LAND-OCEAN INTERACTIONS IN THE COASTAL ZONE

September 2001 http://www.nioz.nl/loicz No. 20

LOICZ NEWSLETTER

This is the twentieth 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

Global change in the coastal zone: The case of South-east Asia

Liana Talaue-McManus
Marine Science Institute, University of the Philippines, Quezon City, Philippines & Rosenstiel School of Marine and Atmospheric Science, University of Miami, Florida, USA

South-east Asia highlights the human-natural interactions and feedbacks between changing climate regimes, a rapidly increasing population, and an extremely rich though seriously threatened living resource base within the coastal domain. The current state of coastal science in the region has begun to unravel the local-global dynamics of these interactions. What is known to date provides compelling reasons to make the knowledge base transparent to the policy process so that local action throughout the world can maintain the life support functions of the global coastal zone.

Where is the coastal zone and why South-east Asia?

The coastal zone represents the interphase domain between the atmosphere, land and sea. It includes the coastal plains, estuaries and embayments, and extends to the edge of continental and island shelves (Pernetta & Milliman 1995). On a global scale, the coastal zone occupies about 20% of the earth's surface, but accounts for 90% of the world's fisheries. The rich ecosystems in shallow waters including coral reefs, seagrasses and mangroves are not only home for some diverse groups of living organisms, but also areas where nutrients cycle among their dissolved and particulate forms.

Because of its proximity to land, the living resources in the coastal zone are heavily exploited, often beyond rates at which these can regenerate. Coastal ecosystems continue to deteriorate with heavy harvesting or are altered for other uses such as aquaculture. The coastal zone receives waste generated by land-based activities including sewage, sediments and industrial effluents. Agricultural chemicals notably fertilizers and pesticides contribute to degrading the quality of coastal waters. The continuing assault on the coastal zone through extraction of goods and through modification has profound impacts on food and environmental security for humankind.

South-east Asia showcases the most diverse assemblage of marine life inhabiting shallow waters, with 20 of 50 known seagrass species, 45 of 51 mangrove species, and 50 of 70 hard coral genera are found in the region. The countries of South-east Asia have among the highest population growth rates in the world and economies that rely heavily on living resources from land and sea. The archipelagos, low-lying areas of islands and continental shelves are extremely vulnerable to changes in sea level rise, and to flooding and storm surges that result from a changing monsoonal climate. Thus, the interactions between human societies and the environment within the domain of the coastal zone is most dramatic in South-east Asia. Indeed, the coastal zone of this region is a global environmental hot-spot.

Pressures on the coastal zone: population and a resource-dependent economy.

South-east Asia is home to 500 million people. Ninety percent of them live within 100 km from a coast (Burke et al. 2000). About 85 million, 7% of the world's poor, subsist on USD 1.00 per person per day or less (ESCAP 2001). The developing economies of the region are largely defined by the trade of natural resources to earn foreign exchange as evidenced by the significant contribution of agriculture to the gross domestic product (GDP) of each country (Table 1).

Country	Coastal length[1] (km)	Area of continental shelf[1] (x 1000 km^2)	Pop. in 2000[2] (x 1000) and annual growth rate[3] (%)	Pop. within 100 km from coast[1] (%)	Per cap. fish food supply[4] (kg/P/Y)	Per cap. GDP[3] (US $) (same year as food supply)	GDP from Agriculture[3] (%) (same year as food supply)
Cambodia	1,127	34.6	12,212 (2.4)	24	(1995) 9.0	309	51
Indonesia	95,181	1,847.7	224,784 (1.3)	96	(1998) 16.3	1,018	24
Malaysia	9,323	335.9	21,793 (2.0)	98	(1999) 69.0	4,523	12
Myanmar	14,708	216.4	41,735 (1.8)	49	(1994) 16.6	220	38
Philippines	33,900	244.5	81,160 (2.0)	100	(1998) 25.9	644	17
Thailand	7,066	185.4	61,231 (1.0)	39	(1998) 23.6	1,970	11
Vietnam	11,409	352.4	78,774 (1.4)	83	(1996) 11.5	267	40
Cf Japan	29,020	304.2	126,550 (0.2)	96	(1997) 64.0	(1998) 24,070	2

Table 1. Socio-economic indicators for South-east Asian countries. *Sources:* [1]*Burke et al., 2001;* [2]*The World Almanac, 2001;* [3]*ESCAP & ADB, 2000;* [4]*Fishery Country Profile from* www.fao.org/fi/fcp.

The fluxes of materials (gaseous emissions, sediments, nutrients, solid and liquid waste) resulting from this trade underpin, among others, the current state of the coastal zone in the region. With high annual population growth rates and a high degree of dependence on natural resources, the people of South-east Asia are among those most vulnerable to global environmental change.

Vertical interactions: air pollution and climatic changes.

Because 90% of South-east Asians live near the coast, anthropogenic gas emissions in the region mostly emanate from the coastal domain. In a global context, East and South-east Asia releases 17-24% of total gas emissions worldwide (Lelieveld et al. 2001) (Fig. 1).

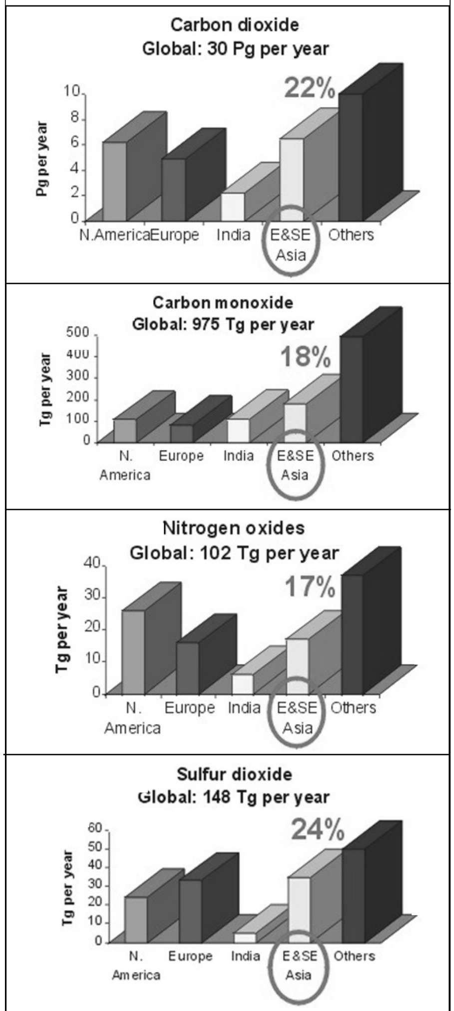

Fig. 1. Greenhouse gas emissions from East and South-east Asia and other regions (data from Lelieveld et al. 2001).

The collective composition of these gases reduces the oxidizing power of the atmosphere, allowing methane gas to remain longer in the air, increasing the latter's impact as a greenhouse gas. The increasing amount of nitrogen in the atmosphere in the form of nitrous oxides can lead to enhanced direct deposition of nitrogen through rain (Paerl 1997; Paerl et al. 1999). Nitrogen loading through precipitation can increase the flux of new nitrogen to the coastal zone and potentially exacerbate eutrophication.

Over a 37-year period, profound climatic changes in South-east Asia have been recorded which directly influence the fluxes and the temperature regime at which chemical transformations occur on land, in air and sea (Manton et al. 2001). The number of hot days and warm nights per year has increased and the contribution of extreme events like La Niña to the annual rainfall in the region has increased. These regional changes interact with larger-scale increases in the heat content of the ocean over the last 45 years (Barnett et al. 2001). Monsoonal shifts in the climate patterns have begun to have dramatic effects on the natural resource-based economies of South-east Asia and on the increasing vulnerability of low-lying areas to increasing frequency of typhoons and flooding events.

Horizontal interactions: sediments and nutrients.

The vertical interactions between the coastal zone and the atmosphere represent one complex subset of changes. The horizontal interactions of the coast with the land and the sea represent another. From deforested land and poorly managed tillage, large quantities of soil end up as mud in tropical estuaries with serious environmental consequences (Wolanski & Spagnol 2000). Asian rivers account for about 40% of total annual sediment discharge from land to sea or about 3000 t km^{-2} yr^{-1}(Milliman & Syvitsky 1992). Burial of filter-feeding animals including corals (Wesseling et al. 1999) and benthic plants (causing a decrease in their biodiversity and productivity) (Terrados et al. 2000), decreased water transparency for phytoplankton and other autotrophs, and economic losses from degraded aesthetics are among the major impacts of increased sedimentation. Biogeochemically, the sediments contain a significant amount of organic carbon that is an important component of the global carbon cycle (Schlünz & Schneider 2000).

Nutrients from minimally treated domestic waste of a rapidly increasing population and from fertilizer applications in a widening expanse of tillage explain why eutrophication is the most pressing pollution problem in coastal waters (Tilman et al. 2001). Asia currently uses 50% of annual global fertilizer production or about 70 million t. In three study sites in South-east Asia, dissolved inorganic nitrogen discharged to coastal basins have been found to represent anywhere from 10 to 50% of waste generated by land-based activities notably agriculture and the household sectors (Talaue-McManus in prep.; Table 2).

Nutrients reaching nearshore waters via rivers or direct loading lead to profound changes in ecosystem structure and function. These can include toxic algal blooms (Tilman et al. 2001), shifts from coral to algal dominated coral reef communities in synergism with the over-harvest of herbivorous fish (McManus et al. 2000), and the occurrence of hypoxic zones which produce nitrous oxide and methane, both potent greenhouse gases (Naqvi et al. 2000; Purvaja & Ramesh 2000). Hypoxic zones probably commonly occur in the shallow waters of South-east Asia given intense rainfall, large river runoff, and high nutrient and organic matter loading. The frequency and extent of their occurrence remain to be established and quantified.

Coastal ecosystems: corals and mangroves.

Changing climatic patterns, the extent of material delivery, as well as those of harvest and habitat modification, determine the state of the coastal ecosystems of South-east Asia.

South-east Asia contains 25% of the world's charted reefs, with Indonesia and the Philippines accounting for 80% of this, or 20% of the known global area (Bryant et al. 1998). A risk assessment of corals is being conducted under the aegis of the World Resources Institute with partners from the region (see www.wri.org). Their findings as of October 2000 indicate that 86% of all reefs in the region

Parameter	Red River Delta, Vietnam	Lingayen Gulf, Philippines	Merbok Estuary, Malaysia
Coastal population (X 1000)	19,870	2,600	300
Drainage area (km^2)	117,700	8,810	550
Coastal basin area (km^2)	(mudflats) 1,510	2,100	(waterways) 10 (mangroves) 45
Anthropogenic generated DIN (mmoles km^{-2} basin area yr^{-1})	4,410	800	2,480
DIN discharged to coastal basin (mmoles km^{-2} basin area yr^{-1})	405	420	600

Table 2. Nutrient fluxes in three South-east Asian sites (Talaue-McManus et al. in prep). DIN = dissolved inorganic nitrogen is a major component of sewage and fertilizer that cause eutrophication in coastal waters.

are at medium or higher anthropogenic threat. Overfishing affects about 60% of reefs, destructive fishing 50%, while coastal development and sedimentation each impacts about 20% of reefs in South-east Asia. Preliminary analyses further show that only less than 1% of the reefs are in well-managed marine protected areas.

Superimposed on the human-induced threats to coral reefs are anomalous occurrences of prolonged high sea surface temperatures, as witnessed during the 1997-1998 El Niño event. Mortality because of bleaching as documented during this extreme event was unprecedented in the past 3000 years (Aronson et al. 2000). In addition to elevated sea surface temperatures, the increasing concentration of carbon dioxide in the air has been shown to decrease the extent to which corals can produce chalk or calcium carbonate (Kleypas et al. 1999). Leclerq et al. (2000) predict that the calcification rate of reef-dominated communities including corals, calcareous algae, crustaceans, gastropods and echinoderms, may decrease by as much as 21% from the pre-industrial period (1880) to the time when CO_2 is expected to double its concentration in 2065. Although Baker's (2001) results indicate that coral bleaching has adaptive value that allows corals to expel sub-optimal symbionts and to acquire healthy ones, the question remains to what extent corals under siege by anthropogenic threats can survive adverse climate change.

Like corals, mangroves in South-east Asia represent a heavily altered coastal ecosystem in the reduction of its area to about a third of the cover estimated for the early 1900s. Estimated loss rates range from 1 to 4% of total area per year. At present rates, the region will lose its mangrove forests by about 2030 (Talaue-McManus 2000). The dominant pressure, as always, is economic. Mangrove swamps continue to be converted to short-lived shrimp production ponds to earn foreign exchange, among other uses. Thus, four countries in the region accounteded for 50% of the global shrimp trade in 1984, increasing to70% in 1994 (FAO 1997). Naylor et al. (2000) estimate a reduction of fish biomass of about 434 g for every kg of farmed shrimp because of habitat conversion alone. In addition, the loss of major ecological functions such as sediment trapping and shoreline protection serves to underscore the unsustainability of mangrove conversion as an attempt to increase food production.

Regionalizing global change science for policy contexts.
Interactions and feedbacks between natural and anthropogenic components of the earth system within the coastal domain are complex and require a multiplicity and synergy of actions from many disciplines and stakeholders. Coastal zone science and management are daunting tasks. In the South-east Asian context, good science and sound management are matters of survival. So what can we do?

We need to put global earth science in regional contexts so that the variability and magnitude of environmental change can be made transparent and accessible to the policy-making process. Global models do not provide sufficient finer-grain nuances of the causes and impacts of environmental change needed in formulating economic and legal instruments within jurisdictional limits. Action plans from various states will need to be harmonized so that they can effectively address the transboundary features of coastal issues and problems. Thus, regional models should aim to evoke local action that addresses issues of global significance.

A prudent strategy to pursue might be to amplify existing scientific and management support at the local scale with the goal of providing the experience for regional collective action. The Land Use and Cover Change (LUCC) and the Land-Ocean Interactions in the Coastal Zone (LOICZ) Projects of the International Geosphere-Biosphere Programme have designed regional projects in South-east Asia that address the complexity of natural and human interactions in the coastal zone and associated catchments. They are good templates for much needed integrative and synthetic research at local scales and are excellent platforms for site comparisons that can allow researchers to evolve regional scenarios of change. The knowledge base these initiatives provide should stimulate a progressive policy climate for a holistic and functional management of the coastal domain at the local and national levels. At the regional scale, regional conventions may be appropriately designed to address transboundary interactions.

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Supply and flux of sediment along hydrological pathways: Anthropogenic influences at the global scale

James P.M. Syvitski
Environmental Computation and Imaging Group, Institute of Arctic and Alpine Research, University of Colorado, Boulder CO, 80309-0450

This is a summary of a panel report from the IGBP Water Group

Introduction

Humans and changing climate both influence the supply and flux of sediments along hydrological pathways and to the coastal zone. River systems evolve through time and modern rivers are strongly influenced both by paleo conditions within the watershed and perturbations by humans. Understanding sediment discharge across this broad time-scale allows us to better predict the impact of humans and changes to global climate. For example, the trapping efficiency of terrestrial reservoirs, both man-made and natural, is fundamental to our understanding on the future discharge of sediment to the coastal oceans..

1. Sediment flux to the coast: past, present, and future.

Present flux to coast

Current estimates put the annual sediment flux to the global ocean between 18x109 to 24x109 metric tons (Milliman & Syvitski 1992; Syvitski, Vorosmarty & Morehead, in prep.). These estimates are based on the extrapolation of measurements (sediment gauging records of varying time-scales and quality) across the world's landmass. The variance in these estimates is due to the methods used to extrapolate data to less-studied regions. There are several important considerations when viewing the uncertainty in these estimates. Firstly, the measurements are based solely on a river's suspended load – bedload was not considered. For some regions (Siberian Arctic) bedload may represent a significant proportion of the annual sediment flux. Secondly, very few small rivers have been monitored throughout the world. The large number of small rivers in many regions leads to a severe lack of data in some areas. It is difficult (perhaps impossible) to extrapolate data from large rivers to the smaller rivers – akin to a comparison of apples and oranges. The importance of events (e.g., landslides, floods) from small rivers has also been neglected. Thirdly, the actual global estimate is not of sediment flux to the coastal ocean, but sediment flux to the last gauging station on the rivers. These stations may be well inland, and many factors (such as estuarine trapping) could influence the fate of the sediment after the gauging station and before the coastal ocean. Fourthly, most water discharge and/or sediment concentration data are collected only for a short duration (a few years). This leads to the question of the usefulness of mean numbers for sediment and water discharge. Both inter- and intra-annual variations within river basins need to be considered. Finally, much of the data are from the 1960's and 1970's, so sediment flux estimates are a few decades old. The construction of dams and other engineering within watersheds may have affected this number significantly. Approximately 30% of the sediment is trapped behind the large reservoirs of the world (Vorosmarty et al. 1997).

Paleo-flux under pristine conditions

The fluvial systems of the past are the keys to the geomorphic character of rivers today. Fluvial systems evolve along with the landscape, and much of the sediment yield we see today is influenced by the paleo systems. It is difficult to determine what a "pristine" river would be, due to natural variability within river systems. There is no accepted value for the paleo-flux of sediment to the coastal oceans. One region may have had pristine conditions long after the intense development by humans in other regions. Over what time period do we try to calculate the paleo-flux? When were all rivers pristine? Some studies have determined the times of maximum sedimentation rates on the continental shelves. Should this time period be used for the paleo estimation? One approach is to use a substitution of space for time, so data from modern pristine rivers can be used to estimate the sediment flux from rivers that are no longer pristine. Changes due to man and/or climate affect small river basins more dramatically than larger river basins. This modulation by larger rivers, coupled with a predominance of studies in larger basins may provide a skewed view on paleo-flux estimates.

Future sediment flux

The future flux of sediment to the coastal oceans will be influenced by man and/or climate change. Determining the balance between increasing sediment loads (land use, engineering, climate change, climate variability) and decreasing sediment loads (reservoirs, engineering, climate change and climate variability) is of utmost importance. In general, the future load of rivers should be less than the current estimates provided above, mostly because of the construction of large dams on rivers. We need time-series data to determine trends, with a focus on the last 20 years. New methods need to be developed (or old ones reassessed) to utilize available data for water discharge.

When modeling possible future sediment flux, economics needs to be considered. The effects of development and land-use are vital in understanding the global sediment flux. The change in the sediment yield on a regional basis may be of much more importance than the global volume of sediment entering the coastal zone. Sediment-starved regions may undergo erosion, while sediment-inundated regions may experience biological consequences such as burial of benthic biota. The global mass also says nothing about changes in sediment composition (texture, quality).

Sediments in river basins

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 does it take for this transport? How does sediment make the journey? Sediment budgets are the best method to increase understanding in these systems. Many budget questions remain unanswered.

- What is the source type of the eroded sediment?
- Did it come from slopes, gullies, or landslides?
- How does a river's size scale with natural storage capacity for water and sediment?
- What are the sediment-transit times for different segments of the river?
- What roles do biogeochemical processes play in these transit times? What is the affect of man on the system (reservoirs, levees, other engineering projects)?
- Is sediment permanently removed from the system or transferred to another river basin (sand mining, dredging)?
- What is the delivery ratio of eroded sediment in a catchment, region, globally? Some estimate that globally it may be ~4%.
- On a global basis, how long until we fill the terrestrial sediment sinks (natural and man made)?
- What effect will this have on the coastal zone and the global sediment flux?
- What is the sensitivity to erosion on a global scale? Can we create some index related to this that may inform us of the relative erosion change in regions due to disturbance (man or climate)?

2. Global change and sensitive areas

A sensitive region or process, in the light of global change and sediment transport conditions, may be defined by geographic regions, curvilinear features such as river channels or coastlines, biological communities that may be especially vulnerable to warming, changes in quantity or style of runoff, or new forms of erosional processes. One might also include regions or situations that rapidly demonstrate the effects of global change to policy makers and regions where the interactions between growing populations and their associated infrastructure greatly alters the erosion and sediment transport processes such that people are placed at risk.

Sensitivity as a research issue

The Earth's environment is not in a steady state; everything is transitory: regional populations and economies, sediment sinks, soil inventories, vegetation cover, and so on. Moreover, we are not necessarily dealing with linear (cause and effect) systems. Our understanding of forcing and responses remains inadequate. An analysis of sensitivity should therefore be oriented towards an understanding of the dynamics of landscapes. A critical issue in analysis of the effects of global change on sediment fluxes is the role of thresholds, which, when crossed, effect a substantial change in the nature of erosion and sediment transport. What are these thresholds? For a particular scenario, what is the likelihood that a threshold will be crossed? How do we aggregate scales? How long does it take for the effects of local processes to propagate into larger-scale systems (e.g., Gilbert cycles)?

Most rivers are event-driven, with the tendency for the greatest impact to be on smaller and drier river systems. We need to monitor these significant events on a variety of scales to characterize fluxes to oceans and the eventual fate of sediments. What is the role of stream order in a sensitivity analysis? Presumably there is a strong relation to stream order. Do low-order rivers that deliver to the ocean have major impact? We also need better understandings on the teleconnections, whereby changes in one region substantially modify the state of another, perhaps distant, and region. For example, drying and land-use change in Africa cause substantial dust deposition in the Caribbean.

Paleo reconstruction and the mining of historic data

We need to document the prehistoric impact of changes in climate in the post-glacial world. Geomorphic analysis of landforms and reconstruction of sedimentary histories are clearly important. In the historic timeframe, data related to the effects of land-use change, from government or academic data archives, need to be identified, preserved, catalogued and mined. Extreme years in the historic record may reflect conditions that resemble the world under a changed-climate scenario.

Arctic

The Arctic may be the only terrestrial region where the effects of climate change may dominate over human effects. We must consider the interaction of glacial and snow-melt-dominated hydrological regimes and sediment transport. Presumably, changes in erosion and sediment transport will be markedly different in mountainous regions such as Alaska, compared to the vast flat regions in northern Europe, Siberia and Canada. Fire, for example, is a major element of the Boreal forest. In these regions, much of the landscape is so flat that there is not enough erosivity to form gullies, and the erosional response of deforestation appears minimal and regeneration is rapid. Instead we must consider the effects of an extension of the warm season and changes in precipitation. For example, in Amur River, a one-degree warming would cause an eleven-day increase the warm period per year; precipitation would increase by 38 mm per year (from 600 mm/yr) (N. Bobrovitskaya, pers. comm. 1999). In mountainous areas with glaciers, there may be big spikes in the sediment load, followed by a decrease in load with soil formation and reforestation. Would this decrease drop erosion to rates that were less than at times when glaciers were the dominating force? We must also consider the role of mining and oil exploration on sediment transport down river to ocean, including consideration of economic activity/inactivity cycles.

Low-runoff areas

The superposition of climate (drying) and human water utilization drive many hydrological and erosional systems. Two issues might be considered:

1) areas that become moister and start generating runoff, thereby initiating sediment transport to the ocean; and more probably
2) areas that cease flowing to the ocean because of a combination of drying and water utilization by growing populations. Important regions include the Mediterranean basin, Sub-Saharan Africa, south-western North America and Central Asia.

Research must identify the population thresholds and behaviors that have strong hydrologic and erosional effects. Some coastal issues include the erosion or subsidence of sediment-starved deltas and delayed responses. The coupling of increased nutrient inputs and decreased sediment loads may promote coastal-zone eutrophication (dominated by cyanobacteria) and hypoxia. Does air-borne sediment transport out of these regions exceed fluvial transport?

Wet mountainous areas

In many regions, landslides dominate the hillslope erosional regime. Triggering events such as threshold-crossing rainfall or earthquakes are often required for natural landslide erosion. Climate shifts might increase the number of landslide-producing rainstorms. Many human activities, notably intensive agriculture, construction and road building, promote landslides by undercutting hillslopes or by altering hillslope hydrology. Where lands have been deforested, rates of slide-related erosion are many-fold greater. We know that in tropical mountains, without supply-limited substrates, rates of physical erosion increase steeply at runoffs greater than 800 mm/yr. We also know enough to be able to construct landslide-hazard maps in any region given a sufficiently high-resolution DEM, geology and rainfall distribution. In this context, prognostications about both the roles of growing populations and shifting rainfall regimes should be possible. Deforestation also reduces ET and induces spikier runoff in deforested mountainous regions. How does land-use change affect erosion? What is the role of road building and mechanized agriculture/sylviculture? What about tillage styles? How important is mining in steep versus mountainous landscapes?

3. Data - Typology (upscaling, downscaling)

Data

Discharge and sediment loads are available for about 700 of the largest rivers; these drain about 80% of the total landmass. Based on the total length of the coastline, global data remain sparse. Using total discharge and sediment load budgets, global data are much better. The number of small rivers draining to the ocean (including very small ones) is very large (thousands), but their total contribution (in terms of discharge) is small compared to the big rivers. The quality of discharge and sediment load data is not the same for all rivers. Cores and other proxy stratigraphic data are the "tape recorders" of earth history, and include lake cores, delta and mangroves cores, and other bore holes. Satellite imagery is not yet compiled for use to hindcast the sediment flux to the ocean.

Access to data and other data issues

Countries, such as the U.S. and Canada, have open access to all sediment discharge data. In most other countries, governments or industries hold the data as proprietary. Some databases are established in the academic community (e.g. Milliman & Syvitski 1992; Mulder & Syvitski, 1995; Meybeck & Ragu 1996; Nash 1998; Syvitski et al. 2000; Milliman & Farnsworth, in press). Compatibility between data sets from different sources (e.g. countries) becomes a problem. Different countries use very different methodologies. In addition global data often mix different periods of observation (years spanned), with different temporal resolutions. Further, there is no metadata that indicate what if any pristine basins can be used as a benchmark to measure change. Pristine basins may tend to be more headward; further from coasts, yet most of the population is concentrated in the coastal zone.

Typology

Synthesis is now imminent based on collection of data and collection of tools. The conjunction of several data sets allows value-added products through typology. Typology is essentially a spatial-statistical similarity analysis. An example from the analysis of deltas is the classical fluvial- vs. tidal- vs. wave-dominated delta descriptors. The Milliman & Syvitski (1992) approach is a "crude" typology, as is the Syvitski & Morehead (1999) approach. Other examples are the similarity/scaling of river plumes using dimensionless numbers (Skene et al. 1998), or the Master Environmental Library that describes the climatology in the coastal ocean (http://mel.dmso.mil). New products would include:

- Global, consistent data sets for fluxes of sediment to the coastal zone (including error checking, harmonization, verification, and temporal compatibility)
- GIS layers of global inventories with ability to engage in sub-grid-scale parameterization
- Upscaling, downscaling algorithms for process-level understanding
- Remotely sensed sediment discharge data.

4. Knowledge Gaps and Opportunities

There is a need to assemble existing maps and databases for the coastal zone morphology and sediment situations at the global scale. Observations could be linked to upriver processes and information about rates of change of documented human impact. Vignettes should be compiled for each critical region, globally. Clearly-documented examples provide a way to construct a typology guided by the use of typical scenarios for these representative regions.

The science community must establish linkages with the risk community such as the insurance industry and public policy groups, and with the agricultural community. The sediment erosion and discharge community must begin bridging the gap with the satellite community. Microwave remote sensing could be used for salinity and coastal plume studies (also SeaWiFs). Tropical Rainfall Monitoring Mission could be used for rainfall intensity and landslide work. Can we upscale fine-grained information in SLAR topographic maps of the earth, to practical scales for other types of data?

Recommendations

IGBP Water Group participants recommend the following:

- Establish global maps delineating sediment sources and/or sensitivity to disturbance. This would allow for a better understanding of the effect of change on the system.
- Create of an index to encapsulate sediment transit times within basins. This index must be scale-independent as small river basins are expected to have much shorter transit times than larger river basins. This infers that changes occur much more rapidly in smaller basins than larger ones.
- Determine how long before river loads will fill up the terrestrial sediment traps, and what the subsequent impacts will be downstream (e.g. the coastal zone). Effort needs to establish the linkages between land and ocean.
- Research the balance between increasing and decreasing sediment loads due to man and/or climate change.
- Link coastal sediment budgets to terrestrial sediment budgets. This would allow a bridge between the data from upstream gauging stations and the coastal ocean, taking into account interactions within estuaries.

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LOICZ IPO NOTES

The 12th meeting of the LOICZ SSC in Amsterdam, 7-8 July, focussed on the current Synthesis process within LOICZ and considered directions for LOICZ's future under the proposed new program of IGBP. The Synthesis work of bringing together the last 9 years of LOICZ activities to address its core questions is proceeding well. Many contributions and offers of help have come from the global network of LOICZ researchers to the lead authors of the chapters of the book that is in preparation (see LOICZ Newsletter No 17, December 2000). We aim to bring these developments into the wider LOICZ forum over the next months.

The SSC has started planning for a new Science Plan to underpin a future land-ocean project within IGBP II, due to start January 2003. At this stage, we are preparing a prospectus for the future, including research goals and objectives, thematic and cross-cutting issues, administrative and operating structures, links with companion agencies and networks. The structures and linkage areas will be described in the prospectus and open for comment and advice in the near future. A draft outline of potential themes and research questions is being developed as a discussion document for wider consultation within and beyond LOICZ – more of that over the next few months. We need your input! Development of the research program is expected to extend through to the middle of 2002, and to interact with (and probably incorporate some elements of) Futures discussions on Oceans and Terrestrial science within IGBP. Importantly, the proposed IGBP II will see a close association of IGBP, IHDP and WCRP within core projects of each program and conjointly in cross-cutting projects.

In late May 2002, LOICZ will be holding a workshop on Synthesis and Futures in Miami, USA. It is expected that about 130-140 invited participants will consider and review the Synthesis chapters, identify key outcomes and needs for new research, and give consideration to a draft set of scientific research goals and themes for LOICZ II.

Early July was a busy period for many IGBP researchers involved in the IGBP Congress, Amsterdam and in the allied workshops and meetings surrounding Congress. More than 1500 people took part and had a very successful time in discussion, debate and learning about the wide and fascinating scientific achievements of the last decade of IGBP. The next newsletter from IGBP will contain a full coverage of the Congress – if you do not get a copy, check the IGBP web-site in October. The article in this LOICZ Newsletter by Liana Talaue-McManus is an abstract of her plenary paper to the Congress; papers presented by other LOICZ researchers will be highlighted in the next two LOICZ Newsletters.

Hartwig and Connie Kremer have achieved a complementing pair with the birth of a son, Linus, on 27 September. Hartwig will be now less distracted than over the last few weeks, but undoubtedly a little shorter on sleep for the near future!

HAVE YOU SEEN

The **European Geophysical Society** (EGS) has launched a new interdisciplinary working group (IWG) on Biogeosciences (BG). The goal of this IWG is to increase the visibility of biological disciplines within EGS, attract new members and promote interaction of Biology with Geology, Hydrology and Geophysics. Tight coordination with the existing EGS sections and IWG will be achieved through co-sponsorship of symposia. Interaction with the Biogeoscience section of the American Geophysical Union (AGU) will also be sought, beginning with the upcoming joint EGS-AGU meeting due to take place in 2003.

Additional information on BG can be found at http://www.obs-vlfr.fr/~gattuso/jpg_bg.htm and a more detailed document can be downloaded at http://www.obs- lfr.fr/~gattuso/files/EGS_BG.pdf.

BG will organize sessions at the EGS General Assembly that will take place in Nice in March 2002. The tentative list of sessions is shown at http://www.copernicus.org/EGS/egsga/nice02/programme/BGS.program.htm. Information about registration and submission of abstracts will be posted soon on the EGS web-site.

Encyclopedia of Global Environmental Change
John Wiley & Sons. A 5-volume invaluable resource for the environmental scientist. For further information, FREE-sample articles and your chance to win a copy visit: http://www.wiley.co.uk/egec

Land Ocean Interaction Measuring and Modelling Fluxes from River Basins to Coastal Seas
Editor(s): D. Huntley, G. Leeks, D. Walling, July 2001, ISBN: 1900222108. IWA Members Price: £ 53.00/ UD$ 80.00 Non Members £70.00/US$105.00. Jo Bell. Visit: http://www.iwapublishing.com/template. cfm?name=isbn1900222108

WHAT'S ON THE WWWEB

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) and (www.kgs.ukans.edu/Hexacoral/Workshops)

SURVAS Overview Workshop Report (June 2001, UK) on the project outcomes and achievements on http://www.survas.mdx.ac.uk

IGBP/IHDP/WRCP Joint Carbon Project: Prospectus (in pdf format) and related information on project development is available on http:gaim.sr.unh.edu/cjp

The ODINAFRICA web site for September: http://odinafrica.org.
For more info on the ODINAFRICA project please contact Mika Odido (m.odido@unesco.org) or Sekou Cisse (s.cisse@unesco.org)

The new OceanPortal on http://oceanportal.org enables you to submit URLs, suggest corrections and make detailed searches in the portal database. There are now almost 2400 links to important ocean-related sites on the web, so we believe it is fair to say that it is the largest ocean-related Portal on the Internet. The OceanPortal has been developed by Greg Reed and Murray Brown. We hope these newly improved resources from the IODE Program will better meet researchers' data and information needs, and provide institutions with a higher visibility in the general ocean community.

LOICZ Publications are available as printed copies and are downloadable from the LOICZ web-site: www/nioz.nl/loicz

LOICZ CALENDAR

AfriBasins II workshop on African river catchments/coastal fluxes and human dimensions. 29 October - 1 November 2001, Nairobi, Kenya (by invitation). Contact: LOICZ IPO.

LOICZ-UNEP Global Synthesis Expert workshop on Coastal Biogeochemistry and Scaling. 11-14 November 2001, Lawrence, Kansas USA. (by invitation) Contact LOICZ IPO.

LOICZ Synthesis and Futures meeting, 29 May-1 June 2002, Miami, Florida, USA. Contact LOICZ IPO.

OTHER MEETINGS

Joint IAPSO-IABO Assembly and XII Colloquium: 2001 - An Ocean Odyssey. 21-28 October 2001, Mar del Plata, Argentina: (perillo@criba.edu.ar or iado @criba.edu.ar).

IGCP Project 464 1st Annual Conference (Asian Venue) 25-28 October 2001, The University of Hong Kong, Hong Kong Island: http://www.uniroma1/igcp464.html

6th international conference of the Aquatic ecosystem health and management society (aehms), Aquatic ecosystem health: barometer of integrity and sustainable development, November 4-7 2001 Amsterdam, The Netherlands: (www.caos.nl/aehms).

Euresco CLIVAR/PAGES Conference on Abrupt Climate Change Dynamics. 10-15 November 2001, Castelvecchio Pascoli, Italy: PAGES IPO (pages@pages.unibe.ch).

EMECS 2001: 5th International Conference on the Environmental Management of Enclosed Coastal Seas: Towards Coastal Zone Management that Ensures Coexistence between People and Nature in the 21st Century, 19-22 November 2001, City of Kobe and Awaji Island, Japan: emecs2001@jtbcom.co.jp Visit: http://emecs2001.jtbcom.co.jp

IASC (International Arctic Sciences Committee) project ACD (Arctic Coastal Dynamics). 2nd ACD workshop, 26-30 November 2001, Potsdam, Germany: Volker Rachold (vrachold@AWI-Potsdam.DE) or (http://www.awi-potsdam.de/www-pot/geo/acd.html).

International Training Workshop on Recent Trends in Eco-hydrology: A contribution to UNESCO International Hydrological Programme (IHP) Phase V, Project 2 Ecohydrological processes in the surficial environment. School of Environmental Sciences, Jawaharlal Nehru University, 26-30 November 2001, New Delhi, India: Prof. V. Subramanian (subra@jnuniv.ernet.in), Dr. A.L. Ramanathan (alrama@jnuniv.ernet.in), or Dr. R. Jayakumar (r.jayakumar@ unesco.org).

Management Center for Priorize programs and Project (GEPROP) and the Cuban National Program for the Global Change and the Evolution of the Cuban Environment :Scientific Forum About The Studies of the Global Change, 28-30 November 2001, Havana, Cuba: Caridad Camejo (geprop@ceniai.inf.cu) or http://www2cubamar.cu

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

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

International Conference on " Coastal Zone management and Development (ICCZMD)", 18-20 March 2002, Kuwait: Dr. Mohammad Al-Sarawi (sarawi@epa.org.kw) or (alobaid@epa.org.kw). Visit: www.epa.org.kw/cc/

Coastal Zone Asia-Pacific: "Improving the State of the Coastal Areas" May 12-16, 2002, Bankok, Thailand. Deadline for abstracts 15 January 2002: www.vims.edu/czap or: Dr. Ratana Chuenpagdee (ratana@ vims.edu)

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
WWW HOME PAGE: HTTP://WWW.NIOZ.NL/LOICZ/