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FECUNDITY OF GREENLAND HALIBUT (*REINHARDTIUS HIPPOGLOSSIDES* WALBAUM) IN EAST GREENLANDIC WATERS.

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ABSTRACT

Studies on fish fecundity is of importance for understanding reproduction biology and relations between spawning stock and recruitment. Fecundity is defined as the number of vitellogenic oocytes developing in a female prior to the spawning. For Greenland halibut in East-Greenland waters fecundity has not been described so far.

This paper describes a fecundity study on Greenland halibut in ICES area XIVb, East-Greenland, based on 112 ovaries collected in July 1997. The ovaries contained oocytes with a visual oocyte diameter of 1-2mm. Mean gonadosomatic index (GSI) was 2.9%, ranging from 1.0% to 4.9%.

Among the eggs in the ovary, a recruitment group in the connective tissue, small oocytes (mean egg diameter 0.73mm after preservation) and vitellogenic oocytes (mean egg diameter 1.25mm after preservation, range 0.9 – 1.65mm) were observed. The fecundity estimates are based on the vitellogenic oocytes in the last group.

Mean fecundity was estimated to 113 700 eggs, the number of eggs per female, ranging from 32 500 to 277 100. The fecundity-length and fecundity-weight (F-W) relationships have been estimated.

Key words

East Greenland – Fecundity – Greenland halibut – *Reinhardtius hippoglossoides* – Westnordic stock

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INTRODUCTION

The Greenland halibut is a deepwater flatfish found at water temperatures from -1° to $+10^{\circ}C$ (Fedorov 1971), at depth down to 2000m (Boje & Hareide 1993). In the last five to six years the fishery for Greenland halibut in the waters of East-Greenland has increased. In 1996 the annual reported catch was 7.500 tons (ICES 1997), and preliminary results for 1997 indicate a catch around 8.500 tons (ICES 1998).

Greenland halibut in East-Greenland, Icelandic and Faeroe waters constitute a separate management unit in ICES. The stock seems to have decreased considerably during the past few years and the spawning stock biomass is estimated to be below safe biological limits (ICES 1998). Spawning stock biomass has decreased since 1988 and is no below safe biological levels (ICES 1998). Scientists are concerned for the stock status and the need of biological research on the species.

The fecundity study of fish species is an important aspect for understanding the reproduction biology of fishes, and the link between spawning stock and recruitment. Fecundity is defined as the number of vitellogenic oocytes developing in a female prior to the spawning (Bagenal 1978). So far, no information on fecundity of the Greenland halibut at the East-Greenland area has been available. Some studies has been done in the Newfoundland area (Lear 1970), Bering Sea (D'yakov 1978), Southern Labrador and Gulf of St. Lawrence (Bowering 1980) and Northwest Atlantic (Serebryakov 1992).

This paper presents the results from fecundity studies conducted in July 1997 at the East Coast of Greenland.

MATERIALS AND METHODS

Gonads from 112 maturing female Greenland halibut were sampled during a longline survey in ICES Division XIVb at the Kap Bille Bank (62°05N) (**Fig. 1**). The ovaries were collected during a short period (20–27 July 1997). Gonads in maturity stage 3 were sampled, that is eggs with an average egg diameter around 1-2 mm (Nielsen & Boje 1995).

Total length was recorded, and weight of total body, gonad, liver and viscera was recorded. The sampling was length stratified, with 15 individuals in each 5-cm group in the length range 70-115cm. The gonads were preserved in 3,6% solution of phosphate buffered formalin. The gravimetric method was used to determine fecundity (Bagenal & Braum 1978) in the laboratory.

Subsample size

3 different subsamples were taken from the middle part of the right lobe of three different gonads. The sample weight giving the lowest percent standard derivation (CV) (iv) under 5% where chosen. The sample weight used in the further analysis was 0,75 gram.

Homogeneity

To study homogenity of the ovaries, a homogeneity test was conducted. A total of 16 samples were taken from each of 5 randomly chosen ovaries. 4 samples were taken from each of the anterior, middle and posterior part of the right lobe, and from the middle part of the left lobe. All of the samples were counted, and mean fecundity was estimated.

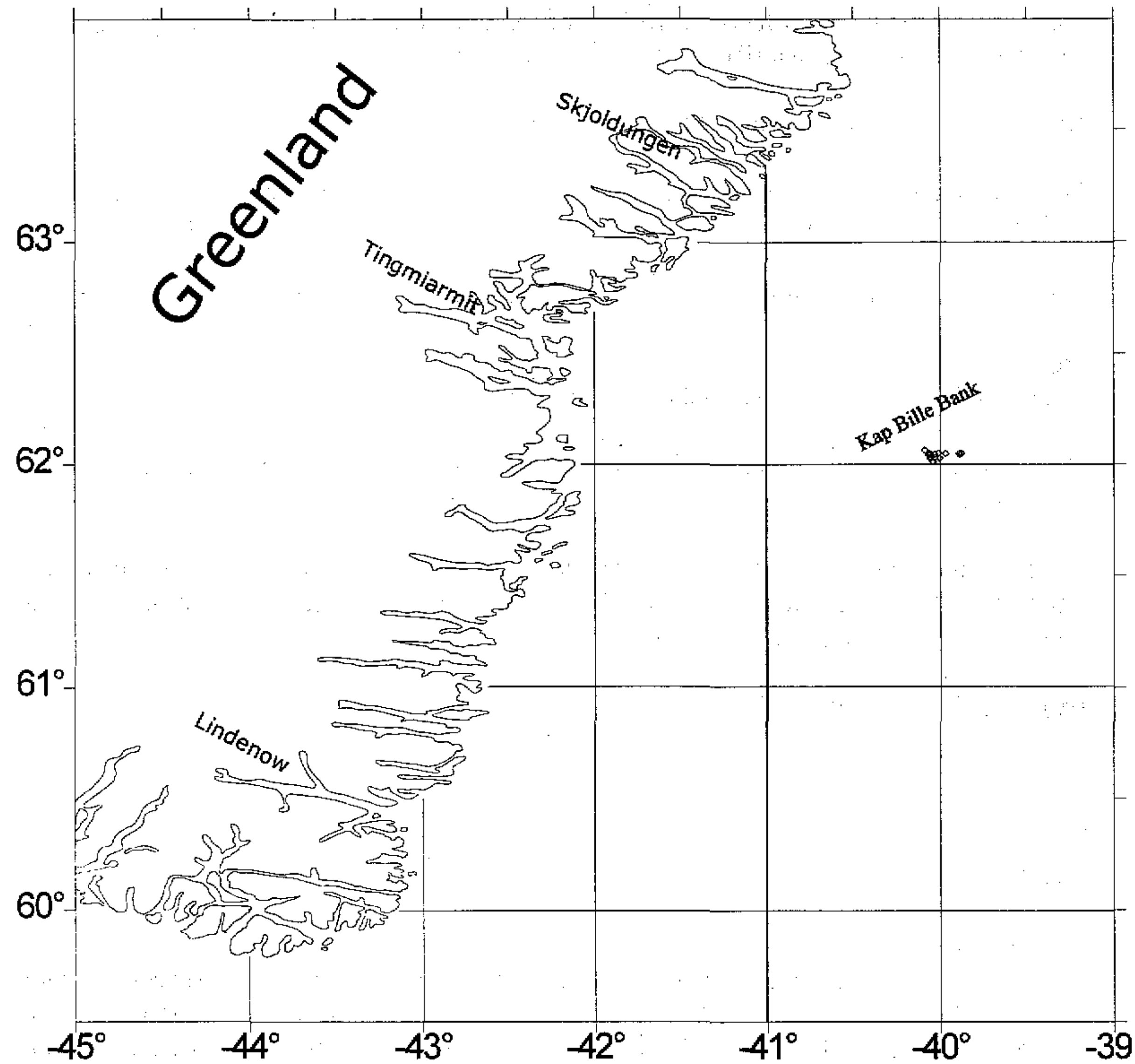

Fig. 1. Survey area during the longline survey in July-August 1997. Shaded area indicates where the Greenland halibut used in the fecundity sample were caught.

Egg size

Measures of egg size (diameter) were obtained from the middle section of the right lobe. 5 ovaries were chosen at random. Each oocyte was measured 2 times (longest/shortest diameter) and the average was used in the estimates.

Fecundity

4 subsamples were taken from the right mid section of each ovary. Fecundity estimates were based on the egg number counted in sample 1 and 2. If coefficient of variation (CV) (iv) exceeded 5% sample 3 and 4 were counted and used in the analyses.

Fecundity was estimated using the equation (i): (May 1967):

(i) Total gonad weight (g) /subsample weight (g) * the number eggs counted = fecundity

Index
Gonadosomatic index (GSI) is defined as the relation between the gonad weight (g) and the total weight (g) of the fish (ii).

(ii) GSI = (gonad weight*100%) / total weight

Hepatosomatic index (HSI) is defined as the relation between the liver weight (g) and the total weight (g) of the fish (iii).

(iii) HSI = (liver weight (g) * 100%) / total weight

Data analyses
Microsoft Excel-97 was used in the data analyses.

Regression analyses of fecundity/length and fecundity/weight were made using log–log transformation.

Coefficient of variation was used to evaluate the fecundity estimates (iv). Coefficient of variation (CV) is defined as the standard deviation (std) of the estimates divided by the mean fecundity (F_{mean}) (Sokal & Rohlf 1995).

(iv) CV = std * 100% / F_{mean}

RESULTS

Homogenity
The results indicated that the anterior and the posterior location had a higher coefficient of variation (CV) than the two middle sections (**Fig. 2**). The CV of the posterior and anterior section of the right lobe were in the range 1.05-9.49%. The CV for the right and left midle section were in the range 1.66-4.72%.

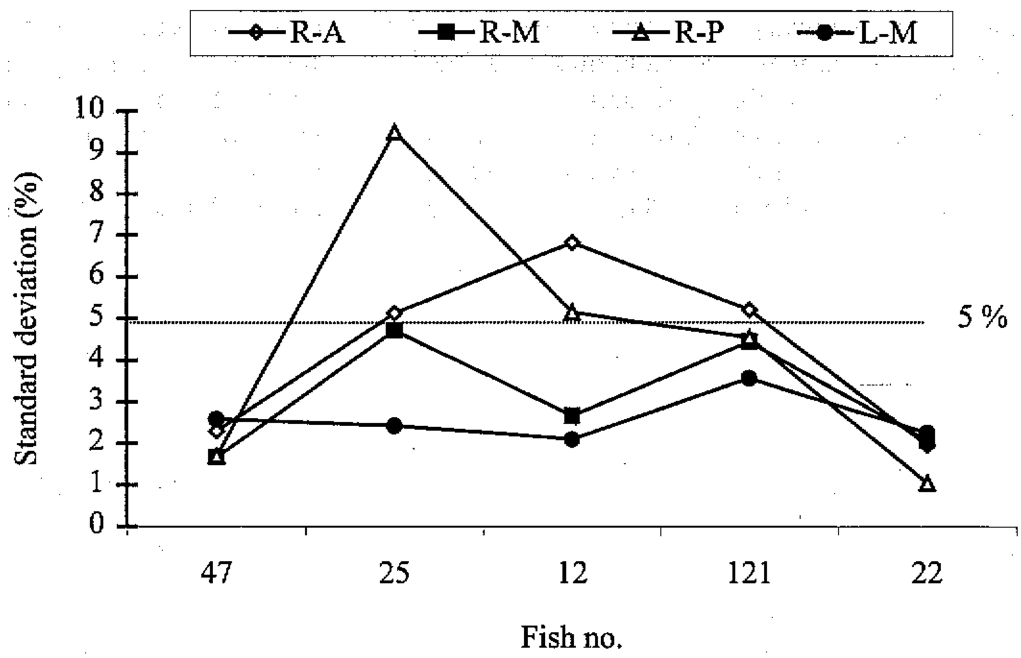

Fig. 2. Comparison of coefficients of variation for the homogenity study on Greenland halibut gonads. The different subsampling locations are referred to as follows: R-A = right lobe anterior section, R-M = right lobe middle section R-P = right lobe posterior section, L-M = left lobe middle section.

Comparing the midsection of the two lobes within each ovary indicated a minor variability between the two lobes (**Fig. 3**).

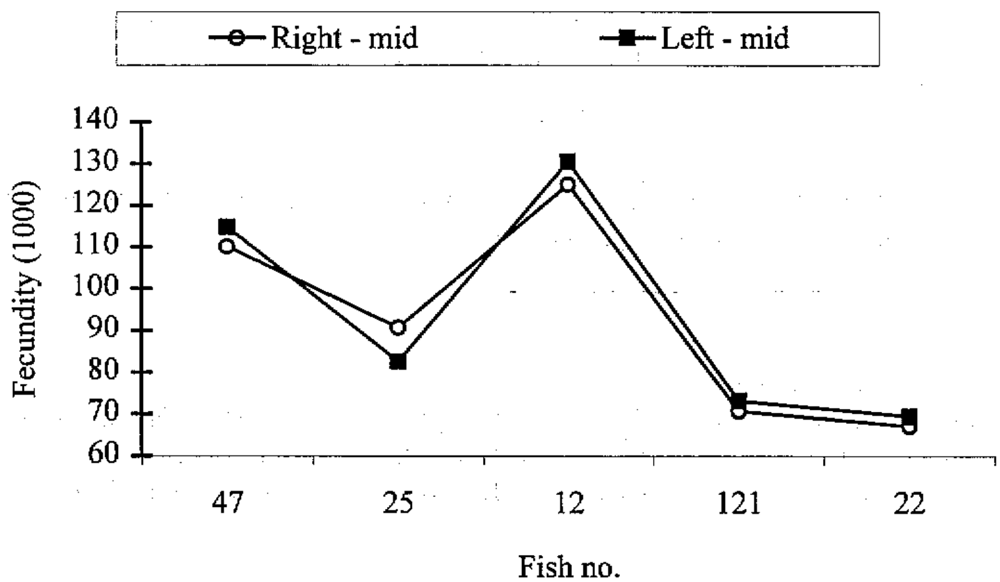

Fig. 3. Mean fecundity (1000) of the left and right lobe represented by samples taken in the middle section of the 5 gonads on which the homogenity study was conducted.

Egg size

Among the eggs in the ovary there were three groups of eggs. In the connective tissue small recruitment oocytes (defines as R) were observed. Further small oocytes containing yolk with a developing nucleus were observed (defined as G2). Mean egg diameter this group was 0.75mm after preservation. The third group consisted of vitellogenic oocytes, that was dark in the light microscope (defined as G1). Mean egg diameter of this group was 1.25mm after preservation, range 0.9 – 1.65mm (**Fig. 4**) The fecundity estimates are based on the last group (G1).

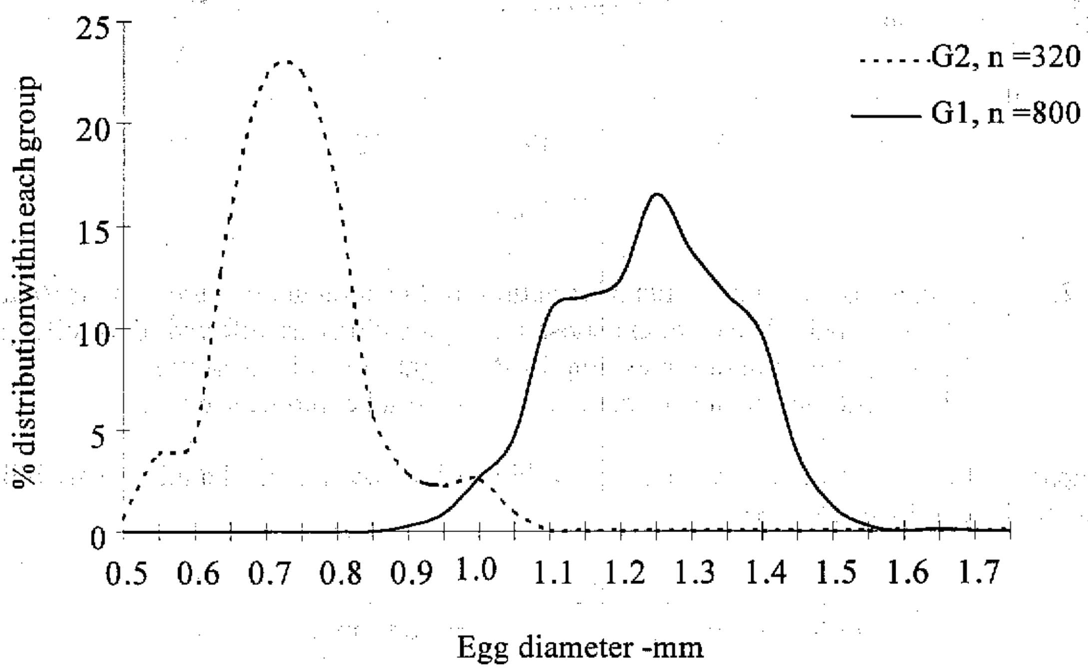

Fig. 4. Percentage distribution of mean egg diameter within each of the two groups (G1 and G2), n = number of eggs measured.

Fecundity of Greenland halibut

Mean fecundity was estimated to 113 700 eggs (range 32 500-277 000). The mean total length of the Greenland halibut of the sample was 88cm. Fecundity varied for Greenland halibut of the same total length. For two females, both 100cm long, the fecundity ranged from 98.000 eggs to 221.500 eggs.

The relationship between fecundity (F, in 1000) and length (L, in cm) was $F= 5.16* 10^{-6} L^{3.75}$ (r^2=0.81) (**Fig. 5**).

The relationship between fecundity (F, in 1000) and weight (W, in g) was $F= 7.16*10^{-3} V^{1.07}$ (r^2=0.80) (**Fig. 6**).

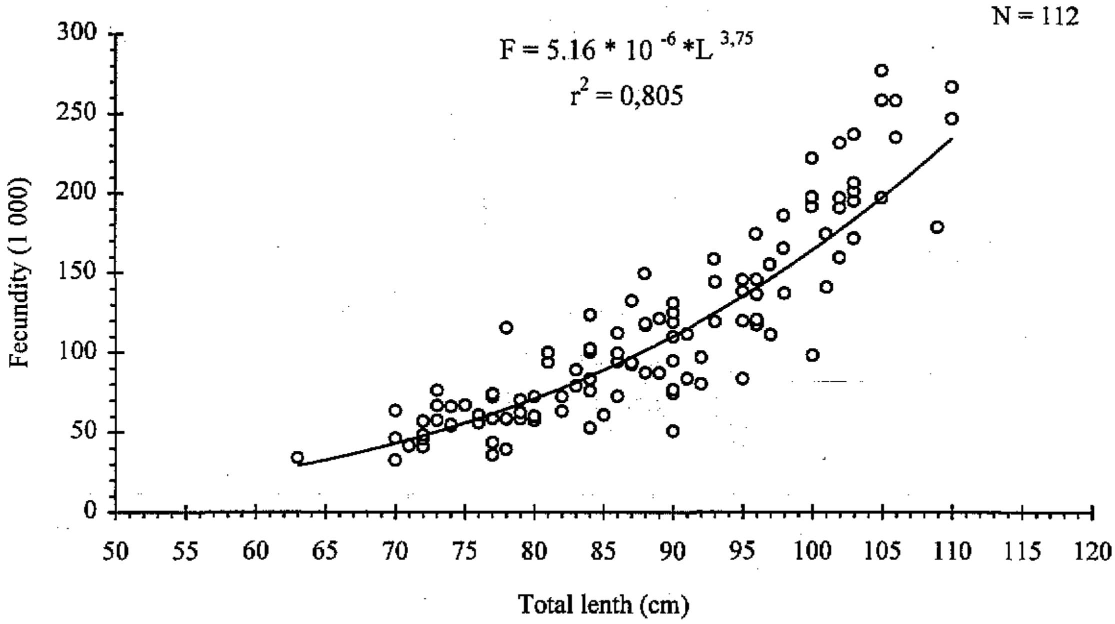

Fig. 5. Fecundity (1000) of East Greenland halibut related to total length (cm).

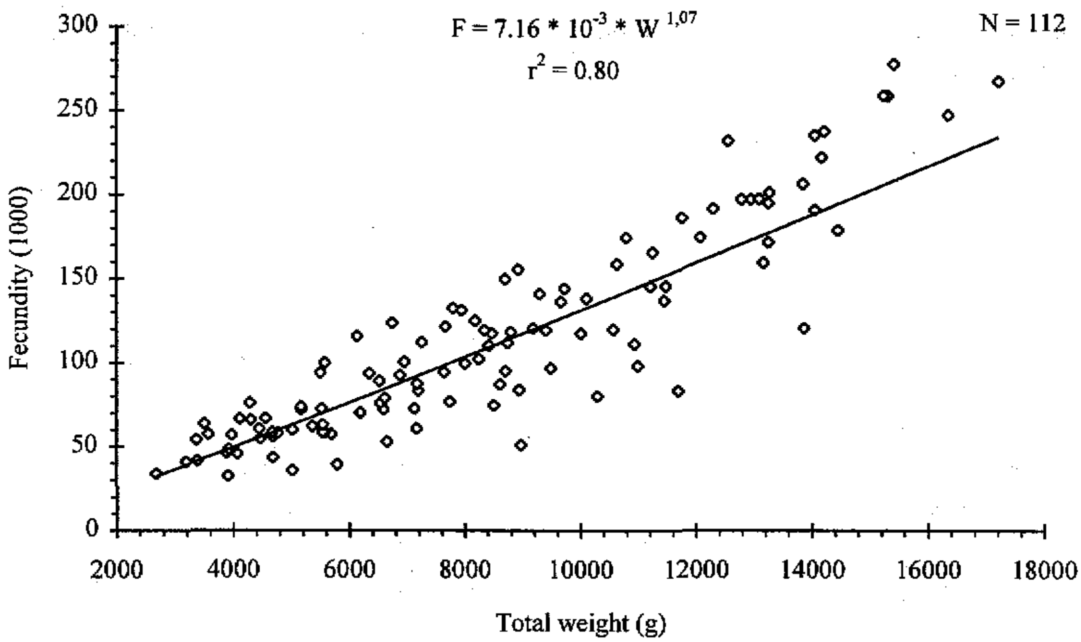

Fig. 6. Fecundity (1000) of East Greenland halibut related to total weight (g).

Gonadosomatisc index (GSI) is defined as the relative proportion of which the ovaries constitute, to total weight. Mean GSI was 2.9% (range 1.0-4.9%) (**Fig. 7**).

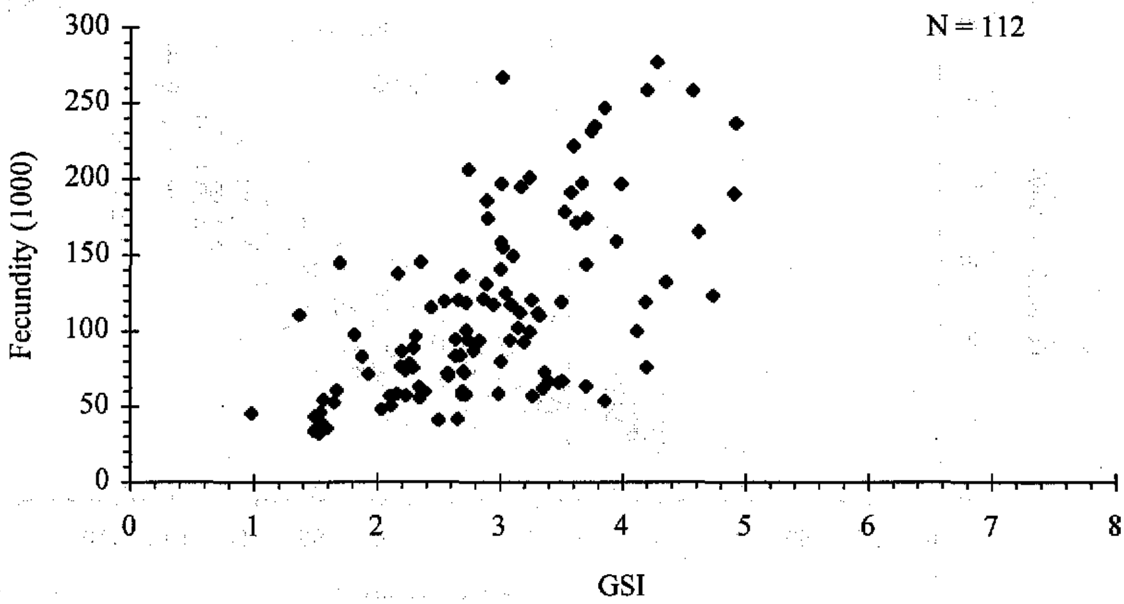

Fig. 7. Fecundity (1000) related to gonadosomatc index (GSI).

Hepatosomatic index (HSI) is defined as the relative proportion of which the liver constitutes of the total weight (**Fig. 8**).

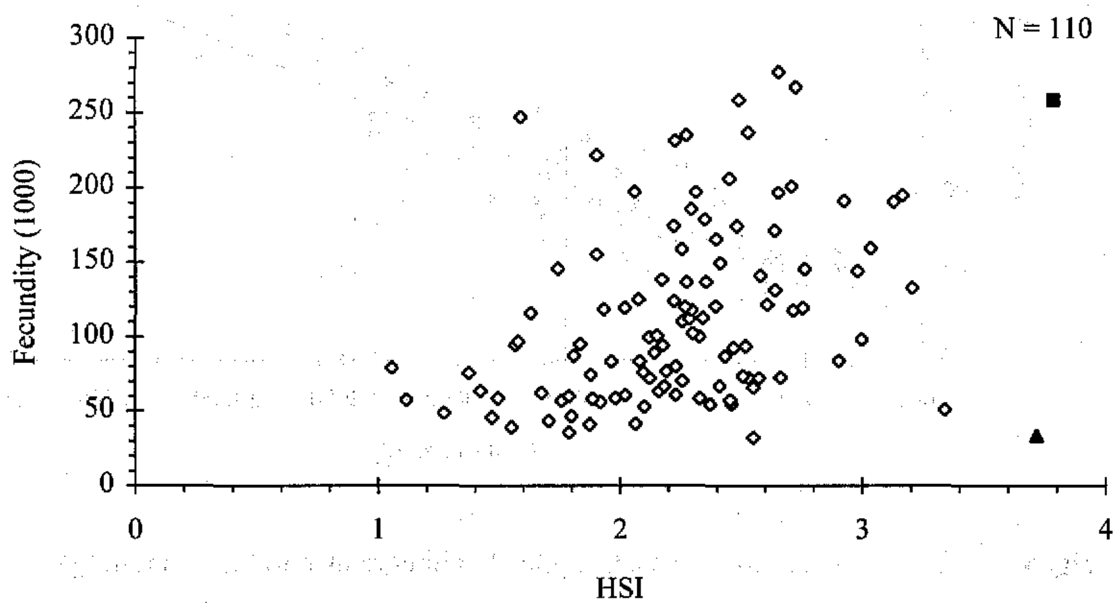

Fig. 8. Fecundity (1000) related to Hepatosomatic index (HSI). ▲ - Fish with high HSI and low fecundity. ■ - Fish with high HSI and high fecundity.

DISCUSSION

Sampling of Greenland halibut was conducted over a relatively short period in July 1997. The Greenland halibut used in the study were mainly in maturity stage 3 (Nielsen & Boje 1995). Of the three groups of eggs observed in the ovaries two were developing. However, the oocyte diameter showed two distinct peaks, indicating two different spawning batches. The oocytes defined as vitellogenic (G1) were assumed to be spawned in the next spawning season, and therefore chosen for the fecundity study.

Spawning had not started and the mean egg diameter of group G1 indicates that there are several months left before spawning occur. This is also verified by the gonadosomatic index (GSI) that was below 5%. GSI have been estimated for Greenland halibut in West Greenland waters. Jørgensen & Akimoto (1990) estimated GSI in the range 1-3% in April-July in NAFO Subarea 1CD. In October GSI had increased to 10% in the same area. Fedorov (1968) assumed that Greenland halibut approaching spawning or even in the spawning season have GSI in the range 15-18.

GSI varied from 1% to 5%. Most of the results were between 2% and 3%. This corresponds to other results reported from surveys in the area in 1994, 1995 and 1996 (Gundersen *et al.* 1995; Gundersen *et al.* 1997; Gundersen & Woll 1997). In the present study the results did not indicate a connection between fecundity and GSI. Gundersen *et al.* (1998) observed a slight relation between fecundity and GSI for Greenland halibut in the Barents Sea, GSI increasing with increasing fecundity. Boje (1990) point out a relation between GSI and fecundity for Greenland halibut sampled in February at the western coast of Greenland.

Fecundity of Greenland halibut in East Greenland waters was in the range 32 500 – 277 000 eggs per female. This gives a maximum fecundity at the same level as Jensen (1935) observed for one female in West Greenland waters. Lear (1970) estimated the fecundity of Greenland halibut in the Newfoundland-Labrador area to be in the range 15 000-215 000, covering nearly the same length range as the present study. Bowering (1980) studied fecundity for Greenland halibut in the Gulf of St. Lawrence and in the Labrador area. Based on the fecundity-length relationship presented in this work a 90cm Greenland halibut sampled in the Labrador area had a fecundity of 66 000. This is lower than observed in the present study at East Greenland: a 90cm female on average producing *ca.* 100 000 eggs. In the Gulf of St. Lawrence the Greenland halibut sampled, were smaller, but the fecundity was slightly higher than for Greenland halibut in the Labrador area (Bowering 1980).

In Icelandic waters only a few Greenland halibut have been studied with respect to fecundity (Magnusson 1977). The fecundity in these waters was in the range 17 500 (total length 66cm) to 42 200 (total length 74cm). This seem to be close to the observed fecundity of Greenland halibut in East Greenland waters.

In the Northeast Atlantic Millinsky (1944) described fecundity of two females sampled in the Barents Sea. The fecundity estimates of the two females were 28 000 and 33 000 eggs. A comprehensive study on fecundity of Greenland halibut is in progress (Gundersen and others in progress). Gundersen *et al.* (1998) presents a fecundity-length relationship for Greenland halibut sampled on the continental slope of the Barents Sea, in 1996. The fecundity was in the range 6 800 – 70 500. Although the length interval of the Greenland halibut was more narrow than what is presented in this paper, with a maximum total length of 80cm, the fecundity seemed to be slightly lower in the Northeast Atlantic compared to fecundity of Greenland halibut in East Greenland waters.

The fecundity varied between females of the same total length. Similar results are observed for plaice (Simpson 1951). This variation could be explained by different growth patterns and maturity at age, caused by changes in environmental conditions, e.g. food supply and temperature. Further, changes in population density might be of importance (Bagenal 1978). The fecundity for Greenland halibut increases with increasing length (cm). This is similar to several other species, for example Atlantic Cod, *Gadus morhua* (May 1967) and Plaice, *Hippoglossoides platesoides* (Simpson 1951; Pitt 1964). Hodder (1963) proposed that individual fecundity might be related to the number of spawnings. A first time spawner is suuposed to spawn fewer eggs than a repeat spawner. As the fish grows, the abdominal cavity increases, allowing the ovary to increase in size. D'yakov (1978) has observed the same for Greenland halibut in the Bering Strait.

The results indicate that the right lobe gives a slightly lower fecundity estimate than the left lobe. However, no systematic trend was observed, neither was the CV above 5% and so the middle section of the right lobe was regarded as representative for the entire ovary.

The relation between fecundity and length had a correlation coefficient, $r^2 = 0.81$. The exponent of the allometric relationship was 3.75. Bagenal (1978) stated that this might range from 2.3 to 5.3. However it is usually found a little above 3. Earlier studies on fecundity of Greenland halibut have shown the exponent to be in the same range as in this study: D'yakov (1978) 2.58, Bowering (1980) 3.08, Serebryakov *et al.* (1992) 3.62, Lear (1970) 4.66, and Gundersen (1998) 4.60.

A relationship between fecundity and weight was found, having a correlation coefficient, $r^2 = 0.80$. The exponent of the curved relationship was 1.07. This is close to what D'yakov (1978) and Serebryakov *et al.* (1992) found for Greenland halibut: 1.15 and 1.07 respectively.

The Greenland halibut included in this study are sampled in a restricted area. The environmental conditions should therefore not be too variable, at least not in the time of sampling. Little is known about the migration of Greenland halibut in East Greenland waters. There was no evidence that Greenland halibut caught on the Kap Bille Bank originated from the same areas. Hence, the environmental conditions might have been different for the individuals in the years before 1997. The variable individual fecundity may therefore bee explained by different nursery areas. Individuals living their first years in areas with high density and little food supply will grow slower then fish in areas of low density and unlimited food supply. Such conditions result in increasing growth rate and better condition. These are factors influencing positively on the specific growth rate and fecundity (Bagenal 1978; Kjesbu *et al.* 1991; Rijnsdorp *et al.* 1991).

Fecundity has been reported to vary from one geographical area to another, within the same species. (Simpson 1951; Bagenal 1978). When comparing the results in the present study with fecundity studies on Greenland halibut from other areas, this confirms the other findings. Bowering (1980) found that the fecundity related to length varied between the Gulf of St. Lawrence and the Labrador area.

The hepatosomatic index (HSI) varied between 1% and 4%. Most of the results were between 2% and 3.5%. This is a little higher then the results Møre Research found in the same area in

1996 (Gundersen & Woll 1997). They found the HSI mainly was in the range 1% to 3%. The results in the present study do not indicate any trend between HSI and fecundity. Gundersen *et al.* (1998) observed a weak positive correlation between fecundity and HSI.

The fish marked ▲ in *fig.* 8 had a HSI of 3.8%. This may indicate a healthy condition. GSI for the same fish was 1.5% and the total length 63 cm. Considering this, it is likely that the individual is a first time spawner.

The fish marked ■ in *fig.* 8, had the highest observed HSI (3.9). Total length was 106cm. This individual also had the highest observed fecundity of the females examined. Nikolskii (1969) proved that fish in good condition had a high fecundity. In the material analysed in the present study two individuals had a total length of 106cm, having a fecundity of 235 000 and 277 000 respectively. The relatively higher HSI of the female showing highest fecundity may be the explanation for this difference.

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