Gear selectivity, escapement rate, and the discarded proportion

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Abstract

One approach to reduce discards is to deploy more selective devices or gears. A simple calculation though shows that even when the escapement rate of unwanted catch recorded during sea trials is significant, the expected gains in proportion discarded are low in many instances.

Keywords

Discard reduction, selective devices, escapement rate.

1 Introduction

Gear-based measures have been the most prevailing management measures meant to reduce discards over the last decades (Walsh *et al.*, 2002). Fishing technologists have developped and tested a wide variety of mesh shapes and positions, materials, grids, or other kinds of gear modifications, and combinations thereof, to let unwanted catch escape. Many projects have been implemented locally. These efforts have been coordinated internationally, *e.g.* through the Working Group on Fishing Technology and Fish Behaviour (WGFTFB) under the auspices of both the Food and Agriculture Organization of the United Nations (FAO) and the International Council for the Exploration of the Seas (ICES). Many of these trials have been conducted in cooperation with fishers. When

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implemented by the fleets however, the modified gears have not always been as efficient at reducing discarded proportions as would have been expected from the technical trials at sea, even when escapement measured during these trials was significant (e.g., Catchpole et al., 2006; Nikolic et al., 2015; Suuronen and Sardà, 2007). Discrepancies have been ascribed to several factors, from limited uptake to intentional misuse of the selective device (Romero et al., 2010).

Here we suggest another, simple explanation for this apparent discrepancy – the success of selective devices, as measured in technical trials by retention rate or its counterpart escapement rate, may not be translated into similar gains in discarded proportions. This happens because sea trials measure the escapement rate relative to the baseline gear, that is, the proportion of unwanted fish caught by the baseline gear but not by the selective device; whereas escapement interacts with fishing effort and fish abundance to determine the catch, hence, the discards and discarded proportion. Moreover, selective devices often decrease not just unwanted catches, but also the catch of marketable target species. Below we develop a simple calculation of changes in discarded proportions when there is, or not, loss of commercial catch, and illustrate with two selective devices currently or potentially deployed in the French *Nephrops* fishery. This high-value fishery targets Norway lobster (*Nephrops norvegicus*) in the Bay of Biscay. As the fishing grounds largely overlap with a major nursery of the Northern stock of European hake (*Merluccius merluccius*), significant amounts of hake are bycaught and mostly discarded, in addition to undersized *Nephrops*, and other species (Catchpole et al., 2014; Uhlmann et al., 2014). This happens even though mandatory selective devices meant to decrease discards of hake (European Union, 2006, Appendix III) and *Nephrops* (République Française, 2008) are deployed.

2 Calculation

Let C be catch in weight, E fishing effort, S the available biomass of undersized fish, and B the available biomass of legal-sized fish. Small and big fish are caught with the initial gear with different catchabilities q_S and q_B. We can write the catch $C = \left(q_S S + q_B B\right) E$

(eqn 1). If all and only undersized fish are discarded, the discarded proportion is $d = q_S S/(q_S S + q_B B)$.

The new, selective gear will let escape some undersized fish so that their catchability is now $(1-f_S)q_S$ where f_S is the escapement rate in [0; 1]. If the selective gear also catches less fish of commercial sizes, the same applies to big fish, with a new catchability $(1-f_B)q_B$.

With some easy algebra we find that the new discarded proportion d_2 writes $d_2 = (1-f_S)d/[(1-f_S)d + (1-f_B)(1-d)]$ (eqn 2). In the case of no loss of commercial catch, $f_B = 0$ and this simplifies to $d_2 = (1-f_S)d/(1-f_S d)$ (eqn 3).

3 Results

When there is no loss of commercial catch, the discarded proportion of the selective gear decreases slowly with the escapement rate – the more so as the initial discarded proportion was low (Figure 1a). For example, a square mesh panel (SMP) is used to decrease hake catch in the Bay of Biscay *Nephrops* fishery on a legal basis since 2005 (Appendix III of EC regulation No. 51/2006). This device was found during technical trials to let on average 26% of undersized hake escape, compared to the standard trawl without SMP (Comité National des Pêches et des Elevages Marins, 2004). Since the discarded proportion of hake fluctuated around 70% before the regulation came into force (Nikolic et al., 2015), the expected discarded proportion with the SMP, all other things being equal, would have been 65% (triangles on Figure 1). Only high levels of escapement (above 60%) will make a significant change in the discarded proportion (Figure 1a), and only for intermediate levels of discarded proportions (Figure 1b).

Escapement necessary to make a difference in discarded proportion is still higher when the selective device also catches less fish of commercial size (Figure 2). As long as unwanted catch escapement rate is lower than escapement of marketable catch, the selective device actually increases the discarded proportion (discontinuity between diamonds and curves in 2a; continuous curve above the 1:1 line in 2b). A selective device currently trialed which seems to let 40% of undersized and 30% of commercial *Nephrops* escape, for example, would decrease the *Nephrops* discarded proportion from 50 to 46% (triangles on Figure 2).

4 Discussion

Gains in the proportion discarded expected from usual gains in unwanted catch escapement appear to be low. In many instances, they would probably not show up against the ordinary fluctuations in discard amounts or proportions, which vary in response to a variety of factors (Rochet and Trenkel, 2005), most of which in turn fluctuate in time and/or space. These findings suggest that the relative escapement required to make a real change in the catch composition might be high in most instances. For example, Nikolic *et al.* (2015) found that the wide uptake of the SMP in the *Nephrops* fishery when this device became mandatory in 2005 did not result in any detectable change in hake catch, discarded proportion or discarded amount as estimated from onboard observer data. Our calculations provide an explanation for this outcome, since they show that the difference in discarded proportion to be expected from the introduction of the device was well below the range of its interannual fluctuations.

These results suggest that if the aim would be to decrease discarded proportions, developments by large steps should be favored, that is, selective devices that change escapement by 90% rather than 10%. However, discarded proportions alone may not be relevant to evaluate the efficacy of new selective devices, because they do not convey a sense of the number of fish escaping. Escapees are important though, if a significant part of them survive and contribute to stock renewal. In this perspective, even low increments of escapement may also be useful, provided escapees survive. This study points to the need to better assess discard survival, and to consider escapees' survival when developing and evaluating new selective gears and devices.

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6 Figure captions

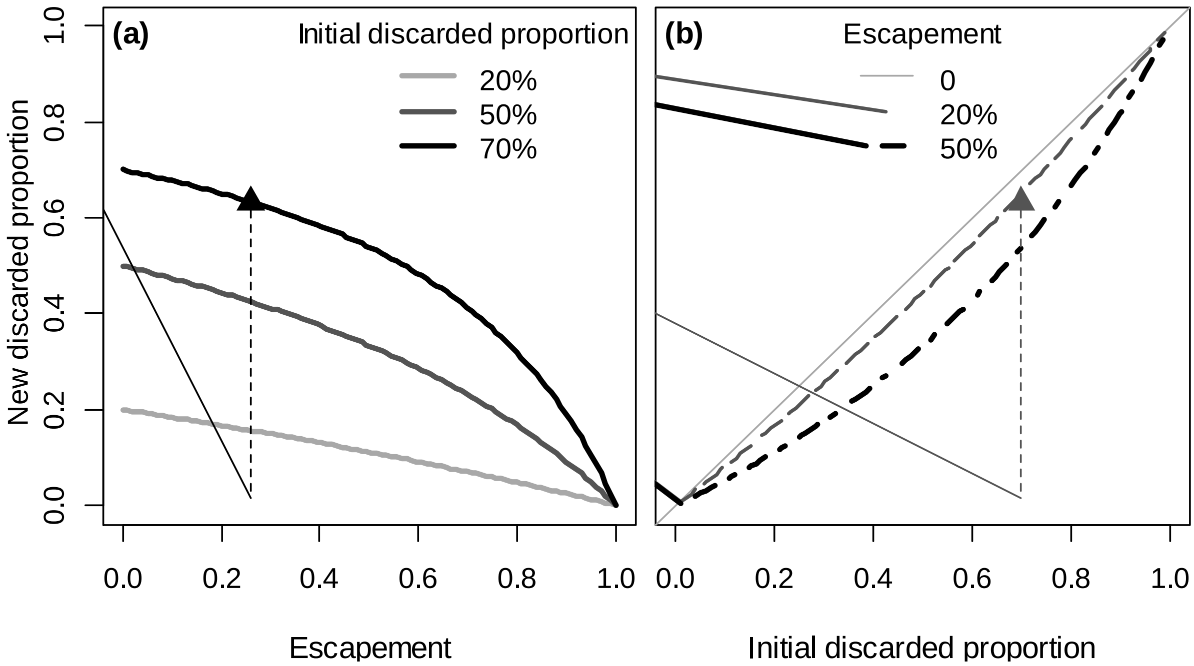

Figure 1. Predicted discarded proportion with the new gear as a function of (a) escapement and (b) the discarded proportion with the initial gear, when there is no loss of commercial catch (from eqn 3). Triangles show the expected discarded proportion after the introduction of the square mesh panel in the *Nephrops* fishery in the Bay of Biscay (which lets 20% small hake escape), given that around 70% of hake catch was discarded prior to the regulation.

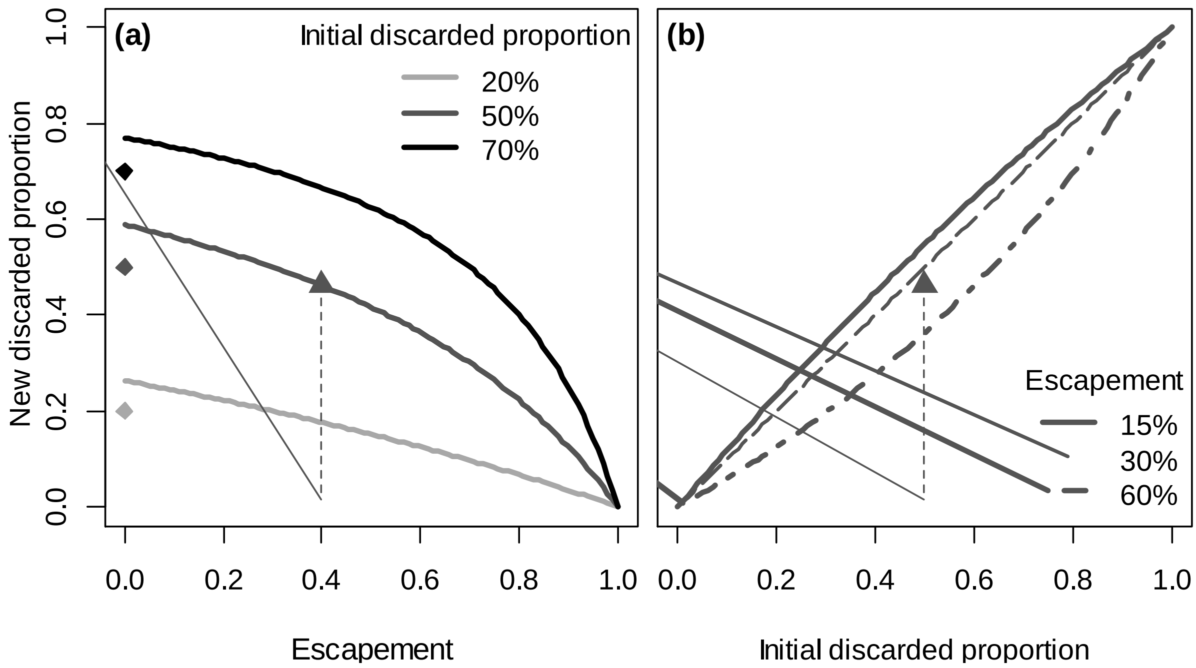

Figure 2. Predicted discarded proportion with the new gear as a function of (a) escapement and (b) the discarded proportion with the initial gear, when the new gear catches 30% less commercial sizes than the initial gear (from eqn 2). Diamonds in 1a show the discarded proportion without the selective device. Triangles show the expected discarded proportion after the introduction of a selective device that would let 40% undersized and 30% marketable *Nephrops* escape, given that around 50% of *Nephrops* catch was discarded without that device.

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