



## Land-Ocean Interactions in the Coastal Zone



# INPRINT

Coastal Zones are complex socio-ecological systems, delivery and sustainability of goods and services are dependant on functions and processes which are under increasing anthropogenic and climatic influence. Biogeochemical fluxes are key indicators mirroring land-based activities and potential scales for social response. This newsletter looks into new aspects of biogeochemical assessment and nutrient accounting as a means to ultimately inform decisions relevant for management across the dynamic land - sea boundary. We also feature the recent changes in the IPO team and their implications in the new phase of LOICZ.

**Joint IMBER/LOICZ Continental Margins Open Science Conference** – Impacts of global, local and human forcings on biogeochemical cycles and ecosystems. Shanghai, 17–21 September 2007



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## Scientific Reports

### Management outcomes from LOICZ biogeochemical budgeting in New Zealand

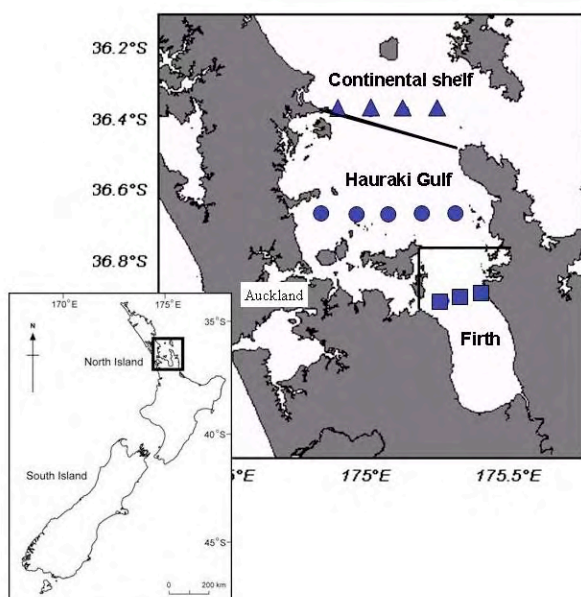
John Zeldis, j.zeldis@niwa.co.nz

#### Introduction

LOICZ II is increasingly concerned with implications of human activities and the governance of the coastal zone on the environmental state of the world's estuaries and other coastal ecosystems. The application of biogeochemical budgeting to these issues was not the focus of LOICZ I, but we are now trying to consider how to best apply these approaches to management questions. This report describes three case studies which illustrate how important outcomes for resource managers and industry have been realised using LOICZ budgeting in New Zealand. They consider the balance of terrestrial and oceanic forcing of nutrient flux, estimating absolute magnitudes of allochthonous dissolved and particulate carbon and nitrogen fluxes, and evaluating aquaculture impacts in coastal ecosystems.

#### The balance of terrestrial and oceanic forcing of nutrient flux

The primary information for this work was a LOICZ budget created for the Hauraki Gulf and adjacent Firth of Thames (Zeldis 2006), in northeastern New Zealand (Fig. 1). The Hauraki Gulf is a large temperate latitude embayment on the northeastern coast. New Zealand's largest city, Auckland (1.2 million population), borders the Gulf's southwestern shoreline, while the remainder of its catchments are largely pastoral or in native forest.



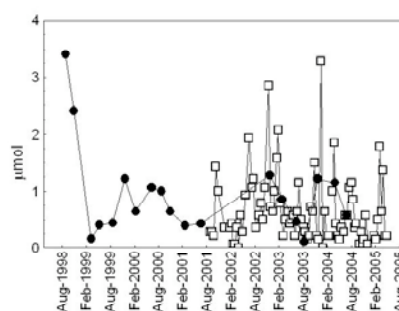
**Figure 1:** Hauraki Gulf in northeastern New Zealand (inset) and place names, sampling stations and system boundaries used in the 2000–01 Hauraki Gulf /Firth of Thames LOICZ budget.

The Hauraki budget allowed conclusions about relative importance of oceanic, riverine and sewage loading rates to the Firth and Hauraki Gulf under variable oceanographic conditions (here I use the standard LOICZ budgeting notation for river, residual, and exchange flows:  $V_O$ ,  $V_R$  and  $V_X$ , respectively, and denote fluxes with respect to the Firth and Gulf with subscripts 1 and 2 respectively). For the Firth, the ratio of fluxes of DIN from rivers to the total riverine and oceanic flux was derived as:

$$V_{O1}DIN_{O1} / (V_{O1}DIN_{O1} - V_{R1}DIN_{R1} + V_{X1}(DIN_2 - DIN_1))$$

This showed that rivers contributed about 65% of the total of river + ocean DIN supply to the Firth, while mixing between the Firth and the seaward Gulf contributed 35%. Similar calculations for the Gulf showed that rivers (including those discharging to the Firth) supplied only 8% of DIN, and sewage from Auckland City contributed 5%, demonstrating the dominance of mixing supply from the adjacent ocean, to the Gulf.

It was clear that most DIN was supplied to the Firth by its rivers during the budgeted period (2000-01). However, during most of that time, the Gulf and Firth were oligotrophic, with relatively low near-bed  $NO_3^-$  concentrations detected in the outer Firth (Fig. 2). Over longer time frames, the Firth has protracted phases of high or low  $NO_3^-$  concentrations, each lasting a number of months, driven by upwelling dynamics over the adjacent continental shelf (Zeldis et al. 2004, Zeldis 2004). Upwelling causes near-bed Firth  $NO_3^-$  to vary 2 to 3-fold (Fig. 2), although the salinities of the upwelled and downwelled waters are very similar. This plasticity of ocean loading suggests that it has great potential to drive long-term variation in Firth DIN loads.



**Figure 2:** Nitrate sampling in the outer Firth of Thames September 1998 - June 2005 in the NIWA Cross-Shelf Exchange programme (circles) and the Wilson Bay (Group A) mussel farm monitoring programme (squares). Note protracted phases of higher  $NO_3^-$  in 1998, 1999–00, 2002–03, and 2003–04. The  $NO_3^-$  concentrations at the times of the 4 seasonal surveys used in the LOICZ budget are enclosed in the rectangle.



This hypothesis was tested by gauging the response of the budget to increased system DIN concentrations in Firth and Gulf boxes, i.e.,  $DIN_{1,2}$ . When  $DIN_{1,2}$  values were doubled and trebled to emulate increased upwelled supply, but river inputs were held constant, the percentages of river supply of DIN of the total DIN supply into the Firth decreased from 65% to 45% and 36%. The study thus indicated that the major source of long-term variation in DIN supply to the Firth of Thames originates from upwelling dynamics offshore.

These LOICZ findings have been used by Auckland Regional Council and Environment Waikato, the local authorities mandated to maintain sustainable resource use in the Auckland and Waikato Districts, in State of Environment Reporting for the Hauraki Gulf (Hauraki Gulf Forum 2004). The budget showed that rivers are a significant, often dominant, term in Firth of Thames nutrient dynamics. Significant increase or decrease in long-term loading from the Firth catchments (such as could arise from land-use change) could alter Firth nutrient dynamics. However, it is also clear that upwelling can also dominate Firth nutrient dynamics, dependent on offshore conditions. This information has provided Regional Councils with improved perspectives regarding management of land use in catchments and about land – coast interactions, in the nationally important Hauraki Gulf region.

#### Dissolved and particulate C and N fluxes to coastal systems

Particulate material fluxes are not explicitly budgeted in the LOICZ procedure because of inherent imprecision in their estimation (Gordon et al. 1996). However, it is possible to infer their magnitudes, which may be valuable for coastal system management. For the Hauraki Gulf / Firth system, the amount of allochthonous PON needed to support denitrification flux, given summed DIN and DON fluxes (i.e., DN fluxes), was

$$-(\text{fix-denit}_{\text{inorg+org}}) + V_{Q1}DN_{Q1} + V_{R1}DN_{R1} + V_{X1}(DN_2 - DN_1),$$

where the first term indicates net denitrification calculated for both inorganic and organic N fluxes and subscripts 1 and 2 indicate Firth and Gulf systems. For the Firth, this evaluated to ~9000 tonnes of allochthonous PON  $y^{-1}$ . DIN inputs to the Firth accounted for only about 38% of this N required to balance the denitrification flux (Zeldis 2006).

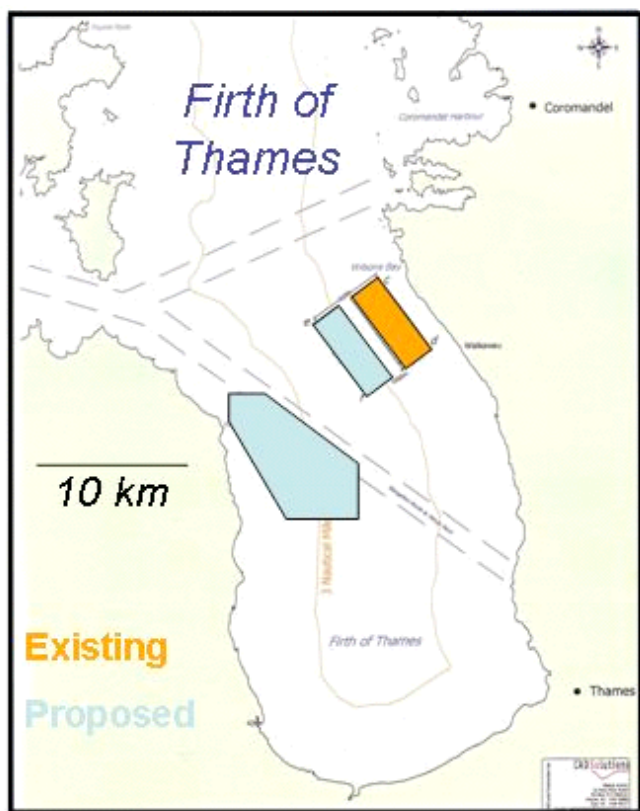
The Firth also had an excess of oxidation over production ( $p-r = -12 \text{ mmol C m}^{-2} \text{ d}^{-1}$ ), which must be subsidised by net import of substantial amounts of labile organic carbon and its oxidation in the Firth. This import was mainly in POC rather than dissolved organic carbon (DOC) because net flux of DOP (and hence DOC) was small: Zeldis 2006). The required net POC flux was ~ 55 000 tC  $y^{-1}$ .

These calculations do not determine the provenance of this particulate material: while it will certainly be from both marine and terrestrial sources, the ratio of the sources is not known (see Zeldis 2005) and further research is required on the provenance, geochemistry and reactivity of particulate material to elaborate on these findings. Sedimentation is a key management issue in the inner Firth (Fig. 3) and these calculations provide a system-level estimate of this loading. They also inform management policy in that they estimate the capacity for denitrification to 'buffer' the Firth against excessive N loading from terrestrial and marine sources, which could otherwise cause eutrophication (Hauraki Gulf Forum 2004). The findings suggest that management initiatives to limit dissolved nutrient flux from catchments should also consider the flux of particulates



**Figure 3:** Hauraki Gulf scene showing high suspended sediment environment in inner Firth of Thames, acquired by MODIS, 23 October 2002. Data used courtesy of NASA, source: NIWA. Evaluating aquaculture impacts in coastal ecosystems

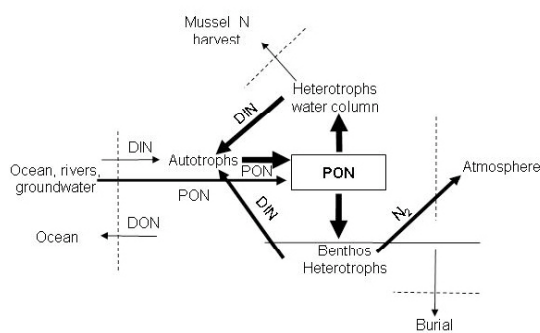
Greenshell mussel farming is the largest aquaculture industry in New Zealand, returning over \$NZ 200 M  $y^{-1}$  to the economy. Mussels are grown using suspended rope culture and feed on phytoplankton and other suspended particles drifting through the farms. The eastern Firth of Thames (Fig. 4) supports the largest single block of mussel farms in New Zealand, within the Wilson Bay Aquaculture Management Area (AMA). In addition to this development in the eastern Firth, another zone, approximately twice the size of the Wilson Bay AMA, was under consideration by Auckland Regional Council in the western Firth. The scale of these developments has made it incumbent on these regional councils to assess and predict environmental performance of Firth aquaculture at Firth-wide scales.



**Figure 4:** Locations of the Wilson Bay Aquaculture Management Area (AMA) in the Eastern Firth of Thames and the proposed Western Firth AMA. Note scales of the developments.

Using LOICZ and primary production information, this case study estimates incorporation of C and N into organic material through system import and primary production, and losses of C and N through system respiration, denitrification, and export. These were compared with C and N assimilation and respiration by mussel farms, at the various AMA development intensities. They provided perspective on the relative magnitudes of ecosystem and farm processes, under the various intensities of AMA development, to address the issue of aquaculture sustainability from a systems-level perspective.

The context of mussel aquaculture within Firth ecosystem N-cycling is shown in Fig. 5. This shows the loading of PON and DIN to the system, uptake of the new DIN by autotrophs in primary production (180,000 tC y<sup>-1</sup>), decomposition of PON by heterotrophs (including mussels) to DIN, and recycling of the DIN via autotrophs to PON. Competing with the internal production:decomposition cycle is the major N<sub>2</sub> sink through denitrification (11,000 tN y<sup>-1</sup>) and a smaller burial sink. Also competing with the internal primary production cycle is the removal of N by the harvest of mussels.



**Figure 5:** Net N fluxes in the Firth production cycle. System boundaries are dashed. Increasing arrow thicknesses denote small, medium and large flows. 'Autotrophs' are all primary producers and 'Heterotrophs' are all secondary producers including mussels.

Carbon cycling (not shown) has similar dynamics, centred on POC, with recycled production of DIC, and its major sink to the atmosphere as CO<sub>2</sub>. The DIC production is Firth system respiration (240,000 tC y<sup>-1</sup>), produced by all biota including mussels. Carbon is also removed by the mussel harvest. These results were compared with information on farmed mussel biomass, C and N composition, and weight-specific respiration (Zeldis 2005), to draw conclusions about the importance of mussel aquaculture within the Firth ecosystem (Table 1).

Annual Harvest Tonnage (green weight)	9000	13000	63000
Mussel C production:Firth C primary production	0.2	0.3	1.6
Mussel C respiration:Firth C respiration	0.3	0.4	1.8
Mussel N production:Firth denitrification	0.4	0.6	2.8

**Table 1:** Firth of Thames mussel farm fluxes compared to Firth system fluxes, for three annual mussel harvest scenarios: harvest at Wilson Bay as of May 2005 (9000 t); projected harvest as of end of 2007 (13 000 t), and at maximum development of Wilson Bay plus Western Firth (63 000 t; see Fig. 4).

Across the range of harvest scenarios, harvest removes between 0.2 and 1.6% of Firth C primary production y<sup>-1</sup> and mussel C respiration accounts for between 0.2 and 1.8% of present Firth system respiration. At maximum development, the size of the harvest N sink is about 2.8% of size of the denitrification sink, demonstrating the relative sizes of these constraints on Firth N supply and primary production. These calculations give perspectives on the significance of C and N removal by farmed mussels, relative to the amount of these materials currently supplied to the Firth, which sustain its primary productivity, respiration and denitrification.

Obvious shortcomings of the LOICZ-based analysis are that it is not spatially nor temporally resolved. For this reason, we consider that its benefits are maximised



when complemented with other analyses: in our case we have compared the budget results with farm-site water quality monitoring (Zeldis et al. 2006) and biophysical modelling (Broekhuizen et al. 2005), both of which have found that present levels of farming cause virtually undetectable amounts of phytoplankton depletion. Thus, three entirely independent approaches have yielded similar results with respect to marine farming in the Firth ecosystem. Along with this other information, the LOICZ approach has had a strong guiding influence on management of Firth aquaculture, with the conclusion that present farming levels present low risk, in terms of impact on food webs (M. Felsing, Environment Waikato, pers. comm., October 2006).

### Conclusion

These case studies show that LOICZ-based biogeochemical budgeting can complement findings from other studies, to inform stakeholders about important properties of their coastal systems. The LOICZ approach is effective in providing stakeholders with 'system-level' perspectives over processes and impacts, enabling new and valuable outcomes for environmental management.

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### LOICZ News

#### Arctic Frontiers 21–26 January Tromsø, Norway

The impact of Global Change is most apparent in the Arctic; temperature increase, permafrost thawing, sea ice cover decline, and severe coastal erosion are its already obvious consequences in the Arctic Basin and Arctic Coastal Zones. On the biological side, the decreasing sea ice cover and thus increasing irradiation alone leads to alterations in species composition, from phytoplankton to marine mammals.

In addition to these phenomena concerning changes in physical, chemical and biological oceanography, the interaction between the human dimension and the coast is also altered: new forms of land and sea use are anticipated. The North-West passage north of Canada from the Atlantic to the Pacific probably is about to open, and with the retreat of sea ice an opening of the Northern Sea route from Europe to the Far East is also anticipated. The oil and gas fields in Western Siberia are among the largest in Russia and exploitation activities are being extended. About 25% of the global reserves of fossil energy resources are expected to be located in the Arctic.

With these – already occurring or anticipated – severe changes in mind, science is challenged to assess the current status and future scenarios of ecosystem and socio-economic system functioning in order to forecast the implications of global change processes for the Arctic system. This needs to go hand in hand with socio-economic evaluation of human land and sea use and change/response options in light of the modelled scenarios of change in a warming Arctic.

The coastal zone is central in these considerations, and consequently, coastal and marine processes were a key focus in the „Arctic Frontiers“ conference jointly organised by the University of Tromsø and the Norwegian company Akvaplan-Niva. This conference was a first effort to combine natural sciences, economy and politics and showcased the relevance of this integrated perspective. However it also revealed the unique complexity in passing the traditional boundaries between the different communities. Co-sponsored by the private sector, the conference indeed had a strong participation and active involvement of the user community. This is a very welcome approach and it is hoped that Arctic Frontiers will (as co-organizer, Paul Wassmann, announced at the end of the conference) evolve into a continuous process. This would indeed be a very interesting platform for LOICZ to explore and engage in taking a regional look into its priority topics such as the socio ecological system coupling and governance baselines. LOICZ, IASC, AMAP and IHDP are planning an own workshop in autumn, (see under „Arctic Coastal Zones at Risk“ (<http://w3k.gkss.de/events/arctic07/>) which will pick up a variety of issues addressed in Arctic Frontiers.



Participants of Arctic Frontiers watching a theatre performance celebrating the return of the sun after the Arctic winter. (Photo H. Kremer)

### **SCOR-LOICZ Working Group 122 „Mechanism of Sediment Retention in Estuaries“**

The SCOR-LOICZ Working Group 122 „Mechanism of Sediment Retention in Estuaries“ will meet on September 23-27 at INSTAAR, University of Colorado, Boulder, Co, USA.

Although the meeting will concentrate in finalizing the Terms of References (TOR) of the WG and defining the publication of its findings, it will be open to other participants interested in the subject matter. The meeting will consist in invited presentations, selected contributions and round-table discussions about the TOR. Those in the

LOICZ community interested in attending should provide the organizers with a title and abstract to indicate their interest in attending.

#### **Contact:**

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### **Some highlights of the Workshop on Integrated Budgeting of Nitrogen Fluxes in Regional Watersheds: Linking Atmospheric, Terrestrial, Aquatic and Coastal Interactions.**

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A workshop held in Paris, during January 14-17, 2007, and co-sponsored by LOICZ and the European Science Foundation's NINE networking program ([http://www.esf.org/esf\\_article.php?language=0&article=528&domain=3&activity=1](http://www.esf.org/esf_article.php?language=0&article=528&domain=3&activity=1)) brought together European and American investigators to extend some concepts relating nitrogen inputs to watersheds to nitrogen exports in rivers. The main goal of the meeting was to review several concepts pertaining to the nitrogen budget of large watersheds in Europe and elsewhere, to extend these to other critical nutrients (i.e. phosphorus and silica), to compare different approaches and methodologies for assessing the nitrogen cascade within watersheds, and to evaluate the impacts of nutrient loads on coastal ecosystems.

#### **History**

The concept of Net Anthropogenic Nitrogen Inputs (NANI) to large watersheds was first elaborated in a workshop on nitrogen and phosphorus fluxes in the North Atlantic and its regional catchments, held at Block Island, in the northeastern US in 1994, which resulted in several influential papers in Biogeochemistry (Howarth et al., 1996). The concept was further refined at a second workshop focusing on major watersheds of the eastern United States (Boyer et al., 2002). In January 2005, a meeting was held in Sigtuna, Sweden, to discuss integrated approaches for estimating nutrient fluxes in large watersheds. The meeting brought together European and American groups interested in nutrient accounting and hydrology-based modeling. The Paris workshop in January 2007 was a follow-up meeting to further engage those who participated in the Sigtuna

meeting and others in exchanging datasets, defining a common methodology, and addressing the relationships between terrestrial nutrient fluxes and coastal ecosystem dynamics.

While the workshop sustained a lively and wide-ranging discussion of watershed and coastal zone nutrient issues, we highlight four general focus areas here.

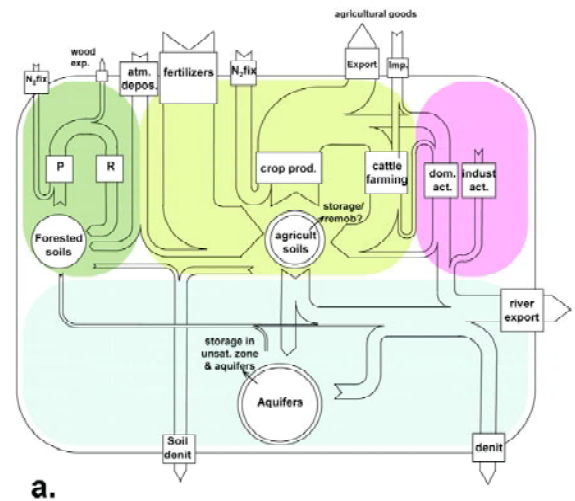
### NANI

The Net Anthropogenic Nitrogen Inputs to watersheds is an accounting method by which nitrogen sources are summed to estimate an upper limit of the nitrogen available for export from a watershed. Four categories of net anthropogenic inputs are considered:

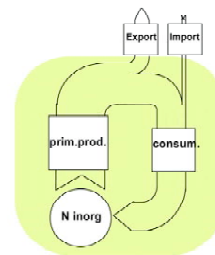
- atmospheric deposition,
- fertilizer,
- agricultural nitrogen fixation, and
- food and feed transfers across watershed boundaries

Note that NANI does not include all nitrogen fluxes – it is intended to estimate only anthropogenically generated nitrogen, and thus those terms in addition to „background“ flows of N which might be associated with unperturbed ecosystems. Thus NANI indicates a measure of N impact by humans, and a goal is to relate it to the response observed in rivers, estuaries, and other coastal ecosystems. Other nutrients, especially P and Si, could be assessed in a similar manner, though some terms would drop out or be replaced by other terms (e.g. „fixation“ might be replaced by enhanced weathering for Si, which tends to be the dominant source term).

Previous studies showed that only 20-25% of NANI leaves a watershed in river-borne nitrogen (Howarth et al., 1996; Boyer et al., 2002). The same is true for NTNI, the Net Total Nitrogen Inputs. Determining what happens to the 'remaining' nitrogen is an active area of current research. Gaseous loss as  $N_2$  (and also as  $N_2O$ ) is probably the most important fate, although storage in soil organic matter and in contaminated aquifers are other possibilities. Assessing the respective part of „landscape“ versus „in-stream“ processes in the nitrogen cascade across different watersheds with variable levels of human perturbation will be the subject of further investigations.



**Figure 1a:** Schematic diagram of nitrogen flows in a watershed. The pink (domestic and industrial sectors) and beige (agricultural sector) are those areas most affected by anthropogenic nitrogen inputs. Forested areas (green) and aquifers (light blue) are areas of nitrogen processing in the landscape.



Balance between  
Agricultural Prim. Production → autotrophy  
Human+livestock consumption → heterotrophy

**b.**

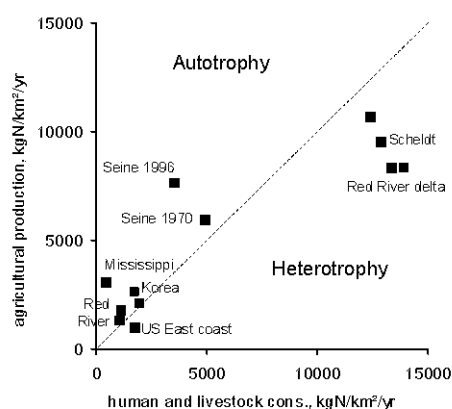
**Figure 1b:** In human dominated ecosystems, watershed autotrophy/heterotrophy is determined by the balance of agricultural primary production and consumption of food and feed by humans and livestock.

### Watershed heterotrophy/autotrophy

The notion of whether an ecosystem is autotrophic or heterotrophic is conventionally discussed in terms of its carbon or energy budget: if the primary production of an ecosystem exceeds its ecosystem respiration ( $P/R > 1$ ), it is regarded as autotrophic; conversely, if respiration exceeds production ( $P/R < 1$ ), the system is heterotrophic. Most ecosystems unperturbed by human activity are in approximate balance ( $P=R$ ). However, in modern times, most ecosystems are affected in many ways by human activity. Le et al. (2005) have addressed the question of human impact on this question by recasting the calculations of autotrophy/heterotrophy in terms of N flows, and evaluating the principal flows of nitrogen associated with food and feed production and consumption associated with the distribution of humans and livestock through the landscape – flows which are critical components of NANI (Figure 1b). Today, this „human component“ of ecosystem autotrophy/hetero-



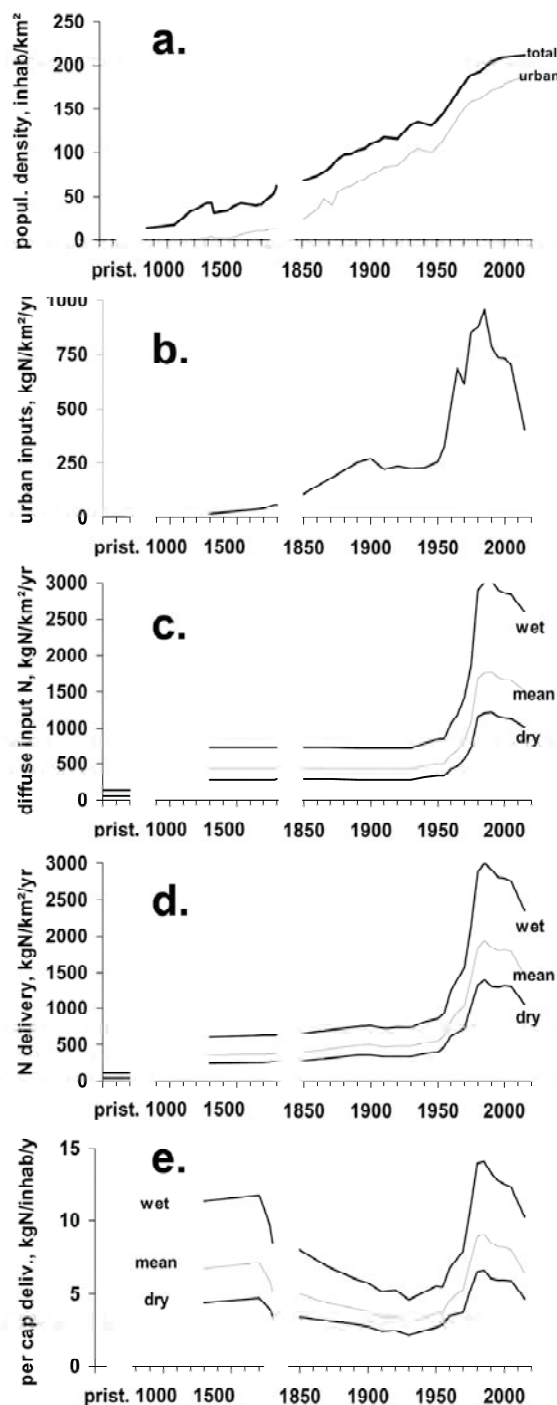
trophy typically dominates the „natural“ component, and exhibits a radically different spatial structure (Figure 2). Using this approach, heterotrophic systems are considered those in which agricultural production does not meet local demand, and thus food and feed must be imported. Autotrophic systems typically export food and feed. In many instances in Europe and North America, the nitrogen fluxes associated with food and feed export or import are larger than other components of the nitrogen budget like riverine flows of nitrogen and landscape retention.



**Figure 2:** Watersheds dominated by agricultural cropping systems tend to be autotrophic (agricultural productivity exceeds consumption). Those with high human and animal population densities tend toward heterotrophy. After Le et al., 2005.

### Per capita rate of riverine nitrogen export

Modern levels of riverine nitrogen flows are much larger than those of earlier periods of human history (Figure 3). The same is true for phosphorus. Many authors, basing their studies on statistical analysis of large river data bases, have derived rough per capita contributions to enhanced nutrient fluvial delivery from continent to the coastal ocean (Meybeck, 1982; Green et al, 2004, Seitzinger et al, 2002b, Smith et al, 2003). This index is largely dependent on the hydrology, reflecting the dominant contribution of agricultural soil leaching. Long term historical reconstitution of nitrogen deliveries in relationship with total population in the watershed shows surprising trends that deserve further examination (Figure 3). For phosphorus loadings, often dominated by point urban release, the overall per capita delivery remained close to  $0.4 \text{ kgP}\cdot\text{cap}^{-1}\cdot\text{yr}^{-1}$  until 1950; it then increased 4-fold in a few decades, before recently falling back to much lower values.



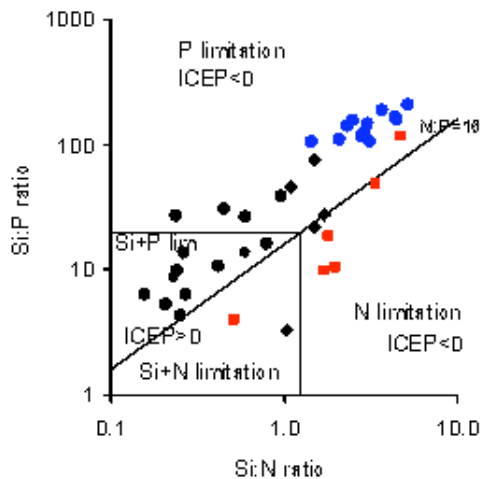
**Figure 3:** Reconstruction of historical changes in the nitrogen budget of the Seine drainage network for three hydrological regimes.

a. population density; b. urban point sources of nitrogen to surface water; c. diffuse sources of nitrogen to surface water; d. corresponding simulated coastal N delivery from the Seine basin. e. calculated per capita rate of N delivery.

After Billen et al., 2006.

## ICEP

Harmful algal blooms (HABs) are troubling symptoms of excessive nutrient loading in some coastal ecosystems. While their origins are not well understood, a recognized aspect of HABs is that most (not all) of them are associated with non-siliceous algal species; that is, most of the troublesome species are not diatoms. While all algae require nitrogen and phosphorus to sustain growth, diatom species of algae (and some others) require silica as a nutrient to create their structural „skeleton“, their „frustule“ in addition to nitrogen and phosphorus. While eutrophication (excessive production due to excess nutrients) can occur irrespective of the availability of silica, it makes sense to consider the load of nitrogen and phosphorus in excess of the demand of siliceous algae when considering the potential occurrence of HABs (Figure 4).



**Figure 4:** Following the Redfield ratio, coastal ecosystems with molar N:P ratios greater than 16 are P limited. However, irrespective of N or P limitation, if the ratio of Si to these nutrients falls below the requirements of diatoms, Si limitation can be inferred, and the potential for HAB occurrence is increased (ie ICEP > 0). Redrawn from Billen and Garnier, 2006.

Billen and Garnier (2006) have defined an indicator of coastal eutrophication potential (ICEP) of riverine nutrient inputs as the carbon biomass potentially produced in the receiving coastal water body based on the flux of nitrogen or phosphorus (depending upon which is limiting with respect to the other) delivered in excess over silica. The indicator expresses the potential for new production of non-siliceous algae sustained by riverine nutrient delivery. It is expressed in units of carbon per day, the units generally used for reporting marine primary production, and is scaled to the river watershed area, for the sake of basin to basin comparison.

It can be calculated by the following relationships (based on the Redfield molar C:N:P:Si ratios 106:16:1:20):

$$\text{ICEP} = \left[ \frac{\text{NFlx}}{14 \cdot 16} - \frac{\text{SiFlx}}{28 \cdot 20} \right] \cdot 106 \cdot 12$$

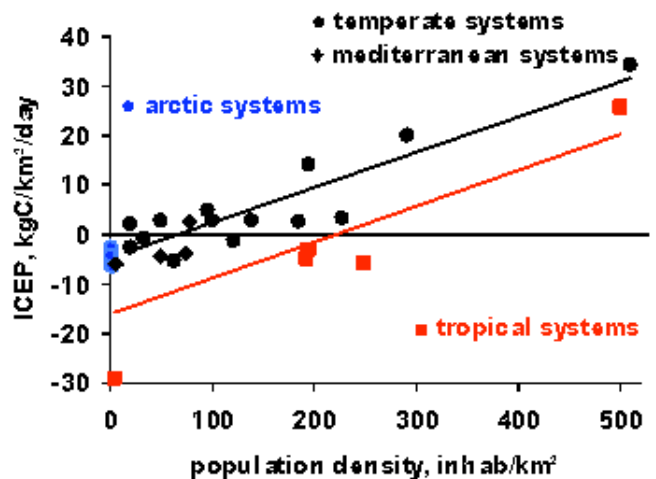
if N/P < 16 (N limiting)

$$\text{ICEP} = \left[ \frac{\text{PFlx}}{31} - \frac{\text{SiFlx}}{28 \cdot 20} \right] \cdot 106 \cdot 12$$

if N/P > 16 (P limiting)

where NFlx, PFlx and SiFlx are the mean daily fluxes of total nitrogen, total phosphorus and dissolved silica expressed in kg of the respective nutrient per watershed km<sup>2</sup>.

Not surprisingly, ICEP increases with the population density of watersheds because of the correlation of nutrient flux with population. However, for a given level of watershed population, ICEP is lower in tropical areas than in temperate areas due to the higher silica loading characterizing tropical rivers (Figure 5). One of the aims of workshop participants over the next year is to examine the coincidence of HABs and in areas of positive ICEP in order to test the validity of this index.



**Figure 5:** ICEP, a Si based eutrophication index, is positive when riverine N or P fluxes exceed the potential demand for N or P associated with siliceous algae and thus indicate the potential for harmful algal blooms. Because riverine nutrient fluxes increase with population density (cf Smith et al., 2003) the index does as well. Tropical rivers exhibit a lower value of ICEP at the same loading rate than temperate rivers because of a generally higher silica specific delivery. From Billen and Garnier, 2007.

### Workplan

As a result of the meeting, a plan was developed to organize, over the next year, a special issue of a journal to discuss the above conceptual and methodological issues, including:

- comparison of NANI estimates with measured riverine fluxes,
- discussion of autotrophy/heterotrophy of watersheds and its relationship to NANI,
- fate of non-exported nutrients in the landscape and the river continuum,
- evaluation of uncertainties of NANI and riverine flux estimates,
- discussion of effects of nutrient delivery to coastal ecosystems,
- discussion of scale issues,
- comparisons with other methodological approaches,
- the importance of the agricultural system on nutrient fluxes, and

- case studies of watersheds of particular interest
- historical reconstitution of nutrient fluxes in well documented watersheds

Toward this end, over the next few months, meeting participants will assemble their collective datasets on European and American watersheds in a common format suitable for comparative analysis. When possible, complementary P and Si budgets will be assembled in order to address the coastal eutrophication potential of the watershed under study. Upon publication of the special issue devoted to the results of these analyses, the database will be available for general use.

For more information on products and outcomes of the workshop, contact Josette Garnier (Josette.Garnier@ccr.jussieu.fr) or Gilles Billen (billen@ccr.jussieu.fr)

### Workshop participants

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## Arctic Coastal Zones at Risk

Scientific Workshop on the Impact of Global Climate Change on the Arctic Coastal Zones. Jointly organized by the international organizations LOICZ, IASC, IHDP and AMAP.

1-3 October 2007, Polar Environmental Centre, Tromsø, Norway.

The Arctic organisations IASC (International Arctic Science Committee) and AMAP (Arctic Monitoring and Assessment Programme), together with LOICZ, the Land-Ocean Interaction in the Coastal Zone core research project of the IGBP (International Geosphere Biosphere Programme) and the IHDP (International Human Dimensions Programme on Global Environmental Change), will jointly organise a

scientific workshop aimed at the impact of Global Warming on Arctic Coastal Zones. The workshop is co-sponsored by the International Permafrost Association (IPA) More Details: <http://w3k.gkss.de/events/arctic07/>

Of particular interest is the response of Arctic geophysical and ecosystem features to effects of Global Warming i.e., the decreasing sea ice cover, the destabilisation of permafrost systems and increased exposure of the coast to storms. Embedded in this context will be the important issue of reactions of human societies to these Arctic changes. This includes both adaptation to changing living conditions bearing threats and options for human welfare as well as new forms of land and sea use such as enhanced access to resource extraction, or the increasing ship traffic along the coast.

## SECOND ANNOUNCEMENT

# Arctic Coastal Zones at Risk



Photo © Nadi Pocat

01. - 03. October 2007

Polar Environmental Centre  
Tromsø



## „Biogeochemistry of coastal seas and continental shelves“ – Session during the EGU meeting 15–20 April in Vienna

Helmuth Thomas and Alberto Borges

The session aims at fostering our understanding of the roles of coastal environments and of exchange processes along the terrestrial – coastal sea – open ocean continuum in global biogeochemical cycles. During the session recent advancements in the field of coastal and shelf biogeochemistry will be discussed. Contributions focusing on carbon and nutrient and all other element's cycles in coastal, shelf and shelf break environments are invited.

Details can be found under:

<http://meetings.copernicus.org/egu2007/> or by contacting Helmuth Thomas, Dalhousie University, Canada, [helmuth.thomas@dal.ca](mailto:helmuth.thomas@dal.ca)

## Workshop on Integrating biogeochemical processes and fish dynamics in food web models for end-to-end conceptualisation of marine ecosystems

ICTP, Trieste, Italy, 25–26 November 2007

### Objectives – Goals – Scope

The workshop is devoted to the integration of food web models with biogeochemical models for an ecosystem approach to marine resources. This activity is intended to give broad and general insights on the food web modelling by means of the software package Ecopath with Ecosim, and possibly some exercises and examples will be shown. Lectures will present experiences in linking biogeochemical models outputs with food web models, for an end-to-end conceptualisation of ecosystems. This is intended both to provide basics on these tools to scientific investigators interested in studying and managing marine resources and to enhance discussion on possible solutions for best coupling low level representations with approaches focussed on high trophic levels.

The workshop includes: 1. theoretical introduction to the mass-balance routine Ecopath and to data requirements and sources for building the model; 2. overview of first outputs of the model, evaluation of indicators of performance and descriptive of ecosystem status; 3. description of methods for incorporating uncertainty into models; 4. theoretical basis on the time-dynamic routine Ecosim and of the use of time series to calibrate the model; 5. methods for assessing performance of fisheries on the basis of ecological, economic and social indicators; using Ecosim for policy exploration; 6. possible use of the model for end to end conceptualization of marine ecosystem and, possibly, of ecosystem approach to marine resource.

This Workshop is a side activity of the 6th European Conference of Ecological Modelling (ECEM), to be held on November 26-30, 2007 at ICTP- Trieste. Organized by the OGS - Istituto Nazionale di Oceanografia e di Geofisica Sperimentale and the European Society of Ecological Modelling (ESEM), hosted by ICTP – The Abdus Salam International Centre for Theoretical Physics.

Maximum number of participants is fixed to 30 individuals. Applicants will be selected on the basis of filled application form and CV. Participation to the workshop of applicants from emerging countries is encouraged and available funding is provided for supporting participants from disadvantaged countries. Interested applicants should contact the organizing committee via email: [e-mail@e.mail.ciapa](mailto:e-mail@e.mail.ciapa).

Applicants from emerging countries (define here EC), post-doc and students can apply for a grant for supporting their participation to the workshop. Due to the limited amount of funds available early subscription is strongly encouraged.



## IMBER – LOICZ Continental Margins Open Science Conference

IMBER and LOICZ are jointly organizing this Continental Margins Conference to provide a discussion platform for highlighting the most recent advances in the field and try to identify emerging directions and future research challenges. The conference is open to all students and scientists involved in biogeochemical cycles and ecosystems in the continental margins.

Please have a look at the conferences website:

<https://www.confmanager.com/main.cfm?cid=792>



## The backbone of LOICZ: affiliated projects

LOICZ has a mandate to address key issues of coastal change and use in the context of scenarios of future human activity and environmental change. LOICZ endorses and seeks to support both fundamental coastal zone research and research that synthesises and up-scales results for dissemination within the scientific community, and outreach to policy makers and the public. An important part of this research is carried out by scientists who affiliate their projects to LOICZ thereby becoming part of the global network of LOICZ. These projects build the backbone for up- and down-scaling of LOICZ results and the LOICZ synthesis.

LOICZ provides a forum to assimilate, integrate and synthesise the outputs of its affiliated projects. Additionally, it provides an opportunity to communicate and disseminate these outputs making them available not only to other scientists, but also the public, decision-makers and managers. Information on affiliated projects is held in a central database that is accessible online through the LOICZ website. It makes basic information and regular updates available to the wider community as well as to LOICZ for its reporting requirements.

Once a project has been entered to the database by its Principle Investigator (PI), it will be reviewed by the IPO and the coordinator of the theme/topic it is contributing to most. As soon as the project is accepted it will appear in the public part of the database. This lean procedure allows LOICZ to maintain an up-to-date record of global research activity that relates to the LOICZ Science Plan as well as ensure that affiliated projects are given opportunity to fully participate in LOICZ activities such as workshops and joint projects.

Moreover, the database accomplishes an essential element that applies for all LOICZ interdisciplinary studies within and beyond the project namely data sharing and exchange. To facilitate this exchange LOICZ has developed a Data Policy to help affiliated projects and LOICZ to fully benefit from each other. Both documents, the Terms of Reference for affiliated activities and the Data Policy, can be found on the LOICZ website.

LOICZ protects its community members by restricting access to contact details in the public part of the database. But every community member and person interested in the activities affiliated to LOICZ is invited to register and then view full contact details and be able to submit and edit own projects. As the database is linked to the LOICZ contact database, all newsletter recipients are already recorded. If you wish to receive your login name and password for the database, please do not use the form as shown in Figure 1, but send us an email to [loicz.ipo@loicz.org](mailto:loicz.ipo@loicz.org)

## Call for research proposals concerned with Land-Ocean Interactions in the Coastal Zone

LOICZ seeks to expand its network of scientists by endorsing research activities concerned with any of its priority topics on a global, regional or national level. Within these topics LOICZ strives to develop:

- methodologies or models that allow data assimilation, processing and synthesis, including up and/or down scaling;
- scenarios of change and/or response to change in socio-ecological systems;
- scientific context for the evaluation of existing policies and structures;
- globally applicable tools for scientific synthesis, decision support and structure development; and
- dissemination interfaces to provide information and assist sustainable coastal development on appropriate scales.

To achieve this, **LOICZ is calling for proposals to bring high quality research activities into the LOICZ cluster of affiliated projects.** As well as fundamental science projects, LOICZ also seeks projects that have a multidisciplinary perspective, especially combining natural and social sciences. Projects can have global, regional or local scales and be focused on coastal sciences and/or coastal management. Projects that collaborate with other Earth Science System Partnership (ESSP) projects, especially with other Core Projects of IHDP and IGBP, are sought in particular, as well as projects that synthesise and analyse research outcomes already available or involve dissemination and outreach that will lead to better public knowledge. Details about projects already affiliated to LOICZ can be found in the LOICZ Project database accessible through the LOICZ website. Although LOICZ cannot offer funding to affiliated projects, its endorsement provides the following benefits:

- support in proposing for funding;
- promotion of the project and associated activities, its contributing team, outputs and outcomes through the LOICZ website and/or newsletter;
- contribution to workshops, conferences and meetings organised by LOICZ and hence establish linkages to other projects operating in similar fields and/or addressing similar issues; and
- access to a wide circle of information related to funding and the science community that is available through the LOICZ database.

Researchers whose work fits into the LOICZ portfolio are encouraged to submit proposals to the LOICZ IPO as soon as possible. The required form is accessible after registration to the LOICZ project database and additional information can be obtained from the LOICZ website or via contacting the LOICZ IPO.

**Do we hold your current contact details?**

To receive LOICZ INPRINT it is sufficient that we know your email address, or if you receive the newsletter in hardcopy your postal address. But there is much more information available at the LOICZ IPO that does not make it into the newsletter, for various reasons. **If you are interested in receiving information targeted to your field of expertise, please request your login details from us and update your profile online.**

**Figure 1:** Registration form of the LOICZ database. Recipients of LOICZ INPRINT and other active or formerly active members of the LOICZ community should contact the IPO for registration. Everybody else is invited to fill in this form.

**LOICZ Notes**

The LOICZ Regional Node in Singapore will hold the first workshop for the APN funded project **„Integrated Vulnerability Assessment of Coastal Areas in the Southeast Asia and East Asia Region“** from 3<sup>rd</sup> to 4<sup>th</sup> March.

The workshop will involve mainly the SEA and EA collaborators named in the project document (Cambodia – 1; Indonesia – 1; Malaysia – 1; Philippines – 3; Singapore – 1, Thailand – 2; Vietnam – 2, Japan – 1) who will be funded by this project grant. Also, DINAS-COAST and LOICZ-IPO/SSC collaborators will be participating.

**IPO Notes**

**The future of the LOICZ Typology**

Following up on the conceptualising workshop for the LOICZ Typology (see INPRINT 2006/3) the new server was installed successfully early this year. Our new intern Christoph Sebald together with Gisbert Breitbach from GKSS will now prepare the server to allow LOICZ in a first step to mirror the database hosted by the Kansas Geological Survey (KGS). Christoph will work on setting up a GIS workplace in the LOICZ IPO and will conduct work relating to the LOICZ Typology in close collaboration with colleagues from KGS.

The server will also offer space for the new LOICZ website which is currently in planning process by Maïke and Barbe and the project database which then can be administrated directly from the LOICZ IPO.

**IPO staff changes**

**Mission accomplished**



Over the last 1.5 years I was a regular member of the LOICZ IPO staff and enjoyed it. My internship in Texel was followed by the exiting move to the new location in Germany and with it a lot of new tasks for me. I was involved in harmonising the administrative procedures between LOICZ and our new host GKSS. Parallel I was involved in workshop organisation and public relation which allowed me to stay in close email exchange with the LOICZ community. I learned a lot in these fields and am sure this knowledge will help me in the future.

Although we had busy times in the office, I never lost track of my original task: The LOICZ project database.

This database now has a new face and is available online to support the affiliated projects. I think it is a great tool that will become even more powerful once the LOICZ community accustoms to use and visit it regularly.

With this task fulfilled, my mission at the LOICZ IPO is accomplished and I am leaving the team end of March to pursue my own scientific career and hopefully will start a PhD later this year. I enjoyed being part of this dynamic team and am sure I will remain an active member of the LOICZ community in the future.

**How time flies when one is enjoying oneself**



...it hardly seems as if 3 years have passed since joining the IPO. What a time it has been that has seen the production of the SPIS, Synthesis book and the start of a new generation of R&S series that firmly establish the second generation of LOICZ activity. It has been a

good time to be involved in LOICZ and for me personally extremely gratifying to be able to work and interact with an SSC, past and present that I think constitutes an amazing group of people. Amazing maybe but not always plain sailing to work with – with such greatness sometimes comes the frustration of dealing with people who one wonders how they manage to put on matching socks each morning, and I'm pretty sure often don't. And that is just the beginning; space does not allow me to elaborate further. And for my colleagues in the IPO, it has been fun working with you, and with Hartwig and his enthusiasm I can only say thanks.



The decision to leave had a mixture of reasons, but predominantly that, with the IPO now established in a new home and a path set for the future direction of its activities, it was time to leave the job to others better suited to the new demands and find new avenues. As many of you know, I am also part of a small consultancy company and we are busy working in, and developing, a wide range of coastal oriented projects, some of which are affiliated to LOICZ so the association does not end and I am sure will continue and even grow. With this continued association I hope to remain in contact with many of you and look forward to being part of the continuing success of LOICZ.

### Jürgen Weichselgartner joins the team



Dr. Jürgen Weichselgartner joined the LOICZ IPO as Senior Science Coordinator on 1<sup>st</sup> March 2007, to promote, coordinate and implement the research activities of LOICZ worldwide along the decisions and guidance of the SSC. Jürgen studied geography, political science, and ethnology in Heidelberg, Malta, Santander and Bonn (MSc 1997) and completed his Ph.D. research (2001) at Bonn University with a system-theoretical analysis of the social discussion of natural risks. Before joining the LOICZ IPO, he worked at Harvard University, Tokyo University, and the International Institute for Applied Systems Analysis (IIASA).

He conducted research on risk perception, disaster management, social vulnerability, and system analysis in various European and Asian countries and published several articles, book chapters, and books. His current research interests include social global change processes and knowledge systems. Weichselgartner is a recipient of the PhD Prize of the Franzke'sche Foundation Berlin, a Feodor Lynen Fellowship from the Alexander von Humboldt Foundation, two research fellowships from the Japan Society for the Promotion of Science, and an ERASMUS and two Marie Curie Fellowships from the European Commission.

We welcome Jürgen Weichselgartner in the LOICZ team.

### Strong support for LOICZ Typology



My name is Christoph Sebald and I am about to start my training with LOICZ in April 2007. In the follow-up of this summer's training period I will continue working with LOICZ towards my Master Thesis hopefully by conducting the Geo-information Science and Earth Observation for Environmental Modelling and Management (GEM) Erasmus Mundus Master programme.

Prior to the current basic & advanced training in GIS I have completed my undergrad studies in Human Geography with The Open University (Milton Keynes, UK). Before and during this time I was mainly working for the car manufacturing branch, as well as governmental bodies.

In collaboration and support with our colleagues in Kansas, I will work on setting up a GIS workplace at the LOICZ IPO in Geesthacht, Germany. This then should lead to work on a project of the LOICZ Typology, possibly even 'The use of river basins as a georeference base for environmental data'. I am looking forward to the opportunity of learning a great deal from people engaged in LOICZ and GKSS.

### Publications

#### The environment in Asia Pacific harbours – Eric Wolanski (ed.)

2006, XX, 497 p., Hardcover, ISBN: 978-1-4020-3654-5



Worldwide, urbanization has already reached unprecedented levels in the estuarine and coastal zone. This is particularly the case in the Asia Pacific region where mega-cities and mega-harbours have developed and are still growing. As a result environmental degradation is significant and growing. This book details how science can provide solutions so that economic and social developments can be ecologically sustainable. This book demonstrates the different solutions and pitfalls, successes and failures in a large number of ports and harbours in the Asia Pacific Region, and this will be based on science and aimed at management.

It has won a UN Ocean Atlas award for excellence.

#### UNESCO/IOC announced a new manual A handbook for measuring the progress and outcomes of integrated coastal and ocean management



- The handbook aims to contribute to the sustainable development of coastal and marine areas by promoting a more outcome-oriented, accountable and adaptive approach to ICOM.

- It provides a step-by-step guide to help users in develop-

ing, selecting and applying a common set of governance, ecological and socioeconomic indicators to measure, evaluate and report on the progress and outcomes of ICOM interventions.

- Intended as a generic tool with no prescriptive character, the handbook proposes analytical frameworks and indicators that form the basis for the customized design of sets of indicators.

- The handbook also includes results, outcomes and lessons learned from eight pilot case studies conducted in several countries. A network of ICOM experts in these countries has also been established.

- The target audience is wide, and includes coastal and ocean managers, practitioners, evaluators and researchers.

- The handbook forms part of an IOC toolkit on indicators. Its preparation is part of an effort to promote the development and use of ICOM indicators led by the Intergovernmental Oceanographic Commission, the Department of Fisheries and Oceans of Canada and the U.S. National Oceanic and Atmospheric Administration.

Download <http://ioc3.unesco.org/icam/>



**Update us so we can update you**

LOICZ INPRINT informs you about the LOICZ Project and its activities. But LOICZ has access to much more information and wants to make this information available to you as effectively as possible. To be able to provide you with LOICZ information that fits your expertise and interests most, we need input from your side telling us what your interests in LOICZ are and how we can contact you.

Please complete the following form where applicable and return by fax, post or e-mail to the LOICZ IPO.  
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\*\* Detailed descriptions of the topics are featured in first issue of INPRINT and on the website

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## Have you seen

### MAIRS

MAIRS is a new international research organization. It has been implemented by START, the START TEA-RC and Chinese donors. It collaborates with the Earth System Science Partnership Programs: IGBP, WCRP, IHDP and DIVERSITAS. Different from other monsoon research projects, MAIRS will not address the monsoon climate itself, but focus on human monsoon system interaction. It attempts to understand to what extent the human activities modulate the Asia monsoon climate and how the changed monsoon climate will impact further the social and economic development of Asia. MAIRS will also study to what extent societies can adapt to such impacts or mitigate them through regulating policies, law and institutions in order to achieve the sustainable development.

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The first African Marine Atlas was officially launched on 23 Feb 2007 at the Project Office of the International Oceanographic Data and Information Exchange (IODE) in Ostend, Belgium. The Atlas was developed by the Ocean Data and Information Network for Africa (ODINAFRICA) with support from the Intergovernmental Oceanographic Commission's (IOC) of UNESCO and the Government of Flanders, Belgium. The African Marine Atlas can be accessed at <http://iodeweb2.vliz.be/omap/OMAP/index.htm> and provides substantial maps, images, data and information to coastal resource managers, planners and decision-makers from various administrative institutions and specialized agencies in Africa.

## What's new on the web

### Launch of Environmental Research Letters

Following the recent launch of Environmental Research Letters (ERL) the first complete online issue is now permanently free to read at <http://herald.iop.org/ERL/m85/rsm/link/519>.

ERL is the world's first open-access, electronic-only journal to cover the whole of environmental science.

For full information about submitting work to ERL, please visit the journal homepage at <http://erl.iop.org> or contact Dr De Blanger, [erl@iop.org](mailto:erl@iop.org).

### New website for the Western Pacific Marginal Sea

A new website for the Western Pacific Marginal Sea – Large River and Delta System is online. You can click the Bohai Sea, Yellow Sea, East China Sea, and South China Sea to access the bibliographic data for the Yellow, Yangtze, Pearl, Red, and Mekong, etc.

<http://www.meas.ncsu.edu/sealevel/pacific/>

Note: whether you are able to access to the full text files or not depends on your institution's e-journal subscriptions.

### New forum online

Environmentalresearchweb is an online forum, designed to help you to stay on top of developments in environmental science.

The website provides a mixture of daily news and analysis, coupled with opinion articles and research highlights. The forum is accessible through <http://environmentalresearchweb.org>

## Update us so we can update you

LOICZ INPRINT informs you about the LOICZ Project and its activities. But LOICZ has access to much more information and wants to make this information available to you as effectively as possible. To be able to provide you with LOICZ information that fits your expertise and interests most, we need input from your side telling us what your interests in LOICZ are and how we can contact you. Please complete the form on page 21.

## Calendar

„Biogeochemistry of coastal seas and continental shelves“ to be held during the EGU meeting in Vienna, 15–20 April 2007. <http://meetings.copernicus.org/egu2007/>

**Global Assessments: Bridging Scales & Linking to Policy** 9–11 May, 2007; Washington, DC More information can be found under [www.tias-web.info](http://www.tias-web.info) and [www.watermatex2007.org](http://www.watermatex2007.org)

XXII International Coastal Conference „Management and sustainable Development Problems of the nearshore Zone“ 16<sup>th</sup>–20<sup>th</sup> May, 2007 Gelendzhik, Krasnodar region, RUSSIA – [www.icc07.coastdyn.ru](http://www.icc07.coastdyn.ru)

### 5<sup>th</sup> Study Conference on BALTEX

<http://www.baltex-research.eu/> Island of Saaremaa, Estonia, 4–8 June 2007

### Draft Conference Programme available on

[http://www.gkss.de/baltex/baltex\\_frame\\_builder.html](http://www.gkss.de/baltex/baltex_frame_builder.html)

**A very visible truth – Climate Change at the Coast**, to be held at Cardiff University with Ministerial welcome and a varied and interesting programme. Provisional date 22<sup>nd</sup> June 2007. <http://www.coastnet.org.uk/>

**ERF 2007: Science and Management: Observations/Syntheses/Solutions** – Providence, Rhode Island, USA, November 4–8, 2007 – <http://www.erf.org/meetings.html>

„1st International Conference on Adaptive & Integrated Water Management: Coping with complexity and uncertainty“ (CAIWA 2007) will be held November 12–15, 2007 in Basel, Switzerland. <http://www.usf.uos.de/projects/caiwa/index.htm>

**The 6th European Conference on Ecological Modelling, ECEM'07 – „Challenges for ecological modelling in a changing world: Global Changes, Sustainability and Ecosystem Based Management“** November 27–30, 2007, Trieste, Italy <http://www2.ogs.trieste.it/ecem07/>

The Nordic Countries invite you to the 33<sup>rd</sup> International Geological Congress Oslo 2008 Oslo, August 5–14, 2008 More information and flyer download can be found on: <http://www.33igc.org/>

**XIIIth World Water Congress Montpellier, France – 1–4 September 2008**

<http://wwc2008.msem.univ-montp2.fr/>

CALL FOR ABSTRACTS (DEADLINE: 31 March 2007)

For more meetings and regular updates please also visit the LOICZ website [www.loicz.org](http://www.loicz.org)



### Publication details

The LOICZ Newsletter is produced three times per year to provide news and information regarding LOICZ activities. The views and opinions in this newsletter do not necessarily represent the position of LOICZ or its sponsoring organizations.

#### Published and edited by:

The Land-Ocean Interactions in the Coastal Zone International Project Office

#### Design:

Hester Whyte

#### Printing and lay-out:

GKSS-Hausdruckerei, Geesthacht, Germany

#### Photographs and illustration:

The illustration of the coastal zone on the front page is made by the artist Glynn Gorick, UK, 2005 and commissioned by LOICZ/IGBP. The photographs on the front and back page of this newsletter are copyright to Martin Le Tissier.

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### LOICZ in brief

LOICZ aims to provide science that contributes towards understanding the Earth system in order to inform, educate and contribute to the sustainability of the world's coastal zone. LOICZ is a core project of the International Geosphere-Biosphere Programme (IGBP) and the International Human Dimensions Programme on Global Environmental Change (IHDP).

The LOICZ IPO is hosted by the Institute of Coastal Research at GKSS Research Centre which is part of the Helmholtz foundation.

LOICZ research as outlined in the science plan and implementation strategy is organised around five themes:

- Vulnerability of coastal systems and hazards to society
- Implications of global change for coastal ecosystems and sustainable development
- Human influences on river-basin-coastal zone interaction
- Biogeochemical cycles of coastal and shelf waters
- Towards coastal system sustainability by managing land-ocean interactions

The Science Plan and Implementation Strategy is available electronically on the LOICZ website and in hard copy at the LOICZ IPO.

### Get involved

If you wish to contribute to **LOICZ INPRINT** please send an e-mail to: [loicz.ipo@loicz.org](mailto:loicz.ipo@loicz.org) or visit the LOICZ website [www.loicz.org](http://www.loicz.org) for article requirements.

If you have a project you would like to affiliate to LOICZ please go to [www.loicz.org](http://www.loicz.org) and click on research for detailed information.

