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Selective haddock (*Melanogrammus aeglefinus*) trawling: Avoiding cod (*Gadus morhua*) bycatch

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ABSTRACT

The critical condition of the North Sea cod stocks has resulted in restrictions on not only cod, but also haddock and other species that are caught together with cod. Thus full exploitation of the haddock stock is unachievable unless cod can be excluded from the haddock catch. We designed a selective trawl based on the behavioral differences between haddock and cod as they enter a trawl, i.e., cod stay close to the seabed whereas haddock rise above it. The trawl's fishing line is raised ~60 cm above the seabed to allow cod to escape beneath the trawl while haddock are retained. To collect the escapees, three sampling bags were attached beneath the raised fishing line. The selective haddock trawl reduced the total catch of cod by 55% during the day and 82% at night, and 99% of the marketable haddock was caught during the day and 89% at night. Cod escape rates were highly length dependent: smaller cod escaped the trawl in greater numbers than did larger individuals. Whiting, saithe, lemon sole, and plaice were included in the analysis.

1. Introduction

The majority of towed fishing today occurs in a multispecies setting, where to a large extent the trawl catch reflects the species diversity present in the trawl's path. In general, these multispecies fisheries are not able to adjust their catch composition to stock fluctuations and other management concerns. Thus, the protection of one species in a multispecies fishery can affect the exploitation of other species and reduce the total cost efficiency of the given fishery.

In recent years, North Sea cod (*Gadus morhua*) stocks have been at a critical level, in contrast to the species such as haddock (*Melanogrammus aeglefinus*), which today is classified as having full reproductive capacity and is being harvested sustainably (ICES, 2008). Since 2000, the North Sea cod stock has been in such a bad state that ICES advised the closure of all fisheries in which cod is caught (ICES, 2002). At the same time, the North Sea haddock stock was at its highest level in 30 years. Nonetheless, because haddock is taken mostly with cod, ICES advised that "Unless ways to harvest haddock without bycatch or discards of cod can be demonstrated fishing for haddock should not be permitted" (ICES, 2002). Thus, a strong biological and economic incentive exists to solve this classic mixed-species fishery problem: how can we restrict fishing on cod without restricting fishing on haddock taken in the same fishery?

Mechanical sorting of haddock and cod based on size is difficult due to the morphological similarities between the two species. Caddy and Agnew (2003) suggested that restoring both the age structure of the population and the stock biomass is an appropriate approach to rebuild groundfish (e.g., cod) stocks. They warned that focusing solely on improving juvenile survival through a supplementary mesh size increase or using minimum sizes in a recovery plan based on quotas might increase the pressure on the few remaining large and fertile spawners.

Using behavioral differences among species is another approach to address this problem. Species-specific behavioral differences exist between cod and haddock as they enter the trawl mouth: haddock rise from the seabed whereas cod maintain a position close to the seabed (Main and Sangster, 1981). Their follow-up study reported that the best separation of cod and haddock occurred when the separator panel was placed 75 cm over the seabed (Main and Sangster, 1982). Several other studies have tried to utilize this behavioral difference to separate cod and haddock and other species in demersal trawls (Main and Sangster, 1985; Galbraith and Main, 1989; Engås et al., 1998; Ferro et al., 2007). These trials demonstrated a separation by which the majority of haddock enter the top compartment and the majority of cod enter the lower compartment. In the North Sea demersal fisheries several other species, such as plaice (*Pleuronectes platessa*), lemon sole (*Microstomus kitt*),

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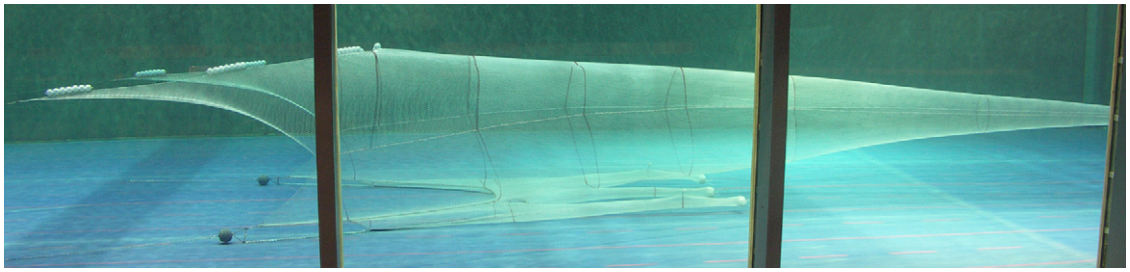

Fig. 1. Model (scale = 1:8) of the selective haddock trawl in the Hirtshals flume tank. Note the three lower collecting bags.

dab (*Limanda limanda*), witch (*Glyptocephalus cynoglossus*), monkfish (*Lophius piscatorius*), rays (*Raja* spp.), and *Nephrops* (*Nephrops norvegicus*), enter the lower part of the trawl along with cod (Main and Sangster, 1982, 1985; Ferro et al., 2007). This diverse group of species represents different sizes, morphological shapes, and minimum landing sizes (MLS), and the species therefore are difficult to separate mechanically from cod.

This study describes the development and commercial testing of a selective haddock trawl in which the fishing line is raised above the seabed. Fish and other marine organisms that pass beneath the raised fishing line escape the trawl (in contrast to separator trawls designs) with a minimum of contact with the fishing gear. During the experiment, we used small mesh collecting bags to quantify the escapement of fish beneath the raised fishing line. The consistency in the vertical separation of haddock and cod over length and between day and night was estimated. We also evaluated the gear design's commercial applicability to reduce the catch of cod in the haddock fishery.

2. Materials and methods

2.1. Flume tank experiments

Danish fishermen in the North Sea and Skagerrak typically target haddock with a high opening two-panel modified version of a Scottish haddock trawl known in Denmark as a Jackson trawl. Thus, this trawl (with 750 160 mm meshes in the fishing circle) was selected for this study and a 1:8 scale model was built and tested in the Hirtshals flume tank (Fig. 1). The fishing line was raised to the equivalent of 75 cm by a large danleno bobbin. Three collecting bags were made following the design described in Ingolfsson and Jørgensen (2006) to quantify the escapement beneath the raised fishing line. The headline height of the trawl was equal to 8 m and the spread of the upper wings to 22 m and of the lower wings to 20 m; towing speed was equal to three knots. The total width of the three collecting bags equaled about 15 m (i.e., the width of each bag, perpendicular to the towing direction, was about 5 m). A float equivalent to a 20 cm float was attached to each of the three collecting bag codends to keep them off of the bottom.

2.2. Commercial testing

A full-scale experimental trawl was built according to the scale model. The collecting bags and the main codend were constructed of 40 mm mesh size (full mesh) made of 1.4 mm nylon twine. The position to the raised fishingline relative to the colleting bags and main trawl body is illustrated in Fig. 2. Before the sea trials, a row of 20 meshes from each codend was measured with an ICES spring-loaded mesh gauge set at 4 kg. The ground gear was made of 18 cm rock hopper discs in the centre section and 13 cm rock hopper discs in the wing sections, both with 30 cm intervals. In the fisheries, heavy rock hopper gears with about 50 cm discs normally are used. The smaller rock hopper discs used in this study were chosen to minimize the escapement of fish beneath the collecting bags. It is assumed that all fish in the path of the trawl are caught. However, fishing with small discs restricts fishing to areas with a relatively smooth bottom compared to the grounds that can be fished with heavy rock hopper gears. A 53 cm bunt bobbin was connected to an 80 cm butterfly by a crowfoot made of 19 mm chain (8.5 kg/m). The false fishing line was made of a 19 mm chain (8.5 kg/m), and the raised fishing line was made of a 13 mm chain (3.8 kg/m). The trawl was rigged with 163 m sweeps and 55 m bridles and was spread with a set of Thyborøn V doors each weighing 1799 kg. The sea trails were conducted onboard the commercial vessel HM 128 *Borkumrif* (28 m and 728 kW) from 7 to 17 October 2006. Fishing was conducted in the southwestern part of the Skagerrak along *Jyske rev* (ICES area 44).

2.3. Catch measurement

Fourteen successful tows were taken the days and nights. Day tows were conducted from an hour after sunrise to an hour before sunset, and the night tows were conducted between an hour after sunset to an hour before sunrise. The towing time was 30 min at about 3 knots; the short towing time was due to the high density of fish and the small mesh size used in both the collecting bags and in the main codend. Haddock, cod, whiting, saithe, plaice, and lemon sole were collected and measured. In some hauls, haddock, whiting, and saithe were subsampled due to large catches in the main codend. A representative sample was taken by measuring 2–3 30 l baskets of whiting, 8–10 baskets of haddock, and 12–15 baskets of saithe. These numbers of baskets correspond to about 500 fish measured per species in each tow when subsampling was conducted. The weight of subsamples and the total catches of the respective species were determined and raising factors estimated. The total

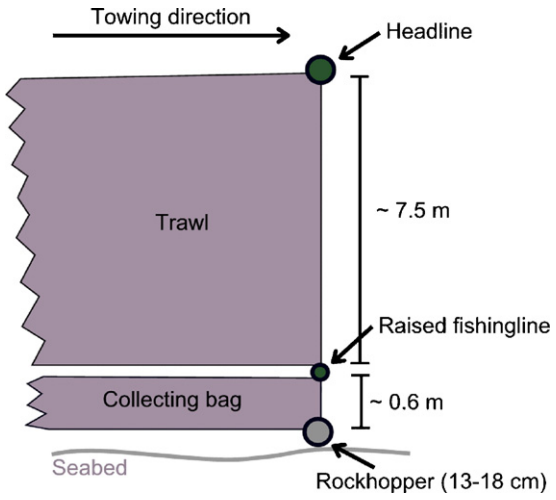

Fig. 2. Schematic side view of the collecting bags, raised fishing line and main trawl body.