PROJECT Nº 96/005: SIZE SELECTIVITY AND RELATIVE FISHING POWER OF BALTIC COD GILL-NETS

KEY WORDS
Selectivity, fishing power, Baltic Sea, statistical model, fisheries management, cod (Gadus morhua).

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OBJECTIVES
There were two specific objectives for this study:
• To measure the effect of gill-net design parameters upon the size selectivity and relative fishing power of Baltic cod gill-nets.
• To produce a statistical model describing these changes in selectivity which can be used in simulations of possible fisheries management scenarios.

APPROACH AND METHODOLOGY
Gear surveys
Gear surveys were made in Denmark and Sweden in order to determine which gill-net design parameters varied most between fishermen targeting Baltic cod and which of them were likely to have a significant effect upon selectivity or fishing power. These revealed that Baltic Sea gill-net vessels are typically small, under 15 GRT, have 1 or 2 crew members and operate a day fishery for cod where the nets are cleaned and reset every 24 hours. Typically, 5-6 km of nets are used (range 2-20 km). Only traditional single-sheet gill-nets are used mainly of multi-mono twine. Height varies between 2.7 and 6 m. Mesh sizes range from 105 mm to 200 mm with 120 mm or 130 mm most popular at that time. Twine thickness is generally increased with mesh size but the most popular mesh sizes are used in 3 different twine thickness (1.5 x 4, 1.5 x 5 and 1.5 x 6 where the second number refers to the number of mono-filament twines twisted together). Netting is available in a variety of different colours. This is reported to have little if any effect upon performance. Floatlines are always hung at a hanging ratio of 50% in Denmark (so the floatline length is half the stretched netting length) but Swedish fishermen hang their cod nets at ratios varying from 38% to 52%. Leadlines are made 1-16% longer than the floatlines (the difference is less in Sweden than in Denmark).
Experimental design

The two gill-net design parameters (in addition to mesh size) that varied most between the fishermen interviewed and were reputed to have a significant effect upon selectivity or fishing power, were twine thickness and floatline hanging ratio. These were therefore selected for study.

Gill-net selectivity is measured by fishing simultaneously nets made in several different mesh sizes. The nominal mesh sizes chosen were 70, 79, 90, 101, 115 and 130 mm stretched mesh. All nets were 65 m long and 3.2 m high. The Danish tests were to compare 2 twines of different thickness, 1.5 x 4 and 1.5 x 6, giving 12 different experimental nets (all with 50% hanging ratio). Fleets, or tiers, could then be a typical commercial length of 12 nets - one net of each category arranged in random order. The Swedish tests were to similarly examine the effect of two different hanging ratios on the floatline, 40% and 50%, using 1.5 x 4 twine. Unfortunately most of the nets hung at 40% were produced at a later date and were subsequently found to have a thicker twine. The measured twine thicknesses were:

- 1.5 x 4 twine  
  First production 0.26 mm
- 1.5 x 4 twine  
  Second production 0.31 mm
- 1.5 x 6 twine  
  0.36 mm

Sea trials obtaining measurements of selectivity were to be made in Denmark and Sweden on typical commercial gill-net vessels in the autumn and in the spring. It was hoped that the cod would be in different condition at these two times of the year.

The four sea trials

The Danish trials were carried out in September 1997 and April 1998 from the harbour of Nexo, Bornholm. The commercial vessel chartered was 10.4 m long and 3.9–4.9 km of experimental nets were used. The Swedish trials were carried out in the Sound of Hanoe in September-October 1997 and April–May 1998. The vessel used was 11.6 m long and 5.5 km of nets were used. 14–17 valid sets, usually of 23 hours soak time, were completed in each of the trials.

The following measurements were taken:

- Length of all fish caught by set and net category (mesh size and twine or hanging ratio).
- Numbers of incidental by-catches of mammals and birds by net category.
- Ungutted weight of individuals for a sub-sample of cod.
- Maxillary, gill and maximum soft body girths for a sub sample of cod.
- Method of capture (enmeshed behind the gills, enmeshed behind the maxillaries (jawbones), entangled by the teeth or otherwise entangled) for a sub-sample of cod.

Catches obtained

15,739 cod were caught at a mean catch rate of approximately 4 cod per 65 m long net per set. The nets were clearly highly size selective with the mean cod length increasing from approximately 33 cm in the 70 mm nets to 52 cm in the 130 mm nets. Catch numbers decreased rapidly with increasing mesh size but the highest catch weights of marketable cod above the 35 cm minimum landing size were in the 90 – 130 mm mesh sizes. The Danish nets in the thicker 1.5 x 6 twine only caught two thirds the numbers of cod caught in the standard 1.5 x 4 nets.

It was found that there was in fact little difference in the condition of the cod for the four different trials. Virtually all were well fed with little or no roe content. Girth-length ratios were also very similar, approximately 0.31 behind the maxillae, 0.48 behind the gills and 0.50 at the maximum soft body girth.
By-catch numbers were very low in all trials consisting mainly of flounder in the largest mesh sizes and some herring in the first Danish trials. Incidental by-catches of birds were two golden-eyes, one guillemot and one cormorant. No sea mammals were caught.

**Method of capture for cod**

Classification into the different methods of capture was relatively easy despite the fact that the cod normally had penetrated the netting several times and were well and truly entangled in the netting. Gilled cod were characterised by having a series of meshes caught behind one or both sides of the gill covers, behind the ventral fins or behind the pectoral fins. Maxillary caught cod tended to have a large ball of netting behind the maxillae and the main part of the body was only loosely entangled in the netting.

The majority of the cod were found to be gilled, 60-90% depending on trials period. Their mean length was approximately 4.4 times the mesh size, which is as would be anticipated from the girth measurements.

A much smaller proportion of the cod was caught by the maxillae, 10-26%. The mean transformed lengths (or length/mesh size) of the maxillary caught cod were much lower than the expected optimal value suggested by girth measurements taken directly behind the maxillae. For most trial periods and gears, they were only about 10-20% higher than those of the gilled cod. The cod must have been enmeshed at a position well behind the maxillae. Photographs were taken of some cod showing obvious mesh marks between the maxillae and gills. These were located well behind the maxillae, a short distance behind the eyes where the forward end of the gill covers met the underside of the cod.

Up to 15% of the cod were entangled by their teeth (i.e. they had bars of netting stuck in their mouths) but were not also enmeshed. It appears that both large and small cod can be caught in this way. It was observed to be the principal method of capture for the few very small cod of about 20 cm caught. A few (mainly large) cod were otherwise entangled by their fins. These could form up to 5% of the total catch numbers.

**MAIN FINDINGS AND CONCLUSIONS**

**Size selectivity of the gill-nets**

It can clearly be seen from the final selectivity curves given in Figure 1 that gill-nets mainly
capture fish from an extremely narrow length band. The curves shown are for 115 mm mesh size. All three curves are very steep each side of the optimal fish length that has highest retention probability. With mesh sizes between 100 and 130 mm the majority of cod caught were within 5 cm of this optimal length. These are the cod that were enmeshed behind the gill covers. The left-hand side of this primary mode rapidly slopes down towards the x-axis indicating a very low retention of small cod. On the right-hand side, above a length of 60 cm, a lower, wider second peak (the 'second mode') can be seen. These cod were too large to be gilled and were principally those observed to be maxillary enmeshed (held by meshes between the jawbones and start of the gill covers).

It is worth noting that the optimal length of cod with 79 mm mesh size is roughly the same as the minimum landing size (MLS). This is why it was necessary to use such small mesh sizes in order to estimate how high retention rates of cod around MLS were in mesh sizes used commercially.

The effects of hanging ratio and twine thickness on the size selectivity

The effects of hanging ratio and twine thickness on the size selectivity of the gill-nets were very marginal. At commercial mesh sizes of 105 mm to 130 mm decreasing hanging ratio from 50% to 40% was estimated to have about the same effect as increasing mesh size by about 2 mm. Changing from 1.5 x 4 to 1.5 x 6 twine would have about the same effect as a 3 mm reduction in mesh size. Differences in size selectivity between the two trials periods and two trials areas for the standard 1.5 x 4 nets hung at 50% were found to be similarly small.

The selectivity curves are drawn as if all cod of the optimal length were caught. This is definitely not the case. Only a proportion of the cod of optimal length contacting a net will be retained. A cod appear to usually have to swim through the net several times and get several meshes fast round its head or body before it is caught. What the curves show for example is that for 1.5 x 4 twine, 50% hanging ratio and 115 mm mesh size the net is only half as good at catching 46 cm cod as it is at catching cod of the optimal length 51 cm. Because the 1.5 x 6 twine nets were fished within the same fleets of nets as the 1.5 x 4 standard nets, it was possible to determine how efficient the thicker twine was compared to the thinner twine at catching cod of the optimal length. Similarly, the efficiency of the nets hung by 40% could be compared with those hung by 50%.

Effect of twine thickness and hanging ratio on the catching efficiency

The efficiency of the nets made in 1.5 x 6 twine was found to be 70% that of nets with 1.5 x 4 twine during the first trials and 64% during the second trials. In both cases, the reduction was found to be highly significant.

Overall, no difference was found between the catching efficiency of the nets hung by 50% and those hung by 40%. It appears that reducing hanging ratio to 40% increased catching efficiency slightly but that this was counteracted in these trials by two-thirds of the nets hung by 40% having thicker twine. This result was for nets of the same finished length. If nets of 1000 meshes long are considered instead (this is the way commercial nets are usually supplied) then nets hung by 40% would have a 20% shorter finished length than those hung by 50% and would probably have caught less cod even if all nets had had the same twine thickness!

Gill-nets compared to trawls

It is now possible to make a first comparison of the size selective properties of gill-nets and trawls in the Baltic Sea cod fishery. The size selectivity data for standard diamond-mesh cod-ends have been collected on a database and analysed. The mean selectivity of a trawl cod-end with 120 mm mesh size is compared in the table below to that predicted for gill-nets with 105 mm and 120 mm mesh sizes.
<table>
<thead>
<tr>
<th>Gear</th>
<th>Diamond-mesh Cod-end</th>
<th>Gill-net</th>
<th>Gill-net</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mesh size (mm)</td>
<td>120.0</td>
<td>105.0</td>
<td>120.0</td>
</tr>
<tr>
<td>25% retention length (cm)</td>
<td>31.3</td>
<td>40.9</td>
<td>46.7</td>
</tr>
<tr>
<td>50% retention length (cm)</td>
<td>35.6</td>
<td>42.3</td>
<td>48.3</td>
</tr>
<tr>
<td>75% retention length (cm)</td>
<td>40.0</td>
<td>43.5</td>
<td>49.7</td>
</tr>
<tr>
<td>Relative retention rate for 35 cm cod</td>
<td>46.0%</td>
<td>1.7%</td>
<td>0.8%</td>
</tr>
<tr>
<td>Relative retention rate for 38 cm cod</td>
<td>64.4%</td>
<td>4.5%</td>
<td>1.2%</td>
</tr>
</tbody>
</table>

It is immediately clear that gill-nets are much more size selective than trawl cod-ends. The current minimum landing size is 35 cm for Baltic cod. It has often been stated that this should correspond to the 25% retention rate with minimum legal mesh size. With trawls, it appears that this objective will not be fulfilled with the current minimum legal mesh size of 120 mm. Gill-nets on the other hand already have a 25% retention length of over 40 cm for the minimum legal mesh size of 105 mm.

A policy of protecting Baltic cod below 38 cm to let them ‘spawn-at-least-once’ is being widely discussed. The biological background for this idea is that 50% of cod females spawn for the first time at lengths above 38 cm. If the approach, to allow the majority of cod under 38 cm long to escape, is to be a management aim, it seems clear that gill-nets will meet this requirement already with the present minimum mesh size of 105 mm. A gill-net’s retention probability for 38 cm cod with 105 mm mesh size was estimated to be less than 5%. For most trawls with a 120 mm diamond-mesh cod-end, it appears to be likely to be over 50%.