

Improved Information Systems for Mine Burial Prediction: FY2002 Report

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LONG-TERM GOAL

Improve the quality and availability of seabed information to modellers and operational units concerned with Mine Burial Prediction (MBP).

OBJECTIVES

- (i) Improve the delivery of data on the physical properties of the seabed for use in mine burial prediction, namely in the fields of geotechnics, sediment hydrodynamics and seabed classification. Interface these with other current efforts in MBP.
- (ii) Improve the delivery of indexes of the reliability of this seabed data, with development of appropriate visualizations of these uncertainties.

APPROACH

Progressive innovation in the handling of seabed data by information systems, carried out with these processes in parallel: (i) ingestion of new datasets, (ii) development of algorithms, (iii) delivery of digital products to MBP community, with feedback.

The work is done within the framework of the dbSEABED structure (Jenkins 1997), a system for the extraction of information about the seafloor from many diverse types of input seafloor data including samples, cores, probes, images, diver reports. The spatial resolution of outputs is the same as that of the original input samplings; the data is entered in the same terms as original; biogenic materials,

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consolidation and bioturbation are fully incorporated; the algorithmic structure allows nearly limitless extension and improvement of output capabilities without resort to data re-formatting.

- i. *Ingestion of new datasets.* To obtain extended and more detailed coverage of US and international waters, significant observational datasets are entered into a standardized digital format. These datasets are donated by sources in science, engineering, environmental monitoring, and navigational surveying. The arrangement of data is novel, not an orthodox relational system, but like a core-log or an XML script. It is designed for several purposes: (a) to be computed on so that numeric and word-based data can be manipulated, and so that metadata and information on accuracies can be realized, (b) to be human-readable, for efficient data entry and error checking, (c) to be a vendor-independent legacy dataset, capable of being worked on in the future by other programmers and projects.
- ii. *Development of algorithms.* New data mining modules are being written (a) to recognize new data types and (b) to output the parameters most significant to MBP. Newly incorporated datasets often contain new types of input data which present fresh opportunities for output of parameters of interest to MBP.

But more significant, modules are written to extend the coverage, reliability and scope of output parameters. For fundamental parameters like grainsize, most output is an echo of original values. But for important yet infrequently measured properties like Critical Shear Strength and Bottom Roughness predictions are made based on the best and nearest observational evidence, and accompanied with quantified uncertainties. The prediction is a central value - in the absence of unusual factors. As data coverages and calibrations improved the uncertainties will shrink.

- iii. *Delivery of digital products.* Internet postings of digital products present modellers and others with novel sources of information to feed the predictive MBP models. Two primary issues here are: (a) nature of the output variables, since many models require inputs of great detail (eg spectral roughness), (b) spatial scales of resolution, and (c) digital data formats (point data, grids, visualizations, interactive). After postings, we gather and act on the feedback from the MBP community and others.

WORK COMPLETED

Ingestion of new datasets.

- (a) *New sets.* Many new datasets were added in FY02 in collaboration with the USGS (Mike Field, Co-PI), NOAA, industry, universities, NRL and the Royal Australian Navy. The total holdings of attributed sampled sites is now just less than 1 million globally and 400,000 for US waters (usSEABED), growing at a rate of about 3,000 each week. Special effort has been directed to the West Florida Shelf and Atlantic US Margin, in order to work with the ONR experimental programs.
- (b) *Specialist dataset types.* A number have been entered in FY02, namely the Australian Beach Safety Management Database (ABSMD; Andy Short, Co-PI) which is employed internationally now for beach characterization, the (classified) RAN Mine Countermeasures Diver Database, NOAA physical properties datasets of MGG073/074 format. Semi-automated tools for these made their entry quite efficient.

Development of algorithms.

(a) *Critical Shear Strength (CSS)*. This most important MBP parameter is now enabled in outputs. Despite its significant spatial variability, it is possible now to visualize the wider-scale (2-100km) patterns of variation across its dynamic range. dbSEABED puts out CSS as a value for the most erodable part of the seabed materials, unmodified by cementation, or bioturbation. This predicted 'central' value may then be adjusted by users to account modifications to allow varying runs of MBP models. This process simply implements what the modelling community have always done to input CSS into models.

CSS is calculated using empirical relations from clayey through to boulder particle sizes, and for consolidated materials water contents or Undrained Shear Strengths (USS) are described. Examinations of many datasets of CSS show that uncertainties on values of CSS even under careful laboratory and field measurement are very wide due to machinery, the scenario in physics, timing, etc. More data is being acquired to refine the empirical relation and its uncertainties.

(b) *Seabed Roughness*. We developed a data mining module to output Mesoscale Bottom Roughness - an important parameter in sediment transport, inshore wave damping, habitat and acoustics. The module gives good values, but is still in review. Observed dimensions of outsized clasts and shells, of ripples and waves, of biological mounds and pits, burrows and upstanding shelled epibenthos are used – where possible – to calculate a roughness statistic of the form height:length (ie., an aspect ratio, but absolute; Jenkins 2002b). Methods of visualization have also been developed (Fig. 1).

(c) *Spatial variability*. The aggregation of so many observations presents special opportunities for the measurement of spatial variation among seabed parameters. We have developed in FY02 software to map (grid) on an automated basis, spatial variance of parameters over regions, using geostatistical methods (Fig. 2). The result is firstly that the patchiness of the seabed can now be mapped, and second that mappings of seabed properties like grainsize, may now be accompanied by mappings of the 1SD uncertainty on values. Many areas show spatial dependence of character out to 4-10 km range.

(d) *Temporal change issues*. We have tackled these in 3 ways: assembling datasets to rate areas according to their environmental volatility, placing seabed data in imagery which is classified by to environment using image processing techniques, observing changes in seafloor sediment patterns where repeat datasets exist. The results clearly show that temporal change is an important issue in large dataset compilations, but that also those sets can be used to quantify it over large areas, which will be useful to MBP. The issue stands as a primary task to progress FY03 (including work by the Postgraduate Student J Hohnen at Sydney University).

Delivery of digital products.

(a) *Downloadable grids*. A multitheme gridded dataset for the West Florida Shelf was made public at Jenkins (2002e) early in FY02 and MBP modellers were notified. A difficulty appears to be that few MBP sediment transport models can accept map-base data, since they are 1D or 2D in structure. For that reason an ArcIMS site is now under development (draft: "<http://deeppurple.colorado.edu/aims/website/css/viewer.htm>") which can be queried online for spot values of CSS and shortly, grainsizes, porosity, etc.

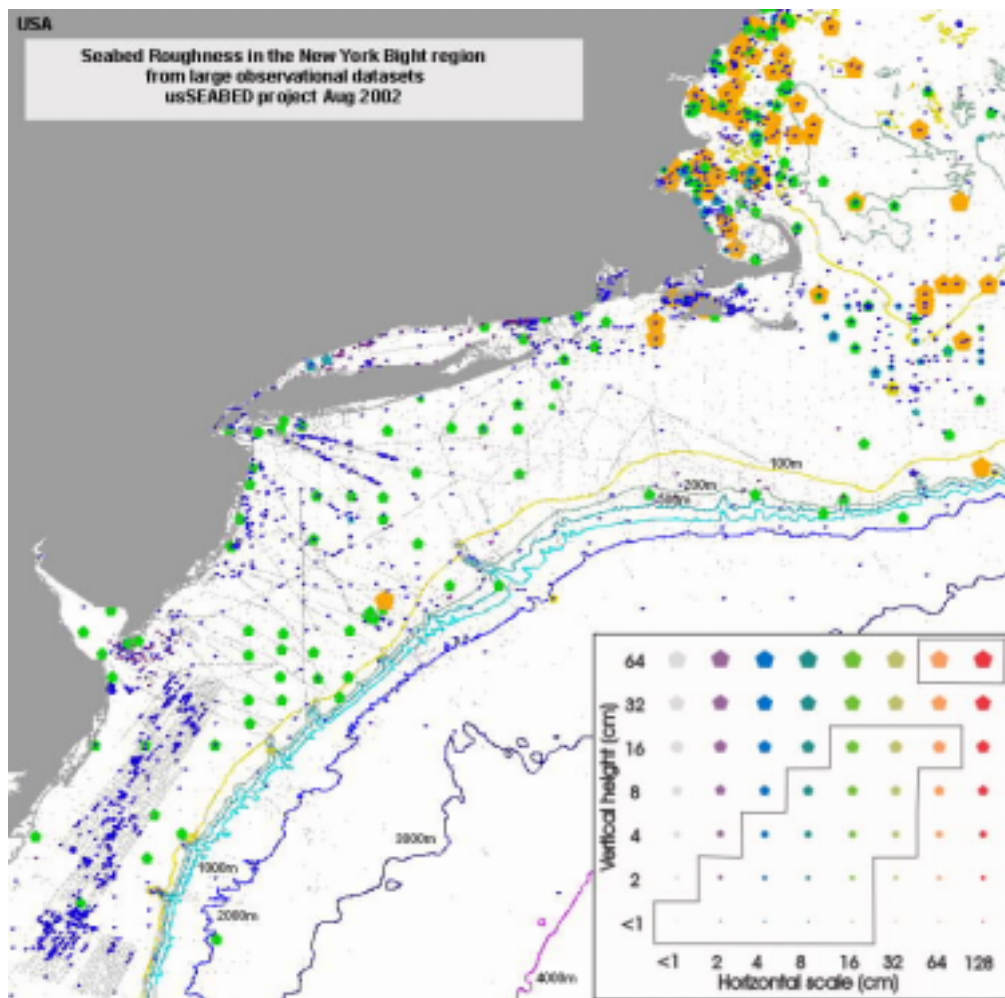


Fig. 1. Prototype mapping of Mesoscale Seabed Roughness. Notice that the mapped roughness height:length aspect symbols are stepped in log2 scales. Strong regional variations are apparent, due to glacial debris, shell materials, gravels and ripple fields.

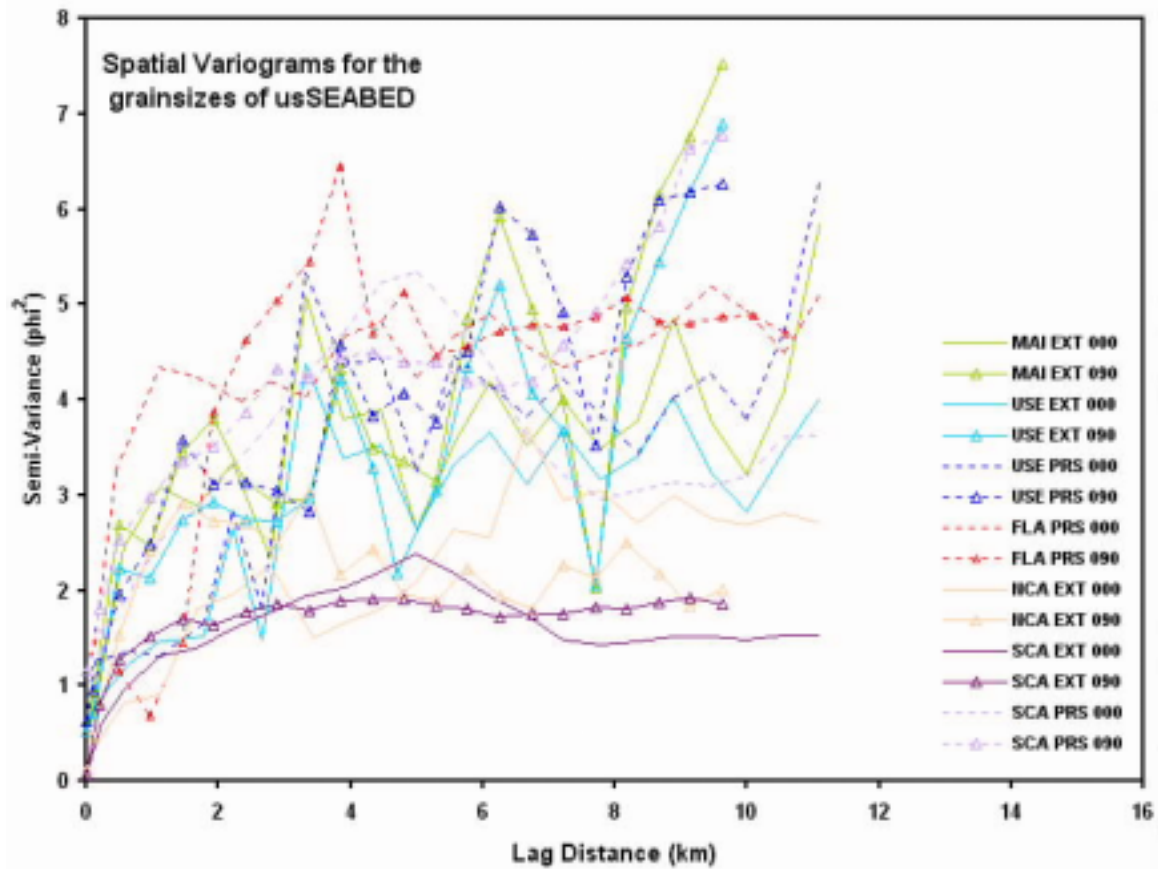


Fig. 2. Prototype analysis of the spatial variation ('patchiness') of the seabed on mapping scales for Gulf of Maine (MAI), US East Coast (USE), West Florida Shelf (FLA) and N and S California margine (NCA,SCA). 000 and 090 indicate N and S analysis directions.

RESULTS

- i. First ever data mining of large observational datasets for critical shear stress, mesoscopic bottom roughness and sediment colour.
- ii. Enormous extension in coverage, resolution and attribute density of the amount of accessible information on seabed properties around the US and also through foreign waters.
- iii. First ever mappings of regional changes in the patchiness of the seafloor, with important applications in the attachment of reliabilities to common seabed maps of grainsize, composition and physical properties.

IMPACT/APPLICATIONS

- i. The newly available datasets will help to solve a major problem in MBP – an inadequacy of input data for the properties of the seabed.

- ii. The methods we develop to mine seabed data are innovative and will become available for application in other marine database systems.
- iii. The output products are finding application in diverse fields –fisheries and habitat management, offshore aggregate resources, beach replenishment, geoscience research, biogeochemical modeling, undersea engineering, search and rescue debris location, and naval tactical planning. This is happening through partnership with USGS, NOAA, companies and the Australian Navy.
- iv. The datasets we compile are the largest and most detailed point datasets ever compiled. They are in a well organized readable format and will be available in future years to other applications and software developments.

TRANSITIONS

The dbSEABED software - with enhancements built under this ONR program - is being used now within the USGS (Santa Cruz, Woods Hole) and in the Australian Navy, producing their respective national scale mappings.

RELATED PROJECTS

- i. usSEABED, joint development between The University of Colorado, US Geological Survey (M Field, J Williams) and The University of Sydney; Jenkins (2002c, Web Document).
- ii. goSEABED, joint development between The University of Colorado, National Geophysical Data Center (NGDC, of NOAA); DRAFT web page at <http://instaar.colorado.edu/~jenkinsc/dbseabed/goseabed/>.
- iii. Australian Beach Safety and Management Program (AMSMP), of Australian Surf Living Saving Association and the University of Sydney (A Short).
- iv. Likely involvement of A Short and C Jenkins with foreshadowed ONR program ‘Mine Burial in the Nearshore Environment: using recent scientific developments to assist prediction’, Bob Dolan coordinator.

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