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Length–Weight Relationships for Greenland Halibut (*Reinhardtius hippoglossoides*) in NAFO Divisions 2GHJ and 3KLMNO, 1990-1997

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Abstract

Based on data from the annual Canadian fall surveys, length-weight relationships of Greenland halibut (Reinhardtius hippoglossides) were estimated for NAFO Divisions 2GHJ and 3KLMNO for the years 1990-1997. The relationship between length and weight varied between different areas within one year, and also between years.

The estimated weight for a 50 cm Greenland halibut varied over the time period investigated. The overall trend in all divisions is a decrease in estimated round weight until 1995, followed by an increase in round weight in 1996, stabilizing in 1997.

Key words: Greenland halibut, Northwest Atlantic, length-weight

Introduction

The fishery for Greenland halibut in NAFO Subareas 2 and 3 began in the early 1960s. Catches increased from fairly low levels in the early 1960s to over 36,000 tons by 1969 and ranged from 24,000 tons to 39,000 tons over the next 15 years, before declining in the late 1980's to around 20,000 tons (Brodie et al. 1998). In the early 1990's, an intense fishery for Greenland halibut developed in the deepwater areas of the NAFO Regulatory Area (NRA) of Div 3L and 3M. The development of this fishery resulted in a rapid escalation of catches to between 47,000 and 65,000 tons in each year from 1990 to 1994, although some estimates were nearer 75,000 tons in at least one of these years. As a result of management measures introduced by the NAFO Fisheries Commission in 1995 (extensive quota restrictions and 100% observer coverage in the NRA), catches were greatly reduced to about 15,000 to 20,000 tons from 1995 to 1997.

The assessment of this stock, conducted annually in NAFO Scientific Council, relies on the interpretation of research vessel surveys and commercial catch rate indices. No analytical assessments, based on sequential population models (SPA) have been successfully completed for this stock in recent years. This is due mainly to uncertainties in catch and catch at age data, and because there are no survey series which are long enough or cover enough of the stock to be used as indices of abundance, to calibrate SPA.

An additional consideration in the analysis of the Canadian survey data has been the switch in trawl gears, in 1995, from a lined commercial otter trawl, Engel 145, to a lined shrimp trawl, Campelen 1800 (McCallum and Walsh 1996). These are very different trawl gears, which is reflected in the amount and sizes of fish caught by each net. To allow comparisons of the data from the two different time periods, length based conversion factors were derived from comparative fishing experiments between the two gears (Warren 1996). To convert population numbers at length to biomass, one of the length-weight equations of Bowering and Stansbury, (1984) was used. However, this showed a difference of about 10% between the calculated biomass (from lengths) and the actual biomass, based on set by set catch data.

One possible source of this difference is obviously the length weight relationship. The relationship between length and weight of an individual fish may vary from one year to another due to variations in growth, feeding, health of the fish, and other factors. The relationship is sometimes used as an index of condition, or in analyses of condition factors. This paper examines data collected in the 1990's, to establish annual relationships between length and weight for the different areas covered by the annual Canadian fall survey in NAFO Subareas 2 and 3.

Materials and Methods

Data on Greenland halibut were collected during the annual autumn stratified random surveys conducted on Canadian research vessels from 1990 to 1997. Table 1 shows the vessels and trawls involved in the various surveys.The Engel trawls used on the *Gadus Atlantica* and *Wilfred Templeman* were similar, but not identical, while the Campelen trawl used in the 1995-97 period were identical on all ships (McCallum and Walsh 1996). Surveys were generally conducted during October to December, although have some sets occurred in late September, and the 1995 survey was actually completed in early 1996. Most depths from 100 to 1500 meters were fished in each Division, although waters deeper than about 700 meters were poorly sampled in Divs. 3NO (Brodie et al 1998).

Samples were collected from NAFO Divisions 2G, 2H, 2J, 3K, 3L, 3M, 3N, and 3O, although only Divisions 2J, 3K, and 3L were sampled in each year (Table 2, Fig. 1). Other areas, such as Divisions 2GH and 3M, were not surveyed each year. Samples were generally spread by depth to cover the main distribution of Greenland halibut throughout the survey area (Fig. 1). For each year, sample size within a division usually exceeded 100 fish for each sex, with the exception of some samples in Divs. 3MNO.

The weights of individual fish were collected at sea, using electronic balances. Each fish that was sampled for otoliths, using length stratified sampling by sex, had its whole weight recorded in kilograms to 3 decimal places. All lengths were recorded on measuring boards in centimeters, from the tip of the snout to the fork of the tail. The data appeared consistent, and only 3 individuals (from 1990) had to be removed from the analysis due to obvious errors in measurement.

The relation between round weight and length was obtained from regressions of the data, using log transformations of both length and weight. Equations for the length-weight relationships were obtained by retransformation of the data. Microsoft Excel '97 was used to carry out all analyses.

Results and Discussion

Relations of length and weight varied over the period investigated. The length-weight relationships estimated for the entire surveyed area each year are given in Table 3. The length-weight relationships for the different divisions and each year are given in tables 4-11.

Figure 2 shows the round weight versus total length for Greenland halibut in NAFO Division 2J, 3KL, and total (all divisions) for 1997. The number of observations was in the same range for the three divisions: 417-470 (Fig.2). The length-weight relationship estimated for Greenland halibut caught on the northern Grand Bank (NAFO Division 3L) concurred with the relationship estimated for all individuals sampled during the fall survey in 1997 (Divisions 2GHJ and 3KLMNO). Relationships for Divs. 3K and 2J indicated a slightly lower round weight than 3L and Total for the same length groups.

A closer examination of the data from Div. 3K was made for the years 1990-1997. Length-weight relationships by sex and for all individuals from the 1997 survey in Div 3K are shown in Figure 3. When the 1997 data for females and males are graphed in the same plot (Figure 4) no difference in the length-weight relationship between sexes was observed. This may, however, vary from one year to another.

A comparison of estimated round weight for Greenland halibut in selected length groups was conducted for the investigated period. Lengths of 30 cm, 50 cm and 70 cm were chosen (Figure 5). The estimated length-weight relationships for each year (total surveyed area) were used as a basis for the comparison. For the largest size group, there was a decrease from 1993 to 1995 and then an increase between 1995 and 1996. The same trend was observed for the 50 cm fish, whereas 30 cm fish showed a different pattern. The highest estimated round weight for a 30 cm

Greenland halibut was observed in 1991. A drop was observed every year up to 1996, except for an increase from 1993-94. The variation in trends in the estimated round weight for the various length groups (eg. the different trend seen for 30 cm Greenland halibut compared to 50 cm and 70 cm) may reflect the different year-classes passing through the system, or the different conditions for fish of various sizes.

For the different NAFO Divisions variations were observed for fish of the same length groups when comparing the length-weight relationships obtained within a year. Figure 6 illustrates the relationships for the different NAFO Divisions and the total for Greenland halibut of lengths30, 40, 50, 60 and 70 cm. For Greenland halibut sized 50-70 cm, Divisions 2J and 3K had the lowest estimated round weight, and 3LM the highest. For Greenland halibut sized 30 and 40cm, Divisions 2H and 3M had the lowest estimated round weight and 3L the highest. The reasons for these differences are not immediately obvious, but are likely related to the distribution of G. halibut with respect to depth and temperature in the various NAFO Divisions. As well, not all Divisions are sampled over all depths where this species occurs (eg. Div. 3M was not surveyed in waters less than 731 m in 1997).

The estimated weights for Greenland halibut sized 30, 50 and 70 cm over the years 1990-1997 were compared across NAFO Divisions (Figure 7-9). The trend in Div. 2J was more or less a decrease in estimated weight for the Greenland halibut sized 50 and 70 cm from 1990-1995. A substantial increase in estimated weight was observed from 1995 to 1996, followed by a slight decrease in 1997. Only data from 1996 and 1997 were available for divisions 2GH, and both years were at the same level. For 30 cm Greenland halibut, the lowest estimated round weight was observed in 1993 (Division 2J). A large increase in estimated weight was observed from 1993 to 1994. This happened one year earlier than was observed for older Greenland halibut, and may be explained by distribution patterns of the species related to age and size. The younger Greenland halibut in the survey area inhabits shallower water, which has different characteristics with respect to temperature, salinity, and prey availability. In the Barents Sea, nursery grounds (for fish less than 40cm) are located in the waters north and east of Spitsbergen, which is further north than the distribution areas of the older fish (Gundersen *et al*. 1997).

In Divisions 3KL data were available for the entire period (Figure 7-9). Fish sized 50 and 70 cm varied with respect to estimated weight, although weights were generally estimated to be lower in 1995-97 than in most other years. Round weight estimated for Greenland halibut in 3L was usually higher than in 3K. Exceptions to this were 1995 when Greenland halibut in Division 3K showed a higher estimated weight than 3L, and 1996 when the estimated weights were at the same level both for 50 and 70 cm fish. Also, for Greenland halibut sized 30 cm, Div. 3L showed higher estimated round weights than 3K. Exceptions were observed here as well, such as 1990.

Figure 10 shows the estimated round weight for 50 cm Greenland halibut for all Divisions and years, also including data from 1980-1982 (Bowering and Stansbury 1984). As mentioned previously, the estimated weight for a 50 cm Greenland halibut varied over the time period investigated. The overall trend in all divisions seem to be a decrease in estimated round weight until 1995, when the trend seem to change to an increased round weight in 1996, stabilizing in 1997. The estimated round weights presented by Bowering and Stansbury (1984) are at the level calculated for 1996-1997.

As noted previously, length-weight relationships from Bowering and Stansbury (1984) were used in recent assessments of this Greenland halibut stock to convert population abundance at length from fall surveys into population biomass at length. This produced a discrepancy in the 1997 estimate of about 8% between this calculated biomass at length and the swept-area biomass estimated from the set by set catch weights during the survey (301 thousand tons from the former calculation vs 324 thousand tons from the latter). A similar difference existed for the 1996 survey also (Brodie et al. 1998). Using our length- weight relationship (the 1997 values in Table 3), the calculated biomass at length from the 1997 survey (323.1 thousand tons) was virtually identical to the swept area estimate of 323.8 thousand tons. A fundamental difference in the methodology of Bowering and Stansbury (1984) is that frozen then thawed fish were used, as electronic balances were not available for use with fresh specimens at sea. The thawing process may have resulted in a slight weight loss, which could explain the consistently lower weights at length in their study compared to ours.

Comparison of the estimated round weight of a 50 cm. fish from the relationships calculated in Bowering and Stansbury (1984) with those calculated in our paper showed little difference (Fig. 10), particularly for the 1997 data (1.052 kg. vs 1.054 from the 1984 paper). However, further comparisons showed that a 30 cm fish had an estimated weight of 0.210 kg using the 1997 relationship compared to only 0.191 kg using the 1984 regression. The explanation for the similarity at 50 cm and the difference at 30 cm can be found in the shape of the curve of the 2 regression lines. Given the predominance of fish less than 35 cm in the biomass from the 1997 survey, this fundamental difference in the 1984 and 1997 relationships easily explains the discrepancy noted in the 1998 assessment between the length-based biomass and the swept area estimate. The updated length-weight relationships presented here will be used to correct the biomass at length calculations for the period 1990-97.

Future work on the length-weight relationships for Greenland halibut should include analyses such as ANCOVA to test for significant differences in the regression lines, examination of possible explanatory variables such as temperature, and extension of the work into areas such as condition factors

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Table 1. Vessels and type of trawl used in the fall surveys during the years 1990-1997.

Years	**Research Vessels**	**Trawl gears**
1990-94	*Gadus Atlantica, Wilfred Templeman*	Engel 145
1995-97	*Teleost, Wilfred Templeman, Alfred Needler*	Campelen 1800

Table 2. Samples taken during the Fall survey, 1990-1997 indicating the number of measurements on length and weight for the different divisions and with respect to sex. Areas are referred to as NAFO Divisions 2G, 2H, …,3O.

		NAFO Division								
	Year	**2G**	**2H**	**2J**	**3K**	**3L**	**3M**	**3N**	**3O**	**Total**
Both sexes	1990			553	512	662				1 727
	1991			511	562	611				1 684
	1992			504	430	789				1 723
	1993			472	510	543		290	143	1 958
	1994			639	449	701		258	54	2 101
	1995			449	569	501		400	104	2 073
	1996	343	619	722	699	661	349	314	131	3 838
	1997	325	346	417	470	447	105	115	80	2 305
Females	1990			320	297	371				988
	1991			269	296	339				904
	1992			254	229	429				912
	1993			229	274	291		179	81	1 054
	1994			325	226	358		145	36	1 090
	1995			262	290	255		209	67	1 083
	1996	184	306	381	361	336	204	168	71	2 011
	1997	158	180	212	235	244	58	64	41	1 192
Males	1990			233	215	291				739
	1991			242	266	272				780
	1992			250	201	360				811
	1993			243	236	252		111	62	904
	1994			314	223	342		113	18	1 010
	1995			232	269	231		183	36	951
	1996	159	309	339	333	323	145	144	55	1 807
	1997	166	165	194	232	200	47	50	39	1 093

Table 3. Re-transformed length-weight relationships for Greenland halibut, for the areas investigated, 1990-1997. W = round weight (kg) and L = total length (cm).

Year	Sex	Re-transformed Equations	N	r^2
1990	All	$W = 4.721 * 10^{-6} L^{3.159}$	1 727	0.982
1991	All	$W = 6.826 * 10^{-6} L^{3.058}$	1 684	0.988
1992	All	$W = 5.353 * 10^{-6} L^{3.122}$	1 723	0.985
1993	All	$W = 4.486 * 10^{-6} L^{3.164}$	1 958	0.988
1994	All	$W = 7.413 * 10^{-6} L^{3.029}$	2 101	0.985
1995	All	$W = 8.713 *10^{-6} L^{2.974}$	2 073	0.979
1996	All	$W = 4.095 *10^{-6} L^{3.187}$	3 838	0.991
1997	All	$W = 4.538 *10^{-6} L^{3.158}$	2 305	0.989

Table 4. Re-transformed length-weight relationships for Greenland halibut estimated for each NAFO Division investigated in 1990.
a) Both sexes, b) females and c) males.

a)

Year	Area	Sex	Re-transformed Equations	N	R^2
1990	2 G				
	2 H				
	2 J	All	$W = 3.903 *10^{-6} L^{3.209}$	553	0.981
	3 K	All	$W = 5.155 *10^{-6} L^{3.140}$	512	0.984
	3 L	All	$W = 5.344 *10^{-6} L^{3.123}$	662	0.981
	3 M				
	3 N				
	3O				

b)

Year	Area	Sex	Re-transformed Equations	N	R^2
1990	2 G				
	2 H				
	2 J	Females	$W = 4.252 *10^{-6} L^{3.190}$	320	0.981
	3 K	Females	$W = 5.143 *10^{-6} L^{3.143}$	297	0.982
	3 L	Females	$W = 4.470 *10^{-6} L^{3.174}$	371	0.985
	3 M				
	3 N				
	3O				

c)

Year	Area	Sex	Re-transformed Equations	N	r^2
1990	2 G				
	2 H				
	2 J	Males	$W = 3.641 *10^{-6} L^{3.222}$	233	0.979
	3 K	Males	$W = 5.560 *10^{-6} L^{3.133}$	215	0.987
	3 L	Males	$W = 6.894 *10^{-6} L^{3.049}$	291	0.975
	3 M				
	3 N				
	3O				

Table 5. Re-transformed length-weight relationships for Greenland halibut estimated for each NAFO Division investigated in 1991.
a) Both sexes, b) females and c) males..

a)

Year	Area	Sex	Re-transformed Equations	N	r^2
1991	2 G				
	2 H				
	2 J	All	$W = 8.616 *10^{-6} L^{2.982}$	511	0.988
	3 K	All	$W = 6.940 *10^{-6} L^{3.052}$	562	0.989
	3 L	All	$W = 5.244 *10^{-6} L^{3.138}$	611	0.988
	3 M				
	3 N				
	3O				

b)

Year	Area	Sex	Re-transformed Equations	N	r^2
1991	2 G				
	2 H				
	2 J	Females	$W = 7.905 *10^{-6} L^{3.011}$	269	0.990
	3 K	Females	$W = 5.631 *10^{-6} L^{3.133}$	296	0.993
	3 L	Females	$W = 4.347 *10^{-6} L^{3.191}$	339	0.990
	3 M				
	3 N				
	3O				

c)

Year	Area	Sex	Re-transformed Equations	N	r^2
1991	2 G				
	2 H				
	2 J	Males	$W = 1.005 *10^{-5} L^{2.931}$	242	0.985
	3 K	Males	$W = 8.123 *10^{-6} L^{2.979}$	266	0.986
	3 L	Males	$W = 6.470 *10^{-6} L^{3.079}$	272	0.986
	3 M				
	3 N				
	3O				

Table 6. Re-transformed length-weight relationships for Greenland halibut estimated for each NAFO Division investigated in 1992.
a) Both sexes, b) females and c) males.

a)

Year	Area	Sex	Re-transformed Equations	N	r^2
1992	2 G				
	2 H				
	2 J	All	$W = 7.786 * 10^{-6} L^{3.001}$	504	0.986
	3 K	All	$W = 5.623 * 10^{-6} L^{3.114}$	430	0.982
	3 L	All	$W = 3.730 * 10^{-6} L^{3.232}$	789	0.990
	3 M				
	3 N				
	3O				

b)

Year	Area	Sex	Re-transformed Equations	N	r^2
1992	2 G				
	2 H				
	2 J	Females	$W = 6.281 * 10^{-6} L^{3.065}$	254	0.992
	3 K	Females	$W = 6.606 * 10^{-6} L^{3.070}$	229	0.978
	3 L	Females	$W = 3.716 * 10^{-6} L^{3.235}$	429	0.991
	3 M				
	3 N				
	3O				

c)

Year	Area	Sex	Re-transformed Equations	N	r^2
1992	2 G				
	2 H				
	2 J	Males	$W = 9.330 * 10^{-6} L^{2.945}$	250	0.981
	3 K	Males	$W = 4.471 * 10^{-6} L^{3.172}$	201	0.990
	3 L	Males	$W = 3.772 * 10^{-6} L^{3.225}$	360	0.988
	3 M				
	3 N				
	3O				

Table 7. Re-transformed length-weight relationships for Greenland halibut estimated for each NAFO Division investigated in 1993.
a) Both sexes, b) females and c) males.

a)

Year	Area	Sex	Re-transformed Equations	N	r^2
1993	2 G				
	2 H				
	2 J	All	$W = 4.574 *10^{-6} L^{3.148}$	472	0.992
	3 K	All	$W = 4.304 *10^{-6} L^{3.181}$	510	0.989
	3 L	All	$W = 5.358 *10^{-6} L^{3.130}$	543	0.985
	3 M				
	3 N	All	$W = 3.831 *10^{-6} L^{3.197}$	290	0.991
	3O	All	$W = 3.160 *10^{-6} L^{3.248}$	143	0.994

b)

Year	Area	Sex	Re-transformed Equations	N	r^2
1993	2 G				
	2 H				
	2 J	Females	$W = 4.248 *10^{-6} L^{3.173}$	229	0.992
	3 K	Females	$W = 3.844 *10^{-6} L^{3.215}$	274	0.990
	3 L	Females	$W = 5.107 *10^{-6} L^{3.145}$	291	0.984
	3 M				
	3 N	Females	$W = 3.458 *10^{-6} L^{3.225}$	179	0.991
	3O	Females	$W = 3.231 *10^{-6} L^{3.245}$	81	0.995

c)

Year	Area	Sex	Re-transformed Equations	N	r^2
1993	2 G				
	2 H				
	2 J	Males	$W = 4.975 *10^{-6} L^{3.120}$	243	0.992
	3 K	Males	$W = 4.942 *10^{-6} L^{3.140}$	236	0.989
	3 L	Males	$W = 5.761 *10^{-6} L^{3.108}$	252	0.986
	3 M				
	3 N	Males	$W = 4.745 *10^{-6} L^{3.133}$	111	0.990
	3O	Males	$W = 3.779 *10^{-6} L^{3.188}$	62	0.985

Table 8. Re-transformed length-weight relationships for Greenland halibut estimated for each NAFO Division investigated in 1994.
a) Both sexes, b) females and c) males.

a)

Year	Area	Sex	Re-transformed Equations	N	r^2
1994	2 G				
	2 H				
	2 J	All	$W = 9.555 *10^{-6} L^{2.952}$	639	0.984
	3 K	All	$W = 7.714 *10^{-6} L^{3.019}$	449	0.985
	3 L	All	$W = 5.000 *10^{-6} L^{3.150}$	701	0.988
	3 M				
	3 N	All	$W = 3\text{-}966 *10^{-6} L^{3.197}$	258	0.990
	3O	All	$W = 3.141 *10^{-6} L^{3.261}$	54	0.991

b)

Year	Area	Sex	Re-transformed Equations	N	r^2
1994	2 G				
	2 H				
	2 J	Females	$W = 5.793 *10^{-6} L^{3.099}$	325	0.987
	3 K	Females	$W = 6.934 *10^{-6} L^{3.054}$	226	0.990
	3 L	Females	$W = 5.574 *10^{-6} L^{3.120}$	358	0.988
	3 M				
	3 N	Females	$W = 4.772 *10^{-6} L^{3.148}$	145	0.989
	3O	Females	$W = 2.978 *10^{-6} L^{3.275}$	36	0.992

c)

Year	Area	Sex	Re-transformed Equations	N	r^2
1994	2 G				
	2 H				
	2 J	Males	$W = 1.343 *10^{-5} L^{2.847}$	314	0.984
	3 K	Males	$W = 8.644 *10^{-6} L^{2.982}$	223	0.979
	3 L	Males	$W = 4.252 *10^{-6} L^{3.194}$	342	0.989
	3 M				
	3 N	Males	$W = 3.213 *10^{-6} L^{3.252}$	113	0.992
	3O	Males	$W = 3.688 *10^{-6} L^{3.217}$	18	0.987

Table 9. Re-transformed length-weight relationships for Greenland halibut estimated for each NAFO Division investigated in 1995.
a) Both sexes, b) females and c) males.

a)

Year	Area	Sex	Re-transformed Equations	N	r^2
1995	2 G				
	2 H				
	2 J	All	$W = 1.172 * 10^{-5} L^{2.884}$	449	0.982
	3 K	All	$W = 6.275 * 10^{-6} L^{3.078}$	569	0.986
	3 L	All	$W = 1.073 * 10^{-5} L^{2.923}$	501	0.976
	3 M				
	3 N	All	$W = 6.505 * 10^{-6} L^{3.045}$	400	0.977
	3O	All	$W = 6.436 * 10^{-6} L^{3.046}$	104	0.980

b)

Year	Area	Sex	Re-transformed Equations	N	r^2
1995	2 G				
	2 H				
	2 J	Females	$W = 1.014 * 10^{-5} L^{2.930}$	262	0.984
	3 K	Females	$W = 5.753 * 10^{-6} L^{3.104}$	290	0.988
	3 L	Females	$W = 7.640 * 10^{-6} L^{3.025}$	255	0.977
	3 M				
	3 N	Females	$W = 3.473 * 10^{-6} L^{3.231}$	209	0.989
	3O	Females	$W = 3.373 * 10^{-6} L^{3.237}$	67	0.992

c)

Year	Area	Sex	Re-transformed Equations	N	r^2
1995	2 G				
	2 H				
	2 J	Males	$W = 1.248 * 10^{-5} L^{2.860}$	232	0.980
	3 K	Males	$W = 4.723 * 10^{-6} L^{3.159}$	269	0.989
	3 L	Males	$W = 1.055 * 10^{-5} L^{2.925}$	231	0.976
	3 M				
	3 N	Males	$W = 5.861 * 10^{-6} L^{3.070}$	183	0.978
	3O	Males	$W = 8.411 * 10^{-6} L^{2.954}$	36	0.978

Table 10. Re-transformed length-weight relationships for Greenland halibut estimated for each NAFO Division investigated in 1996.
a) Both sexes, b) females and c) males.

a)

Year	Area	Sex	Re-transformed Equations	N	r^2
1996	2 G	All	$W = 4.160 * 10^{-6} L^{3.190}$	343	0.991
	2 H	All	$W = 3.518 * 10^{-6} L^{3.220}$	619	0.993
	2 J	All	$W = 3.797 * 10^{-6} L^{3. 209}$	722	0.991
	3 K	All	$W = 4.249 * 10^{-6} L^{3.179}$	699	0.995
	3 L	All	$W = 5.213 * 10^{-6} L^{3.127}$	661	0.991
	3 M	All	$W = 3.875 * 10^{-6} L^{3.205}$	349	0.993
	3 N	All	$W = 4.655 * 10^{-6} L^{3.140}$	314	0.987
	3O	All	$W = 7.306 * 10^{-6} L^{2.996}$	131	0.984

b)

Year	Area	Sex	Re-transformed Equations	N	r^2
1996	2 G	Females	$W = 3.803 * 10^{-6} L^{3.221}$	184	0.993
	2 H	Females	$W = 3.169 * 10^{-6} L^{3.250}$	306	0.995
	2 J	Females	$W = 3.682 * 10^{-6} L^{3.221}$	381	0.992
	3 K	Females	$W = 3.683 * 10^{-6} L^{3.222}$	361	0.992
	3 L	Females	$W = 4.586 * 10^{-6} L^{3.164}$	336	0.992
	3 M	Females	$W = 3.370 * 10^{-6} L^{3.246}$	204	0.993
	3 N	Females	$W = 4.729 * 10^{-6} L^{3.138}$	168	0.987
	3O	Females	$W = 3.689 * 10^{-6} L^{2.200}$	71	0.991

c)

Year	Area	Sex	Re-transformed Equations	N	R^2
1996	2 G	Males	$W = 4.909 * 10^{-6} L^{3.135}$	159	0.988
	2 H	Males	$W = 3.526 * 10^{-6} L^{3.218}$	309	0.993
	2 J	Males	$W = 3.592 * 10^{-6} L^{3.220}$	339	0.992
	3 K	Males	$W = 3.773 * 10^{-6} L^{3.208}$	333	0.992
	3 L	Males	$W = 5.457 * 10^{-6} L^{3.111}$	323	0.992
	3 M	Males	$W = 4.975 * 10^{-6} L^{3.130}$	145	0.993
	3 N	Males	$W = 3.940 * 10^{-6} L^{3.185}$	144	0.989
	3O	Males	$W = 9.669 * 10^{-6} L^{2.902}$	55	0.975

Table 11. Re-transformed length-weight relationships for Greenland halibut estimated for each NAFO Division investigated in 1997.
a) Both sexes, b) females and c) males.

a)

Year	Area	Sex	Re-transformed Equations	N	r^2
1997	2 G	All	$W = 3.192 * 10^{-6} L^{3.254}$	325	0.993
	2 H	All	$W = 2.979 * 10^{-6} L^{3.267}$	346	0.995
	2 J	All	$W = 5.532 * 10^{-6} L^{3.102}$	417	0.988
	3 K	All	$W = 6.440 * 10^{-6} L^{3.062}$	470	0.984
	3 L	All	$W = 5.045 * 10^{-6} L^{3.136}$	447	0.989
	3 M	All	$W = 2.491 * 10^{-6} L^{3.314}$	105	0.973
	3 N	All	$W = 3.526 * 10^{-6} L^{3.222}$	115	0.989
	3O	All	$W = 3.562 * 10^{-6} L^{3.220}$	80	0.988

b)

Year	Area	Sex	Re-transformed Equations	N	r^2
1997	2 G	Females	$W = 2.764 * 10^{-6} L^{3.298}$	158	0.994
	2 H	Females	$W = 2.679 * 10^{-6} L^{3.299}$	180	0.995
	2 J	Females	$W = 3.980 * 10^{-6} L^{3.195}$	212	0.992
	3 K	Females	$W = 6.755 * 10^{-6} L^{3.054}$	235	0.977
	3 L	Females	$W = 5.092 * 10^{-6} L^{3.138}$	244	0.991
	3 M	Females	$W = 1.919 * 10^{-6} L^{3.380}$	58	0.985
	3 N	Females	$W = 2.326 * 10^{-6} L^{3.341}$	64	0.991
	3O	Females	$W = 3.124 * 10^{-6} L^{3.261}$	41	0.980

c)

Year	Area	Sex	Re-transformed Equations	N	R^2
1997	2 G	Males	$W = 3.882 * 10^{-6} L^{3.195}$	166	0.992
	2 H	Males	$W = 3.457 * 10^{-6} L^{3.221}$	165	0.994
	2 J	Males	$W = 4.350 * 10^{-6} L^{3.166}$	194	0.990
	3 K	Males	$W = 5.436 * 10^{-6} L^{3.104}$	232	0.991
	3 L	Males	$W = 5.054 * 10^{-6} L^{3.130}$	200	0.985
	3 M	Males	$W = 4.972 * 10^{-6} L^{3.132}$	47	0.927
	3 N	Males	$W = 2.914 * 10^{-6} L^{3.272}$	50	0.989
	3O	Males	$W = 4.057 * 10^{-6} L^{3.177}$	39	0.992

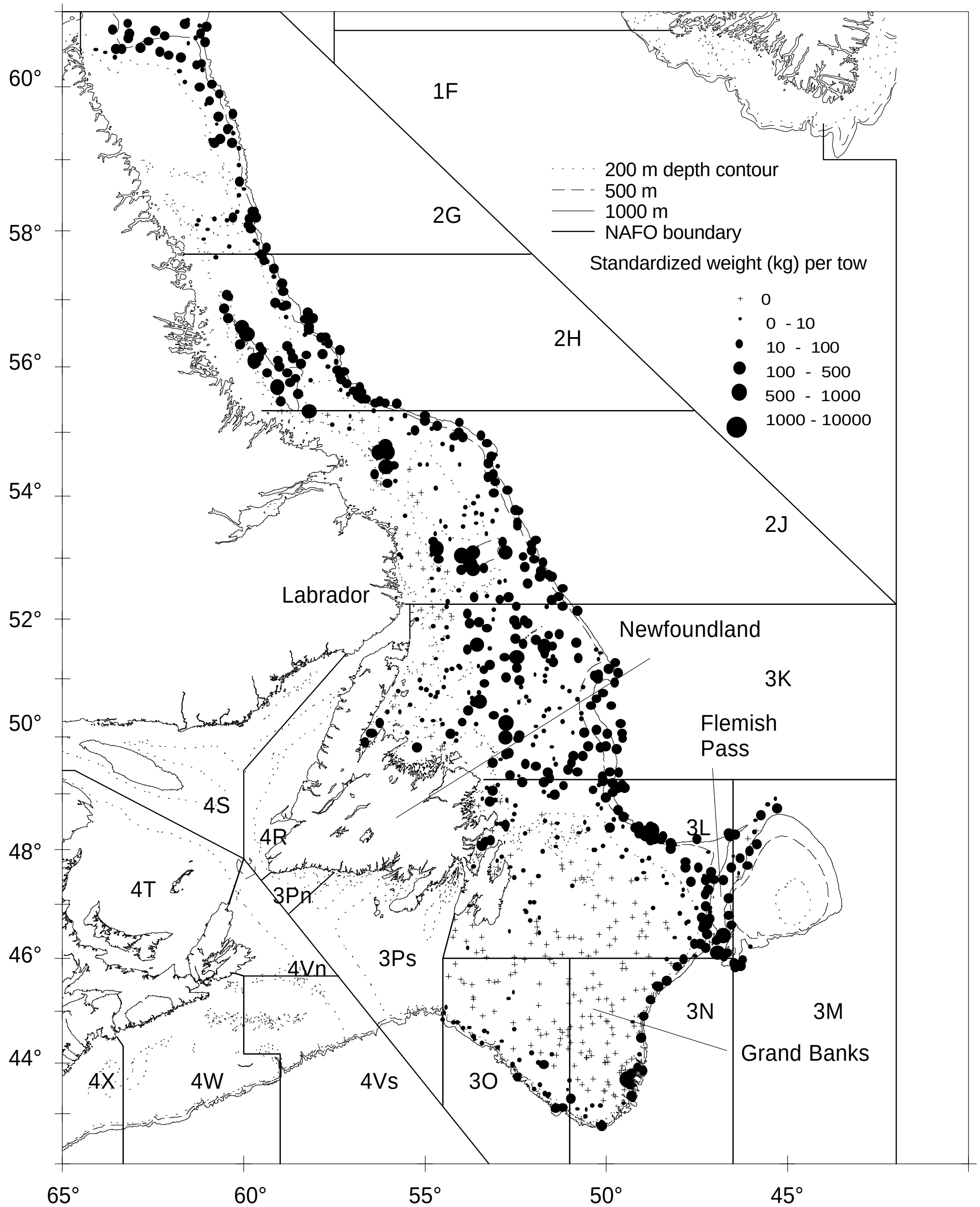


Fig. 1. Map illustrating the NAFO Divisions and sampling areas during the fall survey of 1997. Catches of Greenland halibut are indicated by circles, which vary in size according to the amount of Greenland halibut caught.

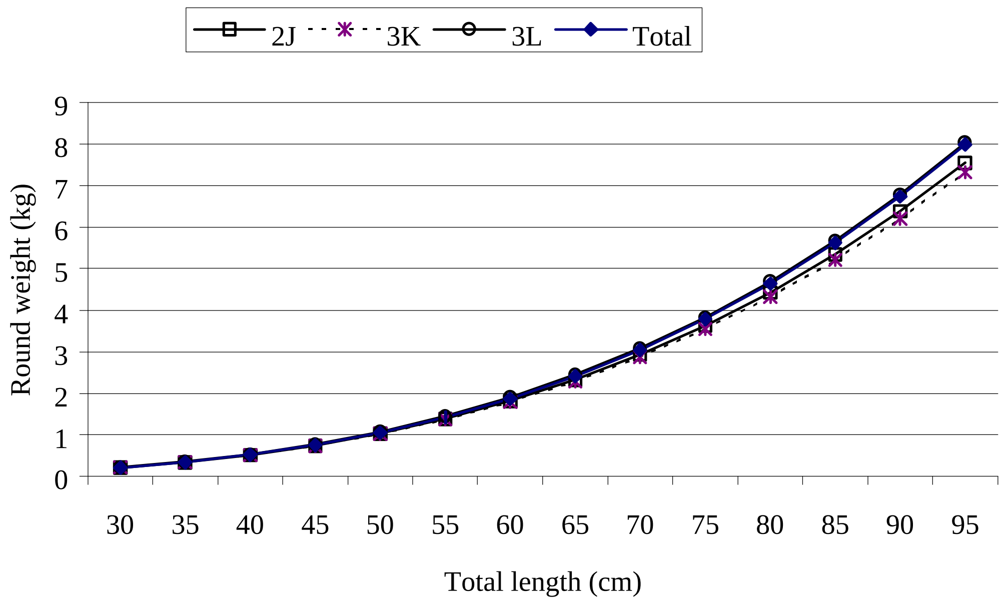


Fig. 2. Regression lines (re-transformed) for Greenland halibut in NAFO Division 2J (N = 417), 3K (N = 470), 3L (N = 447) and Total (N = 2305) for 1997.

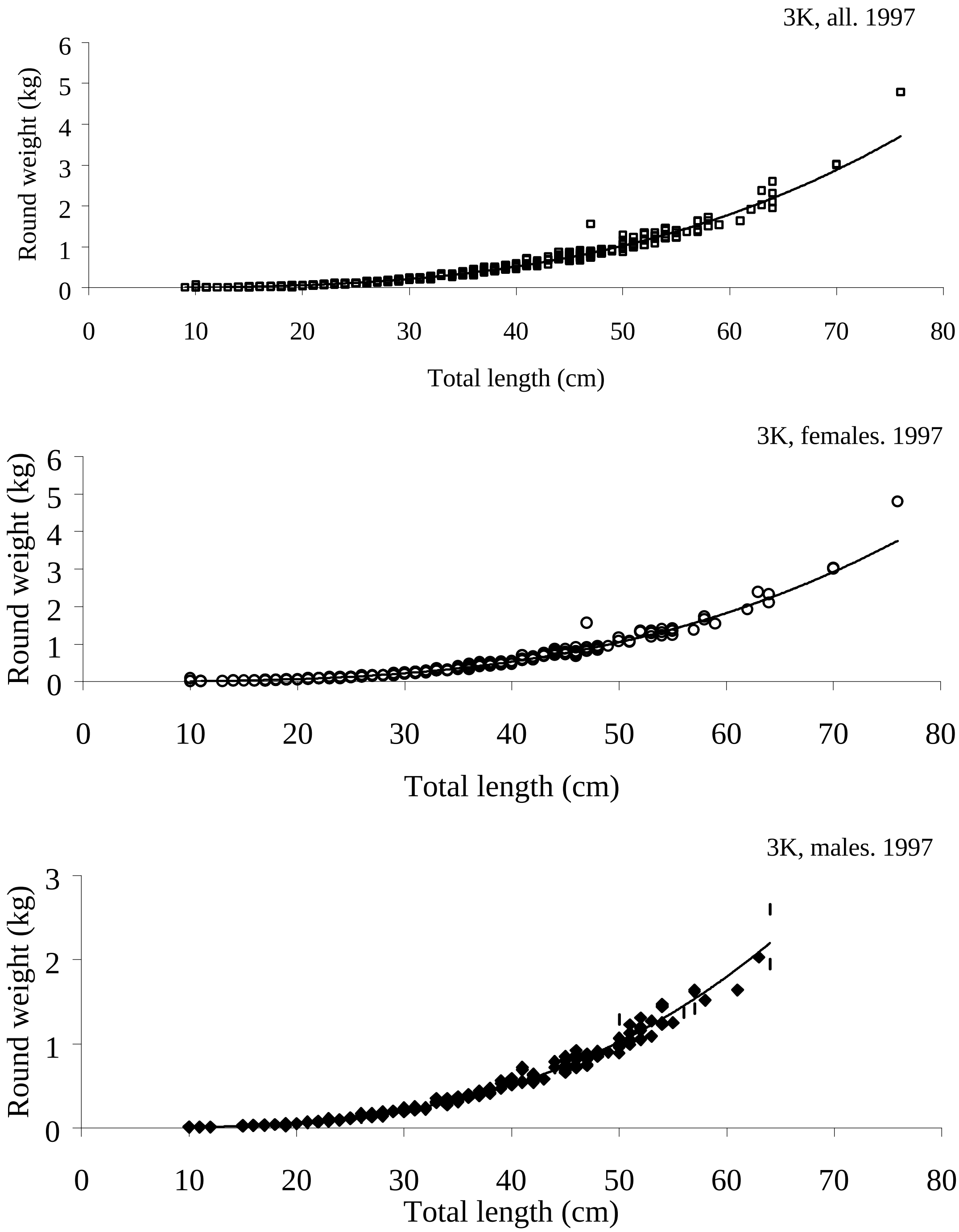


Fig. 3. Regression lines (re-transformed) for Greenland halibut in NAFO Division 3K from 1997. Data are shown for males+females, and for each sex separately.

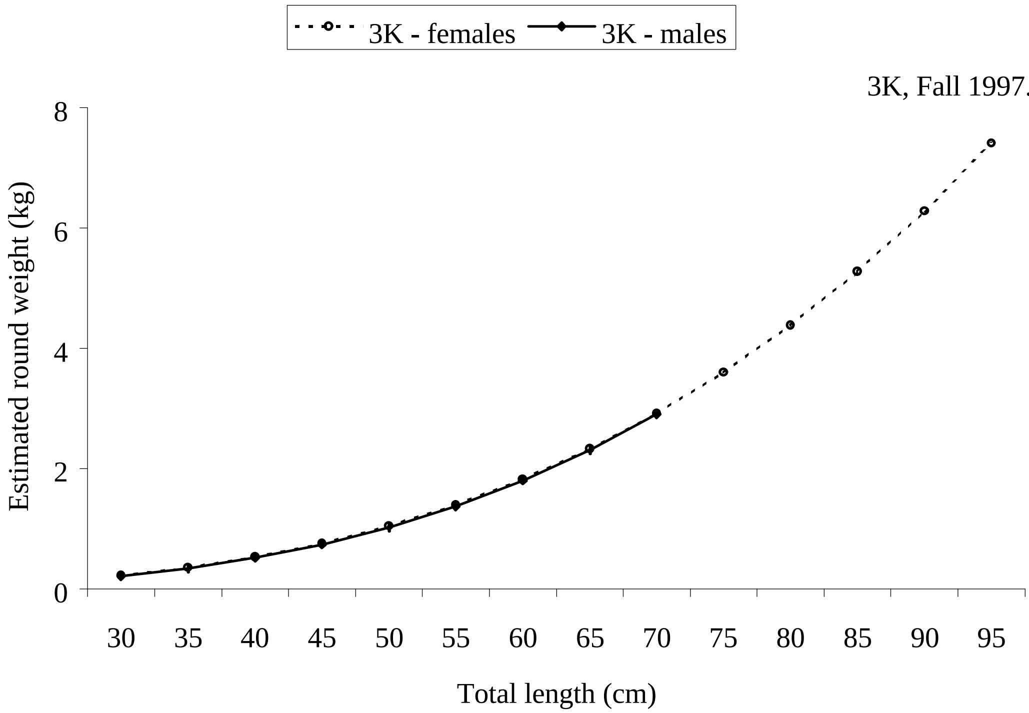


Fig. 4. Comparison of length- weight regressions of male and female Greenland halibut in NAFO Division 3K, during fall survey 1997.

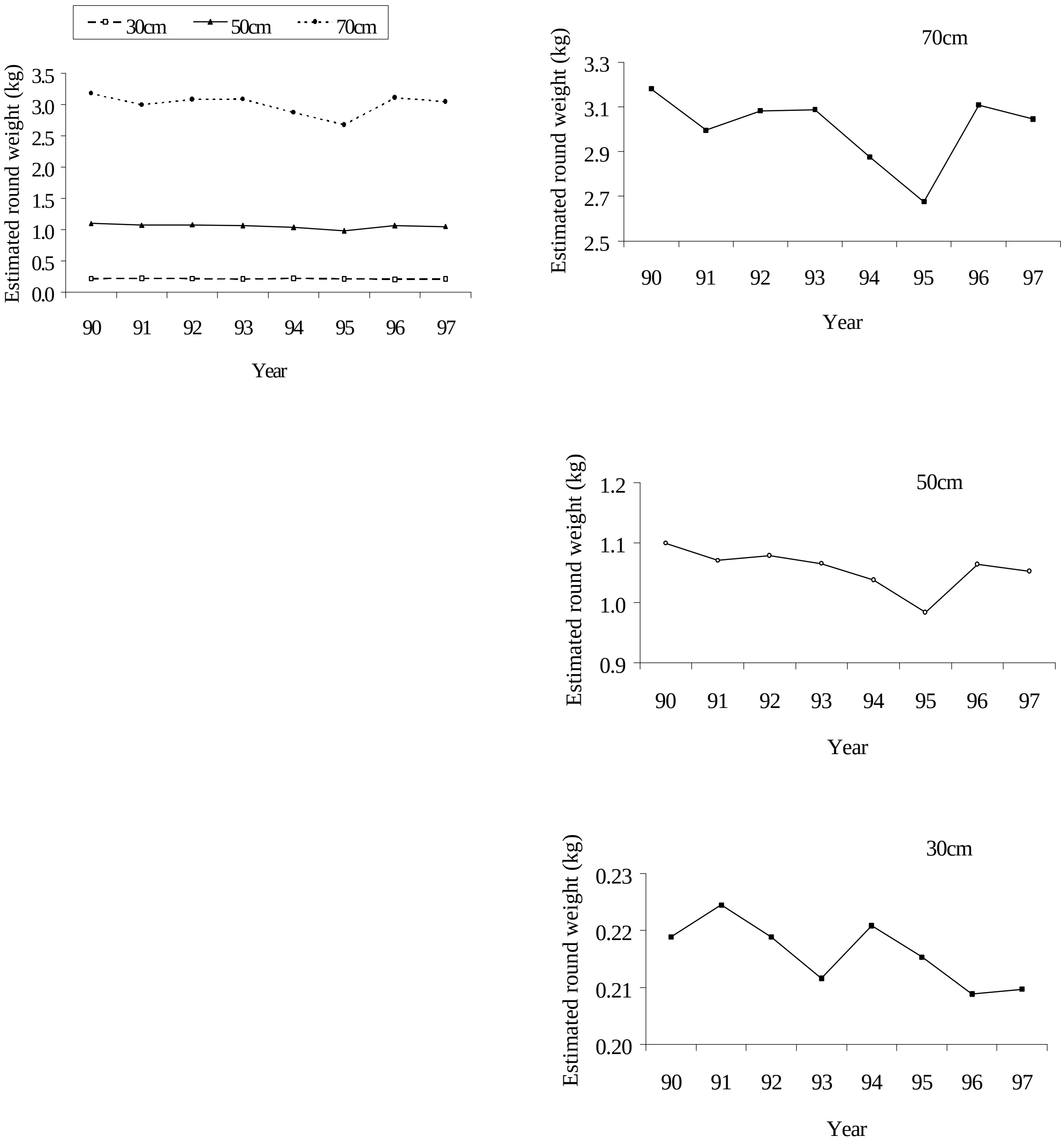
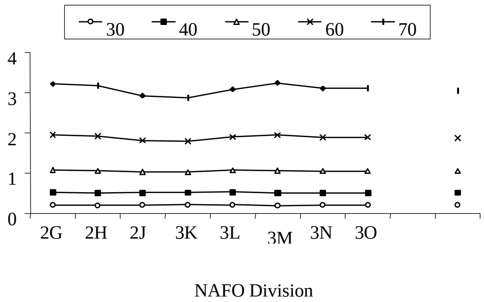


Fig. 5. Estimated round weight from the given length-weight relationships for Greenland halibut from fall surveys 1990-1997 (all Divisions combined).



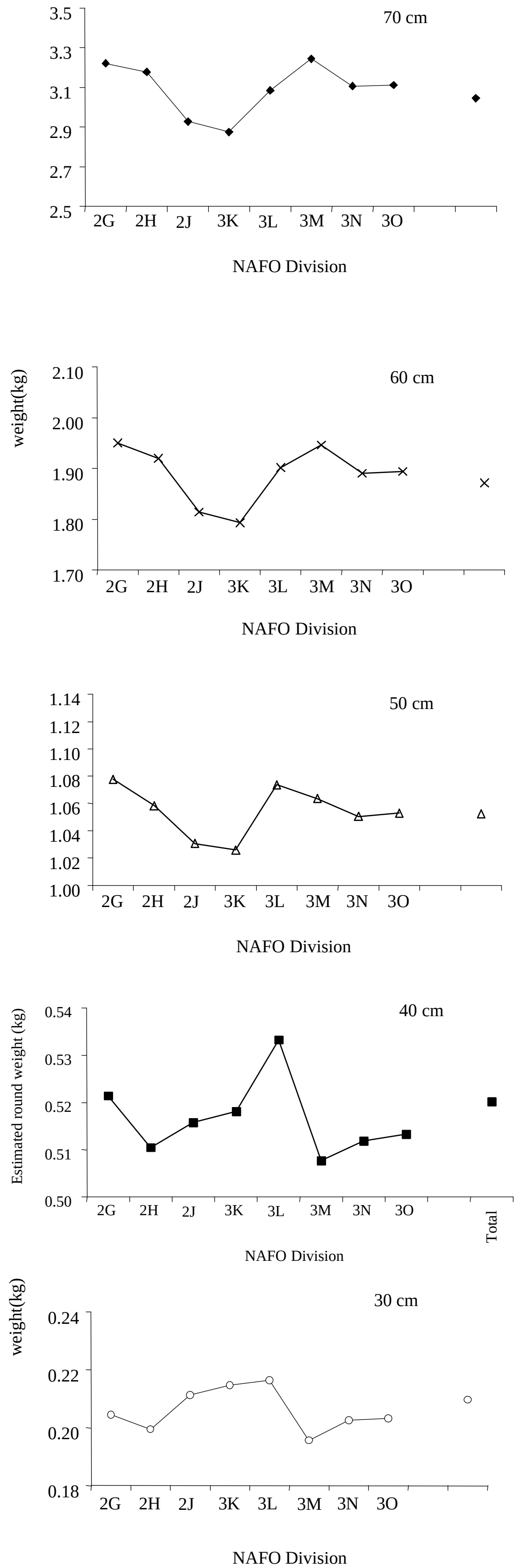


Fig. 6. Estimated round weight for Greenland halibut during Fall surveys 1997.

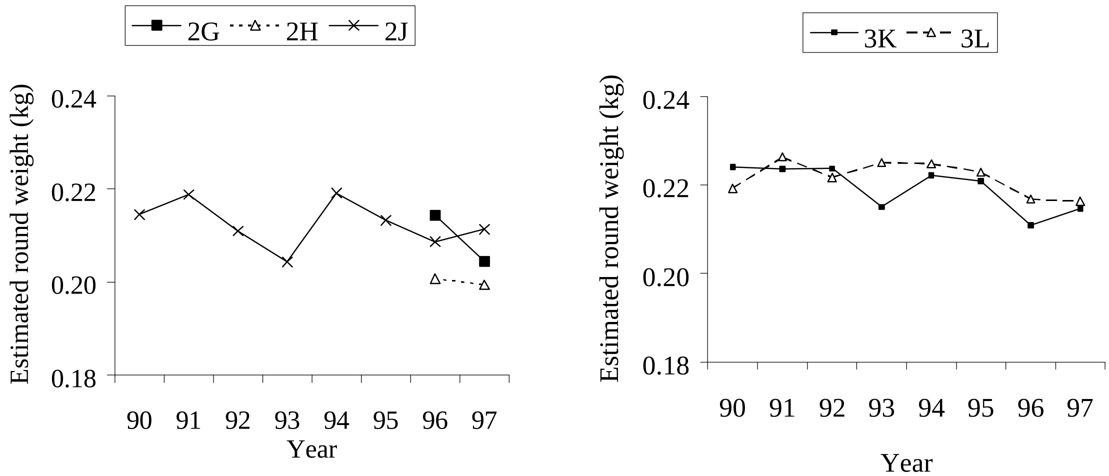


Fig. 7. Variation in round weight for a 30 cm Greenland halibut over the years 1990-1997 based on samples taken in different NAFO Divisions. Weight estimates are based on length-weight relationships.

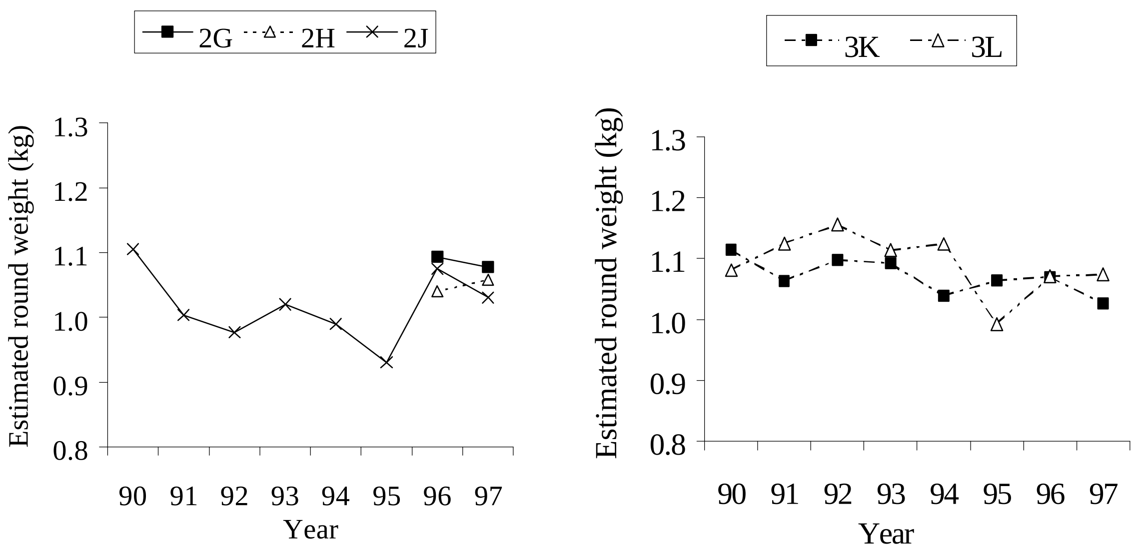


Fig. 8. Variation in round weight for a 50 cm Greenland halibut over the years 1990-1997 based on samples taken in different NAFO Divisions. Weight estimates are based on length-weight relationships.

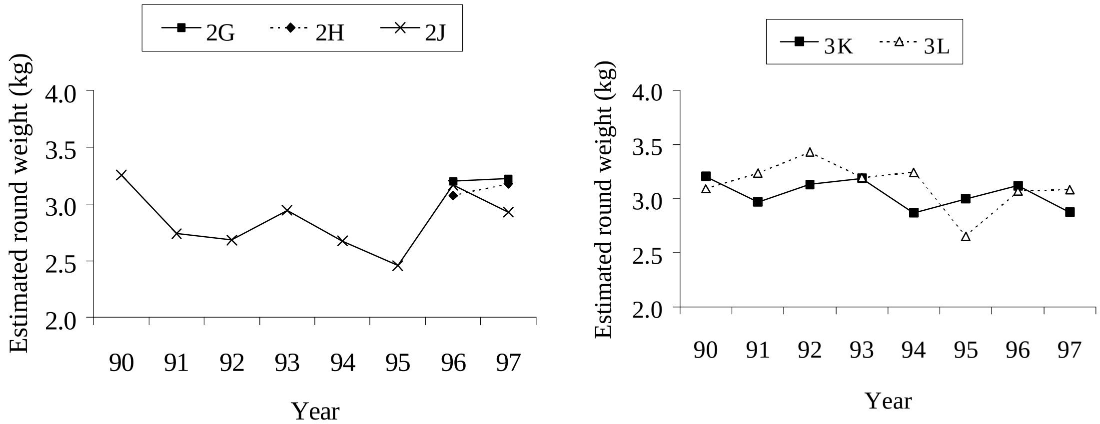


Fig. 9. Variation in round weight for a 70 cm Greenland halibut over the years 1990-1997 based on samples taken in different NAFO Divisions. Weight estimates are based on length-weight relationships.

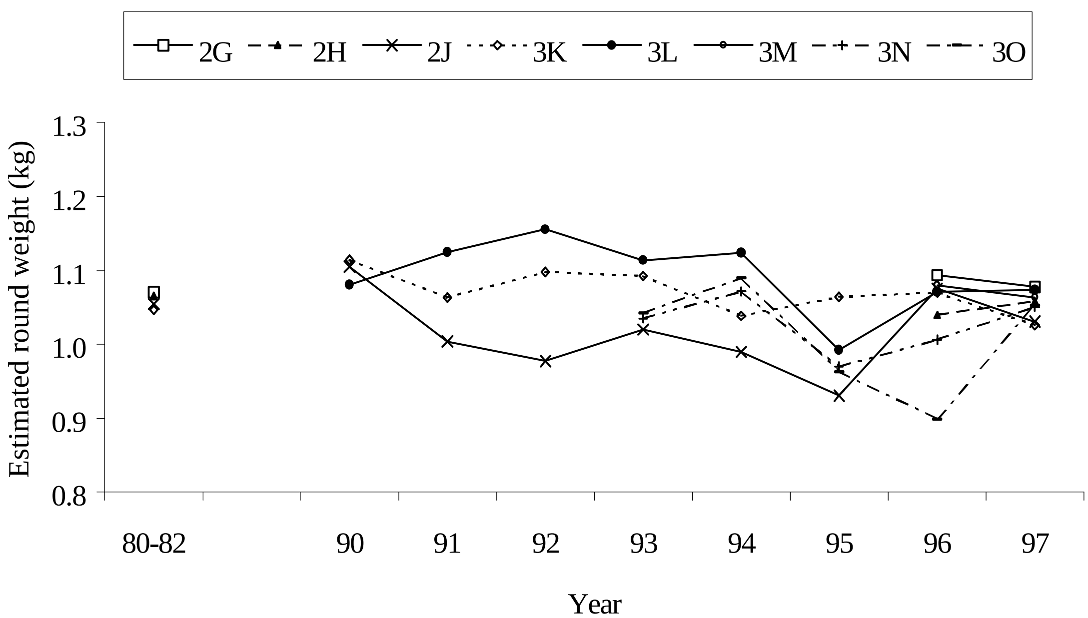


Fig. 10. Estimated round weight of a 50 cm Greenland halibut for NAFO division 2GHJ and 3KLMNO in the period 1990-1998, and data for the period 1980-1982 (Bowering and Stansbury 1984). The estimated round weight for Division 3MNO is based on few observations.