

SEA FISHERIES INSTITUTE IN GDYNIA
Gdynia, Poland

**Report on the Polish fishing survey of Greenland halibut
(*Reinhardtius hippoglossoides*) in the Svalbard Protection Zone
(ICES IIb) in October 2006**

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1. INTRODUCTION	3
2. MATERIALS AND METHODS	3
3. VESSEL AND GEAR SPECIFICATIONS	5
<u>3. 1. Vessel characteristics</u>	5
<u>3. 2. Description of gear</u>	5
4. RESULTS	6
<u>4. 1. Species composition of catches</u>	6
<u>4. 2. Catch rates</u>	6
<u>4. 3. Biological characteristics of Greenland halibut</u>	7
<u>4. 5. Density, abundance, and biomass of Greenland halibut in the survey area</u>	8
<u>4. 6. Other information</u>	8
TABLES.....	9
FIGURES	14
ANNEXES 1-3.....	21

1. Introduction

The Polish bottom trawl survey of Greenland halibut (*Reinhardtius hippoglossoides*) was conducted during October 2006 on the west slope of Bear Island in the Svalbard Protection Zone (ICES IIb). The investigations were carried out according to the Polish permit application that was granted by the Directorate of Fisheries in Bergen, Norway. The Polish operating authority was the Sea Fisheries Institute in Gdynia (MIR) in cooperation with the North Atlantic Producers Organization Ltd. (PAOP sp. z o. o.),

The main objectives of the survey were:

- to determine the biological structure of Greenland halibut (*Reinhardtius hippoglossoides*) their distribution, density, and standing biomass at the slope of Bear Island and the Svalbard area;
- to determine the species composition of catches;
- to determine the incidental mortality of birds and mammals.

2. Materials and Methods

The surveys took place from 12 to 26 October 2006 and were conducted at a depth range of 500 to 1000 meters on the west slope of Bear Island and Svalbard covering the area between the latitudes of 73° 30'N and 76° 30'N (ICES IIb). The fishing vessel POLONUS (Fig. 1) was engaged in the survey. The bottom trawl used during the surveys. A research team comprised of two MIR scientists collected fisheries and biological data aboard the vessel. Samples were taken at two depth strata – shallower 500-699 meters and deeper 700-1000 meters. The depth strata were divided into parallel sections of 10 nautical miles which created squares limited by the depth strata. The surface was divided into a total of 36 designated squares (Fig. 2). The surface of each square was calculated with the ArcGIS program. Calculations were made for each square separately between isobaths obtained from data from the International Bathymetric Chart of the Arctic Ocean (IBCAO) and the SRTM30_Plus model (The Shuttle Radar Topography Mission).

Fifty-seven hauls were performed over the course of 15 effective fishing days; one of these hauls failed. At least one haul was carried out in each square. The positions of the hauls are presented in Figure 3. Generally, the duration of hauls was limited to a towing distance of 4 nm, but some hauls took longer. The mean speed of the vessel during trawling was 3.4 knots.

The fishing data recorded for each haul included the following: date, time and position of the start and end of the tow, duration of the tow, depth, vessel speed, catch. Each haul was sorted by species to determine the species composition of the catches. The bycatch species were separated from the Greenland halibut and then weighed, counted, and recorded giving the species composition of catches by number and weight.

Samples of Greenland halibut, which was the target species, were collected for length measurements and biological analysis. The fish for length measurement (total length) were collected randomly from the conveyer and measured by rounding down to the nearest centimeter. In total, 16,908 specimens of Greenland halibut were measured, and 301 fish were taken for biological analysis. Each analysis included data concerning length, weight (to the nearest 10 g), sex, gonad maturation, and stomach fullness. Otoliths were collected for later age determination. The sex proportion was determined based on the analysis of 439 specimens, while gonad maturity was based on 301 halibut specimens. The gonad maturity stages were determined according to a 6-grade scale: immature (I), early maturing-A (II), maturing-B (III), late maturing-C (IV), spawning (V) and resting (VI). (Ridget, F., J. Boje. 1989. Fishery and some biological aspects of Greenland halibut (*Reinhardtius hippoglossoides*) in West Greenland waters. NAFO Sci. Coun. Studies 13: 41-52.).

Observations of tagged Greenland halibut and the incidental mortality of birds and mammals were also performed.

To determine the distribution of Greenland halibut in the survey area, the CPUE was calculated for each square. Catches from each haul were standardized to one hour of trawling and to one square kilometer of trawling surface according to the following formulae:

$$1. CPUE = \frac{W}{t}$$

$$2. CPUE = \frac{W}{D \times p}$$

Where:

CPUE – catch per unit effort (1- kg/h and 2 - kg/km²);

W – weight of catch (kg);

t – duration of trawl (hours);

D – towing distance (km);

p – horizontal opening of the net (km)

The area swept by trawl was defined as the distance between the wings multiplied by the towed distance. It was assumed that the catchability coefficient for Greenland halibut is equal to 1; therefore, the total effect of escapement of fish is equal 0. The mean catch rates (t/hr) and density (t/km²) were calculated for each square.

The “swept area” method was also used to determine the biomass of Greenland halibut in the depth strata and in the total survey area according to the formula:

$$B = \frac{CPUE \times A}{q}$$

B - biomass (tons)

CPUE - catch per unit effort (t/km²)

A – area of survey (km²);

q – catchability coefficient

3. Vessel and gear specifications

3. 1. Vessel characteristics

Name: **POLONUS GDY-36**

Nationality: **POLISH**

Registration port and number **GDYNIA, GDY-36**

Overall length: (in meters) **60.33**

Maximum draught: (in meters) **7.00**

GRT:**1805**

Net tonnage: **563**

Propulsion e.g. diesel/steam: **DIESEL**

Call sign: **SNHE**

3. 2. Description of gear

Bottom trawl type – BACALO 630

Float rope : 70.2 m

Ground rope : 39.8m

Vertical opening of trawl : 5m

Average net opening between wings: 14.0m

NET:

Bag of coral 30 m with 140 mm mesh size

Codend of nylon with 40 mm mesh size

GROUND GEAR :

Central section 39.8 m : with 21" rubber discs

DOORS:

Type of doors : INJECTOR 9.5 m²

Weight of doors : 4000 Kg.

FLOATS :

Number of floats - 210

Float diameter - 250 mm

LEGS : 60/75m

BRIDLES : 140m

The diagram of net used in the fishing survey is presented in Figure 4

4. Results

4. 1. Species composition of catches

A total 199.8 tons of fish were caught during the fishing survey. Greenland halibut dominated the catches by weight and contributed nearly 99.7% of the total catch (Table 1). Bycatch was only 629 kg and consisted of 14 fish species. All 14 species with a weight of 443 kg were noted in the shallower depth strata (500-699m) and 11 species with a weight of 186 kg were noted in the deeper depth strata (700-1000m). Roughhead grenadier dominated the bycatch with a weight of 173 kg and was caught in the shallower depth strata only. Blue whiting and redfish were the next in weight (104 and 82 kg, respectively) and the shares of them were higher in the shallower waters. The species composition of catches by depth strata in number and weight of specimens is presented in Table 2.

No sea birds or mammals were noted in the net during the cruise.

4. 2. Catch rates

A total of 36 squares were designated in the trawl survey area in the two depth strata between the latitudes of 73° 30'N and 76° 30'N. The total surface of the survey area was calculated to be 5424 square km of which 3346 square km belonged to the deeper strata and 2078 to the shallower depth strata. The average catch rate of Greenland halibut in the total survey area was 2.02 t/hr and was nearly similar in both depth strata. However, there were significant differences in catch rates among the squares. Higher differences were observed in the southern part of the survey area. The maximum catch rate occurred in the northern part of the area in square d-12 where the value exceeded 4.5 t/hr and in s-14 at nearly 3.8t/hr. The lowest CPUE was observed in the southern part of the area in square d-01 at only 57kg/hr. Table 3

presents the catch of Greenland halibut and catch rates in kg per trawling hour calculated for each square.

4. 3. Biological characteristics of Greenland halibut

Length measurements were collected from 16,908 halibut specimens. The length of the halibut sampled ranged from 30cm to 99cm TL. The length compositions according to the two depth strata are presented in Figure 5. The length distribution was slightly different between the depths. In shallower waters to 700m the dominant fish measured between 44-55cm (mean 50.8cm) in length, while in the deeper waters the fish had smaller lengths of 40-52cm (mean 48.0cm).

It was also noted that the halibut length distribution depended on the water temperature at the towing depth. This was indicated by the share of larger fishes (older) increasing in catches made at higher (over 3° C) water temperatures (Fig. 6).

The otoliths collected from 301 Greenland halibut specimens during biological analysis were used for age determination. Whole otoliths were read in water under a microscope with reflected light. The age composition of catches was calculated from an age-length key and is presented in Figure 7. Since Greenland halibut otoliths are difficult to interpret, thin section analysis will be performed at a later date.

The sex ratio was calculated from the examination of 439 specimens. Males dominated the catches and comprised over 73% of the sampled fish. The proportion of the sexes in the catches differed with halibut length. In younger fish (up to 35 cm) the proportion males and females was equal. As length increased the share of males increased, and a higher share of males was noted in fish measuring 46-50cm, while the frequency of males in length classes 56-60cm decreased and was equal with that of the females. Females dominated among the largest fish. The sex ratio of halibut at length classes is presented in Figure 8.

Maturity stage data were collected for 301 halibut specimens. The unweighted maturity composition for all halibut sampled showed that 51% of males and 55% of females were in maturing (III) condition. Only 3% of males and 5% of females were actively spawning (Table 4).

Weight was recorded for 301 halibut specimens. The halibut attained weights ranging from 221g to 8560g. The mean weight of the sampled males was 996g while that of females was 2709g. The weight of fish at length classes is presented in Table 5. The observed mean body weight to length relationship for the sexes combined

was estimated directly from data when more than five halibut were weighed. The mean weight at length was estimated as: $W(g) = 0.0024 * TL (cm)^{3.3257}$ and is presented in Figure 9.

The examination of halibut stomachs indicated that that feeding was very weak. More than 84% of the fish had empty stomachs (Table 6). While no detailed examinations of food composition were conducted, undigested fish and shrimp dominated in the stomachs of the halibut examined.

4. 5. Density, abundance, and biomass of Greenland halibut in the survey area

The density of Greenland halibut in kg/km² for each square and depth strata was estimated with the swept area method. The results presented in Figure 10 show that halibut was distributed throughout the survey area but that density was patchy. Relative and stable high density of fish was observed mainly in the northern part of the survey area. The mean density was 23.12 t/km² and was quite similar in the shallower and deeper depth strata at 22.97 and 23.34 t/km², respectively.

The average catch rates shown in Table 3 were used to estimate the abundance of halibut using the swept area method. The total abundance of Greenland halibut in the survey area was calculated at 230,229 fish, 61% (142,059 fish) of which inhabited the deeper depth strata (700-1000m).

The total standing stock of halibut in the survey area calculated as the sum of biomass in each square was estimated to be 116.5 thousand tons. About 64% of fish was found in the deeper depth strata (700-1000m).

4. 6. Other information

Three tagged specimens of Greenland halibut were caught during the survey. Unfortunately, two of them were headed before the tags were noted, so it was difficult to obtain a full biological description of these two fish. A protocol was prepared for each of the tagged fish, and all the available fishery and biological data were included. The three tags and the otoliths from the Greenland halibut were attached to the protocols, which are included in Annexes 1-3.

TABLES

Table 1. Catch by species in the Polish bottom trawl survey in ICES IIb Area in 2006

Common name	Scientific name	Total catch	Promille by catch
Greenland halibut	<i>Reinhardtius hippoglossoides</i>	199 192.00	996.85
Roughhead grenadier	<i>Macrourus berglax</i>	173.02	0.87
Blue whiting	<i>Micromesistius poutassou</i>	104.00	0.52
Redfish	<i>Sebastes mentella</i>	82.00	0.41
Spinetail ray	<i>Bathyraja spinicauda</i>	76.68	0.38
Cod	<i>Gadus morhua</i>	63.71	0.32
Northern wolffish	<i>Anarhichas denticulatus</i>	62.23	0.31
Esmarks eelpout	<i>Lycodes esmarki</i>	32.47	0.16
Saithe	<i>Pollachius virens</i>	18.00	0.09
Haddock	<i>Melanogrammus aeglefinus</i>	5.40	0.03
Round ray	<i>Raja fyllae</i>	3.90	0.02
Argentina	<i>Argentina silus</i>	2.80	0.01
Arctic rockling	<i>Onogadus sp.</i>	1.86	0.01
Witch flounder	<i>Glyptocephalus cynoglossus</i>	1.67	0.01
Arctic sculpin	<i>Cottunculus microps</i>	1.40	0.01
Total		199 821.13	1000.00

Table 2. Species composition of catches by depth strata, number, and weight of specimens

Common name	Scientific name	Subarea S			Subarea D			Research area			
		Number caught	Weight of fish (kg)	Mean weight of fish (kg)	Number caught	Weight of fish (kg)	Mean weight of fish (kg)	Number caught	Length range	Weight of fish (kg)	Mean weight of fish (kg)
Greenland halibut	<i>Reinhardtius hippoglossoides</i>	109 222	114 192.00	1.046	65 990	85 000.00	1.288	175 212	31-99	199 192.00	1.137
Roughhead grenadier	<i>Macrourus berglax</i>	140	172.32	1.231	1	0.70	0.700	141	45-90	173.02	1.227
Blue whiting	<i>Micromesistius poutassou</i>	439	64.50	0.147	209	39.50	0.189	648	26-36	104.00	0.160
Redfish	<i>Sebastes mentella</i>	60	44.64	0.744	67	37.36	0.558	127	31-40	82.00	0.646
Spinetail ray	<i>Bathyraja spinicauda</i>	33	53.56	1.623	10	23.12	2.312	43	34-85	76.68	1.783
Cod	<i>Gadus morhua</i>	6	20.38	3.397	16	43.33	2.708	22	38-80	63.71	2.896
Northern wolffish	<i>Anarhichas denticulatus</i>	3	34.43	11.475	4	27.80	6.950	7	90-100	62.23	8.889
Esmarks eelpout	<i>Lycodes esmarki</i>	45	29.12	0.647	5	3.35	0.670	50	22-50	32.47	0.649
Saithe	<i>Pollachius virens</i>	10	14.90	1.490	2	3.10	1.550	12	45-60	18.00	1.500
Haddock	<i>Melanogrammus aeglefinus</i>	1	1.10	1.100	3	4.30	1.433	4	30-50	5.40	1.350
Round ray	<i>Raja fyllae</i>	1	1.20	1.200	3	2.70	0.900	4	56-60	3.90	0.975
Argentina	<i>Argentina silus</i>	6	2.80	0.467				6	33-35	2.80	0.467
Arctic rockling	<i>Onogadus sp.</i>	3	1.20	0.400	3	0.66	0.220	6	15-25	1.86	0.310
Witch flounder	<i>Glyptocephalus cynoglossus</i>	7	1.67	0.239				7	17-22	1.67	0.239
Arctic sculpin	<i>Cottunculus microps</i>	6	1.40	0.233				6	25-27	1.40	0.233
Total		109 982	114 635.22	-	66 313	85 185.92	-	176 295		199 821.13	-

Table 3. Catch and CPUE of Greenland halibut by depth strata and squares

	Square	No. of hauls	Catch (kg)	CPUE (kg/h)	Square	No. of hauls	Catch (kg)	CPUE (kg/h)
Shallower depth strata (500-699m)	s-01	4	13 377.0	1 689.7	d-01	2	195.0	57.1
	s-02	2	13 728.0	1 631.0	d-02	1	390.0	334.3
	s-03	2	1 482.0	538.9	d-03	2	4 095.0	1 198.5
	s-04	2	10 506.4	2 932.0	d-04	2	975.0	344.1
	s-05	1	2 535.0	2 340.0	d-05	1	1 911.0	1 528.8
	s-06	1	468.0	401.1	d-06	1	2 496.0	2 304.0
	s-07	1	390.0	312.0	d-07	3	15 093.0	3 483.0
	s-08	2	3 042.0	1 073.6	d-08	1	4 329.0	2 886.0
	s-09	1	1 911.0	1 433.3	d-09	1	2 730.0	1 724.2
	s-10	2	3 386.0	1 128.7	d-10	1	1 677.0	1 118.0
	s-11	1	2 847.0	2 009.6	d-11	1	3 705.0	2 340.0
	s-12	2	858.0	381.3	d-12	1	5 265.0	4 512.9
	s-13	1	2 847.0	2 277.6	d-13	1	2 457.0	1 965.6
	s-14	2	18 009.6	3 791.5	d-14	1	2 067.0	1 653.6
	s-15	1	5 538.0	2 889.4	d-15	1	4 836.0	2 637.8
	s-16	1	2 769.0	1 846.0	d-16	1	1 794.0	1 794.0
	s-17	3	27 417.0	3 046.3	d-17	3	20 923.0	2 688.2
	s-18	1	3 081.0	2 310.8	d-18	2	10 062.0	2 569.0
	Total	30	114 192.0	2 012.2	Total	26	85 000.0	2 030.3

Table 4. Maturity stages of Greenland halibut sampled in 2006

Sex		Maturity stages						Total
		I	II	III	IV	V	VI	
Males	N	29	28	77	5	4	37	151
	%	19.2	18.5	51.0	3.3	2.6	24.5	
Females	N	36	12	82	6	7	43	150
	%	24.0	8.0	54.7	4.0	4.7	28.7	
Total	N	65	40	159	11	11	80	301
	%	21.6	13.3	52.8	3.7	3.7	26.6	

Table 5. Mean weight of Greenland halibut in the Polish fishing survey in November 2006

Length classes (cm)	Males		Females		Total	
	N	Mean weight (g)	N	Mean weight (g)	N	Mean weight (g)
31	4	221.3			4	221.3
32	2	247.5	1	275.0	3	256.7
33	1	225.0	1	240.0	2	232.5
34	4	310.0	2	277.5	6	299.2
35	2	347.5	3	340.0	5	343.0
36	3	340.0	3	366.7	6	353.3
37	4	392.5	3	398.3	7	395.0
38	5	434.0			5	434.0
39	3	455.0	2	497.5	5	472.0
40	3	501.7	4	528.8	7	517.1
41	4	565.0	4	520.0	8	542.5
42	4	627.5	1	580.0	5	618.0
43	5	644.0	1	605.0	6	637.5
44	8	697.5	1	635.0	9	690.6
45	8	752.5	3	806.7	11	767.3
46	5	823.0	2	830.0	7	825.0
47	8	841.9			8	841.9
48	4	928.8	2	1012.5	6	956.7
49	7	1020.0			7	1020.0
50	8	1071.9			8	1071.9
51	6	1140.0	2	1062.5	8	1120.6
52	6	1257.5	1	1380.0	7	1275.0
53	8	1328.1			8	1328.1
54	6	1419.2			6	1419.2
55	5	1512.0	2	1735.0	7	1575.7
56	6	1610.8	1	1700.0	7	1623.6
57	6	1586.7	3	1735.0	9	1636.1
58	4	1727.5	3	1780.0	7	1750.0
59	6	1642.5	3	1863.3	9	1716.1
60	4	1932.5	3	2145.0	7	2023.6
61			5	2194.0	5	2194.0
62	1	2180.0	4	2105.0	5	2120.0
63			5	2408.0	5	2408.0
64			5	2453.0	5	2453.0
65	1	2365.0	6	2468.3	7	2453.6
66			6	2619.2	6	2619.2
67			5	2894.0	5	2894.0
68			6	3048.3	6	3048.3
69			6	3204.2	6	3204.2
70			7	3469.3	7	3469.3
71			7	3640.7	7	3640.7
72			6	3413.3	6	3413.3
73			5	3645.0	5	3645.0
74			3	3530.0	3	3530.0
76			2	4275.0	2	4275.0
77			2	4565.0	2	4565.0
78			2	4807.5	2	4807.5
79			3	5050.0	3	5050.0
80			2	5077.5	2	5077.5
81			1	4970.0	1	4970.0
82			1	6420.0	1	6420.0
83			1	6380.0	1	6380.0
84			1	6660.0	1	6660.0
85			4	6453.8	4	6453.8
86			1	6870.0	1	6870.0
88			1	6760.0	1	6760.0
90			1	7240.0	1	7240.0
91			1	8560.0	1	8560.0
Mean weight (g)	151	995.7	150	2708.6	301	1849.3

Table 6. Fullness of halibut stomachs during the Polish fishing survey in 2006

Sex		Fullness of halibut stomachs					Total
		0	1	2	3	4	
Males	N	132	13	5	1	0	151
	%	87.4	8.6	3.3	0.7	0.0	
Females	N	122	13	9	6	0	150
	%	81.3	8.7	6.0	4.0	0.0	
Total	N	254	26	14	7	0	301
	%	84.4	8.6	4.7	2.3	0.0	

FIGURES



Figure 1. Polish fishing vessel “Polonus”

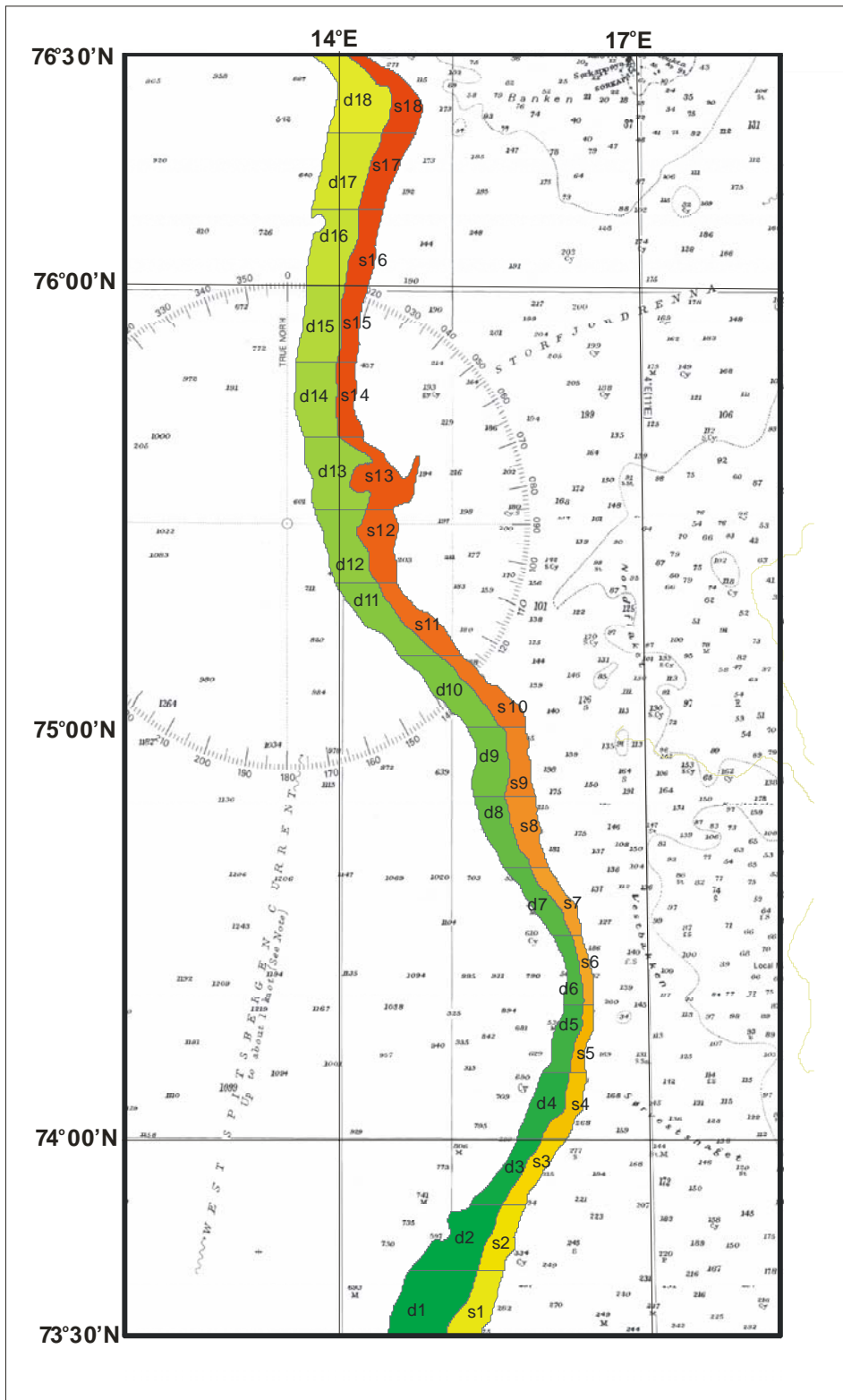


Figure 2. The depth strata and squares in the survey area

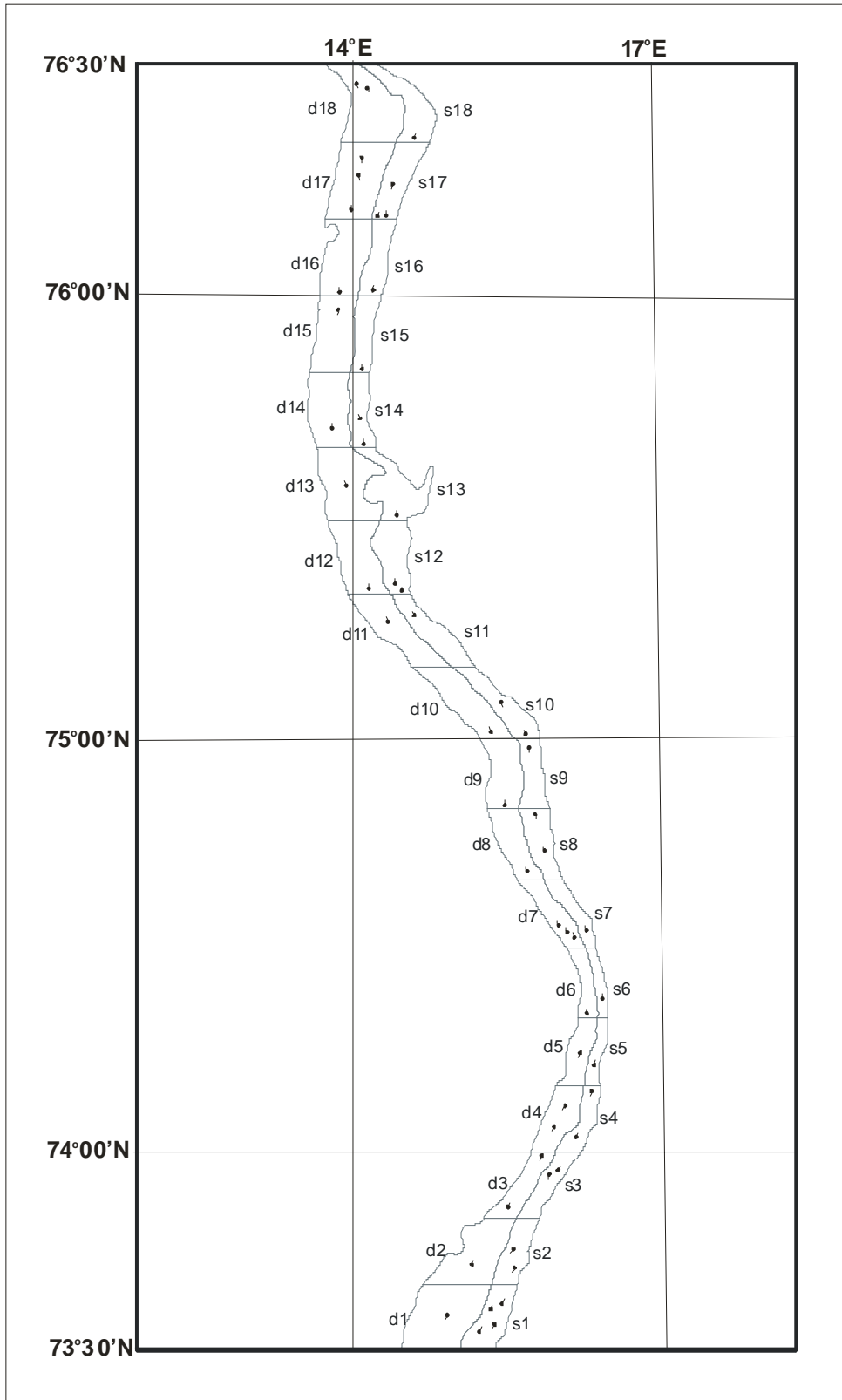


Figure 3. Geographical positions of control hauls during Polish trawl survey in November 2006

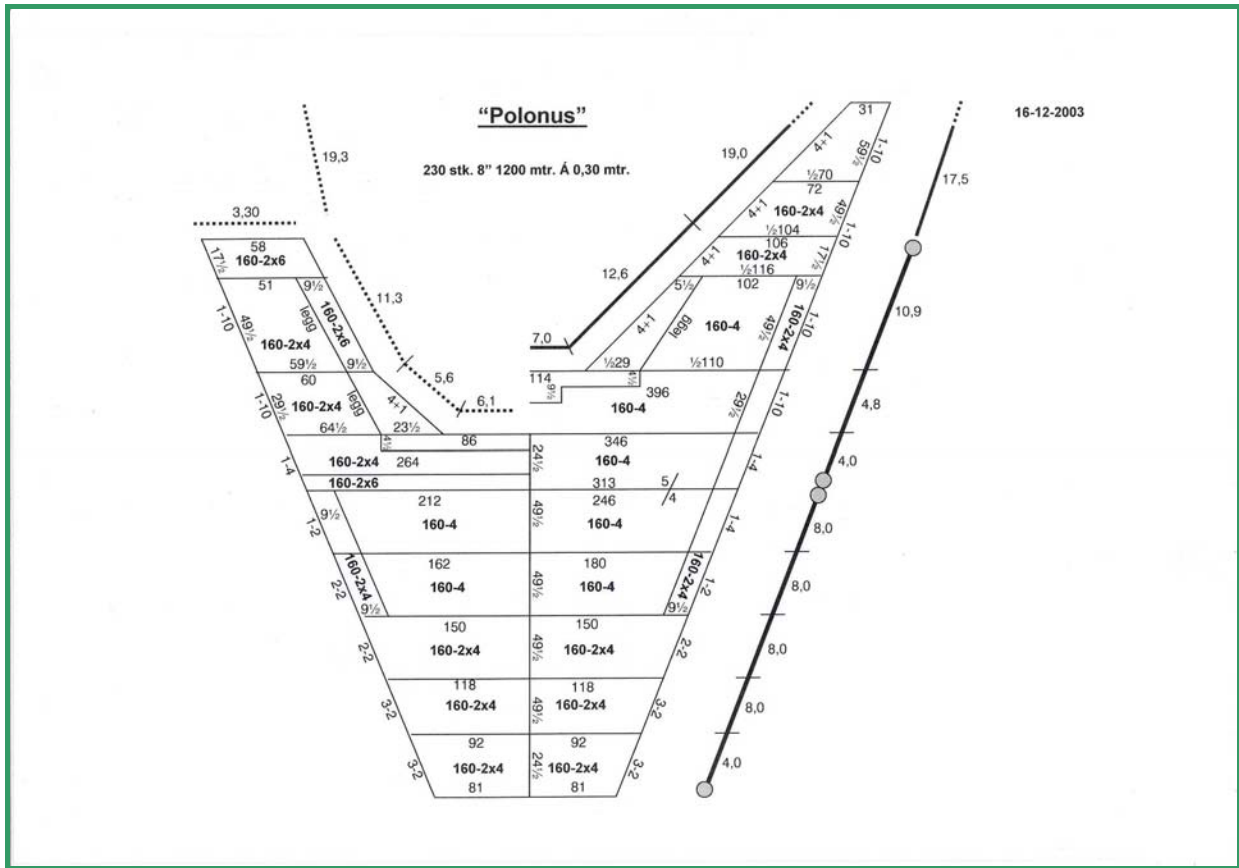


Figure 4. Schema of the net Bacalao 630

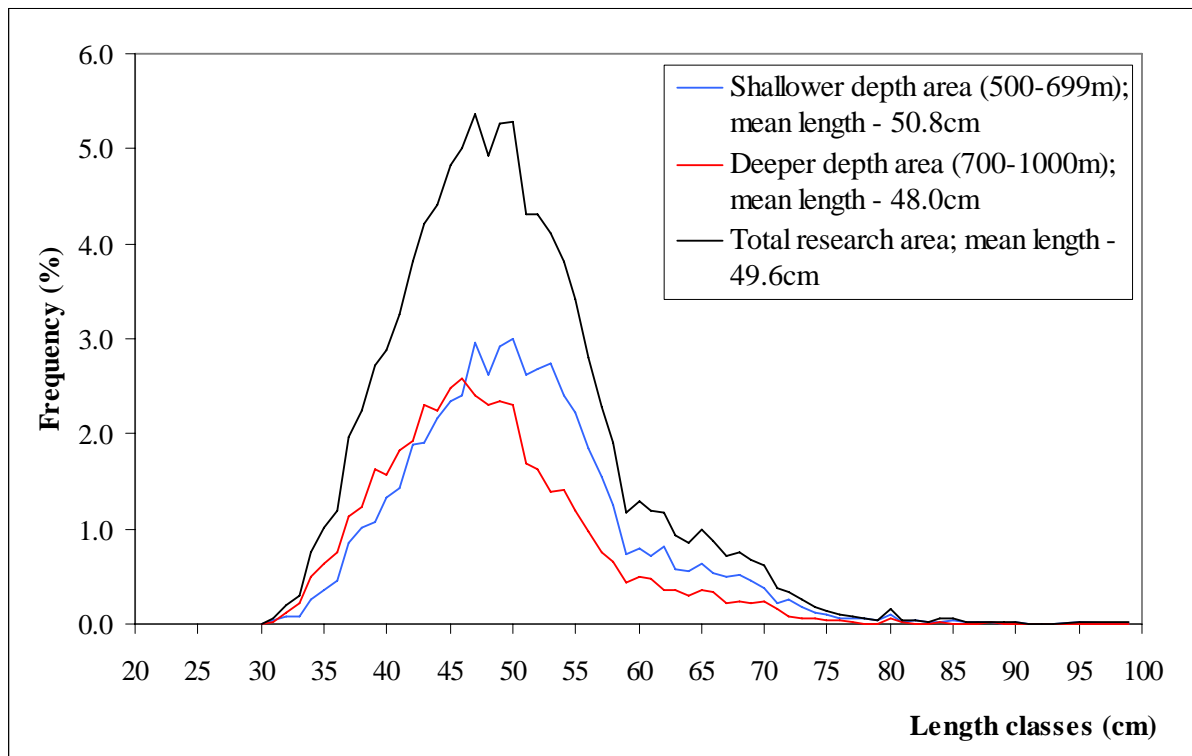


Figure 5. Length compositions of Greenland halibut in Polish trawl survey in November 2006

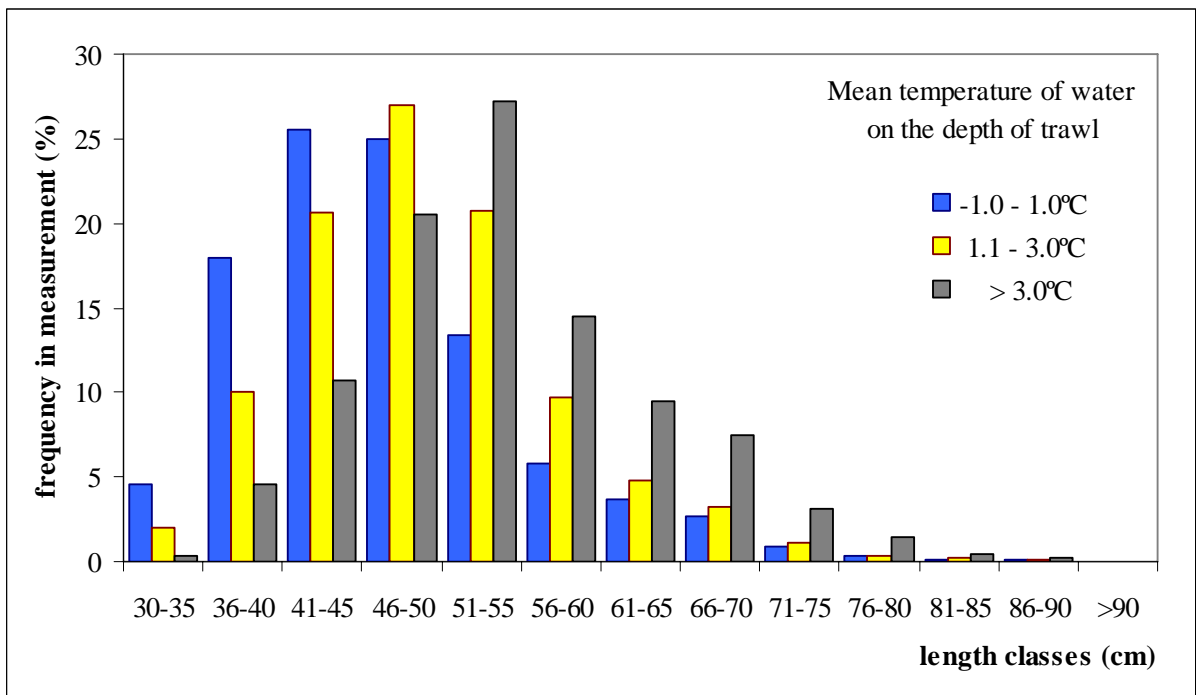


Figure 6. The frequency of the halibut length classes depending on the water temperature

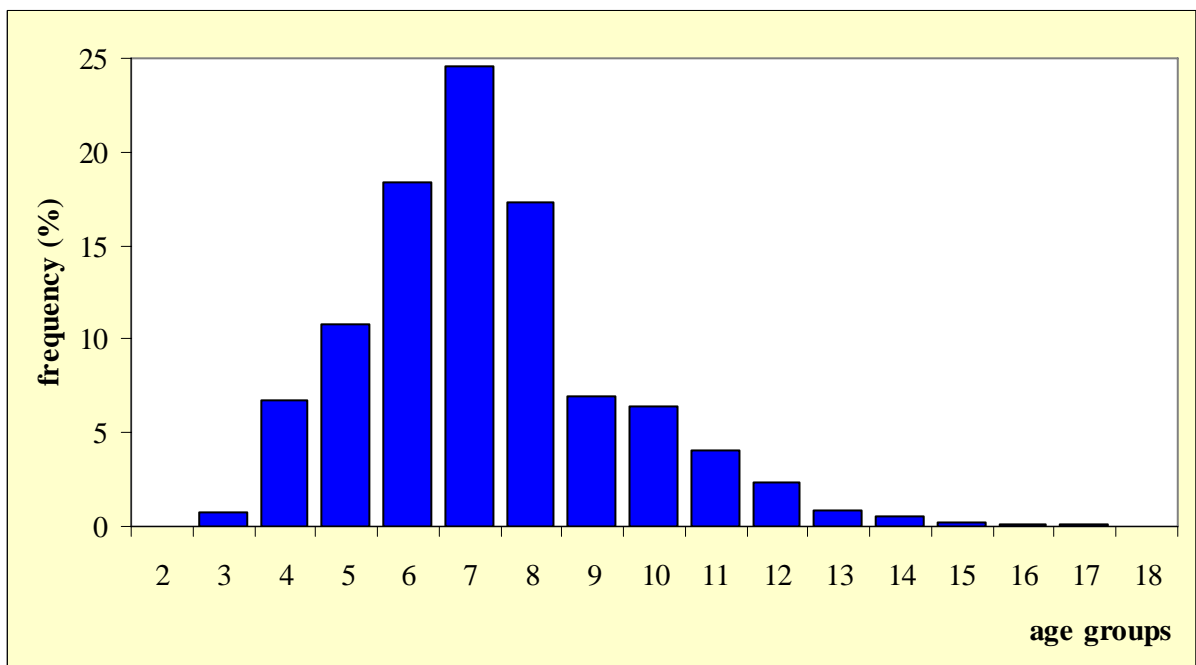


Fig. 7 Age composition of Greenland halibut in Polish trawl survey in November 2006

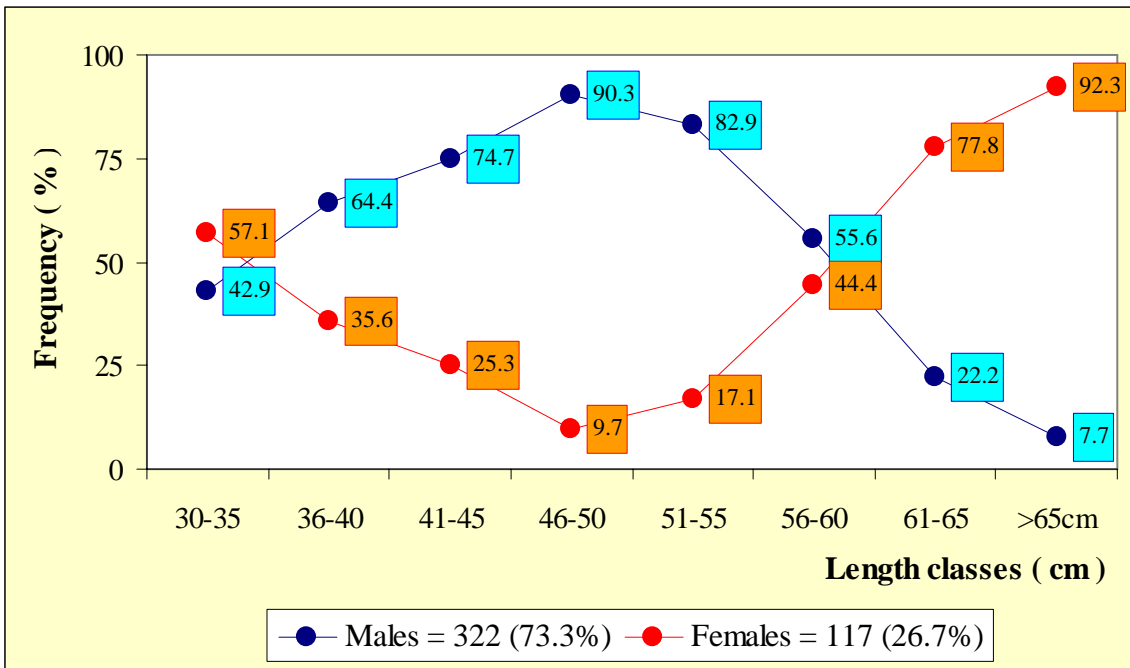


Figure 8. Sex ratio of Greenland halibut in Polish trawl survey in 2006

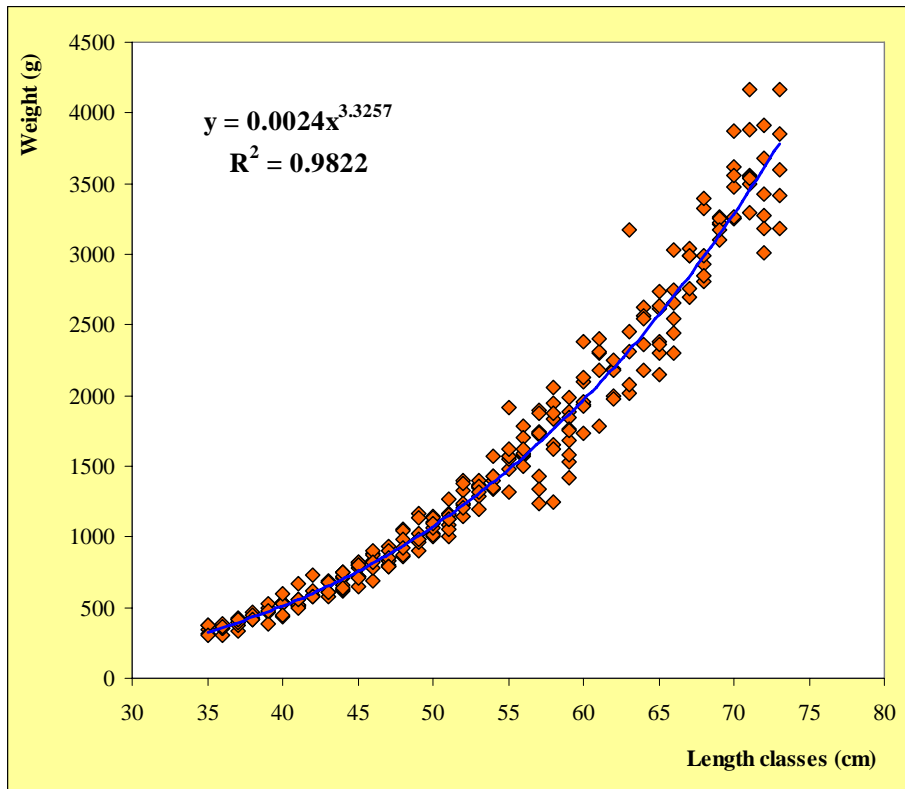


Figure 9. Mean weight at length of Greenland halibut (sexes combined) observed during Polish 2006 trawl survey

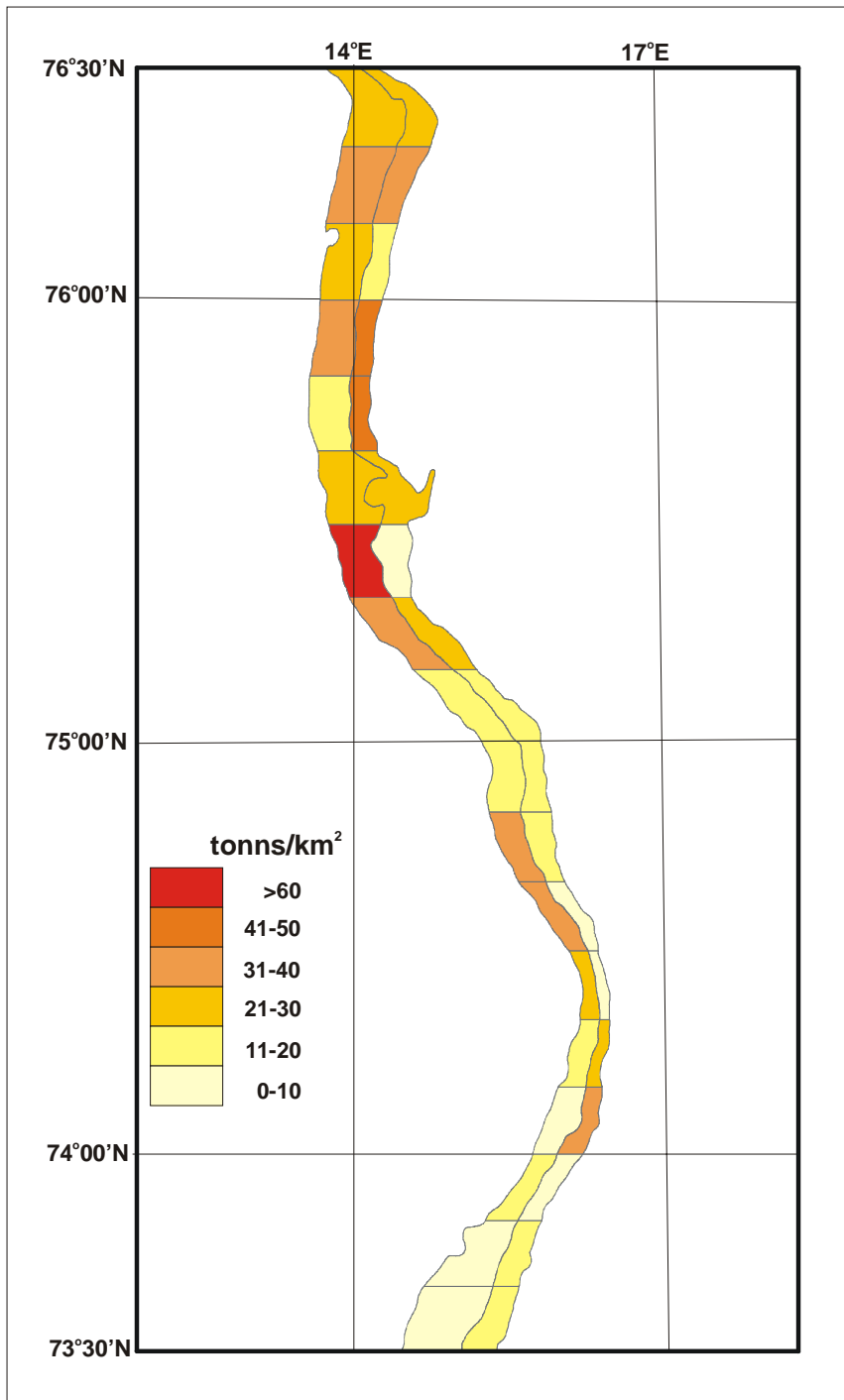


Figure 9. Density of Greenland halibut (tonnes/km²) in the Polish trawl survey in November 2006

ANNEXES 1-3

Annex 1.

Protocol no 1

Number of TAG: **5817 BERGEN TAG NO. 10415**

Species: **Greenland halibut (*Reinhardtius hippoglossoides*)**

Date of catch: **22 October 2006**

Position of catch: **LAT: 76°28'8 N**

LONG: 014°11'9 E

Time: **0.45 LT**

Ship: **f/v Polonus**

Type of cruise: **fishing survey**

Depth: **660 - 699 m**

Temperature at the bottom: **1,8 - 2.2°C**

Length: approximate **51-53 cm**

Weight: -

Sex: -

Gonad's maturity: -

Stomach fullness: -

Remarks: ***the tag was found on the fish without head and tail (dressed)***

Protocol no 2

Number of TAG: **5817 BERGEN TAG NO. 20504**

Species: **Greenland halibut** (*Reinhardtius hippoglossoides*)

Date of catch: **23 October 2006**

Position of catch: **LAT: 75°43'8 N**
LON: 013°58'1 E

Time: **18.15 LT**

Ship: **f/v Polonus**

Type of cruise: **fishing survey**

Depth: **685 m**

Temperature at the bottom: **2,8°C**

Length: **45 cm TL**

Weight: **785 g**

Sex: **Male**

Gonad's maturity: **IV**

Stomach fullness: **0**

Age: **6**

Remarks: ***photo of the fish***



Protocol no 3

Number of TAG: **5817 BERGEN TAG NO. 10609**

Species: **Greenland halibut** (*Reinhardtius hippoglossoides*)

Date of catch: **23 October 2006**

Position of catch: **LAT: 74°59'7 N**
LON: 015.36'4 E

Time: **18.55 LT**

Ship: **f/v Polonus**

Type of cruise: **fishing survey**

Depth: **619 m**

Temperature at the bottom: **1,7°C**

Length: approximate **49-51 cm**

Weight: -

Sex: **Male**

Gonad's maturity: **IV**

Stomach fullness: -

Remarks: ***the tag was found on the fish without head and tail (dressed)***