THE BENTHIC SHIFT IN THE FRISIAN FRONT ECOSYSTEM – POSSIBLE MECHANISMS

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Annual monitoring of the bottom fauna living at the Frisian Front (southern North Sea) has shown a shift from a stable state dominated by the britllestar Amphiura filiformis to another stable state dominated by the burrowing mud shrimp *Callianassa subterranea*. Due to this shift, a substantial increase of the bottom roughness, especially in the summer, is expected. Resuspension of silt increases, which makes the habitat unfavourable for the restoration of an *A. filiformis* population.

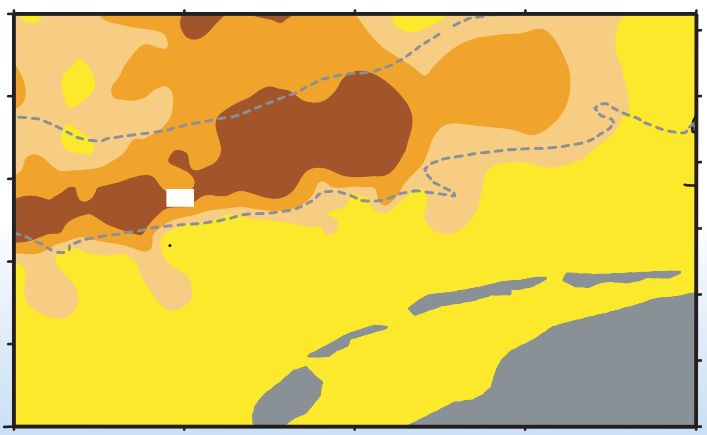
From brittle star to mud shrimp population

The Frisian Front is situated about 40 miles north of Texel at the southern edge of the Oyster Ground. It is known as a rich area with a high level of biological productivity. It is positioned at the transition between the shallow waters of the Southern Bight (25 m depth) and the deeper water of the Oyster Ground (depth >35 m). The coastal waters are well mixed all the year round, but a vertical layering occurs in the Oyster Ground between May and October, with a warm surface layer (up to 20ºC) developing above a cold lower layer (≈ 12ºC) during summer. Many nutrients become available as fuel to promote the growth of algae, forming the basis for the biological productivity in and on the seabed of the Frisian Front.

In the period 1992-1997, the populations of the brittle star (*Amphiura filiformis)* and the mud shrimp (*Callianassa subterranea),* underwent striking changes. In 1992, the density of brittle stars was at its peak, at 1750 per m^2. At that time, the population consisted primarily of adults. After a 10-year period of high densities, the population decreased to a density of 100 per m^2. In the meantime, the numbers of mud shrimps, which live in tunnels in the seabed, increased from about 40 per m^2 in 1992 to more than 300 per m^2 in 2000 and following years. The seabed ecosystem of the Frisian Front seems to have moved from one stable situation to another. Apparently, ecosystems can have more than one stable situation.

Sediment stability

Laboratory experiments showed that high brittle star densities lead to a sticky sediment, less vulnerable to erosion by currents than a seabed dominated by mud shrimps. Mud shrimps produce piles of sediment that are easily resuspended by turbulence. The shift from a community dominated by *A. filiformis* to *C. subterranea* might have aggravated the resuspension and turbidity at the Frisian Front. The effect of *C. subterranea* seems to be even more pronounced when northerly and west-



White box: Location of the Frisian Front

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erly winds are above 10 m/s (Bft 6). Erosion might prevent planktonic larvae of *A. filiformis* to settle or cause that settled stages are transported away. In contrast, *C. subterranea* lives deep in the sediment and is hardly affected by resuspension. It is hypothesized that resuspension of bottom material affects the quality of food for benthic filterfeeders like *A. filiformis*. This may affect their condition and survival and lead to a reduced reproductive output. The change in sediment conditions keeps the community in its present state and prevents the recovery towards the former situation. Once initiated, this shift in the abundance of the two species might have developed a persistent character. Given the negative impact of resuspension and turbidity on seston feeders in general, it appears unlikely that the *A. filiformis* population will be restored. Since *A. filiformis* and Thalassinid shrimps like *C. subterranea* and *Upogebia* spp., are likely to compete for the same food source, a recovery of *A. filiformis* is also hampered by concurrence.

The cause

Although we identified possible reasons for the apparent stability of the two contrasting states, it was not possible to clarify what factors initially caused the decrease and increase of *A. filiformis* and *C. subterranea* populations, respectively. Trawl fishing is intensive in the area. In general the passage of demersal fishing gear flattens the contours of the sediment surface and can severely damage the burrows or tube systems of the infauna. It is likely that commercial bottom trawling affects the composition of the benthic community. However, the decrease in abundance of *A. filiformis* took place over a period of 5 years (1992-1997). The Frisian Front has been fished for many years before that period, without any effect on the *A. filiformis* population. So this makes it an unlikely trigger for the observed shift. Another explanation for the shift may be found in the population structure of *A. filiformis* itself. During the time that the species was abundant (1982 to 1992) there were only very few juveniles. So, it could be that when the adult population started to die off the few juveniles were not able to restore the population. This might have opened the way for other organisms, with the mud shrimp eventually coming out as the winner.

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Amphiura filiformis

Callianassa subterranea