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Analysis of Data from a Trawl Survey in NAFO Division 0A, 1999

by

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Abstract

A stratified random otter trawl survey covering depths of 400 m to 1500 m and targeting Greenland halibut (*Reinhardtius hippoglossoides)* was conducted in NAFO Division 0A from October 7 to 19, 1999. This was the first deepwater trawl survey within the Canadian waters of Baffin Bay and was a collaborative effort between Fisheries and Oceans Canada, the Nunavut Wildlife Management Board, the Qikiqtaaluk Wildlife Board and the Greenland Institute of Natural Resources (GINR). Survey coverage was 1 set per 750 km^2 with a minimum of two tows per stratum. This criteria was met in all but four strata with 66 of 90 planned tows conducted. Greenland halibut were present in all tows with the highest densities between 1001 m and 1250 m. total estimated biomass and abundance for the survey area were 83,340 tons and $141x10^6$, respectively. Lengths ranged from 6.5 cm to 94.5 cm with 71.5% less than 42.5 cm. The modal length was 38.5 cm. Age distribution was estimated using an age-length key from the GINR 1999 survey of NAFO Divisions 1CD. Ages ranged from two to 15 years with a modal age of four years. The majority (96.1%) were less than eight years old. The catch of other commercially important species was minimal. However, data on these and other non-commercial species from the by-catch are also presented.

Introduction

A stratified random survey in the North West Atlantic Fisheries Organization (NAFO) Division 0A was conducted from October 7 to 19, 2000. It was the first survey within NAFO Subarea 0 to extend north of 69°N and came about as a collaborative effort between Fisheries and Oceans Canada (Newfoundland and Central and Arctic Regions), the Nunavut Wildlife Management Board, the Qikiqtaaluk Wildlife Board and the Greenland Institute of Natural Resources (GINR). Previous work in this region had consisted of a survey in Davis Strait but only covering a very small portion of Div. 0A in the south (Bowering 1987). Some exploratory fishing was also carried out in Div. 0A during 1993, 1994 and 1996-1998 (Hathaway 1993, Northlands Consulting 1994, and Treble 1999). The GINR research vessel Paamiut was used to conduct the survey. The science crew was comprised of six Canadians and one scientist from Greenland. The survey in Division 0A was conducted immediately following the survey in 1CD. The objectives of the survey were, (1) to fish at randomly-selected fishing stations to determine the distribution and abundance of various groundfish species, (2) to collect biological samples from Greenland halibut, (*Reinhardtius hippoglossoides)* and (3) to collect oceanographic data at each fishing station. A comparison of survey results between Div. 0A and 1CD is made easier through the use of the same vessel, fishing gear and crew. This should assist in the overall assessment of the stock complex in Subarea 0+1.

Materials and Methods

Stratification of Division 0A, and Set Selection

Table 1 contains the stratification scheme used for the survey in Div. 0A. This is also shown in Fig. 1. Strata 24, 25, and 30-34 are from a previous stratification scheme (Bowering, 1987). Strata 40-61 are from a new stratification scheme of Div 0A (401 – 1500 m) developed in 1999 for this survey. The total area encompassed by these strata is approximately 61,747 km^2 (18,002 nm^2), of which 75.4% is contained in the new strata. Survey coverage was intended to be approximately 1 set per 750 km^2 (220 nm^2), with a minimum of 2 tows per stratum. A total of 90 tows were preselected, randomly within each stratum, along with an additional 2 tows per stratum to be used as alternate fishing stations if necessary.

Vessel and Gear

The MV Paamiut is a 722 GRT stern trawler measuring 53 m in length. An Alfredo III bottom otter trawl with rock hopper ground gear was used for the survey. Mesh size was 140 mm with a 30 mm mesh liner in the cod end. Trawl doors were Greenland Perfect (370 cm x 250 cm) weighing 2400 kg mounted with an extra 20 kg. Jørgensen (1998) contains more information about the trawl and gear. A Furuno net sonde mounted on the head rope measured net height and was used to determine bottom contact and the start/finish of each tow. Scanmar sensors measured the distance between the trawl doors. Wingspread, taken as the distance between the outer bobbins, was calculated as: distance between outer bobbins=10.122 + distance between trawl doors (m) x 0.142. This relationship was based on flume tank measurements of the trawl and rigging (Jørgensen 1998).

A Seamon temperature sensor mounted on one of the trawl doors was used to measure near bottom temperatures to within $\pm 0.1^{o}$ C.

Trawling Procedure

The targeted tow duration was 30 minutes, however, tows down to 15 minutes in length were considered acceptable. Average towing speed was 3.0 kn. Trawling took place throughout a 24 hr period in order to maximize the ships time and complete the necessary tows.

Biological Data Collection and Analysis

Numbers and total weight caught were recorded on a set by set basis for each species. Total weight of invertebrates and the % composition of major invertebrate species were also recorded. Commercial fish species other than Greenland halibut (gadoids, flatfish, redfish, grenadiers, skates) were sexed and individual length measurements taken. Measuring boards using an offset of 0.5 cm were used, and lengths measured to the nearest 1 cm (0.5 cm for grenadiers). For example any fish between 24.50 cm and 25.49 would be measured as 25 cm. Two large catches of Greenland halibut were sub-sampled with 48% and 50% of the catch sampled in each case.

Greenland halibut were the targeted species and were therefore sampled in more detail. A maturity assessment for all individuals was done visually, based on maturity stages described in Templeman et al. (1978). Fish less than 14 cm fork length were recorded as unsexed. For each sampled fish >=14 cm the whole weight was recorded at sea using an electronic balance. Otoliths for age determination were collected, 10 per 1 cm length group per sex for fish >=14 cm. For fish <14 cm (unsexed), 6 per 1cm group were collected. Stomachs were collected and frozen for more detailed analysis later, three per 5 cm length group per set.

Various species from the catch were collected or tissue samples taken for use by other researchers within DFO, the University of Manitoba and the Zoological Museum, University of Copenhagen.

Biomass and Abundance Indices

The swept area method was used in the estimation of biomass and abundance: Swept area=wingspread (m) x trawl time (min) x trawl speed (kn/hr) x $1.852/6x10^4$. A standard trawl speed of 3 kts. was used in the calculation of swept area for all tows. Abundance and biomass were calculated for each set and standardized to 1 sq km:

Abundance (no./sq. km)=catch (no.)/sweptarea (sq km) and biomass (tons/sq km)=catch (kgs)/swept area (sq km)/1000. Mean and standard error for abundance and biomass were calculated for each stratum. An estimate of total abundance and biomass was calculated for each stratum (mean x stratum area (sq km)). These values were then summed to determine overall estimates for the survey area.

A computer program named STRAP (Smith and Somerton 1981) used by DFO-Newfoundland region was used to analyze length data and produce length frequencies using 2 cm size groups. This program used standard values across all tows for wingspread (88.6 ft) and tow distance (1.5 nmi) and calculated mean number per tow rather than per sq km. The overall length distribution was estimated by multiplying the mean value per tow by the number of trawlable units for the stratum area.

DFO-Central and Arctic Region is looking to develop the ability to age Greenland halibut otoliths and hope to age the otoliths collected during this survey within 2000/01. In the meantime an age-length key from the GINR age determination lab was used to develop the age distribution for Division 0A. This key is based on 482 samples collected during the survey of Division 1CD in September, 1999. The length-weight relationship applied to the data was the same for males and females: weight (kg) = length (cm) x $(2.184x10^6)^{3.3454}$ (Bowering and Stansbury 1984).

Results and Discussion

Survey Area

The stratified area within Division 0A covers 61,747 sq km (18,002 sq nm) (Table 2, Fig. 1). A minimum of two tows were completed in all but four strata (53,54,55 and 57). Sixty-six of the 90 hauls planned were conducted with only one unsuccessful. A coral outcrop was encountered shortly after tow number 23 began and the net was torn away from the rest of the gear. Table 3 contains set by set information on stratum, swept area, mean depth, near bottom temperature and catch for Greenland halibut, roundnose grenadier (*Coryphaenoides rupestris*), roughhead grenadier (*Macrourus berglax*), deep sea redfish (*Sebastes mentella*) and American plaice (*Hippoglossoides platessoides*).

Near bottom temperatures ranged from a high of 3.8 ^{o}C in stratum 24 to a low of –0.1 ^{o}C in stratum 48 (Table 3, Fig. 1). The majority of tows (91%) had temperatures below 1.5 ^{o}C. Mean temperatures by depth stratum ranged from 1.6 ^{o}C for the 401-500 m depth stratum to 0.1 ^{o}C for the 1251-1500 m depth stratum (Table 4).

Greenland Halibut

Greenland halibut were distributed throughout the survey area and were present in each tow (Fig. 2). Catches varied from 3.75 kg (n=14, 467 m) to 572.80 kg (n=1042, 1016 m) (Table 3). The greatest densities were within the 1001 to 1250 m depth strata and were distributed throughout both the Baffin Bay and Davis Strait portions of the survey area (Fig. 2, Tables 5 and 6).

Total biomass for the survey area was estimated at 83,340 tons (Table 5). The biomass estimated for strata 30 to 42 was 28,354 tons. This compares to 32,219 tons estimated for these strata in a 1986 survey in Subarea 0 and 1 conducted Aug. 15 to Sept. 18 by the Gadus Atlanticus (Bowering 1987).

Abundance was estimated at 141 x 10^6 with the highest values occurring in the 751-1000 m and 1001-1250 m strata (Table 6).

Lengths ranged from 6.5 cm to 94.5 cm with the mode at 38.5 cm (Table 7, Fig. 3). A majority of fish (71.5%) were less than 42.5 cm.

Ages ranged from 2 to 15 years with the highest abundance at age four for both males and females (Table 8, Fig. 4). The majority (96.1%) were less than eight years of age. Males were more abundant than females up to age seven (Fig. 4). This age distribution was developed using a weight-length relationship and an age-length key from two different areas, both of which are different from the survey area. Therefore, the data may not reflect the true age distribution for Div. 0A. However, it is clear that the majority of the fish in this area are young and well below the established age of maturity for Greenland halibut.

Differences observed in the abundance values between Tables 6, 7 and 8 are a result of the slight differences in methods applied to the calculation of catch densities, length distribution and age distribution described above. It is felt the differences are relatively small and should not affect the overall interpretation of the data.

Bowering and Parsons (1986) present survey data that show a catchability effect for young Greenland halibut between day and evening tows. Due to time constraints and for reasons of economy the survey of 0A consisted of tows taken throughout the day and night. When the survey began there were approximately 10.5 hours of daylight with sunrise at 7:00 (NST) and sunset at 17:33. At the conclusion of the survey there were approximately 8.5 hours of daylight with sunrise at 8:33 and sunset at 16:46. The length frequency distribution (Fig. 3) shows very few fish below 24.5 cm therefore, it is concluded that if a similar catchability effect occurs for Greenland halibut in the Div. 0A survey area it is likely to have a minimal effect on the overall estimation of abundance and biomass.

Grenadiers, Redfish, American Plaice and Atlantic Cod

Commercially important finfish species other than Greenland halibut are present in Division 0A but are not abundant (Table 3, Appendix 1). The least abundant were roundnose grenadier and Atlantic cod (*Gadus morhua*) both present in only one tow. Roughead grenadier were present in 21 of 65 tows for a total number and weight of 32 and 15.78 kg, respectively. American plaice was present in 12 of 65 tows for a total number and weight of 33 and 6.98 kg, respectively. Deep sea redfish was the most abundant, present in 24 of 65 tows for a total number and weight of 432 and 29.77 kg, respectively.

Elasmobranchs

There were four species of elasmobranchs caught during this survey, Greenland shark *(Somniosus microcephalus*) and three species of skates (Appendix 1). The Greenland shark were encountered during two tows, 39 (n=3) and 65 (n=2). It was not possible to get weight data for any of these sharks. However, the two caught in tow 65 were examined. One was female, 2.8 m total length (2.68 m FL), with 1 young harp seal and one young ring seal in the stomach along with arctic cod (*Boreogadus saida*). The other was male 2.6 m total length (2.45 m FL) with partial remains of a hooded seal and polar cod in the stomach.

There was a single record for round skate (*Raja fyllae*) (0.2 kg). Arctic skate (*Raja hyperborea*) was more abundant than thorny skate (*Raja radiata*). Estimates of total biomass and abundance for thorny skate were 241 tons and 617,002, respectively (Table 9). The majority was located at depths <751 m. Arctic skate were distributed between 501 m and 1500 m with the majority found between 1251 m and 1500 m (Table 10). Estimated total biomass and abundance were 2,268 tons and 2.02×10^6, respectively).

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Table 1. Stratification of Division OA used in the survey by *Paamiut* in October 1999. Strata 40-61 are from a new stratification scheme developed for this survey. Strata 24, 25, and 30-34 are from a previous stratification scheme (Bowering, 1987). The areas for the older strata are the areas in Division 0A, as parts of some strata extend into other NAFO Divisions, which were not surveyed at this time.

Stratum	Sq. N Miles	Units	Depth Range (m)
024	457	130	401-500
025	1780	510	501-750
030	1099	310	751-1000
031	496	140	1001-1250
032	301	90	1251-1500
033	184	50	501-750
034	75	20	401-500
040	1671	480	1251-1500
041	698	200	1001-1250
042	577	160	751-1000
043	609	170	501-750
044	375	110	401-500
045	348	100	501-750
046	370	110	751-1000
047	883	250	1001-1250
048	843	240	1251-1500
049	712	200	1251-1500
050	650	190	1001-1250
051	574	160	751-1000
052	635	180	501-750
053	276	80	401-500
054	852	240	501-750
055	334	100	401-500
056	200	60	401-500
057	652	190	501-750
058	350	100	501-750
059	600	170	751-1000
060	671	190	1001-1250
061	730	210	1251-1500

Table 2. Area of depth strata for NAFO Division 0A with the number of hauls planned ( ) and conducted. A conversion factor of 3.430 was used to calculate square kilometers from square nautical miles.

Depth Stratum (m)	401-500	501-750	751-1000	1001-1250	1251-1500	Total
Area (sq. nm)	1717	5410	3220	3398	4257	18002
Area (sq. km)	5889	18556	11045	11655	14602	61747
Hauls	(12) 8	(27) 18	(16) 13	(15) 12	(20) 15	(90) 66

Table 3. Catch weight and numbers (not standardised to kg/km^2) of Greenland halibut, roundnose grenadier and roughhead grenadier, Sebastes mentella and American plaice by haul for NAFO Division 0A. Depth in m, swept area in km^2 and bottom temperature in ^{o}C.

			Mean	Sweptarea		Temp.	Time	Greenland halibut		Roundnose grenadier		Roughhead grenadier		S. mentella		American plaice	
Set No.	Month	Day	Depth (m)	(sq. km)	Stratum	(^{o}C)	(NST)	Number	Kg	Number	Kg	Number	Kg	Number	Kg	Number	Kg
1	10	8	608	0.07371	25	2.4	6:42	43	36.35	0	0	0	0	33	6.15	0	0
2	10	8	611	0.05856	25	2.3	9:07	34	13.95	0	0	1	0.03	15	2.40	0	0
3	10	8	656	0.07813	25	1.3	12:08	129	59.80	0	0	1	0.55	4	0.27	0	0
4	10	8	715	0.07648	25	1.2	15:02	112	37.10	0	0	3	1.08	1	0.03	0	0
5	10	8	690	0.07801	25	1.2	17:21	79	32.30	0	0	0	0	3	0.23	0	0
6	10	8	443	0.07419	24	0.9	20:27	117	35.40	0	0	1	1.25	9	0.48	0	0
7	10	8	521	0.07892	25	1.2	22:26	53	17.55	1	0.07	0	0	6	0.36	1	0.28
8	10	9	598	0.07553	25	1.2	0:34	126	46.50	0	0	0	0	0	0	1	0.11
9	10	9	510	0.07111	24	1.2	3:23	242	80.10	0	0	0	0	13	1.01	0	0
10	10	9	457	0.07395	44	1.1	4:58	222	69.45	0	0	0	0	14	0.67	2	0.18
11	10	9	572	0.07553	43	1.2	6:44	128	46.20	0	0	0	0	3	0.15	2	0.68
12	10	9	607	0.07837	43	1.2	9:19	67	22.20	0	0	0	0	0	0	1	0.11
13	10	9	991	0.08066	42	0.9	12:28	116	59.25	0	0	1	0.50	0	0	0	0
14	10	9	959	0.07845	42	0.9	14:32	173	88.20	0	0	0	0	0	0	0	0
15	10	9	901	0.07837	30	1.0	16:45	86	49.35	0	0	2	0.22	0	0	0	0
16	10	9	864	0.05059	30	1.1	23:33	303	177.45	0	0	4	0.38	1	0.06	0	0
17	10	10	797	0.06730	30	1.1	2:25	146	81.45	0	0	2	0.17	1	0.04	0	0
18	10	10	1288	0.07987	32	0.2	7:11	30	29.65	0	0	0	0	0	0	0	0
19	10	10	1337	0.07592	32	0.3	10:11	24	19.75	0	0	0	0	1	0.05	0	0
20	10	10	1187	0.08271	31	0.5	13:22	114	112.05	0	0	0	0	0	0	0	0
21	10	10	673	0.04654	33	2.6	16:11	64	28.30	0	0	1	0.01	1	0.09	8	1.66
22	10	10	451	0.06985	34	4.0	18:20	32	11.00	0	0	0	0	130	5.50	3	0.30
23	10	10	.	.	30	0.8	23:15	.	.	.	.	.	.	.	.	.	.
24	10	11	458	0.06843	34	3.8	1:54	23	9.35	0	0	0	0	70	2.24	5	1.25
25	10	11	552	0.07198	33	3.0	4:45	57	25.00	0	0	0	0	105	8.15	2	0.63
26	10	11	1342	0.08145	40	0.2	8:38	139	190.00	0	0	0	0	3	0.16	0	0
27	10	11	1323	0.08192	40	0.2	10:52	158	184.45	0	0	0	0	0	0	0	0
28	10	11	1106	0.07506	31	0.6	13:33	1007	650.60	0	0	2	2.26	0	0	0	0
29	10	11	1437	0.08018	40	0.0	18:24	14	22.85	0	0	0	0	1	0.06	0	0
30	10	11	1482	0.07845	40	0.0	23:31	12	16.45	0	0	0	0	0	0	0	0
31	10	12	1395	0.08263	40	0.1	3:21	13	10.45	0	0	0	0	0	0	0	0
32	10	12	1389	0.08030	40	0.1	6:26	18	20.70	0	0	0	0	1	0.06	0	0
33	10	12	1139	0.07947	41	0.5	10:26	135	126.20	0	0	0	0	0	0	0	0
34	10	12	1060	0.08231	41	0.7	12:30	174	145.60	0	0	1	0.80	0	0	0	0

Table 3. Continued.

			Mean	Sweptarea		Temp.	Time	Greenland halibut		Roundnose grenadier		Roughhead grenadier		S. mentella		American plaice	
Set No.	Month	Day	Depth (m)	(sq. km)	Stratum	(°C)	(NST)	Number	Kg	Number	Kg	Number	Kg	Number	Kg	Number	Kg
35	10	12	1048	0.07955	41	0.7	14:48	177	125.10	0	0	1	0.32	0	0	0	0
36	10	12	840	0.08200	42	1.0	16:27	502	256.50	0	0	0	0	0	0	0	0
37	10	12	690	0.07596	43	1.2	18:42	501	171.20	0	0	1	0.24	0	0	6	1.33
38	10	12	683	0.07371	45	1.2	21:18	339	105.10	0	0	0	0	0	0	0	0
39	10	13	635	0.06646	45	1.2	2:53	756	255.45	0	0	2	1.20	3	0.35	0	0
40	10	13	1383	0.07861	48	0.1	6:46	22	22.20	0	0	0	0	0	0	0	0
41	10	13	1173	0.07632	47	0.4	9:38	52	46.10	0	0	1	0.40	0	0	0	0
42	10	13	1297	0.08074	48	0.3	11:57	41	47.80	0	0	1	0.87	0	0	0	0
43	10	13	918	0.07679	46	1.1	15:30	311	134.60	0	0	2	0.28	0	0	0	0
44	10	13	1293	0.07774	48	-0.1	22:02	29	20.19	0	0	0	0	0	0	0	0
45	10	14	1210	0.08121	47	0.2	1:22	165	120.95	0	0	0	0	0	0	0	0
46	10	14	1090	0.08160	47	0.6	3:39	353	246.75	0	0	2	2.02	0	0	0	0
47	10	14	849	0.07821	46	1.2	8:06	658	255.80	0	0	0	0	0	0	0	0
48	10	14	412	0.06914	44	0.7	12:34	18	6.40	0	0	0	0	5	0.37	0	0
49	10	14	1106	0.05301	50	0.8	16:54	125	60.00	0	0	0	0	0	0	0	0
50	10	14	528	0.06922	52	0.2	22:42	42	13.60	0	0	0	0	8	0.75	0	0
51	10	15	1263	0.07916	49	0.4	1:47	60	56.75	0	0	1	1.19	0	0	0	0
52	10	15	1016	0.07521	50	0.7	4:52	1042	572.80	0	0	0	0	0	0	0	0
53	10	15	1283	0.07703	49	0.2	8:37	115	144.65	0	0	1	0.33	0	0	0	0
54	10	15	893	0.07308	51	1.0	11:04	370	163.50	0	0	1	1.68	0	0	1	0.31
55	10	15	592	0.07695	52	1.0	13:26	157	48.15	0	0	0	0	0	0	0	0
56	10	15	885	0.07821	51	1.0	17:07	202	72.50	0	0	0	0	0	0	0	0
57	10	15	629	0.07182	58	1.2	19:54	31	8.95	0	0	0	0	0	0	0	0
58	10	15	1130	0.07356	60	0.7	23:05	426	288.70	0	0	0	0	0	0	0	0
59	10	16	825	0.07600	59	1.1	2:14	190	53.45	0	0	0	0	0	0	0	0
60	10	16	1019	0.07805	60	0.8	5:18	214	91.35	0	0	0	0	0	0	0	0
61	10	16	1283	0.07537	61	0.2	8:58	254	271.95	0	0	0	0	0	0	0	0
62	10	16	1320	0.08184	61	0.0	12:02	340	445.95	0	0	0	0	0	0	0	0
63	10	16	678	0.07403	58	1.2	14:03	101	28.20	0	0	0	0	1	0.14	0	0
64	10	16	866	0.07829	59	1.0	16:05	77	15.50	0	0	0	0	0	0	0	0
65	10	16	467	0.06953	56	0.8	17:48	14	3.75	0	0	0	0	0	0	0	0
66	10	16	421	0.06784	56	0.5	21:16	61	15.65	0	0	0	0	0	0	1	0.14
Total All Tows								11935	6724.54	1	0.07	32	15.78	432	29.77	33	6.98

Table 4. Mean temperature, S.E. and number of observations for NAFO Division 0A by depth stratum measured during the October, 1999 survey.

Depth Stratum (m)	401-500	501-750	751-1000	1001-1250	1251-1500
°C	1.6	1.4	1.0	0.6	0.1
S.E.	0.50	0.16	0.03	0.05	0.04
Number obs.	8	18	12	12	15

Table 5. Biomass estimates (tons) of Greenland halibut by stratum for NAFO Division 0A, 1999.

Depth (m)	Stratum	Area (sq. nm)	Area (sq. km)	No. tows	Mean Biomass (t/sq. km)	SE	Biomass (tons)
401-500	24	457	1567.51	2	0.80179	0.32462	1257
	34	75	257.25	2	0.14706	0.01042	38
	44	375	1286.25	2	0.51585	0.42328	664
	53	276	946.68	0	.	.	.
	55	334	1145.62	0	.	.	.
	56	200	686.00	2	0.14232	0.08838	98
Subtotal		1717	5889.31	8	0.40175	0.14610	2056
501-750	25	1780	6105.40	7	0.46198	0.07351	2821
	33	184	631.12	2	0.47770	0.13038	301
	43	609	2088.87	3	1.04957	0.60950	2192
	45	348	1193.64	2	2.63482	1.20904	3145
	52	635	2178.05	2	0.41111	0.21463	895
	54	852	2922.36	0	.	.	.
	57	652	2236.36	0	.	.	.
	58	350	1200.50	2	0.25277	0.12816	303
Subtotal		5410	18556.30	18	0.77419	0.21659	9658
751-1000	30	1099	3769.57	3	1.78259	0.87877	6720
	42	577	1979.11	3	1.66235	0.74148	3290
	46	370	1269.10	2	2.51172	0.75891	3188
	51	574	1968.82	2	1.58208	0.65510	3115
	59	600	2058.00	2	0.45063	0.25264	927
Subtotal		3220	11044.60	12	1.61864	0.33124	17239
1001-1250	41	698	2394.14	3	1.64312	0.06302	3934
	31	496	1701.28	2	5.01151	3.65674	8526
	47	883	3028.69	3	1.70573	0.70684	5166
	50	650	2229.50	2	4.37378	3.24189	9751
	60	671	2301.53	2	2.54761	1.37726	5863
Subtotal		3398	11655.14	12	2.82603	0.76396	33241
1251-1500	32	301	1032.43	2	0.31568	0.05555	326
	40	1671	5731.53	6	0.91056	0.43760	5219
	48	843	2891.49	3	0.37807	0.10720	1093
	49	712	2442.16	2	1.29741	0.58049	3168
	61	730	2503.90	2	4.52860	0.92045	11339
Subtotal		4257	14601.51	15	1.25873	0.40478	21146
Overall					1.37487	0.20901	83340

Table 6. Abundance estimates (000's) of Greenland halibut by stratum for NAFO Division 0A, 1999.

Depth (m)	Stratum	Area (sq. nm)	Area (sq. km)	No. tows	Mean Abundance (sq. km)	SE	Abundance
401-500	24	457	1567.51	2	2490.10	913.02	3903
	34	75	257.25	2	397.12	61.00	102
	44	375	1286.25	2	1631.16	1370.82	2098
	53	276	946.68	0	.	.	.
	55	334	1145.62	0	.	.	.
	56	200	686.00	2	550.28	348.93	377
Subtotal		1717	5889.31	8	1267.17	452.66	6481
501-750	25	1780	6105.40	7	1090.27	188.14	6657
	33	184	631.12	2	1083.54	291.64	684
	43	609	2088.87	3	3048.33	1790.00	6368
	45	348	1193.64	2	7987.33	3388.50	9534
	52	635	2178.05	2	1323.55	716.77	2883
	54	852	2922.36	0	.	.	.
	57	652	2236.36	0	.	.	.
	58	350	1200.50	2	897.97	466.34	1078
Subtotal		5410	18556.3	18	2186.76	653.02	27203
751-1000	30	1099	3769.57	3	3085.47	1484.76	11631
	42	577	1979.11	3	3255.20	1450.46	6442
	51	574	1968.82	2	3822.73	1239.98	7526
	46	370	1269.10	2	6231.54	2181.59	7908
	59	600	2058.00	2	1741.72	758.20	3584
Subtotal		3220	11044.6	12	3551.17	682.97	37092
1001-1250	31	496	1701.28	2	7397.54	6019.19	12585
	41	698	2394.14	3	2012.50	160.15	4818
	47	883	3028.69	3	2346.32	1063.75	7106
	50	650	2229.50	2	8106.02	5747.91	18072
	60	671	2301.53	2	4266.58	1524.87	9820
Subtotal		3398	11655.14	12	4384.73	1306.62	52402
1251-1500	32	301	1032.43	2	345.86	29.76	357
	40	1671	5731.53	6	724.08	347.17	4150
	48	843	2891.49	3	386.92	66.17	1119
	49	712	2442.16	2	1125.47	367.49	2749
	61	730	2503.90	2	3762.22	392.23	9420
Subtotal		4257	14601.51	15	1064.82	322.86	17795
Overall					2472.34	364.09	140973

Table 7. Length distribution (2cm groups) in total numbers (000's) for Greenland halibut from NAFO Division 0A. Upper and lower 95% confidence limits are also given.

Length	Total Numbers	Upper Limit	Lower Limit
6.5	11.63	34.83	-11.56
8.5	40.97	95.8	-13.87
10.5	0		
12.5	60.15	106.44	13.86
14.5	60.15	106.44	13.86
16.5	23.27	53.21	-6.68
18.5	252.4	394.01	110.79
20.5	503.99	804.98	203
22.5	612.03	864.78	359.27
24.5	1818.02	2320.36	1315.68
26.5	4317.48	5241.6	3393.36
28.5	7765.27	9779.93	5750.62
30.5	9232.06	11769.22	6694.9
32.5	10995.68	14219.85	7771.51
34.5	13090.57	17295.79	8885.35
36.5	13044.88	17344.46	8745.3
38.5	14006.11	19133.62	8878.6
40.5	13940.41	19286.14	8594.69
42.5	12436.99	17414.89	7459.1
44.5	10379.3	14650.09	6108.51
46.5	8759.71	12137.64	5381.78
48.5	6025.76	8098.48	3953.05
50.5	4631.52	5900.8	3362.23
52.5	3328.21	4507.98	2148.44
54.5	2197.03	2890.52	1503.53
56.5	1617.82	2183.87	1051.77
58.5	1258.18	1847.69	668.68
60.5	676.23	1046.37	306.08
62.5	701.01	1154.66	247.36
64.5	363.57	587.31	139.82
66.5	263.14	439.66	86.62
68.5	138.65	242.63	34.66
70.5	80.75	148.78	12.72
72.5	129.36	211.38	47.35
74.5	49.97	97.17	2.77
76.5	0		
78.5	11.63	34.83	-11.56
80.5	11.35	33.97	-11.28
82.5	12.74	38.15	-12.66
84.5	0		
86.5	0		
88.5	0		
90.5	0		
92.5	0		
94.5	8.46	25.34	-8.41
Total	142856.45	192543.67	93169.24

Table 8. Adjusted age-length distribution (000's) for both sexes combined for Greenland halibut from Div. 0A, 1999. The age-length key from the Div. 1CD survey in 1999 was applied to the Division 0A length data.

Length	Age (yr.)														
(mm)	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
18.5	110	0	0	0	0	0	0	0	0	0	0	0	0	0	110
20.5	175	0	0	0	0	0	0	0	0	0	0	0	0	0	175
22.5	159	80	0	0	0	0	0	0	0	0	0	0	0	0	239
24.5	270	1548	0	0	0	0	0	0	0	0	0	0	0	0	1818
26.5	0	4317	0	0	0	0	0	0	0	0	0	0	0	0	4317
28.5	0	7178	588	0	0	0	0	0	0	0	0	0	0	0	7766
30.5	0	7765	1467	0	0	0	0	0	0	0	0	0	0	0	9232
32.5	0	4641	6356	0	0	0	0	0	0	0	0	0	0	0	10997
34.5	0	0	13091	0	0	0	0	0	0	0	0	0	0	0	13091
36.5	0	404	11834	808	0	0	0	0	0	0	0	0	0	0	13046
38.5	0	0	6280	7233	0	494	0	0	0	0	0	0	0	0	14007
40.5	0	0	0	13148	792	0	0	0	0	0	0	0	0	0	13940
42.5	0	0	566	9449	2423	0	0	0	0	0	0	0	0	0	12438
44.5	0	0	0	3652	6727	0	0	0	0	0	0	0	0	0	10379
46.5	0	0	0	616	5568	1540	0	0	0	0	0	0	0	0	7724
48.5	0	0	0	0	4923	1102	0	0	0	0	0	0	0	0	6025
50.5	0	0	0	0	454	4178	0	0	0	0	0	0	0	0	4632
52.5	0	0	0	0	0	3231	98	0	0	0	0	0	0	0	3329
54.5	0	0	0	0	0	1382	695	120	0	0	0	0	0	0	2197
56.5	0	0	0	0	0	550	1068	0	0	0	0	0	0	0	1618
58.5	0	0	0	0	0	78	953	228	0	0	0	0	0	0	1259
60.5	0	0	0	0	0	4	482	63	127	0	0	0	0	0	676
62.5	0	0	0	0	0	0	224	184	196	49	0	0	0	0	653
64.5	0	0	0	0	0	0	33	70	163	65	0	0	0	0	331
66.5	0	0	0	0	0	0	0	9	131	94	28	0	0	0	262
68.5	0	0	0	0	0	0	0	0	38	96	5	0	0	0	139
70.5	0	0	0	0	0	0	0	0	0	27	45	9	0	0	81
72.5	0	0	0	0	0	0	0	0	0	24	94	12	0	0	130
74.5	0	0	0	0	0	0	0	0	0	0	43	7	0	0	50
78.5	0	0	0	0	0	0	0	0	0	0	9	3	0	0	12
80.5	0	0	0	0	0	0	0	0	0	0	0	8	2	2	12
82.5	0	0	0	0	0	0	0	0	0	0	0	10	3	0	13
94.5	0	0	0	0	0	0	0	0	0	0	0	0	8	0	8
total	714	25933	40182	34906	20887	12559	3553	674	655	355	224	49	13	2	140182

Table 9. Estimates of biomass (tons) and abundance of thorny skate (raja radiata) by stratum for NAFO Division 0A, 1999.

Depth (m)	Stratum	Area (sq. km)	No. sets	Mean Biomass (t/sq. km)	SE	Biomass (tons)	Mean Abundance (sq. km)	SE	Abundance
401-500	24	1567.51	2	0.03033	.	48	80.88	.	126780
	34	257.25	2	0.01432	.	4	14.32	.	3684
	44	1286.25	2	0.01474	.	19	67.61	.	86963
	53	946.68	0	.	.	.	.	.	.
	55	1145.62	0	.	.	.	.	.	.
	56	686.00	2	0.01251	.	9	14.38	.	9865
Subtotal		5889.31	8			79			227292
501-750	25	6105.40	7	0.00578	0.00097	35	19.29	6.05	117773
	33	631.12	2	0.00709	0.00472	4	24.64	3.15	15551
	43	2088.87	3	0.04311	0.01751	90	87.5	29.38	182776
	45	1193.64	2	0.01419	0.00833	17	41.44	26.39	49464
	52	2178.05	2	.	.	.	.	.	.
	54	2922.36	0	.	.	.	.	.	.
	57	2236.36	0	.	.	.	.	.	.
	58	1200.50	2	.	.	.	.	.	.
Subtotal		18556.30	18			147			365565
751-1000	30	3769.57	3	.	.	.	.	.	.
	42	1979.11	3	0.00805	.	16	12.2	.	24145
	46	1269.10	2	.	.	.	.	.	.
	51	1968.82	2	.	.	.	.	.	.
	59	2058.00	2	.	.	.	.	.	.
Subtotal		11044.60	12			16			24145
1001-1250	31	1701.28	2	.	.	.	.	.	.
	41	2394.14	3	.	.	.	.	.	.
	47	3028.69	3	.	.	.	.	.	.
	60	2301.53	2	.	.	.	.	.	.
	50	2229.50	2	.	.	.	.	.	.
Subtotal		11655.14	12						
1251-1500	32	1032.43	2	.	.	.	.	.	.
	40	5731.53	6	.	.	.	.	.	.
	48	2891.49	3	.	.	.	.	.	.
	49	2442.16	2	.	.	.	.	.	.
	61	2503.90	2	.	.	.	.	.	.
Subtotal		14601.51	15						
Overall				0.01881	0.00512	241	44.47	10.22	617002

Table 10. Estimates of biomass (tons) and abundance of arctic skate (raja hyperborea) by stratum for NAFO Division 0A, 1999.

Depth (m)	Stratum	Area (sq. km)	No. sets	Mean Biomass (t/sq. km)	SE	Biomass (tons)	Mean Abundance (sq. km)	SE	Abundance
401-500	24	1567.51	2	.	.	.	.	.	.
	34	257.25	2	.	.	.	.	.	.
	44	1286.25	2	.	.	.	.	.	.
	53	946.68	0	.	.	.	.	.	.
	55	1145.62	0	.	.	.	.	.	.
	56	686.00	2	.	.	.	.	.	.
Subtotal		5889.31	8						.
501-750	25	6105.40	7	0.00038	0.00000	1	12.81	0.01	78210
	33	631.12	2	.	.	.	.	.	.
	43	2088.87	3	0.00404	0.00272	8	25.76	12.52	53809
	45	1193.64	2	.	.	.	.	.	.
	52	2178.05	2	.	.	.	.	.	.
	54	2922.36	0	.	.	.	.	.	.
	57	2236.36	0	.	.	.	.	.	.
	58	1200.50	2	0.00230	.	5	67.54	.	81082
Subtotal		18556.30	18			14			213101
751-1000	30	3769.57	3	0.08619	.	526	39.54	.	149049
	42	1979.11	3	0.00298	.	7	24.8	.	49082
	46	1269.10	2	0.00102	.	1	12.79	.	16232
	51	1968.82	2	.	.	.	.	.	.
	59	2058.00	2	0.00728	0.00601	9	19.54	6.77	40213
Subtotal		11044.60	12			543			254576
1001-1250	31	1701.28	2	0.03941	0.00170	149	31.46	4.81	53522
	41	2394.14	3	.	.	.	.	.	.
	47	3028.69	3	0.02480	0.01633	31	16.66	3.99	50458
	50	2229.50	2	.	.	.	.	.	.
	60	2301.53	2	.	.	.	.	.	.
Subtotal		11655.14	12			180			103980
1251-1500	32	1032.43	2	0.56357	0.02518	959	451.88	101.31	466534
	40	5731.53	6	0.12770	0.03642	33	111.55	34.39	639352
	48	2891.49	3	0.03246	0.00978	98	42.42	11.61	122657
	49	2442.16	2	0.09802	.	283	38.95	.	95122
	61	2503.90	2	0.06843	.	157	48.88	.	122391
Subtotal		14601.51	15			1531			1446056
Overall				0.08665	0.02808	2268	77.21	22.86	2017714

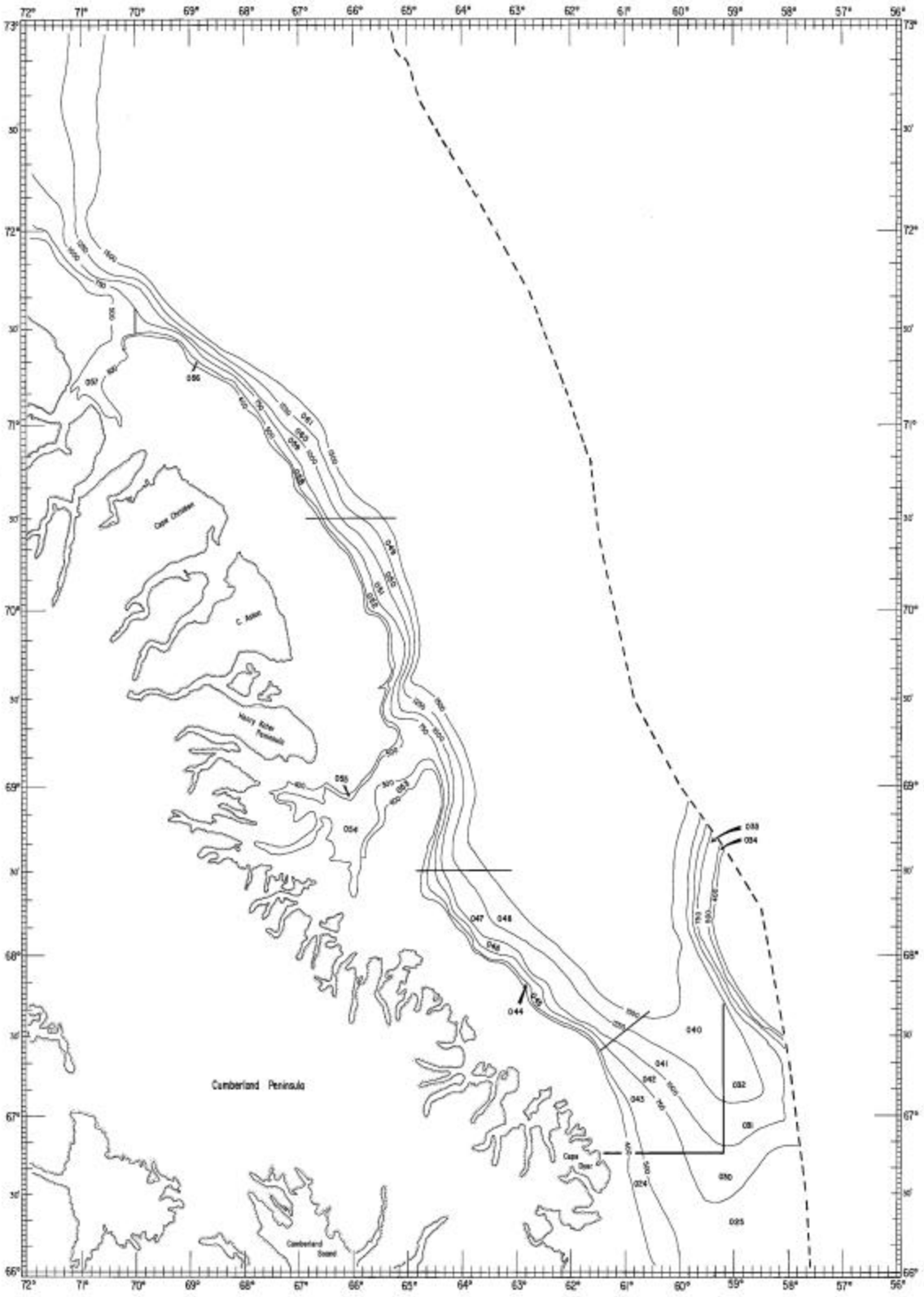

Figure 1. Stratification scheme for North Atlantic Fisheries Organization Division 0A.

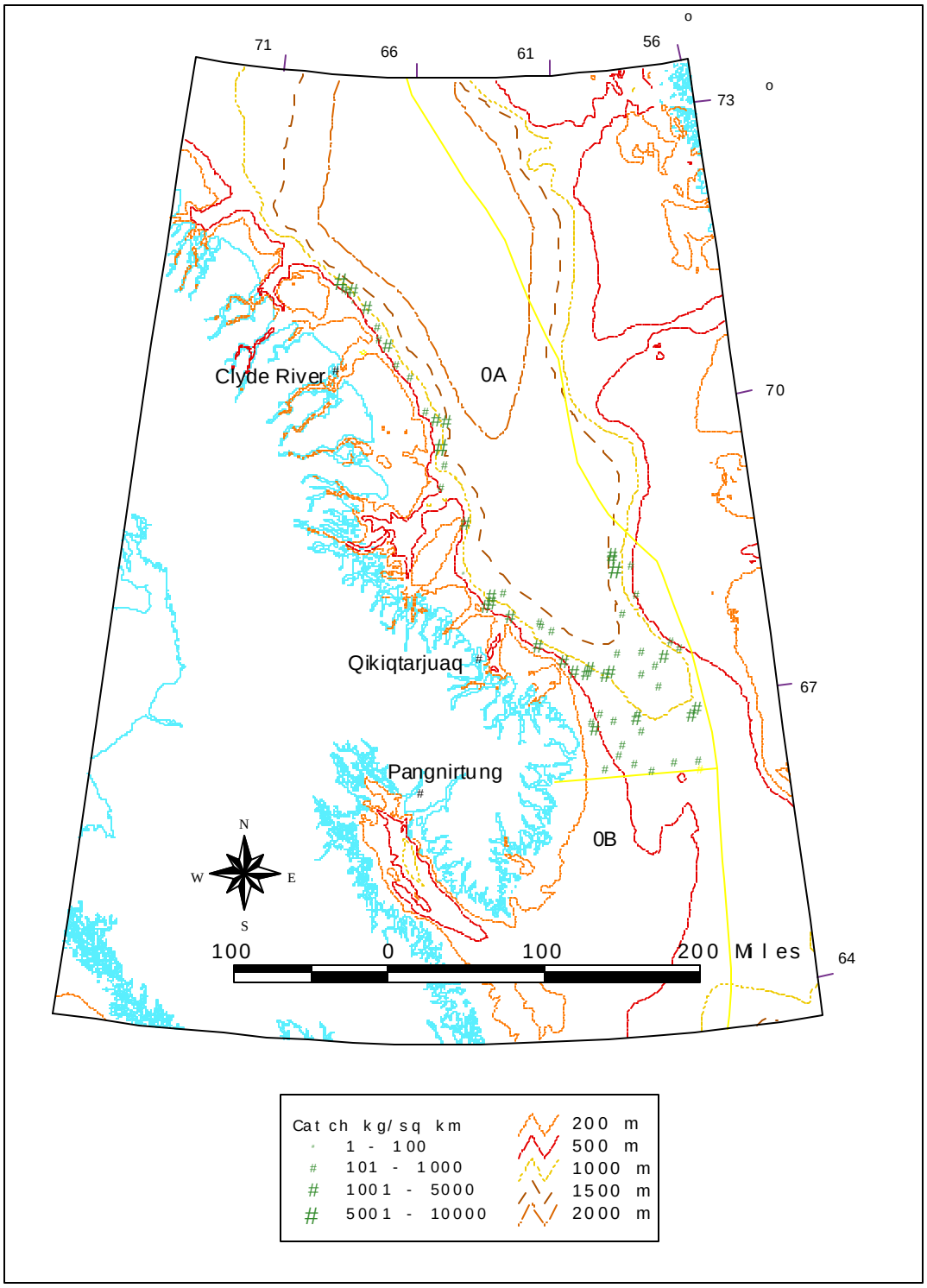

Figure 2. Distribution of catches of Greenland halibut from NAFO Division 0A in 1999.

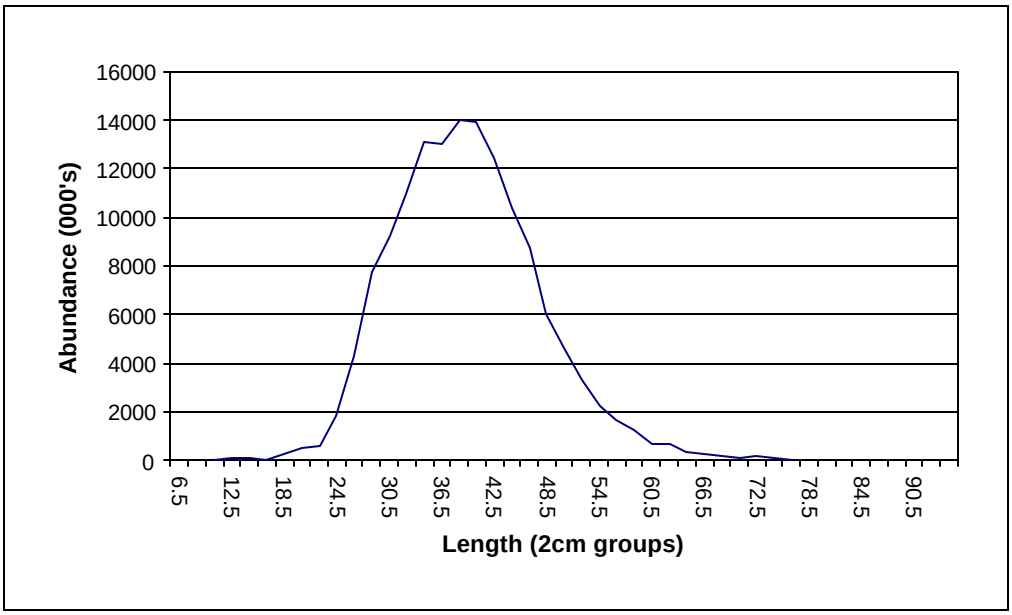

Figure 3. Abundance at length for Greenland halibut from NAFO Division 0A in 1999.

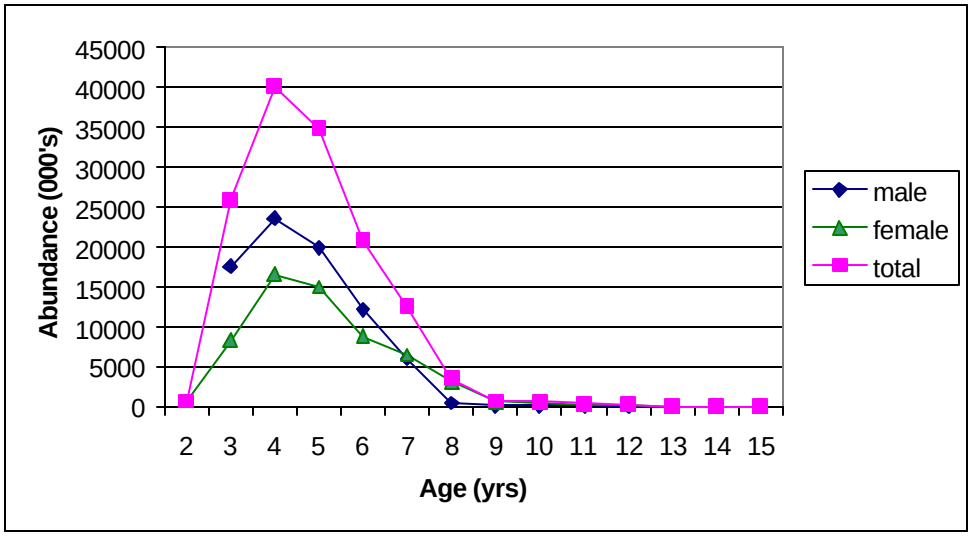

Figure 4. Abundance at age for male, female and both sexes combined for Greenland halibut from NAFO Division 0A in 1999.

Appendix 1. List of species caught during the 1999 NAFO Division 0A survey, including minimum and maximum weight, minimum and maximum numbers per tow (not standardized to km^2 swept), minimum and maximum length, minimum and maximum depth, minimum and maximum temperature and minimum and maximum latitude.

Obs	Sp. Code	Species name	No. of Tows	Min. Wt. (kg)	Max. Wt. (kg)	Min. No.	Max. No.	Min. Depth (m)	Max. Depth (m)	Min. Temp. (C)	Max Temp. (C)	Min. Latitude (N)	Max. Latitude (N)
1	20	Somniosus microcephalus	2			2	3	467	635	0.8	1.2	67° 37'0	71° 08'6
2	90	Raja radiata	14	0.11	5.90	1	11	443	840	0.8	4.0	66° 20'9	71° 08'6
3	94	Raja fyllae	1	0.20	0.20	1	1	451	451	4.0	4.0	67° 34'8	67° 34'8
4	95	Raja hyperborea	28	0.03	44.70	1	42	572	1482	-0.1	1.3	66° 21'3	71° 21'2
5	165	Alepocephalus agassizii	1	0.14	0.14	1	1	1337	1337	0.3	0.3	67° 20'9	67° 20'9
6	202	Bathylagus euryops	16	0.01	0.07	1	4	412	1383	-0.1	1.2	66° 48'9	71° 16'2
7	208	Cyclothone microdon	12	0.01	0.01	1	2	678	1437	0.0	1.2	67° 19'8	71° 16'0
8	230	Stomias boa ferox	2	0.02	0.05	1	3	598	656	1.2	1.3	66° 21'3	66° 35'6
9	283	Lampanyctus macdonaldi	1	0.01	0.01	1	1	1187	1187	0.5	0.5	67° 25'7	67° 25'7
10	290	Benthosema glaciale	47	0.01	0.82	1	194	412	1395	-0.1	2.3	66° 20'9	71° 16'0
11	320	Arctozenus rissoi	2	0.03	0.06	1	1	635	1048	0.7	1.2	67° 22'3	67° 37'0
12	386	Notacanthus chemnitzi	5	0.60	1.33	1	2	611	1139	0.5	2.3	66° 21'1	68° 21'9
13	438	Gadus morhua	1	0.78	0.78	3	3	458	458	3.8	3.8	68° 05'6	68° 05'6
14	451	Boreogadus saida	32	0.01	80.25	1	4293	412	1389	-0.1	4.0	66° 17'4	71° 16'2
15	452	Arctogadus glacialis	2	0.02	0.06	1	2	572	797	1.1	1.2	66° 48'2	66° 53'7
16	454	Gaidropsarus ensis	54	0.01	7.85	1	37	510	1482	-0.1	2.6	66° 16'4	71° 21'2
17	455	Gaidropsarus argentatus	8	0.01	0.60	1	1	683	1389	0.1	1.2	66° 48'2	68° 31'5
18	474	Macrourus berglax	21	0.01	2.26	1	4	443	1297	0.2	2.6	66° 17'4	69° 58'4
19	481	Coryphaenoides rupestris	1	0.07	0.07	1	1	521	521	1.2	1.2	66° 28'8	66° 28'8
20	699	Anarhichas denticulatus	1	1.52	1.52	1	1	451	451	4.0	4.0	67° 34'8	67° 34'8
21	701	Anarhichas minor	1	0.22	0.22	2	2	458	458	3.8	3.8	68° 05'6	68° 05'6
22	723	Lycodes luetkeni	1	0.04	0.04	1	1	635	635	1.2	1.2	67° 37'0	67° 37'0
23	724	Lycodes adolfi	7	0.01	0.04	1	3	1187	1482	-0.1	0.5	67° 20'9	68° 11'3
24	725	Lycodes sp. 1 (new)	17	0.03	0.31	1	9	572	1337	0.2	2.3	66° 17'4	70° 54'1
25	1	Lycodes sp. 2 (new)	1	0.08	0.08	1	1	592	592	1.0	1.0	70° 02'9	70° 02'9
26	729	Lycodes reticulatus	5	0.21	3.73	1	8	412	635	0.2	1.2	66° 20'9	70° 47'1
27	736	Lycodes eudipleurostictus	31	0.02	1.11	1	27	443	1187	0.5	4.0	66° 16'4	71° 16'0
28	740	Lycodes pallidus	1	0.40	0.40	1	1	412	412	0.7	0.7	68° 23'8	68° 23'8

Obs	Sp. Code	Species name	No. of Tows	Min. Wt. (kg)	Max. Wt. (kg)	Min. No.	Max. No.	Min. Depth (m)	Max. Depth (m)	Min. Temp. (C)	Max Temp. (C)	Min. Latitude (N)	Max. Latitude (N)
29	743	Lycodonus mirabilis	3	0.01	0.01	1	2	1288	1383	0.1	0.3	67° 08’2	67° 47’6
30	747	Lycenchelys muraena	2	0.01	0.01	1	1	1139	1337	0.3	0.5	67° 19’8	67° 20’9
31	751	Lycenchelys sarsi	1	0.01	0.01	1	1	451	451	4.0	4.0	67° 34’8	67° 34’8
32	793	Sebastes marinus	3	0.96	4.65	2	7	451	552	3.0	4.0	67° 34’8	68° 23’8
33	794	Sebastes mentella	24	0.03	8.15	1	130	412	1437	0.0	4.0	66° 16’4	71° 16’0
34	811	Artediellus atlanticus	17	0.03	1.62	1	27	412	885	0.2	4.0	66° 20’9	71° 16’0
35	815	Triglops nybelini	14	0.01	1.26	1	162	412	1263	0.2	4.0	66° 49’6	71° 08’6
36	829	Cottunculus microps	17	0.01	0.70	1	15	552	1342	0.2	3.0	66° 17’4	71° 14’7
37	836	Leptagonus decagonus	4	0.01	0.02	1	1	412	457	0.5	1.1	66° 20’9	70° 47’1
38	844	Eumicrotremus spinosus	2	0.07	0.08	1	2	412	528	0.2	0.7	68° 23’8	69° 16’2
39	852	Rhodichthys regina	15	0.02	0.36	1	8	1130	1482	0.0	0.7	67° 16’8	70° 42’5
40	855	Paraliparis bathybius	11	0.03	0.70	1	17	1173	1482	-0.1	0.4	67° 16’8	69° 30’2
41	859	Liparis fabricii	62	0.02	2.62	1	57	412	1482	-0.1	3.8	66° 17’4	71° 21’2
42	863	Careproctus spp.	8	0.01	0.10	1	5	1139	1482	0.0	0.5	67° 08’2	67° 54’5
43	865	Careproctus reinhardti	3	0.03	0.07	1	2	412	635	0.7	1.2	67° 37’0	71° 08’6
44	889	Hippoglossoides platessoides	12	0.11	1.66	1	8	421	893	0.5	4.0	66° 28’8	70° 47’1
45	892	Reinhardtius hippoglossoides	65	3.75	650.60	12	1042	412	1482	-0.1	4.0	66° 16’4	71° 21’2
46	1100	Invertebrata	64	0.06	102.70			412	1482	-0.1	4.0	66° 17’4	71° 21’2
47	4770	Gonatus fabricii	2	0.02	0.43	1	3	521	608	1.2	2.4	66° 16’4	66° 28’8
48	4846	Octopoda	1	0.17	0.17	1	1	521	521	1.2	1.2	66° 28’8	66° 28’8
49	8111	Pandalus borealis	1	0.19	0.19			608	608	2.4	2.4	66° 16’4	66° 16’4