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Assessment of dual selection in grid based selectivity systems

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ABSTRACT

Herein we propose a method to assess dual selection in grid based selectivity systems. This method takes into account the parameter "grid contact likelihood" (C_{grid}), which can be interpreted as the proportion of fish that actually makes an attempt to escape through the grid. In a case study of the Barents Sea cod and haddock trawl fishery, we demonstrate that our model describes the experimental data better than the models previously used to fit similar data.

For both cod and haddock, C_{grid} was significantly smaller than 1.0, which demonstrated the relevance of the proposed model. C_{grid} was higher for haddock than for cod, which might be due to behavioral differences between the species. The C_{grid} values for both species suggest that the grid functions well, as on average more than 75% of the cod and more than 94% of the haddock were predicted to able to attempt an escape through the device. For both species the contact L50 for the grid ($L50_{grid}$) was significantly higher than the L50 for the codend ($L50_{codend}$). These values agree with the experimental observations that most of the escaping fish use the grid to escape, whereas only a very few escape occurs through the codend.

By parametric simulation and using the case study results as the baseline, we investigated and compared the precision of the selectivity parameters estimated with our model for two different experimental setups. The results show that except for some extreme situations, the data for such studies need to be collected with a three-compartment setup to avoid imprecise estimates of C_{grid}, $L50_{grid}$, SR_{grid}, $L50_{codend}$, and SR_{codend}. In general, only the combined selectivity of the grid and the codend could be estimated with acceptable precision using a standard two-compartment sampling approach.

1. Introduction

As the problems with discards and juvenile overexploitation continue in many trawl fisheries around the world, in some areas, such as the northeast Atlantic, diamond mesh codends alone are seen as an insufficient size selection device by some authorities. Therefore, selection systems used in this area consist of combined selection systems whereby escapement occurs not only through the codend but also through a device installed in the codend or in a preceding section of the trawl gear. Square mesh panels installed in codends and grid + codend selection systems are combined devices in which fish are selected out of the trawl through a process of dual selection.

Traditionally, the selectivity of grid based systems has been measured as the combined selectivity of a joint grid + codend selection system (Graham et al., 2004; Grimaldo et al., 2008; Sistiaga et al., 2008). In the grid + diamond mesh codend dual selection systems legalized in the northeast Atlantic, the fraction of the fish that enter the grid section and then actually have the possibility to attempt an escape through the grid has yet to be quantified. Furthermore, no one has investigated in detail whether behavioral differences in grid escapement exist between cod (*Gadus morhua* L.) and haddock (*Melanogrammus aeglefinus* L.), which are the two main targeted species in the area. Only Kvamme and Isaksen (2004) and Jørgensen et al. (2006) have considered the dual aspect of the selection process in this combined selection device. Using a three-compartment setup similar to that shown in Fig. 1, Kvamme and Isaksen (2004) estimated separately the selectivity of a 55 mm bar spacing Sort-V sorting grid and a 135 mm diamond mesh codend. However, their selectivity analyses did not specifically consider the "grid contact likelihood" (C_{grid}). In the method proposed in this paper, C_{grid} quantifies the fraction of the fish entering the gear that actually comes into contact with the grid and attempts to escape through it. Kvamme and Isaksen (2004) estimated what could be interpreted as "available selectivity" of the grid, whereby an actual contact lower than 100% (not all fish attempt escaping through the grid) would be reflected in the estimated $L50_{grid}$ and SR_{grid} values (L50 is the length at which a fish has a 50% chance of bring retained by the gear, whereas SR is the difference between L75 and L25).

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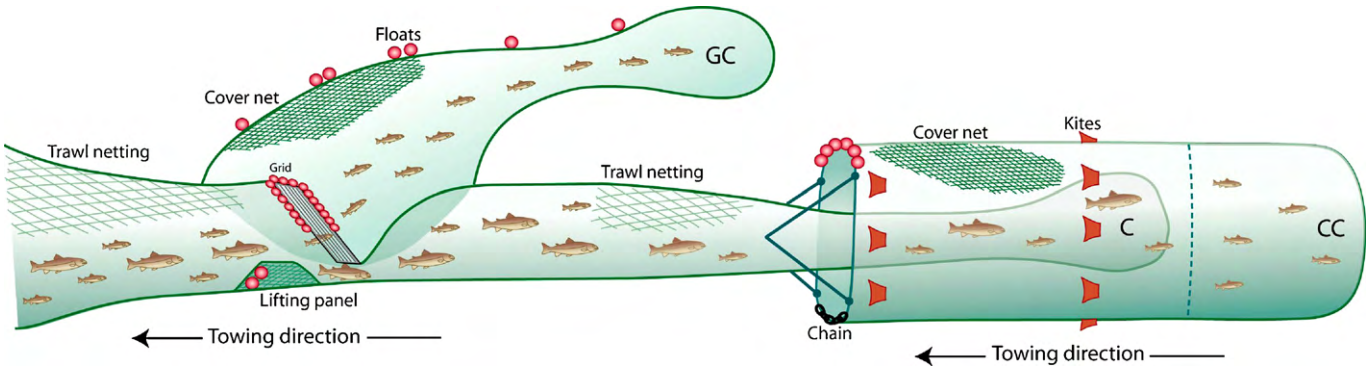

Fig. 1. Grid + codend setup with the covers used onboard the R/V Jan Mayen in March 2009. GC: grid cover; C: codend; and CC: codend cover.

In contrast, an estimation of $L50_{grid}$ and SR_{grid} based solely on the fish that actually did come into contact with the grid would result in the estimation of the "contact selectivity" for the grid. The distinction between "available selection" and "contact selection" was introduced by Millar and Fryer (1999). The estimation of "contact selectivity" for the grid requires a model that explicitly includes the estimation of C_{grid} in addition to $L50_{grid}$ and SR_{grid}.

Explicit quantification of C_{grid} is important because it can determine the future plan of action for the improvement of the performance of the grid. For a fish to escape through the grid, two conditions must be fulfilled: First, the fish needs to come into contact with the grid and second, it should be able to physically pass through the grid. Unsatisfactory selectivity results with a low C_{grid} would indicate a malfunction or design problem of the gear whereby few fish are coming into contact with the grid. Problems with the lifting panel (see Fig. 1), a too small grid area, or an incorrect grid angle of attack could create such a situation. Also, very high entry rates of fish could prevent some of them from coming into contact with the grid. On the other hand, unsatisfactory selectivity results with a high C_{grid} would indicate that the gear is working properly but the characteristics of the grid (e.g., grid bar spacing) need to be changed to improve selectivity.

In this study we present a model that explicitly includes the estimation of C_{grid} together with $L50_{grid}$, SR_{grid}, $L50_{codend}$, and SR_{codend}. This model is of similar structure to that proposed by Zuur et al. (2001). Zuur et al. (2001) collected selectivity data for a dual selection system composed of a square mesh panel and a diamond mesh codend using a three-compartment data collection setup. They evaluated the effectiveness of the selection panel, which was installed in a section of the trawl preceding the codend, and developed a model to separately estimate the selectivity of both the square mesh panel and the codend. O'Neill et al. (2006) also attempted to quantify separately the selectivity of a codend and a square mesh panel following Zuur et al.'s (2001) model but using a two-compartment setup for the data collection. Using a two-compartment approach reduces considerably the complexity of the sampling setup. This study opens up the debate on whether using a three-compartment setup to collect dual selection data is necessary or not.

The aim of the present study was to propose and investigate a method for the estimation of selectivity parameters of grid based dual selection systems. In this study, we directly compare our model to other models that did not include C_{grid} and were previously implemented for similar data analyses. Using parametric simulation and a case study from the Barents Sea cod and haddock trawl fishery as the baseline, we studied the precision of C_{grid}, $L50_{grid}$, SR_{grid}, $L50_{codend}$, and SR_{codend} estimates when the selectivity data were collected by a two-compartment sampling setup. The importance of using a three-compartment setup then was evaluated. Finally, we also investigated the effect of the number of fish measured per haul and the difference between $L50_{grid}$ and $L50_{codend}$ on the precision of C_{grid}, $L50_{grid}$, SR_{grid}, $L50_{codend}$, and SR_{codend} estimates.

2. Materials and methods

2.1. Sea trials and data collection

The data collection for the present investigation was conducted onboard the R/V Jan Mayen (63.8 m LOA and 4080 HP) between 10 and 19 March 2009 off the coast of northern Norway. The fishing gear utilized during the trials at sea consisted of two injector scorpion (3100 kg and 8.0 m^2 each) otter boards, an 88.7 m ground gear, and an Alfredo nr 5 trawl. The otter boards were attached to the ground gear by 80 m sweeps and 16.5 m double bridles (butterfly rig). The ground gear was composed of 14 steel bobbins (24 in.; 61 cm diameter) and a 21.3 m rockhopper built from 3×33 rubber discs (21 in.; 53 cm diameter). The trawl had a headline of 38 m and a fishing line of 21 m and was constructed of 4 mm PE twine. At the trawling speed employed in this cruise, which oscillated between 3.5 and 4 knots, the average headline height was around 4 m. The entire trawl, except for the top front panel and the wings that were built from 200 mm mesh, was built from 155 mm diamond mesh. Prior to the codend we installed a Sort-V sorting grid section with a 55 mm bar spacing grid mounted on it. The grid is fixed to the netting section so that its angle of attack remains as close as possible to 25–26°, which is considered optimal for its selectivity. During the cruise we alternated two different codends of 135.2 ± 2.6 mm and 140.7 ± 2.8 mm (mean $\pm$ standard deviation) built from 8.0 mm single Euroline premium twine. Both codends were 70 meshes long and had 70 meshes around and two selvedges. The cover (CC) installed over the codend (C) was identical to that used by Sistiaga et al. (2009) during cruises 1 and 2 of their investigation. The top cover (GC) installed over the grid was of the same design as that used by Larsen and Isaksen (1993) (Fig. 1). GC was constructed of 48 mm diamond meshes while CC was constructed of 60 mm square meshes.

All of the cod and haddock greater than 30 cm long collected in each of the three compartments (C, CC, and GC) were measured to the nearest centimeter below. There was no subsampling. All saithe (*Pollachius virens* L.) and redfish (*Sebastes marinus* L.) captured were weighed.

As two different gear setups were tested and data were collected for two different species, the final dataset from the sea trials included four different study cases: "cod grid + 135 mm codend", "cod grid + 140 mm codend", "haddock grid + 135 mm codend" and "haddock grid + 140 mm codend".