Quantifying bell-shaped size selectivity in shrimp trawl fisheries: effect of codend design

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/ BACKGROUND

Trawlers targeting shrimp use often a Nordmøre sorting grid ahead of a small-mesh codend. The purpose is to avoid bycatch of fish while shrimps are efficiently caught. However, small fish and other unwanted bycatch can pass through the grid to enter the codend with the risk of being retained. This makes the size selection process complex, and the size-dependent curve often adopts a bell-shaped signature.

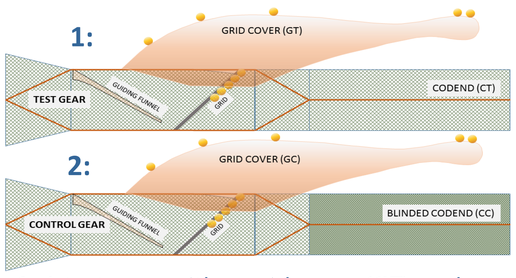
In the Northeast Atlantic, the use of the (maximum) 19 mm bar-spaced Nordmøre grid combined with (minimum) 35 mm mesh size in the codend has been compulsory since 1993. Today, the Norwegian shrimp trawler fleet comprises a range of vessel sizes from small inshore (coastal) boats <10 m to deep-sea vessels >80 m. Thus, the operational areas and bycatch challenges vary.

/ STUDY I: NEW APPROACH FOR MODELLING SIZE SELECTIVITY IN SHRIMP TRAWL FISHERIES

These tests were used as our baseline study, and we aimed at:

a) Developing a new model to estimate size selection in shrimp trawls using a Nordmøre grid and a small mesh codend.

b) Quantifying the individual and combined size selection of a 19 mm bar-spaced Nordmøre grid and a 35 mm codend for deep-water shrimp and redfish, a typical bycatch species in the fishery.



1: *A test gear with a grid cover (GT) and a conventional 35 mm codend (CT).*

2: *A control gear with a grid cover (GC) and a non-selective, blinded codend (CC).*

Model for size selection:

The retention probability for fish and shrimp equals: $r_{combined}(l) = r_{grid}(l) \times r_{codend}(l)$ and the combined selection for grid and codend equals:

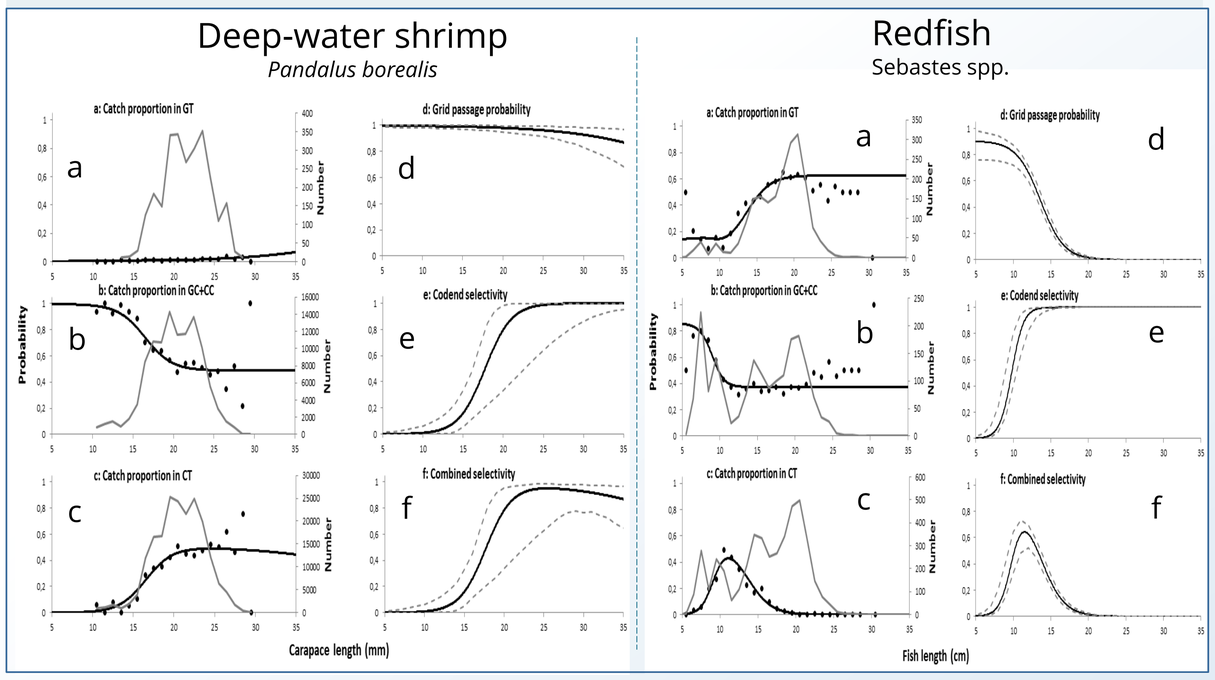
$$r_{combined}(l, C_{grid}, L50_{grid}, SR_{grid}, L50_{codend}, SR_{codend}) = \frac{C_{grid}}{1.0+exp\left(\frac{ln(9)}{SR_{grid}} \times (l - L50_{grid})\right)} \times \frac{exp\left(\frac{ln(9)}{SR_{codend}} \times (l - L50_{codend})\right)}{1.0+exp\left(\frac{ln(9)}{SR_{codend}} \times (l - L50_{codend})\right)}$$

/ Size selectivity plots for shrimps and redfish:

The left column shows the fit of the selection model to the experimental catch portioning rates. Plot "a" shows the length dependent portioning found in the grid cover of the test gear, plot "b" shows the length dependent portioning observed in the codend of the test gear (left y-axis) and plot "c" shows the length dependent portioning found in the control gear.

The points in plots "a"-"c" represent the observed experimental length dependent portioning of the catches between the three compartments GT, CT and GC + CC. The grey curves in plots "a-c" represent the total catches in number of individuals (right y-axis) in the three compartments GT, CT and GC + CC.

The plots in the right column show the selectivity curves for the test gear. Plot "d" shows the length-dependent grid passage probability, plot "e" shows the length dependent codend selectivity in the test gear, and plot "f" shows the combined size selectivity of the Nordmøre grid and the codend for the test gear. The stippled curves in plots "d"-"f" represent 95% confidence bands.



/ RESULTS AND CONCLUSION

Redfish: The combined size selection showed a clear bell-shaped signature, with > 60% of redfish around 12 cm long being retained by the gear, but < 25% of redfish < 9 cm and > 15 cm long being retained. For other species such as American plaice the combined selectivity curve also showed a clear bell-shaped signature.

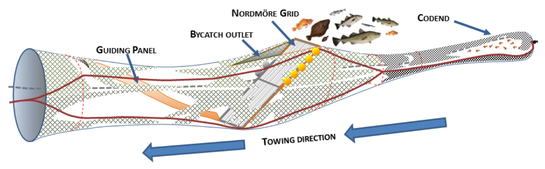
Deep-water Shrimp: The combined selectivity for the grid and codend exhibited a slightly bell-shaped signature, with few shrimp < 15 mm being retained, a maximum retention rate for shrimp with carapace length of 25 mm, and a slight decrease for shrimp above this size.

Despite the combined selection system reduces almost all bycatch problems in the examined fishery, our data show very clear that certain sizes of fish will continue to be a problem for the shrimp fleets of the Northeast Atlantic.

/ CURRENT REGULATIONS FOR THE NORTHEAST ATLANTIC

Bycatch limits/10 kg shrimps (north of 62ºN):

- 8 cod *(Gadus morhua),*
- 20 haddock *(Melanogrammus aeglefinus),*
- 3 redfish (Sebastes spp),
- 3 Greenland halibut *(Reinhardtius hippoglossoides),*
- 10% shrimp below 15 mm carapace length

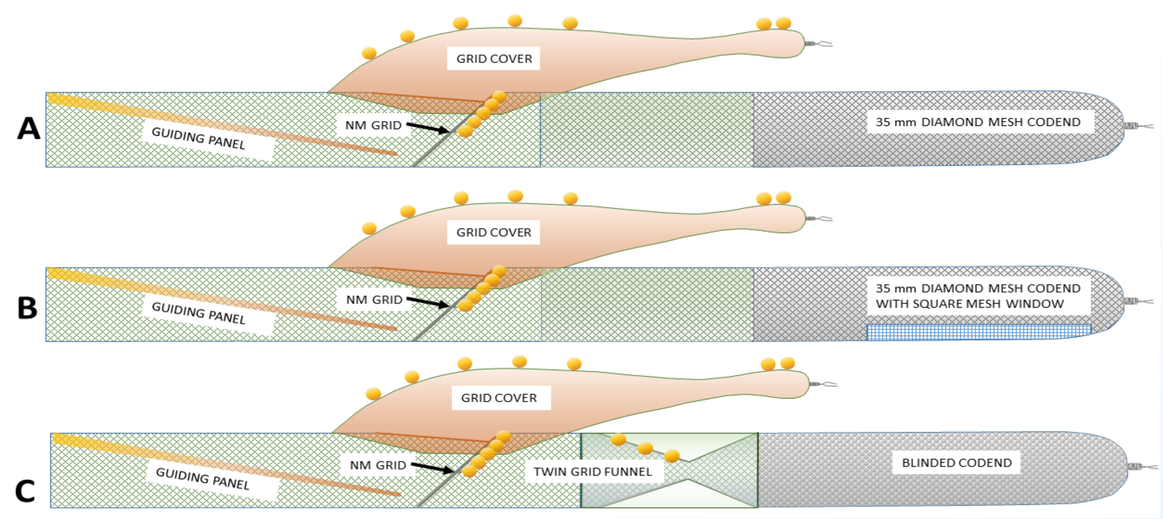


The working principle of a Nordmøre grid bycatch excluder system

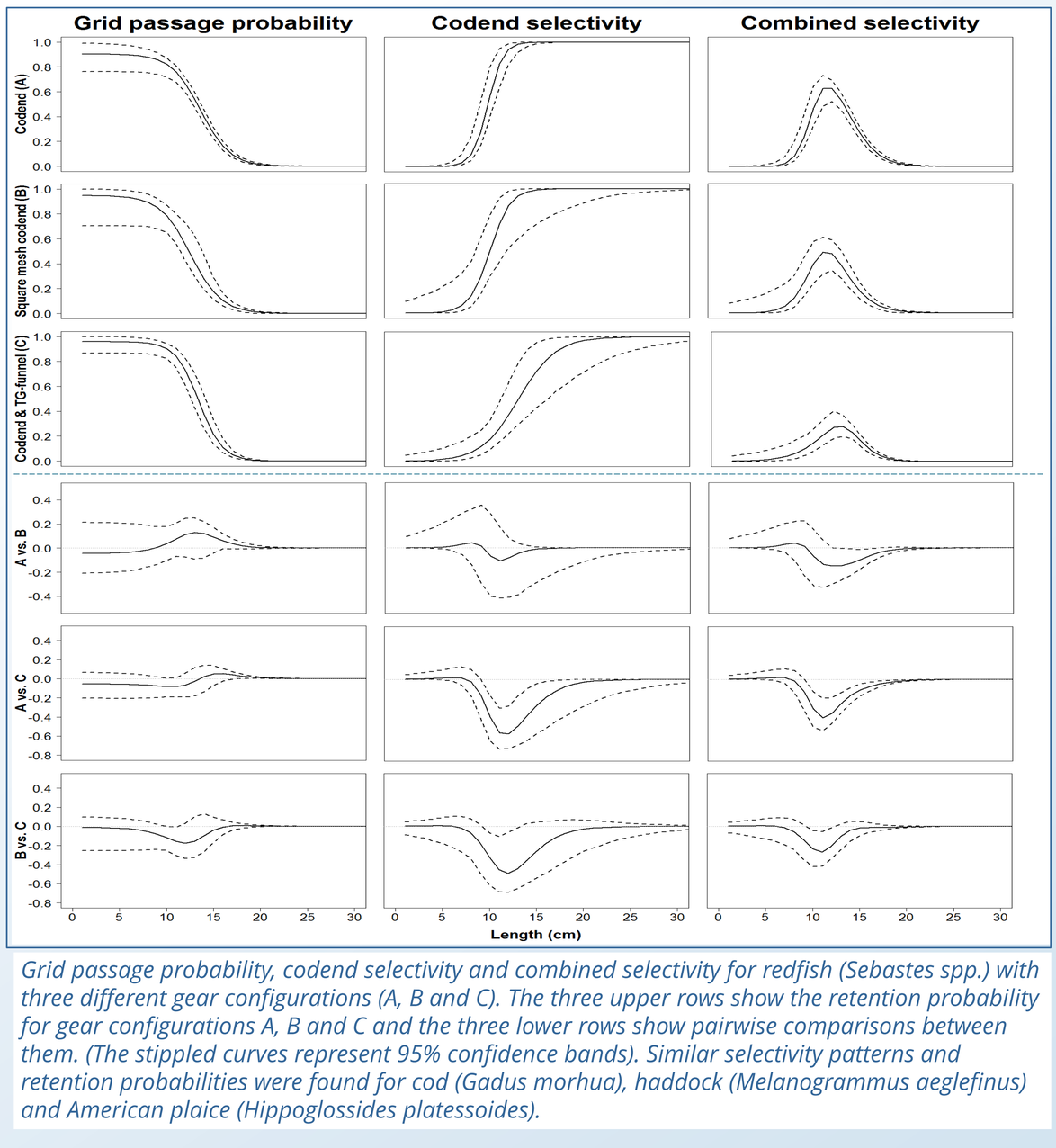
/ STUDY 2: BYCATCH REDUCTION WITH A NORDMØRE GRID COMBINED WITH VARIOUS CODENDS

In this study, we quantified the bell-shaped size selection pattern for the standard Nordmøre grid combined with three different codend designs:

1) The baseline with a 35 mm diamond mesh codend.
2) A 35 mm square mesh window inserted in the lower panel of the codend.
3) A "twin-grid funnel" comprising two 9 mm bar-spaced grids inserted between the Nordmøre grid and the 35 mm diamond mesh codend.



The standard 19 mm Nordmøre grid system combined with three different codends.



Grid passage probability, codend selectivity and combined selectivity for redfish (Sebastes spp.) with three different gear configurations (A, B and C). The three upper rows show the retention probability for gear configurations A, B and C and the three lower rows show pairwise comparisons between them. (The stippled curves represent 95% confidence bands). Similar selectivity patterns and retention probabilities were found for cod (Gadus morhua), haddock (Melanogrammus aeglefinus) and American plaice (Hippoglossides platessoides).

/ RESULTS AND CONCLUSION

Results were obtained for Deep-water shrimp (*Pandalus borealis*) and four bycatch species (cod, haddock, redfish and American plaice) based on fishing trials in the Northeast Atlantic, i.e. Barents Sea.

The size selectivity for the bycatch species showed the characteristic bell-shaped size selection pattern expected with low retention probability of very small fish and bigger fish, while certain sizes of juveniles had high retention probability.

Our results identified which size ranges of the different bycatch species that for the different codends would result in high risk of capture and thereby provided guidance on which size ranges that should be avoided with the different codends.

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