

SEA CUCUMBER – SÆBJÚGA

Cucumaria frondosa

COMMERCIAL FISHING

An experimental fishery for sea cucumber started in Breiðafjörður in 2003, but little was landed until 2008 when fisheries started in Faxaflói with catch of 998 t. Since then the landings have increased and in 2009 three fishing zones were demarcated: 1) Western area: Reykjanes to Skagatá, 2) Northern area: Skagatá to Glettinganes and 3) Southern and eastern area: Glettinganes to Reykjanes. For each of these zones three fishing licenses were issued and it was not allowed to move from one zone to another as the license was only valid in one zone. However, no fishing was conducted in the Northern area as fishing sites were not known and the few searches which have been conducted by the fishermen did not give any results. In 2013 the nine boats that had fishing licenses were now allowed to fish in all zones.

The main fishing areas were in the beginning Faxaflói and Aðalvík in the Western area, and since 2009 also off the east coast belonging to the Southern and eastern area. In 2013 the main fishing areas were defined by the following coordinates in 2013 (Regulation 795/2013):

Faxaflói:

1. 64°06,00N-22°24,00V
2. 64°06,00N-22°49,20V
3. 64°21,00N-22°49,20V
4. 64°21,00N-22°24,00V
5. 64°06,00N-22°24,00V

Off the east coast:

1. 65°05,40N-13°21,00V
2. 65°05,40N-13°33,00V
3. 64°43,20N-13°53,40V
4. 64°43,20N-13°41,40V
5. 65°05,40N-13°21,00V

Aðalvík:

1. 66°21,00V-23°03,00V
2. 66°21,00V-23°15,00V
3. 66°25,80V-23°15,00V
4. 66°25,80V-23°03,00V
5. 66°21,00V-23°03,00V

Since February 2010, a small subarea (17 km²) within Faxaflói has been closed because of overfishing (Regulation 110/2010). This subarea is defined by the following coordinates:

1. 64°08,91N-22°39,70V
2. 64°10,42N-22°36,87V
3. 64°09,28N-22°32,62V
4. 64°07,98N-22°35,96V
5. 64°08,91N-22°39,70V

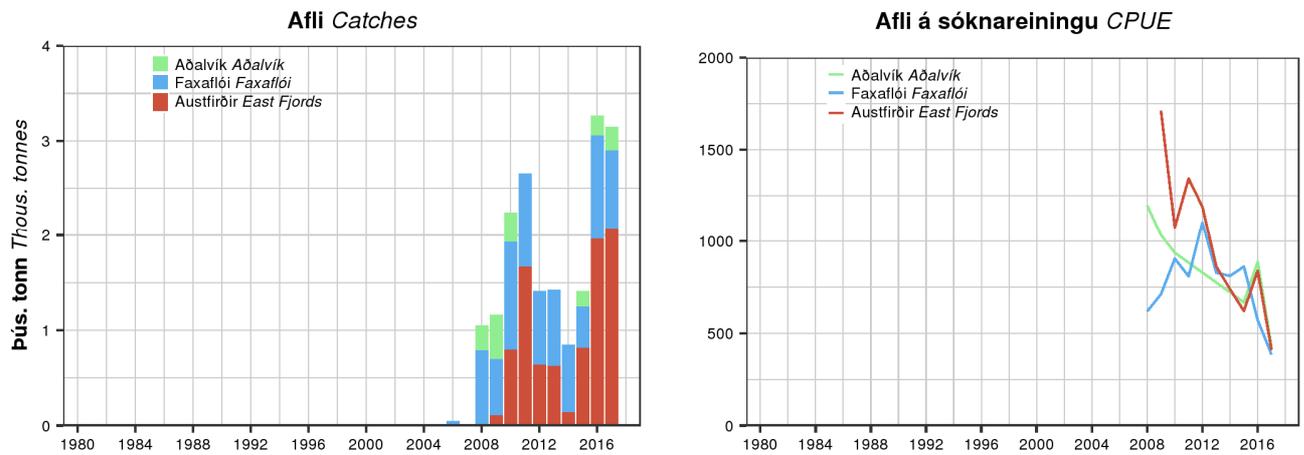
In 2009 the stock status in Faxaflói and Aðalvík were estimated, the fishing areas defined and TAC given for first time. In 2012, the stock status off the east coast was estimated resulting in TAC for a defined area for the fishing year 2013/2014. When the maximum allowable catch has been reached within an area, the area is closed for fishing but further fishing can be continued outside the defined areas.

The annual catches have been fluctuating, mostly because of different effort in each defined fishing area, as well as in outside areas. The annual total catch in Faxaflói has ranged from 433-1130 t, off the east coast from 108-2073 t and in Aðalvík 159-467 t. The maximum total landings (inside and outside marked fishing areas) in the years 2008-2017, were in 2016, 3266 t. In 2017 annual total landings were 3222 t, 828 t from Faxaflói, 2073 t off the east coast and 247 t from Aðalvík. Beside that 74 t were fished in Breiðafjörður.

Landings within an area and total landings 2008-2017.

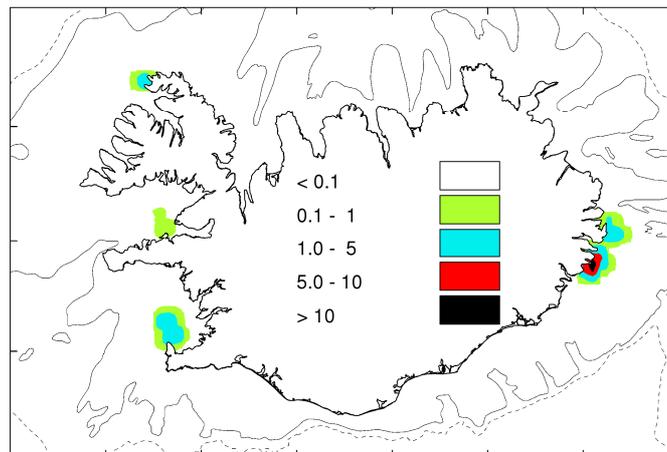
Year	Faxaflói	East coast	Aðalvík	Breiðafjör	Total
2008	788	0	263		1051
2009	591	108	467		1166
2010	1130	799	316		2245
2011	985	1670	0		2655
2012	775	640	0		1415
2013	799	625	0		1424
2014	705	142	0		847
2015	433	819	159		1411
2016	1089	1966	210		3265
2017	828	2073	247	74	3222

Catch per unit effort (CPUE) has differed between years, ranging from 384-1103 kg/hour in Faxaflói, 409-1713 off the east coast and 425-1197 in Aðalvík. CPUE for the whole fishery has ranged from 677-1090 kg/hour fished. There is an annual variation in CPUE where catches are higher in spring and summer mostly depending on weather conditions. The lowest mean CPUE in each area was observed in 2017. Sea cucumber are fished by a dredge, 250 cm in width and with minimum mesh size of 100 mm. In recent years most of the boats have been using two dredges at the same time increasing the effort considerably. A maximum of nine fishing licenses have been issued annually in this fishery. No fishing is permitted in May and June in the Western area and in June and July in other areas due to spawning of sea cucumber.



Sea Cucumber. Total catch and catch per unit effort by area.

Sæbjúga. Afli og afli á sóknareiningu eftir svæðum.

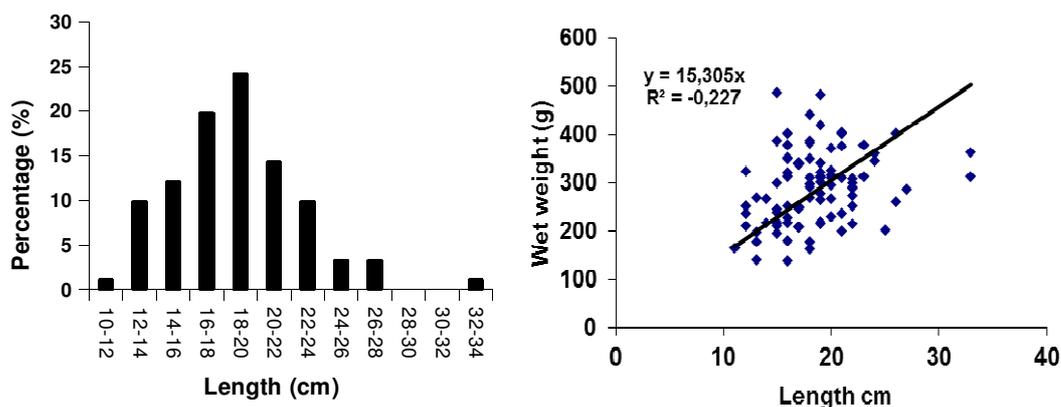


Sea Cucumber. Fishing grounds in 2010-2017. The colour indicates the size of the catch (t/nm²).

Sæbjúga. Veiðisvæði við Ísland 2010-2017. Liturinn sýnir afla (t/sj m²).

SURVEYS

A dredge survey for sea cucumber was conducted in Aðalvík northwest Iceland in April 2008, to get information on stock size and investigate the population structure. Swept area method was used in order to determine the density/abundance of cucumbers, where each catch was weighted and the distance covered by the dredge was calculated. The total catch weight was divided by the size of the area covered in each tow to give biomass in kg/m². Biomass estimate was calculated from the mean biomass in the area multiplied by the total size of the area which was estimated to be 12 km². The density (ind./m²) was calculated by dividing the mean wet weight of the individuals in an area into the abundance (kg/m²) of the area. Twenty four stations were taken at 22-30 m depth. The stock in the area was assessed to be 3600 t based on biomass from the area swept (0.3 kg/m²) and on 100% gear efficiency. The mean length, wet weight (drained) and the mantle weight from subsamples was measured 18.35 cm (SD=3.1), 290 g (SD=60.6), and 157 g (SD=30.4) respectively.



Sea Cucumber. Size distribution and correlation between wet weight and size in Aðalvík 2008.

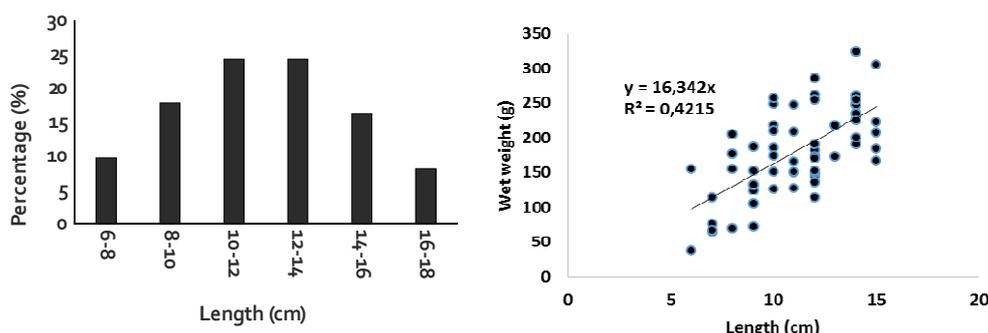
Sæbjúga. *Stærðardreifing og lengdar-vigtarsamband sæbjúgna í Aðalvík 2008.*

In Faxaflói, one day surveys were conducted in May, June, August and November 2008 to assess the stock in two fishing areas Vestrahraun and Syðrahraun by the swept area method. The stock at Vestrahraun was assessed to be 1 200 t (based on 100% efficiency of dredge, biomass 0.13 kg/m² and the size of the area 9.1 km²) and at Syðrahraun 8 300 t (based on 100% efficiency of dredge, biomass 0.18 kg/m² and the size of the area 45.8 km²). The mean size of the cucumbers in June 2008 at Syðrahraun was 16.5 cm, (SD=2.0), the whole wet weight 227.6 g (SD=44.2) and the mantle weight 128,6 g (SD=25.8). At Vestrahraun, the mean size was 15.8 cm, (SD=1.4), the whole wet weight 179 g (SD=31) and the mantle weight 93 g (SD=18.5).

In August 2009, a two days survey in Faxaflói was conducted to estimate the stock and study the population structure. Until then 2 subareas had been estimated but now they were enlarged and the stock size estimate increased to 15 000 t. Swept area method was used as before and based

on 100% efficiency of the dredge. The mean size of the cucumbers at Syðrahraun was now 11,1 cm (SD=2.0), wet weight 194.5 g (SD=45.8) mantle weight 111.2 g (SD=30.3).

The closed subarea in Faxaflói (from February 2010) was investigated in May 2008, August 2009, May 2012 and July 2016. In May 2008, the average size was 16.7 cm (SD=2.1), the wet weight 297 g (SD=37.9) and the mantle weight 147 g (SD=18.6). The mean biomass was estimated 0.15 kg/m² but had decreased to 0.07 kg/m² in August 2009. In 2012, the biomass had increased to 0.14 kg/m². In July 2016 the mean size of the sea cucumber was 13.6 cm (SD=1.4), the whole wet weight 275.8 g (SD=52.5) and the mantle weight 135 g. (SD=25).



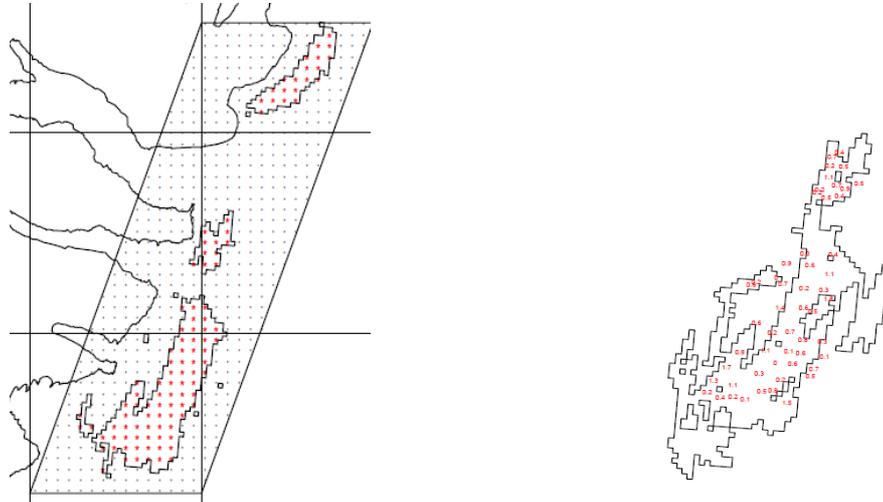
Sea Cucumber. Size distribution and correlation between wet weight and size at Syðrahraun in Faxaflói in August 2008. *Sæbjúga. Stærðardreifing og lengdar-byngdar samband á Syðrahrauni í Faxaflóa 2008.*

The population structure (size, wet weight, mantle weight) and SD of Sea Cucumber in Faxaflói.

Area	Date	Size (cm)	SD (cm)	Wet weight (g)	SD (g)	Mantle weight (g)	SD (g)
Syðrahraun	06.2008	16.5	2	227.6	44.2	128.6	25.8
Vestrahraun	06.2008	15.8	1.4	179	31	93	18.5
Syðrahraun	08.2009	11.1	2	194.5	45.8	111.2	30.3
Closed area	05.2008	16.7	2.1	297	37.9	147	18.6
Closed area	05.2016	13.6	1.4	275.8	52.5	135	25

In September 2017 a five days drop-frame camera survey was conducted to assess the stock size of sea cucumbers in the main fishing area off the east coast of Iceland. In total there were 55 stations within two (south; 43 stations, middle; 12 stations) out of the three subareas inside the main fishing area investigated. At each station photographs were taken at ten drops/locations, total of 550 photos. Later the cucumbers from the photos were counted and the density (no/m²) estimated. In the southern and the middle part of the area, the mean density of sea cucumbers was 0.6 and 0.7 individuals/m² respectively. The mean whole wet weight of sea cucumber from this area in autumn 2017 was 198 g giving a biomass of 119 and 139 g/m² respectively (mean

130 g/ m²). If this average density is used for the whole fishing area which has been estimated to be 134 km² (north part included), the total stock size is 17 400 t.



Sea Cucumber. The three subareas within the fishing ground off the east coast in 2017 are shown on the left. To the right the areas that were photographed in September 2017 are shown (southern and middle part of the fishing ground).

Sæbjúga. Til vinstri á myndinni eru Veðisvæðin þrjú innan veðisvæðis við Austurland. Til hægri eru sýnd svæðin sem mynduð voru í september 2017 (suður og miðsvæðið).

ADVICE

TAC was first recommended for sea cucumber by the Marine Research Institute (MRI) in 2009 for Faxaflói and Aðalvík. The advice was of 10% of estimated abundance in each known fishing area, that is 350 t in Aðalvík, 120 t in Faxaflói west, and 830 t in Faxaflói south; in total TAC of 1 300 t (Anon 2009). Utilization rate of 10% has been used for many invertebrate species which have similar longevity and age at reproduction as sea cucumbers. The same advice was given for the three next fishing years 2010/2011, 2011/2012, 2012/2013 (Anon 2010, 2011, 2012). In 2009 the estimated fishing stock in Faxaflói had increased to 15 000 t after a survey, leading to total advice of 1 810 t in 2010/2011 and 2011/2012 in these two areas.

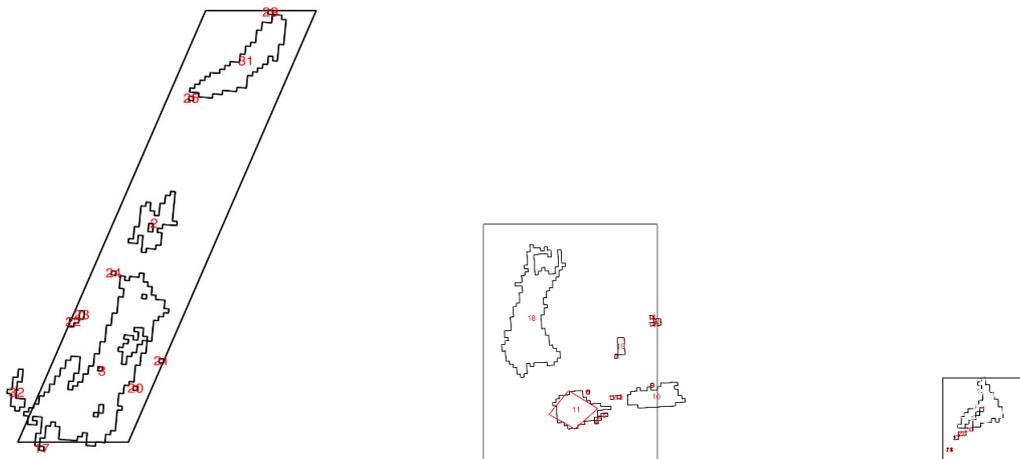
In 2012, the stock status in Faxaflói, Aðalvík and off the east coast was estimated, now based on measurement of the total fishing area based on logbooks locations multiplied with the average abundance derived from CPUE and based on 100% gear efficiency. The stock in Faxaflói was now estimated to be 10 300 t; in Aðalvík 1 700 t and off the east coast 14 000 t. Harvest ratio of 10% of stock size was recommended for the quota years 2013/2014 and 2014/2015 (Anon 2013, 2014, 2015).

As CPUE had declined in Faxaflói from 2012 and rather rapidly off the east coast since 2009, the advice was lowered and recommended that catches in the fishing year 2016/2017 should not

exceed 644 t in Faxaflói, 623 t off the east coast and 190 t in Aðalvík (Anon 2016). The basis for the advice was the mean catch of 2010-2015, for each fishing area. Because of decreasing CPUE and lack of knowledge about biology of this species, 20% reduction in the mean catch was advised.

In spring 2017, the total size of the main fishing sites within each fishing area that had been demarcated (Faxaflói, east coast, and Aðalvík) was estimated based on VMS data. VMS records were extracted from the database only for combination of vessels and dates in which there are catches registered in the logbooks. Only fishing events with landings over 1 t were included. Records close to (<2km) a harbour, and erroneous records (e.g with unrealistic positions or vessel speed) were removed. Records from each vessel were classified as fishing vs. not fishing based on vessel speed, using a k-means clustering algorithm with two groups. The group with lower speed was classified as fishing, and the group with higher speed was classified as non-fishing. To avoid false positives, a minimum and maximum fishing speed were used to classify some points from the lower speed group as "fishing". The minimum fishing speed is 1 knot and the maximum fishing speed 3.5 knots.

A grid size of 400 x 400 m was used with a minimum of 4 fishing events within each grid. In total, this method gave 32 separated patches (areas) and the whole area investigated was 207 km².



Sea Cucumber. The three fishing areas in 2016, the east coast, Faxaflói and Aðalvík. The main fishing sites within each area assessed by VMS data in 2017 are also shown.

Sæbjúga. *Veðisvæðin 2016, við Austurland, í Faxaflóa og Aðalvík. Aðalveiðislóðir innan hvers svæðis metnar með VMS gögnum 2017 eru einnig sýndar.*

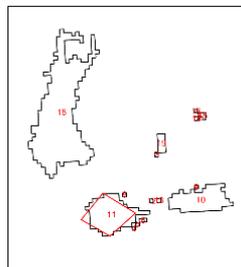
As a result, the main fishing sites off the east coast within the demarcated fishing area were estimated to be 108 km², in Faxaflói 71 km² and Aðalvík 11.2 km². The closed subarea in Faxaflói is 17 km². Based on the advice given in 2016, and the new area estimates, the advice in 2016 was 9.1 t/km² in Faxaflói, 5.8 t/km² off the east coast and 16 t/km² in Aðalvík.

The size of the fishing sites (VMS) within each fishing area, advice and catch t/ km² in 2015 and 2016.

Fishing area	Km ²	Advice '16	Catch '16	Catch '15
Faxaflói	71	9.1	13.2	6
East coast	108	5.8	18.1	7.3
Aðalvík	11.2	16	15.5	14.3

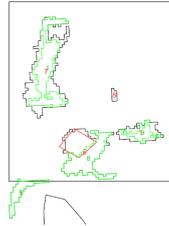
In 2017, the advice for the three areas were coordinated, based on the 2016 advice for Faxaflói (which has the longest catch history), or 9.1t/km². That yielded maximum catch of 985 t off the east coast, 644 t in Faxaflói and of 102 t in Aðalvík, for the fishing year of 2017/2018. Additionally it was advised to enlargen the size of the area in Faxaflói by moving the eastern line further east to include a fishing site on the boarder, which was assessed by VMS data. However, the advice from 2016 was not increased as this site was included in the VMS data in 2017. In the same way it is advised that the fishing area off the east coast should be enlarged to include a fishing site close to the south-western corner. Also here, this fishing site was included in the VMS data in 2017. The new coordinates for fishing areas in Faxaflói and off the east coast for the fishing year 2017/2018 were:

1. 64°06,00N-22°18,00V
2. 64°06,00N-22°49,20V
3. 64°21,00N-22°49,20V
4. 64°21,00N-22°18,00V
5. 64°06,00N-22°18,00V



Sea Cucumber. The fishing area in Faxaflói for the fishing year 2017/2018. The main fishing sites assessed by VMS data in 2017 are shown inside the fishing area and the closed subarea from 2010 (red).

Sæbjúga. *Veidisvæðið í Faxaflóa fiskveiðiaríð 2017/2018. Aðalveiðislóðir innan svæðis metnar með VMS gögnum 2017 eru einnig sýndar. Lokaða svæðið frá 2010 er merkt rautt.*

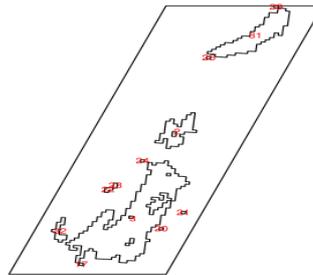


Sea Cucumber. The fishing sites in Faxaflói for the fishing year 2017/2018. The main fishing sites estimated by VMS data in 2008-2017 are shown in green. The closed subarea from 2010 is shown in red.

Sæbjúga. *Veðisvæðin í Faxaflóa fiskveiðiárið 2017/2018. Aðalveiðislóðir metnar með VMS gögnum 2008-2017 eru einnig sýndar. Lokaða svæðið frá 2010 er merkt rautt.*

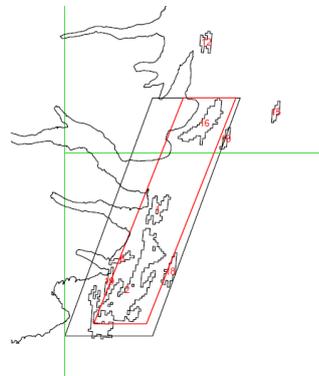
Off the east coast:

1. 65°05,40N-13°20,00V
2. 65°05,40N-13°40,00V
3. 64°42,00N-14°00,00V
4. 64°42,00N-13°40,00V
5. 65°05,40N-13°20,00V



Sea Cucumber. The fishing area off the east coast for the fishing year 2017/2018. The main fishing sites assessed by VMS data in 2017 are shown inside the fishing area.

Sæbjúga. *Veðisvæðið við austurland fiskveiðiárið 2017/2018. Aðalveiðislóðir innan svæðis metnar með VMS gögnum 2017 eru einnig sýndar.*



Sea Cucumber. The fishing areas off the east coast for the fishing year 2017/2018. The main fishing sites assessed by VMS data in 2018 are shown. The red rectangle is the defined fishing area from 2016/2017, the black one from 2017/2018

Sæbjúga. *Veðisvæði við austurland fiskveiðiaríð 2017/2018. Aðalveiðislóðir metnar með VMS gögnum 2018 eru einnig sýndar. Rauði ferningurinn er veiðisvæðið 2016/2017 og sá svarti 2017/2018.*

During the last two TAC years, total yield of all areas has surpassed the recommended TAC. This has been more pronounced off the east coast as when the total TAC is passed, it can take few days to weeks to close the fishing area. Further there has been a lot of fishing activities at the border of the areas, especially off the east coast, mainly after closure of the main defined grounds. The area enlargement that was recommend in last year's advice was further not implemented until May of 2018.

Fishing activities in 2017, increased the estimated areas size which is based on VMS data. More parsimonious method of limiting the size of the areas with at least 10 pings was adopted, with data from 2008-2017. As such the size of the areas in the east increased from 108 km² to 134 km², 69,4 to 83,3 in Faxaflói, but little changes in the small area in Aðalvík, between 2016 and 2017.

At the same time the CPUE on all areas has been decreasing rather rapidly. This has happened as there has been expansion in the fishery with increasing effort. For the fishing year 2018/2019 it is recommended to keep the same TAC of previous year and further increase the size of the defined areas to encompass the "boarder" fishing activities. If the negative trend in CPUE continuous, decrease in recommended TAC is inevitable.

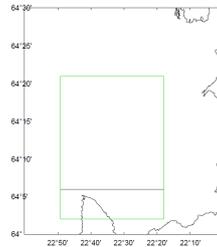
As such, it is advised that the size of the area in Faxaflói to be enlarged by moving the southern line to include a fishing site on the boarder and to reopen the closed area from 2010 (17 km²). In the same way it is advised that the fishing area off the east coast to be enlarged by moving all lines to include fishing sites north, east and south of the defined fishing area. The fishing area off the east coast is now divided into two parts (the northern part and the southern part) and advice given for each part separately. The size of the fishing area in Aðalvík is also enlarged by moving the northern line.

MFRI advises that when the precautionary approach is applied, catches in the fishing year 2018/2019 should not exceed 1 731 tonnes in the enlarged demarcated fishing areas; 644 tonnes in Faxaflói, 985 tonnes off the east coast which has now been divided into northern (245 t) and southern part (740 t), and 102 tonnes in Aðalvík.

MFRI also recommends a change in the demarcation of all fishing areas defined, based on the distribution of fishing in recent years. The new coordinates for the fishing areas (Faxaflói, off the east coast, Aðalvík) and a map of each area for the fishing year 2018/2019 follows.

Faxaflói 2018/2019:

1. 64°02,00N-22°18,00V
2. 64°02,00N-22°49,20V
3. 64°21,00N-22°49,20V
4. 64°21,00N-22°18,00V
5. 64°02,00N-22°18,00V



Sea Cucumber. The enlarged fishing area in Faxaflói for the fishing year 2018/2019 (green). The area has been enlarged to south (old line black).

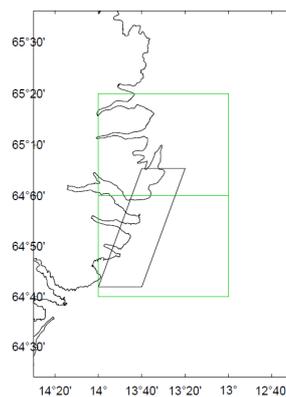
Sæbjúga. *Veðisvæðið í Faxaflóa fiskveiðiaríð 2018/2019 (grænt). Svæðið er stækkað í suður frá fiskveiðiarinu 2017/2018.*

Off the east coast north 2018/2019:

1. 65°00,00N-13°00,00V
2. 65°00,00N -14°00,00V
3. 65°20,00N -14°00,00V
4. 65°20,00N -13°00,00V
5. 65°00,00N -13°00,00V

Off the east coast south 2018/2019:

1. 64°40,00N-13°00,00V
2. 64°40,00N -14°00,00V
3. 65°00,00N-14°00,00V
4. 65°00,00N -13°00,00V
5. 64°40,00N -13°00,00V

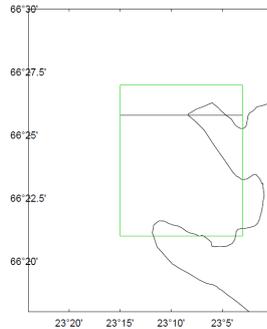


Sea Cucumber. The enlarged fishing area off the east coast for the fishing year 2018/2019 (green). The fishing area was enlarged in all directions. The fishing year 2017/2018 is shown inside (black).

Sæbjúga. *Veðisvæðið við austurland fiskveiðiaríð 2018/2019 (grænt). Veðisvæðið er stækkað í allar áttir. Veðisvæði 2017/2018 er sýnt innan svæðis (svart).*

Aðalvík 2018/2019:

1. 66°21,00V-23°03,00V
2. 66°21,00V-23°15,00V
3. 66°27,00V-23°15,00V
4. 66°27,00V-23°03,00V
5. 66°21,00V-23°03,00V



Sea Cucumber. The enlarged fishing area in Aðalvík for the fishing year 2018/2019 (green). The area has been enlarged to north (old line black).

Sæbjúga. *Veiðisvæðið í Aðalvík fiskveiðiárið 2018/2019 (grænt). Svæðið er stækkað í norður frá fiskveiðiarinu 2017/2018.*

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