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 around 800 t. Since then, landings have increased and in 2009 three fishing zones were demarcated by the Ministry: 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 limited fishing trials did not give positive results. In 2013, the Ministry abolished the area restriction.

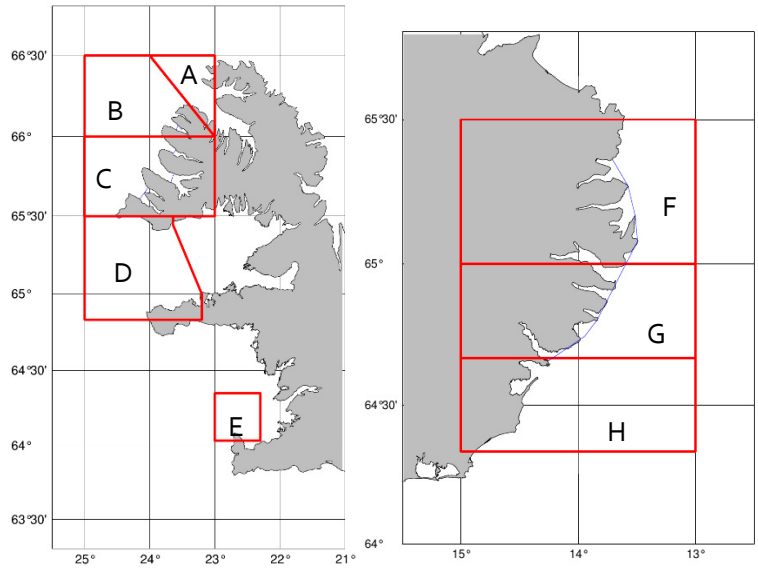
Initially, the main fishing areas were in Faxaflói and Aðalvík in the Western area, and since 2009 also off the East coast belonging to the Southern and eastern area. In 2013, the main fishing areas were defined by coordinates (Regulation 795/2013).

In 2009, the stock status in Faxaflói and Aðalvík were estimated, the fishing areas defined, and TAC advice issued for the first time. In February 2010, a small subarea (17 km^2) within Faxaflói was closed because of overfishing (Regulation 110/2010). In the MFRI advice of 2018, it was recommended to reopen the area (Anon, 2018).

In 2012, the stock status off the east coast was estimated, which resulted in advice for demarcated area during the fishing year 2013/2014. Total TAC was given for the eastern are even tough it was divided into two areas, until 2018/2019 when the TAC was divided (F and G). When the maximum allowable catch had been reached within an area, the area was closed with a regulation issued by the Ministry, but further fishing could be continued outside the defined areas.

No fishing is permitted in May and June in the old Western area (A-E) and in June and July in other areas due to spawning of sea cucumber.

In a letter from 20 February 2019, the Ministry of Industries and Innovation requested an advice on fishing opportunities for sea cucumber by increasing number of sea cucumber management areas built on fishing ventures outside the previously managed areas (A, E, F, G). The new areas were granted and the management areas are now eight (A-H) (Anon, 2019). The demarcated fishing grounds from 2019 are shown on the map below and the coordinates given (Regulation draft and Anon, 2019).



Sea cucumber. Fishing grounds (A-H) according to regulation draft from February 2019.

Sæbjúga. *Skipting veiðisvæða skv. reglugerðardrögum í febrúar 2019.*

Coordinates for the demarcated fishing areas from 2019:

A. Westfjords North – Aðalvík area:

1. 66°00,00N – 23°00,00V
2. 66°30,00N – 24°00,00V
3. 66°30,00N – 23°00,00V
4. 66°00,00N – 23°00,00V

B. Westfjords mid area:

1. 66°00,00N – 23°00,00V
2. 66°00,00N – 25°00,00V
3. 66°30,00N – 25°00,00V
4. 66°30,00N – 24°00,00V
5. 66°00,00N – 23°00,00V

Closure within Önundarfjörður:

1. 66°04,35 N – 23°33,96 V
2. 66°02,53 N – 23°35,47 V

C. Westfjords south area:

1. 65°30,00N – 23°00,00V
2. 65°30,00N – 25°00,00V
3. 66°00,00N – 25°00,00V
4. 66°00,00N – 23°00,00V
5. 65°30,00N – 23°00,00V

Closure within Dýrafjörður:

1. 65°55,00N – 23°35,86 V
2. 65°53,76 N – 23°38,18 V

Closure within Arnarfjörður:

1. 65°46,17N – 23°37,81V
2. 65°42,76N – 23°40,62V

Closure within Tálknafjörður and Patreksfjörður:

1. 65°40,72N – 24°01,73V
2. 65°38,85N – 24°04,81V
3. 65°36,46N – 24°09,60V

D. Outer Breiðafjörður:

1. 64°50,00N – 23°12,00V
2. 64°50,00N – 25°00,00V
3. 65°30,00N – 25°00,00V
4. 65°30,00N – 23°38,45V
5. 65°26,85N – 23°38,75V
6. 65°00,00N – 23°12,00V
7. 64°50,00N – 23°12,00V

E. Faxaflói:

1. 64°02,00N – 22°18,00V
2. 64°02,00N – 23°00,00V
3. 64°21,00N – 23°00,00V
4. 64°21,00N – 22°18,00V
5. 64°02,00N – 22°18,00V

F. East Iceland north area:

1. 65°00,00N – 13°00,00V
2. 65°00,00N – 15°00,00V
3. 65°30,00N – 15°00,00V
4. 65°30,00N – 13°00,00V
5. 65°00,00N – 13°00,00V

Closure within the Eastfjords:

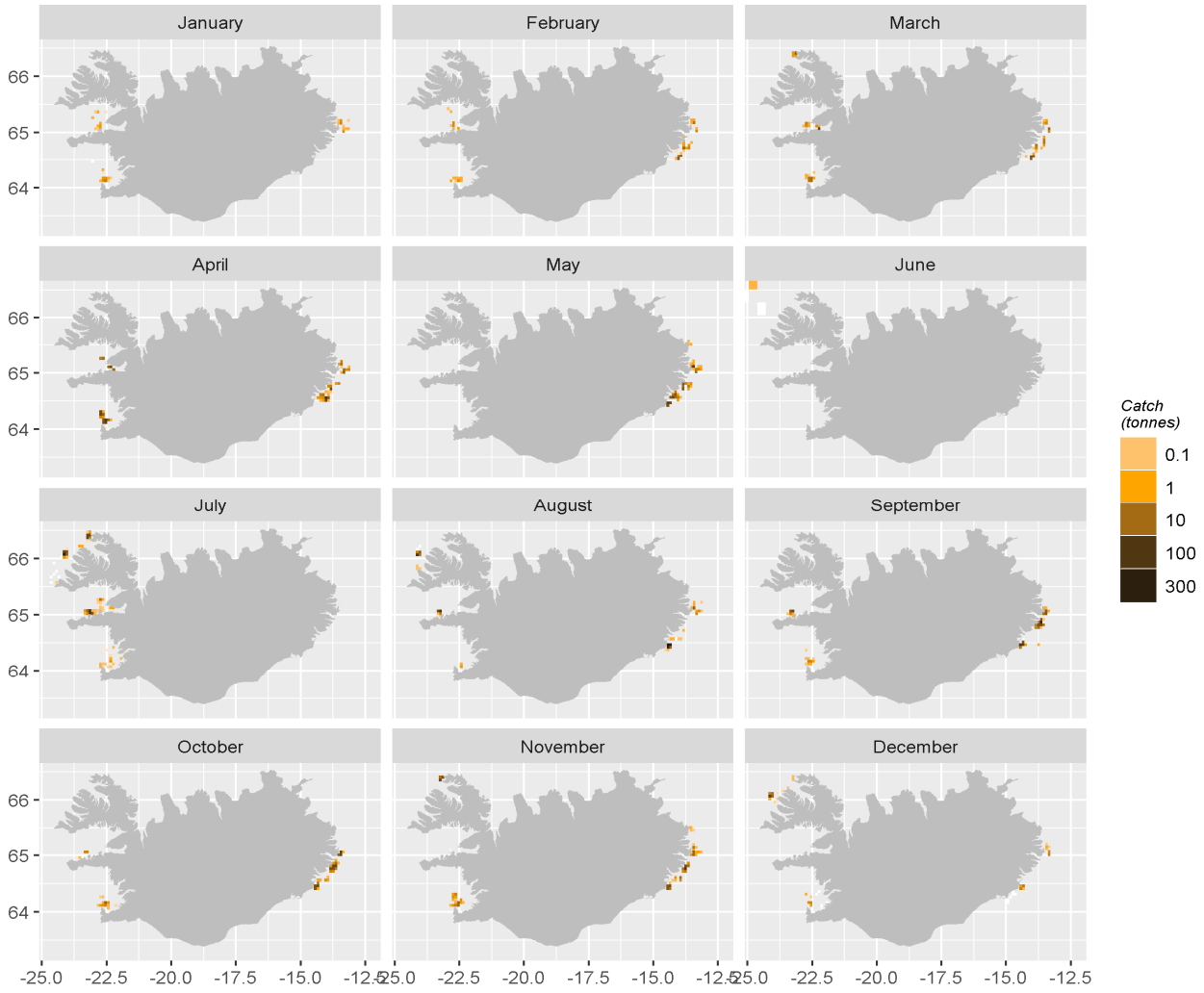
1. 65°21,82N – 13°42,57V
2. 65°16,25N – 13°34,47V
3. 65°10,00N – 13°30,80V
4. 65°04,70N – 13°29,60V
5. 64°48,10N – 13°50,30V
6. 64°44,61N – 13°56,74V
7. 64°39,44N – 14°15,21V

G. East Iceland mid area:

1. 64°40,00N – 13°00,00V
2. 64°40,00N – 15°00,00V
3. 65°00,00N – 15°00,00V
4. 65°00,00N – 13°00,00V
5. 64°40,00N – 13°00,00V

H. East Iceland south area:

1. 64°20,00N – 13°00,00V
2. 64°20,00N – 15°00,00V
3. 64°40,00N – 15°00,00V
4. 64°40,00N – 13°00,00V
5. 64°20,00N – 13°00,00V



Sea cucumber. Distribution of fishing by months in 2018.

Sæbjúga. *Veiðisvæði eftir mánuðum árið 2018.*

Through the years 2008-2018, annual catches have fluctuated, mostly because of different effort in each defined fishing area, as well as in outside areas. The annual catch in Faxaflói (E) has ranged from 448-1135 t, off the east coast (F+G) from 136-2103 t and 0–559 t in Aðalvík (A). There has been an increase in the catches (inside and outside demarcated fishing areas) for the past three years, with a maximum of 5985 t in 2018; almost twofold increase from the previous year.

In 2018, 341 t were landed from Aðalvík (A), 627 t on a new fishing ground in area B, 292 t from outer Breiðafjörður area (D) and 496 from the inner part of Breiðafjörður (Dcl.), an area closed due to overlap with Iceland scallop (*Chlamys islandica*) and green sea urchin (*Strongylocentrotus droebachiensis*) fishing grounds, during late 2018. From Faxaflói (E) 525 t were landed in 2018,

534 t from the northerly eastern fishing area (F), 975 t from the middle eastern area and 2195 t from a newly discovered fishing ground on the new demarcated southeastern area H.

Sea cucumber. Annual landings by areas (A-H and closed area Dcl., within area D) and total landings during 2008-2018, based on logbooks and scaled with annual landings.

Sæbjúga. *Afli eftir árum á veiðisvæðum sæbjúgna (A-H og á lokuðu svæði inn af svæði D, Dcl.) og heildarafli hvers árs. Aflinn er reiknaður út frá afladagbókum, stöðluðum út frá heildarafla hvers árs.*

Year	A	B	C	D	Dcl.	E	F	G	H	Total
2008	2	210	0	8	0	832	0	0	0	1052
2009	559	25	0	0	0	448	136	0	0	1168
2010	167	0,5	27	0	54	1135	286	577	0	2246,5
2011	0	0	0	0	0	910	231	1514	0	2655
2012	0	0	0	0	0	753	39	622	0	1414
2013	0	0	0	0	285	493	10	636	0	1424
2014	0	0	0	0	2	687	22	137	0,6	848,6
2015	163	0	0	0	0	435	15	797	0	1410
2016	176	9	15	0	0	989	316	1760	0	3265
2017	242	0,7	0,3	0	70	805	408	1695	1,4	3222,4
2018	341	627	0,4	292	496	525	534	975	2195	5985,4

There has been an overall declining trend in catch per unit effort (CPUE) through the history of the sea cucumber fisheries. As such, the CPUE has been declining from 2012 in Faxaflói (E) from 1100 kg/h to 371 kg/hour in 2018. Off the east coast (F+G) there has also been a decline in CPUE during recent years from over 1000 kg/h during 2010-2013, to below 500 kg/h during the past two years. The fisheries have been more periodic in Aðalvík (A), but during past two year the CPUE has been 428 kg/h, considerably lower than during the years 2015 and 2016.

Sea cucumber. CPUE by areas (A-H and closed area Dcl., within area D) and CPUE for all areas, during 2008-2018.

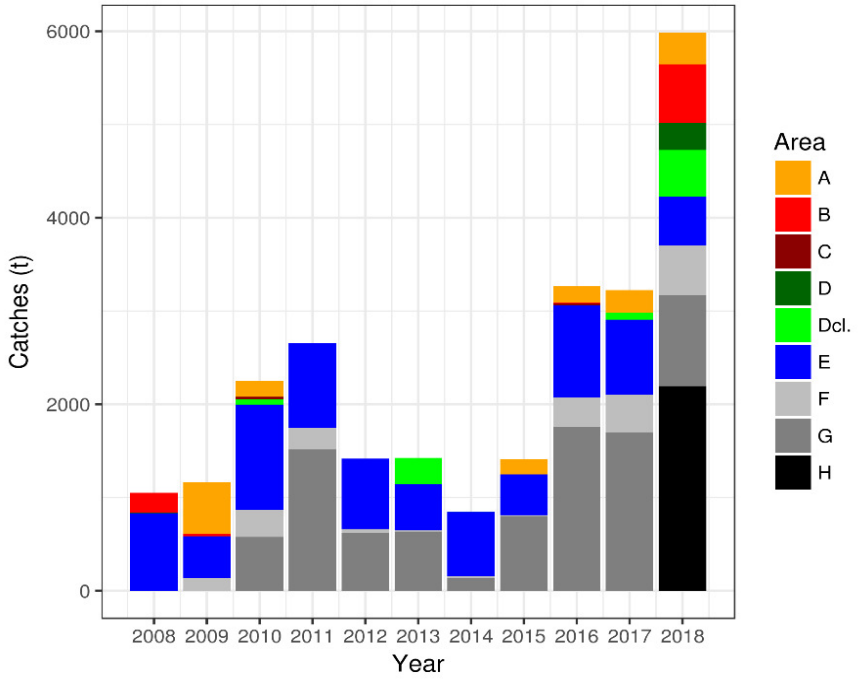
Sæbjúga. *Afli á sóknareiningu eftir veiðisvæðum sæbjúgna og heildar, árin 2008-2018.*

Year	A	B	C	D	Dcl.	E	F	G	H	All
2008		1190		1323		618				688
2009	1041	882				712	1713			916
2010	941	334	300		660	904	1090	1071		932
2011						808	1237	1362		1084
2012						1100	1309	1182		1124
2013					757	825	522	871		819
2014					235	669	906	729	159	658
2015	667					861	362	628		676
2016	993	284	295			569	574	914		727
2017	428	181	91		227	386	407	410	162	395
2018	428	757	47	916	732	371	382	479	682	540

Catch per unit effort (CPUE) was higher on the newly established fishing grounds in 2018. As such it was 757 kg/h in area B, 916 kg/h in area D and 682 kg/h on area H. As expected, the initial CPUE was higher during the first month of fishing on virgin grounds during the summer of 2018, but in many of those new grounds the fishing pressure has been really high and has most likely reduced the abundance of sea cucumbers (Anon, 2019).

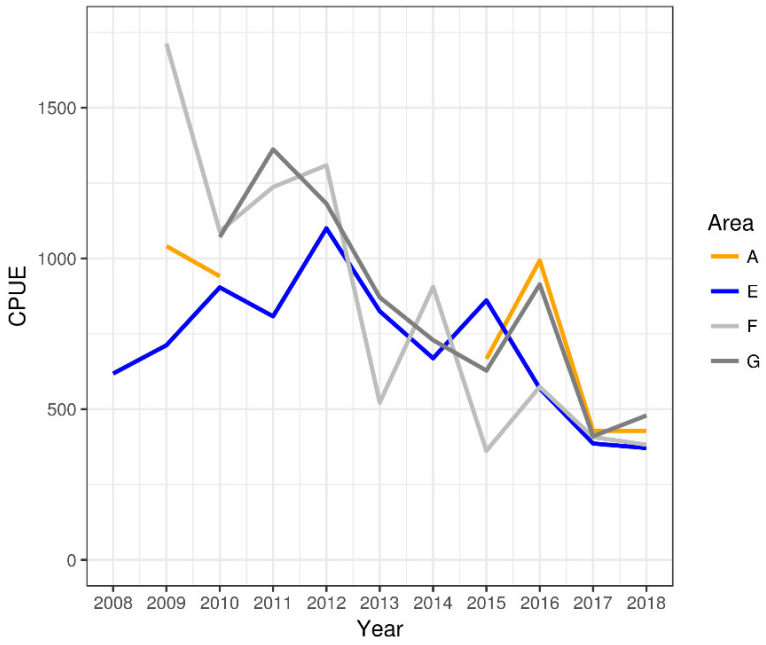
There is an annual variation in CPUE where catches are higher in spring and summer mostly depending on weather conditions. During recent two – three years, the fishing has been conducted more or less throughout the year. During worse autumn/winter weather, the catchability is lower which could contribute partly to the observed low CPUE. There has also been changes in the fleet composition, with larger boats entering the fisheries, which can operate in worse weather conditions.

Sea cucumber are fished by a dredge, 250 cm in width and with minimum mesh size of 100 mm. There is a lack of registration if one or two dredges have been used, but in recent years most of the boats have operated with two dredges (the effort of those boats was raised by the factor of 1.8).



Sea cucumber. Total catch by area during 2008-2018.

Sæbjúga. *Afli eftir svæðum árin 2018-2018.*



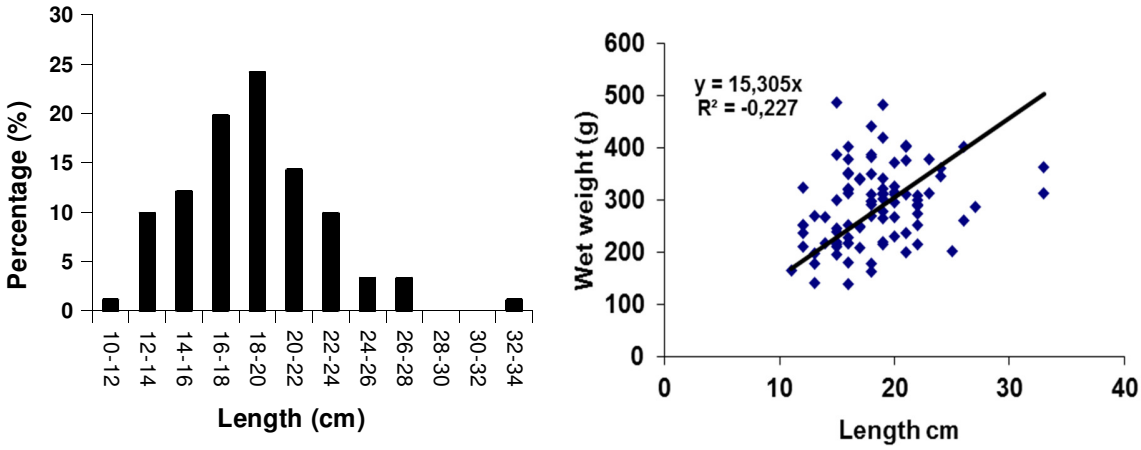
Sea cucumber. CPUE by area during 2008-2018.

Sæbjúga. *Afli á sóknareiningu eftir svæðum árin 2018-2018.*

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/m^2.

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 km^2. The density (ind./m^2) was calculated by dividing the mean wet weight of the individuals in an area into the abundance (kg/m^2) 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/m^2) 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.

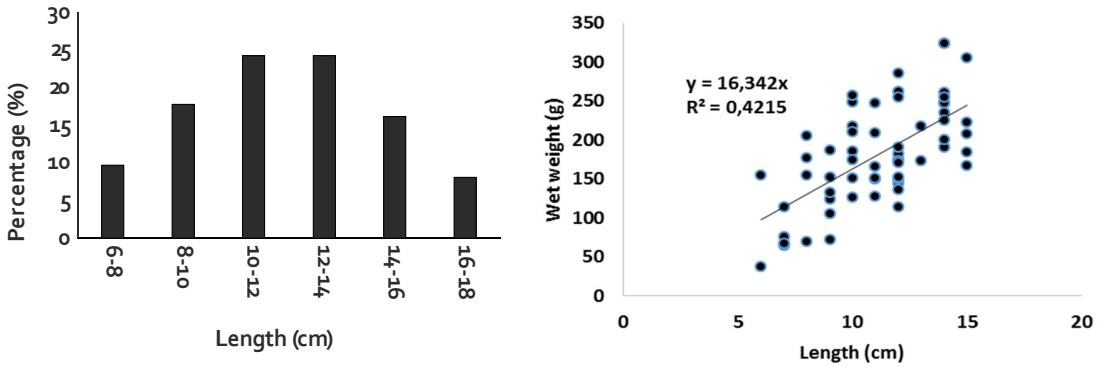


Sea cucumber. Size distribution and correlation between wet weight and size in Aðalvík 2008.
Sæbjúga. *Stærðardreifing og lengdar-þyngdar samband í Aðalvík 2008.*

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 are method. The stock at Vestrahraun was assessed to be 1 200 t (based on 100% efficiency of dredge, biomass 0.13 kg/m^{2}and the size of the area 9.1 km^2) and at Syðrahraun 8 300 t (based on 100% efficiency of dredge, biomass 0.18 kg/m^{2}and the size of the area 45.8 km^2). 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, two subareas had been estimated but now they were enlarged and merged into one area and the total 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/m^2 but had decreased to 0.07 kg/m^2 in August 2009. In 2012, the biomass had increased to 0.14 kg/m^2. 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).

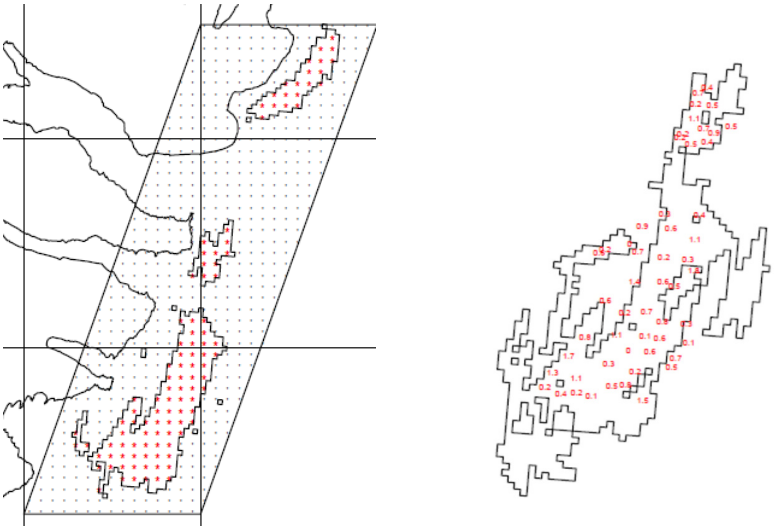


Sea cucumber. Size distribution and correlation between wet weight and size at Syðrahraun, Faxaflói in August 2008.
Sæbjúga. *Stærðardreifing og lengdar-þyngdar samband á Syðrahrauni í Faxaflóa 2008.*

Sea cucumber. Population structure (size, wet weight, mantle weight, with SD) in Faxaflói.
Sæbjúga. *Stærð og þyngd sæbjúgna í Faxaflóa.*

Area	Date	Size (cm)	SD	Wet weight (g)	SD	Mantle weight (g)	SD
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/m^2) estimated. In the southern and the middle part of the area, the mean density of sea cucumbers was 0.6 and 0.7 individuals/m^2 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/m^2, respectively (mean 130 g/m^2). If this average density is used for the whole fishing area which has been estimated to be 134 km^2 (north part included), the total stock size is 17400 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 veiðisvæðin þrjú innan veiðisvæðis 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 areas in Aðalvík (area A) and Faxaflói (area E). The initial advice in Aðalvík was 350 t and 950 t in Faxaflói and was based on 10% of estimated abundance from dredge surveys in each area (Anon, 2009). In 2009 the estimated fishing stock in Faxaflói had increased to 15 000 t after a survey, which resulted in advice of 1500 t in Faxaflói and 350 t in Aðalvík for 2010/2011. The same advice was given for the two next fishing seasons: 2011/2012 and 2012/2013 (Anon; 2010, 2011, 2012). 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 and 1700 t in Aðalvík. In 2012 advice was also given for areas east of Iceland (areas F & G) as the fishing had increased considerable there and in similar manner the stock off the east coast was estimated to be 14 000 t. Harvest ratio of 10% of stock size was recommended for the quota years 2013/2014 and 2014/2015, or 170 t in Aðalvík, 1030 t in Faxaflói and 1400 t off the east coast (Anon; 2013, 2014, 2015).

For the quota year 2016/2017 the TAC was lowered in Faxaflói and off the east coast. The TAC was never met in Faxaflói (highest catch was 1135 t in 2010), and from 2012 the CPUE had declined. Off the east coast the CPUE had declined rather rapidly since 2011. Due to these facts and lack of knowledge about biology of the species 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 average catch of the years 2010-2015 for each fishing area, lowered by a precautionary 20% rule, based on ICES guidelines (Anon, 2016).

Further, in 2017 the size of the fishable area was estimated with VMS data. The main fishing sites off the east coast within the demarcated fishing area were estimated to be 108 km^2, in Faxaflói 71 km^2 and Aðalvík 11.2 km^2. Given the advice in 2016 and the new area estimates, the advice in 2016 was 9.1 t/km^2 in Faxaflói, 5.8 t/km^2 off the east coast and 16 t/km^2 in Aðalvík. In 2017, the advice for the three areas were coordinated, based on the 2016 advice for Faxaflói (which had the longest catch history), or 9.1t/km^2. That yielded maximum catch of 985 t off the east coast (F+G), 644 t in Faxaflói and of 102 t in Aðalvík, for the fishing year of 2017/2018 (Anon, 2017). The same advice was given for the fishing year of 2018/2019 although the estimated sizes of the areas based on more parsimonious estimate had increased as the negative trend in CPUE continued (Anon, 2018).

During the last two fishing years, total yield of all demarcated areas, except Faxaflói, has greatly surpassed the recommended TAC. This has been more pronounced off the east coast. As the fishery is operated it can take few days to weeks for to close the fishing area, when the total TAC has been reached. 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 defined grounds. The area enlargement that was recommend in in 2017 (Anon, 2017) was further not implemented until May of 2018. Likewise, the proposed enlargement of the eastern grounds (F & H) in 2018 was not implemented until May of 2019, but limited fishing activity was at boarder of the old defined ground during the current fishing year.

Despite higher yield than advised and more fishing activity during winter months on areas A (Aðalvík), F (north east) and G (middle east) the CPUE has stayed similar between 2017 and 2018. In area E (Faxaflói) there has been slight decline in CPUE between 2017 and 2018, despite that the landings have been close to the advice and most of the fishing activity occurred in late winter (April). For the fishing year 2019/2020 it is recommended to keep the same TAC of previous year in areas A, F and G. Further, following a precautionary approach it is recommended to lower the recommended TAC by 20 % in area E. Further it is recommended to keep the same initial advice for areas B, C, D and H as was issued in March of 2019 for the fishing year of 2018/2019 (Anon, 2019). Those areas have now been closed for the remaining of the current fishing season, but landings were higher than advised.

MFRI advices that when the precautionary approach is applied, catches in the fishing year 2019/2020 should not exceed 2245 t; Area: A (Aðalvík) 102 t, B (Westfjords north) 131 t , C (Westfjords south) 50 t, D (outer Breiðafjörður) 56 t, E (Faxaflói) 515 t, F (north east) 245 t, G (middle east) 740 t and H (south east) 406 t.

Stock assessment surveys at the demarcated fishing grounds are necessary in the near future to get more knowledge about size of stock and fishing areas.

Sea cucumber. Recommended TAC, national TAC, and landings 2007/2008-2019/2020. Landings are based on logbooks and scaled with total annual landings. The areas are the newly demarcated areas and are larger than all older defined areas apart from area E (Faxaflói).

Sæbjúga. *Ráðlagður hámarksafli og afli fiskveiðiárin 2007/2008-2019/2020. Landaður afli er byggður á aflaskýrslum skalað með heildarafla. Skiptingin er samkvæmt svæðum sem skilgreind eru í þessari skýrslu og eru þau stærri en eldri svæði fyrir utan svæði E (Faxaflói).*

	Area A (Aðalvík)			**Area B (Westfjord; north)**			**Area C (Westfjord; south)**			**Area D (Breiðafjörður; out)**			**Area E (Faxaflói)**		
Quota year	**R.TAC**	**TAC**	**Landings**	**R.TAC**	**TAC**	**Landings**	**R.TAC**	**TAC**	**Landings**	**R.TAC**	**TAC**	**Landings**	**R.TAC**	**TAC**	**Landings**
2007/2008			2			107						8			478
2008/2009	350		469			124						0	950	*	477
2009/2010	350		173			3						0	950	*	1066
2010/2011	310	*	85			0,5			27			0	1500	*	900
2011/2012	310	*	0			0			0			0	1500	*	1015
2012/2013	310	*	0			0			0			0	1500	*	349
2013/2014	170	*	0			0			0			0	1030	*	814
2014/2015	170	*	160			0			0			0	1000	*	446
2015/2016	170	*	169			9			15			0	1000	*	981
2016/2017	190	*	244			0			0			0	644	*	684
2017/2018	102	*	248			523			0,7			198	644	*	700
2018/2019	102	*											644	*	
2019/2020	102			131			50			56			515		

	Area F+G (East)			**Area F (East; north)**			**Area G (East; middle)**			**Area H (East; south)**		
2007/2008			0									
2008/2009			0									
2009/2010			572			414			159			
2010/2011			1880			229			1651			
2011/2012			791			39			752			
2012/2013			807			19			787			
2013/2014	1400	*	72		*	7		*	65			
2014/2015	1400	*	600		*	4		*	596			
2015/2016	1400	*	1740		*	115		*	1625			
2016/2017	623	*	1738		*	415		*	1323			0,2
2017/2018			1482	245	*	481	740	*	1001			1710
2018/2019				245	*		740	*				
2019/2020				245			740			406		

**Areas are closed by regulation issued by the Ministry when the TAC is reached.*

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