SOFI Workshop Report
UK Sediment Initiative 2009: Developing multidisciplinary sediment dynamics research in a strategic context.

April 27th-29th 2009

Foresight Centre
Liverpool

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Introduction.

The Natural Environment Research Council (NERC) recently funded the Proudman Oceanographic Laboratory to host a United Kingdom Sediments Research Workshop - **UKSediments09** - under the Oceans2025 Strategic Ocean Funding Initiative (SOFI). The main aim of this workshop was to bring together UK based researchers, stakeholders and policy makers with an interest in sediment processes to help foster collaborative links and to encourage the coordination of future research in this area.

The UKSediments09 workshop was held in the Foresight Centre in Liverpool on 27th – 29th April 2009. There were 53 participants comprising a well balanced mix of NERC Oceans2025 partners, HEI researchers, industry consultants and government departments and agencies.

Specific objectives of the workshop were:

- To review state-of-the-art on sediment dynamics research.
- To identify gaps in knowledge and prioritise research needs towards formulating a UK-wide sediment transport research strategy.
- To understand the practical needs of stakeholders and industrial consultants.
- To identify sediment transport related questions that will help formulate the NERC strategy, “Next Generation Science for Planet Earth”.
- To explore possible mechanism for funding collaborative research.

Workshop structure.

Six invited speakers presented a number of different perspectives on sediments research, setting the scene for the wide ranging discussions that would follow:

- ***Policy Drivers*** - Darius Campbell (DEFRA)
- ***Industry Needs*** - Richard Whitehouse (HR Wallingford) and David Lambkin (ABPMer)
- ***NERC Theme Action Plans and Funding Opportunities*** John Rees (NERC Natural Hazards Theme Leader)
- ***Academic Research Perspective*** - Alan Davies (U. Bangor)
- ***International Perspective*** - Chris Sherwood (United States Geological Survey) on coordination, lessons learned and outcomes of the US Community Sediments Programme

These talks were followed by three sets of four parallel breakout discussions, each focussed on different aspects and perspectives on sediments research needs. Participants organised themselves into the groups they felt most appropriate in each round, resulting in pleasingly balanced numbers in each:

Round 1 Breakout Discussions – Applications/Stakeholder Interests:

- Human impact (Richard Whitehouse – HR Wallingford)
- Coastal defence (Ian Holden – Peel Ports)
- Bio-effects (David Paterson – U.St.Andrews)
- Impact of renewables (Jon Rees - CEFAS)

Round 2 Breakout Discussions – Spatial Scales:

- Nearshore sediment transport (Dan Conley – U.Plymouth)
- Shelf wide sediment transport (Alex Souza – NERC/POL)
- Process studies. (Tom O'Donoghue – U.Aberdeen)
- Sediment transport in estuaries. (Jon Williams – U.Plymouth)

Round 3 Breakout Discussions – Temporal Scales:

- Waves - Hours (Pete Thorne – NERC/POL)
- Tidal - Days (Peter Stansby – U.Manchester)
- Seasonal - Years (Alan Davies – U.Bangor)
- Decadal (John Rees – NERC/BGS)

Summaries of the main points of discussion from each topic were presented to the workshop by the group chairs following each round of discussions, and are presented in edited form later in this report since the original reports naturally varied widely in style and length. A number of common themes emerged repeatedly from the different discussion groups and these can be encapsulated by a small number of big ideas:

- Sediment pathways and drivers, particularly around coasts and estuaries
- Nearshore & swash processes
- Effects of cohesive and mixed sediments
- Sediment-biological interactions
- Effects on sediment dynamics of active structures such as renewable energy devices

Discussions were concluded at the end of the workshop with re-iterations of the types of funding available through NERC and potentially from other stakeholder organisations if the sediments research community are able to put forward a well reasoned, targeted and balanced set of proposals.

The opportunity for all participants to display posters of their recent research work was provided in the social area and breakout rooms for the duration of the workshop, and PDFs of these (where available) were distributed on a CD to all participants. Every effort was also made by the organisers to provide opportunities for individual discussions during extended coffee breaks, lunches and evening meals, hopefully addressing the common complaint that such meetings rarely provide enough opportunity simply to talk to each other.

Summaries of Breakout Discussions

The chairs of each of the breakout discussions produced a short report of the key points discussed. These have been further edited below:

Human impact

The subject of human impact needs to capture the impact of human activity on sediment sinks and sources and the sediment pathways and transfer rates for multimodal sediments induced by currents and waves. The improved analysis and prediction of sediment responses to human interventions and climate change will provide an enhanced basis for decision making about resource management and human responses and adaptation to change over decadal timescales. Decisions made now have to rely on judgement about uncertainties in our evidence base. Future decision makers will benefit from reduced levels of uncertainty which can be gained through a multi-disciplinary and strategic science programme. This will underpin future decisions made by government and regulators concerning the sustainable development of our coasts, estuaries and marine areas and delivery of equitable societal goals.

Drivers for Research include:

- Resource management of our shoreline - Flood and Coastal Risk Management, conservation, navigation, industrial uses, recreational uses, water and sediment quality
- Hinterland, coasts, estuaries, offshore (shelf) - Contrasting geomorphologies and sediments
- Deliver results of relevance to
    1. Government agencies and local authorities
    2. Regulators (EA, CCW, NE, MFA, MMO….)
    3. Consultants and contractors
    4. Industry
- Improved evidence base and methods for predicting changes in Hydrology, biology, geology, chemistry.

Questions that encapsulate the problems being faced regarding human impact that could be tested as hypotheses might include:

- What are the relative sensitivities of soft sediment systems to the varying spring tide daylight low water exposure around the coastline of the UK and how resilient are they to extreme events?
- What are the key factors in understanding the role of sediment sources and the cross-shore transfer of sediment at tidal, storm and decadal levels in promoting coastal resilience?
- What mechanisms of sediment dynamics and biogeochemistry in mixed sediment systems lead to distinct sediment environments and how will these respond to climate change?

In order to deliver a comprehensive science led management approach it will be necessary to identify, map and match the links across NERC/EPSRC/BBSRC/ESRC programmes. This will need to be driven by the policy and evidence led approaches of government departments and agencies including Defra and Environment Agency, Natural England, Countryside Council for Wales, DECC and BERR in their own areas of responsibility. Funding streams from the research councils, government departments and agencies as well as opportunities for European funding should all be sought.

Coastal Defence

The common theme within this topic was sediment pathways. From the discussion many research topics emerged as follows:

- ***Sediments:*** It is not fully understood how estuaries affect the sediment pathway and how sediments become spatially distributed. How the sediment distribution then affects the morphology is not clearly known. The sediment supply of an area needs to be quantified accurately. It was recognized that more knowledge of the bed roughness is also required for accurate prediction.
- ***Morphology:*** An accurate initial bathymetry and sediment distribution is required to allow robust predictions. Areas of erosion and accretion need to be accurately modelled. A baseline (without intervention) for long-term equilibrium morphology is required for defence planning. This raises question such as what time and special scales need to be simulated as there is still a limit to what can feasibly be modelled.
- ***Structures:*** How do different structures (soft / hard) affect an area and change the sediment pathways?
- ***Physical conditions:*** Wave, tide and surge modelling is required to determine their affects on natural and man made structures. The influence of fresh water in estuaries is also a key factor affecting the sediment pathway. Insight into how sea level rise, storm events, tides and surges affect structures is required for future planning.

For many of the topics seasonal variation is an important issue. For each topic it is important to produce transferable skills that are not location specific. The sharing of data to provide up to date boundary conditions / bathymetry is essential. Re-analysis of the available data to define baseline conditions is also required.

Biological Effects

The erosion, transport, deposition and consolidation of sediments are key to understanding the ecology and ecosystem services provided by marine depositional habitats (shelf and coastal sea beds, beaches, dunes, estuaries and mudflats). The improved modelling of regional sediment dynamics can help provide greater understanding of marine systems and provide predictive capacity to assess the threats of global climate change. At present biological and biochemical processes and biogenic mediation of sediment transport need to be better represented within regional models. We should aim to create new advances in understanding regional sediment dynamics by interdisciplinary research at the interface of biology, chemistry, physics and computer modelling. The UK capacity in both areas of science will allow us to make a major contribution to the prediction of sediment erosion, transport and deposition.

- Consideration must be paid to analysis of biotope distribution supported by detailed analysis of biological properties and processes at a smaller scale.
- At the higher level, we need to consider the regional impacts of sediment dynamics based on habitat mapping and using existing frameworks to create models linking habitat form with function in terms of sediment dynamics.
- Model accuracy needs to be assessed to determine where input of biological and biogeochemical modules may be considered to improve model performance.
- The gradient in biological impact for decreasing particle size (sand to mud) needs to be investigated to improve model formulation.
- Process studies are also required such as: Influence of biology on bed structure and consequence for flow structure; induction of turbulence in flow, links between sediment dynamics and nutrient release; biological influence on particle flocculation and bioturbation and bio-resuspension.

Using observational and modelling studies and upscaling to large scale regional modelling offers a number of opportunities for future engagement with stakeholders. Such research will also contribute to understanding: Managing sediment transport for coastal protection; Integration of biology, biogeochemistry and sediment transport to modelling systems; Carbon, nitrogen and phosphorous dynamics and draw-down in marine systems; Habitat stability and resilience.

Impact of Renewables

Renewables can be split into three sub-themes – wind farms; “wet” renewables (wave and tidal stream devices) and tidal elevation (barrages/lagoons). Some of the issues are:

- Need to make predictions of the impacts (including Marine landscape, navigation and socio-economic) over long (century) timescales and also of the associated significance of these impacts with respect to natural variability.
- Barrages/lagoons are often situated in estuarine environments with significant sediment particle size gradients thus requiring the use of mixed sediment transport models
- Need to upscale impacts from devices both spatially (metres to regional) and temporally (hours to centuries)
- The industry is developing rapidly and new structures could include tripod structures and Gravity based structures with potentially larger impacts on sediments transport due to their cross-sectional area. This may become significant for tidal stream devices in restricted estuaries e.g the cumulative impact of a series of tidal stream devices in Morecambe bay.
- Transfer of energy from the mean flow to turbulent energy and the impacts on vertical stratification and resuspension/deposition.
- Need to create accurate estuarine sediment budgets to enable sustainable management and correct location of sluices/turbines and also to predict long-term geomorphological impacts.
- Timescales are challenging with R3 wind farms potentially starting in 2012

Can we engineer renewables devices in order to produce the “best” habitats for other stakeholders e.g. Marine Conservation Zones, improved shoreline protection, enhanced water quality (e.g. water column and sediment/water interface behind barrages/lagoons)? Two big questions of immediate relevance are:

- Do arrays of wind farms change patterns and pathways of sediment transport and hence impact on region habitats?
- Can scale effects from large wind farms and arrays of wind farms be distinguished from natural variability?

Models should be tested to ensure that they are “robust” and thus ensure confidence in predictions of sediment behaviour. Validation via targeted fieldwork, linking with Coastal Observatories or LWEC (UK’s Living With Environmental Change programme) is encouraged.

Nearshore sediment transport.

Because of the need of end-users to know reliably the direction of sediment transport, a priority must be placed on cross-shore sediment transport from the swash through the surf-zone and out onto the shelf.

The continued inability to reliably determine the polarity of sediment transport under field conditions drives the need for a large scale field study to create a definitive data set for the study of processes as well as providing a community standard for future model validation. However, considering the expense and effort that such an activity requires, it was considered fundamental that such an experiment would provide features which preceding efforts did not.

- A key feature ensuring both strategic value and uniqueness would be observations of short term nearshore morphological change including time series of near-bed (<< 10 cm above bed) and in-bed profiles of sediment concentration and velocity.
- Uniqueness can also be pursued by performing the experiment in a location which has to date not been explored, for example a tidally influenced dissipative beach backed by notable dune fields, possibly in an estuarine context.
- To provide true value, these observations would need to encompass multiple events, which could be assured through a focus on bar migration and judicious site selection consisting of an environment where 2-D onshore and offshore bar migration occur on a regular basis.
- Complete measurements in such a context would extend to processes such as porous flow in the beach face, granular mechanics and identification of the complete sediment pathways for the system studied.

Shelf wide sediment transport

Determining the effect of sediment transport on primary production and habitats, predicting the sediment pathways and studying the impact of storms are all of interest to the scientific community and end-users. Progress in shelf sediment transport in particular requires the upscaling problems that are typical of sediment transport to be addressed.

An important concerted effort on obtaining large data sets, for which the different Coastal Observatories will be crucial, is also necessary. In addition, there is the need to improve the characterisation of the bed properties, bed mapping and riverine inputs for shelf evolution.

Process studies

Although practical formulations giving predictions within a factor 2 to 5 now exist for medium and coarse sands in well-defined hydraulic conditions, our predictive ability is generally much worse for fine sands and silts, and relatively little research has been carried out on mixtures of sand, silt and cohesive sediments. Furthermore, much more research is needed at the process level in order to better understand and quantify the biota-sediment interactions and to develop practical formulations that account for the primary biota effects in large-scale sediment transport models.

The breakout group identified 3 main areas for further "process studies" research: ***non-cohesive sediments***, ***sediment mixtures*** and ***biota effects*** on sediment transport:

- The focus of non-cohesive studies should now shift to field measurements aimed at the detailed wave-current boundary layer structure and sediment dynamics very close to the bed, which will require advanced instrumentation, beyond the capability of standard field instrumentation currently in use.
- For cohesive sediment and sediment mixtures, the most pressing need is for carefully designed laboratory experiments which isolate key processes in mud, sand-silt and sand-mud mixtures across the range of hydraulic regimes.
- Similarly, there is a particular need for laboratory experiments targeted at isolating key processes of the biota-sediment-flow interactions, for which both careful selection of experimental conditions and collaboration between physical and biological scientists is needed to yield results of generic value.

Sediment transport in estuaries

A key to understanding estuarine sediment transport is the establishment of the sediment budget for: the fluvial supply network; the estuary; aeolian dunes; and adjacent coastlines and offshore areas. To that end research should focus on:

- Quantification of ***exchange rates and pathways*** between ebb/flood deltas and offshore, coastal and dune sediments and fluvial sediment.
- Investigation of ***wave phasing with respect to tides*** influence sediment transport magnitude and direction and sorting processes.
- Understanding processes that control ***cyclical switching between flood or ebb dominance*** in estuaries and the resulting spatial and temporal interactions between different sediment types.
- Further development of ***models to predict morphological changes*** in estuaries and consequential impacts on flood risk, flood defence measures, and habitats.

The response of estuaries to sea level rise cannot yet be predicted with any certainty and advances will need investigations of estuary response to sea level rise through studies of sediment supply derived from offshore/coastal sources and internal scavenging, and assessment of the constraints imposed by anthropogenic activities and their impact on natural roll over processes.
A further important area of research concerns the potentially cumulative impact of tidal barrages, in the near and far-field, on intertidal and sub-tidal habitats and on production, recruitment and retention of sediments.

Finally, scientific progress in general in estuaries requires measurements of present day and subsequent temporal changes in bathymetry and topography, detailed sediment and bedform mapping, and extensive flow and suspended sediment data collection.

Waves – Hours Scales

Wind driven waves are ubiquitous to coastal waters, combined with the tides they are the primary movers of sediments, shaping and forming the coastline and nearshore bathymetry. A number of components contribute to present day limitations in wave modelling and the prediction of sediment transport:

- In the nearshore zone the formation of ***bedforms*** are common features and they profoundly impact on how sediment is entrained into the water column and then transported. However, understanding of the boundary dynamics is still developing.
- Further as ***waves propagate up a beach*** they change form, become asymmetric, steepen and eventually break. Descriptions of the hydrodynamic processes in this complex regime are under development and at the cutting edge of our theoretical capability.

- Also how the ***progressively modifying wave interacts with the bed sediments*** in the breaking region, the surf zones, and the run up region, the swash zone, is presently poorly understood.

Therefore in the most dynamic region of sediment transport, in the upper region of the beach, predictive modelling capability is at it weakest.

Tidal – Days Scales

Tidal – days scales are important due to the need of coastal modelling for navigation, port and harbour managment, dredging impacts, effects of renewable devices and water quality.

For all of them the ***sediment pathways*** is an important parameter. However progress is hampered by a general lack of basic field data such as:

- ***Sediment flux boundary conditions*** **–** e.g. longshore fluxes
- ***bathymetry & sediment properties*** **–** data availability and accuracy highly variable; ***fresh water and sediment discharges*** in estuaries
- ***bedforms and their evolution*** - especially larger scale features such as mega ripples and dunes

Tidal turbulence knowledge is also sparse and measurements using arrays of ADCPs are needed to understand the horizontal structure of large tidally induced turbulent structures. This knowledge will be vital for tidal turbine design and predicting the resulting sediment transport from their wakes. The effects of waves on tidal turbulence are also poorly understood.

Modelling the behaviour of ***mixed sediments*** is not well developed. The understanding of bed load transport of both mixed and fine sediments. For greater grain diameters existing formulae are thought to be acceptable.

Effects of ***stratification in estuaries*** thought to be modelled reasonably using Boussinesq assumption in 3-D hyrostatic models.

Seasons – Years Scales

Annual/seasonal changes in the marine environment are caused by a variety of effects including changes in storminess, river input and temperature both seasonally and through inter-annual variability, leading to major sources of uncertainty for predicting sediment behaviour over such time scales.

Seasonal biological effects exemplify this uncertainty. Seasonal variation in the production of particular chemicals by the biological community affects the stability of the seabed sediment, due to (i) a micro-phytobenthos coating of the seabed which (probably) depends upon light availability, and (ii) a ‘fluff’ layer, formed in the water column and containing chemicals that ‘stick’ particles together, which further coats the seabed when settling occurs.

Further sediment-biological process research could

- Clarify the presently uncertain ‘tipping point’ at which biological effects dominate over physical effects in relation to seabed erosion.
- Explore the time scale over which the biologically-produced chemicals degrade.
- Explore the ‘competition’ involving nutrient release that occurs when sediment gets into the water column - the nutrients supply foodstuff for phytoplankton, but they also reduce light levels thereby reducing productivity.
- Study anthropogenic seasonal effects such as the agricultural input to rivers that gives rise to the biofilms that are observed in estuaries.

Over an annual cycle, sediment transport patterns on the continental shelf are believed to be dominated by ‘medium sized tides combined with medium sized waves’, rather than by extreme events of short duration. However, would this be the case if climate change resulted in increased storminess? Regarding morphodynamics, better understanding of seasonal changes is needed in relation to beaches, estuaries and the movement of large bed features.

Further research could:

- Link beach erosion and recovery to seasonal changes in cross-shore transport mechanisms, which remain a major gap in knowledge regarding both theory and also observation.
- Improve modelling of beach behaviour through the simulation of storm sequences (i.e. multiple computer runs that produce statistical outcomes for beach profiles).
- Improve our knowledge of the migration of large-scale bed features (bars on beaches and dunes in estuaries) through innovative observational methods and modelling focussed on sediment pathways and sediment segregation. Here ecological consequences are potentially important, e.g. for migrating birds.
- Demonstrate the effect of seasonally variable (a) river input on meanders in estuaries and (b) waves on ebb- versus flood-dominated sediment transport at estuary mouths. Hindcasting could improve existing models while forecasting based on multiple realisations and upscaled inputs should lead to greater realism in the prediction of future estuarine morphodynamic behaviour.
- Clarify how much of the nitrate coming down rivers affects seasonal biological productivity within estuaries and how much of the nitrate is trapped in the sediment leading, ultimately, to a global greenhouse gas contribution from estuaries which is presently poorly understood.

End user needs would be addressed through the respective topics and factors of uncertainty in prediction would be reduced by further research. In addition, the topics above lend themselves to study within a collaborative project framework of conventional 3-5 year duration.

Decadal scales

The main issues that need to be considered over this timescale, which will not be the focus of hourly, daily, seasonal or annual timeframes, include the following:

- Changes associated with climate change, not only primary drivers such as changes in temperature and precipitation, but also changes in seawater pH and sea-level-rise.
- Bedform change over longer periods (especially in mixed, and muddy, sediments), changes in sediment erosion, for instance associated with infauna, and ecological change.
- Response of coastal systems to longer term natural changes, for instance through tidal asymmetry as well as long-term cycles (e.g. 18 years) in estuaries.
- The greater likelihood of the occurrence of extreme events, and of tipping-points where we can expect to see changes in state of the system.
- Longer term changes associated with coastal infrastructure and management options.

End-users will mainly want to know about how coastlines will change, for instance what will happen to dune systems, how will habitats change, and how will society respond?

Areas of ***potential research*** include developing expertise based on lessons learned through assimilation, or improving long-term modelling of dune, spit and barrier-beach migration, and coastal erosion (e.g. of cliffs). However, two main areas, particularly addressing decadal changes, were identified:

- Learning from historical analysis and hindcasting (particularly relevant over longer timescales) to gain a better understanding of long-term coastal change, for instance through transgressions. This may include analysis of trends in the frequency of extreme events, perhaps through coring of sites of coastal shelf sediment accumulation (e.g. the Lune Deep, the Hurd Deep).
- Development of intermediate complexity system-scale modelling, such as that developed within the Tyndall Centre Coastal Simulator. Such models are simple enough to test coastal response to a range of drivers, including sea-level rise, and may be adapted for use on a wide range of coasts including those backed by dunes and in estuaries. They would be particularly useful in establishing the impacts of rates of change, and provide better future assessments than those based on expert-judgement alone.

Summary of Key Themes

Changes in sediment distribution have economic consequences and are directly observable as changes in beach morphology, movement in sand banks and bars, siltation and erosion of navigation channels etc. These lead directly to the fundamental questions of:

- ***How much sediment has moved from one position to another?***
- ***By what mechanisms and pathways?***

We attempt to parameterise the various ways in which sediments are mobilised given a particular set of environmental drivers, but these parameterisations are largely based on a large number of laboratory scale experiments together with a small number of field studies that extend their region of applicability. The laboratory experiments have naturally attempted to deal with one variable at a time hence the tendency to work with single sediment sizes. However, mixtures of two or more sediment sizes have been shown ***not*** to behave on a sliding scale between the individual sediment types, but rather exhibit much more complex behaviour, particularly where significant fractions of fine sediments are involved. The issue of how such mixed sediments behave emerged repeatedly in many of the discussions and is starting to be considered by researchers.

Further, the existing parameterisations of bedforms such as ripples, mega ripples & dunes have again largely been developed based on laboratory data and their accuracy for the formation and behaviour of the larger bedforms in particular under field conditions is poor. Part of the reason for this is the difficulty of measuring such features in a field context – the formation and evolution of large features tends to occur under highly energetic conditions which inherently make in-situ measurements a problem – the risk of losing equipment placed in areas where the sea bed is highly mobile is very high, and the cost of such equipment makes this risk too great for most research groups. This leaves repeat surveys and remote sensing the only viable options for investigating such features – both being expensive and specialised options, but options that do exist within the UK sediments research community.

At the other extreme, where waves impact on beaches, the physics of breaking waves are not easily described and nor are their effects on beach sediments. This is one of the major regimes where sediments become mobilised and have a variety of impacts on the environment, so further work is needed here.

The interaction of biology with sediments is another poorly researched area, where the need for interdisciplinary work is now evident. Reproducing appropriate conditions to study biology-sediment interactions in the lab is not straightforward, so future research will most likely (but not exclusively) have to be focussed at suitable field sites, with all the associated complications of experiment design that entails.

With efforts on improving parameterisations of sediment behaviour continuing at the process scale, these must then be integrated up to model grid scales, a task that will necessitate carefully designed field campaigns that operate at that scale to provide the required validation data.

One of the most pressing needs for sediment modellers working in any practical situation is for the data simply to initialise their models – adequate bathymetric and topographic surveys, maps of sediment type, bedforms, together with suitable forcing and boundary conditions for wave, current and sediment flux. Models cannot be expected to perform accurately if insufficient data constraining the main variables are available. For ongoing research it will be prudent to take advantage of sites that are already well documented in this sense, however new study sites will almost certainly still be needed for particular environmental conditions.

This summary represents an ambitious wish list for sediment researchers, and the scale of investment required to address the issues discussed here points to the need to take advantage of existing monitoring infrastructure wherever possible – particularly the coastal observatories, and potentially with marine stakeholders who can (and already do in some cases) assist by providing access to their own data and facilities, and who will benefit from the ongoing knowledge exchange. Particular examples of where such ongoing research can be integrated with stakeholders are in the marine renewables industry, where the impacts of renewables on sediment dynamics and vice versa will be key to the long term success of the industry. Port authorities are another example where the knowledge gained from close cooperation between stakeholders and sediments researchers could generate long term gains for both parties.

The UK sediments research community comprises a great deal of expertise but at present there is little in the way of a grand plan or strategy around which individual researchers can pull together and effectively compete with the large community programmes enjoyed in other countries. This is partly a resources issue and partly an issue of vision. The workshop closed with a clear interest from participants in collaborating on a larger scale than has been usual and possible in recent years, together with the sense that given a common goal and support from funding organisations a great deal could be achieved. It is hoped that the discussions begun at this workshop will act as the catalyst for such future collaborations.

As a next step, the Sediments Research Group at POL in collaboration with key workshop participants will begin the process by producing a discussion document outlining some of the options for a future UK sediments research strategy. This will be made available as a starting point around which to focus ideas and future discussions.

Annex 1. Workshop Programme

Monday 27th:

12:30 Lunch
14:00 Welcome by Andrew Wilmott
14:10 Introduction (Alex and/or Paul)
14:15 Darius Campbell - Policy drivers
14:45 Richard Whitehouse - Industry needs
15:15 David Lambkin – Industry needs
15:35 Coffee & posters
16:00 John Rees - NERC context and funding opportunities
16:30 Alan Davies - Research context
17:00 Close for the day - details of evening meal & Tuesday start
Hotel check-in.
19:30 Dinner.

Tuesday 28th:

9:00 Welcome back & coffee
9:15 Chris Sherwood - US experience of large projects
10:00 General discussion led by the stakeholders.
10:45 Coffee & posters
11:15 Breakout sessions led by stakeholders:

- Coastal defense (Ian Holden)
- Human impact (Richard Whitehouse)
- Bio-effects (David Paterson)
- Impact of renewables (Jon Rees)

12:00 Summary of issues raised by stakeholders and plan for the afternoon
12:30 Lunch
14:00 Breakout sessions:

- Nearshore sediment transport (Dan Conley)
- Shelf wide sediment transport (Alex Souza)
- Process studies. (Tom O'Donoghue)
- Sediment transport in estuaries. (Jon Williams)

15:15 Coffee
15:45 Breakout sessions: Time scales of sediment transport

- Hours – Waves (Pete Thorne)
- Days – Tidal (Peter Stansby)
- Years – Seasonal (Alan Davies)
- Decadal (John Rees)

17:00 Close and plans for evening meal
19:30 Dinner

Wednesday 29th

9:00 Welcome back and Coffee
9:15 Summary of breakout sessions
10:15 coffee & posters
10:45 Discussion of funding streams
11:45 Close & Thank Yous
12:00 Lunch

Annex 2. List of Participants

Name	Affiliation
Amoudry, Laurent	POL
Bell, Paul	POL
Betteridge, Kyle	POL
Black, Kevin	Partrac Ltd
Bolanos-Sanchez, Rodolfo	POL
Brown, Jenny	POL
Campbell, Darius	DEFRA
Chini, Nicolas	University of Manchester
Conley, Daniel	University of Plymouth
Davies, Alan	Bangor University
Defew, Emma	University of St Andrews
Dix, Justin	NOCS
Dodd, Nick	University of Nottingham
Dong, Ping	University of Dundee
Holden, Ian	Peel Ports (Liverpool and Manchester Ship Canal)
Ilic, Suzana	Lancaster University
Jones, Rod	CCW
Kelly-Gerreyn, Boris	NOC
Laeger, Stephan	EA
Lambkin, David	ABPMer
Lane, Andy	POL
Larcombe, Piers	CEFAS
Li, Ming	University of Liverpool
MacDonald, Ian	University of East Anglia
Malarkey, Jonathan	Bangor University
Manning, Andrew	University of Plymouth and HR Wallingford
Metje, Nicole	University of Birmingham
Miles, Jon	University of Plymouth
Moate, Ben	POL
O'Donoghue, Tom	University of Aberdeen
Pan, Shunqi	University of Plymouth
Paterson, David M	University of St Andrews
Plater, Andy	University of Liverpool
Price, Darren	Halcrow
Pritchard, David	University of Strathclyde
Rauen, William	Cardiff University
Rees, John	BGS
Rees, Jon	CEFAS
Sherwood, Chris	USGS
Simons, Richard	University College London
Souza, Alex	POL
Stansby, Peter	University of Manchester
Sykes, Peter	Met Office
Thompson, Charlie	NOCS

Thorne, Peter	POL
Turnbull, Barbara	University of Nottingham
Van der A, Dominic	University of Aberdeen
Villarroel-Lamb, Deborah	University of the West Indies, St. Augustine. University College London
Walkden, Mike	Royal Haskoning
Whitehouse, Richard	HR Wallingford Ltd
Williams, Jon	University of Plymouth
Williamson, Phil	University of East Anglia