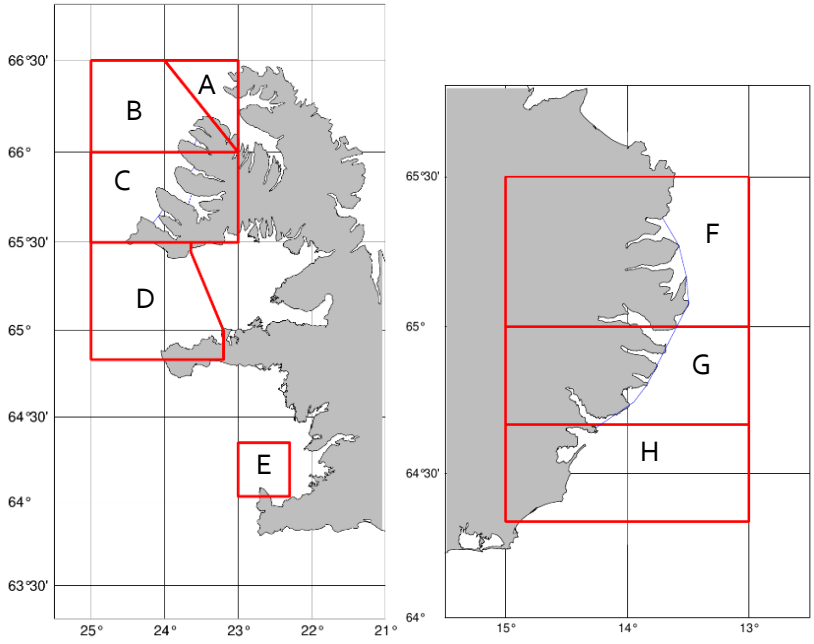
SEA CUCUMBER
Cucumaria frondosa

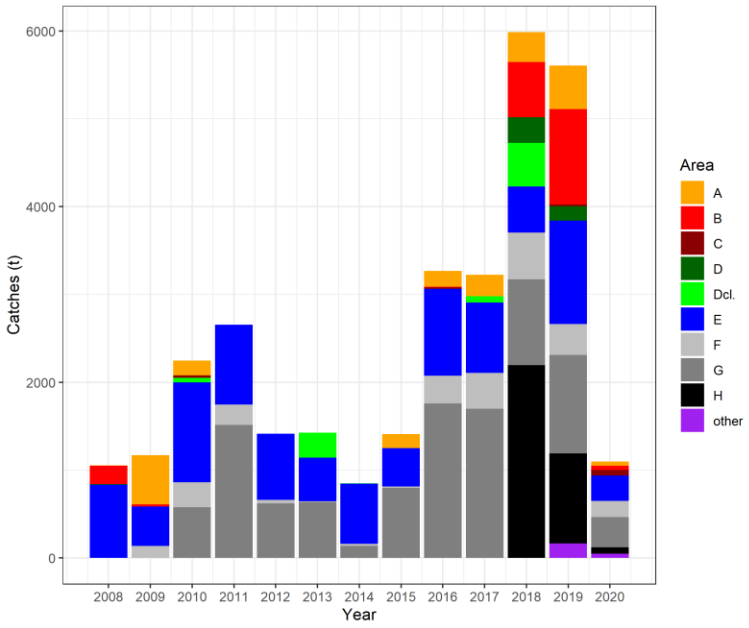
COMMERCIAL FISHING

An experimental fishery for sea cucumber started in Breiðafjörður in 2003, but little was landed until 2008 when fisheries started in Faxaflói (area E) with catch of around 800 t.

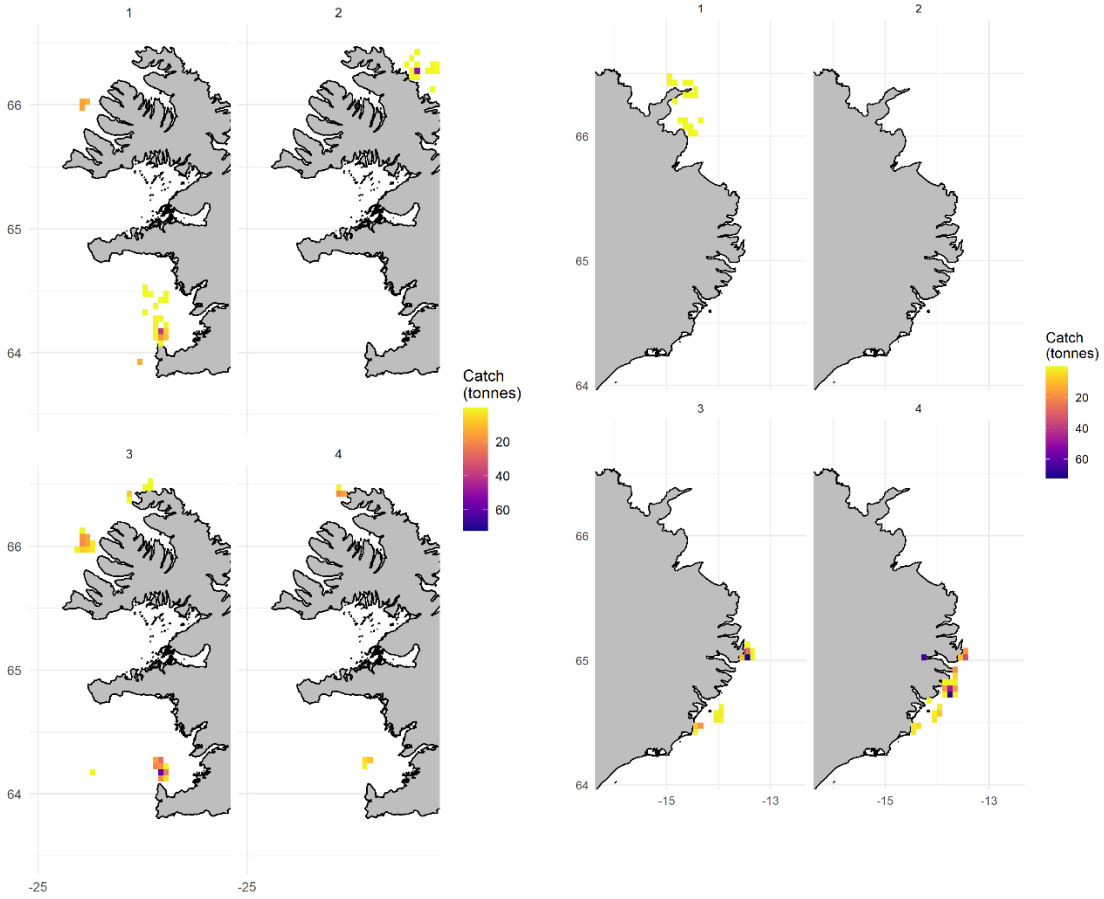


Sea cucumber. Fishing grounds (A-H) according to regulation from August 2019.

Through the years 2008-2020, annual catches of sea cucumber have fluctuated. The annual catch in Faxaflói (E) has ranged from 286-1175 t, off the east coast (areas F & G) from 136-2103 t and 0-559 t in Aðalvík (A). There was an increase in the catches during 2016 – 2019, but a considerable drop in catches in 2020. Maximum landings were 5985 t in 2018; almost twofold increase from 2017, but catches declined to 5606 t in 2019 and to1098 t in 2020. The low landings in 2020 can partly be explained by the fact that TAC of the 2019/20 fishing year was almost fully reached during the autumn of 2019 and slower start of the autumn fishery in 2020. According to the stakeholders, the slow start was because of mutual agreement to even out the fishing effort over the full fishing year of 2020/21. Difficult markets due to the COVID-19 pandemic could also explain the decreased effort.



Sea cucumber. Total catch by area during 2008-2020.



Sea cucumber. Distribution of fishing by quarters (1=Jan-Mar, 2=Apr-Jun, 3=Jul-Sep, 4=Oct-Dec) 2020.

Sea cucumber. Annual landings by areas (A-H and closed area Dcl., within area D) and total landings during 2008-2020, based on logbooks and scaled with annual landings.

Year	A	B	C	D	Dcl.	E	F	G	H	Other	Total
2008	2	210	0	8	0	832	0	0	0	0	1052
2009	559	25	0	0	0	448	136	0	0	0	1168
2010	167	0,5	27	0	54	1135	286	577	0	0	2247
2011	0	0	0	0	0	910	231	1514	0	0	2655
2012	0	0	0	0	0	753	39	622	0	0	1414
2013	0	0	0	0	285	493	10	636	0	0	1424
2014	0	0	0	0	2	687	22	137	0,6	0	848,6
2015	163	0	0	0	0	435	15	797	0	0	1410
2016	176	9	15	0	0	989	316	1760	0	0	3265
2017	242	0,7	0,3	0	70	805	408	1695	1,4	0	3222
2018	341	627	0,4	292	496	525	534	975	2195	0	5985
2019	496	1083	23	164	0	1175	354	1121	1024	165	5606
2020	50	46	66	0	0	286	99	345	73	49	1098

In 2020, 50 t were landed from Aðalvík (A), 46 t from area B, 66 t from area C, but nothing was landed from area D. From Faxaflói (E), 286 t were landed in 2020, 99 t from the north area in the Eastfjords (F), 345 t from the middle area in the Eastfjords (G), and 73 t from the south area in the Eastfjords (H).

In August of 2019, new regulation for the sea cucumber fishery was implemented. Fishing was only allowed on the eight demarcated areas (A-H) and experimental license was mandatory for fishing activity outside of those. Within the experimental framework, fishing took place in February 2020 north and west of area E, but with limited success. Experimental fishing was conducted in northwestern Húnaflói (east of area A), with 49 tonnes caught in the second quarter of 2020. Experimental license was also issued in north of area A (Guðrún G. Þórarinsdóttir *et al.*, 2020) and Langanes in northeast Iceland in first quarter of 2020, with limited success and no landings.

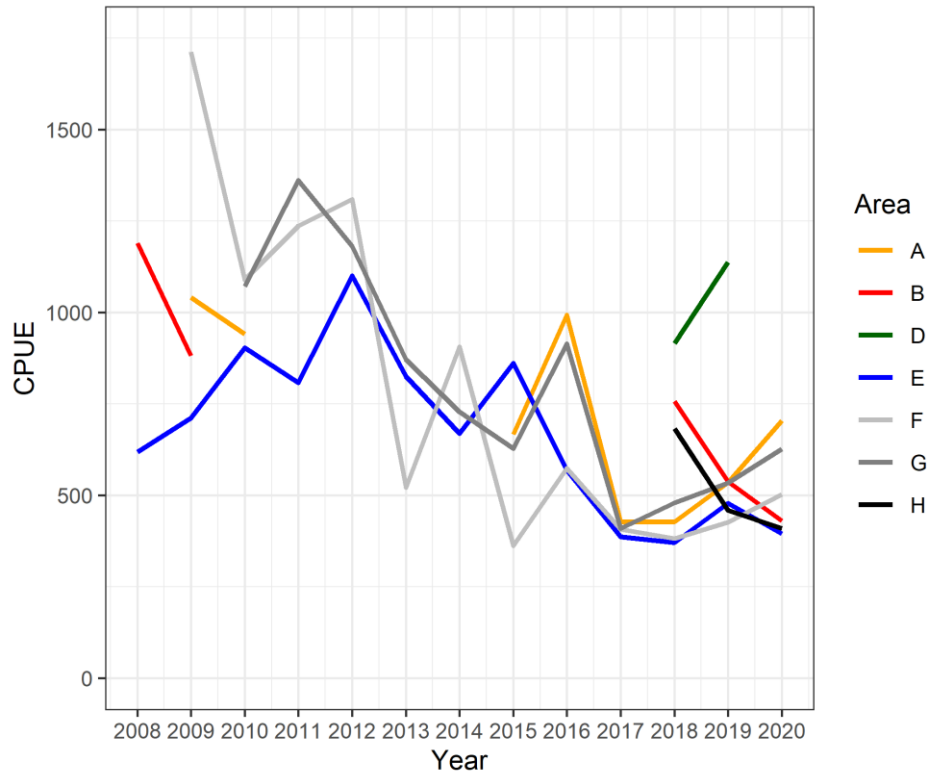
No fishing is permitted in May and June in the western areas (A-E) and in June and July in other areas due to spawning of sea cucumber. Sea cucumber are fished by a dredge, 250 cm in width and with minimum mesh size of 80 mm. There is a lack of registration if one or two dredges have been used, but in recent years most of the boats have operated with two dredges (the effort of those boats was raised by the factor of 1.8).

There has been an overall declining trend in the raw catch per unit effort (CPUE) through the history of the sea cucumber fisheries. CPUE has been declining from 2012 in Faxaflói (E) from 1100 kg/h to 395 kg/hour in 2020. Off the east coast (areas F & G) there has also been a decline in CPUE during recent years from over 1000 kg/h during 2010-2013, to around 500-600 kg/h during the past two years. The fisheries have been more periodic in Aðalvík (A), where raw CPUE increased in 2019-2020 but is still considerably lower than during the years 2015 and 2016.

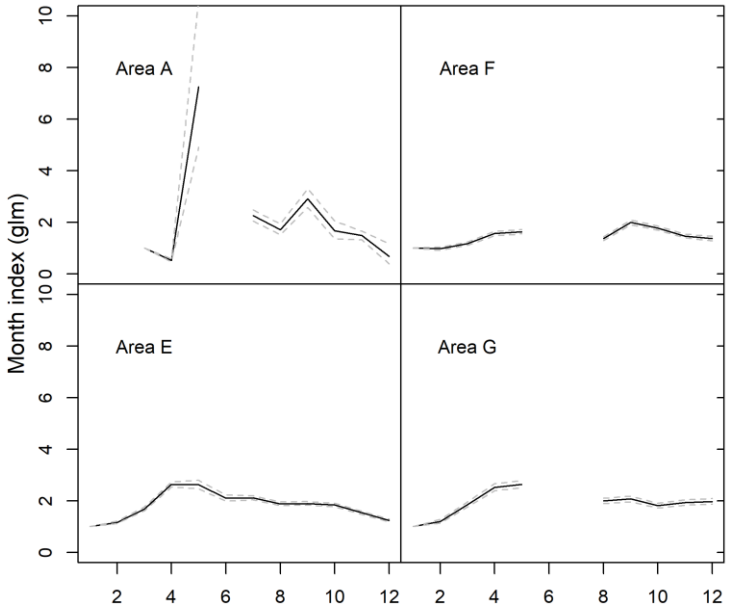
CPUE has been declining on the newly established fishing ground B and H, reaching similar levels as other areas. It decreased from 757 to 430 kg/h in area B and in area H, CPUE has decreased from 682 kg/h in 2018 to 409 kg/h in 2020. Nothing was fished in area D in 2020, but CPUE was around 1000 kg/hour in 2018-2019

Sea cucumber. Raw CPUE by areas (A-H and closed area Dcl., within area D) and CPUE for all areas, during 2008-2020.

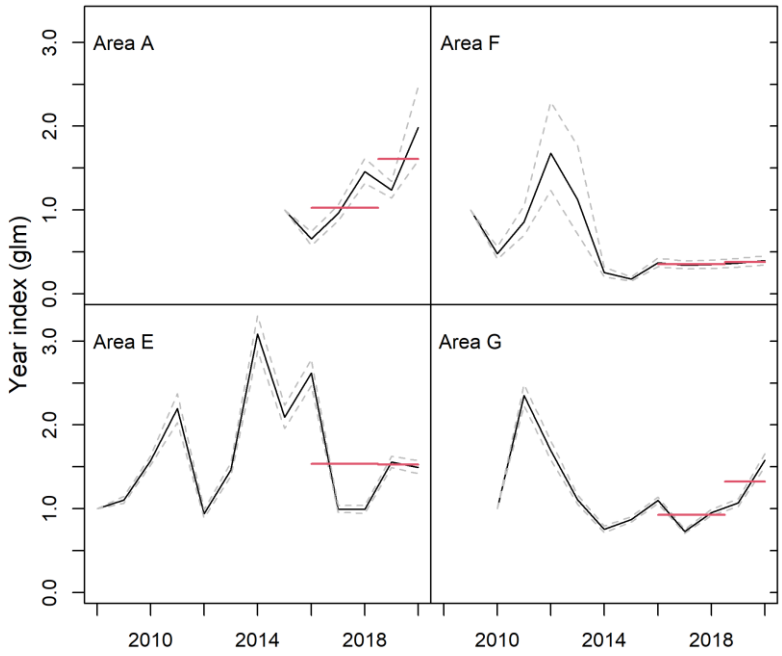
Year	A	B	C	D	Dcl.	E	F	G	H	All
2008		1190		1323		618				688
2009	1041	882				712	1713			916
2010	941	334	300		660	904	1090	1071		932
2011						808	1237	1362		1084
2012						1100	1309	1182		1124
2013					757	825	522	871		819
2014					235	669	906	729	159	658
2015	667					861	362	628		676
2016	993	284	295			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
2019	535	537	388	1138		478	426	534	459	494
2020	704	430	380			395	502	627	409	452



Sea cucumber. CPUE by area during 2008-2020.



Sea cucumber. Month index in glm model in areas A, F, E and G.



Sea cucumber. Year index in glm model in areas A, F, E and G. The horizontal red lines are the average of the latest 1:2 and 3:5 years used as an index.

There is an interannual variation in CPUE as catches are usually higher in spring and summer, mostly depending on weather conditions. During recent years, 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 have also been changes in the fleet composition, with larger boats entering the fisheries, which can operate in worse weather conditions. In order to reduce the bias in the raw CPUE index, the trends in CPUE were

standardized in areas with long enough catch history (areas A, E, F and G), using a generalized linear model (*glm*):

$$\log(\text{catch}) = \text{towtime} + \text{year} + \text{month} + \text{ship}$$

The results of the models indicated that on average the catches are lower during winter months (December – March). The recent trend of the year effect in the model, fluctuated in similar manner as the raw CPUE index. In area A, the *glm* year index of last two recent years was higher than the previous three years. The recent years index is similar in Faxaflói (area E), but there is an increase in the eastern area G and little changes in the eastern area F.

Sea cucumber. Anova output of glm model in area A, Aðalvík.

Source	Rs df.	Rs Dev.	F	*P*
Null	1901	1835		
Towtime	1900	1576	453	<0.001
Year	1895	1484	33	<0.001
Month	1887	1255	50	<0.001
Ship	1882	1071	65	<0.001

Sea cucumber. Anova output of glm model in area E, Faxaflói.

Source	Rs df.	Rs Dev.	F	*P*
Null	9590	8781		
Towtime	9589	4654	11274	<0.001
Year	9577	4179	108	<0.001
Month	9566	3780	99	<0.001
Ship	9554	3497	64	<0.001

Sea cucumber. Anova output of glm model in area F, Eastfjords north area.

Source	Rs df.	Rs Dev.	F	*P*
Null	4369	2918		
Towtime	4368	2048	2784	<0.001
Year	4357	1910	40	<0.001
Month	4348	1677	82	<0.001
Ship	4338	1355	103	<0.001

Sea cucumber. Output of glm model in area G, Eastfjords middle area.

Source	Rs df.	Rs Dev.	F	*P*
Null	10096	7642		
Towtime	10095	4217	10966	<0.001
Year	10085	3692	168	<0.001
Month	10076	3382	110	<0.001
Ship	10067	3144	85	<0.001

SURVEYS

Older surveys

From 2008 to 2010 few surveys were carried out on commercial fishing boats in Aðalvík (A) and Faxaflói (E). Based on 100% gear efficiency biomass was estimated to be 0.3 kg/m^2 in Aðalvík (A) in 2008. In Faxaflói (E) during 2008, biomass was estimated to be 0.13 kg/m^2 at Vestrahraun and 0.18 kg/m^2 at Syðrahraun sub-locations.

In September 2017, a five days drop-frame camera survey was conducted to assess the stock size of sea cucumbers in area G off the east coast of Iceland. In total there were 55 stations investigated on two grounds in southern part of the area. At each station photographs were taken at ten drops/locations, total of 550 photos. The density of sea cucumbers on those grounds were 0.6 and 0.7 individuals/m^2, respectively. The mean whole wet weight (from fish processing) of sea cucumber from this area during the autumn of 2017 was 198 g, that yields a biomass of 0.119 and 0.139 kg/m^2, respectively (mean 0.13 kg/m^2).

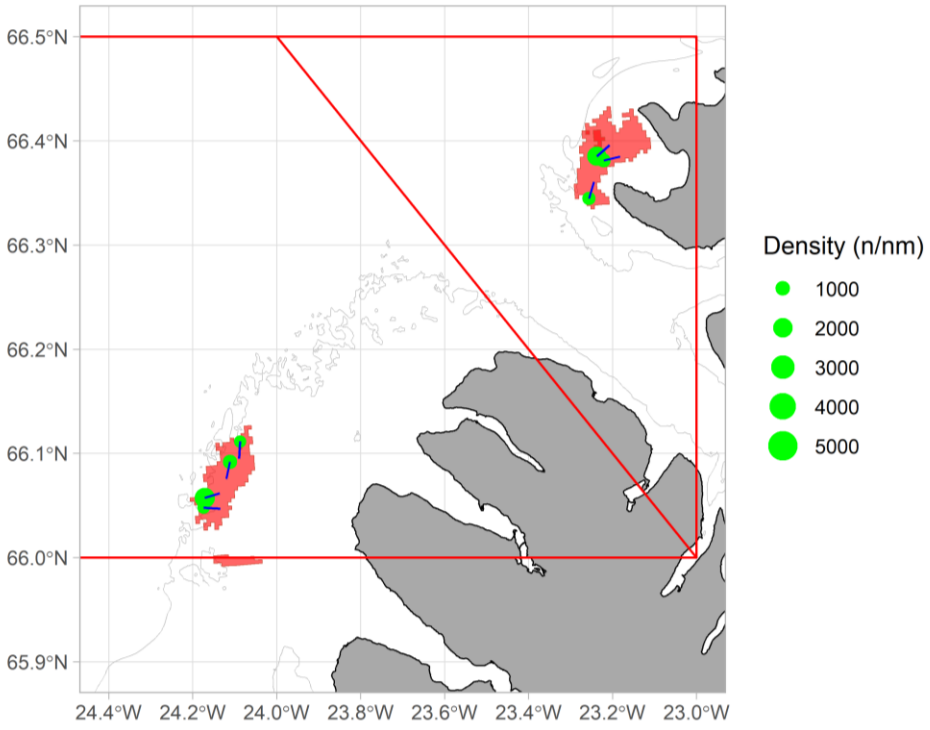
2020 survey

Sea cucumber areas A, B, E, F, G and H were surveyed during the groundfish beam trawl survey during the autumn of 2020. The gear used was a 4 m wide beam trawl, lined with a 40 mm mesh size in the cod end. The beam trawl was towed between 0.5 to 1.2 nautical miles at each station (μ = 0.89) at speed of 4 nm/h. Start position of each tow and towing direction were randomly generated. Overlapping tows and tows that ended outside known fishing areas based on VMS data were excluded.

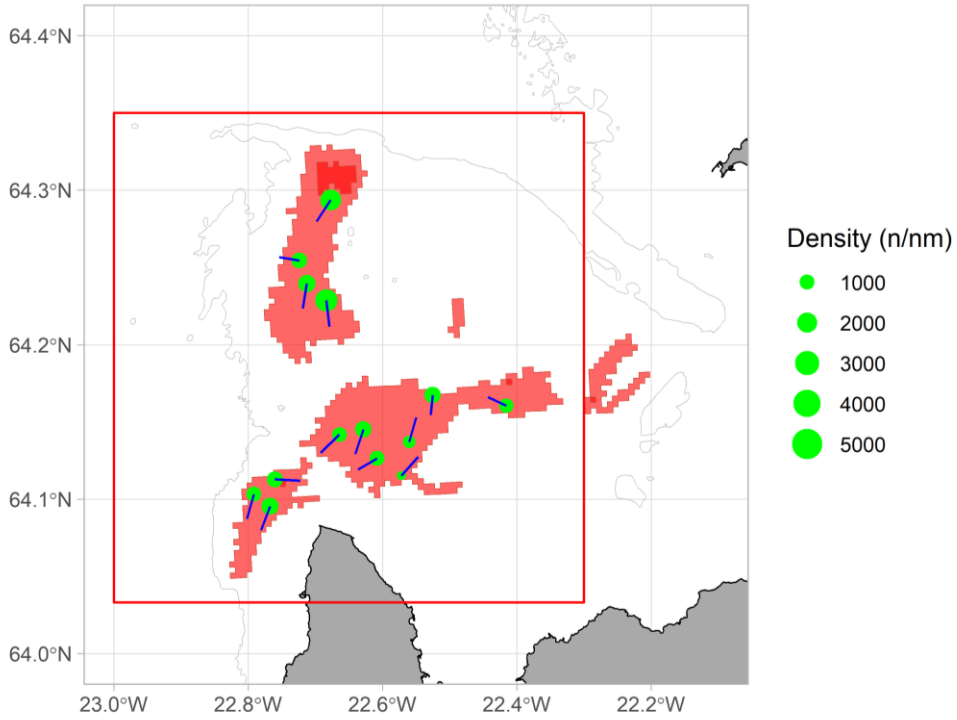
Average density of sea cucumber varied from 906 individuals per towed mile in area H to 1713 in area G. The average catch of drained sea cucumber per towed mile varied from 229 kg/nm in area H to 489 kg/nm in area G.

Sea cucumber. Summary of the 2020 beam trawl survey. Number of tows in each area, average number of sea cucumber per towed nautical mile with standard error, average catch of drained sea cucumbers with standard error, average drained weight (g), average weight (gr), average length (cm) and the average circumference or girth (cm).

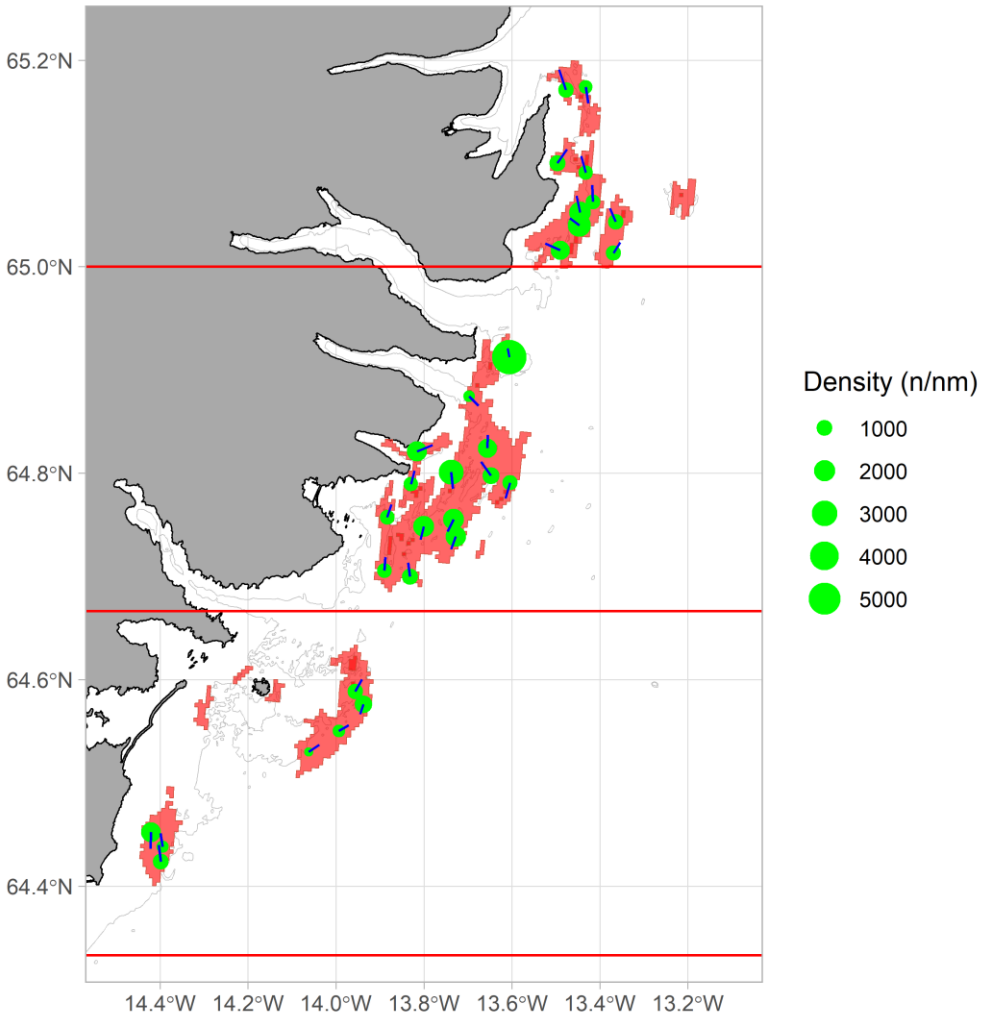
Area	N. tows	N. per nm (se)	A. d.catch (se)	D. weight	Weight	Length	Circumference
A	3	1229 (368)	391 (86)	334	443	12.6	24.8
B	4	1130 (355)	334 (97)	299	366	12.0	22.5
E	14	1225 (152)	259 (24)	226	289	11.8	20.3
F	10	1225 (185)	350 (47)	290	654	14.7	28.1
G	14	1713 (361)	489 (95)	290	665	14.1	28.4
H	7	906 (189)	229 (43)	256	597	14.0	27.1



Sea cucumber. Density (n/nm) in the 2020 beam trawl survey in areas A (top right) and B (lower left). Blue lines are tows, red lines define the fishing areas and red polygons represent fishing grounds based on VMS.

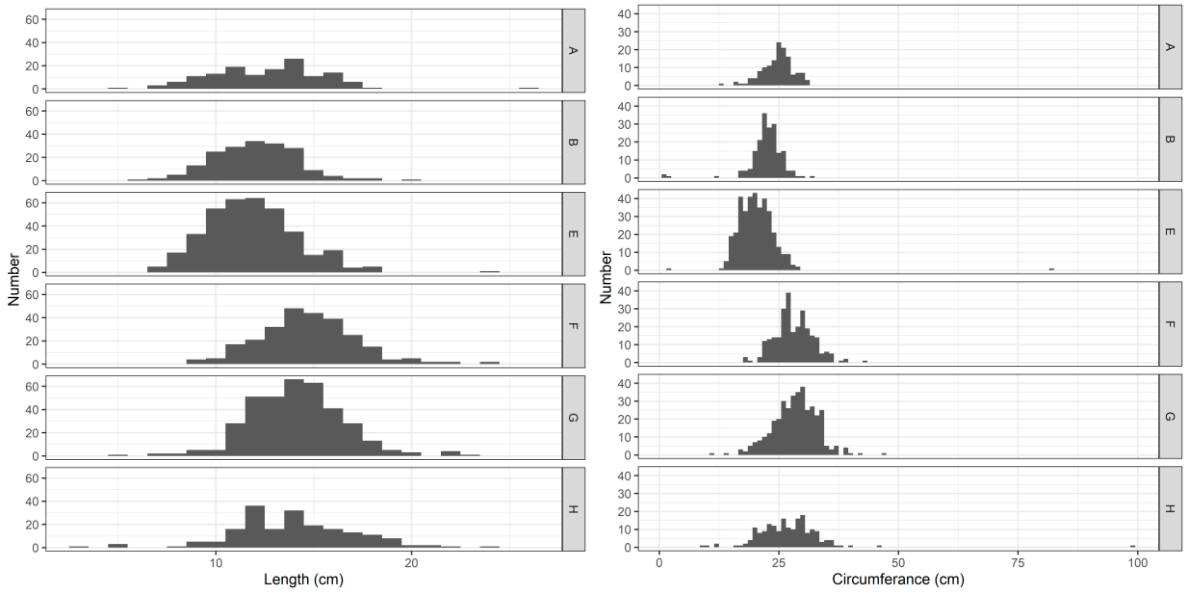


Sea cucumber. Density (n/nm) in the 2020 beam trawl survey in area E. Blue lines are tows, red lines define the fishing areas and red polygons represent fishing grounds based on VMS.

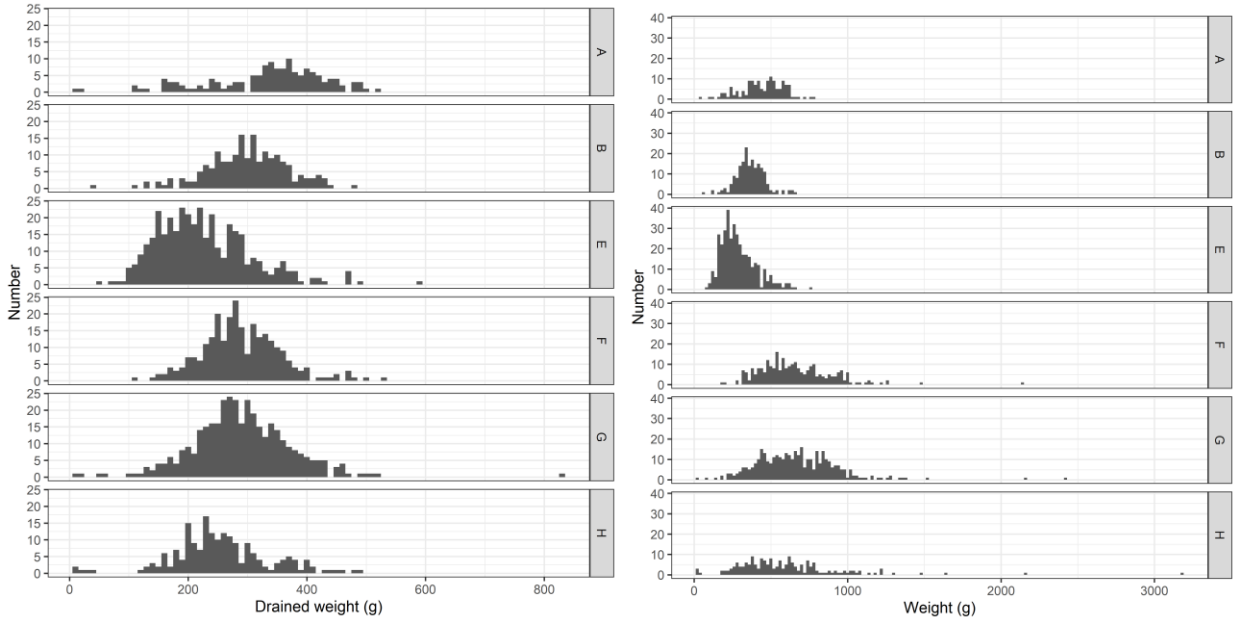


Sea cucumber. Density (n/nm) in the 2020 beam trawl survey in area F (top), G (middle) and H (lowest). Blue lines are tows, red lines define the fishing areas and red polygons represent fishing grounds based on VMS.

The average drained weight was highest in area A in the Westfjords 334 gr, but the lowest average weight was in Faxaflói (area E) 226 gr. The average undrained weight was higher in eastern Icelandic waters (Areas F – H), compared to the areas in western Iceland (areas A, B & E). The average circumference and length were also larger in the east and in general the cucumbers had thinner walls and were full of water.



Sea cucumber. Length (left) and circumference (girth) distributions (right) in the 2020 beam trawl survey in areas A, B, E-H.



Sea cucumber. Drained weight distribution (left) and weight distribution (right) in the 2020 beam trawl survey in areas A, B, E-H.

MANAGEMENT

The Ministry of Industries and Innovation is responsible for management of the Icelandic fisheries and implementation of legislation. The sea cucumber stocks have not been included in the ITQ system, but when the issued TAC has been reached the area are closed with a regulation issued by the Ministry.

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. 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 total allowable catch (TAC) advice issued for the first time. 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 (area F and G). When the maximum allowable catch had been reached within an area, the area was closed, but further fishing could be continued outside the defined areas.

In a letter in 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 (mostly adjacent) areas were granted, and the management areas are now eight (A-H) (Anon, 2019).

The sea cucumber stocks in Icelandic waters are considered to be a data limited stocks and the catch advice follows the ICES framework for such stocks (category 3.2) i.e. the advice is based on the ratio of the mean of the last two modelled CPUEs indices (Index A) and the mean of the three preceding values (Index B), multiplied by the previously recommended TAC (ICES, 2012). That method is applicable for areas A, E, F and G where catch history and logbooks time series stretch more than 5 years. If the index ratio is estimated to be above 1.2 or below 0.8 an uncertainty cap is applied (applied for area A and G this year). Catch advice for each area is given in the advice sheets but a summary table for previous years is found below.

Sea cucumber. Recommended TAC, national TAC, and landings 2007/2008-2020/2021 by areas.

	Area A (Aðalvík)			Area B (Westfjord; middle)			Area C (Westfjord; south)			Area D (Breiðafjörður, outer)			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			469			124						0		*	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			1			198	644	*	700
2018/2019	102	*	321			860			23			207	644	*	833
2019/2020	102	*	276	131	*	324	50		51	56		52	515	*	539
2020/2021	122	*		131	*		50			56			330	*	
	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	*	345	740	*	781			1089			
2019/2020				245	*	240	740	*	1091	406	*	392			
2020/2021				280	*		828	*		406					

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

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Guðrún G. Þórarinsdóttir, Steinunn Hilma Ólafsdóttir og Jónas P. Jónasson, 2020. Könnun á útbreiðslu brimbúts (*Cucumaria frondosa*) norðvestur af Hornströndum. Haf- og vatnarannsóknir. HV 2020–50, 1–20.