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Short Communication

Development of catch control devices in the Barents Sea cod fishery

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ABSTRACT

Four catch control devices were tested in the Barents Sea cod fishery. Three of the devices were codends that close and partially detach from the rest of the trawl when they have filled up with the desired amount of fish. Each of these three systems had a different release mechanism (based on an acoustic releaser or a weak link). The fourth prototype was a codend with two side splits along the gear in the N-direction. For each prototype, the simplicity of the device, its cost, and its operational reliability in securing the desired catch size while releasing excess fish at fishing depth were evaluated.

1. Introduction

In recent years, the cod (*Gadus morhua*) fishery in the Barents Sea has shown exceptionally high stock levels that have led to large quota allocations for fishing vessels. These vessels are factory vessels that fish very efficiently when the availability of fish is high. In this scenario, trawl hauls often exceed the production capacity of the vessels (i.e., 50 tons of fish in just a few minutes of towing). High densities of fish mean that large quantities of fish can enter the trawl within minutes, and this process is difficult to control even with electronic monitoring sensors attached to the trawl. Large catches sometimes result in poor quality of the catch and burst codends, as well health, safety, and environment issues (Fig. 1).

A limited number of studies have focused on developing catch control devices for trawls. For example, Goudey and Randazzo (2001) and Pol and Chosid (2012) developed the stretch-mesh concept and the self-closing codend, respectively, to reduce the waste of resources associated with regulatory discards in the New England groundfishery. Icelandic trawlers occasionally use zipper lines in the upper panel of the extension piece in mackerel trawls to prevent the occurrence of unwanted big catches (pers. comm., H. Einarsson, Institute of Marine Research, Iceland). These zipper lines break and unzip when the codend fills up. Several prototypes of catch control devices have been tested in the Norwegian ground fishery in the last two years as discussed at the Working Group on Fishing Technology and Fish Behavior of the International Council for the Exploration of the Sea in May 2013 (ICES, 2013), including: (1) semi-detachable codends; (2) thin twine that breaks due to drag of the catch or expansion of the codend; (3) side splits along the gear in the N-direction in the foremost part of the codend; (4) large meshes that open as the codend fills up; (5) a motorized gate that opens upon a signal from an operator so that excess fish are guided out of the trawl; and (6) a hatch in the upper panel of the codend that opens when the codend fills up. This last device is based on a hole in the upper panel of the codend that is covered with a rubber flap. The flap stays closed until the flow dynamic in the swelling codend opens the flap and releases the excess fish. Although some of these devices have been shown to be very effective at controlling catch size, fishermen are still not allowed to use any of them in the Barents Sea cod fishery at present.

This paper describes in detail the development and functioning of some of the devices described above that were developed by the authors. Important features that were taken into account when evaluating these devices include the simplicity of the device, the equipment cost, and the operational reliability in securing the desired catch size while gently releasing the excess of fish at fishing depth.

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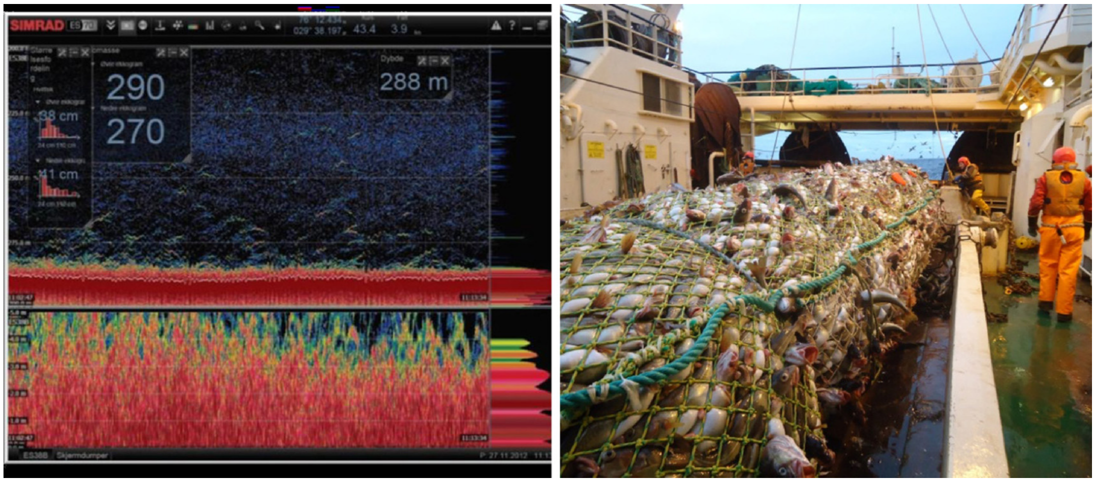

Fig. 1. A photograph that illustrates the screen of an echo sounder with the 5-m expansion zone showing dense registration of cod (left) and a codend with the resulting catch after a 10-min tow (right).

2. Materials and methods

Four different catch control devices were designed, fabricated and tested: three devices with semi-detachable codends and one device based on two splits cut in the N-direction in the foremost part of the codend. The working principle of the semi-detachable codends was based on a codend that partially detached from the extension piece after a certain (desired) catch level was reached. In this system, once the codend was detached from the extension piece, the fish that remained inside the trawl had the chance to escape unharmed at the fishing depth. Information about when the codend was full, closed, and detached was provided by Scanmar catch sensors mounted on the codend (Fig. 2A). Once the sensor indicated that the codend was full to the desired limit, and it had detached, the retrieving process could begin. The working principle of the codend with the side splits was based on side openings (10 meshes in the N-direction) that progressively opened as the catch accumulated and the codend swelled (Fig. 2B). Scanmar sensors were used in the same way as for the semi-detachable codend.

2.1. Semi-detachable codend prototypes

Three semi-detachable codend prototypes were developed, each with a different release mechanism:

(1) In the first prototype (Fig. 3A), an acoustic signal was sent to an acoustic releaser that released a 1 m^2 sea anchor. Due to the hydrodynamic force created by the towing of the vessel, the sea anchor pulled on an 8 mm nylon rope that laced together the codend and the extension piece. When the codend was detached, two 16 mm spectra ropes that were braided around the codend mouth closed it immediately as it fell backwards. The codend then hanged closed from the two spectra ropes (Fig. 2A). A similar technique for detaching the codend from the extension piece was shown by Soldal and Engås (1997). Initial small-scale testing of this prototype was performed in a flume tank (Hirtshals, Denmark) in April 2011 with an IXSEA acoustic releaser (Model: OCEANO 2500 Universal Acoustic Release, IXSEA Ltd., UK).

(2) The second prototype combined the use of an acoustic releaser, two supporting ropes that held the tension of the selvedges, and a piece of thin (Ø 1.8 mm) PE twine. The thin twine was braided around the whole circumference of the gear between the extension piece and the codend so that it held them together (Fig. 3B). When the catch sensors indicated that the desired catch size had been reached, an acoustic signal was manually sent to the acoustic releaser, which released the supporting ropes. Once these ropes were released, the load of the codend was transferred to the thin PE twine. Because the load exceeded the breaking force of the thin twine, the codend was released from the extension piece. As the detached codend fell backwards, two 16 mm spectra ropes closed it immediately. The codend then hanged closed from the spectra ropes.

(3) The third prototype used two pieces of thin (Ø 1.8 mm) PE twine as the release mechanism (i.e., a weak link) (Fig. 3C). In this prototype, the codend was attached to the extension piece by only two thin twines (one per selvedge) that linked together the selvedges of the extension piece with the selvedges of the codend. An even thinner twine (Ø 1.2 mm) was braided between the extension piece and the codend to ensure that the hydrodynamic forces in the gear did not create gaps in the gear. When the codend was loaded and the breaking strength of the twines in the selvedges was reached, the weak link broke and released the codend from the extension piece. The twine braided between the extension piece and the codend broke easily, as its breaking strength was lower than that of the weak links in the selvedges. As the detached codend fell backwards, two 16 mm spectra ropes closed it immediately. The codend then hanged closed from the spectra ropes.

All three prototypes had three free meshes in the aft part of the extension piece that acted as a skirt and guaranteed that no gaps were created between the two pieces of the gear during the fishing process (see Fig. 3A–C).

2.2. Non-detachable codend prototype

In this prototype, the catch control mechanism was based on modifications in the codend. The modifications consisted of two side cuts along the codend in the N-direction and a funnel installed inside the codend just after the cuts (Fig. 3D). The function of the side cuts was to release excess fish once the codend was full, whereas the function of the funnel was to prevent the fish that had already entered the codend from moving forward and escaping through the side openings. The position of the funnel and the cuts can be adjusted depending on the catch volume desired. In this prototype, we cut 10 meshes on each side of the codend, and the funnel was placed 2 meshes behind the cuts. To keep the cuts from opening too much before the codend was full, an 8 mm nylon rope that ended in a 20.3 cm diameter float was braided through the cuts

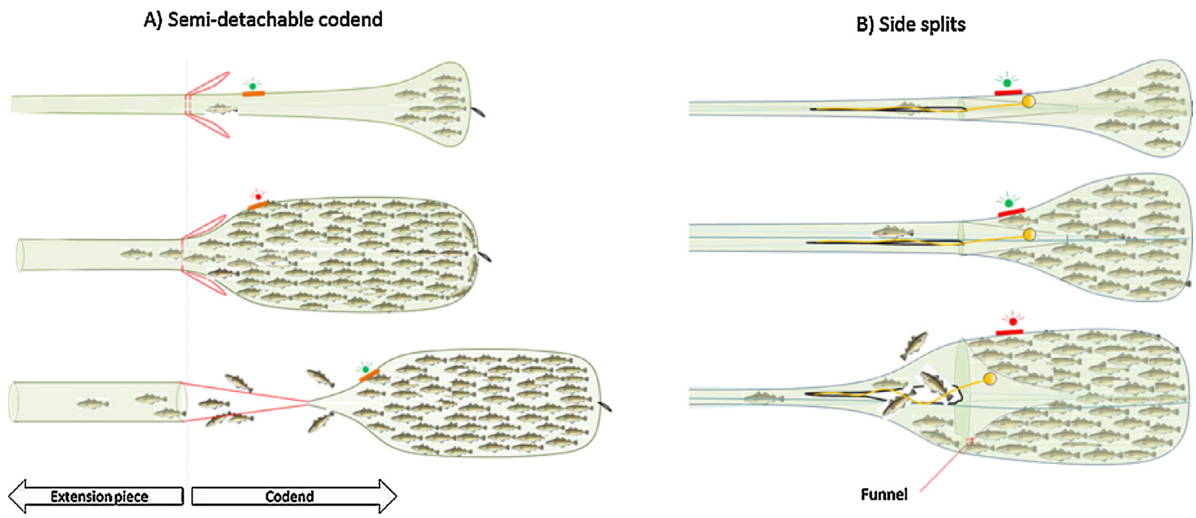

Fig. 2. Schematic representation of the working principle of a semi-detachable codend (A) and the codend with side splits (B). Note that Scanmar catch sensors were used to identify when the codend was full (and closed and detached in the case of the semi-detachable codend) so that the haul back operation could be started. In the figure, the sensor is green when the codend is empty, red when it is full, and green again when it is detached. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

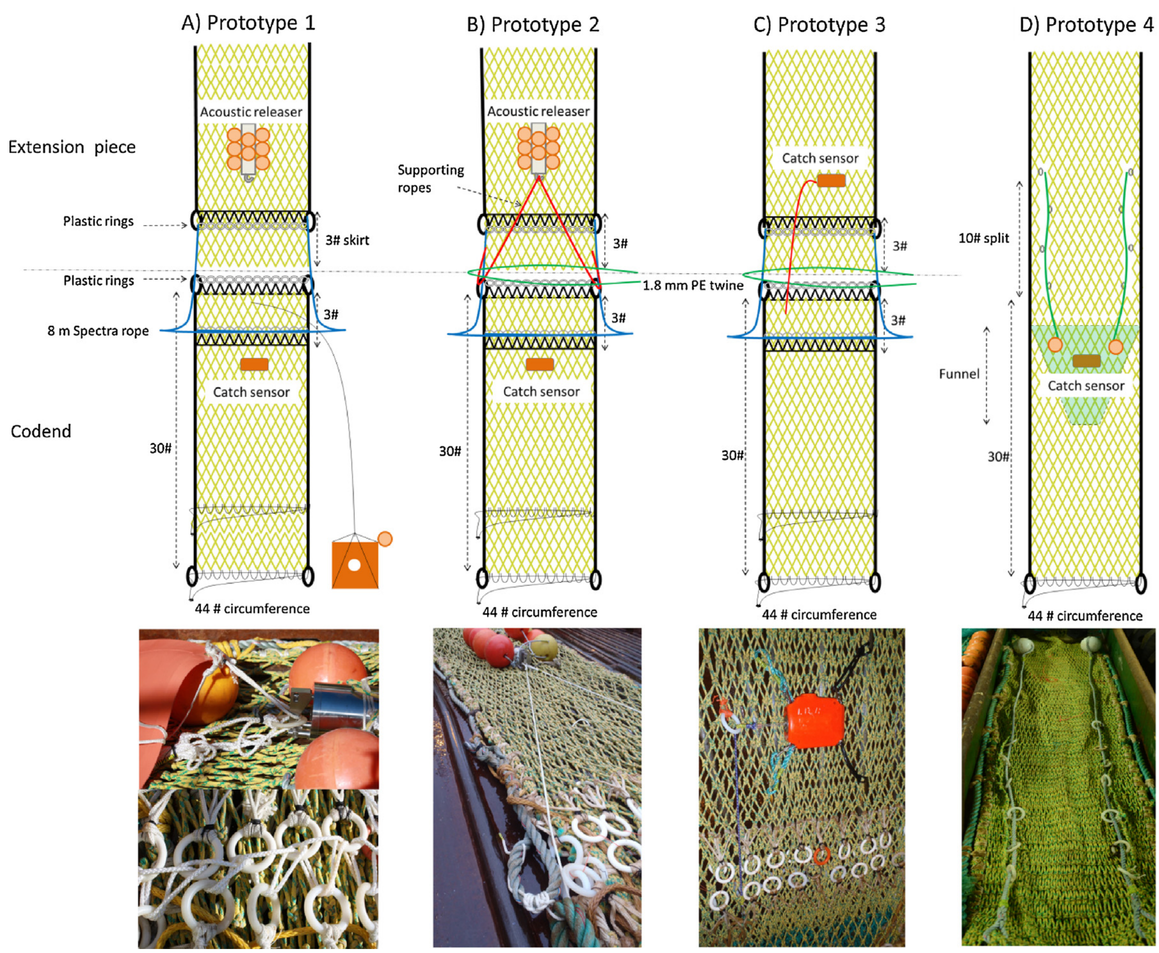

Fig. 3. Illustrations of the four prototypes tested at sea.

(see Fig. 3D). Using underwater recordings, we confirmed that the pulling force of the float was enough to keep the splits closed until the catch bulk reached the position of the funnel and the expanding force of the bulk opened the splits to release the excess fish.

Full-scale experiments using the semi-detachable prototypes were performed on board the R/V Helmer Hansen (63.8 m LOA and 4080 BHP) from May 12 to 19, 2011 and from March 5 to 12, 2012. The trials to test the side split prototype were carried out from February 27 to March 10, 2013. The fishing areas for all experiments were off the coast of Finnmark, northern Norway. The main objective of these cruises was to conduct controlled tests in commercial fishing grounds using commercial equipment. For these

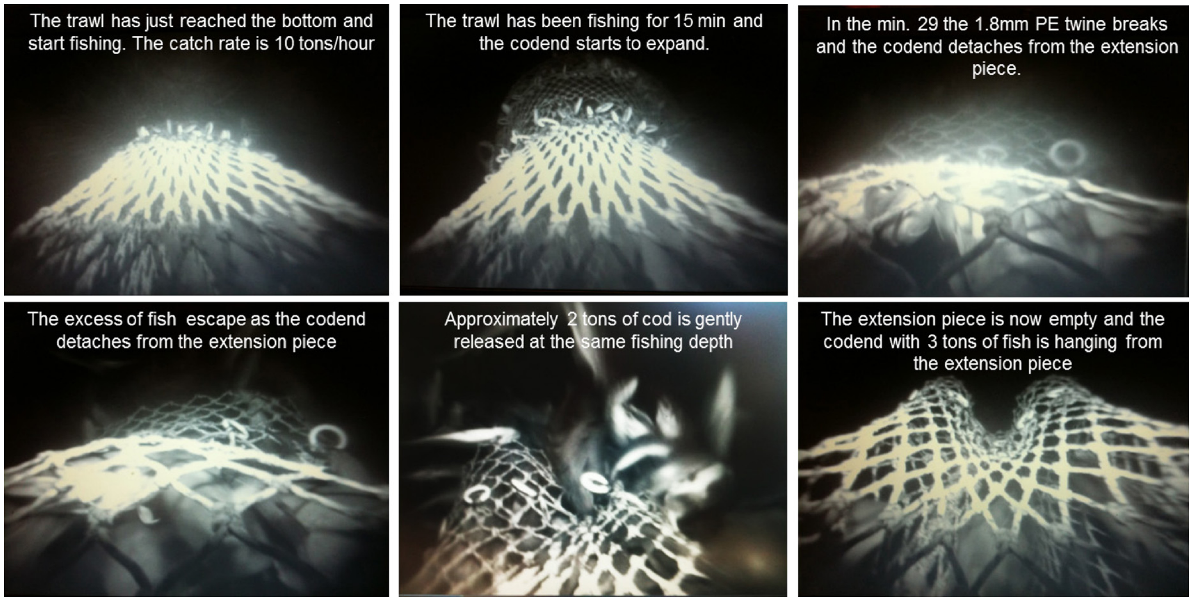

Fig. 4. Sequence of underwater photographs showing prototype 3 (weak link) during the detaching process.

Fig. 5. Photographs showing a semi-detached codend (left) and a codend with side splits (right) being hauled on board the fishing vessel.

experiments, we used a standard ALFREDO 5 bottom trawl that had a headline of 37.7 m, a fishing line of 21.3 m, and a circumference of 342 meshes at the trawl mouth with 155 mm nominal mesh size. The 88.7 m long groundgear consisted of 14 steel bobbins (61 cm in diameter) and a 21.3 m long rockhopper with rubber disks 53 cm in diameter. All four codends were built using 8 mm single twine Euroline premium PE netting (Polar Gold) with 135 mm nominal mesh size. The codends had a circumference of 46 meshes and were 30 meshes long, but they could be shortened to 23 meshes in length if desired in order to restrict the catch from 3 to 2 tons, which was the capacity of the 30 and 23 mesh codends, respectively. The extension piece was built using the same PE netting material and was 23 meshes long. In prototypes 1 and 2 (Fig. 3A and B), an IXSEA acoustic control unit (model TT801) connected to an IXSEA portable transducer (model: OITT801-30P, IXSEA Ltd., UK) was used to transmit the signal from the vessel to the acoustic releaser mounted on the extension piece. Once the acoustic releaser responded to the signal, the control unit display gave confirmation that the acoustic releaser had unlocked. Information about when to send the acoustic signal to detach the codend was obtained from the Scanmar catch sensors. We used a high definition enhanced low light underwater camera (Model: Kongsberg oe14-110, Kongsberg Marine AS, Norway) fixed to the codend top panel to make underwater observations of the codend's detaching process and to study the reaction of the fish to this process.

3. Results

Thirty-five hauls were conducted during the three cruises: 13 hauls were performed with the acoustic releaser (11 with prototype 1 and 2 with prototype 2) in May 2011; 16 hauls were conducted using prototype 3 in March 2012; and 6 hauls were carried out with prototype 4 in March 2013. The acoustic releaser malfunctioned in four hauls. The connectivity between the double communication link (sender and receiver) failed and therefore did not release the sea anchor to detach the codend from the extension piece. In the remaining nine hauls the acoustic releaser effectively activated the release mechanism and detached the codend from the extension piece. The catch control device based on a weak link (prototype 3) and that with side splits (prototype 4) functioned as expected in all cases. Underwater observations confirmed the successful operation of all prototypes and showed the gradual release of excess fish at fishing depth before haul back began (Figs. 4 and 5).

4. Discussion

Operationally, prototypes 1 and 2 effectively detached the codend from the extension piece when the acoustic signal was received by the acoustic releaser. However, the use of the IXSEA portable transducer required two people, one to deploy a wing with the transducer at sea (either manually or using a crane) and another to operate the acoustic control unit. In addition, the acoustic releaser occasionally required more than one attempt to activate the release mechanism to detach the codend from the extension piece. The function of the acoustic signal was likely affected by the propeller's wake, turbulence, or wave action when towing at 3 knots. Furthermore, the detachment process of the codend took up to 30 s. Ideally, this process should be immediate; otherwise there is a risk of losing fish from the codend. When considering the handling characteristics of the acoustic release-based prototypes, the process of re-connecting the codend to the extension piece took too long (~10–15 min) to be accepted by the commercial fleet. Moreover, the process of re-connecting required special attention in order to avoid incorrect connection or entangling as reported by fishermen. Furthermore, for prototype 1, the manual recovery of the 1 m^2 sea anchor was a demanding task when the boat was still moving, especially under adverse sea conditions.

Prototype 3 (weak link) worked well and the codend effectively detached with catches of 2 or 3 tons. Underwater recordings showed that the codend closed immediately after detaching from the extension piece. On deck, the process of resetting the codend was fast and unproblematic, and there was virtually no risk of incorrect connection or masking. However, determining the corresponding twine thickness (strength) for different catch sizes may prove to be difficult. Furthermore, pulsing movements of the gear created by waves and vessel motion make it difficult to establish the correct relationship between twine thickness and desired catch amount.

Although only six hauls were conducted using prototype 4, in all cases it efficiently released excess fish after the codend had filled up. Underwater observation showed fish escaping immediately after coming in contact with the side splits. This codend was also the easiest to work with on deck because it did not require any attention or adjustment between hauls.

5. Conclusions

The acoustic releaser technique works well but requires a lot of attention and additional time to attach the codend to the extension piece between each haul. It also requires more than one person to operate the control unit and the portable transducer. Finally, it is an expensive solution, as an acoustic releaser costs about 10,000 US dollars. The weak link technique is much simpler and cheaper than the acoustic releaser technique, but fishermen are still reluctant to use it because of the additional time needed to attach the codend to the extension piece. The side split prototype works very well, and it is a simple and cheap solution; once installed it does not require any attention between hauls.

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