LAND-OCEAN INTERACTIONS IN THE COASTAL ZONE

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LOICZ NEWSLETTER

The impact of economic activities on biogeochemical cycling in Lingayen Gulf, northern Philippines: A preliminary synthesis

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Man's actions to extract goods and derive services from nature have long been recognized as major determinants of environmental change. Economic activities on land and in water generate waste that affects the cycling of materials and the consequent health of the coastal environment. This study attempts to determine how residuals derived from economic activities, influence biogeochemical processes in Lingayen Gulf, northern Philippines. (Figure 1).

Lingayen Gulf is a u-shaped embayment located along the northwest coast of Luzon, facing the South China Sea. About 2,100 km^2 wide, its coastline extends approx. 160 km long. The gulf has an average depth of 46 m, reaching a maximum of 110 m at its mouth. Its western section is dominated by about 200 km^2 of coral reefs and associated seagrass and algal beds. The bayhead has mostly a muddy substrate as it receives materials from the Agno River, the largest of six river systems emptying into the Gulf. Most of the estuarine aquaculture areas with secondary stands of mangrove and nipa swamps are located here. Inland areas are used extensively for agriculture. The eastern section has a sandy substrate and its beaches provide for a moderately flourishing coastal tourism.

Six major river systems drain into the Lingayen Gulf. Their total drainage area extends to 8,810 km^2 and annual aggregate freshwater discharge reaches 9,880 X 10^6 m^3. Agno River is the longest at 275 km, drains 70% of total catchment area and accounts for 70% of total discharge into the Gulf. Groundwater seepage into the Gulf was estimated to be 1 X 10^9 m^3/yr or 10% of total surface runoff. Flushing time is approx. 1.1 months.

The provinces of Pangasinan and La Union surround the Lingayen Gulf. From a total of 2.6 million people in 1990, population is expected to reach 4.6 million in 30 years at an annual growth rate of 1.45%, which is lower than the national growth rate of 2.3% per year. The agriculture, fishery and forestry sectors collectively accounted for 43% of regional GDP while the service sector contributed 42%, and industry generated 15% in 1995. In this study, the contributions of nitrogen and phosphorus generated by economic activities were determined as major parameters in calculating nutrient budgets. Using the rapid assessment method developed by the World Health Organization (1), appropriate economic sectors generating each residual were identified, and the residual production and environmental assimilation along its transport to coastal waters were calculated. Table 1 summarizes waste generation by each economic activity or sector. Household activities accounted for 32% of nitrogen and 52% of phosphorus estimated to reach coastal waters. Non-point agricultural

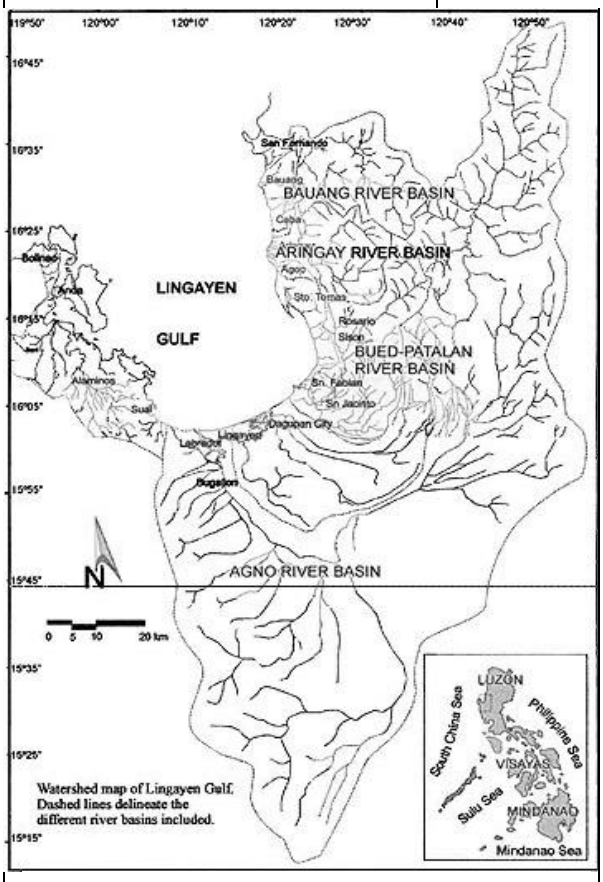

Figure 1 Lingayen Gulf

runoff contributed 64% of total nitrogen, 45% of total phosphorus and 97% of suspended solids. These values show that population and agriculture significantly contribute to the loading of nutrients and suspended solids in Lingayen Gulf.

Estimates of waste loading were used in refining calculations of stoichiometrically linked water-salt-nutrient budgets. Preliminary budgets were made using the LOICZ Biogeochemical Modelling Guidelines (2). Complete mixing of the water column was assumed and only annual means were considered. The influence of groundwater seepage was also taken into account.

About 15,000 mt/yr (1 X 10^9 moles/yr) of nitrogen, mainly from agricultural run-off and household activities, enter the gulf. This estimated input was obtained using derived values of assimilation rates for different nitrogen sources, and which ranged from 60% for domestic sewage to 80% for agriculture and domestic solid waste (3,4). Because only 33% of total nitrogen were inorganic (5), DIN input from economic activities was estimated to be 360 X 10^6 moles/yr or 41% of ambient DIN concentration in the Gulf (Table 2).

The important sources of phosphorus in terms of economic activities include household activities and agricultural run-off. Estimated total P input assuming an average assimilation rate of 80% as for nitrogen, was 2,400 mt/yr (77 X 10^6 moles/yr). Of this input, only 50% or 39 X 10^6 moles/yr were inorganic (DIP) (5) and accounted for 33% of ambient DIP concentration in the Gulf (Table 2).

The calculated phosphorus budget indicated that the Gulf is a net DIP source with ΔDIP being +0.001 mol/m^2/yr. Assuming that organic matter entering the Gulf includes plankton with C:P = 106:1 as well as organic waste material with a C:P = 47:1 due to partial oxidation, (p-r) was estimated to range from –0.07 to –0.03 mol/m^2/yr. Overall, the small DIP flux and correspondingly low (p-r) values suggest that the system is nearly in balance metabolically as it efficiently recycles organic matter. However, the slight heterotrophy and a high initial estimate of ΔDOP at +0.09 mol/m^2/yr (almost 2 orders of magnitude higher than ΔDIP), suggest that an increase in organic pollution could lead to changes in recyling efficiency and perhaps to a likely greater metabolic imbalance.

The ΔDIN estimated for the Gulf was –0.1 mol/m^2/yr and which translated to a (nfix-denit) of the same rate. A net denitrifying state of the Gulf could be sustained by significant concentrations of DON and decomposition of organic matter.

Suspended solids derived from economic activities and that reached the Gulf were estimated to be 2.8 million mt/yr, 97% of which came from agricultural run-off (Table 1). This delivery could account for 37 to 100% of measured ambient concentration (Table 2). Given this level of anthropogenic influence on the flux of suspended solids into the Gulf, changes in economic activities that increase delivery rates can have profound impacts. These may include changes in carbon fixation by and in the species composition of autotrophs and changes in sediment dispersal patterns and their consequences on bathymetry and coastal geomorphology, among others.

Future studies in Lingayen Gulf will include the empirical measurements of concentrations and fluxes of the dissolved organic forms of nitrogen and phosphorus along a distance gradient from river mouths and point sources. The nutrient characterization of groundwater will also be done. With these additional parameters, net metabolic rates can be established along a distance gradient using disaggregated box models to validate if net autotrophy dominates near river mouths, and if net heterotrophy increases with increasing distance from shore. Simulations of changes in demography and economic activities can be made to determine first-order changes in nutrient concentrations, and their consequences on net metabolism at various levels of the gulf's assimilative capacity.

Table 1. Residuals from economic activities entering coastal waters of Lingayen Gulf (in metric tons yr^{-1}).

Economic Activity	Nitrogen	Phosphorus	Suspended solids
Household activities	**4,912**	**1,252**	-
• Domestic sewage	4,467	563	-
• Solid waste	445	69	-
• Detergents	-	620	-
Urban Runoff	**354**	**29**	**66,253**
Agricultural Runoff	**9,706**	**1,081**	**2,743,592**
• Crop fertilization	5,097	973	-
• Cropland erosion	4,607	108	2,743.592
Livestock	**83**	**14**	**2,687**
• Commercial piggery	71	14	2,194
• Poultry	12	-	493
Aquaculture	**62**	**11**	**66**
Mining	**-**	**-**	**20,732**
TOTAL	***15,117***	***2,387***	***2,833,329***

References:

(1) World Health Organization (WHO). 1993. Rapid Assessment of Sources of Air, Water, and Land Pollution. Geneva, Switzerland.

(2) Gordon, D. C. Jr., P. R. Boudreau, K. H. Mann, J.-E. Ong, W. L. Silvert, S. V. Smith, G. Wattayakorn, F. Wulff and T. Yanagi. 1995. LOICZ Biogeochemical Modelling Guidelines. LOICZ/R&S/95-5, vi + 96 pp LOICZ, Texel, The Netherlands.

(3) Valiela, I., G. Collins, J. Kremer, K. Lajtha, M. Geist, B. Seely, J. Brawley and C. H. Sham. 1997. Nitrogen loading from coastal watersheds to receiving estuaries: New method and application. Ecological Applications 7(2), pp. 358-380.

(4) Moffat, A. S. 1998. Global nitrogen overload problem grows critical. Science 279 (5353): 988-989.

(5) San Diego-McGlone, M.L., S. V. Smith, and V. Nicholas. Stoichiometric interpretation of C:N:P ratios in organic waste materials. (Submitted)

Table 2. Total material concentrations in Lingayen Gulf and those contributed by economic activities.

Material	Ambient Concentration	Concentration derived from economic activities (% contribution)
DIN	0.81 µmol/L	0.33 µmol/L (41)
DIP	0.12 µmol/L	0.04 µmol/L (33)
TSS	2.5 ± 4.5 mg/L	2.6 mg/L (37-100)

Submarine Groundwater Discharge: Global Assessment

by Bill Burnett, Florida State University, USA

The Scientific Committee on Oceanic Research (SCOR) and Submarine Groundwater Discharge have recently established a working group of experts to examine groundwater discharge in the coastal zone. Direct groundwater flow into the ocean occurs as springs and seeps in near-shore areas in many parts of the world. Submarine springs are well known off both coasts of Florida; Mexico's Yucatan Peninsula; in several areas around the Pacific rim including Chile, Hawaii, Guam, American Samoa, and Australia; in the Persian Gulf near Bahrain; in the Mediterranean Sea Off Spain, France, Italy, Greece, Syria, Lebanon, Israel, and Libya; and many other locations around the world. Some of these springs are large enough to have been exploited for human needs. Perhaps much more important is the slow yet persistent seepage of groundwater that flows out along most shorelines of the world. Although less spectacular than large springs, seepage may occur over broad areas and deliver a potentially significant amount of flow and dissolved components to the world's oceans.

Although submarine groundwater discharge has been recognised for many years, the process has not received much scientific attention because of either (i) a perception that it is unimportant; and/or (ii) the difficulty in measurement. Studies performed over the past few years have presented convincing arguments that direct groundwater flow to the ocean can be important, at least in some areas. The measurement difficulties haven't been overcome but progress is being made.

It thus appeared opportune to establish an international working group to address questions relating to assessment of the magnitude and influence of groundwater discharge in the coastal zone. SCOR/LOICZ Working group 112 was approved at the General Meeting of SCOR in Rio de Janeiro in October, 1997. Bill Burnett (USA) and Evgeny Kontar (Russia) are the co-chairs and Robert Buddemeier (USA) is the LOICZ liaison for the team. The group held an organisational meeting in conjunction with the Western Pacific Geophysical Meeting in Taipei (July 20-24, 1998) and plans a meeting of the full working group during the International Association of Hydrological Sciences (IAHS) Meeting in Birmingham, UK (July 19-30, 1999).

More Estuarine Budgets from Australasia

More than 30 new estuarine biogeochemical budgets were developed for Australia, New Zealand and New Guinea at a workshop in Canberra, Australia on 12-14 October 1998. Hosted by CSIRO Land & Water and led by Steve Smith, the 20 scientists presented stoichiometric C-N-P budgets across tropical and subtropical systems with locations ranging in scales from 10's to 100's of km2. The resulting budgets add to the handful of existing assessments for the region and are being posted to the LOICZ Web site. A comprehensive report (LOICZ Reports & Studies No. 12) will be published in March 1999.

The workshop demonstrated an extensive amount of data and continuing research on nutrients science and management regimes to ameliorate impacts on catchments waters from urban and agricultural developments, and groundwater aquifers. It is likely that further evaluations of existing time-course data could demonstrate direct system responses resulting from options taken in the management of human activities in estuarine catchments and the biogeochemical processes and systems performance.

Latitudinal comparisons of estuarine net productivity, nitrification and nutrient loads are being made from the array of sites investigated. These are reported in the workshop publication, and are expected to link closely with companion developments LOICZ is making in its global typology approaches.

The workshop provided a vital opportunity for detailed discussions on the LOICZ "budgets" approach. While there was accord on the approach, issues such as effects of water residency times, and the implications of spatial and temporal variation on methodologies were considered in some depth, and added further to the successful progress of LOICZ Focus 3 initiatives.

A Boost for Coastal Typology

The development of a coastal typology system that describes the global coastal zones is an imperative for LOICZ. This has been a taxing issue for the program as a whole - not just the collection and development of "useful" databases but, importantly, the development of an appropriate methodology. While vital to LOICZ, this is a "red-hot" issue in current global research.

Some exciting and cutting-edge developments are being made by LOICZ researchers. These developments were carried further in a recent LOICZ workshop (16-18 October 1998) hosted by the University of Hawaii and led by Bob Buddemeier. Eight researchers brought together their research advances, previously developed through e-mail collaboration. Questions of scaling, databases, coastal system analyses, methods and approaches to aggregation of sites and pixels, and the selection of test sites were debated and tested.

The questions of scaling and aggregation of data are vexing issues, in which fractal analyses may contribute some partial answers. The modification of databases to discriminate between coastal (coastline), coastal seas and terrestrial blocks of information is not a trivial process - the LOICZ Typology Database offered a starting point for examination of direct and derivative information and indicators of processes and numeric parameters. Ways to define similarity or disimilarity between the 9000-odd 1-degree pixels which outline the global coastal zone is a challenge - simple regression and correlation approaches are not useful

to segregate or aggregate the heirachies of information.

The group is continuing its work and gaining a wider collaboration with other interested researchers. It is currently building on the workshop outcomes, presently further developing methods and approaches, acquiring and adapting databases, and delivering preliminary products in-house.
The apparent quantum jump being made in these developments is expected to be more widely demonstrated by scientific publications in the near future.

Climate Change and Coastal Processes in West Africa

Current research across West Africa on climate change and coastal processes was addressed at a recent workshop hosted by the Université Nationale du Benin and sponsored by START-IOC-LOICZ. About 40 scientists from Morocco to South Africa, from francophone and anglophone nations enthusiastically joined in presentations and discussions of environmental issues, current research on coastal and catchment changes, and management implications from the science.
The diversity of the West Africa coastal zone and the human pressures provided the backdrop for clear outcomes dealing with priorities for sub-regional research on natural and socio-economic processes, data standard and access, communication and dissemination of science findings, and risk and policy considerations.
Water and erosion along with the disjunct between science findings and effective policy-making were major messages. The coastal zone of the region is the location of large cities and high population density. Natural oceanographic forcing coupled with anthropogenic activities is causing widespread degradation of the coastal environment through shoreline erosion, siltation, flooding, salt water intrusion, subsidence and pollution. These hazards are leading to major socio-economic problems. In addressing these issues, the workshop demonstrated clearly that climate change at global and regional scales can have major implications for the region's coastal zone; its processes, biogeomorphology and its socio-economic future.
The workshop was not a one-off event but was a further step in the process of building a framework of communication and research effort on land-ocean interaction within the region. The workshop report and recommendations will be published in early new year.

IGBP Synthesis of Global Change

An IGBP Congress of the 11 projects, including LOICZ, to be held in Yokohama, Japan in May will provide a major step in the synthesis of the inidividual core project science to a programme statement on Global Change.
The IGBP Congress will greatly extend and follow up on the "synthesis process". Here IGBP is working to bring together the results and build an integrated picture of global change.
The recent IGBP-SC meeting in Estoril set further guidelines and a framework for the "synthesis process". A major Conference is planned for Amsterdam in mid 2001 which will see the presentation of the global change picture. The "younger" IGBP projects (LOICZ, GLOBEC and LUCC) are contributing to the synthesis, and will continue their own work through and beyond this period. Their outcomes will combine with and extend the current "synthesis" results particularly in highlighting the human dimension in global change processes.

IPO News & Update

Administrative and meetings of the LOICZ Executive Committee (September 1998) and IGBP IPO's (October 1998) have assisted the direction and activities of LOICZ.
LOICZ science activities are rapidly increasing as we move into the second year of our second 5-year phase. New projects, new regional collaborations, increasing involvement of individual researchers, and science-delivering workshops and publications (some reported here) are the norm across all four LOICZ Foci.
A 5-year Strategic Work Plan is being completed by the SSC to guide LOICZ towards meeting the goal of a first global synthesis of LOICZ questions for IGBP by end 2002. The Plan, founded on the LOICZ Implementation Plan, sets key priorities and directions and will be listed on the LOICZ Website and published in the immediate future. Its tenets form the basis of current activities.
LOICZ is extending its regional activities and involvement in Europe, South Asia, Oceania, the Caribbean, and Latin America. In Europe, we have developed a strong working association with the ELOISE program and built close links with the UK LOIS program. Collaboration with other global (eg. IOC-GOOS, IOC-ICAM), regional (eg. SASCOM) and IGBP (eg. START, LUCC) projects is proving a fruitful approach to further engage with coastal research in the other regions.
More details are available on the LOICZ web site - www.nioz.nl/loicz/

HAVE YOU SEEN.....

- Meybeck, M., 1998. *Man and river interface: multiple impacts on water and particulates chemistry illustrated in the Seine river basin.* Hydrobiologia 373/374: 1-20.
- Gilbert, A.J. & R. Janssen, 1998. *Use of environmental functions to communicate the values of a mangrove ecosystem under different management regimes.* Ecological Economics 25: 323-346.
- Arthurton, R.S, 1998. *Marine-related physical natural hazards affecting coastal megacities of the Asia-Pacific region - awareness and mitigation.* Ocean & Coastal Management 40: 65-85.

- Mackenzie, F.T, A. Lerman & L. M. B. Ver, 1998. *Role of the continental margin in the global carbon balance during the past three centuries.* Geology; May; v. 26; no. 5; p. 423-426; 3 figures; 1 table.

- Brandt, A., J. Calmen & J.R. Rottier, 1998. *A quatitative littoral classification system.* Oceanography 11 (1): 51-57.

- ESCAP (1998), *Emerging policy initiatives and activities in coastal zone management and non-living resources assessment in Asia and the Pacific.* Development and Management of Non-living resources in the coastal zones of the Asia-Pacific Region Series, Vol. 3. Economic and social commission for Asia and the Pacific, United Nations, N.Y., 143 p.

- Scialabbam, Nadia (ed.). 1998. *Integrated coastal area management and agriculture, forestry and fisheries. FAO Guidelines.* Environment and Natural Resources Service, FAO, Rome, 256 p.

LOICZ PUBLICATIONS

SCOR Working Group 104 (American Zoology limited copies available from the LOICZ IPO).
Copies will be available in January 99.

Towards Integrated Modelling and Analysis in Coastal Zones: Principles and Practices, *LOICZ Reports & Studies No. 11.*

Australasian Estuarine Systems: Carbon, Nitrogen and Phosphorus Fluxes, *LOICZ Reports & Studies No. 12. Will be published in April 99.*

Mexican & Central American Coastal Lagoon Systems: Carbon, Nitrogen and Phosphorus Fluxes, *LOICZ Reports & Studies No. 13. Will be published in May 99.*

The River Basin Dimension of Coastal Region Management, *LOICZ Reports & Studies No. 14. Will be published within 1 or 2 months time.*

Other reports:
People and Pixels. Linking remote sensing and social science. *National Research Council, USA. (Limited copies are available from IPO).*

LOICZ CALENDAR

- LUCC Data Expert Meeting on Coastal Zones of Southern India (LUCC-DIS, in collaboration with LOICZ), 7-9 April 1999, Goa, India.

- 2nd IGBP Congress and SSC9 Meeting, 7-13 May 1999, Yokohama, Japan.

- **LOICZ 4th Open Science Meeting, 15-18 November 1999, Bahía Blanca, Argentina.**

- South American Estuaries Modelling Workshop, November 1999, Bahía Blanca, Argentina.

- ELOISE Conference, 1-4 December 1999, Noordwijkerhout, The Netherlands.

- IGBP Open Science Millennium Conference, April or May 2001, (proposed) Washington, USA.

OTHER MEETINGS

- 2nd International Convention on Environment and Development. 14-18 June, Havana, Cuba.

- 1999 Open Meeting of the Human Dimensions of Global Environmental Change Research Community, 24-26 June, Kanagawa, Japan.

- Advanced Study Course on Multiscale Coastal Dynamics: Fluxes and Predictions for the Physical Component. 28 June till 9 July, Barcelona, Spain.

- Non-CO_2 Greenhouse Gases (NCGG-2) Scientific understanding, control and implementation. 8-10 September 99, Noordwijkerhout, The Netherlands.

- 15th Biennial International Estuarine Research Federation Conference, "Where the River meets the Sea", 25-30 September 99.

- 3rd International Symposium Environmental Geochemistry in Tropical Countries. 25-29 October 99, Rio de Janeiro, Brazil.

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