XVII IMEKO World Congress
Metrology in the 3rd Millennium
June 22–27, 2003, Dubrovnik, Croatia

INVENTORY INTO A DIGITAL LIBRARY OF THE COMPLETED STUDIES TO ASSES THE CHARACTERIZATION OF THE GULF OF GUAYAQUIL BASED ON THE PERFORMING INFORMATION UTILIZING ELECTRONIC CHARTING AND DISPLAY SYSTEMS AND GEOGRAPHICAL INFORMATION SYSTEMS

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Abstract − The university institution plays an important role as generator and bank of information through research (starting with thesis works), human and technological resources, while keeping up-to-date with the demands of the community on the formation of professionals. It is the commitment of the authors and the whole of the research team to elaborate, with all the means available at the academic institutions they belong to, this Geographic Information System to accomplish the goal of providing the stakeholders in the Gulf of Guayaquil (GG), Ecuador, objective means for decision-making. The methodology applied to build up digital thematic information useful for management of the ecosystem of the Gulf of Guayaquil consists of:

1. Set-up an Electronic Charting and Display System - ECDIS with the database inventory and the digital cartography available;
2. Select out of the databank that information that is competent and constitute with it a geographic database suitable for the identification of regions in the gulf;
3. Work out spatial relationships with the output of that selection to characterize the gulf in terms of spatial and temporal driving factors;
4. Produce presentation maps synthesizing the results of the analysis.

Several of the maps realised are discussed, which show the analysis performed on the variables that describe natural and man-driven activities in the GG. For instance, at the base of an Internet-accessible alert system lies information on production and management of shrimp farms in the region, summarised in an index that is used to map the variation between the monthly performance and the historical one. A second example shows rather a lesser abstraction of the information, and shows layers describing the natural set-up regarding the hydro-dynamics of the inner estuary, which would be a second building block toward the integrated vision on how to manage the ecosystem in view of the economic interests, and also the sustainability ones.

Keywords: Temporal and spatial ecosystem, Gulf of Guayaquil, Geographic Information System

1. INTRODUCTION

To accomplish the goal of informing stakeholders in the GG, an inventory of the spatial and temporal attributes is being implemented. Therewith a database is envisaged that contains the references to the completed studies of the internal and external estuaries in the GG, which is capable of providing elements for the abstraction of information by being built on well-documented, long-term, multi-disciplinary data, of as many sources as possible.

The work here presented generates geographic information of few temporal characteristics relevant to the ecosystem of the Gulf of Guayaquil. A methodology is followed that discriminates between information that documents a cartographic element in function of thorough measurements and information that issues knowledge in a more abstract manner. This latter is mapped, yet a link to a qualitative description is given textually. Likewise, its contribution for the characterization of the GG is regarded as “large scale”. The information sources available are various, and cover the basic sciences like biology, chemistry and physics, up to engineering designs, and economic evaluations. The references cited are by far not comprehensive, and many are cited with the quotations available. The current work is run by the “Environmental Management Systems for Agriculture and Aquaculture (EMSAA)” component of a joint project between Flemish universities and the Polytechnic School of Higher education of the Littoral (ESPOL) with the sponsorship of the Flemish Inter-university Council (VLIR). The maps with physical characteristics at the water channels and with a warning grid

for the shrimp culture settled at the shore, both at the inner gulf, are partial completions of the phases foreseen to constitute a Geographic Information System (GIS) based application to generate scenarios/models of the confluence of multi-disciplinary factors in the region.

Few bibliographic references are included, the reason being that much of the data and information is extracted from internal reports and databanks, which haven't been published for public consultation.

2. THE CARTOGRAPHIC MODEL

The cartographic elements to constitute the digital cartographic model for the two applications described in the next section are listed in Table I. The satellite image, a Landsat-7 of February the 7th, 2001 with a spatial resolution of 15 m was classified for colour composition utilising the bands 7, 4 and 1, thus enabling one to get a detail level as small as a pond used for shrimp culture. Other sources used were printed maps of the Military Geographic Institute, and Global Positioning System (GPS) locations measured in the field. Projected digitally in the common Provisional South American Datum 1956, Universal Transect Mercator projection, they serve as graphic down-loaders of the information.

TABLE I. Detail of the principal cartographic elements

Description	Type	Scale	Source	Digital Cartographic Model
Grid	Region	1:25000	Cartography	Scanned, digitised on screen
Coastline	Line	1:250000	Cartography	Scanned, digitised on screen
Roads	Line	1:250000	Cartography	Scanned, digitised on screen
Measurement stations	Point	1:100	GPS	Attribute in database
Centres of ponds	Point	1:10000	GPS referential	Attribute in database
Centres of shrimp farms	Point	1:10000	GPS referential	Attribute in database
Ponds' limits	Region	1:100000	Digital satellite image	Digitised on screen
Shrimp farms' limits	Region	1:100000	Digital satellite image	Digitised on screen

For the development of the thematic maps the types of information output e.g. quantitative, function of abundance and documentation of parameters, were defined, and the cartographic model elements chosen, where the information would be downloaded, e.g. the minimal information unit (MIU) as the measurement station, or a unitary cell of the grid to deliver information for a coverage of some 128 square kilometres. The following programs were used:

- MicroStation 95 and MicrostationGeographics 5.0 for digitalisation and topological clean-up
- LineaBase 1.0 for geo-codification
- MapInfo 7.0 for automatic charting
- PCI Image Works for remote sensing
- PCI Ortho-engine for curvature correction
- Pathfinder Office for differential correction

3. THE GG GEOGRAPHIC INFORMATION

Following the recommendations by the Programme of Coastal Resources Management (PMRC) [1], and the Environmental Assessment Commission (CAAM) [2], the sedimentation and hydraulic behaviour are revised, as well as production and management parameters of the shrimp culture sector through two GIS applications. These two Ecuadorian governmental-linked actors have approached the characterization of the GG through inter-disciplinary means to come with medium to long-term strategies for its management, and follow therefore the same commitment of the current research. Two applications of the GIS are discussed in this section, as examples of the processing of information from the database inventory and the cartographic model in its current state.

3.1 Physical set-up

Fig. 1 shows a thematic compilation of both, cartographic and numerical data, with map oriented in N-S direction. The map depicts the morphology of the coastline in vector format, mangrove forest and shrimp ponds in islands and land shore, sediment's plumes in the channels there where the clouds' coverage allows -in raster format-, and physical parameters specified in the legend. The suspended sediments' concentration (SS) as measured by two projects that worked with similar methodology in different time periods differs notably. The time series thereof could be used together with other relevant data, to attempt a quantification of the difference. Other studies, though, haven't sampled the water column at fixed locations along the evolution of the tidal phases, but grouping the data in function of the tidal phase, type and/or height at the water column could produce a statistical inference. The map depicts schematically the ebb currents (no magnitude, no timing), to sketch the relative energetic conditions in the two channels. The ebb tides are usually reported as the strongest, and those on the map are, same as the SS, the average over measurements at each meter in the water column at the location marked. Another referential layer depicts three zones in the Western (tidal) channel of the inner estuary, which differentiate in function of the thickness of accumulated sediments at the stratigraphic record and/or the water column height. Zone 3 would hold a sedimentary wedge increasing eastward from nil to some 10 m building up a slope of 1:1000 in water depths ranging between 20 and 8 m to the East; zone 2 would be rather horizontal, thus maintaining the 8 m water column, and have a sedimentary layer thicker than 10 m, and zone 1 would

accumulate similar thickness of sediments, but within a channel deepening to more than 20 m. This channel and the region to the West have often been subject of geologic research to identify the tectonic (structural) set-up. This active subduction region of the Pacific plate interacting with the South-American plate is characterised by faulted blocks, and horsts and grabens with trends E-W, N-W and N-E [3], [4], which can be found back at the morphology of the channels on a 2-D representation, and have been inferred through the zonification just described.

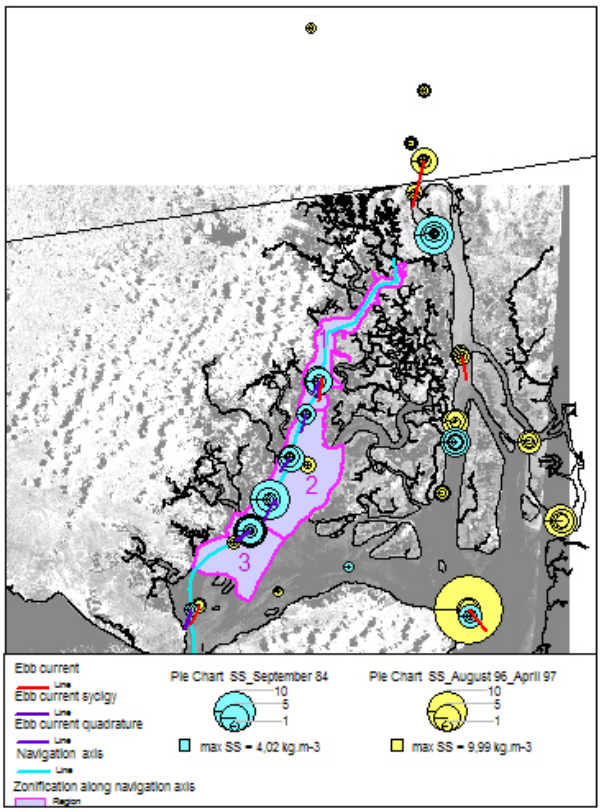

Fig. 1. Physical parameters describing energetic conditions in the inner GG

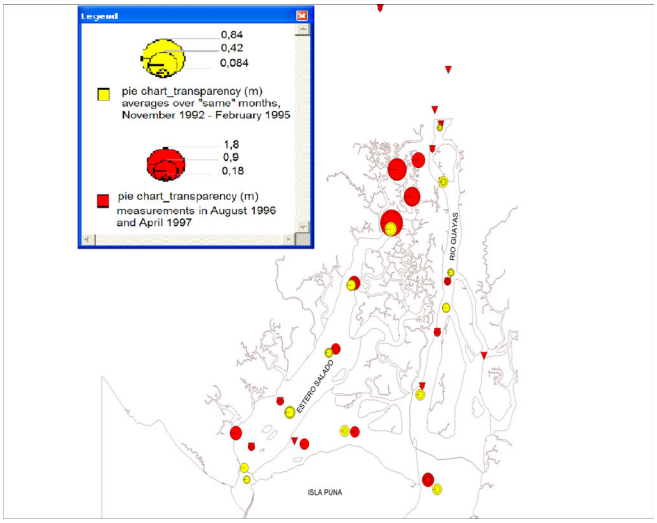

Fig. 2 Transparency in the inner GG, working window in MapInfo

Fig. 2 depicts the parameter transparency. The recurrent highest values correlate with the zone 1 where the channel cuts deep, the suspended sediments are few, and the stratigraphy in the first 30 cm reports variants of the kind presented in Fig. 3, with silt and clay as main components [5], and a tendency for compaction beyond the 15 cm depth.

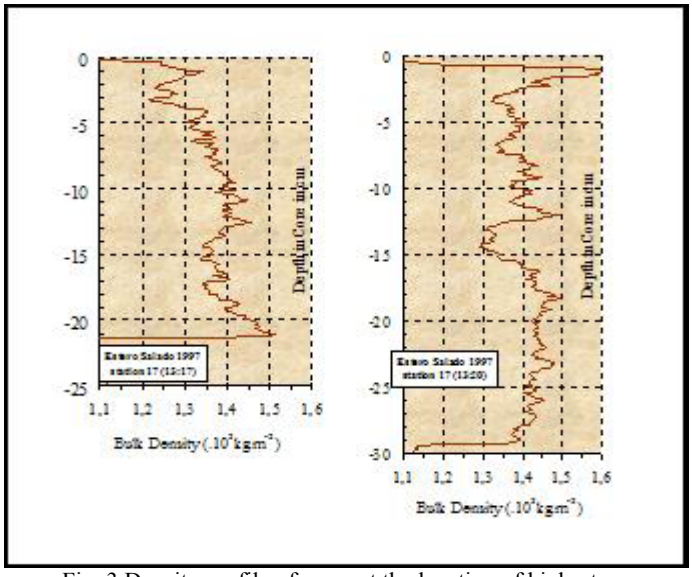

Fig. 3 Density profile of cores at the location of highest transparency in zone 1

3.2 Shrimp culture indicators

The shrimp culture sector that operates in the GG has faced several states of stress, the causes of which have never been solidly identified. The latest and worse of all has been linked to the strike of the White Spot Syndrome Virus (WSSV). Under the umbrella of causes, several possibly inter-related factors are comprised, which deal with the geo-bio-chemical equilibrium in the estuarine channels –not an isolated system- and with management strategies at the shrimp farms [6].

The EMSAA group together with the National Centre of Aquaculture Investigation and Management (CENAIM), after the strike of WSSV worked out, with the support of few producers who offered their time series information, an index based on the variables of production and management: V_s that weighs the parameters: final production –Prod-, area of the pond -Area-, density of sowed larvae –sow density-, and a weighing parameter for absolute growth –abs growth- taken as the average weight of cropped shrimp over the total days of growing:

$$V_s = \frac{\mathrm{Pr}\,od}{Area} \times (sow.density)^{-1} \times (abs.growth) \qquad (1)$$

The standardised anomaly of this index, i.e. the difference between V_s at time x and the average of the time series divided by the standard deviation of the individual V_s of the time series has become the current reference for the warning system [7].

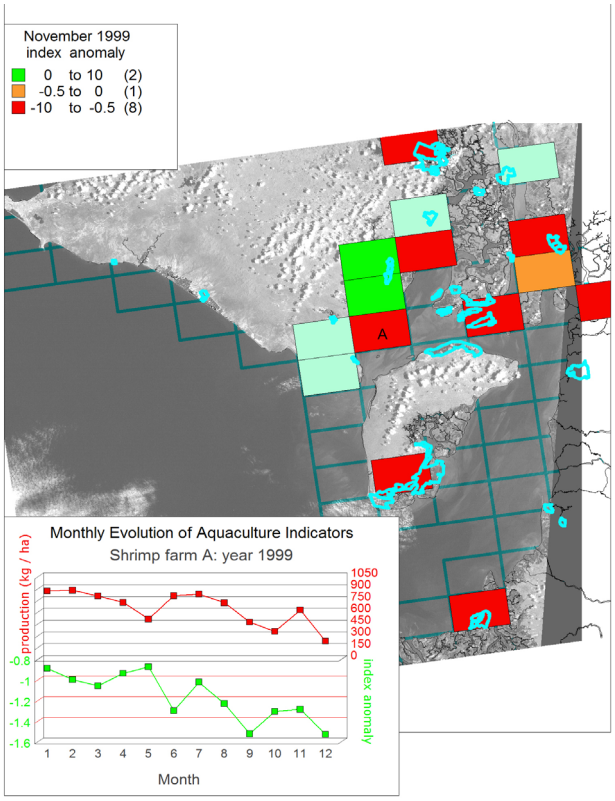

Fig. 4 Shrimp culture warning system

Fig. 4 illustrates an example of the latter, and revises a particular query of a user who inquires a display of the performance of his farm/pond for the year 1999. The vector farms highlighted serve as example of the geographic attributes, for which information may be retrieved [8]. The unitary cell of the grid is used as information output in this case, not to point to particular farms, but to regions.

4. CONCLUSION

The case study presented shows the potential of the GIS-digital library to gain access to scenarios of the GG that describe it in function of time and space, with information abstraction levels. The GIS largely relies on logic of mathematics and statistics in its current state. The new knowledge acquisition, e.g. through derivative mapping and process modeling [9], is being conceptualised in close cooperation with those concerned with policy and resource allocation decisions [7]. The underlying database is built upon documentation the university has gathered along the current and various other projects, including thesis, thus, processed for academic concerns. Priority for bibliographic references was given to the documents with comprehensive and/or links to digital information, which would allow the extraction of information in a simple way. The next phase of EMSAA foresees the refinement of information abstraction, for which the digital library enhancement is a basic step to complete.

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