

## LOICZ NEWSLETTER

## Changes in Mississippi River Nutrient Fluxes and Consequences for the Northern Gulf of Mexico Coastal Ecosystem<sup>1</sup>

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Nutrient over-enrichment from anthropogenic sources is one of the major stresses impacting coastal ecosystems. There is increasing concern in many areas around the world that an oversupply of nutrients from multiple sources is having pervasive ecological effects on shallow coastal and estuarine areas (Nixon 1995, Diaz and Rosenberg 1995). These effects include reduced light penetration, loss of aquatic habitat, harmful algal blooms, a decrease in dissolved oxygen (=hypoxia) and impacts on living resources. The largest zone of oxygen-depleted coastal waters in the United States, and the entire western Atlantic Ocean, is found in the northern Gulf of Mexico on the Louisiana/Texas continental shelf influenced by the freshwater discharge and nutrient flux of the Mississippi River system that drains much of the North American continent (Rabalais et al. 1991, 1996, 1998, 1999).

**General dimensions of hypoxia**—The mid-summer bottom areal extent of hypoxic waters ( $\leq 2$  mg/l O<sub>2</sub>, or ppm) in 1985-1992 averaged 8,000 to 9,000 km<sup>2</sup> but increased to 16,000 to 20,000 km<sup>2</sup> in 1993-1999. The estimated extent was 12,500 km<sup>2</sup> in mid-summer of 1998. Hypoxia covers broad regions of the

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shelf for extended periods in mid-summer. A compilation of thirteen mid-summer shelfwide surveys (1985-1997) demonstrates that the frequency of occurrence of hypoxia is higher to the west of the discharges of the Mississippi and Atchafalaya Rivers in a down-current direction from their influence (Rabalais et al. 1999) (Figure 1). Hypoxic waters are most prevalent from late spring through late summer and hypoxia is more widespread and persistent in some years than in others. Hypoxic waters are distributed from shallow depths near shore (4 to 5 m) to as deep as 60 m water depth but more typically between 5 and 30 m. Hypoxia occurs mostly in the lower water column but encompasses as much as the lower half to two-thirds of the water column.

**River discharge and flux of materials**—The Mississippi River sys-

tem encompasses 41% of the conterminous United States and delivers an average of 580 km<sup>3</sup> of fresh water to the Gulf of Mexico yearly along with sediment yields of 210 x 10<sup>6</sup> t/yr, 1.6 x 10<sup>5</sup> t/yr nitrate, 0.1 x 10<sup>6</sup> t/yr phosphorus and 2.1 x 10<sup>6</sup> t/yr silica (Turner and Rabalais 1991). The best current knowledge is that the outflows of the Mississippi and Atchafalaya Rivers dominate the nutrient loads to the continental shelf where hypoxia is likely to develop. The 1820-1992 average discharge rate (decadal time scale) for the Mississippi River at Vicksburg is remarkably stable near 14,000 m<sup>3</sup>/s despite significant interannual variability and some decadal trends. Since the 1700s humans have altered the morphology and flow of the Mississippi River so that now 30% is diverted to the Atchafalaya that also captures the flow of the Red River. The discharge of the Atchafalaya increased during the period 1900-1992, primarily as a result of the tendency for the Atchafalaya to capture more of the flow of the Mississippi (until stabilized at 30% in 1977) (Bratkovich et al. 1994). A slight increase in Mississippi River discharge for 1900-1992 is accounted for by an increased discharge in September through December, a period that is much less important in the coastal ocean than spring and summer in the timing of important biological processes that lead to the development of hypoxia or the physical processes important in its maintenance.

Mississippi River nutrient concentrations and loading to the adjacent continental shelf have changed dramatically this century, with an acceleration of these changes in the last four decades depending on the

<sup>1</sup> Modified Executive Summary from Rabalais et al. (1999).

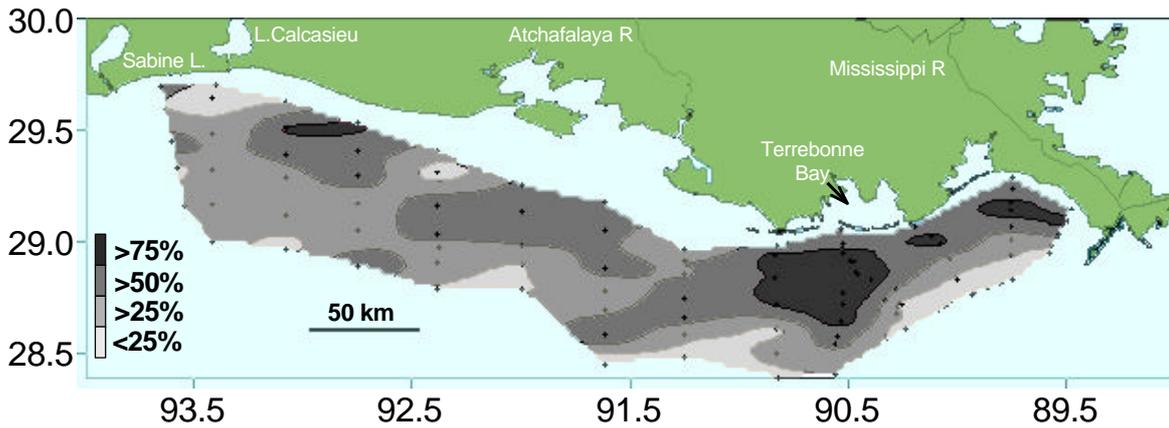


Figure 1. Distribution of frequency of occurrence of mid-summer hypoxia over the 60- to 80-station grid from 1985-1999 (modified from Rabalais et al. 1999).

constituent of concern. The mean annual concentration of nitrate was approximately the same in 1905-1906 and 1933-1934 as in the 1950s, but it has doubled (or tripled depending on the comparative periods) from the 1950s to 1960s (Turner and Rabalais 1991). The increase in total nitrogen is almost entirely due to changes in nitrate concentration (Turner and Rabalais 1991, Goolsby et al. 1999). The mean annual concentration of silicate was approximately the same in 1905-1906 as in the early 1950s, then it declined by 30 to 50%, depending on the analysis or period of record. Concentrations of nitrate and silicate appear to have stabilized, but trends are masked by increased variability in the 1980s and 1990s data. There are no substantial records of total phosphorus concentrations in the lower Mississippi River before 1973 and subsequent values vary greatly among years. Application of a linear least-squares regression on the 1973-1987 data, however, indicates a two-fold increase in the total phosphorus concentration (Justic et al. 1995a). There was no pronounced seasonal peak in nitrate concentration prior to 1960, whereas there was a spring peak from 1975 to 1985. Prior to the 1960s, nitrogen flux closely paralleled river discharge, a pattern that still holds but the load of nitrogen per volume discharge is greater than historically. There is no doubt that the concentration and flux of nitrogen (per unit volume discharge) has increased from the 1950s to 1960s, especially in the spring.

The proportions of dissolved Si, N and P in the lower Mississippi River have changed historically such that they now closely approximate the Redfield ratio (Si:N:P = 16:16:1) (Justic et al. 1995a,b). Thus any single nutrient is more likely to be limiting to phytoplankton production now than historically. Another reasonable hypothesis that follows a more balanced nutrient composition is that surface offshore primary productivity has increased. Fluctuations in the Si:N ratio within the riverine effluents and the offshore waters can affect diatom production and are believed to be major determinants in the coastal food web structure on a seasonal basis, with major implications to oxygen and carbon cycling (Turner et al. 1998).

**Interaction of physics and biology**—The physics of the system and the biological processes are linked and related to the freshwater discharge and nutrient flux of the Mississippi River system. The physics of the system define where hypoxia can occur, and the biological processes of carbon production, flux and respiration lead to oxygen depletion. The high freshwater discharge, general circulation patterns of the Louisiana shelf and the presence of the Louisiana coastal current dictate a stratified system for much of the year, interrupted on occasion by wind-mixing events, notably tropical storms and winter cold fronts.

**Nutrient-enhanced productivity**—The evidence for nutrient enhanced primary production in the northern Gulf of Mexico and its linkage with oxygen depletion in the

lower water column comes from information on a variety of scales—experiments for a parcel of water from a particular locale over a limited time to more integrative measures of ecosystem response (e.g., net production, carbon flux and respiration) and change over broader spatial and temporal scales. The concentrations, total loads and ratios of nutrients (nitrogen, phosphorus and silica) delivered to the coastal ocean influence the productivity of the phytoplankton community as well as the types of phytoplankton that are most likely to grow.

The nutrient most relevant to overall phytoplankton production over the broad region fueling hypoxia is nitrogen, and nitrate-nitrogen makes up approximately two-thirds of the total nitrogen input from the Mississippi River. Silica and phosphorus may also be limiting at some times and places. There is clear evidence that primary production in shelf waters near the delta and to some distance from it are significantly correlated with nutrient inputs (nitrate+nitrite and orthophosphate) (Lohrenz et al. 1999). Similar relationships exist with net production (an indicator of the amount of carbon available for export to the lower water column and sediments) and nitrate flux (Justic et al. 1997). There is also a strong relationship between the net production in surface waters, the amount of carbon exported, the accumulation rates of carbon, and the depletion of oxygen in bottom waters (Rabalais et al. 1999). Spatial and temporal variability in these components is closely related to the amplitude and

phasing of Mississippi River discharge and nutrient fluxes. Thus, there are clear lines of evidence for nitrogen (particularly nitrate) driven phytoplankton production that leads to hypoxia. Although the Mississippi and Atchafalaya Rivers discharge organic matter to the shelf, the principal source of carbon reaching the bottom waters in the northern Gulf influenced by the river effluent and characterized by hypoxia is from *in situ* phytoplankton production (Turner and Rabalais 1994a, Eadie et al. 1994).

#### Long-term changes in the coastal ecosystem

—It follows, and is supported with evidence from long-term data sets and the sedimentary record, that increases in riverine dissolved inorganic nitrogen concentration and loads are highly correlated with indicators of increased productivity in the overlying water column, i.e., eutrophication of the continental shelf waters, and subsequent worsening of oxygen stress in the bottom waters. Evidence comes from changes in diatom production, increased accumulation of diatom remains in the sediments, increased carbon accumulation in the sediments, decreased diversity of selected benthic fauna, and relative changes in selected benthic fauna that indicate a worsening oxygen environment (Turner and Rabalais 1994a,b, Eadie et al. 1994, Nelsen et al. 1994, Rabalais et al. 1996, Sen Gupta et al. 1996). Human activities in the watershed undoubtedly changed the natural functioning of the Mississippi River system. Century-long patterns of freshwater discharge are not evident; thus, the long-term changes on the Louisiana shelf are linked to the quality of the discharge (nutrient loads and ratios of nutrients) and not the amount. Century-long changes are evident in some of the retrospective analyses, however, the most dramatic and accelerating changes have been since the 1950s, when nitrogen loads began to increase, primarily from nitrate inputs, and eventually doubled to tripled over their historic values. The fact that the most dramatic changes in the continental shelf ecosystem have occurred since the 1950s and are coincident with an increase in nitrate load, points to that aspect of human ecology for future manage-

ment scenarios.

Evidence associates increased coastal ocean productivity and worsening oxygen depletion with changes in landscape use and nutrient management that resulted in nutrient enrichment of receiving waters. Nutrient flux to coastal systems, while essential to the overall productivity of those systems, has increased over time due to anthropogenic activities and has led to broad-scale degradation of the marine environment.

**Modeling results**—The northern Gulf of Mexico adjacent to the discharge of the Mississippi River system is an example of a coastal ocean that has undergone eutrophication (increased rate of primary production) as a result of increasing nutrients and that has worsened hypoxic conditions on century-long and accelerating recent decadal time scales. Models that link Mississippi River discharge with Gulf of Mexico hypoxia demonstrate worsening hypoxia in bottom waters with increased freshwater discharge and even worse hypoxia with additional nitrogen accompanying the increased discharge. Conversely, the models show that a reduction in oxygen demand in the lower water column will result from a reduction in nitrogen (and to a lesser degree the phosphorus) load to the surface waters. In other words, hypoxia in the northern Gulf of Mexico can be alleviated to some degree by a reduction in the nutrient loading.

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<sup>2</sup> Full report available at [http://state-of-coast.noaa.gov/bulletins/html/hyp\\_09/hyp.html](http://state-of-coast.noaa.gov/bulletins/html/hyp_09/hyp.html)

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### Silica a key factor

#### LOICZ-SCOPE Workshop on Land-Ocean Nutrient Fluxes: The Changing

#### Silica Cycle, Linköping, Sweden, (3-4 October 1999)

The International Workshop jointly organized by the Universities of Linköping and Stockholm in Sweden, and Hamburg in Germany addressed the overall issue of degradation of water bodies from land-based activities. It was part of a series sponsored and here jointly organised by SCOPE (Scientific Committee on Problems of the Environment) and LOICZ. Special reference was made to the mobilization and retention of silicate on land and its fluxes to the oceans and, *inter alia*:

- (1) Consideration of historical data sets on nutrient inputs to the ocean with emphasis on silicate,
- (2) Assessment of nutrient removal in reservoir lakes behind dams and its effect on the nutrient mix,
- (3) Assessment of the impact of changes in hydrological cycles associated with climate change on land-ocean nutrient fluxes, and
- (4) Investigation of the link be-

tween land-ocean nutrient fluxes and changes in fisheries, biodiversity and the carbon cycle.

### LOICZ strengthens links with East Asia LOICZ-START-IOCAS East Asia Coastal Zone Workshop, Qingdao, China, (12-14 October 1999)

The Institute of Oceanology, Chinese Academy of Sciences (IOCAS) in Qingdao, hosted a first East Asia LOICZ workshop on 12-14 October 1999. Twelve participants from China, Korea, Russia, Vietnam and Japan with correspondent interests expressed from the USA and Europe aimed to consolidate a regional network of researchers and establish a basis for collaborative coastal research and capacity, synthesis of information, and to develop joint research addressing material flux and related human dimension issues for the land-ocean compartment of the region.

The workshop also formed a first step towards an East Asia-BASIN project reviewing the available scientific information on material fluxes through the major regional basins, coastal estuaries and shelves and highlighting the anthropogenic factors influencing those fluxes and changes. An East Asia LOICZ Committee (EALOICZ) was launched to develop a core project and work plan including international co-operation, multidisciplinary research and key sites from which to further derive information on the relevant processes operating in the wider coastal zone of the region. Research and integrating workshops are planned.

### SARCS-WOTRO-LOICZ (SWOL) Phase I Final Synthesis meeting and Workshop, Bahia Blanca, Argentina (12-13 November 1999)

Prior to the Open Science Meeting the national SWOL research groups summarized the final results of their first 4 years of work linking regimes of coastal flux changes to socio-economic drivers in South East Asia. They considered the proposals for a potential SWOL Phase

II as prepared in 1999 and submitted to WOTRO, Netherlands Foundation for the Advancement of Tropical Research. The synthesis demonstrated an overall structure for the integration of biogeochemical budgets and the human dimension in terms of socio-economic data. Results will be published in a LOICZ R&S Report in 2000. Key innovative outputs of the meeting include:

- to pursue national typology efforts in each country i.e., to gather data, which are inputs to a regional typology as a necessary step towards generalizing site-specific scientific results and generating a regional picture of coastal areas in South East Asia;
- to strengthen training activities for SE-Asian and non-SWOL scientists and regional projects;
- to continue the link to the LOICZ network as the overall scientific framework for a presumed SWOL II project. It was considered that the expansion and elaboration of Phase 1 will require new, diversified models and their application to new sites. Additional expertise and analytical techniques will have to be employed, which parallels the internal developments in LOICZ.
- to pursue efforts to link the SWOL Project with other IGBP projects being implemented in the region, particularly through SARCS and LOICZ to tie in with Land Use and Cover Change (LUCC), Global Change and Terrestrial Ecosystems (GCTE), and Biospheric Aspects of the Hydrological Cycle (BAHC).
- To seek links to the UNEP South Asia Sea Program and to the Southeast Asia/BASINS project (APN-START-University of Washington, USA).

### LOICZ-UNEP South American Estuaries Workshop, Bahia Blanca, Argentina, (10-12 November 1999)

South America formed the regional focus of the second of the UNEP-GEF supported biogeochemical flux study activities. The workshop was held as a pre-meeting of the LOICZ OSM 4 at Instituto Argentino de

Oceanografía in Bahia Blanca. Ten scientists from Argentina, Brazil, Chile and Uruguay joined a LOICZ resource group. About 11 site budgets were developed across the region and training was received in the use of the LOICZ Guidelines.

A prototype software for computerized assessment of biogeochemical budgets (CABARET) was evaluated and further developed during the workshop. A second UNEP-LOICZ Biogeochemical Budgets Traineeship was set up allowing a South American Scientist to stay for up to 8 weeks in early 2000 working with the Regional Mentor, Dr Victor Camacho, at UABC, Ensenada in association with Prof Steve Smith, University of Hawaii.

A LOICZ R&S Report (No. 15) is being prepared for publication. Additional site budgets and training are continuing at research institutes in the region, assisted by participants in the workshop. An additional flow-on will be a national workshop in Colombia in early 2000, co-ordinated by the Regional Mentor.

### **LOICZ South American BASINS (SAMBAS) Workshop,**

**Bahia Blanca, Argentina  
(11-13 November 1999)**

Preceding the 4<sup>th</sup> Open Science Meeting some 16, mainly Latin American experts met to investigate the state of the art of scientific knowledge about catchment coastal sea interactions in South America including continental parts of the Caribbean. Discussions followed the approach taken in EuroBASINS and reviewed the various regional settings along the DPSIR framework. The heterogeneity of natural conditions like catchment size, geological activity (Andes versus Eastern Plains) as well as of the human dimensions such as land use and pollution were identified to need priority consideration in any effort aimed at regional synthesis. Products from this meeting will be:

- a LOICZ R&S report to be published in early 2000 – expanding on the currently available knowledge and giving emphasis to future changes of fluxes, considering major pressures relating to water, sediments and contaminants issues. It

will address the research niche of land use change in catchments and their impact on the coastal zone;

- a data base on catchment characteristics and fluxes in Latin America, which is supposed to be linked to respective information compiled through the BAHC project in due time;

- a set of review articles to be prepared in 2000 following the DPSIR framework and focusing on specific rivers in Patagonia, the Rio de las Plata, Rio San Francisco, Par del Sul, the Orinoco, the Rio Magdalena and rivers along the Pacific coast.

Together they form the scientific background from which to develop a science plan and targeted project proposals for integrated BASIN research in Latin America. The respective "SAMBAS" meeting is scheduled for September 2000 in Caracas, Venezuela. The meeting will also discuss whether or not to marry this effort in South America to the LOICZ initiative in the Caribbean, which would expand on the island dominated regions focussing also on groundwater issues.

4th OPEN SCIENCE MEETING



### **A way towards integration & synthesis 4<sup>th</sup> LOICZ Open Science Meeting, Bahia Blanca, Argentina, (15-18 November 1999)**

The LOICZ Open Science Meeting (OSM 4) was hosted by the Instituto Argentino de Oceanografía, Bahia Blanca. It brought together nearly 180 key researchers and coastal managers, and the Argentinean chapter of IAPSO, held its regular annual meeting. While the major regional focus was on Latin America, all other regions were well represented. Participants contributed more than 120 topical presentations and posters among which the contribution of Ms Monica Gil, Centro Nacional Patagónica, Puerto Madryn, Chubut, Argentina, received the LOICZ OSM Poster Award supporting her attendance at an international conference in 2000.

The OSM 4 represented a major step in our integration and synthesis process, providing a status review of the LOICZ programme and recommending on directions for further research. The Meeting also served as a focal point for continued improvement of the working relationships with potential users, and for links with intergovernmental bodies.

The human dimension of coastal change regimes provided a vital strand in the tapestry of the discussions, working groups and the three preceding workshops (mentioned separately). Understanding processes and derivation of models and budgets for materials (esp. C-N-P and sediments) across the whole coastal water continuum of catchments, estuaries and coastal seas, was a second strand.

The scaling of findings and modeling from local- via regional to-global scales continues to be a crucial issue and the coastal typology approach taken by LOICZ is essential to its global commitment. Discussion on typology included a first joint BAHC/LOICZ river basin/coastal zone typology working group, which concentrates on merging the typology efforts of both programs on a higher detailed half degree grid scale. The final synthesis of the SARCS/WOTRO/LOICZ (SWOL see there for more detail) project demonstrated considerable experience has been gained in quantifying residual production and flux changes driven by various socio-economic activities. Evolving from a working group dealing with LOICZ issues in global island regions LOICZ made efforts to enhance its scientific presence and networking in the Wider Caribbean and in island/atoll regions, including Oceania and South Asia. The DPSIR framework and the SWOL approach have been identified to provide a sound platform on which to develop two projects in the regions. More detailed information can be obtained from the OSM 4 Conference Proceedings published in December (see LOICZ Publications). Further products will include three LOICZ R&S Reports and publication of major contributions to the Meeting is anticipated in special issues of the Journal of Sea Research, ELSEVIER, and the journal, Regional Environmental Change SPRINGER.

**Coastal Change in Europe  
Third Annual ELOISE  
Conference, Noordwijkerhout,  
The Netherlands  
(1-4 December 1999)**

Following the incorporation of the European ELOISE project into the group of LOICZ core projects in 1999, LOICZ contributed to the 3<sup>rd</sup> ELOISE Open Science Meeting held from 1-4 December in Noordwijkerhout, the Netherlands, to four specific sessions:

- a) Biogeochemical budgets in coastal systems;
- a) Continental Aquatic Systems: The BASIN Approach;
- a) Cycling of Pollutants and Socio Economic Impacts and
- a) a plenary session on interdisciplinary science approaches in LOICZ, the current scientific status of global coastal change research and future developments globally and in the Netherlands;

From a few hundred participants in total some 20-30 attended each of the topical sessions and addressed various issues of current state of the art research in fields such as biogeochemical and gas fluxes following horizontal transport processes including groundwater. Nutrients and trace gas cycling were reviewed considering biotic and abiotic system functions and transboundary processes including the atmospheric and benthic interface. Basin research focusing on river catchment – coastal sea interaction was reflected in various scientific contributions e.g. from the Mediterranean and Black Sea and also picked up by the Commission itself through its Joint Research Centre, giving some background for a scientific network on European rivers-coastal zone studies.

The human dimensions formed a leading strand in many of the contributions such as groundwater transports of nutrients, cycling of pollutants as well as changing economies and human activities affecting coastal zones. In response to the requirements of the new 5<sup>th</sup> Framework Programme accelerate issue driven science the final topical plenary session on integrated science expanded on the efforts taken in the South East Asian LOICZ core project, SWOL. Ways to quantify residual production of C, N and P

driven by different economic sectors and to model ecosystem and management implications were outlined by an economist of the Philippine study team. Through introduction of valuation terms this approach might in the near future prove to contribute sound scientific scenario simulation against the needs of decision making.

**Looking inside  
What's new on the LOICZ  
SSC - an interim note**

The 10<sup>th</sup> LOICZ SSC meeting which followed the OSM at Bahia Blanca, Argentina (18-19 November) was the second one in 1999. Discussions concentrated on the introduction of the integration and synthesis process LOICZ will undergo until 2002. The OSM was reviewed for its potential contributions to this LOICZ commitment. A first list of LOICZ products including the CMTT and the LOICZ book were drafted.

An Executive Committee Meeting scheduled for March 2000 will pick up on these issues in more detail also considering the outcomes to be expected from the forthcoming IGBP SC and IPO Meetings in Mexico 22-28 February. Newsletter 14 will elaborate in higher detail on the outcomes of the integration and synthesis discussions.

The EXCOMM will also provide an excellent opportunity to introduce the two new members entering the LOICZ SSC in 2000 who were unable to follow the invitation to the OSM. Those are Prof. Peter Burbridge, Newcastle, UK, and Prof. Robert Costanza, Maryland, USA. Prof. Shu Gao the third new SSC member was already welcomed in Bahia Blanca and attended the SSC Meeting as an observer.

In the following we are happy to provide you with an introductory note on the exciting professional background of each of our new members. LOICZ is grateful for having had the opportunity to appoint three new members. We expect that this will ensure LOICZ to carry on enhancing its regional presence in East Asia which made considerable progress in the recent workshop (see the Qingdao Meeting report – this volume). LOICZ also looks forward to integrate new expertise and gain momentum around the challenging Focus 4.

This seems very timely in particular considering that science is undergoing an increasingly critical review of its usefulness for the people which in the LOICZ case reflects in the raising importance of human dimension issues in coastal global change discussions. With these appointments the SSC will also be enabled to appropriately follow up on the invaluable and highly acknowledged contributions provided to LOICZ science and its products made by those experts who left the SSC in 1999:

- Prof. Dunxin Hu, Qingdao, PR China, who among many other things initiated the establishment of an East Asian LOICZ project and
- Prof. Kerry Turner, Norwich, UK, who together with his team at CSERGE generated major impetus for the development of Focus 4 and provided the guidelines for integrated modelling and application of the DP-SIR framework – both important features in the human dimension questions.

We are looking forward to future co-operation knowing that both of them will keep up their scientific links to LOICZ and our science community and welcome their involvement and contributions in the upcoming LOICZ integration and first synthesis.

**New LOICZ SSC members:  
who is who?**



Over the past thirty years **Professor Peter Burbridge** has undertaken applied research and the provision of technical and management advice on a wide range of resource development and environmental management issues. The majority of his work has been associated with resources management in developing countries, including

applied research, training, and project formulation and assessment. This work has been undertaken for e.g. the International Council for Exploration of the Seas (ICES), World Bank, United Nations Agencies (UNFAO, UNEP, UNDP, UNESCO), the World Conservation Union (IUCN), World Wide Fund for Nature (WWF), international aid agencies, and private consultant firms. He has acted as the scientific and management advisor for a tri-lateral study on the Wadden Sea for the governments of Denmark, Germany and the Netherlands, and the WWF. Besides that he prepared a training manual on environmental considerations in the design of sustainable agriculture projects for the UNFAO, Rome where he also assisted in developing a new programme for integrated fisheries and coastal management. Having received his Ph.D. in natural resource management from Cornell University, USA, Professor Burbridge is currently Director of the Centre for Tropical Coastal Management at the Marine Sciences and Coastal Management Department at the University of Newcastle, UK.



**Dr Robert Costanza** is director of the University of Maryland Institute for Ecological Economics, and a professor in the Center for Environmental Science, at Solomons, and in the Biology Department at College Park. He received his Ph.D. from the University of Florida in 1979 in systems ecology, with a minor in economics. He also has a Masters degree in Architecture and Urban and Regional Planning from the University of Florida.

Dr Costanza is co-founder and past-president of the International Society for Ecological Economics (ISEE) and chief editor of the society's journal: *Ecological Economics*. He currently serves on the editorial board of eight other international

academic journals. He is also vice president of the International Society for Ecosystem Health. Dr Costanza's research has focused on the interface between ecological and economic systems, particularly at larger temporal and spatial scales. This includes landscape level spatial simulation modeling, analysis of energy and material flows through economic and ecological systems, valuation of ecosystem services, biodiversity, and natural capital, and analysis of dysfunctional incentive systems and ways to correct them. Dr Costanza was awarded several times for his broad experience and contribution to the global integrative science.



**Professor Shu Gao** received his Ph. D. in marine sediment dynamics from the University of Southampton, England and has been working as a research professor since 1996 at the Institute of Oceanology at the Chinese Academy of Sciences in Qingdao, P.R. of China. His interest lies in fine-grained sediment transport and accumulation in coastal and shelf areas, geological approaches to sediment movement in shelf seas, and physical oceanographic processes associated with material fluxes. In 1998 he became a member of the Continental Margins Task Team within the LOICZ/JGOFS framework that recently took on a second phase of activity aimed at assessment and global synthesis of CO<sub>2</sub> and nutrient fluxes in marginal seas and boundary currents. Contributions to different research and consultant programmes varies from the Department of Oceanology, University of Southampton, UK to the Second Institute of Oceanography, State Oceanic Administration in China and the Department of Geography at Nanjing University, China.

## CAPACITY BUILDING & TRAINING

### Second International Human Dimensions Workshop organised by IHDP: Human Dimensions Issues in the Coastal Zones. Bonn/Germany, (10 - 22 September 2000)

IHDP (International Human Dimensions Programme on Global Environmental Change) and START (Global Change SysTEm for Analysis, Research and Training) announce the second bi-annual International Human Dimensions Workshop, to be held from 10-22 September 2000 in Bonn, Germany.

Tailored for younger researchers from developing countries, at the beginning of their careers, the purpose is to provide an intensive learning experience, which exposes the participants to the field of Human Dimensions of Global Environmental Change (GEC), and allows for their integration into the international GEC network.

The central theme for this workshop is "Human Dimensions Issues in the Coastal Zones". 30 young scientists will focus on HD issues in the coastal zone areas from a variety of different perspectives and disciplines. The group will work out and highlight how each of the IHDP's four Science Projects is addressing particular issues in Coastal Zones. Further workshop sessions will focus on the ways major regional and international research initiatives examine Coastal Zone issues. Emphasis will for example be on experiences made in the Land Ocean Interaction in the Coastal Zone, LOICZ, project of IGBP in particular in integrated modelling, linking biogeochemistry and social science and those issues in global change with relevance for integrated management.

Deadline for applications: April 10, 2000. Contact: Ms. Ramine V. Shaw, IHDP, Walter-Flex-Str.3, 53113 Bonn, Germany. Fax: +49-228-739054; Phone: +49-228-739050. Email: shaw.ihdp@uni-bonn.de; Web: <http://www.uni-bonn.de/ihdp/IHDW2000.htm>

### Processes in the Coastal Zone: Links to Management Issues

Leonardo da Vinci – International Advanced School, Summer Course 3-14 July, 2000, Bologna Italy Aimed at postgraduate, Ph.D. and other interested scientists this course is dealing with hot issues of integrated coastal zone management looking at it from the coastal processes perspective.

Through involving land based interactions and global change the main objective is to highlight the key forcing functions of coastal developments by linking system responses to socio economic pressures and to reveal the major implications for management. The course is open for global participation (max. 70 students) and will deal with trans-boundary transports, circulation and benthic processes, geomorphology, and various pressures, natural hazards as well as management issues, risk assessments and conflict resolution. Input is coming from a global scientist community including LOICZ and the European Commission with special focus on the demonstration programme for Coastal Management. Deadline for application is 28 April 2000; more information can be obtained from the web: <http://www.bo.cnr.it/ldavinci/school.htm>;  
E mail: [frignani@igm.bo.cnr.it](mailto:frignani@igm.bo.cnr.it)

### HAVE YOU SEEN.....

Regional Environmental Change. Eds. W. Salomons & Ilona Liesner. Vol.1 issue 1, pp. 1-57, 1999. Web Link: <http://link.springer-ny.com/link/service/journals/10113/index.htm>

### LOICZ PUBLICATIONS

- Conference Proceedings LOICZ OSM4. C.J. Crossland, H. Kremer, J.I. Marshall Crossland.
- LOICZ SSC10, Bahia Blanca, Argentina. *LOICZ Meeting Report no. 34, 1999.*

### LOICZ CALENDAR

- LOICZ-UNEP workshop on estuarine systems of South Asia 14-18 February 2000, Goa, India (*by invitation*)
- AfriBasins I workshop on catchment/ coastal fluxes and human dimensions. May 2000, TBA. (*by invitation*)
- LOICZ-UNEP workshop on estuarine systems of East Asia June 2000, TBA. (*by invitation*)
- South American Basins on catchment/ coastal fluxes and human dimensions SAMBAS II. September 2000, Caracas, Venezuela. (*by invitation*)
- LOICZ-UNEP Africa workshop on estuarine systems. September 2000, Zanzibar. (*by invitation*)
- LOICZ SSC Meeting, 2-5 October 2000, Arcachon, France. (*by invitation*)

### OTHER MEETINGS

- 15th SC-IGBP Meeting & IPO Executive Officers Meeting. 22-26 February, 2000, Cuernavaca, Mexico.
- Oceanology International 2000. 7-10 March, 2000, Brighton, UK.
- Second World Water Forum. 17-22 March, 2000, The Hague, The Netherlands.
- JGOFS 2nd Open Science Conference. 13-17 April, 2000, Bergen, Norway.
- Sustainable use of estuaries and mangroves: challenges and prospects. 22-28 May 2000, Recife, Brasil.
- 5th Congress on Marine Sciences Marcuba. 19-23 June, 2000, Havana, Cuba.
- 6th Annual CERCI Conference on Marine Environment: Science and Law. 10-13 July

2000, Scarborough, UK.

- Coastal Zone Canada 2000. 17-22 September, New Brunswick, Canada.
- IEP 2000: Issues in Global Change. 16-18 October 2000, Lisbon, Portugal.
- 9th International Coral Reef Symposium. 23-27 October 2000, Bali, Indonesia.
- The Third World Fisheries Congress. 31 October-3 November 2000, Beijing, P.R. of China.
- IGBP Open Science Conference. 10-14 July, 2001, Amsterdam, The Netherlands.
- Detecting Environmental Change: science and society. 16-20 July 2001, London, UK.

### IPO STAFF

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