5th IMMERSE Transnational Estuary Exchange Lab:

'Microplastics and sediment-bound pollutants'

22.-23. March 2023, Hull

Workshop Report

The IMMERSE Transnational Estuary Exchange Labs (TEELs) provide a platform to share practices and progress on developing solutions for estuarine management issues. The purpose is to advance the development and transfer of solutions across those involved in estuary management in the North Sea Region.

IMMERSE organised the fifth TEEL on 22/23 March 2023, in Hull, UK, hosted by the IMMERSE partner University of Hull. Through interactive discussions, it offered a place for transnational exchange for IMMERSE partners, North Sea Region estuary managers, and further relevant stakeholders who jointly explored solutions and shared experiences during two plenary sessions and four dedicated topical sessions. The main theme of the fifth exchange lab was **emerging pollutants**, more precisely on, **sediment-bound pollutants and microplastics**. Two plenary and four breakout sessions tackled the state of play in North Sea estuaries, explored how to prevent and filter microplastics using **nature-based and innovative solutions**, and introduced current research, **monitoring,** and **management** of sediment-bound pollutants. The participants visited management realignment sites in the Humber estuary on the second day.

This report summarises the presentations, discussions, and audience engagement from all sessions on 22 March, starting with an **Introductory Session – 'Setting the Scene,'** which introduced participants to the IMMERSE project, the TEEL concept, and the topic of Emerging pollutants in North Sea Estuaries.

After this introduction, two keynote presentations were held: **Sediment-bound pollutants in the North Sea Region – posing a threat to estuarine functions**, which discussed the INTERREG North Sea project **Sullied Sediments** and a presentation of the INTERREG UK/France **Preventing Plastic Pollution project.**

The plenary session was followed by two parallel breakout sessions dedicated to **Mapping and Managing Sediment-bound Pollutants in Estuaries and Coastal Waters** and **Building on the Overview of Microplastics Occurrences in NSR Estuaries**, presenting the state of knowledge on sources, sinks, transport pathways and methodologies for analysis. Another two parallel sessions took place afterwards. These were dedicated to **Understanding the Interactions between Biota and Pollutants** and their direct and indirect benefits, introducing a habitat restoration and design method**. Testing Solutions Tackling Microplastics from Source to Estuary**, discussing different types of solutions which can prevent microplastics from entering the estuarine environment.

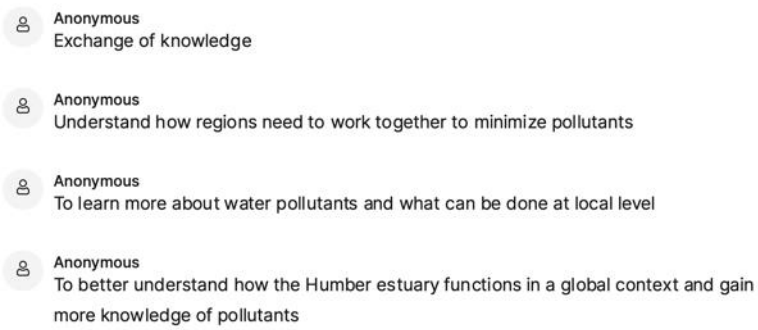
The final session saw presentations and discussions on managed realignment projects in the Humber to be visited the next day.

The TEEL was attended by 38 individuals and closed off with a wrap-up session. All materials from the TEEL can be found on the IMMERSE TEEL webpage: https://northsearegion.eu/immerse/transnational-estuary-exchange-labs/.

Introductory Session: Setting the Scene

Kicking off the TEEL, the IMMERSE Project Lead Frederik Roose from the Flemish Government Department for Mobility & Public Works introduced the IMMERSE project. Slido was used as an interactive tool, engaging participants in an icebreaker quiz with real-time audience feedback (see screenshots below). This was followed by an introduction to the TEEL concept by Frederik Roose, who subsequently introduced the three speakers in the session.

"In 1 Sentence, what do we want to achieve by the end of this TEEL?"



Sediment-bound Pollutants in the North Sea Region – Posing a threat to estuarine functions

Prof. Jeanette Rotchell and Dr Samantha Richardson, University of Hull

Summary

In their presentation, Jeanette and Samantha introduced the extent and pressure of sediment-bound contaminants at nine inland waterway sites (as part of the EU Sullied Sediments project) to estuaries and the North Sea. An overview of the sediment chemical analysis datasets for legacy and emerging contaminants was presented. Parallel work attempting to relate sediment chemical contaminant profiles to rapid ecotoxicology approaches was presented briefly. The talk also touched upon the detrimental biological effects observed at the Dogger Bank, a hotspot for pollutants and the tumours identified in the local fauna. The nine sites of the Sullied Sediments project provide an idea of the scale of the potential problem for the North Sea Region. The challenges in finding solutions, including a brief overview of the related sediment re-use investigations conducted by Sullied Sediments partners, were touched upon.

Presentation: Sediment-bound Pollutants in the North Sea Region – Posing a threat to estuarine functions

Q1: *Is there any thought on the chemicals that go from the water column into the sediments?*

A1: *It depends on the kind of chemistry. Mainly. The organic ones regularly stick to the sediment, and they tend to become relatively stable at that point. Once in the sediment, they are stuck there. So typically, many contaminants are found on very fine sediment particles.*

Q2: *In the context of the different pollutants and some emergent ones, which ones should be researched most?*

A2: *The combination is what needs to be understood. It is straightforward to understand the toxicity of contaminant A and contaminant B. But understanding, the effects of 50 of them in a sample need to be understood.*

Q3: *If I could do a toxicity test on sediment and I had an opportunity to do one test, which one should I choose?*

A3: *The shrimp test worked quite well for certain sediments. It had a moderate colouration (at least in the Humber).*

Preventing Plastic Pollution

Kim Goonesekera, UK Environment Agency

Summary

In her presentation, Kim covered the positives and negatives of plastic and provided an overview of the Preventing Plastic Pollution project funded under the UK/France INTERREG programme, including the three work packages: Enabling transformational change from first use to end of life, reducing and removing the legacy of plastic pollution and understanding plastic pollution from source to sea. She explained and gave various examples of project activities to prevent plastic pollution through engaging with governments to influence policy, working closely with businesses and retailers, and engaging with the public and schools. The session highlighted to what extent general stakeholder engagement is essential and how challenging it can be.

Presentation: Preventing Plastic Pollution

Q1: *Which area was the easiest and most challenging to work with?*

A1: *The easiest was the schools and young people. They were receptive to our messages and open to working with us. The hardest was business and retail. Some of that was because of Covid starting three months into the project. As a result of that, many businesses had other priorities. Many were fighting for business survival, so talking about environmental issues and plastic was challenging. But we found a way for businesses to get involved with existing business networks.*

Q2: *The presentation showed that 215 businesses signed up for a plastic reduction commitment. What included that, and what was an easy commitment that businesses wanted to make?*

A2: *There were different levels of commitment (gold, silver, bronze) they could make, depending on the story on the results of the types of commitment they would make. Some might have been looking at their supply chain and seeing what they were buying to see if they could make changes. It was targeted to different sectors, as well, to make it appropriate for that individual sector.*

Q3: *In Sweden, tires were identified as an initial source of microplastic in the environment. In the UK, are there any actions with a case on tires?*

A3: *Yes, one piece of work was related to this. The University of Plymouth was working on tire waste that was coming into roads, and they did some sampling and analysis.*

Frederik Roose introduced the IMMERSE project

Prof. Jeanette Rotchell and Dr Samantha Richardson.

Breakout Session 1: Mapping and Managing Sediment-bound Pollutants in Estuaries & Coastal Waters

Sediment-bound pollutants such as PCBs, DDT, HCB, and heavy metals seriously threaten North Sea Region estuaries and its coastal waters. These pollutants often originate from historic industries but remain within the system, bound to the sediment. They make it challenging for good sediment management to move or reuse sediments and impact the good ecological health of the system. The session introduced the state of knowledge on mapping and managing sediment-bound pollutants in estuaries, harbours, and coastal waters. Using case studies from the Elbe estuary (DE), UK and Scheldt estuary (BE), participants were informed about knowledge being developed, work being carried out, and experiences managing sediment-bound pollutants. Presentations lasted around 20 minutes, followed by an interactive discussion with the audience allowing participants to share their knowledge and experiences in managing sediment-bound pollutants. The IMMERSE Project Coordinator, Frederik Roose from the Flemish Government Department for Mobility & Public Works, introduced the session and the speakers and facilitated the discussion.

State of knowledge and mapping of sediment-bound pollutants in the Elbe estuary

Victoria Ortiz, German Federal Waterways Engineering and Research Institute
Pascal Richtarski, Helmholtz-Zentrum hereon, Germany

Summary

In their presentations, Victoria and Pascal focused on the R&D project CTM-Elbe (Contaminant transport modelling in the Elbe) and related work as part of IMMERSE. Victoria talked about the legacy pollution at the Elbe estuary and introduced her ongoing research on modelling the transport of sediment-bound pollutants under variable, estuarine conditions. Her work focuses on the distribution of priority pollutants in dynamic well-mixed estuaries like the Elbe estuary. Pascal presented the sampling methods and campaigns, which will feed into the modelling development. Pascal discussed the analytical process of sediment, water and suspended particulate matter (SPM) samples from the tidal Elbe River. In particular, he presented the analytical procedures of important pollutants of the Elbe estuary, such as the inorganic pollutants cadmium, copper, and zinc and the organic pollutants hexachlorobenzene, dichlorodiphenyltrichloroethane, and polychlorinated biphenyls.

Presentation: State of knowledge and mapping of sediment-bound pollutants in the Elbe estuary

Legacy wastes in coastal zones

Prof. William Mayes, University of Hull

Summary

In the first part of his presentation, William introduced the latest findings on waste on the British coastline. In the second part, he presented his nationally-funded research project investigating how we can improve the management of environmental legacies from some of the most carbon-intensive and polluting sectors of our economies. In particular, he showed the results of waste impacts and ecological risks in coastal areas of the UK, now and in future climate scenarios. He presented an example on the Brickyard Lane in the Humber explained in more detail.

Presentation: Legacy wastes in coastal zones

Monitoring and managing sediment-bound pollutants – a practical case for the Scheldt estuary

Jürgen Suffis, Flemish Department of Mobility and Public Works

Summary

In his presentation, Jürgen introduced the monitoring carried out in the Dutch Western Scheldt and Flemish Sea Scheldt by the Flemish Government of Mobility and Public Works to manage sediment-bound pollutants in the estuary. Further, he introduced the legal framework of sediment-bound pollutants in the Scheldt area and gave insights into their building, maintenance, and dredging activities.

Presentation: Monitoring and managing sediment-bound pollutants – a practical case for the Scheldt Estuary

Breakout session 2: Building on the Overview of Microplastics Occurrences in NSR Estuaries

Before introducing the session, moderator Eline Van Malderen from the Flemish Government Department for Mobility & Public Works briefly introduced microplastics. Microplastics are abundantly present in North Sea Region estuaries. However, their spatial and temporal distribution has yet to be well known because of the complex transport pathways they follow. Getting insights into the occurrences of microplastics in estuaries allowed participants to make an overview of the North Sea Region. This session provided knowledge on the occurrences, distribution, transport pathways and effects of microplastics in different NSR estuaries. Presentations lasted around 15 minutes, followed by a discussion with the audience.

About plastics and how they pollute

Clare Collins, University of Hull

Summary

Clare, an environmental scientist working on microplastics, provided in her presentation a general background to plastics, how they are produced and how they get into our environment as pollutants, as part of a work she is voluntarily committed to. She then provided an interactive map of the Humber estuary with small figures of sinks, pollutants, and sources to show the origins and distribution of microplastics within the Humber as a specific use case. The activity stimulated a discussion about the transport pathways and primary sources of microplastics concluding that it is a societal problem which requires behaviour change and education.

Presentation: About plastics and how they pollute

Interactive map of the Humber estuary


Interactive discussion on microplastics

State of knowledge of the effects and distribution of microplastics in estuarine environments

Julie Hope, St. Andrews University

In her presentation, Julie pointed out that while our understanding of microplastics as a pollutant in estuaries advances daily, we need to clarify and identify the different sources of this pollutant and understand microplastic transport, accumulation, and residency times in estuarine environments. While data is relatively scarce for the North Sea Region, microplastic pollution in European river and estuarine sediments can be comparable to that in several Asian systems. Microplastic pollution may lead to adverse environmental and socio-economic effects in estuarine environments. In her presentation, Julie provided a general overview of the state of knowledge of microplastics (what they are, where they come from), entry into estuaries (sources and pathways), and what is known about NSR estuaries to date. Further, she discussed the processes influencing microplastic entry and distribution in estuaries, microplastic transport and settling, fate and effects, methodological issues, potential risks, and mitigation strategies.

Presentation: State of knowledge of the effects and distribution of microplastics in estuarine environments

Microplastics monitoring in the Flemish Sea Scheldt

Mathilde Falcou-Préfol, Universities of Antwerpen and Ghent

Summary

Since September 2020, Mathilde has been a joint PhD student at UAntwerpen and UGhent (Belgium). Her project aims to develop methods to detect and assess plastic particles smaller than 10 µm in the aquatic environment. Her study site is located along the Scheldt estuary. Mathilde is involved in the OMES – IMMERSE project on the microplastic part in water and sediment matrices. In her presentation, she reported on the sampling carried out for Flemish Waterways, including water and sediment samples, which were taken upstream of the Scheldt and some of its tributaries and showed the distribution in the different phases of an estuarine system.

Presentation: Microplastics monitoring in the Flemish Sea Scheldt

Q1: What are some opportunities for managing microplastics as a pollutant, based on the information we already have available from research?

A1: Estuaries are important for industry, living, recreation and nature, making developing solutions and strategies more difficult as it has to consider these multiple services, e.g. there is no solution to stop dredging or forbid people to come near estuaries. A lot of the pollution comes from the landside, making it more difficult for estuary managers to develop solutions.

Breakout session 3: Understanding the Interactions between Biota and Pollutants

Emerging pollutants such as microplastics severely risk estuaries' water and sediment quality. Pollutants interact with the biota, which can filter these compounds. In this session, these interactions were showcased, discussing whether they can be used to remove emerging pollutants from estuaries. The session featured three speakers presenting a feeding experiment investigating the interactions between biota and pollutants, a feasibility study of co-locating mariculture inside a wind farm, and a presentation about oyster restoration. The presentations gave participants a basis for discussing good practices and cross-cutting topics. Guest moderator, Ben Lamb from Tees Rivers Trust, introduced the session and the speakers and facilitated the discussion.

Where does the plastic go - can benthic animals remove plastics from the environment?

Felicitas ten Brink, University of Hull

Many marine organisms in various environments ingest microplastics, but what drives the variability between species and what happens after ingestion has yet to be determined. The occurrence of microplastic in field samples and the potential of microplastic accumulation in animals and the intertidal system. In her presentation, Felicitas presented her first results of a lab-based exposure study to explain the possible future evolution of microplastics in the benthic ecosystem.

Presentation: Where does the plastic go - can benthic animals remove plastics from the environment?

Q1: *When do microplastics become toxic?*

A1: *Many studies that prove the toxicology of plastics use more plastics than we find in the environment. It remains a question of whether what is found in animals is the correct amount. But if we keep producing plastics, we will eventually have these high amounts.*

Q2: *Do we concentrate plastics on the animals themselves?*

A2: *No, we did not find in our studies that we accumulate plastics in animals. We only found accumulation plastics in faeces. In the real environment, we still must find out whether faeces stay localised.*

Growing native oysters in the Tees Estuary

Ben Lamb & Henry Short, Tees Rivers Trust

Summary

The Tees Estuary pilot in the IMMERSE project aimed to address the issue of a coastal squeeze on this heavily modified estuary through a feasibility study to investigate opportunities to locate a mariculture enterprise within the Tees Bay Windfarm. The study examined the potential costs and benefits of cultivating bivalves in the estuary. With the Tees' long industrial history, pollution constantly threatens mariculture and fisheries. In their presentation, Ben and Henry summarised the feasibility of the study, identified pollutant-biota interactions, and prospects for mariculture as an estuary management measure in the Tees and beyond.

Presentation: Growing native oysters in the Tees Estuary

Q1: *Do you have any water quality assessments before 1864?*

A1*: Oysters have been everywhere in waters before the industrial revolution. That is why in most archaeological sites, they found oysters. Thus, since the industrial revolution, water quality has declined.*

Q2*: In an ideal scenario, oysters from the study have many babies, and in nine years, there are oysters everywhere. Could that be a new problem we are creating?*

A2*: Theoretically, they only settle along where you have done your restoration because they will not settle along bare mud, so you confine it to that area. It is not much of a concern as they are very picky about where they settle. Moreover, in our study project, they grow under control.*

Q3*: There is much greenwashing among companies as people do not care about sea beds.*

A3*: There has to be some engagement to get improvement—more than regulation is required.*

Breakout session 4: Designing and Testing Solutions Tackling Microplastics from Source to Estuary

Microplastics are widely present in oceans, seas, estuaries, rivers, and streams. Finding solutions which filter microplastics before they can enter estuarine systems is crucial as these systems act as a sink, affecting water quality and influencing organisms living here. This session introduced and discussed solutions to manage microplastic pollution in estuaries. The session featured three speakers, discussing how to manage plastic waste and engage the community, presenting a research project using innovative rain gardens to filter microplastics from stormwater and its results, and investigating biofilms' role in filtering microplastics. Presentations lasted 15 minutes, followed by a discussion with the audience. Guest moderator Ann-Margret Strömvall from Chalmers University of Technology in Gothenburg introduced the session and the speakers and facilitated the discussion.

Managing plastic pollution

Clare Collins, University of Hull

Clare presented ideas and actions on reducing sources of microplastic pollution to estuary environments by individual people, focussing on the landward source of plastics. Further, she gave examples of encouraging community action and behaviour change and discussed engagement with the government and industry.

Presentation: Managing plastic pollution

Innovative rain gardens to filter microplastics from stormwater

Karin Karlfeldt Fedje, Chalmers University of Technology & Renova AB

Karin works as a researcher on the Gothenburg waste and recycling company Renova and is an adjunct professor at the Chalmers University of Technology. Her research focuses on recovering metals and other valuables in contaminated material. In her presentation, she introduced ongoing research about purifying contaminated stormwater from microplastics and other pollutants (metals and organic compounds) using filters and phytoremediation. Initial results indicate that passing the stormwater through the filters improves the water quality. However, the efficiencies are, to some extent, dependent on the filter materials and the kind of pollutant.

Presentation: Innovative rain gardens to filter microplastics from stormwater

***Q1**: Where does the used water come from?*

***A1**: The water was collected from a major highway road next to the pilot location in Gothenburg.*

***Q2**: How do heavy rain showers or floods affect the results?*

***A2**: This will be further studied as part of some experiments, but the filters are expected to be less effective as the stormwater will pass through faster. Or would even have a negative impact as these amounts of water could remobilise pollutants.*

The role of biofilms in filtering microplastics

Julie Hope, St. Andrews University

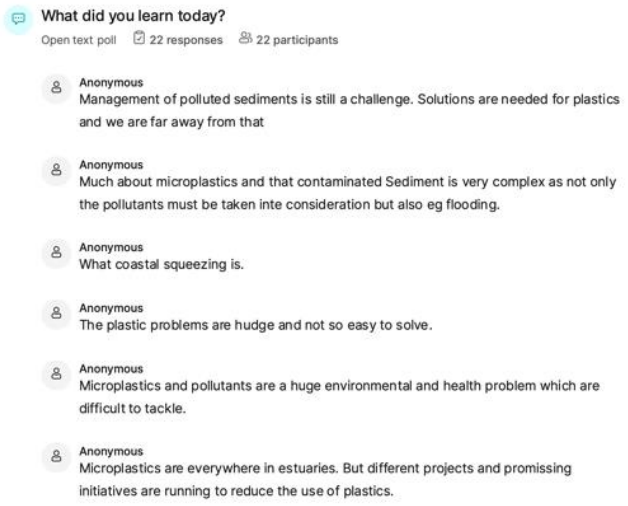
Benthic biofilms are known to capture and retain fine sediment particles from the overlying water so that they may play a role in microplastic retention and accumulation on the bed. In her presentation, Julie showed preliminary results from recent experiments investigating the resuspension of microplastics from different biofilms and the effects of heavy metal accumulation on plastics. She explored whether biofilms could stem the flow of microplastics as they transport through estuaries and the potential to use knowledge of biofilm growth and distribution to target areas for microplastic immobilisation or physical removal from the environment. It was discussed that these biofilms make the areas where they grow a

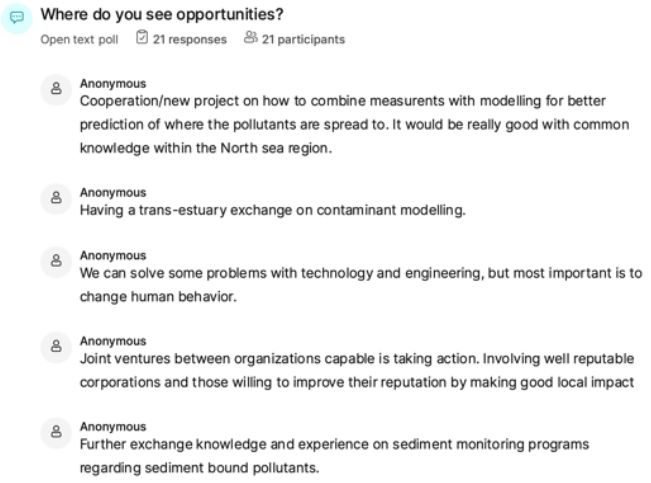
sink for different types of pollutants, including microplastics. Using these biofilms as a solution will be difficult, as they would have to be removed from the system, which is very difficult. However, knowing they are kept out of the rest of the estuary might already be good.

Presentation: The role of biofilms in filtering microplastics

Plenary session 2

Pedro Brosei (s.Pro) moderated the final session. The audience was asked for feedback regarding the overall workshop using Slido (see below screenshots).





This was followed by a short introduction of the tour to the University of Hull's Total Environment Simulator at The Deep Aquarium and the Frontage Scheme flood defences by Robert Thomas from the University of Hull, to be visited before the dinner this evening. Pedro then introduced the two speakers from the UK Environment Agency, which manages two realignments sites in the Humber estuary to be visited by participants the next day.

The need for managed realignments in the Humber due to coastal squeeze Introduction to the site visit

Andrew Gee and Dan Normandale, UK Environment Agency

In his presentation, Dan talked about Managed Realignments on the Humber, specifically introducing the Paull Holme Strays site, which is already completed and in use. Andrew introduced the Skeffling Managed Realignment project, which is currently being constructed. The Skeffling Managed Realignment project is jointly funded by the Environment Agency and the Associated British Ports and aims to create new intertidal mudflats and salt marsh areas on the estuary to provide compensatory habitat for losses on the designated Humber as well as to compensate for direct losses from future port expansion.

Presentations: Outstrays to Skeffling Managed Realignment Scheme, An introduction to Managed Realignment on the Humber estuary

Finally, the IMMERSE Project Lead, Frederik Roose from the Flemish Government Department for Mobility & Public Works, closed the session by giving general conclusions from the TEEL and IMMERSE project.

Conclusion

The TEEL highlighted the importance of the transnational exchange of ideas, sharing knowledge and experiences, and learning to work together to manage estuarine pressures.:

- Much research has been done on mapping and better understanding pollutants' occurrences, transport, and effects.
- Additional research and monitoring of pollutants remain essential to strengthen our understanding and to be able to manage better and find solutions.
- Research about the interactions between biota and pollutants is being carried out. However, many uncertainties remain that need to be further researched, also looking at the effects on the biota.
- Sharing knowledge and experiences about this and comparing the results for different estuarine systems strengthens our understanding.
- Estuary managers need to develop solutions and strategies to manage pollutants which often originate from landward sources, making it more difficult.
- Estuaries are complex and dynamic environments where various processes influence each other.
- Estuary managers must consider the multiple ecosystem services of estuarine systems when developing solutions and strategies.
- Solutions for managing pollutants are being developed.
- Developing solutions and strategies is a long-term process, which can take several years to decades before implementation.

Finally, there was a call for participants to use the LinkedIn group for North Sea Estuary managers created during IMMERSE to keep each other updated on the latest developments. At the same time, it was also emphasised that meeting in person regularly to share research findings and methods is very valuable.

Site visit to Skeffling

Site visit to Skeffling

Site visit to Paull Holme Strays

Site visit to Paull Holme Strays

Site visit to Paull Holme Strays

Participants

Anne	Baar	University of Hull
Pedro	Brosei	s.Pro - sustainable projects GmbH
Clare	Collins	University of Hull
Bart	De Maerschalck	Flanders Hydraulics Research
Mathilde	Falcou-Prefol	University of Antwerp (ECOSPHERE)
Richard	Freeman	FAMENET / Newcastle University
Andrew	Gee	UK Environment Agency
Andrew	Gibson	Yorkshire Wildlife Trust
Kim	Goonesekera	UK Environment Agency

Karolina	Granja	s.Pro - sustainable projects GmbH
Alex	Hay	UK Environment Agency
Charlotte	Hebditch	Tees Rivers Trust
Julie	Hope	Univer Of St Andrews
Clare	Humphrey	Yorkshire Wildlife Trust
Veronica	Hurtado	University of Hull
Karin	Karlfeldt Fedje	Renova AB/Chalmers University of Technology
Carmen	Kleisinger	Federal Institute of Hydrology
Ben	Lamb	Tees Rivers Trust
Susan	Manson	UK Environment Agency
Will	Mayes	University of Hull
Dan	Normandale	UK Environment Agency
Victoria	Ortiz	BAW
Holger	Rahlf	BAW
Samantha	Richardson	University of Hull
Pascal	Richtarski	Helmholtz-Zentrum Hereon
Frederik	Roose	Dep. of Mobility and Public Works - Maritime Access
Jeanette	Rotchell	University of Hull
Eva	Schick	HafenCity University Hamburg
Henry	Short	Tees Rivers Trust
Ann-Margret	Strömvall	Chalmers University of Technology
Jürgen	Suffis	MOW - Maritime Access
Felicitas	ten Brink	University of Hull
Robert	Thomas	University of Hull
Piet	Thys	De Vlaamse Waterweg nv
Charlie	Trotman	University of Hull
Eline	Van Malderen	MOW - Maritime Access
Kirsten	Wolfstein	Hamburg Port Authority
Mark	Zindorf	Federal Institute for Hydrology