The 4th Nereis Park Conference
7th-10th July 2014, Plymouth Marine Laboratory

Does bioturbation of chironomids increase or decrease phosphorus release from lacustrine sediments?

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ABSTRACT

The strong impact of the non-biting midge larvae, i.e. *Chironomus plumosus* (L.,1758), on phosphorus (P) release from the lacustrine sediments was shown more than 40 years ago. Traditionally, scientists assume that chironomids increase P release from sediment via increasing organic matter decomposition and by enforced fluxes across the sediment- water interface. At the same time iron oxidation in the walls of the larval burrows might lead to fixation of dissolved P. In few instances scientists observed, contrary to expectations, that Chironomidae bioturbation decreases P concentrations in the overlying water. We assume that the impact of chironomid larvae on P retention/release depends on the chemical composition of the sediment, particularly on content of iron and sulphure and their relation. To test this assumption we conducted several mesocosm experiments and varied sediment composition (iron content), composition of the overlying water (sulphate and phosphate concentration) and chironomid densities. First result indicate clear impacts of larvae and sediment composition on P cycling.

The 4th Nereis Park Conference

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Incorporating functional biodiversity as bioturbation in models to predict benthic biogeochemical cycling

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ABSTRACT

Coastal marine systems are currently subject to a variety of anthropogenic and climate-change induced pressures. An important challenge is to predict how marine sediment communities and benthic biogeochemical cycling will be affected by these ongoing changes. To this end, it is of paramount importance to first better understand the natural variability in coastal benthic biogeochemical cycling and how this is influenced by local environmental conditions and faunal biodiversity. Here, we studied sedimentary biogeochemical cycling at 10 coastal stations in the Southern North Sea on a monthly basis from February until October 2011. We explored the spatio-temporal variability in oxygen consumption, dissolved inorganic nitrogen and alkalinity fluxes and estimated rates of nitrification and denitrification from a mass budget. In a next step, we statistically modeled their relation with environmental variables and structural and functional macrobenthic community characteristics.

Our results show that the muddy sediments were poor in functional macrobenthic diversity and displayed intermediate oxygen consumption rates, but the highest ammonium effluxes. These muddy sites also showed an elevated alkalinity release from the sediment, which can be explained by the elevated rate of anaerobic processes taking place. Fine sandy sediments were rich in functional macrobenthic diversity and had the maximum oxygen consumption and estimated denitrification rates. Permeable sediments were also poor in macrobenthic functional diversity and showed the lowest oxygen consumption rates and only small fluxes of ammonium and alkalinity. Macrobenthic functional biodiversity as estimated from bioturbation potential appeared a better variable than macrobenthic density in explaining oxygen consumption, ammonium and alkalinity fluxes. However, this importance of functional biodiversity was manifested particularly in fine sandy sediments, to a lesser account in permeable sediments, but not in muddy sediments. The strong relationship between macrobenthic functional biodiversity and biogeochemical cycling in fine sandy sediments implies that a future loss of macrobenthic functional diversity has important repercussions for benthic ecosystem functioning.

Provisional theme: Integration of bioturbation into models

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Top-down and bottom-up interactions indirectly mediate interference effect of the bioturbator *Macomona liliana* on meiobenthos communities in a sand flat ecosystem

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ABSTRACT

The loss or decline of key species can instigate a cascade of effects that have implications for interacting species, therewith impacting biodiversity and ecosystem functioning. We examined how top-down and bottom-up interactions may determine knock-on effects of a coastal deposit-feeding clam, *Macomona liliana* (hereafter *Macomona*), on sandflat meiobenthos densities. Therefore we manipulated densities of *Macomona* in combination with predator exclusion and experimental reduction in benthic microphyte biomass in a sandflat ecosystem. We show that *Macomona* regulated densities of meiobenthic (38 – 500 µm) nematodes, copepodes, polychaetes, turbellarians, and ostracodes during the three months of incubation via indirect mechanisms. Our experiment revealed empirical evidence that predator pressure on *Macomona* by eagle rays (*Myliobatis tenuicaudatus*) has a negative effect on meiobenthos densities. In contrast, the loss of *Macomona* facilitation of microphytobenthos biomass through experimental shading resulted in an increase of meiobenthic taxa densities. We suggest that the latter mechanism can be explained by the release from bioturbation interference effects of the cockle *Austrovenus stutchburyi* that was found to strive in the presence of *Macomona* under ambient (non-shaded) conditions. Our results highlight the importance of interactions between macrofaunal bioturbation, microphyte biomass, sediment stability, and predation pressure for the structuring of benthic communities. This experiment illustrates that manipulative field experiments may be particularly suitable to study such multiple indirect mechanisms of that regulate ecosystem diversity and related functioning because such approaches may best capture the complex feedbacks and processes operating over different space and time scales that determine ecosystem dynamics.

Provisional session:
Impact of environmental change on bioturbators and bioturbation rates

Long-term effects of multiple stressors on infaunal behavior and ecosystem function

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ABSTRACT

Many of the anthropogenic and climate-change-induced pressures that ecosystems face, reflect gradual forcing that extend over longer time scales (months, years or decades). Yet conclusions on the biological, ecological and biogeochemical responses of marine benthic systems to biotic and abiotic drivers of change are largely based on the findings of short-term (days – weeks) experiments that have investigated the effects of single drivers of change. Whether marine organisms are able to maintain biological processes and ecosystem functioning over long time scales remains an open empirical question. Here, I briefly summarize present understanding of the effects of key environmental drivers on benthic species behavior, ecosystem process and functioning, before presenting data from an 18-month investigation of the effects of exposure to warming and ocean acidification. Specifically, I present data from two functionally important benthic invertebrates (brittlestar *Amphiura filiformis*; nereid polychaete *Alitta* (*Nereis*) *virens*) simultaneously exposed to three levels of atmospheric CO_2 concentration (380, 750, 1000 ppm) and two temperature regimes (ambient and ambient + 4°C). I show that responses associated with surviving in an acidified and warmer ocean are species-specific and manifest over time through changes in growth, bioturbation and bioirrigation behavior that, in turn, affect nutrient generation. Importantly, these changes are closely linked to seasonal variation in environmental conditions (temperature and photoperiod), which either exacerbate or buffer the effects of long-term climatic forcing. Collectively these findings have implications for assigning species into functional response groups and for those attempting to forecast the likely ecological consequences of climatic forcing.

Long-term effects of multiple stressors on infaunal behavior and ecosystem function

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[1]Ocean and Earth Science, University of Southampton, National Oceanography Centre

ABSTRACT

Many of the anthropogenic and climate-change-induced pressures that ecosystems face, reflect gradual forcing that extend over longer time scales (months, years or decades). Yet conclusions on the biological, ecological and biogeochemical responses of marine benthic systems to biotic and abiotic drivers of change are largely based on the findings of short-term (days – weeks) experiments that have investigated the effects of single drivers of change. Whether marine organisms are able to maintain biological processes and ecosystem functioning over long time scales remains an open empirical question. Here, I briefly summarize present understanding of the effects of key environmental drivers on benthic species behavior, ecosystem process and functioning, before presenting data from an 18-month investigation of the effects of exposure to warming and ocean acidification. Specifically, I present data from two functionally important benthic invertebrates (brittlestar *Amphiura filiformis*; nereid polychaete *Alitta* (*Nereis*) *virens*) simultaneously exposed to three levels of atmospheric CO_2 concentration (380, 750, 1000 ppm) and two temperature regimes (ambient and ambient + 4°C). I show that responses associated with surviving in an acidified and warmer ocean are species-specific and manifest over time through changes in growth, bioturbation and bioirrigation behavior that, in turn, affect nutrient generation. Importantly, these changes are closely linked to seasonal variation in environmental conditions (temperature and photoperiod), which either exacerbate or buffer the effects of long-term climatic forcing. Collectively these findings have implications for assigning species into functional response groups and for those attempting to forecast the likely ecological consequences of climatic forcing.

The 4th Nereis Park Conference

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Long-term, integrated observatories as tools in understanding coastal ecosystems.

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ABSTRACT

Coastal ecosystems mediate important biogeochemical fluxes, support autotrophic and heterotrophic production, high biodiversity and the cycling and exchange of climate-active gases with the atmosphere. The coastal zone has high socio-economic value supporting direct services (tourism, fisheries and recreation) as well as indirect services such as climate regulation and waste remediation. However, due to its proximity to land it is also susceptible to anthropogenic pressures (eutrophication, pollution). It is also a highly variable, dynamic environment, subject to local- and long-range forcing (e.g. fluvial runoff vs. decadal climatic oscillations). Integrated long-term biogeochemical observatories provide a powerful tool for understanding this variability, exploring benthic-pelagic interactions, placing perturbation studies in the context of inter- and intra-annual variability and as a test-bed for developing novel ideas. Here, I use the Western English Channel Observatory (WECO) as an exemplar, focusing primarily on the ongoing benthic component of the observatory. The WECO combines sustained pelagic and benthic components as well as a more recent atmospheric observatory. The benthic component specifically, encompasses a suite of biogeochemical measurements alongside microbial-, meio- and macro-fauna dynamics which form the basis for further specific studies.

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Molecular ecology as a tool for understanding bioturbation and ecosystem function

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ABSTRACT

Bioturbation can increase the abundance, diversity and activity of microorganisms within the sediment. The activities of bioturbating meio- and macrofauna enhance the microbial transformations of key porewater components (e.g. nitrate, NO_3^-) within the sediment, by (i) irrigating the burrow, thereby introducing fresh, oxygenated seawater and extending the oxic-anoxic interface of the surface sediment; and (ii) actively increasing the availability of organic matter and biopolymers within the burrow wall. Increasingly, bioturbation research uses molecular tools to investigate this important relationship by understanding variation in the presence, abundance and diversity of bacterial and archaeal genes. In particular, molecular analyses may be applied to understand microbial community structure and diversity (e.g. high-throughput DNA sequencing) or functional gene abundance and activity (e.g. the quantitative polymerase chain reaction, q-PCR).

Molecular ecology is a rapidly advancing field, and the cost of sequencing and availability of dedicated labs for sequence processing have opened up the microbial world to macro-ecologists. However, there are fundamental questions that should be applied to any molecular microbial study. Does gene abundance relate to ecosystem function? Does microbial diversity matter? Which high-throughput sequencing platform/methodology is most appropriate to large-scale ecological studies?

In this talk, I will firstly summarise the research linking microbial community dynamics with bioturbation in aquatic environments. Secondly, I will discuss the broader applications of molecular microbial ecology, with respect to the appropriate scales of investigation, the likely methodological constraints, and how to ensure a good match between technique and hypothesis.

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The underestimated impact of tube-dwelling macrozoobenthos in lake ecosystems: Eroding a long-lasting limnological paradigm

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ABSTRACT

Small but abundant tube-dwelling macrozoobenthos such as chironomids have been largely neglected, but have the potential to control water quality and trophic state of shallow lakes and lakes with extensive shallow areas. They pump large water volumes, including suspended and dissolved substances, through the sediment. Turnover times of volumes equivalent to whole water bodies of shallow lakes might be on a time scale of days to weeks. Filter rates of macrozoobenthos are in the same order of magnitude as filter rates of zooplankton. Intermittent pumping by macrozoobenthos introduces oxygen into anoxic sediment layers and creates a dynamic, three-dimensional mosaic of redox conditions. Hotspots of element cycling occur at the oxic-anoxic interfaces controlling the fate of organic matter and nutrients in shallow aquatic ecosystems as well as fluxes of nutrients (N, P) between sediment and overlying water. Surprisingly, the exact mechanisms, controls, and magnitude of interactions are still poorly understood. By integrating the missing functional traits in an ecosystem model, we postulate that tube-dwelling macrozoobenthos are small but abundant ‘ecosystem engineers’ exerting high filter-feeding pressure and affecting biogeochemical processes from the micro to the ecosystem scale, especially in shallow lakes ecosystems. Thus, they play a central role in controlling water quality and trophic status which is in contrast to the long-lasting limnological paradigm of mainly pelagic controlled food webs.

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Bioturbation by benthic macrofauna: experimental quantification and functional classification based on particle and solute transport

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ABSTRACT

One of the most important effects from activities by benthic macrofauna in bioturbated deposits is the continuous modification of the pore water/sediment matrix. Alteration of requisites for transport of particles and solutes within surface sediments and across the sediment-water interface has profound effects on mass transport and redox conditions in the surface sediment. In the present contribution, a general classification of bioturbators based on quantification of transport of material is presented. In essence, quantification of proxies for particle reworking, resuspension, ventilation and community respiration were used for functional classification of four common marine bioturbators in marine sediments (*Amphiura filiformis, Abra nitida*, *Nuculana pernula* and *Nephtys incisa)*.

Patterns and modes of bioturbation were analyzed both within and between species. In a monospecies setup, individuals were added to Plexiglass cores for sediment-water incubations in a range of densities, biomasses and sizes according to natural abundances.

Results from this study suggest that the predictability of mass transport by benthic macrofauna is highly species-dependent. For some species, measured transport proxies correlated well to e.g. biomass (*A. filiformis* and *A. nitida*), but not for others (*N. pernula* and *N. incisa*). *A. filiformis* distinguished itself as a bioturbator extraordinaire, with high impact on surface transport, ventilation, resuspension as well as translocation of particles to deep sediment layers. While some treatments for all four species were inseparable from each other, it was demonstrated that *A. nitida* and *N. pernula* share common bioturbation functionalities, while *N. incisa* formed a functional group dissimilar from the others.

Topic: Novel methods for quantifying and visualising bioturbation or
Integration of bioturbation into models

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Bioturbation by the polychaete *Melinna palmata* structures bacterial communities at the sediment surface

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ABSTRACT

Here, we propose to investigate interactions between bioturbation by *Melinna palmata* and bacterial community composition at the very sediment-water interface. The polychaete *M. palmata*, a tentaculate feeder, induces a clear zonation of the sediment water interface through its trophic activities. An experiment (17°C, continuous water flow) was performed to further characterise these bioturbated zones, and to test whether these zones are inhabited by different bacterial communities. Worms (ca 2.5 cm length) were sampled in the Arcachon Bay and individually acclimatized for 10 days in 12×18 cm aquaria filled with 1.3 L of mud from the sampling site. Their activity was then monitored during 10 days through video recording (16 replicates). Results showed that feeding (ca 84.8 % of time) and defaecation (every ca 28 minutes) were the two dominant activities resulting in the creation of the two clearly distinguishable surface sediment areas: a prospecting zone of ca 6 cm in diameter and a faecal mound of ca 3 cm in diameter. At the end of each experiment, sediment properties (e.g. granulometry, oxygen penetration depth and phaeophytin a) and bacterial community compositions were assessed in the prospecting zone, faecal mound and undisturbed sediment (13 replicates). Results show significant differences (i.e., coarser sediments, lower oxygen penetration depth and lower phaeophytin *a*) in the prospecting zone compared to the faecal mound and the undisturbed sediment. Bacterial community compositions (by ARISA) also significantly differed between each of the three zones. Moreover, based on Simpson's index, bacterial diversity was higher in the prospecting zone compared to the undisturbed sediment surface. These results revealed the creation by *M. palmata* bioturbation of a horizontal micro-heterogeneity with three different zones on the sediment water interface, inhabited by three different bacterial communities.

Interactions between bioturbators and microbes

The 4th Nereis Park Conference 7th-10th July 2014, Plymouth Marine Laboratory

Novel methods for quantifying and visualising bioturbation

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ABSTRACT

Bioturbation provides an excellent measure of ecosystem functioning since it drives a large number of sedimentary processes including benthic metabolism, biogeochemical cycling and sediment dynamics. Quantifying bioturbation targets a large number of key ecosystem processes and is therefore essential to understanding some of the complex mechanisms that influence ecosystem functioning. Despite its importance, techniques for the measurement of bioturbation have, until recently, been limited.

Here, techniques for the visualisation and quantification of biogenic structures, focussing on the novel application of high resolution micro computer tomography (microCT) to the quantification of the properties of marine biogenic structures, are described. The microCT technique developed here used a standard core sample of estuarine sediment. Innovative histomorphometry software (based on software to characterise trabecular (spongy) bone) was used to calculate the axial variation of the following burrow parameters: number, diameter, volume, surface area and density. This technique enables accurate detection and quantification of macrobenthic burrow structures and the increased resolution has resulted in the first quantification of meiofaunal burrow structures. MicroCT offers an obvious advantage over normal clinical CT in that the image resolution is much higher and increases as the size of the sample decreases, allowing the detection of very small, meiofaunal features. (For example, a 150mm diameter core will have a typical image resolution of 0.2mm, while a 20mm diameter core will have a resolution of 0.025mm).

MicroCT is a potentially valuable tool for assessing ecological functioning in soft sediments with potential applications in pollution studies, habitat restoration, ecosystem recovery and investigations into the mode of life of benthic species.

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Spatio-temporal variations of bioturbation activity in a high arctic fjord (Kongsfjorden, Svalbard)

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ABSTRACT

Climate change effects are enhanced in the Arctic. These changes will have repercussions on the entire ecosystem functioning and carbon cycling. It is still unclear how benthic organisms will respond to variations in food sources and environmental conditions in such environments. Kongsfjorden, a high Arctic fjord in the west site of Svalbard, is highly influenced by warm Atlantic waters inflows, and its ice cover has been decreasing over the last decade. Kongsfjorden was widely studied in 2012-2013 during the ECOTAB project which aims to investigate how spatial and seasonal changes in vertical fluxes can impact benthic communities. Four field campaigns (May, August, October and January) were performed along a gradient glacier-outer fjord in order to evaluate the impact of organic matter fluxes from the water column to the sea floor (chlorophyll a, particulate organic carbon, phytoplankton carbon, zooplankton fecal pellet carbon, lipids, protids, carbohydrates). The bioturbation activities were quantified in terms of two sediment transport rates (biodiffusion and bioadvection), as a proxy of benthos activities, using the luminophores technique. Preliminary results suggested that although vertical fluxes changed throughout seasons and stations, bioturbation activities did not show similar tendencies, suggesting that the benthos of Kongsfjorden may not rely on seasonal inputs of organic matter such as in other Arctic shelves with more important ice covers.

Provisional theme addressed: "Impact of environmental change on bioturbators and bioturbation rates".

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Bioturbations studies from single species and specific traits to assess change in biodiversity and benthic community function

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ABSTRACT

Aquatic sediments inhabited by macrofauna become a structural and functional 3D matrix where burrows and tubes extend the sediment-water interface and increase microbial activity mediated by transport of solids and solutes. Importance of macrofauna for ecosystem functions has been investigated both in laboratory experiments and natural systems. Experimental studies often describe different macrofaunal sediment activities, such as feeding, excavation, tube and gallery construction quantified as transport of particle or sediment reworking, while the ventilation of pore-water solutes out of tubes and burrows is quantify as irrigation. The general effects of bioturbation are increased sediment-water interface, oxygenation of deeper anoxic sediment and enhanced microbial activity and organic matter mineralisation.

Single species treatment show significant impact on bioturbation, fluxes and pore-water solutes when compared to controls without macrofauna. Different species resembling functional parallels has also been compared and support the use of traits and functional groups when assessing species importance for fluxes and pore-waters. Designs using natural benthic communities suffer from high variability that force the ecologist and geochemist to study replicated mesocosms and choose effective treatments to ensure ecologically relevant results among the multiple ecosystem functions measured.

Recent work has increased the effort to investigate impacts from multiple stressors and follow the response among macrofauna, meiofauna, microbial communities, and bioturbation and sediment biogeochemistry after short and longer term exposures. Reported results include physical, chemical and biological stressors and quantified response in sediment communities to assess change in benthic ecosystem functions and services. Experiences and results from over 10 years of macrofauna, bioturbation and ecosystem research will be presented and discussed with the Nereis Park members to facilitate future investigations of sediment community's ecosystem functions.

Provisional themes:

- Impact of environmental change on bioturbators and bioturbation rates

- Estimating the value of bioturbation as an ecosystem service

- Integrating knowledge: scaling up from experiments

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From the ecosystem engineering to the trophic autonomy: The case of interaction between *Cerastoderma edule bioturbation, microphytobenthic biofilm growth and resuspension*

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ABSTRACT

Uniformity does not exist in ecological landscapes at any studied scale. Recent ecological literature stresses the relevance of considering patchiness for vegetal organisms and, for instance, regarding microphytobenthic assemblages in aquatic systems, to survey the rapid changes of patchy distribution at the surface of benthic environments. The most exciting challenge in bioturbation studies is to scale up from individual traits to community performance and trophic flow (in relation to metacommunity concept). Mechanistic models must be developed on the basis of realistic observation at the scale of the organism, before being able to use them for resolving such upscaling investigations. To refine mechanisms at the organism scale and upscaling ecological processes related to bioturbation, thorough investigation of patchiness must be performed. For instance, for the ubiquist and widespread bivalve *Cerastoderma edule*, there are still debates regarding the respective roles of direct destabilizing and indirect stabilizing forces. Cockle bioresuspension and microphytobenthic (MPB) biofilm was studied during erosion experiments by a new approach combining actographic measurements of bioturbation, 3-dimensional sediment microtopography and biofilm patchiness (biomass and photobiology) at the organism scale. The experiments were performed to compare micro-landscapes before and after flow simulation provoking a "chronic" erosion. Despite the MPB resuspension close to the burrows, adjacent areas were characterized by positive effects on MPB biomass and primary production. Cockle bioturbation also enhanced exportation of MPB to the water column under flow, showing the relevant role that plays *C. edule* as an ecosystem engineer in coastal ecosystems, able 1) to stimulate MPB production ("gardening" behavior) and 2) export this production to the water column, hence providing an evidence for a potential trophic autonomy of this suspension-feeding bioturbator.

Provisional theme - Integrating knowledge: scaling up from experiments

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Bioturbation activities and biogeochemical impact of the mud shrimp *Upogebia pusilla* in the Arcachon Bay

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ABSTRACT

The Arcachon Bay shelters the largest eelgrass (*Zostera noltei*) bed in Europe. This very productive ecosystem has however to deal since 2005 with a severe decline. Beyond the decrease of both the surface and the density of *Zostera* meadows *per se,* this ongoing process also induces the loss of some tightly associated macrobenthic species, such as the ecosystem engineer *Upogebia pusilla.* The functional consequences of such a loss are potentially harmful but yet poorly understood.

In this study, we performed a series of mesocosm experiments to characterize the bioturbation activities of *U. pusilla* and investigate their influence on biogeochemical fluxes at the sediment-water interface. Results show that this large crustacean (adult size > 4 cm), which lives in deep U or Y burrows, is an efficient bioturbator. Burrowing, wandering and ventilating activities (62 % of the time on average) lead to high sediment reworking (D_b= 57 cm² yr^{-1}) and bioirrigation rates (Q= 46 ml h^{-1}). Moreover, temporal analyses of vertical luminophore profiles reveal the simultaneous occurrence of two different reworking processes: (1) The passive burying of surficial particles through continuous upward transport of deep sediment and (2) the homogeneous mixing of a 2 cm thick sediment layer around the burrow.

These bioturbation processes led to significant enhancements of (1) oxygen and nitrate uptakes by the sediment (2.5 and 16.4 fold higher, respectively), and (2) ammonium and silicate releases to the overlying water (3.0 and 3.9 fold higher, respectively) relatively to sediment unaffected by this species. Our results show that *U. pusilla*, plays a major role in organic matter mineralization processes through its intense activities of bioturbation. They also suggest that the bust of mud shrimp populations resulting from the decline of seagrass meadows may greatly modify the biogeochemical functioning of intertidal benthic ecosystems in the Arcachon Bay.

Theme

Beyond quantification of particle and fluid transport: quantification of organism-sediment interactions

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Integrating knowledge: scaling up from experiments

Placing community bioturbation in ecosystem models without getting lost in translation.

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ABSTRACT

One of the key challenges to the progress of our understanding of the role of biodiversity in the sustenance of ecosystem processes and functioning is the ability to extrapolate the results of two decades of dedicated, empirical science to the landscape. Ecosystem models can provide a platform for this progression, offering a holistic view of ecosystems where, guided by a deep mechanistic understanding of processes, large-scale questions can be investigated. While the benefits of depicting biodiversity in such models are widely recognized, its application is limited by difficulties in the transfer of knowledge from small process oriented ecology into macro-scale modelling. Here, we build on previous work, breaking down key challenges of that process into a tangible framework, and highlight successful interaction strategies developed by the modelling and ecology communities. We use examples from the Western Channel Observatory long term monitoring program to illustrate how aspects of the link between biodiversity and ecosystem processes like bioturbation and primary productivity can be depicted in ecosystem models, from data, to conceptualization. We hope that this framework may help future interactions between biodiversity researchers and model developers by highlighting concrete solutions to common problems.

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7th-10th July 2014, Plymouth Marine Laboratory

Effect of *Cerastoderma edule* Bioturbation on Microphytobenthos Resuspension: a Modelling Approach

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ABSTRACT

Microphytobenthos (MPB) represents an important food source for primary consumers in estuarine ecosystems. The availability of MPB as food element is a result of complex physical, chemical and biological interactions. Macrofaunal bioturbation in estuaries is a key process regulating the MPB flux in the water column. The common cockle *Cerastoderma edule* constitutes the major bioturbator species in the ecosystem of Bay des Veys (Lower Normandy, France). *C. edule* intensely modifies the top layer of the sediment by changing its roughness and by increasing its erodability through active valve movement. Cockle bioturbation leads to the creation of a biogenic layer that is easily eroded with tidal hydrodynamic forces. Associated MPB can then be exported to the water column and fuelling suspension feeders. The aim of this work is to develop a numerical model that reproduces the export of MPB associated to the biogenic layer erosion. Kinetics of suspended MPB, obtained by flume experiments (Erodimeter), were used to parameterize the model. Results show that *C. edule* biomass was positively correlated with MPB resuspension in the water column, and that a linear model was, sufficient to statistically describe the process. Our model consistently reproduces the tendency encountered in laboratory analyses. We then performed a validation of the model with results from the same flume experiments, conducted with cores sampled in-situ. A significant agreement was observed between model simulations and the recorded MPB resuspension. This work thus provides reliable estimates of the daily food availability from sediment to primary consumers, in an estuarine system where cockles dominate the bioturbating assemblage.

Keywords: Modelling, Microphytobenthos, *Cerastoderma edule*, Bioturbation

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Species contributions to ecosystem level processes are modified by anthropogenic underwater noise

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ABSTRACT

Coastal and shelf environments support high levels of biodiversity that are of significant importance in mediating ecosystem properties, but they are also subject to increasing levels of noise associated with human activities. Whilst physiological and behavioural effects on a range of marine organisms have been demonstrated, the significance of sound exposure for the faunal mediation of ecosystem processes has not been addressed. Here, we show that medium-term exposure to two main classes of broadband noise (continuous and impulsive) can modify the way in which benthic invertebrates interact with the sediment environment. Importantly, these responses are species-specific and depend on the class of noise. Our findings indicate that the impacts of anthropogenic noise in the marine environment may be more complex and have wider ecosystem consequences than are presently realized. Consequently, in addition to spatial extent, the absolute intensity and type of noise need to be considered when estimating likely impacts.

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Explicit representation of bioturbation in an ecosystem model: infaunal and biogeochemical responses

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ABSTRACT

Biologically mediated nutrient fluxes between the sediment and water column are of fundamental importance in regulating carbon related processes and reactions in shallow shelf sea environments. Infauna responds to the quantity and quality of organic material supply to the sediments, oxygen availability, and biological reworking of the sediment layers. Recently, an explicit description of the vertical structure of the benthic sediments has been included in the ERSEM model to give a more robust ability to simulate benthic processes.

Bioturbation, the biologically mediated reworking of the sediment layers, stimulates response in ecosystem structure and mediates fluxes across the pelagic-benthic boundary. The inclusion of bioturbation is particularly important in benthic models and a number of differing bioturbation schemes have been implemented in the ERSEM model. We outline biological and chemical response to the actions of one of these descriptions in a whole ecosystem context, evaluating the response against data from the Western Channel Observatory time series L4 sampling site.

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Bioturbation by *Hediste* (*Nereis) diversicolor* enhances oil degradation and changes active microbial community composition in oil contaminated estuarine sediments

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Abstract

The polychaete worm *Hediste* (*Nereis*) *diversicolor* is an important bioturbator within estuarine sediments. In today's oil dependant world contamination events are ever increasing, particularly in areas with high human activity such as estuaries. Previous studies have shown that *H.diversicolor* may significantly affect the composition of bacterial communities in oil contaminated sediments. We wanted to further test the hypothesis that sediments with *H.diversicolor* would be more efficient at degrading oil and that bioturbation would have a significant impact on the eukaryotic microbial community as well as the prokaryotic microbial community. Eukaryotic degradation of oil in sediments is not well characterised and we expected fungi to play an important role. Oil contaminated estuarine sediments were incubated in cores for 30 days with or without *H. diversicolor*. After this time, samples were taken for DNA/RNA and analysis of hydrocarbons. The microbial community was profiled using qPCR and high throughput sequencing (Ion torrent PGM) of cDNA. Cores that did not have worms had significantly more PAHs and aliphatic hydrocarbons than those incubated with worms. Cores with worms had significantly more 16s and 18s gene transcripts per gram of sediment than those without worms. We saw a dominance of marine fungi in sequence libraries from both treatments and a significant enrichment of bactivorous Centrohelida, Discosea, Cercozoa and Nematoda in cores with worms. As shown previously in other studies there were distinct differences between bacterial communities from cores with worms and without. This study represents the first detailed assessment of the affect of bioturbation on the microeukaryote community in oil contaminated sediments. In addition it further shows that bioturbation may be an important factor in determining microbial abundance and diversity within sediments and plays an important role in the cycling of hydrocarbons.

Provisional theme:
- Interactions between bioturbators and microbes

Seasonal variability in benthic community structure and function

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ABSTRACT

The seasonal fluctuation of organic matter to the sea floor results is a major food source for the benthos, and influences the abundance, activities and community dynamics of benthic fauna. In coastal waters, the source of this organic matter is predominantly from phytoplankton. In this study, we have conducted a fine-scale temporal survey of both the macrofauna and bacterial community response to a prolonged spring bloom at the Western English Channel Observatory site L4. Compared to the past two decades, the spring bloom in 2012 was both unusually long in duration and contained a higher than average biomass. Analysis of chlorophyll *a* and associated degradation products indicated that the phytoplankton material was heavily degraded only when it reached the sediment. The nature of the main chlorophyll *a* degradation products, pheophorbide and hydroxychlorophyllone, suggest that the phytoplankton material was grazed by the benthic fauna. The deposition of the phytoplankton material to the sea floor resulted in an almost immediate increase in macrofauna abundance and diversity, a shift in community composition and a corresponding increase in measurements of bioturbation potential (BP_C). Decreases in abundance during late summer were thought to be associated with oxygen depletion at depth. Also established was a close link between the bacterial abundance and sediment pigment content, suggesting microbes fed on the faecal material of larger fauna. The composition of the bacterial community rapidly shifted through-out the prolonged spring bloom period: this was primarily due to an increase in the abundance of members of the Flavobacteria.

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Does macrofauna functional diversity affects bacterial and archaeal diveristy: a field study from the Belgian part of the North Sea.

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ABSTRACT

Experimental and field studies showed that macrofaunal functional diversity affects the benthic N-cycle. This effect is indirect, and related to the habitat-modifying capacities of macrofaunal organisms. These can alter characteristics of the communities of the key players in the N-cyle, the ammonia oxidising bacteria and archaea. Evidence for this was derived from lab experiment, often with strong ecosystem engineers, but temporal and spatially replicated research in field situations is still lacking.

We sampled 7 stations on the Belgian part of the North Sea, representing sediment types ranging from muddy to permeable sediments. Stations were sampled in April, June and September 2011 to reflect different situations with respect to the phytoplankton bloom. Macrofaunal functional diversity was calculated as the Bioturbation Potential (BPc). Additional samples were collected for the analysis of the full bacterial and archaeal communities. Further analyses were devoted to metabolically active ammonia oxidising bacteria (AOB) and archaea (AOA), involved in the first and rate-limiting step of nitrification: ammonia-oxidation, We used a DistLM approach to relate functional diversity of macrofauna to aspects of diversity (richness, Shannon diversity) of the microbial communities.

Our analyses show that BPc was indeed related to the species richness of total bacterial communities and AOA. Furthermore, BPc affected Shannon diversity of AOB, while Shannon diversity of AOB was related to macrofaunal density. This shows that, integrated over a relatively large geographical and temporal scale, functional diversity of macrofauna is indeed important for structuring the key players in the N-cycle. This suggests that the experimentally-derived hypothesis that macrofaunal functional diversity indirectly affects affects N-cycling by shaping the diversity of the microbial communities, is valid in field situations as well. It furthermore confirms the capacity of BPc to integrate those functional aspects of macrofaunal communities needed to link macrofauna, microbes and ecosystem functions.

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The impacts of bait collection on the macrobenthic community

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ABSTRACT

Bait collection is a contentious issue in UK coastal areas as it removes target species (e.g. *Nereis virens* and *Arenicola marina*), damages benthic communities, disturbs wading birds and alters the physical characteristics of the mudflat. However, the long-term and larger spatial scale impacts on the sediment and benthic community have not been assessed. Using three sites within the Solent bait dug areas were mapped with macrofauna and sediment cores taken from inside and outside these areas and analysed for species diversity, abundance and sediment characteristics. Dug sediment constituted a significant proportion of the mapped area of Fareham Creek and Dell Quay (7.5% and 8.4%, respectively), but covered only 0.5% for Pagham Harbour. Differences between sediment characteristics and the associated macrofauna were not present between dug and undug sites for Fareham Creek. The lack of differences are likely to be due to an environmental gradient across transects combined with extensive historical collection that has homogenised the sediment. In contrast, at Dell Quay dug sites differed in their median particle size, organic content and other key aspects of the sediment; together these show that dug sediment is less muddy due to the loss of finer fractions. Multivariate analysis shows that under 'natural' levels of bait collection there are major changes in the macrofaunal community between dug and undug sites. These manifest themselves as reductions in the abundances of the most plentiful species if the same height on the shore is compared. These impacts will be discussed in the context of bioturbation, ecological function and bioavailability of pollutants in inter-tidal mudflats where favourable condition must be maintained to comply with European SACs and SPA designations.

Keywords: Polychaetes, bait collection, management, MPAs, ecosystem function

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Direct contribution of Clams (*Ruditapes Philipinarum)* to benthic fluxes, nitrification, denitrification and nitrous oxide emissions

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ABSTRACT

The influence of the manila clam (*Ruditapes philippinarum*) on processes and fluxes in a farmed sediment was investigated using a multiple core incubation approach and parallel incubations of individual clams. Clam population/biomass density varied ~8-fold between cores and all sediment-water column solute (O_2. N_2, N_2O, NH_4^+, NO_X and DIN) fluxes and process (ammonification, nitrification and denitrification) rates were strongly and significantly correlated with clam density/biomass. Isolated clams exhibited high rates of respiration, N-excretion, nitrification and denitrification of 2,050 ± 70, 395 ± 49, 201 ± 42 and 235 ± 40 nmol individual^{-1} h^{-1}, respectively.
The direct contribution of the clams and their associated microbiota to benthic processes was estimated by multiplying the per individual rates by the number of clams in each incubated core. The clams on average directly accounted for 64-133% of total rates of SOD, ammonification, nitrification and denitrification, indicating that they regulated processes primarily through their own metabolic activity and that of bacteria that colonise them.
Clams and the farmed sediments were significant sources of the greenhouse gas N_2O, due to their high rates of nitrification and denitrification, as the N_2O emissions represented <1% of total N_2O + N_2 production. The clam-farmed sediments had a high denitrification efficiency of 67 ± 10%, but this ecosystem service came at the environmental cost of increased N-regeneration and N_2O emission rates. The measured N_2O emissions indicate that bivalve aquaculture may be a significant source of N_2O. It is therefore recommended that N_2O emissions should be included in the impact assessments of current and future bivalve-farming projects.

Theme
Interactions between bioturbators and microbes
Or
Estimating the value of bioturbation as an ecosystem service

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Impacts of CCS leakage on benthic communities and bioturbation: Results from the ECO2 project.

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ABSTRACT

There is now both a societal and political acceptance that anthropogenic CO_2 emissions need to be significantly reduced if long-term negative impacts on ecosystems are to be prevented or minimised. The most obvious way of reducing these emissions is through increased energy efficiency and reduced energy generation. However, due to current technical and political considerations, obtaining the reductions needed entirely through these methods would be highly unlikely. Consequently, a number of other engineering based, mitigation techniques are being considered to support existing efforts to reduce CO_2 generation and emission.

Geological CO_2 capture and storage (CCS) involves the capturing of waste CO_2 at source (mainly from large industries such as coal and natural gas fired power plants), then transporting it and depositing it in deep geological formations such as depleted oil and gas fields, unmineable coal seams or deep saline aquifers One significant consideration for the future implementation of industrial CCS projects is the need to secure scientific and public acceptance that the geological storage of CO_2 poses no significant risks to either humans or the environment.

In many countries, future implementation of geological CCS will primarily occur offshore and will most likely be located on the continental shelf, situated largely below areas of unconsolidated sediments ranging from course sand to fine mud. If leakage were to occur, sediment communities and the processes they support, including bioturbation, could be affected. As part of a large EC funded project (ECO2), mesocosm experiments have been conducted to assess the potential impact CCS leakage on infaunal bioturbators and bioturbation activity.

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Bulldozing, Bioadvection, Density: Which Driver 'Wins'

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ABSTRACT

Bulldozing bioturbators alter sediment topography, physical advection, spatial-temporal patterns of benthic-pelagic fluxes and photosynthetic activity. Hydraulic pumpers, sedentary infauna that pump water into sediments at depth, cause bioadvection and upward transport of porewater and nutrients through the sediment water interface, affecting fluxes and primary productivity. Sedentary infauna, which do not pump water into the sediment or bulldoze actively, are expected to have smaller effects on sediment topography and advection. All these functional groups contribute to the N budget via excretion. The sedimentary habitats of New Zealand offer an ideal setting in which to compare impacts on ecosystem function across these three types of ecosystem engineers: a bulldozing disturbance agent, the irregular urchin *Echinocardium cordatum*; a surface-feeding, bioadvective tellinid bivalve, *Macomona liliana*; and a large suspension-feeding venerid bivalve, *Austrovenus stutchburyi* that forms dense groupings in the upper sediment layer. All three dominate large areas of muddy sands by biomass, are well-studied in terms of effects on fluxes, excretion, rates of movement, and hydraulic activity.

Field and laboratory recordings of porewater pressures plus laboratory oxygen optode imagery quantified the importance of bioadvection by the tellinid. Neither the irregular urchin nor the venerid bivalve showed evidence of significant bioadvection, but bulldozing by the irregular urchin modified the sediment surface and increased nutrient fluxes. To ask which organisms contributed to local productivity, we compared ammonium flux in light and dark as well as rates of photosynthesis with and without normalization by chlorophyll a biomass. The impact of *Austrovenus* on benthic productivity and nitrogen flux is dominated by excretion, while those of *Echinocardium* and *Macomona* are primarily driven by bulldozing (*Echinocardium*) and bioadvection (*Macomona*). The apparent effect of increased surface area due to bulldozing was not expected and represents another mechanism for alteration of ecosystem function in terms of surface driven phenomena such as photosynthesis.

Provisional themes:
Estimating the value of bioturbation as an ecosystem service
Beyond quantification of particle and fluid transport: quantification of organism-sediment Interactions
Integrating knowledge: scaling up from experiments

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Investigating the changes in benthic macrofauna community structure and bioturbation during mudflat colonization by mangrove

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ABSTRACT

The changes in mangrove assemblages impact the benthic macrofauna communities (composition and structure). Nevertheless, how changes in vegetation structure due to mangrove growth affect macrozoobenthic assemblages and their bioturbation activities are still unknown. Initial stages of mangrove development were investigated in order to compare and quantify relationship between vegetation characteristics, macrofauna species, functional groups of bioturbation and sediment reworking during process of mangrove colonization.

Mangroves of French Guiana (South America), adapted to recurrent sediment disturbances, colonize rapidly new substrata which make possible the study of distinct stages of mangrove development spatially close. The stages considered were an emergent mud bank, a pioneer and a young mangrove of the Sinnamary coast (French Guiana). Vegetation structure was assessed through tree species identification, density measurements as well as biomass calculations, and sediment environmental parameters were determined. Sediment cores from each site were incubated in tanks and subjected to tidal cycle for 10 days. Vertical distributions of macrofauna and fluorescent microspheres deposited at the sediment surface were recorded.

The results will confront variation in sediment reworking (intensity, mode) and infaunal community structure to environmental parameters changes throughout the mangrove development stages. The variations of specific richness within functional groups of bioturbation and of functional richness in relation to mangrove development and vegetation structure will be examined. This study will provide information on the importance of functional diversity for the sediment mixing when mangrove grows.
Provisional theme addressed: "Impact of environmental change on bioturbators and bioturbation rates".

Experimental assessment of the effects of temperature and food availability on particle mixing by the bivalve *Abra alba* using new image analysis techniques

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ABSTRACT

The effect of food addition on particle mixing in the deposit-feeding bivalve *Abra alba* were assessed at two different seasons using an experimental approach for the tracking of individual fluorescent particle (luminophores) displacements. This allowed for the computations of both overall mean values and vertical profiles of: (1) a set of parameters describing the particle movements induced by the bivalves, and (2) particle tracking biodiffusion coefficients (D_b). Data originated from 32 experiments carried out under 4 combinations of 2 seasons (*Se*) and 2 food addition levels (*Fo*). For each of these treatments, parameters were computed for 5 experimental durations (*Ed*). The effects of *Se*, *Fo* and *Ed* were assessed using PERMANOVAs carried out either on vertical profiles or on overall mean values. The comparison of profiles resulted in a detection of a higher number of significant effects than the comparison of overall mean values**,** thereby suggesting that it is more efficient in detecting the effect of environmental factors on particle mixing by *A. alba*. The proportion of jumping luminophores was not affected by *Ed*, suggesting that it constitutes a suitable proxy of jump frequency when assessing particle mixing based on the measure of individual particle displacements at short time-scale. Particle mixing was low during autumn and not affected by *Fo*, which was attributed to low temperature. Conversely, particle mixing was high during summer and transitory inhibited by *Fo*. This last result is coherent with the functional responses (both in terms of activity and particle mixing) already measured for individual of the closely related clam *A. ovata* originating from temperate populations. It also partly resulted from a transitory switch between deposit- and suspension-feeding caused by the high concentration of suspended particulate organic matter immediately following food addition.

Provisional themes:

- Novel methods for quantifying and visualising bioturbation

- Integration of bioturbation into models

- Impact of environmental change on bioturbators and bioturbation rates

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Quantifying Chinese mitten crab (*Eriocheir sinensis*) bioturbation using fluorescent sediment profile imaging (f-SPI)

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ABSTRACT

Theme being submitted to: Impact of environmental change on bioturbators and bioturbation rates

Eriocheir sinensis (Chinese mitten crab) is an aggressive invader spreading around the UK coast. It is recorded in the IUCN list of the 100 most damaging invasive species in the UK. It first appeared in the UK in 1935 is now well established in the Thames and has nearly reached the border of Scotland. The crab has a significant socio-economic effect in shallow subtidal waters by disturbing natural habitats. Bioturbation by benthic organisms through burrowing, feeding and locomotory behavior is known to greatly influence ecosystem functioning. The study set out to examine the influence of *E. sinensis* on ecosystem function (sediment destabilisation, sediment erosion and burrow formation) in synthetic assemblages to reveal the progressive effect on the ecosystem as the invader becomes established. Initial observations show marked differences in the turbidity between the treatments, with higher densities of crabs having increased turbidity suggesting bioturbatory activity. Therefore, variation in bioturbation of *E. sinensis* was measured using a fluorescent sediment profile imaging camera (f-SPI) and fluorescent dyed sediment particles (luminophores). Factors in the experiment included size of the crabs (carapace width 21-23 mm & 26-29 mm) and temperature (10°C, 15°C and 19°C).

Acknowledgements
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Does burrow shape govern differences in solute exchange among species of Marenzelleria in the Baltic?

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ABSTRACT

Three invasive sibling polychaete species of the genus Marenzelleria spp. are spreading in the Baltic Sea. Owing to their burrowing depth which is deep compared to indigenous fauna they are currently stimulating interest in investigations addressing their impact on biogeochemical fluxes and functioning of the ecosystem. In experimental investigations using all three species we found that their impact on solutes ranked as M. arctia < M. neglecta ≤ M. viridis as judged from tracer experiments and modelling, NH_4^+-interface fluxes, calculated equivalent overlying water exchange and burrow wall oxygen consumption inferred from TOU incubation measurements.

Marenzelleria arctia has been shown to construct burrows of a shape distinctly different from those of M. neglecta or M. viridis. While the latter construct single-ended burrows to considerable depth (> 20 cm), M. arctia only reaches ~ 7 cm depth and has two open ends to its burrow. The comparatively shallow burrowing depth has considerable consequences for the impact on solutes exchange, e. g. NH_4^+. The fact that the burrow-sediment interface in M. arctia is constrained within the upper, more oxidized, sediment layers might explain most of the observed difference in measured ecosystem function. An approximately 4-fold larger burrow surface wall per individual worm in the two bigger species suggests that oxygen input to the sediment is governed strictly by geometry. Caution is advised when interpretation of data or future projections are founded on the genus Marenzelleria spp. without knowledge of the exact species identity.

Scaled to biomass M. arctia's mean water exchange parallels that of the two larger species, however, this abundance (8500 Ind/m²) hardly ever occurs in the natural ecosystem.

Provisional themes:

Estimating the value of bioturbation as an ecosystem service

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How does bioturbation influence the vertical distribution of benthic foraminifera?

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Abstract

In shallow cohesive sediments, the vertical distribution of living benthic foraminifera seems largely controlled by bioturbation processes. However, it still remains unclear whether foraminifera actively migrate from the sediment surface to reach deeper food-rich microenvironments around biogenic structures or are passively transported as inert particles. In this last case, the main question deals with the ability of aerobic species to resist downward transport and avoid long-term burial into anoxic layers through upward migration to the oxic zone.

Here, we investigated the influence of macrofaunal bioturbation on the vertical distribution of *Ammonia tepida,* one of the dominant foraminifera in intertidal mud flats. In a first set of experiments, foraminifera and luminophores (i.e. coloured particles) were added at the surface of sediment cores with large bioturbators belonging to different functional groups (*Echinocardium cordatum*, *Upogebia pusilla* or *Hediste diversicolor*). For all single species assemblages, after 16 days of incubation *A. tepida* and luminophores were similarly distributed within the reworked sediment layer thus suggesting that foraminifera did not develop any special mechanisms (e.g. attachment to sediment grains with pseudopodia) to resist downward transport.

The response of *A. tepida* to passive burial was examined in a second set of experiments. Distributions of both foraminifera and luminophores were assessed after 3, 6, 9, 16 and 32 days following an initial mimicked sediment mixing event. *A. tepida* did not display any discernable vertical displacements during the whole duration of the experiments as evidenced by the absence of temporal changes in depth profiles. Furthermore, comparison of video recordings successively made in oxic and anoxic conditions confirmed that the immediate response of *A. tepida* to anoxia consists of quick and drastic reduction of locomotion activity. Further experiments are currently carried out to investigate the potential onset of delayed upward migratory behaviour.

Provisional themes:

- Beyond quantification of particle and fluid transport: quantification of organism-sediment interactions

The 4th Nereis Park Conference

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Sediment particle reworking induced by two dominant species: *Nereis diversicolor* (Polychaetes, Annelids) and *Scrobicularia plana* (Mollusks, Bivalves) from a Loire estuary intertidal mudflat (France).

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ABSTRACT

The Brillantes intertidal mudflat is one of the largest of the Loire estuary (French Atlantic coast) and of ecologically high importance, but also submitted to high anthropogenic and natural stresses. This mudflat is investigated in the frame of a multidisciplinary research program to understand its biogeochemistry and functioning. The main aims of this study are 1) to assess the health status of two sentinel species commonly found in the Loire estuary, the bivalve *Scrobicularia plana* and the polychaete *Nereis diversicolor* using a battery of biomarkers at different levels of biological organization 2) to investigate, using experimental indoor microcosms, the sediment reworking activity by quantifying bioturbation as this activity integrates by itself the most important biological functions (respiration, feeding, defecating).
Two intertidal sites (S1: upper zone, S2: 300 m from the shore) have been selected. Macrofauna data showed a typical assemblage of the Loire estuarine mudflats with *S. plana* and *N. diversicolor* highly represented except for S2 where *Heteromastus filiformis* dominated (42%). According to AMBI index, S1 was classified as slightly disturbed, good ecological status with an unbalanced benthic community health whereas S2 was classified as moderately polluted with a transitional to pollution benthic community health. For biochemical biomarkers of defense or damage (Lactate deshydrogenase-LDH, Catalase-CAT, Gluthatione-S-Transferases-GST, Acetylcholinesterase-AChE, Metallothionein), only CAT (oxidative stress) and AChE (neurotoxic stress) were significantly different corroborating with AMBI index. Behavioral biomarkers (burrowing tests) followed usually the same trend. For bioturbation quantification, vertical profiles of relocated fluorescent microspheres were typical of particle reworking induced by biodiffusors: gallery biodiffusors for *N. diversicolor*, and epifaunal biodiffusors for *S. plana*, suggesting the potential high impact of both species on the stability and composition of the Brillantes mudflat sediment. Biodiffusion (Db) and bioadvection (V) coefficients showed that *S. plana* may contribute more intensively than *N. diversicolor* to the sediment reworking.

Provisional theme:
"Impact of environmental change on bioturbators and bioturbation rates"

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Variability of bioturbation intensity: a concept to explain geographic patterns

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ABSTRACT

Bioturbation is thought to be a transport process fundamental to the functioning of marine ecosystems (e.g. benthic-pelagic coupling) and rarely bioturbation or its effects are considered unimportant to the ecosystem. Bioturbation - intensity and/or mode - change with species and abundance. In the Baltic Sea salinity gradients and availability of oxygen are the cause for distinct benthic community changes from west to east.

We investigate particle reworking in areas in the western and southern Baltic Sea. Vertical chlorophyll a - profiles and their interpretation using the model mixing.exe (Soetaert *et al.* 1996) are routinely examined at 6 sampling locations within one area (roughly 10 000 m²) and compared to the benthic fauna. This investigation is part of a broader attempt to evaluate the services of sediments in the marine ecosystem.

First results indicate that for chlorophyll a - distributions typical for diffusive mixing the sediment mixing coefficients, DB, differ more than 75% on this spatial scale. Furthermore, 20 % of the chlorophyll a – distributions characterizing one benthic community show clear signs of non-local transport.

We discuss to which extend the concept of guilds in benthic infauna can explain the geographic patterns found for particle reworking in the south-western Baltic.

Provisional theme: Integrating knowledge: scaling up from experiments
Also:
Estimating the value of bioturbation as an ecosystem service

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Placing bioturbation in ecosystem models without getting lost in translation

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ABSTRACT

A key challenge to progress our understanding of bioturbation's role in the sustenance of ecosystem function is the extrapolation of the results of empirical research to regional, global and future landscapes. Ecosystem models provide a platform for this progression, potentially offering a holistic view of ecosystems where, guided by the mechanistic understanding of processes and their connection to the environment and biota, large-scale questions can be investigated. While the benefits of depicting bioturbation in such models are recognized, its application has been limited by difficulties in the transfer of knowledge from small process oriented ecology into macro-scale modelling. These difficulties have been exacerbated by a fragmented approach in the bioturbation research community, and a lack of logistic and mathematical consensus about how to quantify bioturbation as a community level process. Here, we break down key challenges of that knowledge transference, and highlight the steps taken to improve the description of bioturbation in the European Regional Seas Ecosystem Model. In particular, we discuss the journey from data to conceptualization, which is now supporting model development. This journey has stemmed from a need to bring together the different aspects of bioturbation research, and thus better inform models about bioturbation at the community level, in the face of environmental variability. We hope to help advance the mechanistic understanding of the role of bioturbation in marine ecosystems, and expand the use of ecosystem models as tools to investigate this question.

Effects of bioturbation in the biogeochemistry of the sediment-water interface with seasonal anoxia: modeling study

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ABSTRACT

We use a 1-dimensional C-N-P-Si-O-S-Mn-Fe Bottom RedOx Model (BROM) describing both the sediments and bottom boundary layers (BBL) coupled with biogeochemical block simulating changeable redox conditions, and carbonate system processes. In BROM we parameterize OM formation and decay, reduction and oxidation of species of nitrogen, sulfur, manganese, iron, and the transformation of phosphorus, silicate and carbon species. BROM includes a simplified ecological model with phytoplankton, heterotrophic organisms, aerobic autotrophic and heterotrophic bacteria, anaerobic autotrophic and heterotrophic bacteria. BROM is coupled to FAMB (Framework for Aquatic Biogeochemical Models) as a transport model and a biogeochemical model. The BROM domain includes the water column, the bottom boundary later (BBL) and the upper layer of the sediments. To parameterize the water column turbulence we used results of simulation of turbulent mixing performed with GOTM (Bolding et al., 2001). In the limits of the BBL mixing was assumed to be constant. In the sediments Molecular diffusion and bioirrigation/bioturbation were parameterized in the sediments.

The model simulations show a possibility of a periodic replacement of oxic conditions with anoxic, that leads to changes in the distributions of the parameters and their fluxes. This was taken as a background for the bioturbation/bioirrigation numerical experiments.

It was shown that in the presence of bioturbation oxygen penetrates in the upper 4-5 cm of sediment, while in the reverse situation the depth of oxygen penetration is about first millimeters.

In presence of bioturbation, Mn (IV) and Fe(III) form a thicker layer that leads to disappearance of H2S in the top centimeters of the sediment during the winter-spring period.

Model can be used for analyzing and interpreting data on sediment-water exchange and estimating consequences of forcing (i.e. connected with eutophication, climate change, CCS leakages) as well as for boundary conditions parameterization for 3D models.