Summary NCK symposium "Impact of bed composition on the environment"

Art Centre Delft, 11 January 2018, sponsored by NCK,
organised by Bas Huisman (Delft University of Technology/Deltares) &
Martin Baptist (Wageningen Marine Research)

Speakers:

Session 1: *Bed sediment composition of the Dutch coast*

Steven Degraer (University of Ghent)
Key note: About sediments and marine life: A clear cut and tight relationship?

Stuart Pearson (Delft University of Technology)
Sediment connectivity and Transport Pathways as a Function of Grain Size

Harriëtte Holzhauer (University of Twente/Deltares)
Ecology and bed composition of the Amelander Zeegat

Bas Huisman (Delft University of Technology /Deltares)
Relevance of suspension sorting at the lower shoreface of the Sand Motor

Session 2: *Relevance of the abiotic environment for marine ecology*

Eelke Folmer (NIOZ)
Sediment composition and benthos communities in the intertidal Dutch Wadden Sea

Marjolein Post (WMR)
Sediment preference of juvenile flatfish

Marin van Regteren (WMR)
Oligochaetes in muddy sediments

Session 3: *Bed sediment composition monitoring & modelling*

Maarten Kleinhans (Utrecht University)
Key note: Sorting out estuaries: similar effects of bed armouring and inherited cohesive layers

Joep van der Zanden (University of Twente)
Cross-shore sediment sorting: laboratory experiments and numerical modelling

Helena van der Vegt (Delft University of Technology)
The selective preservation of sediment supply in deltas

Bas Borsje (University of Twente)
Bed level changes at saltmarsh-mudflat transitions

Discussion session

Chair: Martin Baptist (WMR)

Panel:

Peter Herman (Delft University of Technology /Deltares)

Sytze van Heteren (TNO Geological Survey of the Netherlands)

Bram van Prooijen (Delft University of Technology)

The day started in thick fog, but nonetheless the participants found their way to the Art Centre Delft, in the middle of nowhere between Delft and Rotterdam, to start at (already) 09:15 h. The theme day attracted public from the different NCK partners and some external companies.

Bas Huisman opened the day with a warm welcome to the 40 participants. Martin Baptist followed with a short introduction into the topic, based on a simple conceptual model and showing some old, but very important, literature.

Steven Degraer held a keynote presentation. He explained that benthic distribution is affected by sediment and vice-versa, and also by other factors. In the Belgian Continental Shelf four subtidal communities were distinguished along a gradient of increasing median grain size and decreasing mud content. This was fed into a quantitative habitat suitability model applied to North Sea benthos, and linked to higher trophic level birds. Last but not least he discussed species traits and feedback from organism behaviour to water content, chl-a levels, etc. and affecting morphology, such as *Lanice* aggregations.

Stuart Pearson applied the concept of connectivity (well-established in ecology) to sediment transport travelling from A to B in the Amelander Zeegat. He used graph theory with tabulated sediment compartments denoting transport-relationships/pathways. The results give an in-depth view on the transport pathways in the Amelander Zeegat and will be coupled to the benthic distribution.

Harriette Holzhauer studies the benthic distribution in the Amelander Zeegat. As a first step she defined groups of environmental parameters to derive 'habitats' based on several parameters such as bathymetry, slope direction, slope magnitude, and sedimentation/erosion. In total 66 boxcore samples were taken, distributed over the habitats. Large differences in benthic composition could be explained by the environmental parameters.

Bas Huisman discussed how grains behave in a mixture. Fine or coarse grains can move faster depending on conditions such as flow velocity and suspension mode. On the Sand Motor the tidal-driven mean bed shear stress drives the sediment composition leading to coarsening near the seaward tip and fining on the flanks. The coarsening is caused by suspension of finer fractions. His study yields generic knowledge on hydrodynamic effects of large coastal structures affecting bed shear stress and fines, and therefore, benthos.

Eelke Folmer studied sediment composition in the Wadden Sea based on annual monitoring data. He found a correlation between the anomaly of the median grain size (mgs) and the anomaly of mud (particles < 63 µm). He applied spatial panel data models on the anomaly of mgs as function of the mgs in the previous year, the wind climate 10 days before sampling, the day number (as a proxy for seasonality) and year. There was significant effect of the mgs in the previous year denoting a negative feedback equilibrium response to previous conditions. A Wadden Sea wide coarsening of 0,75 µm/year was found, which showed most locally at the higher tidal flats.

Marjolein Post studies flatfish in relation to sand nourishments. She performed a laboratory test on the grain size preference of juvenile sole and found that they prefer finer fractions. In the field flatfish distribution is governed by temperature, shelter against predation, food, burial capacity and other factors. Along the Sand Motor a relationship was found between flatfish distribution and the percentage medium sand (250-500 µm). Sediment colour might also be important to juvenile flatfish. When nourishing in spring, a mismatch can occur between benthos recovery (as food for fish) and the growth and survival of juvenile fish in the shallow coastal zone.

Marin van Regteren studies an often overlooked group of small worms: oligochaetes. These small worms can reach very high densities in mudflats. They are conveyor belt feeders and are able to live in anoxic sediments, affecting microbial activity resource flows. They also increase the erosion rate of sediments by their bioturbation. She studied the distribution of oligochaetes in transects from mudflats to saltmarsh and found highest densities in the pioneer zone. Their distribution was unrelated to grain size, and might possibly be affected by predation pressure.

Maarten Kleinhans held a keynote lecture on estuaries. Human interference and initial conditions drive the morphology of estuaries. The study into this field is multi-disciplinary between geology-morphology-biology. The initiation of motion is an important aspect for understanding that a particle has to pivot before it moves, and mixed sediments can change this behaviour for different particle sizes. A well-known example is the 'Brazil nut effect' in which the larger particles move upwards when shaken. This effect can lead to reverse sorting effects in avalanches on the leeward side of bedforms. Bedrock is an important limiting factor in otherwise fluvial beds as shown in various river

systems. Bedrock Dutch style can be old peat layers, such as found the Ems-Dollard estuary. A new insight is that suspended sediment can erode bedrock.

Joep van der Zanden performed laboratory experiments on sand mixtures and improved numerical modelling. He showed a nice example on the sediment transport capacity for unimodal 200 µm sediment versus bimodal 100 and 300 µm sediment. Although the median grain sizes of these sediments are equal, the transport capacity doubles for the mixture. He showed examples of hiding and sorting effects in sand dunes and ripples. Remarkably, the rather simple process formulations in Delft3D perform well on mixtures as long as the model is well-calibrated.

Helena van der Vegt studies delta deposits that are dependent on the grain sizes of the outflowing sediments. A coarse input leads to a coarse delta top layer, a muddy input leads to a muddy delta top and a big prodelta. She compared her numerical modelling results with geological delta's and came up with a conceptual model on basin filling consisting of sediment supply and accommodation space and reworking processes.

Bas Borsje studied salt marsh width dynamics with sediment elevation dynamics (SED) –sensors from NIOZ. These sensors measure bed height, but don't tell anything about sorting. He applied SEDs in a transect along the marsh and marsh edge for a 10-month period. He did not find a good correlation between storm events and sedimentation/erosion of the bed. Processed evolving around clay vs. sand and vegetated vs. non-vegetated should be resolved for explanations.

Panel discussion

General impressions

Martin Baptist: What is your general impression of today?

Bram van Prooijen starts off and mentions that he was triggered by the information on the relation between the bed composition and benthos in the morning sessions. It seemed that the influence was not very strong (at least for the Wadden Sea), or not very well measurable. Even though we have the idea this relation should be there. Martin suggests it may be that the variations in bed composition are not so large on the Dutch coast. Gravels are not very common? Sytze van Heteren, however, quickly mentioned that we have gravels at the Dutch coast. Even rocks of up to a meter at a recently nourished site. Divers also found coarse gravel in sea and they are present at morenes off the coast of Texel. So, differences in the bed composition are there.

A general impression from Sytze van Heteren was that he found it interesting to hear (counter intuitive) information from other disciplines which you would otherwise not think of. The combination of different disciplines makes for more open information.

Difficulties in finding relations between ecology (benthos) and bed composition in the field data

Peter Herman was triggered by Maarten Kleinhans, the coarse fractions (or hard substrate layers) break the equilibrium. A lot of places in the Netherlands have very similar combination of bed composition, hydrodynamics and ecology, which is most likely related to the ample supply of sediment from upstream. Consequently, there are not very many regions where a different combination of these three (bed, hydrodynamics and ecology) is present than elsewhere (i.e. all three are very well correlated) which would be very beneficial when you, for example, want to find relations between bed and ecology. If sediment and hydrodynamics are already well correlated then it is hard to find correlations of sediment and ecology (because there is already a relation with hydrodynamics). Low supply regions show more complex behaviour. So, the coarse layers may be interesting, since they are different.

Eelke Folmer suggests that more experimental work should be done. For example, by relating benthos to the environment. There are quite some people who seem to agree on that, and a few with doubts as conditions in the lab can never mimic complexity of reality (e.g. influence on other related species). Martin mentions that there are various co-variants such as food/benthos and burial which are different in depending on the type of bed sediment.

Maarten Kleinhans suggests looking at different sites (around the world) which have different combinations of bed, hydrodynamics and ecology. According to Peter Herman the Eastern and Western Scheldt are already very different. Very different communities of species and there is a different mud/fines composition in Eastern Scheldt. Differences in hydrodynamics play an important role here. It is notable (according to Peter Herman) that other parameters than just the bed composition play an important role. But this is difficult to ascertain. It is important to unravel the natural correlations. Then you can see something.

What about relevance of bed composition for morphology
Martin: What about the morphological processes? What would happen to morphology if you change the sediment we bring to the coast? Bram van Prooijen suggests that a not so different response may be provided if other types of sediments would be brought to the coast. Instead of including more detailed sediment fractions in the modelling of the coast, it would be better to include more detailed processes (e.g. transport related). Harriette Holzhauer, however, suggests that this really depends on the question you are asking. Obviously, some regions are more influenced than others. Maarten Kleinhans notes that hard layers are quite important constraints to the morphological development in some regions, which however also means that the precise representation of the fractions inside the mixture is not that important. It is constraint by some hard boundary.

Effect of nourishment policy on bed composition
Helena van der Vegt has a question relating to a previous discussion on locally coarser sand at a nourishment site. Is it really a problem if coarse sand is nourished, since the bed composition will most-likely go back to its original state? Bert van der Valk adds to this that any eroding section of the coast (i.e. where sediment is typically nourished) will already have a coarser composition than the surrounding sections. According to Peter Herman a 50 micron change is already an issue. Bert van der Valk does, however, add that the characteristics of nourished sand (from a borrow area at sea) also depends on availability. For example, it is always fluvial and therefore not rounded such as the coastal sands. Sytze suggest that they may just need to sail a bit longer. Selection of sources is a way forward. For such a decision we do, however, lack evidence of adverse effects on ecology. So, Martin asks: What is the knowledge gap? Peter Herman suggests that there is lots of variability in grain size, but insufficient data (and/or) modelling to do something substantial. Bert van der Valk suggests redoing old studies, such as those by Eisma (it is not all that expensive). It provides a clear overview of the Dutch coast and was performed before the nourishment policies came into place. While Sytze van Heteren rather opts for repeating Gullentops' research. In general it might be useful to bring legacy data sets back to life by digitizing reports/measurements and by making it easily accessible. Maarten adds to that, that ecological data collection may be needed. Most data is not stored properly according to Peter Herman. Martin notes that some data on ecology is still on floppy disks!

Can a small area with some change in bed composition be isolated from the rest of the coast?
Matthieu de Schipper asks whether effects of bed on ecology are co-located? For example, has the bed changed or has the benthos changed locally. What about time and spatial lags? And Sytze also wonders whether other external factors play a role. Peter Herman notes that research is available on the mortality and restoration of ecology at construction sites (e.g. for large nourishments). The

benthos population needs time to restore. Typically 2 to 4 years. Martin adds to the discussion that yearly variations play a role. And there are a lot of complicating factors. Peter Herman suggests that storms may not be all that important for some species. Some animals have no difficulty to react to a storm since they can easily hide for some time, but are more affected by normal conditions or the sand of the bed. Simeon Moons suggests it may be nice to experiment at the Sand Motor, since a coarse layer may persist in somewhat deeper water after the perturbation of the Sand Motor nourishment has disappeared.

The million dollar question

Martin asks the million dollar question, which triggered a lot of response: What experiment do you want to design if you would get 1 million subsidy?

- Bram van Prooijen would invest in laboratory experiments which would give insight in the burial of fine sediment into the bed of the North Sea (for mild conditions) and out of the bed during extreme situations. Especially this exchange with the top-layer (and burial) is an important unexplained factor in the North Sea.
- Sytze van Heteren would bring old data sets back. Make the overview complete again. Combine old data with new data (cable laying, wind parks, RWS etc.). Vera van Lancker suggests that better field and lab protocols for analysing samples, and optimizing sampling would also help. Data quality is, at the moment, not always optimal. Peter Herman would have liked an obligation for anyone collecting sediment or benthic species (i.e. community property) to give the data back to society!
- Peter Herman likes to make optimal use of the dis-continuum between sediment (sand/gravel) and hydrodynamics or ecology. We need something like a shields-curve for species. There must be some general lines. Peter notes there can be specific thresholds for species at which their behaviour / habitat is affected. For example, initial mobility of sediment is important for species. The mobility of the sand may result in infill of the holes of the animals. The interaction between bottom shear, sediment and benthos/animals should be investigated in more detail. A combination of lab-experiments on behaviour of species should be combined with field data. Especially hypotheses which indicate a particular condition / mechanism as a driver for changes in benthic communities may be investigated. There can also be different thresholds. For example, at high transport rates or when liquefaction / sheet flow takes place, which may washout species from the bed.

Closing

Martin Baptist closes the day and thanks the presenters and the audience for their contributions. It is uncertain how to proceed, but it can be concluded that today we have discussed a very interesting multidisciplinary topic within a well-established NCK network, so we will sure find ways to go forward.

Additional comments by Bas Huisman based on his interpretation of the presentations:

- It is easier to understand changes / patterns in deep water. This holds for (modelling) of bed composition changes, which is easier in the offshore than for the swash zone. And holds also for the relation between bed composition and ecology, which was quite strong for the (deep) Belgian North Sea and difficult to find for the shallow Waddenzee.
  I think it is likely that the much larger influence of the weather conditions in shallow water plays an important role. The deep water only experiences tide and some yearly variation in temperature and nutrients.
- Understanding the different transport behaviour of coarse and fine sediment size fractions can be essential for complex areas such as the Amelander Zeegat. There is hardly any

knowledge on the way in which grains are transported through tidal inlets and how they interact with the bed. How are we going to solve the morphological challenges of these basins if we do not know what happens with grains at the bed?

- Taking into account information on bed composition may provide information on the morphology/transport patterns which would otherwise not be available in regions with little morphological changes (i.e. little morphological change to calibrate models against).
- The assessment of the change in bed composition at large scale structures (or collection of sediment data) is relatively easy to perform but not accounted for in Environmental Impact Assessments. It seems to be a good thing to do, even though interpretation of the effects on the ecology is complex.