Nortek User Symposium 2010

Using Nortek Vectors for coastal zone research

Saul Reynolds, School of Marine Science and Engineering,

University of Plymouth, UK

Overview

- Introduction
  - UoP Coastal Processes Research Group (CPRG)
- CPRG Projects
  - Flocsam (estuaries), Matrix and DRIBS (beaches), TSSAR (Laboratory), WHISSP (beaches and offshore)
- My research
  - Change of direction – research objectives
  - Site description
  - Instrumentation and methodology
  - Some early results
- Summary

Research topic

- Seabed Response to a Changing Wave Climate
- Part of a larger project – WaveHub Impacts to Seabed and Shoreline Processes (WHISSP)
- Investigate the potential change to tidal currents and the wave climate in the lee of the WaveHub , North Coast of Cornwall, UK
- Consequences of these changes to the sediment transport along the coast

Coastal Processes Research Group

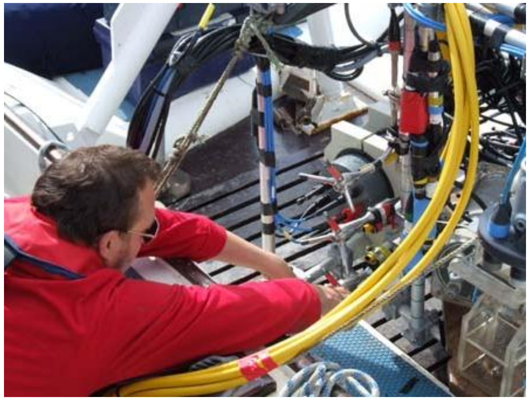
http://www.research.plymouth.ac.uk/coastal-processes/default.shtml

- To be a leading contributor to the international research community seeking to understand and predict the behaviour of coastal and estuarine systems in support of appropriate management of coastal resources and activities
- 13 Academics, 5 PDRAs, 13 PhD students and 1 Scientific officer
- Since 2006, members of the group have received external funding in excess of £2.4 million, published over 75 papers in refereed journals and presented over 25 papers at major international conferences
- Research opportunities:
  - beach morphodynamics and nearshore sediment transport
  - coastal erosion and storm impacts
  - video monitoring of coastal systems
  - coastal process modelling
  - estuarine and cohesive sediment dynamics
  - water column turbulence and mixing

Flocsam

http://www.uea.ac.uk/env/research/Coastal/flocsam

In Partnership with University of East Anglia, UK and Proudman Oceanographic Laboratory, UK



Investigate the long-standing and scientifically-challenging problem of how sound responds to muddy sediments

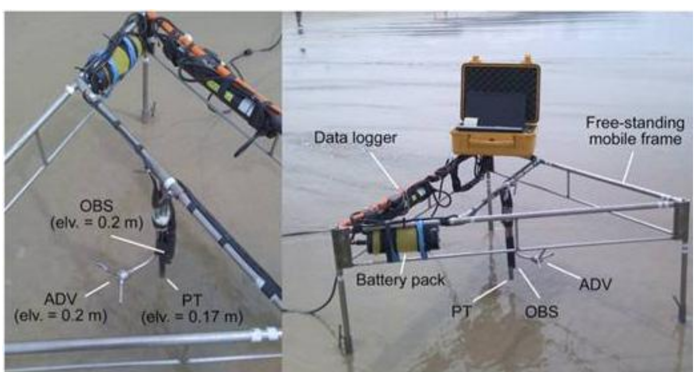
Develop, through a combination of theory and experiment, algorithms capable of quantitatively inverting acoustic backscatter signals from cohesive sediment to predict mass concentration, and to combining these with the best features of optical sensors.

3 Nortek Vector ADVs, at 15 cm spacing, were used to calculate the velocity gradient of the water column. Backscatter intensities will also be investigated for concentration calibrations

MaTRIX

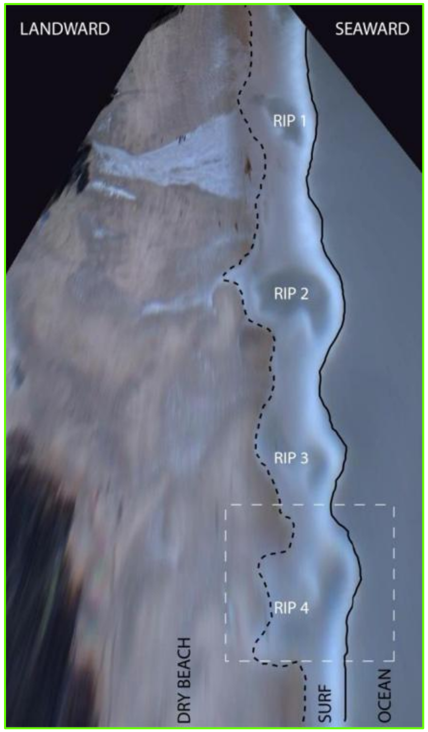
Macro-Tidal RIp EXperiment

Pilot study conducted by Dr Martin Austin and Dr Tim Scott at Perranporth, Cornwall, UK. Part funded by the RNLI.

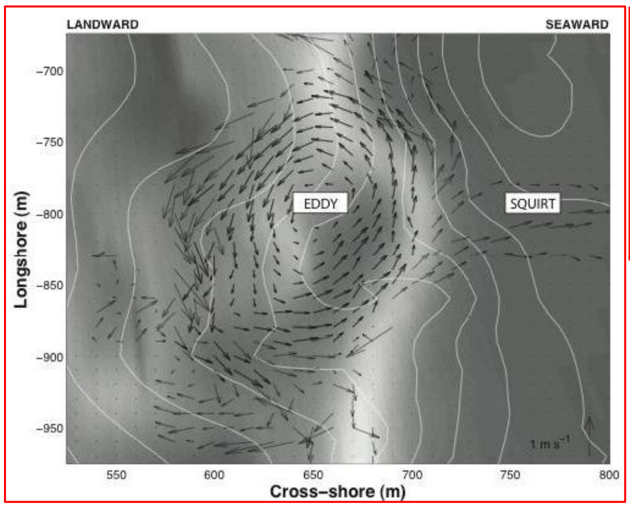


Used a number of Lagrangian GPS Drifters and one *in-situ* Nortek Vector ADV to measure velocities within a low tide bar/rip circulation system over a few days.

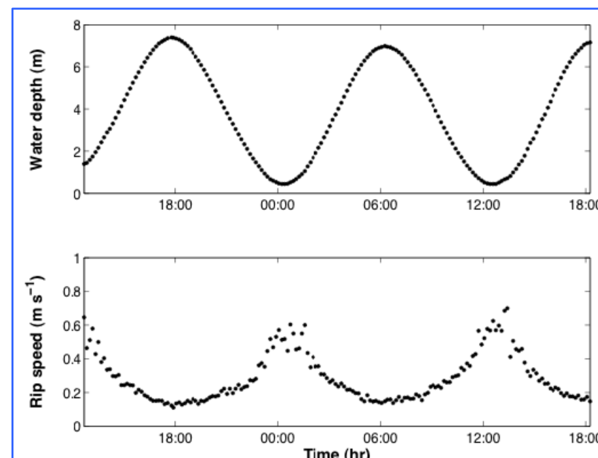
MaTRIX



Rectified ARGUS camera image of 4 rip current systems at Perranporth Beach. The rips are separated by transverse bars and retained within the surf zone by a longshore bar (Austin et al., 2009).



Rip number 4 superimposed with the Lagrangian flow pattern recorded using specialist GPS drifters.

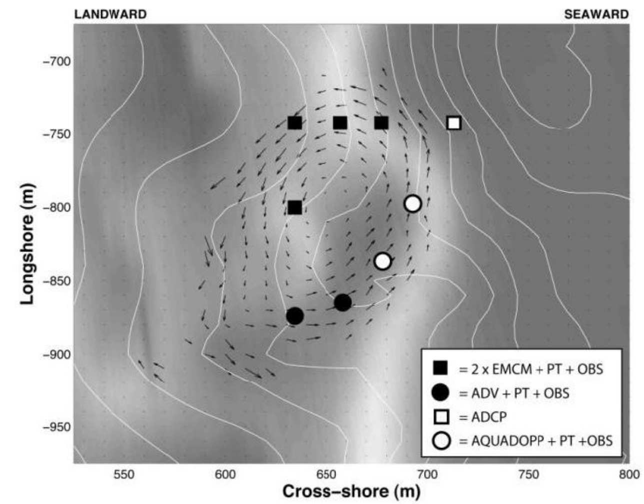


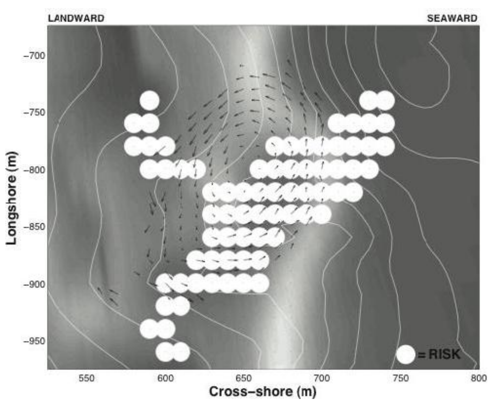
Tidal modulation of rip current velocity during MATRIX pilot study. The strongest rip flows (> 0.6 m s-1) prevail around low tide when wave breaking occurs over the nearshore bars (Austin et al., 2009).

DRIBS

Dynamics of Rip currents and Implications for Beach Safety (NERC/RNLI Funded)

○Longer term study to better understand the dynamics of rip currents.
○Two six week experiments at two different beaches on the North Cornish coast.
○Eight Instrument rigs to be deployed, using a PTs, EMCMs and OBSs.
○Two of the rigs will have Nortek AQUADOPP current profilers and two will have Nortek Vector ADVs.

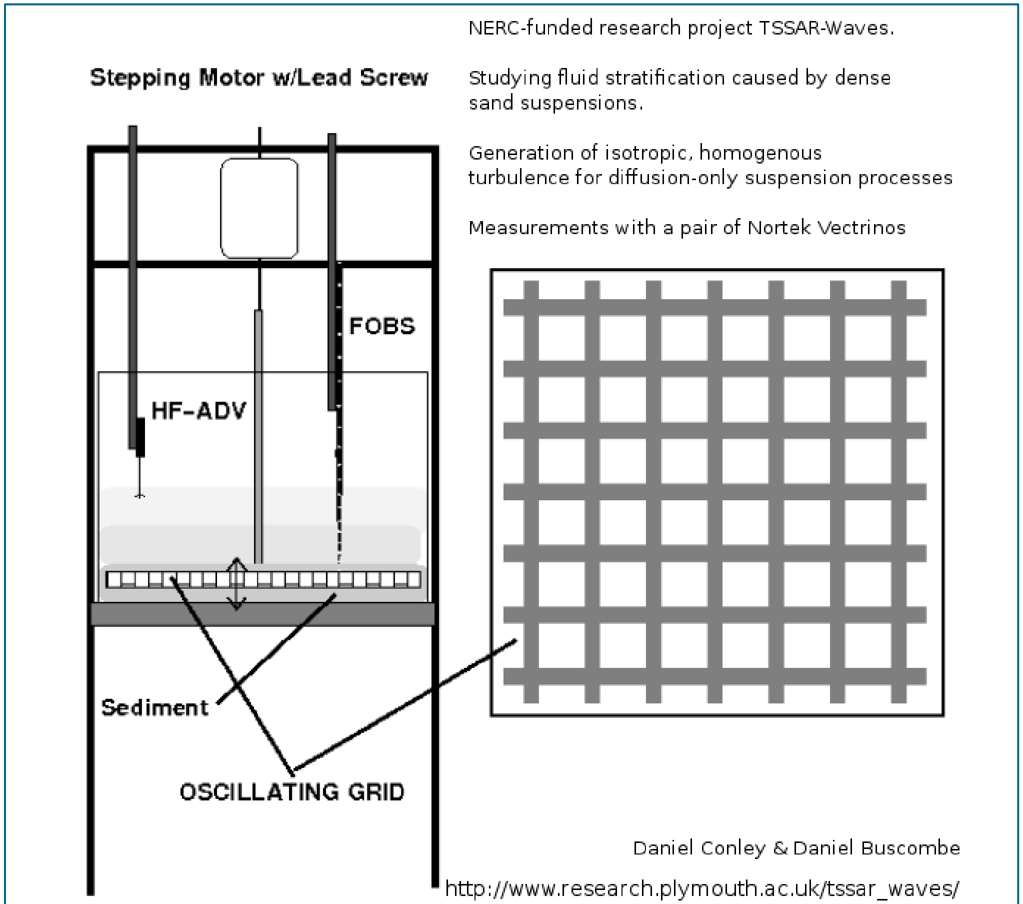




The work in *DRIBS* will be underpinned by numerical modelling throughout all phases of the work.
Rip Risk Plot showing where predicted offshore-directed mean currents exceed 0.3 m s-1. The dominant measured circulating eddy is included, together with the observed wave breaker pattern (white regions) and bathymetry (contour lines).

TSSARWaves

Turbulence, Sediment Stratification and Altered Resuspension under Waves



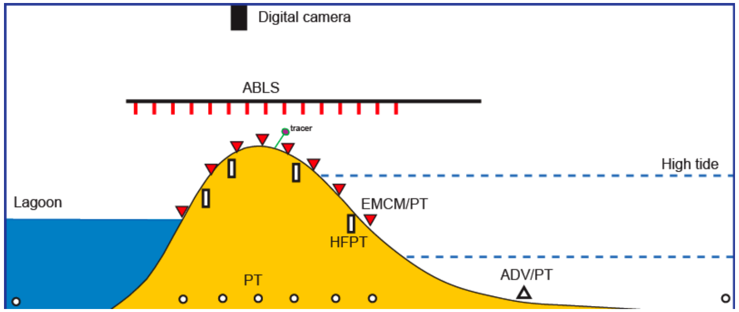
The leading hypothesis for this work is that the two way feedback between instantaneous flow stratification by suspended sediment and the turbulence which suspends that sediment is a key factor in the generation of nearshore morphology

Turbulence tank to be constructed to recreate nearshore conditions – Turbulent flow to be measure using 2 Nortek Vectrinos

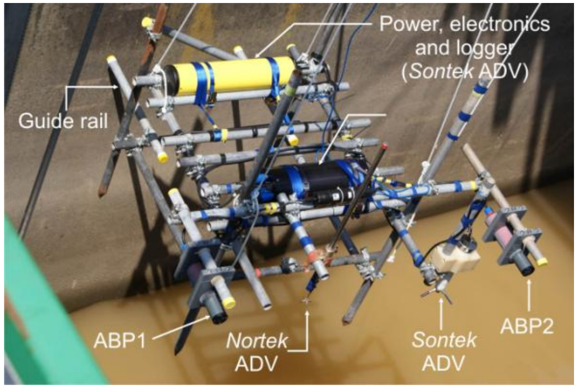
BARDEX

BARrier Dynamics EXperiment

Project aim: to investigate the dynamic response of gravel beaches to both tides and waves



Gravel barrier 4m high and 50m long in a flume over 200m long, 5m wide and 7 m deep

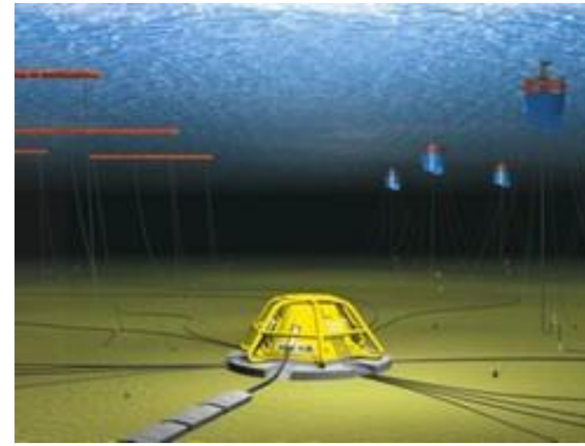


WHISSP

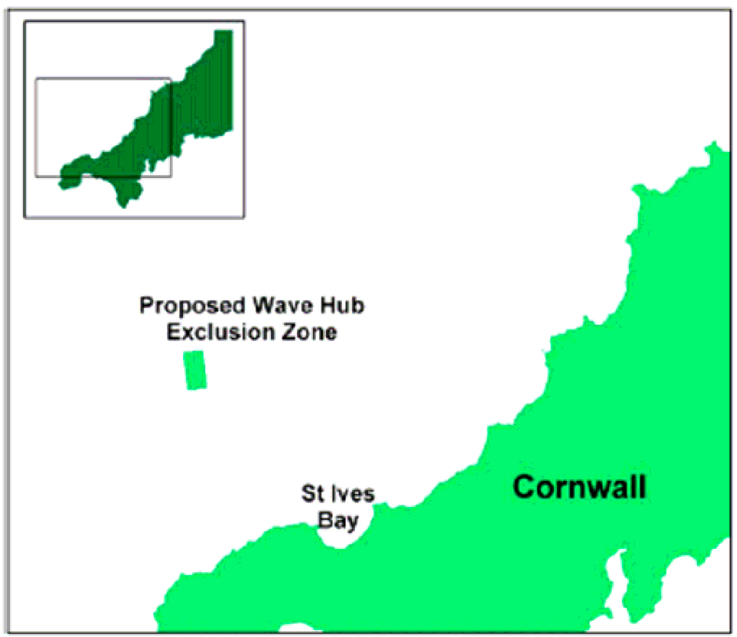
WaveHub Impacts to Seabed and Shoreline Processes

What is Wave Hub?

An electrical socket on the seabed with the capability of transferring electricity, generated from wave energy conversion devices, back to land and into the national grid.



Artists impression of *Wave Hub* *(Industrial Art Studio Ltd)*



Approximately 12 miles off the coast of St. Ives, Cornwall.

WHISSP

WaveHub Impacts to Seabed and Shoreline Processes

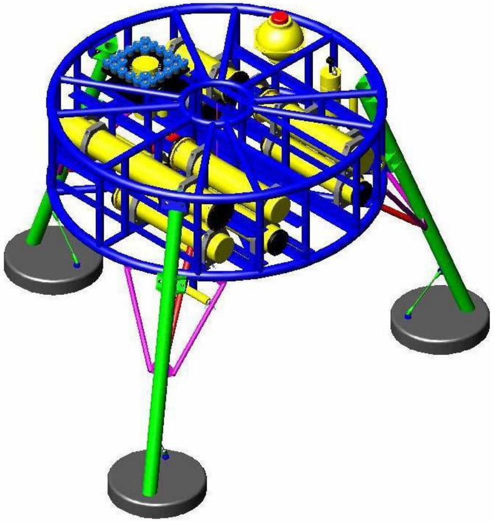
Potential impacts of Wave Hub

- 3 – 6% attenuation in wave height in the lee of the Wave Hub (Black, K, P., 2007)
- Impacts to the shoreline morphology at a number of Cornish beaches
- Changes to near-bed hydrodynamics from the Wave Hub site to the shore – subsequent consequences to sediment transport
- Potential impacts to the surfing community and other recreational beach users in Cornwall

WHISSP

WaveHub Impacts to Seabed and Shoreline Processes

- Shoreline monitoring
- DGPS surveys every spring tide for the last 25 months on 4 Cornish beaches in the shadow of the WaveHub
- Need for surveys to continue in order for any potential impacts of WaveHub are to be revealed



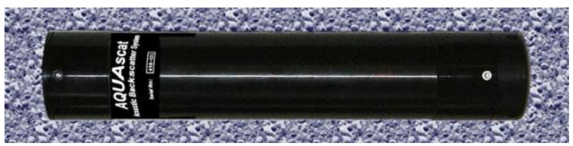
- Offshore monitoring.
- Using a Benthic Lander and a suite of acoustic instrumentation.
- Characterise the physical environment in the bottom 2 m of the water column at high temporal and spatial resolution

WHISSP

WaveHub Impacts to Seabed and Shoreline Processes

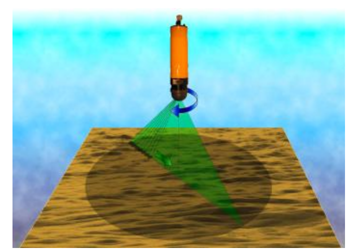
Benthic Rig Instrumentation

2 x RDI ADCPs. 1 x 1200kHz downward looking and 1 x 600 kHz upward looking



AquaTech AquaScat, tri-frequency ABS

2 x Nortek Vector ADVs



Marine Electronics 3d Imaging Sonar

WHISSP

WaveHub Impacts to Seabed and Shoreline Processes

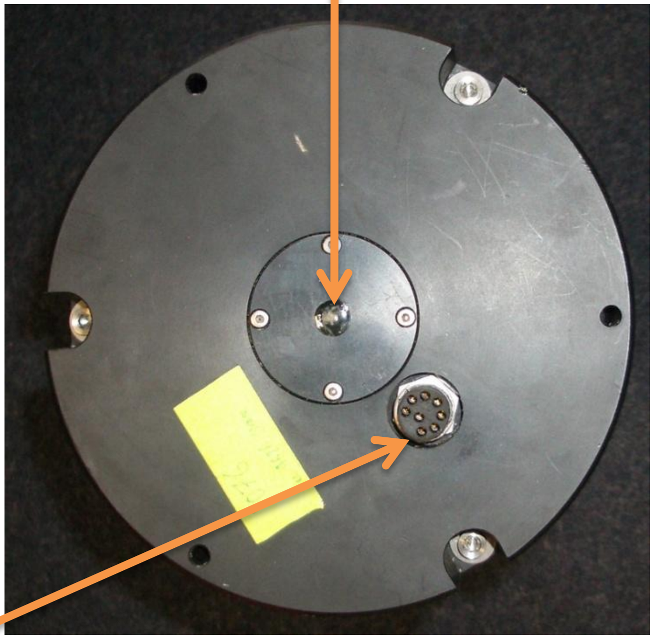
- Lander deployment for a period of 1 month to collect a high spatial and temporal resolution data-set
- Posed a problem in terms of data collection, particularly for the ADV's

…UoP modifications…

- Problem to be solved:
  - Log 2 Vectors at 64Hz, for 20 minutes every hour, for a period of 4 weeks
- Solution:
  - Use external RS232 binary string data loggers in standard Nortek external battery housing

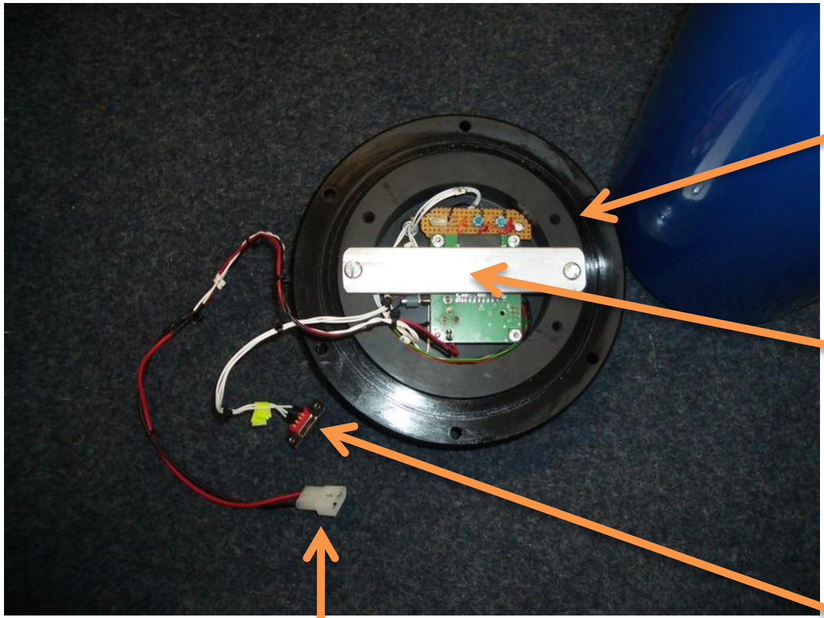
Starting with the external battery housing

LED addition to end cap



Connection to Vector

Inside the end cap



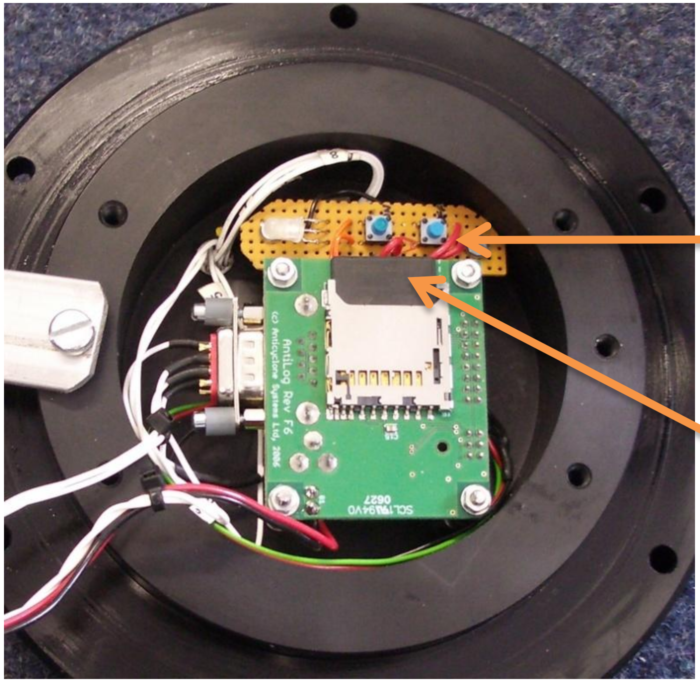
Cap machined out to create area for logger

Bar added to prevent damage from battery packs

Second serial port for communication with data logger

Power connector to link to battery pack

The logger



Prototype version

2 micro-switches for logger setup

4GB SD card memory

Bi-colour LED on outside indicates logger status (standby, data coming in etc.)

Our results:

Successful deployments with Vectors and loggers

We run 2 sync'd Vectors each with individual loggers

Very fast data download via SD card reader

Software 'front end' works but could be better

This external logger solution worked for our problem

4GB of Vector binary data is HUGE when converted to ASCII!!!

My Research

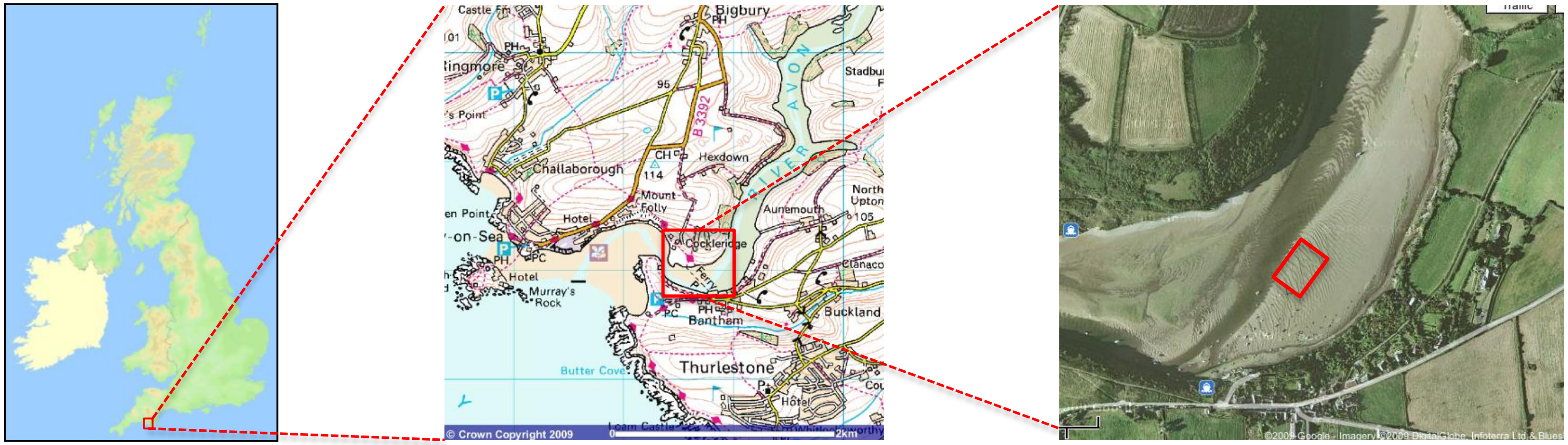
- Change of direction
  - Why?
    - Delay to the deployment of the Wave Hub
    - Lack of a designated exclusion zone for shipping/fishing

    - Problems with deployment vessel

- Consequences
  - Needed to find a new study site and research strategy using the existing suite of acoustic instrumentation

- New study site relatively close to Plymouth
- Change from an offshore to an estuarine environment

New study site



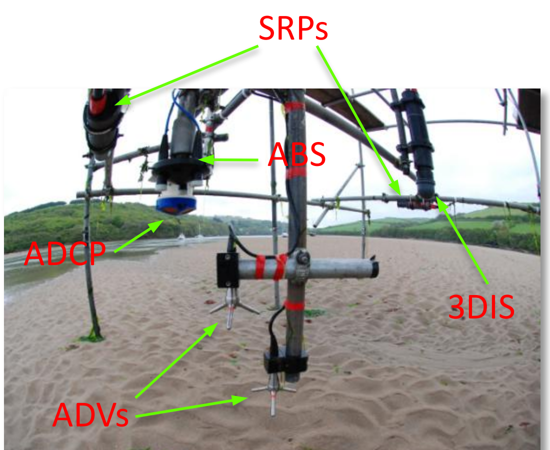
The Avon estuary, Bantham, is on the south coast of Devon in southwest England.

Mean spring and mean neap tidal ranges are 4.7 m and 2.2 m, respectively.

According to Masslink *et al.,* [2009], the estuary can be said to be shallow and flood dominant and the mouth should be a net importer of marine sediments.

Uncles *et al*., [2007] measured flows in the lower estuary at Bantham Harbour during a one week period in both summer and winter in 2006. Peak flows measured during the flood (0.4-0.8 ms^{-1}) were weaker than during the ebb (0.6-1 ms^{-1}).

Experimental Setup



Instrument Configuration

All instruments set to collect data as soon as they were covered with water.

•ADVs logging at 32 Hz

•ABS logging at 32 Hz

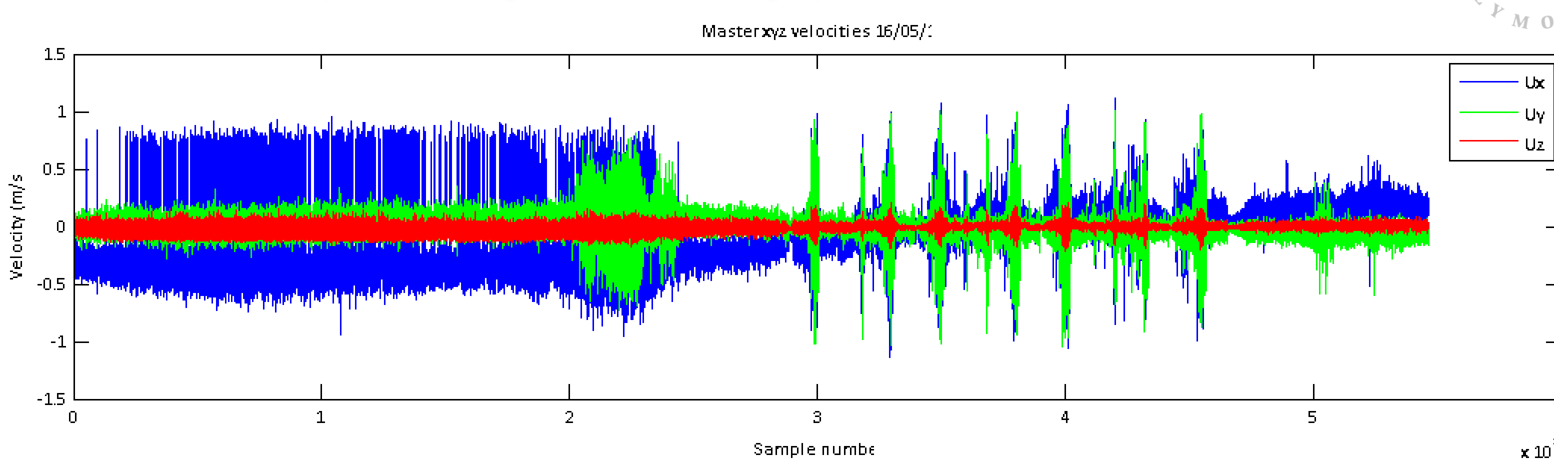
•ADCP logging in high resolution mode every 3 second

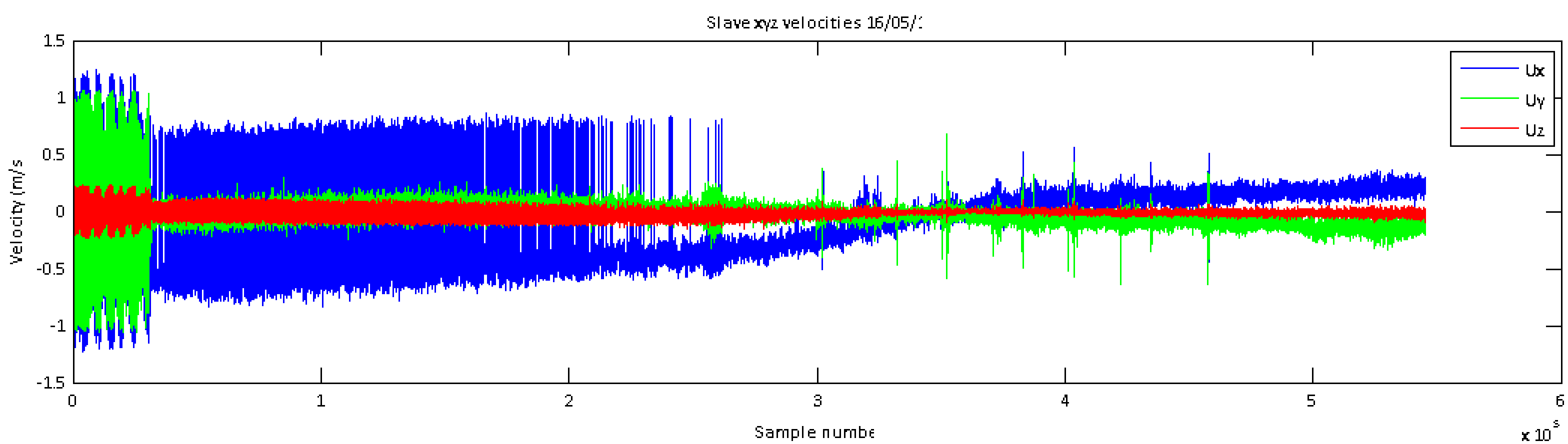
•SRPs taking 1 scan each every 2 minutes

•3 PTs logging every 10 seconds

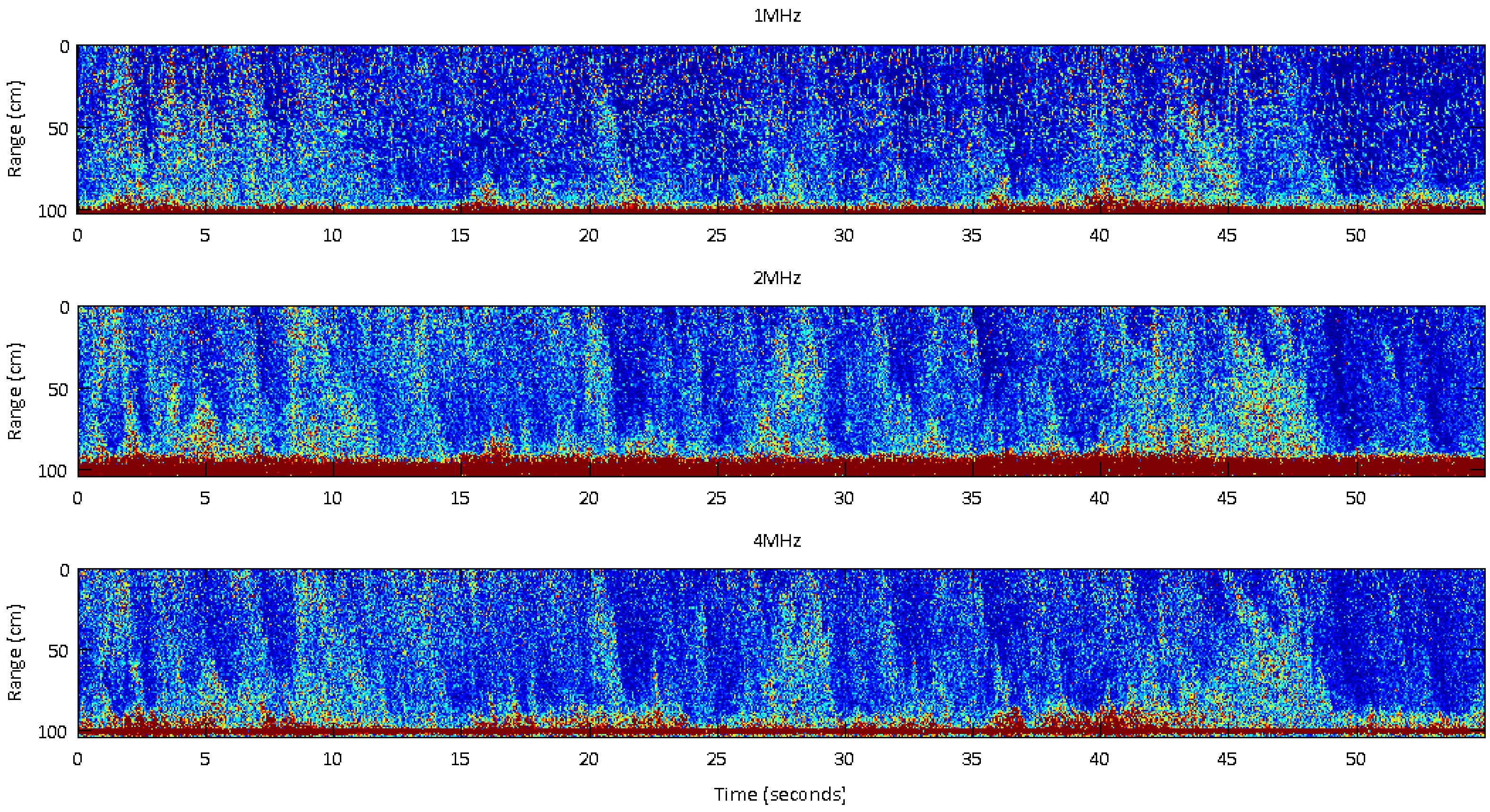
Pump sampling was carried out as often as possible for determination of volume of sediment in suspension and calibrating the ABS

Some (very early) results

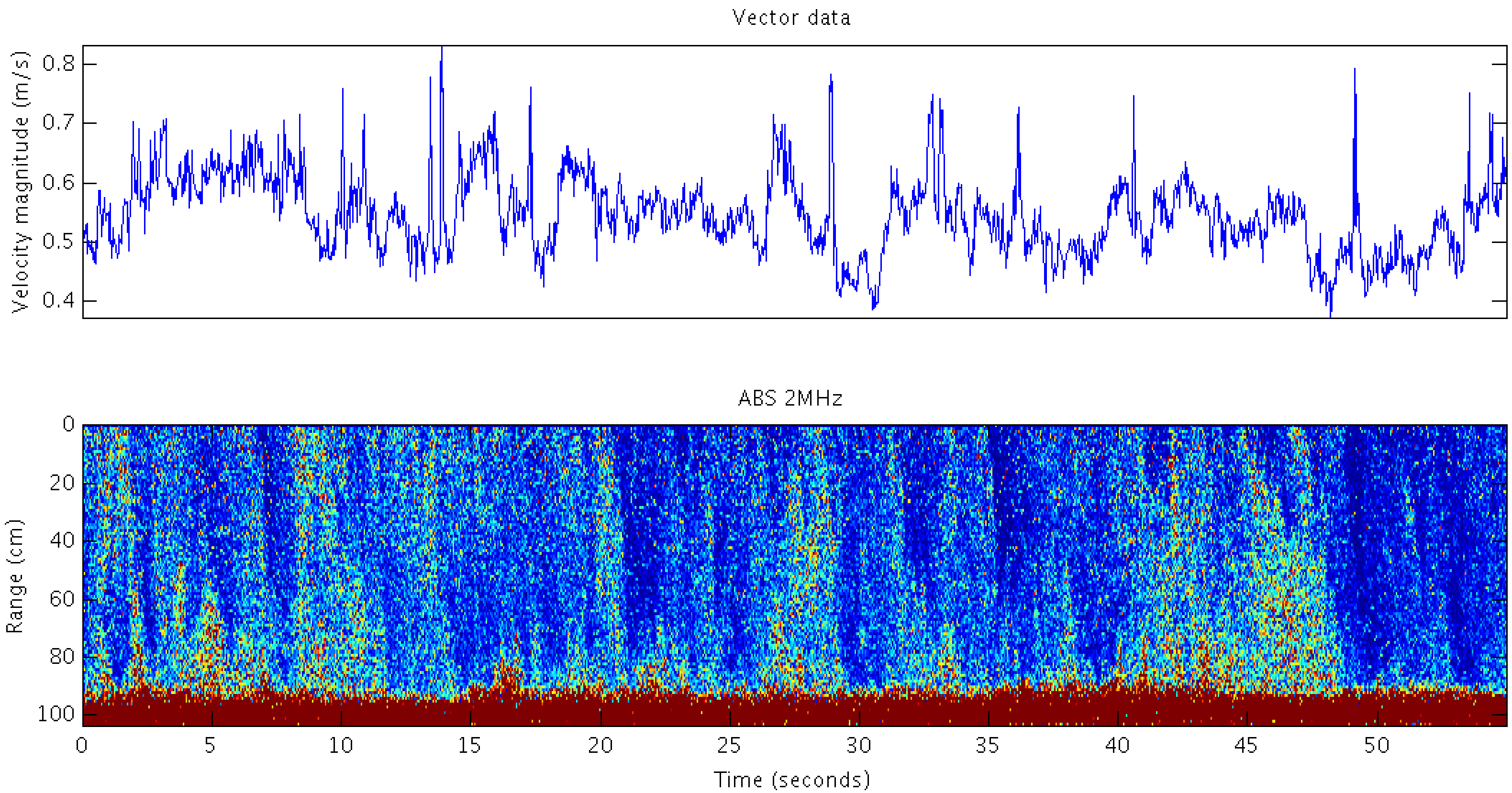




Some (very early) results

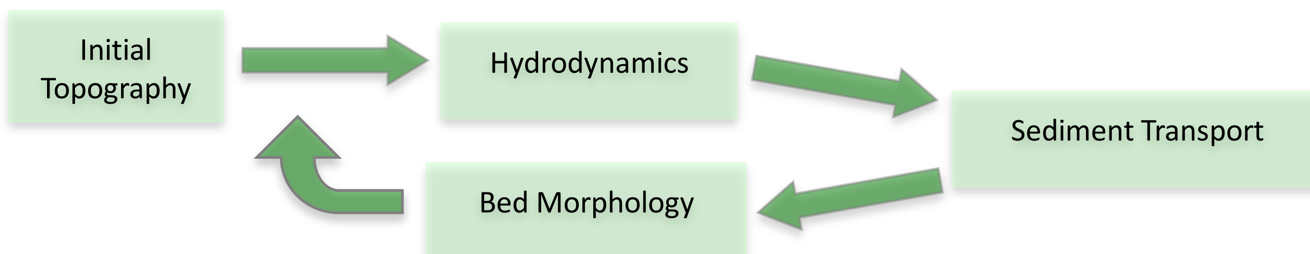


Some (very early) results



Future analysis

•Calibrate the ABS data from the pump sample volumes.
•Identify sections of the data where there sediment is in suspension.
•Correlate suspension events with ADV data using Reynolds stress and Turbulent Kinetic Energy methods – i.e. see how turbulence in the boundary layer is affecting the bed.
•Investigate the morphodynamic loop, whereby:



Investigate how the ADVs acoustic backscatter intensity may be related to instantaneous suspended sediment concentration using:

$$BSI = 10^{-5} \times 10^{0.043 \times Ampl}$$

Where BSI is the acoustic backscatter amplitude, Ampl is the average signal amplitude in counts by the ADV (*Chanson et al*., 2008)


AVON SAUL
TIM