Fisheries Research 167 (2015) 114–122

Contents lists available at ScienceDirect

Fisheries Research

journal homepage: www.elsevier.com/locate/fishres

Seal exclusion devices in cod pots prevent seal bycatch and affect their catchability of cod

Sara Königson[a,*], Johan Lövgren[b], Joakim Hjelm[b], Mikael Ovegård[b], Fredrik Ljunghager[c], Sven-Gunnar Lunneryd[a]

[a] Institute of Coastal Research, Department of Aquatic Resources, Swedish University of Agricultural Sciences, Turistgatan 5, 453 30 Lysekil, Sweden
[b] Institute of Marine Research, Department of Aquatic Resources, Swedish University of Agricultural Sciences, Turistgatan 5, 453 30 Lysekil, Sweden
[c] The Swedish Agency for Marine and Water Management, Box 11930, 404 39 Göteborg, Sweden

ARTICLE INFO

Article history:
Received 17 January 2014
Received in revised form
16 September 2014
Accepted 30 January 2015
Handling Editor Dr. P. He
Available online 9 March 2015

Keywords:
Cod pot
Bycatch
Seal exclusion device
Catchability
Grey seal

ABSTRACT

In order to maintain a viable inshore fishing industry, it is important to limit the incidence of seal-inflicted damage to static fishing gear and additional catch losses. Studies in the Baltic Sea have shown that this could be achieved by implementing alternative fishing methods, e.g. by using fish pots instead of lines or gillnets. However, as in net and line fisheries, a pot fishery could also result in bycatch of seals. In order to prevent these bycatches, pot entrances were equipped with seal exclusion devices (SEDs) of various sizes and shapes. A field study was conducted to investigate what effect different types of SEDs had on the bycatch of seals as well as on the pot's catchability. When pots where equipped with SEDs the bycatch of seals was reduced to zero without negatively affecting the pot's catchability. The shape and size of the entrance did have a significant effect on the pot's catchability and the size of the fish. Using symmetrical oval shaped entrances along with larger rectangular entrances divided into two smaller openings increased the pot's catchability.

1. Introduction

The small-scale coastal fishing industry has an important function, both economic and social, for Swedish coastal communities (Neuman and Piriz, 2000; Bruckmeier and Höj Larsen, 2008; Waldo et al., 2010). In recent decades, the increasing seal populations around the Swedish coastline have resulted in a growing conflict between seals and fishermen. Seal-inflicted damage to fishing gear and catch losses have significantly increased (Lunneryd et al., 2005; Hemmingsson et al., 2008; Varjopuro, 2011). Grey seals (*Halichoerus grypus*) are the dominant species in the Baltic, although there is also a small population of harbour seals (*Phoca vitulina*) south of Öland. On the west coast of Sweden the dominant species is the harbour seal. Fisheries most subjected to the conflict are the Baltic small-scale coastal fisheries using gillnets, longlines and trapnets (Westerberg et al., 2006; Königson, 2011). According to the Helcom recommendation 27-28/2 (HELCOM, 2006) the grey seal population, which today is responsible for most part of the seal inflicted losses, shall increase to its carrying capacity (K). To be able to retain a viable small-scale coastal fishery, with a seal population continuously increasing, measures are needed. Developing and implementing seal-proof fishing gear is one measure to reduce the conflict. The gillnet fishery for Atlantic cod (*Gadus morhua*) is a coastal fishery which has experienced an extensive surge in damage caused by grey seal during the past 5 years (Königson et al., 2009). Cod pots have been studied as a seal-safe alternative fishing gear for Atlantic cod instead of gillnets and long-lines (Ovegård et al., 2011; Königson, 2011). Cod pots have occasionally given high catch rates of the target species (Furevik, 1997; Furevik and Hågensen, 1997) however they are not commonly used in a commercial fishery for cod in Europe at this time. Pots are routinely used for a related species, Pacific cod (*Gadus macrocephalus*) in U.S. waters off Alaska. The pots used in this area are most often one-chambered pots with fish retention devices in the entrance compared to the two-chambered pots with open entrances tried in Europe. The environmental impact of alternative passive fishing gear such as traps and pots is considered less severe compared to traditional fishing methods. Suuronen et al. (2012) included pots in the compilation of LIFE (Low Impact and Fuel Efficient) fishing gear due to their low energy use, effective species selectivity and low gear construction costs. They are also considered size selective (Ovegård et al., 2011). However bycatch of seals have been reported in passive fishing gear such as eel fyke-nets used off the Swedish west coast as well as in

* Corresponding author. Tel.: +46 702215915.
E-mail addresses: sara.konigson@slu.se, sven-gunnar.lunneryd@slu.se (S. Königson).

http://dx.doi.org/10.1016/j.fishres.2015.01.013
0165-7836/

pound-nets and trap-nets in the Baltic (Lunneryd et al., 2004, 2005). When developing passive fishing gear it is important to take into consideration and minimize the new fishing gears negative effect i.e. on the environment. If cod pots should be considered LIFE fishing gear, by-catch of marine mammals and birds needs to be minimal or at least low. It is therefore important to try to reduce this bycatch without actually decreasing the pot's catchability. Catchability is defined by Ellis and Wang (2007) as the proportion of available fish in the population that would be caught by a unit of effort.

Trials with the pontoon trap used in salmon fisheries in the Northern Baltic have shown that large grey seals cannot enter the trap when a Seal Exclusion Device, an SED, in this case in the form of a rigid metal frame with a wire set in the middle of the frame, is placed in the trap's entrance (Hemmingsson et al., 2008). The original cod pots have a rectangular entrance, made of thick nylon threads, which do not prevent bycatch of seals. However, placing an SED in the entrance of the pot can decrease bycatch of seals but it also changes the design of the pot, which likely affects its ability to catch and retain the fish (Hubert, 1996; Li et al., 2006). The most critical phase in pot fishing is when the fish move towards the pot's entrance (Furevik, 1994). The design of the entrance is crucial to the pot's catchability and may affect which species and which size of species that enters the pot (Thomsen et al., 2010). Several experiments aimed at increasing the pot's catchability by optimizing the design of the entrance in different ways has been described (Thomsen et al., 2010). However, in what way different types of SEDs placed in the pot entrance might affect the catchability of a pot is not known mainly because SEDs in these types of fishing gears have not been tried out before. Catchability in different pot's has been studied, however, it was pots with variable designs with regard to many factors such as size, entrance and shape of the pot, which were tested and not pots where only the appearance of the entrance varied. The aim of this study was to optimize the entrance so that it prevented seals from getting bycaught and in parallel not affecting the pot's catchability. The questions we address in this study, therefore, are firstly whether an SED placed in the entrance of a cod pot successfully prevents seals from entering and getting trapped in the pot, and secondly how different SEDs might affect pot's catchability. In an attempt to answer these questions, we compare fishing effort including seal bycatch events in cod pots with and without SEDs, as well as testing the effect of different types of SEDs on the pot's catchability relative to pots with an unmodified entrance.

2. Materials and methods

2.1. Study area and data collection method

Experimental fishing trials with cod pots were conducted at four locations along the Swedish coastline between 2003 and 2010 (Fig. 1, Table 1). The trials were carried out in collaboration with local professional fishermen, except for trials in location 4 (Koster archipelago) on the west coast of Sweden where test fishing was conducted by one of the authors.

All pots used in the study were baited with fresh herring. In locations 1–3, pots were deployed in strings of up to eight pots along the same bottom line. In location 1, the fishermen would set up to twelve such strings of pots, in locations 2 and 3 up to 5 strings of pots were set out. In location 4 on the west coast, at most six pots were set, and these were set individually. Soak-times varied from 1 day to 28 days, depending on factors such as location, weather conditions and fishing routines. The fishermen used a standardized protocol on which they recorded catches (weights and numbers of fish), types of SED fitted, when applicable, and soak times for each pot in every string. The catch was divided into cod greater

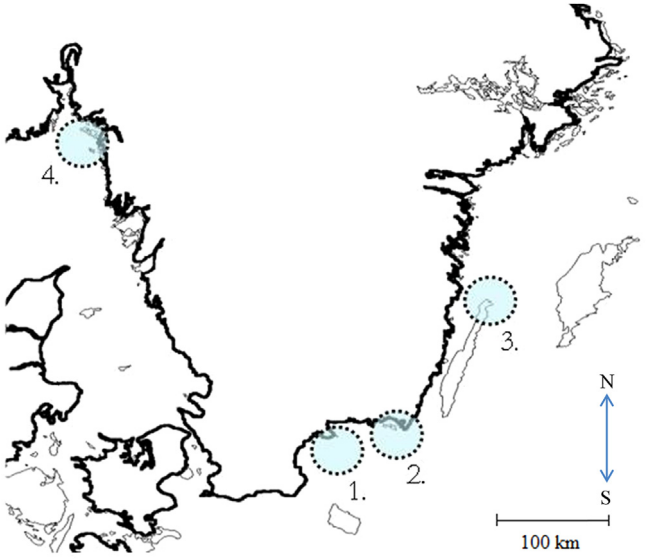

Fig. 1. Positions of the experimental fishing locations along the Swedish coastline. (1) Bay of Hanö, N55°57′43 E14°51′30. (2) Karlskrona archipelago, N56°5′45 E15°20′55. (3) North of Öland, N57°19′9 E16°56′22 and (4) Koster archipelago, N58°53′14 E10°59′24.

or less than 38 cm in length (the minimum legal landing size for Baltic cod). In location 4 the main target was crustacean and very small amount of fish was caught. On 40% of the fishing trips in location 1 (Bay of Hanö) and 22% in location 3 (Öland), on-board observers (personnel from SLU) joined the fishermen on their daily fishing trips. On these occasions the lengths of all fish caught were measured from the tip of the snout to the tip of the caudal fin as well as the above mentioned data being noted. In location 2 (Karlskrona), observers were present less frequently, however regular contact was maintained in order to verify the quality of the data.

2.2. Gear used and design of entrance frames

The gear used was the two-chambered single-entrance floating cod pot described by Furevik et al. (2008) and Ovegård et al. (2011), except in area 4 where the two-chambered two-entrance pot secured to the seabed was used (Fig. 2). To avoid catching undersized cod (<38 cm), all pots were fitted with a 45 mm escape window (Ovegård et al., 2011). In their original and unmodified form i.e. control pots, the pots had an entrance with a circumference of 80 cm at the narrowest point and a cross-sectional area of 375 cm^2. Experimental pots were modified with vertically mounted metal frames (SEDs) secured with nylon line at the narrow end of the pot's entrance hereafter called SED pots (Fig. 3). Five different types of SEDs made of a metal frames, with different shapes, thicknesses of material or inner circumferences were used. SEDs had a circumference of either 54 cm, 56 cm, 64 cm or 70 cm (Fig. 2). These measurements were set as a reasonable size to prevent juvenile seals of both species from entering the pot. The SEDs surface areas ranged from 182 cm^2 to 542 cm^2.

2.3. Seal bycatch experimental setup and analysis

Fishing trials in all four areas were at first carried out only with control pots. In three of the four locations we found that seals were getting trapped and were drowning in the control pots. In order to mitigate this problem, we started mounting different seal exclusion devices (SEDs) in the pots. Eventually all pots in locations 2, 3 and 4 were fitted with SEDs. The fishing effort when SED pots were used was not equal to the fishing effort when control pots were