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DEVELOPING A REGIONAL CARIBBEAN COASTAL RESOURCE INFORMATION SYSTEM: THE INSIDE STORY

Abstract: Through the Caribbean Planning for Adaptation to Global Climate Change (CPACC) project, a Coastal Resource Information System (CRIS) has been developed for 12 Caribbean countries, providing a flexible environment in which each country can customize and maintain their own specific database of coastal resources. This paper provides an overview of the approach used to develop the CPACC CRIS. It includes details on a generalized approach for storing spatial and attribute data related to coastal zone management. A description of how off-the-shelf software products, such as ArcView, Access and Excel, can be integrated together to produce a system that can be fully customized by each country will also be presented.

INTRODUCTION

The Caribbean Planning for Adaptation to Global Climate Change (CPACC) project is a multi-year initiative funded through the World Bank Global Environment Facility, and implemented through a Regional Project Implementation Unit (RPIU) located in Barbados. CPACC's objective is to support Caribbean countries in preparing to cope with the adverse effects of climate change, particularly the impacts of sea-level rise in coastal areas. A major component of the CPACC project includes designing and implementing a Coastal Resource Information System (CRIS), providing a flexible environment in which each of the 12 participating countries can customize and maintain their own specific database of coastal resources. A first version of the CRIS was completed in July 2001, and is currently being delivered by the CPACC RPIU to each participating country.

The objectives of the CRIS are as follows:

- facilitate storage, retrieval, updating, analysis and manipulation of coastal resource data, including spatially referenced information, in each country;
- build capacity to create, use and maintain a coastal resource inventory in each country; and
- facilitate sharing of coastal resource data within and between countries in the Caribbean.

The CRIS consists of 2 parts: a database for storing the spatial and monitoring data for each country, and a simple set of software tools that will provide users with basic querying, updating and reporting capabilities. Each country receives a common set of tools, based upon a common database design for all of the countries in the region, but with their own specific coastal resource inventory. Individuals in each participating country's repository agency have been trained in how the tools were developed, and will be provided with access to the source code required to make modifications to the system. In this way they can update, modify and extend the functionality of their own CRIS in the future.

The CRIS is designed to be used by two broad groups: regular end-users (e.g., resource managers, scientists, technicians) and system administrators. Two different versions of the CRIS have been developed: one for the CRIS administrators in each country, and the other for regular users. The Administrator's version of the CRIS

provides the ability to edit and modify the data in the database, and to view and modify all aspects of the application design. The User's version only provides the ability to browse (but not edit) the data; it also prevents users from viewing and modifying the application itself.

SOFTWARE ENVIRONMENT

The CRIS has been designed using standard, off-the-shelf products already widely used throughout the region. The software requirements of the system include the following:

- Operating System: Windows 95/98/NT/2000
- Database Software: Microsoft Access 2000
- Office Software: Microsoft Excel 2000 and Word 2000
- GIS Software: ESRI ArcView 3.2

DATABASE DESIGN

Due to the highly spatial nature of the data to be collected for this project, the database for the CRIS was designed to have two components:

1. **Monitoring database** - this will consist of environmental monitoring data, to be stored in a relational database (i.e., Microsoft Access).
2. **Spatial database** - this includes data stored directly within a GIS (i.e., ArcView).

A key consideration in any spatial database design is deciding which data should be stored in the GIS, and which data should be stored within a relational database. In order to design a database structure that provides for maximum flexibility, our rule-of-thumb was to place as much data as possible in the Access relational database, and to use the ArcView GIS to store only the explicitly spatial data. At present, all major GIS products provide the capability to link to data stored within a relational database. For example, ArcView provides the ability to link to any data stored within an ODBC compliant relational database (e.g., Microsoft Access). As a result, any data stored within a relational database can be made available to a GIS very easily, as required.

Another important aspect of the database design is the linkage between spatial data and monitoring data. The CRIS database design requires that every attribute data item entered into the relational database be explicitly georeferenced in the GIS.

Monitoring Database

The structure for the CRIS monitoring database has been designed to be simple, yet flexible. The objective was to design a simple database structure (or "data model") that could accommodate a wide range of data types. All categories of biophysical and resource-use data are stored in the same manner, making it easy to expand the structure in the future to accommodate additional, unanticipated, categories of data. The structure allows for variation in the level of detail provided for each variable and country. The design has also been kept simple in an effort to ensure that the system can be supported and maintained once the CPACC project is complete.

Table 1 lists the minimum information required in order to import data into the CRIS monitoring database, along with 2 examples of data loaded into the CRIS.

TABLE 1
DATA ITEMS REQUIRED FOR THE CRIS MONITORING DATABASE

Database Item	**Example Record #1: Daily Temperature Data**	**Example Record #2: Sea Defense Structure**
Sampling Location	Discovery Bay	Leguan Island 001
Start Date	21-Jul-2000	19-Mar-2001
Start Time (optional)		13:45
End Date (optional)	21-Jul-2000	
End Time (optional)		
Variable Measured	Mn. Daily Temperature	Foreshore Type
Measurement Value	28.6	Sand
Source (optional)	www.cpaccrac.org	

Spatial Database

The spatial database has been designed to store a wide range of GIS data. Each database consists of an ArcView 3.2 project and its associated data files. This project can consist of multiple Views, Themes and Tables, using any of the ArcView data types.

At a minimum, each spatial database must contain a theme identifying all of the “Locations” referenced in the companion Monitoring Database. For Example #1 shown in Table 1 above, a corresponding spatial database would contain a theme identifying the location “Discovery Bay” where the Daily Temperature measurement was recorded.

SYSTEM ARCHITECTURE

Figure 1 shows the overall architecture of the CRIS. The system consists of a number of interconnected components:

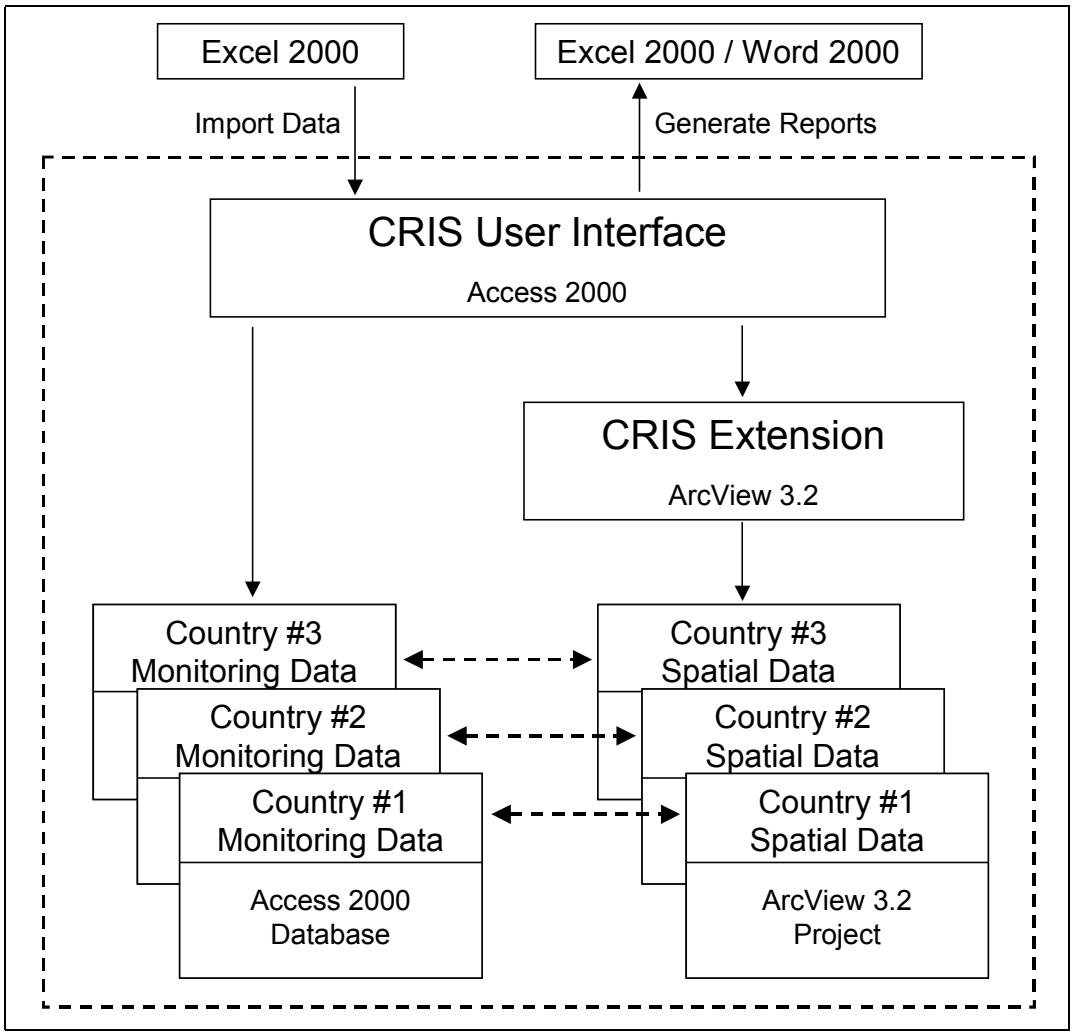
1. **CRIS User Interface.** Developed in Access 2000, this component provides a user-friendly interface to the data and functions of the CRIS. It provides the ability to view the CRIS data, to generate reports and, for administrators, to import data and customize the system. At present the CRIS User Interface is common to all users, although it could be customized by individual administrators in each country in the future, as required.

2. **Country-specific Monitoring Data.** The monitoring data for each country or island are stored in a separate Microsoft Access 2000 database file. In general there is one database file per country – where a country consists of more than one major island, a separate database file has been created for each island (e.g. St. Kitts & Nevis consists of 2 databases: one for St. Kitts and one for Nevis).

3. **Country-specific Spatial Data.** The spatial data for each country or island are stored in a separate ArcView 3.2 project file. At present there is one ArcView project file corresponding to each Access monitoring database file.

4. **CRIS ArcView Extension.** The final component is a small program, written in ArcView Avenue, which is loaded as an ArcView extension. This component allows the CRIS User Interface to communicate with ArcView; it also connects each country-specific monitoring database to its corresponding project file in ArcView.

FIGURE 1
SYSTEM ARCHITECTURE OF THE CRIS



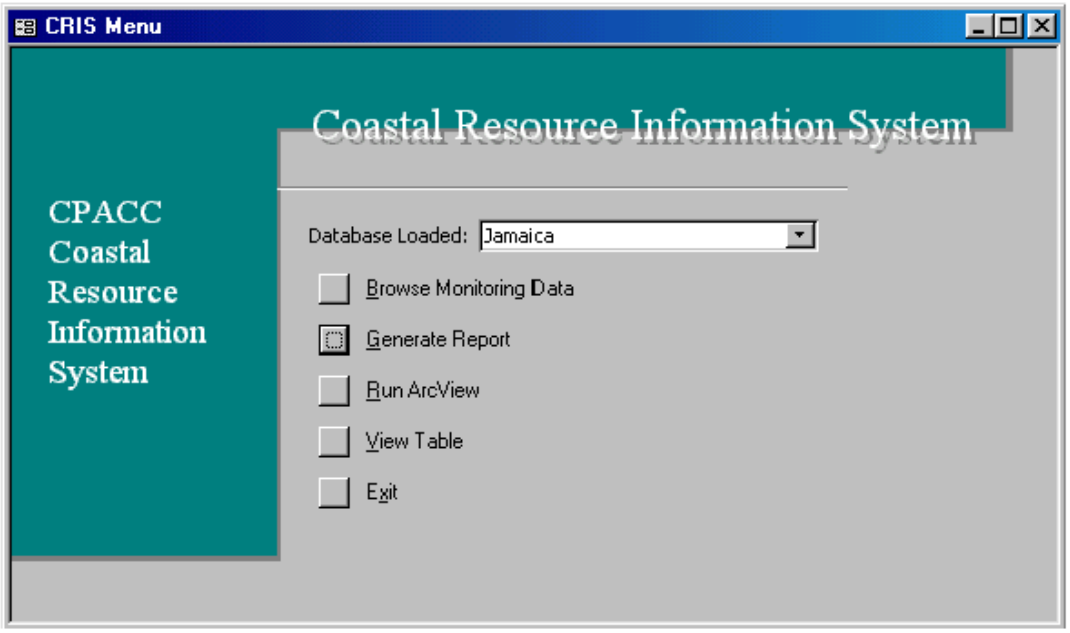
In developing the CRIS, software was selected that makes it easy to move data from one component to another (e.g., between Access and ArcView, or between Access and Excel/Word). We have used the Windows ODBC standard to communicate between the country-specific ArcView projects and Access monitoring databases, allowing the CRIS to treat data in Access as tables in ArcView.

USING THE CRIS

Each country-specific CRIS database is stored and distributed on a separate, self-installing CD. This provides simple control over the distribution of data to appropriate countries and users. Aside from disk space, there is no limit to the number of CRIS databases that can be installed for any one user. For example, the CPACC Regional Project Implementation Unit is currently able to install all 16 CRIS databases; users in each country would generally only install the 1 or 2 databases relevant to their country, while other regional agencies may install multiple databases, as required.

The CRIS User Interface is designed around a simple menu. Users begin by selecting the database of coastal resource information with which they would like to work, and then select the function they would like to perform (Figure 2).

FIGURE 2
MAIN MENU OF THE CRIS USER INTERFACE



View Monitoring Data

A key function of the system is the ability to generate simple tabular and graphical reports of the CRIS monitoring data. By selecting the “Generate Report” option from the CRIS main menu (see Figure 2), users are able to select the report they want, and then either preview it on the screen, print it, or send it to a Word or Excel file for further analysis and formatting (Figure 3).

FIGURE 3
GENERATING REPORTS FROM THE CRIS USER INTERFACE

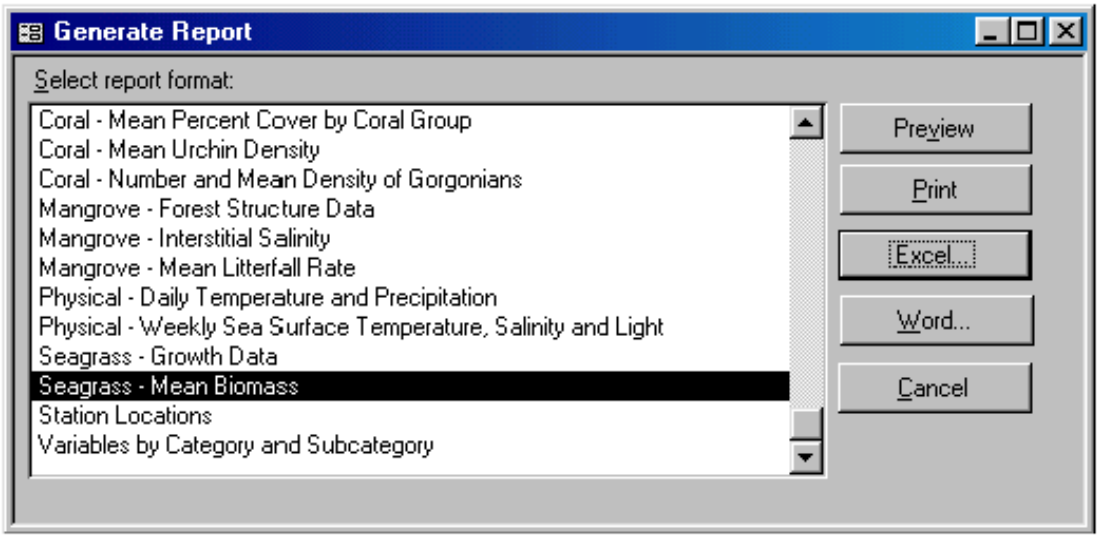
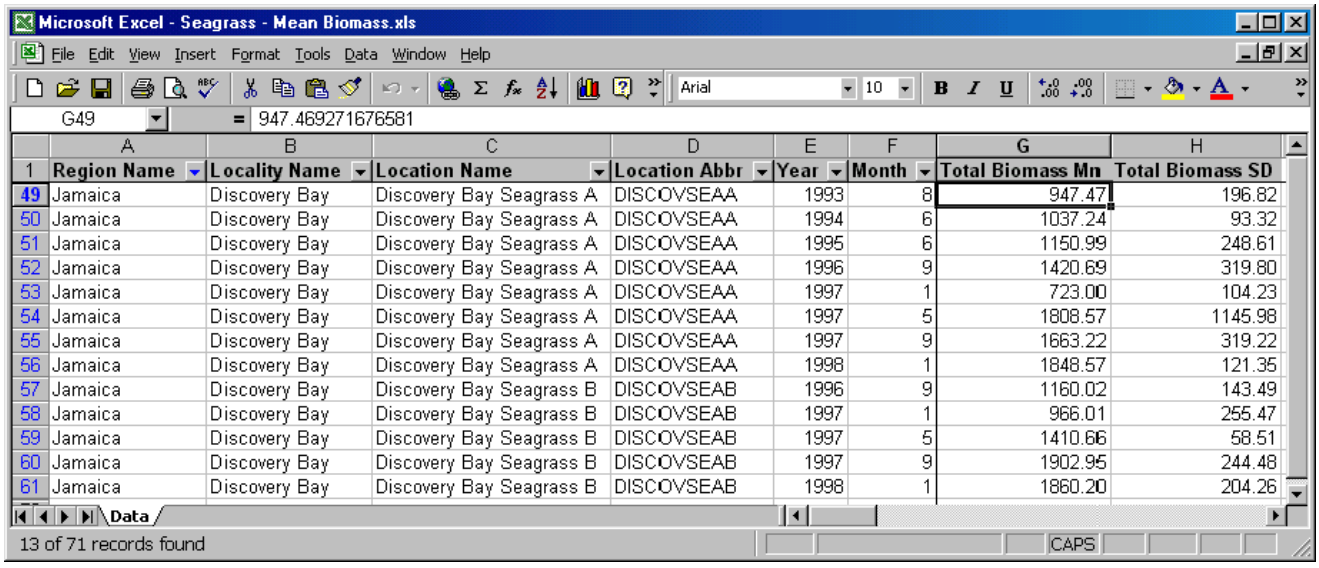


Figure 4 shows a sample report generated by the CRIS in Excel. Reports in Excel and Word are generated by automatically combining data from the Access database with predefined Excel and Word formatting. In addition to sending the results to a Word or Excel file, choosing to send a report to Word or Excel also places predetermined formatting, such as headers, footers, text, graphs, calculations, etc. in the output file.

FIGURE 4
SAMPLE CRIS REPORT GENERATED IN EXCEL

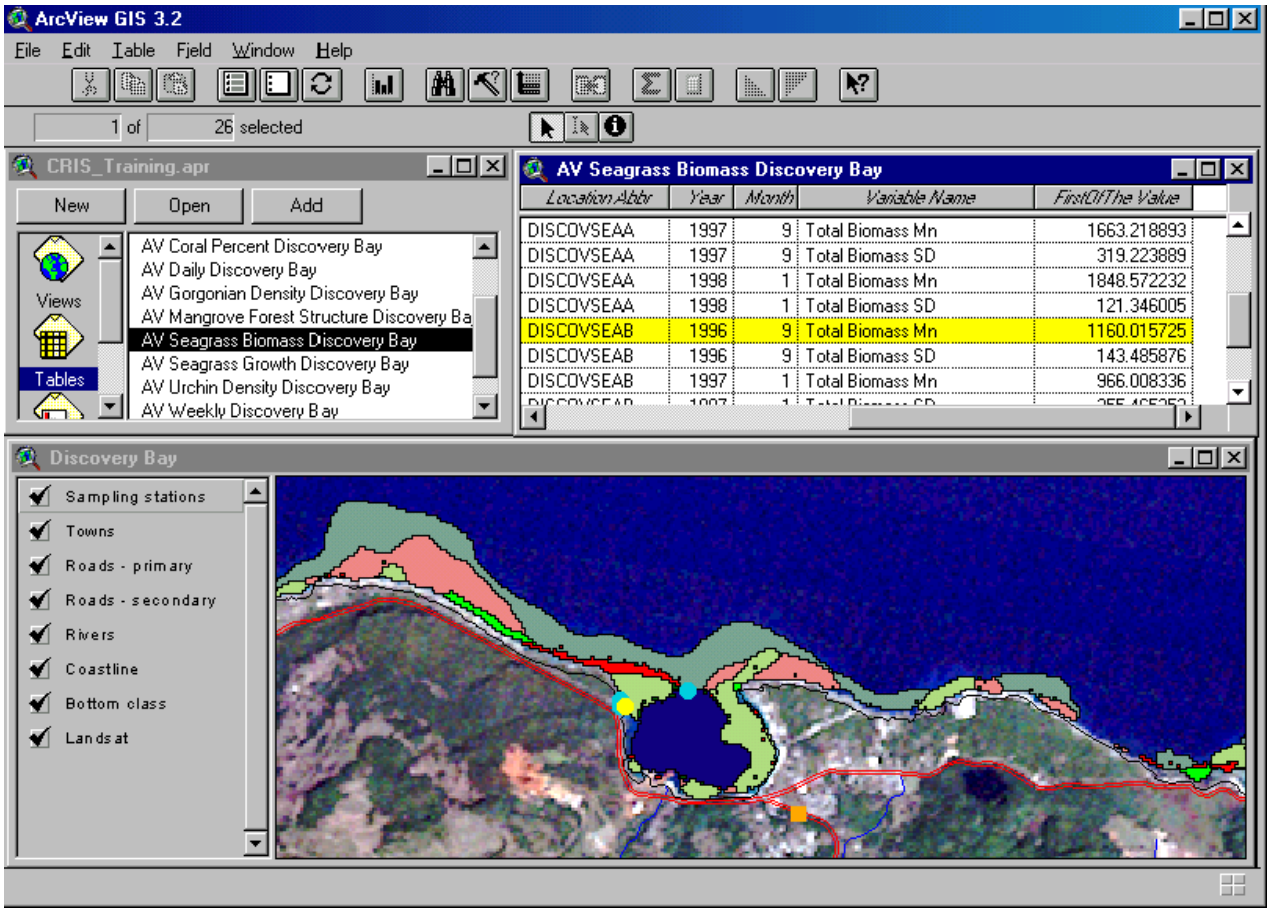


	A	B	C	D	E	F	G	H
1	Region Name	Locality Name	Location Name	Location Abbr	Year	Month	Total Biomass Mn	Total Biomass SD
49	Jamaica	Discovery Bay	Discovery Bay Seagrass A	DISCOVSEAA	1993	8	947.47	196.82
50	Jamaica	Discovery Bay	Discovery Bay Seagrass A	DISCOVSEAA	1994	6	1037.24	93.32
51	Jamaica	Discovery Bay	Discovery Bay Seagrass A	DISCOVSEAA	1995	6	1150.99	248.61
52	Jamaica	Discovery Bay	Discovery Bay Seagrass A	DISCOVSEAA	1996	9	1420.69	319.80
53	Jamaica	Discovery Bay	Discovery Bay Seagrass A	DISCOVSEAA	1997	1	723.00	104.23
54	Jamaica	Discovery Bay	Discovery Bay Seagrass A	DISCOVSEAA	1997	5	1808.57	1145.98
55	Jamaica	Discovery Bay	Discovery Bay Seagrass A	DISCOVSEAA	1997	9	1663.22	319.22
56	Jamaica	Discovery Bay	Discovery Bay Seagrass A	DISCOVSEAA	1998	1	1848.57	121.35
57	Jamaica	Discovery Bay	Discovery Bay Seagrass B	DISCOVSEAB	1996	9	1160.02	143.49
58	Jamaica	Discovery Bay	Discovery Bay Seagrass B	DISCOVSEAB	1997	1	966.01	255.47
59	Jamaica	Discovery Bay	Discovery Bay Seagrass B	DISCOVSEAB	1997	5	1410.66	58.51
60	Jamaica	Discovery Bay	Discovery Bay Seagrass B	DISCOVSEAB	1997	9	1902.95	244.48
61	Jamaica	Discovery Bay	Discovery Bay Seagrass B	DISCOVSEAB	1998	1	1860.20	204.26

View Spatial Data

By selecting the “Run ArcView” option from the CRIS main menu (see Figure 2), users can automatically display the GIS data associated with the currently loaded database. For each country a number of ArcView views, themes and tables are displayed (Figure 5). Additionally, the CRIS automatically links data from the monitoring database with the appropriate theme in the GIS. This feature is critical to the integration of the spatial and monitoring data in the CRIS, as it allows users to associate the location of specific monitoring sites on the ArcView theme with the corresponding records in the Access monitoring database.

FIGURE 5
RUNNING ARCVIEW FROM THE CRIS USER INTERFACE



CONCLUSION

Understanding environmental condition is an important element of coastal resource management. This usually requires a great deal of data, and an information system can provide tremendous assistance in organizing, managing, understanding, and reporting this information.

Together, relational databases and GIS provide powerful tools for organising and analysing environmental data. The CPACC Coastal Resource Information System has been designed to be simple, yet flexible. The database structure allows for variation in the level of detail provided for each variable and country. In addition to the ability to view, query and report monitoring data, the CRIS also allows users to display the data spatially using a GIS. The design of the CRIS has been kept simple in an effort to ensure that the system can be supported and maintained once the CPACC project is complete.

ACKNOWLEDGEMENTS

The author wishes to thank Ms. Dulcie Linton of the CARICOMP Data Management Centre, Centre for Marine Sciences, University of the West Indies, Mona Campus, Jamaica, for providing access to the CARICOMP data stored within the CRIS and presented in this paper. Thanks also to Dr. Ulric Trotz, Mr. Ian King and Mr. Leslie Walling of the CPACC Regional Project Implementation Unit for their ongoing vision and support throughout the development of both the CRIS and this paper.