New Ways for an Improvement of the Selectivity of Trawl Codends in the Baltic Cod Fishery

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Abstract

Two trawl types of innovative design constructed with the aim to release at least 50 % of the caught cod of 38 cm length, as demanded by the new fishery rules of the IBSFC, as tested on German research cruises with the FRC „Solea“ in 1998. One of the trawls was derived from the Swedish Multipanel codend design as described by Suuronen *et al.* (1996) whereas the other one was built from material turned around 90 degrees as described from Polish trials by Moderhak (1997). The first one was tested on three cruises in April, June and September 1998 whereas the second one was tested with one mesh-size in April 1998 and with two mesh-sizes in September 1998.

Both trawl types proved scarcely reduced selectivity compared with a 120 mm standard legal codend even when their mesh openings were considerably diminished. With regard to the selectivity factor the Multipanel codend demonstrated a significantly improved selectivity whereas the apparent achievements of both codends with turned meshes were masked by the strong between haul variance. Seasonal variation could not be used as explanation for this phenomenon. In contrast to observations with other gadoids cod showed hardly any effect of seasonal variation.

***Key words**: codends, trawl selectivity, Swedish multipanel, turned meshes, cod*

Introduction

Since years the situation of the stock of cod in the Central Baltic is considered as being critical (Tschernij *et al.* 1996). The decision of the International Baltic Sea Fishery Commission (IBSFC) issued already in 1993, to raise the minimum codend mesh opening from 105 to 120 mm has not been able to improve this situation. This is demonstrated by a backward trend in the catches of cod from the Baltic by German fishermen as illustrated by Figure1. In 1998 in total 10985 t of cod were landed. The quota received for this year amounting to 16846 t could only be used at a rate of 65 %.

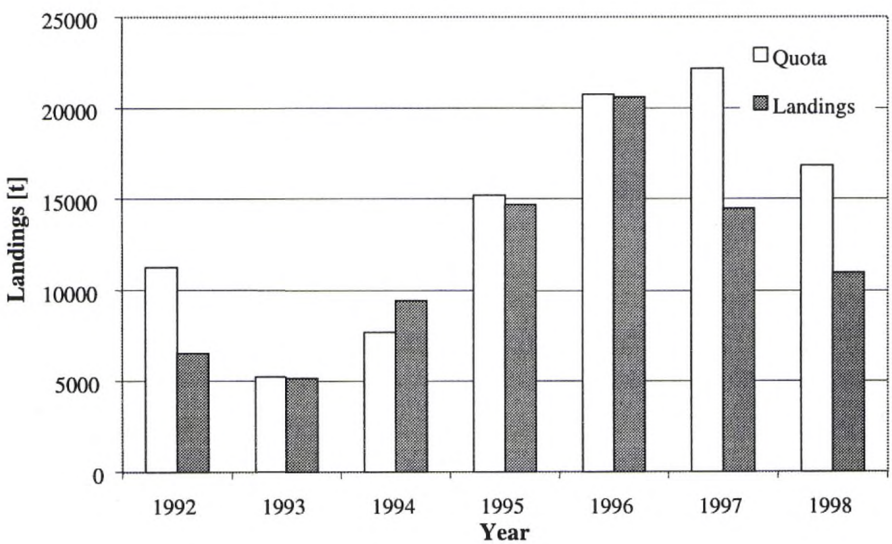

***Figure 1.** Quotas and actual catches of cod of German fishermen in the Baltic in the period from1992 to 1998.*

In account of protests of the commercial fishery in 1993 also alternative and cheaper codend constructions were allowed. All these modified codends have to prove that they are efficient in releasing cod of 38 cm at a rate of at least 50 percent before being accepted.

Two new codend constructions with so-called escape windows, one of Swedish (Larsson 1994) and the other of Danish design (Lowry *et al.* 1995), however, were declared immediately as being in accordance with the fishery rules of the IBSFC without having to prove this in a scientifically sound manner.

When a group of experts of the International Council for the Exploration of the Sea in 1995/1996 examined this new construction it was shown that at least with the Danish type of codend the requested selectivity for cod could not be reached. With the Swedish codend the requested properties could be proven (Anon 1996). However, Swedish investigations indicated that the selective properties of these alternative codends deteriorated after short time of operation by washing out of the special impregnation of the exit windows (Tschernij *et al.* 1996).

With conventional diamond meshes, in addition, numerous methods to manipulate the actual codend mesh opening became common knowledge in the meantime (Stewart & Galbraith 1989). As examples for the widespread use of such means should be mentioned here the increase of the codend circumference or of the codend netting yarn or special strengthening bags particularly designed to impede the full opening of the codend meshes.

Further, in an EU-project a seasonally conditioned changed selectivity of codends could be proven for the haddock of the North Sea (Özbilgin 1998). Since cod is also a gadoid and temperature was demonstrated as a main effective factor. As first suggestion it can also be assumed that Baltic cod would react likewise. If verified, it would make any previous findings on cod selectivity by a given mesh size doubtful.

Recently, at this state of the art, the European Union has decided to finance a bigger research project (BACOMA = Baltic Cod Management) which shall clarify the following points:

1. Investigation of factors affecting the variability of trawl codend selectivity in the Baltic cod fishery. It is intended to investigate the effectiveness of different codend modifications and of the mode of operation with cod trawls.

2. Investigations of different codend types with regard to their effect on the survival of escaped fishes.

3. Development of a numerical model able to describe the biological and socio-economical effects of an improvement of the selectivity of Baltic cod trawls.

Directly participating at this ambitious project are researchers from Denmark, Sweden and Finland. Germany contributes to the project by a nationally implemented additional research program, which is co-ordinated with the current EU-program.

General aim of the effort of the researchers from all countries bordering the Baltic is to find until the year 2000 a scientifically sound and generally accepted solution for an optimum technical mean for the protection of young cod.

Material and Methods

Few remarks in an earlier publication (Tschernij *et al.* 1996) as well as a recent work (Moderhak 1997) indicated particularly prospective codend constructions with good selective properties. They were tested in spring, summer and autumn 1998 in the Western and Central Baltic during three cruises with the FRV „Solea". All selectivity trials were carried out with the „Kabeljauhopser", a bottom trawl with 528 meshes circumference at the forward edge of the belly.

64 hauls were carried out with the codends mentioned on the cruises in April, June and September. Due to low catches of cod the average towing duration was 2 to 3 hours. There was no danger of masking the codend meshes with the catches obtained below 1 t per haul.

Fishing grounds used lay predominantly in the Arkona bight West of Bornholm. Towing speed, opening height and spread were continuously recorded.

All cod caught in main codend and cover were measured and weighed. Other by-catch was sorted by species and recorded by weight only. 74823 cod with a weight of 24.572 t were measured in total.

The cover used (Fig. 2, I) was fixed at the end of the tunnel and spread by a ring made from PVC plastic pipe with a diameter of 2.6m. Floats at the upper panel of the cover created a further empty space above the upper panel of the codend so that fishes can escape there unimpeded through the codend meshes.

Covers with 40 and 60 mm mesh opening which had an aft part of meshes of 80 mm mesh opening were used to catch the escaped fishes. This uncommonly big mesh opening in the end of the cover had become necessary to bypass problems with the high by-catch of herring which otherwise would have created sorting problems with the catch.

A conventional diamond mesh codend made from 4 mm PE single yarn and a mesh opening of 117 mm served as reference. This mesh size refers to measurements being made with an ICES mesh gauge. Careful experiments carried out in Scotland have shown that such values have to be corrected by ca 1.03 to obtain what would have been measured with the official legal measuring instrument wedge gauge (Ferro & Xu 1996). Hence the codend used could be assessed to correspond to legal requirements.

Two new codend constructions offered good prospects for a better and sharper selection.

The first codend was completely made of the same diamond meshes as the reference and differed in so far as the netting was turned clockwise 90 degrees. If diamond meshes are stressed in different direction to the main running direction of the netting yarn they will show a different shape (Fig. 2, II). Case (*b*) shows the effect if the netting is turned 90 degrees. The stiffer the netting yarn is the more open the mesh will be. At equal mesh opening and netting material an improved selectivity should be expected.

In recent Polish experiments (Moderhak 1997) this type of codend has exhibited better selectivity indices and increased properties to better protect undersized fish. Two different mesh openings of 103 and 113 mm were tested in the experiments reported here.

The second codend was a so-called Multipanel codend. A similar design was first tested in Swedish/Finnish experiments in the early 90's (Suuronen *et al.* 1996) and demonstrated some favourable properties but, nevertheless, had proved inadequate to release cod of 38 cm at the required rate due to the fact that its mesh size was only 95 mm. As in the Swedish tests the codend examined in trials reported here was made completely from knot-less netting of PE with 6-mm yarn diameter (Fig. 2, III).

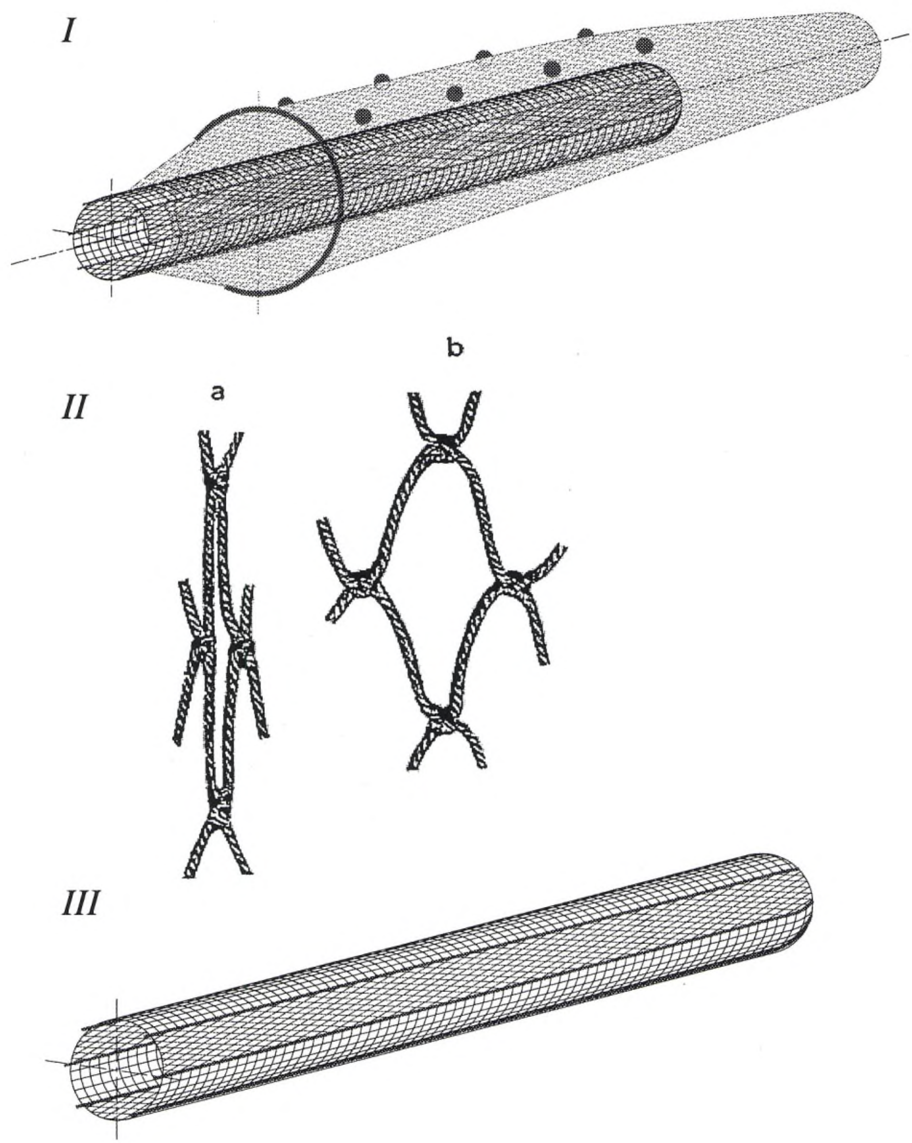

Figure 2. *I. Schematic drawing of the cover type used*
II. Shape of a knotted mesh torn in different direction:
a) in N-direction, b) in T-direction (after Moderhak 1997)
III. Sketch of the appearance of a multipanel codend in operation

This codend consists of 6 panels of which 3 are of diamond and three of square meshes. They had a mesh opening of 105 mm. The combination of diamond and square meshes results in a more flexible codend in comparison to a codend totally made from square meshes without ignoring the already demonstrated advantage of an improved selectivity.

Previous own underwater observations of a pure square mesh codend have revealed that fishes increasingly demonstrate panic reactions at the transition of the tapered fore net to the square mesh codend. Underwater observations during the experiments with the MPC revealed that the transition between tapered sections and the extension is now much more smooth and even.

So far, an unsolved question in square mesh netting in general is the mode of production. Knotted diamond mesh netting turned by 45 degrees from its normal orientation takes the shape of square mesh netting but holds this shape only for a limited time. The meshes are only stressed on two of their four bars and may degenerate by shifting of the knots in a rather short time.

Hence in these trials knot-less braided netting (trade name „Ultracross“) was used which allows for no mesh deterioration due to its different main running direction of the netting yarn.

This material, however, can only be purchased with difficulties on the European market.

For the calculation of the selection parameters the logistic curve (Pope *et al.* 1975) is commonly used to describe the distribution of retention rates in codend selection experiments.

$$y = \frac{1}{1 + e^{(a+b \cdot x)}} \qquad \textbf{(1)}$$

y = retention rate
x = fish length
a,b = parameters of the curve

$$L(50) = \frac{a}{b}$$

L(50) is the retention length of 50 %

The calculation of the resulting symmetric sigmoid curve from several hauls with similar configuration was performed with the help of a computer program according to the Variation Component Analysis as described by Fryer (1991).

Fish reactions as well as codend shapes were recorded with a manoeuvrable underwater video camera.

Results

The length distribution of cod population is given in Figure 3. The two-peak distribution of the cod lengths as detected in spring has only one peak in September because of the natural growth of the cod population. In account of the selectivity of the cover the length classes of cod below 25 cm are underrepresented. The length classes of cod essential for the investigation of selectivity, however, lie well above 25 cm. The calculated L_{50} lie at the descending slope of the main frequency peak of the cod length distribution.

It was already mentioned that on all trips, only small to medium sized catches of cod could be achieved.

Figure 4 shows the resulting selectivity curves of all codend types investigated. It has to be stated that, in spite of considerably smaller mesh openings compared to the reference, all codend types tested fulfil the condition of the escape of more than 50 % of the cod at 38-cm length.

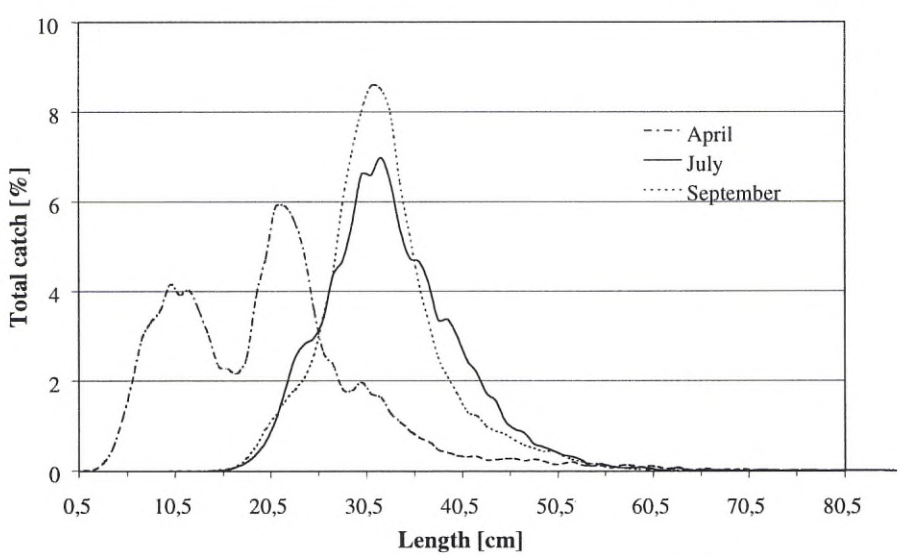

Figure 3. *Length distribution of cod population in different seasons*

The reference codend made of diamond meshes and a mesh opening of 117 mm also showed this condition on both cruises in April and September which is in clear contradiction to the findings of the mentioned ICES group of experts. Even with the smaller type of the codend with the meshes turned 90 degrees this condition could be met exactly.

By grouping the selectivity curves according to codend types differences can be demonstrated in the results of the tests made at different times of the year (Fig. 5). Seasonal effects have a distinct influence on the selective effect of the different codend types. The reference trawl showed the same effect over the year. Smaller sizes of cod were caught at a higher rate in spring because of being more abundant then.

For the codend with the meshes turned 90 degrees the escape rates deviate to smaller sizes from April to September. A similar trend was confirmed for the Multipanel codend with the observed effect being even bigger.

Table I contains the essential parameters of the resulting selectivity curves. These are:

- the fish length, L_{50}, where 50 % of the caught fishes are able to escape from the net.

- the selection range SR, the length range between 25 and 75 % escape. It serves as a measure for the slope of the selection curve and hence the sharpness of the selection.

- the selection factor SF, calculated as the relation of L_{50} to the mean mesh opening of the codend in question. It serves as a criterion of goodness of the selectivity in comparisons of different codend types.

The L(50) exceeds for all codend types and for all seasons the 38-cm condition. In the comparison of the new codend types against the reference the selectivity range decreases meaning that the selection takes places in a essentially smaller length range and, thus, leads to fewer undersized fish in the catch.

Cod selection

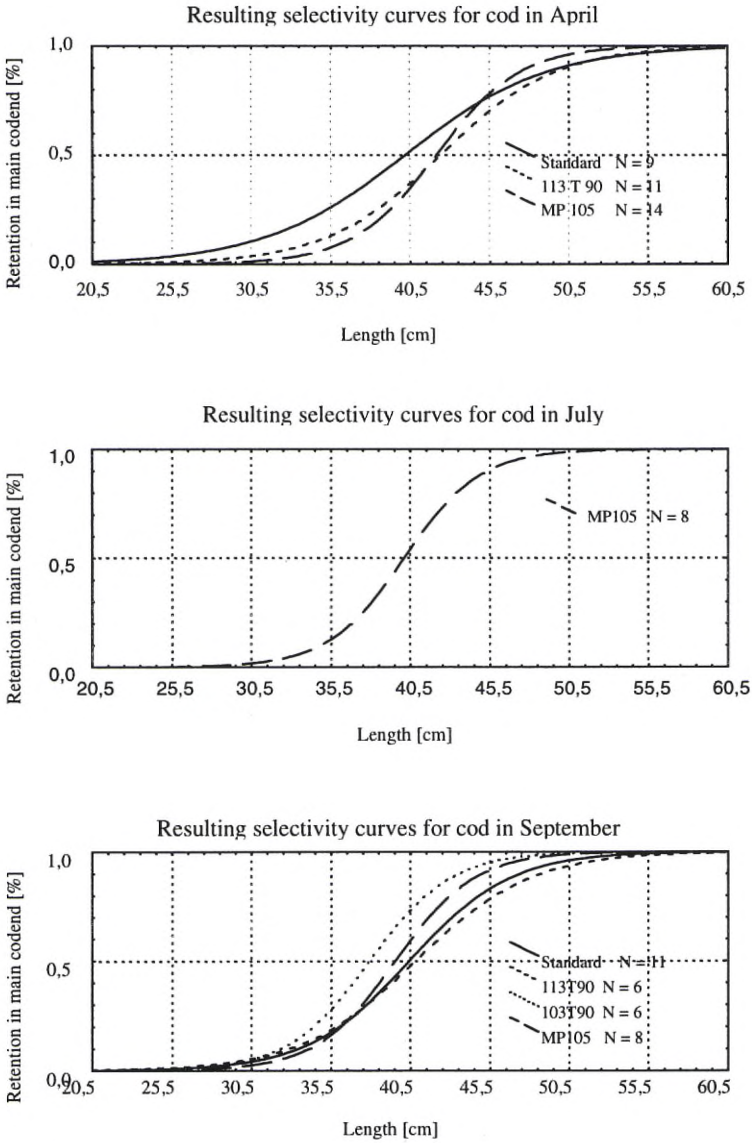

Figure 4. *Resulting selectivity curves of all codend types investigated in three different cruises*

Seasonal effects

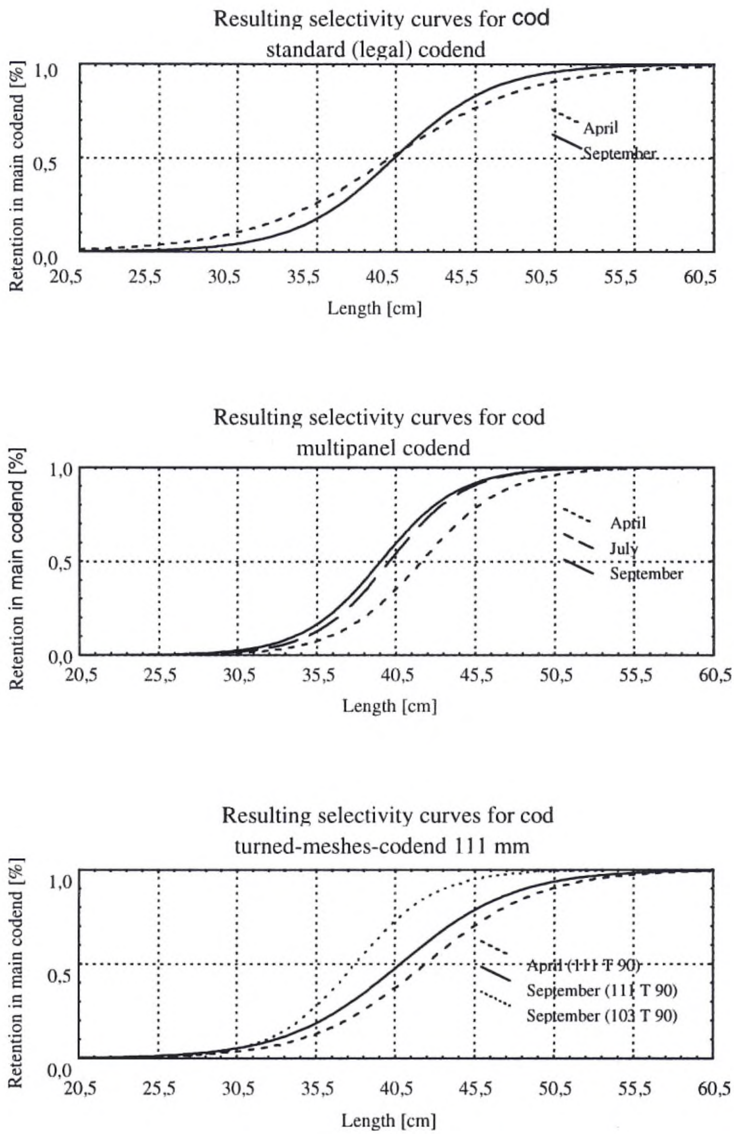

Figure 5. *Seasonal effects on the selectivity of three different codend types*

Table 1. *Resulting numerical selectivity parameters of the three codend types investigated*

	L50	SR	SF
April 1998			
117 mm standard	40.2	9.8	3.43
113 mm T90	42.4	8.0	3.75
MP 105 mm	42.1	5.8	4.01
July 1998			
105 mm MP	40.1	5.2	3.82
September 1998			
117 mm Standard	40.4	7.0	3.45
113 mm T90	40.8	8.0	3.61
103 mm T90	38.0	5.6	3.67
105 mm MP	39.5	5.4	3.77

During all cruises the Multipanel codend attained the highest selection factor. If regarded under the aspect of the selective effect this codend lies ahead. It is closely followed by the type of codend with meshes turned 90 degrees with the smaller mesh opening, than by the one with the bigger meshes and the reference codend carries the closing red light. A statistical test (F-test) on the significance between the selection factor for each codend and haul shows that it exists with a probability of 95 % between standard codend and Multipanel codend for the September cruise and at the 90 % level for all tests carried out over the year. The attempt to prove significant differences between standard codend and codends with turned meshes, however, failed.

Discussion

From results of this study it was obvious, that with the use of a Multipanel codend type with a mesh opening of approximately 100 mm, the minimum landing size can be attained with optimum selectivity and lowest percentage of discard. Problems, however, have to be anticipated with regard to the acceptance by the commercial fishery. They will certainly oppose to such relatively complex construction. As an alternative it may be sufficient to provide conventional codends with three of such square mesh windows. Problems with repairs are than confined to the windows which may be changed in whole.

The used Ultra Cross net material is not available on the European market and very expensive, but with increasing demand availability and costs of the knot-less material are thought to improve.

The codend with the meshes turned 90 degrees has to be considered as an alternative with still existing advantages compared to the reference codend. There are, however, technological questions to be solved in further tests. Thus it has to be investigated by longer operation on commercial fishery ships with their bigger catches if this will lead on the long run to deformation of meshes and subsequent fitting towards the properties of a normal codend.

As demonstrated by underwater observations loose meshes and wrinkles could be detected at the joining of the codend to the extension. During the trials they were joined in a 1:1 relation. It remains open whether this or stiffness of the netting material has an influence on the selective efficiency in this codend type. Polish trials demonstrated even more positive results as those presented here. Their codends however, were made from less stiff PA netting and attached to the extension in a two to one relation.

It is hard to understand what may have caused the seasonal variation being just contrasting to what has been found with haddock in the North Sea. A few records of the temperatures close to the bottom taken during the experiments, however, show few seasonal changes in the Baltic. This is completely different from the environmental conditions observed in the mentioned haddock trials in the North Sea. Obviously there was no physiological reason for the Baltic cod to react more vigorously in summer than in spring.

Though the existing results are conclusive, selectivity curves derived from catches with several tons of cod are lacking. As is general knowledge large catches lead to an important negative influence in selectivity in schooling pelagic fish. Thus, it might be assumed that such results from a research ship are not adequate to commercial fishing. However, recent research results from an EU-project on round fishes (VARSEL) show against expectation a steadily improving selectivity with increasing catches. Thus, the results presented here give a rather conservative assessment of the selective effects of certain codend mesh openings or codend types and, hence, taken as a basis for legal definitions of the codend mesh size would take into consideration the now much stressed precautionary approach.

This research will be continued in the coming year with the main objective to attain an optimum protection of the young cod. As it seems there are good prospects to present to the IBSFC an acceptable and scientifically sound solution until the end of the BACOMA project.

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