APPENDICES

Appendix I. A simple method for estimating V_x from mixing equations in a 1-dimensional, steady-state system for LOICZ biogeochemical modelling.

Tetsuo Yanagi

For LOICZ biogeochemical modelling, it is important to estimate the mixing volume (V_X, in $m^3\ d^{-1}$) across the open boundary of the system (e.g., Gordon *et al.* 1996). Clearly this open-boundary transport is required to balance salt transport in estuaries. Less obviously, it can be an important source or sink for nutrient transport between estuaries and the coastal ocean. In the procedure recommended by the LOICZ guidelines, V_X is estimated from the water and salt budgets, where V_R is the residual volume transport associated with freshwater discharge, S_{syst} and S_{ocn} are the system and adjacent ocean salinity values, respectively; and S_R is the average of the ocean and system salinity:

$$V_X = \frac{-V_R S_R}{\left(S_{ocn} - S_{syst}\right)} \qquad (1)$$

Positive flux is into the system. Obviously this equation can be solved only if there is a quantifiable salinity difference between the system and the ocean, yet some systems lack a salinity gradient. V_X is still an important variable.

We offer an alternative way to estimate the mixing volume V_X without relying on a salinity difference between the system and the ocean. The water mixing across the open boundary of the system is governed by the dispersion process (Yanagi 2000), and the magnitude of the horizontal dispersion coefficient D_H ($m^2\ s^{-1}$) is estimated from the current shear and the diffusivity normal to the current shear by the following equations (from Taylor, 1953):

a) In the case of dominant vertical shear (narrow and deep estuarine system):

$$D_H = \frac{1}{120}\left(\frac{H^4}{K_V}\right)\left(\frac{U}{H}\right)^2 \qquad (2)$$

b) In the case of dominant horizontal shear (wide and shallow estuarine system):

$$D_H = \frac{1}{120}\left(\frac{W^4}{K_h}\right)\left(\frac{U}{W}\right)^2 \qquad (3)$$

where H (in m) is the average depth of the open boundary of the system; W (in m) is the length of the open boundary, that is the width of the system mouth, in m; U (in $m\ d^{-1}$) is the residual flow velocity at the surface layer of the open boundary (if this value is not independently known, it typically has a numerical value of about 0.1 $m\ s^{-1}$ or 8,640 $m\ d^{-1}$ (Yanagi 2000); K_V is the vertical diffusivity (typically ~ $10^{-4}\ m^2\ s^{-1}$ or 8.64 $m^2\ d^{-1}$ in the case of stratification and $10^{-3}\ m^2\ s^{-1}$ or 86.4 $m^2\ d^{-1}$ in the case of vertically well-mixed systems; we assume no stratification for the calculations here); and K_h is the horizontal diffusivity (also in $m^2\ s^{-1}$ or $m^2\ d^{-1}$; varies as a function of mixing scale [see below]).

The following criteria can be used to decide if a system should be treated as "narrow and deep" or "wide and shallow." The distance from the center of the system to its mouth is denoted L (m). A system is considered to be “narrow and deep” if L/W > 2 and W/H <500. A system is considered “wide and shallow” if L/W <2 and W/H >500.

The LOICZ notation is more readily followed if U is rescaled to m d^{-1} (if not known it can be approximated as 10^5); and K_v is re-scaled to m^2 d^{-1} (~ 10 in a vertically well-mixed system). D_H (in m^2 d^{-1}) according to equation (2) is then approximated in a narrow, deep estuarine system:

$$D_H \approx \frac{1}{1{,}000}\left(HU\right)^2 \tag{2a}$$

To retain proper dimensionality, the coefficient 1,000 has the units m^2 d^{-1}, because this coefficient includes the estimated value for K_v. Note that, if K_v is explicitly known, equation (2a) should be modified accordingly.

Okubo (1971) gives data demonstrating the validity of a well-recognized relationship between the horizontal diffusion coefficient (K_h, in cm^2 s^{-1}) the horizontal scale of the diffusion (l, in cm). The equation he offers to summarize that relationship is $K_h = 0.0103\ l^{1.15}$. It is assumed here that the diffusion scale for K_h in an estuary or embayment is given by the length of the open boundary (i.e., width of the system mouth, W). Expressing K_h in m^2 d^{-1} and W (l) in m, Okubo’s equation becomes:

$$K_h = 18W^{1.15} \tag{4}$$

Equations (3) and (4) can be combined for use with the LOICZ notation, expressing D_H in m^2 d^{-1} in a wide, shallow estuarine system:

$$D_H = \frac{W^{0.85}U^2}{2{,}180} \tag{3a}$$

D_H has the typical dimensions of diffusion (area/time), whereas the LOICZ notation is expressed as a volume exchange rate (volume/time). D_H derived from either equation (2a) or (3a) can then be used to approximate the mixing volume (V_X, in m^3 d^{-1}) as used in the LOICZ notation:

$$Vx = D_H\left(\frac{A}{F}\right) \tag{5}$$

where A denotes the cross sectional area of the open boundary of the system (m^2) and F is the distance (m) between the geographic center of the system and the observation point for oceanic salinity (typically near the mouth of the system).

As detailed examples of the calculations, including explicit definition of U, D_H, and the K’s, we apply these calculations to two systems in Japan: a narrow and deep bay (Dokai Bay) and a wide, shallow bay (Hakata Bay) (Table I.1). In the case of Dokai Bay, the salt balance method and the mixing equation method of estimating V_X agree within about 5%. In the case of Hakata Bay, the agreement is about a factor of two. Further examples should be explored to evaluate the general agreement between these two methods.

Table I.1. Sample calculations. U, the K's, and D_H are reported both in notation commonly given in the oceanographic literature and in the notation used here, in order to facilitate both comparison with that literature and calculations reported here.

VARIABLE/SYSTEM	**Dokai Bay**	**Hakata Bay**
L (m)	10,000	10,000
W (m)	1,200	6,000
H (m)	8.3	7
A (m^2)	10,000	42,000
L/W	8	2
W/H	145	857
Classification	narrow and deep	wide and shallow
U ($m\ s^{-1}$; $m\ d^{-1}$)	0.07; 6,000	0.05; 4,000
K_v, K_h ($cm^2\ s^{-1}$; $m^2\ d^{-1}$)	K_v = 1; 9 (assumed)	K_h = 45x10^3; 398x10^3 (from Okubo, 1971)
D_H ($cm^2\ s^{-1}$; $m^2\ d^{-1}$)	290x10^3; 2.5x10^6	1,440x10^3; 12x10^6
F (m)	6,000	12,000
V_X ($m^3\ d^{-1}$) — eq. (5)	4.2x10^6	42x10^6
V_X ($m^3\ d^{-1}$) — eq. (1)	4.0x10^6	90x10^6

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Appendix II. Possible modifications of the LOICZ two-layer box model in order to account for horizontal mixing

Tetsuo Yanagi, S. V. Smith, and V. Dupra

Introduction

When two-layer box model analysis is carried out according to the LOICZ biogeochemical budgeting guidelines (Gordon *et al.*1996), the horizontal mixing volume (V_X) across the open boundary of the system is ignored. Of course this is not generally correct (see e.g., Dyer 1997). However, we cannot solve the salt and water balance, algebraically including the horizontal mixing term, because there are five unknowns, but only four equations (see Table II.1). It should be noted that the equations presented here are for the case of a 2-layer system with a single horizontal box. The equations in Gordon *et al.* (1996) could also be extended to include the case of boxes in series.

If we could estimate one unknown independently of the water and salt balances, then only four equations and four unknowns would remain. In the discussion here, it is proposed that the vertical mixing volume (V_Z) be estimated based on physical considerations independently of the salt balance. Then only four unknowns remain to balance the four water and salt equations. This is the situation in principle; it remains a challenge to develop a general formulation for V_Z that is at once consistent with physical oceanographic theory and direct observation.

In order both to illustrate the problem and to stimulate discussion, we present two theoretically based calculations, compare results derived from them with field estimates of V_Z, and discuss the two approaches in the context of the standard LOICZ box model. All terms used in the equations are defined in Table II.2. We refer to the first of the theoretical approaches, derived from Munk and Anderson (1948), as MA48. The second is derived from Yanagi (1999), or Y99.

Theoretical approaches

<u>MA48</u>

The vertical mixing volume V_Z is governed by vertical diffusion from the physical viewpoint, and vertical diffusivity K_Z can be expressed by the following formulation (MA48):

$$K_Z = K_0\left((1+aR_i \right)^{-b} \qquad (1)$$

$$R_i = -(g / r)(\partial r / \partial z)\left(\partial U \big/ \partial z\right)^{-2} \qquad (2)$$

Here K_0 denotes the vertical diffusivity in the case of no stratification (≈ 1 $cm^2\ sec^{-1}$), a = 3.33 and b = 1.5 are experimental constants; and R_i is the Richardson number. We use g = 980 cm sec^{-2}, *ñ* = 1.020 g cm^{-3}, (U/ z)=6.0x10^{-2} sec^{-1}. The vertical density difference can be approximated as $0.0007\times(S_{syst-d} - S_{syst-s})$, where ($S_{syst-d}$ - S_{syst-s}) denotes the salinity difference between the upper and lower boxes; h is the vertical distance (in cm) between the centers of the upper and lower boxes, so $(\partial r / \partial z) \approx 0.007\times\frac{\left(S_{syst-d} - S_{syst-s}\right)}{h}$. Substituting into Equation (2) the Richardson number, R_i, is approximated by the expression $187\times\left(\frac{S_{syst-d} - S_{syst-s}}{h}\right)$.

Because only salinity is being considered to account for the density gradient of the system, it is convenient to refer to the ratio $\left(\frac{S_{syst-d} - S_{syst-s}}{h}\right)$ as the "stratification parameter." When this ratio is large, the system is strongly stratified; when it approaches 0, the system is not stratified.

Equation (1) is then re-written as an approximation using this value for the Richardson number:

$$K_Z = K_0 \left\{1 + 620\left(\frac{S_{syst-d} - S_{syst-s}}{h}\right)\right\}^{-1.5} \tag{3}$$

Because K_0 is approximately 1 cm^2 sec^{-1}, equation (3) can be further simplified:

$$K_Z = \left\{1 + 620\left(\frac{S_{syst-d} - S_{syst-s}}{h}\right)\right\}^{-1.5} \tag{4}$$

If we consider Equation (4) in detail, we see that K_Z ranges between 0 and 1 cm^2 sec^{-1}. A value of <0.1 cm^2 sec^{-1} is obtained when the stratification parameter exceeds about 0.006, while the value is 1 cm^2 sec^{-1} if there is no vertical stratification.

Y99

In the case (Y99), the physically determined vertical diffusivity K_Z is expressed by the following equation using the vertical salinity gradient (from Yanagi 1999):

$$K_Z = K_b + \frac{h_0}{10^5\left(\frac{S_{syst-d} - S_{syst-s}}{h}\right)} \tag{5}$$

The stratification parameter remains the same. Here, K_b denotes a background vertical diffusivity (≈ 0.5 cm^2 sec^{-1}), and h_0 is a background vertical viscosity (≈ 5.0 cm^2 sec^{-1}). Other notation remains the same. It is convenient to re-state this equation:

$$K_Z = K_b + \left[\frac{20{,}000\left(S_{syst-d} - S_{syst-s}\right)}{h}\right]^{-1} \tag{6}$$

According to Equation (6) K_Z will never be less than K_b (here assumed to be 0.5 cm^2 sec^{-1}). K_Z will be no more than 0.1 cm sec^{-1} larger than K_b if the stratification parameter is greater than 0.0005. K_Z becomes large as the stratification parameter decreases below this value.

Comparisons with published values of K_Z

The two formulations (Equations [4] and [6]) each have, as a variable quantity, an inverse function of the stratification parameter. As a result (and as should be the case), K_Z becomes larger as stratification decreases. The MA48 formulation will assume some value between 0 and 1 cm^2 sec^{-1}, while Y99 remains near (but larger than) K_b unless stratification becomes very slight; the value is then unbounded. It is useful to compare the results with one another and with direct estimates of K_Z. The relationships between the two formulations of K_Z are summarized in Figure II.1. Between stratification parameter values of about 0.0001 and 0.001 (K_Z values slightly below 1 cm^2 sec^{-1} for both formulations), the two formulations agree fairly well; outside of those values, they do not.

Figure II.2 summarizes comparative information between the two methods presented here and observations given in Dyer (1997; D97). For this comparison, we assume that the "bed depth" reported by D97 is twice the value *h* in the above equations. Most of the points in MA48 roughly parallel the observations summarized in D97. However, the MA48 values are about an order of magnitude lower. Across the range of values given by D97, Y99 values show little variability. Consistent with Figure II.1, K_Z values for the two formulations slightly below 1 cm^2 sec^{-1} tend to agree; these values remain well below the observed values.

Additional insight is gained from a paper by Gargett (1984). He derived a formulation close to MA48, and then goes on to state that the constant multiplier (equivalent to K_0 in Equation [4]) "...will be site-specific, since they depend upon the actual amount of energy in a particular internal wave field, as well as the magnitude… [of a correlative term among the vertical and horizontal diffusivities [our words}]...". He then presents data from two experiments. One gives values of K_Z well within the range of Equation (4) (i.e., <1 cm^2 sec^{-1}). The second experiment gives values up to ~4 cm^2 sec^{-1}.

We are forced to conclude that neither of the theoretical approaches is providing a good approximation of observations. These relationships might be improved if there were some independent estimate of either the multiplier (Equation [4]) or the additive term (Equation [6]).

Comparison of V_Z Calculated According to MA48, Y99, and LOICZ Formulations

It remains at least conceptually useful to consider how we would improve on the LOICZ formulation if we had an independent estimate of K_Z. We used the calculations for Manila Bay, the Philippines (Jacinto *et al.* 2000).

Table II.2 summarizes the relevant characteristics of that system. $S_{syst\text{-}d}$ = 33.0 psu, $S_{syst\text{-}s}$ = 32.0 psu, and *h* = 850 cm. The stratification parameter is thus 0.0012; this is approximately in the range where the two theoretical formulations should agree. According to MA48 (Equation [4]), K_Z becomes 0.44 cm^2 sec^{-1}. Y99 (Equation [7]) gives a value of 0.54 cm^2 sec^{-1}. As expected, in this system, the two physically-based estimates of K_Z agree relatively well.

K_Z can then be converted to a vertical mixing volume, V_Z, by the following equation:

$$V_Z = \frac{K_Z A_{syst}}{h} \qquad (7)$$

where A_{syst} is the cross sectional area between the upper and lower boxes (1.7×10^9 m^2 in Manila Bay).

The water and salt budgets for the steady-state vertically stratified model applied by LOICZ are expressed by the following equations slightly modified from Gordon *et al.* (1996). In that notation, fluxes into a box are positive.

$$V_{Q*} + V_{ent} = -V_{surf} \qquad (8)$$

In this notation V_{Q*} includes both runoff and the difference between rainfall and evaporation. Entrainment is defined to be positive with respect to the upper box:

$$V_{ent} = V_{deep} \qquad (9)$$

$$0 = V_{surf} S_{syst-s} + V_{Xsurf}\left(S_{ocn-s} - S_{syst-s}\right) + V_{ent} S_{syst-d} + V_Z\left(S_{syst-d} - S_{syst-s}\right) \qquad (10)$$

and

$$0 = V_{deep} S_{ocn-d} + V_{Xdeep}\left(S_{ocn-d} - S_{syst-d}\right) - V_{ent} S_{syst-d} - V_Z\left(S_{syst-d} - S_{syst-s}\right) \qquad (11)$$

See Table II.3 for the numerical values used in the sample calculations for Manila Bay.

V_{Xsurf} and V_{Xdeep}, the mixing volumes for the surface and deep layers, are expressed using the horizontal dispersion coefficient D_H (assumed the same for the surface and deep boxes) by the following equations:

$$V_{Xsurf} = \frac{D_H A_{surf}}{F} \tag{12}$$

$$V_{Xdeep} = \frac{D_H A_{deep}}{F} \tag{13}$$

Here A_{surf} denotes the cross sectional area of the upper box (= 220x10^3 m^2 for Manila Bay), A_{deep} the cross sectional area of the lower box (= 150x10^3 m^2); these are estimated as the layer depth multiplied by the layer thickness. F is the distance between the center of the box and the observation point of ocean salinity (≈ 40,000 m).

We can then solve these equations for the four unknowns: V_{surf}, V_{deep}, V_{ent}, and D_H., and subsequently for V_{Xsurf} and V_{Xdeep}. The equation for water exchange time for the system (t), from Gordon *et al.* (1996) can be modified to allow for inclusion of the horizontal mixing:

$$t = \frac{V_{syst}}{(V_{Q*} + V_{deep} + V_{Xsurf} + V_{Xdeep})} \tag{14}$$

Comparison between the result without the horizontal mixing by Jacinto *et al.* (2000) and those with the two different formulations of horizontal mixing are presented in Table II.3. For the example presented here, vertical mixing, vertical advection and horizontal advection calculated by either of these methods are smaller than those by Jacinto *et al.* Part of the salt balance for the system results from horizontal mixing, so the inflow→entrainment→outflow of ocean water are smaller than calculated without the horizontal mixing term. At the same time, the estimated value for vertical mixing without the horizontal mixing term is not greatly different than vertical mixing with horizontal mixing. Water exchange time is about the same with and without the horizontal mixing terms.

These results underscore two points. There will be a difference in the salt and water budgets (hence, also in the nutrient budgets) calculated with and without horizontal mixing. Except in those systems for which independent external estimates of mixing can be made, there is presently no obvious, unambiguous way to calculate the “right” budgets. Until this problem can be resolved, we recommend that, at a minimum, biogeochemical budgeting be carried out without the horizontal mixing term; this at least provides an objective (if inaccurate) characterization of the system circulation and net biogeochemical reactions. A more detailed analysis might involve calculations by all three approaches: without horizontal mixing, and with the two formulations presented here. This would allow evaluation of the qualitative robustness of the calculations. If a generic and robust method were presented to improve the estimates of horizontal mixing, these calculations should be re-done.

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Table II.1. Equations and variables used in standard LOICZ analysis and the present analysis.

	Standard LOICZ?	**Present formulations?**
EQUATIONS		
Upper box water balance	Yes	Yes
Lower box water balance	Yes	Yes
Upper box salt balance	Yes	Yes
Lower box salt balance	Yes	Yes
Vertical mixing equation	No	Yes
UNKNOWNS		
surface box → ocean advection	Yes	Yes
ocean → deep box advection	Yes	Yes
deep box → surface box advection	Yes	Yes
deep box ⇔ surface box vertical mixing	Yes	Yes
system ⇔ ocean horizontal mixing	No	Yes

Table II.2. Constants or parameters used to solve for the two formulations of K_Z.

QUANTITY	**DEFINITION**	**VALUE**	
		MA48	*Y99*
K_0	vertical diffusivity without stratification	≈ 1 cm^2 sec^{-1}	
a	experimental constant	3.33	
b	experimental constant	1.5	
R_i	Richardson number	Equation (2)	
g	gravitational acceleration	980 cm sec^{-2}	
r	nominal seawater density	1.02 g cm^{-3}	
$\partial U / \partial z$	nominal vertical velocity gradient	≈0.06 sec^{-1}	
K_b	Background vertical diffusivity.	---	≈0.5 cm^2 sec^{-1}
h_0	Background vertical viscosity.	---	≈5 cm^2 sec^{-1}

Table II.3. Comparisons among LOICZ, MA48, and Y99 calculations of water fluxes in Manila Bay (based on data in Jacinto *et al.* 2000).

QUANTITY	**Manila Bay** (Jacinto *et al.* 2000)	***LOICZ*** (10^9 m^3 yr^{-1}) [except as noted]	***MA48*** (10^9 m^3 yr^{-1}) [except as noted]	***Y99*** (10^9 m^3 yr^{-1}) [except as noted]
h	850 cm			
F	40,000 m			
$S_{syst\text{-}d}$	33.0 psu			
$S_{syst\text{-}s}$	32.0 psu			
$S_{ocn\text{-}d}$	34.4 psu			
$S_{ocn\text{-}s}$	34.4 psu			
Stratification parameter	0.0012			
V_{syst}	30x10^9 m^3			
A_{syst}	1.7x10^9 m^2			
A_{deep}	150x10^3 m^2			
A_{surf}	220x10^3 m^2			
V_{Q*}	25x10^9 m^3 yr^{--1}			
K_Z		0.74 cm^2 sec^{-1}	0.44 cm^2 sec^{-1}	0.54 cm^2 sec^{-1}
V_Z		466	278	340
D_H		---	9.7 x 10^6 cm^2 sec^{-1}	6.5 x 10^6 cm^2 sec^{-1}
V_{Xdeep}		---	115	77
V_{Xsurf}		---	169	114
V_{deep}		333	116	188
V_{surf}		-358	-141	-213
V_{ent}		333	116	188
t		31 days	26 days	26 days

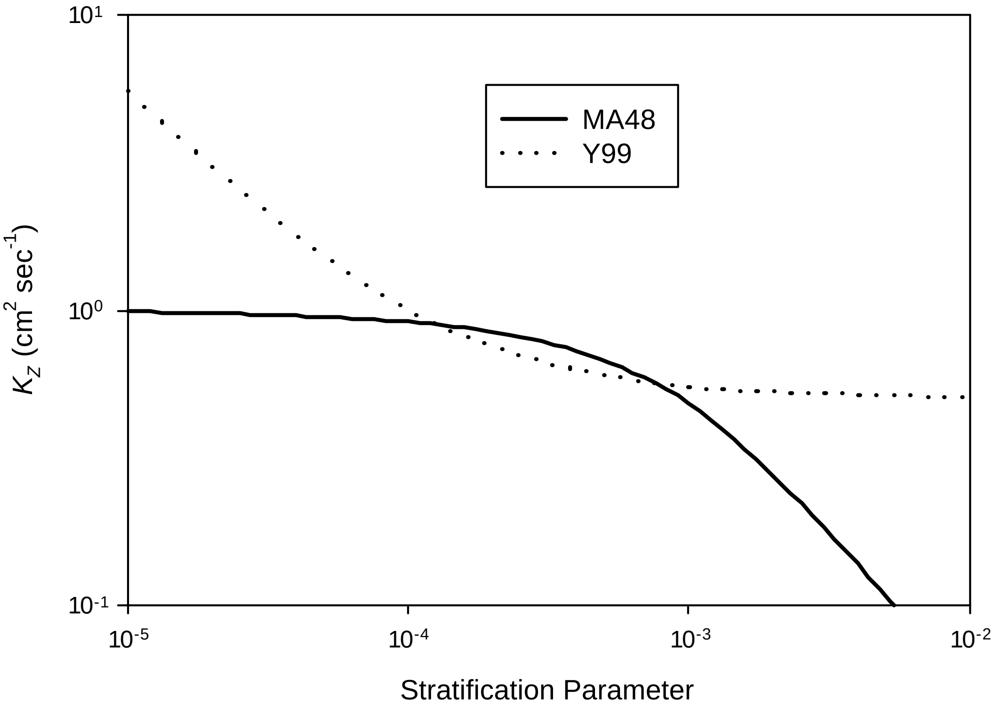

Figure II.1. Stratification parameter versus two estimates of K_Z as a function of that parameter (see text for definitions of terms).

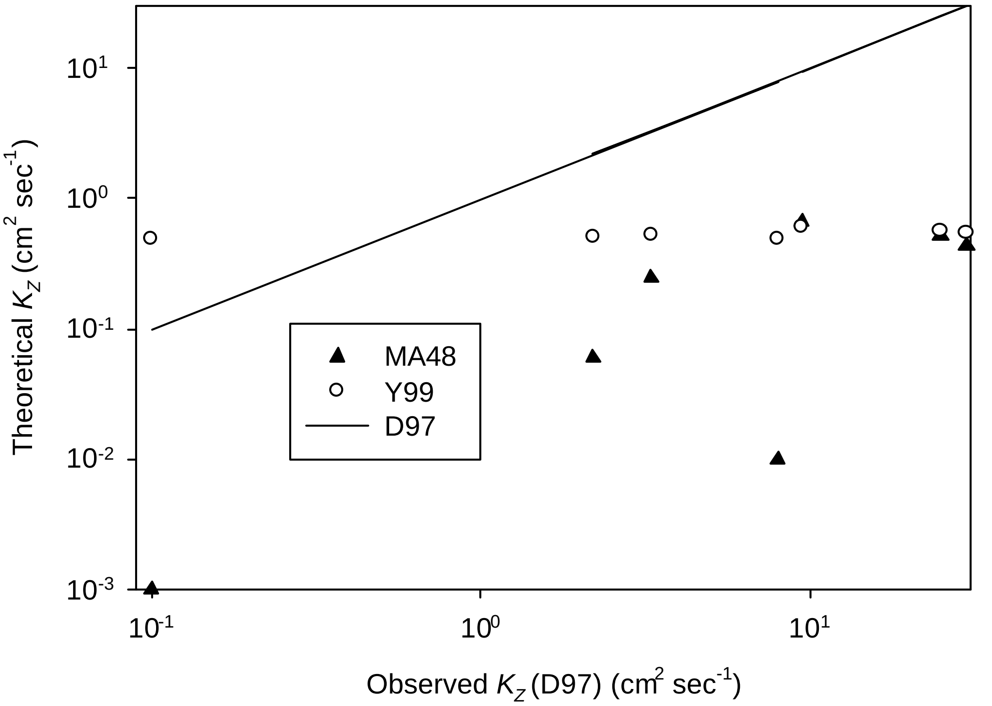

Figure II.2. Observed K_Z for 7 estuaries (from Dyer, 1997) versus K_Z calculated for those systems.

Appendix III Workshop Report

Welcome

Participants (Appendix IV) were welcomed to the workshop venue at the Hong Kong Baptist University, Kowloon, Hong Kong by the local host, Prof. Ming Wong. Support arrangements and the purpose of the workshop were outlined. The agenda (Appendix V) was introduced and working documents, diskettes and CD-ROMs of support and tutorial materials were distributed to participants.

Introduction and Tutorials

An introduction to the LOICZ Core Project of IGBP (Dr Chris Crossland) provided a context of goals and approaches being undertaken to describe global changes in materials fluxes in the coastal zone, and a framework for the workshop activities. A comprehensive description of the LOICZ biogeochemical budgeting approach by Prof. Stephen Smith, and the planned interpolation of local scaled information to global scales gave a foundation for the workshop enterprise. A detailed tutorial addressed key elements and tools available to researchers for the derivation of C-N-P budget models and estimation of net metabolism of coastal systems. These included:

- Biogeochemical budget construction and calculations (Vilma Dupra);
- Introduction and description of a new tool developed for use in site nutrient budget calculation – CABARET software (Dr Laura David). CD-ROM copies of the software were provided to all workshop participants;
- Waste load estimation and relationships for calculation were described (Dr Maria Lourdes San Diego McGlone) and copies of a recent publication in Marine Pollution Bulletin by McGlone and others were circulated;
- Alternative methods for estimating system exchange were addressed by Prof. Tetsuo Yanagi, and case examples were discussed.

Presentation of Site Biogeochemical Budgets

The preliminary budgets brought by the participants for regional sites were briefly presented and discussed. Key points included system settings, box arrays needed to encompass the sites, data availability and quality, and key features about the socio-economic settings and changes.

System sites included:

Japan
Dokai Bay (and comparison with an existing model for Hakata Bay)

China
Aimen Estuary, Pearl River delta
Modaomen Estuary, Pearl River delta
Jiulong River estuary

Korea
Nakdong River estuary
Sumjin River estuary

Regional Sea
Yellow Sea

Russia
Amursky Bay and Tavrichanka River estuary

Taiwan
Chiku Lagoon
Tapong Bay
Tsengwen River estuary
Tanshui River estuary

[Budgets recently developed for sites from the adjacent South China Sea region are also included, following on from efforts after the previous regional workshop: PhanThiet Bay, VanPhong Bay, Tien River estuary, ThuBon River estuary (Vietnam); and Teluk Banten (Indonesia). The Vietnam budgets were developed by Nguyen Huan as a result of his time in Hawaii on the South China Sea Regional Workshop Scholarship].

Budgets Development

Break-out groups worked interactively on the development of these systems, supplemented with methodological and site/issue tutorials and discussions. Estimates for sites and evolution of assessment approaches were made and budget refinements emerged from resolution of techniques, application of derivative data, and assessment of estuarine mixing/exchange and watershed information.

Participants identified further sites which could be the subject of additional budget developments including : Amur River estuary, Amursky Bay (Russia); addition of allied systems such as Xiamen Arm to the Jiulong River estuary (China); estuaries on eastern side of Yellow Sea (Korea) and Yalujiang River estuary (China/North Korea)

Outcomes and Wrap-up

Budgets for all systems were developed to interim draft stage of completion during the workshop; text additions and checks on data sources were required for completion of most budgets. A schedule for contribution of final documents, report and publication, along with the process for review and editing was agreed, noting that hard-copy reports, web-posting and CD-ROM products are planned.

Members of the Project steering committee met informally during the workshop to plan content and programs for further workshops, and to review and finalise arrangements for preparation and publication of tutorial materials.

The participants joined with LOICZ in expressing thanks to Prof. Ming Wong, Dr K.C. Cheung and Ms Doris Ng, Department of Biology and Institute of Waste Management, Hong Kong Baptist University, for the excellent support and hosting of the workshop in Hong Kong. The financial support of the Global Environment Facility was gratefully acknowledged.

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Appendix V Workshop Agenda

LOICZ/UNEP Workshop on
Estuarine Systems of the East Asia Region
Hong Kong Baptist University
Hong Kong
13-15 June 2000

Tuesday, June 13:

0900-0915	Welcome, introduction and housekeeping (Stephen Smith, Ming Wong, Chris Crossland)
0915-0930	Overview of LOICZ (Chris Crossland)
0930-1020	Technical overview: LOICZ budgeting and interpolation (Stephen Smith)
1020	Coffee and discussion
1040-1100	Tutorial: details of LOICZ budgeting (Vilma Dupra)
1100-1120	Tutorial: tools for calculations (CABARET software), run off algorithm (Laura David)
1120-1140	Tutorial: waste load estimates (Maria Lourdes McGlone)
1140-1200	Example: “non-budget” approach to estimating exchange (Tetsuo Yanagi)
1200	Lunch and discussions
1300	Case studies overview
1300-1320	Dokai Bay, Japan (Tetsuo Yanagi)
1320-1340	Pearl River delta (Ming Wong and KC Cheung)
1340-1400	Amursky Bay/Tavichanka estuary (Anatoly Mozherovsky)
1400-1420	Yellow Sea (Chang Soo Chung)
1420-1440	Nakdong River estuary (Sung RyullYang)
1440-1500	Jiulong River estuary (Hua-sheng Hong and Wenzhi Cao)
1500	Coffee and discussion
1520-1540	Chiku Lagoon (Jia-Jang Hung)
1540-1600	Tapong Bay (Jia-Jang Hung)
1600-1700	Discussion of ongoing workshop structure: What mix of tutorial, formal presentations and/or plenary discussions will fit the needs of the workshop participants.

Wednesday June 14:

0900-0915	Brief reminder of working arrangements
0915-1200	Breakout groups/individuals refining budgets
1200	Lunch
1300-1630	Breakout groups or plenary, as required to refine and present developed budgets
1630-1700	Plenary to present or discuss budgets

Thursday June 15:

0900-0915	Brief review of program and working arrangements
0915-1200	Breakout groups, plenary to discuss budgets and start preliminary regional synthesis
1200	Lunch
1300-1500	Plenary wrap-up discussion
1445-1500	Closing announcements
1500+	Informal discussions

LOICZ/UNEP Workshop on
Estuarine Systems of the East Asia Region
Hong Kong Baptist University
Hong Kong
13-15 June 2000

Primary Goals:

To work with researchers dealing with estuarine systems of the East Asia region, in order to extract C,N,P budgetary information from as many systems as feasible from existing data. The East Asian systems include one of the major coastal regions of the world oceans and are heavily influenced by anthropogenic activity. The workshop provides the opportunity to characterize terrigenous inputs to the estuaries of the region, and outputs from the estuaries - hence the net role of the estuarine zone of this region as a source or sink for carbon, nitrogen, and phosphorus.

This workshop will complement earlier workshops, held in

- Ensenada, Mexico (June 1997);
- Canberra, Australia (October 1998);
- Merida, Mexico (January 1999);
- Manila, Philippines (July 1999);
- Bahia Blanca, Argentina (November 1999); and
- Goa, India (February 2000).

It is hoped that each workshop participant will be able to bring the available data for at least two budgets: one from one of the "pollution hot spot" regions within their country, and one for a physiographically fairly similar region which is apparently subjected to less pollution. By this strategy, we hope to compile a set of sites that will represent a relatively wide range of human pressures in the East Asia region.

Anticipated Products:

1. Develop budgets for as many systems as feasible during the workshop.
2. Examine additional data, brought by the researchers, or provided in advance, to scope out how many other systems can be budgeted over an additional two months.
3. Prepare a LOICZ technical report and a CD-ROM summarizing this information.
4. Contribution of these sites to 1-2 papers to be published in the refereed scientific literature.
5. It is anticipated that one participant from the workshop will be offered the opportunity to spend up to two months in Hawaii or Manila, getting further experience and developing additional budgets for the region.

Participation:

The number of participants will be limited to fewer than 18 persons, to allow the active involvement of all participants. Nominees include:

- Three to five resource persons (regional and external);
- Up to 13 researchers from the region (see below).

Workplan:

Participants will be expected to come prepared to participate in discussions on coastal budgets. Preparation should include reading the LOICZ Biogeochemical Modelling Guidelines (Gordon *et al.* 1996), the Mexican Lagoons Workshop Report (Smith *et al.* 1997), examination of the budgets and tutorials presented on the LOICZ Modelling web page (http://data.ecology.su.se/MNODE/), and arriving with preliminary budgets, electronic maps, and 1-3 page write-ups from "their" sites. In order to be included in the workshop report, the budgets should conform as well as possible to the budgeting protocol laid out in the above documentation. Guidelines for budget preparation and write-ups and a tutorial package entitled CABARET can (and should) be downloaded from the LOICZ Modelling website.

Further Details:
At an absolute minimum, each participant is expected to arrive at the workshop (or send us in advance) the following materials:

1. A 1-3 page description of the area (see materials posted on the Web and in the various workshop reports) and a map of the site. These should be in electronic format.
2. Within the context of needs for the overall LOICZ project, some estimate of water exchange (most commonly via water and salt budgets) and budgets for the dissolved inorganic nutrients, nitrogen and phosphorus, constitute the minimum useful derivations from the biogeochemical budgeting. Budgets of other materials, while potentially interesting for other purposes, do not satisfy this minimum requirement. The minimum data requirements are as follows:
   a. The primary seasonal pattern of the region is at least one wet season and one dry season per annum. Ideally, a budget for each season should be developed. If a system is vertically stratified, then a 2-layer budget is preferred over a single-layer budget. If a system has a strong land-to-sea salinity gradient, then it is preferable to break the system along its length into several boxes.
   b. Data requirements to construct a satisfactory water and salt budget include: salinity of the system and the immediately adjacent ocean, runoff, rainfall, evaporation, and (if likely to be important) inputs from other freshwater sources such as groundwater or sewage. Preferably, the salinity and freshwater inflow data are for the same time period (for example, freshwater inflow data for a month or so immediately prior to the period of salinity measurement). In the absence of direct runoff estimates for small catchments, estimations can be made from a knowledge of catchment area and monthly rainfall and air temperature for the catchment. See materials on the LOICZ biogeochemical modelling web site.
   c. Data requirements for the nutrient budgets are: concentrations of dissolved nutrients (phosphate, nitrate, ammonium and, if available, dissolved organic N and P) for the system and the adjacent ocean, concentrations of nutrients in inflowing river water (and, if important, in groundwater), some estimate of nutrient (or at least BOD) loading from sewage or other waste discharges. If atmospheric deposition (particularly of N) is likely to be important, an estimate of this is also useful. If direct waste load measurements are not available, estimations can be made from a knowledge of the activities contributing to the waste loads and the magnitudes of those activities. See the materials on the website.

Workshop Schedule (All participants are expected to stay for the entire workshop):

June 12: Arrival
June 13: General introduction to the budgeting procedure and related issues; presentation of preliminary budgets (no details, simply a quick summary to see who has what.)
Breakout groups to revise and refine budgets. This will vary, as needed, from tutorial, through detailed help, to procedural discussions.
June 14: Continue breakouts; afternoon plenary to evaluate progress.
June 15: Breakouts/plenary as required to develop synthesis.
June 16: Departure.

Background Documents:

1. Gordon, D.C., Boudreau, P.R., Mann, K.H., Ong, J.-E., Silvert, W., Smith, S.V., Wattayakorn, G., Wulff, F. and Yanagi, T. 1996 LOICZ Biogeochemical Modelling Guidelines. *LOICZ Reports and Studies* **5**, 96 pages.
2. Smith, S.V., Ibarra-Obando, S., Boudreau, P.R. and Camacho-Ibar, V.F. 1997 Comparison of Carbon, Nitrogen and Phosphorus fluxes in Mexican coastal lagoons. *LOICZ Reports and Studies* **10**, 84 pages.
3. LOICZ Modelling web page, for everyone with www access: (http://data.ecology.su.se/MNODE/).

- The LOICZ web pages, including the guidelines, are frequently updated. Recent additions to the site include several PowerPoint presentations designed to familiarize participants further with the budgeting procedures and with an overview of the LOICZ budgeting efforts.
- A CD-ROM with the current web page will be available during the workshop.
- CABARET (Computer Assisted Budget Analysis, Research, Education, and Training). A version of this software and a PowerPoint demonstration of its use are available on the web site and update version will be provided at the workshop.

Appendix VII Glossary of Abbreviations

NH_4	Ammonium
NO_3	Nitrate
DIN	Dissolved inorganic nitrogen
DON	Dissolved organic nitrogen
DIP	Dissolved inorganic phosphorus
DOP	Dissolved organic phosphorus
POP	Particulate organic phosphorus
PON	Particulate organic nitrogen
PTN	Particulate total nitrogen
PTP	Particulate total phosphorus
ON	Organic nitrogen
OP	Organic phosphorus
TN	Total nitrogen
TP	Total phosphorus
DOC	Dissolved organic carbon
DIC	Dissolved inorganic carbon
POC	Particulate organic carbon
OC	Organic carbon
SiO_4	Silicate
nfix	Nitrogen fixation
denit	Denitrification
p	Primary production
r	Respiration
TDN	Total dissolved nitrogen
TDP	Total dissolved phosphorus
CTD	Conductivity Temperature Depth