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Size selection in codends made of thin-twined Dyneema netting compared to standard codends: A case study with cod, plaice and flounder

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ABSTRACT

In an experimental trawl fishery, diamond mesh codends made out of 2.5 mm flexible Dyneema twine were tested. The principle aim was to investigate the effect of the number of meshes in the codend circumference, the number of twines (single or double), and netting orientation (T0 or T90) on the size selection of cod (*Gadus morhua*), plaice (*Pleuronectes platessa*) and flounder (*Platichthys flesus*). In addition, the obtained size selectivity for the codends made of Dyneema netting were compared to results obtained for T90 codends made of standard 5 mm single twine PE netting, and to previous results for other PE codends used in the same fishery. It was observed that the selective performance of the Dyneema netting codends was very high compared to other T0 and T90 codends of the same mesh size and number of meshes in the codends circumference. This demonstrates the high selective potential of the thin and flexible Dyneema netting compared to nettings which are traditionally used in the construction of trawl codends. Furthermore, reducing the number of meshes in the codend circumference for the Dyneema codends significantly increased the size selection of cod but did not affect the size selection of plaice and flounder. This difference between the species is likely linked to their different morphologies. No differences in the size selection of the T0 and T90 designs made of Dyneema twine tested were observed for any of the three species. For cod, the effect of using single or double twine in the Dyneema codends was also tested, however, no significant differences were found.

1. Introduction

The extensive use of diamond mesh codends in European demersal trawl fisheries has been largely due to their simple construction and ease of operation. They have traditionally been used to fish for round fish species, such as cod (*Gadus morhua*), and flatfish species, such a plaice (*Pleuronectes platessa*) and flounder (*Platichthys flesus*) (Graham et al., 2007; O'Neill and Herrmann, 2007; Krag et al., 2008). In recent years, many European trawl fisheries have introduced stronger, stiffer, and thicker twines, often in collaboration with double twine netting, particularly in diamond mesh codends (Herrmann and O'Neill, 2006). However, several studies have shown that using thicker and stiffer twine materials in the construction of diamond mesh codends tends to reduce the size selection of round fish (Lowry and Robertson, 1996; Kynoch et al., 1999; Herrmann and O'Neill, 2006; Sala et al., 2007; Herrmann et al., 2013a) and flatfish species (Herrmann et al., 2013a).

In the Baltic Sea demersal trawl fishery targeting cod, T0-codends made solely from diamond mesh netting have been banned since 2003, while it is legal to use codends where the diamond mesh netting direction is turned 90 degrees (T90) (EU Regulation No. 2187/2005) and codends where a square mesh netting is inserted in the upper panel of a T0-codend (Bacoma codend). For

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a specific PE netting type with 5 mm single twine, Wienbeck et al. (2011) documented that the T90 codend had a significantly higher size selection for cod compared to a similar diamond mesh codend (T0). However, Wienbeck et al. (2011) also found that the number of meshes in codend circumference affects the size selection of cod in T0 and T90 codends and therefore this design parameter also needs to be considered when comparing the selective performance of different T0 and T90 codends with similar mesh sizes. Additionally, the improvement in size selection of cod by turning the netting direction from T0 to T90 is strongly dependent on the twine thickness of the netting (Herrmann et al., 2013a). In general, the difference in the size selection of cod between T0 and T90 codends is much smaller when using thinner twines. In contrast to roundfish species like cod, T0 codends have a higher size selection for flatfish species compared to T90 codends with similar mesh sizes (Herrmann et al., 2013a), but this difference tend to decrease the thinner the twine is.

Based on the above description, a number of questions can be raised:

(i) What would be the size selective performance of similar T0 and T90 codends if the netting material is very thin and fully flexible with negligible twine bending stiffness?
(ii) Would those codends have similar or even improved size selectivity for cod compared to a similar T90 codend made from the more traditionally used thicker and stiffer PE material?
(iii) How does the size selectivity of flatfish species in codends made from such thin and flexible material differ when compared to T0 and T90 codends made of more traditional PE material?

One material which fulfills the above criteria regarding flexibility in terms of negligible twine bending stiffness is netting made of thin Dyneema twine. Dyneema is an ultrastrong special Polyethylen twine that was developed by the Dutch company 'Royal DSM N.V.'. Based on producer information, the material has a tensile strength 15 times higher than steel. Therefore, the added strength means it is possible to use thinner twine. The use of nettings made of Dyneema to improve selectivity in trawls is well known in the scientific literature. Previous studies have used Dyneema nettings to try and improve size and especially species selection in a *Nephrops* (*Nephrops norvegicus*) directed fishery, where the escapement window was made of 2.5 mm Dyneema and integrated into the top panel of the trawl (Revill et al., 2007) and as release panel in the bottom of a beam trawl (Revill and Jennings, 2005). Marlen (2003) reports on testing a large mesh top panel made of 9 mm Dyneema netting to improve the selectivity of beam trawls. However, these studies have looked at replacing only a part of the codend with Dyneema netting. To our knowledge, no systematic studies have been carried out to investigate how the size selective performance of trawl codends with different constructions, regarding twine direction (T0 and T90), number of twines (single and double), number of meshes in codend circumference, made completely of thin Dyneema netting are available. Furthermore, it has not been reported in scientific literature before how such Dyneema codends perform compared to T90 and T0 codends made of more traditional codend materials regarding size selection of round and flatfish species.

Based on the above description, the objective of this study is to report on the results from an experimental investigation on the size selection of roundfish (cod) and flatfish (plaice and flounder) in trawl codends made from 2.5 mm thin and flexible Dyneema twine in comparison to the performance of codends made from more traditional codend material (PE).

2. Material and methods

2.1. Experimental design and data collection

To investigate the size selective performance of codends made from thin and flexible Dyneema twine, five Dyneema codends (Table 1 and Fig. 1) of a similar mesh size and twine thickness, but different designs regarding the netting orientation (T0 or T90), the number of meshes in codend circumference, and the number of twines (single or double), were tested during two experimental fishing cruises. Furthermore, the Dyneema nettings used were double knotted (Fig. 1) which is standard for this type of netting to avoid knot slippage. In addition to the Dyneema codends, two different T90 codends made from 5 mm single twine PE netting were also tested (Table 1 and Fig. 1) to compare the selective properties of Dyneema-codends and codends with thicker and less flexible twine, as often used in this fishery.

During the first cruise, selectivity data were collected only for cod, while during the second cruise, selectivity data were collected for cod, plaice and flounder. During the first cruise, Dyneema codends with single and double twine were tested, while only single twine codends were tested during the second cruise. Therefore, the effect of twine number on the size selection can only be assessed for cod. During the first cruise, five codends were tested, while four codends were tested during the second cruise (Table 1).

The different codends were tested, one at a time, while attached to the same trawl and extension piece. The trawl used was a "Codhopper," with a circumference of 530 meshes and a mesh size of 160 mm in the belly. The trawl was spread using two 3.5 m^2 Bison trawl doors. The codend was the only change in gear between the individual tows.

The covered codend method (Wileman et al., 1996) was applied. Supporting hoops with a diameter of 2.6 m were used to keep the cover netting clear of the test codend. The cover, with a mesh size of 80 mm, was connected to the extension piece two mesh rows before the codend. The large mesh size used in the cover was because previous experience during experimental fisheries in the same region demonstrated that fishing with a smaller mesh size in the cover was obstructed by large catches of herring (Wienbeck et al., 2011). Compared to the recommendations of Wileman et al. (1996), this cover mesh size was rather large compared with the mesh sizes tested in the codends (Table 1). Therefore, special attention was given in the analysis to remove length classes where the selection in the cover and test codend potentially overlapped (Wienbeck et al., 2011). No subsampling was performed, and the catch was sorted by species, whereby all individuals measured were rounded down to the nearest centimeter.

The experimental fishing was conducted onboard the German Research Vessel (FRV) "Solea" (total length = 42 m, 950 kW). The first cruise was conducted between 5 and 25 September 2008, while the second cruise was conducted between 19 and 31 March 2010. Both cruises were conducted in the Arkona Sea, Western Baltic Sea (ICES Subarea 24).

2.2. Data analysis

To model the size selection of cod, plaice and flounder for the individual hauls, we used a logistic curve described by the parameters L50 (the length at which 50% of a given size class is retained in the codend) and the selection range SR (=L75 – L25) (Wileman et al., 1996). The capacity of the logistic curve for modeling the data from individual hauls was inspected based on the *p*-value, following the procedures described by Wileman et al. (1996). In case of a poor fit statistic (p-value < 0.05), the residuals were inspected to determine whether the poor result was due to structural problems when modeling the experimental data using the logistic curve, or