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GEODATABASE DEVELOPMENT TO SUPPORT HYPERSPECTRAL IMAGERY EXPLOITATION

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ABSTRACT

Geodatabase development for coastal studies conducted by the Naval Research Laboratory (NRL) is essential to support the exploitation of hyperspectral imagery (HSI). NRL has found that the remote sensing and mapping science community benefits from coastal classifications that group coastal types based on similar features. Selected features in project geodatabases relate to significant biological and physical forces that shape the coast. The project geodatabases help researchers understand factors that are necessary for imagery post processing, especially those features having a high degree of temporal and spatial variability. NRL project geodatabases include a hierarchy of environmental factors that extend from shallow water bottom types and beach composition to inland soil and vegetation characteristics. These geodatabases developed by NRL allow researchers to compare features among coast types. The project geodatabases may also be used to enhance littoral data archives that are sparse. This paper highlights geodatabase development for recent remote sensing experiments in barrier island, coral, and mangrove coast types.

Index Terms—geodatabase, coast type, hyperspectral imagery, ground control, geospatial analysis

1. INTRODUCTION

The NRL routinely investigates coastal regions, a dynamic environment that numerous researchers have tried to partition into descriptive groups [1], [2], [3]. This paper will summarize how data were archived during remote sensing campaigns conducted in littoral areas surrounding the Virginia Coast Reserve (VCR), Marine Corps Base Hawaii (MCB-HI), and Shoalwater Bay Training Area (SWBTA) in Queensland, Australia. The first investigation used NRL's Compact Airborne Spectral Imager (CASI) (www.itres.com), a visible and near infra-red (VNIR) hyperspectral sensor, to study the barrier island coast and lagoons found along Cape Charles, Virginia [4], [5], [6], [7]. The second study occurred during January and February 2009 and involved analysis of the coralline coast surrounding Kaneohe and Waimanalo Bays in Hawaii. A third experiment was conducted during May 2009 along the extensive mangrove coast surrounding Shoalwater Bay in Queensland, Australia. Remote sensing campaigns in Hawaii and Australia both used HyMap™, a VNIR

and short-wave infra-red (SWIR) hperspectral sensor (www.hyvista.com), to acquire HSI over the study area.

All three investigations included a comprehensive calibration and validation component where scientists collected in-water optical data, meteorological data, geotechnical information and substrate reflectance data, and canopy and leaf level spectral reflectance. Calibration for bathymetry consisted of both in-water spectral reflectance profiles measured with an Analytical Spectral Devices (ASD) spectrometer as a function of depth for various bottom types with validation data provided by small boat soundings and beach surveys with post-processed kinematic GPS in the foreshore. Other beach properties measured along transects consisted of grain size profiles, substrate moisture, bearing strength, shear, as well as the *in situ* spectral reflectance and GPS location of each position along beach transects. Vegetation spectral libraries were also developed including both canopy and leaf level spectral reflectance to retrieve vegetation coverage maps.

2. PROJECT GEODATABASES

The geodatabase combines spatial data collected from the coast in a data repository that supports imagery analysis and remote sensing research. For the VCR, MCB-HI, and SWBTA remote sensing campaigns, NRL developed project geodatabases representing a barrier island, coral, and mangrove coast. The coastal geodatabases have a common look and feel and support the objective determination of the dominant influences contributing to the characteristics of a particular coast. They are also described in data reports produced following remote sensing campaigns [8], [9], and [10].

Once imagery post processing was complete, all HSI was stored in the geodatabase along with other forms of digital products (raster) such as nautical charts and historical images. Table 1 provides a list of data provided in the geodatabase.

Table 1. Selected geodatabase contents.

Data Description	Type	Purpose
Coastal Spectra	Text	Spectral Matching
Dynamic Deflection Modulus	Text	Imagery Processing
Geodetic Control	Vecto r	Imagery Processing
Imagery	Raster	Mapping
METOC Time Series (e.g., winds, humidity, visibility, water levels)	Text	Atmospheric Correction and Imagery Processing
Photographs	Raster	Imagery Processing
Sediment Cores	Text	Imagery Processing
Soundings	Text	Imagery Processing
Underwater Spectra	Text	Spectral Matching

Data used for atmospheric correction, calibration, and validation of imagery (ascii text) forms the basis for a hierarchical coastal classification system. Data includes information ranging from grain size distributions (microscale) to prevailing winds (synoptic scale). Considerable background information (vector) provides the location of man-made objects, the extent of vegetation, and important ground control. Data extracted from the geodatabase supports the development of look up tables and models that are key to developing statistical relationships needed to produce bathymetric retrievals, bearing strength maps, and other coastal products.

NRL coastal remote sensing campaigns rely on a single-user geodatabase for individual GIS work in a desktop environment. The ArcGIS Desktop facilitates the analysis of observed data elements and parameters across investigations and coast types [11]. ESRI's ArcCatalog is used to store geographical information, while tabular data are stored as Microsoft® Excel spreadsheets divided into similar attribute data folders in Microsoft® Explorer. Study data are viewed using ArcMap. The geodatabase supports tasks such as atmospheric correction since information on atmospheric gases, winds, and waves are accessed to remove spectral atmospheric transmission and scattered path radiance from radiance data collected by hyperspectral imaging [12]. In addition, the geodatabase includes all ground-based or laboratory-based spectral libraries to identify key features in the imagery. In ArcMap and ArcGIS Explorer attribute data are accessed by linking to spreadsheets or document files. Linking to spreadsheets containing the attribute data allows one to view actual instrument measurements as well as graphs pertaining to the data. By utilizing the identify tool in ArcMap, links to attribute data spreadsheets, photographs, web sites, and text files can be accessed by simply clicking the hyperlink icon. ArcGIS Explorer also allows for access to important archives that are web-enabled such as weather station observations. One can link to website attribute data by clicking the shapefile and navigating to the website in the pop-up window. Project attribute

data such as spreadsheets of bearing strength of beach sediments and the corresponding photographs are accessed through relative file pathname links in the contents section of the GIS.

For those researchers not having an ArcGIS Desktop license, NRL provides collaborators with a geodatabase that was built using ArcGIS Explorer 900, a free-ware version of ArcGIS Desktop. The freeware version has allowed non-ArcGIS specialists to be able to easily view quicklook format images of HSI; view and obtain data from GPS ground truth points; and use the attribute data for those points to develop mapping products with the use of HSI and ENVI. The combined data in the geodatabase was essential in the production of shallow water bathymetric charts, vegetation layers, and bearing strength maps. This work extends the work of Francis Shepard's classification system [1] to support the remote sensing and mapping science community.

3. RESULTS

The ArcGIS file geodatabase benefits NRL researchers for various structural, performance and data management reasons. It has few size limitations, allows the storage of vector, raster, and text products, is easily migrated to collaborators, and allows updates to spatial indexes. Geodatabase size is provided in Table 2.

Table 2. NRL geodatabases contain considerable information that supports imagery analysis and map making.

NRL Remote Sensing Campaign	Size, GB			Total Size
	Raster	Vector	Text	
VCR	704	2.2	0.8	707GB
MCB-HI	222	0.8	0.2	223GB
SWBTA	293	2.5	0.5	296GB

The geodatabase contains rapidly accessible information. Ground control information (e.g., Ground and bathymetric surveys) supports geo-rectification and the tide synchronization of imagery collections. Meteorological data (e.g., wind speed, relative humidity, ozone, and aerosol data) supports atmospheric correction. Oceanographic information (e.g., water levels fluctuations and soundings) supports the retrieval of bathymetry from HSI. Geotechnical data, e.g., grain size distributions, are especially useful to support engineering studies. Figure 1 displays a typical geotechnical product describing the beach along a particular transect during the remote sensing campaign in Australia.

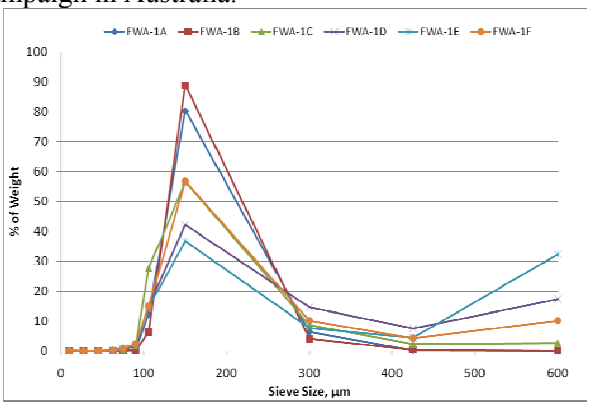

Figure 1. Comparison of grain size distributions along a transect at the SWBTA.

Grain size distribution data in addition to other forms of geotechnical data help to characterize coastal types and these data are used to develop bearing strength maps. Figure 2 presents a bearing strength map which was created from geotechnical data and HSI.

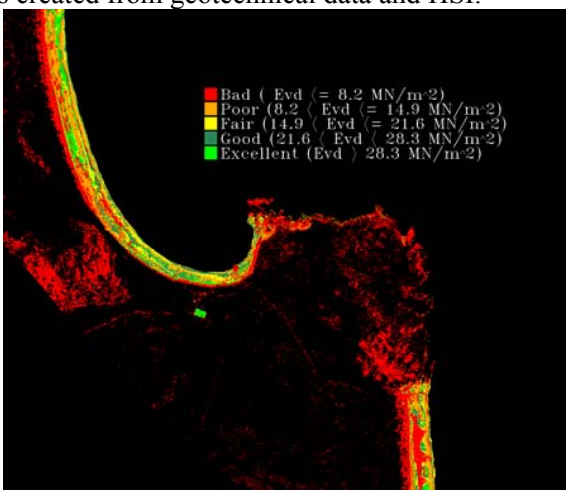

Figure 2. Bearing strength map created from geotechnical data collection at freshwater beach in the SWBTA.

The project geodatabases were provided to collaborators from University of Virginia for the VCR, resource managers from Marine Corps Installations for MCB-HI, and environmental managers from the Australian Defence Force and imagery analysts from the Naval Oceanographic Office for SWBTA.

4. CONCLUSIONS

The format of NRL project geodatabases are leading to a hierarchical coastal classifaction system. The project geodatabases help establish rules for key data layers and feature classes common to specific coast

types. They are contributing to new algorithms and models which can be used to build HSI-based bearing strength map, shallow water bathymetric charts, and other coastal products for representative coast types.

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