1. OVERVIEW OF WORKSHOP AND BUDGETS RESULTS

The key objectives of the Land-Ocean Interactions in the Coastal Zone (LOICZ) core project of the International Biosphere-Geosphere Programme (IGBP) are to:

- gain a better understanding of the global cycles of the key nutrient elements carbon (C), nitrogen (N) and phosphorus (P);
- understand how the coastal zone affects material fluxes through biogeochemical processes; and
- characterise the relationship of these fluxes to environmental change, including human intervention (Pernetta and Milliman 1995).

To achieve these objectives, the LOICZ programme of activities has two major thrusts. The first is the development of horizontal and, to a lesser extent, vertical material flux models and their dynamics from continental basins through regional seas to continental oceanic margins, based on our understanding of biogeochemical processes and data for coastal ecosystems and habitats and the human dimension. The second is the scaling of the material flux models to evaluate coastal changes at spatial scales to global levels and, eventually, across temporal scales.

It is recognised that there is a large amount of existing and recorded data and work in progress around the world on coastal habitats at a variety of scales. LOICZ is developing scientific networks to integrate expertise and information at these levels in order to deliver science knowledge that addresses LOICZ's regional and global goals.

The United Nations Environment Programme (UNEP) and Global Environment Facility (GEF) have similar interests, through the sub-programme: "Sustainable Management and Use of Natural Resources". LOICZ and UNEP, with GEF funding support, have established a project: "The Role of the Coastal Ocean in the Disturbed and Undisturbed Nutrient and Carbon Cycles" to address these mutual interests; this Workshop is the fourth of a series of regional activities within the project.

The coastal regions of East Asia extend over about 30 degrees of latitude, from tropical to subpolar climatic conditions. Physiographically, the mainland comprises extensive coastal plains and dynamic deltaic systems, mountains and steep inclines often close to the coast, and major river systems (especially in China) commonly discharging large volumes of water, sediment, nutrients and chemicals into the coastal seas. Large islands, including Taiwan and the Japanese group, share a similar topography. In addition to major rivers, many relatively short-course river systems drain into bays and estuarine systems. Seasonal patterns of discharge range from monsoonal systems in the south to ephemeral flow systems in the north that become frozen in winter. The coastal interface contains many estuaries and embayments, especially below 38 degrees North e.g., along the coast of China. Large sea systems (e.g., Yellow and East China Seas, Sea of Japan) characterise the relatively wide continental shelf and have complex circulation and mixing patterns. The Kuroshio Current has a major influence along the southern continental shelf margin. The region supports a large population that continues to greatly modify the terrestrial environment through changing and increasingly intensive land uses, *inter alia* agriculture, urban conurbations (including a number of coastal megacities) and industries. As a consequence, the human dimensions of change are marked and various, as is their pressure on the coastal zone. To the north of the 38ºN latitude, population densities are relatively small and frequently sparse. The region, thus, has a wide spectrum of natural and human conditions interacting in the coastal zone.

The Workshop was held at the Hong Kong Baptist University, Kowloon, Hong Kong on 13-15 June 2000. The terms of reference for the Workshop (Appendix VI) and a summary of activities (Appendices III and V) are contained in this report. The resource persons worked with Workshop participants from five countries (China, Japan, Korea, Russia, Taiwan) to develop and assess biogeochemical budgets for twelve coastal systems in the region, ranging from estuarine environments

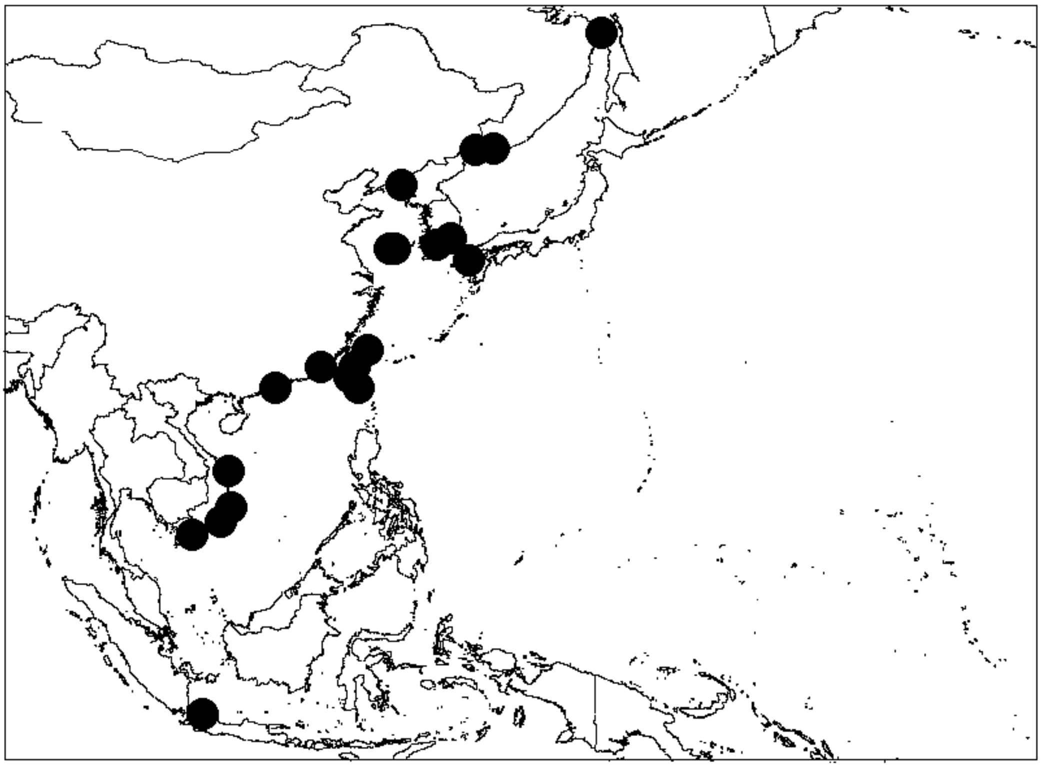

Figure 1.1 Map of budget sites developed during the East Asia regional workshop.

associated with large and small river catchments to large bays and a regional sea. Further site budgets are being developed at home institutions; two from Russia (Amur River, Ussuriysky Bay) are included here.

Biogeochemical budget models for four Vietnam estuaries and one from Indonesia are also reported here, reflecting work following on from an earlier workshop in the South China Sea region. These continuing activities from the regional biogeochemical workshop series are a vital part of the Project, in part reflecting the success of the awareness and training components of the formal workshops. Additional training opportunities are coordinated and supported by the project-funded Asia Regional Mentors (Drs Laura David and Malou McGlone). Dr Anatoly Mozherovsky, from the Pacific Oceanological Institute, Far East Branch Russian Academy of Sciences will take up the LOICZ/UNEP Regional Training Scholarship (East Asia) in late 2000, for additional training in budget analyses at the University of the Philippines (with the Asia Regional Mentors) and at the University of Hawaii (with Prof. Stephen Smith)

The initial plenary session of the Workshop outlined the LOICZ approach to biogeochemical budget modelling of nutrient fluxes in estuaries, and described tools which have been developed for site assessment and budget derivations. The final version of the CABARET software programme (for calculation of sites budget and models), presented by Dr Laura David, provides an extra dimension to the tools and training elements. The pivotal role of the Budgets and Modelling electronic website was emphasised, along with its use by scientists globally in making budget contributions to the LOICZ purpose. It was noted that in the website publication, the authorship of contributed budgets is clearly indicated, and that there is provision to update and provide additional assessment of budgets.

Twelve budgets were developed during the Workshop (Figure 1.1, Table 1.1), with additional sites identified for future work. The budgets under consideration were refined and discussed within small working groups and during plenary sessions. A method was developed (Appendix I; Prof. Tetsuo Yanagi) for calculation of exchange in systems for which there is no salinity difference between the system and the ocean; the Indonesian system (Teluk Banten) is used as a test case for this method. As well, a preliminary approach was made to development of a method for calculating both advection and mixing in stratified systems (Appendix II), as the current LOICZ salt-water budget approach does not include an estimate of horizontal mixing but assumes all of the horizontal exchange of salt is due to advection.

The common element in the budget descriptions is the use of the LOICZ approach to budget development, which allows for global comparisons and application of the typology approach. The differences in the descriptive presentations reflect the variability in richness of site data, the complexity of the sites and processes, and the extent of general knowledge and detailed understanding of processes for each site. Background information for the various estuarine locations (describing the physical environmental conditions and related forcing functions, history and potential anthropogenic pressure) is an important part of the budget information for each site. These budgets, associated data and wider availability in electronic form (CD-ROM, LOICZ website) will provide opportunities for further assessment, comparisons and the potential for use with wider scales of patterns in system response and human pressures.

The budget information for each site is discussed individually and reported in units that are convenient for that system (either as daily or annual rates). To provide for an overview and ease of comparison, the key data are presented in an "annualised" form and nonconservative fluxes are reported per unit area (Tables 1.1 and 1.2).

Key outcomes and findings from the Workshop include:

1. The Net Ecosystem Metabolism (NEM; [*p-r*]) and [*nfix-denit*] values calculated for the systems changed seasonally in value (and sometimes in sign). Commonly, the wet or flood season rates were greater than the dry season rates by several-fold. While this may reflect a response to nutrient loads, companion changes were observed in water exchange rates and the relative dominance of freshwater and coastal ocean waters in the systems.

2. Loads of DIN and DIP from riverine sources seasonally increased with wet or flood conditions yielding nutrient loads up to an order of magnitude higher than the dry season. Nitrogen load (as DIN) showed a greater increase than for DIP, probably reflecting increased drainage and leaching from agricultural lands as well as from sources due to other human activities. Nutrient loading from precipitation is sometimes a significant input factor.

3. Understandably, water exchange rates for the systems were less during the wet or flood seasons, in some cases down to less than one day. In these circumstances, system budget estimates were not made, as the signal for assessment of biological activity in the system is uncertain and materials are probably functioning conservatively with regard to the system. Indeed, there are cases described in which wet season river input effectively "jets" through the system, apparently flushing materials from the catchment to the coastal shelf.

4. An assessment was made for a large delta system and its component estuaries (the Pearl River) and for a regional sea (Yellow Sea). The Pearl River estuaries show differing net metabolic activities reflecting both their inherent characteristics and catchment inputs. The Yellow Sea net metabolic performance is of interest in its apparently low rates per unit area. Recognising the highly reactive system metabolism in adjacent river estuaries (several of which are described here), we infer that much of the metabolic transformation of land-derived nutrients to the Yellow Sea is occurring within the near coastal sublittoral and tidal areas.

LOICZ is grateful for the support and efforts of Professor Ming Wong and his Institute staff in hosting the workshop, and to the resource scientists for their contributions to the success of the workshop. LOICZ particularly acknowledges the effort and work of the participants not only for their significant contributions to the workshop goals, but also for their continued interaction beyond the meeting activities.

The workshop and this report are contributions to the GEF-funded UNEP project: *The Role of the Coastal Ocean in the Disturbed and Undisturbed Nutrient and Carbon Cycles,* recently established with LOICZ and contributing to the UNEP sub-programme: Sustainable Management and Use of Natural Resources.

Table 1.1 Budgeted East Asian and South China Sea region sites, locations, sizes and water exchange times.

System Name	**Long.** (°E)	**Lat.** (°N)	**Area** (km^2)	**Depth** (m)	**Exchange Time** (days)
East Asia region					
Russia					
Amursky Bay	131.8	43.2	400	15	250
Amur River estuary	141.3	53.0	20000	30	30
Ussuriysky Bay	131.8	43.3	75	3	6
Korea					
Nakdong River estuary	128.9	35.1	96	5	7
Sumjin River estuary	127.8	34.9	55	21	156
China					
Jiulong River	118.0	24.4	85	6	2
Pearl River estuary(total system)	113.6	22.6	1180	7	<3
Aimen estuary	113.1	22.0	440	4	15
Modaomen estuary	113.4	22.2	350	5	10
Yalujiang River estuary	124.3	39.8	170	6	5
Yellow Sea system	124.0	36.0	420000	44	7 years
Japan					
Dokai Bay	130.8	33.9	11	8	21
Taiwan					
Chiku Lagoon	120.1	23.1	10	2	6
Tapong Bay	120.2	22.7	5	2	11
Tsengwen River estuary	120.1	23.0	3	2	184 (dry), 6 (wet)
Tanshui River estuary	121.4	25.2	17	4	4
South China Sea region					
Vietnam					
PhanThiet Bay	108.1	10.8	370	15	30
VanPhong Bay	109.5	12.6	410	17	52
Tien River estuary	106.5	9.8	230	6	5
ThuBon River estuary	108.8	15.8	12	7	4
Indonesia					
Teluk Banten	106.2	-6.0	150	7	3

Table 1.2 Budgeted East Asia and South China Sea region sites, loads and estimated *[nfix-denit]* and *[p-r]*.

System Name	DIP load	DIN load	DDIP	DDIN	*[nfix-denit]*	*[p-r]*
	mmol m^{-2} yr^{-1}					
East Asia region						
Russia						
Amursky Bay	5	144	18	-154	-440	-1800
Amur River estuary	35	1240	36	-730	-1820	-4750
Ussuriysky Bay	10	38	27	110	-1850	-2700
Korea						
Nakdong River estuary	350	58000	-186	-49500	-37000	18000
Sumjin River estuary	40	2820	-25	-1700	-1460	3000
China						
Jiulong River	35	8800	-160	-930	1700	18000
Pearl River estuary (total system)	680	23100	7000	-2000	-8000	-43000
Aimen estuary[A]	95	4630	-70	-3760	-2750	7300
Modaomen estuary[A]	260	13000	-190	-3600	-550	20200
Yalujiang River estuary	70	78000	70	31000	-32000	-7700
Yellow Sea system	1	110	<1	-100	-100	-21
Japan						
Dokai Bay	270	11	-4	-232	-220	365
Taiwan						
Chiku Lagoon	400	3400	-100	-2300	-1500	10600
Tapong Bay	300	1200	-60	140	2200	6200
Tsengwen River estuary[B]	35	1650	-10	-300	-300	100
Tanshui River estuary	1120	51000	-200	-13000	-26000	6000
South China Sea region						
Vietnam						
PhanThiet Bay	13	320	44	-1860	-2550	-4750
VanPhong Bay	0	0	0	800	800	4
Tien River estuary[C]	800	13600	18	220	-90	-1800
ThuBon River estuary[C]	9800	26600	-4700	-12000	62000	50000
Indonesia						
Teluk Banten	2	7	-11	-220	-44	1170

A – The Aimen and Modaomen estuaries are elements of the greater Pearl River estuary; the Pearl River estuary results are the sum of those two estuaries plus the Pearl River element (see Dupra *et al*. 2000) of the total system.

B – Includes dry and wet season estimates but not flood periods when nutrients are considered to behave conservatively.

C – ΔDIP, ΔDIN and stoichiometric values are calculated from dry season data only; nutrients are considered to behave conservatively during the wet season.