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Short-term survival of discarded target fish and non-target invertebrate species in the "eurocutter" beam trawl fishery of the southern North Sea

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ABSTRACT

Few studies have examined discard survival in beam trawl fisheries, especially in 4 m beam trawl fisheries using chain mats and limited haul durations. This so-called "eurocutter" fishery is carried out by beam trawlers with an engine power ≤221 kW and is allowed in the 6 to 12 nm zone in contrast to larger beam trawlers which operate solely outside of the 12 nm limit. Chain mat beam trawling was developed to prevent large boulders from entering the net, and is typically conducted at lower fishing speed than tickler chain beam trawling. This study obtained short-term survival estimates for this "eurocutter" fishery by monitoring post-capture mortality in tank-held organisms. Survival was high to very high (>75%) for benthic invertebrates, but not for fish. All examined whiting (Merlangius merlangus) and pouting (Trisopterus sp.) died. Only 14% of sole (Solea solea) survived to 91 h of observation, and 48% of plaice (Pleuronectes platessa) to 77 h. The survival probability was higher for cod (Gadus morhua) (66% to 88 h) and skates (Rajidae) (72% to 80 h). However, the mortality rate had not stabilized within the period of observation. Survival models were used to estimate the minimum duration of captivity required to properly evaluate short-term survival, and to investigate the role of physical injuries and other pertinent covariates (catch weight, fish length, fishing depth, salinity, sea surface temperature, air temperature and fishing trip) in determining fish discard survival. The results of this study indicate a high variability in discard survival amongst taxa and highlight that physical injuries when taken alone are a limited proxy for survival of 4 m beam trawl discards and that small fish specimens have a limited chance of surviving discarding.

1. Introduction

The overall ecological impact of beam trawl fisheries is amongst the highest of different gear types (Suuronen et al., 2012). In addition to the well-documented effects on benthic habitats, discarding is also of particular concern. The UK beam trawler fleet discards approximately one third of the weight of their fish catch in the North Sea (Enever et al., 2009), while the German flatfish-directed beam trawler fleet discards between 56 and 72% of their total catch (Ulleweit et al., 2008). Despite a number of initiatives to reduce discards in beam trawl and other fisheries, the European Commission (EC) has deemed progress to be insufficient and has therefore proposed a ban on discards of commercial species (European Commission (EC), 2013). However, decision making concerning a ban is on-going and survival of fishery discards is a ponderous subject of debate (European Council (EC), 2013). Information is required on the relative conservation benefits that might arise from accounting for all fishery catches as part of a ban in which all discards die, versus those arising from regulations that allow for discarding of certain species, with ensuing survival of some organisms.

In practice, considerable efforts are made to understand discard amounts, but relatively little is known about the survival of discarded organisms. Formal estimates of discard survival are difficult to obtain due to the complex logistics for survival studies (see review in Broadhurst et al., 2006). A number of those survival studies of discards in beam trawl fisheries were conducted mainly in the early 1990s. They focussed primarily on beam trawling with tickler chains and either very short (≤0.5 h) or long hauls (≥2 h) (Table 1). This study focuses on the "eurocutter" fishery with 4 m beam trawls and chain mats and with haul durations of approximately 1.5 h. Beam trawling with tickler chains is typically conducted at higher fishing speeds than with chain mats (Rijnsdorp et al., 2008). Also, in contrast to tickler chain beam trawling, chain mat trawling can be conducted in rocky fishing grounds as the chain configuration prevents boulders from entering and tearing up the

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Table 1
Summary of environmental, technical and biological data collected during six five-day fishing trips by RV "Belgica" in the southern North Sea.

Fishing trip	24–28 November 2008	1–5 December 2008	2–6 February 2009	30 March–3 April 2009	26–30 November 2009	30 November–4 December 2009
ICES rectangles fished	31F2, 33F1 and 34F1	32F1 and 33F1	31F1, 32F1, 33F1, 33F2	31F2	33F1	33F1
Depth fished (m)	14–35	25–33	28–50	10–13	15–32	28–33
Salinity (PSU)	33.8 (0.4)	34.0 (0.1)	35.0 (0.0)	35.0 (0.0)	34.9 (0.1)	34.2 (0.2)
Sea surface temperature (°C)	9.3 (0.8)	9.3 (0.4)	5.8 (0.4)	8.2 (0.1)	12.1 (0.1)	11.3 (0.1)
Air temperature (°C)	7.5 (0.9)	5.2 (1.0)	4.9 (0.5)	9.3 (0.6)	10.84 (0.37)	9.43 (0.54)
Commercial hauls						
Catch weight (kg)	40.0–414.5	67.2–197.0	70.9–200.6	64.5–251.9	70.9–200.6	64.5–153.0
Haul duration (min)	97.0 (9.7)	99.3 (8.9)	91.7 (4.1)	87.0 (6.1)	84.2 (16.9)	91.3 (3.5)
Number of hauls	5	7	6	9	7	5
Number of individuals:						
Gadus morhua	17	9	–	27	3	8
Merlangius merlangus	–	30	–	–	26	20
Pleuronectes platessa	–	5	24	47	9	12
Rajidae	–	34	38	–	39	44
Solea solea	42	48	52	24	48	56
Trisopterus sp.	–	31	–	–	13	5
Total length (cm)						
Gadus *morhua*	32–52	33–63	–	32–56	54–63	42–75
Merlangius *merlangus*	–	17–35	–	–	17–36	15–28
Pleuronectes *platessa*	–	20–27	17–29	15–31	17–29	18–32
Rajidae	–	10–43	14–46	–	8–53	7–47
Solea *solea*	13–35	16–31	17–31	19–33	15–28	15–28
Trisopterus sp.	–	13–30	–	–	15–28	16 – 29
"Reference" hauls						
Number of hauls	–	–	1	2	–	2
Number of individuals:						
Pleuronectes platessa	–	–	1	24	–	–
Solea *solea*	–	–	8	18	–	20
Total length (cm)						
Pleuronectes *platessa*	–	–	16	18–31	–	–
Solea *solea*	–	–	21–34	23–34	–	19–29
Commercial hauls						
Asterias rubens	103	40	75	–	–	–
Ophiura sp.	–	–	27	20	1	7
Psammechinus *miliaris*	59	60	–	–	–	–
Cancer *pagarus*	5	5	8	–	–	22
Liocarcinus sp.	18	–	29	21	–	5
Pagurus *bernhardus*	13	42	17	–	–	–
Aphrodite *aculeata*	–	–	25	–	15	–

net. Given that haul duration (Van Beek et al., 1990), catch composition and towing speed affect fishing induced stress, injuries and survival (Davis, 2002), differences in survival between trawls with tickler chains and chain mats are expected (e.g. Lindeboom and de Groot, 1998: 170). "Eurocutter" beam trawlers have an engine power ≤221 kW and have different fishing rights than larger vessels. They are allowed to fish in the 6 to 12 nm zone and in the plaice box (Beare et al., 2013), thus exhibiting different fishing patterns than larger vessels (Poos and Rijnsdorp, 2007). Differences in the environment in which fishing takes place (e.g. depth, salinity, temperature) may also influence discard survival. The Dutch and Belgian "eurocutter" fishery mainly takes place in the southern North Sea (Taal et al., 2010; Tessens and Velghe, 2009; Van Hal et al., 2010). Dutch "eurocutters" predominantly fish with tickler chain beam trawls during the summer period in the southeastern North Sea, whereas most of the Belgian beam trawl landings and discards originate from the winter period (Marchal, 2006; Tessens and Velghe, 2009; Depestele et al., 2011). Although the "eurocutter" fleet is small (10.7% and 19.6% of the Dutch resp. Belgian beam trawler fleet in 2009), the envisaged differences in discard survival between beam trawl fisheries could lead to different advice for the "small" and "large" beam trawler fleet in the framework of the discard ban, thereby motivating this study.

This study had three main objectives. The primary aim was to obtain estimates of the short-term survival of a wide range of discarded organisms in the "eurocutter" fishery. The fish species selected in this study were those that constituted most of the discards in the fishery and represent a diversity of biological characteristics (e.g. Depestele et al., 2011; Silva et al., 2012; Uhlmann et al., 2011): two flatfish species, i.e. sole (*Solea solea*) and European plaice (*Pleuronectes platessa*), three roundfish species, i.e. whiting (*Merlangius merlangus*), pouting (*Trisopterus sp*, >90% *T. luscus*) and cod (*Gadus morhua*), and skates (*Rajidae*) for the elasmobranchs. The survival of benthic invertebrate species was also examined to investigate the effect of longer haul durations on survival, as the only "chain mat" study on their discard survival was conducted during 30 min hauls (Kaiser and Spencer, 1995). The selected invertebrates were common starfish (*Asterias rubens*), ophiurids (*Ophiura* sp.), edible crab (*Cancer pagurus*), hermit crab (*Pagurus bernhardus*), sea mouse (*Aphrodita aculeata*), green sea urchins (*Psammechinus miliaris*) and swimming crabs (*Liocarcinus* sp., of which >90 % were *L. holsatus*).

The second aim of the study was to evaluate whether the degree of injury sustained by an organism can predict eventual discard survival in the "eurocutter" fishery. The relationship between injuries and discard survival has been found for invertebrates and fish in other fisheries (e.g. Enever et al., 2008; Benoît et al., 2010, 2012). The benefit of defining such relevant proxies for discard survival is that they represent a much more cost-effective manner of evaluating and accounting for the various factors that can affect discard survival (e.g., Benoît et al., 2010, 2012; Davis, 2010).