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The Land-Ocean Interactions in the Coastal Zone Project is a Core Project of the "International Geosphere-Biosphere Programme: A Study Of Global Change" (IGBP), of the International Council of Scientific Unions.

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This report and allied workshops are contributions to the project: The Role of the Coastal Ocean in the Disturbed and Undisturbed Nutrient and Carbon Cycles (Project Number GF 1100-99-07), implemented by LOICZ with the support of the United Nations Environment Programme and financing from by the Global Environment Facility.

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Cover: The cover shows an image of the world (GTOPO30 elevation map), divided into the three sections as covered by the three regional workshops.

The LOICZ Reports and Studies Series is published and distributed free of charge to scientists involved in global change research in coastal areas.

TABLE OF CONTENTS

Page

Enclosure

The enclosed CD-ROM (see inside back cover) provides a full compendium of the workshop tools, methods and products, plus additional electronic information resources. Go to readme.html on the CD-ROM for directions. The "Title, Authors, Contents" link connects to a contents page that provides access to the three components of the CD:

1. A printable (pdf) version of the actual published report.
2. A browser-viewable (html version) of the report for browsing or reading from the CD (contains a limited number of internal and resource links).
3. Augmented sections of the report, accessible from the menu links on the left margin of certain pages, that contain or provide access to the electronic products of the workshops and additional supporting and background information from the project web pages.

We recommend that readers use the html report to familiarise themselves with general content and organisation, and then explore the augmented sections of interest for more information and detail. For descriptions of the file formats, notation conventions, organisation and recommendations for use of the electronic version of the report, use the "About this report and CD" link.

Acknowledgements

The workshops and their products are the result of work from a large number of scientists who have been involved as participants, as innovators and contributors to methodological and tools development, as providers of data and data sets. Workshop participants and contributors are listed in meeting report appendices. We are particularly indebted to the LOICZ resource team members identified in the participant lists for their dedication and sustained support of the workshops and the overall project.

Many institutions have provided venues for workshops and support for the developmental science involved and for operational platforms that underpin the typology tools and databases. Workshop venues are listed in the appendices. Our thanks to all concerned in coordinating workshops and providing support.

Core funding for the workshops and much of the developmental work has been provided by the LOICZ core project of IGBP and by United Nations Environment Programme, supported by the Global Environment Facility. The OBIS project, through US NSF grant OCE 00-03970, has provided additional support for the development of the typology tools and databases in meeting complementing goals for global scaling and assessment of the biogeoinformatics of Hexacorallia (corals, sea anemones and their allies).

1. Overview of Regional Workshops objectives and process

The key objectives of the Land-Ocean Interactions in the Coastal Zone (LOICZ) core project of the International Biosphere-Geosphere Programme (IGBP) are to:

- gain a better understanding of the global cycles of the key nutrient elements carbon (C), nitrogen (N) and phosphorus (P);
- understand how the coastal zone affects material fluxes through biogeochemical processes; and
- characterise the relationship of these fluxes to environmental change, including human intervention (Pernetta and Milliman 1995).

To achieve these objectives, the LOICZ programme of activities has two major thrusts. The first is the development of horizontal and, to a lesser extent, vertical material flux models and their dynamics from continental basins through regional seas to continental oceanic margins, based on our understanding of biogeochemical processes and data for coastal ecosystems and habitats and the human dimension. The second is the scaling of the material flux models to evaluate coastal changes at spatial scales to global levels and, eventually, across temporal scales.

It is recognised that there is a large amount of existing and recorded data and work in progress around the world on coastal habitats at a variety of scales. LOICZ is developing the scientific networks to integrate the expertise and information at these levels in order to deliver science knowledge that addresses regional and global goals.

The United Nations Environment Programme (UNEP) and the Global Environment Facility (GEF) have similar interests through the sub-programme: "Sustainable Management and Use of Natural Resources". LOICZ and UNEP, with GEF funding support, have established a project: "The Role of the Coastal Ocean in the Disturbed and Undisturbed Nutrient and Carbon Cycles" to address these mutual interests.

The work and products from a series of three regional workshops – Asia and Australasia, the Americas, Africa and Europe – are described here. They encompass efforts to integrate the regional geographical settings for the suite of about 170 biogeochemical site budgets derived from earlier and companion workshops, and to expand access to the data and tools in the global scientific community.

A set of common goals was established for the typology workshop series (Appendices I, II, and III). These included the development of typologies or classification of various geographical settings within the longitudinally-bounded region addressed by each workshop. Up-scaling and integration of data in a context of expert judgement and expert typologies were the corner-stones of activities within each workshop. The provision of training and awareness of a typology tool developed by the LOICZ project for these purposes was a major objective as was, where information was available, comparison with other scaling and typology approaches.

The C-N-P biogeochemical models for estuaries and coastal seas (Section 2.2 and Appendix V), developed by the common methodology of the LOICZ approach (Gordon et al. 1995), are delimited by their external forcings (material loads, human populations, oceanographic influences), climate regime and nature of the ecosystems that comprise the locality. These conditions form a tapestry of geographical settings that can be described across a variety of scales through a suite of variables. In our efforts to describe the biogeochemically functional state of the coastal systems, it is necessary to integrate the information across larger scales in order to determine patterns of nutrient effects and transformations and to derive information about "hot spots" and changing conditions and drivers of ecosystem function. LOICZ had earlier identified the use of a typology or classification approach as being an important tool that could be applied to the issue of up-scaling and integration.

The LOICZView clustering tool (Section 2.3 and Appendix VI) and databases (Section 2.1 and Appendix IV) had been developed to an early stage of utility before these workshops as one method for scaling and appraising the biogeochemical information. An array of physical, chemical, human dimensions and biological variables had been acquired and fitted to a global coastal zone matrix at half-degree resolution. The ability to aggregate or cluster multivariable data had been tested and the workshops provided the opportunity for further testing, development, and application of the approach.

Most of the participants in the workshops had been involved in earlier biogeochemical budget workshops for their region and were aware of the purpose of the project, including the two-pronged approach of a) budgets derivation and b) up-scaling and integration. A major activity of the typology workshops was for participants to develop typologies with relevance to the biogeochemical budgets settings (for example, climatic settings, river basin loads, coastal ecosystems and habitats distribution) and to compare the outcomes with both their expert judgements and/or similar existing subjective typologies. In the process the typology tool and databases were extended and improved to meet the use requirements of the participants and the design requirements for products from the LOICZ-UNEP project. This set of evolutionary outcomes has seen the LOICZView scaling approach being applied to other related work in national coastal zone management and international projects addressing scaling and integration issues.

The training and capacity-building purpose of the workshops was a major thrust. There is a cadre of global scientists actively involved in use and extension of the approach to meet the goals of this project and the wider LOICZ project, and to applying the methods to local and regional questions. A significant outcome of the workshops will be the application of the acquired knowledge in a final workshop (November 2001) of the project in order to develop a global assessment of the C-N-P biogeochemical performance of estuaries and coastal seas.

Throughout the project, use has been made of the World-Wide-Web as a research and teaching tool, as a repository of scientific results from the C-N-P biogeochemical model developments (http://data.ecology.su.se/MNODE/) and the typology outcomes, and as a device for discussion and provision of training materials within the network of participants. Separate web-sites support the typology database (www.kgs.ukans.edu/Hexacoral/Envirodata'envirodata.html) and the typology clustering tool (www.palantir.swarthmore.edu/loicz), and they are linked for use. The continued access to interim and final electronic publications and upgrades of the tools has assisted in the rapid development and application of the tools and dissemination of the modelling and typology approaches.

This report is structured to provide an introduction and overview to the typology work of the three regional workshops in a text form. The work focuses on typology development rather than the biogeochemical model descriptions, although some workshop activities were directed at sub-set questions immediately related to the biogeochemical objectives. Detailed results and products from the workshops and the associated databases are contained in the companion CD-ROM as well as posted on project web-sites that can be readily accessed for a full account of the effort and work of the many participants in the project.

2. Typology Approach and Products

2.1 Typology Database

2.1.1 Database Description

The LOICZ typology database is developed and maintained with the joint support of the partner project, Biogeography of the Hexacorallia. It is based at the Kansas Geological Survey of the University of Kansas, operates in Oracle® database software, and is served to users on the World-Wide-Web through an interface designed in Cold Fusion® software. The features of the database, described below, include the geographic grid and cell structure of the basic design, the present contents of the database in terms of environmental variables (listed in Appendix IV), and the user interface for selecting, modifying, acquiring and analyzing the data.

2.1.1.1 Geographic grid and typology cell structure

The objectives of the LOICZ cell structure are to provide a geographically structured basis for database design that will:

- classify coastal environments in a conceptually useful fashion;
- permit integration and consistent analysis of available global data sets dealing with land, sea, air, and human dimension variables;
- operate at a scale of resolution useful for the data and applications envisioned; and
- provide a manageable number of data points for analysis and global upscaling or extrapolation.

Half-degree resolution has been selected as the most realistically useful compromise between desired resolution and the available data and methods. Of the 259,200 half-degree cells on the earth's surface, a total of 47,057 have been identified as primary typology cells (coastal, terrestrial and ocean-I). The remaining oceanic cells (145,989) are included to provide complete coverage for both the larger LOICZ budget sites and for the NOPP/OBIS partner program, Biogeography of the Hexacorallia. This cell structure also serves the needs of other partner projects.

Land or Terrestrial cells (T) are typically defined as the cells containing only land (or fresh water). Coverage typically extends two cells (one degree) inland from the most landward coastal cell, although they have been extended farther inland in a few areas (e.g., estuaries not well represented by the shoreline data set). These do not have ocean variables.
Coastal cells (C) are defined as those containing a significant length of the World Vector Shoreline. These cover significant areas of both land and (marine or estuarine) water, and are populated with all classes of variables.
Oceanic I cells (O-I) are those extending seaward from the coastal cells the greater of (a) one degree, or (b) the 50 or 100 m isobath in areas of a broad shelf, or (c) to include all of a biogeochemically budgeted area. These will have only oceanic and atmospheric variables.
Oceanic II cells (O-II) are those additional cells needed to complete the in-filling of relatively enclosed water bodies or coastal seas that might be the target of future up-scaled biogeochemical budgeting exercises.
Oceanic III cells (O-III) cover all remaining oceanic areas not included in the other classes.
Inland Cells (I) cover all remaining land areas not included in other classes.

Geographic conventions: NORTH latitude and EAST longitude are <u>positive</u> numbers; SOUTH latitude and WEST longitude are <u>negative</u> numbers.

Cell ID numbers are based on a sequential global grid of half-degree cells (Table 2.1). Numbering (from 1 to 259,200) begins with the cell centered at 89.5 degrees N latitude and 179.5 degrees W latitude (89.5, -179.5) and proceeds from west to east. When a full circle (or row, in a planar projection) of 720 cells (360 degrees/0.5 degrees/cell) is completed, the numbering steps one cell south along the -180 meridian and continues sequentially west to east.

Table 2.1 Statistics on cell types and numbers

Cell Class	Number of Cells
Total primary Typology cells	47,057
Oceanic-III	143,394
Oceanic-II	2,595
Oceanic-I	19,330
Coastal	15,278
Terrestrial	12,449
Inland	66,317
Non-Typology Cells	209,517
Total number of 0.5 degree cells in the world	259,200

2.1.1.2 Data contents

Appendix IV provides a listing of the environmental variables, the type of data, cell assignments, and a summary identification of the source. Biogeochemical budget variables contained in the database are discussed in Section 2.2 and Appendix V of this report. For a complete review and overview of current database contents and form, go to www.kgs.ukans.edu/Hexcoral/Envirodata/envirodata.html. Additional examples and illustrations may be found in the CD-ROM accompanying this report.

The environmental data contained in the database are derived primarily from public-domain sources, and metadata listings are provided so that users may access and refer to the original data source. In order to meet the needs of global synthesis, only datasets that are global or near-global in extent are included in the database at present. The data are divided into categories for ease of searching and reference: these are (in addition to database structure and location references) Atmospheric, Geomorphic, Human Dimension, Oceanic, Terrestrial, Basin and Budget.

The Basin variables are supplied by Charles Vörösmarty, University of New Hampshire, under the aegis of the IGBP-BAHC project. These consist of modeled annual and monthly outflow (runoff) for all world river basins above a size threshold of a few tens of thousands of km^2, plus supporting data in the form of basin population, size, and land cover. The Budget variables, recently included in the database, are the site and biogeochemical budget characteristics assembled by the LOICZ Biogeochemical Budgets activity (see Section 2.2, Appendix V, and http://data.ecology.su.se/mnode/).

2.1.1.3 User interface features

The WWW-based data access site is publicly accessible for review and occasional use by a guest log-in option. More extensive users are issued a password on request; this provision is designed to regulate traffic and avoid electronic conflicts, not to restrict access.

The sequence of normal use proceeds in two phases, first:

- Selection of database version – selected (short form) or full environmental data, with or without budget data. This option was instituted to provide archival access and variety in the full database option, while keeping the list of variables that have to be reviewed by the typical user to a workable number.
- Selection of geographic region – by pre-determined zone or by user input of latitude and longitude.
- Selection of variables.
- Assembly (automatic) of the user dataset.

Second, after the data set is assembled in the Oracle system, the interface offers the user a variety of options for review and modification. These include:

- Reviewing the selection criteria.
- Viewing the statistics (tabular) and distribution (histogram) of any variable; the histogram display is user-controlled for range and number of classes, and offers some data transformation options (e.g., log, square root).
- Excluding cells with null values (no data).
- Modifying the dataset by excluding or resetting numerical values for any variable above, below, or within a user-specified range.
- Modifying the dataset by transforming any variable (e.g., log, ln, absolute value, square root).
- Creating a correlation matrix for the selected variables (with modifications).
- Generating a report specifying the data selected and all operations performed.

When the final dataset is assembled, the user may view or download it as a comma-separated text file, and/or send it directly to the Web-LOICZView clustering tool via an internet link.

2.1.2 Database Access

2.1.2.1 Internet-based

The use of the internet to maintain and serve the data is considered the only cost-effective and reliable way to make up-to-date data readily available to a widespread user community. It is recognized, however, that connection, hardware, and software limitations may make access problematic from some parts of the world. To reduce these problems, all of the interface tools have been designed to run "server-side" to minimize the amount of material that must be actually exchanged between the site and the user. However, since even these measures will not address all problems, alternative approaches to data dissemination are also used and under development.

2.1.2.2 Portable

Distribution of CD-ROM versions of websites, datasets, and products has been used by LOICZ as part of its workshop process, and is available on request to people who have problems with internet access. A particular issue is the provision of remote database equivalents, including the selection functionality. A product under development by Dr L.T. David and existing in prototype form is a database front-end designed to operate in Microsoft Access®, a widely available microcomputer database system that is compatible with the structure of the central Oracle system.

This product would permit distribution of subsets of the database (on CD-ROM), or provision of the entire system on DVD disks, in a form that would support the same basic functionalities and output products as the WWW-based system.

2.2 Biogeochemical Budgets Database

2.2.1 Biogeochemical budgets – background

The LOICZ project set up a "globally applicable" method of estimating fluxes of carbon, nitrogen and phosphorus within the coastal ocean, especially the bays and estuaries of the inner coastal zone (Gordon *et al.* 1995). It was necessary to erect a methodology that could depend largely on secondary data, that had minimal data requirements and that was widely applicable and uniform, in order to allow effective comparison among sites. Finally, the method had to be informative about processes influencing CNP fluxes.

The implementation strategy for developing a biogeochemical budget database was to mount a two-pronged attack on acquainting the scientific community with the budgeting procedures. The first prong has been publication of a web-page (http://data.ecology.su.se/MNODE) that summarizes and updates the budgeting procedures, provides tools for implementing the procedures, provides various forms of teaching materials, and posts existing budgets as they are developed. The second prong has been to hold a series of workshops around the world, in order to teach people how to do the budgets and to get them to prepare budgets that can be used by LOICZ. At time of writing, about 170 budgets have been developed, largely as products of more than 15 workshops held around the world. The sites budgeted are indicated in Figure 2.1.

Figure 2.1 Map of LOICZ budget sites, October 2001.

The LOICZ approach is based on one of the most fundamental concepts of the physical sciences: conservation of mass. Details of the approach are given in Gordon *et al*. (1995) and on the LOICZ Modelling web page (http://data.ecology.su.se/MNODE). Steady-state conditions are assumed in which water volume and salt content in the system remain constant over time, as water flows through the system and mixes with adjacent systems. The net flow of water can be described by a water budget. Information about mixing can be deduced from a salt budget of non-reactive materials. The data to establish at least first-order water and salt budgets can be found for many sites around the globe.

Nutrients not only move with the water but also undergo reactions within the system. Nutrient data (especially data on the dissolved inorganic forms of phosphorus and nitrogen, here termed DIP and DIN) can be found for many of these same sites and used to establish nutrient budgets. These nutrient budgets include water flow and mixing, as defined by the water and salt budgets, and an additional term that describes net uptake or release of these nutrients within the system. In the jargon of oceanography, these are termed "nonconservative fluxes," because the nutrients do not follow exactly the flux pathways of water and salt.

The nonconservative flux of DIP can be used as an approximation of net uptake of phosphorus into organic matter during primary production, or release from organic matter by respiration. While it would be desirable to have direct measurement of carbon uptake into organic matter, such data are not available for most locations. Therefore the flux of DIP becomes a proxy for net carbon flux. In the open ocean DIN is often scaled in exactly this manner to carbon. That scaling in general does not work well in the coastal ocean, for a reason that contains a great deal of information itself. Nitrogen fixation and denitrification are important metabolic processes in bottom-dominated systems and can account for most of the observed nonconservative flux of DIN. Therefore calculations are derived from the budgets:

1.) using DIP flux as a proxy to calculate how much net carbon uptake or release has occurred,
2.) scaling DIP flux to estimate the expected nitrogen (DIN) flux (typically using the Redfield N:P ratio of 16:1), and
3.) using the deviation between the observed DIN flux and the expected DIN flux to estimate the net of nitrogen fixation and denitrification.

2.2.2 Interactions with the regional typology workshop process

Development of biogeochemical budgets through workshops has continued in parallel with the regional synthesis workshop process, with budget node personnel heavily involved in the synthesis workshops. This ensured that the latest information on developments in the budget process were available to the synthesis workshop participants, and provided critical opportunities for developing the needed interconnections among the developing biogeochemical budget database, the typology database (Section 2.1, Appendix IV) and the Web-LOICZView (WLV) clustering and visualization tool (Section 2.3, Appendix VI).

The close coordination of synthesis (typology) and budget efforts through the workshop process developed both a cadre of scientists familiar with the developing combined effort, and a series of data integration and analysis trials that led ultimately to the combined database system. This process was augmented by key 'mini-workshops' held among the technical resource personnel in August and October 2001 to work through and test the practical details of the joint database operation and the applications of WLV to the combined data.

2.2.3 The joint "Synthesis Database" product

The budget sites (Figure 2.1) vary dramatically in their characteristics: from lagoons and estuaries of less than 1 km^2 in area, to the 10^6 km^2 East China Sea; from sites that are decimeters deep to sites that are hundreds of meters deep; from sites that are virtually devoid of loading from land to sites that receive heavy loads of inorganic nutrients derived from human wastes, agriculture, and other sources; from sites that are river-dominated estuaries to hypersaline embayments; and from tropical to arctic climatic zones. For some sites, data quality and quantity are both high; other sites suffer in the quality and quantity of information available. For the initial analysis we have identified a "preferred" subset of budget site data that excludes systems for which the basic data are incomplete, open shelf systems, and systems with an average depth >100 m, in order to facilitate comparisons among sites. This preferred dataset includes about 80 systems.

Initial experiments have shown the importance of data transformations and scaling in developing relationships that will be useful for upscaling as well as interpretation. The basic biogeochemical budget dataset has therefore been augmented with alternative presentations of many of the variables, so that users can take advantage of the accumulated experience without having to reformulate the data set.

The entire biogeochemical budget database has been incorporated into the Oracle-based, web-accessible Typology database at http://www/kgs/ukans.edu/Hexacoral/Envirodata/envirodata.html. It can be accessed as either the complete or the preferred budget dataset, and in combination with either the full inventory of environmental variables, or a more concise set of variables selected for their appropriateness to representing the ecosystems processes. The budget database includes descriptive and transformed variables, and all of the budget variables can be manipulated (separately or in combination with typology variables) by the database and WLV features described elsewhere in this report.

Appendix V provides a summary list of the budget variables accessible through the integrated database.

2.3 Geospatial Clustering Tools (Web-LOICZView)

2.3.1 Concept and Capabilities: Web-LOICZView

Web-LOICZView [WLV] is a web-based graphical user interface to a set of data analysis tools. These tools are intended to facilitate analysis and understanding of trends and groupings that exist in a spatially indexed data set. WLV was developed with the support of the Land-Ocean Interactions in the Coastal Zone [LOICZ] program, which is core project of the International Geosphere-Biosphere Program [IGBP]. WLV has been developed mainly for working on geographic data sets with multiple variables defined at each geographic location. It is tightly integrated with the LOICZ/Hexacoral database at the University of Kansas (Section 2.1 and Appendix IV), that contains a wide variety of geographically indexed data sets. WLV is reasonably flexible, however, and can be used with a wide variety of datasets.

The capabilities and use of WLV are addressed in more detail in Appendix VI of this report, and are described in Maxwell and Buddemeier (2001). A more extensively illustrated version of Appendix VI can be found in the CD-ROM portion of this report, as can numerous examples of WLV output. Similar information is also available on the project web sites.

The primary data analysis tool in WLV is a set of clustering routines that group together similar data points into classes. WLV then gives the user a variety of ways to visualize the classes and the data. To provide for ease of experimentation, there is a variety of data management tools that allow users to manipulate and control how the data is treated in each analysis step. For example, you can select subsets of variables and weight them according to their importance.

Data sets may be imported into WLV by transfer from the typology database, or by independent upload according to a set of simple instructions on the website. Similarly, products may be downloaded or captured with browser software.

WLV also includes a tool for executing an eigenvector, or principal components analysis on the data set. This tool permits users to understand the principal causes of variation in their dataset. It also permits effective visualization of high dimensional data sets.

Finally, WLV includes a tool for analyzing the overall complexity of a data set based on the Minimum Description Length principle. This can be used as an aid in discovering the appropriate number of classes for a given set of variables and data points.

2.3.2 Access

Access to Web-LOICZView is offered as a courtesy to the scientific community. As is the case with the Typology database, access is controlled by password not to restrict use, but to manage traffic and prevent overloads. New or occasional users may take advantage of a “guest” log-in, and passwords are issued on request to more frequent users.

WLV runs on a LINUX (or UNIX) operating system, and requires no more than a modest laptop computer to support its operations. It has been transported to, and run locally at, all of the workshops. An early version (LV) was made available for download and local installation on LINUX or UNIX systems. Although this is still available, the rapid pace of development of WLV over the past year has precluded updates of the stand-alone version.

WLV will continue to be served and supported for the remaining lifetime of the LOICZ project, but long-term continuation, and development of updated stand-alone software for distribution, will depend on future institutional and funding arrangements.

3. Results and Applications

3.1 Community and Capacity Building

The workshop series has provided an enhanced awareness of the issues and problems of integrating data and information across spatial scales. A cadre of scientists have had opportunities to apply the LOICZ typology tools and database and to contribute to the further development of the methodology and approach by contribution of outcomes and identification of additional data requirements. Discussions and interactions during the workshops have led to further collaboration and utility of the tools and their applications to other local and regional issues beyond the goals of the LOICZ-UNEP project. For example, New Zealand scientists are developing an estuarine classification system for environmental management purposes. This requires a finer scale of resolution than the global half-degree scale application of LOICZ. The LOICZView tool is being used with a separate and detailed database in these developments. Similarly, the tool and databases are being applied to questions in other parts of the world, often augmented with local regional data relevant to the research issues.

Most participants in the workshops had attended earlier and companion workshops addressing biogeochemical budget development in different continental regions of the world. The network of scientists from the biogeochemical budgets has been active and sustained in the further development of biogeochemical budgets for additional sites, these have been incorporated in the database. This work continues and the approach is used in formal teaching and training courses in various regions. The typology workshops have involved additional scientists, particularly those with experience in geoinformatics, and the resultant interactions have led to a number of products exemplified in the attached CD-ROM. Importantly, the network of scientists continues to collaborate on scaling and typological research beyond the workshops, adding to the products for the project and applying the approach to allied problems. A final global integration workshop for the project held in November 2001 added further impetus to the network and the wider issue of scaling and coastal classification.

3.2 Coastal characterization

3.2.1 General

Major progress was made over the course of the three workshops in terms of both coastal characterization itself (typology) and the conceptual and operational tools available for the task. The strategy of having workshop participants work on and report typology experiments of their own devising produced an eclectic mixture of products and experience. These are listed and briefly described or discussed in section 3.2.4 below, and in more detail in Appendices IC, IIC, and IIIC. Most of the contributions were prepared in electronic, browser-viewable form; these are available for review and examination on the CD-ROM accompanying this report, and on the project web-site.

Sections 3.2.2 and 3.2.3 below briefly summarize the developments in the Web-LOICZView tool and in the typology (now combined with budgets) database. This is done for two purposes: to document the power of the workshop process in identifying and shaping the necessary developments; and to provide a context in which to view the participant contributions from the three workshops. Major changes in both the presentational and analytical tools available over the course of the project, as well as in the variables available for analysis, mean that there are substantial differences in form and content between otherwise similar experiments in the first (Australia-Asia) and the final (Europe-Africa) workshops. It is a tribute to both the underlying robustness of the approach and the dedication and quality of the workshop participants that this developing framework does not lessen the conceptual and practical significance of the work done in the earlier stages of the development.

3.2.2 Web-LOICZView developments

The major capabilities added to the WLV application over the course of the project were the eigenvector analysis (principal components) package, and the cross-clustering operation (see the CD-ROM or web-site tutorial pages for descriptions of these features). Other developments, however, had comparably significant effects on the ease of use and the products. These include file management options such as the ability to rename and combine files, enhancements to the tolerance of the application for the formats of uploaded files, and substantial expansion of the labels and information messages provided to the user.

Equally important were the major additions in terms of information available for easy use, capture and download. The "point identification" function in the cluster visualization was added, as were additional summary statistics in the "information" outputs of the overlay and dual visualization operations. The extent of data available for download and the ease of doing so were increased, and the ability to save products in conveniently usable format (html, pdf, text) was expanded.

3.2.3 Database developments

Over the course of the project the actual contents of the database were greatly expanded, while 'debugging' and refinement improved the utility of the existing contents. A major effort was devoted to incorporating the river basin variables provided by the University of New Hampshire-BAHC groups; this involved not only adapting the model flow and cell structure to the LOICZ system, but also populating the basins with additional variables and working through the ways of presenting and using cumulative basin data projected onto one or a few coastal cells. Other substantial additions included addition of ocean color (chlorophyll) data, and greatly expanded hydroclimatology data.

User-support tools in the 'front end' of the database were developed to provide major improvements in the user's ability to review, select, and modify the available data. Additional cell categories were added to provide truly global coverage, and various options for the arrangement of the variable selection pages were provided. The major development efforts provided extensive new capabilities for dealing with the dataset assembled. The user can now view summary statistics and a histogram, exclude null values, filter, selectively modify or transform any of the variables in a data set, and can create a correlation matrix for the entire data set. These added tools greatly facilitate data selection for clustering.

3.2.4 Workshop typology contributions.

At each of the three regional workshops, participants were provided with on-line computer access to the database and clustering tools, and encouraged to explore regions and topics of interest with the assistance of the resource people. Working individually or in small groups, all of the participants completed some form of project-relevant typologic study and prepared results for collection and inclusion in the workshop reports. The workshop processes and products are described more fully in Appendices I to III, and the project results are contained in the CD-ROM accompanying this report, and posted on the project web-site.

These activities served the dual purpose of training the participants in the overall project approach and the use of the tools, and of providing user tests of the database contents and the web tools designs.

Table 3.1 Participant Contributions, Asia-Australia Workshop, Brisbane

See Appendix I for a more detailed description and discussion, and the CD-ROM version of the report for the actual products.

	Author(s)	Region(s) and Subjects
1	Tetsuo Yanagi	Japan/East Asia: Classification of coastal eutrophication in Japan and application to other areas of Asia.
2	Jia-Jang Hung	NE Asia (China/Taiwan/Japan): classification of the East China Sea region.
3	Wenzhi Cao, MingWong	China (Japan, Korea): Typologies for the Chinese coast, with emphasis on cluster comparisons and human activities.
4	Liana Talaue-McManus	SE Asia (world comparison): Clustered typologies for SE Asia, applied to the world and compared with independent typologies.
5	Vilma Dupra	SE/East Asia: Proxies for biogeochemical budgets.
6	Gullaya Wattayakorn	Thailand/SE Asia: Human impacts on SE Asian coasts.
7	M.L. San Diego-McGlone	Philippines: Classification of eutrophication in Philippine waters.
8	Laura David	Asia-Australia: Extreme events and vulnerability.
9	John Zeldis, Terry Hume	NZ-southern Australia: New Zealand estuary classification and scaling evaluations.
10	Bradley Eyre	Australia: Australian estuaries classification.
11	David Pullar	Australia: defining functional zones in Australian coasts - coastal productivity.
12	Bill Dennison	Australia: *Trichodesmium* spp. distribution.
13	LynneTurner	Australia: Comparative classification of Australian estuaries.
14	Victor Camacho-Ibar	Australia/South America: Freshwater discharge comparisons
15	Wajih Naqvi	South Asia (Indian subcontinent): coastal typologies with biophysical variables
16	Fred Wulff, Dennis Swaney	Europe: classification of coastal runoff and nutrient loads.
17	Bradley Opdyke, Bill Dennison	World (tropics): Mapping of tropical benthic habitats.
18	Stephen V. Smith	World: Proxies for biogeochemical budgets – ocean and river systems.

Table 3.2 Participant Contributions – Americas Workshop, Ensenada
See Appendix II for a more detailed description and discussion, and the CD-ROM version of the report for the actual products.

	Author(s)	**Region(s) and Subject**
1	Dennis Swaney	Biogeochemical budgets: Comparison spreadsheet & metadata.
2	Laura David, Victor Camacho, Dennis Swaney	Typology and biogeochemical assessment approaches.
3	Carlos Lechuga, Martin Merino, Francisco Contreras	Classification variables for CNP inputs – Mexico.
4	Paul Boudreau	Global classification: Biogeochemical approach – inputs and exchange processes.
5	Eduardo Marone, Eunice Machado, Bastiaan Knoppers	Comparison of classifications and physiographic parameters – Brazilian coast.
6	Joanie Kleypas, Gerard Szejwach	Classification of carbonate shelves – Caribbean.
7	Jose Carriquiry	Coral reefs classification – East Tropical Pacific and Caribbean.
8	Ramon Ahumada, Laura Farias	Discriminating oceanic and climatic values – Peru-Chilean coast.
9	Jorge Herrera	i) Identifying variables to discriminate groundwater and karst Regions –Caribbean and Atlantic coasts ii) Supervised clustering for global extrapolation
10	Jorge Marcovecchio	Impact of freshwater on coastal estuaries – Atlantic South America
11	Victor Rivera, Robert Twilley	Mangrove distribution – Caribbean.
12	Victor Rivera	Elevation and runoff – Southern Caribbean.
13	Mike Kemp, Robert Twilley	Estuaries classification and biogeochemical budgets estimates – Continental USA.
14	Vilma Dupra	DeltaDIP means and weighting by typology –SE Asia and Australasia.

Table 3.3 Participant Contributions: Africa-Europe Workshop, the Hague
See Appendix III for a more detailed description and discussion, and the CD-ROM version of the report for the actual products.

	Author(s)	**Region(s) and Subject**
1	Robert Buddemeier	Global: Humans in a changing coastal zone
2	Dennis Swaney, Bruce Maxwell	Global: Assessment of ΔDIP and ΔDIN from biogeochemical models data set
3	Howard Waldron, Dan Baird, Tickie Forbes	Regional characteristics of sub-equatorial Africa for budgets settings
4	Xavier Niell, Ricardo Prego	Gradients and drivers describing coastal types in Iberian Peninsular
5	Natasha Brion	Typology for linked riverine N and P loads to the ocean - European North Atlantic
6	Amani Ngusaru, Mwakio Tole	East Africa: Comparison of expert coastal typology and differentiating variables
7	J-P Gattuso	Characterising estuary and ecosystem types, and human pressures - Europe
8	Lars Ramm, Christoph Humborg, Sukru Besiktepe, Adriana Cociasu, Inna Yurkova, Fred Wulff	Comparison of Baltic and Black Seas
9	Charles Gabche, Nick Murray	Coastal typology and variables influencing nutrient fluxes – West Africa
10	Christos Anagnostou, Hassan Awad	Scaling issues and data trials for ocean and coastal site sensitivities – Eastern Mediterranean Sea
11	Steve Duardze	Evaluation of applications to land cover and oceans typologies – Northwest Africa
12	Laura David	Tool development: Portable search engine
13	Hartwig Kremer	Scaling and database integration for riverine DPSIR and chemical data

4. Future Directions

The developments under this program of regional workshops have provided a solid basis for the final Expert Workshop on Global Biogeochemistry and Upscaling, held in Lawrence, Kansas November 11-14, 2001. The work, with the outcomes of the final synthesis workshop, also provides one of the major information frameworks for the final synthesis effort of the first phase of the LOICZ core project of IGBP, which is scheduled to culminate in the production of a book at the end of 2002.

Specific products and outcomes of the workshops include development, expansion and refinement of the database contents, data manipulation tools, and Web-LOICZView analysis applications. In a more focused scientific sense, they also include:

- demonstration of the power of supervised and unsupervised (WLV) clustering in developing both descriptive and functional classifications of the coastal zone;
- organization and understanding of the biogeochemical budget data in terms relevant to the process of up-scaling and synthesis;
- development of initial products and results of the coastal typology approach; and
- expansion of the range of applications and users of the approach, tools and data.

The final point above encompasses not only additional users of the LOICZ budget and typology approaches, but also those who are adapting the approach to higher resolution characterizations at smaller scales, and extensions of the tools and conceptual approaches to variables, problems and issues (such as biogeography) that flow naturally from but go well beyond the biogeochemical budgets issues. These developments provide a rich basis for continued development, in which the LOICZ synthesis process will be both a documentation of accomplishments to date and a springboard for future progress.

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LOICZ Typology Databases
www.kgs.ukans.edu/Hexacoral/Environdata/environdata.html

LoiczView Clustering and Visualisation Tool
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Appendix I Asia-Australia Regional Workshop Report

LOICZ/UNEP Regional Synthesis Thematic Workshop for the Asian-Australian Region
CRC for Coastal Zone, Estuary and Waterway Management
Brisbane, Australia
14-17 January 2001

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Appendix IB Agenda

LOICZ/UNEP Regional Synthesis Thematic Workshop for
the Asian-Australian Region
CRC for Coastal Zone, Estuary and Waterway Management
Brisbane, Australia
14-17 January 2001

Sunday, 14 January

0900h	Opening or workshop and welcome
0930h	General introduction to workshop schedule, plans and goals. Plenary review of pre-workshop tests and outcomes. Tutorial presentations on databases and LOICZView clustering tool.
1400h	Breakout work using the system to gain familiarity with LOICZView --
1600h	Plenary discussion of problems and issues
1630h	Refinement of workshop strategy; development of teams and assignments.

Monday, 15 January

0900h	Teams of participants and resource people address specific subsets of issues and techniques. Emphasis on classification and calibration. Breakout work on tasks.
1400h	Plenary presentation.
1445h	Continue breakout task work after plenary to evaluate progress.
1630h	Plenary review of progress and discussion of amendments and additions to the database and clustering tool.

Tuesday, 16 January

0900h	Plenary discussion of daily schedule and workshop issues/critique.
0930h	Breakout work on tasks.
1400h	Plenary presentation.
1445h	Continue breakout task work.
1630h	Plenary review of task status. Collection of initial materials for CD-ROM preparation.

Wednesday, 17 January

0900h	Breakouts continue on task work and systems documentation. Collection of final materials for workshop CD-ROM.
1400h	Plenary synthesis overview, presentations and discussion of outcomes. Plan for follow-up and completion. Discussion of LOICZView application. Distribution of workshop CD-ROM
1630h	Close of workshop.

Appendix IC Workshop Report

LOICZ/UNEP Regional Synthesis Thematic Workshop for the Asian-Australian Region
CRC for Coastal Zone Estuary & Waterways Management
Brisbane, Australia
14-17 January 2001

Welcome

Participants were welcomed to the CRC for Coastal Zone Estuary & Waterway Management (Coastal CRC) Brisbane Australia by Dr Paul Lawrence Acting-CEO, Coastal CRC and coordination details were provided by the local organiser, Dr Lynne Turner.

Computer facilities were set up, both local and laptop. A Local Area Network was established with the LOICZ typology database and the LOICZView software supported through a local server arrangement. Electronic services for the typology were provided via either the local LAN or the internet access to the University of Kansas database linked to the Swarthmore College LOICZView site.

Introduction

An introduction to the LOICZ/UNEP project and the LOICZ typology approach for interpolation of data was provided by Dr Buddemeier. While the typology tool has a number of applications, its relevance to the LOICZ initiatives involving global up-scaling of local assessment and evaluation of nutrient biogeochemical budget models data were identified as a primary objective for LOICZ. The application to the Asia-Australasia region was central to the theme and work of the workshop, recognising that activities would be addressing a range of scales, regions and sub-regions, and global-scale trials of data cluster analysis. The workshop was placed in the context of the three global region thematic workshops planned for the LOICZ/UNEP project and the final global synthesis workshop which will aim to build a global picture of C-N-P fluxes in coastal systems. Additional and wider applications were considered both within LOICZ and more widely to meet participant research and interests with application to LOICZ. The LOICZ typology software and tools provide a unique method for scaling and to achieve the global assessment goals of LOICZ.

Workshop Approach

The individual and team approach for application, assessment and further development of the typology methodologies (Appendix VI) was discussed, and a schedule for workshop activities was adopted (Appendix IV).

Participants were introduced and each identified their interest and questions for trial and application of the typology data-clustering tool within the Asia-Australasia region, in addition to the LOICZ training and regional scaling objectives. A number of tasks for application and development of the typology methodology were noted by participants, to provide a framework for their tutorial activities.

The workshop activities were set to encompass four elements of tutorial, trials, application and development of the LOICZ typology method, to address workshop objectives:

- How can we best identify and use budget-relevant data to create coastal classifications for categorizing and extrapolating biogeochemical budgets?

- What effect does the detailed form and nature of the variable portrayal (e.g., max, min, mean values), the scale of consideration, and the clustering approach have on the outcomes? What is 'budget-relevance' in our data, and how do we test or develop it?

- Where can we find or create 'expert typologies' (qualitative or quantitative) developed by other techniques or with other datasets to compare and test the LOICZ typologies against? How do they compare, and how well can we 'tune' them or understand the differences?

- What are the effects of, and how can we best use, discrete (classified) and continuous data? What are the ways to use classification to convert qualitative, highly aggregated, or semi-quantitative data into variables suitable for clustering, or to simplify complex or highly skewed data sets?

Key questions to support these goals included:
1. Cluster-based typologies – What are the appropriate parameters for nutrient budget-related typologies? How can cross-scale and cross-regional comparisons be derived?
2. Expert typologies – Do they exist or can we create them? How do cluster-based typologies compare? Can they be tuned?
3. Form of variables – maximum, minimum, mean values; what are they good for? What do they proxy? What proxies can be developed for process representation in scaling approaches?
4. Variables and typologies – Continuous variables versus discrete classifications – quantifying expertise. For example, how can we deal with discrete location (single pixel data populations) information sets, such as are found with river basin parameters, in the context of continuous datasets across coastal pixels? Are existing datasets robust and what are their characteristics?

Tutorials

LOICZ Typology Database (Jeremy Bartley)

The current database maintained at the University of Kansas is derived from existing global datasets and fitted to 0.5-degree coastal pixels represented in the LOICZ global cell array. This has been derived from an earlier one-degree pixel representation. More than 180,000 megabytes of information are contained as a table in an ORACLE base system which provides for uploading of selected variables (and scale) into the LOICZView clustering tool.

The database and system structure were described, including the process of addressing and using the database interrogation tool, selection of variables and their metadata provenance and information, and linkage to other developmental datasets – for example, the IGBP BAHC coastal basins data and model outputs.

Utility of the database directly and linked to the LOICZView typology clustering tool were outlined, noting the linkage recently developed for "cold fusion" between the two elements (which has helped make the typology method accessible by LAN at the workshop).

Tutorial presentation provided opportunity for participants to step through the variable selection, and familiarise themselves with the database structure. The issue of derivative data sets and new data set developments were discussed.

LOICZView (Dr Bruce Maxwell)

The clustering tool was described in detail and the various sections of operation were discussed, including:

i) Data and data variables
ii) Processing (including selection of distance calculation and statistics)
iii) Visualisation and options
iv) Downloading, data format and statistical assessment of clusters, and file and image storage.

It was noted that the LOICZView internet site offers a set of trial data as well as the opportunity to upload from the LOICZ dataset site or to import derived geospatially-referenced data.

Tasks and Typologies Development

Participants introduced their questions and task objectives for the workshop.

Initial tasks included:
- Australia and New Zealand estuary types and classification.

- Southeast Asia – how many clusters are needed to represent budgets and seasons?
- Australasia and global distribution of tropical habitats (reefs, seagrasses and mangroves).
- Expert Southeast Asian typologies – comparisons.
- China – coastal provinces and major deltas.
- East Asia and Taiwan - comparison of parameters across grid sizes.
- South Asia – coastal typologies on biophysical parameters.

Break-out groups (2-3 participants) and individuals worked interactively during days 2-4 on the development of different typologies, supplemented with methodological and problem/project tutorials and discussions. Daily summary notes were compiled and distributed addressing, *inter alia*, shortfalls in variable capabilities, methods upgrades incorporated into the tools, product and document handling options

Discussion of problems and methods upgrades

Plenary discussions throughout the workshop addressed a range of issues and problems that came to light with the databases, clustering actions and saving and working with image outputs and statistics of cluster evaluations. Amendments were made to the database and clustering tools as methodological improvements during the workshop.

Cautions and issues for data use (Jeremy Bartley)

Database utility and issues were identified:

- Selection of lat.-long; select N to S and W to E;
- Wave height database is not good; a new set from NOAA is being introduced;
- BAHC runoff dataset requires modification;
- Image download to PC (Open CorelDraw and use colour intensity for differentiation);
- Easy to select "inappropriate" data in cells where there are many zero points, and is a function of cell types e.g., terrestrial, coastal, oceanic I cells;
- Marine values in coastal cells are extrapolations of oceanic data that may not accurately reflect extremes and variability of nearshore waters;
- Procedures for saving results were addressed and a protocol developed;
- Need for additional key variables for up-scaling applications, especially 0-40^{o} latitudes; and
- Biogeochemical models data (to date) were included in the current database for use in overlay activities.

Global maps were prepared (J. Bartley and Prof. S.V. Smith) for each variable to assist in visualisation of coverage and gradients, thus supporting choice of databases for typology purposes.

Upgrades to LOICZ View (Casey Smith, Dr Bruce Maxwell)

The LOICZView tools were amended in response to participant comments and use, including the LOICZView clustering tool (Dr Bruce Maxwell) and the Web interface (Casey Smith). Changes included:

- Improved statistical output for clusters
- Cluster information extended re. variables and files in cluster summary
- Image and data can be saved together as "save" or "view" function
- The "source" element was modified
- Overlay facilities amended (cluster then overlay to compare typologies)
- Size of image can be selected for the "visualisation" mode
- Two different clusters can be overlaid, but must be at a comparable scale
- Clustering with parameters that include a high level of missing data (zero values) will be more robust due to statistics modifications.

A format and procedure for saving results and images was developed (Table A-I.1).

Table A-1.1. Proforma for data reports and archiving information

DATA REPORTS
OPERATOR(S) NAME:
DATE:

Database Information
Geographic zones selected (leave blank if done by zones):
Geographic range selected (leave blank if done by zones):
Cell types selected from database (Terrestrial, Coastal, Oceanic I, Oceanic II, Oceanic III):
Variables selected from database:
What do you expect to get out of clustering these variables or what are you trying to achieve?
Additional comments on problems or improvements needed:

LOICZVIEW INFORMATION
Cluster Run Number:__
Variables selected in cluster (include any weights if not set at 1):
Number of clusters:

SAVE IMAGE
Step1: Click on the View image as one layer button
Step2: After the new window pops up Right-Click on Image and select the Save image as option
Step3: Place the image in the LOICZ folder on your desktop
Insert Image into the space below:

COMMENTS OR DESCRIPTION ON CLUSTER OUTPUT:

NOTES ON SAVING YOUR INFORMATION:
Cluster information:
Step1: On the Visualize tab click on "Source" button
Step2: Under the View Column click on the "clu" button
Step3: Select all of the text in the bottom right window and copy it to the clipboard (edit copy or ctrl-C)
Step4: Open Notepad and paste the information in and save it into your LOICZ folder
Step5: Save the file with a unique name like clusterNum_clu.txt and then write the name below:

CLUSTER ASSIGNMENT FOR EACH DATA CELL:
ONLY DO THIS IF YOU PLAN ON USING IT IN ARCVIEW!!!
Step1: On the Visualize tab click on "Source" button
Step2: Under the View Column click on the "tag" button
Step3: Select all of the text in the bottom right window and copy it to the clipboard (edit copy or ctrl-C)
Step4: Open Notepad and paste the information in and save it into your LOICZ
Step5: Save the file with a unique name like clusterdata_tag.txt and then write the name below.

Plenary presentations
Three plenary presentations provided points for discussion and potential application of the typology products.

"Coastal system processes and science- links with policy" (Dr Bill Dennison) provided a description of multi-disciplinary scientific studies of processes and changes in Moreton Bay, Queensland. There, the involvement of management and policy agencies in the research design, implementation and analyses has yielded an effective partnership for science transfer.

"Regional material flux" (Prof. Ming Wong) is a vital issue in East Asia, with increasing scientific effort and efforts for effective environmental management and resource protection. Biogeochemical process assessments and scaling issues are of key interest.

"A fine-scale approach to estuarine classification in New Zealand" (Dr Terry Hume) is currently a high-priority research-management project, to describe and characterise status and changes in more than 300 estuaries along 11,000 km of coast. Limited knowledge about many estuaries makes a typological approach attractive and here, the selection and development of derivative proxies is a leading issue.

Presentation of Developed Typologies
The task outcomes were summarised and constructive comments made on shortfalls in databases and techniques (Table A-I.2). The typologies developed during the workshop and authors notes are more completely described in the accompanying CD-ROM.

TABLE A-I.2. Participant Contributions.

#	Name(s)	Region(s)	Subjects	Notes
1	Yanagi	Japan/E Asia	Eutrophication	
2	Hung	NE Asia (China/Taiwan/Japan)	Classification	5 clusters
3	Cao	China (Japan, Korea)	Cluster comparison	2-7 variables
4	Wong	East Asia	Human activities	
5	Dupra	SE/E Asia	Process proxies	5 clusters
6	McManus/Swaney	SE/E Asia	Coastal typology	Cluster no. effect
7	Wattayakorn	Thailand/SE Asia	Humans/nutrients	
8	McGlone	Philippines	Production/eutrophy	
9	David	Asia-Australia	Extreme events	Latitude-independent variables
10	Zeldis/Hume	NZ-S Australia	CZ classification	6 variables
11	Eyre	Australia	Estuarine classification.	3 variables.
12	Pullar	Queensland coast	Coastal productivity	4 variables.
13	Dennison	World	*Trichodesmium* distribution	
14	Turner	Australia	Process classification	
15	Robb	Australia/S Africa	Coast/estuary classification.	
16	Broadman	Australian latitude band	Scale comparisons	
17	Camacho-Ibar	Australia/S America	Hydrology comparisons.	
18	Naqvi	S Asia (Indian subcont.)	Typology	
19	Wulff/Swaney	Europe	Nutrient loads	5 var.
20	Opdyke/Dennison	World	Benthic habitats	
21	Smith	World	Land-ocean influence	2 derived variables

1. Australian estuaries classification (Dr Bradley Eyre)
Constructed a LOICZView typology and compared with an existing fine-scale classification using the same variables. Rainfall variables and tidal range yielded a good relationship at regional levels, though there was a mis-match of some classes and the overlay tool was not effective for inter-comparison. The variables were applied to a global view with acceptable outcomes; a lesser number of classes but similar patterns.

2. Tropical habitat mapping (Dr Bradley Opdyke)
Coral distribution in Australia was classified using parameters for depositional environments and the typology was extended (with Dr Bill Dennison) to seagrass and mangrove environments. The classification was extended to a global scale where 27 clusters gave a successful representation (>70% agreement with expert typology). Salinity, temperature, wind speed and tide were key variables; runoff data was not very useful; sediment database would be a valuable addition along with coastal temperature data determined in coastal areas. Weightings: salinity was a major driver; tidal range and wind speed weighted to influence clusters.

3. *Trichodesmium* distribution (Dr Bill Dennison)
SST, runoff and tidal range provided useful proxies for the Australasian-Indonesian region. Global scale elicited the "hot spots". LOICZ typology method may be a valuable search tool for susceptible areas; data will be compared with satellite techniques being developed elsewhere.

4. Defining functional zones in Australian coasts (Dr David Pullen)
A staged approach was made with the Queensland coast. Salinity, SST, tidal range, chlorophyll and bathymetry variables were evaluated to yield discrete area locations but not a spatial pattern. Comparison made with "impacts" (population and runoff variables); results suggest a N-S gradient driven by SST and impact of land flow on the coastal environment. A terrestrial cell classification will be applied to make further pattern evaluations.

5. Extreme events and vulnerability (Dr Laura David)
The Asia-Australasia regions were evaluated for assessment of storm event changes. Coastal regions were clustered for a latitudinal typology total precipitation, bathymetry, population, salinity, basin runoff. Storm events were then developed by proxies (standard deviation of precipitation and annual average wind) to give a before and after (extreme event) picture. 60% of the pixels (1850 of 3221 cells) were not affected by extreme events. Recalculation of total runoff provided higher or added flow *vs* uncharacteristic flow or flooding (usually in drier areas) to elucidate vulnerable areas.

6. New Zealand estuary classification – scaling evaluations (Dr John Zeldis, Dr Terry Hume)
Aimed to develop an estuarine classification using appropriate LOICZ parameters and further derivative parameters and proxies that can represent the finer scales required. Catchment parameters were evaluated and a typology was reassembled using oceanographic data; the latter were preferable and provided a reasonable clustering of NZ coast with windspeed, salinity, SST, tidal range, soil texture and a derived "flow volume". Highlighted use of derivative parameters and awareness of metadata supporting the variables. Looking to cluster about 300 NZ estuaries in 2001 with LOICZView (at fine scale) and link to Australian assessments and classifications.

7. Comparative classification of Australian estuaries (Dr Lynne Turner)
Earlier AGSO classification was classified into six classes based on energy and relative wave-tide dominance discriminants (variables: runoff, tidal range, wave height). Using 3- and 6-cluster selection (MDL indicated 27 clusters), this was applied to a global scale. The 6-cluster approach resulted in the Australian estuaries apparent within the global picture – however, the cluster statistics need to be reviewed. A follow up analysis of data sets (variations and gaps) is to be made to check whether the Australian classification can be fully applied as a surrogate (ground truth) for the global scale.

8. Proxies for biogeochemical budgets in South East Asia (Vilma Dupra)
A key question was: how do the budgets fit to characteristics of the coastal region? This was addressed by analysing for similarity between budgets and similarity of coastal characteristics (by assessment of gradients in each parameter). Key variables included: bathymetry (minimum depth), precipitation, runoff (and salinity gradient), water exchange and bathymetry. Loadings that fall into areas of high precipitation need to be refined, but can compare budgets across precipitation classes for different locations. Population, represented as DIP load estimates (ranked as high, medium or low) have yet to be overlaid and evaluated.

9. Freshwater discharge comparison of Australia and eastern South America (Dr. Victor Camacho)
Discharge typology to provide a basis for assessment of biogeochemical budget sites. Evaluated various variables to cluster (initially four variables but temperature and precipitation provided best similarity). It was noted that datasets for coastal runoff variables in Australia have many missing data; runoff datasets are more complete for South America. The database was upgraded during the workshop and the cluster analyses will be repeated. The datasets were useful at global and continental scales; clustering rigour degrades at finer scales.

10. Classification of coastal eutrophication in Japan and application to South East Asia (Prof. Tetsuo Yanagi)
A 4-parameter and 10-cluster analysis, including [p-r] valuations yielded a "sensible" outcome for further applications.

11. Classification of the East China Sea region (Dr Jia-Jang Hung)
A range of variables was trialled (temperature, precipitation, salinity, runoff, population). Temperature, salinity and precipitation provided an acceptable typology *vs* expert judgement for Taiwan; the runoff variable was not consistent. A 5-cluster approach delivered output little different from a 10-cluster approach for Taiwan, but a 10-cluster approach was more representative of the region, including Japan.

12. Classification of eutrophication in Philippine waters (Dr Malou San Diego-McGlone)
A number of variables were tested as proxies for eutrophic conditions: water exchange (salinity gradient as a proxy, but this was small), light, mean SST, nutrients (population density and precipitation as an indicator of runoff and quality). Hot spots were visualised for a good agreement with expert knowledge. Terrestrial inputs will be applied to the classification and the Philippines output will be trialled as a surrogate location for South East Asia.

13. Coastal typologies for South Asia using biophysical variables (Dr Wajih Naqvi)
Applied up to 12 variables and clusters initially. Five variables and 5 clusters yielded a typology for South Asia that fits expert judgement. This was further applied to the Arabian-South Asia regions yielding an acceptable typological representation of 10 coastal types (with 8 variables). Extension to South East Asia required 10 variables and 10 clusters. The classification sorted upwelling areas.

14. Human impacts on South East Asian coasts (Dr Gullaya Wattayakorn)
The coasts of Thailand, Malaysia and Vietnam were used as demonstration areas and, with a 5-variable array, a reasonably good classification was developed, though some sites were unresolved. A trial of population and data variables was followed and delivered acceptable visualisation. Application to the wider South East Asian region was in progress, making further assessment of discriminating variables and clusters numbers, and assessing by expert judgement classification "sensibilities".

15. Typologies for the China coast (Prof. Ming Wong, Dr Wenzhi Cao)
Evaluated a range of variables in both coastal and terrestrial cells for data quality and representation on the coast of China. Applied a number of combinations of variables and clusters to develop a coastal cell typology; this was compared with expert judgement and an independent database. Temperature, precipitation and organic carbon proved to be key variables for classification of the coast. Effects of human activities (noting that 70% of major cities are coastal) were evaluated. Effort was put into formatting and entering a comprehensive dataset for coastal regions of China that had been brought to the workshop. A preliminary run had been made with application of these data, and work will continue post-workshop.

16. Classification of coastal runoff and nutrients in Europe (Prof. Fred Wulff, Dennis Swaney)
Single variables for the region were individually assessed and their characteristics appraised as discriminatory criteria within the region. A 4-variable (annual mean temperature, precipitation, drainage basins, drainage basin population) typology was developed that gave a good fit against expert judgement. However, the major river discharge areas were not resolved in the cluster development.

The typology appeared useful for the region and could be tested for application to other parts of the globe.

17. Proxies for biogeochemical budgets – ocean and river systems (Prof. Steve Smith)
Earlier trials were built on. Derived variables were developed as a proxy for residual flow and $(\text{windspeed})^2$ was used to represent energy (both were constructed off-line and input to the database); missing data were stripped from the databases. Pattern evaluation of clustering included cell-by-cell analysis for "sensibility". The results confirm that the LOICZView clustering can deal with non-adjacent point pattern analysis at small scales. Global clustering, following application to Australia as a trial area, yielded a 20-cluster output which showed that the derivative variables behaved as expected and that the Australian surrogate fit well for production of a global pattern

Utility and Application of LOICZView
Use and potential application of the LOICZView methodology was discussed in light of the workshop trials and activities. Key points included:

A. As a general access tool for geo-referenced data
- The Oracle data base will continue to be expanded as will the LOICZView access. The immediate priority will be to meeting the demands of LOICZ-based projects.
- Continue development of techniques for fitting and use as a tool within LOICZ, and compilation of derivative data sets, utility for scaling patterns.
- Options for mirror sites are under consideration. Transfer of tool to a central agency for support and maintenance is being considered.
- A network of key users will be provided personal access codes, via University of Kansas in the short term, with facility provided for general or guest users.

Application to science and wider users
- Global scale habitat mapping (actual, expected, changes).
- Inventory comparisons and mapping e.g., marine taxonomic systems, sediment chemistry, groundwater attributes.
- Application to access specialist geo-referenced data.
- Application on different scales of data sets, global to very fine-scale.
- Conceptualisation and visualisation of data.

Outcomes and Wrap-up
Typologies were developed to interim draft stage during the workshop; text additions and checks on data sources were required for completion of most tasks. A schedule for contribution of final documents, report and publication, along with the process for review and editing was agreed, noting that hard-copy reports, web-posting and CD-ROM products are planned.

A CD-ROM of workshop databases, materials and developed typologies was prepared and distributed to all workshop participants as an interim product and for further use by participants.

Members of the Project steering committee met informally during the workshop to plan content and programs for further workshops, and to review and finalise arrangements for preparation and publication of tutorial materials.

The participants joined with LOICZ in expressing thanks to Dr Lynne Turner and Kerry Rosenthal for their preparation and support throughout the workshop, and to the CRC for Coastal Zone Estuary and waterway Management for the arrangements and hosting of the workshop in Brisbane. The financial support of the Global Environmental Facility was gratefully acknowledged.

Appendix ID Terms of Reference

LOICZ/UNEP REGIONAL SYNTHESIS THEMATIC WORKSHOP FOR THE ASIAN-AUSTRALIAN REGION
CRC for Coastal Zone Estuary & Waterways Management
Brisbane, Australia
14-17 January 2001

Background Information:

A major overall objective of LOICZ (http://www.nioz.nl/loicz/) and the facilitating UNEP GEF project is to provide an assessment of uptake and release of nutrients (nitrogen and phosphorus) in the global coastal zone. The tools being used to meet this objective are biogeochemical budgets of nitrogen and phosphorus for specific sites (primarily bays, estuaries, and lagoons) in the coastal zone, and application of an objective classification, or "typology," (http://water.kgs.ukans.edu:8888/public/Typpages/index.htm) to extrapolate from individual sites to the global coastal zone. To date, approximately 150 site budgets have been developed (http://data.ecology.su.se/MNODE), mostly through a series of workshops sponsored by GEF. The primary classification tool will be the geospatial clustering program "LOICZView," which has been developed for this specific application (http://www.palantir.swarthmore.edu/~maxwell/loicz/; refer to LOICZ Newsletter No.15 June 2000, available on the LOICZ web-site).

Over the course of the year 2001, a series of three regional synthesis workshops will be held to develop objective classifications for the global coastal zone, to reconcile the objective classifications with "expert classifications" and to relate the coastal classes to the budgets. The workshops will be targeted at specific regions, but each will also have a classification theme to provide a conceptual as well as a geographic focus. The first of these workshops will be held in Brisbane, Australia, in January 2001. This workshop will be the regional synthesis for the Asia/Australasia region, and the classification theme will be Hydrologic Variability (Effects of episodic water discharge). This region is appropriate for the first synthesis workshop, because three budgeting workshops have been held there (two with UNEP GEF funding) and almost half of the available biogeochemical budgets are from this region.

Primary Goals:

To work with resource persons and researchers dealing with coastal fluxes and biogeochemistry in the general region of East Asia, South East Asia, South Asia and Australasia, in order to relate C-N-P biogeochemical budgetary information to coastal system classifications that will be developed by cluster analysis of suites of environmental and human-dimension variables

The workshop provides the opportunity to test and develop coastal and budget classification techniques for the region and selected sub-regions, and to apply these to a regional synthesis of biogeochemical fluxes and budgets as well as to the initial steps of a global synthesis.

Anticipated Products:

1. The following tests of coastal and budget classification schemes [Note: it is expected that much of this will be accomplished, posted electronically, and disseminated to participants during the 2-month pre-workshop period]:
   a. Preliminary whole-region classifications based on physical environmental variables (list to be posted).
   b. Exploratory tests of coastal classification by sub-region (e.g., tropical *vs.* temperate, rainfall/runoff or other classes).
   c. Classification of budget types by selected key variables, and initial correlations with environmental variables.
   d. Classification of coastal regions by human-dimension and related variables.

2. [Note: the following are the primary in-workshop and post-workshop goals] Classifications of the Asian/Australasian region and reconciliation of objective and expert classifications for the region, based on physical variables and the results of #1 above.
3. Trial extrapolations of classifications from this region to the remainder of the global coastal zone.
4. Overprinting of variations in socio-economic conditions onto these physically-based classifications.
5. Estimates of mean and variability of budget variables (water, salt, nutrients) within the coastal classes deemed most suitable for optimisation and extrapolation.
6. Prompt, updated electronic presentations (WWW and stand-alone files) of the typology/synthesis results and progress; further development of databases, procedures and tools on the basis of experience gained.
7. Printed reports and submissions to the scientific literature as appropriate.

Workplan:
Participants will be expected to come prepared to contribute actively to the classification and synthesis process. Preparation should include: reading, examination of the data, tools, and tutorials presented on the LOICZ Typology and Web- LOICZView web pages (see URLs, above), and completion (on- or off-line) of pre-workshop tests and exercises (see Item #1 under Anticipated Products). This pre-workshop activity should include electronic submission of preliminary results in agreed format so that these can be posted and made available as the resource base for the workshop

NOTE: This is the first in a series of workshops that will rely heavily on the use of on-line internet tools and data, and on prompt web-site posting and electronic dissemination of products and progress. Alternative distribution and access channels for those lacking ready WWW access will be provided, and it is anticipated that the workshops will be run via local networks on-site. Some of the procedures are necessarily experimental, and will be developed throughout the synthesis process.

Further Details:
LOICZ will arrange travel and make other workshop arrangements in consultation with the CRC Coasts. LOICZ will pay for all travel, accommodation and support costs for the participants.

Further details will be provided to participants during the lead-up to the workshop.

Draft Workshop Schedule:
Preworkshop:
ca. 11 Oct -- participants invited; schedule confirmed
Oct 16-18 -- Preparatory Typology Workshop for key resource people
ca. 1 Nov -- Final adjustments to database, interface, Web-LOICZView, and tutorial material made; participants given Web access.
ca. 15 Nov -- Suggested pre-workshop 'assignments' (based on interests and expertise) given to participants, to complete and bring to workshop. Ongoing discussions and outputs posted to WWW.
ca. 15 Dec -- Pre-conference summary, follow-ups, and final instructions/requests

Workshop:
January 13: Arrival; set up and test hardware and software
January 14: (am) General introduction to workshop schedule, plans and goals. Plenary review of pre-workshop tests and outcomes. Refinement of workshop strategy; development of teams and assignments.
(pm) Breakout work as decided - teams of participants and resource people address specific subsets of issues and techniques. Emphasis on classification and calibration.
January 15: Continue breakouts; midday plenary to evaluate progress, shift activity emphasis to budget extrapolation via typology.

January 16: Breakouts/plenary as above - transition to developing synthesis.
January 17: (am) Breakouts continue coordinated synthesis activities.
(pm) Plenary synthesis overview and assembly; plan for follow-up and completion.
January 18: Departure.

Postworkshop:
ca. February 1 -- all electronic products edited, summarized/explained, and posted to website. Preparation of workshop report for LOICZ R&S series. Participants in Regional Workshop #2 invited; pre-workshop cycle begins.

Background Documents:

1. Gordon, D.C., P.R. Boudreau, K.H. Mann, J.-E. Ong, W. Silvert, S.V. Smith, G. Wattayakorn, F. Wulff, and T. Yanagi. 1996. LOICZ Biogeochemical Modelling Guidelines. *LOICZ Reports and Studies* **5**, 96 pages.
2. All LOICZ R&S budget workshop reports from the region: The earlier workshops on Australasian systems (*LOICZ R&S* **12**, 1999) and the South China Sea region (*LOICZ R&S* **14**, 2000) are available in hard copy or electronically from the LOICZ web-site. Reports from South Asia and East Asia regions are in preparation and will be made available to participants before the workshop.
3. All LOICZ "typology" reports. These are in preparation and will be made available to all participants in the near future.
4. LOICZ Modelling web page, for everyone with www access:(http://data.ecology.su.se/MNODE/).
   - The web pages, including the guidelines, are frequently updated. *Recent additions to the site include several PowerPoint presentations designed to familiarize you further with the budgeting procedures and with an overview of the LOICZ budgeting efforts.*
   - If you do not have access to the World Wide Web but do have access to a computer with a CD-ROM, please let us know; we will send you a CD-ROM with the web page. Please do not request the CD-ROM at this time if you have access; you will be furnished one during the workshop.
   - CABARET (Computer Assisted Budget Analysis, Research, Education, and Training). *A version of this software and a PowerPoint demonstration of its use are now available on the web-site.*

Appendix II Americas Regional Workshop Report

LOICZ/UNEP Regional Synthesis Thematic Workshop
for the Americas region
Instituto de Investigaciones Oceanologicas
Universidad Autonoma de Baja California
Ensenada, Mexico
29 April – 2 May 2001

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Appendix IIB Workshop Agenda

LOICZ/UNEP Regional Synthesis Thematic Workshop
for the Americas Region
Instituto de Investigaciones Oceanologicas
Universidad Autonoma de Baja California
Ensenada, Mexico
29 April – 2 May 2001

Summary of Objectives and Products:
Each participant will:
- Gain conceptual and operational familiarity with CZ typology applications
- Produce at least one product using the approach in their area of expertise
- Contribute to common efforts to evaluate and improve both products and process

LOICZ will:
- Gain further experience with intra- and inter-regional comparisons
- Incorporate findings and recommendations into products and activities
- Distribute results to participants and others
- Build on local/regional expertise to move toward the global synthesis

Schedule
April 29: (am) Plenary Session
Introductory, overview and tutorial presentations:
(note: presentations will be brief, informal, and interactive)
- Welcome, introductions, local arrangements – Victor Camacho-Ibar
- IGBP-LOICZ introduction – Chris Crossland
- Coastal Biogeochemical fluxes and budgets – Steve Smith
- Typology overview – Bob Buddemeier
- Clustering and LOICZVIEW – Bruce Maxwell/Casey Smith
- Example: Classifying river basin influence on the coast – Casey McLaughlin

Review of pre-workshop tests, outcomes, questions (participant discussion).
Refinement of workshop strategy; development of teams and assignments.
(pm) Breakout work
Teams of participants and resource people address specific subsets of issues and techniques. Emphasis on classification, calibration, mastering technique.

April 30: (am) Continue breakouts
Midday plenary -- evaluate progress, share experiences and interim results, shift activity emphasis to budget classification and extrapolation
(pm) Resume breakouts
May 1: (am) Continue breakouts – consideration of synthesis
Midday plenary presentation: Prof. Gerard Szewach, IGBP-DIS:
The Earth System Atlas
(pm) Resume breakouts start on product definition, setup.
May 2: (am) Assisted breakouts – resource advisors work with participants to coordinate synthesis activities, final preparations of products.
CD master produced at noon/early pm for duplication and distribution
(pm) Plenary synthesis – overview, participant products, follow-up plans
Meeting closure
May 4: Departure.

Postworkshop:
ca. May 15 -- all electronic products edited, summarized/explained, and posted to website. Preparation of workshop report for CD and print LOICZ R&S series. Pre-workshop cycle begins for #3.

Appendix IIC Workshop Report

LOICZ/UNEP Regional Synthesis Thematic Workshop
for the Americas Region
Instituto de Investigaciones Oceanologicas
Universidad Autonoma de Baja California
Ensenada, Mexico
29 April – 2 May 2001

Welcome

Participants were welcomed to the Instituto de Investigaciones Oceanologicas, Universidad Autonoma de Baja California, Ensenada, Mexico by Dr Victor Camarcho and coordination details were provided. Support arrangements and the purpose of the workshop were outlined by the workshop leader, Dr Robert Buddemeier. Participants were introduced, the agenda was confirmed and working documents were reviewed.

An overview of LOICZ was presented by Dr Chris Crossland, as a context for the biogeochemical budgets assessments and the typological goals of the workshop. The status of the LOICZ biogeochemical budgets development and the approach was provided by Prof. Stephen Smith, noting the global geographical spread, some emerging trends and the recent commencement of "synthesis" process within LOICZ. The results from a small-group, Latin American region budgeting workshop held immediately prior to this typology workshop, were placed into the context of the LOICZ global assessment.

Introduction
An introduction to the LOICZ UNEP project and the LOICZ typology approach for interpolation of data was provided by Dr Robert Buddemeier. While the typology tool has a number of applications, its relevance to the LOICZ initiatives involving global up-scaling of local assessment and evaluation of nutrient biogeochemical budget models data were identified as a primary objective for LOICZ. The application to the Americas region was central to the theme and action of the workshop, recognising that activities would be addressing a range of scales, regions and sub-regions, and global scale trials of data cluster analysis. The workshop was placed in the context of the three global region thematic workshops arranged for the LOICZ-UNEP project and the final global synthesis workshop which will aim to build a global picture of C-N-P fluxes in coastal systems. Additional and wider applications were considered both within LOICZ and more widely to meet participant research and interests with application to LOICZ. The LOICZ typology software and tools provide a unique method for scaling and to achieve the global assessment goals of LOICZ.

Tutorials
<u>LOICZView</u>
Dr Bruce Maxwell described the clustering tool in detail and the various sections of operation were discussed, including:

- Data and data variables
- Processing (including selection of distance calculation and statistics)
- Visualisation and options
- Downloading, data format and statistical assessment of clusters, and file and image storage.

Recent advances in access to and utility of the LOICZView tool were demonstrated, including the ability to plot and visualise relationships between variables, filter capabilities for variables, overlay and dual classification comparisons, and new cluster summary elements.

<u>LOICZ Typology Database</u>
Dr Robert Buddemeier outlined the current database that is maintained at the University of Kansas. It is derived from existing global datasets fitted to 0.5 degree coastal pixels represented in the LOICZ global cell array. This has been developed from an earlier one-degree pixel representation. More than 180,000

Mbytes of information is contained as a table in an ORACLE base system which provides for uploading of selected variables (and scale) into the LOICZView clustering tool.

The database and system structure were described, including the process of addressing and using the database interrogation tool, selection of variables and their metadata provenance and information, and linkage to other developmental datasets – for example, the IGBP BAHC coastal basins data and model outputs.

Utility of the database directly and linked to the LOICZView typology clustering tool were outlined, noting the linkage recently developed for "cold fusion" between the two elements.

Tutorial presentation provided opportunity for participants to step through the variable selection, and familiarise themselves with the database structure

It was noted that the LOICZView internet site offers a set of trial data as well as an opportunity to upload from the LOICZ dataset site or to import self-generated geospatially-referenced data.

Tasks and Typologies Development

Participants carried out trials with the databases and clustering tool, developing familiarity with the application system in consultation with the workshop resource people. A number of tasks for application and development of the typology methodology were noted by participants.

Break-out groups (2-3 participants) and individuals worked interactively during days 2-4 on the development of different typologies, supplemented with methodological and problem/project tutorials and discussions. Daily plenary sessions addressed, *inter alia*, shortfalls in variable capabilities, methods upgrades incorporated into the tools, and product and document handling options

Discussion of problems and methods upgrades.

Discussions throughout the workshop covered a range of issues and problems that came to light with the databases, clustering actions, and saving and working with image outputs and statistics of cluster evaluations. Amendments were made to the database and clustering tools as new methodological improvements were made during the workshop, including:

- Development of a supervised clustering facility,
- Refining the world map database access point to allow auto-selection of east or west coasts of the Americas,
- Revised Cluster Summary page for text comments and archiving of data, and
- Refinement and evaluation of biogeochemical budgets database and assessment of approaches and options for typological assessment.

Plenary presentations

Two plenary presentations provided points for discussion and potential application of the typology products.

The prototype Earth System Atlas being developed within IGBP was outlined by Prof. Gerard Szejwach. The opportunity for inclusion of LOICZ typologies was highlighted. Participants looked forward to close collaboration between the researchers working on the Atlas initiative and those involved in the typology developments within LOICZ, at both global and regional scales.

Presentation of Developed Typologies

The task outcomes were summarised and constructive comments made on the utility of the databases and analytical techniques contained in the typology suite (Table V-1).

TABLE V-1. Participant Contributions.

#	Name(s)	Region(s)	Subjects
1	Dennis Swaney	Global	Biogeochemical budgets: Spreadsheets and metadata
2	Dr Laura David, Dr Victor Camacho, Dennis Swaney	Global	Typological and biogeochemical budgets assessment approaches
3	Drs Carlos Lechuga, Martin Merino, Francisco Contreras	Mexico	Classification variables for C-N-P inputs
4	Paul Boudreau	Americas, global	Global classification for biogeochemical budget assessment: inputs and exchange processes
5	Drs Eduardo Marone, Eunice Machado, Bastiaan Knoppers	Brazil	Comparison of classifications and physiographic parameters
6	Drs Joanie Kleypas, Gerard Szejwach	Caribbean, Australia	Classification of carbonate shelves
7	Dr Jose Carriquiry	Caribbean, east tropical Pacific	Coral reefs classification
8	Drs Ramon Ahumada, Laura Farias	Peru-Chilean coast	Discriminating oceanic and climatic values
9	Dr Jorge Herrera	Caribbean and Atlantic coasts	Identifying variables to discriminate groundwater and karst regions
10	Dr Jorge Marcovecchio	Atlantic South America	Impact of freshwater on coastal estuaries
11	Drs Victor Rivera, Robert Twilley	Caribbean	Mangrove distribution
12	Dr Victor Rivera	Southern Caribbean	Elevation and runoff to mangrove systems
13	Drs Mike Kemp, Robert Twilley	Continental USA	Estuarine classification and biogeochemical budget estimates
14	Vilma Dupra	South East Asia, Australasia	Delta DIP means and weighting by typology

1. Biogeochemical budgets: Spreadsheets and metadata (Dennis Swaney)

2 Typological and biogeochemical budgets assessment approaches (Dennis Swaney et al.)

Work on resolving linkages between and approaches for analyses of biogeochemical datasets and typology variables scales was addresses as a core LOICZ project activity. A trial was made of combining ARCView and LOICZView methods, in which remote sensing methods were combined with existing biogeochemical data for "banding" of data using the clustering technique. Principal component analysis of delta-DIP and delta-DIN was applied with continuous grouping analyses and inspection. Derived delta-DIN data refined by delta-DIP assessment yielded about 40 clusters for the global coastal region. These clusters accounted for 99.5% of the cells. A supervised clustering approach is to be tried.

3. Classification variables for C-N-P inputs (Dr Lechuga et al.)

Initial case evaluation of Mexican coasts spatially relating land use and C, N, P inputs. Seven clusters were developed that represented the Mexican coasts based on variables that acted as proxies for run-off, coastal geomorphology and C, N, P inputs. Expert judgement suggested that the resultant clusters were generally sound although there was some variability. Improved database of N and P variables (currently N is at first trial level in database) may improve the outcome. Attempted global classification with addition of sea surface temperature variable yielded a preliminary global description with 12 clusters; further evaluation is required.

4 Global classification for biogeochemical budget assessment: inputs and exchange processes (Paul Boudreau).

Trial of Database variable and LOICZView tools showed basin runoff was a key variable for global classification. Runoff, population per basin and an exchange proxy (area of water per cell x tidal range) yielded a preliminary classification identifying big cities (anthropogenic inputs), isolated large river flows and high horizontal heterogeneity. The exchange rate proxy needs further development for better association of exchange rate and pixel characteristic; depth/tidal range may prove useful. Generally the results were judged OK outside the tropics. Initial efforts with population density and cropland yielded a large class that is considered worth further work to tease out tropical discriminates.

5. Comparison of classifications and physiographic parameters - Brazil (Dr Marone et al.).
Recent coastal analysis of E and NE Brazilian coast has shown 4 distinct geomorphic regions along 7700km of coastline and five geographical regions. An array of 31 database variables was tested with LOICZView; coupled terrestrial-oceanic variables yielded 4 typological regions, similar to the expert classification. Application of the coastal cells only provided similar output. The 31 variables were refined to 6 variables with maintenance of cluster output. Sub-regional cluster analyses were tried with the 31 variables and confirmed earlier expert typology from down-scaling. The system seems robust but runoff and tidal data are not dependable due to some erroneous data cells. Finer-scale geographical nesting trials indicate a diminished explicitness with the half-degree resolution database.

6. Classification of carbonate shelves (Drs Kleypas and Szejwach).
Trials with selected variable and tools (use of filters) yielded a classification that discriminated coral reef elements of coastal shelves in the wider Caribbean area. Application of the clusters to the Australia region showed that there is a much wider range of clusters needed to be developed to resolve the tropical carbonate coastal environment of the southern continent. The potential to use principal component analysis or Eigen vectors in development of applicable datasets was discussed.

7. Coral reefs classification (Dr Carriquiry)
An array of variables for atmospheric, geomorphic and coastal parameters was systematically explored ending with five variables (bathymetry, sea surface temperature, salinity, runoff) and five clusters to classify the eastern tropical Pacific and Caribbean coral reefs; Pacific reefs were differentiated from those of the Caribbean. The Yucatan Peninsula and the Florida Keys proved variant from expert judgement, although the overall fit was OK. The same variables, though with differential weightings, were applied to the wider Pacific region and gave an apparently useful classification of South East Asia-Pacific-Caribbean coral reefs. Bathymetry and runoff variables showed some important discriminatory powers, brought out by weightings. A proxy for water clarity/turbidity was considered to be of potential advantage.

8. Discriminating oceanic and climatic values – Peru-Chile coast (Prof. Ahumada and Dr Farias).
Two themes were addressed: i) evaluation of coastal processes across the Peru (10-30^{o}S), Chile (30-40^{o}S) and Patagonia (40^{o}+S) regions, and ii) discrimination between upwelling and El Nino conditions. Five clusters gave reasonable representation with ocean, coastal and land typologies. Ocean I data masked the coastal data cells due to upwelling intensity. The cluster method worked well but there is need for finer resolution data to evaluate the known variance in the region, though global scale evaluation appears OK.

9. Identifying variables to discriminate groundwater and karst regions – Caribbean and Florida (Dr Herrera)
Used a sediment approach then a hydrological approach. Percentage carbonate in soils was not a useful discriminator. Obtained a useful set of cluster arrays and applied elevation and bathymetry, that yielded a clustering akin to coral reef areas. Pixel size is too coarse to finely resolve karst structure scale and refined database on coastal SST/salinity may improve the typology solution. The supervised clustering tool was tested; changing the standard deviation yielded different typologies that need further interpretation. The supervised clustering tool held good promise for use in up-scaling from regional to global assessment.

10. Impact of freshwater on coastal estuaries – Atlantic South America (Dr Marcovecchio)

Inspected and trialled an array of relevant variables in 5 experiments. Some successful typologies were developed that characterised the freshwater inputs and yielded clear clusters that well-fitted expert judgement for the region.

11. Mangrove distribution – Caribbean (Dr Rivera and Prof. Twilley)
12. Elevation and runoff to mangrove systems – south Caribbean (Dr Rivera)
Utilised coastal cells and selected proxies for mangrove locations (e.g., frost days, sea temperature-min, sea temperature-inter-annual). Caribbean outcomes fitted expert assessment but the classification derived for the southern US tropics yield up to 20% variance from expert judgement. Global application of the clusters did not match well in Africa and Australia; it was suggested that an additional integrative variable such as evapo-transpiration would have value (now being developed by Casey McLachlin).

Preliminary work was done to derive a productivity setting and classification for the Magdalena River, Colombia. Trial of variable (e.g., elevation) and various LOICZView tools were carried out – overlapping, selection of filter, archetype point evaluations. A need for improved user-descriptions of the tools was noted.

13. Estuarine classification and biogeochemical budget estimates (Profs. Kemp and Twilley)
A preliminary cluster analysis of coastal and estuarine sites yielded a classification of the continental US. This formed a basis for identifying about 35 potential systems for which nutrient budgets could be developed (studies and data probably exist) to provide a basis for comparison between regional estuarine performance – notably comparison of east and west coast systems. This work is expected to be followed up in association with an up-coming ERF conference and to contribute to the LOICZ enterprise.

13. Delta DIP means and weighting by typology (Vilma Dupra and Dr Camacho)
A comparison was made between simple averages and weighted means for delta-DIP. Delta DIP values (omitting several outlier system values) were used with different variables and evaluated as 5 and 10 clusters to assess the percentage incorporation of values in each cluster. A preliminary trial for delta-DIP trends (DIP_{sys} vs DIP_{ocean}) using proxy variables was carried out. For example, DIP retention in a system will be a function of –Vr/Vx, where Vx in turn will be some function of tide range/depth.

Outcomes and Wrap-up

Typologies were developed to interim draft stage of completion during the workshop; text additions and checks on data sources were required for subsequent completion of most tasks. A schedule for contribution of final documents, report and publication, along with the process for review and editing was agreed, noting that hard-copy reports, web-posting and CD-ROM products are planned.

A CD-ROM of workshop databases, materials and developed typologies was prepared and distributed to all workshop participants as an interim product and for further use by participants.

Members of the Project steering committee met informally during the workshop to plan content and programs for later workshops under the LOICZ UNEP project, and to review and finalise arrangements for preparation and publication of tutorial materials.

The participants joined with LOICZ in expressing thanks to Dr Victor Camacho-Ibar and assistants for their preparation and support throughout the workshop, and to the UABC for hosting of the workshop in Ensenada. The financial support of the Global Environmental Facility was gratefully acknowledged for regional participant attendance; LOICZ supported attendance of participants from non-GEF eligible countries.

Appendix IID Terms of Reference

LOICZ/UNEP Regional Synthesis Thematic Workshop
for the Americas Region
Instituto de Investigaciones Oceanologicas
Universidad Autonoma de Baja California
Ensenada, Mexico
29 April – 2 May 2001

Background Information:

A major overall objective of LOICZ (http://www.nioz.nl/loicz/) and the facilitating UNEP GEF project is to provide an assessment of uptake and release of nutrients (nitrogen and phosphorus) in the global coastal zone. The tools being used to meet this objective are biogeochemical budgets of nitrogen and phosphorus for specific sites (primarily bays, estuaries, and lagoons) in the coastal zone, and application of an objective classification, or "typology," (http://www.kgs.ukans.edu/Hexacoral) to extrapolate from individual sites to the global coastal zone. To date, approximately 150 site budgets have been developed (http://data.ecology.su.se/MNODE), mostly through a series of workshops sponsored by GEF. The primary classification tool will be the geospatial clustering program "LoiczView," which has been developed for this specific application (http://www.palantir.swarthmore.edu/~maxwell/loicz/; refer LOICZ Newsletter No.15 June 2000, available on LOICZ web site).

Over the course of the year 2001, a series of three regional synthesis workshops have been organised in order to develop objective classifications for the global coastal zone, to reconcile the objective classifications with "expert classifications," and to relate the coastal classes to the budgets. The workshops will be targeted at specific regions, but each will also have a classification theme to provide a conceptual as well as a geographic focus. The first of these workshops was held in Brisbane, Australia, in January 2001 to address the Asia-Australasia regions.

This workshop will be the regional synthesis for the Americas region, and the classification theme will be small *vs* large river systems. An extensive spread of data for estuaries and river load characteristics is available, though in parts of South America and at the latitudinal extremes there is a limited set of information. Three budgeting workshops have been held in the region: two in Mexico and one in South America (with UNEP GEF funding) and a number of estuarine biogeochemical systems budgets for North America are contained on the LOICZ website.

Primary Goals:

To work with resource persons and researchers dealing with coastal fluxes and biogeochemistry in the Americas region, in order to relate C,N,P biogeochemical budgetary information to coastal system classifications that will be developed by cluster analysis of suites of environmental and human-dimension variables.

The workshop provides the opportunity to test and develop coastal and budget classification techniques for the region and selected sub-regions, and to apply these to a regional synthesis of biogeochemical fluxes and budgets as well as to the initial steps of a global synthesis.

Anticipated Products:

1. The following tests of coastal and budget classification schemes [Note: it is expected that much of this will be accomplished, posted electronically and disseminated to participants during the two-month pre-workshop period]:
   a. Preliminary whole-region classifications based on physical environmental variables (list to be posted).
   b. Exploratory tests of coastal classification by subregion (e.g., tropical *vs* temperate, rainfall/runoff or other classes).

2. Classification of budget types by selected key variables, and initial correlations with environmental variables.
3. Classification of coastal regions by human-dimension and related variables.
4. [Note: the following are the primary in-workshop and post-workshop goals] Classifications of the Americas region and reconciliation of objective and expert classifications for the region, based on physical variables and the results of #1 above.
5. Trial extrapolations of classifications from this region to the remainder of the global coastal zone.
6. Overprinting of variations in socio-economic conditions onto these physically-based classifications.
7. Estimates of mean and variability of budget variables (water, salt, nutrients) within the coastal classes deemed most suitable for optimisation and extrapolation.
8. Prompt, updated electronic presentations (WWW and stand-alone files) of the typology/synthesis results and progress; further development of databases, procedures and tools on the basis of experience gained.
9. Printed reports and submissions to the scientific literature as appropriate.

Workplan:
Participants will be expected to come prepared to contribute actively to the classification and synthesis process. Preparation should include: reading, examination of the data, tools and tutorials presented on the LOICZ Typology and Web-LOICZView web pages (see URLs, above), and completion (on- or off-line) of pre-workshop tests and exercises (see Item #1 under Anticipated Products). This pre-workshop activity should include electronic submission of preliminary results in agreed format so that these can be posted and made available as the resource base for the workshop

NOTE: This workshops will rely heavily on use of on-line internet tools and data, and on prompt website posting and electronic dissemination of products and progress. Alternative distribution and access channels for those lacking ready WWW access will be provided, and it is anticipated that the workshops will be run via local networks on-site. Some of the procedures are necessarily experimental, and will be developed throughout the synthesis process

LOICZ will arrange travel, and make other workshop arrangements in consultation with the Institute. LOICZ will pay for all travel, accommodation and support costs for the participants.

Further details will be provided to participants during the lead-up to the workshop.

Draft Workshop Schedule:

April 28:	Arrival; set up and test hardware and software
April 29:	(am) General introduction to workshop schedule, plans and goals. Plenary review of pre-workshop tests and outcomes. Refinement of workshop strategy; development of teams and assignments. (pm) Breakout work as decided – teams of participants and resource people address specific subsets of issues and techniques. Emphasis on classification and calibration.
April 30:	Continue breakouts; midday plenary to evaluate progress, shift activity emphasis to budget extrapolation via typology.
May 1:	Breakouts/plenary as above – transition to developing synthesis.
May 2:	(am) Breakouts continue coordinated synthesis activities. (pm) Plenary synthesis overview and assembly; plan for follow-up and completion.
May 3:	Departure.

<u>Postworkshop</u>:

ca. May 20 – all electronic products edited, summarized/explained, and posted to website. Preparation of workshop report for LOICZ R&S series.

Background Documents:

1. Gordon, D.C., P.R. Boudreau, K.H. Mann, J.-E. Ong, W. Silvert, S.V. Smith, G. Wattayakorn, F. Wulff, and T. Yanagi. 1996. LOICZ Biogeochemical Modelling Guidelines. LOICZ Reports and Studies 5, 96 pp.
2. All LOICZ R&S budget workshop reports from the region: The earlier workshops on Australasian systems (LOICZ R&S No.12, 1999) and the South China Sea region (LOICZ R&S No. 14, 2000) are available in hard copy or electronically from the LOICZ web site. Reports from South Asia and East Asia regions are in preparation and will be made available to participants before the workshop.
3. All LOICZ "typology" reports. These are in preparation and will be made available to all participants in the near future.
4. LOICZ Modelling web page, for everyone with www access: (http://data.ecology.su.se/MNODE/).
    - The web pages, including the guidelines, are frequently updated. *Recent additions to the site include several PowerPoint presentations designed to familiarize you further with the budgeting procedures and with an overview of the LOICZ budgeting efforts.*
    - If you do not have access to the worldwide web but do have access to a computer with a CD-ROM, please let us know; we will send you a CD with the web page. Please do not request the CD at this time if you have access; you will be furnished one during the workshop.
    - CABARET (Computer Assisted Budget Analysis, Research, Education, and Training). *A version of this software and a PowerPoint demonstration of its use are now available on the web-site.*

Appendix III Europe-Africa Regional Workshop Report

LOICZ/UNEP Regional Synthesis Thematic Workshop for
the Africa-Europe Regions
Coastal Zone Management Centre, RIKZ
The Hague, The Netherlands
2-5 July 2001

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Appendix IIIB Workshop Agenda

1 July Arrival of participants in The Hague

2 July: (am) Plenary Session

Introductory, overview and tutorial presentations:

- Welcome, introductions, local arrangements – Maarten Scheffers
- IGBP-LOICZ introduction – Chris Crossland.
- Typology overview – Bob Buddemeier.
- Clustering and LOICZVIEW – Bruce Maxwell/Casey Smith.

Review of pre-workshop tests, outcomes, questions (participant discussion).
Refinement of workshop strategy; development of teams and assignments.
(pm) Breakout work.
Teams of participants and resource people address specific subsets of issues and techniques. Emphasis on classification, calibration, mastering technique.

3 July: (am) Continue breakouts.
Participants to confirm questions and projects.
Groups commence project work, supported by resource people.
Midday plenary -- evaluate progress, share experiences and interim results.
(pm) Resume breakouts.
Continue project work.

4 July: (am) Continue breakouts –
Midday plenary presentation: *Dr Bob Buddemeier – Humans in a changing coastal zone*
(pm) Resume breakouts start on product definition.

5 July:(am) Assisted breakouts – resource advisors work with participants to coordinate synthesis activities, final preparations of products.
CD master produced at noon/early pm for duplication and distribution.
(pm) Plenary synthesis – overview, participant products, follow-up plans.
Meeting closure.

6 July: Departure.

Postworkshop:
15 September – all electronic products edited, summarized/explained, and posted to website. Preparation of workshop report for CD and print LOICZ R&S series.

Appendix IIIC Workshop Report

Welcome

Participants were welcomed to the Coastal Zone Management Centre of RIKZ, The Hague, The Netherlands by Maarten Scheffers and coordination details were provided. Support arrangements and the purpose of the workshop were outlined by the workshop leader, Dr Robert Buddemeier. Participants were introduced and working documents were reviewed.

An overview of LOICZ purpose was presented by Dr Chris Crossland, as a context for the biogeochemical budgets assessments and the typological goals of the workshop.

Introduction

An introduction to the LOICZ typology approach for interpolation of data were provided by Dr Robert Buddemeier. While the typology tool has a number of applications, its relevance to the LOICZ initiatives involving global up-scaling of local assessment and evaluation of nutrient biogeochemical budget models data were identified as a primary objective for LOICZ. The application to the Africa-Europe region was central to the theme and action of the workshop, recognising that activities would be addressing a range of scales, regions and sub-regions, and global-scale trials of data cluster analysis. Additional and wider applications were considered both within LOICZ and more widely to meet participant research and interests with application to LOICZ. The LOICZ typology software and tools provided a unique method for scaling and to achieve the global assessment goals of LOICZ.

Tutorials

Database

Dr Buddemeier outlined the structure of the database, including the up-grades made especially to the Environdata sets, noting that climatic data clusters are contained only in the terrestrial cells. Apparently duplicate data sets for variables may have different discriminatory features subject to their derivation. For example the Willmot data sets are modelled to ocean and global cover (e.g., precipitation) and time-series data have been synthesised to annual statistics. It is important to understand the dataset foundation; this can be accessed through the attached metadata decriptors for each set.

The use of the database was demonstrated by Jeremy Bartley, including selection of global areas, cell types and variables. A demonstration case was carried out to address the question: "How to estimate water exchange times?" and linked to the LOICZView clustering tool for product

Upload/download of datasets was demonstrated, to provide participants with example of ability to introduce custom geo-referenced data sets or to modify existing datasets to derivative indices before clustering.

LOICZView

Dr Bruce Maxwell described the clustering tool in detail and the various sections of operation were discussed, including:

i) Data and data variables
ii) Processing (including selection of distance calculation and statistics)
iii) Visualisation and options
iv) Downloading, data format and statistical assessment of clusters, and file and image storage.

An array of new tools was discussed and demonstrated – dual and overlay function, subset tools, Eigenvector analyses and application of various filters.

Biogeochemical budgets datbase

The status of development and refinements to the biogeochemical budgets database was outlined by Dennis Swaney. More than 160 budget sites are collated with another 50-60 in the process of development and entry to the central database. Key variables (20-25) are being extracted from each site description to form a matrix table for typological and other analyses. (This compares with 49,000 typology cells containing about 100 variables.). The spatial range of biogeochemical variables extends up to six orders of magnitude and residence times exceed four orders of magnitude; this requires development of derivative data to obviate bias in cluster developments. The range of data quality is being assessed for the sites. Further development of the dataset and some derivative products are being addressed by a core group before final posting of the data for general access.

Tasks and Typologies Development
Participants carried out trials with the databases and clustering tools, developing familiarity with the application system in consultation with the workshop resource people. Simple typologies, mainly using climatic data, were developed during the earlier part of the workshop and these were extended to specific regional case questions or new questions through the body of the workshop.

Break-out groups (2-3 participants) and individuals worked interactively during Days 2-4 on the development of different typologies, supplemented with methodological and problem/project tutorials and discussions. Daily plenary sessions addressed progress and problems encountered by the groups, ranging from utility of the existing tools to questions for variation and amendment of the datasets and clustering/visualisation tool box. Amendments were made to the database and clustering tools as new methodological improvements were made during the workshop, including refinement and evaluation of biogeochemical budgets database and assessment of approaches and options for typological assessment.

Presentation of Developed Typologies
The task outcomes were summarised and constructive comments made on the utility of the databases and analytical techniques contained in the typology suite (Table V-1).

TABLE V-1. Participant Contributions.

#	Name(s)	Region(s)	Subjects
1	Dr Bob Buddemeier	Global	Humans in a changing coastal zone
2	Dennis Swaney, Dr Bruce Maxwell	Global	Assessment of ΔDIP and ΔDIN from biogeochemical models data set
3	Dr Howard Waldron, Prof. Dan Baird, Prof Tickie Forbes	Southern Africa	Regional characteristics of sub-equatorial Africa for budgets settings
4	Drs Xavier Niell, Ricardo Prego	Iberian region	Gradients and drivers describing coastal types in Iberian Peninsular
5	Natasha Brion	European North Atlantic	Typology for linked riverine N and P loads to the ocean
6	Dr Amani Ngusaru, Prof. Mwakio Tole	East Africa	Comparison of expert coastal typology and differentiating variables
7	Dr J-P Gattuso	Europe	Characterising estuary and ecosystem types, and human pressures
8	Drs Lars Ramm, Sukru Besiktepe, Christoph Humborg, Adriana Cociasu, Inna Yurkova, Prof. Fred Wulff	Europe	Comparison of Baltic and Black Seas
9	Drs Charles Gabche, Nick Murray	Western Africa	Coastal typology and variables influencing nutrient fluxes
10	Dr. Christos Anagnostou, Prof Hassan Awad	Eastern Mediterranean	Scaling issues and data trials for ocean and coastal site sensitivities
11	Dr Steve Duardze	North west Africa	Evaluation of applications to land cover and oceans typologies
12	Dr Laura David	Global	Tool development – Portable search engine
13	Dr Hartwig Kremer	Global	Scaling and database integration for riverine DPSIR and chemical data

1. Humans in a changing coastal zone (Dr Buddemeier)
Human activities in the coastal zone are key elements for change and demographic typologies will be needed for interpretation and predictions to derive from the current LOICZ "synthesis". Interestingly,

there is no substantiated assessment of global population associated with the global coastal zone – oft-quoted proportions range from less than 40% to as high as 80%. Using data filters (deleting the polar region, offsetting the megacities to remove overwhelming influence on clustering) and selecting population densities >10 people per km^2 plus >5% croplands, a typology was developed based on the human demographic data set (from night sky assessment). While this yielded no surprises in global distribution of population – distribution is patchy with Europe, South East Asia, South Asia and north east America as major areas of coastal populations) - it gives a template of likely coastal perturbation areas as a setting for biogeochemical (and other) information. From the population data statistics associated with the typology, some 52% of the global population lives in the coastal zone; an area prescribed by about 100 km inland from the coastal-ocean interface. The information contributes to a lead paper presented at the IGBP Congress in Amsterdam, July 2001.

2. Assessment of ΔDIP and ΔDIN from biogeochemical models data set (Dennis Swaney and Dr Maxwell)

The developing database for the biogeochemical budgets information was interrogated by trials to assess relationships of ΔDIP and ΔDIN with human demographic data. This initial work was aimed to trial the data and tools as well as to get insight into the "people pressure" relationships and net metabolism characteristics of the budgets set. The data were filtered for outliers (water residency, 1 day - >1 year); population density was log-transformed (only works for positive, >0 values); budget variables for ΔDIP and ΔDIN were clustered and plotted against each other; log population was overlaid on the clusters; statistics of the overlays were examined to assess how clusters fall into various population categories, and how various population categories fall into clusters of ΔDIP and ΔDIN. Outcomes were promising, and provide a basis for further follow-up, generally including:

ΔDIN, ΔDIP around 0 (balanced)	correspond to low population density (most sites)
ΔDIN <0/-ve, ΔDIP>0 and ΔDIP<0 or ΔDIP>0	correspond to high population density (some sites) high N load?
ΔDIN >0, ΔDIP around 0	correspond to intermediate population density (only a few sites. N fixing systems due to N limitations?

3. Regional characteristics of sub-equatorial Africa for budgets settings (Dr Waldron, Profs. Baird and Forbes)

The coastline of Africa below the equator was characterised from predominantly climatic data and the broad spatial scale was minimised to southern Africa, into which were added human dimension variables. Toggling between the two spatial scales allowed consideration and ideas for controlling factors influencing settings for the biogeochemical budgets e.g., the relative dominance of ocean *vs* land in different coastal regions. Generally, the typology was consistent with broadscale and regional characteristics from expert typology data and participant knowledge. The coastal setting for the budgets were assessed by climatic variable (including arid, subtropical, transitional classifications) and tested against the existing budget site data. Estuarine metabolic characteristics provided little differentiation between Berg River estuary (arid coast) and Thukele and Mhlathuzi River estuaries (sub-tropical coast). However, analysis and normalisation of V_R resulted in differentiation of the arid coast Berg system from the sub-tropical river systems. Could now compare sub-tropical systems with other similar regions in sub-equatorial Africa.

4. Gradients and drivers describing coastal types in Iberian Peninsula (Drs Niell and Prego)

Applied clustering and eigenvector assessments to characterise the ocean-coastal waters around the Iberian peninsular. By aggregating the main gradients and drivers the key coastal types of the Peninsula were described. Application of all coastal and ocean variables yielded 6 clusters to describe the coastal region (included 80% variability) and 5 clusters to describe the Ocean I region (included 91% of the variability).

5. Typology for linked riverine N and P loads to the ocean: Europe (Dr Brion)

The goal was to derive and evaluate a classification of European North Atlantic coastal environments based on typological data that reflect N and P loads from rivers and adjacent basins. Existing database variables for typology and budgets were downloaded and filtered, with new (own) data added for nine river sites and estuaries. The uploaded database was clustered and N-load data overlaid. Initial evaluation showed that N load is greatest from the "large basins" rivers (e.g., Elbe, Rhine); further analysis with rainfall, population and cropland variables to be applied. Phosphorus was highest mainly from "large basins" rivers, and corresponded with N load. A strong correlation was evident with population and cropland values. Caveat: the sample size of nine river systems is too small for a reliable assessment. However the work gave a nice suggested trend outcome for further evaluation. [Dr Prego offered to supply a number of additional data for Spanish river systems for input.]

6. Comparison of expert coastal typology and differentiating variables: East Africa (Dr Ngusaru and Prof. Tole)
A WWF expert typology was compared with ones developed from the LOICZ dataset. Total variable sets were taken and, through a process of reduction and individual variable analyses, a set of determinant variables were established yielding a good fit. About five variable were required to replicate the expert classification. [It was noted that both tide and wave variable in the LOICZ database need be improved; the GLOSS database in UK or the new TOPEX database (0.25 degree scale) are possible sources.]

7. Characterising estuary and ecosystem types, and human pressures: Europe (Dr Gattuso)
Established a set of questions to explore the typology tools, databases and to address science questions; a constructive critique was developed as well as further insights into utility and science outcomes.

a) Surface area of the European coastal zone: The LOICZView approach yielded an estimate of 25.4×10^6 km^2 (compared with 26×10^6 km^2, Gattuso *et al.* 1998).
b) Identify and categorise European estuaries for habitat type and ecosystem type. Runoff data needed log transformation, but generally had discrimination of estuaries.
c) Categorise human pressures on estuaries. Log transform of population data probably unnecessary. Yielded 11 clusters with two variables and should be able to reduce cluster number with additional human dimension variables. However, this suggests that human pressure varies widely.
d) Application of own database. Tried P and R data for offshore Mediterranean and looked for drivers to relate to the data. Merging of the databases was difficult.
e) Linking LOICZ typology and budgets database files. Split to positive and nul values delta-DIP *vs* negative values delta-DIP. Best application may be to prepare a physical typology and a metabolic typology and overlay with the Dual function

The tools performed well and a number of problems were identified in ease of use or options for development, some of which were put into play during the workshop.

8. Comparison of Baltic and Black Seas (Drs Ramm, Humborg, Besiktepe, Cociasu, Inna Yurkova and Prof. Wulff)
Trial of the typology tool for up-scaling between basins, comparison of climatological-hydrographic-hydrological-human pressure variables, and application of calculated external variable on runoff and loading. Some of the problems identified (and solutions) included double accounting by addition of cells for human population (database problem); runoff is modelled and is a problem [log-transformation (Dr Gattuso) may be an intermediate answer]. Database is generally sound and the ability to examine and manipulate data is good. Clustering technique is robust. Trial of salinity intercomparison for the two seas required Ocean II data – interestingly, the outcomes showed gyres and plumes which could be useful in determining boundary settings for budgetting.

9. Coastal typology and variables influencing nutrient fluxes: Western Africa (Drs Gabche and Murray)
Characterised the western African coast from Morocco to Namibia, identifying parameters influencing nutrient flows to the coastal zone. The studies yielded gross climatological variations discriminating regions. A preliminary assessment was made of the settings for the existing four budget sites; this will be extended post-workshop. Cropland variable was not very useful as a discriminating variable in the region, showing about 60% reliability based on expert judgement.

10. Scaling issues and data trials for ocean and coastal site sensitivities: Eastern Mediterranean (Dr Anagnostou and Prof. Awad)
Trial of the ocean variables for the eastern Mediterranean region using Ocean-I and Ocean-II yield a relatively poor agreement with expert judgement. This is a data quality problem as a test with dummy database yielded an effective outcome. Further work will be done post-workshop using existing institutional data (on a LOICZ gridded system provided by Jeremy Bartley). The developed typology will then be used to explore lower, small-scale applications, especially to compare the highly populated and averaged descriptor institutional data set using the LOICZ 0.5 degree cell structure. This will allow vital comparison of variance and data dispersion characteristics during inter-scaling and to see how much is detail is captured or homogenised in the process.

11. Evaluation of applications to land cover and oceans typologies: North West Africa (Dr Duardze)
The land-based cover database was not adequate to develop detailed typologies at the regional scale. Evaluation of salinity typologies yielded five classes from Ocean I data sets and showed salinity increased with latitude across Zone 12 – similar to the typology developed for Atlantic South America. Precipitation gradient south to north and a drier drainage network to the south were demonstrated in the typology. Generally, the LOICZView has good capabilities for regional analyses.

12. Tool development - Portable search engine (Dr David)
The search engine was developed for use by people with slow or no internet access, utilising the CD-ROM version of the tools. The program uses MS Access, has "read me" files, can search the LOICZ database and has a demonstration database for Asia/Australasia. The tool is to be included in CD-ROM versions of the typology tool and to be available through the typology web-site.

13. Scaling and database integration for riverine DPSIR and chemical data (Dr Kremer)
Development of a data matrix for capture of river basins information within non-contiguous coastal cells, allowing the typology tools to be used in regional and global scaling analyses. An East Asia basins dataset was used, aiming to develop a common matrix for use across all global regions. Advances were made in this process of developing ways to achieve the basin data integration.

Outcomes and Wrap-up

Typologies were developed to interim draft stage of completion during the workshop; text additions and checks on data sources were required for subsequent completion of most tasks. A schedule for contribution of final documents, report and publication, along with the process for review and editing was agreed, noting that hard-copy reports, web-posting and CD-ROM products are planned.

A CD-ROM of workshop databases, materials and developed typologies was prepared and distributed to all workshop participants as an interim product and for further use by participants.

The participants joined with LOICZ in expressing thanks to Dr Maarten Scheffers and assistants for their preparation and support throughout the workshop, and to the Coastal Zone Management Centre and RIKZ for hosting the workshop. The financial support of the Global Environmental Facility was gratefully acknowledged for regional participant attendance; LOICZ supported attendance of participants from non-GEF eligible countries.

Appendix IIID Terms of Reference

Background Information:
A major overall objective of LOICZ (http://www.nioz.nl/loicz/) and the facilitating UNEP GEF project is to provide an assessment of uptake and release of nutrients (nitrogen and phosphorus) in the global coastal zone. The tools being used to meet this objective are biogeochemical budgets of nitrogen and phosphorus for specific sites (primarily bays, estuaries and lagoons) in the coastal zone, and application of an objective classification, or "typology," (http://water.kgs.ukans.edu:8888/public/Typpages/index.htm) to extrapolate from individual sites to the global coastal zone. To date, approximately 150 site budgets have been developed (http://data.ecology.su.se/MNODE), mostly through a series of workshops sponsored by GEF. The primary classification tool will be the geospatial clustering program "LOICZView," which has been developed for this specific application (http://www.palantir.swarthmore.edu/~maxwell/loicz/; refer LOICZ Newsletter No.15 June 2000, available on LOICZ web site).

Over the course of the year 2001, a series of three regional synthesis workshops will be held in order to develop objective classifications for the global coastal zone, to reconcile the objective classifications with "expert classifications" and to relate the coastal classes to the budgets. The workshops will be targeted at specific regions, but each will also have a classification theme to provide a conceptual as well as a geographic focus. The first of these workshops was held in Brisbane, Australia, in January 2001 to address the Asia-Australasia regions and the second in Ensenada, Mexico in May 2001 to address the Americas region.

This workshop will provide the regional synthesis for the Africa-Europe regions, and the classification theme will be small *vs* large rivers and human influences on the systems. An extensive spread of data for estuaries and river load characteristics is available, though in parts of Africa and at the latitudinal extremes there is only a limited set of information. Four budgeting workshops have been held in the regions; two in Africa and two in Europe; a number of estuarine biogeochemical systems budgets for regions are contained on the LOICZ biogeochemical modelling web-site and in LOICZ publications.

Primary Goals:
To work with resource persons and researchers dealing with coastal fluxes and biogeochemistry in the regions of Africa and Europe, in order to relate C, N, P biogeochemical budgetary information to coastal system classifications that will be developed by cluster analysis of suites of environmental and human-dimension variables.

The workshop provides the opportunity to test and develop coastal and budget classification techniques for the region and selected sub-regions, and to apply these to a regional synthesis of biogeochemical fluxes and budgets as well as to the initial steps of a global synthesis.

Anticipated Products:

1. The following tests of coastal and budget classification schemes [Note: it is expected that much of this will be accomplished, posted electronically, and disseminated to participants during the 2-month pre-workshop period]:

a) Preliminary whole-region classifications based on physical environmental variables (list to be posted).
b) Exploratory tests of coastal classification by sub-region (e.g., tropical vs. temperate, rainfall/runoff or other classes).

3. Classification of budget types by selected key variables, and initial correlations with environmental variables.
4. Classification of coastal regions by human-dimension and related variables.

5. [Note: the following are the primary in-workshop and post-workshop goals] Classifications of the region and reconciliation of objective and expert classifications for the region, based on physical variables and the results of #1 above.
6. Trial extrapolations of classifications from this region to the remainder of the global coastal zone.
7. Overprinting of variations in socio-economic conditions onto these physically-based classifications.
8. Estimates of mean and variability of budget variables (water, salt, nutrients) within the coastal classes deemed most suitable for optimisation and extrapolation.
9. Prompt, updated electronic presentations (WWW and stand-alone files) of the typology/synthesis results and progress; further development of databases, procedures and tools on the basis of experience gained.
10. Printed reports and submissions to the scientific literature as appropriate.

Workplan:
Participants will be expected to come prepared to contribute actively to the classification and synthesis process. Preparation should include: reading, examination of the data, tools, and tutorials presented on the LOICZ Typology and Web-LOICZView web pages (see URLs, above), and completion (on- or off-line) of pre-workshop tests and exercises (see item #1 under Anticipated Products). This pre-workshop activity should include electronic submission of preliminary results in agreed format so that these can be posted and made available as the resource base for the workshop.

NOTE: This is one of a series of workshops that will rely heavily on use of on-line internet tools and data, and on prompt web-site posting and electronic dissemination of products and progress. Alternative distribution and access channels for those lacking ready WWW access will be provided, and it is anticipated that the workshops will be run via local networks on-site. Some of the procedures are necessarily experimental, and will be developed throughout the synthesis process.

Further Details:
LOICZ will arrange travel, and make other workshop arrangements in consultation with the Centre. LOICZ will pay for all travel, accommodation and support costs for the participants.

Further details will be provided to participants during the lead-up to the workshop.

Draft Workshop Schedule:
(All participants are expected to stay for the entire workshop):
Workshop:

July 1: Arrival; set up and test hardware and software.

July 2: (am) General introduction to workshop schedule, plans and goals. Plenary review of pre-workshop tests and outcomes. Refinement of workshop strategy; development of teams and assignments.
(pm) Breakout work as decided -- teams of participants and resource people address specific subsets of issues and techniques. Emphasis on classification and calibration.

July 3: Continue breakouts; midday plenary to evaluate progress, shift activity emphasis to budget extrapolation via typology.

July 4: Breakouts/plenary as above -- transition to developing synthesis.

July 5: (am) Breakouts continue coordinated synthesis activities
(pm) Plenary synthesis overview and assembly; plan for follow-up and completion

July 6: Departure.

Post-workshop:
ca. September 20 -- all electronic products edited, summarized/explained, and posted to website. Preparation of workshop report for LOICZ R&S series.

Background Documents:

1. Gordon, D.C., P.R. Boudreau, K.H. Mann, J.-E. Ong, W. Silvert, S.V. Smith, G. Wattayakorn, F. Wulff, and T. Yanagi. 1996. LOICZ Biogeochemical Modelling Guidelines. LOICZ Reports and Studies 5, 96 pp.
2. All LOICZ R&S budget workshop reports from the region: The earlier workshops on African systems (Lagos - LOICZ R&S No.9, 1996; Zanzibar - LOICZ R&S No.17, 2001) are available in hard copy or electronically from the LOICZ web site. Reports from Mediterranean-Black Sea region (Athens workshop) is in preparation and will be made available to participants before the workshop.
3. All LOICZ "typology" reports. These are in preparation and will be made available to all participants in the near future.
4. LOICZ Modelling web page, for everyone with www access: (http://data.ecology.su.se/MNODE/).
    - The web pages, including the guidelines, are frequently updated. *Recent additions to the site include several PowerPoint presentations designed to familiarize you further with the budgeting procedures and with an overview of the LOICZ budgeting efforts.*
    - If you do not have access to the worldwide web but do have access to a computer with a CD-ROM, please let us know; we will send you a CD with the web page. Please do not request the CD at this time if you have access; you will be furnished one during the workshop.
    - CABARET (Computer Assisted Budget Analysis, Research, Education, and Training). *A version of this software and a PowerPoint demonstration of its use are now available on the web site.*

Appendix IV LOICZ Typology Database

The LOICZ Typology Database contains an array of parameters and variables providing data for atmospheric, geomorphic, human dimensions, oceanic, terrestrial and river basin conditions at the scale of half-degree resolution. Details may be obtained from the LOICZ Typology web site; metadata available on the web site describe the sources of the global data sets. The database is continuing to expand and the listing below describes data sets available 1 November 2001. (Cont, continuous data

Atmospheric Variables

PARAMETER	VARIABLE	TYPE	UNITS	CELLTYPE	SOURCE
Air Temp (Traditional Interpolation)	12 month avg	Cont	'Deg C	T, C, all O	Willmott et al. (UDel)
" "	12 month median	Cont	'Deg C	T, C, all O	" "
" "	Std dev of 12 month avg	Cont	'Deg C	T, C, all O	" "
" "	min month (avg)	Cont	'Deg C	T, C, all O	" "
" "	max month (avg)	Cont	'Deg C	T, C, all O	" "
" "	range of max and min months (avg)	Cont	'Deg C	T, C, all O	" "
Air Temp (DEM Interpolation)	12 month avg	Cont	'Deg C	T, C, all O	" "
" "	12 month median	Cont	'Deg C	T, C, all O	" "
" "	Std dev of 12 month avg	Cont	'Deg C	T, C, all O	" "
" "	min month (avg)	Cont	'Deg C	T, C, all O	" "
" "	max month (avg)	Cont	'Deg C	T, C, all O	" "
" "	range of max and min months (avg)	Cont	'Deg C	T, C, all O	" "
" "	cv of 12 month avg	Cont	'Deg K	T, C, all O	" "
" "	cv* (unbiased) of 12 month avg	Cont	mm	T, C, all O	" "
Precip (Raw)	12 month total	Cont	mm	T, C, all O	" "
Precip (Raw)	12 month median	Cont	mm	T, C, all O	" "
Precip (Raw)	Std dev of 12 month avg	Cont	mm	T, C, all O	" "
Precip (Raw)	cv of 12 month avg	Cont	mm	T, C, all O	" "
Precip (Raw)	cv* (unbiased) of 12 month avg	Cont	mm	T, C, all O	" "
Precip (Raw)	min month (avg)	Cont	mm	T, C, all O	" "
Precip (Raw)	max month (avg)	Cont	mm	T, C, all O	" "
Precip (Raw)	range of max and min months (avg)	Cont	mm	T, C, all O	" "
Precip (gauge-corrected)	12 month total	Cont	mm	T, C, all O	" "
" "	12 month median	Cont	mm	T, C, all O	" "
" "	Std dev of 12 month avg	Cont	mm	T, C, all O	" "
" "	cv of 12 month avg	Cont	mm	T, C, all O	" "
" "	cv* (unbiased) of 12 month avg	Cont	mm	T, C, all O	" "
" "	min month (avg)	Cont	mm	T, C, all O	" "
" "	max month (avg)	Cont	mm	T, C, all O	" "
" "	range of max and min months (avg)	Cont	mm	T, C, all O	" "

Precip	avg total annual	Cont	mm	T, C	Willmott & Matsuura (UDel)
Precip	avg month	Cont	mm	T, C	" "
Precip	median month	Cont	mm	T, C	" "
Precip	Std dev of avg annual	Cont	mm	T, C	" "
Precip	cv of avg annual	Cont	mm	T, C	" "
Precip	min month	Cont	mm	T, C	" "
Precip	max month	Cont	mm	T, C	" "
Precip	range of min-max month	Cont	mm	T, C	" "
Temp	avg month	Cont	'Deg C	T, C	" "
Temp	median month	Cont	'Deg C	T, C	" "
Temp	Std dev of avg month	Cont	'Deg C	T, C	" "
Temp	min month	Cont	'Deg C	T, C	" "
Temp	max month	Cont	'Deg C	T, C	" "
Water Surplus	Avg Month	Cont	mm	I,T,C	" "
Temp	range of min-max month	Cont	'Deg C	T, C	" "
Water Surplus	Median Month	Cont	mm	I,T,C	" "
Water Surplus	Min Month	Cont	mm	I,T,C	" "
Water Surplus	Max Month	Cont	mm	I,T,C	" "
Water Surplus	Min-Max Range	Cont	mm	I,T,C	" "
Water Surplus	Std dev of annual totals	Cont	mm	I,T,C	" "
Water Surplus	Avg of annual totals	Cont	mm	I,T,C	" "
Water Deficit	Avg Month	Cont	mm	I,T,C	" "
Water Deficit	Median Month	Cont	mm	I,T,C	" "
Water Deficit	Min Month	Cont	mm	I,T,C	" "
Water Deficit	Max Month	Cont	mm	I,T,C	" "
Water Deficit	Min-Max Range	Cont	mm	I,T,C	" "
Water Deficit	Std dev of annual totals	Cont	mm	I,T,C	" "
Water Deficit	Avg of annual totals	Cont	mm	I,T,C	" "
Potential Evaporation	Avg Month	Cont	mm	I,T,C	" "
Potential Evaporation	Median Month	Cont	mm	I,T,C	" "
Potential Evaporation	Min Month	Cont	mm	I,T,C	" "
Potential Evaporation	Max Month	Cont	mm	I,T,C	" "
Potential Evaporation	Min-Max Range	Cont	mm	I,T,C	" "
Potential Evaporation	Std dev of annual totals	Cont	mm	I,T,C	" "
Potential Evaporation	avg of annual totals	Cont	mm	I,T,C	" "
Evapotrans.	Avg Month	Cont	mm	I,T,C	" "
Evapotrans.	Median Month	Cont	mm	I,T,C	" "
Evapotrans.	Min Month	Cont	mm	I,T,C	" "
Evapotrans.	Max Month	Cont	mm	I,T,C	" "
Evapotrans.	Min-Max Range	Cont	mm	I,T,C	" "
Evapotrans.	Std dev of annual totals	Cont	mm	I,T,C	" "
Evapotrans.	avg of annual totals	Cont	mm	I,T,C	" "
Water Deficit	Min Month	Cont	mm	I,T,C	" "

Water Deficit	Max Month	Cont	mm	I,T,C	"	"
Water Deficit	Avg Month	Cont	mm	I,T,C	"	"
Water Deficit	Annual Sum	Cont	mm	I,T,C	"	"
Water Deficit	Intra-Annual Std Dev	Cont	mm	I,T,C	"	"
Water Deficit	Intra-Annual CVB	Cont	mm	I,T,C	"	"
Evapotrans.	Min Month	Cont	mm	I,T,C	"	"
Evapotrans.	Max Month	Cont	mm	I,T,C	"	"
Evapotrans.	Avg Month	Cont	mm	I,T,C	"	"
Evapotrans.	Annual Sum	Cont	mm	I,T,C	"	"
Evapotrans.	Intra-Annual Std Dev	Cont	mm	I,T,C	"	"
Evapotrans.	Intra-Annual CVB	Cont	mm	I,T,C	"	"
Potential Evaporation	Min Month	Cont	mm	I,T,C	"	"
Potential Evaporation	Max Month	Cont	mm	I,T,C	"	"
Potential Evaporation	Avg Month	Cont	mm	I,T,C	"	"
Potential Evaporation	Annual Sum	Cont	mm	I,T,C	"	"
Potential Evaporation	Intra-Annual Std Dev	Cont	mm	I,T,C	"	"
Potential Evaporation	Intra-Annual CVB	Cont	mm	I,T,C	"	"
Snow Melt	Min Month	Cont	mm	I,T,C	"	"
Snow Melt	Max Month	Cont	mm	I,T,C	"	"
Snow Melt	Avg Month	Cont	mm	I,T,C	"	"
Snow Melt	Annual Sum	Cont	mm	I,T,C	"	"
Snow Melt	Intra-Annual Std Dev	Cont	mm	I,T,C	"	"
Snow Melt	Intra-Annual CVB	Cont	mm	I,T,C	"	"
Water Surplus	Min Month	Cont	mm	I,T,C	"	"
Water Surplus	Max Month	Cont	mm	I,T,C	"	"
Water Surplus	Avg Month	Cont	mm	I,T,C	"	"
Water Surplus	Annual Sum	Cont	mm	I,T,C	"	"
Water Surplus	Intra-Annual Std Dev	Cont	mm	I,T,C	"	"
Water Surplus	Intra-Annual CVB	Cont	mm	I,T,C	"	"
Mid-Month Soil Moisture	Min Month	Cont	mm	I,T,C	"	"
Mid-Month Soil Moisture	Max Month	Cont	mm	I,T,C	"	"
Mid-Month Soil Moisture	Avg Month	Cont	mm	I,T,C	"	"
Mid-Month Soil Moisture	Annual Sum	Cont	mm	I,T,C	"	"
Mid-Month Soil Moisture	Intra-Annual Std Dev	Cont	mm	I,T,C	"	"
Mid-Month Soil Moisture	Intra-Annual CVB	Cont	mm	I,T,C	"	"
Mid-Month Snow Cover	Min Month	Cont	mm	I,T,C	"	"
Mid-Month Snow Cover	Max Month	Cont	mm	I,T,C	"	"
Mid-Month Snow Cover	Avg Month	Cont	mm	I,T,C	"	"
Mid-Month Snow Cover	Annual Sum	Cont	mm	I,T,C	"	"
Mid-Month Snow Cover	Intra-Annual Std Dev	Cont	mm	I,T,C	"	"
Mid-Month	Intra-Annual CVB	Cont	mm	I,T,C	"	"

Snow Cover					
Wind Speed	Annual mean	Cont	m/s, avg	T, C	Climatic Research Unit
Frost Days	tot num	Cont	Days/Year	T, C	Climatic Research Unit
Temp	Annual mean	Cont	Deg C	T, C	Climatic Research Unit
Vapour Pressure	Annual mean	Cont	hPa	T, C	Climatic Research Unit
Precip	Annual mean	Cont	mm/year	T, C	Climatic Research Unit

Geomorphic variables

Land	percent	Cont	% land	C	World Vector Shoreline
Islands	number	Cont		C	World Vector Shoreline
Islands	mean perim/area	Cont	length/area	C	World Vector Shoreline
CZ Bath/Elev	mean SS2 value	Cont	m rel to msl	T, C, O-1	Smith and Sandwell
CZ Bath/Elev	std dev of SS2 value	Cont	m rel to msl	T, C, O-1	Smith and Sandwell
CZ Bath/Elev	median SS2 value	Cont	m rel to msl	T, C, O-1	Smith and Sandwell
CZ Bath/Elev	max SS2 value	Cont	m rel to msl	T, C, O-1	Smith and Sandwell
CZ Bath/Elev	min SS2 value	Cont	m rel to msl	T, C, O-1	Smith and Sandwell
Ocean Bath	mean SS2 value	Cont	m below msl	C, all O	Smith and Sandwell
Ocean Bath	stddev SS2 value	Cont	m below msl	C, all O	Smith and Sandwell
Ocean Bath	range SS2 value	Cont	m below msl	C, all O	Smith and Sandwell
Ocean Bath	maxdpth SS2 value	Cont	m below msl	C, all O	Smith and Sandwell
Ocean Bath	min SS2 value	Cont	m below msl	C, all O	Smith and Sandwell
Ocean Bath	number of SS2 cells	Cont		C, all O	Smith and Sandwell
Land Elev	mean G30 value	Cont	m above msl	T, C	GTOPO30 Elevation
Land Elev	std dev of G30 values	Cont	m above msl	T, C	GTOPO30 Elevation
Land Elev	median G30 value	Cont	m above msl	T, C	GTOPO30 Elevation
Land Elev	max G30 value	Cont	m above msl	T, C	GTOPO30 Elevation
Land Elev	min G30 value	Cont	m above msl	T, C	GTOPO30 Elevation
Land Elev	number of G30 cells	Cont		T, C	GTOPO30 Elevation
Depth	Greater than 100 Meters	Cont	km2	C, all O	Smith and Sandwell
Depth	Area (km2) 0_20 Meters	Cont	km2	C, all O	Smith and Sandwell
Depth	Area (km2) 20_40 Meters	Cont	km2	C, all O	Smith and Sandwell

Depth	Area (km2) 40_60 Meters	Cont	km2	C, all O	Smith and Sandwell
Depth	Area (km2) 60_80 Meters	Cont	km2	C, all O	Smith and Sandwell
Depth	Area (km2) 80_100 Meters	Cont	km2	C, all O	Smith and Sandwell
Depth	Above Sea Level	Cont	km2	C, all O	Smith and Sandwell
Cell Area	km2			T, C, all O	0.5 degree typology cell structure
Cell Perimeter	km			T, C, all O	0.5 degree typology cell structure

Human Dimension Variables

Population	density per km2 land area	Cont	km-1	T, C	LandScan
Population	30' cell total	Cont		T, C	LandScan
Roads	Area Ratio	Cont		I,T,C	Landscan

Oceanic variables

SSTemp	18yr mean monthly	Cont	'Deg C	C, all O	NCEP SST Climatology (1982-1999)
SSTemp	18yr median monthly	Cont	'Deg C	C, all O	NCEP SST Climatology (1982-1999)
SSTemp	18yr min-max month range	Cont	'Deg C	C, all O	NCEP SST Climatology (1982-1999)
SSTemp	18yr max month	Cont	'Deg C	C, all O	NCEP SST Climatology (1982-1999)
SSTemp	18yr min month	Cont	'Deg C	C, all O	NCEP SST Climatology (1982-1999)
SSTemp	stdev of ann avg	Cont	'Deg C	C, all O	NCEP SST Climatology (1982-1999)
SSTemp	stdev of avg jan, feb,,,dec	Cont	'Deg C	C, all O	NCEP SST Climatology (1982-1999)
Salinity	ann mean	Cont	'PSU (~o/oo)	C, all O	World Ocean Atlas
Salinity	max month	Cont	'PSU (~o/oo)	C, all O	World Ocean Atlas
Salinity	min month	Cont	'PSU (~o/oo)	C, all O	World Ocean Atlas
Salinity	coastal gradient	Cont	'PSU (~o/oo)	C, all O	World Ocean Atlas
Tidal Range		ScDisc	0, 1, 3, 6, 10 (m)	C, O-1	Oiginal LOICZ Dbase
Wave Height		ScDisc	0, 1, 3, 4, 6, 7	C, O-1	Original LOICZ Dbase
Chlorophyll A	years of record 1997-2000	Cont	mg/m3	C, all O	SeaWifs
Chlorophyll A	temporal avg of	Cont	mg/m-3	C, all O	SeaWifs

	spatial avg of 1997-2000				
Chlorophyll A	spavgstd	Cont	mg/m-3	C, all O	SeaWifs
Chlorophyll A	spatial min for 1997-2000	Cont	mg/m-3	C, all O	SeaWifs
Chlorophyll A	spatial max 1997-2000	Cont	mg/m-3	C, all O	SeaWifs
Chlorophyll A	spatial mean of temporal mean for 1997-2000	Cont	mg/m-3	C, all O	SeaWifs
Chlorophyll A	std	Cont	mg/m-3	C, all O	SeaWifs

Terrestrial variables

Terrestrial	Runoff	annual mean	Cont	mm/yr	C, T	World Runoff
Terrestrial	Runoff	monthly mean	Cont	mm/yr	C, T	World Runoff
Terrestrial	Runoff	Intra-Annual Std Dev	Cont	mm/yr	C, T	World Runoff
Terrestrial	Runoff	Intra-Annual Range	Cont	mm/yr	C, T	World Runoff
Terrestrial	Runoff	relative % std. Dev. Of intra-annual runoff	Cont	rel% stdev.	C, T	World Runoff
Terrestrial	Runoff	Max Month	Cont	mm/yr	C, T	World Runoff
Terrestrial	Runoff	Min Month	Cont	mm/yr	C, T	World Runoff
Terrestrial	Cell Landcover	% Water	Cont		T, C	UMD World Landcover
Terrestrial	Cell Landcover	% Evergreen Needleleaf Forest	Cont		T, C	UMD World Landcover
Terrestrial	Cell Landcover	% Evergreen Broadleaf Forest	Cont		T, C	UMD World Landcover
Terrestrial	Cell Landcover	% Deciduous Needleleaf Forest	Cont		T, C	UMD World Landcover
Terrestrial	Cell Landcover	% Deciduous Broadleaf Forest	Cont		T, C	UMD World Landcover
Terrestrial	Cell Landcover	% Mixed Forest	Cont		T, C	UMD World Landcover
Terrestrial	Cell Landcover	% Woodland	Cont		T, C	UMD World Landcover
Terrestrial	Cell Landcover	% Wooded Grassland	Cont		T, C	UMD World Landcover
Terrestrial	Cell Landcover	% Closed Shrubland	Cont		T, C	UMD World Landcover
Terrestrial	Cell Landcover	% Open Shrubland	Cont		T, C	UMD World Landcover
Terrestrial	Cell Landcover	% Grassland	Cont		T, C	UMD World Landcover
Terrestrial	Cell Landcover	% Cropland	Cont		T, C	UMD World Landcover
Terrestrial	Cell Landcover	% Bare Ground	Cont		T, C	UMD World Landcover
Terrestrial	Cell Landcover	% Urban and Built-up	Cont		T, C	UMD World Landcover
Terrestrial	Soil Texture	coarse to fine	Discr	coarse-fine = 1 - 5	T, C	Zobler Soil Texture
Terrestrial	Soil	kgC/m2 (0-30m)	ScDisc	kgC/m2,	T, C	ISRIC-WISE Soil

	Organic C			0-.3 m		Properties	
Terrestrial	Soil Organic C	kgC/m2 (0-1m)	ScDisc	kgC/m2, 0-1 m	T, C	ISRIC-WISE Properties	Soil
Terrestrial	Soil Carbonate C	kgC/m2 (0-1m)	ScDisc	kgC/m2, 0-1 m	T, C	ISRIC-WISE Properties	Soil

River Basin Variables

Basin	Basin Population Density			km-2	C	BAHC World Basins (UNH)
Basin	Basin Population				C	BAHC World Basins (UNH)
Basin					C	BAHC World Basins (UNH)
Basin	Basin Area			km2	C	BAHC World Basins (UNH)
Basin	Basin Runoff			m3	C	BAHC World Basins (UNH)
Basin	Basin ID				C	BAHC World Basins (UNH)
Basin	Basin Runoff	min month	Cont	m3	C	BAHC World Basins (UNH)
Basin	Basin Runoff	max month	Cont	m3	C	BAHC World Basins (UNH)
Basin	Basin Runoff	avg month	Cont	m3	C	BAHC World Basins (UNH)
Basin	Basin Runoff	total annual	Cont	m3	C	BAHC World Basins (UNH)
Basin	Basin Runoff	Intra-annual std. dev.	Cont	m3	C	BAHC World Basins (UNH)
Basin	Basin Runoff	relative % std. dev. of intra-annual runoff (unbiased)	Cont	m3	C	BAHC World Basins (UNH)

Appendix V LOICZ Biogeochemical Budgets Database

Biogeochemical budgets for about 170 estuarine and coastal ocean sites have been developed by LOICZ scientists and published in workshop reports (Dupra et al. 2000a, 2000b, 2000c, 2001a, 2001b; Smith and Crossland 1999; Smith at al. 1997, 1999), and posted to the Biogeochemical Modelling web site (http://data.ecology.su.se/MNODE). More sites are being described and the listing of locations (A, below). Summary variables (B, below) for each site have been compiled and included in a database associated with the typology database. The listings are current 1 November 2001. Details can be obtained from the LOICZ Typology Database web site (www.kgs.ukans.edu/Hexacoral/Environdata /envirodata.html).

A. Location of Biogeochemical Budget Sites

(North latitude and East longitude are positive; South latitude and West longitude are negative)

Longitude	Latitude	System Number	System Name
113.5900	22.5700	1.0000	Pearl River Estuary
114.7000	22.5000	2.0000	Mirs Bay
113.0800	22.0100	3.0000	Aimen Estuary
113.3900	22.1300	4.0000	Modaomen Estuary
118.0000	24.4500	5.0000	Jiulong Bay
137.9000	-1.6000	6.0000	Mamberamo Estuary
103.1000	5.3500	7.0000	Kuala Terengganu Estuary
122.1700	14.1500	8.0000	Calauag Bay
123.8800	13.5200	9.0000	Lagonoy Bay
119.9000	16.3500	10.0000	Lingayen Gulf
120.7800	14.5500	11.0000	Manila Bay
123.0800	13.5000	12.0000	Ragay Gulf
123.1600	13.9300	13.0000	San Miguel Bay
123.8900	12.9000	14.0000	Sorsogon Bay
120.2100	14.7900	15.0000	Subic Bay
124.6800	11.3600	16.0000	Carigara Bay
125.7800	6.7400	17.0000	Davao Gulf
125.1200	10.7000	18.0000	Sogod Bay
99.6700	9.2000	19.0000	Bandon Bay
101.5000	13.7500	20.0000	Bangpakong Estuary
100.5500	14.0500	21.0000	Chao Phraya Estuary
100.1800	8.3700	23.0000	Pakphanang River
99.7500	14.5000	25.0000	Tachin River
106.0600	9.7200	26.0000	Hau River
107.7300	16.3600	27.0000	Cau Hai Lagoon
109.2700	12.2200	28.0000	Nha Trang Bay
108.1000	10.8000	29.0000	PhanTheit Bay
109.5000	12.6000	30.0000	VanPhong Bay
106.5000	9.8000	31.0000	Tien Estuary
128.9000	35.1000	34.0000	Nakdong Estuary
127.8000	34.9000	35.0000	Sumjin Estuary
124.3000	39.8000	36.0000	Yalujiang estuary
124.0000	36.0000	37.0000	Yellow Sea system
120.1000	23.1000	38.0000	Chiku Lagoon
120.2000	22.7000	39.0000	Tapong Bay
120.1000	23.0000	40.0000	Tsengwen Estuary
121.4000	25.2000	41.0000	Tanshui Estuary
106.2000	-6.0000	42.0000	Teluk Banten Bay
130.8000	33.9000	43.0000	Dokai Bay

131.8200	43.2700	45.0000	Ussuriyskiy Bay
145.2700	-15.5300	46.0000	Annan
153.0300	-30.6500	47.0000	Bellinger
153.1700	-27.3700	48.0000	Brisbane
153.5500	-28.5300	49.0000	Brunswick
153.0300	-27.1500	50.0000	Caboolture
147.0000	-18.0000	51.0000	Central Great Barrier Reef
153.3500	-29.4300	52.0000	Clarence
115.8000	-32.2000	53.0000	Cockburn Sound
145.4300	-16.2800	54.0000	Daintree
143.5000	-8.5000	56.0000	Fly River Estuary
152.8700	-31.4200	57.0000	Hastings
175.0000	-36.5000	58.0000	Hauraki Gulf
151.8000	-32.9000	59.0000	Hawkesbury-Nepean
142.2000	-11.1500	60.0000	Jardine
150.8000	-34.0000	61.0000	Lake Illawara
147.0000	-38.0000	62.0000	Lakes Victoria-Wellington
147.0000	-38.0000	62.0000	Lakes Victoria-Wellington
153.3300	-27.6800	63.0000	Logan
153.0500	-30.9000	64.0000	Macleay
152.5000	-31.8700	65.0000	Manning
174.3000	-37.0000	66.0000	Manukau Harbour
146.1200	-17.6000	67.0000	Moresby
153.0200	-30.6500	68.0000	Nambucca
174.0000	-41.1000	69.0000	Pelorus Sound
145.0000	-38.0000	70.0000	Port Phillip Bay
153.5800	-28.8800	71.0000	Richmond
114.0000	-26.0000	72.0000	Shark Bay
137.0000	-34.3000	73.0000	Spencer Gulf
115.9000	-32.0000	74.0000	Swan-Canning Estuary
153.5500	-28.1700	75.0000	Tweed
117.3000	-35.0000	76.0000	Wilson Inlet
-42.2000	-22.8100	77.0000	Araruama lagoon
-73.5800	-45.5000	78.0000	Aysen
-111.5000	26.6500	79.0000	Bahia Concepcion
-107.6300	24.4200	80.0000	Bahia de Altata-Ensenada del Pabellon
-88.1000	18.6100	81.0000	Bahia de Chetumal
-65.0000	-42.7400	82.0000	Bahia Nueva
-115.9700	30.4500	83.0000	Bahia San Quintin
18.0000	57.0000	84.0000	Baltic Proper
18.0000	57.0000	84.0000	Baltic Proper
12.0000	55.0000	85.0000	Belt Sea
-71.0000	42.5000	86.0000	Boston Harbor
23.0000	64.0000	87.0000	Bothnian Bay
23.0000	64.0000	87.0000	Bothnian Bay
19.0000	62.0000	88.0000	Bothnian Sea
19.0000	62.0000	88.0000	Bothnian Sea
-48.6000	-27.0000	89.0000	Camboriu Estuary
-171.7000	-1.9000	90.0000	Canton Atoll lagoon
-93.8300	18.3500	91.0000	Carmen-Machona Lagoons
-93.1700	15.4500	92.0000	Carretas-Pereyra
-92.8300	15.2200	93.0000	Chantuto-Panzacola
-76.2000	38.2000	94.0000	Chesapeake Bay
-157.4000	2.0000	95.0000	Christmas Island lagoon
21.0000	55.0000	96.0000	Curonian Lagoon

-88.6700	21.4300	97.0000	Dzilam Lagoon
125.0000	31.0000	98.0000	East China Sea
-110.3700	24.1300	99.0000	Ensenada de la Paz
-112.3100	29.3300	100.0000	Estero El Sargento
-111.5300	28.7500	101.0000	Estero La Cruz
-80.0000	-2.6700	103.0000	Guayaquil Estuary
19.1000	54.3000	104.0000	Gulf of Gdansk
-85.0000	10.0000	105.0000	Gulf of Nicoya
23.0000	58.0000	106.0000	Gulf of Riga
130.3000	33.6000	107.0000	Hakata Bay
17.7000	59.0000	108.0000	Himmerfjard
-5.5000	52.7000	109.0000	Irish Sea
136.8000	34.8000	110.0000	Ise Bay
-157.5000	21.5000	111.0000	Kaneohe Bay
-157.5000	21.5000	111.0000	Kaneohe Bay
12.0000	57.0000	112.0000	Kattegat
3.5000	6.5000	113.0000	Lagos Lagoon
-90.4100	20.8300	114.0000	Laguna de Celestun
-89.7000	21.2700	115.0000	Laguna de Chelem
-91.6900	18.6700	116.0000	Laguna de Terminos
-97.5000	24.0000	117.0000	Laguna Madre
-64.1300	10.5200	118.0000	Laguna Restinga
-9.0000	51.5000	119.0000	Lough Hyne
-42.7000	-22.9300	120.0000	Marica-Guarapina
-93.1500	18.3800	121.0000	Mecoacan Lagoon
-71.3000	41.6000	122.0000	Narragansett Bay
-86.7600	21.1000	123.0000	Nichupte Lagoonal system
-84.4000	30.0000	124.0000	Ochlockonee Bay
135.2000	34.5000	125.0000	Osaka Bay
-48.5000	-25.5000	126.0000	Paranagua
-43.0700	-22.9500	127.0000	Piratininga-Itaipu
-87.0300	21.5800	128.0000	Ria Lagartos
-8.8000	42.2000	129.0000	Ria of Vigo
-56.7000	-34.9000	131.0000	Rio de la Plata estuary
-56.0000	-35.0000	131.0000	Rio de la Plata front
-37.3300	-11.0000	132.0000	Rio Piaui
-37.0300	-10.8700	133.0000	Rio Sergipe
-114.3800	29.8200	134.0000	San Luis Gonzaga
-1.3000	50.8000	135.0000	Solent Estuary
3.0000	57.0000	136.0000	Southern North Sea
14.3500	53.7500	137.0000	Szczecin Lagoon
-105.5300	22.1300	138.0000	Teacapan-Agua Brava-Marismas Nacionales
138.9000	34.5000	139.0000	Tokyo Bay
-123.0000	38.0000	140.0000	Tomales Bay
-88.0000	30.5000	141.0000	Mobile Bay
-84.9700	29.6700	142.0000	Apalachicola Bay
39.4700	-6.1900	143.0000	Chwaka Bay
40.1500	-3.2000	145.0000	Malindi Bay
9.7000	3.9000	146.0000	Cameroon estuarine system
8.2800	4.8000	147.0000	Rio-del-Rey system
12.3000	-6.0500	148.0000	Congo (Zaire) River estuary
24.8500	-34.1500	150.0000	Kromme estuary
25.0700	-33.9700	151.0000	Gamtoos estuary
25.6300	-32.8700	152.0000	Swartkops estuary
25.4200	-33.7200	153.0000	Sundays estuary

32.0500	-28.8000	154.0000	Mhlathuze estuary
32.0500	-28.8000	154.0000	Mhlathuze estuary
32.0500	-28.8000	154.0000	Mhlathuze estuary
32.0500	-28.8000	154.0000	Mhlathuze estuary
30.5000	-29.2200	155.0000	Thukela estuary
-122.0000	37.7500	156.0000	North San Francisco Bay
-122.0000	37.7500	157.0000	South San Francisco Bay
73.8400	16.1700	158.0000	Mandovi Bay
4.5000	43.0000	159.0000	Gulf of Lions
22.7500	40.4200	160.0000	Inner Thermaikos Gulf
18.4500	40.2000	162.0000	Lake Alimini Grande
12.2900	44.8000	163.0000	Sacca di Goro lagoon
8.6700	39.8300	164.0000	S'Ena Arrubia
12.2300	44.5800	165.0000	Valle Smarlacca
12.2800	44.6300	166.0000	Valli di Comacchio
-6.2700	34.8300	167.0000	Moulay Bousselham
31.5000	46.6000	168.0000	Dnieper-Bug
30.4800	46.0800	169.0000	Dniester
33.0000	45.3300	170.0000	Donuzlav
32.0200	46.5900	171.0000	Malii Adzalik

B. Variables for Biogeochemical Budget Description and Analysis

cell id _entry number
Longitude
Latitude
System Number
System Name
checked by
Budget description
Continent/Country
layers
horizontalmultiplebox
seasoncode_0annual_1annualavg_2season
Annual or averageis1_seasonalis0
Area budgeted
Depth
Volume
texchange
DDIP daily
DDIP annual
DDIN daily
DDIN annual
pminusr daily
nfixminusdenit daily
DIPload daily
DIPload annual
DINload daily
DINload annual
Ssyst
Socn
DIPsys
DIPocn
DINsys
DINocn
VR daily
VR annual
VQ daily
VQ annual
Vx_Vd daily
Vx_Vd annual
thydraulic
drainage basin area
thydraulicovrtexchange
DDINovrDDIP
DDINovr DINloadovrarea
DDIPovr DIPloadovrarea
SoceanminusSsyst
DIPsysminusDIPocean
DINsysminusDINocean
DINsysminusDINoceanovrDIPsysminusDIPocean
DINsysovrDIPsys
DINocnovrDIPocn

Appendix VI: Clustering and LOICZView

This appendix contains material adapted from the WLV tutorial and help material that can be found in complete form on the report CD-Rom and on the web-sites. It is intended to provide a basic understanding of the tool and how it is used.

VI-A: Clustering

Clustering involves grouping data points together according to some measure of similarity. One goal of clustering is to extract trends and information from raw datasets. An alternative goal is to develop a compact representation of a dataset by creating a set of models that represent it. The former is generally the goal in geographic information systems, the latter generally the goal of pattern recognition systems. Both fields use similar, or identical techniques for clustering datasets.

There are two general types of clustering that are used on geographic data: supervised and unsupervised clustering. Supervised clustering uses a set of example data to classify the rest of the dataset. For example, consider a set of colored balls (all colors) that you want to classify into three groups: red, green, and blue. A logical way to do this is to pick out one example of each class - a red ball, a green ball, and a blue ball - and set them each next to a bucket. Then go through the remaining balls, compare each ball to the three examples and put each ball in the bucket whose example it matches the best.

This example of supervised clustering is illustrative because there are two potential problems. First, the result you get is going to be dependent upon the balls you select as examples. If you were to select a red, an orange and a blue ball, then it might be difficult to classify a green ball. Second, unless you are careful about selecting examples, you may select examples that don't represent the distribution of data. For example, you might select red, green and blue balls, only to discover that most of the colored balls were cyan, purple and magenta (which are in between the other 3 colors). This shows the importance of selecting representative samples when you execute supervised clustering.

Unsupervised clustering, on the other hand, tries to discover the natural groupings inside a dataset without any input from a trainer. The main input a typical unsupervised clustering algorithm takes is the number of classes it should find. In the colored balls case, this would be like dumping them into an automatic sorting machine and telling it to create three piles. The goal of unsupervised clustering is to create three piles where the balls within each pile are very similar, but the piles are different from one another.

WLV implements both unsupervised and supervised clustering. The unsupervised clustering algorithm is the k-means algorithm, originally described by MacQueen (1965). It incorporates some modifications to improve its robustness to missing data and poorly-behaved datasets.

One of the most important characteristics of any supervised or unsupervised clustering process is how to measure the similarity of two data points. In the case of geographically indexed data, a data point is a geographic location. A single location will generally have multiple variables associated with it. So we can define a similarity measure between two data points based on the values of their variables.

In WLV, the clustering tab lets the user control all of the important parameters for supervised or unsupervised clustering. For supervised clustering, the only relevant parameter is the distance measure, or similarity measure. Typically, the scaled distance measure is the first one to try on geographic datasets.

For unsupervised clustering, all of the parameters and checkboxes affect the outcome of the algorithm. The most important box is the *Number of Clusters* parameter that specifies how many classes the algorithm will create from the data. If you are at a loss as to how many clusters there should be, try using the minimum description length [MDL] tool. Often, the best thing to do is experiment. Start with ten and then go up or down depending upon how you like the results.

The remaining parameters on the left side of the tab control mostly internal aspects of the k-means clustering algorithm. The *Maximum Number of Iterations* parameter specifies how long the program waits for a single clustering run to finish. If you have a large or complex dataset, it is reasonable to make this number larger. There is almost no reason to make it smaller.

The *Number of Clustering Runs* parameter is kind of like the quality *vs* speed slider on a color printer dialog window. When you make this number smaller (e.g., 1 or 2), you will get results faster, but they may not be as good. When you really want a high quality result, boost the number to a value from 10-20. Using the value 5 for this parameter seems to be a good tradeoff of speed versus quality.

Finally, the *Random Seed* parameter controls the random numbers used by the clustering algorithm (which is a stochastic, or randomized process). If you want to duplicate a previous clustering, for example, set the random seed to the previous value. This will guarantee that you get identical results. Most of the time, however, you will not need to change this parameter.

The *K-means*/*Region Growing* checkboxes are currently not worth changing. Make sure K-means is checked as in the above example.

VI-B: Visualization

The visualization tab is where you look at the results of classification, or clustering runs. There are a variety of ways to look at the data; which one is best for your situation depends upon what you are trying to accomplish. The following chart gives a quick overview and identifies the strengths of each visualization option.

Visualization Method	Summary description	Strengths of this method
Visualize with Standard Axes	Plots a 2D map of the data points, colored by cluster, using longitude/latitude coordinates and a geographic projection.	This visualization is useful for seeing geographic relationships and making high-level comparisons with expert analyses.
Visualize with User-Selected Axes	Plots the data in 2D using the user-selected variables as coordinates. Each cluster is displayed in a unique color.	This visualization is useful for seeing how well the clusters map to natural breaks in the data space and discovering outliers and potentially bad data.

Overlay Visualization (standard axes)	Plots a standard visualization of the data points, and then overlays one selected variable on top of it. The overlaid variable is divided into classes, with each class receiving a different color.	If the variable was not used to generate the clusters, this is one way to examine how well the clusters predict a particular variable or expert classification. If the variable was used to generate the clusters, this provides a graphical representation of how the clusters track, or are influenced by the variable.
Dual Visualization (standard axes)	Plots two clusterings of the same dataset using latitude/longitude, one on top of the other.	This visualization is useful for comparing two clusterings created using different variables or variable weightings.

For all visualizations, if the *relate colors to similarity* box is not checked, the colors are selected for maximum differentiation between the clusters. If the box is checked, then the colors are selected so that similar clusters get similar colors.

Visualize with Standard Axes

To execute a standard visualization, select a file in the large list box in the View tab and then click on the *Visualize* button. For standard axes (latitude/longitude), make sure the *Standard Axes* checkbox is checked.

The visualization screen provides a large amount of information about the dataset and the clustering results (for examples, see the WLV tutorial on-line, or the CD-ROM version of this report). To begin with, when you click on a file to visualize inside the *View* tab the fields to the right of the file display information about the cluster file. The top line indicates the name of the dataset, and whether the clusters were created directly, or are the result of merging together a larger number of clusters. The second line indicates the method used to classify the data and the distance measure. Finally, the third line provides a unique time stamp. This information lets you quickly identify exactly which clustering result you want to visualize.

The *image height* field lets you control the height of the visualization image that will appear below the screen shown above. In this example it is 200, which permits all of the visualization information to fit on the screen at once. For printing, or visualizing larger datasets, you may want to make this value larger. Note that the bigger you make it, the longer it takes to upload the images to your computer.

In the visualization image that is created after the dataset is selected and the *Visualize* button is clicked, each cluster will have a unique color and a checkbox next to some highlighted text in the identical color. If you uncheck a box, the associated cluster will turn grey. Clicking on the *Select All* or the *Deselect All* buttons in the image has the effect of checking or unchecking all of the boxes. Being able to turn a cluster on and off makes it easier to see the extent of particular clusters in the image. If you click on the colored text, the program will send up a new window that has statistical information about that cluster, including the mean, standard deviation and max and min values for each variable.

If you click on the visualization image itself, you will get a large cross-hair, and the latitude and longitude of the closest data point will display on the two text fields. You can then get the actual data values for that data point by clicking on the *Data point info* button. Points that may be of particular interest to examine are the archetype points, which are shown at double size in the visualization. The archetype point in each cluster is the data point that is closest to that cluster's mean value. Thus, the archetype is a typical point for that cluster.

The *Cluster Summary* button is a way of saving all of the key information associated with a visualization in a compact form. You can choose whether the cluster summary is in *pdf* or *html* format (If you want to include the cluster summary information in another document, choose the html format.)

In some situations, you may wish to select a subset of the clusters to recluster in order to get a finer resolution in some areas. The *Create dataset from selected clusters* builds a new dataset from the currently selected clusters, just as it says. You can then work with this subset of the data as an independent dataset and recluster it as you wish.

Finally, the *View image as one Layer (for downloading)* button is also self-explanatory. If you want to include the visualization image in another document, use this button to get a useful version of the image. The standard visualization map is actually multiple layers to facilitate turning individual clusters on and off.

Visualize with User-Selected Axes

To execute a visualization with user-selected axes, first un-check the *Standard Axes* checkbox in the View tab. Then select a cluster file in the large list box and click on the *Visualize* button. WLV will then ask you to select which variables you wish to use as axes for plotting. After selecting the axes, click on the *Visualize* button in the lower frame to continue. The functionality of the resulting screen is similar to the standard visualization. The only major difference is the change in axes.

Overlay Visualization (standard axes)

To execute an overlay visualization, select a cluster file in the large list box in the View tab, then click on the *Overlay* button. Then select which variable to overlay from the options that appear in a menu box below the screen. If the variable is a continuous variable, enter how many classes to divide it into for the visualization. Then click *Select* to continue.

In the overlay case, the colored text markers below the image correspond to subdivisions of the overlaid variable. Probably the most important feature of this visualization is the *overlay statistics* button. This brings up a window with tables indicating the percentage of overlap between the variable classes and the computed clusters.

When executing an overlay visualization, you can use either a discrete or a continuous variable. The program will automatically determine whether a variable is discrete. If the variable appears to be continuous, it will divide the overlay variable into the specified number of classes. Currently, the program simply divides the overlay variable into equal magnitude divisions.

Dual Visualization

To execute a dual visualization, first select a cluster file in the large list box in the View tab, then click on the *Dual* button. Then select which cluster file to overlay and click on *Select* to continue.

This visualization is intended to permit visual comparison of two different clusterings of the same dataset. In addition, like the overlay visualization, it provides statistics on the overlap of the different clusters.

In the dual visualization, the checkboxes control the overlaid cluster result. The background image (what you get when all of the check boxes are unchecked) is the base visualization.

In addition to the visualization, you can also get the overlap statistics, and statistics on both clusterings. The highlighted text below the checkboxes gives access to this data.

VI-C: Variable Selection

One of the key decisions a user must make before executing the data analysis tools is to select the variables to use. It is not necessary to use all of the variables in a dataset, and often this is not desirable.

To select and weight the variables use the *select variables* button on the left of the WLV screen. You do not have to be in the Data tab to select variables. Clicking on the *select variables* button brings up a list of all of the variables in the dataset, as shown below.

Next to each variable is a checkbox and a text box. The checkbox selects whether a variable is to be used (active). The text box indicates the relative weight of the variable. If all of the weights are the same, then each variable is treated equivalently during the data analysis. Variables with higher weights will receive proportionately more importance in subsequent analyses. Weights can be any non-negative number, including decimals. It is good to try the first analysis of a dataset with uniformly weighted variables (the default values).

Once you have chosen the active variables and specified their weights, **you must click the button that says *set these variables as active* at the bottom of the variable list in order to save your settings.** After you have saved the active variables, WLV will print out the current set of active variables and their weights on the screen.

VI-D: Principal Components Analysis

Principal components analysis [PCA] is a tool for manipulating and visualizing a dataset, and for verifying and evaluating a particular clustering. It can be an extremely useful tool for understanding the relationships in a dataset, but you have to be careful how you interpret the results.

Overview

PCA is, at its essence, a rotation and scaling of a dataset. The rotation is selected so that the axes are aligned with the directions of greatest variation in the dataset. The scaling is selected so that distances along each axis are comparable in a statistical sense. Rotation and scaling are linear operations, so the PCA transformation maintains all linear relationships.

The rotation and scaling for PCA are given by the eigenvectors and eigenvalues of the covariance matrix. The covariance matrix contains the relationships (correlations) between the variables in the dataset.

One way to think about PCA is that it generates a set of directions, or vectors in the data space. The first vector shows you the direction of greatest variation in the dataset; the second vector shows the next direction of greatest variation, and so on. The amount of variation represented by each subsequent vector decreases monotonically.

In many datasets, the variables are related to one another (sea surface temperature and air temperature along a coastline, for example). What this means is that there are usually fewer directions (vectors) of useful variation than there are variables in the dataset. The directions of useful variation are sometimes called *factors*. The factors are weighted combinations of the variables, where the weights describe the influence of each variable on that factor. If there are fewer important factors than there are variables in the data, then we can express the dataset with fewer variables. Furthermore, the new variables are independent, which is a good property for clustering and analysis.

So once you've executed a PCA, what can you do? The following table gives an overview.

What can you do?	Summary	What's it good for?
Examine the eigenvalues associated with each principal component	Look at a plot of the eigenvalues from the first to the last principal component. The plot will generally fall off sharply from the first component and then level off.	This plot gives you an idea of how many independent *factors* there are in the dataset. When the plot levels off, the remaining principal components do not explain much about the dataset. Therefore, only the first N principal components really matter in terms of explaining the variation in the data.
Examine the principal components	Look at the numerical values associated with each variable for the first 2-3 principal components	This tells you what variables are the most important for each principal component. Variables with large magnitude weights in the principal component vector are more important. Variables with similar magnitudes are correlated.

Transform the dataset	Project each data point onto the first N principal components, where N is determined as noted above (by looking at the plot of the eigenvalues).	This reduces the size of the dataset and makes the variables independent, both of which generally make the clustering algorithms more effective.
Visualize the data projected onto the first 2-3 principal components	Take the dot product of each data point with the first 2 or 3 principal components. The resulting plot shows the data in the principal component space (2D or 3D).	This is a good space in which to view the data. You can project the clusters into this space and verify whether they form coherent groupings. It may also give you a sense as to how many natural groupings exist in the data space

There are lots of other sites devoted to PCA, factor analysis, and their applications. One that is a nice description with biological examples is http://www.okstate.edu/artsci/botany/ordinate/PCA.htm. If you are comfortable with statistics, you might try this high-level discussion of PCA and factor analysis: http://www.statsoftinc.com/textbook/stfacan.html.

Principal Components Analysis in WLV

The *Eigen* tab in WLV gives you access to the PCA tools. The screen shot below shows the control panel for the analysisAfter selecting a dataset, the Perform Eigenanlysis button creates an eigen file which can be viewed.

In order to get a plot of the eigenanalysis results, you have to execute the following steps:

1. Perform an eigenanalysis on the dataset selected by clicking the *Eigen* button on the *Eigen* tab. Once the computer has completed the eigenanalysis, the dataset's name will appear in the *eigenfiles* list box.

2. Select an eigenfile from the list box to view.

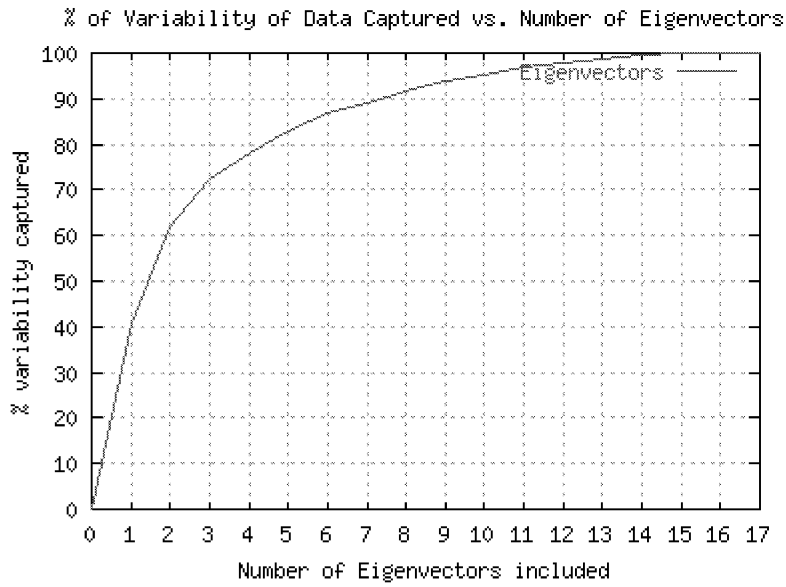
3. Select which principal components to use in the visualization. The default values are the first two principal components.

4. If you have executed a clustering on this dataset, you may want to associate a clustering with the visualization. To do this, click the *Associate a clustering for visualization* checkbox.

5. Click on the *View* button to generate the visualization. Like the standard visualization screen, if you have associated a clustering with the visualization, you can turn clusters on and off and view the cluster data. Likewise, you can generate a cluster summary in either PDF or HTML format.

Examining the eigenvalues and eigenvectors

As noted above, it is useful to have a plot of the eigenvalues. If you click on the *EigenInfo* button in the visualization frame it will bring up a window with a plot of the eigenvalues, and the numerical values for the eigenvectors. Below is an example plot of the eigenvalues for the AustraliaCoast dataset (all variables).



This example shows a typical eigenvalue plot. Depending upon your point of view, it would be possible to argue that anywhere from 4-10 of the principal components are important. The principal components from 10-17 account for less than 5% of the variability of the dataset.

3-D visualization

WLV also permits visualization of the dataset in 3D, projected onto the first three principal components. To assist in visualizing the 3D space, the 3D projection is animated (see example on website, or the CD-ROM of this report).

VI-E: Minimum Description Length

"Pluralitas non est ponenda sine neccesitate"

- Friar William of Occam

Occam's razor states that "*entities should not be multiplied unnecessarily."* One of the major questions when trying to cluster data is how many clusters to create. Sometimes we have an *a priori* answer to this question based on knowledge of the dataset. Other times we have to fit the data into a certain pre-specified number of categories or management units. When exploring a dataset for the purpose of discovering relationships within it, however, it is important to avoid preconceived notions of the complexity of the data.

One way to explore the appropriate number of clusters is to simply try a number of different clusterings and see what provides the most interesting result. We can also use a concept like Occam's Razor to give us guidance. The main point of Occam's Razor applied to clustering is that, at some point, having more clusters for a given dataset is not worth the added information it may provide.

The Minimum Description Length [MDL] principle is a mathematical method for applying Occam's Razor to models for data - a set of clusters is a model for a given dataset. The MDL principle says that the model that takes the least number of bits to represent is the best model for a set of data. In the case of clusters, we can encode the number of cluster parameters and the representational error as the amount of information it takes to represent the data. When these two are balanced, then we have the optimal number of clusters.

The MDL tab in WLV allows the user to execute an MDL analysis of a particular dataset. It calculates many clusterings with different numbers of clusters and calculates the description length for each run. It then provides a plot of the description length values and suggests a range of values for the number of clusters to use. The screen shot below demonstrates a typical result for the AustraliaCoast dataset.

In our experience with the MDL tool, the number of suggested clusters tends to be higher than experts have found useful. However, the low end of the suggested MDL range tends to be within an acceptable range. If you consider the graph of MDL values, it is clear that from 10 to 16 clusters the descriptions lengths all fall within a similar range. For this dataset, experts have found 10-12 clusters to be a useful number. Below that, important features in the coastline get merged together and lost. Above 16, the value of additional clusters to human analysis is unclear.

To execute an MDL analysis, first select the dataset to analyze. Then enter a starting and ending number of clusters to examine. Note that as the number of clusters gets higher, the clustering takes longer. Keep the *End* number of clusters as small as is reasonable for faster analysis. Once these fields are set, then click on *Do MDL*. When the analysis is complete, you can click on the MDL File in the list box and then click *View* to see the chart and plot of the MDL results. Clicking on the *Variables* button will show you the active variables for that particular MDL analysis. Note that you will usually get different MDL results for different variables.

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Use the MDL tool as a guide in your exploration. As with all tools, use your judgement as to whether the results make sense. If they do not make sense, figuring out why can often lead to new insights about the dataset.

We have done our best to ensure the correctness of the underlying tools, but we can make no guarantees about the correctness or utility of the results. What you get out of WLV is largely dependent upon what you put into it. Furthermore, WLV is still under development as we continue to add features and tools. The help files on the web-site and in the CD-ROM are intended to help users understand how to effectively use WLV for their own tasks.

If you either A) have a suggestion about how to improve WLV, or B) believe you've found an error in one of the tools, please email maxwell@swarthmore.edu. New users may use one of the numbered user accounts (user##) or ask for a username and password by emailing the address above.

Appendix VII List of abbreviations and acronyms

AGSO	Australian Geological Survey Organisation
BAHC	Biospheric Aspects of the Hydrological Cycle
C	Carbon
CABARET	Computer Assisted Budget Analysis, Research, Education and Training
CRC	Cooperative Research Centre
cv	Coefficient of variation
DEM	Digital Elevation Model
DIN	Dissolved inorganic nitrogen
DIP	Dissolved inorganic phosphorus
DPSIR	Driver-Pressure-State-Impact-Response
ELOISE	European Land-Ocean Interaction Studies
GEF	Global Environmental Facility
GLOSS	Global Sea Level Observing System
IGBP	International Geosphere Biosphere Programme
LOICZ	Land Ocean Interactions in the Coastal Zone
MDL	Minimum Description Length
N	Nitrogen
nfix-denit	Net nitrogen fixation minus denitrification
NOAA	National Oceans and Atmospheric Administration
NOPP	National Oceanographic Partnership Program
OBIS	Ocean Biogeographic Information System
P	Phosphorus
PCA	Principal components analysis
p-r	Net primary production minus respiration
RIKZ	Rijksinstituut voor Kust en Zee
SST	Standard salinity and temperature
Std dev	Standard deviation
TOPEX	Joint US/French Ocean Topography Experiment
UABC	Universidad Autonoma de Baja California
UNEP	United Nations Environment Programme
UNH	University of New Hampshire
WLV	Web LOICZView
WWF	World Wildlife Fund