

Preface and acknowledgements

Intertidal mudflats, sandbanks and shallow subtidal sediments are an important component of estuaries and they fringe large areas of the European coastline. Together with salt marshes and mangroves, they form natural barriers which protect coastal areas from the sea by reducing erosion and attenuating the energy of storm surges. The removal of these natural coastal defences can have devastating consequences, as shown in August 2005 after the passage of hurricane Katrina over the Gulf coast of the United States.

Intertidal and subtidal sediments are also biologically highly productive areas, representing important nursery and feeding grounds for higher organisms including birds, fish and shellfish. Dense concentrations of wading birds in particular are attracted by the rich supply of food, chiefly sediment-dwelling invertebrates, which in turn depend upon the presence at the sediment surface of a diverse assemblage of phototrophic microalgae (*microphytobenthos*¹). Microphytobenthos supply organic matter to the ecosystem by the process of photosynthesis, and also influence nutrient fluxes in and out of the sediment. The microphytobenthic assemblages are most frequently dominated by diatoms, with other micro-organisms such as cyanobacteria and euglenoids found in lesser numbers. Up to 50% of primary production in estuaries can take place on sediments, despite the fact that the microalgal cells are only active in a thin surface layer of the sediment subject to rapid fluctuations in light, temperature and salinity. Although microphytobenthos activity is restricted to the uppermost surface sediment layer, they have a large impact on whole estuary morphology and ecosystem functioning. In addition to their impact on sediment chemistry and benthic-pelagic nutrient exchange, diatoms together with their associated communities of bacteria and animals can produce copious amounts of extracellular polysaccharides. These sticky substances can bind and trap sediment particles and cause the formation of cohesive surface biofilms that eventually become strong enough to stabilise the mudflats against erosion. In this way microphytobenthos can influence the morphology of coastal zones, and play an important role in the sediment balance of estuaries. Thus, microphytobenthos exerts its effect over a range of different spatial scales going from the hundred micron thick photic zone where photosynthesis occurs, to the scale of whole estuaries of many square kilometers where biofilms are able to influence the shape of the coastline.

¹ commonly called *microphytobenthos* (*MPB*) in Europe, and *benthic microalgae* (*BMA*) in the United States and elsewhere

In spite of the important roles that microphytobenthos play in estuarine environments, research on the physiology and ecology of these organisms is still at an early stage. For example it is apparent that benthic diatom species differ from phytoplanktonic diatoms in their photosynthetic responses, ability to move, and in a greatly increased resistance to environmental stressors such as ultraviolet radiation. However, the biochemical and genetic mechanisms underlying these differences are not known. At the ecosystem level, the contribution of microphytobenthos to the dynamics of estuaries is apparent, but integration of biological processes with hydrodynamic models of sediment movement has rarely been attempted. This is partly because of the highly dynamic nature of estuarine ecosystems and partly because of the extremely complex interplay between biological, physical and sedimentological processes. An interdisciplinary approach is clearly needed in order to come to a more thorough understanding of these processes. Almost all estuaries now have multiple, conflicting uses: important transport hubs such as container ports are located next to sites for migratory birds to rest and forage, excess nutrients from the land are deposited in the same waters that commercial fish stocks use as spawning grounds. Our ability to monitor the status of these ecosystems and to manage the multiple functions of estuaries in a sustainable manner will definitely require a more holistic approach. Therefore to facilitate exchange of ideas in the diverse fields of evolutionary ecology, ecophysiology, benthic ecology, sedimentology, and coastal zone management a colloquium was organised in Amsterdam in August 2003. Fifty leading scientists attended, and the contributions of many of the speakers can be found in this book. The meeting was financed by the Royal Netherlands Academy of Arts and Sciences (KNAW) and we are very grateful for their sponsorship and logistical support.

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The symposium was organised around eight central themes, each with three speakers and followed by a discussion session. Additional round-table discussions were held for the exchange of views on several 'hot topic' themes in which there is currently division of opinions, or in which the introduction of new methods has caused a rethink of old ideas. These themes were 'Biodiversity of microphytobenthos' in which the classical and modern taxonomic methods were discussed. 'Methods for estimating microphytobenthic biomass and primary production' debated the wide variety of methods developed for sampling in a spatially heterogeneous environment, and the difficulties of comparing photosynthetic measurements between sites and studies, and participants in 'Quantification and definitions of extracellular polymeric substances' discussed the problems of extraction and nomenclature of different extracellular fractions produced by microphytobenthos. The submitted papers are arranged in this volume in the original sequence of the symposium, beginning with studies of microalgal genetics and ecophysiology, through to holistic works on ecosystem modelling and socioeconomic perspectives.

(I) *Taxonomy, evolution and biodiversity of microphytobenthos*

Diatoms are the most important functional group within the microphytobenthos, but the taxonomy of this group is currently in a state of flux since the introduction of molecular classification methods in the 1990s. The paper by Linda Medlin describes the evolutionary history of diatoms, explains the most recent classification system for these algae based on DNA sequences and morphological studies, and describes the relationships between benthic diatoms and other diatom clades.

(II) *Photosynthesis in marine diatom assemblages*

Two papers are presented in this section: the paper by Jacco Kromkamp and Rodney Forster gives an overview of the methodologies used to measure biomass, photosynthesis and primary production of microphytobenthos (MPB). Photosynthetic physiology is described and the most frequently used variants of oxygen evolution and radiocarbon-based methods are described. The use of variable fluorescence techniques is covered in detail, and procedures (and precautions) are given for conversion from fluorescence-based measurements of electron flow to more conventional units of carbon fixation. The paper by Ronnie Glud describes the use of microsensor techniques to measure photosynthesis, particularly in subtidal sediments. Also the recent application of planar optodes is discussed which gives unparalleled 2D-information on O₂-fluxes.

(III) *Extracellular Polymeric Substances: function and role in mudflats*

In this section Jody de Brouwer *et al.* review the origin, structure and function of extracellular polymeric substances. The composition of EPS extracted from laboratory cultures of diatoms is compared to material from natural sediments. The focus lies on the difficulties of obtaining good samples, understanding the complexity of EPS and the need for better definitions.

(IV) *Use of stable isotopes in foodweb research*

It is well known that microphytobenthos can be an important foodsource for meiofauna. The paper by Kevin Carman *et al.* explores the role of MPB as foodsources in relation to temporal variation in MPB availability for different copepods using stable isotope signatures of both C and N.

(V) *Upscaling primary production*

There is a large mismatch between the scale and frequency at which samples are taken during field measurements, and the need for results at much greater scales. For example, photosynthetic rates measured at only one time during the day are frequently used to predict rates of primary production for the whole of that day. In this section, Gerard Blanchard *et al.* investigate short term dynamics in MPB biomass, and modelling results indicate that loss rates will balance productivity. Lawrence Cahoon reviews (the lack) and uncertainty of regional and global estimates of primary production. Finally, Rodney Forster and Jacco Kromkamp use different approaches to model net primary production and propose a method using remote sensing data to map primary production at the whole estuary scale.

(VI) *Microphytobenthos and benthic-pelagic exchange*

Two papers are presented in this section: Graham Underwood and Mark Barnett use a statistical approach to investigate the relationship between nutrient availability and other abiotic variables and species composition. Jay Pickney takes an

ecosystem approach to study nutrient dynamics in order to understand interannual variation in nutrient concentrations in Galveston Bay, Texas.

(VII) *Mudflat ecosystem models*

Two very different contributions are presented in this section. The paper by Laurent Seuront and Céline Leterme investigates the mechanisms and scale relationships behind the patchiness in MPB biomass distribution. The paper by Jean-Marc Guarini *et al.* proposes an integrated model which simulates local dynamics in MPB biomass and primary productivity based on physiological behaviour and changes in the abiotic environment.

(VIII) *Mudflats and socioeconomics*

Two papers are presented in this section: eutrophication of estuaries by agriculture is a well known phenomenon, usually with deleterious consequences. Increased nutrient inputs may increase turbidity in the water column, and cause blooms of opportunistic macroalgal species, with resulting negative effects on faunal biodiversity. However, the link between processes on land, and biological processes in the estuary has rarely been researched. The role of farming strategies and awareness of farmers of their role in the context of ‘nitrate vulnerable zones’ is investigated in the paper by Colin Macgregor. Carsten Brockmann *et al.* investigate the use and its implementation of remote sensing as a tool for monitoring and managing of estuarine ecosystems.

We hope you enjoy this special book about the role of microphytobenthos in estuarine ecology.

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