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Further Comparisons of Estimates of Maturity for Greenland Halibut from Surveys Covering Different Portions of the Stock Area

by

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Abstract

Maturity at age and size were examined for male and female Greenland halibut. Estimates were produced for a portion of the stock area (Div. 2J3K) from 1978-2000 and from 'synoptic' surveys covering the stock area from Div. 2GH in the north to 3NO in the south from 1996-1999. The estimates from the Div. 2J3K area were similar to those from the wider area but were extremely variable, particularly since the late 1980's. This variability limits their usefulness for the production of spawning stock biomass. However, there was no apparent trend over time in the estimates for the Div. 2J3K area and the best estimates for the entire time period may be those produced from the synoptic surveys of 1996-1999. Estimated age at 50% maturity for females from these surveys is 13.6 years.

Keywords: Greenland halibut, maturity, length, age, variability

Introduction

Studies on the maturation and spawning of Greenland halibut have revealed a great deal of variability. The proportion of adult fish at size and age has been found to exhibit a high degree of geographic and temporal variation (Junquera, MS 1994; Junquera and Saborido-Rey, MS 1995; Morgan and Bowering, 1997; Morgan and Bowering, MS 1999). The occurrence of immature fish at large size also appears to be common (Fedorov, 1971; Jorgensen and Boje, MS 1994; Morgan and Bowering, 1997).

Morgan and Bowering (1997) hypothesised that this apparent variability in maturity may be the result of changing distribution of adult fish. This is consistent with the hypothesis of Junquera (MS 1994) that differences in the Div. 3LMN area may be caused by the movement of mature fish in relation to changes in the distribution of suitable environmental conditions. Such inconsistency in the distribution of adult fish would mean that surveys covering only a portion of the stock area would produce highly variable estimates of maturity at age or size and of spawning times for this species. This was confirmed in an analyses of maturity at length conducted on data from 'synoptic' surveys covering the stock area from Div. 2GH in the north to 3NO in the south in comparison with data from the Div. 2J3K portion of the stock area only (Morgan and Bowering, MS 2000).

The surveys covering most of the stock area occurred from 1996 to 1999 and were discontinued in 2000. This paper conducts a further comparison of data on maturity at length and age from the synoptic surveys in comparison with the Div. 2J3K portion only. The aim is to determine if the Div. 2J3K portion can serve as a proxy for the whole area.

Materials and Methods

Data from 1996-99 from the Canadian fall (September to December) stratified random research vessel surveys in NAFO Subarea 2 and Div. 3KLMNO were examined. In addition, data from 1978 to 2000 were examined for the Div. 2J3K area. Fish were assigned to the categories immature (juvenile) or mature (adult) according to the classification of Tempelman et. al. (1978).

Estimated proportions mature at age and length were produced for male and female Greenland halibut in NAFO Div. 2J3K and for the synoptic surveys for each year using probit analyses with a logit link function and a binomial error structure (SAS Institute Inc., 1989). Statistical analyses of temporal variability in the Div. 2J3K data were conducted using generalised linear models with a logit link function and binomial error structure (McCullagh and Nelder, 1983; SAS Institute Inc., 1993). As well, the estimated age and length at 50% maturity from Div. 2J3K and the synoptic surveys were compared for those years in which the synoptic surveys were conducted. The estimated proportions mature at age were also compared. Estimates or proportion mature at age were also produced by cohort for Div. 2J3K.

Results and Discussion

Length at 50% maturity for males and females in Div. 2J3K combined is shown in Fig. 1 and age at 50% maturity in Fig. 2. There is significant interannual variability for both proportion mature at length and age for both sexes.

Males Length source	Deviance	Num DF	Den DF	F Value	Pr > F	ChiSq	Pr > ChiSq
Intercept	416.614						
length-class	1040.6492	1	618	3940.99	<.0001	3940.99	<.0001
year	487.0563	20	618	35.12	<.0001	702.42	<.0001
Females Length source	**Deviance**	**Num DF**	**Den DF**	**F Value**	**Pr > F**	**ChiSq**	**Pr > ChiSq**
Intercept	8089.7911						
length-class	858.9666	1	797	10397.6	<.0001	10397.6	<.0001
year	554.2592	18	797	24.34	<.0001	1438.16	<.0001
Males Age source	**Deviance**	**Num DF**	**Den DF**	**F Value**	**Pr > F**	**ChiSq**	**Pr > ChiSq**
Intercept	1644.2177						
age	441.3553	1	187	1755.45	<.0001	1755.45	<.0001
year	128.1356	17	187	26.89	<.0001	457.11	<.0001
Females Age source	**Deviance**	**Num DF**	**Den DF**	**F Value**	**Pr > F**	**ChiSq**	**Pr > ChiSq**
Intercept	3767.6895						
Age	421.6149	1	275	5602.61	<.0001	5602.61	<.0001
Year	164.2397	17	275	25.35	<.0001	430.94	<.0001

Although there is significant interannual variability in the estimates there is no apparent trend over time. However, estimates since the late 1980's or early 1990's are more variable than those before that time, with much wider fiducial limits and frequent occurrences of years where the model did not give a significant fit to the data.

Estimated length and age at 50% maturity for data from Div. 2J3K were compared to estimates from the entire Subarea 2 + Div. 3KLMNO area (Fig. 3). There was not a significant fit of the model to the data for either age or length for females in 1998 in the Div. 2J3K area alone. Estimates tended to be similar, although the fiducial limits

for estimates using only the Div. 2J3K data are greater, sometimes substantially so. When the estimated proportions mature at age are compared, they are also similar in most years (Fig. 4). That the estimates are similar is perhaps not surprising since the Div. 2J3K data comprise a substantial portion of the data for the entire area. The greater variability of estimates from only a portion of the area has been previously recognised (Morgan and Bowering, 1997).

Age at 50% maturity by cohort for males and females in Div. 2J3K is presented in Fig. 5. A similar pattern is seen in these estimates as for the estimates by year with substantial variability, particularly in the later part of the time series. As with the estimates on an annual basis, there is no apparent trend over time in the estimates by cohort.

The variability of the estimates from the Div. 2J3K area, particularly since the late 1980's, makes it difficult to use these estimates in the production of spawning stock biomass. Estimates from the entire Subarea 2 + Div. 3KLMNO area are similar to those from the Div. 2J3K area but are available for only 4 years (1996-1999). However, the NAFO Div. 2J3K time series does not indicate any trend in maturity at age or size. Therefore, it may be advisable to use estimates produced from the 1996-1999 surveys in the production of spawning stock biomass. Estimated proportions mature at age using all the data from this 1996-1999 survey series are presented for females in Fig. 6. Since the survey is in the fall and it is thought that most of the fish will not spawn until the next year, 1 has been added to the age of the fish. This method gives an estimated age at 50% maturity for females of 13.6 years. Estimates for females ages 1 to 21 are given below.

Age	Estimated proportion mature
1	0.0000
2	0.0000
3	0.0000
4	0.00001
5	0.00004
6	0.00012
7	0.0004
8	0.00128
9	0.00416
10	0.0134
11	0.0422
12	0.1252
13	0.3172
14	0.6014
15	0.8305
16	0.9409
17	0.9810
18	0.9941
19	0.9982
20	0.9994
21	0.9998

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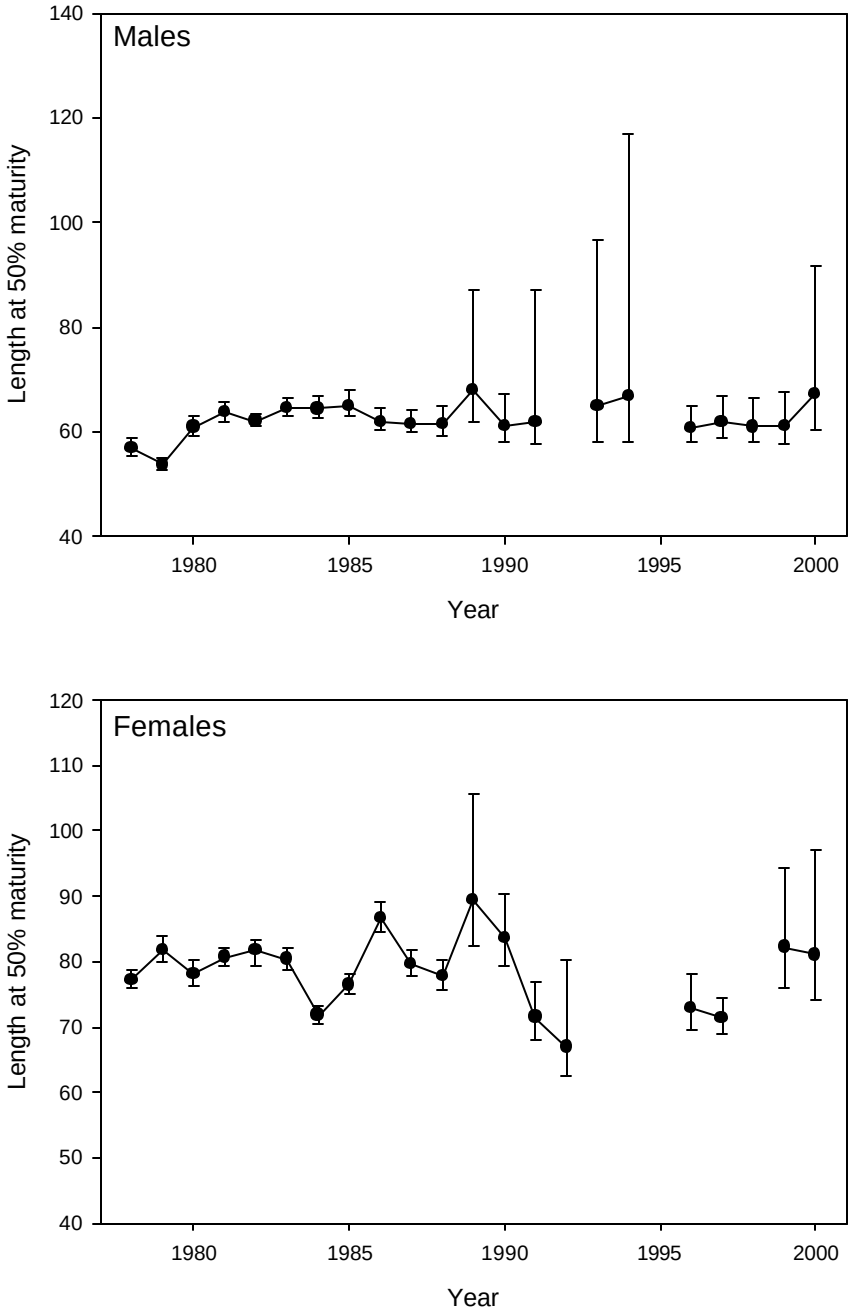

Figure 1. Length at 50% maturity (± 95% fiducial limits) for male and female Greenland halibut in NAFO Divs. 2J3K from 1978 to 2000. Data are from Canadian fall surveys.

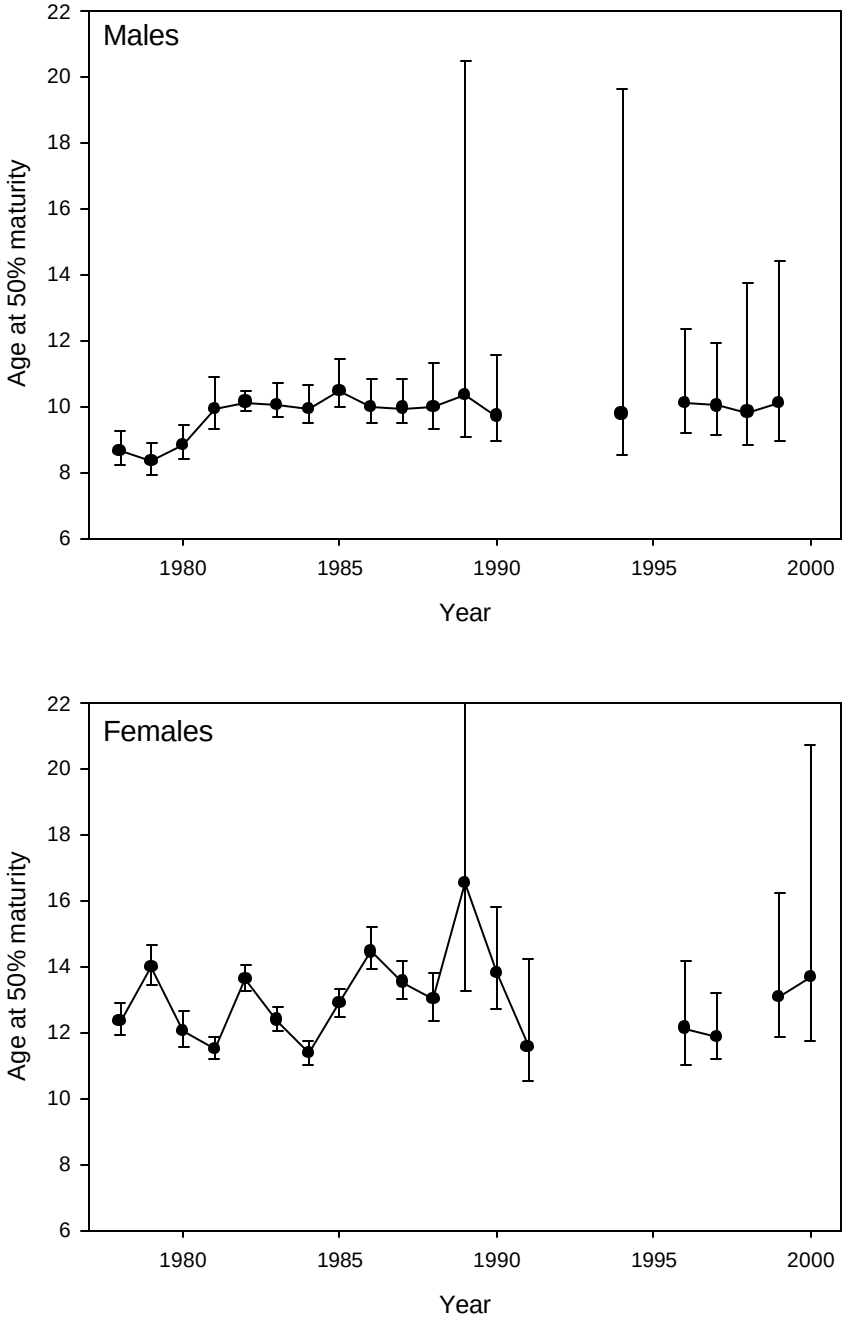

Figure 2. Age at 50% maturity (± 95% fiducial limits) for male and female Greenland halibut in NAFO Divs. 2J3K from 1978 to 2000. Data are from Canadian fall surveys.

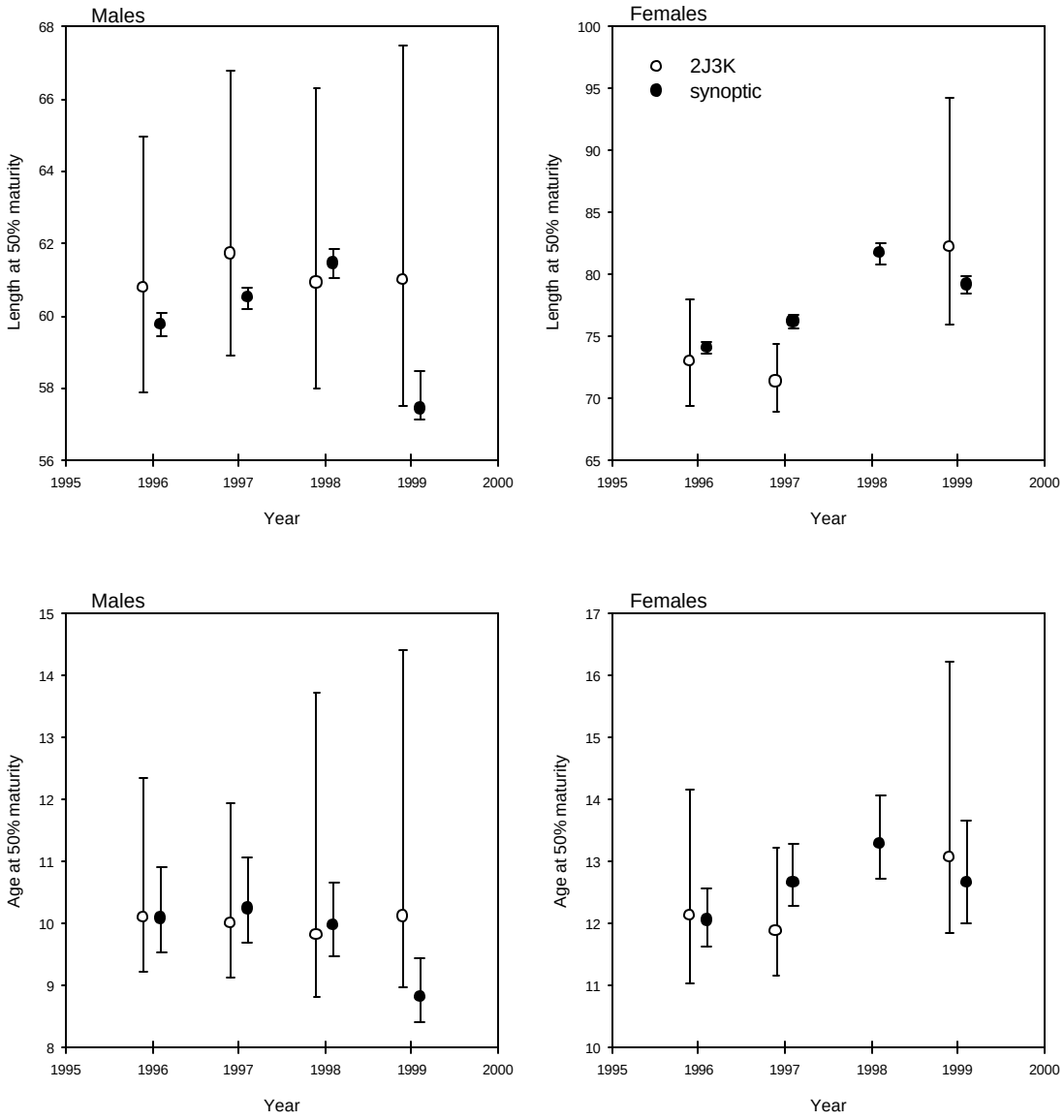

Figure 3. Age and length at 50% (± 95% fiducial limits) maturity for male and female Greenland halibut in 1996 to 1998 from Canadian fall research vessel surveys. Data are from the Div. 2J3K area only and for synoptic surveys of the 2GHJ3KLMNO area.

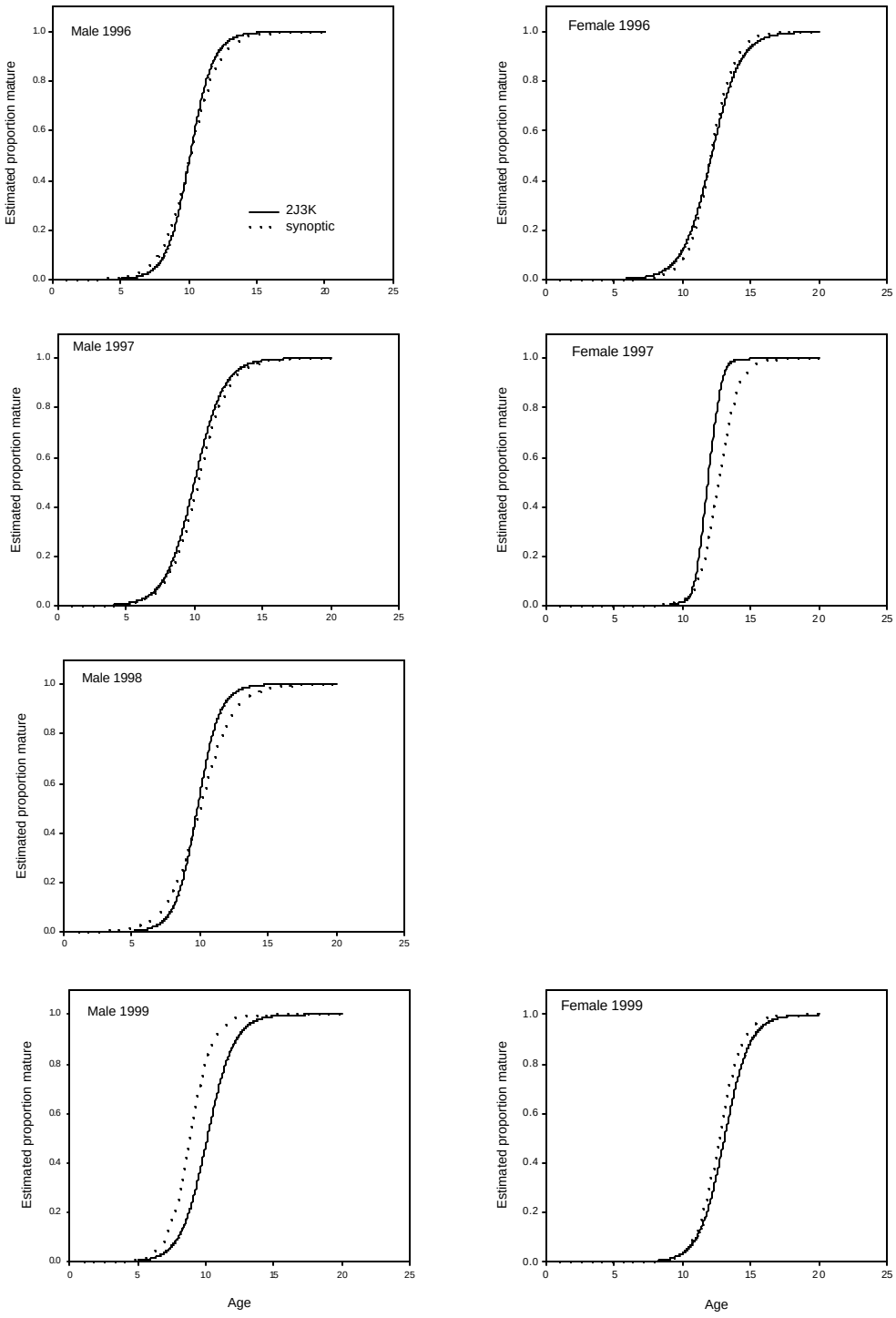

Figure 4. Estimated proportion mature at age for male and female Greenland halibut from the Div. 2J3K area only and from synoptic surveys of Div. 2GHJ3KLMNO.

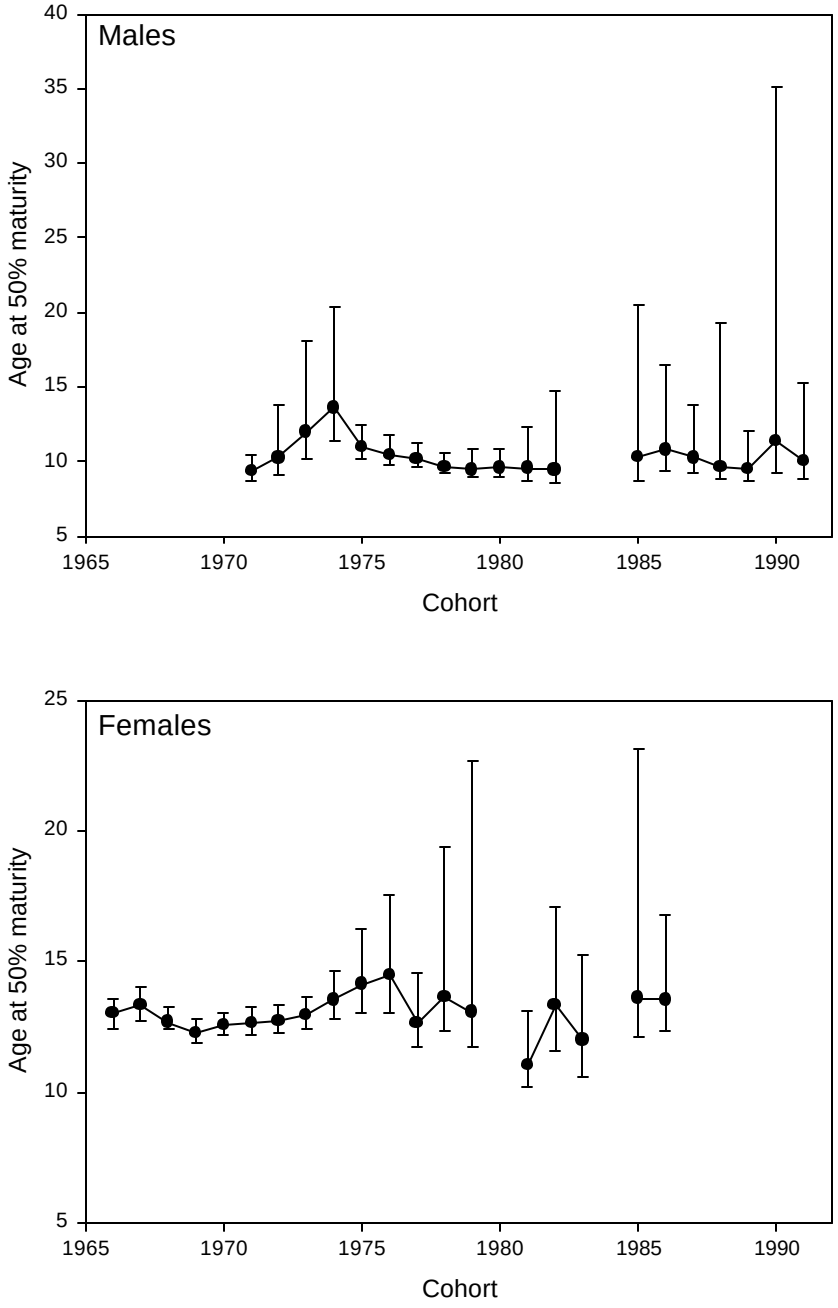

Figure 5. Age at 50% maturity (± 95% fiducial limits) for male and female Greenland halibut in NAFO Divs. 2J3K by cohort. Data are from Canadian fall surveys.

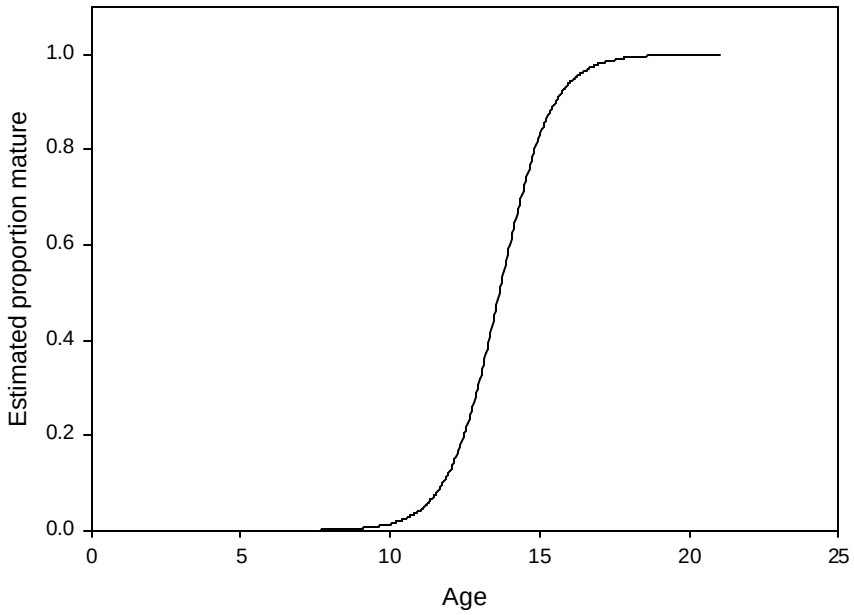

Figure 6. Estimated proportion mature at age for female Greenland halibut in NAFO Div. 2GHJ3KLMNO. Estimates are derived from data from Canadian fall surveys of the area in 1996 to 1999.