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# Development and test of selective sorting grids used in the Norway lobster (*Nephrops norvegicus*) fishery

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Due to generally high discard rates in Norway lobster (*Nephrops norvegicus*) fisheries, a discard ban coming up and to the cod recovery plan in several areas, selective sorting grids have been tested in many areas and are specified by legislation for use in the Kattegat and Skagerrak area bordering Norway, Denmark and Sweden. Grids are very selective, but they can lead to loss of landable Norway lobster and valuable fish species. To improve retention of these species, we developed three new grids using made by polyurethane to make them flexible: One grid had horizontal bars, one had vertical bars, and one had vertical bars and a guiding funnel in front of the grid. Four unselective net bags were used to collect the catch escaping through different parts of the grid or escaping without passing through the grid. Water flow around the grid bars was measured in a flume tank. The three grids were tested from a commercial trawler in the Kattegat and Skagerrak area. Underwater filming was conducted to assess grid performance and fish behavior. Results showed that a bottom hole in the lower part of the grid allowed species in the lower part of the gear to pass and retained in the bag behind the hole. More flatfish passed the grid with horizontal bars compared to that with vertical bars, but the retention rate was still low. Use of the guiding funnel increased the contact with the grid considerably for both target and unwanted species. In all three grid designs, there were losses of Norway lobster above minimum landing size.



## 1. Introduction

The Norway lobster (*Nephrops norvegicus*) fishery is among the most economically important demersal species for human consumption in European fisheries (Catchpole and Revill, 2007). To retain Norway lobster, the mesh sizes used are relatively small (normally below 100 mm), which results in high bycatch and discard rates in most Norway lobster fisheries (Catchpole and Revill, 2007) and concern about the effects of this fishery on declining stocks of other species, particularly cod (*Gadus morhua*) (Madsen and Valentinsson, 2010; Eliasen, 2014). Additionally, the high bycatch rates in Norway lobster fisheries will cause problems by the reform of the European Union common fisheries policy that plans for gradual elimination of discards by landing obligations where all individuals of certain species caught are landed (Sardà et al., 2015). This means that unwanted catch (i.e., species or sizes with landing obligations but not of commercial interest) will be attributed to a given vessel's quota.

Results of several experiments from different fisheries indicate that sorting grids can be very selective and help reduce the volume of unwanted bycatch species in the catch of Norway lobster fisheries (Catchpole et al., 2006; Graham and Fryer, 2006; Loaec et al., 2006; Valentinsson and Ulmestrand, 2008; Frandsen et al., 2009; Drewery et al., 2010). Their use has been introduced by legislation in the Skagerrak and Kattegat (Valentinsson and Ulmestrand, 2008; Frandsen et al., 2009; Madsen and Valentinsson, 2010), and the grids are widely used by Swedish fishermen fishing in this area, whereas Danish fishermen use other selective devices (Madsen and Valentinsson, 2010).

Several studies reported a loss of marketable fish bycatch when grids were used in the Norway lobster fishery (Catchpole et al., 2006; Frandsen et al., 2009; Drewery et al., 2010). The fish bycatch constitutes a part of the economy in most Norway lobster fisheries, particularly flatfish species. A loss of commercial sized Norway lobster also has been identified (Frandsen et al., 2009). Thus,

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improvements of grids in order to retain commercial fish species and lobster are essential.

Some studies have focused on improving the performance of the grid (Valentinsson and Ulmestrand, 2008; Frandsen et al., 2009; Madsen et al., 2010). Results indicate that it is possible to make improvements but also that further development is necessary. In relation to increasing sustainability in the Norway lobster fishery by reducing unwanted bycatches, the upcoming discard ban and an environmental certification (e.g., Marine Stewardship Council; www.msc.org) that may be required of these fisheries. It is thus crucial to improve the grid to make it commercially feasible because of the expected increased use of grids by fishermen in the future.

The main objective of this study was to develop and test an improved grid system that is able to increase the retention of marketable fish and Norway lobster but still be highly selective to non-target species. Most previous studies have been conducted based on relative catch comparisons (Catchpole et al., 2006; Valentinsson and Ulmestrand, 2008; Drewery et al., 2010), in which results depend on the size structure of the populations that come in contact with the grid. In this study we used small meshed collecting bags to provide estimates that were population independent. By covering different parts of the grids with the collecting bags we aim at gaining information about where escape takes place. The experiments were conducted in the Kattegat and Skagerrak area, which is characterized by high discard rates (Feekings et al., 2012; Uhlmann et al., 2014) and where management plans have been made to ensure recovery of the cod stock that has been declining over the past 30 years (Madsen and Valentinsson, 2010; Kraak et al., 2013; Eliasen, 2014). During the last decade, development and implementation of selective fishing gears has been a cornerstone of fisheries management in this area (Madsen and Valentinsson, 2010).

## 2. Materials and methods

### 2.1. Grid development

The grid designs are illustrated in Fig. 1. To avoid fishermen safety issues and improve handling properties, the grids were not constructed of metal. Instead, they were made of polyurethane (Carlsen Nets, Denmark) that is very strong and able to sustain temperatures from −30 to 70 °C. This material is flexible, making it possible to wind it directly on the net drum.

To improve the performance of the grid, several changes were made compared to the grid specified by legislation and the grids tested in previous experiments (Valentinsson and Ulmestrand, 2008; Frandsen et al., 2009; Madsen and Valentinsson, 2010; Madsen et al., 2016). First, the grid colour was black to provide a potential contrast effect (Glass and Wardle, 1995; Glass et al., 1995) so that fish might react by trying to avoid the bars and swim out. Second, the bar distance was increased to 45 mm from the 35 mm required by legislation (Madsen and Valentinsson, 2010) and the 40 mm tested in previous experiments (Madsen et al., 2016). This change was aimed particularly at reducing loss of Norway lobster above minimum landing size (MLS). Third, a hole (henceforth bottom hole) was made in the lowest part of the bottom of the grid having only two bars left to guide fish away, particularly cod. The purpose of this hole was to stop benthic debris from blocking the bars in an area which is essential for the passage of Norway lobster, to allow a substantial proportion of Norway lobster to enter the codend (Madsen and Hansen, 2001) without coming into physical contact with the grid, and to let commercial important ground fish (particularly flatfish) enter the codend directly. The height of the bottom hole was increased from 15 cm in a past experiment (Madsen et al., 2016) to 17.5 cm. Two designs of the grid were constructed: one with traditional vertical bars and one with horizontal bars; the aim of the latter was to make it easier for flatfish to pass through the bars since they are of commercial importance in the Danish Norway lobster fishery (particularly plaice).

The grids were inserted at an angle of 45° in a four-panel section made of 90 mm single thread polyurethane (Fig. 2). A four-panel section was used because it is expected to be more stable than a traditional round two-panel section (Madsen et al., 2010). A wedge section inserted in front of the grid section served as the conversion to the conventional two-panel sections in front of the grid section. The vertical bars grid was tested in two different riggings: one without a guiding funnel and one with a 2 m long guiding funnel ending 70 cm in front of the grid having a vertical opening on 20 cm (Fig. 2). The advantage of using a guiding funnel is that the catch is concentrated in the lower part of the fishing gear, potentially providing a larger contact area for Norway lobster that might hit the middle or upper part of a grid (Krag et al., 2009). The disadvantage is that the funnel disrupts behavior, particularly by guiding fish downwards, and reduces the use of species-specific behavior as a selectivity tool (e.g., cod are expected to stay higher in the net than Norway lobster and flatfish).

Four 8 m long separate small meshed collecting bags made of netting with a 35 mm nominal mesh opening were inserted in the codend and attached to the grid where they were used to collect fish penetrating and escaping from the grid system (Fig. 2). The bags collected individuals escaping through: 1) the hole in the lower part of the grid; 2) the lower half of the grid; 3) the upper half of the grid; and 4) the escape hole above the grid after being rejected by the grid system.

### 2.2. Experimental work

All grid systems were tested in a flume tank (Hirtshals, Denmark) to assess performance and make adjustments before the sea trials. Approximately 20 fishermen and net markers participated in these tests to comment and discuss the performance of the systems. Measurements of the water flow inside the codend were conducted at the maximum speed for the flume tank of 0.9 m/s (1.8 knots), using an electromagnetic current flow sensor (Valeport, model 802) with a precision of flow measurements ±4%. The measurements were taken 10 cm in front of the grid and midway in the vertical direction for the hole, the lower grid and the upper grid sections (Fig. 2). Measurements were also taken 10 cm behind the grid at the same positions for the two vertical bars grids; this measurement was not taken for the horizontal bars grid because it was impossible to penetrate this grid (from above) with the flow meter. A total of 1000 measurements were taken at each position.

Experimental sea trials were conducted in March 2010 in the Kattegat and Skagerrak area from a 20 m long commercial stern trawler (vessel number: FN 234) with an engine power of 298 kW. The trawler was rigged with a twin trawl system that fishing with its own two identical trawls made for the fishery in this area that mainly targets Norway lobster, having a nominal 100 mm mesh size throughout, 460 meshes in circumference, a horizontal opening around 20 m and a headline height around 2 m. The grid with horizontal bars was fished on one side of the twin trawl system, and the other side was used for other experiments. The grid with vertical bars and the grid with vertical bars and guiding funnel were fished simultaneously in each side of the twin trawl system. For all three grid systems the side position in the twin trawl system was change midway during the sea trials.The towing time varied from around 2–4 h. This duration was on the low end compared to most commercial fisheries, but it was chosen to minimize the risk of potential blocking of the grids by debris that would obscure the selective effect of the grid and blur the results.