

8.3.3.2 Answer to the European Commission on: *Ways to improve selectivity in Baltic cod fisheries for which cod is recognised as target species*

Background

An important parameter for the exploitation of fish stocks is the selectivity of fishing gears and its effect on fish population. During the past years, two basic approaches to improve the selectivity of trawls in Baltic cod trawl fisheries were developed and successfully tested. Both are cod end modifications. First, the Bacoma window is a panel of square meshed net, which is included in the cod end. The second approach is the use of net material for the entire cod end, which is turned by 90° compared to the *typical* configuration (as also used for Bacoma cod ends). Therefore, this configuration is called T90 (turned 90°). Numerous studies have been conducted to investigate the selectivity of trawls in the Baltic Sea. The European Commission presented a report on selectivity for trawl fisheries for cod in the Baltic to Council in January 2009. The main conclusion of the report is that there are no data to support big differences in selectivity between the two gears Bacoma and T90. Several member states have requested the Commission to continue assessing new ways to increase selectivity in the Baltic cod fisheries, to reduce current levels of discards, such as an increase in mesh sizes. The Commission believes there is scope for increased selectivity in the fishery and wishes to consider approaches to achieve this goal including alternative ways other than simple mesh size increase.

1. Request

The request concerns towed gears (trawls) and gillnets in the Baltic cod fisheries and includes five items that are addressed individually in the text below. The five items are:

- Identify current L_0 , L_{100} and L_{50} for gillnet and trawl fishing cod in the Baltic Sea.
- Identify L_{50} corresponding to MSY for current exploitation levels.
- Assuming that the minimum landing size remains at 38 cm, what would be the corresponding L_{50} that would keep discards at a low level?
- What would be the short-term loss and long-term gain of any proposal for change in L_{50} that ICES may propose?
- What gear adaptations might be suggested?

Several of these questions must be answered by considering the trawl and gillnet fisheries together; changing the L_{50} for the combined exploitation pattern may require coordinated changes in selectivity properties for both trawl and gillnets.

Reduction of discards can be achieved by improving the selectivity of the gear but also through changing the fishing strategy, e.g. through closed areas and seasons. In several fisheries sorting grids are mandatory and move-on rules are also implemented in some fisheries.

The current fishery is dominated by trawl; estimates of catch in numbers by age and gear suggest that about 25% of the total fishing mortality is generated by gillnets while the trawls are responsible for about 75%.

ICES (2007) addressed a similar request for active gears (trawl, Danish Seines and similar gears). Updated analyses confirmed the conclusions drawn in that previous advice and improved the precision of some of the previously derived estimates.

The Technical Annex (ICES, 2007) provides a review of gear components affecting the selectivity of trawls and gillnets. For trawls it is concluded that the selectivity is influenced by a range of design parameters including the mesh size. It is therefore difficult to advise on a single trawl design that provides the desired selection properties. It is relatively easy to improve size selectivity in the gillnet fishery by simply increasing the mesh size, since the other technical parameters do not influence selectivity to any great degree, as in trawl fisheries.

ICES proposes that the technical regulation for trawls be changed to allow trawls for which there are documentation that they meet well-defined selection criteria. Because the gillnet selection is largely controlled by the mesh size there seems little reason to alter the current gill net regulations.

ICES conclusions to each item are given below. For a complete updated overview on gear adaptations, see the Annex to this response.

1.1 Current L_0 , L_{100} and L_{50}

Request: What are the current L_0 , L_{100} and L_{50} (length of first catch; length corresponding to the maximum level of vulnerability; length corresponding to a vulnerability representing 50 % of the maximum one) related to selectivity ogives already evaluated for towed gears used by those métiers in such fisheries

1.1.1. Trawls

ICES has updated the analysis of selectivity parameters for cod trawl (BACOMA and T90 meshes), see Figure 8.3.3.2.1 and this did not make any substantial change to the understanding of the selection properties of the gear.

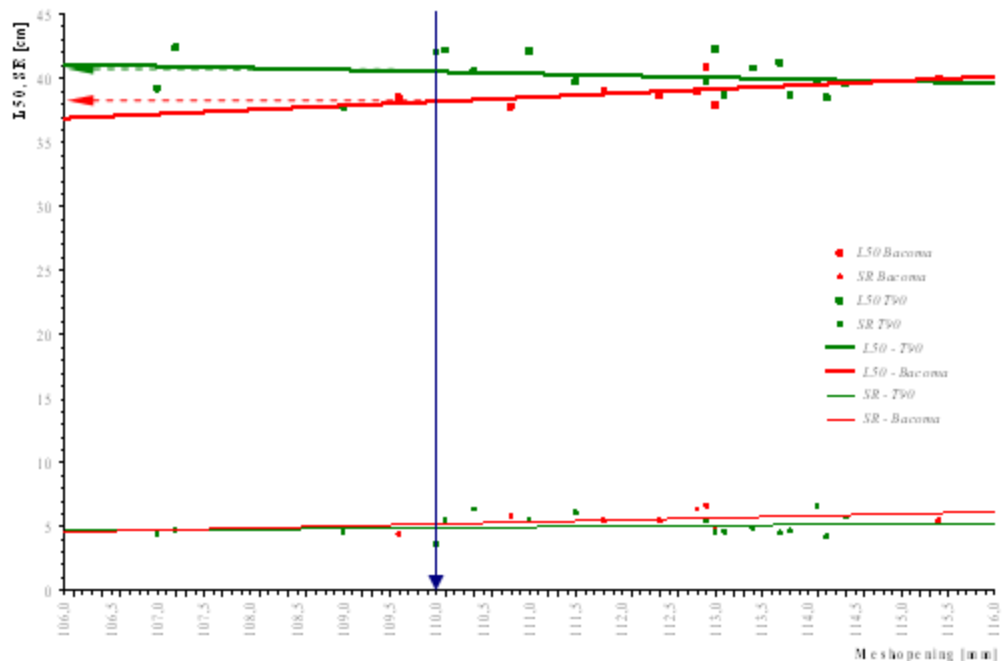


Figure 8.3.3.2.1 L_{50} and SR vs. Mesh Opening made for data restricted to “standard” T90 and Bacoma PE codends – Omega gauge only – CR (EC) 2187/2005.

Figure 8.3.3.2.1 shows the L_{50} and the selection range (the range between L_{25} and L_{75} ; SR) depending on mesh size.. The current L_{50} for the current regulation of 110 mm mesh opening is assessed to be 38–41 cm and the selection range about 5 cm for trawl, whereby the L_{50} for T90 codend is slightly higher compared to Bacoma.

1.1.2 Gillnets

There is no new data available for gillnet selectivity and based on previous data and analyses the L_{50} (maximum of the dome shaped selection curve) is estimated to be 43.4–45.5 cm, L_{25} is 42.8 cm and hence the width of the selection curve 4-5 cm (see Annex to this response for precise details).

1.1.3 Conclusion

The L_0 , L_{100} and L_{50} are around 30 cm, around 48 cm and 38–40 cm respectively because the trawl fishery is dominating in recent years. The selection curves are illustrated in Figure 8.3.3.2.2

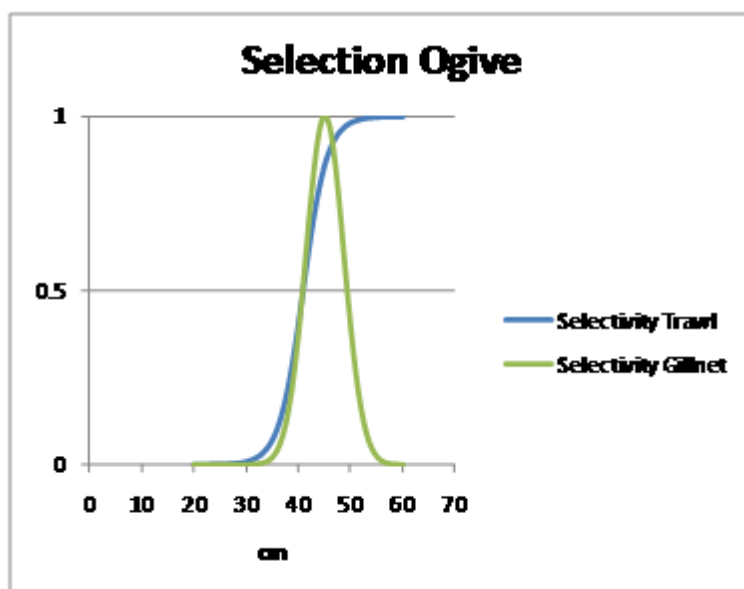


Figure 8.3.3.2.2 Selection ogive for Baltic cod trawl and gillnet corresponding to the current exploitation pattern

2. L_{50} maximising yield-per-recruit

Request: By considering a similar exploitation pattern to this currently observed, what would be the L_{50} that would maximise yield-per-recruit?

This item can only be answered for trawl and gillnet considered together. Changing the selection properties of one gear must be accompanied by a corresponding change of the other.

L_{50} and MSY exploitation level are closely related. The relationship is *inter alia* determined by the growth and natural mortality. The general relation is that the effort level corresponding to MSY increases with increasing L_{50} .

The L_{50} that maximises yield per recruit is calculated at around 67 cm at current exploitation level. If the exploitation level is twice the current level the calculated L_{50} that maximises yield per recruit increases to around 77 cm. Extrapolations to such extremes are very uncertain and the corresponding large spawning stock biomass is likely not attainable because species interactions, that are ignored in the yield per recruit calculations, would change the population dynamics.

The current exploitation level (0.24) with the current selection pattern is close to the MSY level (0.24). Figure 8.3.3.2.3 shows the Yield per recruit curve for the current exploitation pattern. The introduction of a selection with $L_{25} = 38$ cm does not change the yield per recruit noticeably. For a given level of effort the fishing mortality will be slightly lower in the $L_{25}=38$ cm option compared to the current situation.

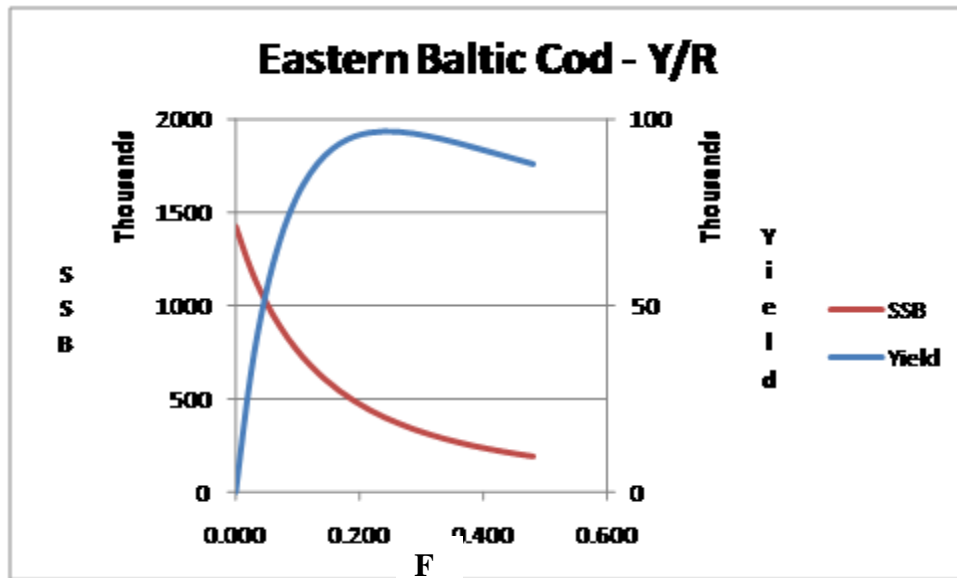


Figure 8.3.3.2.3 Eastern Baltic cod yield-per-recruit curve for current exploitation pattern

3. L_{50} required to reduce catches of cod below the minimum landing size (MLS 38 cm)

Request: By taking into account similar selectivity ogives to those already evaluated for towed gears in the Baltic cod fisheries, what should the L_{50} be to eliminate (or to reduce to very low levels) catches of cod below the Minimum Landing Size (38 cm)?

Since no target level for the catch of undersized cod was given in the request, restricting discards may be interpreted as $L_{25} = \text{MLS}$ (38 cm) suggesting that L_{50} should be around 41 cm or an increase for the Bacoma trawl of about 1–2 cm. Gillnets should not produce any significant amount of discards. A more restrictive reduction would be to set the $L_{10} = \text{MLS}$ (38 cm) suggesting an L_{50} of about 43 cm.

Table 8.3.3.2.1 Predicted L_{25} for a range of trawl and gill net mesh sizes

MESH SIZE (MM)	TRAWL	PREDICTED L_{25} (CM)
105 mm	34.2	40.9
110 mm	36.0	42.8
120 mm	39.5	46.7
130 mm	43.0	50.6
140 mm	46.5	54.5
150 mm	50.0	58.4
160 mm	53.5	62.3
170 mm	57.0	66.2
180 mm	60.5	70.1

The total discard of cod in 2008 is 8.7 mill. individuals or 3762 t (18% of the total catch in numbers and 8.3% in weight).

4. Short- and long-term yield

Request: For each of the above two L_{50} s, describe: What would be the expected evolution to be observed in yields in the short- and in the long-terms?

Maintaining the current exploitation level, the increase in overall long-term yield from an increase of L_{50} to ~41 cm, corresponding to a L_{25} of ~38 cm, is 6%. The change is assumed to affect only the trawl selectivity because the gillnet selectivity has a L_{25} well above 38 cm.

The medium-term projection shows a small loss during the first year (2010) when the change takes effect.

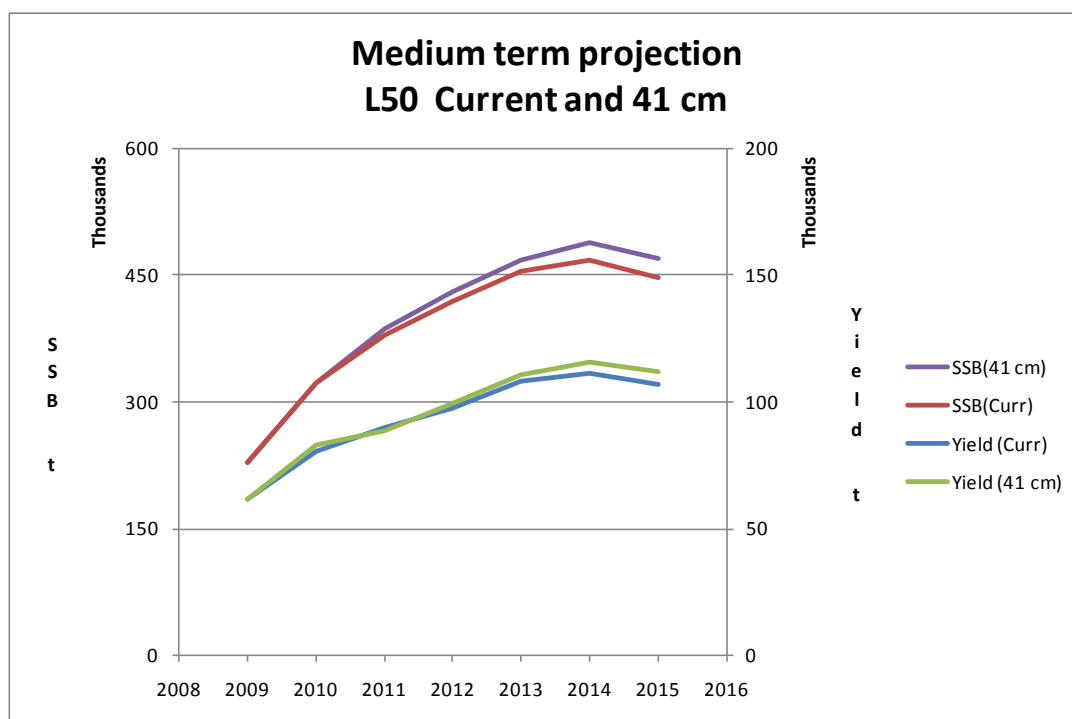


Figure 8.3.3.2.4 Eastern Baltic cod medium term projection for introducing a change in the exploitation pattern by the beginning of 2010. Change is introduced for trawl only.

However, most of the loss will be during the first half year after the change is introduced. The calculations that are presented are for annual increases and the growth that is required to bring cod into the selection range will occur during the first half year.

The calculations are done assuming a constant recruitment.

5. Gear adaptations

Request: For each of the above two L_{50} s, describe: What necessary gear adaptations (especially changes, for Bacoma and T90, in mesh size and/or codend design) might be suggested? What alternative technical measures (e.g. spatial and/or temporal distribution of the fishing effort) should be introduced to reduce discards?

ICES cannot advise on a particular change that is the only option to achieve the change in selectivity. Technically, there is a large range of options that can be utilized to affect selectivity but it has not been possible to identify a particular change that drastically will improve the exploitation pattern. There exist a range of gear designs that all will meet the requirement of an $L_{50} \sim 41$ cm and an $L_{25} > 38$ cm. These options are discussed in the Technical Annex to this report.

ICES' proposes that any gear that has been shown to have the desired selection properties (or better) shall be considered legal. This implies that a certification scheme be established under which scheme such data are vetted. ICES can assist in providing such reviews, if requested.

Summary of the advice and outlook

As in previous reports and previous advice (ICES, 2007), selectivity parameters for relevant gears are provided. While new information has been used for the analysis, general results did not change significantly. Selection parameters differed between gill net ($L_{50} = \sim 44$ cm), Bacoma-Trawl ($L_{50} = 38$ cm) and T90-Trawl (only T90-cod end, $L_{50} = 41$ cm).

6. Sources of information

Report of the Baltic Fisheries Assessment Working Group, ICES Headquarters, 22–28 April 2009 (ICES CM 2009/ACOM:07).

ICES.2007. Report of the ICES Advisory Committee on Fishery Management, Advisory Committee on the Marine Environment and Advisory Committee on Ecosystems. ICES Advice. Book 8, 147 pp. Section 8.3.3.3 entitled: ICES response to EU on selectivity of active gears targeting cod in the Baltic Sea.

Annex – Background information in support of ICES’ response

This annex is based on a working document provided by Dominic Rihan on the basis of work produced by ICES’ Working Group on Fisheries Technology and Fish Behaviour.

Gear Adaptations

Bacoma and T90 are among the most studied gear modifications in European fisheries having been the subject of extensive testing for more than a decade. The problem, however, still remains that this work has been done under different conditions with varying gear configurations in terms of twine material, twine thickness, codend circumference, on a mixture of commercial and research vessels, and using different methodologies. This continues to make direct comparison of the two gears problematical as reported previously by ICES (2007) in a response to an EU request for advice on Bacoma and T90. There is though strong evidence from the earlier analysis by ICES (Holst, 2005) and additional work carried out mainly in Poland and German to conclude that both Bacoma windows and T90 codends correctly fished as per the current regulations both give an L50 of 38–40cm, equivalent to the Minimum Landing Size (MLS) for cod of 38 cm, with lower selection ranges than conventional diamond mesh codends. This is further illustrated by an analysis completed by Modehak (2009) of data collected since 2004 with Bacoma and T90 as per the current regulations, which confirms the L50 to be around this size range for both gears, with narrow selection ranges. This analysis does highlight that for the regulation 110 mm/50 meshes T90 codend construction, L50 is higher by 2–2.5 cm than for Bacoma 110 mm/105 mm and the Selection Range for T90 is 0.5–1.0 cm lower than the Bacoma codend (Figure – below). This indicates that the current T90 codend is more selective although this is still subject to the underlying variability between experimental results that was apparent in previous analysis.

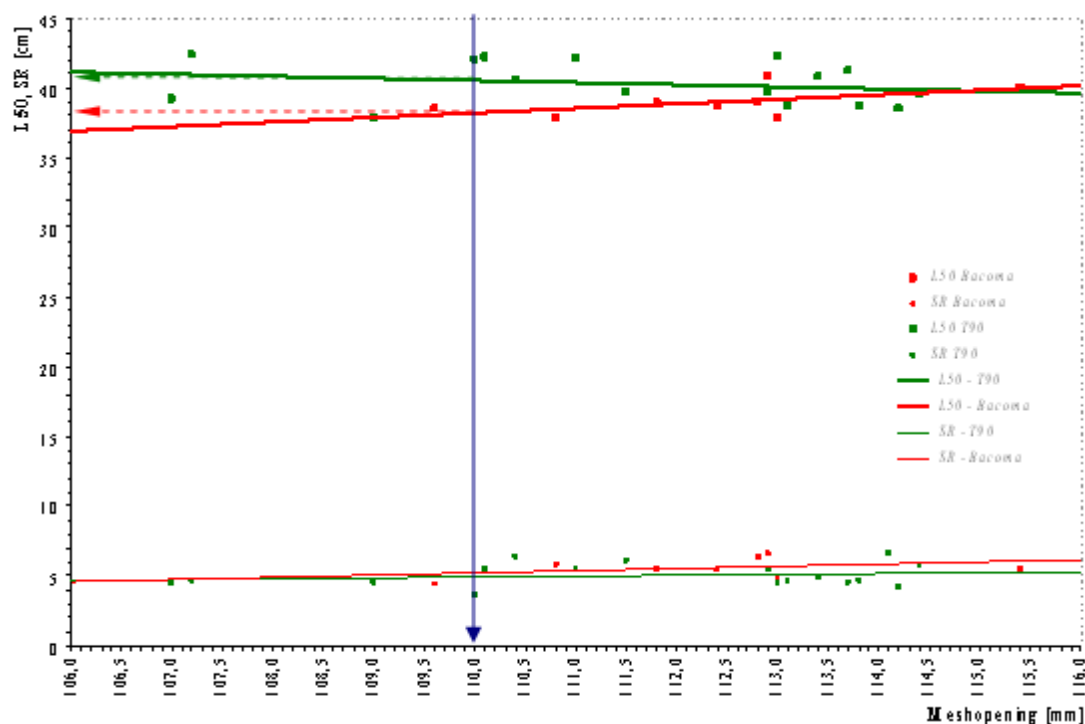


Figure -- L50 and SR vs. MO made for data restricted to “standard” T90 and Bacoma PE codends – Omega gauge only – CR (EC) 2187/2005

Following an assessment of the ICES response to the EU that concluded that both gears were relatively selective, STECF (2008) recommended that, “*measures resulting in improved exploitation pattern for Baltic cod be considered*”. By inference this would include alterations to the existing gear regulations as well as additional technical measures such as spatial or temporal measures. Before discussing alterations to the existing gears, though, it is important for managers to clearly define what the objectives of such measures would be in terms of specific targets for the fishery, as this will make a difference to the scale of the alterations required. If the management objective is to match L25 with MLS, then as ICES concluded earlier there is still potentially a mis-match between the current gears and MLS which can partially be addressed through reasonably minor modifications or even through a reduction in the MLS. If the objective is for a reduction of cod discards below this level then the current gears will not meet this target without fairly major modification, supplemented with other technical measures. On the basis that the overall objective is to reduce discarding to the lowest practical level based on L25, WGFTFB has carried out an assessment of the current selectivity of the two legal gears and how these could possibly be improved. In addition some alternative gear options and elements of the current regulations that should be examined are suggested.

In considering any amendments to the existing gears, WGFTFB also re-iterate the point made in the previous response to the EU on Baltic cod selectivity (ICES, 2007), which stated that, “given the difficult and contentious evolution of the gear-based management measures in the Baltic, it is concluded that an element of caution should be exercised in making significant changes to the current regulations in the short term”. WGFTFB finds that it is essential there is extensive industry dialogue, facilitated through the Baltic Sea RAC. Any experimental work to test alterations to the existing gears and possible alternatives should consider not only the selectivity of the gears tested but also the practicalities of introducing such alterations, including the economic impacts. In this regard WGFTFB understand that the Baltic Sea RAC has already made a submission to the EU Commission outlining a proposed 2–3 pilot project considering measures to improve Baltic cod selectivity and this is felt to be a good initiative.

Bacoma

In January 2002, the use of a 120 mm Bacoma window was introduced into the Baltic Sea. This represented a major increase in trawl selectivity but ultimately led to unsustainable catch losses of 70% by weight for trawlers (Tschernij *et al.*, 2004). This resulted in the mesh size of the Bacoma window being reduced to the current 110 mm/105 mm codend arrangement. Trials carried out by Sweden, Poland, Germany, Denmark and two experiments in Russia over the period 1999-2004 with 120mm Bacoma windows gave an indicative L50 of ~43.6 cm and a SR of ~8.9 cm. This is undoubtedly an improvement in terms of matching L25 and the current mls but if introduced would result in similar high losses of marketable fish as experienced in 2002. Therefore it would seem inappropriate from an economic perspective to increase the mesh size immediately but perhaps considered on a phased basis taking account that the average lifespan of a codend/Bacoma window is around 2–3 years. This would allow a full biological, technical and economic assessment of the impact of increasing the mesh size of the Bacoma window.

Other than simply increasing the mesh size of the Bacoma window there are few other modifications that would seem appropriate to the current regulations in the short term. However, information from Swedish on-board observations and also from fishermen does indicate that the size-selective properties of the current Bacoma window are unsatisfactory when catches are larger than approximately 2 tonnes (Valentinsson, 2007). The results from a study reported by Valentinsson and Tschernij (2003) did demonstrate this to some degree, showing a significant decrease in L50 with increased catches even with Bacoma 120mm windows, while showing increased selection range with increased catch weight, an indication of poorer selectivity. Despite this analysis being based on only a few data points with larger catches Valentinsson and Tschernij (2003) reported that “the effect of large catches was evident as the catch bulk was large enough to fill up the codend above the upper end of the Bacoma window panel”. Intuitively the simple solution to this would be to increase the size of the Bacoma window (currently 3.5 m). Suuronen *et al.* (2007) does report of some Swedish fishermen using double-length Bacoma windows in 2005 and 2006 in an attempt to improve the codend selectivity for larger catches of small cod but there have been no specific studies that have definitively shown that extending the window length would necessarily result in such improvements.

It is worth noting work carried out investigating the relationship between catch size and codend selectivity in diamond mesh as an indication. A modelling exercise carried out by Hermann *et al.*, (2007) using the simulation model PRESEMO and a meta analysis carried out by O’Neill (2008) on haddock, backed up with experimental trials (O’Neill and Kynoch, 1996; Dahm *et al.*, 2002; Graham *et al.*, 2004), has shown that L50 first increases and then decreases with catch size. The scale of these increases is, however, uncertain and equally many experimental data sets have not found a dependency between selectivity and catch size. Hence it is difficult to be conclusive about the nature of such a relationship. Work by O’Neill (1997; 1999) does show that with conventional diamond mesh codends as catch increases mesh opening along the codend decreases. Adapting this model for a Bacoma window, the relationship between the length of Bacoma panel that remains “uncovered” ahead of the catch against increasing catch size can be estimated as shown in table below. This analysis shows that as the catch size increases the “uncovered” portion of the panel becomes shorter and shorter reducing the escape area available to a large volume of fish i.e. for a catch of 1 tonne, approximately 1.64 m of the panel is essentially covered by the catch leaving the other 1.86 m for fish to escape and the potential escape area is reduced to 1.38 m with a catch of 2.25 tonnes. Given that underwater observations have shown that fish generally try to escape as they swim in front of the bulk catch in the codend, as the escape area decreases and the catch increases the opportunities for escape are greatly reduced. This may account for the reduction of selectivity experienced with the Bacoma window.

Table – Relationship of catch to area of Bacoma panel left unexposed

CATCH (KG)	EXPOSED PANEL (M)
1000	1.86
1250	1.74
1500	1.64
1750	1.54
2000	1.46
2250	1.38

Any increases in length, though, should be closely related to the length of the codend and straight extension piece commonly used in Baltic trawls. An indicative length of 5.5 m (100 bars x 55 mm bar length) would seem reasonable based on standard European trawl designs. Given that catches of 2 tonnes are probably an irregular occurrence on smaller vessels this perhaps should be restricted to larger vessels but this along with the appropriate length of panel needs further consultation with industry to verify. The practicalities of increasing the panel in terms of strength should also be considered.

The current regulation requires that the Bacoma window be constructed from braided knotless netting or “netting with similar selective properties”. Based on the results of work carried out by Revall *et al.* (2007) in the North Sea with square mesh panels constructed in low diameter/high tenacity Dyneema twine, there may be scope to relax this part of the regulation. These trials showed square mesh panels constructed in this material to be highly selective, albeit in this case for haddock and whiting. Dyneema netting is expensive compared to conventional netting but a similar price to the Ultra Cross knotless netting commonly used for construction of Bacoma panels and is also fairly readily available. Dyneema netting does have the disadvantage of being difficult to mend due to its stiffness (see Section 1.2) but used as a square mesh panel is likely to be a reasonable alternative to the heavy knotless netting required by the regulation and giving the same if not better selectivity.

T90 codends

The regulation T90 codend has shown to be selective if fished as per the current regulations. The most contentious issue, however, with the current regulation T90 codend centres on the requirement for a codend circumference of 50 meshes. There is a reasonable body of evidence to show that a reduction in codend circumference improves selectivity. The predicted effect of reducing the number of meshes round has been estimated at a reduction in L50 of ~1.7cm for an increase in codend circumference of 20 meshes (Anon., 2003). Hermann *et al.* (2007) noted that the effect of increasing rather than alteration to mesh geometry per se. In order to compensate for the increased codend circumference due to the wider mesh opening of a T90 codend the number of T90 meshes has to be lower than for a conventional codend (Graham, in press). Reports from SINTEF in Denmark based on Flume Tank tests and information from commercial fishermen suggest, however, that the current 50 meshes round regulation is flawed in that the forces become doubled on each bar reducing the strength of the codend. In addition anecdotal observations from German and Polish studies have shown large scale meshing of fish above the T90 to diamond mesh join due to the narrowness of the codend (see figure below). A ratio of 3:2 (around 67 meshes) or 4:3 (75 meshes) has been put forward as an alternative to the current 50 meshes, although the effect on selectivity of such a change has not been fully tested. There is some data from a joint German/Polish cruise in 2005 that showed a 110 mm T90 codend with 76 meshes in the circumference gave an L50 of 34.1 cm and a SF 6.6 cm and with a 67 mesh circumference gave a L50 of 35.3 mm and SF of 6.0 cm. From these results it is concluded that if the number of meshes in the circumference are increased then to compensate for the loss in selectivity the mesh size of the T90 may also have to be increased to compensate for the reduction in selectivity. The exact relationship between codend circumference and mesh size in T90 has not been clearly defined and it is recommended that this issue be addressed by the ICES Study Group on Tumed 90° Codend Selectivity, focusing on Baltic Cod Selectivity (SGTCOD).



Figure – Heavy meshing of herring above a regulation T90 codend

The other modification to the T90 codend identified that could be considered in the short term is a reduction in allowable twine thickness, currently double 4 mm (codend only) or single 6mm. Using the PRESEMO model it has

been shown that for standard diamond mesh codends a 1 mm increase in twine diameter decreases L50 by 1 cm (Hermann *et al.*, 2007). A meta-analysis of Scottish haddock selectivity data carried out by O'Neill (2008) similarly showed a 1mm increase in twine thickness decreases L50 by 1.5cm. Therefore there would seem scope to look at the effect of reducing the twine thickness of the current T90 regulation.

Weinbeck (2009) reports on recent trials with T90 codends made from low diameter/high tenacity Dyneema twines carried out in September 2008. These trials showed that these codends were highly selective with an L50 of 41 cm and SR of 4.6 cm with a T90 codend constructed in 2.5 mm single Dyneema twine. Using the T90 Dyneema codends very low levels of cod below 38 cm (~3%) although, catches of fish above mls were decreased by over 55%, which would be unacceptable to fishermen. Weinbeck (2009) concluded that to give the same selective properties of the current regulation T90 codends the mesh size would need to be reduced by about 5 mm. At face value this makes the use of Dyneema codends attractive from a selectivity point of view but WGFTFB would caution against such a change to the regulations in the short term. Double 4mm and single 6 mm twines are widely available and used by fishermen throughout Europe for the construction of codends. Whereas Dyneema has been used successfully in the construction of square mesh panels (Revell *et al.*, 2007), it is approximately ~5 times the cost of normal netting and there are practical difficulties with mending Dyneema given its latent stiffness, which does not lend itself as a good material for codend construction. In this respect it is also worth noting that according to O'Neill and Prior (in press) it is twine flexural rigidity (also known as twine bending stiffness) rather than twine thickness that ultimately determines mesh resistance to opening. Twine flexural rigidity is a function of the properties of the component fibres, the structure and the method of manufacture of the twine. By altering the structure and/or materials it is possible to produce "thin yet stiff twines" which may not necessarily be selective.

Fish Survival

With respect to both T90 and Bacoma windows the issue of the survival of escaping fish should also be considered. A recent study by Nowakowski *et al.* (2009) using an innovative split codend cover showed that a large proportion of the escaping fish from both Bacoma (35%) and T90 codends (37%) escaped during haul back rather than when towing. A study by Madsen (2007) also showed similar results from trials in the Kattegat/Skagerrak which compared T90 against standard diamond mesh codends. The results from these experiments showed over 50% of cod escaped from the T90 codend during haul-back compared to 34% with the diamond mesh. From a fish survival point of view this is not ideal because of the additional stress caused by decompression which is likely to increase mortality. Very little research has been conducted to assess the mortality of cod escaping at the surface other than a study by Soldal and Isaksen (1993) which showed a mortality of only 1% for cod escaping a Danish seine. This suggests this may not be a significant source of mortality but nonetheless further investigation of survival rates during the capture process should be encouraged given the potential at fleet level for this is a significant source of unaccounted mortality.

Alternative Gear Options

WGFTFB recently carried out an extensive review of gear modifications to reduce the bycatch of cod for NAFO (ICES, 2009). This review identified a number of gears that can eliminate or reduce cod bycatch but found few gears that actually improved size selection of cod other than the Bacoma and T90 codends. Thus the alternative options are that could be applied in the Baltic Sea cod fishery are limited.

Diamond Mesh Codends

The most obvious alternative gear option would be to simply revert back to a diamond mesh codend, which gives an L25 equivalent to the mls of 38 cm. Based on previous assessments this would equate to a codend constructed in double 4 mm PE twine with 100 meshes in the circumference and a mesh size of ~135-140 mm without attachments such as strengthening bags or rescue buoys as possible (Madsen, 1999; Valentinsson and Tschemij, 2003; Jorgenson *et al.*, 2006; Madsen, 2007). On the one hand this is a very simple solution that means all fishermen using the same codend but undoubtedly would be unpopular with industry and as highlighted by Suuronen (2002) and Valentinsson and Tschemij (2003), diamond mesh codends can be easily manipulated both legally and illegally. If it was seen as an option, experiences in Norway would suggest that there should be incremental increases in mesh size from the baseline level but done on a phased basis over a period of 3-5 years.

Side Panel Codends

One modification/alternative to the Bacoma window that has been mooted by Swedish fishermen is the use of side-panel codends (Valentinsson, 2009). In April-May 2009, the Swedish Board of Fisheries tested these side-panel codends, which are similar to the Swedish and Danish exit windows used previously in the Baltic prior to the introduction of the Bacoma panel (Madsen, 2007). The windows tested were 8 m long square mesh panels made in standard double 4 mm PE twine and with strengthening ropes along the selvages to stabilize the square mesh (See figure below). They were tested against a regulation Bacoma 110 mm/105 mm using a twin-trawl arrangement. A total

of fourteen hauls were sampled with an average cod catch per haul of 1150 kg. The results showed no apparent improvements in selectivity for cod without any reduction in cod discards compared to the standard Bacoma window suggesting them to be an alternative rather than a replacement for Bacoma. Further consultation with industry is planned with modifications to the gear design to be tested.



Figure – An 8 m long square mesh side panel codend

Rigid Grids

Another commonly used selective device that might be considered for use in the Baltic Sea would be rigid grids, which have been shown to give improvements in mean selection length for cod compared to diamond mesh codends (Jørgensen *et al.*, 2006). In this respect it is worth noting the Norwegian originated design known as the ‘Sort-X’TM grid system. This was designed to improve size selection of selected groundfish species including cod. Whereas the normal Nordmore shrimp sorting grid relies more on mechanical separation of species, the ‘Sort-X’TM grid provides a stable arrangement of escape openings in the codend region. This encourages positive escape reactions to occur, usually based on visual stimuli. Strategic positioning of the grid combined with carefully selected bar spacing provides undersize fish with escape routes out of the gear. In recent years The Sort-V grid was developed as a user-friendlier version of the Sort-X and is now more typically used by the commercial fleets in Norway and Iceland. Both grids used have the minimum legal bar spacing of 55 mm and used with a 135 mm codend giving an L50 for cod of ~55 cm, equivalent to a 155 cm diamond mesh codend and with a similar SR (Jørgensen *et al.*, 2006). For the Baltic fishery the bar spacing would have to be reduced considerably to match the current mls but the grid has the advantage from a management point of view of being difficult to circumvent. The effect on flatfish species is not well reported in any of these studies, other than the blocking effects of large flatfish species but it is felt likely that flatfish catches are not unduly reduced by using the Sort-XTM or Sort-V grids, which is an advantage in the Baltic given the bycatch of flounder in the cod fishery. There are obvious issues of practicalities for Baltic Sea vessels in particular for smaller vessels but many of these issues have been resolved in Norway and Iceland so these are not felt to be insurmountable.

Gear Attachments

WGFTFB re-iterates the point made in the earlier response to the EU on Baltic cod selectivity regarding the use of gear attachments (ICES, 2007). Under Article 5 of Regulation 2187/2005, several legal gear attachments are described that may have an adverse effect on selectivity or can be rigged in an illegal manner to restrict mesh opening. The use of bottom side chafers, large “rescue” floats attached to the codline, flappers and round straps all have an effect on selectivity depending on how they are rigged and the continued need for such attachments on strength and safety grounds should be balanced against their negative effects on selectivity, whether with a Bacoma window, T90 codend or diamond mesh codend.

Gillnets

A minimum mesh size of 105 mm was introduced in the Baltic cod gill net fishery for the first time in 1990 (Madsen, 2007). From 2002 the minimum mesh size was increased to 110 mm and this is the current regulation (Madsen, 2007). Few studies have accurately measured the selectivity of gill nets used in the Baltic Sea but the L50 for 105 mm and 110mm gill nets has been estimated at 43.4–45.5 cm respectively by Madsen (2007) using a bi-normal selection curve. This is higher than for trawls and is comparable to the L50 of a standard 140 mm codend. The selection curve is relatively steep compared to trawls (Madsen, 2007) and it is reported that many gill net fishermen use larger mesh sizes than the minimum allowed, possibly reflecting the availability of materials. The L25s for a standard twine (1.5x4 thread, 50% hanging ratio) and for a range of mesh sizes has been calculated from this earlier analysis and are provided in the table below. This shows this is well in excess of the current MLS for the range of mesh sizes.

Table – Predicted L25 for a range of gill net mesh sizes

MESH SIZE (MM)	PREDICTED L25 (CM)
105 mm	40.9
110 mm	42.8
120 mm	46.7
130 mm	50.6
140 mm	54.5
150 mm	58.4
160 mm	62.3
170 mm	66.2
180 mm	70.1

Studies by Holst *et al* (2002) and Wileman *et al* (2000) have shown parameters such as twine thickness, hanging ratio and season have relatively little effect on the selectivity of Baltic cod gillnets. Madsen (2007) showed in experiments testing different gill nets with varying twine thicknesses that from a management point of view the actual effect of twine thickness on selectivity was so limited that it does not have to be considered as an important parameter. Several studies have shown that the fishing power (i.e. the ability to retain fish at the optimal modal length) of a gill net is highly dependent upon the twine diameter with thinner twines catching larger numbers of fish (Hamley, 1975; Wileman *et al.*, 2000) but none affect selectivity. Madsen (2007) concludes that it is relatively easy to improve size selectivity in the gill net fishery by simply increasing the mesh sizes, since the other technical parameters don't influence selectivity to any great degree, as in trawl fisheries. On this basis WGFTFB see little reason to alter the current gill net regulations. The L25 for the current legal gear is in excess of mls and the restrictions on length of gear and soak time seem in line with similar fisheries in other parts of Europe. However, WGFTFB do note the concerns expressed by Suuronen *et al* (2007) that if trawl size selectivity is improved and the numbers of larger cod increase, then it is reasonable to assume that the gill net vessels would catch a major part of those fish given previous experience has shown larger cod tend to be found on fishing grounds where trawling is not possible. This could lead to increases in effort in gill net fishery, which ultimately could have a detrimental effect on the stock by removing too many of the large fish in the population.

Alternative Management Measures

The Baltic cod fishery is a relatively simple single species fishery, which is well studied. It would seem a candidate fishery to move to a target based system, allowing fishermen to adjust their gear or fishing pattern to meet appropriate management targets set for the fishery. This would remove the need for the large scale and frequent changes to the current technical measures regulations, which have occurred over the last decade in the Baltic cod fishery and caused many of the current problems. It would allow fishermen to use the gears that most suit their operation and fine-tune them to suit the situation on the grounds. It would appear according to comments by Weinbeck (2009) and Suuronen *et al.* (2007) there is already evidence to some degree of this with fishermen voluntarily using more selective gears to reduce discarding e.g. 125 mm T90 codends and double Bacoma windows. This target based approach also has the advantage of being able to do away with a lot of the very complicated and prescriptive text within the current regulation e.g. the detailed descriptions of how to mend a Bacoma panel can be removed. It also subverts the emotive argument that has continued regarding whether the Bacoma or T90 codend is the better gear solution. The monitoring and "burden of proof" element of such an approach is of course critical as are the incentives to encourage fishermen to comply but it is felt the Baltic RAC could play an important role in developing such a system and encouraging cooperation. Elements of a target based approach are already included in the Baltic Sea RAC proposals sent to the Commission (Clink, pers. comm.) and could be developed further.

Conclusions

The conclusion from the earlier ICES response on the relative selectivity of Bacoma and T90 remains. Both are selective but as has been discussed could potentially be modified to improve selectivity. Several alternatives including a return to a simple large diamond mesh codend or the use of side panel codends or a rigid grid are also put forward.

For the Bacoma it seems the most sensible modifications would be to consider extending the length of the panel to maintain selectivity with larger catches and/or increase the mesh size of the panel. There are some field observations and evidence from modelling data to support this move but without further studies the effectiveness of this modification is unproven. The practicalities of extending the length of the window, particularly for smaller vessels also need to be considered. There is also merit in considering increasing the mesh size of the Bacoma window to 120 mm to better match L25 to the current mls. This, however, should only be done on a phased basis and with due regard to the potential economic losses that may occur.

There is reasonable evidence to show that the current regulation T90 codend gives an L25 close to the current mls. The current legal limit for the codend circumference of 50 meshes does seem to be problematical though, with respect to strength and meshing of fish and there is a case for increasing the number of meshes allowed to address this issue. Studies have shown that there is a strong link between the selectivity of T90 codends and codend circumference so an increase in this parameter may have to be balanced with an increase in mesh size. Twine thickness and material used in the construction of T90 codends also have a bearing on selectivity and studies have shown using low diameter/high tenacity twines can increase the selectivity of T90 codends. The cost of such materials and practical handling difficulties, however, make the use of such materials seem impractical at the current time.

Regarding other gear modifications only the Swedish side panel codends and rigid grids seem options that could be tested further, although indications with the side panel codends is that they will only give as good a selectivity as the current Bacoma windows without out further modification, while grids may not be a practical option on Baltic Sea vessels.

A more obvious alternative gear option would be to revert back to a diamond mesh codend regulation, which gives an L25 equivalent to the mls of 38 cm. Based on previous assessments this would equate to a codend of ~135–140 mm. On the one hand this is a very simple solution that means all fishermen using the same codend but undoubtedly would be unpopular and can be easily manipulated both legally and illegally.

It is relatively easy to improve size selectivity in the gill net fishery by simply increasing the mesh sizes, since the other technical parameters don't influence selectivity to any great degree, as in trawl fisheries. On this basis there seems little reason to alter the current gill net regulations. The L25 for the current legal gear is in excess of mls and the restrictions on length of gear and soak time seem in line with similar fisheries in other parts of Europe.

Leaving aside the suggestions for improving the current gears and alternatives the fact that the Baltic cod fishery is essentially a simple single species fishery, means it is an ideal candidate to manage through a target based approach. It is concluded that this should be explored further with the Baltic Sea RAC as an alternative management plan for the fishery.

References

- Anon. 2003. Appendix 5 of Report of Expert Meeting on Cod Assessment and Technical Measures, Brussels, April/May 2003. DG Fish, European Commission, Brussels.
- Dahm, E., Wienbeck, H., West, C.W., Valdermarsen, J.W. and O'Neill, F.G. 2002. On the influence of towing speed and gear size on the selective performance of bottom trawls. *Fisheries Research*, 55: 103-119.
- Graham, N. (in press). Technical measures to reduce bycatch and discards in trawl fisheries.
- Graham, N., O'Neill, F.G., Fryer, R.J., Galbraith, R.D. and Myklebust, A., 2004. Selectivity of a diamond mesh codend and the effect of inserting a grid or a square mesh panel. *Fisheries Research*, 67: 151-161.
- Hamley JM (1975) Review of gillnet selectivity. *J Fish Res Board Can*, 32:1943–1969.
- Hansen U.J., 2004. Performance of trawl codend made from 90° turned netting (T90) compared with that of traditional codends. Paper presented at ICES-FAO Fishing Technology and Fish Behaviour Working Group Meeting, Gdynia, April 20-23, 2004. 17pp.
- Herrmann B., Priour D., and Krag L.A., 2007. Simulation-based study of the combined effect on cod-end size selection of turning meshes by 90° and reducing the number of meshes in the circumference for round fish. *Fisheries Research*, 84: 222-232.
- Holst R, Wileman D, Madsen N (2002) The effect of twine thickness on the size selectivity and fishing power of Baltic cod gill nets. *Fish Res*, 56: 303–312
- Holst R., Dahm E., Modenhak W., Valentinsson D., and Graham N. 2005. A meta-analysis of data from experiments with T90 and Bacoma Codends. Paper to International Baltic Sea Fisheries Commission (IBSFC).
- ICES, 2005. Report of the ICES-FAO Working Group on Fishing Technology and Fish Behaviour (WGFTFB), 18-22 April 2005, Rome, Italy. ICES CM 2005/B:04. 283pp.
- ICES, 2007. ICES response to EU on selectivity of active gears targeting cod in the Baltic Sea.

- ICES. 2009. Report of the ICES - FAO Working Group on Fishing Technology & Fish Behaviour (WGFTFB), 18-22 May 2009, Ancona, Italy. ICES CM 2009/FTC:06. 252 pp.
- Jørgensen T, Ingólfsson OA, Graham N and Isaksen B. 2006. Size selection of cod by rigid grids—Is anything gained compared to diamond mesh codends only? *Fish. Res.*, 79: 337-348.
- Madsen N., 2007. Selectivity of fishing gears used in the Baltic Sea cod fishery. *Rev Fish. BioL fisheries*. 14th February 2007.
- Madsen, N., Holst, R., Foldager, L., 1999. The escape window as a management option to improve the size selectivity of the Baltic cod fishery. ICES CM 199/R:01.
- Moderhak, W. 2009. Short evaluation of T90 and Bacoma codends selectivity results obtained in the period of 2004 – 2009. Working Paper. August 2009.
- Nowakowski, P., Sendlak, H., Berest, K., Rowinski, P. 2009. Characteristics of physical and selective properties of the Bacoma and T90 cod codend types and ways to improve their construction. West Pomerian University of Technology, Faculty of Food Sciences and Fisheries, Department of Fishing Techniques.
- O'Neill, F.G., 1997. Differential equations governing the geometry of a diamond mesh cod-end of a trawl net. *ASME Journal of Applied Mechanics*, 64: 7-14.
- O'Neill, F.G. 1999. Axisymmetric trawl cod-ends made from netting of a generalised mesh shape. *IMA Journal of Applied Mathematics*, 62: 245-262.
- O'Neill FG and Kynoch RJ. 1996. The effect of cover mesh size and codend catch size on codend selectivity. *Fish. Res.* 28: 291-303.
- O'Neill, F.G. and Priour, D. (in press). Comparison and validation of two models of netting deformation. *ASME Journal of Applied Mechanics*.
- Revoll, A.S., Catchpole, T.S., Dunlin, G. 2007. Recent work to improve the efficacy of square-mesh panels used in a North Sea *Nephrops norvegicus* directed fishery. *Fish. Res.*, 85(3): 321-327.
- Soldal, A.V., and Isaksen, B. 1993. Survival of cod (*Gadus morhua*) and Haddock (*Melanogrammus aeglefinus*) escaping from a Danish seine at the sea surface. Fishing gear Technology and Fish behaviour Working Group meeting, Gothenborg, Sweden.
- STECF, 2008. Commission staff working paper: Scientific, Technical and Economic Committee for Fisheries advice on selectivity of active gears targeting cod in the Baltic Sea.
- Suuronen, P., Tschernij, V., Jounela, P., Valentinsson, D., and Larsson, P.O. 2007. Factors affecting rule compliance with mesh size regulations in the Baltic cod trawl fishery. *ICES Journal of Marine Science*. 5th September 2007. 4pp.
- Tscemij, V., Suuronen, P., and Jounela, P. 2004. A modelling approach for assessing short-term catch losses of a mesh size increase. *Fisheries Research*, 69:399-406.
- Valentinsson, D. 2009. Recent Swedish investigations in the Baltic Sea. Presentation to ICES SGTCOD. Ancona, May 2009.
- Valentinsson, D., and Tschemij, V. 2003. An assessment of a mesh size for the “Bacoma design” and the traditional diamond mesh codend to harmonise trawl selectivity and minimum mesh size. Working report. Lysekil, Sweden, May 2003.
- Valentinsson D. 2007. Swedish information regarding selectivity in trawl fisheries for cod. Communication from National Board of Fisheries for Sweden to European Commission. 4th July 2007.
- Wienbeck H., 2009. Recent German selectivity trials in Baltic Sea. Presentation to ICES SGTCOD. Ancona, May 2009.
- Wileman D.A., Tschernij, V., Madsen, N., Holst, R., 2000. Size selectivity and relative fishing power of Baltic cod gillnets. *Meddelande från Havsfiskelaboratoriet*, 329: 110–148