MSY} = 0.31.

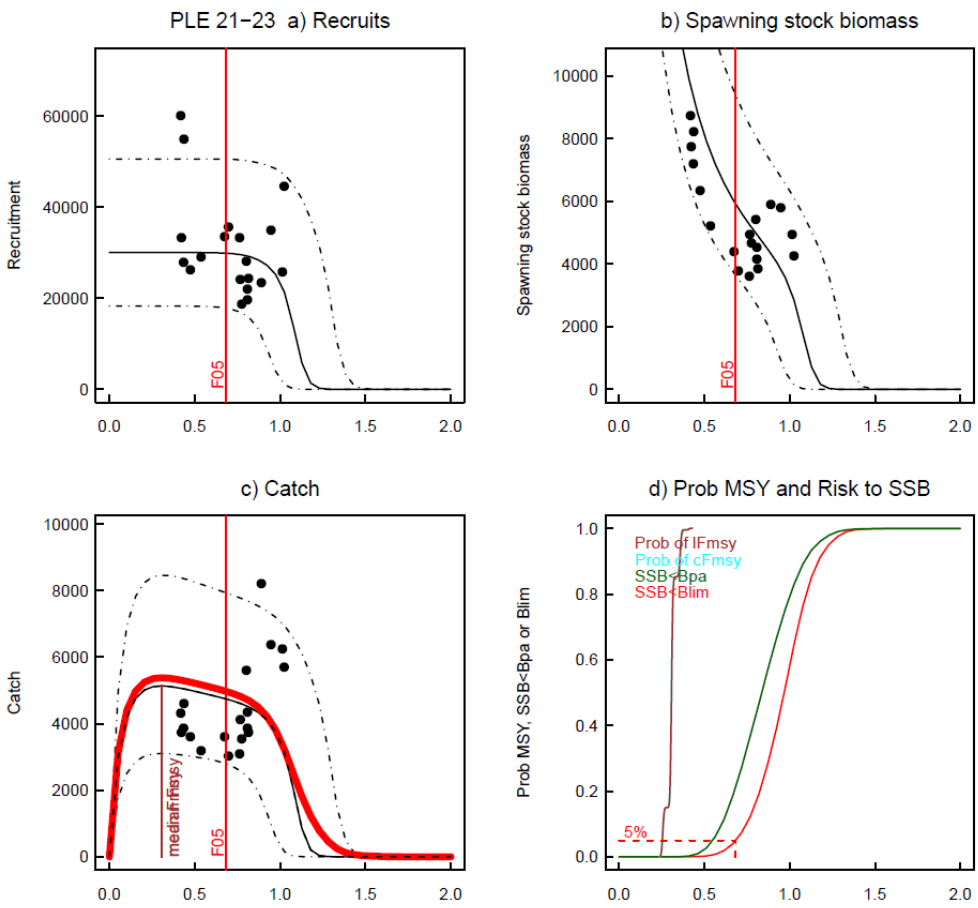

Figure 9. Simulation for estimation of F_{MSY}.

Table 1. Key results of 1 EQSIM including implementation errors.

Without Btrigger (advice rule)

	[,1]
FmsyMedianC	0.3115578
FmsylowerMedianC	0.1809045
FmsyupperMedianC	0.5728643
FmsyMedianL	0.3115578
FmsylowerMedianL	0.1809045
FmsyupperMedianL	0.5728643
F5percRiskBlim	0.6824434
Btrigger	0.0000000

With Btrigger (advice rule)

FmsyMedianC	0.3115578
FmsylowerMedianC	0.1809045
FmsyupperMedianC	0.5929648
FmsyMedianL	0.3115578
FmsylowerMedianL	0.1809045
FmsyupperMedianL	0.5929648
F5percRiskBlim	0.8087956
Btrigger	4729.4509190

$B_{trigger}$ (=B_{pa}) based on a profile of total fishing mortality.

The present (2018) SSB for the stock is well above estimated B_{pa} while the estimated F is above F_{MSY} (Figure 10). In 2020, an ICES decision to redefine F_{pa} as equal to $F_{p=0.05}$ means that the value of F_{pa} changed to 0.8088 from the 2020 assessment onwards.

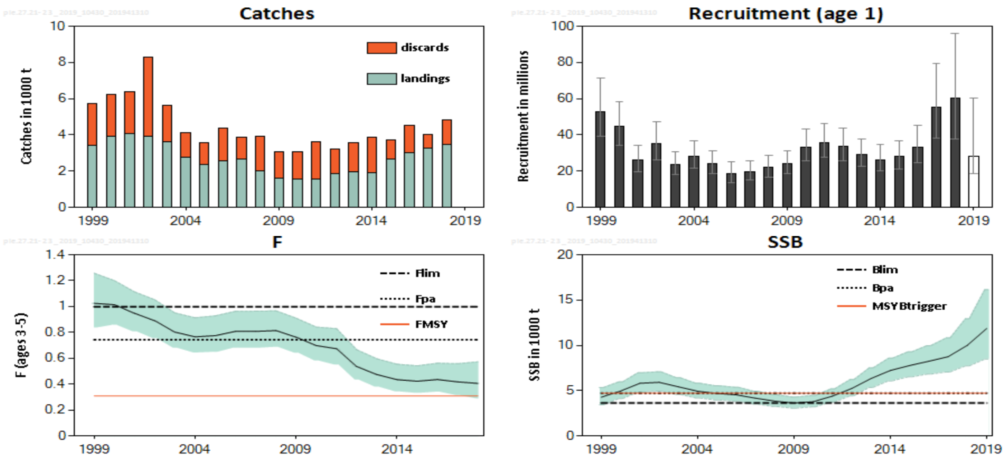

Figure 10. Stock status 2019

The F_{MSY} value estimated for PLE-2123 is comparable to those estimated for other plaice stocks of neighbouring areas (Table 3).

Table 3. Comparable F_{MSY} values for ple-2123 and two other plaice stocks within European waters.

Stock	F_{MSY}	F_{pa}
PLE-2123 (2019)	0.31	0.74
PLE-27.420 (2020)	0.21	0.77
PLE-27.7d (2018)	0.25	?(only reported without advice rule, Btrigger)

G. References

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