Stock Annex: Cod (*Gadus morhua*) in NAFO Subarea 1, inshore (West Greenland cod)

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Cod
Working Group	North Western Working Group (NWWG)
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Authors:	
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A. General

A.1. Stock definition

ICES advice is given for three separate cod stocks in Greenland waters:

1) West Greenland offshore (NAFO 1A–1E)

2) East Greenland offshore (NAFO1F and ICES 14.b)

3) West Greenland inshore (NAFO 1A–1F) inside the 3 nm limit.

Inshore spawning cod is found in many fjords between 64 and 67°N in West Greenland (Hansen, 1949; Smidt, 1979; Buch *et al*., 1994). Recent summaries of the stock structure and developments includes: Buch *et al*. (1994), Wieland and Hovgård (2002), Storr-Paulsen *et al*. (2004), Wieland and Storr-Paulsen *(*2005*),* Hovgård and Wieland (2008), and Therkildsen *et al.* (2013).

Tagging information show that cod tagged in the fjords are predominately recaptured in the same fjord as tagged or in the adjacent coastal areas (Hansen (1949), Hovgård and Christensen (1990), Storr-Paulsen *et al.* (2004)). Tagged bank cod are predominately recaptured on the Banks and to a lesser extent in the coastal areas. In contrast, cod tagged in coastal areas are re-captured in all areas. Hence, the tagging experiments indicate that the offshore and inshore cod are generally separated but that the coastal area is a mixing zone, especially during the juvenile stages. A considerable number of tags are returned from Icelandic waters, especially from tagging in the coastal areas in Southwest Greenland (south of 61°N) and the banks in East and Southwest Greenland (ICES XIV, NAFO Division 1EF). Hence the genetic and tagging studies shows that inshore catches must be considered a mix of inshore cod, West Greenland offshore cod and East Greenland/Icelandic offshore cod. The proportional contribution has however never been quantified.

In 2012 the West Greenland inshore cod stock was split from the offshore stocks, and a separate advice has been given for this stock since.

A.2. Fishery

Short historical review

The inshore Greenland commercial cod fishery in West Greenland started in 1911 by opening the cod trading at localities where cod seemed to occur regularly. The fishery expanded over the next decades through a development of a number of new trading places. Annual catches above 20 000 t have been taken inshore during the period 1955–1969 but declined to around 5000 t in the 1970s. In the 1980s catches fluctuated between 5000 and 35 000 t, partly driven by a few strong year classes (1979 and 1984) entering from the offshore stock (Horsted, 2000). From 1993 to 2001 the inshore catches were low; in the range 500–2000 t. In the 2000s catches have gradually increased with maximum catches in 2013 of 18 500 t. No licence was required until 2009 and the fishery has historically not been constrained by a TAC (for 2009 a TAC of 10 000 t was introduced) but a minimum landing size of 40 cm has been enforced. The most important gear has been pound-net (taking between 60% and 80% of the annual catches) anchored at shore and fishing the upper 20 m. Due to ice poundnets are not used during November–April but instead jigs, longlines and gillnets. Trawling is not allowed within 3 nm off the baseline. The fishery is carried out along the entire coastline of West Greenland from Disko Bay to Cap Farewell, with the majority of the catches being taken in mid-Greenland.

The present fishery

Coastal vessels in the inshore fishery are defined as vessels below 75BT/120BT. Inshore catches have since 00s increased with highest catches of 18 500 tons in 2014. In recent years the fishery has expanded north, and catches in this area are to a large extent caught as bycatch by longlines and gillnets in the Greenland halibut fishery. Fish caught with these gears are on average 10 cm larger than poundnet catches. In general the mean length in the fishery has been increasing over the past ten years, and is currently 53 cm. All landings are reported, no discarding is assumed to take place and the data quality is considered high.

A.3. Ecosystem aspects

There is little bycatch in the poundnet or jig fishery. Additionally, fish below the minimum size are easily released from the poundnets and are believed to survive. Poundnet selectivity means that fish ages six and older are not caught in proportion to the stock composition.

B. Data

B.1. Commercial catch

Information on landings in weight are compiled and processed by the Greenland Fisheries Licence Control (GFLK). Inshore catches are in addition documented by sale slips and from logbooks which have been mandatory since 2008 for vessels larger than 30 ft. The main fishing gear of these vessels are pound nets that catch live fish until the nets are saturated and information on CPUE from this type of fishing gear is therefore questionable. Information from vessels smaller than 30 ft are only from sale slips, and until 2011 these where off poor quality meaning that catches where compiled using landing data from the factories with no information on effort, gear type or fieldcode of actual catch. From 2012 the qualities of sale slips have improved and include information on effort, gear type and fieldcode of each catch that is landed to a factory. The preferred

gear used by small dinghies is jigs and CPUE from this type of fishing gear is questionable.

Sampling of length frequencies and information on age, weights and maturities are collected and compiled by the Greenland Institute of Natural Resources. A well-balanced sampling of the Greenland coastal fleets catches has always been impeded by the geographical conditions, i.e. the existence of many small landing sites separated along the over 1000 km coast. Except for the Nuuk area that is easily covered samplings relies on dedicated sampling trips supplemented with ad hoc sampling. The sampling coverage was especially poor in the late 1990s when catches were very low (<1000 t annually) and length frequencies are missing in 1998 and 2001. The sampling coverage has improved since around 2004 through a formal cooperation with GFLK observers. Currently, sampling is considered adequate to reliably describe the age composition of the catches.

Recent genetic studies have documented the presence of different stocks in Greenland waters (see Section A1). Furthermore, results show that these stocks are present in catches in varying proportions in offshore regions, and something similar may apply to inshore landings. Hence, catches of the inshore stock may be overestimated but the proportions are unknown. This stock mixing also influence the recruitment index, as stock input from other regions may cause overestimation of recruitment.

B.2. Biological

Spawning

Spawning cod have been collected from 2008–2010 in order to investigate the extent of spawning. In addition a spawning survey was conducted in spring 2011 in order to investigate those fjords without samples of spawning cod. The results show that spawning occurs in the coastal zone and in the fjords and is especially pronounced between Sisimiut (NAFO 1B) and Paamiut (NAFO 1E) (figure B.2.1, Retzel & Hedeholm 2012).

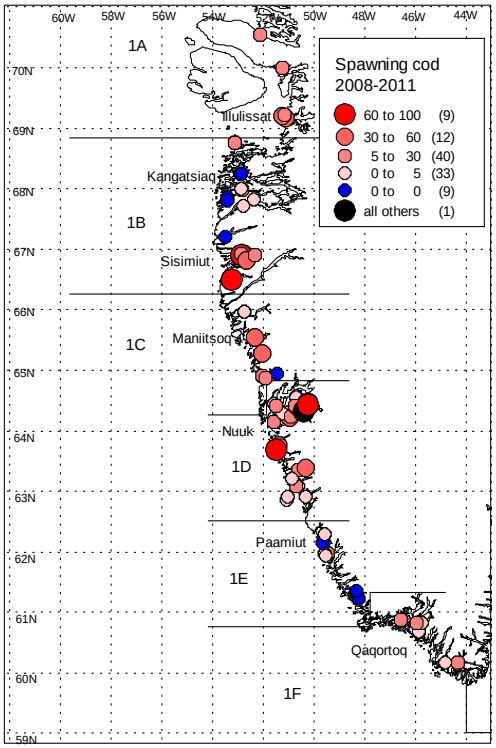

Figure B.2.1: Numbers of spawning cod collected from commercial catches 2008-2011 and spawning survey 2011.

B.3. Surveys

Inshore gillnet survey

The objective of the gillnet survey is to assess the abundance and distribution of pre recruit (age 2 and 3) cod in fjord areas in West Greenland. The survey has been conducted annually since 1985 covering three inshore areas along the cost of West Greenland: Sisimiut (NAFO Division 1B), Nuuk (NAFO Division 1D) and more occasionally Qaqortoq (NAFO Division 1F; Figure B.3.1).

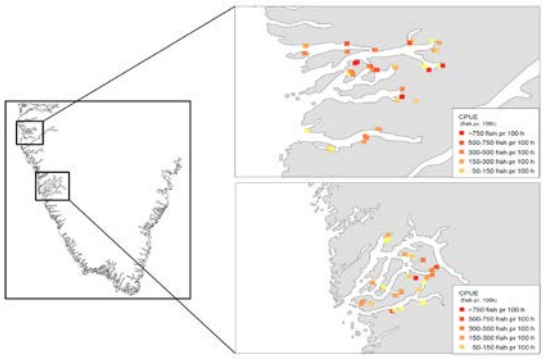

Figure B.3.1. Map with two fjord system most regularly surveyed in the West Greenland inshore gillnet survey. Data shown are 2013 results.

The survey uses gangs of gillnets with different mesh sizes (16.5, 18, 24, 28 and 33 mm, ½ mesh). 100–150 nets are set annually and are set perpendicular to the coast in order to keep depth constant. The survey effort is allocated evenly between the depth zones

of 0–5 m, 5–10 m, 10–15 m and 15–20 m. The abundance index used in the survey is defined as 100*(# caught/net*hour).

The original net materials are no longer commercially available for the three smallest mesh sizes. From 2004 this has implied a change in twine thickness (particularly for the 24 mm mesh) that is expected to change the catchability of the nets.

The selection curve for the individual meshes is bimodal with cod being either gilled or snagged (Figure B.3.2; Hovgård, 1996a). For cod, as well as the bycatch of other species, the catchability depends on the twine thickness (Hovgård, 1996b). The effect of the potential change in catchability, associated with the change in net material, can be evaluated from parameters in Hovgård and Lassen (2000) that updates the selectivity estimates based on an improved version of the selection model (Hovgård *et al.*, 1999). The change in the catchability appears limited and confined to cod lengths between 20 and 27 cm.

Mesh-size (mm)	16.5	18.5	24	28	33
Old twine Ø (mm)	0.24	0.20	0.38	0.28	0.33
New twine Ø (mm)	0.20	0.22	0.25	0.28	0.33

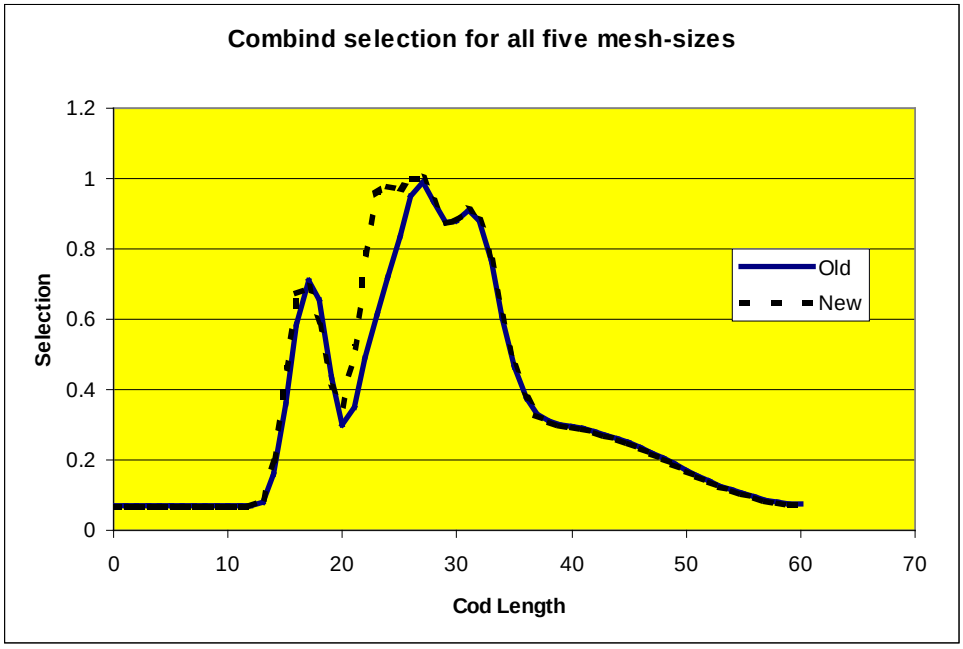

Figure B.3.2. Upper, mesh size description. Lower, combined selection for the gillnet survey. (Old) prior 2004, (New) from 2004 and onwards.

B.4. Commercial cpue

The cpue data quality depend very much on the gear used. Gillnet catches are usually bycatch. Jigs are only used from smaller boats that are not obligated to fill out logbooks. Finally, poundnet data are not useful in cpue calculations as nets are left in the water until they are full, and the information from the fishery does not allow for an evaluation of the fishing time.

Hence, commercial cpue are only available for a limited part of the fishery, and the data obtained are not considered as an indicator of stock size and cpue are not used in the assessment.

B.5. Other relevant data

C. Assessment: data and method

C.1. Regression approach

The survey index in a given year was related to the catch in the next year (Figure C.1.1). The advice is then based on the survey index multiplied by a factor. The validity of this approach rests on a number of assumptions. Among others, the fishery has been at a stable sustainable level (ideally the same across years). Based on the model outputs and catch curves (Hedeholm and Post, 2015) this seems to be a reasonable assumption, at least during the last 15 years. Some years in the 1980s did not follow the overall trend, and were most likely subjected to a very high fishing intensity and a very high offshore input to the fishery, and these years are therefore excluded from the regression analyses. The fish enter the fishery at age 4. Accordingly the survey index of ages 3–8 was used to generate advice

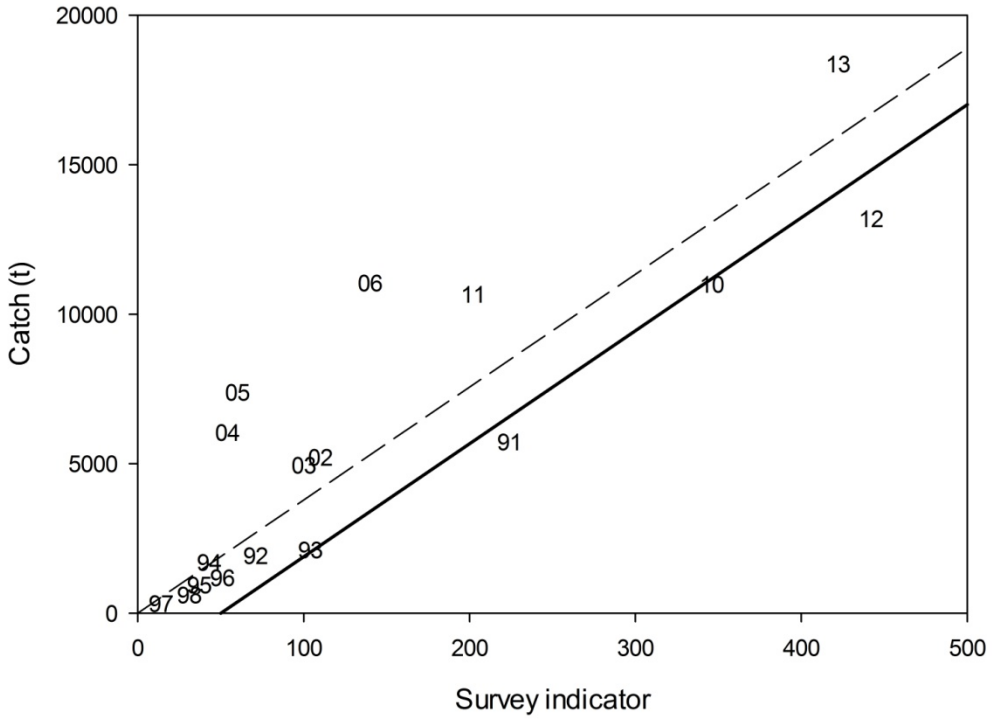

Figure D.1.1. Survey index of 3–8 year olds vs. the catch the following year. $r^2 = 0.76$. Based on data from 1991–2014. points are labelled by survey year.

Given that this approach is based on variable data a precautionary approach should be taken. So rather than having the regression pass through the origin, the intercept with the x-axis is set at a survey index value of 50 and slope is 37.9. The survey tends to vary considerably between years, and to avoid having the advice fluctuate accordingly the average of the last two years survey index values were used when calculating the catch advice. Consequently, the advice is generated as follows:

$$C_{y+1} = 37.9 * (U_{3-8y} - U_{trigger}) \quad (1)$$

where U_{3-8y} is the combined survey value for ages 3–8 and $U_{trigger}$ is 50.

E. Medium-term projections

F. Long-term projections

G. Biological reference points

	Type	Value	Technical basis
MSY	MSY Btrigger		Not defined
Approach	FMSY		Not definedExplain
	Blim		Not defined Explain
Precautionary	BPA		Not defined Explain
Approach	Flim		Not defined Explain
	FPA		Not defined Explain
	UTrigger	50	From the Gillnet survey

H. Other issues

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