

# LOICZ NEWSLETTER

## LOICZ Group Investigates Groundwater Discharge in Australia

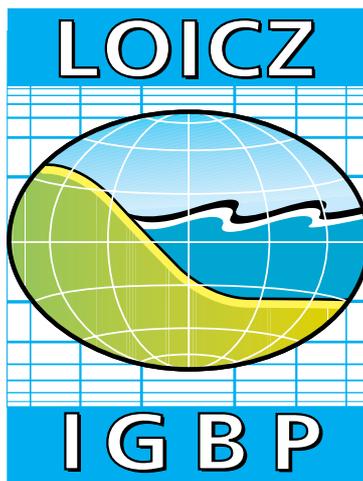
by Bill Burnett<sup>1</sup> and Jeffrey Turner<sup>2</sup>

### Abstract

The direct discharge of groundwater into the coastal zone has received increased attention in the last few years as it is now recognized that this process represents an important pathway for material transport. Assessing these material fluxes and their impacts on the near-shore marine environment is difficult, as there is no simple means to gauge the groundwater flux. To meet this challenge, a working group established by the Scientific Committee on Oceanic Research (SCOR) and the Land-Ocean Interactions in the Coastal Zone (LOICZ) project of IGBP is conducting a series of groundwater discharge assessment intercomparison experiments. One such experiment was recently held in Cockburn Sound, Western Australia. A multi-disciplinary group of investigators made estimates of submarine groundwater discharge based on a range of methodologies including seepage meter measurements, natural isotopic tracers, onshore and offshore CTD profiling and hydrogeological modeling approaches. Preliminary results suggest good correspondence between tracers and seepage meters.

### Introduction

While the major rivers of the world are reasonably well gauged and analyzed, thus allowing comparatively precise estimates of riverine inputs to the ocean, it remains very difficult to evaluate the influence of direct groundwater discharge into the ocean. The principal reason that groundwater estimates have not attained the precision base that is typically achieved of other oceanic inputs is that the direct discharge of groundwater into the coastal zone is inherently very difficult to measure. Concerted efforts are requi-



This is the eighteenth newsletter of the Land Ocean Interactions in the Coastal Zone (LOICZ) International Project of the IGBP. It is produced quarterly to provide news and information regarding LOICZ activities

red to improve this situation by integrated application of hydrological and oceanographic techniques. Standard hydrological and oceanographic methodological approaches are quite different and have rarely been systematically applied to compare results at a single location. Hydrogeologists and oceanographers are literally approaching the same problem from different ends.

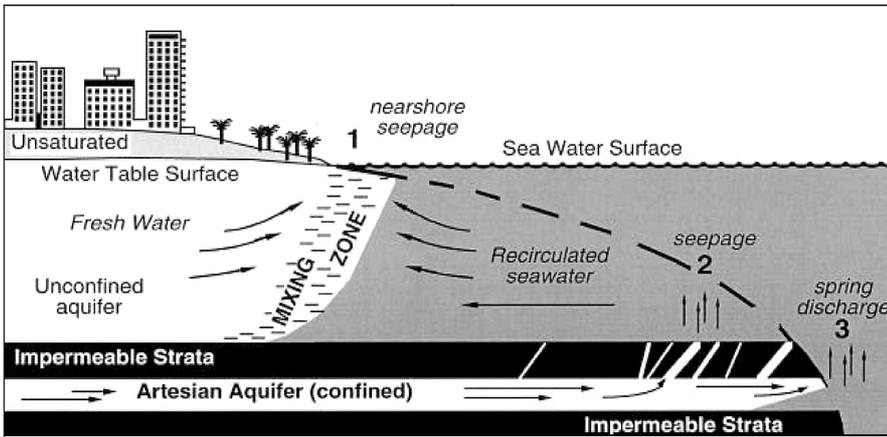
Like surface water, groundwater flows down-gradient. Therefore, groundwater flows directly into the ocean wherever a coastal aquifer is connected to the sea. Furthermore, artesian aquifers can extend for considerable distances from shore, underneath the continental shelf with discharge to the ocean at their points of outcrop (Figure 1). While the magnitude of such discharge may be relatively minor in areas dominated by river flow, recent studies have indicated that groundwater may occasionally account for a significant fraction of the fresh water inflow (e.g., Buddemeier,

1996; Moore, 1996). Because the composition of groundwater is typically different than receiving coastal waters, submarine groundwater discharge (SGD) may be important as a pathway for dissolved constituents such as nutrients. The concentrations of many parameters (e.g., nitrate) in groundwater is typically several times higher than seawater, even in pristine aquifers. In areas where groundwater contamination has occurred, SGD may also be a pathway for anthropogenic material fluxes.

Although submarine springs and seeps have been known for many years (written accounts exist from at least the Roman period), these features have traditionally been perceived as hydrologic "curiosities" rather than objects for serious scientific investigation. This perception is changing. Within the last two decades there has emerged a recognition that, at least in some cases, SGD may be both volumetrically and chemically important (Johannes, 1980). Although this process may not play a significant role in the global water balance, there are reasons to believe that the geochemical cycles of some major and minor elements may be strongly influenced either by the direct discharge of fresh groundwater into the sea or by chemical reactions that occur during the recirculation of seawater through a coastal aquifer system. It is also recognized that groundwater discharge may be an important pathway for diffuse pollution to enter the coastal zone where coastal aquifers have become contaminated by septic systems or other pollution sources.

### SCOR/LOICZ Working Group 112

One of the outcomes of the recent interest in SGD has been the establishment of a small group of experts "...to define more accurately and completely how submarine groundwater discharge influences chemical and biological processes in the coastal ocean" (Burnett, 1999).



**Figure 1.** Diagrammatic view of the relationships between coastal aquifers, seawater, and groundwater discharge. Three types of submarine groundwater discharge are illustrated: (1) nearshore seepage; (2) offshore seepage; and (3) submarine springs (Burnett et al., 2001).

This working group (SCOR working group 112, "Magnitude of Submarine Groundwater Discharge and Its Influence on Coastal Oceanographic Processes") is co-sponsored by LOICZ. The group quickly recognized the need to define further and improve the methodologies of SGD assessment. One mechanism towards this end is to conduct a series of SGD assessment intercomparison experiments. Additional support has now been obtained from the Intergovernmental Oceanographic Commission (IOC) to organize a series of these experiments in different hydrogeologic environments over the next several years. The sites will be selected based on a variety of criteria including logistics, background information, amount of SGD expected and hydrological and geological characteristics. Each intercomparison exercise will involve as many methodologies as possible including various modeling approaches, "direct" measurements (seepage meters of varying design, piezometers), natural tracer studies (radium isotopes, radon, methane), and possibly artificial tracers ( $\text{SF}_6$ ,  $^{18}\text{O}$ -enriched water).

### Cockburn Sound, Australia

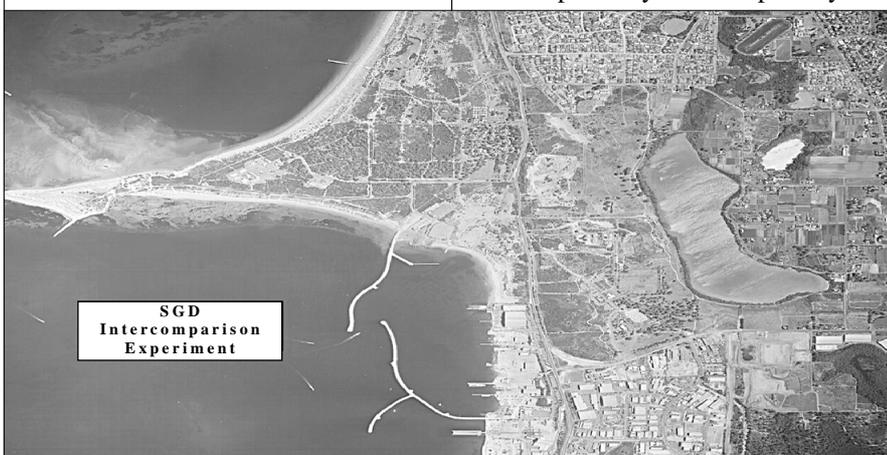
We performed our first large-scale intercomparison (Nov. 25-Dec. 6, 2000) at Cockburn Sound, located in the southwest margin of continental Australia, near metropolitan Perth and Fremantle (**Figure 2**). Cockburn Sound is a marine embayment protected from the open Indian Ocean by reefs, a chain of islands and a man-made causeway. The area has recently been the subject of extensive environmental assessment in order to address strategic environmental management and the management of waste discharges into Perth's coastal waters. Cockburn Sound itself is flanked on its eastern margin by a low-lying sandy coastal plain. Much of Perth's commercial and industrial activity is focused along the southern metropolitan coastline and includes the shoreline of Cockburn Sound. Influx of pollutants to the nearshore marine environment from these activities has been a point of major concern in recent years and SGD has been recognized as an important pathway for contaminants. Accordingly, a significant amount of baseline environmental information has been gathered over the past 20 years. The primary site

for the SGD assessment intercomparison was along an open beach in the Northern Harbor area.

### Preliminary Results

Over 20 scientists from Australia, U.S.A., Japan, Sweden, and Russia participated in this experiment (**Table 1**). Several types of SGD assessment approaches, including hydrogeologic measurements, manual and automated seepage meter readings, and tracer measurements were collected during the 10-day intensive experiment. The weather conditions were generally favorable although brisk on-shore sea breezes typical of the west Australian coast were present at times. Although several research teams are still analyzing samples, developing models, collating and synthesizing their results, enough information is now available for a "first-look" at some results. More detailed presentations of each of the data sets, including hydrogeological modeling results, will be forthcoming.

Several manual seepage meter measurements were made each day of the experiment for each of the 8 "Lee-type" meters deployed along the two transects (4 meters on each transect). A traditional seepage meter is simply an open-ended chamber (top or bottom section of a 55-gallon oil drum) implanted open-end down into the sea bed with a small opening on the top of the chamber for installation of plastic collection bags. The collector bags are deployed over measured time intervals to assess the volume of water displaced via seepage. Once several measurements are taken, the results are pooled as a "daily average" and integrated by distance offshore to obtain estimates of total seepage per meter shoreline (**Figure 3**). Once this has been done, it is a simple matter to estimate discharge into a designated area (100 m wide in this case). A dramatic improvement in seepage meter design has been achieved by automating the measurement process by either heat-pulse (Taniguchi and Fukuo, 1993) or acoustic Doppler technologies (Paulsen et al., 1997). These automated systems were deployed during the intercomparison as well with specific discharge being recorded on 15-minute intervals. One of the stations in a central portion of the experimental area was equipped with a device for continuously sampling near-bottom seawater and analyzing for  $^{222}\text{Rn}$ , a good natural tracer of SGD (high in groundwater, low in seawater,

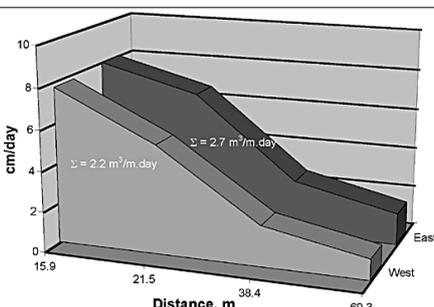


**Figure 2.** Low altitude site map prior to land reclamation of Northern Harbor, Woodman Point, Western Australia (photo from S. Kruppa).

**Table 1.** Participants in the SGD assessment intercomparison experiment, Cockburn Sound, Western Australia (Nov. 28 – Dec. 5, 2000).

Participants	Affiliation	Activity
Jeff Turner David Herne Tony Smith Wayne Hick	CSIRO Land and Water Floreast Laboratory Perth, Western Australia	Logistics Automatic seepage meters modeling
Bill Burnett Mike Lambert	Florida State University Tallahassee, FL, U.S.A.	Natural tracers: <sup>222</sup> Rn, <sup>226</sup> Ra Manual seepage meters
Evgeny Kontar	P.P. Shirshov Institute of Oceanology, Moscow	Geophysics Sampling logistics
Makoto Taniguchi	Department of Earth Sciences Nara University of Education Nara 630-8528, Japan	Heat pulse automated seepage meters Sub-surface thermal gradients
Henry Bokuniewicz Chris Smith Dan O'Rourke Ron Paulsen	SUNY Stony Brook Cornell Cooperative Ex. Marine Program Riverhead, NY, U.S.A.	Ultrasonic automatic seepage meters Porewater resistivity measurements
Leslie Smith	Dept. Earth & Ocean Sciences Univ. British Columbia Vancouver, Canada	Hydrogeological measurements Modeling
Willard Moore	University of South Carolina Columbia, SC, U.S.A.	Radium isotopes ( <sup>223</sup> Ra, <sup>224</sup> Ra, <sup>228</sup> Ra, <sup>226</sup> Ra)
June Oberdorfer	Department of Geology San Jose State Univ., San Jose, CA, U.S.A.	Hydrogeological measurements Modeling
Dr. Georgia Destouni Carmen Prieto	Royal Institute of Technology Water Resources Engineering Stockholm, Sweden	Hydrogeological measurements Modeling
Geoff Garrison	Dept. Geology & Geophysics Univ. of Hawaii, Honolulu, HI, U.S.A.	<sup>222</sup> Rn, <sup>226</sup> Ra, Cl
Charlene Grall Zafer Top Jim Happell	RSMAS University of Miami Miami, FL, U.S.A.	He isotopes, <sup>3</sup> H fluorocarbons
Steve Krupa Cynthia Gefvert Mandy Krupa	South Florida Water Management District Palm Beach, FL, U.S.A.	"Krupaseep" automatic seepage meter Water quality sensors
Sydney T. Bacchus	Institute of Ecology Univ. of Georgia	Seepage meter measurements Geophysics
Chari Patariachi	Centre for Water Research, Univ. Western Australia.	CDT Profiling of offshore marine water column
Thomas Stieglitz	James Cook University Townsville, Australia	Geophysics: seismic profiling, conductivity probes

conservative). The monitor measures total <sup>222</sup>Rn from a continuous stream of water brought to the surface via a submersible pump (Burnett et al., 2001). Grab samples of seawater were also collected from the same location at various times and analyzed by conventional radon emanation techniques with results very close to those provided by the continuous monitor. The radon data shows a pattern generally similar to that of the automated seepage meter



**Figure 3.** Manual seepage meter results for November 28, 2000, Cockburn Sound. The two trends correspond to the west (integrated flux = 2.2 m<sup>3</sup>/m·d) and east (2.7 m<sup>3</sup>/m·d) transects, respectively.

(**Figure 4**) and show higher concentrations during the lowest tides, a feature we have noted elsewhere. Both the radon record and the seepage meter results are suggestive of a strong tidal influence on the transient magnitude of the SGD flux. We applied a 1-dimensional advection-diffusion model (Cable et al., 1996) to account for the observed radon inventories by estimated an upwelling rate for the radon-enriched groundwater. These estimates agree well with the integrated seepage meter values (**Table 2**). The seepage meter estimates may be somewhat higher because the measurements were all made during the day, coinciding with the low tide (higher seepage) intervals. The hydrogeologic modeling results are not available as yet. Rough Darcy's Law calculations indicate much lower apparent flow than that based on the seepage meter or tracer studies. This may be an indication that recirculated seawater plays an important role in this environment (the simple modeling would account for only the freshwater

component).

**Future Intercomparisons**

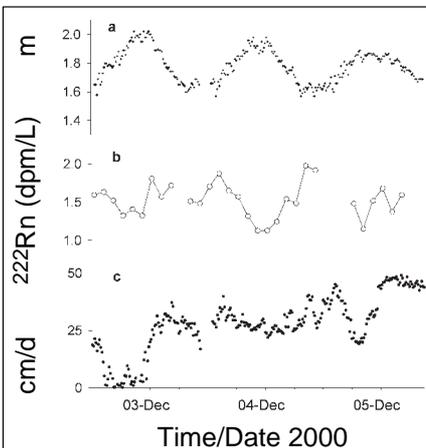
Sites for additional SGD assessment intercomparisons have not been selected as yet but serious consideration is being given to a coastal plain area on eastern Long Island (West Neck, N.Y.) where there is a tremendous fresh water head driving discharge in addition to tidal pumping of SGD. We also hope to include at least one volcanically-based coastal aquifer system (perhaps in Hawaii or Japan), a karst system (e.g., Sicily, Croatia), and a deltaic system (e.g., Venice). It is also planned to include coastal management aspects in future intercomparisons in order to provide coastal planners and scientists with the knowledge and some of the tools for assessment of SGD, the invisible pathway between land and sea.

**Acknowledgments**

The participants gratefully acknowledge the very helpful support of the Perth laboratory of CSIRO Land and Water for their generous personnel and logistical support. The working group is sponsored by the Scientific Committee on Oceanic Research (SCOR) and the Land-Ocean Interactions in the Coastal Zone (LOICZ) project of IGBP. Scientific support for some of the measurements made during the Cockburn Sound intercomparison was provided by grants to WCB from the Office of Naval Research (N00014-00-0175) and Florida Sea Grant (R/C-E-42) and to WSM from the National Science Foundation (OCE-9712298).

**Table 2.** Comparison of discharge estimates via integrated seepage meter and radon measurements. The discharge values represent flow into a 10,000m<sup>2</sup> domain.

Date	Lee meter daily rate	Radon monitor daily rate	Remarks
11/27/00	0.17		
11/28/00	0.17	0.15	
11/29/00	0.22	0.15	
11/30/00	0.22	0.14	
12/1/00	0.24	0.19	
12/2/00	0.26	0.19	
12/3/00	0.21	0.09	Lost 6 hrs data
12/4/00		0.16	At Rn peak
12/5/00	0.16		
12/6/00		0.41	Only 4 hrs data



**Figure 4.** Temporal variation of (a) tidal height; (b) radon concentration; and (c) specific discharge during the time period Dec. 2 2000 to Dec. 5 0900. Data for specific discharge measured at one location via an ultrasonically-based automatic seepage meter on a 15-minute schedule (Smith, Paulsen, and O'Rourke, unpublished).

### References

- Buddemeier, R.W. (ed.) 1996. Groundwater flux to the oceans: definitions, data, applications, uncertainties. In: Proceedings, "The International Symposium on Groundwater Discharges to the Coastal Zone" LOICZ/R&S/96-8, iv+179 pp. LOICZ, Texel, The Netherlands.
- Burnett, W.C., 1999. Offshore springs and seeps are focus of working group. *EOS*, 80, 13-15.
- Burnett, W.C., G. Kim, and D. Lane-Smith, 2001. A continuous radon monitor for use in coastal ocean waters. *Jour. Radioanal. Nucl. Chem.*, in press.
- Cable, J., G. Bugna, W. Burnett, and J. Chanton, 1996. Application of  $^{222}\text{Rn}$  and  $\text{CH}_4$  for assessment of groundwater discharge to the coastal ocean. *Limnol. Oceanog.* 41, 1347-1353.
- Johannes, R.E., 1980. The ecological significance of the submarine discharge of groundwater. *Mar. Ecol. Prog. Ser.* 3, 365-373.
- Moore, W. S., 1996. Large groundwater inputs to coastal waters revealed by  $^{226}\text{Ra}$  enrichments. *Nature* 380, 612-614.
- Paulsen, R.J., C.F. Smith, and T.-F. Wong, 1997. Development and evaluation of an ultrasonic groundwater seepage meter. In: "Geology of Long Island and Metropolitan New York," 88-97.
- Taniguchi, M. and Y. Fukuo, 1993. Continuous measurements of groundwater seepage using an automatic seepage meter. *Ground Water*, 31, 675-679.

### Author address list:

1. Department of Oceanography, Florida State University, Tallahassee, FL 32306, U.S.A.; [wburnett@mailers.fsu.edu](mailto:wburnett@mailers.fsu.edu)
2. International Atomic Energy Agency, Isotope Hydrology Section, Vienna, Austria; [J.V.Turner@iaea.org](mailto:J.V.Turner@iaea.org)

### PAGES-LOICZ Workshop on Coastal Records of Sea-Level and Climate Variability over the last 2000 years

*I. Goodwin<sup>1</sup>, N. Harvey<sup>2</sup>, O. van de Plassche<sup>3</sup>, R. Oglesby<sup>4</sup>, and F. Oldfield<sup>5</sup>*

Recently the IGBP core projects on Past Global Changes (PAGES) and LOICZ sponsored a workshop to: examine the characteristics, temporal resolution, geographic coverage and forcing of relative sea-level histories for the last 1-2000 years; to assess existing geochronological control of sea-level histories and the application of new or developing geochronological techniques; and, to review the paleoclimate archive spanning the last 1-2000 years.

Over 30 scientists, including, coastal geologists and geomorphologists, climatologists and oceanographers with both modern and palaeo specialisations, and ocean and geodynamic modellers participated in the workshop. The workshop participants had strong geographic research foci on the tropical Pacific and Indian Ocean regions, and on the North Atlantic Ocean region.

Sea-level rise as a consequence of 'Greenhouse induced' global warming has been a major focus of global change science for the last 2 decades. The main approach has been to test climate-forced sea-level models by comparing model results with regional or global averages of sea-level rise based on multi-decadal, and in a few cases, centennial tide-gauge records corrected for local crustal movements which in turn are based on millennial-scale records of relative sea-level change. The majority of the multi-decadal instrumental records are inherently noisy ( $\pm 0.3$  m) due to sub-decadal and decadal variability in ocean temperature, salinity fields and circulation (any of which can affect density and hence local sea level). This variability is induced by atmospheric and oceanographic phenomena such as ENSO and the NAO.

Field research has continually produced

relative sea-level data sets, which in part, indicate that relative sea-level has been non-linear and has fluctuated about the modelled long-term Post-Glacial hydro-isostatic sea-level history. Factors influencing the non-linearity are: local vertical movements of the land through tectonic processes; small eustatic contributions from fluctuations in global ice volume; and the impact of small climate fluctuations on ocean temperatures and salinity, which affect the ocean density and steric sea-level. The recognition that the field-derived relative sea-level records describe variability not explained by the post-glacial isostatic adjustments alone indicates that both the tectonic effects, and the climate forcing of multi-decadal to centennial sea-level fluctuations may indeed be significant. This underscores the need for high-resolution sea-level studies for the past 2000 years.

An expanding archive of paleoclimate data spanning the last few thousand years has enabled researchers to conclude that significant regional, and perhaps hemispherical climatic fluctuations have occurred on multi-decadal and centennial timescales during the last few thousand years. Critical to future climate and sea-level predictions, is the extent to which these climatic fluctuations have affected decadal to centennial sea-level and coastal evolutionary response over the past 2,000 years. Whilst the sea-level anomalies are likely to be on the order of ca. 0.5 to 1.0 m, this magnitude is critical to the habitation of many small island states and low lying continental regions. Reciprocally, spatial and temporal variation in high-resolution paleo sea-level records is relevant to the study of ocean-atmosphere interactions.

Key conclusions from the workshop, which provide the foundation for the future development of the project, include:

- That coastal responses to climate forced sea-level variability can be detected at a sub-decadal to millennial scale, in the period since the post-glacial sea-level highstand was attained;
- That fluctuations in sea-level over the last few millennia are the same magnitude as that are predicted for the future, under 'Greenhouse conditions';
- That empirical fluctuations are not presently captured by numerical modeling; and

- That scientific techniques are developing which will enable the separation of climate-forced sea-level changes from the cumulative or integrated sea-level curve.

The project, entitled, "Coastal Records of Sea-Level and Climate Variability over the last 2000 Years", will contribute to overall sea-level studies by yielding critical data from which a global sea-level budget for the last 2,000 years can be refined. It is anticipated that the project will develop a focus on glacio-eustatic contributions in the future, but its present focus will remain on resolving the influence of decadal to centennial, ocean thermal and circulation changes on steric sea-level. Field projects will be focused on both expanding the spatial coverage or relative sea-level histories and refining the existing relative sea-level histories at key geographic locations to achieve at least 0.5-1.0 m resolution in the sea-level archives. The tectonic history at each site will be a key area for research, and particularly, the resolution of pre- and post-seismic tectonic adjustments.

The workshop was held at the East West Center, University of Hawaii, Honolulu, 6-8 November 1999, in conjunction with the IGCP 437 symposium on 'The Non-Steady State of the Inner Shelf and Shoreline: Coastal Change on the Time Scale of Decades to Millennia in the Late Quaternary'. Abstracts from the PAGES-LOICZ workshop and further information about the project can be obtained from Dr Ian Goodwin, Ian.Goodwin@newcastle.edu.au. A full workshop report by Goodwin et al. (2000) was published in EOS.

#### References

Goodwin, I., Harvey, N., van de Plassche, O., Oglesby, R. and Oldfield, F. (2000). Prospects for resolving climate-induced sea level fluctuations over the last 2,000 years. *EOS, Transactions, American Geophysical Union* 81 (28), 311-312

#### Author address list:

1. School of Geosciences, University of Newcastle, Callaghan NSW 2308 Australia.
2. Department of Geographical and Environmental Studies, The University of Adelaide, Australia 5005.
3. Faculty of Earth Sciences, Vrije Universiteit, De Boelelaan 1085, 1081 HV Amsterdam, The Netherlands.

4. Department of Earth and Atmospheric Sciences, Purdue University, West Lafayette, Indiana 47907, U.S.A.
5. PAGES IPO, Barenplatz 2, CH-3011 Bern, Switzerland.

#### IGBP Water-Sediment Workshop

A subset of IGBP Water Group (representatives from BAHG, LOICZ, PAGES) augmented by selected invitees met at the Institute of Arctic and Alpine Research, University of Colorado, Boulder 25-27 September 2000. The workshop participants discussed anthropogenic influences at the global scale, on the supply and flux of sediment along hydrological pathways. Key issues included:

#### 1. Sediment flux to the coast, presently, in the past, and under pristine conditions.

River systems evolve through time, and as such the modern river systems are strongly influenced by past conditions within the watershed as well as modern conditions. Understanding the discharge of sediment across a broad time-scale will allow us to make better predictions for the future. The trapping efficiency of terrestrial reservoirs, both man-made and natural, is important to understanding the future discharge of sediment to the coastal oceans.

##### 1.1 *Present Flux to Coast*

Current estimates put the annual sediment flux to the global ocean between  $18 \times 10^9$  to  $24 \times 10^9$  metric tons

##### 1.2 *Paleo Flux and Pristine Conditions*

Fluvial systems evolve along with the landscape, and much of the sediment yield we see today is influenced by the paleo-systems.

##### 1.3 *Future Sediment Flux*

The main understanding needed is the balance of increased sediment versus decreased sediment due to the influence of man and/or climate change biological consequences such as burial of benthic biota.

##### 1.4 *Sediments in River Basins*

It is understood that the erosion of bedrock by rivers takes place almost entirely in the headwaters of the catchment. This newly eroded sediment must then be transported to the coastal zone. How long it takes for this transport and how sediment makes the journey are the two important questions

2. Global Change & Sensitive Areas
3. Data - Typology (upscaling, downscaling)

#### Recommendations

- Global mapping of sediment sources and/or sensitivity to disturbance; to allow for a better understanding of the affect of change on the system.
- Creation of an index to understand sediment transit times within basins. This needs inclusion of smaller river basins, as transit times are expected to be much shorter than that for the larger rivers. This infers that changes occur much more rapidly in smaller basins than larger ones.
- Determination of how long before river loads fill up the terrestrial sediment traps, and what the subsequent impacts will be downstream (e.g. the coastal zone).
- Research the balance between increasing and decreasing sediment loads due to man and/or climate change.
- Coastal sediment budgets need to be linked to terrestrial sediment budgets; to allow a bridge between the data from upstream gauging station and the coastal ocean, taking into account the interaction within estuaries.

A full report will be published as a special issue of Global and Planetary Change.

#### CMTT Progress and "Synthesis"

The Continental Margin Task Team (a joint LOICZ/JGOFS) effort has been tasked with assessing the fluxes of major biogenic elements in continental margins relevant to climate change. The product of the assessment will be a synthesis book supported by IGBP.

The CMTT has divided the task up into sub-groups: eastern and western boundary systems, polar margins, tropical margins and marginal seas.

The eastern and western boundary systems group met in November 2000 in Norfolk, Virginia, USA with Larry Atkinson as local host and Renato Quinones and Larry as co-hosts. Attending the meeting were the following: Larry Atkinson (USA), Renato Quinones (Chile), Francisco Chavez (USA), Lei Chou (Belgium), Lou Codispoti (USA), George Cresswell (Australia), Richard Jahnke (USA), K. K. Liu (Taiwan), John Moisan (USA), Pedro Monteiro (South Africa), and Wajih Naqvi (India).

The outcome of the meeting was the design of the synthesis chapter and

recommendations to LOICZ and JGOFS regarding issues of coverage.

Workshops on polar seas hosted by Robbie McDonald (Canada) and marginal and tropical seas hosted by K. K. Liu are being planned.

#### Land Interactions in the Russian Arctic

The third LOIRA workshop held at in Moscow, Russia (5-8 December 2000) provided an exciting new window into research findings relating to the Arctic coastal zone of Russia. Despite the onus and time conflicts enforced by end-of year reports, the workshop was attended by more than 50 LOIRA and other related scientists plus interested members of the Institute of Oceanology.

Natural science issues ranged across river catchment science to river and estuarine fluxes and processes to coastal seas of the Arctic Ocean. Geographical distribution of work extended across the entire polar coast including the Barent, Kara and East Siberian Seas and their subsidiary sea element, notably the Pechora, Laptev and White Seas. Characteristics of river flows, loads and changes were considered in light of earlier evaluations. Advances in coastal and deltaic biogeochemical processes in major systems were described with new information on seasonal characteristics or winter and summer conditions. A joint German-Russian program studying the Laptev Sea provided new information on coastal circulation and material transport, particularly demonstrating use of an acoustic *in situ* sensor whose results raised some tantalising questions about linked biology and physical processes under surface ice conditions. The Pechora Sea is a major focus for land-ocean studies encompassing nearly every issue familiar to coastal scientists. Socio-economic research and program developments also were highlighted – here a key issue is the development of gas and oil exploration/extraction and how to achieve appropriate wise use of the relevant coastal regions to advantage of all stakeholders.

The Arctic region is vital to the big picture of global change and earth system function. The LOIRA plan and the scientific response and enthusiasm is strong, and global collaboration is being actively sought by Russian researchers. Contact Dr V.V. Gordeev for more information ([gordeev@geo.sio.rssi.ru](mailto:gordeev@geo.sio.rssi.ru)).

#### Biogeochemical Budgets and Typology

The further development of estuarine and coastal biogeochemical budgets, following the LOICZ approach, gained further impetus through several recent workshops. With UNEP and EU support, a workshop was held in Athens (February 2001) which addressed the Mediterranean and Black Sea region. More than a dozen C-N-P budgets for sites in North Africa, from Spain to Turkey and within the Black Sea were developed, ranging from systems of a few km<sup>2</sup> to large seas. The participants continue to evaluate further sites. The participants spent time considering the LOICZ typology approach and its application for a variety of scientific purposes, including use as a tool in assisting the further synthesis of ELOISE project outcomes.

The workshop contributed to the regional series that has been supported by UNEP GEF over the last 18 months, wherein training and use of the LOICZ budgetting approach has been coupled with the delivery of budget sites in regions of the world (Latin America, South East Asia, East Asia, South Asia, Sub-saharan Africa). The LOICZ biogeochemical modelling project now has in excess of 180 sites described (<http://data.ecology.su.se/MNODE/>), with additional sites continuing to be contributed from the global research community. A proposed Polar region workshop later this year is expected to give further insights into the latitudinal performance and characteristics of coastal systems.

The UNEP GEF project supported the first “integration” workshop held in Brisbane Australia in January 2001 addressing the Asian and Australasian regions, providing training in use and application of the LOICZ typology methods. Participants developed typologies at various scales to address coastal forcing function and vulnerability, habitat and estuarine distribution, and coastal processes. This work will be extended to the Americas and Africa-Europe regions by two workshops over the next few months. A final synthesis workshop will be held later in the year to develop a global typology of estuarine system performance.

The typology databases (located at University of Kansas) and the LOICZ-View methodology (Swarthmore College, Pennsylvania) continue to evolve as workshop participants and other users

highlight applications beyond the LOICZ purpose and ancillary tools to assist use. Great interest (and developmental support) is being shown in the LOICZ typology initiative by scientists, environmental managers and policy agencies. Some of these developments and applications can be seen and accessed at <http://www.kgs.ukans.edu/Hexacoral/>.

#### BASINS Developments and Status

The LOICZ BASINS project continues to address coastal change issues from the perspective of the sustainable management of river catchments or islands. The aim is to develop and apply a set of methods and tools to assess coastal state changes and to make predictions of future trends under various natural and human forcing of the water cascade. BASINS regional assessment workshops are integrating scientific information on how coastal change reflects catchment-based pressures.

Catchments are dynamic. In the short term, scientific tools are needed to help predict the impact of point sources of nutrient or chemical loads (e.g., the Romanian cyanide accident), and sudden events like weather extremes (e.g., the recent weather extremes in the UK and southern Europe). Equally important is the prediction and assessment of long term changes of pressures (e.g., population growth/migration, land use change, urbanisation) that impact on material fluxes along the water pathways and ultimately affect coastal goods and services and environmental health. BASINS analyses also provide insights into policy responses, such as :

- nutrient control and the implementation of best agricultural practice
- erosion control
- regulation of water - diversion and damming
- upgrading of sewage treatment plants especially in growing economies
- changes in rural land cover
- regulatory changes in point and diffuse source discharges, and
- the demands of road traffic, tourism.

These management responses and associated long-term investments differentially influence the ecological status of surface waters and the quality of groundwater. To allow global comparison of the regional BASINS assessments, emphasis is placed on using a standardised procedure and process for information.

Recent workshops in Europe, South America and Africa (1999-2000) and in East Asia (2001), and current regional studies in the Caribbean and Oceania, closely follow the DPSIR (Driver-Pressure-State-Impact-Response) framework.

Taking biogeochemical and socio-economic factors into consideration, we are developing a descriptive set of indices to quantify observations and expected trends. Coastal impacts/issues and land-based drivers and pressures are being categorised and ranked for subsequent comparison and upscaling, using the LOICZ typology approach.

An example in Europe is the Rotterdam – Rhine project dealing with forecasting of sediment quality where BASINS provides a scientific frame for trend analysis and interdisciplinary catchment scale approaches against concrete user needs ([http://w3g.gkss.de/i\\_a/dredged\\_material/index.html](http://w3g.gkss.de/i_a/dredged_material/index.html)).

The BASINS task group (Wim Salomons, Horst Behrendt, Jozef Pacyna, Nicola Pirrone, Kerry Turner, Hartwig Kremer) recently confirmed this approach with a set of standardized assessment tables for use in the process of regional syntheses (usually the phase two BASIN workshops). It was applied in the East Asian BASINS workshop in Hong Kong (late February), and provided guidance to working group discussions, allowing comprehensive regional overviews in a limited timeframe.

The BASINS assessment tables are distributed to participants prior to workshops and finalized during in the synthesis process. Moving from coastal issues upwards along the river catchment at various spatial scales, they follow a sequence of steps guided by a set of key questions:

1. Assessing Issues/Impacts (critical thresholds) based on coastal change in the region.
  - What are the major impacts (coastal issues) on/in the coastal zone and do we know anything on
  - How close they are to a critical threshold of system functioning?
2. Assessment and synthesis of major Drivers/ Pressures generating the coastal Impact/Issues.
  - What are the major (up to 10) driver/ pressure settings on catchment level causing coastal change?
  - Can we identify spatial scales on which certain driver/pressure settings dominate coastal issues?
3. Assessment and synthesis of regional Driver/Pressure settings generating the coastal Impact/Issues and expected trends in a hierarchical upscaling approach.

- What are the major driver/pressure settings causing coastal impact observed and what are the future trends: on catchment level, on sub-regional/island or country level, on regional level?
- 4. Assessment and synthesis of scientific and/or policy/management response.
  - What is the current status of response taken on scientific or policy/management level against the major coastal issues in the region?
- 5. Assessment and synthesis of gaps in understanding, hot spots and research needs.
  - What are the major gaps in our current understanding of river catchment – coastal sea interaction in the region of concern and which hot spots should be addressed in a future integrated scientific effort/ proposal (natural and socio economic disciplines)

It is intended to apply this approach to all the BASINS studies, South American BASINS II in May, Caribbean BASINS II in June, African BASINS II in August, and to an Australasian assessment meeting in December. The Oceania island assessment desk study currently underway at the University of Adelaide will follow the same lines. The EURO-CAT project (<http://www.iaa-cnr.unical.it/EUROCAT/project.htm>) will apply the BASINS tables to provide a first European baseline study of our understanding of these issues.

## LOICZ IPO Notes

### LOICZ Synthesis

The outline for the LOICZ Synthesis Book (1993-2002) [LOICZ Newsletter No 17, December 2000] has been moving forward. Lead authors have been refining and developing chapter content in collaboration with a wide range of global scientists. This is not and cannot be an exclusive exercise. Please accept the challenge to be part of this collective effort and talk with the lead authors about how you can contribute and become part of the wider team.

LOICZ plans to hold a “Synthesis Science Meeting” in early-middle May next year. This is seen as a mini-Open Science Meeting to which we will invite key people from within and outside the LOICZ community, and all other interested people to attend. The core of the meeting would be presentation of the highlights of the draft synthesis chapters and, through working groups, we would aim to address gaps and start to develop an across-project synthesis (for Chapter 7). The IPO will start making arrangements for the meeting over the next few months, including additional

support funding to support participants.

### IGBP-SC 2001

The IGBP Scientific Committee held its annual meeting in Chiang Mai, Thailand 20-23 February 2001. Major issues included election of a new Chair, the future of IGBP (science and structure), the Amsterdam Congress, and status of core project activities.

Guy Brasseur (Chair IGAC) was nominated for IGBP Chair commencing January 2002. The Vice Presidents (Bob Wasson, Paul Crutzen) will increase their formal involvement through identified portfolio activities in IGBP.

The future of IGBP was discussed at length. Major questions about functioning of the whole Earth system is the theme for future work. The representational model involving three compartments (land, ocean, atmosphere) and three inter-compartmental interfaces (land-atmosphere, ocean-atmosphere, land-ocean), adopted at IGBP-SC Cuernavaca in 2000, forms the basis for the development of an identified IGBP II (Earth Systems Science) Program - to extend for another 10 years from January 2003.

While existing core projects are identified as foci for the further development of questions, objectives and structure discussions which will proceed over the next 18 months, there is a reasonably clear recognition that IGBP II will not be a retrofit of objectives to the existing structure. The Oceans futures (with SCOR) and Terrestrial futures working groups will continue in this year to identify the key sectoral issues for global questions - and are structured to work beyond these compartment to encompass elements of the interfaces. The refined SOLAS project has been approved (jointly by SCOR and IGBP-SC) as the basis for the ocean-atmosphere interface; a land-atmosphere core project is mooted. IGAC will lead towards middle and upper atmosphere questions.

LOICZ was identified - and clearly expected by the SC - to continue beyond 2002 as the focus for land-ocean interactions, noting that new/additional questions and an appropriate structure would need be evolved. This is a challenge that will be addressed, initially, by the LOICZ SSC through development in this year of a discussion paper. Also, LOICZ is investigating sponsorship

arrangement with several agencies and national governments which have previously indicated an interest in being co-sponsors of the core project.

#### LOICZ sponsors

The committee of Dutch core funders of LOICZ met in late January to review our status and progress. The committee was positive and greatly encouraged by our performance and direction.

#### Farewell to SSC member

Dr Silvia Ibarra Obando has finished her 6 year term on the LOICZ SSC. However, she will remain in close contact with LOICZ, and will be contributing to the LOICZ Synthesis book.

#### Correction and apology

Dr Han Lindeboom's correct email address is:

**H.J.Lindeboom@Alterra.wag-ur.nl**

Please note the error in LOICZ Newsletter No.17 December 2000.

#### HAVE YOU SEEN

The CD-ROM on Arctic river gauges for all major river basins:

Lammers, R.B., Shiklomanov, A.I. compilers, 2000. **R-ArcticNet, A Regional Hydrographic Data Network for the Pan-Arctic Region**. Durham NH: Water Systems Analysis Group, Univ. of New Hampshire, distributed by the National Snow and Ice Data Centre (nsidc@kryos.colorado.edu).

#### LOICZ PUBLICATIONS

[Available as printed copies or from the LOICZ web site: [www.nioz.nl/loicz](http://www.nioz.nl/loicz)]

Estuarine Systems of the East Asian Region: C, N, P Fluxes, 2000. LOICZ UNEP workshop report. Eds. V. Dupra, S.V. Smith, J.I. Marshall Crossland and C.J. Crossland. LOICZ R&S no. 16, 2000.

SARCS-WOTRO-LOICZ: Biogeochemical and Human Dimensions of Coastal Functioning and Change in Southeast Asia. LOICZ R&S No. 17, 2001.

LOICZ Web Site: Biogeochemical Budgets and Modelling – new sites and tutorial materials (<http://data.ecology.su.se/MNODE?>).

LOICZ Web Site: Typology (<http://water.kgs.ukans.edu:8888/public/Typpages/index.htm>) Also ([www.kgs.ukans.edu/Hexacoral/Workshops](http://www.kgs.ukans.edu/Hexacoral/Workshops))

#### LOICZ CALENDAR

**LOICZ UNEP Americas** thematic workshop on upscaling and assessment of nutrient fluxes in coastal estuarine systems. 29 April–2 May 2001.

Ensenada, Mexico (by invitation).

Contact: LOICZ IPO.

**SAMBAS II** workshop on South American Basins and Caribbean river catchments/coastal fluxes and human dimensions. 2-6 May 2001. Fortaleza, Brazil. (by invitation). Contact: LOICZ IPO.

**LOICZ UNEP Africa and Europe** thematic workshop on upscaling and assessment of nutrient fluxes in coastal estuarine systems. 2-5 July 2001. RIKZ-CZMC, The Hague, The Netherlands (by invitation). Contact: LOICZ IPO.

**LOICZ Scientific Steering Committee Meeting**. 7-8 July 2001, Amsterdam. Contact: LOICZ IPO.

**AfriBASINS II** workshop on African river catchments/coastal fluxes and human dimensions. August 2001.

Nairobi, Kenya (by invitation).

Contact: LOICZ IPO.

**LOICZ-UNEP Polar** regions workshop on biogeochemical modelling of estuarine systems. Tromsø, Norway. September, 2001. (tentative)

**LOICZ UNEP Global** thematic workshop on upscaling and assessment of nutrient fluxes in coastal estuarine systems. 5-9 November, 2001. TBA.

**Austral-AsiaBASINS** workshop on Australasian and Southeast Asian river catchments/coastal fluxes and human dimensions. Australia, December, 2001 (tentative)

**LOICZ "Synthesis"** and Open Science Meeting. May 2002. TBA.

#### OTHER MEETINGS

**GEOTROP** 4<sup>th</sup> Internat'l Conference on Environmental Chemistry & Geochemistry in the Tropics. 7-11 May 2001, Townsville, Australia. Contact: Greg Brunskill (g.brunskill@aims.gov.au) or [www.tvl.clw.csiro.au/geotrop2001/](http://www.tvl.clw.csiro.au/geotrop2001/)  
**CoastGIS 2001**: 4<sup>th</sup> International Conference on Computer Mapping and GIS for CZM – Managing the Interfaces.

18-20 June 2001, Halifax, Nova Scotia, Canada. More information on <http://agc.bio.ns.ca/coastgis2001>

**IGBP Open Science Conference**.

10-14 July, 2001, Amsterdam, The Netherlands. Contact: [igbp@congrex.nl](mailto:igbp@congrex.nl), [www.sciconf.igbp.kva.se](http://www.sciconf.igbp.kva.se)

**3<sup>rd</sup> International Conference on Land Degradation** and Meeting of the IUSS Subcommission C – Soil and Water Conservation. 17-21 Sept 2001, Rio de Janeiro, Brazil. More information on [www.cnps.embrapa.br/icld3/](http://www.cnps.embrapa.br/icld3/)

**IAPSO-IABO Assembly and XII Colloquium: 2001 - An Ocean Odyssey**. 21-28 October 2001, Mar del Plata, Argentina. Contact: [gmperrill@criba.edu.ar](mailto:gmperrill@criba.edu.ar) or [iado@criba.edu.ar](mailto:iado@criba.edu.ar)

**Global Conference on Oceans and Coasts at Rio+10: Assessing Progress, Addressing Continuing and New Challenges**. 3-7 December 2001. UNESCO, Paris. Contact: IOC Secretariat, Paris.

**IAS/SEPM Environmental Sedimentology Workshop: Continental Shelves – Processes, Record, Utilization and Management**. 7-10 January 2002. Hong Kong. Contact: Wyss Yim ([wwsyim@khu.hk](mailto:wwsyim@khu.hk)).

#### IPO STAFF

**CHRIS CROSSLAND**

Executive Officer

**HARTWIG KREMER**

Deputy Executive Officer

**HESTER WHYTE,**

Office Manager

**MILDRED JOURDAN,**

Office Assistant

**MAARTEN SCHEFFERS**

Liaison Officer

**FOR MORE INFORMATION,  
PLEASE CONTACT:**

**LOICZ INTERNATIONAL PROJECT  
OFFICE**

**NETHERLANDS INSTITUTE FOR  
SEA RESEARCH  
PO Box 59  
1790 AB DEN BURG - TEXEL  
THE NETHERLANDS**

**PHONE: 31-222 369404**

**FAX: 31-222 369430**

**E-MAIL: [LOICZ@NIOZ.NL](mailto:LOICZ@NIOZ.NL)**

**WWW HOME PAGE:**

**[HTTP://WWW.NIOZ.NL/LOICZ/](http://WWW.NIOZ.NL/LOICZ/)**