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Effects of cockle abundance and cockle fishery on bivalve recruitment

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ABSTRACT

Understanding possible effects of cockle dredging on bivalve dynamics should include studies of the influence of cockle abundance on bivalve recruitment and of effects of fishery on survival of recruits present at the time of fishing and on future recruitments. Numerical densities of adult cockles and of recruits of *Cerastoderma edule, Limecola balthica* and *Mya arenaria* were monitored by twice annual sampling for 21 years (1973–1993) along 7 transects in the fished part of Balgzand, a 50-km^2 tidal flat area in the westernmost part of the Wadden Sea. Between-year variability in recruitment success in all 3 species was negatively correlated with adult-cockle abundance. Recruit densities as estimated in August were relatively low in years of cockle fishing in all of these species. This was so already well before fishing started in September. So these low densities were not an effect of fishery, but of the high cockle abundance that made cockle dredging profitable. The proportions of recruit numbers estimated in August (just before cockle dredging) that were still present half a year after fishing (in March) were not different between fishing and non-fishing years nor between fished and unfished areas in fishing years. Densities of new recruits in years following cockle-dredging somewhere in the area were not different from densities in years not preceded by any fishery nor were they lower at the fished sites in the year after fishing than in other years. The lack of significant influences of fishery in the studied area and period was observed in all 3 bivalve species. The above results were obtained in areas with relatively muddy sediments. Earlier reported negative effects of cockle-dredging on bivalve recruitment may be limited to the minority of tidal flats characterized by relatively coarse sediments with < 1% of silt.

1. Introduction

Cockle (*Cerastoderma edule)* abundance may exert positive or negative influences on recruitment success of their own spat and of that of other bivalve species. Donadi et al. (2014) found a positive effect of experimentally introduced cockles on cockle recruitment by sediment stabilization in sandy areas with high wave and current energy. On the other hand, Flach (1996, 2003) found a negative effect of experimentally introduced cockles on recruitment of *Cerastoderma edule, Limecola (Macoma) balthica, Mya arenaria* and other species caused by sediment disturbance produced by crawling and shaking behavior of adult cockles. Moreover, bivalve larvae are consumed by adult cockles (André and Rosenberg, 1991). The stock-recruitment relationship presented by Hancock (1973) for 20 years of observations suggest lower cockle recruitment at higher densities of older cockles. Such negative relationship was found also by Beukema (1982) and Van der Meer et al. (2001). Therefore, several studies suggest an influence of the size of the adult-cockle stock on recruitment of bivalves and this influence appears to be negative in most areas.

Various effects have been reported of shellfish fishery on recruit densities of bivalves. De Vlas (1987) found that 10 to 50, 5 to 30, and 10 to 60% of the recruits of *C. edule, L. balthica,* and *M. arenaria*, respectively, were killed within the fishing tracks during mechanical cockle dredging. Recruitment success in the year after fishing was not different between fished and non-fished areas in all 3 species (De Vlas, 1982). Hiddink (2003) observed a similar lack of effect of cockle dredging on recruitment of *C. edule* and *L. balthica*. Piersma et al. (2001), however, concluded that recovery of bivalve recruitment after cockle fishing would take some 8 years. Similar negative effects of cockle dredging were suggested by Kraan et al. (2007), (2011) and by Compton et al. (2016).

The aim of the present study is to analyze a series of data gathered during > 20 years in a tidal-flat area (Balgzand) in the Wadden Sea on abundance of cockles and recruitment of some important bivalves (*C. edule, L. balthica* and *M. arenaria*). In part of these years, fishing for cockles (or mussels) took place in parts of the study area. Recruitment is defined as the numerical density (n m^{-2}) of 0-group bivalves as estimated in August. We hypothesize that the numbers of recruits were reduced in years with high adult-cockle abundance and in years with cockle fishery, that fishery negatively affected the survival of stocks of

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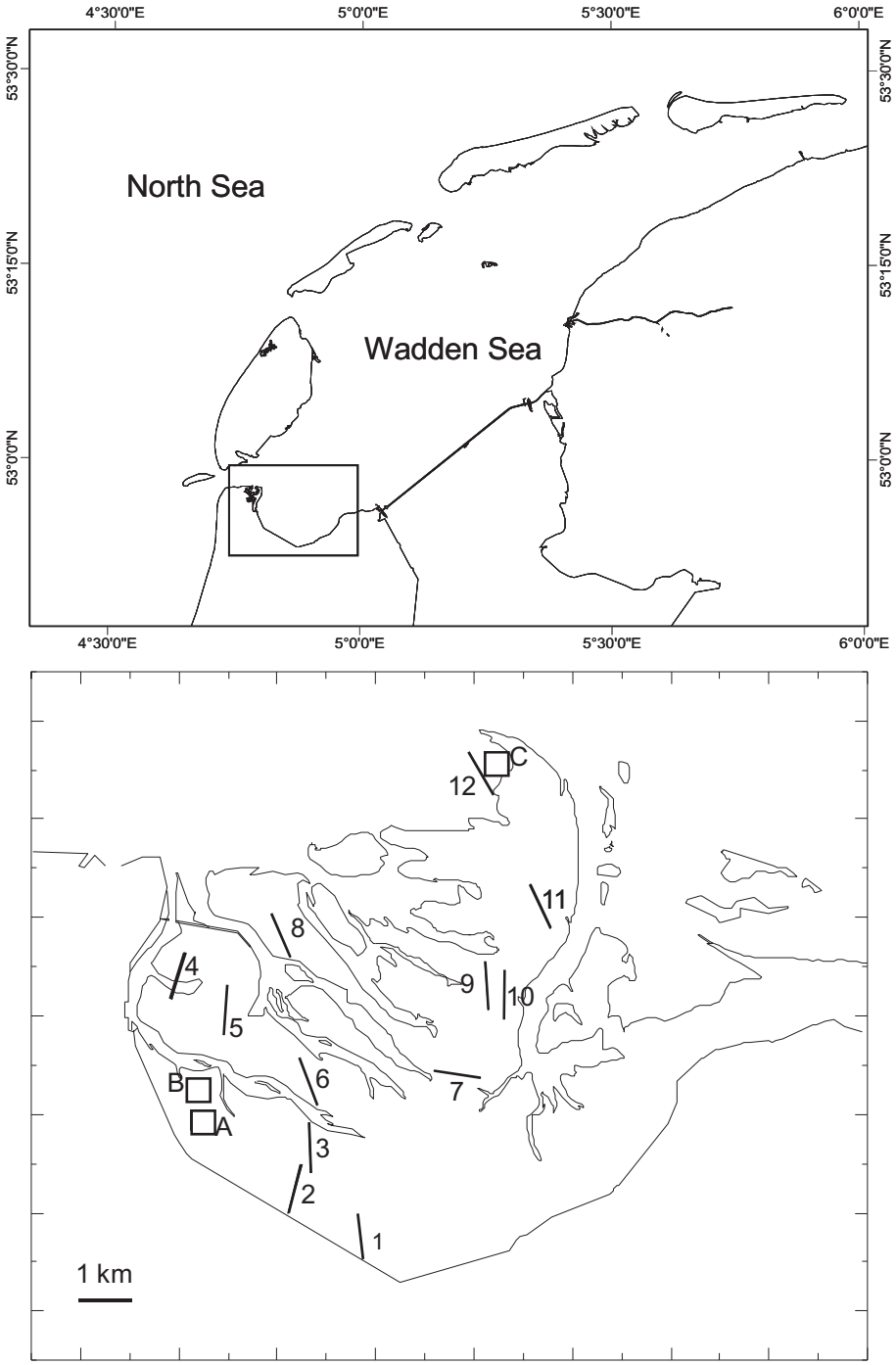

Fig. 1. Map of (top) the westernmost part of the Wadden Sea and (bottom) the tidal-flat area called Balgzand. The permanent sampling sites are indicated: 12 transects (numbered 1–12) and 3 squares (A, B, and C). Shellfish fishery took place particularly in the central part of the area (at transects 4, 5, 8, 9, 10, and 11) and also incidentally in the northern part (at transect 12).

bivalve recruits that were present at the time of fishing and that bivalve recruitment was reduced in a year that followed a fishery year.

2. Methods

2.1. Study area and period

We studied bivalve dynamics at a 50-km^2 tidal flat area called Balgzand, where we sampled the macrozoobenthos ever since the 1970s at 15 permanent stations (Fig. 1). Details on the environmental conditions and fauna of the 15 sampling stations can be found in Beukema and Cadée (1997). Balgzand is located in the westernmost part of the Wadden Sea, at about 53° N and 5° E. Cockle dredging was detected directly by spotting fishing vessels or fishing tracks left behind in the sediment, which can persist for several months, or indirectly from strong (> 75% within half a year) local declines in numbers of adult cockles that could not be explained otherwise. Shellfish fishing was almost restricted to the central part of Balgzand, covering parts of 7 sampling transects, numbered 4, 5, 8, 9, 10, 11, and 12 (Fig. 1). These transects were hit by fishery in 1, 2, 4, 3, 3, 6, and 1 years, respectively. Mud (clay + silt particles of < 60 μm) percentages at these sites amounted to 2–10% at transects 4 and 5, to 1–3% at transects 8, 9, 10,