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Mussel fishery affects diet and reduces body condition of Eiders *Somateria mollissima* in the Wadden Sea

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ABSTRACT

Although the Danish Wadden Sea is of international importance for several bird species, large-scale blue mussel *Mytilus edulis* fishing took place from 1984–1987, ceasing thereafter due to low mussel stocks. Mussel fishing removes much of the blue mussel biomass, especially larger individuals. Hence we predict that intensive mussel fishing will affect their predators, such as the Eider *Somateria mollissima*, which is predominantly a blue mussel feeder by, 1) reducing the amount of blue mussels in their diet relative to alternative prey items, 2) exploitation of smaller blue mussel shell classes, 3) loss of body condition, 4) changing feeding distribution to aggregate to the remaining mussel stocks, and 5) decreasing numbers. Before winter 1986/87 blue mussel biomass was estimated at 40,600 tons, decreasing to 15,400 tons in 1987/88 due to mussel fishery. We collected Eiders in both periods to monitor their diet and body mass and used aerial surveys to determine changes in numbers and distribution. Between the two periods, blue mussels declined in the Eiders diet, numbers of Eiders with empty stomachs increased and the mean length of blue mussel taken by Eiders decreased. Eider body condition declined from 1986/87 to 1987/88, mostly the result of the reduction in numbers of individuals with blue mussel remains in their gizzards and in better body condition compared to those taking alternative food items or having empty gizzards. Eiders shifted their distribution from the southern part of the Danish Wadden Sea to the northern part, where the remaining blue mussel stocks were situated. Eider numbers were lowest in 1987/88, the year of lowest blue mussel stocks. We conclude that intensive mussel fishery affected the Eider's diet, reduced their body condition and affected distribution and abundance. The results also showed that availability of blue mussels may have a key role in building up and maintaining body condition in Eiders during winter.

1. Introduction

Several bird species of conservational importance in the Wadden Sea, such as the Oystercatcher *Haematoepus ostralegus*, Red Knot *Calidris canutus* and Eider *Somateria mollissima* depend on a shellfish diet during the non-breeding season (Smit and Wolff, 1983). Human exploitation has the potential to deplete this food resource and affect bird populations, although detailed knowledge of the processes is weak (see Lambeck et al., 1996). Stillman et al. (2001) modelled impacts of shellfish fishing on predator species, using the Oystercatcher as a model species. When fishing pressure was low, the impact on non-target species may be low or even absent. When fishing pressure was high, the model predicted a shift in diet, a decrease in body mass and an increase in mortality of the predator species. Empirical studies support aspects of this latter scenario. Elevated mortality amongst Eiders, Oystercatcher and Red Knots was described as a consequence of intensive mussel and cockle fishery in the early 1990s and 2000s in the Dutch Wadden Sea (Camphuysen et al., 1996; Smit et al., 1998; Beukema & Cadée, 1999; Koffijberg et al., 2001; Camphuysen et al., 2002; Ens, 2006; Van Gils et al., 2006). From the Wash in Great Britain, studies have also shown that cockle fishery seriously affected Oystercatcher numbers (Atkinson et al., 2003; Atkinson et al., 2005). In addition to the direct effect on the bird fauna, dredging for shell fish also affect the non-target benthic fauna in both the short and long term (Piersma et al., 2001; Kraan et al., 2007).

This study focussed on the shellfish fishery in the Danish Wadden Sea and its effects on Eider. Blue mussels are the principal food item for Eiders; constituting 40–98% of their total diet in north-western Europe (Madsen, 1954; Swennen, 1976; Hilgerloh, 1999; Nehls, 2002), making the Eider a suitable candidate for this study.

A large-scale blue mussel fishery was established in the Danish Wadden Sea during 1984–1987 probably stimulated by reduced landings in the Netherlands, and consequently the relative high prices during 1986–1988 (Essink et al., 2005; Imeson and van der Berg,

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2006). In 1988, blue mussel stocks were seriously reduced and the fishery ceased due to lack of commercial sized mussels (>5 cm) (Kristensen and Borgstrøm, 2005). There is little information on blue mussel stocks and distribution during the first years of the intensive fishery, but observations from aircraft reveal that most fishing activity took place from Fanø and south to Rømø (Fig. 1), although activity was recorded in all areas between the mainland coast and the islands (NERI unpublished data). Mostly subtidal mussel banks were fished, but there were indications that also the littoral banks were used. The fishery removed a substantial part of the mussel biomass and especially the upper size classes (>5 cm) of blue mussels were taken. In response, we predicted that Eiders would 1) reduce the amount of blue mussels in the diet relative to alternative prey items, 2) take smaller mussel shell sizes (either because larger shell sizes are not available or they occurred in too low densities), 3) shift to sites where blue mussels stocks remained high, 4) exhibit reductions in mean body condition and 5) Eider numbers would decrease.

A precondition for these predictions is that the mussel fishery was so intensive that it removed a substantial part of the blue mussel biomass. The landed catch of blue mussels during 1980–1989 and estimations of the blue mussel biomass present in 1986–1989 in the Danish Wadden Sea shows that a large-scale mussel fishery developed during 1984–1987 (Fig. 2, Kristensen and Hoffmann, 2000). In 1987, about 70% of the total blue mussel stock was fished out and the biomass fell markedly to only 15,400 tons in 1988, when the mussel fishery collapsed due to the absence of commercially-sized mussels (Kristensen, 1994). These figures demonstrate the intensity of the blue mussel fishery that took place during 1984–1987, and that a substantial part of the biomass was removed. Thus it is reasonable to assume that the precondition for the predictions is present.

2. Methods

2.1. Study area

The Danish Wadden Sea is a Special Protection Area designated under the EU Birds Directive. The area is situated in south-west Denmark and comprises the northern 10% of the Wadden Sea, shared

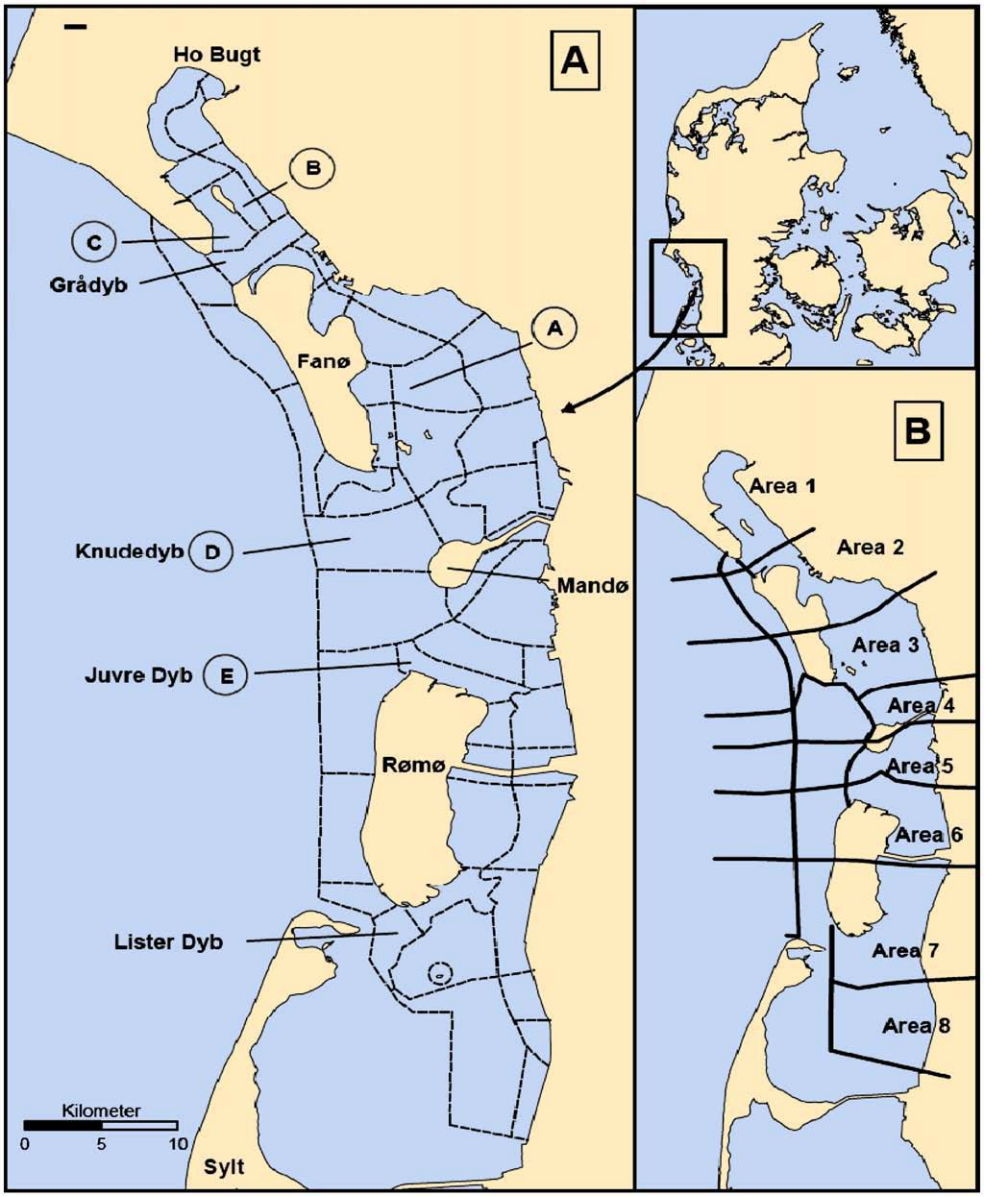

Fig. 1. A: Map of the Danish Wadden Sea with aerial survey-areas (broken lines) used for Eider counts. A–E indicate major sampling sites for Eiders collected for diet analysis. B: Eider numbers in sub-areas between the mainland coast and the islands were pooled into Areas 1–8.