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Effect of fisher's soak tactic on catch pattern in the Danish gillnet plaice fishery

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ABSTRACT

Soak duration in the gillnet fisheries can vary from a few hours to several days. The industry reports a variation of soak tactics between target species, but also between seasons for the same species. These are determined by the robustness of the target species and the catch of unwanted species. Different soak tactics were compared to estimate the role that the choice of a soak tactic plays in the catch efficiency of both target and unwanted species. In the Danish summer gillnet fishery targeting plaice *(Pleuronectes platessa)*, nets are deployed approximately 12 h (h) during day. Unwanted species are common dab (*Limanda limanda*) and edible crab (*Cancer pagurus*). The commercially used 12 h deployment during day was compared to 12 h deployment during night and 24 h deployment. On average, there were about 1.5 more catches of commercial size plaice (above 27 cm), and 2 and 4 times less catches of the unwanted dab and edible crab, respectively, for 12 h at day compared to the other soak tactics (12 h at night or 24 h). Gillnetters participating in the coastal summer fishery for plaice follow the theoretical optimal soak tactic. The commercially used 12 h deployment during day maximises the catch of commercial sized plaice and limits handling time by catching less unwanted dab and crabs.

1. Introduction

Approximately 40% of the European fishing vessels deploy set gillnets as main fishing gear (E.C., 2017). In Denmark, gillnetters represents approximately 90% of the fishing fleet. Many of the European gillnetters participate in small-scale fisheries and play a vital role in the coastal areas (Veiga et al., 2016). Gillnets are, in general, considered to be highly size selective, with larger mesh sizes catching larger fish (Stergiou and Erzini, 2002; He and Pol, 2010). All species are not, however, equally vulnerable to the gear (Fonseca et al., 2002; Valdemarsen and Suuronen, 2003; He and Pol, 2010; Breen et al., 2016). Limiting unwanted species is in the fisher's interest as it reduces handling time, which can be intensive in gillnet fisheries. Handling time affects the fishing power, i.e., the number and length of gillnets that can be handled during a fishing trip (Morandeau et al., 2014; Fauconnet and Rochet, 2016). The selection properties of gillnets may be improved by altering mesh size, netting material, or twine size. But due to the nature of the gear, one would most likely also impair the catch efficiency of the net. More complex gears proved to successfully reduce bycatch, e.g., gillnets that float above the seabed (norsel-mounted nets) to reduce bycatch of red king crab (*Paralithodes camtschaticus*) in the cod (*Gadus morhua*) fishery (Godøy et al., 2003), but are usually limited in passive fisheries (Kennelly and Broadhurst, 2002; Andersen et al., 2012; Eliasen et al., 2014; Fauconnet et al., 2015; Breen et al., 2016; Fauconnet and Rochet, 2016). In many cases, the fisher's operational tactic plays a dominant role. It also has the advantage of no additional capital cost (SigurÐardóttir et al., 2015).

Soak duration in the gillnet fisheries varies considerably. In Denmark, it can be from a few hours in the wreck fishery for cod to several days in the turbot (*Scophthalmus maximus*) or monkfish (*Lophius piscatorius*) fisheries. It can even vary between seasons for the same species. Time of day and soak duration are easily adjustable factors which appear to play a key role in the gillnet fisheries. Previous studies suggested a relationship between soak time and catch size for short soak times (up to 6 h) but none for longer soak times (Acosta, 1994; Gonçalves et al., 2008; Hickford and Schiel, 1996; Losanes et al., 1992; Minns and Hurley, 1988; Rotherham et al., 2006; Schmalz and Staples, 2014). The soak tactic should ensure an acceptable catch rate of commercial species to optimize landings with regard to fishing effort, fuel consumption and labour cost (Hickford and Schiel, 1996; Hopper et al., 2003). The theoretical optimal soak tactic in a given gillnet fishery is the one that best maximizes catches of target species while minimizing unwanted catch. However, not all fishing tactics are associated with catch maximization. Some fishers are satisfied with recovering the

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operating costs only, or minimizing physical and economic risks (Salas and Gaertner, 2004). This can especially be relevant in small-scale fisheries, which represent a majority of the gillnetters (Salas and Gaertner, 2004).

To investigate the effect of soak tactic on catch pattern in the gillnet fisheries, the following questions were addressed:

- What role does the choice of soak tactic play in the catch pattern, i.e., how big is the difference in catches of target and unwanted species between different soak tactics employing differences in time of the day and duration?
- If the catch efficiency is different, is this difference size dependent?
- Are the fishers able to adjust to use the theoretical optimal soak tactic?

We used the Danish summer plaice (*Pleuronectes platessa*) gillnet fishery in the Skagerrak (ICES area IIIa) as a case study. The plaice fishery in the Skagerrak is one of the most important commercial gillnet fisheries in Denmark (Ulrich and Andersen, 2004). It takes place in coastal sandy and shallow fishing grounds. It is characterized by shorter soaks in the summer compared to the winter to reduce the excessive bycatch of edible crabs (*Cancer pagurus*). Pincers of the larger edible crabs can be sold, but crabs are mostly seen as a nuisance by gillnetters as they can severely increase handling time. It is common practice to crush the larger crabs in order to facilitate their disentanglement from the netting. Most of the other non-target species, such as dab (*Limanda limanda*), usually represent low selling value at the fish auction. We carried out a gillnet experiment following commercial practices with three different soak tactics, i.e., the commercially used 12 h (h) during day, as well as 12 h at night and 24 h to document differences in species composition, catch efficiency and specifically examine whether the fishermen have adopted the best theoretical soak tactic.

2. Materials and methods

2.1. Experimental design and sea trials

Trials were conducted on the Danish commercial gillnetter Skovsmose HG5 (11.99m, 171 kW) for eight consecutive days in September 2014. A total of 27 identical plaice gillnets (http://daconet.dk/) with all specifications corresponding to commercial practice were used (Table 1). A total of nine fleets each consisting of three gillnets tied together were constructed. Every day, three fleets were soaked for 24 h. Simultaneously, three fleets were soaked for 12 h during the day and three others during the night (Figs. 1 and 2). The soak durations of 12 and 24 h covered the usual range of commercial practices in Danish coastal waters. Gillnets were set at a known sandy bottom habitat at the same depth. Soak tactics were alternated at each position. Fleets were positioned with the current, parallel to the coast, and anchored at both ends using 6 m bridle lines and 4 kg anchors following commercial practices. Fleets were hauled according to commercial practices using a hydraulically-powered net hauler with top roller (http://www.net-op.dk/). Two fishers disentangled the catch from the netting on a sorting table during hauling.

Table 1
Specifications of an individual net panel used in the experimental set-up. Height is given as stretched height.

Gear specifications		
Net	Type	Gillnet
	Target species	Plaice
Twine	Diameter	0.30 mm
	Type	Monofil
	Material	Nylon
	Color	Snow-white
	Knot	Double
Mesh size	Nominal (bar length)	68 mm
Dimensions	Height (mesh depth)	2 m (14.5)
	Length (No. of knots)	82 m (4800 kn)
	Hanging ratio	25%
Floatline	Buoyancy per 100 m	900 g
Leadline	Weight per 100 m	5 kg

2.2. Data collection

All fish and invertebrate mega-fauna were sorted to species level and counted. Fish total length was measured to the nearest cm below on a measuring board (E.U., 2016). Invertebrates were measured with a caliper to the nearest mm below as carapace width for edible (*Cancer pagurus*), common (*Carcinus maenas*) and swimming (*Liocarcinus depurator*) crabs (ICES, 2015). Carapace height was measured for hermit crabs (*Pagurus bernhardus*). Diameter was measured for common (*Asterias rubens*), Northern (*Leptasterias muelleri*) and spiny (*Marthasterias glacialis*) starfish and edible sea urchin (*Echinus esculentus*). Data were collected at the fleet level to account for the between-fleet variation (Millar and Anderson, 2004). It was not always possible to process invertebrates as soon as they were hauled aboard and some were therefore kept in the vessel cooling room or frozen for later analysis.

2.3. Species composition

Relative abundance was calculated per fleet as the ratio between the number of individuals of a given species and the total number of individuals. Species occurrence was calculated as the ratio between the number of fleets where a given species was present and the total number of fleets (per soak tactic).

2.4. Catch comparison analysis

The method developed by Herrmann et al. (2017) for investigating the effect of design changes on catch efficiency in passive gears was used. The catch comparison analysis aimed to determine whether; (1) there was a significant difference in the catch efficiency between the different soak tactics tested, and (2) a potential difference between the different soaks could be related to the size of the individuals. Catch data of each soak tactic were summed over the different fleets to account for the variability in numbers and sizes of the individuals available at the specific time and position of each fleet's deployment. The experimental summed catch comparison rate cc_l is given by:

$$cc_l = \frac{\sum_{j=1}^{bq} nb_{lj}}{\sum_{i=1}^{aq} na_{li} + \sum_{j=1}^{bq} nb_{lj}} \quad (1)$$

where na_{li} and nb_{lj} are the numbers of individuals measured in each length class l for soak tactic a in fleet i and for soak tactic b in fleet j, respectively. aq and bq are the number of fleets deployed with soak tactics a and b, respectively. aq and bq were identical in our experiment (3 fleets × 7 cruise days for each soak tactic).

The experimental cc_l is often modelled by the function $cc(l, \boldsymbol{v})$, or catch comparison curve, which expresses the probability of finding a fish of length l in one of the fleets of soak tactic b given that it was found in one of the fleets of soak tactic a or b. $\boldsymbol{v}$ represents the parameters describing the catch comparison curve. The function $cc(l, \boldsymbol{v})$ has the following form:

$$cc(l, \boldsymbol{v}) = \frac{exp(f(l, v_0, ..., v_k))}{1 + exp(f(l, v_0, ..., v_k))} \quad (2)$$

where f is a polynomial of order k with coefficients v_0 to v_k. The values of the parameters $\boldsymbol{v}$ describing $cc(l, \boldsymbol{v})$ are estimated by minimizing the following equation: