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Improving catch efficiency by changing ground gear design: Case study of Northeast Atlantic cod (*Gadus morhua*) in the Barents Sea bottom trawl fishery

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ABSTRACT

The aim of this study was to determine if catch efficiency for cod (*Gadus morhua* L.) in the Barents Sea bottom trawl fishery could be improved by replacing the conventional rockhopper ground gear with a new type of ground gear called semicircular spreading gear (SCSG). Based on experimental fishing conducted in 2014 and 2015, we quantified the escape rate of cod beneath the fishing line of the trawl for each of the two ground gears and thereby obtained a measure for the ground gears' catching efficiency. Fish escapees were collected in a retainer bag attached to the fishing line of the trawl and behind the ground gear, and its catches were compared with those in the trawl codend. A significant improvement in the catch efficiency was found for the SCSG relative to the rockhopper gear for cod between 56 and 105 cm, as significantly fewer cod escaped under the trawl equipped with the new ground gear. The results demonstrated that ground gear efficiency was length dependent for both ground gear types, as both showed increasing efficiency with increased fish length. The average catch efficiency for cod above 56 cm increased 9.19%–22.4% (depending on the herding efficiency) with the SCSG compared to the rockhopper, which corresponds to a reduction in the escape rate of 57.1%–61.73% (depending on the herding efficiency). This study demonstrates that improved catch efficiency can be obtained by substituting the conventional rockhopper gear with the newly developed SCSG without increasing trawl dimensions.

1. Introduction

Although research in recent decades has led to improved size- and species-selective properties of bottom trawling (Walsh et al., 2002), less focus has been placed on improving catch performance and gear efficiency without making the trawls bigger and heavier. The tendency in the trawling fleet has been to increase the length of the footrope and ground gear to improve catch performance. However, ground gear enlargements and the total increase in weight have led to subsequent enlargements of the net and otter boards to balance the forces, resulting in increased towing resistance. This results in more fuel consumed per hour of trawling as well as increased impact on the seabed fauna. Previous investigations have pointed out that the rate of escape underneath the trawl's fishing line can be high (Main and Sangster, 1981; Engås and Godø, 1989; Godø and Walsh, 1992; Ingólfsson and Jørgensen, 2006). We believe that any reduction in the escape of legal size target species beneath the trawl could be a more favorable way to improve catch performance without enlarging various trawl components with the subsequent negative effects mentioned above.

The herding process of fish into a trawl starts at the otter boards and proceeds to the sweeps, resulting in fish being aggregated in front of the trawl mouth (Winger et al., 2010). Once fish are herded in front of the trawl mouth they alter their swimming direction in an attempt to maintain a constant position in front of the trawl (often described as an optomotoric response) (Wardle, 1993). The behavior of fish in front of the trawl mouth, which influences the capture efficiency, is species dependent (Engås and Godø, 1989; Ingólfsson and Jørgensen, 2006; Winger et al., 2010). Cod (*Gadus morhua* L.) herded in front of the trawl tend to seek an escape route close to the seabed under the fishing line and between the rockhopper discs, and this process is shown to be size dependent (Engås and Godø, 1989; Ingólfsson and Jørgensen, 2006; Winger et al., 2010). The size of space is the same for small and large fish. But relative,

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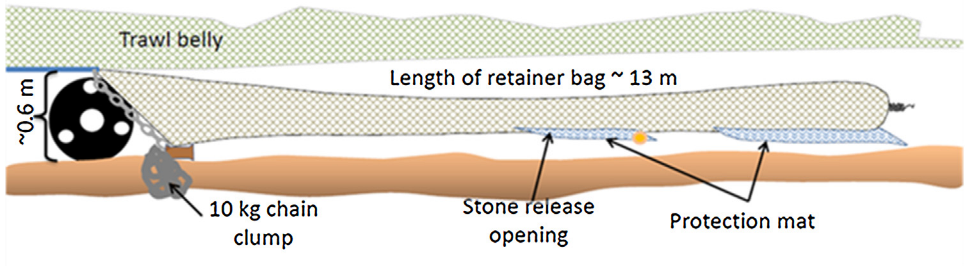

Fig. 1. Sketch of the retainer bag mounted under the trawl for catching the escapees.

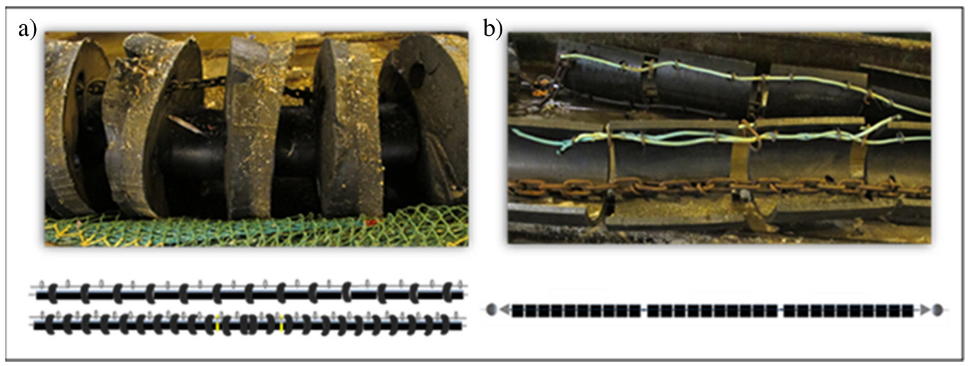

Fig. 2. Photo and sketch of the rockhopper gear (a) and the new semicircular spreading gear (SCSG) (b).

small fish has larger space: Logically, smaller fish have more space to escape between the discs of the rockhopper gear than larger fish. However, fish escaping underneath the fishing line frequently incur injuries in the form of external scrape marks and internal ecchymosis (Ingólfsson and Jørgensen, 2006), which likely lead to increased mortality due to behavioral impairment, increased risk of predation, and disease susceptibility (Chopin and Arimoto, 1995; Ryer, 2004). Although Engås and Godø (1989) reported a reduction in escapement after the transition from steel bobbins gear to the rockhopper gear, escape rates of 33% underneath the rockhopper gear have been documented for cod (Ingólfsson and Jørgensen, 2006). To our knowledge, no solution has been presented to reduce the evident escapement underneath the rockhopper gear. Although several other ground gear types exist besides the rockhopper gear, none of these withstands the hard and rocky seabed encountered in many areas.

The main objective of this study was to compare the catch efficiency of the widely used rockhopper gear to that of a new type of ground gear called semicircular spreading gear (SCSG). The SCSG was developed by SINTEF Fisheries and Aquaculture and is assumed to be equal to or better than the conventional rockhopper gear in terms of catch and trawl performance (Grimaldo et al., 2014). However, the rate of escape underneath the fishing line has not yet been documented. Therefore, the specific goals of this study were to answer the following research questions:

- How many cod swimming in front of the trawl escape underneath the fishing line and is this escape length dependent?
- Is there any significant difference in the catch efficiency (i.e., escape rate) between the rockhopper gear and the SCSG?
- Is there any difference in the escape rate between different seasons and areas for these ground gears?
- Does diurnal variability influence the escape rate underneath the fishing line?

2. Materials and methods

2.1. Experimental design and sea trials

To quantify the overall efficiency of the trawl and the fish escape rate under it, retainer bags (Engås and Godø, 1989; Ingólfsson and Jørgensen, 2006; Krag et al., 2010) were mounted under the trawl to enable us to sample the fish escaping under the fishing line and to compare this catch with the catch retained in the codend (Fig. 1).

This experimental procedure was applied during two different sea trials conducted onboard the R/V “Helmer Hanssen” (63.8 m, and 4080 HP). The first cruise (Cruise 1) was conducted in the central Barents Sea on the fishing grounds east of Hopen Island (N 75°59′–74°41′; E 37°47′–27°13′) from 17 to 24 November 2014. The second cruise (Cruise 2) was executed in the southeastern Barents Sea in the southern part of Nordbanken (N 70°50′–70°45′; E 31°05′–30°43′) from 17 to 27 February 2015. The technical trawl setup of otter boards and sweeps differed somewhat between the two cruises. Specifically, the setup during the first cruise consisted of a pair of semi-pelagic Injector XF9 high aspect otter boards (each 7 m^2, weighing 2200 kg) followed by 15.9 m long backstraps that were connected to the sweeps by a 12 m long Ø19 mm connector chain. The sweeps were 60 m long, resulting in a sweep angle of approximately 30°, and divided in the middle by a Ø19 mm chain for attaching chain clumps (450 kg each) to ensure proper bottom contact of the ground gear (Fig. 3). During the second cruise, we used a pair of Injector bottom trawl otter boards (each 7.5 m^2, weighing 2800 kg) followed by 3 m long backstraps that were connected to the sweeps by a 7 m long Ø19 mm connector chain. The chain clumps in the middle of the 60 m long sweeps were replaced by a Ø53.3 cm steel bobbin.

The rest of the trawl setup was the same for the two cruises. The 46 m long ground gear consisted of a 14 m long Ø19 mm chain equipped with four steel bobbins (Ø53.3 cm) on each side and a 18.9 m long ground gear along the footrope. The ground gear was either a standard rockhopper (Ø53.3 cm) or a SCSG (Ø50.8 cm). The