Stock Annex: Greater silver smelt (*Argentina silus*) in divisions 5.b and 6.a (Faroes grounds and west of Scotland)

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Greater silver smelt
Working Group:	Working Group on Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP)
Created:	2015
Author:	Lise H. Ofstad
Last updated:	April 2021
Last updated by:	Lise H. Ofstad, Martin Pastoors and Hannipoula Olsen, WGDEEP 2021

A. General

A.1. Stock definition

ICES revised the advice units for greater silver smelt in 2015. The stock structure of greater silver smelt is unknown, but the species is not thought to be highly migratory and spawning takes place in most of the distribution area. Fishing of greater silver smelt takes place in fairly well defined distinct areas. As a precautionary measure, to reduce the risk of local depletion, ICES gives advice for four advisory units of greater silver smelt where greater silver smelt in Divisions 5.b and 6.a is accorded as one unit.

A.2. Fishery

The targeted fisheries for the Divisions 5.b and 6.a management unit are mainly conducted by Faroese and European trawlers. In 2019, the catches in 5.b were mainly taken by three pairs of Faroese pair trawlers deploying semi-pelagic trawls (99%) while the catches in 6.a were mostly taken by European trawlers (65%) and the remainder mainly by Faroese trawlers (35%, inside the Faroese EEZ). Another nation landing significant quantities in 2018–2019 was Germany. Landings since 1988 are presented in Figure 1.

Historically, greater silver smelt was only taken as bycatch in shelf-edge deep-water fisheries and either discarded or landed in small quantities. Targeted fishery for greater silver smelt in Faroese waters did not develop until the mid-1990s. The direct fishery is mainly conducted by semi-pelagic trawls.

The greater silver smelt fishing grounds in Faroese waters from the mid-1990s to 2007 were located north and west on the Faroe Plateau and around Faroe Bank/Lousy Bank at depths between 300 and 700 meters. Since 2008, the Faroese fishery has extended the fishing grounds to include the area around the Wyville-Thomson Ridge south of the islands. Since 2012 around 50% of the Faroese catches were fished inside the Faroese EEZ on the Wyville-Thomson Ridge (in Divisions 5.b and 6.a).

There is a bycatch of greater silver smelt of the Faroese and Russian in the commercial blue whiting fishery in the Faroese EEZ.

A main fleet producing catches of greater silver smelt are the Dutch freezer trawlers operating in 5.b, 6 and 7, west and northwest of the Hebrides, with 25 % of the total catches in 2019.

The European fisheries on silver smelt mostly takes place on the shelf edge within Divisions 6a, 5.b and 4.a. New information from the self-sampling program carried out by the European fisheries (Pelagic Freezer-trawler Association, PFA) was presented to the Working Group in 2018 and updated in 2019 (Pastoors, WD 2019). The self-sampling program consists of historical information derived from skipper's notes (2002-2018) and new information collected as part of the research program within the PFA.

Irish landings were very high in the late 1980s when an exploratory fishery was developed by large pelagic trawlers. However by the early 1990s landings had declined to a few hundred tonnes and directed fishing had ceased by 1993. There was some directed fishing for the species in subsequent years. In 2000 larger Irish pelagic trawlers began to direct effort at this species on the shelf edge of Division 6.a. Because of a restrictive quota there was no Irish directed fishery for greater silver smelt. The landings by Scottish vessels also increased in 2000–2002 and between 65 and 75% of these landings were outside the UK. The Scottish landings also dropped abruptly to a very low level in 2003. In some of the years where landings are very high, there is possibly some misreporting but no documentation of quantities is available.

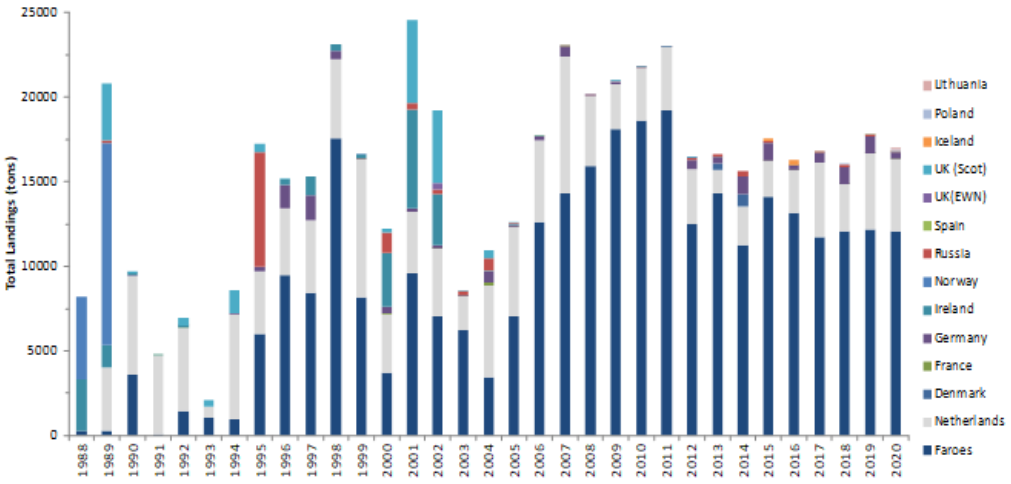


Figure 1. Nominal landings of greater silver smelt in Divisions 5.b and 6.a from 1988 to 2020.

A.3. Ecosystem aspects

It seems like the primary production on the Faroe shelf (<130 m) and the subpolar gyre index (for deeper areas) has importance for species like cod, haddock and saithe in Faroese waters (Section 2.1.3 in ICES NWWG report, 2011). Greater silver smelt was caught in very small amounts in depths shallower than 130 m, so this would probably not have impact on the greater silver smelt. Observations from groundfish surveys of spawning individuals in the spring, summer and autumn indicate that there is no particular spawning season, but that the spawning is stretched throughout the year.

A.4. Management

The Ministry of Fisheries is responsible for management of the Faroese fisheries and implementation of the legislation. The Ministry issues regulations for commercial fishing for each fishing year. The fishing year started on 1st September and ended 31st August the following year.

During the 1980s and 1990s the Faroe authorities have regulated the fishery and the investment in fishing vessels. In 1987 a system of fishing licenses was introduced. The demersal fishery at the Faroes has been regulated by technical measures (minimum mesh sizes and closed areas). A reduction of effort has been attempted through banning of new licences and buy-back of old licences.

A quota system, based on individual quotas, was introduced in 1994 for cod, haddock, saithe and redfish. A new system entered into force on 1st June 1996 that is based on individual transferable quotas in days within fleet categories. Nearer description of the day quota system is in Section 2.1.2 in the ICES NWWG report, 2011.

A system of instant area closure is in place for many species. The aim of the system is to minimize fishing on juveniles. An area is closed temporarily (for two weeks) for fishing if on-board inspections (not 100% coverage) reveal that more than a certain percentage of the catch is composed of fish less than the defined minimum length. To prevent fishing of small fish various measures such as mesh size regulation and closure of fishing areas are in place. Discard is banned in the Faroese demersal fishery.

All fishing boats operating in Faroese waters have to maintain a logbook record of catches in each haul/set. The records are available to the stock assessors at the Faroe Marine Research Institute.

In the period from 2010–2013, the Faroese greater silver smelt fishery was managed by an agreement between the Faroese fleet that were licensed to conduct direct greater silver smelt fishery and the Faroese authorities, guided by the stock assessment and scientific advice of Faroe Marine Research Institute. The agreement was that total annual landings should not exceed 18 thousand tonnes in the Faroese EEZ.

In 2014, the Faroese authorities introduced species-specific TAC for greater silver smelt applicable for Faroese trawlers fishing inside the Faroese EEZ. Six trawlers had licences to target greater silver smelt, the technical measures continued to apply and the TAC are presented in the table below. The reason for this reduction in TAC was the decrease in the biomass index as estimated by the exploratory assessment of greater silver smelt in Faroese waters.

The Faroese Government will allow five Russian vessels to undertake experimental fishing in the Faroese Fishing Zone at depths deeper than 700 meters, provided that a Russian scientific observer is on board. No more than three vessels can be operating simultaneously. Two of these vessels can undertake experimental fishery in deep waters around Outer Bailey and Bill Baileys Banks, at depth between 500 and 700 meters, provided that catches in this area do not exceed 500 tonnes of deep-sea species.

The EU introduced TAC management in 2003, and for each year quotas were set for greater silver smelt. EU TACs as valid for community vessels fishing in community waters and waters not under the sovereignty or jurisdiction of third countries.

The table below summarizes the ICES advice for greater silver smelt and the TACs that have been set by the Faroese authorities and the European Union. The summed TACs of the Faroe Islands and EU exceed the ICES advice for the years where advice has been provided for this stock unit.

	Area\Year	2014	2015	2016	2017	2018	2019	2020
ICES advice	5b, 6a	*	*	10030	10030	12036	12036	7703
TAC Faroe Islands	5b, 6a	16000	14400	13000	11500	11700	11700	11700
TAC EU	5,6,7 1)	4316	4316	4316	3884	4661	4661	3729
Summed TACs		20316	18716	17316	15384	16361	16361	15429

1) The EU TAC applies to all of areas 5, 6 and 7. However, only minor catches have been taken outside of divisions 5.b and 6.a.

B. Data

B.1. Commercial catch

Landings from Divisions 5.b and 6.a were available for all relevant fleets. No estimates of discards of greater silver smelt were available for Division 5.b. But since there is a ban on discarding and catches of all sizes have commercial value in Division 5.b, incentives for illegal discarding are believed to be low. The landings statistics are therefore regarded as being adequate for assessment purposes.

Discarding is known to take place, but ICES cannot quantify the corresponding catches. However, in Subarea 6 and 7 greater silver smelt can be a very significant discard of the trawl fisheries on the continental slope, particularly at depths 300–700 m (e.g. Girard and Biseau, WD 2004). Information was available on discards in 2009 and 2013 in the Basque country and Spanish fisheries in Subareas 6–7, and Divisions 8.a,b,c,d and northern 9.a. These estimates have been in the range 1000–4000 t, for all these areas together, since 2003. In 2010 and 2011 they were around 2000 t. New calculation of the estimates for 2012 and 2013 reduce strongly the discards reported by Spain, so in 2014–2015 there appears to have been no Spanish discards of this species in Subarea 6 (only in 7). In 2019 the total discard was 63941 kg, which accounted for less than one percent of the total landings (InterCatch 2020), and was reported by UK(Scotland).

Based upon on-board observations from EU data collection framework (DCF) sampling, the catch composition of the French mixed trawl fisheries in 5.b, 6 and 7 include 5.3% of greater silver smelt, based upon data for year 2011 (Dubé *et al*., 2012). This species is discarded in that fishery; it represents 25.3% of the discards in 2011. Raised to the total landings from that fishery an estimated 280 t of discarded greater silver smelt was estimated for 2011. The discards in 2014 were from the French fishery in Division 6.a (808 t) and from the German fishery (92 t from InterCatch). In 2019, only Scotland reported discard of greater silver smelt in Divisions 5.b and 6.a, comprising less than one percent of the total catches.

Faroese greater silver smelt catch in tonnes by month, area and gear are obtained from Statistical Faroe Islands (www.hagstovan.fo) and Faroese Coast Guard (www.vorn.fo). The distribution of catches is obtained from logbook statistic where location of each haul, effort (hours), depth of trawling and total catch of greater silver smelt is given. Logbook information of selected commercial trawlers are available since 1995. From 2010 to present are almost all logbooks available. Landings from foreign nations fishing in Division 5.b are given by the Faroese Coast Guard and reported to the Directorate of Fisheries.

Latest years landings and discard information from other countries is from ICES preliminary data and InterCatch.

The landings statistics are regarded as being adequate for assessment purposes.

B.2. Biological

Biological data from the commercial longline and trawl fleet catches are collected from landings by technicians of the Faroe Marine Research Institute (FAMRI). The biological data collected are length (cm), gutted weight, and otoliths for age reading. Most of the fish that otoliths were collected from were also weighted (to the nearest gram). Each sample consists of 200 length measurements and from 1995 were also 60 weights and otoliths taken in some of the samples, approximately 10 otoliths and weights samples per year have been collected since 1995.

The biological data from the Faroese fishery is stored in a database at FAMRI. The data are used for description of the catches from the fishery and abundance indices.

There are length distributions of commercial catches from Faroese commercial trawl catches in 5.b and from the Russian commercial bottom-trawl catches in the Faroese Fishing Zone. In addition, length measurements from the Netherlands fishery in 6.a are available. Length distribution data of greater silver smelt from Faroese waters are available from the Faroese spring- and summer groundfish trawl surveys on the Faroe Plateau and Faroese deep-water surveys, as well.

Age compositions from Faroese landings in Faroese waters were used in the exploratory assessment. In addition, age data are available from the Netherlands fishery in Division 6.a in some years. There are also age data of greater silver smelt from the Faroese groundfish surveys in Division 5.b.

Weight-at-age data of greater silver smelt from the Faroese commercial trawl fisheries were used in the age-based assessment. In addition, data were also available from the Dutch fishery in Division 6.a in some years.

Information on the maturity of greater silver smelt caught in commercial catches in Division 5.b is mainly from 2006–2011 and these proportions are used in the assessment. In addition, maturity of greater silver smelt from Russian commercial bottom-trawl catches in the Faroese Fishing Zone are available.

Natural mortality was set to 0.15 in the assessment. This new value is was agreed at the benchmark in 2020 and is based on results using life history parameters in a DLS program where the mortality rate is estimated to lie between 0.15 and 0.22. The group discussed this and agreed to set M= 0.15 (Woods et al. 2020, WD16 WKGSS 2020) since greater silver smelt is a long lived fish with a plus group of 21+. When analysing the catch curves for the earliest years of the fisheries an M of 0.10 seemed to low, while an M of 0.20 seems to high with a substantial proportion of the population of age 15+ today, this led to the conclusion that an M of 0.15 was suitable for this population (Woods et al. WD16 WKGSS 2020).

In the previous exploratory age based assessment (WGDEEP 2019), the instantaneous mortality rate (M) was used at 0.1. The reason for that was that, for a virgin population in 1995, it was observed that 20% of the fish in the catch were 14+ years old (mean age of around 18 years). This corresponds to an M of 0.11, i.e. justifies the choice of M=0.10.

Biological information of greater silver smelt in Faroese EEZ (Ofstad, WD10 WKDEEP 2010): Growth of greater silver smelt until maturation was around 4 cm per year (age 3 to 6) and around 1 cm per year after maturation. It seems like the female greater silver smelt grow a bit larger and reaches older ages than males. Proportion of females analysed by length in landings data showed that males were slightly more numerous in length less than 37 cm, and over 37 cm females were predominant. Length at first maturity (L_{50}) was calculated to be 34 cm for females and 36 cm for males. This corresponds to an age at maturity of around six years for females and eight years for males. Gonadosomatic index (GSI) values higher than 6% were taken to indicate signs of

maturation and were found in females larger than 34 cm and male of about 31 cm. Based on observations of spawning greater silver smelt and GSI data, there does not seem to be any fixed spawning season for this species. Findings of pelagic greater silver smelt larvae, together with observations of spawning fish on all surveys (spring, summer and autumn), suggests that there is spawning activity of greater silver smelt in Faroese waters.

In the Faroese deep water surveys in September 2014-2019 were spawning greater silver smelt observed west of the Faroe Islands.

B.3. Surveys

Spring groundfish survey

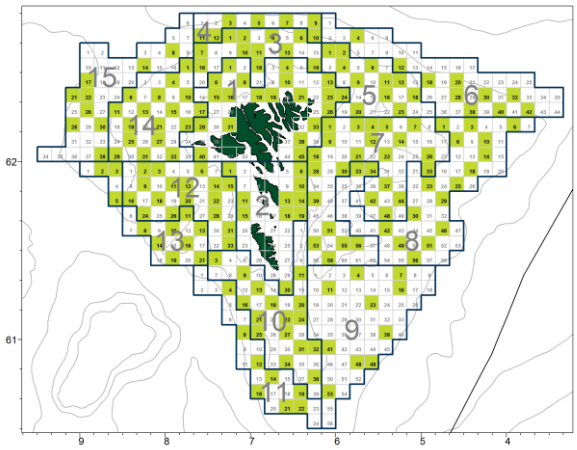
The spring groundfish surveys in Faroese waters were initiated in 1983 with the research vessel Magnus Heinason. Up to 1991 three cruises per year were conducted between February and the end of March, with 50 stations per cruise selected each year based on random stratified sampling (by depth) and on general knowledge of the distribution of fish in the area. In 1992 the first cruise was not conducted and one third of the stations used up to 1991 were fixed. Since 1993 all the 100 stations on the Faroe Plateau are fixed.

Summer groundfish survey

The summer (August–September) groundfish survey was initiated in 1996 and covers the Faroe Plateau with 200 fixed stations distributed within the 65 to 520 m contour. Half of the stations were the same as in the spring survey. Effort for both surveys is recorded in terms of minutes towed (~60 minutes).

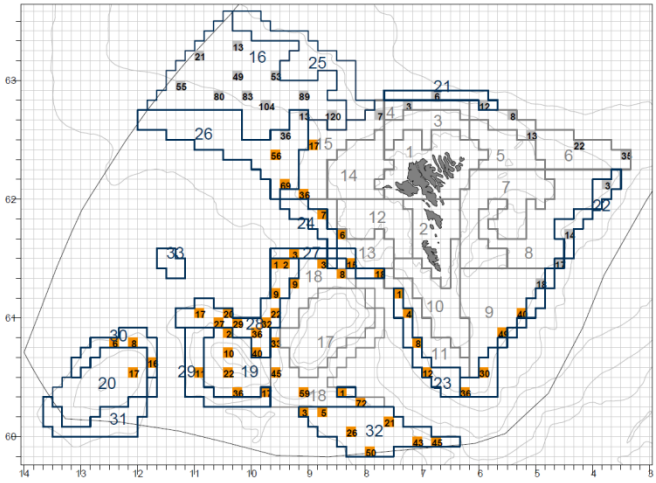
Survey indices for greater silver smelt in Faroese area are available from an annual spring (since 1994) and summer (since 1996) groundfish survey. The survey covers the Faroe Plateau (depths less than 500 m) and the spring survey in February cover 100 stations while the summer survey in August has 200 stations. Density (mean kg/h for the whole survey period) and spatial distribution from the same survey can also be done. There are lengths (cm) and round weights of greater silver smelt from these two groundfish surveys and a recruitment index was calculated as the stratified number and biomass of greater silver smelt less than 40 cm. The abundance indices from the groundfish surveys are standardized according to number of stations in each stratum and weighted with strata area for all the different strata. Although the greater silver smelt is not a target species in these surveys the 2010 WKDEEP regarded them as a useful indicator of trends in relative abundance. It has to be noted that these surveys have very few stations (<five) deeper than 500 m and are therefore only likely to cover the younger year classes adequately. The adult part of the population is not fully covered by these surveys and they may not necessarily reflect correctly the temporal variation of the biomass of the stock.

The summer groundfish survey is used as a tuning series in the age based assessment. It is named tuning series 1. The spring survey showed great variability and hence it was decided not to use it as a tuning series.



Faroese Deep water survey

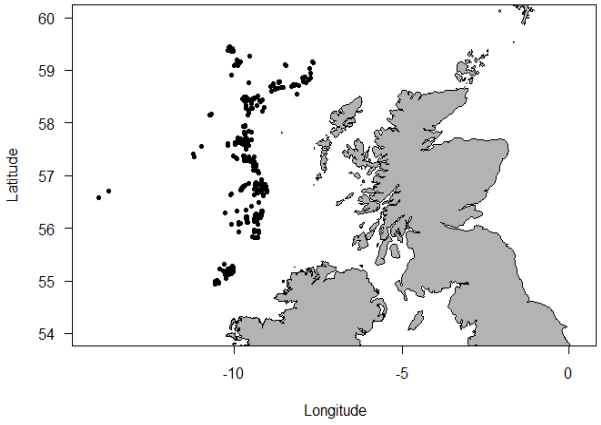
In 2014, a deep-water trawl survey was introduced and has been repeated since, covering the slope and banks around the Faroe Islands. This deep-water survey samples the fishing area for greater silver smelt in Faroese EEZ (Ofstad, WD WKGSS 2020). The Faroese deep water survey is used as a tuning series, and is named tuning series 2.



Scottish deep water survey

A regular trawl survey of the fish community in the deep waters to the northwest of Scotland has been undertaken between 1998 and 2019, using the MRV Scotia. The bottom trawl was originally rigged with 21″ rock-hopper ground-gear, switching to lighter 16″ bobbins in 2009, 1700-kg doors (area 5.82 m^2); 100-m sweeps and 8″ titanium floats (rated to 2500 m). Warp-to-depth ratio ranges between 3:1 and 2:1, decreasing gradually with depth. Mesh size in the codend is 20 mm. Net geometry is monitored using SCANMAR sensors to give headline height, depth, and distance of wings and doors to ensure the net is fishing correctly and in a consistent manner. Tows have been focussed on strata of 500m, 1000m, 1500m and 1800m, with hauls at intermediate depths being conducted as time and conditions allow. The survey covers ICES Div 6a from the northwest of Ireland, along the shelf slope, to the north of Scotland . Hauls at Rockall and at

Rosemary Bank are conducted irregularly, and so have been excluded from this analysis. The Scottish deep water survey is used as a biomass index series and is named tuning series 3.

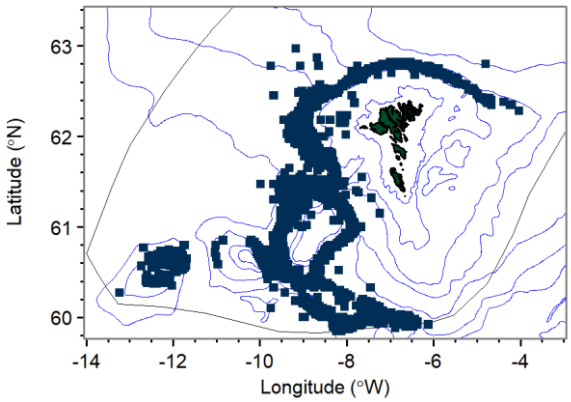


B.4. Commercial cpue

Faroese semipelagic trawlers CPUE

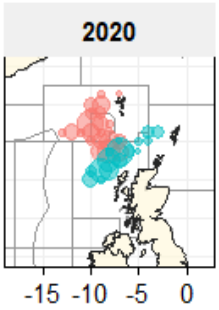
A standardized cpue series from commercial trawlers targeting greater silver smelt in Faroese EEZ is available. Data used to estimate cpue for greater silver smelt in Faroese EEZ are obtained from logbooks of the Faroese trawler fleet. The effort obtained from the logbooks is estimated as number of fishing (trawling) hours from the trawlers and the catch as kg stated in the logbooks. The targeted series for greater silver smelt from the Faroese pair trawlers >1000 HP is limited to hauls where the catch of greater silver smelt is more than 50% of the total catch in the haul.

A general linear model (GLM) was used to standardize all the cpue series (kg/h) for the commercial fleet where the independent variables were the following: vessel (actually the pair ID for the pair trawlers), month (January–April, May–August, September–December), five different fishing areas and years. The dependent variable was the square root kg per hour measure for each trawl haul, which was back-transformed prior to use. The reason for this selection of hauls was to try to get a series that represents changes in stock abundance.



Pelagic Freezer Association CPUE.

A preliminary standardized CPUE series from the PFA (Pelagic Freezer Association) self-sampled fisheries in Division 6.a was presented at the WKGSS 2020 (Quirijns and Pastoors 2020). This new CPUE series has been developed for the European pelagic fisheries based on the skippers' logbooks and self-sampling data.



Combined Cpue series

A suggestion from the working group was to investigate if these two series could be combined.

Catch and effort data by haul for the commercial Faroese (1995-2019) and PFA fishery (2005-2008, 2012-2019) were available from Faroese logbooks and the PFA self-sampling program. Catch from the Faroese trawlers logbook data account for more than 80% of the Faroese landings from 2005 and onwards, so therefore this period was chosen for calculating CPUE index. The PFA self-sampling logbooks account for varying percentages of the total registered catch by Germany and the Netherlands in area 5b6a.

The general modelling approach was to use a GLM model to assess the dependency on the CPUE (catch/day) of greater silversmelt on different variables. In the first instance, a test has been carried out to apply a negative binomial probability distribution to the catch data.

The basic model consists of CPUE (catch/day) as the response variable. The main explanatory variable is year (as factor). Other potential explanatory variables are explored: week, depth, latitude and time of setting the net. Based on the percentages of deviance explained by variable, variables were selected (>5%) or rejected (<5%) for the model.

A single fleet analysis was carried out to assess the year trends in CPUE if the data from one of the two contracting parties was left out.

The final model for standardizing the CPUE of these fleets models the catch by day and takes into account of the week and depth. The new standardized CPUE series starts in 2005.

A 'single fleet analysis' was carried out by removing the data of one of the contracting parties from the analysis to explore the sensitivity of the results to the data being used. The conclusion from that analysis is that the trends are similar when only the Faroese data are analysed and that the time series of the PFA fleet alone is too short for an indexed CPUE series.

This combined Cpue series was used in the age based SAM approach as tuning fleet 4.

B.5. Other relevant data

None.

C. Historical stock development

Assessment: data and method

Model used: Survey trends.

Greater silver smelt was a category 3 stock according to the ICES DLS approach proposed by the ADG in 2012.

In the advice in 2015 a 3.2 rule was used: The Faroese summer groundfish survey was applied as index for the stock development. The advice is based on a comparison of the two latest index values (index A) with the three preceding values (index B), combined with average landings in

recent years. The index is estimated to have decreased by more than 20% and thus the uncertainty cap was applied to calculate the landings advice. The stock status relative to candidate reference points is unknown. Therefore, the precautionary buffer was applied to calculate the landings advice. Discarding is known to take place, but ICES cannot quantify the corresponding catches.

Exploratory analysis

An exploratory assessment of greater silver smelt in Faroese EEZ was done by using an age-based extended survivor analysis model (XSA). This assessment approach has been performed during a number of years. The commercial cpue series and the summer survey series was used as tuning series. Although the exploratory age-based stock assessment has not been benchmarked, it seemed to indicate the absolute level of stock size and fishing mortality and may provide a valid perception of the temporal variation of the stock.

Age based assessment currently used.

At the benchmark meeting in February 2020 it was decided to replace the 3.2 rule with an age based assessment using the State-space fish stock assessment model (SAM) (ICES, 2021).

One benefit of using SAM was that the model provided uncertainty estimates. SAM also provided a short term forecast that carried the trends from the assessment into the forecast. Yet another benefit was that the assessment could be stored on the website (www.stockassessment.org) making it readily accessible for the site users.

SAM is a state-space assessment model (Nielsen and Berg, 2014). The current implementation (https://github.com/fishfollower/SAM) is an R-package that is based on the Template Model Builder (TMB) (Kristensen *et al*., 2016). The states (α) are the log-transformed stock sizes (log of population numbers N at age) and fishing mortalities (log of fishing mortalities F at age). For greater silver smelt it is assumed that the fishing mortalities for ages 5 years and older are the same. In any given year the state is the combined vector of population numbers and fishing mortalities. The transition equation describes the distribution of the next years' state from a given state in the current year. The transition equation is technically composed of a transition function (T) and an error term (actually the prediction noise or process error).

$$\alpha_y = T(\alpha_{y-1}) + \eta_y$$

The SAM model is run from the website (www.stockassessment.org). The input files are uploaded to the website on beforehand. The SAM model may also be run from the laptop. The R-package is used on the webpage as well as on the laptop.

Configuration in the SAM-run was the following (as obtained by the R-package):

> conf

$minAge

5$maxAge

21

$maxAgePlusGroup

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$keyLogFsta

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-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1

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$corFlag

2

$keyLogFpar

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6 7 8 9 10 10 10 10 10 10 -1 -1 -1 -1 -1 -1 -1 -1

11 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1

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$keyVarLogN

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$keyVarObs

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3 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1

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$keyCorObs

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$stockRecruitmentModelCode

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$noScaledYears

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$keyScaledYears

$keyParScaledYA

$fbarRange

6-14

$keyBiomassTreat

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$obsLikelihoodFlag

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$fixVarToWeight

0

$fracMixF

0

$fracMixN

0

$fracMixObs

0 0 0 0 0

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Canum	Catch at age in numbers	1995–last data year	5–21+	Yes
Weca	Weight at age in the commercial catch	1995–last data year	5–21+	Yes
West	Weight at age of the spawning stock at spawning time.	1995–last data year	5–21+	Yes, the same data as for the commercial catch
Mprop	Proportion of natural mortality before spawning	1995–last data year	5–21+	No, set to 0 for all ages in all years

Fprop	Proportion of fishing mortality before spawning	1995–last data year	5–21+	No, so to 0 for all ages in all years
Matprop	Proportion mature at age	1995–last data year	5–21+	No, constant values i.e., average maturities during 1995–2019
Natmor	Natural mortality	1995–last data year	5–21+	No, set to 0.15 for all ages in all years

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	Faroese Summer Survey	1998– last data year	5–12
Tuning fleet 2	Faroese Deepwater Survey	2014– last data year	5–14
Tuning fleet 3	Scottish Deepwater Survey	1998– last data year , not every year	
Tuning fleet 4	Combined Faroe-EU CPUE	2005– last data year	

D. Short-term projection

Model used: Age structured. The SAM model was adopted at the benchmark in February and used as the assessment tool and for short-term and long-term forecast.

Maturity ogives: Proportion mature is the same for the whole period. The background data are from different Faroese surveys in the period 2000-2019. There are no maturity data from the Scottish deep-water survey.

Weight at age in the stock: Catch weight at age is the output from InterCatch for 2005-2018 and Faroese data 1995-2004.

In case of missing data, the average from the previous 5 years is used. Stock weights at age are set to the same values as catch weight at age (1995-2018, ages 5 to 21+). This procedure was investigated and confirmed at the benchmark meeting in February 2020. The reason was that the stock biomass using survey weights for all ages was very similar to the current procedure to use catch weights as stock weights.

Weight at age in the catch: See above. This also applies for landings and discards at age.

F before spawning is set to zero.

As the discard in this stock is negligible the landing fraction is set to 1. Natural mortality before spawning is set to zero.

There was some discussion during the Benchmark in February 2020 on whether to keep the natural mortality at 0.1 or to change it. In the benchmark, the natural mortality was changed to 0.15 (WD 16). This new value was based on results using life history parameters in a DLS program, where the mortality rate was estimated to lie between 0.15 and 0.22. The group discussed this and agreed to set M= 0.15 (WD 16) because GSS is a long lived fish (plus group of 21+).

E. Medium-term projections

None.

F. Long-term projections

None.

G. Biological reference points

Since the assessment model was replaced at the benchmark in February 2020, it was necessary to recalculate reference points, this was done shortly after the Benchmark meeting.

According to ICES technical guidelines, two types of reference points are referred to when giving advice for Category 1 stocks: precautionary approach (PA) reference points and maximum sustainable yield (MSY) reference points. The PA reference points are used when assessing the state of stocks and their exploitation rate relative to the precautionary approach objectives. The MSY reference points are used in the advice rule applied by ICES to give advice consistent with the objective of achieving MSY.

ICES standard EqSim reference point analyses were done using the EqSim script.

In calculation of reference points, aru.5b6a was defined to a stock type 6, stocks with a narrow dynamic range of SSB and no evidence that the recruitment is or has been impaired. A SegregBlim model is used. Recruitment is thought to be strongly autocorrelated for this stock. FMSY is larger than F_{pa}, so reduced to F_{pa}. B_{pa} = $B_{trigger}$ was set to 82999 t, which is the lowest historical SSB recorded in 2014. B_{lim} was calculated according to the equation:

$$B_{lim} = B_{pa}/\exp(\text{sigmaSSB}*1.645)$$

B_{lim} is 59729.65 tons and B_{pa} 82999 tons.

A summary of the reference points can be seen in the table below.

	$MSY_{Btrigger}$	$5thPerc\_SSB_{msy}$	B_{pa}	B_{lim}	F_{pa}	F_{lim}	F_{p05}	$F_{msy\_unconstr}$	F_{msy}
Values	82999	68357.53	82999	59729.65	0.2	0.29	0.33	0.24	0.2

In total 2001 iterations were performed that projected the stock 200 years into the future, of which, the last 50 years were kept to calculate 'equilibrium' values.

The result of the analyses was that F_{MSY} = 0.2. The fishing mortality that is associated with a risk of 5% to fall below B_{lim}, $F_{p0.5}$, was estimated to be 0.33, greater than F_{MSY}.

Framework	Reference point	Value	Technical basis	Source

MSY approach	MSY $B_{trigger}$	82 999	B_{pa}; in tonnes	(ICES, 2021a)
	F_{MSY}	0.2	Stochastic simulations (EqSim) with segmented regression fixed at B_{lim}	(ICES, 2021a)
Precautionary approach	B_{lim}	59 730	$B_{lim}=B_{pa}/(\exp(\sigma\times SSB\times 1.645),\sigma=0.2)$; in tonnes	(ICES, 2021a)
	B_{pa}	82 999	B_{loss}, lowest observed SSB (2014) from 2020 benchmark; in tonnes	(ICES, 2021a)
	F_{lim}	Not defined	F_{lim} was set to 0.29 at WKGSS which is below new F_{pa} based on F_{p05}. F_{pa} in WKGSS was set to 0.2.	
	F_{pa}	0.33	The F that provides a 95% probability for SSB to be above B_{lim} (F_{P05}).	(ICES, 2021a)

H. Other issues

None.

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