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Floated cod pots with one entrance reduce probability of escape and increase catch rates compared with pots with two entrances

Terje Jørgensen[a], Svein Løkkeborg[a,*], Dag Furevik[a], Odd-Børre Humborstad[a], Francesco De Carlo[b]

[a] Institute of Marine Research, P.O. Box 1870, NO-5817 Bergen, Norway
[b] Aplysia Soc. Coop. r.l., via Menichetti 35, 57121 Livorno, Italy

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ABSTRACT

The development of low impact and fuel efficient (LIFE) fishing is being paid growing attention. Pot fishing has lower environmental impact and fuel consumption than most other fishing methods. However, pots typically have low capture efficiency for most ground-fish species, and efforts to develop effective commercial pots are needed. Bycatch of red king crab (*Paralithodes camtschaticus*) is a severe problem in the coastal fishery for cod (*Gadus morhua*) in the Barents Sea. In a previous publication, we demonstrated that cod pots floated off the bottom eliminated this problem. Our original bottom-set cod pot has two entrances in order to increase the rate of entry of fish, but when this pot is floated, fish that search for food by following chemical cues up-current will only encounter the entrance that is oriented down-current. We therefore compared the catch rates of floated pots with one and two entrances, and predicted that the new design with only one entrance would achieve higher catch rates due to a lower rate of escape. Pots with one entrance caught significantly more cod and haddock (*Melanogrammus aeglefinus*) than pots with two entrances. The catch rate of cod above minimum landing size (≥44 cm) of pots with one entrance was 82% higher than that of pots with two entrances. Pots that were snagged and did not float properly caught large numbers of king crab. The larger catches of pots with one entrance could be explained by lower escape rate from this design. The observed difference in catch rates between the two pot types indicates that more than 50% of the large cod and haddock that entered the pot with two entrances escaped. There is therefore great potential for increased catching efficiency of pots through improved pot design.

1. Introduction

Both fishery management authorities and consumers are becoming increasingly concerned about the impact of commercial fishing on marine and atmospheric ecosystems. As a result, the development of low impact and fuel efficient (LIFE) fishing is gradually receiving more attention (Suuronen et al., 2012). Fishing practices and gears vary widely in their environmental impacts and fuel efficiency, but generally speaking, the impacts of passive gears such as pots, traps and longlines are considered to be less severe and fuel consumption is lower than for towed gears (Jennings and Kaiser, 1998). In particular, pots possess several appealing characteristics such as low energy use, minimal habitat impact, low bycatch and high catch quality (Thomsen et al., 2010), and are thus classified as LIFE fishing gear (Suuronen et al., 2012).

Pots have been shown to be a financially viable fishing method for Pacific cod (*Gadus macrocephalus*) and sablefish (*Anoplopoma fimbria*) in the Gulf of Alaska and the Bering Sea (Thomsen et al., 2010). However, pots typically have relatively low capture efficiency for most ground-fish species. In the north Atlantic, for example, the use of pots in the fisheries that target finfish is negligible. Thus efforts are being made to improve the catching efficiency of pots for cod (*Gadus morhua*) in order to stimulate the use of pots and encourage a shift towards a more sustainable fishery in this region (Bryhn et al., 2014; Furevik et al., 2008; Königson et al., 2015; Ovegård et al., 2011; Thomsen et al., 2010).

Such efforts to develop effective commercial cod pots have been carried out mainly in the Baltic Sea and along the coast of northern Norway. The traditional cod fisheries in these two coastal areas are facing bycatch problems that are being attempted to be solved through the introduction of pots as a sustainable alternative fish-

* Corresponding author.
E-mail address: svein.lokkeborg@imr.no (S. Løkkeborg).

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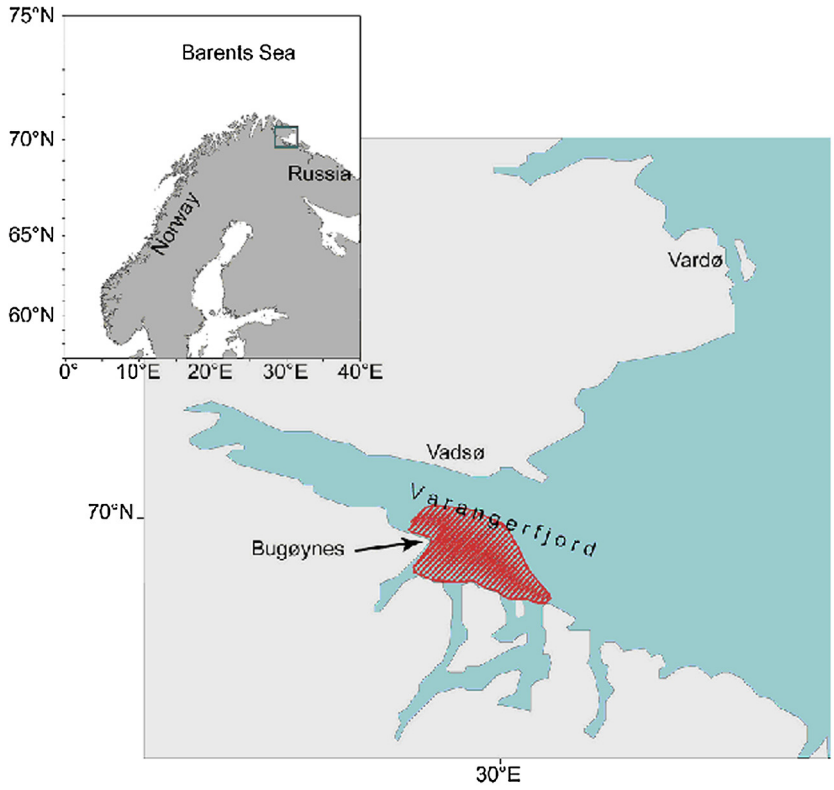

Fig. 1. The area in the Varangerfjord where the pots were set.

ing method. Interactions between seals and the gillnet and longline fisheries for cod along the Swedish west coast and in the Baltic Sea have increased rapidly during the past two decades, and fishermen are experiencing severe seal-inflicted damage to fishing gear and catch losses (Königson et al., 2009; Westerberg et al., 2006). Pots have been suggested as an alternative seal-proof fishing method that encloses the caught fish in a chamber, which makes it much harder for the seals to get at the fish than when gillnets and longlines are used (Königson et al., 2015; Ovegård et al., 2011).

The red king crab (*Paralithodes camtschaticus*) was introduced in the Barents Sea in the 1960s and is now abundant along the Norwegian coast of Finnmark. Bycatch of king crab causes severe problems for the coastal vessels that use stationary gear, especially for the gillnet fishery targeting cod, where large bycatches cause extra work load, damage to gear and reduced catches (Godøy et al., 2003). Pots are an efficient gear also for catching crabs, and using cod pots as an alternative gear may therefore lead to crab bycatches and similar problems. However, in a previous work we have shown that floating cod pots off the bottom successfully eliminates bycatches of king crab (Furevik et al., 2008).

Furthermore, the floated pots were shown to result in a significantly higher catch rate of cod than bottom-set pots. Cod have been shown to swim up-current when approaching a baited gear (Løkkeborg, 1998; Løkkeborg and Fernö, 1999), and the catch increase was explained by the orientation of the two pot designs. A floated pot turns with the current, and this innovative design ensures that one of its two entrances always faces down-current, whereas a pot set on the bottom maintains its orientation when the current changes direction.

The original bottom-set pot had two entrances in order to increase the rate of entry of fish. When floated off the bottom, however, the entrance maintaining an up-current orientation is unlikely to increase the rate of entry. Therefore, we compared the catch rates of floated pots with one and two entrances, respectively. We predicted that the likelihood of fish entering these two pot designs would be equal, but that the new design with only one entrance would have a lower escape rate, and thus would display higher catch rates. In other words: a floated pot with one down-current entrance only is likely to be more efficient than a pot that also has an extra exit.

2. Material and methods

The fishing experiment was carried out in the Varangerfjord, near the Russo-Norwegian boarder, in September 2007 (Fig. 1). The floated two-chamber cod pot tested has been described in detail by Furevik et al. (2008). The pot is collapsible and when unfolded is 100 cm wide, 150 cm long and 120 cm high. The original pot has two wide entrances (25 × 15 cm) that lead into the lower chamber, and a single narrow entrance between the lower and upper chambers (Fig. 2). The suspension arrangement mounted on one of the short sides allows the pot to turn with the current about 70 cm above the seabed. Underwater video observation confirmed that the pots were rotating. Standard pots with two entrances were compared with pots with one entrance. This new pot design did not have an entrance at the side on which the suspension arrangement was mounted, i.e. the up-current side.

The pots were baited with three frozen squid (*Illex* sp.) cut into five pieces and placed in a bait bag suspended in the lower chamber. Five pots with one entrance and five pots with two entrances were attached alternately to a common ground rope at intervals of about 50 m. Two fleets, each of ten pots, were set at different locations each day and hauled the next day (about 24 h soak time). A total of 14 fleets were set (i.e. 70 pots of each type) at depths of 108–150 m. During hauling, the number of each species caught was noted and the fish length was measured.

Catch in number per pot was modelled as a function of pot type (PotType). To account for the inherent dependency between pots