ICES WGDEEP REPORT 2017

ICES ADVISORY COMMITTEE

ICES CM 2017/ACOM:14

Report of the Working Group on the Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP)

24 April–1 May 2017

Copenhagen, Denmark

ICES CIEM
International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

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Recommended format for purposes of citation:

ICES. 2017. Report of the Working Group on the Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP), 24 April–1 May 2017, Copenhagen, Denmark. ICES CM 2017/ACOM:14. 21 pp.

7 Greater silver smelt

7.3 Greater silver smelt (*Argentina silus*) in Division 5.a

7.3.1 The fishery

Greater silver smelt is mostly fished along the south and southwest coast of Iceland, at depths between 500 and 800 m. Greater silver smelt has been caught in bottom trawls for years as a bycatch in the redfish fishery. Only small amounts were reported prior to 1996 as most of the greater silver smelt was discarded. However discarding is not considered significant because of the relatively large mesh size used in the redfish fishery. Since 1997, a directed fishery for greater silver smelt has been ongoing and the landings have increased significantly (Table. 7.3.1).

7.3.1.1 Fleets

Since 1996 between 20 and39 trawlers have annually reported catches of greater silver smelt in 5.a (Table 7.3.1). The trawlers participating in the greater silver smelt fishery also target redfish (*Sebastes marinus* and *S. mentella*) and to lesser extent Greenland halibut and blue ling.

Number of hauls peaked in 2010, but the number of hauls have decreased since then in line with lower total catches. In most years between 70–90% of the greater silver smelt catches are taken in hauls were the species is more than 50% of the catch (Table 7.3.2).

Table 7.3.1. Greater silver smelt in 5.a. Information on the fleet reporting catches of greater silver smelt.

YEAR	NUMBER TRAWLERS	NUMBER HAULS	REPORTED CATCH	NO. HAULS WHICH GSS >50% OF CATCH	PROPORTION OF REPORTED CATCH IN HAULS WERE GSS >50%
1997	26	854	2257	384	0,846
1998	39	2587	11132	1968	0,955
1999	24	1451	4456	824	0,865
2000	23	1263	3491	643	0,827
2001	26	767	1577	255	0,715
2002	32	1134	3127	504	0,777
2003	30	1127	1965	253	0,538
2004	27	1017	2688	340	0,705
2005	30	1368	3520	361	0,732
2006	31	1542	3725	395	0,715
2007	26	1259	3440	461	0,759
2008	31	3143	8428	863	0,663
2009	34	3434	10233	1010	0,694
2010	36	4724	16280	1836	0,740
2011	34	3244	10155	973	0,723
2012	31	3334	9732	985	0,713
2013	31	2704	7192	618	0,651
2014	24	2336	6157	487	0,614
2015	24	1836	5312	334	0,600
2016	26	2090	5708	387	0,596

7.3.1.2 Targeting and mixed fisheries issues in the Greater Silver Smelt fishery in 5.a

Mixed fisheries issues: species composition in the fishery

Redfish spp. (*Sebastus marinus* and *S. mentella*) are the main species when it comes to mixed fishery of greater silver smelt. Other species of lesser importance are Greenland halibut, blue ling and ling. Other species than these rarely exceed 10% of the bycatch in the greater silver smelt fishery in 5.a (Table 7.3.2).

Table 7.3.2. Greater silver smelt in 5.a. Proportional species composition where greater silver smelt was more than 50% of the total catch in a haul.

Year	Redfish		Greenland halibut	Ling	Blue ling	Other
	S. marinus	*S. mentella*				
1997	1,4	79	0,0	6,9	7,2	5,5
1998	5,3	77,9	0,0	3,6	6,4	6,8
1999	4	79,9	0,0	2,5	5,9	7,6
2000	4,8	71	0,2	0,3	9,7	14,1
2001	22,4	55,4	4,5	0,5	0,9	16,3
2002	16,9	74,2	0,4	1,2	4,0	3,2
2003	37,7	52	0,4	0,1	5,1	4,7
2004	25,1	68,4	0,7	0,1	0,9	4,8
2005	15,6	69,5	4,3	1,4	3,0	6,2
2006	28,8	59,8	1,4	0,9	1,0	8,1
2007	12,1	70,9	5,9	0,3	6,1	4,6
2008	26,7	60,8	2,8	1,2	5,0	3,4
2009	20,9	63,7	3,3	0,2	7,9	4,1
2010	16	63,7	2,0	0,9	6,4	11,1
2011	13,4	66,3	2,2	0,4	4,8	12,9
2012	8,9	67,5	1,3	0,2	7,5	14,5
2013	9,6	63,8	4,7	0,2	9	12,8
2014	2,4	78,3	2,8	0,3	5,5	10,7
2015	13,8	67,1	3,1	0,3	4,2	11,7
2016	10,9	73,5	5,5	0,2	2,8	7,1

Spatial distribution of catches through time

Spatial distribution of catches in 1996–2016 is presented in Figures 7.3.1 and 7.3.2. With the exception of 1996 most of the catches have been from the southern edge of the Icelandic shelf. However in recent years there has been a gradual increase in the proportion caught in the western area and even in the northwestern area. The reason for this is the fleet is focusing on redfish and Greenland halibut but then takes few hauls of greater silver smelt in the area (Figures 7.3.1 and 7.3.2).

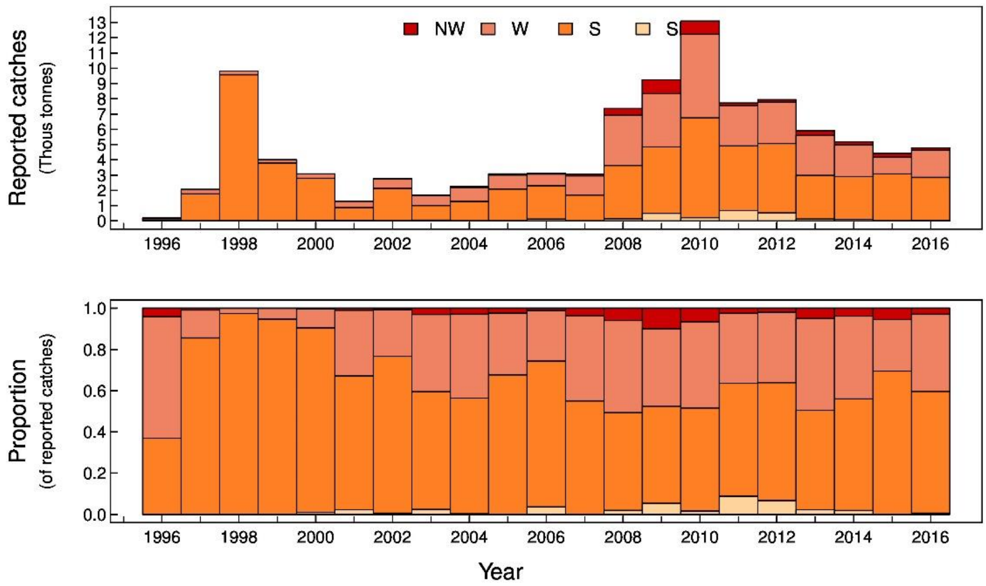

Figure 7.3.1. Greater silver smelt in 5.a. Catches defined by survey regions deeper than 400 m by year (See stock annex for details). Above are the catches on absolute scale and below in proportions.

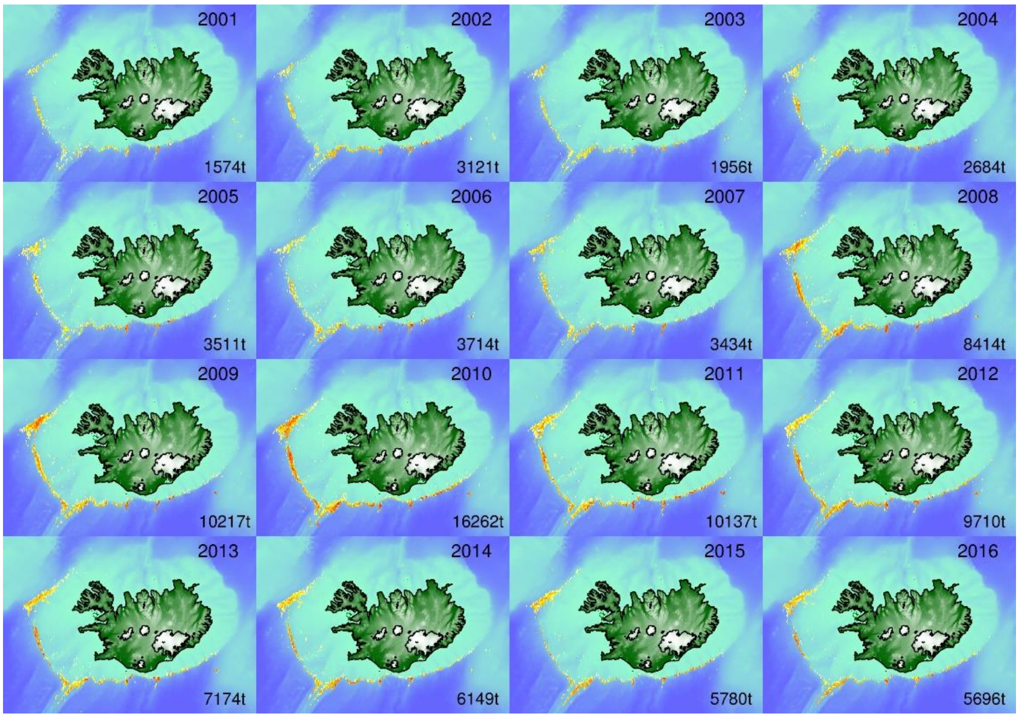

Figure 7.3.2. Greater silver smelt in 5.a. Spatial distribution of catches as reported in logbooks.

7.3.2 Landings trends

Landings of Greater Silver Smelt are presented in Table 7.3.1 and Figure 7.3.3. Since directed fishery started in 1997–1998, the landings increased from 800 t in 1996 to 13 000 t in 1998. Between 1999 and 2007 catches varied between 2600 to 6700 t. Since 2008 landings have increased substantially, from 4200 t in 2007 to almost 16 500 t in 2010. In 2011 landings started to decrease due increased management actions, and landings in 2016 amounted to approximately 5500 tonnes.

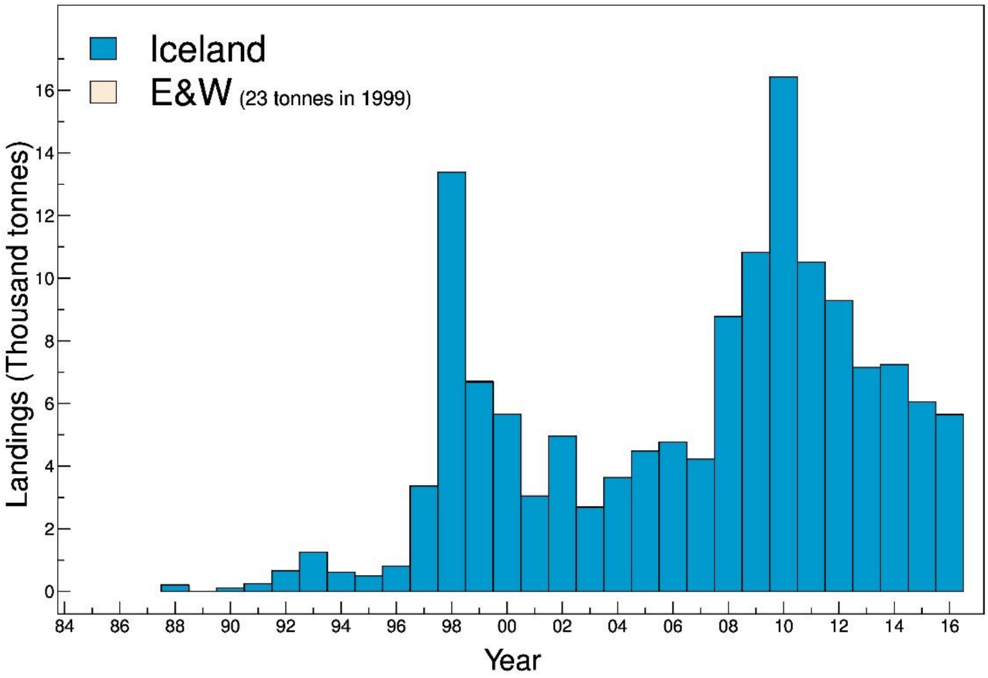

Figure 7.3.3. Greater silver smelt in 5.a. Nominal landings. 23 tonnes were landed by foreign vessels (England and Wales) in 1999, which is the only year of reported by foreign vessels.

7.3.3 ICES Advice

The ICES advice for 2017 is: Based on the ICES approach for data-limited stocks, ICES advises that catches should be no more than 9310 tonnes.

The basis for the advice was the following: For data-limited stocks with reliable abundance information from fisheries-independent data and a target F_{proxy}, where abundance is considered above MSY $B_{trigger}$, ICES uses a harvest control rule that calculates catches based on the F_{proxy} target multiplied by the most recent survey biomass estimates.

For this stock the F_{proxy} of 0.171 is applied, with an additional uncertainty cap of 20%, as a factor to the 2016 biomass estimate, resulting in catch advice of no more than 9310 t. ICES does not implement the default rule as used for other data-limited stocks because the fishing mortality has increased significantly in the last two years.

7.3.4 Management

Before the 2013/2014 fishing year the Icelandic fishery was managed as an exploratory fishery subject to licensing since 1997. Detailed description of regulations on the fishery of greater silver smelt in 5.a is given in the stock annex.

The TAC for the 2013/2014 fishing year was set at 8000 based on the recommendations of MRI using a preliminary Gadget model and the 2014/2015 fishing year the recommendation was to maintain the catches at 8000 t. For the fishing year 2015/2016 it was also maintained at 8000 t but 7885 t for 2016/2017.

7.3.5 Data available

7.3.5.1 Landings and discards

Landings by Icelandic vessels are given by the Icelandic Directorate of Fisheries. Discarding is banned in Icelandic waters, and currently there is no available information on greater silver smelt discards. It is however likely that unknown quantities of greater silver smelt were discarded prior to 1996.

7.3.5.2 Length compositions

Table 7.3.3 gives the number of samples and measurements available for calculations of catch in numbers of Greater Silver Smelt in 5.a. Length distributions are presented in Figure 7.3.4.

7.3.5.3 Age compositions

Table 7.3.3 gives the number of samples and measurements available for calculations of catch in numbers of greater silver smelt in 5.a. Estimates of catch in numbers are given in Figure 7.3.5.

Table 7.3.3. Greater silver smelt in 5.a. Summary of sampling intensity and overview of available data for estimation of catch in numbers.

Year	No. length samples	No. length measurements	No. otolith samples	No. otoliths	No. aged otoliths
1997	45	4863	28	1319	985
1998	141	14911	102	6018	890
1999	58	4163	44	2180	82
2000	27	2967	18	1011	113
2001	10	489	6	245	17
2002	21	2270	10	360	127
2003	63	5095	13	425	0
2004	34	996	7	225	84
2005	49	3708	14	772	0
2006	29	4186	13	616	465
2007	14	2158	8	285	272
2008	44	3726	39	1768	1387
2009	53	5701	36	1746	1387
2010	134	16351	68	3370	3120
2011	63	6866	40	1953	1774
2012	35	3891	23	1094	405
2013	47	4925	34	710	704
2014	32	4709	16	350	340
2015	11	1275	8	221	217
2016	45	5880	13	285	184

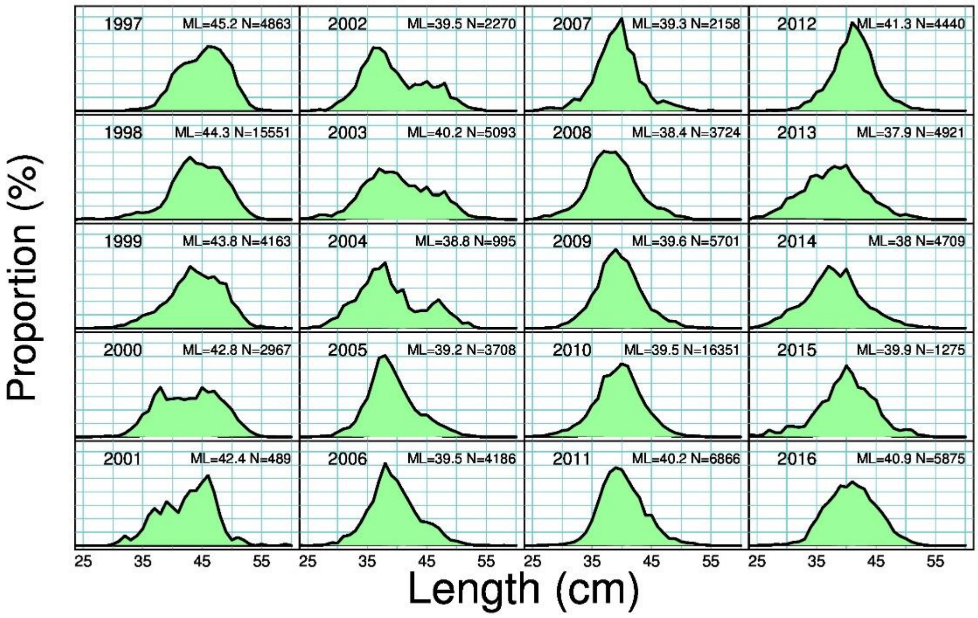

Figure 7.3.4. Greater silver smelt in 5.a. Length distributions from commercial catches.

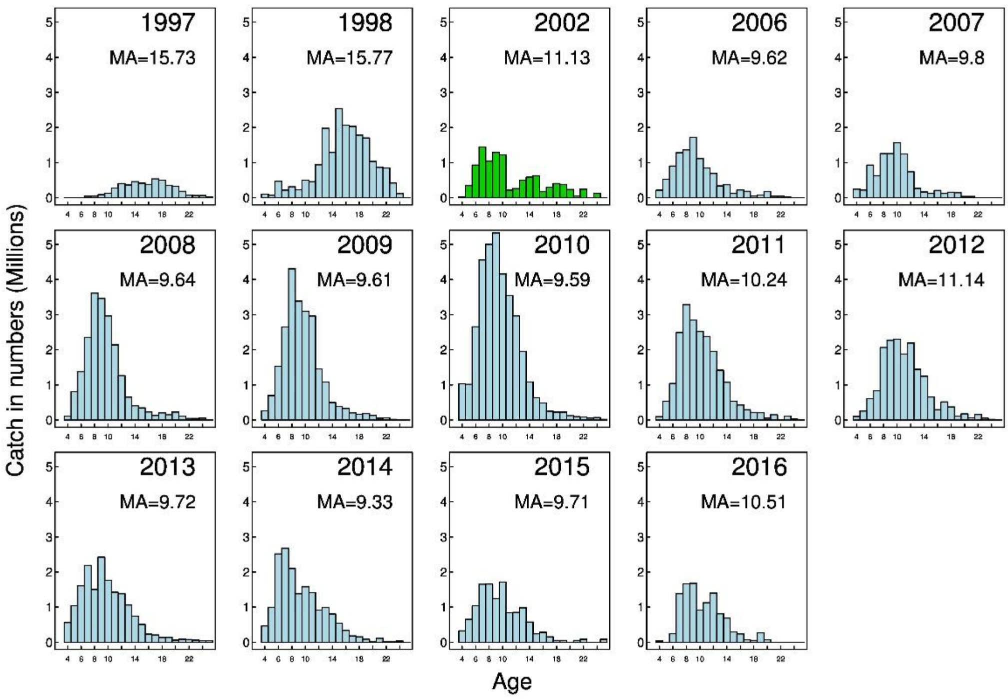

Figure. 7.3.5. Greater silver smelt in 5.a. Catch in numbers. Estimates for 2002 are based on limited number of aged otoliths (See Table 7.3.3).

7.3.5.4 Weight-at-age

No marked changes can be observed in mean weight-at-age from commercial catches between 1997–1998 and 2006–2013.

7.3.5.5 Maturity and natural mortality

Estimates of maturity ogives of greater silver smelt in 5.a were presented at the WKDEEP 2010 meeting for both age and length (WKDEEP 2010, GSS-04) using data collected in the Icelandic autumn survey (See stock annex for details). Males tend on average to mature at a slightly higher age or at 6.5 compared to 5.6 for females but at a similar length as females 35.3 cm. Most of the greater silver smelt caught in commercial catches in 5.a are mature.

No information exists on natural mortality of greater silver smelt in 5.a.

7.3.5.6 Catch, effort and research vessel data

Catch per unit of effort and effort data from the commercial fleets

At WKDEEP 2010 a glm cpue series was presented (WKDEEP 2010, GSS-05), however because of strong residual patterns the group concluded that the glm-cpue series was not suitable to use as an indicator of stock trends.

The cpue is not considered to represent changes in stock abundance as the fishery is mostly controlled by market factors, oil prices and quota status in other species, mainly redfish.

Icelandic survey data

Indices

The Icelandic spring groundfish survey, which has been conducted annually in March since 1985, gives trends on fishable biomass of many exploited stocks on the Icelandic fishing grounds. In total, about 550 stations are taken annually at depths down to 500 m. The survey area does not cover the most important distribution area of the greater silver smelt fishery in 5.a and is therefore not considered representative of stock biomass. However the survey may be indicative of recruitment but the data have not been explored in sufficient detail. In addition, the autumn survey was commenced in 1996 and expanded in 2000. A detailed description of the autumn groundfish survey is given in the stock annex for greater silver smelt in 5.a. The survey is considered representative of stock biomass of greater silver smelt since it was expanded in 2000. Figure 7.3.6 gives trend in biomass and juvenile abundance for the spring survey in 1985 to 2017 and for the autumn survey in 2000 to 2016. Due to industrial action in 2011 the autumn survey was cancelled after about one week of survey time. Greater Silver Smelt is among the most difficult demersal fish stocks to get reliable information on from bottom-trawl surveys. This is in large part due to the fact that most of the greater silver smelt caught in the survey is taken in few but relatively large hauls. This can result in very high indices with large variances particularly if the tow-station in question happens to be in a large stratum with relatively few tow-stations. Therefore the index is winsorized when used in the advisory procedure (See stock annex for details). A comparison of indices, with or without winsorization are shown in Figure 7.3.7.

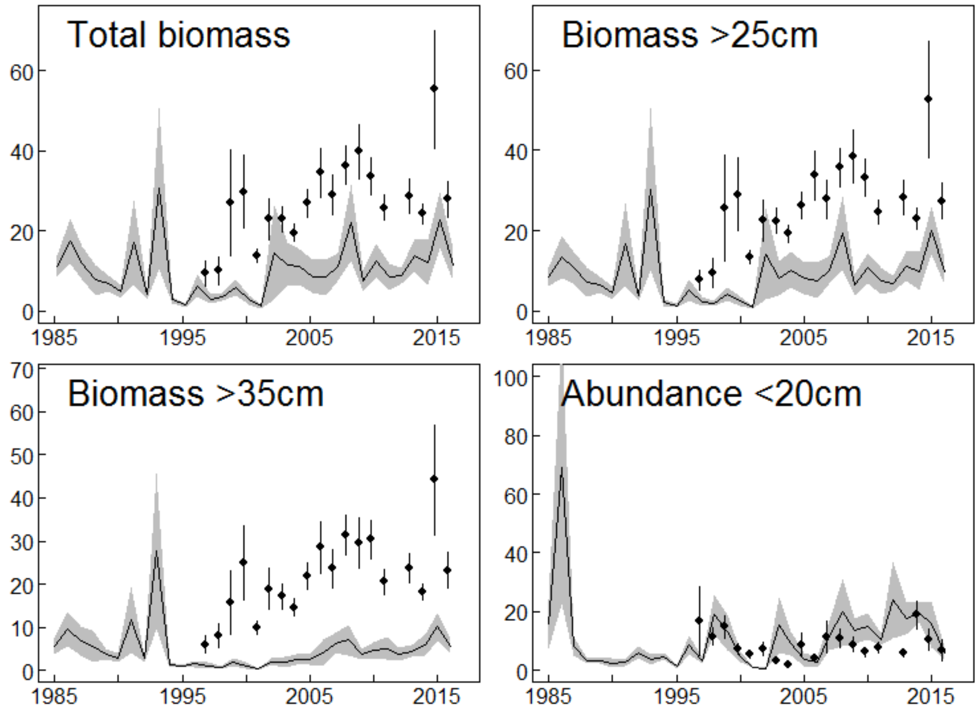

Figure 7.3.6. Greater silver smelt in 5.a. Indices from the Icelandic spring survey (black lines and shaded area) and from the autumn survey (dots and vertical lines). Vertical lines and shaded area represent +/- 1 standard error.

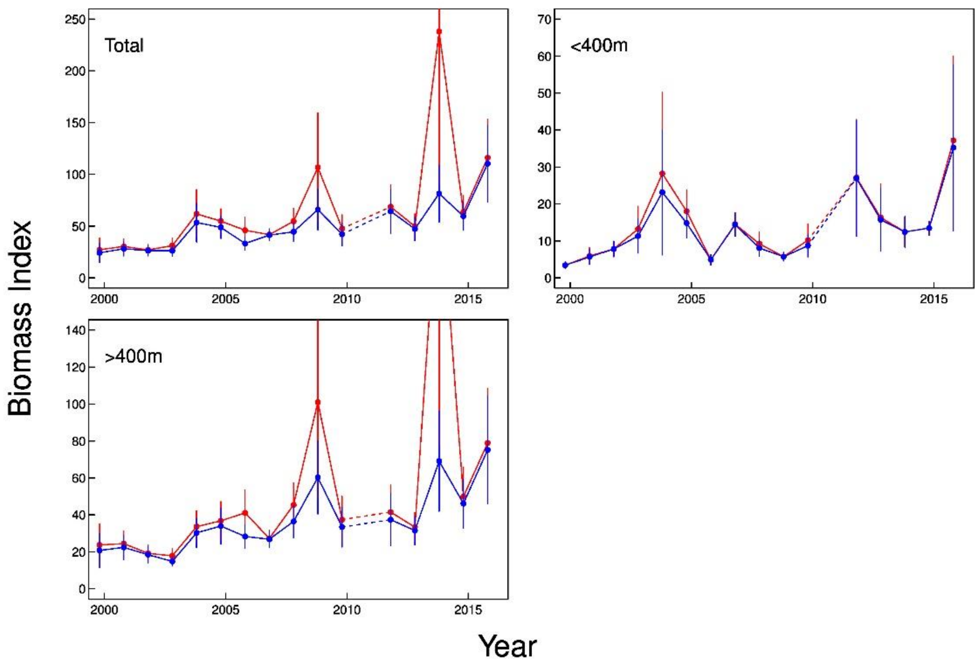

Figure 7.3.7. Greater silver smelt in 5.a. Index from the Icelandic autumn survey, divided by depth. The line colour indicates the biomass index used, either un-altered or Winsorized (see text for further details).

7.3.6 Data analyses

Landings and sampling

Spatial distribution of catches did not change markedly between 2015 and 2016 and fishing for greater silver smelt in the NW area seems to have stopped (Figures 7.3.1 and 7.3.2). Landings of greater silver smelt increased rapidly from 2007 to 2010 when they peaked at around 16 000 tonnes, since then they have decreased to around 5646 tonnes in 2016 (Figure 7.3.3 and Table 7.3.4). The decrease in catches is the result of increased vigilance by the managers to constrain catches to those advised and also lesser interest by the fleet in the stock. At the same time mean length in catches decreased from around 44 cm in 1998 to 38–40 in 2008 to 2011 however there is a slight increase in mean length in 2012 but that increase was not present in 2016 (Figure 7.3.4). A similar continuous downward trend in mean age in the commercial catches is also observed. Mean age in the fishery has decreased since the late nineties from around 16 to around 10 in 2006 to 2011 but as for mean length, mean age in catches in 2012 increased and is estimated at 11.5 years in 2012 compared to 10.3 in 2011 and 9.7 in 2013 (Figure 7.3.5). The reason for this change is not known as there is no marked difference in the spatial distribution of the fishery.

Surveys

As mentioned above greater silver smelt is a difficult species to survey in trawl surveys and the indices derived from the both the spring and autumn surveys have high CVs. Occasional spikes in the indices without any clear trend characterize the spring survey biomass indices. The only thing that can be derived from the spring survey is that the biomass indices (total and >25 cm), in 1985–1993 and again from 2002 to 2017 at a higher level than in 1994–2001. The juvenile index has a very high peak in 1986 but then hardly any juveniles are detected in the survey in 1987 to 1995. Since 1998 there have been several small spikes in the recruitment index with the 2015 estimate at the highest level since 1993 (Figure 7.3.6).

The observed trends in the biomass indices from the autumn survey have a considerably different trends than those observed in the spring survey (Figure 7.3.6). According to the autumn survey biomass increased more or less year on year from 2000 to 2008 but then decreased in 2009 and 2010. The total biomass index in the autumn survey showed slight variations until 2014 when the index increased to the highest value observed.

There is a clear gradient in mean length of greater silver smelt with depth, larger fish being in deeper water. Also fishing for greater silver smelt in 5.a is banned at depths less than 400 meters. The autumn survey index for depth greater than 400 meters is therefore considered the best indicator of available biomass to the fishery. As noted in the section above the Winsorized index appears to be less sensitive to the few large hauls in the 2009 and 2014 survey years (Figure 7.3.7).

F_{proxy}

Changes in relative fishing mortality (F_{proxy} = Yield / Survey biomass at depths greater than 400 m) are presented in Figure 7.3.8 and Table 7.3.5. According to the graph, F_{proxy} was relatively stable in 2004 to 2006 but then increased slowly from 2006 to 2008. This was mainly driven by increases in catches. The decrease in 2009 is the result of a very high value of the index in that year but the decrease between 2010 and 2012 is due to decrease in catches as the index was at similar levels between the two years (Figure 7.3.7).

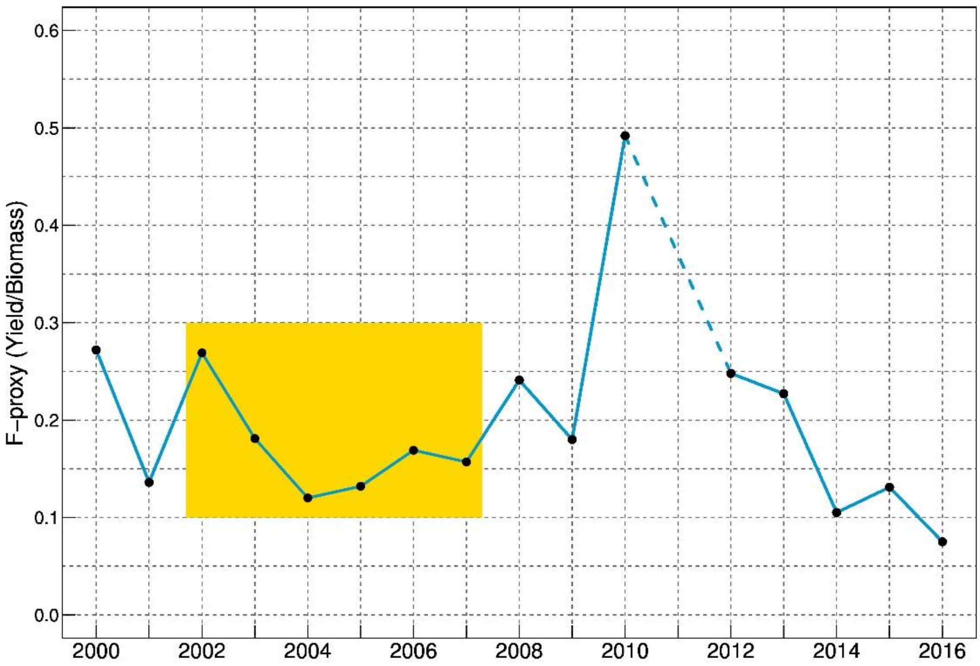

Figure 7.3.8. Greater silver smelt in 5.a. Changes in relative fishing mortality (F_{proxy}). The index used is the >400 m winsorized index from the Icelandic autumn survey (see text for further details).

Analytical assessment

No analytical assessment presented this year.

7.3.7 Comments on the assessment

The assessment was conducted according to the stock annex.

7.3.8 Management considerations

Exploitation of greater silver smelt has been reduced in recent years, coming down from a relatively high level in 2010, to levels lower than the average exploitation rate in the reference period.

7.3.9 Application of MSY proxy reference points (ToR h)

In the ICES response to the: EU request to provide a framework for the classification of stock status relative to MSY proxies for selected category 3 and category 4 stocks in ICES Subareas 5 to 10. ICES set the F_{MSY} proxy for greater silver smelt in 5.a as 0.171 but did not set a B_{MSY} trigger proxy for the stock.

This year WGDEEP re-ran the length-based indicator model used to answer the request and also tried the SPiCT model on the index used for the assessment.

Length-Based Indicator (LBI)

Data and settings

In the LBI-model model run presented here length-at-maturity (L_{mat}) was set at 35.95 cm and Linf at 48.77. These values were obtained from data collected in the Icelandic autumn survey. The length distributions came from commercial catches from 2004 to 2016. Mean weight at length was estimated from a length–weight relationship from the Icelandic autumn survey (Figure 7.3.9). The length bin used was 2 cm.

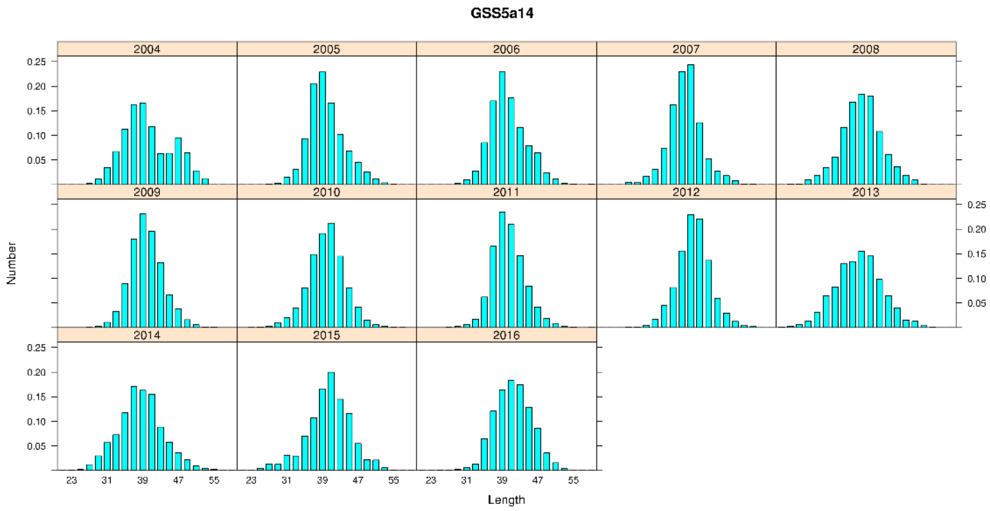

Figure 7.3.9. Length distributions used for estimating LBI.

Results

According to the results, greater silver smelt in 5.a is being harvested at a sustainable level in the period as $L_{mean}/L_{F=M}$ is always larger than 1 (Table 7.3.6 and Figure 7.3.10).

Table 7.3.6. LBI results for 2014 to 2016.

	Traffic light indicators					
	Conservation				**Optimizing Yield**	**MSY**
	Lc/Lmat	L25%/Lmat	Lmax5%/Linf	Pmega	Lmean/Lopt	Lmean/$L_{F=M}$
Ref	**>1**	**>1**	**>0.8**	**>30%**	**~1 (>0.9)**	**≥1**
2014	0.97	0.97	1.00	71%	1.23	1.04
2015	0.75	1.03	1.02	84%	1.23	1.23
2016	1.03	1.06	1.01	91%	1.29	1.05

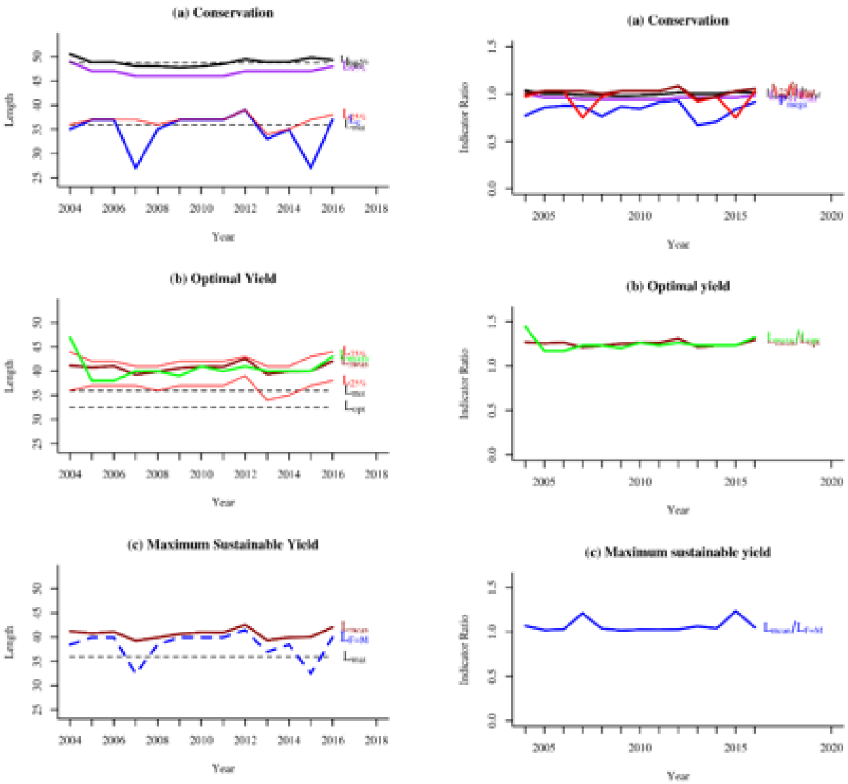

Figure 7.3.10. Results of LBI to commercial length distributions from 5.a.

SPiCT

Settings and data

The input data in the model were the entire catch history of greater silver smelt in 5.a and the winsorized index from the Icelandic Autumn survey used for the assessment that goes back to 2000 (Figure 7.3.11). The model run presented here deviates from the default settings in two ways. The uncertainty in the survey was taken into account in the model and also the prior for the K/B0 ratio was set at 0.95 as the stock was not exploited before the beginning of the assessment period.

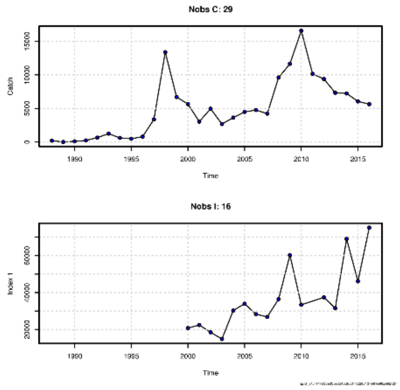

Figure 7.3.11. Input data to the SPiCT model.

Results

The output from the model is shown below. The estimates of r and K do not seem plausible for a long-lived species like greater silver smelt. It would be expected that r would be somewhere in the range of 0.1–0.3 but not at 0.9 and given that the *K* also seems rather low at 59 kt. B_{MSY} is estimated at 33 kt, which is very low. The diagnostic plots are shown in Figure 7.3.12, the results in Figure 7.3.12 and finally the analytical retrospective analysis in Figure 7.3.13.

```
> res <- fit.spict(inp)
        > summary(res)
        Convergence: 0  MSG: relative convergence (4)
        Objective function at optimum: 55.5678617
        Euler time step (years):  1/16 or 0.0625
        Nobs C: 29,  Nobs I1: 16

        Priors
              logn  ~  dnorm[log(2), 2^2]
          logalpha  ~  dnorm[log(1), 2^2]
           logbeta  ~  dnorm[log(1), 2^2]
         logbkfrac  ~  dnorm[log(0.95), 0.2^2]

        Model parameter estimates w 95% CI
                    estimate        cilow        ciupp    log.est
         alpha  1.498083e-01    0.0507490 4.422262e-01 -1.8983985
         beta   5.554681e-01    0.1255107 2.458315e+00 -0.5879442
         r      9.355688e-01    0.0783691 1.116880e+01 -0.0666006
         rc     6.650060e-01    0.1063304 4.159046e+00 -0.4079591
         rold   5.158301e-01    0.0352641 7.545378e+00 -0.6619779
         m      1.113305e+04 2212.4107511 5.602250e+04  9.3176734
         K      5.922856e+04 3150.9782382 1.113312e+06 10.9891591
         q      7.306465e-01    0.0227969 2.341745e+01 -0.3138255
         n      2.813715e+00    0.2294246 3.450804e+01  1.0345057
         sdb    2.949027e-01    0.1576420 5.516778e-01 -1.2211098
         sdf    8.445967e-01    0.4052827 1.760114e+00 -0.1688960
         sdi    4.417890e-02    0.0205698 9.488520e-02 -3.1195083
         sdc    4.691465e-01    0.1989834 1.106114e+00 -0.7568402

        Deterministic reference points (Drp)
                   estimate        cilow        ciupp    log.est
         Bmsyd 33482.550796 1624.9764938 6.899061e+05 10.418780
         Fmsyd     0.332503    0.0531652 2.079523e+00 -1.101106
         MSYd  11133.049351 2212.4107511 5.602250e+04  9.317673
        Stochastic reference points (Srp)
                   estimate       cilow        ciupp   log.est rel.diff.Drp
         Bmsys 2.990691e+04 1598.213558 5.596394e+05 10.30584   -0.1195590
         Fmsys 2.946373e-01    0.030679 2.829659e+00 -1.22201   -0.1285164
         MSYs  8.676299e+03 1857.189077 4.053338e+04  9.06835   -0.2831566

        States w 95% CI (inp$msytype: s)
                            estimate        cilow        ciupp    log.est
         B_2016.00        5.799578e+04 2042.3557930 1.646878e+06 10.9681255
         F_2016.00        1.030988e-01    0.0034385 3.091289e+00 -2.2720680
         B_2016.00/Bmsy 1.939210e+00    0.7115697 5.284845e+00  0.6622807
         F_2016.00/Fmsy 3.499175e-01    0.0304753 4.017756e+00 -1.0500580

        Predictions w 95% CI (inp$msytype: s)
                          prediction        cilow        ciupp    log.est
         B_2017.00        5.314816e+04 1963.5644641 1.438571e+06 10.8808387
         F_2017.00        1.022868e-01    0.0028753 3.638761e+00 -2.2799747
         B_2017.00/Bmsy 1.777120e+00    0.7093039 4.452470e+00  0.5749939
         F_2017.00/Fmsy 3.471617e-01    0.0246214 4.894985e+00 -1.0579646
         Catch_2017.00    5.326821e+03 1080.7996160 2.625373e+04  8.5805100
         E(B_inf)         4.171460e+04           NA           NA 10.6386065
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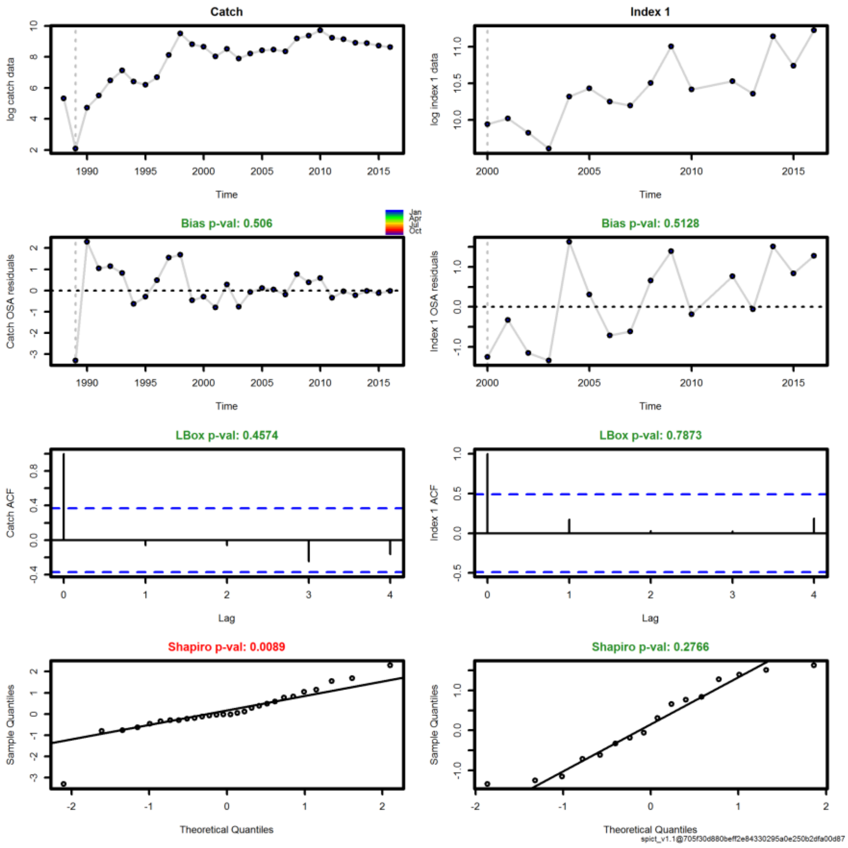

Figure 7.3.12. Diagnostics from the SPiCT-model.

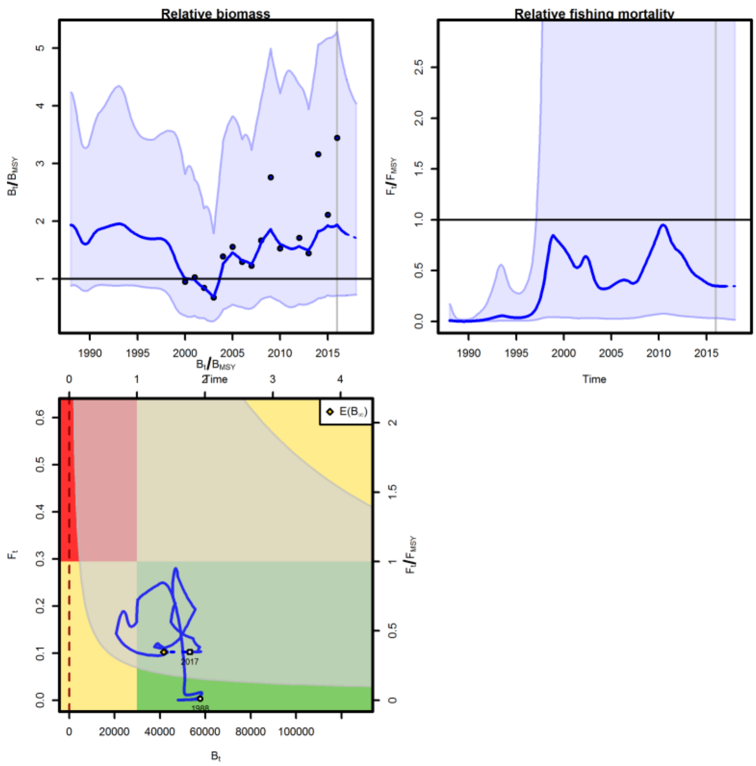

Figure 7.3.12. Results from the SPiCT-model.

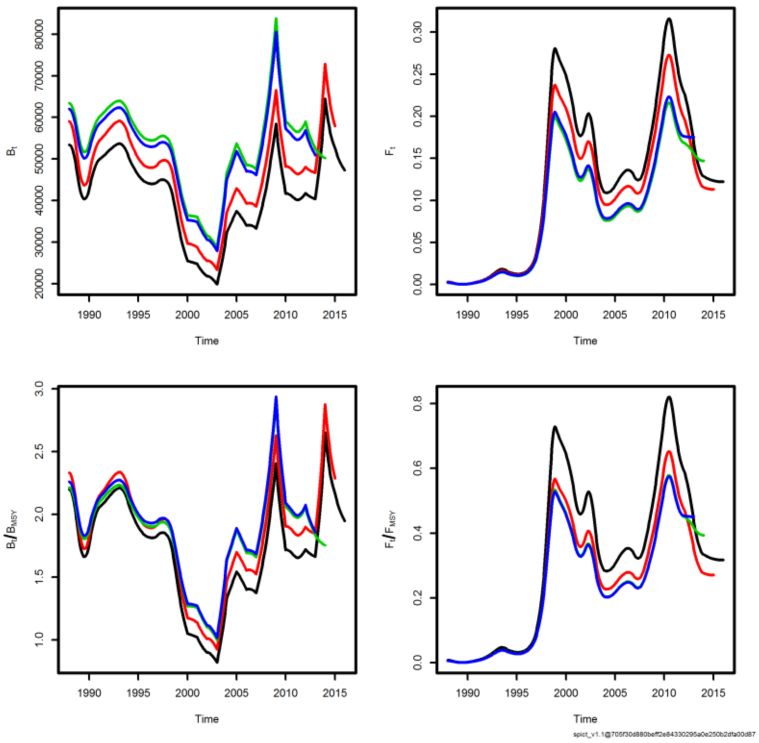

Figure 7.3.12. Analytical retrospective analysis from the SPiCT-model.

Conclusions

The analysis presented above indicates that the fishing pressure is below F_{MSY} and the stock biomass is above possible MSY $B_{trigger,proxy}$. This does not sound unlikely given that the stock has not been fished hard in the past. Catches of greater silver smelt have not been high in the past, normally below 10 kt, compared with catches in 5.b and 6.a. Additionally the distribution area in 5.a is much larger than in 5.b and 6.a. The selection pattern from the fishery is good as fishing for greater silver smelt is only allowed at depths greater than 400 meters, where juveniles are not found.

The findings presented here support the general view of WGDEEP that the stock is at a sustainable level and that the selection pattern is good. However there is a question whether LBI and SPiCT are the correct tools to state that.

Table 7.3.4. Greater silver smelt in 5.a. Nominal landings in 1988–2016.

YEAR	CATCHES
1988	206
1989	8
1990	112
1991	247
1992	657
1993	1.255
1994	613
1995	492
1996	808
1997	3.367
1998	13.387
1999	6.704
2000	5.657
2001	3.043
2002	4.960
2003	2.686
2004	3.637
2005	4.481
2006	4.775
2007	4.226
2008	8.778
2009	10.829
2010	16.428
2011	10.515
2012	9.290
2013	7.154
2014	7.241
2015	6056
2016	5646

Table 7.3.5. Greater silver smelt in 5.a. Landings and survey biomass from the Icelandic autumn survey (greater than 400 m, winsorised) and F_{proxy} (Yield/Survey biomass). The mean of the F_{proxy} values in italic is used as an F_{proxy} target.

YEAR	LANDINGS	INDEX	CV INDEX	F_{PROXY}
2000	5657	20764,4	0,443	0.272
2001	3043	22425,5	0,294	0.136
2002	4960	18464,8	0,24	*0.269*
2003	2686	14826,1	0,17	*0.181*
2004	3637	30289,1	0,26	*0.120*
2005	4481	33955,8	0,289	*0.132*
2006	4775	28317,1	0,224	*0.169*
2007	4226	26832,4	0,165	*0.157*
2008	8778	36458	0,242	0.241
2009	10 829	60277,8	0,328	0.180
2010	16 428	33383,1	0,322	0.492
2011	10 515	No survey		
2012	9290	37413	0,38	0.248
2013	7154	31504,4	0,243	0.227
2014	7241	69072,8	0,393	0.105
2015	6056	46114,0	0,285	0,131
2016	5646	75199,8	0,389	0,075

e of Argentine species in Porcupine Bank surveys (2001–2016).