Journal of Sea Research 75 (2013) 110–117

Contents lists available at SciVerse ScienceDirect

Journal of Sea Research

journal homepage: www.elsevier.com/locate/seares

Identifying potential Greenland halibut spawning areas and nursery grounds off East and South-western Greenland and its management implications

A.C. Gundersen [a,*], J. Kennedy [a], A. Woll [a], I. Fossen [a], J. Boje [b]

[a] Møreforsking AS, Box 5075, NO-6021 Ålesund, Norway
[b] Greenland Institute of Natural Resources, BOX 570, 3900 Nuuk, Greenland

ARTICLE INFO

Article history:
Received 9 November 2011
Received in revised form 23 May 2012
Accepted 30 May 2012
Available online 16 June 2012

Keywords:
Reinhardtius hippoglossoides
Nursery grounds
Spawning
East Greenland
Stock structure
Management units

ABSTRACT

Spawning and nursery grounds are poorly described for the West Nordic stock of Greenland halibut (*Reinhardtius hippoglossoides*) and the entire stock is assumed to originate from a common spawning ground southwest of Iceland. Greenland halibut with hydrated eggs in their ovary were caught during a gillnet survey in 1995 in Greenland waters. This suggests that the spawning areas for the West Nordic stock are not limited to the previously described area southwest of Iceland. Further this paper provides information on distribution of immature Greenland halibut in the fjords of East Greenland. The densities in Tasilaq area suggest that this area may be part of a nursery area in the West-Nordic management unit. However, the importance of this area to the stock is currently unknown. The results have potential implications for the management of the West Nordic Greenland halibut as the management seems to comprise of several stocks, or perhaps a meta-population.

1. Introduction

Greenland halibut (*Reinhardtius hippoglossoides*) are a deep water flatfish species with a distribution covering large areas of the Northern Atlantic and are mainly found at depths from 200 m to 2000 m. Despite it being the target of large international fishery, knowledge on many aspects of its life cycle is lacking. Greenland halibut distributed around East Greenland, Iceland and Faroe Island are managed as a single unit by ICES and are referred to as the West Nordic Stock (ICES, 2010). This management unit has been assumed to originate from one common spawning ground southwest of Iceland (Magnússon, 1977). This assumption was, however, based on a small number of observations. Adult Greenland halibut belonging to the West Nordic management unit are found throughout the continental slopes of East Greenland from Cape Farewell to Tasilaq area (66°N), along the ridge between East Greenland and Iceland and along the north and east coast of Iceland. Greenland halibut also inhabit the waters around the Faroe Islands. The densest aggregations described so far are found just south of the Greenland–Iceland ridge (Hjörleifsson et al., 2000). Since 2005 a small fishery has developed further north along the slope from Irminger Ridge and northwards towards Jan Mayan/Scorsbysund (Boje and Sünksen, 2008) around 68°N. Greenland halibut are believed to have a continuous distribution northwards along the continental slope along East Greenland.

Whether the West Nordic management unit consists of a single or several separate populations is unknown. Greenland halibut tagged in Iceland have been recaptured on the Norwegian coast and also in the Faroe Islands, whereas none have been recaptured in East Greenland despite there being an extensive fishery in the area (Boje, 2002; Godø and Haug, 1989; Sigurõsson, 1979). This wide distribution of adult fish and the lack of migration into East Greenland waters suggest that spawning may also occur in other areas of the distribution area of this management unit. The possibility that the West Nordic stock is comprised of more than one component has implications for management because the individual stocks may differ in their productivity and management of these as a single unit can lead to an unintended depletion of the less productive populations (Iles and Sinclair, 1982; Ruzzante et al., 1999).

The nursery grounds for this management unit have so far not been identified which has hampered descriptions of the stock structure. 0-group surveys in East Greenland/Irminger Sea were carried out by Iceland, beginning in 1970 and ceased in 1998. The targets for these surveys were cod and redfish. 0-group Greenland halibut were present but only in low numbers (Pers. Comm. E. Hjörleifsson, Marine Research Institute, Reykjavík, Iceland). Greenland halibut less than 20 cm have been caught along the East Greenland coast (between 61°30 and 65°00 N at depth mostly below 200 m) in low numbers (Yatsu and Jørgensen, 1988). Currently, no areas in East Greenland have been found where juvenile Greenland halibut occur in high enough numbers to constitute a nursery area similar to that seen in West Greenland (Boje and Hjörleifsson, 2000). Within the literature there are only a few reports of the whereabouts of newly

* Corresponding author. Tel.: +47 926 11 524; fax: +47 70 11 16 01.
E-mail address: Agnes@mfaa.no (AC. Gundersen).

1385-1101/$ – see front matter © 2012 Published by Elsevier B.V.
doi:10.1016/j.seares.2012.05.016

settled Greenland halibut larvae in the East Greenland area. Tåning (1936) assumed that Greenland halibut larvae settle on the bottom in the East Greenland fjords. This was based on the account by Jensen (1935) who reports numerous small (down to 11 cm) juveniles, washed upon shores in South-west Greenland. Sigurõsson and Magnússon (1980) reported the presence of 0-group Greenland halibut in East Greenland and also report an unusually elevated number that were present in the waters of Iceland in February 1980. They concluded that the eggs are normally transported by the current towards East Greenland but in some years, depending on the strength of the currents, the eggs and larvae may be dispersed towards Iceland. This explains why, significant concentrations of 0-group Greenland halibut have never been found in Icelandic waters despite the only known Greenland halibut spawning area (previous to the current study) in the Iceland–East Greenland area being off south-west Iceland.

Accurate knowledge on the reproduction and recruitment is lacking with the West Nordic Greenland halibut stock. Combined with the lack of knowledge regarding nursery grounds this is a hindrance for optimised assessment and management. In an attempt to locate potential nursery grounds and possible indications of spawning, maturity and length distribution data were examined from exploratory longline and gillnet surveys carried out in East Greenland (collaboration between Møreforsking and Greenland Institute of Natural Resources) between 1993 and 2000 and the implications for the management of this stock are considered.

2. Material and methods

Details of the surveys are summarised in Table 1. The longline surveys were carried out using longline fishing gear which is commonly used for the commercial fishing of Greenland halibut. The fishing performance in East Greenland waters is affected by rough bottom and strong currents and longlines are usually set along the continental slope to avoid gear loss. Longlines were set within predefined depth intervals; 400–600 m, 600–800 m, 800–1000 m, 1000–1200 m, 1200–1400 m and deeper than 1400 m. In some areas such as in the fjords, longlines were sometimes set down the slope. In such cases longlines were labelled when crossing the limits of the above mentioned depth intervals as observed from the echo transducer.

The Skarheim 1994 survey was carried out in five areas in the Fjords around 65°N (Fig. 1). The Skarheim 1996 survey was carried out in three areas 60°, 62° and 63°N (Fig. 1). The areas at 63°N covered only offshore areas whereas the areas at 60° and 62°N covered both fjord and offshore areas. The 1997 and 2000 surveys were carried out in offshore areas (Fig. 1). In the longline surveys, each setting usually consisted of two magazines, giving a total of 2600–2800 hooks pr. setting. The catch per unit effort (CPUE) and number per unit effort (NPUE) were calculated for each station in the longline surveys as the weight of Greenland halibut (kg) caught per 1000 hooks and number caught per 1000 hooks respectively. The longline gear used in these trial fisheries was expected to mainly catch Greenland halibut between 40 and 60 cm as shown by the use of this gear to catch Greenland halibut in the Barents Sea (Nedreaas et al., 1996).

In 1995 two gillnet surveys were conducted. Gillnets used were monofilament with a mesh size of 100, 110 or 120 mm (half mesh size), which were expected to catch fish between 50 and 80 cm as shown by the use of this gear to catch Greenland halibut in the Barents Sea (Huse et al., 1999). These were carried out at three locations in East Greenland (areas J, K and L) at depths between 500 and 1400 m (Fig. 1). These surveys were carried using the same gear and close together in time so the results for these surveys were combined. Each station consisted of 30 and 35 nets for the Husøy and Kato surveys respectively. The catch was standardised to the number and weight caught per net (Table 2).

In 1998 a gillnet survey was carried out in the South-east and South-west Greenland (areas G, I and N–R) (Fig. 1), using fine meshed gillnets designed to catch Greenland halibut between 10 and 40 cm (Woll et al., 2001). Between one and seven settings were used per station with a setting consisting of 6 gillnets which had a mesh size of 15, 19, 25, 33, 42 and 55 mm (half mesh). These nets were set in a line with increasing mesh size with a space of 1 m between nets. The catch per station was standardised by dividing the number of Greenland halibut caught by the number of settings used at that station.

The biological sampling varied slightly between years but in all surveys, all Greenland halibut caught were counted and measured for length (to the nearest 1.0 cm below). The sex, total weight (nearest 10 g) and gonad weight (nearest 1.0 g) for a sub-sample of the catch at each station were taken. The numbers of fish caught and sampled during each survey are summarised in Table 1.

Gonadosomatic index (GSI) was calculated as a percentage of the total weight. A GSI of 1% was used as a threshold value for maturity classification with a GSI > 1% being classed as mature (adult) and fish with a GSI < 1% classed as immature (juvenile). This limit is used previously by Burton (1999) for other species. Using GSI is a poor indicator of the ovary developmental stage in Greenland halibut. However, it can be used as a rough guide in assessing whether a group of fish (when caught at a similar time of the year), consists mostly of mature fish or fish which have not begun or are at an early stage of development (Simonsen and Gundersen, 2005). Thus, this labelling of fish as immature or mature does not claim whether the fish will spawn in the coming spawning season.

In 1995 and 1998 gonad stage was assessed macroscopically with fish being classed as immature (ovaries small with no visible oocytes), mature (oocytes > 1 mm and visible to the naked eye), running (ovaries contained hydrated oocytes) or spent (gonads are flaccid and bloodshot). The gonads of females which contained hydrated oocytes were not weighed due to loss of eggs giving an inaccurate weight.

For males, the maturity stage was assessed macroscopically by personnel on board the vessel. These were classed as either immature (gonads are small with no milt present) or maturing (milt is present in the gonads) or running (milt is released under light pressure). The

Table 1
Details of the survey in East Greenland showing the year, dates of the survey, vessel, gear type (LL = longline, Gi = gillnet), areas surveyed (see Fig. 1), the number of stations (St.), the depth range of the stations and the number of Greenland halibut measured/assessed during each survey for each parameter (L = length, W = weight, S = sex, M = maturity).

Year	Dates	Vessel	Gear	Area	St.	Depth (M)	Individuals sampled			
							L	W	S	M
1994	3 Aug–20 Aug	Skarheim	LL	A–F	62	56–900	2231	537	548	478
1995	14 Aug–27 Aug	Kato	Gi	J and L	283	500–1340	7537	257	1580	254
1995	11 Aug–27 Aug	Husøy	Gi	J and K	175	570–1307	7670	356	2241	366
1996	25 Jul–12 Aug	Skarheim	LL	G–K	57	176–1518	7115	798	2882	1025
1997	19 Jul–27 Jul	Loran	LL	J	43	1157–1486	4253	857	2050	472
1998	12 Aug–30 Aug	Audlill	Gi	N–U	71	88–588	787	441	693	693
2000	20 Aug–30 Aug	Fjellmøy	LL	J and M	43	380–1440	4917	667	1285	246