Fisheries Research 185 (2017) 153–160

Contents lists available at ScienceDirect

Fisheries Research

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

Estimation of the effect of gear design changes on catch efficiency: Methodology and a case study for a Spanish longline fishery targeting hake (*Merluccius merluccius*)

Bent Herrmann[a,c,*,1], Manu Sistiaga[b,1], Lasse Rindahl[b], Ivan Tatone[c]

[a] SINTEF Fisheries and Aquaculture, Willemoesvej 2, DK-9850 Hirtshals, Denmark
[b] SINTEF Fisheries and Aquaculture, Brattørkaia 17C, N-7010 Trondheim, Norway
[c] University of Tromsø, Breivika, N-9037 Tromsø, Norway

ARTICLE INFO

Article history:
Received 26 January 2015
Received in revised form 7 September 2016
Accepted 14 September 2016
Handled by Dr. P. He
Available online 20 September 2016

Keywords:
Longline
Hake (*Merluccius merluccius*)
Fishing gear catch efficiency
Catch comparison
Catch ratio
Multi-model inference

ABSTRACT

This paper describes a method to estimate the relative catch efficiency of different fishing gear designs based on comparison of catch data. This method does not require an equal number of deployments or alternation between gears, but it accounts for multiple competing models describing the data by using multi-model inference. By applying a double bootstrapping procedure, this method also accounts for the uncertainty in the estimation resulting from between-deployment variation in catch efficiency and availability of fish as well as uncertainty about the size structure of the catch for the individual deployments. Finally, by incorporating the multi-model inference into each bootstrap iteration, the method also accounts for the uncertainty due to uncertainty in model selection. Using the described method, we investigated the effect of gear design changes on catch efficiency for a Spanish longline fishery targeting hake (*Merluccius merluccius*). We tested and compared four different designs against the traditional design used in the fishery. The first was a design compatible with automation that differed from the traditional one in hook size, snood line length, and snood line diameter (new automatized design). In the other three designs, only one of the parameters was changed. The results demonstrated that the new automatized design resulted in a significant decrease in catch efficiency due to its thicker snood line. The hook type and snood line length used had no effect on the efficiency of the fishery.

1. Introduction

Hake (*Merluccius merluccius*) is one of the most important commercial fish species in the Northeast Atlantic, and it is commonly harvested in mixed demersal fisheries along with cod (*Gadus morhua*), haddock (*Melanogramus aeglefinus*), and whiting *(Merlangius merlangus)*. It is usually found in waters between 30 and 500 m deep and tends to live close to the seabed in daytime and swim up the water column at night (Casey and Pereiro, 1995). There are two stocks of hake in Europe: the northern stock, which is found in the North Sea, Skagerrak, and off the Atlantic coasts of the UK, Ireland, and France, and the southern stock, which is located off the Atlantic coasts of Spain and Portugal (de Pontual et al., 2006). Hake is mainly caught using trawls and longlines both as targeted catch and as bycatch.

There are many different types of longlines, but they all contain three main components: a mainline, branch lines called snoods, and hooks. A snood is a short length of line that is attached to the mainline at a certain interval either directly or by using a clip or swivel, with the hook at the other end (Fig. 1). The design of the longlines can vary in the types of hooks, length of the snoods, thickness and material of the different lines used, intervals at which the snoods are placed along the mainline, and where they are used in reference to the seabed. All of these parameters vary depending on the target species, and they may influence the fishing efficiency of the gear.

Longlining is a widely used passive fishing method. In contrast to active fishing gears, such as trawls and seines, fish are attracted to the longline by the bait on the hooks. In Spain, longlines are widely used to target various demersal fish species, with hake being the most important. Along the north coast, there is a well-developed and important hake longline fishery, but the onboard operation is manpower demanding. Thus, fishing vessel owners and fishermen

* Corresponding author at: SINTEF Fisheries and Aquaculture, Willemoesvej 2, Hirtshals, DK-9850, Denmark.
E-mail address: bent.herrmann@sintef.no (B. Herrmann).
[1] Equal authorship.

http://dx.doi.org/10.1016/j.fishres.2016.09.013
0165-7836/

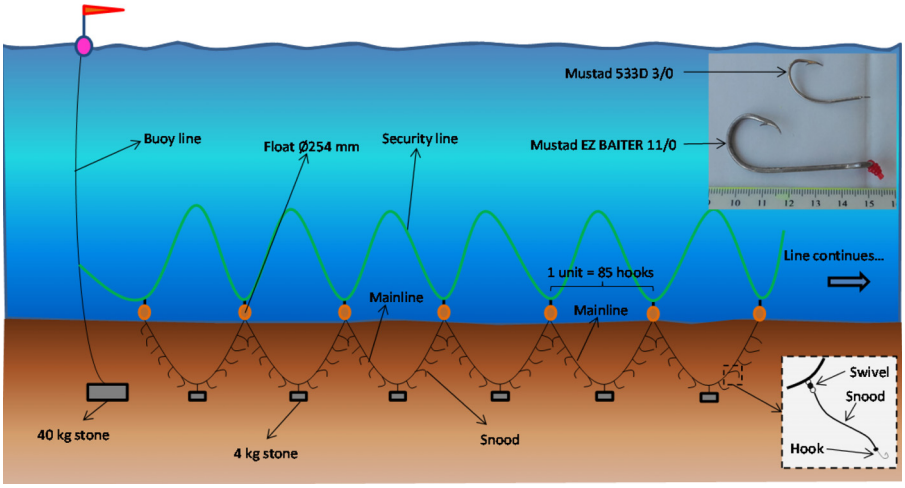

Fig. 1. Illustration of the longline type used during the trials showing the main elements of the gear. A photo showing the two different types of hooks used during the experiments (EZ BAITER 11/0 and 533D 3/0) is also shown.

have expressed interest in automatizing the operations onboard their vessels.

The goal of this study was to test the effectiveness of a Norwegian automatized longline system in the Spanish longline fishery targeting hake. The main design parameters of the gear operated by the Norwegian fishery differ substantially from the longlines traditionally used in the Spanish fishery in terms of: i) the length of the snoods; ii) the diameter of the snoods; and iii) the size of the hooks. The challenges facing installation of such an automatized system onboard vessels in the Spanish fishery could be solved, but concerns regarding the potential negative effects of the Norwegian longline design on the catch efficiency of the fishery must be addressed. If the Norwegian longline design perform differently compared to the traditional Spanish longline design, it is crucial to determine which design parameters are responsible for the catch differences and if these differences are fish size dependent.

Thus, we addressed the following questions in this study:

i) Would the catch efficiency of the Spanish longline fishery change if the Norwegian automatized system were used?
ii) If the catch efficiency is different, is this difference size dependent?
iii) If the catch efficiency is different, can it be related specifically to one or more of the specific differences between the longline designs?

To address these questions, we described and used a general analysis method that estimates the relative catch efficiency between two different designs of a fishing gear.

2. Material and methods

2.1. Experimental fishing

We conducted a cruise onboard the Spanish longline vessel Anxuela (30 m LOA and 500 HP) from May 11 to 16, 2012. The experiments were carried out on the banks of Gran Sole around 100 miles south of the coast of southern Ireland. Over a period of 4 days, we fished a total of 400 longline units (100 units per day). Of these units, 268 were entirely baited with whole sardines and were included in this study to examine the potential effect of gear design on catch efficiency, whereas the rest were tests carried out using different baits. The sardines were all hooked through the eye as is the usual way of baiting in this fishery to focus the study on the potential effect on catch efficiency by design changes to the longline. The main line of each of the 100 longline units fished each day was 250 m long, made of nylon (Polyamide), had a diameter of 2.5 mm and contained 85 snoods attached. The security line of the gear was attached to the top of each of the buoys in the mainline and deployed along with it (see Fig. 1). This security line had the same length as the mainline and was made of Ø8 mm braided Polyethylene, meaning that it had positive buoyancy. Within each unit the longline design parameters were kept constant, meaning that the snood diameter (the material was monofilament (nylon) in every case), snood length, and hook were the same. However, contiguous units could vary in one or several parameters at a time. The unit configurations used during the fishing trials are described in Table 1.

The Spanish unit type (traditional design) was fully configured in the way that the Spanish longline fishery is carried out today, whereas the Norwegian unit type was fully configured in the way that it is used in Norway as a semi-automatized system. Each of the other unit types tested was identical to the traditional Spanish design except that one design parameter was changed to corresponding Norwegian design. Thus, we tested the traditional Spanish design with the Norwegian hook (new hook), the traditional Spanish design with the Norwegian snood length (new length), and the traditional Spanish design with the Norwegian snood diameter (new diameter) (Table 1). During experimental fishing, the longline units were arranged such that every second unit was always a traditional design unit. The other unit types were then placed along the lines in between the traditional design unit.

For each unit (each with 85 hooks), the total length of each hake caught was measured to the nearest cm. Hence, for each unit i deployed during the experimental fishing period, we counted the number of hake n_{il} caught belonging to each length class l. In the following sections we outline the method used to analyse these data to obtain an estimate of the relative catch efficiency of the different fishing gears tested. Although this method is not restricted to the analysis of relative catch efficiency between different longline designs, for simplicity we use the notation for the longline fishing case study.

2.2. Estimation of the catch comparison curve

Using the catch information (numbers and sizes of hake for each of the units), we wanted to determine whether there was a significant difference in the catch efficiency among the different longline