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This study aims to elucidate the discarding patterns of cod throughout the entire North Sea while accounting for the variability that occurs as a result of additional drivers. Demonstrating detailed spatiotemporal discarding patterns provides opportunities to further develop spatial management. This facilitates the move to discard free fisheries as part of the proposed reforms of the CFP and can illustrate what the impacts will be on European fishing fleets.

Discarding is currently one of the most important issues within commercial fishing, and has prompted a commitment from the European Council to end discarding through a phased ban. However, the consequences are still poorly understood due to incomplete knowledge on the spatiotemporal pattern of discards, which tend to be highly variable in space and time. Here we show discard rates of small and large cod (*Gadus morhua* L.) in the North Sea to be highly variable in their spatial and temporal (inter-annual and seasonal) distributions.

Methods: To elucidate the discarding patterns of cod in the North Sea we employ generalized additive mixed models (GAMMs) using discard data from 11370 fishing events collected throughout the period 2003 – 2010. Data were collected across seven European Union (EU) Member States as part of the EU Data Collection Framework (DCF). Furthermore, we aim to account for the variability in discards that occurs as a result of depth, gear and its associated mesh size, and vessel specific characteristics. Discards less than and greater than MLS (small and large cod respectively) were analysed separately. The discard data defined above is collected by different segments of the fishing fleets. Hence, such

data alone cannot define whether heterogeneity in discard rates results from fishing fleet characteristics (e.g. gear type and mesh size) or whether it is the result of spatiotemporal patterns in cod distribution. Therefore, data from the biannual international bottom trawl survey (IBTS) are used to complement the discard data.

Results: Analyses revealed highly significant spatiotemporal heterogeneity among small (<MLS) and large (≥MLS) cod throughout the North Sea on both inter-annual and season time scales (Fig 1). Our analyses also revealed depth, time, location, gear type and mesh size, as well as individual vessel characteristics, to be correlated with discard rates of cod (Fig. 2).
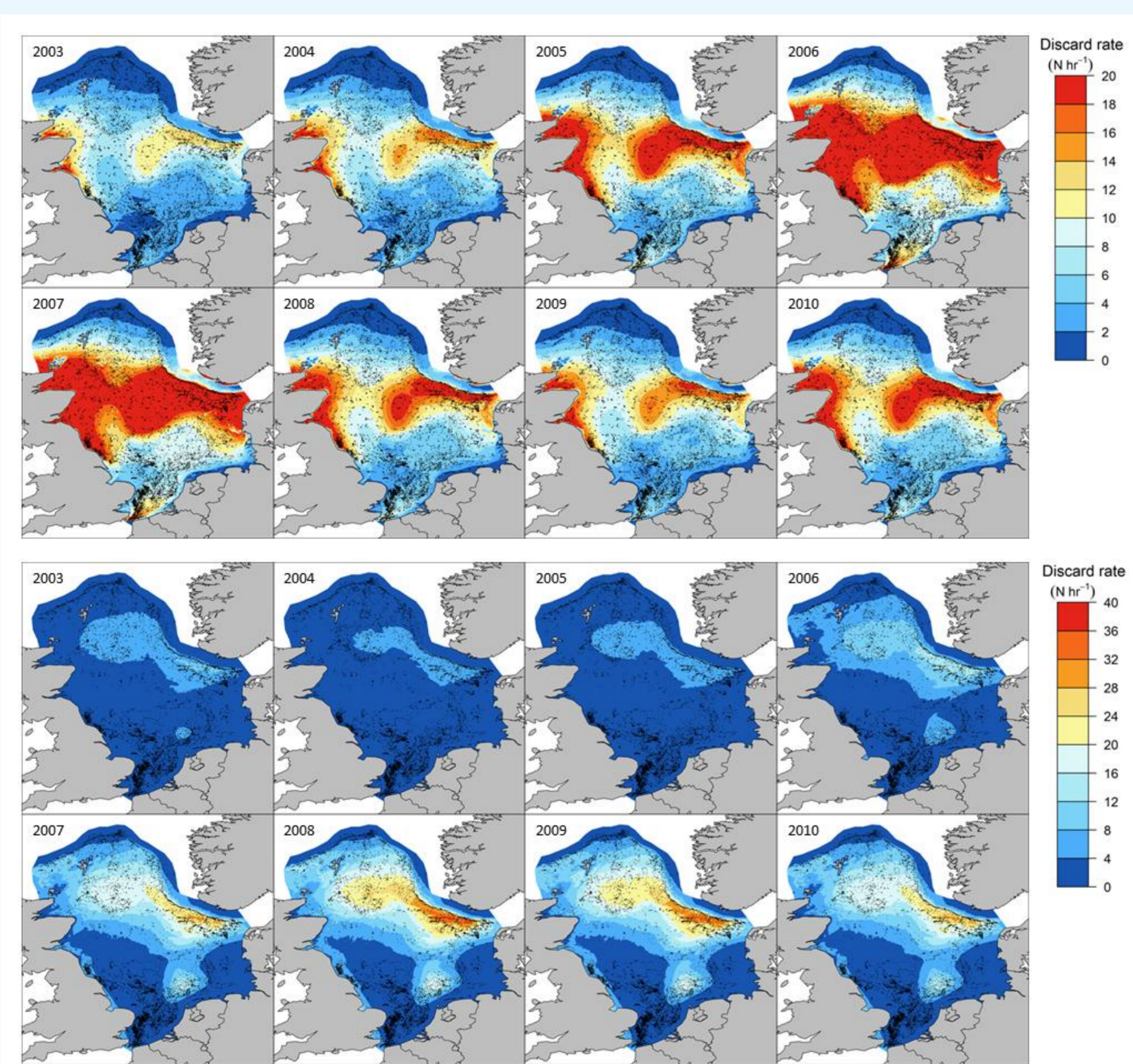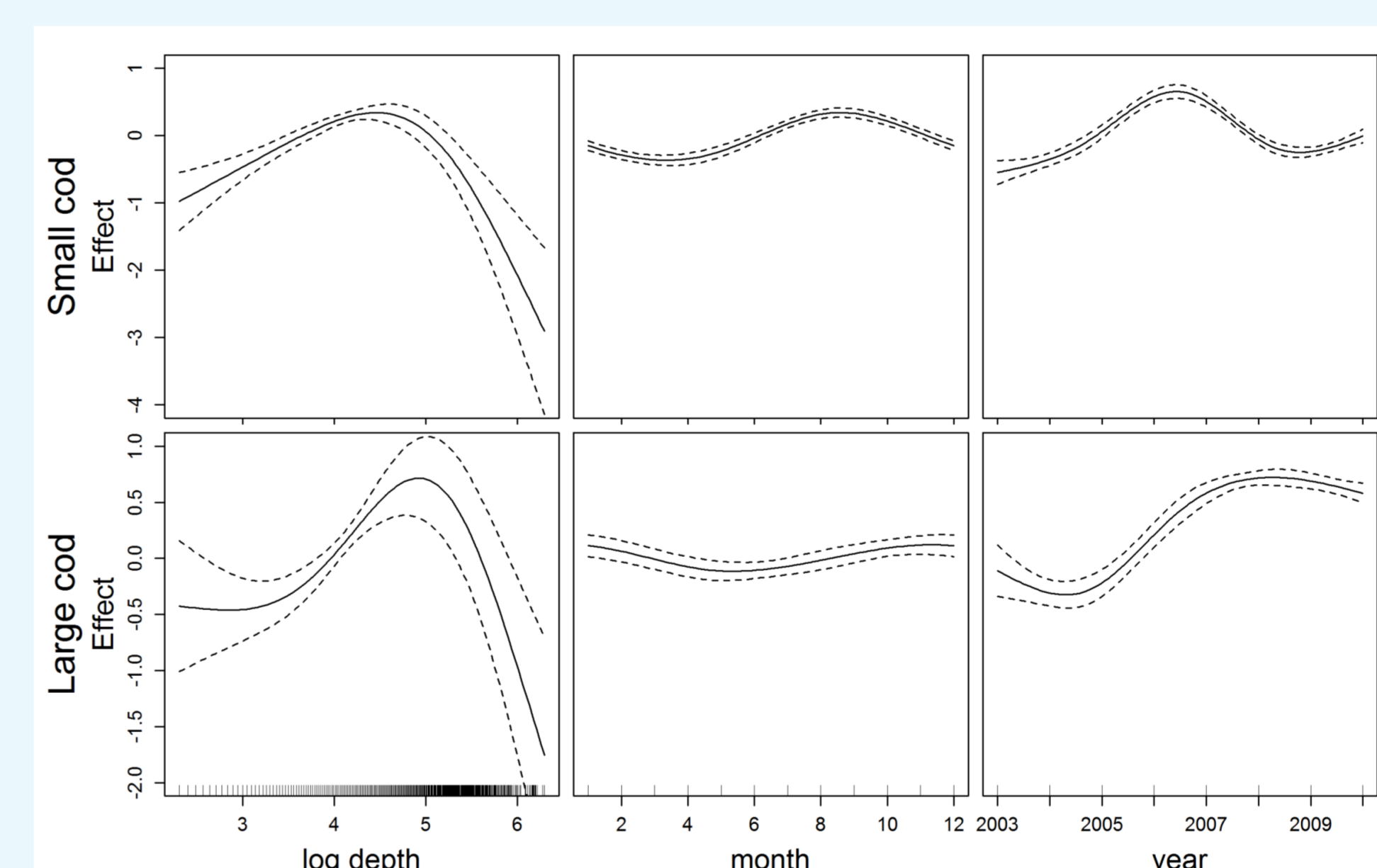

Fig. 2. Model predicted effects of significant smoothing functions (solid lines) on the discard rates of small (top row) and large cod (bottom row) in the North Sea, 2003 – 2010. Dotted lines represent the 95% confidence limits. Vertical bars along the x-axis indicate observational values.

Conclusions: Here we have described the spatiotemporal distribution of small and large cod discards throughout the entire North Sea and conclude that clear seasonal and inter-annual changes have taken place. Knowledge of the spatiotemporal distribution of discards provides valuable information for management. The mortality of cod imposed by discarding could be reduced by defining areas where the use of more selective fishing methods are mandatory and ensuring that vessels catching cod have sufficient quota to land it.

A ban on discards will likely face economic, regulatory, and political hurdles. Under a discard ban several issues emerge including: i) How to minimise the capture of juveniles and large cod for which there is no quota under a discard ban; ii) How to ensure discarding does not take place. The success of a discard ban will depend critically on complementary management measures addressing these issues.

Fig.1. Model predicted densities of small (upper panel) and large (lower panel) cod discards in North Sea 2003 – 2010.