Factors affecting rule compliance with mesh size regulations in the Baltic cod trawl fishery

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In this study, we evaluate the efficiency and applicability of a series of gear-based management measures, enforced since 1990, whose purpose was to improve size selectivity in the trawl fishery for Baltic cod (*Gadus morhua*). In general, our study revealed that these measures had no marked effect on the capture and discard of young cod. Legal and illegal manipulation of selective codends was widespread. The adoption of a codend design that offered a modest increase in selectivity, but had a good match with the legislated minimum landing size (MLS), led to greater compliance, demonstrating that a mismatch between MLS and selectivity should be avoided. It was also obvious that, generally, the fishing industry did not tolerate large short-term losses. Our evaluation is that overly ambitious rules will be circumvented, and frequent and incoherent changes in the regulations represent bad management practice. A gradual introduction of restrictions and participation by fishers in the decision-making process will increase compliance.

Keywords: adaptation strategies, Baltic cod, rule compliance, size-selectivity, trawl fishery.

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Introduction

The basic cause of overfishing in the Baltic Sea dates back to the 1980s, when the great abundance of Baltic cod (*Gadus morhua*) motivated substantial investment in new fishing vessels, leading to excessive exploitation of cod. By the beginning of the 1990s, the good catches of the mid-1980s had declined dramatically. The decline of the eastern Baltic cod stock was caused by high fishing pressure combined with poor reproductive success (Bagge *et al.*, 1994; Köster *et al.*, 2003). Despite declines in stock and catches, bigger and more effective trawlers continued to enter the fishery, and the demersal gillnet fishery for cod also expanded (Tschernij and Suuronen, 2002).

The technical regulations enforced by the International Baltic Sea Fishery Commission (IBSFC) were revised in 1994. The objective was to reduce the capture of young cod in the trawl fishery and thereby to improve stock status. Minimum mesh size of the traditional diamond mesh codend was increased from 105 to 120 mm, and two optional "window codend" alternatives with 105 mm escape panels (Tschernij *et al.*, 1996) were introduced in the legislation. In addition, the minimum landing size (MLS) was increased from 33 to 35 cm. Despite good intentions, these regulations were inadequate to protect young cod. Some minor changes in technical regulations were made in the late 1990s, and a marked change was implemented in 2002. Since then, new measures have been implemented almost annually.

Here, we describe the adaptation of fishers to gear-related technical measures enforced in the Baltic cod trawl fishery. Using this example as a case study, we search for feasible solutions to making technical measures more effective and applicable.

BACOMA project: main results and conclusions

The purpose of the BACOMA project (Improving Technical Management in Baltic Cod Fishery; Suuronen *et al.*, 2000), which operated between 1997 and 2000, was to provide measurements of the dominant factors that cause variability in trawl size selectivity and to develop practical codend designs with good and stable size-selectivity properties. The project also evaluated potential short- and long-term economic consequences of increased selectivity to the Baltic cod trawl fishing fleet.

The results of the modelling work revealed that the harvesting pattern of the Baltic cod stock was far from optimal and that a marked increase in the total annual yield could be achieved by improving size selectivity of the trawl fishery. These results were based on the good growth rate of Baltic cod. Cod 35 cm in length weigh ~0.45 kg and, if allowed to grow for a year, an individual would be ~45–47 cm in length and weigh ~1 kg. Hence, an increase in fishing size selectivity would utilize the growth potential more efficiently. The simulations also suggested that improving size selectivity would increase recruitment of the Baltic cod stock in the long run, and overall yield would become less sensitive to changes in recruitment levels (Kuikka *et al.*, 1999; Suuronen *et al.*, 2000). Taken as a whole, the results suggested that improving trawl size selectivity would bring a substantial return to the fishery and protect young cod.

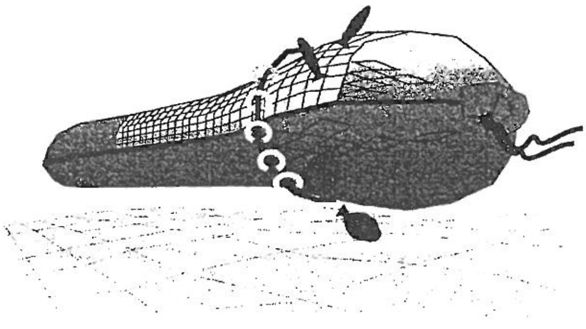

Figure 1. The design of the BACOMA-window codend.

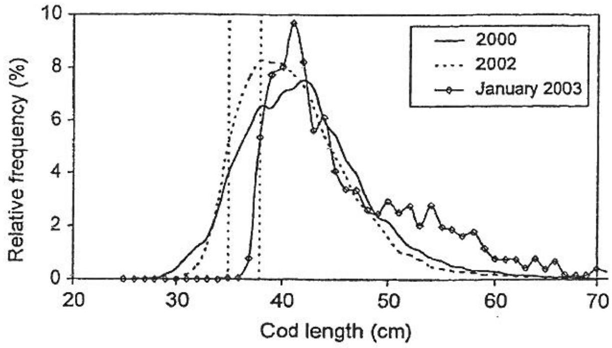

Figure 2. Relative length composition of Swedish cod landings before (2000) and after (2002) the legislative change from a 120 mm diamond-mesh codend to a 120 mm Bacoma-window codend (and to an alternative 130 mm diamond-mesh codend). Also shown is the length composition of landings in January 2003, i.e. after the MLS was increased from 35 to 38 cm (vertical dotted lines).

One of the main aims of the BACOMA project was to find a practical codend type that guaranteed good selectivity under all conditions. Altogether, 465 trawl tows with various types of codends were performed. Gear selectivity of the conventional diamond-mesh codend was highly sensitive to factors such as vessel type, season, and twine diameter (Suuronen *et al.*, 2000; Tschernij and Suuronen, 2002). The results suggested that the variability in selectivity was smaller in a codend equipped with a properly located and designed escape window. The project introduced a square-mesh window installed in the upper rear panel of the codend (Figure 1), called the BACOMA window (Madsen *et al.*, 2002).

The simulation-based estimates predicted increased long-term spawning biomass and landings, and marked reduction in discards, if the whole demersal trawling fleet used a 115 mm BACOMA window (assuming stable fishing effort and recruitment). Simulations also indicated that the short-term catch loss of market-sized fish during the first months would be ~30–50%. Moreover, it is likely that catch losses would be greater in traditional side trawlers than in stern (ramp) trawlers. Further simulations suggested that, if fishers compensated for reductions in their catch through increased effort, the increase would range from 55% to 90%, depending on vessel type (Tschernij *et al.*, 2004). Fishers generally regarded such an effort increase as economically unsustainable. The analyses also suggested that the gillnet fishery would obtain a large proportion of the potential increase in cod catches (Kuikka *et al.*, 1999; Suuronen *et al.*, 2000).

Decision process in 2001

The Baltic fishers' organizations and fishery managers believed that a substantial increase in the fleet's size selectivity might be the most suitable tool to reduce the capture of young cod and to rebuild the declining eastern Baltic cod stock. This was based largely on the estimates made in the BACOMA project. It is notable that, generally, discarding was considered a bad practice and that there was a large interest within the industry and among management authorities to overcome the negative reputation of fishing. The fishing industry preferred improvements in gear selectivity to less attractive management measures, such as significant cuts in TAC or large fishing closures.

In an extraordinary BACOMA session of IBSFC in 2001, the BACOMA window was chosen as the preferred design for improving trawl selectivity, but reaching consensus on the most appropriate mesh size was difficult for the IBSFC member countries. Some countries favoured a 120–130 mm window, whereas others favoured a 105–110 mm window. The potentially large catch losses, as well as the high cost and poor availability of proper window netting material (knotless Ultra-cross), caused concern within the fishing industry. Some member countries also expressed concern about the potentially weak construction of a window codend. Despite these disagreements, a 120 mm BACOMA-window codend came into force in the Baltic cod trawl fishery in January 2002. It represented a major increase in trawl selectivity; the 50% selection length (L_{50}) increased by ~10 cm. A traditional 130 mm diamond-mesh codend was offered as an alternative to the BACOMA-window codend. This decision was a prerequisite to agreement by all member countries for the introduction of the BACOMA design. The MLS of cod remained at 35 cm.

Use of the BACOMA-window codend was widespread in early 2002. The catch losses to trawlers that used the BACOMA codend were great, up to 70% by weight (Tschernij *et al.*, 2004). Those trawlers rapidly replaced BACOMA codends with the alternative 130 mm diamond-mesh codend. The selectivity of this codend type was poorer and more variable than that of the BACOMA codend, and its selectivity properties could be easily and legally manipulated (Tschernij and Suuronen, 2002). A few months later, only a few vessels were using the BACOMA codend, and when used, it was often manipulated to decrease the selectivity (e.g. shut by ropes). The length distributions of landings sampled in the Swedish cod fishery (Figure 2) suggested that the capture, and obviously also the discard, of young undersized cod continued as before. That is, the introduction of the 120 mm BACOMA window was economically unsustainable. Fishers were not able to adapt to the large losses in catch, which were often even greater than predicted in the earlier simulations. The ambitious changes in gear regulations apparently did not improve overall fleet selectivity.

MLS increased and window mesh size decreased in 2003

In January 2003, to encourage fishers to use selective codends, the MLS of cod was increased from 35 to 38 cm. There was a clear change in size distribution of the landed catch of cod (Figure 2). However, Swedish on-board observations made during winter and early spring 2003 revealed that large numbers of cod were

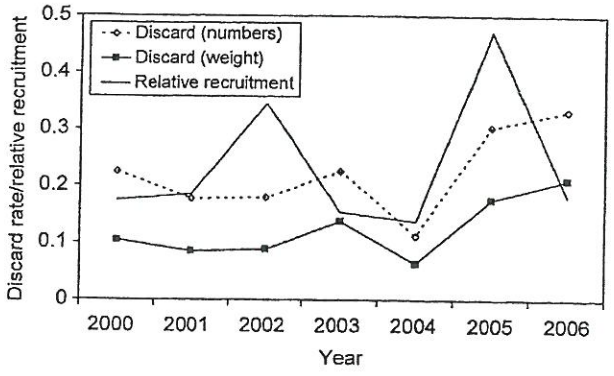

Figure 3. Discard rates, in numbers and weight, in the Swedish cod fishing fleet (from the on-board observer programme) and the relative recruitment of year classes X-2 [estimated from Anon. (2006)].

discarded because undersized fish were being caught (Valentinsson and Tschernij, 2003). This was a result of poor selectivity and a relatively high MLS, which represented a major mismatch between these two management measures. In April 2003, the devastating waste of resources through discarding forced the European Community to close the trawl fishery for cod temporarily in the Baltic EU waters.

To achieve a better match between selectivity and MLS, the minimum mesh size of traditional diamond-mesh codend was increased from 130 to 140 mm. This change was planned to take place in September 2003, but it was never enforced. Instead, the Baltic fishers' organizations promoted a total prohibition of traditional diamond-mesh codend and recommended the exclusive use of a 105 mm or 110 mm BACOMA-window codend. Consequently, the fishing rules were changed as of September 2003. The use of a traditional diamond-mesh codend was prohibited, and only a BACOMA window with a minimum mesh size of 110 mm was allowed in the Baltic cod trawl fishery. This mesh size better matched the new 38 cm MLS (Valentinsson and Tschernij, 2003). Thereafter, most fishers used the 110 mm BACOMA-window codend without serious manipulation, at least in Sweden and Denmark. A reduction in average discard rate was observed in late 2003 and in 2004 in the Swedish trawl fleet (Figure 3). That is, fishers' compliance with the regulations was noticeably greater than previously.

Nevertheless, because of the poor status of the cod stock in 2005, the cod fishery was prohibited in three large areas of the Baltic. According to unofficial information obtained from commercial fishers, these closures displaced fishing effort to the areas with a greater bycatch of young cod and poorer profitability.

New gear regulations in 2006

In 2006, a new codend design, the so-called turned mesh codend (T-90) with 110 mm mesh size, was introduced as an alternative to the 110 mm BACOMA-window codend. The design is based on the observation that conventional knotted netting has more open meshes when turned through 90° and therefore has better selectivity than the corresponding diamond-mesh codend (Moderhak, 1997; Dahm and Wienbeck, 2000). However, as with the diamond mesh codend, the twine characteristics and the number of meshes in circumference have a distinct effect on the selectivity of the T-90 codend. Of 18 Swedish trawl skippers interviewed about their gear practices in 2005 and 2006, 12 had tested the T-90 codend in 2006. When they experienced a strong reduction in selectivity using the T-90 codend, they reverted to the BACOMA-window codend. Apparently, the good selectivity properties of T-90 codend will not last over time. It is notable that some Swedish fishers were using double-length BACOMA windows in 2005 and 2006 in an attempt to improve the codend selectivity for larger catches of small cod, demonstrating their dedication to saving the undersized fish.

Despite the new regulations, the discard rate in 2005 and 2006 increased again (Figure 3). This increase, however, was at least partly caused by the relatively strong 2003 year class of cod that started to recruit into the fishery in 2005. Figure 3 shows the estimated recruitment (arithmetic means of standardized survey indices) of two-group Baltic cod of year class X-2 (data from Anon., 2006).

Discussion

During the past two decades, management of the Baltic cod fishery failed to achieve its two main objectives: (i) to reduce the bycatch and discards of juvenile cod, and (ii) to increase the size of the spawning stocks (and recruitment). Mesh size regulations intended to reduce the capture of juveniles were not successful. The effective selectivity of the fishing fleet was not clearly improved and, in some cases, the changes led to increased discarding of undersized fish. Clearly, any new measure should not create more problems than it solves.

New measures were introduced almost annually in the Baltic cod trawl fishery (Figure 4). In light of the fishers' poor compliance, frequent and incoherent changes in the regulations are not good management practice. Gear regulations should be planned with great care, and the modifications have to be practical, enforceable, and efficient under all conditions. It is notable that poor compliance with fishing regulations, often through illegal landings, has contributed markedly to the difficulties experienced in the management of the Baltic cod fishery (Nielsen and Mathiesen, 2003).

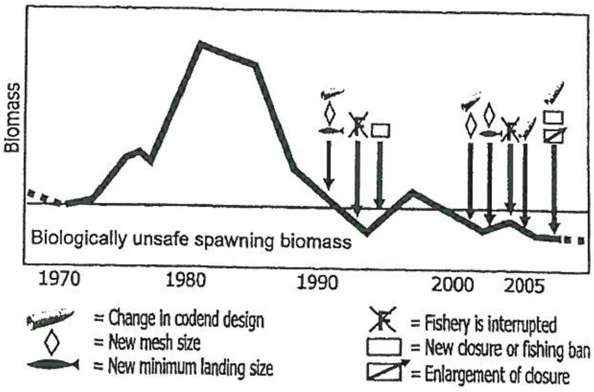

Figure 4. Technical measures enforced during the past 15 years in the Baltic cod demersal fishery. The rules have been changed regularly from 1990 onward. Spawning-stock biomass is indicated by the thick continuous line.

This review demonstrates that the fishers' willingness to deal with new regulations depends largely on their ability to deal with short-term catch losses. A large increase in selectivity introduced in a single step may not be commercially acceptable. The 120 mm BACOMA-window codend came into force in 2002, before the estimated short-term effects had been properly addressed. When short-term catch losses are too large, gears will be manipulated and rules will be circumvented. These types of compensatory action may have negative overall consequences, making a bad situation worse. Apparently, a gradual increase in mesh size or any restrictive measure would often be more acceptable to the fishers.

Although there will always be variation in the selectivity among vessels, we demonstrate that a major mismatch between MLS and selectivity should be avoided. When the MLS of cod was increased to 38 cm, but no effective changes in selectivity were applied, up to 40% of cod caught were discarded by trawlers because the fish were undersized. There is little evidence that the larger MLS encouraged the use of more selective gears. Instead, the increase in MLS generated a significant discard problem. MLS regulations are considered a necessary backup in supporting minimum mesh-size regulation, but the link between MLS, gear selectivity, and discard rate is often poorly understood and defined. It is likely that market forces are more important in determining fishers' behaviour. Nevertheless, the lesson learned here is that gear selectivity and MLS should always be addressed simultaneously.

Neglect of other fisheries using the same resource may also lead to management failure. For the Baltic Sea cod fishery, the management focus was on the trawl fishery, although a substantial part (ca. 40%) of the total cod catch was taken by gillnet. The gillnet fishery targets larger cod that are found primarily on fishing grounds where trawling is not possible. Our assessment predicted that, as soon as the improvement in the trawl size selectivity would start to show results in a growing number of larger cod, gillnet fishers would catch a major part of those fish. However, this did not happen because, apparently, there was no effective increase in trawl selectivity and no increase in the numbers of larger cod. Nevertheless, reallocation of economic benefits among fishers should be addressed before new regulations are imposed. Fishers who make the initial sacrifices should also share in the benefits. The lack of an overview may destroy the whole management scheme.

Generally, there are many ways to improve gear selectivity. A key issue is whether fishers really want to improve selectivity. Therefore, regulations should be planned in close cooperation with those fishers whose practices the new rules are aiming to change. Voluntary adoption of better practices should be encouraged by (economic) incentives. All inconsistencies in the regulations should be corrected.

In conclusion, our review demonstrates that, even in cases where fishing targets one species and the biological preconditions appear favourable, the increase of fleet selectivity is a complex process. The following issues appear crucial to a successful process and should be addressed. How large a change in mesh size is possible? How long will it take to realize economic benefits and who will get them? How easily can the fishers manipulate selective properties of gear, legally and illegally? Will fishers manipulate their gears? How much additional effort is required for fishers to compensate for potential catch losses? How much does it cost to improve trawl selectivity and who will pay? Are other measures, unrelated to gear, more efficient and more appropriate to improving stock status and future conditions? If these critical factors are not addressed, the projected long-term benefits may never be realized.

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