Northwest Atlantic Fisheries Organization

Serial No. N7091 **NAFO SCR Doc. 20/043**

SCIENTIFIC COUNCIL MEETING – JUNE 2020

An assessment of the stocks of Greenland halibut in the South West Greenland fjords division 1BC, 1D and 1EF all located in NAFO subarea 1, using the Depletion Corrected Average Catch model.

by

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Summary

The Greenland halibut fishery in the fjords in West Greenland started with the introduction of longlines about 110 years ago. The fishery is most pronounced in the Disko Bay, the Uummannaq fjord and the fjords near Upernavik, but the fishery in the other fjord areas further south in West Greenland has just as long a history with catch statistics going back to the 1960's in all areas and even back to 1910 in the fjords around Qaqortoq in south Greenland (1F).

In this study, the depletion corrected average catch (DCAC) model is used to approximate a sustainable level of catch, for the fjord stocks of Greenland halibut in NAFO subarea 1 subdivision 1BC, 1D and 1EF inshore. The harvest control rules suggested in the ICES DLS Guidance Report 2012 and supplementary knowledge can be used to advise a stepwise adjustment of the catch to the DCAC approximated sustainable level of catch in the coming years. The approximated sustainable level catch calculated through catch data from 1960 to present is 300 t in the combined area 1B and one 1C (the fjords around Sisimiut and Maniitsoq), 398 t in 1D (the fjords near Nuuk) and 222 t in the combined 1E and 1F area (fjords between Paamiut, Qaqortoq, narsaq and Nanortalik).

Introduction

The Greenland halibut fishery started in the fjords in West Greenland with the introduction of longlines in the beginning of the 19'th century. The fishery has always been most pronounced in the inshore areas in division 1A (Disko Bay, Uummannaq and Upernavik), but the fishery in the other fjord areas further south in West Greenland has just as long a history, with catch statistics going back to the 1960's in all areas and even to 1910 in the fjords around Qaqortoq in south Greenland (1F) (Table 1 and figure 1). The areas from 1B to 1F are characterized by the most developed fishing industry (factories) and infrastructure (harbors) located in both cities (Sisimiut, Maniitsoq, the capitol Nuuk, Paamiut, Narsaq and Qaqortoq) and several larger settlements. Although the fishery has a long history, it has so far never been quota regulated. Greenland halibut in the area is almost exclusively targeted with longlines from small open boats and small vessels.

In the fjords from Kangaatisaq to Sisimiut (1B inshore, Nordre strømfjord), annual catches varied between 200 and 1300 t annually from 1964 to the end of the 1970's. From 1979 where catches peaked at 1275 t, catches gradually decreased and have remained below 100 t since 1986. In 2019, landings reached 80 t in division 1B inshore and therefore far below the historic catch (figure 1a).

In the fjords near Maniitsoq (Division 1C, Hamburger sound and Evighedsfjord) catches varied from 28 to 179 t from 1960 to the end of the 1980's and peaked in 1980 with 327 t. Catches gradually decreased there after and was almost non existing from 1986 to 2004. Since 2005 catches have gradually been increasing and reaching 221 t in 2019.

In the fjords near the Capitol Nuuk (1D inshore, Nuuk fjord/Godthåbsfjord, Ameralik fjord, Buksefjord and Grædefjord) annual landings fluctuated around 500 t annually from 1966 to the end the 1980's. Catches peaked in 1985 with 2,136 t landed to private and public owned factories in Nuuk. After this intense fishing period the fishery gradually ceased and from 1989 to 2002 the fishery was virtually non existing, with only a few t landed per year, mostly likely mainly taken as bycatch in other fisheries. From 2003 catches gradually increased, reaching 1,369 t in 2016, and in general . In 2019, the total catch decreased to 834 t from 1117 t in 2018.

In the fjords around Paamiut and the settlements Arsuk and Ivittuut (1E inshore) the annual catches statistics is available from 1919 to 1939, but the landings were at a low level. No statistics has been found from WWII to the end of the 1950's. From 1960 catches were with few exemptions below 100 t until the end of the 1970's. Catches increased from 1981 and peaked in 1985 with 507 t and after a short decrease again in 1989 at 497 t. From 1995 to 2003 the fishery was virtually non existing and remained below 100 t until 2013. From 2014 the fishery has increased to round 300 t with a peak of 409 t in 2017.

In the fjords around Narsaq, Qaqortoq and Nanortalik (Bredefjord to lichtenau fjord) the catches gradually increased from 1911, peaking in 1923 with 397 landed and gradually decreasing to nothing by 1931. No statistics is available from WWII to the end of the 1950's. From 1960, catches show somewhat similar trends as in division 1E, with catches varying between 50 and 150 t in most years. From 1981 catches increased and peaked in 1985 at 847 t, but gradually decreased and remained below 100 t 1989 to 2013 catches with the exemption of 2006. In the period 2015 to 2018 catches gradually increased reaching 376 t in 2017. In 2019, total catch was more than halved as only 139 t of Greenland halibut was landed to factories in division 1F inshore.

In general, the catch history in the fjords leaves an impression of more localized stocks that at certain periods gradually are fished down to a level where the fishery is no longer profitable. As the stocks gradually are supplied with juvenile recruits from the banks along the coast of West somatic growth of the remaining fish and recruits leads to a gradual rebuilding of the biomass in the fjords whereby the fishery can be reinitiated when it is profitable again.

Material and methods

The Depletion corrected average catch (DCAC) model was applied to the catch history in both individual and combined areas. The depletion corrected average catch model is an extension of the potential-yield formula, providing estimates of sustainable yield for data-poor fisheries on long lived species (MacCall, A. D. 2009). The model is available for download from the NOAA Toolbox at http:\\ntf.nefsc.noaa.gov/. The depletion corrected average catch gives an approximation of MSY.

The method requires a cumulative total catch over several years or even better several decades as the main input. The catch is divided into a sustainable yield component and an unsustainable component associated with a one-time reduction in stock biomass. The size of the unsustainable component is expressed as being equivalent to a number of years of sustainable production, in the form of a “windfall ratio”. The DCAC is calculated as the sum of catches divided by the sum of the number of years in the catch series and this windfall ratio.

ICES DLS Guidance report 2012 p. 19-21 suggest a method to provide advice from the approximated MSY output from the DCAC model. The method uses tow senarios and a subjective adaptation period of 3-5 years. The method follows a ”fast down” – ”slow up” approach taking into account that stocks with a low biomass can not sustain MSY.

Senario 1

If recent catch is greater than DCAC the advice for the following year is reduced by:

C_{y+1}= (1-⍰)C_{sq} + ⍰*DCAC*

Where the ⍰ is gradually increased from 0.6 to 1 in the following 3 to 5 years.

And where C_{sq} is the catch in the most recent year

– Apply a 20% Uncertainty Cap to the advice

Scenarie 2

If the recent catch is less than DCAC, Advised catch should be based on a slow stepwise increase.

C_{y+1}= (1+d)*C_{sq}

Where d is the desired rate of increasing catch to DCAC (e.g. 0,1)

Results

The model was run on both single areas and combined areas. The selected combinations of timeseries, areas and DCAC output is given in table 1. It can be observed that for the DCAC output it matters little whether early periods or areas are combined or not. To simplify things, the areas were combined in 3 groups constituting the combined area 1B+1C, 1D and the combined area 1E+1F. The reason for doing so, is both practical purposes to ease future management, but also due to the fact, that the both the areas 1B+1C and 1E+1F shows somewhat similar trends. The chosen timeseries and area combinations suggest a sustainable level of catch of 300 tons per year in the combined 1BC region (Sisimiut-Maniitsoq fjords), 398 tons in 1D (the Nuuk fjords) and 222 tons in the combined 1E and 1F divisions (Paamiut to Nanortalik fjords).

The Natural mortality M was in all runs set at 0,15 also used in other assessments for long lived species at a higher trophic level. F_{MSY}/M-ratio was set to 1 and B_{MSY}/B_0 was set to 0.5, as in the default settings. The parameter *depletion delta* allows for a subjective guess on the present state of the stock compared to the virgin stock, before the fishery started. If the depletion delta is set at a high value, the present perception of the stock is more negative or reduced compared to the virgin state. If depletion delta is set at a low value, the present perception of the stock is more positive. In all runs, depletion delta was set at 0.2 (see discussion). The input parameters used in the model runs are given in table 2.

To test the sensitivity of the model to the input parameters the DCAC model was run several times with different settings for the catch history in area 1D inshore (Nuuk area). The effect of varying the input parameters is relatively small (table 3). For both Fmsy/M-ratio and B_{MSY}/B_0, the inputs must be changed quite far from the default values normally assumed, to even have an effect on the DCAC result. The largest effect is achieved by varying the depletion delta.

Commercial data

Recent landings by month is given in figure 2. Length distributions from commercial landings are mainly available from the Nuuk area (1D inshore). ommercial data is mainly available from 1D (Nuuk area), whereas length distributions from landings in other areas very limited. Figure 3. In the 1D area A, a decrease in the mean length in the landings was observed during the 1970's and 1980s and again in the most recent years with higher landings.

survey data.

A trawlsurvey was initiated in the fjords near Nuuk (Godthåbs fjord and Ameralik fjord) in 2015 and continued from 2017-2019. The survey reveals a gradual reduction in the numbers of larger Greenland halibut in the Godthåbs fjord and the Ameralik fjord from 2015 to 2019. However higher numbers of pre-fishery recruits at a length of 30-40 cm were found in the 2019 survey leading to an increase in biomass indices. See SCR 20/006 for a full description of the survey and results.

Discussion

The advantage of using the DCAC-model is obviously that only catch data from a long timeseries with both growth and depletion of the stock is needed. Since the fishery in the other areas (1A inshore, East Greenland inshore or Qaanaaq fjord) have not gone through both growth and collapse, caution should be given in using the model in other situations. At the same time, the model does not provide any risk assessment and it is difficult to evaluate the present status of the stock. It should also be noted that if the catch is less than TAC because of uptake issues or previous quota regulations the method may not be appropriate. This does however not seem to be the case as the fishery has taken place in well developed areas for decades, without quota regulations due to the fairly limited extent compared to other fisheries in West Greenland, like the Shrimp, Greenland halibut offshore in 0AB, 1AB and 1CD and inshore in division 1A, cod, lumpfish and other fisheries.

The subjective setting of the Depletion delta was in all selected runs set at 0.2 which is the same as assuming that the stock is only slightly reduced compared to the virgin stock. The value was selected for two reasons.

Firstly, in all areas it is not known for sure whether the stock was indeed virgin in 1960 or whether a fishery had already started back in the 1950's. indeed, catch statistics starts off at a fairly high level in 1960, 1961 and 1963 and 1964. Secondly, it is not known for sure whether the latest fishery has reduced the stocks as the fishery is currently continuing.

The-DCAC advice can to some extent be considered conservative, as the estimated sustainable catch will always be less the average catch for the total timeseries with unregulated fishery. From a fisherman's point of view, is can seem dissatisfactory that the average yield is lower at a constant sustainable utilization of the stock, than in the situation with free and unregulated fishery leading to periods of local depletion. Nevertheless, the DCAC model provides an estimate of a sustainable level of catch until sufficient data has been collected and other more advanced models can be used.

The DCAC output also shows great resilience towards varying the subjectively chosen input parameters. This is likely due to the extremely long timeseries (57-87 years) available to the model runs. It should be noted that there is little difference in the total estimated output if combined or separate areas are chosen or whether shorter or longer timeseries are chosen. For practical purposes it should be ok to use combined areas. However, although the DCAC output suggest that catches can be increased, it should be noted that that the fishery in the Maniitsoq area (1C) is currently higher than the DCAC output sustainable catch, whereas the combined Sisimiut-Maniitsoq (1BC) is below. Therefore, a risk of local depletion in certain areas or even within local areas or even local fjords within areas still exists.

References

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The model is available for download from the NOAA Toolbox at http:\\ntf.nefsc.noaa.gov/. Further information is also available in the RGLIFE report Appendix B (ICES 2013b) and from sources including Anon (2011); Wetzel and Punt (2011), and MacCall (2009).

Catch statistics references

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Table 1. Used timeseries and results of the DCAC runs. Finally chosen timeseries and area combinations are highlighted in Bold.

Inshore Area	Time series	Summed Catch	Number of years	Average catch per year	Depletion delta	DCAC Output
NAFO 1B	1960-2018	13874	56	248	0,2	234
NAFO 1C	1960-2018	4174	58	72	0,2	68
NAFO 1BC	**1960-2018**	**18062**	**57**	**317**	**0,2**	**300**
NAFO 1D	**1960-2018**	**24384**	**58**	**420**	**0,2**	**398**
NAFO 1E	1960-2018	6582	58	113	0,2	107
NAFO 1F	1960-2018	7020	58	121	0,2	115
NAFO 1F	1910-2018	10656	87	122	0,2	118
NAFO 1F	1910-2018	10656	87	122	0,5	112
NAFO 1EF	**1960-2018**	**13602**	**58**	**234**	**0,2**	**222**

Catch estimates are available for all areas from 1960-2019, except for 1963.
Catch estimates are available for 1F 1910-1938.
Catch estimates are available for 1E 1918-1938.

Table 2. Selected parameter settings in the DCAC runs.

Parameter	value	Standard deviation	Distribution
M	0,15	0,5	lognormal
FMSY/M ratio	1	0,2	lognormal
BMSY/B_0	0,5	0,1	Bounded beta [0-1]
Depletion Delta	0,2	1	lognormal

Table 3. Test of Input parameter on NAFO 1D inshore (Nuuk fjords) 1960-2018.

Parameter	Alternavive	DCAC output	Remarks
M	0,1	389	In most literature M is often set to 0.15 for Greenland halibut and other slow growing long lived fish species. The effect of using other values for M is relatively small.
	0,15	398	
	0,2	403	
F_{MSY}/M	0,5	380	Often assumed to be around 1. (small effect)
	1	398	
	1,5	405	
B_{MSY}/B_0	0,4	393	B_{msy} is often assumed to be around half the virgin stock B_0 (small effect)
	0,5	**398**	
	0,6	402	
Depletion delta	0,1	408	Since no catch statistics is available before 1960 it is assumed that the stocks were below virgin biomass in the beginning of the timeseries and that the stocks are not completely fished down since the fishery is currently ongoing.
	0,2	**398**	
	0,3	389	
	0,4	380	
	0,5	372	

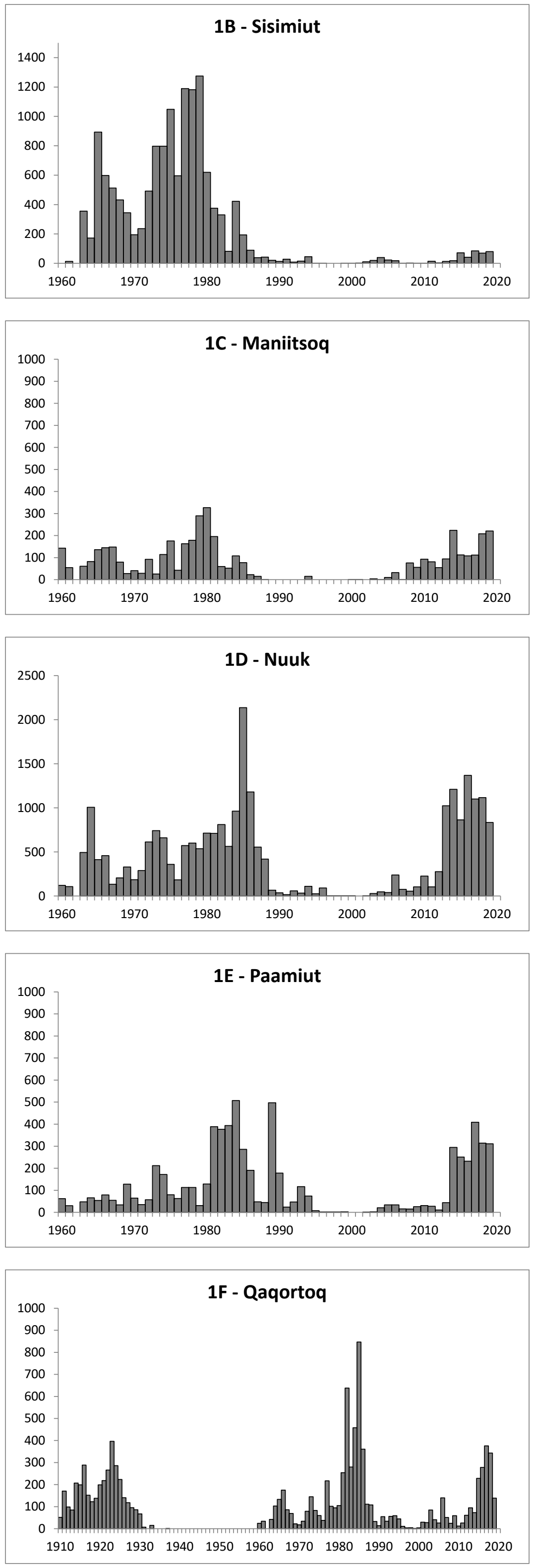

Figure 1. Catches of Greenland halibut by NAFO-division.

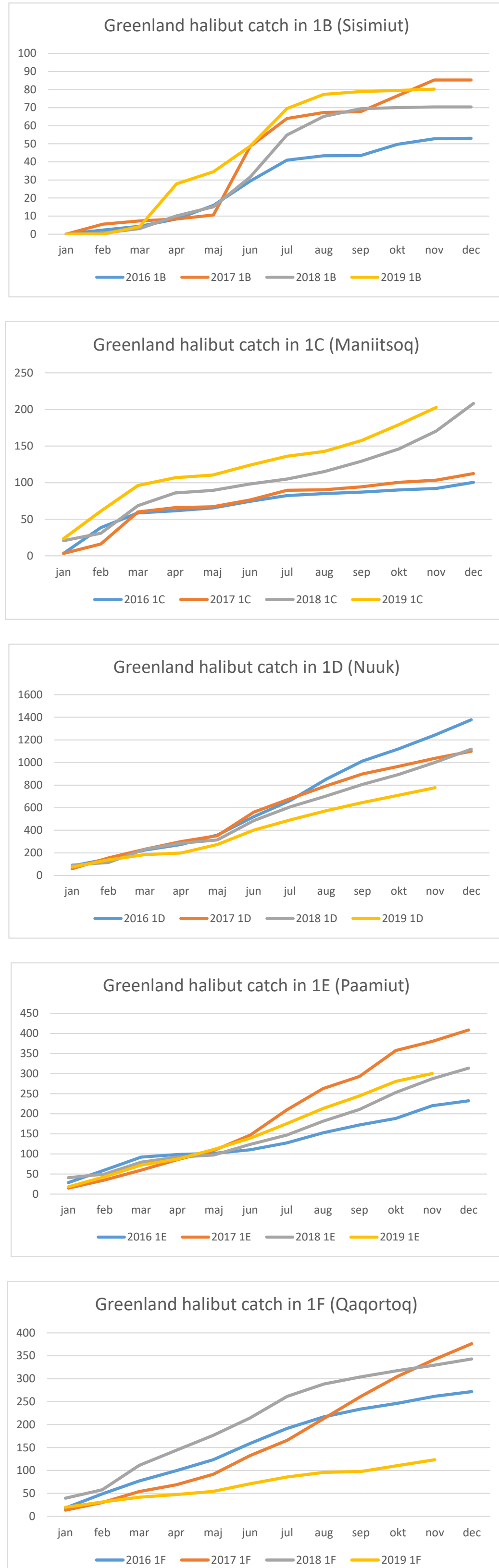

Figure 2. Catch by month from 2016 to 2019 in the inshore fjord areas from division 1B to 1F.

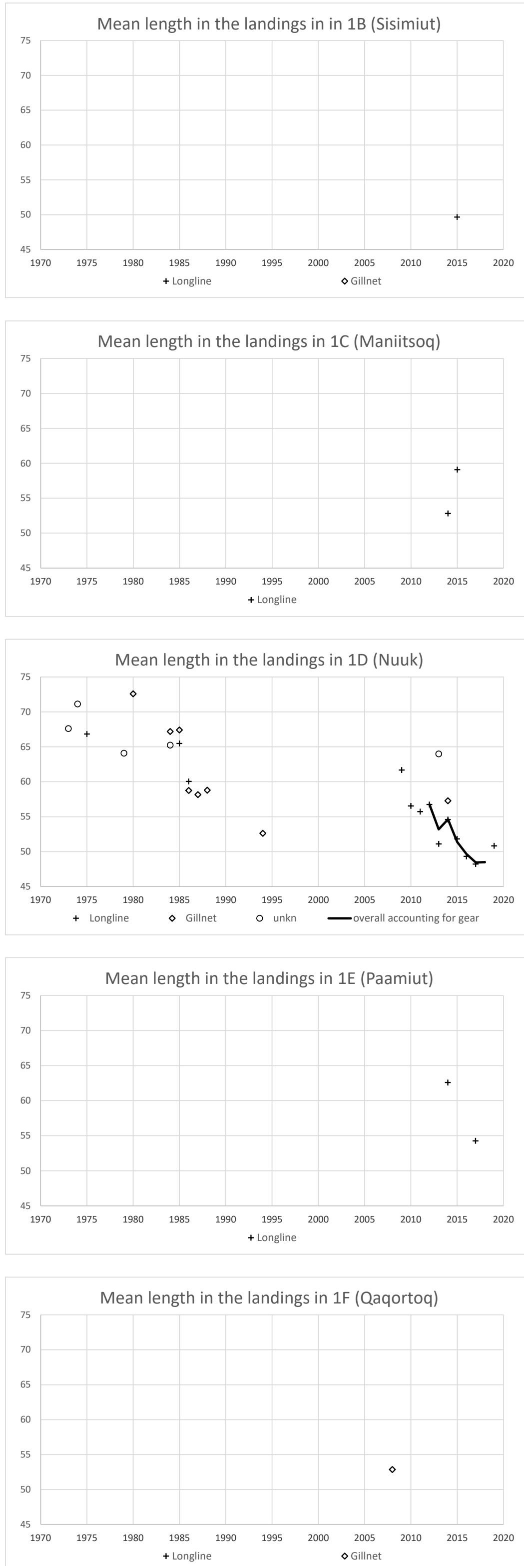

Figure 3. Mean length in the landings Mean length in the landings from 1BC, 1D and 1EF.