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Effects of Selectivity on Results from Gillnet Surveys for Young Atlantic Cod (*Gadus morhua* L.) in West Greenland Waters

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Abstract

Size distribution for Atlantic cod (*Gadus morhua* L.) caught in strings of gillnets with different mesh sizes is compared to size distributions from concurrent trawl and jig catches. It is concluded that the size distribution of the gillnet string is very dependent on the choice of mesh sizes. A bimodal selection pattern is found in the gill nets as cod are mainly attached behind the gill or at the jaw region. The size of fish caught by both methods is simply related to mesh size. Finally, possible effects of selection on survey results are discussed.

Introduction

Prediction of year-class strength of recruiting year-classes is of considerable importance when forecasting developments in the fisheries and providing management advice. In the West Greenland area, such predictions for Atlantic cod (*Gadus morhua* L.) have previously been based on abundance of larvae and hydrographic observations. In an evaluation of these prediction procedures, Hansen and Buch (1986) concluded that temperature and larval data can provide some useful information on year-class strength, but that precise predictions from such data are difficult when the relative importance of recruitment from the East Greenland–Iceland region is not known. For this reason, the authors suggested that year-class prediction for Atlantic cod off West Greenland should be made from young-fish surveys.

In the absence of a research vessel to conduct large-scale trawling operations, the Greenland Fisheries and Environmental Research Institute conducted a pilot survey in 1984 with different passive gears (gillnets, longlines and trapnets) in inshore waters. Only gillnets were successful in catching small Atlantic cod. In 1985, a survey of inshore waters was carried out with strings of gillnets of different mesh sizes (Hansen and Lehmann, MS 1986). The results from that summer survey were generally in good agreement with data from the autumn trawl survey of the offshore grounds by Federal Republic of Germany, in that both surveys found the 1984 year-class of Atlantic cod to be abundant. However, there were problems with interpretation of data from the gillnet catches due to lack of knowledge about selectivity of the nets. Further studies were carried out in 1986. The purpose of this paper is to give a first evaluation of the effects of gillnet selection on survey results.

Materials and Methods

Data for this study were derived mainly from the young-cod surveys which were conducted in inshore waters of West Greenland (NAFO Div. 1B to 1F) during the summer of 1986 (Hovgård, MS 1987). Most of the fishing operations involved the use of standard strings of gillnets, as were used in the 1985 survey (Hansen and Lehmann, MS 1986). Each string consisted of four gillnets of different mesh sizes (16.5, 24, 33 and 55 mm, knot to knot). Delivery problems with the 33-mm mesh gillnets made it necessary to substitute 35-mm mesh gillnets in about half the strings. Fishing depths ranged from 2 to 30 m, and the gillents were set near the surface in some cases and near the bottom in others. The mean fishing time per set was about 8.1 hr.

In order to obtain independent information on the size distribution of young Atlantic cod, two other gear types were used concurrently in the inshore areas: (a) strings of gillnets with mesh sizes of 10, 12.5, 16, 22, 25, 33, 38 and 45 mm (knot to knot), commonly used in the Institute's investigations of Arctic char (*Salvelinus alpinus*); and (b) jigs with small hooks (gape size 12–17 mm). Data on the size distribution of Atlantic cod on the offshore grounds from research trawl catches in Div. 1BCD during the same season were also used for comparison. Mesh size of the codend was 40 mm (stretched). The various research fishing operations in July–August 1986 are summarized in Table 1.

Results

Size distributions of Atlantic cod catches by the various gears differed considerably (Fig. 1). The offshore trawl and inshore jig catches exhibited overall unimodal length distributions, dominated largely by

the 1984 year-class. The mean size of fish in the jig catch was somewhat larger than in the trawl catch, the modes being 27 and 25 cm respectively. It was not possible to evaluate whether the difference was due to areal or selectivity factors.

TABLE 1. Summary of information on research fishing operations in inshore waters of West Greenland, summer 1986.

Gear	NAFO Div.	Period	No. of sets	No. of cod
Otter-trawl	1B	26 Jul–17 Aug	30	805
	1C	24–26 Jul	8	42
	1D	07–11 Jul	12	420
St. gillnet strings	1B	16–23 Aug	64	1,218
	1D	28 Jul–08 Aug	43	277
	1F	03–08 Jul	72	598
Char gillnet strings	1B	16–23 Aug	10	138
	1D	28 Jul–08 Aug	7	48
	1F	03 Jul–06 Aug	13	175
Jiggers	1B	16–23 Aug	6[a]	797
	1C	11–12 Aug	2[a]	111
	1D	28 Jul–08 Aug	5[a]	139
	1E	27 Jun	1[a]	97

[a] Number of operations

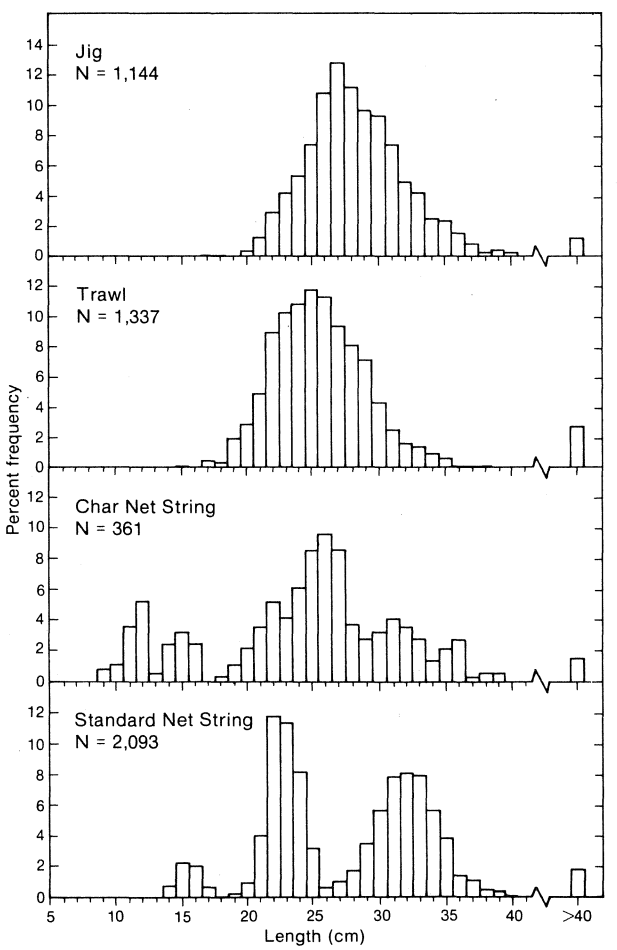

Fig. 1. Length distributions of cod caught by different gears during surveys at West Greenland, July–August 1986.

The size distributions of cod in catches by the two types of gillnet strings (char and standard) are more complex (Fig. 1). The overall char-gillnet catch can be considered as roughly bimodal and composed of the 1985 year-class (9–17 cm) and the 1984 year-class (19–34 cm). However, the overall catch from the standard strings of gillnets, which are normally used in the young-cod surveys, exhibited three distinct modal groups (at 15, 22 and 32-cm) which are not readily explained from knowledge about the available year-classes.

The size distributions of catches by both types of gillnet strings are much easier to interpret when catches are considered in relation to mesh sizes of the gillnets (Fig. 2 and 3). In each case, there is a clear increase in size of fish with increasing mesh size of gillnets. In fact, the size distributions of catches in the char gillnets with mesh sizes of 16, 24 and 33 mm (Fig. 3) were quite similar to those from the standard gillnets of the corresponding mesh sizes (Fig. 2).

The biomodal nature of the length distributions of catches in the standard gillnets with mesh sizes of 16 and 24 mm (Fig. 2) was noticed during the survey, and an investigation of this phenomenon was made in the Nuuk area by observing and recording how the fish were caught in the nets. Fish were generally caught mainly in two ways: either the twine surrounded the

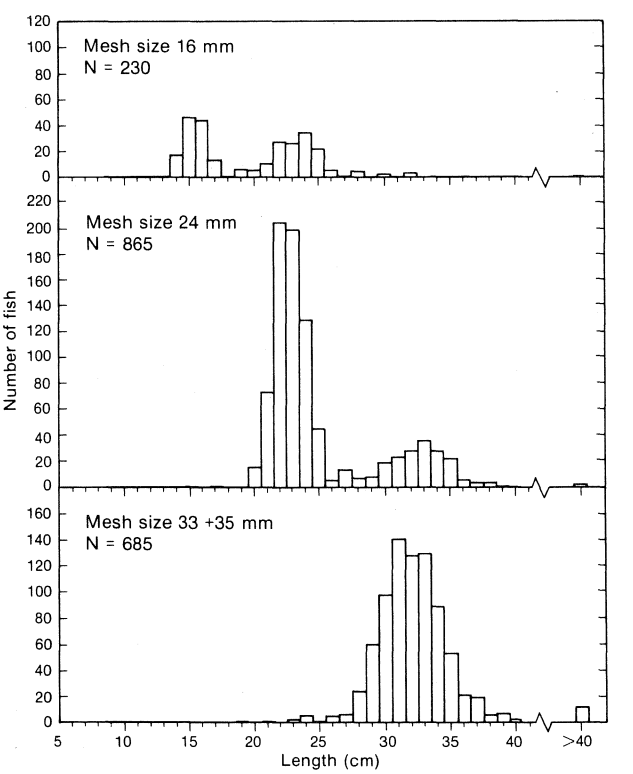

Fig. 2. Length distributions of cod caught in the standard-gillnet string by mesh size. (The 55-mm mesh catch was too small for illustration.)

head behind the gill covers or the twine was tangled in the jaw protrusion (maxilla) on either side of the mouth (Fig. 4). Examination of data by mesh size of gillnet and method of capture (Fig. 5) indicated distinct separation of the two modal groups in the sample from the 24-mm mesh nets, with jaw-caught fish being larger than those caught by the gills. The same trend may apply to the 16-mm mesh nets, but the sample was too small for definitive conclusion. However, nearly all of the fish in the sample from the 33+35 mm mesh nets were caught by the gills. In the case of biomodal length distributions, the smaller fish were caught by the gills and the larger ones were caught by the jaws.

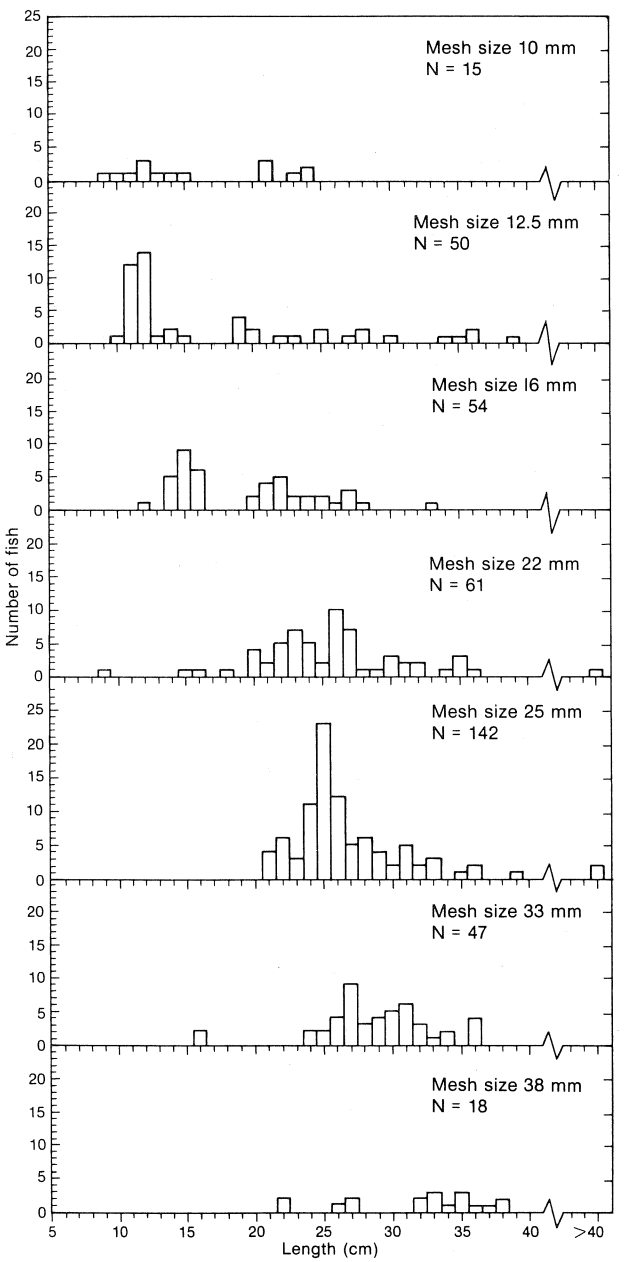

Fig. 3. Length distributions of cod caught in the char-gillnet string by mesh size. (The 45-mm mesh catch was too small for illustration.)

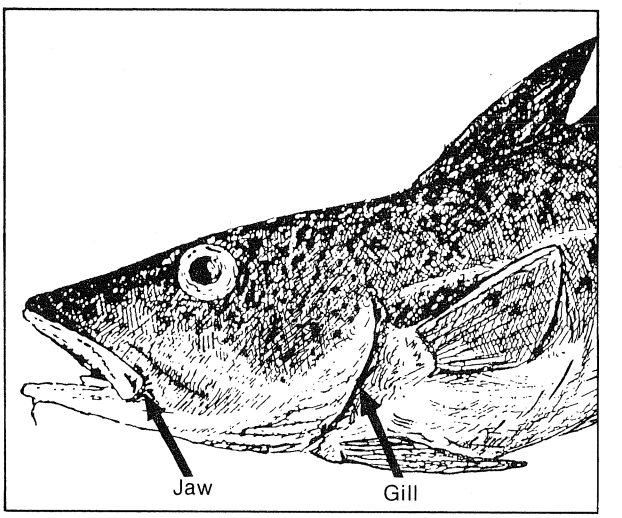

Fig. 4. Sketch of the head showing the two most important structures which cause cod to be caught in gillnets.

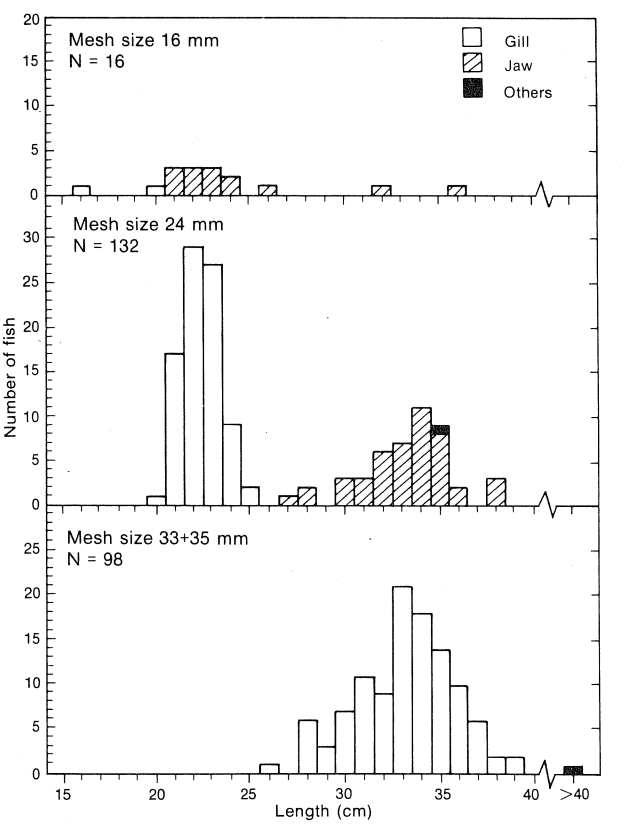

Fig. 5. Length distributions of cod caught during the Nuuk experiment in the standard-gillnet string by mesh size and attachment site.

Discussion

The selection process

Some simple properties of the gillnet strings which are used in the surveys for young Atlantic cod in West Greenland waters emerge from the present study. The bimodal length distributions of fish caught in gillnets of various mesh sizes can be explained by two different methods of capture, i.e. the young cod are caught with the twine either surrounding the head behind the gill covers or tangled in the jaw protrusions. Both of these catching processes are quite selective as more than 95% of the catches consist of young cod whose lengths differ by less than 15% from the optimal length (Table 2). The increase in mean length of young cod between successive gillnet mesh sizes is about 40%, and it appears that fish sizes lying between two modes are inefficiently caught. For this reason, the overall size distribution of cod caught by the gillnet strings (Fig. 1) reflects more the actual choice of mesh sizes than the underlying population structure.

The modal length (i.e. the length groups most efficiently caught) of both the gill-caught and jaw-caught cod can simply be related to mesh size (Fig. 6). The modal length of gill-caught fish is proportional to mesh size, i.e. modal length (cm) = 9.13 × mesh size (cm), with a correlation coefficient (r) of 0.99. For the jaw-caught cod, data were available only for the 16.5 and 24 mm mesh gillnets. In both sizes of gillnets, the modal lengths of jaw-caught cod are approximately 1.5 times the modal lengths of gill-caught fish, thus indicating a simple proportionality between fish length and mesh size for jaw-caught fish, i.e. modal length (cm) = 14.4 × mesh size (cm).

Some consideration must also be given to the relative efficiencies of the gillnets in catching fish by the gills and jaws. This causes a problem in analysis of survey data, because the number of fish in each modal length group is dependent on the number of small fish available. However, by assuming that any size-group is equally available to all mesh sizes, the relative efficiencies of the two catching processes can be estimated by comparing the number caught by the gills in one net with the number caught by the jaw in another net, when looking at the same size-group. By this procedure, the efficiency of gillnets in catching young cod by the jaws was estimated to be about 20% of catching by the gills (Table 3).

Implications of selection on survey results

From the present study, it is clear that the length distribution of Atlantic cod in the standard string of gillnets, used in the young cod surveys at West Greenland, gives a biased picture of the true length distribution of the population, mainly because of gaps in the selection pattern. These gaps may give rise to some inaccuracies, when the catch rate of gillnet strings is used as an index of year-class strength. This is because the size-at-age of Atlantic cod off West Greenland differs considerably from year to year (Hansen, 1987). Therefore, the catch-rate index may be influenced by how well the true size distribution matches the selectivity of the gillnet mesh sizes being used. For this reason, gillnets of intermediate mesh sizes (18.5 and 28 mm) have been added to the gillnet strings for use in conducting future young-cod surveys.

A more satisfactory solution would be to develop a selectivity model which would make appropriate corrections for the actual choice of mesh sizes. Work on this project has been initiated.

TABLE 2. Average length and standard deviation for modal groups of young Atlantic cod in gillnets of different mesh sizes by capture method. (The 95% confidence is interval is expressed as percent of two standard deviations from the mean.)

Mesh size (mm)	How caught in net	Length range (cm)	Mean length (cm)	Standard deviation (SD)	Confidence interval (%)
16.5	Gill	14-18	15.5	0.89	11.5
	Jaws	20-27	23.3	1.49	12.8
24.0	Gill	20-28	22.8	1.19	10.4
	Jaws	28-40	32.7	2.25	13.8
33+35	Gill	26-40	32.1	2.33	14.5

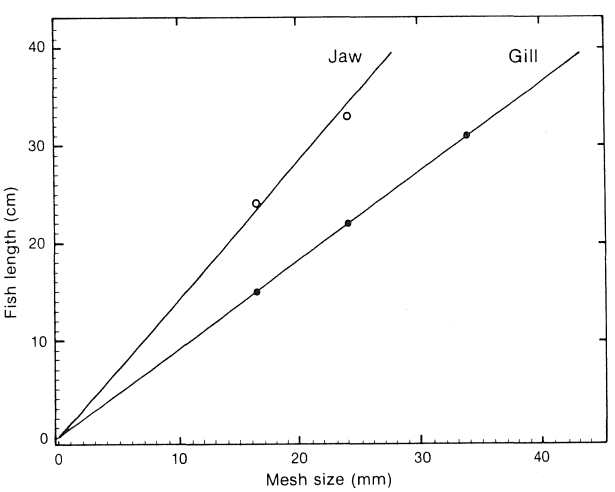

Fig. 6. Relationship between modal lengths of gill-caught and jaw-caught cod by mesh size. (Lines from linear regressions forced through the origin.)

TABLE 3. Estimates of the efficiency of the jaw-catching process relative to the gill-catching process by comparing the numbers caught by selected size-groups.

Length (cm)	Number caught by		Jaw/gill ratio
	Jaws	Gills	
19-26	135	699	0.202
27-39	199	785	0.254

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