

# **Improved Information Systems for Mine Burial Prediction**

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## **INTRODUCTION**

Improve the delivery of seabed information to modellers and operational units concerned with Mine Burial Prediction, especially burial through sediment transport and bedform migration in inshore waters.

## **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.
- (ii) Improve the delivery of indexes of the reliability of this seabed data, with development of appropriate visualizations of these uncertainties.

The project will construct several demonstrators of its new concepts, based on ONR test sites and other areas of collaborative activity. These demonstrators will be interfaced with future ONR programs of MBP modelling.

## **APPROACH**

### **Establishing Levels of Data Reliability**

Seabed information is associated with uncertainties in navigation, sampling, currency and attributes (the parameters).

- a. Usual navigational errors – such as those from GPS and prior technologies - can become very significant close to shore where geomorphic features like headlands and beaches strongly segment the character of the inshore seabed. For example, shorelines are not well defined due to tides, datums and past technologies of survey; beach data are often assigned to a beach centroid.

# Report Documentation Page

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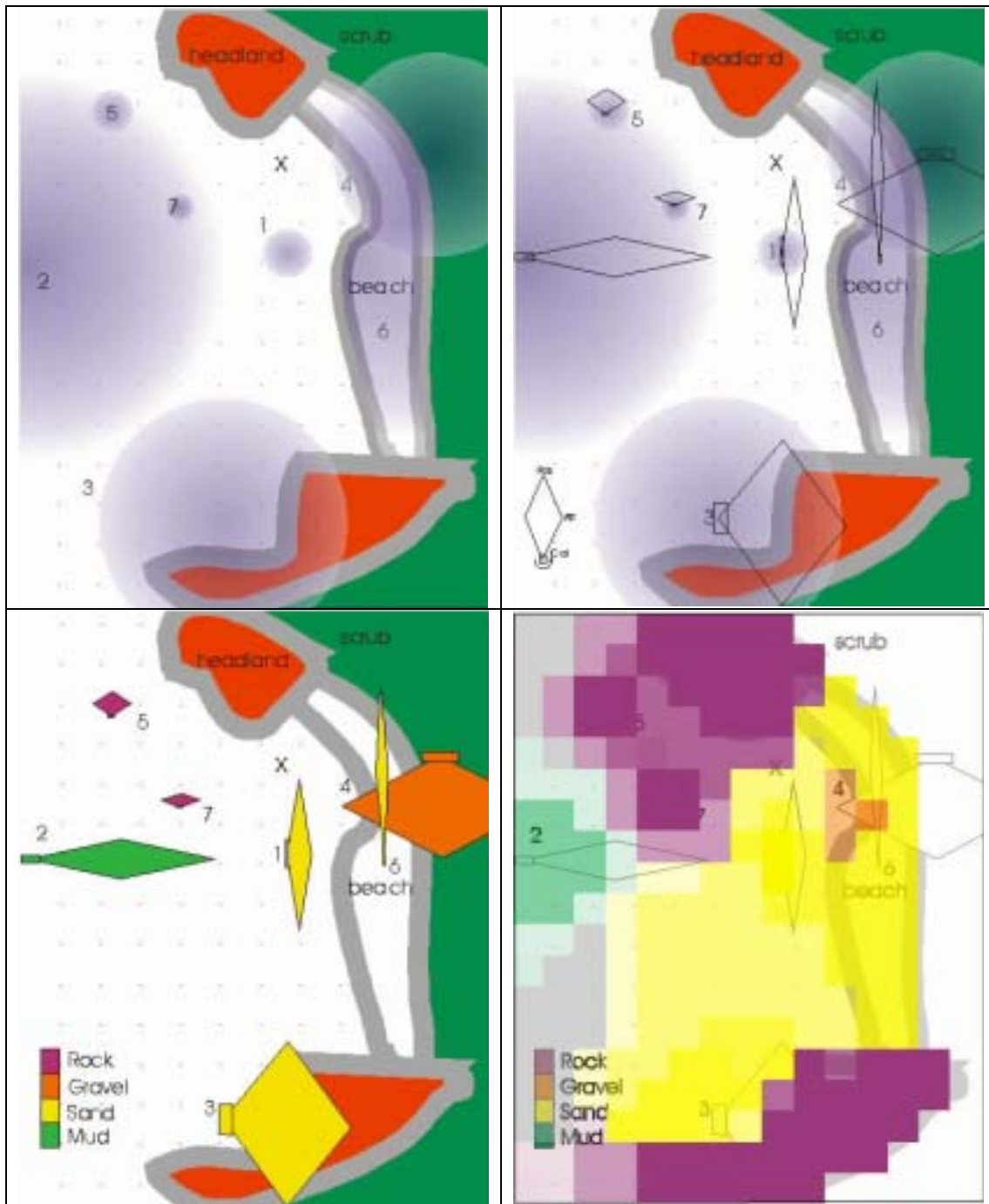
- b. Attribute errors derive from methods of sediment analysis and also reporting. As an example of different data types, a verbal description of a material is less precise, but may be more accurate than a lab analysis if it includes data on consolidation, gas or organics.
- c. Sampling (collection) errors are caused by selection of a sampling / sensing technique and later subsampling. For example, vibrocores which are commonly used in the inshore tend to liquefy and wash coarse sediments; also, many studies exclude outsize shell and any organics from subsamplings for analysis.
- d. Uncertainties stemming from temporal changes of the seabed are dealt with separately (see later).

We have investigated a number of means of visualizing these type of uncertainties in a way that people not familiar with marine science might find straightforward (Figs. 1, 2, 3).

- a. Circles of navigational uncertainty are an obvious visualization (Fig. 1), but should not be confused with the zone of influence a point can contribute to interpolations (griddings).
- b. Glyphs have the potential to convey positional, attribute and collection uncertainties (see Fig. 2; pos, att, col) by their lengths and rotations. By use of colours and patterns the actual attributes can also be conveyed (Fig. 3; R:G:S:M for example only; pendant glyphs mark poor collection method).

Unfortunately, if the properties at point 'X' are required, then some type of interpolation between the samplings and geomorphic elements is required which may involve spatial as well as temporal considerations. Once the interpolation method is decided, uncertainties (errors) can be propagated arithmetically, leading to a visualization that conveys seabed characterization as well as the reliability (Fig. 4). Here we use colour for seabed character and transparency of the colouration for reliability.

Further work on these lines will examine in more detail, the scaling of uncertainties and then propagation of those scalings to grids and other data products.



*Fig. 1. Common display of navigation uncertainties.*

*Fig. 2. Glyph type display of positional, attribute and collection uncertainties.*

*Fig. 3. Glyph type display extended to portray seabed character as well as uncertainties.*

*Fig. 4. Colours convey character; transparency conveys propagated uncertainties. (grey equals unknown character).*

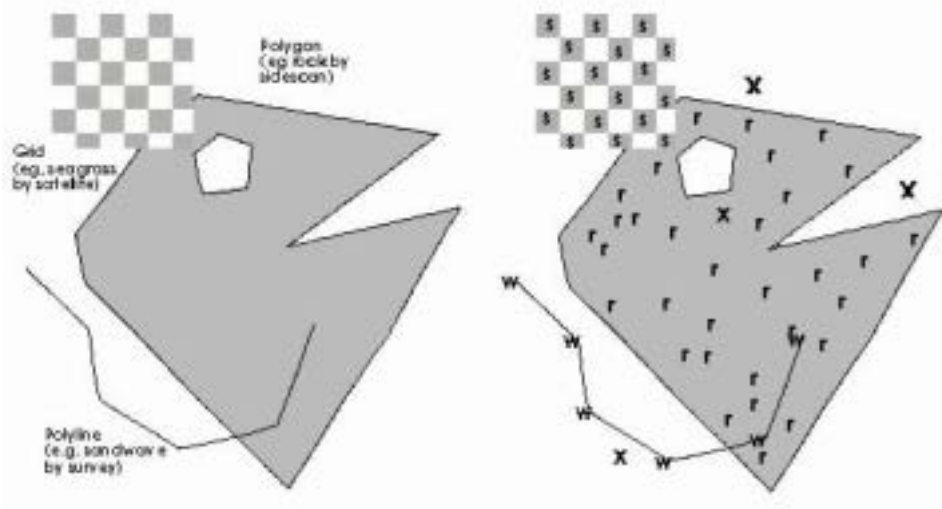
## Polygon vs point data.

Polygon datasets often exist for inshore areas but are difficult to reconcile (combine) with other data types. If the 2 data types could be combined, then much more data would become available in a systematic way to aid MBP.

Polygon data is commonly derived from sonar or satellite mapping classifications (eg. 'rock' or 'kelp' areas), geomorphic studies (eg. 'headlands', 'mangroves', 'coral reefs') or published syntheses of sampling studies. This is particularly true of remote and little-studied areas

In areas where point and polygon data overlap, they are difficult to reconcile:

- in GIS polygons spatially mask or overwhelm the sampled datapoints;
- the classes assigned to polygons are frequently very broad, not detailed sediment analyses
- the polygons as drawn usually damp or destroy the spatial frequency of the natural seafloor patchiness
- positional uncertainties are usually not specified for polygon data.



**Fig. 5. Illustration of a method for reconciling polygon and point seabed data. Points 'r' are rendered (randomly) by the process, 'x' are point samplings in the same area, but from other studies. Polyline data such as from sandwaves can also be reconciled.**

For this and related programs we have devised a process (implemented in software) which renders seabed polygon data as points which can be merged with usual spot-sampling results. The rendering is performed either on regular or random grid and is scaled to a factor of the number of nodes present in the polygon (more detailed polygons obtain denser rendering). A fast point-in-polygon test is used and polygon overlaps and islands are properly treated.

The result is that polygon and usual seabed sampling data are now capable of being merged and then gridded (interpolated) together. Practical applications include cases where pockets of sand are

identified within wide rock areas and where narrow clearways through kelp might be defined, the former illustrated offshore of Sydney, the latter for southern California.

### **Physical properties**

Work is proceeding on improved extraction of salient physical properties information such as bed shear strengths, from commonplace sources of geological and defence information. This is being done within the framework of dbSEABED, an successful seabed information processing system.

Australian collections of navy diver tests are being data mined, assisted with calibrations provided by the RAN. Further validation is being provided from underway penetrometer datasets.

Various improvements have been made to the mining of other physical properties data in dbSEABED. One example, of some interest to visual identification of MLO's is seabed colour, for which it is now possible to make digital mappings (Jenkins, subm.).

### **The Issue of Temporal Change**

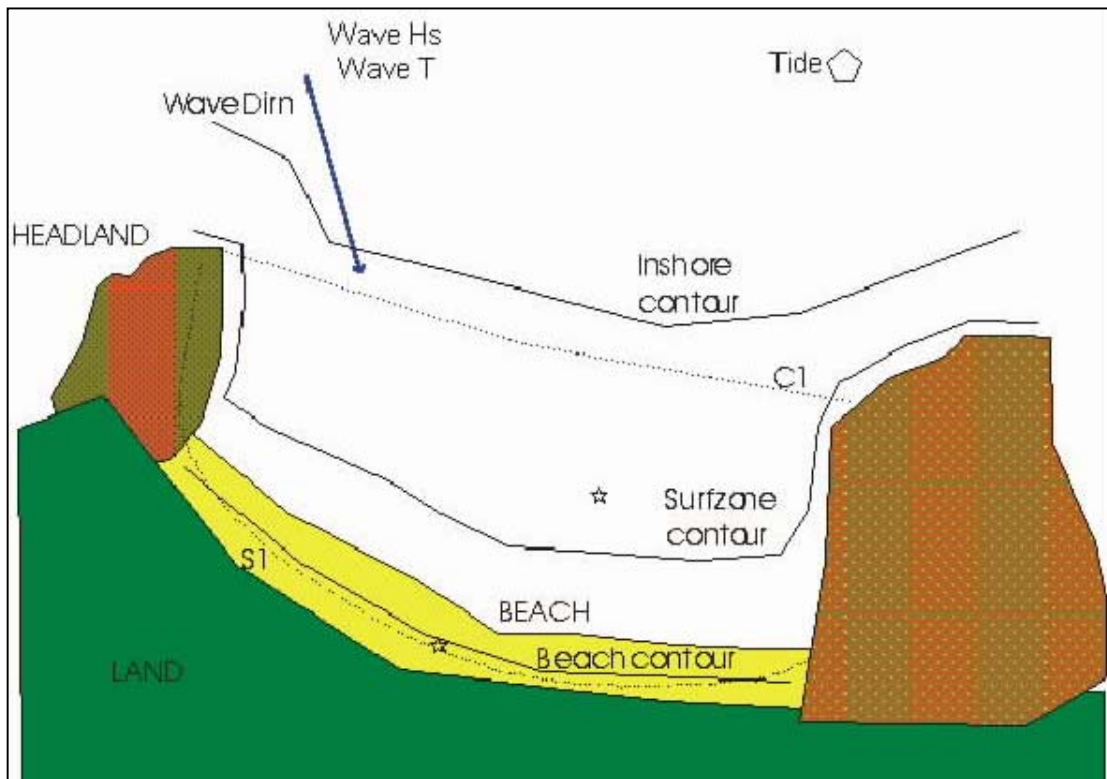
One method of assessing scales of temporal change of the seabed and how that would affect reliability of seabed data for MBP, is to weight the seabed data on the severity of seabed changes that occur in its vicinity.

Two sources of rapid assessment for seabed change over time come to mind:

- a. imagery, including repeat satellite imagery
- b. modellings of the effects of weather, etc.

The ONR postgraduate student will closely examine (a), but in the meanwhile, we have implemented a model of geomorphic change of beaches, based on well-established results in beach morphodynamics (Short 1999).

The model is a high-level beach simulation that computes various morphodynamic parameters from the topography, waves/tides and the sediments. A sketch of the beach in question is made, and functions as input. This may be done over a vertical image (aerial, satellite) or a topographic map. A small set of the significant environmental statistics (properties) are entered along with the sketched geographic features (objects) (Fig. 6). Those features include beach and headlands, incident wave climate ( $H_s$ ,  $T$ ,  $D_{irn}$ ), tidal range, simple beach/surf/inshore contours, embayment chords and some sediment grainsizes. The system is designed for use in remote areas where there may be little on-the-ground information.



**Fig. 6. Example of the GIS sketch in a GIS to submit an instance to the beach geomorphic simulation. The features carry their attributes into the model. Stars represent grainsize information.**

The modelling then works on the input GIS file to compute relevant parameters and statistics and in the manner of an expert system produces these results:

- a. is the beach reflective, intermediate, dissipative
- b. presence and number of bars
- c. presence and spacing of rip currents
- d. dominate processes operating across the surf zone
- e. dominant mode of sediment transport (on-offshore or longshore)
- f. is the beach stable ?

A wave refraction module is being fitted to improve reliability. Also, wave / tide conditions can be cycled. Validation of the simulations will be tested against those numerous Australian, US and Brazilian beaches which have been measured in similar ways over several years.

The simulation will have further application in providing a context for numerical models of inshore sediment transport, bedform change and mine burial to operate.

## **Concept Demonstrators**

So that ONR and collaborating institutions can inspect progress through term of the grant, a set of demonstrators will be made which are relevant to specific ONR programs of field testing. The project will respond in technical aspects, based on reviews of the utility and performance of these demonstrators during those tests.

## **WORK COMPLETED**

### **Levels of Data Reliability**

We have designed methods whereby uncertainties on seabed data can be assigned, propagated and visualized in preparation for MBP.

### **Physical properties**

New data mining tools have been implemented for the extraction of geotechnical information from naval datasets including diver punch tests and underway penetrometer results.

### **Polygon and point data**

A new method for reconciling polygon seabed classifications and point sampling data has been implemented and is applied to inshore areas of Australia and the US.

### **Temporal Change**

A geomorphic simulation of temporal change in the surfzone has been constructed that allows: (i) data to be assessed for effects of seasonal change; (ii) provides a geomorphic context for more detailed numerical MBP.

## **Concept Demonstrators**

Information sets have been obtained from the West Florida Shelf (USF, Tampa), Duck (FRF) and Narrabeen (Univ Sydney) and is being compiled into information structures ready for practical testing during future ONR experiments. The East Coast USA 'Hathaway' dataset has been brought into the dbSEABED system, allowing digital mapping of the US east coast margin but not yet to close inshore.

A recently engaged postgraduate student (PhD candidate, ONR Scholarship) is performing the task of inshore data aggregation, using diverse geologic, bathymetric, acoustic, geotechnic, geomorphic and imagery sources.

## **RESULTS**

The project has created several new tools to assist delivery of information to MBP activities by researchers and operational units. These products are in various stages of implementation as testbed developments at Australian and US sites including RAN METOC, DSTO and USGS.



## IMPACT/APPLICATIONS

These activities have the potential to greatly improve the data which is input to MBP models under development by other ONR programs and already operational. The delivery of data to those models and systems will become more systematic.

## RELATED PROJECTS AND COLLABORATIONS

a. The Australian Beach Survey program (Short, Sydney University) has been using aerial photographs and site inspections, together with available wave and tide data to achieve the following:

- (i) determine the range of beach systems that occur around the Australian coast
- (ii) determine the combination of wave, tide, sediment parameters that contribute to each type of system
- (iii) locate each beach on the coast and compile a GIS database as to its type and a range of physical, environmental and access characteristics
- (iv) obtain digital aerial images of each beach.

These digital geomorphic and oceanographic data cover over 7000 beaches over the environmental gamut of:

- (i) spring tide ranges from 1 to 9m,
  - (ii) modal wave heights from 0.1 to 2.5m,
  - (iii) sediments from fine sand to boulders,
  - (iv) many varying morphologies of headlands, fringing reefs, rock flats, etc.
- In all 12 types of beach system exist around the coast: 6 wave-dominated, 3 tide-modified and 3 tide-dominated. These systems cover most global beach types and are known to be valid for many areas of the US and Brazil.

b. The auSEABED and usSEABED projects are on-going activities to produce detailed wide-area digital mappings of seafloor geology based on a data mining approach developed at Sydney Univ (Jenkins). Sydney University is progressing with auSEABED, now holding and mapping 250,000 data sites through the Australian Maritime Area and into Asia. The USGS at Santa Cruz (Field) is compiling seabed coverages of the US west coast using the same dbSEABED data mining systems. This fall their usSEABED web site has been posted that allows users to interactively map west coast seabed sediments. USGS has also made available for this ONR program, inshore ecological coverages such as seabed vegetation, against which our newly developing methods will be tested.

NGDC at Boulder are making available extensive datasets, which are being incorporated into auSEABED and us SEABED.

c. The DSTO at Pyrmont, Sydney has offered an additional postgraduate student to this ONR program, specifically to investigate technologies of visualization of inshore/coastal areas for defence.

d. The RAN METOC Service has funded several months work to develop tactical displays for mine countermeasures activities, based on seabed information through the Australian maritime area. These displays incorporate the Beach Simulation and improved mining of naval geotechnical data.

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## **Abbreviations**

*USF University of South Florida*

*FRF Field Research Facility of US Army Corps of Engineers*

*NGDC National Geophysical Data Centre of NOAA*

*DSTO Defence Science & Technology Organization (Australia)*

*dbSEABED seabed information system from Sydney Univ*

*RAN METOC Royal Australian Navy Meteorology Oceanography services.*

*USGS US Geological Survey*

*MLO Mine Like Objects*