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Evaluating the effect of fishery closures: Lessons learnt from the Plaice Box☆

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ABSTRACT

To reduce discarding of plaice *Pleuronectes platessa* in the North Sea flatfish fisheries, the major nursery areas were closed to large trawlers in 1995. The area closed was named the 'Plaice Box' (PB) and beam trawl effort fell by over 90%,while the exemption fleets of small flatfish beam trawlers, gill netters targeting sole (*Solea solea*) and shrimp (*Crangon crangon*) trawlers increased their effort. Contrary to the expectation, plaice landings and biomass declined. The initial support for the PB from the fisheries was lost, whereas other stakeholder groups claimed that any failure was due to the fact that fishing had never been completely prohibited in the area. To evaluate whether the PB has been an effective management measure, the changes in the ecosystem (plaice, demersal fish, benthos) and fisheries are analyzed to test whether the observed changes are due to the PB or to changes in the environment unrelated to the PB. Juvenile growth rate of plaice decreased and juveniles moved to deeper waters outside the PB. Demersal fish biomass decreased, whereas the abundance of epibenthic predators (*Asterias rubens* and *Cancer pagurus*) increased in the PB. Endobenthos, in particular the main food items of plaice (polychaetes and small bivalves) remained stable or decreased both inside and outside the PB. Currently catches of both plaice and sole from within the PB are lower than in the late 1980s and the exemption fleet often prefers to fish outside the Plaice Box alongside much larger competitors. It is concluded that the observed changes are most likely related to changes in the North Sea ecosystem, which may be related to changes in eutrophication and temperature. It is less likely that they are related to the change in fishing. This case study highlights the importance of setting testable objectives and an appropriate evaluation framework including both ecological and socio-economic indicators when implementing closed areas.

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1. Introduction

Marine Protected Areas are a potentially useful tool in fisheries management helping to achieve sustainable fisheries and reducing negative ecosystem impacts. This stems from their relative simplicity, ease of enforcement and intuitive logic. The perceived failures of traditional methods of fisheries management worldwide with declining stocks, overfishing, and general fleet overcapacity (Pauly et al., 2002; Worm et al., 2009) have also contributed to the clamor for Marine Protected Areas to be set up (Babcock et al., 1999; Kaiser, 2005; Laurel and Bradbury, 2006; Sumaila et al., 2000). Furthermore some recent studies have shown that, in comparison with other human maritime activities (e.g. oil and gas exploration, mineral dredging, and waste disposal) commercial fishing is by far the most important activity impacting marine ecosystems (Eastwood et al., 2007; Halpern et al., 2008; Röckmann, 2007).

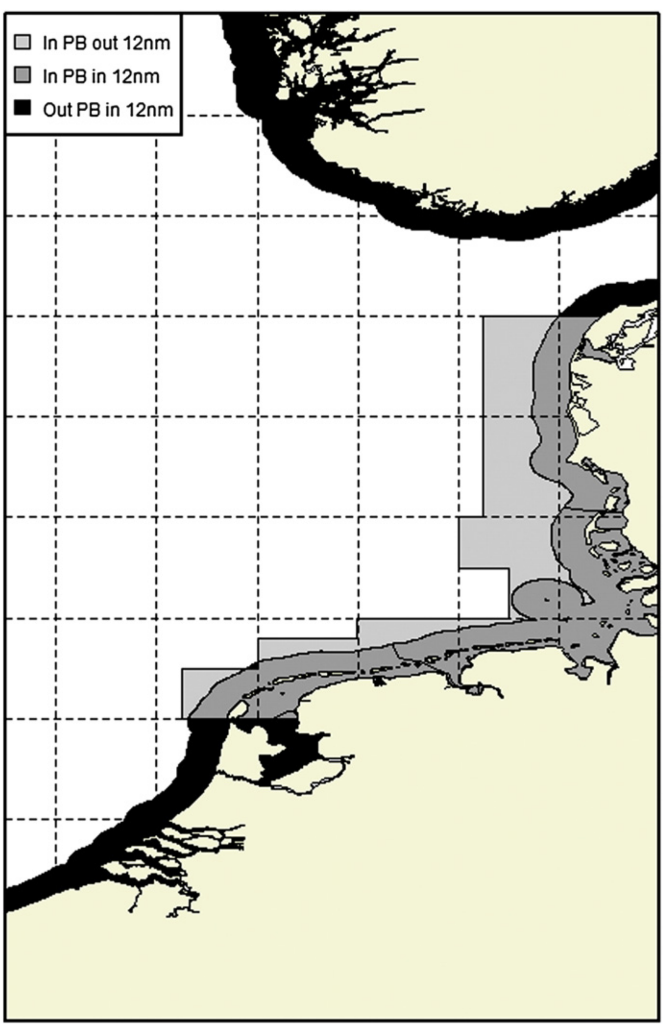

Fig. 1. Map of the Plaice Box and the areas used to assess its effect: (i) inside the PB and the 12 nm zone (in–in); (ii) inside the PB but outside the 12 nm zone (in–out); and (iii) outside the PB and inside the 12 nm zone (out–in); and (iv) outside the PB and outside the 12 nm zone (out–out).

In the context of sustainable fisheries management, modeling studies have shown that MPAs may be effective management instruments to reduce fishing mortality of exploited fish species or protect particular vulnerable life history stages (Hall, 1998; Hastings and Botsford, 2003; Miethe et al., 2010). MPAs are generally thought to influence fish stocks through two main mechanisms: "spill-over" and "export" (e.g. Gell and Roberts, 2003; Higgins et al., 2008). Spill-over is the net emigration of adults and juveniles across the reserve borders into the surrounding areas, while "export" assumes that when protected individuals reach maturity and spawn, their eggs and larvae will be carried to unprotected regions, supporting and enhancing populations outside the marine reserve boundary that may not have the same density of spawning adults (Gell and Roberts, 2003). Since dispersal characteristics and the scale at which dispersal occurs is largely unknown for many species (Carr and Reed, 1992; Gell and Roberts, 2003) export is often difficult to estimate. "Spill-over" will depend on the movements of the fish relative to the surface area of the MPA (Hall, 1998; Codling, 2008; Murawski et al., 2000; Higgins et al., 2008).

Empirical studies evaluating the performance of MPAs, however, are limited (Jennings, 2009; Vandeperre et al., 2011). There is compelling empirical evidence that MPAs have positive effects on fish species inhabiting tropical or temperate reef ecosystems, which have a rather sedentary life style (Claudet et al., 2006). The evidence for positive effects in temperate ecosystems, where fish species are characterized by seasonal migration patterns, is less clear. Positive effects of temperate MPAs have been observed in the northwest Atlantic, where large areas have been closed to fishing to protect depleted groundfish stocks and most, but not all, groundfish stocks recovered (Murawski et al., 2005). Recoveries in benthos and benthic habitats were also observed (Asch and Collie, 2008; Hermsen et al., 2003; Lindholm et al., 2004). A contrasting example is the Plaice Box (PB), an area in the North Sea that was partly closed to large (>221 kW) beam trawlers to reduce discarding of undersized plaice *Pleuronectes platessa* L. since 1989 (Fig. 1). Opposite to the expectation, the landings and biomass decreased since the establishment of the PB (Pastoors et al., 2000), resulting in a loss of credibility in fisheries management advice and a loss of support for Marine Protected Areas in general (Verweij and van Densen, 2010). The decrease in landings and stock, however, does not prove that the PB was unsuccessful, because the decrease might due to a deterioration in environmental conditions affecting the productivity of the stock. Hence for a proper evaluation of the PB and any closed area, we need to separate the effects of changes in fishing following the establishment of the closed area from the effects of changes in the environment that are not related to the area closure.

The difficulties in separating fishing from environmental impacts in the absence of reference areas can be overcome by combining modeling studies of key processes combined with empirical studies (Horwood et al., 1998; Kraus et al., 2009; Pastoors et al., 2000). The crucial question is the extent to which the establishment of a closed