

# Estproc Meeting St Andrews 9-11 June 2003

## **Attendees**

Richard Whitehouse	HRW
Richard Soulsby	HRW
Alison Houghton	HRW
Nigel Tozer	HRW
Jez Spearman	HRW
John Widdows	PML
Reg Uncles	PML
Iris Moller	CCRU
Roz Turner	CCRU
Paddy Friend	SOES
Mike Collins	SOES
David Prandle	POL
Andrew Lane	POL
Mindert de Vries	Delft
Ilka Tanczos	Delft
Federico Maggi	Delft
Han Winterwerp	Delft
Paul Norton	ABP
Ian Townend	ABP
John Harris	ABP
Richard Swift	ABP
Mike Thorn	Funders
Jonathon Rogers	Funders
Kevin Black	USTAN
David Paterson	USTAN
Emma Defew	USTAN
Andy Manning	UoP

## **Day 1**

### Plenary Session

#### **Dr Richard Whitehouse: Introduction and Welcome**

- Review of progress to date
- Overview of workshops
- Breakout sessions

Version 2 of the draft final report has been distributed to the project team. The next 10-12 months of the project are critical and it is important to start focussing on the final report now to ensure that the TOR are met. During this meeting we should aim to identify what the funders are expecting us to put into the final report. It is anticipated that a substantial draft will be ready by May 2004 and we will aim to hold a progress workshop in March 2004 (Plymouth??)

### Technical progress

Areas of reflection and synergy between different areas of the project

## Project management

All milestones have been met and the funders are satisfied with the progress made. The CSG annual report has been delivered to DEFRA. Richard Whitehouse will present a paper at the DEFRA conference.

The project Website is up to date but needs further populating

A brief steering committee meeting will be held on Monday evening and at the end of the workshop on Wednesday. Andreis has handed over SC role to Han Winterwerp.

## Progress Since October workshop

Delft workshop and cohesive sediments workshop in Southampton.

## **Ilka Tanczos: Findings from vegetation workshop in Delft (December 2002)**

Waves and Vegetation

Interactions between biological and sedimentary processes

### **Primary aims**

*To understand and model biogeomorphological processes on the intertidal areas of estuaries.*

Modelling the interaction between the salt marsh and intertidal mudflat using the dedicated Delft3D model.

Depends on an efficient and intensive exchange of knowledge in interdisciplinary specialist workshops with experts to discuss processes, approaches plus state-of-the-art in modelling and monitoring.

December workshop comprising members of the project team and external participants

How to improve data availability

Relevant field and lab experiments in NL and UK

Modelling in Humber and interaction between vegetation and currents, waves and sediment transport

### **Progress since December**

SWAN workshop – Feb 24 – March 7 2003

Evaluate performance of SWAN modelling and applying model to fieldwork sites.

### **Wave attenuation**

*An analysis of field data from the Paulinaschor will be made to establish the relationship between vegetation characteristics and wave attenuation for the proposal and testing of a parameterization of vegetation influence to wave attenuation for use in the SWAN model*

Approach:

Derive a theoretical expression for the energy dissipation resulting from vegetation.

Define a friction factor  $C_w$  to account for the total friction (bottom + vegetation)

Translate this to the Collins friction factor as used in SWAN (Delft3D-WAVE)

### **Other work within Estproc theme 3**

Nico Booij of Digital Hydraulics: A model for wave dissipation due to flexible vegetation.

Rosalind Turner, Iris Moeller and Tom Spencer of CCRU, Application of SWAN model to Dengie data.

3D Modelling of the influence of zoobenthos and bottom-algae on sediment transport and sediment composition (Andries Paarlberg)

3D Modelling the influence of salt marsh vegetation on sediment transport and sedimentation patterns (Linda Kusters and Stijn Temmermans).

### **Future work**

Application of adapted D3D/SWAN model with an adapted Collins coefficient to a case with higher wave energy, like Dengie (this would require additional measurements on vegetation characteristics).

Look at sediment transport and sedimentation patterns at a salt marsh, including waves, using the Paulinaschor experience (Stijn Temmermans).

Look at the interaction of the mudflat and salt marshes with respect to sediment exchange and its relation to biological factors.

### **Discussion**

**Q:** What are the fundamental questions that you are addressing?

**A:** Benefits to people who are responsible for managing these areas. Eg effects of dredging in western Scheldt and managing habitat restoration.

**Q:** Are you primarily addressing how waves attenuate over saltmarsh or are you focussing on the leading edge of the saltmarsh

A comparison of the results from both fieldwork sites will be presented during day 2

**Q:** Is the SWAN model the most suitable for looking at the leading cliff edge of the saltmarsh.

**A:** Some concern about using SWAN model for very shallow water conditions  
SWAN is a community model i.e. it is free.

Comments

RLS: There is a large volume of knowledge about air flow over forests. Has this information been considered?

Urs Neumier Measurement of water flow (Orbital velocities) through saltmarsh.

## **Paul Norton: Review of cohesive sediments workshop in Southampton May 2003**

20 EstProc members and some external participants

### **Workshop objectives**

- What constitutes current best practice
- Develop a research agenda
- Provide link between real world and model inputs
- What is the 'art of the possible'

### **Summary of presentations**

- Laboratory experiments focus on small scale processes
- Variability in bed thickness due to settling rate
- Fracture planes in samples after settling
- Use of artificial polymers dependent on method
- Erosion threshold / floc size are functions of biomass + polymer
- ADCP provides 3D structure of SSC
- Data coverage for estuary-wide models typically poor
- (spatial/temporal, intertidal/subtidal)
- Test bed for cohesive models

### **Key Points**

Seasonal processes produce bedding layers

Layers likely to have different strengths

Modellers need correct processes + parameters

Model outputs appropriate to scale of model

Models to allow erosion deposition simultaneously

Recommend ensemble probabilistic approach

Need to parameterise detailed local processes at larger scale

Include variability in biology

Identify important processes at small scale

Summary of topics for discussion

1 Measuring sediment processes in the field

2 – Parameterising measured data in models

Overall summary

- Differences between 'real world', laboratory and models
- Modellers generally interested in estuary-wide scale
- Important to develop a conceptual model of system
- Difficulties experienced relating shear strength to  $T_{ce}$
- Erosion rate 'E' often used as a calibration parameter
- Measurement of 'E' may be preferable to  $T_{ce}$
- Rates of deposition vary significantly (eg. due to flocculation)
- Flocculation process not normally included (use modified Ws)
- Need to provide 'ensemble' or probabilistic description of results
- Techniques required to measure parameters in subtidal
- Explore potential of acoustic/optical techniques
- Consider use of surrogate parameters
- Need for modelling 'test-beds' (including 'blind' testing)
- Importance of biological control

### **Outstanding tasks**

Circulate note on preliminary ks findings  
 Include suggested research agenda  
 Update note with partner comment  
 Prepare summary report on workshop.

### **Discussion**

Modelling of cohesive sediments is much harder due to the flocculation characteristics between the grains.

**Q:** Do we feel that we have made any steps forward

**B:** Think it was asking too much to have made major advances. Most important message – idea of conceptual model. Look for appropriate discretisations.

Link conceptual model to whatever you are able to measure at various scales.

### **Prof Richard Soulsby: Summary of questionnaire**

2 points that were to be drawn out at cohesives workshop.  
 Aims of process workers and modellers didn't overlap

Questionnaire – results in partners area of the website

Make each side aware of objectives of other side. Allow each subset to pick up on each others work

Chief deliverables – algorithms

Descriptions of processes – format that could be put into a numerical model

Best way forward: people to identify natural links

Look on website for questionnaire results – find connections

Modellers – is there some process research that could be applied to my model.

Process researchers look at level of detail that models can handle. Take care not to over-parameterise

Said he would try and do the same thing for the other elements of the project. Too much of a rush but will ask people to do this before the next workshop.

## **Session 2**

Focus on final report – what needs to be achieved during the next 12 months  
 (discussion of draft report outline)

It might be better to leave short scientific papers until the end?

Important section to consider during this workshop – Algorithms and methods

During the remainder of the afternoon the project team was split into 3 groups in order to discuss how the algorithms and methods session would be populated.

### **Outputs of breakout sessions**

There is some concern that the headings listed in the TOR bear little relation to the work that has been undertaken to date.

It is difficult to identify specific biological algorithms and methods as biology is inherent in virtually all of them.

The majority of the time was spent determining who would actually populate the various different headings.

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## **EstProc Meeting St Andrews 9-11 June 2003**

### **Day 2**

#### **Patrick Friend: Day Night variations of intertidal flat sediment properties in relation to sediment stability**

##### **Implications and aims**

- Implications for models calibrated using sediment stability parameters measured during daylight emersion periods only
- Only partially representative of intertidal flat conditions in any 24 hour period

##### **Aims**

- Examine relationships between parameters related to day- and night-time sediment stability
- Test for differences between day- and night-time stability

##### **Conclusions**

- Significant differences exist between day and night time sediment stability in high biomass areas on sandy intertidal flats
- Cannot be attributed to a single causal mechanism
- Other factors important bacterial and benthic faunal EPS animal activities
- Saline extraction and Dubois assay may not detect uronic acids and acetyl group polymers which promote substrate adhesion

##### **Recommendations**

- More day/night time stability studies on cohesive intertidal flats
- Examine stability during different diatom growth phases
- Include benthic fauna
- Use extraction procedures able to detect uronic acids and acetyl group polymers

##### **Discussion**

Q: influence of algal grazing

A: Didn't look at algal grazing

Could have measured a lot more parameters

Much higher migratory signature on cohesive tidal flats

High biomass signature occurs between December and March

Very little diatom activity during summer months

Tidal flats could become too desiccated.

Q: What is the level of confidence that the day night variation does actually take place everywhere

A: Used results of significance tests to determine level of confidence

Very little work has been carried out on this subject

Paddy's study is merely a first attempt to investigate this.

In sandy sediments motile diatoms may be capable of moving out of the sediment layer being investigated.

Chlorophyll level can vary at a cellular level.

John Widdows: The influence of biota and bed roughness on near bed flows, bed shear stress and sediment erodability – does threshold of erosion occur?

Objectives:-

- Experimental flume and field validation studies (bed shear stress)
- How should we define 'critical erosion threshold'?
- Wave impact on mudflats in shallow sheltered estuaries
- BIOSSED modelling

Comparison of relationship between currents and bed shear stress in annular flume and in situ

Effect of biota on bed roughness and bed shear stress (TKE method)

Comparison of relationship between mean current speed and bed shear stress in annular flume and field

Good agreement

Critical erosion threshold

Problems of definition

Can we distinguish between resuspension of flocs and erosion of bed sediments

Different methods of calculating critical erosion threshold

Problems of comparability

Between erosion devices

Similar units

2-3 fold differences in  $\tau_{cr}$  and  $\tau_d$

How do we set the critical erosion threshold

Need agreement on how to define and estimate  $\tau_{cr}$

Using log transformations just makes it easier to pinpoint erosion threshold

Specific erosion stress – more appropriate term?

What is the shear stress – parameter that describes the velocity field?

Intuitively feel that shear stress ought to be important

What does the velocity field mean in terms of erosion of the sediment surface

Do other factors in sediment affect the rate of erosion

It is easy to measure shear stress in rivers but not in marine and estuarine environments.

Impact of storms on sediment dynamics in a shallow sheltered estuary Tavy

What is the impact of marked changes in sediment levels on biota

Do biostabilisers ameliorate effect of waves

Comparison between late winter and late spring – see chart!!

Biota in Tamar has very low biodiversity – turbulence in estuary and salinity variations

### **BIOSSED Model**

Model developments

Model recast in terms of bed shear stress

Waves have been incorporated into model

Wave ht, Spartina stem ht, offshore sediment supply

Recently added different wave periods to model.

Modelling of bed shear stress due to waves

Short period waves don't effect bed shear stress in deeper water

Incorporating feedback to the bed

## **David Paterson: Questions which physical modellers need to ask biologists**

What physical modellers might ask  
What biologists don't know

The most striking feature of the earth is life  
The most striking feature of life is its diversity – habitats, niches  
How does diversity function  
What is diversity  
The number of different organisms in a given habitat  
Relative abundance

Why is diversity important  
Proposed diversity might influence ecosystem processes  
Some groups of organisms are more important than others  
Functional groupings – Primary producers, shredders, decomposers, carnivores

Shredders are an important functional group in aquatic systems

Redundancy hypothesis  
Ecosystems function well at high diversity species can be removed with detrimental effect up to a point. As more species are removed, the functionality of the system is reduced.

Ecosystem functioning  
Ecosystem services (carbon fixation)  
Ecosystem engineers orgs that change the physical properties of the system

Ecosystem stability

Diversity is declining at rates greater than ever measured - heading towards mass extinctions  
50% reduction in richness – 20% decline in productivity

Ecosystem procs  
Bioturbation  
Biostabilisation  
Flocculation

Consider critical physical features and critical biological processes

There is a direct commercial impact of biological processes  
Much more work is carried out on the links between biological processes and sediment dynamics

Biodiversity is typically low in estuarine systems  
Estuaries are vulnerable systems  
Estuaries are depauperate systems  
An individual species might be the only representative of a functional group within an estuary. If that species is removed, the impact on the system will be much greater.

Ecosystem increases with biomass  
Species identity has greater influence on ecosystem processes  
Site specific difference in relationships  
Unpredictable responses to species removal  
The system is very unpredictable.

### **Questions that need to be addressed**

What is the range of variation imposed by biogenic mediation?  
What are the minimum number of variables that represent this ecosystem service – is there an index?  
How generic is this response?  
Undertake sensitivity analysis to examine if this range is significant.

## **Mindert de Vries: Progress on work in biology-sediment-vegetation effects on intertidal flats**

### Status of biogeophysical modelling at DH

#### **Topics for modelling in 2003**

Sediment stability vs biological components on a mudflat  
Hydrodynamics on a saltmarsh  
Vegetation wave interaction  
Sediment transport on a saltmarsh  
Based on – field work at Paulina Schor

#### **Progress in modelling biology-sediment interactions**

Development of 1DV model  
TuD Dh model for sand –mud mixtures  
Extension of model with influence of stabilisers and destabilisers on critical shear stress or erosion  
Utilisation of field data from mud flat project on Molenplaat (Widdows)  
Utilisation of field data from Skeffling mudflat to produce algorithms ( $\tau_{cr}$  – density)

#### **Model result**

For a case that resembles the average hydrodynamics of the Molenplaat (no waves)  
Based on a sensitivity analysis of different densities of destabilisers and concentrations of algae  
We can produce either sandy non cohesive sediment or sandy cohesive sediment without changing physical forcing  
We see increased average mud content in the sediment under a measured yearly cycle of zoobenthos and algal biomass.

#### **2DH model development**

Extension of D3D online sediment with sand and mud module  
Introduction of impact of stabilisers and destabilisers on :  
-  $\tau_{crit}$  erosion  
- Sediment strength  
- Bioturbation rate

Utilisation of widdows data and publications  
Application to Paulina Schor using all available data  
This model does not include vegetation and will focus on the intertidal mudflat

#### **Results**

Hydrodynamics are calibrated  
Calibration of the sediment composition of the mudflat against data is under way  
Sensitivity analysis of impact of biology on temporal and spatial forcing will be executed in June/July  
Can see how the mudflat changes over a number of months or seasons or years

#### **3D sediment transport modelling**

D3D online sediment + vegetation model  
Application to Paulina Schor (No waves)  
Utilisation of hydrodynamics and vegetation data from 2002 monitoring for boundary conditions and calibration  
Utilisation of data from University of Leuven (PhD of Styn Temmerma on sediment transport and bathymetry)

#### **Model result**

HD calibrated for one month of monitoring data  
Model result for current speed are in agreement with values of monitoring stations for the mudflat in the channels and the vegetation  
No calibration of the vertical resolution of currents due to problems with monitoring data  
Sedimentation figures are in good agreement with sediment trap data  
Impact of vegetation density and height on sedimentation is small

Further testing is underway

### **Conclusions**

1DV model indicates that local patchiness of zoobenthos and algae may induce patchiness in sediment composition

2DV model results are not yet available

3D hydrodynamics/vegetation model for Paulina Schor is performing well. It shows the impact of vegetation on currents but there is no data at present to check vertical profiles.

3D HD/SED/VEG model shows good agreement with sedimentation data for 1 month. The long term development of bathymetry is unknown.

None of the modelling has used any waves

Problems associated with model simplifications

Problem with settling rates of fine particles – what do different sets of scientists expect from settling rates

### **Future developments**

Scaling up to whole estuary scale

Dependent on resources and available sites – Wadden Sea

Utilisation of CT scanner for measuring live impact of zoobenthos on sediment characteristics

Combination of sand/mud and vegetation into one model Analysis of long term development of tidal mudflats

Application to UK - Dengie

Impact of waves

Standardised modules for D3D

Spatial resolution 700x300m

Grid size = few ms

## **Paul Norton: Data Collection in the Humber Estuary**

Objectives

- Identify relationships between benthic faunal communities and sediment erodability
- Improve predictive modelling for the distribution of assemblages

### **Intertidal benthos model (IBM)**

Predicts spatial distribution of invertebrate species from environmental variables – modification of Delft 3D model

Rule based approach

Hydrodynamic model data processed within GIS system

Elevation

Salinity

Current speed

Bed shear stress

Water levels

Modelling of Humber Estuary

Fieldwork in Humber

Sampling in Jan 03

3 sites

6 stations

mid-low tidal elevations

3 replicate cores per station

biology and sediment analysis

Available data:

- numbers and biomass of invertebrates
- particle size analysis
- organic content
- *in situ* erosion thresholds
- (CSM Mk IV, *Sediment Dynamics Research*)

Data is available to EstProc partners  
Data report available – (ask for this to put on the website)

### **Outstanding tasks**

Repeat survey during early July  
Develop rule base in existing IBM in order to  
Improve model using sediment erodability data  
Predict sediment erodability using IBM

### **Discussion**

**Q:** How is the rule based approach developed?

**A:** Existing research mainly

**Q:** What does the CSM measure? A surrogate threshold shear stress for erosion or can you infer erosion rate constant

**A:** The latter is much more important for modelling  
Can derive a relative rate but not absolute rate.

## **Iris Moller: Wave attenuation at saltmarsh mudflat boundaries**

### **Wave attenuation over intertidal surfaces**

Aims and objectives defined in October 2002

- Further development of analytical Stiffkey model
- Validation/calibration of existing models (project partners?)
- Development of field method for quantification of vegetation roughness
- Hydrodynamic - Morphology feedbacks
- Dynamics of suspended sediment
- Link between long-term & short term sedimentation
- Individual wave / water level conditions

### **Activities since Sep 02**

Calibration validation of SWAN model

### **SWAN model**

Eulerian third generation spectral  
Wave-wave interaction/energy exchange

Dissipation due to

- White capping
- Depth induced breaking
- Bottom friction (jonswap (other))

Calibration

15 tides/wave burst records

2D grid of 160mx5m (output from centre transect)

Inputs

Hs,TP, mean dir

Energy distn

Bdy dirn

Mean water level

Bathymetry

Friction representation

Best fit Collins coef

Spatially variable friction drag

Variable friction

Veritca and horizontal photos

Image analysis

%area obscured by plant matter of 10cm depth

Species composition

% surface cover

Estimation of

- Diameter
- Number
- Height

The analysis can only consider 1 species per m<sup>2</sup> at present. This needs to change as the species composition of the saltmarsh is highly variable/

### **Results**

Overall pattern of Hs change corresponds well to observations

Oblique angles lead to error in modelled results

Further analysis of wave records

Hydrodynamic morphology feedback

Existence of spatially varying H/h ration limits (relative importance of friction versus shoaling)

Spectral period shifts and mud

### **Preliminary results**

Mudflat: transfer to lower frequencies

Transition

Low H/h peak reduces

High H/h transfer to higher frequencies

Essentially, the nature of the transition mudflat-saltmarsh affects the attenuation of waves across the surface

### **Progress since Sep 02**

- Validation/calibration of existing models (collaboration with modellers)
- Performance of Collins friction factor
- Performance with spatially varying friction factor
- Use of digital processing of vegetation photographs
- Further data analysis
- Hydrodynamic - Morphology feedbacks
- Shoaling *versus* friction
- Spectral transformations / Energy shifts

### **Future activities**

#### **Model improvements**

- Improved bathy (LIDAR)
- Use of phase II data of partial inundation events
- Further investigation of performance errors under oblique waves
- Effect of triad interactions/quadruples on model performance
- Inclusion of mudflat section
- Model run using spectral using input files

#### **Field measurements**

- Further improvements of method for estimating roughness
- Establish vegetation measurements for comparison with Paulina Schor.

Discussion

**Q:** Why not use X band radar?

## **David Prandle and Andrew Lane: Equilibria between estuarine bathymetry and tides, river flow and sediment supply**

Development of 1D model

Currently developing 2D model

Have done some work on a 3D model to evaluate the hydrodynamics of the Mersey estuary

### **Outline**

Estuarine hydrodynamics

Progress in Emphasys

Relationship between estuary length, depth at mouth and tidal elevation

Sensitive to bed friction  $1/\text{sq root}??$

### **Progress in EstProc**

Develop relationship between estuary depth and river flow

Sediment type – grain size as a function of river flow and elevation

### **To be completed**

Impact of extreme events

### **Hydrodynamics and morphology of the Mersey Estuary**

Estuary volumes decreased by 10% over 70 years

Sea level rise increased by 0.5% per year

Estuarine bathymetry very poor

EA undertook LIDAR survey

Much of the changes occur mid estuary and around the intertidal areas

The main tidal components are quite stable

### **Discussion**

**Q:** How generic are the results given that the Mersey is a very strange estuary

## **Han Winterwerp: Large – Scale Fine Sediment Transport in Shallow Basins – the Humber Estuary**

### **Problem description**

SSC in estuaries, tidal lagoons and inlets >>>> SSC surrounding areas

Flushing of estis is very large

Net transport = gross input-gross output

### **Relevant processes**

Settling and scour lag in combination with

Tidal asymmetry

Gravitational circulation

Channel shoal interaction and water depth effects

Lag effects

Settling lag

Scour lag

Lag effects determine the magnitude of transport not its direction

Tidal asymmetry

High water wave propagates faster than low water wave

Length of slack water period and

Peak ebb and flood velocities

Low concentration and clean bed (asymmetric slack)

Low concentration and starved bed, (asymmetric peak and slack)

Horizontal circulation  
Impact on large scale sediment balance  
Always import by gravitational circulation and sedimentation on intertidal areas

Sometimes import by tidal asymmetry

Turbidity in channels explained by  
Net sediment import processes  
Flow induces erosion and settling lag  
Turbidity on

Waves are very effective eroders  
Waves do explain high turbidity levels on intertidal areas  
Waves prevent accumulation of mud  
Possible

Effective bed shear stress  
Skin friction instead of form drag  
Skin friction reduced by bed structure  
Drag reduction by sediment induced buoyancy effects  
Drag reduction by changes in near bed velocity profile

### **Conclusion**

Many small scale processes affect overall fine sediment behaviour in estuaries, tidal inlets and lagoons with respect to  
Net import/export and  
Turbidity levels

Top down approach

## **Session 2**

### **Visit to Eden Estuary**

During the afternoon the project team visited the Eden Estuary mudflats accompanied by a local Countryside Ranger (Les??). The Estuary runs along the edge of one of St Andrews many golf courses. Erosion to the dune system resulted in a significant coastal protection scheme including: dune fencing, gabions and renourishment. Further into the estuary are active areas of saltmarsh reclamation. The influence of biology was clearly evident across the surface of the mudflats. Notable species included *Ulva lactula*, *Zostera* sp. & (whatever that long ropey one was – need to confirm!). There was also evidence of burrowing polychaets such as *Arenicola*.

**A full description of the Eden Estuary will be put on the website as an independent document.**

# EstProc Workshop St Andrews

## Day 3

### Andrew Manning: Overview of Tamar experiments

#### Tamar Experiment

The Tamar experiment was NERC funded and was conducted between the 13<sup>th</sup> and 17<sup>th</sup> April 2003. The primary aim of the study was to investigate phase relationships between local hydrodynamics, SPM and floc characteristics throughout a tidal cycle. The experiment was carried out at Calstock in the upper Tamar Estuary.

#### Progress

On-going processing

- Floc data to be size banded into mass settling flux
- Flow data to be decomposed into turbulent sub-components
- Results will comprise two papers to be presented at INTERCOH 2003

#### Basic floc types

##### MACROFLOCS

- $D > 160$  mm (Manning, 2001)
- ~ same size as Kolmogorov microscale
- low density, fragile

##### Microflocs

- main constituents of macroflocs
- $D < 160$  mm (Manning, 2001)
- more resistant to break-up
- exhibit wide range in densities
- attribute strong bonding from biogenic “glues”

Model constructed from 3 different algorithms that combine to give the best approximation for a range of bed shear stresses

Evaluation of model

Comparison with empirical data

#### Next stages

- Journal of Geophysical Research paper:
- Prepare detailed internal report for EstProc use
- Examine Algorithm generality:
- compare with full tidal cycle data from recent Tamar exp.
- Algorithm Sensitivity testing:
  - HR Wallingford models (COSINUS)
  - POL 1-DV point model
- Integrate algorithms into HR Wallingford full 3-D TELEMAC estuary model
- Collaboration with: Uni. Copenhagen & DHI
- integrate algorithms within MIKE 21 and MIKE 3-D models
- Tamar estuary
- Gironde estuary
- Danish Wadden Sea
- Evaluate and Assess algorithms performance

#### Progress report on negative diffusion uptake

- Required extensive processing of individual 4096 data point time series from which burst means were calculated:
- check for error spikes
- check sensor polarity correct

- calculate Reynolds Fluxes
- Short paper being prepared entitled: “Negative diffusion in high concentration estuarine near-bed layers”

## **Federico Maggi: Flocculation Characterisation**

Flocculation complexity increases with increasing size  
 Use of entropy function to detect pattern variability and numerosity  
 Wish to learn which types of flocculations become dominant in a population  
 Sediment flocculations have no homogeneous mass density organisation  
 This results in the enucleation of a variety of patterns within the flocculation mass this showing disordered structures

### **Conclusions**

Disorder results in symmetry breakdown  
 Asymmetric reactions can be implemented in a population equation  
 The organisation of flocculations and the resulting population may be self driven but no clear evidence of this has been identified.

## **Reg Uncles: Progress on Salinity Intrusion and structure in the Tamar – its Dependence on Tides, Run-off and Weather**

### **Progress to Date**

- Started experiments on the influence of waves over intertidal mudflats
- Collated historical data on near-bed salinity
- Acquired runoff and meteorological data and analysed for the monitored periods
- Collated historical along-estuary salinity surveys
- Analysed the influences of weather, runoff and tides on salinity

Data collected from a number of sites in the Tamar estuary  
 Interested in salinity as it is related to SPM concentration and the location of the turbidity maximum  
 Turb max is not well defined on the neap tidal cycle  
 There is a very close relationship between position of the turb max and the 1 psu salinity contour

### **Summary**

Salinity contours throughout Tamar:

- Salinity intrusion strongly related to runoff, less dependence on tide range (density flow?)
- Stratification strongly related to runoff & tide range

Peak near-bed salinity:

- Strongly, positively related to HW level at low runoff – much weaker at higher runoff (density flow?)
- Strongly, negatively related to runoff (flushing?)
- Strongly related to longer-term (2 – 8 day) winds & atmospheric pressure (coastal set-up?)

### **Discussion**

**Q:** You used predicted HW instead of actual HW, does this make a difference to the correlations.

**A:** Maybe a bit but not much

**Q:** What are the timescales of response to run-off etc? Can these be related to the estuary geometry.

**A:** Some idea of timescales – flushing etc

**Q:** Can you relate your results to other estuaries in this way?

**A:** Yes

## **Nigel Tozer: Reporting of SWAN, comparisons with TOMAWAC and data for the outer Thames Estuary**

### **Present practice**

Choice of spectral wave transformation model

TOMOWAC written by EDF similar to telemac but has subtle differences

Swan and TOMOWAC

### **Study Site**

Outer Thames Estuary

Data obtained from CEFAS wavenet

### **Preliminary results**

- Results to date
- Steady state runs
- Unsteady runs
- Accuracy/efficiency/required improvements

Stour Orwell is another potential site

### **Conclusions**

- preliminary results compare reasonably well with measurements
- some differences in SWAN and TOMAWAC results
- no apparent advantage in unsteady runs for this site

### **What's next?**

- further analysis to pinpoint deficiencies in models (spectral analysis)
- quantify influence of high temporal resolution of waves on sediment transport
- sensitivity on sediment transport to spectral shape
- other site ? (Stour+Orwell Estuary)

### **Discussion**

**Q:** HF radar is showing much more variation in spectra etc than the models – what is the effect of gustiness etc on wave propagation? The problem may not be wave models but the accompanying data

**Q:** Can the met office provide a better local wind data set?

**Q:** Why don't you use radar or satellite data?

**Q:** When does bottom friction become important

## **Richard Soulsby: Wave and Current Shear Stresses on Smooth and Rough Beds**

### **Background**

- Erosion and deposition formulae for mud rely heavily on bed shear-stresses
- In many estuarine cases these need to be for combined waves and current
- The combined stress is a *non-linear* combination of the wave and current contributions
- Many (>20) theories exist for hydrodynamically rough beds
- But a freshly deposited muddy bed is likely to be hydrodynamically smooth
- Much less work has been done on this case

### **Aims**

- The most important shear-stresses are the mean and max over a wave-cycle ( $\tau_m$  &  $\tau_{max}$ )
- These should (preferably) be predicted by an explicit algebraic formula - many predictors involve either an iterative solution, or a full numerical model
- For rough beds, an *empirical* explicit formula (DATA2) was devised in G6M - can this be replaced with a simple *physics*-based model?

- For smooth beds a different *empirical* formula was devised for DEM - can the *physics*-based model be adapted for smooth-turbulent flow?

### Approach

- Assemble existing rough-bed data (G6M + new), and smooth-bed data
- Code up existing (rough+smooth) predictors: Myrhaug&Slaattelid (1991) and Carmo et al (2003) [the “Portuguese model”]
- Devise new simple-physics (rough+smooth) explicit predictor
- Test all 3 models against data, and decide on best model

### Conclusions

- The new predictors for mean and max shear stress give broadly similar results for rough beds to the proven empirical DATA2 method so should compare well with data
- Like data2 they can be written explicitly (hence are easy to use) and are robust
- The smooth bed version is also explicit and robust
- It gives better comparisons with smooth bed data than existing methods and its simpler
- Note that it is essential that bed shear stresses in mud erosion deposition formulae are compatible with the threshold stresses and erosion rate constant.

## John Harris: Modelling moveable bed roughness

### Introduction

- The sediment bed is normally mobile and responds to flow-induced forcing and the resulting roughness will, in turn, impact on the flow. Therefore, flows over mobile sediment beds involve a feedback between the seabed and the flow above it.
- The physical roughness is based on some physical property of the bedform such as sediment grain size or ripple length/height. The hydrodynamic roughness, whilst related to the physical roughness, is a mathematical parameter that relates the height in the bed at which the velocity profile would go to zero.

### Fixed ripple models

- Bagnold (1946) and Sleath (1985) measured energy dissipation over beds consisting of fixed artificial ripples. Bagnold oscillated a tray covered with artificial ripples in a tank of still water. Sleath (1985) also oscillated a tray covered in artificial roughness elements in a tank of still water.
- The purpose of using the data of Sleath and Bagnold in the present work is that this data can be used to attempt to establish a relationship between ripple geometry and the bed roughness due to the bedform.
- Sleath’s ripples were sinusoidal giving a profile that would produce vortices at high Reynolds numbers but which didn’t force vortex formation at lower values of Reynolds number. Sleath found that the low values of energy dissipation factor occurred during the transitional stage from laminar to turbulent flow, when vortex formation was just starting.
- A high-Reynolds number  $k$ - $\epsilon$  model was run for the laboratory conditions of Bagnold (1946) and Sleath (1985) and the energy dissipation factor and wave friction factor calculated for each fixed ripple test. The bedform drag was assumed as  $4\Delta$  in the model.

### Energy dissipation over a moveable bed

- The fixed bed tests of Bagnold (1946) and Sleath (1985) were used in an attempt to assess the most suitable expression for the form drag of ripples. These tests used a smooth surface for the ripples unlike real sand ripples which have a rough surface. The advantage of the fixed bed tests is that the specific gravity of the sand,  $s$ , the grain diameter,  $d$ , and acceleration due to gravity,  $g$ , are not present, reducing the problem to just the form drag.

### Conclusions

- Comparison of results from the hydrodynamic turbulence model with measured values for the energy dissipation over both fixed and moveable bed ripples show the model to significantly

underpredict the energy dissipation.(the underprediction of the energy dissipation by the 1DV turbulence model is due to a failure to compensate for the effect of vortex shedding off the ripples.)

- Results from the moveable bed model presented within appear promising. The model has not been tested yet to confirm whether the rate of growth of the ripples as predicted by the model is correct.

## **Jez Spearman: Inclusion of Saltmarsh in Estuary Models (LiDAR data and modelling)**

ENDPOSSM

Introduction to dendritic systems and the sub grid approach

The methodology

Test case

Results

Dendritic systems have irregular bathymetry

This bathy varies significantly over a small length scale (<1m)

For estuary modelling scales are typically of the order of 20-100m

Can result in an under estimate of the discharge through

Test case 1 Salcott Channel

Tributary of the Blackwater estuary in Essex

Study of the impacts of breaching of saltmarshes

Used LiDAR data. LiDAR data can be really dodgy always verify it.

You can work magic with numerical models

There are always discrepancies that result from the interpretation of the bathymetry from Admiralty charts.

### **Conclusions**

Improves the model performance in and around saltmarsh for a given grid scale

The extent to which grid resolution can be extended is limited

The use of LiDAR data sets may be the most helpful step towards improving models

LiDAR gives

Future work

Consolidation of results

Extension of fine grid results using porosity method

Application to other system

**These notes are not complete I need to go back to the presentation!**

## **Richard Swift: Raster Modelling of Tidal Creek Systems**

### **Outline of presentation**

- Overview of solution
- Governing equations
- Planar beach test at gradient of 1/1000
- Summary of planar beach results
- Model of Tom Tiddlers Creek, Southampton Water
- Work planned and in progress

### **Overview of solution**

- Temporal and spatial derivatives discarded
- Two solutions possible:
- cellular scheme ~ 1D solution to a 2D problem
- flow between cells depends only on free surface gradient in the given direction
- coupled scheme ~ a 2D solution

- the (x,y) components are linked and this satisfies intuitive expectations of flow across natural plains
- Raster model can be implemented using Chézy or Manning solutions for friction slope

#### **Summary of planar beach experiment**

- Raster model satisfies intuitive expectations of flow across a planar beach
- Predictions agree with results of Bates and Hervouet (1999) and with theoretical solution
- 1 or 2s timestep adequate for predicting inundation
- Short - term velocity instabilities around slack water
- Instabilities mostly removed by decreasing timestep
- Model is stable over many cycles
- Spatial derivatives appear to be  $\ll$  surface slope and could be reasonably omitted
- Temporal accelerations  $\ll$  surface slope except around slack water.
- Further work is required on accelerations

#### **Summary of Tom Tiddlers creek model**

- Coupled and cellular raster models provided satisfactory results
- Cellular model predicted higher water level at Low water - hence smaller tidal range
- Velocities smoother in cellular model but also lower values generally
- Model predicts satisfactory flow reversals
- Coupled scheme took 4% longer than the cellular solution
- Coupled raster solution used 1102 seconds to model 303000 timesteps, with 777 active cells, when the model timestep was 0.25s. This corresponds with a speed of  $4.68 \times 10^{-6}$  seconds per cell per timestep.
- Code written in Fortran and ran on a computer with a clock speed of 300 MHz.
- Horritt and Bates (2001) reported a speed of  $3.5 \times 10^{-6}$  seconds per cell per timestep, using also a computer with a clock speed of 300 MHz and code written in C++.
- Horritt and Bates model was for flood plain flow in one direction only.

#### **Work planned and in progress**

- Compare against new field records taken at Tom Tiddlers
- Compare with Tolsbury Creek data
- Investigate means of increasing timestep:
  - artificial viscosity
  - damped temporal acceleration term
  - position driving boundaries on edges of intertidals
- Provide documented product for open - source license
- Improve grid modelling and go to smaller scales such as 10m and 5m.
- Provide examples for open - source distribution
- Provide animated demos
- Report
- 2 internal reports have so far been provided to ABPmer

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#### **Mike Thorn: Contract overview**

Two fundamental questions need to be addressed:

- Where are we coming from?
- Where are we going to ?

The EstProc contract is part of the processes theme of the joint programme of flood and coastal defence (DEFRA/EA). Mouchel are contracted to manage the processes theme and consequently the EstProc project.

The workshop has been very enjoyabl and much relevant work has been achieved. The funders are really enthusiastic about the progress made and the potential for the project to meet its objective. Interdisciplinary interactions are working really well. (bio/sed/hydro)  
Pleased to see that tasks are delivering objectives

Where are Mixed Sediments??

If we feel that we need to change the emphasis of the project we should justify it to the project officer but there shouldn't be a problem with it.

The underlying objective of this project is to facilitate better flood and coastal defence. We must relate the project outputs to this objective rather than simply presenting the results of the research.

There are no changes to the objectives.

Need to produce overview report in DEFRA EA format to capture all work and outputs. The report will go to peer review (people who represent DEFRA EA interests). The report should contain a summary of technical work capturing the essence of what has been achieved. It is to be aimed at a NON research audience

- What was the rationale for doing the work in terms of flood and coastal defence?
- What are the practical applications and implication of the work undertaken and how can the work be used.
- What are the suggested directions for further work – key gaps and opportunities. DEFRA short form A format.

Compendium of technical and scientific reports aimed at the specialist user – including published paper and resulting discussion.

DEFRA CSG15 contract completion report. 2 page short exec summary and 20 page long technical summary. In the case of a scientific report, the long summary does not need to be completed.

EstProc will be the main feature of the flood and coastal defence newsletter that will be published in December.

## **Richard Whitehouse: Closing comments**

### **Milestones**

1. Ensure that all outputs from Monday's breakout session are completed and supplied to RJSW by the **end of June**.
2. The outputs will be circulated to the project team and to the funders by **mid July 2003**.
3. Preliminary modules/algorithms should be completed by the **end of December 2003** (sooner if possible)
4. Pre-draft report by the end of **January 2004**.
5. A workshop will be held at the **end of February 2004** to push the draft forward. It is proposed that this be held in Plymouth (TBC)
6. Final algorithms end of **March 2004** (incorporate into models)
7. Draft final report by **end of May 2004**
8. Subgroup meeting for modellers to discuss how they have included algorithms to be held in May 2004
9. Deliver draft to peer group review by **31 August 2004**
10. Open meeting of research results in **mid October 2004** (London TBC)
11. Issue final reports by **mid November 2004**

### **12. Project closure (CSG15) end of November 2004**

### **Closing Remarks**

- There has been a fascinating range of work presented and there is an excellent spirit of open exchange of ideas. There is also a willingness to make ideas open to all.
- Excellent re-use of old data as well as links to build upon data collected in fringes of the EstProc project.
- The trip to the Eden Estuary illustrated the variability and complexity of estuarine systems.

**Many thanks to David, Emma and Christine for hosting the workshop and ensuring that everything ran smoothly**