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The effects of shoreface nourishments on *Spisula* and scoters in The Netherlands

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ABSTRACT

The coast of The Netherlands is protected by nourishing sand. Generally, two different techniques are used, beach nourishment and shoreface nourishment. The latter technique supplies sand at a water depth of about 5–8 m in the surf zone, and has been used on a regular basis since 1997 with increasing volumes since 2001. Observations on the bivalve mollusc *Spisula subtruncata* that was abundant before 1997 and a key food species for wintering seaduck show a decline since 2001. This coincided with a decrease in the abundance of the Common Scoter *Melanitta nigra*, the most numerous wintering seaduck off the Dutch coast. These observations raised concern about shoreface nourishments. This study analyses the timing and locations of shoreface nourishments in combination with *S. subtruncata* abundance and spatial distribution. Against the expectation, no causal relationship was found between the decline of *S. subtruncata* and shoreface nourishments. Other causes, such as climate change, fisheries, unsuccessful settlement or predation of spatfall are more likely behind the decline of *Spisula* along the Dutch coast.

1. Introduction

In The Netherlands, coastal protection offered by beaches and dunes is maintained by nourishing sand. At first, this was achieved by supplying sand directly onto the beach but later shoreface nourishment became the preferred technique (Roelse, 2002; Grunnet and Ruessink, 2005; Klein, 2005; Steijn, 2005) Shoreface nourishment supplies sand in between the outer breaker bars along the coast, or offshore from the outer bar, at water depths of about 5–8 m. The supplied sand moves gradually towards the coast by the natural action of waves and currents, re-establishing the original coastline prior to erosion (Van Duin et al., 2004). Since 1997, shoreface nourishments are applied regularly and since 2001 increased volumes of sand have been supplied, Fig. 1.

Sand nourishments can affect the ecosystem in various ways (Van Dalfsen and Essink, 1997; Speybroeck et al., 2006). Direct effects are the burial of benthic species under a layer of sand. In the direct vicinity, suffocation of benthos can occur due to the settling of a plume of suspended particles. A plume of fine particles may also affect primary production and the foraging success of filter–feeding benthos, fish and birds. In addition, there might be disturbance by noise and ship manoeuvering. Indirect effects are habitat change, such as altered morphology and sedimentology. This may also change habitat characteristics such as penetrability, compactness, and organic matter and silt content.

In 1993, a shoreface nourishment was applied as large-scale pilot experiment along Terschelling. Possible ecological effects were extensively monitored (Tydeman, 1994; Van Dalfsen and Oosterbaan, 1996; Van Dalfsen and Essink, 1997). It was concluded that there were mainly short-term, local effects as a result of burial of benthic species. A recovery of the benthic fauna was reached after two years, with the exception of long-lived species of molluscs and echinoderms. Particular attention was paid to *Spisula subtruncata*, a bivalve that formed the staple food source for the Common Scoter (*Melanitta nigra*) (Leopold et al., 1995; Degraer, 1999; Degraer et al., 2007). *S. subtruncata* is found primarily in fine sands of about 200 μm in the lower shoreface at water depths of about 5–20 m (Baptist et al., 2006; Craeymeersch and Perdon, 2006; Degraer et al., 2007). In their study, Van Dalfsen and Essink (1997) gave a warning: "[...] shoreface nourishment may very well strike important *Spisula* banks, and then pose a serious risk to the survival of wintering seaducks".

Spisula surveys in Dutch coastal waters have been conducted since the 1990s (Leopold, 1996; Craeymeersch and Perdon, 2006). *Spisula* was very abundant along large parts of the Dutch coast in the 1990s, but during the period 2000–2005 numbers declined. The total biomass in 2005 was the lowest found since 1995, and has only slightly increased in later years (Craeymeersch and Perdon, 2006; Goudswaard et al., 2008). The decline in total *Spisula* abundance coincided with the increase in shoreface nourishments, Fig. 1. Moreover, the numbers of overwintering Common Scoters also showed a decline in recent years, Fig. 2. This raised concern about the ecological effects of shoreface nourishments, particularly after the warning of Van Dalfsen and Essink (1997).

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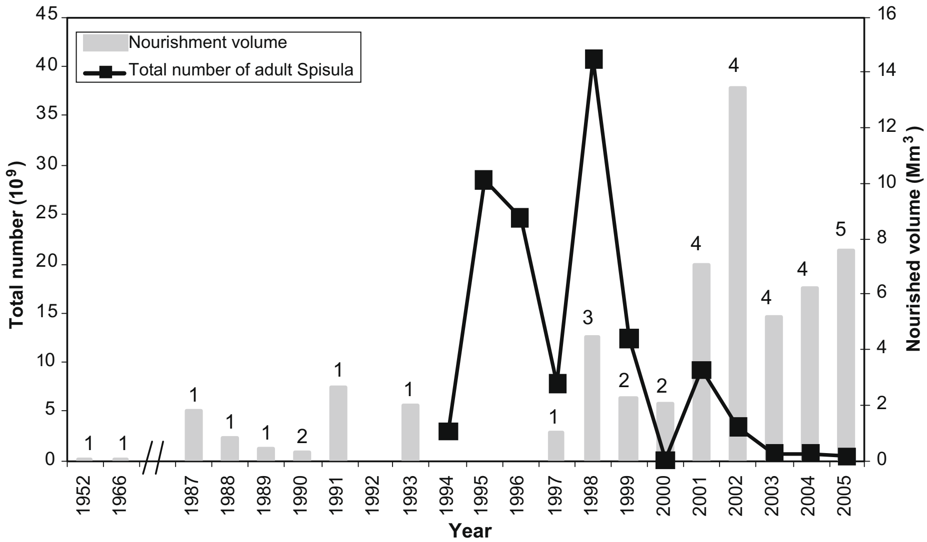

Fig. 1. Total number of adult *S. subtruncata* (solid line, left axis) and the nourished volume of sand (bars, right axis) for the entire Dutch coast. Number of nourishments per year above the bars. Data courtesy of the National Institute for Coastal and Marine Management.

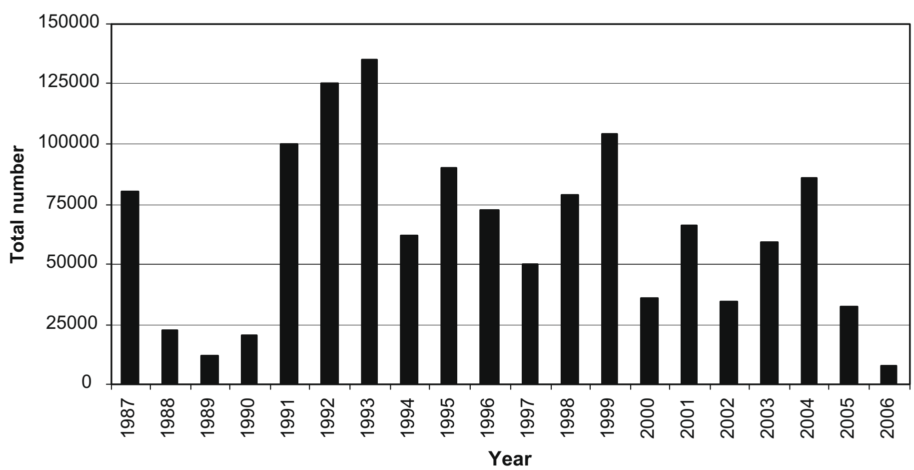

Fig. 2. Winter maxima of abundance of Common Scoter (*M. nigra*) along the entire Dutch coast. Data courtesy of the National Institute for Coastal and Marine Management/RIKZ, IMARES, NIOZ and Dutch Seabird Group.

There is no statistically significant correlation between declining *Spisula* abundance and increasing nourishment volumes (for untransformed data 1994–2005: $r = -0.33$, one tailed probability = 0.14). However, the coincidence implies a possible causal relationship. Therefore, this study aims at assessing the timing and locations of shoreface nourishments and their relation with the spatial and temporal distribution of *S. subtruncata* and the consequences for the Common Scoter.

2. Materials and methods

We first made an inventory of underwater sand nourishment projects, gathering data on their location, extent, date, type and volume, Table 1. Sand nourishments below the water surface were already applied before the pilot experiment in 1993, but these were *channel slope* nourishments instead of shoreface nourishments (Roelse, 2002). Shoreface nourishments are applied to feed the morphologically active breaker bar system in front of beaches in order to shift the coastline seawards. Channel slope nourishments were applied to halt onshore migration of tidal gullies. In recent years, shoreface nourishments became more and more common along the Holland and Wadden coasts, Fig. 3.

Two data sets of *Spisula* surveys have been combined. One set is a yearly *Spisula* survey of the National Institute of Fisheries Research (RIVO), now Wageningen Institute of Marine Resources and Ecosystem Studies (IMARES), which covers the entire Dutch coast from 1995 onwards. Yearly in April and May, more than 800 bed samples are taken, with a sample area of 15 m^2 for the majority of the samples (Craeymeersch and Perdon, 2006). Bed samples were taken with a bottom cutting dredge, with the exception of the Voordelta where a small suction dredge was used (Craeymeersch and Perdon, 2006). The second data set consists of surveys carried out by the Institute of Forest and Nature Research (IBN-DLO), now IMARES as well, from 1994 to 1999. The latter surveys focused mainly on the northern coast of The Netherlands and were carried out with a Van Veen grab (Leopold, 1996). The combination of both sets resulted in maps of *Spisula* densities along the Dutch coast down to −20 m Dutch Ordnance Level (NAP) from 1994 onwards. In the years before 1994 some smaller surveys have been carried out (Craeymeersch, 1992; Leopold, 1993) and